Northern Neck Planning District Commission
Northern Neck Conservation Corridor Planning Outreach

Green Infrastructure Implementation Alternatives
Climate Change Vulnerable Infrastructure Assessment

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Table of Contents

I. NNPDC Green Infrastructure Implementation Alternatives Report

A. Comprehensive Plan page 1
B. Subdivision Ordinances page 3
C. Zoning page 4
1.Agricultural Zoning page 5
2. Large Lot Zoning page 6
3. Cluster Development Zoning page 6
4. Fixed Area Base Zoning page 7
5. Sliding Scale Zoning page 7
D. Urban Growth Boundary/Urban Services Area page 8
E. Conservation Easements page 9
F. Purchase of Development Rights (PDR) page 10
G. Transfer of Development Rights (TDR) page 11
H. Agricultural and Forestal Districts (AFD) page 12
I. Land Use Value Taxation page 13
J. Table Ranking Priority and Ease of Implementations of Green Infrastructure Protection Measures page 14
K. Summary page 17

II. NNPDC Climate Change Vulnerable Infrastructure Assessment

A. Introduction page 18
B. Study Details and Vertical Accuracy Issues page 21
C. Methodology page 22
D. Results page 24
Figure 1 - Lancaster County Possible Impacts to Green Infrastructure (Wetlands) from Sea Level Rise page 28
Figure 2 - Northumberland County Possible Impacts to Green Infrastructure (Wetlands) from Sea Level Rise page 29
Figure 3 - Richmond County Possible Impacts to Green Infrastructure (Wetlands) from Sea Level Rise page 30
Figure 4 - Westmoreland County Possible Impacts to Green Infrastructure (Wetlands) from Sea Level Rise page 31
Figure 5 - Lancaster County Possible Impacts to Grey Infrastructure and Private Buildings from Sea Level Rise page 32
Figure 6 - Northumberland County Possible Impacts to Grey Infrastructure and Private Buildings from Sea Level Rise page 33
Figure 7 - Richmond County Possible Impacts to Grey Infrastructure and Private Buildings from

Sea Level Rise page 34
Figure 8 - Westmoreland County Possible Impacts to Grey Infrastructure and Private Buildings from Sea Level Rise page 35
E. Climate Change Vulnerability Infrastructure Assessment Outreach Activities page 36

III. Appendix
Lancaster County Climate Change Vulnerability Analysis Presentation page 39
Northumberland County Climate Change Vulnerability Analysis Presentation page 60
Richmond County Climate Change Vulnerability Analysis Presentation page 80
Westmoreland County Climate Change Vulnerability Analysis Presentation page 100
Lancaster County Green Infrastructure Implementation Alternatives Report page 120

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I. NNPDC Green Infrastructure Implementation Alternatives Report

Tools Available to Virginia Localities to Protect Green Infrastructure

Introduction

Green infrastructure is valuable to all Virginia citizens, as natural areas in forest and natural vegetative cover provide many ecosystem service benefits to all inhabitants of the Commonwealth. Protecting soil from erosion, filtering air and water, providing habitat for game and other species of wildlife, sequestering carbon, moderating temperatures, as well as a variety of esthetic values that natural areas provide are but some of the benefits that can be attributed to green infrastructure. Protection of those benefits from green infrastructure assets will assure that future generations of Virginians can benefit from their existence. This report is an attempt to provide localities that are interested in protection of green infrastructure assets a comprehensive list of tools available under Virginia law to assist them in protection of local natural areas.

The Commonwealth of Virginia is governed under the Dillon Rule, which states that localities within Virginia can "exercise the following powers, and no other: First, those granted in express words; second, those necessarily or fairly implied in, or incident to, the powers expressly granted; third, those essential to the declared objects and purposes of the corporation not simply convenient, but indispensible. Any fair, reasonable doubt concerning the existence of power is resolved by the courts." Therefore, localities are constrained by Dillon Rule and can only exercise the powers that have been expressly given to them under state code. This document is an attempt to compile the available tools available to Virginia counties primarily in order to protect green infrastructure, but these tools also apply to protection of other open spaces, working lands, forests, scenic vistas, local groundwater wellhead protection, historical, cultural or environmentally sensitive areas within their jurisdiction.

The tools that follow to assist in green infrastructure protection can be used by localities; although, not every tool is appropriate in every situation. The mix of tools for a particular locality will vary, dependent on elected official support, citizen support, as well as county administration support. The most effective green infrastructure protection implementation plan is not a one-size-fits-all approach, but rather a customization of compatible tools that fit a county's personality and willingness to implement.

A. Comprehensive Plan

Comprehensive plans were mandated for all localities by July 1, 1980, in 1975 by the Virginia General Assembly. This session of the General Assembly also mandated localities appoint a local planning commission by July 1, 1976, and a subdivision ordinance by July 1, 1977. Since local planning commission's are charged with creating and revising comprehensive plans, it was necessary to have that institution in place and running with a few years of experience before the comprehensive plan was mandated.

Comprehensive plans, also known as general plans, are plans for the physical development of the territory within the county's jurisdiction Virginia Code Sec. 15.2-2223. Comprehensive plans are required by Virginia State law, and every locality must have one in place, and are required to review (not necessarily revise) the plan every five years. Comprehensive plans contain local government policies, objectives and decision guidelines that govern future development within the county. In addition, the comprehensive plan often gives indication on what type of development is desired and where it is to be located within the jurisdiction. Typically the comprehensive plan also include ways to implement the policies set forth in the plan. Comprehensive plans also provide the framework for zoning ordinances within the jurisdiction and outline the orderly development of public services to coincide with increased growth.

The Virginia Code Section 15.2-2223 identifies the elements that may be included in the comprehensive plan:
Land Use - designates areas within the county for various types of public and private development.
Transportation - describes a system of transportation facilities such are streets, roads, highways, railways, bridges, ports and other like facilities
Community Service Facilities - designates a system of community service facilities such as parks, forests, schools, playgrounds, public buildings and institutions, hospitals, community centers, water and sewer works, and the like.
Historical Areas and Renewal - designates historical areas in the county (if present), and areas for urban renewal.
Groundwater Protection - designates areas for the implementation of reasonable groundwater protection measures (This section is the most likely place for green infrastructure protection measures would be placed within the comprehensive plan).
Affordable Housing - designates areas for the implementation of measures to promote the construction and maintenance of affordable house, sufficient to meet the needs of all county residents, regardless of income now, and into the future.

The future land use plan is perhaps the heart of any comprehensive plan as it shows the future goals of the comprehensive plan in a geographical format. The future land use plan map's principal component is the location of future primary (and sometimes secondary) growth areas in the county. In addition to the growth areas, most county future land use plan maps show constraints to development, future planned public facilities, sensitive environmental areas, as well as envisioned transportation system enhancements. The future land use map is the section of the comprehensive plan that a county, if desired, would show green infrastructure areas, open, space, working farmlands, and/or forests to protect. Any rezoning of land parcels within the county is required by law to be consistent with the comprehensive plan. However, amendments to the comprehensive plan can be made by the county Board of Supervisors to allow potential rezoning in areas where inconsistencies with the comprehensive plan are present.

A comprehensive plan is a general plan for development in the county. While the comprehensive plan is a guide, it does not have the enforcement power of the zoning

ordinance. Regardless, the comprehensive plan in Virginia is an important and legally significant document. A strong comprehensive plan usually has a clear linkage between the comprehensive plan stated and/or implied policies and the zoning and subdivision ordinances. If a county's goal is to protect natural areas and green infrastructure for future generations, the comprehensive plan would be the first place to make mention of this policy, as well as include delineated green infrastructure protection areas in the comprehensive plan's Future Land Use Map.

B. Subdivision Ordinances

A subdivision, unless otherwise defined by local ordinances, means the division of a parcel of land into three or more lots of less than five acres each for the purpose of transfer of ownership or building development, or, if a new street is involved in any such division, and division of a parcel of land Virginia Code Sec. 15.2-2201. The agent designated in the Subdivision Ordinance is responsible for making the determination of a proposed division is a subdivision within the meaning of the Subdivision Ordinance. *See 1987-88 Va. Op. Atty. Gen 208.* The agent is usually appointed by the Board of Supervisors of a county, and in many cases, where county staffs are small, the subdivision ordinance agent staff person is also the Zoning Administrator for the county. Land subdivision and development standards for localities are contained in Virginia Code Sec. 15.2-2240 through Sec. 15.2-2279.

Many localities in Virginia class subdivisions according to size: major, minor, and family. Family subdivisions are usually restricted to immediate family members and are exempt from the subdivision ordinance in most cases. Minor subdivisions usually are small subdivisions less than five lots and without an access road. Major subdivisions often require more information provided, as well as water quality impact and traffic studies, due to the larger area of the locality these subdivisions cover and the number of persons that will reside there.

Subdivision ordinances are in place to help assure that the necessary (and required) infrastructure is put in place for orderly and safe development. Examples of infrastructure that would be required by a subdivision ordinance would be roads (built to either state specifications in the case of roads to be accepted into the state maintained road network, or county specifications in the case of private roads), to be maintained by the homeowners community association, storm water treatment and conveyances, erosion and sediment control, electric, telephone, water, and gas transmission line easements, parking details, septic system suitability and location (or sewer line easements in the case when public sewer is available), and possibly landscaping plans. Without a subdivision ordinance in place, it is unlikely that developers would spend funds to provide the necessary infrastructure stated above which is essential for a viable long term development. Therefore these investments in infrastructure are mandated by the locality and are usually financially bonded so that the locality can assure that these infrastructure projects are completed, even if the developer sells the property or otherwise reneges on his promise to complete the investments.

Subdivision ordinances protect both the local government as well as the citizen who purchases land inside a subdivision. Services are needed by subdivisions, and the subdivision ordinance is an important tool to make sure that these services that modern civilization relies on are provided for prior to development and are permanently protected. The subdivision ordinance assists in protecting the health, safety and welfare of the local citizens by applying principles of sound land use policy, wise resource management and water quality protection.

Open space provisions are often a part of Virginia counties' subdivision ordinances. Localities with cluster development guidelines often insert open space requirements within the subdivision ordinance. Some localities have the trigger for open space requirements tied to the total acreage or number of subdivision tracts within a development. Typically, the larger a subdivision, the more likely a jurisdiction will require some public space for use by residents. In addition to requiring open space within subdivisions for public recreation and water quality, subdivision ordinances often require homeowners associations to be formed to manage this common property amongst subdivision citizens. If a locality is interested in protection natural areas and associated green infrastructure, the locality can add a provision in their subdivision ordinance that any required community open space in a subdivision be protected in perpetuity from development by a conservation easement. Further, a locality can specify some portion of the open space to be reserved for natural vegetation (as opposed to turf grass or working farmland), which would protect natural habitat as well as air and water quality. Currently at least one Northern Neck county already specifies percentages of land cover in their cluster subdivision section of the subdivision ordinance, noting that 50 percent of the open space shall not be wetlands, flood plains, or above ground utility uses (including storm water management).

C. Zoning

Zoning ordinances are the most powerful tools available for localities to implement the policies of their comprehensive plan. Although zoning is not mandatory for Virginia localities, a majority of localities in Virginia have adopted zoning ordinances. Virginia State Code Sec. 15.2-2280 states that any locality, may, by ordinance, classify the territory under its jurisdiction or any substantial portion thereof, into districts of such number size and shape as deemed important to needs of the community and the purposes of zoning defined by the code.

The premise behind zoning laws is to avoid negative external effects that vastly different uses of neighboring properties might have. Thus, like land uses should be grouped together (such as business and commercial), and disparate land uses should be separated (such as industrial and residential). The underlying reasoning is that some uses could negatively impact some properties value, and that properties should be protected from disruptive land uses nearby. Zoning, as applied by Virginia localities, typically feature discreet geographical areas with differing allowances for density and use of the land. Typical categories used in Virginia county zoning are residential, commercial and

industrial. Each classification of zoning type must have a text description of allowable uses and also must be a accompanied by a an official zoning map maintained by the locality.

There is no mandate from the state to review zoning ordinances in a locality; therefore, many localities have zoning that dates back two decades (or more). Maintaining consistency between the comprehensive plan and the zoning ordinance is especially difficult when one document is revised while the other document is not.

If a locality is interested in protecting identified green infrastructure areas within their county, a conservation zoning classification could be created that reduces development within the areas determined and designated by the county as such. The amount of development that the county would want to envision for the future of the conservation area would have to be worked out within each county, depending on their overall future plan for the county.

1. Agricultural Zoning

   In Virginia, all counties utilize non-exclusive agricultural zoning; that is, the zoning classification agriculture allows agricultural and some residential development, as opposed to exclusive agricultural zoning which prohibits any non-farm development. At least one Northern Neck county attempted to eliminate several of the permitted uses in the agricultural zoning category to make it more of a true agriculture zone classification and were met with strong citizen resistance under the claim of private property rights being taken away by the change. That county has decided not to pursue strengthening their agricultural zoning category at this time. There are advantages for non-exclusive agricultural zoning such as being inexpensive, quickly implemented, flexible and limiting to intrusion of new non-agricultural activities. In order to smooth the conflict between agricultural and residential use, many counties in Virginia have anti-nuisance clauses to protect agricultural interests that precede residential development.

   If a county were interested in protection natural areas and green infrastructure in certain parts of the county, they could institute a certain area of the territory under their jurisdiction as an exclusive agriculture zone so as to retain working farmlands. Adjacent to the farmlands, particularly in the Northern Neck, are the forested drainage channels that feed the many freshwater streams and creeks that bisect the landscape. By protecting agricultural lands, the adjacent forested lands would also be protected by their proximity to the agricultural fields. As a result of the long history of agriculture here in the Northern Neck, dating back to the 1700's, most all of the land level enough to farm is already in agricultural production. Therefore, there would be little chance of agricultural producers expanding their fields in these designated area, as most agriculture fields in the Northern Neck are adjacent to steep land formed by drainage channels next to currently farmed fields.

2. Large Lot Zoning

Some counties in Virginia have instituted large lot zoning, under the precept that large lot residential development (with a minimum lot size five or ten acres) helps protect a viable farming community and retains a rural open space feel to the community. One advantages of large lot zoning is that it reduces the population density of the area in which it is instituted and thereby saving the county money as less citizens require less government services. In addition to requiring fewer services, the citizens who can afford such large lots usually build larger than average houses; therefore, the county will receive higher property taxes from these larger than average homes. However, large lot zoning often does create low density development patterns, these "mini-estates" often take land out of agricultural production and creates either idle land or large expanses of turf grass yards that must be maintained. The main disadvantage of large lot zoning is that it promotes residential sprawl. Under conventional 0.5 acre minimum lot size residential zoning, 200 homes would take up 100 acres; however, if the minimum lot size was set at 10 acres, then those same 200 homes would take up 2,000 acres. Another disadvantage of large lot zoning is that it can be viewed as exclusionary zoning since low income citizens would not have the income available to purchase the large amounts of land to make up the minimum allowed, much less the funds to build a house on that land if purchased.

If a locality wanted to protect natural areas using large lot zoning, there would need to be a provision in the ordinance to leave a certain percentage of the lot in natural vegetative cover. This provision would help to protect natural areas, but the disadvantages of large lot zoning sprawl might negate any protection of natural areas that might benefit.

3. Cluster Development Zoning

Congregating development into compact areas in order to protect adjacent open land is the goal of cluster development zoning. The concept is the same as cluster subdivisions in the subdivision ordinance; however, the subdivision ordinance allows the cluster subdivision development to be placed anywhere in the county. Cluster development zoning usually designates geographic areas of the county that the county government would like to preserve as open space. In a rural setting, cluster development is usually designed to protect agriculture land or forest. To protect these designated natural areas further, the county could require that a portion of the open space be left in its natural state (not mowed or farmed). In addition, and perhaps more importantly, the county could mandate that all open space generated from cluster development be put under conservation easement to protect the open, natural area from development in perpetuity.

One of the disadvantages of cluster development zoning is that it promotes pockets of residential development in rural areas, which is actually a form of sprawl. Also, the open spaces that are carved out in these developments area often not large enough for many native animal species and actually fragments natural areas into small, under functioning habitats.

If a county was interested in protecting natural areas as much as possible while still allowing development, then the board of supervisors could designate parts of the county they would like to protect as cluster development only zoning classification, thus mandating cluster development in that particular green infrastructure protection area.

4. Fixed Area Based Zoning

The concept for fixed area based zoning is to keep open space intact, while still allowing some development, which is usually on small lots within the larger parcel and usually clustered. An example of fixed area based zoning is that a landowner would be allowed one house for every 20 acres, with the maximum lot size of 2 acres. In fixed area base zoning, dwellings are built on small lots within the larger parcel. While this approach to zoning allows for open space within these areas, it also can result in relatively high levels of rural residential development. In addition, if the open space area of the development is not protected by conservation easement, they could be subdivided if the ordinance changes.

If a county wanted to protect green infrastructure by using fixed area based zoning, then they could either designate areas within the county to allow fixed base zoning, or implement it county wide. In addition, the county could require any parcel that is "built out" (have utilized the maximum the number of dwellings for their acreage) would be required to put the remaining open land under a conservation easement to protect it in perpetuity.

5. Sliding Scale Zoning

The concept with sliding scale zoning is that as parcel size increased, the number of homes allowed to be built decreases. The thought is that smaller parcels are better suited for development since they have already been carved out of larger tracts. Larger parcels are more economical to farm and practice forestry, so the idea is to limit the subdivision of larger parcels, in order to retain larger tracts (usually rural and either forested or farmed) thereby reducing fragmentation. An example of sliding scale zoning would be for lots up to 10 acres, four building lots would be allowed; for lots from 10-20 acres, five lots would be allowed; from 20 - 50 acres, six lots would be allowed; from 50 - 100 acres, seven lots would be allowed; and 100+ acre lots, each 25 acres above 100 acres would be allowed an additional lot therefore a 150 acre parcel would be allowed nine lots; and a 200 acre parcel would be allowed twelve lots.

Sliding scale zoning allows for some development while protecting larger expanses of working land and forests, making this green infrastructure protection tool somewhat popular in Virginia. In fact, Richmond County, here in the Northern Neck adopted sliding scale zoning back in 2006. The disadvantages of sliding scale zoning is that a county could scrap the ordinance at any time by

action of the Board of Supervisors and any of the lots that were previously subdivided under the sliding scale rule could then be subdivided again. In order to avoid that scenario, in addition to the sliding scale zoning, it would be prudent to consider adding the requirement that larger parcels that remain after the maximum number of lots are subdivided would be required to put into conservation easements to protect in perpetuity, in case the future government rescinds the sliding scale zoning.

If a county was interested in protecting green infrastructure areas within their county, instituting sliding scale zoning would be a good way to add additional protection for natural areas. To further aid in the protection of large parcels of natural areas, the county could add that the remaining large parcels left after the subdivision of the maximum number of buildable lots be required to be put into conservation easement in perpetuity.

D. Urban Growth Boundary/Urban Services Area

In order to concentrate development, protect natural green infrastructure areas, and reduce the amount of urban sprawl in a county, localities have the option of defining an Urban Growth Boundary or Urban Services Area. The location of this line could take into account population projections, public facility capacity, and resource protection goals. The concept of the Urban Growth Boundary/Urban Services Area is to define the location of a line within the jurisdiction where, on the one side, development is encouraged (there is urban infrastructure such as water and sewer to support the development) and on the other side of the line, development is discouraged. The county discourages growth by not extending infrastructure (water and sewer lines) past the urban growth boundary line. The envisioned result is more compact development with increased open space, natural areas, and working lands benefitting the community as a whole.
In Virginia, the most well known and successful example of an urban growth boundary is Virginia Beach. In 1979, the city of Virginia Beach created a growth boundary line, called the Greenline, that ran east and west through the city's center. North of the line urban development and associated urban infrastructure services were encouraged, with the area south of the line designated as a transition area. South of this transition area was zoned agricultural, where development was discouraged. As part of the City of Virginia Beach's comprehensive approach to protecting farm and natural lands, the city also adopted a Purchase of Development Rights program to purchase the development rights to lands south of the Greenline. For over 25 years, Virginia Beach has implemented these controls and has purchased over 4,000 acres of development rights south of the Greenline. Urban Growth Boundaries work best where there is a singular large town or city within a county, as opposed to many smaller towns geographically interspersed throughout the locality. Urban growth boundaries are not actually zoning designations, but instead policy designations outlined in the comprehensive plan which are reinforced within a comprehensive plan

A locality interested in protecting green infrastructure could create an urban growth boundary, as determined by existing infrastructure, and population projections. After public discussion and debate, this urban growth boundary would be depicted in the Future Land Use Plan Map. When the county's comprehensive plan is revised, county policy could be set by stating that county water and sewer service would not be extended past the urban growth boundary. Other ways that a county could discourage growth is to limit special zoning exceptions in the non-development side of the boundary and infrastructure investments.

E. Conservation Easements

Conservation easements are a legal agreement between a landowner and a land trust or governmental agency to extinguish the development rights of their property. Each conservation easement is unique, as the specifics on what uses are allowed or prohibited are negotiated between the landowner and the holder of the easement until both parties are in agreement. The landowner continues to own the land and exercise all other rights not prohibited in the easement. All conservation easements in Virginia are a voluntary agreement between a private landowner and land trust or government entity and their purpose is to protect open space, surface and groundwater quality, wildlife habitat, working lands (farmland), forests or natural areas. Typically, conservation easements are in perpetuity, with the holder of the easement responsible for inspection of the property and legal enforcement of the easement as necessary. Most conservation easements allow the ownership of the property to be passed to heirs, however, the conservation easement conveys with the property to the subsequent owner(s). Most voluntary conservation easements are donations of development rights that earns both state and federal tax credits in Virginia. The tax credits are overseen by the Virginia Land Preservation Tax Credit Program, and as of the end of 2009, has conserved 457,000 acres of land in Virginia. In order to be able to receive tax credits, conservation easements must meet the following criteria, 1) the easement must be perpetual, 2) it must be held by a qualified organization and held for conservation purposes.

While voluntary conservation easements are generally viewed as favorable to green infrastructure protection, the voluntary nature means that easements will usually be scattered throughout the county in small fragments. These small fragments of protected natural areas, due to their size and un-connectivity, would be relatively useless for habitat protection. What would be more advantageous would be a concentrated area of the county that has more conservation easements in place than the remainder of the county. Obviously it is up to the landowner to decide if conservation easements are a good decision for them, and therefore not all landowners in a area will make that decision. However, if a county was interested in protecting natural green infrastructure areas within their jurisdiction, then outlining sections within the county as green infrastructure protection areas in the comprehensive plan might help spur landowners in that area to inquire about conservation easements.

If a local government were interested in promoting voluntary conservation easements in their county, the county could insert language to that effect in the comprehensive plan. As

mentioned above, additionally, the county could indicate areas within the county in the future land use plan map that highlights areas of the county that should be protected. County policy could then encourage persons in those areas to consider voluntary conservation easements by providing contact information for local land trusts that could be in the plan, on their website, or both.

F. Purchase of Development Rights

Virginia's Purchase of Development Rights (PDR) program for localities was approved by the 2001 Virginia General Assembly. Purchase of development rights is very similar to a donation of a conservation easement; however, instead of tax credits, a landowner receives cash payment from the locality or the state for the value of the development rights of the property. Once the cash payment is made, the property is put under a conservation easement that protects the property from being developed in perpetuity. An appraisal is conducted for the property on the difference between the highest and best use of the property (usually residential or commercial) and the current use of the property to determine the amount of payment. Some counties in Virginia have a fixed price per acre, but most use an appraisal process. Typically the cash payments are spread out over a period of time, allowing a steady stream of income for the landowner into the future. The infusion of cash allows the farmer to invest in his farm or possibly retire and lease his farmland to another farmer. Virginia's purchase of development rights program is aimed at protecting working farmland, although it is understood that natural areas adjacent to fields would also be protected.
The primary problem in implementing purchase of development rights for localities is the local funding component of the program. Additional taxation or recordation fees are not very popular, and neither is diverting general county funds away from schools and public safety programs. However, a PDR program needs funding to operate.

As of January 2012, there are currently twenty-two localities in Virginia that have a local PDR program with eighteen of them with some level of local funding. The state matches local funding for the purchase of development rights; however, the amount is not fixed and waxes and wanes depending on the administration and their stated goals. The Commonwealth has funded grants for purchase of development rights for five years, starting in 2008. In fiscal year 2011, state matching funds, available through the Virginia Department of Agriculture and Consumer Services (VDACS), totaled only $100,000 for the entire state. However, this year (2012) the state allocated $1.2 million to VDACS for state matching grants that were awarded to thirteen Virginia localities. In order to receive the state matching funds, a locality must have a purchase of development rights program adopted and funded by the locality.

If a locality was interested in protecting green infrastructure areas in their county, they could consider adopting the necessary ordinances to permit purchase of development rights, as well as creating a funding source to raise the necessary funds. The state has created a "model" PDR program that localities can use to create a customized local PDR program. The model PDR ordinance information is found here:
http://www.vdacs.virginia.gov/preservation/pdf/pdfprogram.pdf

G. Transfer of Development Rights

Transfer of Development Rights (TDR) is similar to Purchase of Development Rights programs. However, TDR programs involve transferring the development rights from one area within the county where the county wants to protect by reducing density (a sending area) to another part of the county where the increased density can be handled (the receiving area). The receiving area, according to Virginia state guidelines, must be better equipped to handle the increased densities (better roads, water and sewer infrastructure, for example) and the sending area needs to have a resource that needs to be protected (working lands, forest lands, environmentally valuable green infrastructure lands). TDR is a way to promote compact development within a county where the infrastructure can support development, while steering development away from sensitive green infrastructure or working farm and forestlands.

Owners of lands in the sending area voluntarily decide whether to participate in the program, with some opting to not to participate. Others that do decide to transfer the development potential of their property to a sending area negotiate with interested developers on a fair and equitable dollar amount for the development rights of their particular parcel. The development rights become a commodity that can be valued and traded, once it is transferred from the sending area. Obviously, local government will still need to track all activity, document, and conduct periodic inspections; however, that cost is much less than outright purchase of development rights. In an ideal TDR situation within a county, there would be several sending areas and several receiving areas, in order to allow maximum flexibility for all types of development scenarios. Most TDR programs allow higher densities in the receiving areas than the current zoning regulations allow to act as an incentive for developers to participate in the program. One advantage of this system is that the local government only has to set up the framework with private entities funding and completing development rights transactions with the local government overseeing the various transactions. This program is also very equitable, as it compensates those who are effectively down-zoning their own property, while those that are to profit from the program (the developers) pay for increased densities in the receiving area.

The Virginia General Assembly authorized localities to provide a program for transfer of development rights in 2006, so this is still a relative new concept for localities in Virginia. As of January 2012, no county with the Commonwealth has instituted a Transfer of Development Rights program. TDR programs in Virginia, by law, are all voluntary, and require a conservation easement placed on the property in the sending area that has transferred its development rights.

Some of the perceived disadvantages of the program, is the identification of the various sending and receiving areas within the county's geographical area. Most citizens would not have a problem with the sending areas; however, citizens in the receiving area may believe that they are bearing the brunt of the burden to protect blue green infrastructure or working lands in other parts of the county. Also, in order for the program to effectively

protect the natural resource areas identified, there must be a certain level of activity of transactions to accomplish this. Under a voluntary system, this can often be difficult to achieve. Another problematic point with a TDR program is how to allocate any transferred development rights, the densities allowed in the receiving area and what kind, incentives, if any, should local government provide to encourage participation in the program.

A locality wishing to implement a TDR program to protect blue green infrastructure would be encouraged to look at the county's defined growth areas (to be considered as receiving areas) and, perhaps more importantly, the natural areas they wish to protect (the sending areas). To inform and bolster citizen support, the county could consider holding a public information meetings on the concept of TDR to further citizen understanding.

H. Agricultural and Forestal Districts

Agricultural and Forestal Districts (AFD's) are areas voluntarily formed by the landowners, in cooperation with local government, to protect their land and operations from encroachment by non-agricultural and non-timber interests. The Virginia State Code provides for AFD's in order to "provide a means for mutual undertaking by landowners and localities to protect and enhance agricultural and timber land as a viable segment of the Commonwealth's economy and as an economic and environmental resource of major importance."

Landowners can request from a local government permission to create a local agricultural forestal district, as there are several benefits that landowners in a district receive. One advantage of forming an AFD is that landowners in an approved district are guaranteed to receive land use value taxation on their property even if the county does have this program in place. Secondly, being within an agricultural and forestal district afford protection from nuisance ordinances (since within the district it will all be similar activities undertaken). Also, being within an agricultural and forestal district provides some protection from imminent domain from the state and the county, as well as consideration of the district within local government planning efforts. In addition, the presence of such a district provides a critical landmass for maintaining the viability of agriculture and forestry businesses that support farming and forestry within the locality.

To form an AFD, there must be a minimum 200 acre core of land, which can have many different owners, but all parcels must be adjacent in this initial core. After a core is formed and approved by the locality, landowners within one mile of the core are allowed to join. After the AFD is formed, there is no parcel minimum size to join, no minimum number of landowners and no maximum size limit for a district. If a landowner is interested in only including a portion of his property in the AFD, then the parcel needs to be a stand-alone parcel with its own tax ID to be included. There are two ways to leave an AFD; if the landowner dies, the heirs have up to 2 years to leave the district, or a landowner can send a written request for withdrawal from the district due to economic hardship.

In order to form an AFD, there are several requirements that must be met, the request must be made to the Board of Supervisors, must include a list of the contiguous land owner names with parcel numbers signed by all owners and witnessed, the term of the district (from 4 to 10 years), whether the district is agricultural or forestal (or both) , several maps showing the extent and location of the district, as well as submittal of the $300 fee associated with an AFD application.

If a locality was interested in having landowners in the county potentially form an agricultural and/or forestal district within their county to help protect green infrastructure area then the comprehensive plan should encourage applications, explain the benefits of AFD's, and briefly outline the requirements, so citizens could move forward if they were so inclined. Agricultural and forestal districts are grass root efforts by citizens to retain working lands, and unfortunately, where counties have land use value taxation in place, there is little incentive for citizens to pursue agricultural and forestal districts.

I. Land Use Value Taxation

Land use value assessment and taxation is a program that is guided by the Commonwealth of Virginia to be implemented by localities which reduces the property tax assessments in order to promote and preserve agriculture, forestal, and open space lands. It is one of the oldest land preservation tools available to localities in Virginia. In 1971, upon adopting a new constitution, Virginia gave localities the power to classify real property in their jurisdiction as agricultural, horticultural, forest, or open space uses, and the power to create local ordinances for special assessments for those types of properties. The concept behind this is that instead of a locality assessing property enrolled into this program at its normal highest and best use (fair market value), the property is assessed at its use value. This results in substantial tax reductions for persons enrolled in the program, allowing for more profit, and making it easier for an individual to continue farming or timbering their land. The original stated purpose for the program is "to foster the preservation of real estate for agricultural, horticultural, forest and open space use in the public interest" Code of Virginia, Section 58.1-3230. However, as of late, in addition to protecting open space in the public interest, the reasoning that these less intensive uses of the land require less government services, in the form of emergency services and education than residential areas of the county. Thus, the agricultural and forest lands should be taxed at a lower rate, since they require a lower level of government services. Regardless of the reasoning for land use value taxation, the program does reduce costs for landowners in agricultural and forestry production.

Land use value taxation gives current landowners of working lands incentive to stay in business in order to reap the benefits of the lower property tax rate. All four Northern Neck localities have land use valuation for agriculture and three of the Northern Neck counties have land use value taxation for forest land. Lancaster County, which does not offer land use value taxation for forested land has stated that in the past, large tracts of forest in the county were owned by large forestry corporations, and Lancaster County reasoned that large corporations do not need tax breaks funded by the citizens of the

county. Since that time, however, most of the large lumber corporations have sold off their lands and the county is considering adding forest land as a land use that is eligible for use value taxation, although no decision has been made yet.

Since all four Northern Neck counties employ land use value taxation, encouraging the counties to use it to protect green infrastructure assets using land use value taxation is redundant. However, counties interested in bolstering the protection of green infrastructure within the county could expand the use value taxation to open space and natural lands, since no county currently has that category of use value taxation in place. The natural areas of the counties contain the vast majority of green infrastructure within the county, with the ecosystem services they provide benefitting all citizens in the county, especially the citizens downstream of the green infrastructure asset. Adding natural areas to the type of land use that allows for lowering of the tax burden would be advantageous to protecting green infrastructure in the region.

J. Table Ranking Priority and Ease of Implementation

Green Infrastructure Implementation Protection Tool	**Priority Rank**	**Ease of Implement-ation**	**Advantages**	**Disadvantages**
Comprehensive Plan	#3	Easy	- Sets as a county policy goal	- A guiding policy document only
Subdivision Ordinace	#6	Relatively Easy	- Requires all subdivisions to set aside open space	- Although open space may be protected, still fragmented
Conservation Zoning	#8	Moderate	- Protects designated areas with legal enforcement	-Special exceptions can be made by the BOS at any time - Can be changed to another class of zoning by the BOS at any time
Agricultural Zoning	#9	Moderate	- Protects large areas of working lands, and adjacent natural areas	- Can be viewed by the citizens in the ag. zone as overly restrictive
Large Lot Zoning	#10	Easy	- Allows large areas to be protected	- Unless cons. easements protect undeveloped land, the land may be subdivided if zoning ordinance is

				changed
Cluster Development Zoning	#7	Moderate	-Can protect sensitive natural sites -Landowners can profit while protecting natural resources	-Unless cons. easements protect undeveloped land, open space may be subdivided if zoning ordinance is changed May lead to pockets of development in mainly rural areas
Fixed Base Area Zoning	#5	Moderate	-Large parcels can be kept available for open space	-Unless conservation easements protect undeveloped land, open space may be subdivided if the zoning ordinance is changed -May encourage high levels of rural residential development
Sliding Scale Zoning	#4	Moderate	-Some development allowed, while protecting a majority of the land area	-Unless conservation easements protect undeveloped land, open space may be subdivided if the zoning ordinance is changed -Smaller lots throughout county can still be developed
Urban Growth Area/Urban Service Boundary	#13	Difficult	-Certainty about how landowners can develop land -Helps to concentrate development into compact areas while saving the majority of land for open space and working lands	-Unless conservation easements protect undeveloped land, open space may be subdivided if the boundary line is changed -To be effective, pairing with a PDR or TDR Program is

				necessary
Conservation Easements	#2	Very Easy	-The only permanent way to protect land from development in perpetuity -Landowners can decide whether conservation easements are right for them and their property	-May lead to disconnected and spread out areas of conservation -Dependent on landowner participation, may not protect large areas of a jurisdiction
Purchase of Development Rights (PDR)	#12	Difficult	-Less expensive than fee simple purchase -Matching funds provided by the state -Permanent easements can enhance the value of neighboring properties, increasing tax revenues to locality	-A local funding mechanism needs to be identified and implemented
Transfer of Development Rights (TDR)	#11	Difficult	-Less expensive that PDR -Fairness, properties with conservation easement compensated, properties receiving density credits pay	- Deciding which areas in the county are the sending areas and more importantly, the receiving areas is a contentious exercise for local government
Agricultural and Forestal Districts	#14	Moderate	-Grassroots support by affected landowners asking for creation of the district	-Incentives not always enough to get farmers to enroll - Process of forming a district can take time and be complex
Land Use Value Taxation	#1	Easy	-Lowers property taxes for landowners with land in agriculture and	-Locality collects less tax revenue. - Locality must reduce services or

			forestry -Shifts tax burden to those who use more services (urban residents)	increase taxes on other residents

K. Summary

As can be surmised by examination of the aforementioned tools available for counties in the Commonwealth of Virginia, there are many different ways to implement a protection program for green infrastructure assets. A single tool will most likely not be the best approach to protect green infrastructure assets; however, several tools that complement each other could give landowner's different choices to consider in protecting their natural areas. In the long run, several different green infrastructure protection tools that work in concert together can substantially protect areas green infrastructure within the county well into the future.

With the ongoing Chesapeake Bay TMDL effort , protecting existing natural areas may become as important as reducing the amount of nutrients going into Bay water, especially when one realizes that the nutrient gap the Bay States are trying to close ends in the year 2035. After 2035, assuming that the Bay States meet the Bay TMDL nutrient reduction goals, localities have to make ongoing efforts to stay below the allowable nutrient cap load for nitrogen, phosphorous, and sediment which will be in place for perpetuity. When the Chesapeake Bay TMDL nutrient cap is in place, green infrastructure may very well play a more important role in filtering and offsetting nutrients than it does today. However, the time to set up the framework to protect valuable green infrastructure assets and natural areas is now.

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II. Northern Neck Planning District Commission Climate Change Vulnerable Infrastructure Assessment

A. Introduction

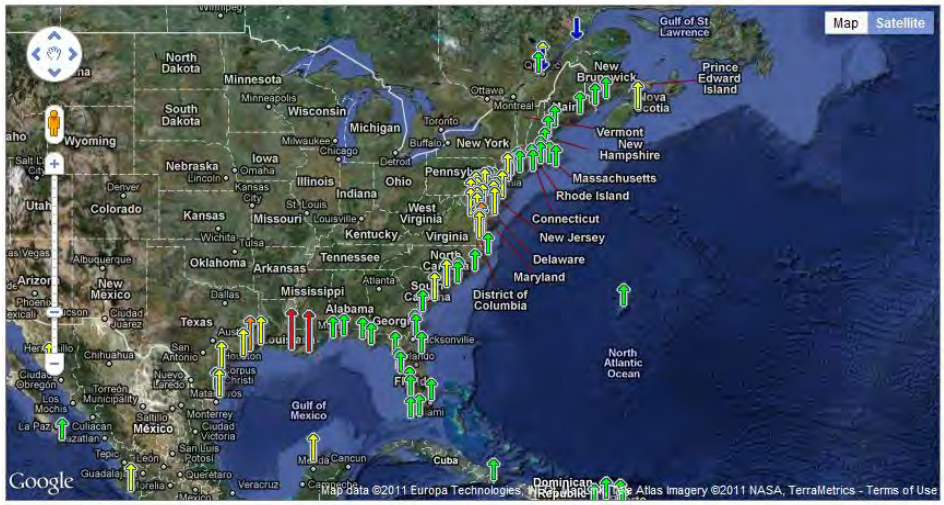
The Northern Neck, being situated in between the Potomac and Rappahannock Rivers, has an abundance of shoreline as well as associated low-lying near shore areas. The four counties of the Northern Neck have approximately 1,500 linear miles of shoreline in total. The coastal counties of the Northern Neck all have areas of their jurisdiction that become inundated due to high storm tides, so any sea level rise will likely increase the land area of the county that is inundated regularly.

The concept of human induced climate change is a politically charged topic, and there are as many supporters as critics. While human induced climate change is difficult to measure (and subsequently interpret), sea level rise is not.

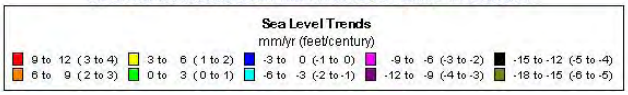
There are two different types of sea level rise: global sea level rise and relative sea level rise. Global sea level rise refers to the rise in water levels of the oceans of the world as a result of glacier and ice cap melt (increase in volume) as well as the expansion of sea water molecules as the temperature of the oceans increase. Relative sea level rise refers to the relationship between the land surface and sea level, usually at a local scale. If the land surface is sinking (subsidence) as the sea level is rising, then the cumulative effect (the level of water as it relates to the level of the land) is much more pronounced. The highest relative sea level rise in the United States is in the Gulf of Mexico, in the state of Louisiana. The subsidence of the land (from drilling and extracting petroleum reserves from deep underground) as well as the rise of global sea level leads to a relative sea level rise of 9 millimeters per year. This equates to around 3 feet of relative sea level rise in 100 years.

The next highest relative sea level rise found in the United States is in the mid-Atlantic region, of which Virginia is a part. Water levels have been rising in the mid-Atlantic region as well due to land subsidence (in part from groundwater extraction, as well as from glacial crust rebound from proximity to glacial areas to the north) and have been documented at the local National Oceanic and Atmospheric Administration tide stations at numerous tide stations in Virginia. A tide station at the Chesapeake Bay Bridge Tunnel has the highest sea level rise in Virginia at 6.0 mm per year. The next highest sea level rise recorded is at Lewisetta, at 4.97 mm/yr, which is on the Northern Neck, in Northumberland County situated on the Potomac River.

Below is a map from NOAA that shows the eastern half of the U.S. with proportional arrows color-coded to different rates of local (relative) sea level rise. Green arrows indicate a slow rise (0 - 3mm/yr), yellow arrows indicate a medium rise (3 to 6 mm/yr), orange arrows indicate a medium-high rise (6 to 9 mm/yr) and red arrows indicate a swift rise (9 to 12 mm/year).

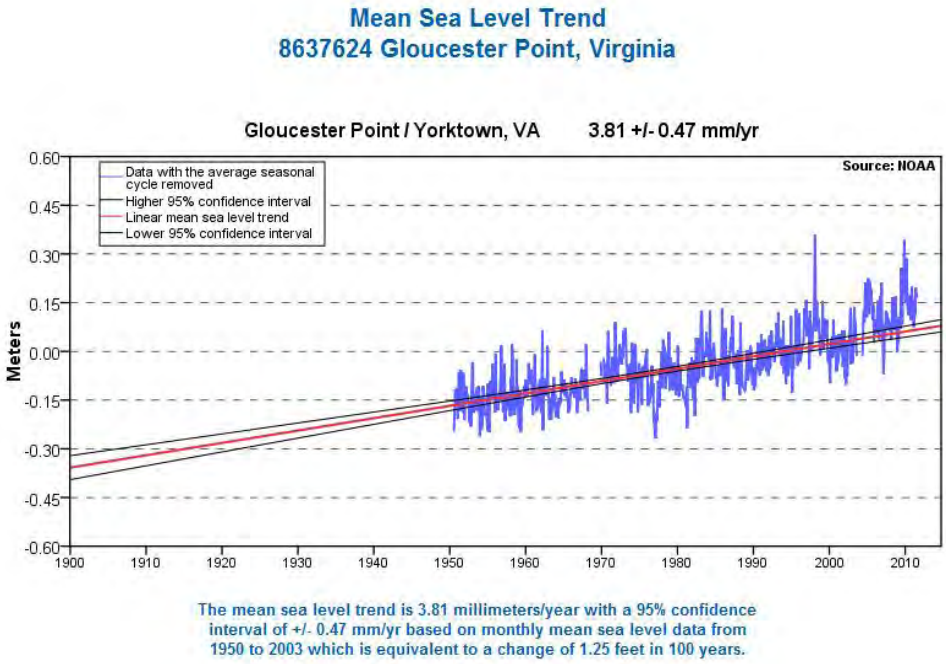


The map above illustrates regional trends in sea level, with arrows representing the direction and magnitude of change. Click on an arrow to access additional information about that station.

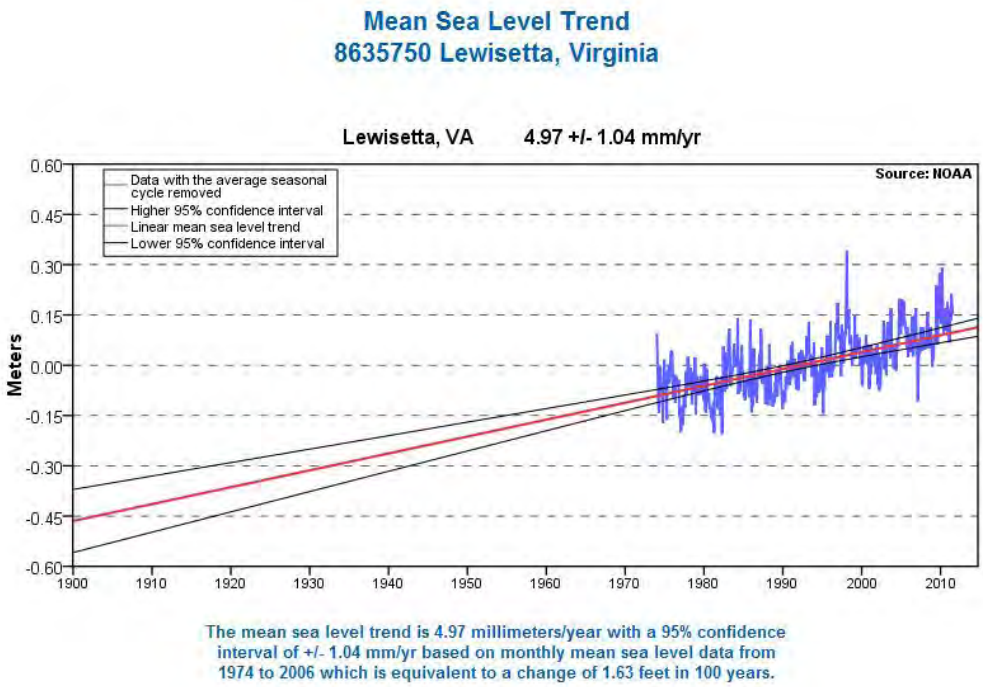


http://tidesandcurrents.noaa.gov/sltrends/sltrends.html

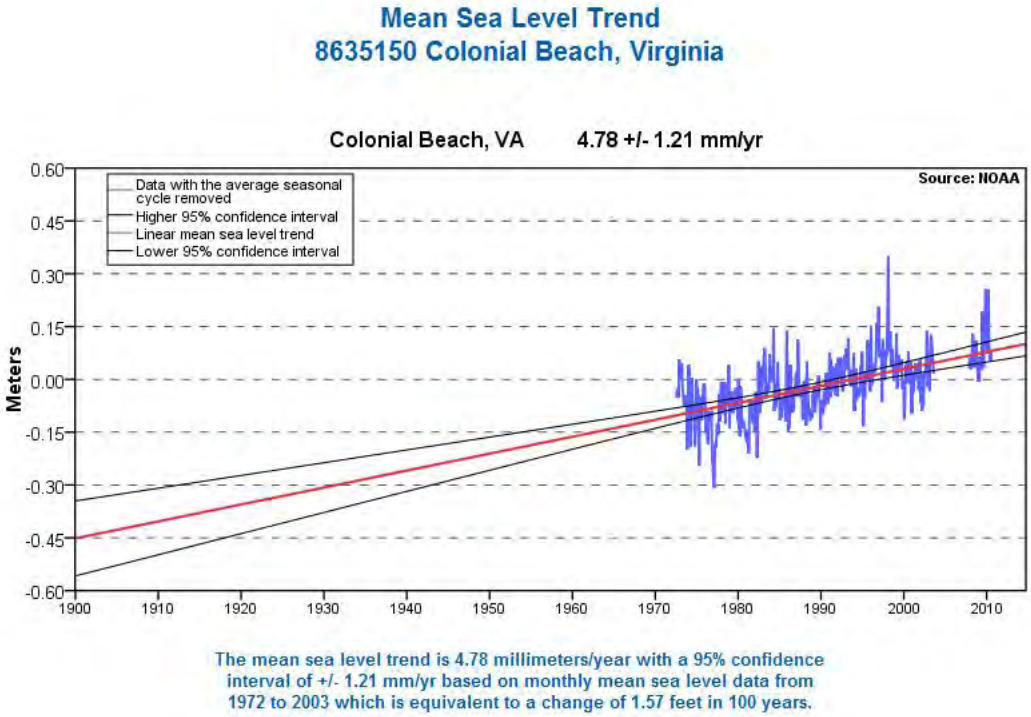
The following three graphs depict data from the three closest Virginia NOAA tide stations to the Northern Neck region. The graphs show data from Gloucester Point, VA; Lewisetta, VA; and Colonial Beach, VA, tides stations for their individual period of record.



http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8637624



http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8635750



http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8635150

As illustrated in the three above graphs, Gloucester Point is experiencing a 3.81 mm per year relative sea level rise, while the rate was 4.97 mm per year at Lewisetta and 4.78 mm per year at Colonial Beach. The local relative sea level rise from these tide stations

equates to a range of 1.25 feet to 1.63 feet 100 years into the future *(if the rate of rise continues at the current rate, which is not certain. There is evidence that the rate of rise may accelerate in the future).*

Clearly, the issue of sea level rise (both global and relative) is an important factor for local governments to consider in future land use planning near the coast in Virginia. Sea level rise most likely will impact areas of each county in the Northern Neck, as well as increase the extent and amount of damage from storm surges from tropical (hurricanes and tropical depressions) and extra tropical storms (nor'easters).

B. Study Details and Vertical Accuracy Issues

The Northern Neck Planning District Commission maintains a Geographic Information System that contains many layers of environmental and local data layers. Data layers used for this analysis included elevation data, shorelines, Emergency 911 (E911) building outlines, public access points, Virginia Ecological Valuation Assessment (VEVA) data (from the Virginia Coastal Zone Management Program), sewage treatment plants, as well as E911 roads and county boundaries.

The NNPDC-wide elevation data set was created by VirGIS, located at Virginia Tech, in the late 1990's. The dataset is in raster format with a 100 foot grid cell size. This elevation data was created by first digitizing select elevation contour lines from USGS 1:24,000 topographic quadrangle maps. The USGS 1:24,000 topographic maps utilized as the primary elevation data used the National Geodetic Vertical Datum of 1929 (NGVD29), and most of the printed maps were published in the late 1970's with some being revised in the late 1980's. Elevation contours on these maps were mapped at a 10 foot interval, however, in some low-lying areas, there are supplemental 5 foot contours (shown on the map as dashed contour lines). These digitized vector contour lines were then interpolated into a raster grid surface so that every cell has an elevation value (in feet) attributed to it.

While this data is good for regional planning and creates a good visual representation of the topography of the Northern Neck peninsula, this data is not detailed enough for an accurate assessment of sea level rise on a site specific basis. The vertical error range of the USGS topographic maps in their unadulterated form is 2.98 feet, and when the errors from digitizing and from interpolation are added in, the vertical error is likely to increase.

Compounding the error, the National Geodetic Vertical Datum of 1929 (used for the USGS 1:24,00 Topographic Maps) has been replaced by more accurate National Geodetic Vertical Datum of 1988 (NGVD88), and the difference between the two datum's in our region is approximately +0.8 feet.

Finally, the elevation data used in this study is orthometric (sea level referenced) elevation datum based on vertical benchmark, while bathymetric data (water depth data) is referenced by a local tidal datum based on observations by the area’s tide stations within a 19-year tidal epoch period. Thus, 0 foot of orthometric elevation is not

necessarily equal to Local Mean Sea Level (LMSL). In actuality, 0 foot of orthometric elevation at NGVD29 is +0.76 feet.

All of these instances of discrepancies compound to make the vertical error larger than the projected 100-year sea level rise rate (*1.25 ft. to 1.63 ft.*). **Thus, this study should not be used to examine any specific site in a county, but instead be used at a county scale to identify areas in the county that may be impacted by future rises in sea level.**

For three of the counties of the Northern Neck (Northumberland, Richmond, and Westmoreland), NNPDC staff had to use lower accuracy VirGIS elevation, as that was the only elevation data available. NNPDC staff examined the land area within the 0-4 foot elevation range in these three counties in order to examine enough land area to be outside of the projected error range.

The remaining county in the Northern Neck to be examined, Lancaster County, had previously purchased elevation contours at a 2 foot interval for the county from the Virginia Geographic Information Network's 2007 Virginia Base Mapping Program's ortho-rectified aerial photography project. The vertical accuracy of this elevation contour data set is 1.5 feet. For the Lancaster County analysis, only the two and four foot elevation contour lines were examined. The Lancaster County climate change analysis has a much greater vertical accuracy than the other three county analyses, and therefore could be used to examine areas at a larger scale, that is, sub-regions of the county. However, NNPDC staff recognizes the accuracy is still too low to be used at an individual site scale, and its best use is locating areas of the county that may be impacted from sea level rise in the future.

C. Methodology

This climate change vulnerability report seeks to answer two questions for each Northern Neck county: 1) what type and where are the natural areas that are vulnerable to climate change (impacts to green infrastructure), and 2) what type and where are water dependent county (and state) infrastructure vulnerable (impacts to grey infrastructure).

For this study, NNPDC staff utilized the latest digital shoreline data from the Virginia Institute of Marine Science (VIMS) shoreline situation reports for all four Northern Neck counties (*http://ccrm.vims.edu/gis_data_maps/shoreline_inventories/index.html*). The dates of the shoreline data created for these reports range from 2001 (Lancaster County) to 2007 (Westmoreland County). Although NNPDC has digital shoreline data digitized from USGS 1:24,000 topographic maps, that data is old (anywhere from the late 1970's to mid 1980's). The shoreline on the Northern Neck, particularly the western shore of the Chesapeake Bay and the Potomac River shoreline in lower Westmoreland and Northumberland counties has fairly high shoreline erosion rates (in some places up to 3 feet per year). Those shorelines have changed shape over the two decades since the USGS recorded the shorelines for the original topographic maps. Thus, the VIMS shoreline data set was deemed to be the most accurate and up to date shoreline that reflects the most current conditions.

As mentioned above, the legacy VirGIS elevation dataset was used for three counties (Northumberland, Richmond, and Westmoreland) and the 2007 VBMP ortho-rectified photography derived 2-foot elevation contours were utilized for the Lancaster County analysis.

Each of the four Northern Neck counties maintain an E911 digital data set that in addition to county road data, contains address points, and most importantly, building structure outlines for the entire county. The date of the building structure outlines used for each county follow: Lancaster's data was from February 2010, Northumberland's data was from November 2010, Richmond's data was from February 2010, and Westmoreland's data was from March 2010.

For the natural area (green infrastructure) vulnerability analysis (question #1), the Virginia Coastal Management Program's Virginia Ecological Valuation Assessment (VEVA) data was used as a basis for examined natural areas that might be vulnerable, as well as their ecological value rank. The VEVA digital map layer was created from data from many state agencies such as Virginia Marine Resources Commission, Virginia Department of Game and Inland Fisheries as well as the Division of Natural Heritage of the Department of Conservation and Recreation. Habitat, food sources, diversity of plant and animal species, and relative abundance (or scarcity) of species are all factors taken into account in the creation of this data set. The VEVA map data ranks areas into five categories: General Ecological Value (the lowest value), Moderate Ecological Value, High Ecological Value, Very High Ecological Value, Outstanding Ecological Value (the highest value).

For the built environment (grey infrastructure) vulnerability analysis (question #2), county provided E911 building structures were used, as well as the locations of boat ramps and sewage treatment plants (grey infrastructure), which were digitized from VBMP aerial photographs by NNPDC staff. NNPDC did not include boathouses or any structures (such as piers or wharves) over the water in this analysis as these structures are already inundated. Since Lancaster County elevation data is deemed to be more accurate, for the green infrastructure impact analysis, only the 0 to 2 foot elevation extent was the area examined. For the Lancaster County grey infrastructure analysis, structures were classed as being located in either 0 to 2 foot elevation or 2 to 4 foot elevation range.

In Northumberland, Richmond, and Westmoreland counties, the VirGIS elevation data was queried to select those elevations that range from 0 to 4 foot. Although estimates for sea level rise in the Northern Neck region are only forecast to be approximately 1.5 foot in one hundred years, the vertical error within the elevation data is near 3 feet, so NNPDC staff chose 4 foot of elevation as the upper limit of elevation to examine to ensure capture of areas that could be vulnerable to sea level rise.

For the natural area vulnerability analysis, the 0 to 4 foot VirGIS elevation area in each county was used to clip out the corresponding section of the VACZMP's Virginia

Ecological Valuation Assessment (VEVA) layer that ranks the overall ecological value of an area.

For the grey infrastructure vulnerability analysis, the county E911 building structure outlines were clipped using the 0-4 foot elevation areas, generating a layer of potentially impacted structures that are within the 0-4 foot elevation range. Due to the recognized vertical errors in the VirGIS elevation data, NNPDC staff examined the potentially impacted buildings overlain on the USGS 1:24,000 topographic map images and deleted any structure that was above the 5 foot supplemental contour. If no 5-foot supplemental contour was present, and the structure was more than halfway between the shoreline and the 10-foot contour line (above 5 feet), then it also was deleted. Unfortunately, the building outlines in these three counties were in line format (as opposed to polygon format), thus there are many records (lines) in the database that compose each structure. Therefore there is no easy way to determine the total number of structures impacted, save for manually grouping the lines of every structure into one unit. Thus, the value in the three county sea level rise maps (those of Northumberland, Richmond and Westmoreland counties) is the qualitative visual representation of areas within the respective counties where structures may be impacted, as opposed to a quantitative report.

D. Results

While each county was evaluated separately and will be examined individually, NNPDC staff deemed it important to also aggregate the green infrastructure (natural area) vulnerability sea level rise analysis data for the whole PDC region for this report. (As mentioned above, the grey infrastructure analysis does not give quantitative information at the PDC scale.) Below is a table that summarizes the potential natural areas that could be vulnerable in future decades for individual counties and the PDC as a whole.

	VEVA Ecological Ranking Impacted by 4 foot of Sea Level Rise*					
County	General	Moderate	High	Very High	Outstand-ing	Total
Lancaster**	312 ac.	363 ac.	457 ac.	1,292 ac.	226 ac.	2,650 ac.
Northumberland	691 ac.	857 ac.	366 ac.	1,493 ac.	140 ac.	3,547 ac.
Richmond	7 ac.	201 ac.	830 ac.	2,651 ac.	1,586 ac.	5,275 ac.
Westmoreland	212 ac.	455 ac.	456 ac.	943 ac.	3 ac.	2,069 ac.
NNPDC Total	1,222 ac.	1,876 ac.	2,109 ac.	6,379 ac.	1,955 ac.	13,541 ac

***Lancaster County area impacted by sea level elevation range is 0-2 feet, while the rest are 0-4 feet.*

**Note: As mentioned previously in this report, the elevation data vertical accuracy error is more than the projected sea level rise in one hundred years for the Northern Neck region, so the above data should be used as an indication of the general trend and not focus as much on individual acre values, but instead the relative magnitude of the numbers as they relate to each other. Lancaster County utilized a different (more accurate) elevation data set and elevation range, so the results of the Lancaster County analysis cannot be realistically compared to the other three county analyses.*

The above table shows that there is potentially 13,451 acres (21 sq. mi.) in the Northern Neck that could be impacted by sea level rise in the future. Twetny-one square miles is the amount of land area impacted from regular inundation, the area impacted during storm events will be much higher. The county with the highest amount of natural areas possibly impacted is Richmond County. Richmond County is also the county with the highest amount of Very High and Outstanding Ecological Value natural areas that are potentially vulnerable to sea level rise. Some of the land impacted is controlled by the Rappahannock River National Wildlife Refuge, either through ownership or conservation easement. The county with the least amount of low-lying natural areas that are potentially vulnerable to sea level rise is Westmoreland County, which is corroborated by the fact that a large portion of the Westmoreland County shoreline on the Potomac River has high banks and/or cliffs.

Something else to note from the analysis results table is that the majority of impacts in *every* county are to the Very High Ecological Value natural area category. The inference here is that not only will the Northern Neck lose wetlands, but also that the loss may be to higher ecologically important valued wetland areas, as opposed to lower ecologically important value natural areas. This is of concern as wetlands and marshes are the nursery to many of the aquatic species (both fish and crustaceans) that inhabit the Chesapeake Bay. In addition, marshes form the base of the food web by providing a source of detritus as nourishment for the lowest tier of the food chain. Marshes and near shore wetlands absorb wave energy, and if inundation occurs rapidly enough, the wetland may not be able to migrate inland. (The Virginia Institute of Marine Science is conducting research on the current state of wetland loss has a result of the current rate of increase in relative sea level rise.) Without the wetland vegetation present, erosion could increase in many shoreline areas further increasing erosion of currently upland areas.

A short narrative of natural areas that are vulnerable to sea level rise on a county-by-county basis follows.

The Lancaster County analysis of possible impacts to green infrastructure (wetlands and natural areas) from sea level rise shows that significant marsh areas near Belle Isle State Park, Towles Point on the Rappahannock River, the head waters of the western branch of the Corrotoman River, the headwaters of Carters Creek, Cherry Point, significant portions of Windmill Point, as well as Antipoison, Poplar, and Fleets Bay Neck on the western shore of the Chesapeake Bay may potentially be threatened by sea level rise. (See Figure 1).

The Northumberland County analysis of possible impacts to green infrastructure (wetlands and natural areas) shows areas of impact in most rivers, with larger areas of impact along the western shore of the Chesapeake Bay, including the shore from Tibitha to Fleeton, Harvey's Neck, Dameron Marsh, Ball Neck down to Hughlett Point, and Jarvis Point to the mouth of Indian Creek could be impacted by sea level rise. (See Figure 2).

The analysis of possible impacts to Richmond County green infrastructure from sea level rise shows impact to major marsh complexes along the Rappahannock River, that of Mulberry Island, and the marshes around Mangoright Point, where Rt. 360 enters the Northern Neck. Possible impacts are also shown for the marsh complex of Cat Point Creek, and Totuskey Creek, as well as the headwaters of Farnham and Lancaster Creek. Areas around Accaceek Point and Suggetts Points along the Rapphannock River show potential impacts as well. (See Figure 3).

The Westmoreland County analysis of possible impacts to green infrastructure (wetlands and natural areas) shows areas impacted in the headwaters of Monroe and Mattox Creek, as well at the mouth and headwaters of Popes Creek. Currioman Island, as well as Buckner Creek off the Nomini, shows impacts as well as areas of the Lower Machodoc, Gardner Creek, and Bonum Creek at the mouth. However, the most significant area of impact is Drakes Marsh above Leedstown on the Rappahannock River. (See Figure 4).

Simple inundation is but one of the many outcomes from relative sea level rise. More than likely, some areas will be eroded, which could cause further migration of open water into previously elevated areas scouring of sediments from previously upland areas. In addition, some new areas of wetland may possibly be created inland where erosion lowers the level of the land. Armored shoreline areas could contribute to erosion of adjacent areas due to scour or upland bank erosion.

The results of the grey infrastructure and private building sea level rise analysis are mostly unquantifiable with the exception being Lancaster County (the only county with individual structures aggregated into polygons). However, there are some regions of each county that could be prone to impacts from sea level rise that will be described county by county.

In Lancaster County, the areas of Morattico, Rogue Point, Weems, Towles Point, Mosquito Point, Windmill Point, Antipoison Neck, Poplar Neck and Fleets Bay Neck all have areas where buildings exist at 2 ft or lower of VBMP elevation. From the analysis, countywide there are 35 buildings at or below 2 foot of VBMP elevation and 667 buildings between 2 and 4 foot of VBMP elevation in Lancaster County. NNPDC staff, after examining the structures identified as being at or below 4 foot of elevation overlaid the 2009 VBMP aerial photographs noted that many of the potentially impacted buildings below 2 foot of elevation were outbuildings or garages that were separate from the primary structure. There were substantially more primary structures located in the 2 to 4 foot elevation range, although outbuildings were still quite common. (See Figure 5).

In Northumberland County, the areas of Lewisetta, Bay Quarter Neck, Hack Neck near Flag Pond, Chesapeake Beach, Fleeton, Reedville, Glebe Point, Harvey’s Neck, Ditchley, the area around Henry’s Creek, and parts of Indian Creek all have concentrations of structures that are at or below 4 foot of VirGIS derived elevation. (See Figure 6).

In Richmond County, most of the structures potentially impacted are located in the lower part of the county. Areas such as Wellford, Sharps, Wilna Point (Little Florida),

Morattico Creek and Simonson have buildings where at least a portion of the building is below four foot of VirGIS derived elevation. (See Figure 7).

In Westmoreland County, Upper Monroe Creek, Dickson Point on Monroe Bay, parts of Colonial Beach, Fox Point on Mattox Creek, Glebe Harbor, Narrow Beach on the Lower Machodoc, near the mouth of Gardener Creek, Sandy Point, and parts of the Northwest Yeocomico River show evidence of buildings located at 4 foot of VirGIS elevation or lower. Along the Rapphannock River, there are only a few instances of structures at or below four foot of VirGIS derived elevation. (See Figure 8).

As noted in the Lancaster County analysis, in the other three counties those structures that were identified to be at or below 4 foot of elevation were mostly accessory structures as opposed to primary structures.

In all four counties, all of the public water access points identified could be impacted. For boat launch sites, the rise in sea level could potentially rise above the usable ramp incline, and render the landing no longer useful for launching except at low tide, when the ramp incline would be exposed. Alternatively, the water could rise above the height of the boat launch tender pier, causing mooring problems. Any sea level rise will reduce the area of the boat launch site, reducing parking and possibly capacity. Other sites that are used for water access recreation could be impacted by inundation of the beach (or shoreline). erosion of said beach, or loss of habitat that potentially could reduce the number of species for nature observing.

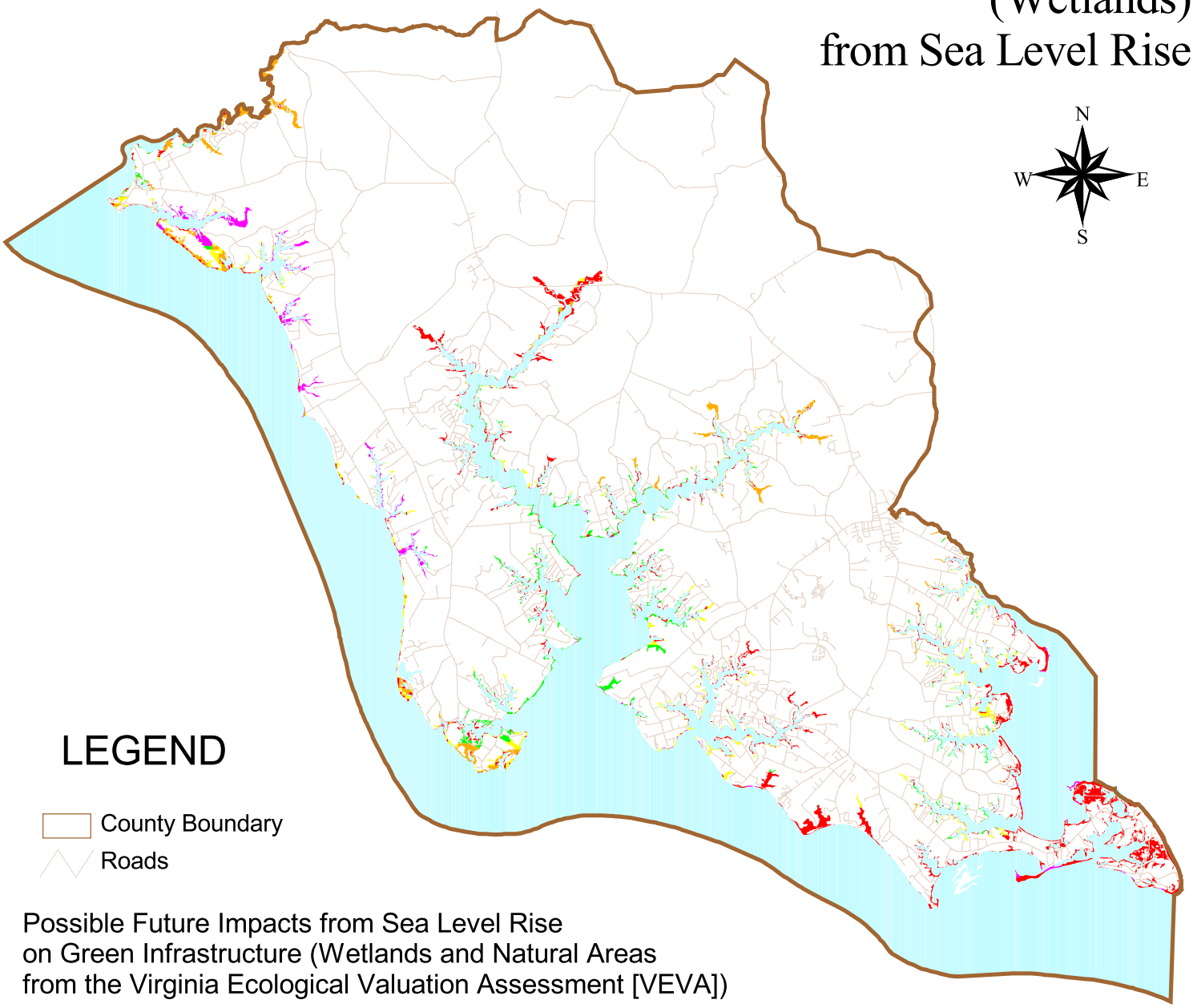
From the Westmoreland County analysis, a state road (Rt. 649 or Federal Farm Road) was identified that could potentially be impacted by sea level rise in the future. The road serves a peninsula with several residences on the western shore of the Nomini Creek, and ends in a dead end, thus is not a through route.

In all four counties, all sewage treatment plants (STPs) were examined and none of the sewage treatment plants had any infrastructure at or below four foot of elevation. Most of the sewage treatment plants were located at higher elevations near the headwaters of the streams they discharge into, such as Colonial Beach STP, Warsaw STP, and Kilmarnock STP. Of the remainder of the other sewage treatment plants, some had ponds heights of 10 foot of elevation; however, this is above the range of elevation examined in this study.

In summary, even though the elevation data has accuracy problems, NNPDC staff believes that this analysis is useful, as most of the areas highlighted in each county have, in the past, had problems during storm events. NNPDC also believe that these areas will most likely have some kind of impacts from sea level rise, even if it is only occasional inundation from tropical storms or nor’easters. The time to begin planning from the effects from sea level rise is now, and proper safeguards should be formulated to minimize the risk from any future development in these areas. Effective planning now by local governments may help to reduce the impacts in the future.

Figure 1

Lancaster County Possible Impacts to Green Infrastructure (Wetlands) from Sea Level Rise



LEGEND

County Boundary

Roads

Possible Future Impacts from Sea Level Rise on Green Infrastructure (Wetlands and Natural Areas from the Virginia Ecological Valuation Assessment [VEVA])

(Sea level to two foot elevation areas shown. Vertical error +/- 1.5 feet)

Total possible area impacted: 2,650 acres

- General Ecological Value = 312 acres (11.8%)
- Moderate Ecological Value = 363 acres (13.7%)
- High Ecological Value = 457 acres (17.2%)
- Very High Ecological Value = 1,292 acres (48.8%)
- Outstanding Ecological Value = 226 acres (8.5%)

2 0 2 4 Miles

Virginia Coastal Zone MANAGEMENT PROGRAM

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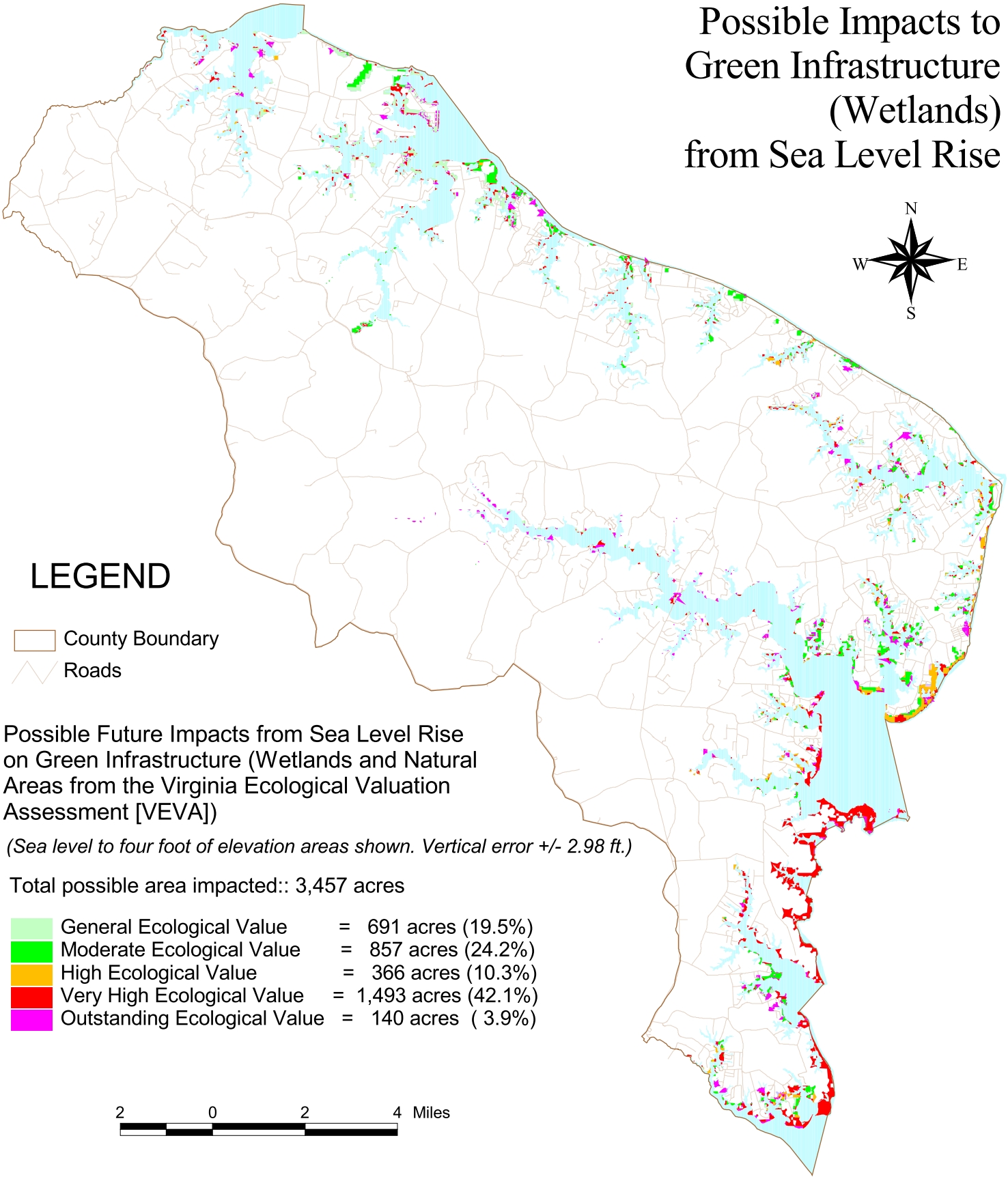
Figure 2

Northumberland County Possible Impacts to Green Infrastructure (Wetlands) from Sea Level Rise



Possible Future Impacts from Sea Level Rise on Green Infrastructure (Wetlands and Natural Areas from the Virginia Ecological Valuation Assessment [VEVA])

(Sea level to four foot of elevation areas shown. Vertical error +/- 2.98 ft.)

Total possible area impacted:: 3,457 acres

General Ecological Value	=	691 acres (19.5%)
Moderate Ecological Value	=	857 acres (24.2%)
High Ecological Value	=	366 acres (10.3%)
Very High Ecological Value	=	1,493 acres (42.1%)
Outstanding Ecological Value	=	140 acres (3.9%)

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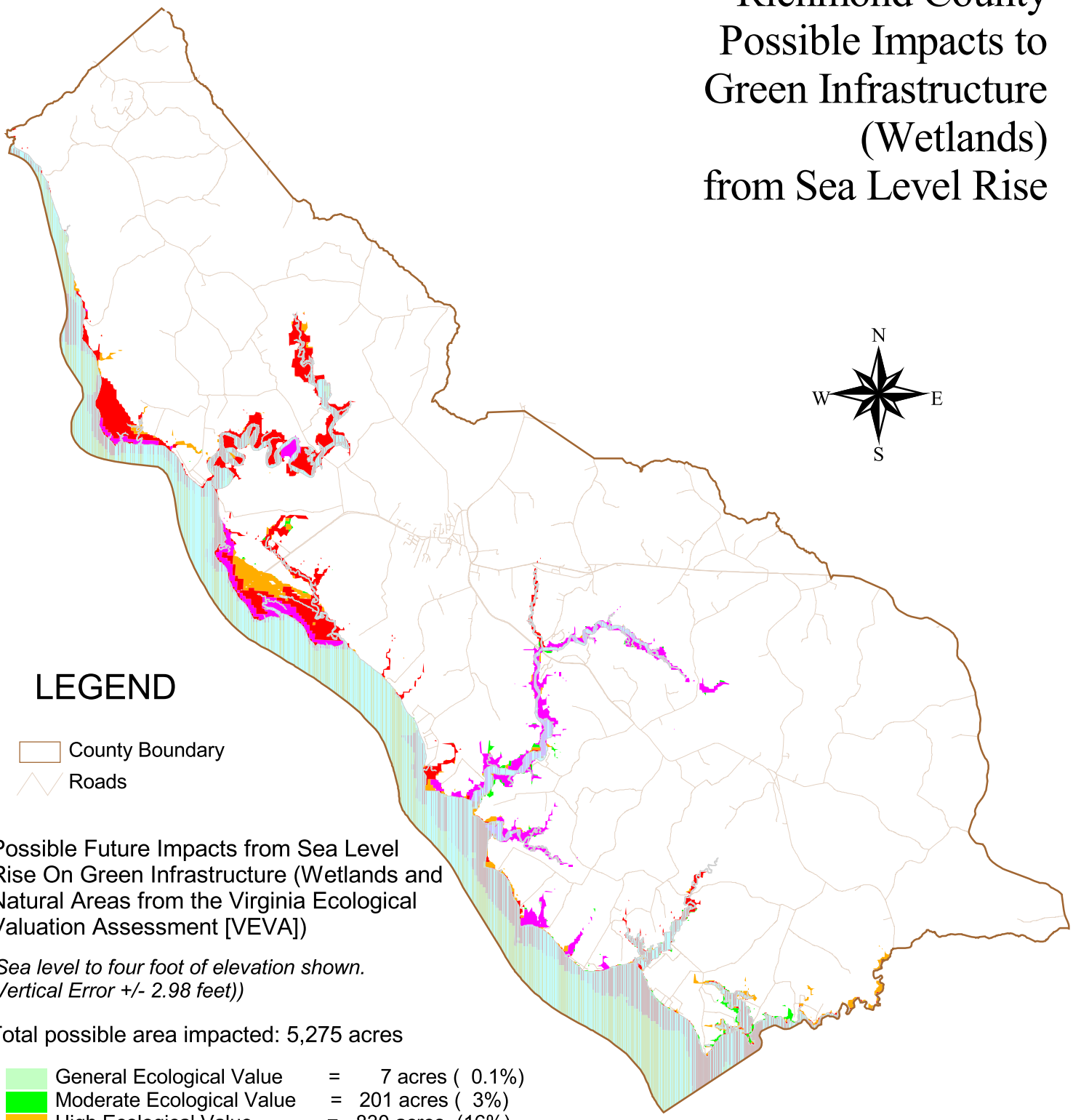
Figure 3

Richmond County Possible Impacts to Green Infrastructure (Wetlands) from Sea Level Rise



LEGEND

County Boundary

Roads

Possible Future Impacts from Sea Level Rise On Green Infrastructure (Wetlands and Natural Areas from the Virginia Ecological Valuation Assessment [VEVA])

(Sea level to four foot of elevation shown. Vertical Error +/- 2.98 feet))

Total possible area impacted: 5,275 acres

General Ecological Value	=	7 acres (0.1%)
Moderate Ecological Value	=	201 acres (3%)
High Ecological Value	=	830 acres (16%)
Very High Ecological Value	=	2,651 acres (50%)
Outstanding Ecological Value	=	1,586 acres (30%)

2 0 2 4 Miles

Virginia Coastal Zone MANAGEMENT PROGRAM

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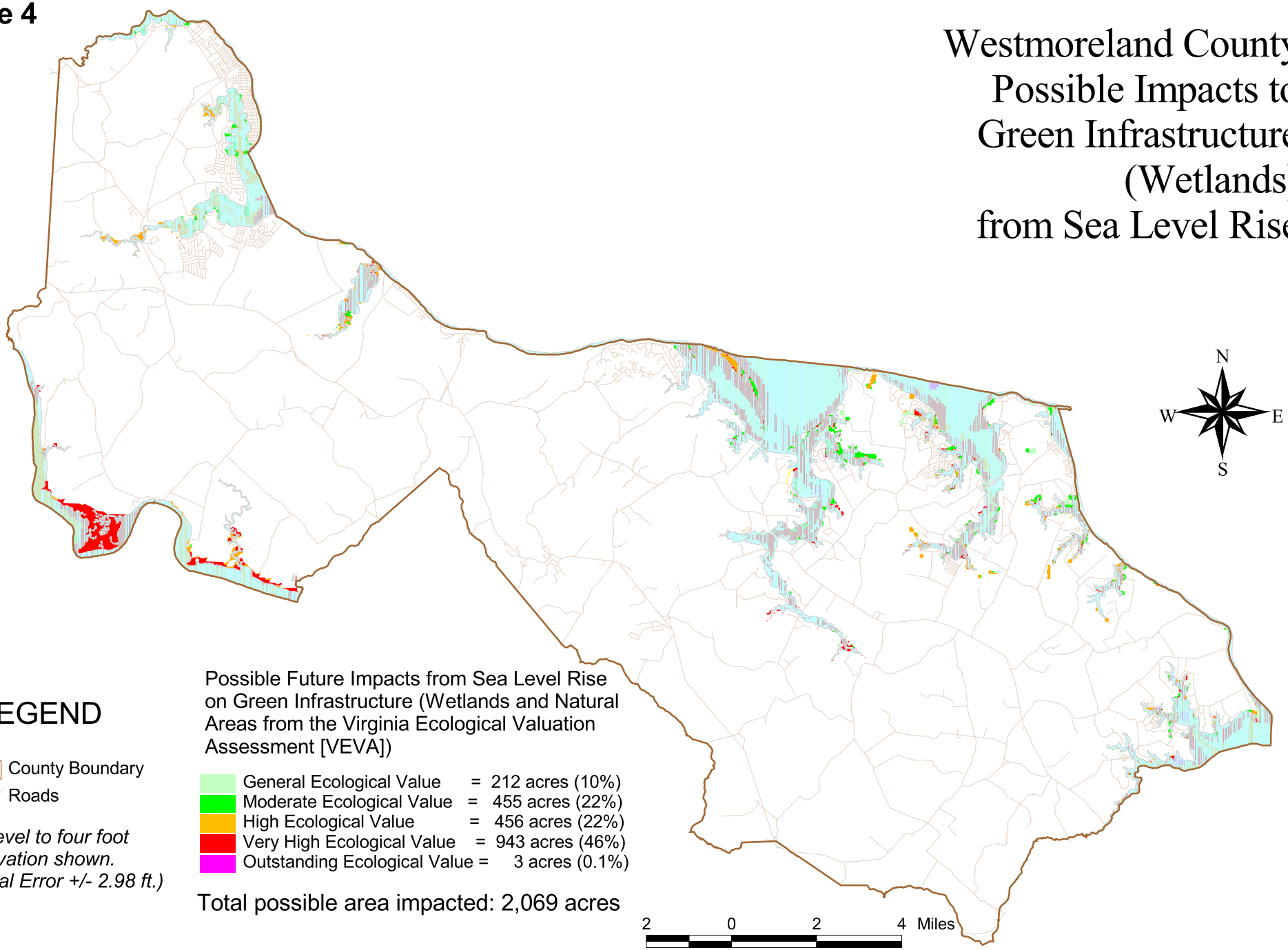
Figure 4

Westmoreland County Possible Impacts to Green Infrastructure (Wetlands) from Sea Level Rise



LEGEND

County Boundary

Roads

(Sea level to four foot of elevation shown. Vertical Error +/- 2.98 ft.)

Possible Future Impacts from Sea Level Rise on Green Infrastructure (Wetlands and Natural Areas from the Virginia Ecological Valuation Assessment [VEVA])

General Ecological Value	=	212 acres (10%)
Moderate Ecological Value	=	455 acres (22%)
High Ecological Value	=	456 acres (22%)
Very High Ecological Value	=	943 acres (46%)
Outstanding Ecological Value	=	3 acres (0.1%)

Total possible area impacted: 2,069 acres

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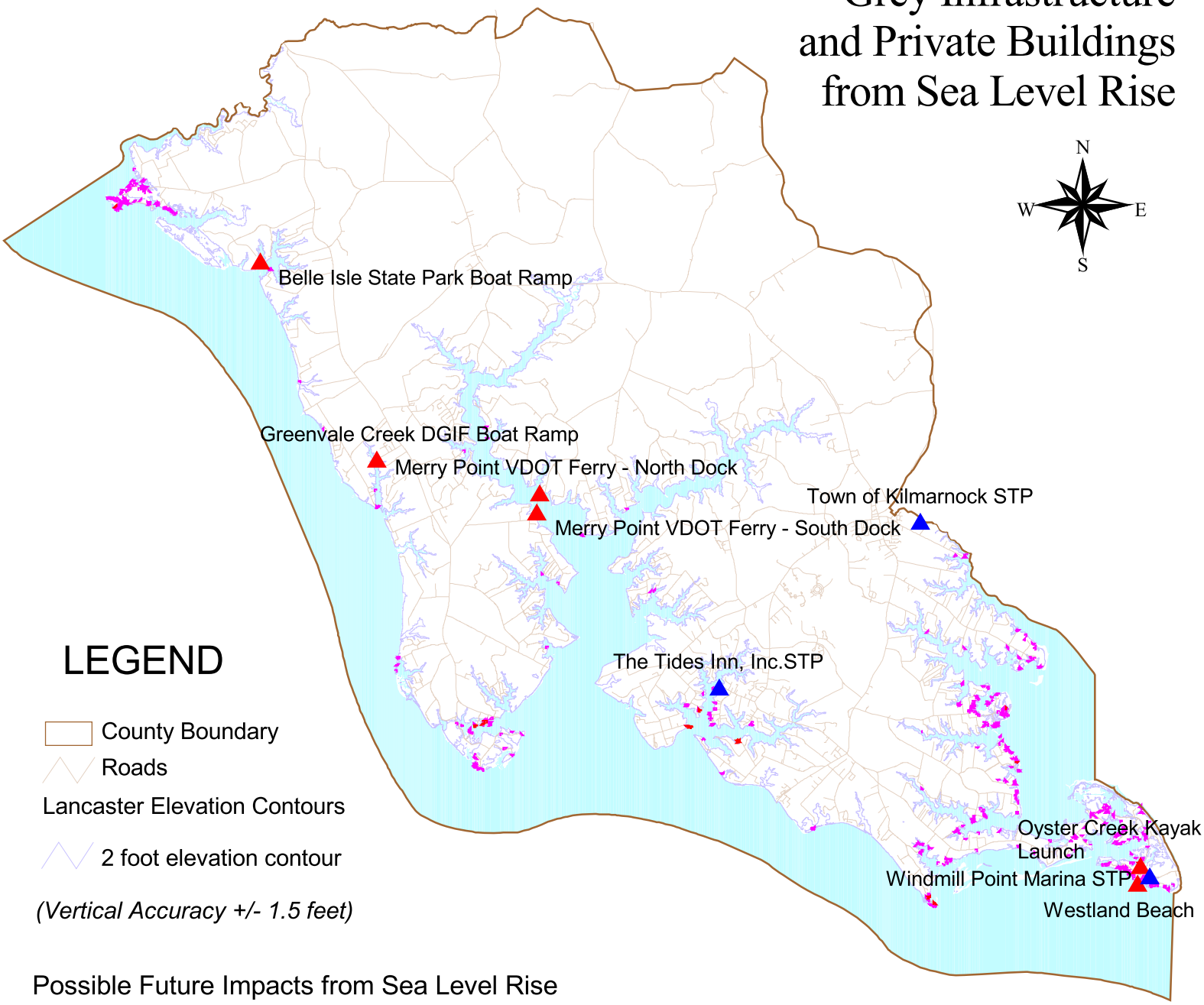
Figure 5

Lancaster County Possible Impacts to Grey Infrastructure and Private Buildings from Sea Level Rise



LEGEND

- County Boundary
- Roads

Lancaster Elevation Contours

- 2 foot elevation contour

(Vertical Accuracy +/- 1.5 feet)

Possible Future Impacts from Sea Level Rise

- Possible Impacted Buildings Between the 2 and 4 foot Elevation Contours (667 bldgs)
- Impacted Buildings Betlow the 2 foot Elevation Contour (35 buildings)

Public Grey Infrastructure Sites

- No Impacts
- Possible Impacts

Virginia Coastal Zone MANAGEMENT PROGRAM

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Figure 6

Northumberland County Possible Impacts to Grey Infrastructure and Private Buildings from Sea Level Rise

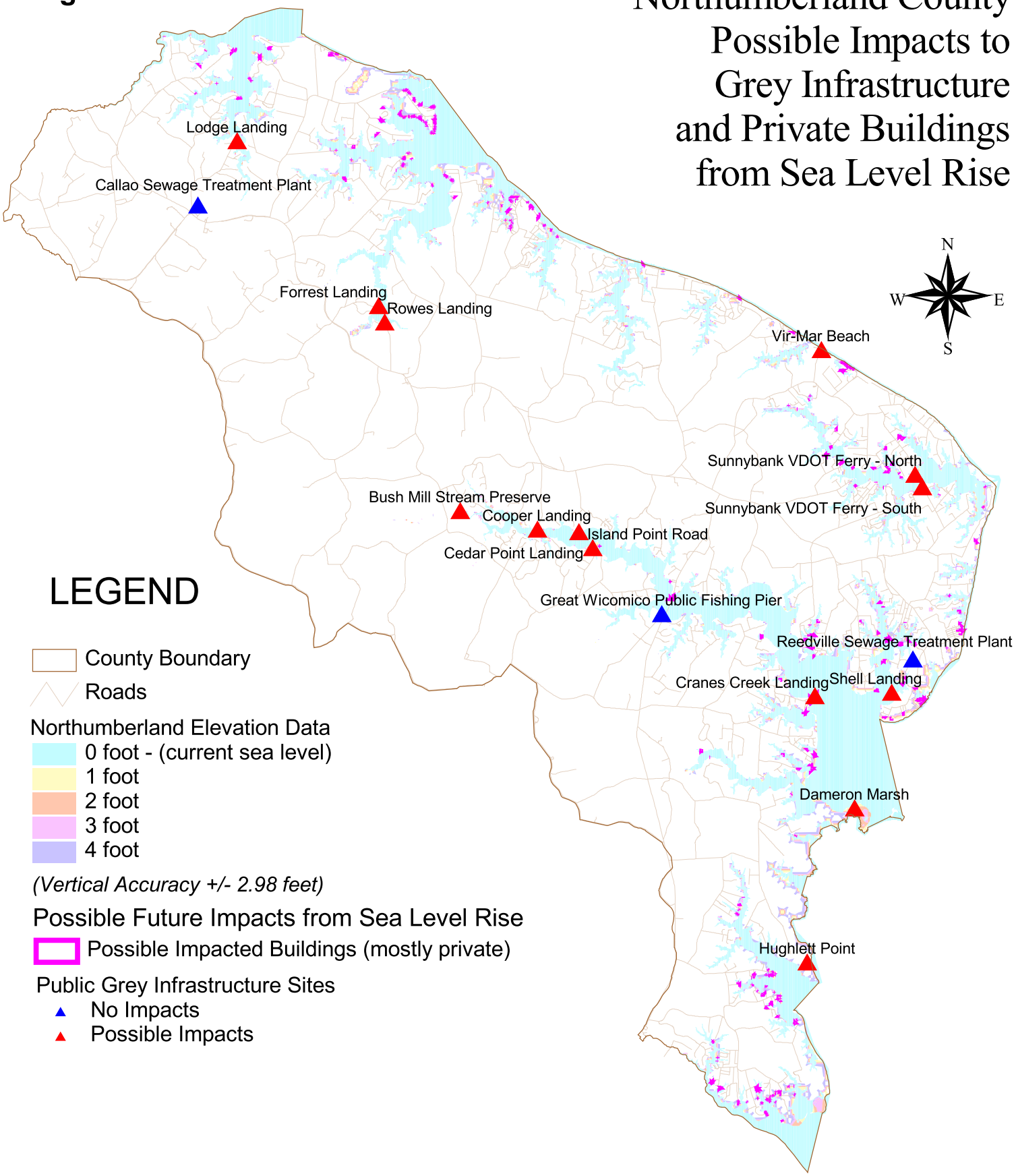

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Figure 7

Richmond County Possible Impacts to Grey Infrastructure and Private Buildings from Sea Level Rise

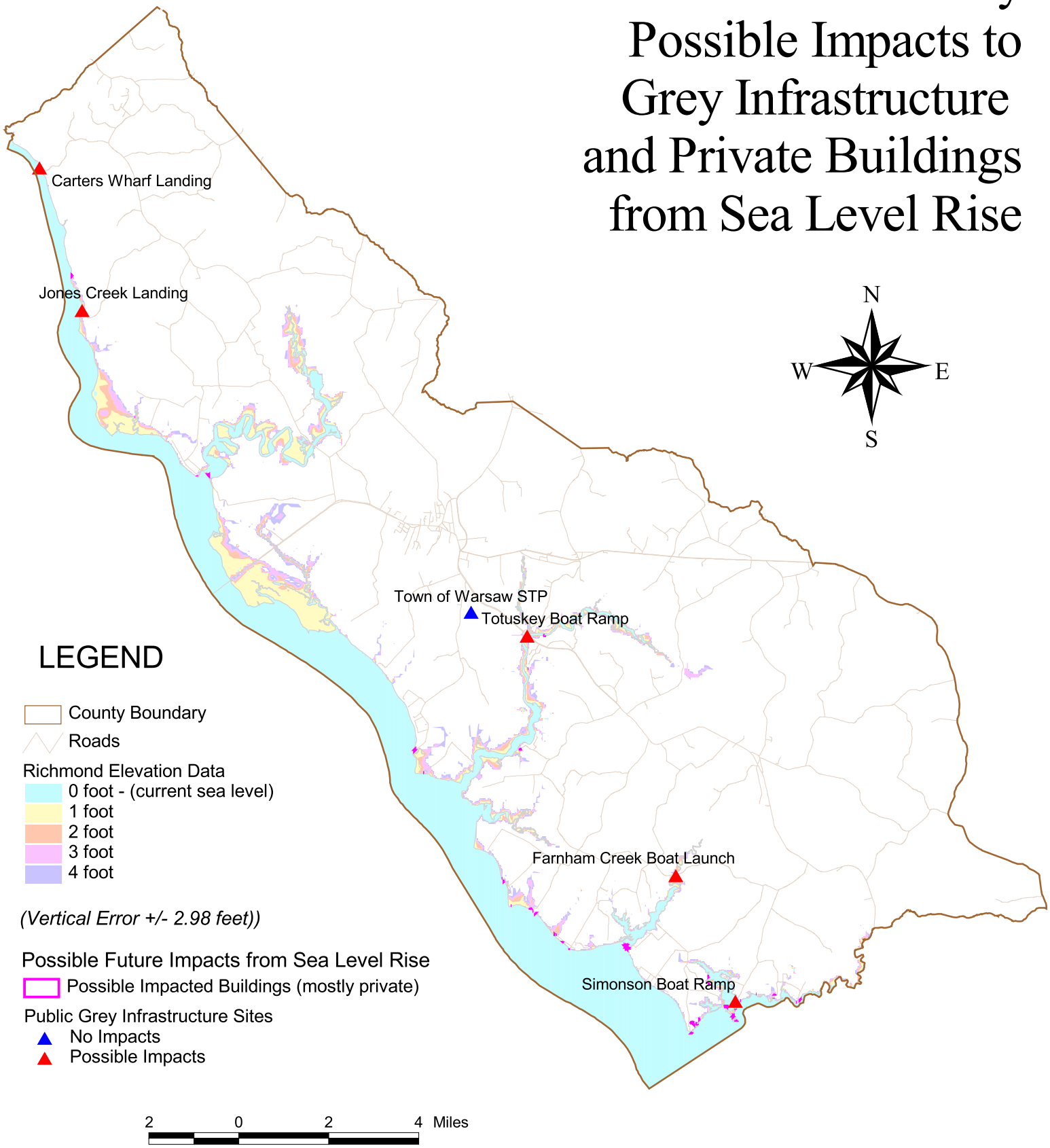

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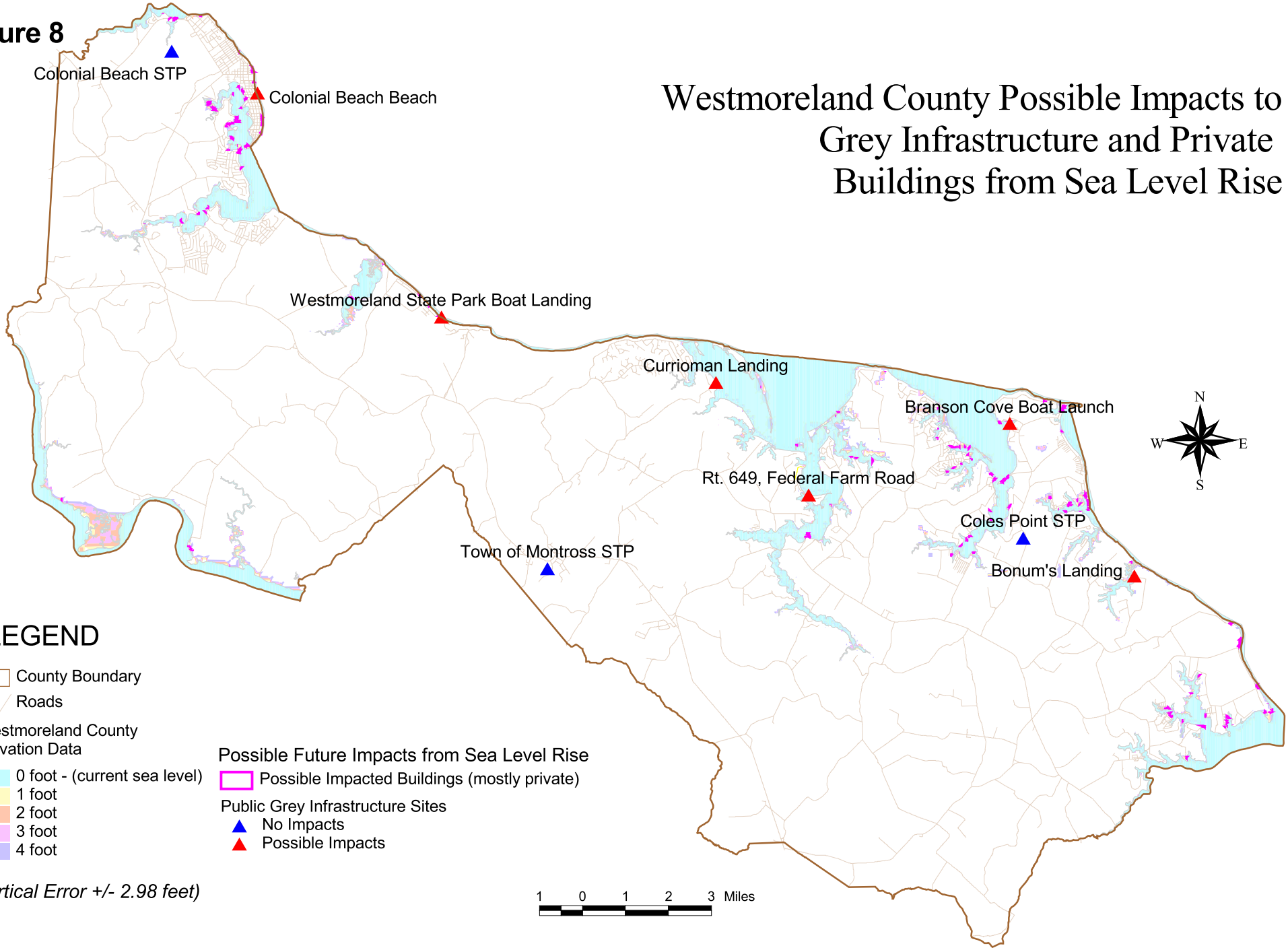
Figure 8

Westmoreland County Possible Impacts to Grey Infrastructure and Private Buildings from Sea Level Rise



Virginia Coastal Zone MANAGEMENT PROGRAM

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E. Climate Change Vulnerability Infrastructure Assessment Outreach Activities

NNPDC staff took the results of the sea level rise vulnerability study as well as the green infrastructure protection implementation alternatives report on the road to all four Northern Neck county planning commissions in late 2011 and early 2012. Presentations were created for the sea level rise and green infrastructure protection implementation alternatives report. The format of both presentations presented to the four counties were basically the same; however, each presentation was customized with maps and data from each county.

On December 5, 2011, NNPDC staff presented to the Richmond County Planning Commission the sea level rise vulnerability report, explaining that large expanses of very high ecological value wetlands along the Rappahannock River were vulnerable to sea level rise. After the presentation one planning commissioner asked, What can we do about it? NNPDC staff mentioned that there was little that could be done; however, it is important to recognize the fact that sea level is rising and start to plan for development that will not be impacted within the next one hundred years. NNPDC staff noted that one thing they could do would be to encourage living shoreline protection for landowners in Richmond County where appropriate. Living shorelines are planted marsh grass along the shore that absorb energy and hold the soil in place with their roots. Living shorelines are most appropriate for low energy shorelines, such as occur within the creeks of the county. Living shoreline protection would not perform very well in high energy shorelines such as the main stem of the Rappahannock River, NNPDC staff explained. NNPDC staff further elaborated that with a proper living shoreline, there is a gradual gradient of the shoreline, instead of a steep embankment. This, in theory should allow the marsh grass to migrate up the shoreline and colonize higher elevation areas as water levels rise and drown out the marsh grasses by permanent inundation at lower levels. The green infrastructure protection implementation tools presentation was given after the sea level rise study presentation, and several commissioners noted that some of the tools mentioned in the presentation had not been heard of before.
On January 19, 2012, NNPDC staff presented the sea level rise vulnerability presentation to the Northumberland County Planning Commission. As in Richmond County, NNPDC staff began with the sea level rise vulnerability study presentation detailing the documented rise in water levels from nearby tidal gauges with historical records. After explaining that the annual rise was approximately 4 mm a year, one of the planning commissioners noted that is a very small amount. NNPDC staff agreed that the annual rise is very small. NNPDC staff went on to explain that over 20 years, that 4 mm annual rise equates to 3.15 inches, and over 100 years, almost 16 inches or 1.31 feet. NNPDC staff also mentioned that while the projected sea level rise would not necessarily inundate existing structures, storm events that cause high tides (such as tropical storms and nor'easters) would compound the effect of the sea level rise. Structures that today have minor inundation could have major inundation in the future during these storm events. NNPDC staff stressed that while local governments cannot stop sea levels from rising,

they can plan so that any new development is out of the inundation zone within the next 100 years. NNPDC staff went on to mention that large areas of high value marsh and wetland on the western shore of the Chesapeake Bay were vulnerable from sea level rise, to include Dameron Marsh and Hughlett Point Natural Area Preserves. There was no comment or questions from planning commission members after NNPDC staff presented on the green infrastructure protection implementation tools.

On February 16, 2012, NNPDC staff presented the sea level rise vulnerability presentation to the Lancaster County Planning Commission. NNPDC staff began the presentation by commending Lancaster County administration on having the foresight to add the digital elevation contours as an additional product to the Virginia Base Mapping Programs 2009 aerial ortho-photography project. While adding the contour generation cost the county additional funds, the 2 foot contour elevation data will be useful for many planning applications, as well as site engineering within the county for years to come. NNPDC staff noted that the low lying Windmill Point area marsh complexes of the county would be especially vulnerable to sea level rise in the future. Planning commissioners questioned the vertical accuracy of the data, and NNPDC reiterated that the sea level rise vulnerability study was intended to be overall countywide planning tool, and not an individual site impact tool. Although the vertical accuracy was as high as the projected sea level rise, at about 1.5 feet, NNPDC staff assured the planning commissioner's that the general areas highlighted in the mapping of the county correspond to known areas that have been impacted in the past by tropical storm surges. Again, NNPDC said that the scale that the sea level rise vulnerability tool should be used is at the countywide scale, to identify regions of the county which could be vulnerable, but not individual structures. NNPDC staff presented the green infrastructure protection implementation tools report. After the presentation, Lancaster County staff mentioned that the report mentioned that Lancaster County did not employ land use value taxation for forest lands (the only county in the Northern Neck that does not). Lancaster County staff verified that was the case and explained that back in the late 1970's when Lancaster County was considering what land uses would be eligible for use value taxation, the majority of large forest tracts in the county was owned by large timber corporations. The county administration at the time did not believe that large corporations should get tax breaks paid for by the citizens of Lancaster County and decided against identifying forestry as a eligible land use. Lancaster County staff stated that now, that is no longer the case, and with Lancaster County revising their comprehensive plan, perhaps the County should revisit whether forest land should be able to benefit from use value taxation.

NNPDC staff presented on the vulnerability of green and select grey infrastructure as well as green infrastructure implementation tools to the Westmoreland County Planning Commission on March 5, 2012. NNPDC staff noted that the areal impacts of sea level rise on green infrastructure was less in Westmoreland county than the other three Northern Neck county's due to the higher banks of the upland shoreline of the Potomac River in Westmoreland County. NNPDC staff noted that along the Rappahannock River, the Westmoreland County is low land, and will have more impacts from sea level rise, as will the wetlands in the upper reaches of the major rivers in the county, such as the Lower

Machodoc, the Nomini, Popes, Mattox, and Monroe Creeks. NNPDC staff noted, regarding the grey infrastructure vulnerability assessment, that all of the county sewage treatment plants are at an elevation that they would not be vulnerable to anticipated sea level rise within the next century. NNPDC staff noted in the grey infrastructure portion of the presentation that all boat ramps and public water access sites on the tidal rivers could be impacted by the predicted sea level rise. NNPDC also noted that a local road, Rt. 649, Federal Farm Road, on the western bank of the Nomini could be impacted by sea level rise in the future. During the presentation, as Westmoreland County Planning Commissioner asked, yes, but what can we do about sea level rise? NNPDC staff explained that many tidal marshes will be lost in Virginia due to sea level rise. NNPDC staff further explained that conventional shoreline erosion control measures such as rip rap and bulkheads act as a barrier to wetlands as they try to migrate up the shore to combat being drowned by higher levels of tidal water. However, living shorelines, if constructed properly, have a gentle slope that allows for marsh grasses to take root at higher elevations and migrate inland to be at the optimal height so that they are inundated at high tide, but are dry at low tide. NNPDC staff further elaborated that the county should do all it can to promote citizens installing living shorelines over hardened shorelines (rip rap and bulkheads). After the Planning Commission meeting ended, a planning commissioner asked what other steps that they, as the planning body for Westmoreland County could take to help reduce impact from further sea level rise. NNPDC staff mentioned that the 100 foot Chesapeake Bay Resource Protection Area is primarily viewed as a pollution buffer, but in the case of low lying properties, it also functions as a buffer from tidal hazards. NNPDC staff elaborated that the number of encroachments of low lying lots into the 100 foot buffer should be avoided to diminish the chance of future flooding impacting structures due to sea level rise.

All four county presentations on sea level rise are included after this section, and one example of the green infrastructure protection implementation alternatives report presentation is included to reduce any redundancy (the green infrastructure protection implementation alternatives report was basically the same for all four counties, except for changing the county name).

III. Appendix

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Lancaster County Climate Change Vulnerability Analysis

Possible Impacts to Green Infrastructure and select Grey Infrastructure

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Possible Climate Change Impacts to Lancaster County

- Sea Level Rise
- Increased drought and severity of droughts
- More intense and frequent storms
- Rise in global temperatures
- Changing salinity associated with sea level rise

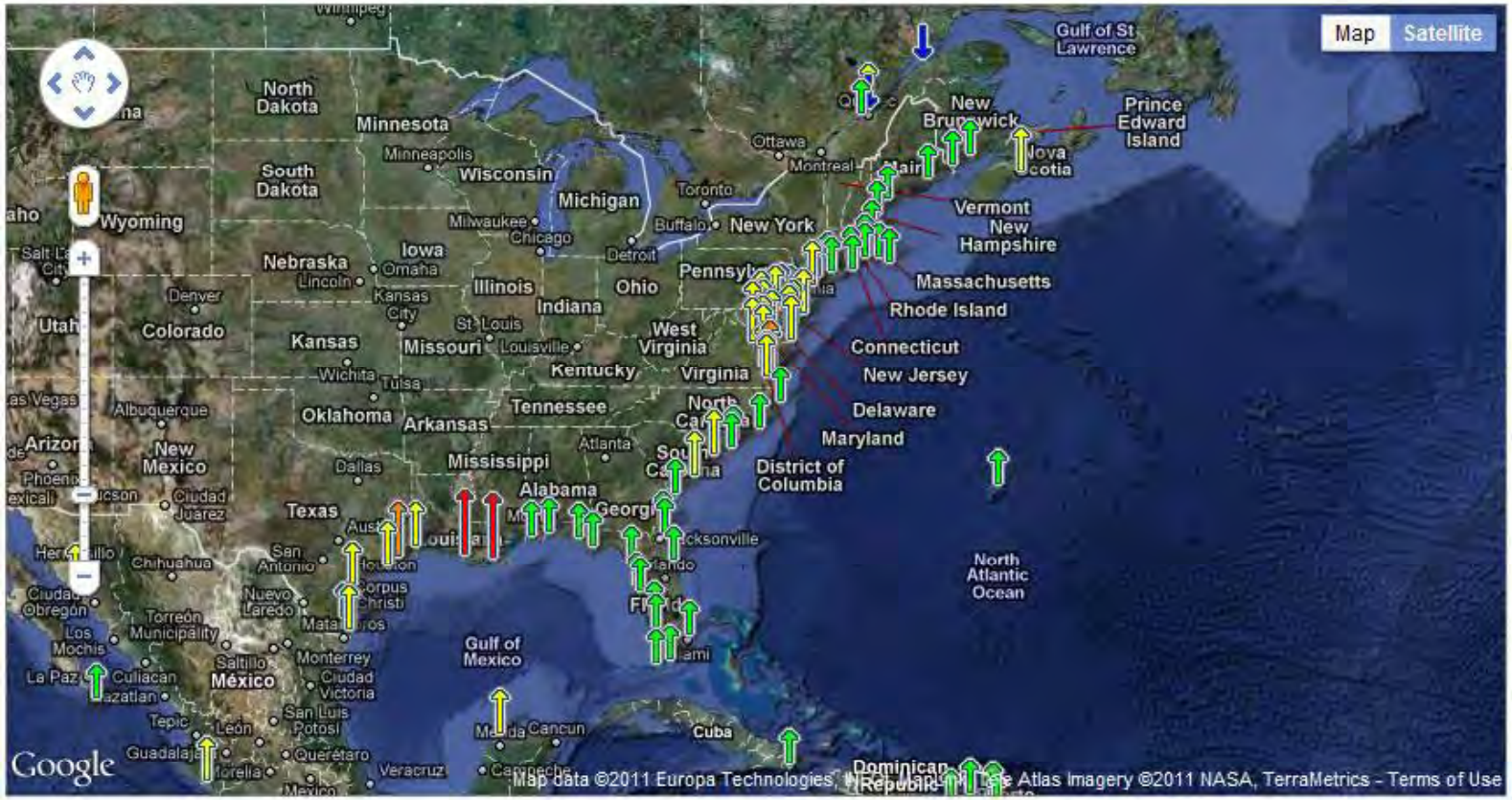
Two Types of Sea Level Rise

- **Global sea level rise**: The increase in height of sea level caused by an increase in volume of water as a result of upland glacier melt, and increase sea temperatures which also increases volume
- **Relative (local) sea level rise**: The relative increase in sea level locally as a result of global sea level rise combined with land subsidence

Mid – Atlantic States Vulnerable

- Land subsidence either from glacial rebound to the north, or from groundwater extraction has increased relative sea level rise
- Mid – Atlantic states have the second highest relative sea level rise in the U. S., with the Gulf states having the highest rate
- Scientific literature states the rates are expected to remain at present levels, or possibly increase

Sea Level Rise - Documented

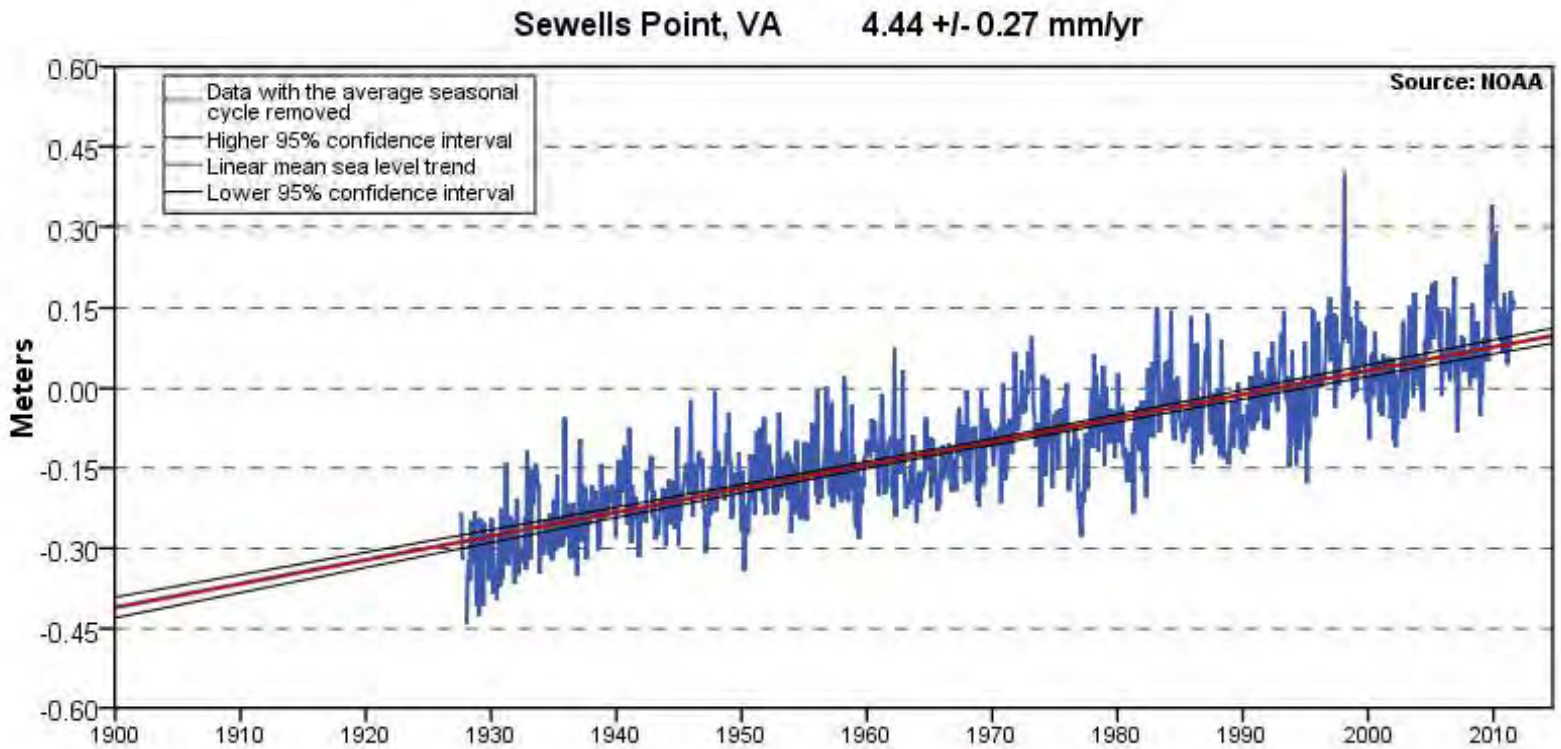


The map above illustrates regional trends in sea level, with arrows representing the direction and magnitude of change. Click on an arrow to access additional information about that station.

http://tidesandcurrents.noaa.gov/sltrends/sltrends.html

Sea Level Rise – Documented (cont'd)

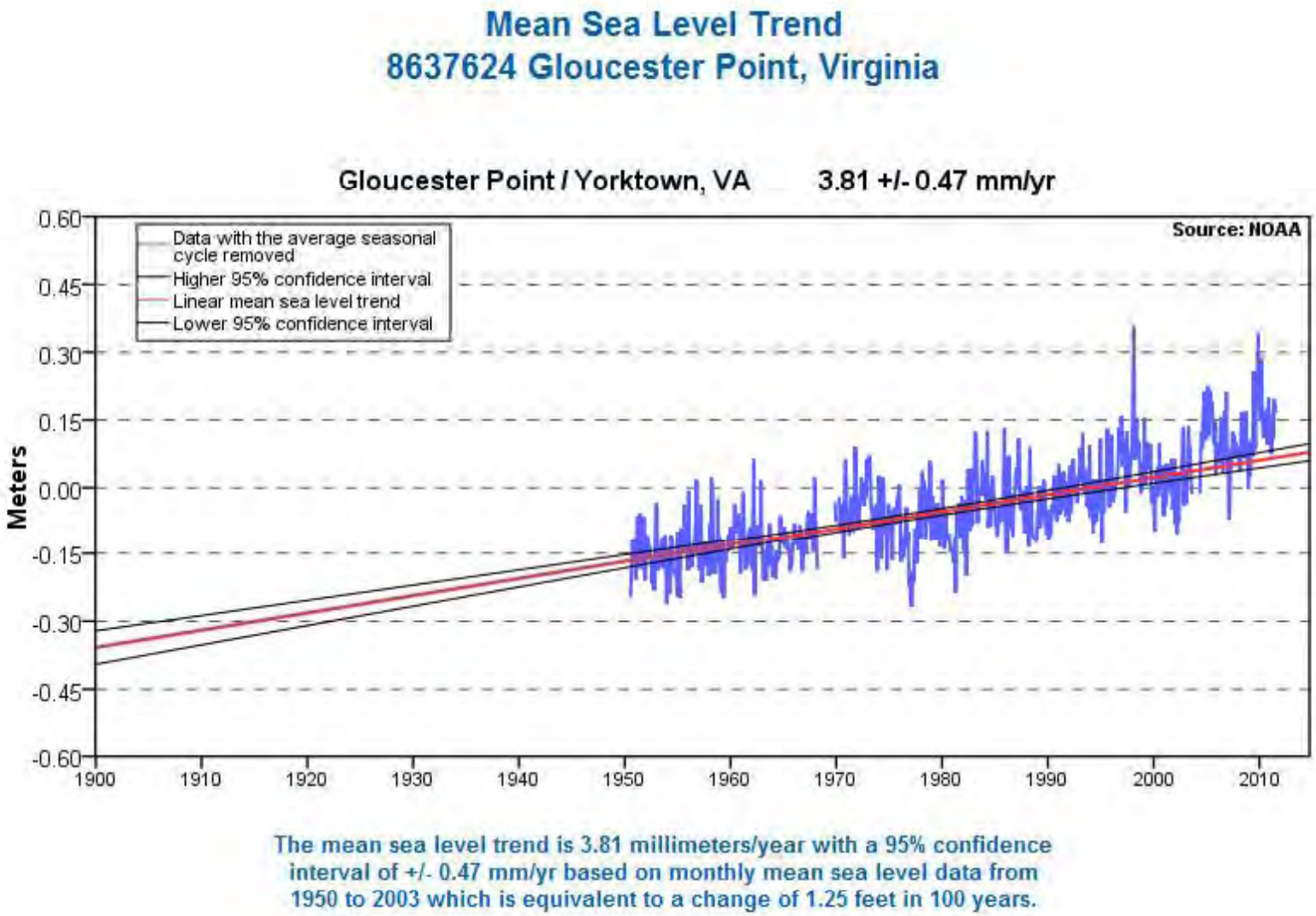
Mean Sea Level Trend
8638610 Sewells Point, Virginia



The mean sea level trend is 4.44 millimeters/year with a 95% confidence interval of +/- 0.27 mm/yr based on monthly mean sea level data from 1927 to 2006 which is equivalent to a change of 1.46 feet in 100 years.

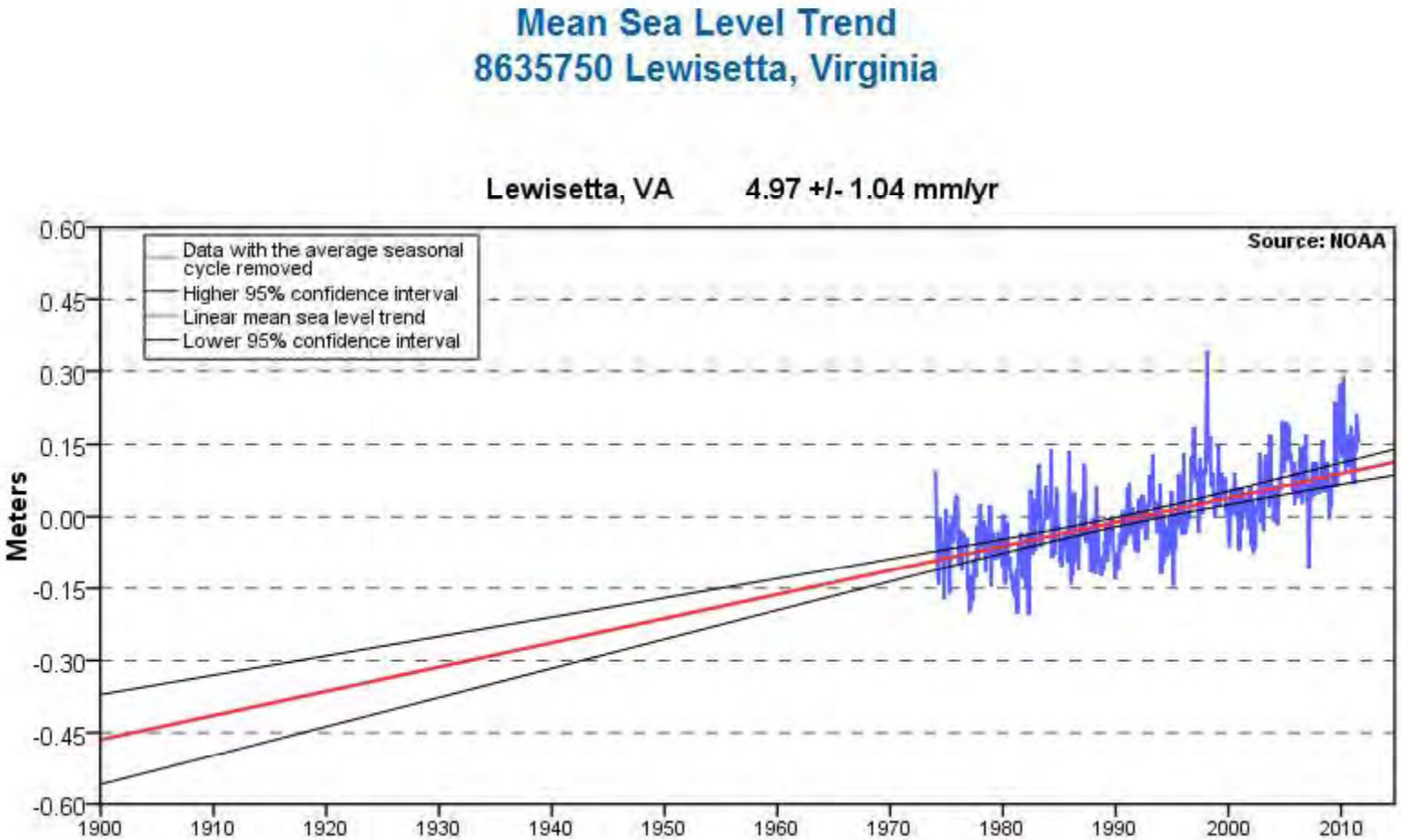
http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8638610

Sea Level Rise - Documented (cont'd)



http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8637624

Sea Level Rise - Documented (cont'd)



http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8635750

Elevation Data Set Accuracy Issues

- Virginia Base Mapping Program's 2009 two foot elevation contour set were used in this assessment
- The vertical accuracy of Lancaster County's VBMP elevation contour data is +/- 1.5 feet

Study Limitations due to Vertical Accuracy Issues

- Projected sea level rise rates are estimated to be in the 1.25 to 1.5 foot range of increase in 100 years
- Vertical Accuracy of the VBMP elevation contour data is also approximately 1.5 feet
- Therefore, this analysis is intended to be used for regional analysis at a county level scale, and is not intended for smaller scale analysis due to vertical accuracy issues

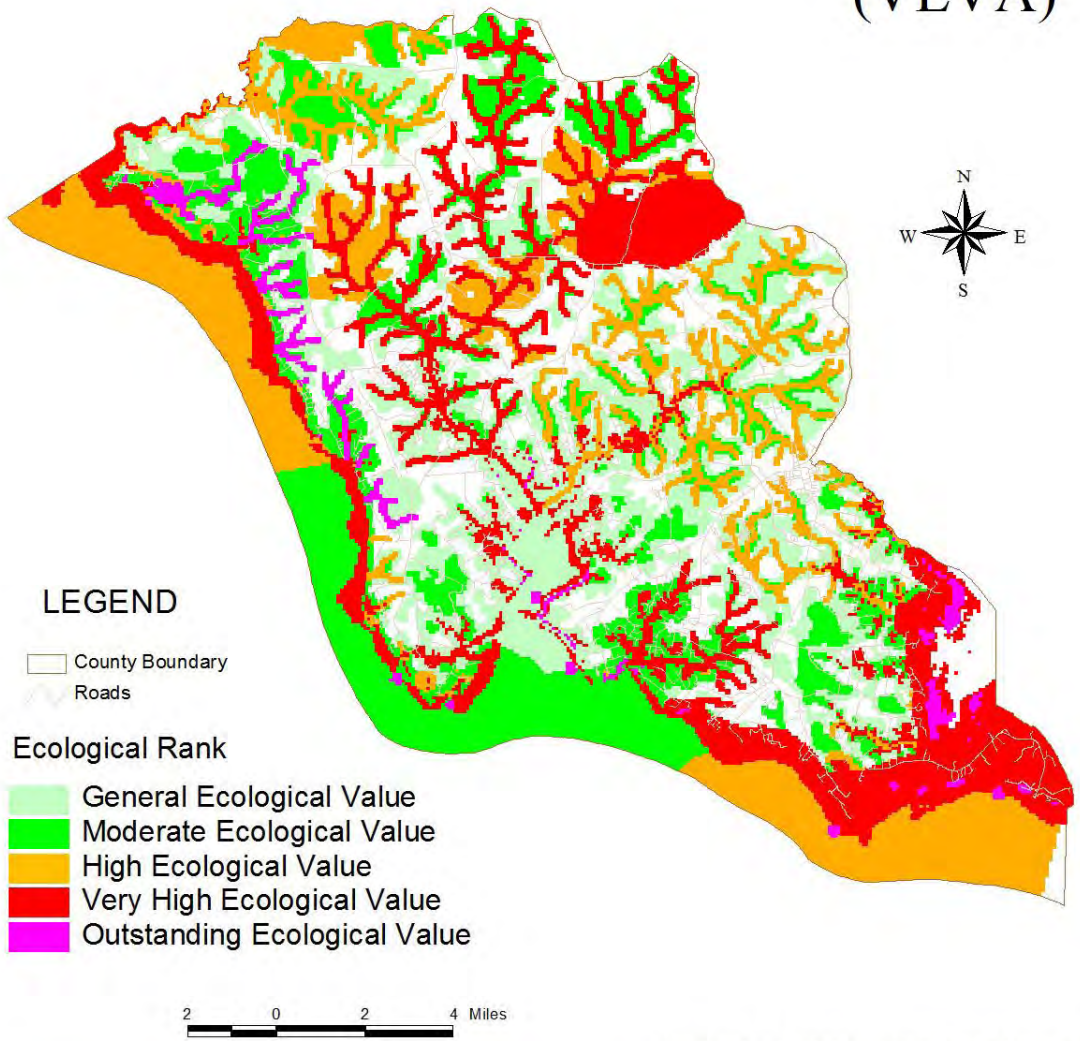
Two Analyses

- **Green Infrastructure Vulnerability Analysis** – examine natural areas that could be possibly be impacted by sea level rise, and their relative ecological importance
- **Grey Infrastructure and Private Buildings Analysis** – examine selected parts of the built environment for potential impacts from sea level rise (sewage treatment plants and public boat ramps) as well as privately owned structures

Study Details

- Area in Lancaster County examined was 0-4 foot of elevation, the two and four foot contour were examined (in order to study areas outside of the vertical error range)
- Shoreline data used from VIMS, create in 2004 using GPS technology
- Green Infrastructure analysis used the Virginia Ecological Valuation Analysis (VEVA)from the Virginia Coastal Zone Management Program
- Grey Infrastructure Analysis examined sewage treatment plants, public boat ramps and E911 building structure outlines

Lancaster County: Virginia Ecological Valuation Assessment (VEVA)



Virginia Coastal Zone
MANAGEMENT PROGRAM

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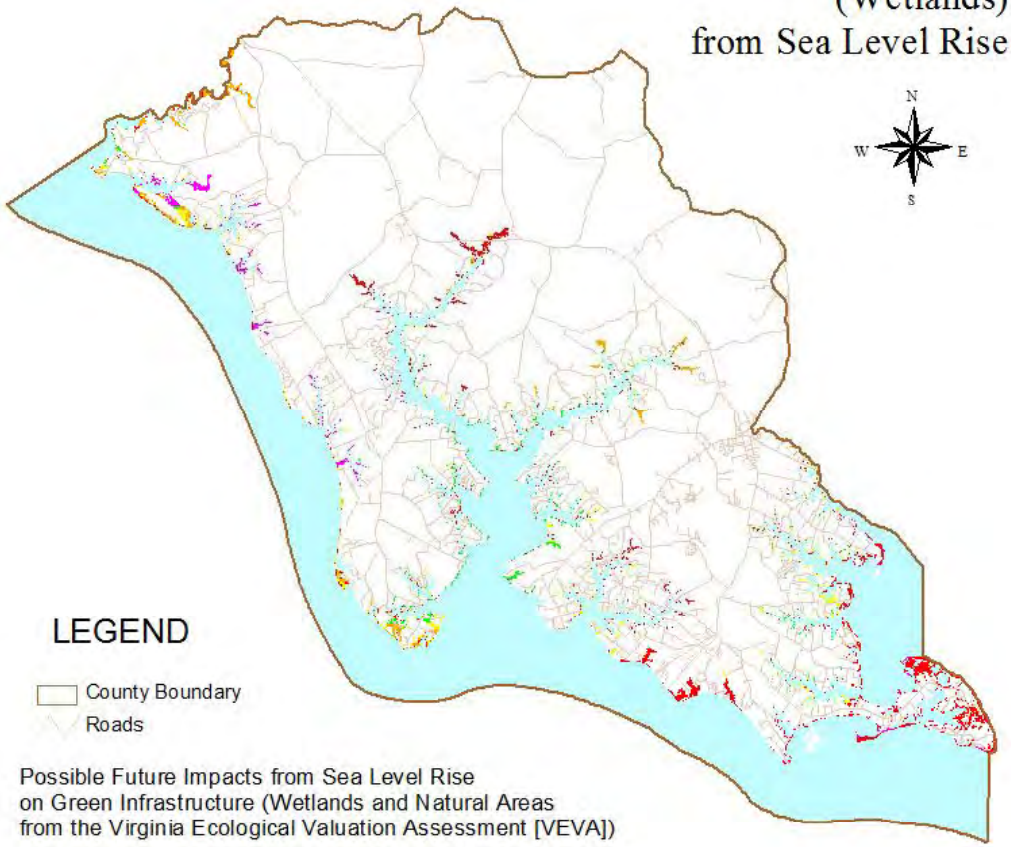
Lancaster County Possible Impacts to Green Infrastructure (Wetlands) from Sea Level Rise



LEGEND

County Boundary
Roads

Possible Future Impacts from Sea Level Rise on Green Infrastructure (Wetlands and Natural Areas from the Virginia Ecological Valuation Assessment [VEVA])

(Sea level to two foot elevation areas shown. Vertical error +/- 1.5 feet)

Total possible area impacted: 2,650 acres

- General Ecological Value = 312 acres (11.8%)
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2 0 2 4 Miles

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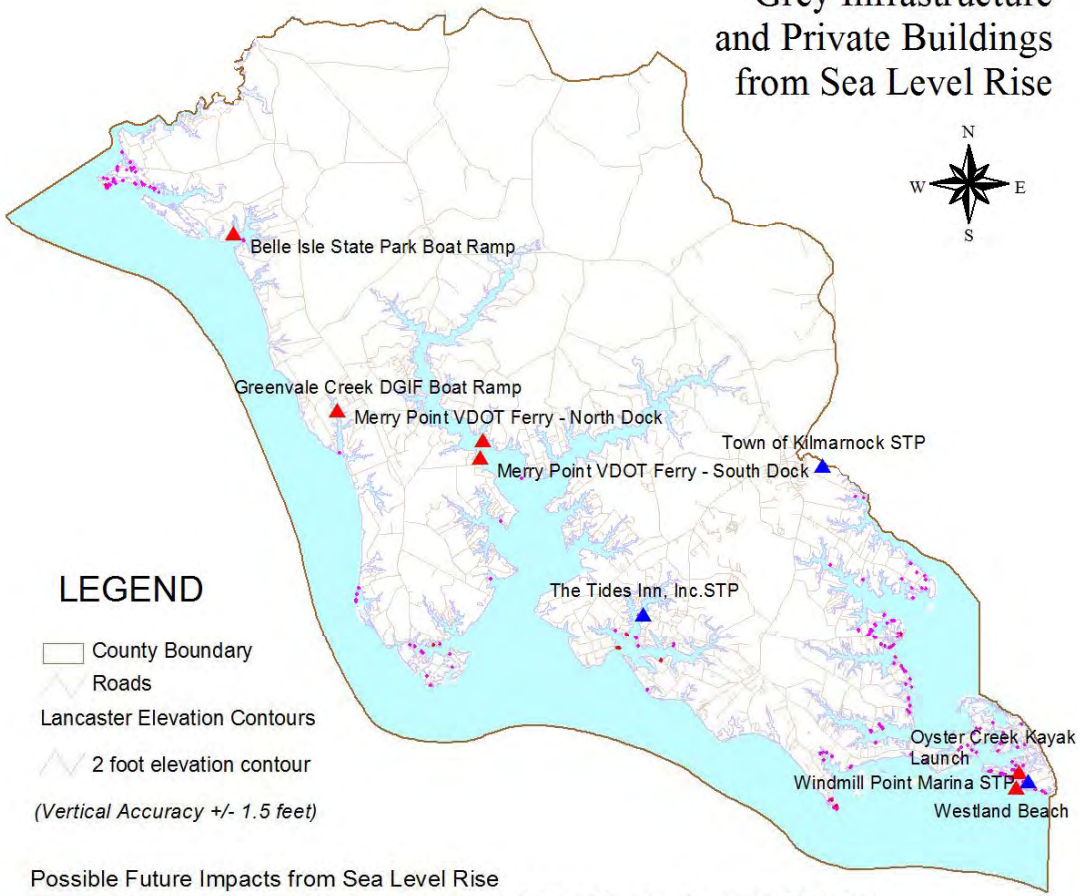
Green Infrastructure Sea Level Rise Vulnerability Analysis Results

- Large expanses of high value natural areas (wetlands) at Belle Isle, Cherry Point, Windmill Point and the Western shores of the Chesapeake Bay are potentially vulnerable
- High ecological value freshwater marshes and wetlands may be impacted in the Mulberry Creek and Western Corrotoman River corridors
- Natural areas near Towles Point and in the headwaters of Mulberry Creek and Eastern Corrotoman River also may be impacted

Lancaster County Possible Impacts to Grey Infrastructure and Private Buildings from Sea Level Rise



LEGEND

County Boundary

Roads

Lancaster Elevation Contours

2 foot elevation contour

(Vertical Accuracy +/- 1.5 feet)

Possible Future Impacts from Sea Level Rise

Possible Impacted Buildings Between the 2 and 4 foot Elevation Contours (667 bldgs)

Impacted Buildings Betlow the 2 foot Elevation Contour (35 buildings)

Public Grey Infrastructure Sites

No Impacts

Possible Impacts

Virginia Coastal Zone MANAGEMENT PROGRAM

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Select Grey Infrastructure Sea Level Rise Vulnerability Analysis

- All public water access sites were deemed to potentially impacted by future sea level rise
- The Town of Kilmarnock, Tides Inn and Windmill Point sewage treatment plant are at a sufficient elevation that there should be no impacts to the facility in the next 100 years
- The analysis of private buildings impacted was separated by elevation contour, those between 0-2 foot of elevation and those 2-4 foot of elevation

Select Grey Infrastructure Sea Level Rise Vulnerability Analysis

- The analysis identified 35 structures that are located between sea level and 2 foot of elevation that may be impacted
- The analysis identified 667 structures that are located between 2 and 4 foot of elevation possibly impacted
- Impacts to privately owned buildings occur in Morattico, Towles Point, Carter Creek, Mosquito Point and Creek, Windmill Point, and the Western Shore of the Chesapeake Bay

Summary - Green Infrastructure Sea Level Rise Vulnerability Analysis

- Impacts to large areas of very high ecological value marsh systems near Belle Isle State Park and Windmill Point are possible, as well as marshes in Mulberry Creek and the Western Corrotoman River
- Potential impacts are disproportionately attributed to Very High ecological value natural areas versus the lower value (general, moderate, or high) ecological value natural areas in Lancaster County

Summary - Grey Infrastructure Sea Level Rise Vulnerability Analysis

- All public water access sites have potential to be impacted from sea level rise
- Location of all sewage treatment plants are high enough to preclude any expected impact from sea level rise within the next 100 years
- Private buildings near the shoreline in the Morattico, Towles Point, Carter Creek, Windmill Point and Western Shores of the Chesapeake Bay may impacted from sea level rise in the future.

Questions?

Stuart McKenzie

Environmental Planner

Northern Neck Planning District Commission

Phone: 804-333-1900 extension 25

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Northumberland County Climate Change Vulnerability Analysis

Possible Impacts to Green Infrastructure and select Grey Infrastructure

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Possible Climate Change Impacts to Northumberland County

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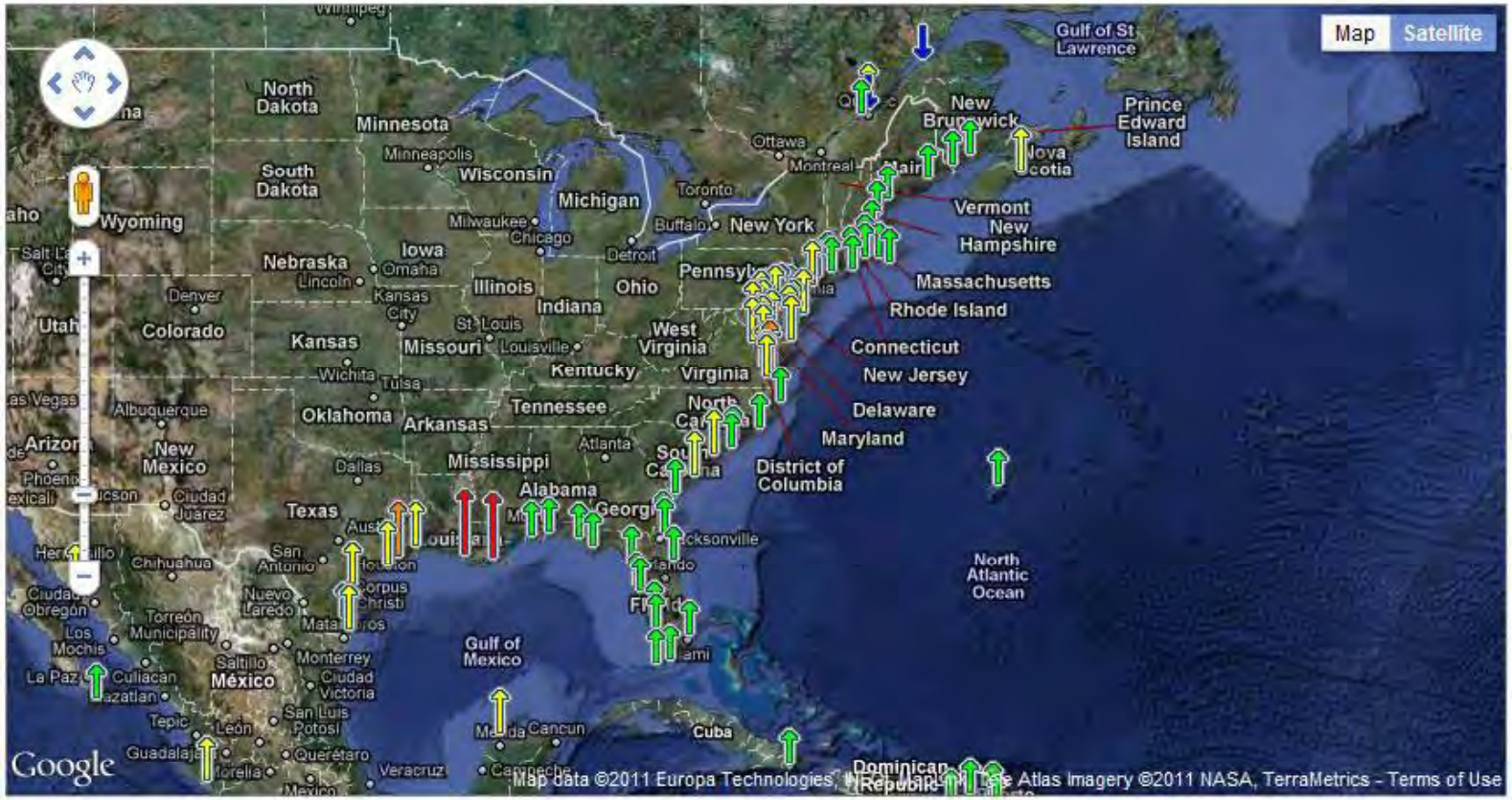
Mid – Atlantic States Vulnerable

- Land subsidence either from glacial rebound, or from groundwater extraction has increased relative sea level rise
- Mid – Atlantic states have the second highest relative sea level rise, with Gulf states leading
- Scientific literature states the rates are expected to remain at present levels, or possibly increase

Sea Level Rise - Documented

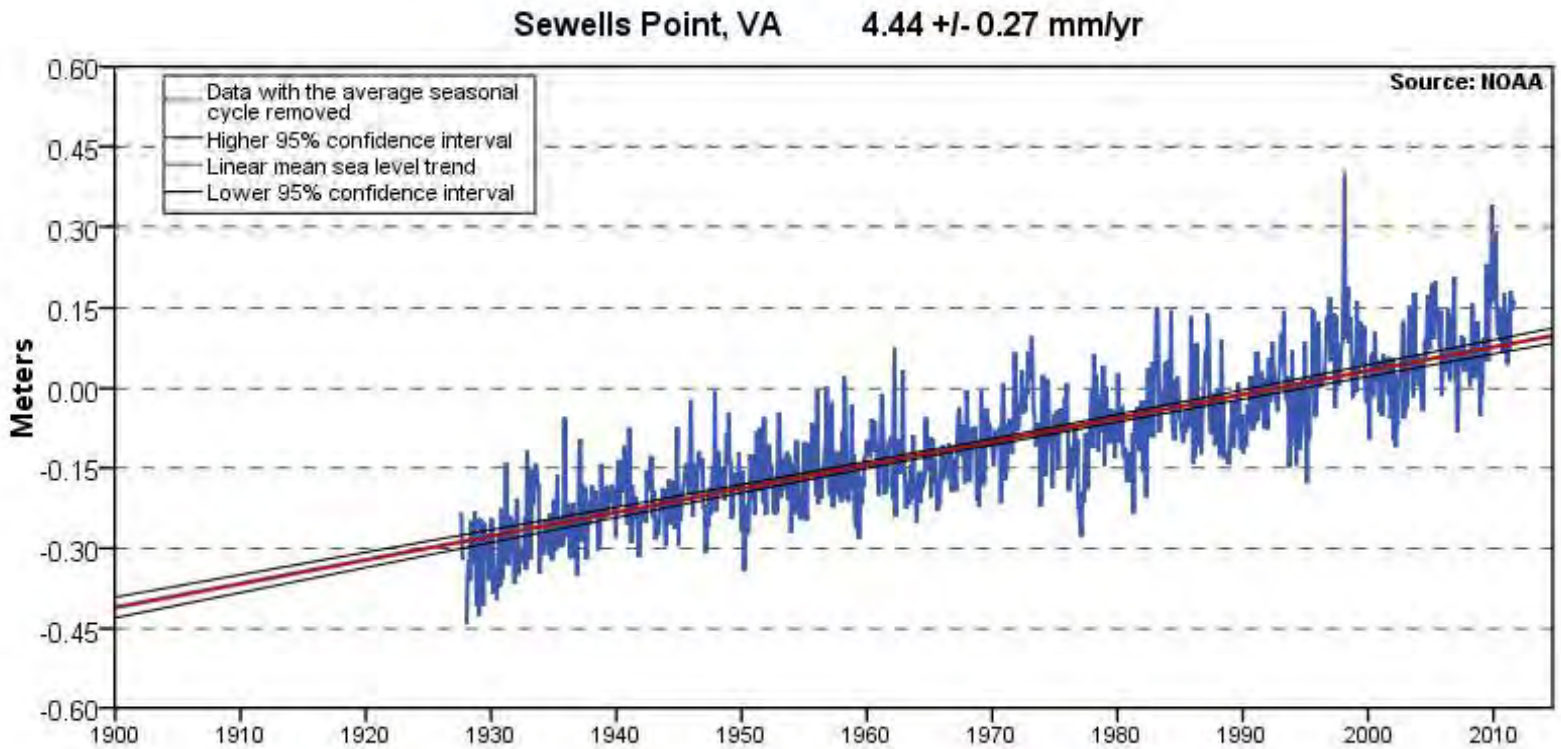


The map above illustrates regional trends in sea level, with arrows representing the direction and magnitude of change. Click on an arrow to access additional information about that station.

http://tidesandcurrents.noaa.gov/sltrends/sltrends.html

Sea Level Rise – Documented (cont'd)

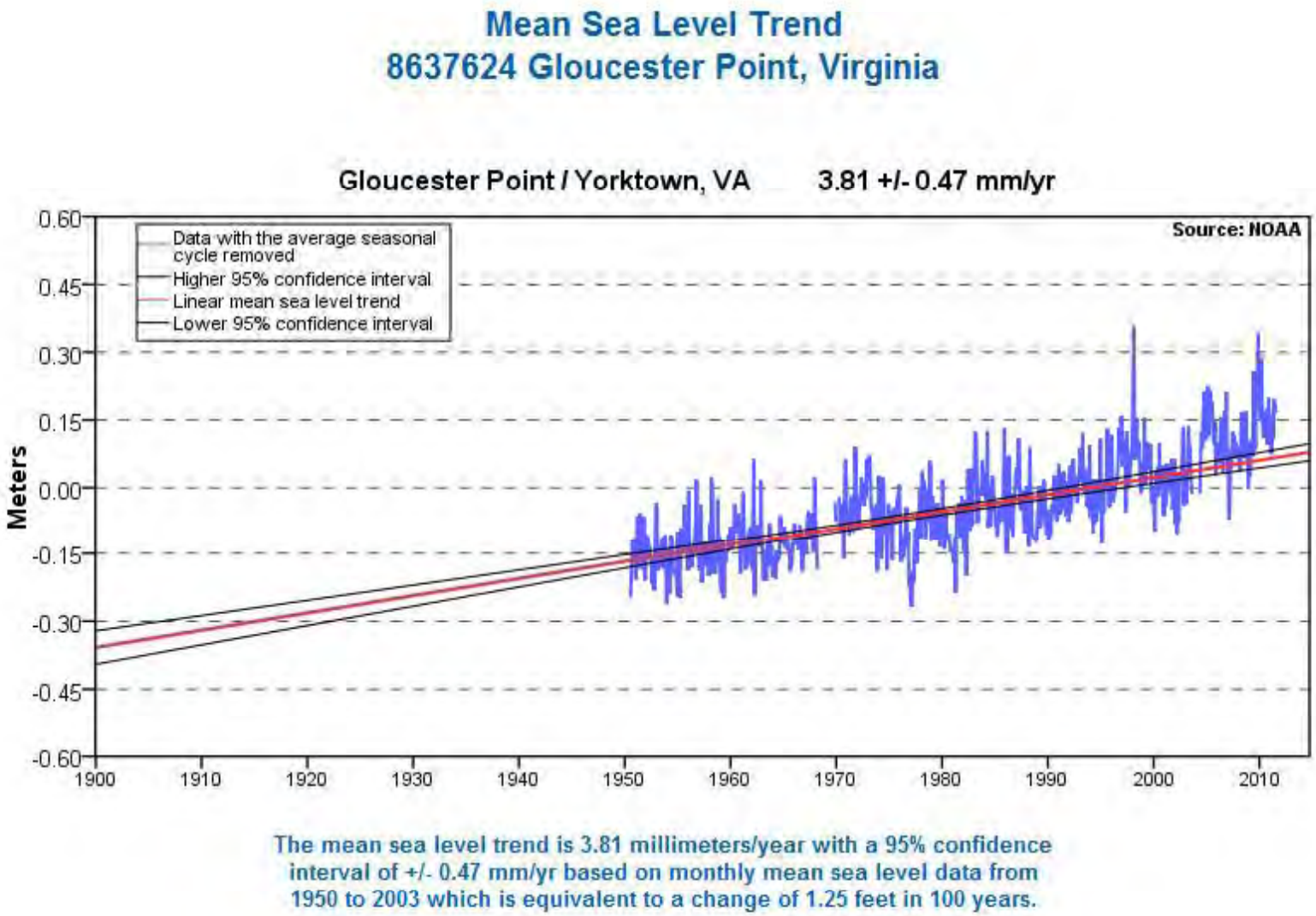
Mean Sea Level Trend
8638610 Sewells Point, Virginia



The mean sea level trend is 4.44 millimeters/year with a 95% confidence interval of +/- 0.27 mm/yr based on monthly mean sea level data from 1927 to 2006 which is equivalent to a change of 1.46 feet in 100 years.

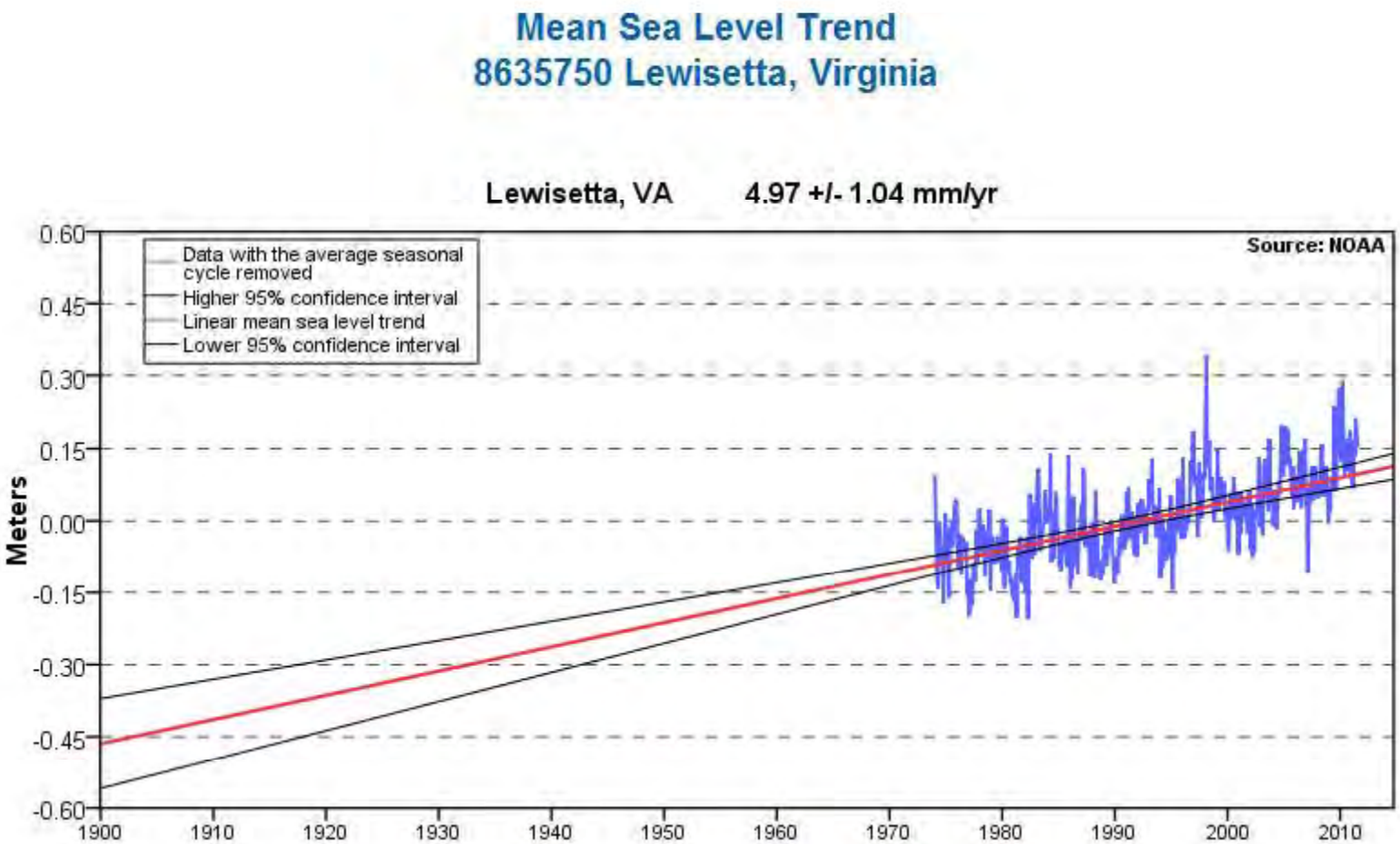
http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8638610

Sea Level Rise - Documented (cont'd)



http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8637624

Sea Level Rise - Documented (cont'd)



http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8635750

Two Analyses

- **Green Infrastructure Vulnerability Analysis** – examine natural areas that could be possibly be impacted by sea level rise, and their relative ecological importance
- **Grey Infrastructure and Private Buildings Analysis** – examine selected parts of the built environment for potential impacts from sea level rise (sewage treatment plants and public boat ramps) as well as privately owned structures

Elevation Data Set Accuracy Issues

- VirGIS digital elevation was used for the study, the source maps (USGS 1:24,000 topographic maps) vertical accuracy is +/- 2.98 ft before any digitizing or interpolation was completed
- VirGIS elevation uses the National Geodetic Vertical Datum of 1929, while today the standard is the revised National Geodetic Vertical Datum of 1988 – a difference of 0.8 ft.

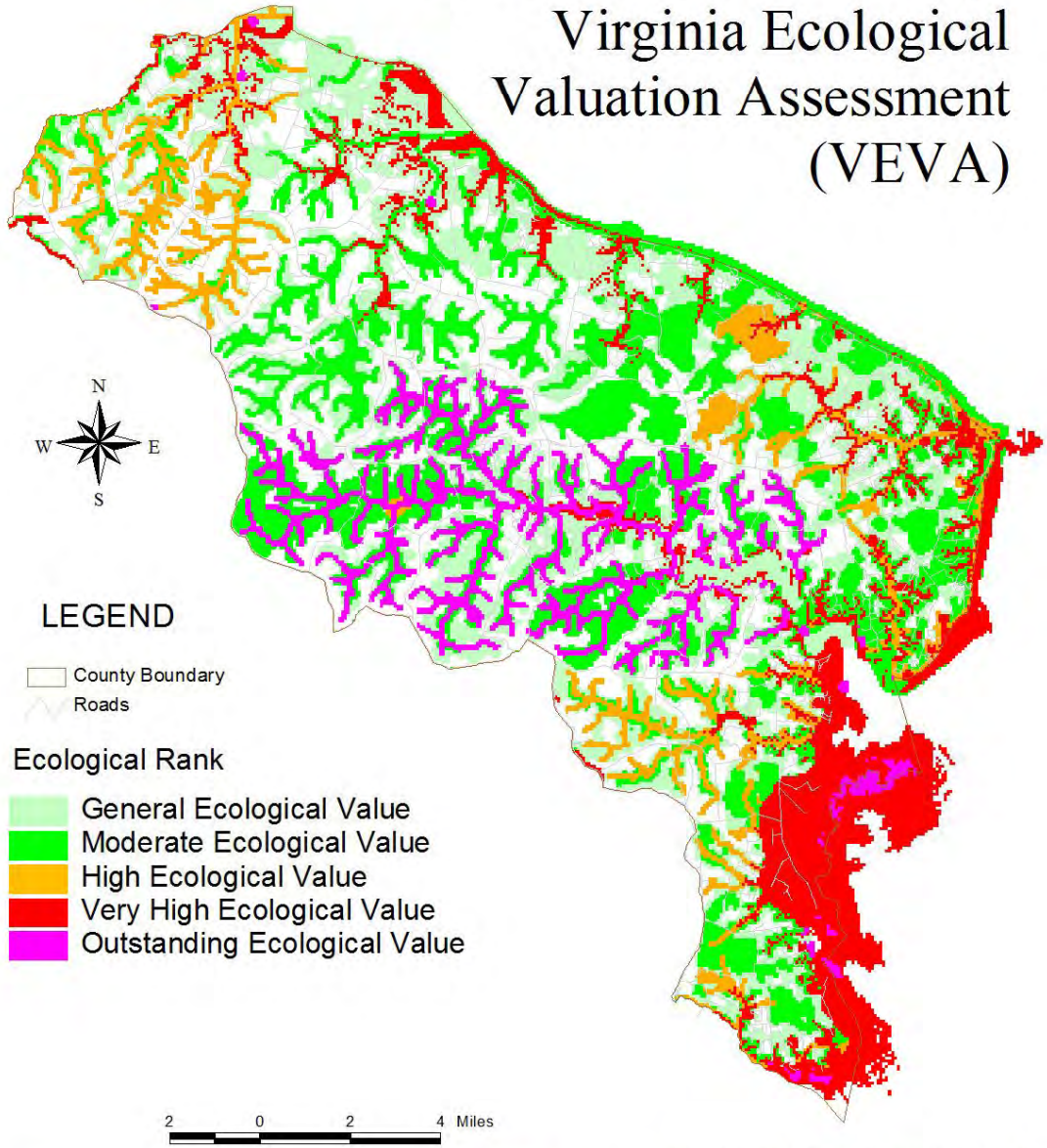
Study Limitations due to Vertical Accuracy Issues

- Projected sea level rise rates are estimated to be in the 1.25 to 1.5 foot range of increase in 100 years
- Vertical Accuracy of the VirGIS data exceeds 3 feet
- Therefore, this analysis is intended to be used for regional analysis at a county level scale, and is not intended for smaller scale analysis due to vertical accuracy issues

Study Details

- Area in Northumberland County examined was 0-4 foot of VirGIS elevation (in order to study areas outside of the vertical error range)
- Shoreline data used from VIMS, create in 2004 using GPS technology
- Green Infrastructure analysis used the Virginia Ecological Valuation Analysis (VEVA)from the Virginia Coastal Zone Management Program
- Grey Infrastructure Analysis examined sewage treatment plants, public boat ramps and E911 building structure outlines

Northumberland County: Virginia Ecological Valuation Assessment (VEVA)



Virginia Coastal Zone MANAGEMENT PROGRAM

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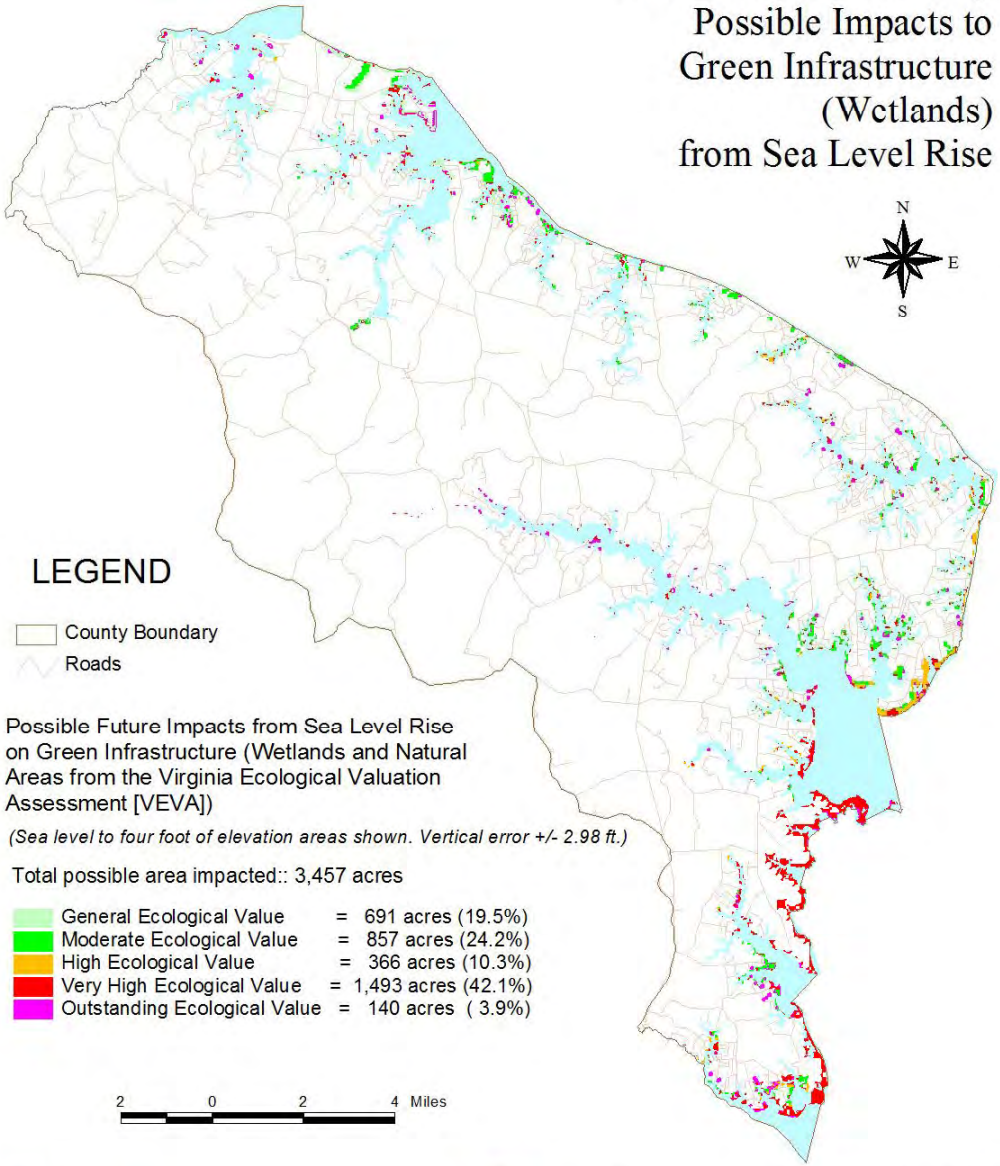
Northumberland County Possible Impacts to Green Infrastructure (Wetlands) from Sea Level Rise



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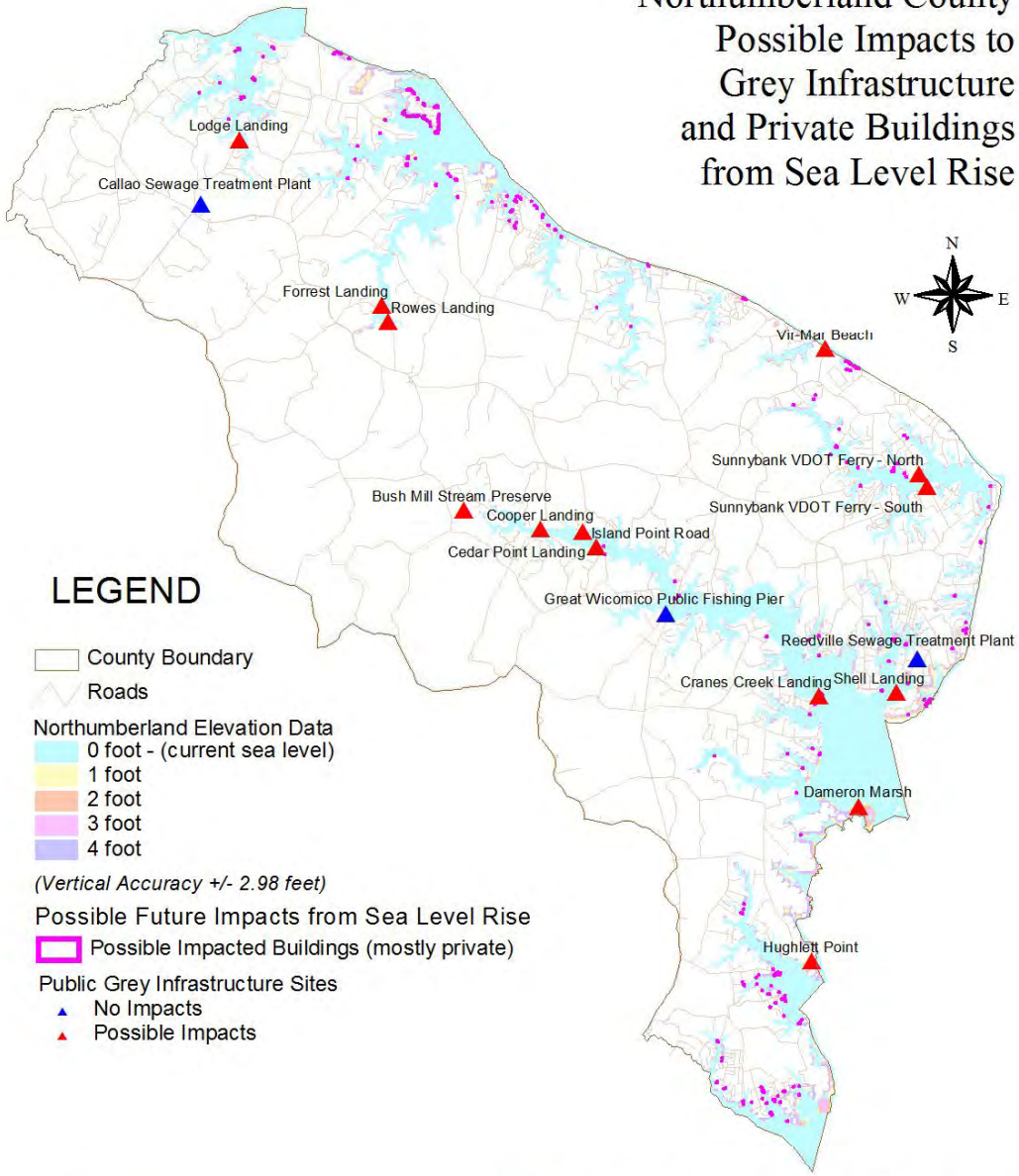
Green Infrastructure Sea Level Rise Vulnerability Analysis Results

- Large expanses of high value natural areas (wetlands) between Dameron Marsh and Hughlett Point are potentially vulnerable
- High and Very High ecological value freshwater marshes and wetlands may be impacted along the edges of the Coan, Little Wicomico, Great Wicomico, Dividing and Indian Creek corridors

Northumberland County Possible Impacts to Grey Infrastructure and Private Buildings from Sea Level Rise



Virginia Coastal Zone MANAGEMENT PROGRAM

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Select Grey Infrastructure Sea Level Rise Vulnerability Analysis

- All public water access sites except the Glebe Point Pier were deemed to potentially impacted by future sea level rise
- The Reedville and Callao sewage treatment plant are at a sufficient elevation that there should be no impacts to the facility
- Impacts to privately owned buildings are concentrated in Lewisetta, Glebe Point and in the Reedville area. Most rivers in the county have areas where structures are impacted.

Green Infrastructure Sea Level Rise Vulnerability Analysis Summary

- Impacts to large areas of very high ecological value marsh systems including Dameron Marsh and Hughlett Point
- Potential impacts along the Potomac River are attributed to lower ecological value natural areas versus areas in the lower county along the Chesapeake Bay where most impacts are to very high ecological value natural areas

Grey Infrastructure Sea Level Rise Vulnerability Analysis Summary

- Most public water access sites have potential to be impacted from sea level rise
- Location of the two Sewage Treatment Plants are high enough to preclude any impact from sea level rise
- Private buildings in Lewisetta, Glebe Point and Reedville may possibly be impacted from sea level rise in the future.

Questions?

Stuart McKenzie

Environmental Planner

Northern Neck Planning District Commission

Phone: 804-333-1900 extension 25

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Richmond County Climate Change Vulnerability Analysis

Possible Impacts to Green Infrastructure and select Grey Infrastructure

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Possible Climate Change Impacts to Richmond County

- Sea Level Rise
- Increased drought and severity of droughts
- More intense and frequent storms
- Rise in global temperatures
- Changing salinity associated with sea level rise

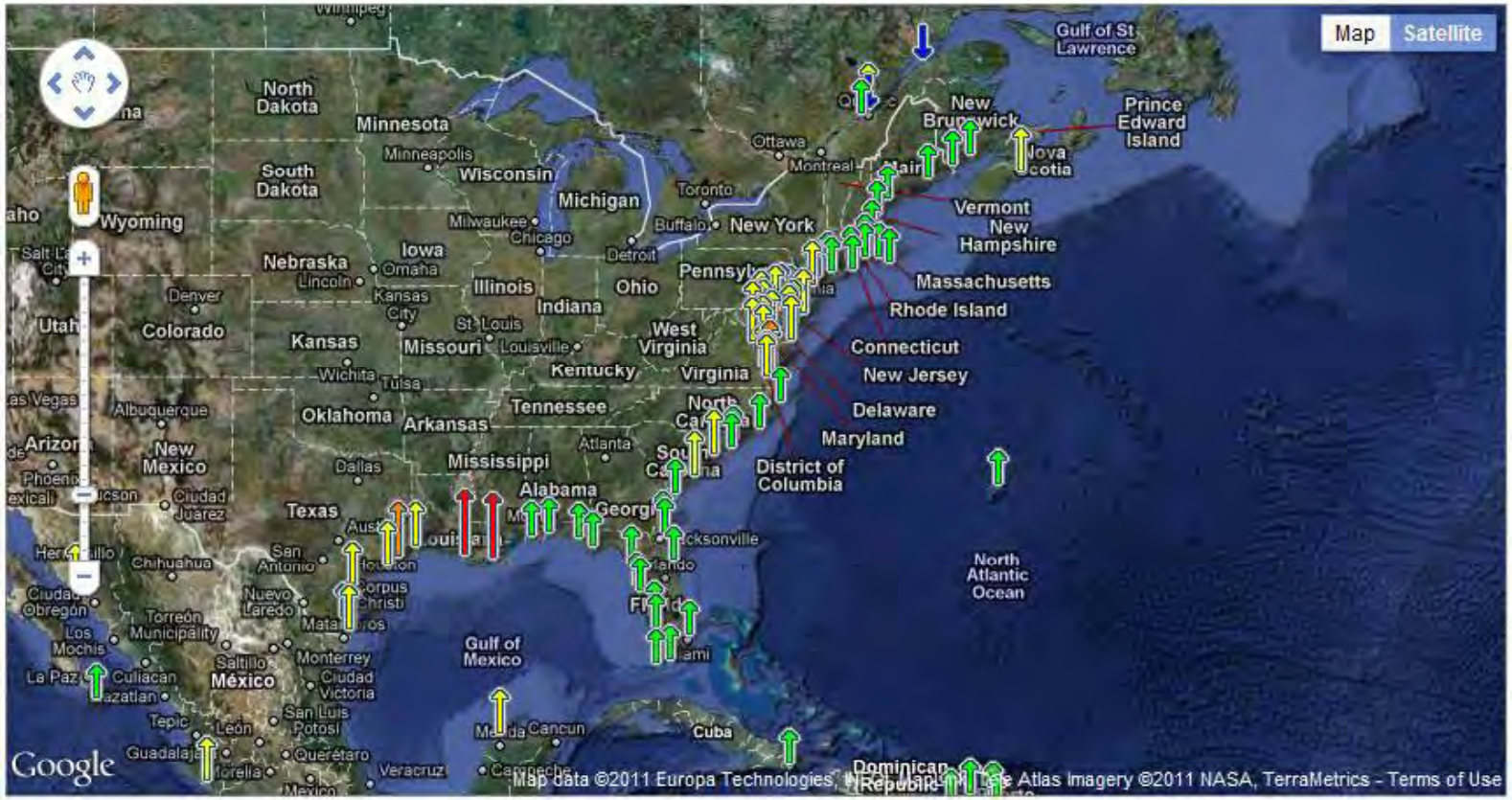
Two Types of Sea Level Rise

- **Global sea level rise**: The increase in height of sea level caused by increase in volume of water as a result of upland glacier melt, and increase sea temperatures
- **Relative (local) sea level rise**: The relative increase in sea level locally as a result of global sea level rise combined with land subsidence

Mid – Atlantic States Vulnerable

- Land subsidence either from glacial rebound, or from groundwater extraction has increased relative sea level rise
- Mid – Atlantic states have the second highest relative sea level rise, with Gulf states leading
- Scientific literature states the rates are expected to remain at present levels, or possibly increase

Sea Level Rise - Documented



The map above illustrates regional trends in sea level, with arrows representing the direction and magnitude of change. Click on an arrow to access additional information about that station.

Sea Level Trends

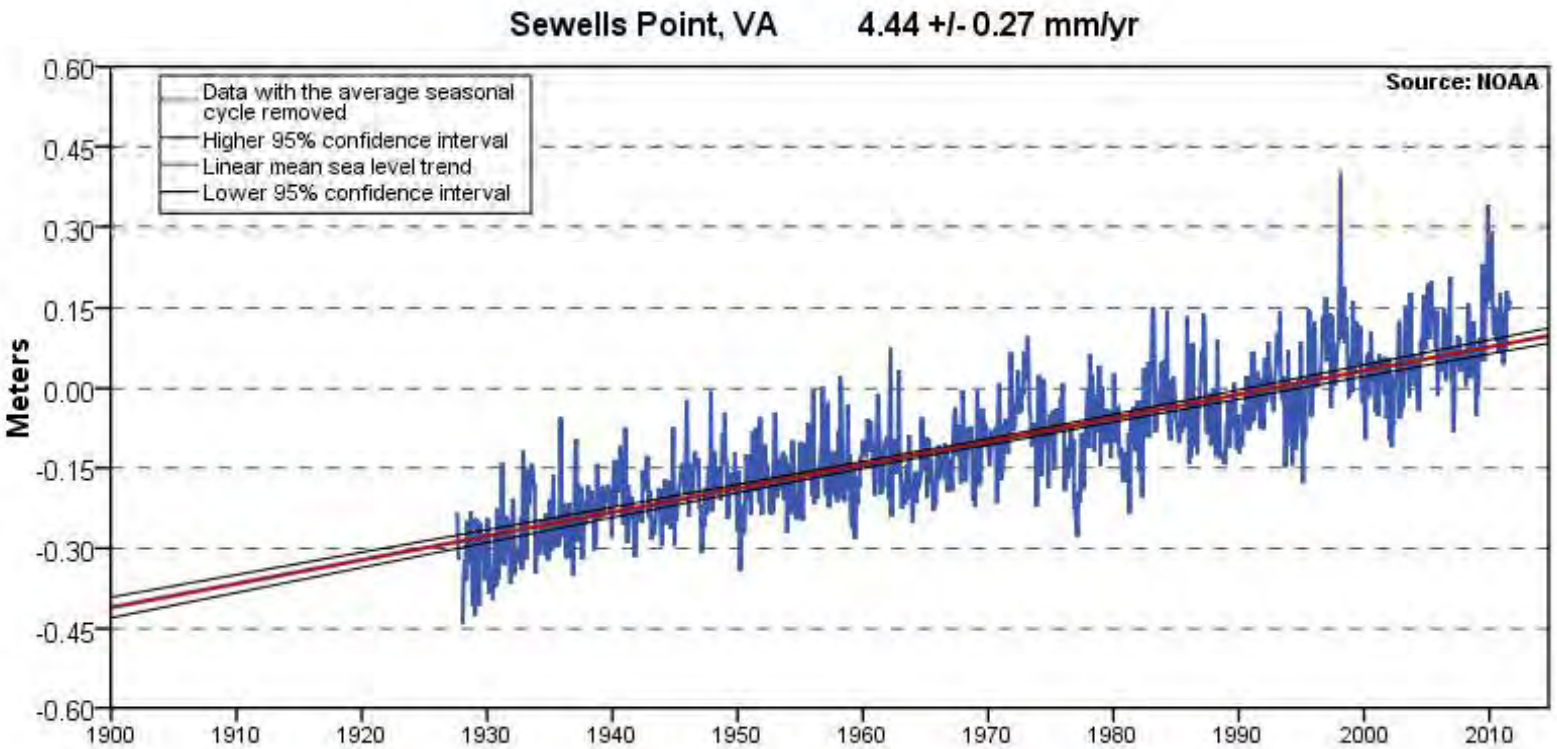
mm/yr (feet/century)

9 to 12 (3 to 4)	3 to 6 (1 to 2)	-3 to 0 (-1 to 0)	-9 to -6 (-3 to -2)	-15 to -12 (-5 to -4)
6 to 9 (2 to 3)	0 to 3 (0 to 1)	-6 to -3 (-2 to -1)	-12 to -9 (-4 to -3)	-18 to -15 (-6 to -5)

http://tidesandcurrents.noaa.gov/sltrends/sltrends.html

Sea Level Rise – Documented (cont'd)

Mean Sea Level Trend
8638610 Sewells Point, Virginia



The mean sea level trend is 4.44 millimeters/year with a 95% confidence interval of +/- 0.27 mm/yr based on monthly mean sea level data from 1927 to 2006 which is equivalent to a change of 1.46 feet in 100 years.

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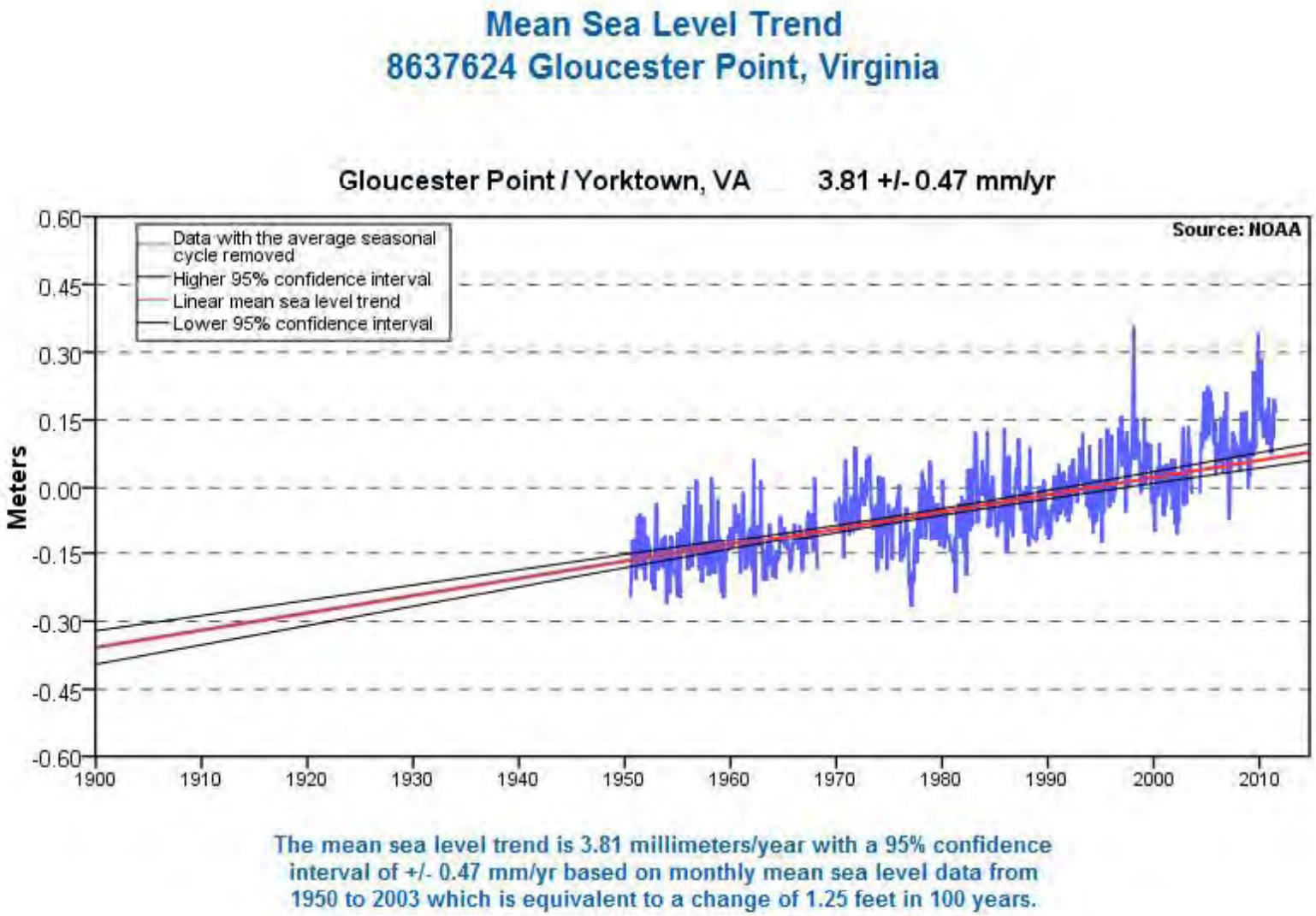
Sea Level Rise - Documented (cont'd)



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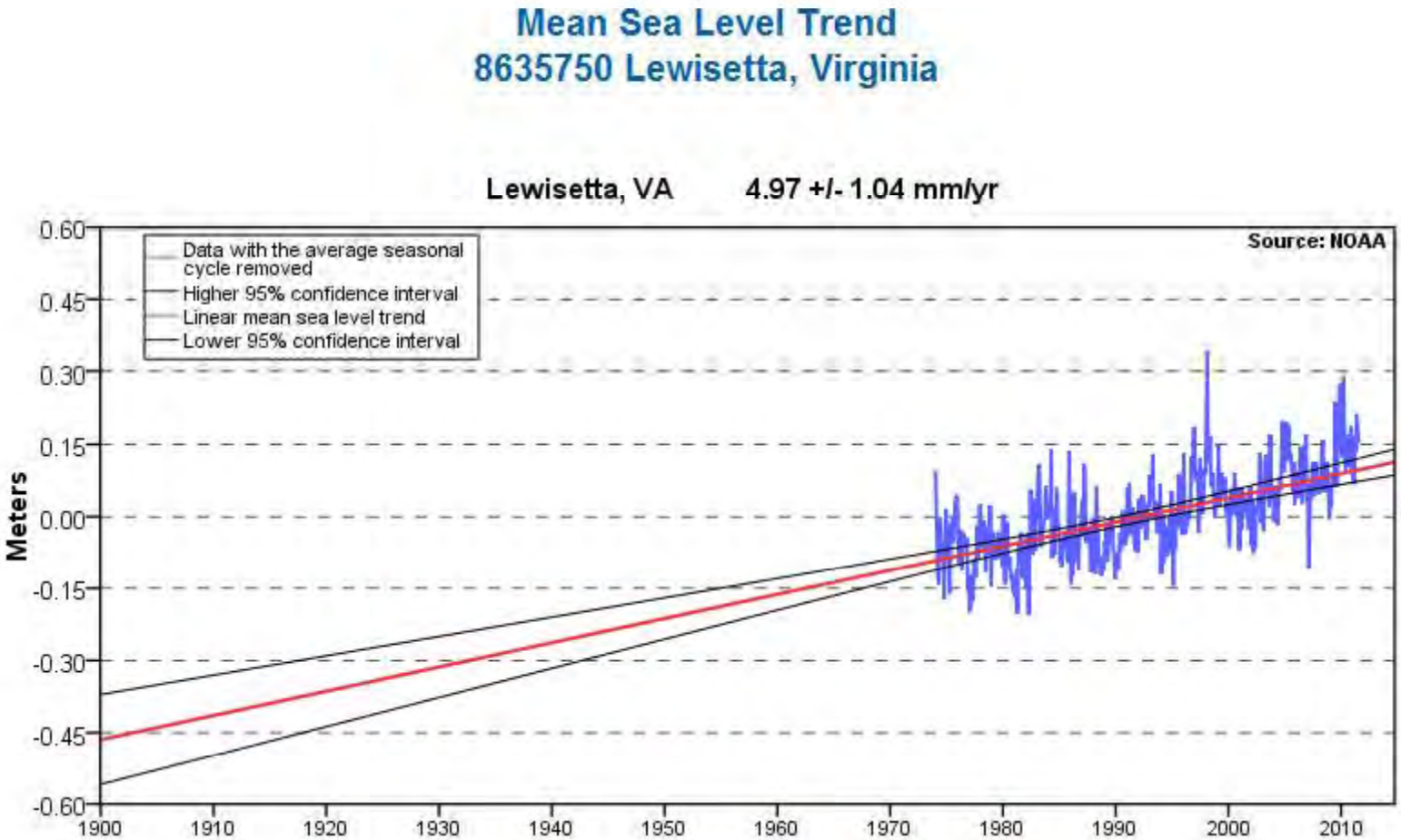
Sea Level Rise - Documented (cont'd)



http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8635750

Two Analyses

- **Green Infrastructure Vulnerability Analysis** – examine natural areas that could be possibly be impacted by sea level rise, and their relative ecological importance
- **Grey Infrastructure and Private Buildings Analysis** – examine selected parts of the built environment for potential impacts from sea level rise (sewage treatment plants and public boat ramps) as well as privately owned structures

Elevation Data Set Accuracy Issues

- VirGIS digital elevation was used for the study, the source maps (USGS 1:24,000 topographic maps) vertical accuracy is +/- 2.98 ft before any digitizing or interpolation was completed
- VirGIS elevation uses the National Geodetic Vertical Datum of 1929, while today the standard is the revised National Geodetic Vertical Datum of 1988 – a difference of 0.8 ft.

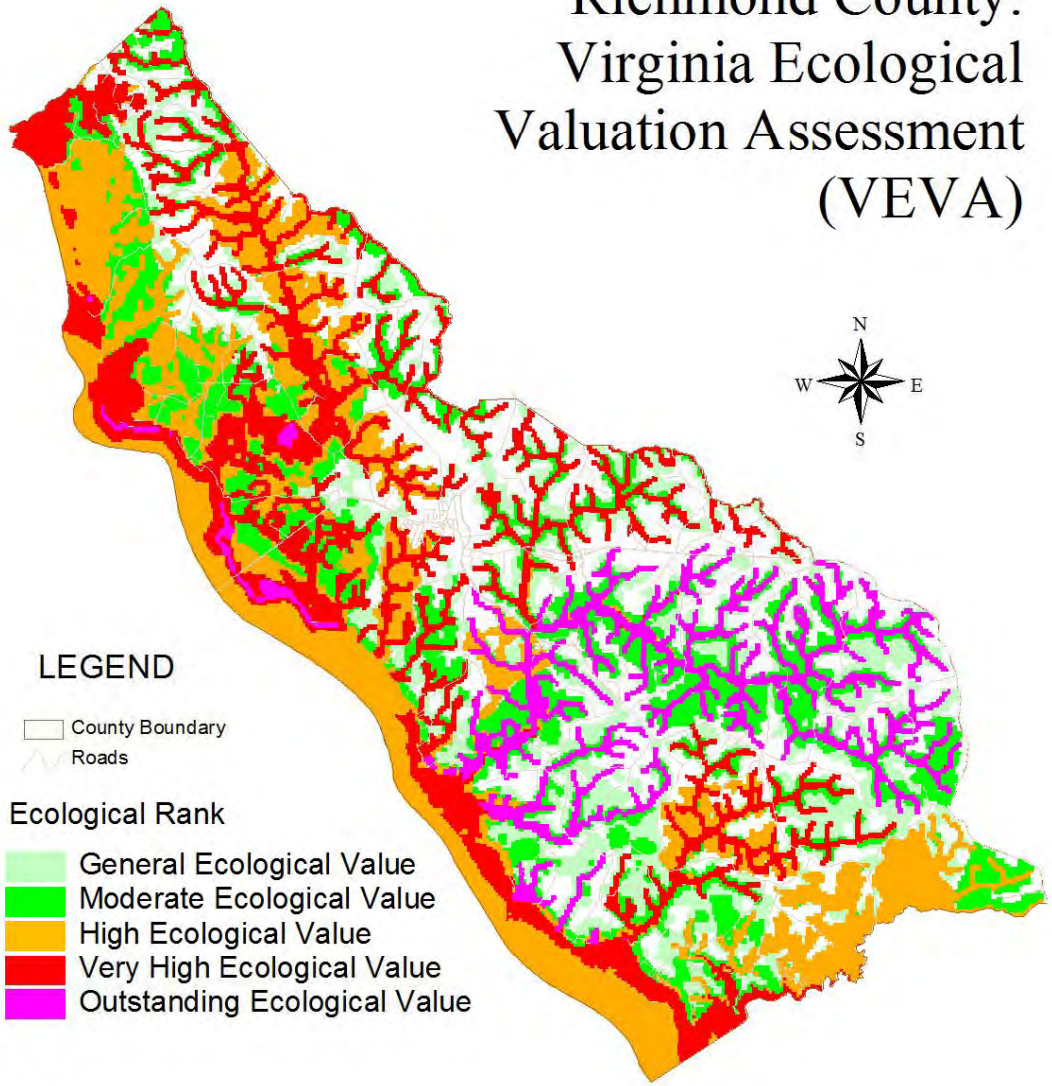
Study Limitations due to Vertical Accuracy Issues

- Projected sea level rise rates are estimated to be in the 1.25 to 1.5 foot range of increase in 100 years
- Vertical Accuracy of the VirGIS data exceeds 3 feet
- Therefore, this analysis is intended to be used for regional analysis at a county level scale, and is not intended for smaller scale analysis due to vertical accuracy issues

Study Details

- Area in Richmond County examined was 0-4 foot of VirGIS elevation (in order to study areas outside of the vertical error range)
- Shoreline data used from VIMS, create in 2004 using GPS technology
- Green Infrastructure analysis used the Virginia Ecological Valuation Analysis (VEVA)from the Virginia Coastal Zone Management Program
- Grey Infrastructure Analysis examined sewage treatment plants, public boat ramps and E911 building structure outlines

Richmond County: Virginia Ecological Valuation Assessment (VEVA)



2 0 2 4 Miles

Virginia Coastal Zone MANAGEMENT PROGRAM

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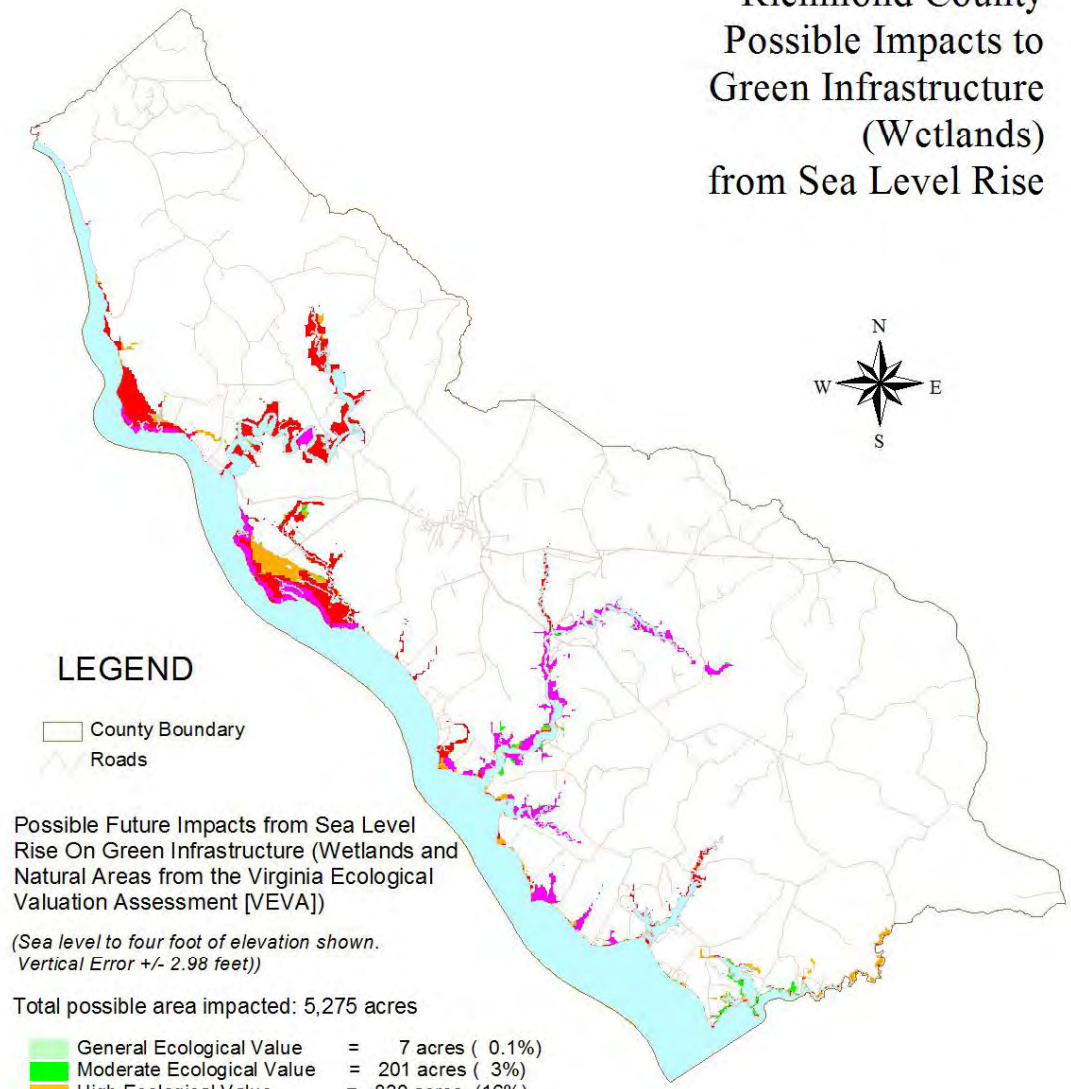
Richmond County Possible Impacts to Green Infrastructure (Wetlands) from Sea Level Rise



LEGEND

County Boundary
Roads

Possible Future Impacts from Sea Level Rise On Green Infrastructure (Wetlands and Natural Areas from the Virginia Ecological Valuation Assessment [VEVA])

(Sea level to four foot of elevation shown. Vertical Error +/- 2.98 feet))

Total possible area impacted: 5,275 acres

General Ecological Value	=	7 acres (0.1%)
Moderate Ecological Value	=	201 acres (3%)
High Ecological Value	=	830 acres (16%)
Very High Ecological Value	=	2,651 acres (50%)
Outstanding Ecological Value	=	1,586 acres (30%)

2 0 2 4 Miles

Virginia Coastal Zone MANAGEMENT PROGRAM

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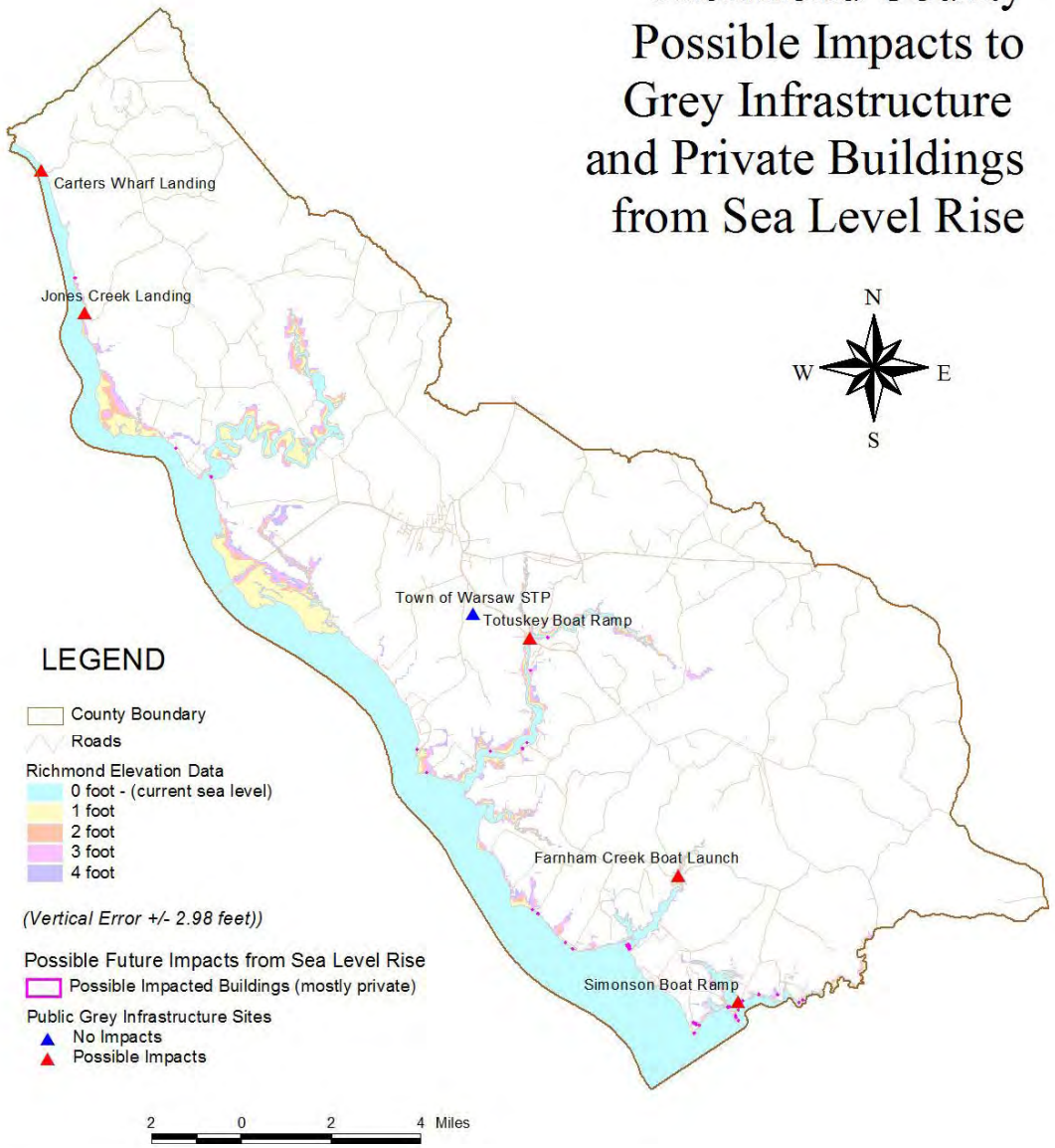
Green Infrastructure Sea Level Rise Vulnerability Analysis Results

- Large expanses of high value natural areas (wetlands) at Mulberry Island and Mangoright Point are potentially vulnerable
- Extensive high ecological value freshwater marshes and wetlands may be impacted in the Cat Point Creek and Totuskey Creek corridors
- Natural areas in the headwaters of Farnham and Lancaster Creeks also may be impacted

Richmond County Possible Impacts to Grey Infrastructure and Private Buildings from Sea Level Rise



Virginia Coastal Zone MANAGEMENT PROGRAM

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Select Grey Infrastructure Sea Level Rise Vulnerability Analysis

- All public water access sites were deemed to potentially impacted by future sea level rise
- The Town of Warsaw sewage treatment plant is at a sufficient elevation that there should be no impacts to the facility
- Impacts to privately owned buildings are mostly in the lower part of the county, Wellfords, Sharps, Wilna Point (Little Florida) and Simonson were areas with structures impacted

Green Infrastructure Sea Level Rise Vulnerability Analysis Summary

- Impacts to large areas of very high ecological value marsh systems along the Rapphannock River are possible, as well as marshes in Cat Point and Totuskey Creek
- Potential impacts are disproportionately attributed to very high and outstanding ecological value natural areas versus general to moderate ecological value natural areas in Richmond County

Grey Infrastructure Sea Level Rise Vulnerability Analysis Summary

- All public water access sites have potential to be impacted from sea level rise
- Location of the Town of Warsaw Sewage Treatment Plant is high enough to preclude any impact from sea level rise
- Private buildings near the shoreline in the lower end of the county may possibly be impacted from sea level rise in the future.

Questions?

Stuart McKenzie

Environmental Planner

Northern Neck Planning District Commission

Phone: 804-333-1900 extension 25

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Westmoreland County Climate Change Vulnerability Analysis

Possible Impacts to Green Infrastructure and select Grey Infrastructure

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Possible Climate Change Impacts to Westmoreland County

- Sea Level Rise
- Increased drought and severity of droughts
- More intense and frequent storms
- Rise in global temperatures
- Changing salinity associated with sea level rise

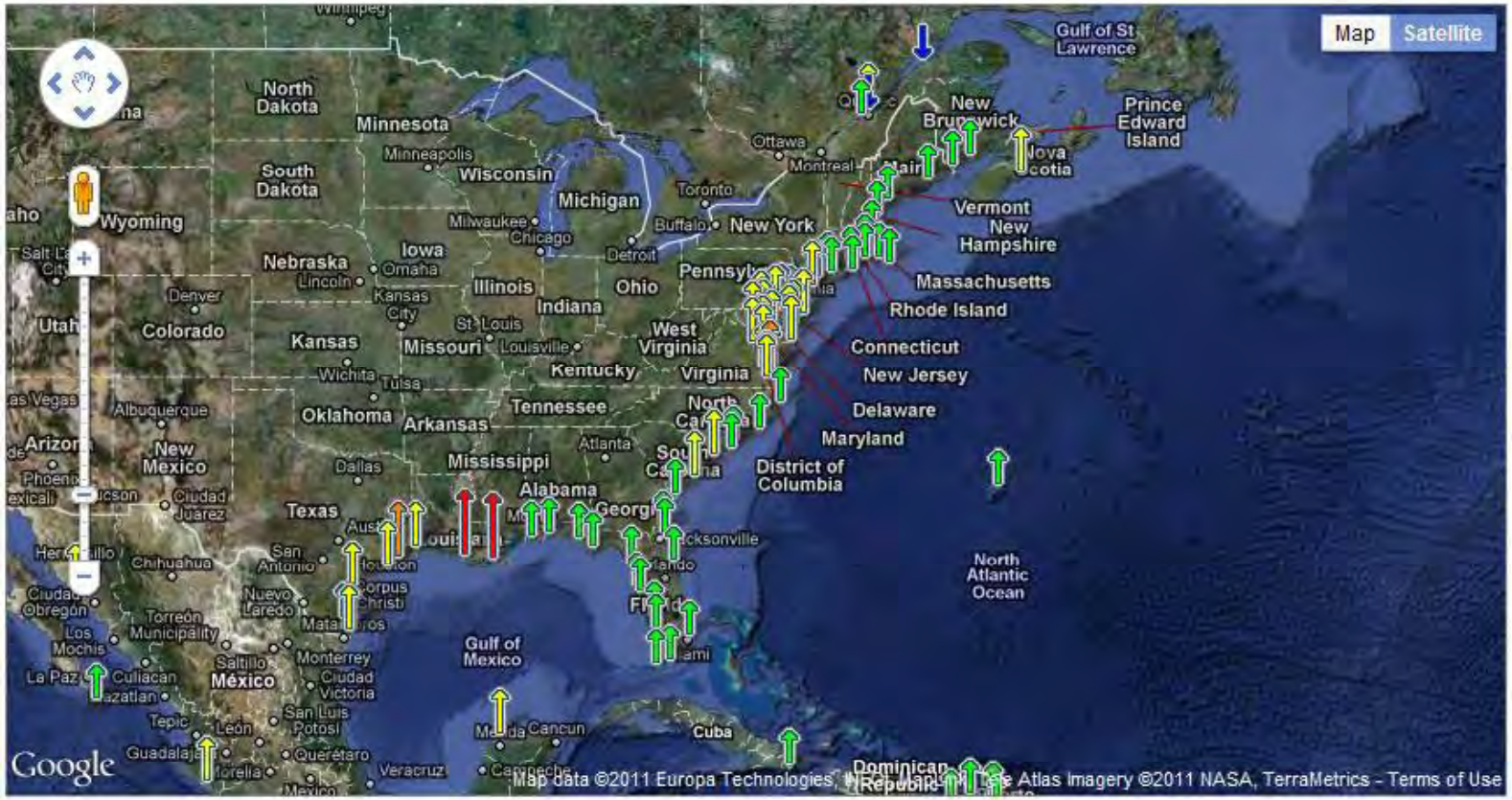
Two Types of Sea Level Rise

- **Global sea level rise**: The increase in height of sea level caused by increase in volume of water as a result of upland glacier melt, and increase sea temperatures
- **Relative (local) sea level rise**: The relative increase in sea level locally as a result of global sea level rise combined with land subsidence

Mid – Atlantic States Vulnerable

- Land subsidence either from glacial rebound, or from groundwater extraction has increased relative sea level rise
- Mid – Atlantic states have the second highest relative sea level rise, with Gulf states leading
- Scientific literature states the rates are expected to remain at present levels, or possibly increase

Sea Level Rise - Documented



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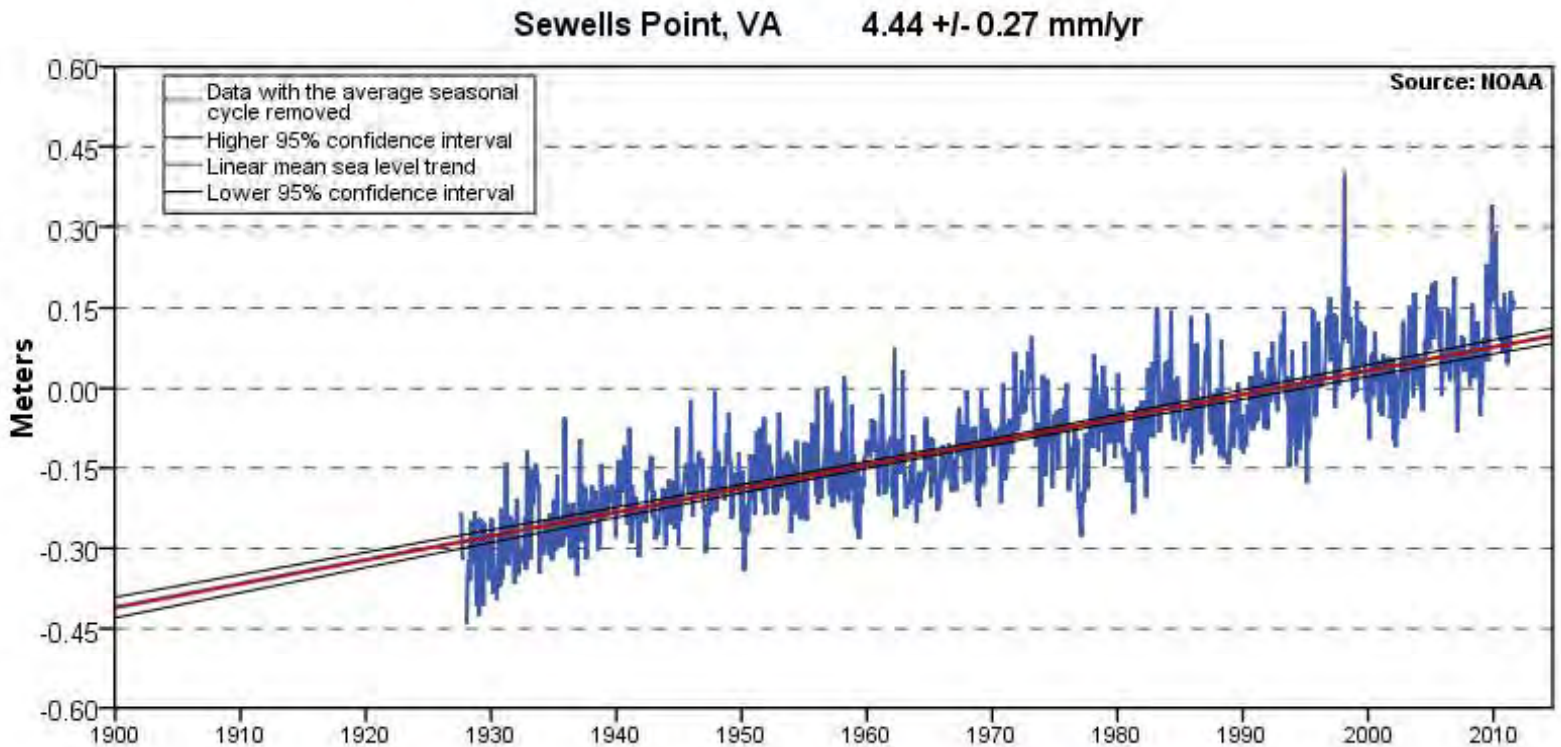
Sea Level Rise – Documented (cont'd)

Mean Sea Level Trend
8638610 Sewells Point, Virginia



The mean sea level trend is 4.44 millimeters/year with a 95% confidence interval of +/- 0.27 mm/yr based on monthly mean sea level data from 1927 to 2006 which is equivalent to a change of 1.46 feet in 100 years.

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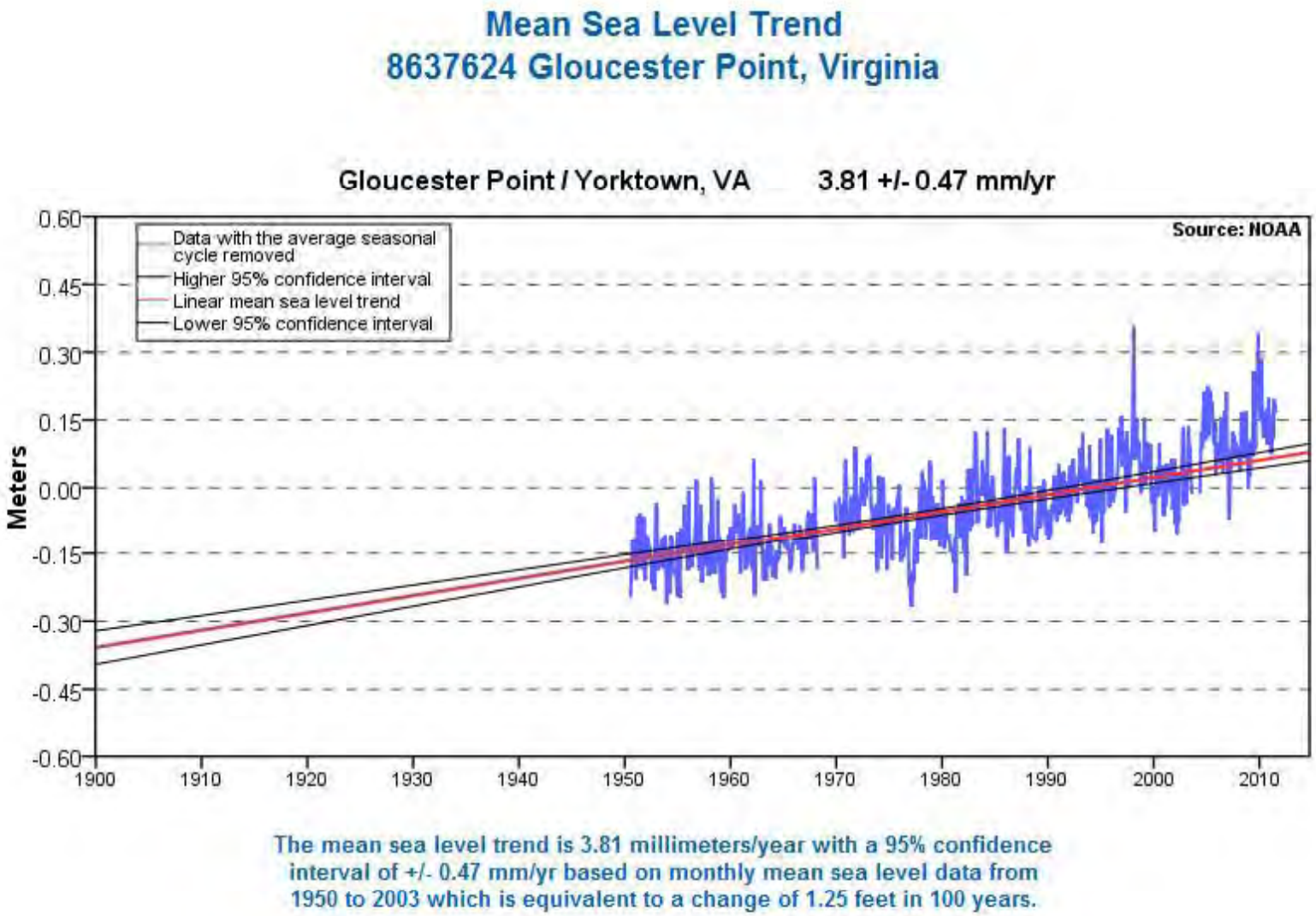
Sea Level Rise - Documented (cont'd)



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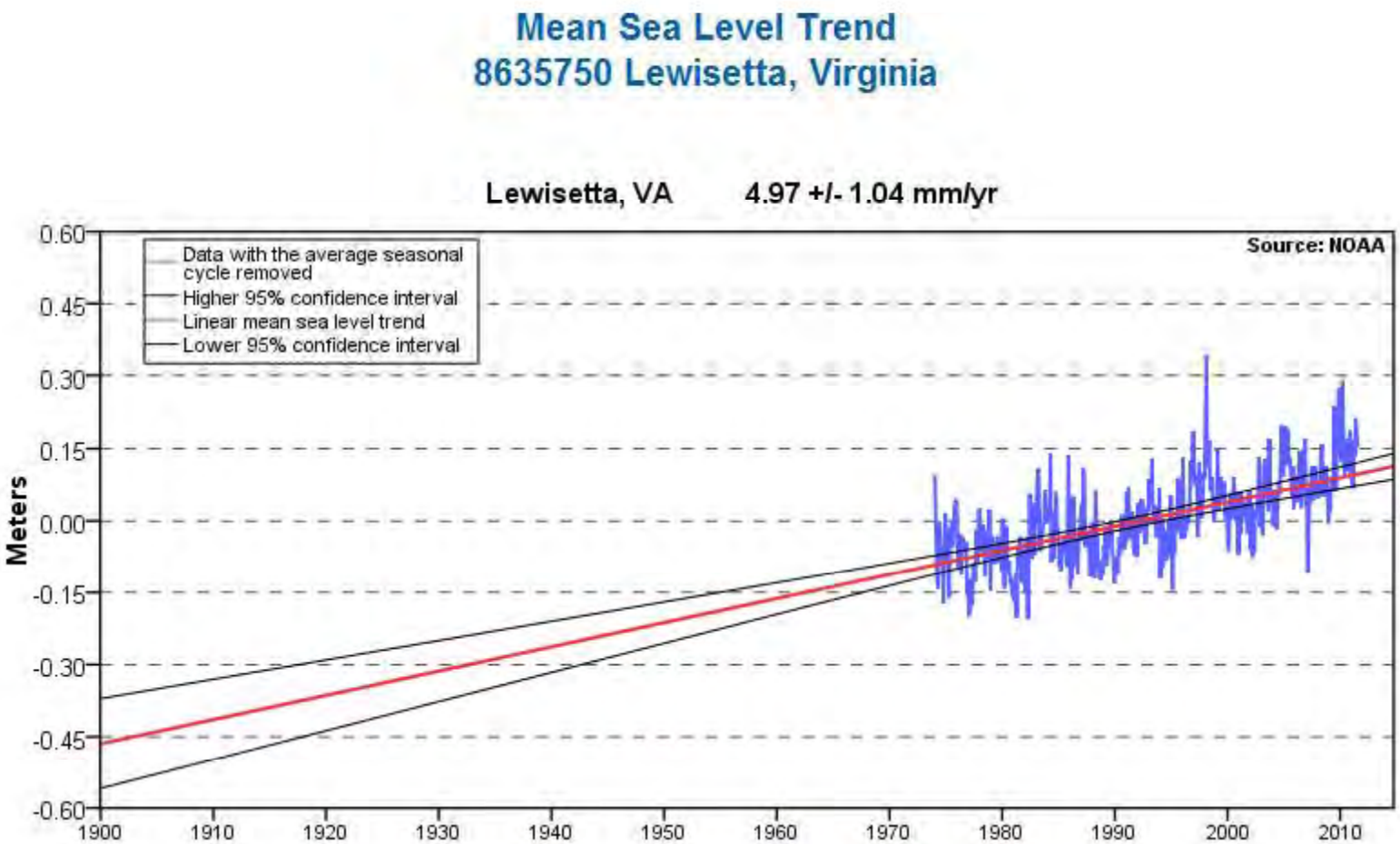
Sea Level Rise - Documented (cont'd)



http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8635750

Two Analyses

- **Green Infrastructure Vulnerability Analysis** – examine natural areas that could be possibly be impacted by sea level rise, and their relative ecological importance
- **Grey Infrastructure and Private Buildings Analysis** – examine selected parts of the built environment for potential impacts from sea level rise (sewage treatment plants and public boat ramps) as well as privately owned structures

Elevation Data Set Accuracy Issues

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- VirGIS elevation uses the National Geodetic Vertical Datum of 1929, while today the standard is the revised National Geodetic Vertical Datum of 1988 – a difference of 0.8 ft.

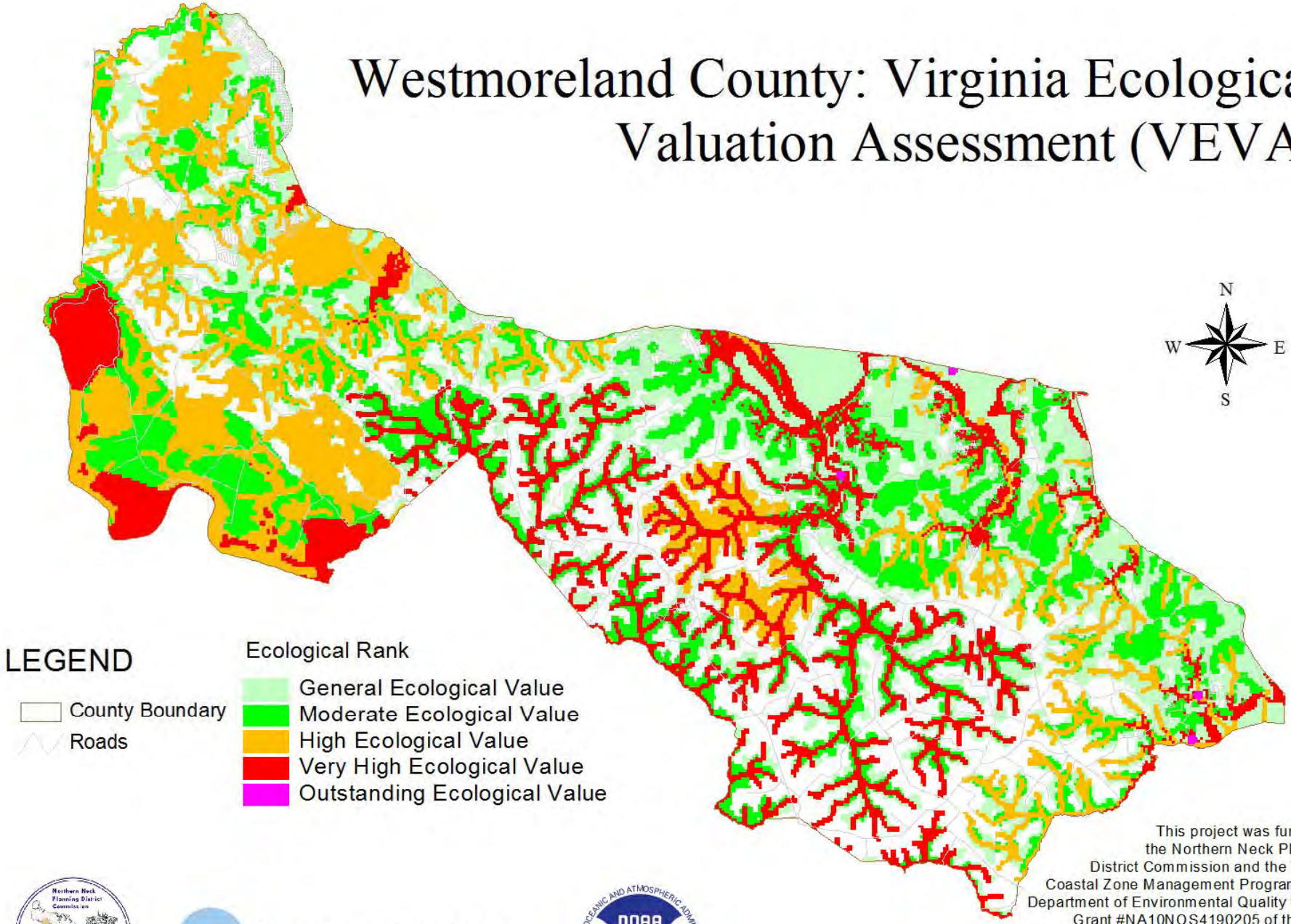
Study Limitations due to Vertical Accuracy Issues

- Projected sea level rise rates are estimated to be in the 1.25 to 1.5 foot range of increase in 100 years
- Vertical Accuracy of the VirGIS data exceeds 3 feet
- Therefore, this analysis is intended to be used for regional analysis at a county level scale, and is not intended for smaller scale analysis due to vertical accuracy issues

Study Details

- Area in Westmoreland County examined was 0-4 foot of VirGIS elevation (in order to study areas outside of the vertical error range)
- Shoreline data used from VIMS, create in 2004 using GPS technology
- Green Infrastructure analysis used the Virginia Ecological Valuation Analysis (VEVA)from the Virginia Coastal Zone Management Program
- Grey Infrastructure Analysis examined sewage treatment plants, public boat ramps and E911 building structure outlines

Westmoreland County: Virginia Ecological Valuation Assessment (VEVA)



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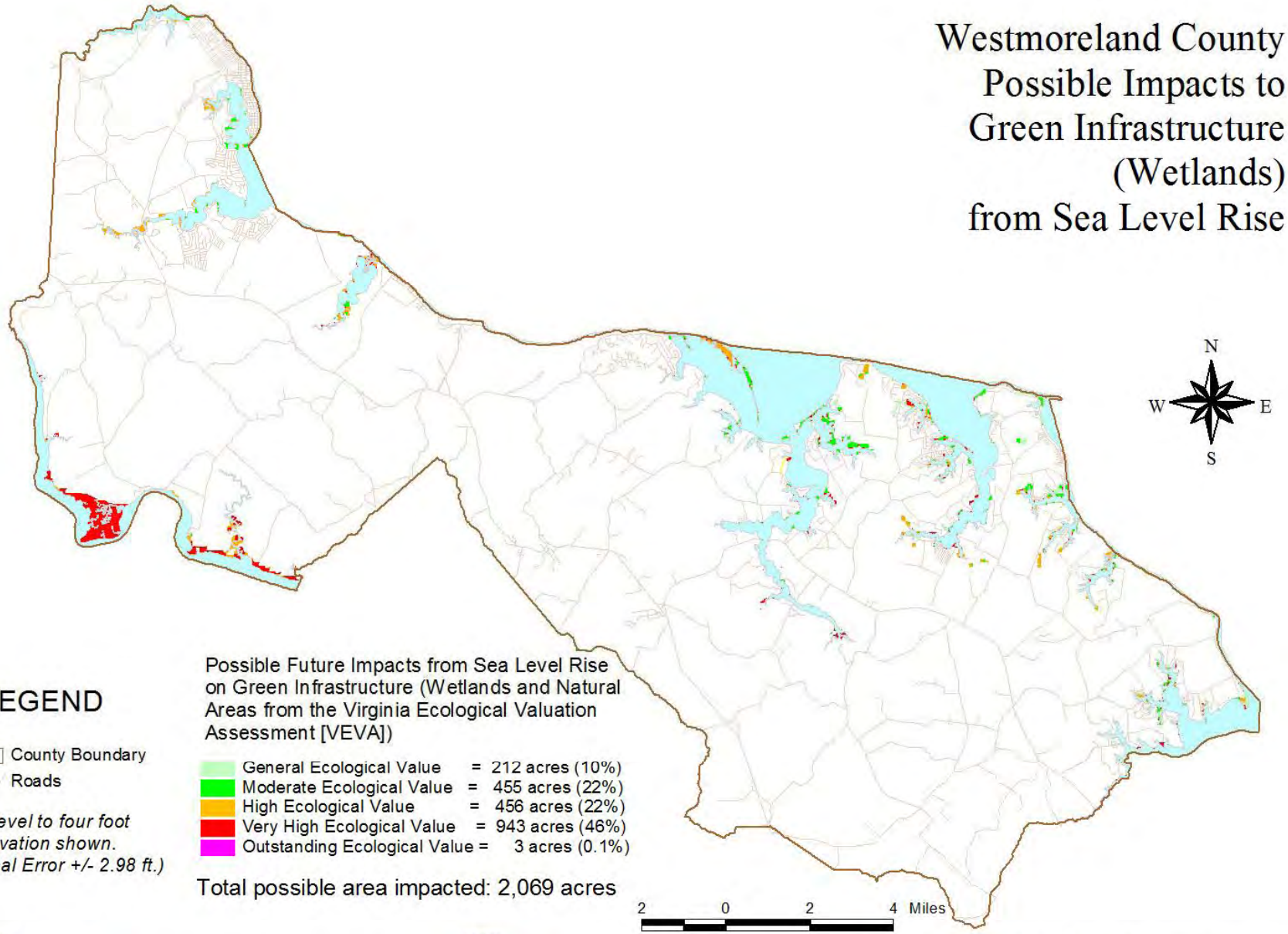
Virginia Coastal Zone
MANAGEMENT PROGRAM

Westmoreland County Possible Impacts to Green Infrastructure (Wetlands) from Sea Level Rise



LEGEND

County Boundary

Roads

(Sea level to four foot of elevation shown. Vertical Error +/- 2.98 ft.)

Possible Future Impacts from Sea Level Rise on Green Infrastructure (Wetlands and Natural Areas from the Virginia Ecological Valuation Assessment [VEVA])

General Ecological Value	=	212 acres (10%)
Moderate Ecological Value	=	455 acres (22%)
High Ecological Value	=	456 acres (22%)
Very High Ecological Value	=	943 acres (46%)
Outstanding Ecological Value	=	3 acres (0.1%)

Total possible area impacted: 2,069 acres

Virginia Coastal Zone MANAGEMENT PROGRAM

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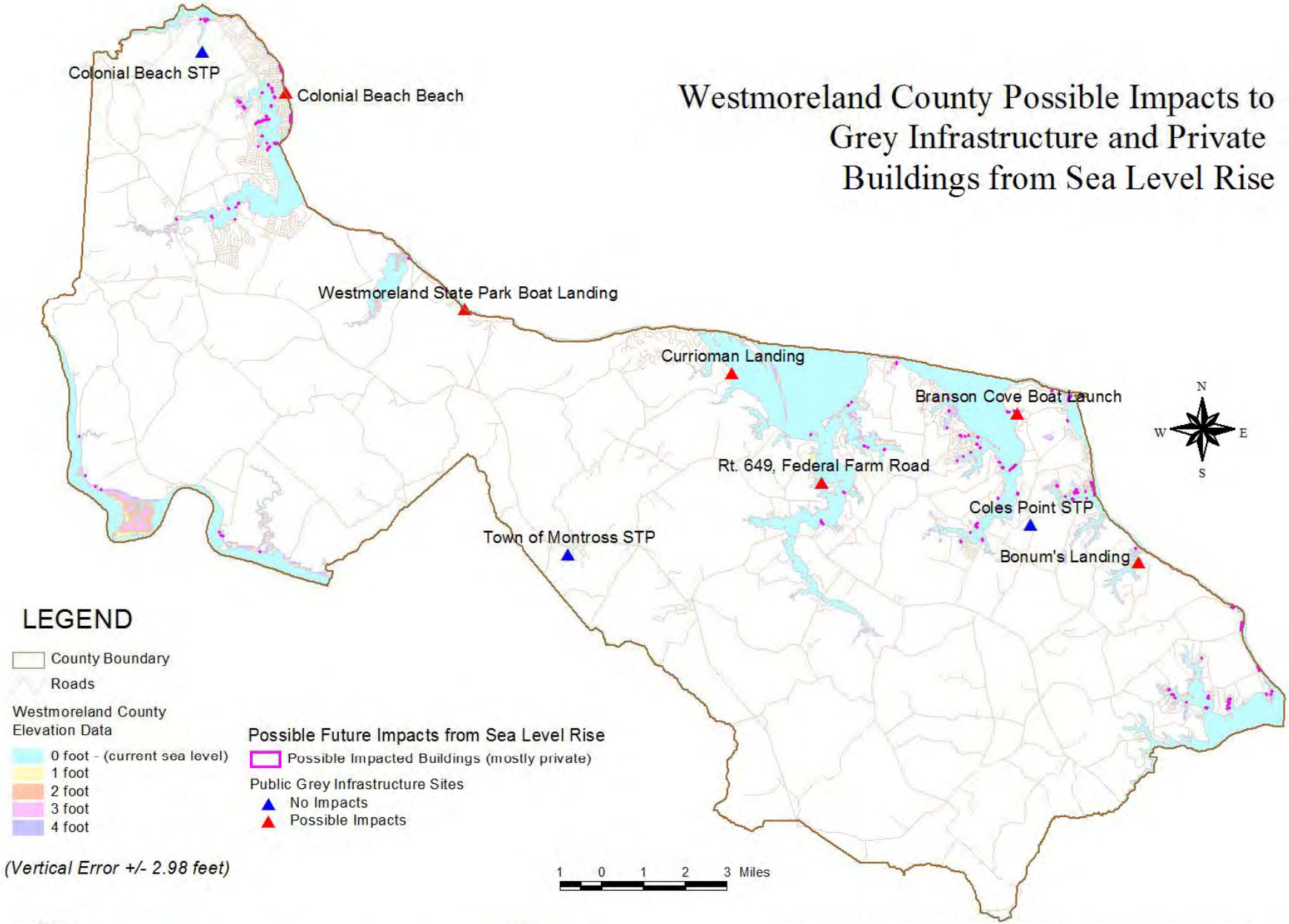
Green Infrastructure Sea Level Rise Vulnerability Analysis Results

- Large expanses of very high value natural areas (wetlands) at Drakes Marsh and downstream from Leedstown
- Extensive high and moderate value marshes and wetlands may be impacted on what is left of Currioman Island (Hollis Marsh)
- Natural areas in the headwaters of Popes and Gardener Creeks also may be impacted

Westmoreland County Possible Impacts to Grey Infrastructure and Private Buildings from Sea Level Rise



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Select Grey Infrastructure Sea Level Rise Vulnerability Analysis

- All public water access sites were deemed to potentially impacted by future sea level rise
- The Town of Montross and Colonial Beach sewage treatment plants are at a sufficient elevation that there should be no impacts to the facility
- Impacts to privately owned buildings are spread out, and occur in Monroe Bay, Mattox Creek, Buckner Creek, Cabin Point Creek, Weatherall Creek, Aimes Creek, Gardener Creek, Sandy Point and parts of the West Yeocomico River

Green Infrastructure Sea Level Rise Vulnerability Analysis Summary

- Impacts to large areas of very high ecological value marsh systems along the Rapphannock River are possible, as well as marshes on Currioman Island
- Potential impacts are disproportionately attributed to very high ecological value natural areas (46%) versus general (10%), moderate (22%), to high(22%) ecological value natural areas in Westmoreland County

Grey Infrastructure Sea Level Rise Vulnerability Analysis Summary

- All public water access sites have potential to be impacted from sea level rise
- Location of the Town of Montross and Colonial Beach Sewage Treatment Plant are high enough to preclude any impact from sea level rise
- Private buildings near the shoreline in the low spots of the county along most rivers may possibly be impacted from sea level rise in the future.

Questions?

Stuart McKenzie

Environmental Planner

Northern Neck Planning District Commission

Phone: 804-333-1900 extension 25

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Lancaster County

Green Infrastructure Implementation Alternatives Report

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Implementation of Green Infrastructure Protection Report

- Counties interested in pursuing protection of natural areas in their County often lack a course of action for implementing the protection or are unaware of the tools available
- NNPDC staff have compiled a document to help counties interested in protection of natural areas implement policies to help retain those areas in their natural state

Policies Available to Local Governments in Virginia to Protect Natural Areas

- Comprehensive Plan
- Subdivision Ordinances
- Zoning
- Conservation Easements
- Purchase of Development Rights
- Transfer of Development Rights
- Agricultural and Forestal Districts
- Use Value Taxation

Comprehensive Plan

- Counties can provide language to promote conservation of natural areas and open space in their Comprehensive Plan
- Counties can show in their future land use plan map where areas in the county that might be best left in a natural state
- The general plan is meant to guide the counties vision of the future and any rezoning must be compatible with the vision

Subdivision Ordinance

- Counties can include performance criteria in their subdivision ordinance to minimize areas disturbed by building areas and protect bordering natural areas

Zoning

- Counties can create zoning districts designed to minimize development and protect natural areas
- Counties can create exclusive agricultural zoning districts to protect working lands
- Cluster Development Zoning can be allowed, often requiring open areas to be put into conservation easements

Conservation Easements

- Citizens in natural areas deemed important by the county to remain largely undeveloped can be encouraged to examine conservation easements for their property to permanently protect it from development, as well as providing financial compensation for the landowner

Purchase of Development Rights

- Counties may create a local ordinance to enable to the purchase of development rights from landowners in high value natural areas
- Counties will need to provide some kind of funding source to pay for the purchase of development rights
- Once purchased, the value of the rights is the permanent protection of natural areas for the benefit of the public, no rights can be sold again or transferred

Transfer of Development Rights

- Similar to the purchase of development rights, however the transactions are now between private parties (developer and landowner)
- The county must create an ordinance enabling transfers, and designate a sending area (the are to be protected) and a receiving area (the area where more intense development is allowed)

Agricultural and Forestal Districts

- Landowners interested petition the local government to create the districts
- There must be a core of at least 200 acres to be considered, and the agreement between landowners and the county can be anywhere from 4 to 10 years in duration
- Landowners agreed to not develop property, but are allowed to intensify their agricultural or forestry business
- After the agreement ends, the parties can either dissolve or renew the districts

Use Value Taxation

- Tax rates for natural areas are based on their use and not fair value assessments
- If landowners develop property, they must pay back five years of taxes at the fair value rate plus interest
- This policy is used in all four counties of the Northern Neck and has helped assist farmers and foresters in maintaining a healthy and vibrant industry

Summary

- There are many tools available to localities to protect high value natural areas within their county
- These tools can be used for many purposes besides natural area protection such as protecting working farmland, scenic views, historical structures or areas and protecting groundwater sources (wellhead protection)

Questions?

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