2004

# Shoreline Evolution Chesapeake Bay Shoreline Northampton County, VA

C. Scott Hardaway Jr.
*Virginia Institute of Marine Science*

Donna A. Milligan
*Virginia Institute of Marine Science*

Lyle M. Varnell
*Virginia Institute of Marine Science*

Christine Wilcox
*Virginia Institute of Marine Science*

George R. Thomas
*Virginia Institute of Marine Science*

*See next page for additional authors*

## Authors

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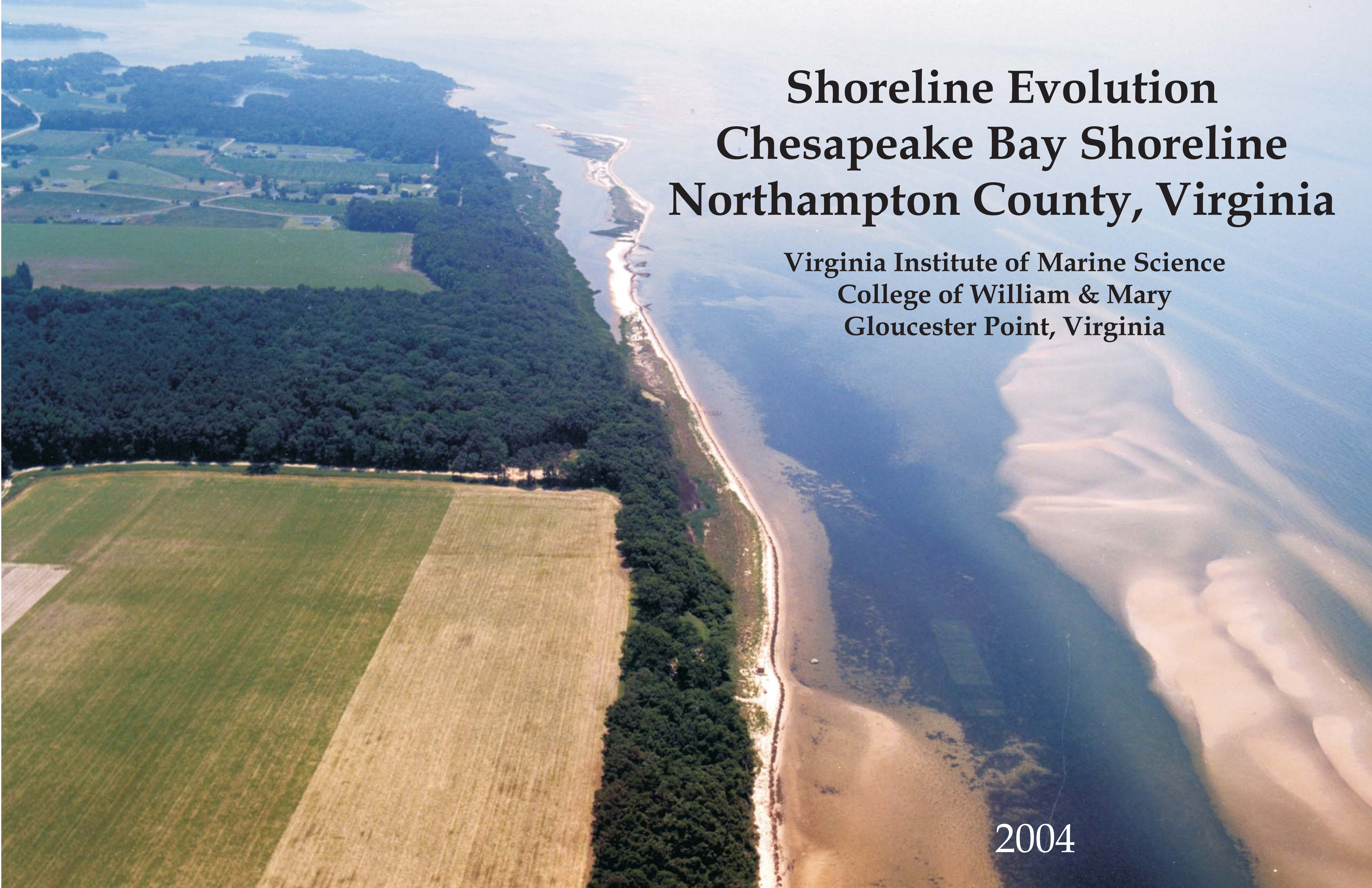

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# Chesapeake Bay Shoreline
# Northampton County, Virginia


Virginia Institute of Marine Science
College of William & Mary
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C. Scott Hardaway, Jr. [1]
Donna A. Milligan [1]
Lyle M. Varnell [2]
Christine Wilcox [1]
George R. Thomas [1]
Travis R. Comer [1]

Shoreline Studies Program [1]
Department of Physical Sciences
and
Wetlands Program [2]
Center for Coastal Resources Management

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College of William & Mary
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**Cover Photo**: Dune site NH17 at Floyd's Farm showing Vaucluse Spit in Northampton County. Photo taken by Shoreline Studies Program on 25 June 2003.

# I. INTRODUCTION

## A. General Information

Shoreline evolution is the change in shore position through time. In fact, it is the material resistance of the coastal geologic underpinnings against the impinging hydrodynamic (and aerodynamic) forces. Along the shores of the Chesapeake Bay, it is a process-based response system. The processes at work include winds, waves, tides, and currents, which together provide the energy which shapes and modifies coastlines by eroding, transporting, and depositing sediments. The shore line is commonly plotted and measured to provide a rate of change, but it is as important to understand the geomorphic patterns of change. Shore analysis provides the basis to know how a particular coast has changed through time and how it may proceed in the future.

The purpose of this report is to document how the Bay shore of Northampton County, Virginia (Figure 1) has evolved since 1938. Aerial imagery was taken for most of the Bay region beginning that year, and it is this imagery that allows one to assess the geomorphic nature of shore change. Aerial imagery shows how the nature of 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. Most of the shore positions will be quantified in this report. Others, particularly very irregular coasts, around inlets, and other areas will be subject to interpretation.

## B. Chesapeake Bay Dunes

The primary reason for developing this Shoreline Evolution Report is to project how dunes and beaches along the Bay coast of Northampton County will evolve through time. The premise is that, in order to determine future trends of these important shore features, one must understand how they got to their present state. Beaches and dunes are protected by the Coastal Primary Sand Dune Protection Act of 1980 (Act)[1]. Research by Hardaway *et al.* (2001) located, classified and enumerated jurisdictional dunes and dune fields within the eight localities listed in the Act. These include the counties of Accomack, Lancaster, Mathews, Northampton and Northumberland and the cities of Hampton, Norfolk and Virginia Beach (Figure 2). Only Chesapeake Bay and river sites were considered in that study.

In 2004, Hardaway *et al.* created the Northampton County Dune Inventory. That report detailed the location and nature of the jurisdictional primary dunes along the Bay shore of Northampton County. For this study, the position of the dune sites are presented using the latest imagery in order to see how the sites sit in the context of past shoreline positions. The dune location information has not been field verified since the original visit in 1999. This information is not intended to be used for jurisdictional determinations regarding dunes.

[1]The General Assembly of Virginia enacted the Coastal Primary Sand Dune Protection Act (the Dune Act) in 1980. The Dune Act was originally codified in § 62.1-13.21 to -13.28. The Dune Act is now recodified as Coastal Primary Sand Dunes and Beaches in § 28.2-1400 to -1420.

# II. SHORE SETTING

## A. Physical Setting

Northampton County lies at the distal end of the Delmarva peninsula. About 40 miles of tidal shoreline exist along the Chesapeake Bay side of the county which extends from Occohannock Creek to the southern end of the peninsula at Cape Charles. The shorelines of Northampton County are basically either on the open Bay or up the tidal creeks with little transition between the two except at the creek mouths. Therefore, the highest erosion takes place along the open bay shore reaches where fetch exposures are the greatest. Erosion rates vary from 0 ft/yr to over 7 ft/yr (Byrne and Anderson, 1978). A monitoring site at Tankard's Beach in the early 1980s measured bank recession at over 19.0 ft/yr.

Three geologic formations outcrop along the Chesapeake Bay coast in Northampton County (Figure 3). From Occohanncock Creek to Silver Beach, the Kent Island Formation (Qk) (upper Pleistocene) is composed of pale gray to yellowish-gray, medium to coarse sand and sandy gravel grading upward into a fine to medium sand that is partly clayey and silty. From Silver Beach to about Picketts Harbor, the coast is composed of the Occohannock Member (Qno) of the Nasswadox Formation (upper Pleistocene). This stratigraphic unit is composed of light yellowish-gray fine to medium sand. At the southern end of the county are the Bulter's Bluff Member (Qnb) of the Nassawadox Formation and Joynes Neck Sands (Qj). Both these units are yellowish-gray, fine to coarse sands and gravels. The Butler's Bluff Member consists of very distinct cross-bedding containing abundant pebbles. Collectively, the geology is very sandy which explains the large dune fields along the Northampton County coast and produces the extensive offshore sand bars. Fisherman's Island is composed of recent (Holocene) sands and marshes.

The coastal geomorphology of the county is a function of the underlying geology and the hydrodynamic forces operating across the land/water interface which is also known as the shoreline. The Chesapeake Bay coast of Northampton County is defined by a series of headlands or necks separated by tidal creeks. These necks of land are the interfluves and the tidal creeks are the drainage watersheds of the coastal plain that formed, in part, as sea level retreated about 75,000 years ago.

During the last sea level low stand, sea level was about 300 ft lower than it is today, which forced the ocean coast about 60 miles to the east causing the coastal plain to be broad and low. The current estuarine system was a series of rivers working their way to the coast. About 18,000 years ago, sea level began to rise, and the coastal plain watersheds began to flood. Shorelines began to recede. The slow rise in sea level is one of two primary long-term processes which cause the shoreline to recede; the other is wave action. As shorelines recede or erode, the bank material provides the sands for the offshore bars, beaches, and dunes.

Sea level is continuing to rise in the Tidewater Region. Tide data collected at Sewells Point in Norfolk show that sea level has risen 4.42 mm/yr (0.17 inches/yr) or 1.45 ft/century (http://www.co-ops.nos.noaa.gov/). This directly effects the reach of storms and their impact on shorelines. Anecdotal evidence of storm surge during Hurricane Isabel, which impacted North Carolina and Virginia on September 18, 2003, put it on par with the storm surge from the "storm of the century" which impacted the lower Chesapeake Bay in August 1933.

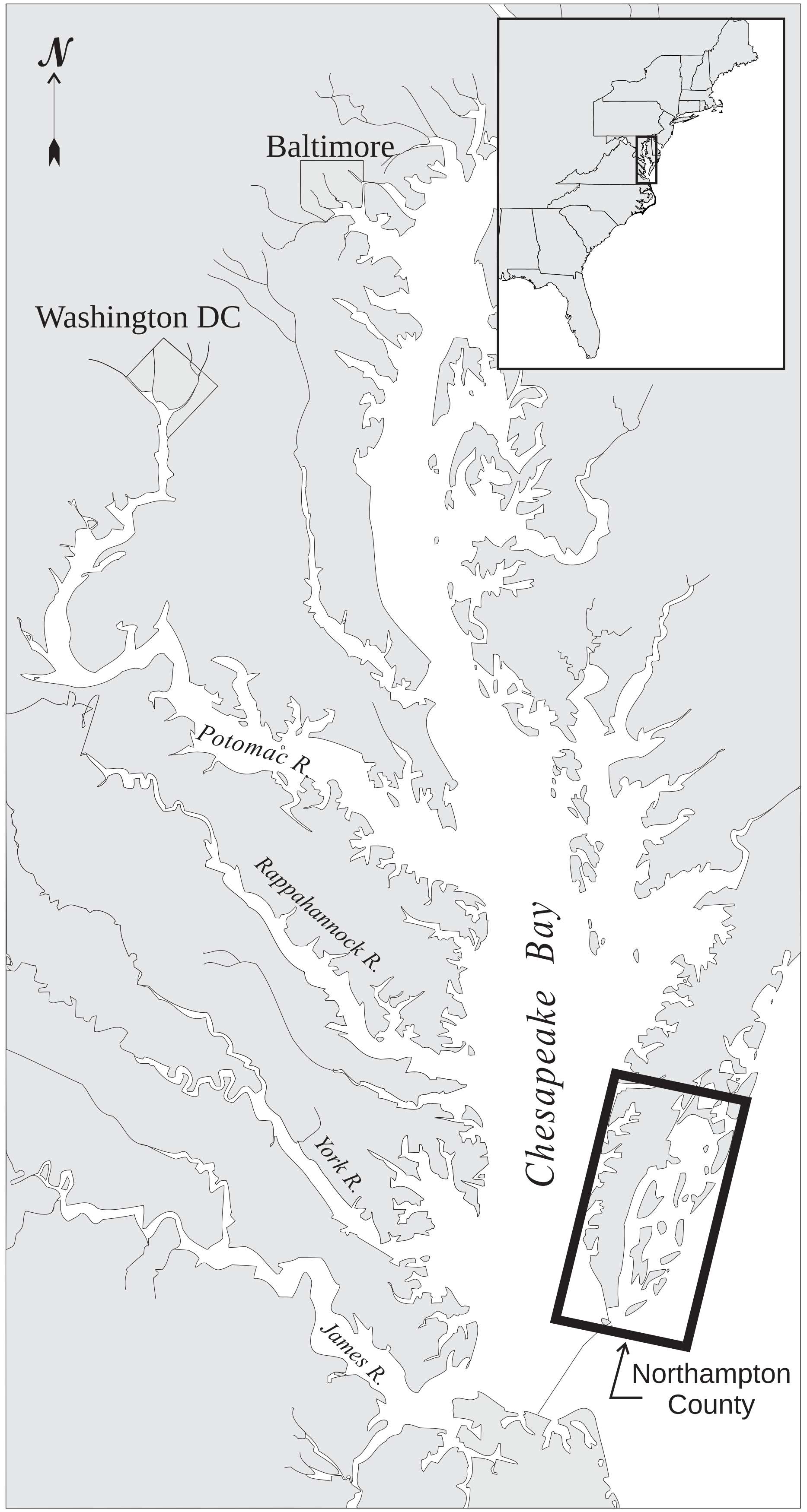


Figure 1. Location of Northampton County within the Chesapeake Bay estuarine system.

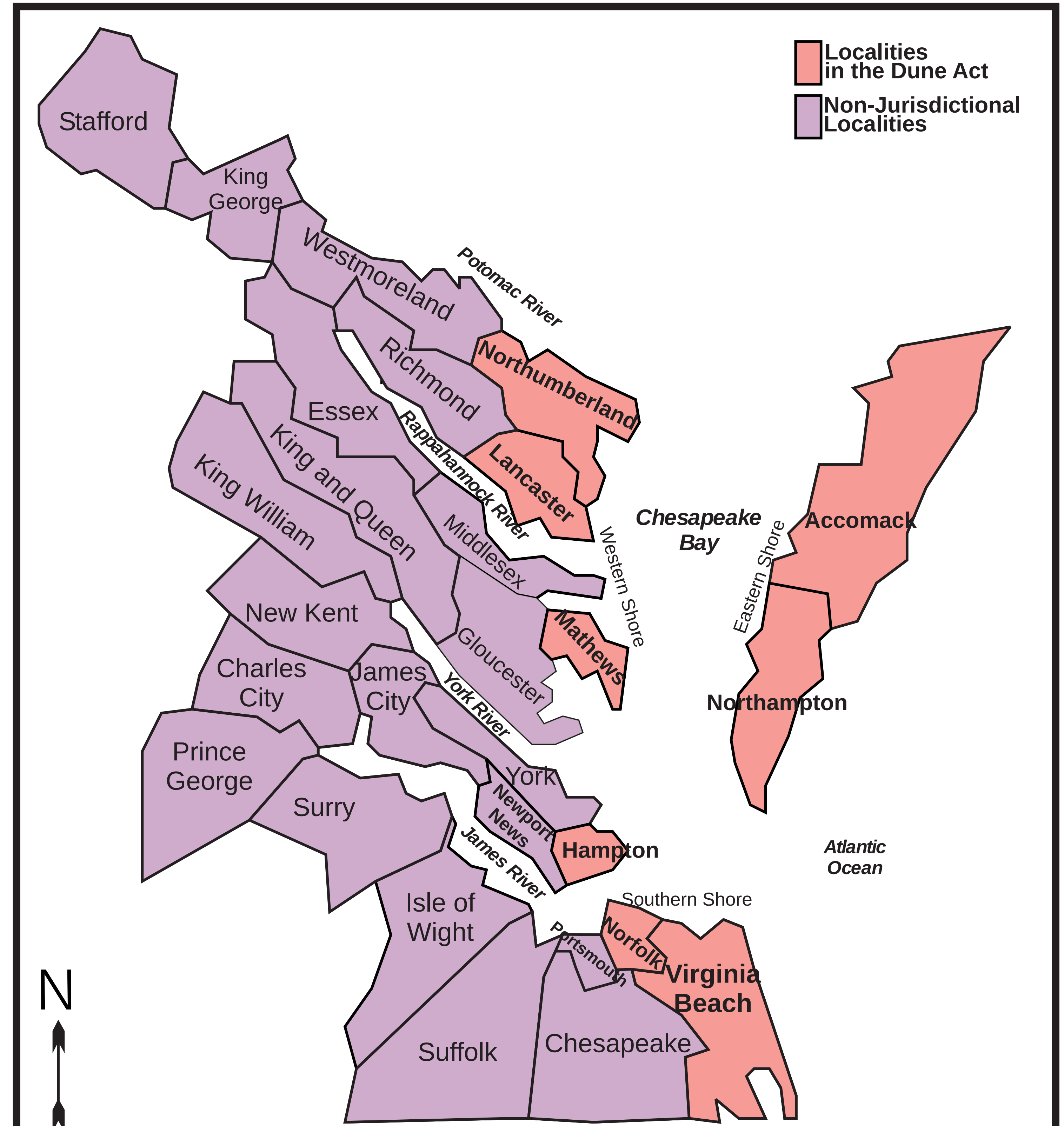


Figure 2. Location of localities in the Dune Act with jurisdictional and non-jurisdictional localities noted.


Figure 3. Geologic map of Northampton County (from Mixon *et al*., 1989).

5 0 5

Miles

**Qs** **Holocene Sand** - Pale gray to light-yellowish gray, fine to coarse, poorly sorted to well sorted, shelly in part; contains angular to rounded fragments and whole valves of mollusks. Comprises deposits of coastal barrier islands and narrow beach-dune ridges bordering brackish-water marshes of Chesapeake Bay. As much as 40 ft in thickness.

**Qm** **Holocene Soft Mud** - Medium to dark-gray, and peat, grayish brown. Comprises sediment of marshes in coastal areas and Chesapeake Bay. Thickness is 0-10 ft.

**Qsm** **Holocene sandy mud and muddy fine sand** - Light- to dark-gray. Locally, contains abundant shell material characterized by *Crassostrea virginica* and *Mercenaria mercenari*a. Comprises sediments of shallow bays and tidal flats in area of coastal lagoons. Unit not mapped in Chesapeake Bay and Back Bay areas. Thickness is 0-30 ft.

**Qk** **Kent Island Formation (Upper Pleistocene)** - Pale gray to yellowish-gray, medium to coarse sand and sandy gravel grading upward into poorly to well-sorted, fine to medium sand, in part clayey and silty. Unit is surficial deposit of broad, bayward-sloping lowland (altitude ranges from sea level to about 20 ft) bordering east side of Chesapeake Bay. Thickness ranges from a featheredge at scarp along eastern edge of lowland to about 40 ft in downdip areas.

**Qwa** **Wachapreague Formation (Upper Pleistocene)** - Coarsening upward sequence includes a lower member of clayey and silty, fine to very fine, gray and interbedded with clay-silt and an upper member of medium to coarse, gravelly sand. Mollusks, including *Mesoderma arctatum* and *Siliqua costata*, and ostracode assemblages dominated by *Elofsonella concinna* and *Muellerina canadensis* indicate cooling ocean temperatures during deposition of unit. Pollen assemblages dominated by pine, spruce, birch, and alder suggests cool- to cold-temperature conditions in nearby land areas. Unit is surficial deposit of narrow, arcuate coastal lowland ranging in altitude from sea level, at eastern boarder with Holocene barrier-lagoon complex, to about 15 ft at toe of ocean-facing scarp forming western boundary. Thickness is 0-40 ft.

**Nassawadox Formation (Upper Pleistocene)** - Surficial sandy and gravelly deposits of narrow, flat upland and adjacent bay-side terrace in Northampton and southernmost Accomack Counties.

**Qno** **Occohannock Member** - Light-yellowish-gray, fine to medium sand underlying southwest-sloping terrace (alt. 30-18 ft) on west side of upland. Sand is dominantly massive to horizontally bedded, but shows some small-scale crossbedding; locally, contains clay and silt as matrix and thin beds. Unit was deposited in a low-energy, open-bay environment. Thickness ranges from a featheredge near bay-facing scarp along western margin of upland to 20 ft in downdip areas near present bay.

**Qnb** **Butlers Bluff Member** - Pale-gray to light-yellowish-gray, fine coarse, crossbedded, pebbly sand and sandy gravel comprising surficial deposits of upland (alt. 35-40 ft). Diverse molluscan assemblages in lower part of unit, including *Marginella*, *Mulinia*, *Nassarius*, *Spisula*, *Pleuromeris*, and *Olivella*, indicates a shallow nearshore-shelf depositional environment. Unit was deposited as a southward-building complex of spit-platform sands and shallow shoals and is as much as 60 ft in thickness. In subsurface, unit overlies 140 ft, or more, of pebbly to cobbly sand, clay-silt, and muddy fine-grained sand of the Stumptown member of the Nassawadox Formation, which fills a late Pleistocene paleochannel of the Susquehanna River System.

**Qj** **Joynes Neck Sand (Upper Pleistocene)** - Yellowish-gray, fine to coarse sand corsening downward to gravelly sand and sandy gravel. Cross-lamination in finer-grained sands accentuated by black, heavy minerals. Unit was deposited in nearshore-shelf depositional environment; constitutes surficial deposit of coast-parallel terrace (alt. 23-26 ft) on eastern side of upland in Accomack County. Thickness ranges from 0 to 30 ft.

Boon (2004) showed that even though the tides during the storms were very similar, the difference being only 4 cm or about an inch and a half, the amount of surge was different. The 1933 storm produced a storm surge that was greater than Isabel's by slightly more than a foot. However, analysis of the mean water levels for the months of both August 1933 and September 2003 showed that sea level has risen by 41 cm (1.35 ft) at Hampton Roads in the seventy years between these two months (Boon, 2004). This is the approximate time span between our earliest aerial imagery (1937 and 1938), and our most recent (2002).

The impact of sea level rise to shore change is significant. The still water elevation in Hampton Roads has risen about 1.4 ft between our earliest aerial imagery (1937 and 1938) and our most recent (2002). The beaches, dunes, and nearshore sand bars are trying to keep pace with the rising sea levels.

Five shore reaches define the necks of land (Figure 4) along the Bay shore of Northampton County. Over time, severe erosion of the sandy banks has provided an abundance of sandy material to the littoral system. This is evidenced by the existence of mostly sand beaches along the coast and by a very extensive and complex system of offshore sand bars. These sand bars greatly influence, and are themselves influenced by, the impinging waves. They dominate the shallow water region and provide a haven for submerged aquatic vegetation (SAV) which otherwise might not survive the rigorous wave climate.

B. Hydrodynamic Setting

Mean tide range along the Bay coast of Northampton County varies from 3.0 ft at Fisherman's Island to 1.7 ft at Occohannock Creek. The wind/wave climate impacting Northampton's Bay coast is defined by the large fetch to the southwest, west, and northwest across Chesapeake Bay (Figure 1). The Bay's width varies north to south. From Kiptopeke to the western shore at Hampton, the width is about 22 nautical miles. From Cherry Stone Inlet across to Mathews County, the Bay is approximately 12 nautical miles wide. From Occohannock Creek to Windmill Point the width is over 22 nautical miles. In addition, there is fetch of over 35 nautical miles up Bay to the Northwest. Wind data from Norfolk International Airport reflect the frequency and speeds of wind occurrences from 1960 to 1990 (Table 1).

The more southern shorelines of Reach I and Reach II are partially impacted by incoming ocean swell. All reaches are impacted by the wind/wave climate crossing the Bay. Northampton County's Bay coast is, for the most part, protected from wind-driven waves during northeasters. However, when a front passes, the surge can remain for several tidal cycles and winds generally shift to the west and northwest which can generate a short, fierce wave field along Northampton's entire Bay coast.

Hurricanes, depending on their proximity and path, can also have an impact on the Northampton County's Bay coast. On September 18, 2003, Hurricane Isabel passed through the Virginia coastal plain. The main damaging winds began from the north and shifted to the east then south. The bay side of the Eastern Shore suffered relatively little impact. However, when Hurricane Floyd passed through the area in 1999, its winds shifted from northeast to northwest which resulted in the significant scarping of many beaches and dunes along the Northampton County shoreline, sometimes causing the loss of the primary dune.

Table 1. Summary wind conditions at Norfolk International Airport from 1960-1990.

| | | WIND DIRECTION | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Wind Speed (mph)** | **Mid Range (mph)** | **South** | **South west** | **West** | **North west** | **North** | **North east** | **East** | **South east** | **Total** |
| **< 5** | 3 | 5497*<br>2.12[+] | 3316<br>1.28 | 2156<br>0.83 | 1221<br>0.47 | 35748<br>13.78 | 2050<br>0.79 | 3611<br>1.39 | 2995<br>1.15 | 56594<br>21.81 |
| **5-11** | 8 | 21083<br>8.13 | 15229<br>5.87 | 9260<br>3.57 | 6432<br>2.48 | 11019<br>4.25 | 13139<br>5.06 | 9957<br>3.84 | 9195<br>3.54 | 95314<br>36.74 |
| **11-21** | 16 | 14790<br>5.70 | 17834<br>6.87 | 10966<br>4.23 | 8404<br>3.24 | 21816<br>8.41 | 16736<br>6.45 | 5720<br>2.20 | 4306<br>1.66 | 100572<br>38.77 |
| **21-31** | 26 | 594<br>0.23 | 994<br>0.38 | 896<br>0.35 | 751<br>0.29 | 1941<br>0.75 | 1103<br>0.43 | 148<br>0.06 | 60<br>0.02 | 6487<br>2.5 |
| **31-41** | 36 | 25<br>0.01 | 73<br>0.03 | 46<br>0.02 | 25<br>0.01 | 162<br>0.06 | 101<br>0.04 | 10<br>0.00 | 8<br>0.00 | 450<br>0.17 |
| **41-51** | 46 | 0<br>0.00 | 0<br>0.00 | 0<br>0.00 | 1<br>0.00 | 4<br>0.00 | 4<br>0.00 | 1<br>0.00 | 0<br>0.00 | 10<br>0.00 |
| **Total** | | 41989<br>16.19 | 37446<br>14.43 | 23324<br>8.99 | 16834<br>6.49 | 70690<br>27.25 | 33133<br>12.77 | 19447<br>7.50 | 16564<br>6.38 | 259427<br>100.00 |

*Number of occurrences [+]Percent

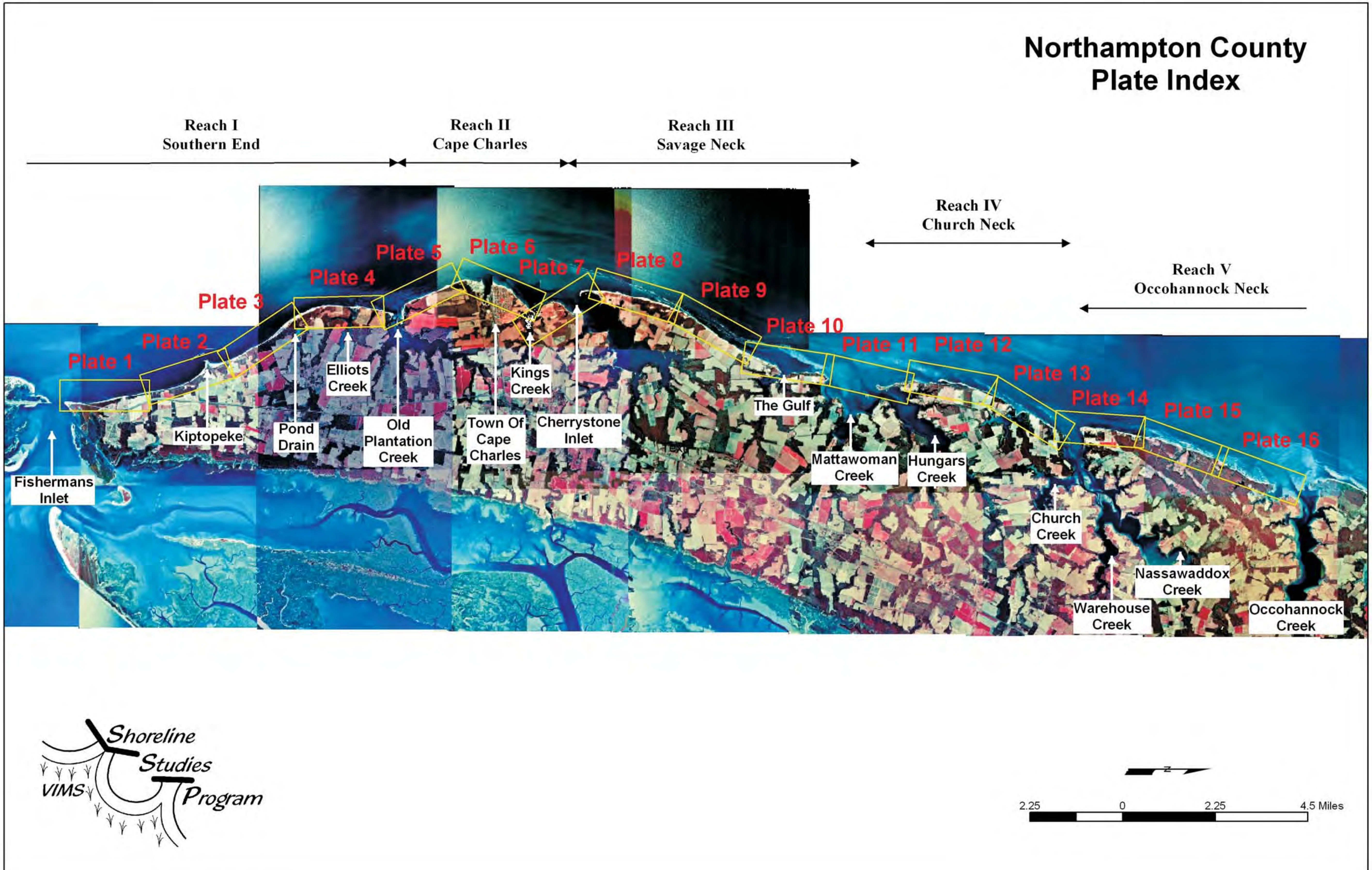


Figure 4. Index of shoreline plates.

# III. METHODS

## A. Photo Rectification and Shoreline Digitizing

Recent and historic aerial photography was used to estimate, observe, and analyze past shoreline positions and trends involving shore evolution for Northampton County. Some of the photographs were available in fully geographically referenced (georeferenced) digital form, and others had to be scanned and georectified for this project.

Aerial photos from the VIMS Shoreline Studies Program archive and the submerged aquatic vegetation (SAV) archives were used. High level black and white aerials were available for 1938, 1949, 1989, and 2002. Color aerials were obtained for 1994. The 1949 and 2002 imagery were already processed and mosaicked by the SAV Program at VIMS (Moore *et al*., 2003), and the 1994 mosaic was acquired from United States Geological Survey (USGS). The aerials for the remaining flight lines were processed and mosaicked by the VIMS Shoreline Study Program.

The images were scanned as tiffs at 300 dpi and converted to ERDAS IMAGINE (.img) format. They were georectified to a reference mosaic, which was the 1994 Digital Orthophoto Quarter Quadrangles (DOQQ) from the United States Geological Survey. The original DOQQs were in MrSid format but were converted into .img format. The software used for georeferencing and mosaicking was ESRI's ArcView 3.3 which included Image Analyst, IMAGINE image support, Legend Tool, MrSid image support, Spatial Analyst, TIFF 6.0 image support, and projection extensions. The digitizing was performed using ESRI ArcMap.

Ground control points (GCP) were created to register all aerial photos to the reference images. GCPs are points that mark features found in common on both the reference image and in the original scanned images that are being georeferenced. While in ArcView, the 1994 DOQQs and the scanned tiffs were displayed, and a control point shapefile was created. Control points were distributed evenly across the image to maintain an accurate registration without too much warp and twist. In addition, enough control points were placed within the area of interest, the shoreline, to ensure accurate registration in these key areas. This can be challenging in areas with little development. Good examples of control points are features such as identifiable road intersections, corners of buildings, and stable natural landmarks. The standard in this project was from eight to sixteen control points for each image and a root mean square (RMS) error under six for each.

Once the individual images were georectified to the corresponding DOQQs, the mosaic tool in ArcView was used to create an aerial mosaic of the entire study area for each year. The final mosaics are in .img format. In ArcMap, heads-up digitizing with the mosaics in the background was used to delineate the shorelines for each year. In areas where the shoreline was not clearly delineated, the location was estimated based on the experience of the digitizer. Digitizing the shoreline brings in perhaps the greatest amount of potential error because of the problems of image clarity and definition of shoreline features. Most of the shoreline analysis of Northampton County was done with beaches present. Figure 5 demonstrates the variability of beach profiles along the county's coast in cross-section. Beach features can be difficult to discern because of their variability. The feature that was digitized for Northampton County is assumed to be mean low water (MLW) (Figure 6) which lies within a few feet horizontally of the toe of the beach slope.

## B. Rate of Change Analysis

A custom Arcview extension called "shoreline" was used to analyze shoreline rate of change. A straight, approximately shore parallel baseline is drawn landward of the shoreline. The extension creates equally-spaced transects along the baseline and calculates distance from the baseline at that location to each year's shoreline. The output from the extension are perpendicular transects of a length and interval specified by the user. The extension provides the transect number, the distance from beginning baseline to each transect, and the distance from the baseline to each digitized shoreline in an attribute table. The attribute table is exported to a spreadsheet, and the distances of the digitized shoreline from the baseline are used to determine the rates of change. The rates of change are summarized as mean or average rates and standard deviations for each Plate.

It is very important to note that this extension is only useful on relatively straight shorelines. In areas that have unique shoreline morphology, such as creek mouths and spits, the data collected by this extension may not provide an accurate representation of true shoreline change. The shore change data was manually checked for accuracy. However, where the shoreline and baseline are not parallel, the rates may not give a true indication of the rate of shoreline change.

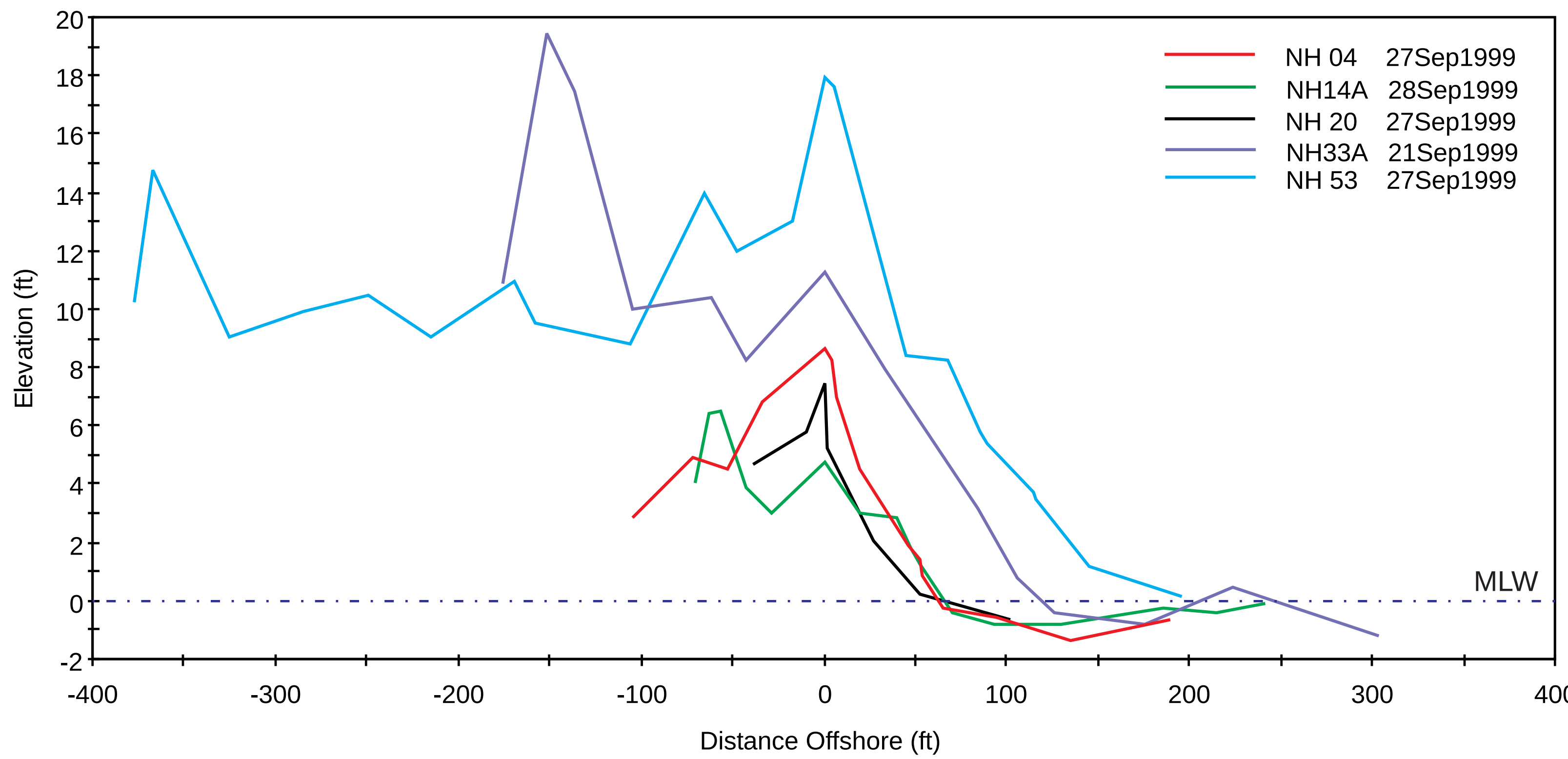


Figure 5. Variability of dune and beach profiles in Northampton County.

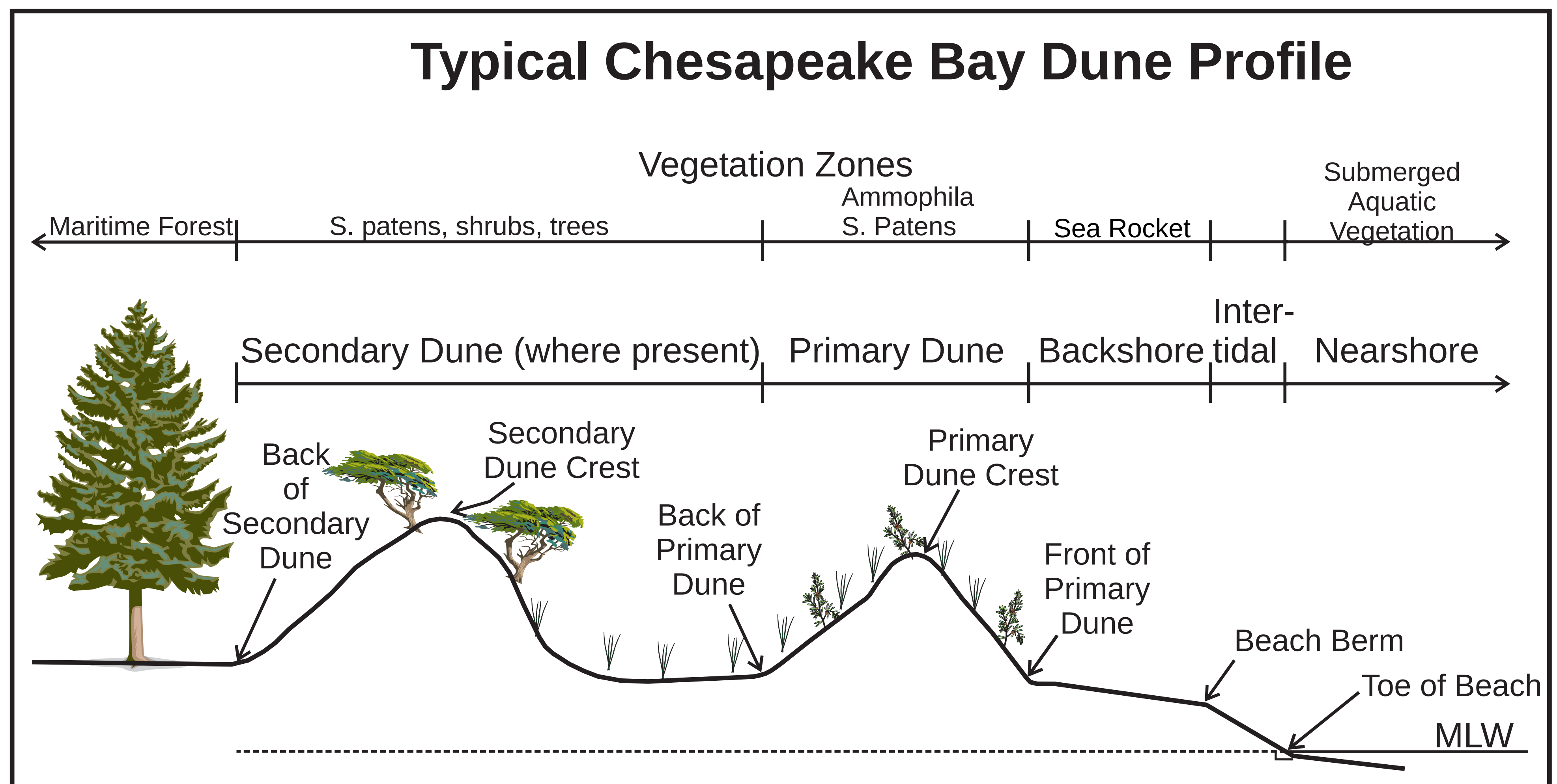


Figure 6. Typical profile of a Chesapeake Bay dune system (from Hardaway *et al.*, 2001).

## IV. RESULTS

The figures referenced in the following sections are in Appendix A. Dune locations are shown on all photo dates for reference only. Dune sites and lengths are positioned accurately on the 2002 photo. Because of changes in coastal morphology, the actual dune site might not have existed earlier. Site information tables are in Appendix B. More detailed information about Chesapeake Bay dunes and individual dune sites in Northampton County can be found in Hardaway *et al.* (2001) and Hardaway *et al.* (2004). Since much of the dune data were collected several years ago and the beach and dune systems may have changed, this report is intended as a resource for coastal zone managers and homeowners; it is not intended for use in determining legal jurisdictional limits.

### A. Reach I

Reach I begins at the southern end of the county where the Chesapeake Bay Bridge Tunnel connects to the mainland (Cape Charles) and extends northward to Old Plantation Creek. Reach I includes Plates 1, 2, 3, 4, and part of 5 and dune sites NH58, NH57, NH54, NH53, NH51, NH49, and NH48. The long-term (1938-2002) shoreline trend in Plate 1 shows recession from the south end (transects 0 to 6000), little or no change from transects 6000 to 8000, and slight recession from transects 8000 to 10500. Plate 1 includes dune sites NH58 and NH57.

Shoreline trends along Plate 2 with dune site NH53 shows continued shore recession from transects 0 to about 7000 as the shoreline adjusts to the Kiptopeke Ferry dock and offshore breakwaters at Kiptopeke State Park. Significant shoreline advance as the result of the Kiptopeke Ferry infrastructure occurs from transects 7000 to 11500. Shoreline recession picks up past transect 11500 and carries over to Plate 3 where recession "peaks" at about transect 2000 and lessens to about transect 5500. At about transect 6000 the shoreline enters an accretionary (NH51A) trend to transect 10500 near the outlet to Pond Drain.

The accretionary trend continues northward onto Plate 4 until about transect 1500 where shore recession begins. Shore recession continues across Plate 4, and "peaks" at transect 7000, which is Elliots Creek, and onto Plate 5. Plate 4 has dune sites NH51B, an extension of NH51A, and NH49 across Elliots Creek.

The general trend along the Reach I shoreline is a series of alternating retreats and advances. Construction of Kiptopeke State Park's dock and breakwaters had a rapid and profound effect on the littoral sand transport system. The larger sand fillet on the south side might indicate a net northward sand movement over time possibly due to the influence of incoming ocean swells.

### B. Reach II

Reach II (Plates 5 and 6) begins at the mouth of Old Plantation Creek which has experienced significant changes though time. Plate 5 dune sites include NH48, NH46, NH45, NH43 and part of NH42. A spit has grown from the south side and has rotated extensively landward (eastward) on the north side spit. This recessionary trend continues to about transect 2000, where the 1989 shore intermittently advances to transect 5500 and the long-term trend becomes accretion. The large advance between transects 5500 to 8500 (Plate 6) from 1938 to 1949 is the result of a large quantity of dredge material being disposed from the dredging of Cape Charles Harbor and entrance channels. This material is clearly seen on the 1949 photo of Plate 6. Subsequent shore recession occurred as the sandy material has eroded.

A long-term accretionary trend extends from transects 0 to 2000 (Plate 6). Transects 4000 to about 6000 (Plate 6) is Cape Charles public beach which had a large beach fill project for 1988 that is reflected in shore advance in 1989 with subsequent recession as the shore adjusted. General shore recession occurs from transects 6500 to about 9000 then spit growth is seen at the mouth of Kings Creek where Reach II ends and Reach III begins. Dune sites shown on Plate 6 include NH42 south of Cape Charles Harbor, NH41A&B which are man-made dunes as part of the public beach, and NH40.

### C. Reach III

Reach III is shown on Plates 7, 8, 9 and 10. The small peninsula between Kings Creek and Cherrystone Inlet appears to have had some dredge material (probably from Kings Creek dredging) placed on it some time between 1938 and 1949 thus causing a shoreline advance with subsequent erosion (Plate 7). The long spit on the north side of the mouth to Cherrystone Inlet gained its full "extension" in 1949 and has retreated and recurved eastward since. Here resides NH36 and part of NH35.

The long sandy coast shown on Plate 8 has 3 dune fields (NH33, NH34, and NH35) and has undergone a complex history of advance and retreat. Shoreline change is controlled, in large part, by the constantly shifting offshore bar system which can cause shore salients when bars weld to shore. On the northern end of the region shown on Plate 8 and on the south end of Plate 9, an erosional trend begins and continues toward the north end. The north end of NH33 exists along this coast. A noticeable nearshore slough or trough exists through time preventing any major bars from welding to the shore.

Along the coasts shown on Plate 9, significant long-term erosion has occurred; however a reduction in rate of loss begins near transect 9500. Beginning at the south end of the region shown on Plate 10, the shore becomes very stable except for erosion near the mouth of The Gulf. The shoreline from transects 0 to 5000 is known as Smith Beach and cottages can be seen along it as early as 1949. Development is mostly bay-front cottages, but many groins and bulkheads have been installed over time which force the erosion rate generally to zero. The shoreline along the Bay shore of Old Town Neck has varied through time becoming erosional toward transect 11000 where a spit into Mattawoman Creek has eroded. Three isolated dune sites, NH30, NH28 and NH27, are shown on Plate 10.

### D. Reach IV

Reach IV is shown on Plates 11, 12 and 13. Plate 11 shows the mouths of Mattawoman Hungars Creeks. The narrow peninsula across the north side of Hungars Creek had an erosional trend on its distal end, but most of it has been relatively stable because this shore lies in the protective lee of an extensive offshore bar system. No dune sites are located on this thin spit, but imagery taken in 1938 and 1949, may indicate the presence of dune vegetation.

Plate 12 displays an array of shore attached spit growths. In 1938, a shore salient can be seen at about transect 5500. By 1949, this salient had become a spit between transects 4000 and 5000 with another spit forming to the north and extending southward to transect 8500. In 1989, another distinct spit had grown from transect 8000 to about transect 4000, and we have termed this spit as "Vaucluse" Spit. The previous spits had welded to the mainland shore.

Vaucluse Spit grew 1,300 ft in length between 1989 to 2002, a rate of 100 ft/yr. Dune fields NH17, NH18A, NH18B and NH19 developed on Vaucluse Spit over time. NH17 is located at the mainland attachment of the spit. Three small isolated dune sites NH20, NH21 and NH23 occur on the mainland. The progradation of Vaucluse Spit has had the effect of protecting the adjacent mainland coast from severe storm wave attack. The mobile sand spit and nearshore sand bar systems not only influence the impinging waves and shore change but also create and alter nearshore habitat of SAV.

Shoreline recession is the overall trend along the region shown on Plate 13 with intermittent accretional salients in 1989 and an extended salient continuing until 2002 at about transect 8500. This sandy salient provided the substrate for the growth of dune site NH13. Other isolated dunes occur on either side of the spits leading into Westerhouse Creek (NH14A, NH14B, NH15 and NH16). These dune sites are erosional remnants of larger past spit features.

E. Reach V

Reach V is Occohannock Neck and is shown on Plates 14, 15, and 16. Plate 14 starts at the erosional coast on the south side of Nassawadox Creek. An erosional trend occurs on the north side of Nassawadox Creek from transect 0, peaking at transect 2000, and decreases in rate to about transect 6000 where the coast is historically stable to the north end of Plate 14. Development of the coast known as Silver Beach began with a few small cottages in 1949; Today’s Silver Beach extends from about transects 2500 to 8000. Bulkheading and groins are responsible for the stability of the coast in 1994 and 2002. Dune sites along the reach include sites NH8, NH10 and NH12.

The entire coast shown on Plate 15 had an overall recessional trend from 1949 to 1994. Shore stability from 1994 to 2002 is mostly due to extensive bulkheading along most of the reach. The northern end of Northampton County is shown in Plate 16. This coast shows intermittent recession and advance from transects 0 to 5000 and then becomes recessional into Killmon Cove. Dune sites NH4 and NH5 occur along this coast.

# V. DISCUSSION: NEAR FUTURE TRENDS OF DUNE SITES

The following discussion is a delineation of shoreline trends based on past performance. Ongoing shore development, shore stabilization and/or beach fill, and storms will have local impacts on the near term. "Near Future" is quite subjective and only implies a reasonable expectation for a given shore reach to continue on its historic course for the next 10 to 20 years. In addition, the basis for the predictions are the shorelines digitized on geo-rectified aerial photography which have an error associated with them (see Methods, Section III). This data is intended as a resource for coastal zone managers and homeowners; it is not intended for use in determining legal jurisdictional limits.

## A. Reach I

Dunes sites NH58 and NH57 are remnants of a once more continuous dune field. They will be subject to further shore recession and reduction in width and extent. Dune sites NH54 and NH53 are a direct result of the construction of the Kiptopeke Ferry and associated wharf and offshore breakwaters at Kiptopeke State Park. They have evolved almost to capacity and should at least remain stable for the near future.

Dune site NH51 (Figure 7), Plate 3, is part of a littoral sand mass that is accreting, perhaps as a result of the corresponding shore recession to the south (Plate 3) and to the north (Plate 4). Although sited on a recessional reach, dune site NH49 has been at least a spit at the mouth of Elliots Creek since 1938. Site NH48 is an isolated dune that has advanced into the mouth of Old Planation Creek and should continue that trend for the near future.

## B. Reach II

Dune sites NH45 and NH46 are erosional remnants of a more continuous beach/dune reach seen in earlier imagery. Dune sites NH43 and NH42 (Figure 8) also are erosional remnants of a more extensive beach/dune system created by the disposal of a large amount of dredge material for the deepening of Cape Charles Harbor in the mid-1940s. Conventional thinking would indicate that the addition of such a large amount of sand would enhance and provide large volumes of sand to the southern, "downdrift" shorelines, possibly even causing more infilling to Old Plantation Creek. It appears, however, that the opposite has happened. The dredge material has moved mostly offshore to form a large shoal which, in turn, may have impacted the local wave climate. The sand fill has been reduced but remains a significant headland.

Dune sites NH41 and NH40 are part of the Cape Charles Public beach in 1987 and were created with beach fill, sand fencing, and dune grass plantings. Sand losses have reduced the size of those features since the 1988 beach fill, but a recent breakwater installation has at least slowed that trend.

## C. Reach III

Dune sites NH36, NH35, NH34, and NH33 (Figure 9) are part of a long continuous beach/dune system extending from Tankards Beach to Cherrystone Inlet. The net alongshore drift is to the south as evidenced by the geomorphology of the Cherrystone Inlet spit. Dune sites NH36 and NH35 occur on the Cherrystone Inlet spit. This feature has changed dramatically over time and appears to be in the process of recurving and narrowing. A breach may occur in the future which would segment the spit leading to further reduction in dune size.

The shoreline along dune sites NH34 and NH33 has had history of advances and retreats due, in part, to the movement of the extensive offshore bar system. The eroding sand banks to the north at Tankards Beach have provided the material to the littoral system to the south. These dunes will continue to exist in a state of dynamic equilibrium given the present shore conditions. Although shoreline recession is the long-term trend, the massive, ancient, upland dune will continue to supply sand to the littoral system.

Dune site NH30 is an isolated remnant of a more extensive beach dune reach along the north end of Savage Neck. Shore protection with bulkheads and groins have reduced the size and extent of the site, but it is presently relatively stable. Dune sites NH28 and NH27 have developed on accretionary salients along Old Town Neck. Their future trend will be dictated by the behavior of the nearby offshore bar which appears to have widened and migrated landward since 1938.

## D. Reach IV

Dune sites NH23, NH21 and NH20 are isolated dunes that were once part of a more continuous beach/dune coast in 1949 which developed into more isolated salients by 1989. By 2002, NH21 and NH20 had fallen into the lee of the rapidly prograding Vaucluse Spit where they should remain stable for some time. Vaucluse Spit has had a history of growth and change and is home to NH19, NH18 and NH17 (Figure 10). The boundaries of these dunes are in constant motion as they are part of a continuous beach/dune system that is broken by intermittent washovers and peat exposures. Potential shoreline development to the north would likely reduce erosion rates locally if the shorelines are hardened, but it also may negatively impact downdrift shores by reducing sand supply.

Dune sites NH16, NH15 and NH14 reside on the spits that enter Westerhouse Creek from both the north and south. These sites were once more continuous beach/dune features but are now small and isolated, but relatively stable. Site NH13 is an interesting dune salient that was a linear feature in 1994 but since has advanced over 200 ft.

## E. Reach V

Five dune sites were identified along Reach V, Occohannonk Neck. Site NH12 developed recently (since 1994) on a spit attached to the north shore at the mouth of Nassawadox Creek. Site NH10 (Figure 11) is a long-term stable dune field just north of the Silver Beach community. Site NH8 is a remnant of a once more extensive beach/dune system. Extensive shoreline hardening with mostly bulkheads to the north since 1989 (refer to Plate 15, transects 2500 to 10500) may have impacted the adjacent beaches by reducing their width possibly by wave reflection and scour.

Site NH5 evolved on a spit and washover fan that filled an unnamed tidal creek in 1949, but presently this section of coast appears to be erosional. Site NH4 is set within a long, curvilinear embayed coast that has been relatively stable over time possibly due to the transport of material eroded from the headland at Killmon Cove downdrift.

Aerial view of
dune site NH51
and Picketts
Harbor

Looking south along
the dune crest
of NH51
18 November 2003
Post Isabel


Looking south along
the beach
face of NH51
15 July 2004

Figure 7. Photos of dune site NH51 at Pond Drain, Plates 3 and 4.


Figure 8. Photos of dune site NH33 at Tankards Beach, Plate 8.


Figure 9. Photos of dune site NH42 south of Cape Charles, Plate 6.


Figure 10. Photos of dune site NH17 at Floyds Farm, Plate 12.

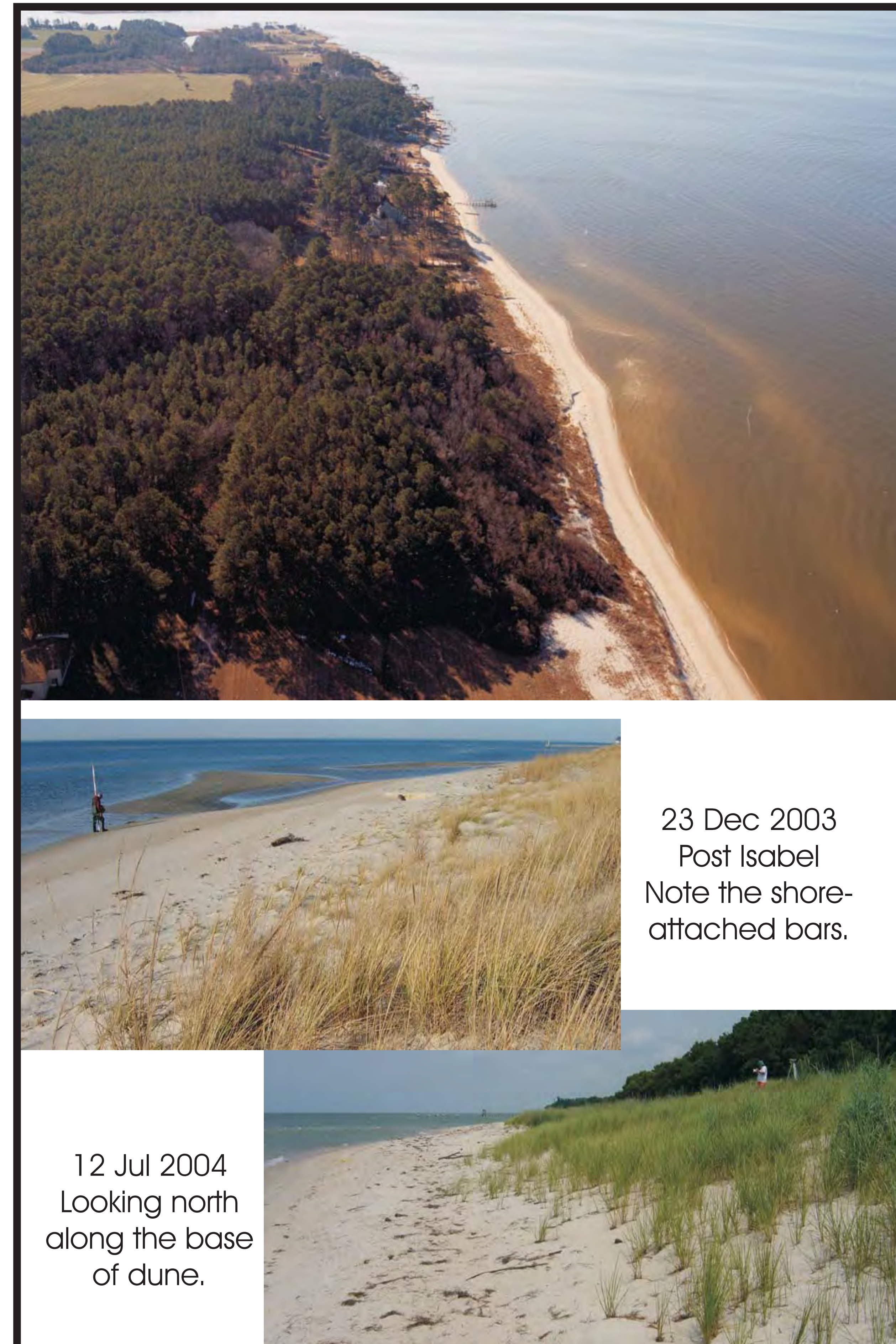


Figure 11. Photos of dune site NH10 at Silver Beach, Plate 14.

# VI. SUMMARY

The Chesapeake Bay coast of Northampton County is very dynamic in terms of shoreline change and sediment transport processes. The overall net movement of sands along the coast is to the south except from the southern end of the Delmarva Peninsula at Cape Charles to about Old Plantation Creek where oceanic swell tends to cause a north-trending net transport. The Northampton County coast is rich in sand along the shoreline and nearshore due to high shoreline recession rates of sandy upland banks. The complex series of offshore sand bars migrate through time and influence the rate and patterns of shoreline change. Shoreline change can be accretionary which leads to the development of extensive modern dune fields.

Shoreline change rates are based on aerial imagery taken at a particular point in time. We have attempted to portray the same shoreline feature for each date along the coast of Northampton County. Every 500 feet along each baseline on each plate the rate of change was calculated. The mean or average rate for each plate is shown in Table 2 for five time periods with the long-term rate determined between 1938 and 2002. The total average and standard deviation (Std Dev) for the entire data set of individual rates is also given. The standard deviation shows the relative spread of values about the mean or average. Larger standard deviation values relative to the mean indicates a wider scatter of erosion rates about the mean while lower standard deviation values indicates erosion rates are concentrated near the mean (*i.e.* all the rates calculated for the entire plate were similar). For instance, on Plate 5 between 1938 and 1949, the standard deviation is more than double the average rate of change indicating that the overall rate is probably not indicative of the change on this section of shore. Indeed, the shoreline has been influenced by the placement of dredge material which has created large variations in shoreline position on the northern end of the baseline. Conversely, on Plate 11 between 1994 and 2002, the shoreline change was minimal (0.4 ft/yr) and the standard deviation was equally small (0.6 ft/yr) indicating that the spit north of Hungars Creek has been relatively stable during that time frame.

The largest erosion rates appear to have been in the time period 1989-1994. Some of the highest recession rates measured were -19.2 ft/yr, -16.0 ft/yr and -12.2 ft/yr in Plates 5, 13 and 15, respectively. This is reflected in the county average for that period with the highest recession rate of all the time periods, -7.1 ft/yr. Conversely, shore accretion or advance was most significant during the 1938-1949 time period with accretion rates of 14.7 ft/yr, 11.3 ft/yr. and 10.4 ft/yr for Plates 6, 5 and 12, respectively. Once again this is reflected in the county average for that time period being the only period of shore advance measured, 1.7 ft/yr. Overall, this indicates that what were extensive beach/dune shorelines in 1938 are now segmented by areas of recession and infrastructure on the upland coast.

These short term trends reflect wind and weather patterns that impacted the coast during those time periods. The long-term average may be a better measure for planning, but the short-term values indicate what can potentially happen. The long-term trend for Northampton County's bay shore, Plates 1 to 14 is about -1.0 ft/yr. No data existed for Plates 15 and 16 in 1938 so the long-term rate is calculated between 1949 and 2002. When these numbers are included in the long-term analysis, the rate becomes -3.0 ft/yr, overall.

However, rate data is complex; specific sites may not be representative of these average results. The abundance of sand shifting through the littoral system helps modify the county-wide, long-term erosional trend creating accretionary zones such as on Plates 2, 3, 6, and 12. The overall average rate for Plates 6 and 12 is positive, but the most recent rates depict erosional shores. Both of these Plates have special considerations that have influenced the rates. Plate 6 has been man-influenced by placement of sand on the shore from dredging of Cape Charles Harbor. Plate 12 reflects the growth and movement of shore attached spits through time. For specific sites, measuring the change in the shore position on the scaled maps in Appendix A and dividing by the number of intervening years will provide a rate of change at the shore location.

Developed shoreline areas are increasing in size and scope. Hopefully, the depiction of historic shorelines through aerial imagery and the delineation of shore change patterns in this report will indicate how the coast will evolve. These data can then be used to provide the basis for proper shoreline management plans and strategies. Dunes and beaches are a valuable resource that should be either maintained, enhanced, or created in order to abate shoreline erosion.

Table 2. Summary shoreline rates of change and their standard deviation.

| Plate No. | Mean Shore Change | | Mean Shore Change | | Mean Shore Change | | Mean Shore Change | | Mean Shore Change | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1938-1949 (ft/yr) | Std Dev (ft/yr) | 1949-1989 (ft/yr) | Std Dev (ft/yr) | 1989-1994 (ft/yr) | Std Dev (ft/yr) | 1994-2002 (ft/yr) | Std Dev (ft/yr) | 1938-2002 (ft/yr) | Std Dev (ft/yr) |
| **Plate 1** | 1.4 | 2.2 | | | | | 2.2 | 3.4 | -0.8 | 0.7 |
| **Plate 2** | 1.8 | 1.8 | | | | | 4.0 | 3.7 | 1.7 | 5.7 |
| **Plate 3** | -6.8 | 12.0 | -0.2 | 3.0 | -8.9 | 12.3 | 1.0 | 9.4 | 1.8 | 6.3 |
| **Plate 4** | | | | | -7.6 | 6.9 | -0.8 | 6.3 | -3.1 | 3.2 |
| **Plate 5** | 11.3 | 23.7 | 0.1 | 3.6 | -19.2 | 17.7 | -2.9 | 5.8 | -0.3 | 6.0 |
| **Plate 6** | 14.7 | 37.7 | -0.6 | 4.7 | -5.2 | 11.5 | -1.3 | 5.8 | 1.6 | 4.6 |
| **Plate 7** | 8.0 | 15.3 | 1.2 | 1.3 | -8.6 | 11.7 | -11.3 | 9.9 | -0.4 | 1.2 |
| **Plate 8** | -1.4 | 9.0 | -2.9 | 1.9 | 6.3 | 6.0 | -2.9 | 7.5 | -1.9 | 1.7 |
| **Plate 9** | -13.0 | 4.1 | -3.6 | 1.7 | -3.4 | 7.6 | -3.1 | 5.8 | -5.1 | 1.7 |
| **Plate 10** | -2.2 | 2.5 | 0.8 | 1.7 | -7.1 | 15.0 | 1.3 | 4.2 | -0.3 | 1.0 |
| **Plate 11** | -1.0 | 4.2 | 0.1 | 0.6 | -2.9 | 3.3 | 0.4 | 0.6 | -0.2 | 0.9 |
| **Plate 12** | 10.4 | 12.9 | 1.4 | 6.9 | -1.4 | 29.3 | -0.6 | 22.2 | 2.5 | 3.9 |
| **Plate 13** | -2.3 | 9.4 | -2.2 | 3.3 | -16.0 | 12.5 | -3.6 | 14.5 | -3.5 | 4.0 |
| **Plate 14** | -3.4 | 2.6 | -0.9 | 1.3 | -6.2 | 5.1 | -1.1 | 3.3 | -2.2 | 1.3 |
| **Plate 15** | | | -2.5 | 1.4 | -12.2 | 13.3 | -3.2 | 4.0 | -3.5* | 1.7 |
| **Plate 16** | | | -0.6 | 3.5 | -8.7 | 10.6 | -3.9 | 2.7 | -2.0* | 3.0 |
| **Total^** | **1.7** | **17.1** | **-1.0** | **3.5** | **-7.1** | **14.8** | **-1.1** | **9.1** | **-1.0** | **4.3** |

*1949-2002 imagery data used for long-term shore change rate.
^Entire data set for each imagery period used to determine average county shore change rate and standard deviation.

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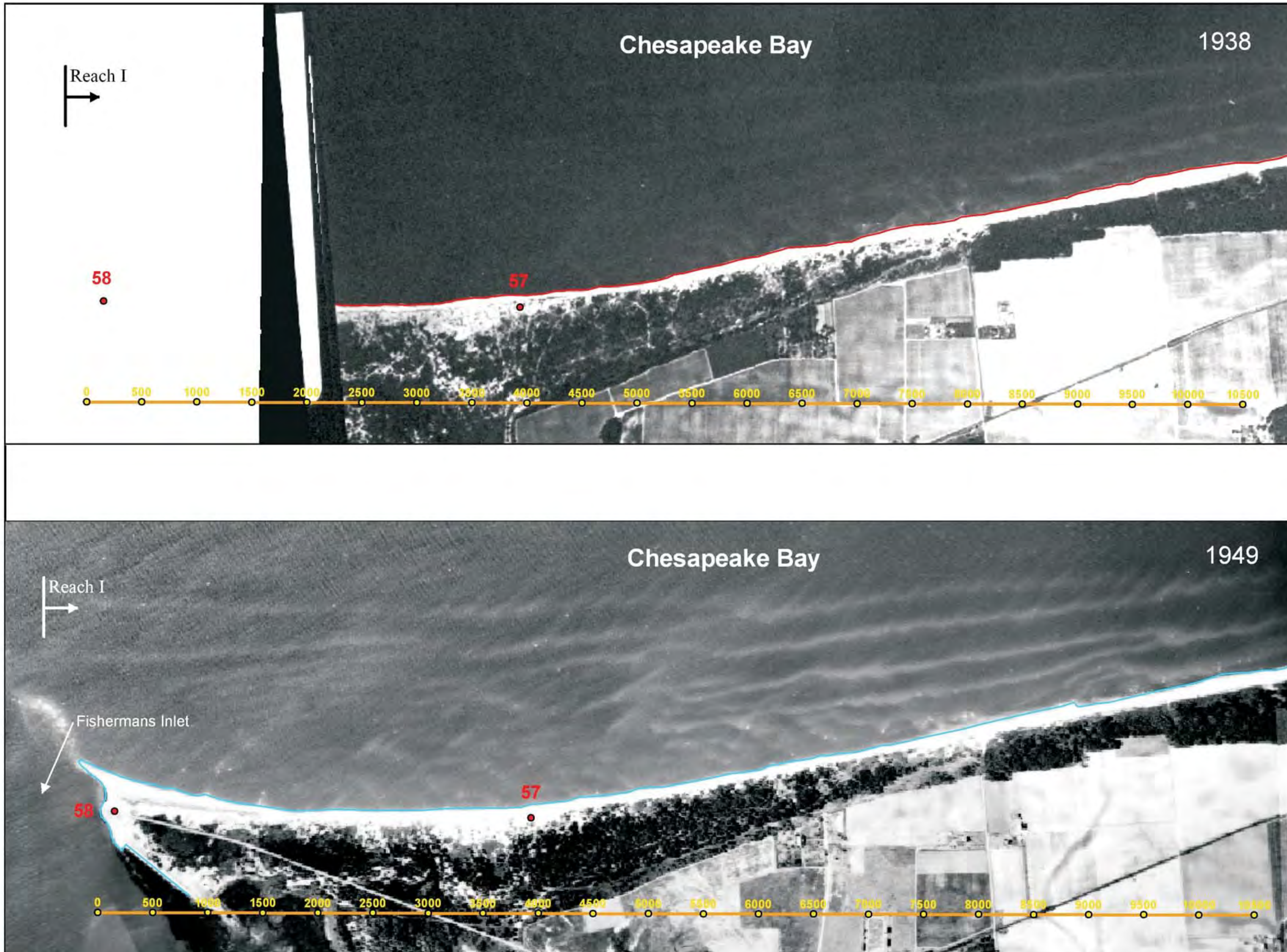
# APPENDIX A

For each Plate shown on Figure 4 (Page 5), Appendix A contains geo-rectified aerial photography flown in 1938, 1949, 1989, 1994, and 2002. Also shown are the digitized shorelines, identified dune sites, and an arbitrarily created baseline. Another copy of the recent photo depicts the relationship of historical shorelines to the present. Finally, a plot shows only the relative locations of the shorelines while another one depicts the rate of shore change between dates. A summary of the average Plate rate of change in ft/yr as well as the standard deviation for each rate is also shown.

**This data is intended as a resource for coastal zone managers and homeowners; it is not intended for use in determining legal jurisdictional limits.**




# Northampton County

## Plate 1

Morphologic Reach I
Southern End

**Legend**

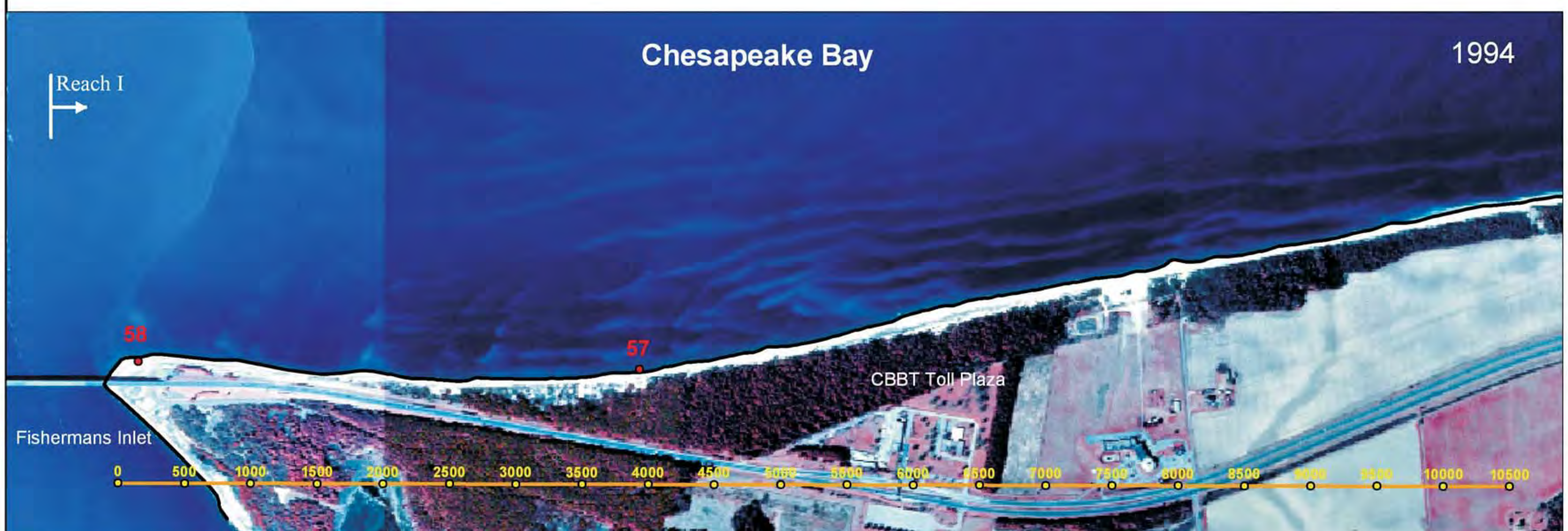
- Identified Dune Sites
- Transect Points
- Baseline
- 1949 Shoreline
- 1938 Shoreline

Shoreline Studies Program
VIMS

1,000 0 1,000 Feet

1989

**No Data Available**




# Northampton County

## Plate 1

Morphologic Reach I
Southern End

**Legend**

- Identified Dune Sites
- Transect Points
- Baseline
- 1994 Shoreline
- 1989 Shoreline

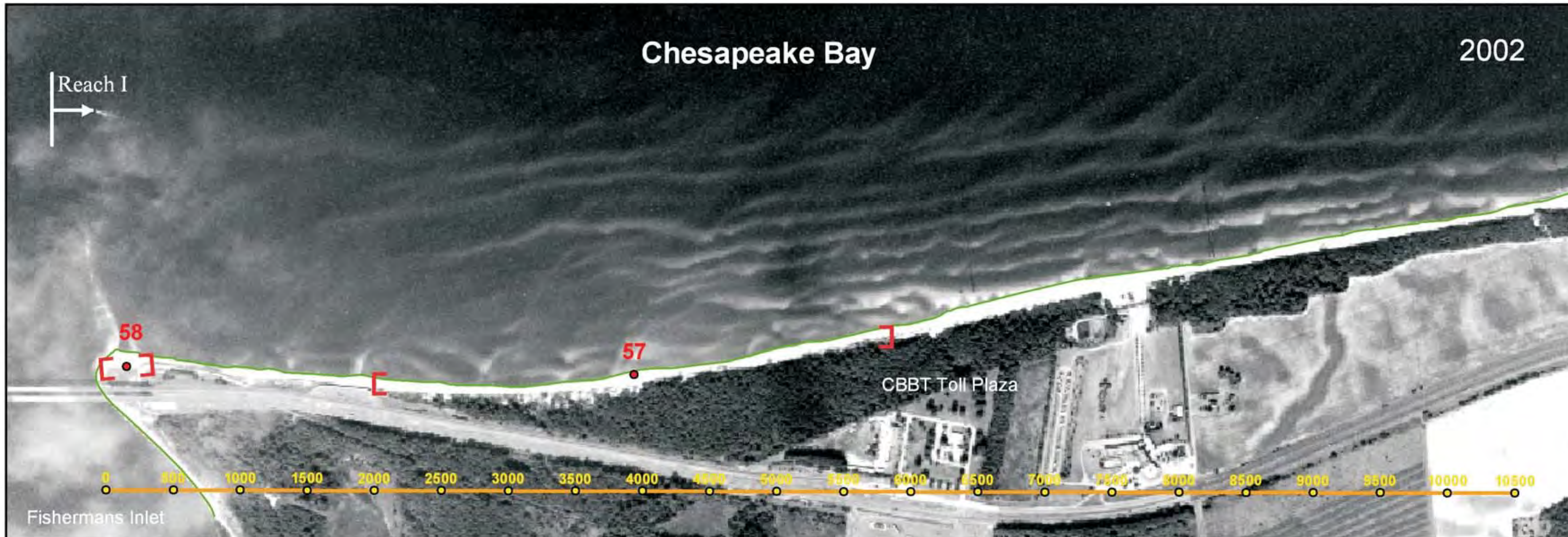
Shoreline Studies Program
VIMS

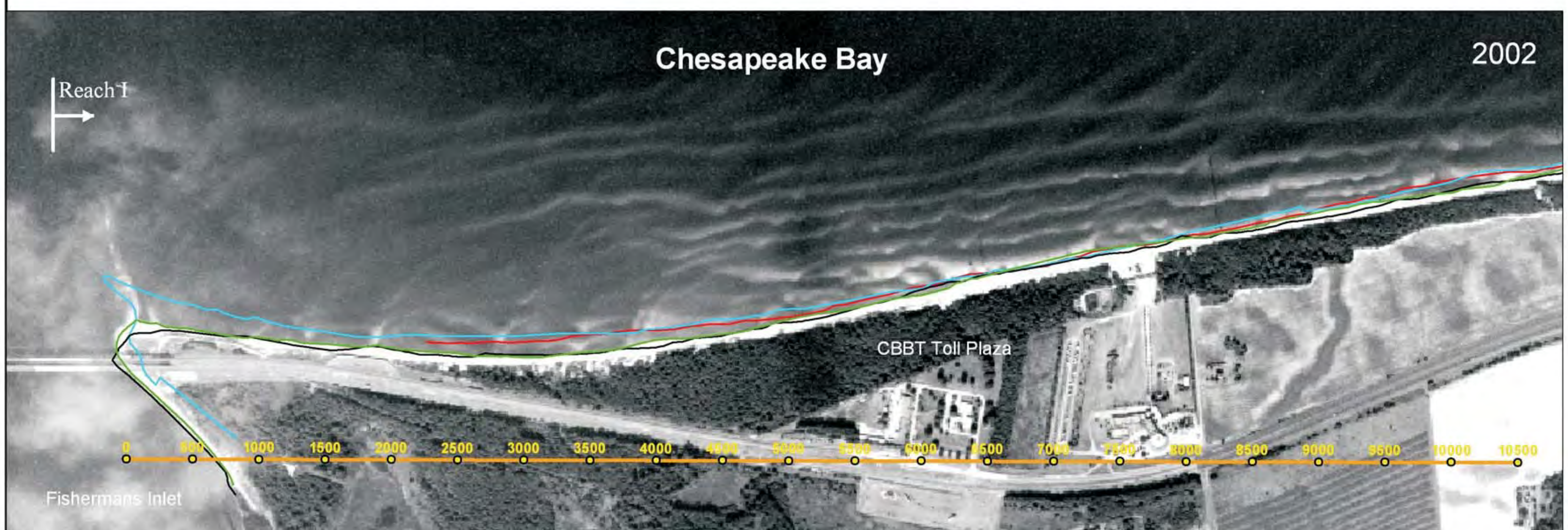
1,000 0 1,000 Feet

# Northampton County

## Plate 1

Morphologic Reach I
Southern End




**Legend**

- Identified Dune Sites
- Transect Points
- Dune Site Limits
- Baseline
- 2002 Shoreline
- 1994 Shoreline
- 1989 Shoreline
- 1949 Shoreline
- 1938 Shoreline

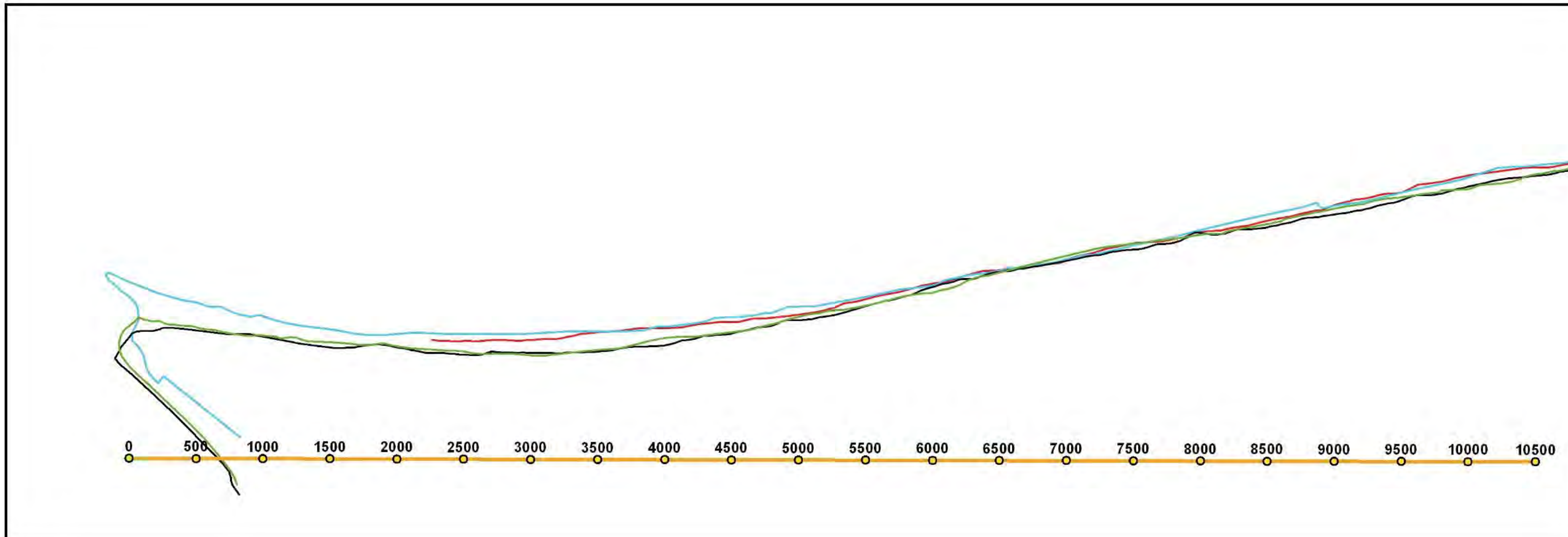
VIMS Shoreline Studies Program

1,000 0 1,000 Feet

# Northampton County

## Plate 1

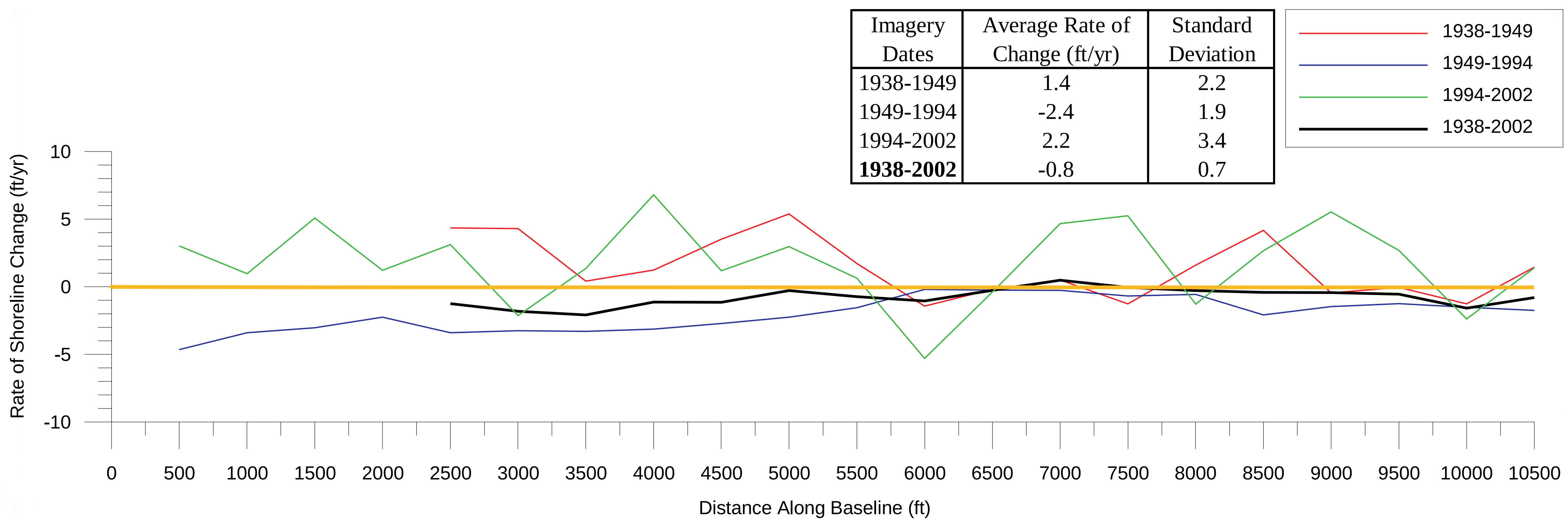
Morphologic Reach I
Southern End




**Legend**

- Transect Points
- Baseline
- 2002 Shoreline
- 1994 Shoreline
- 1989 Shoreline
- 1949 Shoreline
- 1938 Shoreline

| Imagery Dates | Average Rate of Change (ft/yr) | Standard Deviation |
|---|---|---|
| 1938-1949 | 1.4 | 2.2 |
| 1949-1994 | -2.4 | 1.9 |
| 1994-2002 | 2.2 | 3.4 |
| **1938-2002** | -0.8 | 0.7 |




VIMS Shoreline Studies Program

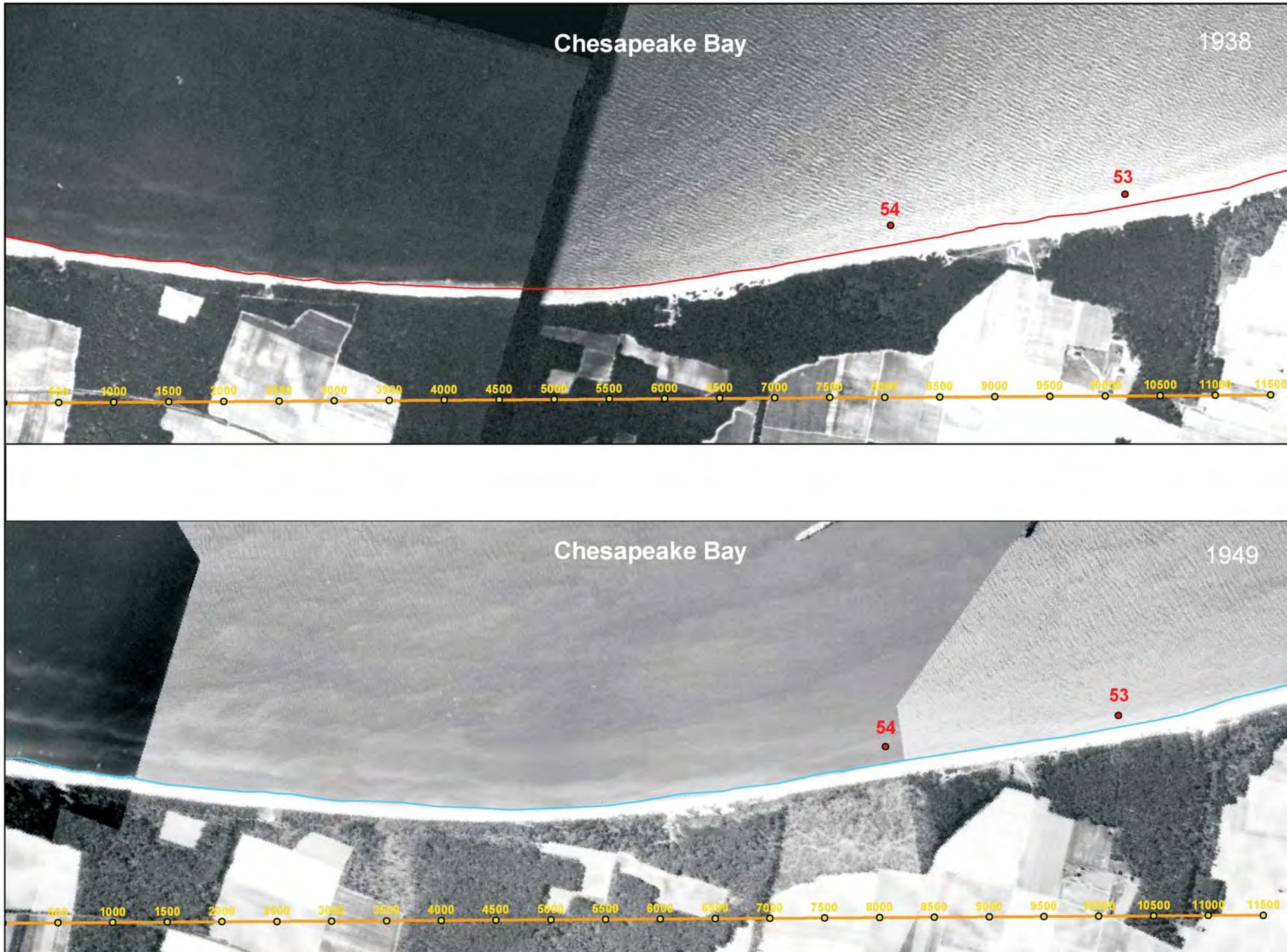
N

1,000 0 1,000 Feet

# Northampton County

## Plate 2

Morphologic Reach I
Southern End

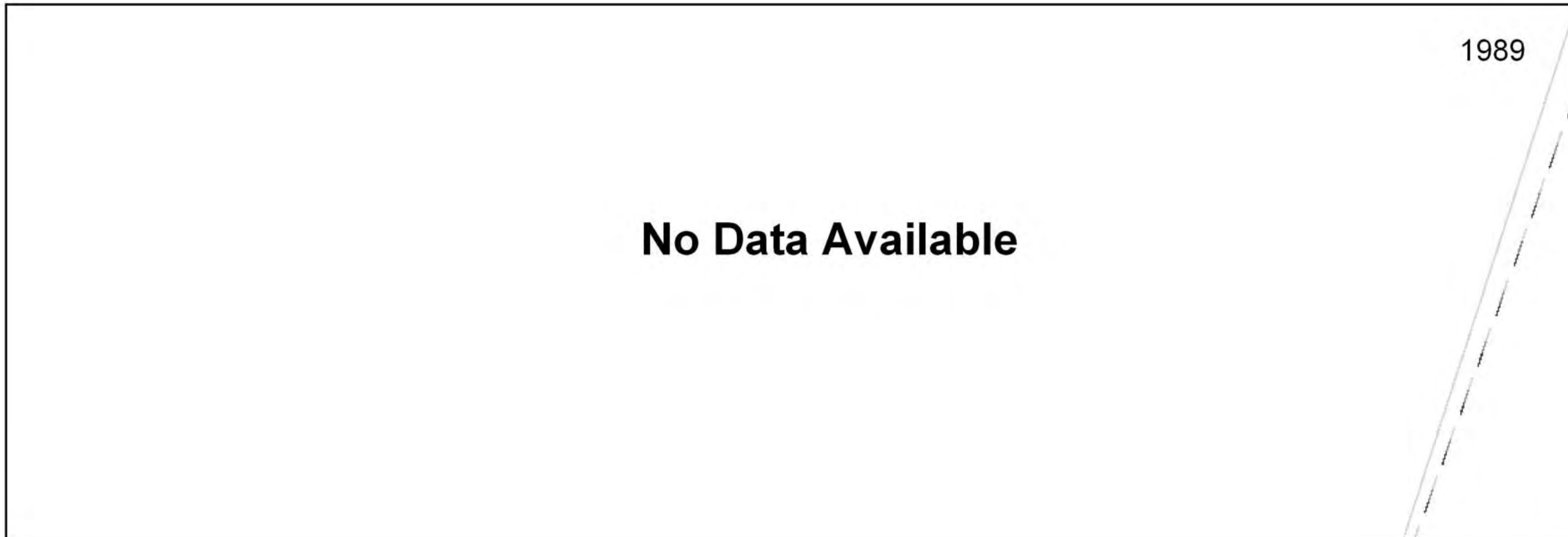


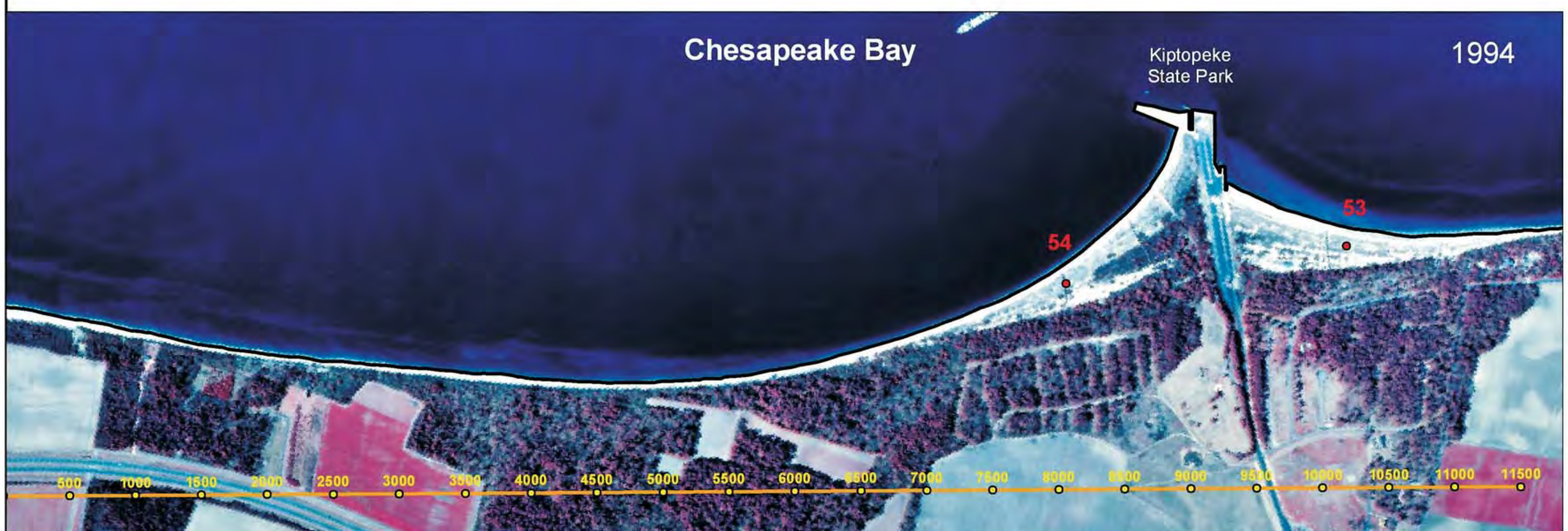

**Legend**

- Identified Dune Sites
- Transect Points
- Baseline
- 1949 Shoreline
- 1938 Shoreline

Shoreline Studies Program
VIMS

1,000 0 1,000 Feet




# Northampton County

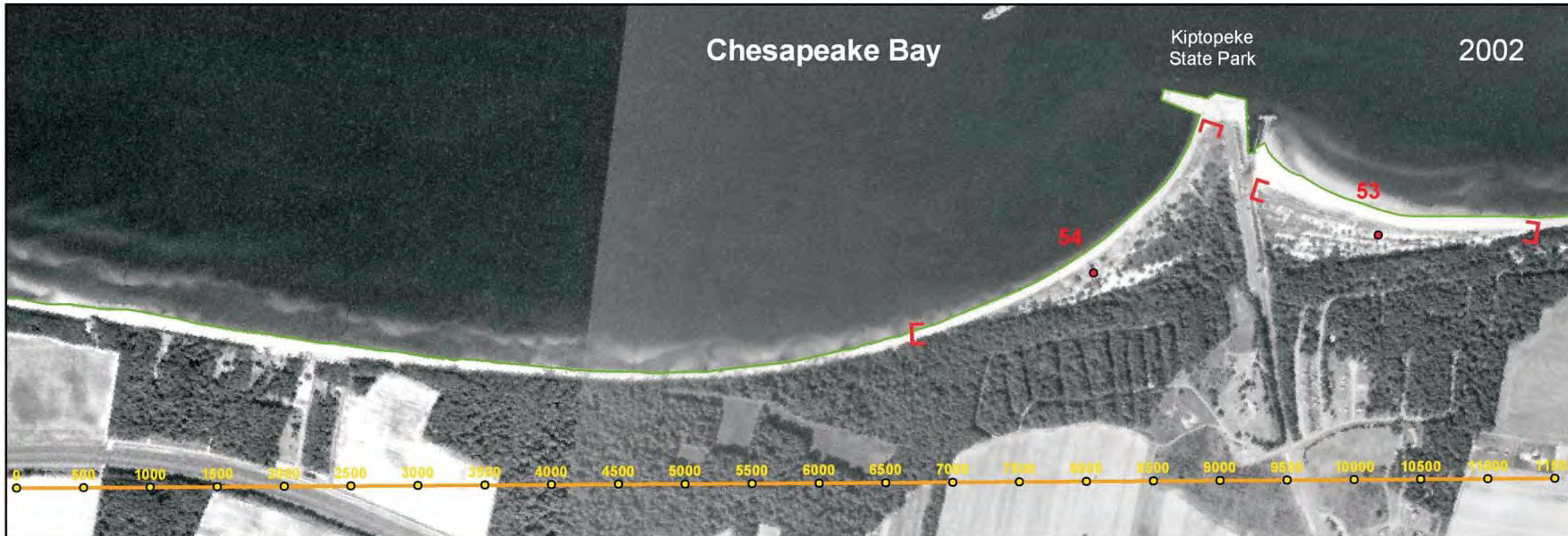
## Plate 2

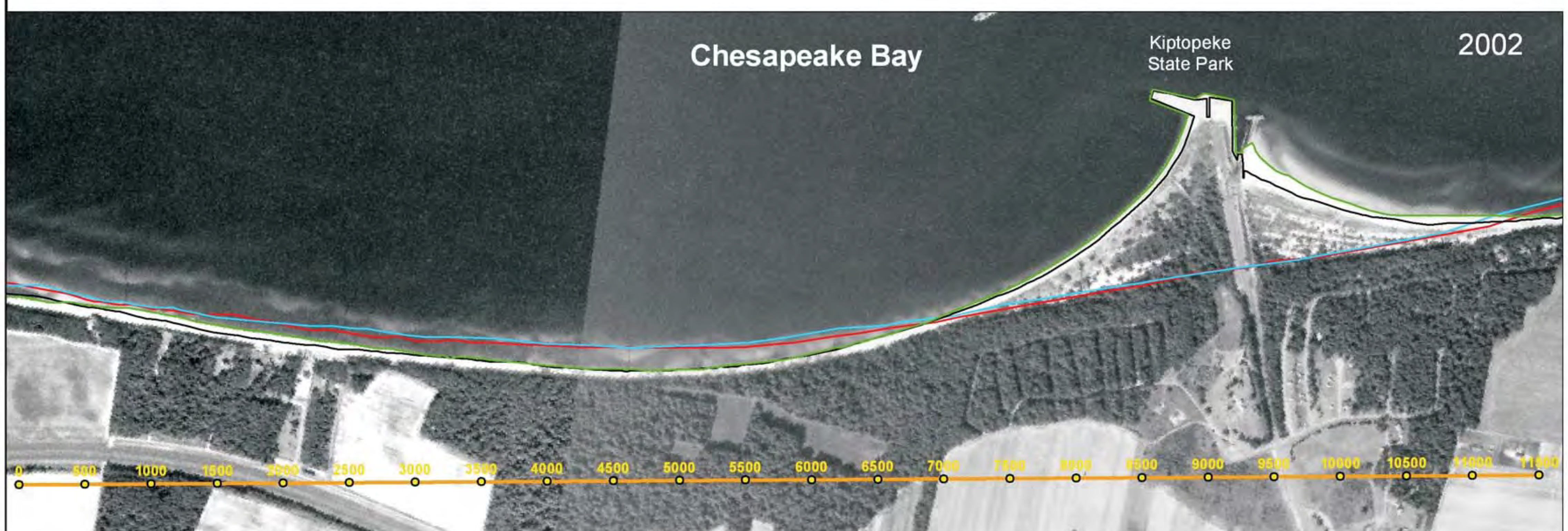
Morphologic Reach I
Southern End

**Legend**

- Identified Dune Sites
- Transect Points
- Baseline
- 1994 Shoreline
- 1989 Shoreline

1,000 0 1,000 Feet




# Northampton County

## Plate 2

Morphologic Reach I
Southern End

**Legend**

- Identified Dune Sites
- Transect Points
- Dune Site Limits
- Baseline
- 2002 Shoreline
- 1994 Shoreline
- 1989 Shoreline
- 1949 Shoreline
- 1938 Shoreline

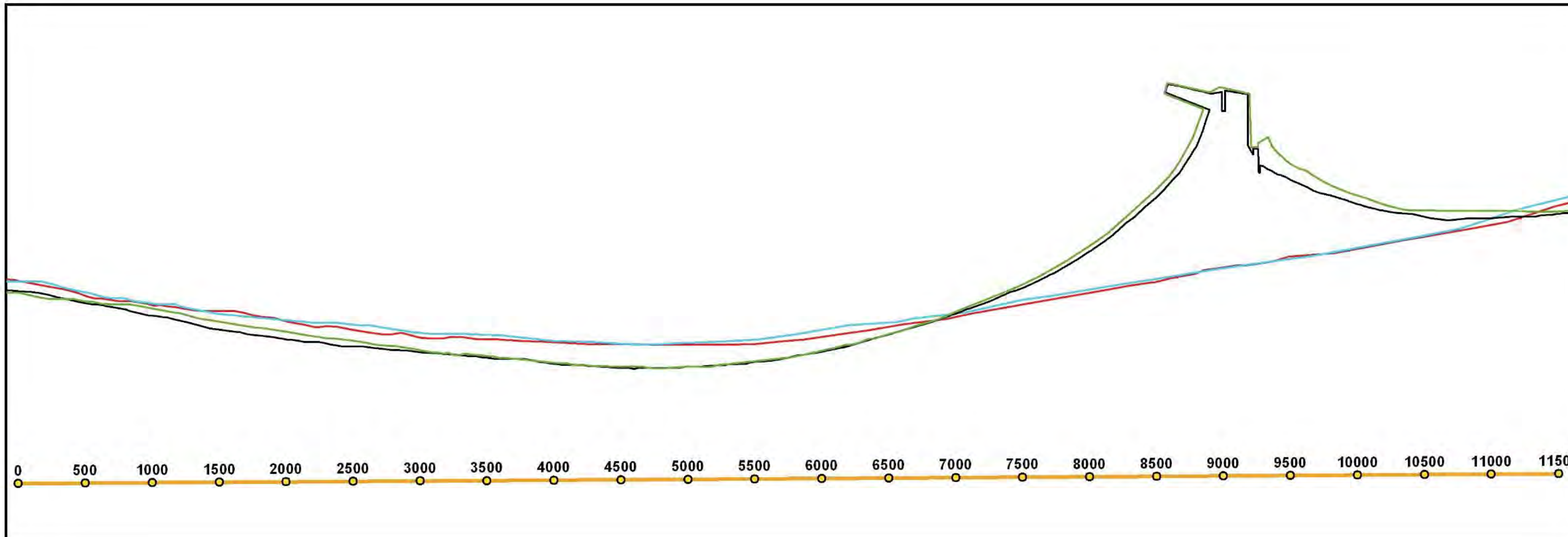
VIMS Shoreline Studies Program

1,000 0 1,000 Feet

# Northampton County

## Plate 2

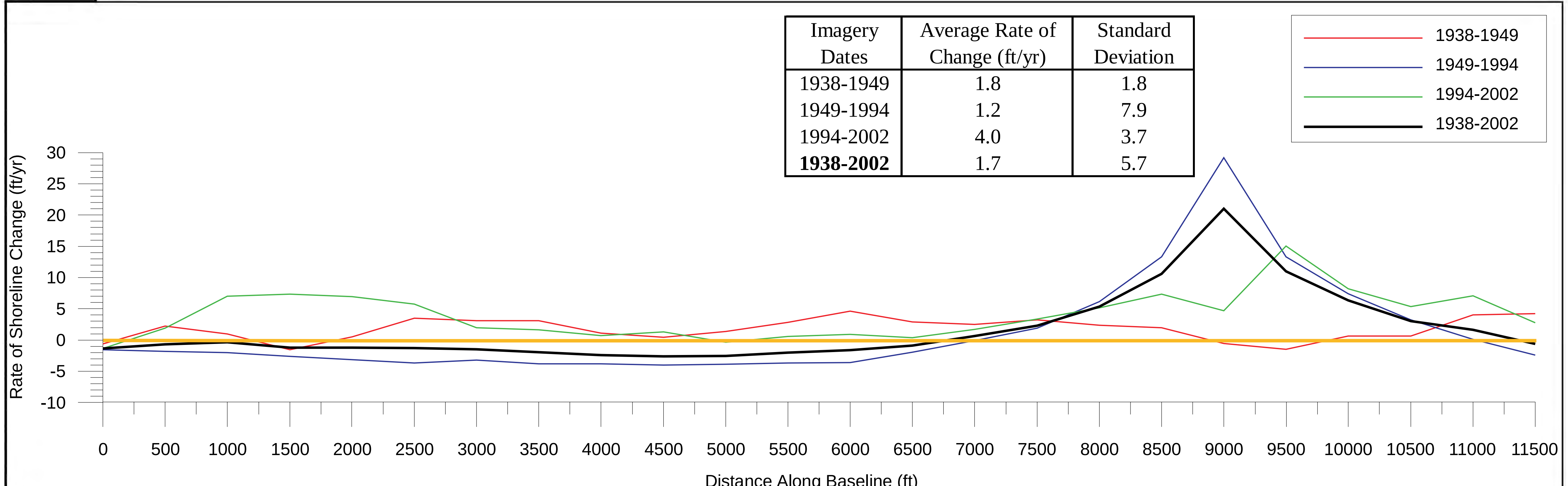
Morphologic Reach I
Southern End



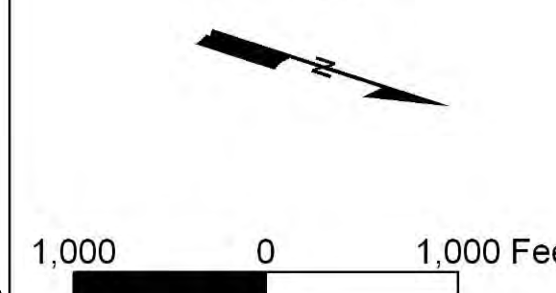

**Legend**

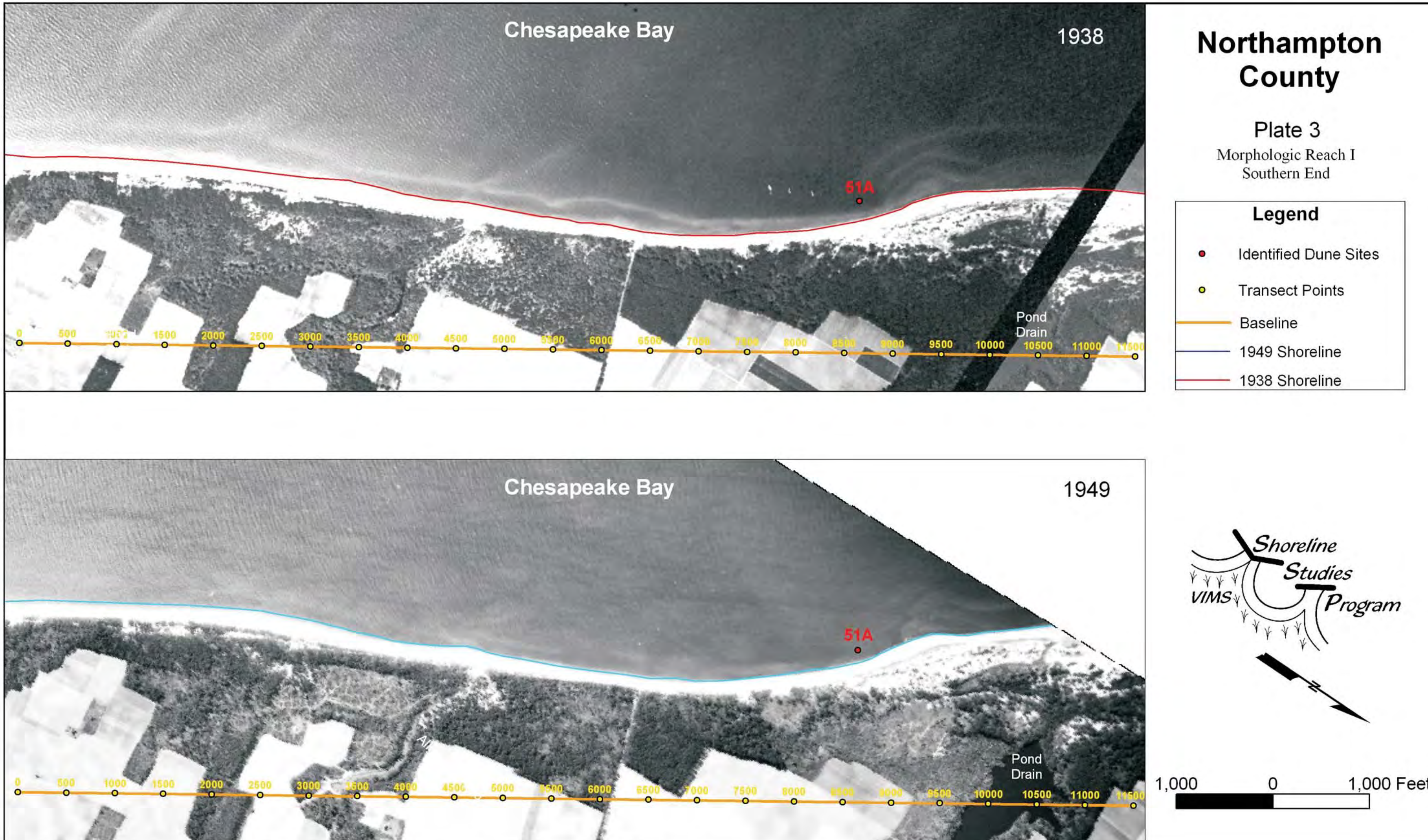
- Transect Points
- Baseline
- 2002 Shoreline
- 1994 Shoreline
- 1989 Shoreline
- 1949 Shoreline
- 1938 Shoreline

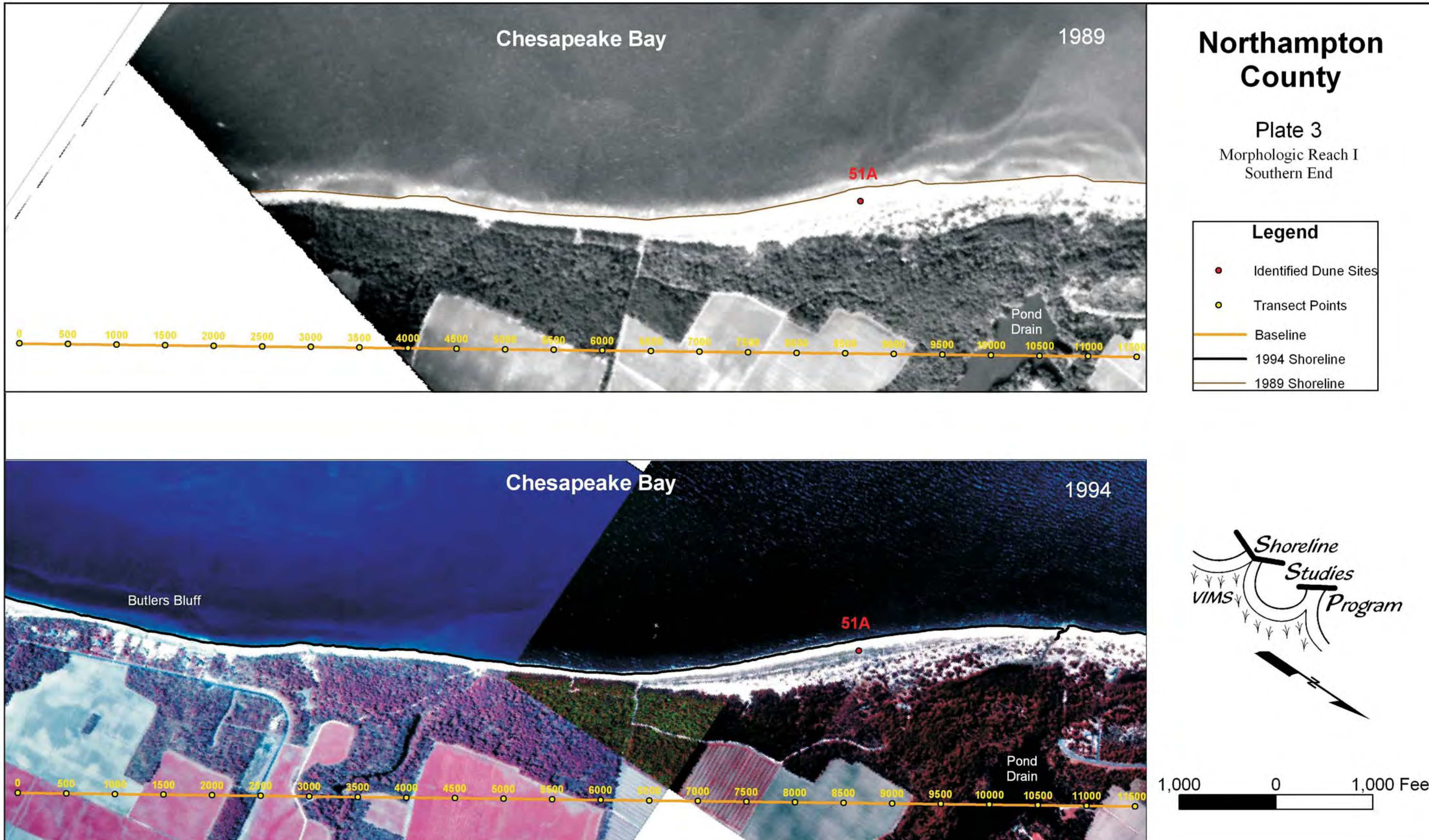
| Imagery Dates | Average Rate of Change (ft/yr) | Standard Deviation |
|---|---|---|
| 1938-1949 | 1.8 | 1.8 |
| 1949-1994 | 1.2 | 7.9 |
| 1994-2002 | 4.0 | 3.7 |
| **1938-2002** | 1.7 | 5.7 |




Shoreline Studies Program
VIMS



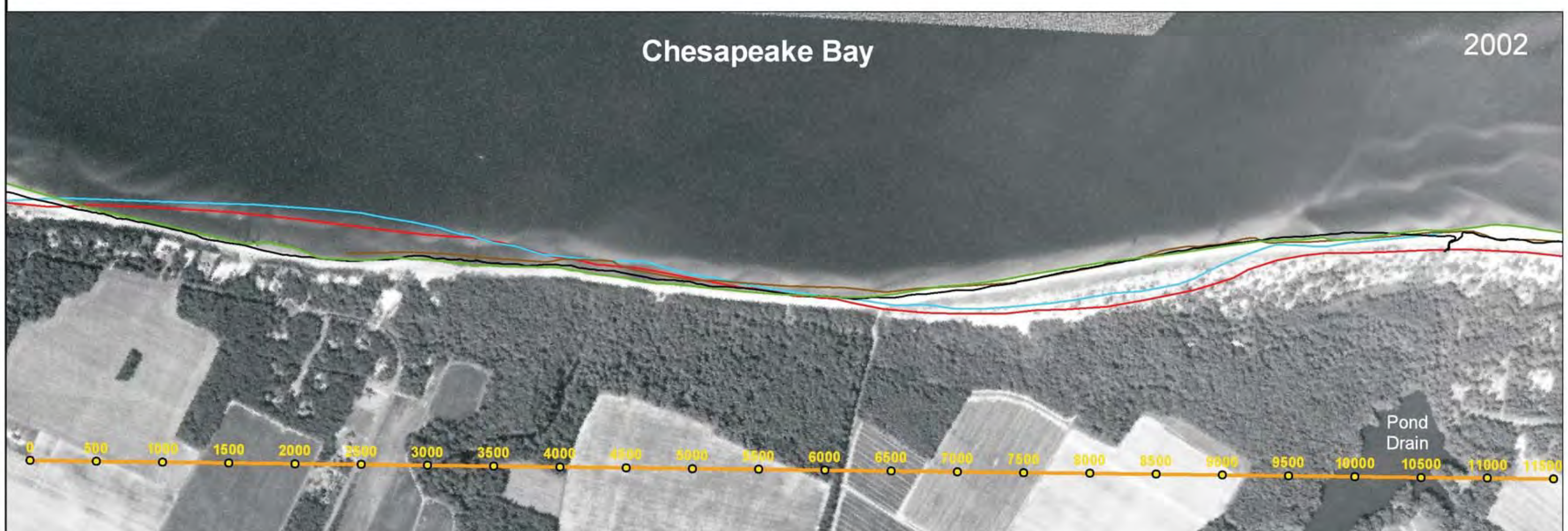

Northampton County
Plate 3
Morphologic Reach I
Southern End
Legend
Identified Dune Sites
Transect Points
Baseline
1949 Shoreline
1938 Shoreline
Chesapeake Bay
1938
51A
Pond
Drain
Chesapeake Bay
1949
51A
Pond
Drain
Shoreline
Studies
Program
VIMS
1,000
0
1,000 Feet


Chesapeake Bay
1989
51A
Pond
Drain
0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000 5500 6000 6500 7000 7500 8000 8500 9000 9500 10000 10500 11000 11500
Chesapeake Bay
1994
Butlers Bluff
51A
Pond
Drain
0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000 5500 6000 6500 7000 7500 8000 8500 9000 9500 10000 10500 11000 11500
Northampton County
Plate 3
Morphologic Reach I
Southern End
Legend
Identified Dune Sites
Transect Points
Baseline
1994 Shoreline
1989 Shoreline
Shoreline Studies Program
VIMS
N
1,000 0 1,000 Feet

# Northampton County

## Plate 3

Morphologic Reach I
Southern End


**Legend**

- Identified Dune Sites
- Transect Points
- Dune Site Limits
- Baseline
- 2002 Shoreline
- 1994 Shoreline
- 1989 Shoreline
- 1949 Shoreline
- 1938 Shoreline

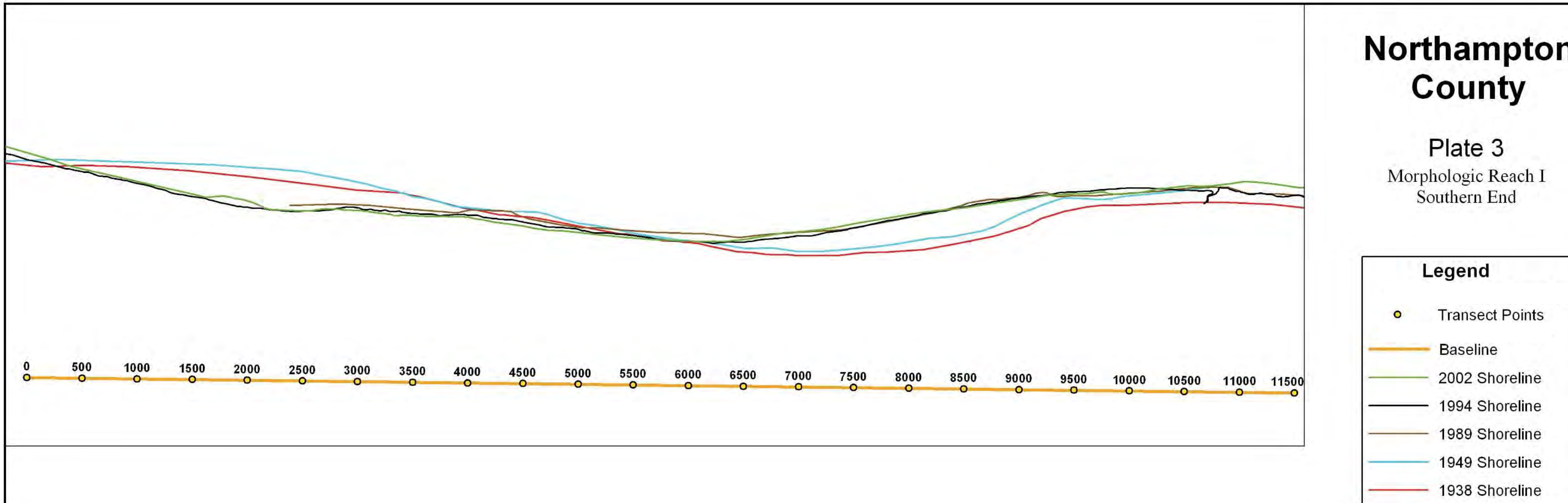
Shoreline Studies Program VIMS

1,000 0 1,000 Feet

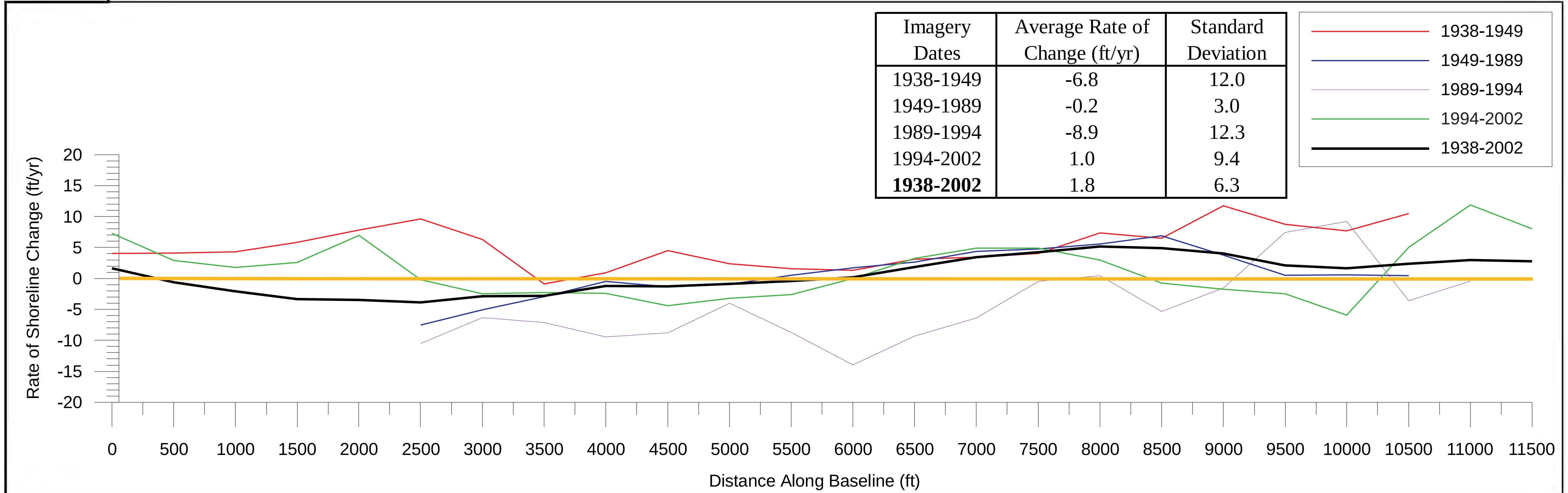
# Northampton County

## Plate 3

Morphologic Reach I
Southern End

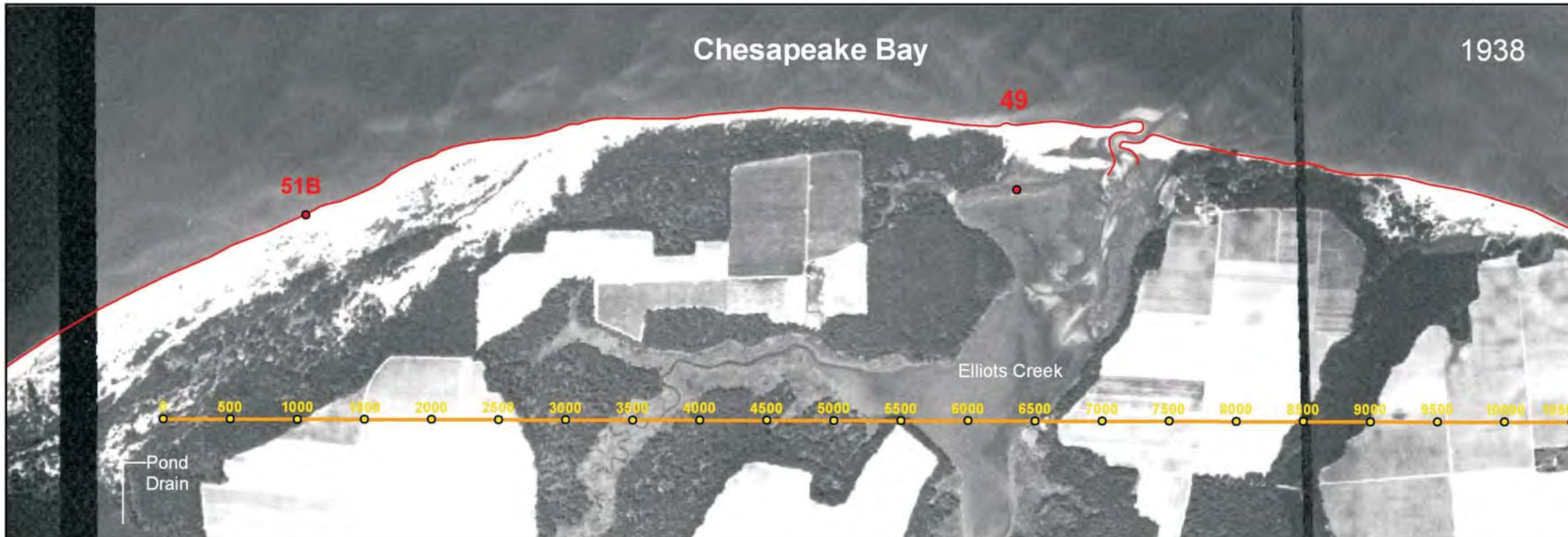



| Imagery Dates | Average Rate of Change (ft/yr) | Standard Deviation |
|---|---|---|
| 1938-1949 | -6.8 | 12.0 |
| 1949-1989 | -0.2 | 3.0 |
| 1989-1994 | -8.9 | 12.3 |
| 1994-2002 | 1.0 | 9.4 |
| **1938-2002** | 1.8 | 6.3 |




Shoreline Studies Program
VIMS

1,000 0 1,000 Feet




# Northampton County

## Plate 4

Morphologic Reach I
Southern End

**Legend**

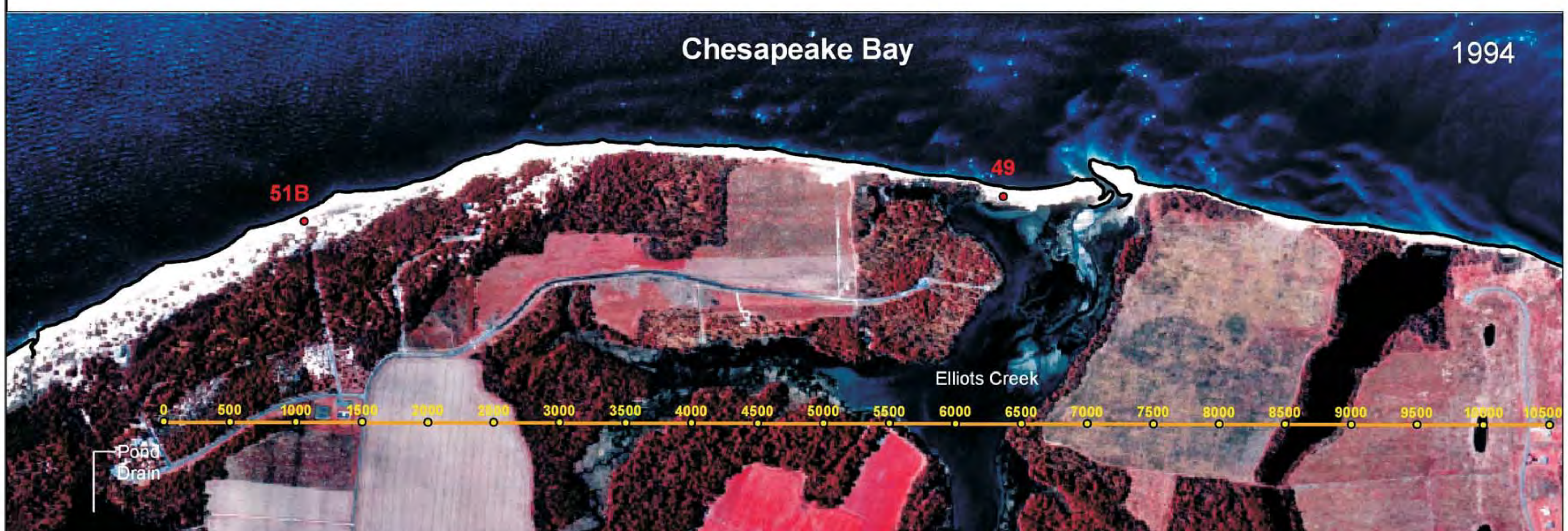
- Identified Dune Sites
- Transect Points
- Baseline
- 1949 Shoreline
- 1938 Shoreline

1949

**No Data Available**

Shoreline Studies Program
VIMS

1,000 0 1,000 Feet


# Northampton County

## Plate 4

Morphologic Reach I

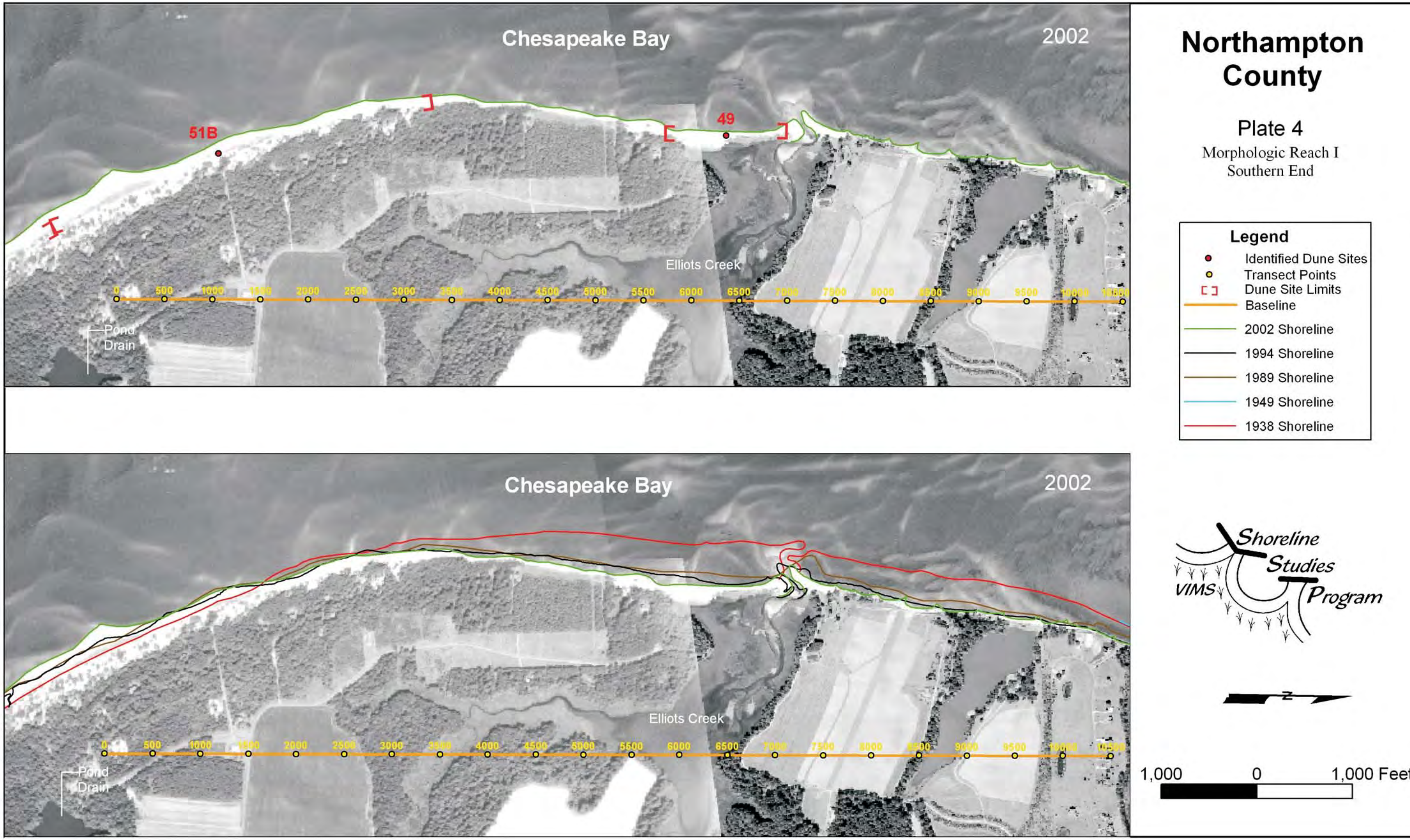
**Legend**

- Identified Dune Sites
- Transect Points
- Baseline
- 1994 Shoreline
- 1989 Shoreline

VIMS Shoreline Studies Program

N

1,000 0 1,000 Feet

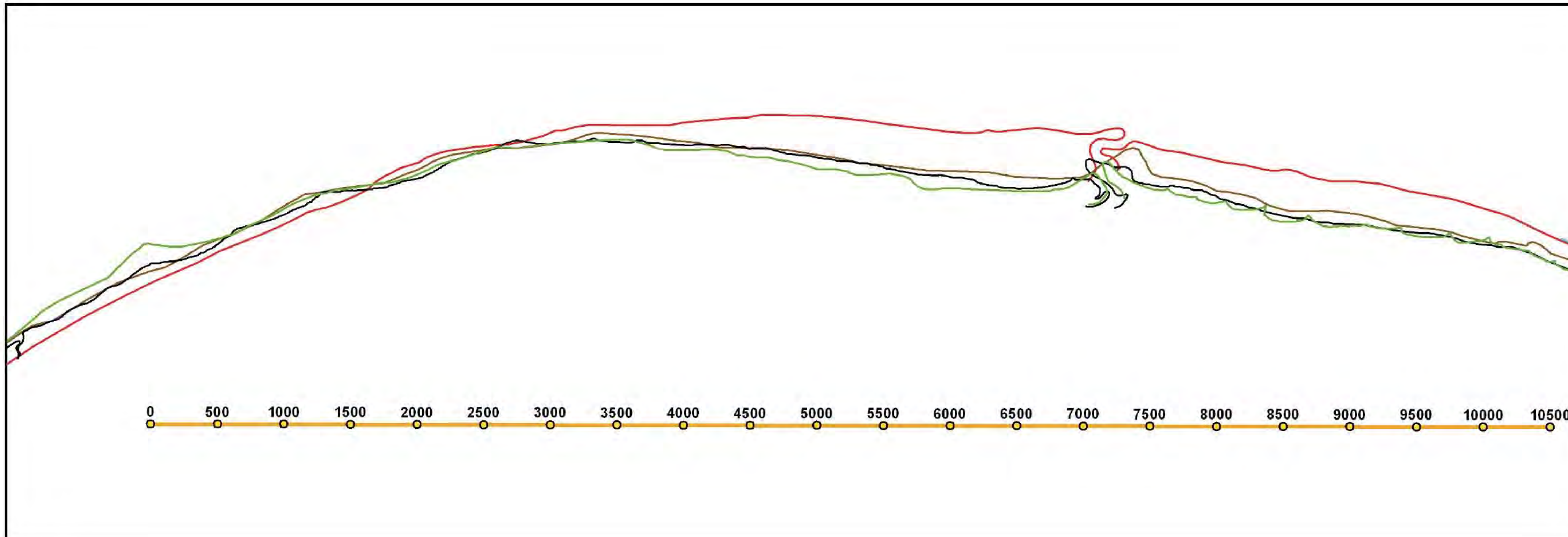


Chesapeake Bay
2002
51B
49
Elliots Creek
Pond Drain
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
7500
8000
8500
9000
9500
10000
10500
Northampton County
Plate 4
Morphologic Reach I
Southern End
Legend
Identified Dune Sites
Transect Points
Dune Site Limits
Baseline
2002 Shoreline
1994 Shoreline
1989 Shoreline
1949 Shoreline
1938 Shoreline
Shoreline Studies Program
VIMS
N
1,000
0
1,000 Feet

# Northampton County

## Plate 4

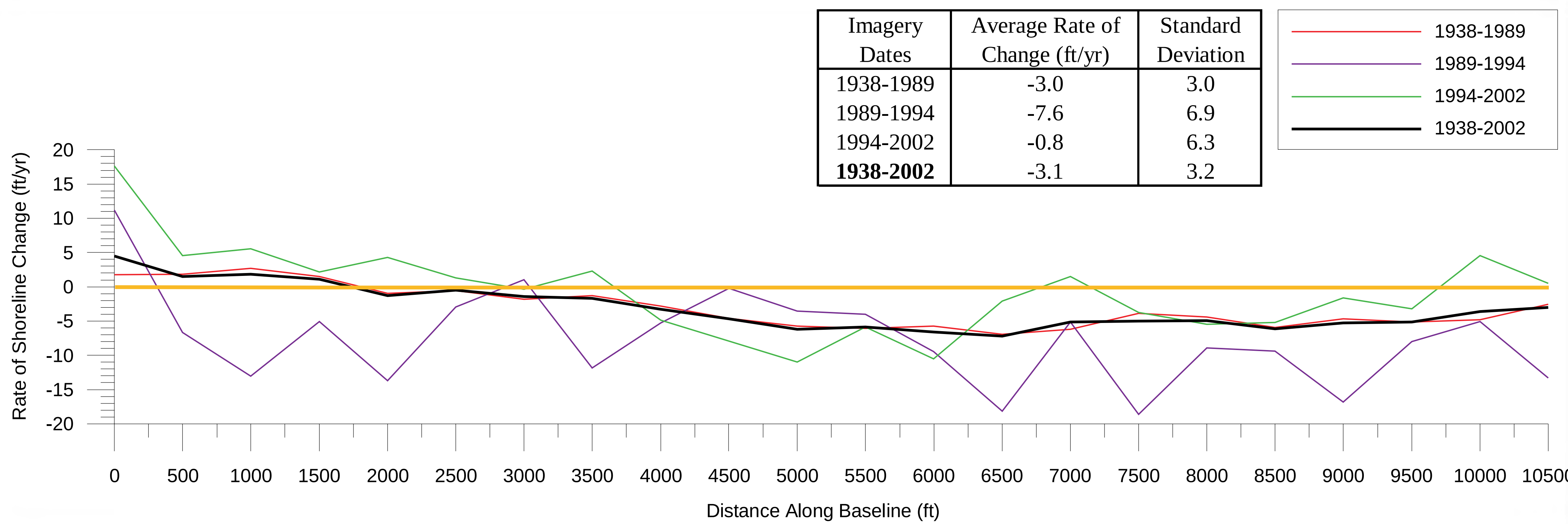
Morphologic Reach I
Southern End




**Legend**

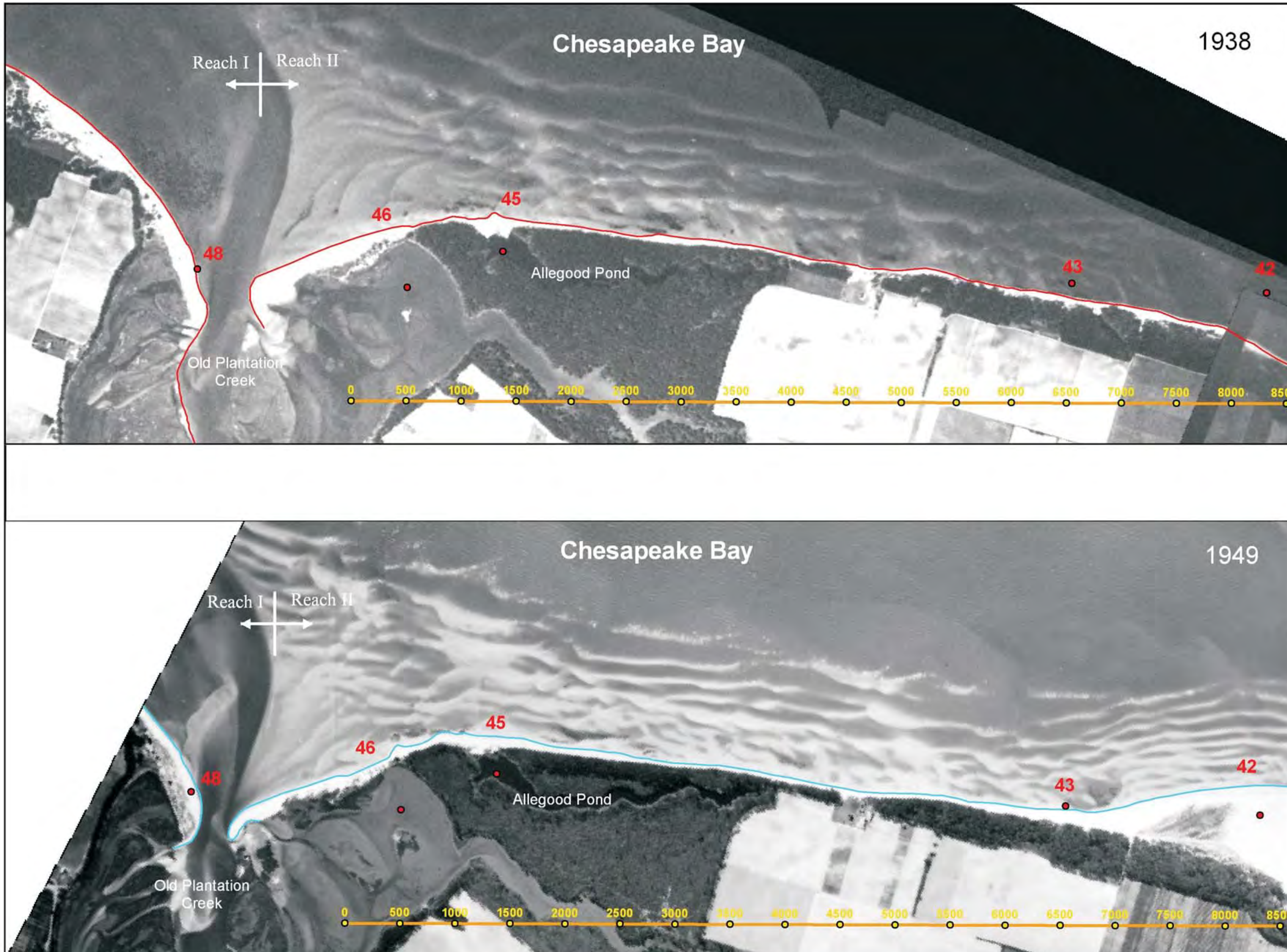
- Transect Points
- Baseline
- 2002 Shoreline
- 1994 Shoreline
- 1989 Shoreline
- 1949 Shoreline
- 1938 Shoreline

| Imagery Dates | Average Rate of Change (ft/yr) | Standard Deviation |
|---|---|---|
| 1938-1989 | -3.0 | 3.0 |
| 1989-1994 | -7.6 | 6.9 |
| 1994-2002 | -0.8 | 6.3 |
| **1938-2002** | -3.1 | 3.2 |




Shoreline Studies Program
VIMS

1,000 0 1,000 Feet




# Northampton County

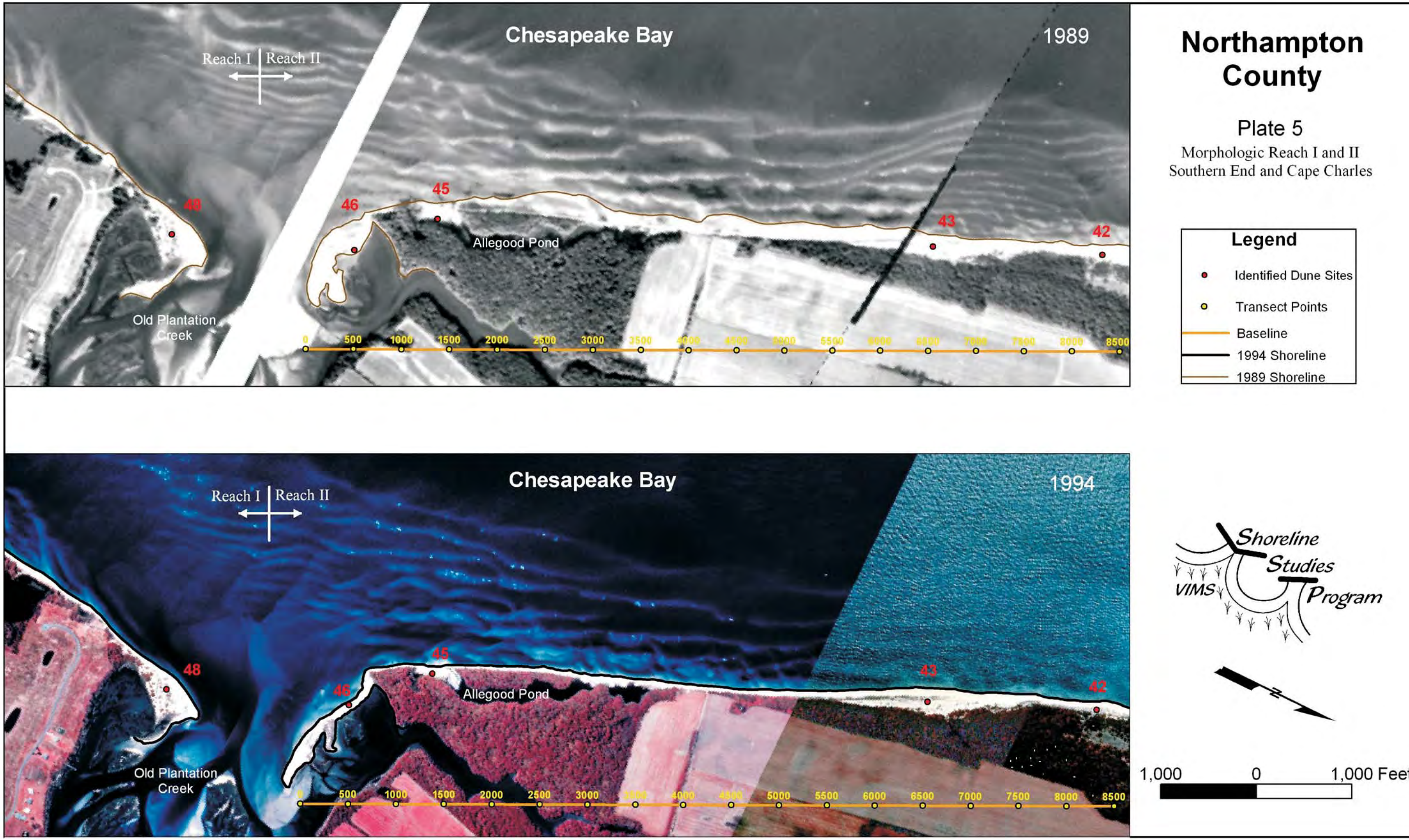
## Plate 5

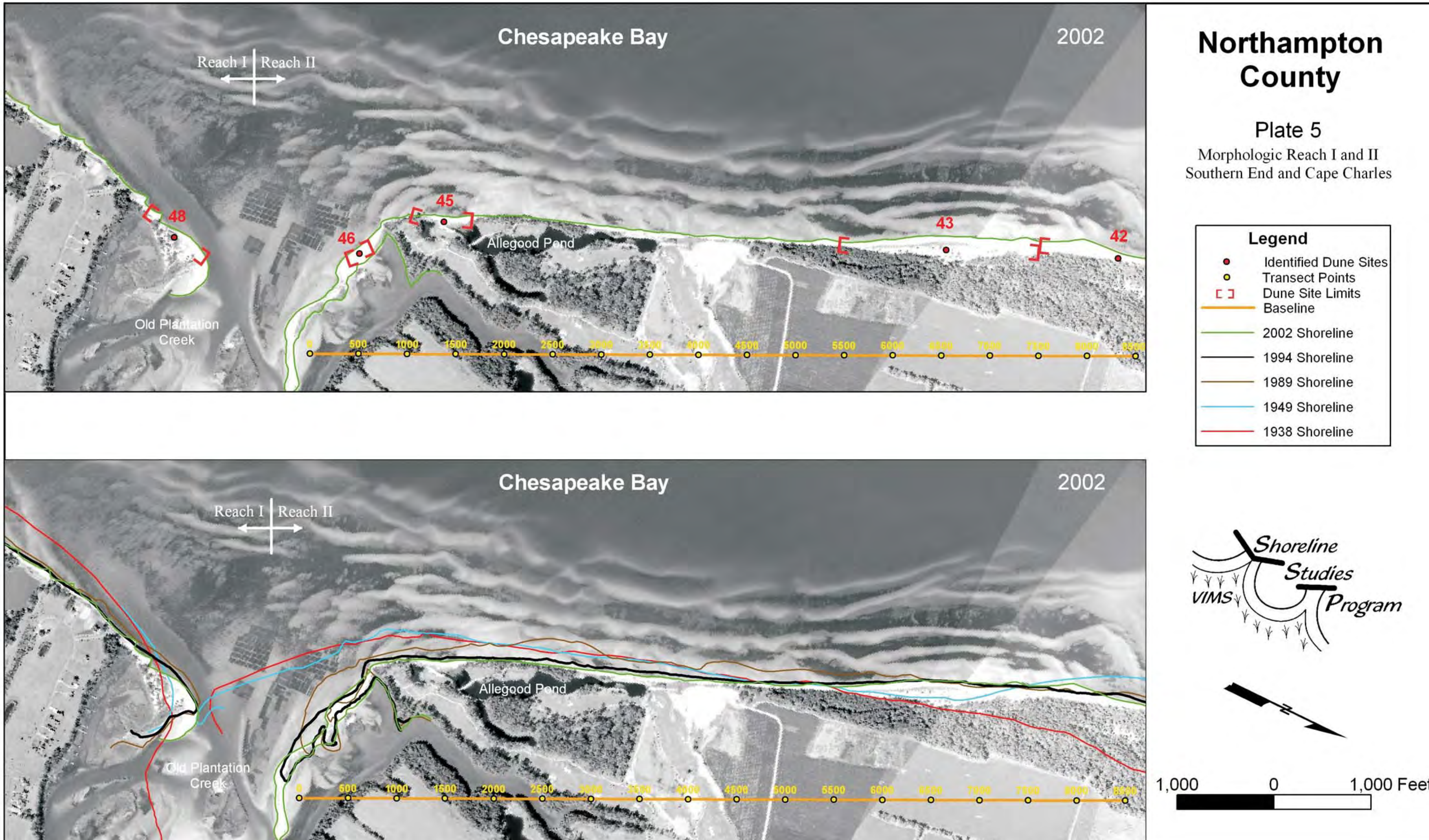
Morphologic Reach I and II
Southern End and Cape Charles

**Legend**

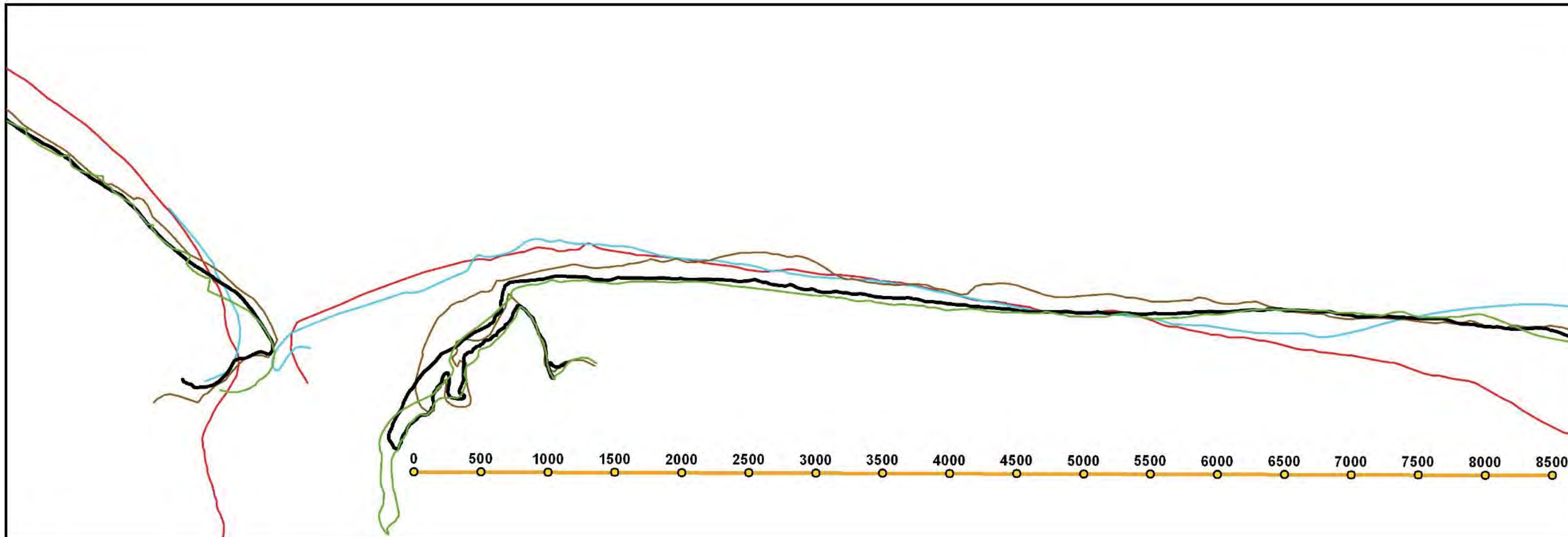
- Identified Dune Sites
- Transect Points
- Baseline
- 1949 Shoreline
- 1938 Shoreline

1,000 0 1,000 Feet


Northampton County
Plate 5
Morphologic Reach I and II
Southern End and Cape Charles
Chesapeake Bay
1989
Reach I
Reach II
48
46
45
43
42
Allegood Pond
Old Plantation Creek
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
7500
8000
8500
Legend
Identified Dune Sites
Transect Points
Baseline
1994 Shoreline
1989 Shoreline
Chesapeake Bay
1994
Reach I
Reach II
48
46
45
43
42
Allegood Pond
Old Plantation Creek
Shoreline Studies Program
VIMS
1,000
0
1,000 Feet



Chesapeake Bay
2002
Reach I
Reach II
48
46
45
43
42
Allegood Pond
Old Plantation Creek
0
500
1000
1500
2000
2500
4500
5000
5500
6000
Chesapeake Bay
2002
Reach I
Reach II
Allegood Pond
Old Plantation Creek
Northampton County
Plate 5
Morphologic Reach I and II
Southern End and Cape Charles
Legend
Identified Dune Sites
Transect Points
Dune Site Limits
Baseline
2002 Shoreline
1994 Shoreline
1989 Shoreline
1949 Shoreline
1938 Shoreline
Shoreline Studies Program
VIMS
1,000
0
1,000 Feet




# Northampton County

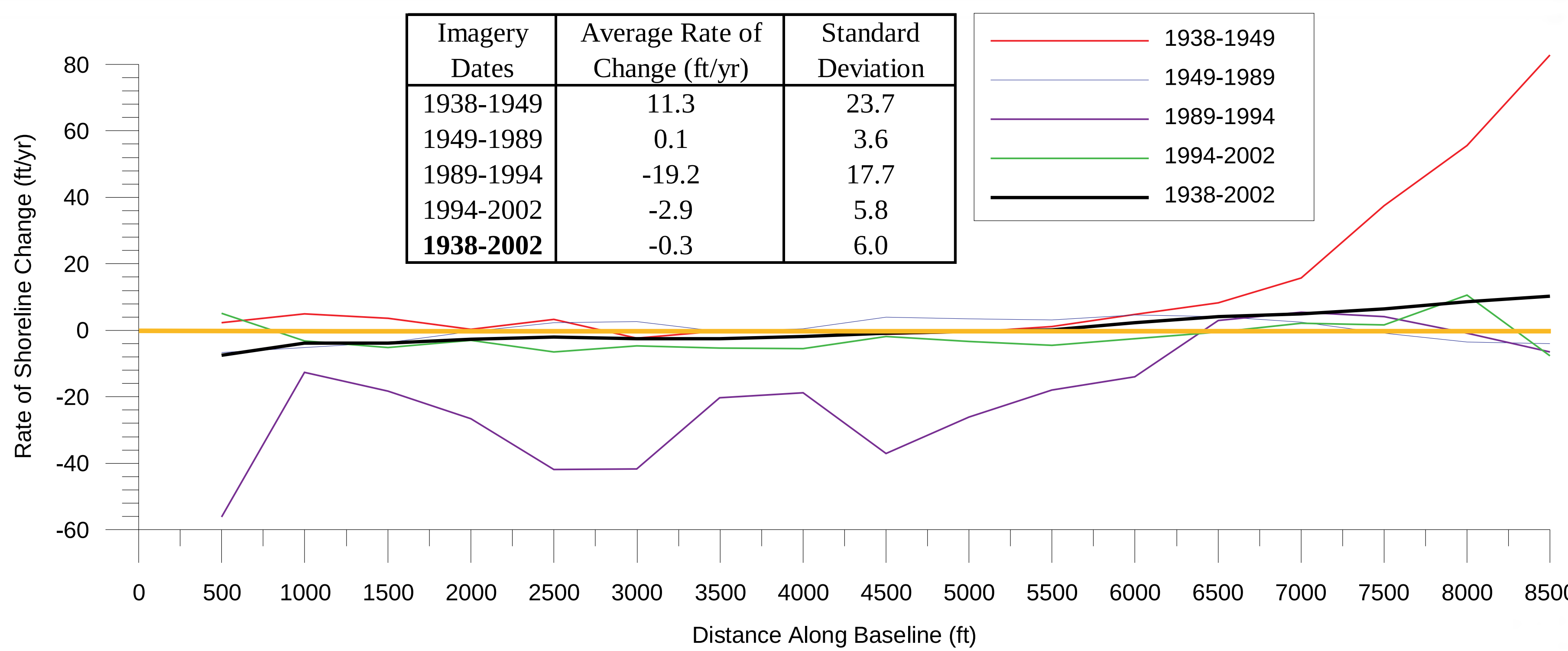
## Plate 5

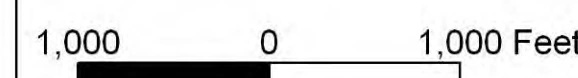
Morphologic Reach I and II
Southern End and Cape Charles

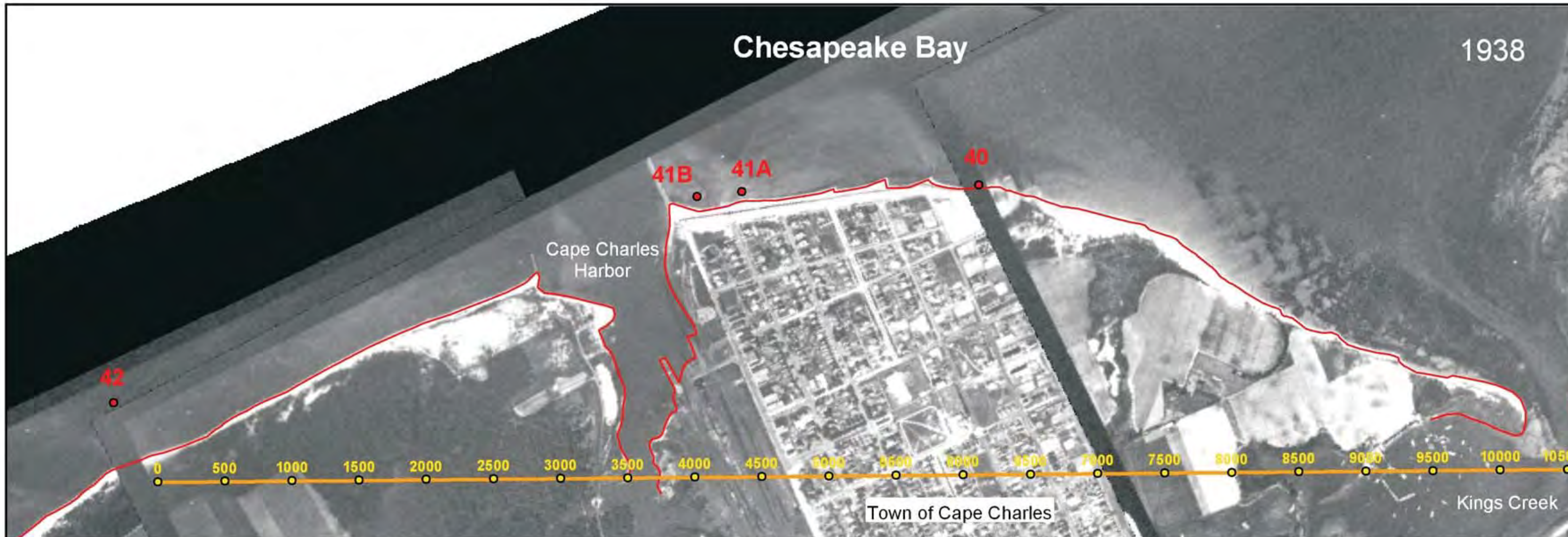
**Legend**

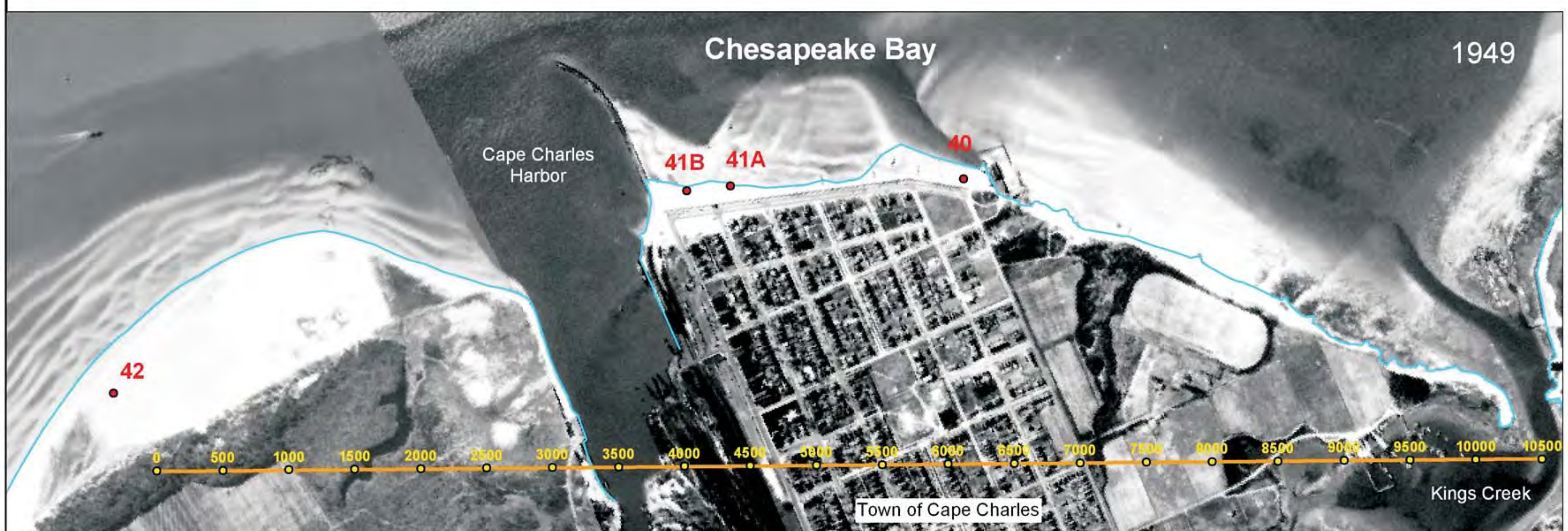
- Transect Points
- Baseline
- 2002 Shoreline
- 1994 Shoreline
- 1989 Shoreline
- 1949 Shoreline
- 1938 Shoreline

| Imagery Dates | Average Rate of Change (ft/yr) | Standard Deviation |
|---|---|---|
| 1938-1949 | 11.3 | 23.7 |
| 1949-1989 | 0.1 | 3.6 |
| 1989-1994 | -19.2 | 17.7 |
| 1994-2002 | -2.9 | 5.8 |
| **1938-2002** | -0.3 | 6.0 |





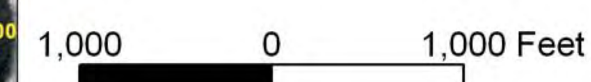

# Northampton County

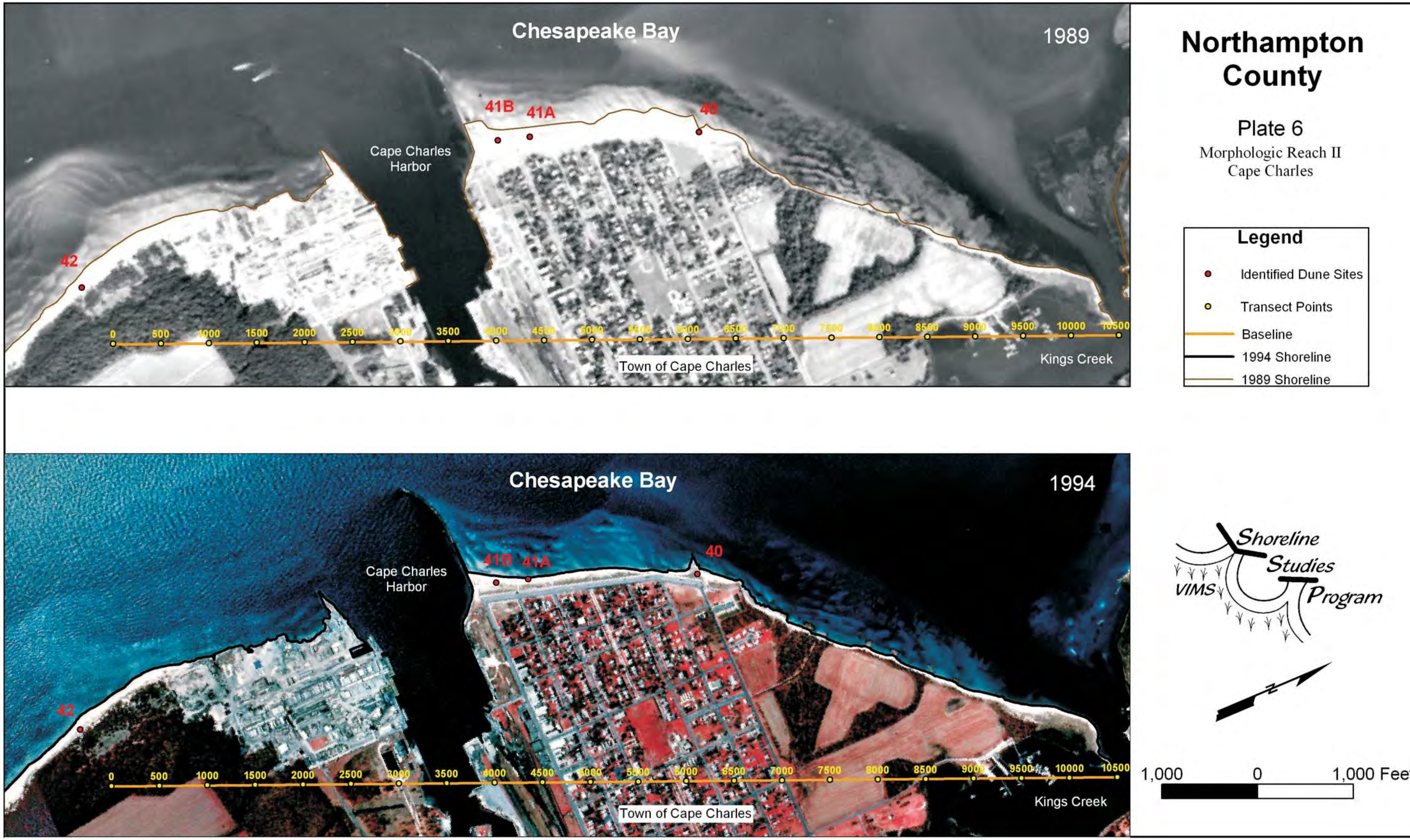
## Plate 6

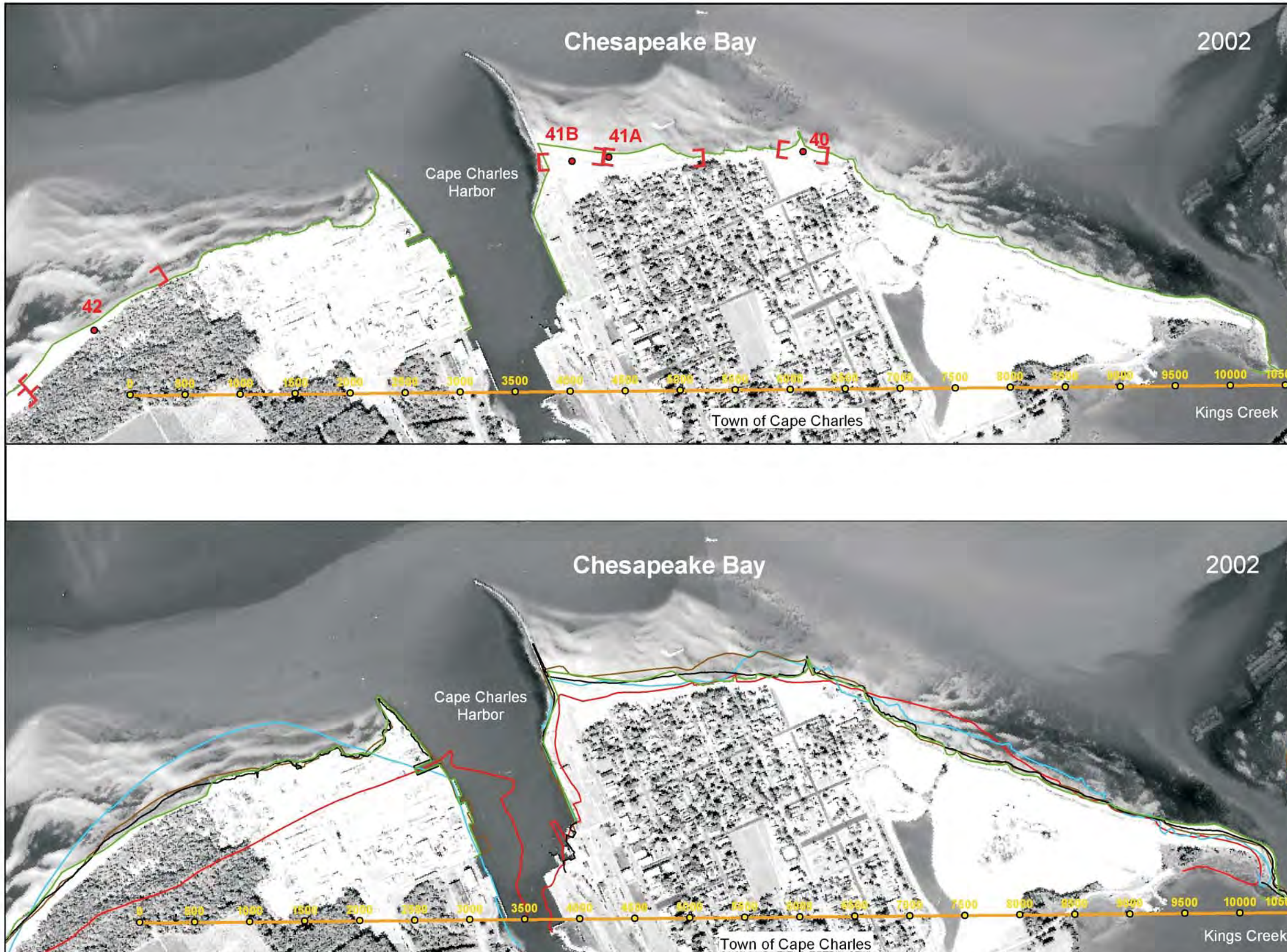
Morphologic Reach II
Cape Charles

**Legend**

- Identified Dune Sites
- Transect Points
- Baseline
- 1949 Shoreline
- 1938 Shoreline




Northampton County
Plate 6
Morphologic Reach II
Cape Charles
Chesapeake Bay
1989
Cape Charles Harbor
41B
41A
40
42
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
7500
8000
8500
9000
9500
10000
10500
Town of Cape Charles
Kings Creek
Chesapeake Bay
1994
Cape Charles Harbor
41B
41A
40
42
Town of Cape Charles
Kings Creek
Legend
Identified Dune Sites
Transect Points
Baseline
1994 Shoreline
1989 Shoreline
Shoreline Studies Program
VIMS
1,000
0
1,000 Feet




# Northampton County

## Plate 6

Morphologic Reach II
Cape Charles

**Legend**

- Identified Dune Sites
- Transect Points
- Dune Site Limits
- Baseline
- 2002 Shoreline
- 1994 Shoreline
- 1989 Shoreline
- 1949 Shoreline
- 1938 Shoreline

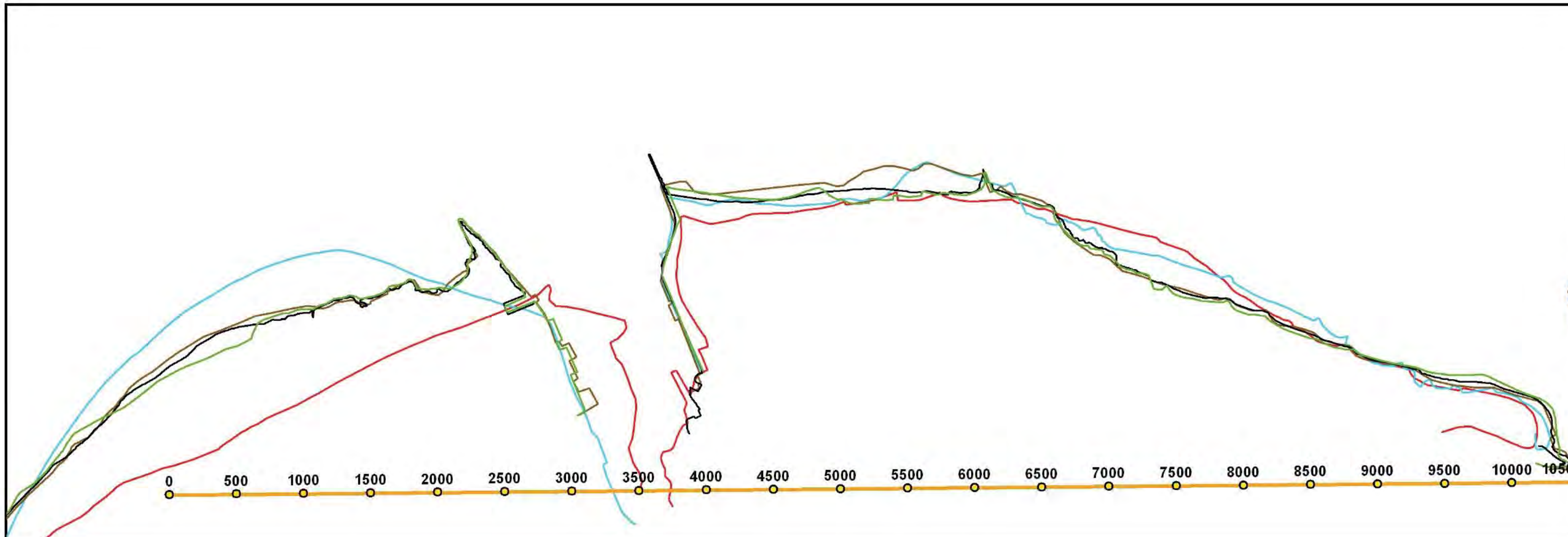
Shoreline Studies Program
VIMS

1,000 0 1,000 Feet

# Northampton County

## Plate 6

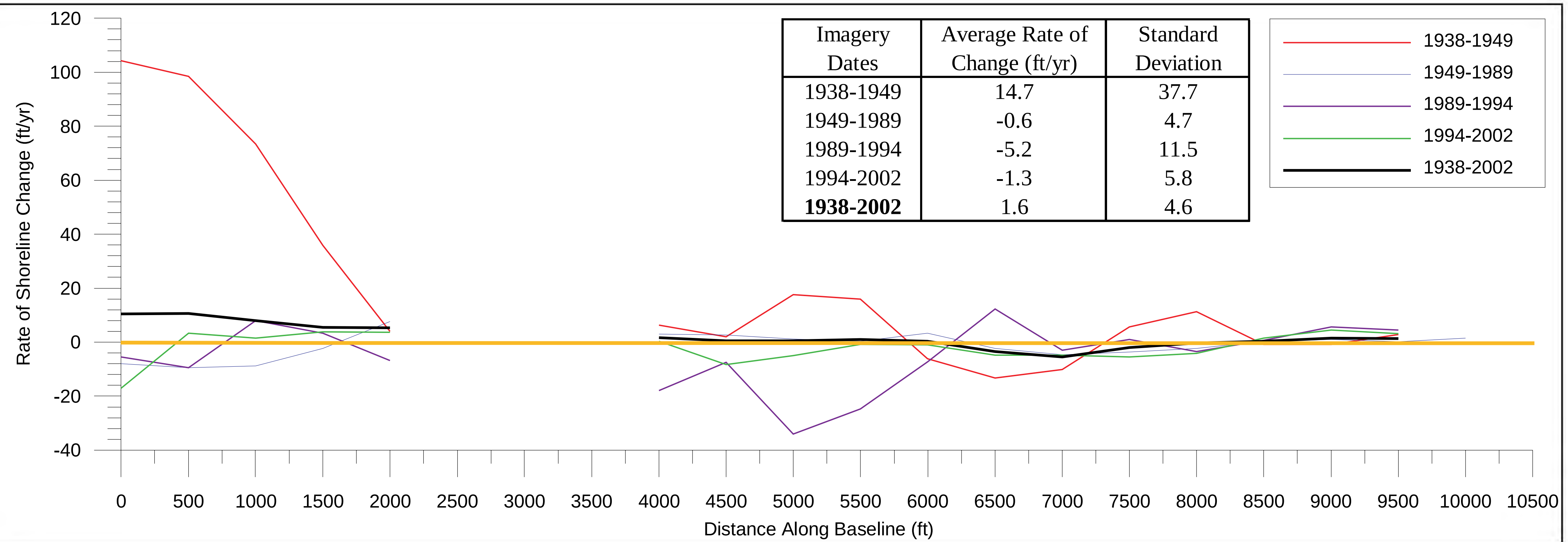
Morphologic Reach II
Cape Charles



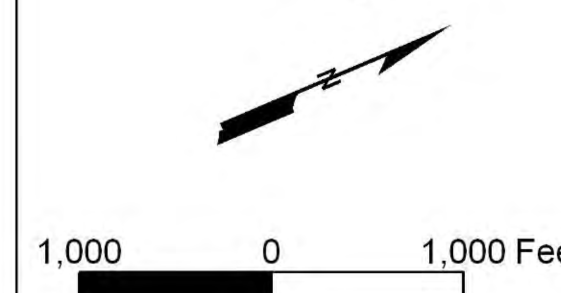

**Legend**

- Transect Points
- Baseline
- 2002 Shoreline
- 1994 Shoreline
- 1989 Shoreline
- 1949 Shoreline
- 1938 Shoreline

| Imagery Dates | Average Rate of Change (ft/yr) | Standard Deviation |
|---|---|---|
| 1938-1949 | 14.7 | 37.7 |
| 1949-1989 | -0.6 | 4.7 |
| 1989-1994 | -5.2 | 11.5 |
| 1994-2002 | -1.3 | 5.8 |
| **1938-2002** | 1.6 | 4.6 |



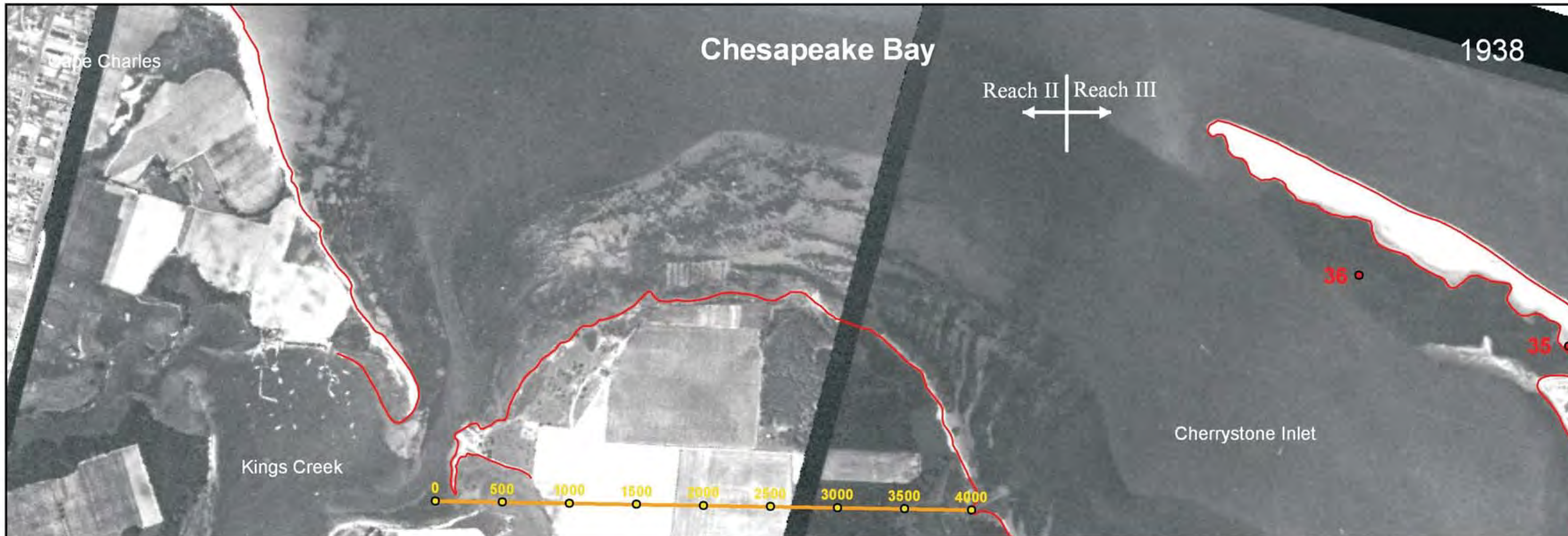

Shoreline Studies Program VIMS

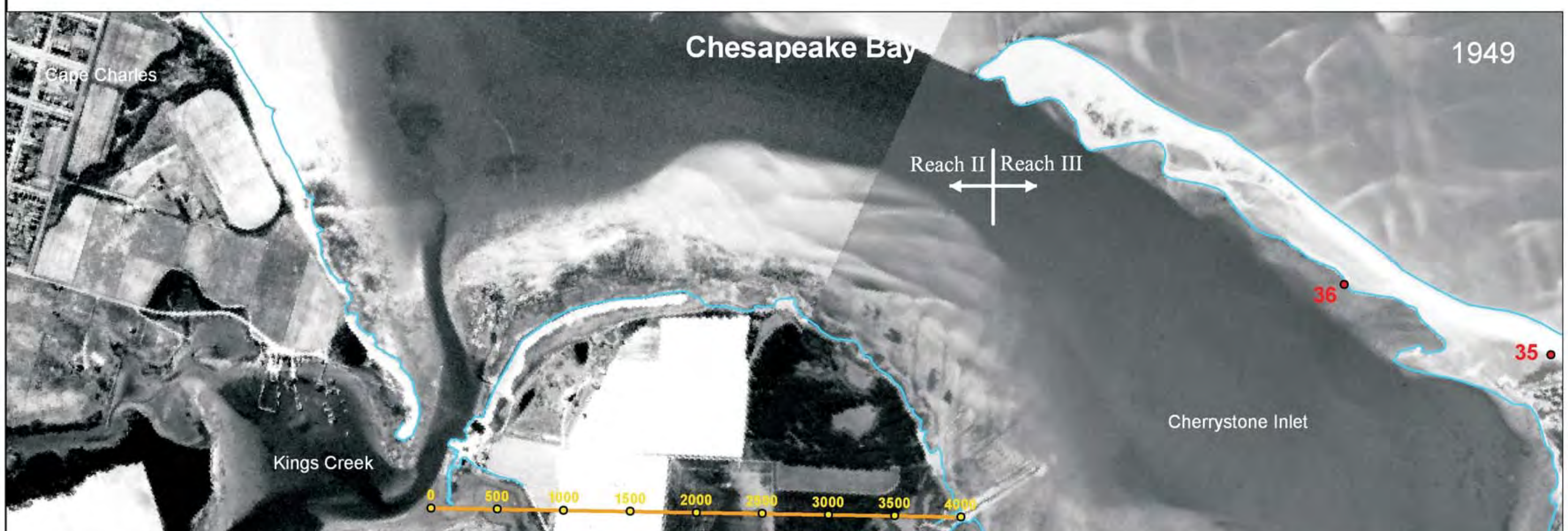


# Northampton County

## Plate 7

Morphologic Reach II and III
Cape Charles and Savage Neck




**Legend**

- Identified Dune Sites
- Transect Points
- Baseline
- 1949 Shoreline
- 1938 Shoreline

VIMS Shoreline Studies Program

1,000 0 1,000 Feet

# Northampton County

## Plate 7

Morphologic Reach II and III
Cape Charles and Savage Neck



**Legend**

- Identified Dune Sites
- Transect Points
- Baseline
- 1994 Shoreline
- 1989 Shoreline

Shoreline Studies Program VIMS

1,000 0 1,000 Feet



# Northampton County

## Plate 7

Morphologic Reach IIand III
Cape Charles and Savage Neck

**Legend**

- Identified Dune Sites
- Transect Points
- Dune Site Limits
- Baseline
- 2002 Shoreline
- 1994 Shoreline
- 1989 Shoreline
- 1949 Shoreline
- 1938 Shoreline

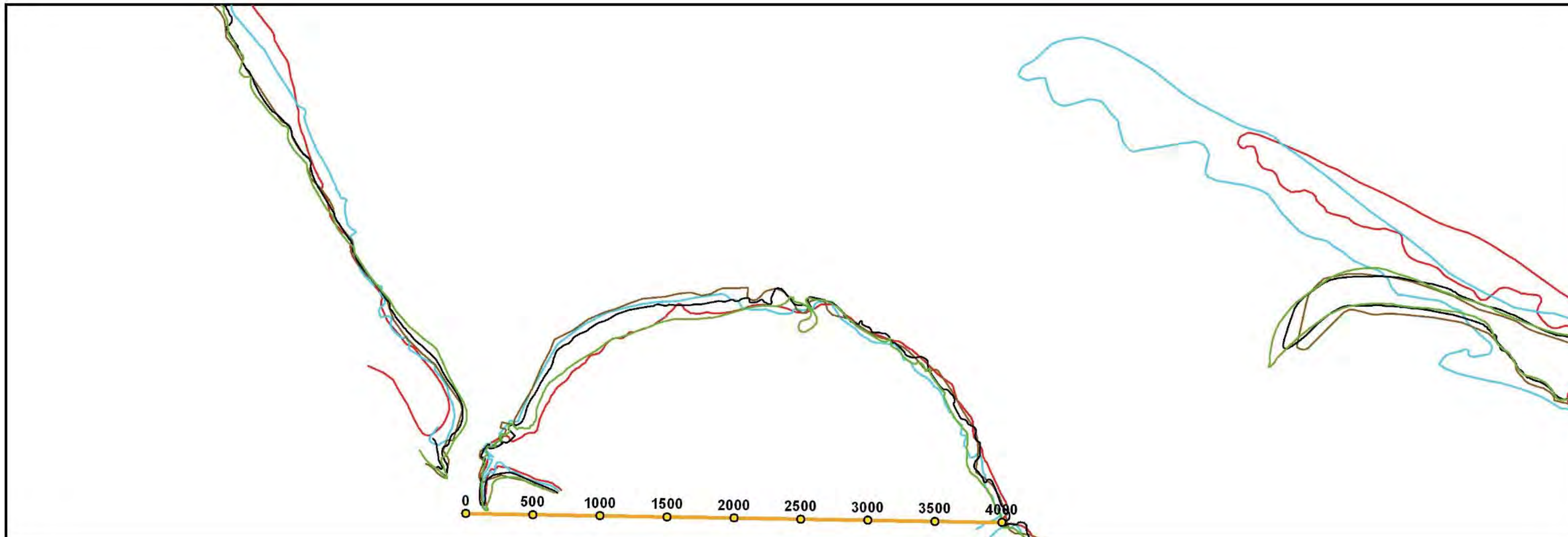
VIMS Shoreline Studies Program

1,000 0 1,000 Feet

# Northampton County

## Plate 7

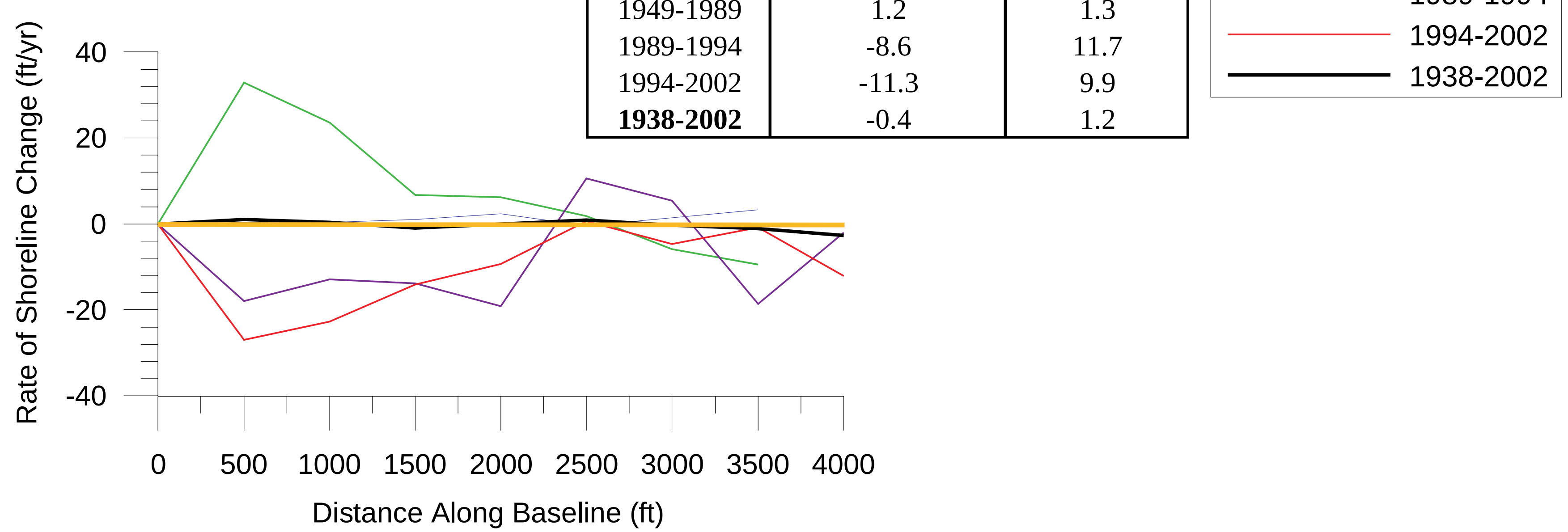
Morphologic Reach IIand III
Cape Charles and Savage Neck




**Legend**

- Transect Points
- Baseline
- 2002 Shoreline
- 1994 Shoreline
- 1989 Shoreline
- 1949 Shoreline
- 1938 Shoreline

| Imagery Dates | Average Rate of Change (ft/yr) | Standard Deviation |
|---|---|---|
| 1938-1949 | 8.0 | 15.3 |
| 1949-1989 | 1.2 | 1.3 |
| 1989-1994 | -8.6 | 11.7 |
| 1994-2002 | -11.3 | 9.9 |
| **1938-2002** | -0.4 | 1.2 |



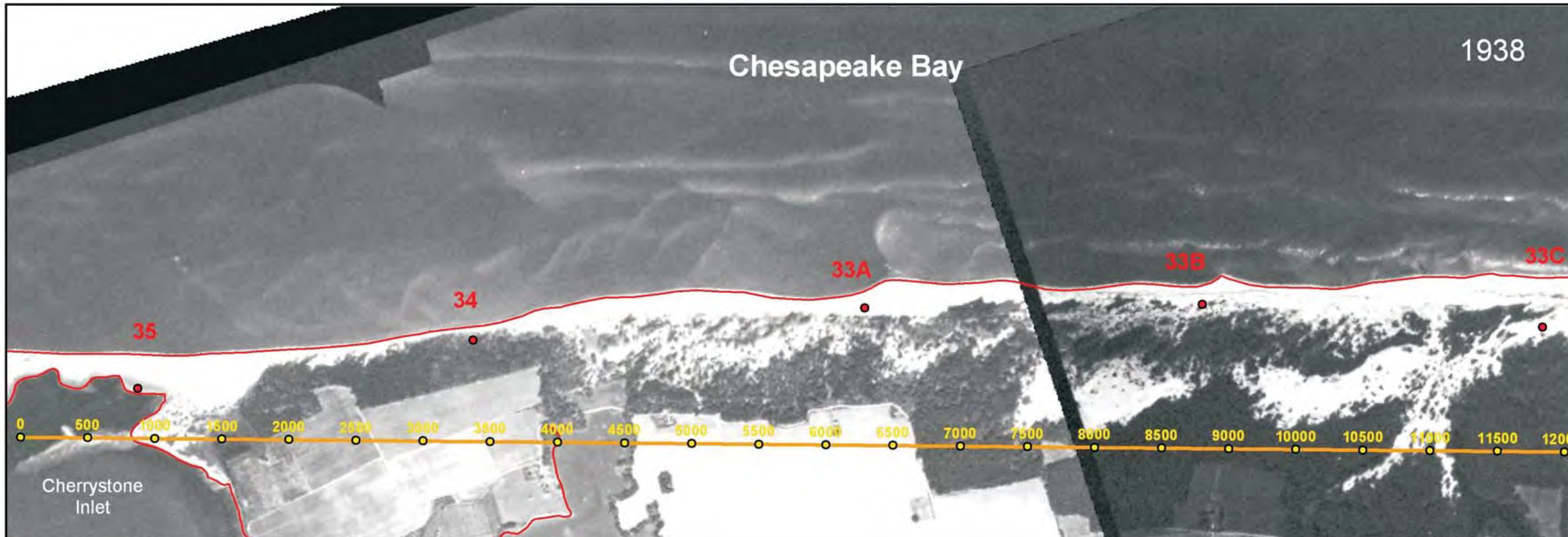

Shoreline Studies Program VIMS

1,000 0 1,000 Feet

# Northampton County

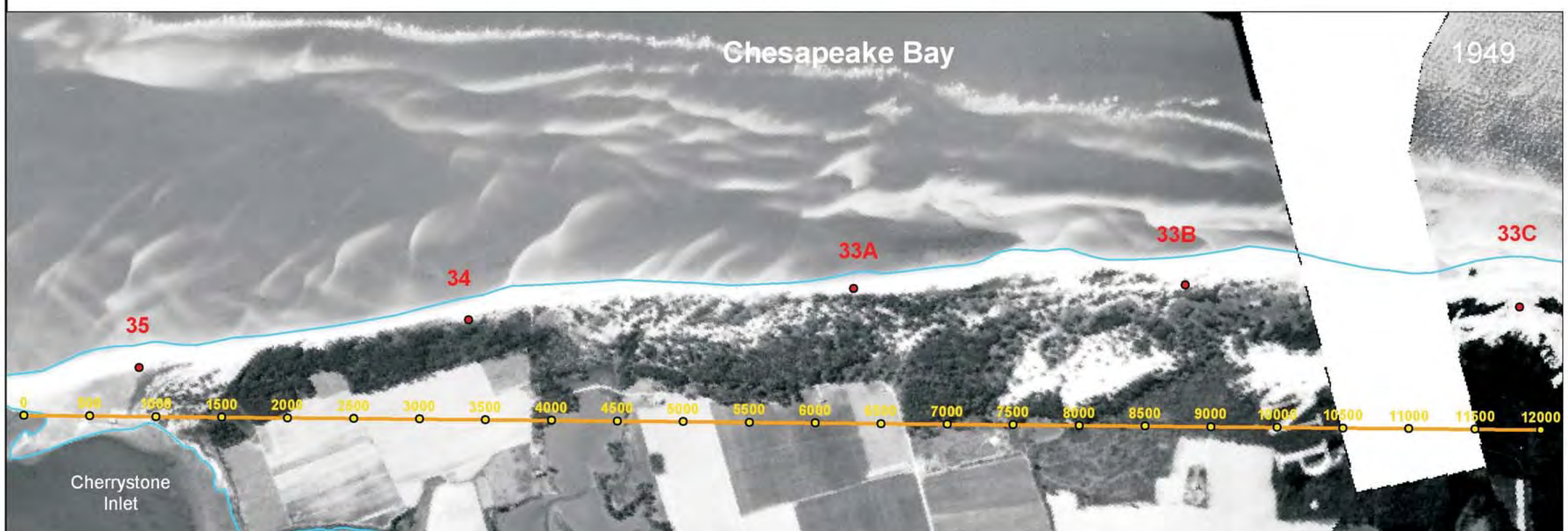
Plate 8

Morphologic Reach II
Savage Neck



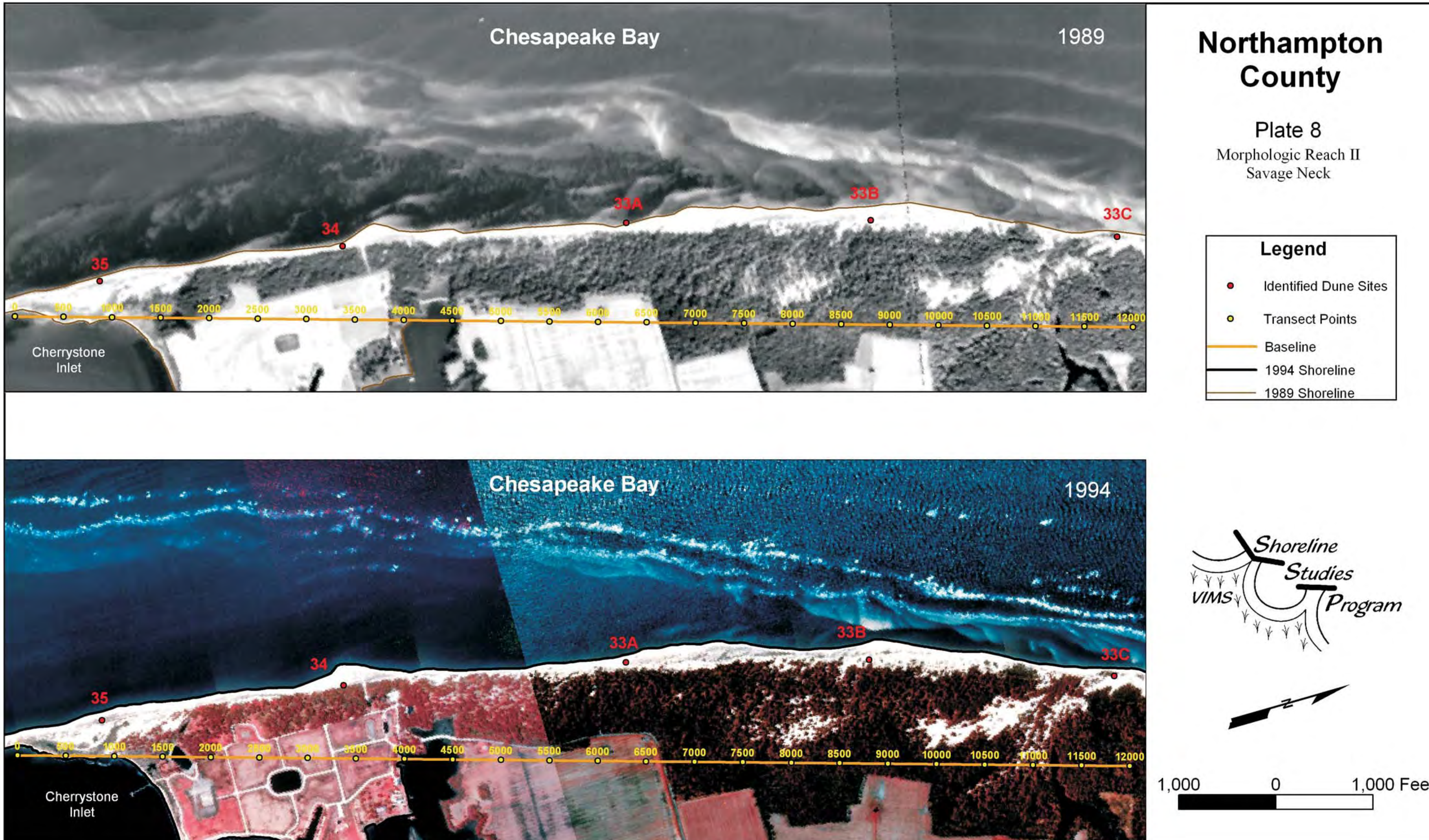

**Legend**

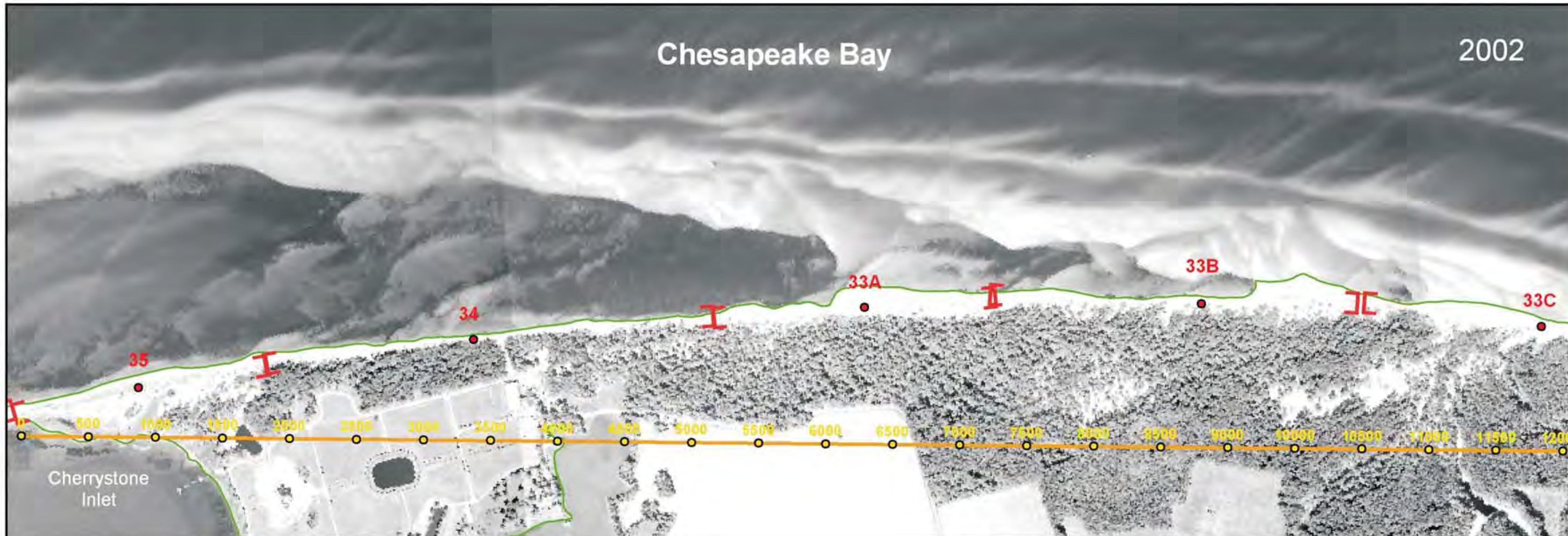
- Identified Dune Sites
- Transect Points
- Baseline
- 1949 Shoreline
- 1938 Shoreline

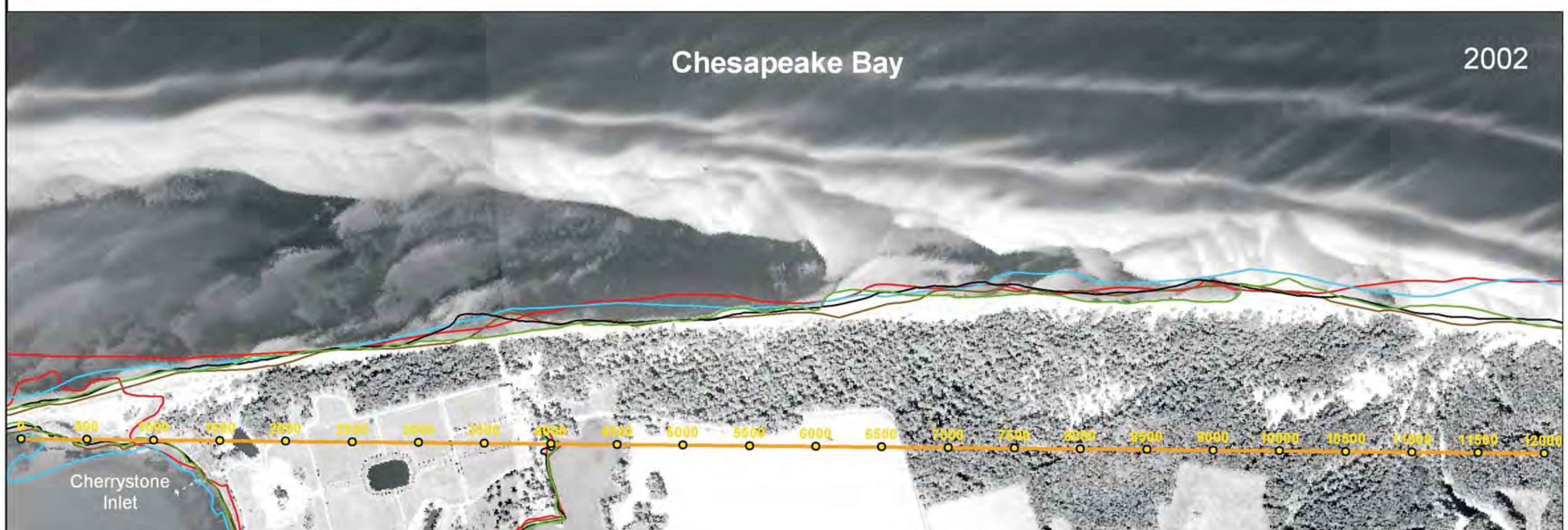



Shoreline Studies Program
VIMS

1,000 0 1,000 Feet


Northampton County
Plate 8
Morphologic Reach II
Savage Neck
Legend
Identified Dune Sites
Transect Points
Baseline
1994 Shoreline
1989 Shoreline
Chesapeake Bay
1989
1994
35
34
33A
33B
33C
Cherrystone Inlet
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
7500
8000
8500
9000
10000
10500
11000
11500
12000
Shoreline Studies Program
VIMS
1,000
0
1,000 Feet




# Northampton County

Plate 8
Morphologic Reach II
Savage Neck

**Legend**

- Identified Dune Sites
- Transect Points
- Dune Site Limits
- Baseline
- 2002 Shoreline
- 1994 Shoreline
- 1989 Shoreline
- 1949 Shoreline
- 1938 Shoreline

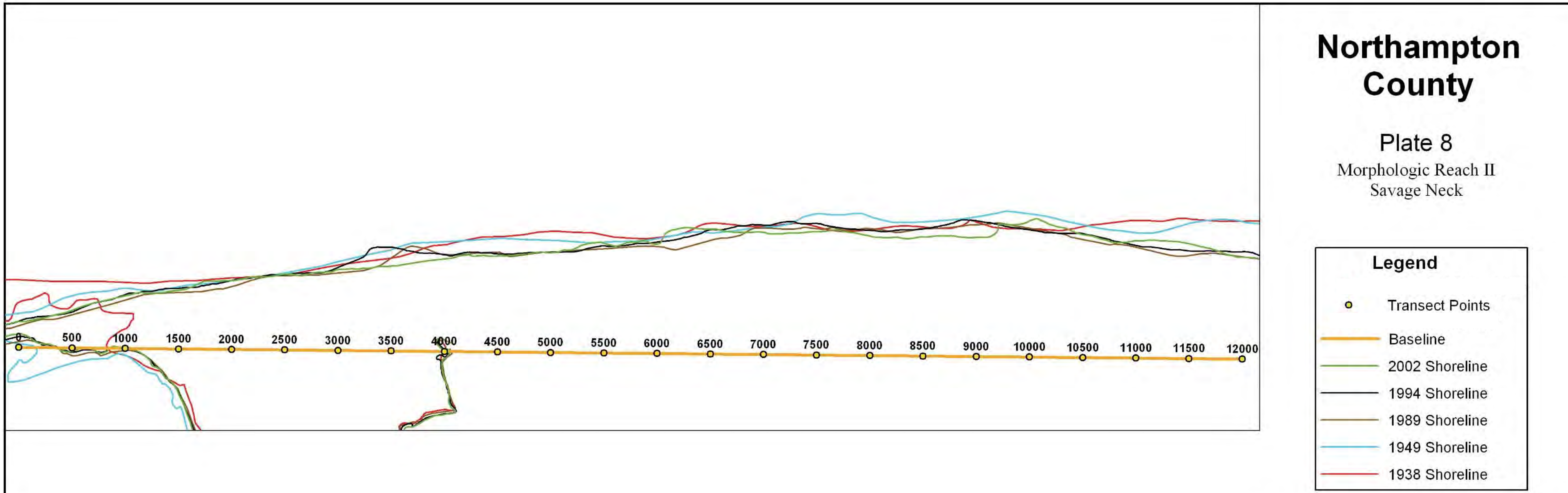
VIMS Shoreline Studies Program

1,000 0 1,000 Feet

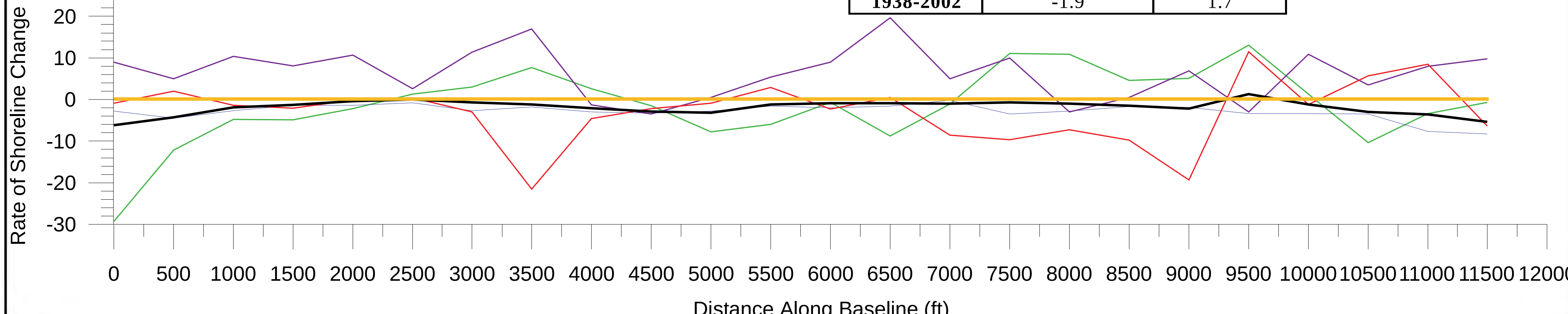
# Northampton County

## Plate 8

Morphologic Reach II
Savage Neck




| Imagery Dates | Average Rate of Change (ft/yr) | Standard Deviation |
|---|---|---|
| 1938-1949 | -1.4 | 9.0 |
| 1949-1989 | -2.9 | 1.9 |
| 1989-1994 | 6.3 | 6.0 |
| 1994-2002 | -2.9 | 7.5 |
| **1938-2002** | -1.9 | 1.7 |

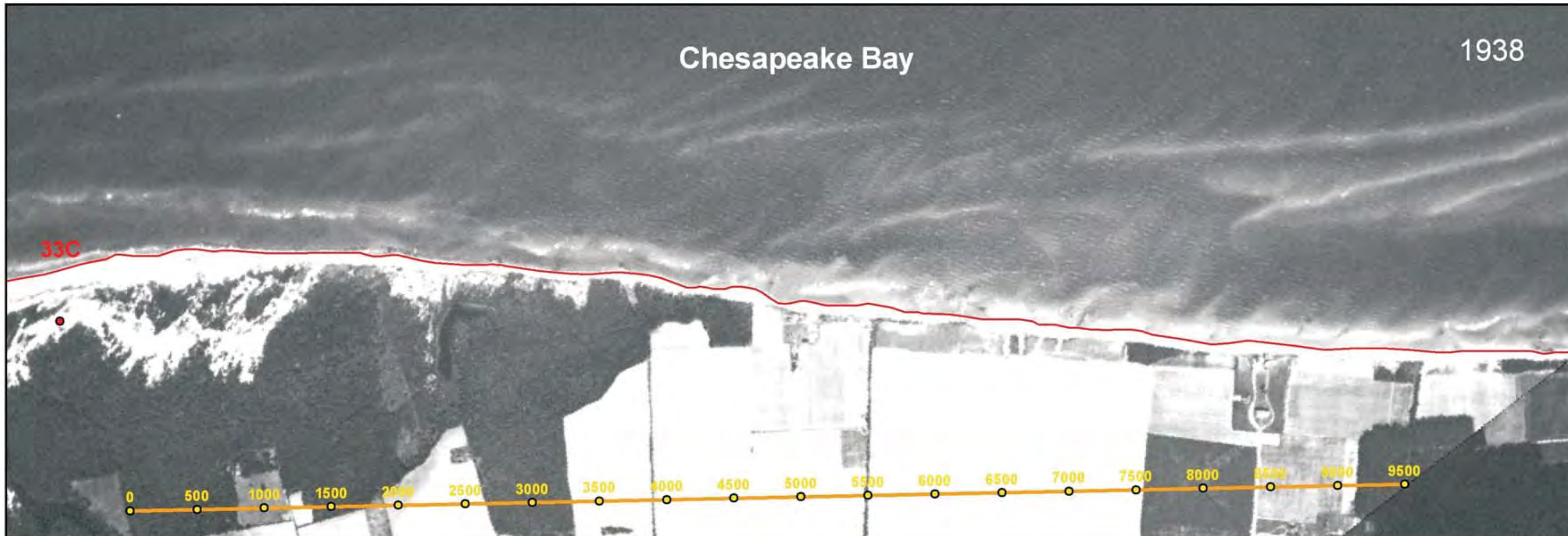


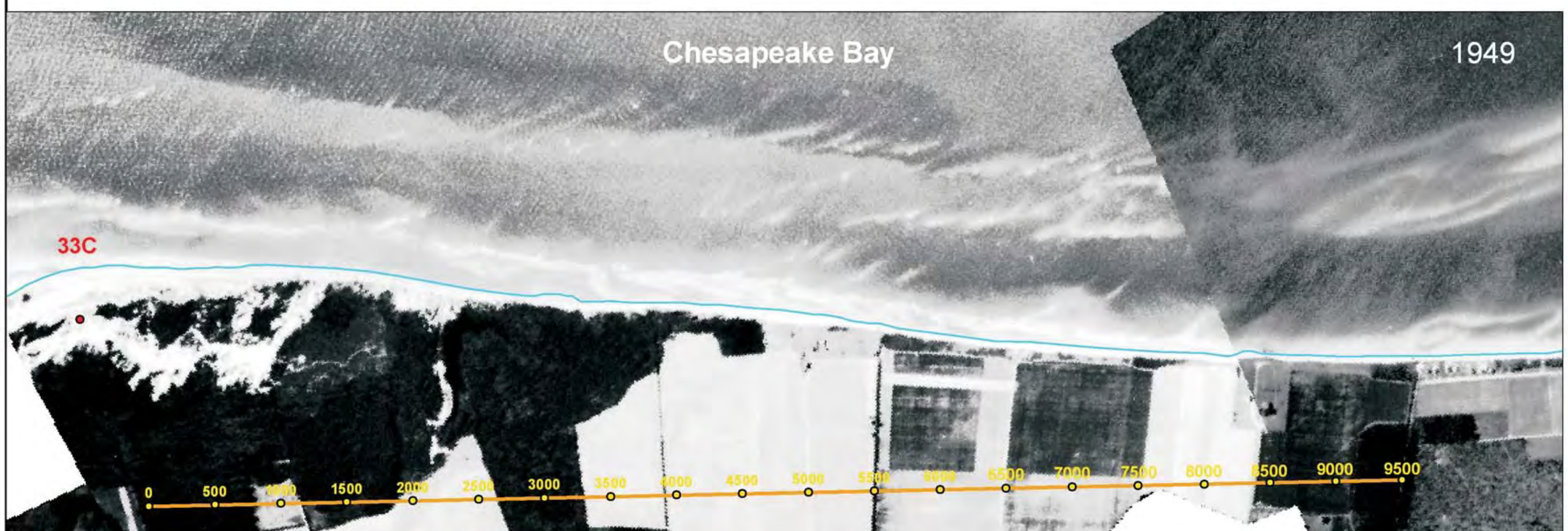

Shoreline Studies Program VIMS

# Northampton County

## Plate 9

Morphologic Reach II
Savage Neck




**Legend**

- Identified Dune Sites
- Transect Points
- Baseline
- 1949 Shoreline
- 1938 Shoreline

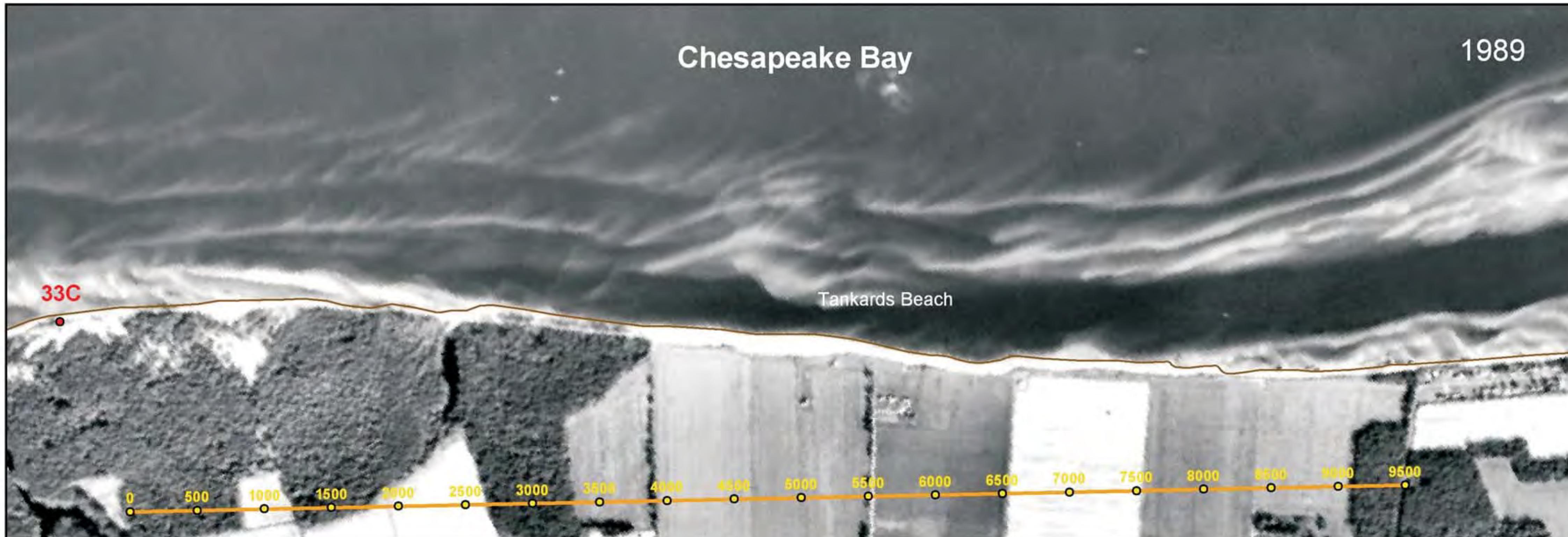
VIMS Shoreline Studies Program

1,000 0 1,000 Feet

# Northampton County

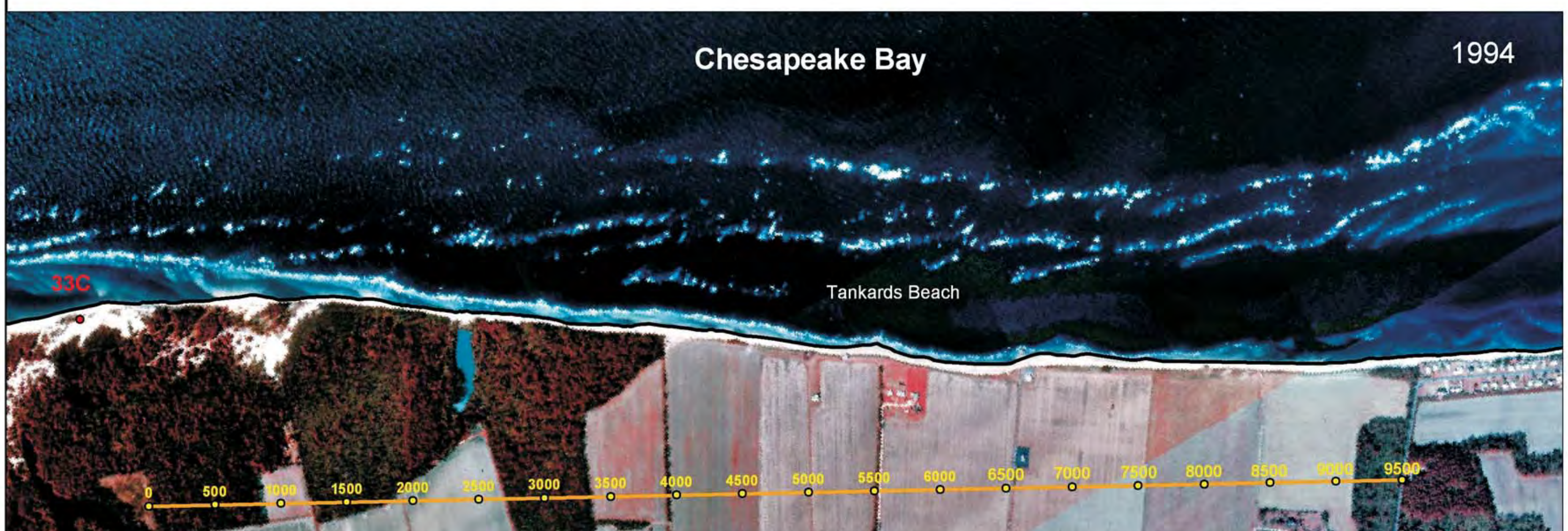
## Plate 9

Morphologic Reach II
Savage Neck




**Legend**

- Identified Dune Sites
- Transect Points
- Baseline
- 1994 Shoreline
- 1989 Shoreline

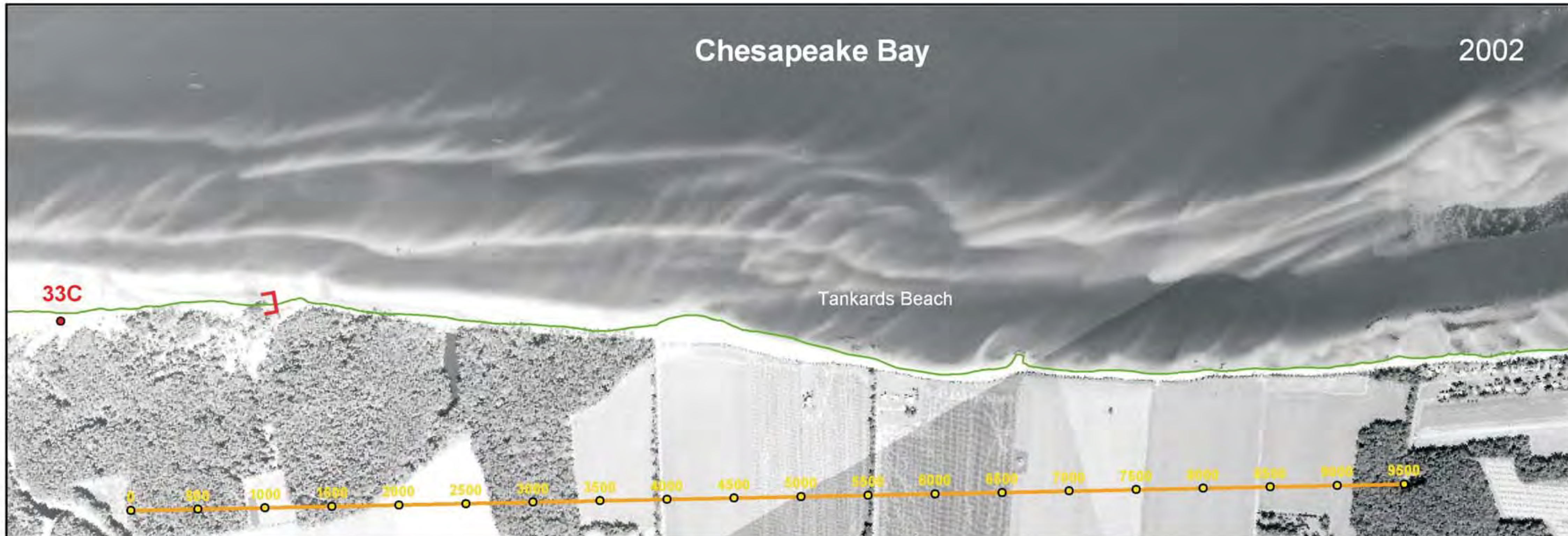


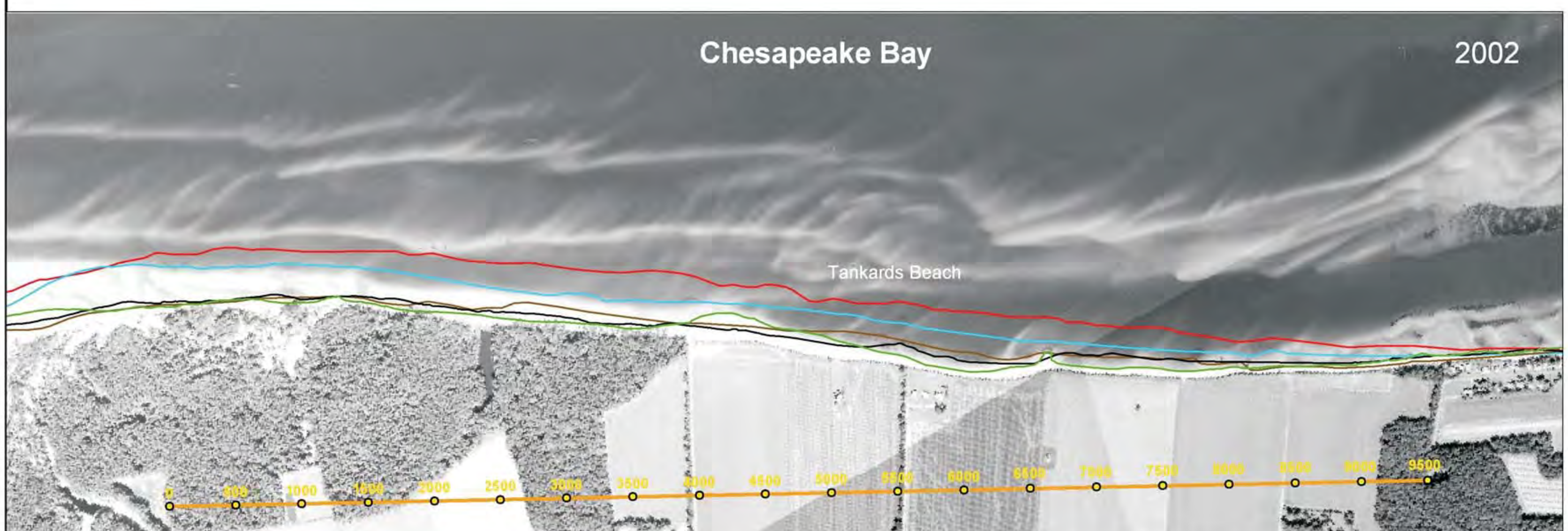

1,000 0 1,000 Feet

# Northampton County

## Plate 9

Morphologic Reach II
Savage Neck




**Legend**
- Identified Dune Sites
- Transect Points
- Dune Site Limits
- Baseline
- 2002 Shoreline
- 1994 Shoreline
- 1989 Shoreline
- 1949 Shoreline
- 1938 Shoreline

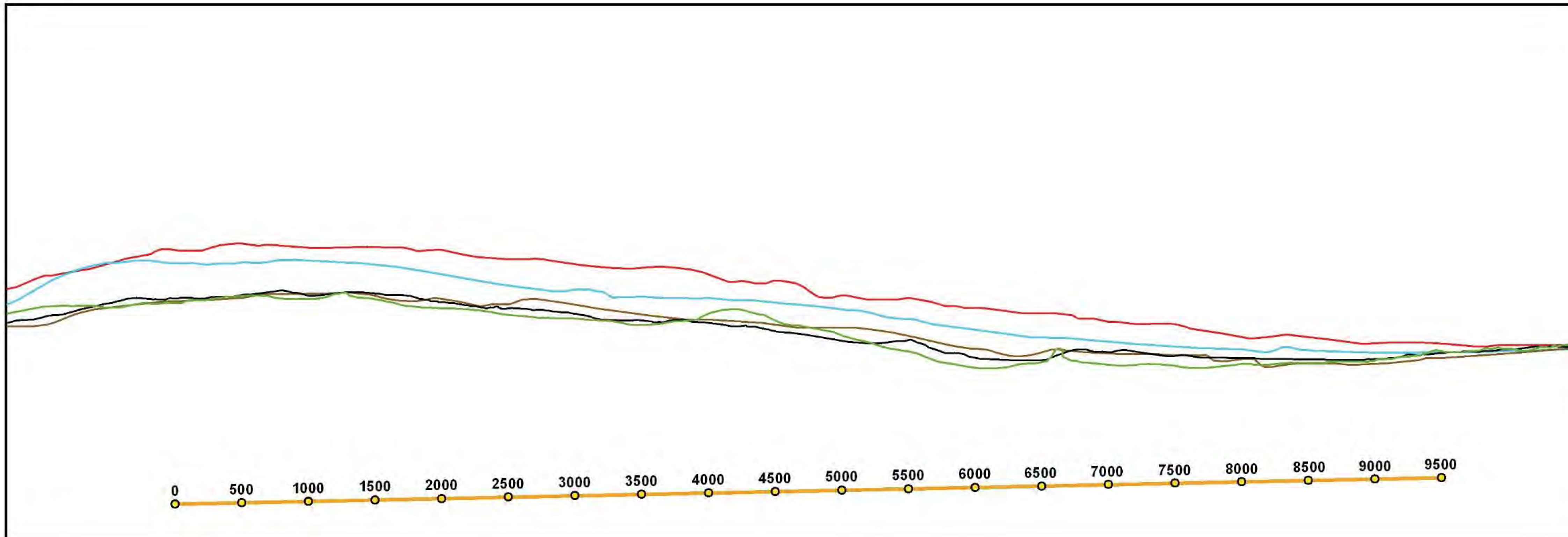
VIMS Shoreline Studies Program

1,000 0 1,000 Feet

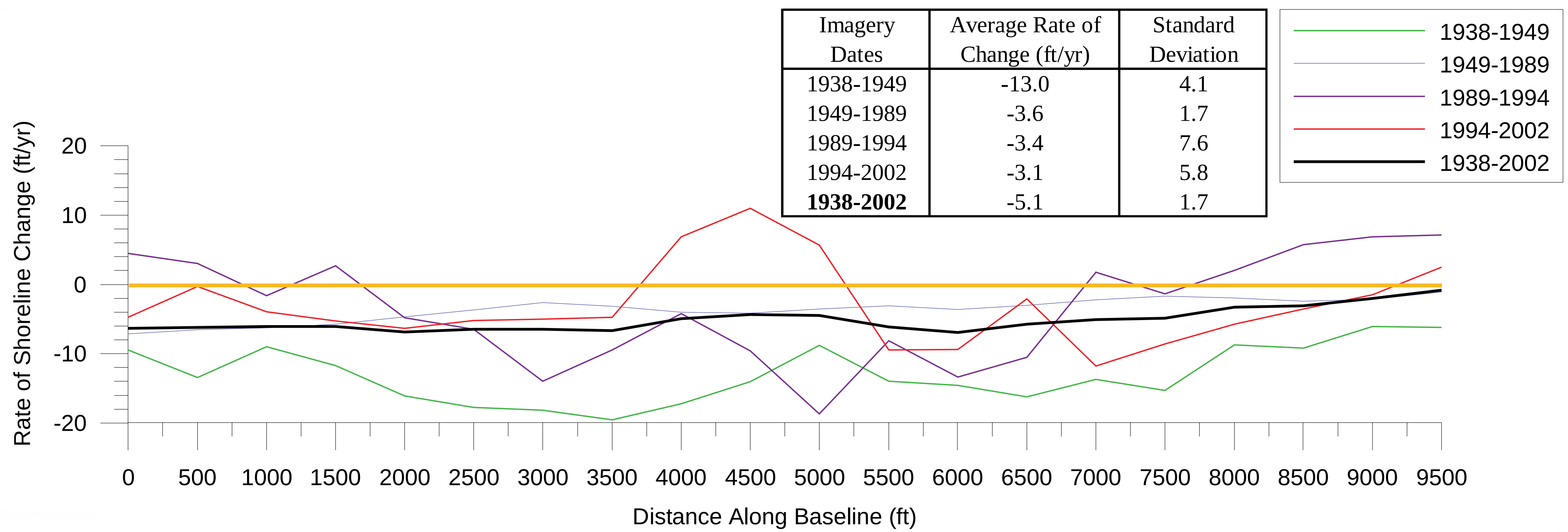
# Northampton County

## Plate 9

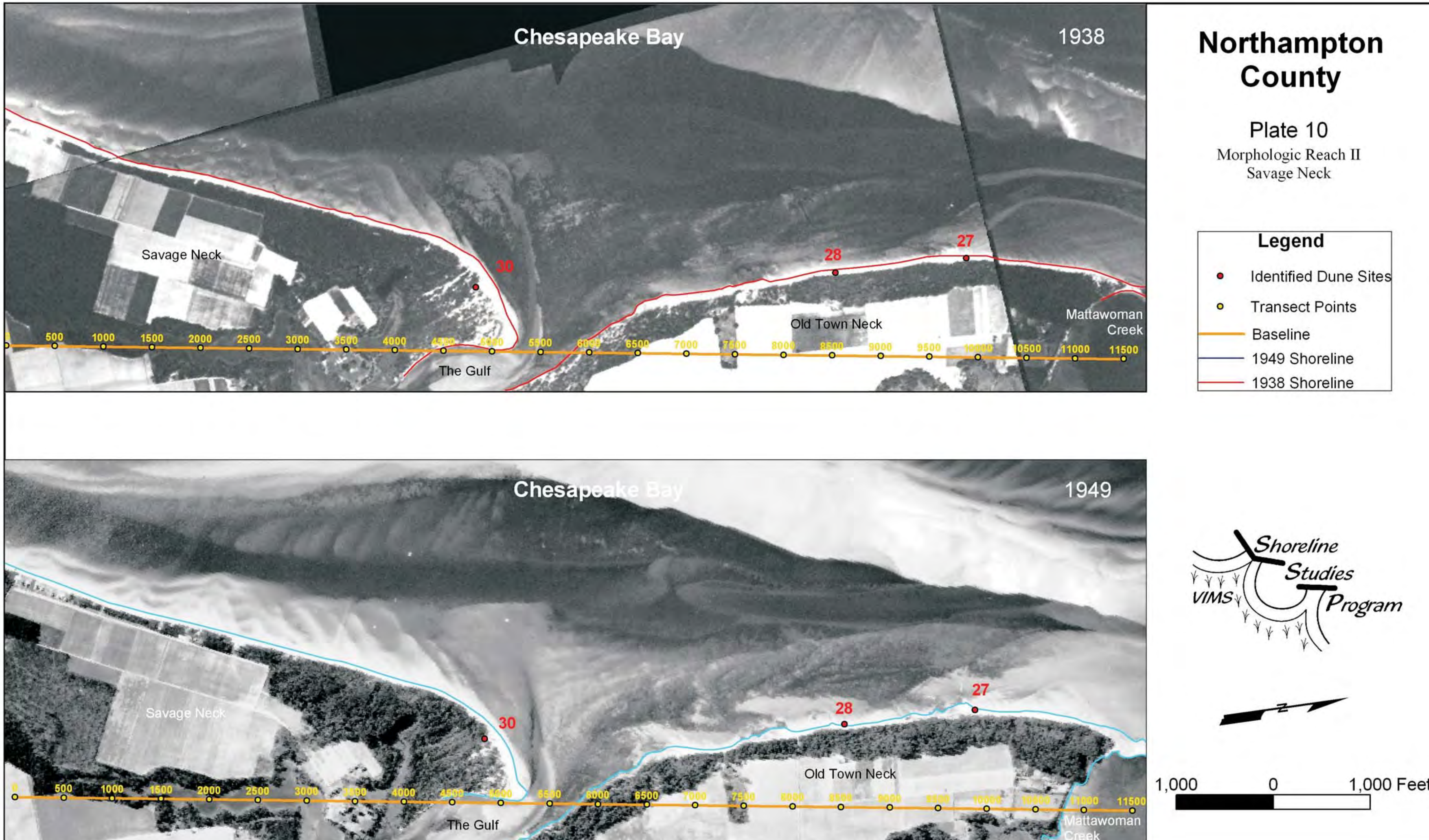
Morphologic Reach II
Savage Neck




| Imagery Dates | Average Rate of Change (ft/yr) | Standard Deviation |
|---|---|---|
| 1938-1949 | -13.0 | 4.1 |
| 1949-1989 | -3.6 | 1.7 |
| 1989-1994 | -3.4 | 7.6 |
| 1994-2002 | -3.1 | 5.8 |
| **1938-2002** | -5.1 | 1.7 |



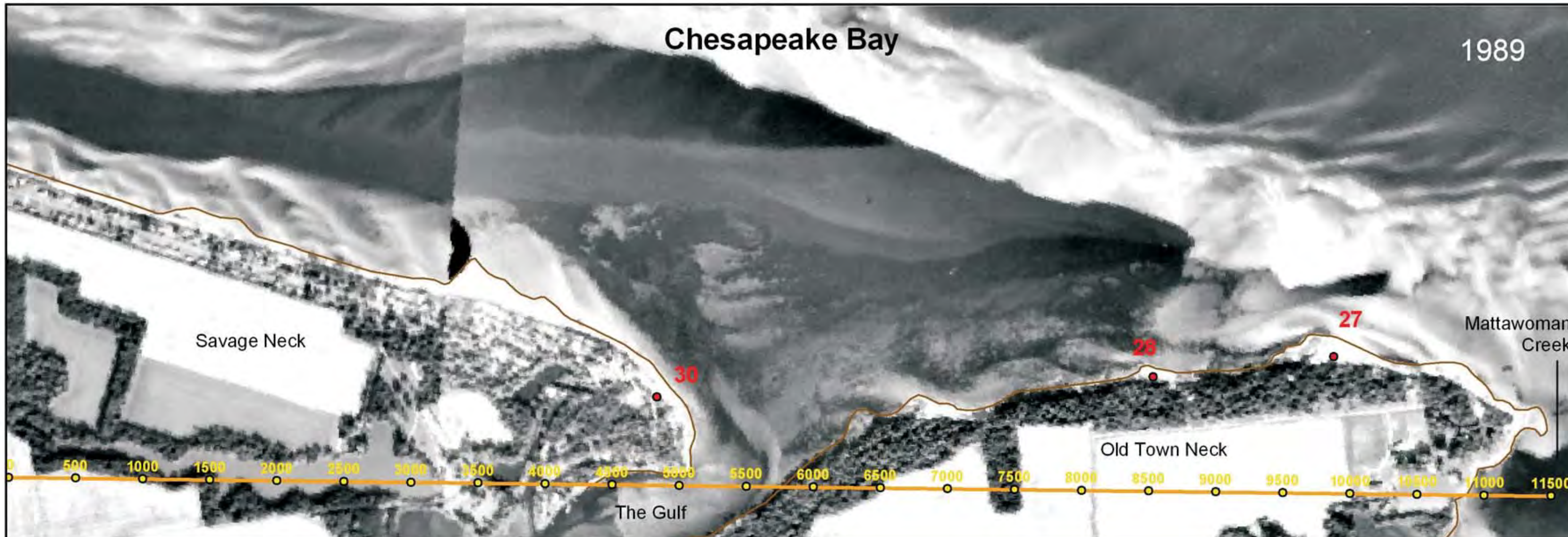

Shoreline Studies Program
VIMS


Northampton County
Plate 10
Morphologic Reach II
Savage Neck
Legend
Identified Dune Sites
Transect Points
Baseline
1949 Shoreline
1938 Shoreline
Shoreline Studies Program
VIMS
1,000
0
1,000 Feet
Chesapeake Bay
1938
Savage Neck
The Gulf
Old Town Neck
Mattawoman Creek
30
28
27
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
7500
8000
8500
9000
9500
10000
10500
11000
11500
Chesapeake Bay
1949
Savage Neck
The Gulf
Old Town Neck
Mattawoman Creek
30
28
27

# Northampton County

## Plate 10

Morphologic Reach II
Savage Neck

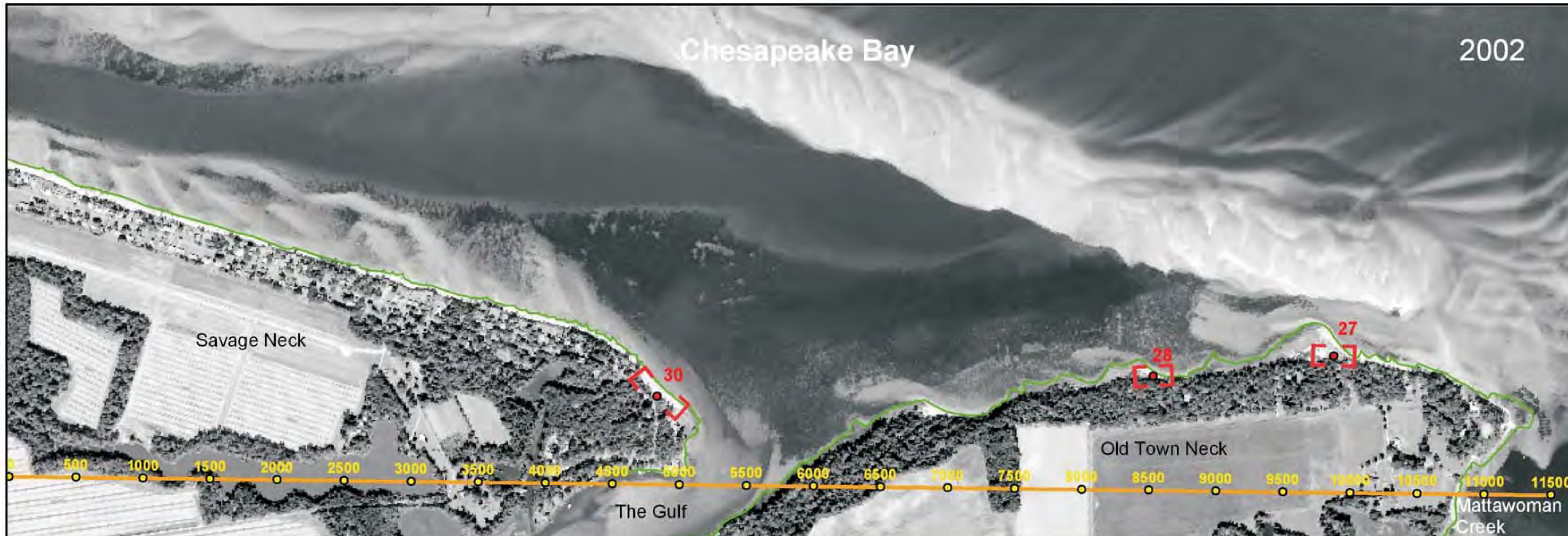


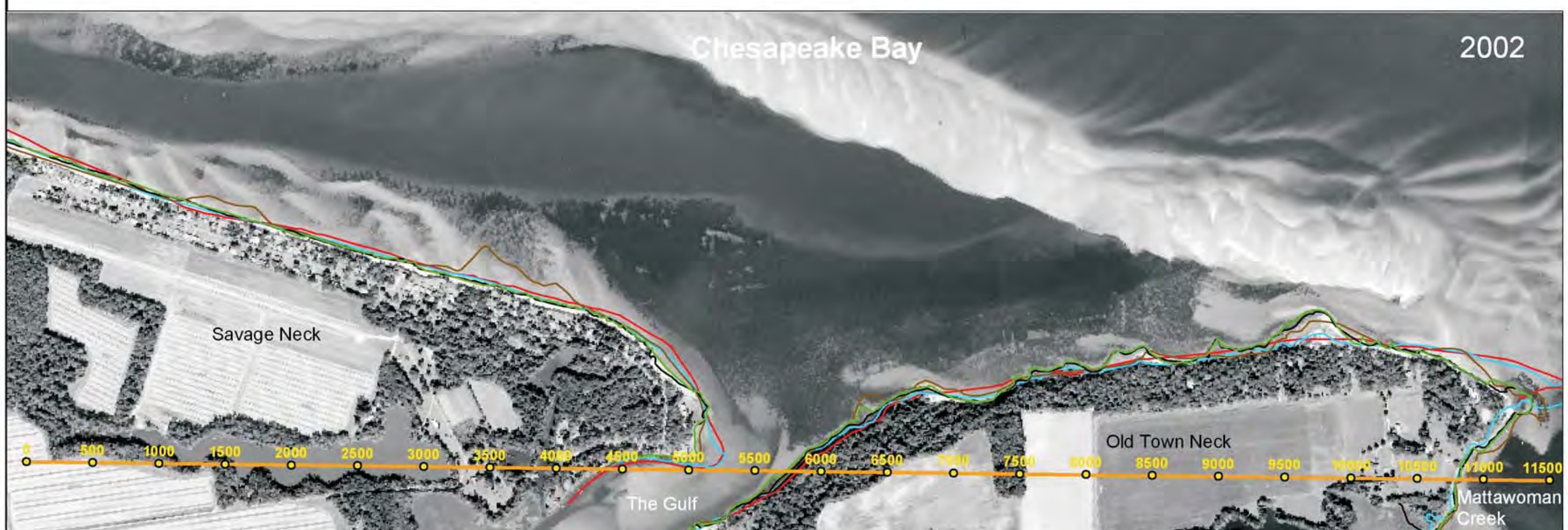

**Legend**

- Identified Dune Sites
- Transect Points
- Baseline
- 1994 Shoreline
- 1989 Shoreline


VIMS Shoreline Studies Program

1,000 0 1,000 Feet




# Northampton County

Plate 10
Morphologic Reach II
Savage Neck

**Legend**
- Identified Dune Sites
- Transect Points
- Dune Site Limits
- Baseline
- 2002 Shoreline
- 1994 Shoreline
- 1989 Shoreline
- 1949 Shoreline
- 1938 Shoreline

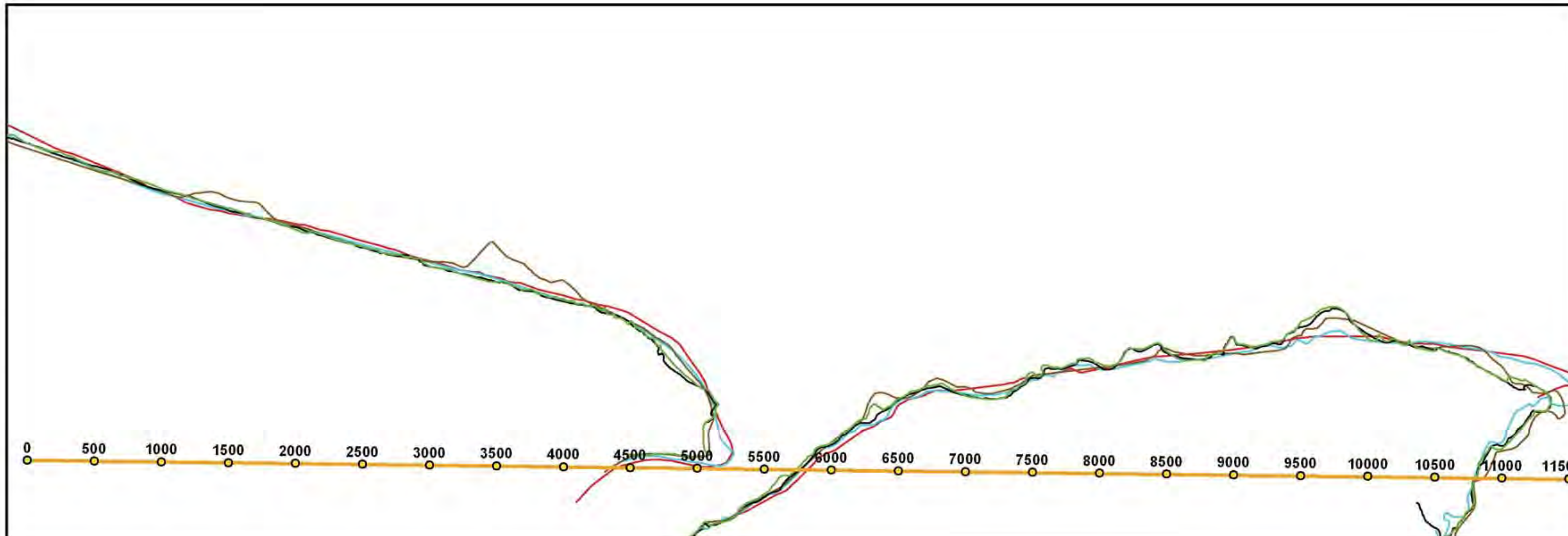
VIMS Shoreline Studies Program

1,000 0 1,000 Feet

# Northampton County

## Plate 10

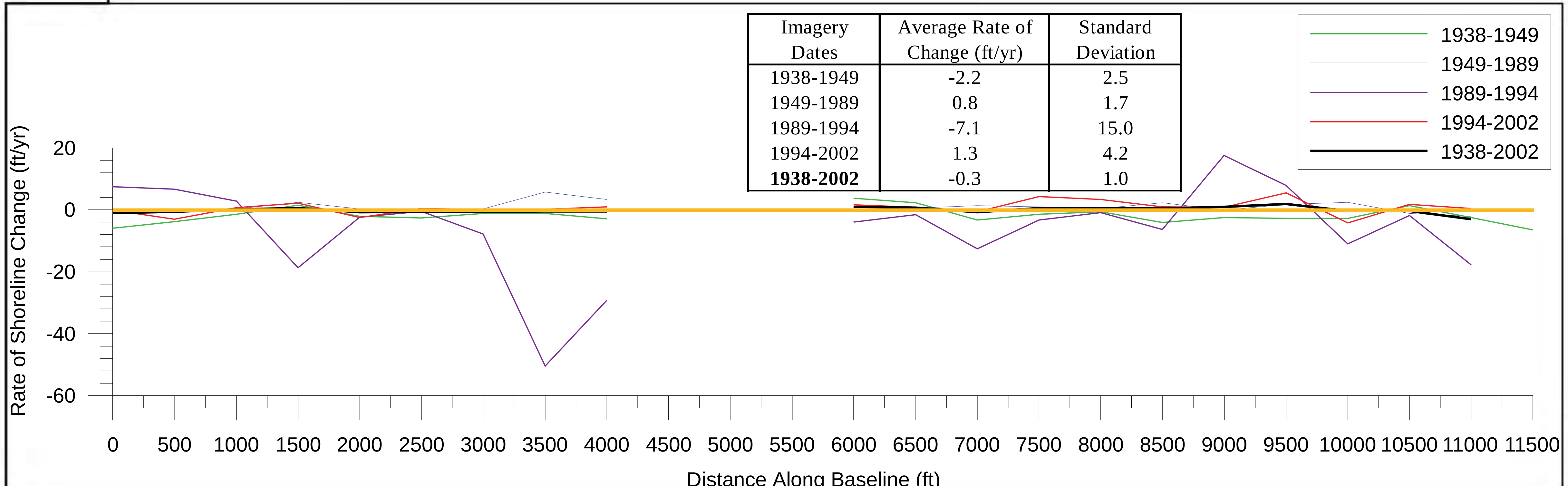
Morphologic Reach II
Savage Neck




**Legend**

- Transect Points
- Baseline
- 2002 Shoreline
- 1994 Shoreline
- 1989 Shoreline
- 1949 Shoreline
- 1938 Shoreline

| Imagery Dates | Average Rate of Change (ft/yr) | Standard Deviation |
|---|---|---|
| 1938-1949 | -2.2 | 2.5 |
| 1949-1989 | 0.8 | 1.7 |
| 1989-1994 | -7.1 | 15.0 |
| 1994-2002 | 1.3 | 4.2 |
| **1938-2002** | -0.3 | 1.0 |

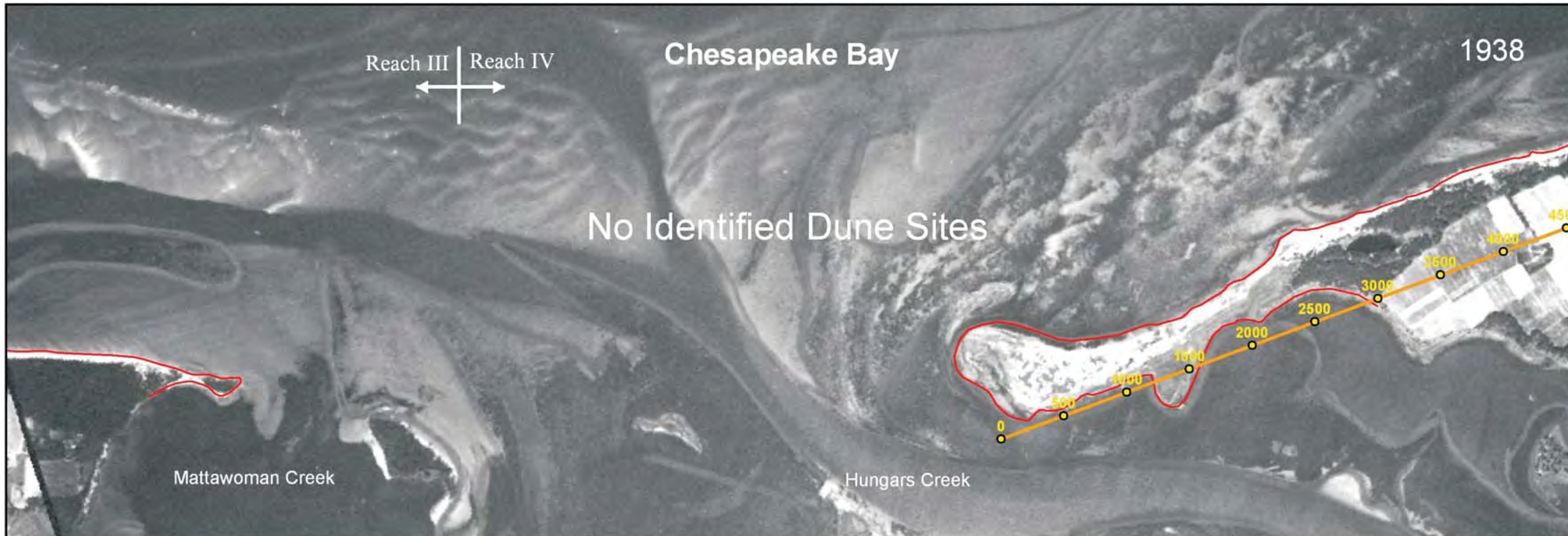



1,000 0 1,000 Feet

# Northampton County

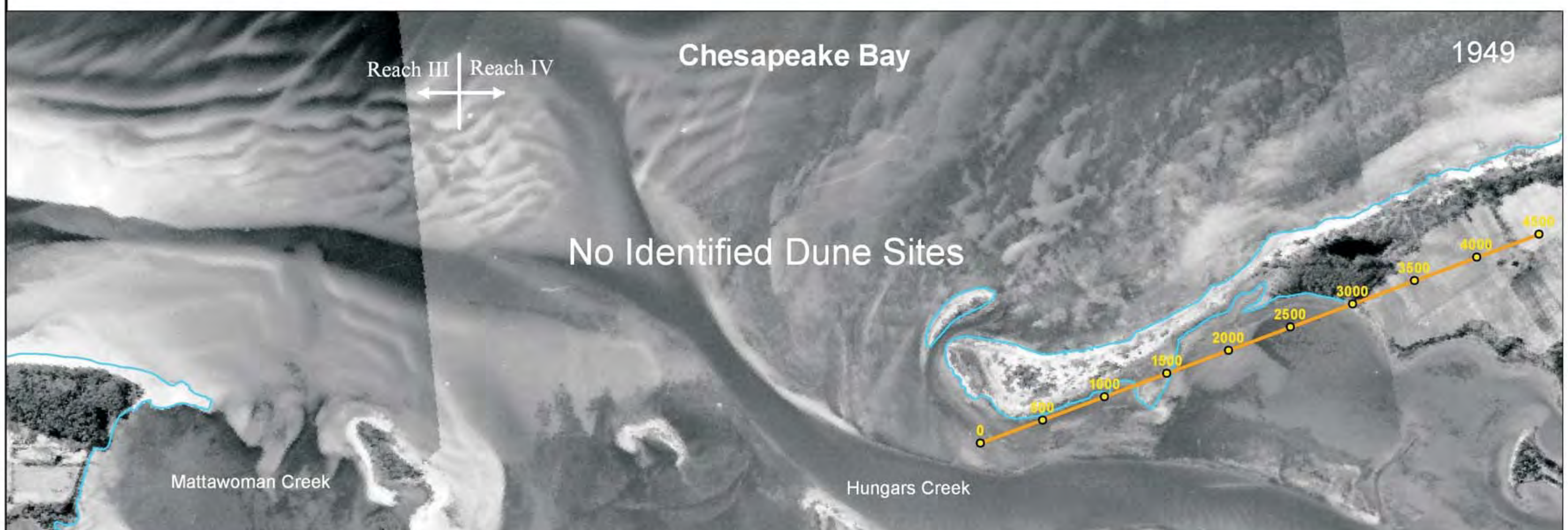
## Plate 11

Morphologic Reach III and IV
Savage Neck to Church Neck



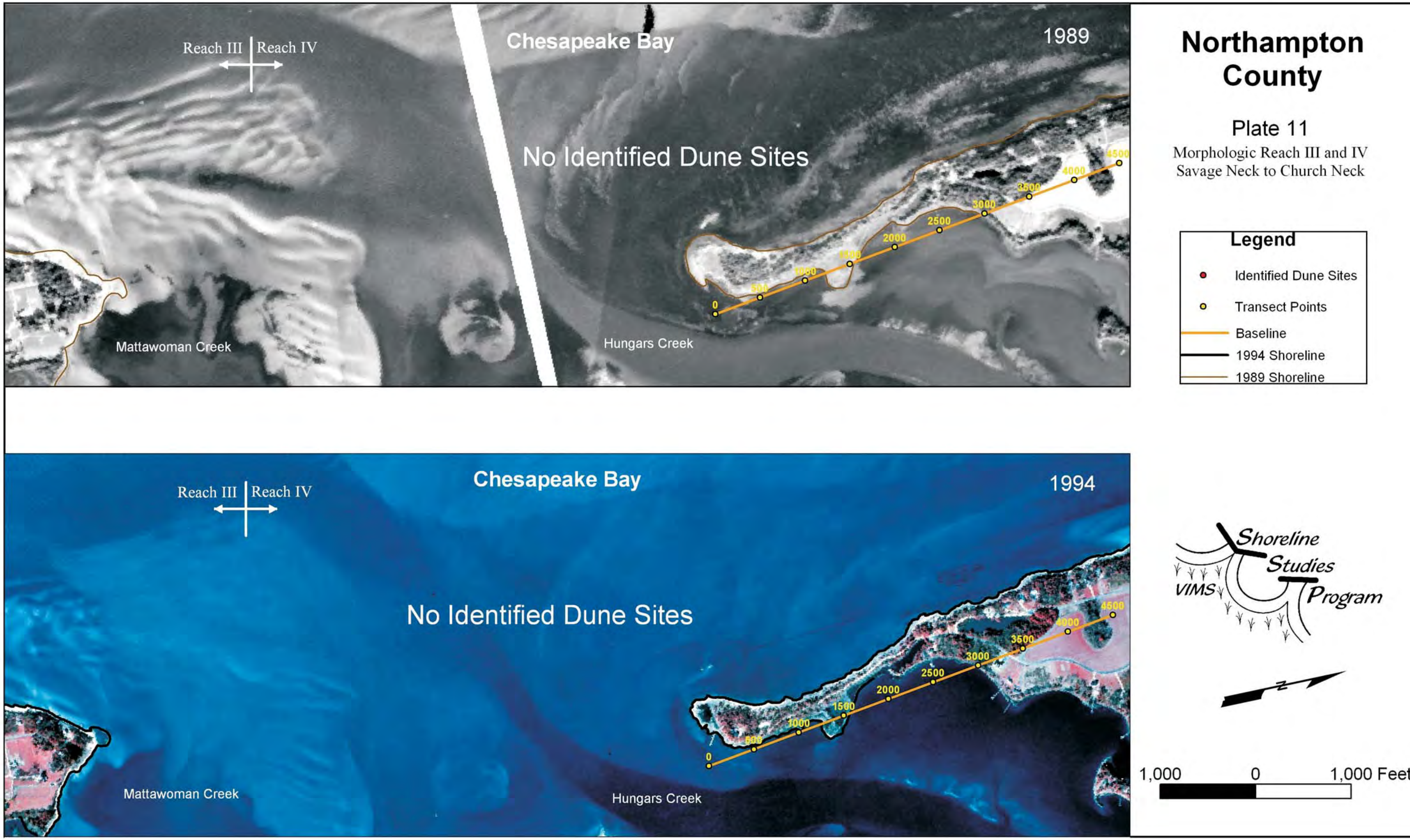

**Legend**

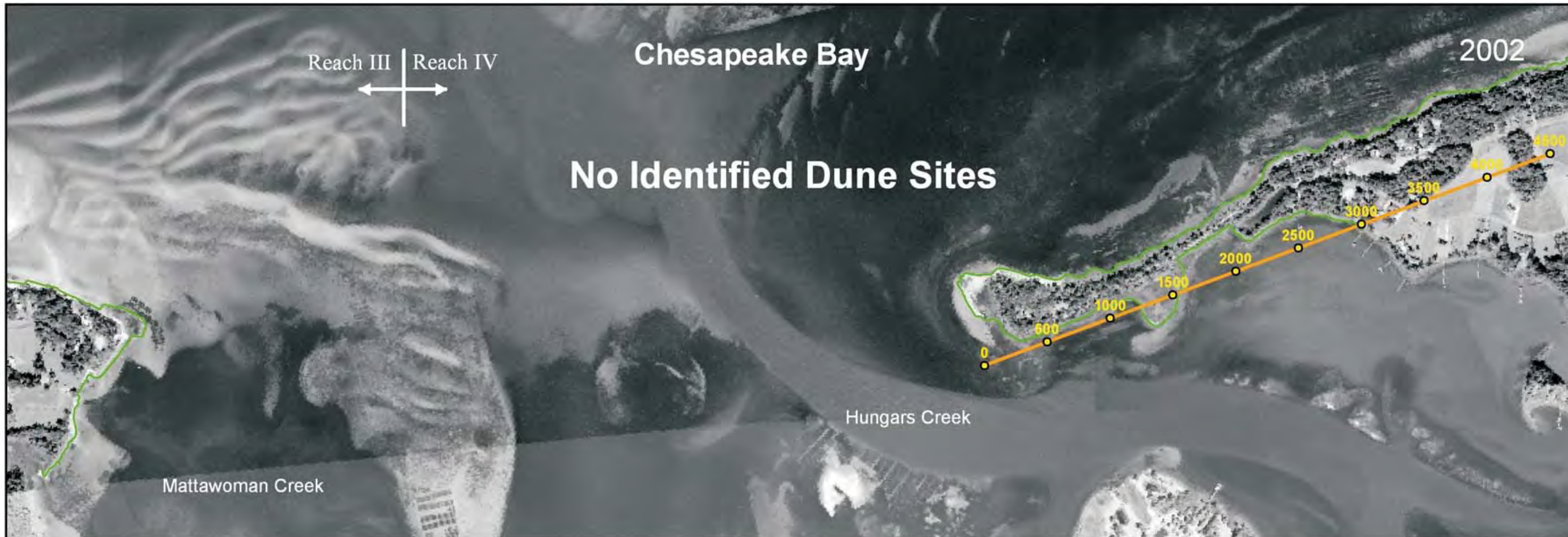
- Identified Dune Sites
- Transect Points
- Baseline
- 1949 Shoreline
- 1938 Shoreline

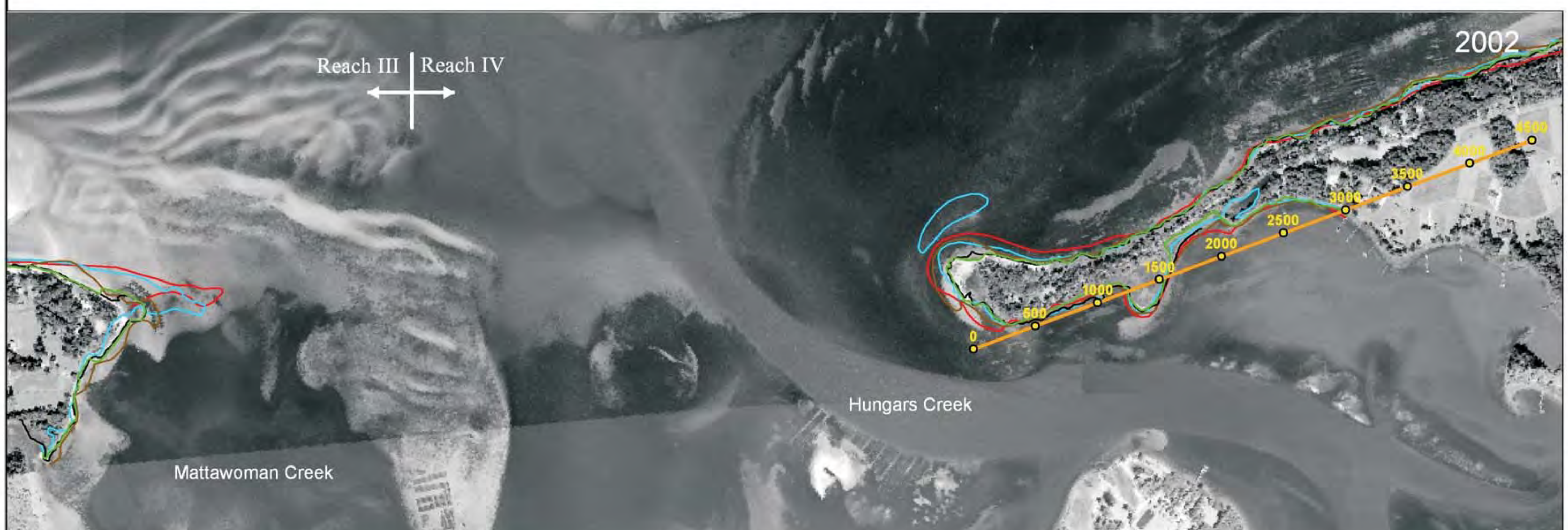



VIMS Shoreline Studies Program

1,000 0 1,000 Feet


Northampton County
Plate 11
Morphologic Reach III and IV
Savage Neck to Church Neck
Legend
Identified Dune Sites
Transect Points
Baseline
1994 Shoreline
1989 Shoreline
Shoreline Studies Program
VIMS
1,000 0 1,000 Feet
Chesapeake Bay
1989
Reach III
Reach IV
No Identified Dune Sites
Mattawoman Creek
Hungars Creek
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Chesapeake Bay
1994
Reach III
Reach IV
No Identified Dune Sites
Mattawoman Creek
Hungars Creek




# Northampton County

## Plate 11

Morphologic Reach III and IV
Savage Neck to Church Neck

**Legend**

- Identified Dune Sites
- Transect Points
- Dune Site Limits
- Baseline
- 2002 Shoreline
- 1994 Shoreline
- 1989 Shoreline
- 1949 Shoreline
- 1938 Shoreline

VIMS Shoreline Studies Program

1,000 0 1,000 Feet

# Northampton County

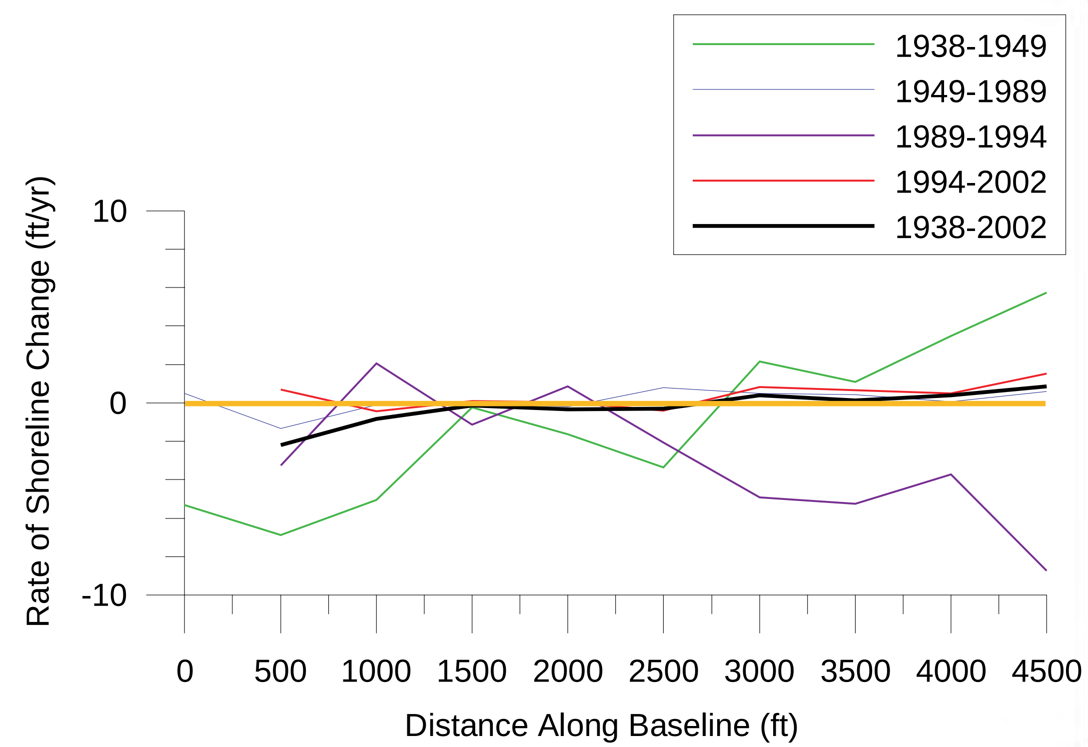
## Plate 11

Morphologic Reach III and IV
Savage Neck to Church Neck


**Legend**

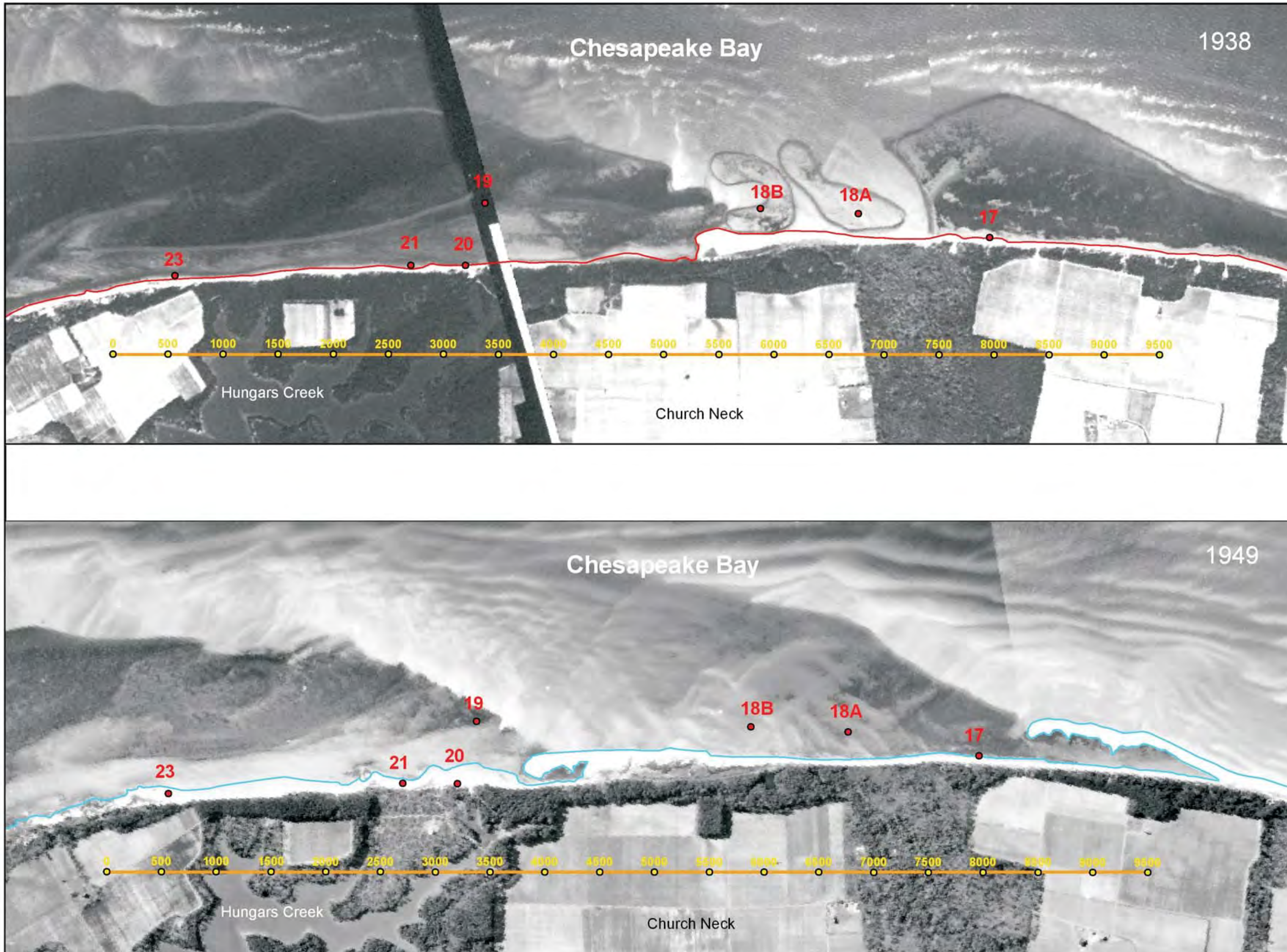
- Transect Points
- Baseline
- 2002 Shoreline
- 1994 Shoreline
- 1989 Shoreline
- 1949 Shoreline
- 1938 Shoreline

| Imagery Dates | Average Rate of Change (ft/yr) | Standard Deviation |
|---|---|---|
| 1938-1949 | -1.0 | 4.2 |
| 1949-1989 | 0.1 | 0.6 |
| 1989-1994 | -2.9 | 3.3 |
| 1994-2002 | 0.4 | 0.6 |
| **1938-2002** | -0.2 | 0.9 |




Shoreline Studies Program
VIMS

1,000 0 1,000 Feet




# Northampton County

## Plate 12

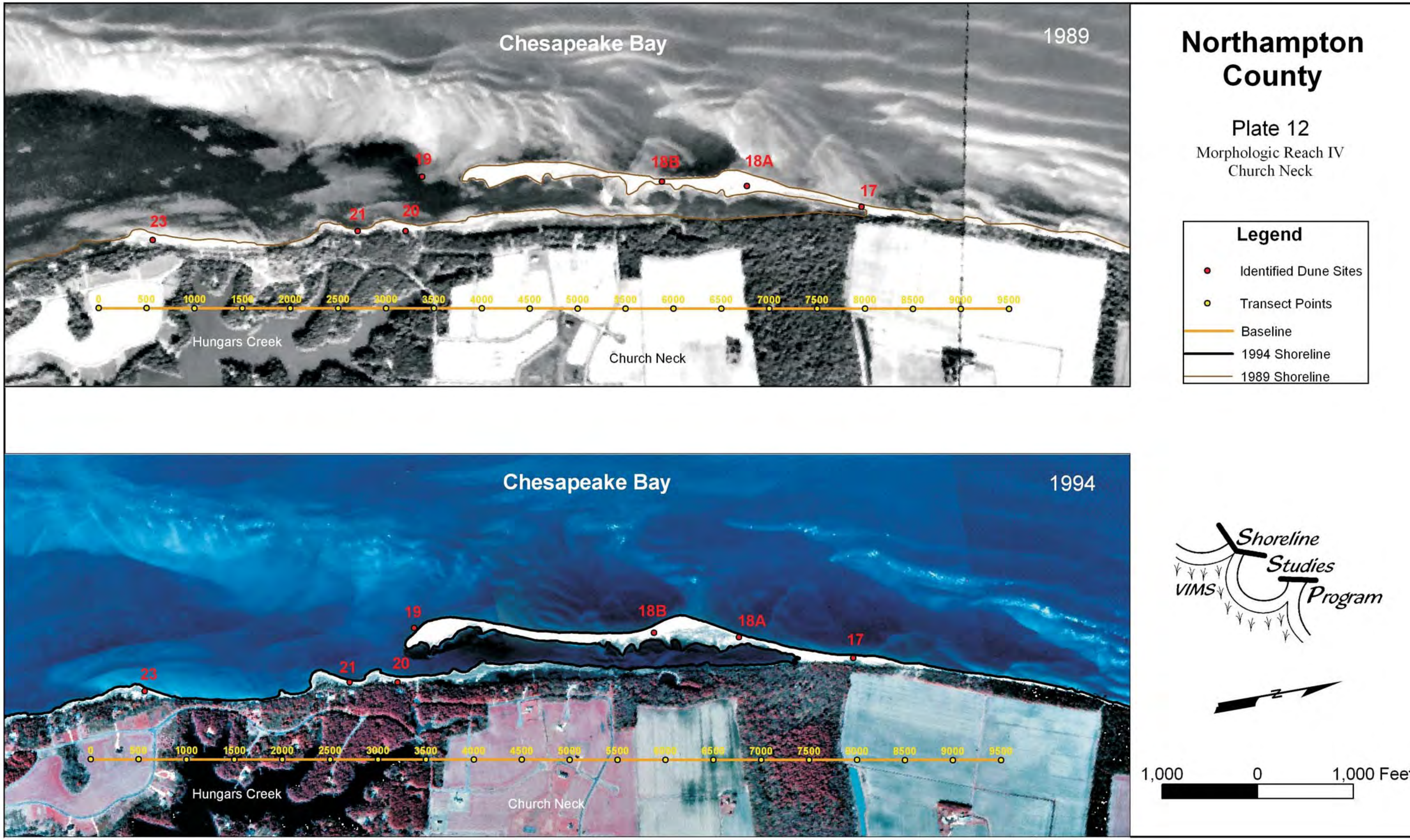
Morphologic Reach IV
Church Neck

**Legend**

- Identified Dune Sites
- Transect Points
- Baseline
- 1949 Shoreline
- 1938 Shoreline

VIMS Shoreline Studies Program

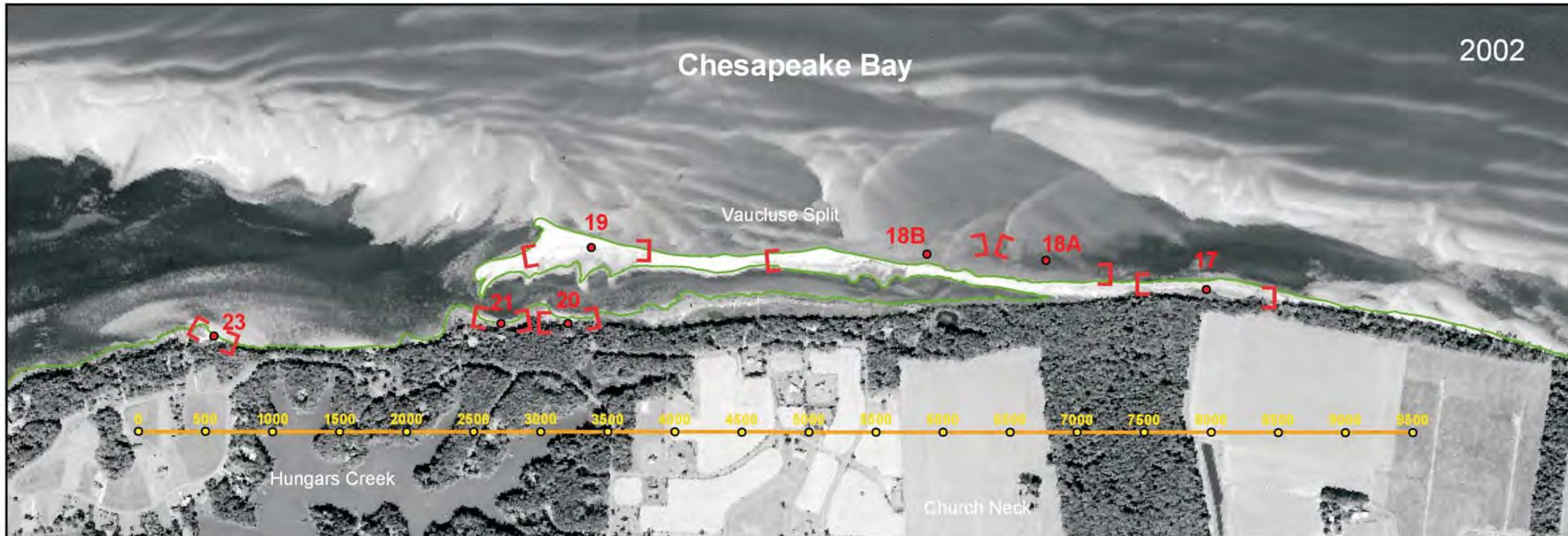
1,000 0 1,000 Feet

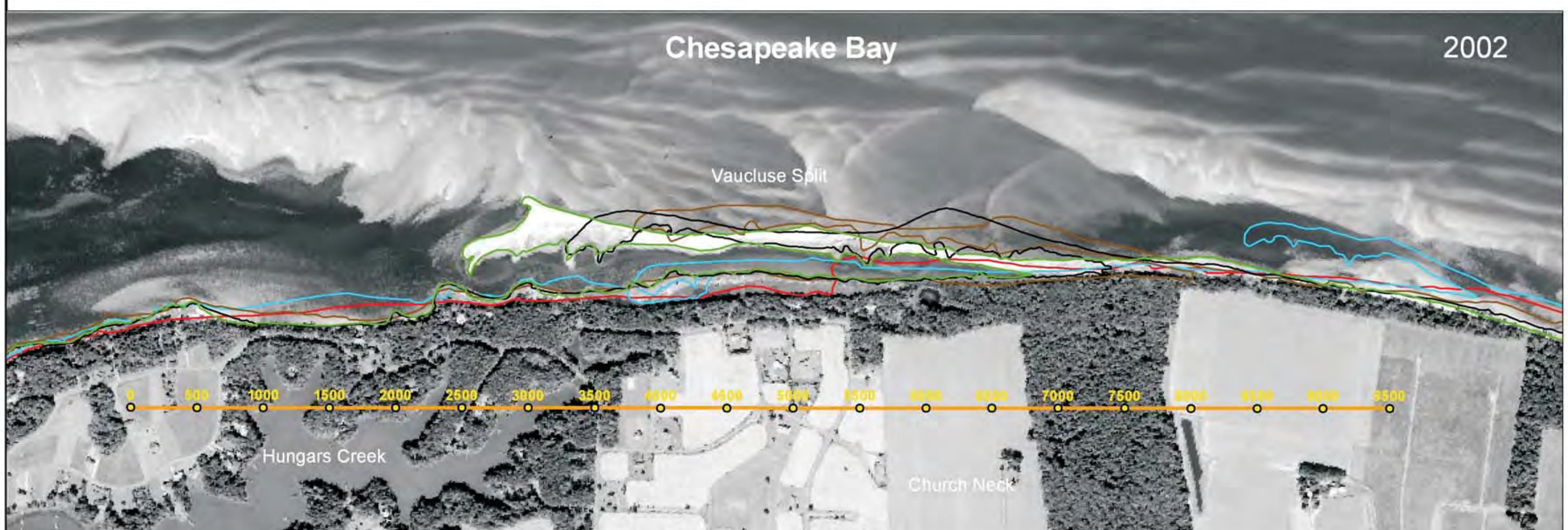

Northampton County
Plate 12
Morphologic Reach IV
Church Neck
Legend
Identified Dune Sites
Transect Points
Baseline
1994 Shoreline
1989 Shoreline
Chesapeake Bay
1989
19
18B
18A
17
23
21
20
0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000 5500 6000 6500 7000 7500 8000 8500 9000 9500
Hungars Creek
Church Neck
Chesapeake Bay
1994
Shoreline Studies Program
VIMS
1,000 0 1,000 Feet

# Northampton County

Plate 12

Morphologic Reach IV
Church Neck




**Legend**

- Identified Dune Sites
- Transect Points
- Dune Site Limits
- Baseline
- 2002 Shoreline
- 1994 Shoreline
- 1989 Shoreline
- 1949 Shoreline
- 1938 Shoreline

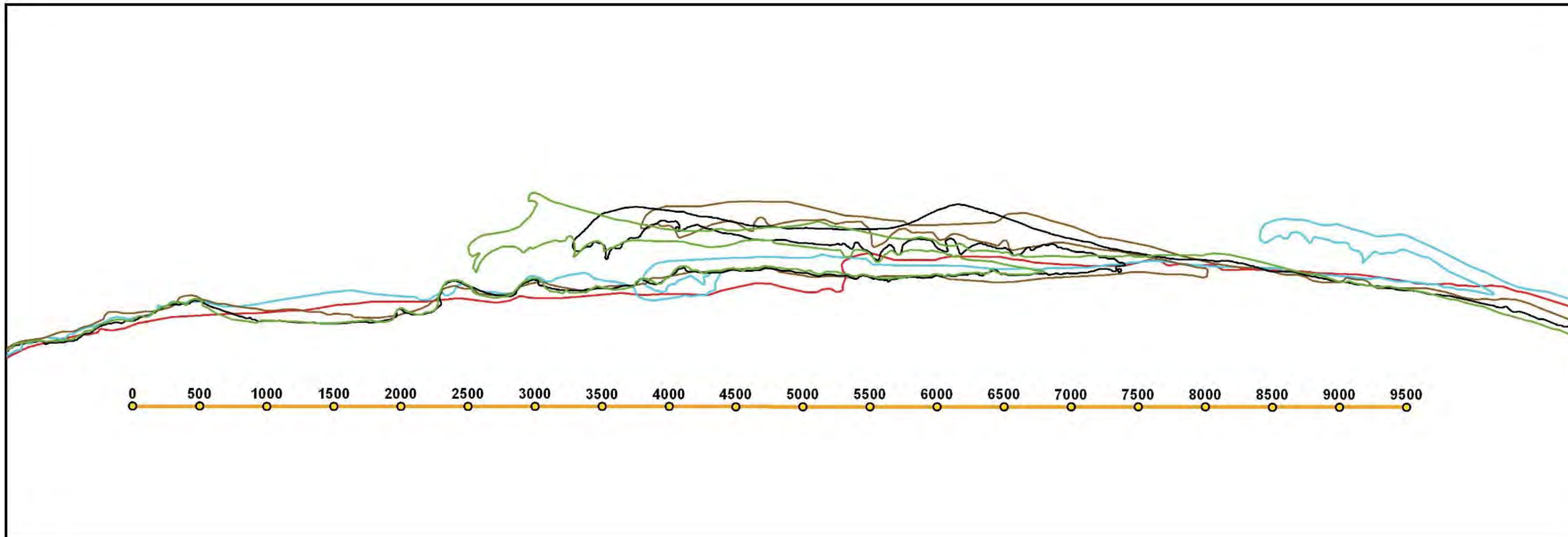
VIMS Shoreline Studies Program

1,000 0 1,000 Feet

# Northampton County

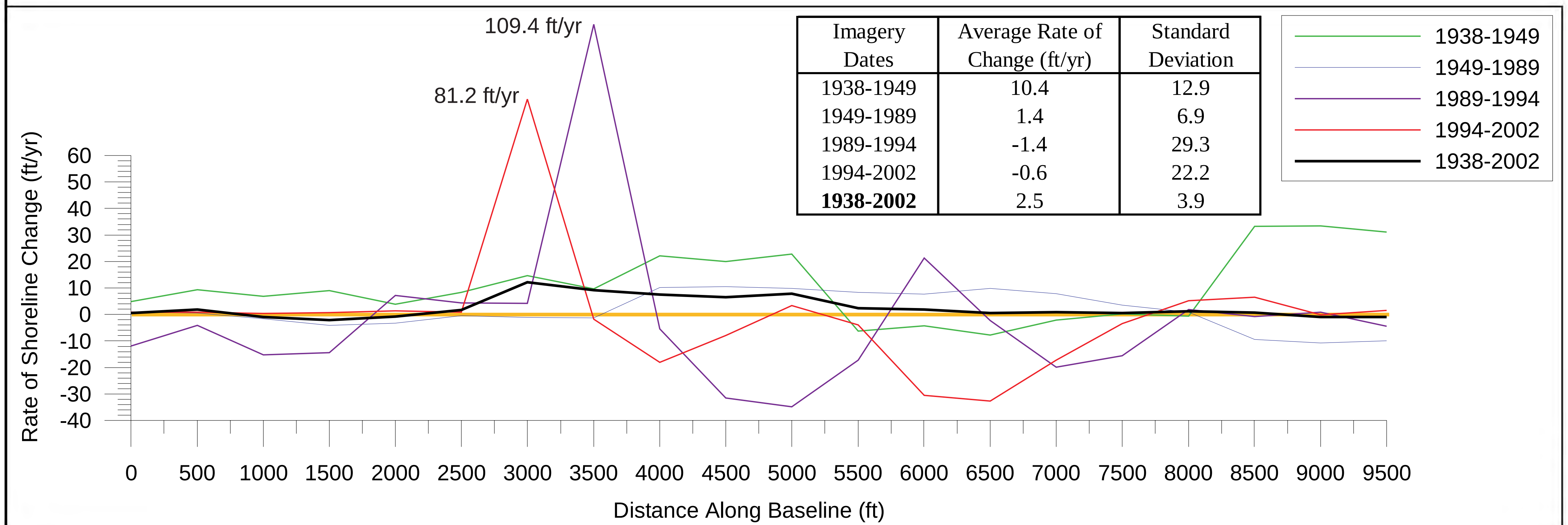
## Plate 12

Morphologic Reach IV
Church Neck



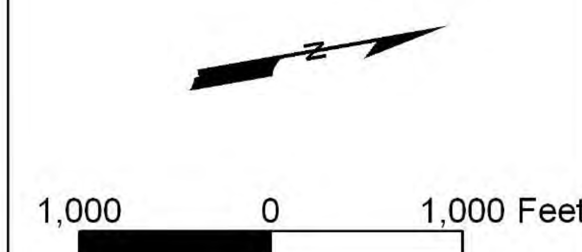

**Legend**

- Transcect Points
- Baseline
- 2002 Shoreline
- 1994 Shoreline
- 1989 Shoreline
- 1949 Shoreline
- 1938 Shoreline




| Imagery Dates | Average Rate of Change (ft/yr) | Standard Deviation |
|---|---|---|
| 1938-1949 | 10.4 | 12.9 |
| 1949-1989 | 1.4 | 6.9 |
| 1989-1994 | -1.4 | 29.3 |
| 1994-2002 | -0.6 | 22.2 |
| **1938-2002** | 2.5 | 3.9 |

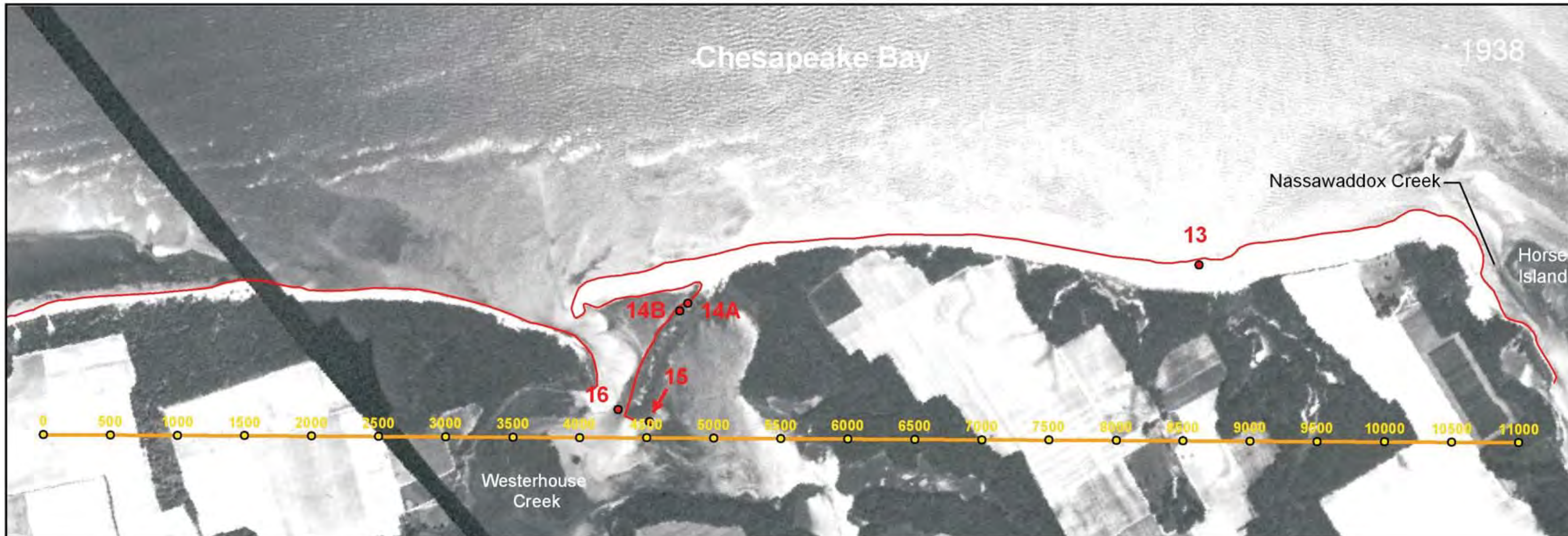
Shoreline Studies Program
VIMS



# Northampton County

## Plate 13

Morphologic Reach IV
Church Neck





**Legend**

- Identified Dune Sites
- Transect Points
- Baseline
- 1949 Shoreline
- 1938 Shoreline

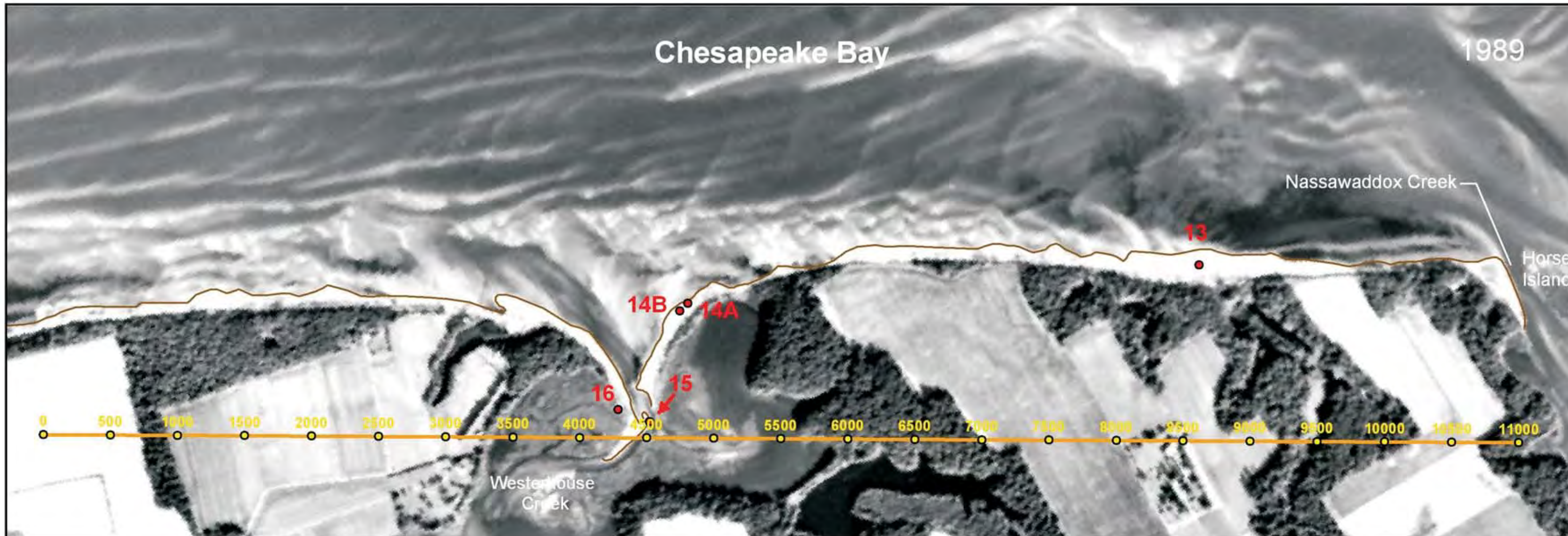
VIMS Shoreline Studies Program

1,000 0 1,000 Feet

# Northampton County

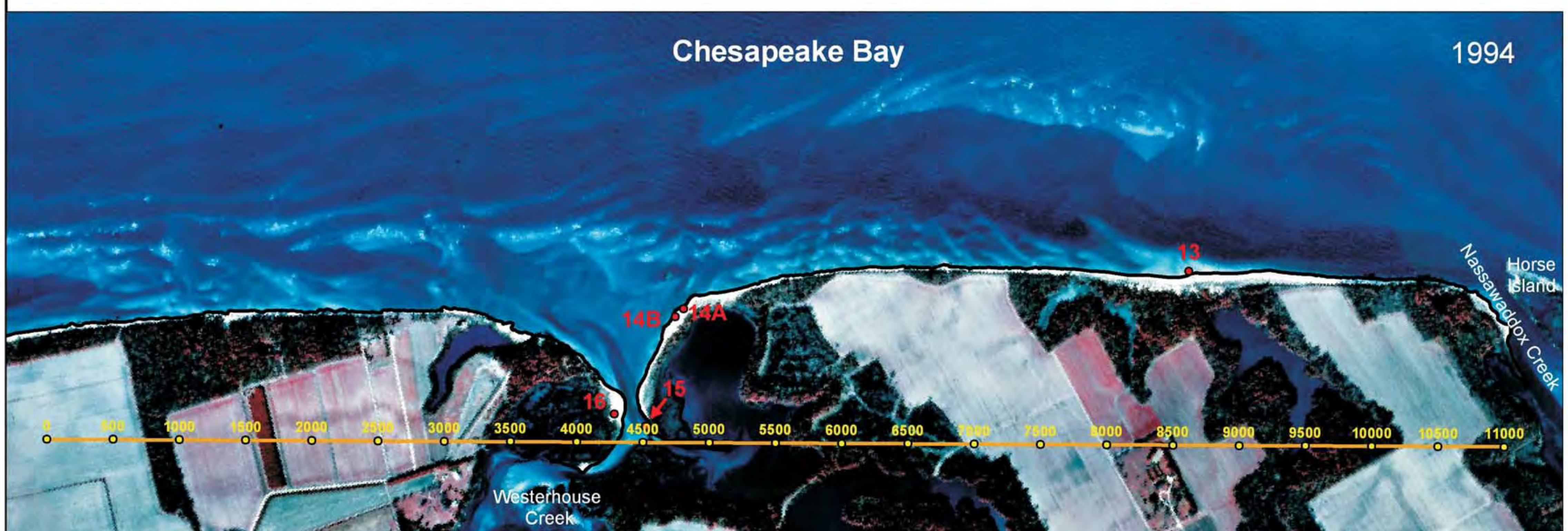
## Plate 13

Morphologic Reach IV
Church Neck




**Legend**

- Identified Dune Sites
- Transect Points
- Baseline
- 1994 Shoreline
- 1989 Shoreline

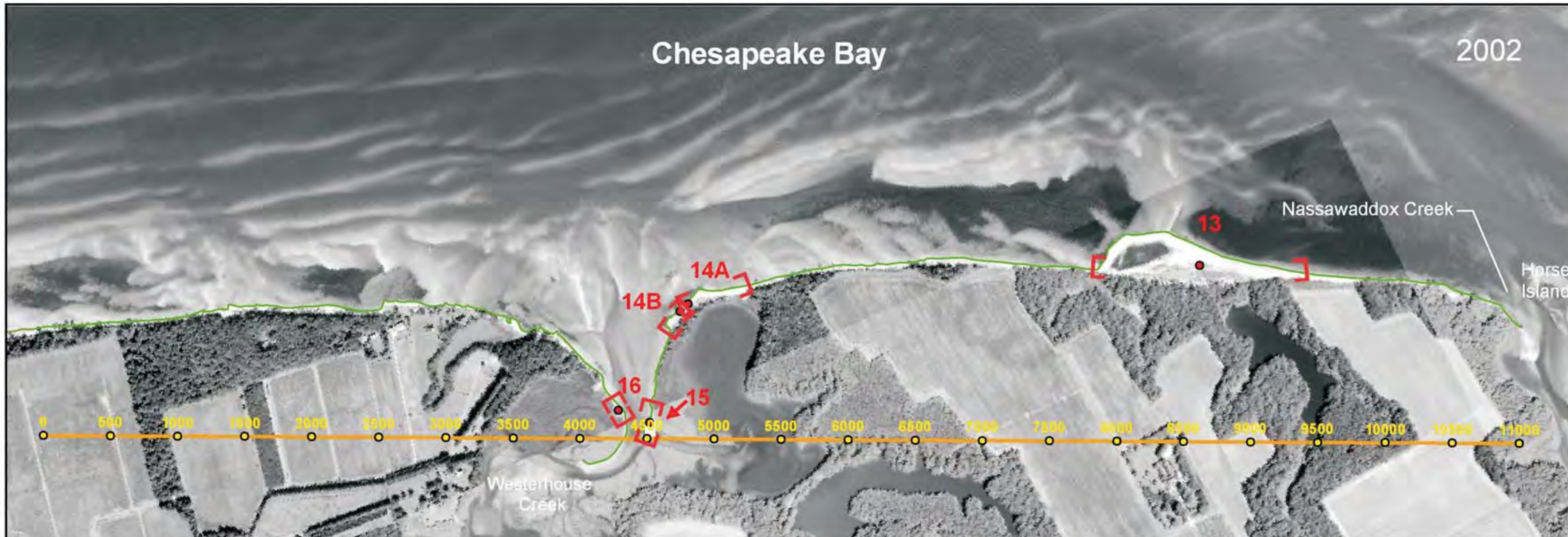


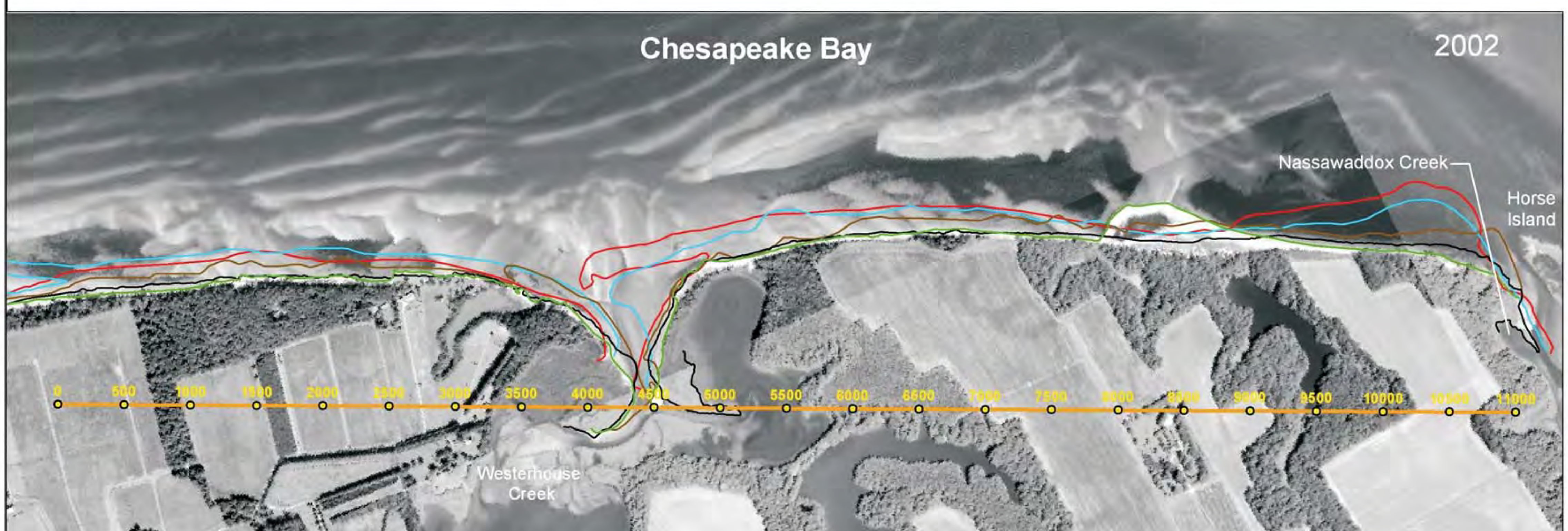

1,000 0 1,000 Feet

# Northampton County

## Plate 13

Morphologic Reach IV
Church Neck




**Legend**

- Identified Dune Sites
- Transect Points
- Dune Site Limits
- Baseline
- 2002 Shoreline
- 1994 Shoreline
- 1989 Shoreline
- 1949 Shoreline
- 1938 Shoreline

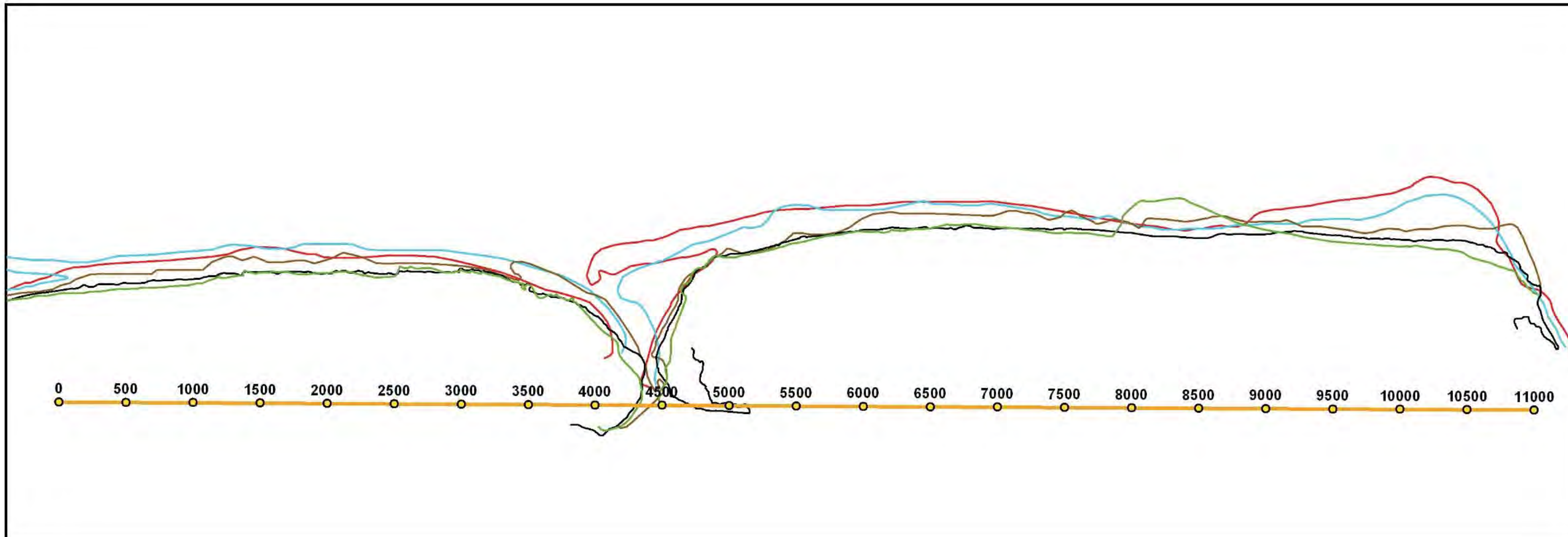
VIMS Shoreline Studies Program

1,000 0 1,000 Feet

# Northampton County

## Plate 13

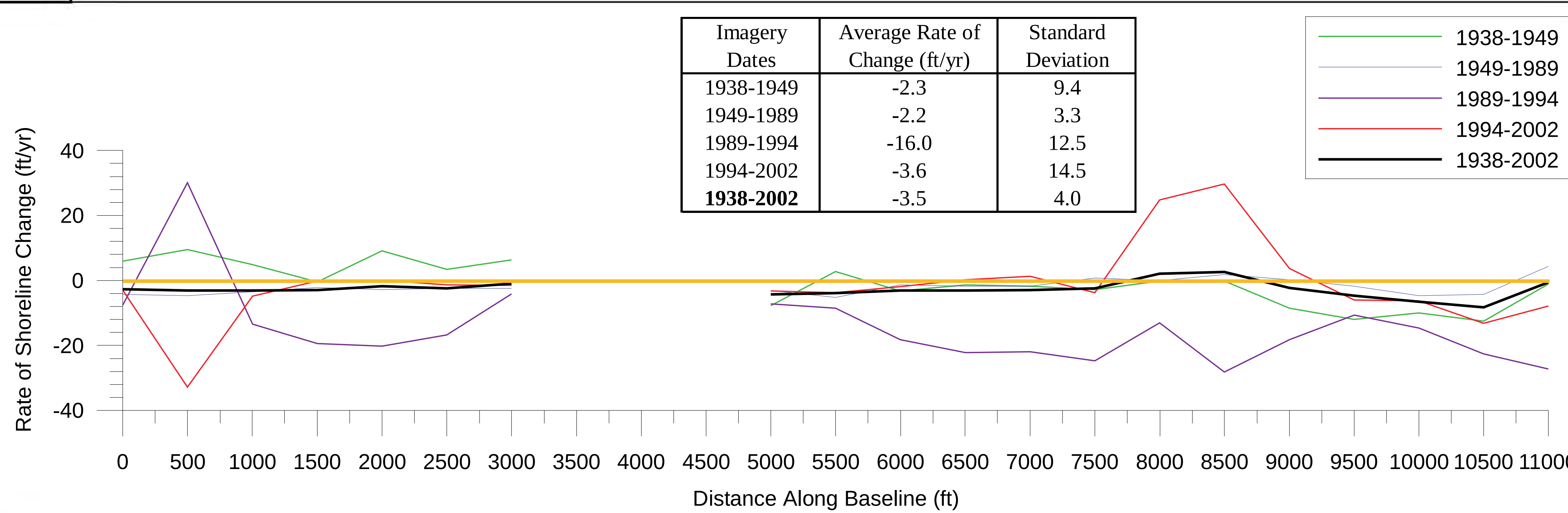
Morphologic Reach IV
Church Neck




**Legend**

- Transcect Points
- Baseline
- 2002 Shoreline
- 1994 Shoreline
- 1989 Shoreline
- 1949 Shoreline
- 1938 Shoreline

| Imagery Dates | Average Rate of Change (ft/yr) | Standard Deviation |
|---|---|---|
| 1938-1949 | -2.3 | 9.4 |
| 1949-1989 | -2.2 | 3.3 |
| 1989-1994 | -16.0 | 12.5 |
| 1994-2002 | -3.6 | 14.5 |
| **1938-2002** | -3.5 | 4.0 |



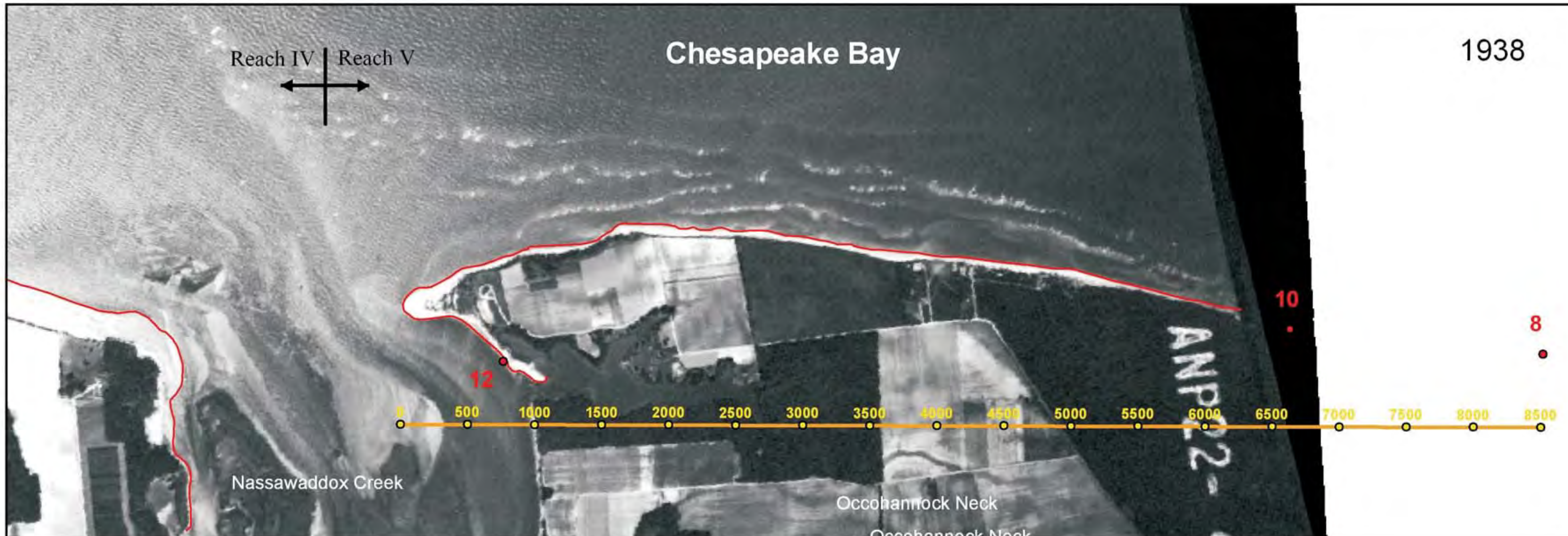

Shoreline Studies Program
VIMS

1,000 0 1,000 Feet

# Northampton County

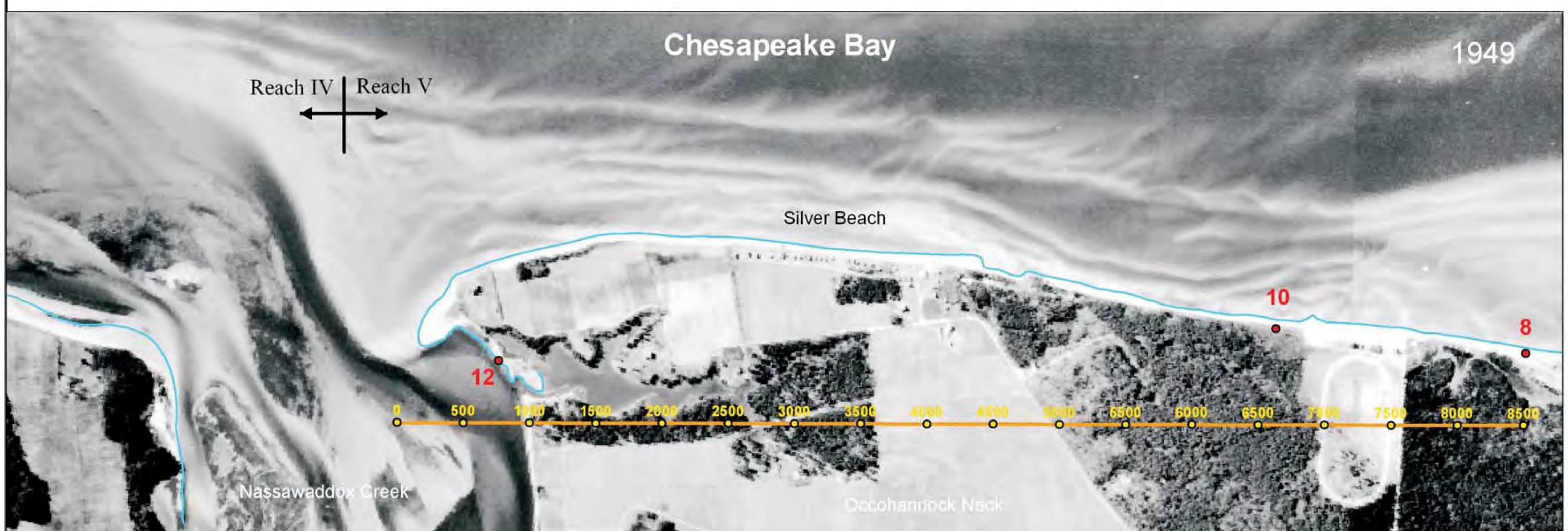
Plate 14

Morphologic Reach IV and V
Church Neck to Occohannock Neck




**Legend**

- Identified Dune Sites
- Transect Points
- Baseline
- 1949 Shoreline
- 1938 Shoreline




Shoreline Studies Program
VIMS

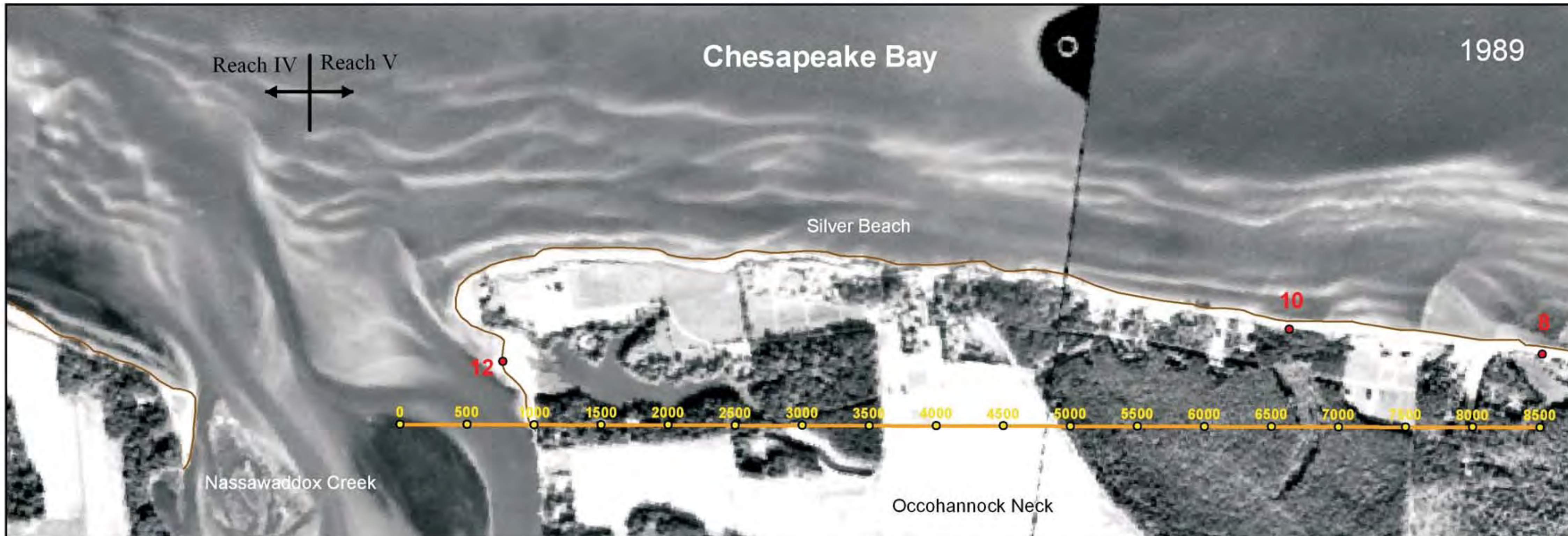
N

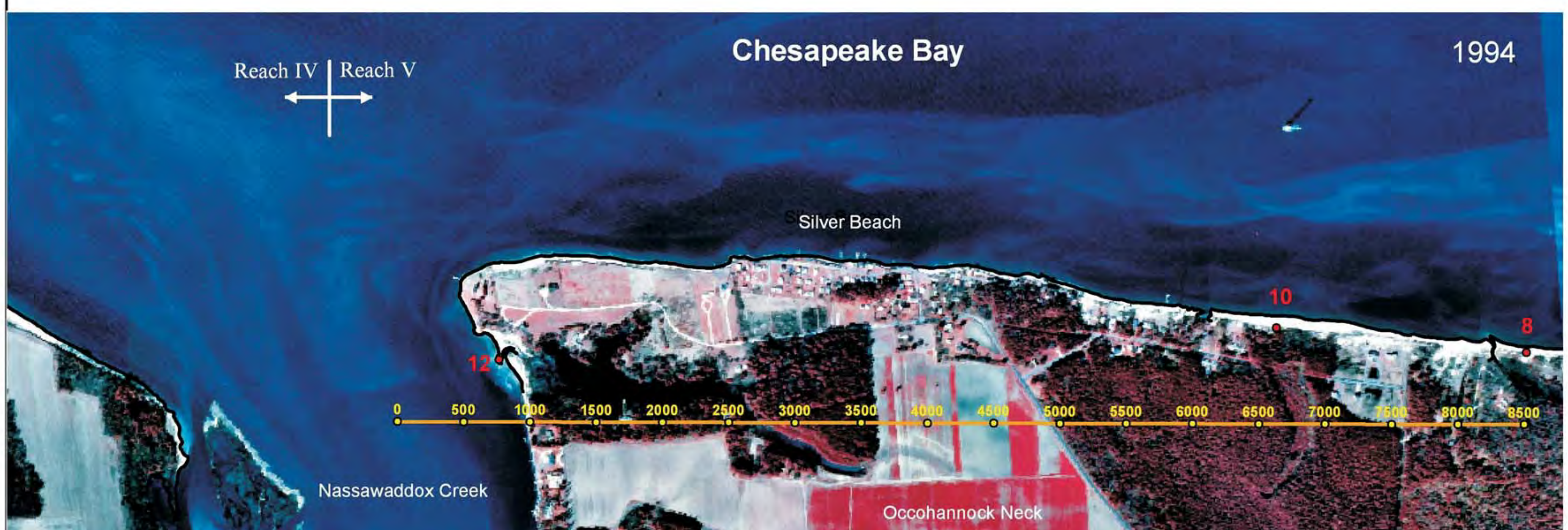
1,000 0 1,000 Feet

# Northampton County

## Plate 14

Morphologic Reach IV and V
Church Neck to Occohannock Neck



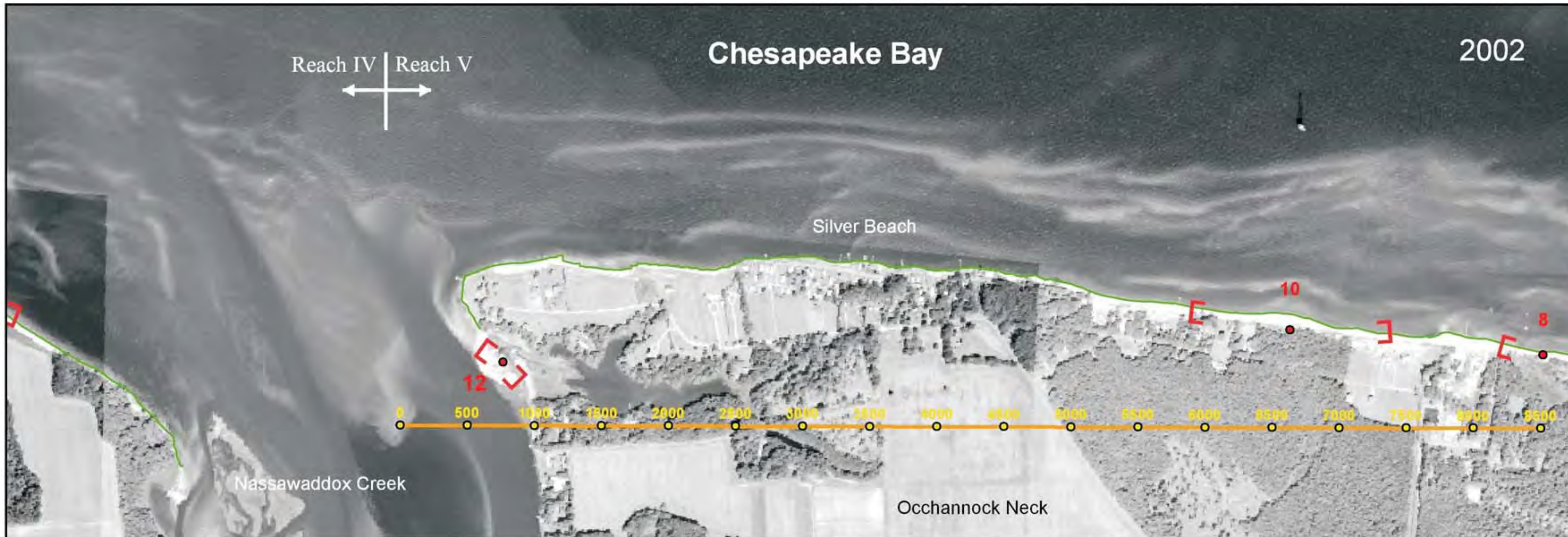



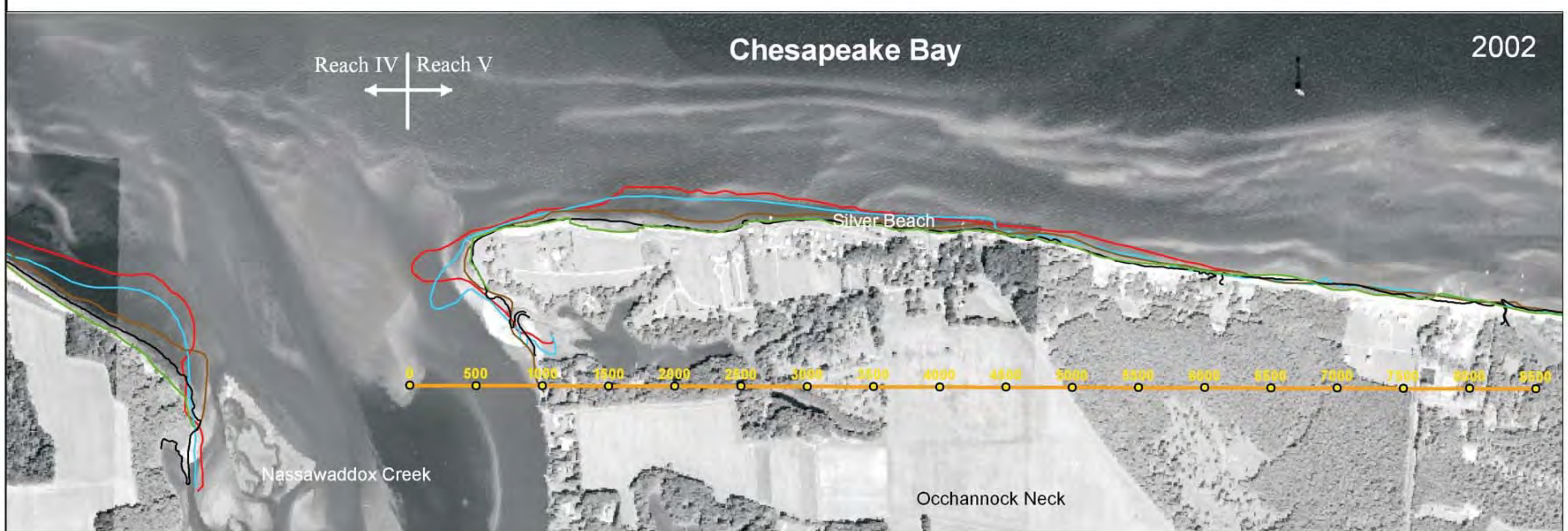

**Legend**

- Identified Dune Sites
- Transect Points
- Baseline
- 1994 Shoreline
- 1989 Shoreline

Shoreline Studies Program
VIMS

1,000 0 1,000 Feet




# Northampton County

## Plate 14

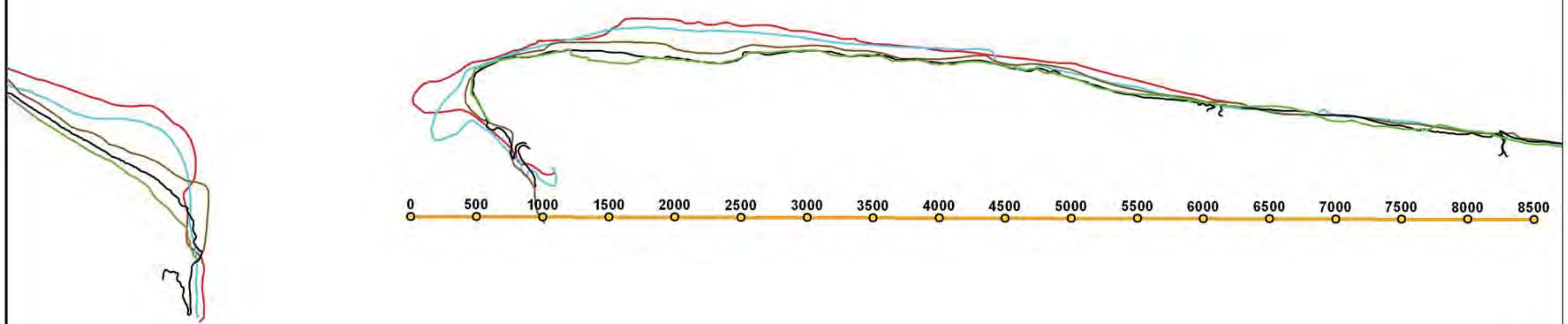
Morphologic Reach IV and V
Church Neck to Occohannock Neck

**Legend**

- Identified Dune Sites
- Transect Points
- Dune Site Limits
- Baseline
- 2002 Shoreline
- 1994 Shoreline
- 1989 Shoreline
- 1949 Shoreline
- 1938 Shoreline

VIMS Shoreline Studies Program

1,000 0 1,000 Feet




# Northampton County

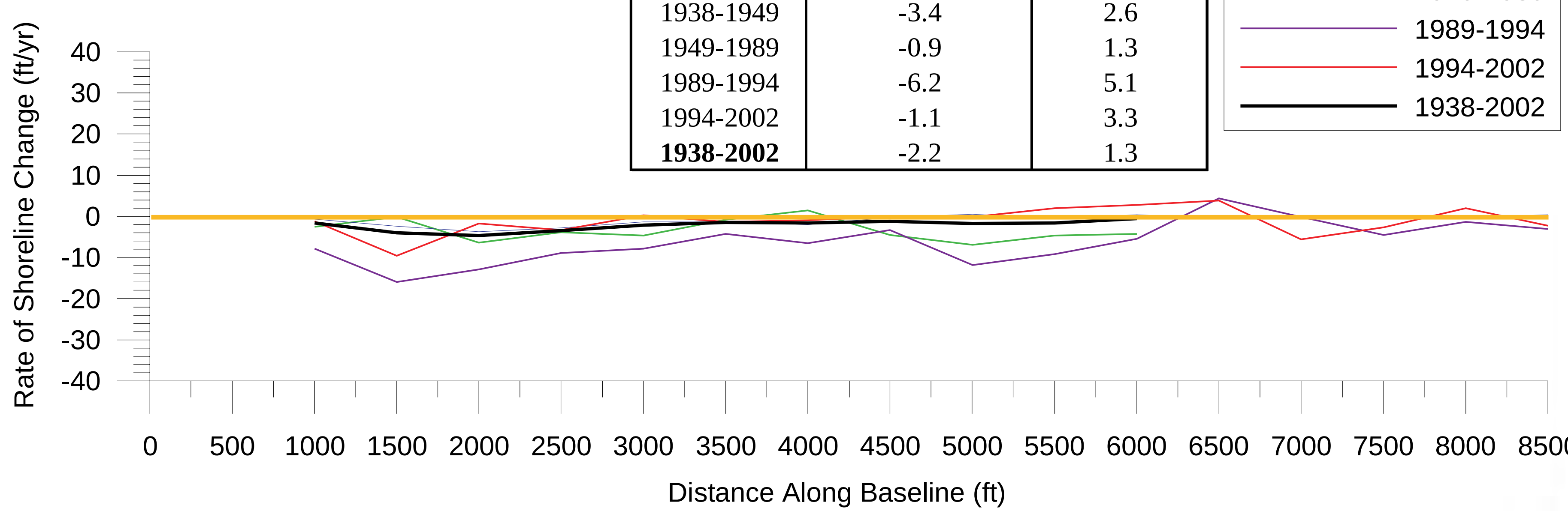
## Plate 14

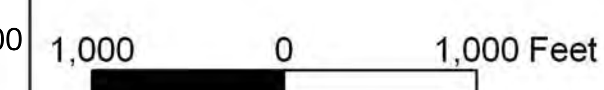
Morphologic Reach IV and V
Church Neck to Occohannock Neck

**Legend**

- Transect Points
- Baseline
- 2002 Shoreline
- 1994 Shoreline
- 1989 Shoreline
- 1949 Shoreline
- 1938 Shoreline

| Imagery Dates | Average Rate of Change (ft/yr) | Standard Deviation |
|---|---|---|
| 1938-1949 | -3.4 | 2.6 |
| 1949-1989 | -0.9 | 1.3 |
| 1989-1994 | -6.2 | 5.1 |
| 1994-2002 | -1.1 | 3.3 |
| **1938-2002** | -2.2 | 1.3 |



# Northampton County

## Plate 15

Morphologic Reach V
Occohannock Neck

1938

**No Data Available**


**Legend**

- Identified Dune Sites
- Transect Points
- Baseline
- 1949 Shoreline
- 1938 Shoreline

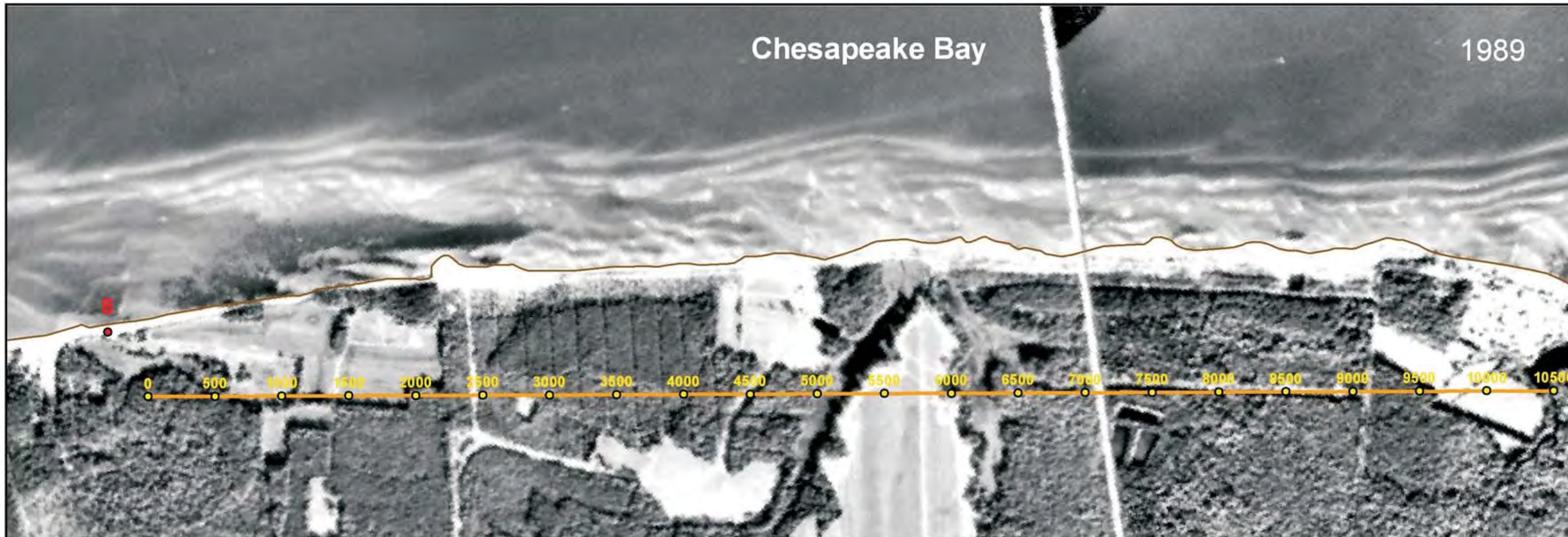
Shoreline Studies Program
VIMS

1,000 0 1,000 Feet

# Northampton County

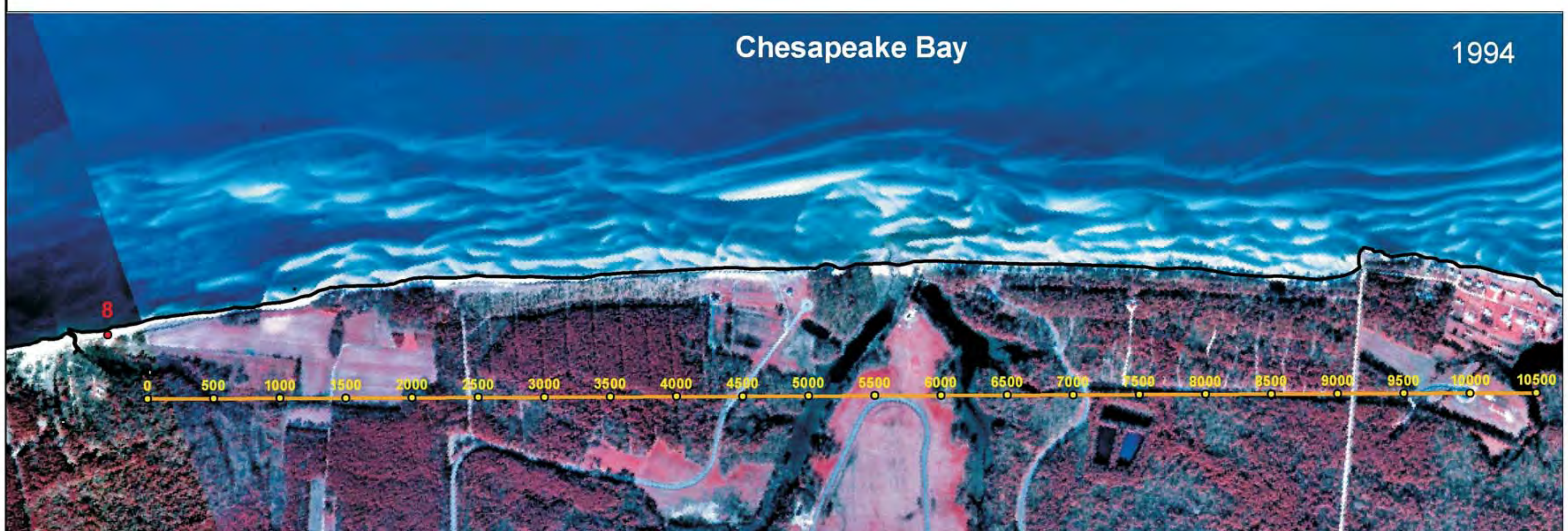
## Plate 15

Morphologic Reach V
Occohannock Neck



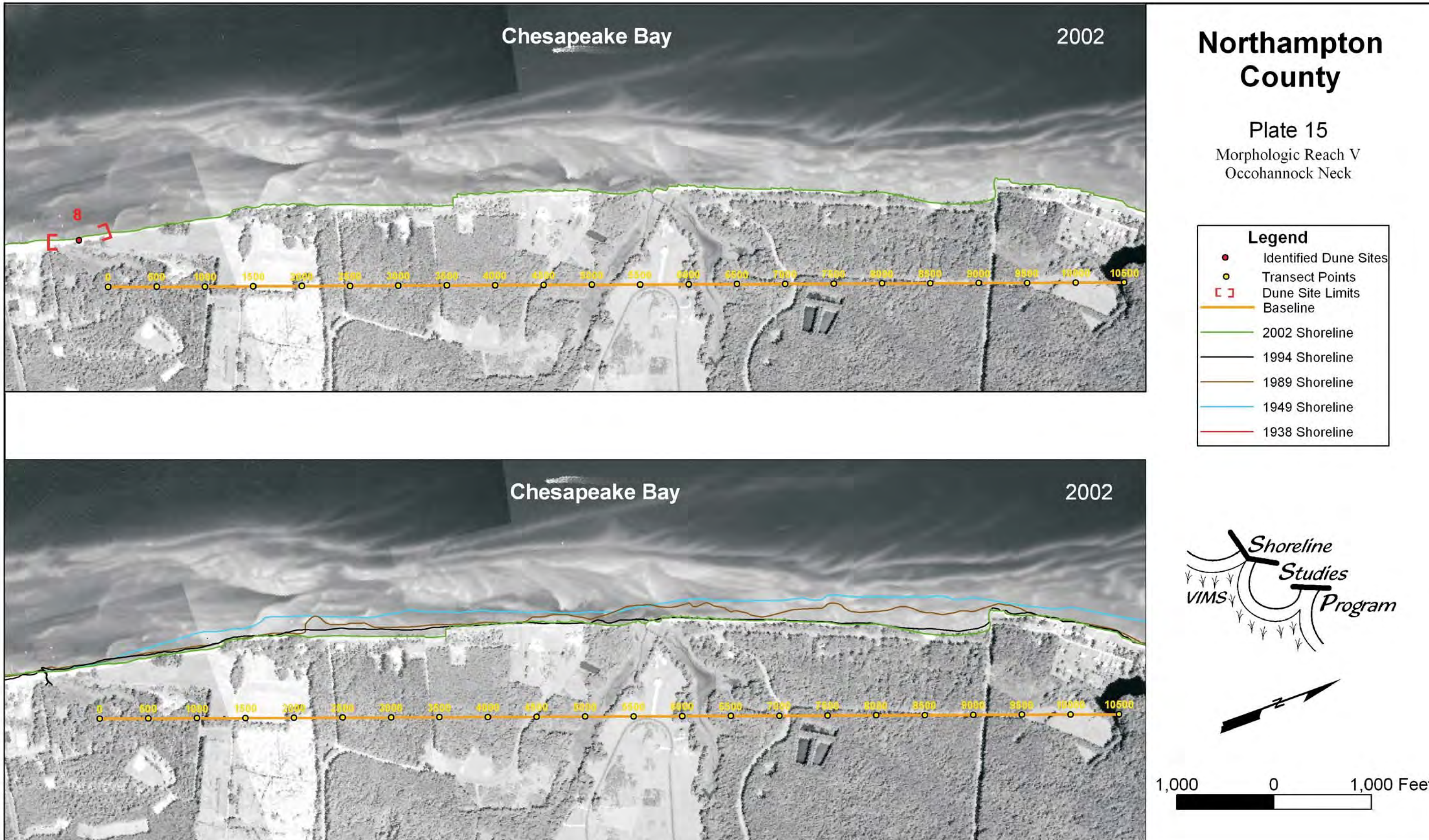

**Legend**

- Identified Dune Sites
- Transect Points
- Baseline
- 1994 Shoreline
- 1989 Shoreline




Shoreline Studies Program
VIMS

1,000 0 1,000 Feet


Chesapeake Bay
2002
8
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
7500
8000
8500
9000
9500
10000
10500
Chesapeake Bay
2002
Northampton County
Plate 15
Morphologic Reach V
Occohannock Neck
Legend
Identified Dune Sites
Transect Points
Dune Site Limits
Baseline
2002 Shoreline
1994 Shoreline
1989 Shoreline
1949 Shoreline
1938 Shoreline
Shoreline Studies Program
VIMS
1,000
0
1,000 Feet

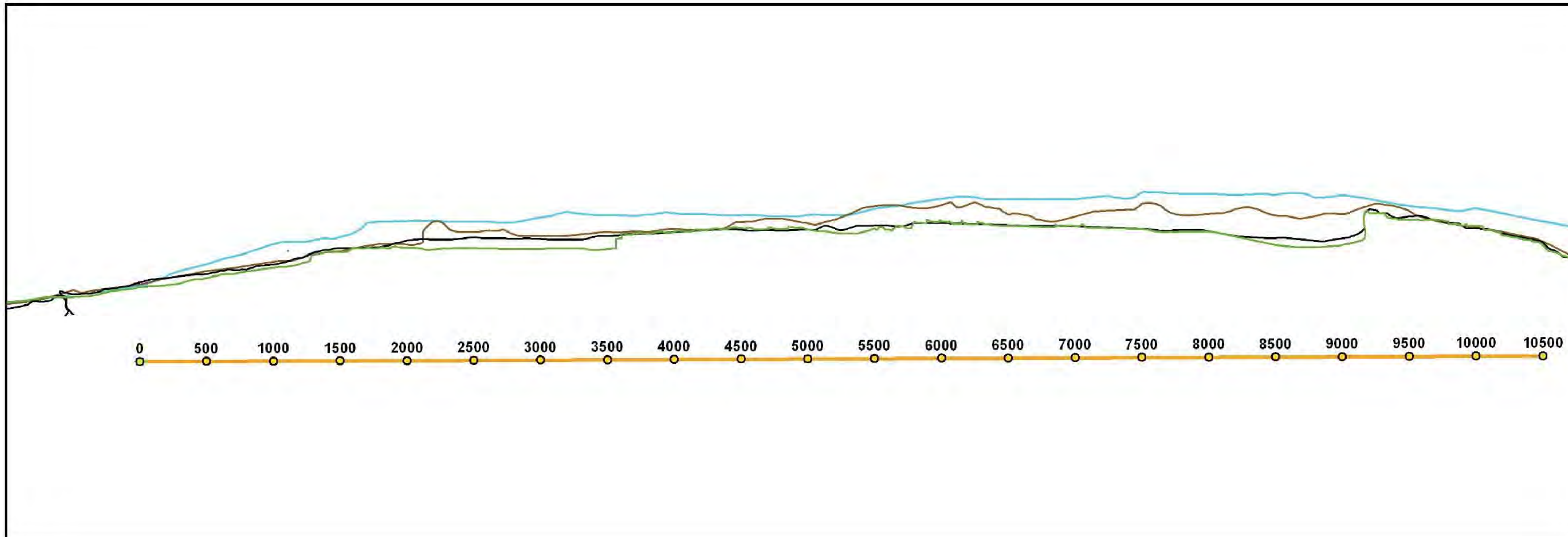
# Northampton County

## Plate 15

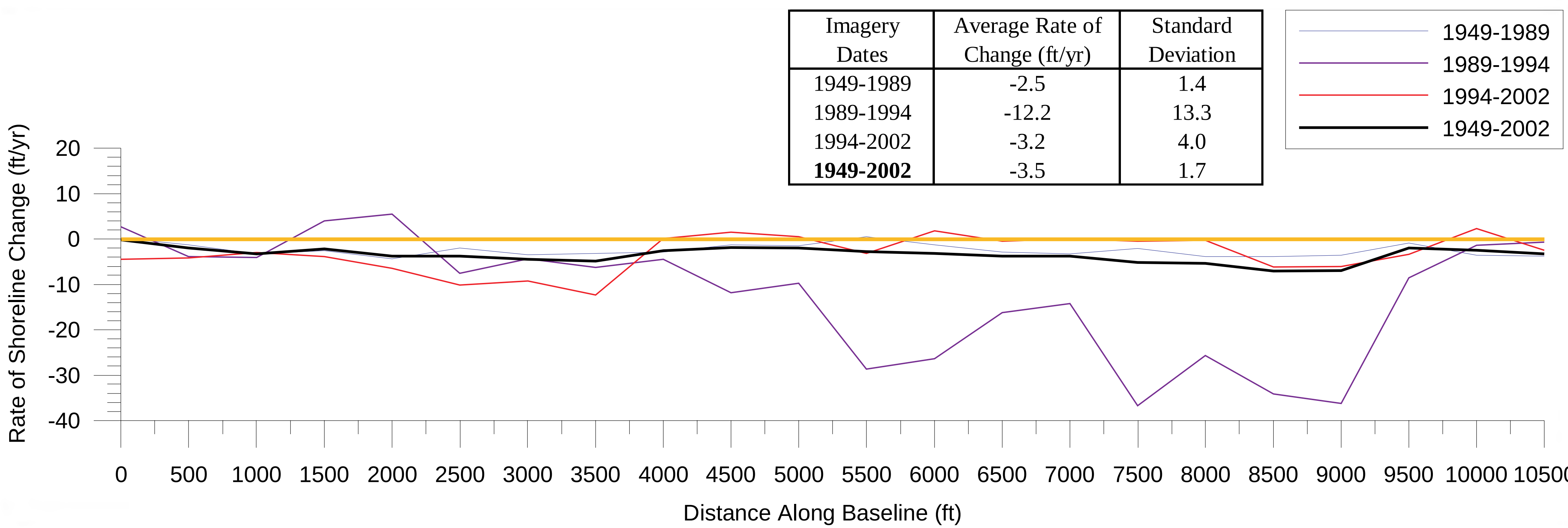
Morphologic Reach V
Occohannock Neck

**Legend**

- Transect Points
- Baseline
- 2002 Shoreline
- 1994 Shoreline
- 1989 Shoreline
- 1949 Shoreline
- 1938 Shoreline




| Imagery Dates | Average Rate of Change (ft/yr) | Standard Deviation |
|---|---|---|
| 1949-1989 | -2.5 | 1.4 |
| 1989-1994 | -12.2 | 13.3 |
| 1994-2002 | -3.2 | 4.0 |
| **1949-2002** | -3.5 | 1.7 |




Shoreline Studies Program
VIMS

1,000 0 1,000 Feet

# Northampton County

## Plate 16

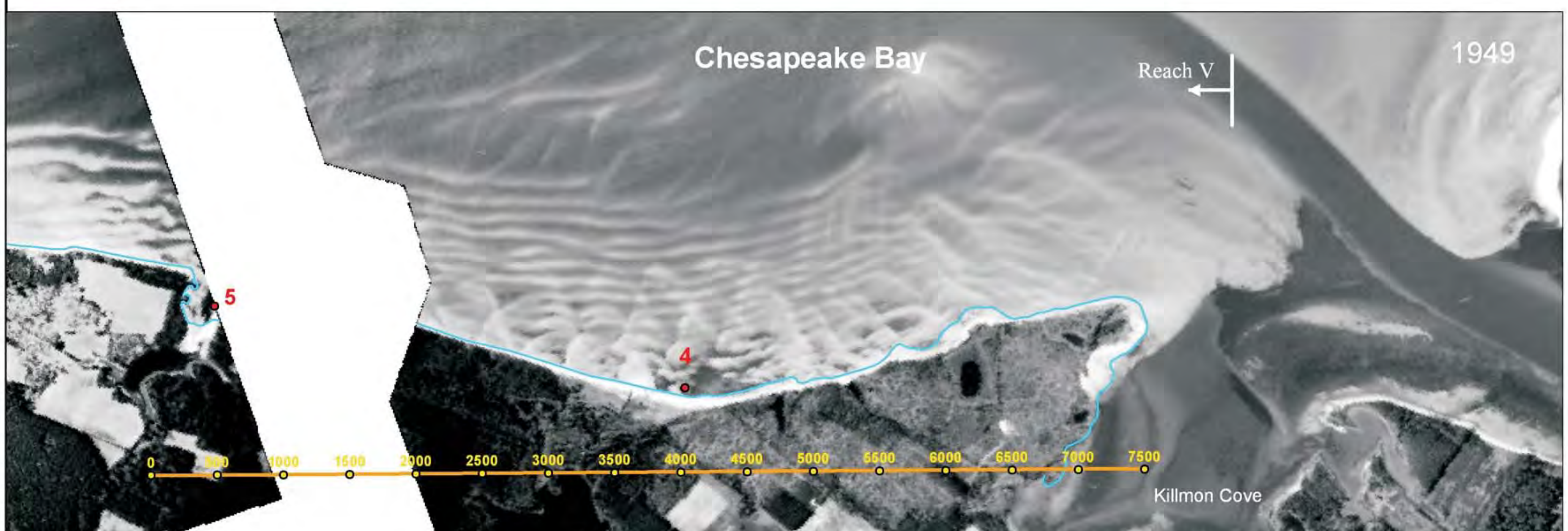
Morphologic Reach V
Occohannock Neck

1938

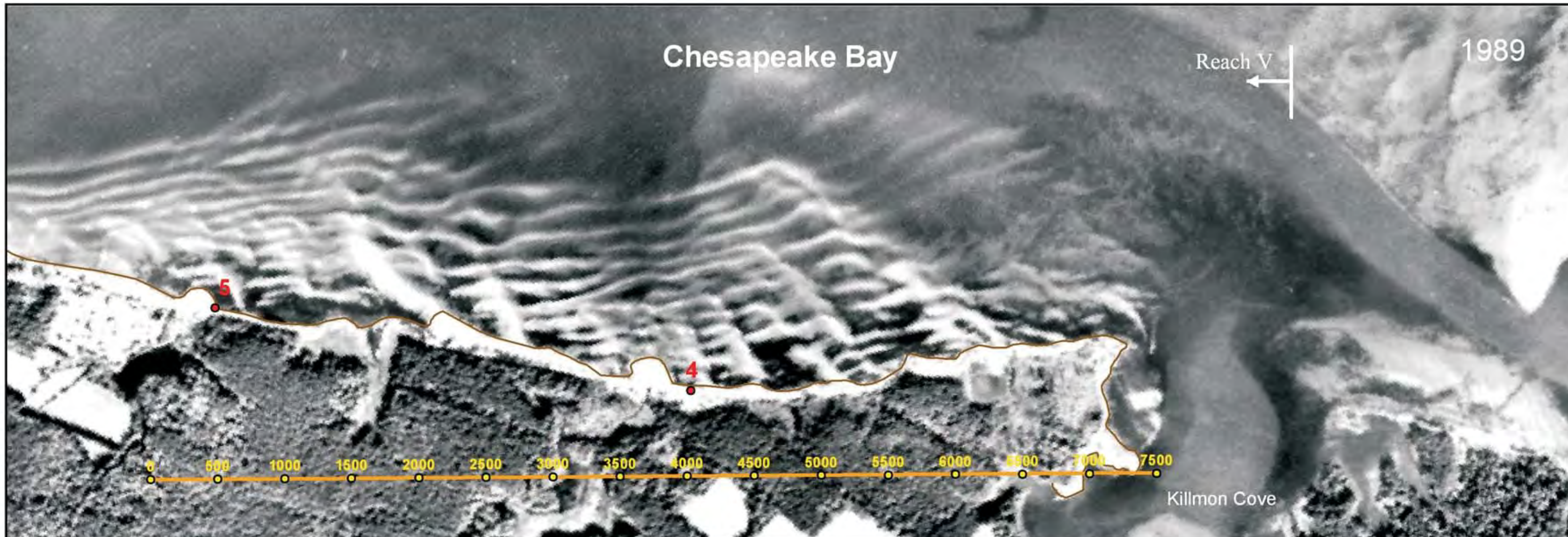
**No Data Available**

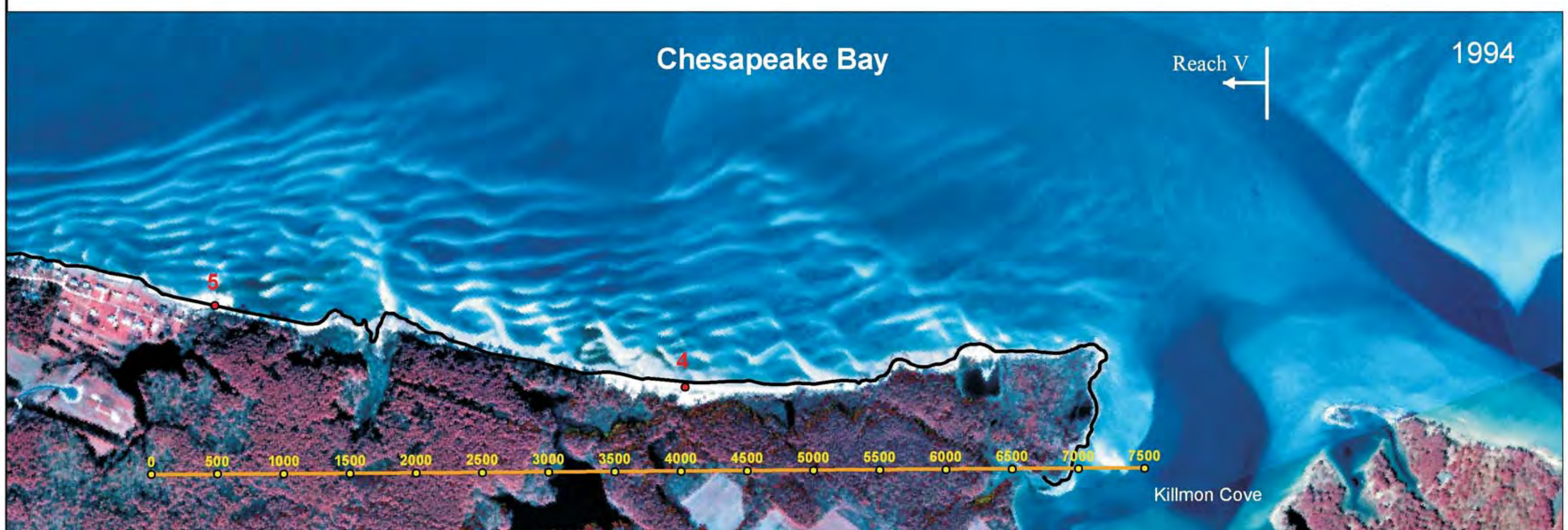
**Legend**

- Identified Dune Sites
- Transect Points
- Baseline
- 1949 Shoreline
- 1938 Shoreline




1,000 0 1,000 Feet




# Northampton County

## Plate 16

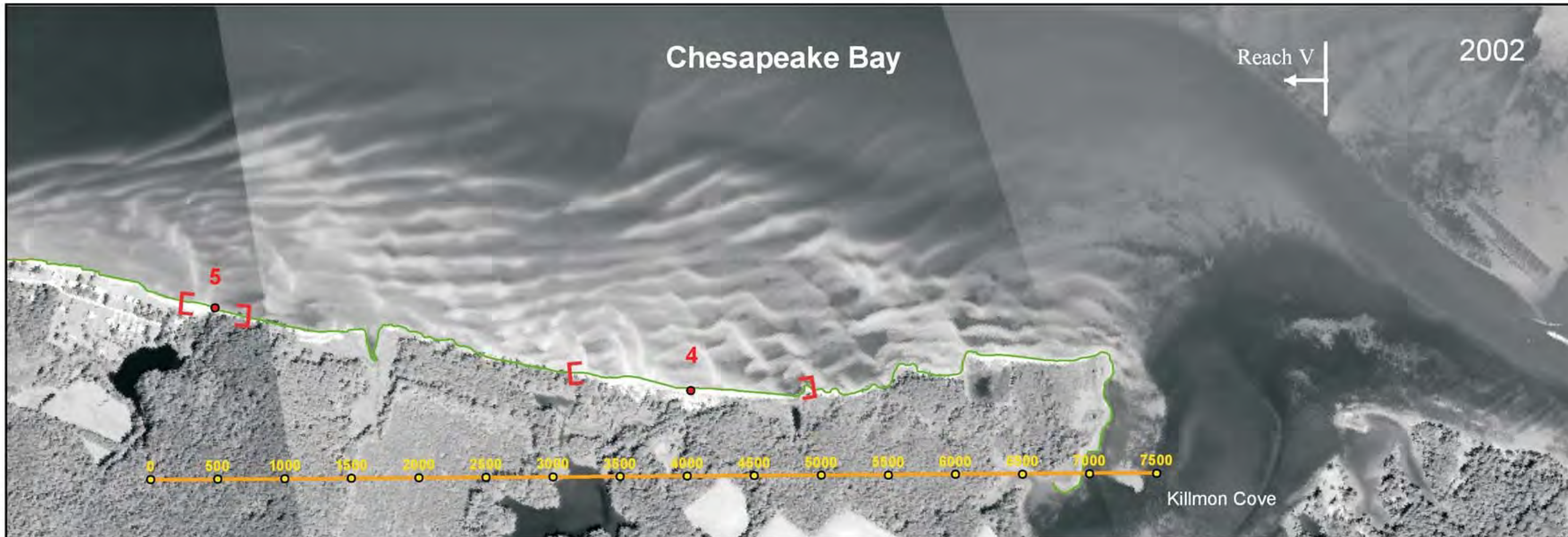
Morphologic Reach V
Occohannock Neck

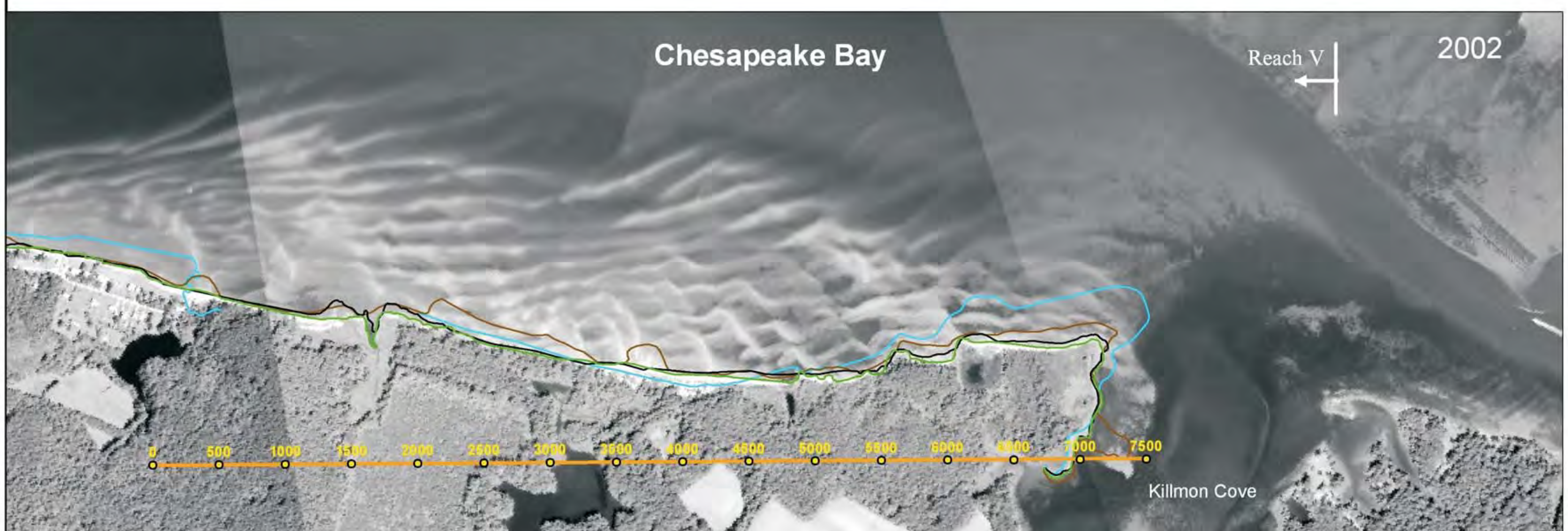
**Legend**

- Identified Dune Sites
- Transect Points
- Baseline
- 1994 Shoreline
- 1989 Shoreline

Shoreline Studies Program
VIMS

1,000 0 1,000 Feet




# Northampton County

## Plate 16

Morphologic Reach V
Occohannock Neck

**Legend**

- Identified Dune Sites
- Transect Points
- Dune Site Limits
- Baseline
- 2002 Shoreline
- 1994 Shoreline
- 1989 Shoreline
- 1949 Shoreline
- 1938 Shoreline

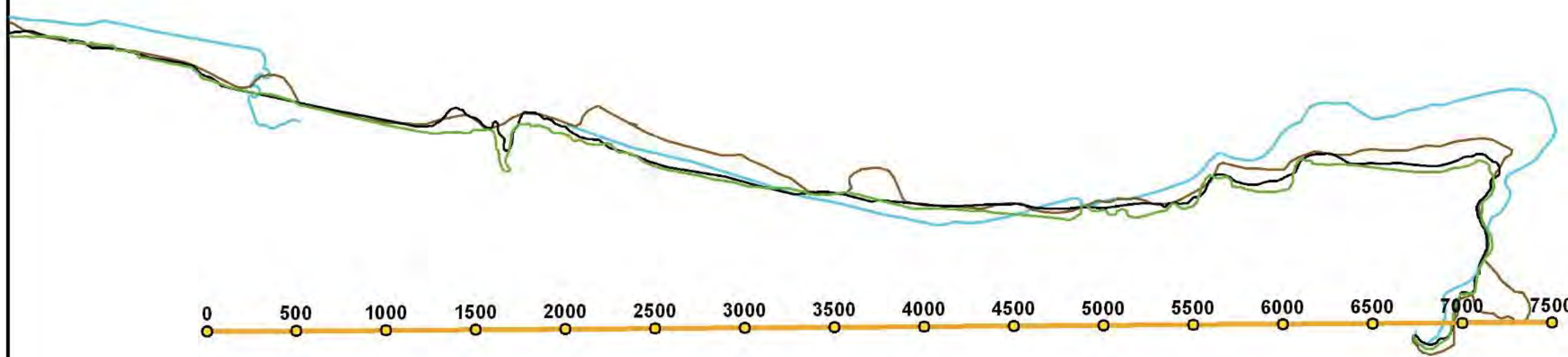
Shoreline Studies Program VIMS

1,000 0 1,000 Feet

# Northampton County

## Plate 16

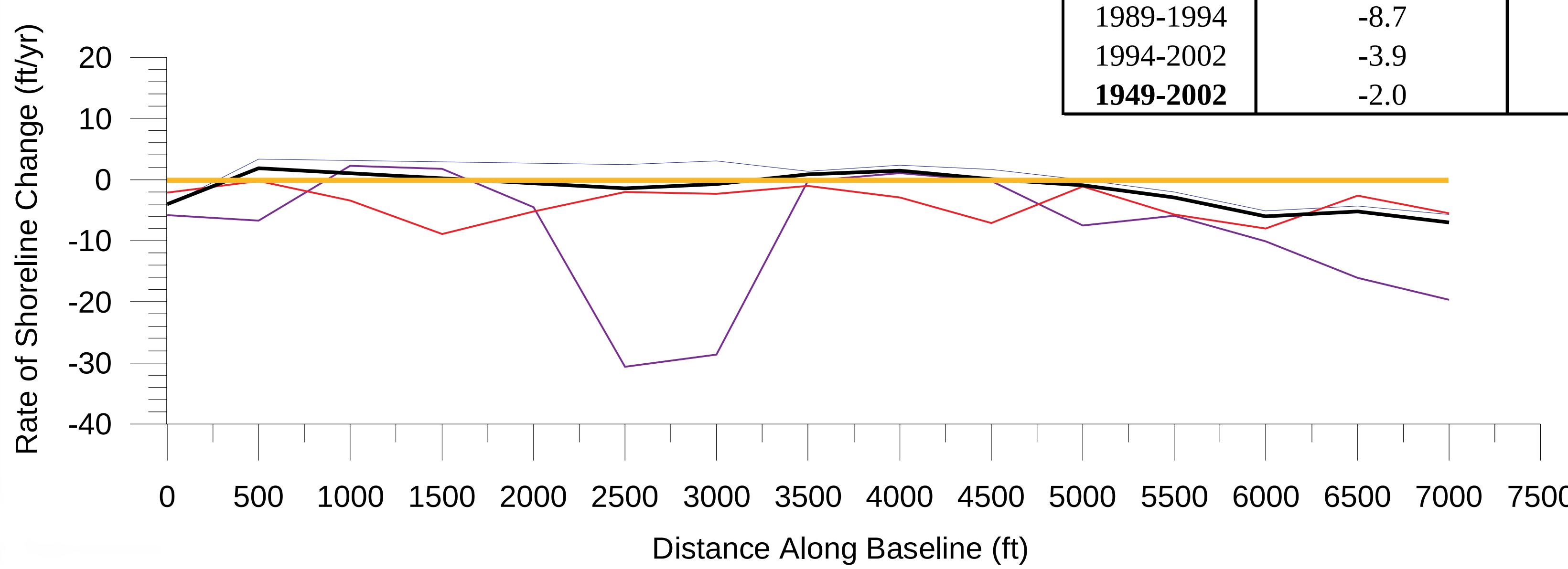
Morphologic Reach V
Occohannock Neck




**Legend**

- Transect Points
- Baseline
- 2002 Shoreline
- 1994 Shoreline
- 1989 Shoreline
- 1949 Shoreline
- 1938 Shoreline

| Imagery Dates | Average Rate of Change (ft/yr) | Standard Deviation |
|---|---|---|
| 1949-1989 | -0.6 | 3.5 |
| 1989-1994 | -8.7 | 10.6 |
| 1994-2002 | -3.9 | 2.7 |
| **1949-2002** | -2.0 | 3.0 |




Shoreline Studies Program
VIMS

1,000 0 1,000 Feet

# APPENDIX B

The data shown in the following tables were primarily collected as part of the Chesapeake Bay Dune: Evolution and Status report and presented in Hardaway *et al.* (2001) and Hardaway *et al.* (2004). Individual site characteristics may now be different due to natural or man-induced shoreline change.

An additional table presents the results of this analysis and describes each dune site's relative long-term, recent, and near-future predicted stability. This data results from the position of the digitized shorelines which have an error associated with them (see Methods, Section III).

**Since much of the dune data were collected several years ago and the beach and dune systems may have changed, this report is intended as a resource for coastal zone managers and homeowners; it is not intended for use in determining legal jurisdictional limits.**

These data were collected as part of the Chesapeake Bay Dune: Evolution and Status Report
(Hardaway *et al.*, 2001). Site characteristics may now be different due to natural or man-induced shoreline change.

Identified dune site information in Northampton County as of 2000.

| Dune Site No. | Location^ Easting (Feet) | Northing (Feet) | Date Visited | Dune Shore Length (feet) | Primary Dune Site? | Secondary Dune Site? | Ownership* |
|---|---|---|---|---|---|---|---|
| 4 | 2,741,960 | 447,360 | 27-Sep-1999 | 1,745 | Yes | No | Private |
| 5 | 2,740,280 | 444,170 | 27-Sep-1999 | 440 | Yes | No | Private |
| 8 | 2,737,010 | 433,300 | 27-Sep-1999 | 542 | Yes | No | Private |
| 10 | 2,736,760 | 431,420 | 27-Sep-1999 | 1,407 | Yes | Yes | Private |
| 12' | 2,736,810 | 425,550 | | 297 | Yes | | Private |
| 13 | 2,735,940 | 421,250 | 27-Sep-1999 | 1,500 | Yes | No | Private |
| 14A | 2,734,350 | 417,770 | 28-Sep-1999 | 450 | Yes | Yes | Private |
| 14B | 2,734,370 | 417,690 | 28-Sep-1999 | 175 | Yes | Yes | Private |
| 15 | 2,734,990 | 417,090 | 28-Sep-1999 | 229 | Yes | Yes | Private |
| 16' | 2,734,790 | 416,930 | | 146 | Yes | | Private |
| 17 | 2,731,590 | 411,450 | 27-Sep-1999 | 959 | Yes | No | Private |
| 18A | 2,731,210 | 410,300 | 27-Sep-1999 | 800 | Yes | No | Private |
| 18B | 2,731,040 | 409,430 | 27-Sep-1999 | 1,540 | Yes | No | Private |
| 19 | 2,730,650 | 406,950 | 27-Sep-1999 | 907 | Yes | No | Private |
| 20 | 2,731,180 | 406,700 | 27-Sep-1999 | 375 | Yes | No | Private |
| 21 | 2,731,110 | 406,210 | 27-Sep-1999 | 323 | Yes | No | Private |
| 23 | 2,730,910 | 404,070 | 27-Sep-1999 | 250 | Yes | No | Private |
| 27 | 2,730,400 | 391,450 | 27-Sep-1999 | 245 | Yes | No | Private |
| 28 | 2,730,410 | 390,100 | 27-Sep-1999 | 188 | Yes | No | Private |
| 30 | 2,730,180 | 386,400 | 27-Sep-1999 | 375 | Yes | No | Private |
| 33A | 2,721,610 | 368,110 | 21-Sep-1999 | 2,680 | Yes | Yes | Public |
| 33B | 2,722,190 | 370,550 | 21-Sep-1999 | 2,660 | Yes | No | Public |
| 33C | 2,722,960 | 372,980 | 21-Sep-1999 | 2,850 | Yes | No | Public |
| 34 | 2,721,150 | 365,220 | 21-Sep-1999 | 3,272 | Yes | No | Private |
| 35 | 2,720,900 | 362,700 | 21-Sep-1999 | 1,824 | Yes | No | Private |
| 36 | 2,720,910 | 361,050 | 21-Sep-1999 | 1,636 | Yes | No | Private |
| 40 | 2,721,130 | 351,520 | 12-Apr-1999 | 359 | Yes | No | Public |
| 41A | 2,720,540 | 349,850 | 12-Apr-1999 | 833 | Yes | No | Public |
| 41B | 2,720,460 | 349,530 | 12-Apr-1999 | 600 | Yes | Yes | Public |
| 42 | 2,720,350 | 344,920 | 21-Sep-1999 | 1,527 | Yes | Yes | Private |
| 43 | 2,721,100 | 343,320 | 21-Sep-1999 | 1,959 | Yes | Yes | Private |
| 45 | 2,723,290 | 338,620 | 21-Sep-1999 | 479 | Yes | No | Private |
| 46 | 2,723,980 | 338,010 | 21-Sep-1999 | 208 | Yes | No | Private |
| 48 | 2,724,740 | 336,250 | 21-Sep-1999 | 703 | Yes | Yes | Private |
| 49 | 2,724,170 | 331,260 | 21-Sep-1999 | 1,193 | Yes | No | Private |
| 51A | 2,727,070 | 322,410 | 21-Sep-1999 | 4,900 | Yes | Yes | Private |
| 51B | 2,724,650 | 325,980 | 21-Sep-1999 | 4,100 | Yes | No | Public |
| 53 | 2,732,110 | 314,400 | 27-Sep-1999 | 2,100 | Yes | Yes | Public |
| 54 | 2,733,110 | 312,500 | 27-Sep-1999 | 2,800 | Yes | Yes | Public |
| 57 | 2,737,460 | 298,900 | 27-Sep-1999 | 3,800 | Yes | Yes | Private |
| 58 | 2,737,540 | 295,120 | 27-Sep-1999 | 300 | Yes | Yes | Public |

Dune site measurements in Northampton County as of 2000.

**Dune Site Measurements**

| Site No. | Dune Shore Length (feet) | Primary Dune: Crest Elev (ftMLW) | Primary Dune: Distance from Crest landward to back base (feet) | Primary Dune: Distance from Crest To MLW (feet) | Secondary Dunes: 2nd Dune Site | Secondary Dunes: Crest Elev (ftMLW) | Secondary Dunes: Distance From Primary Crest to 2nd Crest (feet) | Secondary Dunes: Distance From 2ndCrest landward (feet) | Secondary Dunes: Distance From 2nd Crest seaward to 1st back base (feet) |
|---|---|---|---|---|---|---|---|---|---|
| 4 | 1,745 | 8.7 | 53 | 62 | No | | | | |
| 5 | 440 | 8.4 | 28 | 65 | No | | | | |
| 8 | 542 | 12.6 | 21 | 110 | No | | | | |
| 10 | 1,407 | 9.8 | 27 | 82 | Yes | 14.0 | 42 | 49 | 15 |
| 12' | 297 | | | | | | | | |
| 13 | 1,500 | 8.7 | 48 | 87 | No | | | | |
| 14A | 450 | 4.8 | 28 | 65 | Yes | 6.5 | 56 | 14 | 28 |
| 14B | 175 | 4.6 | 16 | 56 | Yes | 7.6 | 43 | 11 | 27 |
| 15 | 229 | 3.1 | 19 | 60 | Yes | 4.7 | 26 | 10 | 7 |
| 16' | 146 | | | | | | | | |
| 17 | 959 | 8.3 | 21 | 112 | No | | | | |
| 18A | 800 | 4.1 | 37 | 39 | No | | | | |
| 18B | 1,540 | 9.8 | 11 | 108 | No | | | | |
| 19 | 907 | 5.6 | 108 | 65 | No | | | | |
| 20 | 375 | 7.5 | 39 | 65 | No | | | | |
| 21 | 323 | 6.6 | 11 | 75 | No | | | | |
| 23 | 250 | 16.4 | 10 | 170 | No | | | | |
| 27 | 245 | 11.8 | 31 | 162 | No | | | | |
| 28 | 188 | 11.3 | 21 | 85 | No | | | | |
| 30 | 375 | 9.1 | 37 | 121 | No | | | | |
| 33A | 2,680 | 11.3 | 42 | 120 | Yes | 19.4 | 150 | 25 | 109 |
| 33B | 2,660 | 16.1 | 26 | 104 | No | | | | |
| 33C | 2,850 | 30.7 | 106 | 287 | No | | | | |
| 34 | 3,272 | 11.6 | 29 | 82 | No | | | | |
| 35 | 1,824 | 11.1 | 34 | 80 | No | | | | |
| 36 | 1,636 | 6.9 | 13 | 80 | No | | | | |
| 40 | 359 | 11.3 | 3 | 145 | No | | | | |
| 41A | 833 | 14.5 | 30 | 98 | No | | | | |
| 41B | 600 | 13.1 | 26 | 295 | Yes | 8.1 | 90 | 40 | 65 |
| 42 | 1,527 | 9.4 | 15 | 127 | Yes | 10.3 | 38 | 9 | 23 |
| 43 | 1,959 | 11.8 | 44 | 143 | Yes | 12.7 | 58 | 133 | 14 |
| 45 | 479 | 8.1 | 35 | 108 | No | | | | |
| 46 | 208 | 6.6 | 21 | 118 | No | | | | |
| 48 | 703 | 8.4 | 37 | 83 | Yes | 11.5 | 124 | 0 | 87 |
| 49 | 1,193 | 8.7 | 78 | 50 | No | | | | |
| 51A | 4,900 | 10.3 | 30 | 96 | Yes | 11.5 | 65 | 212 | 35 |
| 51B | 4,100 | 14.6 | 78 | 110 | No | | | | |
| 53 | 2,100 | 17.9 | 48 | 200 | Yes | 14.0 | 66 | 312 | 18 |
| 54 | 2,800 | 11.4 | 19 | 105 | Yes | 9.8 | 31 | 132 | 12 |
| 57 | 3,800 | 8.4 | 51 | 80 | Yes | 5.6 | 75 | 61 | 24 |
| 58 | 300 | 8.1 | 27 | 103 | Yes | 9.6 | 58 | 71 | 31 |

*Public ownership includes governmental entities including local, state, and federal;
otherwise ownership is by private parties.
^Location is in Virginia State Plane South, NAD 1927.
‘Sites were noted as dunes but were not photographed or surveyed.

These data were collected as part of the Chesapeake Bay Dune: Evolution and Status Report (Hardaway *et al.*, 2001). Site characteristics may now be different due to natural or man-induced shoreline change.

Dune site parameters in Northampton County as of 2000.

| | | Dune Site Parameters | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Fetch Exposure | Shoreline Direction of Face | Nearshore Gradient | | Morphologic Setting | | Relative Stability | Underlying Substrate | Structure or Fill |
| Site No. | Type | A | B | C | | D | | E | F | G |
| 4 | Natural | Open Bay | Northwest | Shallow | bars | Dune Field | Linear | Stable | Upland | |
| 5 | Natural | Open Bay | Northwest | Shallow | bars | Isolated | Linear | Erosional | Upland | |
| 8 | Natural | Open Bay | West | Medium | bars | Isolated | Linear | Erosional | Upland | |
| 10 | Natural | Open Bay | West | Medium | bars | Dune Field | Linear | Stable | Upland | |
| 12' | Natural | Open Bay | South | Steep | bars | Creek Mouth Barrier/Spit | | Erosional | Marsh/Ck Bottom | |
| 13 | Natural | Open Bay | Northwest | Medium | bars | Dune Field | Linear | Erosional | Upland | |
| 14A | Natural | Riverine, Bay Inf | West | Medium | bars | Creek Mouth Barrier/Spit | | Stable | Marsh/Ck Bottom | |
| 14B | Natural | Riverine, Bay Inf | West | Medium | bars | Creek Mouth Barrier/Spit | | Stable | Marsh/Ck Bottom | |
| 15 | Natural | Riverine, Bay Inf | Southwest | Medium | | Creek Mouth Barrier/Spit | | Stable | Marsh/Ck Bottom | |
| 16' | Natural | Riverine, Bay Inf | North | Medium | bars | Creek Mouth Barrier/Spit | | Stable | Marsh/Ck Bottom | |
| 17 | Natural | Open Bay | Northwest | Medium | bars | Dune Field | Linear | Stable | Upland | |
| 18A | Natural | Open Bay | West | Medium | bars | Spit | | Accretionary | Marsh/Ck Bottom | |
| 18B | Natural | Open Bay | West | Medium | bars | Spit | | Accretionary | Marsh/Ck Bottom | |
| 19 | Natural | Open Bay | West | Shallow | bars | Spit | | Accretionary | Marsh/Ck Bottom | |
| 20 | Natural | Riverine, Bay Inf | West | Shallow | bars | Isolated | Linear | Stable | Upland | |
| 21 | Natural | Riverine, Bay Inf | West | Shallow | bars | Isolated | Shallow Bay | Stable | Upland | |
| 23 | Natural | Open Bay | Northwest | Shallow | bars | Isolated | Linear | Stable | Upland | |
| 27 | Man Inf | Open Bay | Northwest | Medium | bars | Isolated | Linear | Stable | Upland | Groins, Revetment |
| 28 | Man Inf | Open Bay | Northwest | Medium | bars | Isolated | Linear | Erosional | Upland | Bulkhead |
| 30 | Man Inf | Open Bay | Northwest | Medium | bars | Isolated | Linear | Stable | Upland | Revetment, Groins |
| 33A | Natural | Open Bay | West | Medium | bars | Dune Field | Linear | Stable | Upland | |
| 33B | Natural | Open Bay | Northwest | Medium | bars | Dune Field | Linear | Erosional | Upland | |
| 33C | Natural | Open Bay | Northwest | Steep | bars | Dune Field | Linear | Erosional | Upland | |
| 34 | Natural | Open Bay | West | Medium | | Dune Field | Linear | Erosional | Upland | |
| 35 | Natural | Open Bay | West | Shallow | | Spit | | Erosional | Upland | |
| 36 | Natural | Open Bay | West | Shallow | | Spit | | Accretionary | Marsh/Ck Bottom | |
| 40 | Man Inf | Open Bay | West | Shallow | bars | Isolated | Linear | Erosional | Upland | Groin,BH |
| 41A | Man Made | Open Bay | West | Shallow | bars | Dune Field | Linear | Erosional | Upland | BH, Jetty,Beach Fill |
| 41B | Man Made | Open Bay | West | Shallow | bars | Dune Field | Linear | Accretionary | Upland | BH, Jetty,Beach Fill |
| 42 | Natural | Open Bay | West | Medium | bars | Dune Field | Linear | Erosional | Upland | |
| 43 | Natural | Open Bay | Southwest | Medium | bars | Dune Field | Linear | Stable | Upland | |
| 45 | Natural | Open Bay | Southwest | Medium | bars | Creek Mouth Barrier/Spit | | Erosional | Marsh/Ck Bottom | |
| 46 | Natural | Riverine, Bay Inf | South | Shallow | bars | Creek Mouth Barrier/Spit | | Erosional | Marsh/Ck Bottom | |
| 48 | Man Inf | Open Bay | Northwest | Shallow | bars | Spit | | Stable | Marsh/Ck Bottom | Revetment |
| 49 | Man Inf | Open Bay | West | Medium | bars | Creek Mouth Barrier/Spit | | Erosional | Marsh/Ck Bottom | Revetment |
| 51A | Natural | Open Bay | Southwest | Steep | | Dune Field | Linear | Stable | Upland | |
| 51B | Natural | Open Bay | West | Shallow | bars | Dune Field | Linear | Accretionary | Upland | |
| 53 | Man Inf | Open Bay | West | Steep | | Dune Field | Linear | Stable | Upland | Breakwater |
| 54 | Man Inf | Open Bay | Southwest | Steep | | Dune Field | Linear | Stable | Upland | Breakwater |
| 57 | Man Inf | Open Bay | West | Medium | | Dune Field | Linear | Erosional | Upland | Revetment |
| 58 | Man Inf | Open Bay | West | Medium | | Isolated | Salient | Erosional | Upland | Revetment |

'Sites were noted as dunes but were not photographed or surveyed.

Long term, recent stability, and future prediction of sediment erosion and accretion rates for dune sites in Northampton County.

| Site No. | Long-Term Stability 1938-2002 | Recent Stability 1994-2002 | Near Future Prediction |
|---|---|---|---|
| **4*** | Accretionary | Stable | Stable |
| **5*** | Accretionary | Stable | Stable |
| **8*** | Erosional | Stable | Stable |
| **10** | Erosional | Stable | Stable |
| **12** | Erosional | Stable | Stable |
| **13** | Accretionary | Accretionary | Accretionary |
| **14A** | Erosional | Stable | Stable |
| **14B** | Stable | Stable | Stable |
| **15** | Erosional | Erosional | Erosional |
| **16** | Accretionary | Erosional | Erosional |
| **17** | Accretionary | Accretionary | Accretionary |
| **18A** | NA | Erosional | Erosional |
| **18B** | NA | Erosional | Erosional |
| **19** | NA | Erosional | Erosional |
| **20** | Accretionary | Erosional | Stable |
| **21** | Accretionary | Stable | Stable |
| **23** | Accretionary | Stable | Stable |
| **27** | Accretionary | Stable | Stable |
| **28** | Accretionary | Stable | Stable |
| **30** | Erosional | Stable | Stable |
| **33A** | Erosional | Erosional | Erosional |
| **33B** | Erosional | Erosional | Erosional |
| **33C** | Erosional | Stable | Stable |
| **34** | Erosional | Erosional | Erosional |
| **35** | Erosional | Erosional | Erosional |
| **36** | Erosional | Erosional | Erosional |
| **40** | Accretionary | Stable | Stable |
| **41A** | Accretionary | Stable | Stable |
| **41B** | Accretionary | Accretionary | Stable |
| **42** | Accretionary | Erosional | Erosional |
| **43** | Accretionary | Stable | Erosional |
| **45** | Erosional | Erosional | Erosional |
| **46** | Erosional | Stable | Erosional |
| **48** | Accretionary | Accretionary | Accretionary |
| **49** | Erosional | Erosional | Erosional |
| **51A** | Accretionary | Stable | Stable |
| **51B** | Erosional | Accretionary | Accretionary |
| **53** | Accretionary | Accretionary | Accretionary |
| **54** | Accretionary | Accretionary | Stable |
| **57** | Erosional | Stable | Erosional |
| **58** | Erosional | Erosional | Erosional |

*Long-term rate is 1949-2002 since a 1938 shoreline was unavailable.