Task 3-4

HORIZONTAL RECESSION OF THE COAST: THE WALTON -- SENSABAUGH METHOD FOR HURRICANE ELOISE OF SEPTEMBER 1975

by

James H. Balsillie

Analysis/Research Section
Bureau of Coastal Data Acquisition
Division of Beaches and Shores
Florida Department of Natural Resources

BEACHES AND SHORES
TECHNICAL AND DESIGN MEMORANDUM NO. 83-1

February 1983

Reviewed by

Beaches and Shores Resource Center
Institute of Science and Public Affairs
Florida State University
and
Florida Office of Coastal Management
Florida Department of Environmental Regulation

Funded by

A grant from the U. S. Office of Coastal Zone Management
National Oceanic and Atmospheric Administration
(under the Coastal Zone Management Act of 1972, as amended)
through
Florida Office of Coastal Management
Florida Department of Environmental Regulation
and
Florida Department of Natural Resources

FOREWORD

This work presents and describes a computer model for the prediction of dune-bluff erosion due to hurricane impact. The work constitutes partial fullfilment of contractural obligations with the Federal Coastal Zone Management Program (Coastal Zone Management Act of 1972, as amended) through the Florida Office of Coastal Management subject to provisions of contract CM-37 entitled "Engineering Support Enhancement Program" (DNR contract no. C0037). The work is adopted as a Beaches and Shores Technical and Design Memorandum in accordance with provisions of Chapter 16B-33, F. A. C.

At the time of submission for contractural compliance, James H. Balsillie was the Contract Manager, and Administrator of the Analysis/Research Section, Hal N. Bean was Chief of the Bureau of Coastal Data Acquisition, Deborah E. Athos was Director of the Division of Beaches and Shores, and Dr. Elton J. Gissendanner was Executive Director of the Department of Natural Resources.

Deborah E. Flack

Deborah E. Flack, Director
Division of Beaches and Shores

CONTENTS

HORIZONTAL RECESSION OF THE COAST: THE WALTON -- SENSABAUGH METHOD FOR HURRICANE ELOISE OF SEPTEMBER 1975

by

James H. Balsillie
Analysis and Research Section, Bureau of Coastal Data Acquisition, Division of Beaches and Shores, Department of Natural Resources, 3900 Commonwealth Blvd., Tallahassee, FL 32303.

INTRODUCTION

It is desirable that a successful beach-dune-bluff horizontal recession prediction methodology is available which considers all the factors characterizing the nearshore, beach and coast, and possible storm and hurricane events. While considerable work has been accomplished toward this goal, a comprehensive and successful model has not been demonstrated to exist. This is in large part due to the lack of data which quantify water level, wave and profile behavior during extreme event impact for a wide range of nearshore, beach and coastal conditions.

However, an importantly viable alternative is to use simplified methodology for single events, where adequate pre- and post-storm data are available. The approach accomplishes two goals: 1. it attempts to provide reliable results for the characteristics of the extreme event should such an event again strike the same or a similar area, and 2. it provides comparative information for derivation of a more comprehensive model as data from more storms are accumulated.

One such method is proposed by Walton and Sensabaugh (1979) for Hurricane Eloise which struck the northwestern

panhandle coast of Florida (about 40 miles west of Panama City) in September, 1975. Pre-storm profiles were surveyed in October, 1973; post-storm profiles were measured within 4 weeks following hurricane impact. Following the work of Edelman (1968, 1970) and Vallianos (1975) Walton and Sensabaugh determined before and after average beach slopes from which a simple geometric mass conservation model was derived as illustrated in Figure 1.

HURRICANE CONDITIONS AT LANDFALL

Schwerdt, Ho and Watkins (1979) report that at landfall Hurricane Eloise had the following characteristics:

1. Δp = 1.77 inches Hg
2. p_o = 28.2 inches Hg
3. R = 18.0 nautical miles
4. v_f = 23.0 knots

where Δp is the pressure gradient, p_o is the central pressure of the hurricane, R is radius of maximum winds, and v_f is the forward speed.

PEAK STORM SURGE STILL WATER LEVEL

The peak storm surge level achieved during Hurricane Eloise has been subject to some controversy. Chiu (1977) reports that the U. S. Army Corps of Engineers, Mobile District, measured high water marks ranging from +12 to +16 feet NGVD. Using numerical modeling techniques, the National Weather Service estimates that the maximum surge at the

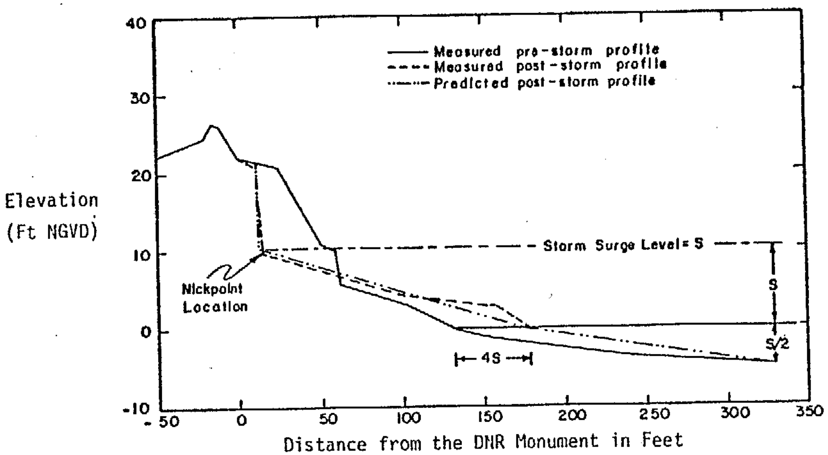


Figure 1. Illustration of Walton -- Sensabaugh geometric constraints for dune erosion.

Bay-Walton County line was about +10.5 feet NGVD (Burdin, 1977) Work accomplished by the Florida Department of Natural Resources, Division of Beaches and Shores (Dean and Chiu, 1982) suggests that the peak surge was at about +12 feet NGVD.

An additional analysis is possible using the nickpoint concept used in fluvial geology (see Figure 1). A sample of 69 profiles in Walton County (i.e, representing the eastern portion of Walton county, coinciding with radius of maximum winds for the first quadrant of Hurricane Eloise) indicates that the elevation of significant deflection in the slope of the eroded profile has an elevation of +10.36 feet NGVD, with a standard deviation of 0.56 feet. Figure 2a illustrates that results of the nickpoint analysis represent a random spatial distribution (i.e., no apparent trend with distance from the center of the hurricane). The nature of the spatial distribution is further substantiated in Figure 2b which illustrates a good fit to a Gaussian distribution plot. Assuming that the nickpoint is not significantly altered as the storm surge water level recedes and any slumping is recognized and accounted for, then the nickpoint analytical procedure appears to provide a reasonable measure of the peak storm surge water level (including setup) for Hurricane Eloise.

MEASURED EROSION

Profile data for analysis are selected to represent the radius of maximum wind velocity reported earlier, and include Walton County profiles from R-37 to R-127. Because there is

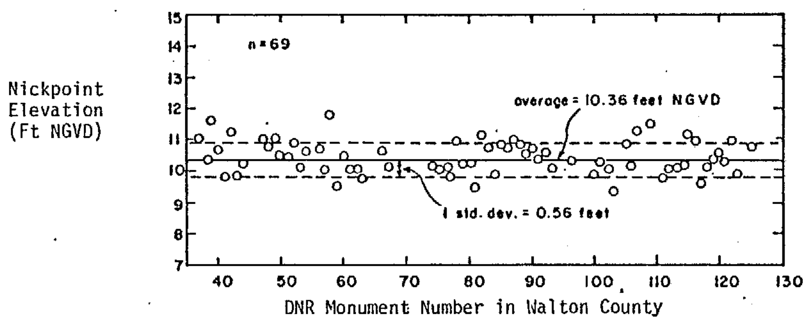


Figure 2a. Spatial distribution of the nickpoint elevation following impact of Hurricane Eloise.

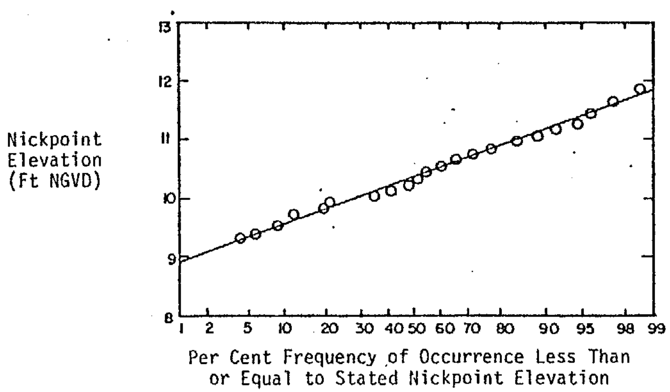


Figure 2b. Probability plot of data of Figure 2a.

a period of two years between the profile surveys, the possibility of non-representative profile conditions at the time of hurricane impact exists. Inspection of before and after profile plots reveals cases where post-storm profile conditions could not possibly have been caused by storm impact (e.g., construction and fill activity), or where processes other than onshore-offshore transport were clearly of more importance. A total of 63 profiles are used in the analysis, where 6 are eliminated from the visual inspection and 21 are unavailable either because the monument was not recovered or was destroyed.

Dune-bluff horizontal recession resulting from Hurricane Eloise is demonstrated in Figure 3a to be random; the corresponding Gaussian plot is provided in Figure 3b. For the coastal segment selected, the average dune-bluff horizontal recession is 53.7 feet with a standard deviation of 12.5 feet.

Measured volumetric changes between surveys, again, exhibit random behavior as illustrated in Figure 4a, closely verified by the Gaussian plot of Figure 4b. The average volume loss is -7.26 cubic yards of sand per lineal foot of beach with a standard deviation of 7.16 cu yds/ft.

PREDICTED EROSION

Although Walton and Sensabaugh (1979) state that their method "..... was applied for a number of cases in the Florida Panhandle area and gave reasonable results .....", they did not publish supporting evidence. Such evidence is to be presented here.

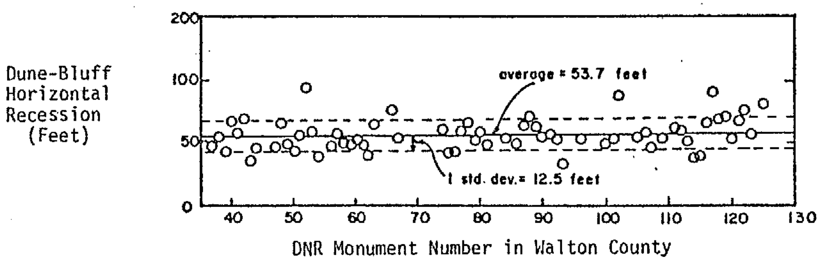


Figure 3a. Spatial distribution of dune-bluff horizontal recession following impact of Hurricane Eloise.

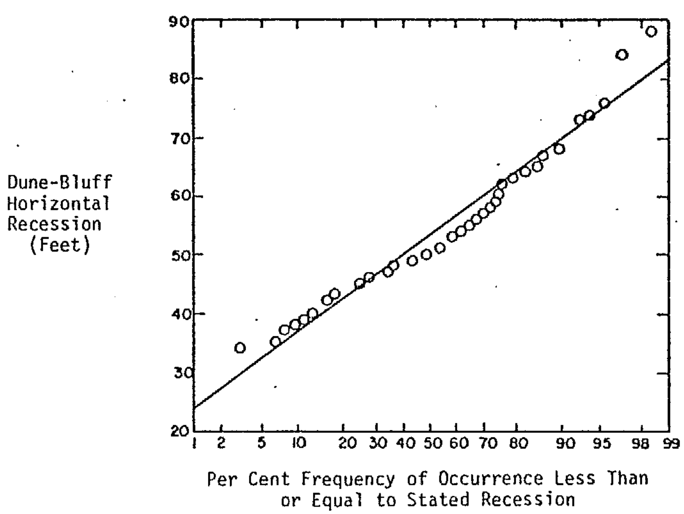


Figure 3b. Probability plot of data of Figure 3a.

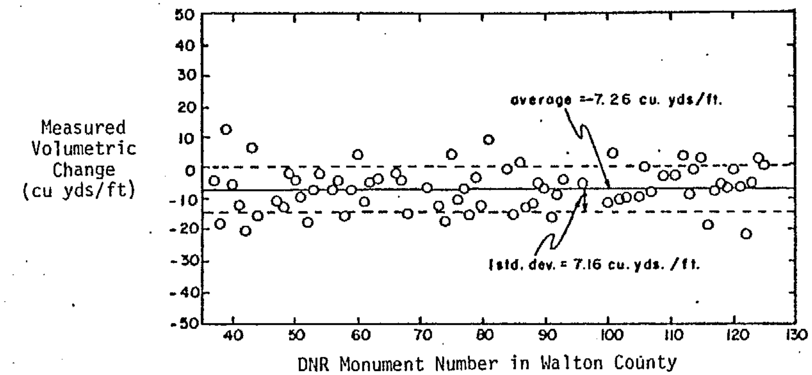


Figure 4a. Spatial distribution of the measured volumetric change following impact of Hurricane Eloise.

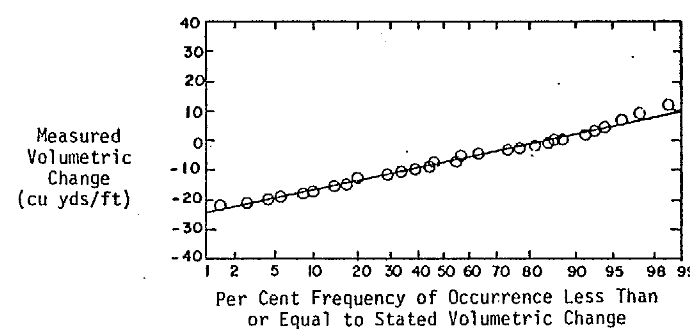


Figure 4b. Probability plot of the data of Figure 4b.

Due to the complexity of topographic conditions, it is not possible to assess the success of the prediction method for Hurricane Eloise using quantitative mathematical means. However, qualitative assessment from visual inspection yields the summarized results of Table 1. As noted in Figure 1 the upland extent of the Walton-Sensabaugh horizontal recession is indicated as a vertical line. In nature, however, the slope of this line is seldom vertical. The assessment factor of Table 1 ,therefore, represents the absolute distance that the predicted vertical recession line must be moved horizontally to closely represent actual recession.

Table 1. Assessment of Horizontal Recession Prediction Using the Walton-Sensabaugh Method.

Goodness of Dune-Bluff Recession Prediction	Number of Profiles	Per Cent	Accum. Per Cent	Assessment Factor (feet)
Excellent	22	34.9	34.9	0 to 3
Good	13	20.6	55.6	3 to 6
Moderate	22	34.9	90.5	6 to 12
Poor	6	9.5	100.0	12 to 18

Results of the Walton-Sensabaugh method are provided, profile-by-profile, in Appendix I. When reviewing plots in Appendix I, the reader is reminded that the pre-storm survey was made 23 months prior to hurricane impact. Hence, actual profile configurations may not have been as represented by the 1973 survey, which may account for some of the deviation between measured and predicted horizontal recession.

The average predicted volumetric loss using the Walton-Sensabaugh method is -7.85 cu yds/ft (a standard deviation of only 0.31 cu yds/ft), which deviates from the measured average loss given earlier by a reasonably small value of 0.69 cu yds/ft.

SPECIAL ISSUES

Several considerations regarding the Walton-Sensabaugh method for Hurricane Eloise and other relevant issues as they pertain to coastal engineering applications deserve special attention. Discussion follows.

Forward Speed of the Hurricane at Landfall

Various investigators (Dean, 1976; van de Graaf, 1977; Hughes, 1981; Hughes and Chiu, 1981; Kriebel, 1982) have noted a relationship between storm duration upon landfall and the extent of horizontal recession. Generally, the longer the storm event impacts the shore, the greater the horizontal recession.

If, for comparative purposes, one assumes that the peak storm surge is approximately maintained for twice the radius of maximum wind, then for Hurricane Eloise the peak storm surge will have impacted the panhandle coast for 1 hour and 34 minutes. It is to be noted, however, that Hurricane Eloise had a significantly high forward speed (23 knots at landfall). The probability plot of Figure 5 includes data for 74 Gulf Coast hurricanes at landfall (data from Schwerdt, Ho and

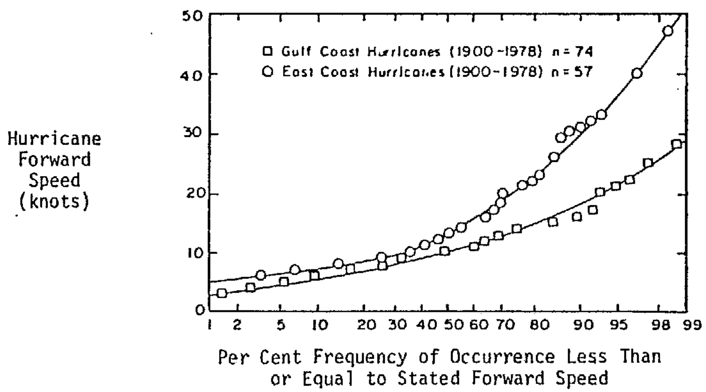


Figure 5. Probability plot of the forward speed of hurricanes for the East and Gulf coasts (data from Schwerdt, Ho and Watkins, 1979).

Watkins, 1979), and shows that at landfall the median forward speed of a Gulf Coast hurricane is 10 knots. Hurricane Eloise exceeded the expected average forward speed by 230%; in fact, there is a 97% chance that the forward speed should be less than the 23-knot forward speed recorded for Eloise. If, by applying the same assumption used above, Hurricane Eloise had a maximum wind radius of 18 nautical miles, but with a forward speed of 10 knots, then the peak storm surge would have been 3 hours and 36 minutes. Hence, for the latter case one would expect more horizontal recession. Kriebel (1982) notes that, in terms of the surge, Hurricane Eloise was probably not a 100-year event, but more nearly represents an event lying between a 75- and 100-year occurrence; Dean (personal communications) suggests that in terms of erosion, Eloise represents about a 40-year event.

How much more horizontal recession should be expected for the latter case suggested above is not known with certainty. However, it is strongly suggested, from studies cited earlier in this section, that peak storm surge duration and dune-bluff volumetric erosion are not linearly related. The relationship is usually represented as exponential (Figure 6); more precise knowledge about the behavior of such curves will be possible only after the collection of more data for for a variety of storm and hurricane impact intensities and coastal conditions.

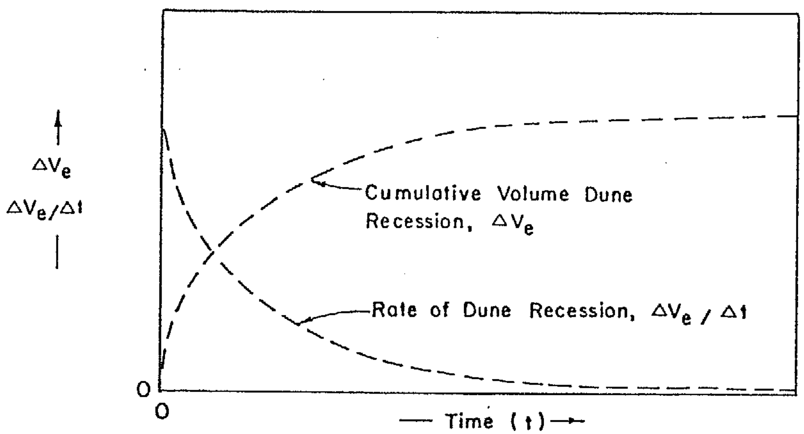


Figure 6. Time dependent erosion trends (after Hughes and Chiu, 1981).

<u>Shoreline Recession as an Indicator of Beach and Coast Stability</u>

The Bureau of Coastal Data Acquisition has one of the most intensive programs of profile data acquisition in the United States (Sensabaugh, Balsillie and Bean, 1977; Balsillie, 1982a, 1982b; Penquite, Bean and Balsillie, 1983). The profile surveying program is concentrated about two efforts. The first is collection of profile data representing normally encountered beach and coast conditions which are used to establish regulatory Coastal Construction Control Lines and, more recently, state-wide condition surveys. Second, the Bureau surveys post-storm profiles in accordance with the Shoreline Emergency Reaction Function (SERF) of the Division of Beaches and Shores. Regarding such data, several issues require discussion.

In simplest coastal engineering terminology, horizontal recession may be regarded as either short-term or long-term. Short-term horizontal recession results from storm or hurricane impact; long-term horizontal recession occurs as the result of refraction-related longshore and onshore-offshore transport processes and because of eustatic sea level rise.

Now, while for the determination of long-term recession rates the position of the shoreline is often used, one must be very careful when using post-storm information as comparative data. The reason is straightforward: storms frequently cause a seaward shift in the shoreline location due to dune-bluff erosion. The seaward shift is quite obvious for Hurricane Eloise. Figure 7a illustrates the

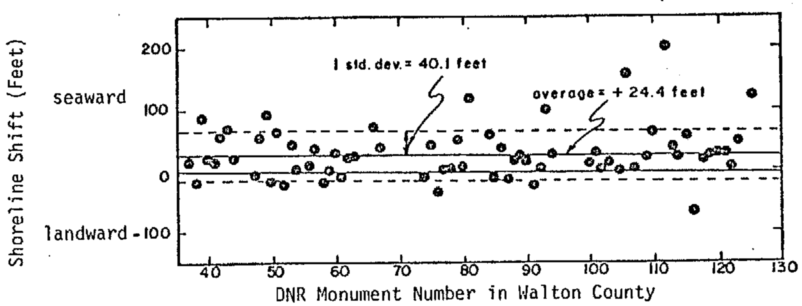


Figure 7a. Spatial distribution of the shoreline shift following impact of Hurricane Eloise.

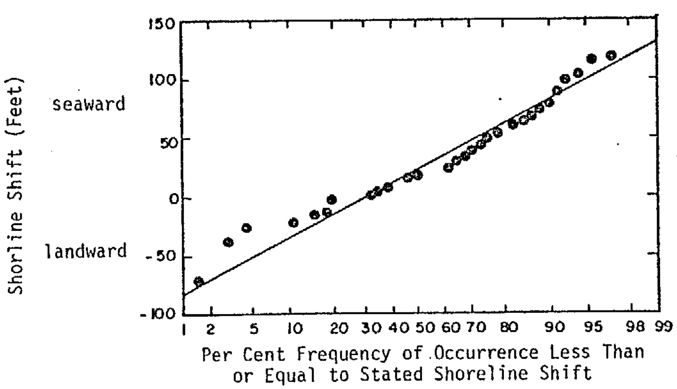


Figure 7b. Probability plot of data of Figure 7a.

random spatial distribution of the shift for the study area; Figure 7b provides the probability plot. Eloise resulted in an average seaward shift of the shoreline of 24.4 feet, with a high standard deviation of 40.1 feet. The rather large amount of scatter in the data may be due to the 23-month period between surveys, but the results never-the-less demonstrate that one must be careful when using post-storm profiles to determine long-term recession rates where the shoreline is the reference contour.

When considering erosion of the beach (i.e., note that this model is primarily for horizontal recession of the coast), one must recognize that vertical recession (i.e., scour) of the inundated portion of the profile will be greater during than following storm impact, due to post-storm recovery. The WANDS computer model accounts, to some extent, for post-storm recovery (i.e., 3 to 4 weeks following impact), but does not allow for prediction of scour.

APPLIED COASTAL ENGINEERING COMPUTER MODEL

The Walton-Sensabaugh (WANDS) method for prediction of dune-bluff horizontal recession resulting from a Hurricane Eloise type event has been programmed to support the coastal engineering needs and responsibilities of the Division of Beaches and Shores. Computer programs in support of the task are written in APL (i.e., A Programming Language) and supported by the Natural Resources Management Systems and Services data center's IBM 4341 Model Group II processor. APL programs written by the author for dune-bluff recession prediction are listed in Appendix II.

Discussion of Required Input

Data required for the WANDS computer model are listed on the data input form of Figure 8. Some discussion of the data is necessary.

Offshore profile information may be obtained from the Beaches and Shores Technical and Design Memorandum No. 82-1-II (Balsillie, 1982b). If not yet available, programming has been developed to determine exponent (i.e., shape coefficient) and scale coefficient values, requiring as input distances measured from the "normally existing" shoreline to about 1200 feet offshore and a corresponding number of depth values as discussed in Beaches and Shores Technical and Design Memorandum No. 82-1-I (Balsillie, 1982a). Distance-depth data pairs should be entered at a constant spacing of not greater than 50 feet.

Terminal input of onshore profile data is required since pre- and post-construction profile data submitted with, for instance a permit application, will invariably not be coincident with DNR reference monument locations and, therefore with DNR profiles. "Profile Type" includes either a pre- or post-construction descriptor (i.e., entered as "Pre-Const" or "Post-Const", or some other pertinent description).

Determination of "Distance range is from the Ref Mon" is the alongshore direction and distance the range (i.e., the profile for which the model is to be applied) is from the nearest DNR reference monument (Figure 9). Ranges should be selected as shore-normal profiles. The compass direction

BEACH AND COAST EROSION PREDICTION
(Walton -- Sensabaugh Method)

*** DATA INPUT FORM ***

OFFSHORE PROFILE INFORMATION

Exponent: 2/3 Scale Factor 0.154 Survey Date ___/ 11 / 73
da mo yr

ONSHORE PROFILE DATA
(List data from the shoreline upland.)

	Dist (ft)	Elev (ft NGVD)		Dist (ft)	Elev (ft NGVD)		Dist (ft)	Elev (ft NGVD)
1	0	0	11	184.8	22.11	21	____	____
2	34.8	3.44	12	234.8	21.97	22	____	____
3	72.8	5.77	13	287.8	21.52	23	____	____
4	76.8	10.39	14	____	____	24	____	____
5	84.8	10.76	15	____	____	25	____	____
6	110.8	20.79	16	____	____	26	____	____
7	134.8	22.01	17	____	____	27	____	____
8	145.8	26.07	18	____	____	28	____	____
9	150.8	26.78	19	____	____	29	____	____
10	155.8	24.12	20	____	____	30	____	____

Survey Date: __/ 11 / 75 /
da mo yr

Profile Type: Pre-Const

LOCATION INFORMATION

DNR Ref Mon: R-101 County Name: Walton

Distance range is from the Ref Mon (e.g., W145 -- the range is located 145 ft west of specified ref mon) W145

Distance from Shoreline to CCCL: 134.8

ADMINISTRATIVE INFORMATION

File I.D.: Test

Engineer Responsible for Input Data: James H. Balsillie

STORM SURGE INFORMATION

	Storm Surge Elevation (ft NGVD)	Return Period (Years)	Source
1	10.36	80	JHB
2	____	____	____
3	____	____	____
4	____	____	____
5	____	____	____

Figure 8. Required input data and data input form.

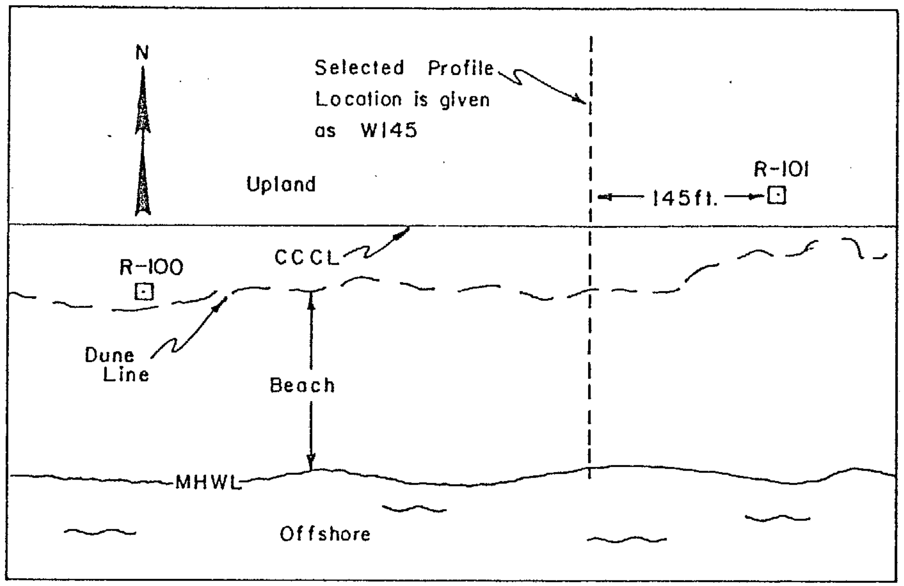


Figure 9. Example of determination of "Distance Range is from Ref Mon" (see Figure 8).

indicator (i.e., N = north, S = south, E = east, W = west, etc.) will, generally, be N or S for the east and lower Gulf coasts and E or W for the panhandle coast. The use of more specific compass direction indicators, such as NE for northeast, are encouraged.

In many cases onshore topographical information will be available only to the mean high water line (MHWL). There will be a need, therefore, to determine the addtional distance from the MHWL to the shoreline (i.e., 0 NGVD), in order to obtain the "Distance from Shoreline to CCCL" (i.e, CCCL is the Coastal Construction Control Line). The foreshore slope can be used to determine the additional distance, since the berm crest is a measure of the MHWL. Table 2 lists foreshore slope data compiled for the Florida panhandle coast. Characteristic foreshore slope information for other coasts will need to be compiled from existing studies and published literature.

Other required data on the form would appear to be straightforward.

Results

Four output formats are available from the dune-bluff horizontal recession computer model.

Figure 10 illustrates the format of the plotted results where the solid line represents the pre-recession profile, the dashed line depicts the eroded profile, and the dash-dot-dash line is the storm surge still water level. The horizontal scale is set at 1 inch = 50 feet, the vertical scale at 1 inch = 10 feet. Plots are formatted to provide a

Table 2. Foreshore Slope Statistics for Florida Panhandle Coast.[1]

Station	Statistics	1969				1970								Average Monthly Mean
		Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	
St. Andrew's State Park	Mean Foreshore Slope	8.7	6.0	6.4	5.9	5.8	5.4	4.9	5.3	5.1	5.4	7.0	6.9	7.0
	Std. Deviation	3.95	2.08	2.54	2.81	2.01	1.23	1.92	1.65	1.85	2.95	1.56	1.16	
	No. Observations	25	30	25	28	29	26	17	17	21	19	27	30	
Grayton State Park	Mean Foreshore Slope	11.8	8.1	7.5	7.5	8.5	6.0	3.8	5.0	7.1	6.7	7.8	7.0	7.2
	Std. Deviation	3.69	2.30	2.27	1.60	1.43	1.56	1.10	1.52	3.08	2.28	2.54	1.63	
	No. Observations	26	30	28	29	31	28	30	28	30	27	28	27	
Crystal Beach	Mean Foreshore Slope	7.6	8.5	7.6	8.8	8.4	7.2	5.8	8.3	8.7	8.5	9.1	9.1	8.1
	Std. Deviation	3.15	3.61	2.45	3.52	2.80	3.31	2.54	2.27	2.67	3.23	1.88	2.70	
	No. Observations	30	29	27	28	30	26	29	30	31	30	31	16	
J.C. Beasley State Park	Mean Foreshore Slope	----	7.0	7.0	4.2	4.6	2.6	2.7	----	12.1	10.1	11.8	12.9	7.5
	Std. Deviation	----	3.22	2.78	2.59	3.41	2.10	1.96	----	3.70	2.89	3.40	2.89	
	No. Observations	--	29	21	25	25	24	21	--	25	30	28	31	
Navarre Beach	Mean Foreshore Slope	----	10.7	9.7	8.5	10.3	9.4	9.0	9.3	10.5	6.3	9.3	9.0	9.3
	Std. Deviation	----	3.50	4.40	4.13	2.57	2.80	4.02	3.78	3.79	3.04	4.47	3.94	
	No. Observations	--	12	20	22	26	19	24	30	30	28	28	31	
Fort Pickens State Park	Mean Foreshore Slope	9.0	10.3	----	----	----	----	9.8	10.9	11.4	10.9	10.8	11.7	10.6
	Std. Deviation	2.64	4.44	----	----	----	----	2.80	3.66	4.66	3.25	2.79	3.37	
	No. Observations	25	12	--	--	--	--	30	24	29	30	31	31	

[1]Reported in degrees.
Data from Balsillie (1975).

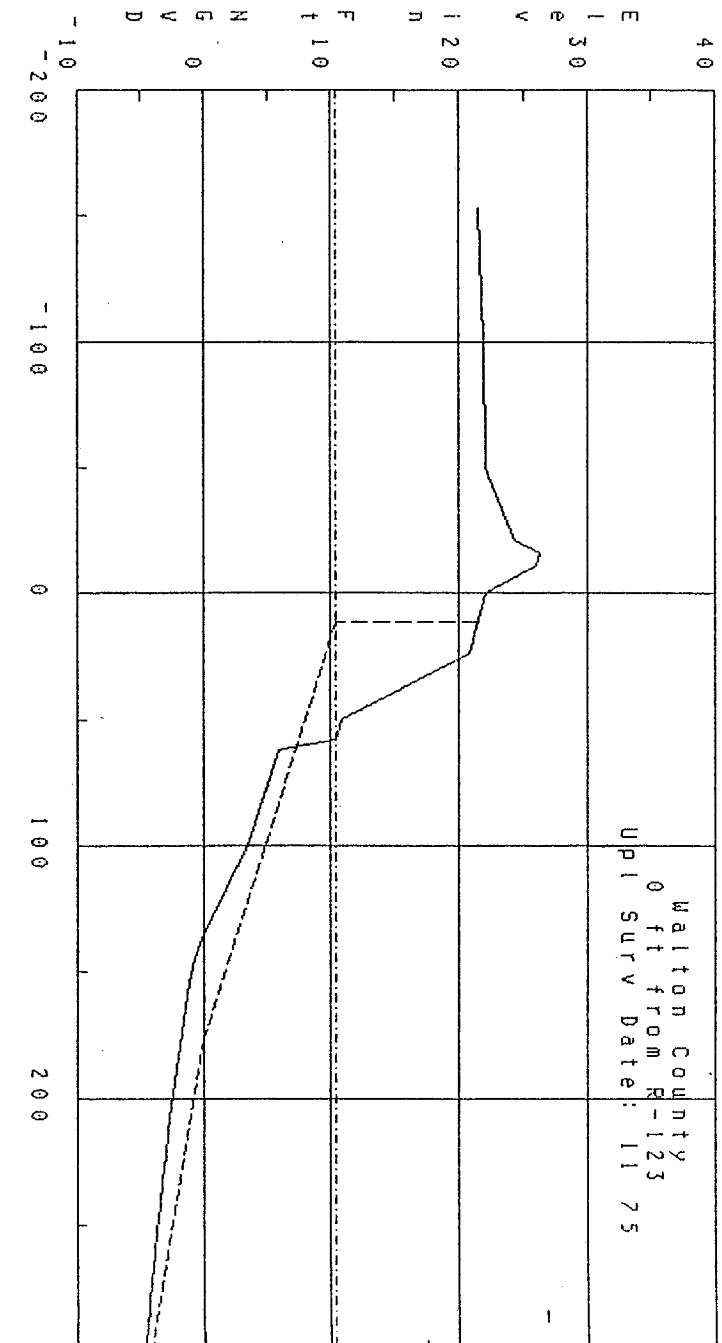


Figure 10. WANDS dune-bluff recession results: the plot.

worksheet on which project dimensions and elevations, and engineering assessments may be drafted. Additional plots are automatically generated should more than one plot be required to adequately represent a given range.

Pertinent input and administrative information and horizontal recession results are printed in standard format (including a key to the plots) as illustrated by Figure 11. Certain terms appearing on Figure 11 which may be ambiguous, are defined in Figure 12.

Entered onshore profile data are listed by a third report (Figure 13), and are referenced to both the shoreline and the CCCL.

Where offshore power curve fit data are not yet available from Beaches and Shores Technical and Design Memorandum No. 82-1-II (Balsillie, 1982b), one may enter appropriate data from which the results of Figure 14 are produced as a fourth report.

Some Coastal Engineering Considerations

Application of the WANDS model requires the consideration of two issues: 1. the model is calibrated to provide average dune-bluff recession values, and 2. while the storm surge level of Hurricane Eloise approaches that of the 100-year event, the amount of dune-bluff recession does not. Due to the significantly high forward speed of Eloise, dune-bluff recession was probably less than is to be expected from a slower average forward speed.

FLORIDA DEPARTMENT OF NATURAL RESOURCES
DIVISION OF BEACHES AND SHORES
BUREAU OF COASTAL DATA ACQUISITION
DUNE-BLUFF RECESSION PREDICTION
(Walton -- Sensabaugh Method)

ADMINISTRATIVE INFORMATION

File Number ....Test
Responsible for Data Input ....James H. Balsillie
Initials ...._____
Date Job Completed (mo/da/yr) 12 2 1982

INPUT INFORMATION

A. OFFSHORE PROFILE DATA
Exponent (i.e., Shape Coefficient) 0.6667
Scale Coefficient 0.154
Date of Profile Survey 11 73

B. ONSHORE PROFILE SURVEY
Date of Profile Survey 11 75
Profile Type ....Pre-Const

C. STORM SURGE DATA
Storm Surge Elevation (ft NGVD) 10.36
Storm Surge Return Period (years) 80
Source of Information ....JHB

D. DNR REFERENCE MONUMENT INFORMATION
DNR Reference Monument I.D. R-123
County ....Walton
Range to Mon Distance (ft) 0
CCCL to Shoreline Distance (ft) 134.8

PREDICTED RESULTS FOR HORIZONTAL DUNE-BLUFF RECESSION

Erosion Distance Measured from the Shoreline (ft).....123.3
Erosion Distance Measured from the CCCL (ft) 11.5

Angle of Eroded Surface (tangent) 0.06289
Angle of Eroded Surface (degrees) 3.603

Volume of Sand Deposited Offshore (cu yds/ft) 8.662
Volume of Sand Eroded from Upland (cu yds/ft) 8.385

Offshore Profile Closeout Distance (ft) 195.1
Offshore Profile Closeout Depth (ft NGVD) ....⁻5.18

KEY TO THE PLOT(S):
Solid Line -- Surveyed Profile
Dashed Line -- Eroded Profile (Predicted)
Dash-dot-dash Line -- Storm Surge Water Level

Figure 11. WANDS dune-bluff recession results: the data listing.

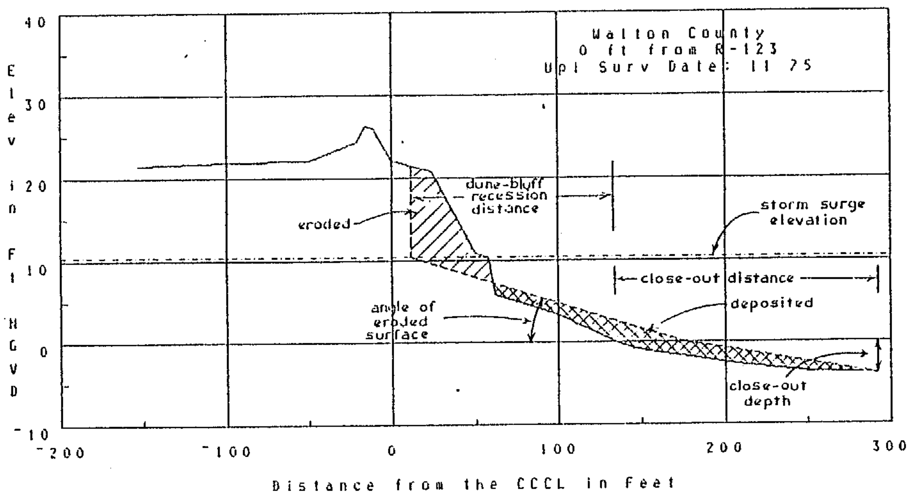


Figure 12. Definition Sketch.

ONSHORE PROFILE SURVEY DATA
County: Walton
Permit I.D.: Test
Profile Location: 0 ft from R-123
Profile Survey Date (da/mo/yr): 11 75

Distance Upland from Shoreline (feet)	Distance from the CCCL (feet)	Elevation (feet NGVD)
.00	-134.80	.00
34.80	-100.00	3.44
72.80	-62.00	5.77
76.80	-58.00	10.39
84.80	-50.00	10.76
110.80	-24.00	20.79
134.80	.00	22.01
145.80	11.00	26.02
150.80	16.00	26.28
155.80	21.00	24.42
184.80	50.00	22.11
234.80	100.00	21.97
287.80	153.00	21.52

NOTE: -ve distances denote locations upland of the CCCL.

Figure 13. WANDS dune-bluff recession results: onshore profile survey data.

ENTER OFFSHORE DISTANCES:

```
 50  100  150  200  250  300  350  400  450  500  550  600
650  700  750  800  850  900  950 1000 1050 1100 1150 1200
```

ENTER CORRESPONDING ELEVATIONS AS +VE VALUES:

```
 2.036  3.232  4.235  5.13   5.953  6.722  7.45   8.143
 8.808  9.449 10.07  10.67  11.26  11.83  12.38  12.93
13.46  13.98  14.5   15     15.5   15.98  16.46  16.94
```

County ____________ Ref Mon I.D. _____ Survey Date ________

	EXPONENT NOT FIXED	EXPONENT FIXED AT 2/3 DIRECT METHOD	EXPONENT FIXED AT 2/3 LOGARITHMIC METHOD
Scale Coefficient:	0.15	0.15	0.15
Exponent:	0.6667	0.6667	0.6667
Correlation Coefficient:	0.9939	0.9939	0.9939
RMS Error:	1.327E¯13	7.603E¯15	5.174E¯15

Figure 14. WANDS dune-bluff recession results: offshore power curve values.

In terms of coastal engineering applications, the first issue is straightforward. Average dune-bluff recession occurring in the region of radius of maximum winds of Eloise was 53.7 feet with a standard deviation of 12.5 feet. Figure 3a illustrates that about 80% of the measured recession values are within + one standard deviation of the average. The coastal engineer, therefore, may find it prudent to consider some additional recession depending on local conditions and proposed design constraints.

The second issue is more difficult to assess, since there are presently no methods available by which to determine the additional amount of expected recession. Again, however, the coastal engineer might consider an additional amount of recession which, based on overall project conditions, would appear prudent to include.

CLOSURE

The Walton - Sensabaugh method for the prediction of dune-bluff horizontal recession due to the impact of a Hurricane Eloise type event has been assessed, based on data measured within the region of impact (i.e., first quadrant of the hurricane. The WANDS computer model should be applied on the basis of this assessment.

The computer approach now allows for the prediction of dune-bluff horizontal recession in a matter of minutes, rather than the hours previously required using graphical and interpretive trial-and-error procedures.

ACKNOWLEDGMENTS

Drafting of many of the figures in this report was accomplished by L. J. Penquite.

REFERENCES

Balsillie, J. H., 1975, Analysis and interpretation of littoral environment observation (LEO) and profile data along the western panhandle coast of Florida: U. S. Army, Coastal Engineering Research Center, Technical Memorandum No. 49, 104 p.

Balsillie, J. H., 1982a, Offshore profile description using the power curve fit, Part I: explanation and discussion: Beaches and Shores Technical and Design Memorandum No. 82-1-I, Florida Department of Natural Resources, 23 p.

Balsillie, J. H., 1982b, Offshore profile description using the power curve fit, Part II: standard Florida offshore profile tables: Beaches and Shores Technical and Design Memorandum No. 82-1-II, Florida Department of Natural Resources.

Burdin, W. W., 1977, Surge effects from Hurricane Eloise: Shore and Beach, v. 45, no. 2.

Chiu, T. Y., 1977, Beach and dune response to Hurricane Eloise of September 1975: Coastal Sediments '77, ASCE, p. 116-134.

Dean, R. G., 1976, Beach erosion: causes, processes and remedial measures: CRC Reviews in Environmental Control, CRC Press, Inc., v. 6, issue 3.

Dean, R. G., and Chiu, T. Y., 1982, Walton County storm surge model study: Florida Department of Natural Resources, Division of Beaches and Shores, 64 p.

Edelman, T., 1968, Dune erosion during storm conditions: Proceedings of the 11th Conference on Coastal Engineering, ASCE, v. 1, chap. 46, p. 719.

Edelman, T., 1972, Dune erosion during storm conditions: Proceedings of the 13th Coastal Engineering Conference, ASCE, v. 2, chap. 70, p. 1305-1311.

Hughes, S. A., 1981, Beach and dune erosion during severe storms: Ph.D. Dissertation, Coastal and Oceanographic Engineering Department, Unversity of Florida, Gainseville.

Hughes, S. A., and Chiu, T. Y., 1981, Beach and dune erosion during severe storms: Coastal and Oceanographic Engineering Department, University of Florida, Gainesville, (funded by the Florida Department of Natural Resources, Division of Beaches and Shores, and Florida Sea Grant Program).

Kriebel, D. L., 1982, Dune and beach response to hurricanes: M. S. Thesis, Civil Engineering Department, University of Delaware.

Penquite, L. J., Bean, H. N., and Balsillie, J. H., 1983, Florida coastal profile location maps: Florida Department of Natural Resources, Divsion of Beaches and Shores, Beaches and Shores Technical and Design Memorandum No. 83-2, 30 p.

Schwerdt, R. W., Ho, F. P., and Watkins, R. R., 1979, Meteorological criteria for standard project hurricane and probable maximum hurricane windfields, Gulf and East coasts of the United States: National Weather Service, U. S. Department of Commerce, National Oceanic and Atmospheric Administration, Technical Report NWS 23.

Sensabaugh, W. M., Balsillie, J. H., and Bean, H. N., 1977, A program of coastal data acquisition: Coastal Sediments '77, A. S. C. E., p. 1073-1085.

Vallianos, L., 1975, Beach fill planning - Brunswick County, North Carolina: Proceedings of the 11th Conference on Coastal Engineering, ASCE.

van de Graaf, J., 1977, Dune erosion during a storm surge: Coastal Engineering, v. 1, p. 99-134.

Walton, T. L., Jr., and Sensabaugh, W. M., 1979, Seawall design on the open coast: Florida Sea Grant Report No. 29, 24 p.

APPENDIX I

Walton County Profile Plots Representing the Radius of Maximum Wind Speed for Hurricane Eloise, Sept. 1975

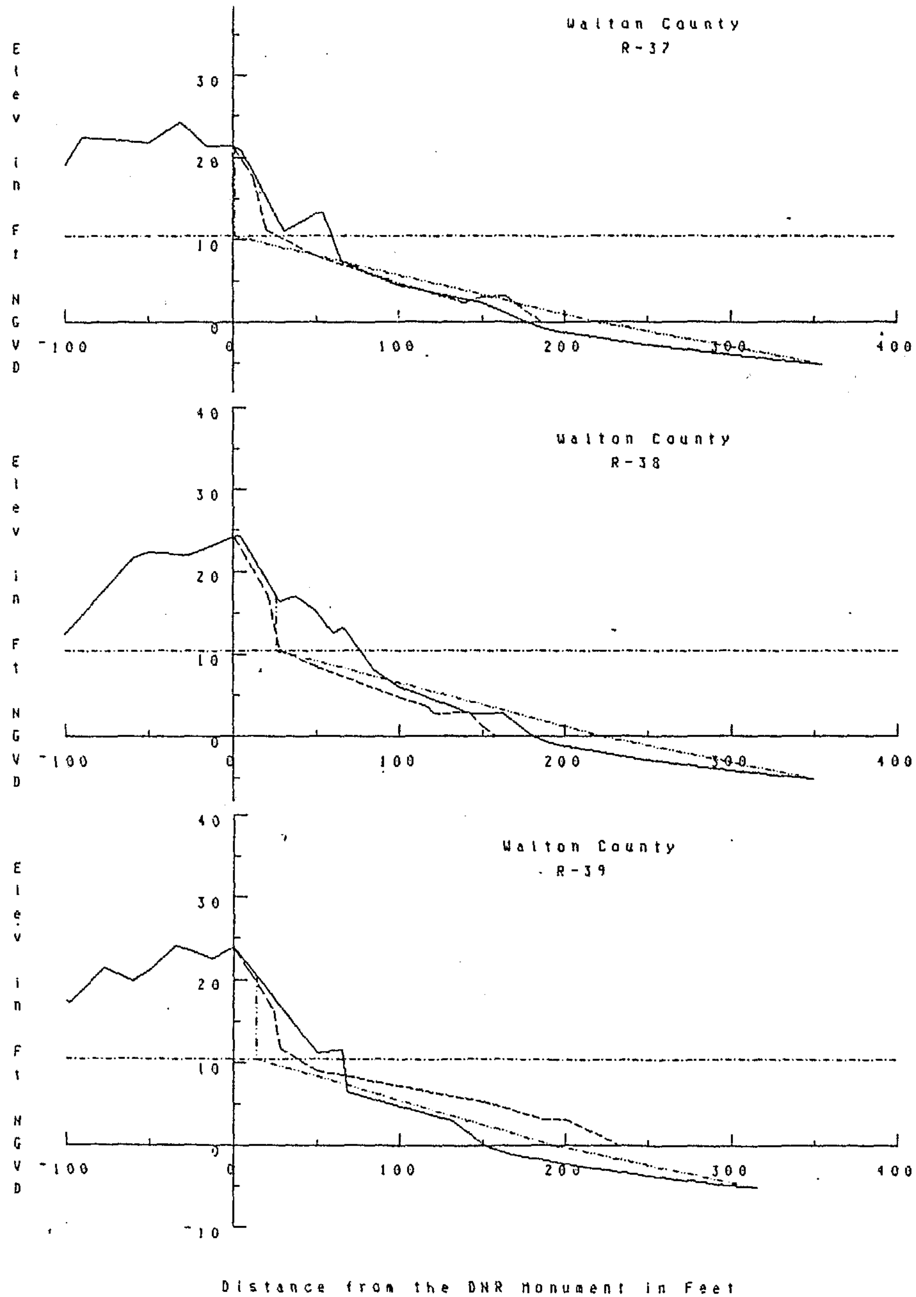
Key to the Plots:

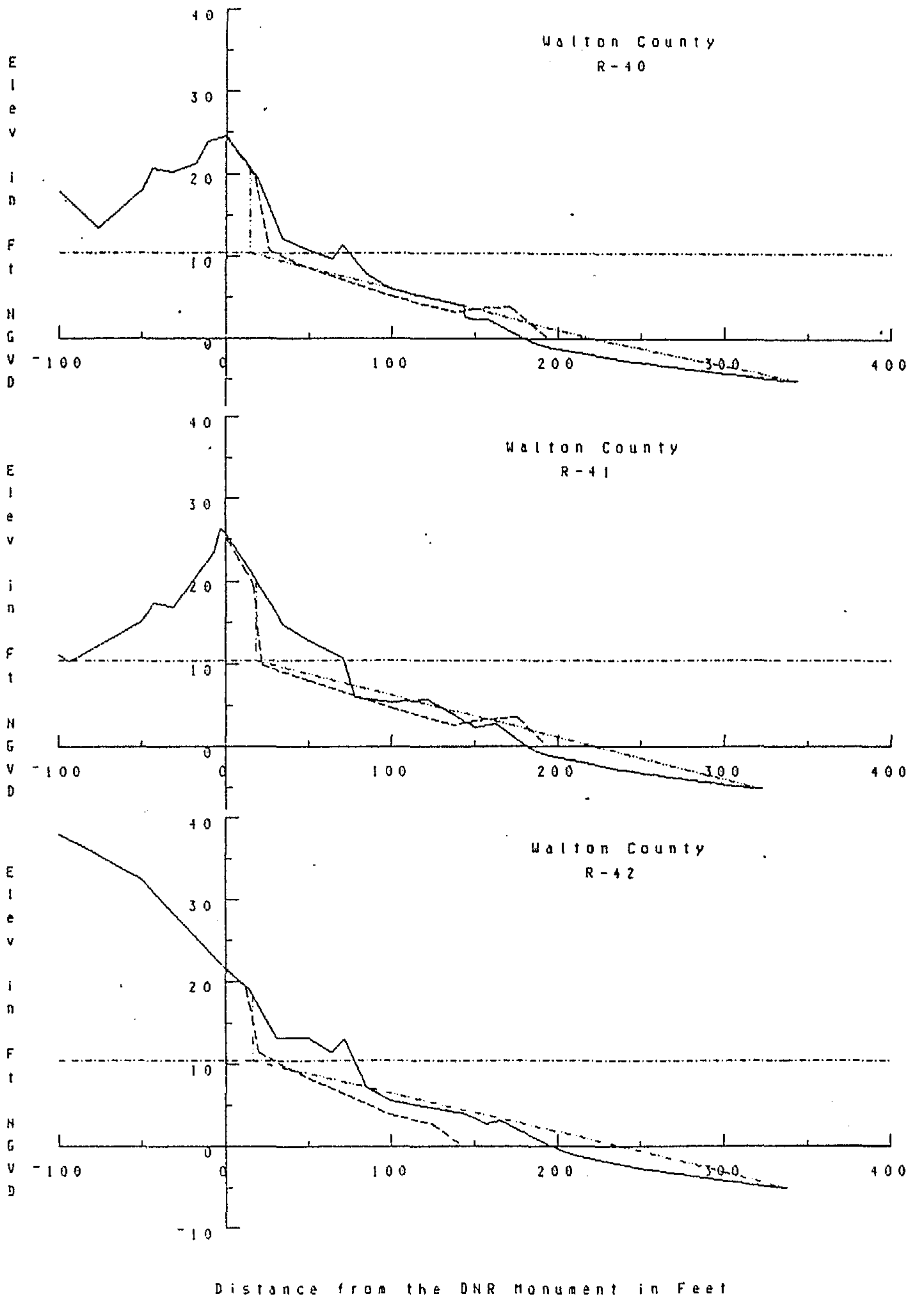
———— Pre-Storm Survey (Oct. 1973)

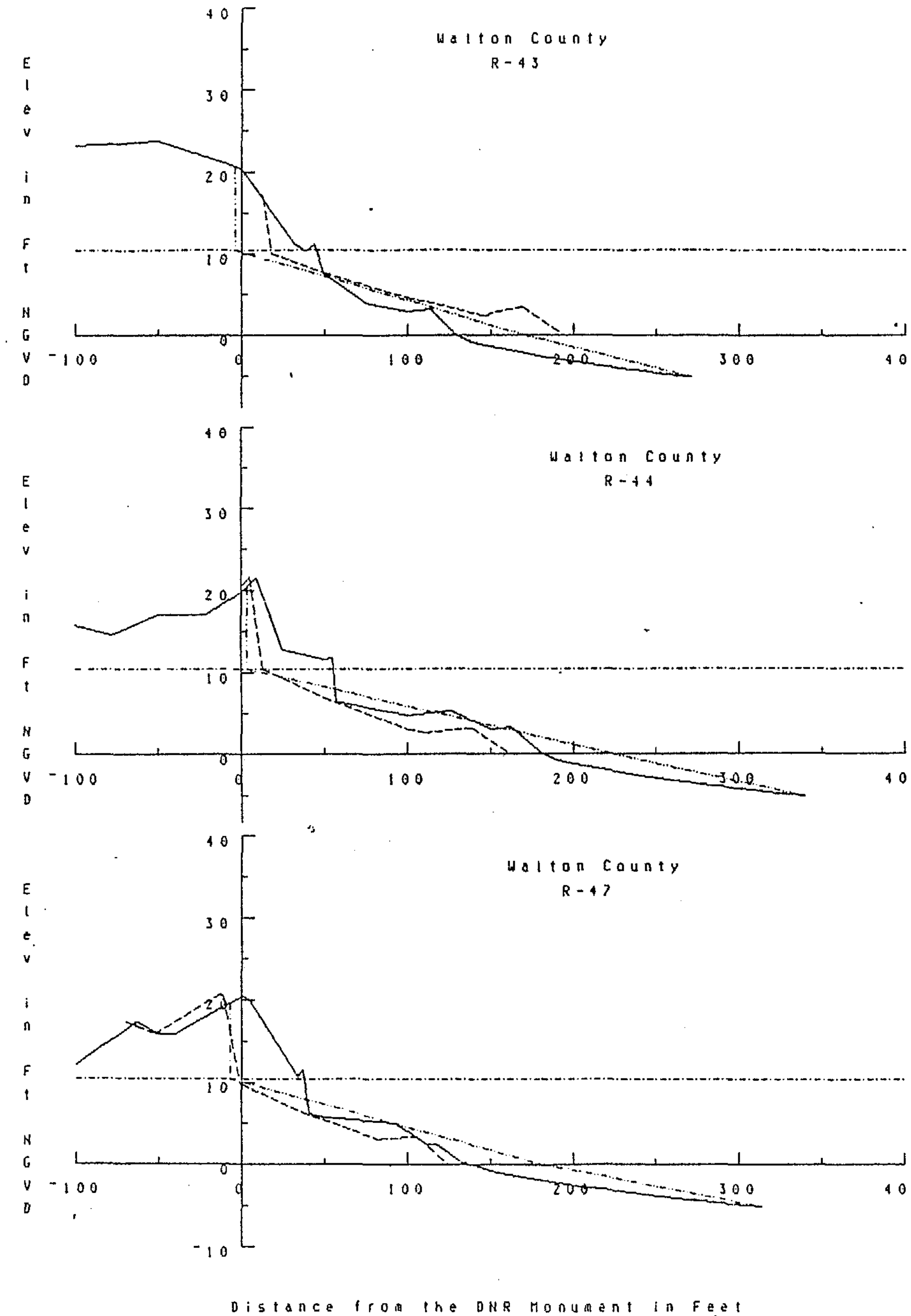
— — — Post-Storm Survey (Oct. 1975)

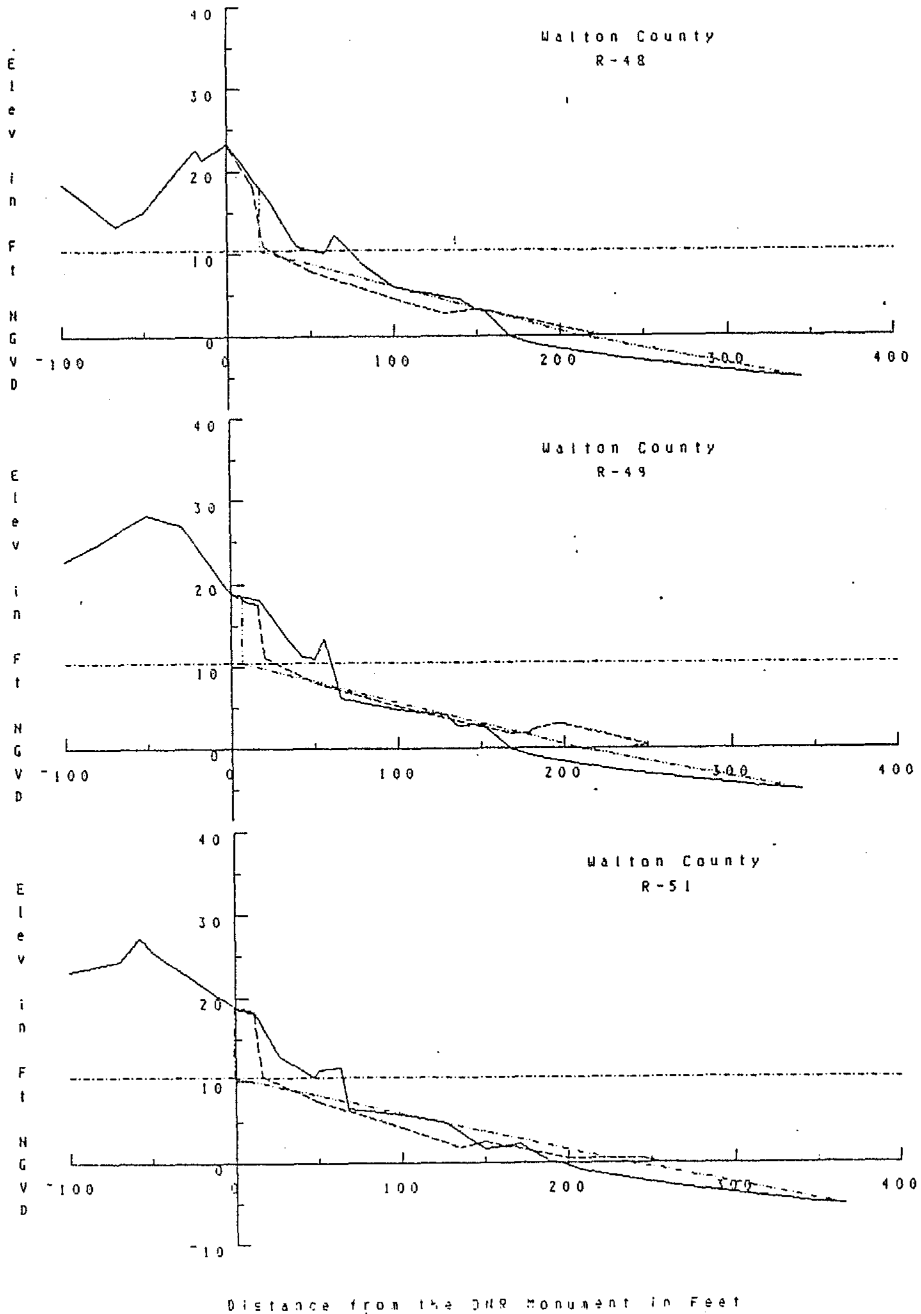
–·–·–·– Storm Surge Still Water Level (10.36 Ft NGVD)

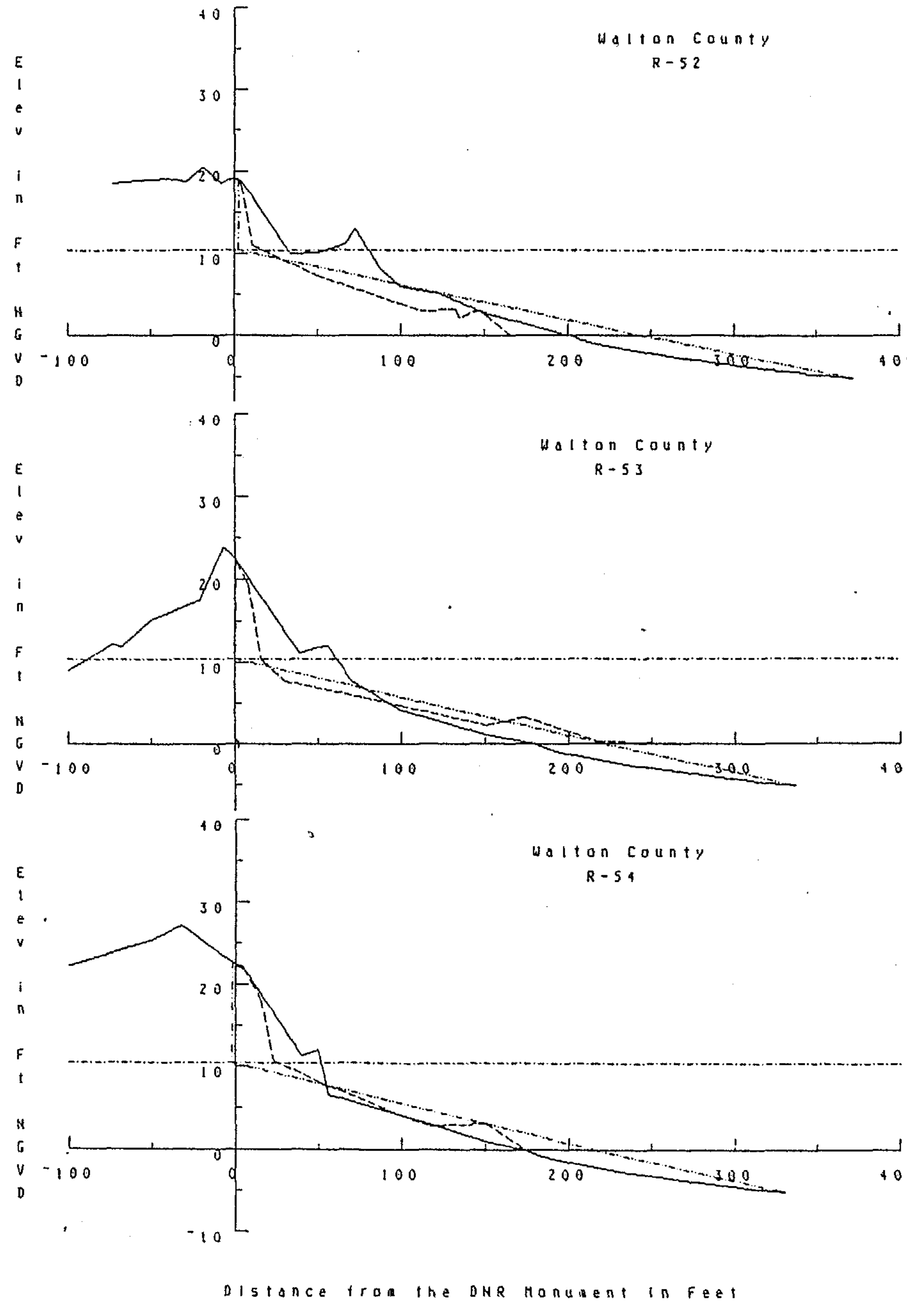
–··–··– Predicted Dune-Bluff Erosion Profile

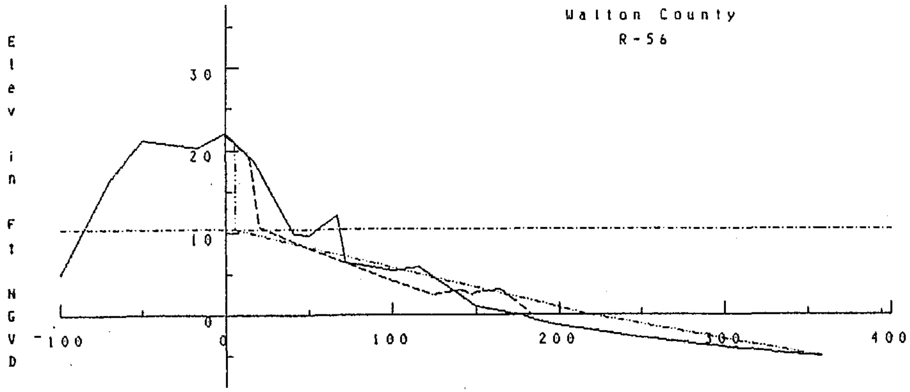


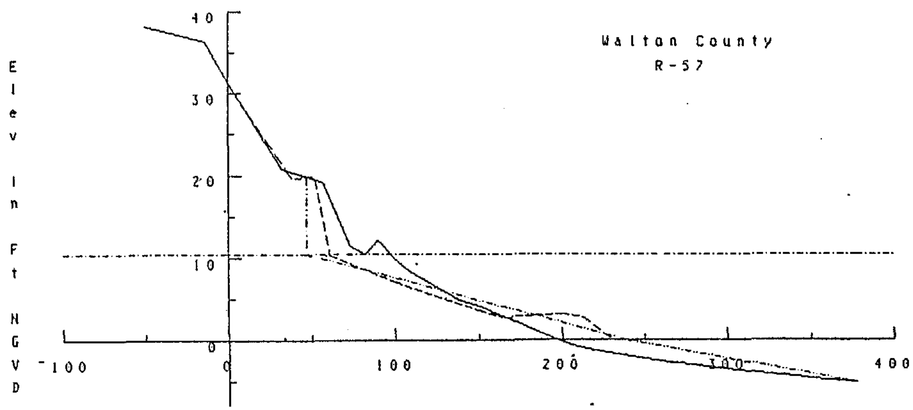

Walton County
R-40
Walton County
R-41
Walton County
R-42
Elev in Ft NGVD
Distance from the DNR Monument in Feet

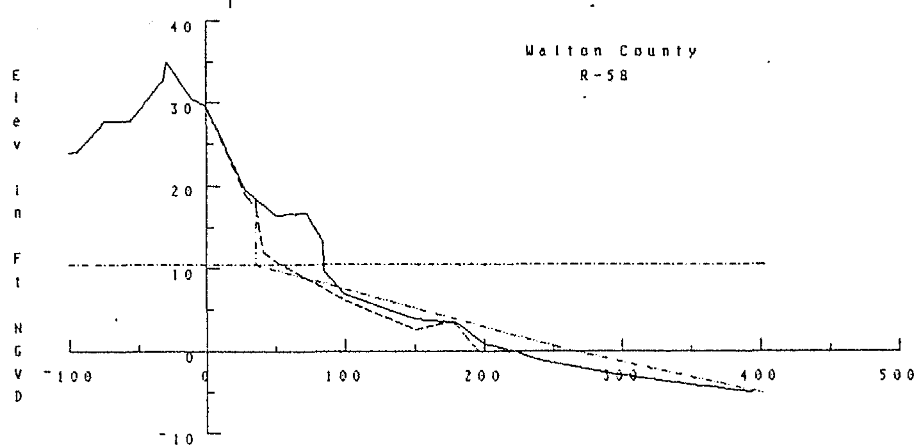

Walton County
R-43
Walton County
R-44
Walton County
R-47
Elev in Ft NGVD
Distance from the DNR Monument in Feet


Walton County
R-48
Walton County
R-49
Walton County
R-51
Elev in Ft NGVD
Distance from the DNR Monument in Feet

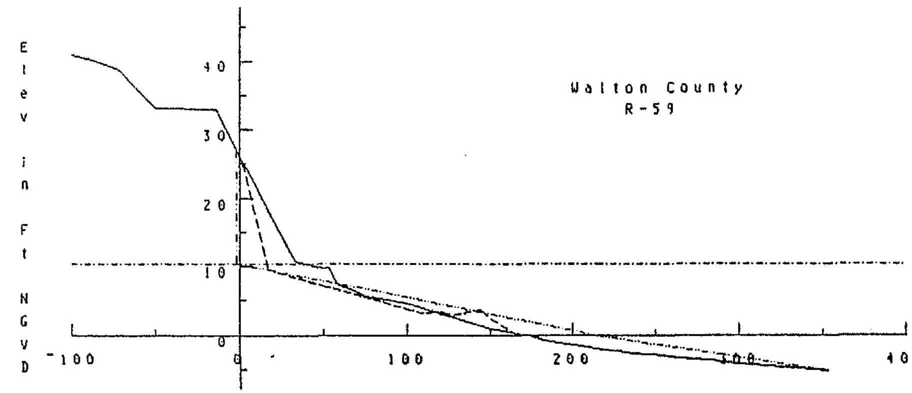

Walton County
R-52
Walton County
R-53
Walton County
R-54
Elev in Ft NGVD
Distance from the DNR Monument in Feet

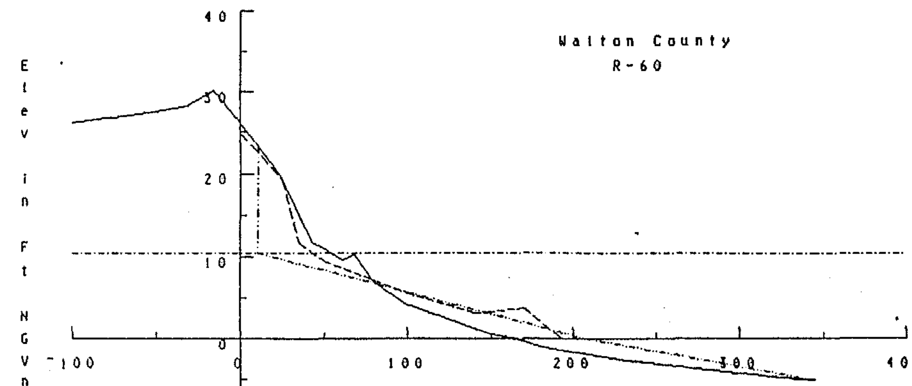


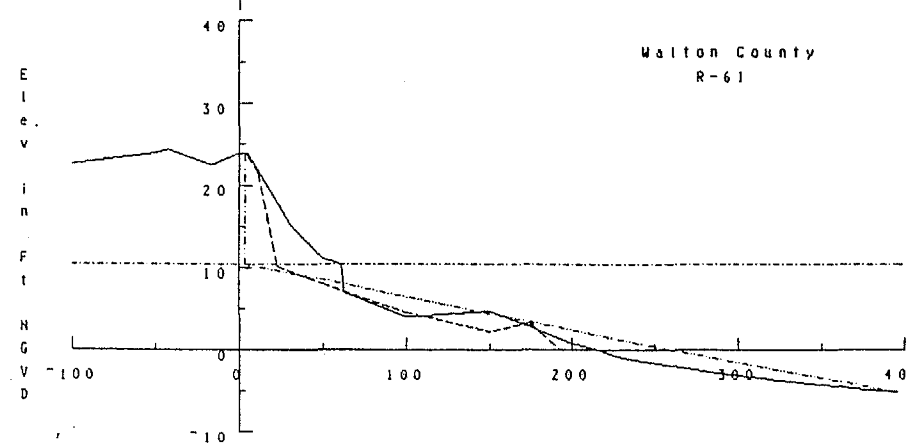




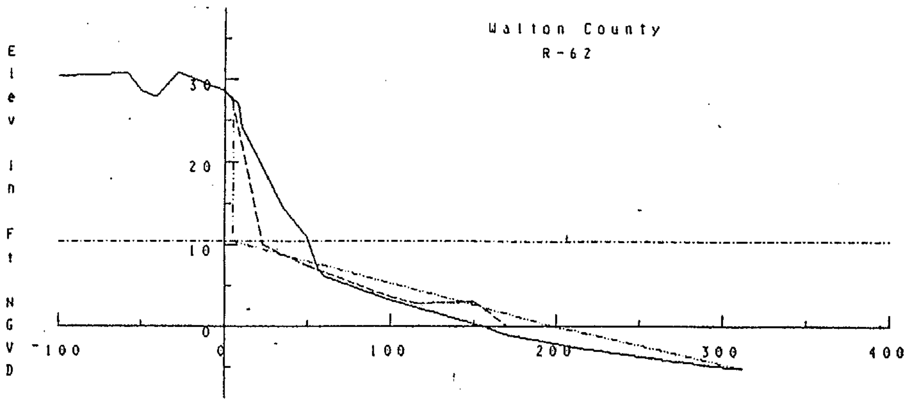
Distance from the DNR Monument in Feet

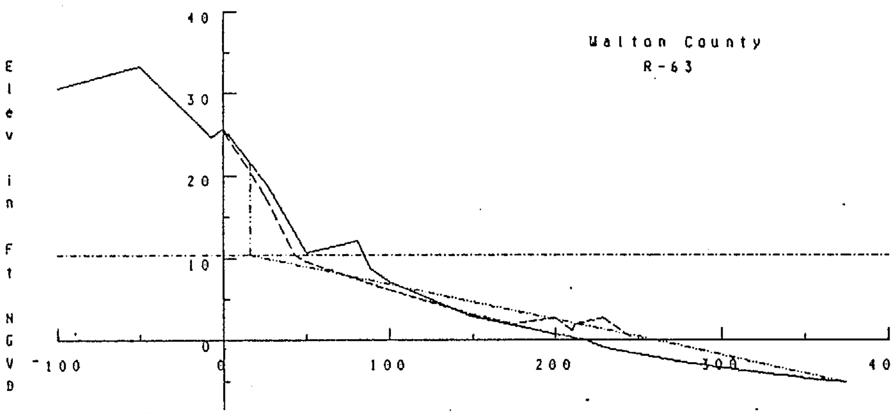


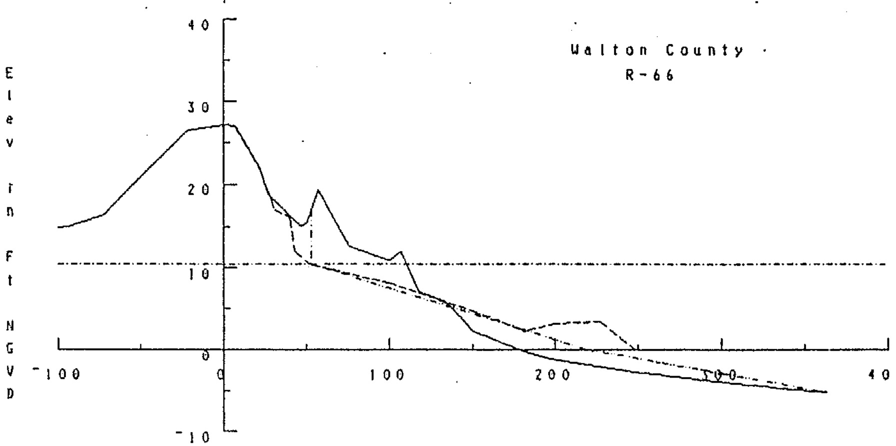




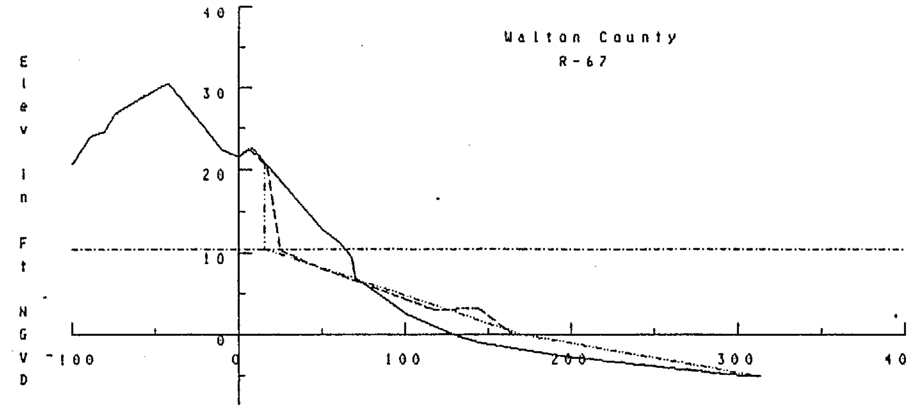
Distance from the DNR Monument in Feet

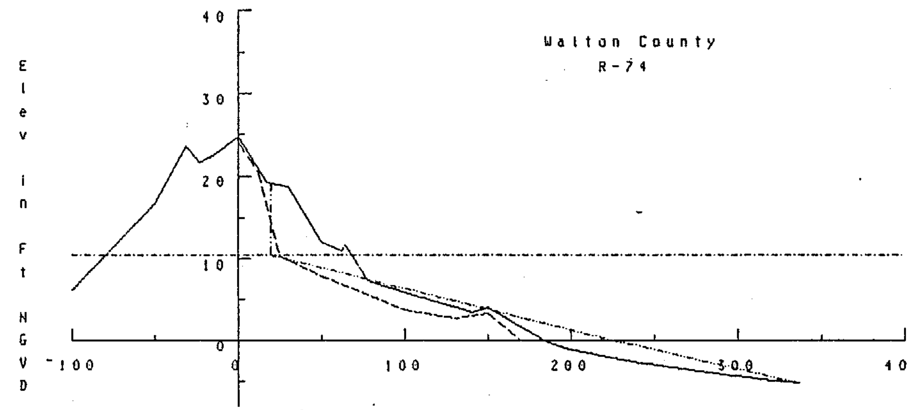


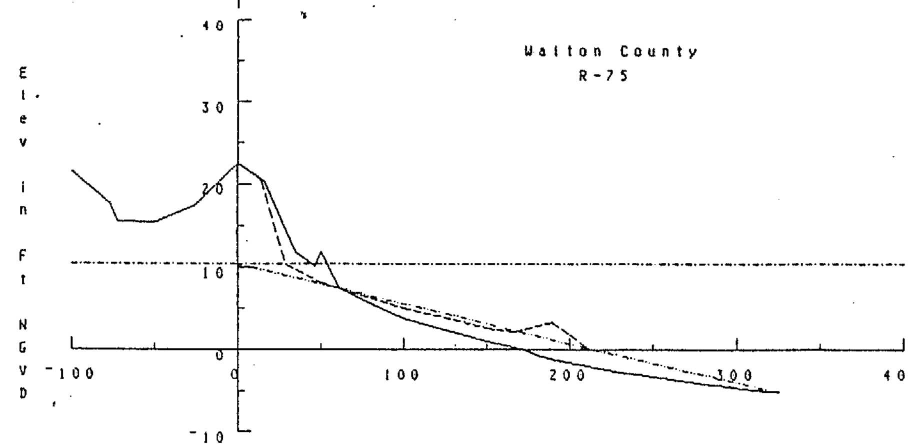




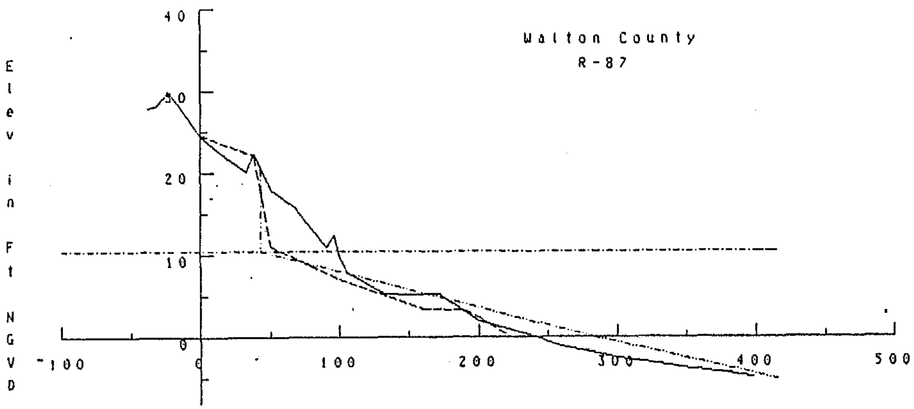
Distance from the DNR Monument in Feet

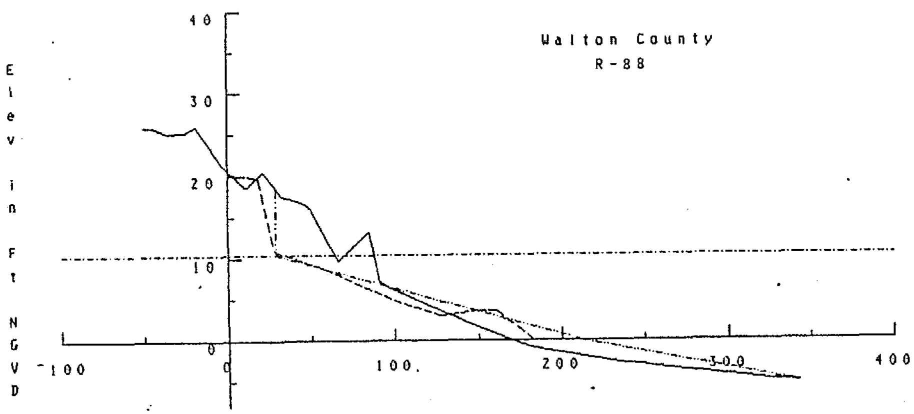


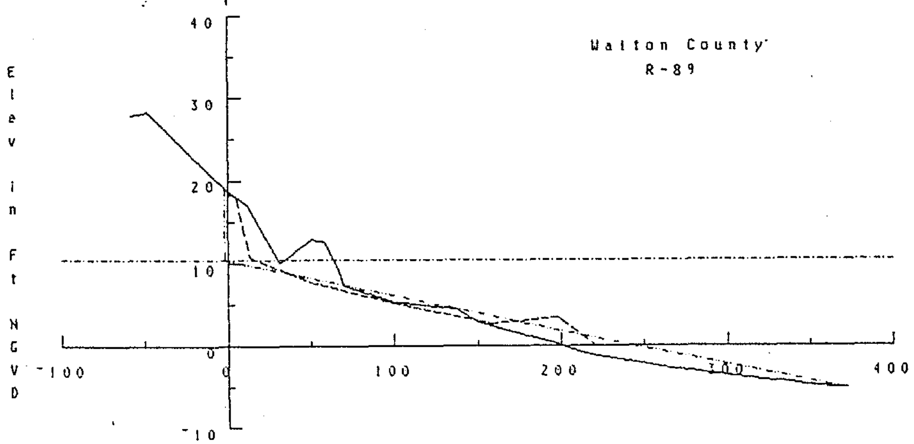




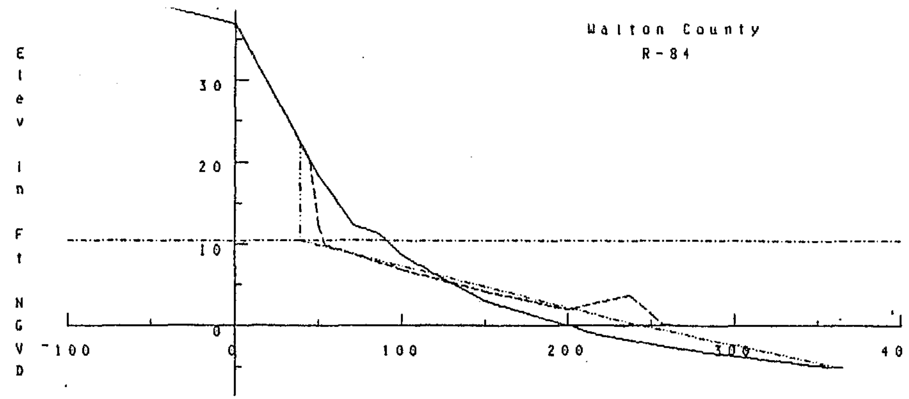
Distance from the DNR Monument in Feet

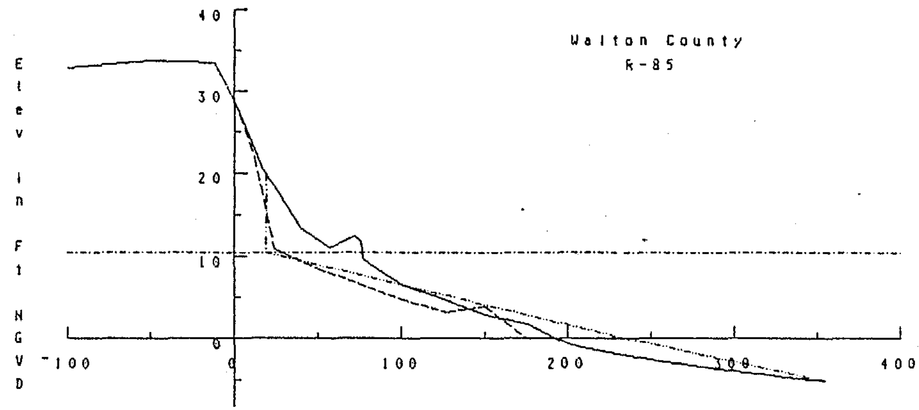


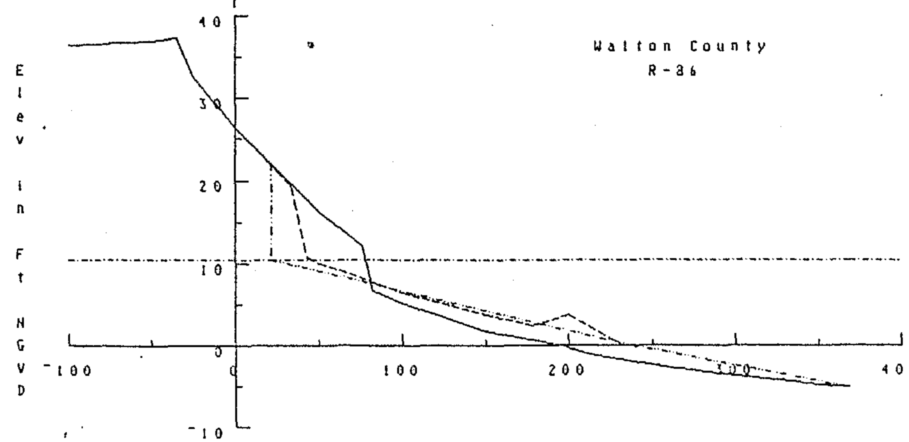




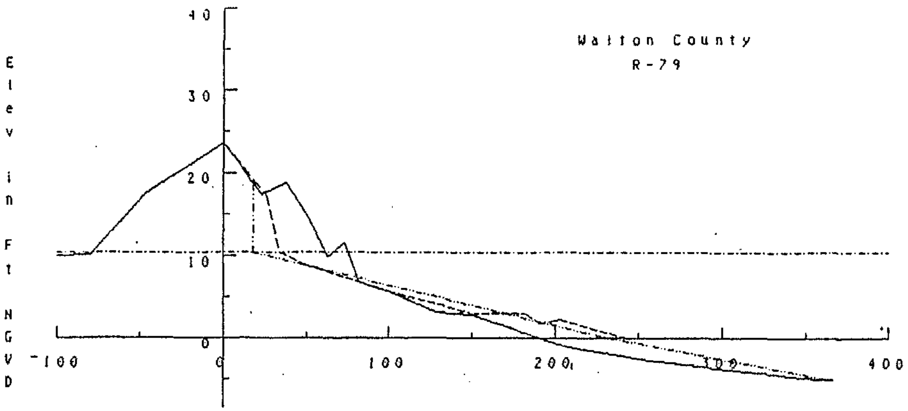
Distance from the DNR Monument in Feet

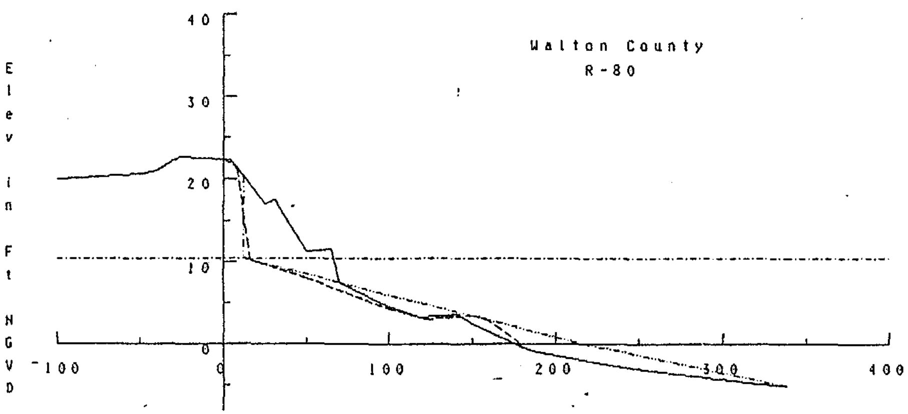


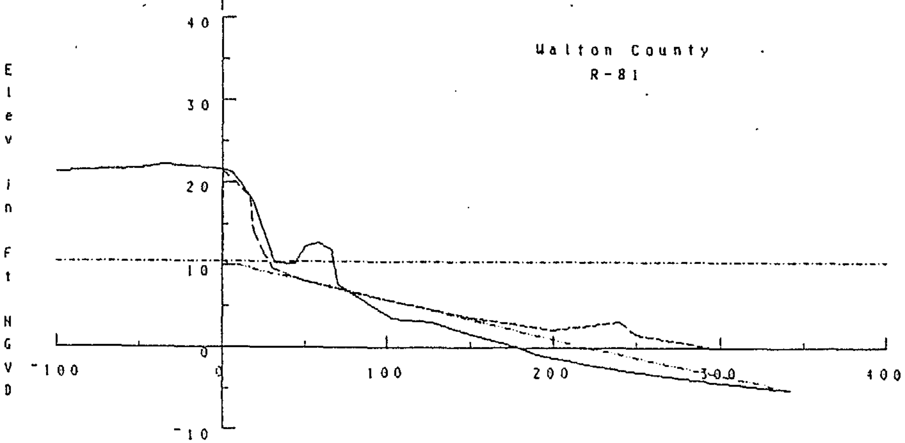




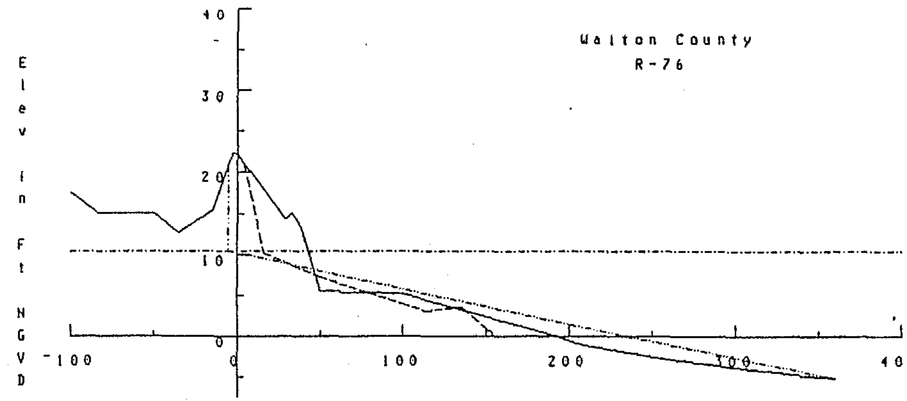
Distance from the DNR Monument in Feet

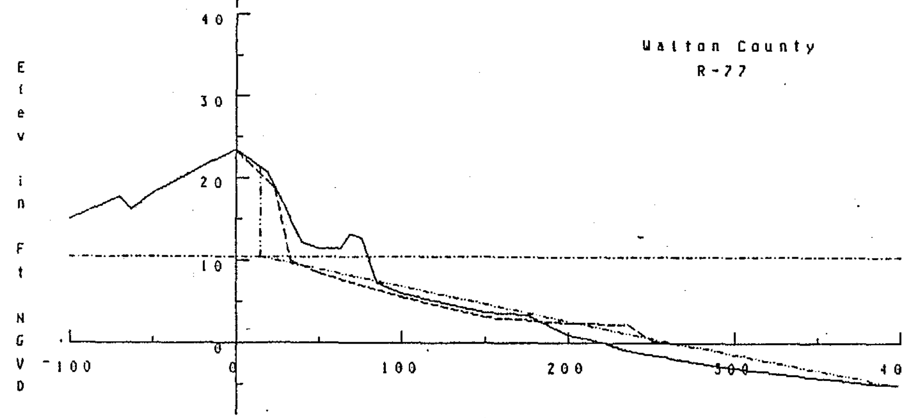


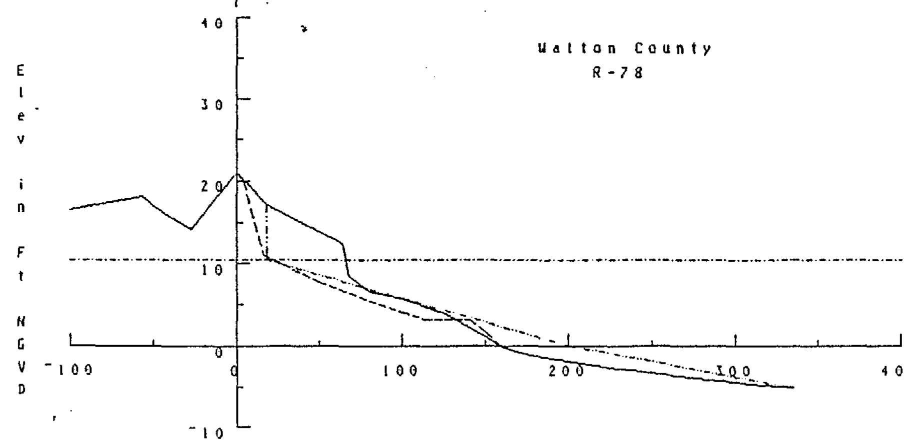




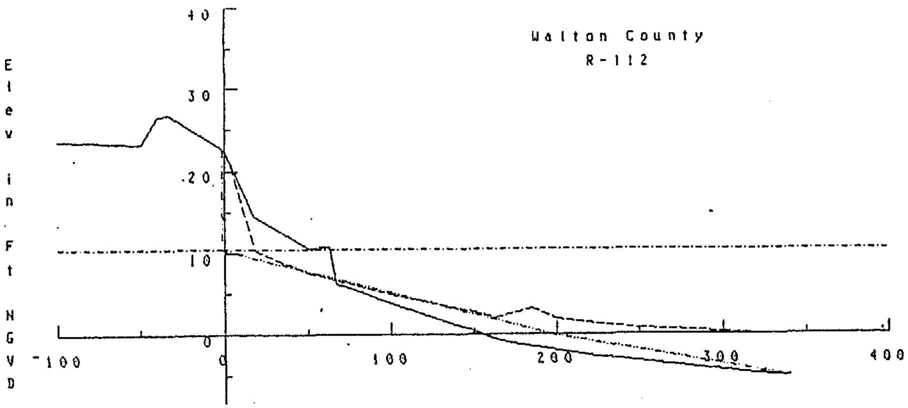
Distance from the DNR Monument in Feet

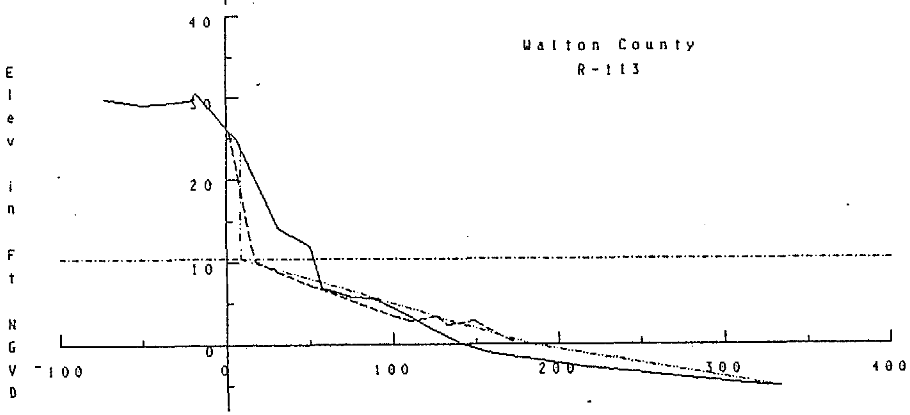


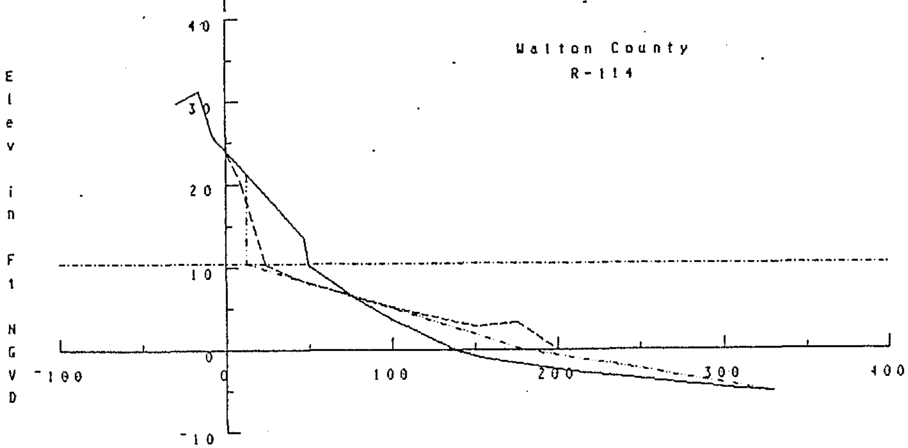




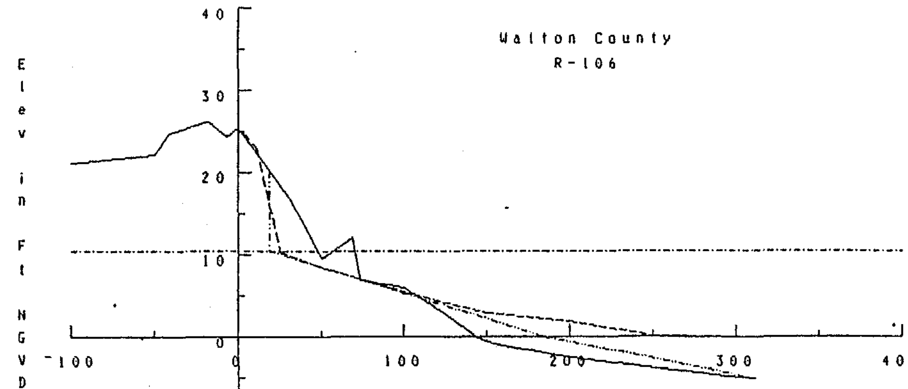
Distance from the DNR Monument in Feet

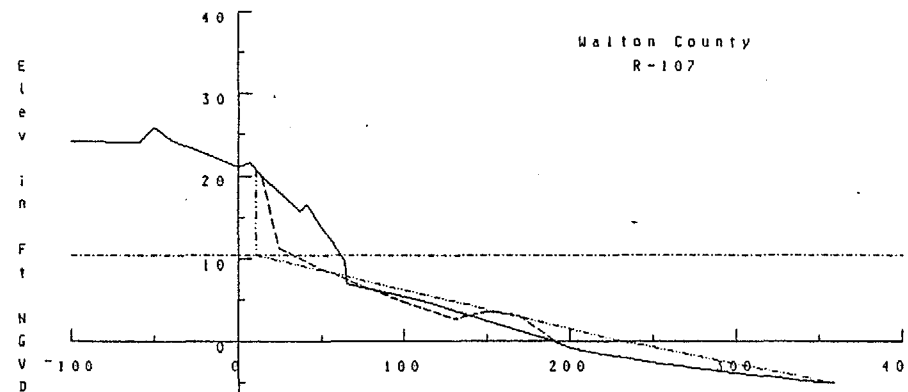


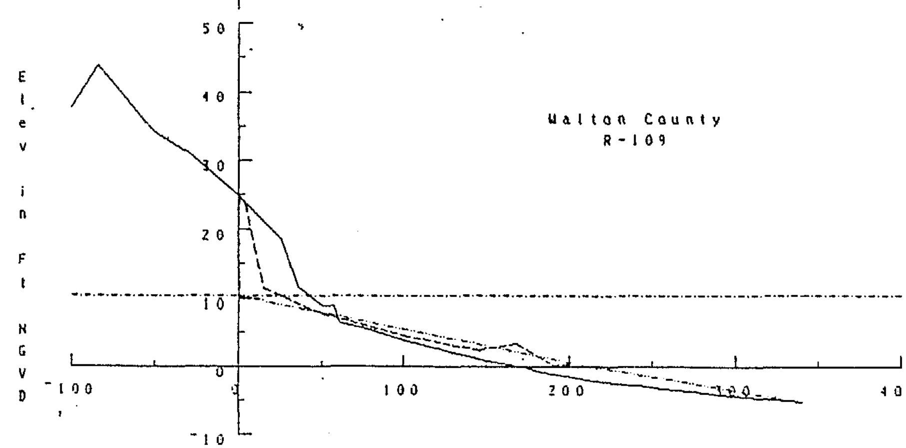




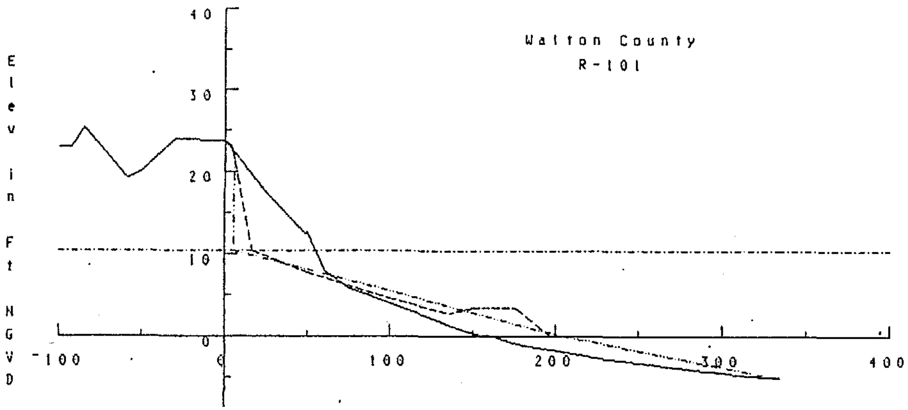
Distance from the DNR Monument in Feet

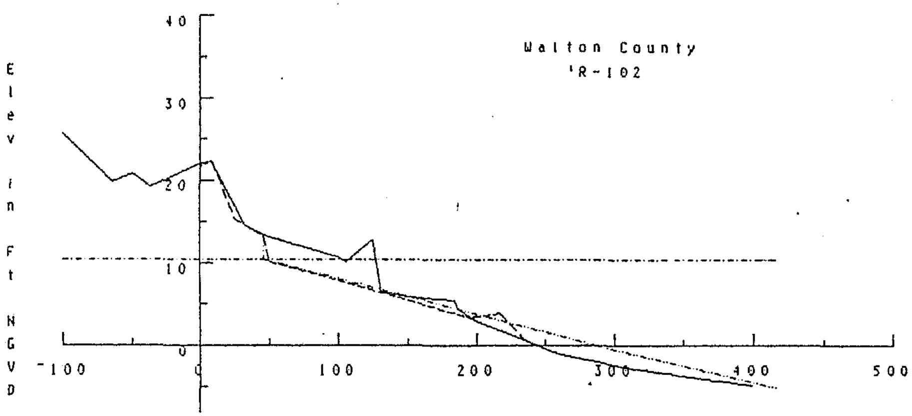


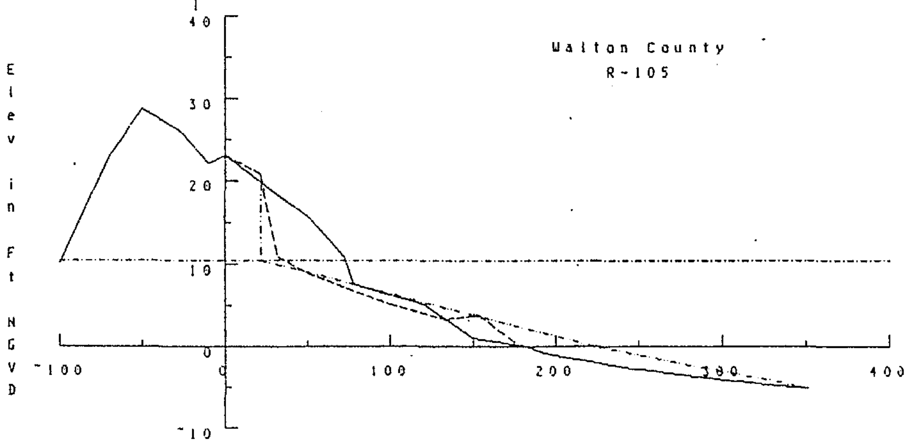




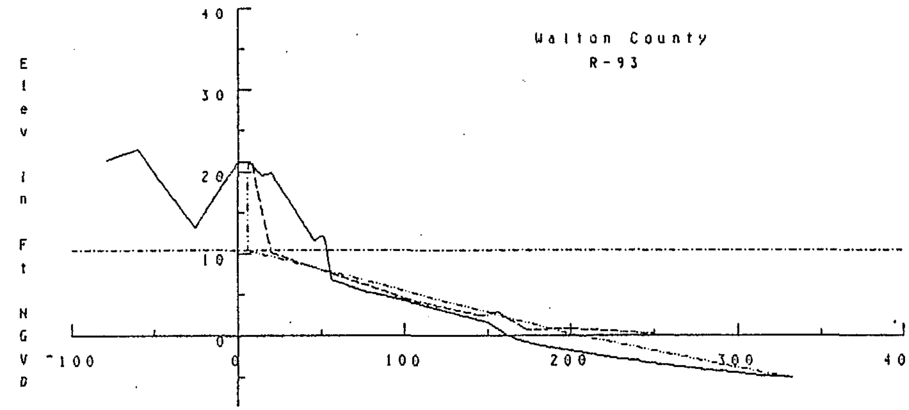
Distance from the DNR Monument in Feet

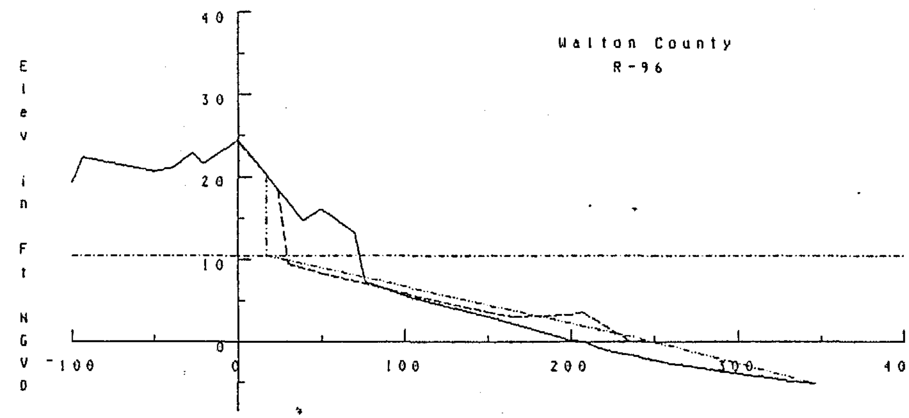


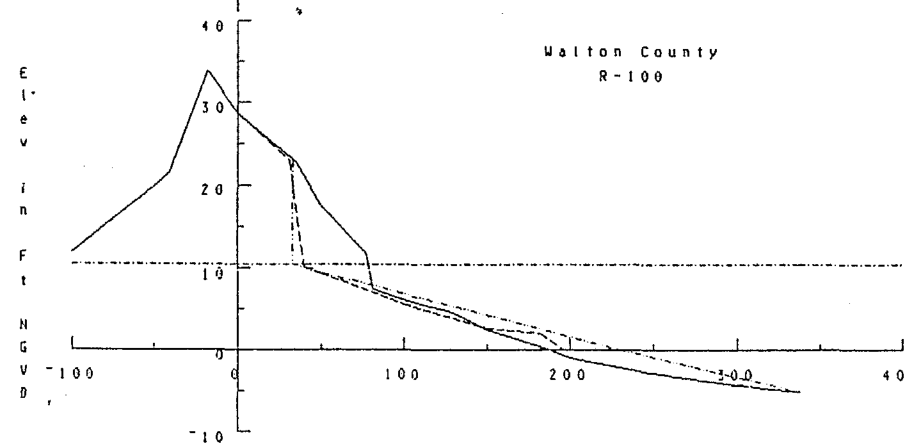




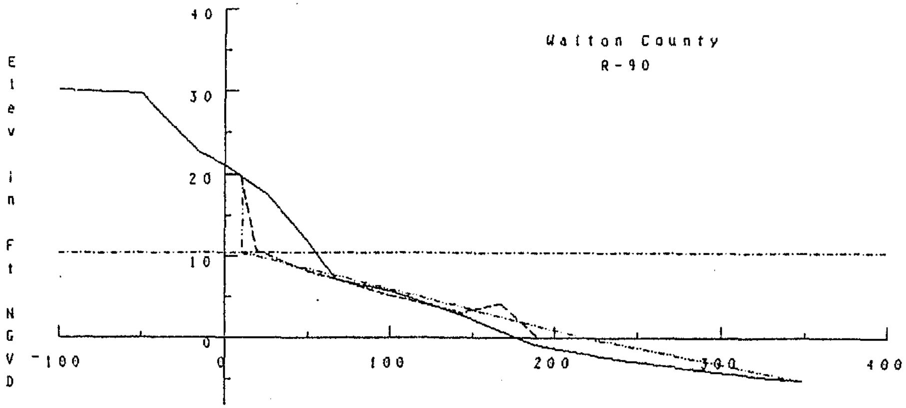
Distance from the DNR Monument in Feet

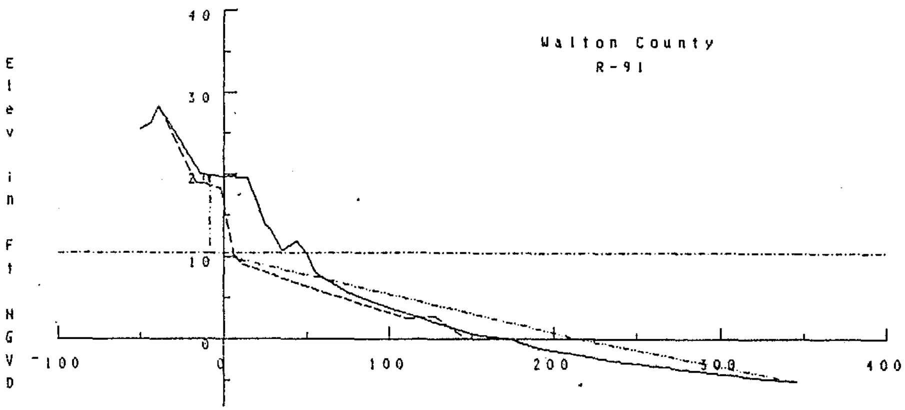


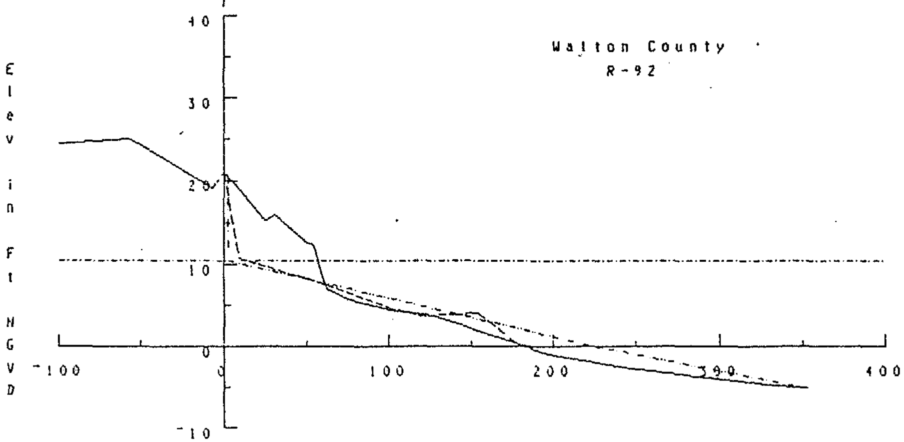




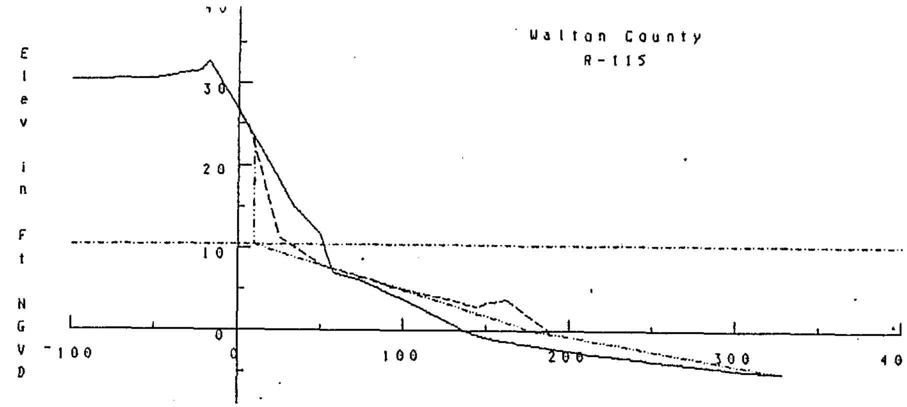
Distance from the DNR Monument in Feet

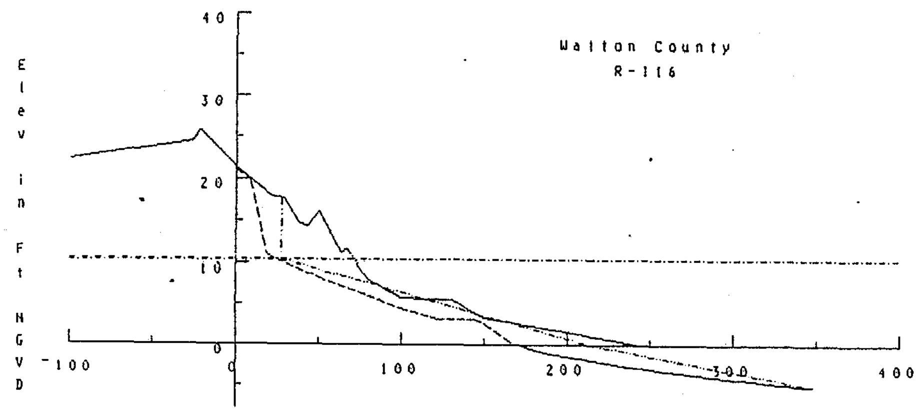


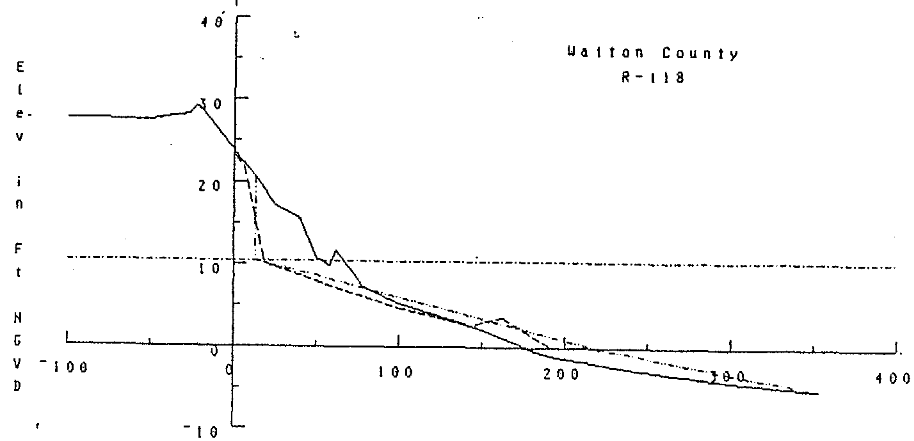




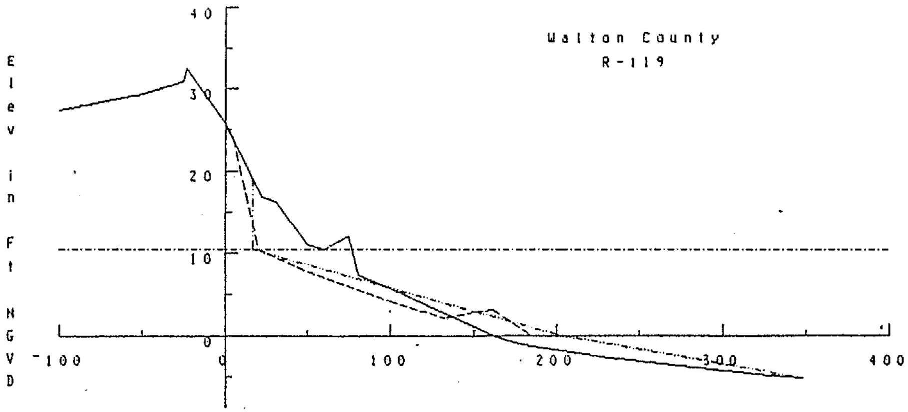
Distance from the DNR Monument in Feet

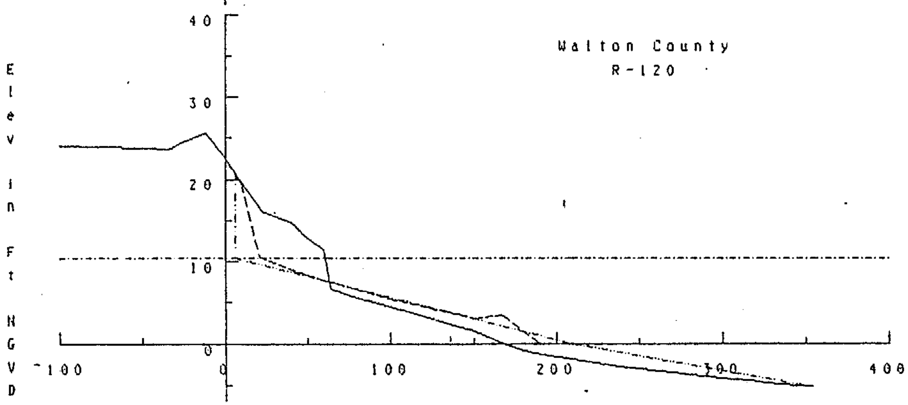


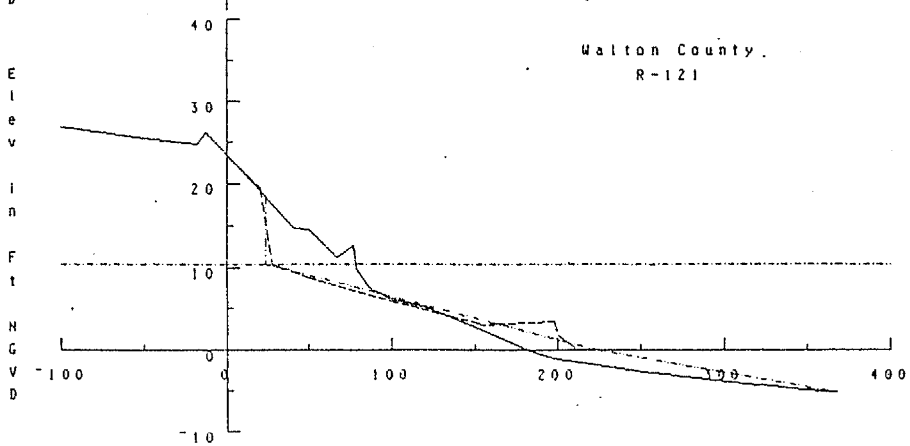




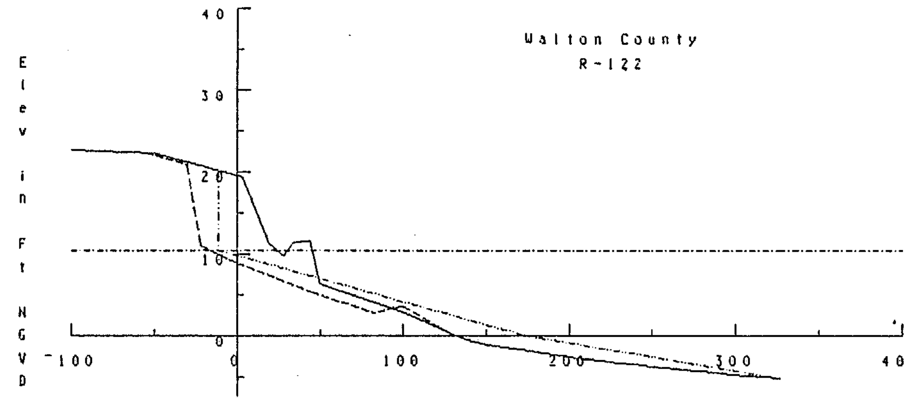
Distance from the DNR Monument in Feet

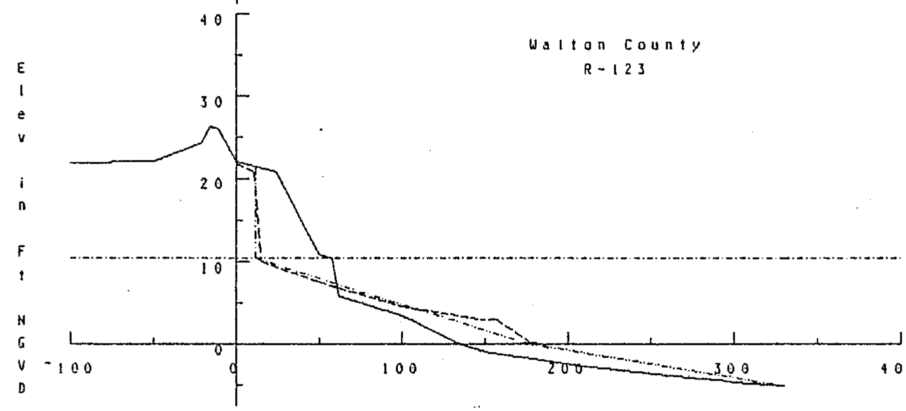


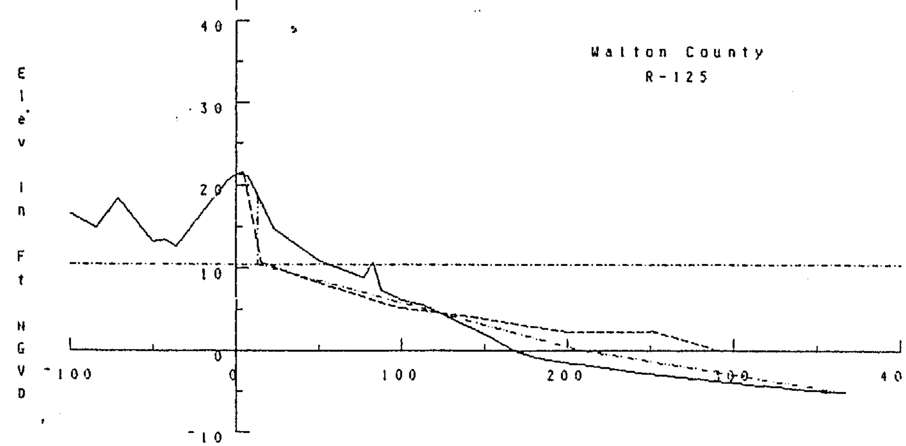




Distance from the DNR Monument in Feet







Distance from the DNR Monument in Feet

APPENDIX II

APL Programs

for

Dune-Bluff Recession

```
      )WSID
IS EROSION
```

HOW

This WORKSPACE provides for dune-bluff horizontal recession using the method developed by Walton and Sensabaugh (1979) for Hurricane Eloise which struck the panhandle coast of Florida in September 1979.

Following is a description of how to use the workspace:

1. Operate in the workspace using the full screen sessions manager (i.e., SMAPL).

2. Type onto the screen.....INPUT.....and enter the requested data. Then wait until the plot appears on the screen or the message....MORE.....appears at the lower right hand corner of the screen (MORE indicates that you must page the screen).

3. Names your plots with a unique label when asked.

4. Use the Full Screen Mode (i.e., PF2 key and COPY ON ID filename) to get file copies of the reports.

5. Report names are TABLE1, ONSHORE and SHAPE. TABLE1 lists the results basic results of the recession model, ONSHORE lists the onshore profile data that your provided, and SHAPE gives the offshore profile curve coefficients where not yet available from Beaches and Shores Technical and Design Memorandum No. 82-1-II (provided you have the offshore data to enter).

6. Exit the workspace (i.e., enter the CMS environment) and invoke either the GPRINT or ADMOPUV module commands (followed by the filenames that you provided).

```
      )FNS
AND      ANNX     ANNY     AVG      AXES     AXIS     AXS      A3D      BY       CDE
CGWRT    CHART    CHECKNAME         CHK      CLEAR    CLIP     CLOSE    CLOSEGP  CMS
COIBM    COLOR    CONTOUR  COPY     COPYID   COPYN    CORR     CSINIT   DECOMMENT
DRAW     ENCODE   ERASE    ERF      FILL     FILLENCODE        FIT      FITFUN   FITFN
FIXVP    FMT      FRAME    FREQ     FRME     FSSAVE   FSSHOW   FTCF     GEP      GRFIELD
HCHART   HIDE     HOR      INDEV0   INDEV1   INDEV3   INPUT    INTERPOLATE
INTERSECTIONS     INTO     ISOMETRIC         LABEL    LBLX     LBLY     LINEAR
LOADSSAUX         LOADSSWS          LOG      LOGLOG   LOC      MAGNIFY  MEMBER   MODE
MSG      NEWPROF  OBLANKS  OBLIQUE  OF       ONSHORE  OPEN     OPENGP   OUTPUT
PERSPECTIVE       PIECHART          PIELABEL          PIELAB   PLO      PLOT     PLOTT1
POLY     POWER    PREPARSE          PROFILE1          PUT      PUTFILE  READ     RESTORE
RESULTS  RETICLE  ROTATE   RSLTS    SAXES    SAXISX   SAXISY   SAXISZ   SCALE    SCISSOR
SCRATCH  SHAPE    SHRFSM   SKETCH   SL       SLABEL   SLBLX    SLBLY    SLBLZ    SM
SMFIELD  SPL      SPLINE   SPLOT    SS       STEP     STEREO   STITLE   STYLE    SURFACE
SURGE    SURVEY   SXFM     SZSF     THREEVIEWS        TITLE    TM       TRANSLATE
TRAVERSE          TYPE     USE      USING    VCAT     VER      VIEW     VIEWPORT
VMG      VS       WANDS    WANDS2   WIDTH    WITH     WRDG     WRITE    WRITESS  W3D
XBLANKS  XFM      PLOT     PLOTINIT          PLINST   PIOV     RELATIVE          STEP
```

```
WT

      )VARS
A         AA        AAA       AD        AE        ALPHA     ALPHANUM            AP        APLFVSS
APL1ISSC            APL2ISSC            ASPEC     A12       A2        B         BB        BSPEC
C         CO        CSPEC     CTLSM     CTLS      C6        DATS      DIST      DNR       E
EXP       FFF       FILE      FULLPATA            FULLPATC            FULLPATG
GDDMCODE            GDDMENT   HOW       I         IN        INC       LABA      LABB      LABC
LABD      LABE      LABF      LABG      LABH      LNX       LNY       N         NAME      NEWX
NEWY      NUM       OFFDATE   ONDATE    OPENFILES           PROCACG   PROFID    RETPER    R1
SEQNO     SOURCE    SSX       SSY       TABLE1    TYPEPR    X         XA        XE        XEP
XN        XNP       XSS       X1        Y         YA        YE        YEP       YMAX      YN
YNP       YSS       Y1        Y2        ALPHA     AMC       APDSK     APFSM     APSM      AV
BW        CO        COPYCTL   COPYNAME            CUR       CVP       DD        DLC       EPS
ERMGP     FITMSG    FITPTS    GF        LGA       MSGW      OFX       OFY       OLD       PA
PC        PIE       POS       PTS       SBW       SCI       SF        SM        SMF       SVP
SW        TM        W


      ∇INPUT[⎕]∇
      ∇ INPUT
[1]   ⍝ PURPOSE OF FUNCTION:  REQUESTS INPUT DATA EXCEPT FOR STORM SURGE
[2]   ⍝ INFORMATION.
[3]   '*******************************************************************'
[4]   ''
[5]   'OFFSHORE PROFILE:'
[6]   'Enter Exponent:'
[7]   EXP←⎕
[8]   'Enter Shape Factor:'
[9]   ASPEC←A←⎕
[10]  'Date of Survey:'
[11]  OFFDATE←⍞
[12]  '-------------------------------------------------------------------'
[13]  ''
[14]  'ONSHORE PROFILE DATA:'
[15]  'Enter distances measured from orignal shoreline at 0 NGVD'
[16]  '(Enter in ascending numberical order in feet):'
[17]  X←⎕
[18]  'Enter elevation corresponding to distances just specified (Ft NGVD):'
[19]  Y←⎕
[20]  'Date of Survey:'
[21]  ONDATE←⍞
[22]  'Profile Type (Pre-Const or Post-Const):'
[23]  TYPEPR←⍞
[24]  '-------------------------------------------------------------------'
[25]  ''
[26]  'DNR REFERENCE MONUMENT INFO:'
[27]  'Enter DNR reference monument number (e.g., R-26):'
[28]  NUM←⍞
[29]  'County Name:'
[30]  CO←⍞
[31]  'Enter distance that range line is from the reference monument:'
[32]  '(e.g., N300 indicates range is 300 feet north of specified monument):'
[33]  DNR←⍞
[34]  'Enter distance from the normal existing shoreline to the CCCL in feet:'
[35]  DIST←⎕
[36]  '-------------------------------------------------------------------'
[37]  ''
[38]  'ADMINISTRATIVE INFO:'
[39]  'Enter File Number:'
[40]  FILE←⍞
[41]  'Full name of the engineer responsible for the input data:'
[42]  NAME←⍞
[43]  SURGE
      ∇


      ∇SURGE[⎕]∇
      ∇ SURGE
[1]   ⍝ PURPOSE OF FUNCTION:  REQUEST STORM SURGE INFORMATION.
[2]   '-------------------------------------------------------------------'
[3]   ''
[4]   'STORM SURGE INFO:'
[5]   'Enter storm surge elevation in feet NGVD:'
[6]   CSPEC←C←⎕
[7]   'Enter the return event which this storm surge represents'
[8]   '(e.g., 100 for the 100-year return event):'
[9]   RETPER←⎕
[10]  'Source of storm surge information (e.g., NOAA, U of F, etc.,):'
[11]  SOURCE←⍞
[12]  '*******************************************************************'
[13]  SEQNO←SEQNO+1
[14]  WANDS
      ∇


      ∇WANDS[⎕]∇
      ∇ WANDS;ACFG;ADFG;CEGH;DEGH;D;AR1;AR2;K;AR;J;M;A1;CC1E;EJHI;AREA;C1RHQ;TE
        ST;XC;YD
[1]   ⍝ PURPOSE OF FUNCTION:  DETERMINES DUNE-BLUFF HORIZONTAL RECESSION
[2]   ⍝ USING THE WALTON--SENSABAUGH METHOD (1979) FOR HURRICANE ELOISE
[3]   ⍝ OF SEPT 1975, WHERE THE PROFILE IS NOT INUNDATED.
[4]    X1←X[⍋X]
[5]    Y1←⊖Y
[6]   ⍝ MAJOR OFFSHORE AREAS.
[7]    YA←C÷2
[8]    XA←(YA÷A)*(1÷EXP)
[9]    XC←C×4
[10]   ACFG←(30-(YA÷2))×(XA-XC)
[11]   YD←A×(XC*EXP)
[12]   ADFG←(30-((YA+YD)÷2))×(XA-XC)
[13]   CEGH←XC×30
[14]   DEGH←(30-(YD÷2))×XC
[15]   D←(ACFG-ADFG)+(CEGH-DEGH)
[16]  ⍝ ONSHORE AREAS EXCEPT FOR AREA CC1E
[17]   AR1←AR2←⍳0
[18]   K←1
[19]   AR←(((Y1[K]+30)+(Y1[K+1]+30))÷2)×(X1[K]-X1[K+1])
[20]   AR1←AR1,AR
[21]   K←K+1
[22]   →16×⍳K≠(⍴X1+1)
[23]   J←0
[24]  L3:NEWX←(1↑X1)-J
[25]   M←(Y1[1]-Y1[2])÷(X1[1]-X1[2])
[26]   A1←Y1[2]-(M×X1[2])
[27]   NEWY←Y1[1]+(M×J×¯1)
[28]   AR2←AR2,(((NEWY+Y1[1])÷2)+30)×J
```

```
[29]  X1←NEWX,1↓X1
[30]  Y1←NEWY,1↓Y1
[31]  →L1×⍳X1[1]<X1[2]
[32]  BSPEC←B←C÷(XC+NEWX)
[33]  →L2×⍳C≥1↑Y[⍒Y]
[34]  Y2←B×(180÷○1)
[35]  A2←B×XC
[36]  CC1E←0.5×A2×XC
[37]  EJHI←(((1↑⊖Y1)÷2)+30)×(1↑⊖X1)
[38]  AREA←((+/AR1)−(+/AR2))+EJHI
[39]  C1RHQ←(((A2+C)÷2)+30)×NEWX
[40] ⍝ RESULTS
[41]  AE←AREA−C1RHQ
[42]  AD←D+CC1E
[43]  TEST←AE−AD
[44]  J←0.5
[45]  →L3×⍳TEST>0
[46]  RESULTS
[47]  →0
[48] L1:X1←1↓X1
[49]  Y1←1↓Y1
[50]  AR1←1↓AR1
[51]  AR2←⍳0
[52]  →L3×⍳⍴X1≥0
[53]  →0
[54] L2:WANDS2
     ∇

     ∇WANDS2[⎕]∇
     ∇ WANDS2;ACFG;ADFG;CEGH;DEGH;D;AR1;AR2;K;AR;J;M;A1;CC1E;EJHI;AREA;C1RHQ;T
       EST;XC;YD
[1]  ⍝ PURPOSE OF FUNCTION:  DETERMINES DUNE-BLUFF HORIZONTAL RECESSION
[2]  ⍝ USING THE WALTON--SENSABAUGH METHOD (1979) FOR HURRICANE ELOISE
[3]  ⍝ OF SEPT 1975, WHERE THE PROFILE IS INUNDATED.
[4]   AR2←AR1←XX←YY←⍳0
[5]   C←1↑Y[⍒Y]
[6]   N←(⍴X)−⍴(Y1←(X≥((Y=C)/X))/Y)
[7]   X1←(X≥((Y=C)/X))/X
[8]   K←1
[9]  L1:AR1←AR1,(((Y[K]+30)+(Y[K+1]+30))÷2)×(X[K+1]−X[K])
[10]  K←K+1
[11]  →L1×⍳K≠N+1
[12]  XX←(N+1)↑X
[13]  YY←(N+1)↑Y
[14]  J←0.5
[15] L2:NEWX←X1[1]+J
[16]  M←(Y1[2]−Y1[1])÷(X1[2]−X1[1])
[17]  A1←Y1[1]−(M×X1[1])
[18]  NEWY←Y1[1]−M×J×¯1
[19]  YA←NEWY÷2
[20]  XA←(YA÷A)⋆1÷EXP
[21]  XC←NEWY×4
[22]  ACFG←(30−(YA÷2))×XA−XC
[23]  YD←A×XC⋆EXP
[24]  ADFG←(30−((YA+YD)÷2))×XA−XC
[25]  CEGH←XC×30
[26]  DEGH←(30−YD÷2)×XC
[27]  D←(ACFG−ADFG)+(CEGH−DEGH)
[28]  AR2←AR2,(((NEWY+1↑⌽YY)÷2)+30)×0.5
[29]  XX←XX,NEWX
[30]  YY←YY,NEWY
[31]  NEWX
[32]  →L3×⍳NEWX≥X[N+2]
[33]  B←NEWY÷(XC+NEWX)
[34]  Y2←B×180÷○1
[35]  A2←B×XC
[36]  CC1E←0.5×A2×XC
[37]  EJHI←((Y[2]÷2)+30)×X[2]
[38]  AREA←(+/AR1)+(+/AR2)
[39]  C1RHQ←(((A2+NEWY)÷2)+30)×NEWX
[40]  AE←AREA−C1RHQ
[41]  AD←D+CC1E
[42]  TEST←AE−AD
[43]  TEST
[44]  J←J+0.5
[45]  C←NEWY
[46]  →L2×⍳TEST<0
[47]  RESULTS
[48]  →0
[49]  →L4×⍳((⍴X1)=1)∧(NEWX≥X1[1])
[50] L3:N←N+1
[51]  J←0.5
[52]  X1←1↓X1
[53]  Y1←1↓Y1
[54]  →L4×⍳(⍴X1)=0
[55]  XX←(⌽1↓⌽XX),X1[1]
[56]  YY←(⌽1↓⌽YY),Y1[1]
[57]  AR2←AR2[⍳(⍴AR2)−1],(30+(Y1[1]+YY[⍴YY])÷2)×X1[1]−XX[⍴XX]
[58]  →L2×⍳(⍴X1)>0
[59] L4:'YOUR DATA DOES NOT EXTEND FAR ENOUGH IN THE UPLAND DIRECTION'
[60]  'TO COMPUTE THE DUNE EROSION.'
     ∇

     ∇RESULTS[⎕]∇
     ∇ RESULTS;L;K;X0;X01;Y01
[1]  ⍝ PURPOSE OF FUNCTION:  ACCUMULATES THE FINAL ERODED PROFILE DATA.
[2]   L←19
[3]   X0←0
[4]   K←XA÷20
[5]  L1:X0←X0,L×K
[6]   X01←(¯1×(20↑XA,1↓X0)),0
[7]   L←L−1
[8]   →L1×⍳L>0
[9]   Y01←¯1×(A×((¯1×X01)⋆EXP))
[10]  XN←¯1×(X01,X)
[11]  YN←Y01,Y
[12]  XE←¯1×(NEWX,NEWX,(¯1×4×C),¯1×XA)
[13]  YE←(1↑Y1),C,0,¯1×YA
[14]  PLOTT1
     ∇

     ∇PLOTT1[⎕]∇
     ∇ PLOTT1;IX;IE;XNN;YNN;XEN;YEN;XNA;IIN;XXX;YYY;IIE;YYE;ANS
[1]  ⍝ PURPOSE OF FUNCTION:  TESSELATES PROFILE DATA FOR PLOTTING WITH
[2]  ⍝ A HORIZONTAL SCALE OF 1 INCH = 50 FEET AND A VERTICAL SCALE OF
```

```
[3]  ⍝ 1 INCH = 10 FEET.
[4]   YYY←XXX←YYE←10
[5]   XNN←DIST+⌽XN
[6]   IX←XNN≥¯500
[7]   XNN←IX/XNN
[8]   YNN←IX/⌽YN
[9]   XEN←XE+DIST
[10]  IE←XEN≥¯500
[11]  XEN←IE/XEN
[12]  YEN←IE/YE
[13]  XNA←⌈100×¯1+(⌈XNN[1]÷100)
[14]  I←XNA,XNA+500
[15] L1:→L6×⍳(⍴XNN)=0
[16]  IIN←(XNN≥I[1])∧XNN≤I[2]
[17]  XNP←XXX,IIN/XNN
[18]  YNP←YYY,IIN/YNN
[19]  IIE←(XEN≥I[1])∧XEN≤I[2]
[20]  XEP←XXX,IIE/XEN
[21]  YEP←YYE,IIE/YEN
[22]  →L4×⍳(XNN[⍴XNN]<I[2])∨(YNP[⍴YNP]≤0)
[23]  ((XNN[(⍴XNP)+1]),XNP[⍴XNP]) LINEAR((YNN[(⍴YNP)+1]),YNP[⍴YNP])
[24]  XNP←XNP,I[2]
[25]  YNP←YNP,AA+BB×I[2]
[26] L4:XNP←XNP,I[2]
[27]  YNP←YNP,¯1×A×(I[2]-DIST)*EXP
[28]  →L2×⍳((⍴XEP)=0)∨(XEP[1]=I[1])∨((⍴YEN)=⍴YEP)
[29]  ((XEN[(⍴XEP)+1]),XEP[⍴XEP]) LINEAR((YEN[(⍴YEP)+1]),YEP[⍴YEP])
[30]  XEP←XEP,I[2]
[31]  YEP←YEP,AA+BB×I[2]
[32]  →L2×⍳XEP[⍴XEP]<XEN[⍴XEN]
[33]  XEP←⌽1↓⌽XEP
[34]  YEP←⌽1↓⌽YEP
[35] L2:XSS←I[1],I[2]
[36]  YSS←C×((⍳⍴XSS)÷⍳⍴XSS)
[37]  YMAX←40+1↑YNP[⍋YNP]
[38]  PLO
[39]  VIEW
[40]  'DO YOU WANT A HARDCOPY PLOT (YES OR NO)?'
[41]  ANS←⍞
[42]  →L3×⍳(ANS[1]='Y')
[43]  →L5
[44] L3:'GIVE THE PLOT A NAME:'
[45]  E←⍞
[46]  COPYN E
[47] L5:XXX←XNP[⍴XNP]
[48]  YYY←YNP[⍴YNP]
[49]  YYE←YEP[⍴YEP]
[50]  I←I+500
[51]  XNN←(⍴XNP)↓XNN
[52]  YNN←(⍴YNP)↓YNN
[53]  XEN←((⍴XEN)-1)↓XEN
[54]  YEN←((⍴YEN)-1)↓YEN
[55]  →L6×⍳(⍴XNN)=0
[56]  →L1×⍳((XNP[⍴XNP])<XNN[⍴XNN])
[57] L6:RSLTS
     ∇

     ∇PLO[⎕]∇
     ∇ PLO;YLOC;XLOC
[1]  ⍝ PURPOSE OF FUNCTION:  PRODUCES THE FINAL PLOT(S) USING IBM
[2]  ⍝ SOFTWARE FROM LIB 2 GRAPHPAK.
[3]   ERASE
[4]   RESTORE
[5]   IM← 1 1
[6]   PA←STYLE 1 6 4 ,COLOR 7 7 7
[7]   SVP← 10 10 86 50
[8]   COPYCTL← 0 0 1 66 0 0 0 80 0 80 132
[9]   →L1×⍳((YSS[1]>9.9)∧YSS[1]<10.1)∨((YSS[1]>19.9)∧YSS[1]<20.1)
[10] L2:
[11]  PLOT(YNP VS XNP) AND(YEP VS XEP) AND(YSS VS XSS) AND YMAX VS I[2]
[12]  10 ANNY 'Elev in Ft NGVD'
[13]  ¯1 ANNX 'Distance from the CCCL in Feet'
[14]  YLOC←10×(⌈YMAX÷10)
[15]  XLOC←I[2]-125
[16]  (XLOC,YLOC-2) TITLE(CO,' County')
[17]  (XLOC,YLOC-4) TITLE(DNR,' ft from ',NUM)
[18]  (XLOC,YLOC-6) TITLE 'Upl Surv Date: ',ONDATE
[19]  →0
[20] L1:YSS←YSS+0.1
[21]  →L2
     ∇

     ∇RSLTS[⎕]∇
     ∇ RSLTS;DATE;DAT1;DAT2;DAT3
[1]  ⍝ PURPOSE OF FUNCTION:  PRODUCES THE WANDS DUNE-BLUFF RECESSION
[2]  ⍝ DATA LISTING.
[3]   DATE←⎕TS[2],⎕TS[3],⎕TS[1]
[4]   DAT1←(20⍴'-'),(((20-⍴FILE)⍴'.'),FILE),(((20-⍴NAME)⍴'.'),NAME)
[5]   DAT1←DAT1,((15⍴'.'),5⍴'_'),(((20-⍴⍕DATE)⍴'.'),⍕DATE),(20⍴'-')
[6]   DAT2←(20⍴'-'),(20⍴' '),(((20-⍴⍕EXP)⍴'.'),⍕EXP),(((20-⍴⍕ASPEC)⍴'.'),⍕ASP
      )
[7]   DAT2←DAT2,(((20-⍴OFFDATE)⍴'.'),OFFDATE),(40⍴' ')
[8]   DAT2←DAT2,(((20-⍴ONDATE)⍴'.'),ONDATE),(((20-⍴TYPEPR)⍴'.'),TYPEPR)
[9]   DAT2←DAT2,(40⍴' '),(((20-⍴⍕CSPEC)⍴'.'),⍕CSPEC),(((20-⍴⍕RETPER)⍴'.'),⍕
       RETPER)
[10]  DAT2←DAT2,(((20-⍴SOURCE)⍴'.'),SOURCE)
[11]  DAT2←DAT2,(40⍴' '),(((20-⍴NUM)⍴'.'),NUM),(((20-⍴CO)⍴'.'),CO)
[12]  DAT2←DAT2,(((20-⍴DNR)⍴'.'),DNR),(((20-⍴⍕DIST)⍴'.'),⍕DIST),20⍴'-'
[13]  DAT3←(10⍴'-'),(((10-⍴⍕NEWX)⍴'.'),⍕NEWX),(((10-⍴⍕DIST-NEWX)⍴'.'),⍕DIST-
       NEWX)
[14]  DAT3←DAT3,(10⍴' '),(((10-⍴⍕BSPEC)⍴'.'),⍕BSPEC),(((10-⍴⍕Y2)⍴'.'),⍕Y2)
[15]  DAT3←DAT3,(10⍴' '),(((10-⍴⍕(AD÷27))⍴'.'),⍕AD÷27)
[16]  DAT3←DAT3,(((10-⍴⍕(AE÷27))⍴'.'),⍕AE÷27),(10⍴' ')
[17]  DAT3←DAT3,(((10-⍴⍕XA)⍴'.'),⍕XA),(((10-⍴⍕(¯1×YA))⍴'.'),⍕¯1×YA),10⍴'-'
[18]  TABLE1←LABD,[1]((6 50 ↑LABA), 6 20 ⍴DAT1)
[19]  TABLE1←TABLE1,[1] LABF,[1]((21 50 ↑LABB), 21 20 ⍴DAT2)
[20]  TABLE1←TABLE1,[1] LABG,[1]((13 60 ↑LABC), 13 10 ⍴DAT3)
[21]  TABLE1←TABLE1,[1] LABH
     ∇

     ∇SHAPE[⎕]∇
     ∇ SHAPE;C;A1;B1;E1;A2;B2;E2;A3;B3;E3;R1;R2;R3
[1]  ⍝ PURPOSE OF FUNCTION:  DETERMINES OFFSHORE PROFILE POWER CURVE FIT
[2]  ⍝ COEFFICIENTS FOR NEW PROFILE DATA.
[3]   '      ENTER DISTANCE OFFSHORE:'
```

```
[4]    X←⎕
[5]    '      ENTER CORRESPONDING ELEVATIONS AS +VE VALUES:'
[6]    Y←⎕
[7]    C←(+/⍟X),(+/((⍟X)*2)),(+/((⍟X)×(⍟Y))),(+/⍟Y),(+/((⍟Y)*2))
[8]    A1←*C6←((C[1]×C[3])-(C[2]×C[4]))÷((C[1]*2)-((⍴X)×C[2]))
[9]    B1←((C[1]×C[4])-((⍴X)×C[3]))÷((C[1]*2)-((⍴X)×C[2]))
[10]   Z1←A1×X*B1
[11]   E1←((1÷⍴X)×(+/(Z1-Y)*2))*0.5
[12]   A2←(+/(Y×(X*(2÷3))))÷(+/(X*4÷3))
[13]   Z2←A2×X*2÷3
[14]   E2←((1÷⍴X)×(+/(Z2-Y)*2))*0.5
[15]   A3←*((C[4]-(C[1]×2÷3))÷⍴X)
[16]   Z3←A3×X*2÷3
[17]   E3←((1÷⍴X)×(+/(Z3-Y)*2))*0.5
[18]   ' '
[19]   '      County ____________ Ref Mon I.D. _____ Survey Date ________'
[20]   '      ------------------------------------------------------------'
[21]   '                            EXPONENT        EXPONENT FIXED AT 2/3'
[22]   '                           NOT  FIXED'
[23]   '                                           DIRECT      LOGARITHMIC'
[24]   '                                           METHOD         METHOD'
[25]   '      ------------------------------------------------------------'
[26]   '      Scale Coefficient:         ',(⍕A1),'          ',(⍕A2),'         ',⍕
       A3
[27]   '      Exponent:                  ',(⍕B1),'        ',(⍕2÷3),'       ',⍕2÷3
[28]   R1←X CORR Z1
[29]   R2←X CORR Z2
[30]   R3←X CORR Z3
[31]   '      Correlation Coefficient:   ',(⍕R1),'        ',(⍕R2),'       ',⍕R3
[32]   '      RMS Error:                 ',(⍕E1),'      ',(⍕E2),'     ',⍕E3
[33]   '      ------------------------------------------------------------'
       ∇


       ∇POWER[⎕]∇
       ∇ POWER
[1]   ⍝ PURPOSE OF FUNCTION:  FITS A POWER CURVE.
[2]    LNX←⍟X
[3]    LNY←⍟Y
[4]    BB←(+/((LNX-((+/LNX)÷⍴X))×LNY))÷(+/((LNX-((+/LNX)÷⍴X))*2))
[5]    AA←*((+/LNY)÷⍴Y)-(BB×((+/LNX)÷⍴X))
       ∇


       ∇LINEAR[⎕]∇
       ∇ X LINEAR Y
[1]   ⍝ PURPOSE OF FUNCTION:  FITS A LINEAR EQUATION.
[2]    BB←(+/((X-((+/X)÷⍴X))×Y))÷(+/((X-((+/X)÷⍴X))*2))
[3]    AA←((+/Y)÷⍴Y)-(BB×((+/X)÷⍴X))
       ∇


       LABA
     ------------------------------------------------------------
         File Number ..........................................
         Responsible for Data Input ...........................
         Initials .............................................
         Date Job Completed (mo/da/yr) ........................
     ------------------------------------------------------------
```

```
LABB
     ------------------------------------------------------------
     A. OFFSHORE PROFILE DATA
        Exponent (i.e., Shape Coefficient) ...............
        Scale Coefficient ................................
        Date of Profile Survey ...........................

     B. ONSHORE PROFILE SURVEY
        Date of Profile Survey ...........................
        Profile Type .....................................

     C. STORM SURGE DATA
        Storm Surge Elevation (ft NGVD) ..................
        Storm Surge Return Period (years) ................
        Source of Information ............................

     D. DNR REFERENCE MONUMENT INFORMATION
        DNR Reference Monument I.D. ......................
        County ...........................................
        Range to Mon Distance (ft) .......................
        CCCL to Shoreline Distance (ft) ..................
     ------------------------------------------------------------


LABC
     ------------------------------------------------------------
      Erosion Distance Measured from the Shoreline (ft) ...
      Erosion Distance Measured from the CCCL (ft) ........

      Angle of Eroded Surface (tangent) ...................
      Angle of Eroded Surface (degrees) ...................

      Volume of Sand Deposited Offshore (cu yds/ft) .......
      Volume of Sand Eroded from Upland (cu yds/ft) .......

      Offshore Profile Closeout Distance (ft) .............
      Offshore Profile Closeout Depth (ft NGVD) ...........
     ------------------------------------------------------------


LABD
              FLORIDA DEPARTMENT OF NATURAL RESOURCES
                   DIVISION OF BEACHES AND SHORES
                BUREAU OF COASTAL DATA ACQUISITION
                  DUNE-BLUFF RECESSION PREDICTION
                   (Walton -- Sensabaugh Method)

                     ADMINISTRATIVE INFORMATION


LABF

                         INPUT INFORMATION


LABG
```

PREDICTED RESULTS FOR HORIZONTAL DUNE-BLUFF RECESSION

LABH

KEY TO THE PLOT(S):

Solid Line -- Surveyed Profile
Dashed Line -- Eroded Profile (Predicted)
Dash-dot-dash Line -- Storm Surge Water Level