Shoreline Change Rate Estimates

Gulf County

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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 Jenny Cheng of the Beaches and Shores Resource Center. Mr. Foster is the author and editor of the text, calculations, and base graphics. Ms. Cheng formatted and assembled the report, detailed the graphics, plotted the profiles, and assisted with outlining and referencing. 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

Gulf County may be considered to be moderately developed. It can be divided into three distinct coastal segments. The northwest segment, R-1 to R-31, on the mainland adjacent to Mexico Beach, has been mildly accretional at + 1.5 to +5 ft/yr. The segment between Cape San Blas and Indian Pass, R-120 to R-162, has been highly accretional in the western portion, mildly accretional in the center to eastern portion, and highly unstable in the easternmost zone affected by Indian Pass. This latter zone, R-153 to R-161, experiences random, large-scale, beach width changes due to ebb shoal changes at the Pass.

The middle segment is St. Joseph Peninsula, extending from Point St. Joseph to Cape San Blas. The northern half is St. Joseph Peninsula State Park, which is mildly erosional from R-41 to R-75 at 0 ft/yr to -2 ft/yr, but strongly accretional along the entire northern Point from R-32 to R-40. The Point is affected by dredging and filling from the USACOE navigational project. The southern half of the Peninsula progresses from moderately erosional, -2 ft/yr near the park entrance at R-75, to extremely erosional at the Cape, up to -43 ft/yr. The “stump hole” area near R-105 has been eroding between -10 ft/yr and -15 ft/yr. The landform comprising the point of the Cape (R-114 to R-118) was largely washed away by storms in the mid and late 1990’s. However, it was a relatively new landform that formed probably in the late 1940’s to mid 1960’s. It is unknown whether it will re-form to the same extent.

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 Historic 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, unsuccessful 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

Gulf County is located in northwest Florida (see Figure 1) on the Gulf of Mexico. It includes three distinct open coast segments. The first is a 5.9 mile (9.5 km) shoreline segment extending from the Bay County line southeastward. It is exposed to Gulf waves entering the gap between St. Joseph Point and the Crooked Islands of Bay County. The second segment is St. Joseph Peninsula, approximately 16 miles (25.7 km) in length, extending from Cape San Blas to St. Joseph Point. It is the most exposed to higher wave energy of the three segments. The third segment, approximately 8.5 miles (13.7 km) in length, extends from Cape San Blas eastward to Indian Pass and the Franklin County line. It is within an embayment bounded by two large offshore shoal systems: those off Cape San Blas on the west, and those off Cape St. George on the east.

There are 162 sequentially numbered DEP survey reference points, generally referred to as "R" monuments, spaced approximately 1,000 ft (300 m) apart. This report uses these reference points to locate various items within the study area.

Gulf County is considered to be moderately developed with a combination of single family and multifamily dwellings. There is no coastal armoring of significance, with the exception of a rock revetment fronting the road between approximately R-105 and R-106.5 on St. Joseph Peninsula, an area commonly referred to as “stump hole”. There is only one significantly sized public park area, St. Joseph Peninsula State Park, which comprises the northern half of St. Joseph Peninsula. There is also a large parcel of federal land including the point area of Cape San Blas, with public access.

3.2 Coastal Setting

3.2.1 Geomorphology

Coastal Gulf County has a complex geomorphology. The barrier islands of Gulf County and western Franklin County, including St. Joseph Peninsula, and the extensive shoals of Cape San Blas and Cape St. George, and the islands within the embayment between them, all appear to be related to a complex deltaic history of the Apalachicola River. It is well beyond the scope of this report to try to explain how the islands came to be where they are today. The authors are aware of no convincing geologic study of the area. It is important to note the presence of the

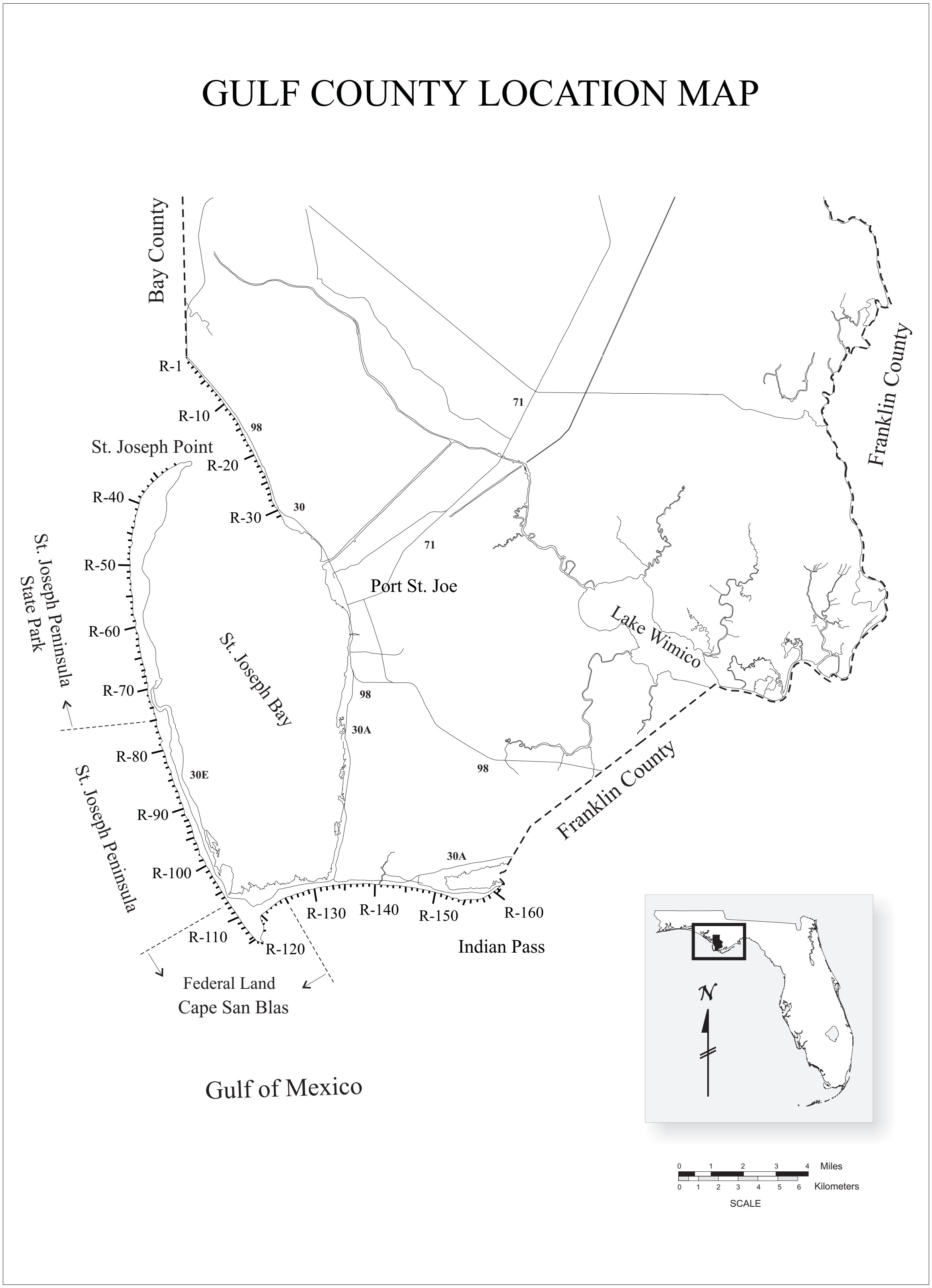

Figure 1. Study area showing Gulf County, Florida.

extensive offshore shoals because they refract and diffract the wave energy reaching the study area, controlling the wave climate inbetween and to either side of Cape San Blas and Cape St. George. These major shoals can be viewed in any navigational chart of the area and in the historic bathymetric maps (e. g. in the DEP Historic Shoreline Database).

There are two other items of significance to note . First, there are extensive peat deposits just below a surface veneer of sand between approximately R-100 and R-113. Second, sand in that area and eastward to San Blas and all the way to Indian Pass, appears finer and darker in color than on St. Joseph Peninsula in general.

The peat is noted because it is not sand and therefore erodes differently. It has probably been a significant factor in preventing an island break-through with a new inlet in the R-105 area, thus far. The sand difference is noted because it strongly suggests different sources of material and possibly different directions of net transport.

3.2.2 Waves and Tides

The shoreline segment extending from R-1 to R-31, because of its' location at the entrance to St. Joseph Bay, is affected primarily by waves out of the west and northwest, as refracted and diffracted through the gap between the Crooked Islands (in Bay County) and St. Joseph Point. Tide gauges at Mexico Beach (in Bay County), at St. Joseph Point, and at Port St. Joe indicate diurnal tides with mean tidal ranges of 1.19 ft (.36m), 1.16 ft (.35m), and 1.15 ft (.35), respectively, all very similar (NOS 1988).

Most of the shoreline of St. Joseph Peninsula is affected primarily by waves out of the south-southwest, the longest fetch direction. The U. S. Army Corps of Engineers WIS station37 located at 62 ft (19m) depth offshore of the Peninsula, experienced a mean significant wave height of 2.0 ft (0.6 m) and a mean period of 4 seconds, 1976-1995.

The shoreline between Cape San Blas and Indian Pass, due to its location within an embayment bordered by two capes and their extensive shoal systems, is affected most frequently by waves out of the south-southeast. The U. S. Army Corps of Engineers WIS Station 36, located at 62 ft (19 m) depth offshore this area and inbetween the two large shoal systems, experienced a mean significant wave height of 2.3 ft (0.7 m) and a mean period of 4 seconds, 1976-1995.

3.2.3 Longshore Transport

Net longshore transport in the R-1 to R-31 segment is from northwest to southeast, as evidenced by accretion on the north side of Mexico Beach Inlet (in Bay County), and the deposition of sand in this segment as wave energy from the Gulf dissipates.

Net longshore transport along the majority of St. Joseph Peninsula is from south to north, consistent with the direction of longest wave fetch and the observed growth of St. Joseph Point (and probably its' shoals). In the area closest to the Cape itself, the R-110 to R-117 area, the net direction is likely southward, as evidenced by aerial photos showing refracted waves, and sand being transported into the adjacent east side of the Cape. Sand in the Cape area and eastward appears finer and darker in color than elsewhere on the Peninsula. It is probable that a point where net transport direction changes on the Peninsula exists in the vicinity of R-100 to R-110, due to shoal sheltering and refraction around the shoals off Cape San Blas.

The above interpretation of net northerly transport over most of St. Joseph Peninsula is consistent with the totality of available information. It is also the only physical explanation that matches the observed shoreline erosion pattern between approximately R-107 and R-75, as determined by a numerical modeling study by Foster (1991). In that study it was shown that the tapered pattern of higher erosion to lesser erosion, south to north, in that area is a sand supply deficit-induced erosion pattern equivalent to those found elsewhere in the state downdrift of inlet jetties.

Net longshore transport along the Cape San Blas to Indian Pass shoreline segment is observed to be west to east on the immediate east side of Cape San Blas. It is further observed to be east to west in the vicinity of both Indian Pass and West Pass (in Franklin County), as evidenced by the ebb shoal locations at those inlets. It is uncertain what the net direction of littoral transport is inbetween the two observed areas.

3.2.4 Storms

Hurricanes in this area occur frequently and both the storms and their effects can remain in the area for long 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, coastal processes can be permanently affected by a storm. Two major storms in recent history were Hurricane Opal in 1995 and Hurricane Kate in 1985. Both caused significant dune erosion and added to ongoing beach erosion. The regional effects of recent hurricanes have been discussed by Leadon (1999) and Leadon et al (1998).

3.3 Inlets

3.3.1 Entrance Channel To St. Joseph Bay

The Entrance Channel to St. Joseph Bay is a federal navigation project that is regularly dredged, and has a controlling effect on the northernmost tip of St. Joseph Peninsula. Before 1970, all of the dredged sand was disposed of in deep water (Dean & O'Brien, 1987). Since that time there have been several placements of sand offshore, nearshore, and onto St. Joseph Point.

3.3.2 Indian Pass

This inlet separates the eastern end of Gulf County from St. Vincent Island (National Wildlife Refuge) in Franklin County. It is navigable by small boats. There is a large ebb shoal along the western Gulf County side which supplies sand to the beaches there and westward. The shoals change frequently and randomly, affecting the shoaling, refraction, and diffraction conditions. It will be seen that most of the shoreline in the vicinity of the shoal has been experiencing frequent random large-scale beach width changes.

3.4 Engineering projects

The only significant beach fill placements have occurred in a remote undeveloped area, St. Joseph Point, in conjunction with navigation channel dredging, as discussed in a previous section.

The only significant coastal armoring structure is the approximately 1500 ft (450m) long rock revetment fronting the frequently washed out road section between R-105 and R-106.5, in the "stump hole" area of St. Joseph Peninsula. This was constructed in 1996 or 1997 after Hurricane Opal.

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

In this report it has been helpful to divide coastal Gulf County into three segments, northwest to southeast. The first two segments are separated by St. Joseph's Bay Entrance Channel and the Bay entrance itself. The second and third segments are separated by the point of Cape San Blas.

5.1 Northwest segment, R-1 to R-31

Figure 2 shows this zone in plan view with selected historic shorelines. Shoreline (MHW) change rate estimates are provided in Figure 3 and Table A-1 (Appendix A). This zone receives sand from the northwest, and as wave energy diminishes further inside the Bay entrance, sand is deposited on the beachface. The R-1 to R-31 area has therefore been moderately accretional overall, with rates ranging from +2.0 ft/yr up to +5.0 ft/yr in the 1973-1997 time period. In the plan view, there are two particular areas of pronounced deposition, in the vicinity of R-16 to R-20, and R-28 to R-30. It is suspected that this is due to an uncommon wave pattern effect, but aerial photos of the area showing actual attacking waves have so far not been found. A series of aerial photos were reviewed. However, the lack of photos with waves could be taken as an indication of the area normally having a relatively mild wave climate.

5.2 St. Joseph Peninsula Segment, R-32 to R-115

The northern half of the Peninsula, R-32 to R-75, is a state park, as previously noted. By far, most of the erosion occurs southeast of the park. This is shown in the plan view of Figure 4 and the rate estimates of Figure 5. In the latter figure, there is a distinct change in the erosion pattern in the vicinity of R-105 to R-107. The erosion rate estimate at R-105 of -12.5 ft/yr tapers progressively down to -2.0 ft/yr at R-75, the park boundary. However, south of R-105 the erosion rates increase sharply to -43 ft/yr at R-113. It is to be noted that points from R-114 to R-118 no longer exist, the tip of the Cape having been reconfigured in 1995 by Hurricane Opal, and by later storms.

The transition in the erosion pattern in the vicinity of R-105 to R-107 is suspected as being due to the change in net transport direction which likely occurs in that vicinity,

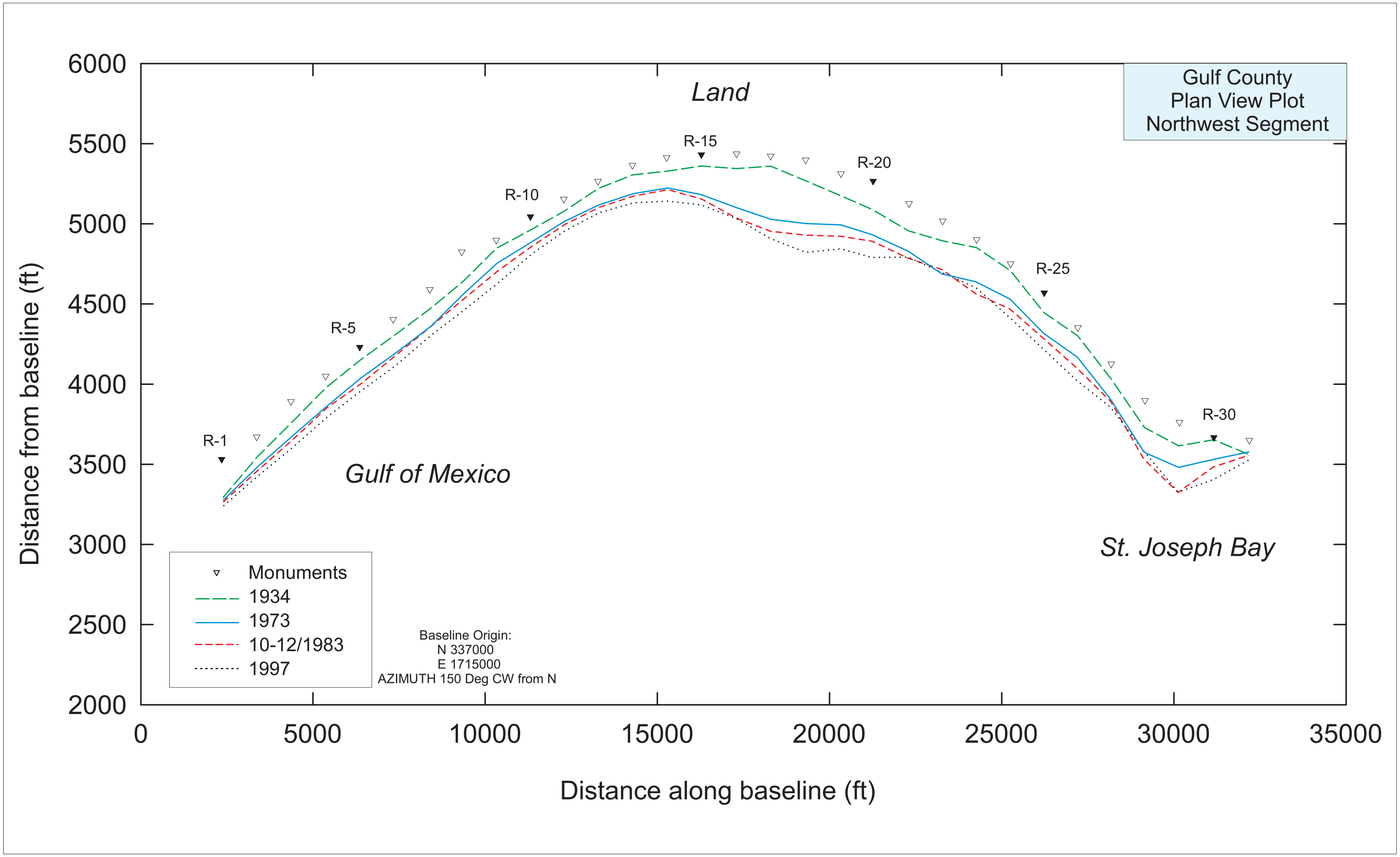

Figure 2. Plan view map of Gulf County, Florida (from R-1 to R-31), comparing years 1934, 1973, 10-12/1983, and 1997.

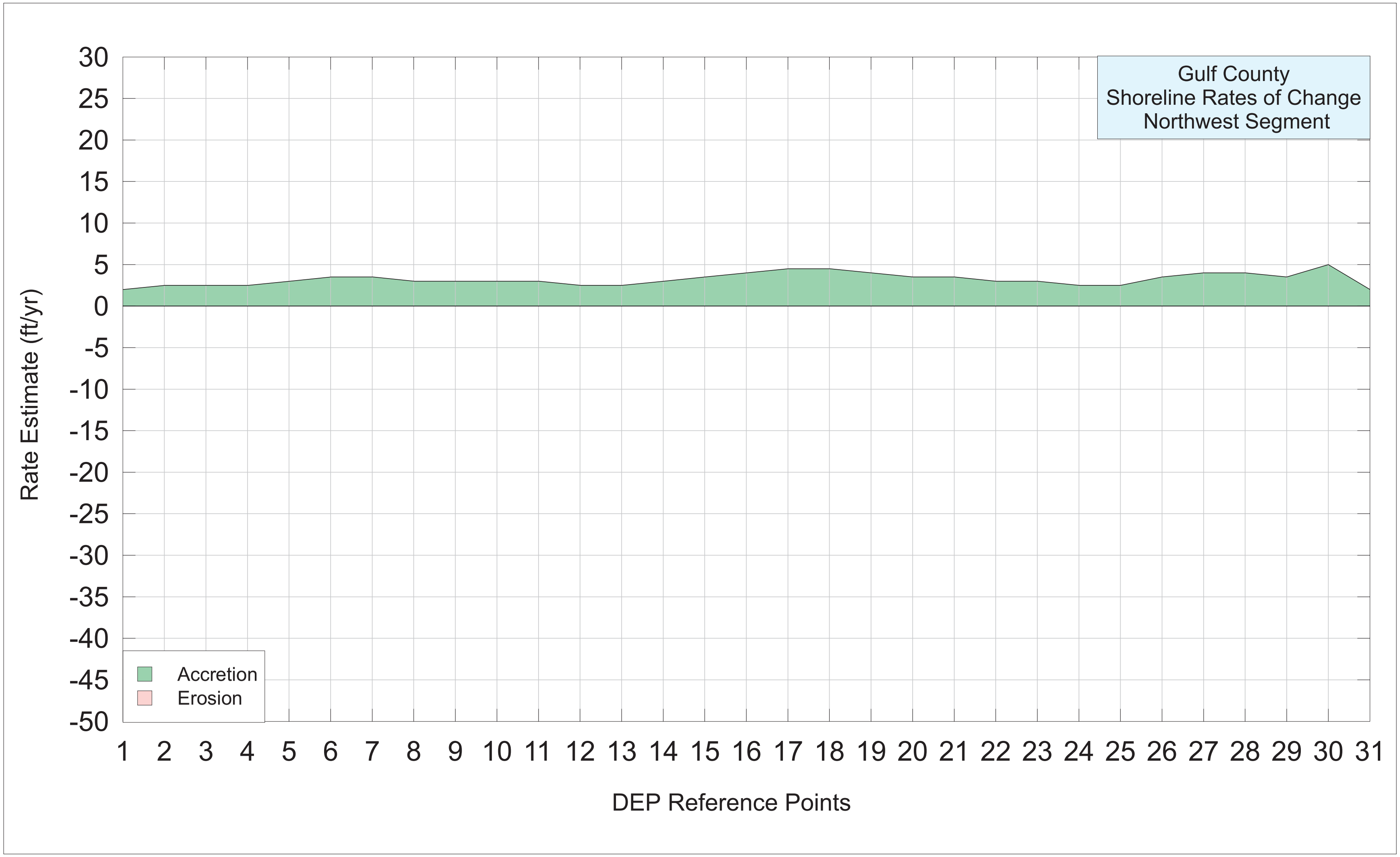

Figure 3. Shoreline rate of change estimates for Bay County, Florida (from R-1 to R-97).

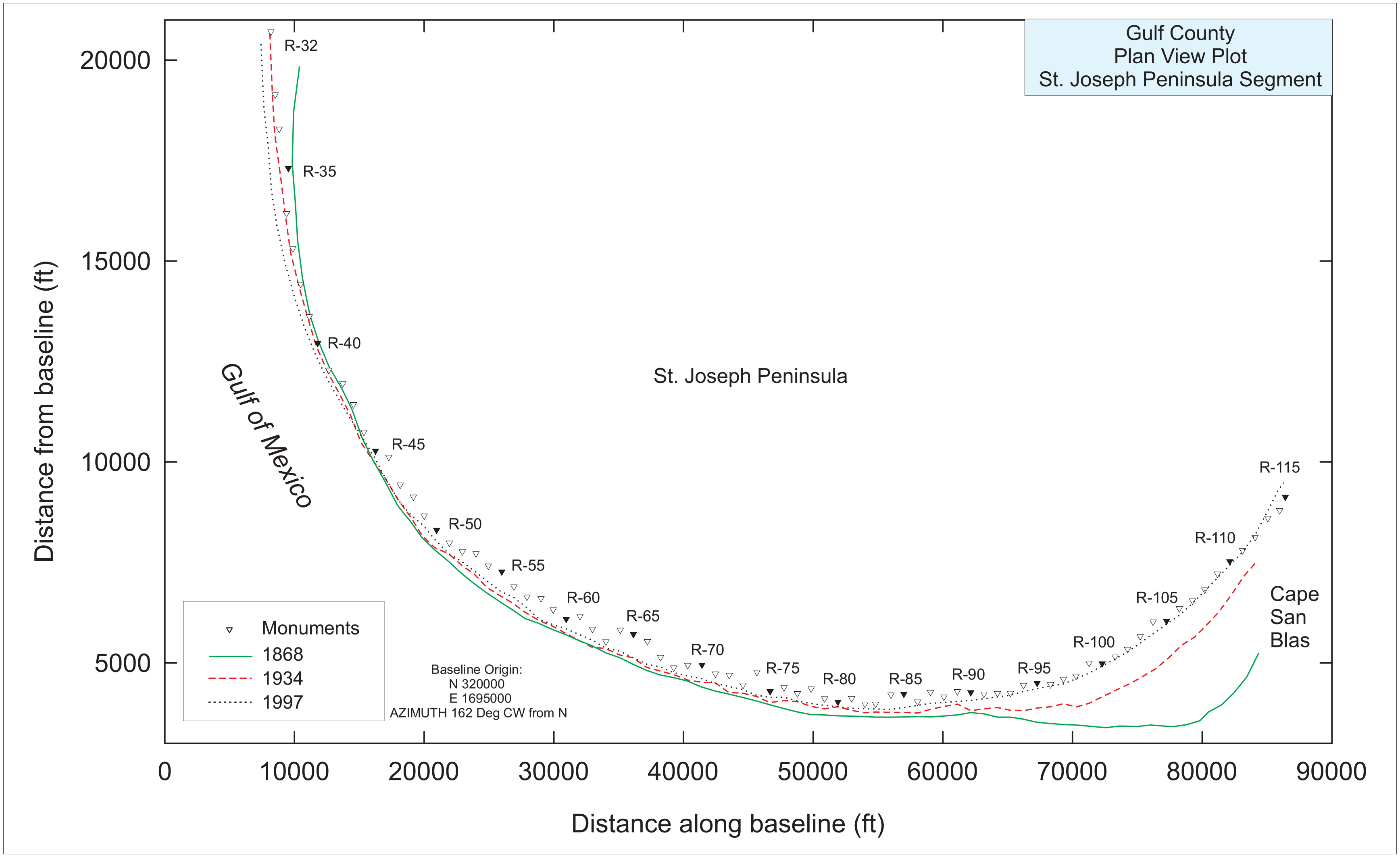

Figure 4. Plan view map of Gulf County, Florida (from R-32 to R-115), comparing years 1868, 1934, and 1997.

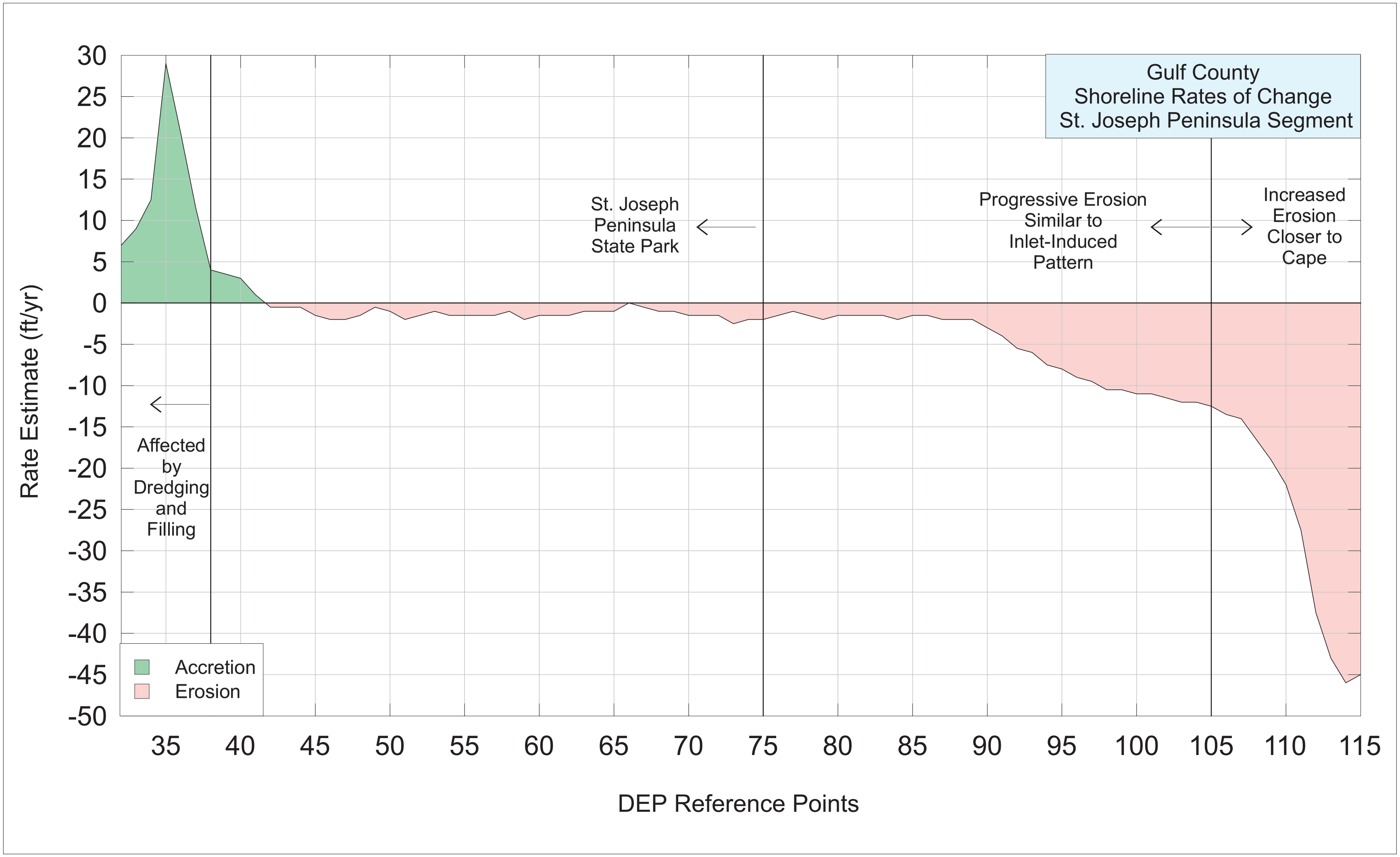

Figure 5. Shoreline rate of change estimates for Gulf County, Florida (from R-32 to R-115).

as previously discussed. Waves from the southeast are refracted and diffracted by the Cape shoals, resulting in a net transport change in direction.

It may also be of interest to note that our historic data indicates that the large landform that existed as the tip of the Cape, from R-113 to R-119, from sometime prior to 1973 to 1995, was a relatively new landform. It did not exist in 1934 or 1868. It likely formed gradually in the late 1940's to early 1960's, judging by the extensive vegetation cover in 1973 aerial photos. It is also noted that because of it's relatively sudden appearance as a large landform, it may have developed as an emergent shoal as well as from longshore transport. It appears that a foundation of shoal material developed over a long time, and was shown in that location in the 1943 historic bathymetry map of the area (in the DEP Historic Shoreline Database). The point was washed out by storms in the mid to late 1990's. Whether it will re-form again is unknown.

A last item of possible interest concerns the possibility of one or more breakthroughs of the Peninsula in the future as very high erosion continues to make the land particularly narrow at two locations, R-105/106 and R-101/102. No one can say when or how, but an eventual breakthrough is more likely than not. It will probably occur during a hurricane. The peat deposits have most likely helped delay the event. The preventive ability of the revetment is unknown. All erosion on the Peninsula and towards the Cape will likely increase drastically in the event of a breakthrough, due to a landward sink effect and a major change in the sand supply. It is also possible a breakthrough will eventually occur at R-71/73, the site of an old inlet channel (Eagle Harbor area).

5.3 Cape to Indian Pass Segment, R-119 to R-162

Figure 6 shows the area in plan view and Figure 7 is a plot of the rate of change estimates. Receiving sand from both ends has been beneficial for this segment, which has been generally accretional, particularly in the western part, R-119 to about R-135. The eastern portion, R-135 to R-150, has been mildly accretional, particularly in recent decades.

The dominant process at the eastern end is the Indian Pass ebb shoal interaction with the shoreline. The result has been random, large-scale beach width changes between R-161 and R-153, and an occasional erosion pocket in the R-152 to R-153 area. The rates calculated for this entire area are not reliable in either hindcast or forecast, and result primarily from the last surveys of 1997 and 1998 showing an accretion event rather than an erosion episode. While it may be possible that in the very long term there will be net accretion, it cannot be relied upon anytime soon. For example, if we only had data through 1983, it would not have predicted the 1997 condition in this area. A reasonable recommendation for this area is to keep development landward of the historic zone of beach width fluctuations.

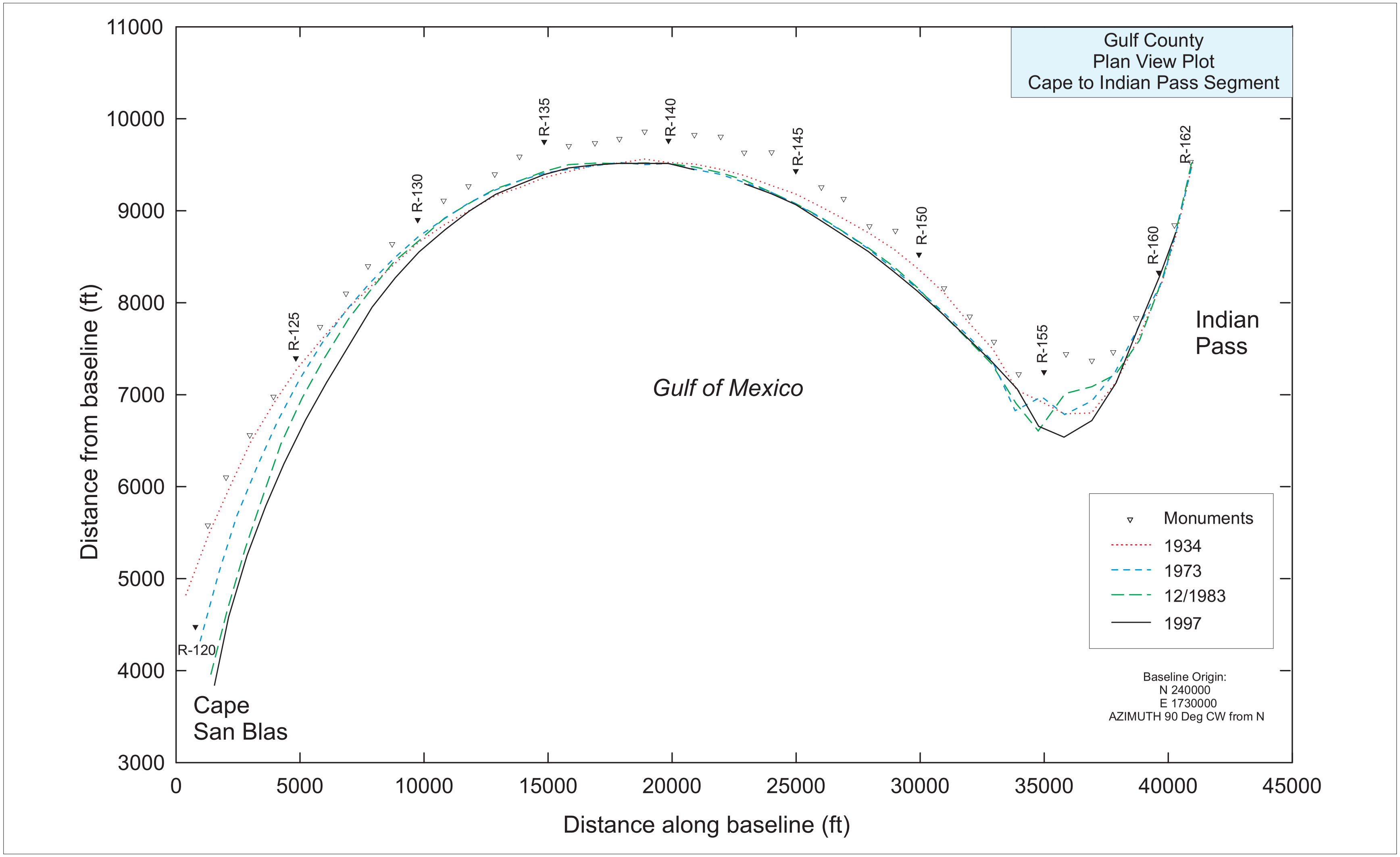

Figure 6. Plan view map of Gulf County, Florida (from R-119 to R-162), comparing years 1934, 1973, 12/1983, and 1997.

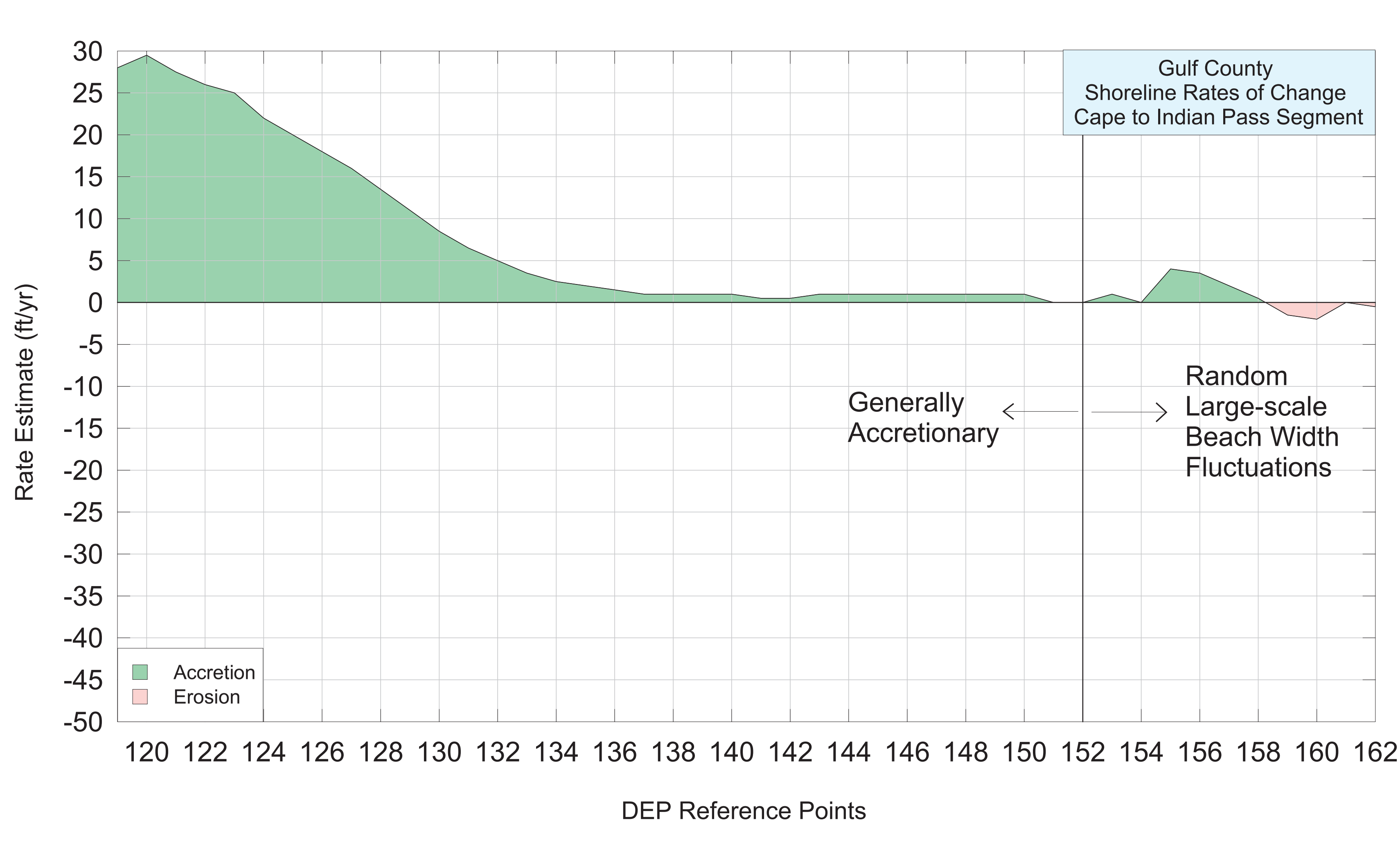

Figure 7. Shoreline rate of change estimates for Gulf County, Florida (from R-119 to R-162).

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7 APPENDICES

7.1 Appendix A: Shoreline Change Rate Estimates

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

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

Range	Time Span	Method			Rounded Concensus Average	Comments
		RA	LS	EP		
1	1973-1997	1.5	1.7	1.5	2	7 pt avg
2	1973-1997	2.4	2.4	2.4	2.5	↓
3	1973-1997	2.6	2.7	3	2.5	
4	1973-1997	2.8	2.9	2.9	2.5	
5	1973-1997	3.4	3.4	3.3	3	
6	1973-1997	3.3	3.5	3.3	3.5	
7	1973-1997	2.4	2.6	2.3	3.5	
8	1973-1997	4.4	4.1	4.2	3	
9	1973-1997	3.2	3.6	5.3	3	
10	1973-1997	2.5	2.8	3.1	3	
11	1973-1997	2.1	2	2.5	3	
12	1973-1997	2.1	1.8	2	2.5	
13	1973-1997	1.9	2.3	2.4	2.5	
14	1973-1997	3	3.3	3.4	3	
15	1973-1997	2.7	2.4	2.6	3.5	
16	1973-1997	3.2	2.6	2.9	4	
17	1973-1997	4.6	4.4	5	4.5	
18	1973-1997	7.2	7.3	7.5	4.5	
19	1973-1997	6.2	6.1	6.2	4	
20	1973-1997	5.7	5.9	5.9	3.5	
21	1973-1997	1.3	1	1.5	3.5	
22	1973-1997	-0.3	-1.6	-0.3	3	
23	1973-1997	2.1	0.5	1.5	3	
24	1973-1997	4.2	3.9	4.8	2.5	
25	1973-1997	3.5	3.5	4.1	2.5	
26	1973-1997	5.4	5.2	6.2	3.5	
27	1973-1997	2.3	2.1	2.1	4	↑
28	1973-1997	-0.2	-0.5	-0.2	4	7 pt avg
29	1973-1997	9.8	6.3	6.4	3.5	5 pt avg
30	1973-1997	5.6	5.7	5.3	5	3 pt avg
31	1973-1997	2.1	2.1	2.1	2	1 pt avg
St. Joseph Bay Entrance						

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

Range	Time Span	Method			Rounded Concensus Average	Comments
		RA	LS	EP		
32	1973-1993	N/A	7.1	6.9	7	LS + EP only; No longshore avg
33	1973-1997	N/A	12.2	5.4	9	
34	1973-1997	N/A	15.3	9.8	12.5	
35	1973-1997	N/A	29.7	28.3	29	
36	1973-1997	N/A	20.9	20	20.5	
37	1973-1997	N/A	11.5	11.7	11.5	
38	1973-1997	5	4	2.6	4	1 pt avg
39	1973-1997	3.3	2.3	2	3.5	3 pt avg
40	1973-1997	4.1	3.9	3.1	3	5 pt avg
41	1973-1997	3.3	3.4	3.1	1	7 pt avg
42	1973-1997	0.1	0.8	0.1	-0.5	↓
43	1973-1997	-1.8	-1.9	-1.6	-0.5	
44	1973-1993	-4.5	-4.3	-3	-0.5	
45	1973-1993	-5.9	-6.4	-6.4	-1.5	
46	1973-1997	1.4	1	2.3	-2	
47	1973-1997	2.8	1.4	2.2	-2	
48	1973-1997	-0.5	-1.5	-0.8	-1.5	
49	1973-1997	-6.6	-6.2	-4.9	-0.5	
50	1973-1997	-0.7	0	0.8	-1	
51	1973-1997	-0.1	0.8	-0.1	-2	
52	1973-1997	-0.4	0.1	1.5	-1.5	
53	1973-1997	-3	-2.8	-2.7	-1	
54	1973-1997	-3.6	-3.3	-3.6	-1.5	
55	1973-1997	-0.1	0.3	-0.1	-1.5	
56	1973-1997	-3.2	-1.3	-1.4	-1.5	
57	1973-1997	-2	-2.1	-3.2	-1.5	
58	1973-1997	1.1	1.7	-1.3	-1	
59	1973-1997	-0.6	-1.1	-2.6	-2	
60	1973-1997	0.7	-0.5	-1	-1.5	
61	1973-1997	-1.7	-1.9	-2.6	-1.5	
62	1973-1997	-3.3	-4.4	-5.8	-1.5	
63	1973-1997	0.2	-0.6	-1.9	-1	
64	1973-1997	-0.5	-0.1	-0.5	-1	

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

Range	Time Span	Method			Rounded Concensus Average	Comments
		RA	LS	EP		
65	1973-1997	0.2	-0.4	0.2	-1	
66	1973-1997	-0.6	0.4	-0.6	0	
67	1973-1997	-0.3	-0.8	-0.3	-0.5	
68	1973-1997	0.7	-1.7	-0.8	-1	
69	1973-1997	0.7	1.1	2.1	-1	
70	1973-1997	-3.5	-3.6	-4.4	-1.5	
71	1973-1997	-1.5	-1.7	-2.1	-1.5	
72	1973-1997	-2.4	-3.1	-3	-1.5	
73	1973-1998	-4.3	-4.4	-3.5	-2.5	
74	1973-1997	-0.3	-0.9	-0.3	-2	
75	1973-1997	0.5	-0.3	1.6	-2	
76	1973-1998	-3.5	-4.1	-4	-1.5	
77	1973-1997	-2.1	-2.5	-3.1	-1	
78	1973-1997	-0.2	0.3	-0.2	-1.5	
79	1973-1997	-1.6	-0.7	-0.7	-2	
80	1973-1998	-0.8	-0.9	-2.3	-1.5	
81	1973-1998	-3.1	-2.4	-3.5	-1.5	
82	1973-1997	-2.7	-0.4	-1.2	-1.5	
83	1973-1997	-1	-0.5	-1	-1.5	
84	1973-1998	-1	-1	-2.9	-2	
85	1973-1997	-1.9	-1.6	-2.7	-1.5	
86	1973-1997	-1	-0.9	-1.7	-1.5	
87	1973-1998	-2.9	-2.1	-3.6	-2	
88	1973-1997	-0.3	0.3	-0.3	-2	
89	1973-1997	-3	-2.1	-3.2	-2	
90	1973-1998	-4.3	-4.1	-5.7	-3	
91	1973-1997	-0.9	-2	-0.9	-4	
92	1973-1997	-2.6	-3.2	-1.8	-5.5	
93	1973-1998	-8	-7.1	-7.4	-6	
94	1973-1998	-7.9	-8.8	-8.7	-7.5	
95	1973-1998	-9.5	-9.3	-9.8	-8	
96	1973-1997	-11.7	-9.7	-7.7	-9	
97	1973-1998	-12.6	-11.2	-12.1	-9.5	

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

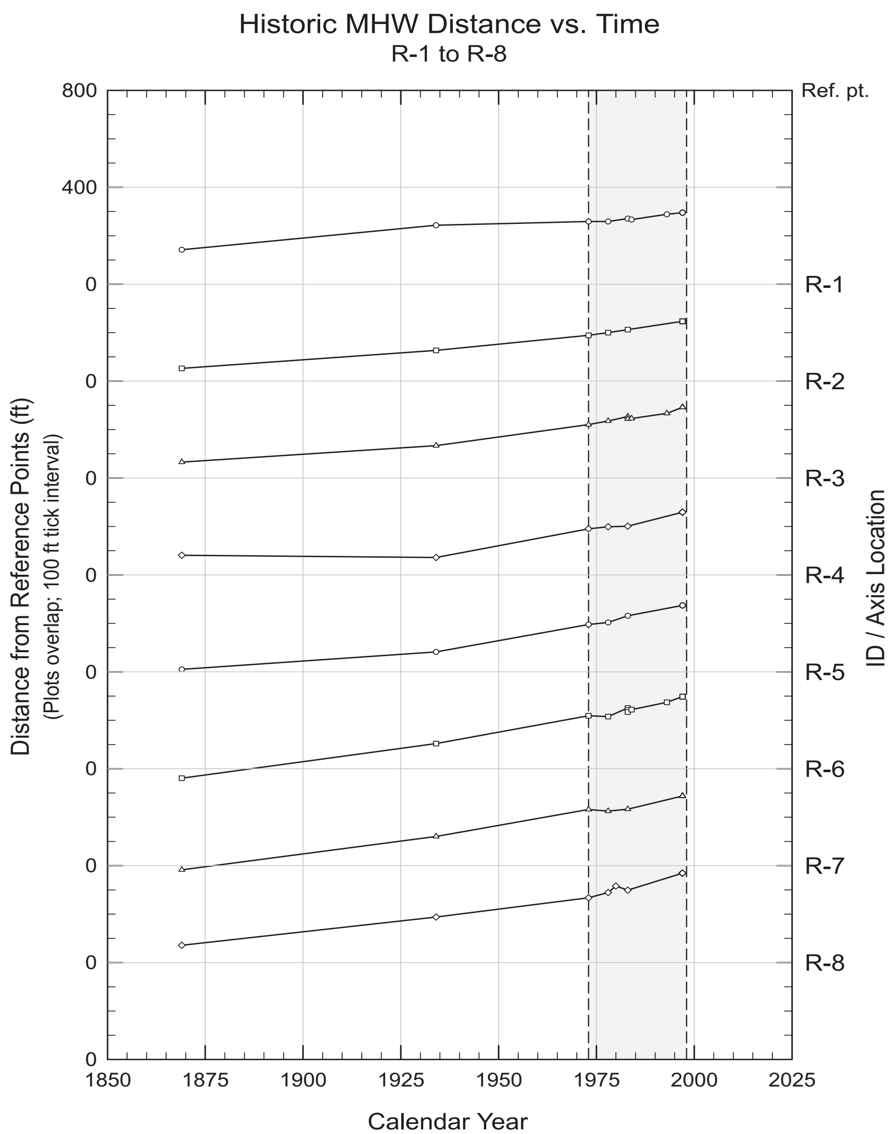
Range	Time Span	Method			Rounded Concensus Average	Comments
		RA	LS	EP		
98	1973-1997	-8.9	-8	-5.9	-10.5	
99	1973-1997	-7.6	-7.4	-6.9	-10.5	
100	1973-1998	-12.8	-12.3	-14.4	-11	
101	1973-1998	-12.5	-12.1	-13	-11	
102	1973-1998	-11.2	-11.5	-11.5	-11.5	
103	1973-1998	-13.2	-14	-13.5	-12	
104	1973-1997	-10.7	-11.4	-11.4	-12	
105	1973-1997	-10.3	-10.6	-9.3	-12.5	↑
106	1973-1998	-14	-13.6	-13.4	-13.5	7 pt avg
107	1973-1997	-12.9	-12.3	-11.5	-14	
108	1973-1997	-17.4	-16.5	-15.4	-16.5	5 pt avg
109	1973-1997	-19.6	-18.7	-17.7	-19	
110	1973-1998	-20.2	-22.5	-21.4	-22	
111	1973-1997	-25.4	-25.4	-25.2	-27.5	
112	1973-1997	-33.1	-35.9	-36.6	-37.5	3 pt avg
113	1973-1997	-45.8	-54.3	-56.8	-43	
114	1973-1993	-32.8	-43.8	-48.1	-46	
115	1976-1993	-39.3	-48	-47.2	-45	1 pt avg
Cape San Blas						
119	1973-1998	28.9	21.7	33.1	28	1 pt avg
120	1973-1997	38.1	30	31.3	29.5	3 pt avg
121	1973-1997	31.1	27	25.9	27.5	5 pt avg
122	1973-1998	26.5	24.7	23.7	26	7 pt avg
123	1973-1998	26.9	22.3	20.8	25	↓
124	1973-1997	24.8	23	22.1	22	
125	1973-1997	22.5	22.3	21	20	
126	1973-1998	19.1	19.1	17.6	18	
127	1973-1996	15.4	16.1	15.7	16	
128	1973-1998	13.5	13.3	12.6	13.5	
129	1973-1997	9.6	10.9	9.1	11	
130	1973-1997	8.1	8.4	7	8.5	
131	1973-1997	6.7	6.6	5.1	6.5	
132	1973-1998	5.5	5.2	3.5	5	

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

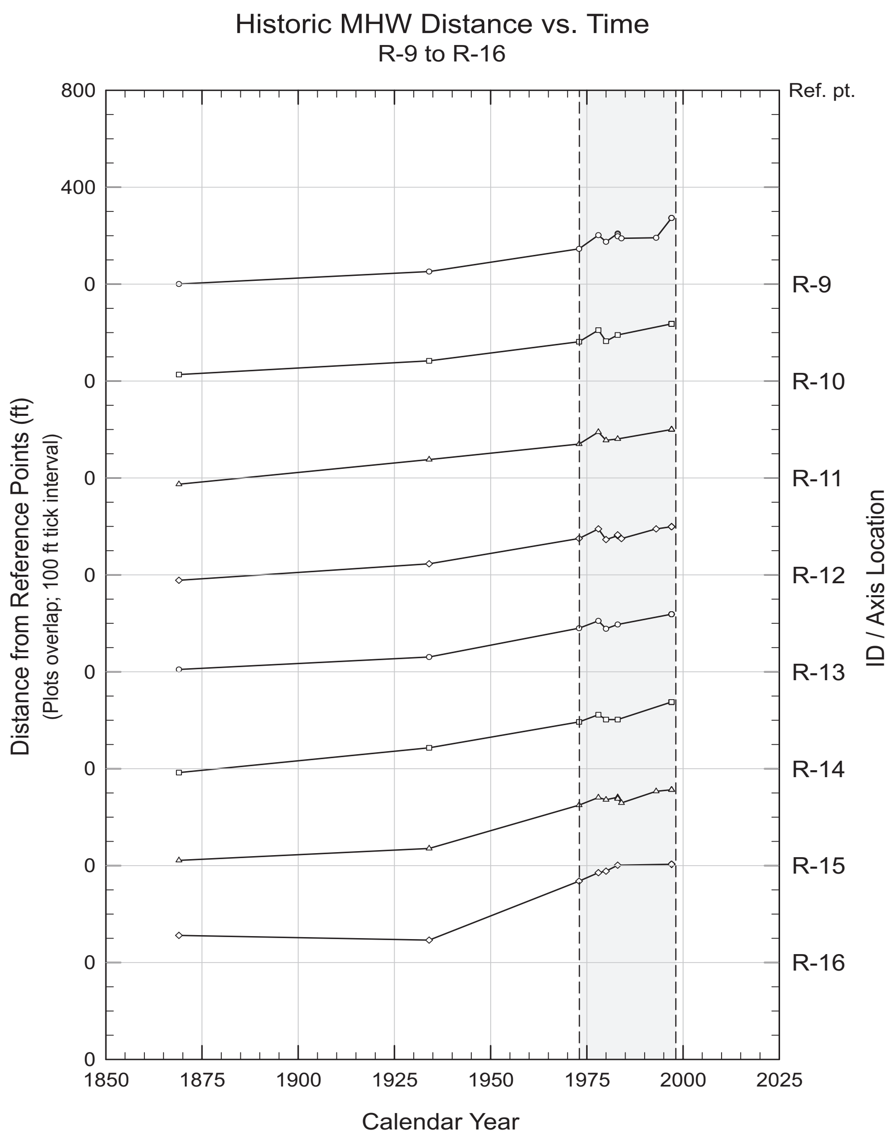
Range	Time Span	Method			Rounded Concensus Average	Comments
		RA	LS	EP		
133	1973-1997	3.5	3.2	2	3.5	
134	1973-1997	2.4	3.3	1.6	2.5	
135	1973-1997	0.6	2.6	0.6	2	
136	1973-1998	-0.2	2	-0.2	1.5	
137	1973-1998	0.5	1.7	0.5	1	
138	1973-1998	0.2	1.1	0.2	1	
139	1973-1998	0	1	0	1	
140	1973-1998	0.7	1.4	0.7	1	
141	1973-1998	0.6	1.5	0.7	0.5	
142	1973-1998	2.1	1.7	1.2	0.5	
143	1973-1998	0	1.6	0	1	
144	1973-1998	-0.1	1.3	-0.6	1	
145	1973-1998	0	1.3	0	1	
146	1973-1998	1.6	2.7	0.9	1	
147	1973-1998	2.4	2.3	1.4	1	↑
148	1973-1998	1	1.7	0.7	1	7 pt avg
149	1973-1998	2.4	2	1.6	1	5 pt avg
150	1973-1998	0.9	1.4	-0.6	1	3 pt avg
151	1973-1998	0	0.3	0	0	1 pt avg
152	1973-1998	N/A	N/A	0.1	0	EP only
153	1973-1998	N/A	N/A	0.8	1	
154	1934-1998	N/A	-0.2	0.4	0	Average EP + LS; No longshore average
155	1934-1998	N/A	4.6	3.7	4	
156	1934-1998	N/A	3.8	3	3.5	
157	1934-1998	N/A	1	2.8	2	
158	1934-1998	N/A	0.2	0.7	0.5	
159	1934-1998	N/A	-1	-1.5	-1.5	
160	1934-1997	-2.7	-1.2	-1.7	-2	3 method average; No longshore average
161	1934-1998	0	-0.2	0	0	
162	1934-1984	-0.7	-0.6	-0.8	-0.5	

7.2 Appendix B: Stack Plots

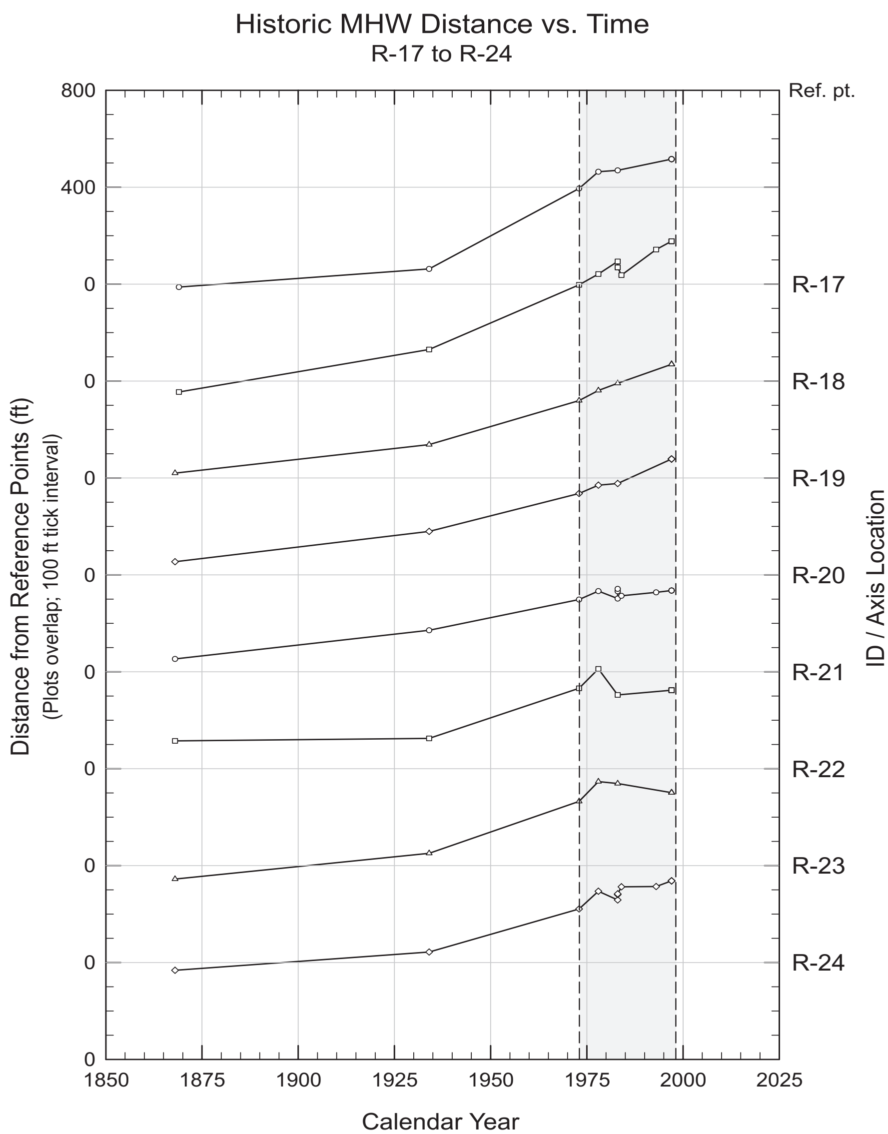
Stack plots from Historic Shoreline Database, Florida Department of Environmental Protection, Office of Beaches and Coastal Systems; slightly modified by authors.



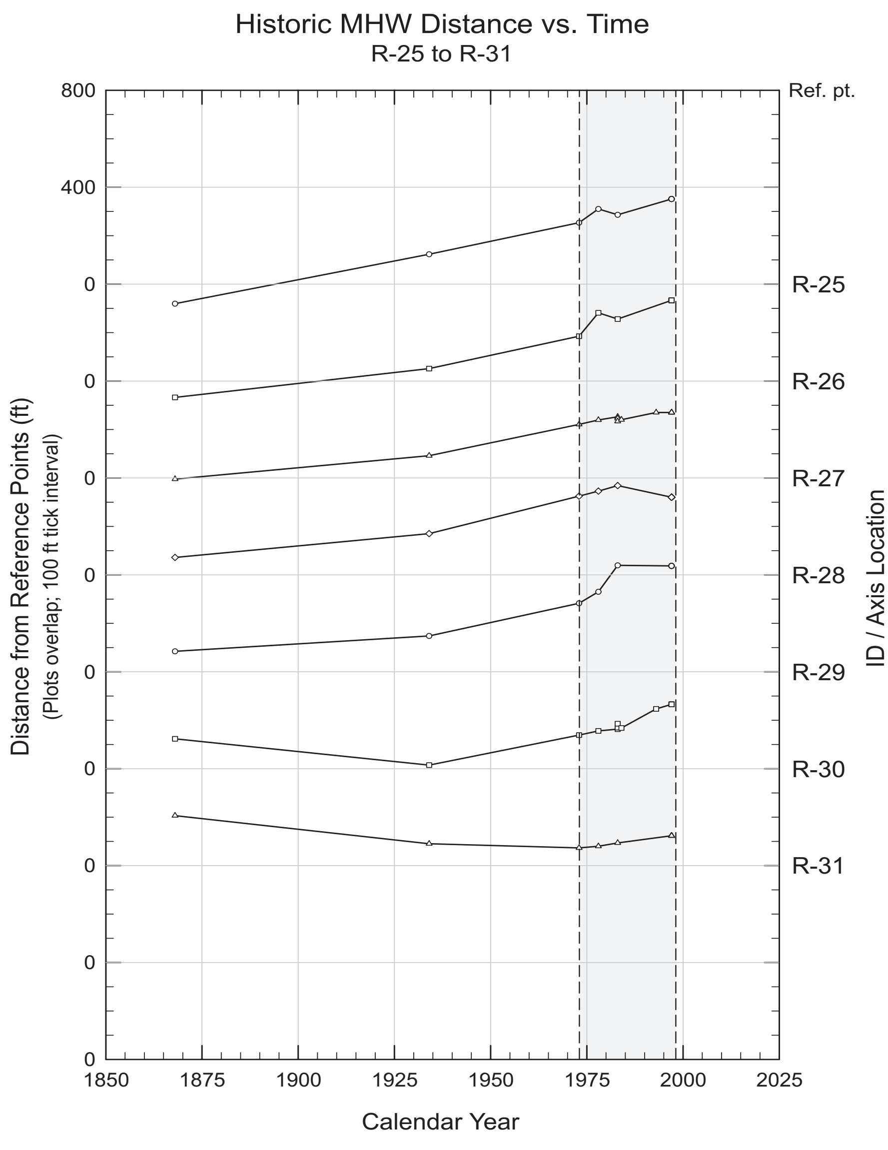
Historic MHW Distance vs. Time
R-1 to R-8
Ref. pt.
800
400
0
0
0
0
0
0
0
0
0
R-1
R-2
R-3
R-4
R-5
R-6
R-7
R-8
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
ID / Axis Location
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year

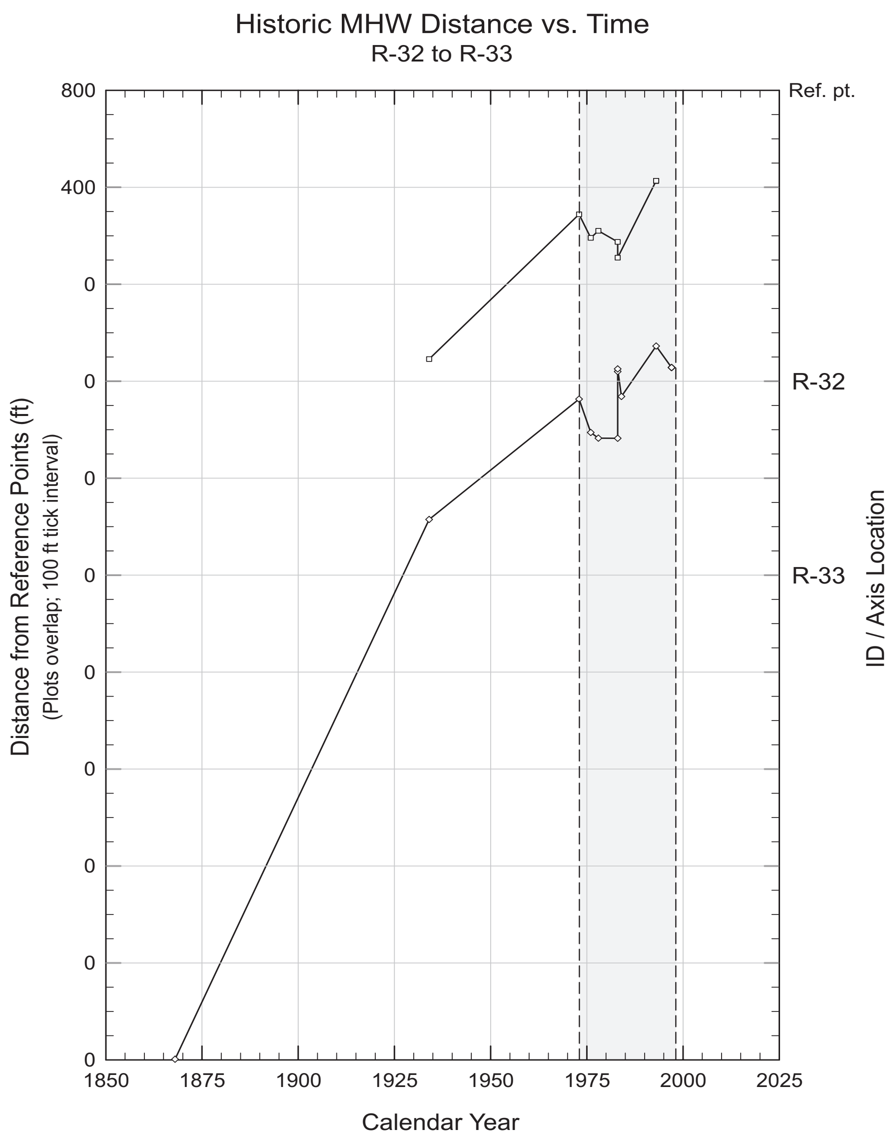


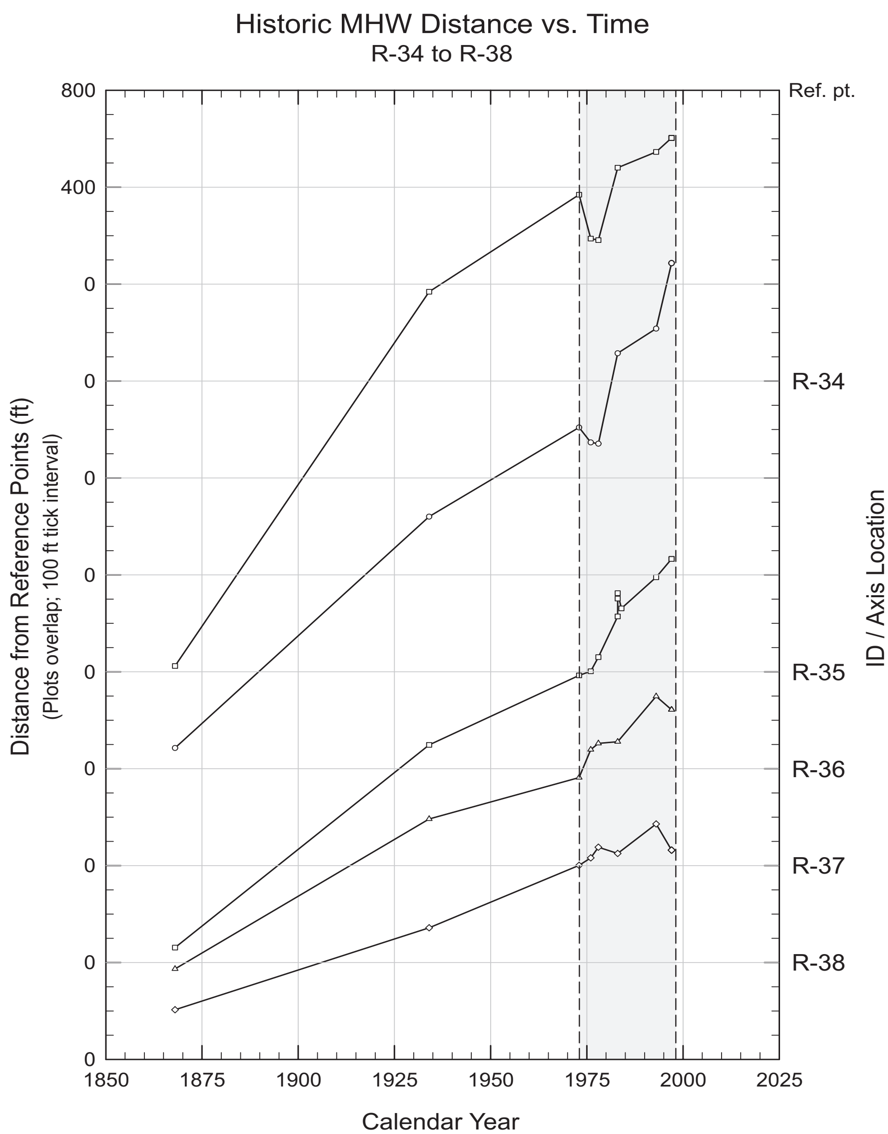
Historic MHW Distance vs. Time
R-9 to R-16
800
400
0
0
0
0
0
0
0
0
0
Ref. pt.
R-9
R-10
R-11
R-12
R-13
R-14
R-15
R-16
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
ID / Axis Location
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year

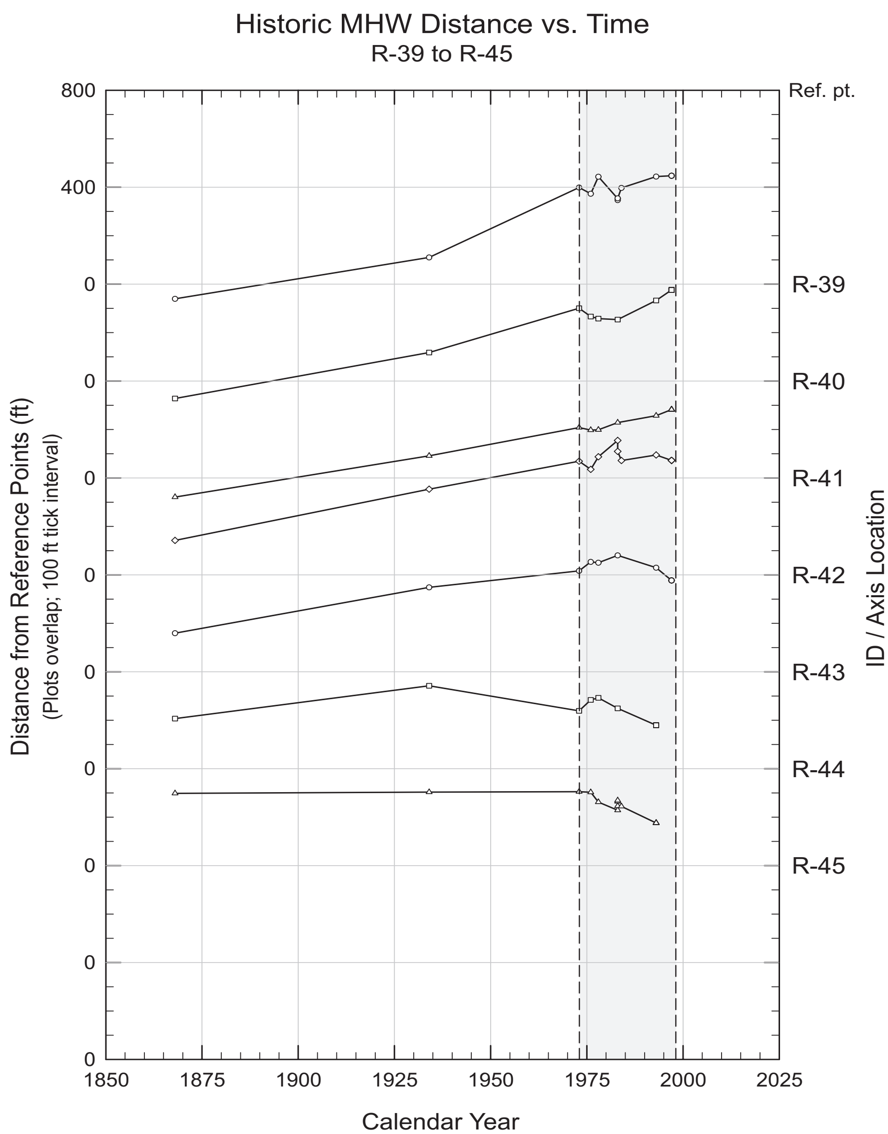


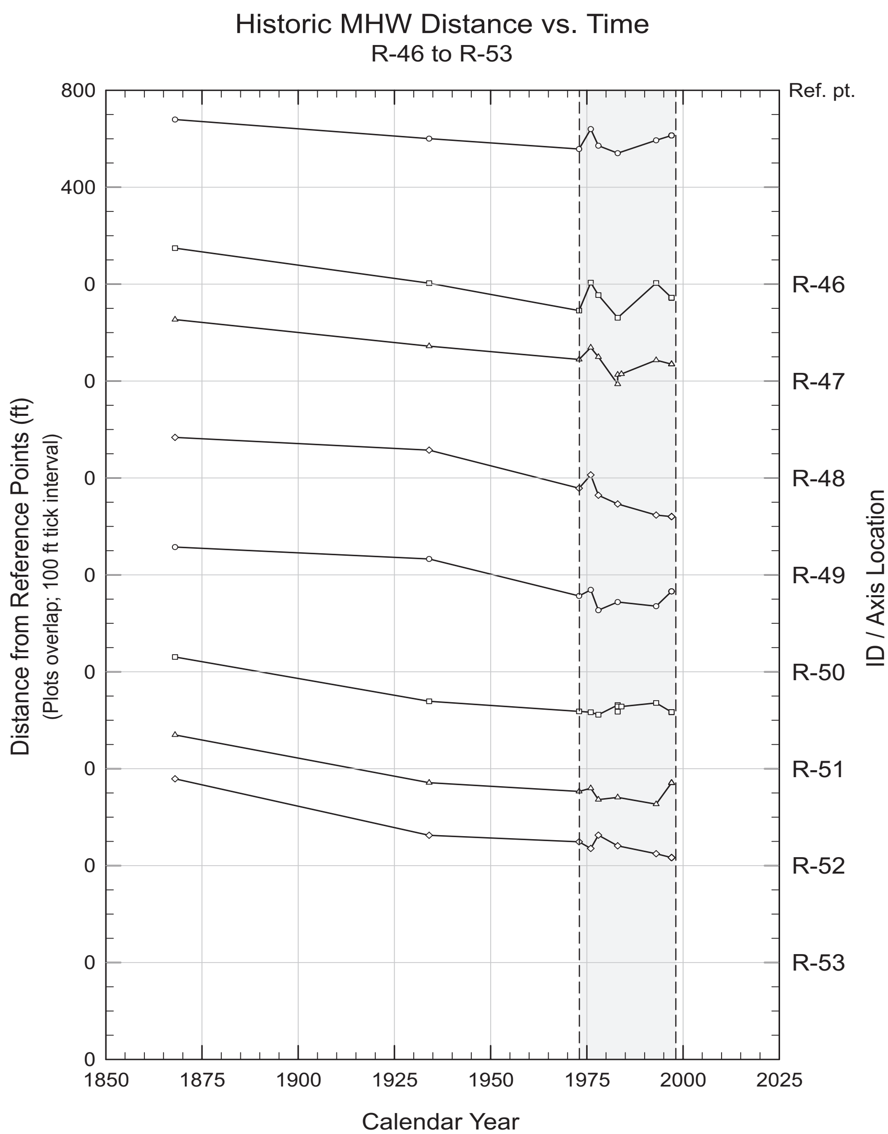
Historic MHW Distance vs. Time
R-17 to R-24
800
400
0
0
0
0
0
0
0
0
0
Ref. pt.
R-17
R-18
R-19
R-20
R-21
R-22
R-23
R-24
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
ID / Axis Location
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year


Historic MHW Distance vs. Time
R-25 to R-31
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)
Ref. pt.
R-25
R-26
R-27
R-28
R-29
R-30
R-31
ID / Axis Location

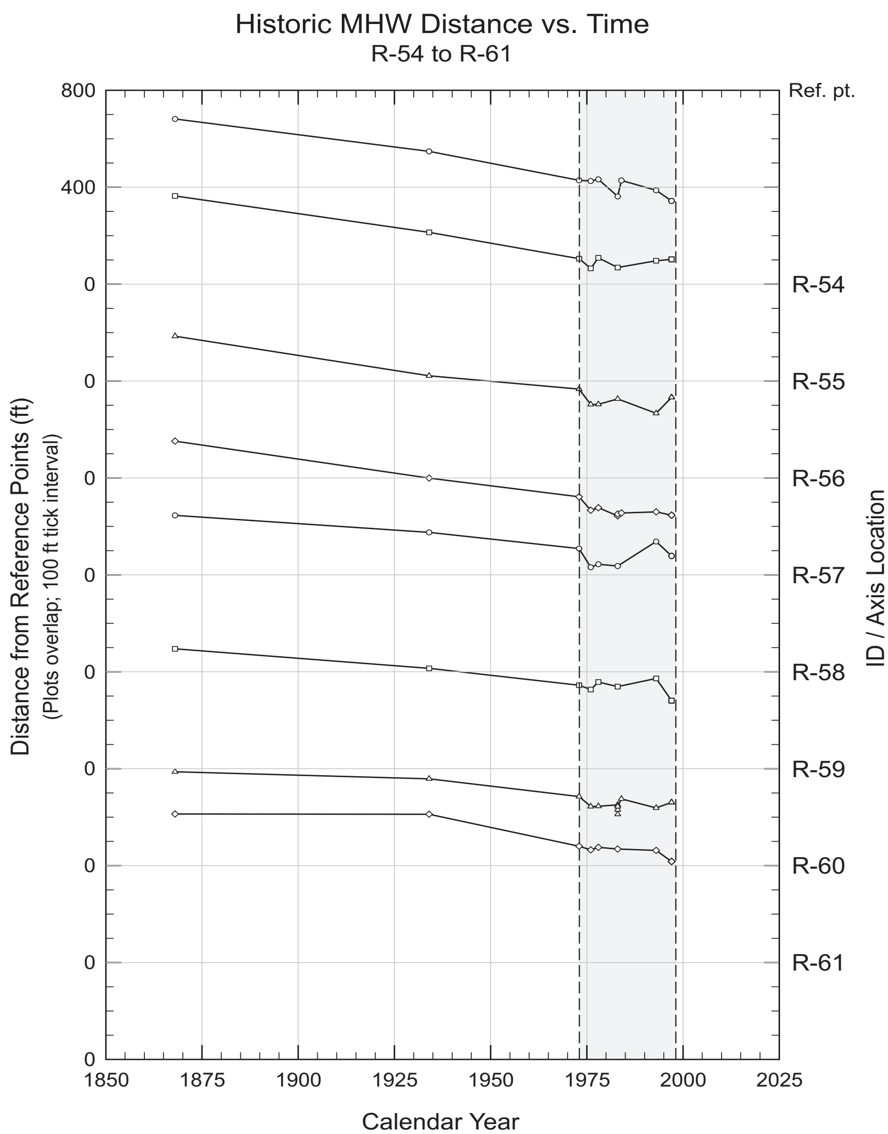

Historic MHW Distance vs. Time
R-32 to R-33
800
400
0
0
0
0
0
0
0
0
0
Ref. pt.
R-32
R-33
ID / Axis Location
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year


Historic MHW Distance vs. Time
R-34 to R-38
800
400
0
0
0
0
0
0
0
0
0
Ref. pt.
R-34
R-35
R-36
R-37
R-38
ID / Axis Location
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year

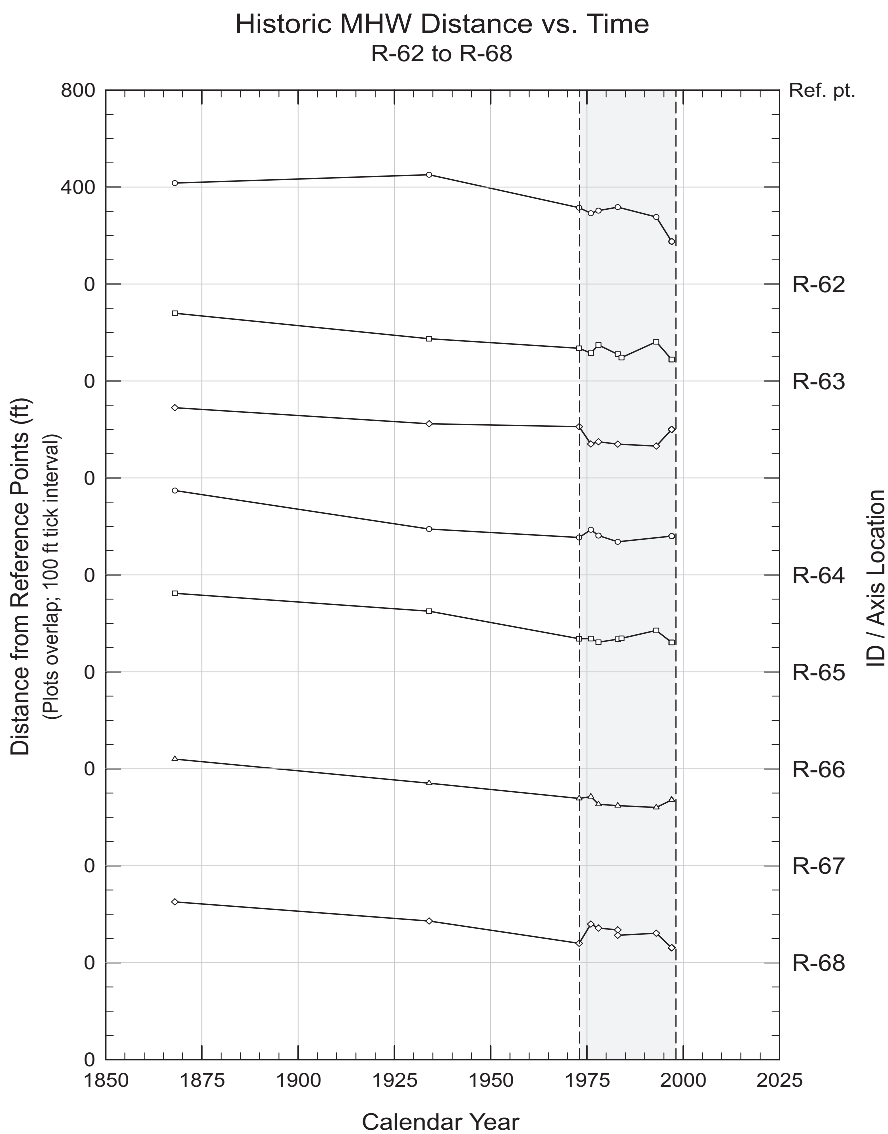

Historic MHW Distance vs. Time
R-39 to R-45
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
800
400
0
Ref. pt.
R-39
R-40
R-41
R-42
R-43
R-44
R-45
ID / Axis Location
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year



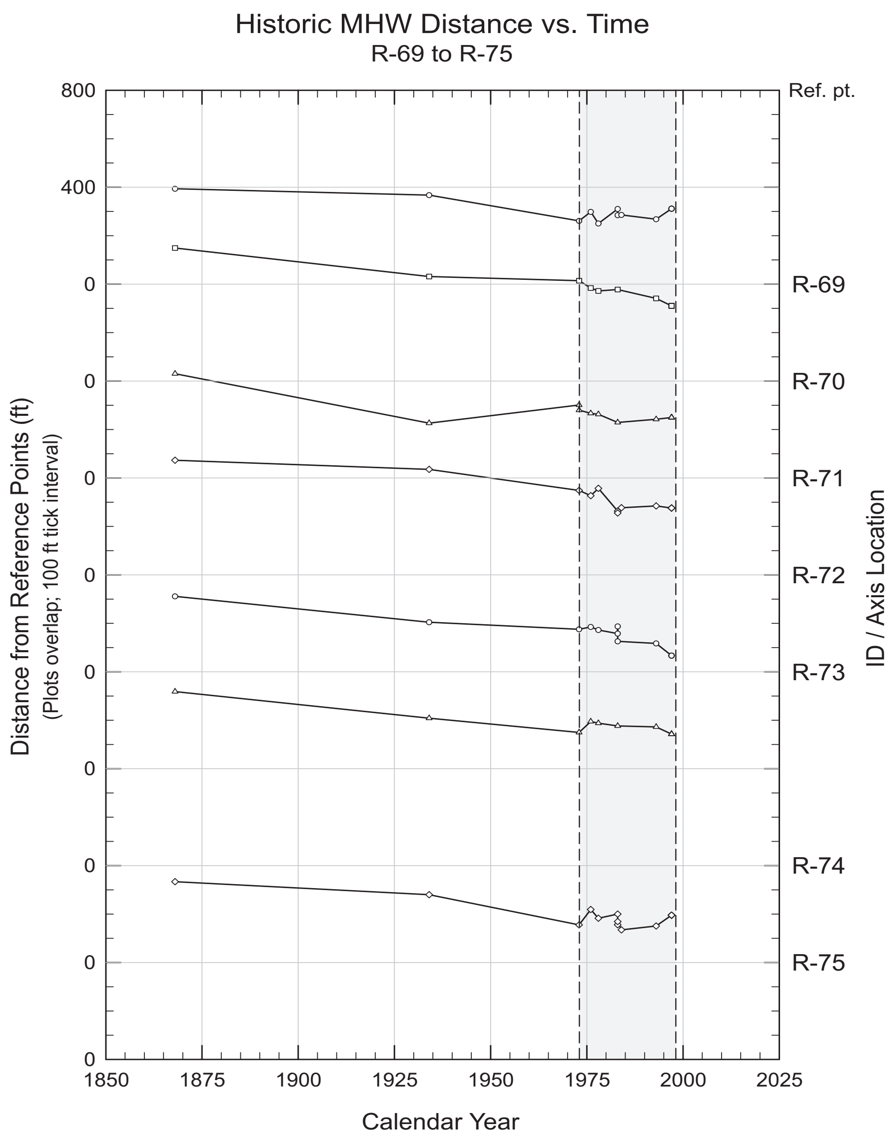
Historic MHW Distance vs. Time
R-46 to R-53
800
400
0
0
0
0
0
0
0
0
0
Ref. pt.
R-46
R-47
R-48
R-49
R-50
R-51
R-52
R-53
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
ID / Axis Location
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year

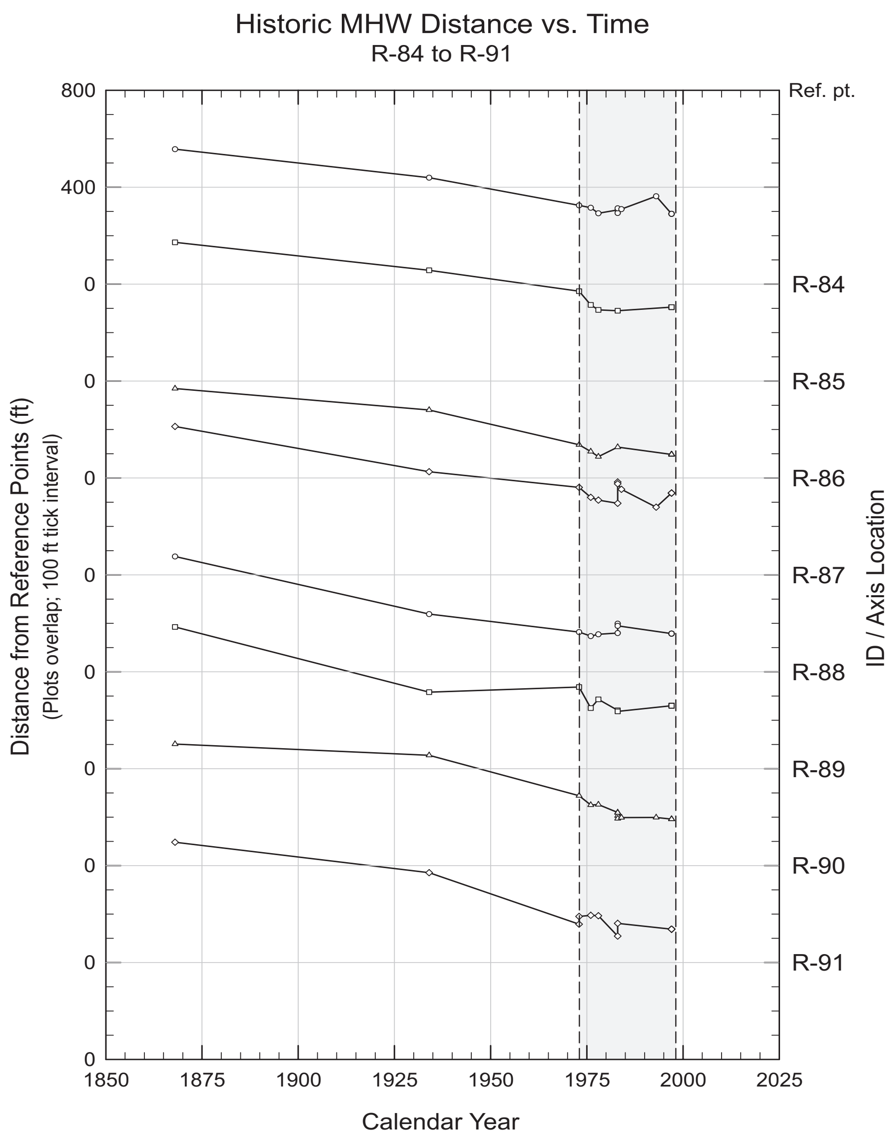


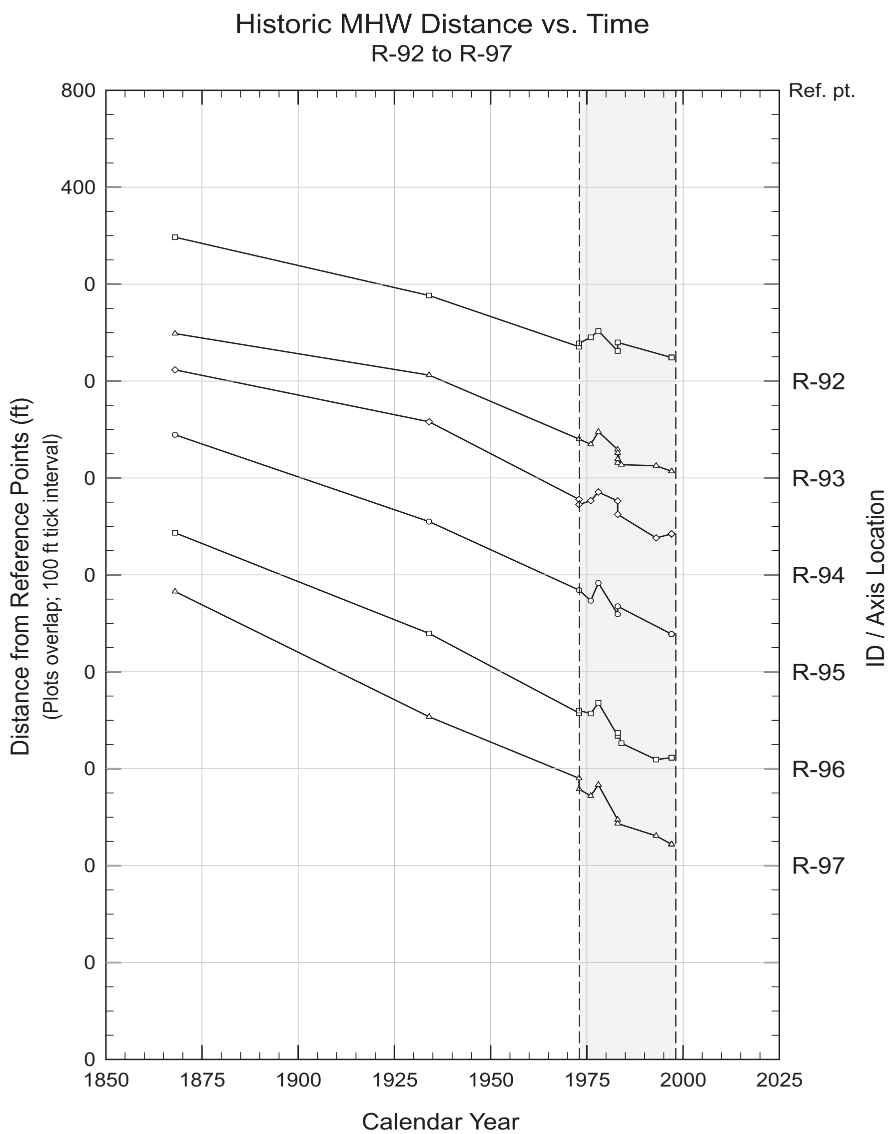
Historic MHW Distance vs. Time
R-54 to R-61
800
400
0
0
0
0
0
0
0
0
0
Ref. pt.
R-54
R-55
R-56
R-57
R-58
R-59
R-60
R-61
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
ID / Axis Location
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year

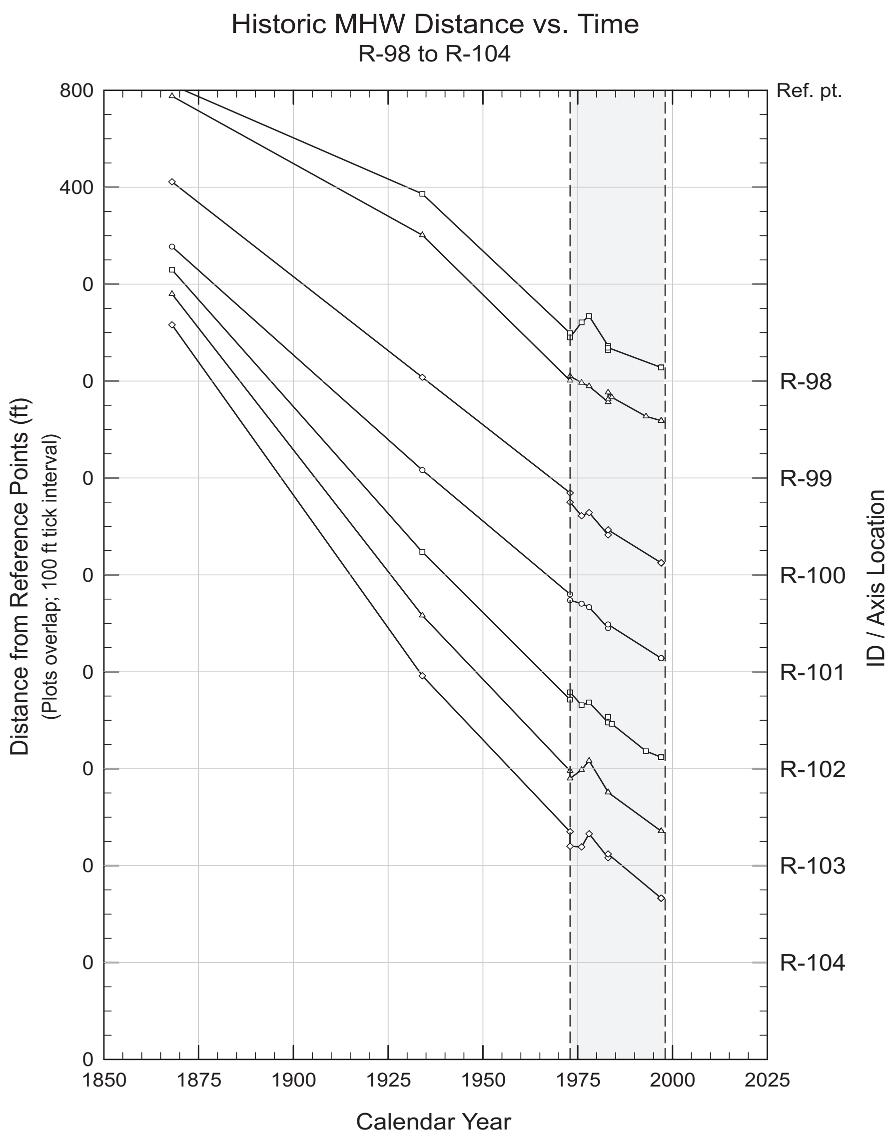


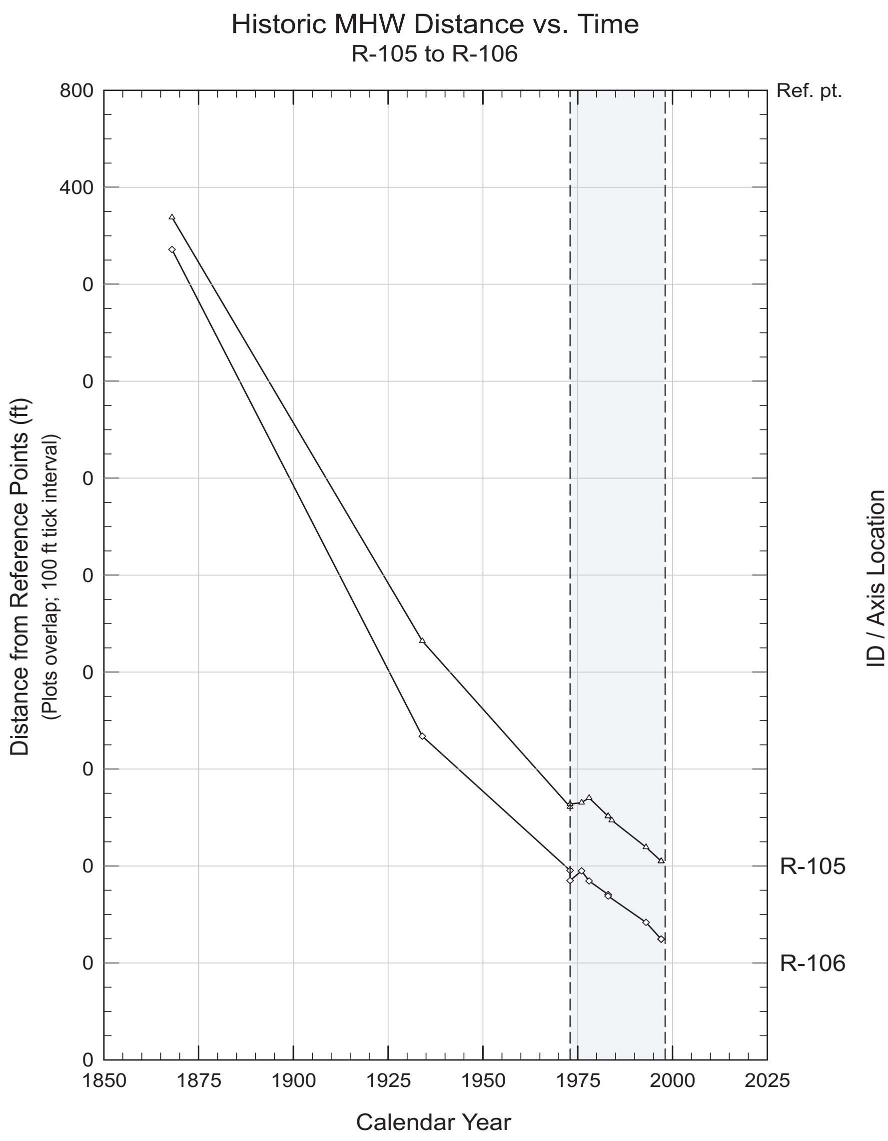
Historic MHW Distance vs. Time
R-62 to R-68
800
400
0
0
0
0
0
0
0
0
Ref. pt.
R-62
R-63
R-64
R-65
R-66
R-67
R-68
ID / Axis Location
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year

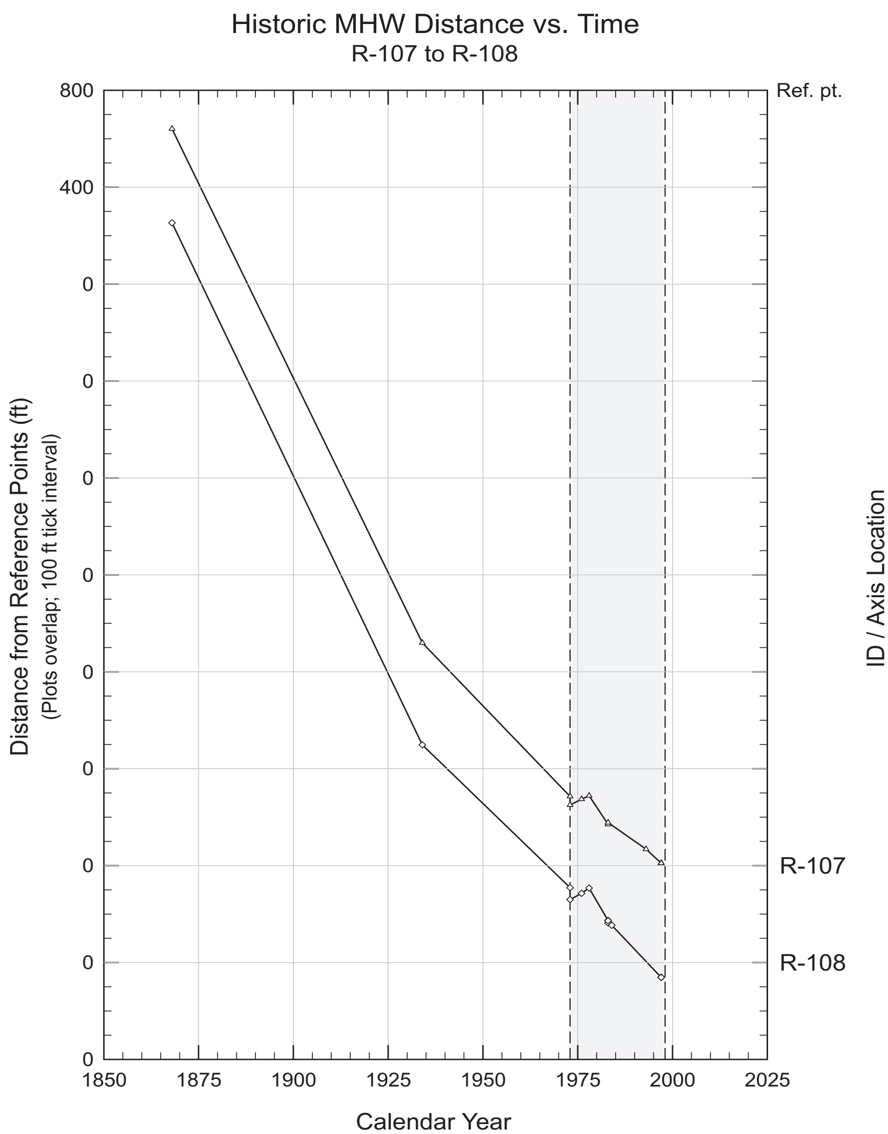

Historic MHW Distance vs. Time
R-69 to R-75
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
800
400
0
0
0
0
0
0
0
0
0
Ref. pt.
R-69
R-70
R-71
R-72
R-73
R-74
R-75
ID / Axis Location
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year


Historic MHW Distance vs. Time
R-84 to R-91
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
800
400
0
0
0
0
0
0
0
0
0
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Ref. pt.
R-84
R-85
R-86
R-87
R-88
R-89
R-90
R-91
ID / Axis Location

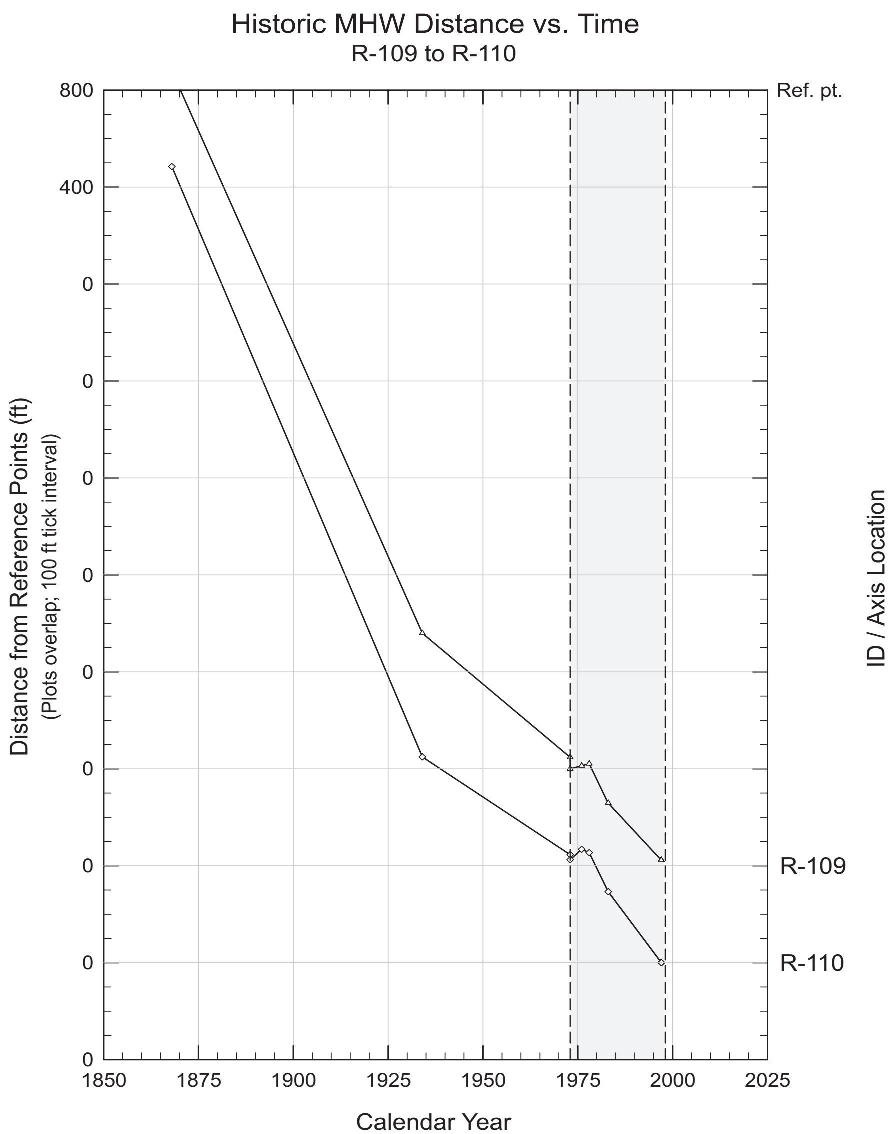

Historic MHW Distance vs. Time
R-92 to R-97
800
400
0
0
0
0
0
0
0
0
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
Ref. pt.
R-92
R-93
R-94
R-95
R-96
R-97
ID / Axis Location


Historic MHW Distance vs. Time
R-98 to R-104
800
400
0
0
0
0
0
0
0
0
0
Ref. pt.
R-98
R-99
R-100
R-101
R-102
R-103
R-104
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
ID / Axis Location
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year

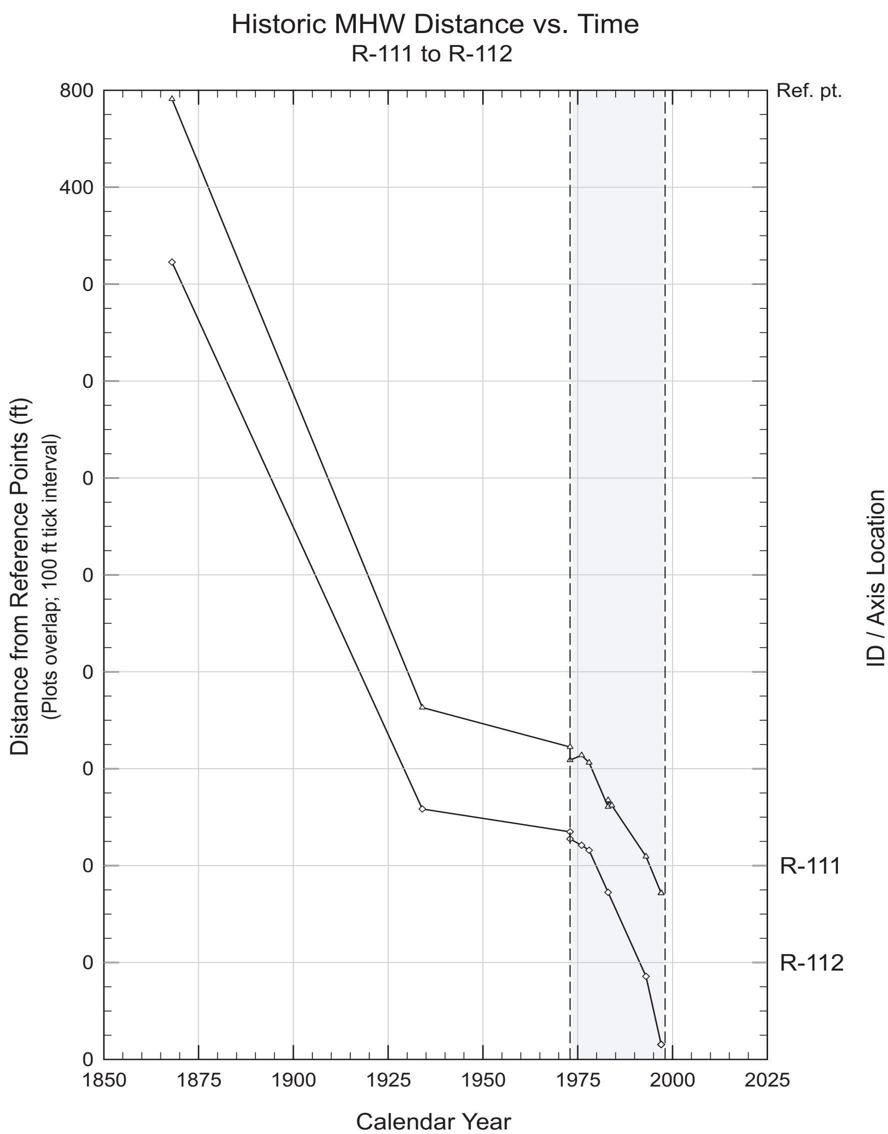

Historic MHW Distance vs. Time
R-105 to R-106
800
400
0
0
0
0
0
0
0
0
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
Ref. pt.
R-105
R-106
ID / Axis Location

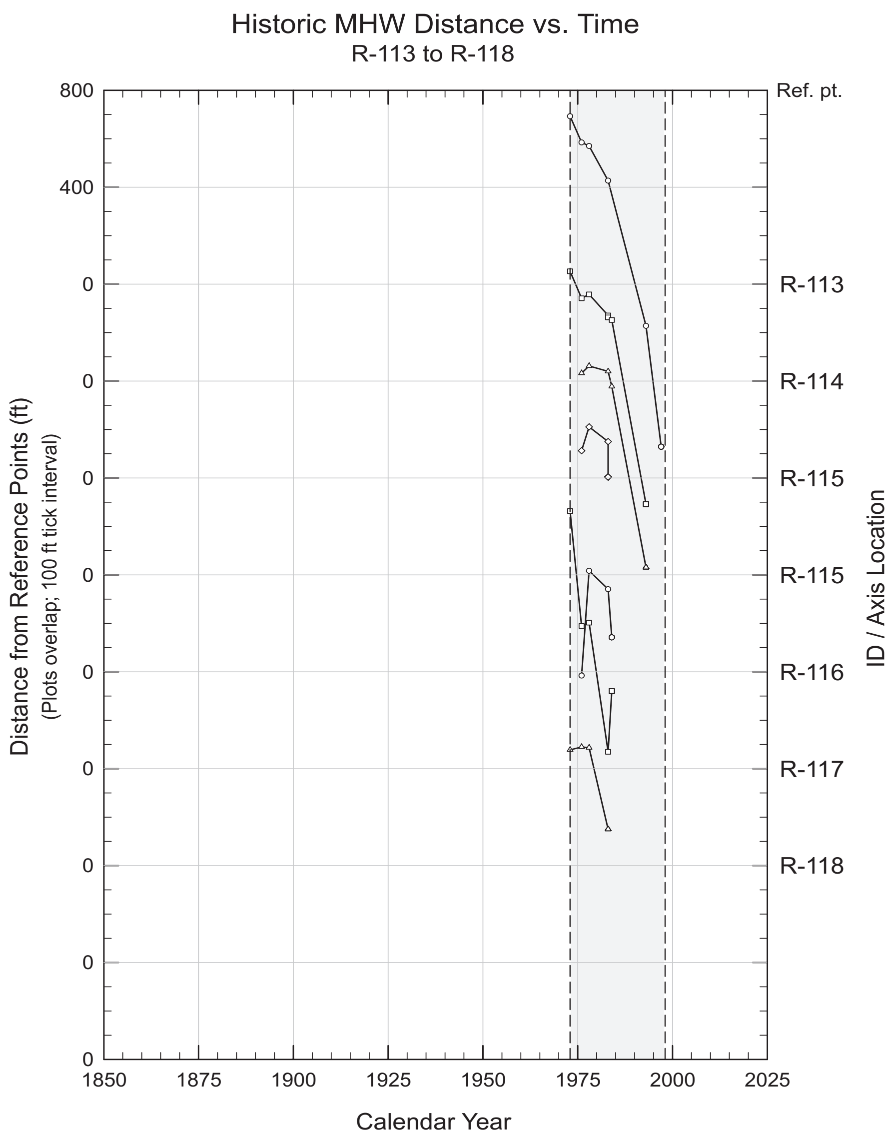


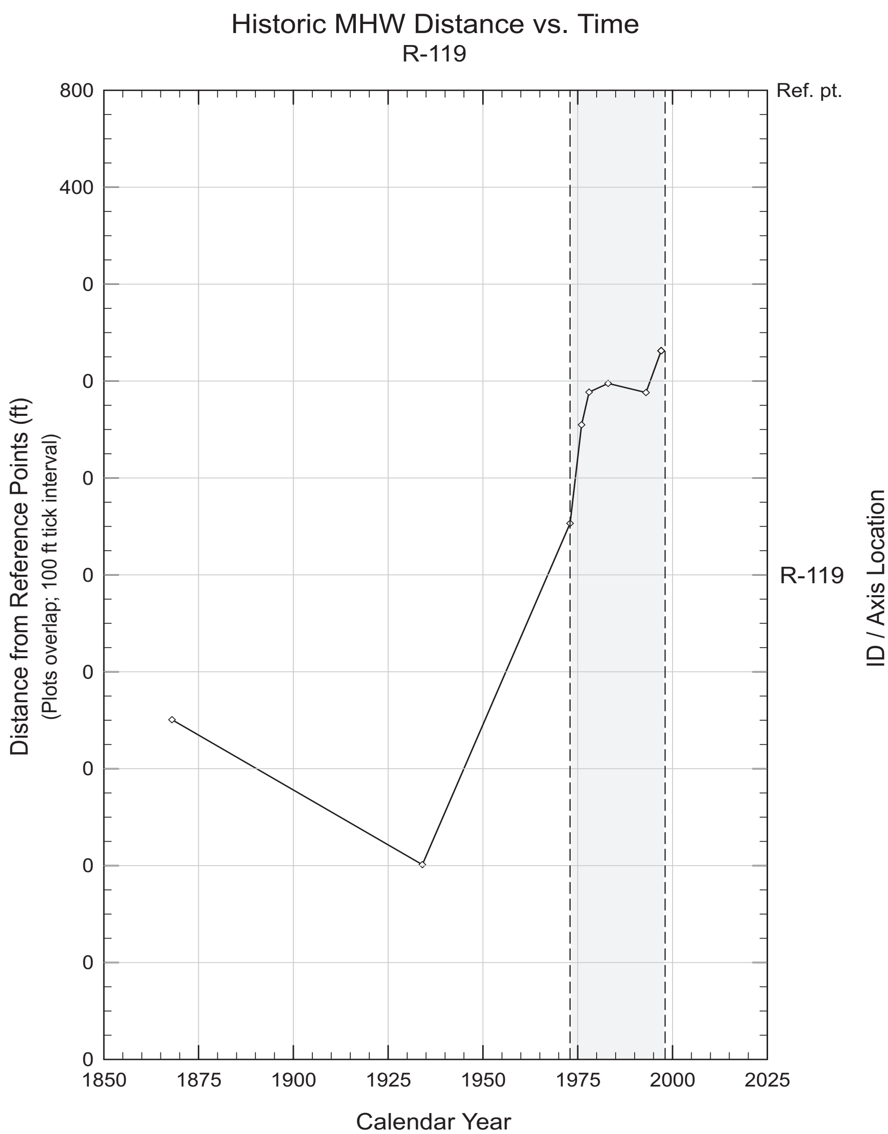
Historic MHW Distance vs. Time
R-107 to R-108
800
400
0
0
0
0
0
0
0
0
0
Ref. pt.
R-107
R-108
ID / Axis Location
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year

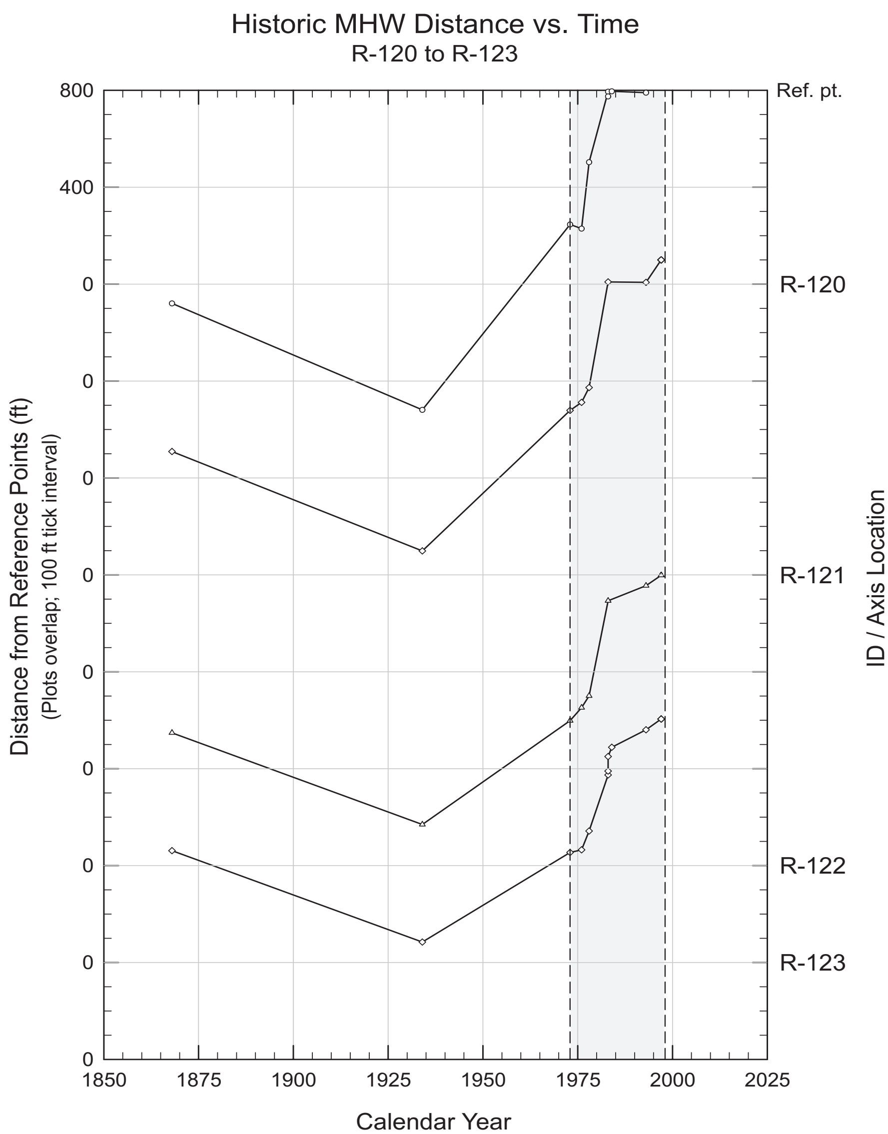


Historic MHW Distance vs. Time
R-109 to R-110
800
400
0
0
0
0
0
0
0
0
Ref. pt.
R-109
R-110
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
ID / Axis Location
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year

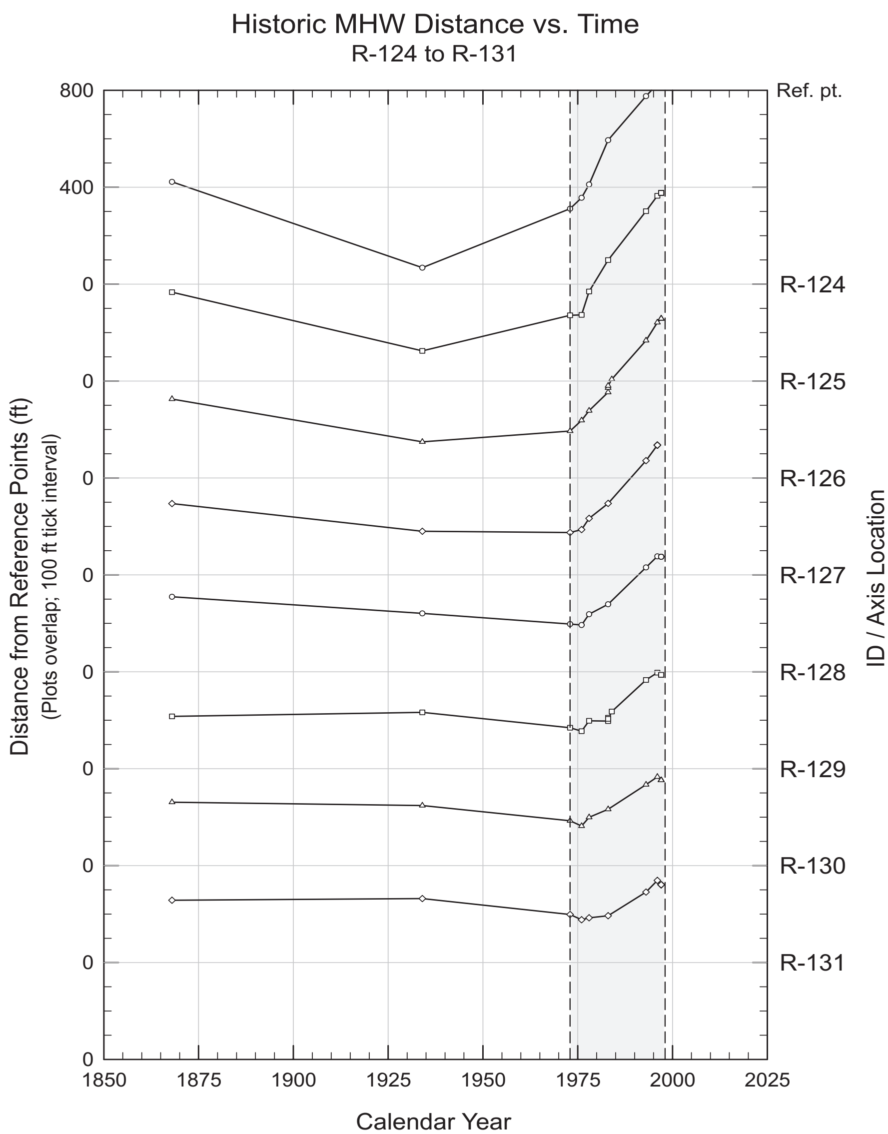

Historic MHW Distance vs. Time
R-111 to R-112
800
400
0
0
0
0
0
0
0
0
0
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Ref. pt.
R-111
R-112
ID / Axis Location

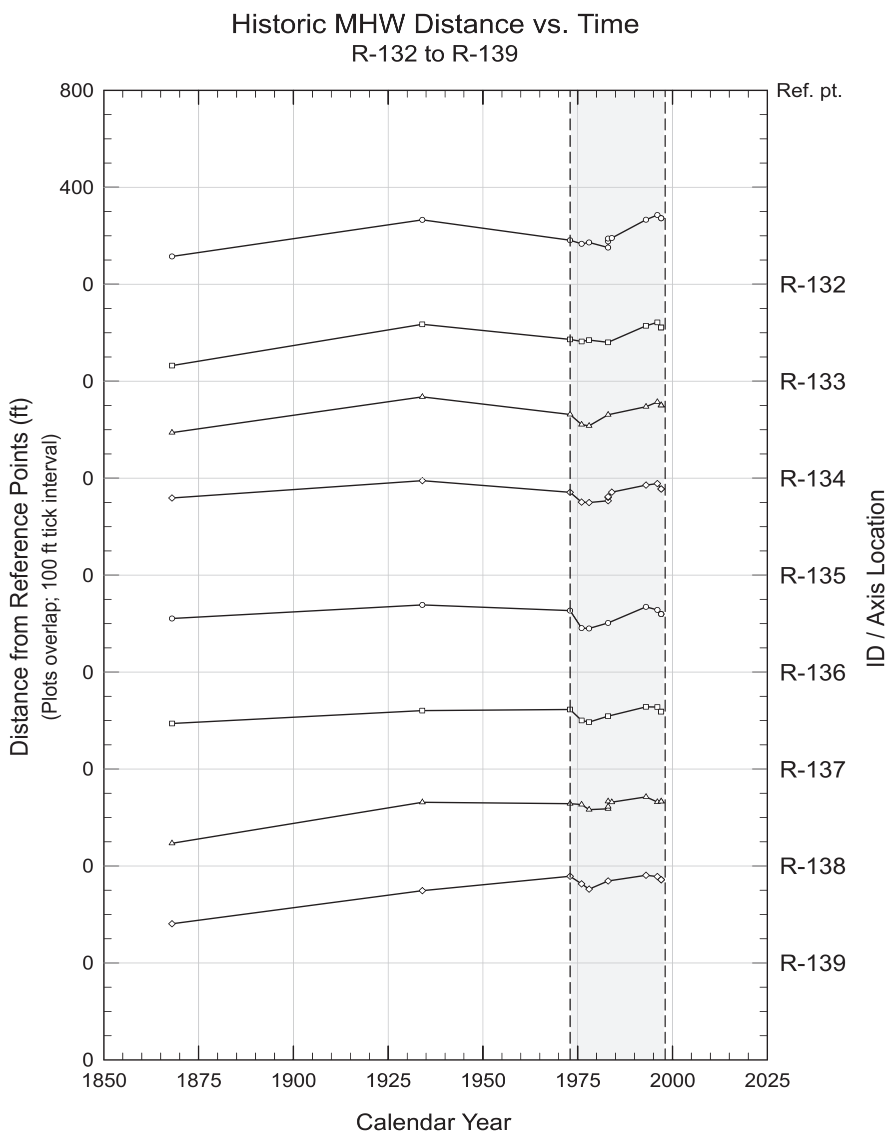

Historic MHW Distance vs. Time
R-113 to R-118
800
400
0
0
0
0
0
0
0
0
0
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Ref. pt.
R-113
R-114
R-115
R-115
R-116
R-117
R-118
ID / Axis Location

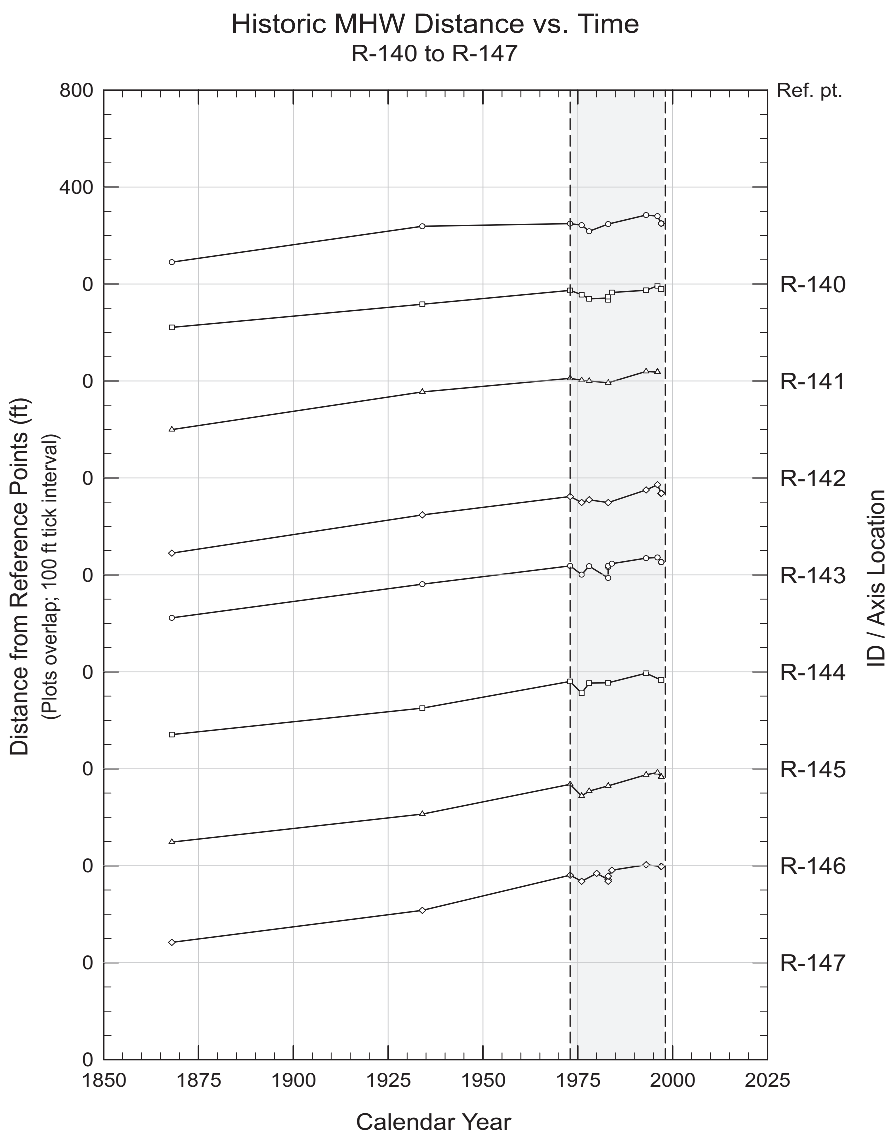

Historic MHW Distance vs. Time
R-119
800
400
0
0
0
0
0
0
0
0
0
Ref. pt.
R-119
ID / Axis Location
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year



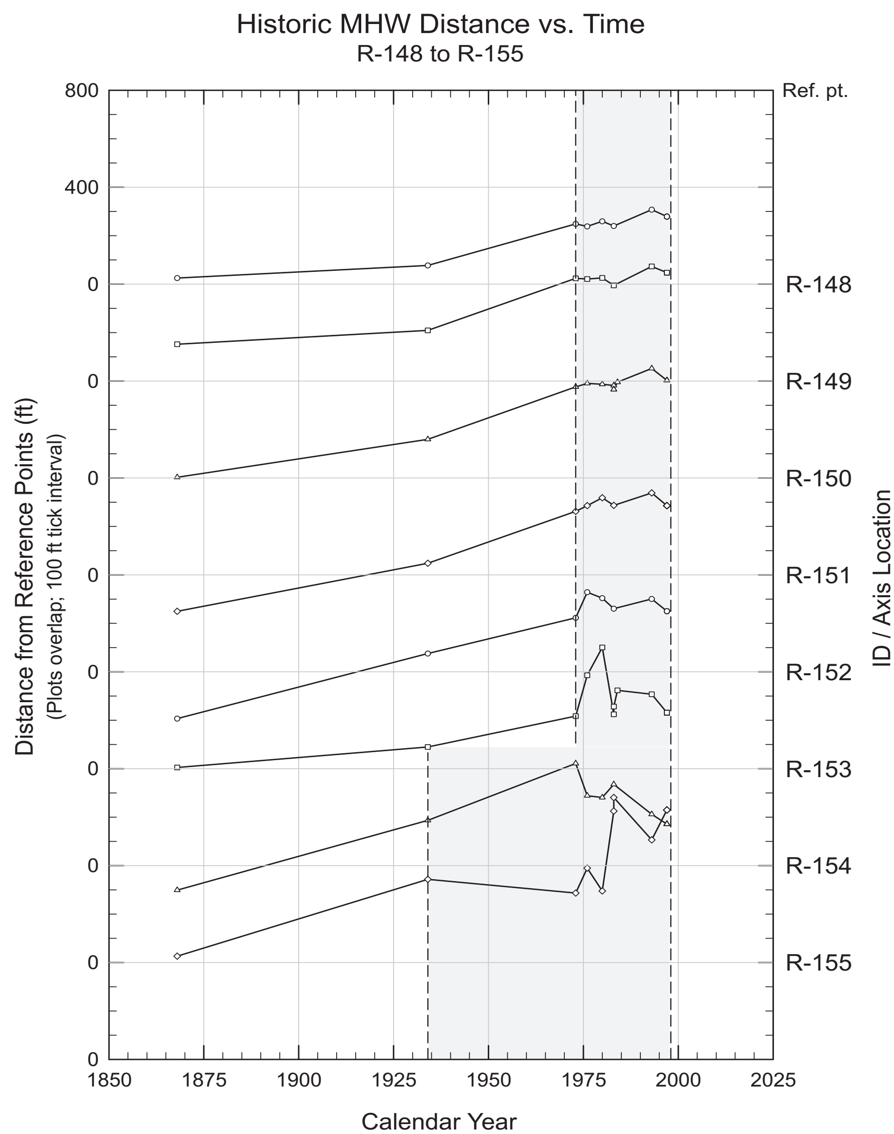
Historic MHW Distance vs. Time
R-120 to R-123
800
400
0
0
0
0
0
0
0
0
0
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Ref. pt.
R-120
R-121
R-122
R-123
ID / Axis Location

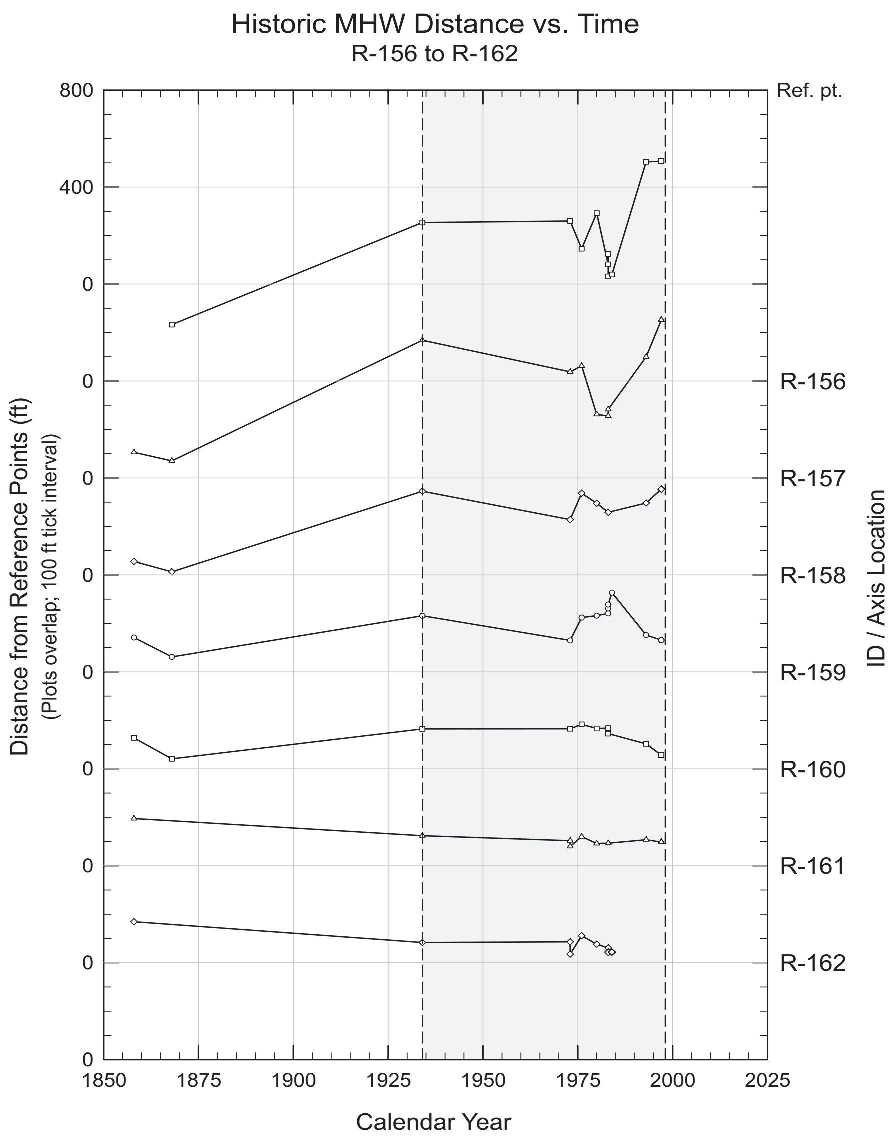

Historic MHW Distance vs. Time
R-124 to R-131
800
400
0
0
0
0
0
0
0
0
0
Ref. pt.
R-124
R-125
R-126
R-127
R-128
R-129
R-130
R-131
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
ID / Axis Location
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year


Historic MHW Distance vs. Time
R-132 to R-139
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
Ref. pt.
800
400
0
R-132
R-133
R-134
R-135
R-136
R-137
R-138
R-139
ID / Axis Location
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year

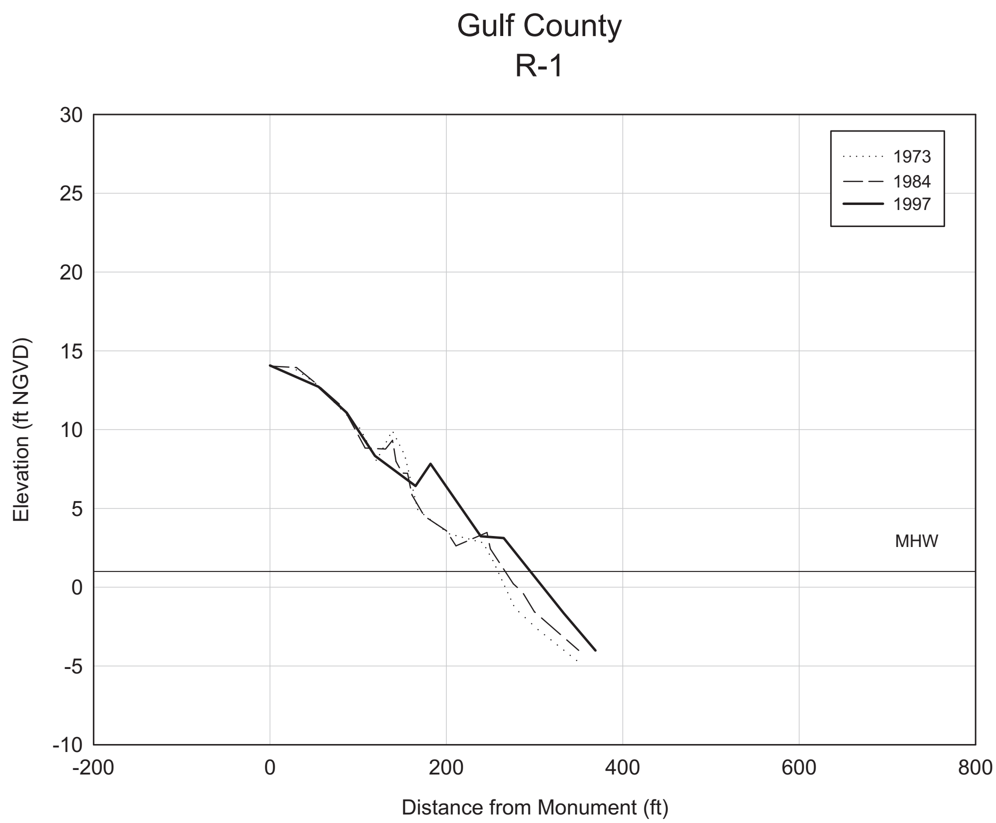


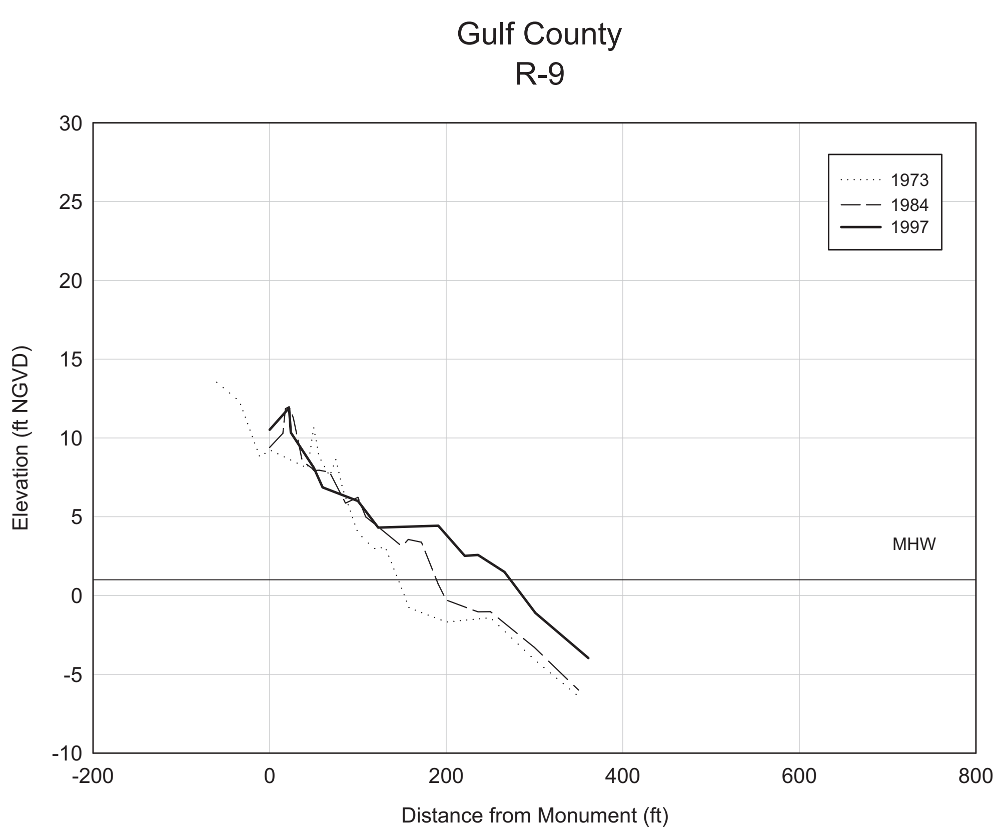
Historic MHW Distance vs. Time
R-140 to R-147
800
400
0
0
0
0
0
0
0
0
0
0
Ref. pt.
R-140
R-141
R-142
R-143
R-144
R-145
R-146
R-147
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
ID / Axis Location

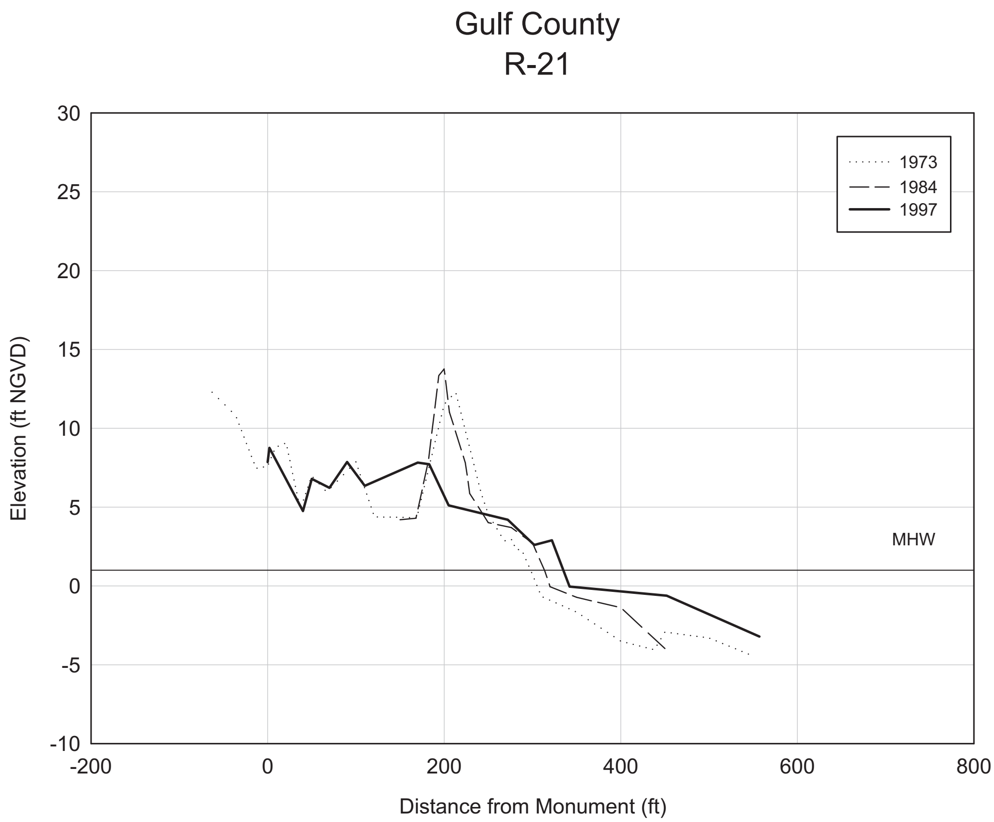

Historic MHW Distance vs. Time
R-148 to R-155
800
400
0
0
0
0
0
0
0
0
0
Ref. pt.
R-148
R-149
R-150
R-151
R-152
R-153
R-154
R-155
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
ID / Axis Location
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year

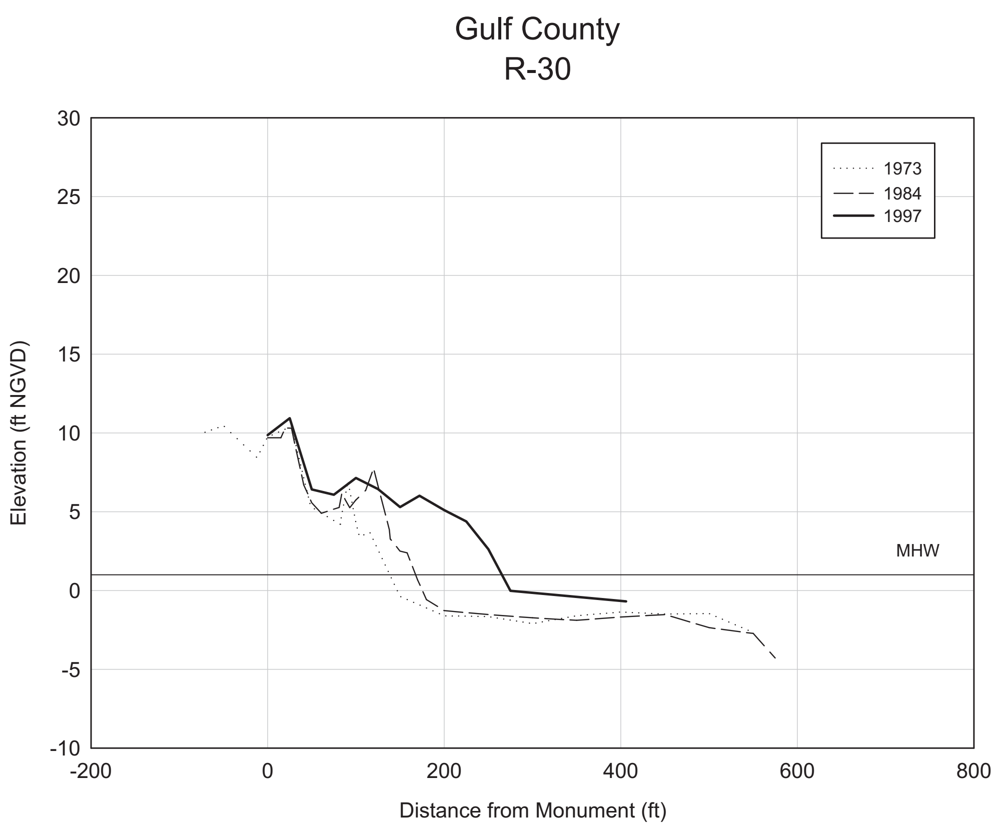

Historic MHW Distance vs. Time
R-156 to R-162
800
400
0
0
0
0
0
0
0
0
0
Ref. pt.
R-156
R-157
R-158
R-159
R-160
R-161
R-162
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
ID / Axis Location
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year

7.3 Appendix C: Profile Plots

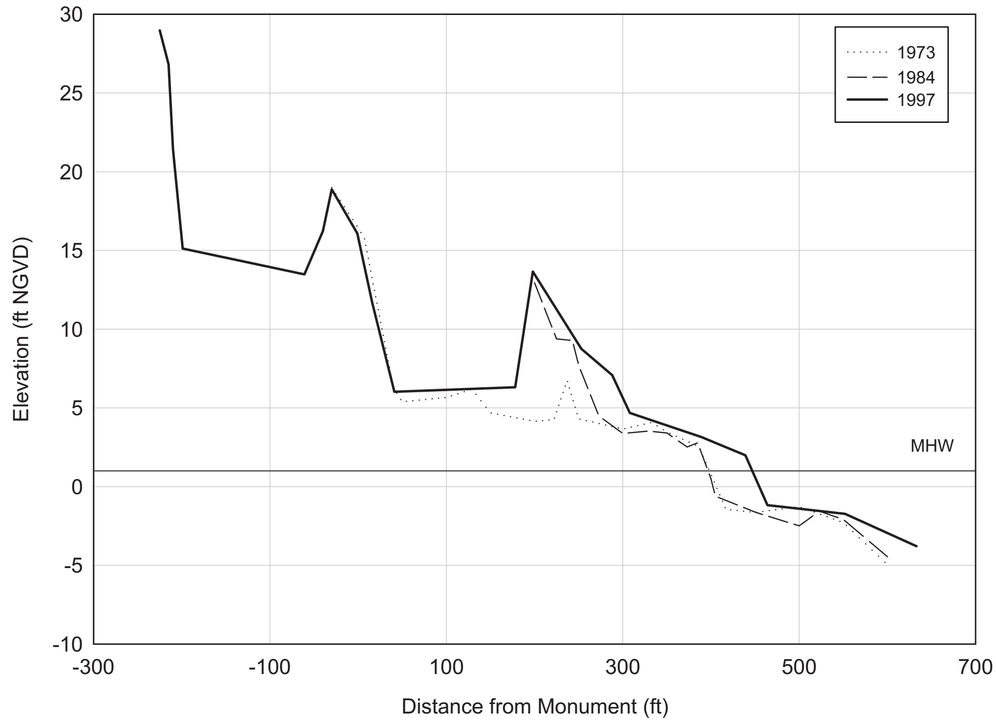

Gulf County
R-1
30
25
20
15
10
5
0
-5
-10
-200
0
200
400
600
800
Elevation (ft NGVD)
Distance from Monument (ft)
1973
1984
1997
MHW


Gulf County
R-9
30
25
20
15
10
5
0
-5
-10
-200
0
200
400
600
800
Elevation (ft NGVD)
Distance from Monument (ft)
1973
1984
1997
MHW

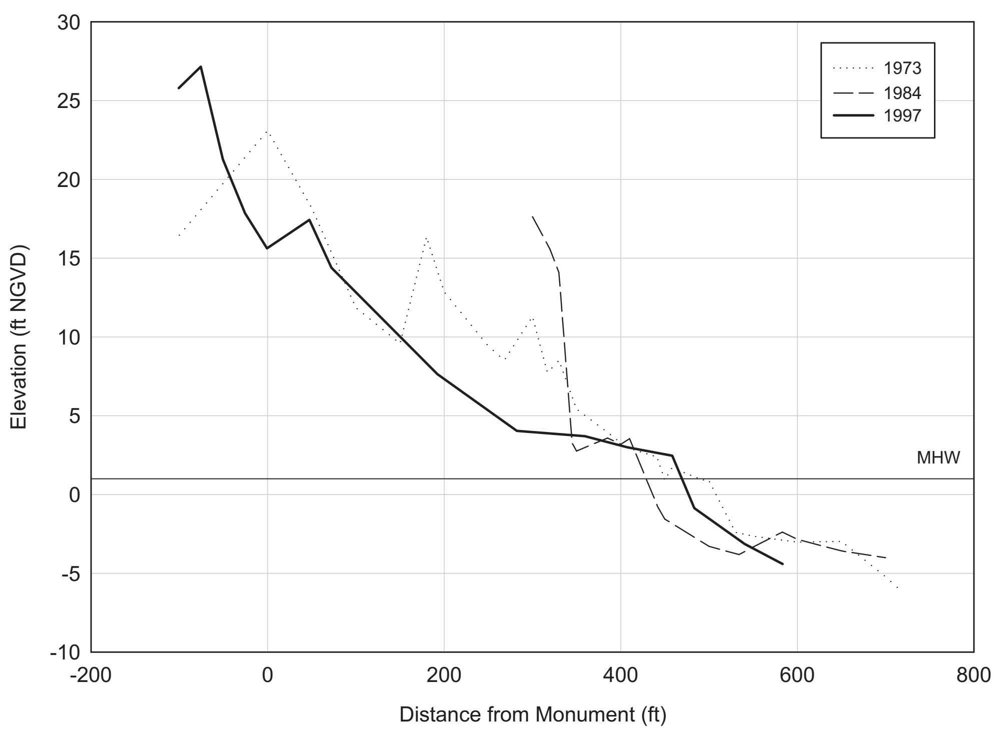

Gulf County
R-21
30
25
20
15
10
5
0
-5
-10
-200
0
200
400
600
800
Elevation (ft NGVD)
Distance from Monument (ft)
1973
1984
1997
MHW

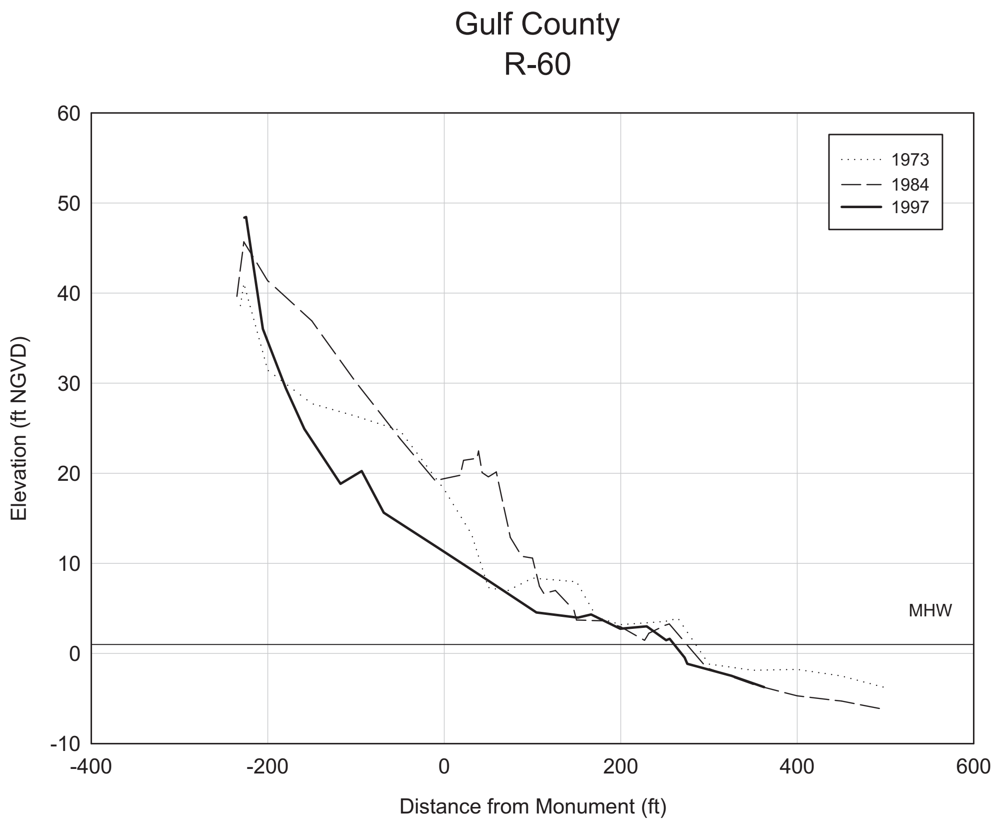

Gulf County
R-30
30
25
20
15
10
5
0
-5
-10
-200
0
200
400
600
800
Elevation (ft NGVD)
Distance from Monument (ft)
1973
1984
1997
MHW

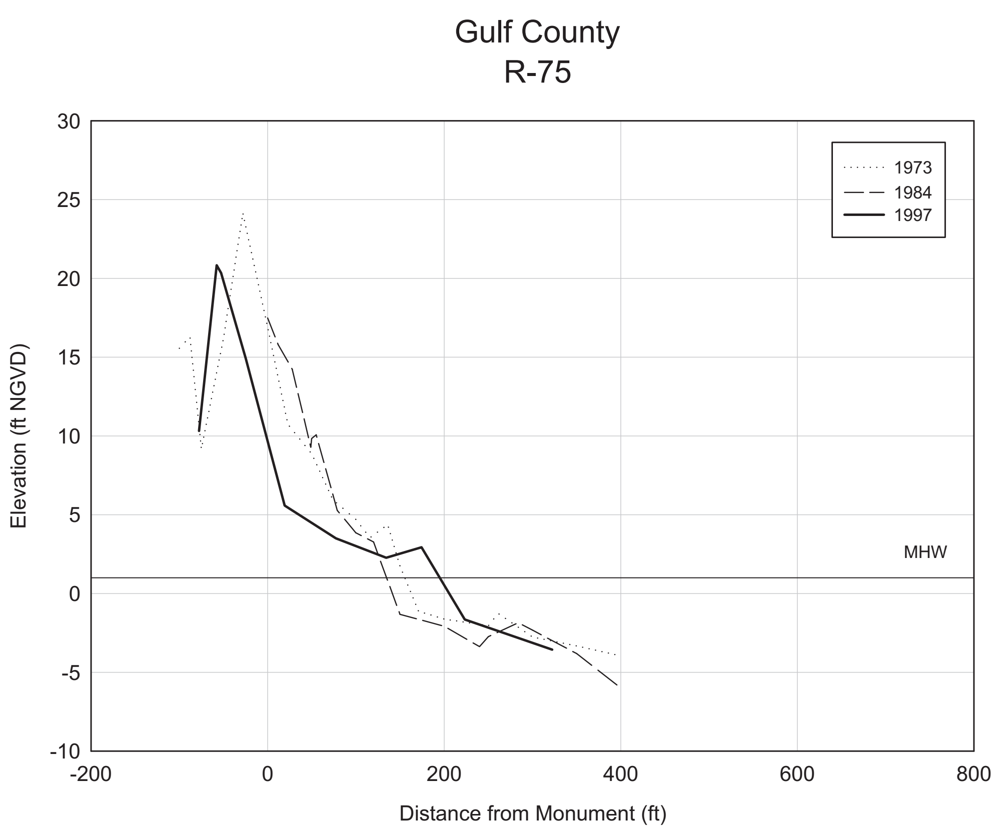
Gulf County
R-39



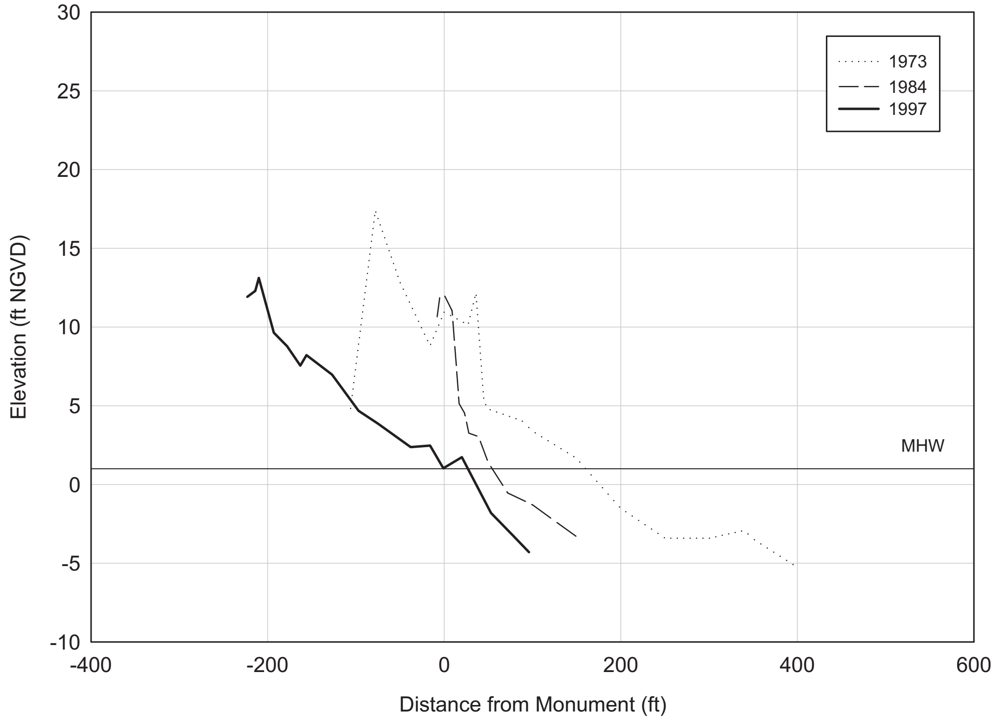
Gulf County
R-48



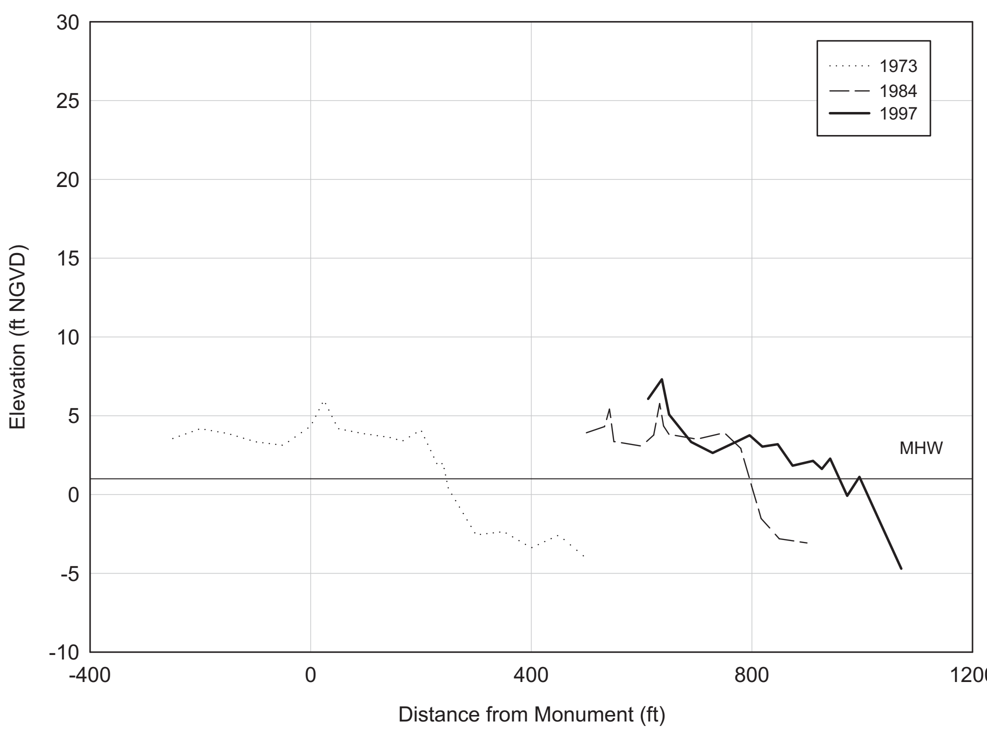

Gulf County
R-60
1973
1984
1997
MHW
60
50
40
30
20
10
0
-10
-400
-200
0
200
400
600
Elevation (ft NGVD)
Distance from Monument (ft)

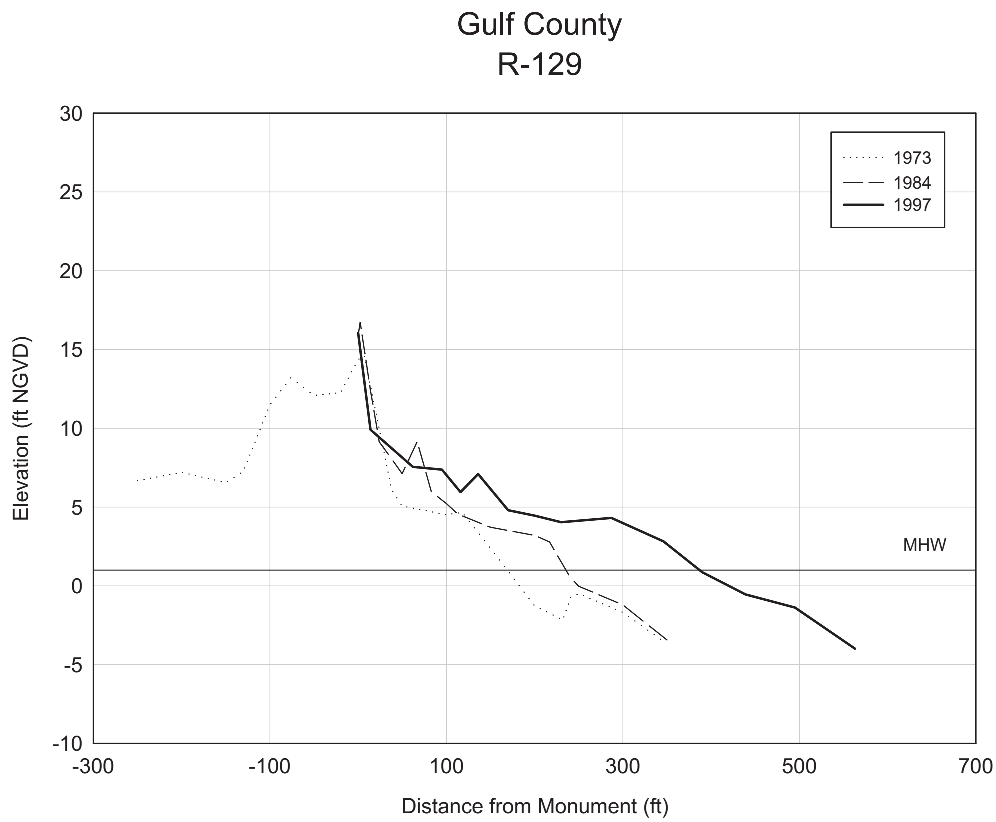

Gulf County
R-75
1973
1984
1997
MHW
30
25
20
15
10
5
0
-5
-10
-200
0
200
400
600
800
Elevation (ft NGVD)
Distance from Monument (ft)

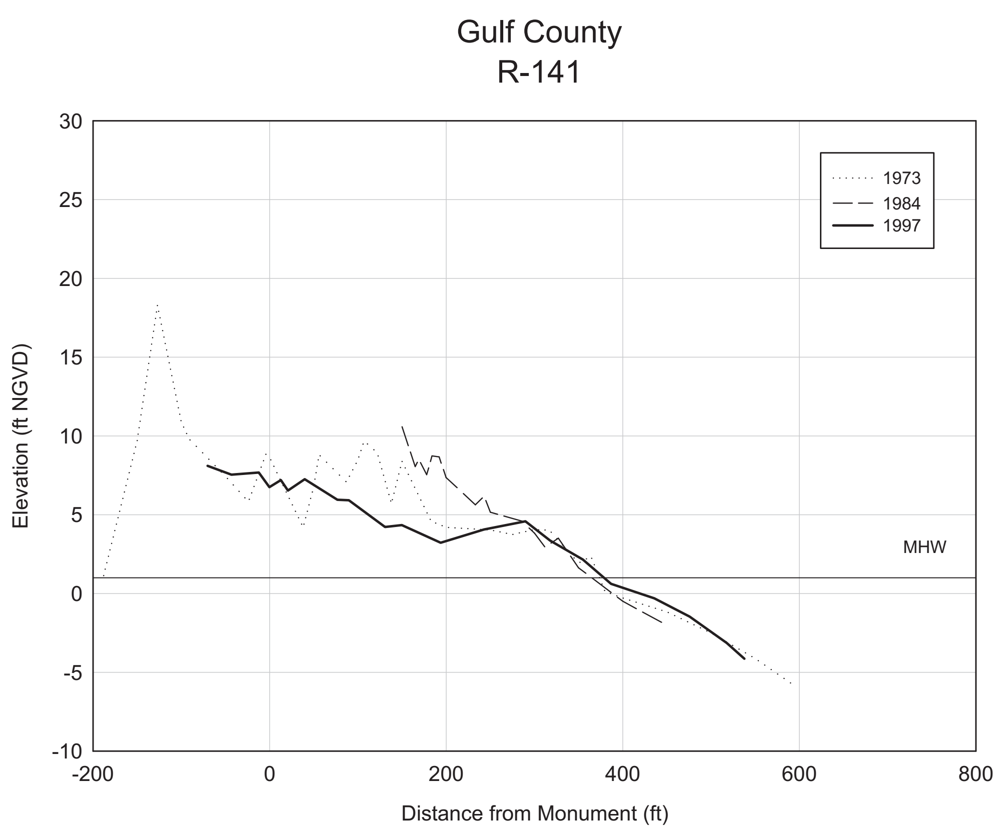
Gulf County
R-93



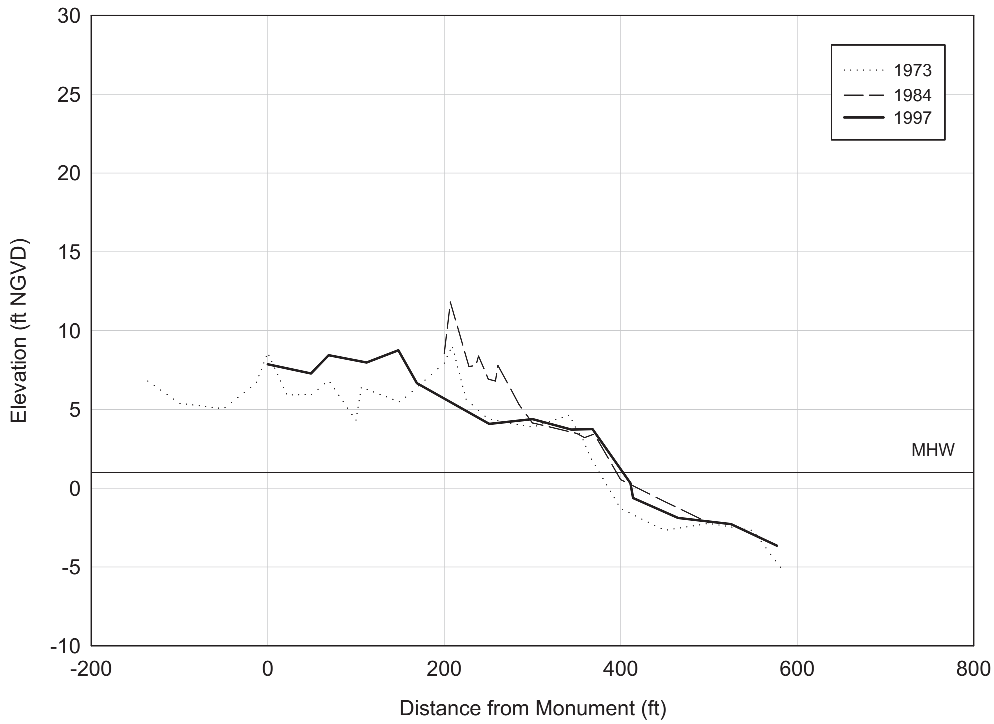
Gulf County
R-120




Gulf County
R-129
30
25
20
15
10
5
0
-5
-10
-300
-100
100
300
500
700
Elevation (ft NGVD)
Distance from Monument (ft)
1973
1984
1997
MHW


Gulf County
R-141
30
25
20
15
10
5
0
-5
-10
-200
0
200
400
600
800
Elevation (ft NGVD)
Distance from Monument (ft)
1973
1984
1997
MHW

Gulf County
R-150



Gulf County
R-159