Shoreline Change Rate Estimates

Nassau County

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Prepared by:
Emmett R. Foster[1]
Darren L. Spurgeon[2] and Jenny Cheng[2]

[1] Office of Beaches & Coastal Systems
Florida Dept. of Environmental Protection
Tallahassee, FL

[2] Beaches & Shores Resource Center
Florida State University
Tallahassee, FL

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FOREWORD

This report was prepared to provide shoreline change rate estimates to assist in regulatory programs and beach management planning efforts. In particular, there is a need to assist project managers within the Office of Beaches and Coastal Systems in ranking proposed beach management projects for State of Florida funding support. Efforts were made in developing the rate estimates to consider and take into account the influences of coastal structures and sand fill placements on shoreline change. However, these influences can be very complex and extensive analysis and consideration of such influences was beyond the scope of this work.

Shoreline change analyses performed for other specific purposes, such as for establishing 30-year erosion projections pursuant to paragraph 161.053(6), F.S., should be developed in accordance with appropriate and applicable procedures for that specific purpose, although these reports may be relevant in that regard.

This report was prepared by Emmett Foster, P. E., of the Office of Beaches and Coastal Systems and Darren Spurgeon and Jenny Cheng of the Beaches and Shores Resource Center. The shoreline change rate estimates are based on the best available data at the time of report preparation. Updates to the report will be performed as new data becomes available and as staff workload allows.

APPROVED BY

Alfred B. Devereaux, Jr., Director
Office of Beaches and Coastal Systems

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1 EXECUTIVE SUMMARY

Shoreline change for Nassau County has been profound. The northern end of Amelia Island has been significantly altered by the stabilization of St. Marys Inlet. The initial effects of this artificially-induced change were a reorientation of the shoreline, morphological change in the inlet channel and ebb shoal system, and effective alteration of the wave refraction/diffraction pattern surrounding the inlet.

These changes have brought erosive conditions to the shoreline inside the throat of St. Marys Inlet and to the area immediately south of the south jetty with averaged rate estimates of -17.0 ft/yr. Farther south, along the central portion of Amelia Island, the shoreline is fairly stable to accretionary with rates that range from 0.0 ft/yr to +4.0 ft/yr. This may be due, in part, to favorable bathymetric features. At the southern end of the island, erosive conditions again dominate with rates of -14.5 ft/yr in some areas.

Both the northern and southern ends of the island have been nourished extensively and it appears likely that this effort will have to continue.

2 INTRODUCTION

This work is part of an ongoing project to develop up-to-date shoreline erosion rate estimates for the Florida sandy beach coastline. The shoreline referred to is the approximate Mean High Water (MHW) elevation contour. The information compiled and analyses conducted are intended to provide quantitative and qualitative information on a county-by-county basis that may be used to assist in beach management planning, coastal regulation, and general shoreline analysis work.

Quantitative erosion information will be focused on providing erosion estimates relative to currently active coastal processes in those places where no renourishment projects exist. Where renourishment or other similar sand fill projects of size exist, erosion rate estimates for the pre-project conditions will be attempted where possible. It is beyond the scope of these reports to analyze renourishment project performance. In such cases, erosion is a combination of initial onshore-offshore adjustments, lateral diffusion, structural interaction, and the "background erosion" process. Because the conditions that affect erosion are being frequently altered (e.g. inlets, shoals, and armoring additions/subtractions), pre-project erosion estimates are useful primarily in a historical sense and in showing what led to the need for the artificial nourishment.

The data used for this analysis is from the Office of Beaches and Coastal Systems Historical Shoreline Database. The database includes beach and offshore profile field surveys, digitized historical shoreline and bathymetric maps, aerial photographs from the Office files, and numerous graphical representations of the data, all within a common set of horizontal and vertical controls. This database was developed and quality controlled by engineers in the Research, Analysis and Policy Section and is continually updated as time and workload allows. Beach profiles were surveyed by the Coastal Data Acquisition Section and, in some cases, by private firms, the latter usually related to the monitoring of coastal erosion control projects.

It is beyond the scope of this report to investigate possible actions that may be necessary to prevent or curb shoreline erosion. Where appropriate, however, recommended actions may be suggested or previous, failed attempts may be pointed out in an effort to help guide the reader towards a better understanding of the dynamics of the coastline and future trends in shoreline change.

3 REGIONAL SETTING

3.1 Study Area

Nassau County is the northernmost county in Florida, located on Florida's east coast between Duval County and the state of Georgia (Figure 1). All of Nassau County's oceanfront shoreline lies on Amelia Island, a barrier island bordered by St. Marys Inlet to the north and Nassau Sound to the south. Amelia Island is approximately 13 mi (21 km) long and has a maximum width of 1.9 mi (13 km). This island is near the end of a chain of barrier islands that extend from Florida northward to South Carolina.

Nassau County contains 82 DEP survey reference points, generally designated as "R" monuments or ranges spaced approximately 1,000 ft (300 m) apart. This report uses these reference points to locate various items within the county.

3.2 Coastal Setting

3.2.1 Waves and Tides

Tides within the study area are semidiurnal with a mean of 5.9 ft (1.8 m) and a spring tidal range of 6.9 ft (2.1 m) at the north jetty of St. Marys Inlet (Kraus et al.–USACE, 1994).

Wave energy is moderate, with a measured mean significant wave height of 3.3 ft (1.0 m) and a mean peak wave period of 7.7 seconds at 59 ft (18 m) water depth (Kraus et al–USACE, 1994). This is consistent with hindcast wave information given by Jensen–USACE (1983). During the winter months, waves for north Florida and south Georgia have a dominant direction out of the northeast with higher wave heights and longer wave periods. In the summer months, however, waves approach mainly from the southeast, having relatively smaller wave heights and a mix of shorter and longer periods (i.e., wind waves and summer swells).

3.2.2 Longshore Transport

The direction of littoral transport is generally from north to south. DEP aerial photography suggests there is probably a localized, refraction/diffraction-induced reversal within 5,000 ft south of the St. Marys Inlet south jetty. Estimates of the net annual

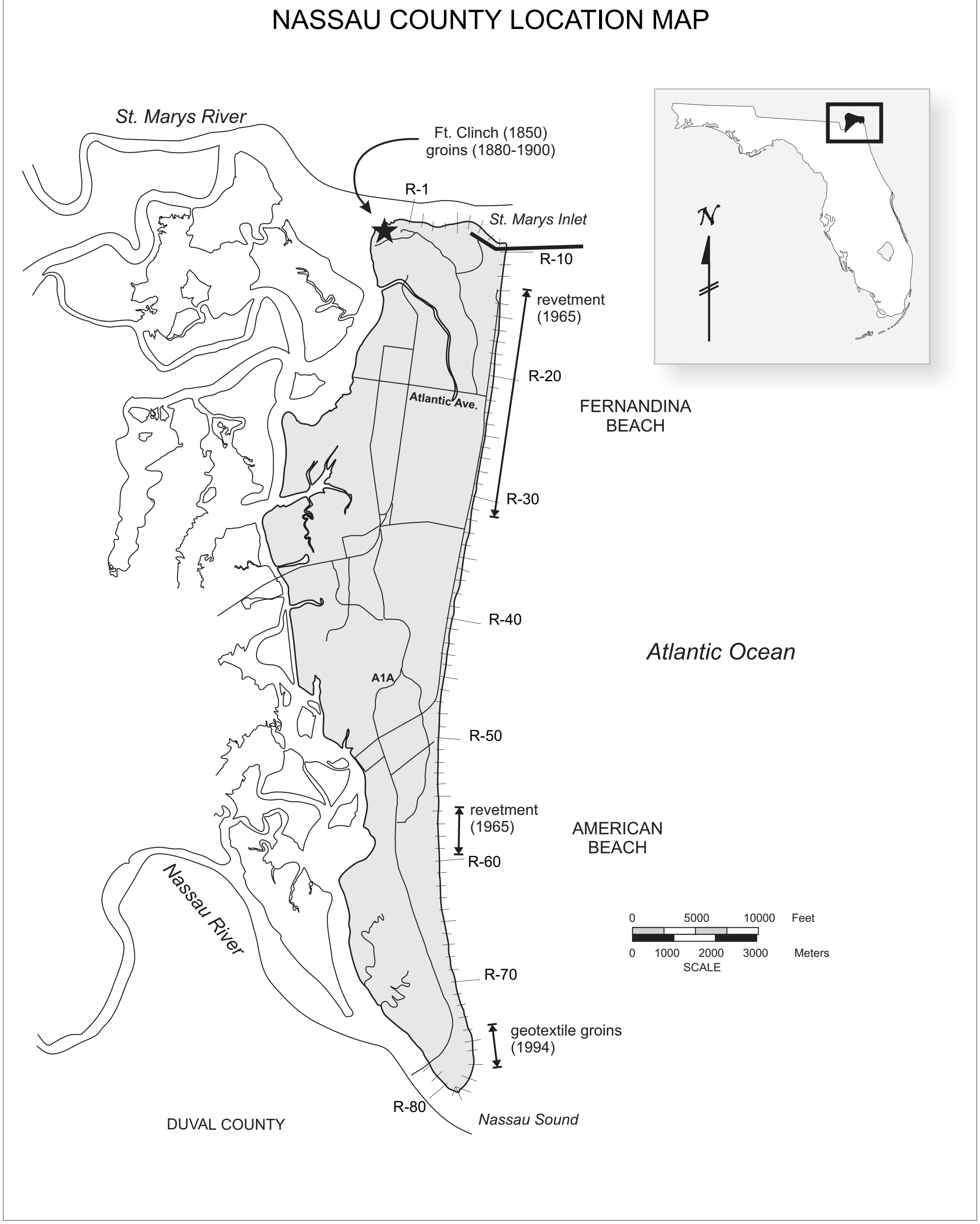

Figure 1. Study area showing Nassau County, Florida.

volume of sediment transport vary widely, ranging from 200,000 to 600,000 yd^3/yr (Raichle et al, 1997; Kraus et al.–USACE, 1994; Dean and O'Brien, 1987).

3.2.3 Storms

There have been numerous hurricanes and northeaster storms that have affected northeast Florida. Hurricane Dora in 1964, and northeasters in the 1960's and in November 1984 were probably the most intense in recent history. In general, winter storms or northeasters are thought to have a greater impact on shoreline change than hurricanes in this county because these winter storms occur with greater frequency and can remain in the area for longer periods of time. However, storms are just peaks in the total normal wind and wave climate record. Experience and observations indicate that severe storms can temporarily disrupt or obscure the longer term erosion pattern, perhaps for up to a decade. In some situations, if a major factor such as the sand supply is altered, or if an inlet is significantly changed, the coastal process and erosion pattern can be permanently changed by a storm. There are no indications of major storms changing the erosion pattern in Nassau County to date. Hurricane effects in 1999 are too recent to be adequately addressed in this report.

3.3 Inlets

3.3.1 St. Marys Inlet

St. Marys Inlet was a natural inlet which has been stabilized and maintained by jetties and dredging operations since 1881-1904. Prior to completion of the initial construction work in 1904, the natural inlet contained two channels that traversed a large ebb shoal. The south channel ran close to the northern shore of Amelia Island and continued seaward east-southeast at a depth of 30 ft. The smaller north channel was probably most active during flood tidal conditions and it trended seaward north-northeast from the inlet. After the inlet was stabilized, St. Marys Inlet changed to a single-channel configuration, with ebb shoals immediately seaward of the jetties. The current authorized channel depth and width are 51 ft and 500 ft, respectively.

3.3.2 Nassau Sound

This inlet is a relatively shallow, natural inlet with no jetties or active dredging operations. There are extensive shoals associated with this inlet and there have been frequent, high-magnitude changes in the inlet's configuration and adjacent shorelines over the years.

3.4 Engineering Projects

3.4.1 Beach Nourishment

Amelia Island's shoreline has been nourished numerous times since 1978 (Figure 2). Most of these fills have been confined to the erosion zones south of the south jetty (R-10 to R-30) and along the south end of the island (R-48 to R-77). The fill volumes in 1987-1989 in the vicinity of R-48 to R-60 are uncertain. Both the fill volume and location in the same area in 1993 are also uncertain. Note that major renourishments (approximately one million cubic yards) have occurred in the northern erosion zone (R-10 to R-30) about once every 10 years, supplemented by more frequent projects of lesser quantities.

3.4.2 Structures

Existing structures are shown in Figure 1. The most notable of these are the jetties stabilizing St. Marys Inlet. Construction of the north and south jetties began in 1881 and was completed in 1904. The north and south jetties are about 19,200 ft (5,852 m) and 11,200 ft (3,414 m) long, respectively (Kraus et al–USACE, 1994). The landwardmost 1,500 ft (457 m) of the south jetty (between R-9 and R-10) was sand-tightened in 1988 (Kraus et al–USACE, 1994). Construction of these jetties has had a significant effect on the inlet, its ebb shoal system, and Amelia Island's shoreline, as will be discussed later in this report.

Seven groins were constructed along the shoreline surrounding Ft. Clinch in 1881-1882, and six more were added west of this area by 1900 (USACE, 1984). It would appear from DEP 12/1974 and 4/1981 aerial photographs that there may be up to seven groins buried to the east of the fort. In 1953, eight asphalt groins were placed along Fernandina Beach at intervals of about 450 ft extending north from Atlantic Avenue (USACE, 1984). These are no longer evident in aerial photographs.

Hurricane Dora (1964) prompted the construction of a granite stone revetment in 1965 along approximately 3.2 miles (5.1 km) of Fernandina Beach (R-13 to R-31), at Fort Clinch, and along approximately 0.5 miles (0.8 km) of American Beach (R-56 to R-59). Some of the Fernandina revetment may have been constructed later than 1965 (i.e., end extensions) and prior to December, 1974.

Four geotextile groins were constructed in 1994 between R-74 and R-77 as terminal structures for the renourishment project to the immediate north.

3.4.3 Dredging

St. Marys Inlet is frequently dredged by the Federal Government to maintain a navigable channel for U.S. Navy ships operating out of King's Bay and commercial shipping. The first dredging was performed in conjunction with jetty construction and the channel was dredged to a depth of approximately -20 ft (MLW). Since then, the channel has been dredged to ever-increasing depths, with the most recent project maintaining the channel at -51 feet deep (MLW). Further widening and/or deepening is expected in the future. All the material for the federal renourishments has come from navigation channel maintenance dredging. Up until the last decade or two, most of the dredged sandy material was disposed of offshore, and not on the beaches. It is estimated that a total of approximately 4.3 M cu. yd. of sand have been placed on the beaches between 1978 and 1992, and a total of 15.2 M cu. yd. has been disposed of offshore during the same time period (Kraus et al.–USACE, 1994; USACE to DEP correspondence, 02/1999). Improved cooperation between the U.S. Army Corps of Engineers, the state, and local interests has increased the amount of sand being placed on the beaches of Amelia Island.

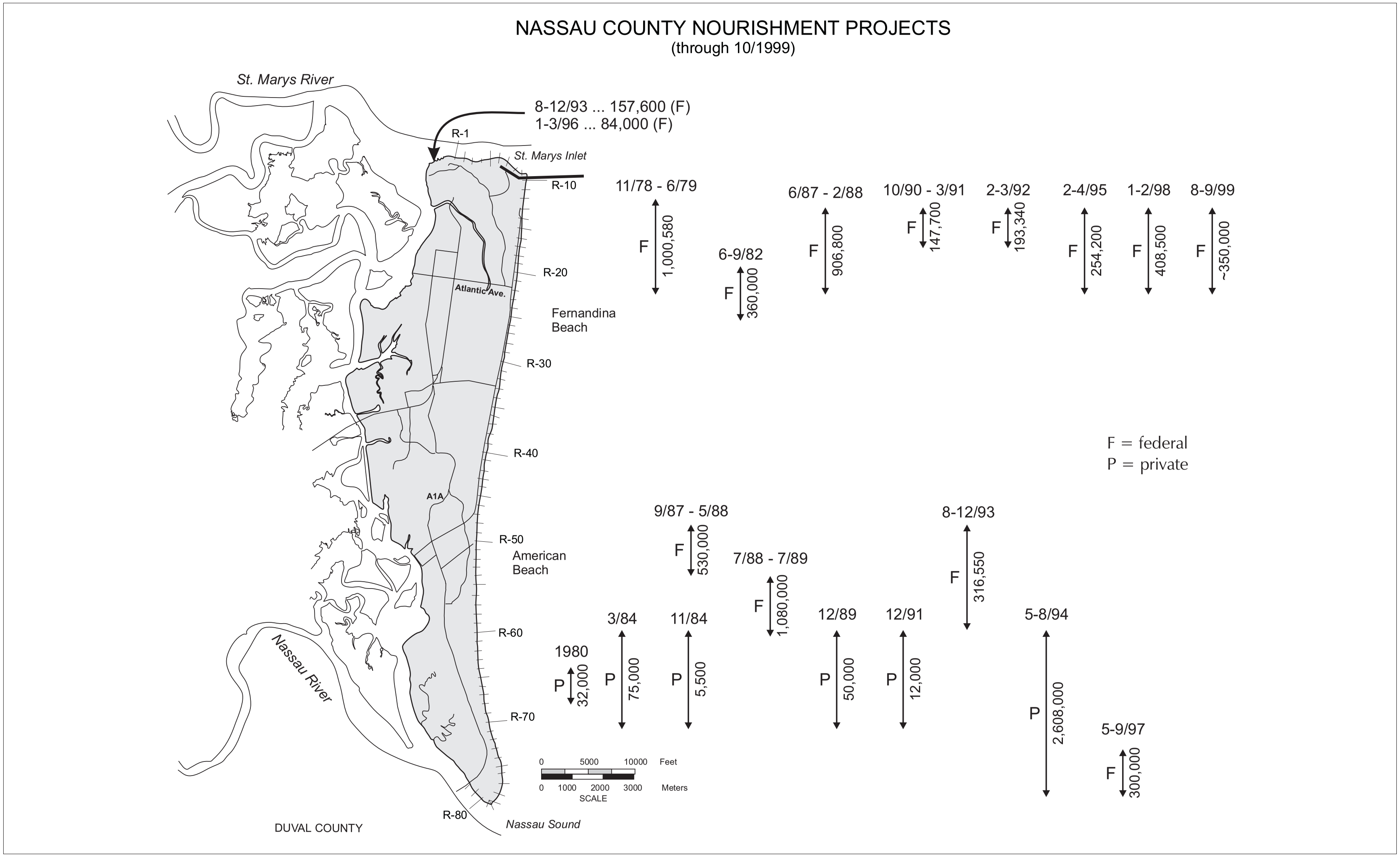

Figure 2. Beach nourishment projects for Nassau County. (data compiled from Kraus et al.–USACE, 1994; Raichle et al., 1997; Olsen Associates, 1998; USACE to DEP correspondence, 2/1999.

4 METHODS

A shoreline change analysis to satisfy the report objectives was performed using the methodology initially developed by Foster and Savage (1989) and Foster (1992). In brief, within the often nonlinear record of shoreline change versus time by reference points, segments are identified consistent with observed coastal processes in which the erosion is relatively constant or can reasonably be approximated as such. Three different rate calculation methods are applied to these approximately linear shoreline change versus time segments: the rate averaging, least squares, and end-point methods. These results are first averaged alongshore and then averaged across the three calculation methods to achieve a consensus average, not dependent on any single rate calculation method. This is because each calculation method has relative advantages and disadvantages. If time segments are selected reasonably well, the differences between rate methods will be minimal. In certain simplified situations it may be better to use a single rate calculation method, such as the end-point method, as necessity and reason dictate. If the averaging is done properly it will achieve results representative of the unaveraged data but will not be overly affected by individual point variability.

In many cases rates from longer and shorter time periods are calculated for comparison purposes (e.g., to show possible progression of an erosion pattern over time or to show that the use of more recent data, which is generally of higher accuracy, yields essentially the same results as the data in a comparative longer time period).

Visual tools used for analysis generally include plan views of shorelines oriented and scaled to emphasize shoreline width changes as well as sometimes subtle but important shoreline orientation differences or geologic features within a county or reach. This analysis is also dependent on the shoreline location versus time plots with overlapping axes, known as "stack plots" because several data plots are stacked in sequence to better see a pattern in the data (Appendix B). There are also representative beach profile plots (Appendix C).

5 SHORELINE CHANGE RESULTS

Shoreline (mhw) change rate estimates for the county are provided in Figure 3 and Table A-1 (Appendix A). These estimates are intended to reflect pre-armoring and/or pre-renourishment conditions where such projects exist. For each area, approximately linear time segments were identified in the distance versus time "stack" plots, as shown in Appendix B, consistent with observed primary coastal processes.

Shoreline changes on at least the northern half of Amelia Island are directly related to the stabilization of St. Marys Inlet for navigation purposes with long jetties in 1881-1904. The historic bathymetry comparisons of Figure 4 show that a new ebb shoal system formed at the mouth of the jetties and a landward retreat of most of the bathymetric contours occurred along the island length through about R-72. These changes were also noted by Kraus et al.–USACE (1994). This process is probably continuing to this day. Also noteworthy is the apparent uncovering of a possible hardbottom near the center of the island. This may be a contributing factor in the accretion trend in that area by affecting wave refraction and diffraction. Along the southern portion of the island between about R-60 and R-70, the -18, -24, and -30 foot bathymetric contours retreated close to the beachface. This likely increased wave energy impacting this area and contributed to the high erosion found there.

Figures 5 through 9 show a sequence of plan view shoreline comparisons relevant to the following discussion. The horizontal and vertical scales and baseline orientations were chosen to emphasize beach width changes as well as relative shoreline orientation.

In the main north erosional area of Amelia Island (R-10 to R-30), the erosional trend began in 1957/58 for reference points R-10 through R-14, and in 1924 for R-15 through R-30. The erosional trend began after a long period of shoreline adjustments to the presence of the jetties. During this adjustment phase, ebb shoal sand from the prior inlet arrangement gradually moved onshore to help smooth out the shoreline. Both accretion and erosion were involved in this adjustment, as can be seen in the plan view shorelines of Figure 5. Once this phase was essentially completed, a sand deficit-induced, southward progressing erosion pattern was established, as shown in Figure 6. The rates given in Figure 3 and Table A-1 for this northern area estimate the magnitude of this erosion pattern through 1974, the next data point in time following extensive coastal armoring in 1965 (approximately R-13 to R-31). Note that a sequence of renourishments, begun shortly thereafter (1978) and continuing to the present day in this area, have effectively kept erosion in check (Figures 7 and 8). Without the renourishments, the armoring would have become completely exposed and erosion would have spread southward as part of the same sand deficit-induced erosion pattern. This erosion pattern was discussed by Foster (1995) both theoretically and specifically for this and similar cases in Florida.

As noted in Section 3.2.2, net sand transport is to the south, except that a reversal to the north probably occurs somewhere between R-10 and R-15 due to wave refraction around the south jetty, as suggested by DEP aerial photos showing northeast wave conditions. Regardless of how effective or not the sand tightening of the south jetty was in 1988, this area will still erode if uncontrolled by renourishments because waves can still remove sand southward and landward via overtopping.

The center of the island (R-31 to R-57) includes a transition zone (R-31 to R-34) followed by a zone in which there has been an approximately linear trend of accretion since the earliest data of 1871. In the later part of this zone, there was a transition to a more stable condition. This lower zone was renourished beginning in 1987 (Figure 2), so the time period for calculations stopped at the prior data point of 1981. There is another transition zone (R-58 to R-61) that also experienced mild erosion, probably resulting from increased wave energy due to the bathymetric changes discussed previously, and from the leading edge of the erosion pattern spreading northward from Nassau Sound.

Erosion along the south end of the island (R-62 to R-82) was in a northward progressing pattern, as seen in Figures 6 and 7. The time period selected for rate calculations was in the later phase of the highly non-linear pattern, just prior to renourishment—evident in Figure 8—and groin field construction in this area in 1994. The calculated rates may be on the low side, because renourishments occurred in the adjacent area to the north from 1987 to 1993. Nevertheless this time period yields the highest erosion rates in the record. Those ranges closest to Nassau Sound (R-77 to R-79) exhibited a high level of fluctuations. Longshore averaging was discontinued in this zone and to the end at R-82 due to significant changes occurring over very short distances.

It may be of interest to note that the northward progressing erosion pattern along the south part of the island is consistent with the inlet (Nassau Sound) losing its holding power as a boundary condition. This could have happened for reasons such as loss of tidal prism (i.e., inlet flow volume) to another inlet and/or inlet channel migration. The highly non-linear history of erosion suggests that the inlet as a boundary had varying degrees of holding power over time. The current hard boundary provided by the set of four sandbag-tube type groins installed in 1994 appears to be holding the adjacent fill to the north quite well so far, supporting the viewpoint that the prior erosion was related to Nassau Sound being an unstable boundary. However, there is a recurring need for filling to maintain the shoreline segment south of the groins.

Returning to the northern part of the island, the R-1 to R-9 area is physically separated from the rest of the island by the south jetty, and it is more difficult to estimate erosion here. Within the inlet there have been variations in how much sand passes through the south jetty, how much dredging occurs, how close to the beach the main channel flows, and how much wave energy reaches the area, via wind generation, through the jetties, and as ship wake. Use of a more recent time period, 1973-75 to the latest available data of 1991 or 1998, was considered to be more helpful here, although it includes the influences of jetty repairs and renourishments to the south. At least such rate estimates would show how the area has fared over the last 20-30 years. The plan view shoreline comparisons shown in Figure 9 illustrate the changes which occurred during this time period. The shoreline change rates in Figure 3 and Table A-1 for this area have not been averaged alongshore because significant changes occur over short distances.

Net sand transport is westward in the R-1 to R-9 zone. The shoreline immediately northwest of the south jetty (R-7 to R-9) has shown accretion from the shoaling of abundant sand flowing through the historically porous south jetty. Sand moves through the jetty via flood tide currents and probably also when there is northward sand transport up to the jetty via seasonal and refracted waves. The effect of sand tightening the south jetty in 1988 may eventually be erosion of this area by reduction of sand supply. Any future consideration of further south jetty sand-tightening should include the potential for shoreline erosion of this zone (R-7 to R-9). This area is followed by a zone of fluctuations beginning at R-6, where the shoaling buildup meets the edge of the main inlet channel. The R-5 and R-4 area is significantly farther removed from the channel than R-6 and appears in DEP aerial photos to be primarily aligned in such a way that minimizes sand movement via northeast waves entering the inlet and/or wind-generated within the inlet. The estimates of mild erosion at R-6, stability at R-5, and mild accretion at R-4 are somewhat unreliable in that relatively large fluctuations are common here.

The rest of the shoreline (R-1 to R-3) is oriented as if the fort at R-1 is a large terminal groin, preceded through R-3 by some type of sand transport hindering roughness agents, probably old buried/submerged groins. The calculated erosion rates of about -3 ft/yr in this area appear reasonable. However, if new groins are built immediately seaward and eastward of the fort (as expected), they may act to create a longer terminal groin effect at the fort, reducing erosion in the R-1 to R-3 area. Alternatively, reduced sand supply through the jetty or a closer/wider main channel could increase erosion here and along the entire R-1 to R-9 zone.

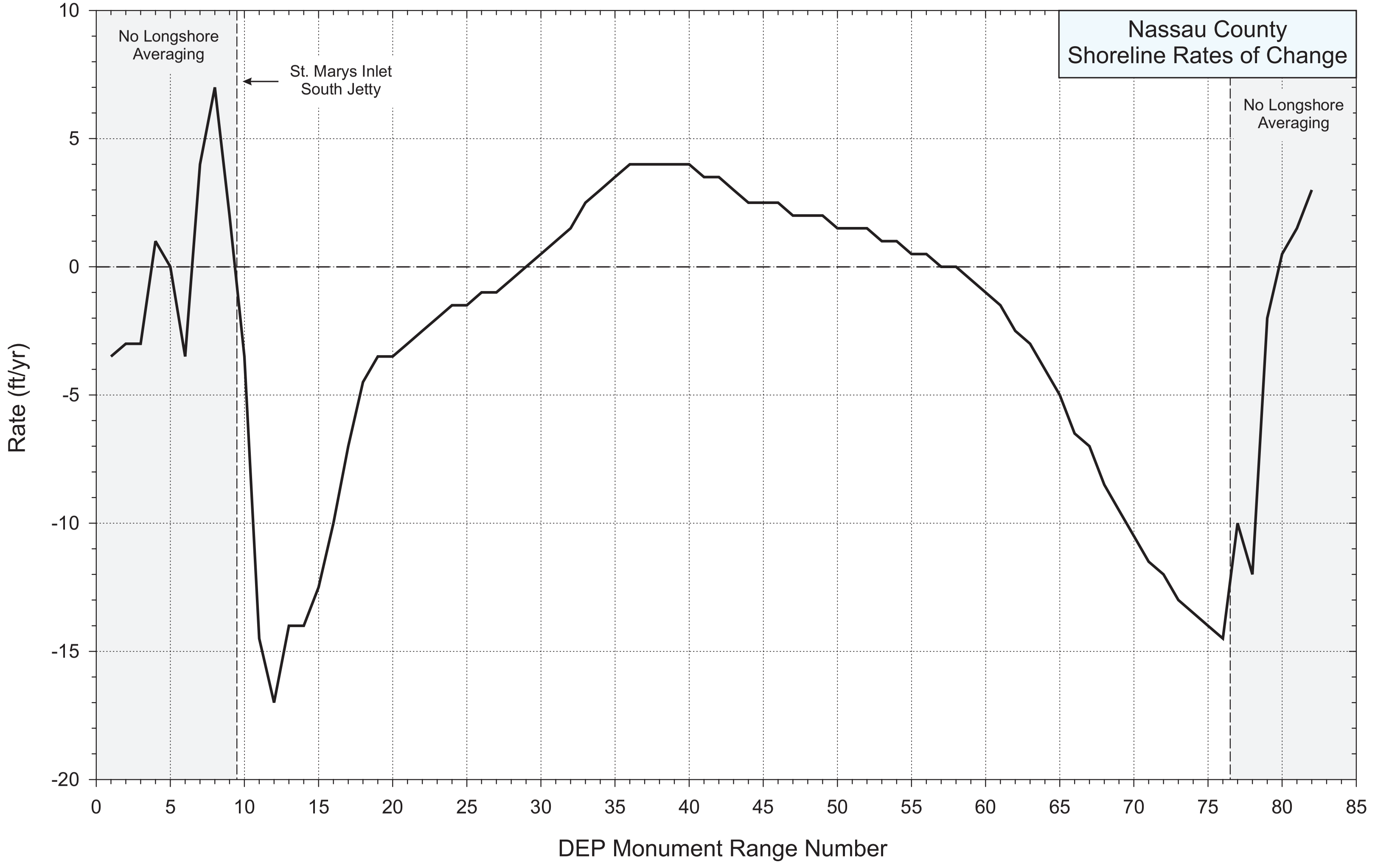

Figure 3. Shoreline rate of change estimates for Nassau County, Florida.

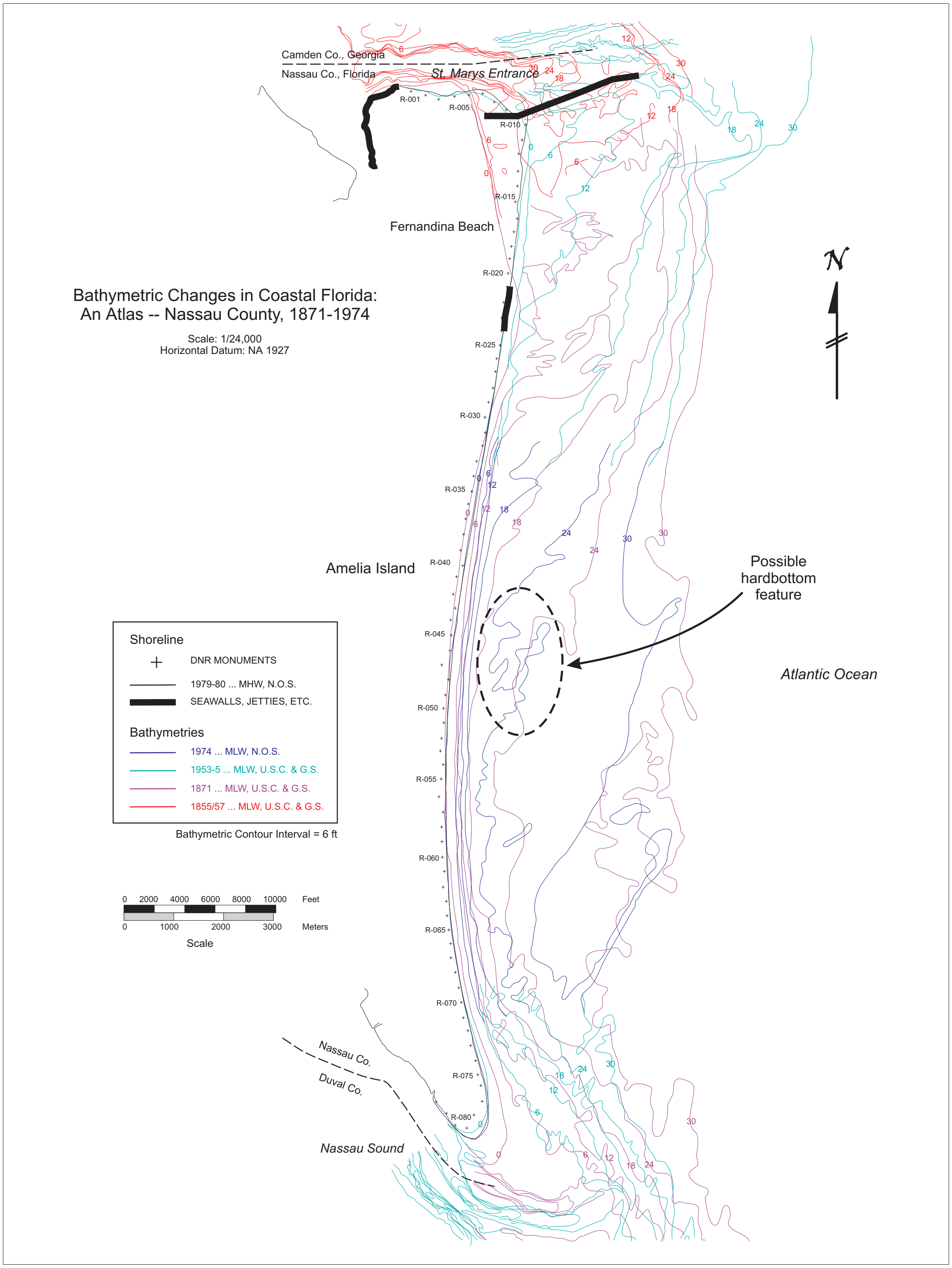

Figure 4. Bathymetric map of Nassau County, Florida.

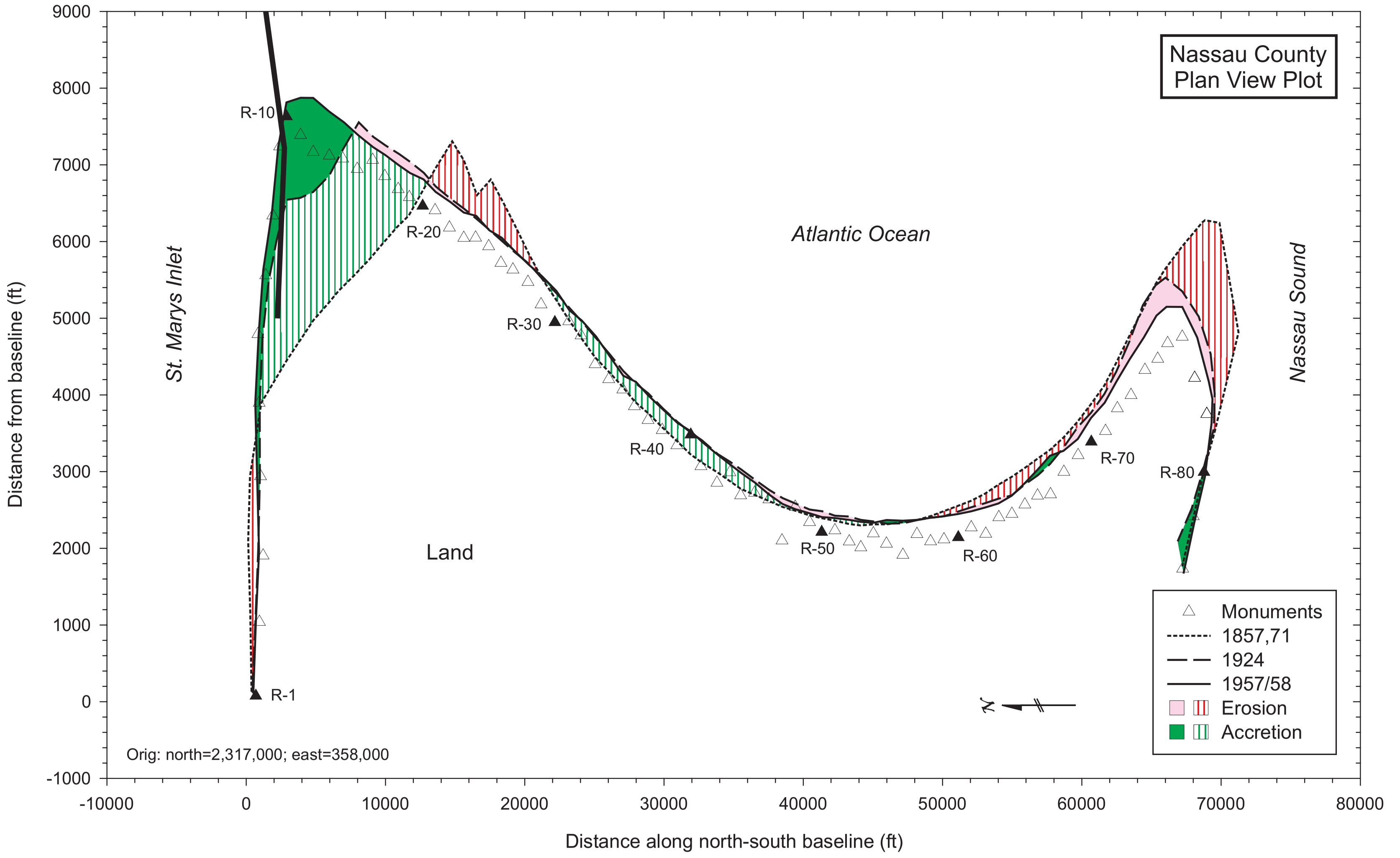

Figure 5. Plan view map of Nassau County, Florida, comparing years 1871, 1924, and 1957/58.

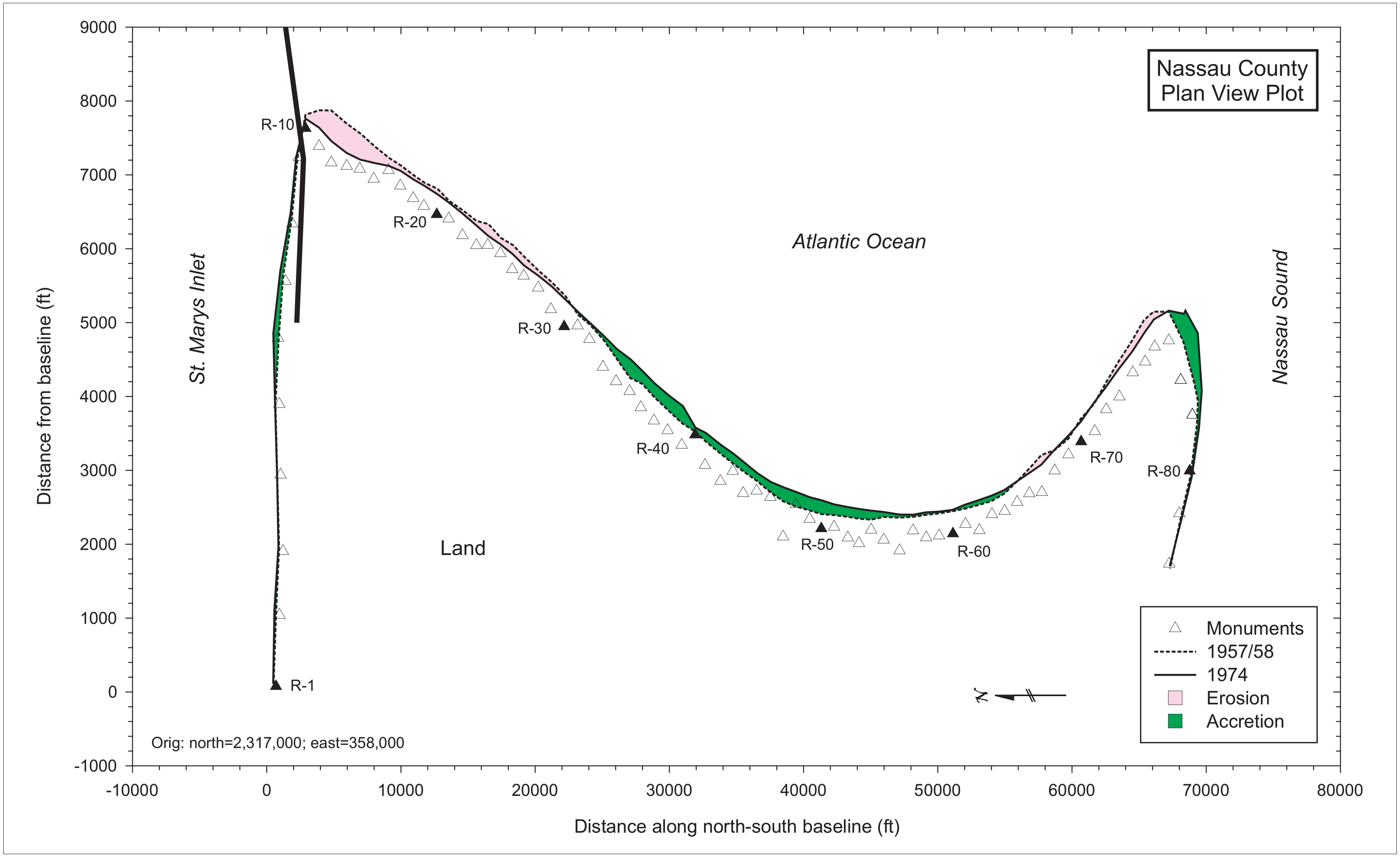

Figure 6. Plan view map of Nassau County, Florida, comparing years 1957/58 and 1974.

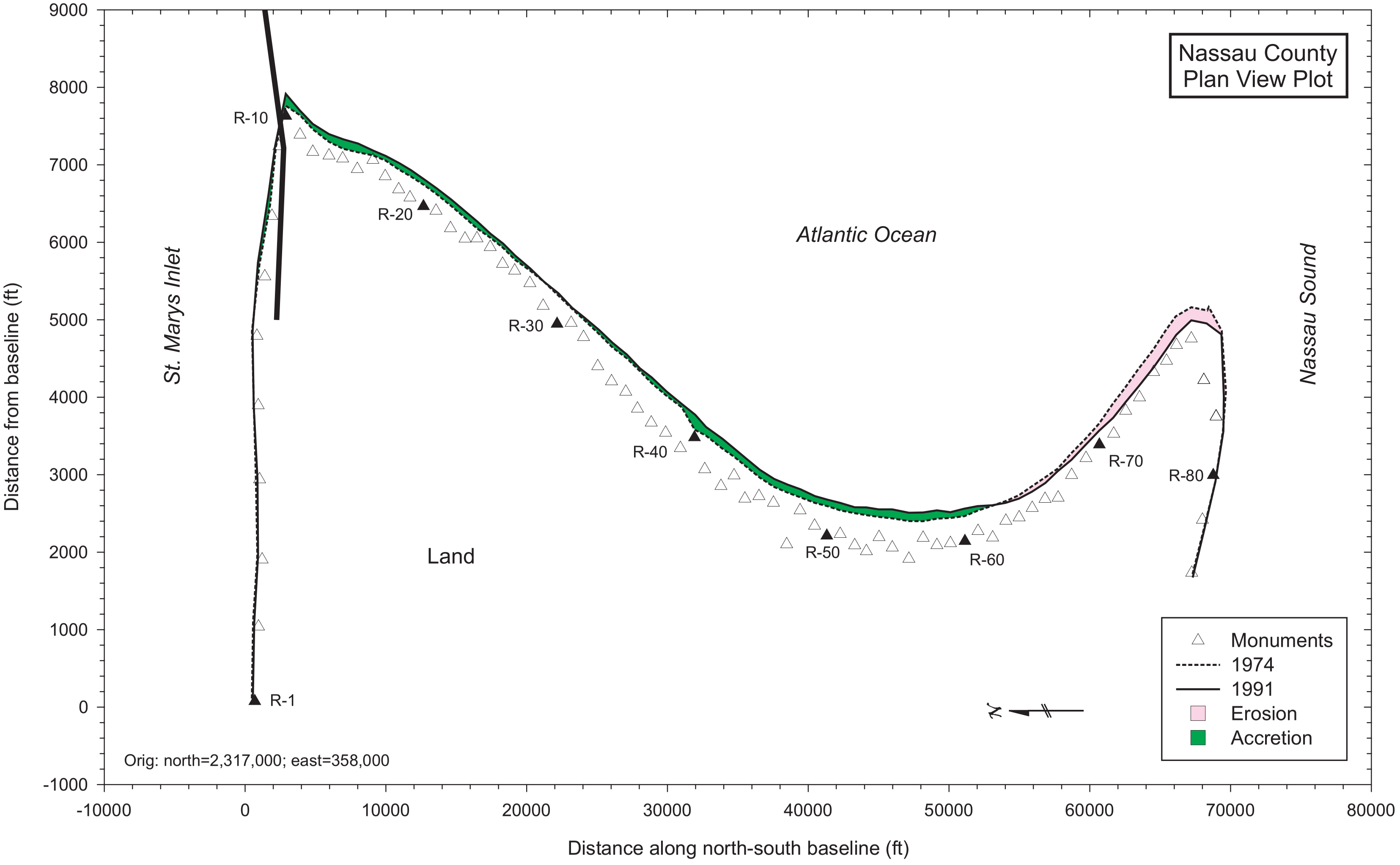

Figure 7. Plan view map of Nassau County, Florida, comparing years 1974 and 1991.

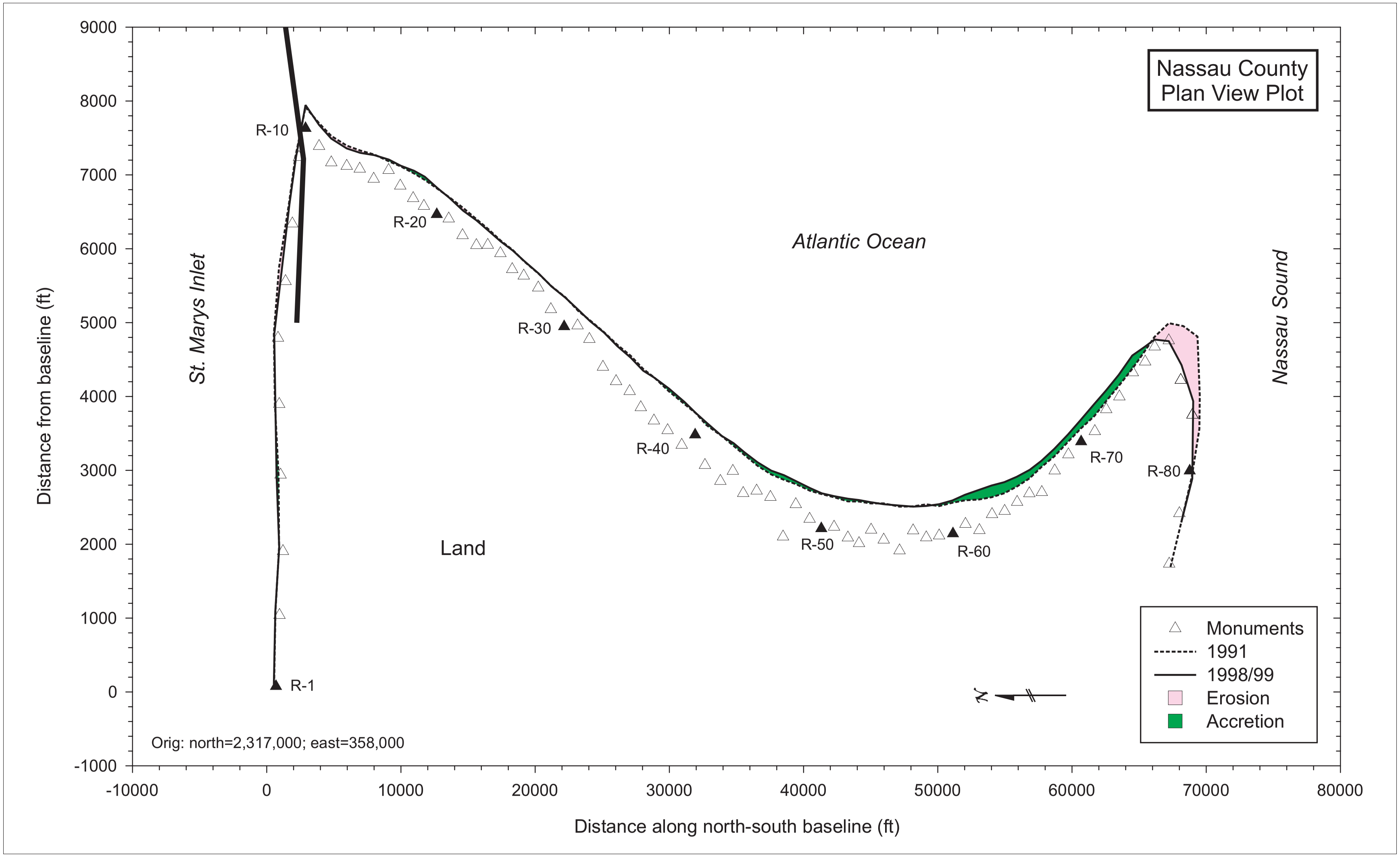

Figure 8. Plan view map of Nassau County, Florida, comparing years 1991 and 1998/99.

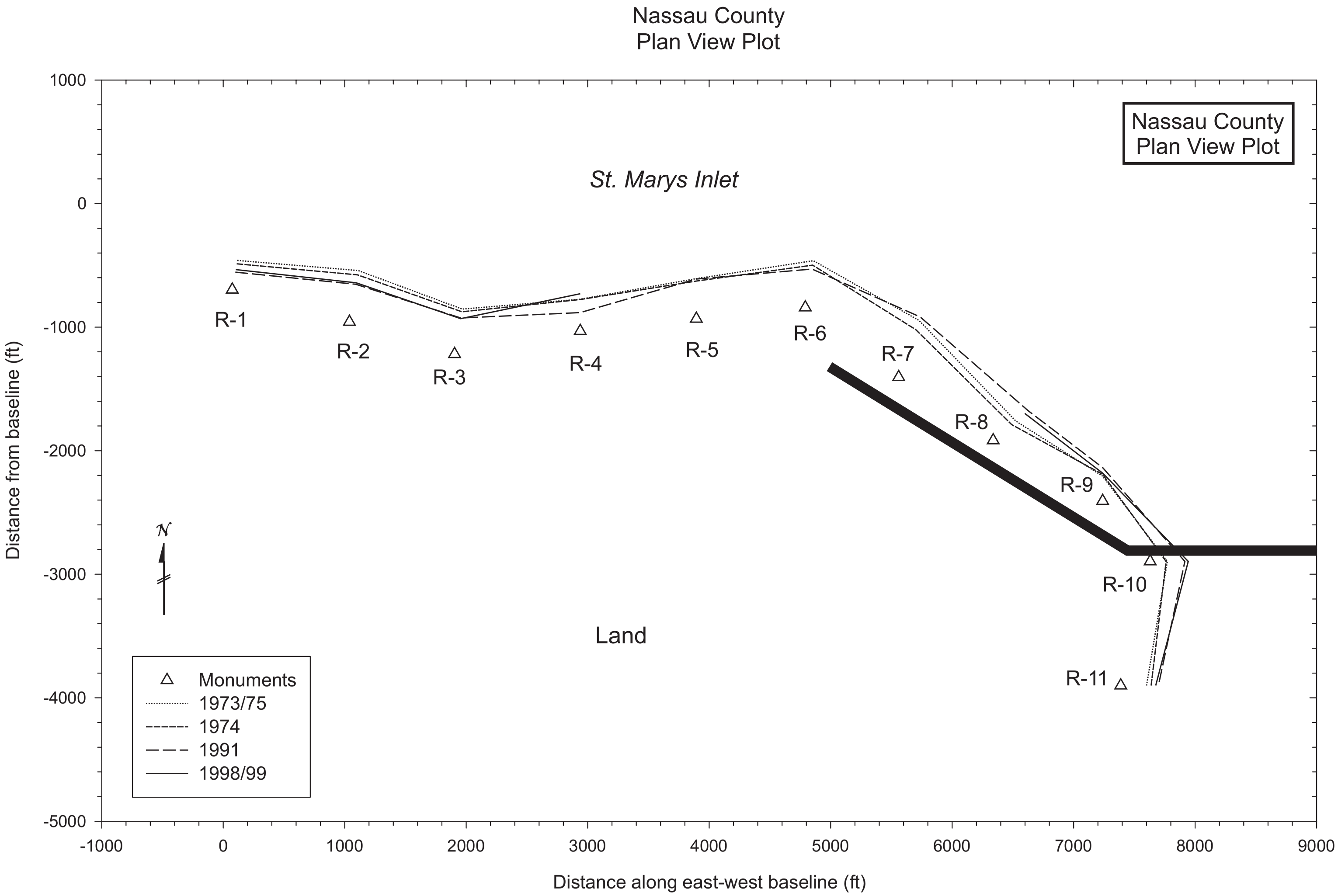

Figure 9. Plan view map of Nassau County, Florida, inside throat of St. Marys Inlet, comparing years 1973/75, 1974, 1991, 1998/99.

6 SUMMARY AND CONCLUDING REMARKS

For a relatively small island, Amelia has seen many significant shoreline changes. In the northern R-10 to R-30 zone, south of the inlet jetty, a progressive erosion pattern was spreading southward. This has since been held in check by beach renourishments since 1978. On the southern end (R-62 to R-82), a progressive erosion pattern was spreading northward. This has recently been brought under control (so far) by a beach renourishment in 1994, which included the placement of terminal groins at the south end of the project. The area south of the groins has since required maintenance with beach fill. The central portion of the island has remained accretionary to stable. The small zone inside the jetty of St. Marys Inlet (R-1 to R-9) has been approximately half erosional, closest to Ft. Clinch, and half accretional since 1973-75. Jetty modifications, possible new groins at Ft. Clinch, and dredging operations can radically alter the situation here in the future.

Because of the uncertainties involved with future climatic conditions such as sea level rise and major storm impacts, it is not recommended to plan for less erosion than -1 ft/yr at any location. Also, it is believed that the accretion in the center of the island will eventually level off.

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8 APPENDICES

8.1 Appendix A: Shoreline Change Rates

Table A-1: This table and accompanying figure provide rates based on the method described in Section 4.

Table A-1. Shoreline rate of change estimates for Nassau County, Florida.

Range	Time Span	Method			Rounded Concensus Average	Comments
		RA	LS	EP		
St. Marys Inlet						
1	1973/75 - 1998	-3.6	-3.4	-3.1	-3.5	No longshore averaging ↓
2	1973/75 - 1998	-1.9	-2.9	-4.2	-3.0	
3	1973/75 - 1998	-3.1	-3.0	-3.3	-3.0	
4	1973/75 - 1998	1.0	0.1	1.9	1.0	
5	1973/75 - 1991	-0.2	0.4	-0.2	0.0	
6	1973/75 - 1998	-2.9	-3.3	-4.3	-3.5	
7	1973/75 - 1991	6.5	3.8	1.8	4.0	
8	1973/75 - 1998	9.1	7.5	4.0	7.0	↑ west of south jetty
9	1973/75 - 1998	1.9	2.5	1.0	2.0	
10	1957/58 - 1978	-3.3	-3.6	-3.9	-3.5	s. of s. jetty ↓
11	1957/58 - 1978	-15.9	-15.9	-15.9	-14.5	3 pt average
12	1957/58 - 1978	-22.8	-24.4	-23.5	-17.0	5 pt average
13	1957/58 - 1978	-22.1	-23.4	-22.7	-14.0	7 pt average ↓
14	1957/58 - 1978	-20.0	-20.5	-19.9	-14.0	
15	1924 - 1974	-8.6	-6.9	-8.0	-12.5	
16	1924 - 1974	-5.0	-4.8	-4.9	-10.0	
17	1924 - 1974	-4.8	-4.6	-4.0	-7.0	
18	1924 - 1974	-4.7	-4.7	-4.1	-4.5	
19	1924 - 1974	-4.2	-4.3	-3.7	-3.5	
20	1924 - 1974	-4.6	-4.1	-3.2	-3.5	
21	1924 - 1974	-2.6	-2.5	-1.9	-3.0	
22	1924 - 1974	-1.7	-2.0	-1.9	-2.5	
23	1924 - 1974	-1.9	-2.2	-2.3	-2.0	
24	1924 - 1974	-2.0	-2.1	-2.5	-1.5	
25	1924 - 1974	0.4	-1.1	-1.9	-1.5	
26	1924 - 1974	1.0	-0.8	-1.7	-1.0	
27	1924 - 1974	-0.5	-1.0	-2.0	-1.0	
28	1924 - 1974	-0.3	-0.6	-1.6	-0.5	
29	1924 - 1974	-0.6	0.1	-0.6	0.0	
30	1924 - 1974	-0.4	-0.1	-0.4	0.5	
31	1924 - 1998	1.0	1.3	0.5	1.0	
32	1924 - 1999	1.8	1.8	0.8	1.5	

Table A-1. Shoreline rate of change estimates for Nassau County, Florida.

Range	Time Span	Method			Rounded Concensus Average	Comments
		RA	LS	EP		
33	1924 - 1999	3.0	2.9	1.7	2.5	
34	1924 - 1998	3.8	3.6	2.0	3.0	
35	1871 - 1998	4.6	3.8	3.4	3.5	
36	1871 - 1998	4.3	4.1	3.7	4.0	
37	1871 - 1998	4.8	4.0	3.9	4.0	
38	1871 - 1998	5.3	4.2	4.2	4.0	
39	1871 - 1998	6.1	4.6	4.4	4.0	
40	1871 - 1981	3.9	3.7	4.1	4.0	
41	1871 - 1981	3.3	3.2	3.3	3.5	
42	1871 - 1981	3.3	3.1	2.9	3.5	
43	1871 - 1981	3.3	3.0	3.1	3.0	
44	1871 - 1981	3.4	2.9	3.1	2.5	
45	1871 - 1981	2.7	2.3	2.5	2.5	
46	1871 - 1981	2.1	1.8	2.0	2.5	
47	1871 - 1981	2.0	1.8	1.9	2.0	
48	1871 - 1981	2.6	1.9	1.9	2.0	
49	1871 - 1981	1.9	1.6	1.7	2.0	
50	1871 - 1981	1.8	1.5	1.6	1.5	
51	1871 - 1981	1.8	1.4	1.5	1.5	
52	1871 - 1981	1.7	1.4	1.5	1.5	
53	1871 - 1981	1.5	1.2	1.1	1.0	
54	1871 - 1981	1.0	1.0	0.7	1.0	
55	1871 - 1981	0.8	0.9	0.6	0.5	
56	1871 - 1981	0.3	0.5	0.3	0.5	
57	1871 - 1981	-0.1	0.0	-0.1	0.0	
58	1871 - 1981	-0.1	-0.1	-0.3	0.0	
59	1871 - 1981	-0.6	-0.3	-0.5	-0.5	
60	1871 - 1981	-0.5	-0.7	-0.9	-1.0	
61	1871 - 1981	-0.5	-0.8	-0.9	-1.5	
62	1974 - 1993	-0.9	-0.5	-2.2	-2.5	
63	1974 - 1993	-2.0	-2.7	-4.3	-3.0	
64	1974 - 1993	-4.1	-4.2	-5.6	-4.0	
65	1974 - 1993	-5.6	-5.3	-7.1	-5.0	

Table A-1. Shoreline rate of change estimates for Nassau County, Florida.

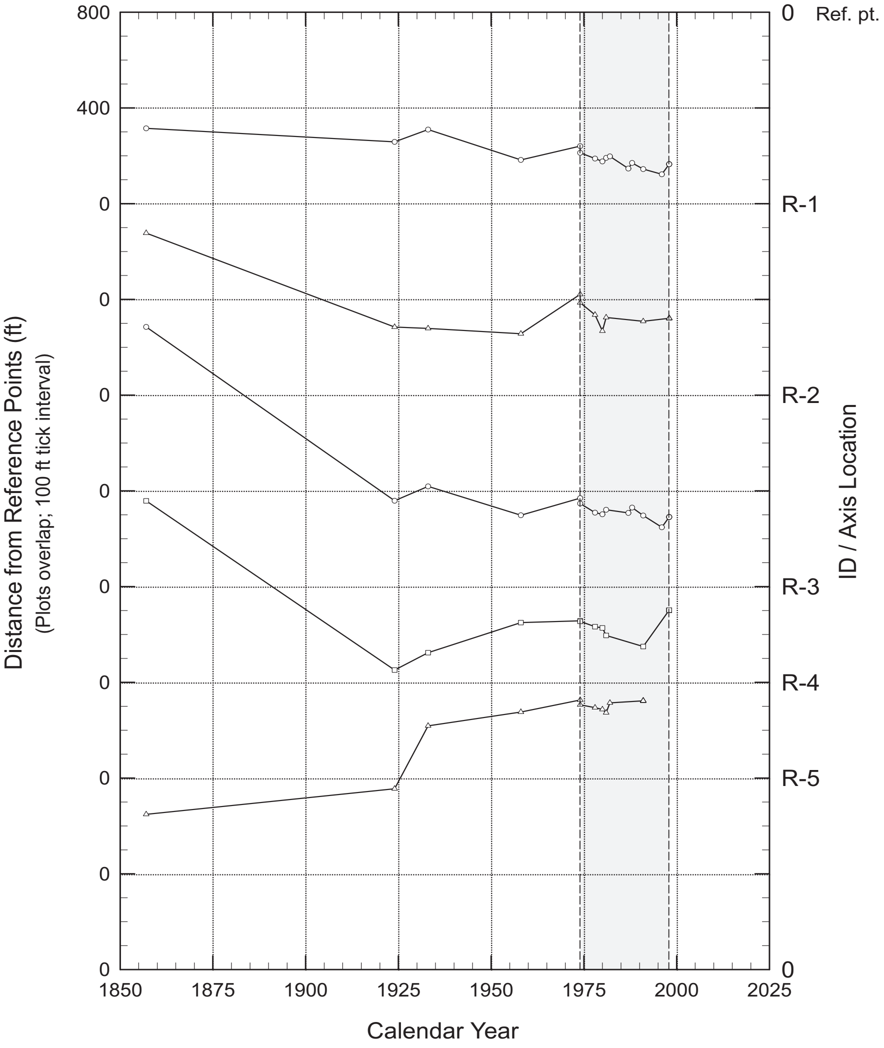
Range	Time Span	Method			Rounded Concensus Average	Comments
		RA	LS	EP		
66	1974 - 1993	-5.5	-5.7	-7.1	-6.5	
67	1974 - 1993	-5.2	-5.9	-8.6	-7.0	
68	1974 - 1993	-7.5	-7.3	-10.4	-8.5	
69	1974 - 1993	-8.9	-8.1	-10.6	-9.5	
70	1974 - 1993	-8.0	-7.8	-10.7	-10.5	
71	1974 - 1993	-12.5	-12.2	-14.4	-11.5	
72	1974 - 1993	-13.2	-12.6	-14.3	-12.0	↑
73	1974 - 1991	-15.1	-12.0	-13.2	-13.0	7 pt average
74	1974 - 1991	-13.5	-12.9	-13.4	-13.5	5 pt average
75	1974 - 1991	-13.9	-13.4	-14.5	-14.0	3 pt average
76	1974 - 1991	-15.3	-13.7	-14.3	-14.5	1 pt average
77	1974 - 1991	-11.1	-9.4	-10.0	-10.0	No longshore averaging
78	1974 - 1991	-12.4	-12.9	-10.1	-12.0	↓
79A	1974 - 1991	-2.2	-1.2	-3.0	-2.0	
80	1974 - 1991	0.2	0.6	0.2	0.5	
81A	1974 - 1991	2.0	1.6	1.5	1.5	
82	1974 - 1991	3.3	2.5	2.8	3.0	
Nassau Sound						

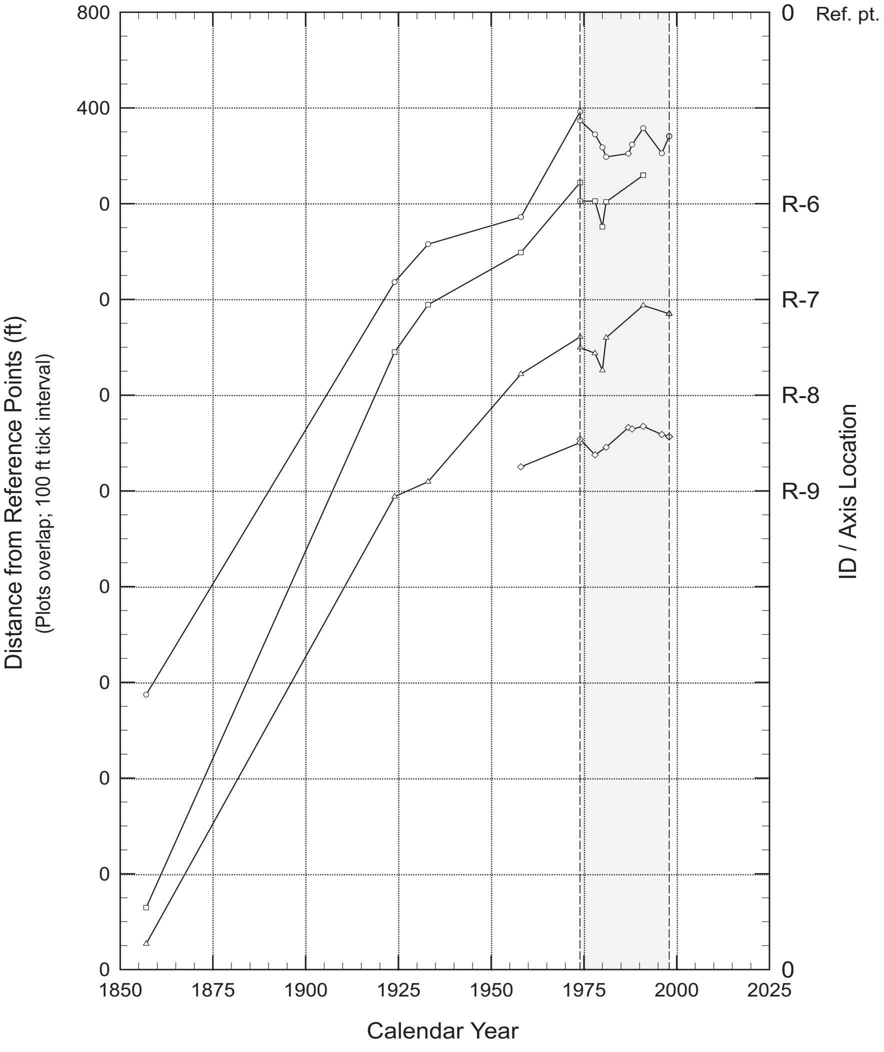
8.2 Appendix B: Stack Plots

Stack plots from Historic Shoreline Database, Florida Department of Environmental Protection, Bureau of Beaches and Coastal Systems; slightly modified by authors.

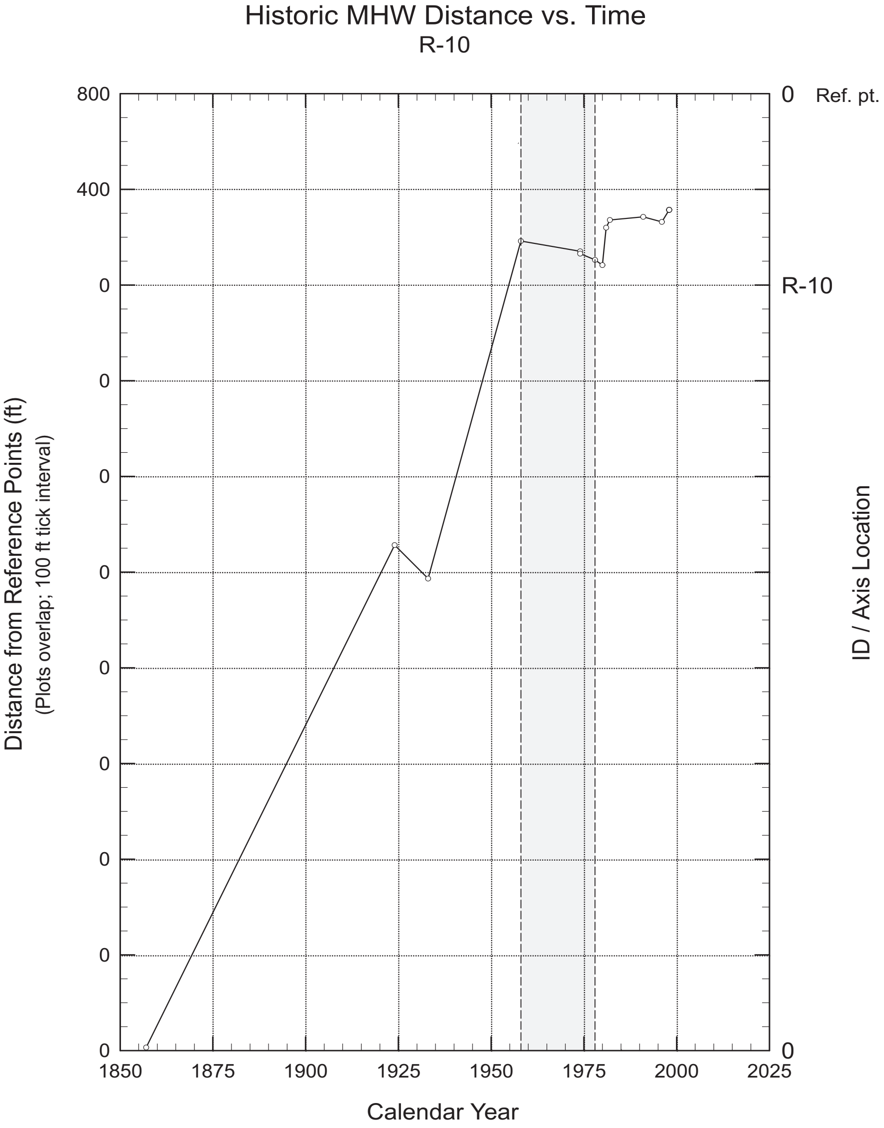
Historic MHW Distance vs. Time

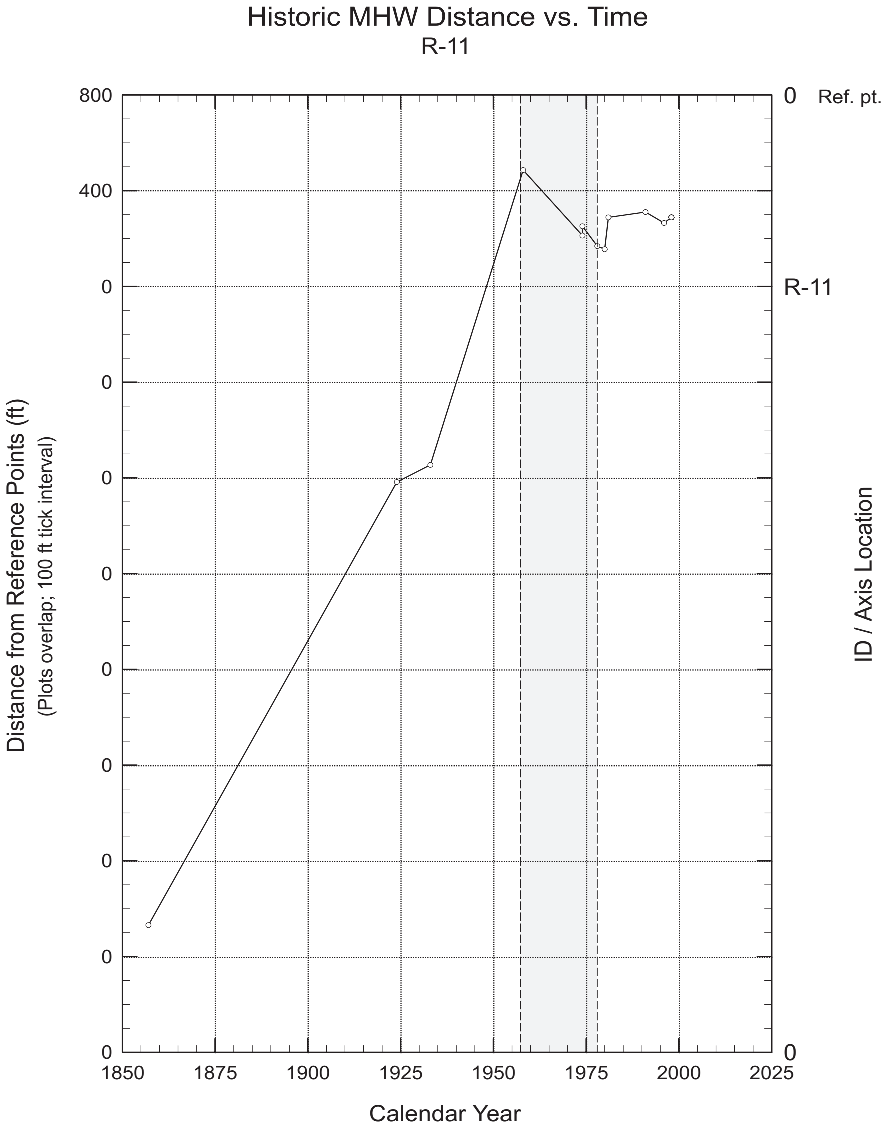
R-1 to R-5



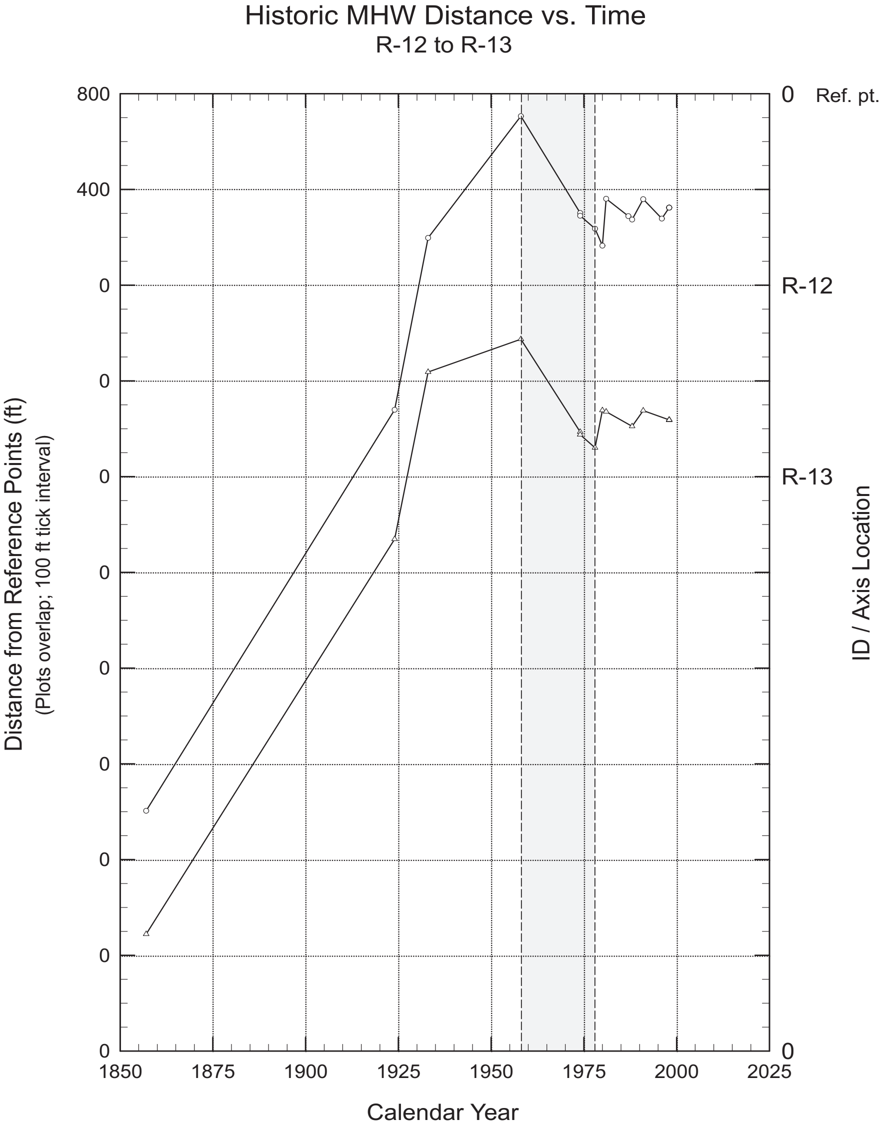


Historic MHW Distance vs. Time
R-6 to R-9


Historic MHW Distance vs. Time
R-10
800
400
0
0
0
0
0
0
0
0
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
0
Ref. pt.
R-10
0
ID / Axis Location

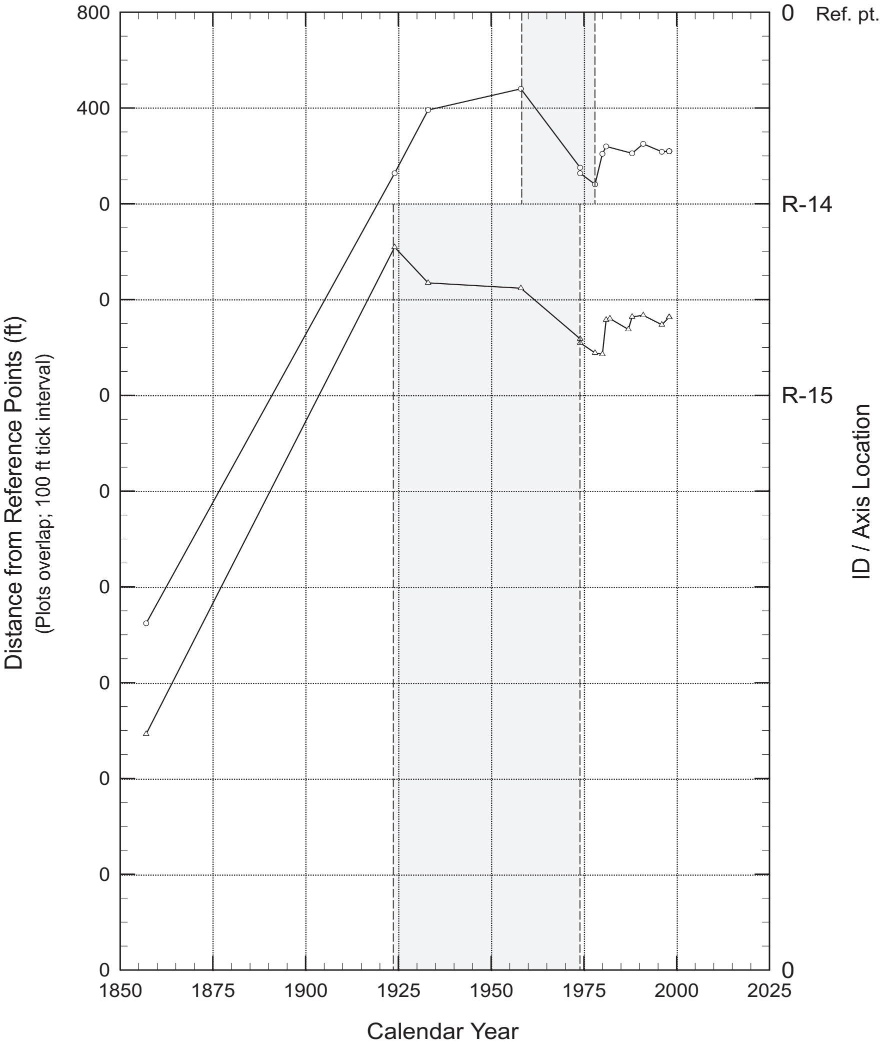


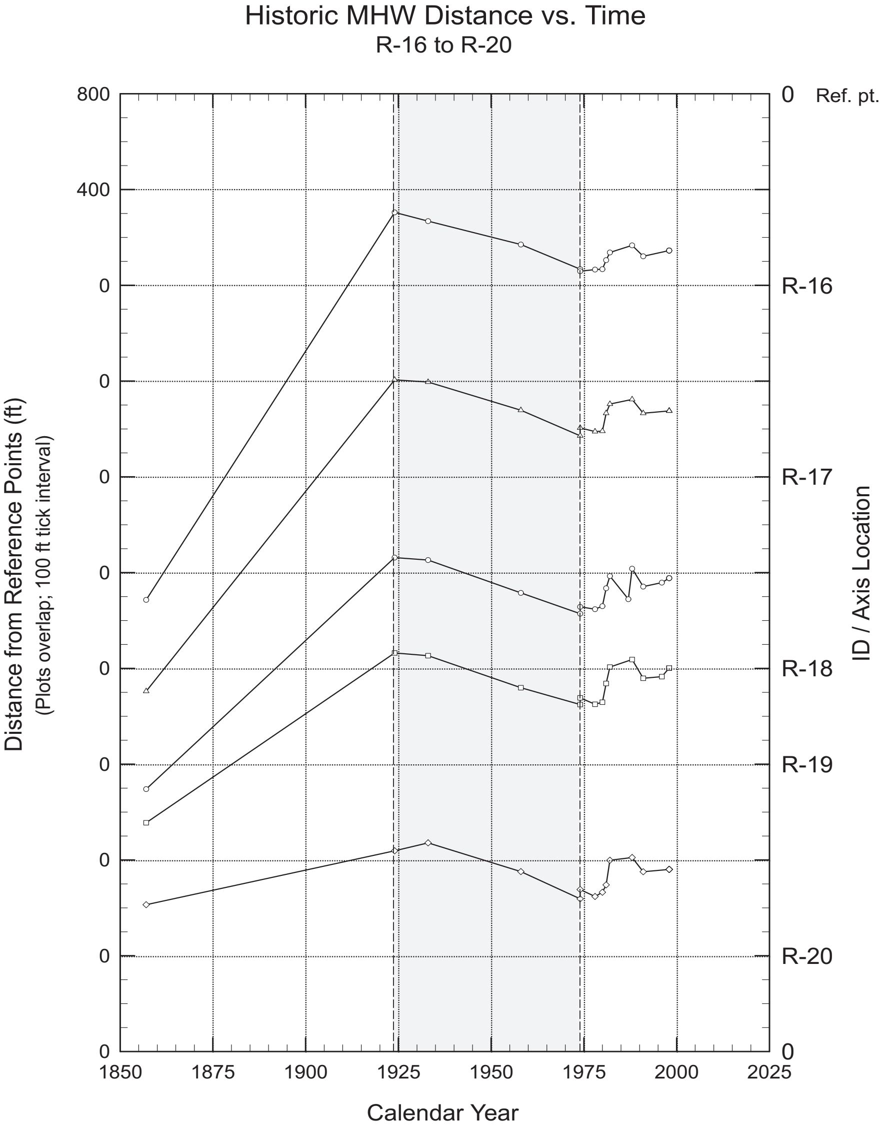
Historic MHW Distance vs. Time
R-11
800
400
0
0
0
0
0
0
0
0
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
0
Ref. pt.
R-11
0
ID / Axis Location

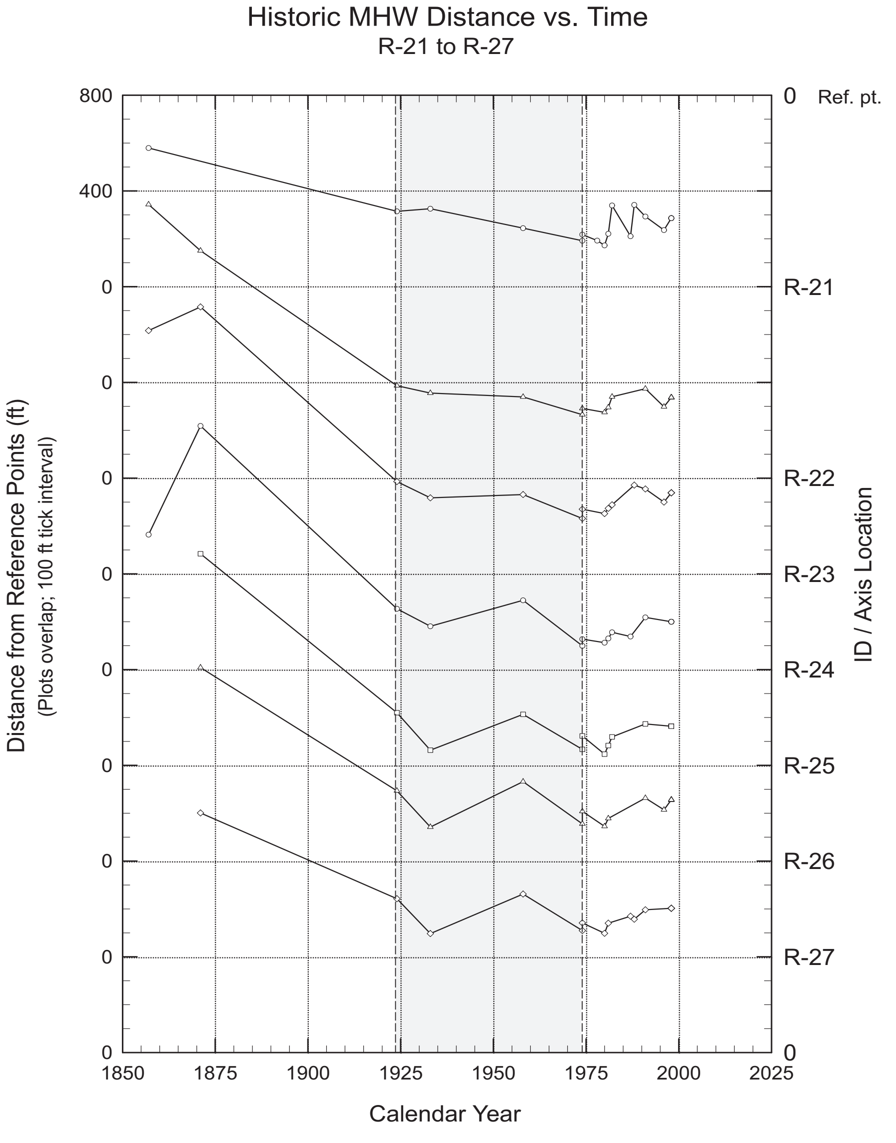

Historic MHW Distance vs. Time
R-12 to R-13
800
400
0
0
0
0
0
0
0
0
0
0 Ref. pt.
R-12
R-13
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
ID / Axis Location

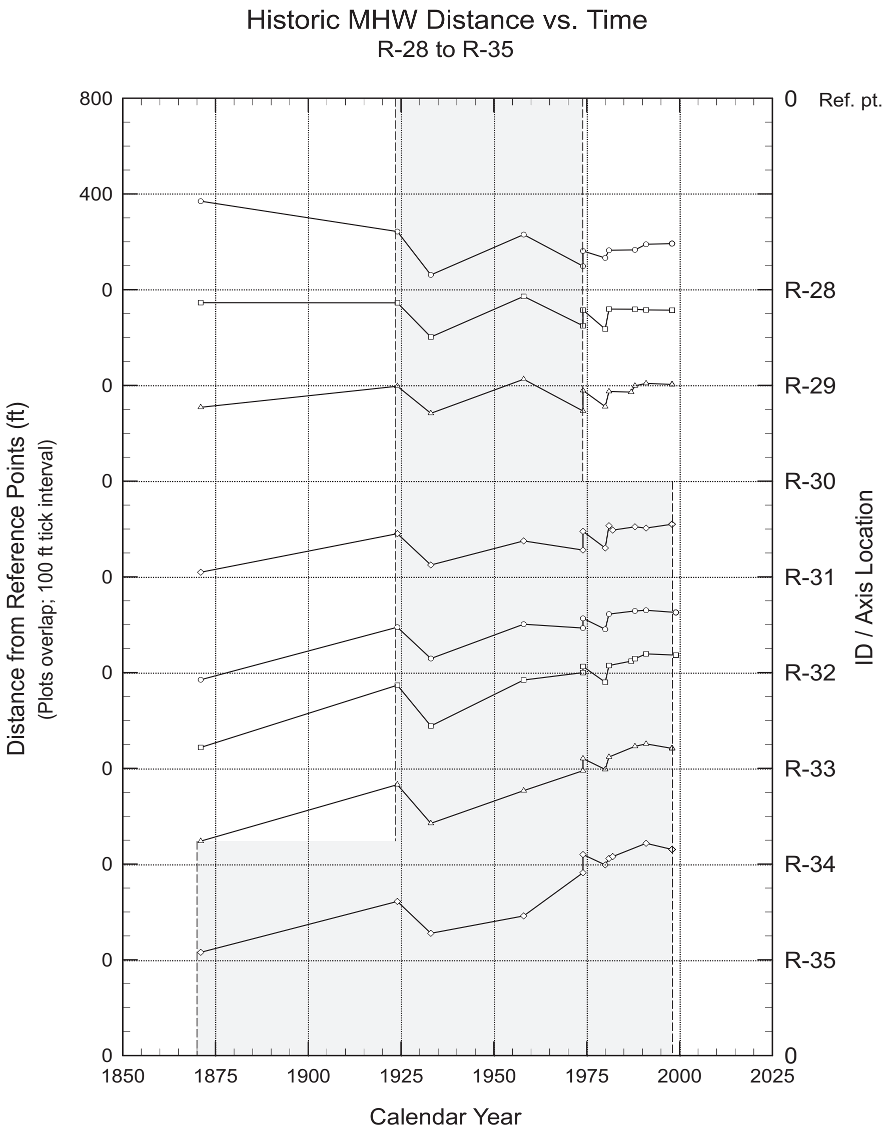
Historic MHW Distance vs. Time

R-14 to R-15



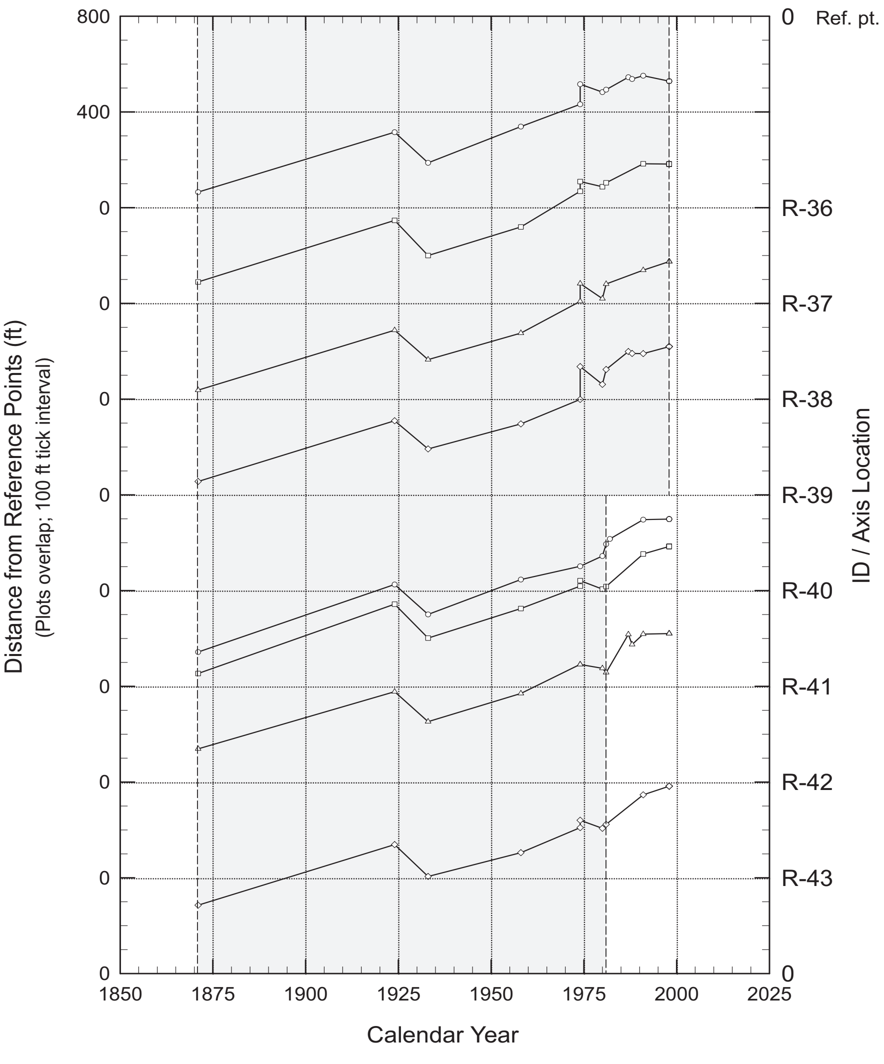

Historic MHW Distance vs. Time
R-16 to R-20
800
400
0
0
0
0
0
0
0
0
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
0 Ref. pt.
R-16
R-17
R-18
R-19
R-20
0
ID / Axis Location

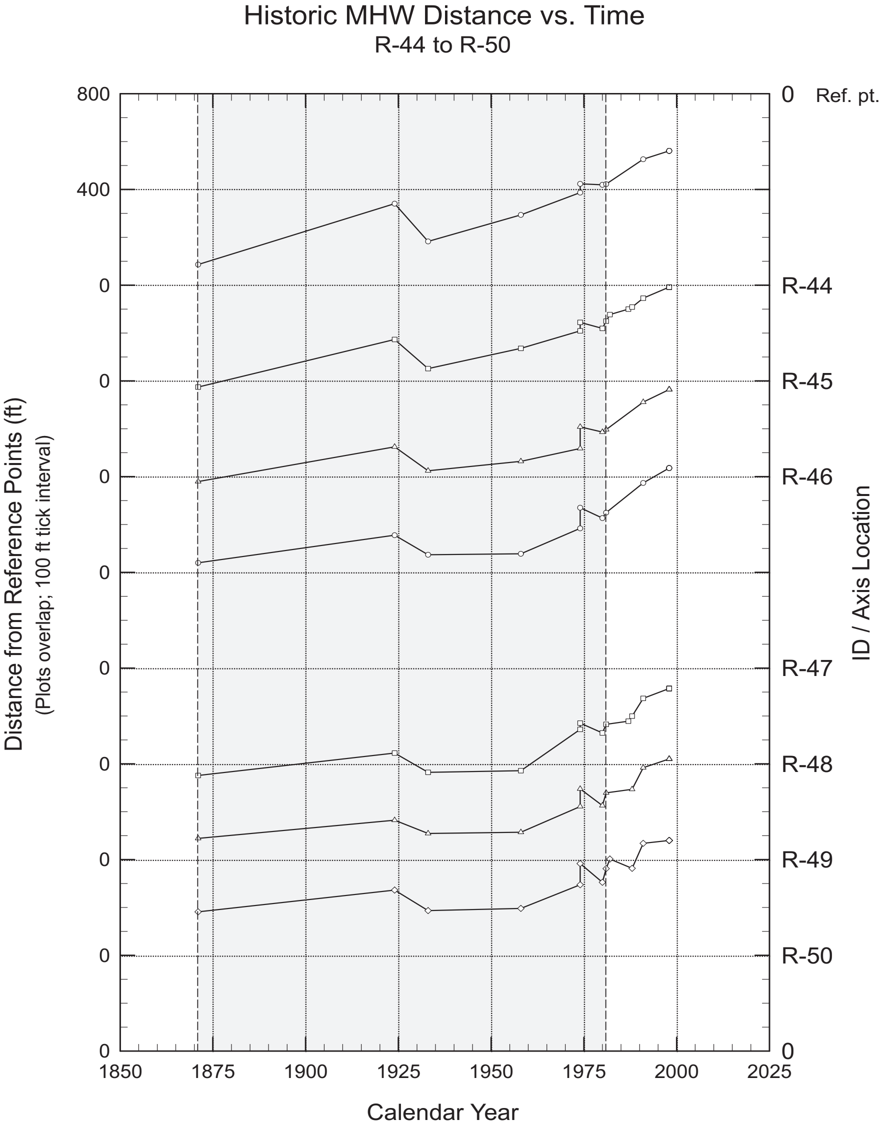

Historic MHW Distance vs. Time
R-21 to R-27
800
400
0
0
0
0
0
0
0
0
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
0 Ref. pt.
R-21
R-22
R-23
R-24
R-25
R-26
R-27
0
ID / Axis Location


Historic MHW Distance vs. Time
R-28 to R-35
800
400
0
0
0
0
0
0
0
0
0
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
0 Ref. pt.
R-28
R-29
R-30
R-31
R-32
R-33
R-34
R-35
0
ID / Axis Location
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year

Historic MHW Distance vs. Time

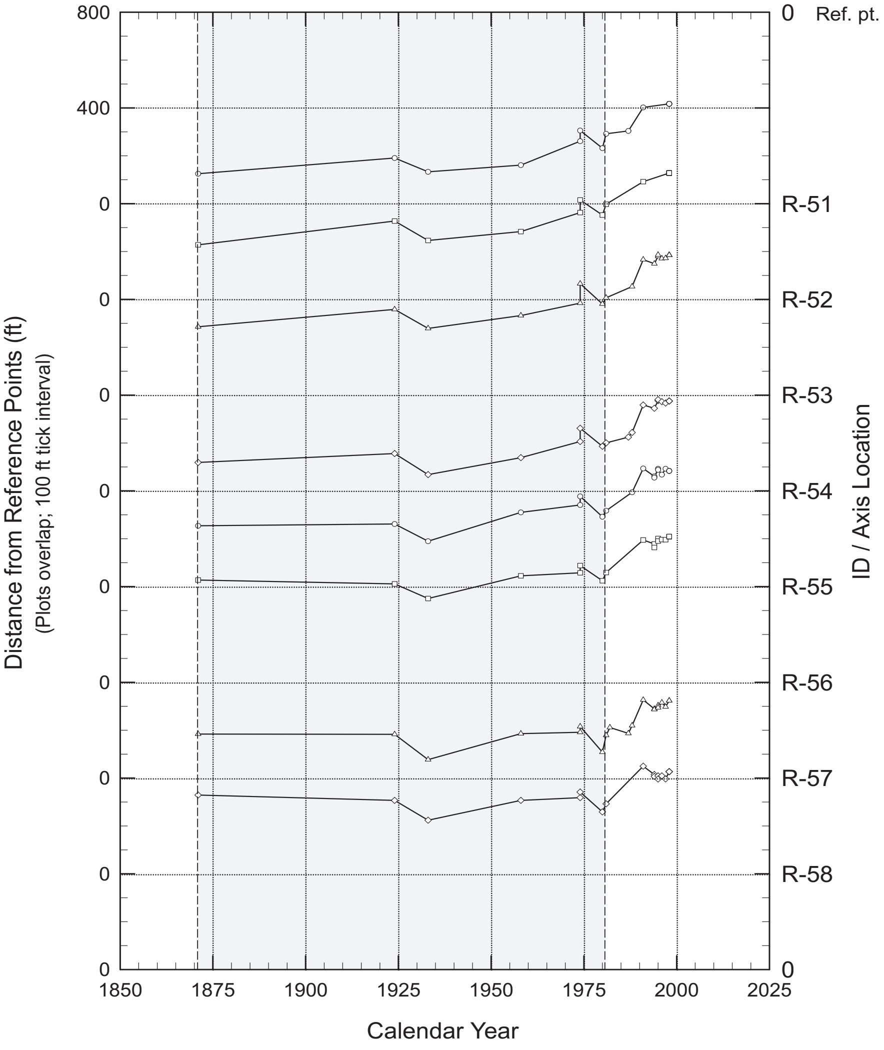
R-36 to R-43




Historic MHW Distance vs. Time
R-44 to R-50
800
400
0
0
0
0
0
0
0
0
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
0 Ref. pt.
R-44
R-45
R-46
R-47
R-48
R-49
R-50
0
ID / Axis Location

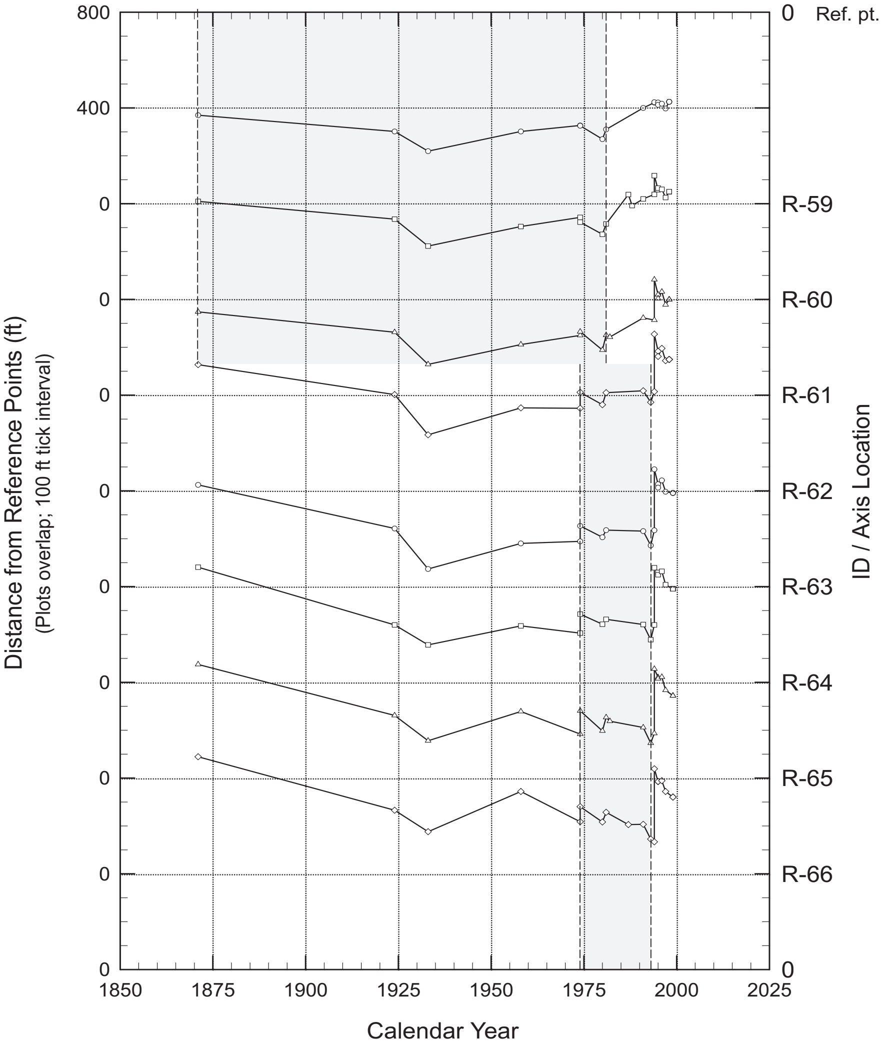
Historic MHW Distance vs. Time

R-51 to R-58



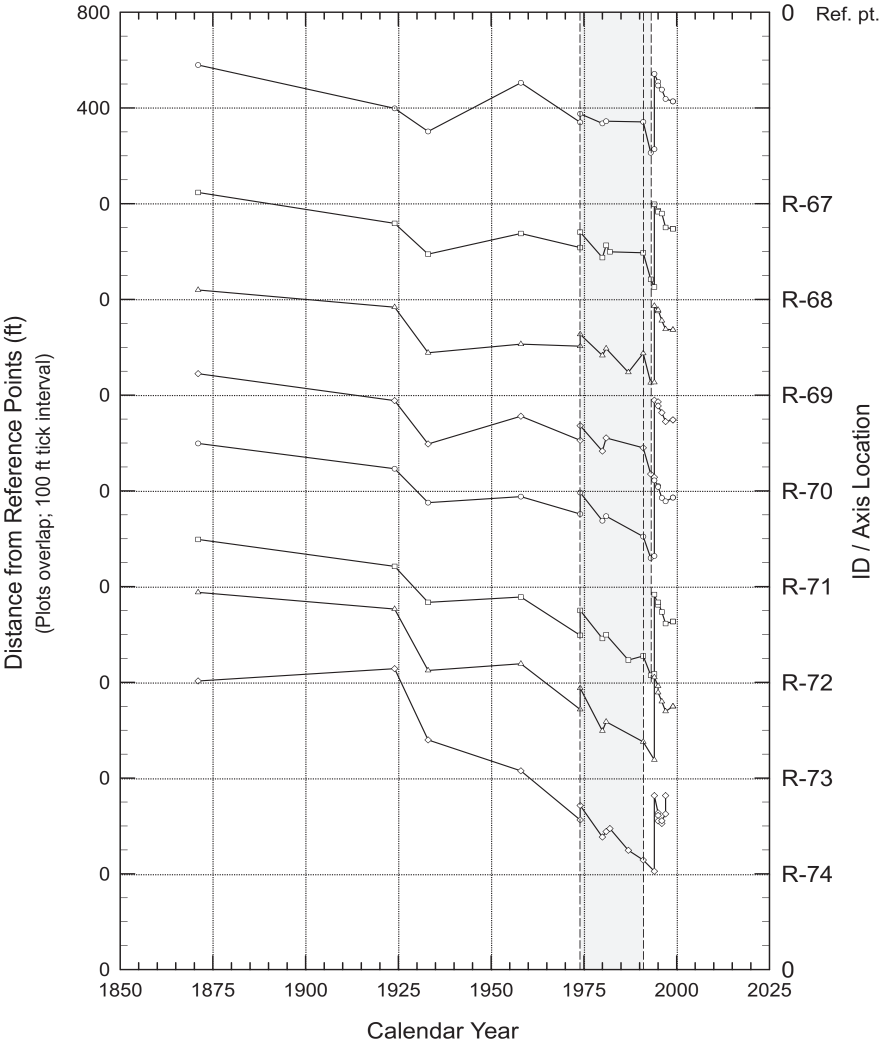
Historic MHW Distance vs. Time

R-59 to R-66

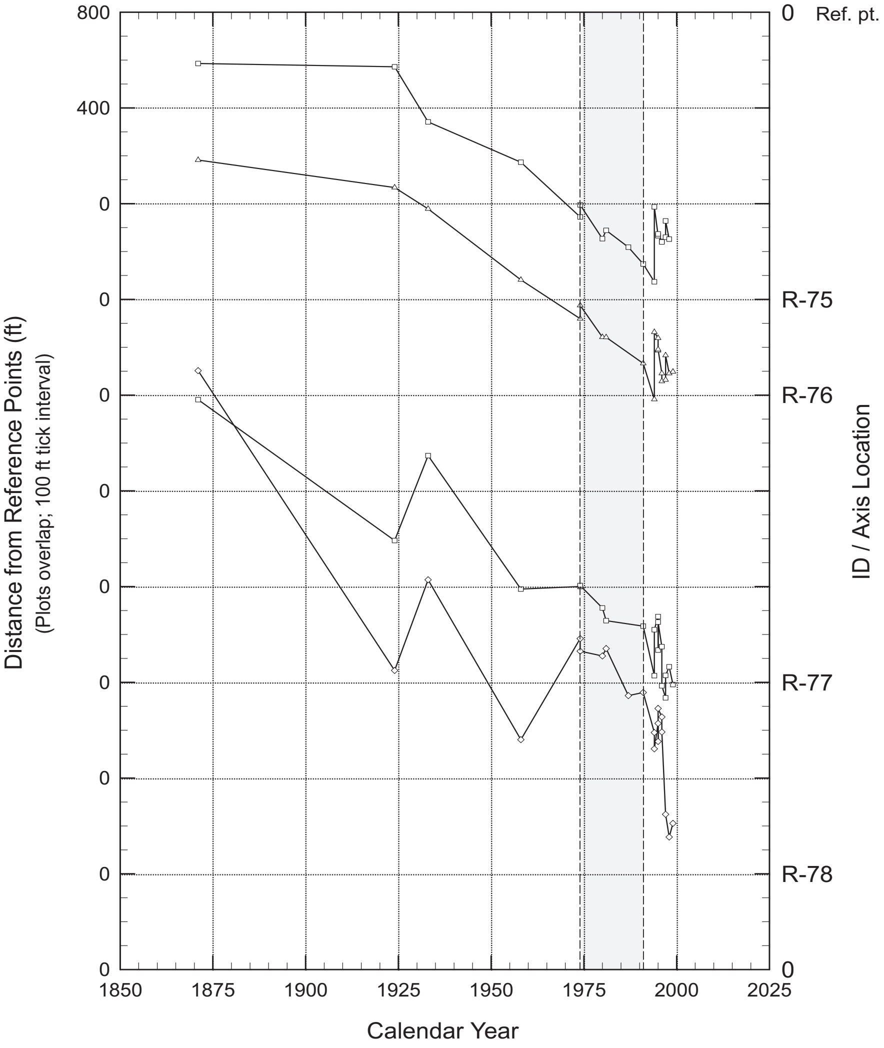


Historic MHW Distance vs. Time

R-67 to R-74

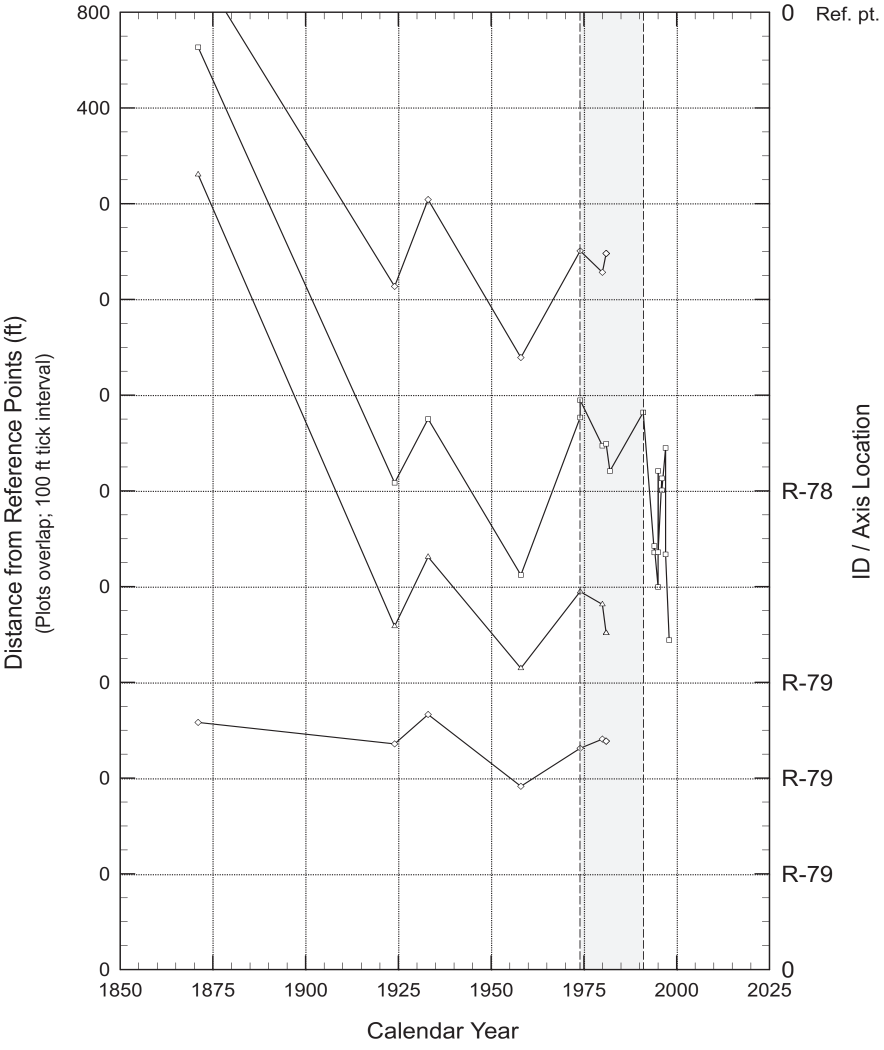


Historic MHW Distance vs. Time
R-75 to R-78



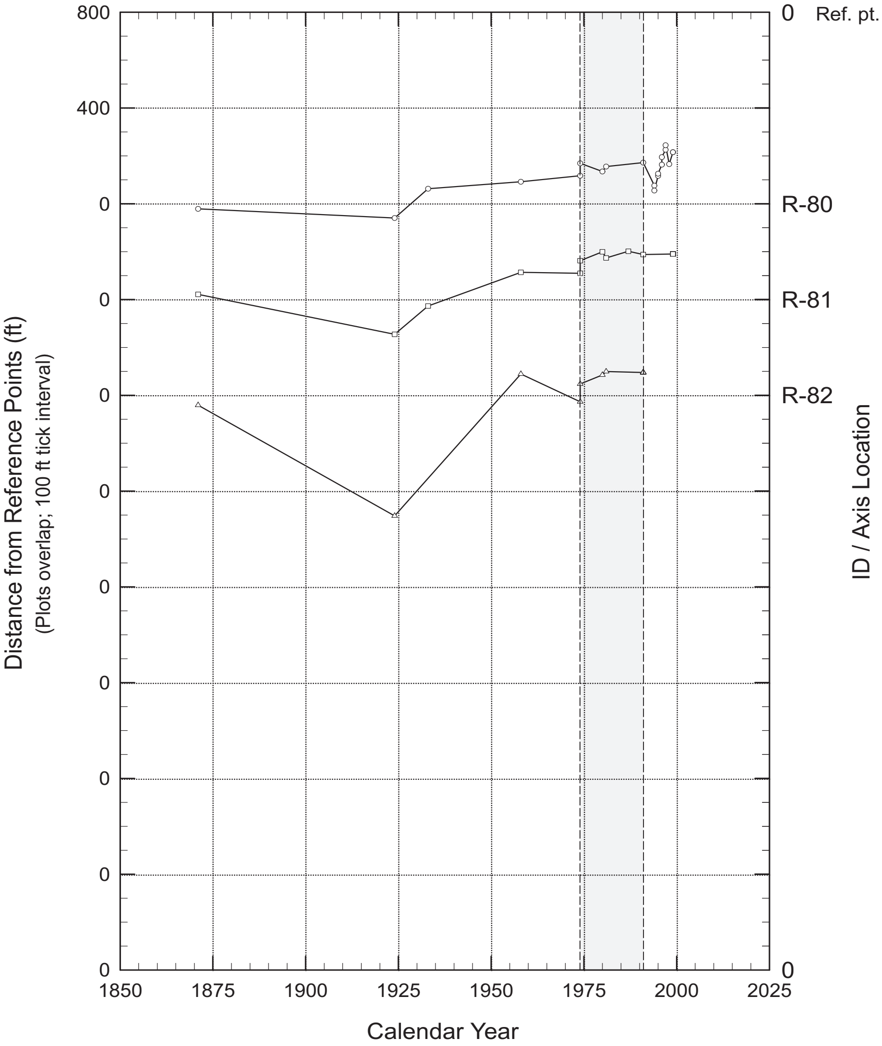
Historic MHW Distance vs. Time

R-78B to R-79C

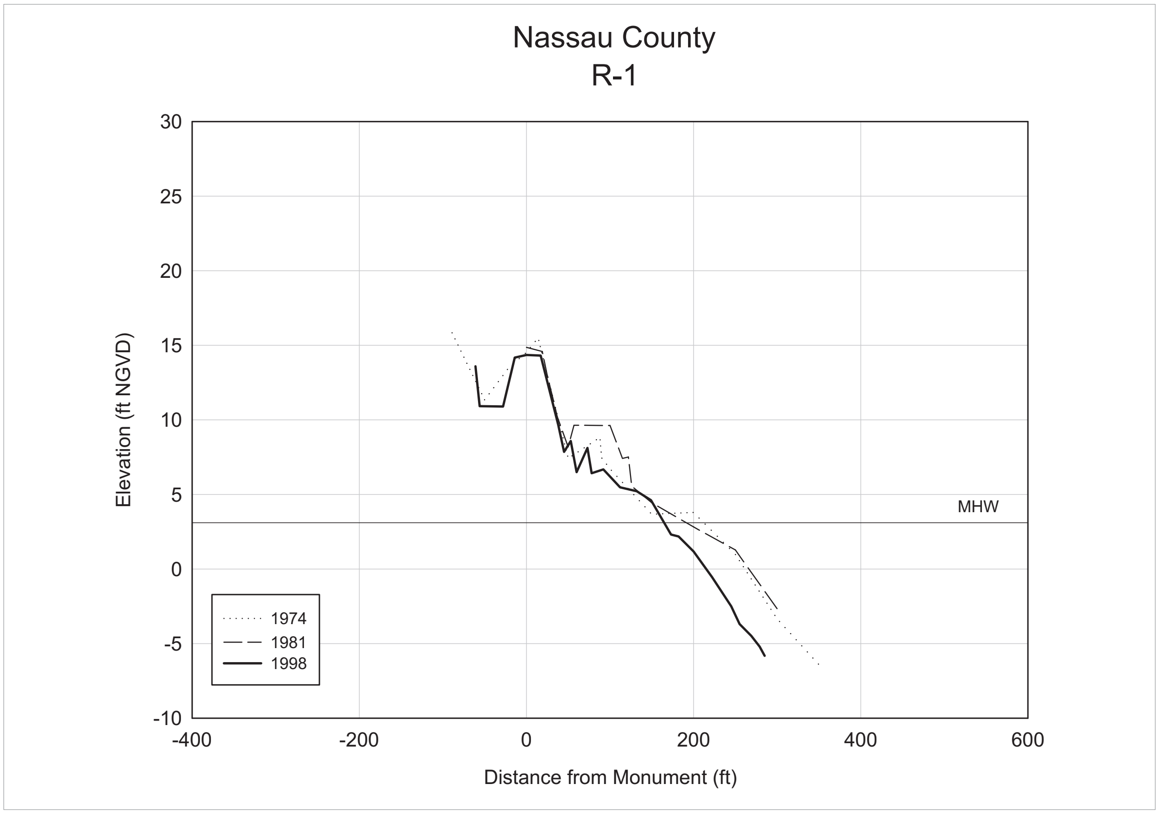


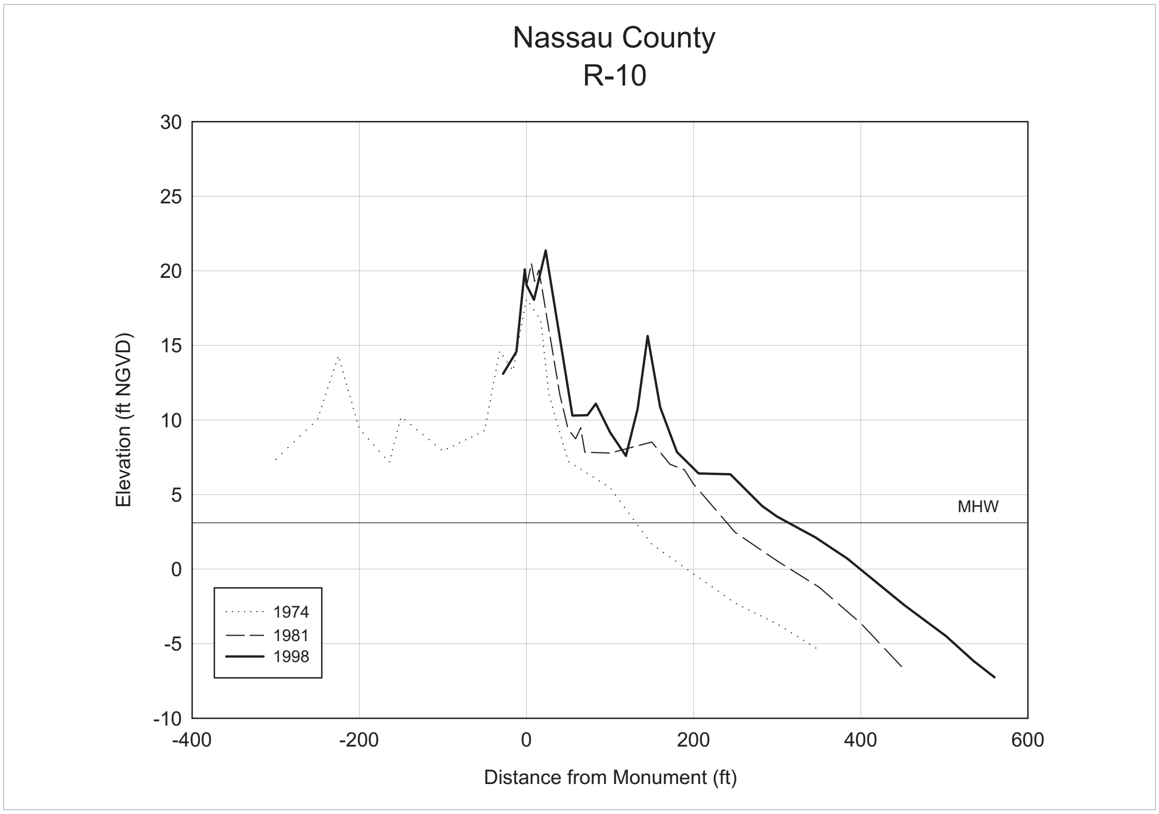
Historic MHW Distance vs. Time

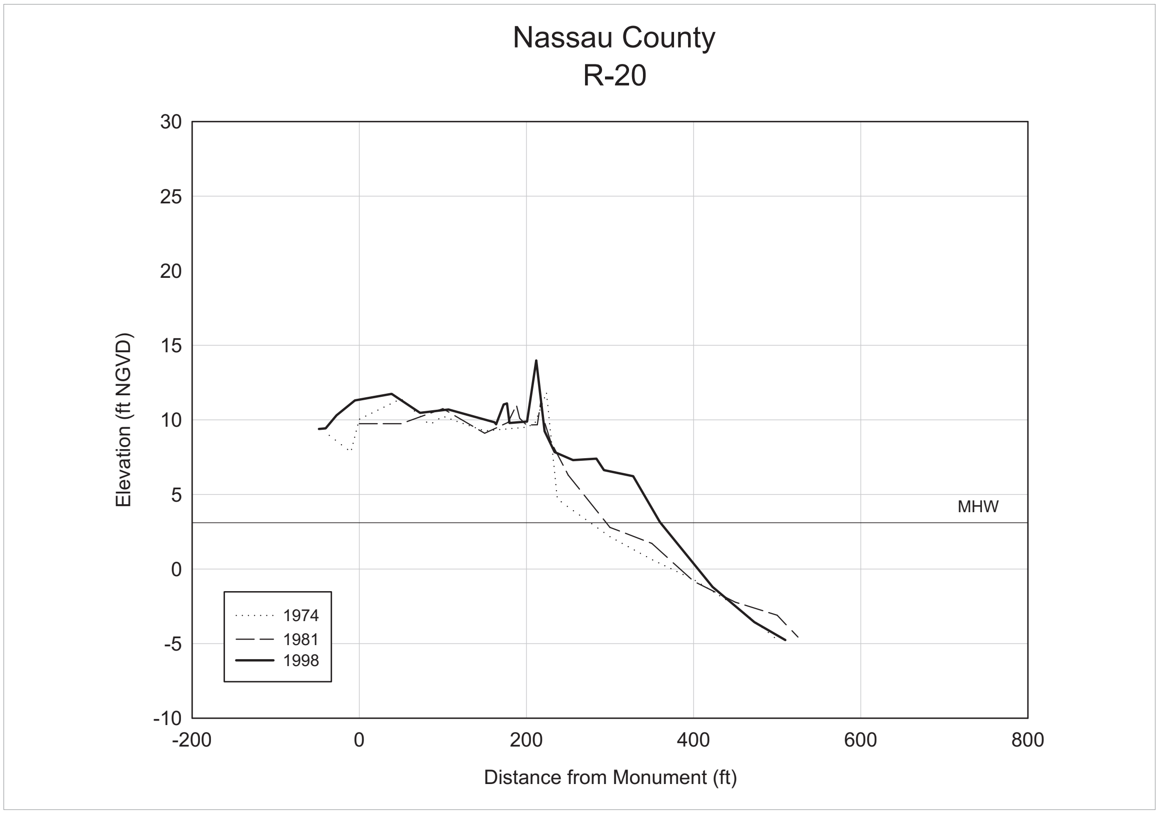
R-80 to R-82

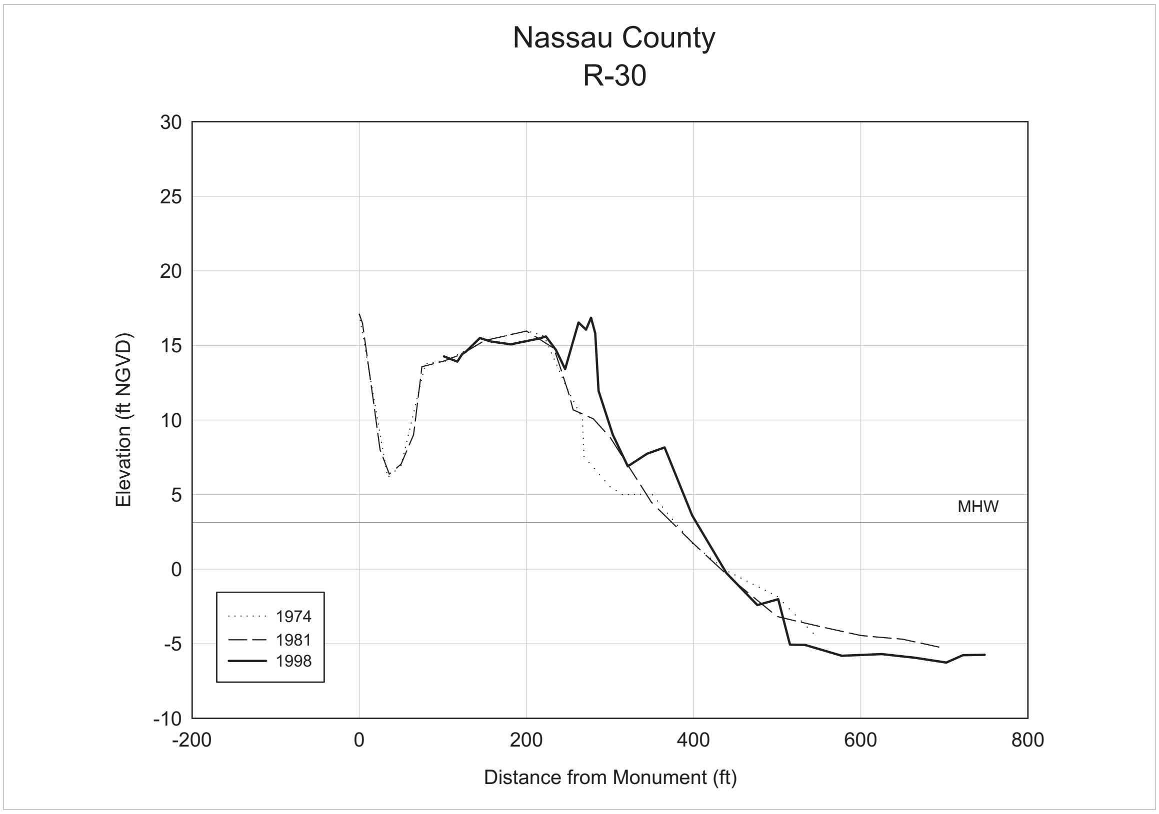


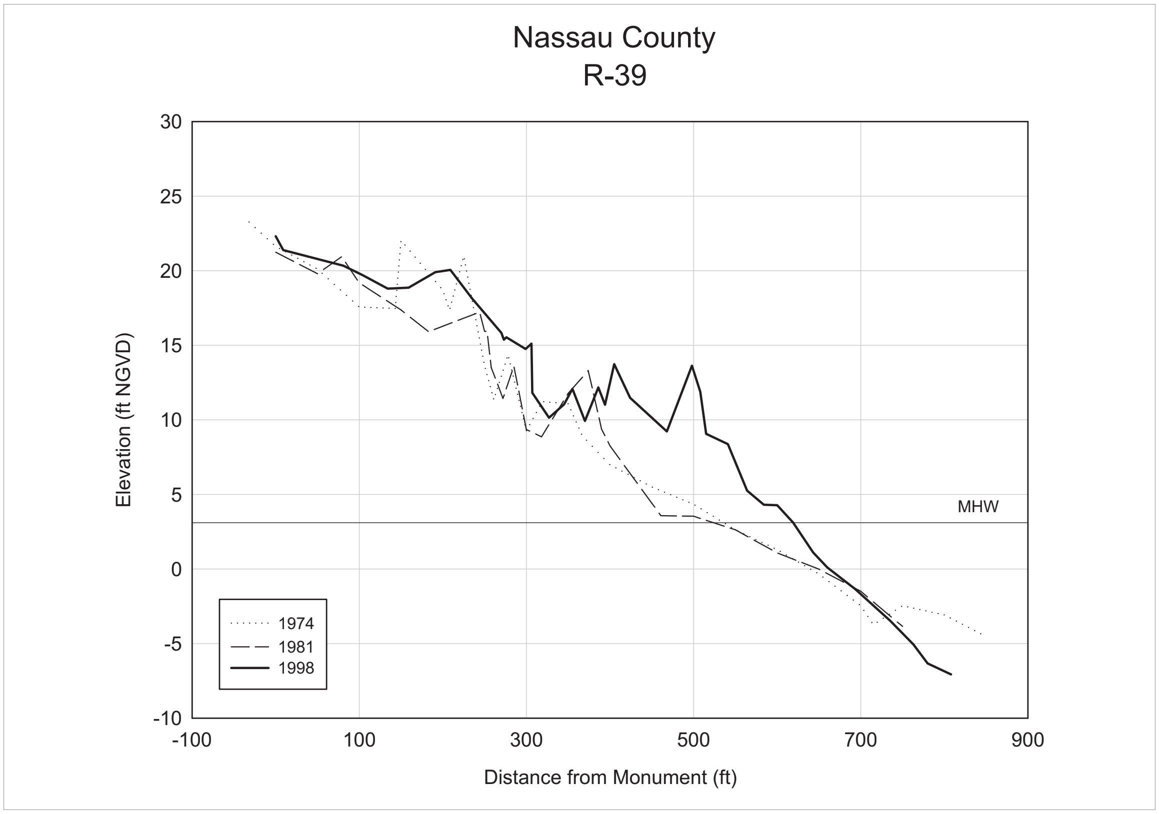
8.3 Appendix C: Profile Plots

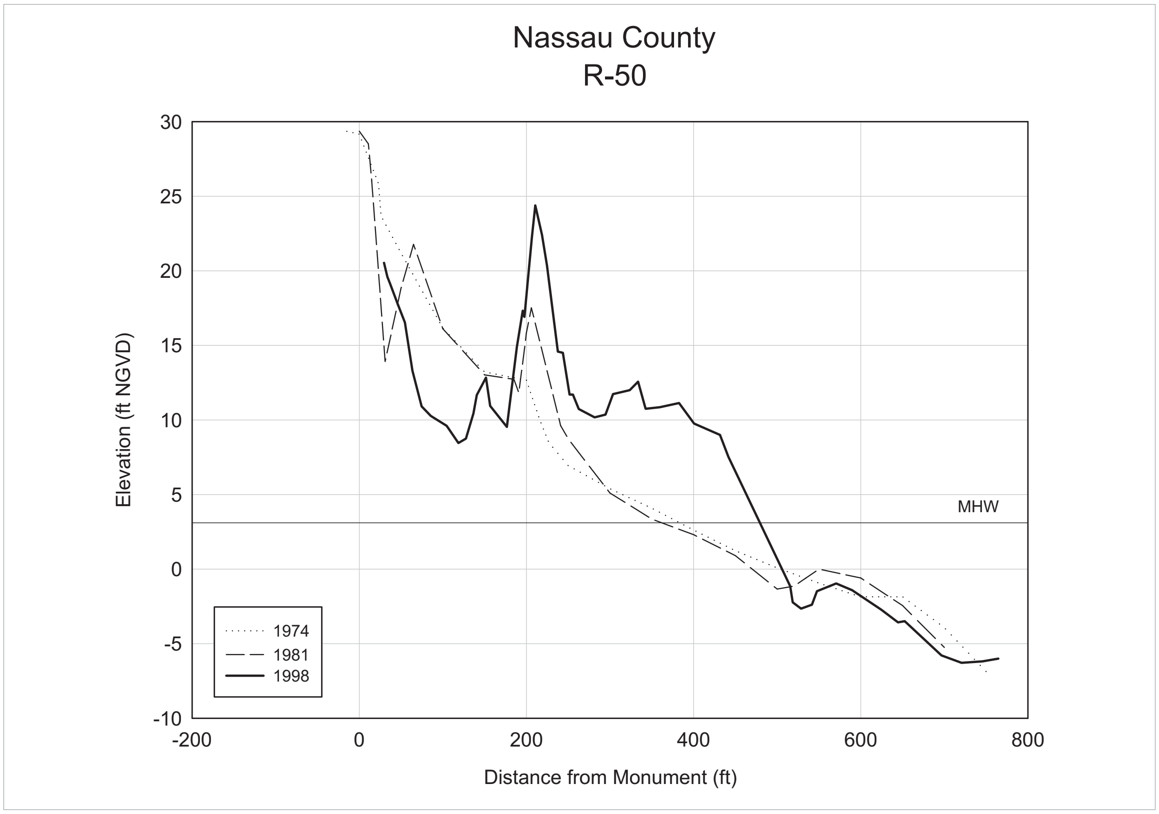

Nassau County
R-1
30
25
20
15
10
5
0
-5
-10
Elevation (ft NGVD)
-400
-200
0
200
400
600
Distance from Monument (ft)
MHW
1974
1981
1998

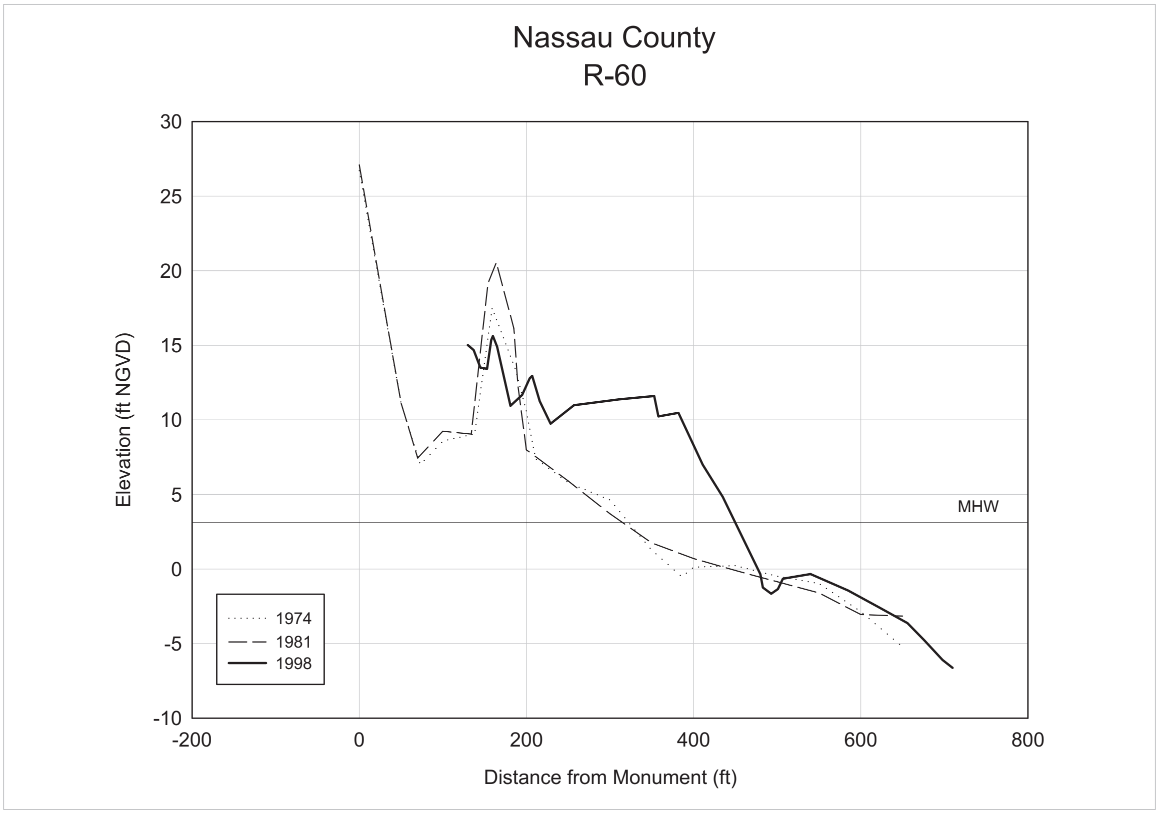

Nassau County
R-10
30
25
20
15
10
5
0
-5
-10
Elevation (ft NGVD)
-400
-200
0
200
400
600
Distance from Monument (ft)
MHW
1974
1981
1998

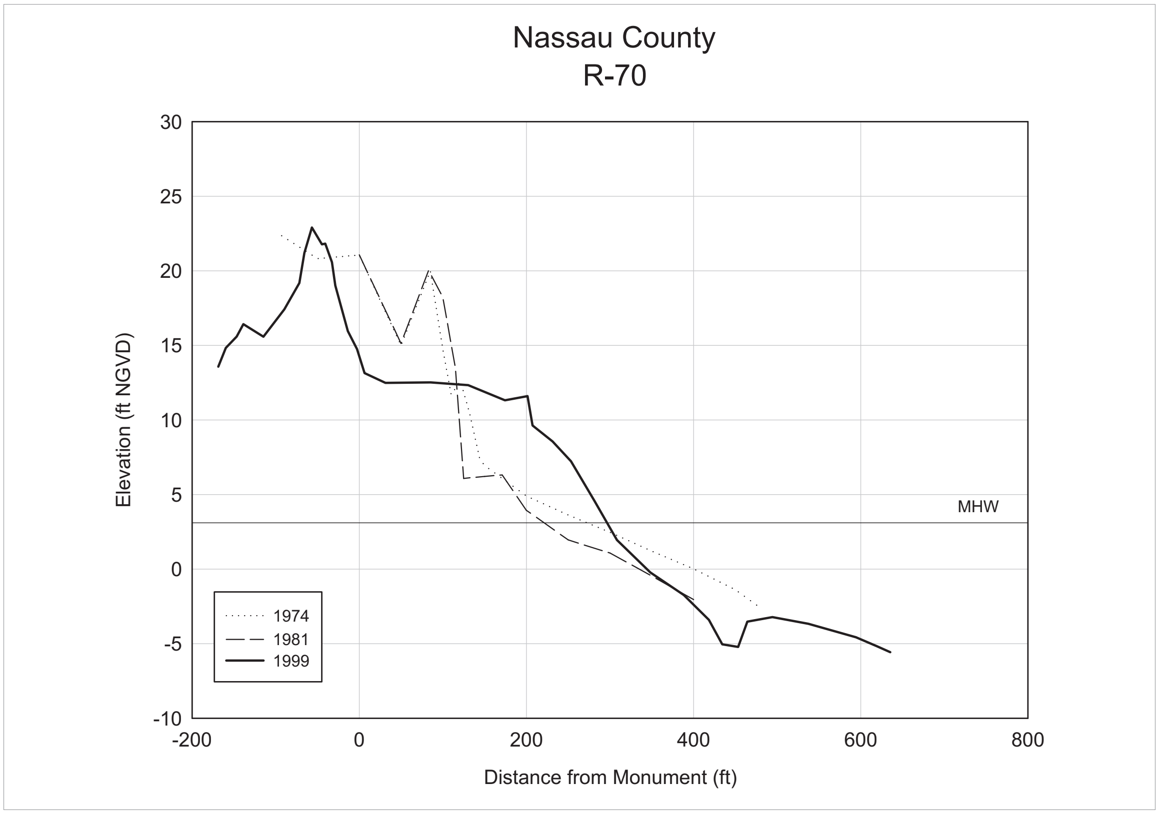

Nassau County
R-20
Elevation (ft NGVD)
30
25
20
15
10
5
0
-5
-10
-200
0
200
400
600
800
Distance from Monument (ft)
MHW
1974
1981
1998

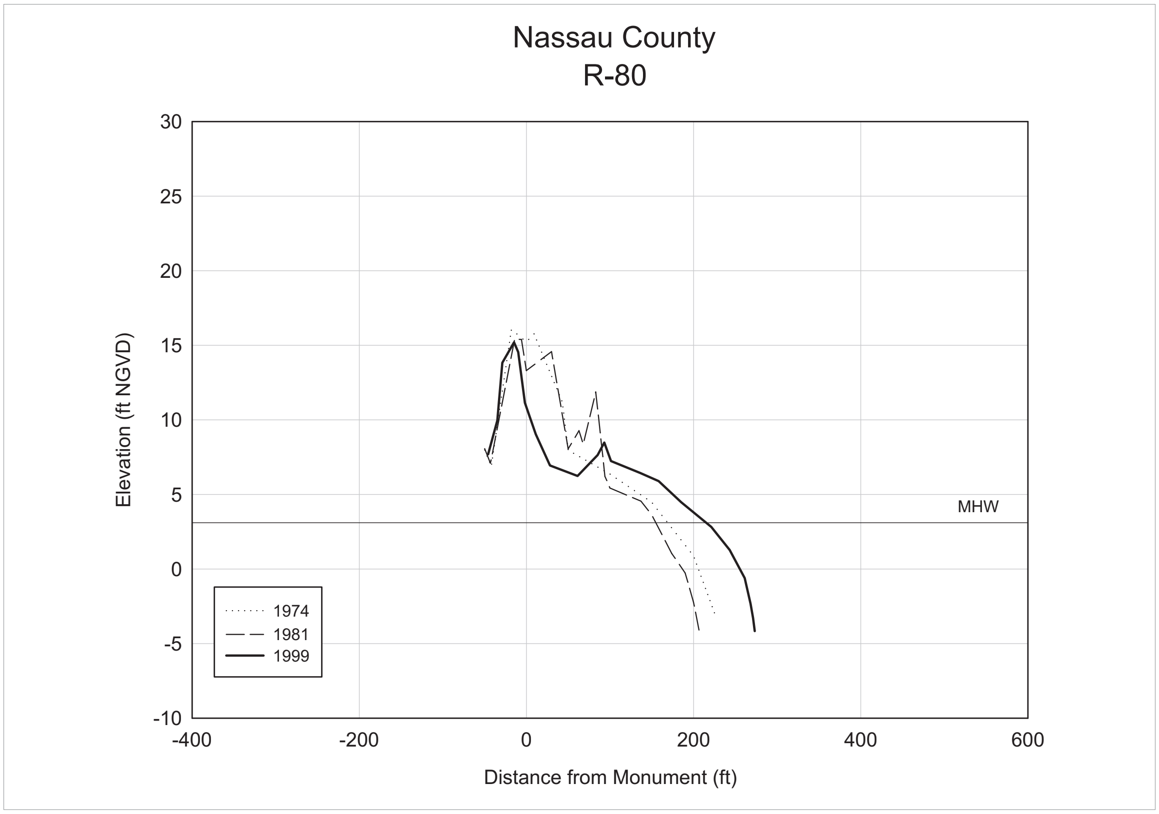

Nassau County
R-30
Elevation (ft NGVD)
30
25
20
15
10
5
0
-5
-10
-200
0
200
400
600
800
Distance from Monument (ft)
MHW
1974
1981
1998


Nassau County
R-39
30
25
20
15
10
5
0
-5
-10
-100
100
300
500
700
900
Elevation (ft NGVD)
Distance from Monument (ft)
MHW
1974
1981
1998


Nassau County
R-50
30
25
20
15
10
5
0
-5
-10
-200
0
200
400
600
800
Elevation (ft NGVD)
Distance from Monument (ft)
MHW
1974
1981
1998


Nassau County
R-60
30
25
20
15
10
5
0
-5
-10
-200
0
200
400
600
800
Elevation (ft NGVD)
Distance from Monument (ft)
MHW
1974
1981
1998


Nassau County
R-70
30
25
20
15
10
5
0
-5
-10
-200
0
200
400
600
800
Elevation (ft NGVD)
Distance from Monument (ft)
MHW
1974
1981
1999


Nassau County
R-80
30
25
20
15
10
5
0
-5
-10
Elevation (ft NGVD)
-400
-200
0
200
400
600
Distance from Monument (ft)
MHW
1974
1981
1999