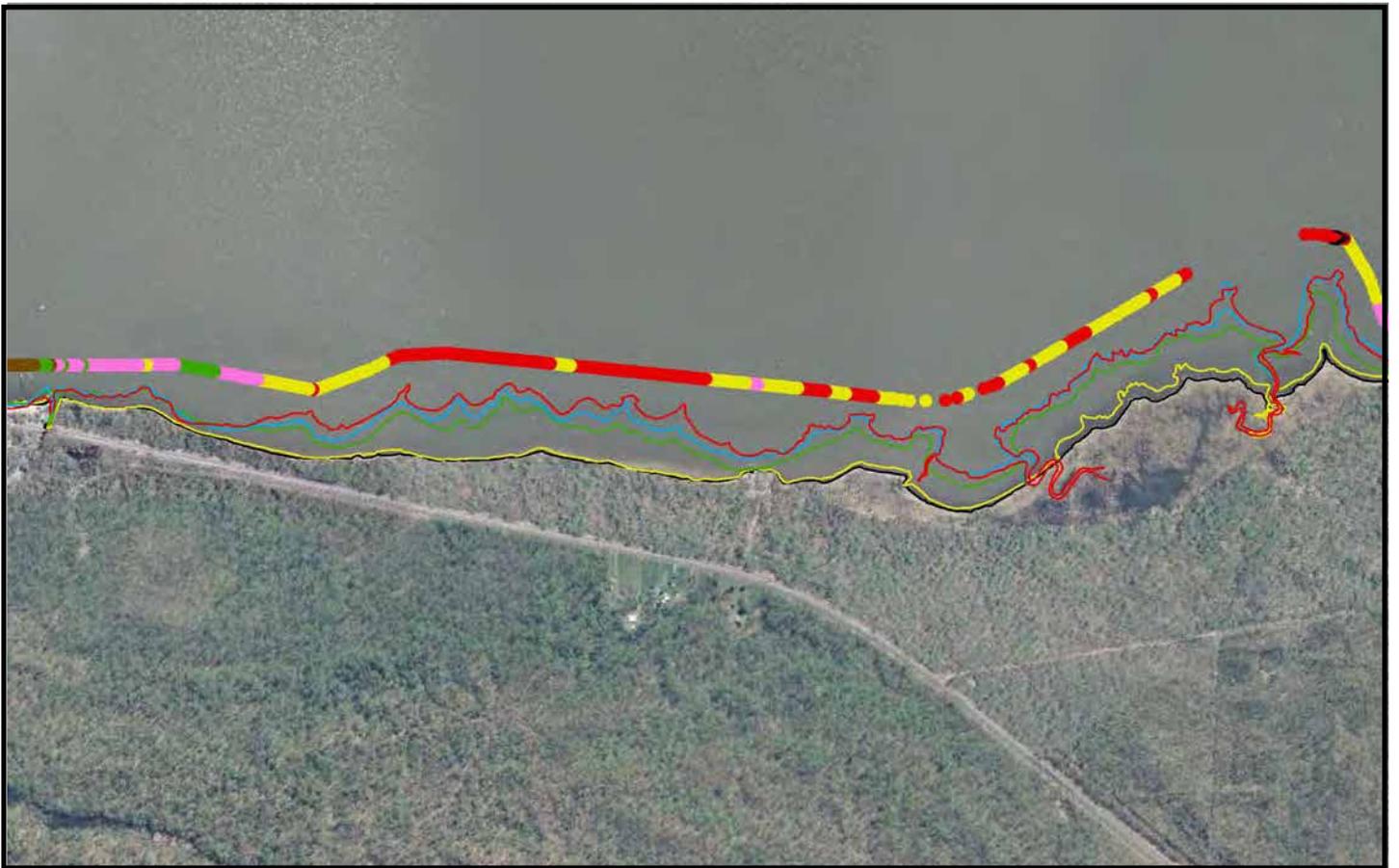


# Shoreline Evolution: Stafford County, Virginia

## Potomac River and Rappahannock River Shorelines



Shoreline Studies Program  
Virginia Institute of Marine Science  
College of William & Mary  
Gloucester Point, Virginia

September 2015

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## Data Summary Report

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**September 2015**

## Table of Contents

1	Introduction.....	1
2	Methods	
	2.1 Photo Rectification and Shoreline Digitizing.....	2
	2.2 Rate of Change Analysis.....	4
3	Results and Summary.....	5
4	Summary.....	8
5	References.....	8

Appendix A. End Point Rate of Shoreline Change Maps

Appendix B. Historical Photo and Digitized Shoreline Maps

## List of Figures

Figure 1. Location of Stafford County in the Chesapeake Bay estuarine system.....	1
Figure 2. The 2009 and 2013 VBMP images showing issues that impacted digitizing of the shoreline.....	3
Figure 3. Plate index for Stafford County's Potomac River shorelines.....	6
Figure 4. Plate index for Stafford County's Rappahannock River shorelines.....	7

## List of Tables

Table 1. Average end point rates of shoreline change in feet per year along sections of Stafford County's coast. ....	8
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# 1 Introduction

Stafford County is situated along the upper reaches of the Potomac and Rappahannock Rivers (Figure 1). Because the County's shoreline is continually changing, determining where the shoreline was in the past, how far and how fast it is moving, and what factors drive shoreline change will help define where the shoreline will be going in the future. These rates and patterns of shore change along Chesapeake Bay's estuarine shores will differ through time as winds, waves, tides and currents shape and modify coastlines by eroding, transporting and depositing sediments.

The purpose of this report is to document how the shore zone of Stafford County has evolved since 1937. Aerial imagery was taken for most of the Bay region beginning that year and can be used to assess the geomorphic nature of shore change. Aerial photos show how the coast has changed, how beaches, dunes, bars, and spits have grown or decayed, how barriers have breached, how inlets have changed course, and how one shore type has displaced another or has not changed at all. Shore change is a natural process but, quite often, the impacts of man, through shore hardening or inlet stabilization, come to dominate a given shore reach. In addition to documenting historical shorelines, the change in shore positions along the larger creeks in Stafford County will be quantified in this report. The shorelines of very irregular coasts, small creeks and around inlets, and other complicated areas will be shown but not quantified.

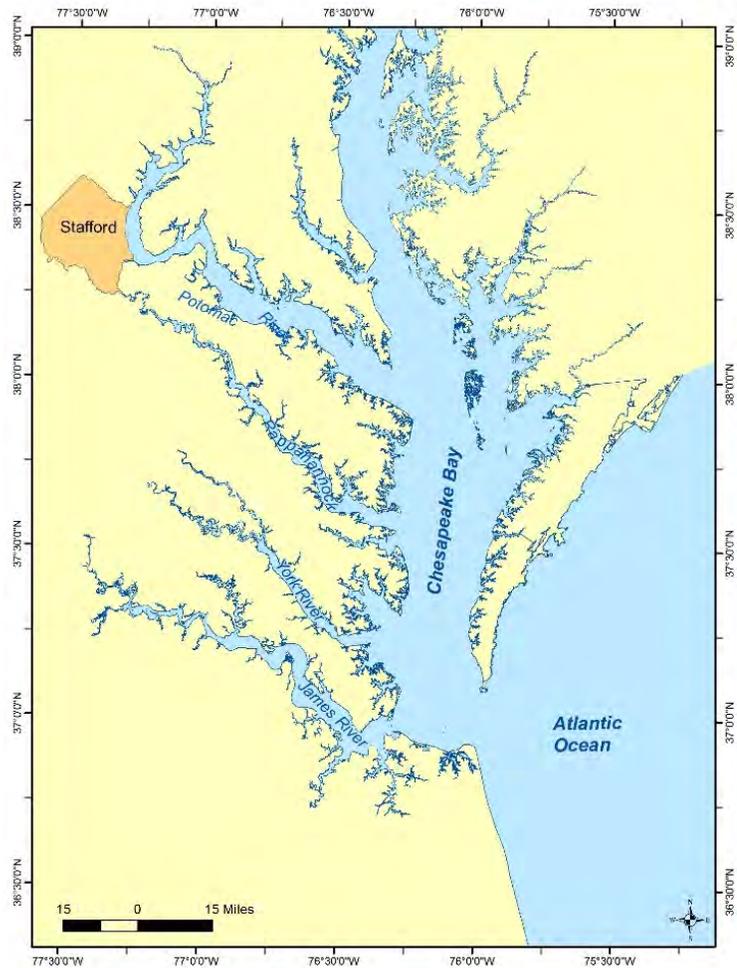


Figure 1. Location of Stafford County within the Chesapeake Bay system.

## 2 Methods

### 2.1 Photo Rectification and Shoreline Digitizing

An analysis of aerial photographs provides the historical data necessary to understand the suite of processes that work to alter a shoreline. Images of the Stafford County Shoreline from 1937, 1953, 1967, 1994, 2002, and 2009, and 2013 were used in the analysis. The 1994, 2002, 2009, and 2013 images were available from other sources. The 1994 imagery was orthorectified by the U.S. Geological Survey (USGS) and the 2002, 2009, and 2013 imagery was orthorectified by the Virginia Base Mapping Program (VBMP). The 1937, 1953, and 1967 photos are part of the VIMS Shoreline Studies Program archives. The historical aerial images used to analyze the entire County shoreline were not always flown on the same day. The exact dates that the 1994 images were flown could not be ascertained; however, the dates for the other years are as follows:

1937: March 3 and May 31;

1953: March 29, Dec 8 and Dec 18;

1967: Oct 20;

2002: Feb 24, 28 and March 10 and 11;

2009: Feb 7, 21, 25;

2013: March 24 and April 14.

The 1937, 1953, and 1967 images were scanned as tiffs at 600 dpi and converted to ERDAS IMAGINE (.img) format. These aerial photographs were orthographically corrected to produce a seamless series of aerial mosaics following a set of standard operating procedures. The 1994 Digital Orthophoto Quarter Quadrangles (DOQQ) from USGS were used as the reference images. The 1994 photos are used rather than higher quality, more recent aeriels because of the difficulty in finding control points that match the earliest 1937 images.

ERDAS Orthobase image processing software was used to orthographically correct the individual flight lines using a bundle block solution. Camera lens calibration data were matched to the image location of fiducial points to define the interior camera model. Control points from 1994 USGS DOQQ images provide the exterior control, which is enhanced by a large number of image-matching tie points produced automatically by the software. The exterior and interior models were combined with a digital elevation model (DEM) from the USGS National Elevation Dataset to produce an orthophoto for each aerial photograph. The orthophotographs were adjusted to approximately uniform brightness and contrast and were mosaicked together using the ERDAS Imagine mosaic tool to produce a one-meter resolution mosaic .img format. To maintain an accurate match with the reference images, it is necessary to distribute the control points evenly, when possible. This can be challenging in

areas given the lack of ground features and poor photo quality on the earliest photos. Good examples of control points were manmade features such as road intersections and stable natural landmarks such as ponds and creeks that have not changed much over time. The base of tall features such as buildings, poles, or trees can be used, but the base can be obscured by other features or shadows making these locations difficult to use accurately. Some areas of the County were difficult to rectify, either due to the lack of development when compared to the reference images or due to no development in the historical and the reference images.

Once the aerial photos were orthorectified and mosaicked, the shorelines were digitized in ArcMap with the mosaics in the background. The morphologic toe of the beach or edge of marsh was used to approximate low water. High water limit of runup can be difficult to determine on some shorelines due to narrow or non-existent beaches against upland banks or vegetated cover. The feature digitized is noted in the 2009 shoreline attributes in the GIS file. Eighty three miles of shoreline were digitized from the 2009 photos. However, not all tidal shoreline was digitized inside very small creeks and marshes. Poor quality photos in some areas made rectifying and digitizing images difficult.

Environmental conditions along the shoreline made it difficult to delineate the shoreline even on the latest photos. In some areas, it was difficult to tell the difference between marsh and tidal flats. The 2009 images have ice along the shoreline that can make digitizing problematic (Figure 2A). Tidal differences between when the latest photos



Figure 2. The 2009 and 2013 VBMP images showing issues that impacted digitizing of the shoreline.

made direct comparison of digitized shorelines difficult. In particular, the 2013 photos seem to have been flown at high tide. Under high tide conditions the toe of the beach or edge of marsh are not always visible (Figure 2B). In areas where the shoreline was not clearly identifiable on the aerial photography, the location was estimated based on the experience of the digitizer. The displayed shorelines are in shapefile format. One shapefile was produced for each year that was mosaicked.

Horizontal positional accuracy is based upon orthorectification of scanned aerial photography against the USGS digital orthophoto quadrangles. For vertical control, the USGS 30m DEM data was used. The 1994 USGS reference images were developed in accordance with National Map Accuracy Standards (NMAS) for Spatial Data Accuracy at the 1:12,000 scale. The 2002 and 2009 Virginia Base Mapping Program's orthophotography were developed in accordance with the National Standard for Spatial Data Accuracy (NSSDA). Horizontal root mean square error (RMSE) for historical mosaics was held to less than 20 ft.

## 2.2 Rate of Change Analysis

AMBUR (Analyzing Moving Boundaries Using R) is a suite of tools that are used to better analyze and understand historic shoreline changes. These tools use the free, open-source R software environment and can be customized to perform not only advanced statistics but also geospatial and geostatistical functions. The AMBUR package provides tools for investigating diverse shoreline types through: multiple shoreline settings, improved transect casting methods, and detailed analysis and output. The package allows import and export of geospatial data in ESRI shapefile format, which is compatible with most commercial and open-source GIS software. The "baseline and transect" method is the primary technique used to quantify distances and rates of shoreline movement, and to detect classification changes across time.

Forty six miles of baselines and 6,760 transects about 30 feet apart were created for Stafford County. Baselines were digitized slightly seaward of the 1937 shoreline and encompassed most of the County's coast. The baselines may not include very small creeks and areas that have unique shoreline morphology such as creek mouths and spits.

The End Point Rate (EPR) is calculated by determining the distance between the oldest and most recent shoreline in the data and dividing it by the number of years between them. This method provides an accurate net rate of change over the long term and is relatively easy to apply to most shorelines since it only requires two dates. This method does not use the intervening shorelines so it may not account for changes in accretion or erosion rates that may occur through time. However, Milligan *et al.* (2010a, 2010b, 2010c,

2010d) found that in several localities within the bay, EPR is a reliable indicator of shore change even when intermediate dates exist.

Using methodology reported in Morton *et al.* (2004) and National Spatial Data Infrastructure (1998), estimates of error in orthorectification, control source, DEM and digitizing were combined to provide an estimate of total maximum shoreline position error. The data sets that were orthorectified (1937, 1953, and 1967) have an estimated total maximum shoreline position error of 20.0 ft, while the total maximum shoreline error for the three existing datasets are estimated at 18.3 ft for USGS and 10.2 ft for VBMP. The maximum annualized error for the shoreline data is  $\pm 0.7$  ft/yr. The smaller rivers and creeks are more prone to error due to their lack of good control points for photo rectification, narrower shore features, tree, and ground cover and overall smaller rates of change. These areas are digitized but due to the higher potential for error, rates of change analysis are not calculated. As shown in Figure 2, the higher tide level at which the 2013 photos were flown made it difficult to accurately depict the actual shore change between 2009 and 2013. The shoreline change analysis, in some areas, may show larger amounts of erosion between 2009 and 2013 than actually occurred. Many areas of Stafford County have shore change rates that fall within the calculated error. Some of the areas that show very low accretion can be due to errors within the method as described above.

In order to display the shoreline data, the Stafford County shoreline was divided into eight plates for the Potomac River shoreline (Figure 3) and four plates for the Rappahannock River shoreline (Figure 4). In Appendix A, the 2009 image is shown with only the 1937 and 2009 shorelines and the calculated EPR of change. In Appendix B, one photo date and the associated shoreline is shown on each. These include the photos taken in 1937, 1953, 1967, 1994, 2002, 2009, and 2013. The shorelines are summarized on the 2013 image.

### 3 Results and Discussion

Most of the river and creek shoreline in Stafford County is experiencing very low erosion (<1 ft/yr). Table 1 shows the average EPR of change for sections of the County based on the digitized shorelines. Those sites that are on the open river and/or are low marsh shoreline tend to have higher rates of change. The images in Appendix A show that many areas reflect a very low accretion rate. This is likely error due to the difficulty digitizing the 1937 photos. Along the high banks of the County, it can be difficult to accurately portray the shoreline due to tree cover and shadows. In addition, when trees on the bank fall, it can exacerbate instability of the high bank creating a slump which temporarily moves the shoreline riverward.

Several areas are noteworthy. Along the Potomac River, Brent Marsh (Plate 2 and 3) was more extensive in 1937. It has been undergoing medium to high erosion. It is the area of highest erosion in Stafford County. A little farther south along the Potomac River, just north of Brent Point (Plate 5) the upland is eroding at slightly less a pace. It has low to medium erosion rates. When the sand stored in the banks is eroded, it lands on the beach slowing the overall rate of erosion until such time the beach erodes and the process begins again.

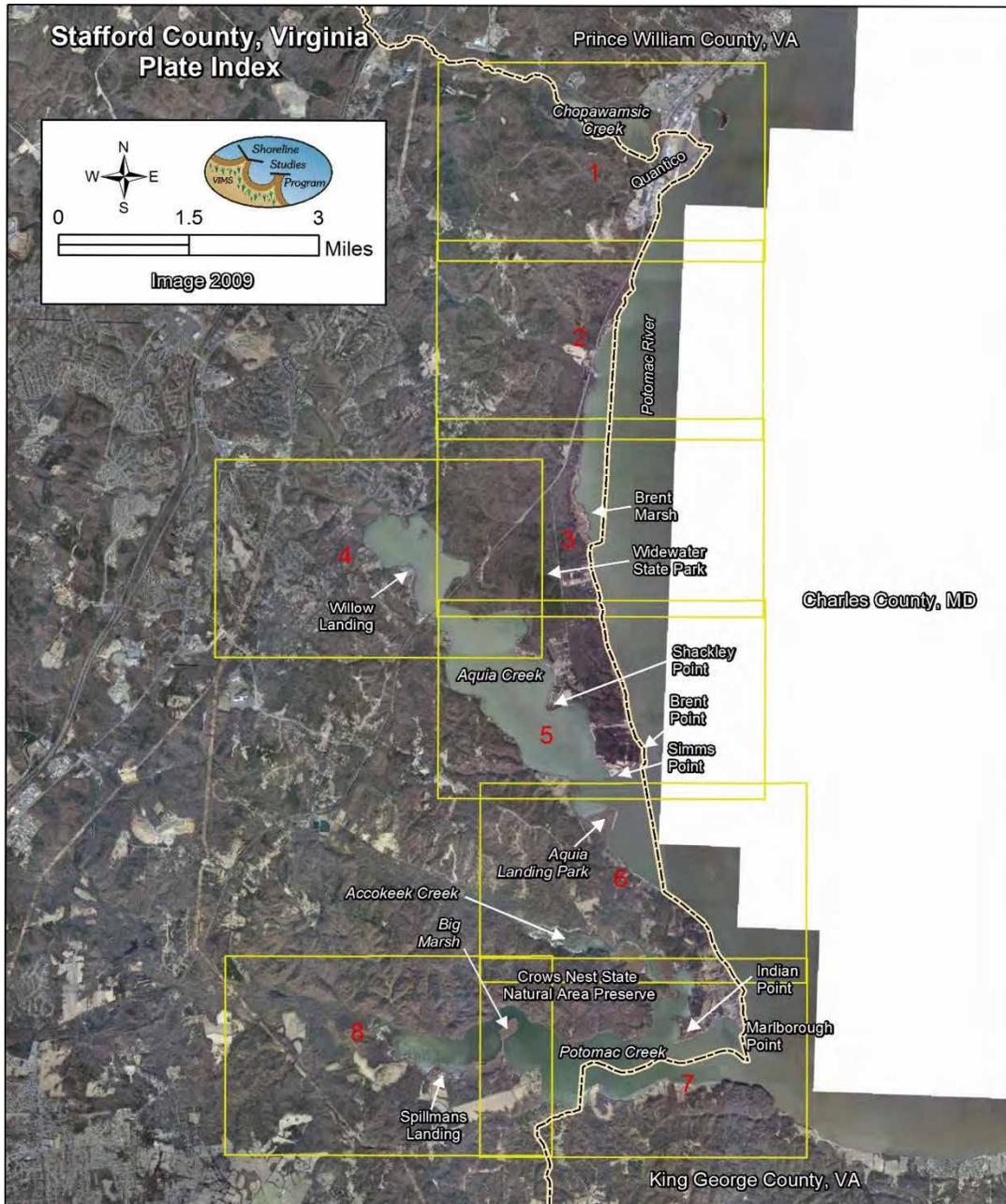


Figure 3. Plate index for Stafford County's Potomac River shorelines.

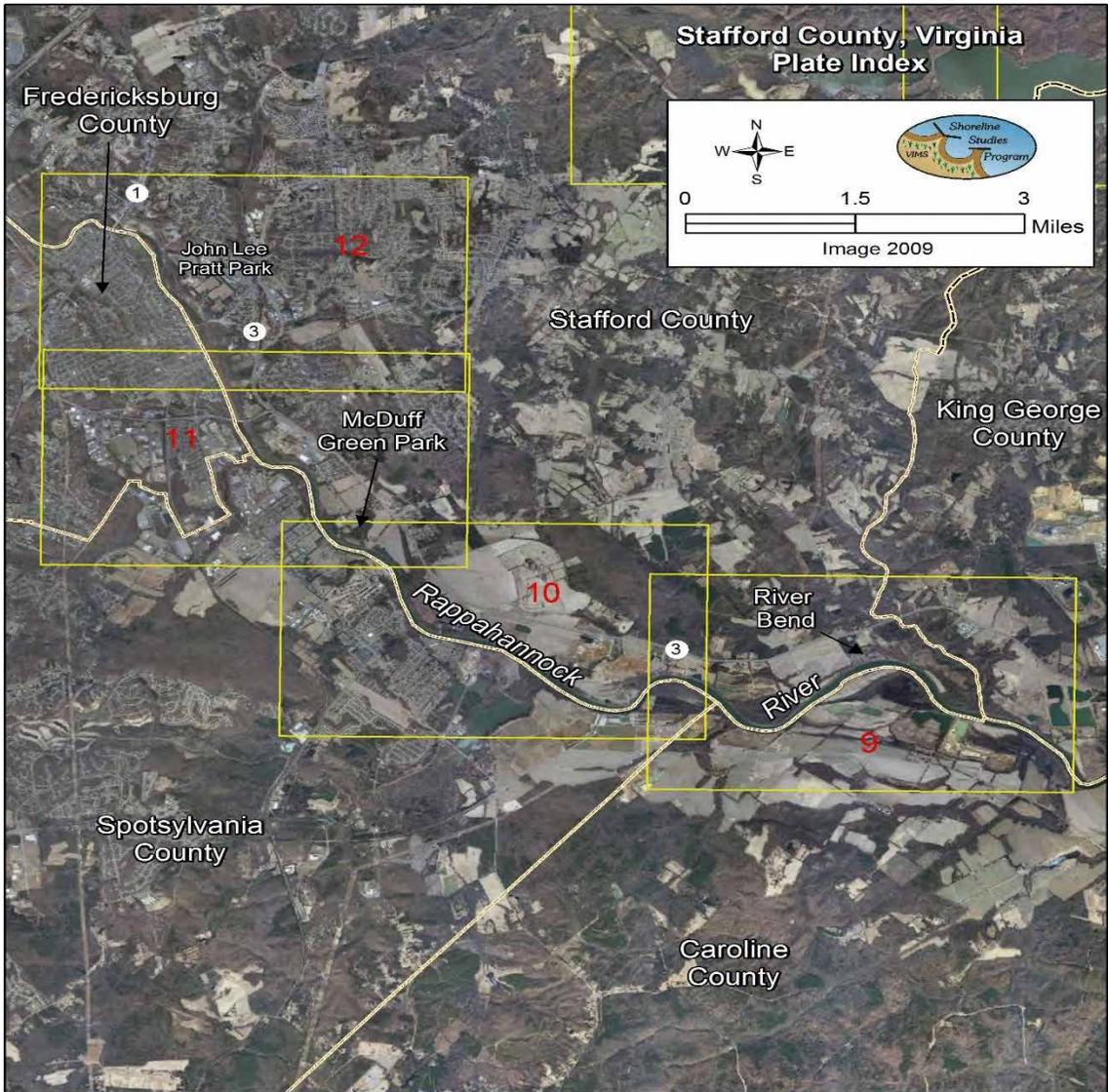


Figure 4. Plate index for Stafford County's Rappahannock River shorelines.

Aquia Landing Park south of Aquia Creek (Plate 6) is a locally-owned public beach. Even in 1953, access existed to the beachy area fronting the marsh. However, between 1953 and 1967, the marsh shoreline eroded about 40 feet leading the County to install groins in the late 1960s (Linden *et al.*, 1991). By 1987, these had deteriorated and a major beach restoration project included the construction of breakwaters and beach fill to maintain a public beach. These breakwaters continue to maintain a publically-accessible beach (Appendix B, Plate 6, 2013).

The Rappahannock River shoreline in Stafford County has had very little change since 1937. The shoreline along this reach has trees along the shoreline making it very difficult to digitize accurately. The very low erosion and very low accretion fall within the error of the method.

**Table 1. Average end point rates of shoreline change in feet per year along sections of Stafford County's coast.**

Reach Name	Plate Number	Avg EPR (ft/yr)	Category
Potomac River from Prince William County Line to Aquia Creek	1, 2, 3, and 5	-1.3	Low Erosion
Aquia Creek	4 and 5	-0.3	Very Low Erosion
Potomac River from Aquia Creek to Potomac Creek	6 and 7	-0.7	Very Low Erosion
Accokeek Creek	6 and 7	-0.5	Very Low Erosion
Potomac Creek	7 and 8	-0.7	Very Low Erosion
Rappahannock River	9, 10, 11, and 12	0.1	Very Low Accretion

## 4 Summary

The rates of change shown in Table 1 are averaged across large sections of shoreline and may not be indicative of rates at specific sites within the reach. Some of the areas with very low accretion, particularly in the smaller creeks and rivers, may be the result of errors within photo rectification and digitizing wooded shorelines.

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## **Appendix A**

### **End Point Rate of Shoreline Change Maps**

Shoreline change rates calculated between 1937 and 2009 are shown on a 2009 VBMP aerial photo. The calculated rates of change were averaged to determine an average rate of change for sections of shoreline as shown in Table 1 of the report.

Note: The location labels on the plates come from U.S. Geological Survey topographic maps, Google Earth, and other map sources and may not be accurate for the historical or even more recent images. They are for reference only.

**Plate 1**

**Plate 5**

**Plate 9**

**Plate 2**

**Plate 6**

**Plate 10**

**Plate 3**

**Plate 7**

**Plate 11**

**Plate 4**

**Plate 8**

**Plate 12**



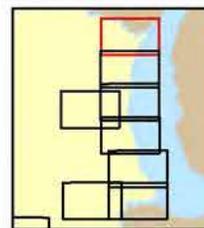
**Shoreline Rates of Change**

- |                                       |                                     |
|---------------------------------------|-------------------------------------|
| ◆ Very High Accretion: > +10 (ft/yr)  | ● Very Low Erosion: 0 to -1 (ft/yr) |
| ● High Accretion: +10 to +5 (ft/yr)   | ● Low Erosion: -1 to -2 (ft/yr)     |
| ● Medium Accretion: +5 to +2 (ft/yr)  | ● Medium Erosion: -2 to -5 (ft/yr)  |
| ● Low Accretion: +2 to +1 (ft/yr)     | ● High Erosion: -5 to -10 (ft/yr)   |
| ● Very Low Accretion: +1 to 0 (ft/yr) | ◆ Very High Erosion: < -10 (ft/yr)  |

**Legend**

- Shoreline 1937
- Shoreline 2009

2009 VBMP Photo



0 2,000 4,000

Feet

Stafford County, Virginia  
Plate 2



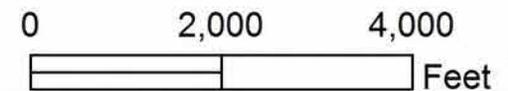
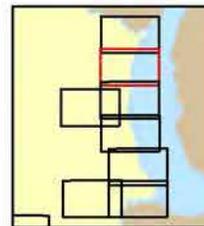
**Shoreline Rates of Change**

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|---------------------------------------|-------------------------------------|
| ◆ Very High Accretion: > +10 (ft/yr)  | ● Very Low Erosion: 0 to -1 (ft/yr) |
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| ● Medium Accretion: +5 to +2 (ft/yr)  | ● Medium Erosion: -2 to -5 (ft/yr)  |
| ● Low Accretion: +2 to +1 (ft/yr)     | ● High Erosion: -5 to -10 (ft/yr)   |
| ● Very Low Accretion: +1 to 0 (ft/yr) | ◆ Very High Erosion: < -10 (ft/yr)  |

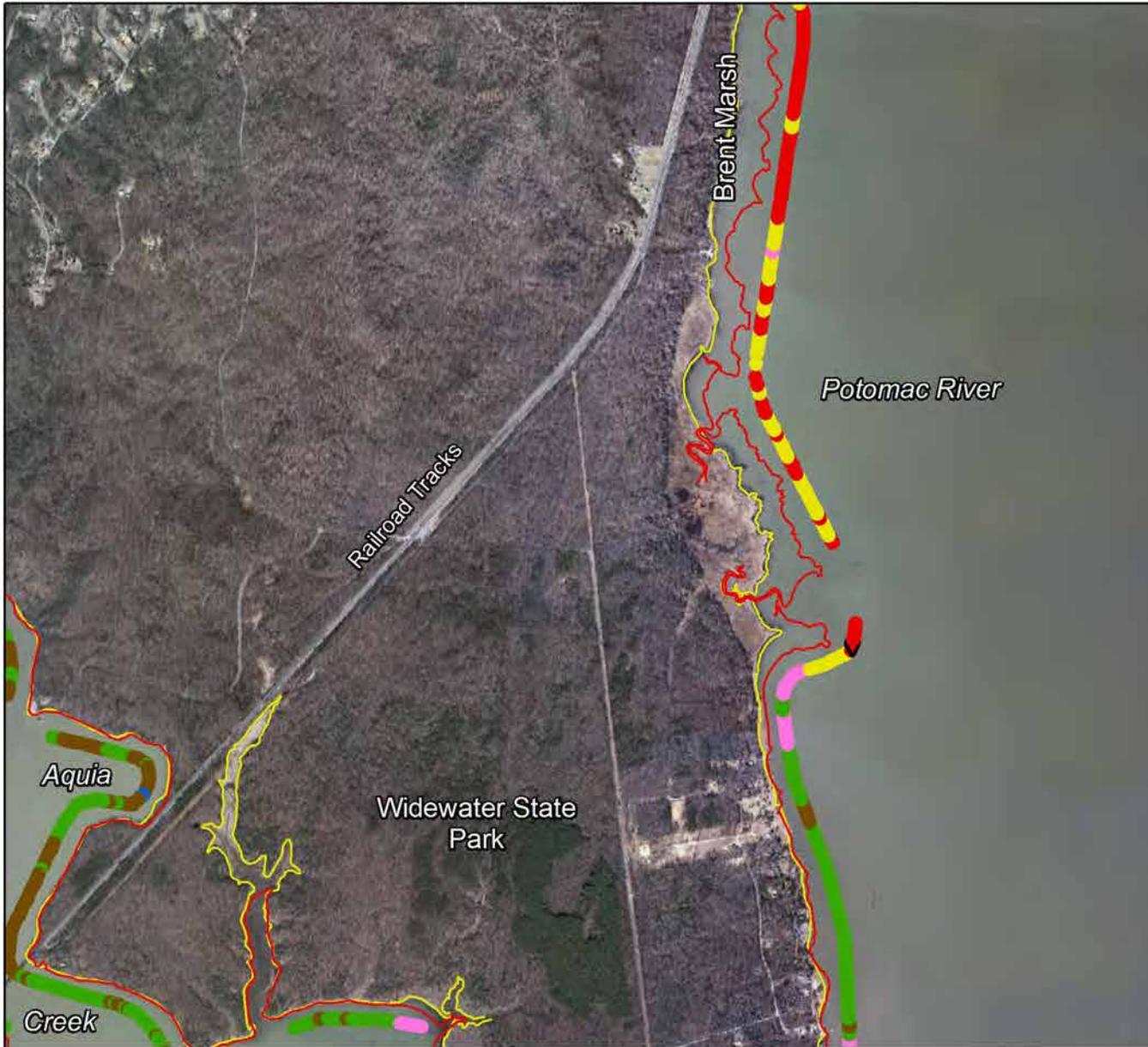
**Legend**

- Shoreline 1937
- Shoreline 2009

2009 VBMP Photo



Stafford County, Virginia  
Plate 3



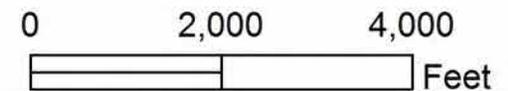
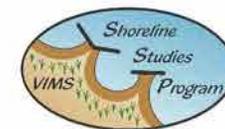
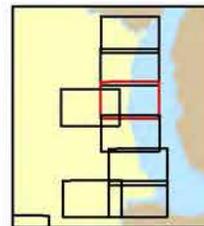
**Shoreline Rates of Change**

- |                                       |                                     |
|---------------------------------------|-------------------------------------|
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| ● Medium Accretion: +5 to +2 (ft/yr)  | ● Medium Erosion: -2 to -5 (ft/yr)  |
| ● Low Accretion: +2 to +1 (ft/yr)     | ● High Erosion: -5 to -10 (ft/yr)   |
| ● Very Low Accretion: +1 to 0 (ft/yr) | ◆ Very High Erosion: < -10 (ft/yr)  |

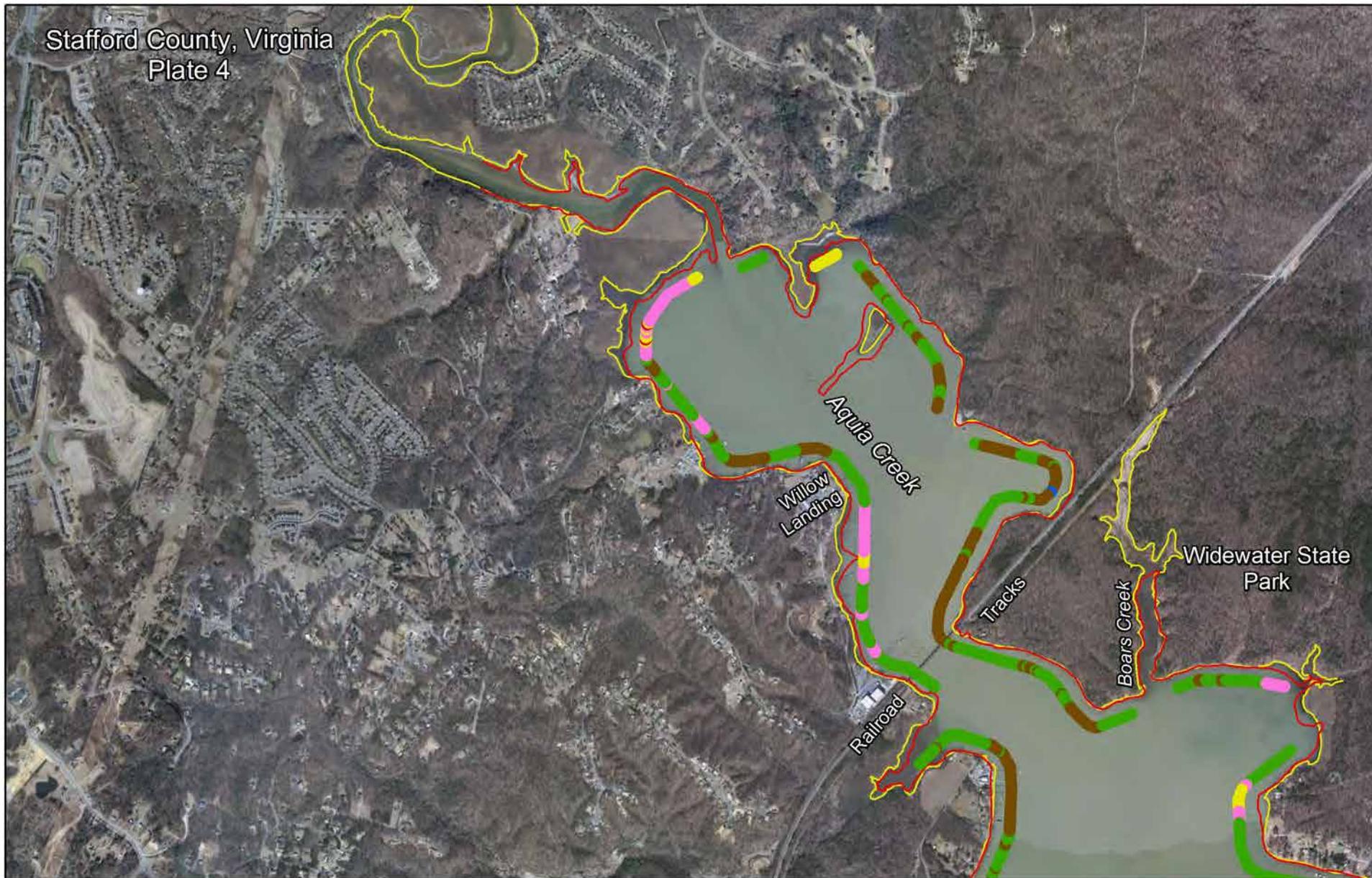
**Legend**

- Shoreline 1937
- Shoreline 2009

2009 VBMP Photo



Stafford County, Virginia  
Plate 4



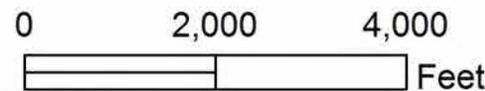
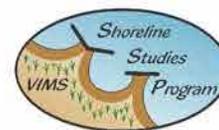
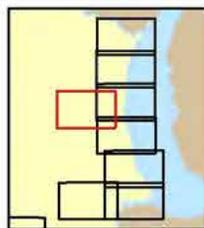
**Shoreline Rates of Change**

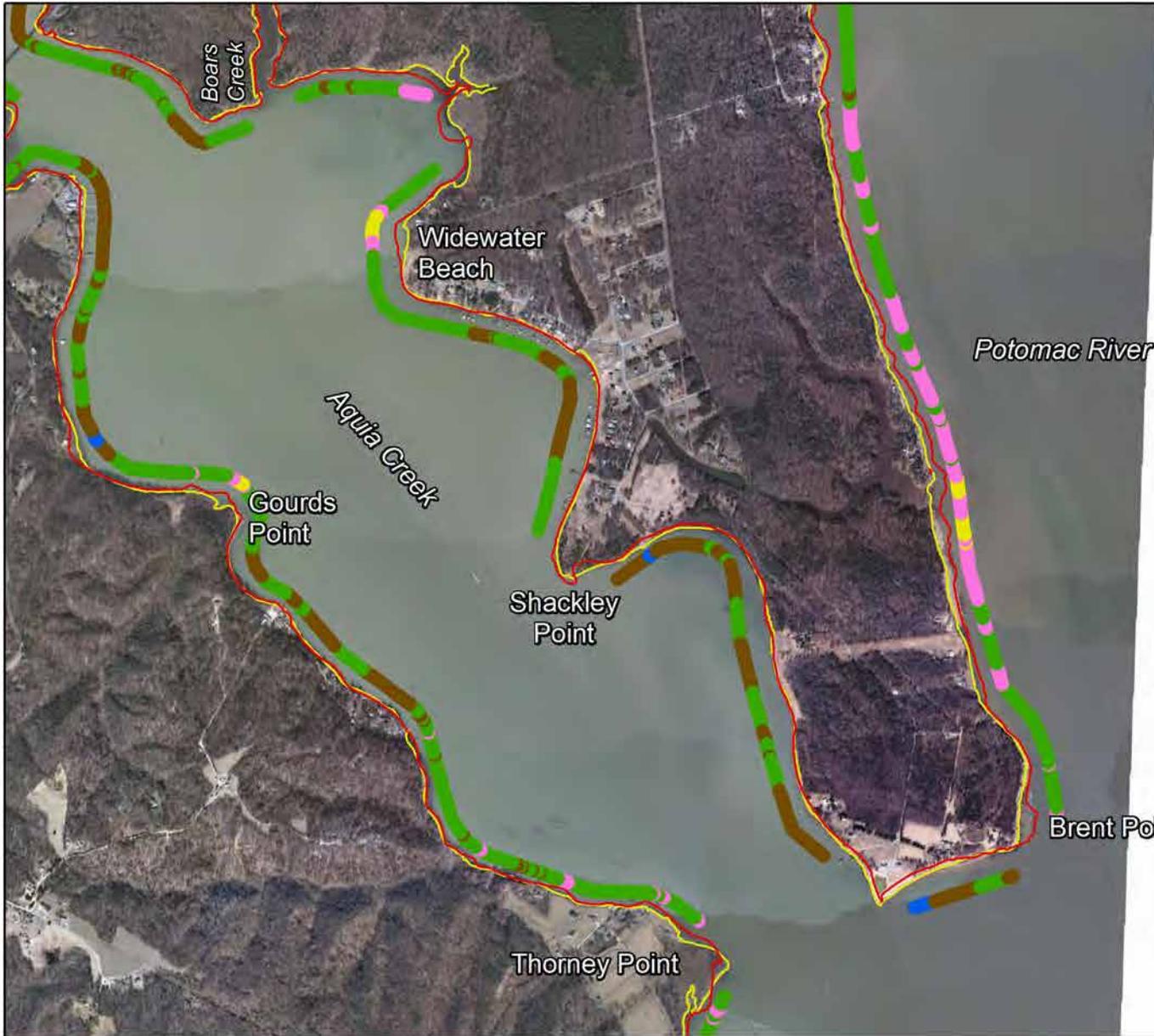
- |                                       |                                     |
|---------------------------------------|-------------------------------------|
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**Legend**

- Shoreline 1937
- Shoreline 2009

2009 VBMP Photo





Potomac River

Brent Point

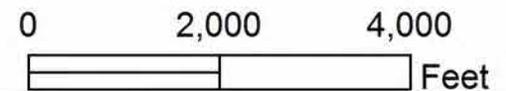
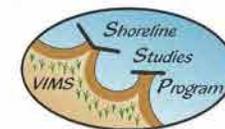
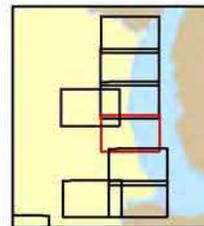
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**Legend**

- Shoreline 1937
- Shoreline 2009

2009 VBMP Photo





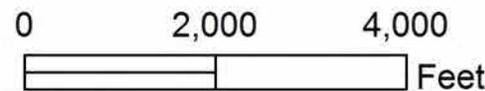
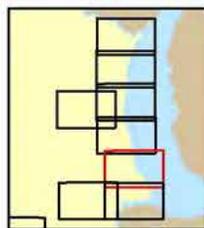
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- |                                       |                                     |
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| ● Very Low Accretion: +1 to 0 (ft/yr) | ◆ Very High Erosion: < -10 (ft/yr)  |

**Legend**

- Shoreline 1937
- Shoreline 2009

2009 VBMP Photo





Stafford County, Virginia  
Plate 7

Crow's Nest State  
Natural Area Preserve

Potomac River

Accokeek  
Creek

Big Marsh

Marlborough  
Point

Old Landing  
Point

Indian  
Point

Potomac Creek

Whipsawasons  
Point

King George  
County

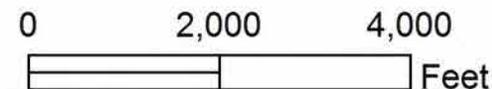
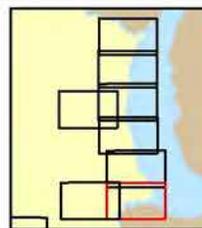
### Shoreline Rates of Change

- |                                       |                                     |
|---------------------------------------|-------------------------------------|
| ◆ Very High Accretion: > +10 (ft/yr)  | ● Very Low Erosion: 0 to -1 (ft/yr) |
| ● High Accretion: +10 to +5 (ft/yr)   | ● Low Erosion: -1 to -2 (ft/yr)     |
| ● Medium Accretion: +5 to +2 (ft/yr)  | ● Medium Erosion: -2 to -5 (ft/yr)  |
| ● Low Accretion: +2 to +1 (ft/yr)     | ● High Erosion: -5 to -10 (ft/yr)   |
| ● Very Low Accretion: +1 to 0 (ft/yr) | ◆ Very High Erosion: < -10 (ft/yr)  |

### Legend

- Shoreline 1937
- Shoreline 2009

2009 VBMP Photo



A-7

Crow's Nest State  
Natural Area Preserve



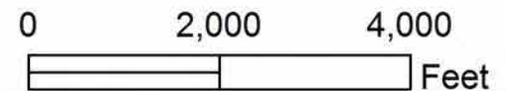
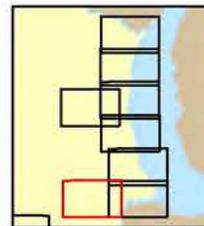
**Shoreline Rates of Change**

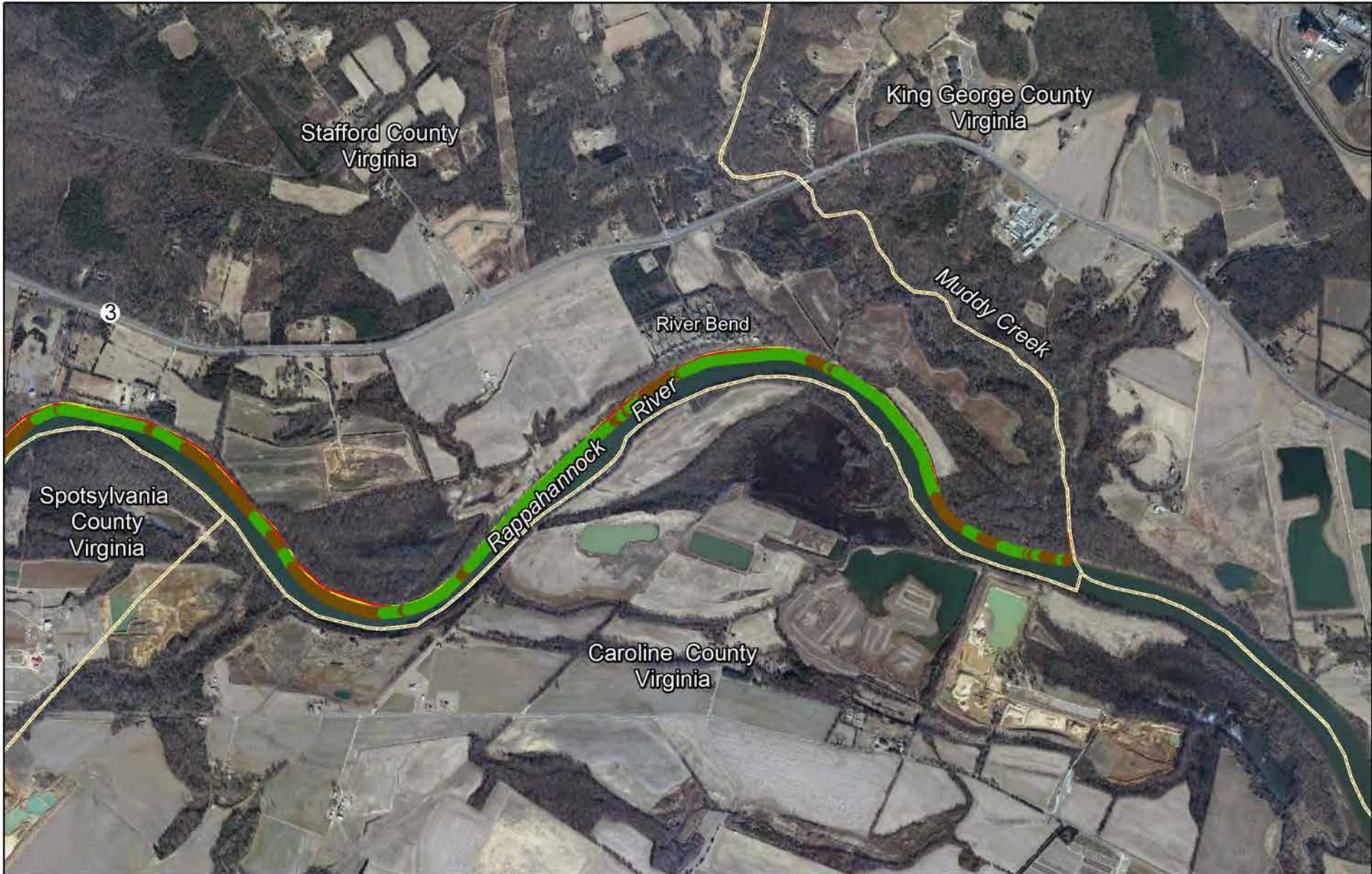
- |                                       |                                     |
|---------------------------------------|-------------------------------------|
| ◆ Very High Accretion: > +10 (ft/yr)  | ● Very Low Erosion: 0 to -1 (ft/yr) |
| ● High Accretion: +10 to +5 (ft/yr)   | ● Low Erosion: -1 to -2 (ft/yr)     |
| ● Medium Accretion: +5 to +2 (ft/yr)  | ● Medium Erosion: -2 to -5 (ft/yr)  |
| ● Low Accretion: +2 to +1 (ft/yr)     | ● High Erosion: -5 to -10 (ft/yr)   |
| ● Very Low Accretion: +1 to 0 (ft/yr) | ◆ Very High Erosion: < -10 (ft/yr)  |

**Legend**

- Shoreline 1937
- Shoreline 2009

2009 VBMP Photo





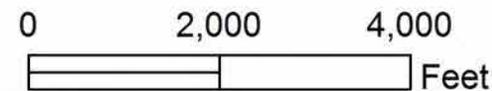
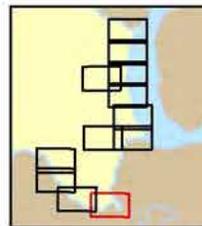
**Shoreline Rates of Change**

- Low Accretion: +2 to +1 (ft/yr)
- Very Low Accretion: +1 to 0 (ft/yr)
- Very Low Erosion: 0 to -1 (ft/yr)
- Low Erosion: -1 to -2 (ft/yr)

**Legend**

- Shoreline 1937
- Shoreline 2009

2009 VBMP Photo



A-9



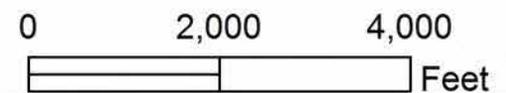
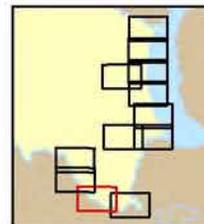
**Shoreline Rates of Change**

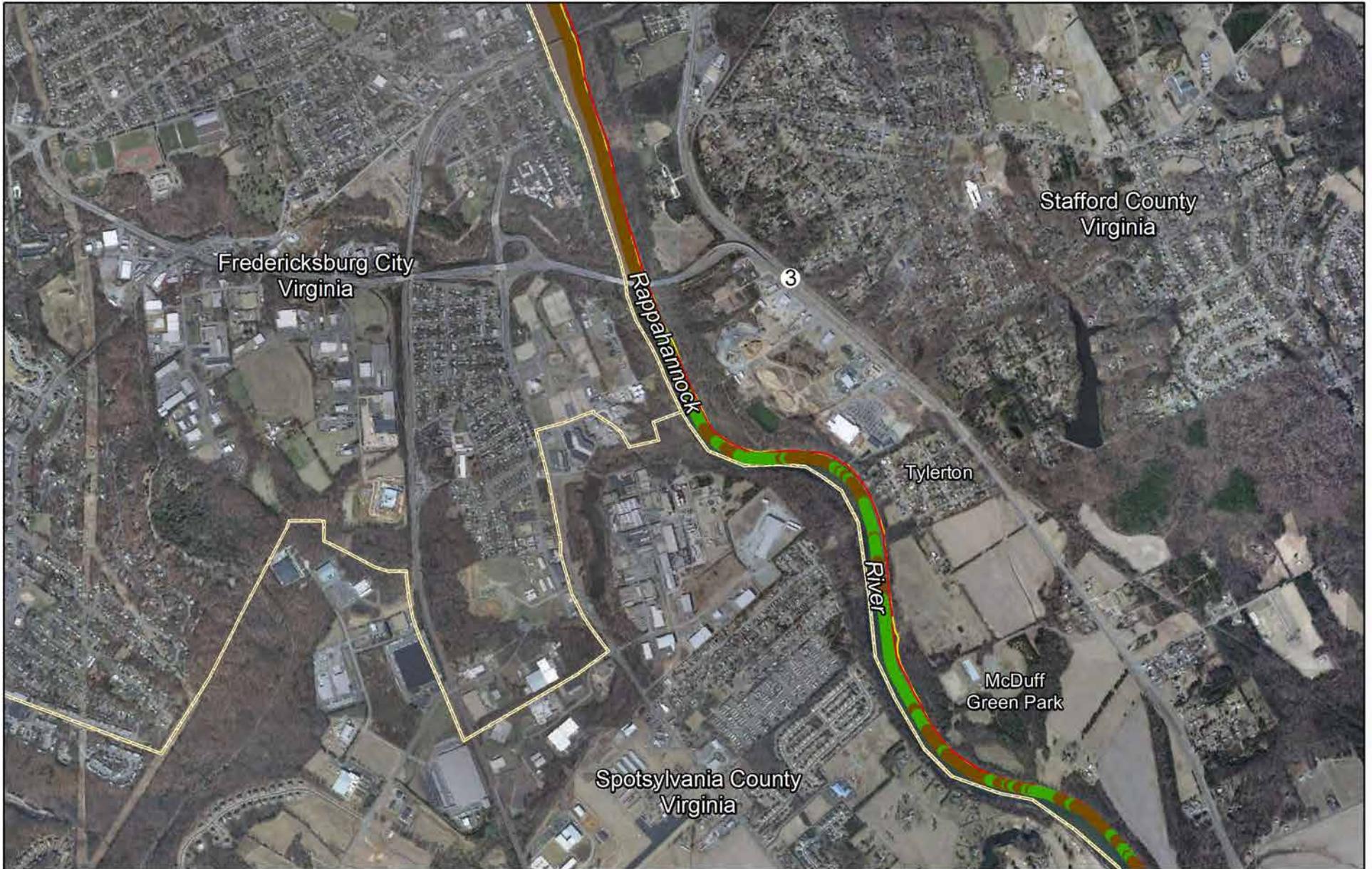
- Low Accretion: +2 to +1 (ft/yr)
- Very Low Accretion: +1 to 0 (ft/yr)
- Very Low Erosion: 0 to -1 (ft/yr)
- Low Erosion: -1 to -2 (ft/yr)

**Legend**

- Shoreline 1937
- Shoreline 2009

2009 VBMP Photo





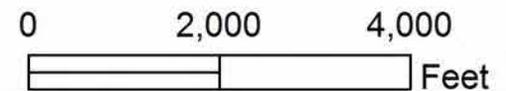
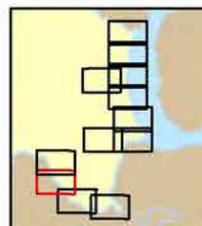
**Shoreline Rates of Change**

- Low Accretion: +2 to +1 (ft/yr)
- Very Low Accretion: +1 to 0 (ft/yr)
- Very Low Erosion: 0 to -1 (ft/yr)
- Low Erosion: -1 to -2 (ft/yr)

**Legend**

- Shoreline 1937
- Shoreline 2009

2009 VBMP Photo





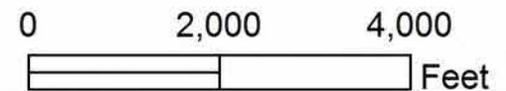
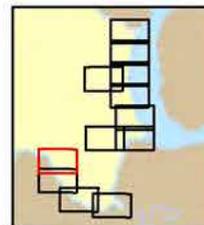
**Shoreline Rates of Change**

- Low Accretion: +2 to +1 (ft/yr)
- Very Low Accretion: +1 to 0 (ft/yr)
- Very Low Erosion: 0 to -1 (ft/yr)
- Low Erosion: -1 to -2 (ft/yr)

**Legend**

- Shoreline 1937
- Shoreline 2009

2009 VBMP Photo



## **Appendix B**

### **Historical Photo and Digitized Shoreline Maps**

Note: The location labels on the plates come from U.S. Geological Survey topographic maps, Google Earth, and other map sources and may not be accurate for the historical or even more recent images. They are for reference only.

**Plate 1**

**Plate 5**

**Plate 9**

**Plate 2**

**Plate 6**

**Plate 10**

**Plate 3**

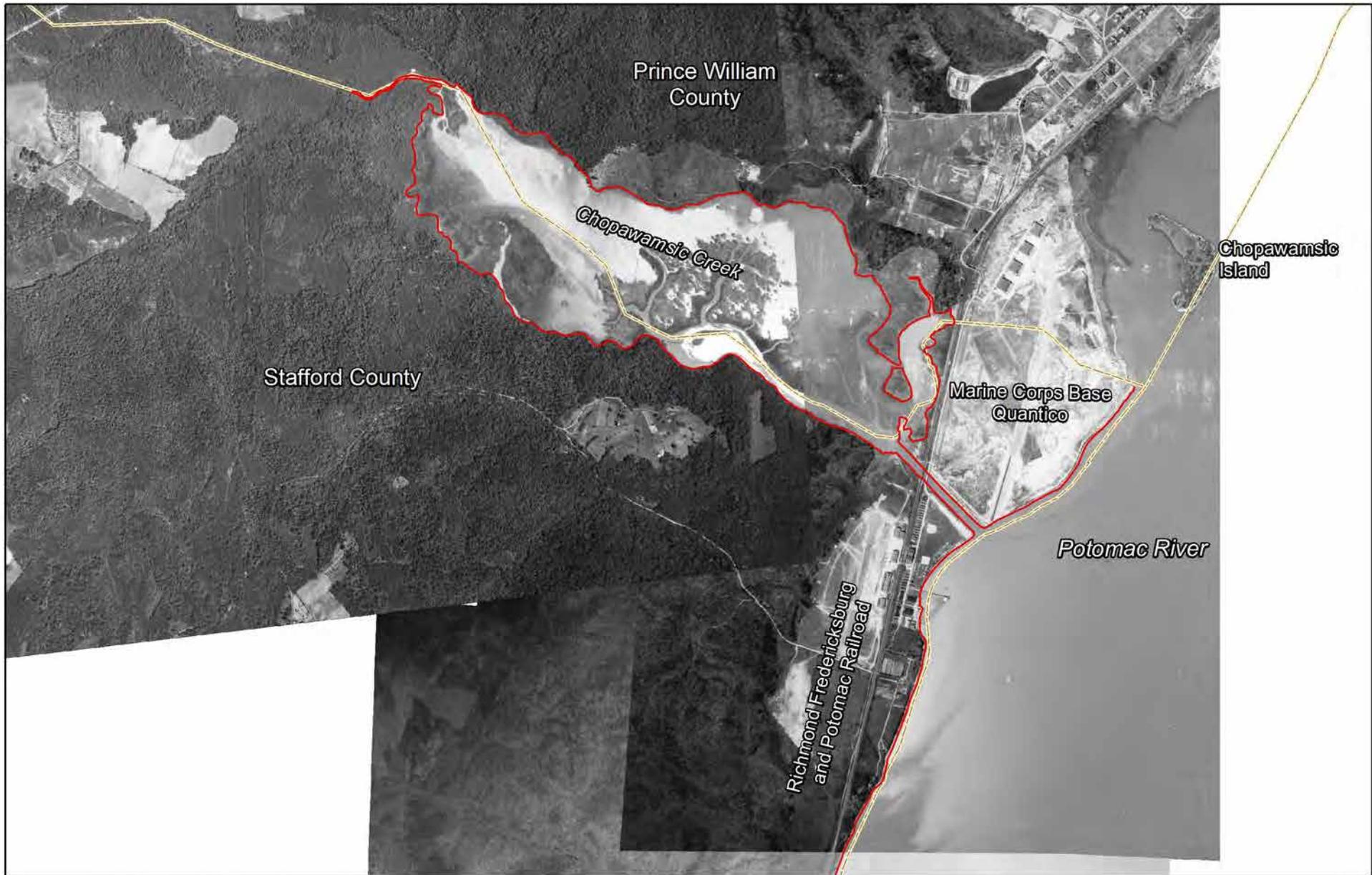
**Plate 7**

**Plate 11**

**Plate 4**

**Plate 8**

**Plate 12**



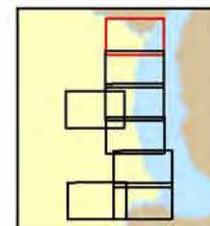
**Legend**  
 — Shoreline 1937

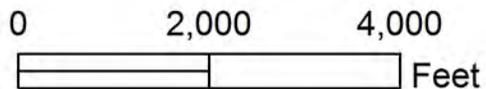


0      2,000      4,000  
 Feet

**Stafford County, Virginia  
 Plate 1**

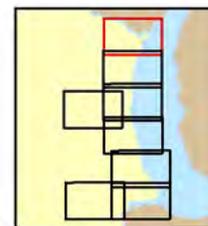
Photo Date: 1937





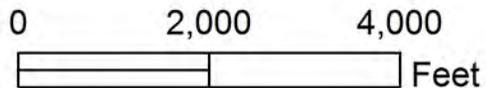
# Stafford County, Virginia Plate 1

Photo Date: 1953



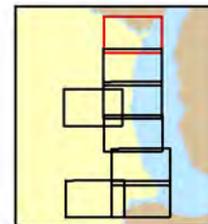


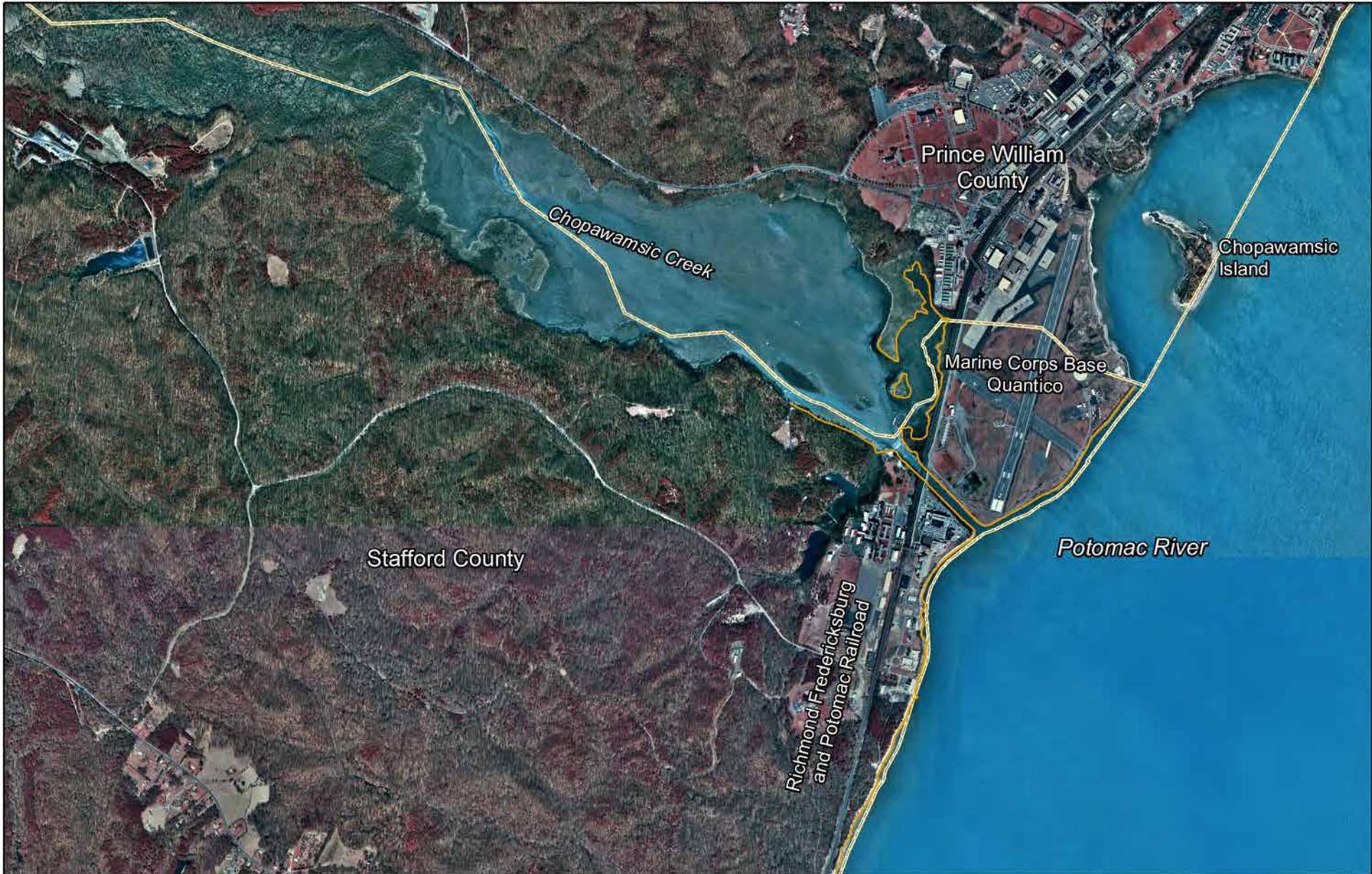
**Legend**  
 — Shoreline 1967



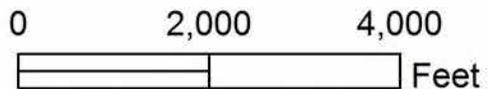
**Stafford County, Virginia  
 Plate 1**

Photo Date: 1967



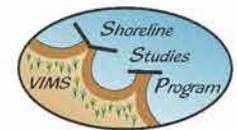
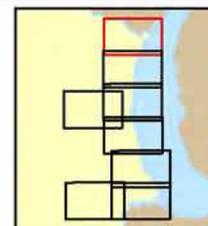


**Legend**  
 Shoreline 1994



## Stafford County, Virginia Plate 1

Photo Date: 1994





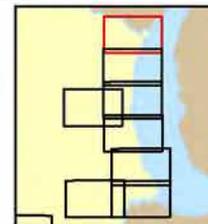
**Legend**  
 — Shoreline 2002

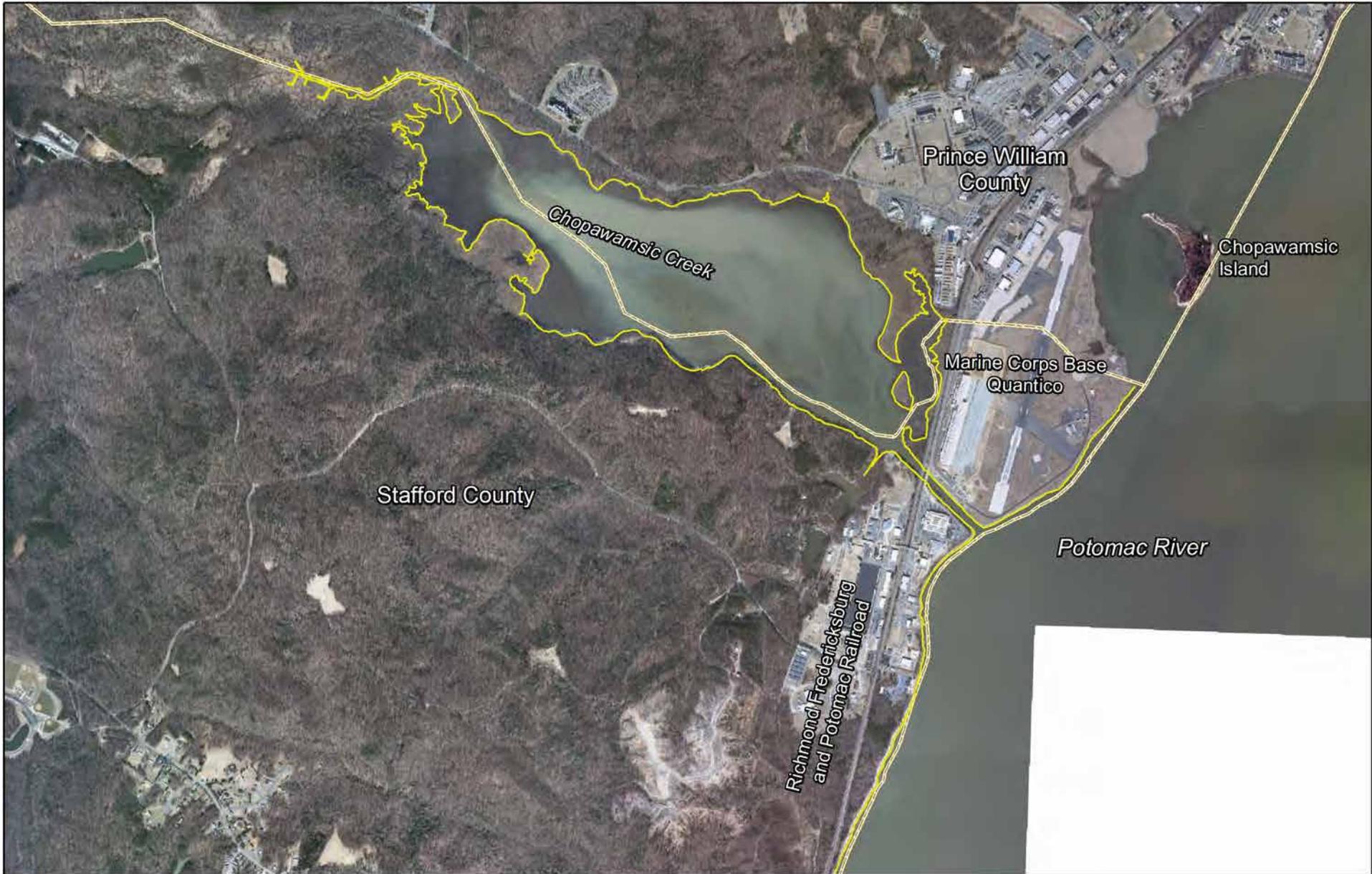


0      2,000      4,000  
 Feet

**Stafford County, Virginia  
 Plate 1**

Photo Date: 2002





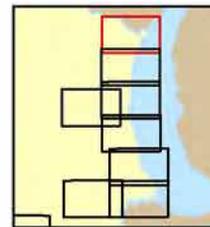
**Legend**  
 — Shoreline 2009

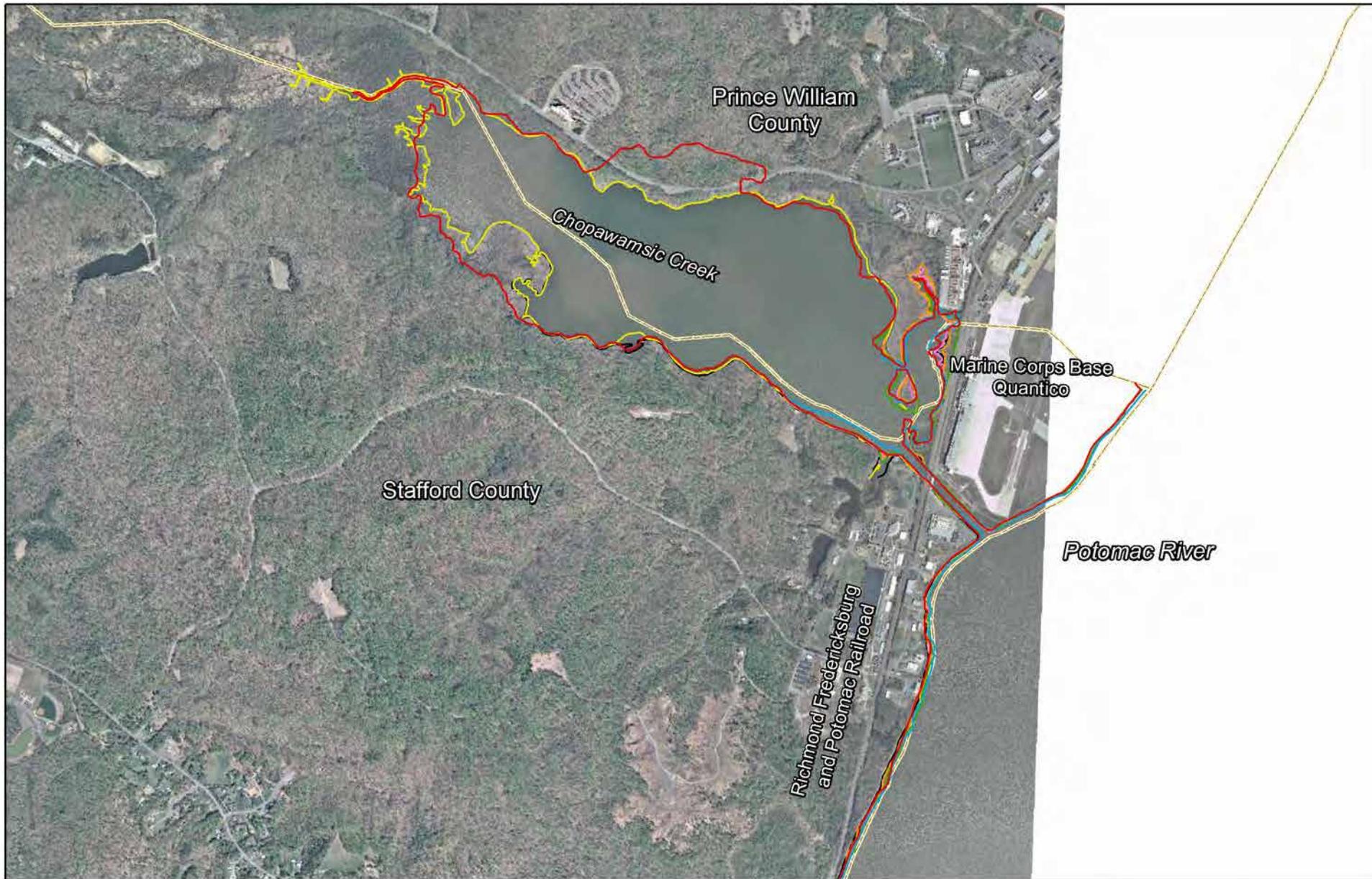


0      2,000      4,000  
 Feet

**Stafford County, Virginia  
 Plate 1**

Photo Date: 2009





**Shorelines**

- Shoreline 1937      — Shoreline 2002
- Shoreline 1953      — Shoreline 2009
- Shoreline 1967      — Shoreline 2013
- Shoreline 1994

**Stafford County, Virginia  
Plate 1**

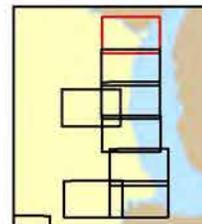
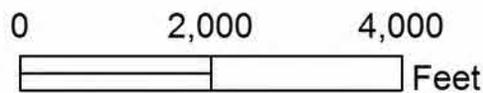
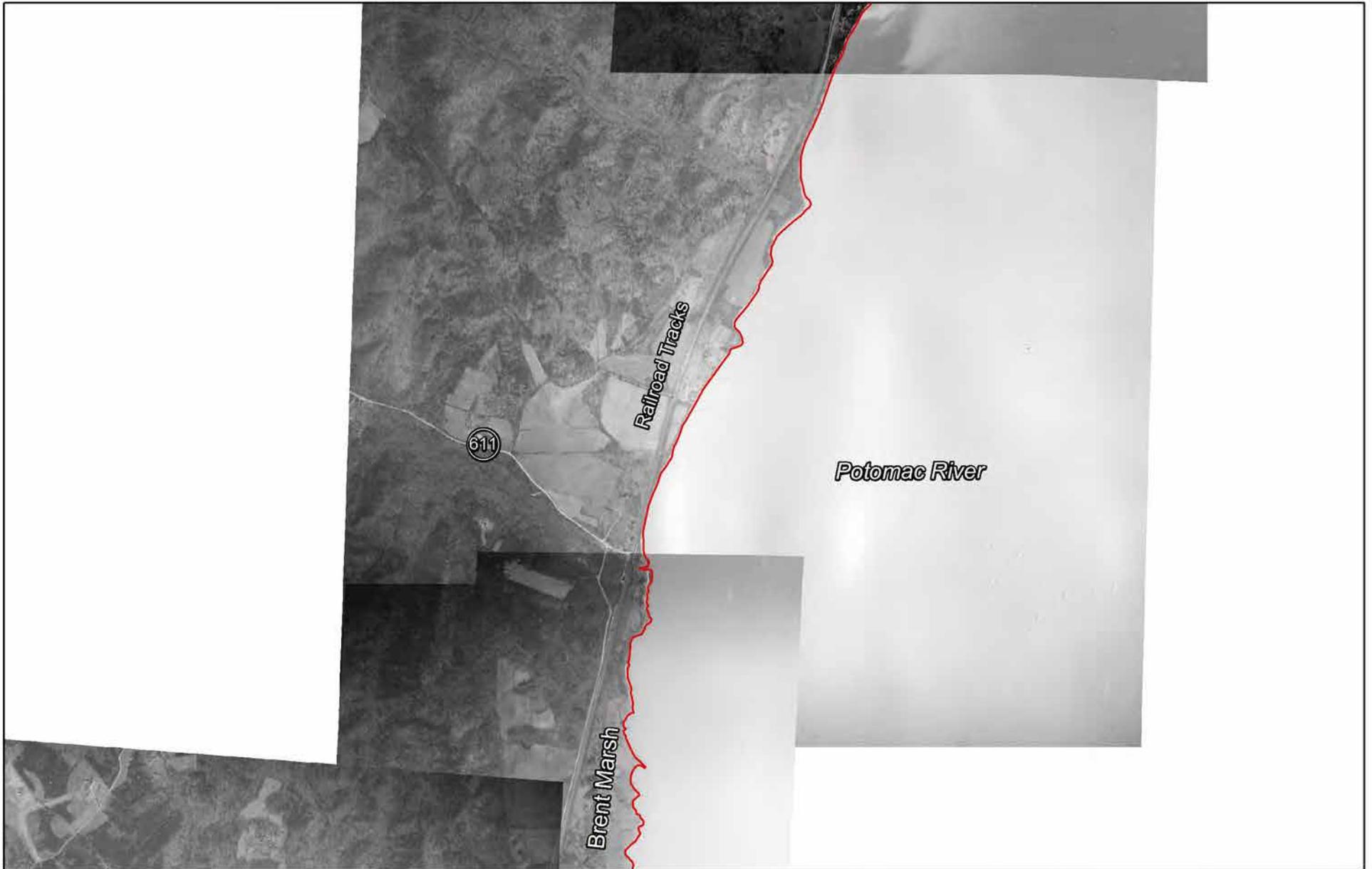
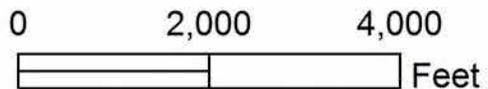


Image Date: 2013

B-7

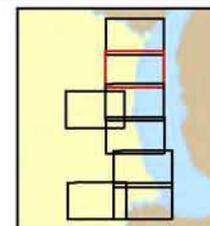


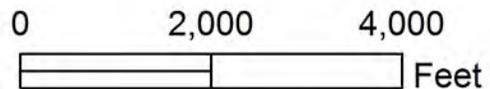
**Legend**  
 — Shoreline 1937



**Stafford County, Virginia  
 Plate 2**

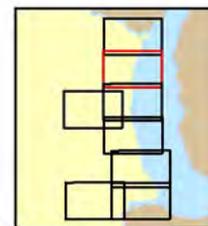
Photo Date: 1937





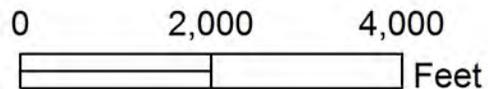
**Stafford County, Virginia  
Plate 2**

Photo Date: 1953



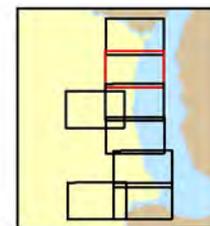


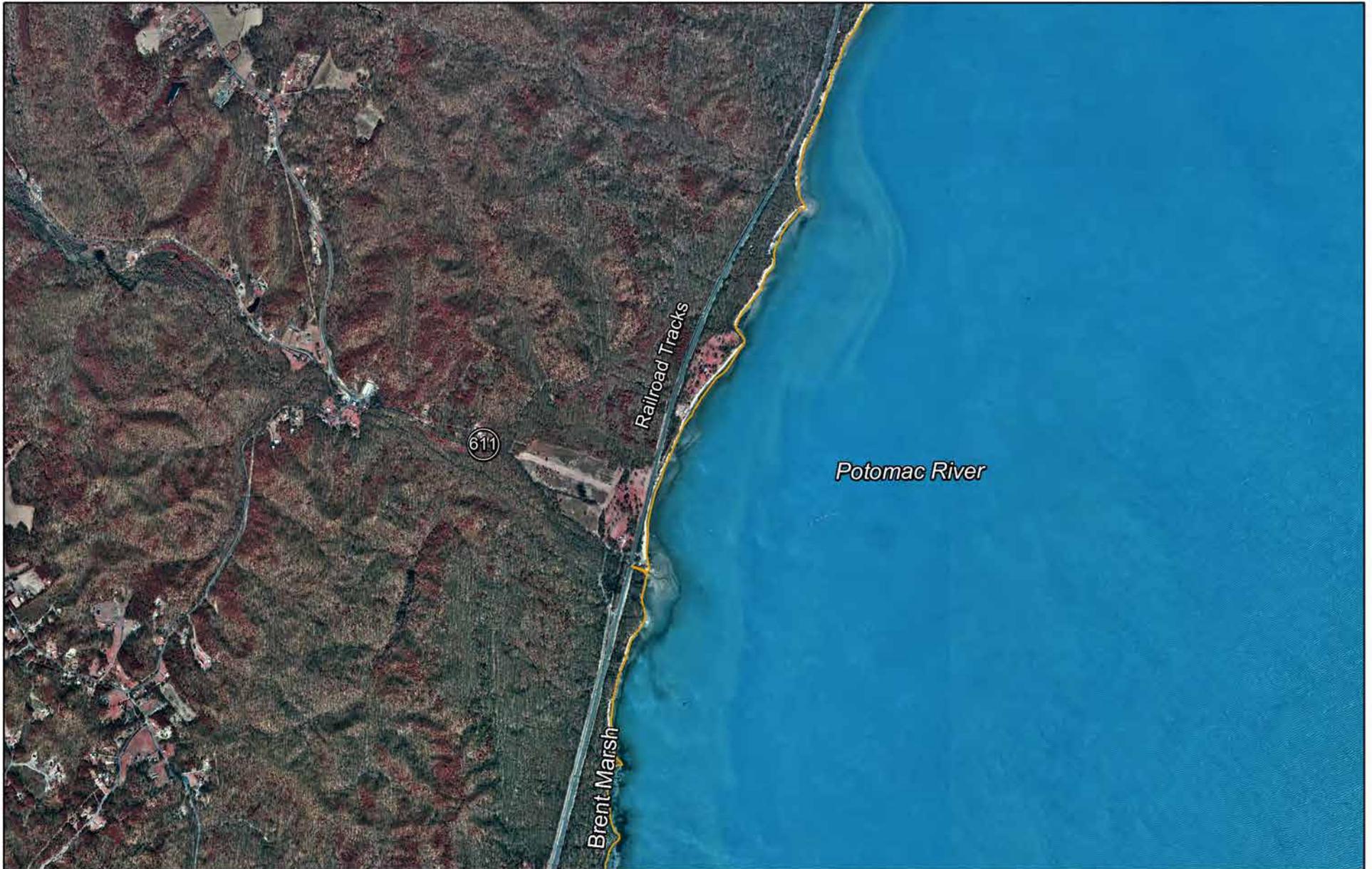
**Legend**  
 — Shoreline 1967



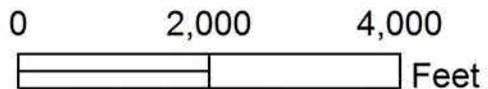
**Stafford County, Virginia  
 Plate 2**

Photo Date: 1967



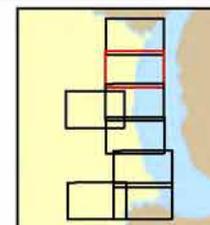


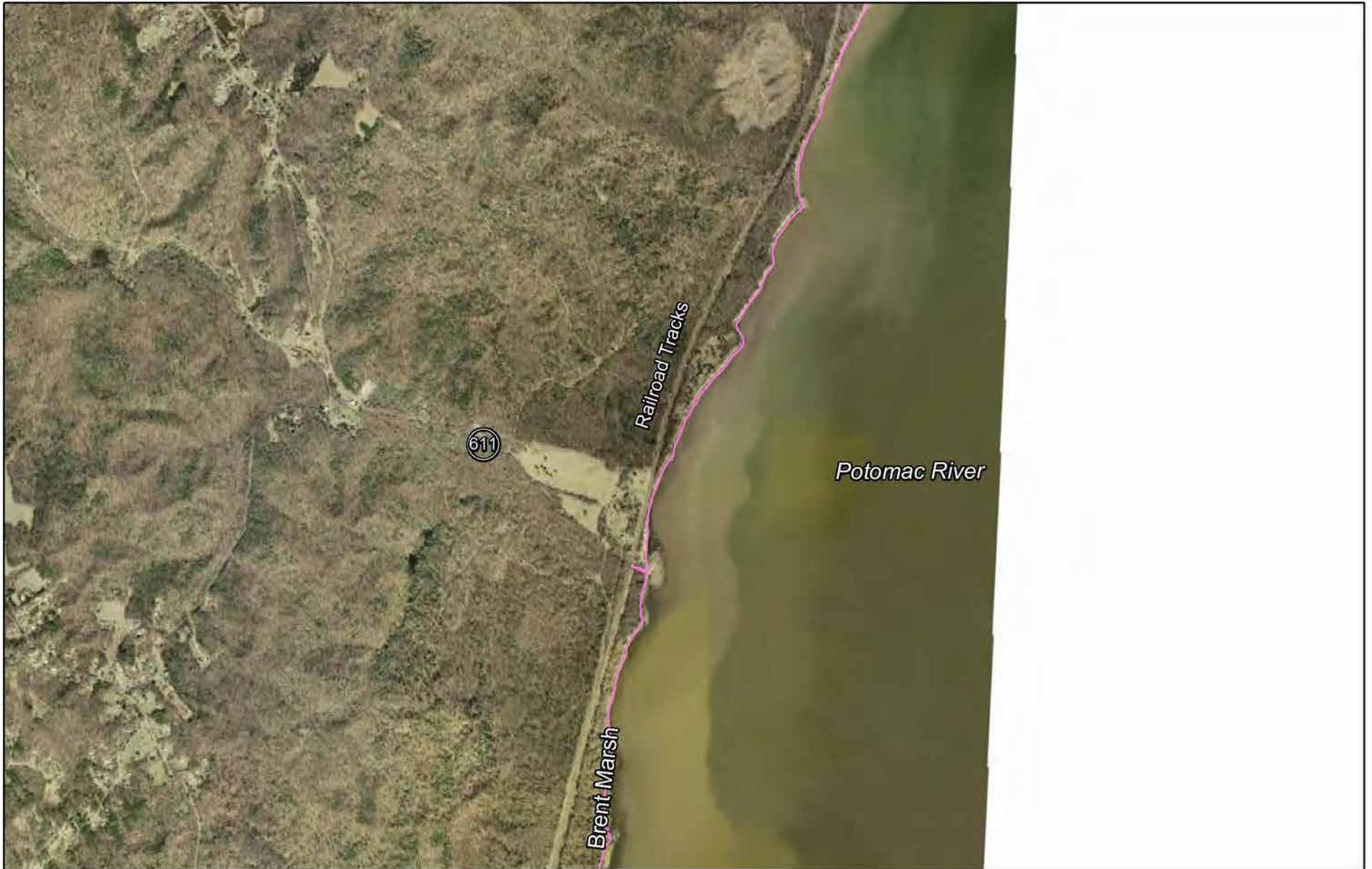
**Legend**  
 Shoreline 1994



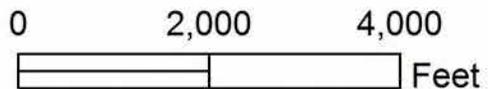
**Stafford County, Virginia  
 Plate 2**

Photo Date: 1994



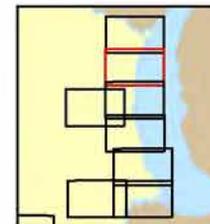


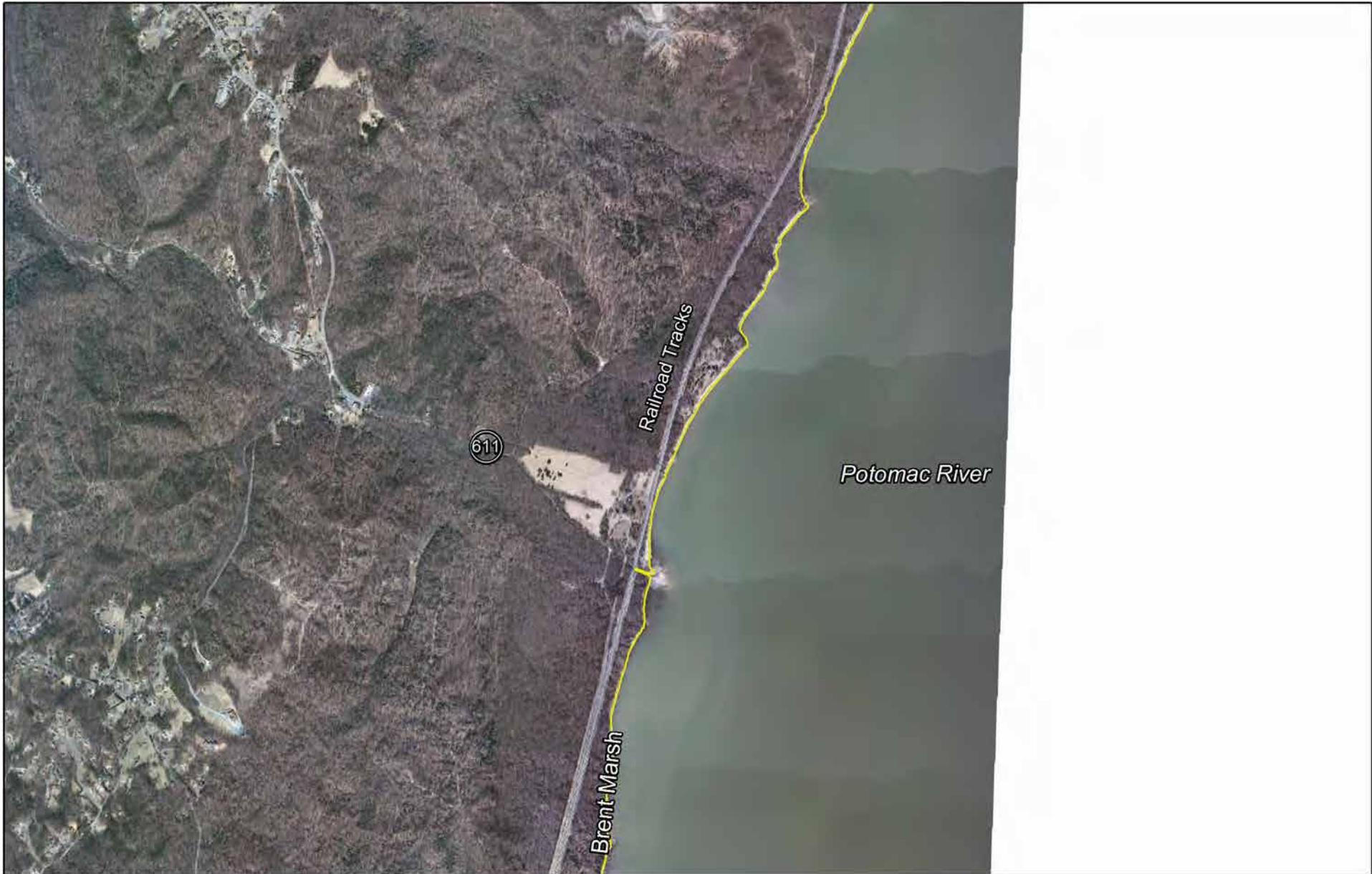
**Legend**  
— Shoreline 2002



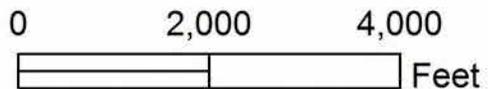
## Stafford County, Virginia Plate 2

Photo Date: 2002



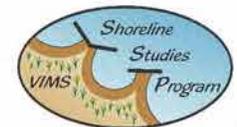
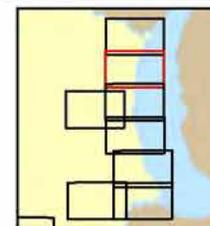


**Legend**  
 — Shoreline 2009



**Stafford County, Virginia  
 Plate 2**

Photo Date: 2009





Shorelines	
— Shoreline 1937	— Shoreline 2002
— Shoreline 1953	— Shoreline 2009
— Shoreline 1967	— Shoreline 2013
— Shoreline 1994	

**Stafford County, Virginia  
Plate 2**

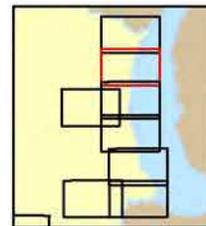
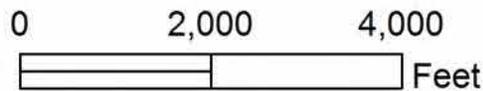


Image Date: 2013



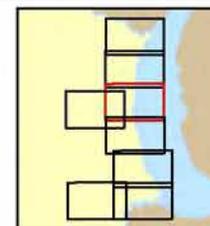
**Legend**  
 — Shoreline 1937

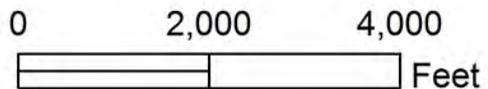


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 Feet

**Stafford County, Virginia  
 Plate 3**

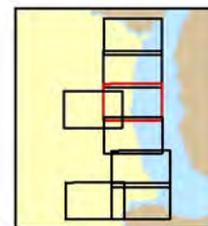
Photo Date: 1937





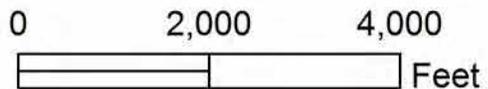
**Stafford County, Virginia  
Plate 3**

Photo Date: 1953



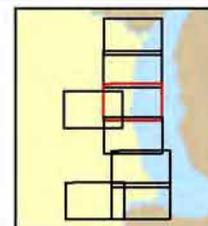


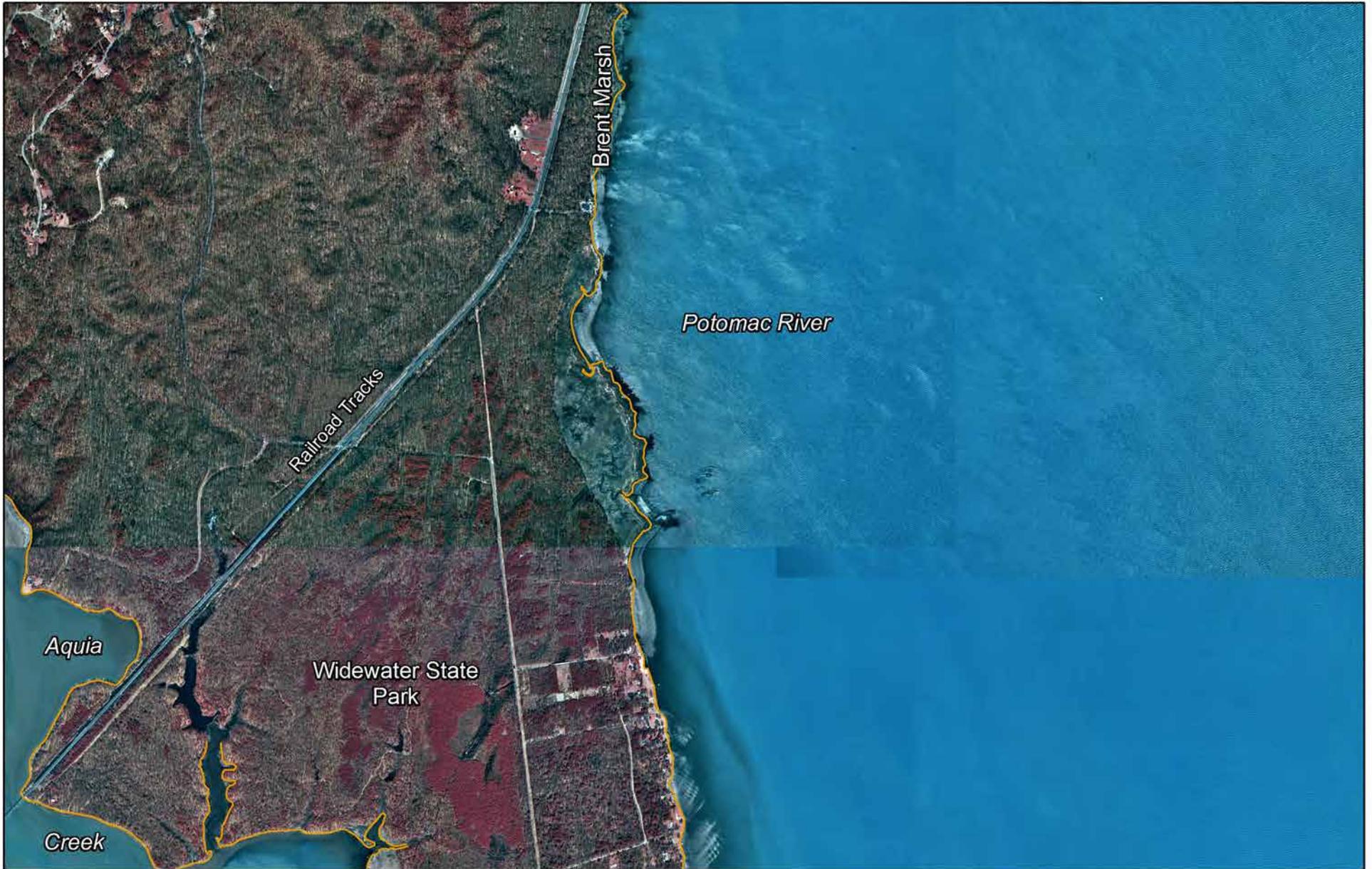
**Legend**  
— Shoreline 1967



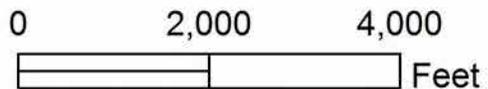
### Stafford County, Virginia Plate 3

Photo Date: 1967



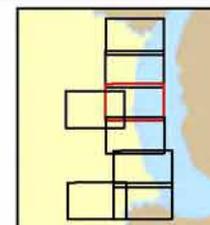


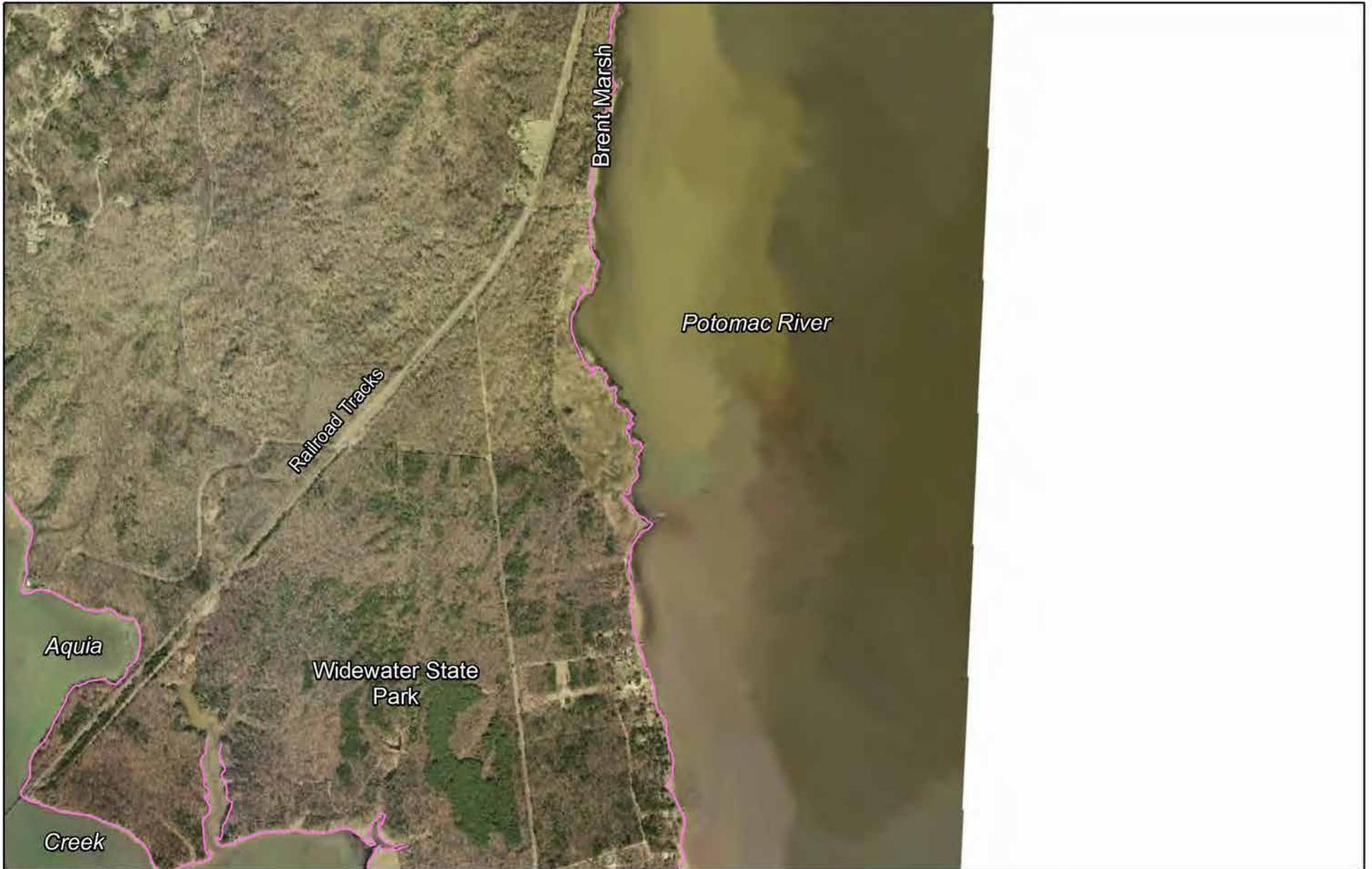
**Legend**  
 Shoreline 1994



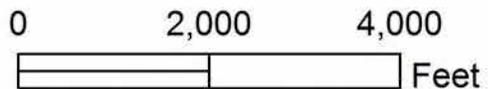
**Stafford County, Virginia  
 Plate 3**

Photo Date: 1994



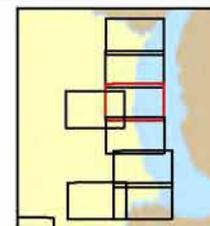


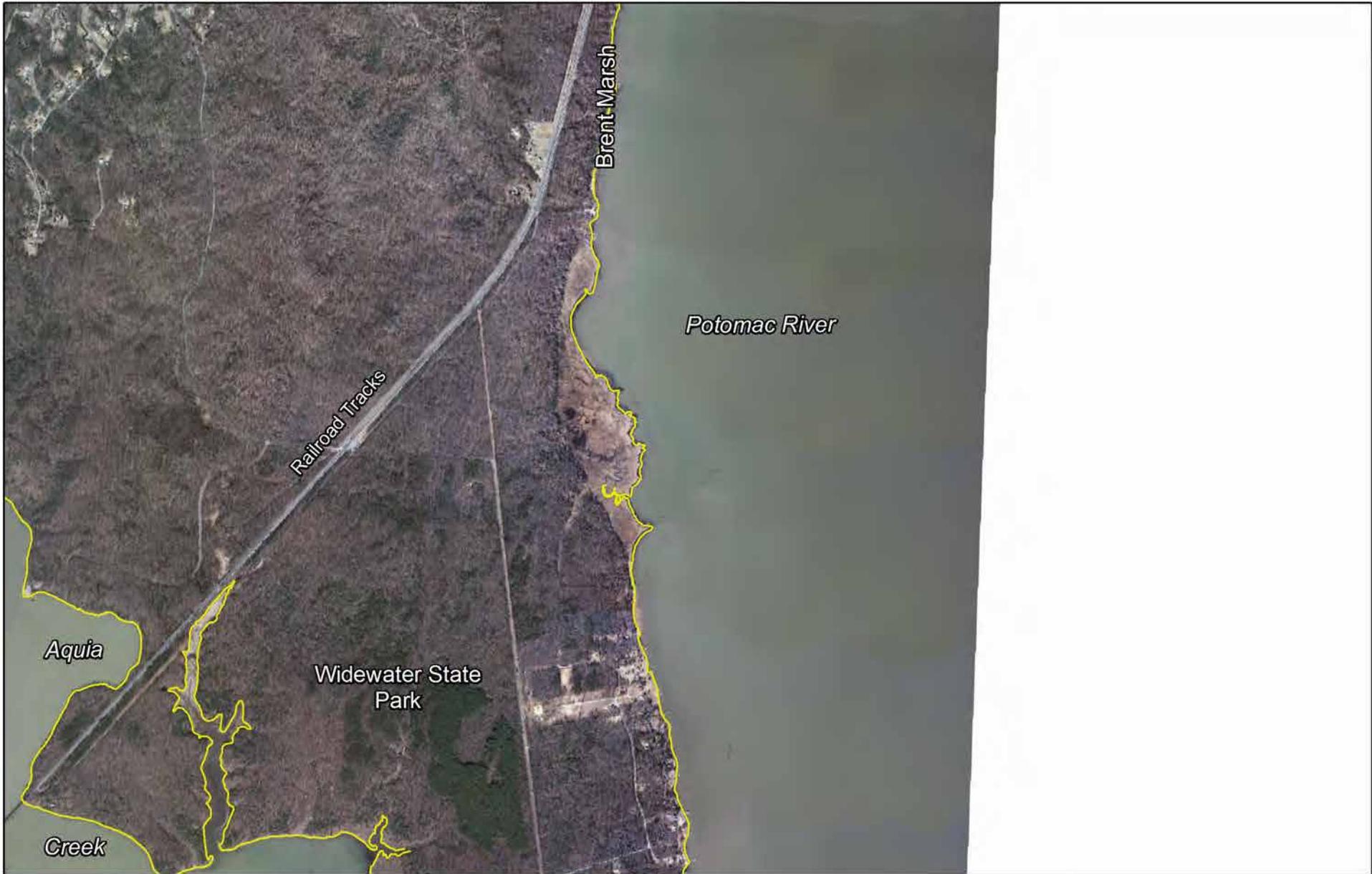
**Legend**  
 — Shoreline 2002



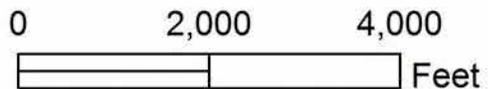
**Stafford County, Virginia  
 Plate 3**

Photo Date: 2002



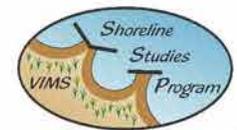
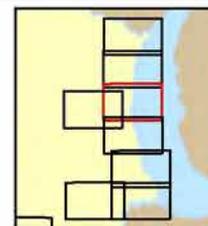


**Legend**  
 Shoreline 2009



**Stafford County, Virginia  
 Plate 3**

Photo Date: 2009





Shorelines	
— Shoreline 1937	— Shoreline 2002
— Shoreline 1953	— Shoreline 2009
— Shoreline 1967	— Shoreline 2013
— Shoreline 1994	

**Stafford County, Virginia  
Plate 3**

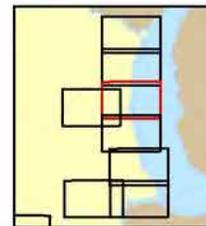
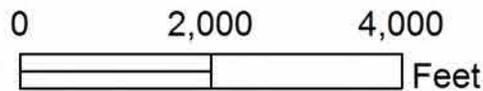
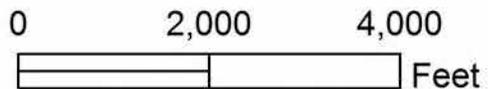


Image Date: 2013

B21

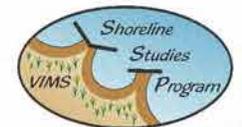
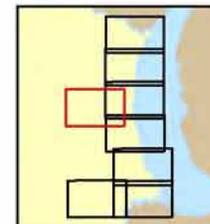


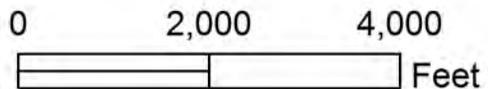
**Legend**  
 — Shoreline 1937



**Stafford County, Virginia  
 Plate 4**

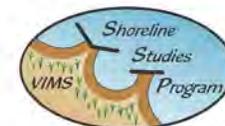
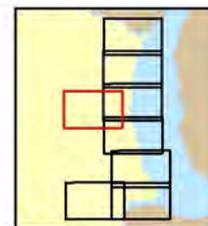
Photo Date: 1937

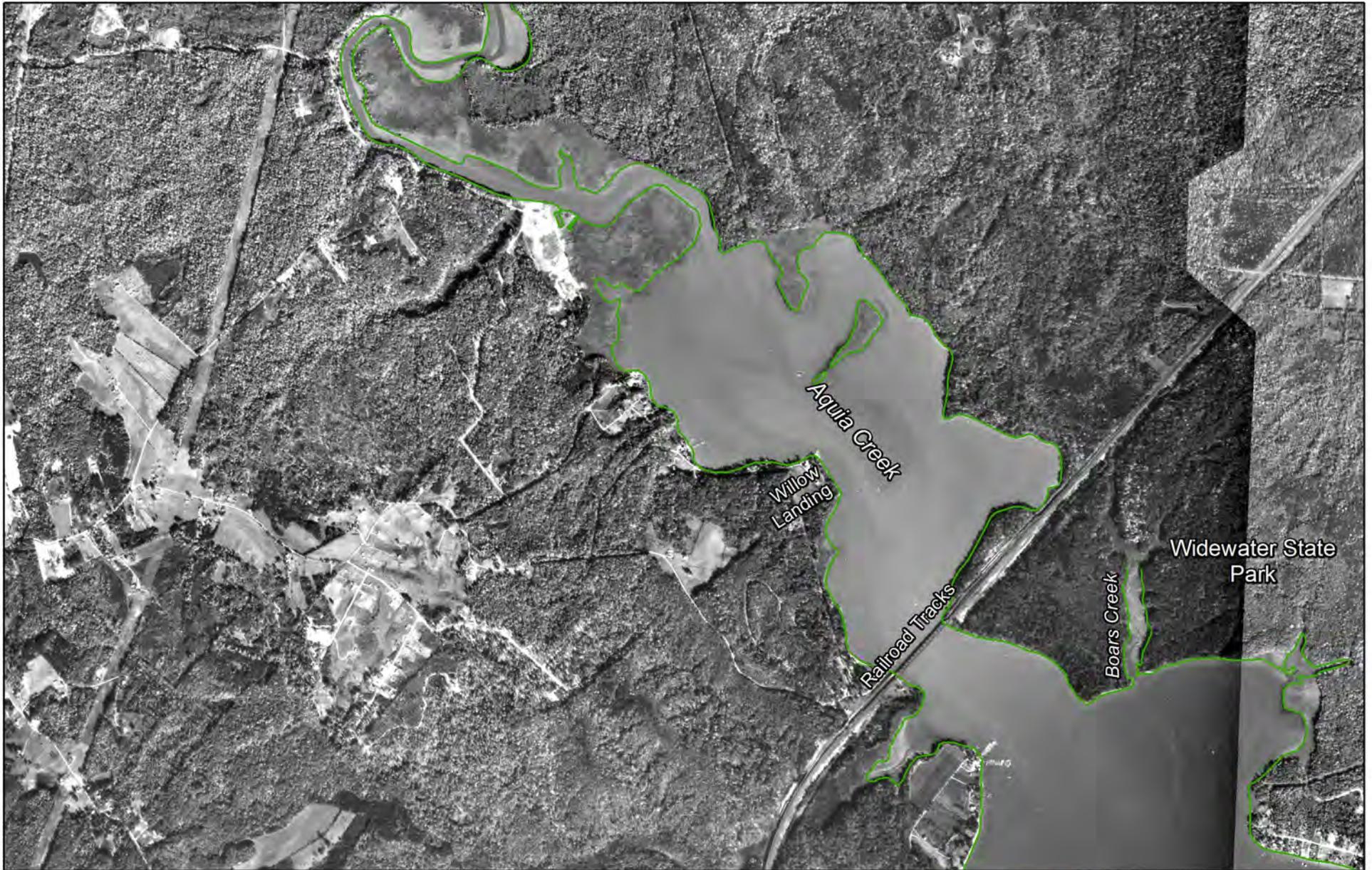




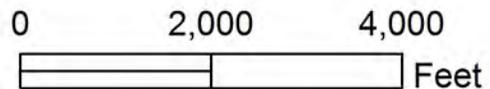
### Stafford County, Virginia Plate 4

Photo Date: 1953



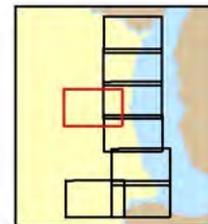


**Legend**  
— Shoreline 1967

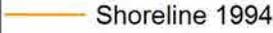


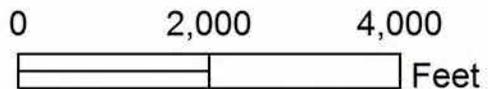
### Stafford County, Virginia Plate 4

Photo Date: 1967



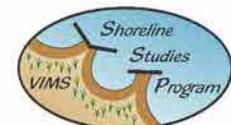
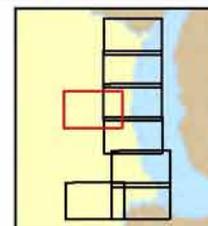


**Legend**  
 Shoreline 1994



**Stafford County, Virginia  
 Plate 4**

Photo Date: 1994





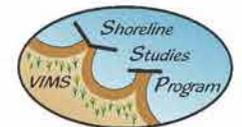
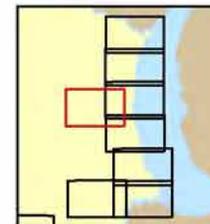
**Legend**  
— Shoreline 2002



0 2,000 4,000  
Feet

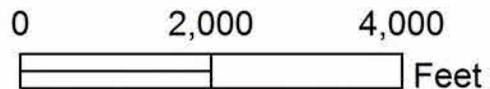
### Stafford County, Virginia Plate 4

Photo Date: 2002



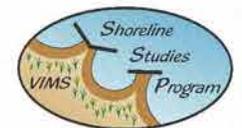
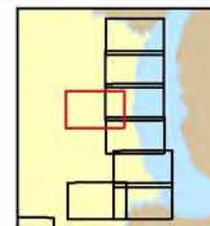


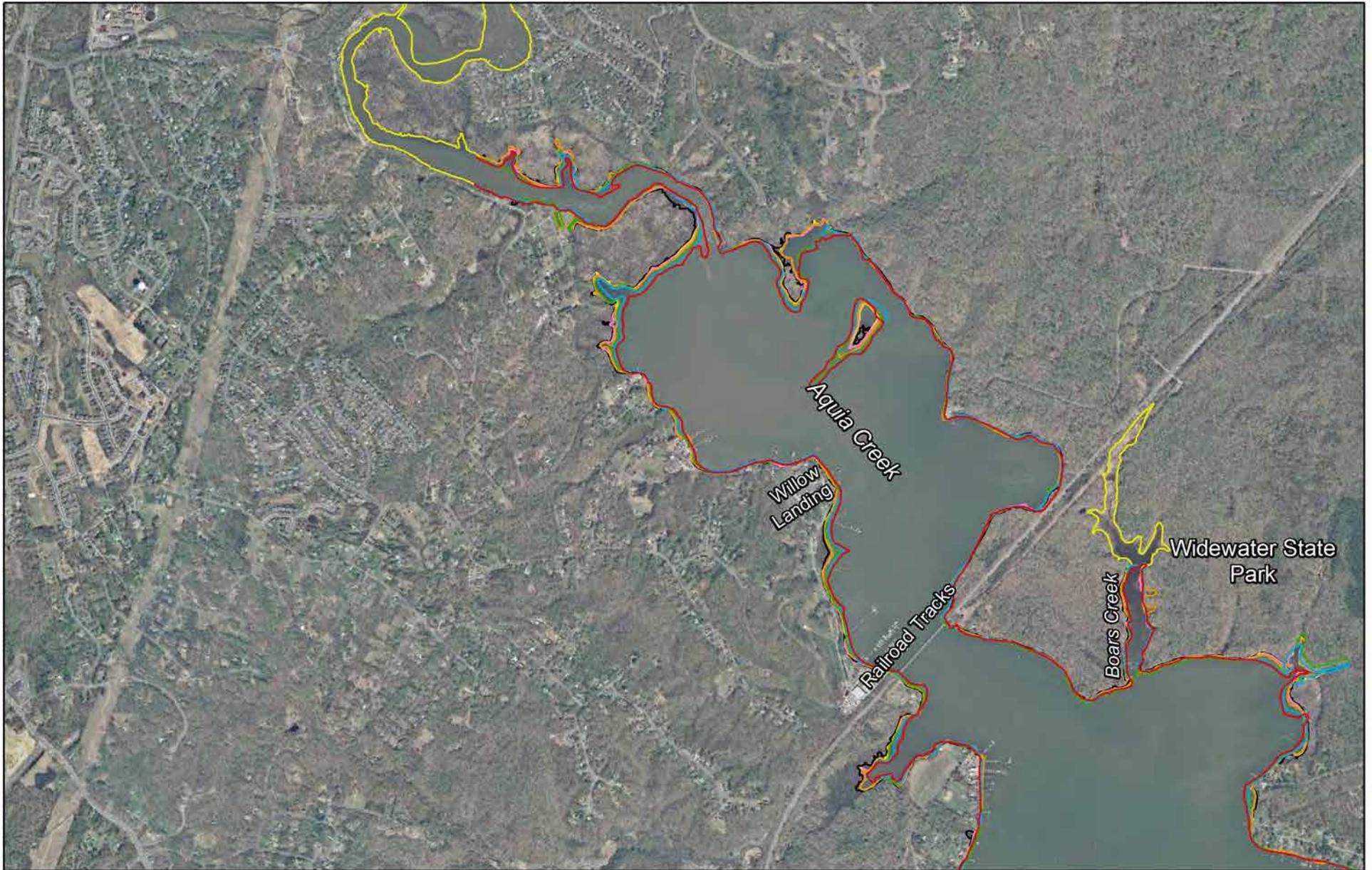
**Legend**  
— Shoreline 2009



### Stafford County, Virginia Plate 4

Photo Date: 2009





**Shorelines**

- Shoreline 1937      — Shoreline 2002
- Shoreline 1953      — Shoreline 2009
- Shoreline 1967      — Shoreline 2013
- Shoreline 1994

**Stafford County, Virginia  
Plate 4**

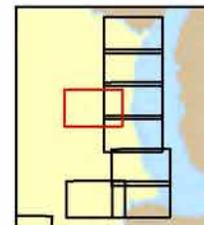
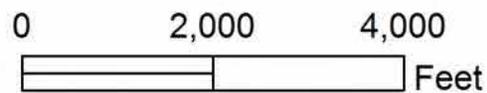
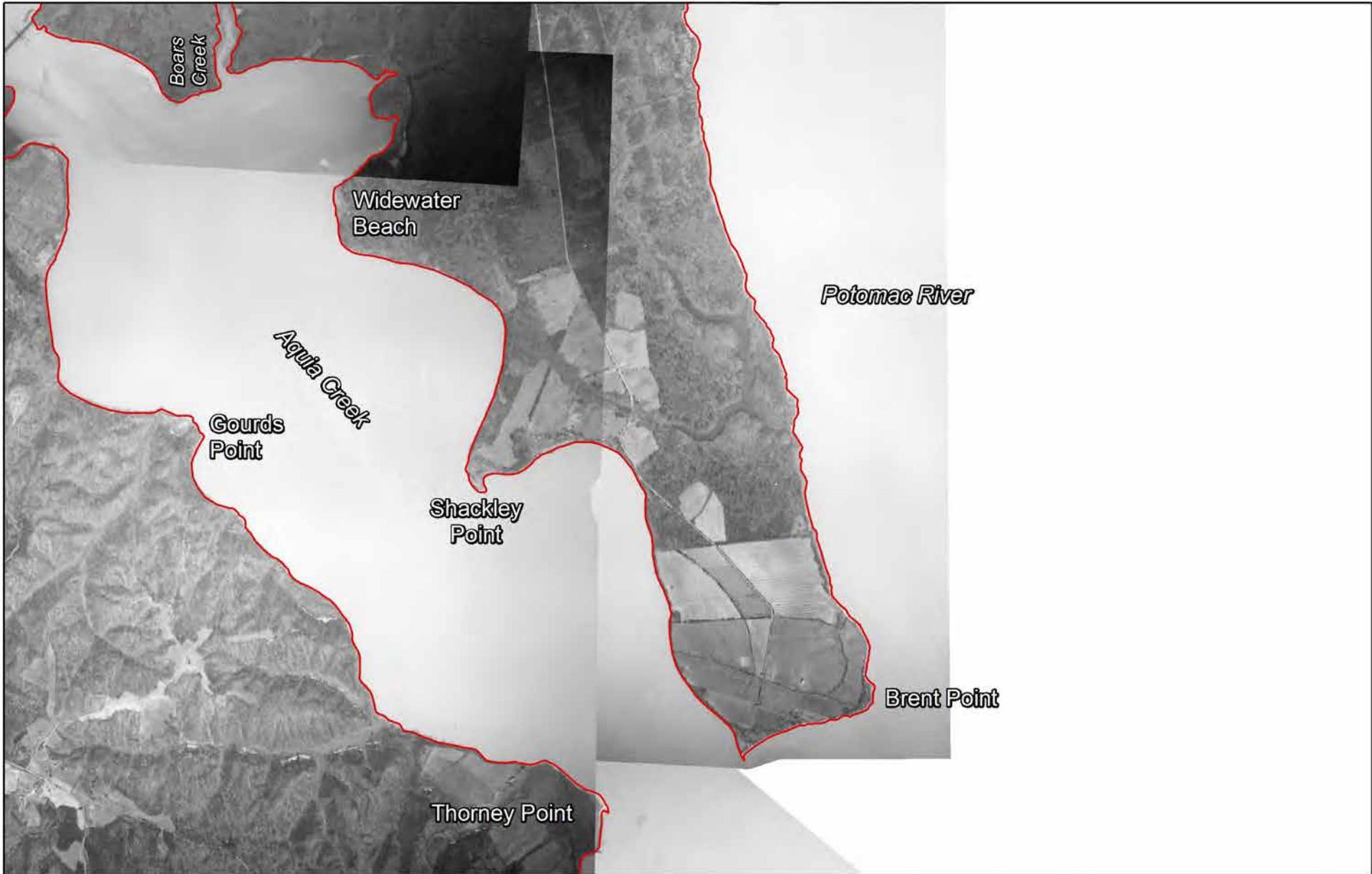
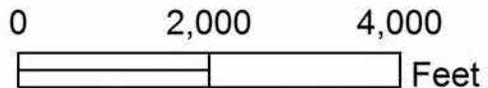


Image Date: 2013

B28

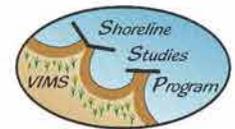
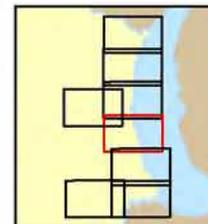


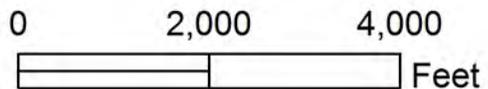
**Legend**  
 — Shoreline 1937



**Stafford County, Virginia  
 Plate 5**

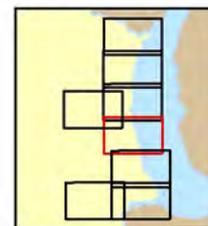
Photo Date: 1937





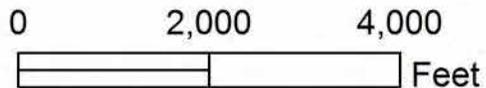
### Stafford County, Virginia Plate 5

Photo Date: 1953



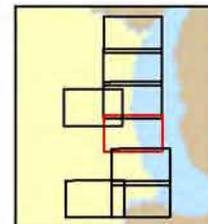


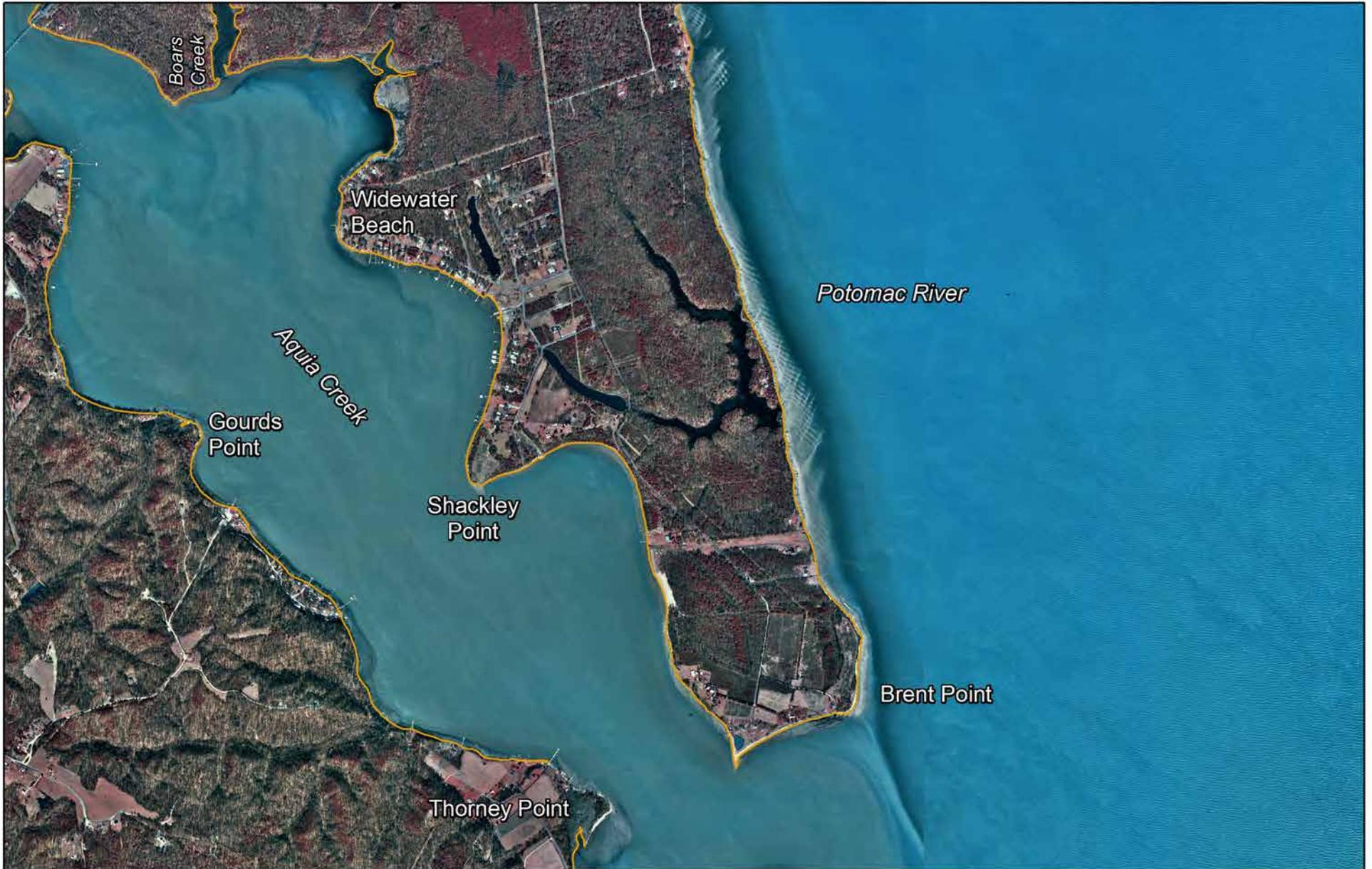
**Legend**  
 — Shoreline 1967



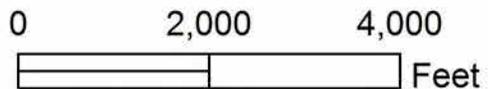
**Stafford County, Virginia  
 Plate 5**

Photo Date: 1967



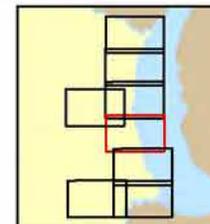


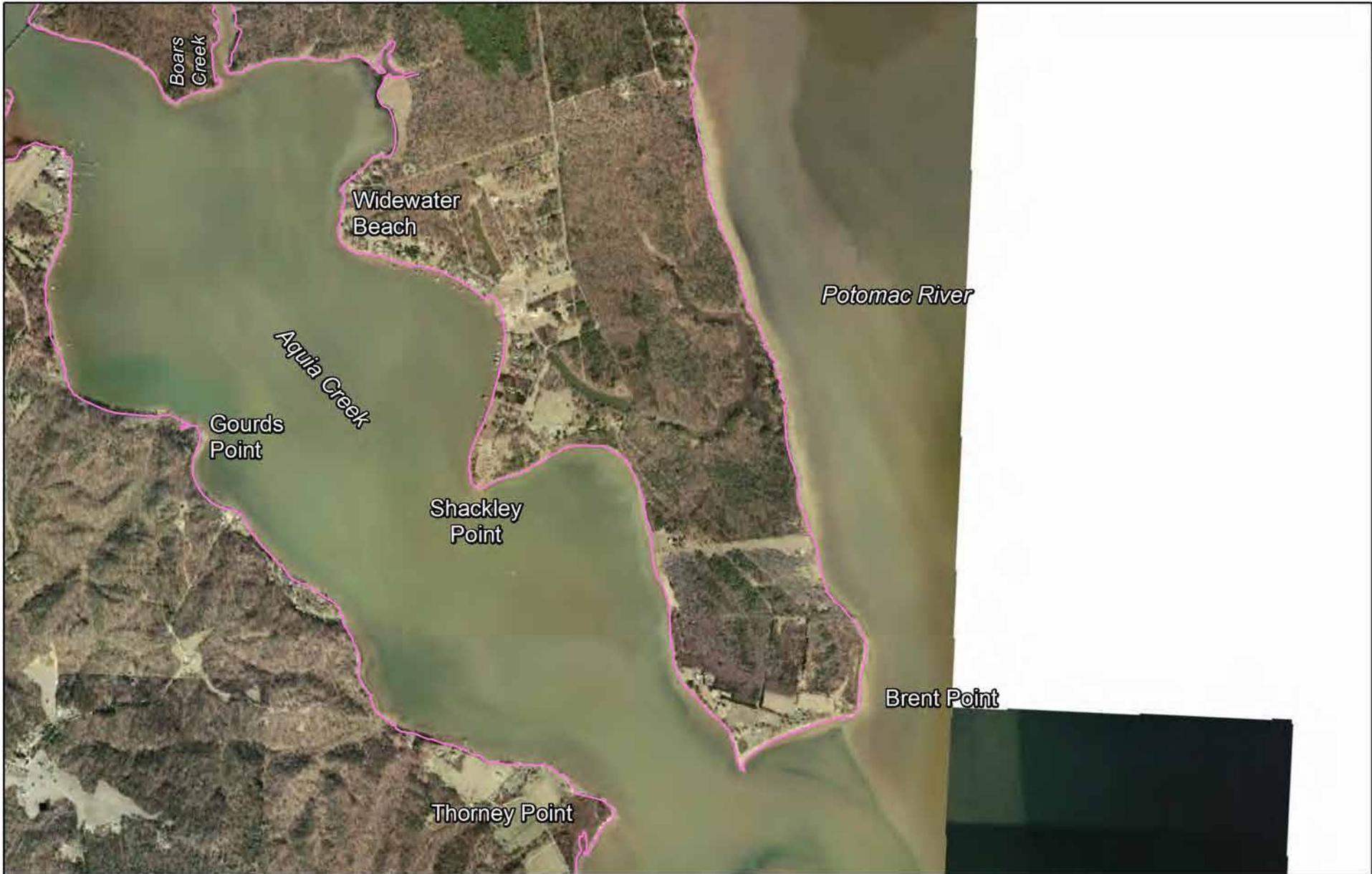
**Legend**  
 — Shoreline 1994



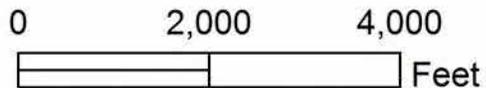
**Stafford County, Virginia  
 Plate 5**

Photo Date: 1994



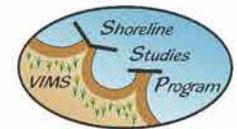
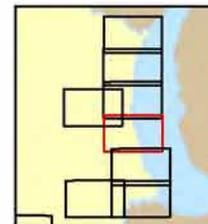


**Legend**  
 — Shoreline 2002



**Stafford County, Virginia  
 Plate 5**

Photo Date: 2002





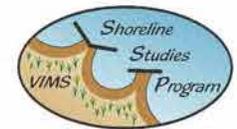
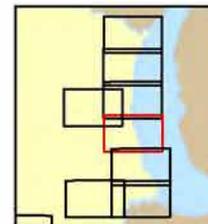
**Legend**  
 — Shoreline 2009



0      2,000      4,000  
 Feet

**Stafford County, Virginia  
 Plate 5**

Photo Date: 2009





Shorelines	
— Shoreline 1937	— Shoreline 2002
— Shoreline 1953	— Shoreline 2009
— Shoreline 1967	— Shoreline 2013
— Shoreline 1994	

### Stafford County, Virginia Plate 5

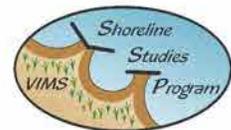
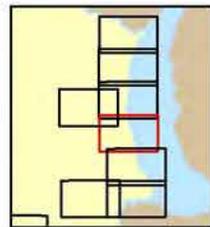
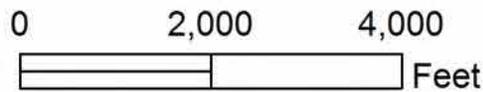
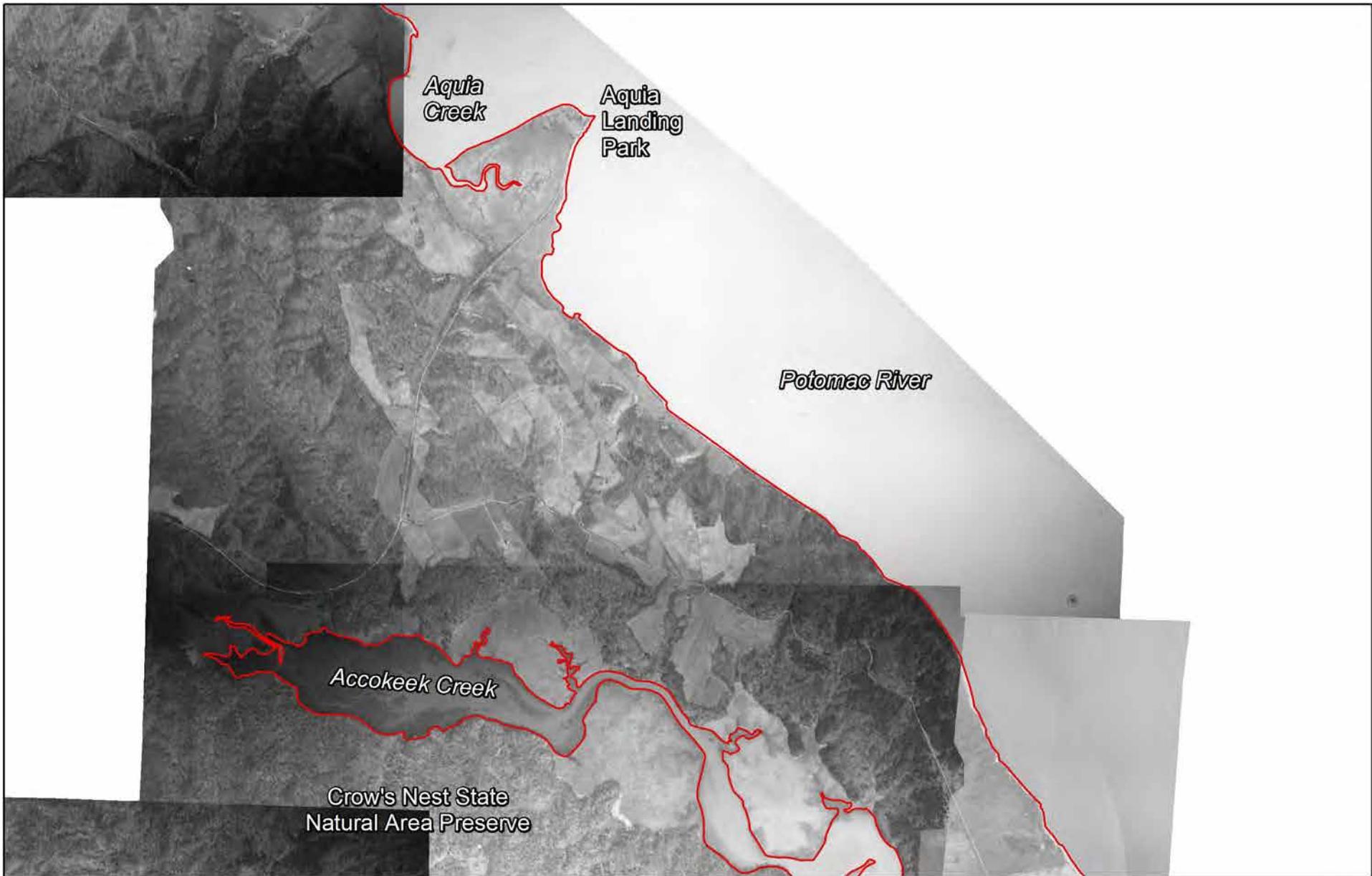
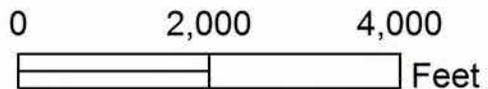


Image Date: 2013

B35

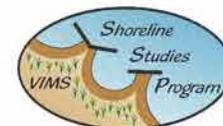
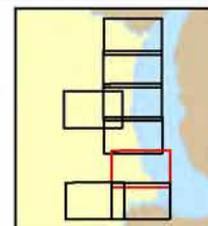


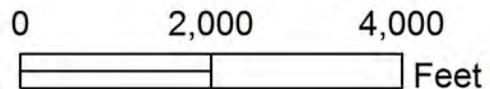
**Legend**  
— Shoreline 1937



### Stafford County, Virginia Plate 6

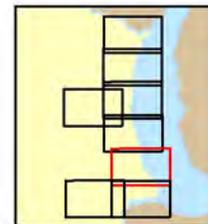
Photo Date: 1937



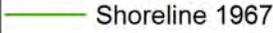


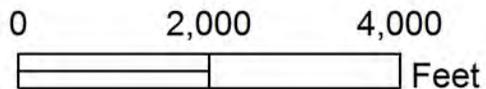
### Stafford County, Virginia Plate 6

Photo Date: 1953



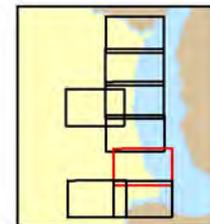


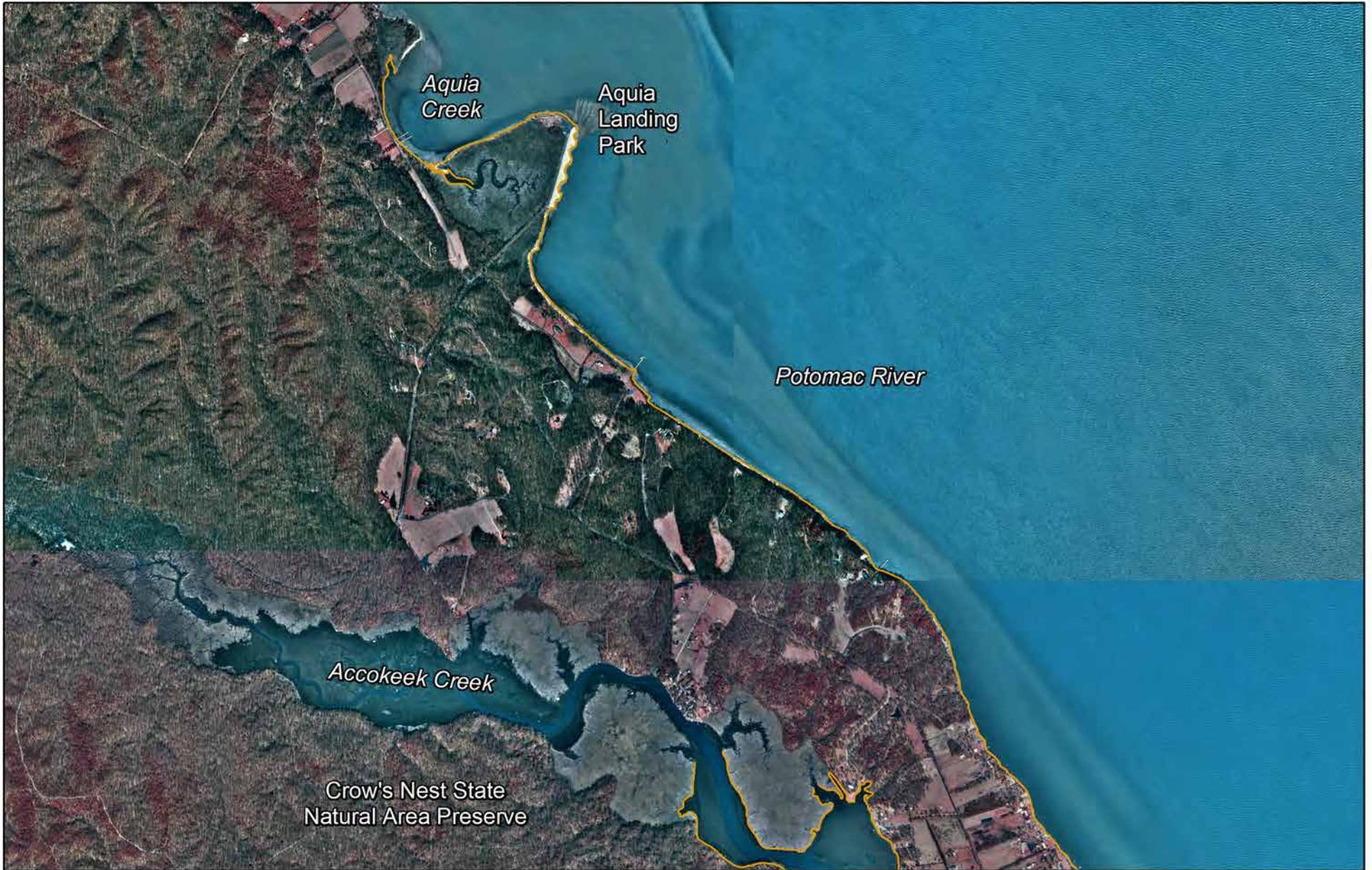
**Legend**  
 Shoreline 1967

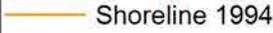


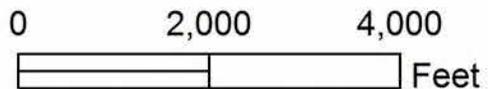
**Stafford County, Virginia  
 Plate 6**

Photo Date: 1967



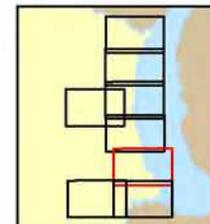


**Legend**  
 Shoreline 1994



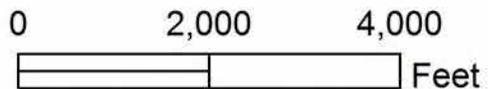
**Stafford County, Virginia  
 Plate 6**

Photo Date: 1994



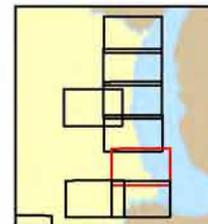


**Legend**  
 — Shoreline 2002



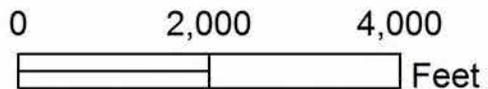
**Stafford County, Virginia  
 Plate 6**

Photo Date: 2002



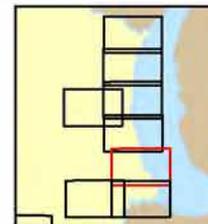


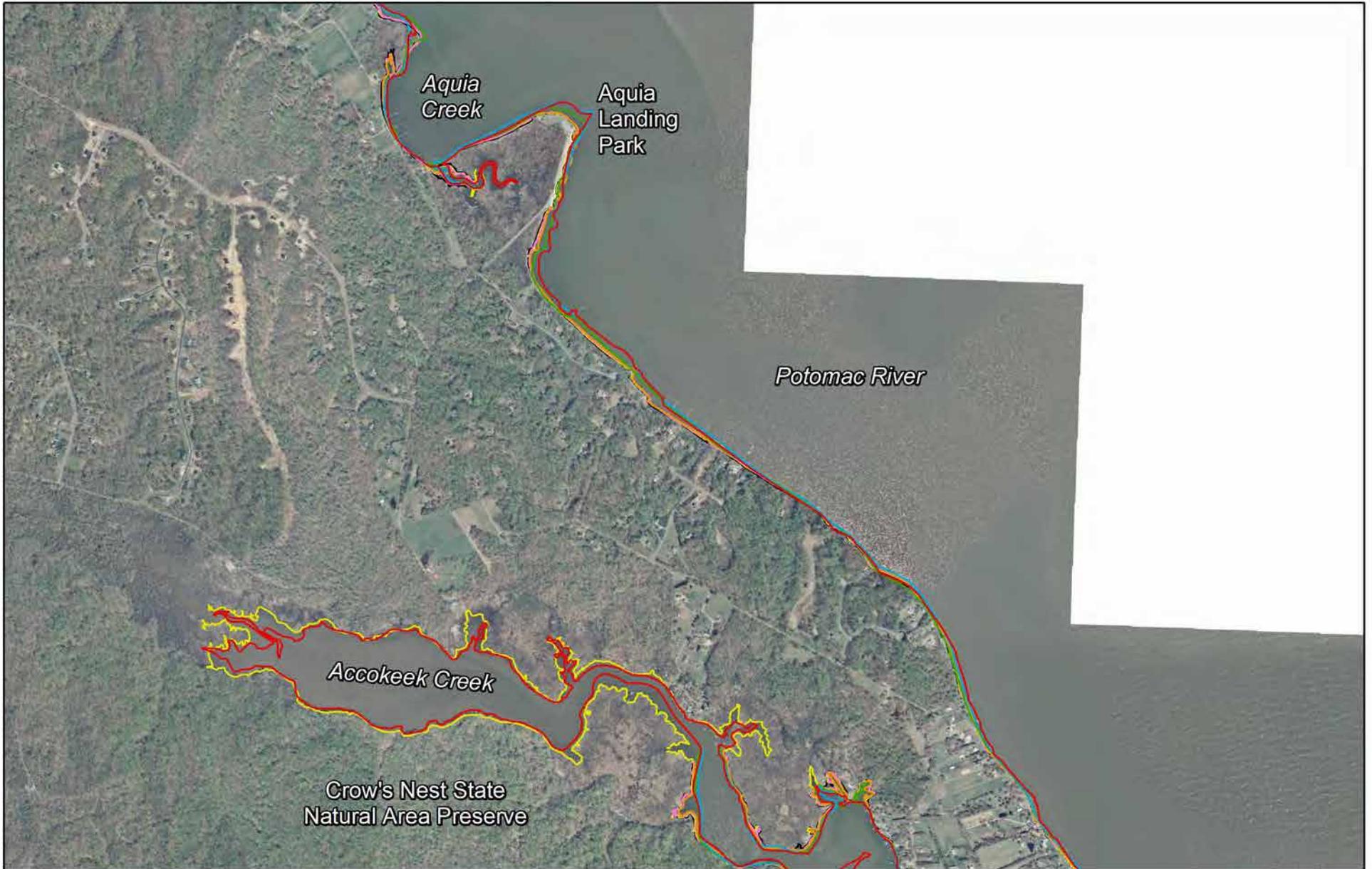
**Legend**  
— Shoreline 2009



## Stafford County, Virginia Plate 6

Photo Date: 2009





**Shorelines**

- Shoreline 1937      — Shoreline 2002
- Shoreline 1953      — Shoreline 2009
- Shoreline 1967      — Shoreline 2013
- Shoreline 1994

**Stafford County, Virginia  
Plate 6**

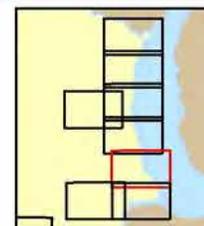
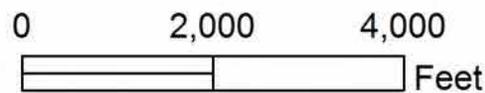
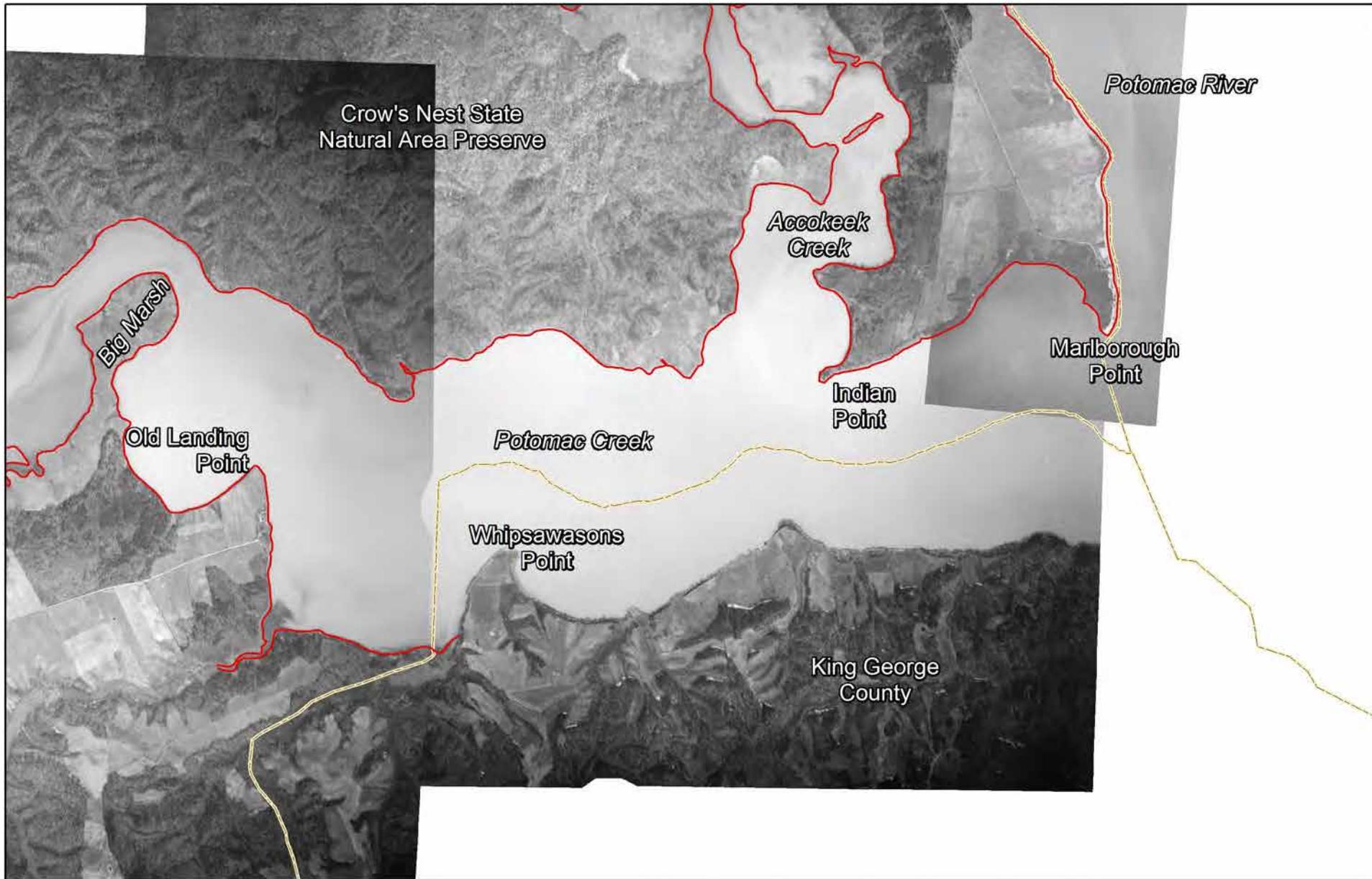
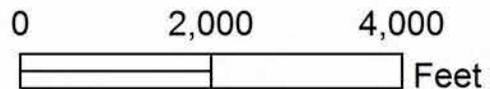


Image Date: 2013

B42

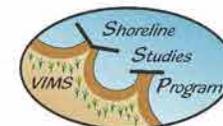
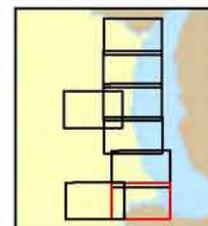


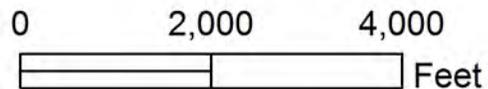
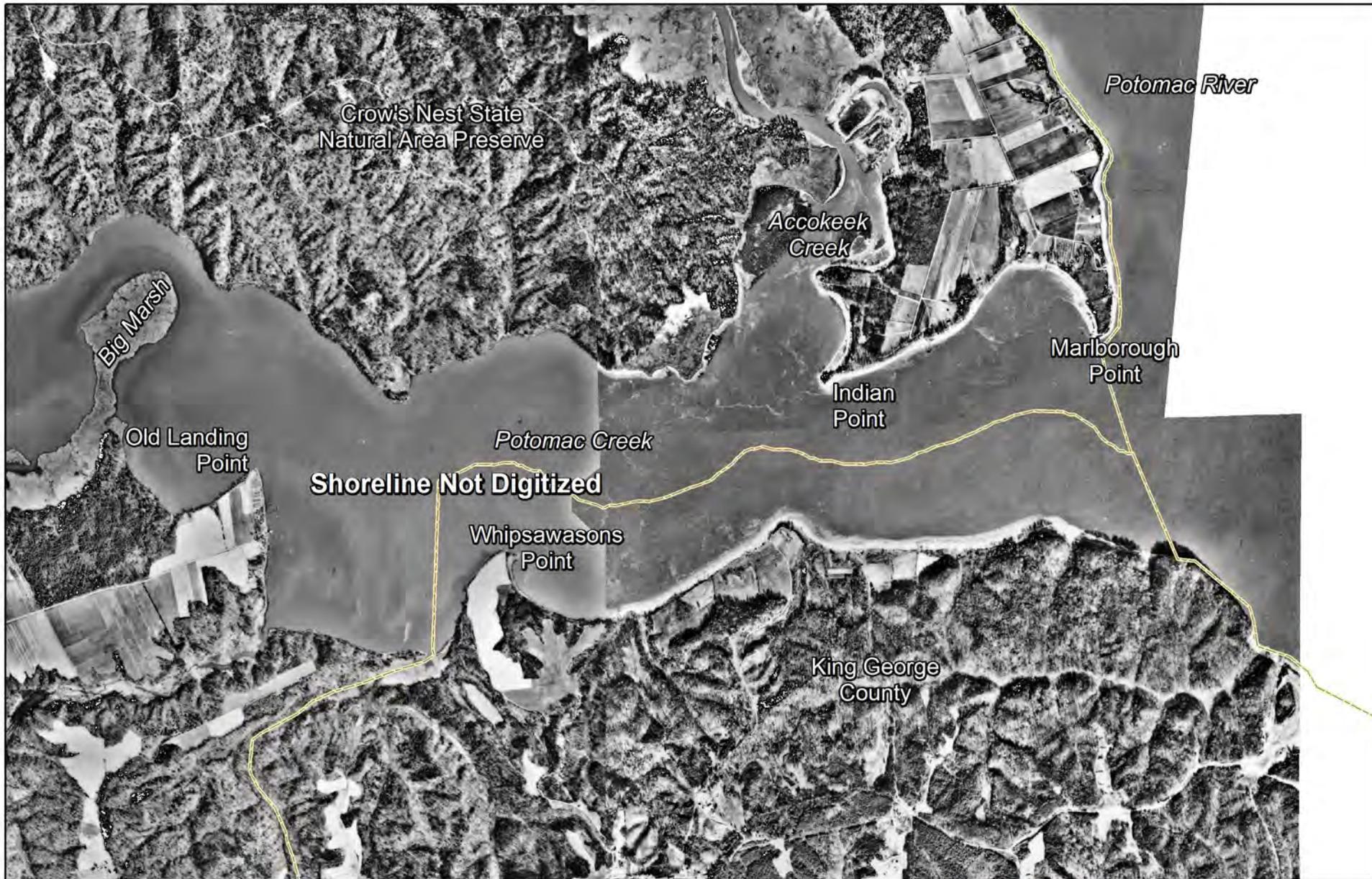
**Legend**



## Stafford County, Virginia Plate 7

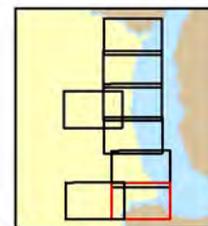
Photo Date: 1937

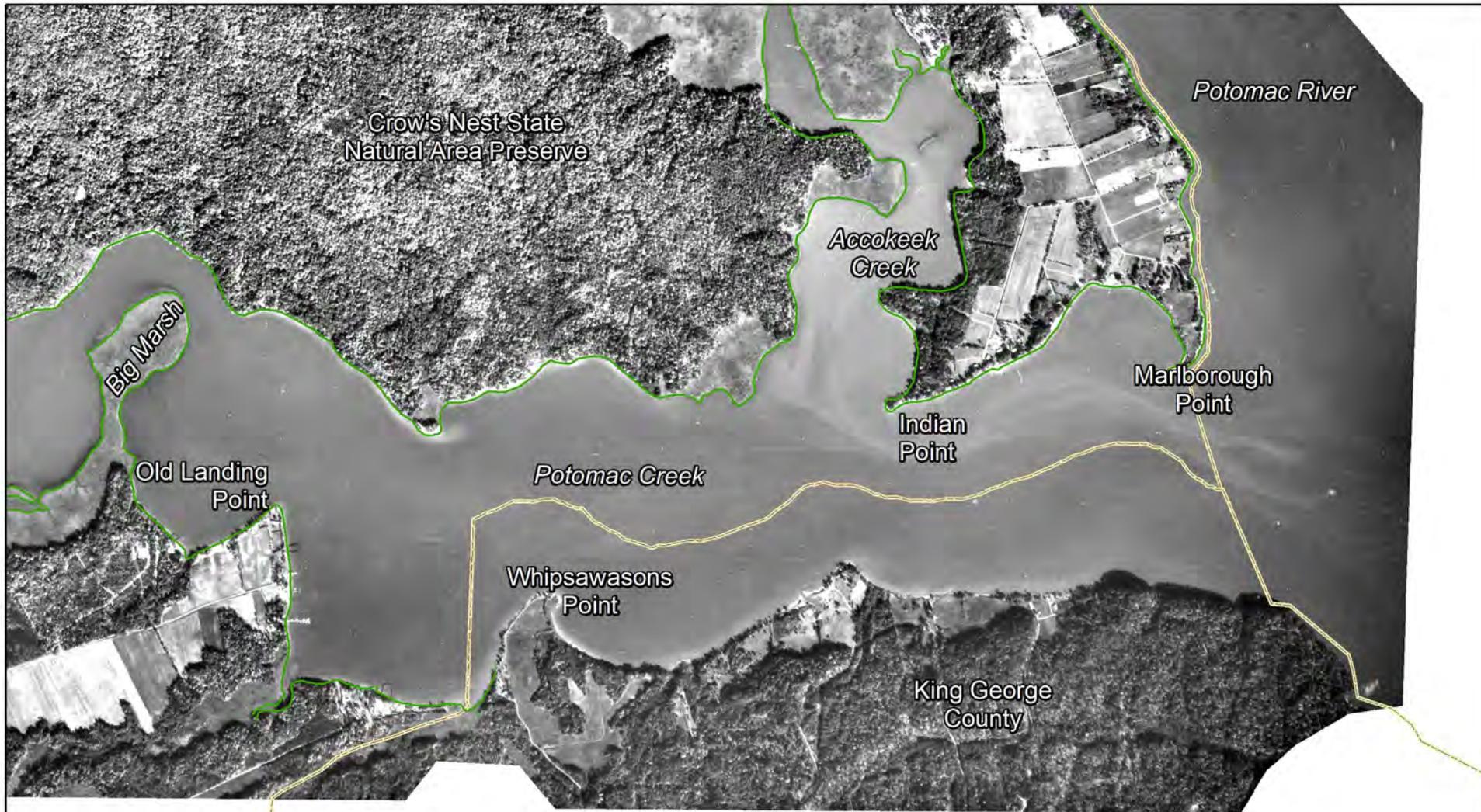




**Stafford County, Virginia  
Plate 7**

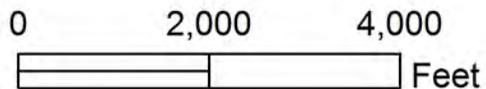
Photo Date: 1953





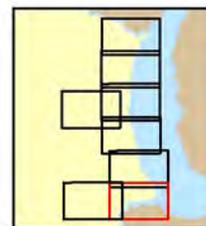
**Legend**

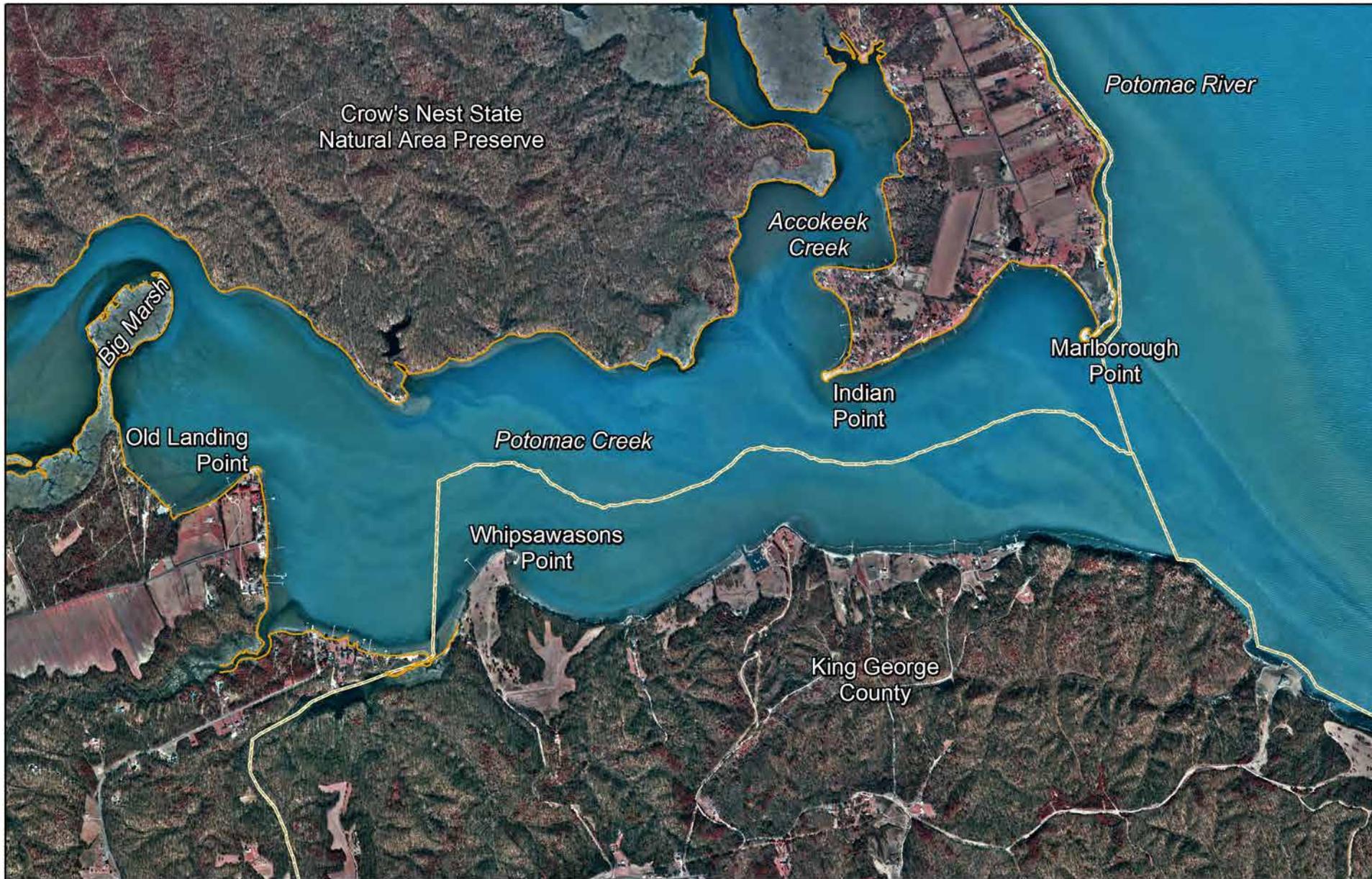
— Shoreline 1967



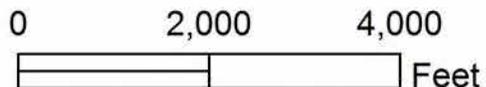
**Stafford County, Virginia  
Plate 7**

Photo Date: 1967



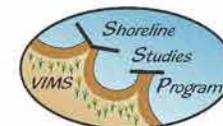
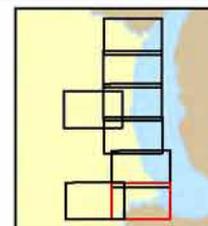


**Legend**  
 — Shoreline 1994



**Stafford County, Virginia  
 Plate 7**

Photo Date: 1994





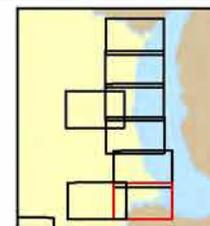
**Legend**  
 — Shoreline 2002

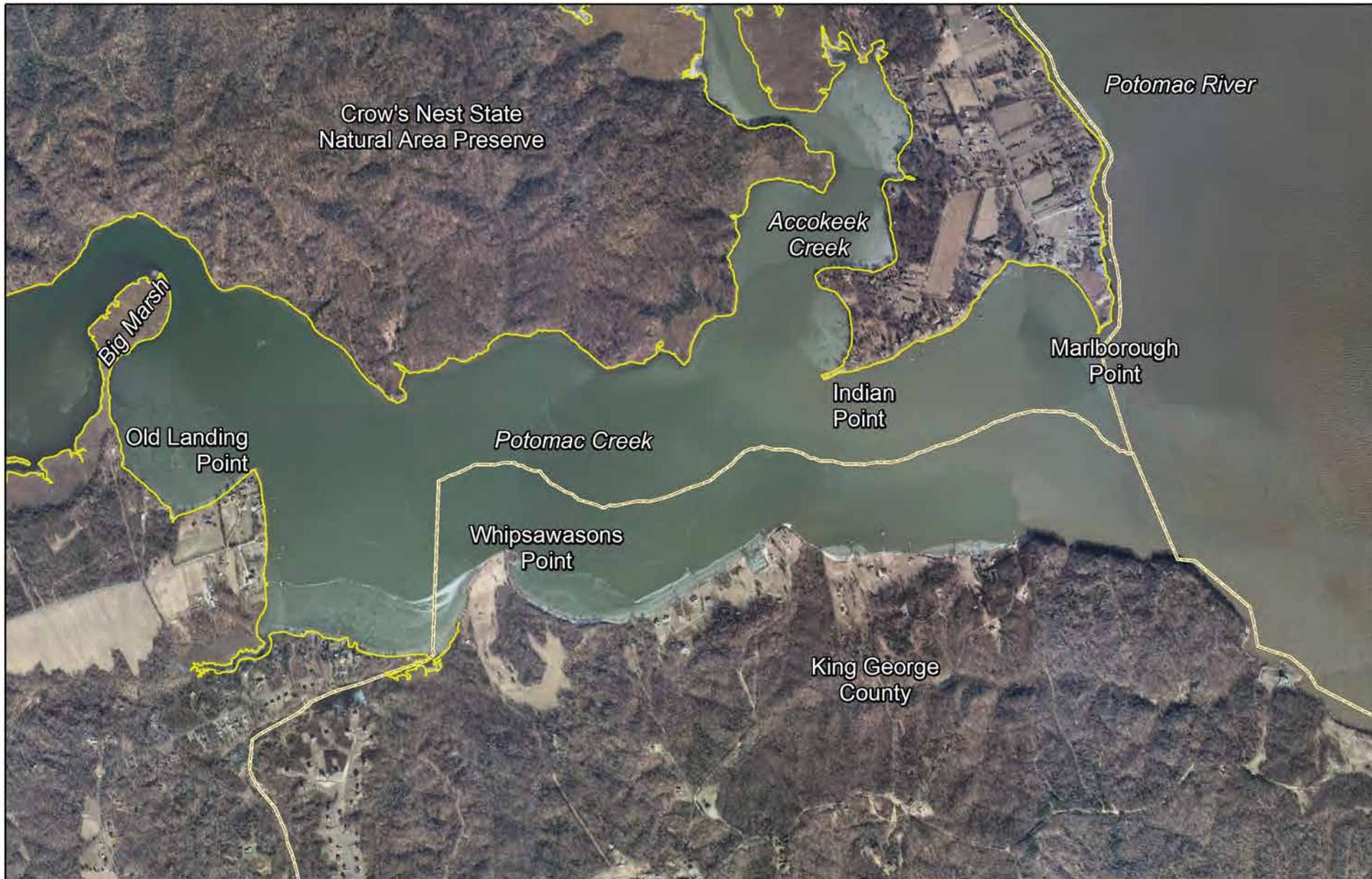


0      2,000      4,000  
 Feet

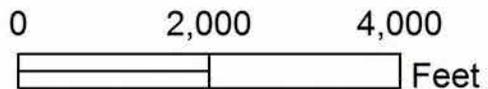
**Stafford County, Virginia  
 Plate 7**

Photo Date: 2002



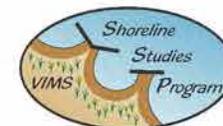
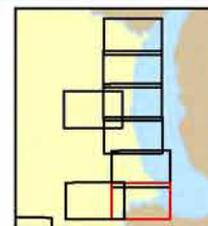


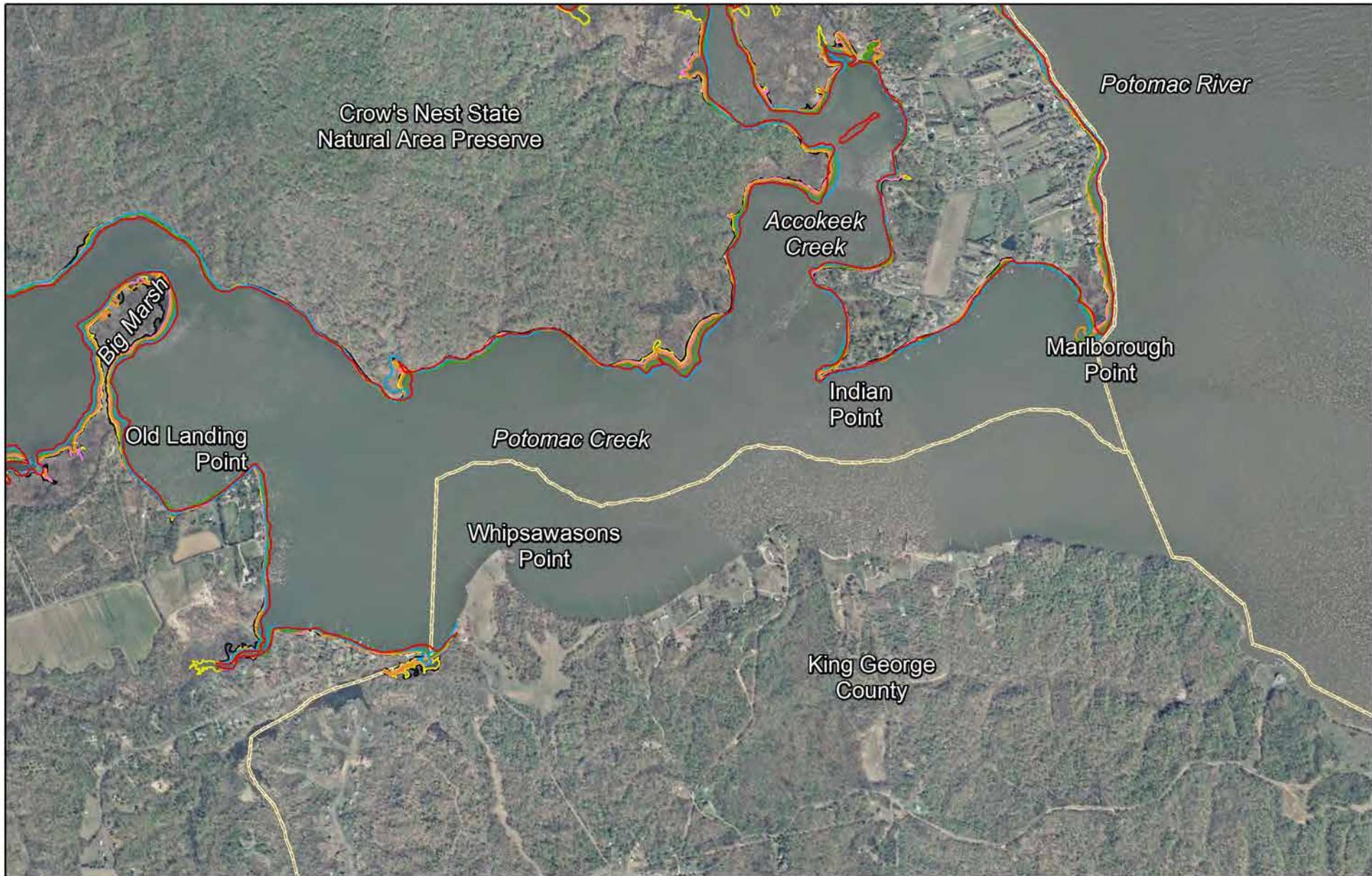
**Legend**  
 — Shoreline 2009



**Stafford County, Virginia  
 Plate 7**

Photo Date: 2009





Shorelines	
— Shoreline 1937	— Shoreline 2002
— Shoreline 1953	— Shoreline 2009
— Shoreline 1967	— Shoreline 2013
— Shoreline 1994	

### Stafford County, Virginia Plate 7

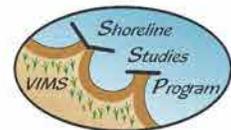
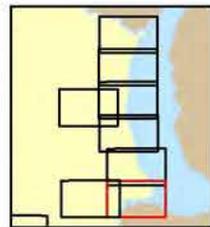
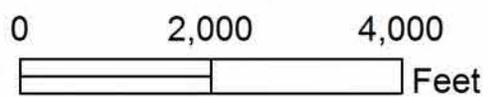
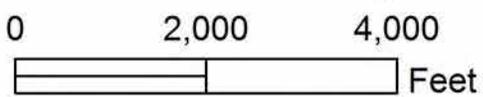


Image Date: 2013

B49

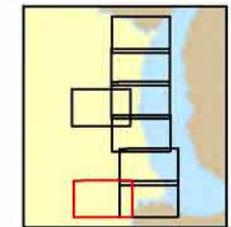


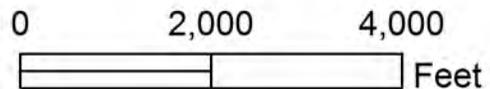
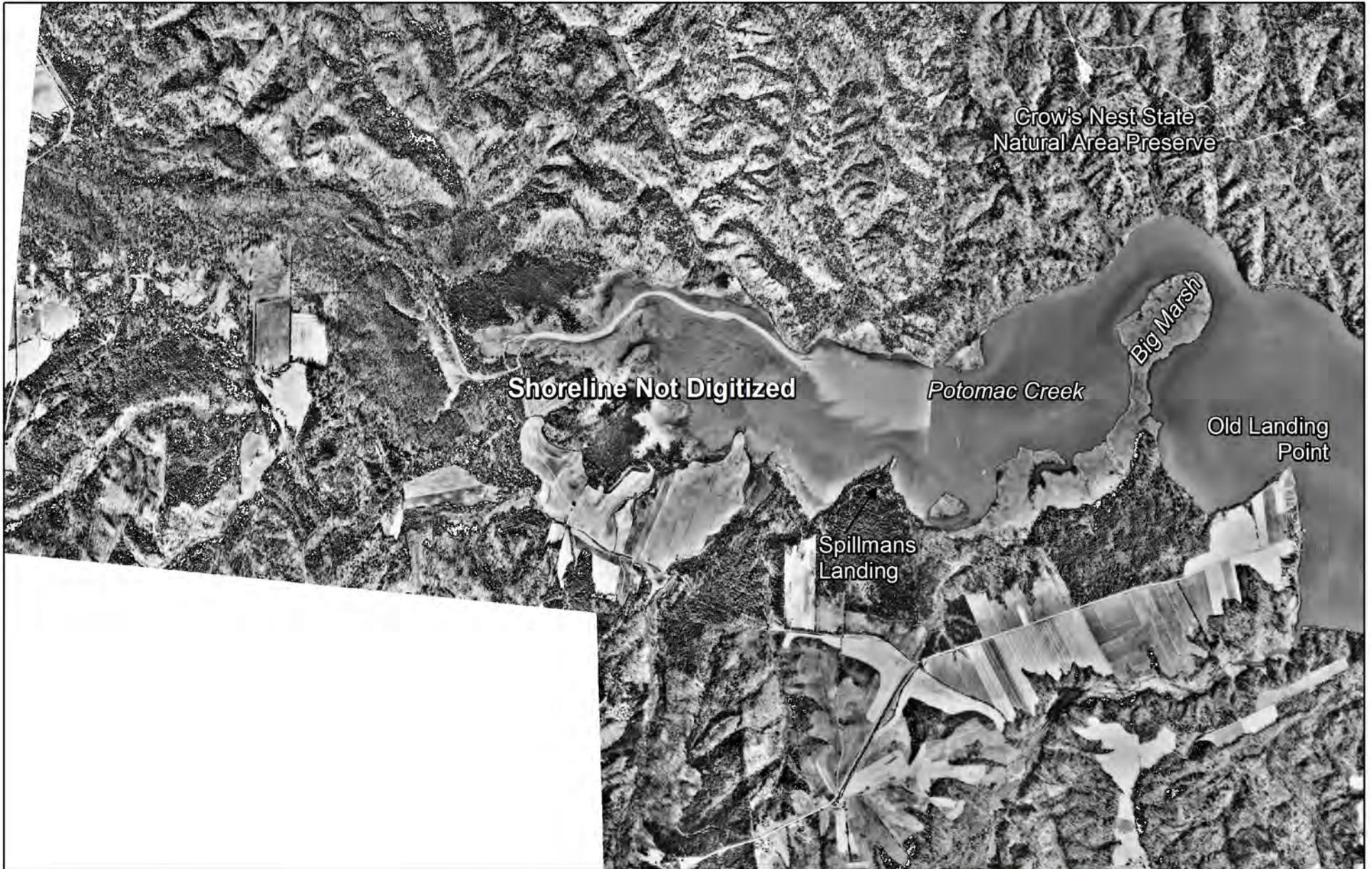
**Legend**  
 — Shoreline 1937



**Stafford County, Virginia  
 Plate 8**

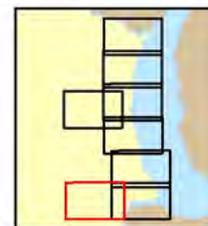
Photo Date: 1937

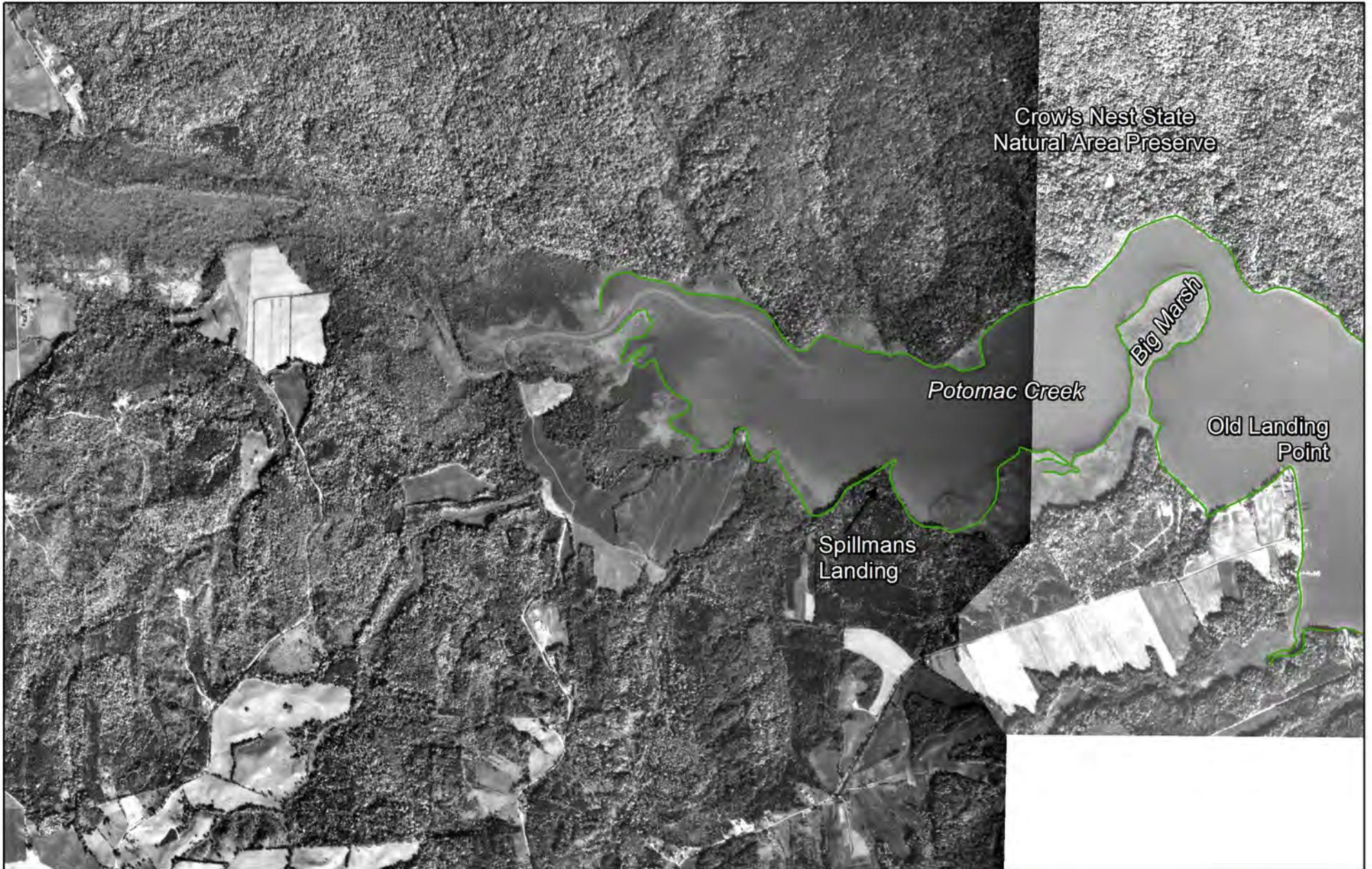




**Stafford County, Virginia  
Plate 8**

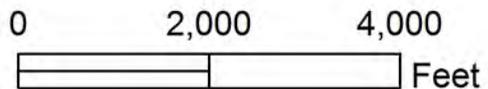
Photo Date: 1953





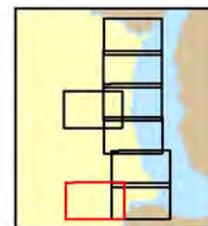
**Legend**

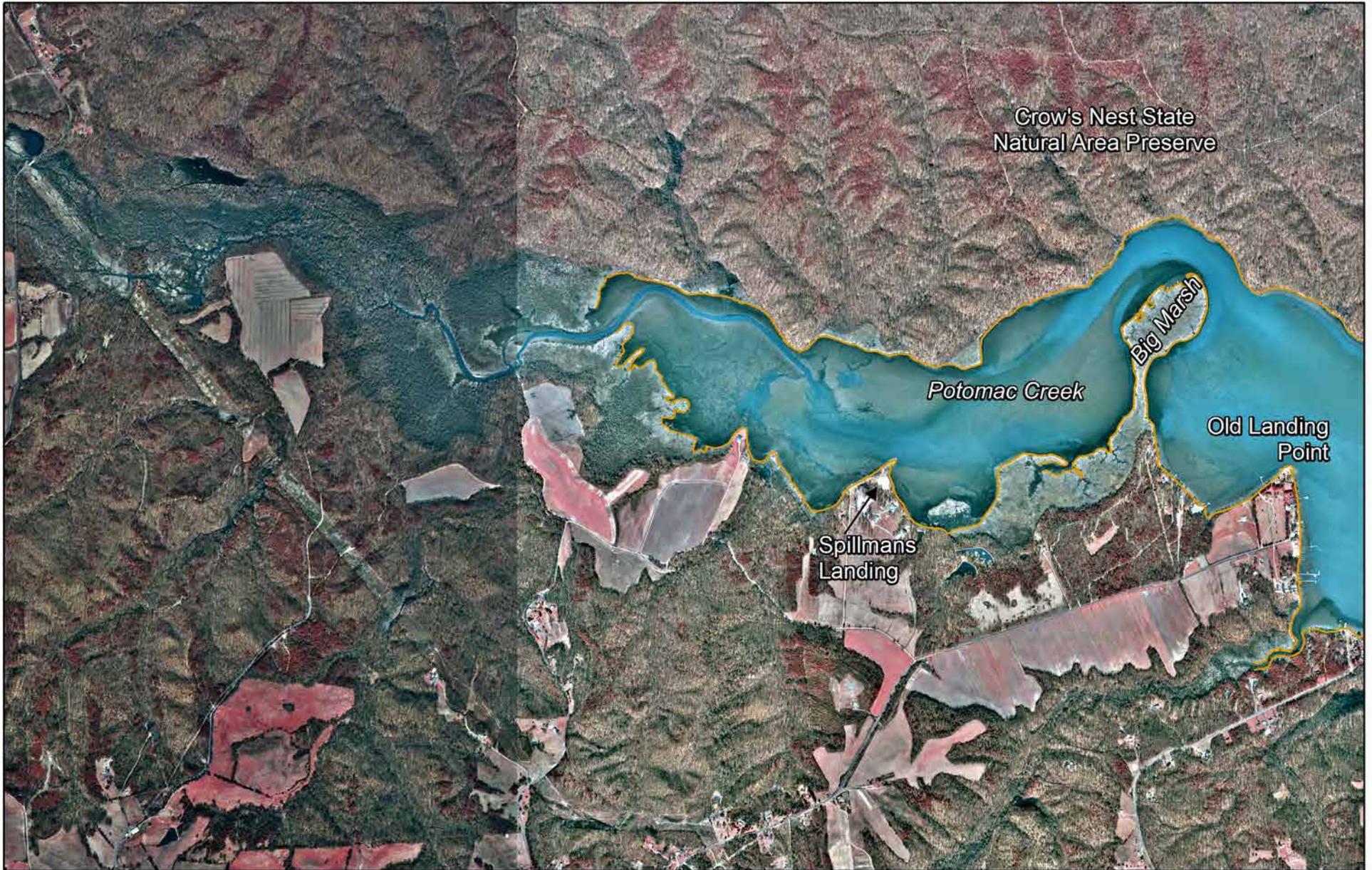
— Shoreline 1967

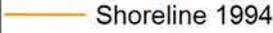


**Stafford County, Virginia  
Plate 8**

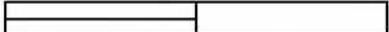
Photo Date: 1967





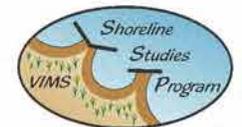
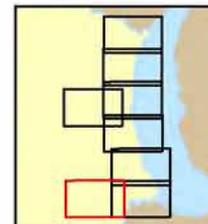
**Legend**  
 Shoreline 1994



0      2,000      4,000  
 Feet

**Stafford County, Virginia  
 Plate 8**

Photo Date: 1994





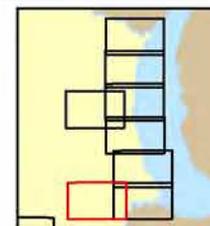
**Legend**  
 — Shoreline 2002



0      2,000      4,000  
 Feet

**Stafford County, Virginia  
 Plate 8**

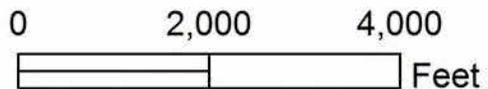
Photo Date: 2002





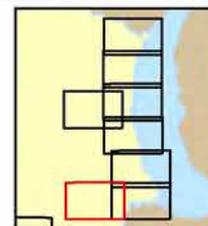
**Legend**

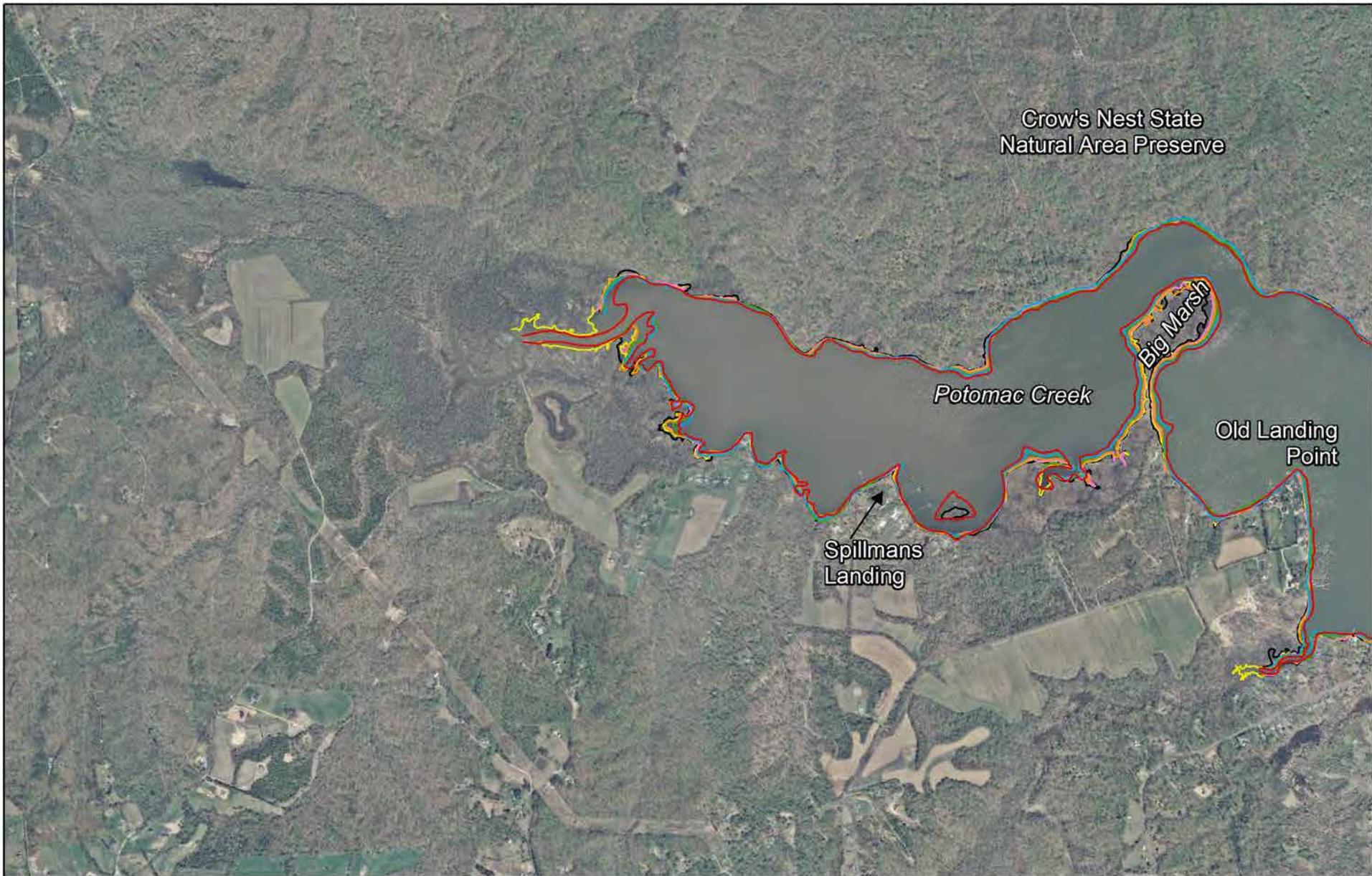
— Shoreline 2009



**Stafford County, Virginia  
Plate 8**

Photo Date: 2009





Shorelines	
— Shoreline 1937	— Shoreline 2002
— Shoreline 1953	— Shoreline 2009
— Shoreline 1967	— Shoreline 2013
— Shoreline 1994	

### Stafford County, Virginia Plate 8

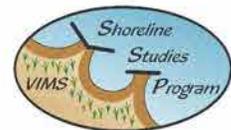
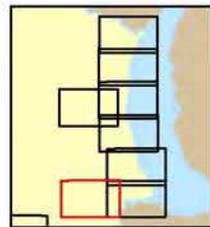
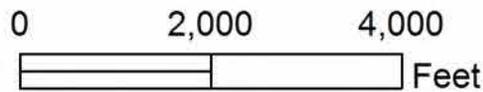
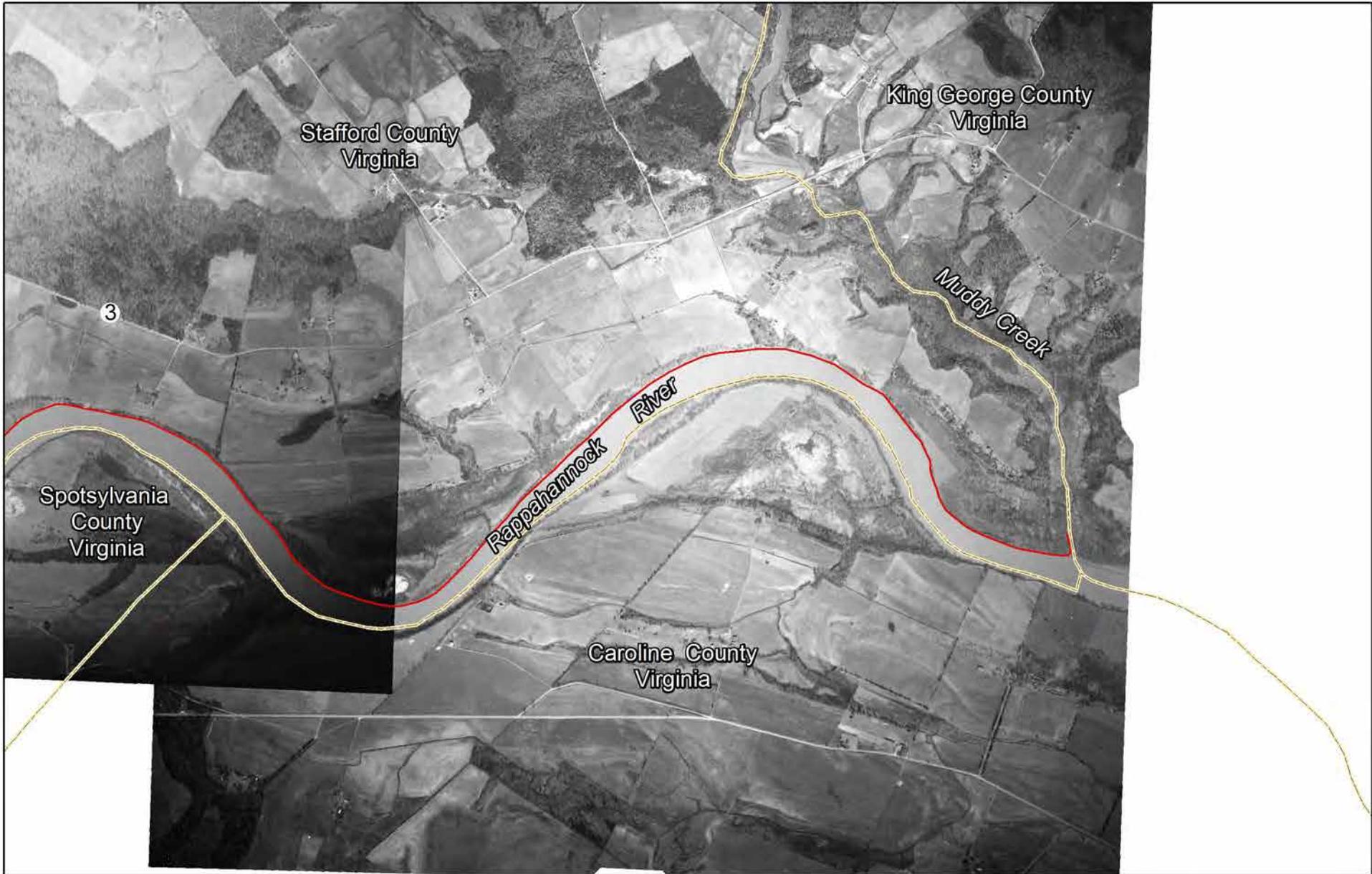


Image Date: 2013

B56



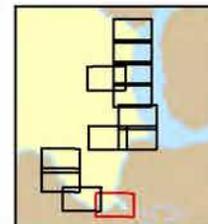
**Legend**  
 — Shoreline 1937

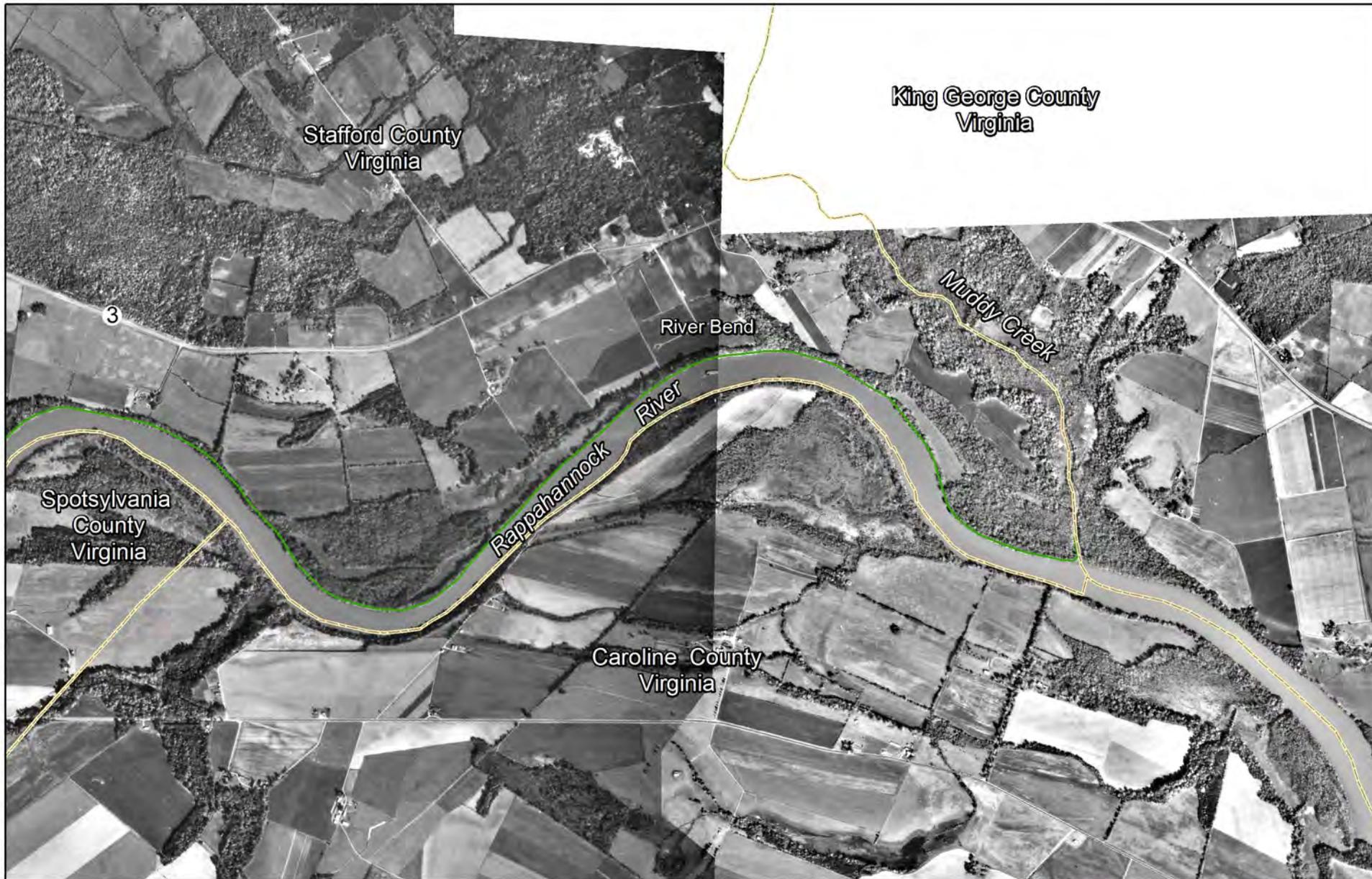


0      2,000      4,000  
 Feet

**Stafford County, Virginia  
 Plate 9**

Photo Date: 1937





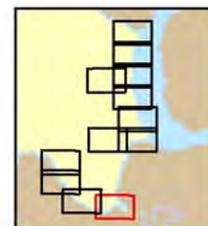
**Legend**  
 — Shoreline 1967



0      2,000      4,000  
 Feet

**Stafford County, Virginia  
 Plate 9**

Photo Date: 1967





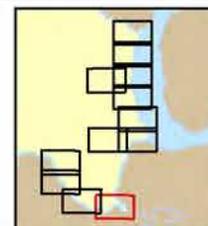
**Legend**  
 — Shoreline 2009

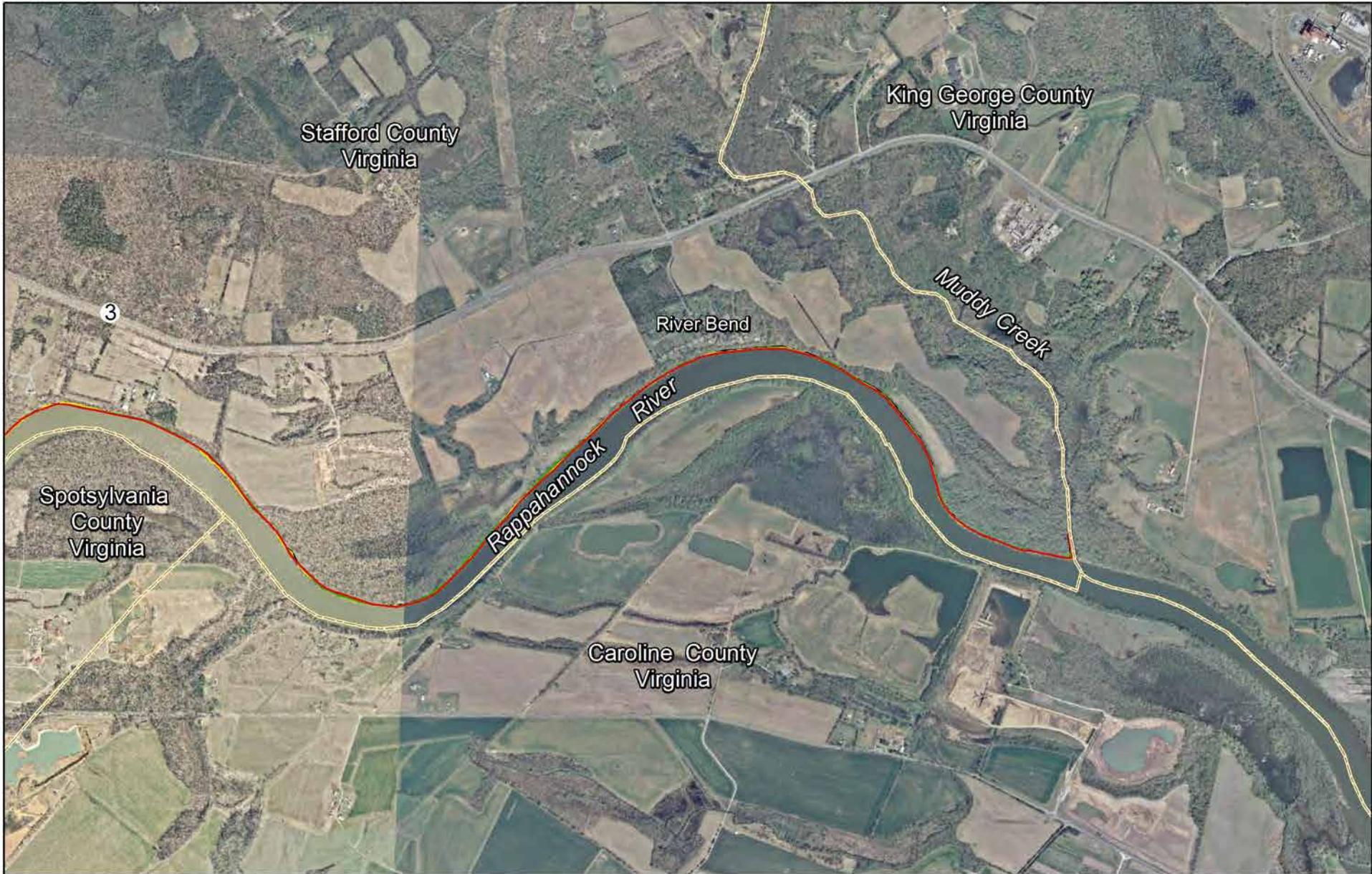


0      2,000      4,000  
 Feet

**Stafford County, Virginia  
 Plate 9**

Photo Date: 2009





**Shorelines**

- Shoreline 1937
- Shoreline 1967
- Shoreline 2009
- Shoreline 2013



**Stafford County, Virginia  
Plate 9**

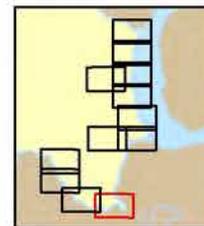
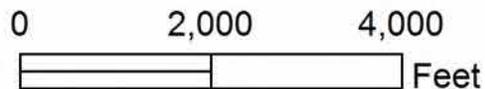
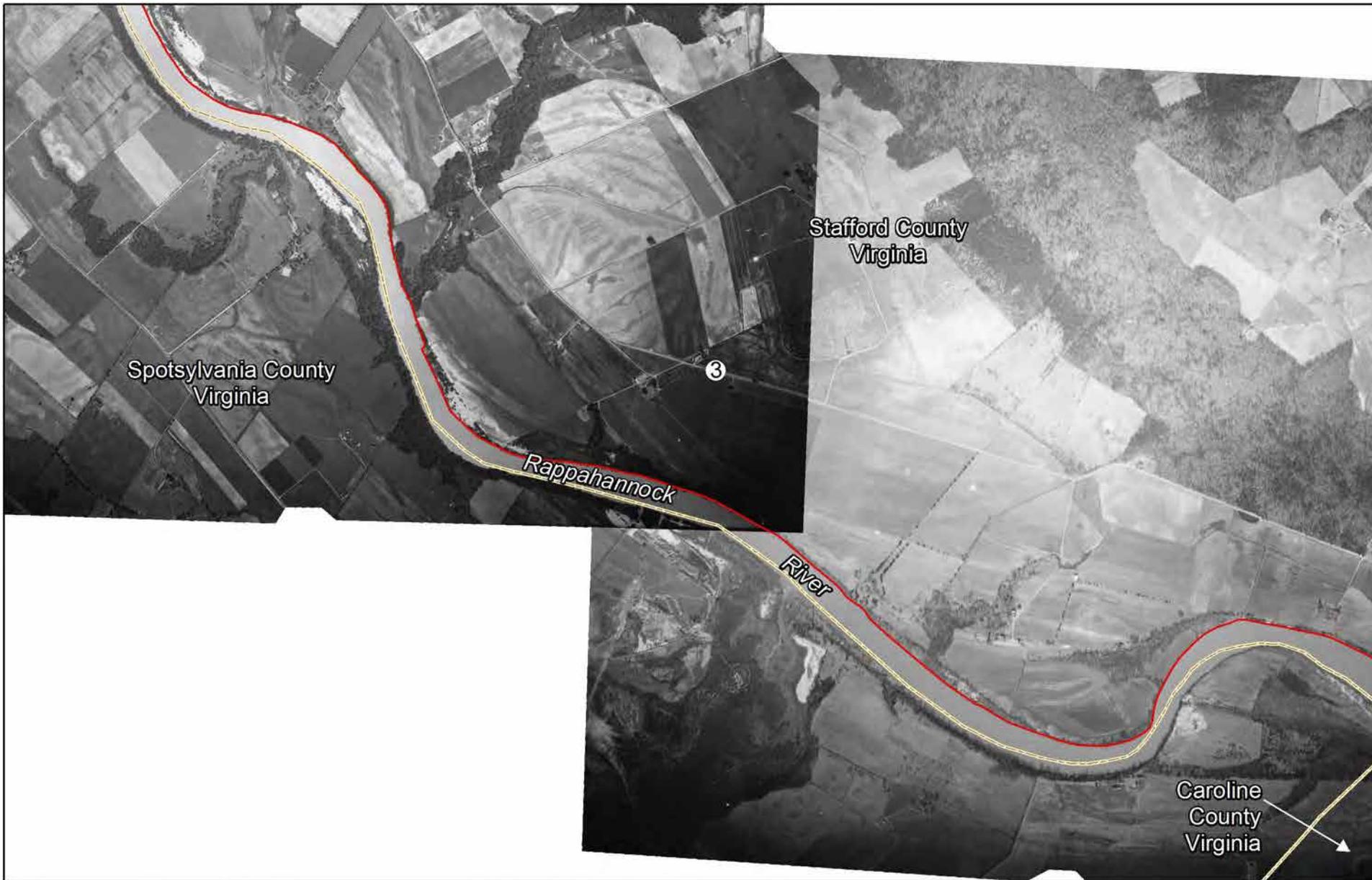


Image Date: 2013

B60



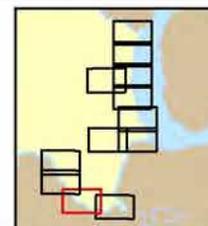
**Legend**  
 — Shoreline 1937



0      2,000      4,000  
 Feet

**Stafford County, Virginia  
 Plate 10**

Photo Date: 1937





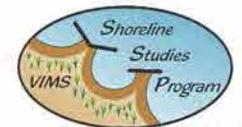
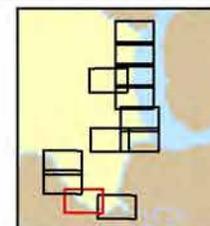
**Legend**  
 — Shoreline 1967



0      2,000      4,000  
 Feet

**Stafford County, Virginia  
 Plate 10**

Photo Date: 1967





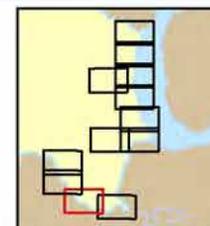
**Legend**  
 — Shoreline 2009

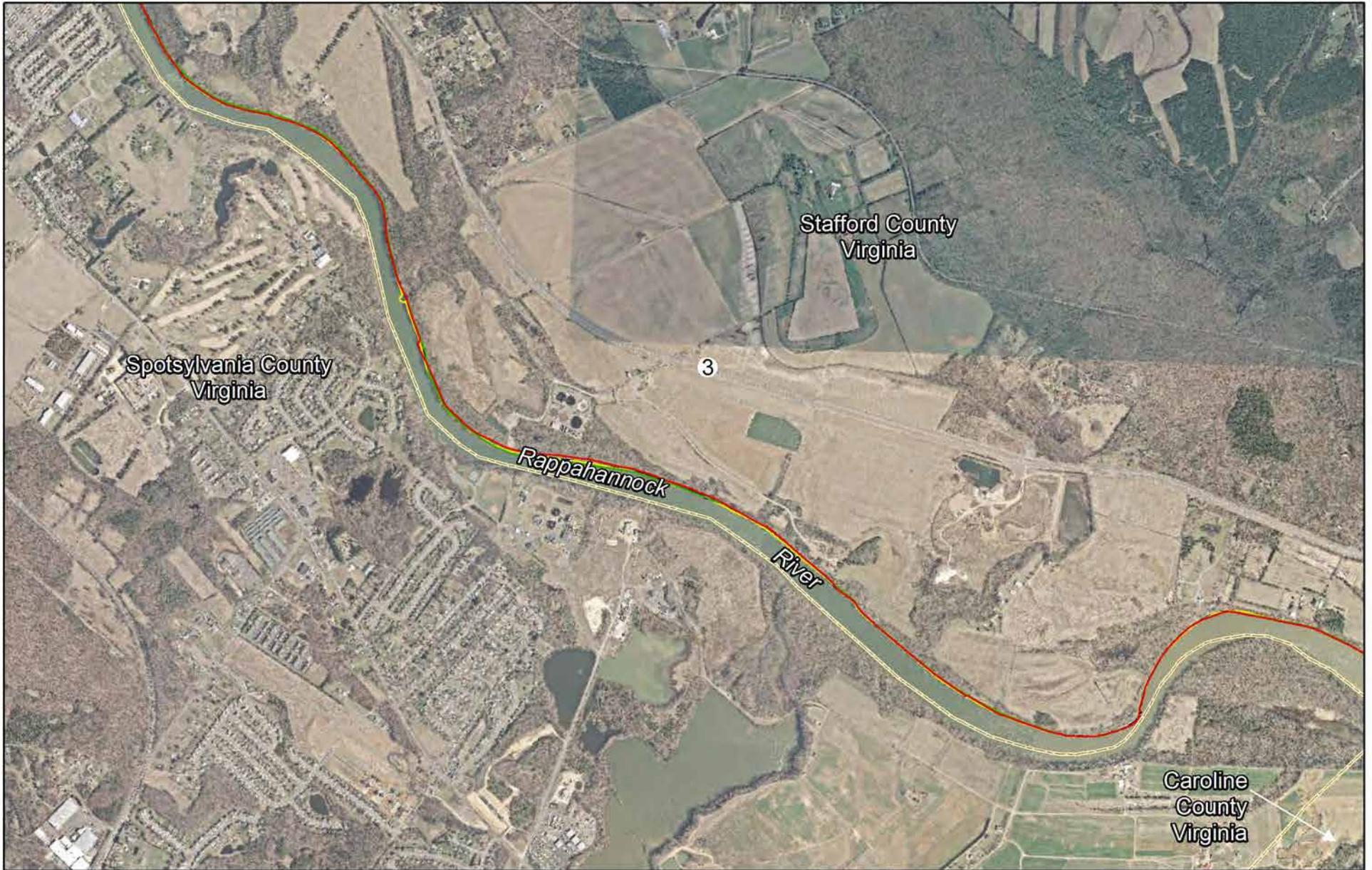


0      2,000      4,000  
 Feet

**Stafford County, Virginia  
 Plate 10**

Photo Date: 2009





**Shorelines**

- Shoreline 1937
- Shoreline 1967
- Shoreline 2009
- Shoreline 2013



**Stafford County, Virginia  
Plate 10**

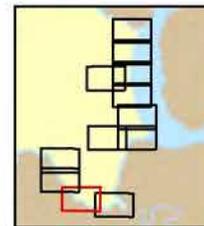
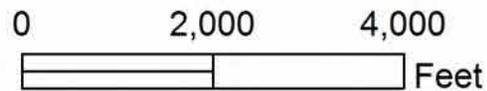
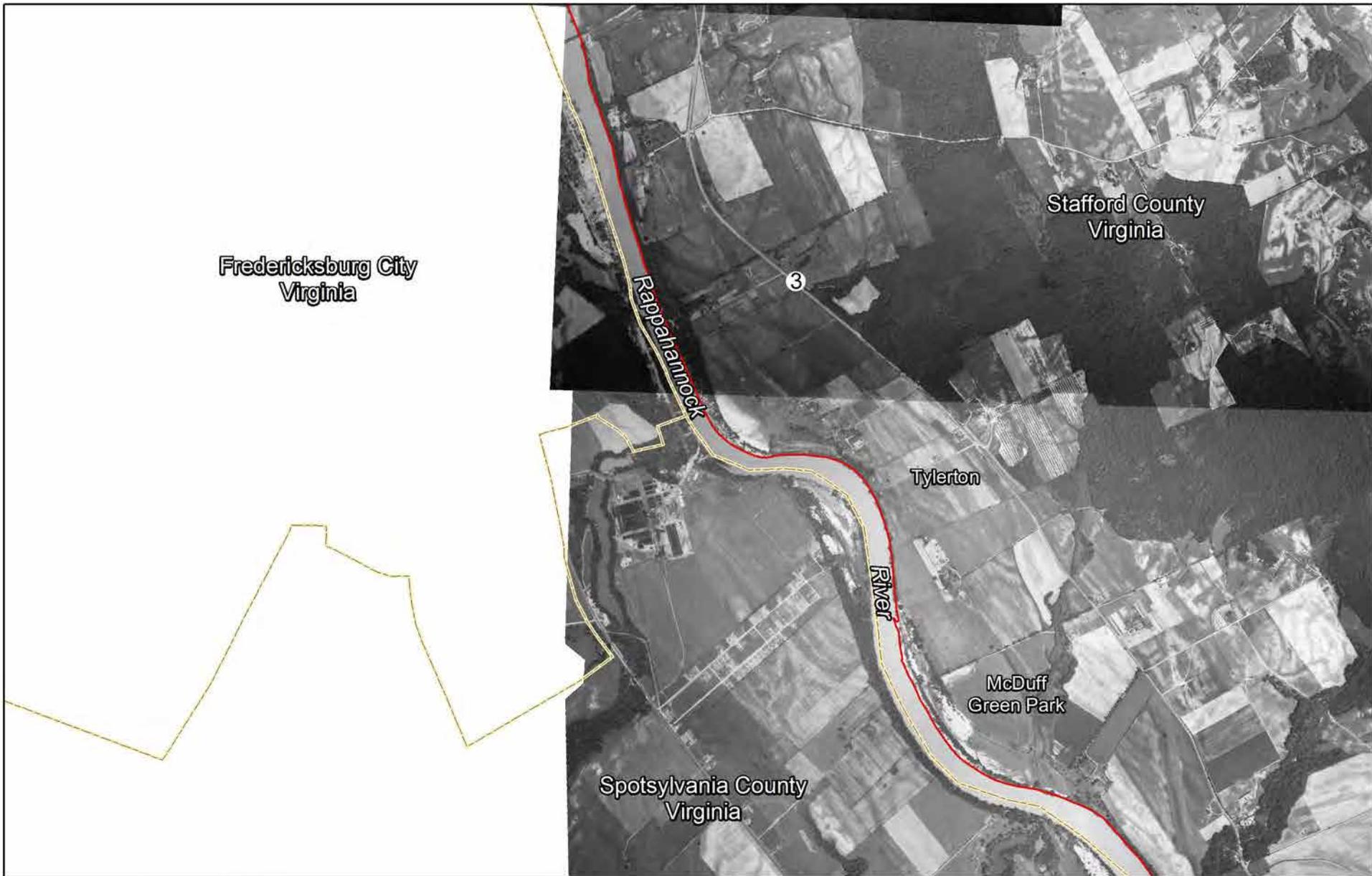
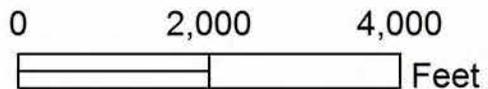


Image Date: 2013

B64

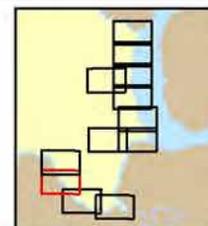


**Legend**  
 — Shoreline 1937

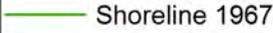


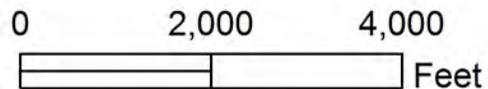
**Stafford County, Virginia  
 Plate 11**

Photo Date: 1937



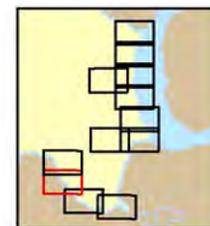


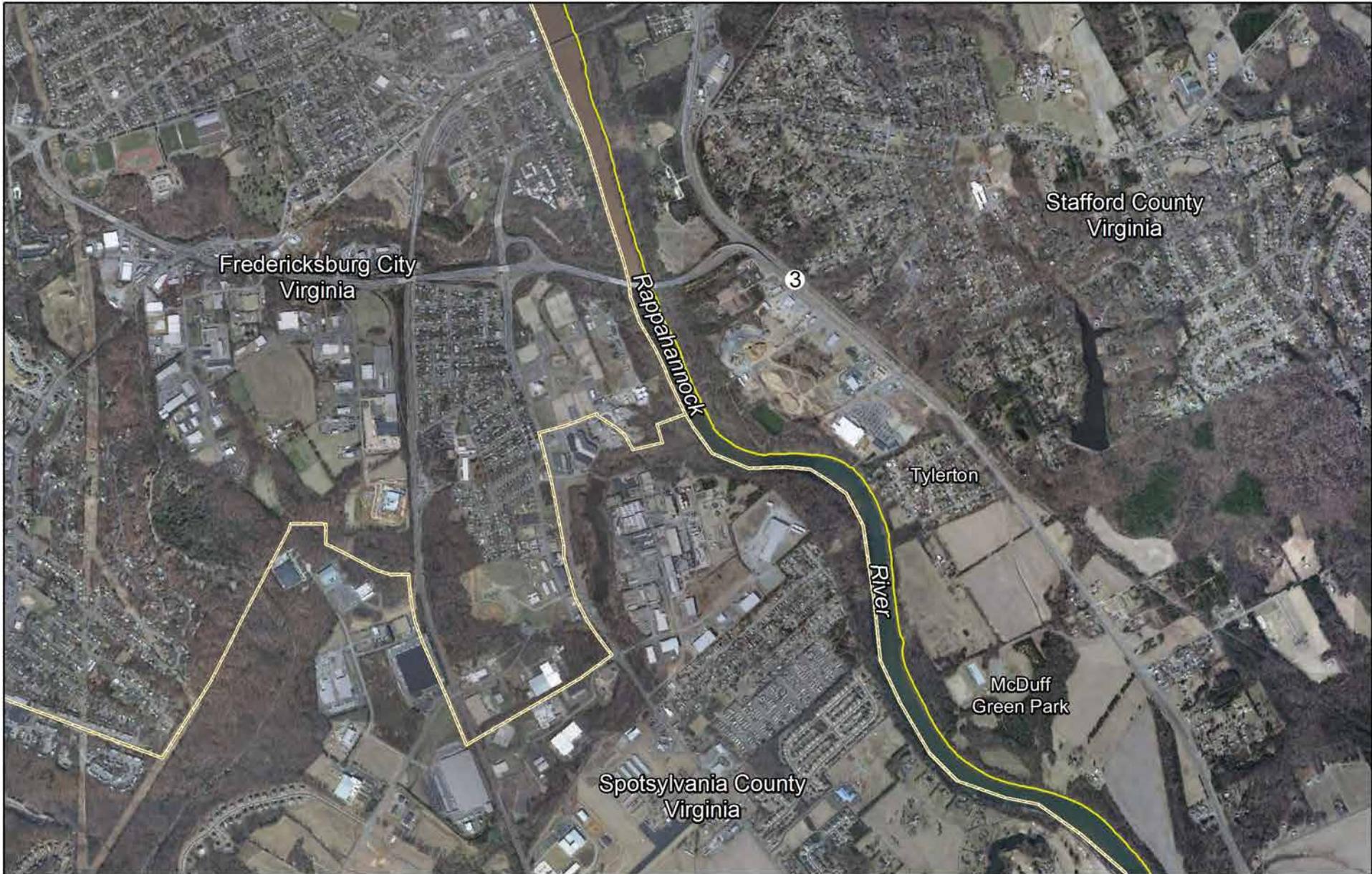
**Legend**  
 Shoreline 1967

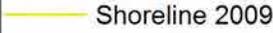


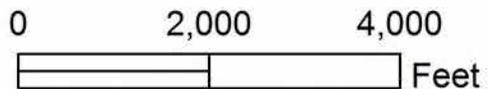
## Stafford County, Virginia Plate 11

Photo Date: 1967



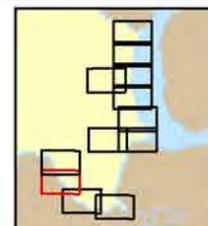


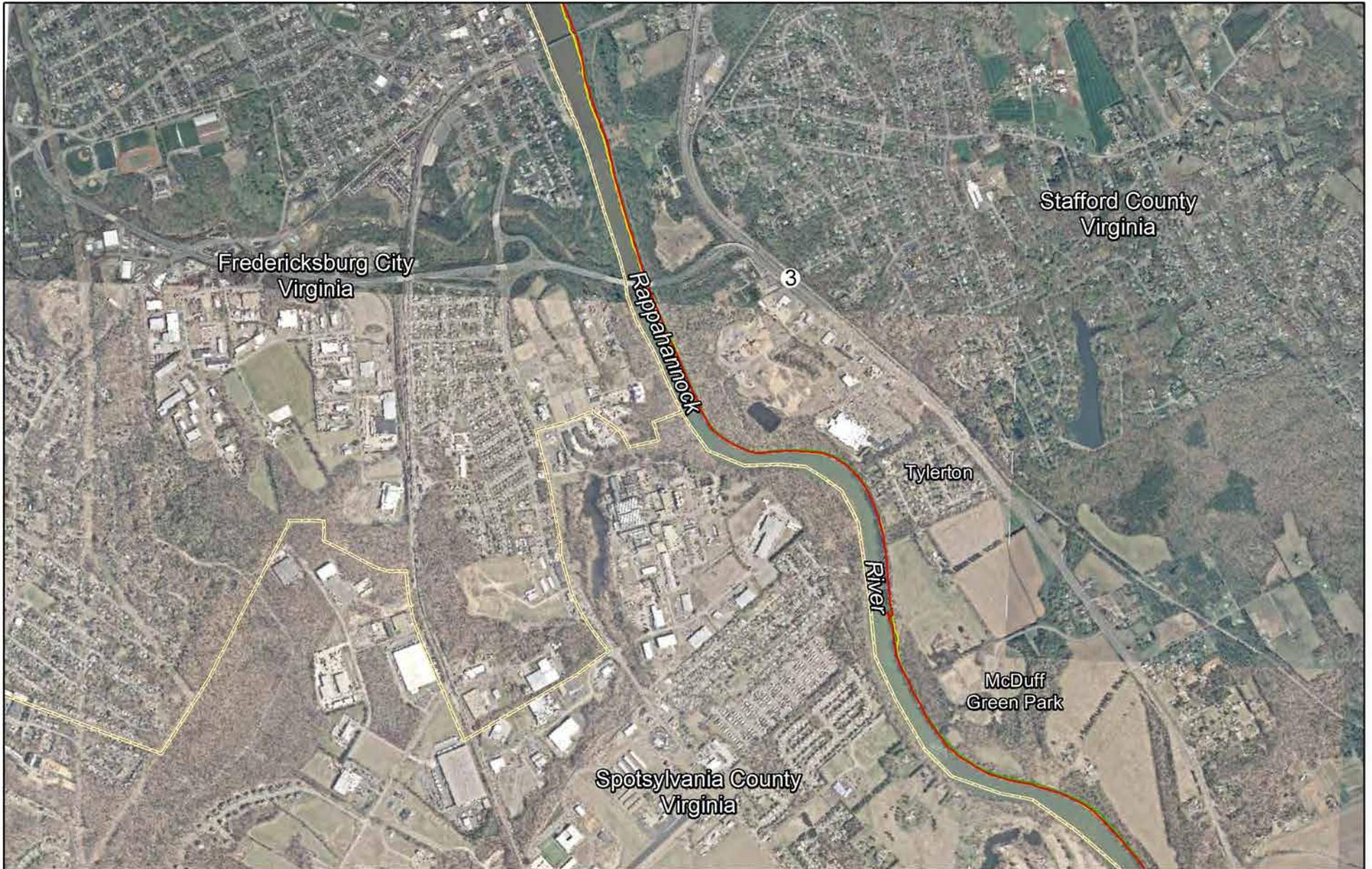
**Legend**  
 Shoreline 2009



## Stafford County, Virginia Plate 11

Photo Date: 2009





**Shorelines**

	Shoreline 1937
	Shoreline 1967
	Shoreline 2009
	Shoreline 2013



**Stafford County, Virginia  
Plate 11**

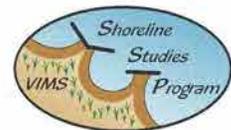
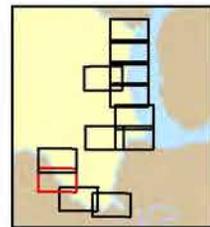
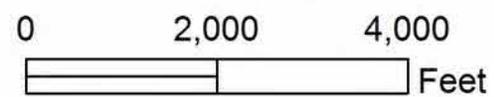
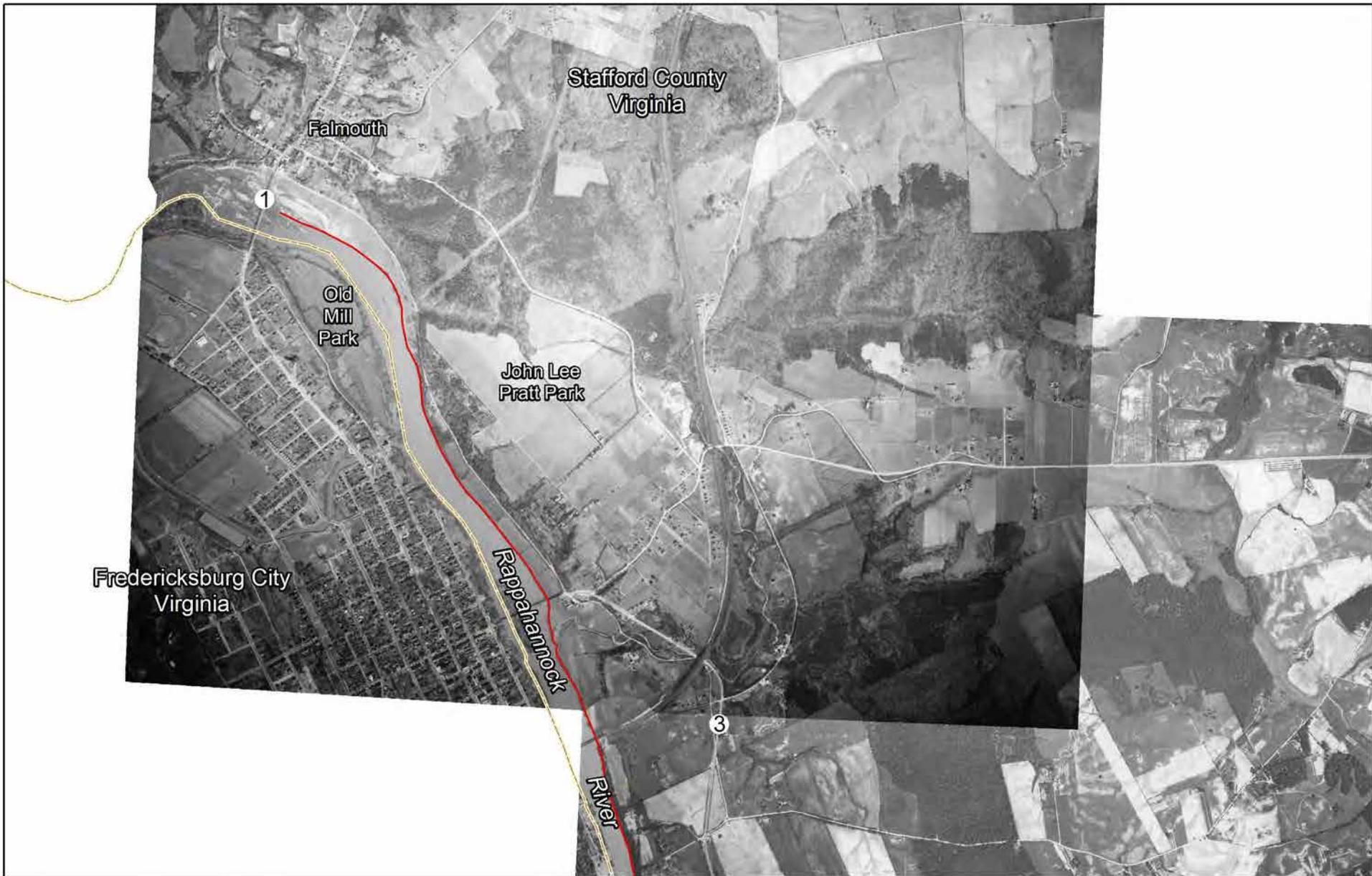


Image Date: 2013

B68



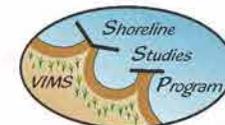
**Legend**  
 — Shoreline 1937



0      2,000      4,000  
 Feet

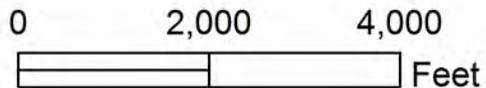
**Stafford County, Virginia  
 Plate 12**

Photo Date: 1937



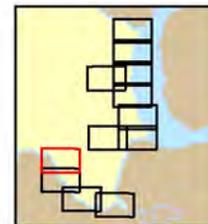


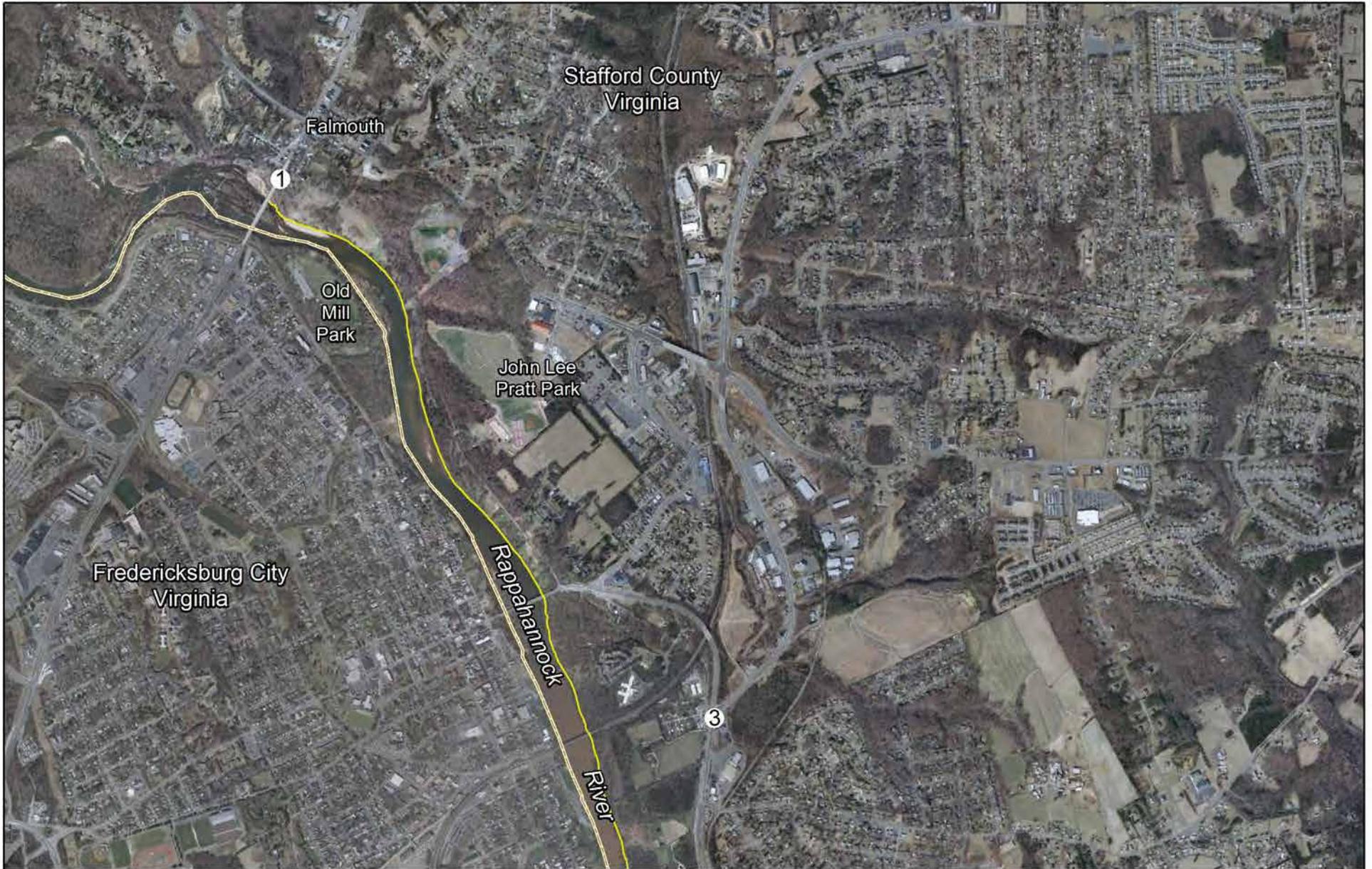
**Legend**  
 — Shoreline 1967



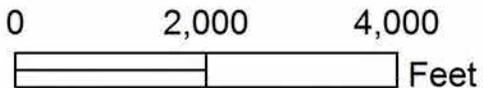
**Stafford County, Virginia  
 Plate 12**

Photo Date: 1967



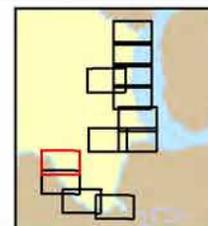


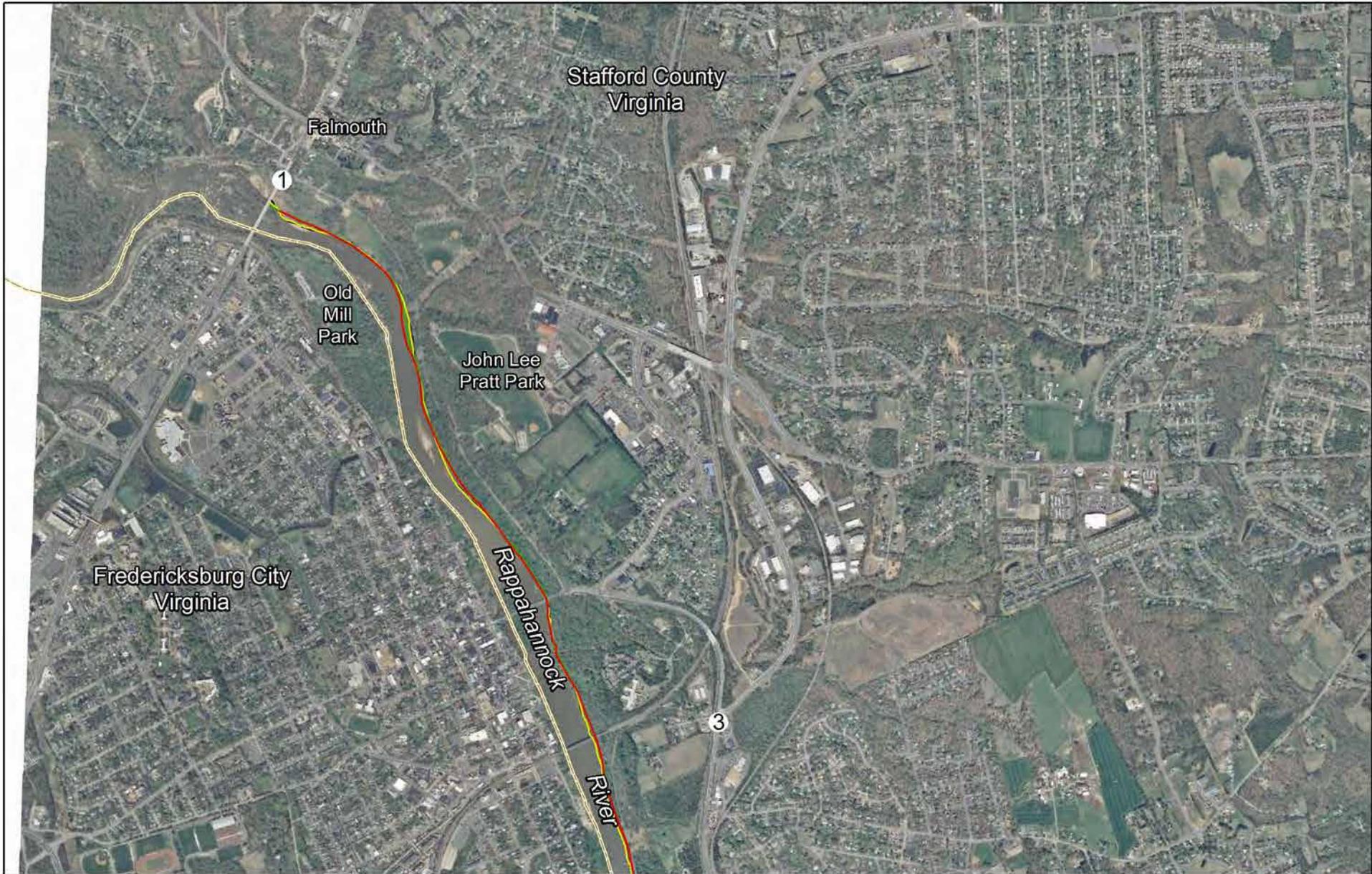
**Legend**  
 — Shoreline 2009



**Stafford County, Virginia  
 Plate 12**

Photo Date: 2009





Shorelines	
	Shoreline 1937
	Shoreline 1967
	Shoreline 2009
	Shoreline 2013



### Stafford County, Virginia Plate 12

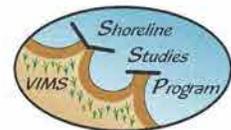
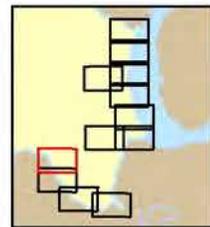
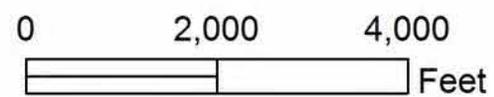


Image Date: 2013

B72