Shoreline Evolution: Fairfax County, Virginia

Potomac River Shoreline

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

December 2014

Shoreline Evolution: County of Fairfax, Virginia Potomac River Shorelines

Data Summary Report

Donna A. Milligan
Christine Wilcox
C. Scott Hardaway, Jr.

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

This project was funded by the Virginia Coastal Zone Management Program through Grant # NA13NOS4190135 of the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, under the Coastal Zone Management Act of 1972, as amended. The views expressed herein are those of the authors and do not necessarily reflect the views of the U.S. Department of Commerce, NOAA, or any of its subagencies.

December 2014

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1 Introduction

Fairfax County is situated along the upper reaches of the Potomac River (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.

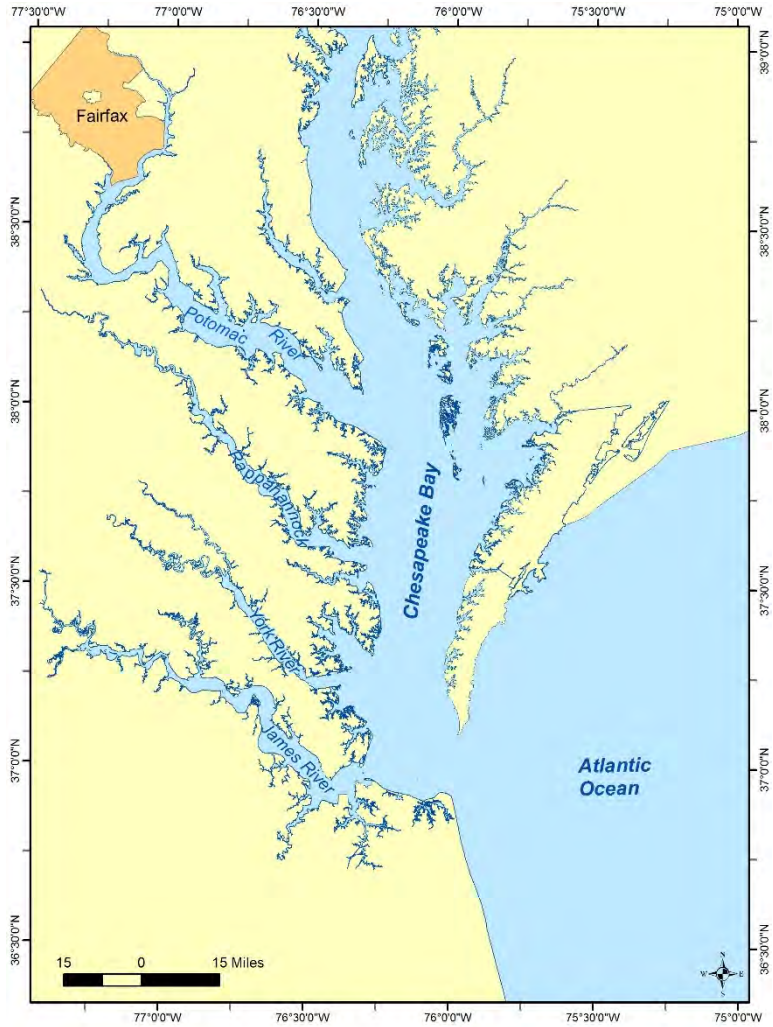


Figure 1. Location of Fairfax County in the Chesapeake Bay estuarine system.

The purpose of this report is to document how the shore zone of Fairfax 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 Fairfax 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.

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 Fairfax County Shoreline from 1937, 1953, 1974, 1994, 2002, 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 1974 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 – April 19 and 30;
1953 – Feb 10, December 17 and 31;
1974 – February 5;
2002 – March 1 and 2;
2009 – February 25, March 20, 21, and 22
2013 – February 21, March 4, 9 and 10.

The 1937, 1953, and 1974 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 aerials 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 changing development between 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 feature digitized is noted in the shoreline attributes for the 2009 photos. For Fairfax, the high water line was approximated. 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. However, tide levels at the time the photos were noticeably variable between photo sets requiring us to approximate the high water line (Figure 2A). In addition, large amounts of submerged aquatic vegetation along the lower fetch areas of the shoreline made it extremely difficult to determine shoreline position (Figure 2B). The shoreline was not digitized on the 1953 photos because many areas had ice along the shoreline completely obstructing our ability to digitize the feature accurately (Figure 2C).

Nearly 90 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 as well. It was difficult to tell the difference between marsh and submerged aquatic vegetation in some areas. In addition, trees exist along many sections of the Fairfax shoreline. These trees can obscure the true shoreline because their branches cover the shoreline. 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 orthothophoto 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.

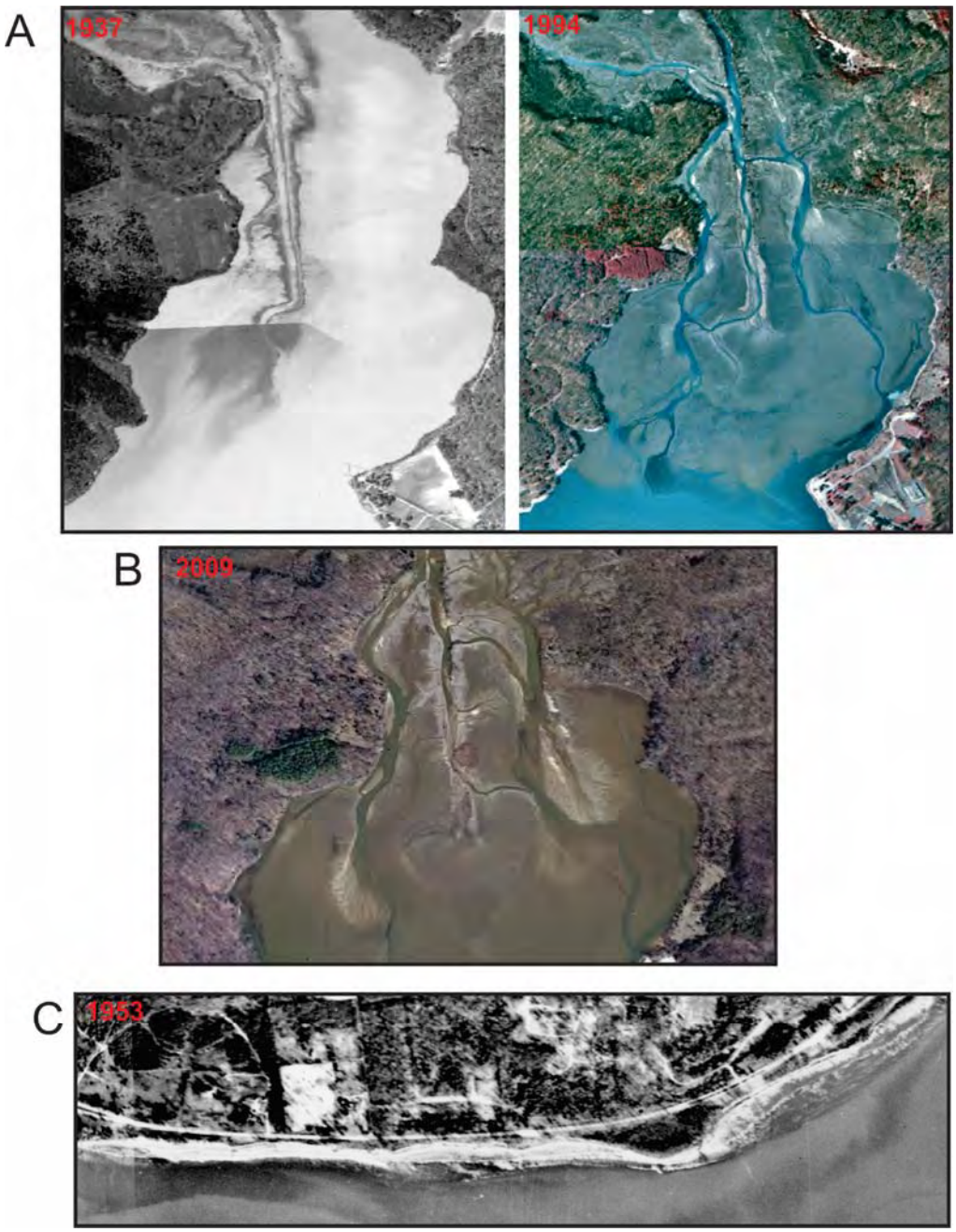


Figure 2. Photos depicting issues encountered during shoreline digitizing that may impact accuracy of data. A) variable water levels between photo dates; B) marshes and submerged grasses made it difficult to determine low water therefore high water was approximated; and C) ice obstructed the shoreline such that for many areas of the County, the shoreline could not be accurately digitized in 1953.

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.

Thirty eight miles of baselines and 5,800 transects about 30 feet apart were created for Fairfax County. Baselines were created 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 1974) 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$0.6 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. Many areas of Fairfax 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.

The Fairfax County shoreline was divided into 10 plates (Figure 3) in order to display the shoreline data. 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, 1968, 1994, 2002, 2009, and 2013. The shorelines are summarized on the 2013 image.

Figure 3. Plate index for Fairfax County shorelines.

3 Results and Discussion

Most of the river and creek shoreline in Fairfax 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, face downriver, and/or occur on a point of land tend to have higher rates of change. In addition, many areas of the shoreline consists of high wooded banks. When trees on the bank fall, it can exacerbate instability of the high bank. Even though wave action is limited due to small fetches, during storms, waves can directly impact the base of bank causing the entire bank to slump. This can deposit enough material to offset the erosion.

Several areas are noteworthy. High Point, where Occoquan Bay meets the Potomac River, is eroding at over three feet per year (Appendix A, Plate 3). Other areas along the Fairfax shoreline have very low erosion or accretion rates because of the placement of structures along the shoreline. These structures affect the long-term rate of change rates. Bulkheads and revetments keep the shoreline line in place while breakwaters are placed offshore and actually show as accretion. In Accotink Bay (Appendix B, Plate 6), fill was placed along the shoreline between 1953 and 1974 creating additional marsh along the eastern side of the Bay. The Dyke Marsh is undergoing very high erosion. A large area of marsh has been lost from the Preserve along its Potomac River shoreline (Appendix A, Plates 9 and 10). Cameron Run at the boundary between Fairfax County and the City of Alexandria has a high rate of accretion due to fill placement between 1953 and 1974 (Appendix B, Plate 10).

Table 1. Average end point rates of shoreline change (1937-2009) in feet per year along sections of Fairfax County's coast.

Reach Name	Plate Number	Avg EPR (ft/yr)	Category
Occoquan River and Belmont Bay	1 and 2	-0.3	Very Low Erosion
Occoquan Bay	3	0.0	Very Low Erosion
Occoquan Bay along Potomac River to Hallowing Point	3 and 4	-0.9	Very Low Erosion
Hallowing Point to Gunston Cove	4	-0.7	Very Low Erosion
Gunston Cove	4-6	0.0	Very Low Erosion
Whitestone Point to Dogue Creek	6	0.4	Very Low Accretion
Dogue Creek	7	0.0	Very Low Erosion
Dogue Creek to Hunting Creek	7 and 8	0.0	Very Low Erosion
Hunting Creek	8	-1.0	Low Erosion
Hunting Creek to Fort Hunt Park	8	-0.4	Very Low Erosion
Potomac River North to Cameron Run	8-10	-3.6	Medium Erosion
Cameron Run	10	7.39	High 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 areas of the County, where the shoreline change rates are categorized as accretion, have structures along the shoreline which results in a positive long-term rate of change due to the structures themselves. 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.

5 References

Milligan, D. A., K.P. O'Brien, C. Wilcox, C. S. Hardaway, JR, 2010a. Shoreline Evolution: City of Newport News, Virginia James River and Hampton Roads Shorelines**.** Virginia Institute of Marine Science. College of William & Mary, Gloucester Point, VA. http://web.vims.edu/physical/research/shoreline/docs/Cascade/Shoreline_Evolution/Newport_News_ShoreEvolve-lr.pdf

Milligan, D. A., K.P. O'Brien, C. Wilcox, C. S. Hardaway, JR, 2010b. Shoreline Evolution: City of Poquoson, Virginia, Poquoson River, Chesapeake Bay, and Back River Shorelines. Virginia Institute of Marine Science. College of William & Mary, Gloucester Point, VA. http://web.vims.edu/physical/research/shoreline/docs/Cascade/Shoreline_Evolution/Poquoson_ShoreEvolve-lr.pdf

Milligan, D. A., K.P. O'Brien, C. Wilcox, C. S. Hardaway, JR, 2010c. Gloucester County, Virginia York River, Mobjack Bay, and Piankatank River Shorelines. Virginia Institute of Marine Science. College of William & Mary, Gloucester Point, VA. http://web.vims.edu/physical/research/shoreline/docs/Cascade/Shoreline_Evolution/Gloucester_ShoreEvolve-lr.pdf

Milligan, D. A., K.P. O'Brien, C. Wilcox, C. S. Hardaway, JR, 2010d. Shoreline Evolution: York County, Virginia York River, Chesapeake Bay and Poquoson River Shorelines. Virginia Institute of Marine Science. College of William & Mary, Gloucester Point, VA. http://web.vims.edu/physical/research/shoreline/docs/Cascade/Shoreline_Evolution/York_ShoreEvolve-lr.pdf

Morton, R.A., T.L. Miller, and L.J. Moore, 2004. National Assessment of Shoreline Change: Part 1 Historical Shoreline Change and Associated Coastal Land Loss along the U.S. Gulf of Mexico. U.S. Department of the Interior, U.S. GeologicalSurvey Open-File Report 2004-1043, 45 p.

National Spatial Data Infrastructure, 1998. Geospatial Positional Accuracy Standards, Part 3: National Standard for Spatial Data Accuracy. Subcommittee for Base Cartographic Data. Federal Geographic Data Committee. Reston, VA.

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 2

Plate 3

Plate 4

Plate 5

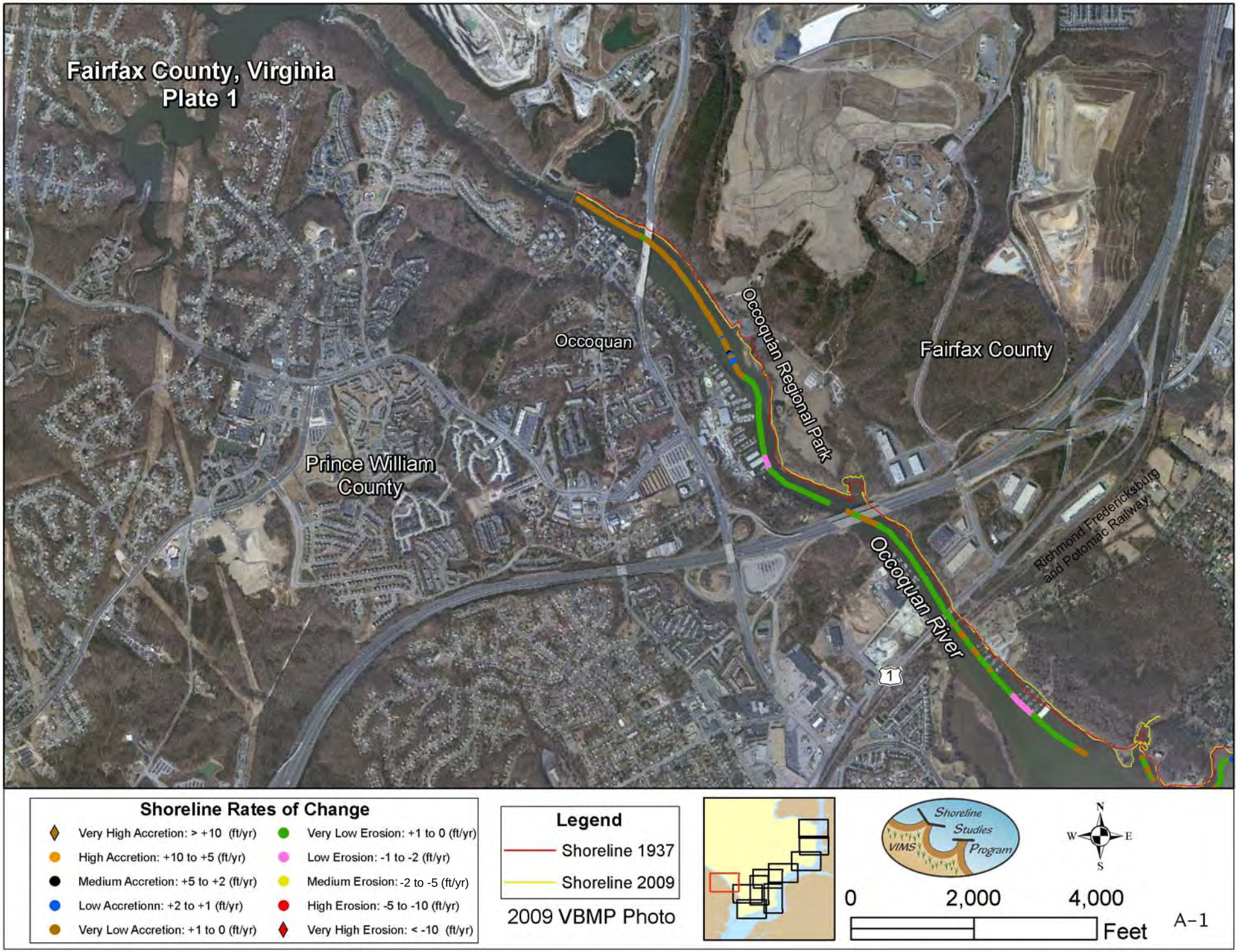
Plate 6

Plate 7

Plate 8

Plate 9

Plate 10


Fairfax County, Virginia
Plate 1
Occoquan
Occoquan Regional Park
Fairfax County
Prince William County
Occoquan River
Richmond Fredericksburg and Potomac Railway
1
Shoreline Rates of Change
Very High Accretion: > +10 (ft/yr)
High Accretion: +10 to +5 (ft/yr)
Medium Accretion: +5 to +2 (ft/yr)
Low Accretionn: +2 to +1 (ft/yr)
Very Low Accretion: +1 to 0 (ft/yr)
Very Low Erosion: +1 to 0 (ft/yr)
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Medium Erosion: -2 to -5 (ft/yr)
High Erosion: -5 to -10 (ft/yr)
Very High Erosion: < -10 (ft/yr)
Legend
Shoreline 1937
Shoreline 2009
2009 VBMP Photo
Shoreline Studies Program
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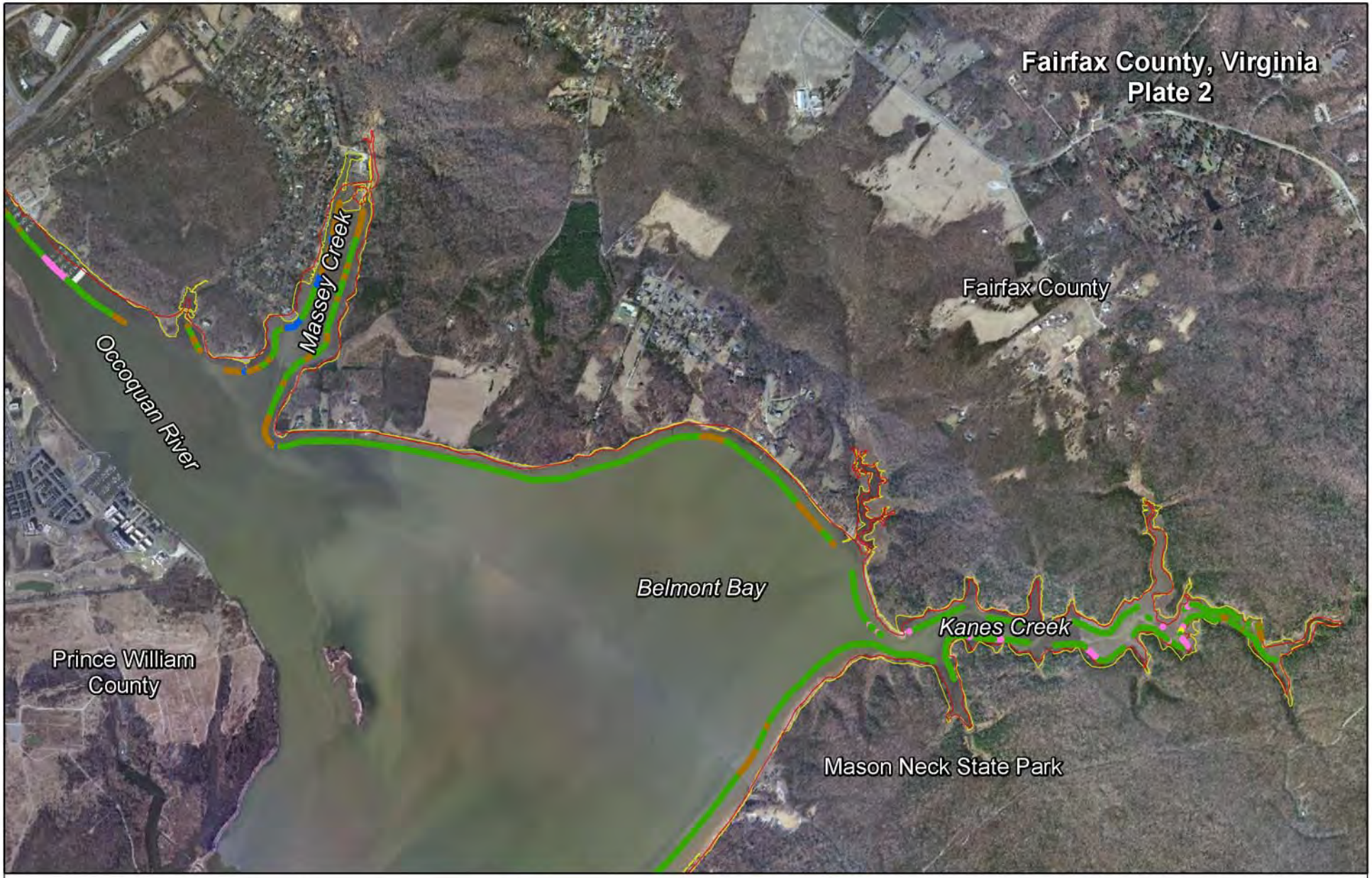

Shoreline Rates of Change

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- Medium Accretion: +5 to +2 (ft/yr)
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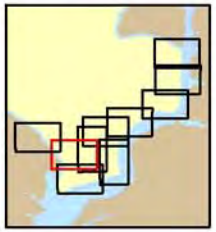
- Very High Erosion: < -10 (ft/yr)

Legend

- Shoreline 1937
- Shoreline 2009

2009 VBMP Photo



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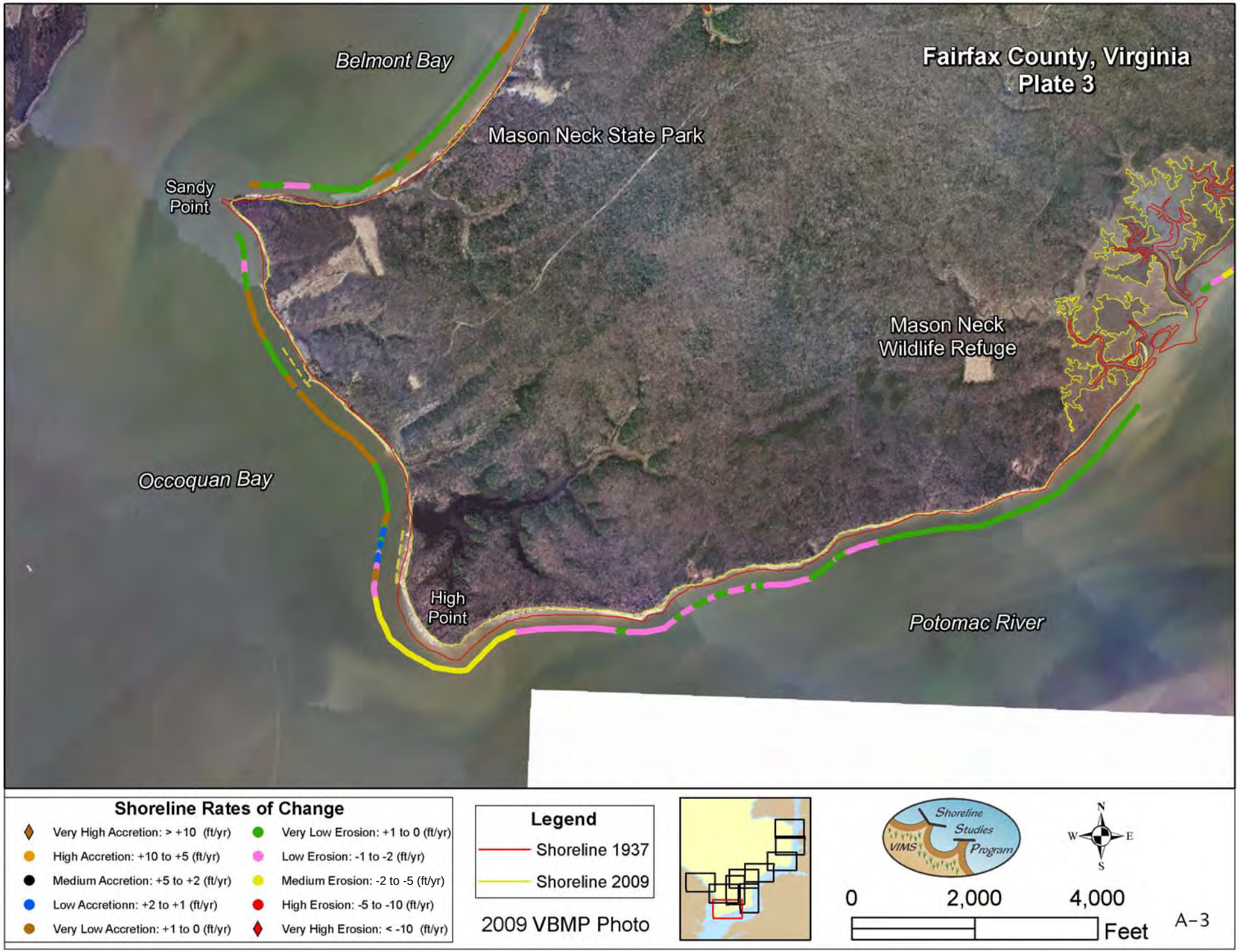
Fairfax County, Virginia
Plate 3
Belmont Bay
Mason Neck State Park
Sandy Point
Mason Neck Wildlife Refuge
Occoquan Bay
High Point
Potomac River
Shoreline Rates of Change
Very High Accretion: > +10 (ft/yr)
High Accretion: +10 to +5 (ft/yr)
Medium Accretion: +5 to +2 (ft/yr)
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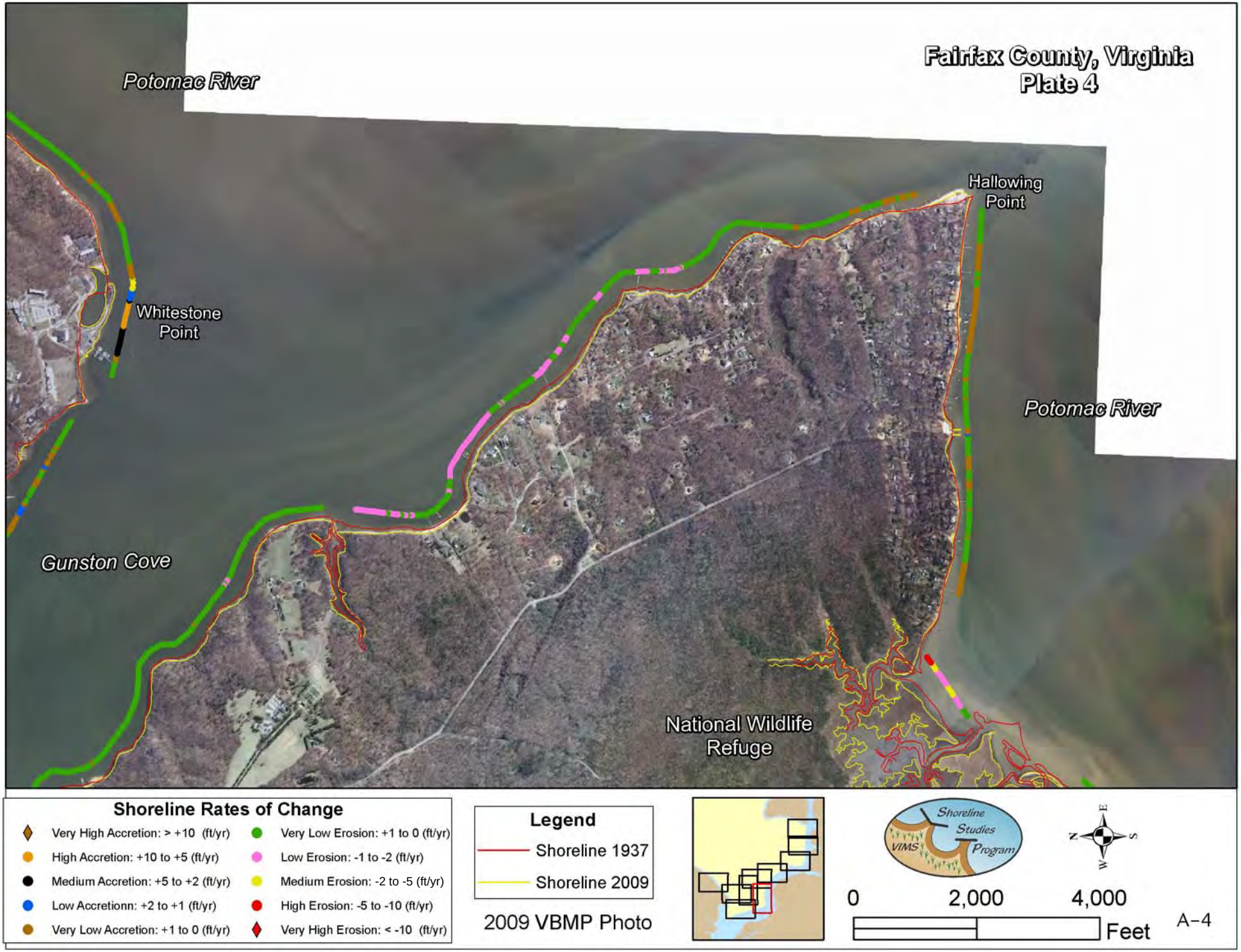
Fairfax County, Virginia
Plate 4
Potomac River
Hallowing Point
Whitestone Point
Potomac River
Gunston Cove
National Wildlife Refuge
Shoreline Rates of Change
Very High Accretion: > +10 (ft/yr)
High Accretion: +10 to +5 (ft/yr)
Medium Accretion: +5 to +2 (ft/yr)
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High Erosion: -5 to -10 (ft/yr)
Very High Erosion: < -10 (ft/yr)
Legend
Shoreline 1937
Shoreline 2009
2009 VBMP Photo
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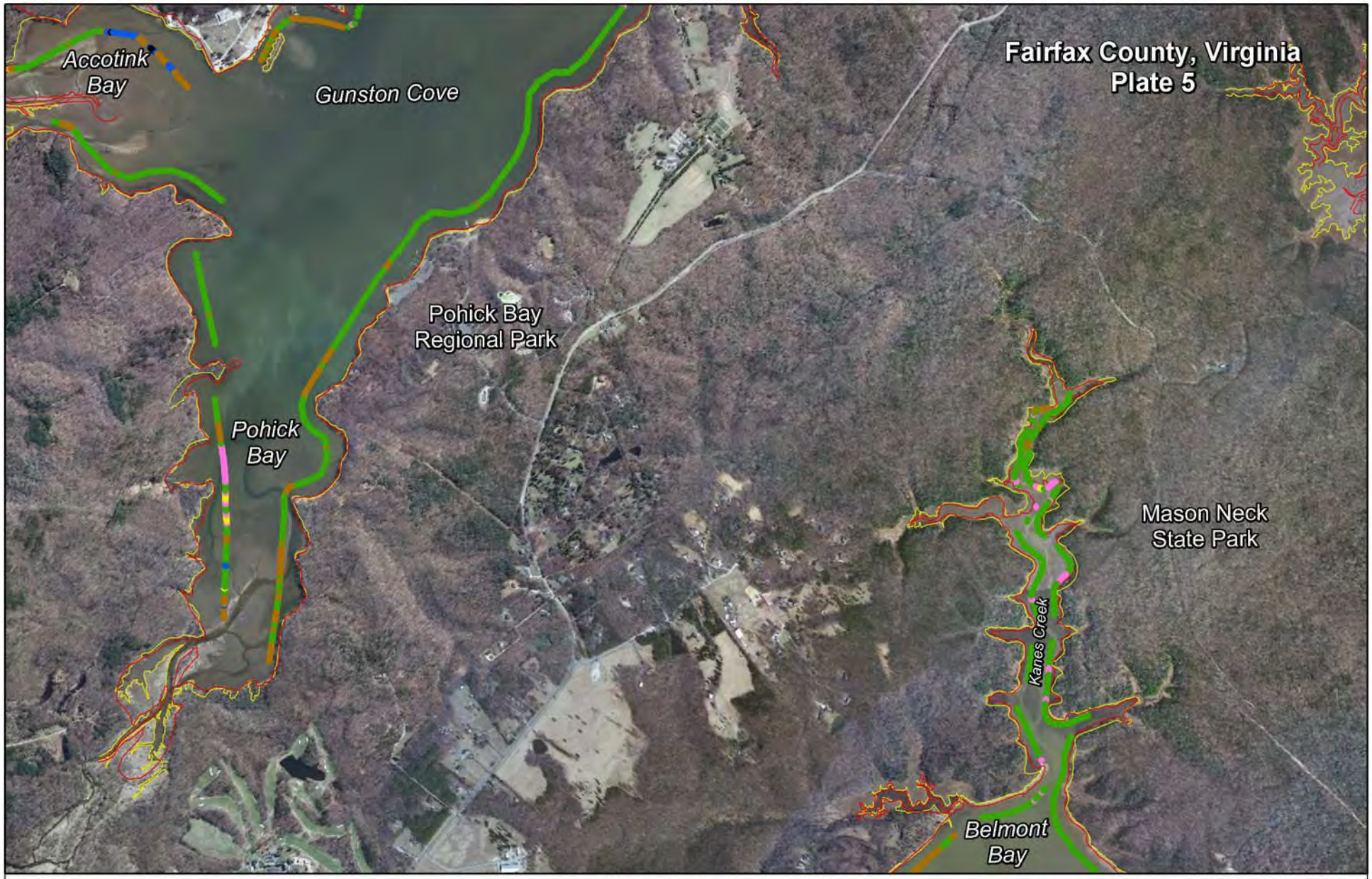

Shoreline Rates of Change

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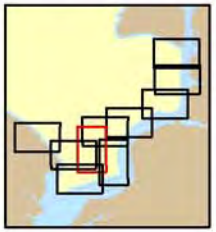
- Very High Erosion: < -10 (ft/yr)

Legend

- Shoreline 1937
- Shoreline 2009

2009 VBMP Photo



Shoreline Studies Program VIMS

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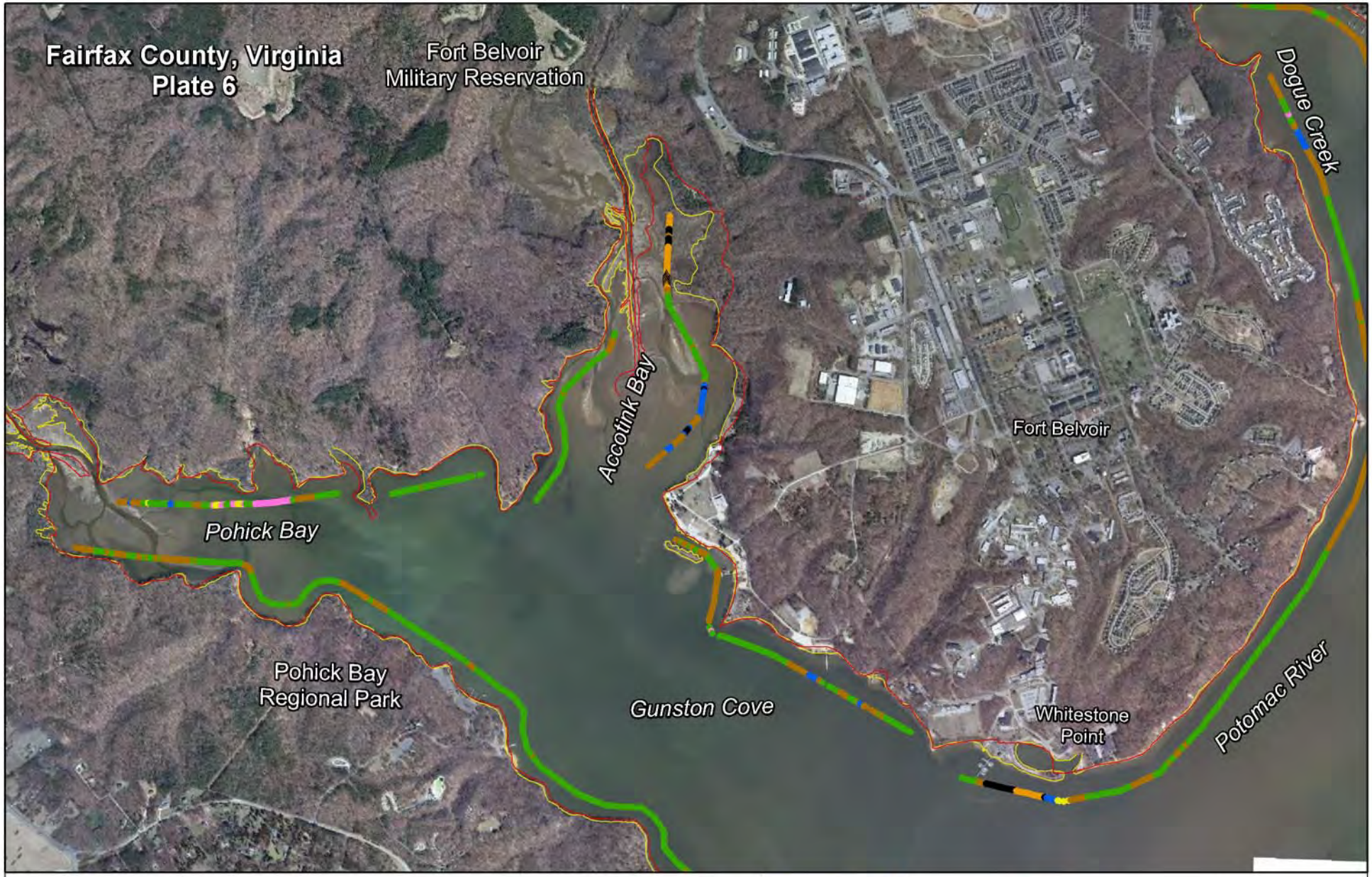

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Legend

- Shoreline 1937
- Shoreline 2009

2009 VBMP Photo

Shoreline Studies Program VIMS

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Legend

- Shoreline 1937
- Shoreline 2009

2009 VBMP Photo

Shoreline Studies Program VIMS

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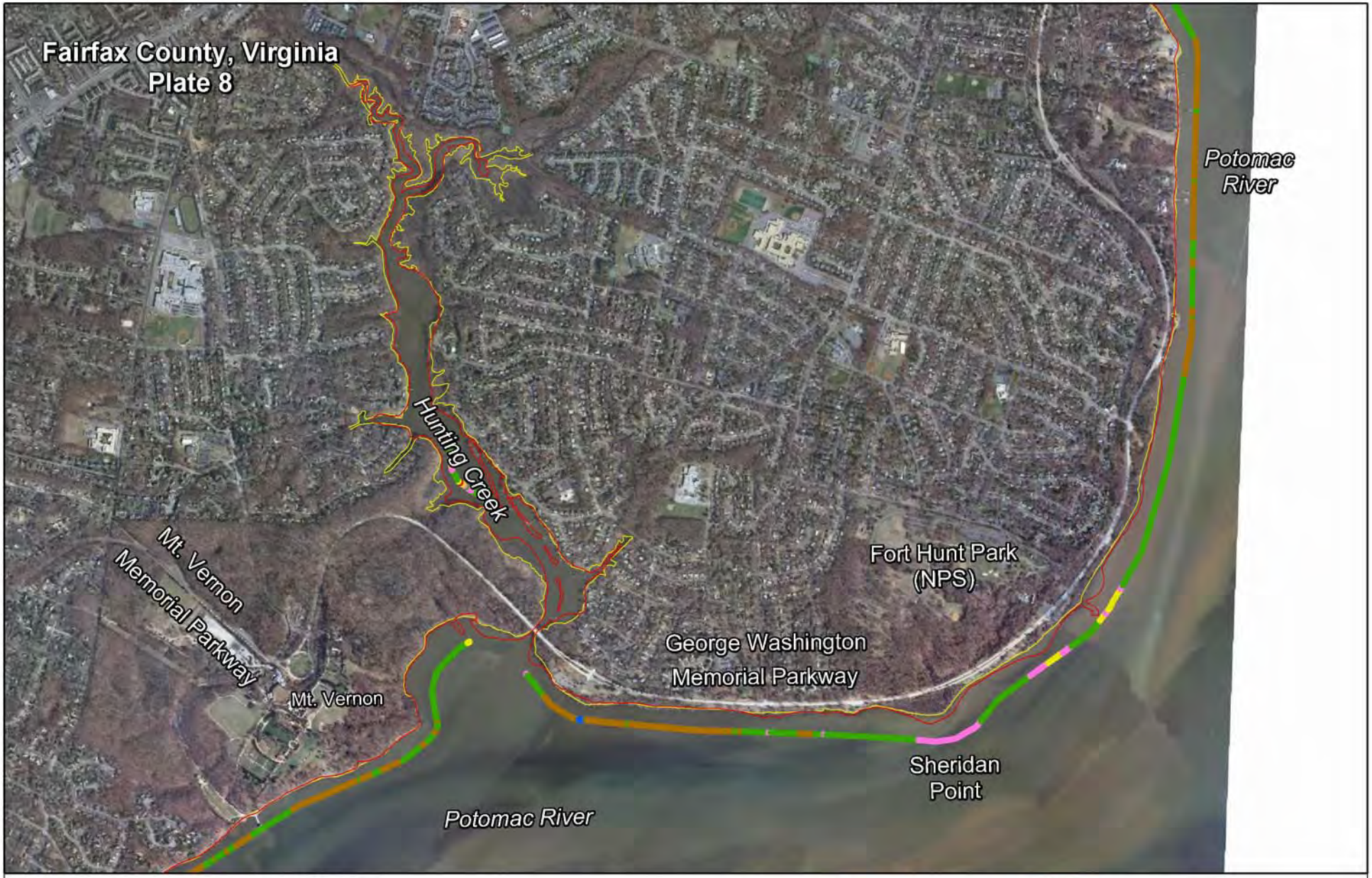

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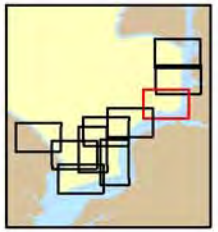
Legend

- Shoreline 1937
- Shoreline 2009

2009 VBMP Photo



Shoreline Studies Program VIMS

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Shoreline Rates of Change

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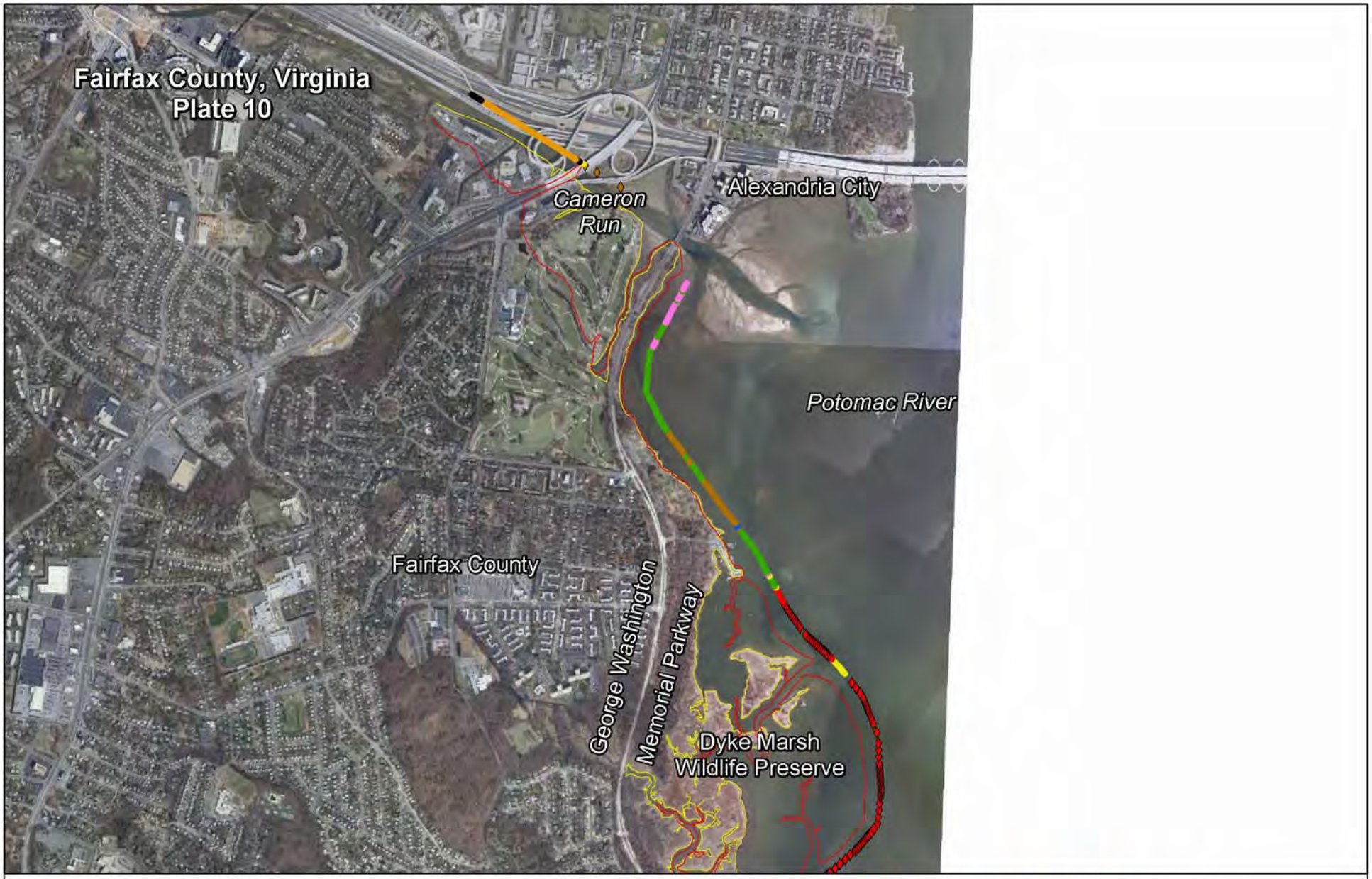
- Shoreline 1937
- Shoreline 2009

2009 VBMP Photo

Shoreline Studies Program VIMS

N W E S

0 2,000 4,000 Feet



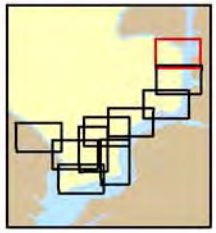
Shoreline Rates of Change

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

Legend

- Shoreline 1937
- Shoreline 2009

2009 VBMP Photo



Shoreline Studies Program VIMS

N W E S

0 2,000 4,000 Feet

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 2

Plate 3

Plate 4

Plate 5

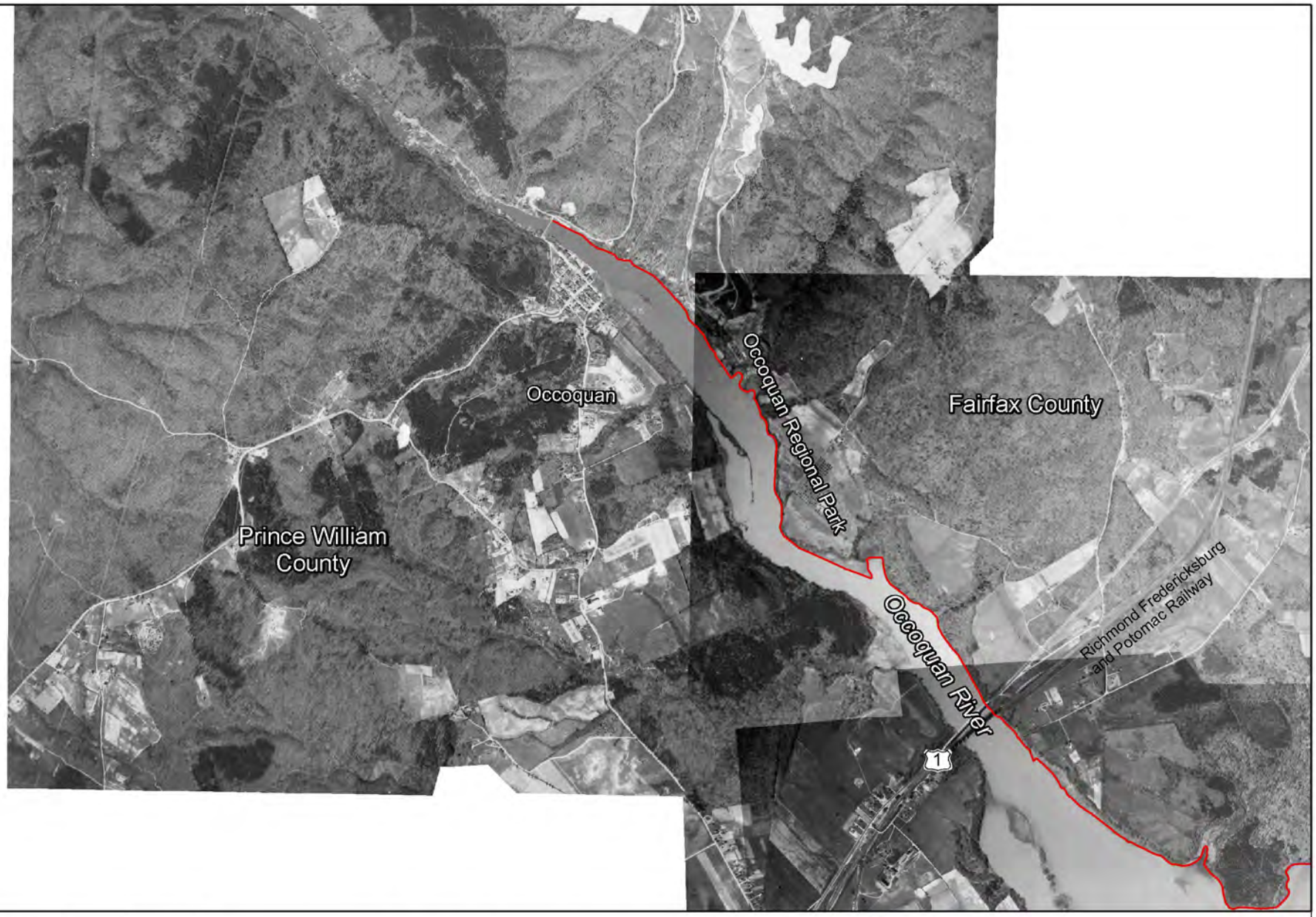
Plate 6

Plate 7

Plate 8

Plate 9

Plate 10



Legend

Shoreline 1937

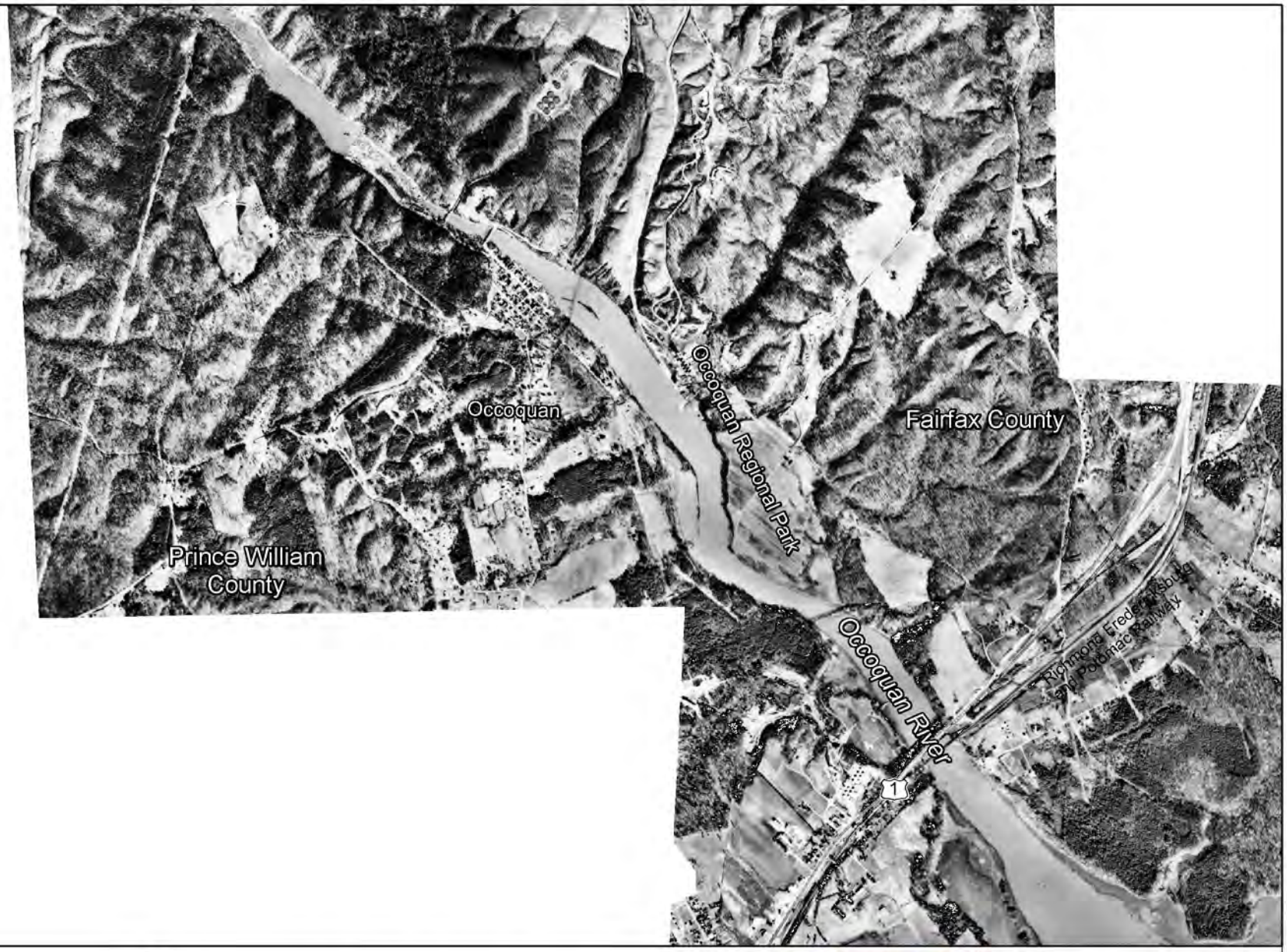
N W E S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 1

Photo Date: 1937

Shoreline Studies Program VIMS



Shoreline Not Shown

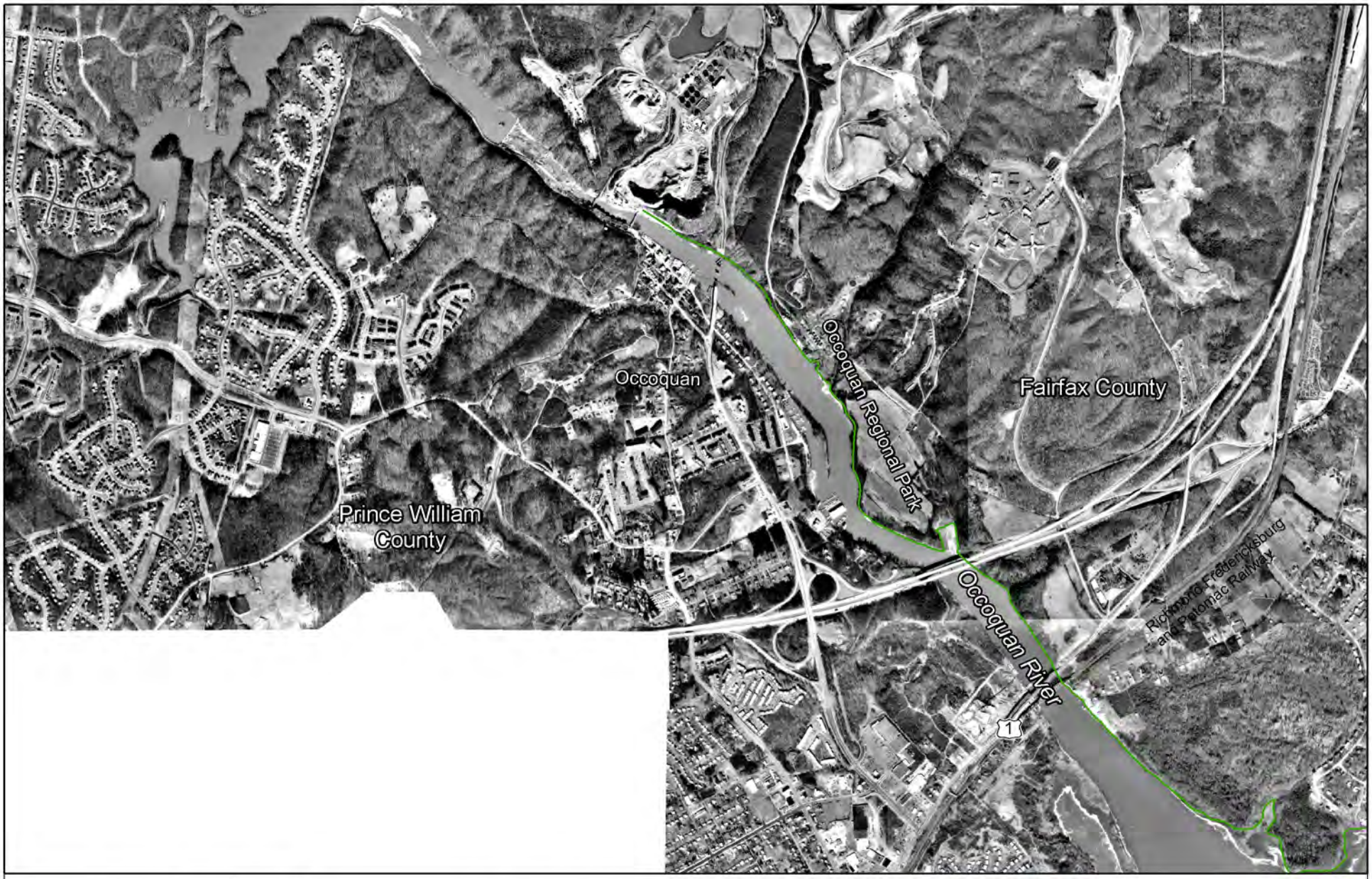
N W E S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 1

Photo Date: 1953

Shoreline Studies Program VIMS



Legend

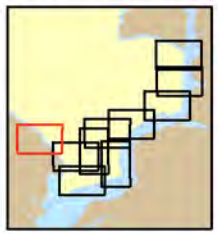
Shoreline 1974

N W E S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 1

Photo Date: 1974



Shoreline Studies Program VIMS

Legend

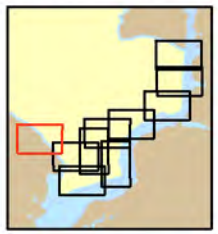
Shoreline 1994

N
W E
S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 1

Photo Date: 1994



Shoreline Studies Program VIMS

Legend

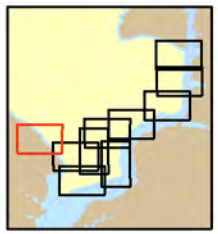
Shoreline 2002

N W E S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 1

Photo Date: 2002



Shoreline Studies Program VIMS

Legend

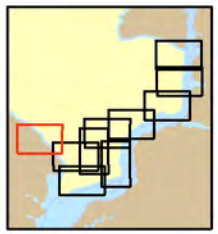
Shoreline 2009

N W E S

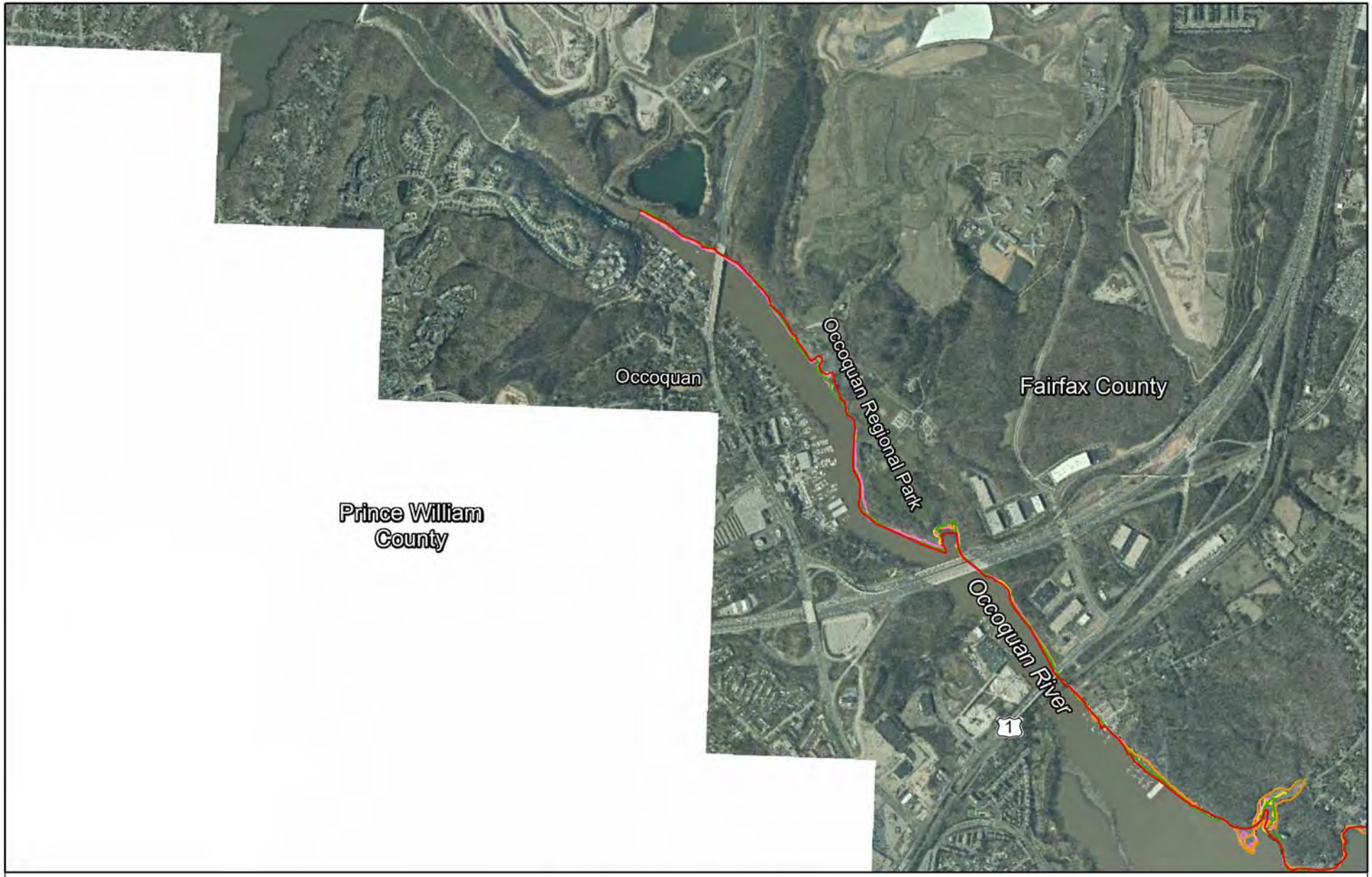
0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 1

Photo Date: 2009



Shoreline Studies Program VIMS



Legend

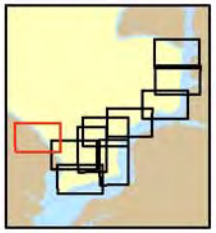
- Shoreline 1937
- Shoreline 1974
- Shoreline 1994
- Shoreline 2002
- Shoreline 2009
- Shoreline 2013

N W E S

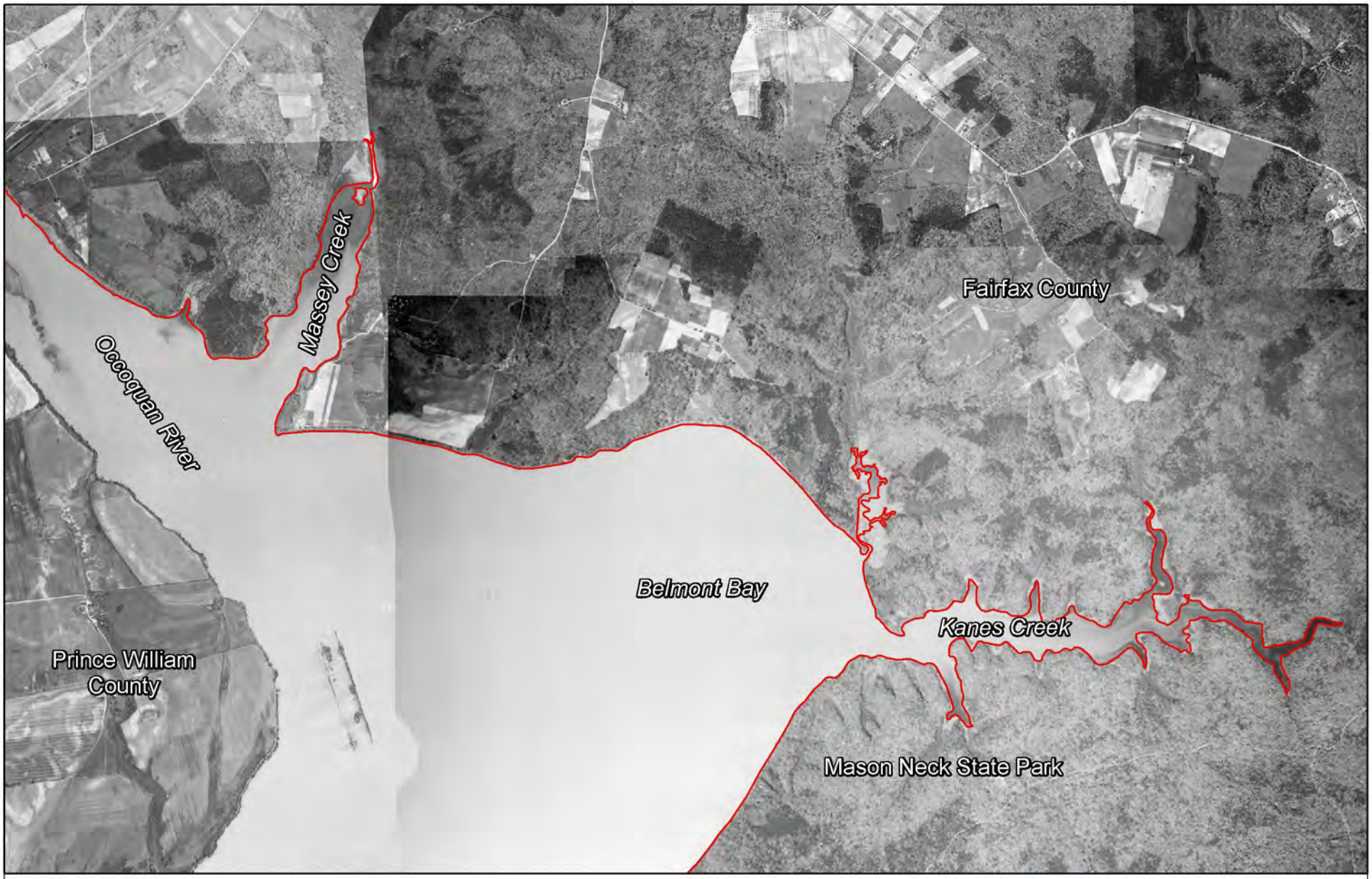
Fairfax County, Virginia
Plate 1

0 2,000 4,000 Feet

Photo Date: 2013



Shoreline Studies Program VIMS



Legend

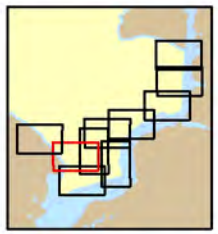
Shoreline 1937

N W E S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 2

Photo Date: 1937



Shoreline Studies Program VIMS

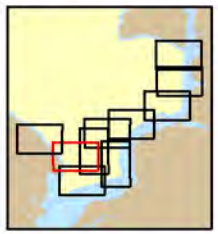
Shoreline Not Shown

N W E S

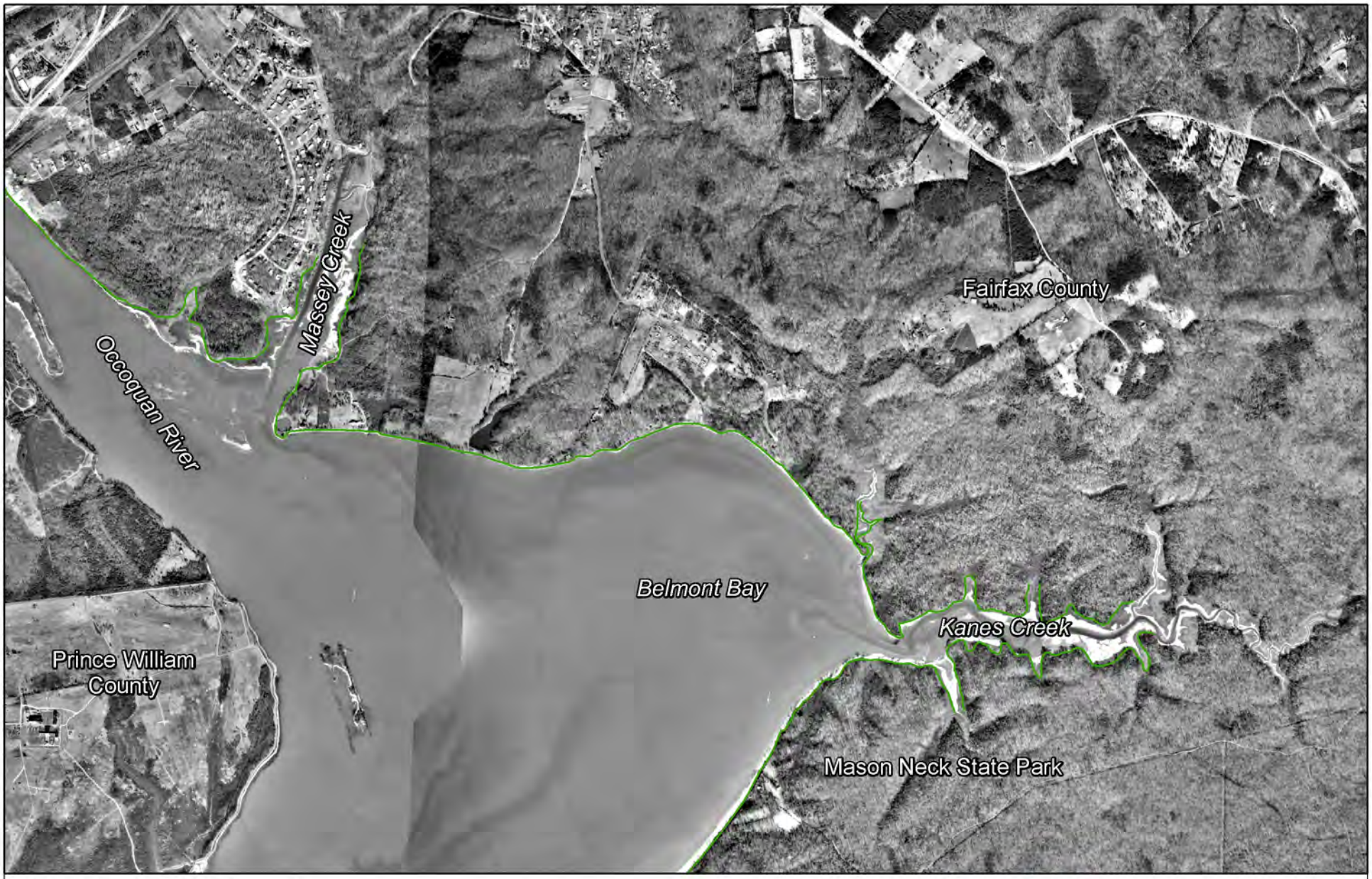
0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 2

Photo Date: 1953



Shoreline Studies Program VIMS



Legend

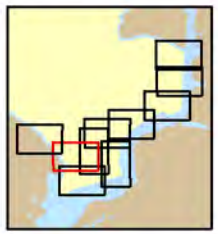
Shoreline 1974

N W E S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 2

Photo Date: 1974



Shoreline Studies Program VIMS

Legend

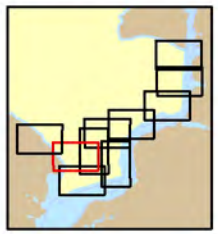
Shoreline 1994

N
W E
S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 2

Photo Date: 1994



Shoreline Studies Program VIMS

Legend

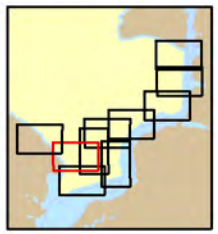
Shoreline 2002

N W E S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 2

Photo Date: 2002



Shoreline Studies Program VIMS

Legend

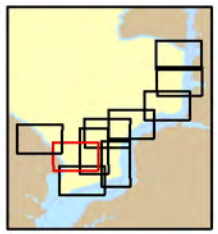
Shoreline 2009

N
W E
S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 2

Photo Date: 2009



Shoreline Studies Program VIMS

Legend

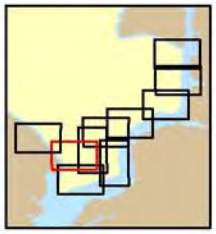
- Shoreline 1937
- Shoreline 1974
- Shoreline 1994
- Shoreline 2002
- Shoreline 2009
- Shoreline 2013

N W E S

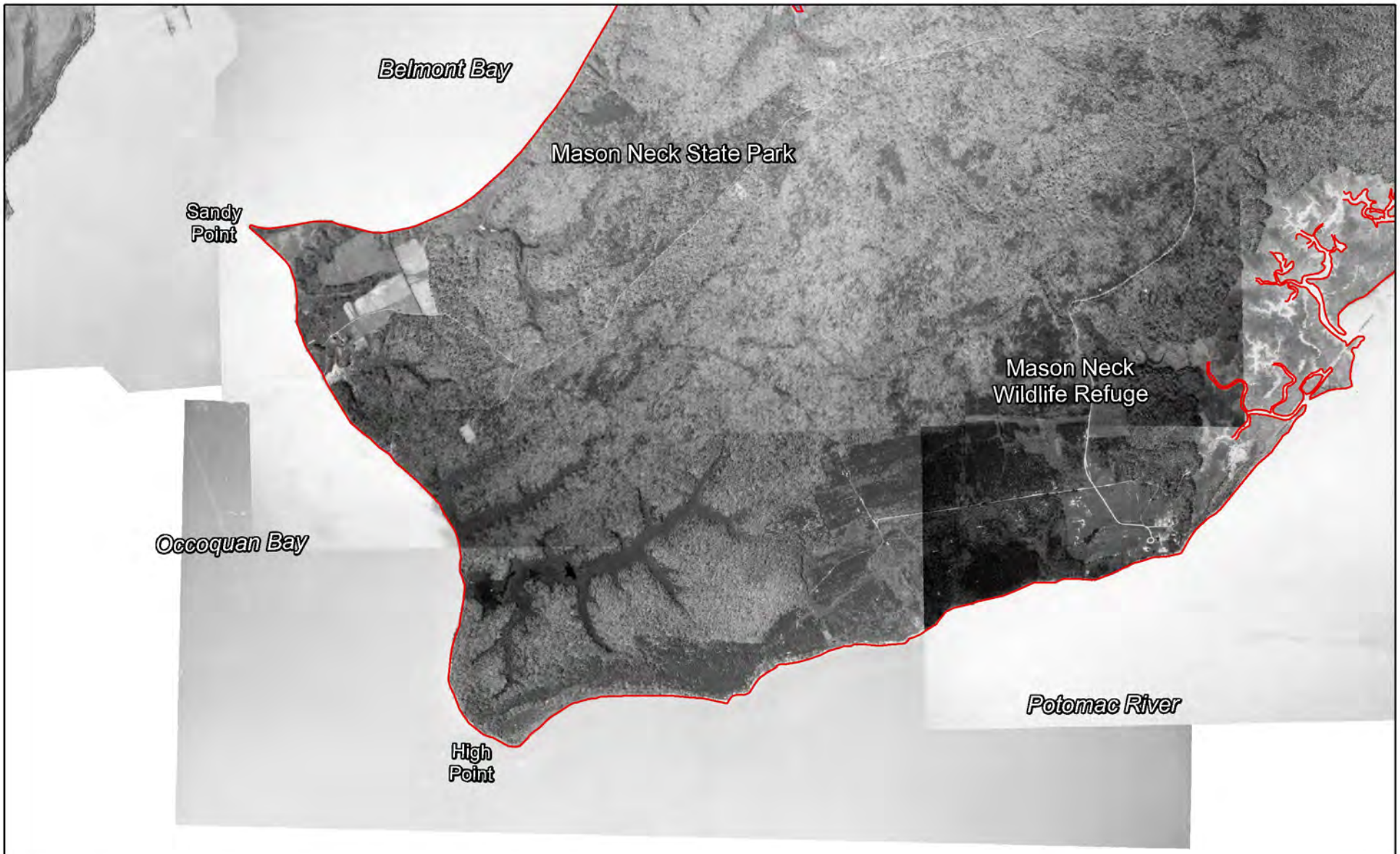
Photo Date: 2013

Fairfax County, Virginia
Plate 2

0 2,000 4,000 Feet



Shoreline Studies Program VIMS



Legend

Shoreline 1937

N W E S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 3

Photo Date: 1937

Shoreline Studies Program VIMS

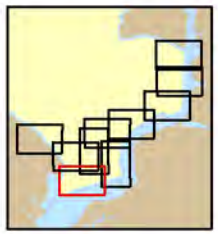
Shoreline Not Shown

N W E S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 3

Photo Date: 1953



Shoreline Studies Program VIMS

Legend

Shoreline 1974

N W E S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 3

Photo Date: 1974

Shoreline Studies Program VIMS

Legend

Shoreline 1994

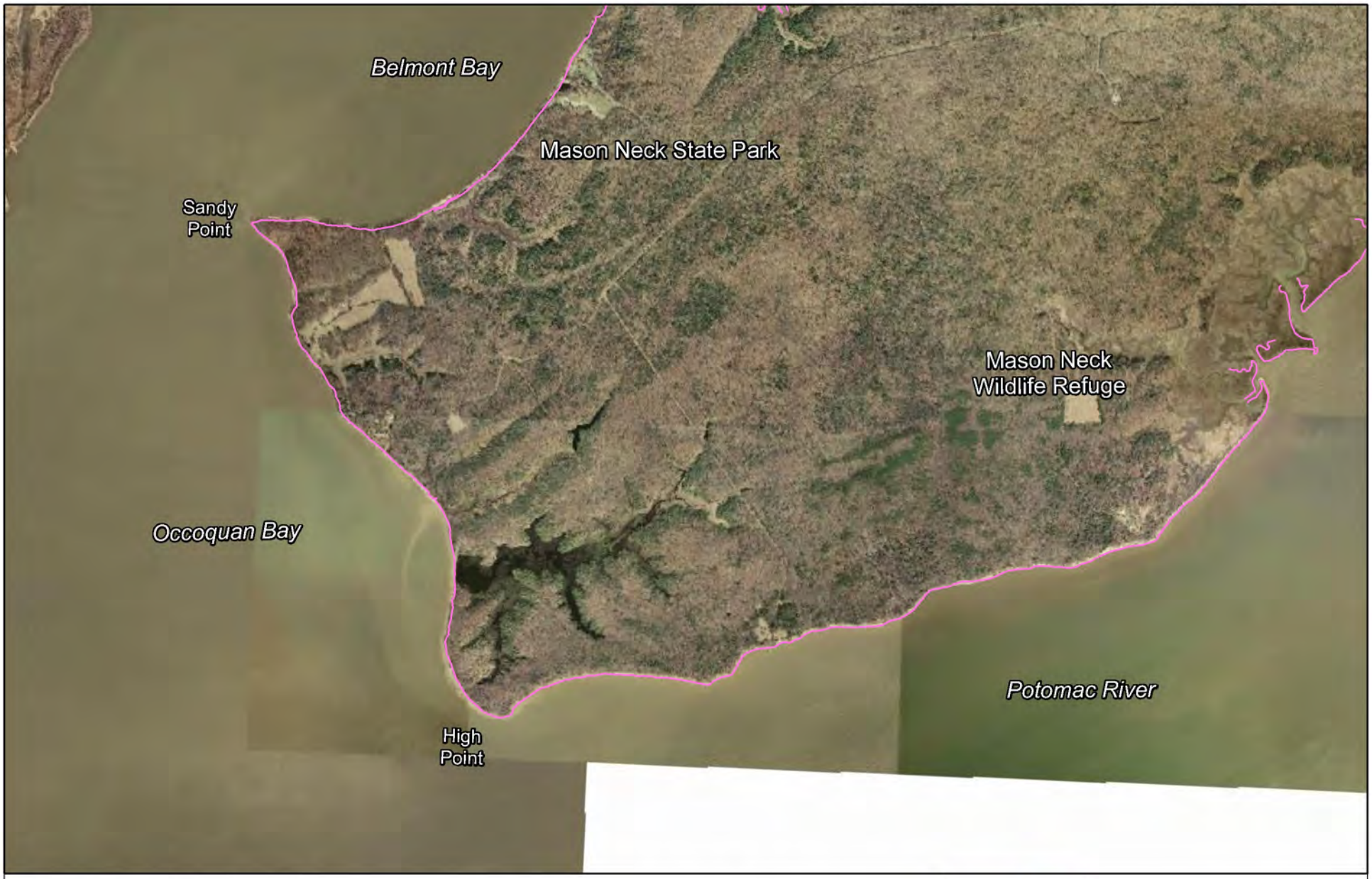
N W E S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 3

Photo Date: 1994

Shoreline Studies Program VIMS



Legend

Shoreline 2002

N W E S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 3

Photo Date: 2002

Shoreline Studies Program VIMS

Legend

Shoreline 2009

N W E S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 3

Photo Date: 2009

Shoreline Studies Program VIMS

Legend

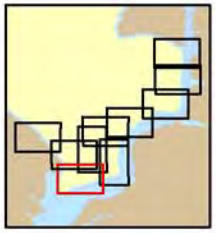
- Shoreline 1937
- Shoreline 1974
- Shoreline 1994
- Shoreline 2002
- Shoreline 2009
- Shoreline 2013

N W E S

Photo Date: 2013

Fairfax County, Virginia
Plate 3

0 2,000 4,000 Feet



Shoreline Studies Program VIMS

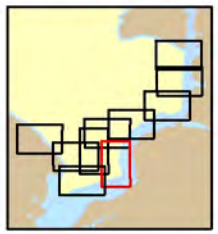
Legend

Shoreline 1937

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 4

Photo Date: 1937



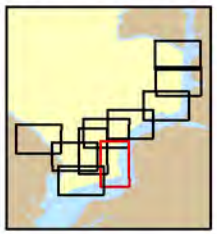
Shoreline Studies Program VIMS

Shoreline Not Shown

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 4

Photo Date: 1953



Shoreline Studies Program VIMS

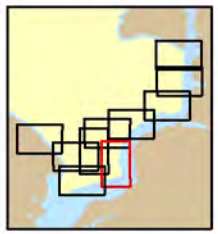
Legend

Shoreline 1974

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 4

Photo Date: 1974



Shoreline Studies Program VIMS

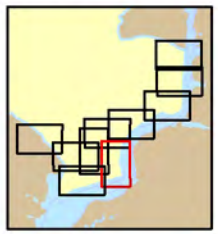
Legend

Shoreline 1994

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 4

Photo Date: 1994



Shoreline Studies Program VIMS

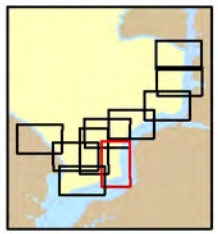
Legend

Shoreline 2002

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 4

Photo Date: 2002



Shoreline Studies Program VIMS

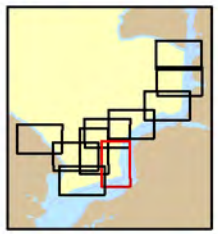
Legend

Shoreline 2009

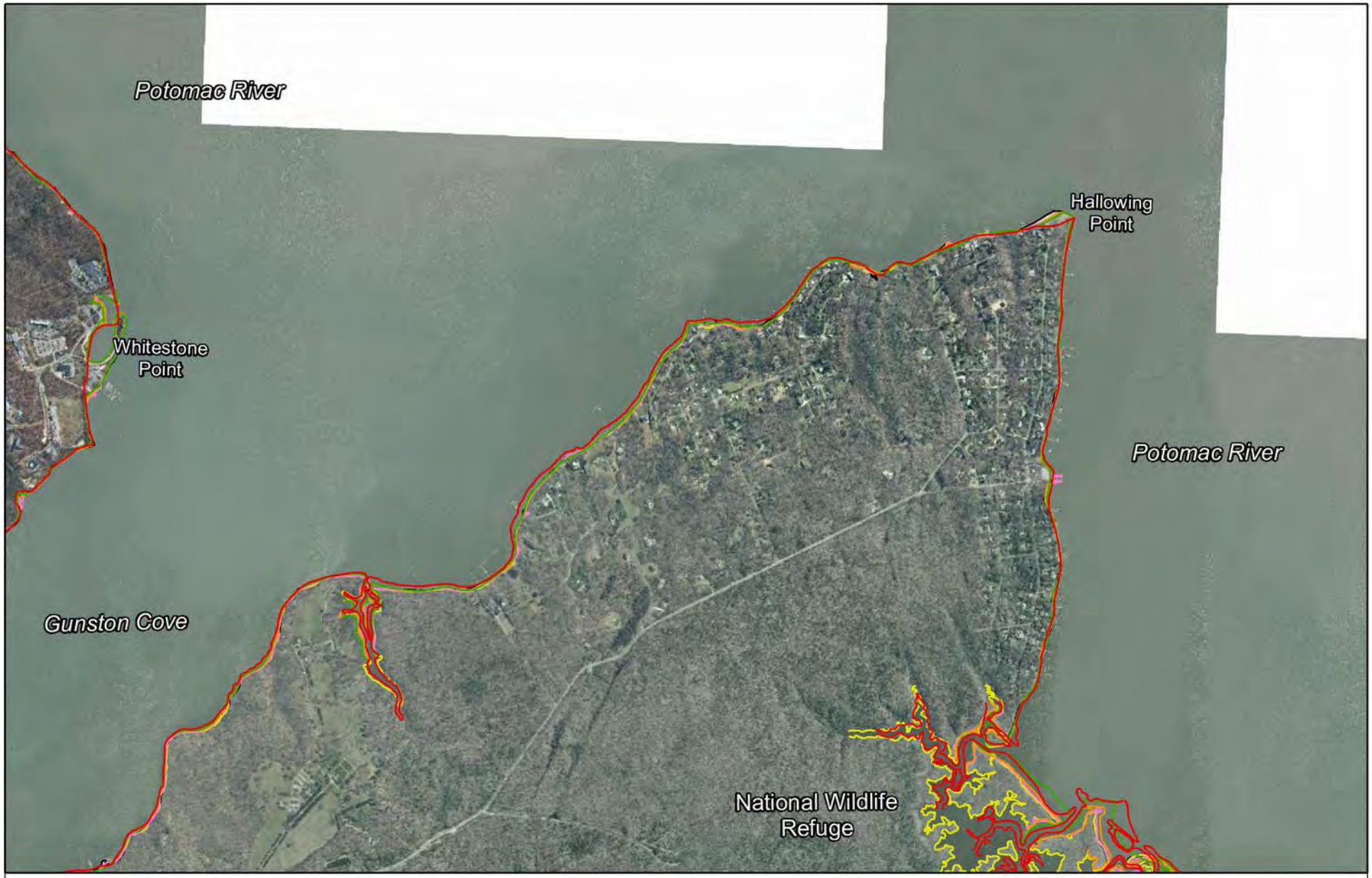
0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 4

Photo Date: 2009



Shoreline Studies Program VIMS



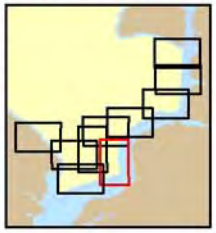
Legend

- Shoreline 1937
- Shoreline 1974
- Shoreline 1994
- Shoreline 2002
- Shoreline 2009
- Shoreline 2013

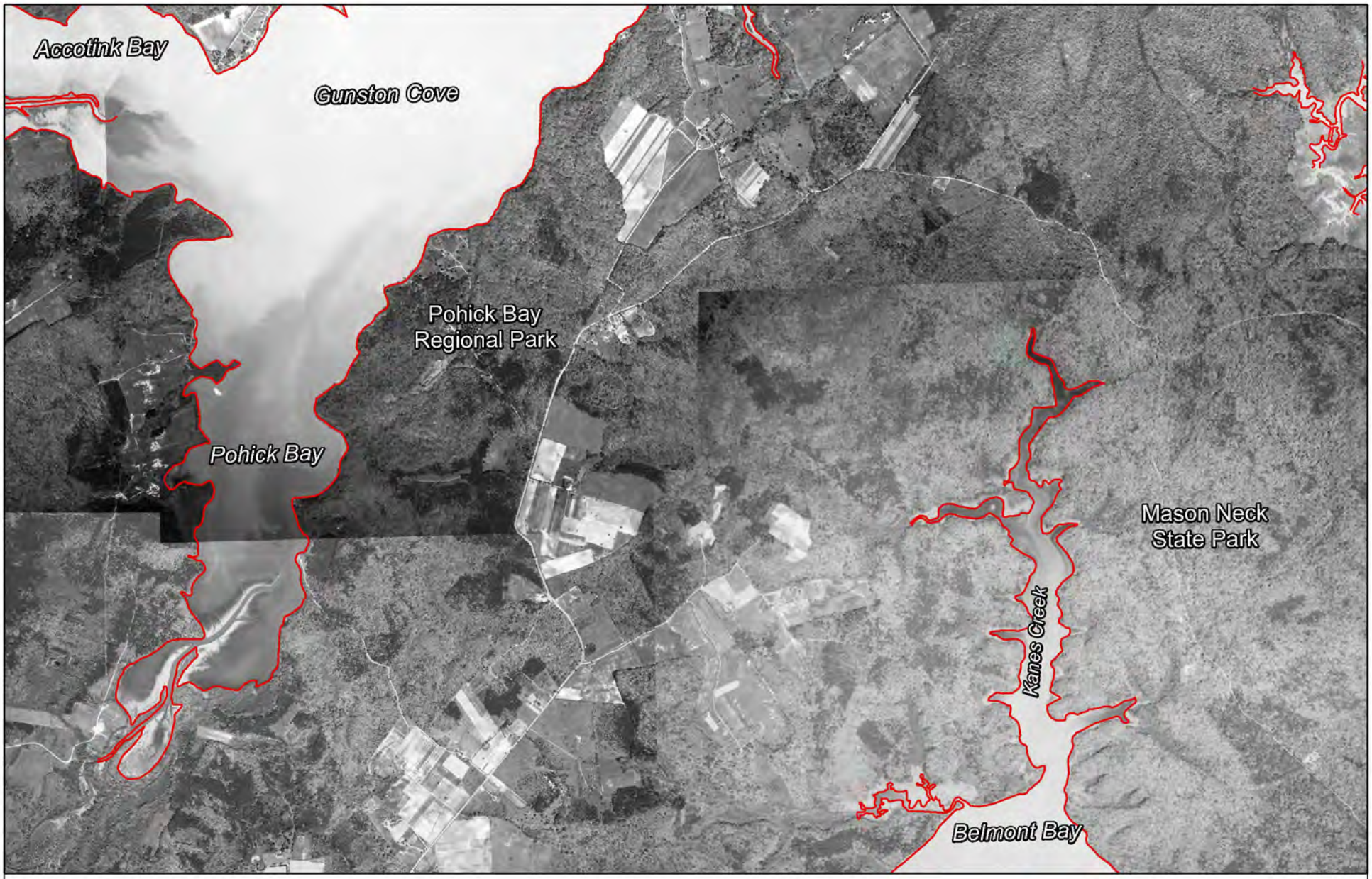
Fairfax County, Virginia
Plate 4

0 2,000 4,000 Feet

Photo Date: 2013



Shoreline Studies Program VIMS



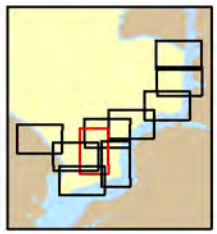
Legend

Shoreline 1937

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 5

Photo Date: 1937



Shoreline Studies Program VIMS

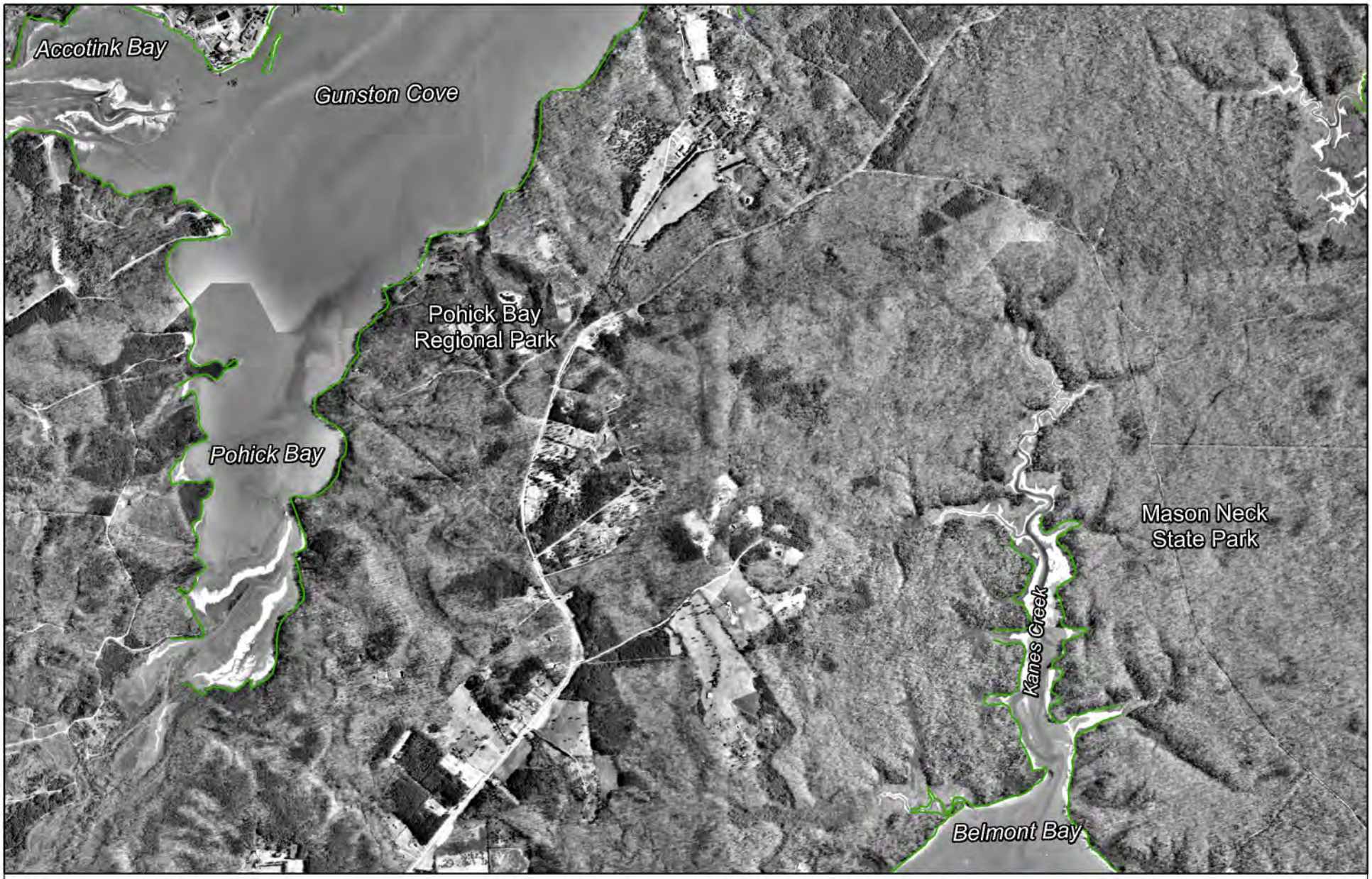
Shoreline Not Shown

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 5

Photo Date: 1953

Shoreline Studies Program VIMS



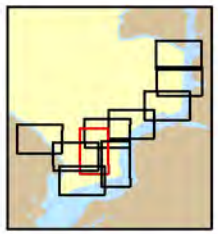
Legend

Shoreline 1974

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 5

Photo Date: 1974



Shoreline Studies Program VIMS

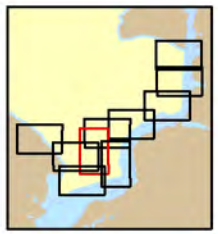
Legend

Shoreline 1994

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 5

Photo Date: 1994



Shoreline Studies Program VIMS

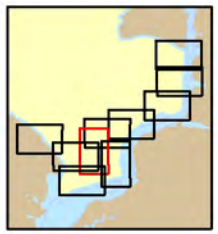
Legend

Shoreline 2002

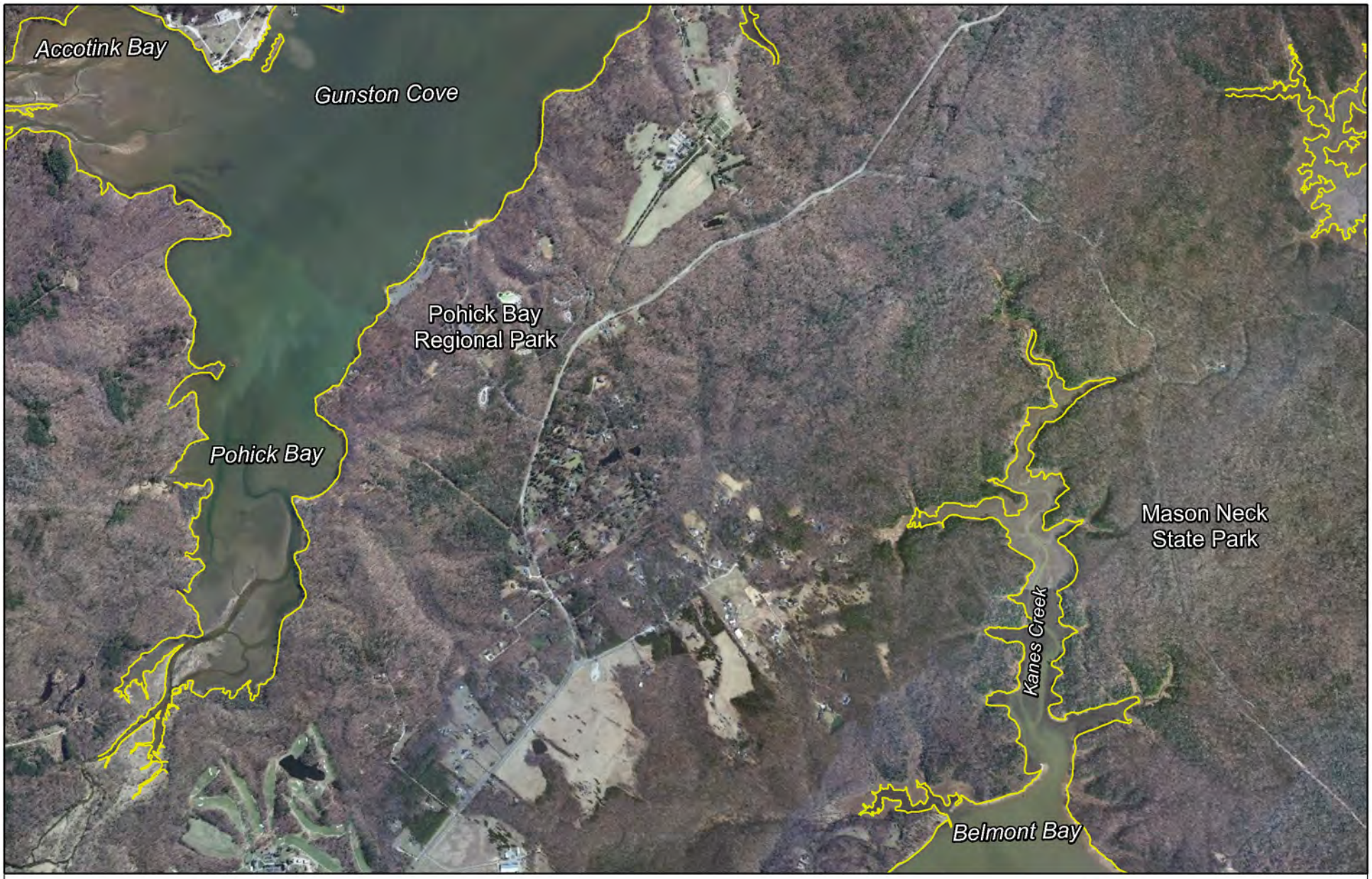
0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 5

Photo Date: 2002



Shoreline Studies Program VIMS



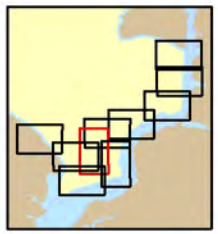
Legend

Shoreline 2009

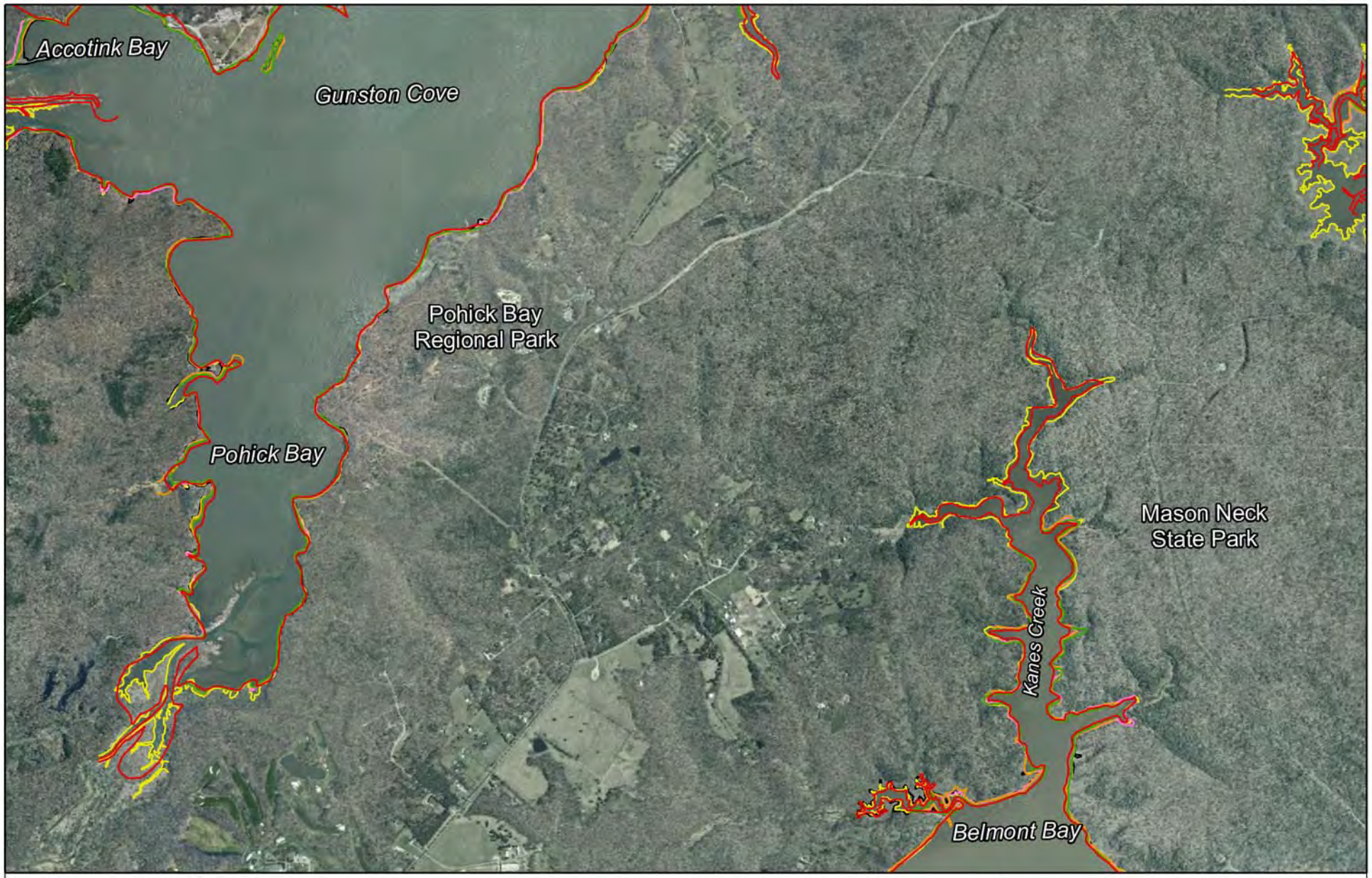
0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 5

Photo Date: 2009



Shoreline Studies Program VIMS



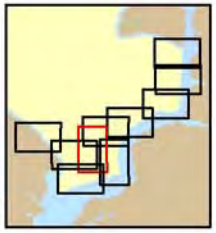
Legend

- Shoreline 1937
- Shoreline 1974
- Shoreline 1994
- Shoreline 2002
- Shoreline 2009
- Shoreline 2013

Photo Date: 2013

Fairfax County, Virginia
Plate 5

0 2,000 4,000 Feet



Shoreline Studies Program VIMS

Legend

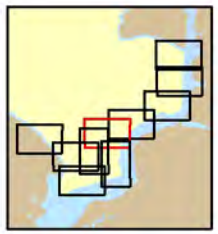
Shoreline 1937

N
W E
S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 6

Photo Date: 1937



Shoreline Studies Program VIMS

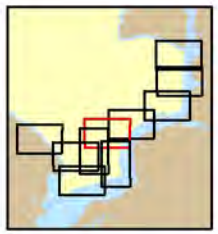
Shoreline Not Shown

N
W E
S

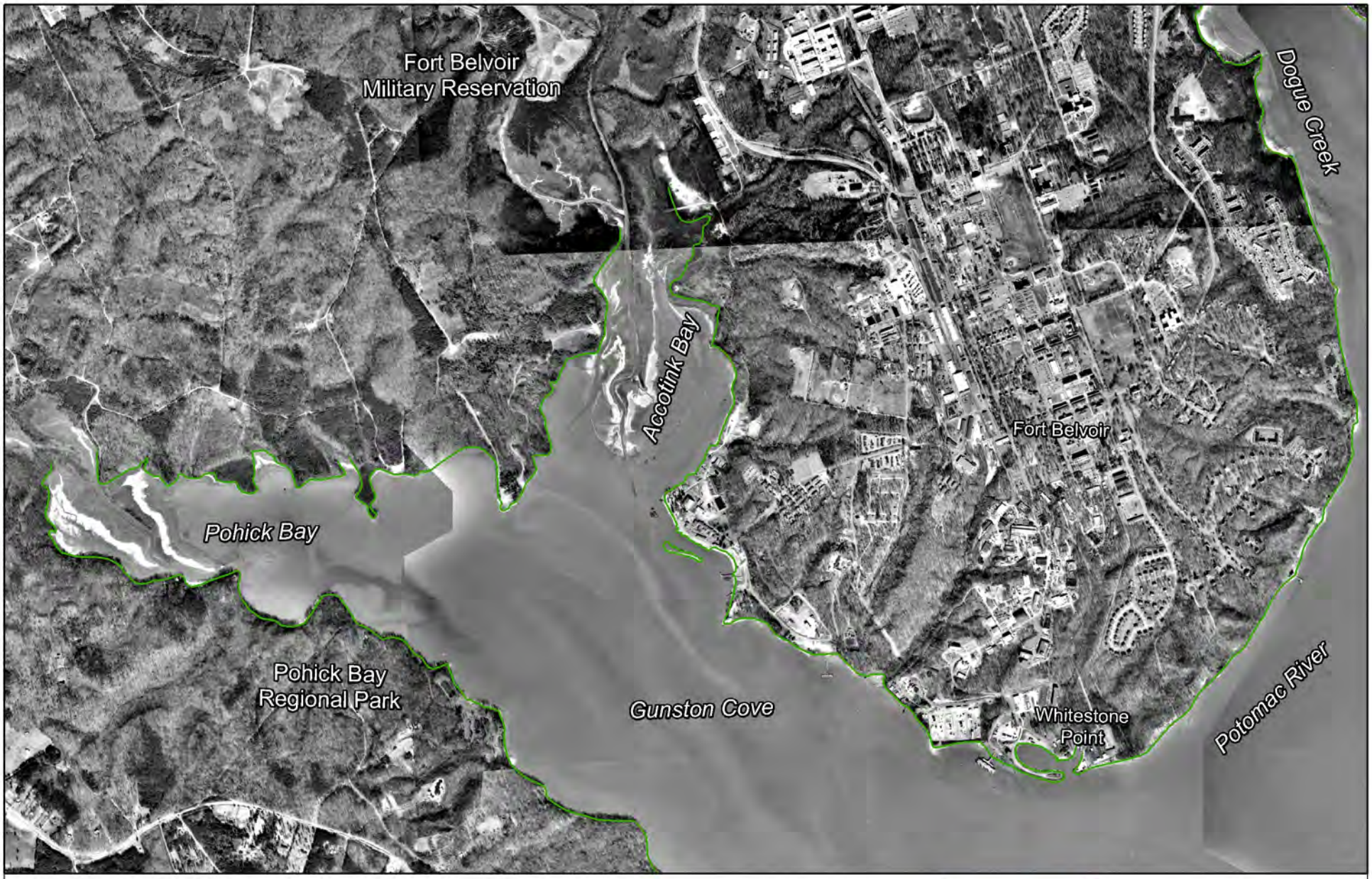
0 2,000 4,000
Feet

Fairfax County, Virginia
Plate 6

Photo Date: 1953



Shoreline Studies Program VIMS



Legend

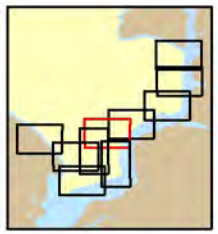
Shoreline 1974

N
W E
S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 6

Photo Date: 1974



Shoreline Studies Program VIMS

Legend

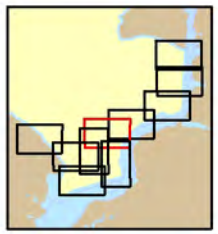
Shoreline 1994

N
W E
S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 6

Photo Date: 1994



Shoreline Studies Program VIMS

Legend

Shoreline 2002

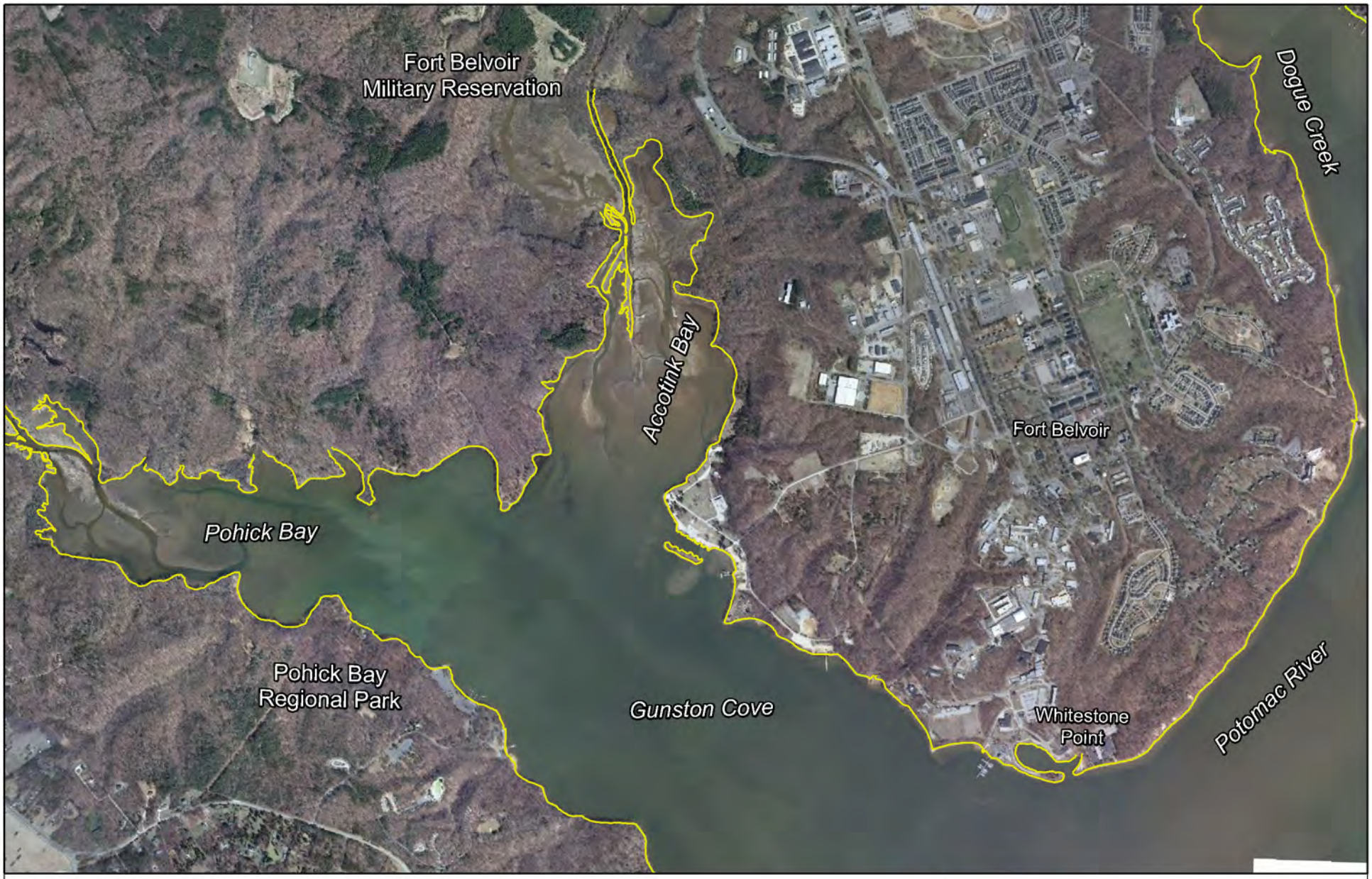
N
W E
S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 6

Photo Date: 2002

Shoreline Studies Program
VIMS



Legend

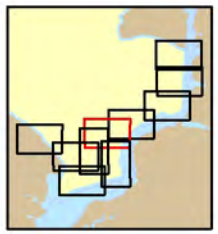
Shoreline 2009

N
W E
S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 6

Photo Date: 2009



Shoreline Studies Program VIMS

Legend

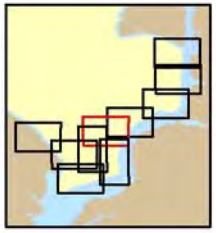
- Shoreline 1937
- Shoreline 1974
- Shoreline 1994
- Shoreline 2002
- Shoreline 2009
- Shoreline 2013

Photo Date: 2013

N W E S

Fairfax County, Virginia
Plate 6

0 2,000 4,000 Feet



Shoreline Studies Program VIMS

Legend

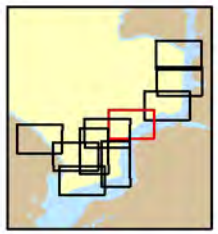
Shoreline 1937

N
W E
S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 7

Photo Date: 1937



Shoreline Studies Program VIMS

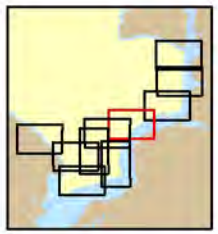
Shoreline Not Shown

N
W E
S

0 2,000 4,000
Feet

Fairfax County, Virginia
Plate 7

Photo Date: 1953



Shoreline Studies Program
VIMS

Legend

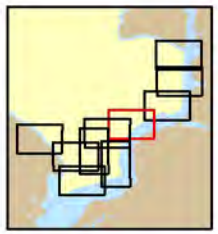
Shoreline 1974

N
W E
S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 7

Photo Date: 1974



Shoreline Studies Program VIMS

Legend

Shoreline 1994

N
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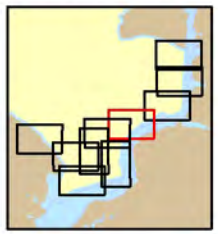
S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 7

Photo Date: 1994



Shoreline Studies Program VIMS

Legend

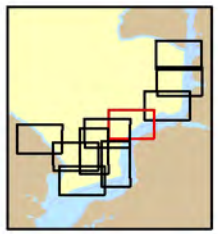
Shoreline 2002

N
W E
S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 7

Photo Date: 2002



Shoreline Studies Program VIMS

Legend

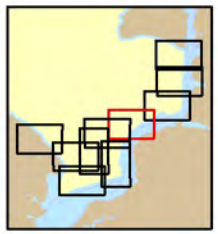
Shoreline 2009

N
W E
S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 7

Photo Date: 2009



Shoreline Studies Program VIMS

Legend

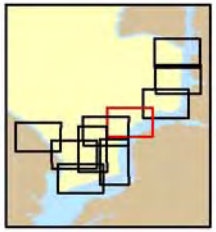
- Shoreline 1937
- Shoreline 1974
- Shoreline 1994
- Shoreline 2002
- Shoreline 2009
- Shoreline 2013

N
W E
S

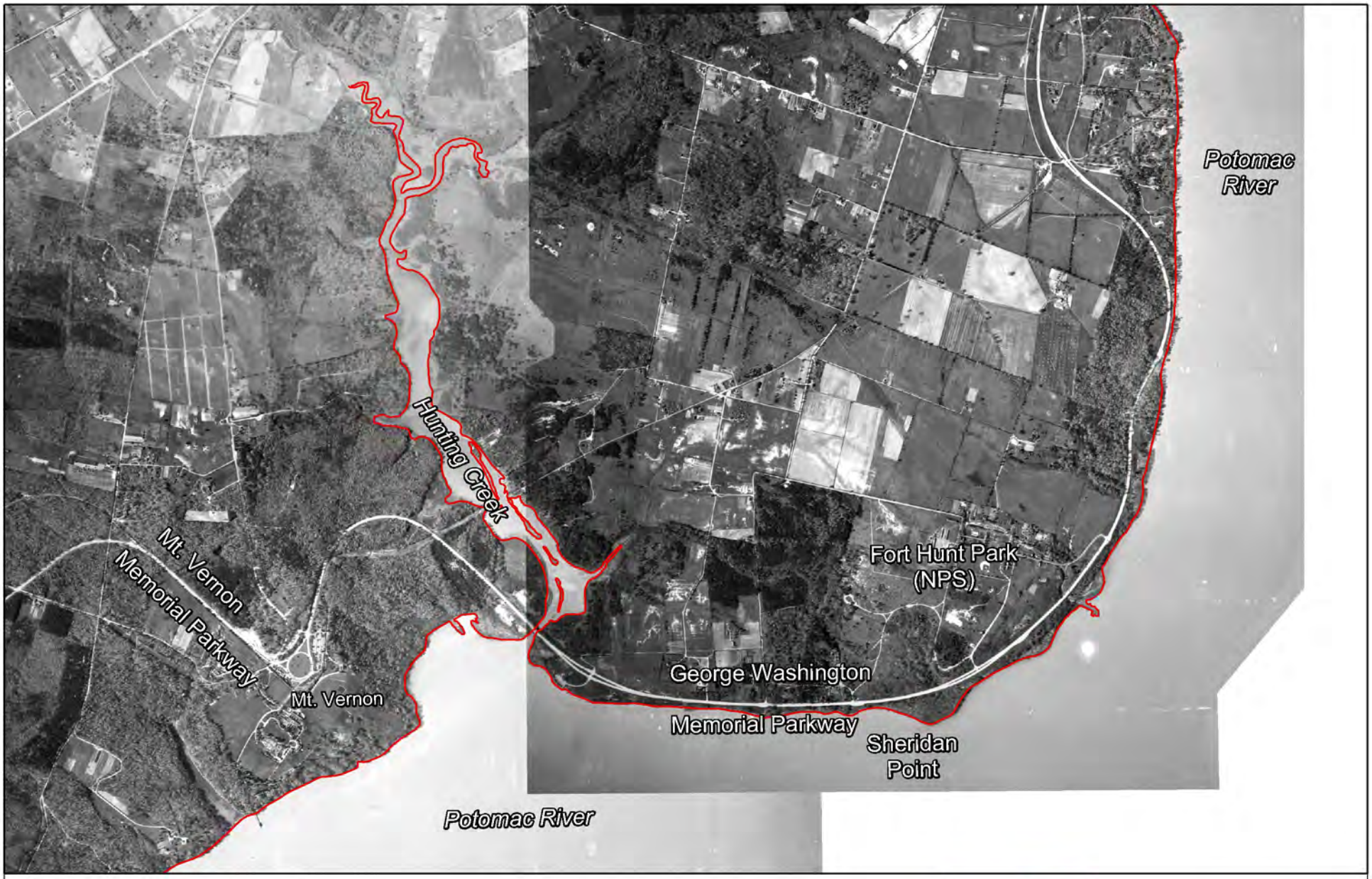
Photo Date: 2013

Fairfax County, Virginia
Plate 7

0 2,000 4,000 Feet



Shoreline Studies Program
VIMS



Legend

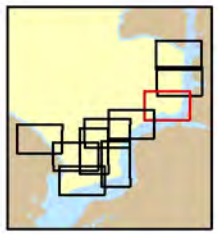
Shoreline 1937

N W E S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 8

Photo Date: 1937



Shoreline Studies Program VIMS

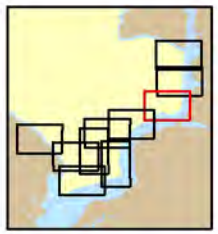
Shoreline Not Shown

N W E S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 8

Photo Date: 1953



Shoreline Studies Program VIMS

Legend

Shoreline 1974

N W E S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 8

Photo Date: 1974

Shoreline Studies Program VIMS

Legend

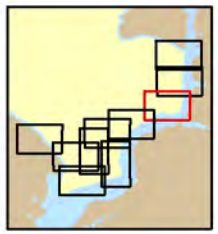
Shoreline 1994

N W E S

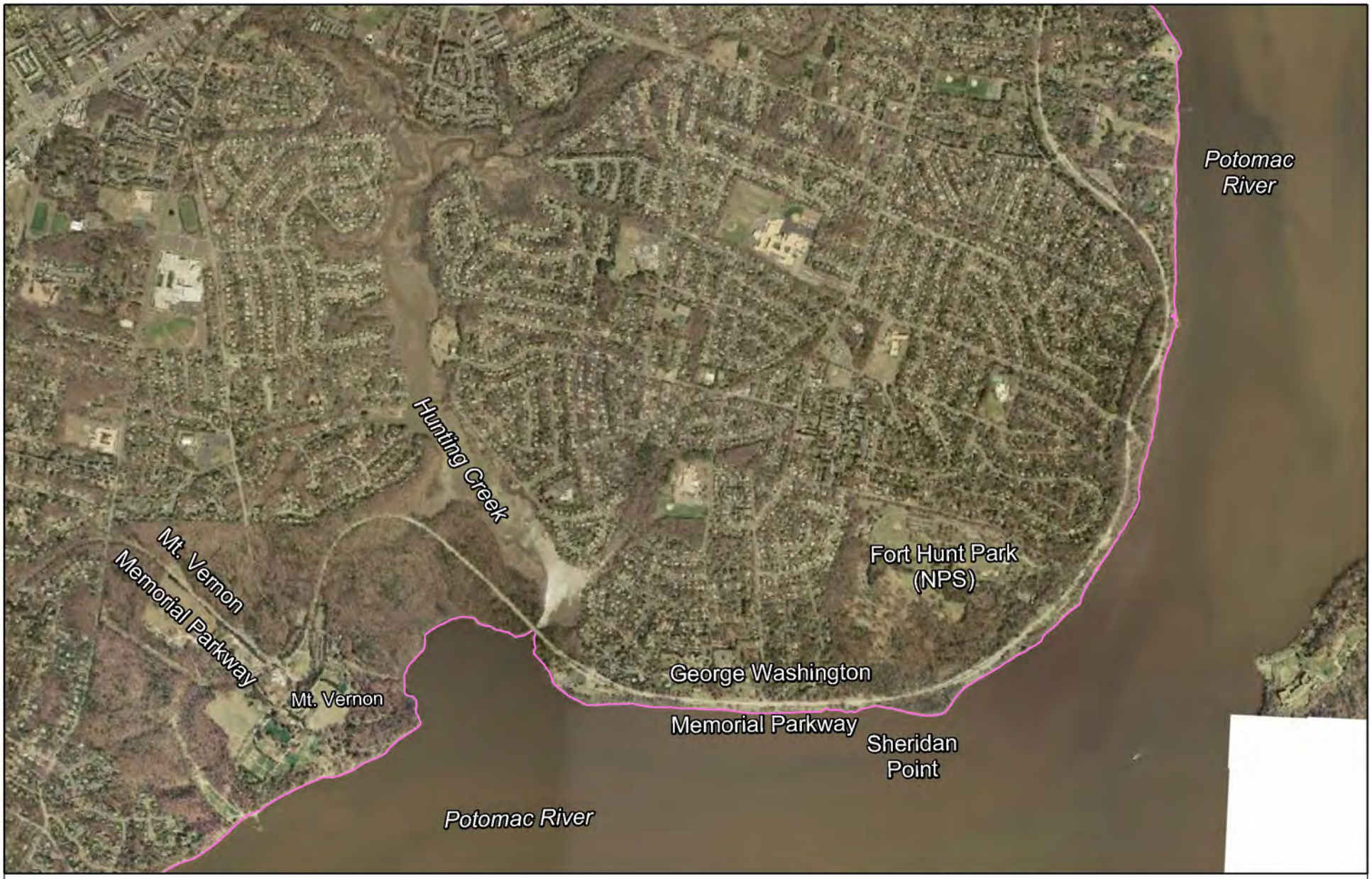
0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 8

Photo Date: 1994



Shoreline Studies Program VIMS



Legend

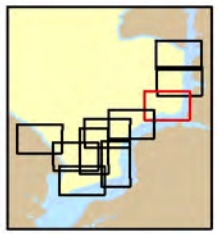
Shoreline 2002

N W E S

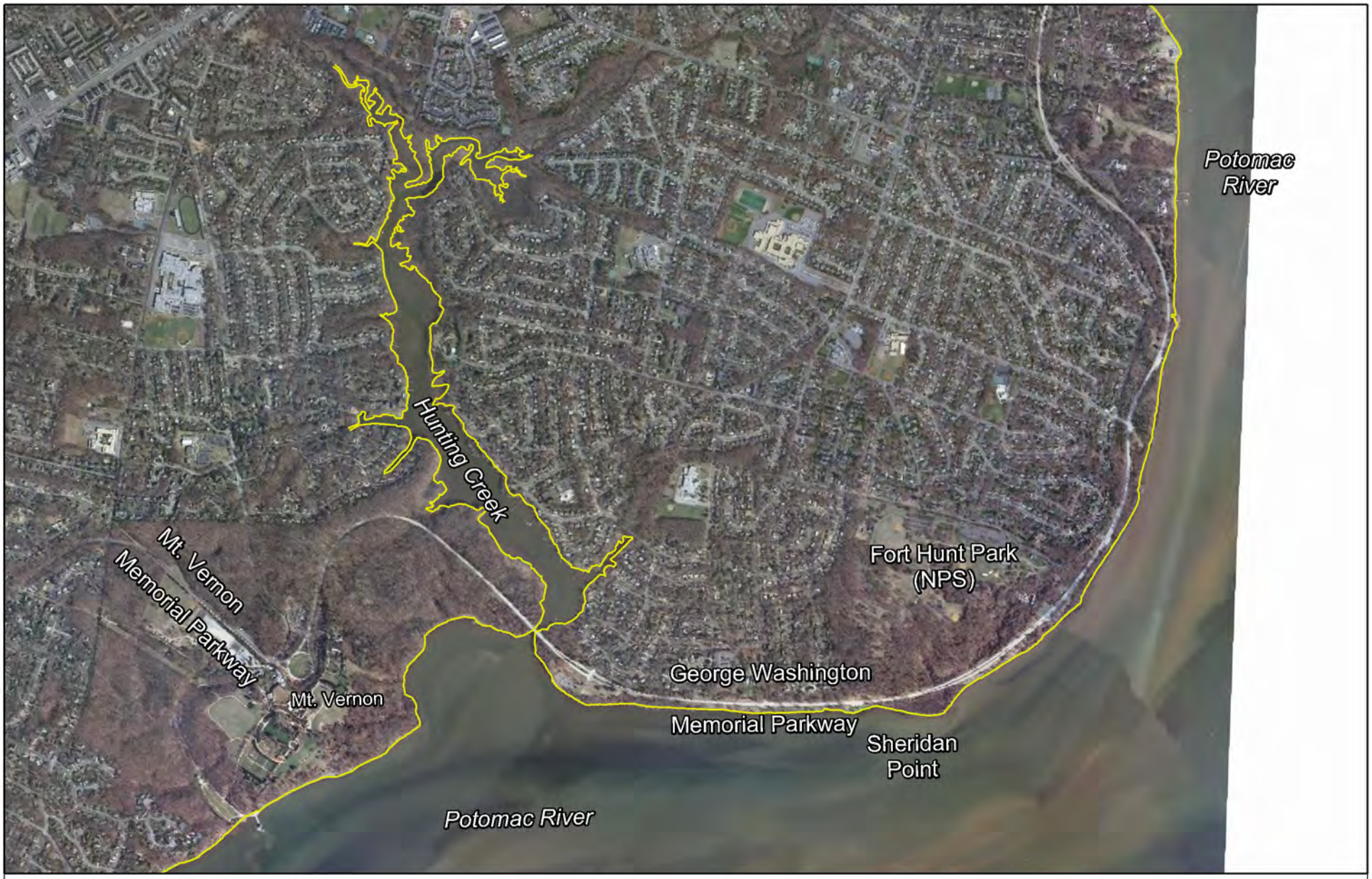
0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 8

Photo Date: 2002



Shoreline Studies Program VIMS



Legend

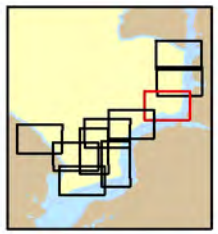
Shoreline 2009

N W E S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 8

Photo Date: 2009



Shoreline Studies Program VIMS

Legend

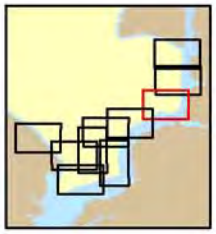
- Shoreline 1937
- Shoreline 1974
- Shoreline 1994
- Shoreline 2002
- Shoreline 2009
- Shoreline 2013

N W E S

Photo Date: 2013

Fairfax County, Virginia
Plate 8

0 2,000 4,000 Feet



Shoreline Studies Program VIMS

Legend

Shoreline 1937

N
W E
S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 9

Photo Date: 1937

Shoreline Studies Program
VIMS

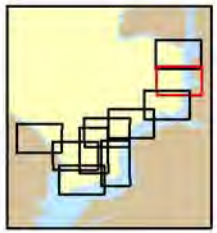
Shoreline Not Shown

N
W E
S

0 2,000 4,000
Feet

Fairfax County, Virginia
Plate 9

Photo Date: 1953



Shoreline Studies Program
VIMS

Legend

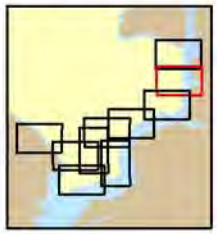
Shoreline 1974

N
W E
S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 9

Photo Date: 1974



Shoreline Studies Program
VIMS

Legend

Shoreline 1994

N
W E
S

0 2,000 4,000
Feet

Fairfax County, Virginia
Plate 9

Photo Date: 1994

Shoreline Studies Program
VIMS

Legend

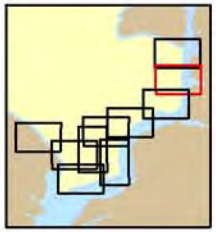
Shoreline 2002

N
W E
S

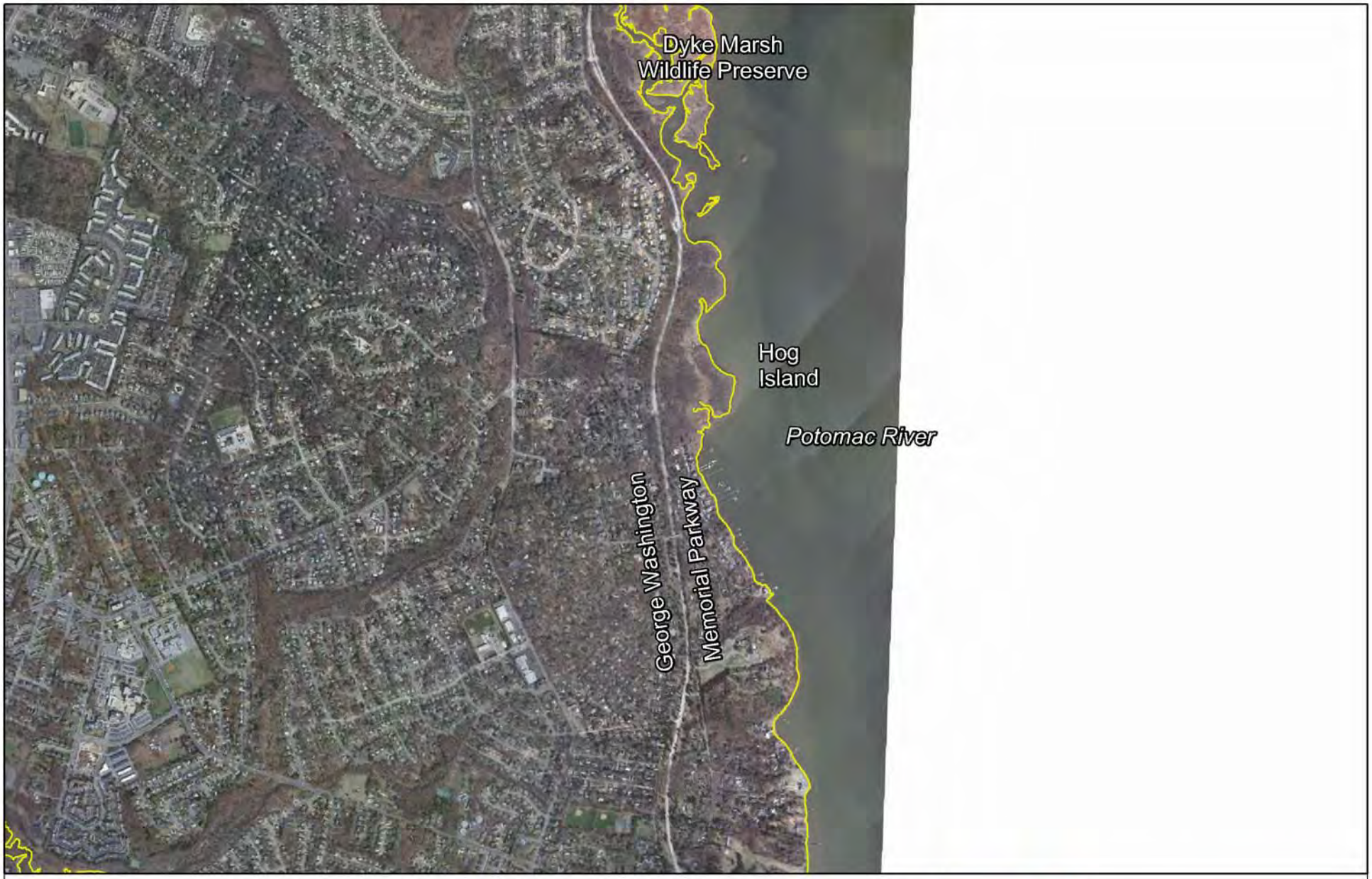
0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 9

Photo Date: 2002



Shoreline Studies Program VIMS



Legend

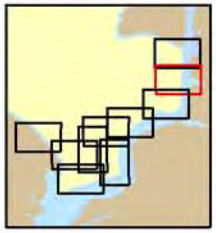
Shoreline 2009

N
W E
S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 9

Photo Date: 2009



Shoreline Studies Program
VIMS

Legend

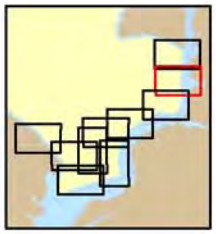
- Shoreline 1937
- Shoreline 1974
- Shoreline 1994
- Shoreline 2002
- Shoreline 2009
- Shoreline 2013

N W E S

Photo Date: 2013

Fairfax County, Virginia
Plate 9

0 2,000 4,000 Feet



Shoreline Studies Program VIMS

Legend

Shoreline 1937

N W E S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 10

Photo Date: 1937

Shoreline Studies Program VIMS

Shoreline Not Shown

N W E S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 10

Photo Date: 1953

Shoreline Studies Program VIMS

Legend

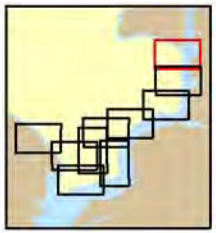
Shoreline 1974

N W E S

0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 10

Photo Date: 1974



Shoreline Studies Program VIMS

Legend

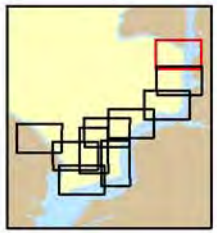
Shoreline 1994

N W E S

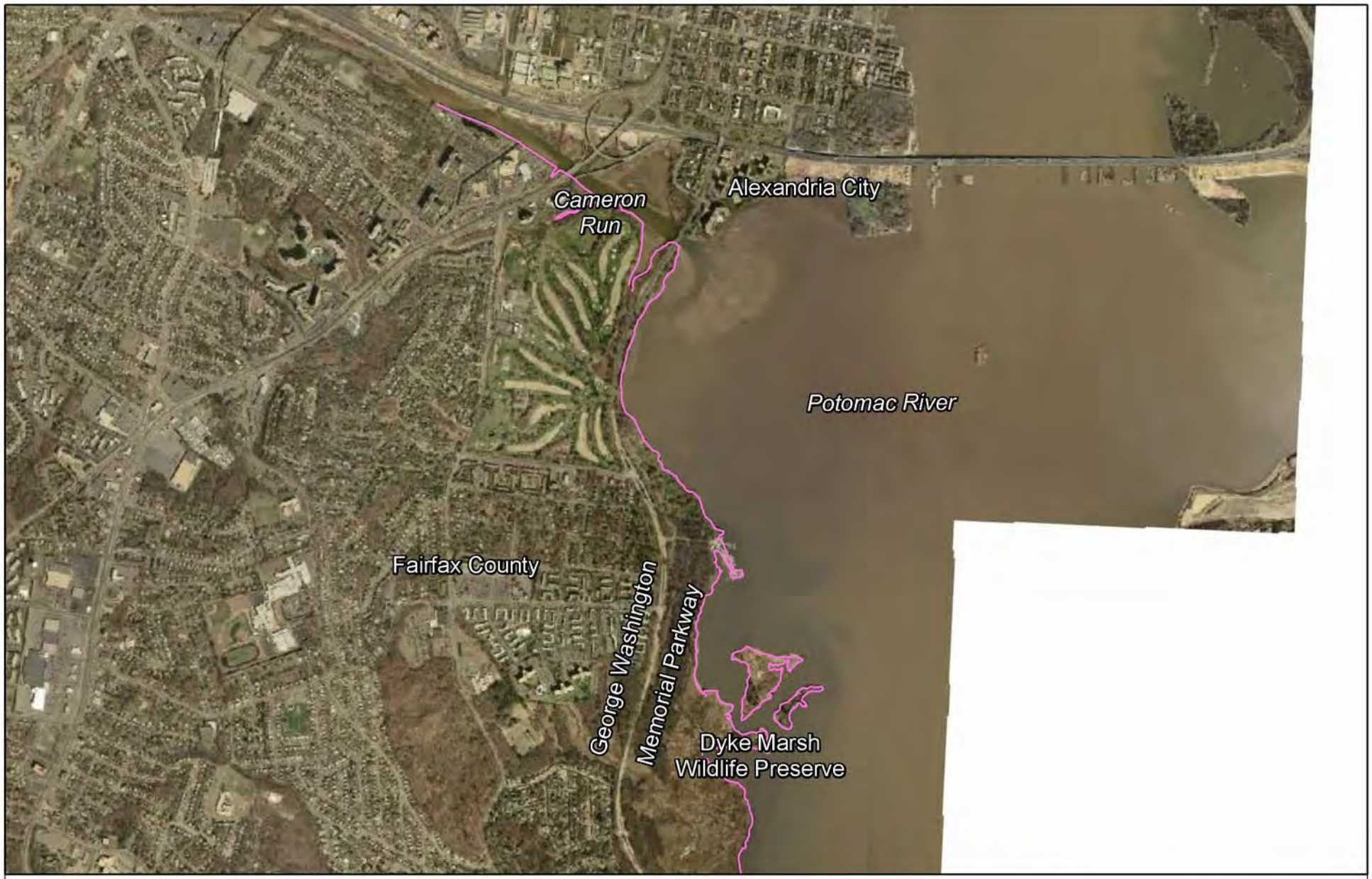
0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 10

Photo Date: 1994



Shoreline Studies Program VIMS



Legend

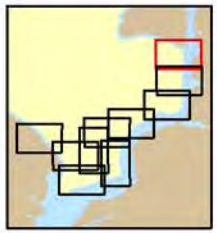
Shoreline 2002

N W E S

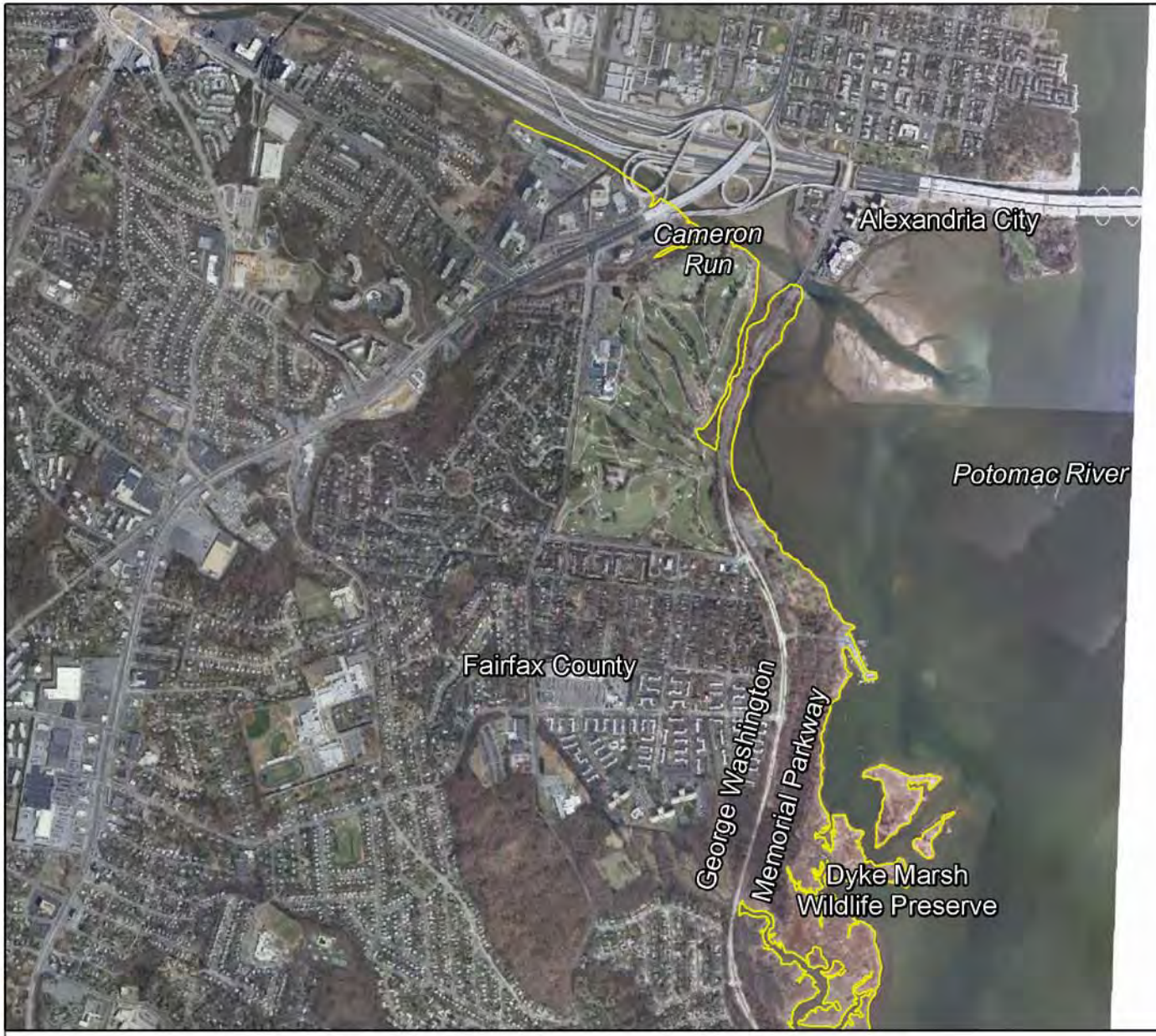
0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 10

Photo Date: 2002



Shoreline Studies Program VIMS



Legend

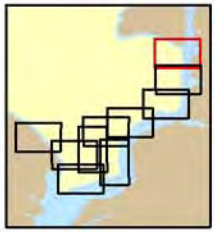
Shoreline 2009

N W E S

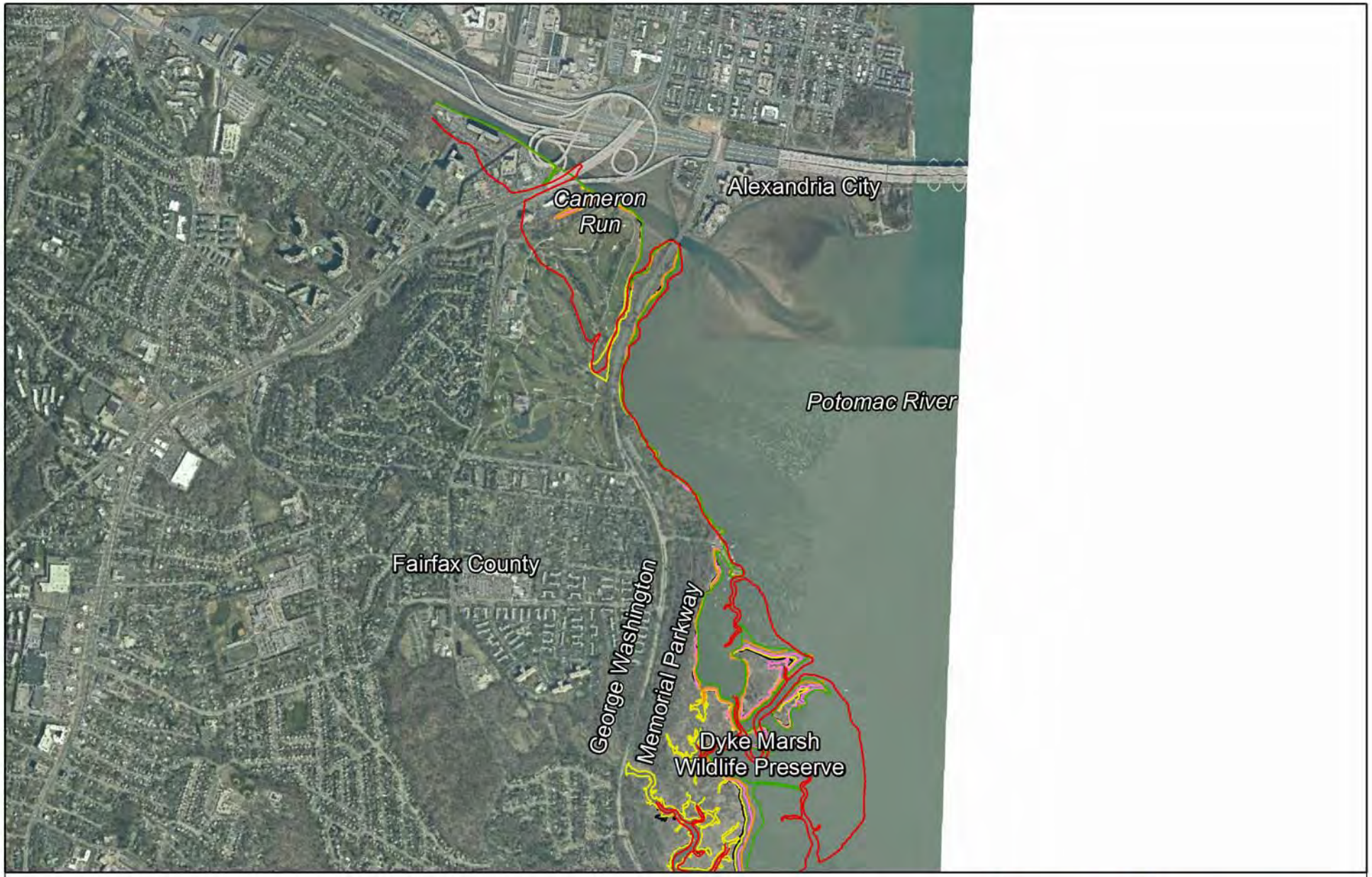
0 2,000 4,000 Feet

Fairfax County, Virginia
Plate 10

Photo Date: 2009



Shoreline Studies Program VIMS



Legend

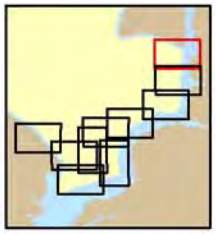
- Shoreline 1937
- Shoreline 1974
- Shoreline 1994
- Shoreline 2002
- Shoreline 2009
- Shoreline 2013

N W E S

Fairfax County, Virginia
Plate 10

0 2,000 4,000 Feet

Photo Date: 2013



Shoreline Studies Program VIMS