Shoreline Change Rate Estimates

Okaloosa 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 changes in Okaloosa County are strongly tied to the relatively recent construction of inlet jetties for East Pass in 1967-1969 and, consequently, erosion rate estimates in the majority of the county are largely confined to the post-construction time period. Hurricane Opal effects have also been excluded, with the exception that post-hurricane data was used where no other data was available west of the inlet.

The beach for approximately 20,000 ft west of East Pass is highly erosive (with progressive rates of -1.0 to -8.5 ft/yr) and this erosion pattern is expected to spread westward into the developed areas (R-1 to R-16). Within the "R" monument areas, the shoreline has been mildly accretional to stable. However, it is recommended that a conservative minimum erosion rate estimate of -1 ft/yr be used in all "R" monument areas at this time, with the caveat that rates should eventually increase in the R-1 to R-16 area, probably starting within the next decade or two, east to west.

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

Okaloosa County is located in Northwest Florida (Figure 1). The western portion of the county's shoreline is situated on Santa Rosa Island. The eastern portion is the Destin area. The two parts are separated by East Pass, which serves as the only direct tidal link between the Gulf of Mexico and Choctawhatchee Bay.

Okaloosa County contains 50 DEP survey reference points, generally designated as "R" monuments or ranges, spaced approximately 1,000 ft (300 m) apart. In addition, there are 72 "V" or "virtual" monuments (i.e., fictitious monuments) used as fixed reference points in important coastal areas not monitored by the DEP. This report uses these reference points to locate various items within the county.

There are two areas of extensive coastal development: a portion of Santa Rosa Island called Okaloosa Island (R-1 to R-16), and most of the Destin area east of the inlet. Undeveloped Air Force managed federal land exists on both sides of the Okaloosa Island zone. Henderson Beach State Park exists on the Destin side, approximately R-33 to R-39.

3.2 Coastal Setting

3.2.1 Waves and Tides

Tides within the study area are diurnal and microtidal. The mean tide range at East Pass is 0.43 ft (m) with a spring tidal range of 0.51 ft (m).

According to the Wave Information Study (WIS) of the Waterways Experiment Station, U.S. Army Corps of Engineers, the mean significant wave height for offshore Okaloosa County is 3.3 ft (1.0 m) and the mean wave period is 8.5 seconds. The most frequent wave direction is out of the east-southeast.

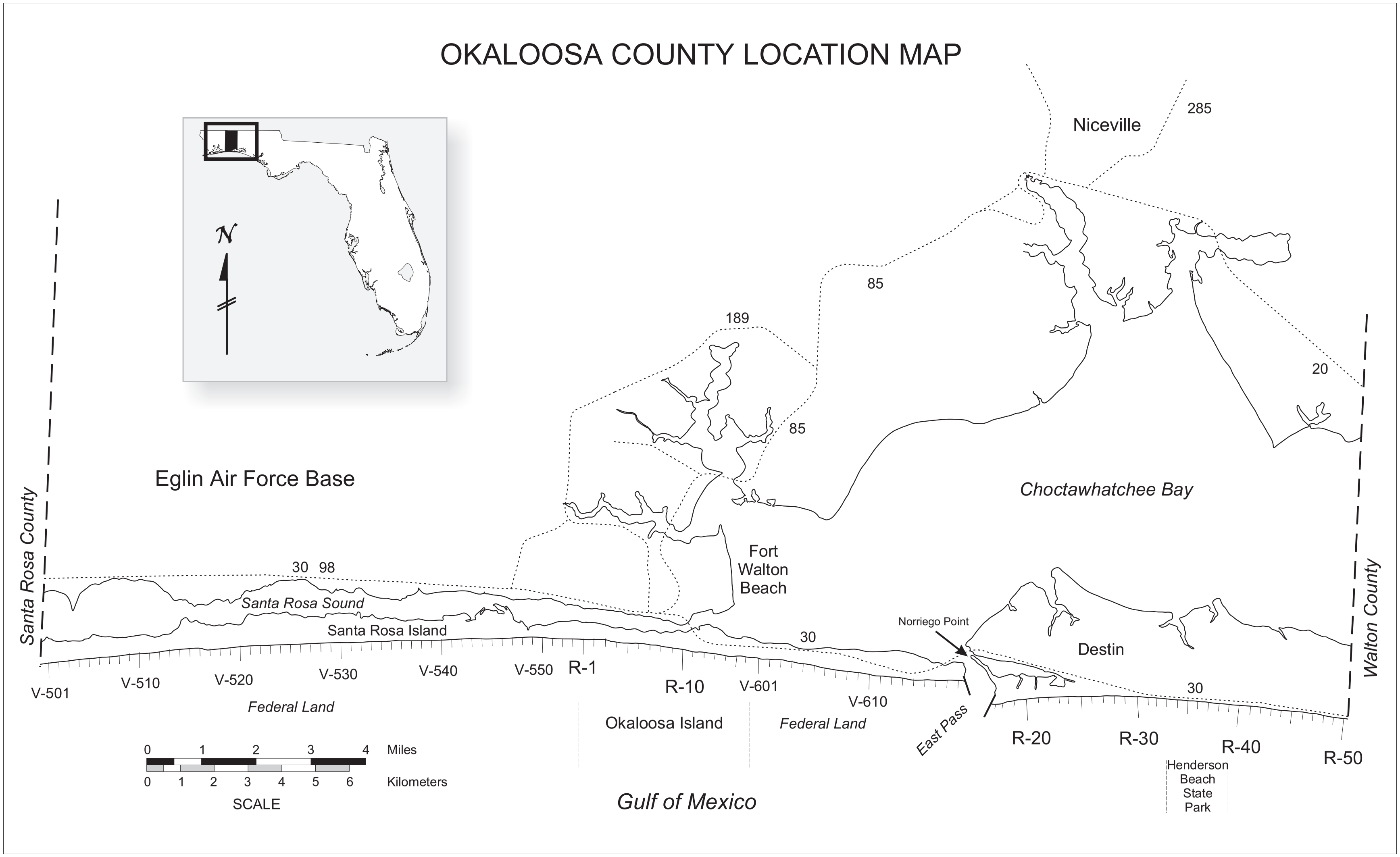

Figure 1. Study area showing Okaloosa County, Florida.

3.2.2 Longshore Transport

There are several widely varying estimates of longshore sediment transport for this area. Gosselin et al. (1998) summarize these estimates and note that most fall between 52,000 and 254,000 yd^3/yr. All estimates indicate that net transport is to the west. Strong evidence for net transport to the west exists in the pattern of erosion west of the inlet and accretion east of the inlet.

3.2.3 Storms

Numerous storms and hurricanes have impacted Okaloosa County in this century, the most recent of which was Hurricane Opal in October 1995. The eye of this Category 3 hurricane made landfall on Santa Rosa Island west of Okaloosa County (Gosselin et al., 1998). The impact of this storm on Okaloosa County included overwashing of Santa Rosa Island and most of the Destin beaches, breaching of Norriego Point, overwashing of areas surrounding both jetties and damage to both jetties, and scouring of the East Pass channel system.

It is too soon to tell if Hurricane Opal (1995) had any significant effect on the long-term erosion pattern of Santa Rosa Island. Opal was a major overtopping event and may have a significant long-term effect on the available sand supply of the region by removing a large quantity of sand from the active beach to more landward locations. In addition, substantial volumes of sand were deposited into deep nearshore waters, the fate of which is uncertain. This study does not specifically address Hurricane Opal effects. However, Leadon (1999) and Leadon et al. (1998) do discuss the impacts of Hurricane Opal in more detail.

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.

3.3 East Pass

East Pass is the only outlet to the Gulf for the 100 miles or so of coastline between Pensacola Pass to the west and St. Andrews Bay Entrance to the east. East Pass connects the Gulf of Mexico with Choctawhatchee Bay, a 122 sq. mi.-large estuarine bay.

The history of East Pass is quite dynamic. An early 1871/72 U.S.C.G.S. map indicates that the inlet channel was located approximately 10,000 feet (3,048 m) east of its current position, as evidenced by the relict lagoonal feature, now Destin Harbor. This suggests that the channel had been migrating steadily eastward over time. In 1928, the easternmost end of Santa Rosa Island was cut by a severe storm, creating a more hydraulically stable inlet in its present-day location. The old channel was still open in 1934, but its configuration had changed drastically and was closing off, with closure occurring shortly thereafter in 1938. This process of channel migration, breaching, and readjustment was likely the rule rather than the exception throughout the history of East Pass.

3.4 Engineering Projects

3.4.1 Structures

The most prevalent coastal structures affecting littoral processes along the open coast in this county are the two converging jetties bordering East Pass. Although the original project to dredge East Pass was completed in 1931, construction of the jetties did not take place until over 35 years later, from December 1967 to January 1969. The east jetty was originally a multi-part configuration—a landward sand dike and a stone jetty section—as was the west jetty, which also included a rubble mound trunk and weir sections. The weir on the west jetty was eventually closed in 1985 after a series of collapses and repairs in the decades before, leaving the total lengths of the east and west jetties at 2,270 ft (692 m) and 4,850 ft (1,478 m), respectively. In addition to the jetties, there are a series of connected bulkheads, running approximately 1,000 ft (305 m) in total length along the east shore of the pass.

3.4.2 Dredging

Dredging has been ongoing since 1931 when East Pass—then known as Old Pass—was dredged within an existing channel breached during a 1928 storm. The main channel, the outer bar, and associated basins were dredged an additional 39 times between 1937 and 1995. As reported by Gosselin et al. (1998), the total volume of sediment dredged from East Pass between 1937 and 1995 was 4,089,412 yd^3 (3,126,580 m^3), with 1,408,809 yd^3 (34%) of that deposited on Norriego Point and 1,355,213 yd^3 (33%) deposited in "open water/surf zone." The west "nearshore site" and "west side" disposal areas received 353,747 yd^3 (9%) and 374,033 yd^3 (9%), respectively. The "scour hole" and "east jetty" disposal areas received 190,084 yd^3 (5%) and 407,526 yd^3 (10%), respectively.

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 relies upon shoreline location versus time plots with overlapping axes. These are 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).

Note that because of the recent armoring of the East Pass inlet with jetties in 1967-1969, relevant data for the rate analysis for a large distance to either side of the inlet is limited to after that time. In addition, all post-hurricane Opal surveys, with one exception, have been excluded from the data set used for rate calculations. Post-storm data sets are useful for studies of temporary storm effects and recovery but are not considered to be useful indicators of longer-term erosion patterns. Experience suggests that this type of data often tends to obscure or hide the longer-term erosion patterns that are eventually reestablished in an area. It may take as long as a decade after a major storm for the pre-storm erosion pattern to again become clearly evident.

The one exception to the use of post-Opal data was the use of the 1996 DEP survey of the V monument area west of the inlet. This was necessary because it is the only shoreline survey data available since the 1970s for that important area.

5 SHORELINE CHANGE

Shoreline (mhw) change rate estimates are provided in Figure 2 and Table A-1 (Appendix A). These estimates are intended to reflect post-inlet jetty conditions for about 35,000 ft to either side of the inlet. 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.

The primary catalyst for change in Okaloosa County has been East Pass. Migration of the inlet likely occurred throughout its history (see Section 3.3), but in the decades since the inlet was initially cut in its present location and the time of jetty construction, the adjacent beaches have been significantly affected. As with many stabilized inlets, erosion has dominated the beach immediately downdrift (west) of East Pass and accretion has dominated updrift (east) of the inlet. The erosion has been severe, achieving averaged rates of -8.5 ft/yr, and is progressing westward over time. The magnitude of accretion east of the inlet has been moderate (no more than 2.5 ft/yr in recent years), consistent with the relatively short east jetty and growth of the inlet shoals. The growth of the inlet ebb shoals can be partially seen in DEP offshore profile data, and has been discussed by Morang, et al. (1996).

Figures 3 through show plan view shoreline comparisons for Okaloosa County. The horizontal and vertical scales and baseline orientations were chosen to emphasize beach width changes as well as relative shoreline orientation. One concern these maps (especially Figure 5) highlight is not only the erosion west of the inlet, but also the progression of this erosion. Within the next couple of decades, the erosion pattern is expected to progress beyond the undeveloped federal property and into the developed area between R-16 and R-1. One caveat is the fact that the 1996 survey shown in Figure 5 took place the year following Hurricane Opal and may amplify the present problem. The 1996 survey was only used to calculate rate estimates in the V-601 to V-619 zone west of the inlet. It was the only survey data available in that area since 1977-1978, and is very consistent with the prior erosion pattern and that expected from theory. Similar erosion patterns have been described theoretically and specifically for this and other Florida inlets (Foster, 1995). It is also noted that, while using Hurricane Opal influenced data may cause erosion estimates to be higher, the onshore and shallow nearshore disposal of dredged material from East Pass to the west of the inlet, and closure of the weir in the west jetty, would likely cause erosion estimates to be lower.

The shoreline east of the inlet is accretionary to stable, with averaged rates approaching +2.5 ft/yr at R-24 and tapering off to essentially zero between R-38 and

R-50. Because this area is updrift of East Pass, this stable trend will likely continue into the foreseeable future although not necessarily with the same rates.

The historically accretionary zone between R-1 and R-16, with averaged rates of 0.0 to +1.5 ft/yr, appears to be part of the shoreline smoothing process associated with the progressive erosion pattern working westwards from the inlet (Foster, 1995).

Throughout Okaloosa County, as in many Florida Panhandle counties, beach cusps are prevalent and persistent features. This large-scale rhythmic topography (Komar, 1976) occurs on the order of 20-150 feet in amplitude and up to several thousand feet in length, observed in the field to be related to nearshore bars merging back onto shore. Averaging does not remove all the effects of the frequently observed large-scale beach cusps. The effects can be seen in small/moderate irregularities in plan views and rate calculation results. Large-scale beach cusps have been observed by two of the authors (Foster and Spurgeon) on many other northwest Florida beaches.

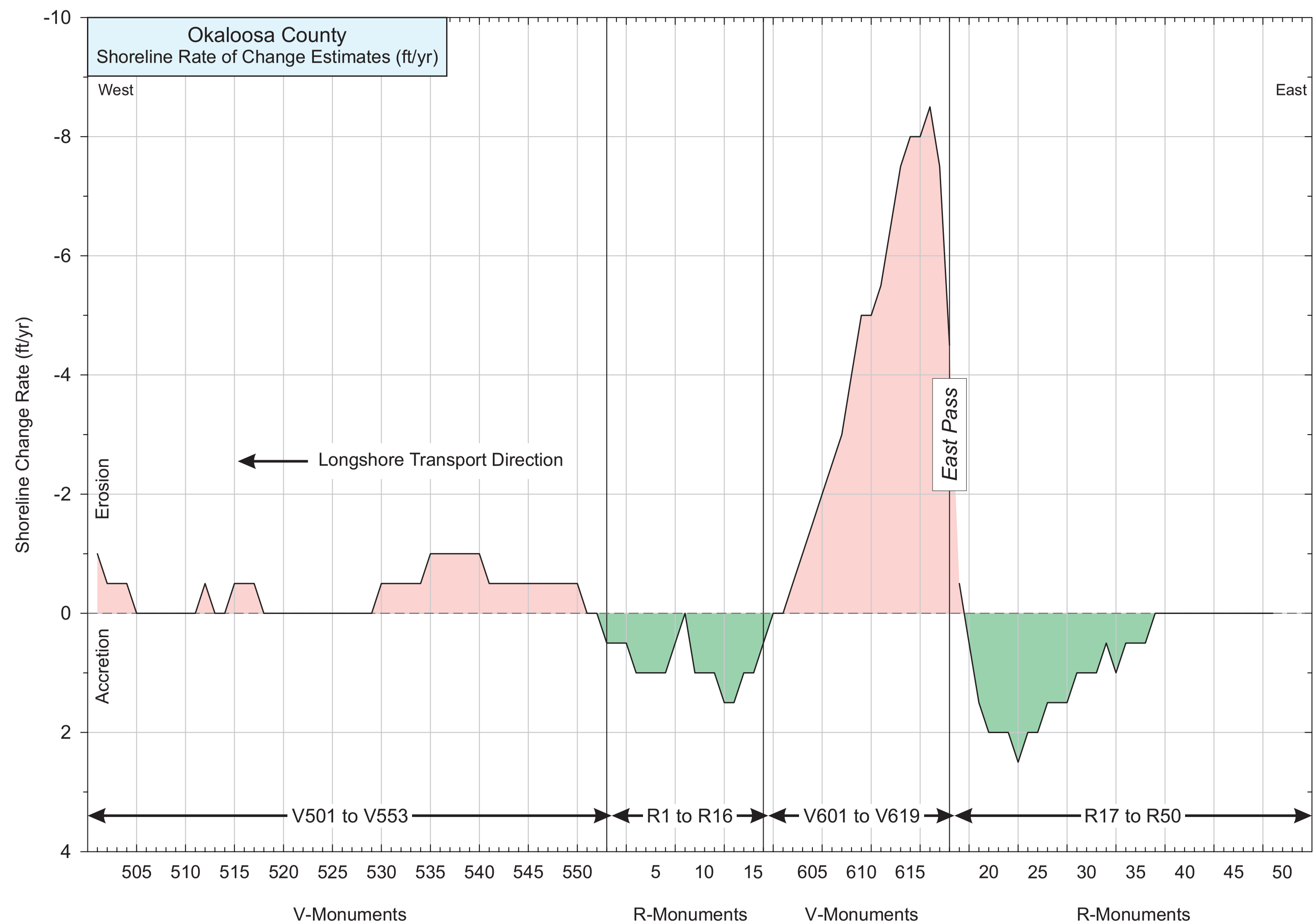

Figure 2. Shoreline change rate estimates for Okaloosa County, Florida.

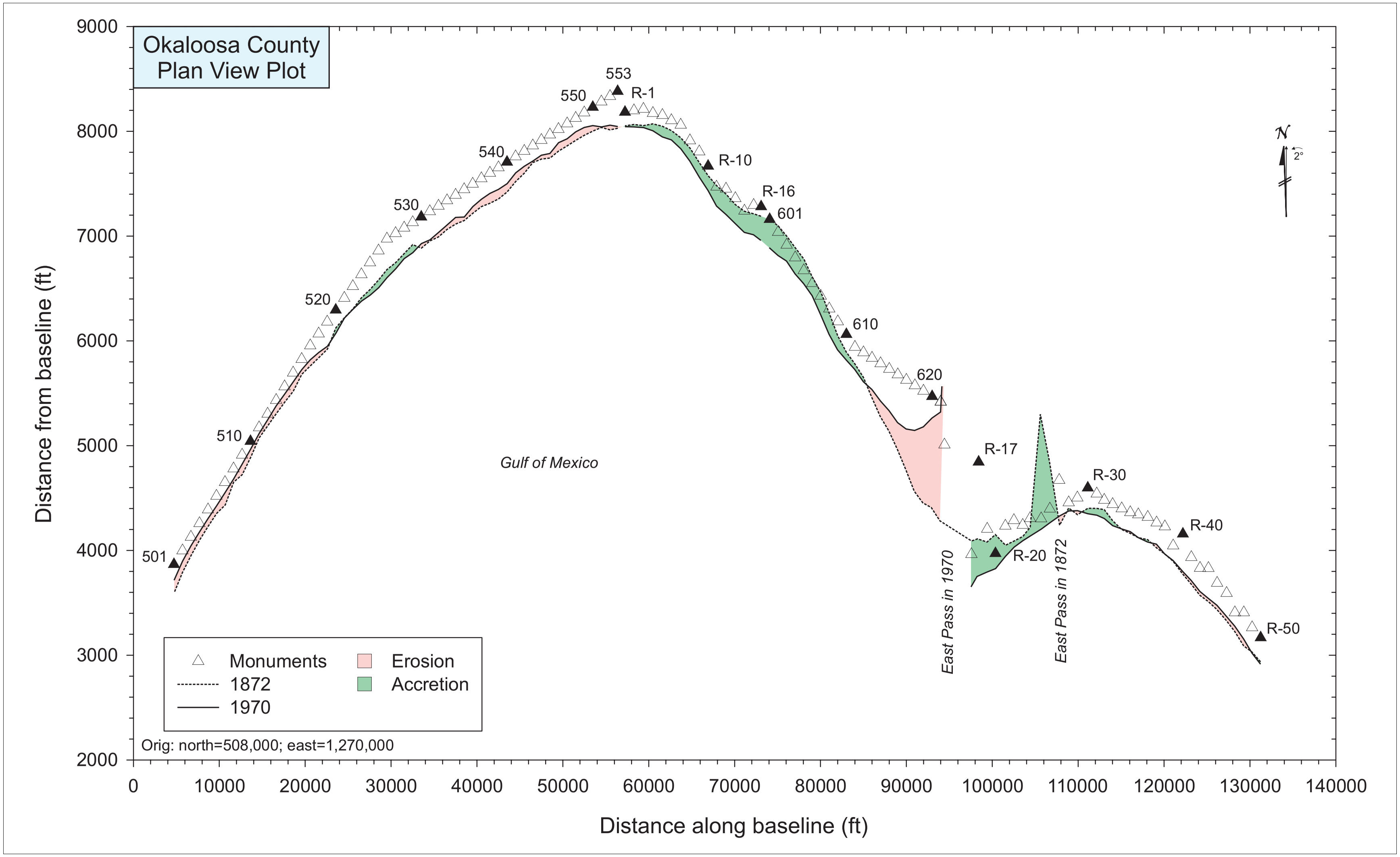

Figure 3. Plan view map of Okaloosa County, Florida, comparing years 1872 and 1970.

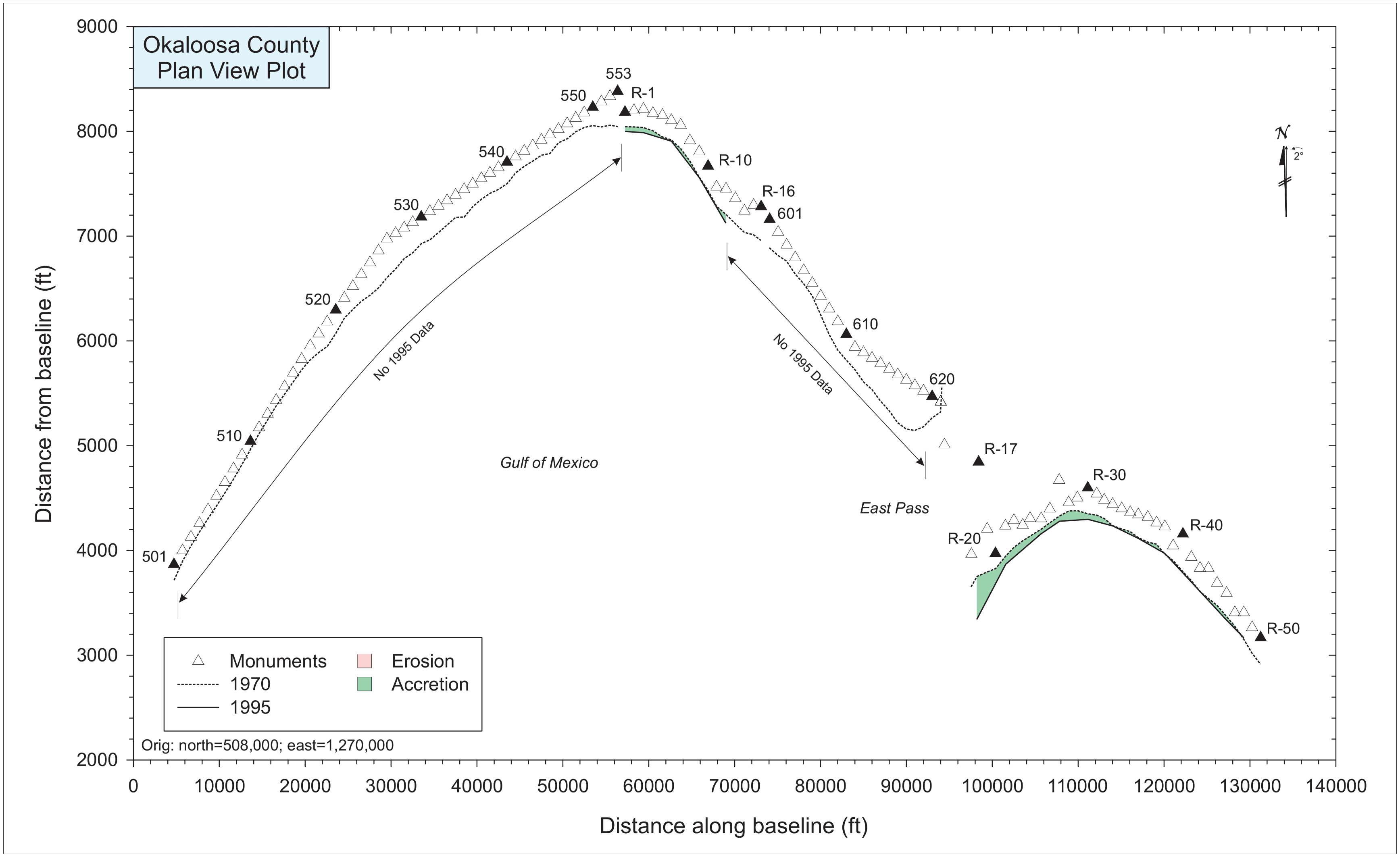

Figure 4. Plan view map of Okaloosa County, Florida, comparing years 1970 and 1995 (pre-Hurricane Opal).

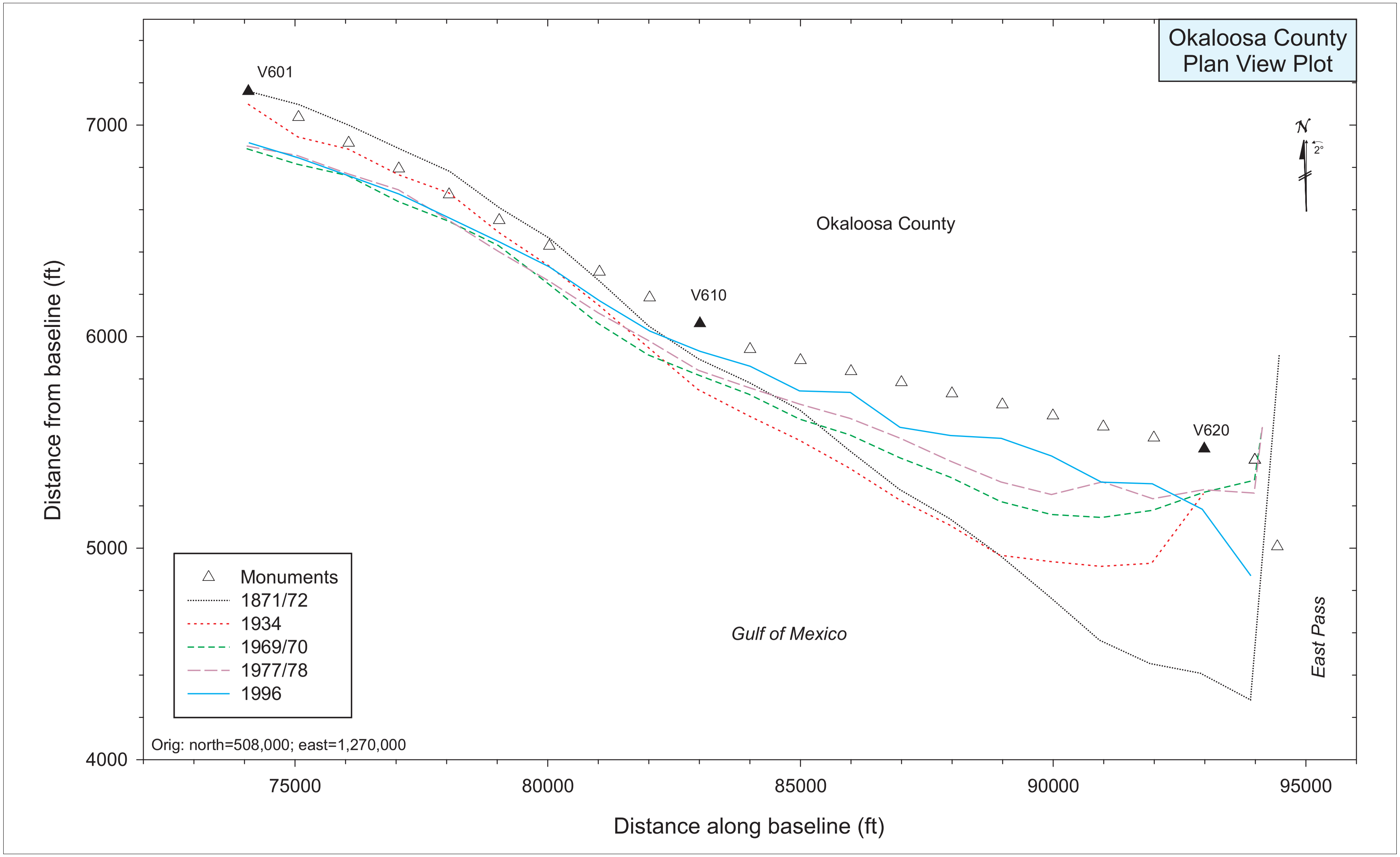

Figure 5. Plan view map of Okaloosa County, Florida, showing ranges V-601 to V-622.

6 SUMMARY AND CONCLUDING REMARKS

The stabilization of East Pass has led to the development of an erosional zone to the west of the inlet that extends for at least 20,000 ft. The averaged rate of this erosion is as high as -8.5 ft/yr. Although this length of shoreline is not under Florida DEP jurisdiction, we still must take note of the trend that strongly indicates that this erosion is progressing westward over time.

Within the Florida DEP jurisdictional areas (i.e., R monument areas), however, the shoreline may be considered relatively stable and in some cases accretional, but no more than a couple of feet per year. It is recommended, then, that a conservative minimum erosion rate estimate of -1 ft/yr be used for planning purposes within these R monument areas.

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8 APPENDICES

8.1 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 Okaloosa County, Florida.

Range	Time Span	Method			Concensus Average	Comments
		RA	LS	EP		
501	1871/72-1978/79	-1.2	-0.7	-0.7	-1.0	Federal Property
502	1871/72-1978/79	-0.4	-0.5	-0.4	-0.5	3 pt average
503	1871/72-1978/79	-0.4	-0.4	-0.4	-0.5	5 pt average
504	1871/72-1978/79	0.0	-0.2	0.0	-0.5	7 pt average ↓
505	1871/72-1978/79	0.0	-0.2	0.0	0.0	
506	1871/72-1978/79	-0.1	-0.1	-0.1	0.0	
507	1871/72-1978/79	-0.4	-0.6	-0.4	0.0	
508	1871/72-1978/79	0.1	0.3	0.5	0.0	
509	1871/72-1978/79	-0.7	-0.5	-0.5	0.0	
510	1871/72-1978/79	-0.2	-0.3	-0.2	0.0	
511	1871/72-1978/79	0.1	-0.1	0.1	0.0	
512	1871/72-1978/79	-0.3	-0.2	-0.3	-0.5	
513	1871/72-1978/79	-0.2	-0.2	-0.2	0.0	
514	1871/72-1978/79	-0.6	-0.4	-0.5	0.0	
515	1871/72-1978/79	-0.3	-0.4	-0.3	-0.5	
516	1871/72-1978/79	0.0	0.0	0.0	-0.5	
517	1871/72-1978/79	-0.2	-0.2	-0.2	-0.5	
518	1871/72-1978/79	-0.5	-0.3	-0.6	0.0	
519	1871/72-1978/79	0.0	-0.4	-1.0	0.0	
520	1871/72-1978/79	0.1	0.5	0.1	0.0	
521	1871/72-1978/79	-0.2	0.0	-0.2	0.0	
522	1871/72-1978/79	-0.4	-0.2	-0.4	0.0	
523	1871/72-1978/79	0.1	0.2	0.1	0.0	
524	1871/72-1978/79	0.1	0.3	0.1	0.0	
525	1871/72-1978/79	0.2	0.5	0.2	0.0	
526	1871/72-1978/79	0.3	0.5	0.3	0.0	
527	1871/72-1978/79	0.0	0.3	0.0	0.0	
528	1871/72-1978/79	0.1	0.3	0.1	0.0	
529	1871/72-1978/79	0.1	0.4	0.1	0.0	
530	1871/72-1978/79	-0.9	-0.6	-0.7	-0.5	
531	1871/72-1978/79	-0.4	-0.2	-0.4	-0.5	
532	1871/72-1978/79	-0.5	-0.4	-0.6	-0.5	
533	1871/72-1978/79	-1.0	-0.6	-0.8	-0.5	

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

Range	Time Span	Method			Concensus Average	Comments
		RA	LS	EP		
534	1871/72-1978/79	-0.9	-0.8	-1.0	-0.5	
535	1871/72-1978/79	-0.7	-0.7	-1.0	-1.0	
536	1871/72-1978/79	-1.1	-0.6	-0.7	-1.0	
537	1871/72-1978/79	-1.4	-0.6	-0.7	-1.0	
538	1871/72-1978/79	-0.4	-1.0	-1.2	-1.0	
539	1871/72-1978/79	-1.7	-0.8	-0.8	-1.0	
540	1871/72-1978/79	-1.4	-0.7	-0.8	-1.0	
541	1871/72-1978/79	-0.7	-0.6	-0.5	-0.5	
542	1871/72-1978/79	-1.1	-0.7	-0.8	-0.5	
543	1871/72-1978/79	-0.1	-0.1	-0.1	-0.5	
544	1871/72-1978/79	-0.4	-0.4	-0.5	-0.5	
545	1871/72-1978/79	-0.5	-0.5	-0.6	-0.5	
546	1871/72-1978/79	-0.4	-0.5	-0.4	-0.5	
547	1871/72-1978/79	-1.0	-0.7	-0.8	-0.5	
548	1871/72-1978/79	-0.4	-0.5	-0.4	-0.5	
549	1871/72-1977/78	-0.6	-0.5	-0.5	-0.5	
550	1871/72-1977/78	-0.2	-0.3	-0.2	-0.5	
551	1871/72-1977/78	0.2	0.1	0.2	0.0	
552	1871/72-1977/78	0.0	-0.1	0.0	0.0	↑ Federal Property
553	1871/72-1977/78	-0.2	-0.1	-0.2	0.5	
1	1871/72-1995	0.3	0.6	0.4	0.5	Developed Area ↓
2	1871/72-1989	0.2	0.4	0.4	0.5	
3	1969/70-1995	2.4	2.5	1.9	1.0	
4	1969/70-1989	2.8	2.3	1.2	1.0	
5	1969/70-1989	-0.7	-0.7	-1.2	1.0	
6	1969/70-1995	0.5	2.4	0.5	1.0	
7	1969/70-1989	0.7	1.6	0.7	0.5	
8	1969/70-1989	0.8	0.2	-1.0	0.0	
9	1969/70-1995	0.3	2.8	0.3	1.0	
10	1969/70-1989	-0.5	0.9	-0.5	1.0	
11	1969/70-1989	0.2	-1.0	-1.4	1.0	
12	1969/70-1995	4.6	3.8	3.3	1.5	
13	1969/70-1989	1.5	1.5	2.2	1.5	

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

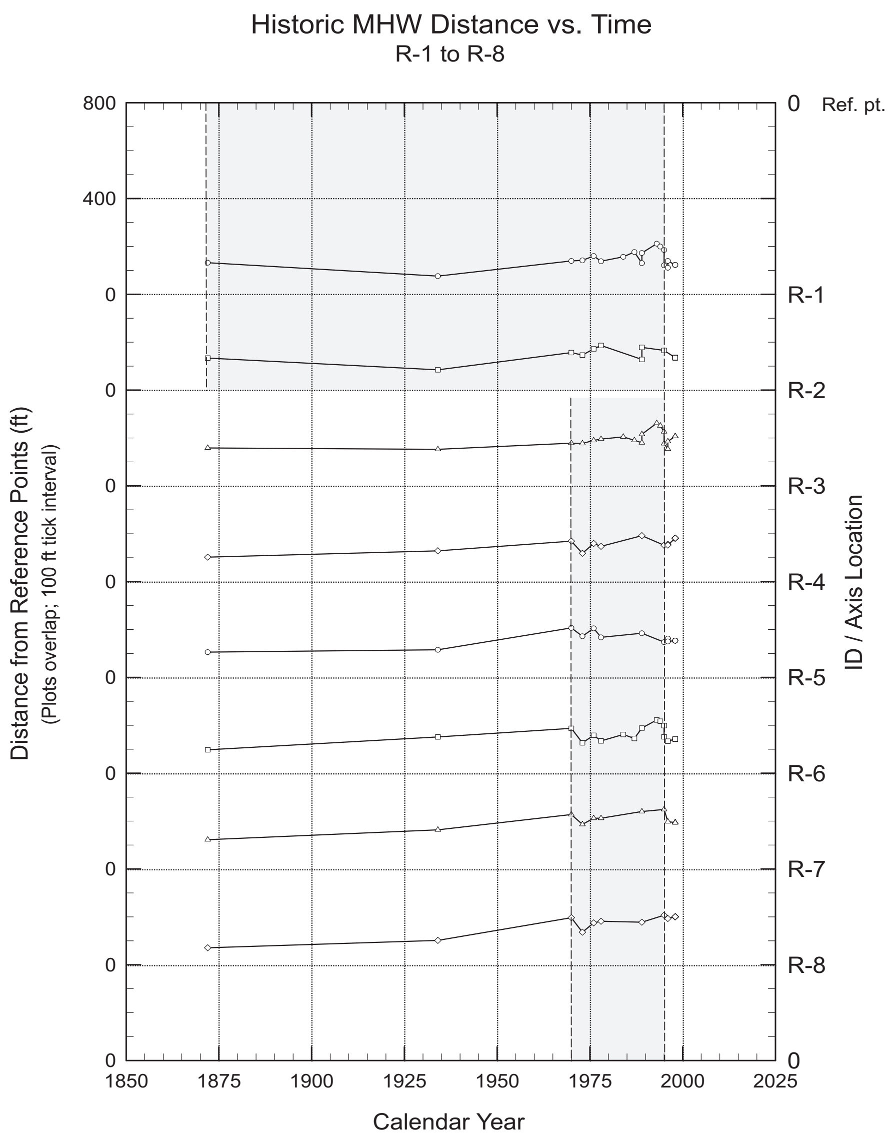
Range	Time Span	Method			Concensus Average	Comments
		RA	LS	EP		
14	1969/70-1989	-0.2	0.2	-0.2	1.0	
15	1969/70-1994	4.2	3.6	3.0	1.0	↑ Developed
16	1969/70-1989	0.7	2.6	0.7	0.5	Area
601	1969/70-1996	-1.1	-1.1	-1.1	0.0	Federal Property
602	1969/70-1996	-1.2	-0.9	-1.2	0.0	↓
603	1969/70-1996	0.0	0.1	0.0	-0.5	
604	1969/70-1996	-1.4	-1.0	-1.4	-1.0	
605	1969/70-1996	-0.6	-0.6	-0.6	-1.5	
606	1969/70-1996	-0.7	-1.0	-0.7	-2.0	
607	1969/70-1996	-3.4	-3.2	-3.1	-2.5	
608	1969/70-1996	-3.7	-4.0	-4.2	-3.0	
609	1969/70-1996	-3.5	-4.1	-4.4	-4.0	
610	1969/70-1996	-4.7	-4.5	-4.4	-5.0	
611	1969/70-1996	-5.4	-5.2	-5.1	-5.0	
612	1969/70-1996	-4.3	-4.8	-5.1	-5.5	
613	1969/70-1996	-8.1	-7.6	-7.7	-6.5	
614	1969/70-1996	-6.7	-5.1	-5.5	-7.5	
615	1969/70-1996	-7.9	-7.4	-7.6	-8.0	↑
616	1969/70-1996	-11.5	-11.5	-11.5	-8.0	7 pt average
617	1969/70-1996	-10.8	-10.5	-10.6	-8.5	5 pt average
618	1969/70-1996	-9.1	-5.3	-6.4	-7.5	3 pt average
619	1969/70-1996	-4.3	-4.6	-4.8	-4.5	Federal Property
East Pass						
17	1976-1990	0.5	-2.6	0.5	-0.5	Developed Area
18	1976-1995	-0.1	1.0	4.0	0.5	3 pt average
19	1976-1989	0.8	0.3	0.8	1.5	5 pt average
20	1976-1990	2.4	3.3	5.4	2.0	7 pt average
21	1976-1995	2.8	1.4	1.4	2.0	↓
23	1976-1990	1.4	2.0	3.4	2.0	
24	1976-1990	3.0	2.4	5.4	2.5	
25	1976-1995	-0.4	-0.2	-0.4	2.0	
26	1976-1990	2.0	1.7	6.5	2.0	
27	1976-1995	3.6	1.0	1.1	1.5	

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

Range	Time Span	Method			Concensus Average	Comments
		RA	LS	EP		
28	1976-1990	0.3	-2.8	3.0	1.5	
29	1976-1990	0.1	-0.2	4.2	1.5	
30	1976-1995	0.3	0.3	0.3	1.0	
31	1976-1990	2.7	1.5	2.2	1.0	
32	1976-1990	1.3	-0.4	2.2	1.0	
33	1976-1995	-0.1	-0.1	-0.1	0.5	
34	1976-1990	2.1	2.5	3.6	1.0	
35	1976-1990	-1.1	-1.4	-1.1	0.5	
36	1871/72-1995	0.1	0.4	0.1	0.5	
37	1871/72-1990	0.6	0.6	0.6	0.5	
38	1871/72-1990	-0.1	0.1	0.3	0.0	
39	1871/72-1995	0.0	0.4	0.0	0.0	
40	1871/72-1990	0.1	0.2	0.1	0.0	
41	1871/72-1995	-0.1	0.1	-0.1	0.0	
42	1871/72-1993	0.0	0.2	0.4	0.0	
43	1871/72-1994	0.1	0.0	0.1	0.0	
44	1871/72-1990	0.0	0.1	0.0	0.0	
45	1871/72-1990	0.0	0.2	0.3	0.0	
46	1871/72-1995	-0.1	0.3	-0.1	0.0	↑
47	1871/72-1990	-0.2	-0.1	-0.2	0.0	7 pt average
48	1871/72-1995	-0.1	-0.2	-0.6	0.0	5 pt average
49	1871/72-1990	-0.1	-0.2	-0.1	0.0	3 pt average
50	1871/72-1990	0.1	-0.1	0.1	0.0	1 pt average

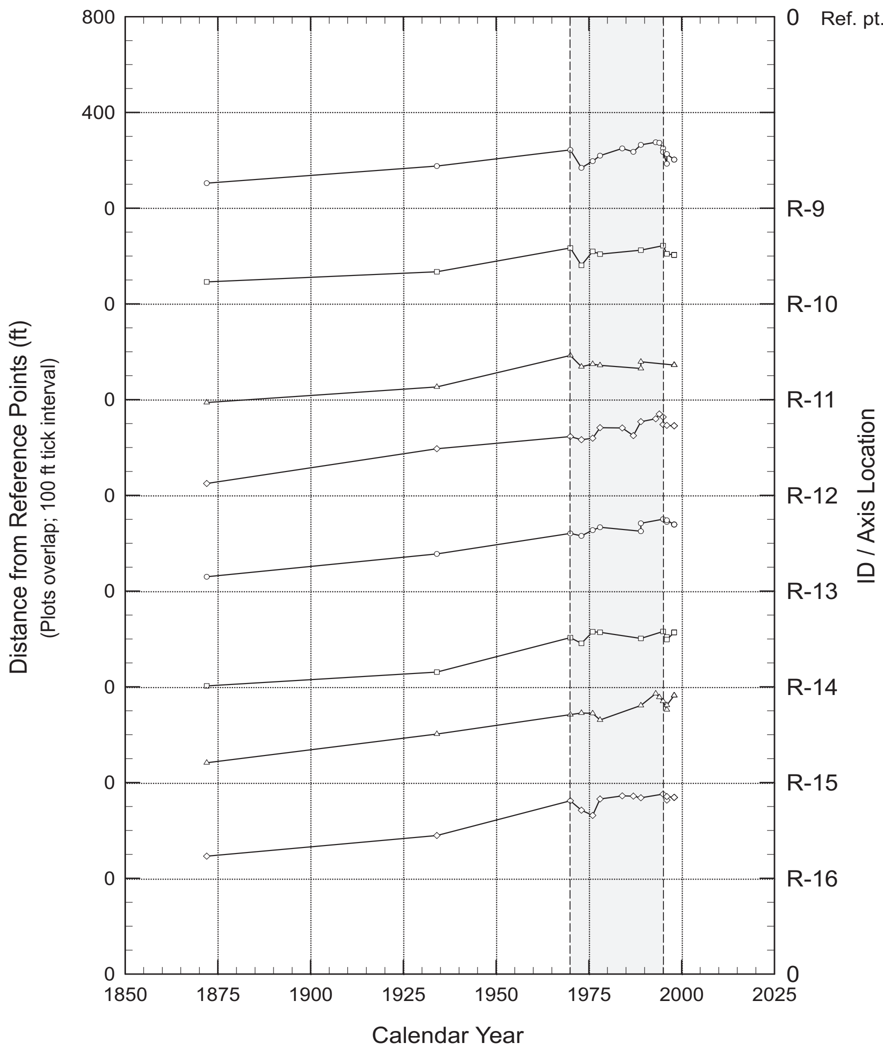
8.2 Appendix B: Stack Plots

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

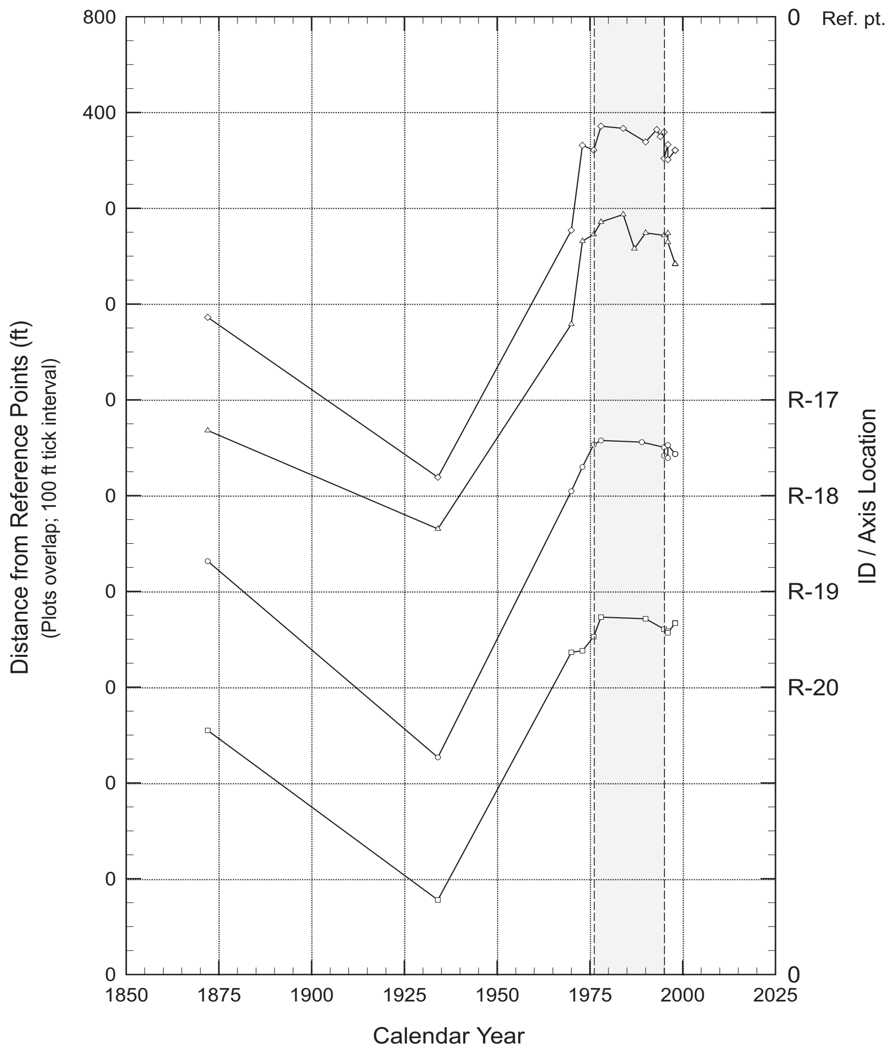


Historic MHW Distance vs. Time
R-1 to R-8
800
400
0
0
0
0
0
0
0
0
0
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
0 Ref. pt.
R-1
R-2
R-3
R-4
R-5
R-6
R-7
R-8
0
ID / Axis Location
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year

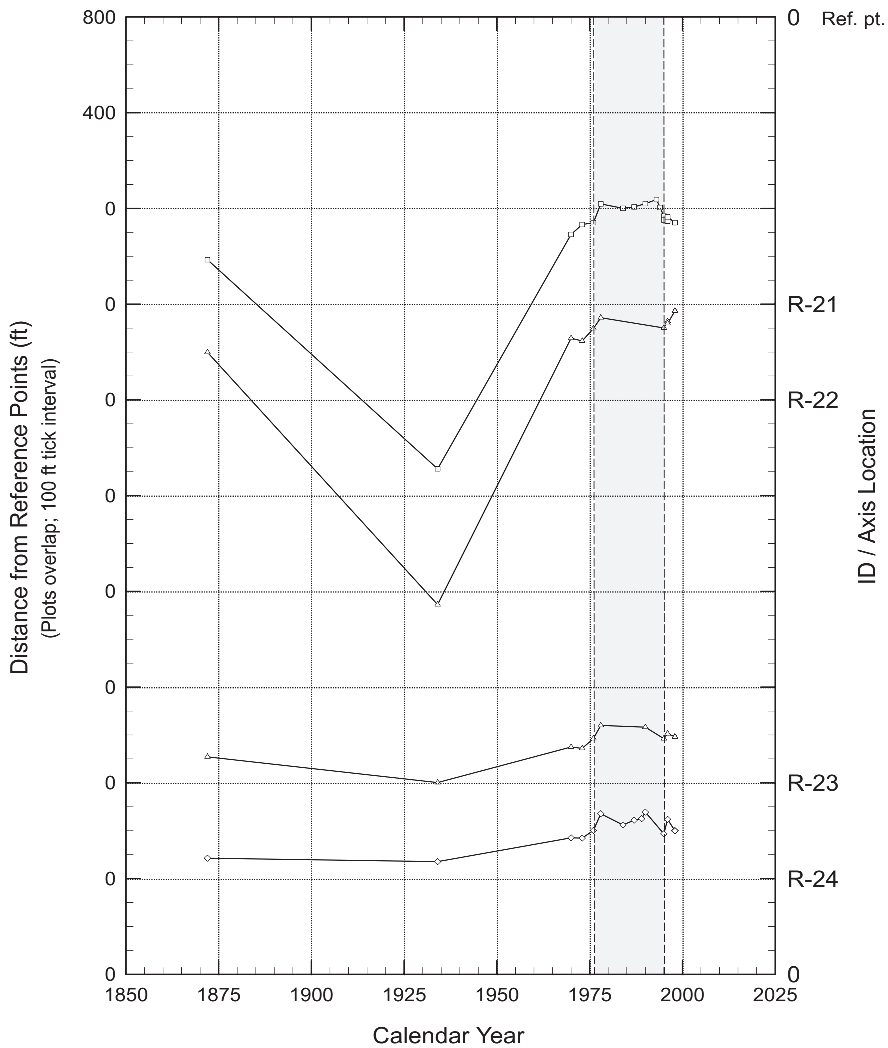
Historic MHW Distance vs. Time
R-9 to R-16



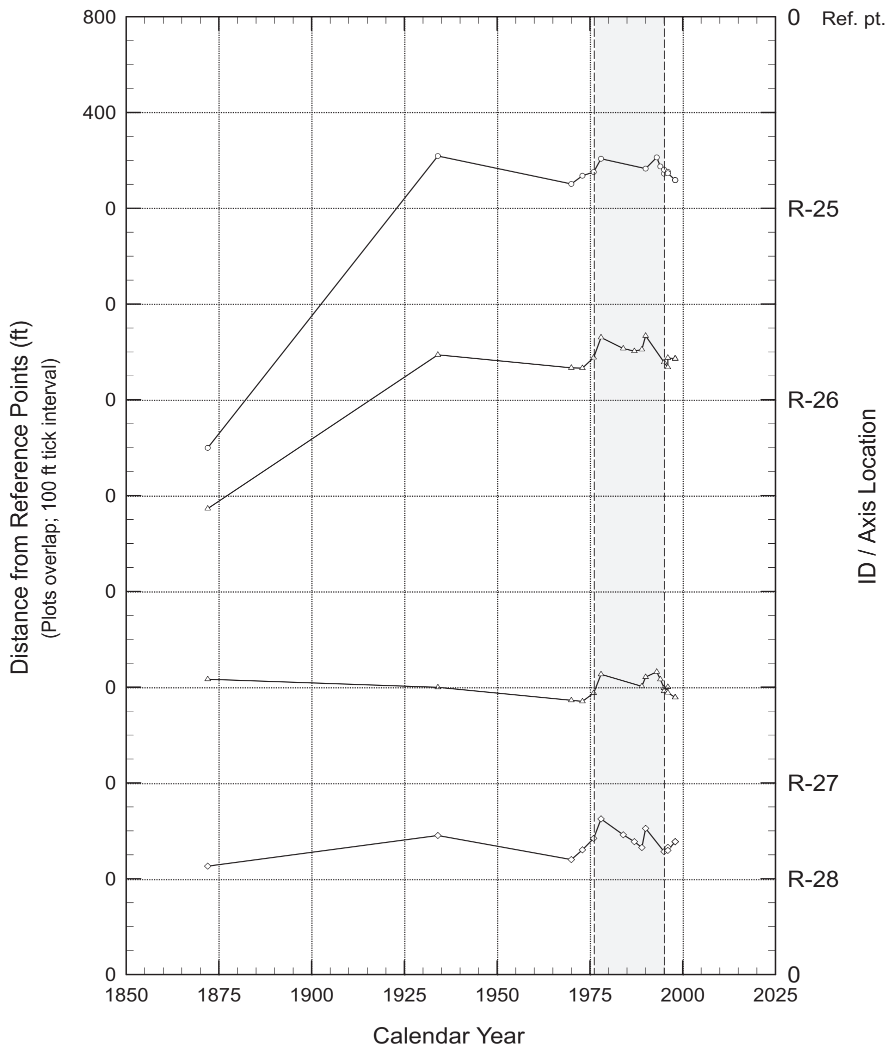
Historic MHW Distance vs. Time
R-17 to R-20

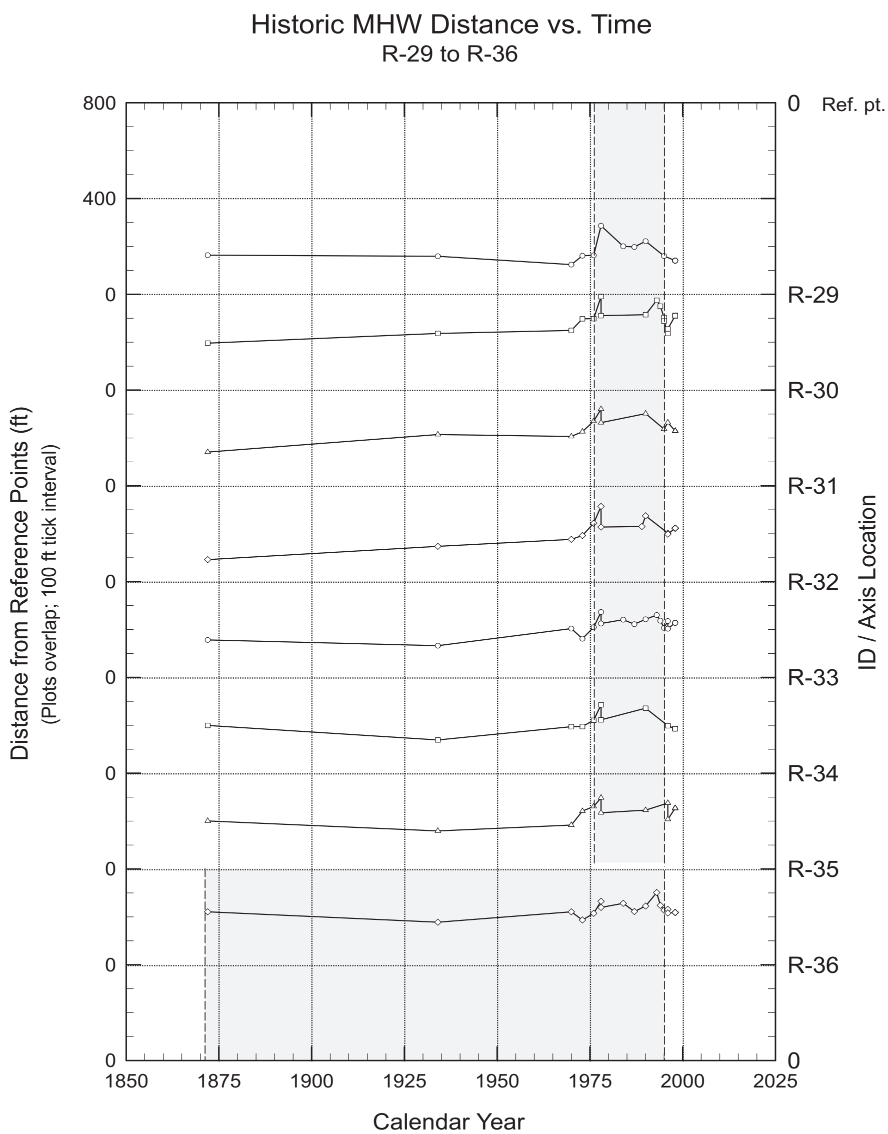


Historic MHW Distance vs. Time
R-21 to R-24

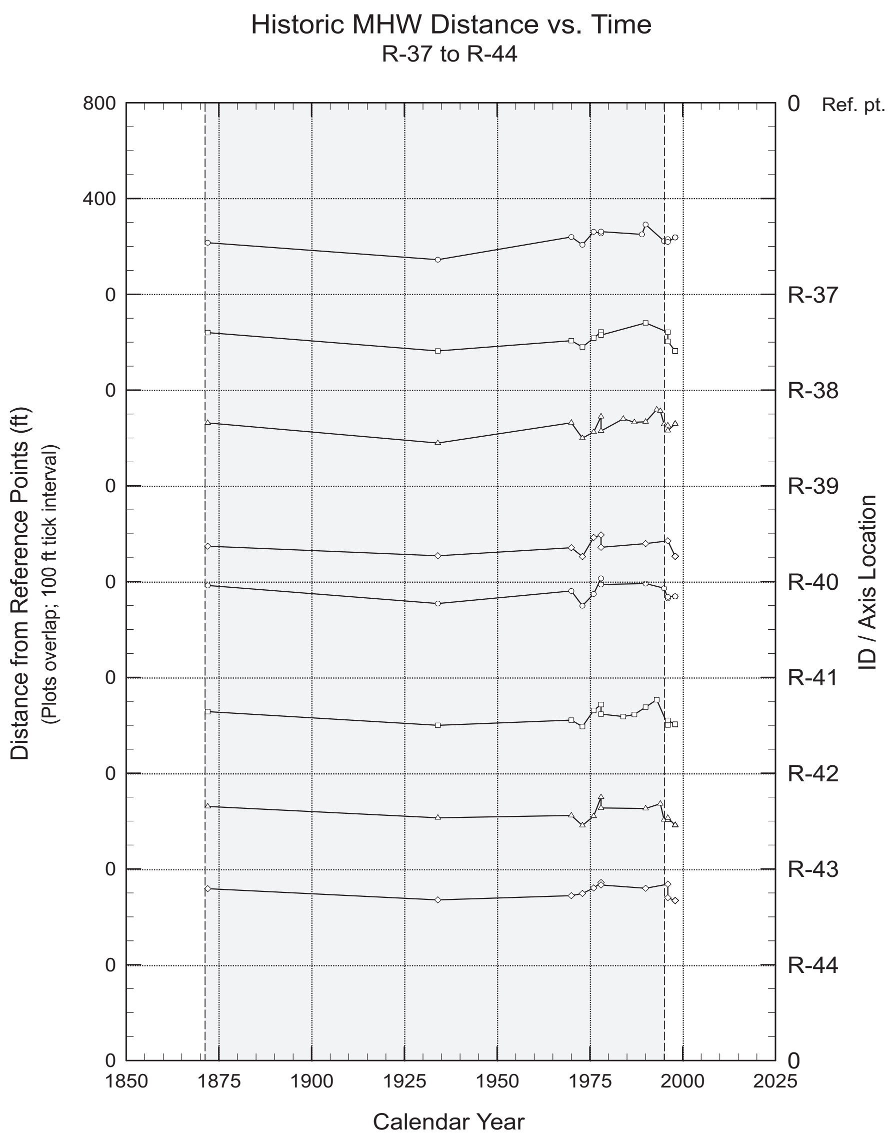


Historic MHW Distance vs. Time
R-25 to R-28

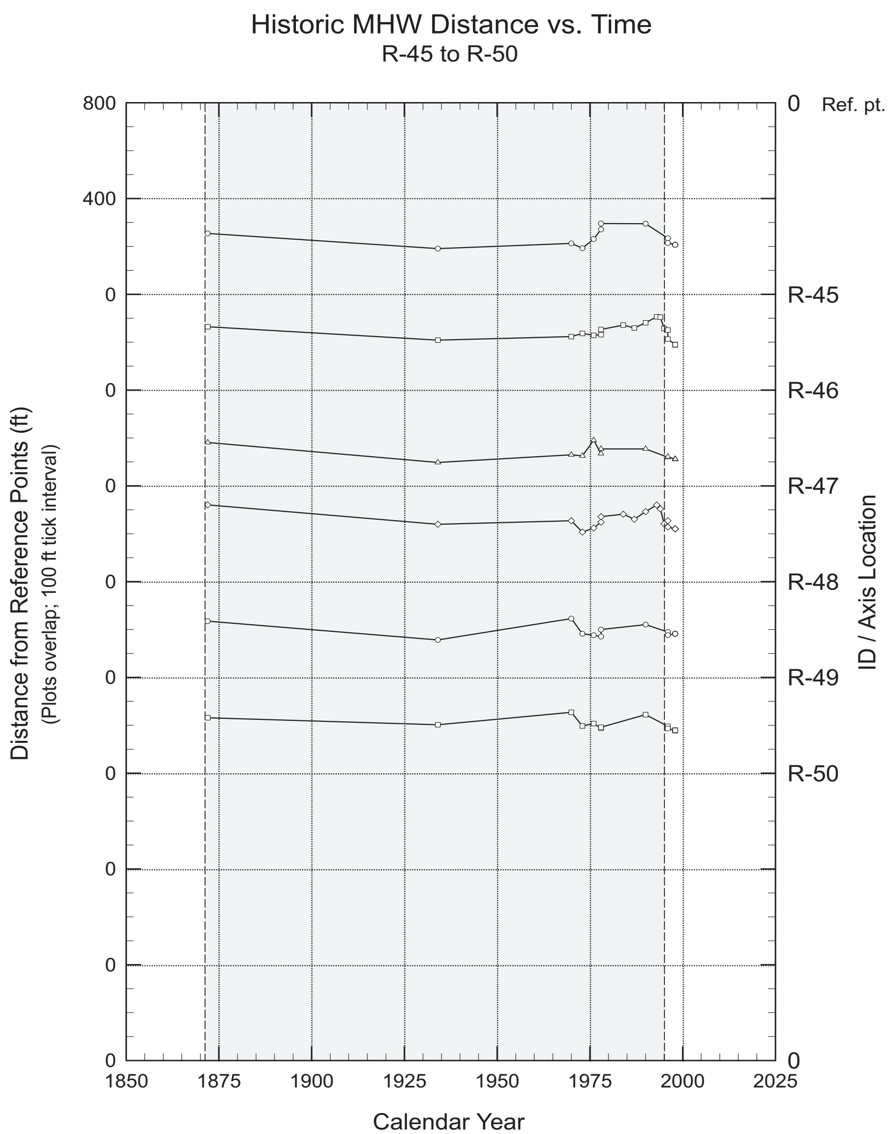




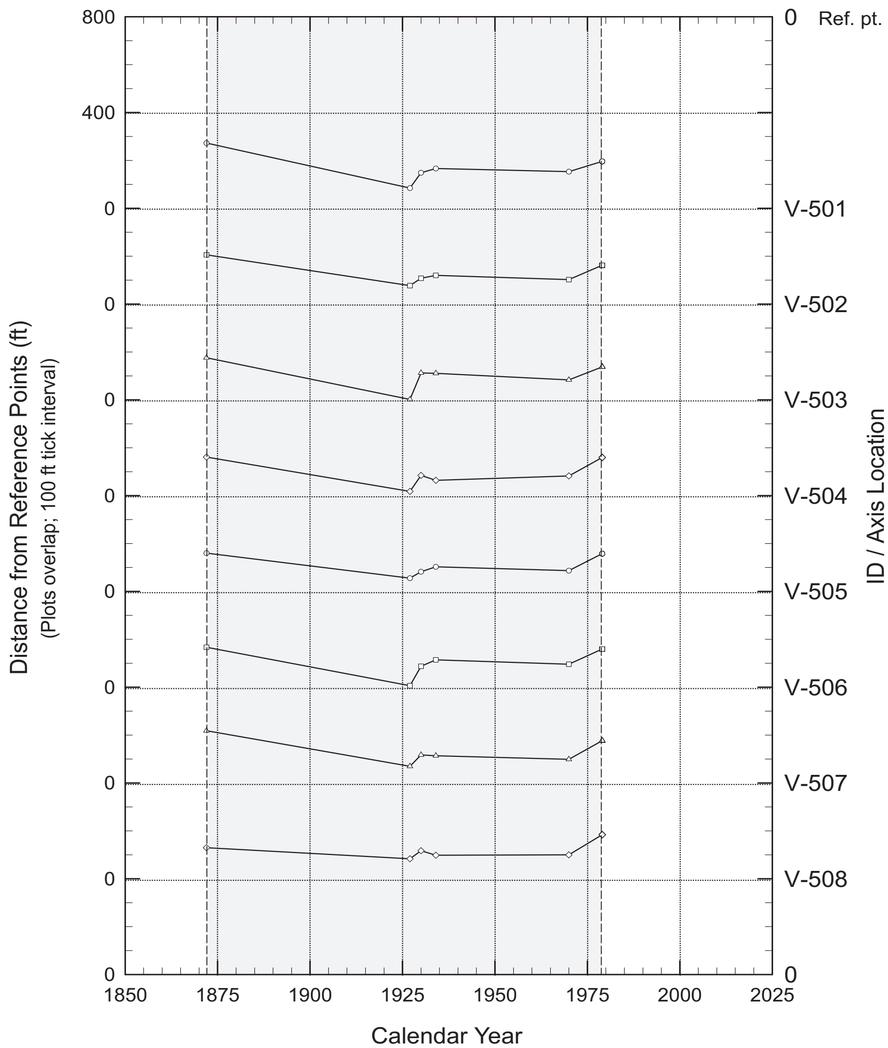
Historic MHW Distance vs. Time
R-29 to R-36
800
400
0
0
0
0
0
0
0
0
0
0 Ref. pt.
R-29
R-30
R-31
R-32
R-33
R-34
R-35
R-36
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
ID / Axis Location

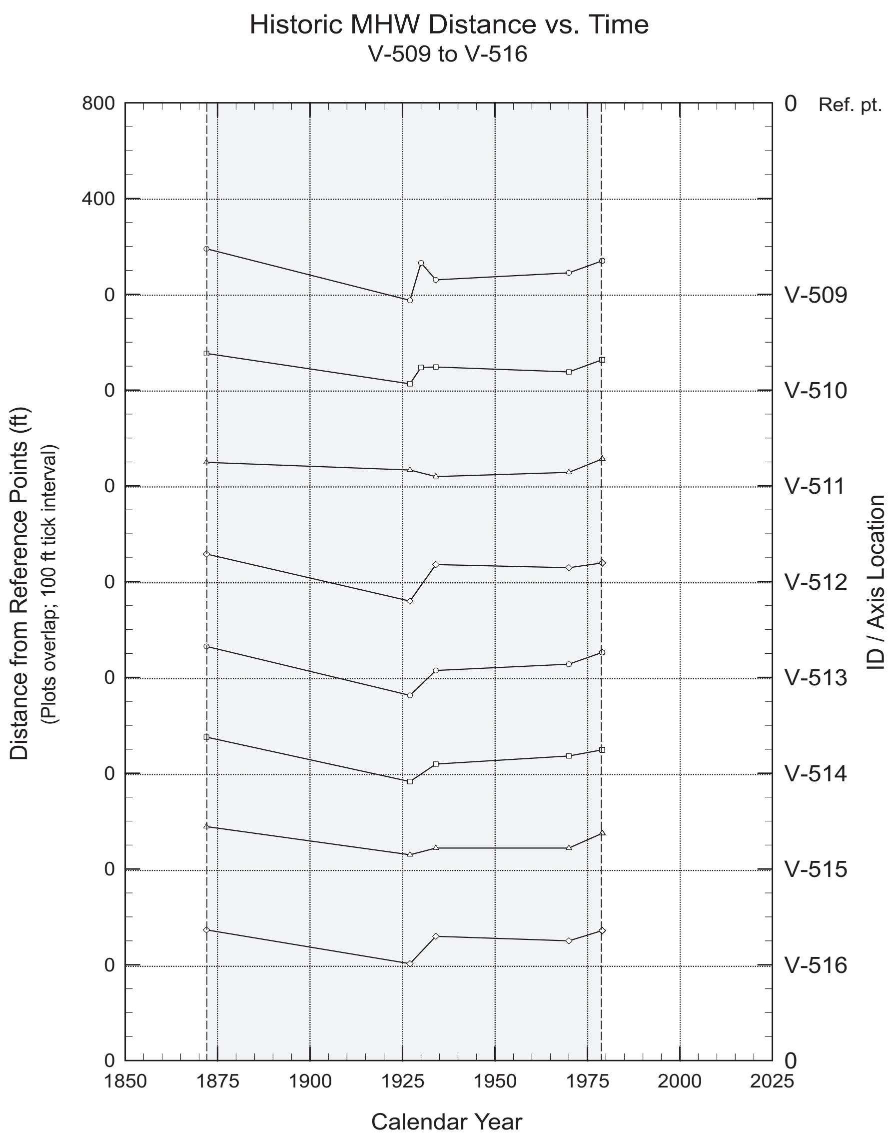


Historic MHW Distance vs. Time
R-37 to R-44
800
400
0
0
0
0
0
0
0
0
0
0
Ref. pt.
R-37
R-38
R-39
R-40
R-41
R-42
R-43
R-44
0
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
ID / Axis Location
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year

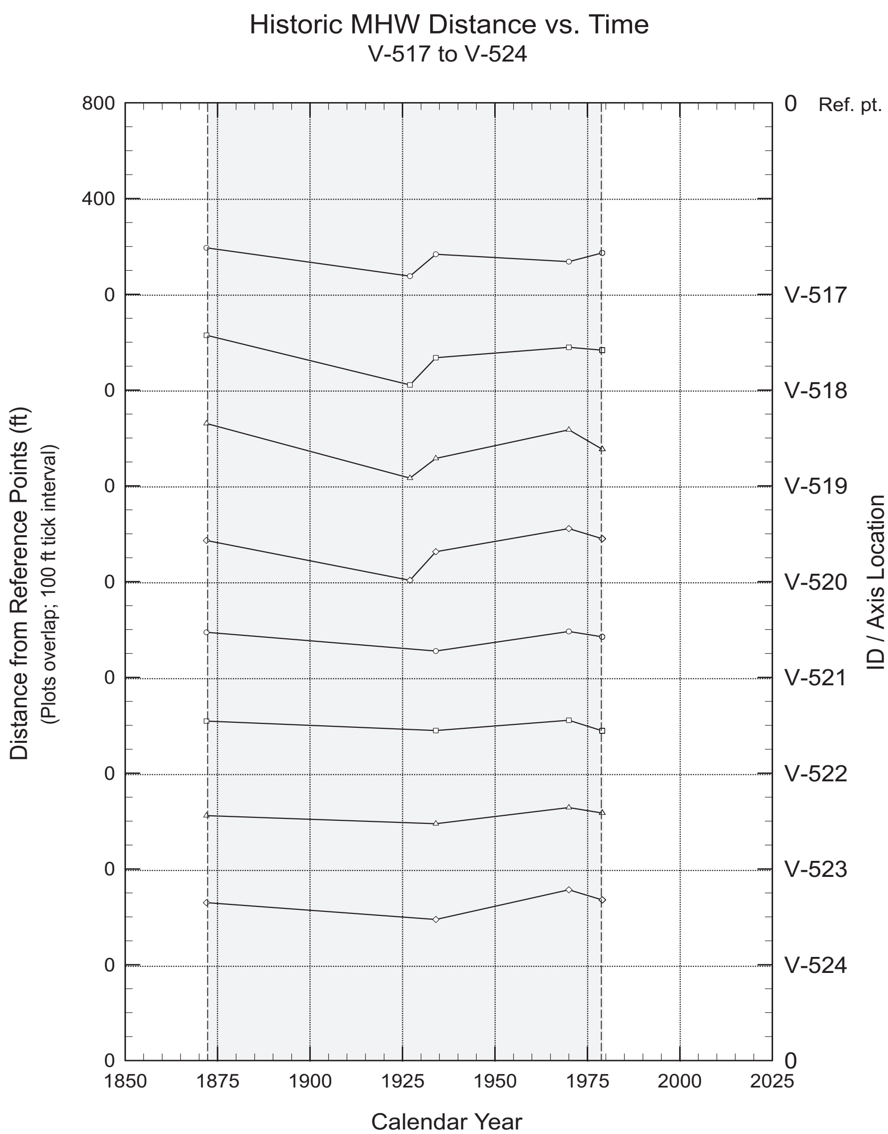

Historic MHW Distance vs. Time
R-45 to R-50
800
400
0
0
0
0
0
0
0
0
0
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
0 Ref. pt.
R-45
R-46
R-47
R-48
R-49
R-50
0
ID / Axis Location
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year

Historic MHW Distance vs. Time
V-501 to V-508

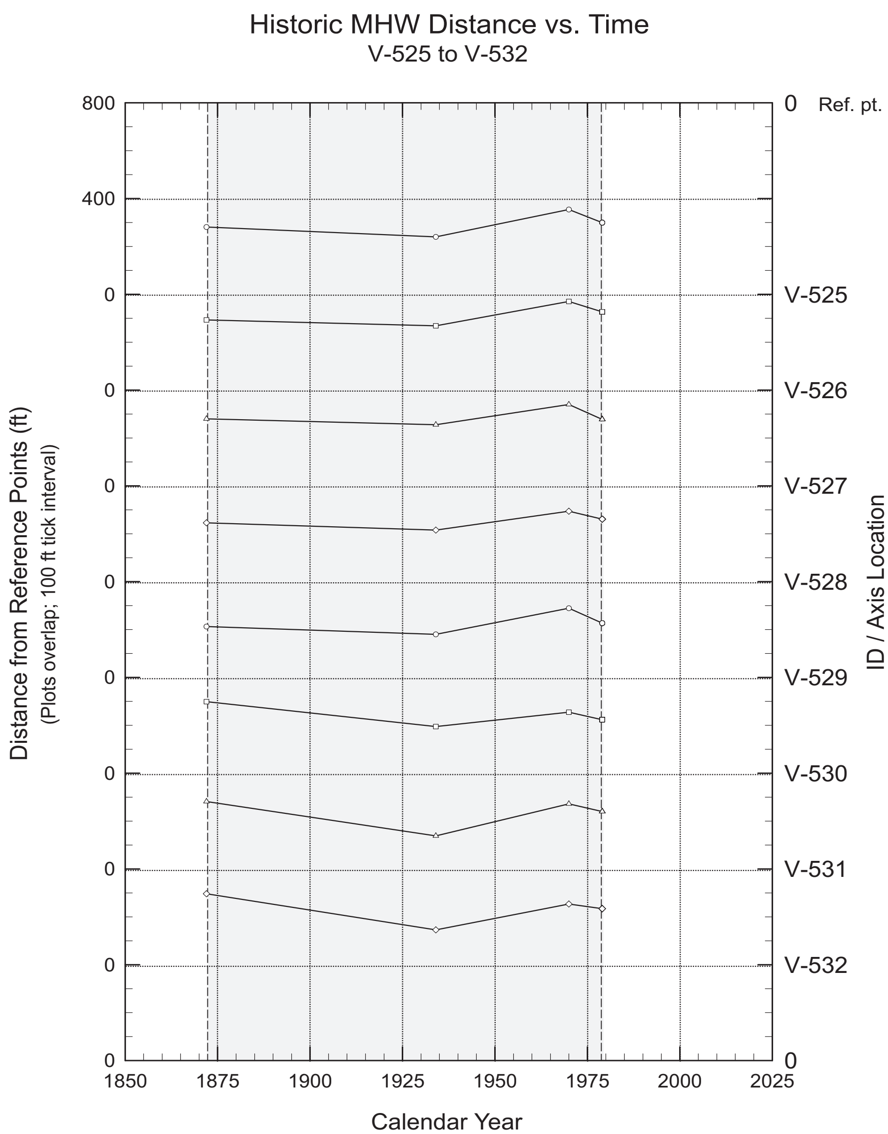




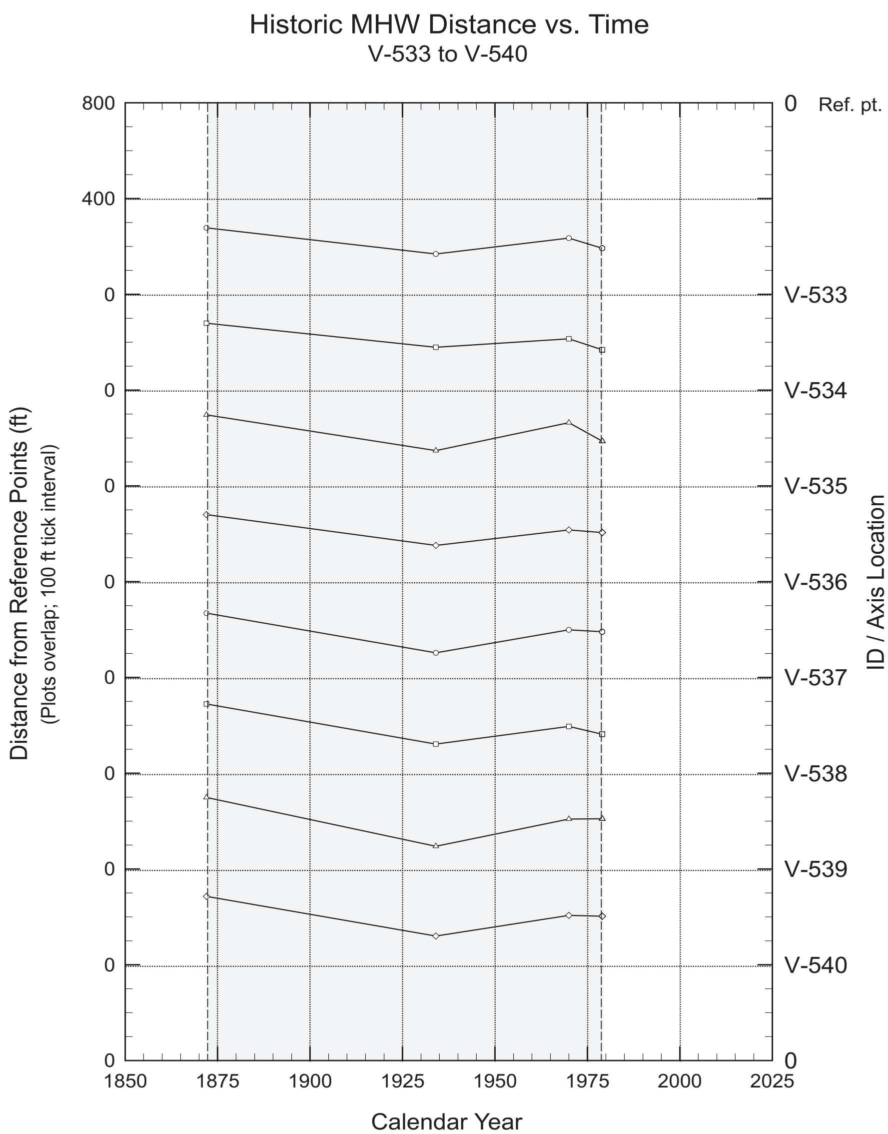
Historic MHW Distance vs. Time
V-509 to V-516
800
400
0
0
0
0
0
0
0
0
0
Ref. pt.
V-509
V-510
V-511
V-512
V-513
V-514
V-515
V-516
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
ID / Axis Location

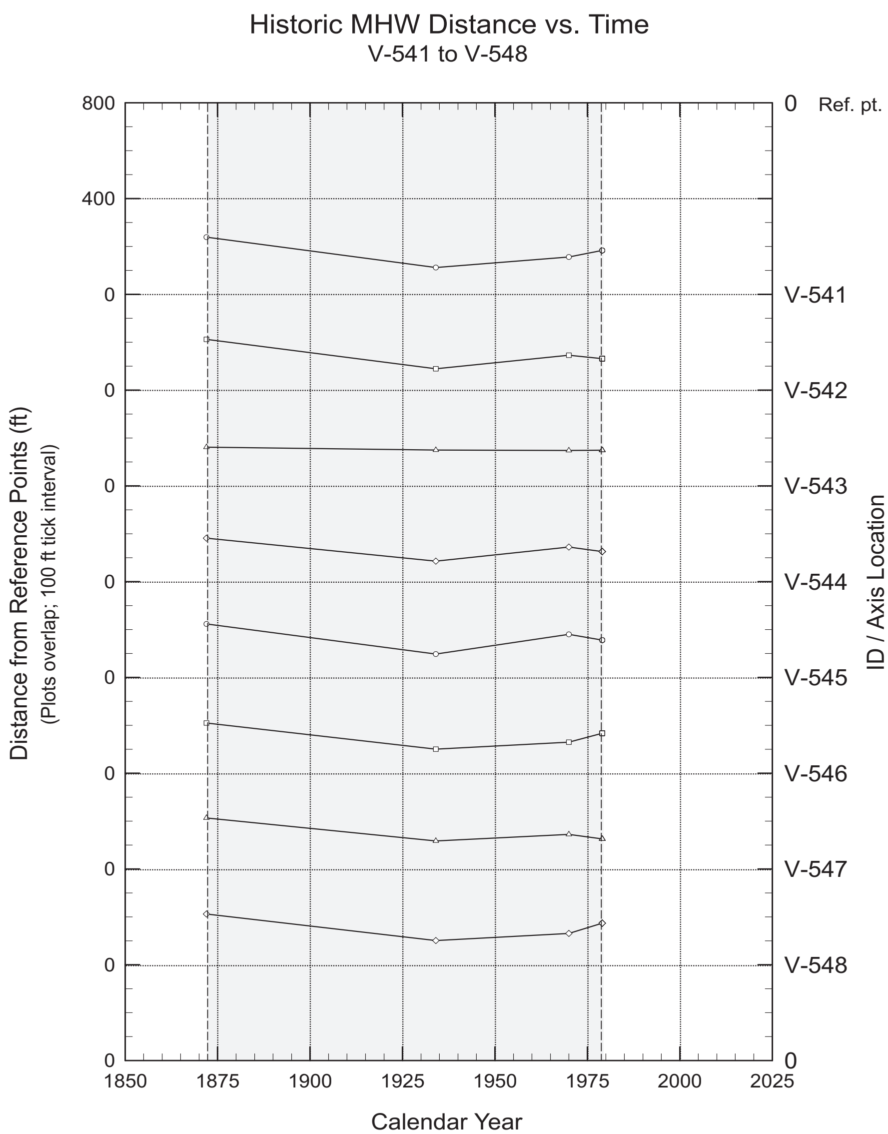


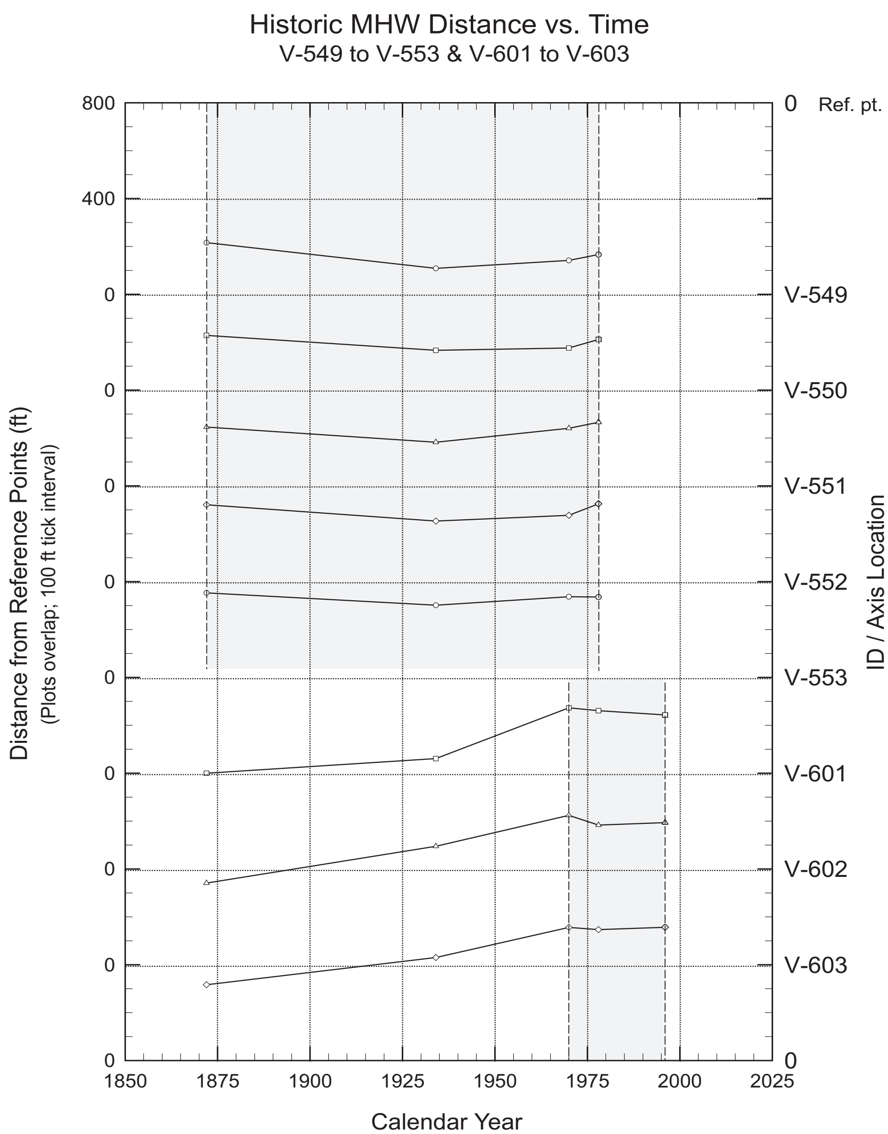
Historic MHW Distance vs. Time
V-517 to V-524
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
ID / Axis Location
Ref. pt.
800
400
0
V-517
V-518
V-519
V-520
V-521
V-522
V-523
V-524
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year

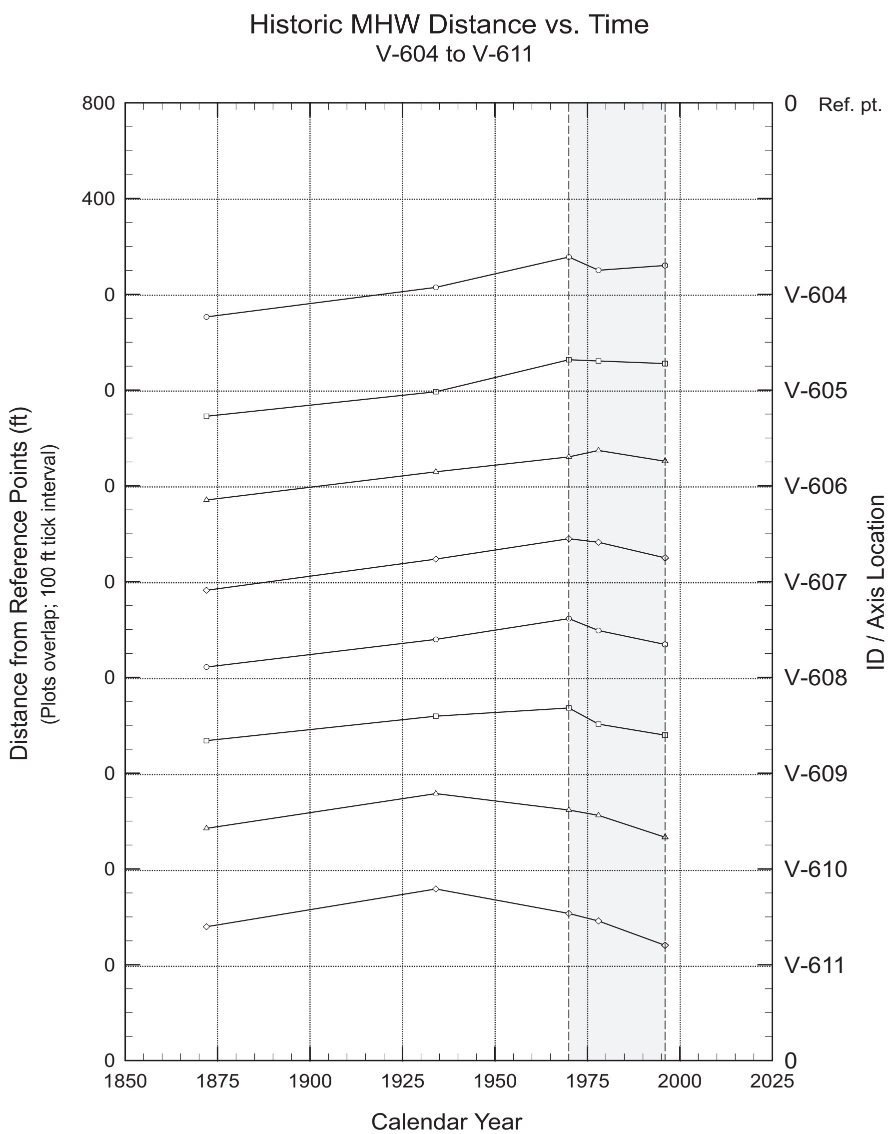


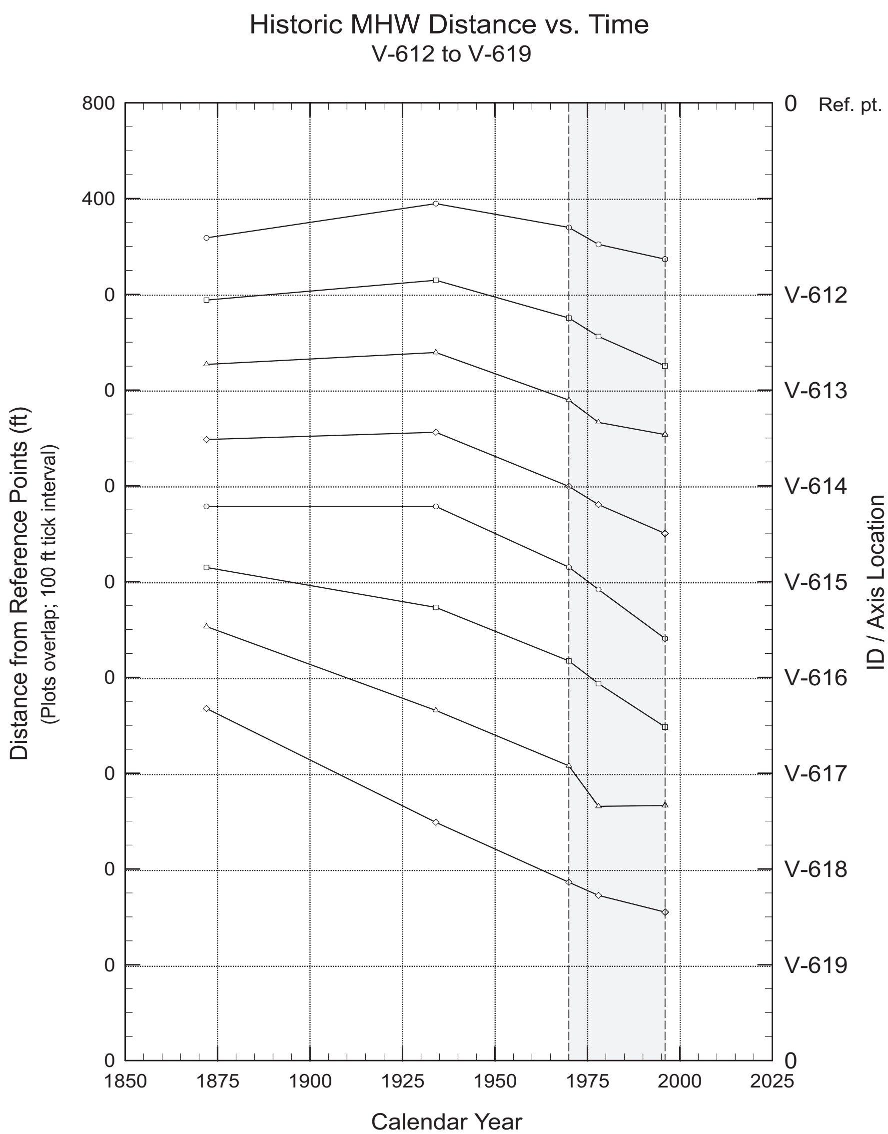
Historic MHW Distance vs. Time
V-525 to V-532
800
400
0
0
0
0
0
0
0
0
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
0
Ref. pt.
V-525
V-526
V-527
V-528
V-529
V-530
V-531
V-532
0
ID / Axis Location

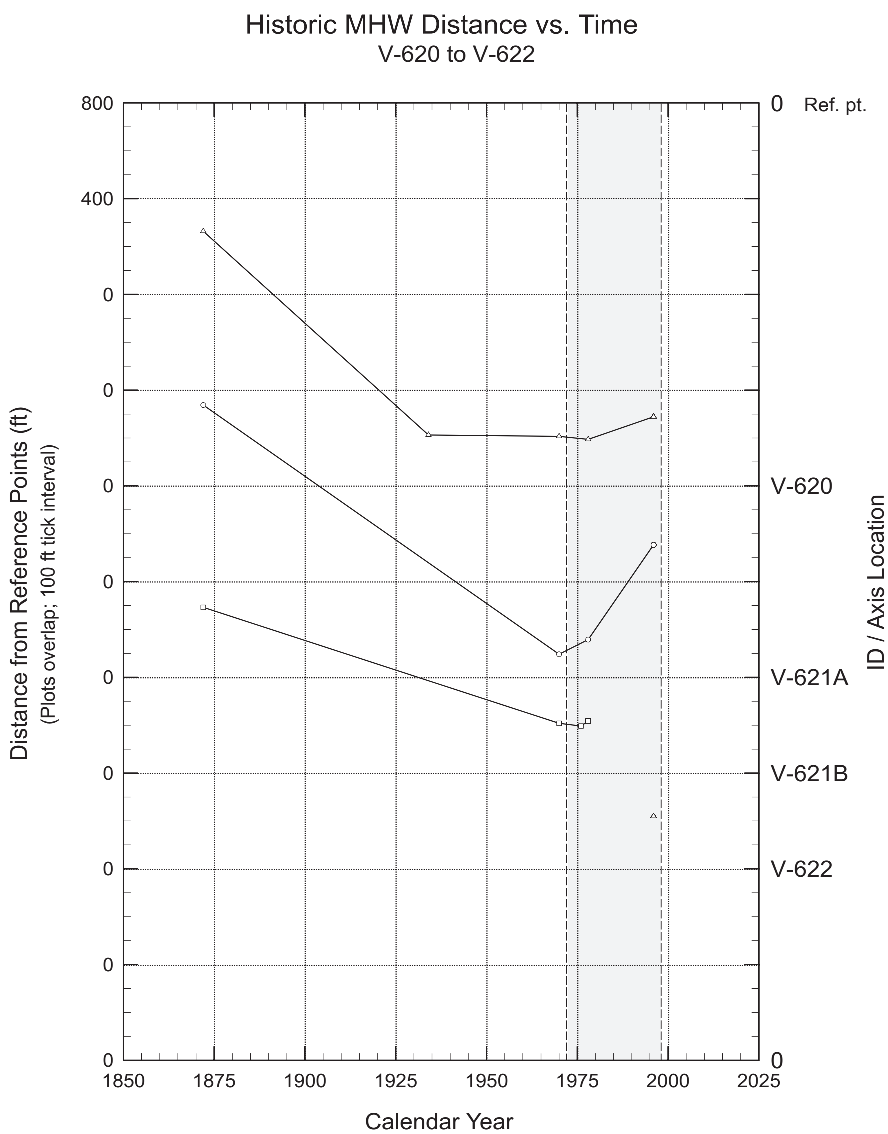

Historic MHW Distance vs. Time
V-533 to V-540
800
400
0
Ref. pt.
V-533
V-534
V-535
V-536
V-537
V-538
V-539
V-540
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
ID / Axis Location
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year


Historic MHW Distance vs. Time
V-541 to V-548
800
400
0
0
0
0
0
0
0
0
0
0 Ref. pt.
V-541
V-542
V-543
V-544
V-545
V-546
V-547
V-548
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

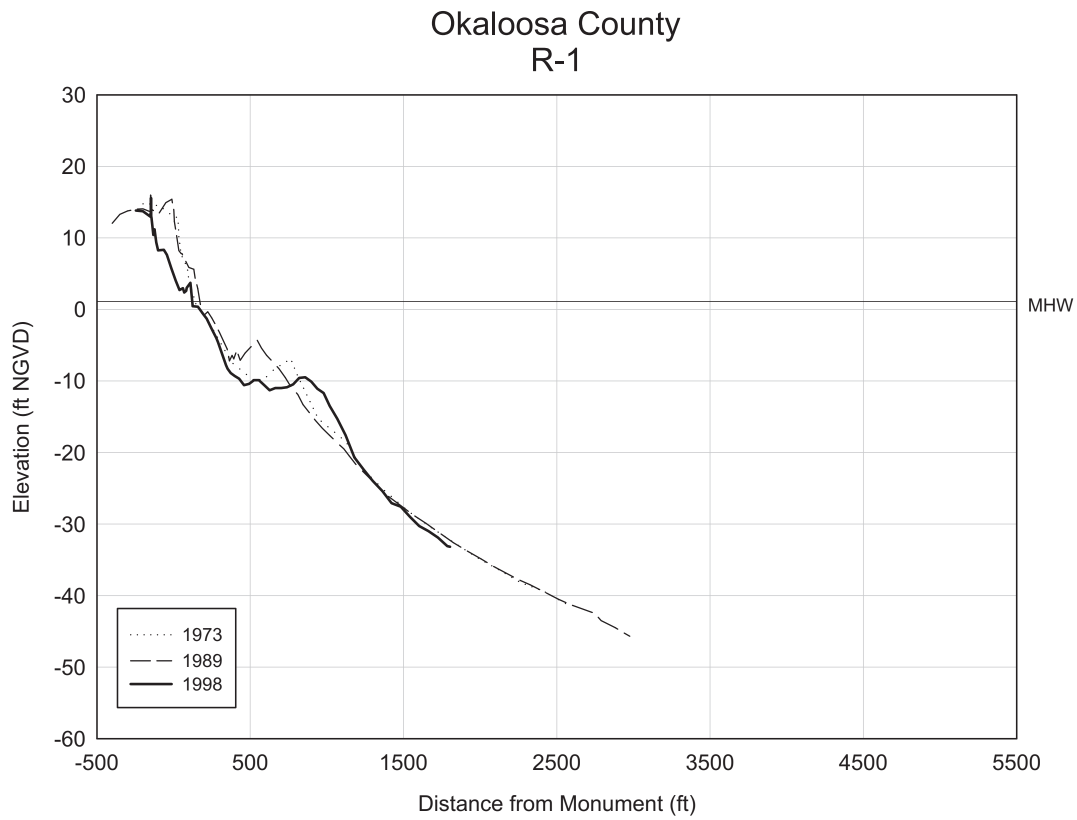

Historic MHW Distance vs. Time
V-549 to V-553 & V-601 to V-603
800
400
0
0
0
0
0
0
0
0
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
0 Ref. pt.
V-549
V-550
V-551
V-552
V-553
V-601
V-602
V-603
0
ID / Axis Location

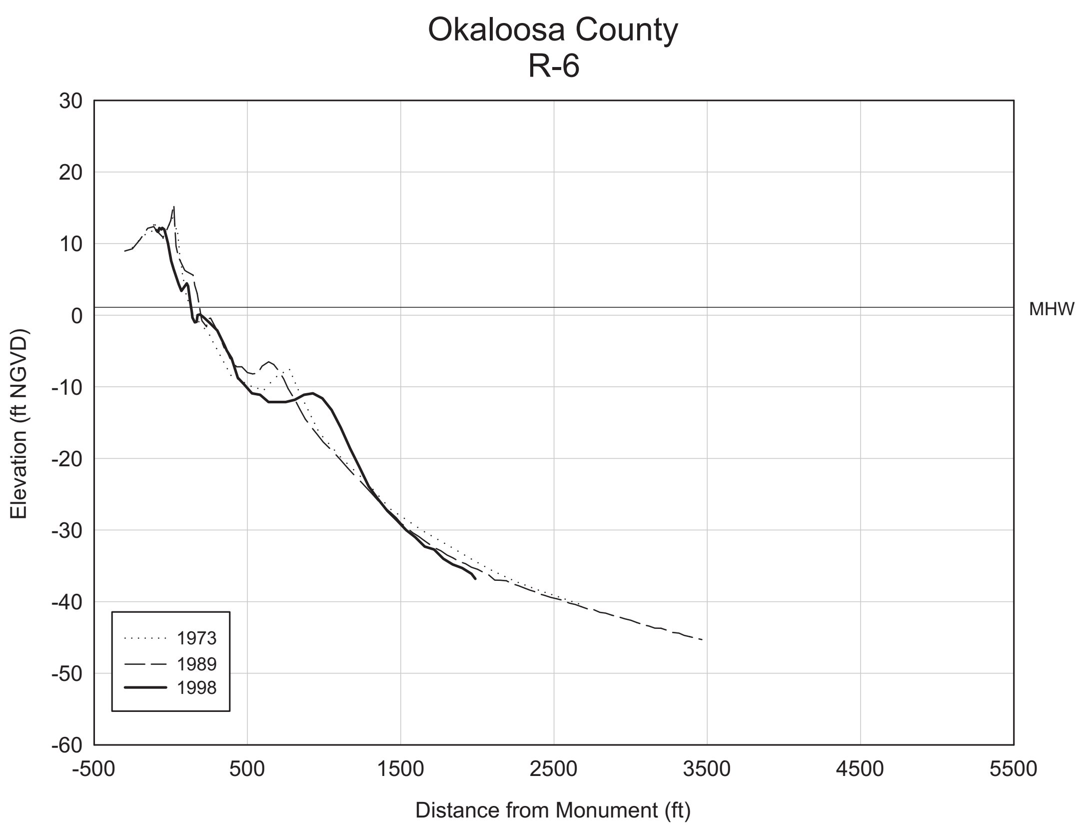

Historic MHW Distance vs. Time
V-604 to V-611
800
400
0
0
0
0
0
0
0
0
0
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
0 Ref. pt.
V-604
V-605
V-606
V-607
V-608
V-609
V-610
V-611
0
ID / Axis Location
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year

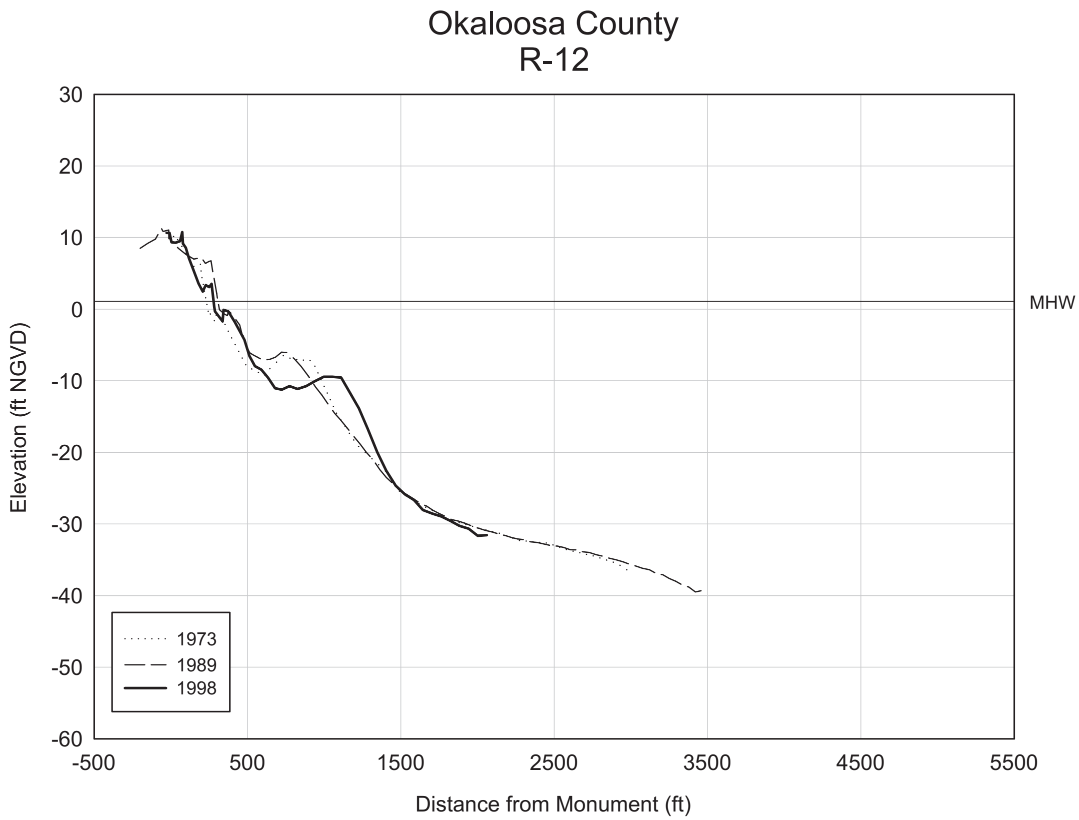

Historic MHW Distance vs. Time
V-612 to V-619
800
400
0
0
0
0
0
0
0
0
0
0 Ref. pt.
V-612
V-613
V-614
V-615
V-616
V-617
V-618
V-619
0
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
ID / Axis Location
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year

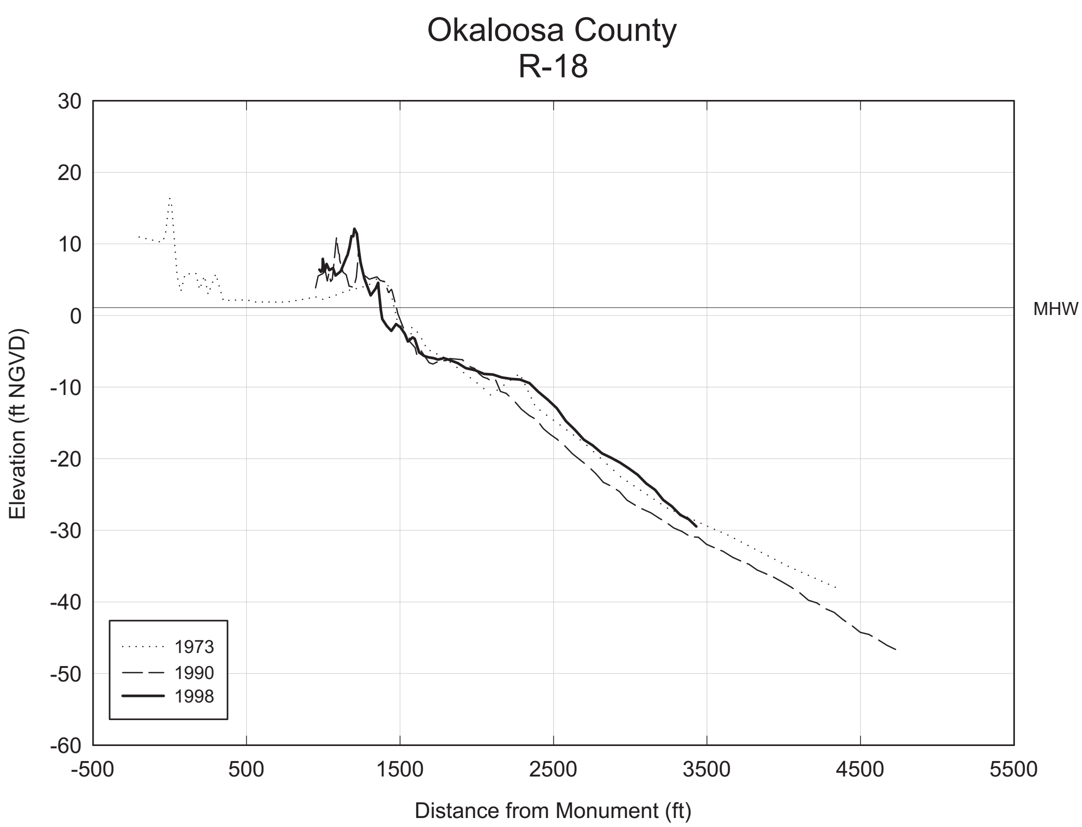

Historic MHW Distance vs. Time
V-620 to V-622
800
400
0
0
0
0
0
0
0
0
0
0 Ref. pt.
V-620
V-621A
V-621B
V-622
0
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
ID / Axis Location
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year

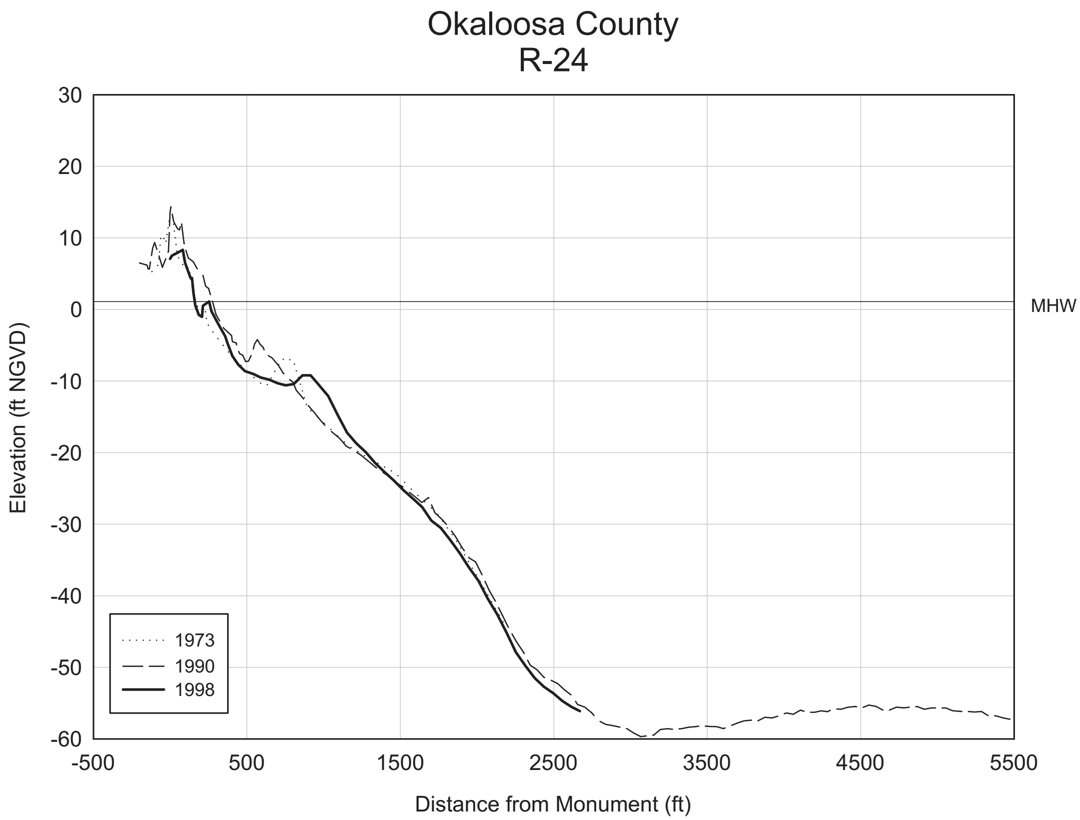
8.3 Appendix C: Profile Plots

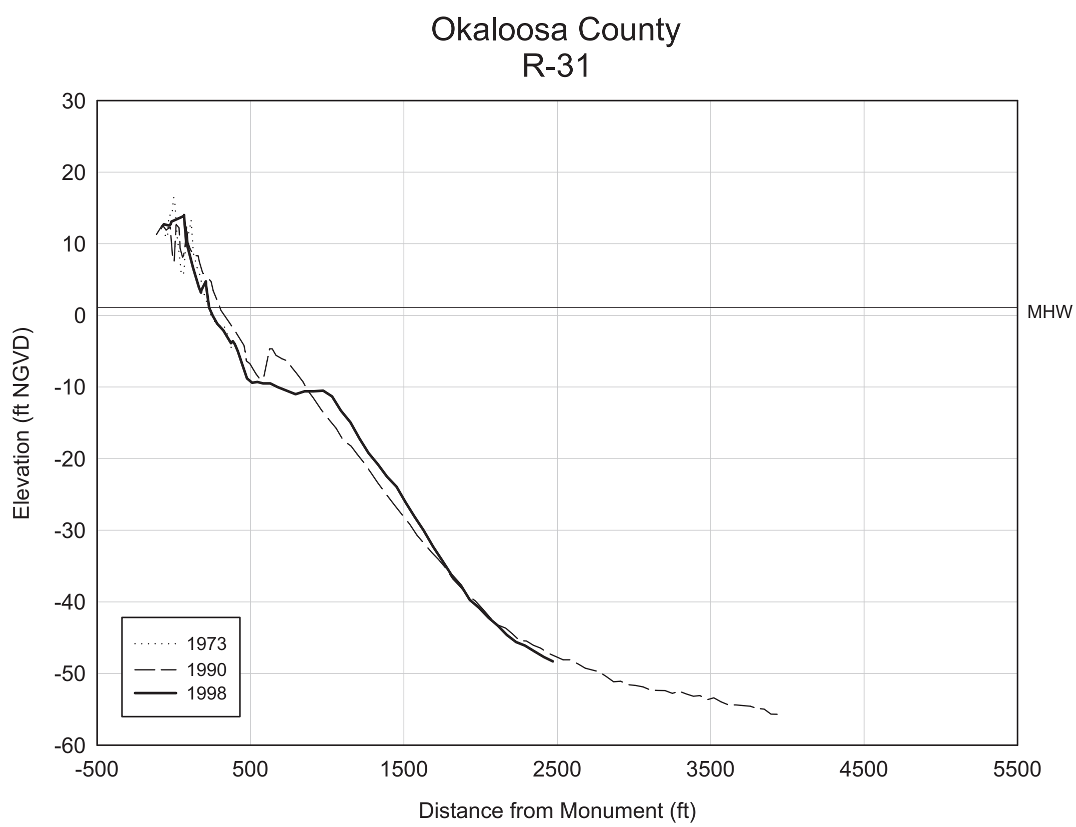

Okaloosa County
R-1
Elevation (ft NGVD)
Distance from Monument (ft)
MHW
1973
1989
1998
30
20
10
0
-10
-20
-30
-40
-50
-60
-500
500
1500
2500
3500
4500
5500

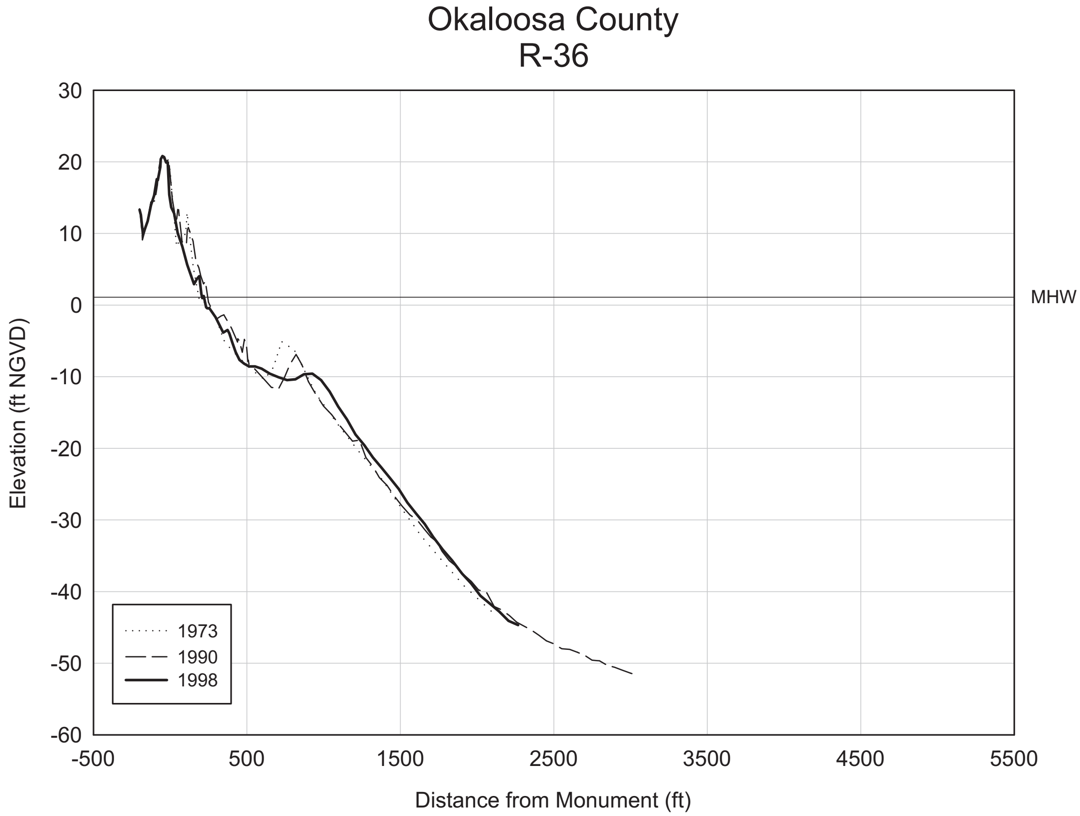

Okaloosa County
R-6
Elevation (ft NGVD)
Distance from Monument (ft)
MHW
1973
1989
1998
30
20
10
0
-10
-20
-30
-40
-50
-60
-500
500
1500
2500
3500
4500
5500


Okaloosa County
R-12
30
20
10
0
-10
-20
-30
-40
-50
-60
Elevation (ft NGVD)
MHW
1973
1989
1998
-500
500
1500
2500
3500
4500
5500
Distance from Monument (ft)

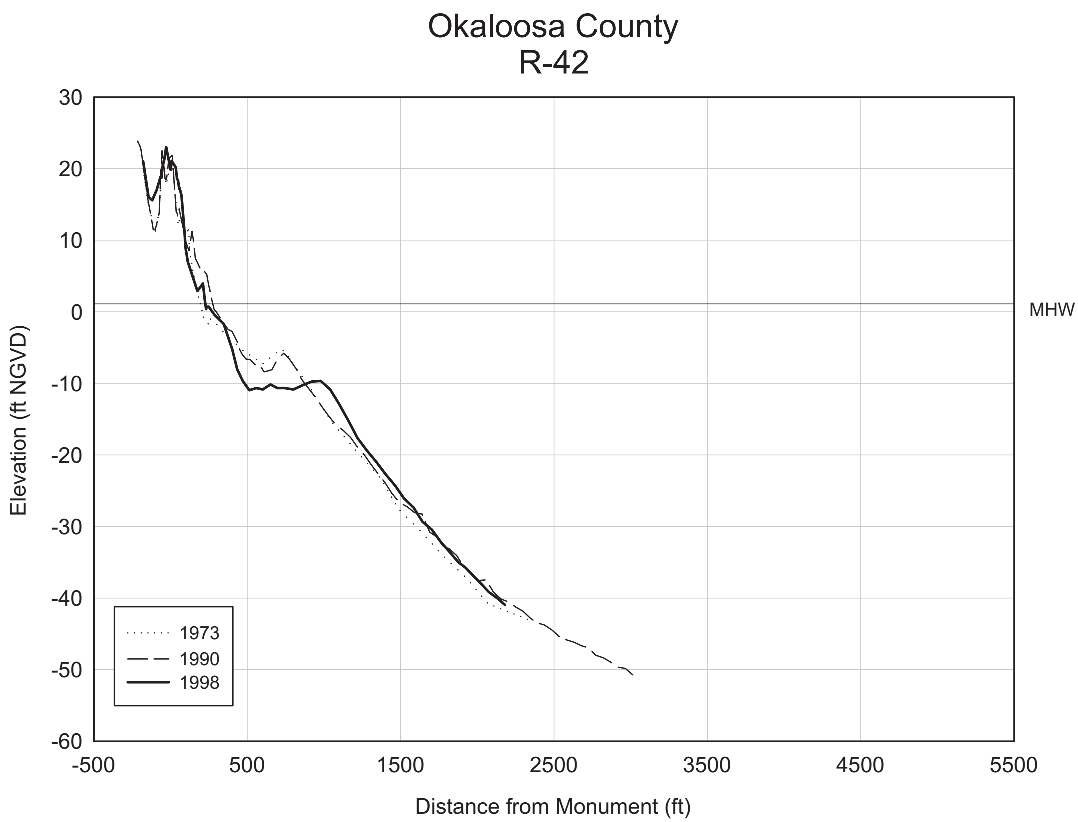

Okaloosa County
R-18
30
20
10
0
-10
-20
-30
-40
-50
-60
Elevation (ft NGVD)
MHW
1973
1990
1998
-500
500
1500
2500
3500
4500
5500
Distance from Monument (ft)


Okaloosa County
R-24
Elevation (ft NGVD)
30
20
10
0
-10
-20
-30
-40
-50
-60
MHW
1973
1990
1998
-500
500
1500
2500
3500
4500
5500
Distance from Monument (ft)

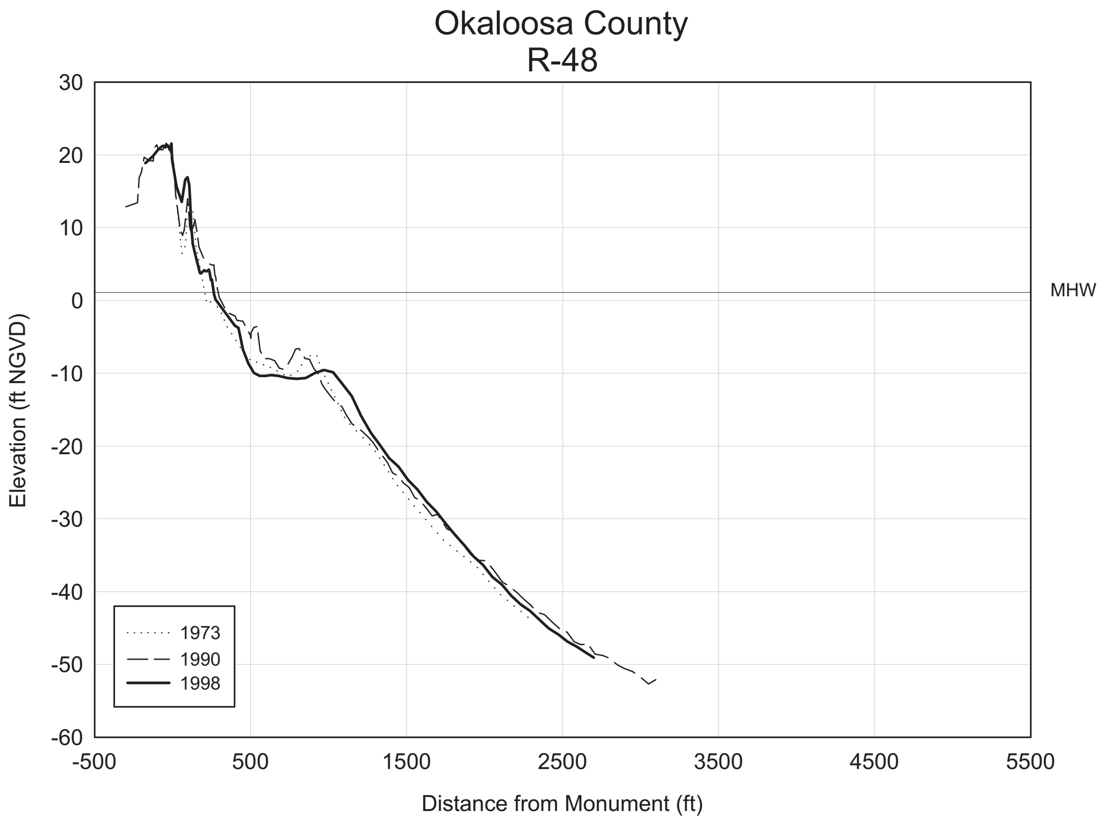

Okaloosa County
R-31
Elevation (ft NGVD)
30
20
10
0
-10
-20
-30
-40
-50
-60
MHW
1973
1990
1998
-500
500
1500
2500
3500
4500
5500
Distance from Monument (ft)



Okaloosa County
R-36
Elevation (ft NGVD)
30
20
10
0
-10
-20
-30
-40
-50
-60
-500
500
1500
2500
3500
4500
5500
Distance from Monument (ft)
MHW
1973
1990
1998



Okaloosa County
R-42
Elevation (ft NGVD)
30
20
10
0
-10
-20
-30
-40
-50
-60
-500
500
1500
2500
3500
4500
5500
Distance from Monument (ft)
MHW
1973
1990
1998


Okaloosa County
R-48
30
20
10
0
-10
-20
-30
-40
-50
-60
Elevation (ft NGVD)
MHW
1973
1990
1998
-500
500
1500
2500
3500
4500
5500
Distance from Monument (ft)