Targeted Living Shoreline Management Planning for Virginia State Parks in Chesapeake Bay

Summary Report

November 2018

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1 Introduction

The Commonwealth of Virginia owns numerous tidal, waterfront properties along Chesapeake Bay and its tributaries including state parks, natural area preserves, and wildlife management areas. Many of these parks have eroding shorelines and are at risk from coastal hazards such as tidal flooding, waves, and sea level rise. These environmental threats impact the safety of park visitors and the mission of the parks.

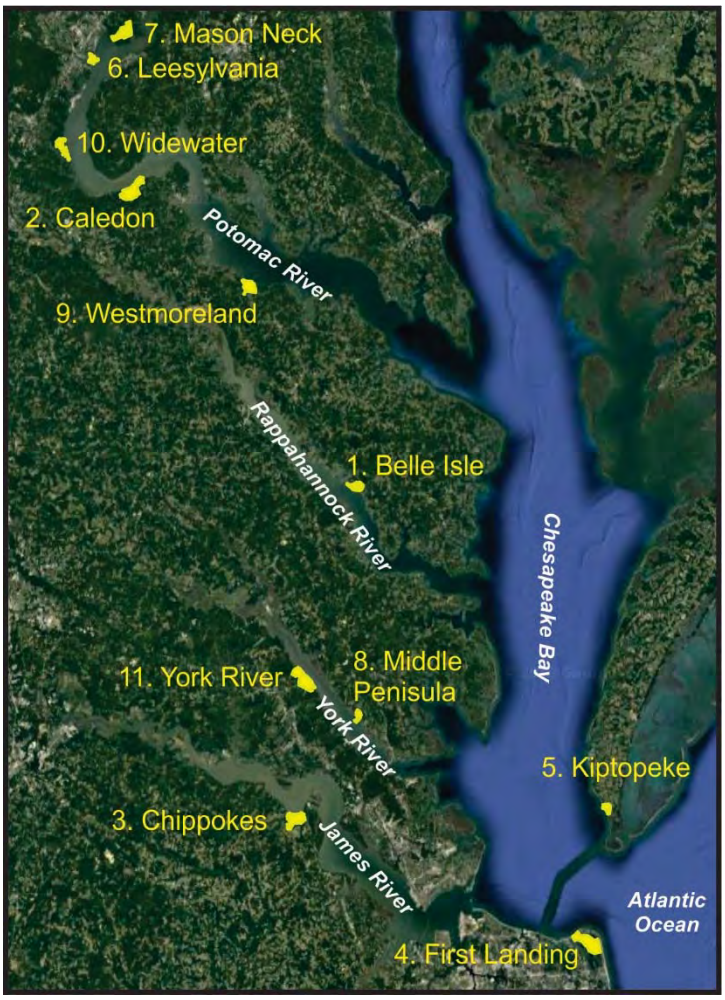

Figure 1. Location of selected state parks within the Chesapeake Bay estuarine system.

In an effort to address these issues for the parks as well as provide education to the public on living shoreline management strategies, eleven state parks with tidal shoreline along the Chesapeake Bay and its tributaries were selected because of their suitablility for living shoreline demonstration projects (Figure 1). These parks: Belle Isle, Caledon, Chippokes, First Landing, Kiptopeke, Leesylvania, Mason Neck, Middle Peninsula, Westmoreland, Widewater, and York River, are spread throughout the Chesapeake Bay and have a variety of coastal conditions due to their locations and underlying geology. Chippokes is on the James River, York River and Middle Peninsula are on the York River, Belle Isle is on the Rappahannock River, and Westmoreland, Caledon, Widewater, Leesylvania, and Mason Neck are on the Potomac River. Two sites, Kiptopeke and First Landing are on the main stem of Chesapeake Bay. Widewater is the newest park that just opened to the public this year. Middle Peninsula was recently acquired as a state park and is not open to the public. It was included for future reference.

This project assessed coastal hazard risk to determine which sites may be suitable for a living shoreline demonstration project. To triage these public properties, a site visit to each park determined the physical condition of the shorelines at the present time along with site-specific parameters. In addition, existing data was utilized to further characterize sites. From this data, the sites were ranked for need and suitability. Of the eleven parks, the three that have the greatest need and highest potential had site-specific shoreline protection/management plans developed for eroding sections of shoreline. These plans will enhance the park's goals as stated in their master plans.

2 Methods

For this project, 9 of the 11 selected state parks was visited by boat to determine site-specific parameters. First Landing State Park and Caledon were visited by land. First Landing was easier to visit by land, and Caledon has a 1,000 foot no boating zone. In addition to noting shore conditions, erosional areas, and threatened infrastructure, ArcGIS referenced photos were taken to document site conditions. Existing data such as shoreline change, flooding potential, and presence of submerged aquatic vegetation were gathered for analysis. These data were used to assess each parks shoreline management needs and develop a ranking for shorelines in each park in regard to their vulnerability to coastal hazards, their potential for coastal resiliency, and probable use as a prospective living shoreline demonstration site. The data for each site is shown in Appendix A.

The ranking system used six parameters: erosion rate, threatened infrastructure, public accessibility, TMDL potential, park attendance, and if a site was identified in its park master plan (Table 2). Erosion rate was determined using the Shoreline Studies Program Shoreline Change Database (Milligan et al., 2018) and averaged across the site of the proposed project. It was categorized as less than 1 ft/year as the lowest weight and greater than 2 ft/year as the highest weight. Threatened infrastructure was noted at the site. If no infrastructure was threatened, it was categorized as 1. If infrastructure was more than 100 ft from the shoreline, it was weighted a 2. If infrastructure was less than 100 ft from the shoreline, it was weighted a 3. Public accessibility relates to how easily reached a site is in order to be an effective demonstration site. If the site is remote, the score was a 1. If there was a walking/hiking/biking path to the site, it received a 2. Sites that had a parking lot nearby received a 3.

Total maximum daily load (TMDL) potential relates to the possibility that the site will provide sediment credits and is based on bank height, shoreline erosion rate, and site length. The score of 1 is low and relates to lower bank heights and lower shore erosion; a score of 3 relates to higher banks and erosion rates. A score of 2 is more complicated; it can be both medium bank height and erosion rate, lower bank with higher erosion rate, or higher bank with lower erosion rate. If the Park's master plan designated the project site as a critical area, then it was scored a 3. If the plan acknowledges erosion and makes general recommendation, the score was a 2. If a project was not in the plan, then it was scored a 1. Attendance relates to the goal of being a demonstration site was scored based on the categories less than 100,000, 100,000 to 200,000, and more than 200,000 using the 2016 attendance figures from the Department of Conservation and Recreation. Middle Peninsula was given a score of zero because it is

Table 1. Ranking parameters used to determine where conceptual plans would be developed.

Ranking Parameter	Weight = 1	Weight = 2	Weight = 3
Erosion Rate	<1 ft/yr	1-2 ft/yr	>2 ft/yr
Threatened Infrastructure	None	>100 ft	<100 ft
Public Accessibility	Remote	Path	Parking Lot
TMDL Credit Potential	low	medium	high
In Park Plan	No	Yes	Yes, specifically
Attendance	< 100,000	100,000 to 200,000	> 200,000

not open to the public. Attendance at Widewater was estimated to be 2 based on nearby park usage because the park just recently opened and attendance numbers are not available.

For the three state parks that were highest ranked on the system described above, the entire park shoreline was anaylzyed and recommendations made. For one area considered a priority area, conceptual plans for a living shoreline demonstration site were created using guidelines and principles outlined in Hardaway et al. (2009 and 2017). Typical planform and cross-sectional views were created in order to estimate quantity of materials, rock, sand, and plants, which would be required. From this information, an approximate cost was determined. The final result was plans and cost-estimates that can be used to create a permit application should funding come available.

3 Ranking Results

The results of the ranking of the state parks is shown in Table 2. Belle Isle scored 3s on erosion rate, threatened infrastructure, accessibility, and in park plan. Along the Rappahannock River, it has an average erosion rate greater than 2 ft/yr, has threatened infrastructure, has good accessibility, and the Belle Isle Master Plan (DCR, 2017) lists several sites as critical areas where shore protection is needed. However, Belle Isle has less than 100,000 visitors per year. Caledon, Chippokes, and First Landing all score low on the ranking. Caledon scored ones in all categories except for TMDL potential. It is not accessible by vehicle, has no threatened infrastructure and has less than 100,000 visitors per year. TMDL credit potential is high because the site has high, eroding banks. Chippokes also has high, eroding banks and stabilizing shoreline erosion is a priority in Phase II of the master plan. First Landing has high accretion on the Chesapeake Bay side of the park and little erosion on the Broad Bay side of the park. It does have a very high attendance rate as it is located in the heart of the City of Virginia Beach. Though Kiptopeke scored higher, it is an accretionary system with no need for shore protection structures.

Leesylvania has a relatively low erosion rate because structures exist along much of the Potomac River shoreline, but it does have threatened infrastructure. Though shore protection is not in its

Table 2. Ranking results for site plan development.

	Erosion Rate	**Threatened Infrastructure**	**Public Accessibility**	**TMDL Credit potential**	**In Park Plan**	**Attendance**	**Total**
Belle Isle	***3***	***3***	***3***	***2***	***3***	***1***	***15***
Caledon	1	1	1	3	1	1	8
Chippokes	1	1	1	3	2	1	9
First Landing	1	1	1	1	1	3	8
Kiptopeke	1	2	3	2	1	3	12
Leesylvania	***1***	***2***	***3***	***2***	***2***	***3***	***13***
Mason Neck	1	1	3	2	2	2	11
Middle Peninsula	2	2	2	2	2	0	10
Westmoreland	2	2	1	3	3	3	14
Widewater	2	1	2	3	1	2	11
York River	***3***	***3***	***3***	***3***	***3***	***2***	***17***

master plan (DCR, 2010), it was given a score of 2 because the park recently has been actively involved in seeking funding for the design and construction of living shoreline structures. Mason Neck has a relatively low erosion rate and no threatened infrastructure. Middle Peninsula has no infrastructure and existing structures provide some protection to the shore although some are failing. Westmoreland scored high in TMDL credit potential, park planning, and attendance. It has some threatened infrastructure, but it is not very publicly accessible in many areas. Widewater has a high TMDL credit potential, but no shoreline planning and attendance is only estimated because it only opened to the public this year. York River scored high in all categories except park attendance which was between 100,000 and 200,000 people per year. The York River master plan (DCR, 2015) identifies stabilizing critical shorelines in the first phase.

The top scoring sites were York River, Belle Isle, Westmoreland, and Leesylvania. The sites chosen for project design were York River, Belle Isle, and Leesylvania. Though Westmoreland scored slightly higher than Leesylvania, it was only by 1 point. Other factors made Leesylvania a better choice for this first round of targeted living shoreline design. First, regional managers and park personnel have been actively looking for funding for shore protection projects. A sill system was built several years ago, and the managers are concerned for other sections of the shoreline that are eroding. It was judged that a design for Leesylvania might be more useful for a living shoreline demonstration project.

4 Living Shoreline Projects

4.1 York River State Park

York River State Park is located on the south shore of the York River in James City County, Virginia (Figure 4-1). The Park has about 4.7 miles of shoreline along the York River. The primary focus of the plan will be the eroding shorelines along the York River; Taskinas Creek shoreline was not included. Along the York River, the shorelines are either eroding marsh protecting uplands or eroding upland banks with little or no protective marsh fringe. Intermittent marsh headlands provide minimal upland bank protection but may represent headland control opportunities.

Figure 4-1. Location of York River State Park in the Chesapeake Bay estuarine system

York River State Park shoreline can be segmented into reaches, based on shore type, land use and orientation (Figure 4-2). Reach 1 extends from a small unnamed creek just upriver of Croaker Landing downriver to Taskinas Creek, about 1.4 miles. Reach 2 extends from Taskinas Creek downriver past the Visitor Center to a drainage with two tidal creeks issuing into the

York River about 1.6 miles, and Reach 3 extends from the Reach 2 boundary downriver about 2.0 miles to another unnamed tidal creek.

4.1.1 Site Assessment

Reach 1 begins just above Croaker Landing (Figure 4-2). The shoreline here is an eroding marsh fringe associated with the small tidal creek drainage (Figure 4-3A). Next to this creek is Croaker Landing, which is a pier and boat ramp facility run by the park. (Figure 4-3B) A small beach has developed on the upriver, updrift side of the boat ramp whose adjacent mooring piers act as groins. On the downriver, downdrift side of the ramp a low, stone revetment hugs the shoreline, after which the shoreline again becomes and eroding marsh fringe.

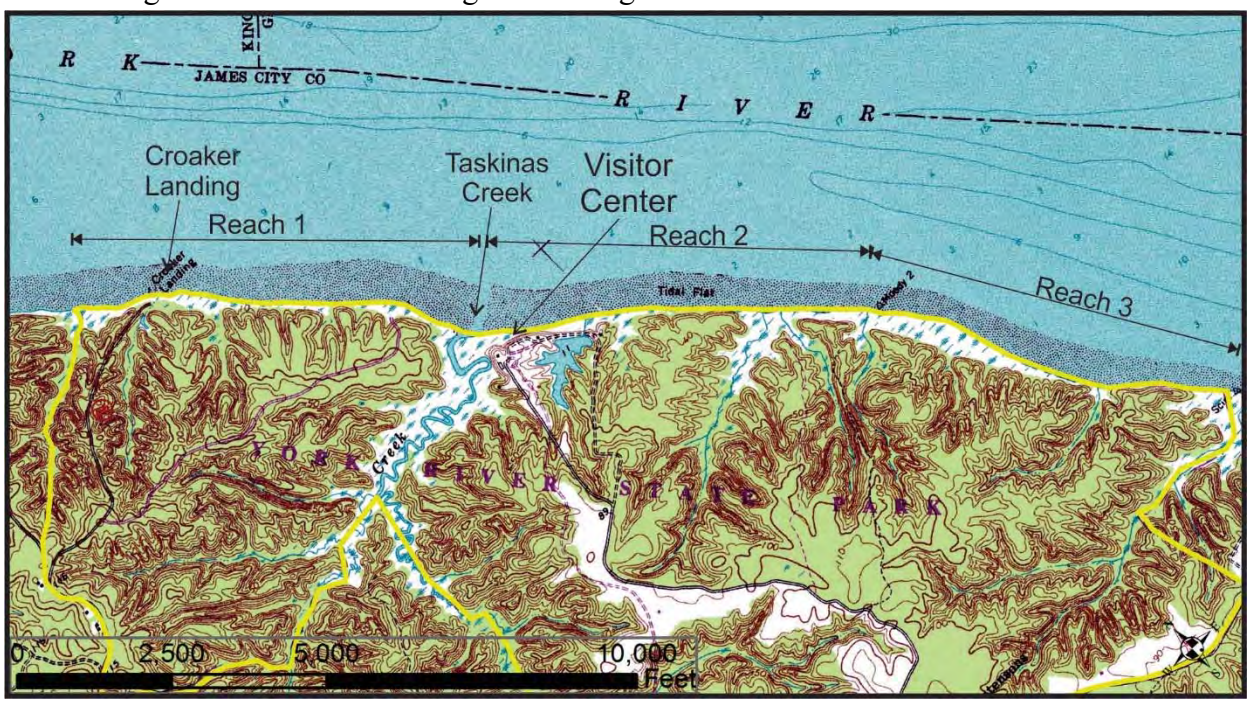

Figure 4-2. Reaches at York River State Park.

The shoreline continues downriver as either eroding marshes or, where they are absent, eroding uplands. The upland banks vary in height (5 ft to 30 ft) due to their undulatory nature and are essentially interfluves between small drainages where marshes have developed. (Figure 4-3C). Where the marsh fringe is wide enough, the adjacent uplands are protected from wind driven waves. (Figure 4-3D. These conditions continue down to Taskinas Creek and its associated tidal marsh and the end of Reach 1.

The Reach 2 shoreline beginning at Taskinas Creek is an eroding tidal marsh that transitions to upland banks without marsh fringe in front of the Visitor Center complex (Figure 4-4A). Most of Reach 2 has been identified for shoreline stabilization due, in part, to threatened infrastructure and archeological sites. Continuing downriver, the shoreline is again a mix of mostly eroding upland banks and intermittent marsh fringes (Figure 4-4B). The shore planform occurs as a series of undulating headlands created by intermittent marsh fringe and fallen trees. Reach 2 ends at the tidal drainage where two creeks enter the York River.

Reach 3 extends downriver from the boundary with Reach 2. The first half of Reach 3, about 4,000 feet, is mostly eroding marsh fringe that is wide enough for upland bank protection (Figure 4-5A). Then the marsh narrows downriver and becomes very intermittent and missing as the upland banks have become exposed and actively eroding for another 3,000 ft (Figure 4-5B). The shoreline planform occurs as series of undulating headlands created by marshes and fallen trees (Figure 4-5C) This transitions to the marsh shoreline associated with the unnamed tidal drainage at the park boundary.

As shown in Appendix A, no SAV beds were identified by VIMS SAV program along the Park shoreline. The mean tide range along the Park shoreline is 2.75 ft, and the average and longest fetches are 1.8 and 2.6 miles, respectively.

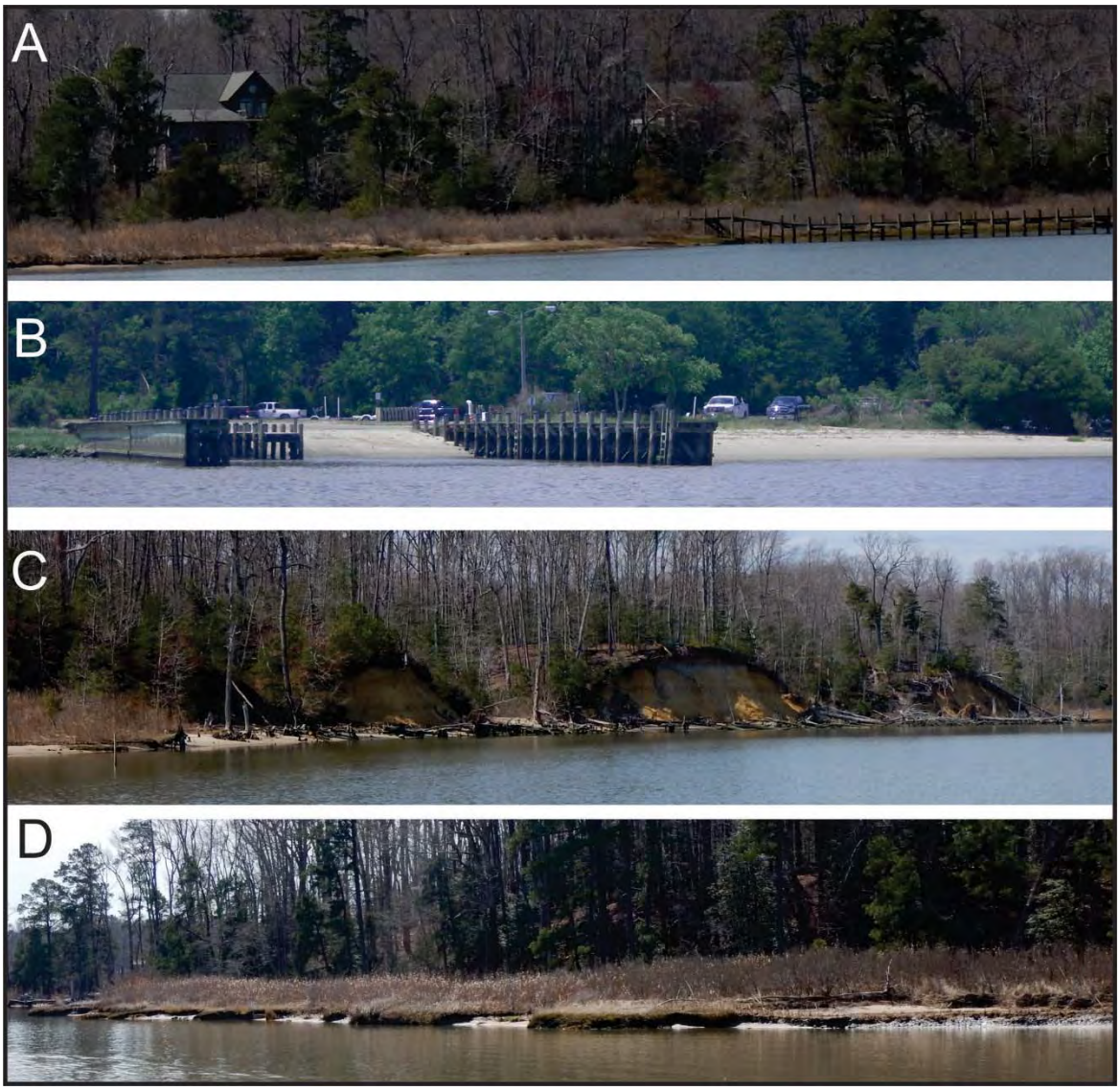

Figure 4-3. A) Eroding marsh at the northern end of Reach 1. B) Croaker Landing. C) Eroding upland banks at the distal end of the upland interfluves. D) Where an eroding marsh exists, the uplands are not eroding.

Figure 4-4. A) Eroding banks at the Visitor's Center along Reach 2. B) Reach 2 is a mix of intermittent eroding uplands and marsh shorelines.

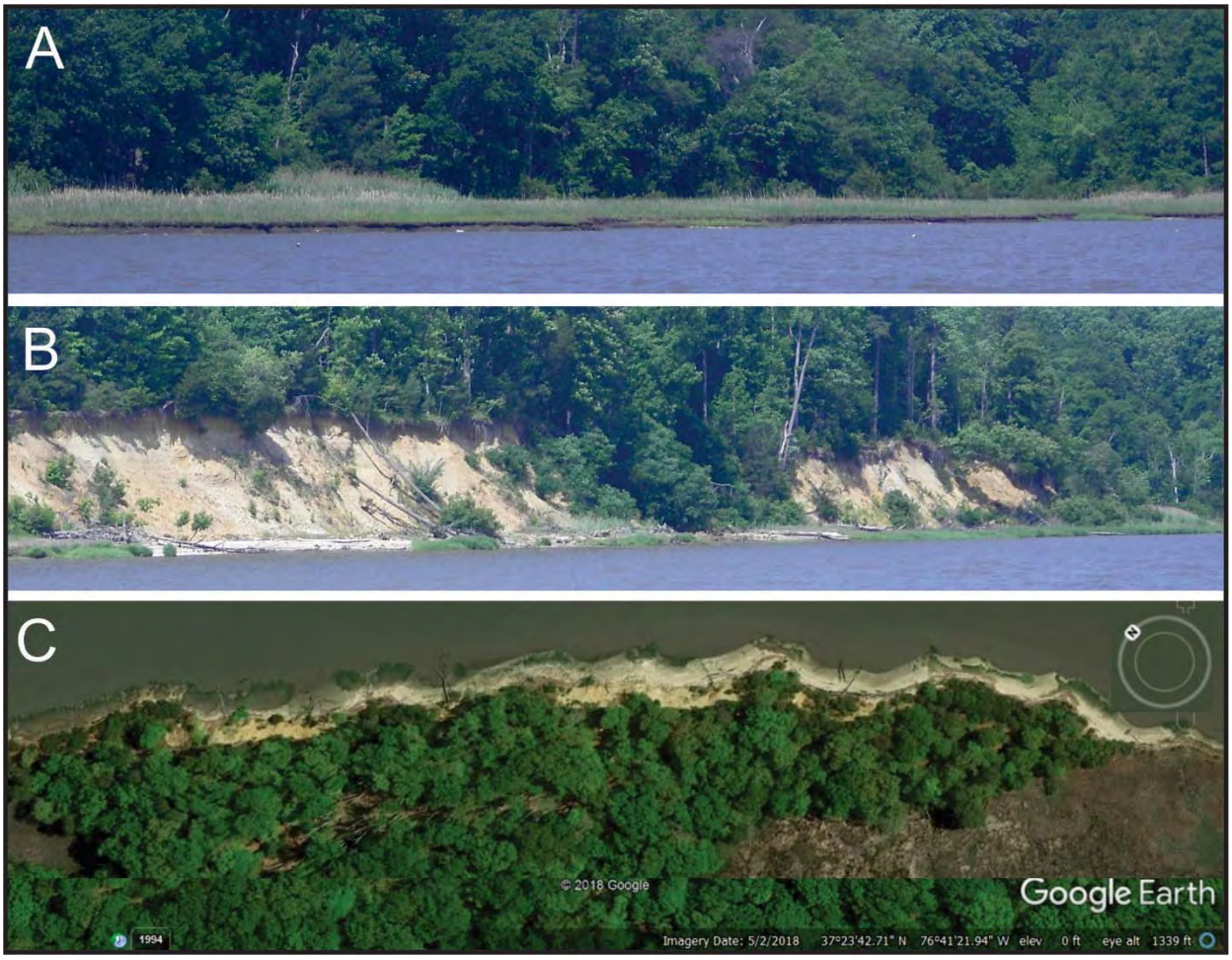

Figure 4-5. A) A wide, eroding marsh protects the upland along Reach 3. B) Farther downriver, the marsh no longer exists in many areas and the upland banks are eroding. C) The section of shoreline at the downriver end of the park occurs as a series of headlands due to remnant marshes or downed trees.

4.1.2 Shore Zone Management Recommendations

Along Reach 1, the general recommendation is a no action approach. However, a sill or small breakwater system could be built adjacent to the boat ramp area along the eroding shoreline there.

Most of Reach 2 has been identified by the Park for shoreline stabilization due to the high eroding banks and infrastructure. In front of the Visitor's Center, marsh sills can be used to stabilize the existing marsh and the eroding upland banks. Farther downriver, the upland banks continue to be actively eroding uplands which creates a series of small beach salients or headlands. Often these headlands often are created by fallen trees which interrupt sediment transport and act like groins. Some tidal marsh has become established on these features. This subreach of coast is about 1,500 feet long and a good candidate for offshore breakwaters. The structures can be placed in front of the existing sand salients to create stable headlands and pocket beaches. Access will be from an existing path down a portion of graded bank and onto the beach. No full scale bank grading is recommended.

Although Reach 3 was not listed as an area of concern due to its remoteness in the park, it does have a very similar shoreline situation as Reach 2 with a series of sand salient headland features occur along about 1,200 feet of coast. Therefore, a headland breakwater system with no bank grading is recommended. A limited upland path access helps makes this feasible.

4.1.3 Living Shoreline Project Plan

The site chosen for the development of a conceptual plan is in front of the Visitor's Center due to the threatened infrastructure and visibility as a demonstration site. A series of gapped sills is recommended in front to the Visitor Center and along the eroding marsh and upland banks just downriver (Figure 4-6). Labeled sills 1 to 6, these structures will provide both shore protection and habitat by using stone sills, sand fill and marsh plantings. Sill 1 is 210 ft long, Sills 2, 3, and 4 are 95 ft long, Sill 5 is 140 ft, and Sill 6 is 120 ft. The typical cross-section is shown in Figure 4-7. Estimated encroachment calculations are shown in Table 3. These values are estimated for the shore position in 2017 and may not accurately reflect the plan farther into the future because of the high erosion rate. The estimate cost (based on the typical cross-section) of installed rock, sand, and plants is $226,500,

Figure 4-6. Conceptual plan for the living shoreline demonstration project at the York River State Park Visitor's Center. Six sills are recommended along the shoreline to protect the narrow, existing marsh and the eroding upland banks.

$235,200, and $25,200, respectively. The total estimated cost of the project with 20% design work, mobilization and demobilization is approximately $584,280. These values also are sensitive to time and may not be applicable into the future.

No bank grading is recommended so once the base of bank is protected, the bank face will continue to slump or sough to a more stable gradient and allow vegetation to become established and further stabilizing the slump material. This project can be constructed in phases as funding becomes available.

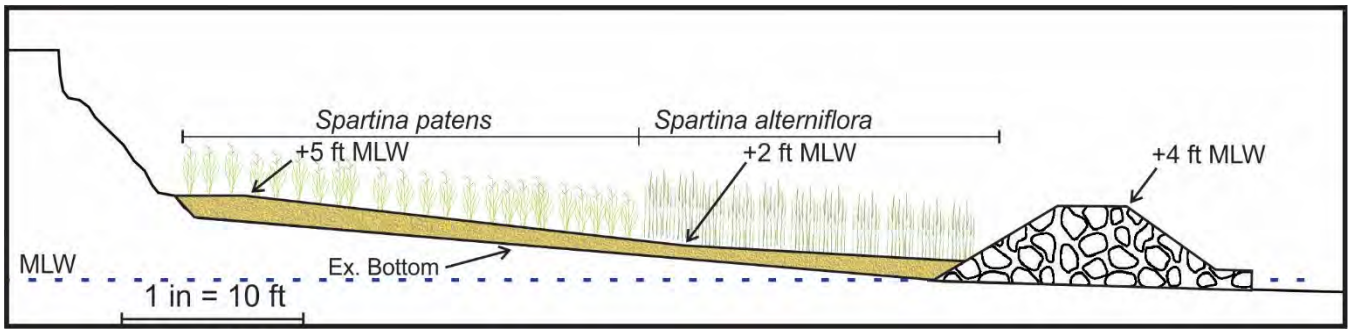

Figure 4-7. Typical cross-section for the sill structures at the Visitor's Center.

Table 3. Encroachment values for the York River Conceptual Plan.

	Encroachment		
	Vegetated wetlands (ft^2)	Non-vegetated wetlands (ft^2)	Maximum encroachment from MLW (ft)
Sills 1&2	0	12,720	45
Sills 3&4	0	8,600	40
Sills 5&6	4,991	5,866	100

4.2 Belle Isle State Park

Belle Isle State Park is located on the Rappahannock River in Lancaster County, Virginia. The Park has about 8.6 miles of shoreline along the Rappahannock River, Deep Creek, and Mulberry Creek (Figure 4-8). Over the years, several shore protection systems have been designed for the Visitor Center and picnic area including plans created by the Department of Conservation and Recreation's Shoreline Erosion Advisory Service (SEAS), the Army Corps of Engineers (USACE), and more recently, by Stantec, Inc. for the Virginia Department of Transportation (VDOT). These efforts are recognized as viable shore protection strategies at those sites. However, based on a site visit and analysis, more recent plans have been developed for these shorelines as well as other reaches of shoreline identified in the Park's Master Plan (DCR, 2017) and those identified as erosional through this project. These plans are

not meant as replacements of previous plans but as our interpretation of the project site and as an alternative approach to the problem with a cost effective strategy, addressing storm surge and sea level rise in the context of coastal resiliency.

Figure 4-8. Location of Belle Isle State Park within the Chesapeake Bay estuarine system.

4.2.1 Site Assessment

There is about 8.6 miles of tidal shoreline along Belle Isle State Park. Approximately 1.9 miles occurs along Mulberry Creek, 4.2 miles along the Rappahannock River and 2.6 miles along Deep Creek. Average shore change rates are lower along the Creek shorelines (less than -1 ft/year), but they are significantly higher along the Rappahannock River shoreline (about -2 ft/year). The shoreline is divided into reaches and subreaches for purposes of discussion based on fetch, shore orientation and/or shore type (Figure 4-9).

The shorelines along Mulberry Creek, Reach I, are mostly very low, undercut upland banks with intermittent eroding marsh fringes (Figure 4-10A). Erosion rates are low due to limited fetch exposures of less than 1 mile. The uplands are wooded with mostly pine forest that buffer farmland along the upper half of the Mulberry Creek. There is an access dock adjacent to a small tidal creek (Figure 4-10B) that flows north into Mulberry Creek. From there toward the mouth of Mulberry Creek, the Reach IB shoreline is very similar with low eroding banks and intermittent marsh fringe. The upland areas that lack marsh fringe are the most erosive. At the northern point of Belle Isle, bank erosion increases with increased fetch exposure.

From the northern point downriver, the Belle Island shoreline turns southeast and extends along the Rappahannock to the southern point. Fetch exposures across the Rappahannock River are larger with the average fetch being 5.3 miles and the longest fetch 12.2 miles. The Belle Isle shoreline is mostly eroding marsh fringe with a few exposed eroding upland areas where the fronting marsh has eroded away (Figure 4-11A and B). A small revetment was installed along a section of shoreline in Reach IA. Reach IIB and IIC shorelines occur as two low necks of land between two small tidal creeks and Deep Creek (Figure 4-9). These subreaches are used for the Park's Picnic Area (Figure 4-11C) and Visitor Center (Figure 4-11D). They are low eroding banks with very narrow beaches.

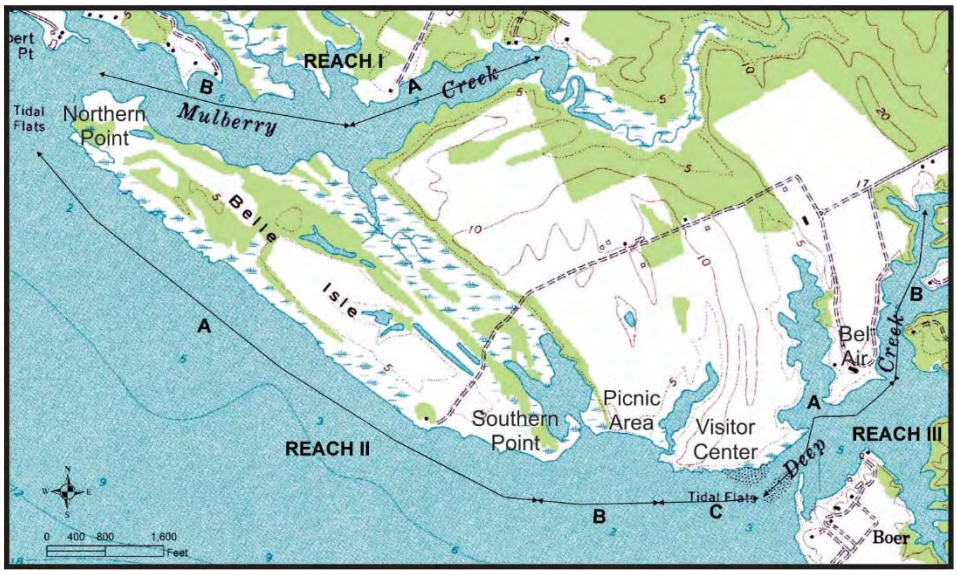

Figure 4-9. Reaches and subreaches along Belle Isle State Park.

Reach III extends along the Deep Creek shoreline and begins as a low eroding spit feature (Figure 4-12A). The low upland bank has increased and is slightly erosional and undercut adjacent to the boat ramp (Figure 4-12B). This bank condition continues along much of Reach III with undercut banks and intermittent marsh fringes. Along the next neck of land, the Bel Air Guest House resides, and the shoreline is more exposed and erosional (Figure 4-12C). Farther up Deep Creek, the undercut bank condition and fallen trees continues.

There are no SAV beds along the Park shoreline. The mean tidal range is 1.6 feet with a spring range of 1.9 feet.

Figure 4-10. A) Low, undercut upland banks with intermittent eroding marsh fringes occur along much of Reach 1 along Mulberry Creek. B) An access pier along Reach 1.

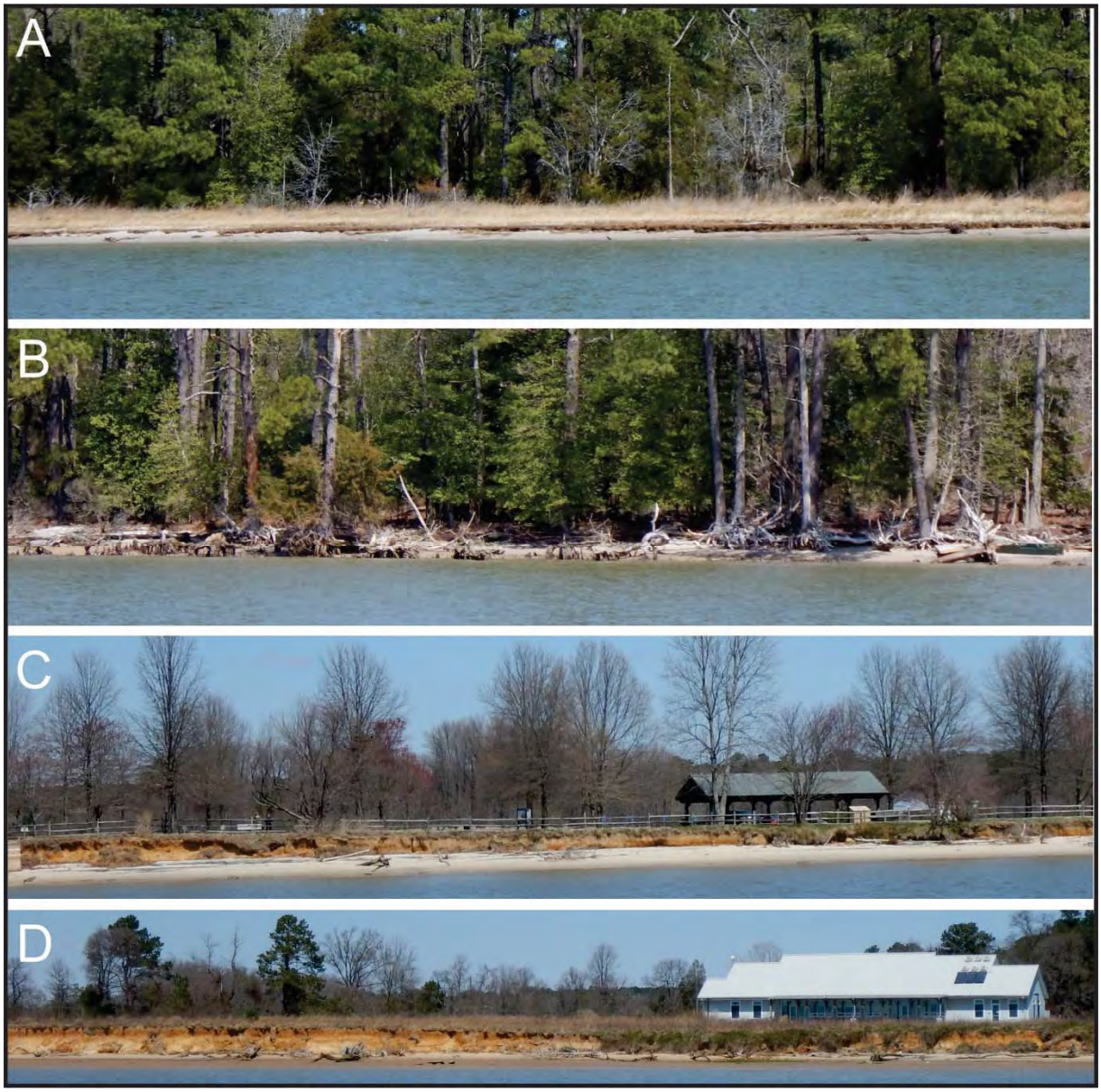

Figure 4-11. A) Belle Isle Reach IIA shoreline with protective marsh fringe. B) Belle Isle shoreline without protective marsh fringe leaving low upland vulnerable to erosion. C) Reach IIB is the picnic area which has a low eroding upland bank with narrow

4.2.2 Shore Zone Management Recommendations

The Mulberry Creek shoreline with its low eroding bank and intermittent marsh fringe has a very low erosion rate and no threatened infrastructure. Only a small dock resides at the downcreek end of Reach IA with erosional marsh fringes on either side. This could be a potential demonstration site using oyster bag sills.

Figure 4-12. A) Reach IIIA shoreline is a low eroding marsh fringe on sandy spit. B) Eroding upland adjacent to boat ramp. Note existing rock for shore erosion control. C) Eroding point at Bel Air Guest House on Deep Creek.

Considering the northern point as the beginning of Reach IIA, this eroding low bank with a narrow beach is very accessible to the public and a good spot for a low gapped sill with a pocket beach. GIS data indicates that there may be threatened archeology along this shore as well. The remainder of Reach IIA is very erosional but with no threatened infrastructure. Access is limited from land, but headland structures could be placed alongshore as a form of headland control. Watch House Trail exits the shoreline between two headland features and could provide the necessary access for the stone sills recommended along this section. Stone sills can be built there to provide some long term headland control for that section of coast.

Two areas of concern identified by the Park Reaches IIB and IIC are the eroding shorelines at the Picnic Area and the Visitor Center. These areas also have mapped archeological resources. Along about 1,000 ft at the picnic area a breakwater system with two headland breakwaters and sand fill are recommended along the eroding upland. These transition to low sills on either end along the eroding marsh spits. Bank grading could occur if no archaeology is impacted. Grading the bank to a gradual 4:1 slope provides the mechanism to address sea level rise, long term coastal resiliency, and public access. The 1,200 ft of shoreline in front of the Visitor Center consists of two marsh headlands on either end of the reach with an eroding upland bank in between. The associated marsh shorelines are low eroding

marsh scarps while the eroding upland bank about 7 feet in height. A Brill system (a large sill system) is recommended along with bank grading if no archeology will be impacted.

Since much of the shorelines in Reach IIIA are exposed to very low energy regimes, most do not need shoreline management; therefore, a no action alternative is recommended. However, the shorelines adjacent to the boat ramp are slightly erosional and would be a good location for a demonstration project. An oyster bag sill may suit the situation and can be built with volunteer labor.

The eroding upland bank at the point beginning Reach IIIB at the Bel Air Guest House could use a small sill. It has a fetch exposure out of the mouth of Deep Creek across the Rappahannock River. Farther up this neck of land, the banks are undercut and slightly erosional, but a no action alternative is recommended.

4.2.3 Living Shoreline Project Plan

The site chosen for the development of a conceptual plan at Belle Isle is in front of the Picnic Area due to the threatened infrastructure and visibility as a demonstration site. A combination of sills and breakwaters are needed at this site (Figure 4-13). These structures will provide both shore protection and habitat by using stone sills and breakwaters, sand fill and marsh plantings. Sills 1, 4, and 5 are 70 ft long, Sill 2 is 90 ft long, Sill 3 is 100 ft long, and Breakwaters 1 and 2 are 150 ft long. The typical cross-sections for the breakwater and sills are shown in Figure 4-14. Estimated encroachment calculations are shown in Table 4. These values are estimated for the shore position in 2017 and may not accurately reflect the plan further into the future because of the high erosion rate. The estimate cost (based on the typical cross-section) of installed rock, sand, and plants is $240,000, $303,000, and $30,000, respectively. The total estimated cost of the project with 20% design work, mobilization and demobilization is $688,560. These values also are sensitive to time and may not be applicable into the future.

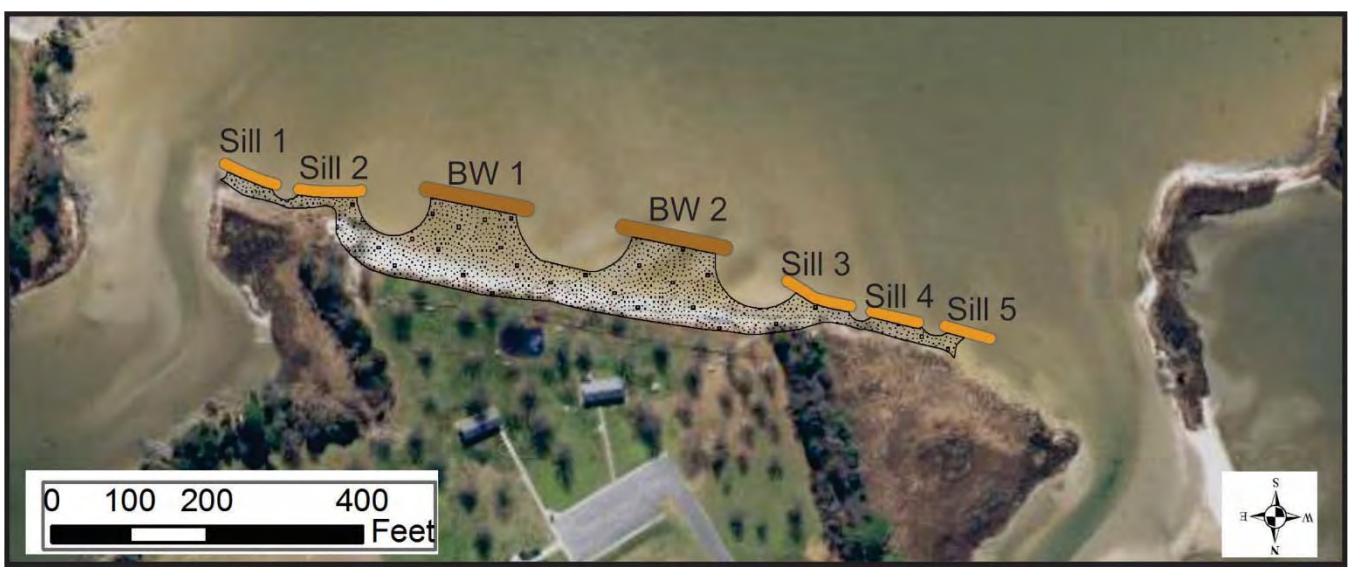

Figure 4-13. Planform of the conceptual design at the Picnic Area at Belle Isle.

Bank grading is suggested for the sandy beach area. This will provide a gentle gradient for public access to the beach. This project can be constructed in phases as funding becomes available. The breakwaters should be constructed first because the marshes on either end of the system are acting like headlands and will help retain the sand behind the structures. However, as the marsh erodes, this ability is reduced, so the sills on either end of the system are necessary.

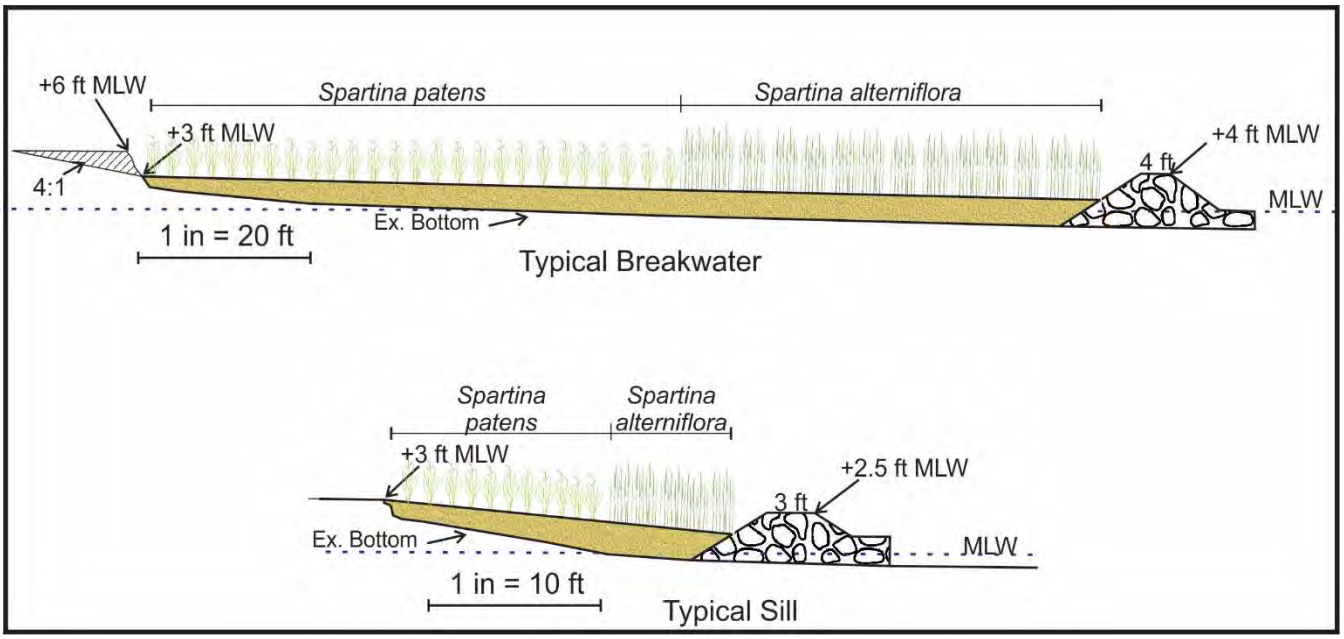

Figure 4-14. Typical cross-sections for the picnic area at Belle Isle.

Table 4. Encroachment values for the Belle Isle Picnic Area Conceptual Plan.

	Encroachment		
	Vegetated wetlands (ft^2)	Non-vegetated wetlands (ft^2)	Maximum encroachment from MLW (ft)
Sills 1&2	0	4,930	56
Breakwaters 3&4	0	38,950	100
Sills 3, 4 &5	1,375	4,100	60

4.3 Leesylvania State Park

Leesylvania State Park is located on the Potomac River in Prince William County, VA (Figure 4-15). Although not specifically listed in the Master Management Plan, 2010. shoreline erosion has since become an issue, especially on the open Potomac River shoreline. Recently, shoreline structures have been installed to abate the shore area just upriver of Park Marina.

Three shoreline reaches are used for ease of discussion (Figure 4-16): Reach 1 extends from the railroad bridge along Occoquan Bay approximately 0.8 miles to Freestone Point. Reach 2 extends from Freestone Point south along the Potomac River for about 1.3 miles to Powells Point. Reach 3 extends from Powells Point up Powells Creek, under the CSX railway bridge to the boundary of the park, about 0.8 miles. Total park shoreline is 2.9 miles.

4.3.1 Site Assessment

Reach 1 extends from the CSX railway bridge southeast to Freestone Point along Occoquan Bay (Figure 4-17A). The railway bridge and its concrete abutment have been a feature for many years. East of the abutment, the banks are lower and more stable as a beach accreted in front of the banks at Neabsco which allowed enough backshore to support the residential housing. Farther east, the Reach 1 shoreline has high eroding bluffs that transition to wooded, intermittently exposed banks and a narrowing beach toward Freestone Point.

Figure 4-15. Location of Leesylvania State Park within the Chesapeake Bay estuarine system. Shoreline structures also are indicated.

Reach 2 begins at Freestone Point which is an actively eroding high bluff with no beach but numerous endurated blocks of fallen bank strata strewn along the base of bank. The erosion rate is very low at Freestone Point owing to its erosion resistant material making it a stable headland feature (Figure 4-17B). South of Freestone Point, a beach occurs with the widest section just north of the park fishing pier (Figure 4-17C). South of the pier, structures occur along the entire shore to the Marina. Gabion revetments and rock revetments were constructed along 800 feet of shore. One section of shore has a gabion revetment that is low and failing and the upland is eroding (Figure 4-17D).

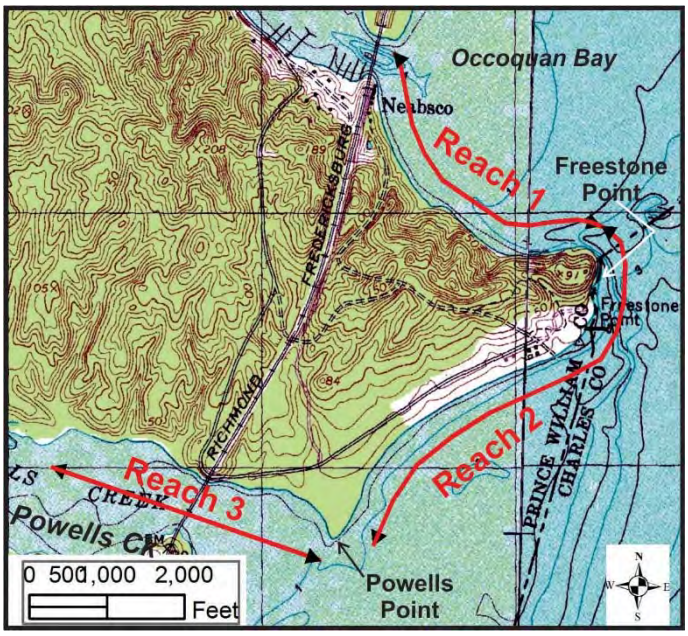

Figure 4-16. Reaches along Leesylvania State Park.

Between the gabion revetments and the Marina, a series of gapped sill were installed in

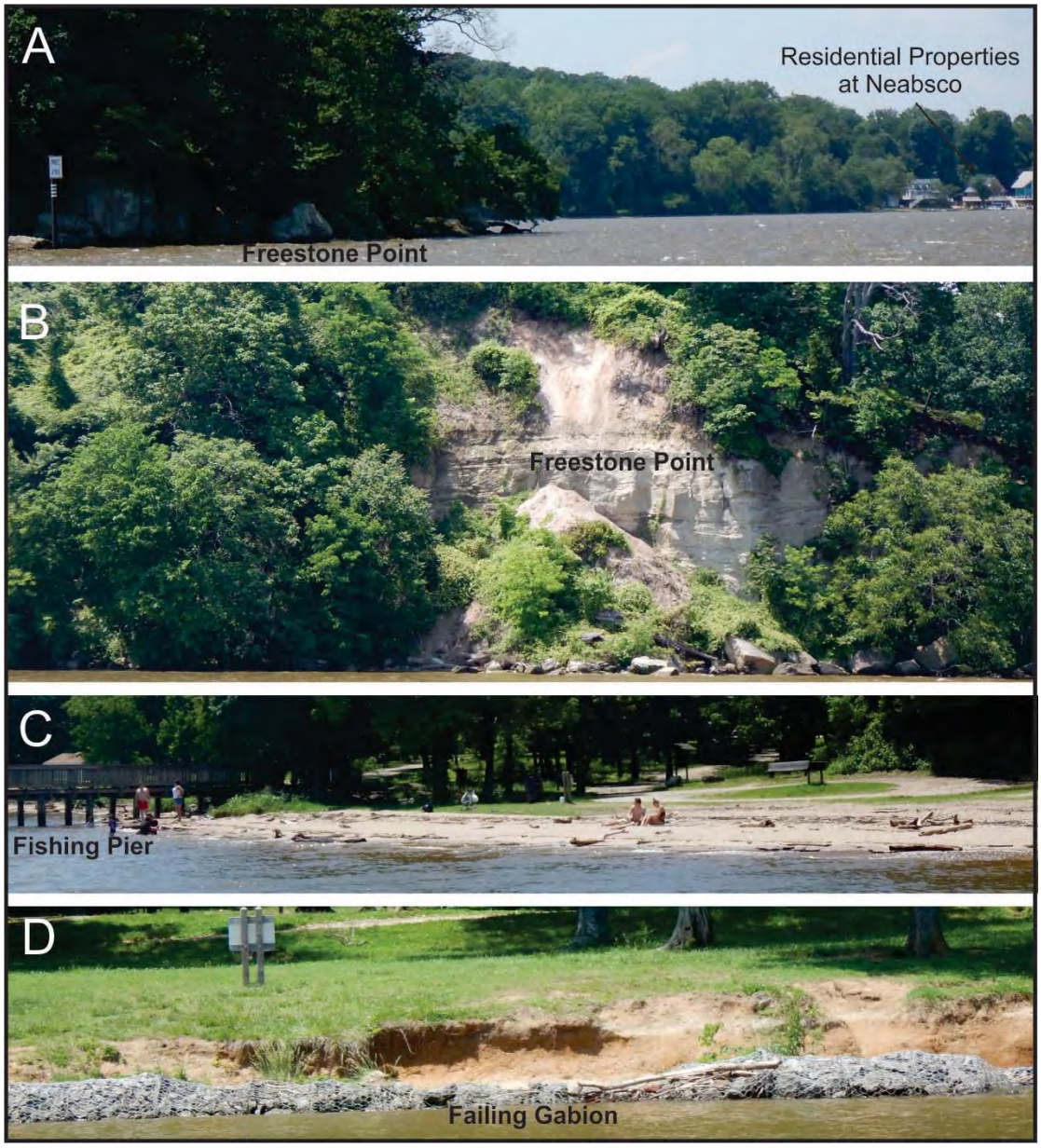

Figure 4-17. A) Leesylvania Reach 1 along Occoquan Bay. B) Eroding headland at Freestone Point. C) Fishing pier and wide beach along the Potomac River. D) Failing gabion revetment and eroding upland.

2015 and 2017 to abate the erosion (Figure 4-18A). The sill system covers about 500 ft of shoreline. Prior to installation of the sill living shoreline, the low upland was actively eroding and falling trees created a hazard to park users. South of the sills, a wide beach created by the upriver park marina jetty. This beach helps protect the very low eroding upland for about 700 ft. The park marina shoreline has about 1,300 feet of hardened shoreline bounded by two rock groins/jetties with two breakwaters across the nearshore to abate wave entering the marina basin. The shoreline is protected by bulkheads adjacent to two boat ramps. Between Powell Point and the marina jetty, the shoreline is very low eroding upland with numerous freshwater trees along shore (Figure 4-18B). A series of low gabion breakwaters were constructed along the coast which, although not particularly effective, they may have slowed the low historic erosion rates. These structures were placed closer to shore sometime before 1994 but presently reside in the nearshore as the shoreline has receded (Figure 4-18C).

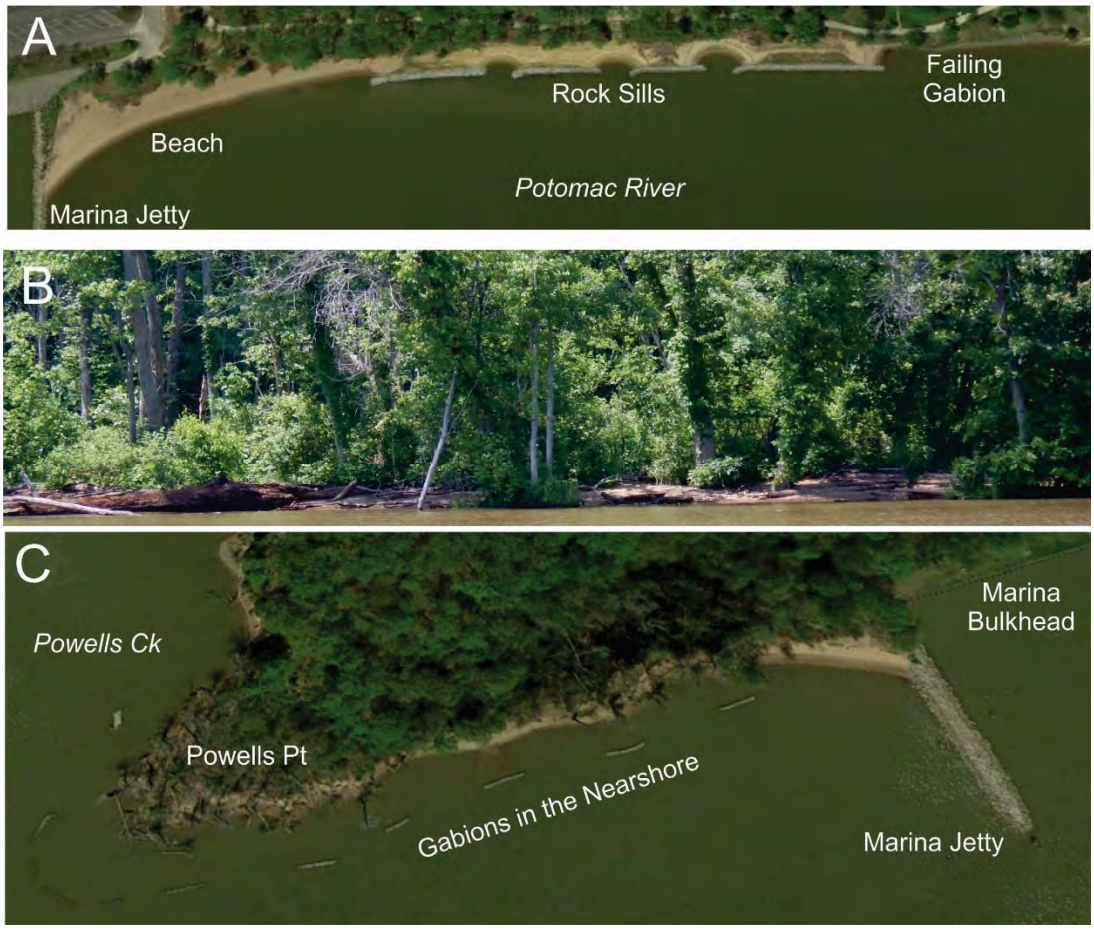

Figure 4-18. A) Google Earth image showing the recently constructed sills at Leesylvania along the Potomac River. B) The low eroding upland banks south of the marina near Powells Point. C) Google Earth image showing the gabion structures in the nearshore

Reach 3 occurs between Powells Point and the park boundary up the creek. The gabion structures continue around Powells Point and into Powells Creek. About 8 gabion sills were constructed between the Pier and railroad bridge in Powells Creek. These structures are slightly more effective in the lower energy environment than those on the Potomac River. The shoreline is relatively low undercut bank with intermittent marsh fringe with gabion sills that have had limited erosion control (Figure 4-19A). A small sand beach has accumulated due to the railway bridge acting like a groin as river waves enter the mouth of Powell Creek. The adjacent park access road under the CSX railway bridge is partially protected by rock. Up creek from the railroad the shoreline occurs as a stable high bluff shoreline where the base of the bank is protected by a wide freshwater marsh fringe (Figure 4-19B).

Substantial SAV beds occupy the nearshore around the shorelines of Leesylvania State Park particularly in Powells Creek and Occoquan Bay (Appendix A). The mean tide range at the Park is 1.75 ft.

4.3.2 Shore Zone Management Recommendations

Figure 4-19. A) A low undercut bank and marsh fringe along Powells Creek; top of gabion in foreground. B) Reach 1 stable, high bank coast.

Shoreline erosion has in large part been addressed at Leesylvania. Reach 1 has a very low erosion rate due to the erosion resistant material in the upland banks. The shoreline is accreting toward the railroad bridge, so no shoreline management recommendations are made for Reach 1.

Much of Reach 2 has been addressed with structures. The recent rock sill construction addressed a long stretch of eroding shoreline along this reach. However, the gabion revetments along the Potomac River are failing and the upland is eroding. It is recommended to continue the rock sill to the north. The two beaches in the reach, the one on the north end near the fishing pier and the one just north of the marina are stable at this point in time and do not need management structures. South of the marina, the shoreline is eroding where the gabion structures are not too far offshore to be effective. A rock sill system that is integrated with marina jetty and wraps around Powells Point is recommended.

Reach 3 has a lower erosion rate, but the upland bank between Powells Point and the railroad bridge is undercut and eroding in areas. The park has a trail system along this shore and constructing low rock sills will reduce bank erosion and protect infrastructure. The banks up creek from the railroad bridge are stable and do not need management strategies at this time.

4.3.3 Living Shoreline Project Plan

The site chosen for the development of a conceptual plan at Leesylvania is adjacent to and north of the recent rock sill installation along the Potomac River. This site was chosen because local and regional managers are working with park personnel to secure additional grant funding to address this shoreline reach. The continuation of the rock sill will protect infrastructure and be a highly visible demonstration site. Three rock sills are needed at this site (Figure 4-20). These structures will provide both shore protection and habitat by using stone sills, sand fill and marsh plantings. Sills 1, 2, and 3 are 130 ft, 110 ft, and 120 ft long, respectively and will transition to the rock revetment north of the proposed sills and the existing sills south of the proposed structures. The typical cross-sections for the sills are shown in Figure 4-21. Estimated encroachment calculations are shown in Table 5. These values are estimated for the shore position in 2017 and may not accurately reflect the plan further into the future because of the high erosion rate. The estimate cost (based on the typical cross-section) of installed rock, sand, and plants is $154,000, $64,000, and $6,000, respectively. The total estimated cost

of the project with 20% design work, mobilization and demobilization is estimated to be $269,520. These values also are sensitive to time and may not be applicable into the future

Bank grading is not suggested. This project can be constructed in phases as funding becomes available. Structures can be built north from the existing sill system.

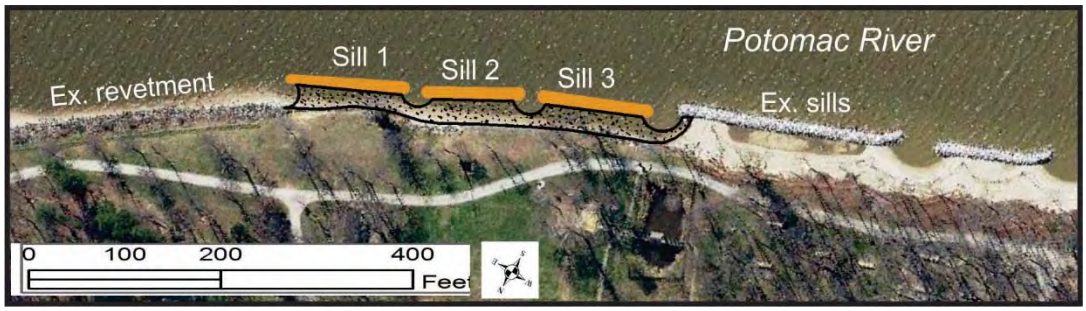

Figure 4-20. Conceptual plan for the living shoreline demonstration project at Leesylvania State Park.

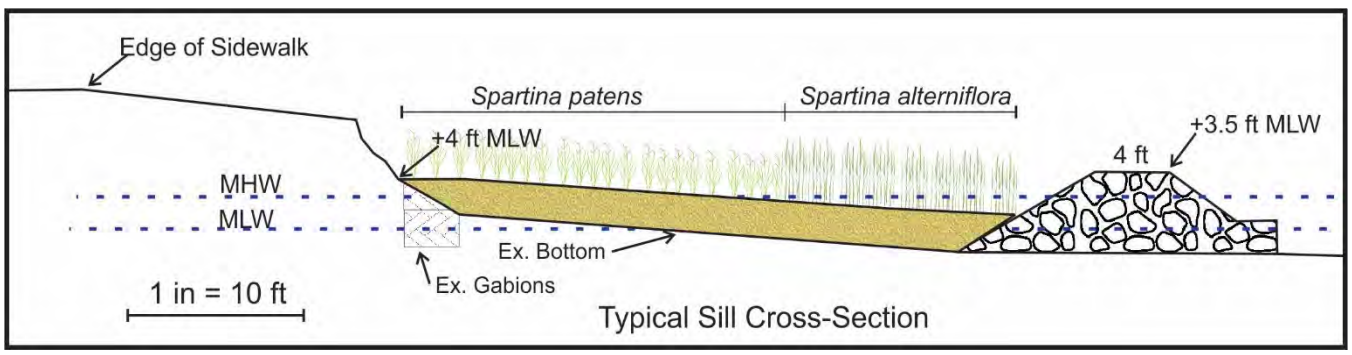

Figure 4-21. Typical sill cross-section for the Leesylvania conceptual plan.

Table 5. Encroachment values for the Belle Isle Picnic Area Conceptual Plan.

	Encroachment		
	Vegetated wetlands (ft^2)	Non-vegetated wetlands (ft^2)	Maximum encroachment from MLW (ft)
Sills 1, 2 &3	0	8,340	40

5 Conclusion

This project has identified areas that are in need of shore erosion protection within the tidewater state parks. In addition, the parks have been ranked so as to target three living shoreline demonstration projects to where they are most needed. Other sites along the parks shorelines are in need of shore

protection and the data collected through this project can be used to develop more park demonstration sites in the future.

At Belle Isle, the master plan has identified three priority areas in addition to the picnic area including the Visitor Center, Watch House Trail, and Bel Air Guesthouse. However, Living shoreline strategies are recommended in other areas such as at the northern point where potential archeology exists and along the eroding Rappahannock River shoreline. In addition, several sites were recommended for oyster bag sills in Mulberry and Deep Creeks.

At Caledon, several areas were identified as potential sites as shore protection is needed along the shoreline. The high eroding banks are hazardous to visitors and could be stabilized with shore protection. In addition, the pond at the northern end of the site recently broke through.

Chippokes has several section of shoreline that would benefit from shore protection. However, a project may be underway to protect some areas.

Overall, First Landing either does not need erosion control, or it already has it in place. Only several areas of shore erosion were identified along Broad Neck. These areas could benefit from a living shoreline project.

Kiptopeke has no need for shore protection.

Leesylvania has a need to address another small area along the Potomac River as well as some eroding and undercut banks along Powells Creek.

Mason Neck has existing structures existing structures that provide shore protection along many sections of shoreline. However, other areas are eroding and would be potential sites for future living shoreline projects. SAV is abundant along the shoreline at Mason Neck and would have to be accounted for in shore protection design.

Middle Peninsula has an array of existing structures along the shoreline. However, some areas of the bulkhead are failing and could be replaced with a living shoreline. The marsh shoreline on either side of the bulkhead is eroding and also would benefit from shore protection. Though Middle Peninsula is not open to the public, it was included in this project so that data from this report could be used in planning for the site.

Westmoreland has many areas of its shoreline already protected with structures. Other areas have very high banks that are still erosional but would be very expensive to build. The beach at the easternmost section of the shoreline is erosional and could use a living shoreline system. Plans developed by Stantec, Inc. exist to address this shore erosion.

Widewater has several areas that are erosional and would benefit from shore protection. It is a newly opened park, so likely infrastructure will be the priority. However, a shoreline plan is being developed for the north segment of Reach 1. SAV occurs along the shoreline and would need to be accounted for in any design.

York River State Park has significant erosion and many areas are in need of shore protection. The marsh/downed tree headlands provide opportunities for rock structures along the shoreline. Most of the park is undeveloped, however, trails do lead to some areas and would provide construction access.

6 References

DCR, 2010. Leesylvania State Park Master Plan Executive Summary, 2010 Update. Department of Conservation & Recreation.

DCR, 2015. York River State Park Master Plan Executive Summary, 2015 Update. Department of Conservation & Recreation.

DCR, 2017. Belle Isle State Park Master Plan Executive Summary, 2015 Update. Department of Conservation & Recreation.

Hardaway, Jr. C.S., D.A. Milligan and K. Duhring, 2017. Living Shoreline Design Guidelines for Shore Protection in Virginia's Estuarine Environments. Contract report for the Virginia Department of Environmental Quality's Coastal Zone Management Program Special Report in Applied Marine Science and Ocean Engineering #421. Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, Virginia.

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Milligan, Wilcox & Hardaway (2018). Shoreline change database. Online database. Shoreline Studies Program, VIMS. http://www.vims.edu/research/departments/physical/programs/ssp/gis_maps/index.php

Appendix A

Site Data

Data sources are discussed in the method section of this report.

Site Data

Location: Latitude and Longitude of the site.
Shoreline Length (ft): Calculated using the 2017 digitized shoreline.
Tide Range (ft): Mean tide range for the site as determined using the Shoreline Studies Program's kml file.
FEMA Flood Levels: Predicted storm surge water levels from the locality's Flood Insurance Study by the Federal Emergency Management Agency.
Wave height (ft): Predicted starting significant wave height resulting from a 1% annual chance storm surge from the locality's Flood Insurance Study by the Federal Emergency Management Agency.
Wave period (s): Predicted starting peak wave period resulting from a 1% annual chance storm surge from the locality's Flood Insurance Study by the Federal Emergency Management Agency.

Reach Data

Waterbody: Location
Shoreline length per reach (ft): Calculated using the 2017 digitized shoreline.
Average EPR (ft/year): Calculated End Point Rate of change for three time periods, 1937-2017, 1937-1994, and 1994-2017.
Avg. distance to 6ft contour (ft): Average of the distance offshore to the 6 ft contour. N/A indicates that the waterbody is too shallow to reach the 6 ft contour. It is an indicator of how much energy can reach the shoreline.
Average fetch (miles): Average distance of which wind can blow to generate waves. It was calculated using five radials from the principal direction of face in the approximate center of each reach.
Longest fetch (miles): Longest radial from the approximate center of the reach.
Shore direction of face: Principal direction of face for each reach.
SAV presence: Whether or not Submerged Aquatic Vegetation was mapped by VIMS within the last 5 years.

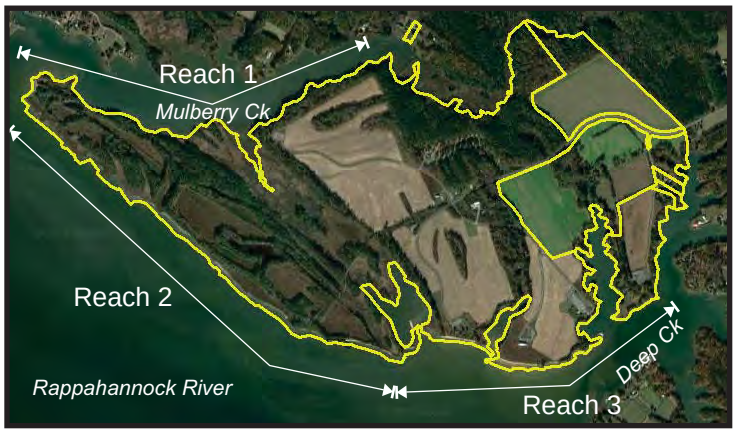
Typical photos are shown for each reach. However, topography varies within each reach.

Bank height for the park was mapped using the Chesapeake Bay Topobathy DEM acquired from the SAV program at VIMS.

Shoreline change is shown per reach. Photo base is the 2017 VGIN Image

Belle Isle State Park
Lancaster County, Virginia

Location	37.78, -76.61
Shoreline length (miles)	8.6
Tide range (ft)	1.58
2016 Attendance	39,725



10% Annual Chance (10 year) MLW	4.90
2% Annual Chance (50 year) MLW	5.80
1% Annual Chance (100 year) MLW	6.10
0.2% Annual Chance (500 year) MLW	7.50
Wave Height (ft)	0.50
Peak Wave Period (sec)	3.70

	Reach 1	**Reach 2**	**Reach 3**
Waterbody	Mulberry Creek	Rapphannock River	Deep Creek
Shoreline length per reach (miles)	1.9	4.2	2.6
Average EPR			
1937-2017	-0.5	-2.1	-0.3
1937-1994	-0.4	-2.0	-0.3
1994-2017	-0.6	-2.5	-0.2
Avg. distance to 6ft contour (ft)	N/A	1,928	N/A
Average fetch (miles)	0.3	5.3	0.2
Longest fetch (miles)	0.4	12.2	0.2
Shore Direction of Face	North	Southwest	South
SAV presence	No	No	No

Belle Isle State Park
Lancaster County, Virginia

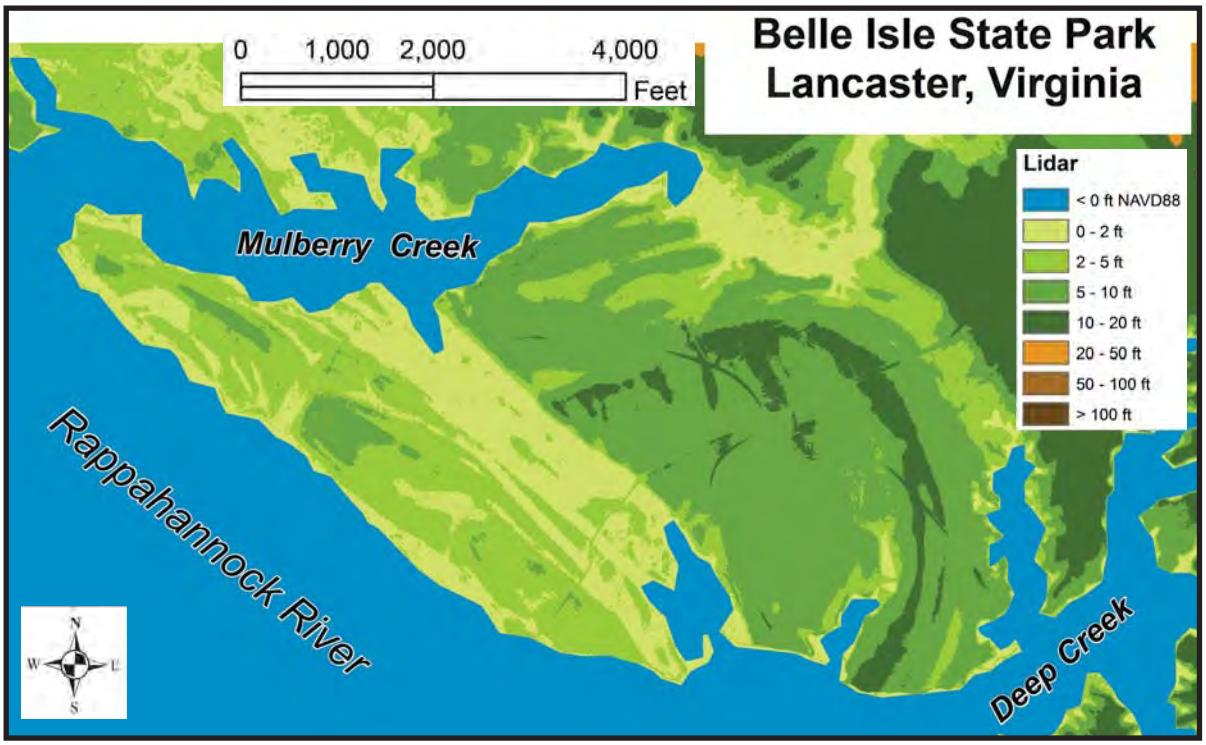
Reach 1

Reach 2

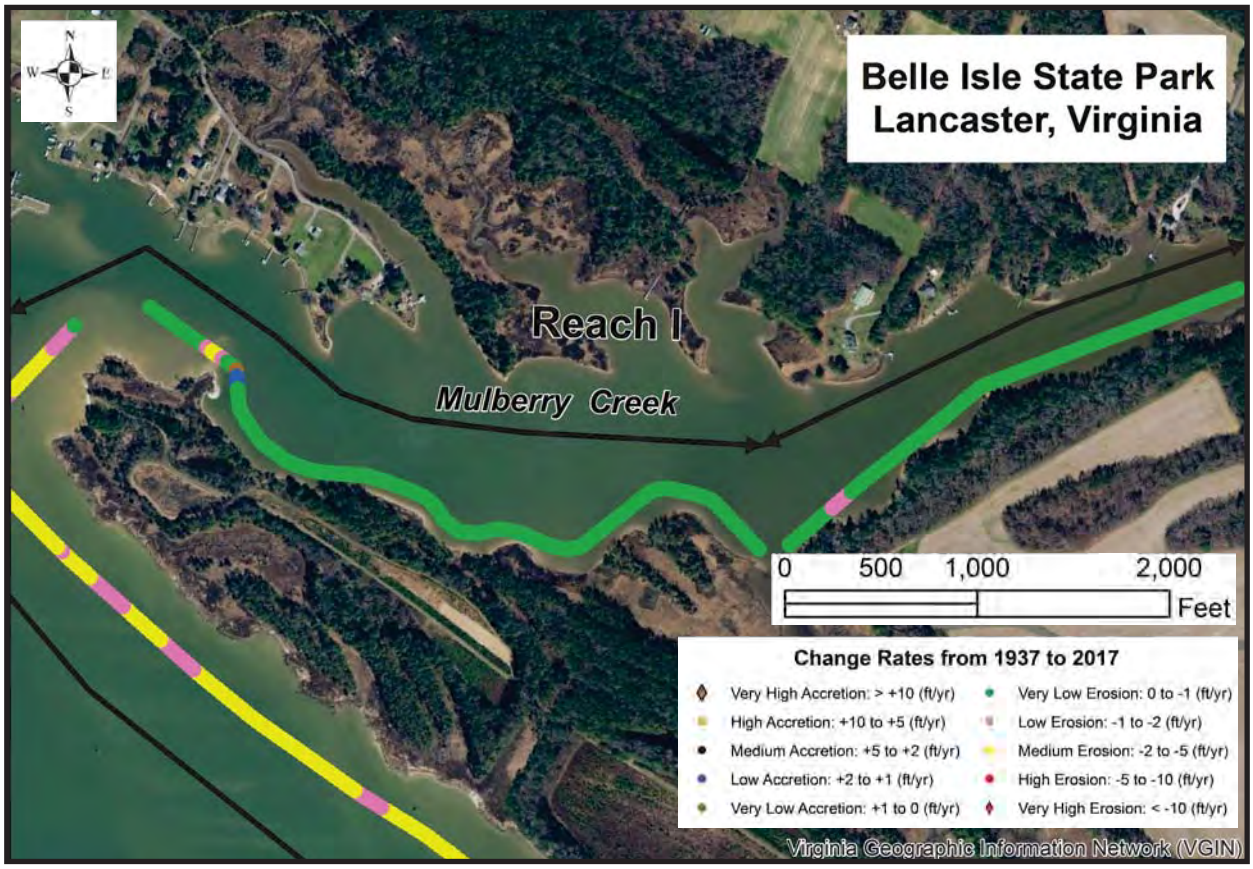
Reach 3

Belle Isle State Park
Lancaster County, Virginia

Bank Height

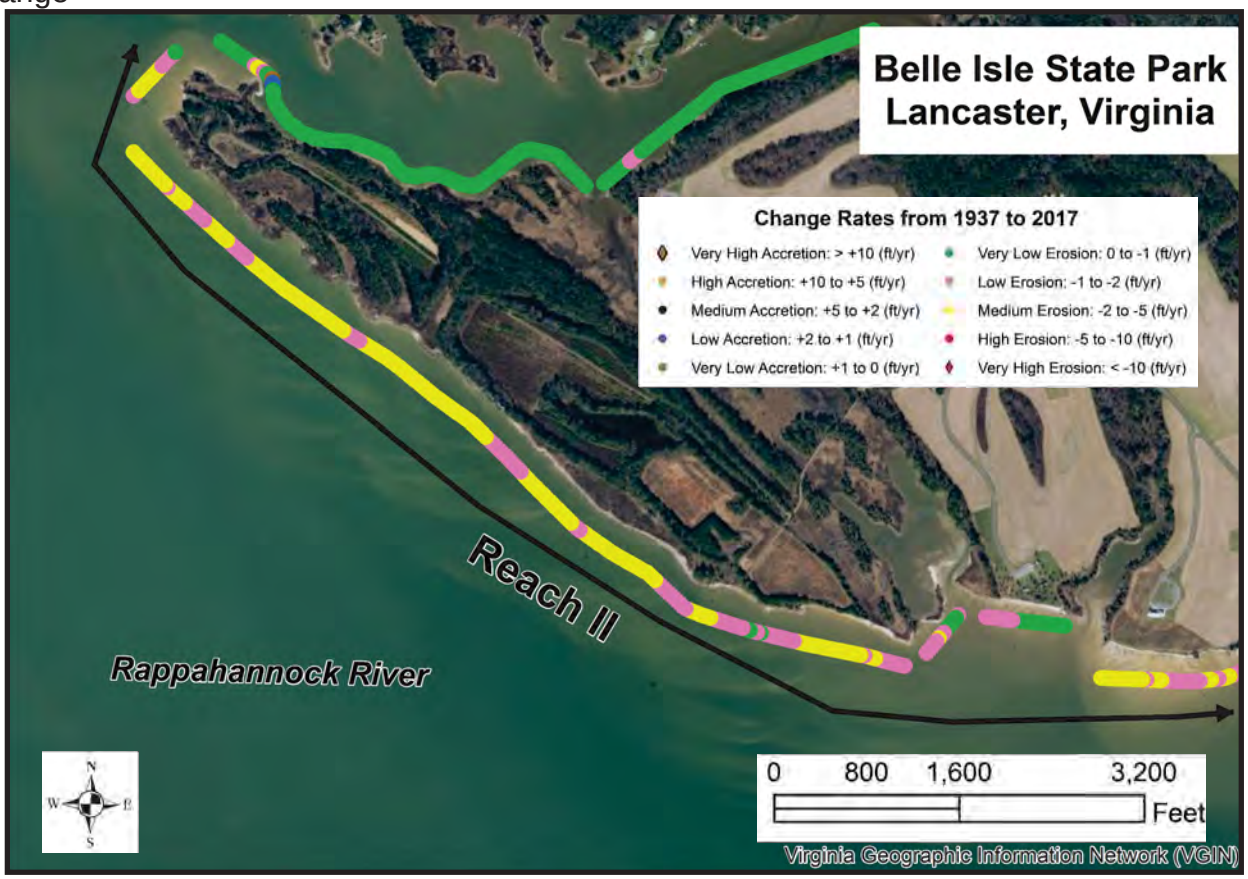


Reach 1
Shoreline Change
1937-2017

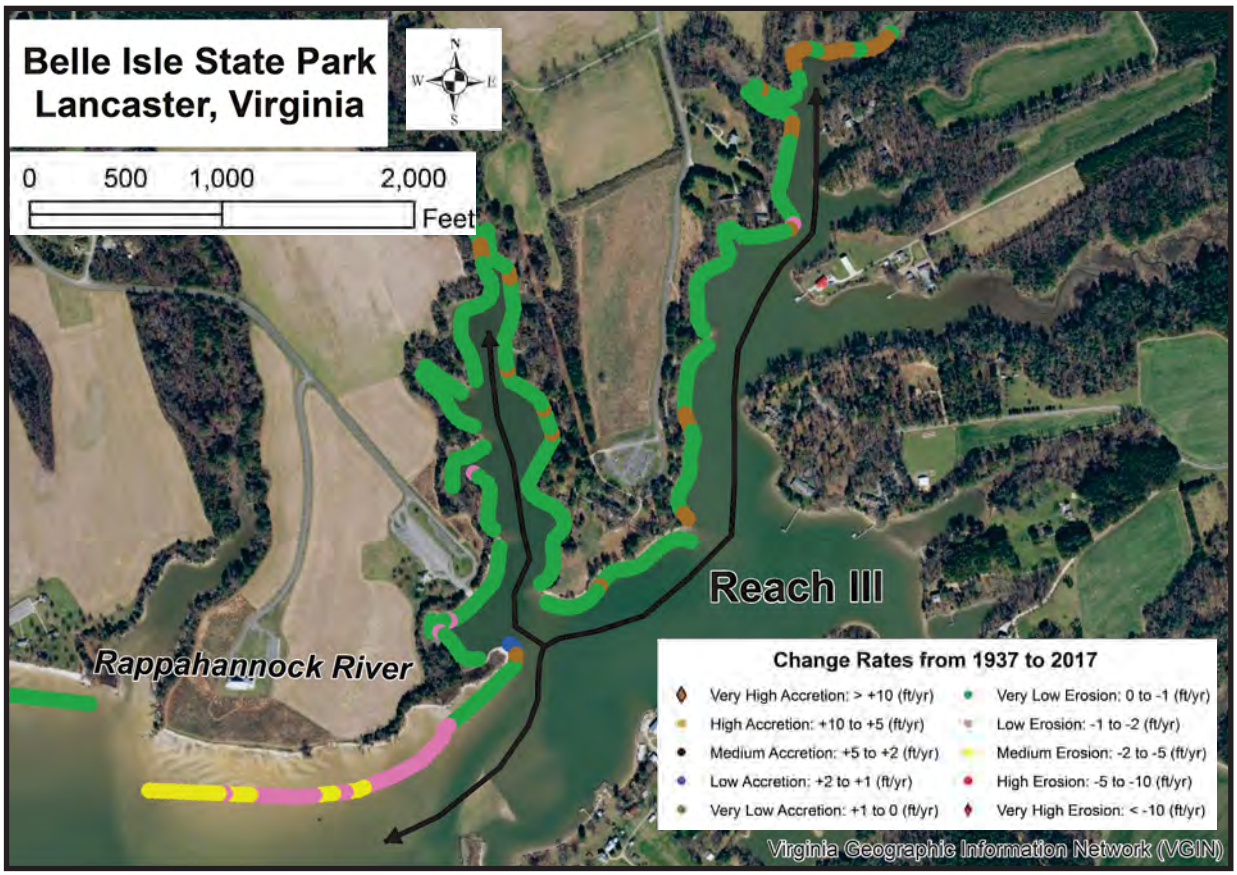


Belle Isle State Park
Lancaster County, Virginia

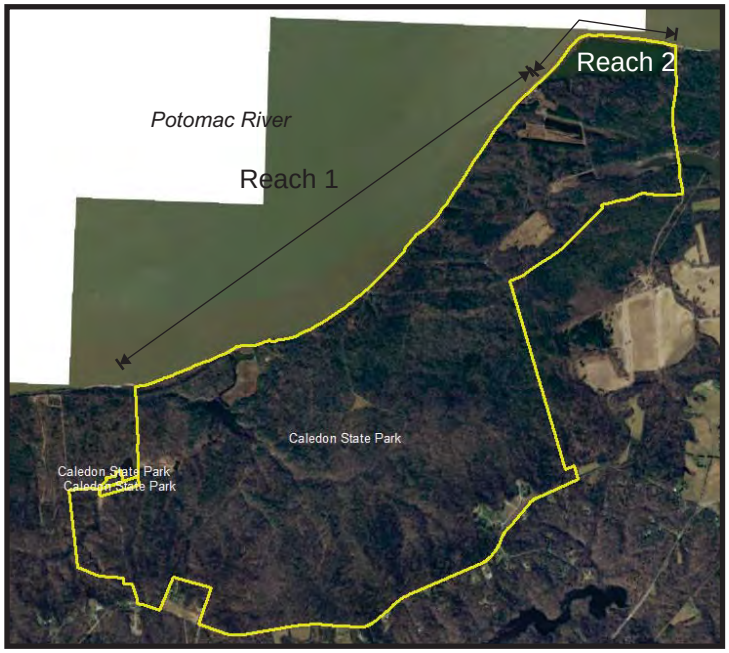
Reach 2
Shoreline Change
1937-2017



Reach 3
Shoreline Change
1937-2017



Caledon State Park
King George County, Virginia



Location	38.35, -77.15
Shoreline length (miles)	3.5
Tide range (ft)	1.25
2016 Attendance	61,875

10% Annual Chance (10 year) MLW	4.90
2% Annual Chance (50 year) MLW	6.30
1% Annual Chance (100 year) MLW	6.90
0.2% Annual Chance (500 year) MLW	7.90
Wave Height (ft)	2.20
Peak Wave Period (sec)	3.30

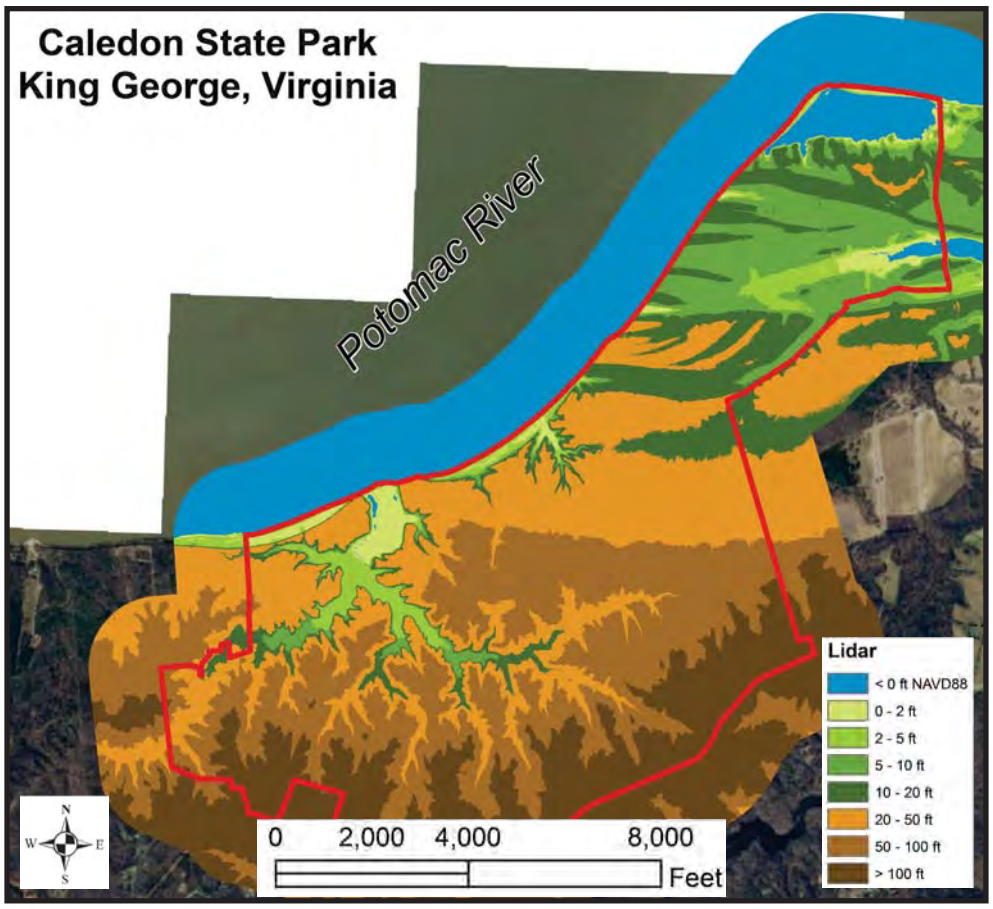
	Reach 1	**Reach 2**
Waterbody	Potomac River	Potomac River
Shoreline length per reach (miles)	2.7	0.8
Average EPR		
1937-2017	-0.6	-0.3
1937-1994	-0.3	-0.1
1994-2017	-1.1	-0.8
Avg. distance to 6ft contour (ft)	817	280
Average fetch (miles)	3.6	9.4
Longest fetch (miles)	3.3	8.5
Shore Direction of Face	Northwest	North
SAV presence	No	No

Caledon State Park
King George County, Virginia

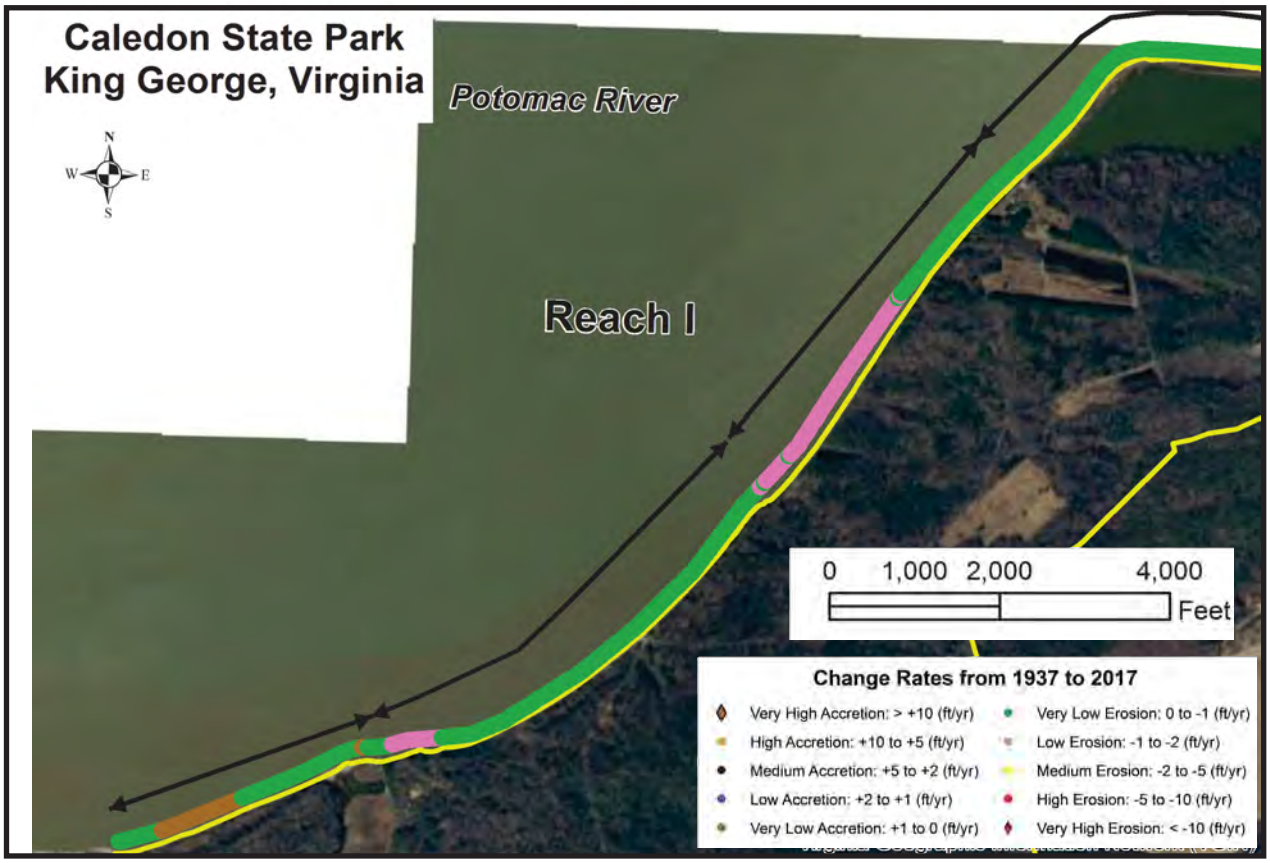
Reach 1

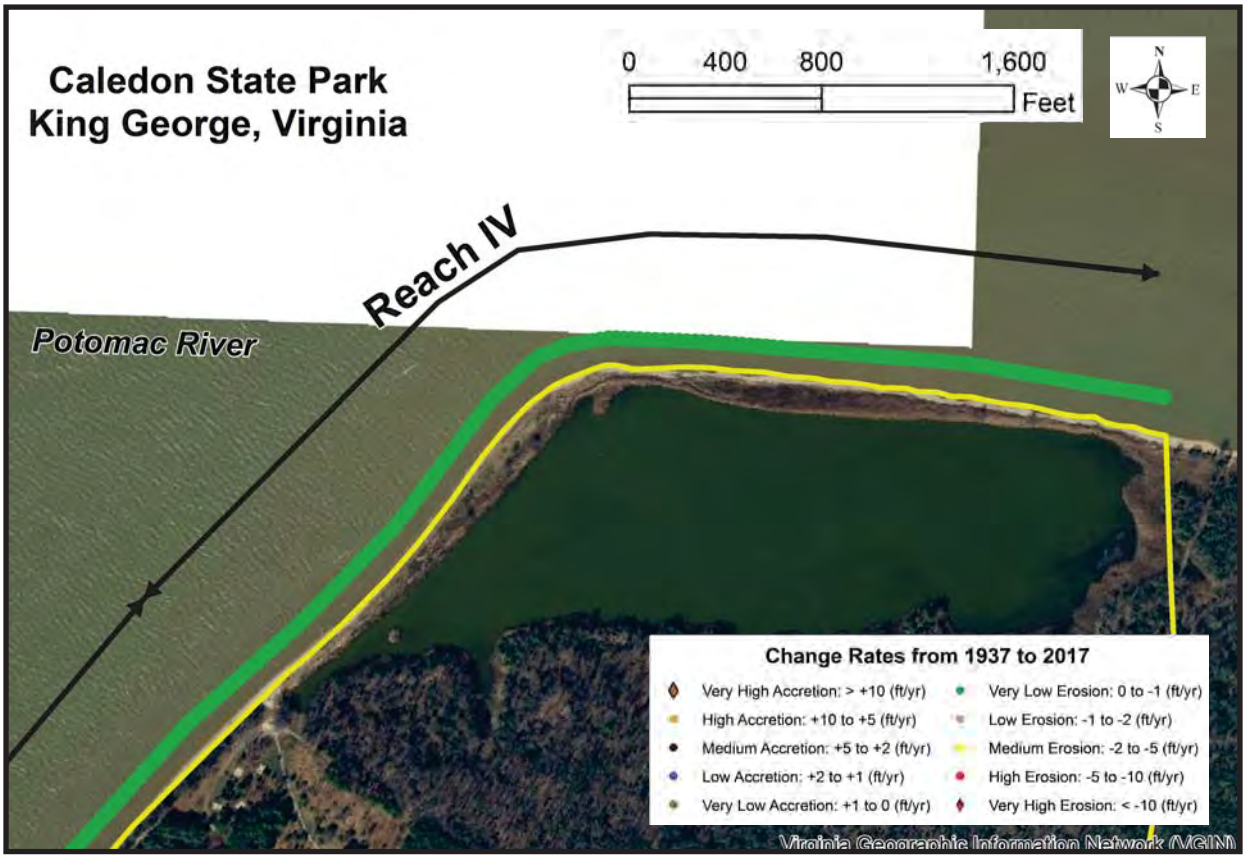
Reach 2

Bank Height

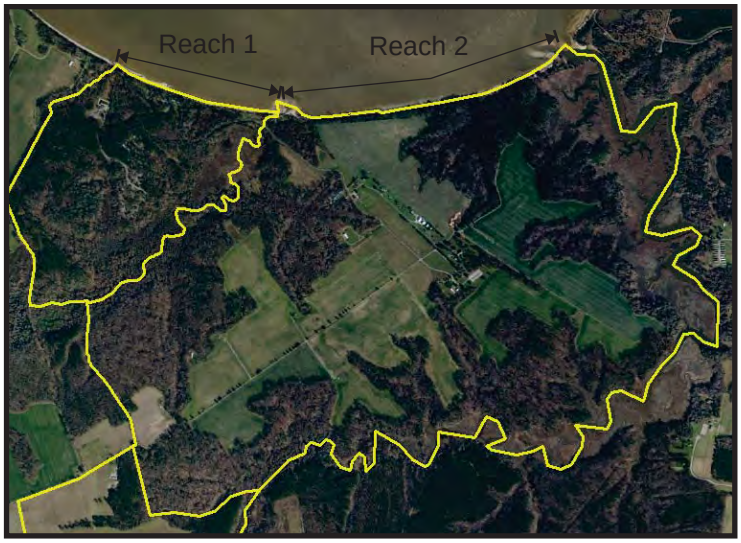


Caledon State Park
King George County, Virginia





Chippokes State Park
Surry County, Virginia



Location	37.15, -79.73
Shoreline length (miles)	6.7
Tide range (ft)	1.92
2016 Attendance	87,181

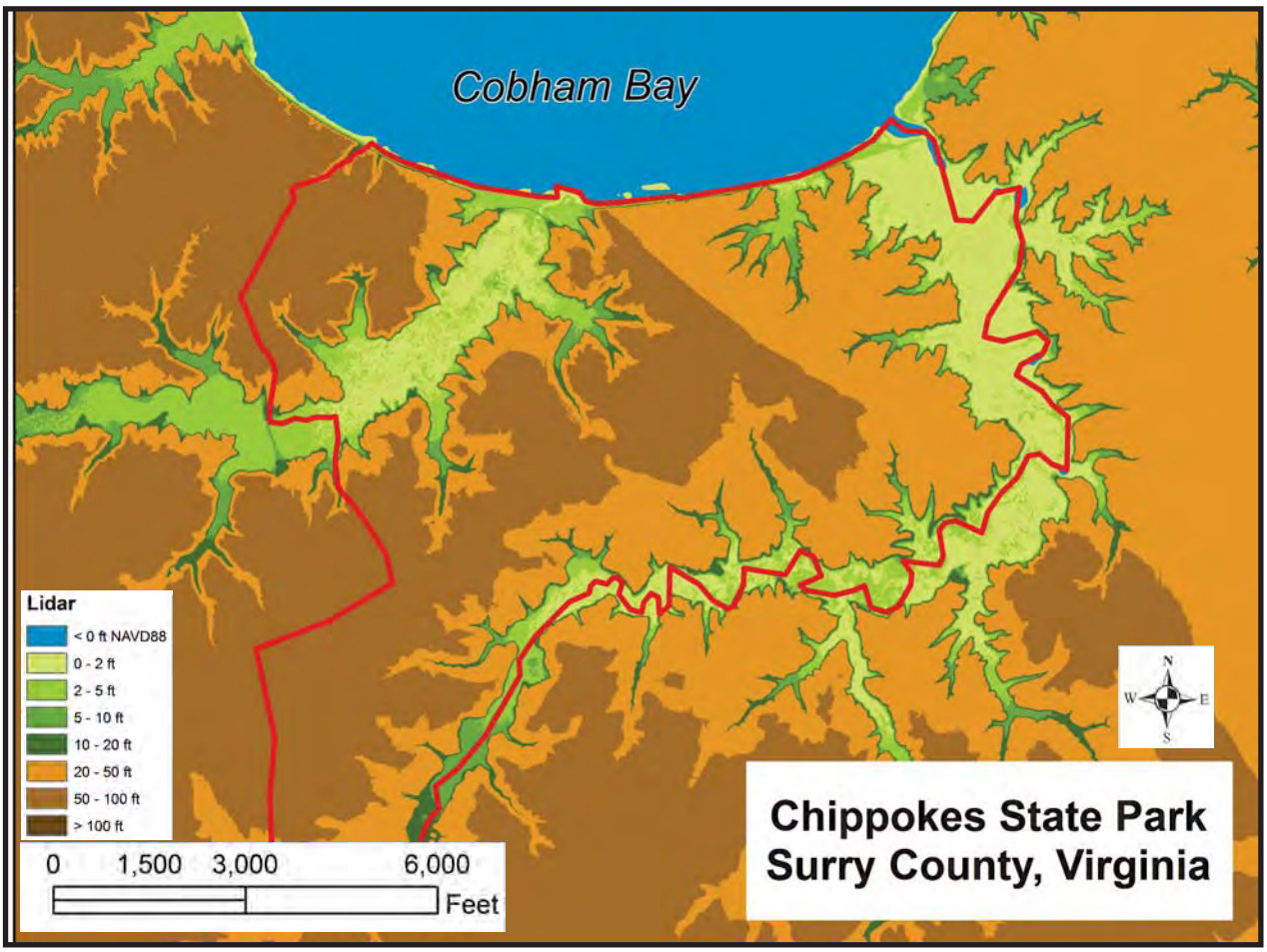
10% Annual Chance (10 year) MLW	6.60
2% Annual Chance (50 year) MLW	7.60
1% Annual Chance (100 year) MLW	8.10
0.2% Annual Chance (500 year) MLW	9.30
Wave Height (ft)	4.70
Peak Wave Period (sec)	3.40

	Reach 1	**Reach 2**
Waterbody	James River	James River
Shoreline length per reach (miles)	0.7	5.9
Average EPR		
1937-2017	0.2	-0.2
1937-1994	0.3	-0.1
1994-2017	-0.1	-0.5
Avg. distance to 6ft contour (ft)	3,037	4,786
Average fetch (miles)	4.4	
Longest fetch (miles)	8.1	
Shore Direction of Face	North	North
SAV presence	No	No

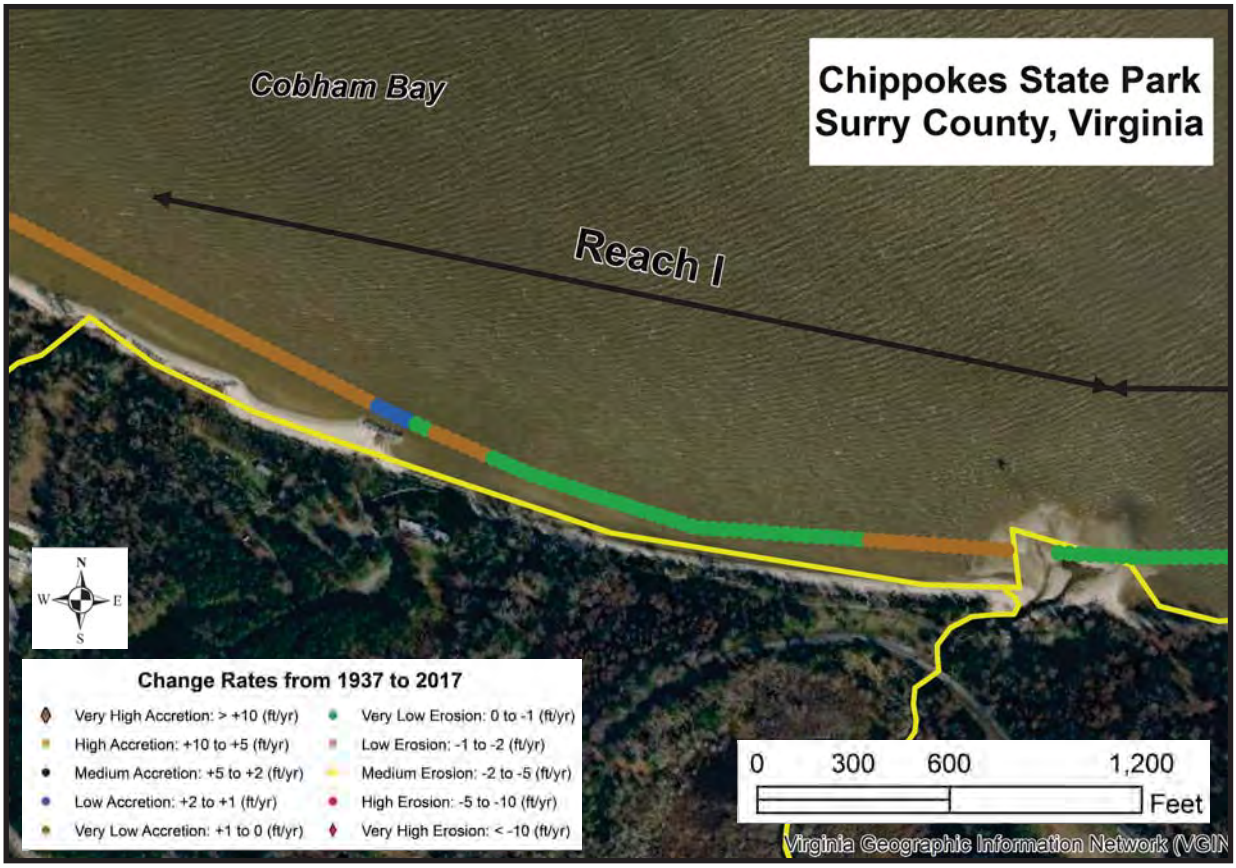
Chippokes State Park
Surry County, Virginia

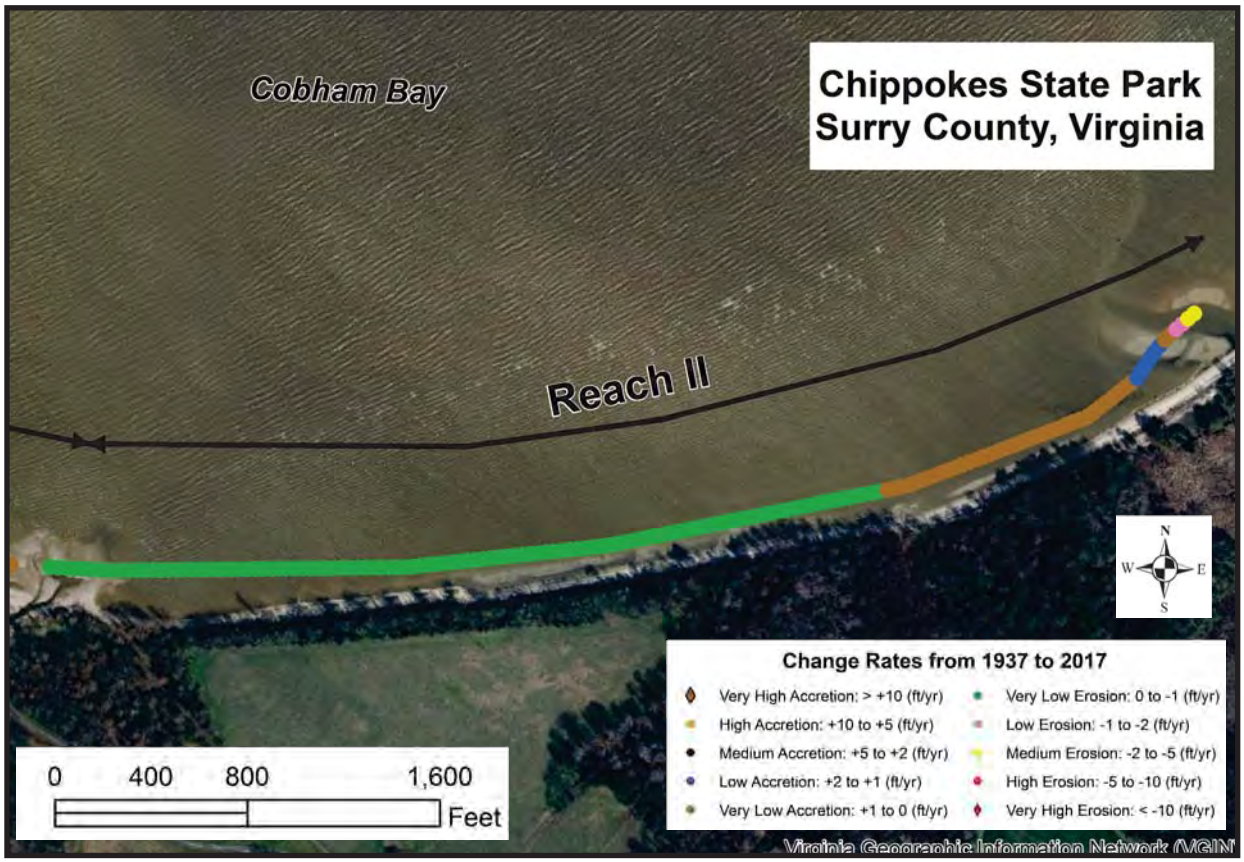
Reach 1

Reach 2



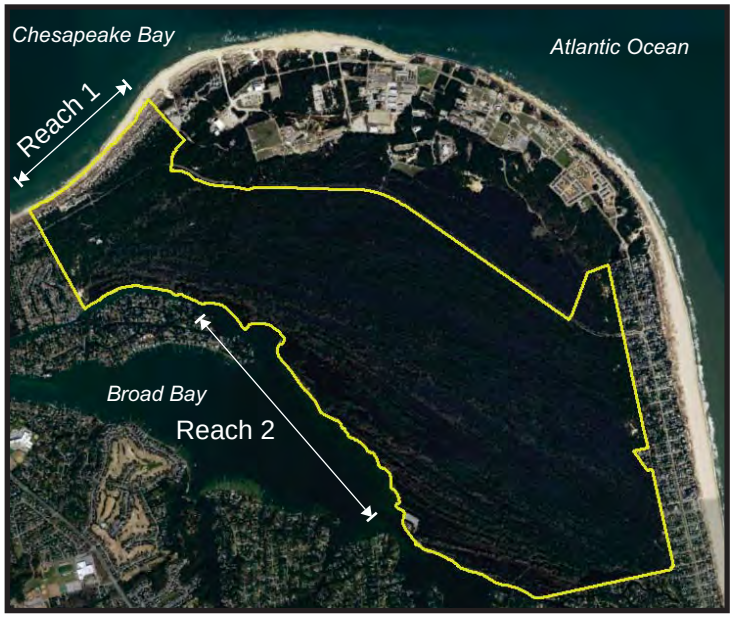
Chippokes State Park
Surry County, Virginia





First Landing State Park
Virginia Beach, Virginia

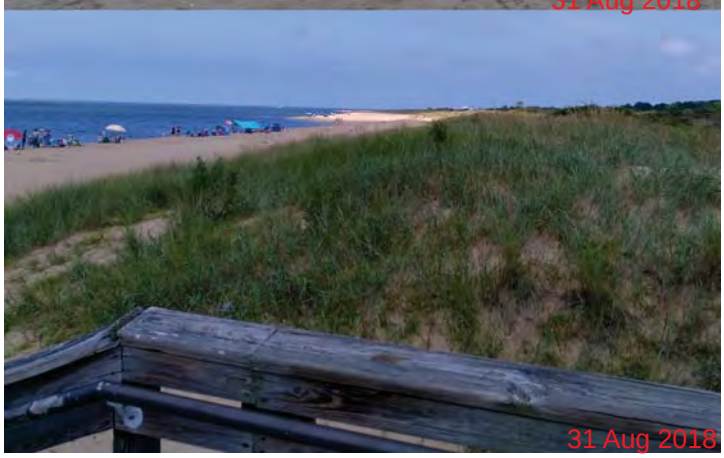
	Chesapeake Bay	Broad Bay
Location	36.92, -76.05	36.92, -76.02
Shoreline length (miles)	8.8	
Tide range (ft)	2.75	1.42
2016 Attendance	1,060,837	



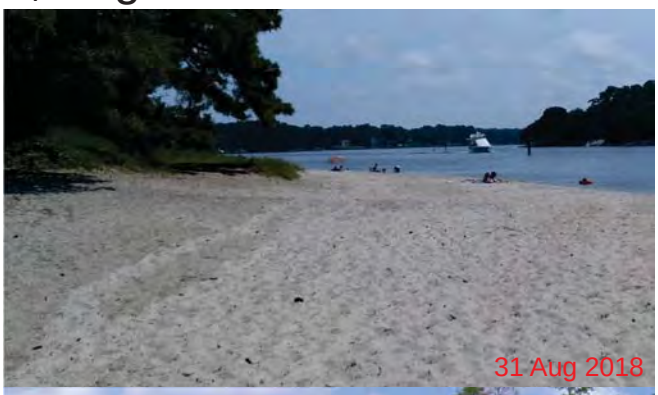
	Chesapeake Bay	Broad Bay
10% Annual Chance (10 year) MLW	6.50	6.00
2% Annual Chance (50 year) MLW	7.80	7.20
1% Annual Chance (100 year) MLW	8.30	7.60
0.2% Annual Chance (500 year) MLW	9.50	8.90
Wave Height (ft)	10.30	
Peak Wave Period (sec)	6.20	

	Reach 1	**Reach 2**
Waterbody	Chesapeake Bay	Broad Bay
Shoreline length per reach (miles)	1.0	7.8
Average EPR		
1937-2017	6.0	-0.5
1937-1994	6.1	-0.5
1994-2017	4.9	-0.4
Avg. distance to 6ft contour (ft)	401	1,175
Average fetch (miles)	30.0	0.9
Longest fetch (miles)	82.8	1.6
Shore Direction of Face	Northwest	Southwest
SAV presence	No	No

First Landing State Park
Virginia Beach, Virginia

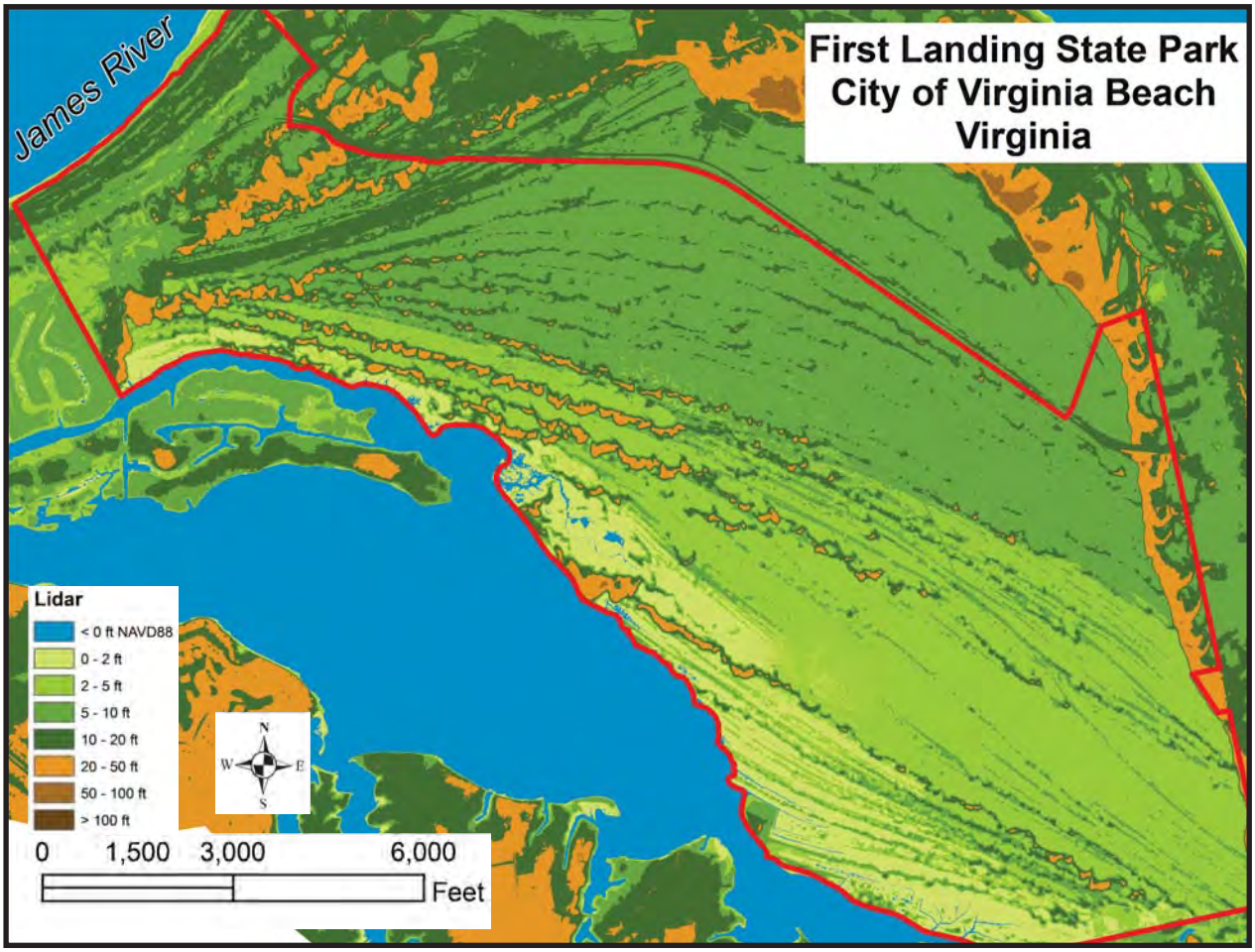


Reach 1

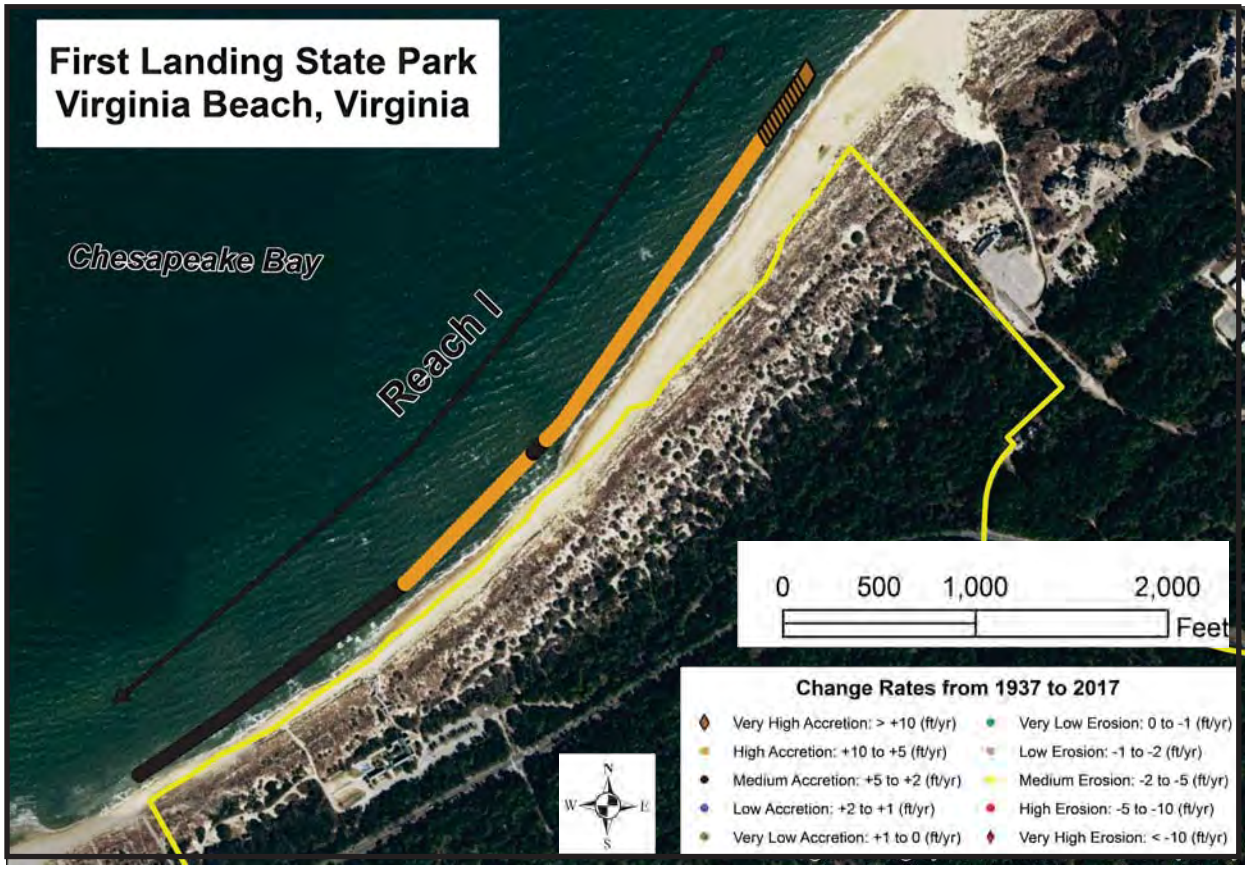


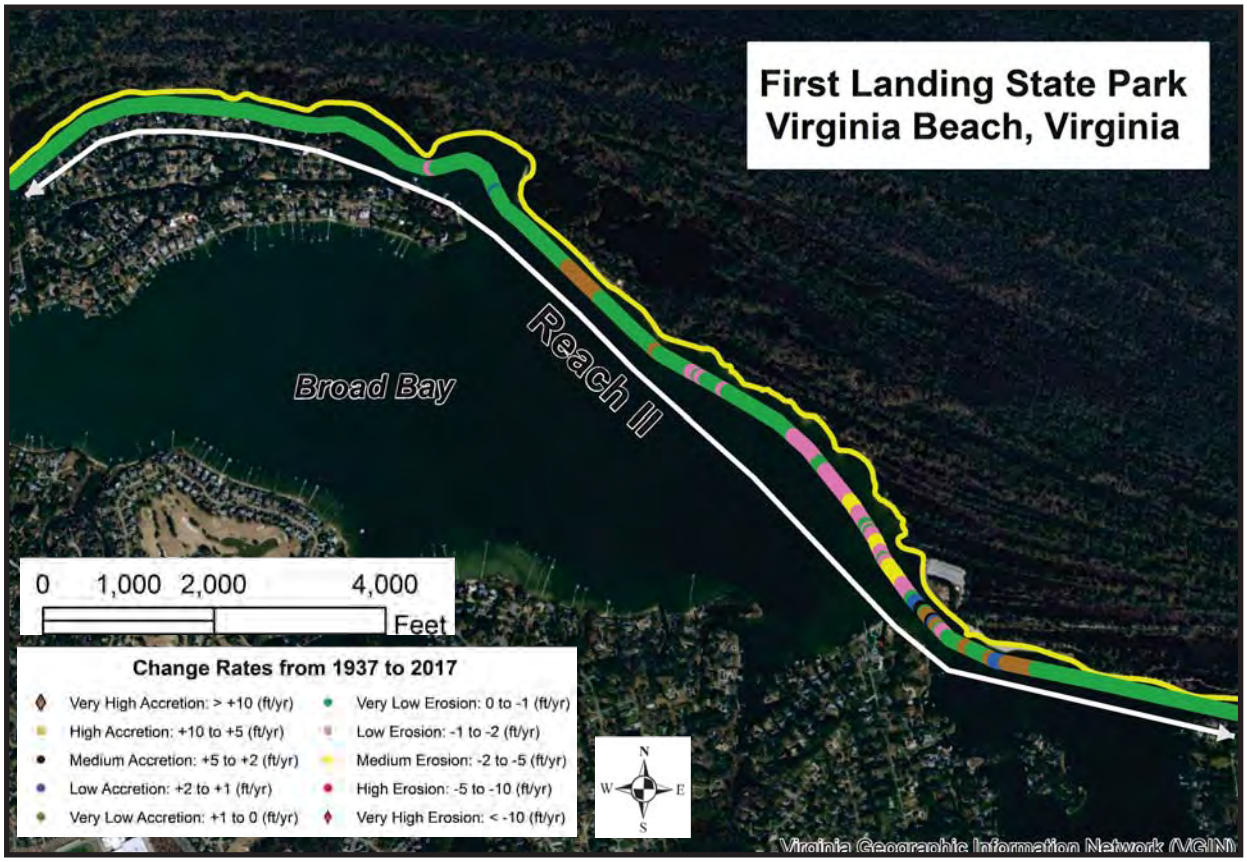
Reach 2

Bank Height



First Landing State Park
Virginia Beach, Virginia





Kiptopeke State Park
Northampton County, Virginia

Location	37.16, -75.98
Shoreline length (miles)	1.6
Tide range (ft)	2.58
2016 Attendance	397,926

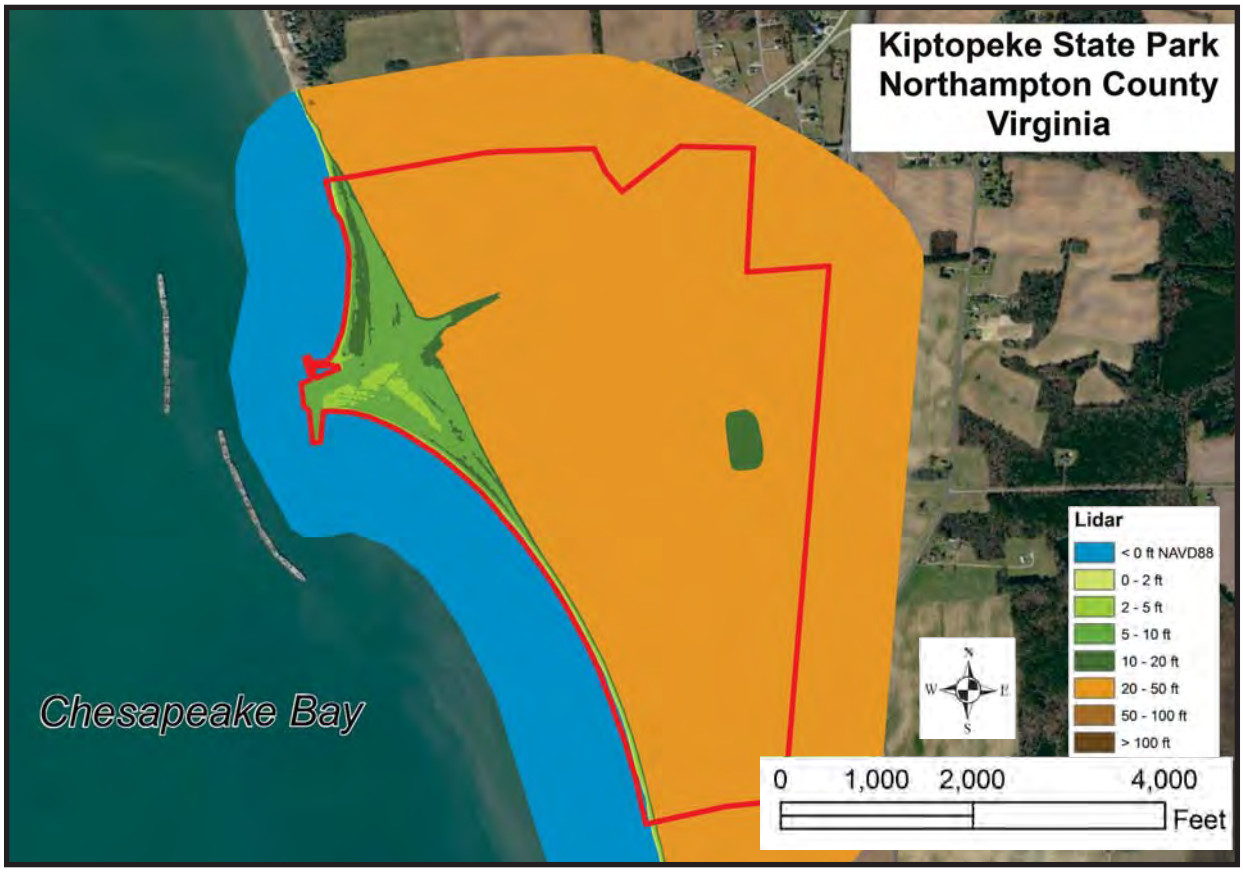
10% Annual Chance (10 year) MLW	6.10
2% Annual Chance (50 year) MLW	7.10
1% Annual Chance (100 year) MLW	7.50
0.2% Annual Chance (500 year) MLW	8.50
Wave Height (ft)	5.50
Peak Wave Period (sec)	4.20

	Reach 1	**Reach 2**
Waterbody	Chesapeake Bay	Chesapeake Bay
Shoreline length per reach (miles)	0.4	1.2
Average EPR		
1937-2017	5.5	0.9
1937-1994	6.3	1.5
1994-2017	3.7	-0.5
Avg. distance to 6ft contour (ft)	1,329	856
Average fetch (miles)	23.4	20.5
Longest fetch (miles)	31.5	27.1
Shore Direction of Face	Northwest	Southwest
SAV presence	No	No

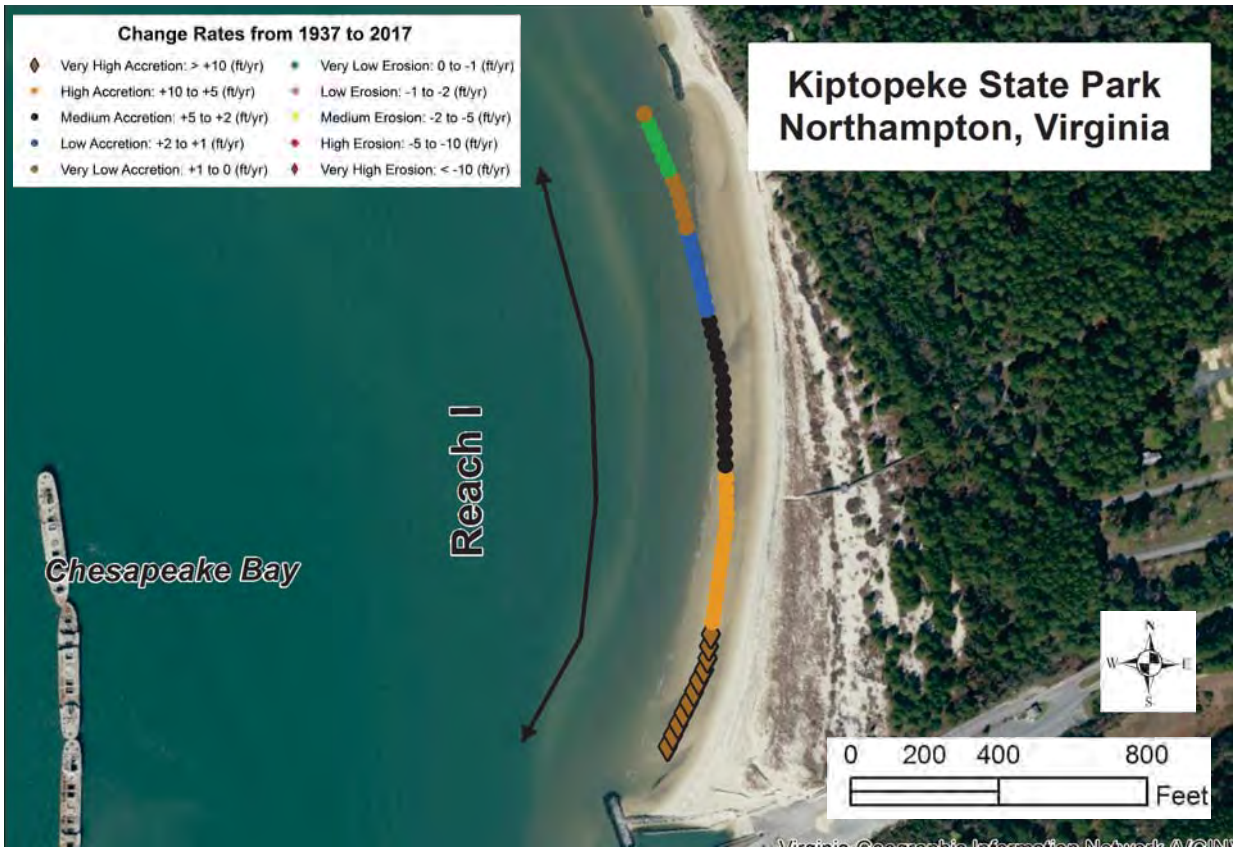
Kiptopeke State Park
Northampton County, Virginia

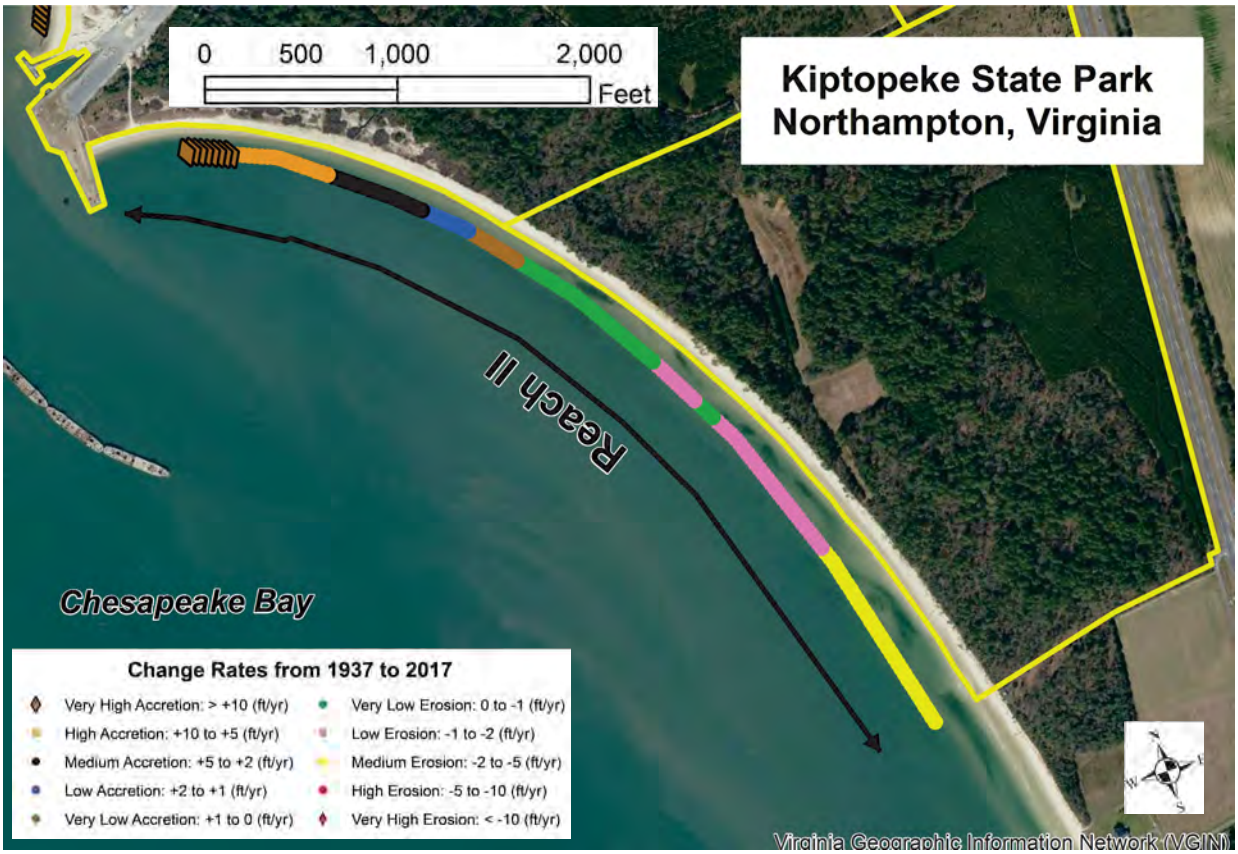
Reach 1

Reach 2



Kiptopeke State Park
Northampton County, Virginia





Leesylvania State Park
Prince William County, Virginia

Location	38.59, -77.25
Shoreline length (miles)	2.9
Tide range (ft)	1.75
2016 Attendance	620,977

10% Annual Chance (10 year) MLW	6.30
2% Annual Chance (50 year) MLW	7.30
1% Annual Chance (100 year) MLW	7.60
0.2% Annual Chance (500 year) MLW	9.90
Wave Height (ft)	3.40
Peak Wave Period (sec)	3.70

	Reach1	**Reach2**	**Reach3**
Waterbody	Potomac River	Potomac River	Powells Creek
Shoreline length per reach (miles)	0.8	1.3	0.8
Average EPR			
1937-2017	-0.4	0.1	-0.5
1937-1994	-0.3	0.2	-0.5
1994-2017	-0.5	-0.4	-0.3
Avg. distance to 6ft contour (ft)	N/a	1,573	N/A
Average fetch (miles)	2.9	2.7	1.1
Longest fetch (miles)	4.2	3.1	2.6
Shore Direction of Face	Northeast	Southeast	South
SAV presence	Yes	Yes	Yes

Leesylvania State Park
Prince William County, Virginia

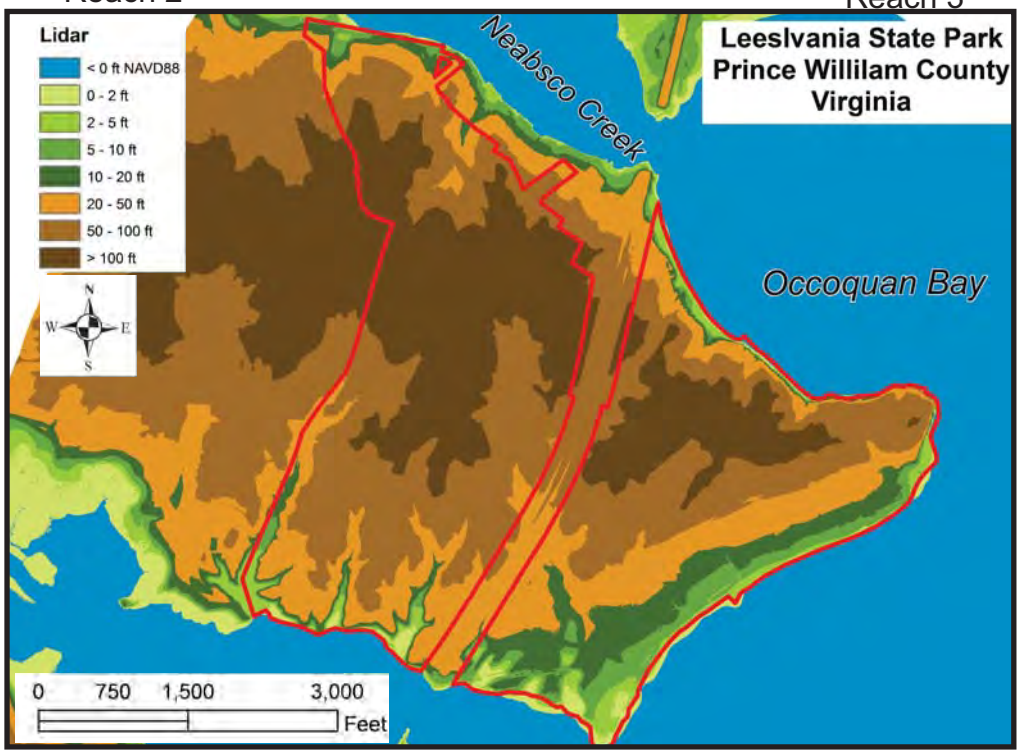
Reach 1

Reach 2

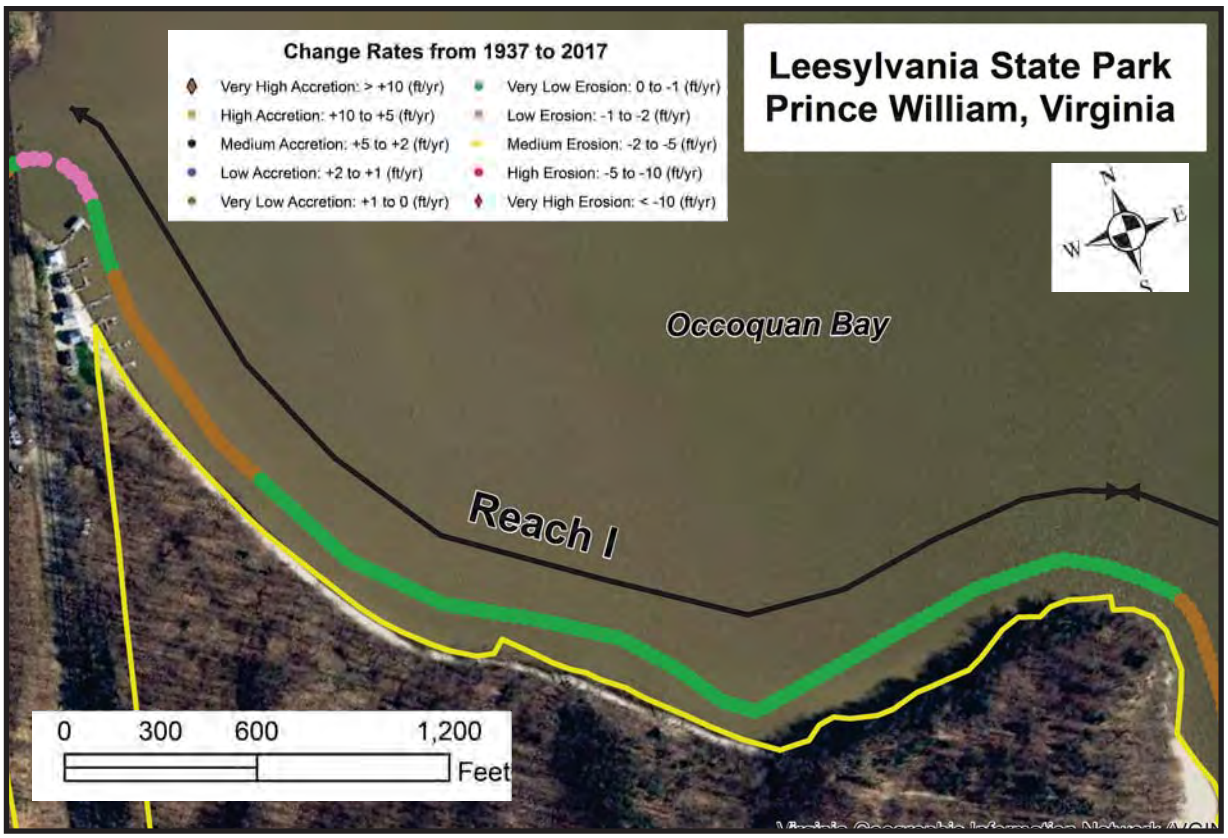
Reach 2

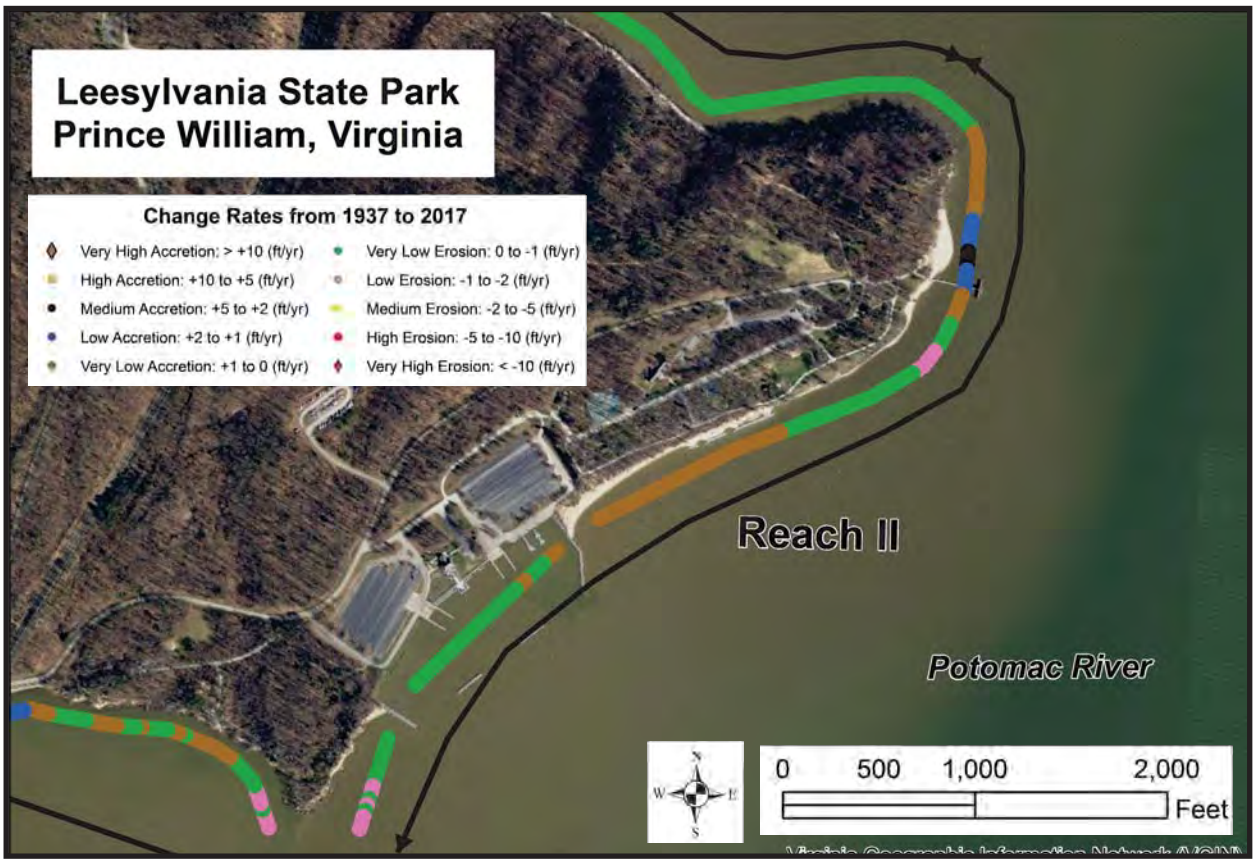
Reach 3

Bank Height

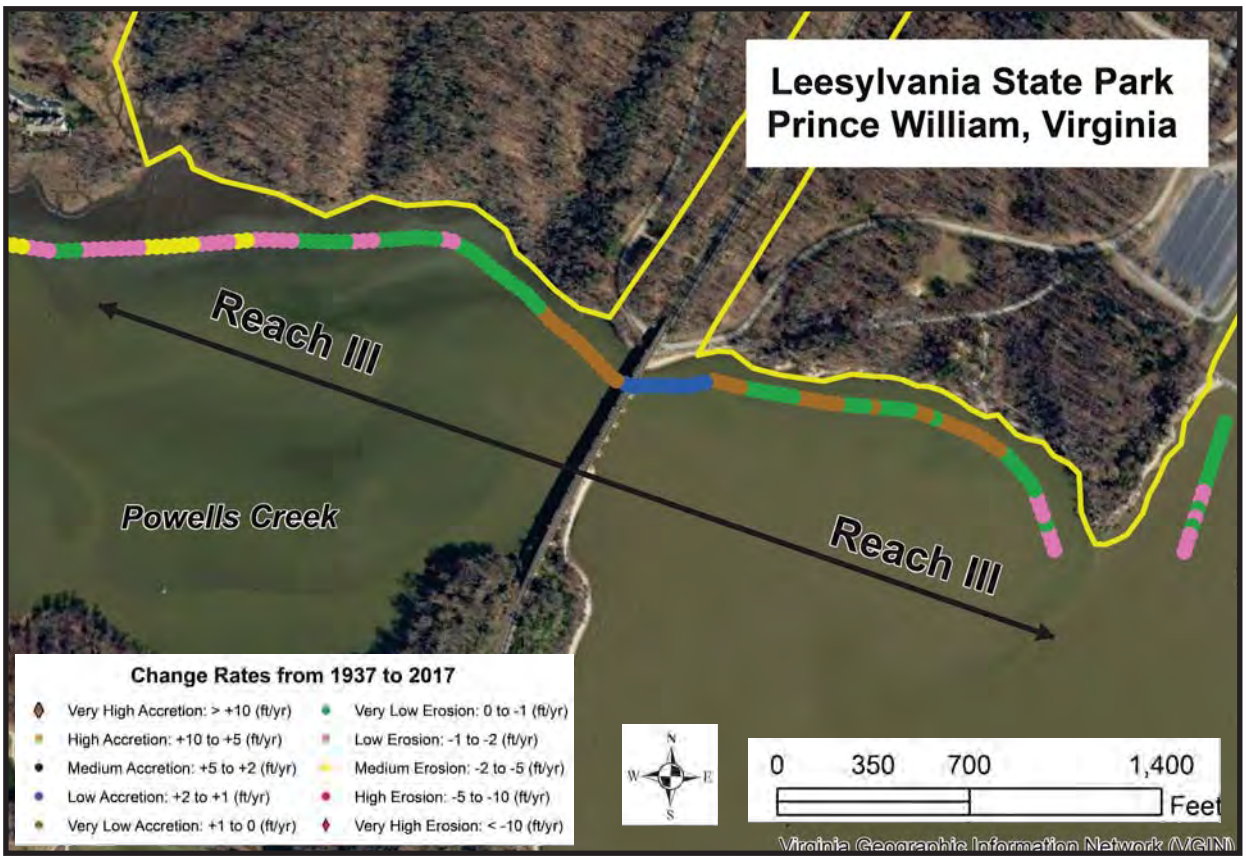


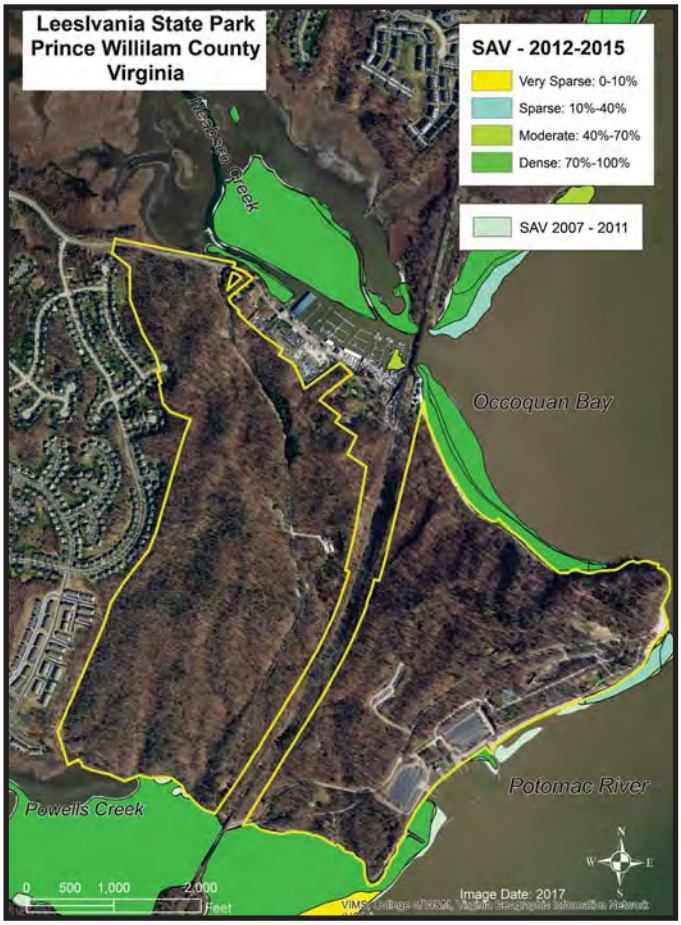
Leesylvania State Park
Prince William County, Virginia



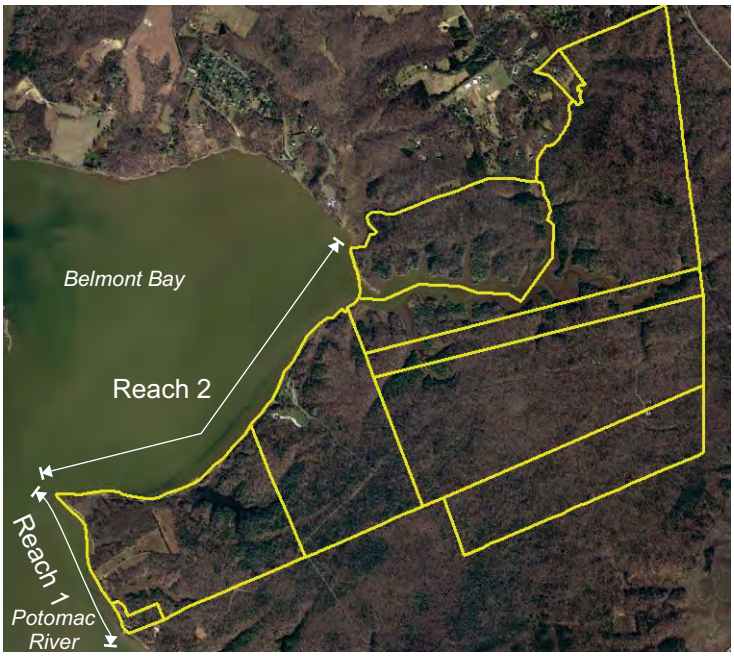


Leesylvania State Park
Prince William County, Virginia





Mason Neck State Park
Fairfax County, Virginia



Location	38.65, -76.59
Shoreline length (miles)	8.6
Tide range (ft)	1.75
2016 Attendance	123,204

No Storm Surge Data Available

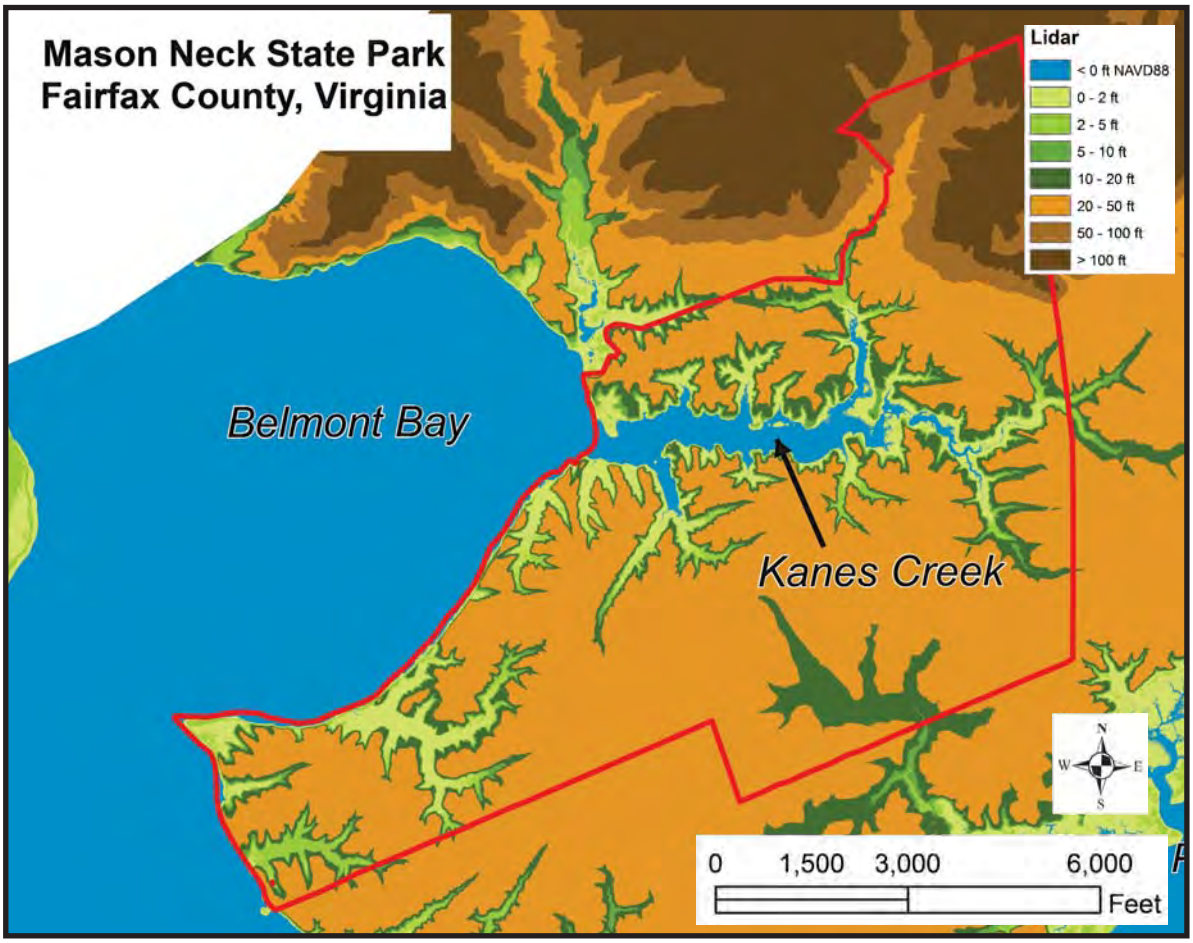
	Reach 1	**Reach 2**
Waterbody	Potomac River	Belmont Bay
Shoreline length per reach (miles)	0.9	7.6
Average EPR		
1937-2017	0.0	-0.4
1937-1994	-0.3	-0.5
1994-2017	0.9	0.1
Avg. distance to 6ft contour (ft)	915	N/A
Average fetch (miles)	2.9	1.7
Longest fetch (miles)	5.6	2.8
Shore Direction of Face	Southwest	Northwest
SAV presence	Yes	Yes

Mason Neck State Park
Fairfax County, Virginia

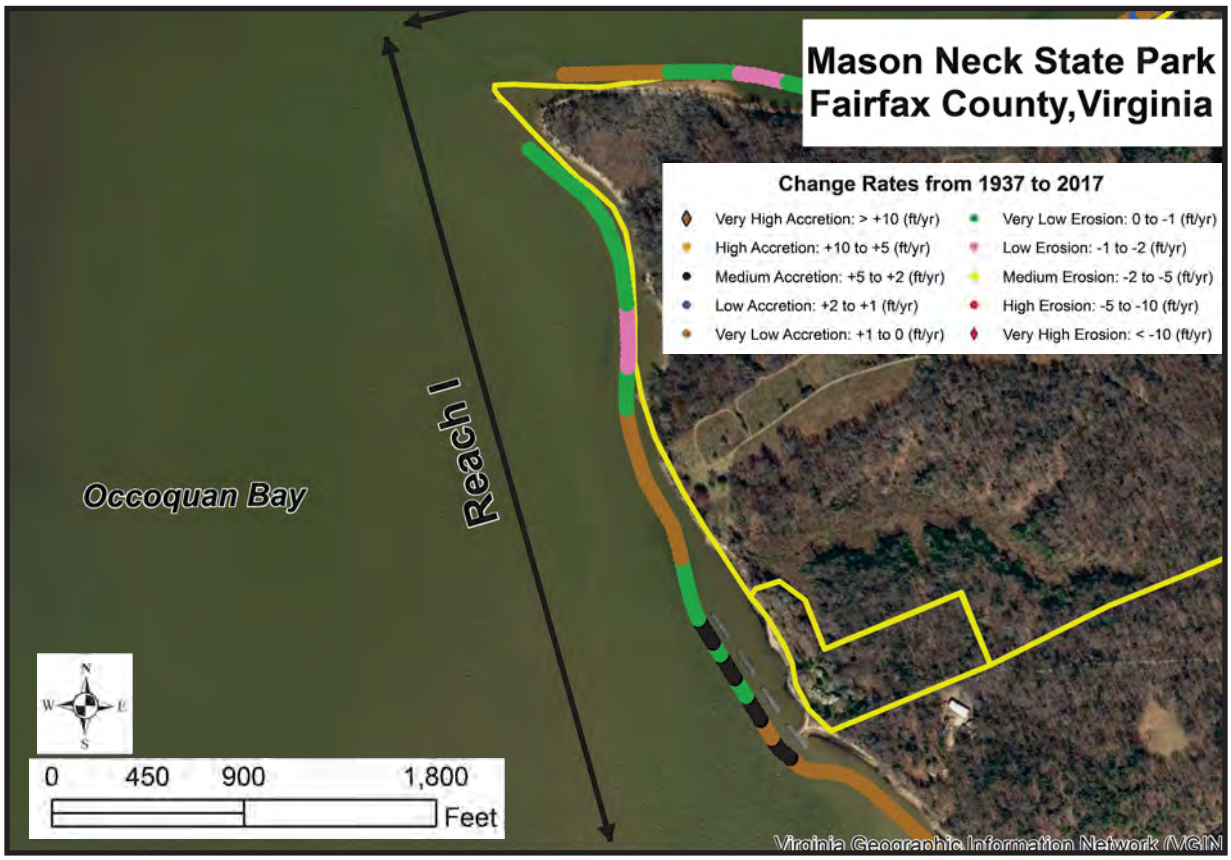
Reach 1

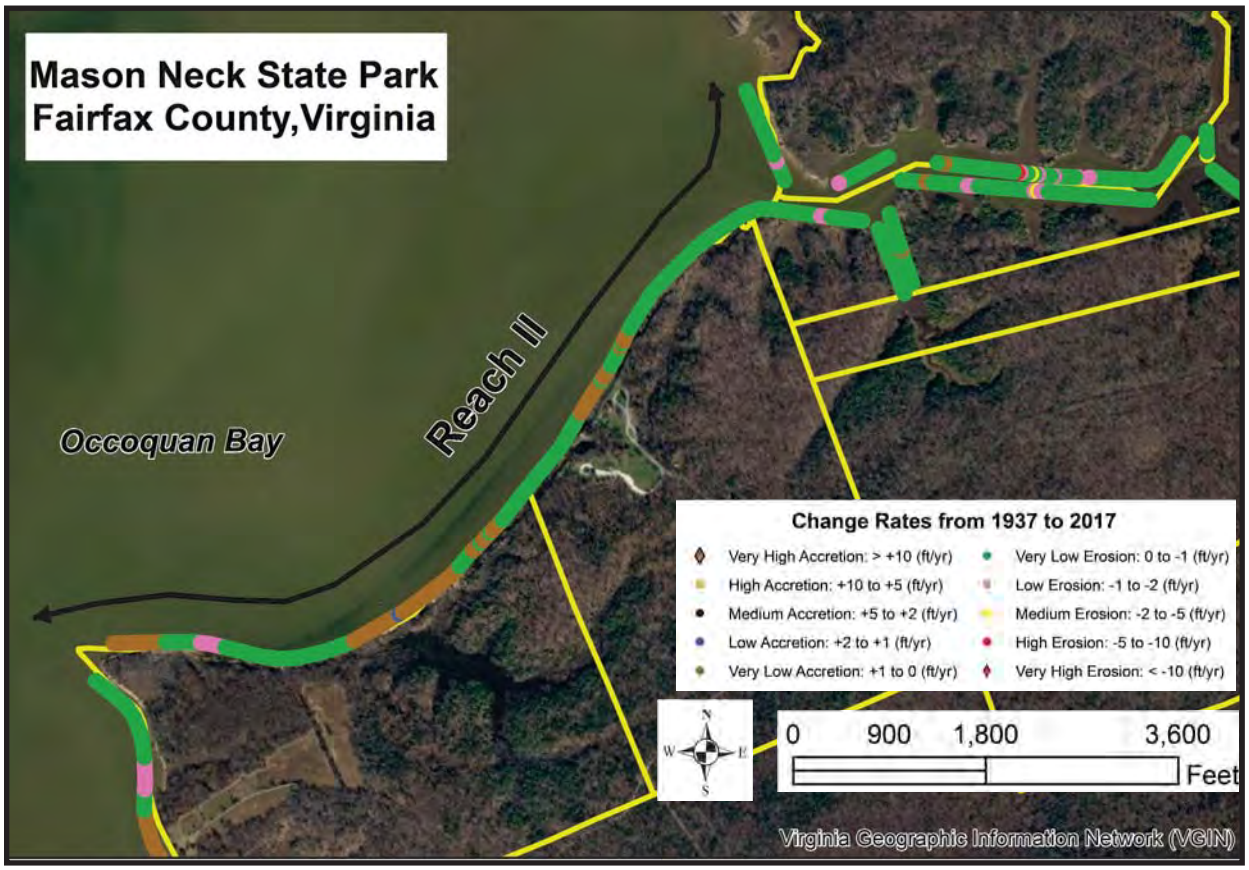
Reach 2

Bank Height

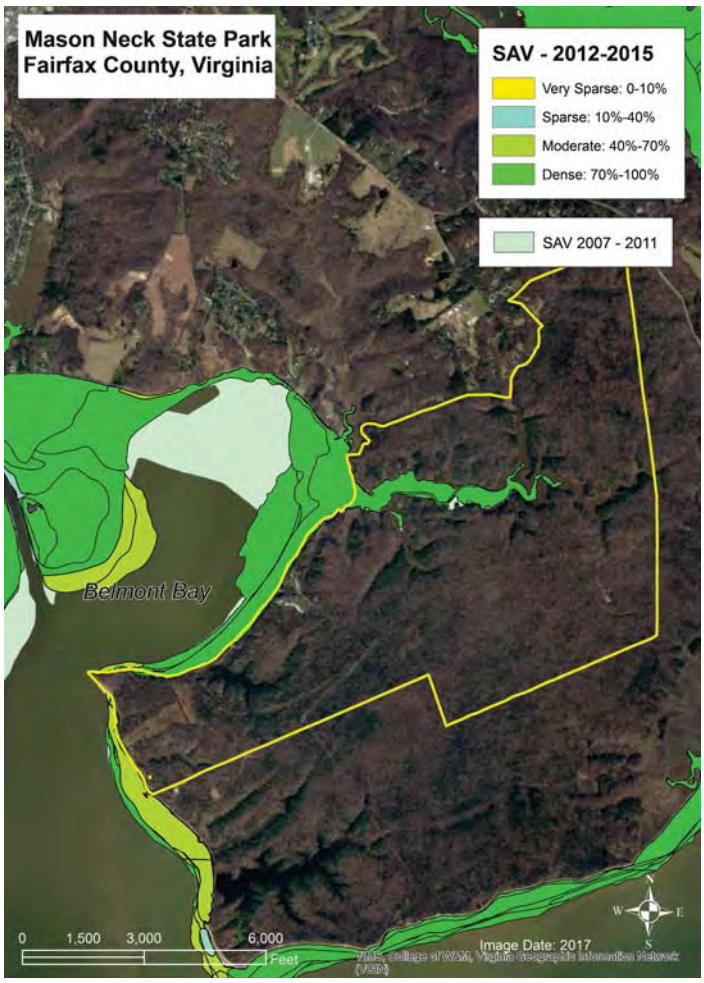


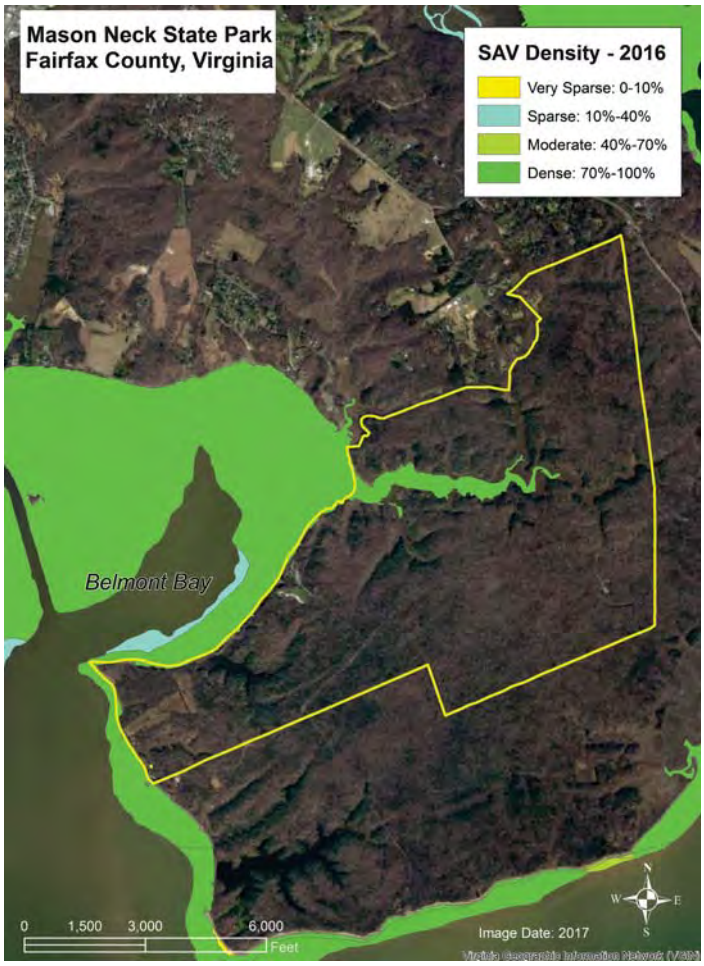
Mason Neck State Park
Fairfax County, Virginia





Mason Neck State Park
Fairfax County, Virginia





Middle Peninsula State Park
Gloucester County, Virginia

Location	37.33, -76.59
Shoreline length (miles)	0.4
Tide range (ft)	2.58

10% Annual Chance (10 year) MLW	6.40
2% Annual Chance (50 year) MLW	7.50
1% Annual Chance (100 year) MLW	8.00
0.2% Annual Chance (500 year) MLW	9.40
Wave Height (ft)	2.62
Peak Wave Period (sec)	3.02

	Reach 1	**Reach 2**	**Reach 3**
Waterbody	York River	York River	York River
Shoreline length per reach (ft)	390.0	1143.0	828.0
Average EPR			
1937-2017	-1.6	-0.7	-1.3
1937-1994	-1.7	-0.8	-1.0
1994-2017	-1.4	-0.3	-2.1
Avg. distance to 6ft contour (ft)	1,900	2,039	2,333
Average fetch (miles)	2.6		
Longest fetch (miles)	3.8		
Shore Direction of Face	Southwest		
SAV presence	No		

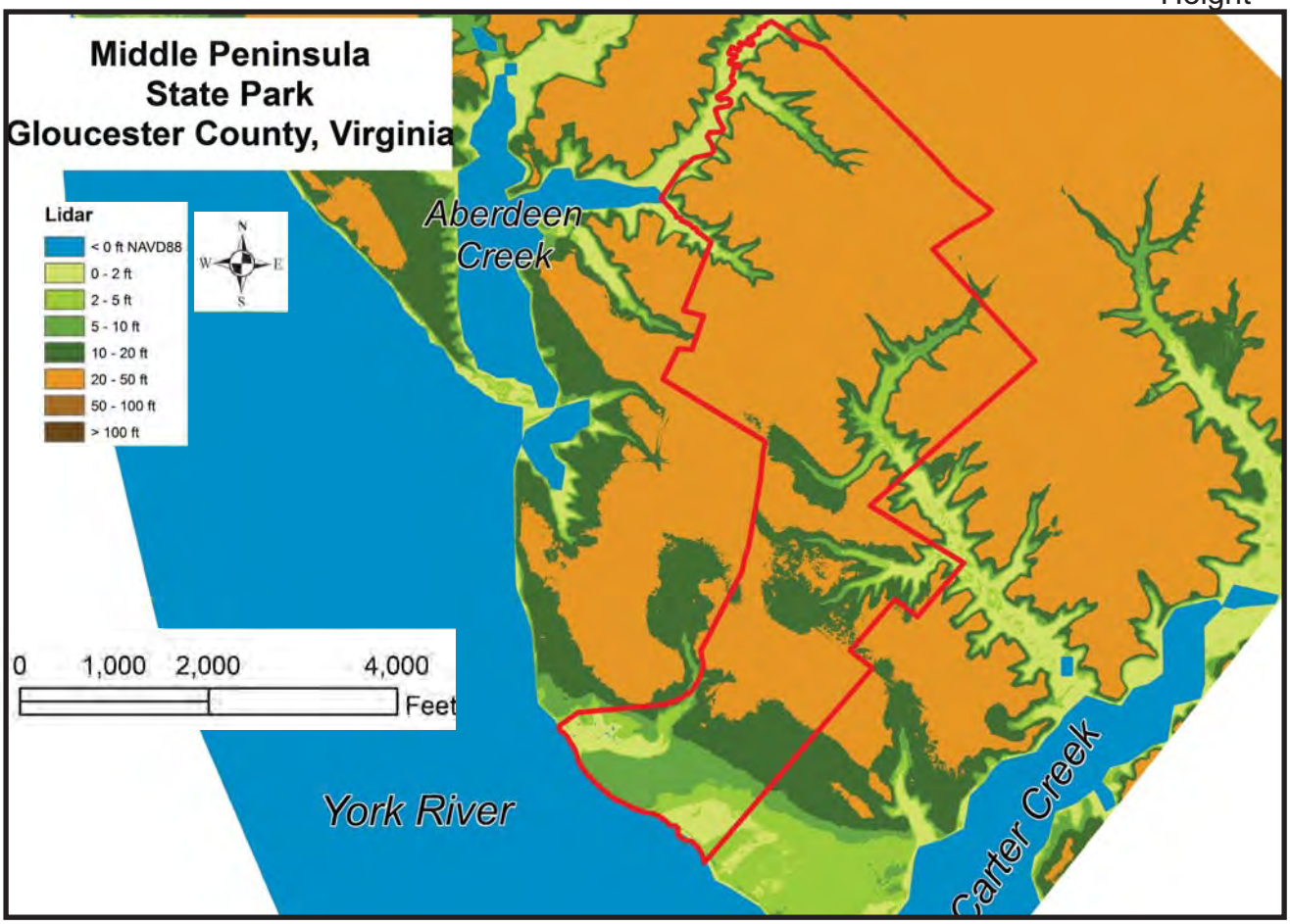
Middle Peninsula State Park
Gloucester County, Virginia

Reach 1

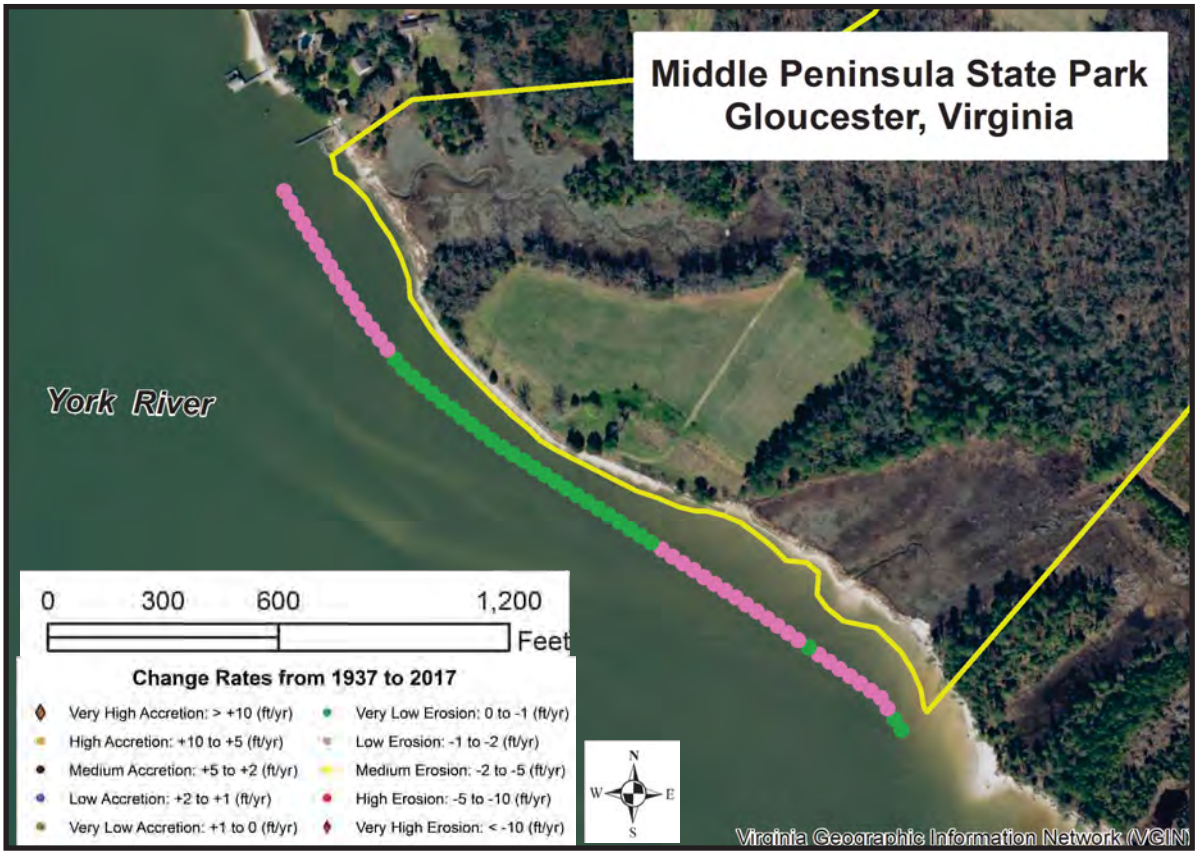
Reach 2

Reach 3

Bank Height



Middle Peninsula State Park
Gloucester County, Virginia



Westmoreland State Park
Westmoreland County, Virginia

Location	38.17, -76.87
Shoreline length (miles)	2.1
Tide range (ft)	1.58
2016 Attendance	245,588

10% Annual Chance (10 year) MLW	4.50
2% Annual Chance (50 year) MLW	5.80
1% Annual Chance (100 year) MLW	6.30
0.2% Annual Chance (500 year) MLW	7.30
Wave Height (ft)	6.09
Peak Wave Period (sec)	5.11

	Reach 1	**Reach 2**	**Reach 3**
Waterbody	Potomac River		
Shoreline length per reach (miles)	0.8	0.7	0.6
Average EPR			
1937-2017	-0.3	-0.6	-1.1
1937-1994	-0.8	-0.9	-1.2
1994-2017	0.9	0.2	-0.9
Avg. distance to 6ft contour (ft)	1267	598	1,106
Average fetch (miles)	8.2		
Longest fetch (miles)	12.2		
Shore Direction of Face	North		
SAV presence	No		

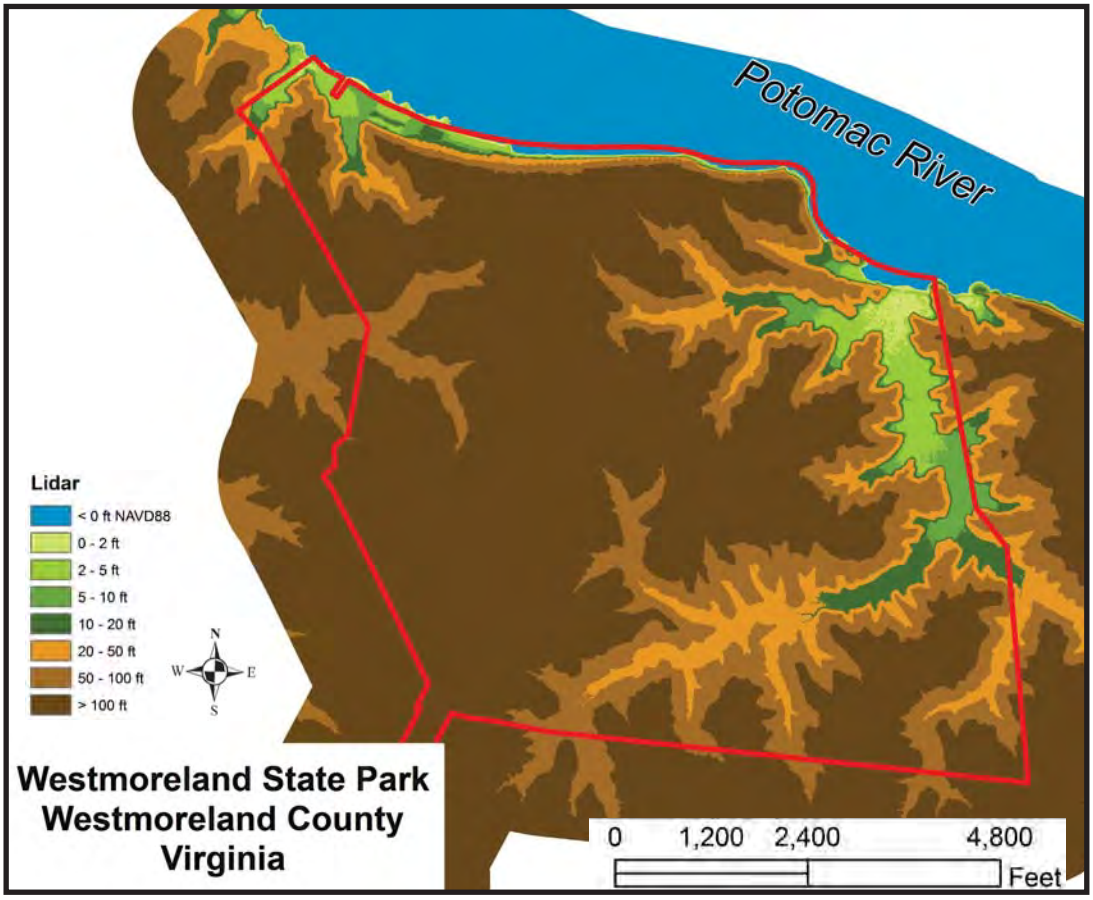
Westmoreland State Park
Westmoreland County, Virginia

Reach 1

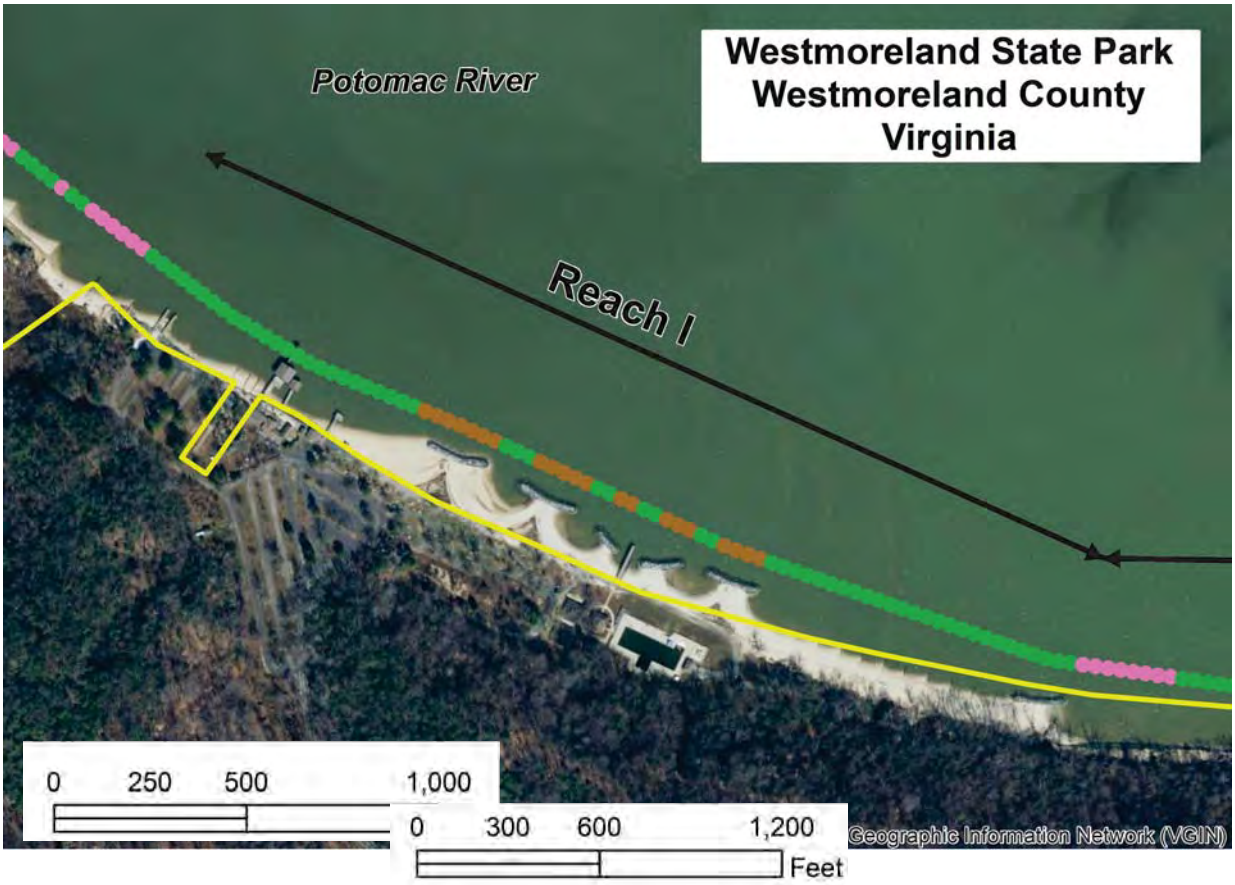
Reach 2

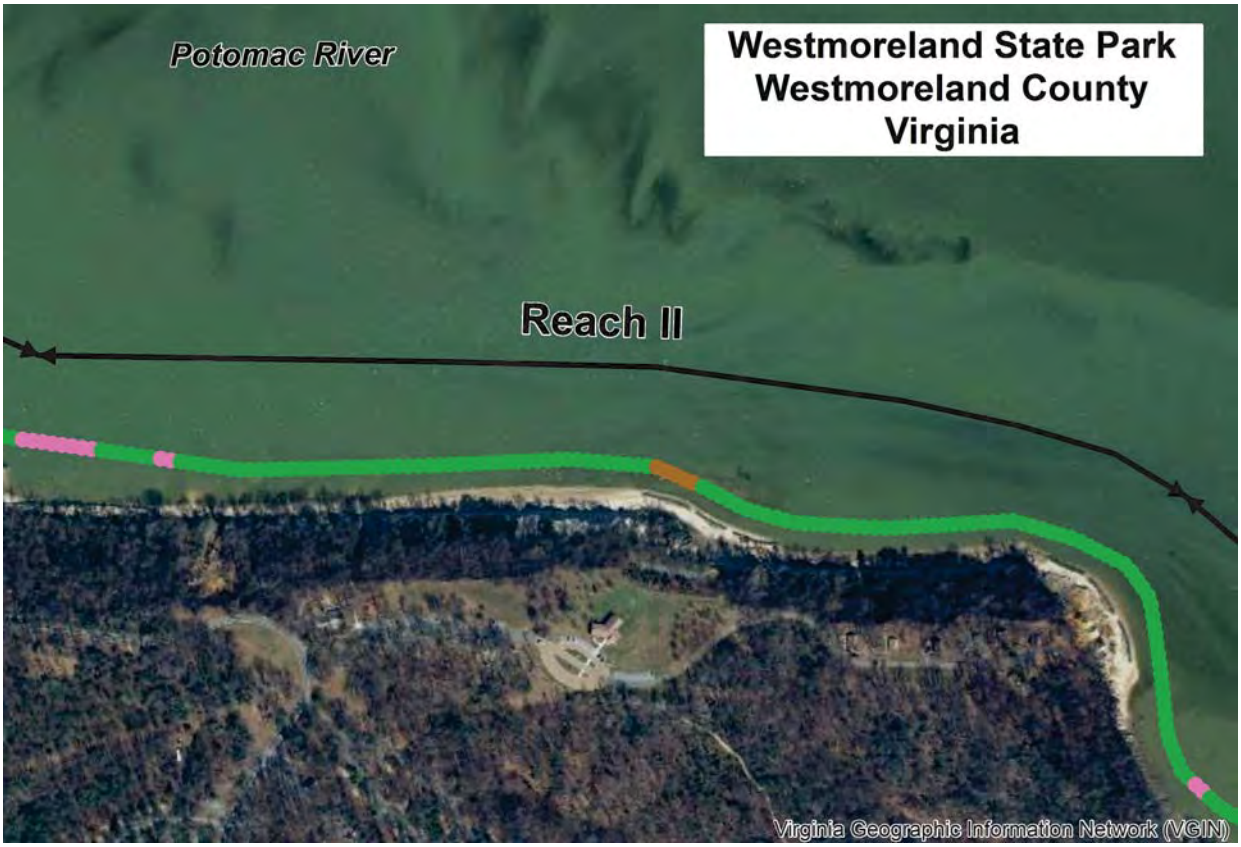
Reach 3

Bank Height

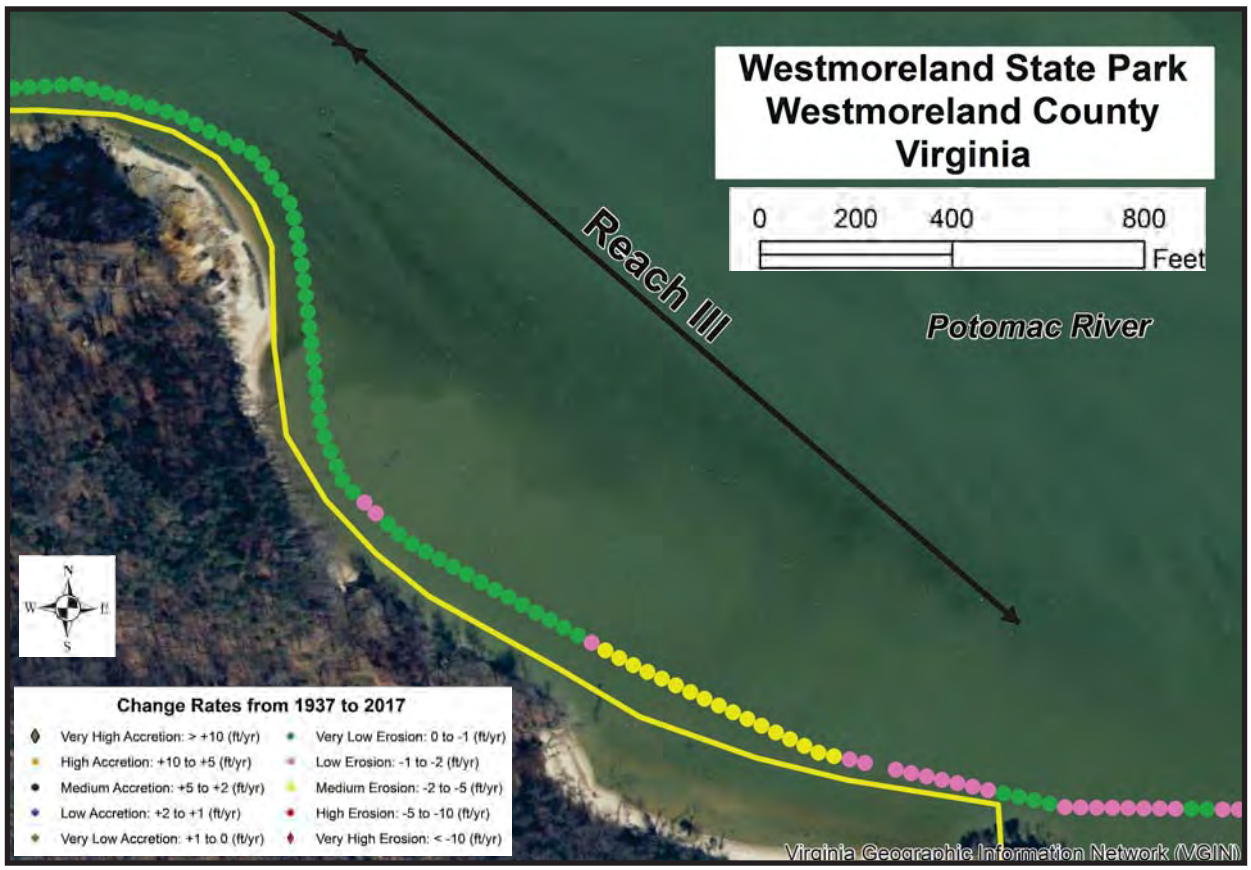


Westmoreland State Park
Westmoreland County, Virginia





Westmoreland State Park
Westmoreland County, Virginia



Widewater State Park
Stafford County, Virginia

	PotomacRiver	AquiaCreek
Location	38.42, -77.32	
Shoreline length (miles)	4.0	
Tide range (ft)	1.42	1.25

	PotomacRiver	AquiaCreek
10% Annual Chance (10 year) MLW	4.90	4.90
2% Annual Chance (50 year) MLW	6.30	6.30
1% Annual Chance (100 year) MLW	6.80	6.80
0.2% Annual Chance (500 year) MLW	7.90	7.90
Wave Height (ft)	4.50	1.90
Peak Wave Period (sec)	4.40	3.20

	Reach 1	**Reach 2**	**Reach 3**	**Reach 4**	**Reach 5**
Waterbody	Potomac River			Aquia Creek	
Shoreline length per reach (miles)	0.4	1.4	0.2	0.5	1.4
Average EPR					
1937-2017	-6.8	-1.3	-0.6	0.1	-0.9
1937-1994	-6.7	-1.4	-0.5	0.5	-0.9
1994-2017	-7.1	-1.0	-0.8	-0.7	-0.9
Avg. distance to 6ft contour (ft)	1,108	1,504	1,769	N/A	N/A
Average fetch (miles)	4.2			0.8	1.2
Longest fetch (miles)	5.9			1.0	2.6
Shore Direction of Face	East	East	East	South	South
SAV presence	Yes				

Widewater State Park
Stafford County, Virginia

Reach 1

Reach 2

Reach 3

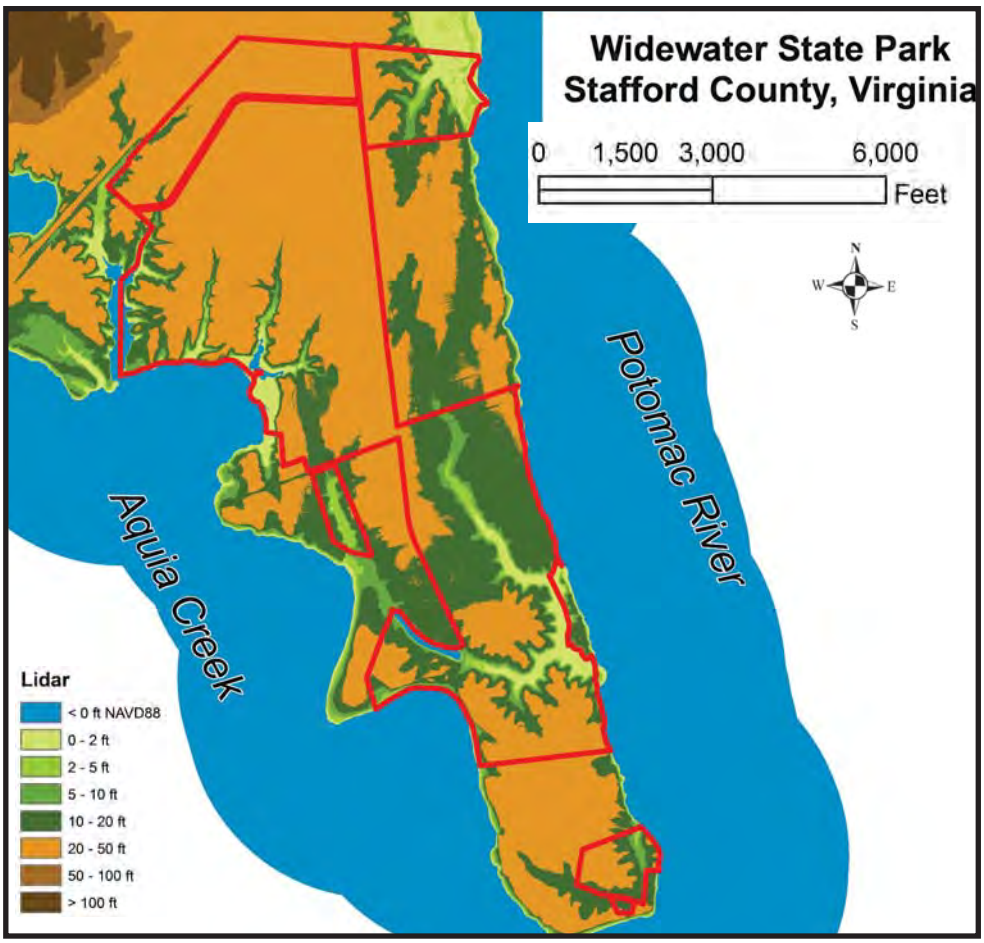
Reach 4

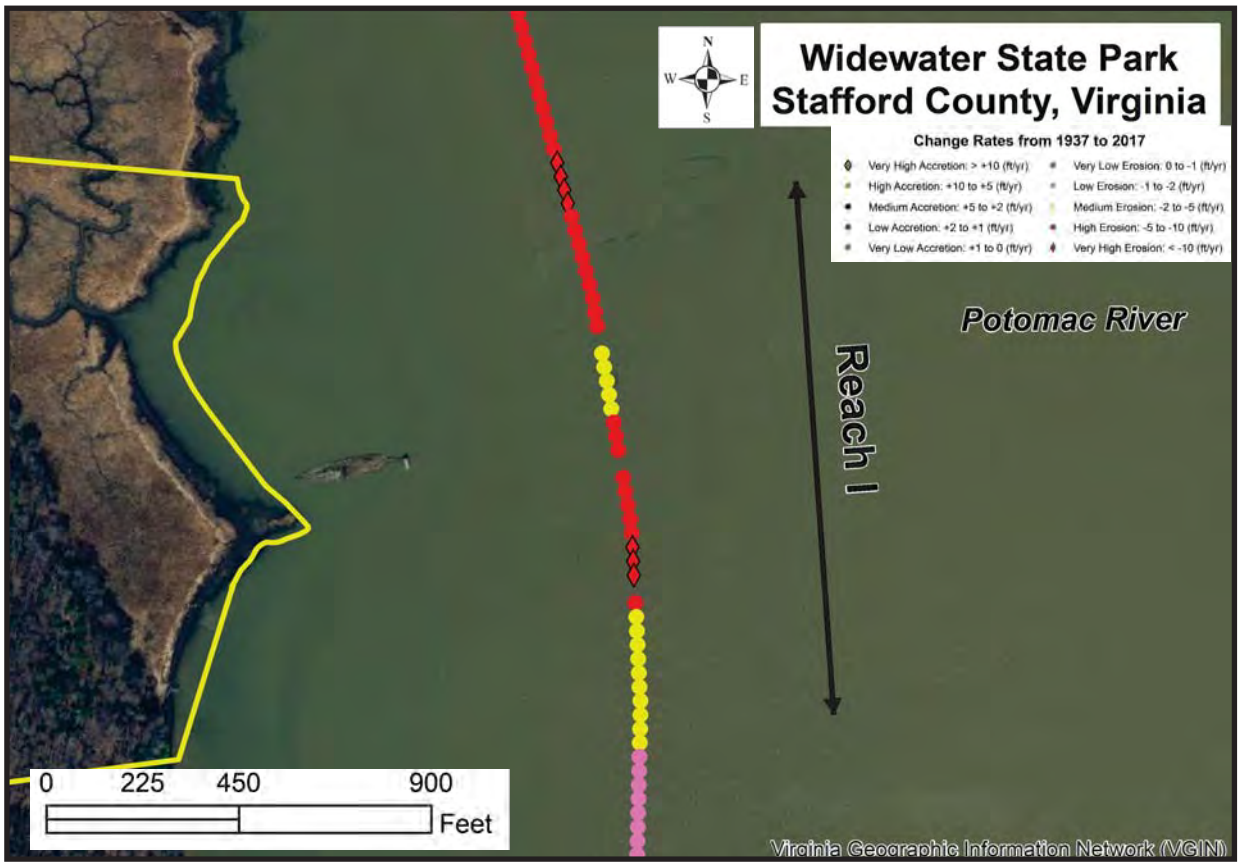
Reach 5

Reach 5

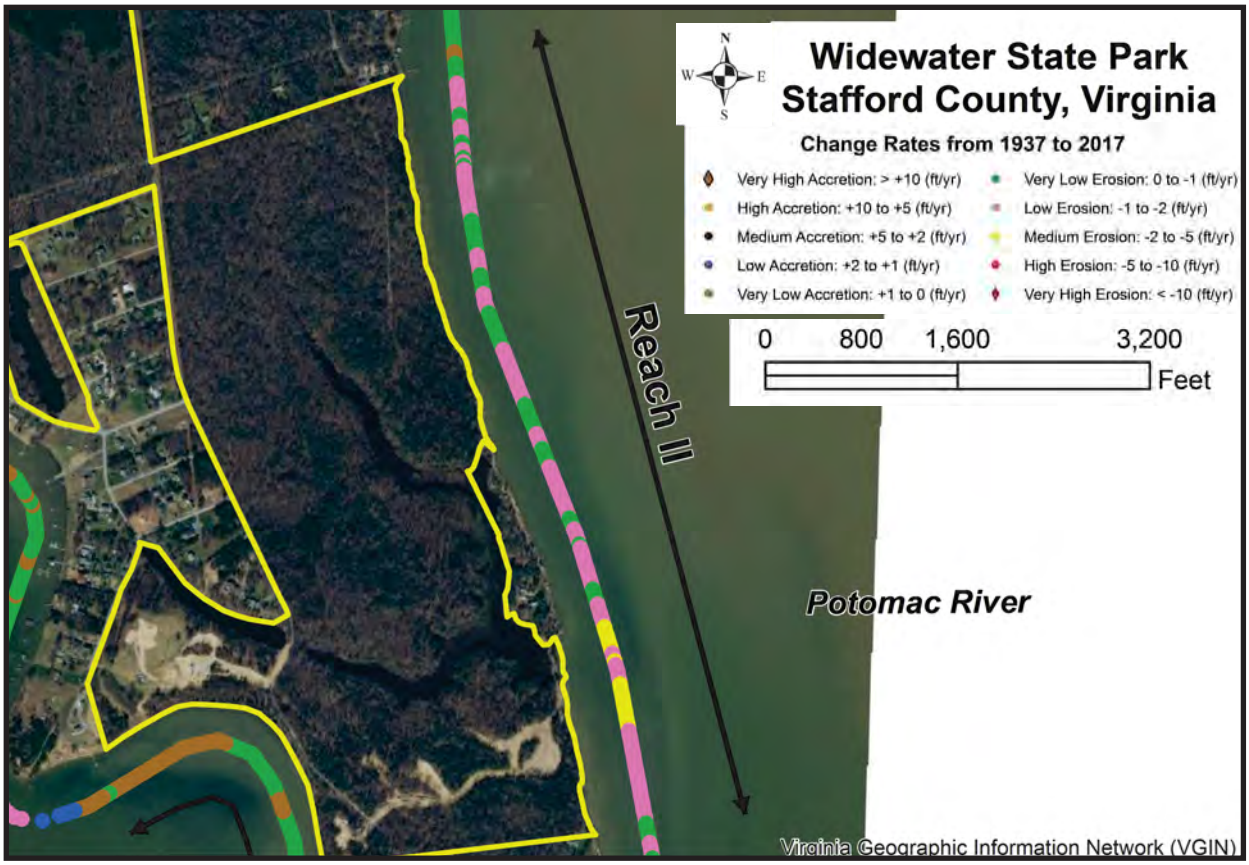
Widewater State Park
Stafford County, Virginia

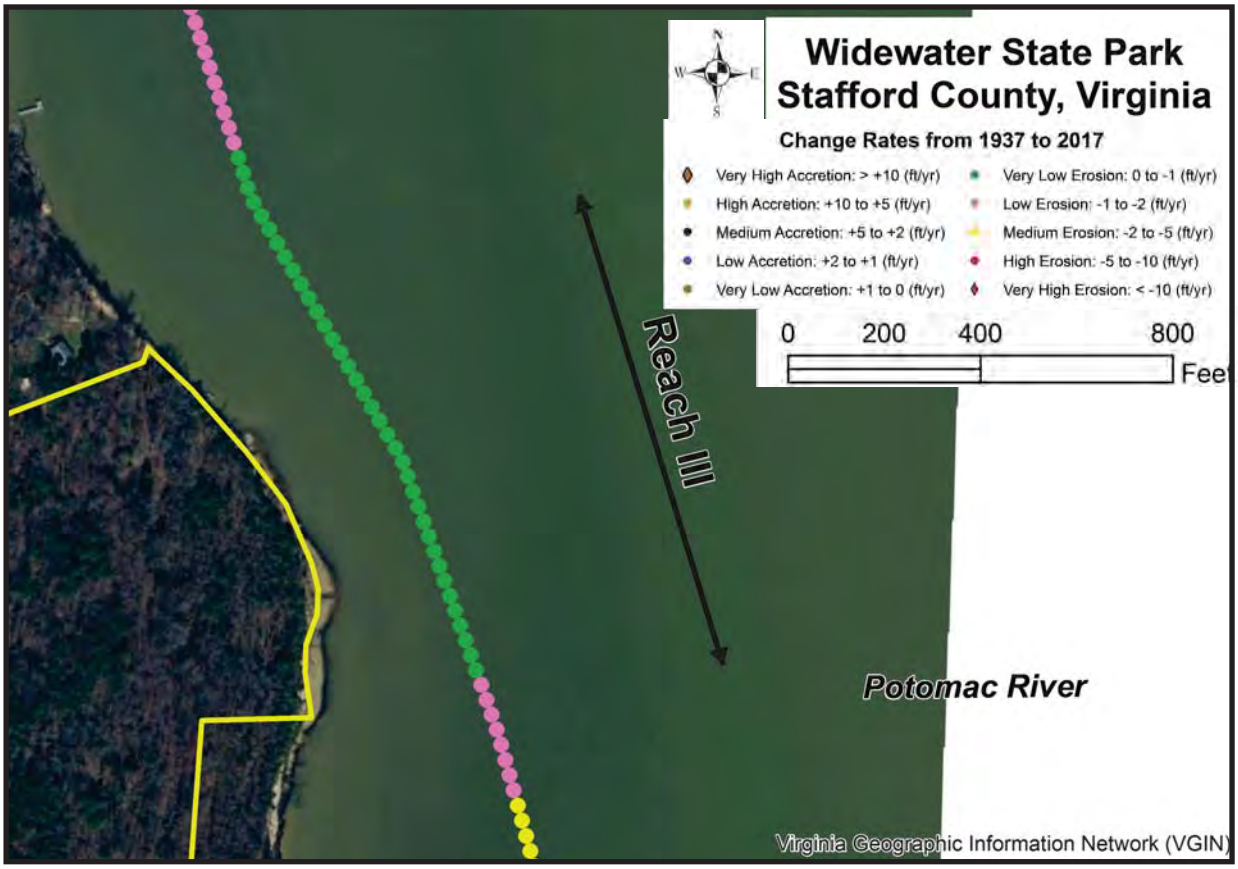
Bank Height



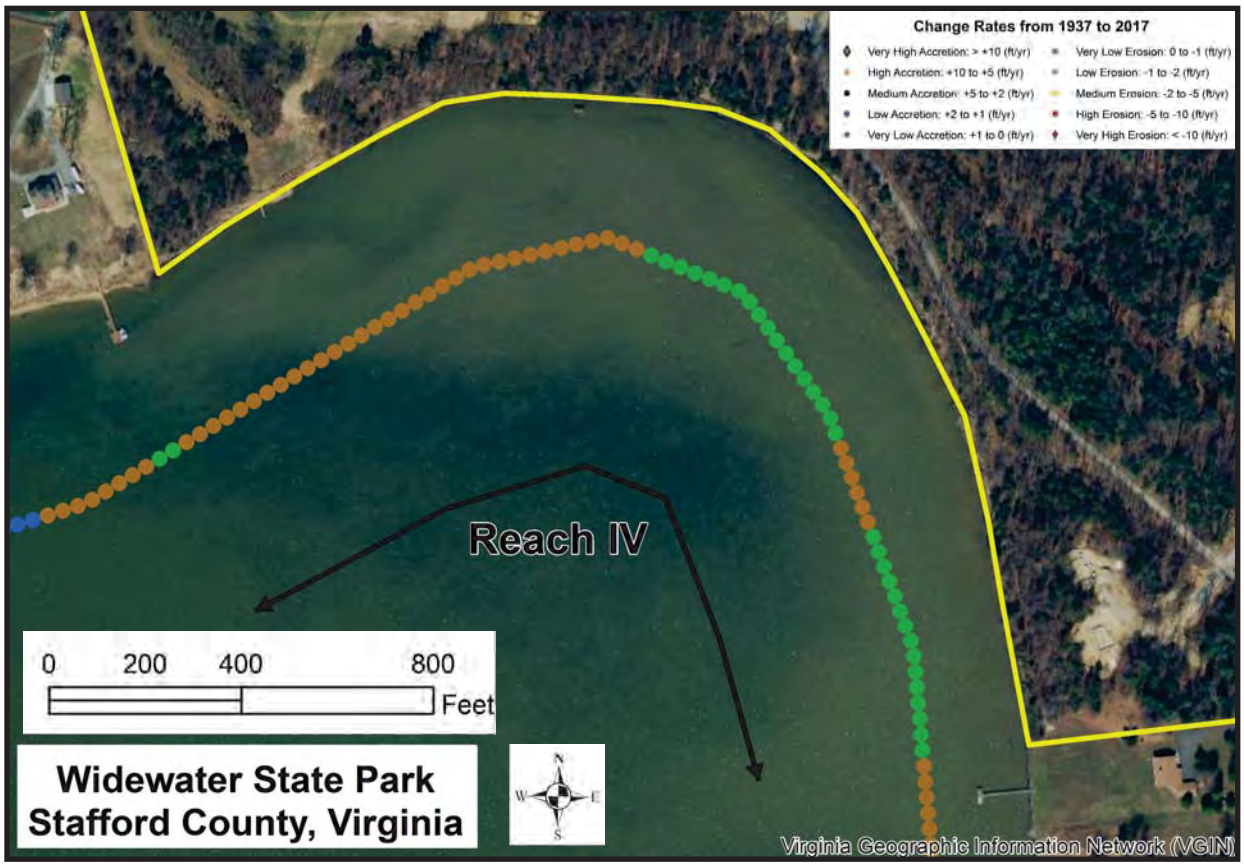


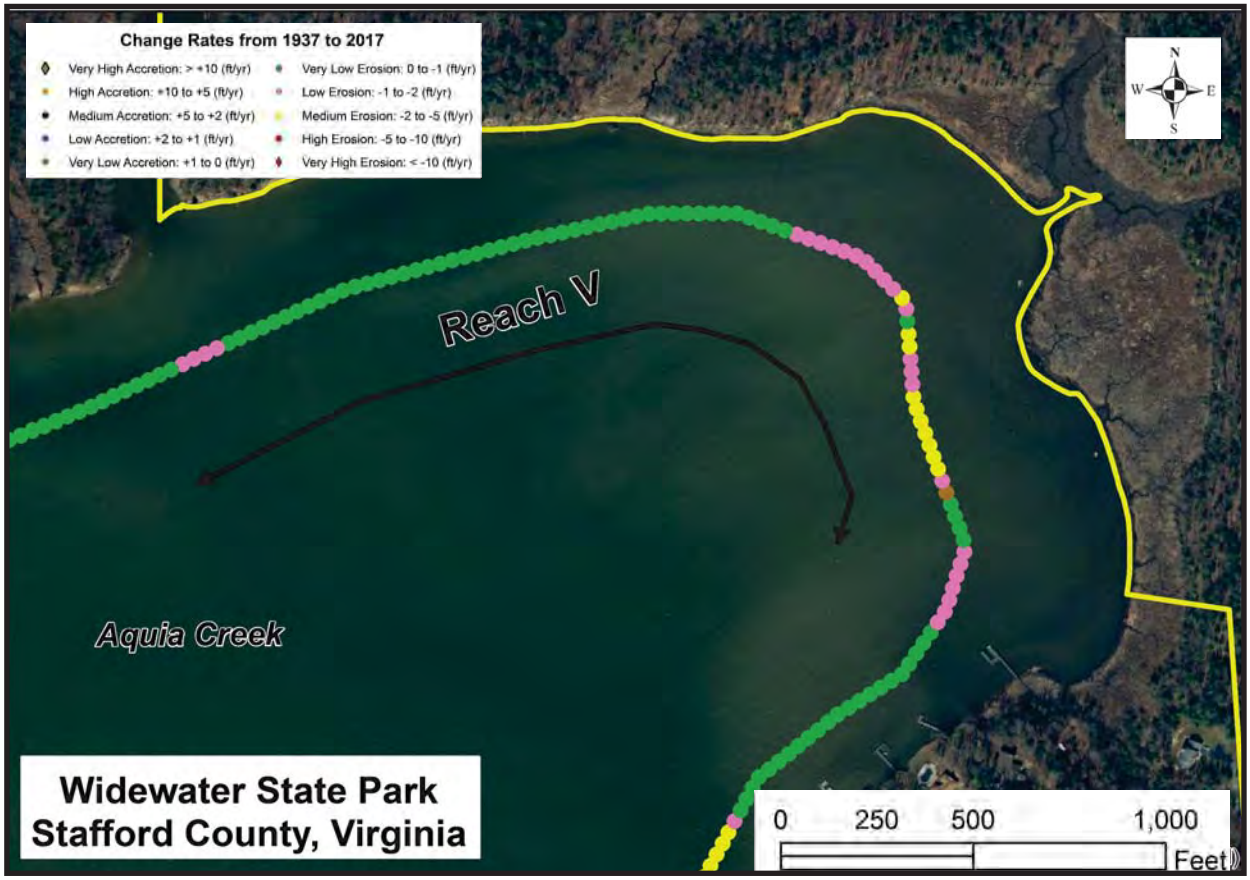
Widewater State Park
Stafford County, Virginia



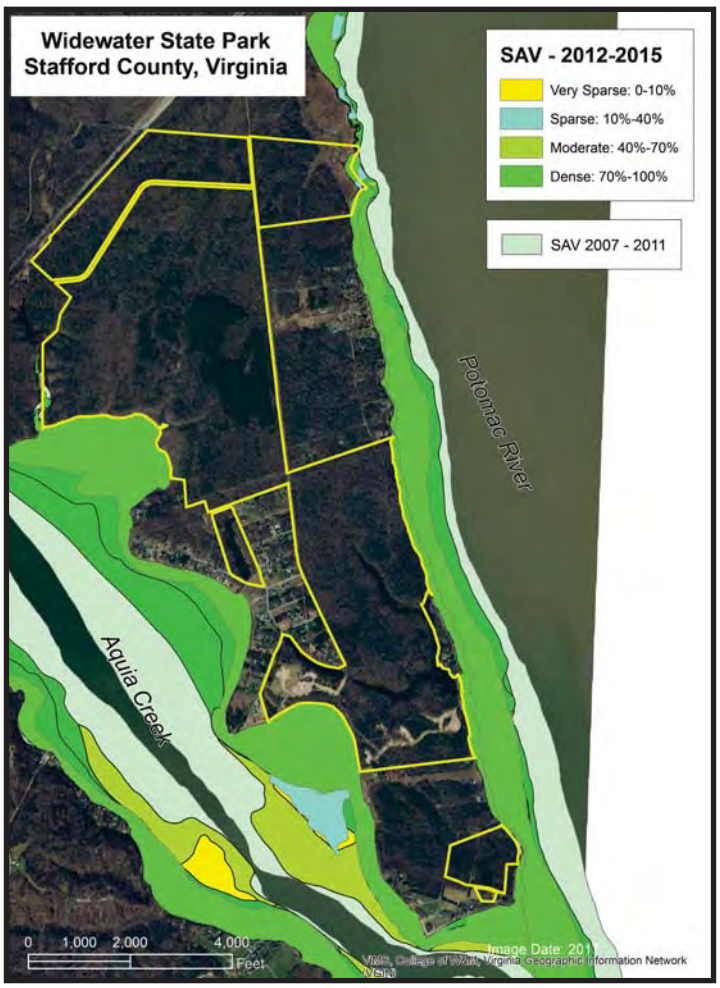


Widewater State Park
Stafford County, Virginia





Widewater State Park
Stafford County, Virginia



York River State Park
James City County, Virginia

Location	37.41, -76.71
Shoreline length (miles)	4.7
Tide range (ft)	2.75
2016 Attendance	125,947

10% Annual Chance (10 year) MLW	6.90
2% Annual Chance (50 year) MLW	8.00
1% Annual Chance (100 year) MLW	8.40
0.2% Annual Chance (500 year) MLW	10.10
Wave Height (ft)	4.60
Peak Wave Period (sec)	3.20

	Reach 1	**Reach 2**	**Reach 3**
Waterbody	York River		
Shoreline length per reach (miles)	1.4	1.6	2.0
Average EPR			
1937-2017	-1.8	-1.9	-2.2
1937-1994	-1.6	-1.7	-1.9
1994-2017	-2.9	-2.4	-2.8
Avg. distance to 6ft contour (ft)	2,961	3,015	1,957
Average fetch (miles)	1.8		
Longest fetch (miles)	2.6		
Shore Direction of Face	Northeast		
SAV presence	No		

York River State Park
James City County, Virginia

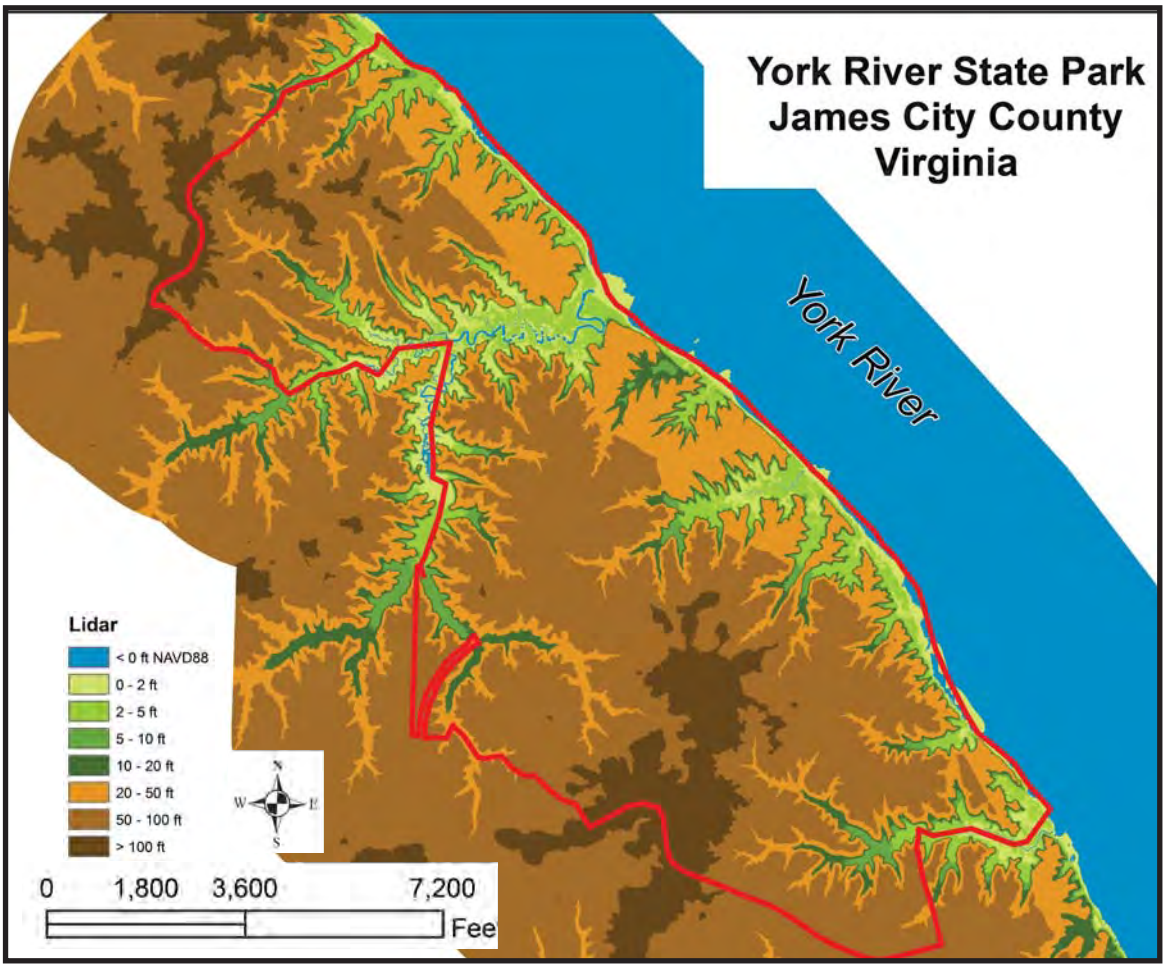
Reach 1

Reach 2

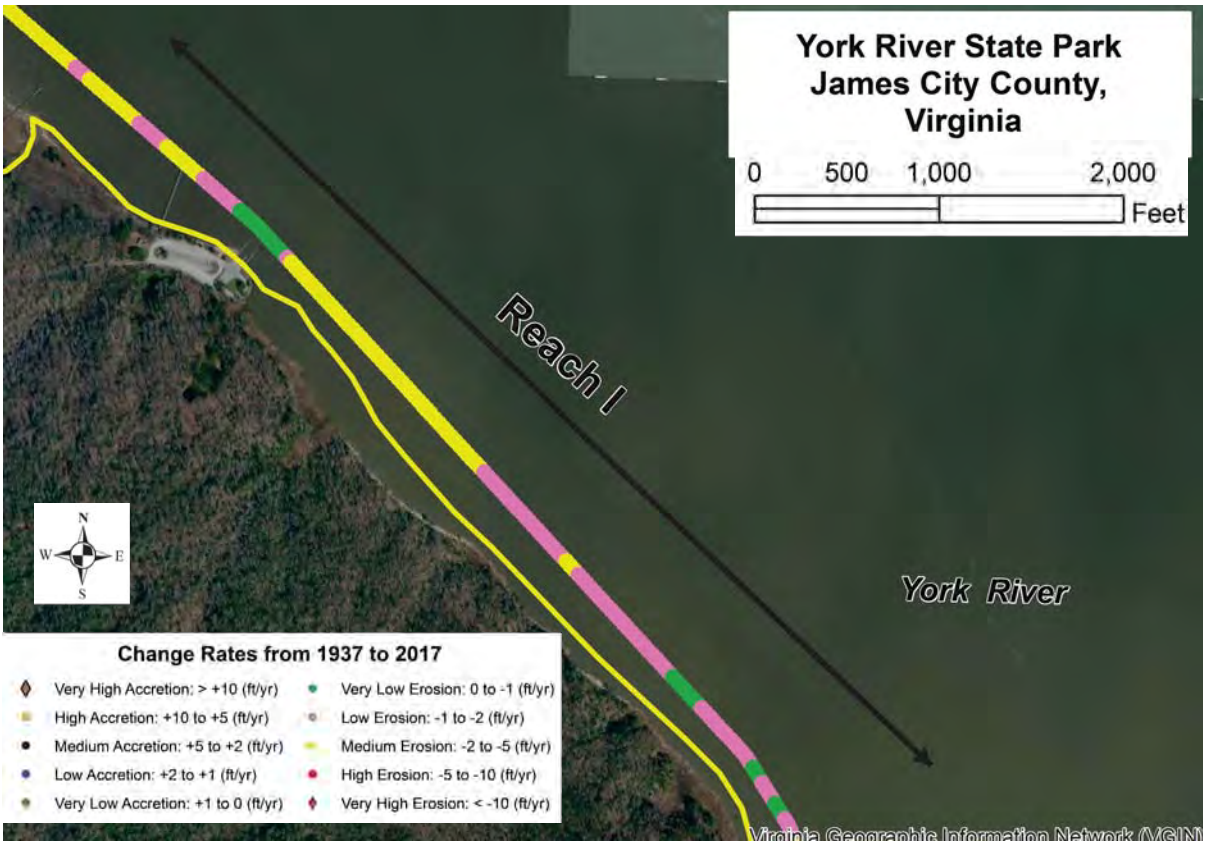
Reach 2

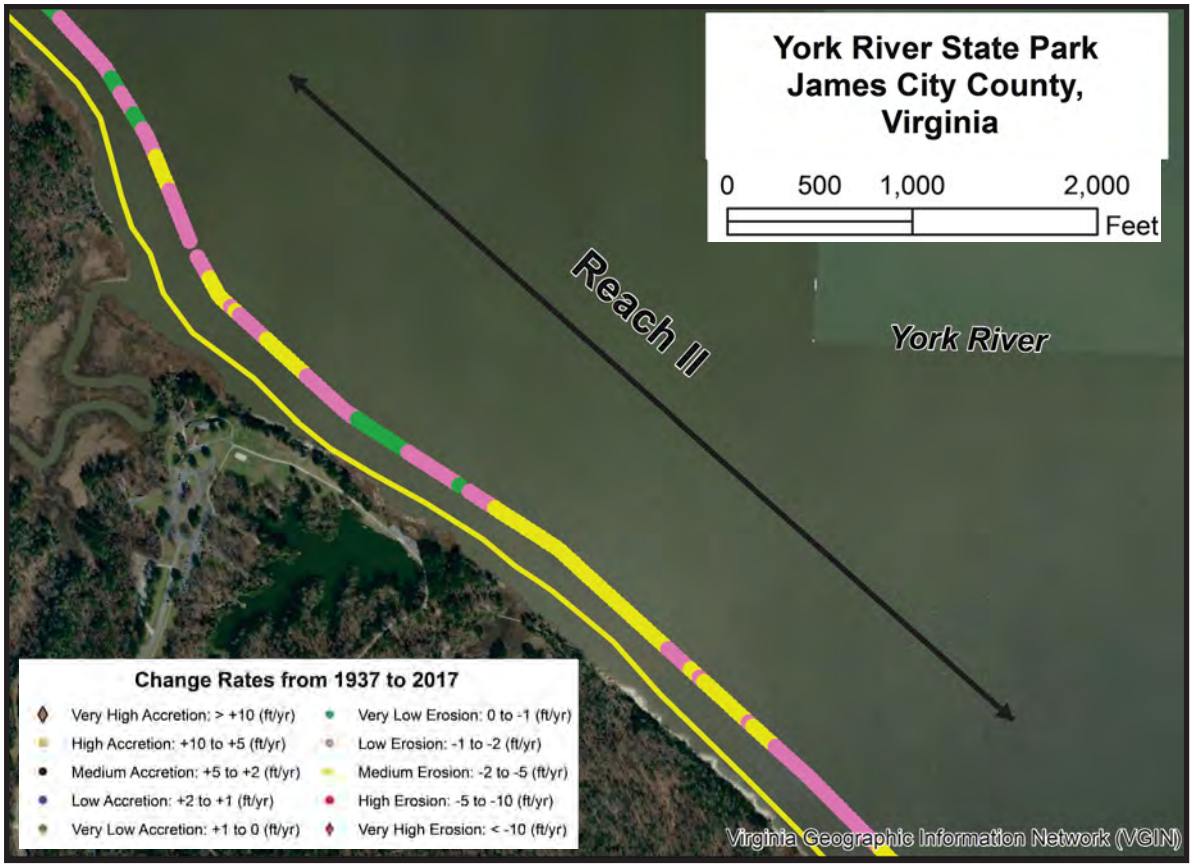
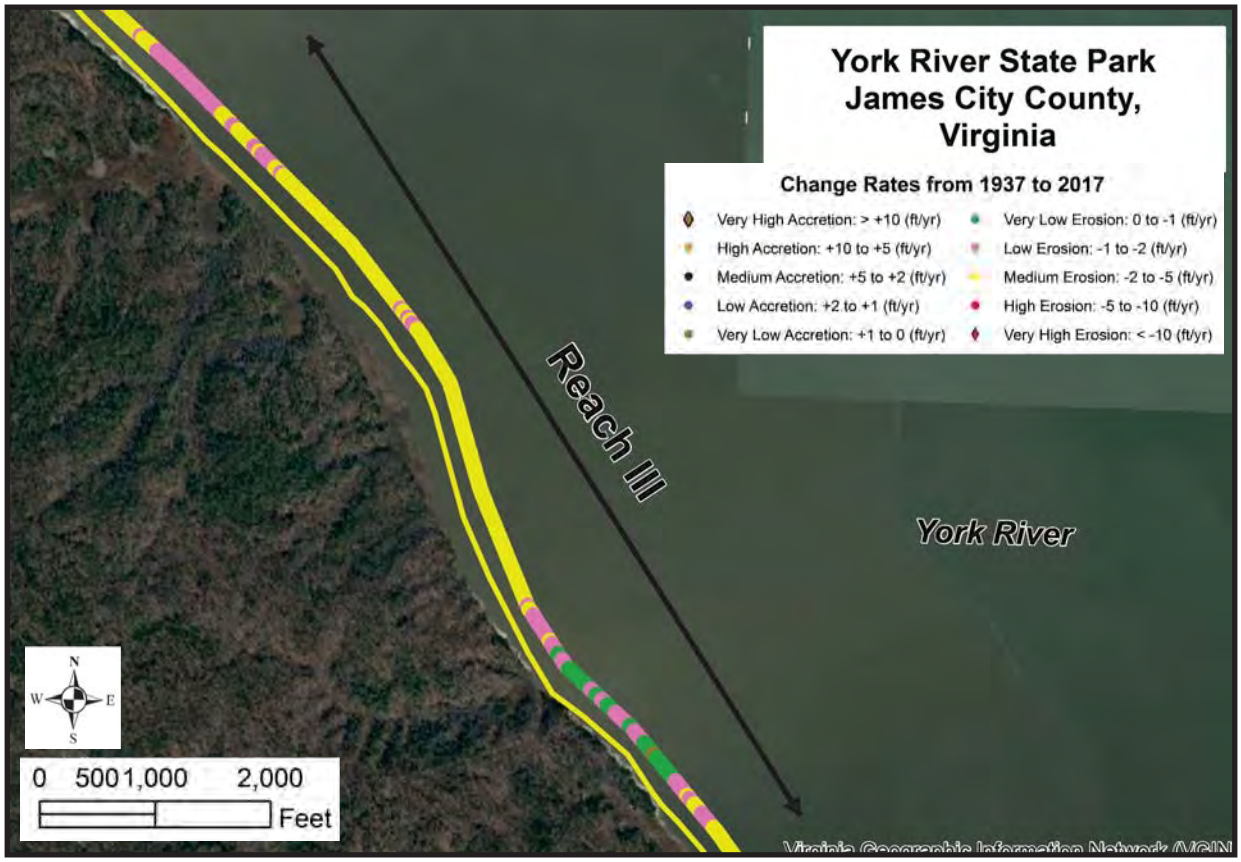
Reach 3

Bank Height



York River State Park
James City County, Virginia





York River State Park
James City County, Virginia