



*2017 Town of Southern Shores, NC Beach Profile Survey Report:*

# **2017 Town of Southern Shores, North Carolina Beach Profile Survey Report**

**Prepared for:**

**Town of Southern Shores, North Carolina**

**Prepared by:**

**Aptim Coastal Planning and Engineering of NC, Inc.  
4038 Masonboro Loop Road  
Wilmington, NC 28409**

**March 2018**





## **Table of Contents**

Abstract  
Survey Methodologies  
Map Preparation  
Ground Digital Photography  
Survey Maps  
Survey Report Notes and Certification

## **List of Appendices**

### Appendix No.

- 1 Monument Information Report
- 2 Profile XYZ data
- 3 Profile Plots
- 4 Ground Digital Photography
- 5 Field Book Pages



## **ABSTRACT**

Aptim Coastal Planning and Engineering of North Carolina, Inc. was contracted by the Town of Southern Shores, North Carolina to provide a topographic and hydrographic survey for the Town's oceanfront shoreline. The survey consisted of twenty-two (22) profile stations, which were surveyed in conjunction with post-construction surveys conducted along the Towns of Duck, Kitty Hawk, and Kill Devil Hills. Aptim Coastal Planning and Engineering of North Carolina, Inc. surveyors conducted the beach and hydrographic surveys November 30, 2017 through December 05, 2017.

The physical monitoring of the Town of Southern Shores included topographic and hydrographic surveys of the beach and offshore areas. The monitoring data is necessary to observe and assess beach conditions for future construction. Monitoring surveys are further needed to continually observe the performance of the nourishment project as well as assess effects of said project on adjacent shorelines.

The scientific monitoring processes provide information necessary to plan, design, and optimize subsequent follow up projects. The information gathered may potentially reduce the need for, and cost of, unnecessary work as well as potentially reducing any environmental impacts that may have occurred or are to be expected.



## SURVEY METHODOLOGIES

The surveys were conducted in accordance with the Minimum Performance Standards for the U.S. Army Corps of Engineers (USACE), Engineering and Design Hydrographic Surveying Manual. All hydrographic surveying was conducted under the direct supervision of an American Congress of Surveying and Mapping (ACSM) Certified Hydrographer (CH). Included in this Hydrographic and Topographic Survey Report are twenty-two (22) profile stations, one (1) project location map, and five (5) plan view maps. The plan view maps show reduced true position elevation data collected during the survey. The location of all published control, as well as control found and used for survey purposes, is presented in the Monument Information Report provided in **Appendix 1**.

Vertical data was collected in the North American Vertical Datum of 1988 (NAVD88). All Horizontal data is provided in the North Carolina State Plane Coordinate System, North American Datum of 1983/2011 (NAD 83/2011) zone 3200. Profile data is presented in xyz format relative to The North American Vertical Datum of 1988 (NAVD88) in **Appendix 2** (digital format only). Profile plots are provided in **Appendix 3**. Ground digital photography obtained during the survey is provided in **Appendix 4**. Copies of all field book pages are provided in **Appendix 5** (digital format only).

The field survey and data collection activities encompassed four (4) phases. Brief descriptions of each survey phase, including methodologies and quality control/quality assurance procedures, are described below.

### **Phase One: Control Reconnaissance/Establishment/Verification**

Prior to the start of the survey, reconnaissance of the monuments was conducted to confirm that survey control was in place and undisturbed. Real Time Kinematic Global Positioning System (RTK GPS) was used to locate and confirm survey control for this project. The horizontal and vertical accuracy of control data meets the accuracy requirements as set forth in the Engineering and Design Hydrographic Surveying Manual (EM 1110-2-1003). In order to achieve required accuracy, the topographic and hydrographic surveys were controlled using 2<sup>nd</sup> order monuments, specifically CAFFEY, ARCH, C255, TIDAL C, TIDAL D, KITTY from the National Geodetic Survey (NGS). Horizontal and vertical positioning checks were conducted at the beginning and end of each day using at least two 2<sup>nd</sup> order monuments in the project area. The RTK GPS utilizes statistical methods to ensure accuracy of RTK GPS data remains within the 95% confidence interval. The control check shots were acquired using a minimum of five (5) epochs which results in a high accuracy location. Results from 2<sup>nd</sup> order control checks are displayed showing northing, easting, monument elevation, inverses, horizontal and vertical root mean square error, location description and photographs as indicated in the Monument Information Report (**Appendix 1**).



## **Phase Two: Beach Profiles**

Upon completion of the control reconnaissance survey, beach/upland and nearshore operations were initiated. Cross-sections of the beach in the project area were surveyed using extended rod RTK GPS rovers, and standard RTK GPS rovers. Extended rod RTK GPS rovers were used to augment RTK GPS survey capability into the nearshore. The current systems allow surveyors from APTIM to collect the entire beach profile with RTK GPS technology. Incorporation of RTK GPS into monitoring surveys greatly reduces the potential for human error during data collection and reduction. Furthermore, RTK GPS provides accuracies of two (2) centimeters  $\pm$  one (1) part per million with true horizontal positioning to the survey data point regardless of sea state.

Profiles commenced from the onshore control point and extend seaward overlapping the offshore data. Nearshore portions of the profiles were surveyed by two (2) surveyors with an Extended Rod Trimble R8 RTK GPS rover who entered the water wearing Personal Floatation Devices (PFD). Trimble TSC3 data collectors are equipped with Bluetooth technology allowing wireless communication with the GPS receiver at a data exchange speed of 2.1 megabits per second. The rover system allows surveyors from APTIM to reach a maximum water depth of eleven (11) feet. The nearshore survey extended seaward to a point overlapping the offshore portion of the profiles by at least fifty (50) feet.

The upland portion of the survey commenced at the waterline and extended 25 feet landward of the dune or until an obstacle was encountered. The upland portions of the profiles were surveyed using an RTK GPS. Elevations were taken at approximately twenty-five (25) foot intervals along each profile line and at all grade breaks. To maintain online accuracy surveyors utilized the RTK GPS feature *stakeout point*. *Stakeout point* allows surveyors to maintain the profile azimuth without relying on survey lathe or conventional compass bearings.

## **Phase Three: Nearshore/Offshore Profiles**

The Nearshore/Offshore profiles were conducted at each required profile station. The profiles were obtained 2,500 feet beyond the shoreline or to the -30 NAVD88 contour, whichever is more landward. The landward limits of the nearshore profiles were based on a minimum overlap of fifty (50) feet beyond the seaward extent of beach profiles. Soundings were collected at a maximum of twenty-five (25) foot intervals with an Odom Hydrotrac, sufficient to provide an accurate depiction of the seafloor.

Nearshore/offshore profiles were collected using an Odom Hydrotrac single frequency sounder with digitizer on APTIM's twenty-eight (28) foot Parker survey vessel with a centrally located hull-mounted transducer. Data was digitally stored using HYPACK 2017 Software. A Trimble R-8 RTK GPS and a TSS DMS-25 dynamic motion sensor were used onboard the



survey vessel to provide instantaneous tide corrections and attitude corrections. Manual tide readings were taken while conducting the onshore portion of the profile to verify onboard tide readings. In order to maintain the vessel navigation along the profile lines, HYPACK 2017 navigation software was used. This software provided horizontal position to the sounding data allowing real-time review of the data in plan view or cross-section format. HYPACK 2017 also provided navigation to the helm to minimize deviation from the online azimuth.

Horizontal and vertical positioning checks were conducted at the beginning and end of each day as described in phase one (1) of the survey. The sounder was calibrated via bar-checks and a sound velocity probe at the beginning and end of the day. The DIGIBAR PRO sound velocity meter offers a fast additional calibration for sound velocity as compared to the traditional bar-check. Bar-checks were performed from a depth of five (5) feet to a depth of at least twenty-five (25) feet. Analog data showing the results of the bar-check calibration was displayed on the sounder charts at five (5) foot increments during descent of the bar. Offshore data was collected within one (1) week of onshore data collection for each line.

#### **Phase Four: Data Reduction/Submittals**

Upon completion of the field work, data was edited and reduced with Trimble Business Center, HYPACK 2017, and APTIM's internal software programs. The upland and nearshore portions of the beach profile were viewed and edited in Trimble Business Center and a comma delimited XYZ file was created. The offshore raw digital data was viewed and edited in HYPACK 2017's *Single Beam Editor*. The offshore RTK GPS tide data that was collected was compared to the manually collected RTK GPS nearshore tide data, local observed, and predicted tides for data verification purposes. Tide corrected offshore data was exported and a comma delimited XYZ file was created. All overlapping profile data was compared in cross section to ensure system accuracy. The edited beach profile data and offshore profile data were merged and a representative cross-section was derived for each profile line. The cross sections were developed using internal APTIM plotting programs.

The final plots were edited and reviewed with comparisons to previous years; discrepancies were noted and resolved. The final approved cross-section data was prepared in the required formats for submittal (**Appendix 3**). Digital data is provided in the State required vertical datum NAVD88.

#### **Map Preparation:**

Upon completion of the surveys and data reduction, the survey maps were prepared in ArcGIS 10.3. In order to avoid congestion, the survey maps do not show all of collected



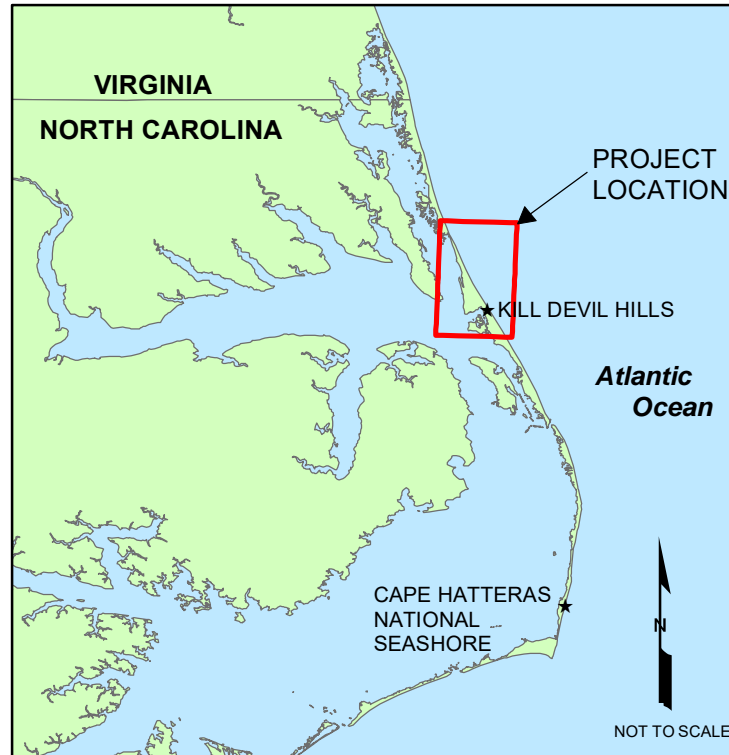
\_\_\_\_\_ *2017 Town of Southern Shores, NC Beach Profile Survey Report:*

elevations but enough to give an accurate depiction of the cross sections. The survey maps display profile data and control monument locations plotted against NCONE 2016 aerial photographs.

**Ground Digital Photography:**

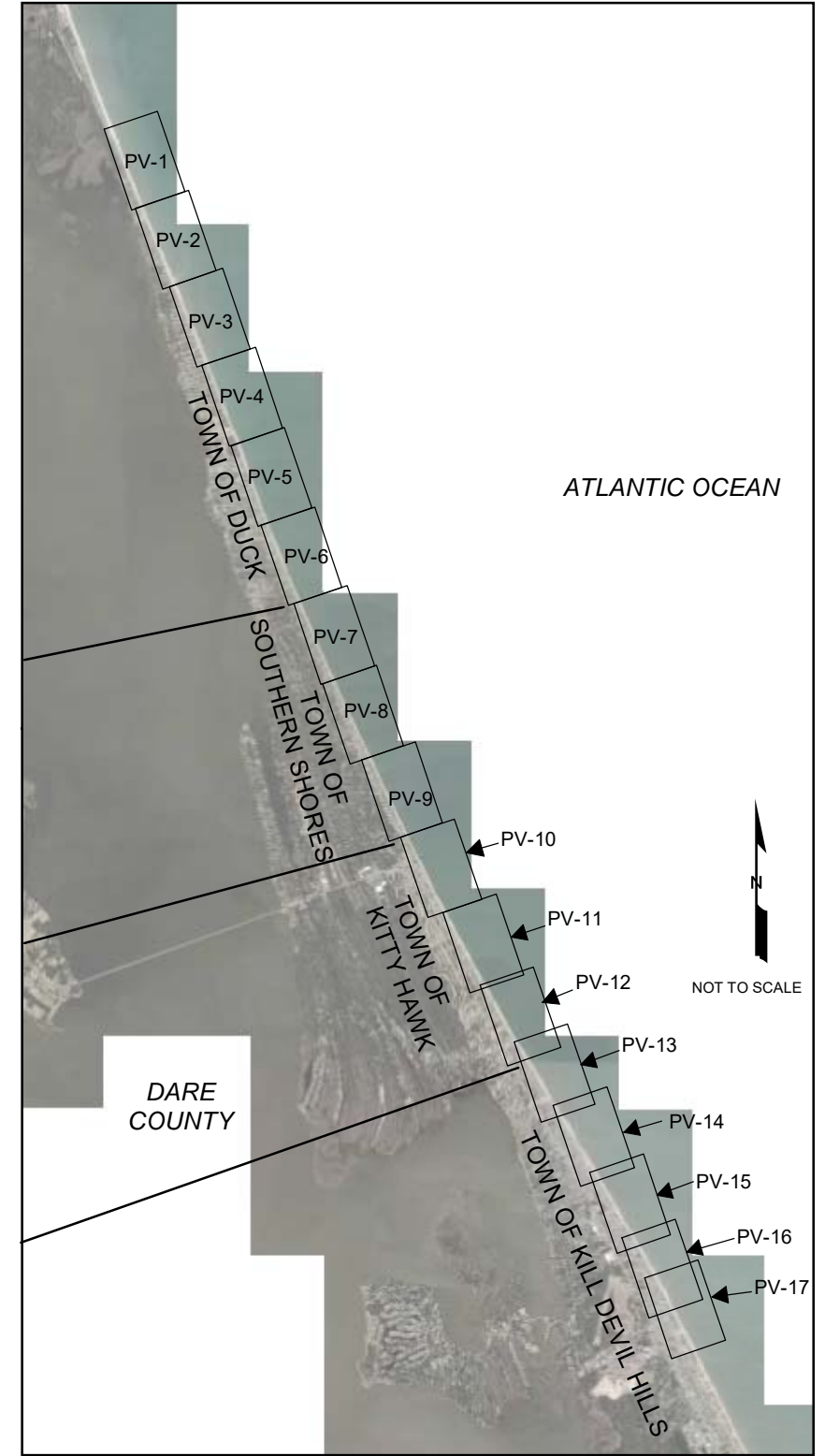
Surveyors from APTIM collected three (3) digital photos at a mid-beach location at each profile location. The three (3) photos included one (1) in each shore-parallel direction and one (1) landward toward the monument. Wherever possible, an additional digital photo was taken of the control identification or stamping on the monument.

# 2017 DARE COUNTY, NC POST-CONSTRUCTION AND MONITORING BEACH PROFILE SURVEY REPORT: TOWN OF DUCK, TOWN OF SOUTHERN SHORES, TOWN OF KITTY HAWK, AND TOWN OF KILL DEVIL HILLS



INDEX TO SHEETS

1	COVER SHEET AND PROJECT LOCATION MAP
2-18	PROJECT PLAN VIEWS



**CONTROL USED BY APTIM 2017 SURVEY**  
DATUMS: NAD83/2011 / NAVD88

STATION	NORTHING	EASTING	AZIMUTH
-170+56	887172.90	2963880.50	66.60
-163+99	886569.90	2964142.00	66.60
-157+41	885966.90	2964403.50	66.60
-150+00	885364.00	2964665.00	65.31
-140+00	884444.00	2965116.00	65.31
-130+00	883452.00	2965239.00	65.31
-120+00	882604.00	2965920.00	65.31
-110+00	881697.00	2966366.00	62.57
-100+00	880778.00	2966790.00	62.57
-90+00	879895.00	2967110.00	62.57
-80+00	878988.00	2967533.00	62.57
-70+00	878106.00	2967951.00	62.57
-60+00	877175.00	2968381.00	62.57
-50+00	876228.00	2968838.00	62.57
-40+00	875440.00	2969249.00	62.57
-30+00	874496.08	2969731.60	62.57
-20+00	873607.16	2970189.67	62.57
-10+00	872720.97	2970653.00	62.57
0+00.00	871890.80	2971224.20	62.60
9+99.90	871003.30	2971685.80	62.60
20+02.68	870116.70	2972153.20	62.20
30+05.52	869230.00	2972621.70	62.20
40+23.88	868329.70	2973097.50	62.20
50+28.29	867441.70	2973566.70	62.20
60+50.00	866538.40	2974044.00	62.20
70+02.90	865695.80	2974489.10	62.20
80+15.19	864800.80	2974962.00	62.20
89+56.91	863968.20	2975401.90	62.20
99+99.71	863052.20	2975900.20	61.50
109+99.46	862189.90	2976406.10	59.60
119+99.14	861327.70	2976911.90	59.60
130+33.04	860436.00	2977435.10	59.60
138+27.64	859735.48	2977811.33	59.60
149+99.46	858740.05	2978430.26	59.60
159+99.55	857895.27	2978966.59	59.60
169+70.21	857040.44	2979427.66	59.60
179+87.62	856163.07	2979942.69	59.60
189+87.10	855301.16	2980448.64	59.60
199+93.01	854433.71	2980957.84	59.58
209+74.44	853579.14	2981440.37	60.53
219+99.94	852686.23	2981944.55	60.53
229+83.39	851830.15	2982428.55	60.52
240+41.84	850908.80	2982949.45	60.52
249+81.53	850076.05	2983384.80	61.90
260+17.44	849165.95	2983879.57	61.90

**CONTROL USED BY APTIM 2017 SURVEY**  
DATUMS: NAD83/2011 / NAVD88

STATION	NORTHING	EASTING	AZIMUTH
269+49.25	848341.66	2984314.02	62.20
279+80.81	847429.13	2984795.03	62.20
289+99.14	846547.02	2985305.30	62.20
299+92.48	845649.70	2985733.15	62.20
309+71.20	844785.81	2986193.06	61.97
320+05.37	843872.99	2986679.03	61.97
329+88.80	843003.79	2987138.95	62.10
340+20.02	842092.34	2987621.23	62.12
349+69.94	841269.59	2988097.30	62.12
359+82.85	840357.49	2988539.16	62.12
369+89.02	839485.48	2989042.40	62.12
PI-17	920098.90	2950657.30	70.00
PI-18	919175.40	2951026.00	70.00
D-01	918267.70	2951387.50	70.00
D-02	917384.40	2951733.80	70.00
D-03	916429.40	2952103.00	70.00
D-04	915495.30	2952464.00	70.00
D-05	914598.00	2952849.30	70.00
D-06	913696.90	2953224.40	70.00
D-07	912798.80	2953607.30	70.00
D-08	911897.90	2953983.00	70.00
D-09	910994.82	2954356.65	70.00
D-10	910066.74	2954759.12	70.00
D-11	909133.14	2955158.05	70.00
D-12	908412.53	2955461.41	70.00
D-13	907478.35	2955874.29	70.00
D-14	906578.33	2956252.15	70.00
D-15	905677.78	2956628.57	70.00
D-16	904767.65	2956978.72	70.00
D-17	903863.92	2957333.66	70.00
D-18	902886.47	2957718.79	70.00
D-19	902331.03	2957932.45	70.00
D-20	901760.74	2958139.73	70.00
D-21	900958.70	2958472.10	70.00
D-22	900228.80	2958754.00	70.00
D-23	899515.60	2958992.70	70.00
D-24	898739.80	2959267.20	70.00
D-25	897824.30	2959601.70	70.00
D-26	896902.30	2959928.60	70.00
D-27	895981.90	2960250.60	70.00
D-28	895073.00	2960604.10	70.00
D-29	894166.20	2960963.60	70.00
D-30	893257.60	2961317.70	70.00
D-31	892350.70	2961676.70	70.00
D-32	891379.40	2962078.10	70.00

**CONTROL USED BY APTIM 2017 SURVEY**  
DATUMS: NAD83/2011 / NAVD88

STATION	NORTHING	EASTING	AZIMUTH
D-33	890553.20	2962439.40	70.00
D-34	889616.10	2962839.60	70.00
SS-01	888697.70	2963230.40	70.00
SS-02	887775.80	2963619.00	70.00

**DARE COUNTY A-MON CONTROL**

MON STAMPING	NORTHING	EASTING	M. ELEV.
ARCH 2005	854412.25	2979783.79	11.64
KITTY 1962	859358.84	2977204.86	9.17
865 1370 C 1977	900621.51	2957662.02	18.46
CAFFEY 1935	915308.87	2952084.11	1.99
C255 1981	900856.11	2958600.06	16.89
865 1370 D 1977	**VERTICAL ONLY**		7.43

**LEGEND**

- ⊕ PROFILE STATION
- ⊕ CONTROL MONUMENT
- PV PLAN VIEW
- CS COVER SHEET
- APTIM APTIM COASTAL PLANNING & ENGINEERING OF NORTH CAROLINA INC.
- C.O.L. CERTIFICATE OF LICENSURE
- NAVD NORTH AMERICAN VERTICAL DATUM
- NAD NORTH AMERICAN DATUM
- NTS NOT TO SCALE
- Rd ROAD
- NC NORTH CAROLINA
- AZ AZIMUTH
- MON MONUMENT
- ID IDENTIFICATION
- MK MARK
- U.S. UNITED STATES OF AMERICA



**APTIM COASTAL PLANNING & ENGINEERING OF NORTH CAROLINA, INC.**

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COL #C2331

Checked by:	Drawn by:	Date:	Project No.:	Scale:	AS NOTED
M. Lowrie	J. Walker	March 2018	17-000000	AS NOTED	

**COVER SHEET**

2017 DARE COUNTY, NC POST-CONSTRUCTION AND MONITORING BEACH PROFILE SURVEY REPORT: TOWN OF DUCK, TOWN OF SOUTHERN SHORES, TOWN OF KITTY HAWK, AND TOWN OF KILL DEVIL HILLS

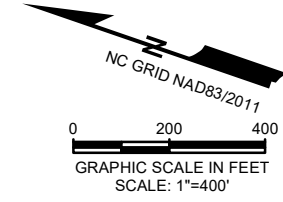
DRAWING NO. **CS**

SHEET 1 OF 18

G:\Enterprise\NorthCarolina\636220429 DARE PostCon\Survey\_Charts\MXDCS.mxd



- NOTES:**
1. DATES OF SURVEY: NOVEMBER 30, 2017 - DECEMBER 05, 2017
  2. COORDINATES SHOWN ARE IN FEET BASED ON THE NORTH CAROLINA STATE PLANE COORDINATE SYSTEM, ZONE 3200  
NORTH AMERICAN DATUM 1983/2011 (NAD83/2011).
  3. ELEVATIONS SHOWN ARE BASED ON THE NORTH AMERICAN VERTICAL DATUM (NAVD) 1988.
  4. YEAR OF AERIAL PHOTOGRAPHY: 2016 BY NCON



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Checked by:	M. Lowrie
Designed by:	M. Lowrie
Drawn by:	J. Walker
Date:	March 2018
Submitted by:	M. Lowrie
Comm. No.:	636220429
AS NOTED	

No.	Date	Description

Reference Files:

2017 DARE COUNTY, NC POST-CONSTRUCTION  
AND MONITORING BEACH PROFILE SURVEY REPORT:  
TOWN OF DUCK, TOWN OF SOUTHERN SHORES,  
TOWN OF KITTY HAWK, AND TOWN OF KILL DEVIL HILLS

**PLAN VIEW**

DRAWING NO.

**PV-6**

- NOTES:**
1. DATES OF SURVEY: NOVEMBER 30, 2017 - DECEMBER 05, 2017
  2. COORDINATES SHOWN ARE IN FEET BASED ON THE NORTH CAROLINA STATE PLANE COORDINATE SYSTEM, ZONE 3200 NORTH AMERICAN DATUM 1983/2011 (NAD83/2011).
  3. ELEVATIONS SHOWN ARE BASED ON THE NORTH AMERICAN VERTICAL DATUM (NAVD) 1988.
  4. YEAR OF AERIAL PHOTOGRAPHY: 2016 BY NCONE



Checked by:	Designed by:	Reference Files:	No.	Date	Description
M. Lowie	M. Lowie				
J. Samsberg	J. Walker				
M. Lowie	March 2018				
636220429	AS NOTED				

**NOTES:**

1. DATES OF SURVEY: NOVEMBER 30, 2017 - DECEMBER 05, 2017
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NORTH AMERICAN DATUM 1983/2011 (NAD83/2011).
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4. YEAR OF AERIAL PHOTOGRAPHY: 2016 BY NCONE



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Reviewed by:	Drawn by:
J. Shattuck	J. Walker
Submitted by:	Date:
M. Lowrie	March 2018
Comm. No.:	Plot Scale:
636220429	AS NOTED

Reference Files:

2017 DARE COUNTY, NC POST-CONSTRUCTION AND MONITORING BEACH PROFILE SURVEY REPORT: TOWN OF DUCK, TOWN OF SOUTHERN SHORES, TOWN OF KITTY HAWK, AND TOWN OF KILL DEVIL HILLS

**PLAN VIEW**

DRAWING NO.  
**PV-8**

SHEET 9 OF 18

MATCHLINE SHEET 9 OF 18

**NOTES:**

1. DATES OF SURVEY: NOVEMBER 30, 2017 - DECEMBER 05, 2017
2. COORDINATES SHOWN ARE IN FEET BASED ON THE NORTH CAROLINA STATE PLANE COORDINATE SYSTEM, ZONE 3200  
NORTH AMERICAN DATUM 1983/2011 (NAD83/2011).
3. ELEVATIONS SHOWN ARE BASED ON THE NORTH AMERICAN VERTICAL DATUM (NAVD) 1988.
4. YEAR OF AERIAL PHOTOGRAPHY: 2016 BY NCON



MATCHLINE SHEET 11 OF 18

**APTIM COASTAL PLANNING & ENGINEERING  
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COL #C2331

4038 MASONBORO LOOP RD.  
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Checked by:	Designed by:	Drawn by:	Date:	Plot Scale:
M. Lowrie	M. Lowrie	J. Walker	March 2018	AS NOTED
Reviewed by:	Submitted by:	Comm. No.:		
J. Shattuck	M. Lowrie	636220429		

Reference Files:

2017 DARE COUNTY, NC POST-CONSTRUCTION  
AND MONITORING BEACH PROFILE SURVEY REPORT:  
TOWN OF DUCK, TOWN OF SOUTHERN SHORES,  
TOWN OF KITTY HAWK, AND TOWN OF KILL DEVIL HILLS

**PLAN VIEW**

DRAWING NO.  
**PV-9**

SHEET 10 OF 18





### Survey Report Notes

**Survey Title:** 2017 Town of Southern Shores Beach Profile Survey Report

**Prepared Date:** March 2018

**Prepared For:** Town of Southern Shores, NC

**Prepared By:** APTIM Coastal Planning & Engineering of North Carolina, Inc.

**Dates of Survey:** November 30, 2017 through December 05, 2017

**Survey Location:** Town of Duck PI-17 through D-34  
Southern Shores -187+14 through 00+00

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#### Notes:

1. The survey is neither valid nor complete without both the survey report and described survey maps. Digital data files encompassing the following have also been provided in the following formats listed.
  - *Monument Information Report (Appendix 1)*
  - *ASCII file (profile xyz data. Digital only) (Appendix 2)*
  - *Profile Plots (Appendix 3)*
  - *Ground Digital Photography (Appendix 4)*
  - *Project field books (Digital Only)(Appendix 5)*
2. The information on this map represents the results of the survey on the dates indicated and can only be considered as indicating the general conditions existing at the time.
3. The coordinates shown are in US survey feet based on the vertical and horizontal data that was collected and presented relative to the North American Vertical Datum of 1988 (NAVD88) and the North Carolina State Plane Coordinate System, North American Datum of 1983/2011 (NAD 83/2011) zone 3200.
4. Vertical measurements are based on second order monuments CAFFEY, ARCH, C255, TIDAL C, TIDAL D, KITTY per published NGS coordinates.



\_\_\_\_\_ *2017 Town of Southern Shores, NC Beach Profile Survey Report:*

5. Bearings are based on a bearing of South 24° 27' 33" East between NGS second order monuments CAFFEY and ARCH per published NGS coordinates.
6. Underground and subaqueous improvements and/or utilities were not located as part of this survey and should be field verified prior to any dredging or construction activities.
7. Refer to APTIM field book No. 489 for the onshore portion and book No. 50 for the offshore portion.
8. Aids to navigation were not located during this survey.
9. Soundings were collected using an Odom Hydrotrac, Single Frequency, survey grade sounder. The sounder was calibrated prior to the start of the survey following manufacturers recommended procedures.
10. This survey was conducted for the Town of Southern Shores for use as a topographic and hydrographic survey.



## **APPENDIX OVERVIEW**

### **1) Monument Information Report**

Data collected during the survey is entered in a spreadsheet format and compared to data provided by NGS. This comparison shows differences in northings, eastings and elevation of NGS published control, what was collected in the field, and what was used during profile reduction.

### **2) XYZ data (digital only)**

Offshore survey data was converted into APTIM files. Onshore data was reduced by standard means of reduction and also entered into APTIM format and merged with the offshore data. APTIM format is used for in-house plotting, volume computations and other engineering analyses. The APTIM formatted data was converted into xyz format. The xyz data is provided in the datum collected (NAVD88) as per state standards.

### **3) Profile Plots**

Profile plots of this year's survey data were compared with historical profile data.

### **4) Ground Digital Photography**

APTIM surveyors collected three (3) digital photos at a mid-beach location at each profile location. The three (3) photos included one (1) in each shore-parallel direction and one (1) landward toward the monument. In addition, wherever possible a digital photo was taken of the control identification or stamping on the monument.

### **5) Field Book Pages (digital only)**

This appendix includes copies of the field book pages used for the survey. Refer to APTIM field book No. 489 for the onshore portion. Navigation field book No. 50 for the offshore survey.



APPENDIX 1

MONUMENT INFORMATION REPORT

APPENDIX 1: Southern Shore Monument Information



*2017 Dare County, NC Post Construction and Monitoring Beach Profile Survey Report:  
Town of Duck, Town of Southern Shores, Town of Kitty Hawk, and Town of Kill Devil Hills*

<b>CONTROL MONUMENT USED BY APTIM FOR 2017 DARE COUNTY ANNUAL MONITORING TOPOGRAPHIC AND HYDROGRAPHIC SURVEY REPORT NOVEMBER 2017</b>	
<b>DATUMS: NAD83/2011- NAVD1988</b>	
<b>Designation</b>	ARCH
<b>Stamping</b>	ARCH 2005
<b>Northing</b>	854412.25
<b>Easting</b>	2979783.79
<b>Horizontal Root Mean Square Error</b>	0.123
<b>Elevation</b>	11.64
<b>Vertical Root Mean Square Error</b>	0.004
<b>Description</b>	Located about 3.2 miles NW of Kill Devil Hills and 4.1 miles SSW of Southern Shores. On US 158 Bypass , 2.4 miles west from the main entrance to The Wright Brothers Memorial to Arch Street, in the northwest quadrant. 57.2 ft. West-Southwest of the centerline of US 158 Southbound Lanes. The Disk is a commemorative of the Wright Brothers first flight NGS, NCGS, NOAA, and NPS agency inscriptions.



Monument: L230



Location Verification: L230

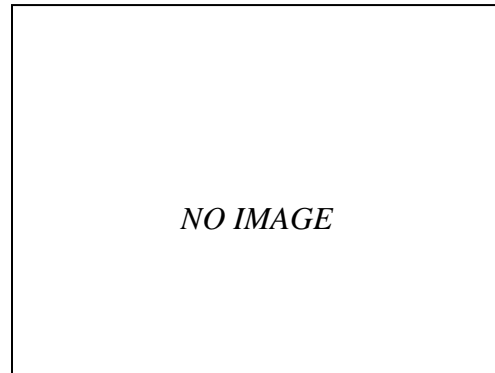
<b>Mean of Inverse Shots - Published Versus APTIM Found</b>				
Monument	No. of Shots	$\Delta N$	$\Delta E$	$\Delta Z$
ARCH	16	-0.01	-0.01	-0.06



<b>CONTROL MONUMENT USED BY APTIM FOR 2017 DARE COUNTY ANNUAL MONITORING TOPOGRAPHIC AND HYDROGRAPHIC SURVEY REPORT FEBRUARY 2017</b>	
<b>DATUMS: NAD83/2011 - NAVD1988</b>	
<b>Designation</b>	C255
<b>Stamping</b>	C255 1981
<b>Northing</b>	900856.11
<b>Easting</b>	2958600.06
<b>Horizontal Root Mean Square Error</b>	0.106
<b>Elevation</b>	16.89
<b>Vertical Root Mean Square Error</b>	0.014
<b>Description</b>	A National Geodetic Survey pin inside a protective casing with lid approximately 3 inches below ground and located between the two steps on the West side of the Army Corp of Engineer's Field Research Facility (1261 Duck Road), approximately 355 feet East of the main parking lot gate, 15 feet South of the Northerly steps, 15 feet North of the Southerly steps, and 2.7 feet West of the flag pole.



Monument: C255



Location Verification: C255

<b>Mean of Inverse Shots - Published Versus APTIM Found</b>				
Monument	No. of Shots	$\Delta N$	$\Delta E$	$\Delta Z$
C255	28	0.01	0.06	-0.01

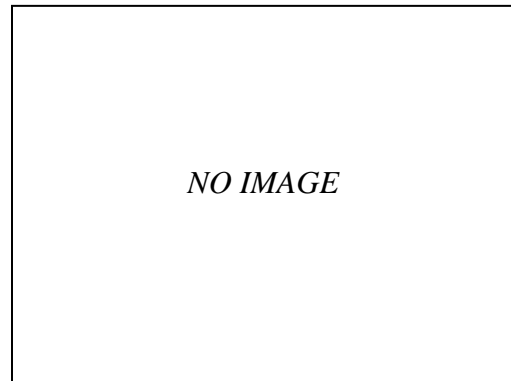


2017 Dare County, NC Post Construction and Monitoring Beach Profile Survey Report:  
 Town of Duck, Town of Southern Shores, Town of Kitty Hawk, and Town of Kill Devil Hills

CONTROL MONUMENT USED BY APTIM FOR 2017 DARE COUNTY ANNUAL MONITORING TOPOGRAPHIC AND HYDROGRAPHIC SURVEY REPORT NOVEMBER 2017	
DATUMS: NAD83/2011 - NAVD1988	
<b>Designation</b>	CAFFEY
<b>Stamping</b>	CAFFEY 1935
<b>Northing</b>	915308.87
<b>Easting</b>	2952084.11
<b>Horizontal Root Mean Square Error</b>	0.254
<b>Elevation</b>	1.99
<b>Vertical Root Mean Square Error</b>	0.051
<b>Description</b>	A U.S. Coast & Geodetic Survey disk in concrete located in thick vegetation approximately 140 feet West of Duck Road and 40 feet South of a parking lot for 1566 Duck Road



Monument: CAFFEY



Location Verification: CAFFEY

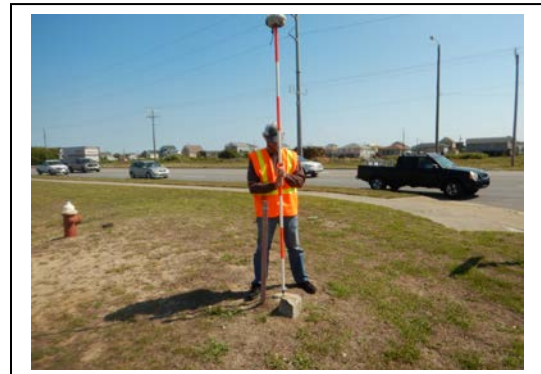
Mean of Inverse Shots - Published Versus APTIM Found				
Monument	No. of Shots	$\Delta N$	$\Delta E$	$\Delta Z$
CAFFEY	19	-0.01	0.01	0.05



<b>CONTROL MONUMENT USED BY APTIM FOR 2017 DARE COUNTY ANNUAL MONITORING TOPOGRAPHIC AND HYDROGRAPHIC SURVEY REPORT NOVEMBER 2017</b>	
<b>DATUMS: NAD83/2011- NAVD1988</b>	
<b>Designation</b>	KITTY
<b>Stamping</b>	KITTY 1962
<b>Northing</b>	849159.56
<b>Easting</b>	298928.60
<b>Horizontal Root Mean Square Error</b>	0.147
<b>Elevation</b>	9.17
<b>Vertical Root Mean Square Error</b>	0.036
<b>Description</b>	Located about 0.65 miles east of the post office in kitty hawk. A Standard disk set in a 12x12 inch concrete monument and tamped Kitty 1962 is 12 feet east-southeast of the intersection. The mark is flush with ground.



Monument: KITTY



Location Verification: KITTY

<b>Mean of Inverse Shots – OPUS Solution Versus APTIM Found</b>				
Monument	No. of Shots	$\Delta N$	$\Delta E$	$\Delta Z$
KITTY	18	0.01	0.01	-0.03

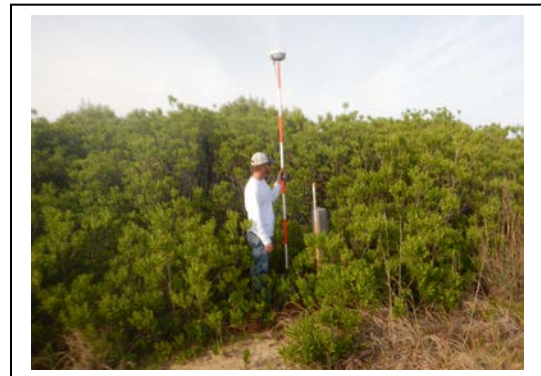


2017 Dare County, NC Post Construction and Monitoring Beach Profile Survey Report:  
 Town of Duck, Town of Southern Shores, Town of Kitty Hawk, and Town of Kill Devil Hills

<b>CONTROL MONUMENT USED BY APTIM FOR 2017 DARE COUNTY ANNUAL MONITORING TOPOGRAPHIC AND HYDROGRAPHIC SURVEY REPORT NOVEMBER 2017</b>	
<b>DATUMS: NAD83/2011 - NAVD1988</b>	
<b>Designation</b>	TIDAL C
<b>Stamping</b>	865 1370 1977
<b>Northing</b>	900621.51
<b>Easting</b>	2957662.02
<b>Horizontal Root Mean Square Error</b>	0.147
<b>Elevation</b>	18.46
<b>Vertical Root Mean Square Error</b>	0.036
<b>Description</b>	A National Ocean Survey disk protected by an open pipe approximately 6 inches above ground and located on the Army Corp of Engineer's Field Research Facility property (1261 Duck Road) approximately 600 feet East of Duck Road, 300 feet West of the gazebo, and 100 feet North of the access road.



Monument: Tidal C



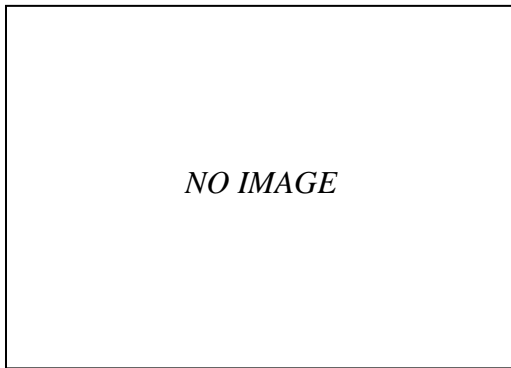
Location Verification: Tidal C

<b>Mean of Inverse Shots – OPUS Solution Versus APTIM Found</b>				
Monument	No. of Shots	$\Delta N$	$\Delta E$	$\Delta Z$
TIDAL C	12	0.01	-0.01	0.00

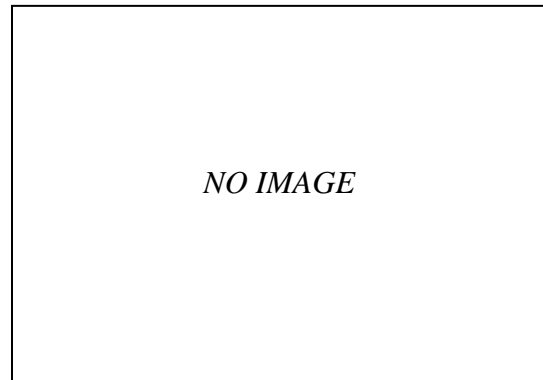


2017 Dare County, NC Post Construction and Monitoring Beach Profile Survey Report:  
 Town of Duck, Town of Southern Shores, Town of Kitty Hawk, and Town of Kill Devil Hills

CONTROL MONUMENT USED BY APTIM FOR 2017 DARE COUNTY ANNUAL MONITORING TOPOGRAPHIC AND HYDROGRAPHIC SURVEY REPORT NOVEMBER 2017	
DATUMS: NAD83/2011 - NAVD1988	
<b>Designation</b>	TIDAL D
<b>Stamping</b>	1370 D 1979
<b>Northing</b>	900450.64
<b>Easting</b>	2957190.64
<b>Horizontal Root Mean Square Error</b>	2.051
<b>Elevation</b>	18.46
<b>Vertical Root Mean Square Error</b>	0.078
<b>Description</b>	Attached to the top of a stainless steel rod driven into the ground and inside a 4-inch PVC pipe that projects 0.6 meters above ground, the disk is recessed 0.3 meters below the top of the pipe. Used as a vertical check only.



Monument: TIDAL D



Location Verification: TIDAL D

Mean of Inverse Shots – OPUS Solution Versus APTIM Found				
Monument	No. of Shots	$\Delta N$	$\Delta E$	$\Delta Z$
TIDAL D	4	1.82	-0.94	-0.07

**KILL DEVIL HILLS STATION INFORMATION****NOVEMBER 2017****DATUMS: NAD83/2011 & NAVD88**

<b>STATION</b>	<b>NORTHING</b>	<b>EASTING</b>	<b>ELEVATION</b>	<b>AZIMUTH</b>
199+93.01	854433.71	2980957.84	9.31	59.58
209+74.44	853579.14	2981440.37	8.82	60.53
219+99.94	852686.23	2981944.55	9.58	60.53
229+83.39	851830.15	2982428.55	8.16	60.52
240+41.84	850908.80	2982949.45	9.03	60.52
249+81.53	850076.05	2983384.80	8.64	61.90
260+17.44	849165.95	2983879.57	6.63	61.90
269+49.25	848341.66	2984314.02	6.77	62.20
279+80.81	847429.13	2984795.03	7.03	62.20
289+99.14	846547.02	2985305.30	6.28	62.20
299+92.48	845649.70	2985733.15	6.43	62.20
309+71.20	844785.81	2986193.06	5.56	61.97
320+05.37	843872.99	2986679.03	5.57	61.97
329+88.80	843003.79	2987138.95	5.68	62.10
340+20	842092.34	2987621.23	N/A	62.12
349+70	841269.59	2988097.3	N/A	62.12
359+83	840357.49	2988539.16	N/A	62.12
369+89	839485.48	2989042.4	N/A	62.12

**KITTY HAWK STATION INFORMATION****NOVEMBER 2017****DATUMS: NAD83/2011 & NAVD88**

<b>STATION</b>	<b>NORTHING</b>	<b>EASTING</b>	<b>ELEVATION</b>	<b>AZIMUTH</b>
0+00.00	871890.80	2971224.20	13.72	62.60
9+99.90	871003.30	2971685.80	9.51	62.60
-10+00	872720.97	2970653.00	100	62.60
-20+00	873607.16	2970189.67	100	62.60
20+02.68	870116.70	2972153.20	10.41	62.60
30+05.52	869230.00	2972621.70	9.78	62.20
40+23.88	868329.70	2973097.50	11.46	62.20
50+28.29	867441.70	2973566.70	11.17	62.20
60+50.00	866538.40	2974044.00	9.47	62.20
70+02.90	865695.80	2974489.10	9.25	62.20
80+15.19	864800.80	2974962.00	9.51	62.20
89+56.91	863968.20	2975401.90	9.55	62.20
99+99.71	863052.20	2975900.20	9.53	61.50
109+99.46	862189.90	2976406.10	9.84	59.60
119+99.14	861327.70	2976911.90	10.55	59.60
130+33.04	860436.00	2977435.10	10.3	59.60
138+27.64	859735.48	2977811.33	13.62	59.60
149+99.46	858740.05	2978430.26	9.68	59.60
159+99.55	857895.27	2978966.59	10.64	59.60
169+70.21	857040.44	2979427.66	8.91	59.60
179+87.62	856163.07	2979942.69	9.86	59.60
189+87.10	855301.16	2980448.64	9.45	59.60



<b>TOWN OF DUCK STATION INFORMATION</b>			
<b>NOVEMBER 2017</b>			
<b>DATUMS: NAD83/90 &amp; NAVD88</b>			
<b>STATION</b>	<b>NORTHING</b>	<b>EASTING</b>	<b>AZIMUTH</b>
PI-17	920098.86	2950657.32	70
PI-18	919175.36	2951025.99	70
D-01	918267.75	2951387.52	70
D-02	917384.44	2951733.76	70
D-03	916429.37	2952102.95	70
D-04	915495.29	2952464.03	70
D-05	914597.97	2952849.30	70
D-06	913696.93	2953224.38	70
D-07	912798.76	2953607.33	70
D-08	911897.95	2953983.04	70
D-09	910994.82	2954356.65	70
D-10	910066.74	2954759.12	70
D-11	909133.14	2955158.05	70
D-12	908412.53	2955461.41	70
D-13	907478.35	2955874.29	70
D-14	906578.33	2956252.15	70
D-15	905677.78	2956628.57	70
D-16	904767.65	2956978.72	70
D-17	903863.92	2957333.66	70
D-18	902886.47	2957718.79	70
D-19	902331.03	2957932.45	70
D-20	901760.74	2958139.73	70
D-21	900958.69	2958472.08	70
D-22	900228.83	2958754.03	70
D-23	899515.64	2958992.70	70
D-24	898739.78	2959267.16	70
D-25	897824.26	2959601.68	70
D-26	896902.26	2959928.60	70
D-27	895981.88	2960250.61	70
D-28	895072.97	2960604.07	70
D-29	894166.25	2960963.56	70
D-30	893257.57	2961317.69	70
D-31	892350.69	2961676.73	70
D-32	891379.42	2962078.13	70
D-33	890553.16	2962439.37	70
D-34	889616.07	2962839.65	70

<b>TOWN OF SOUTHERN SHORES STATION INFORMATION</b>			
<b>NOVEMBER 2017</b>			
<b>DATUMS: NAD83/90 &amp; NAVD88</b>			
<b>STATION</b>	<b>NORTHING</b>	<b>EASTING</b>	<b>AZIMUTH</b>
-187+14	888697.70	2963230.40	70.00
-177+13	887775.80	2963619.00	70.00
-170+56	887172.90	2963880.50	66.60
-163+99	886569.90	2964142.00	66.60
-157+41	885966.90	2964403.50	66.60
-150	885364.00	2964665.00	65.31
-140	884444.00	2965116.00	65.31
-130	883452.00	2965239.00	65.31
-120	882604.00	2965920.00	65.31
-110	881697.00	2966366.00	62.57
-100	880778.00	2966790.00	62.57
-90	879895.00	2967110.00	62.57
-80	878988.00	2967533.00	62.57
-70	878106.00	2967951.00	62.57
-60+00	877175.00	2968381.00	62.57
-50+00	876228.00	2968838.00	62.57
-40+00	875440.00	2969249.00	62.57
-30+00	874496.08	2969731.60	62.57
-20+00	873607.16	2970189.67	62.57
-10+00	872720.97	2970653.00	62.57

APPENDIX 2: Profile XYZ Data  
*(Available in digital format only)*

Sub-Appendix 2A: Town of Duck  
(File: DUCK\_1117\_ALL.xyz)

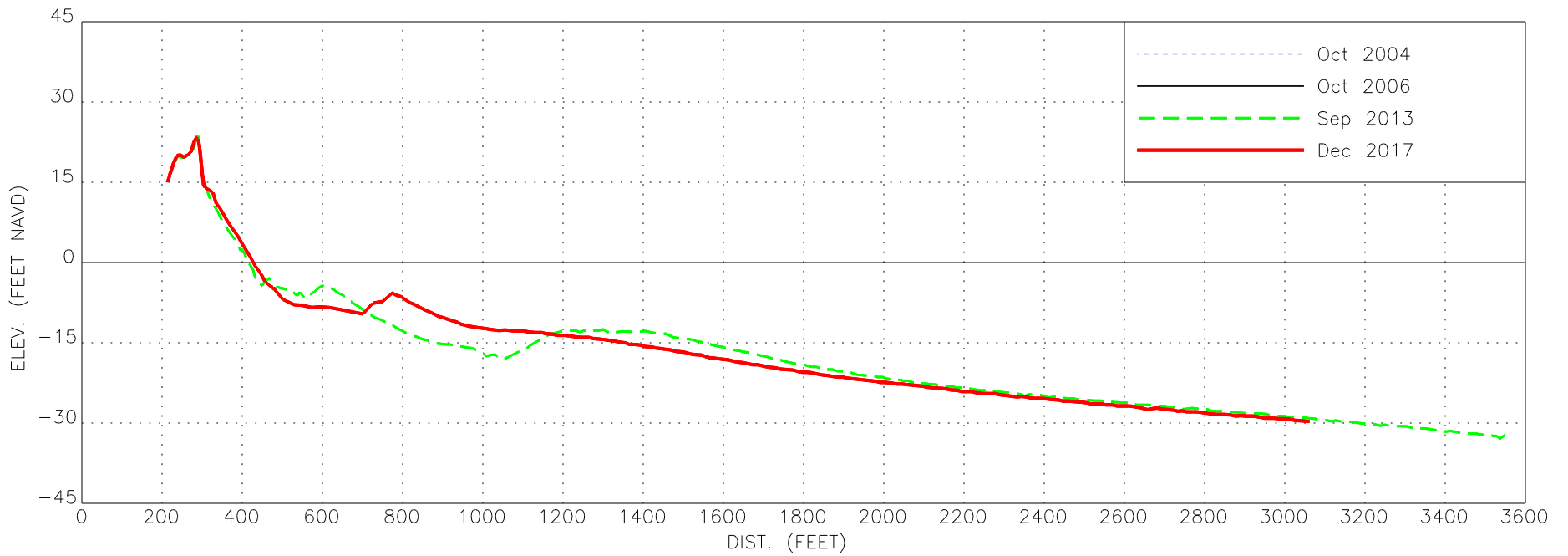
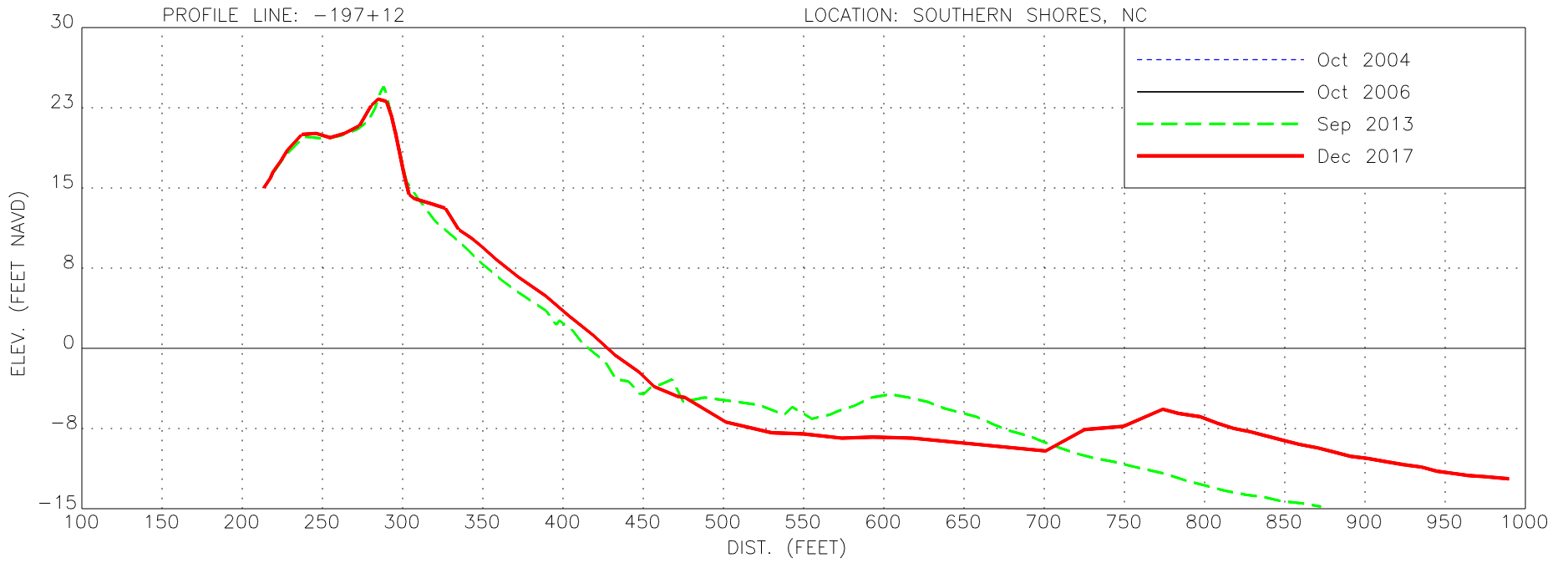
Sub-Appendix 2B: Southern Shores  
(File: SShores1117\_ALL.xyz)

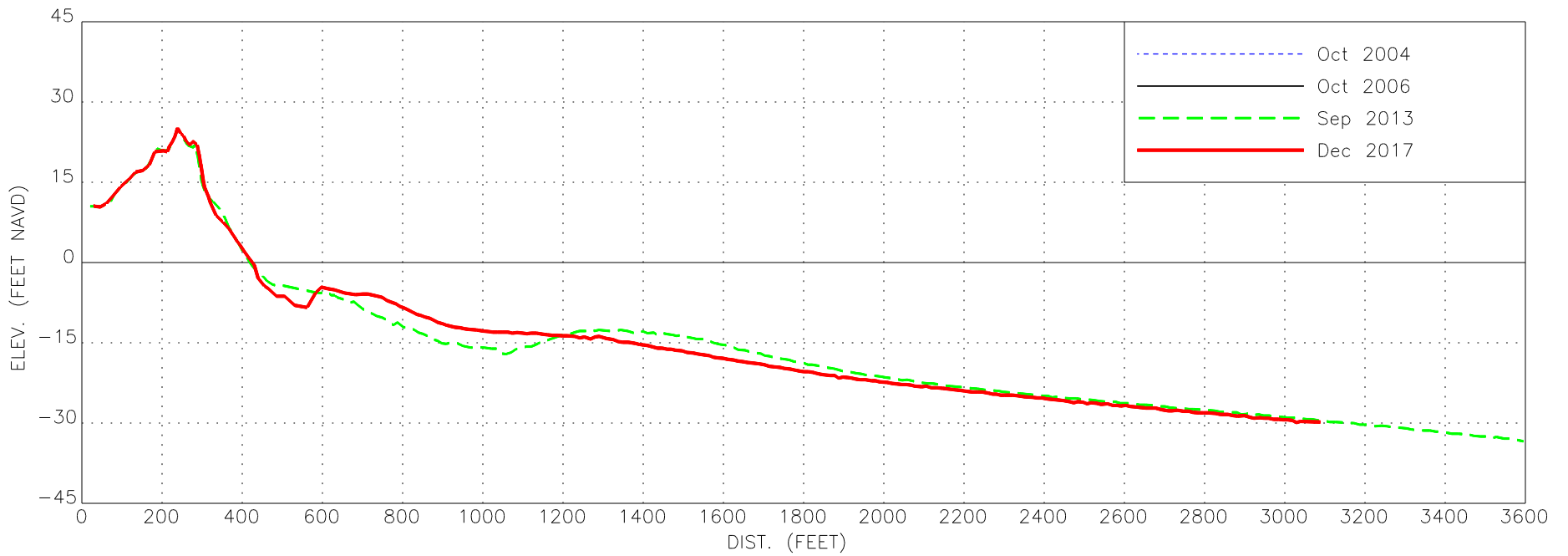
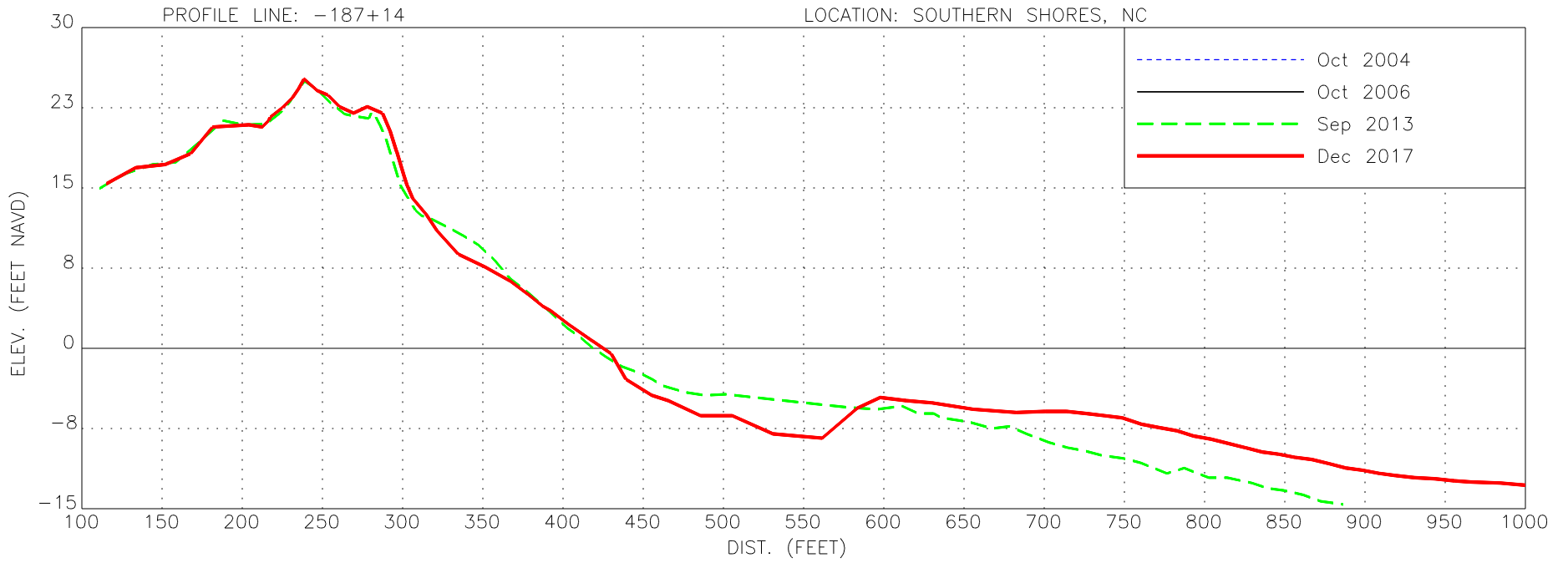
Sub-Appendix 2C: Kitty Hawk  
(File: KH1117\_ALL.xyz)

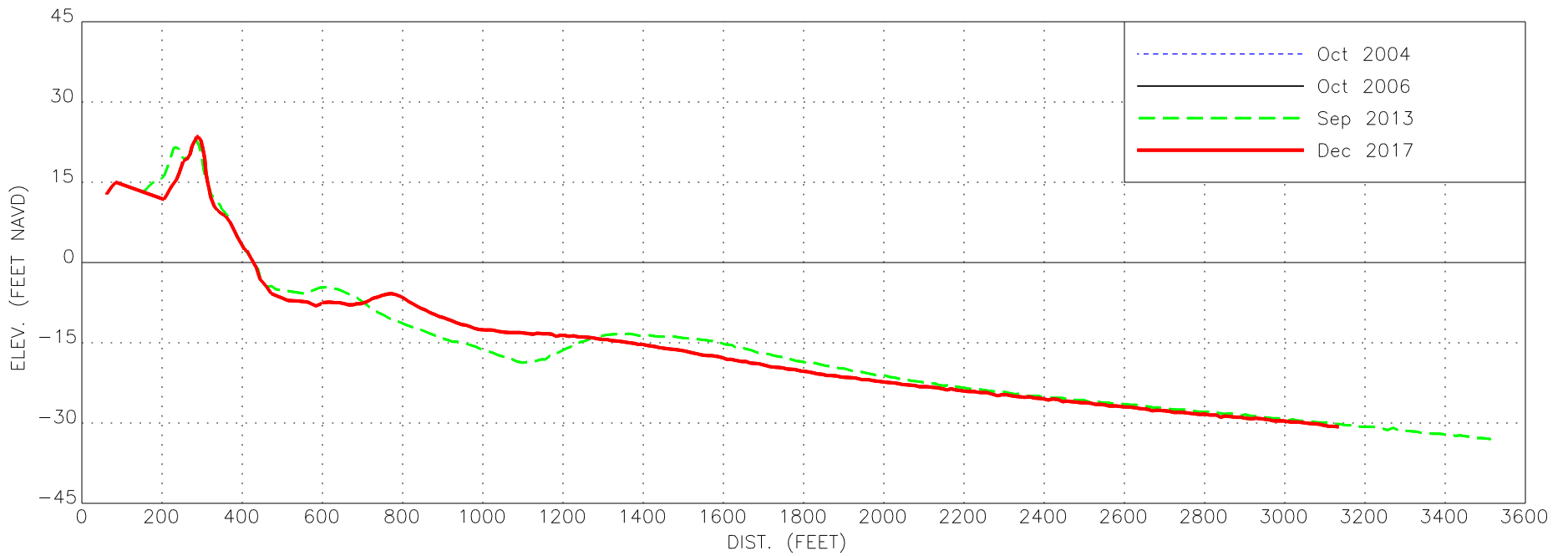
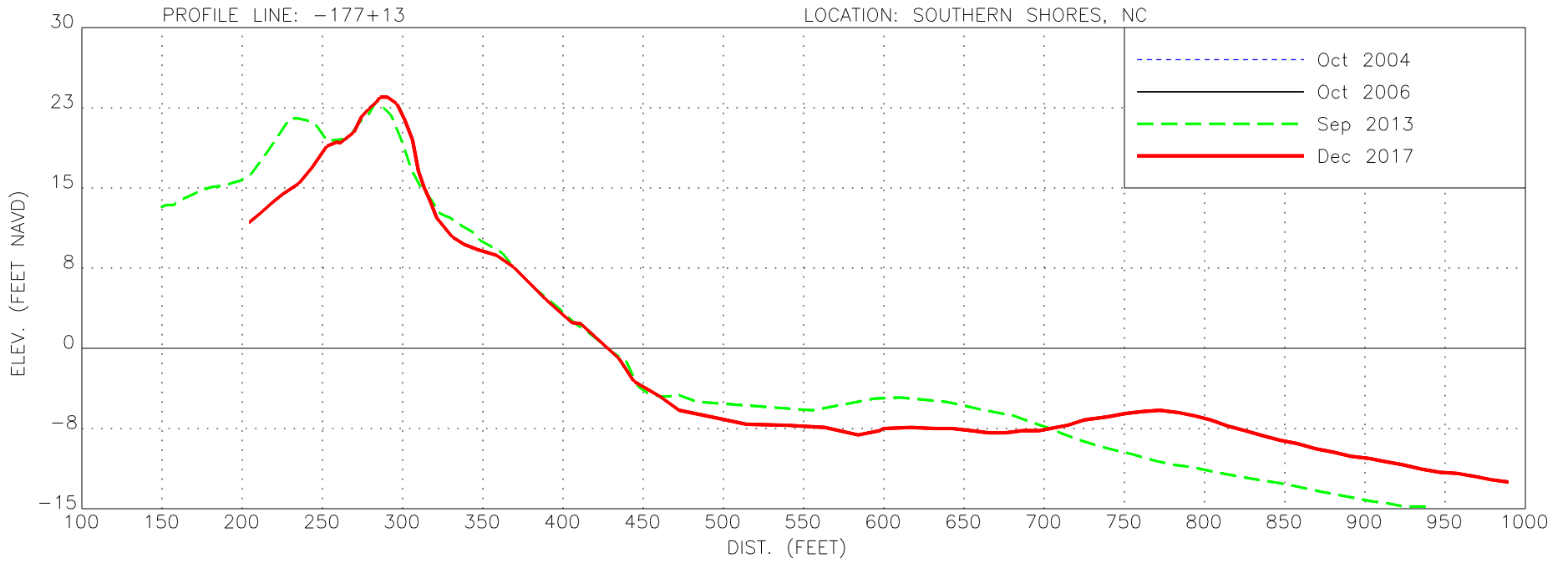
APPENDIX 3

PROFILE PLOTS

APPENDIX 3: Southern Shores Beach Profiles Plots

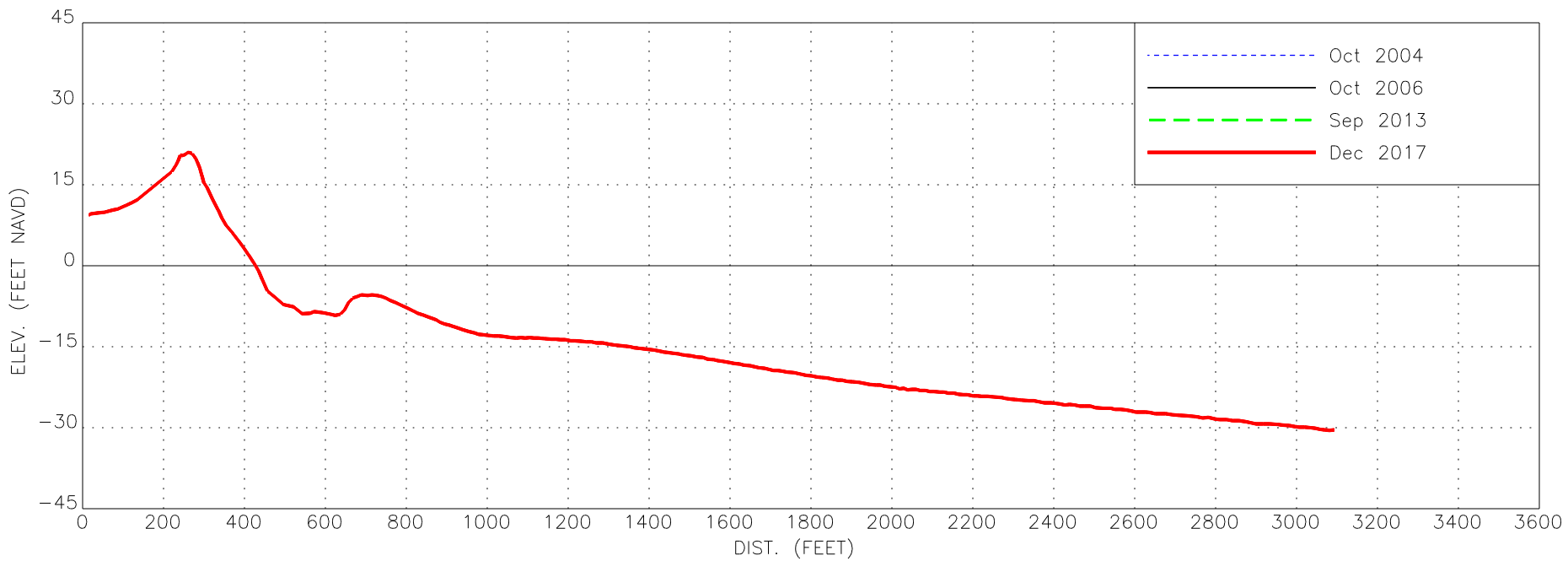
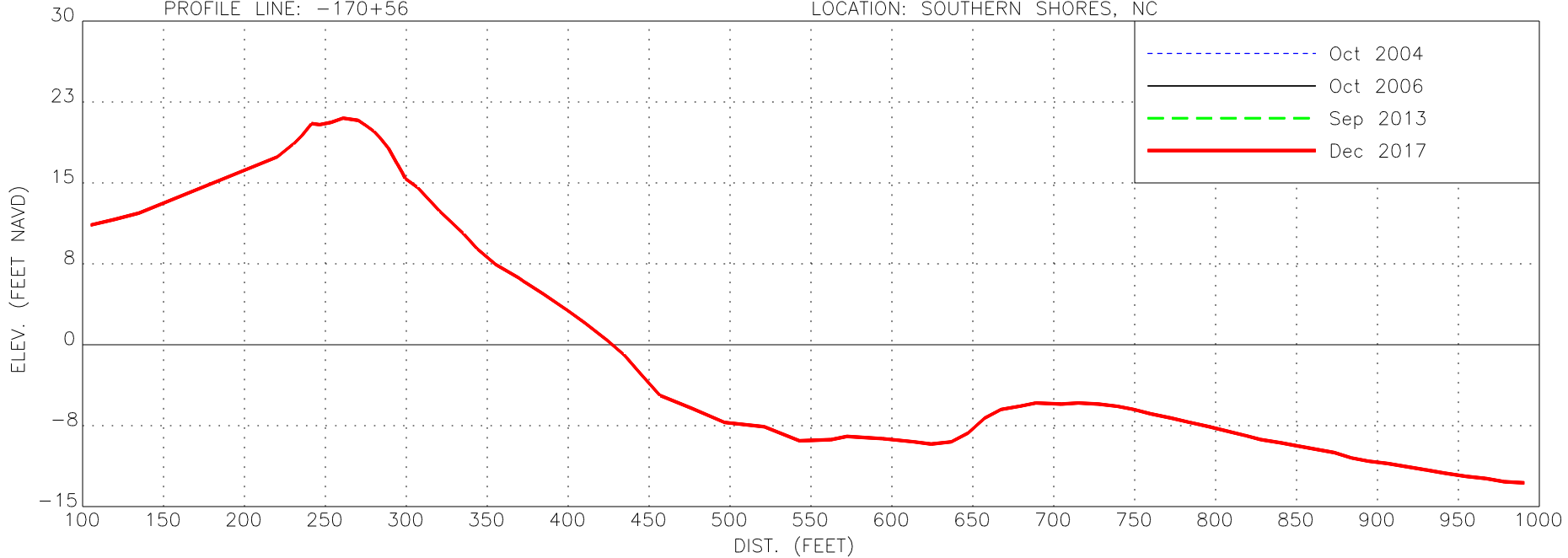


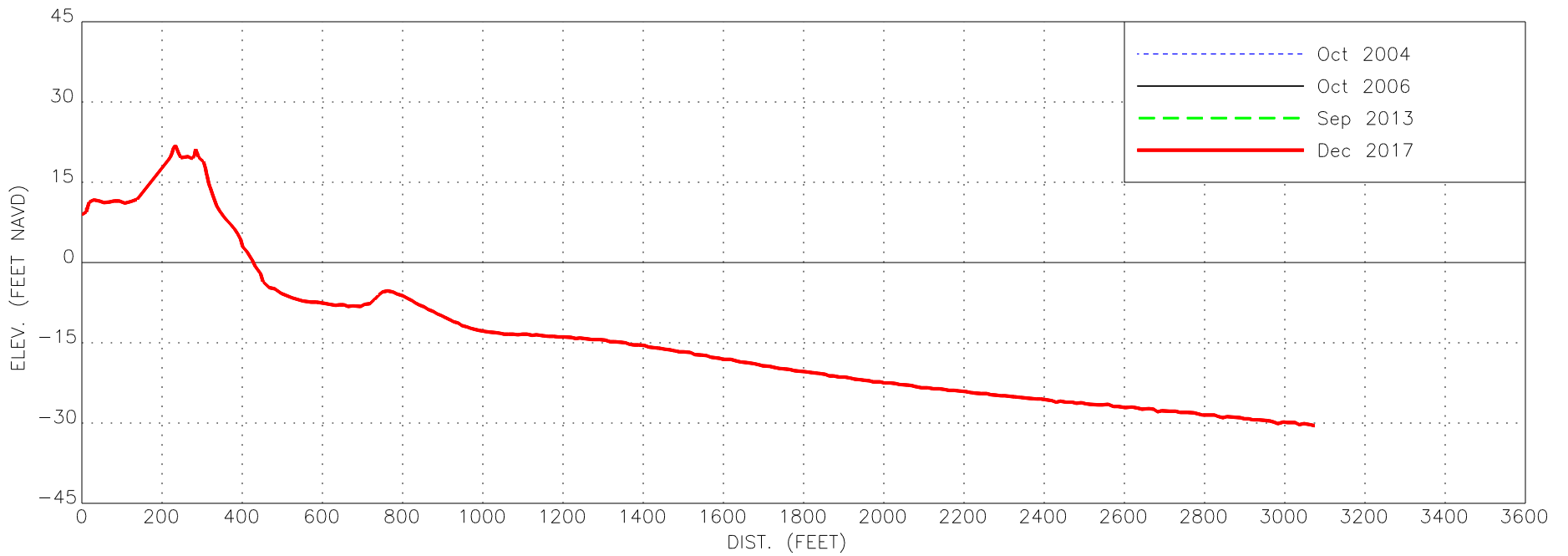
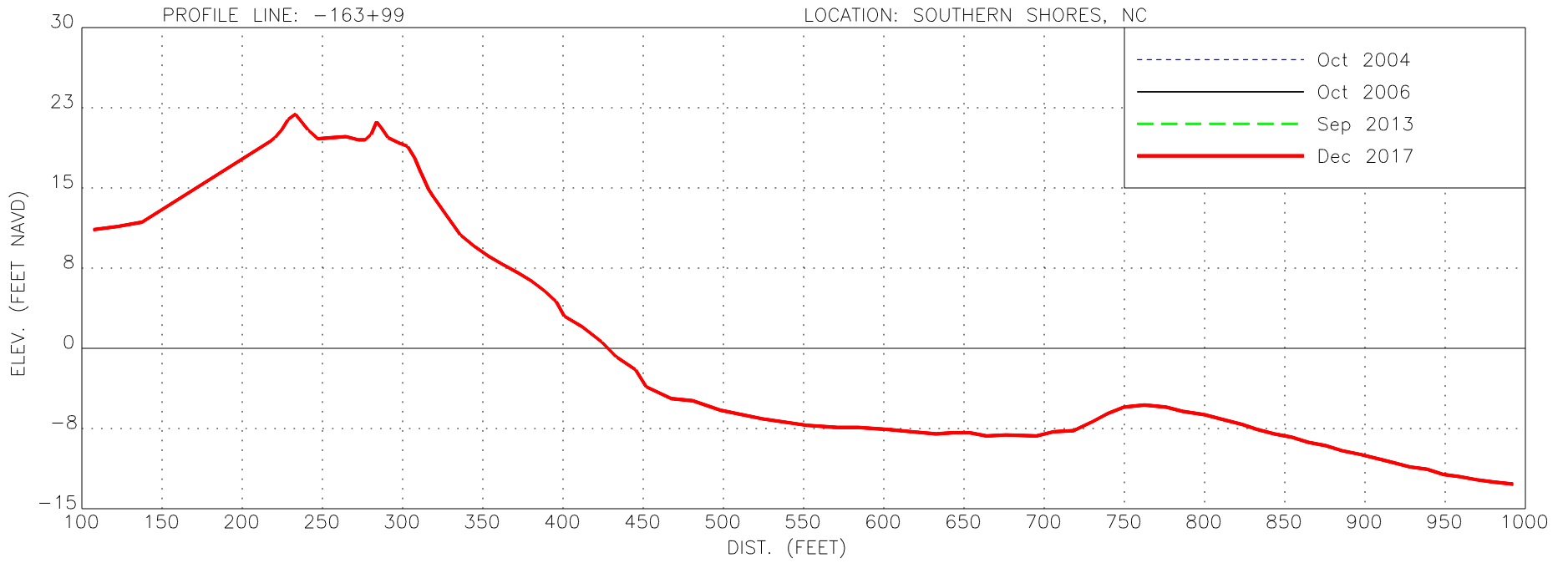




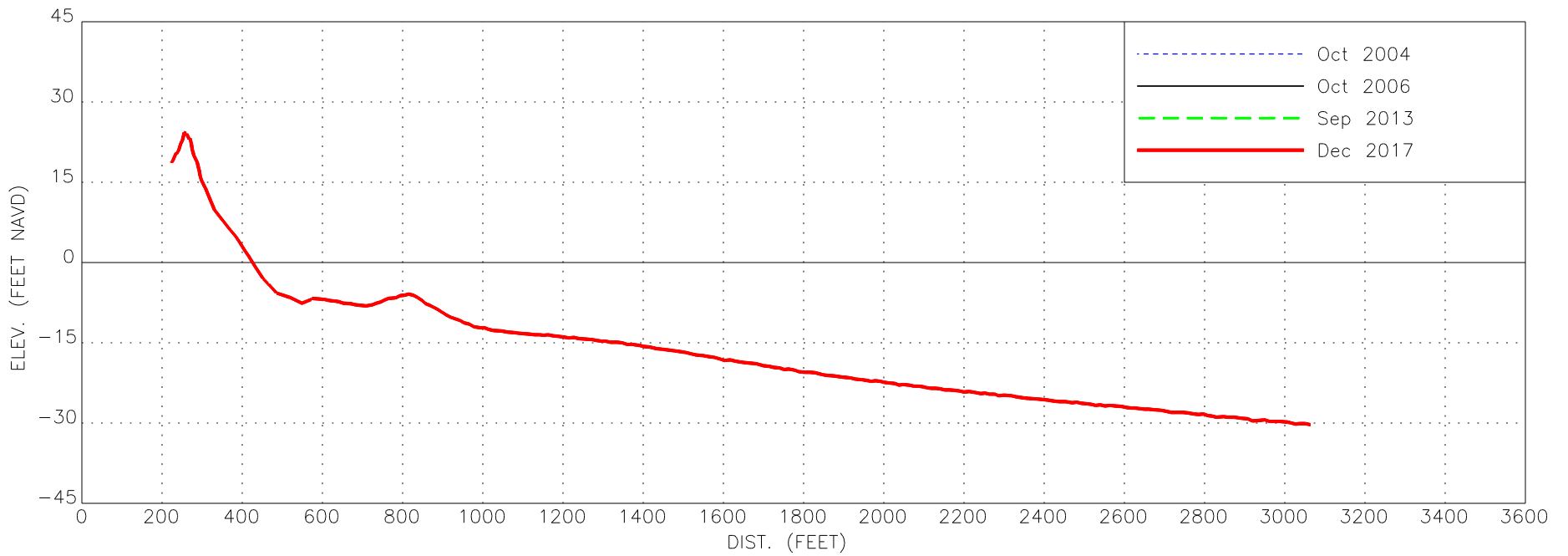
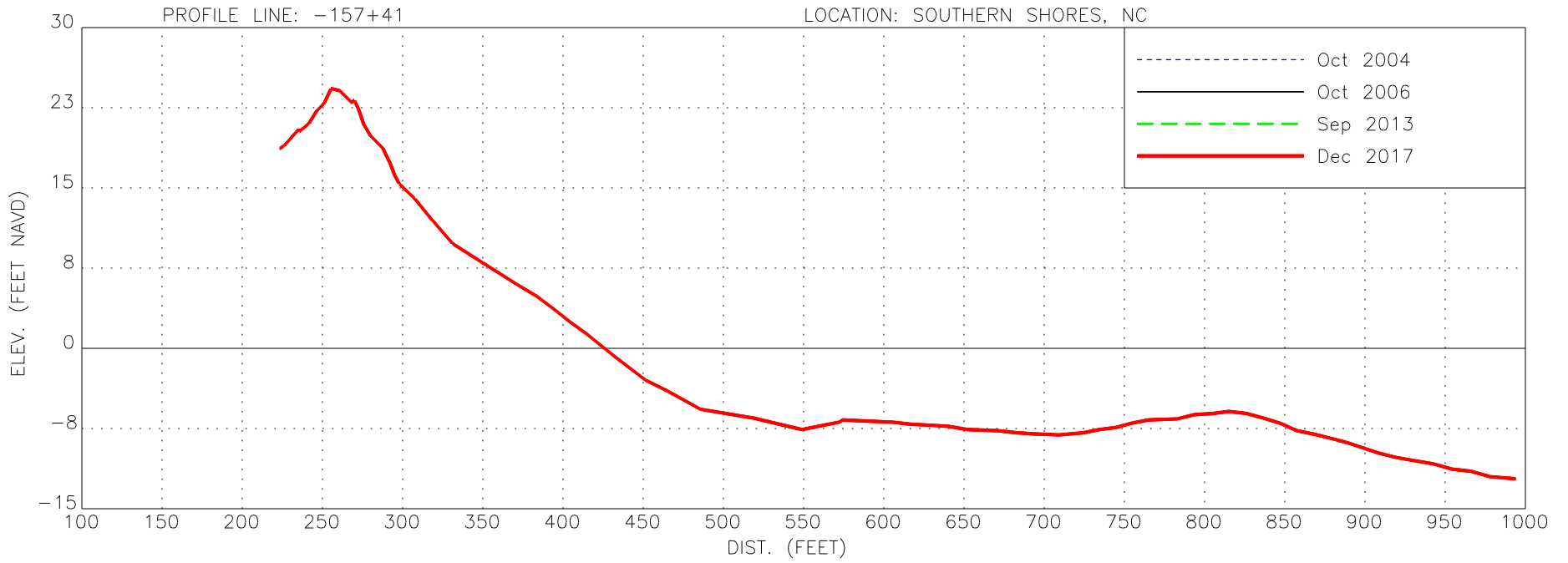
PROFILE LINE: -170+56

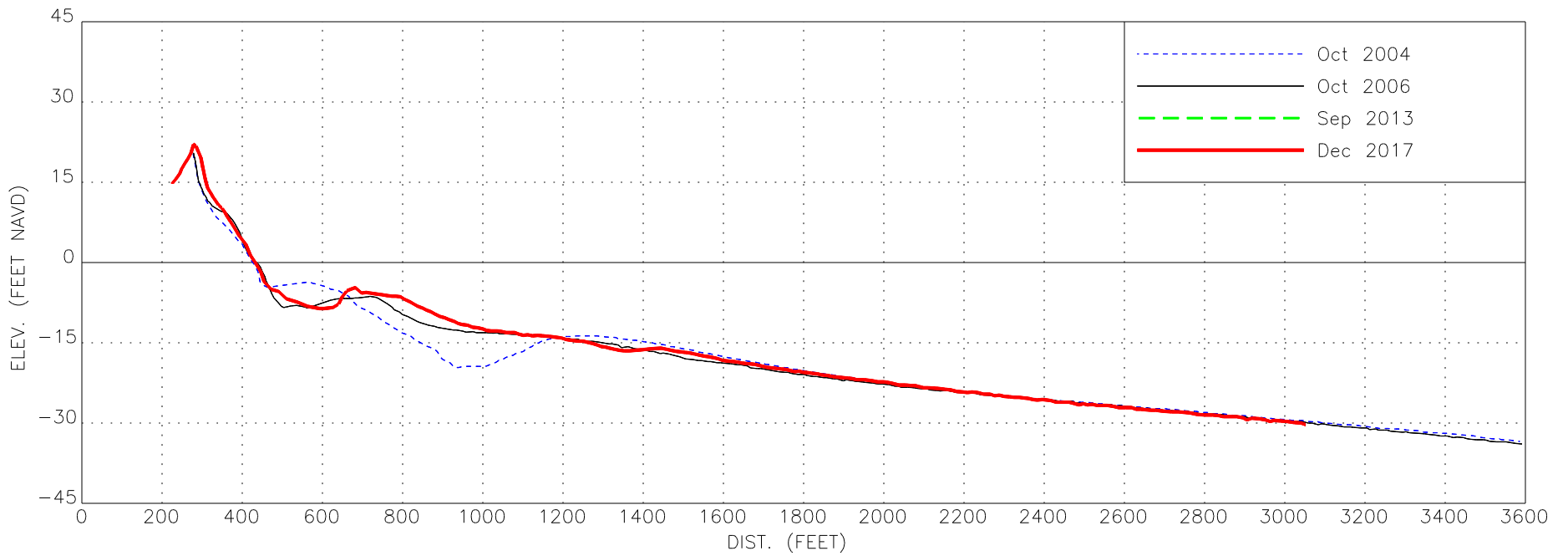
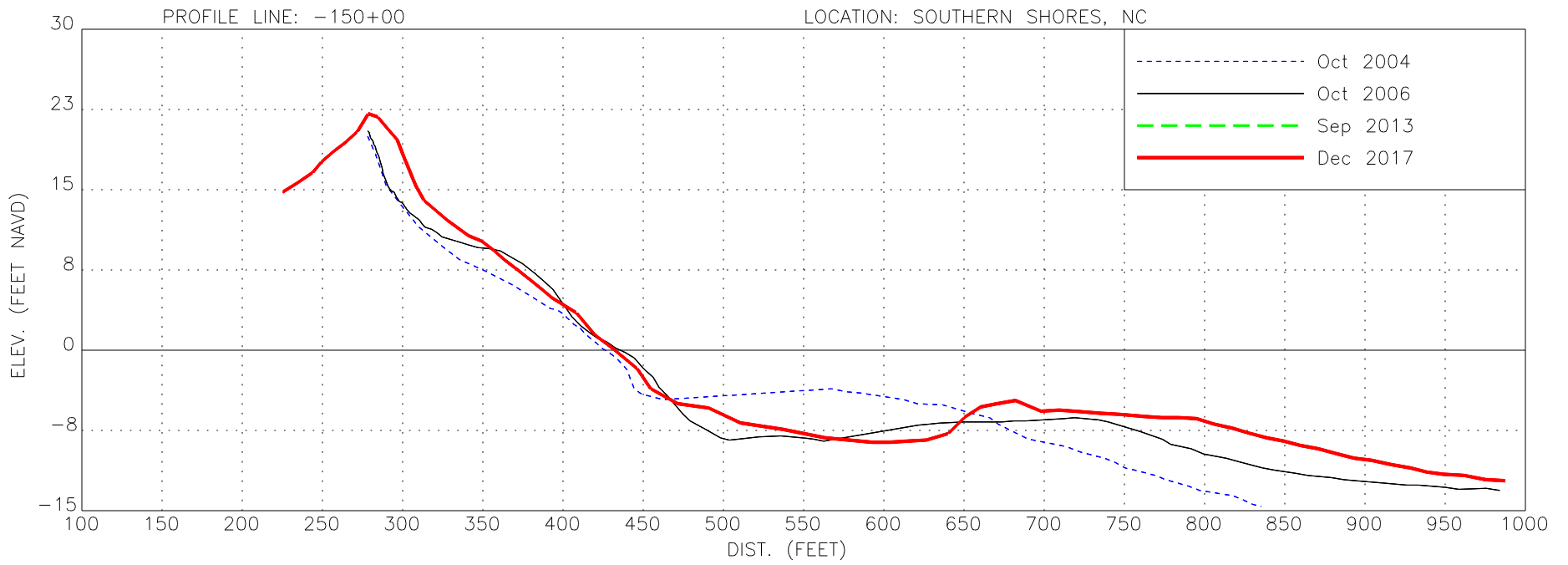
LOCATION: SOUTHERN SHORES, NC

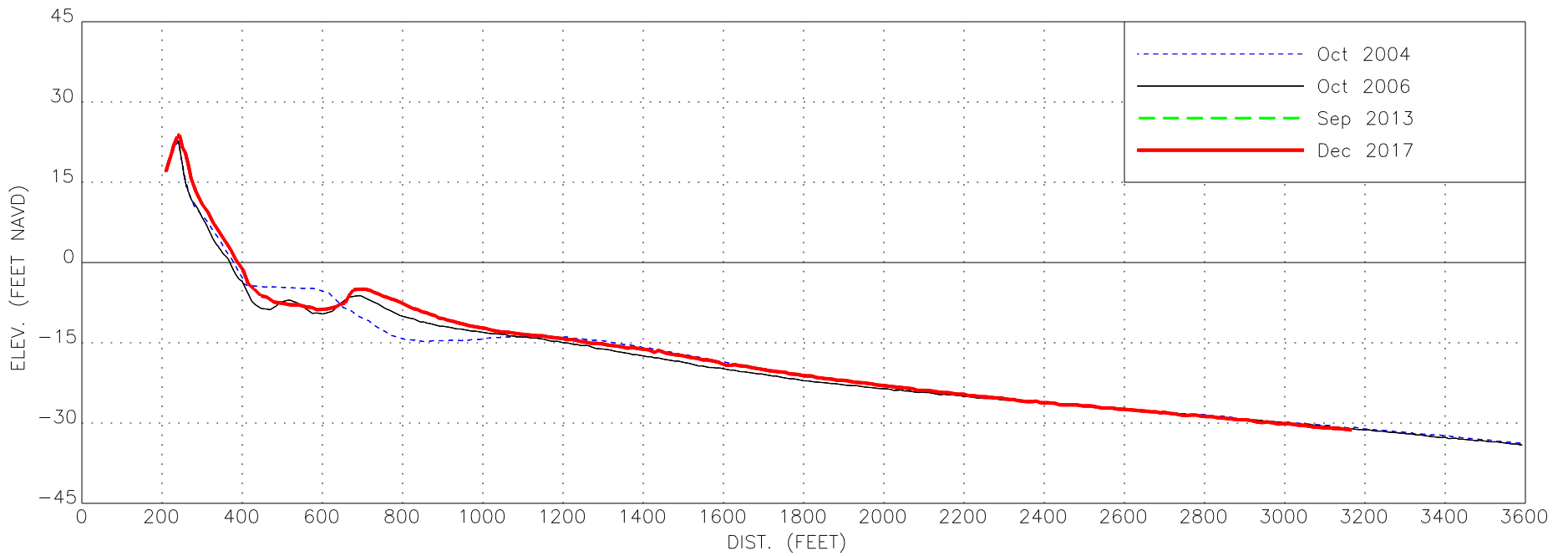
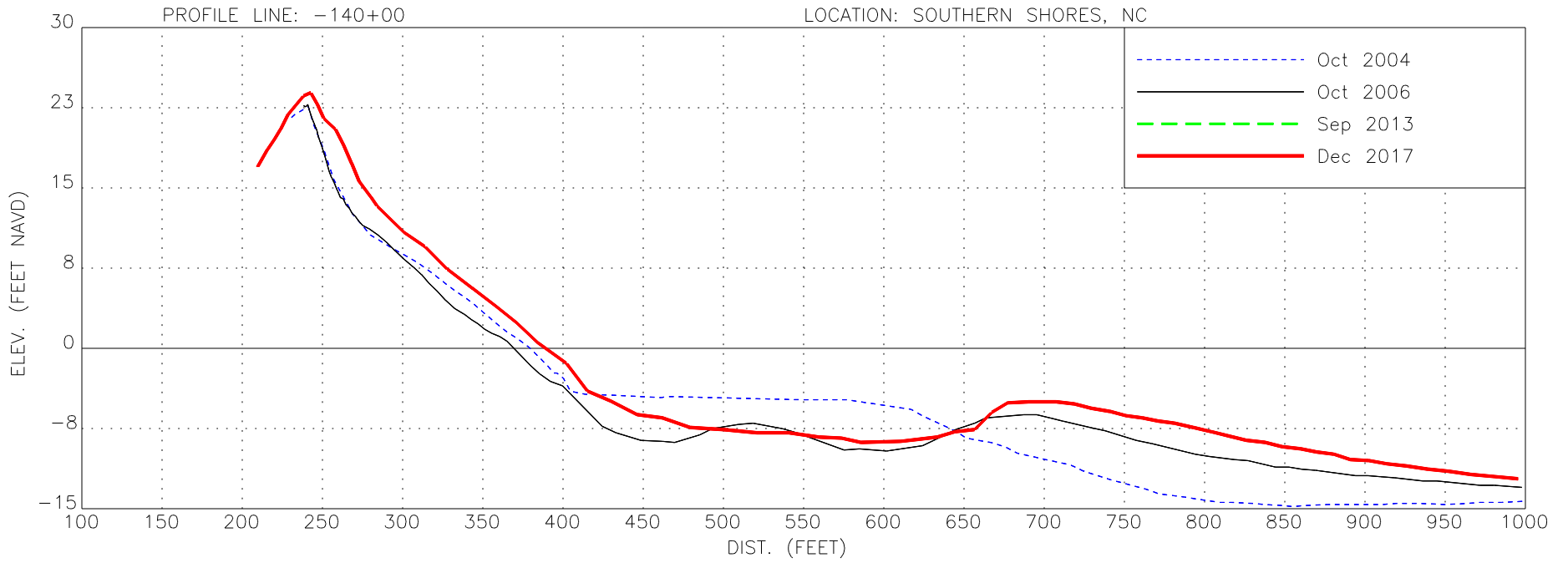


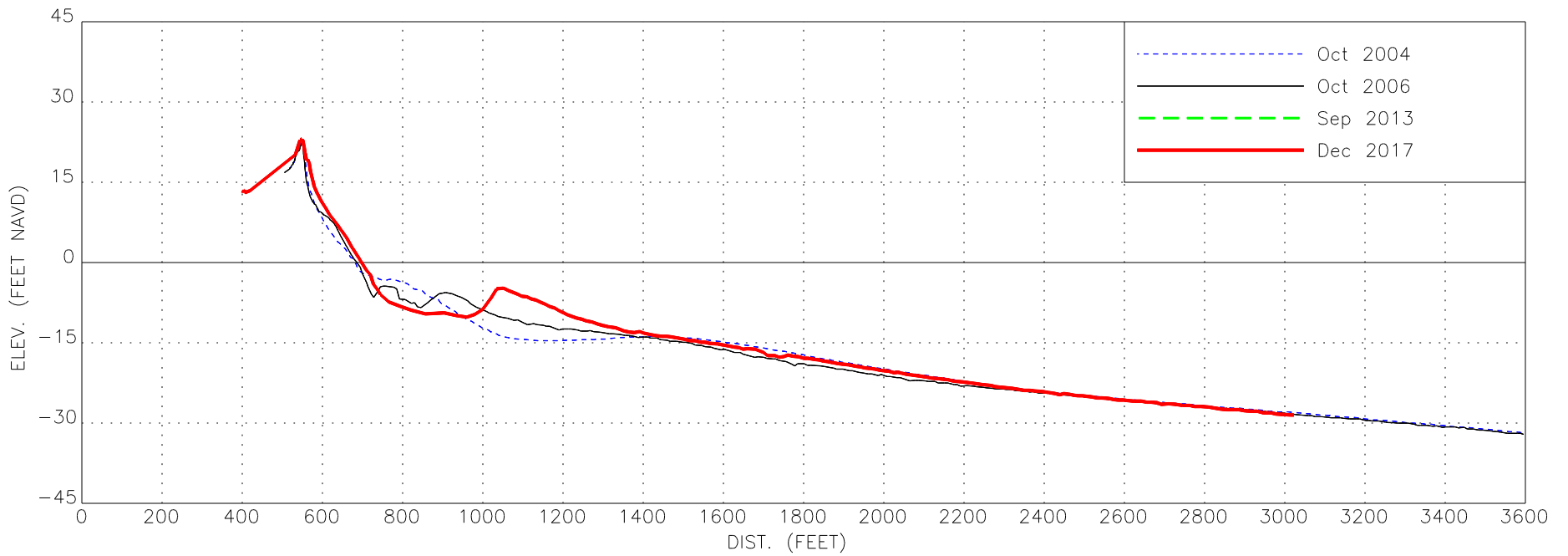
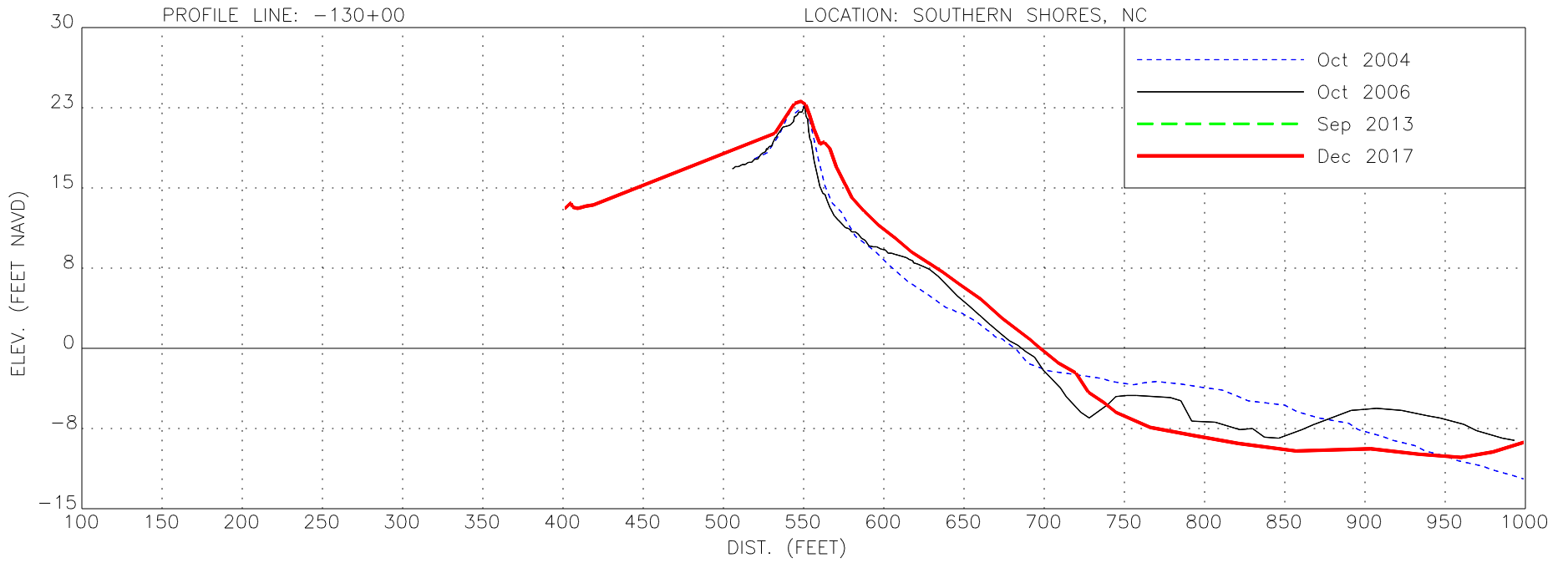


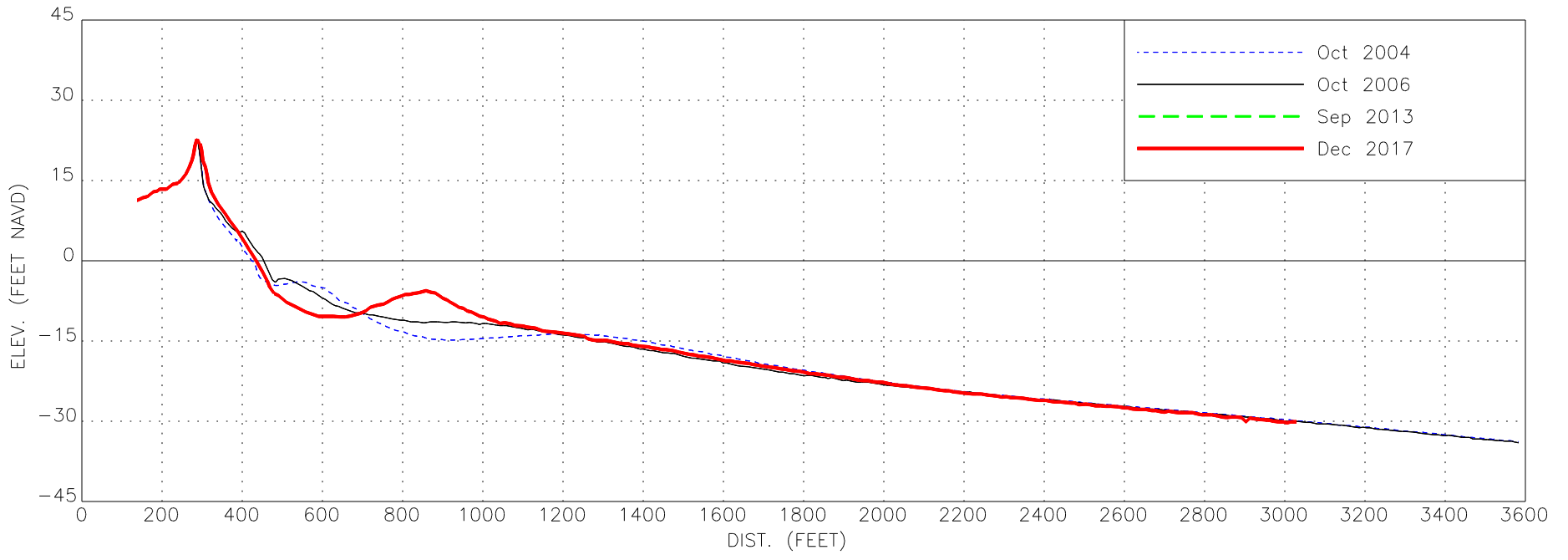
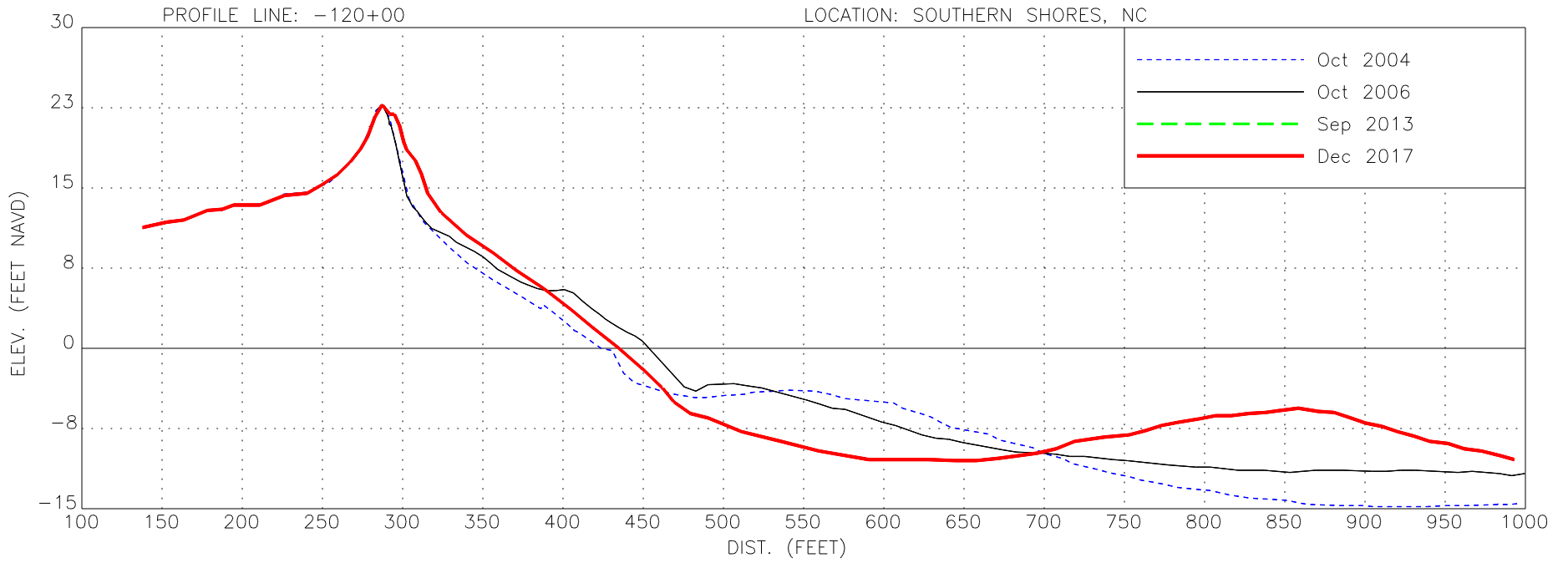


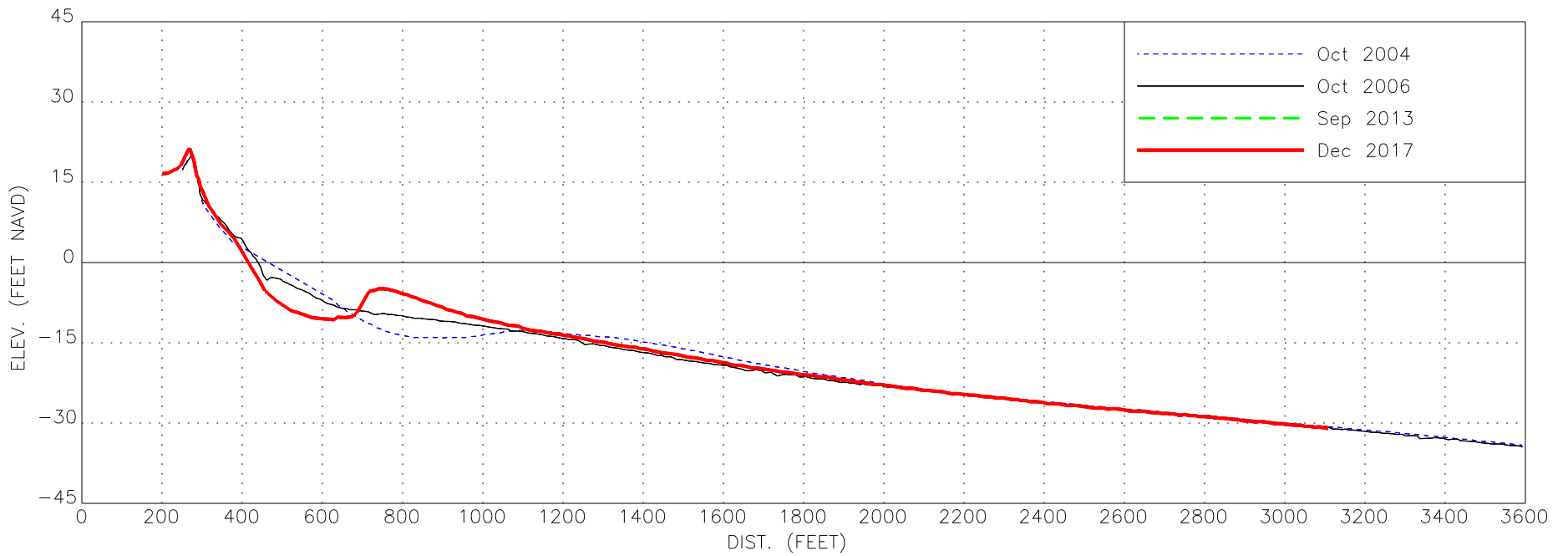
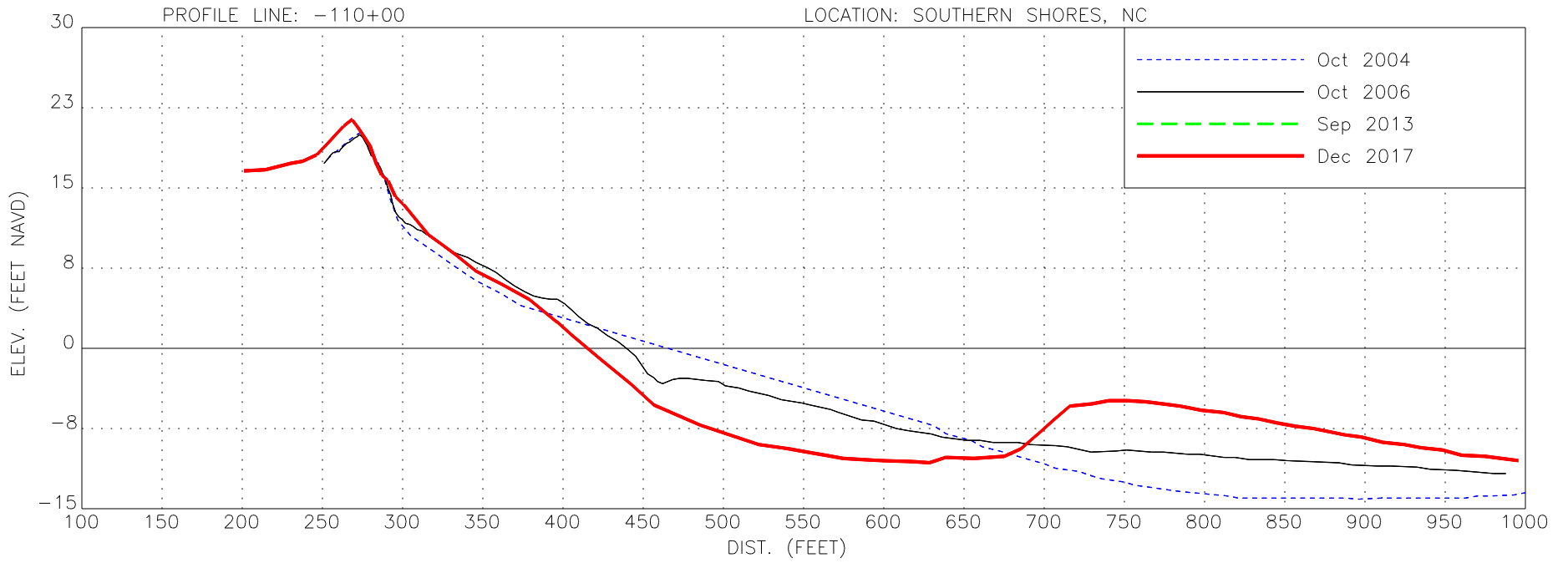


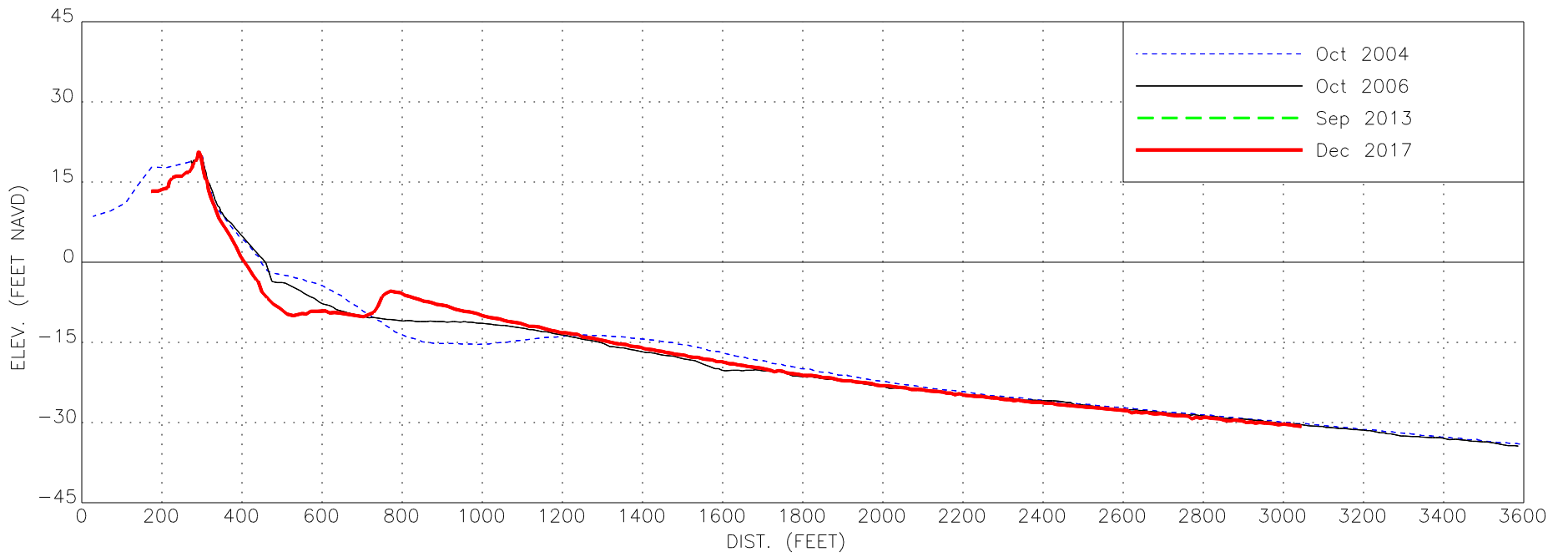
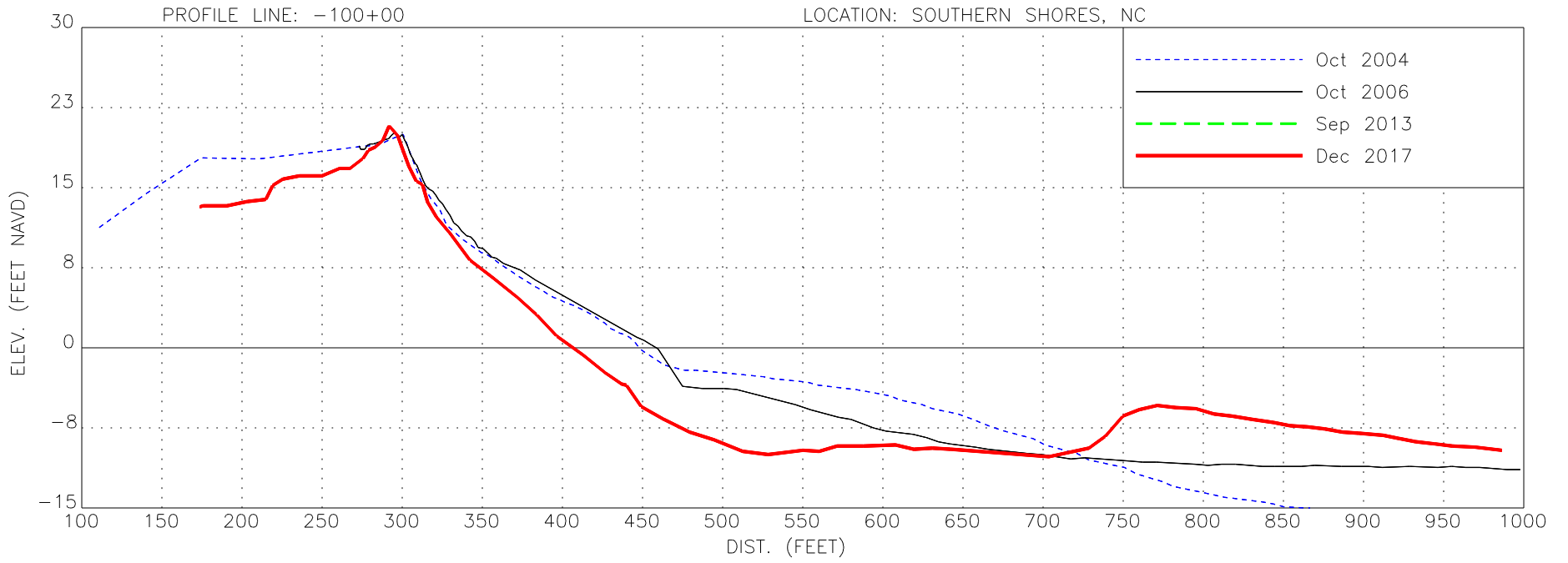


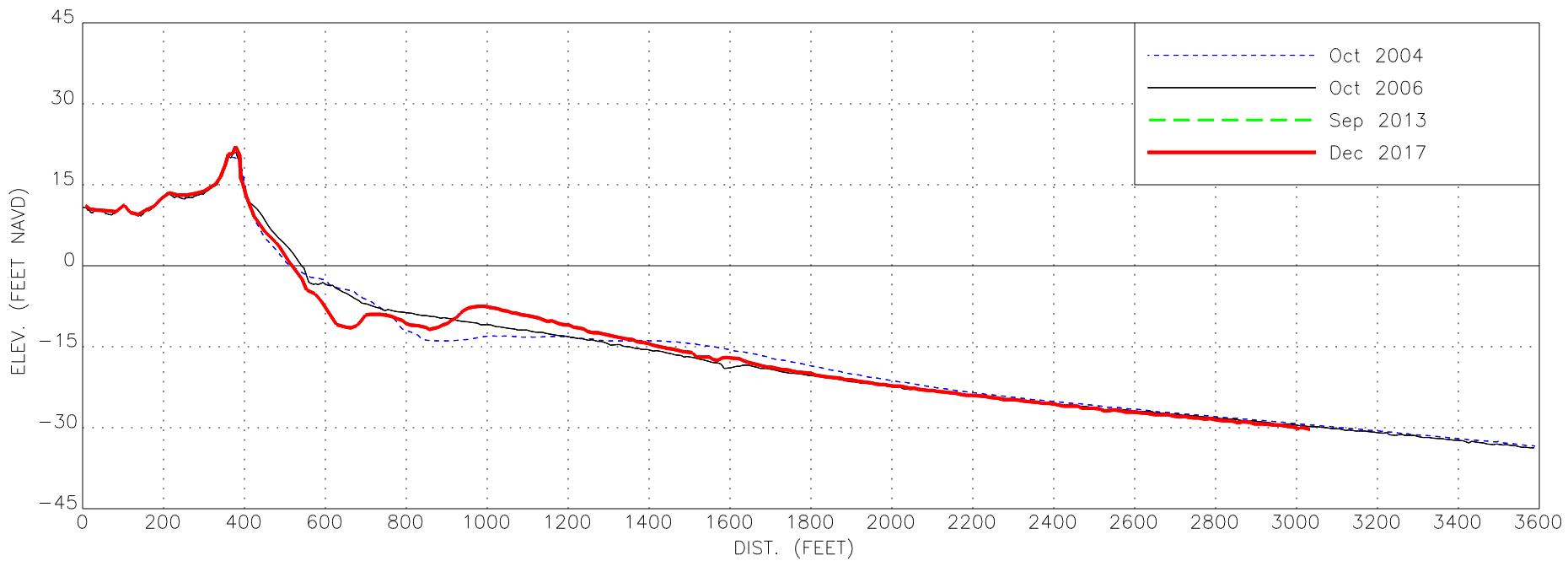
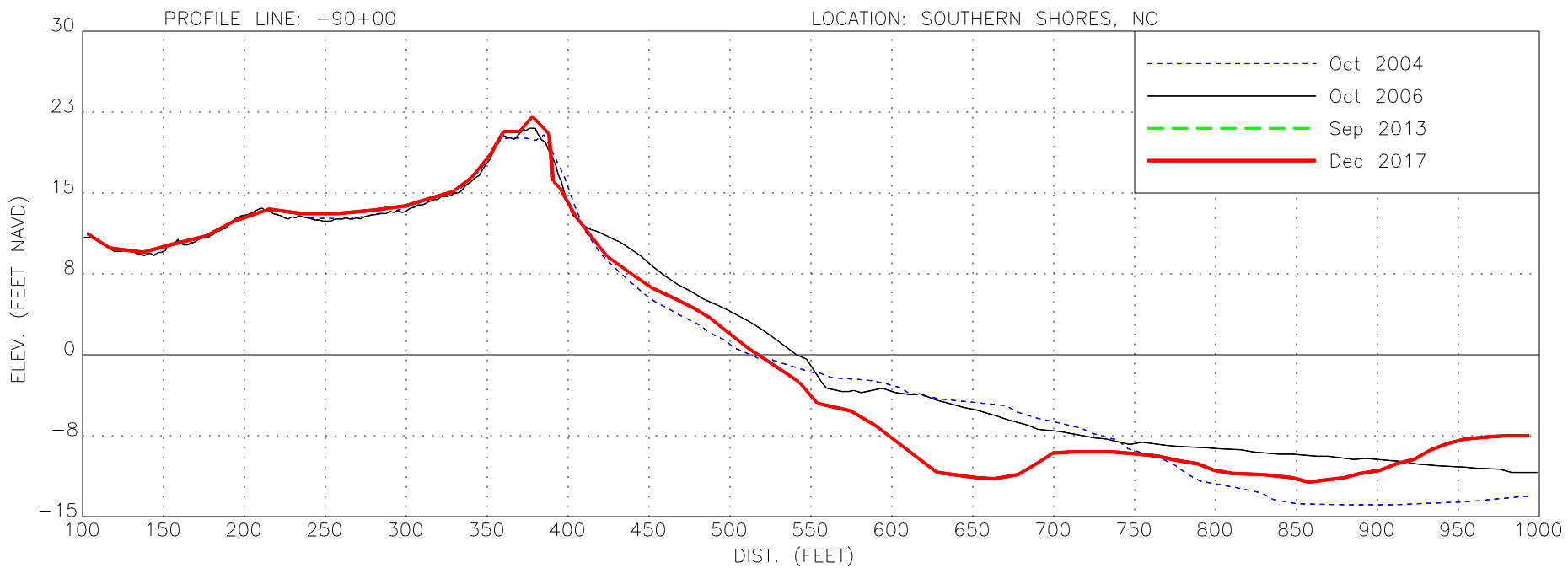




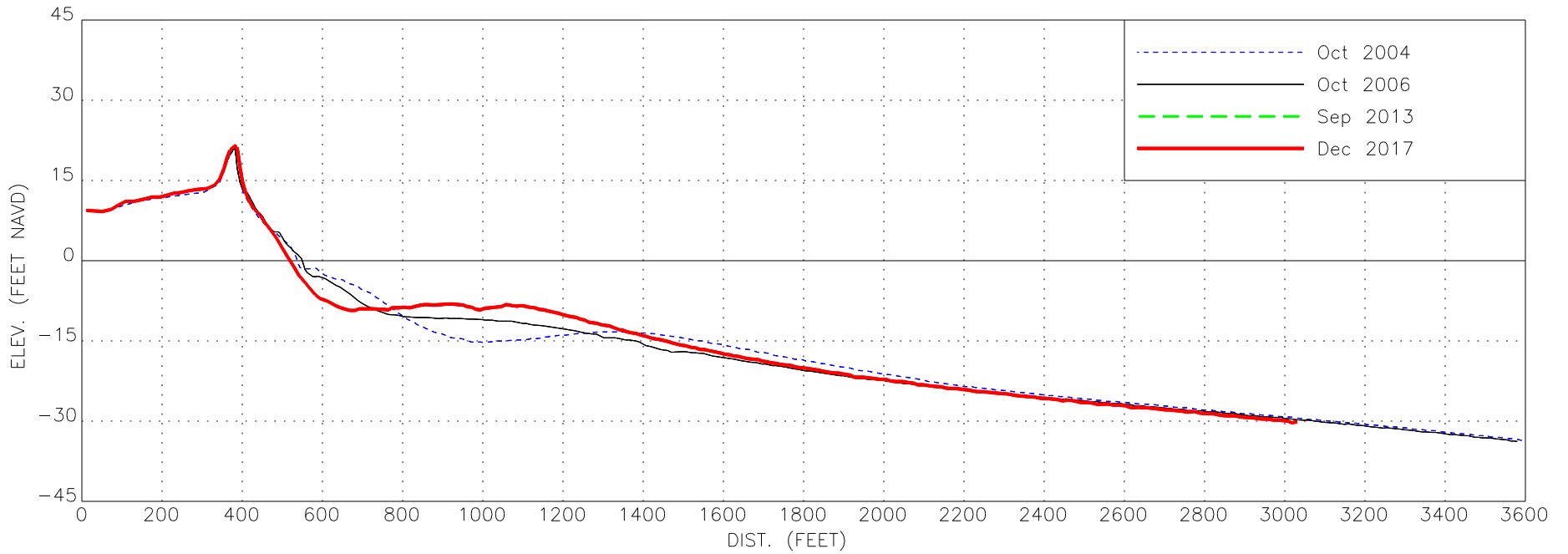
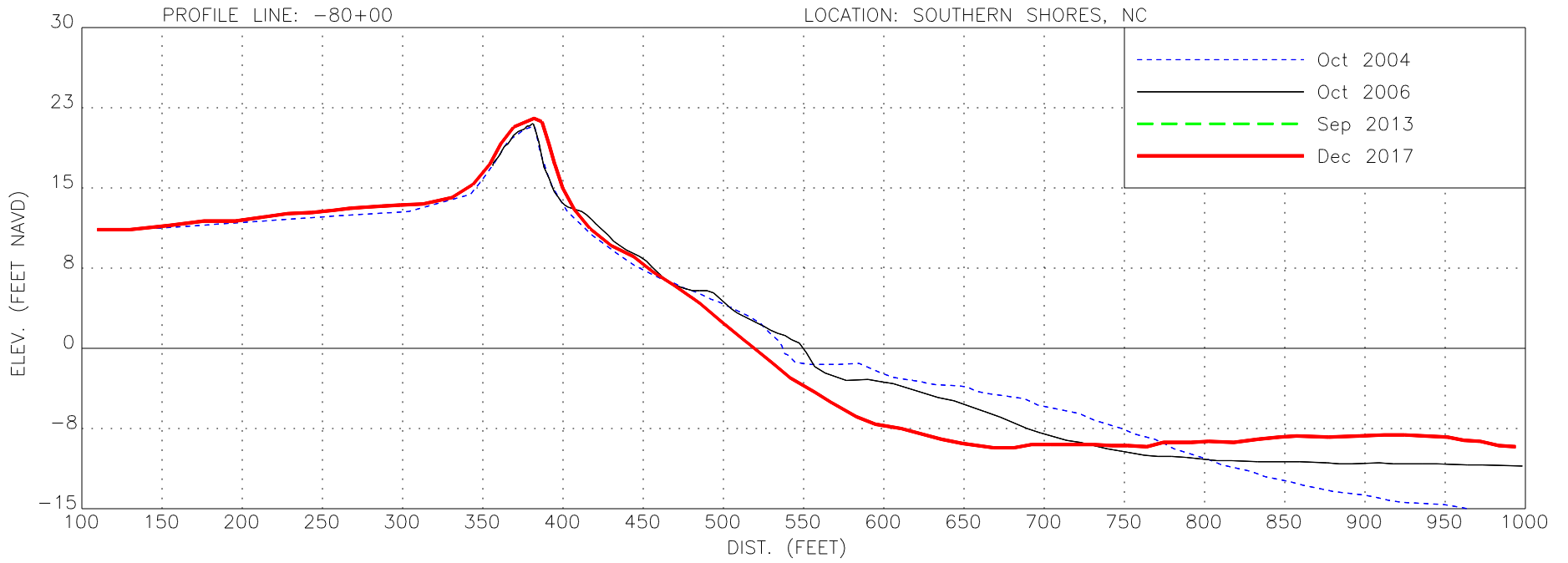


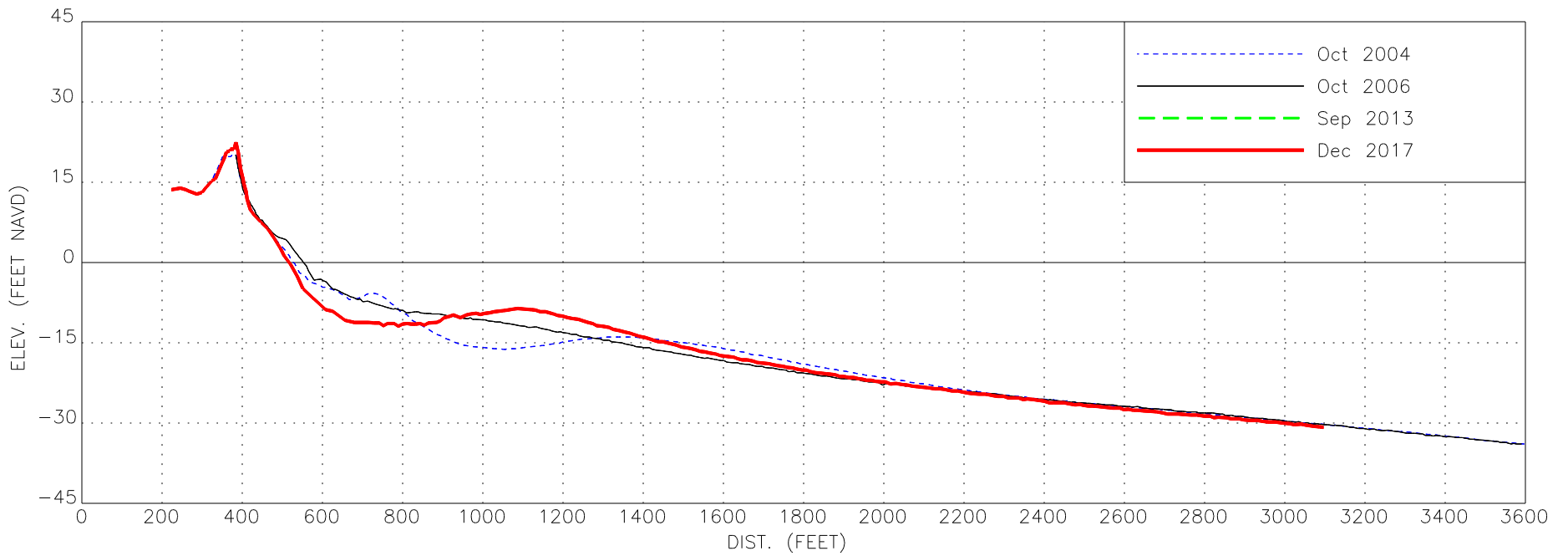
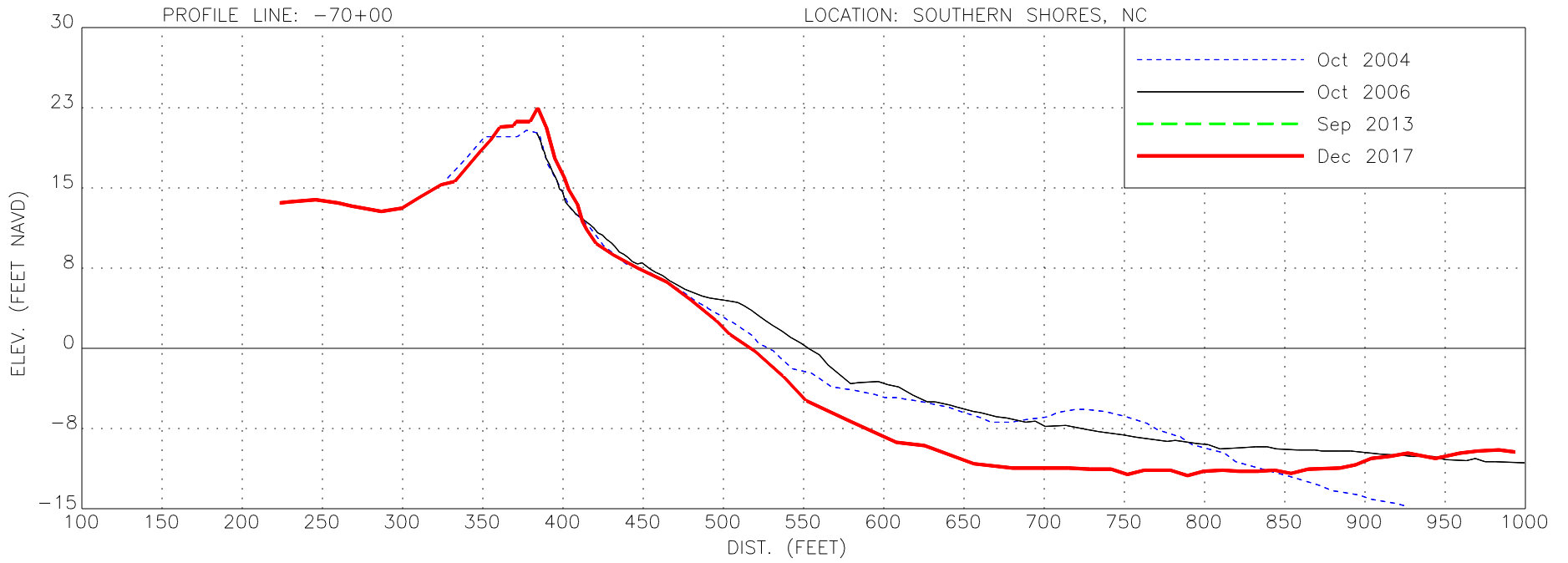


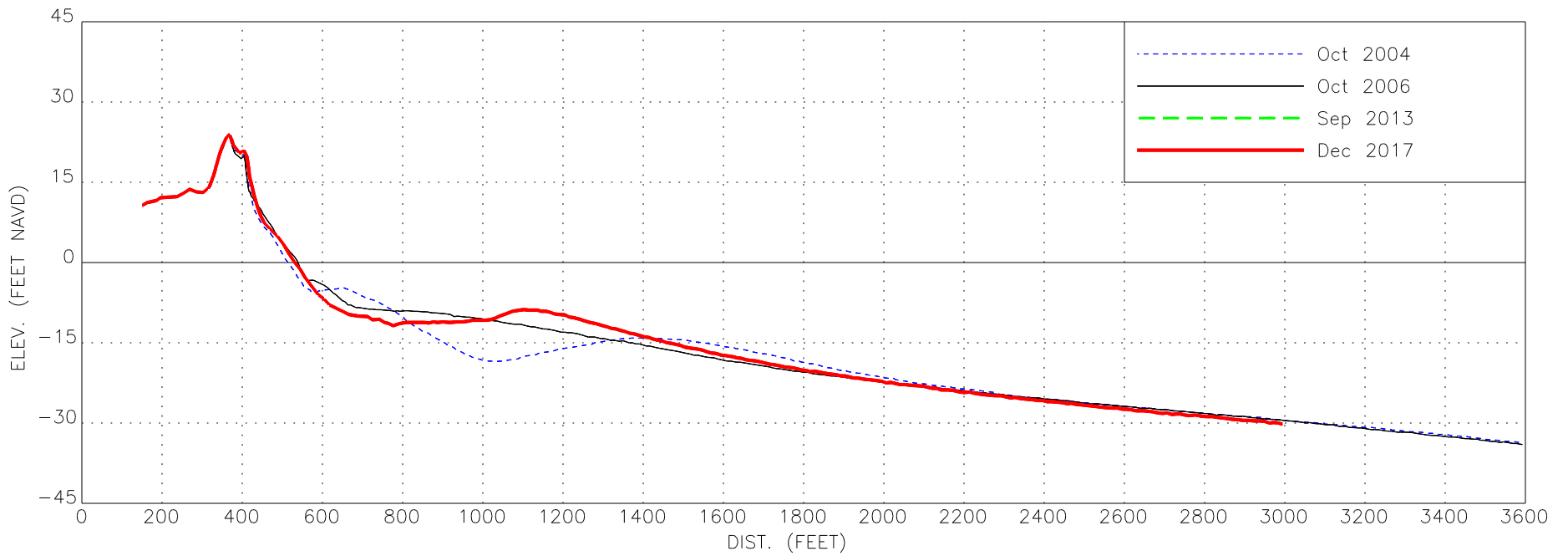
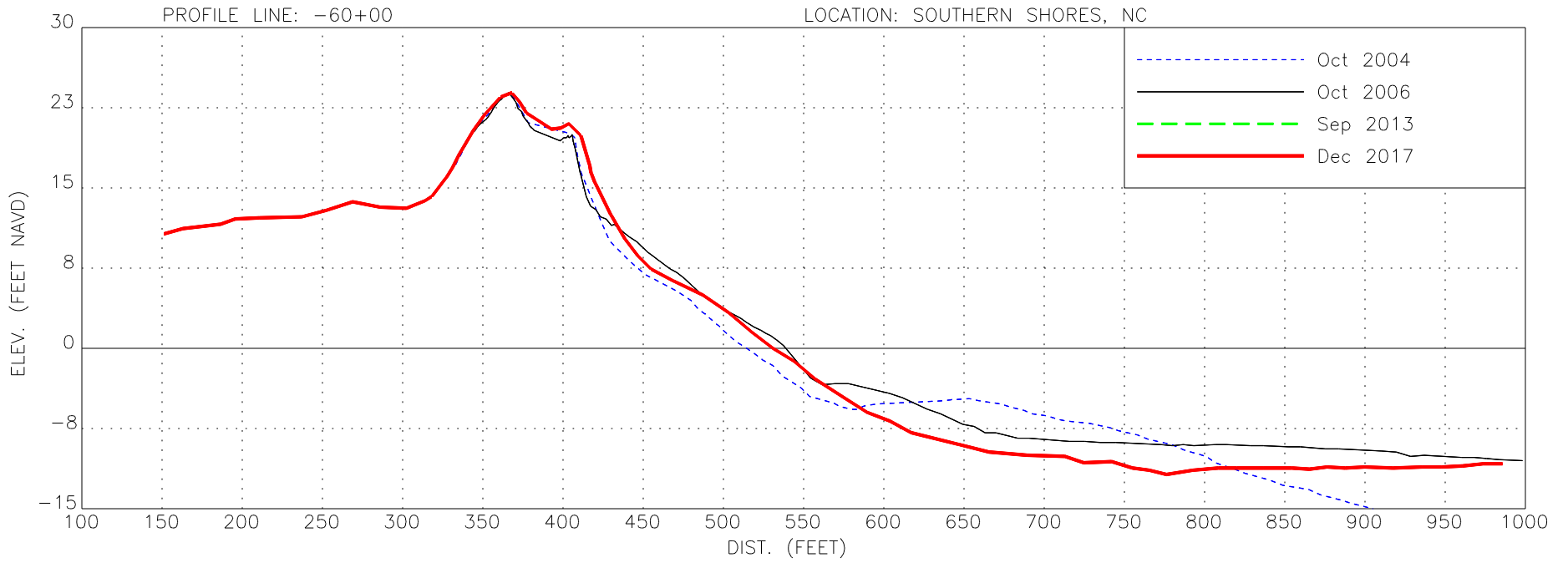


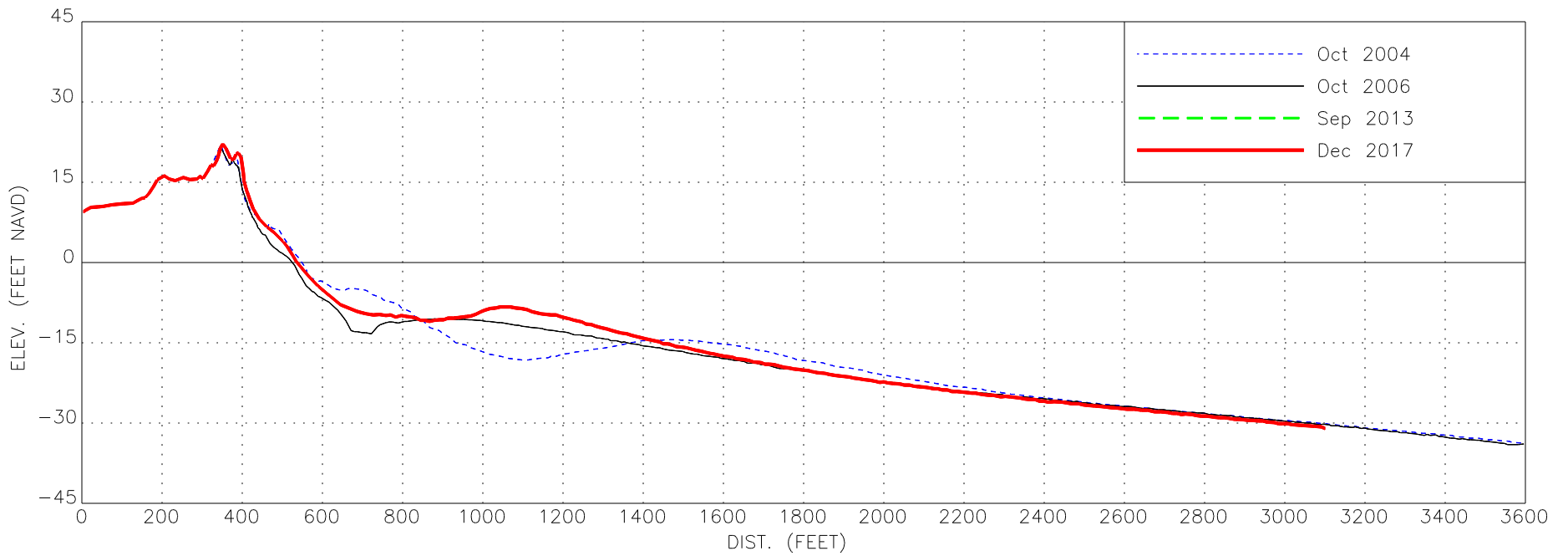
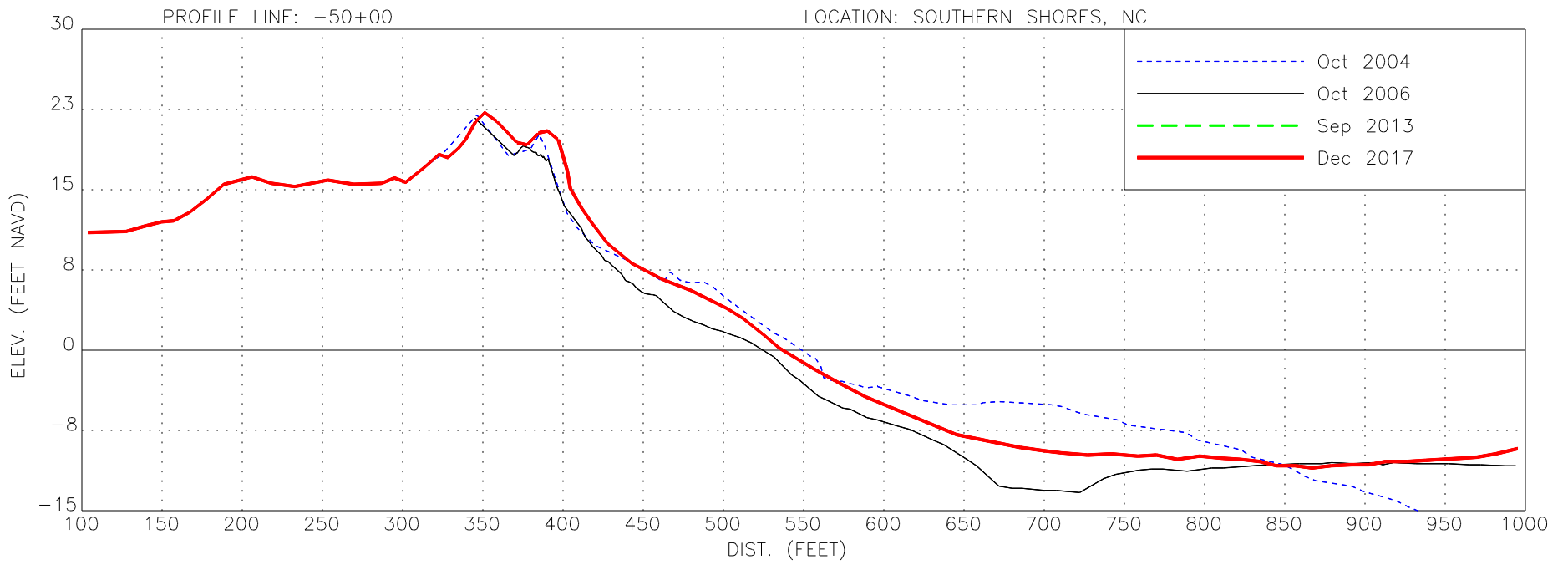


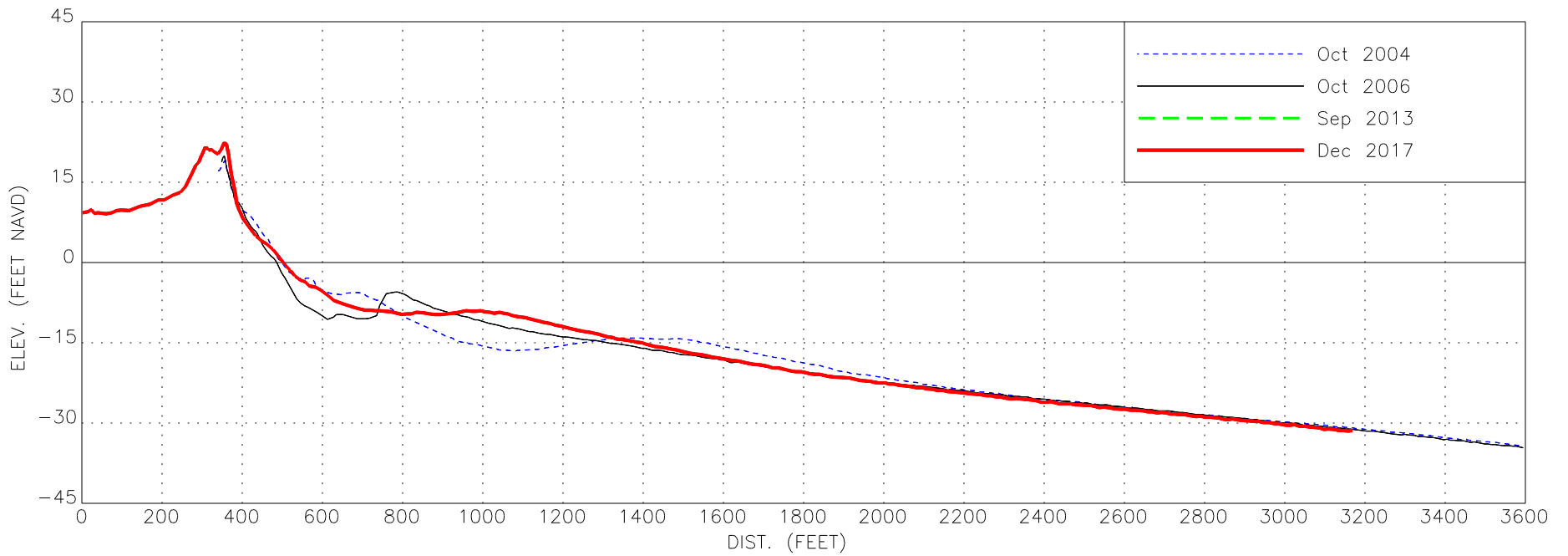
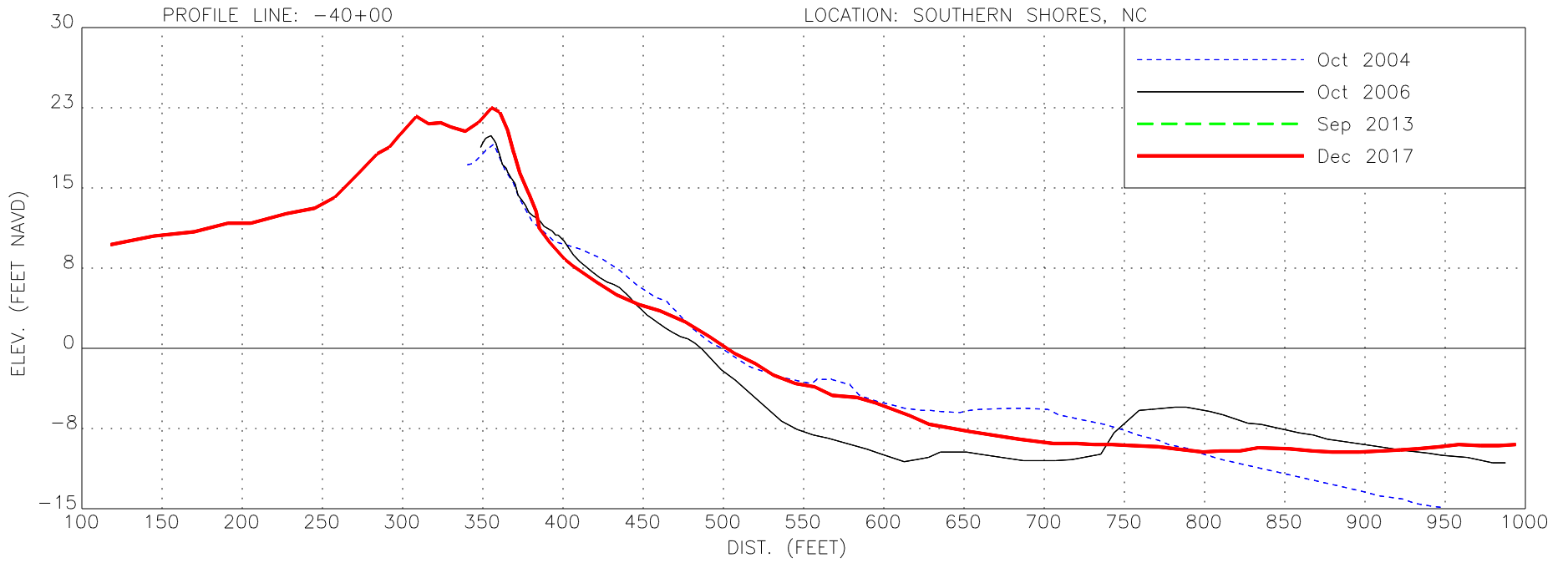


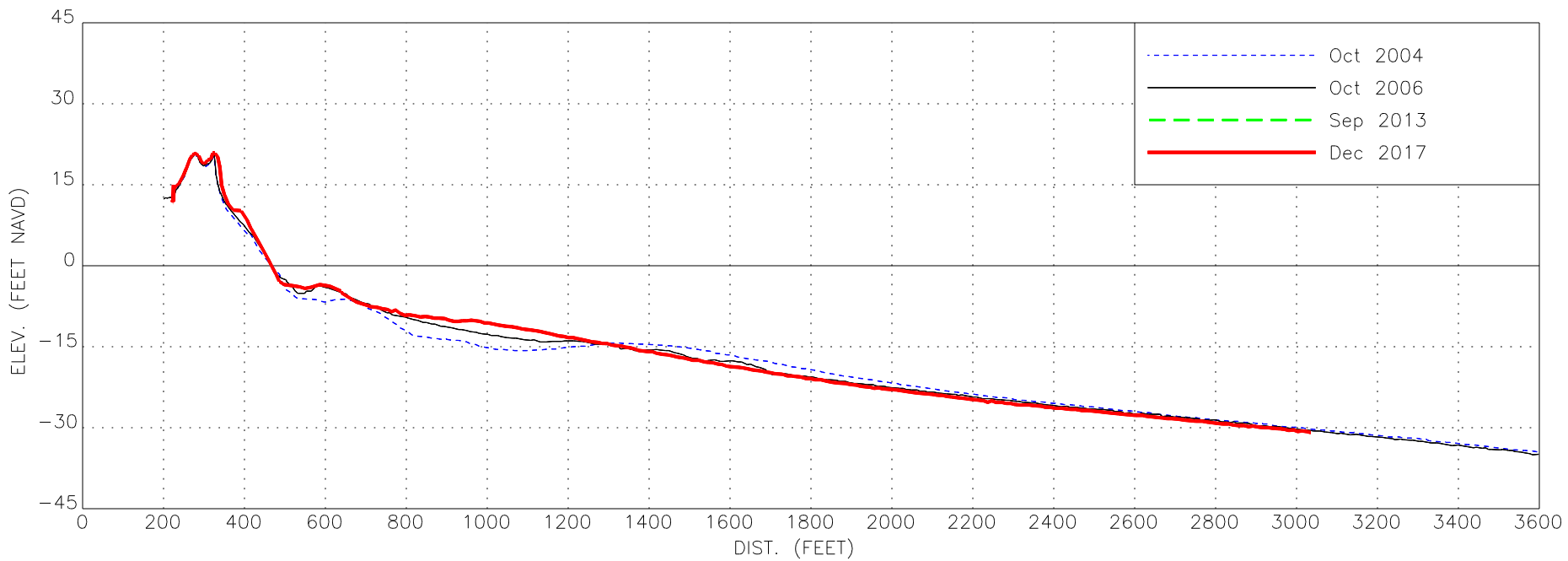
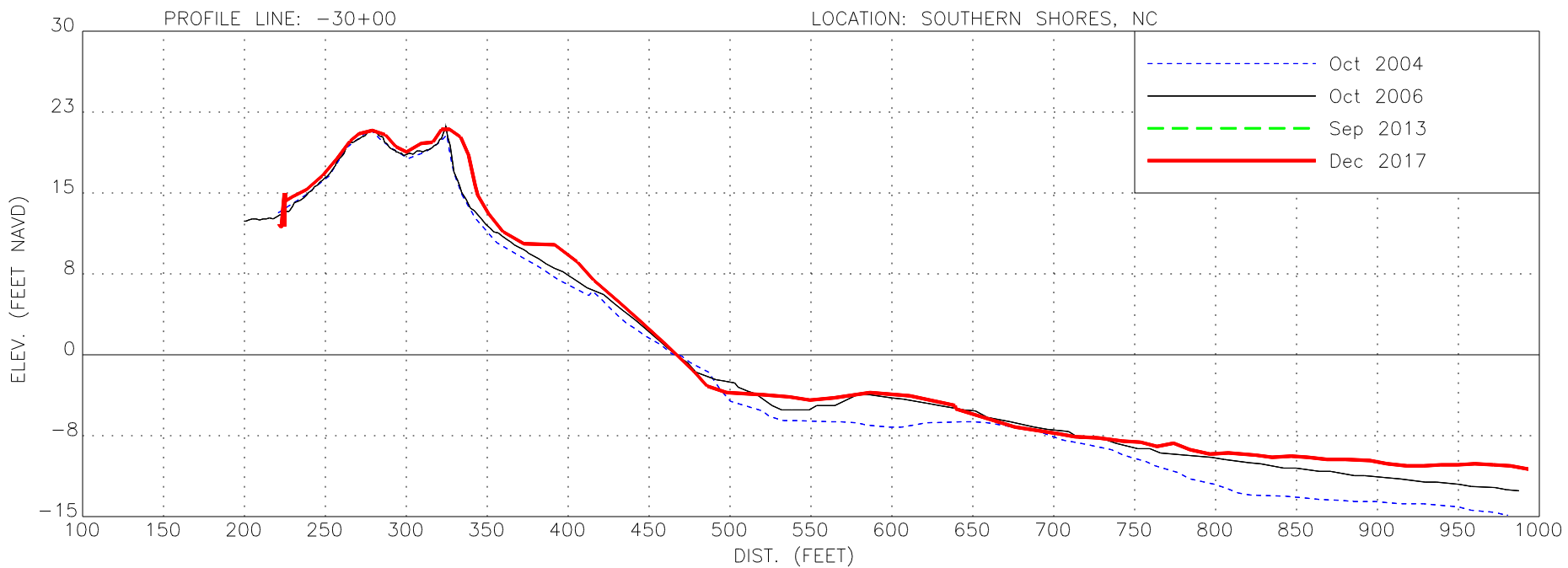


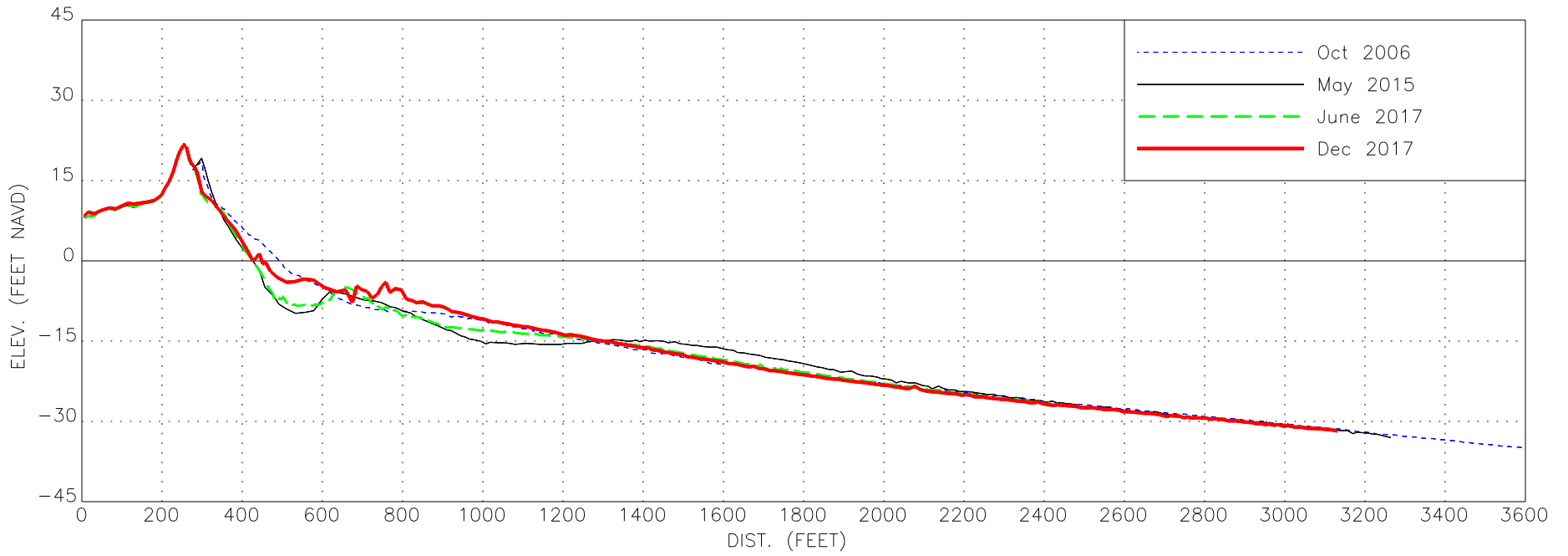
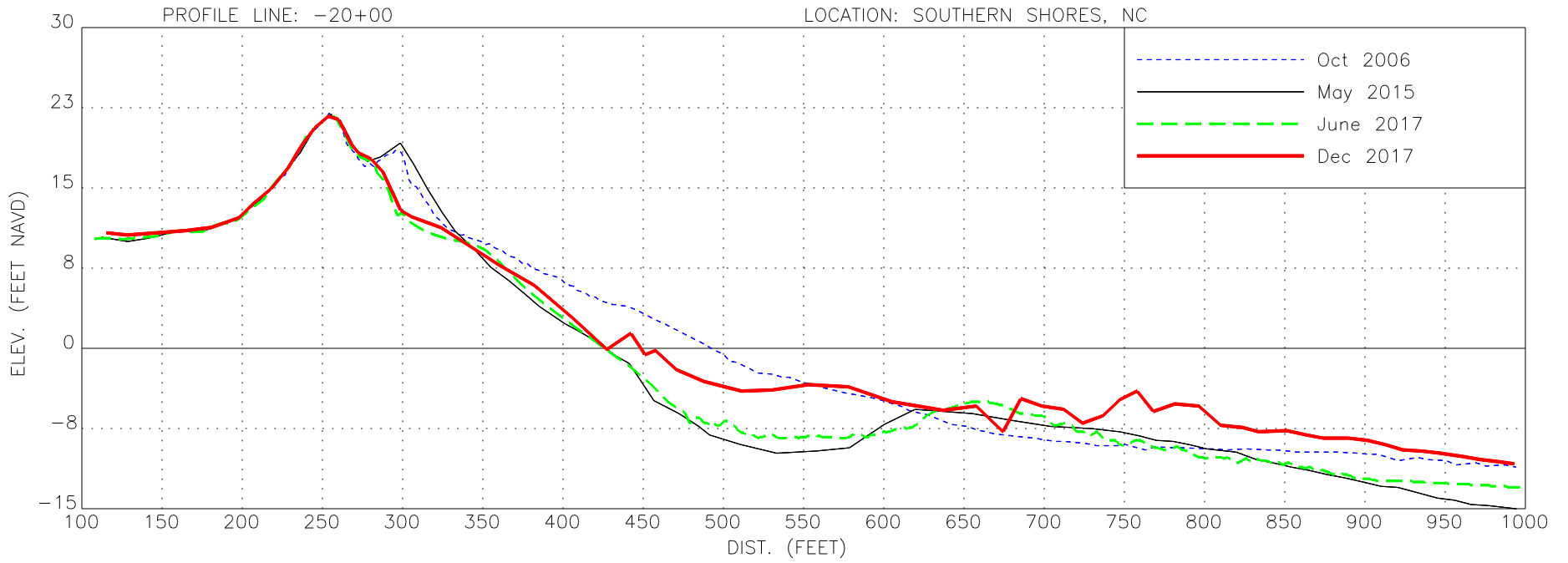


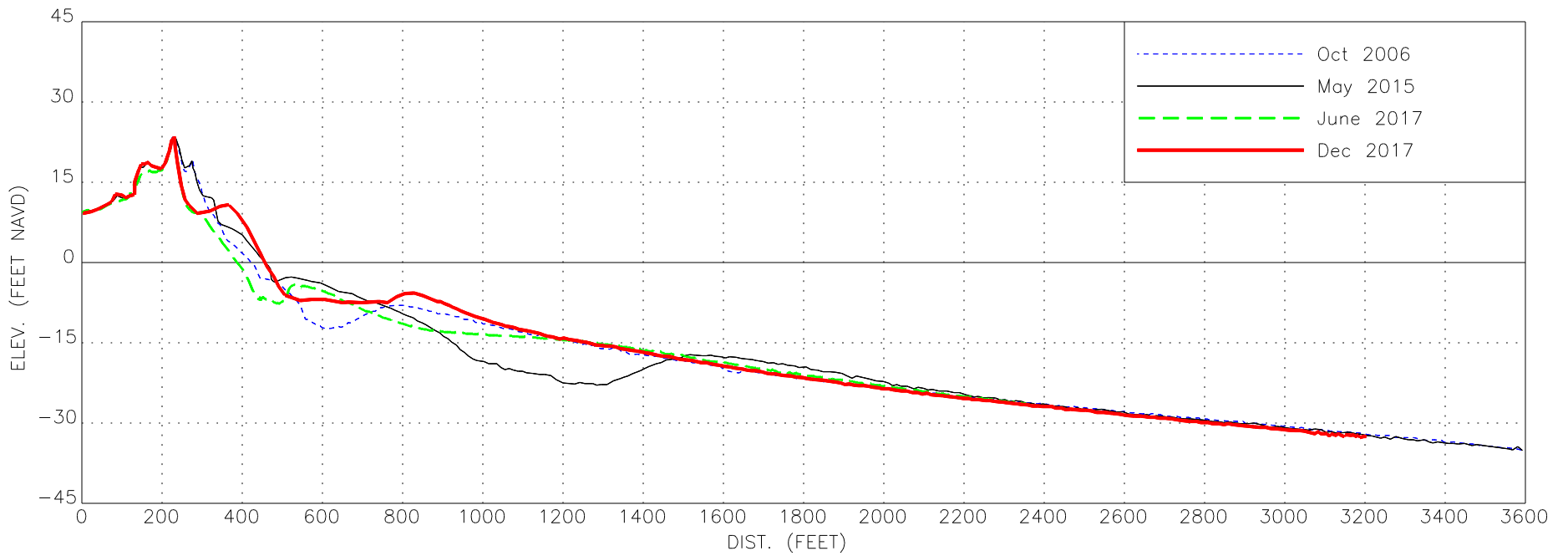
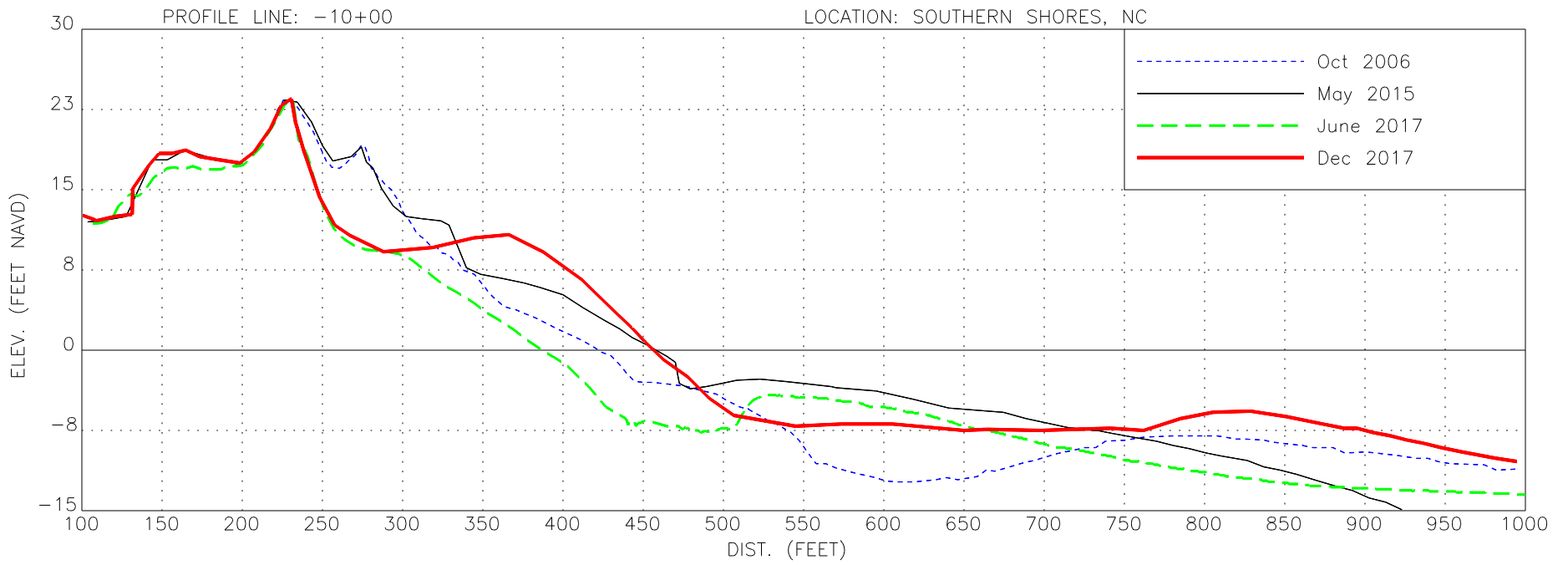




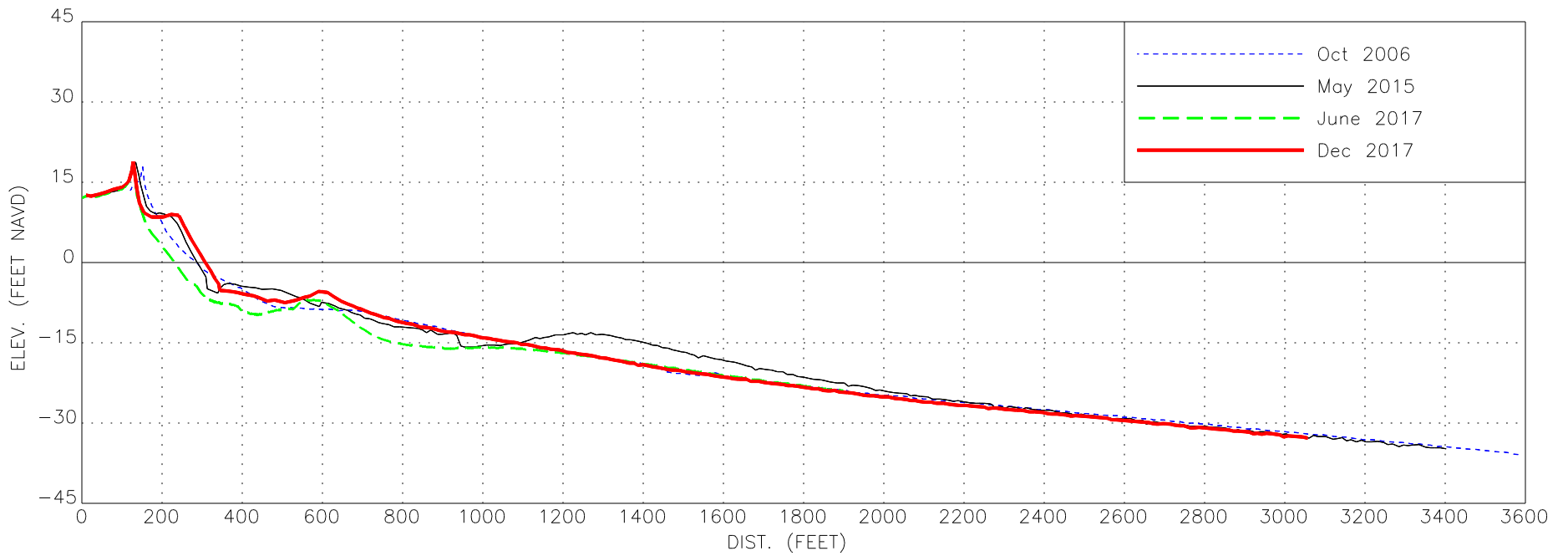
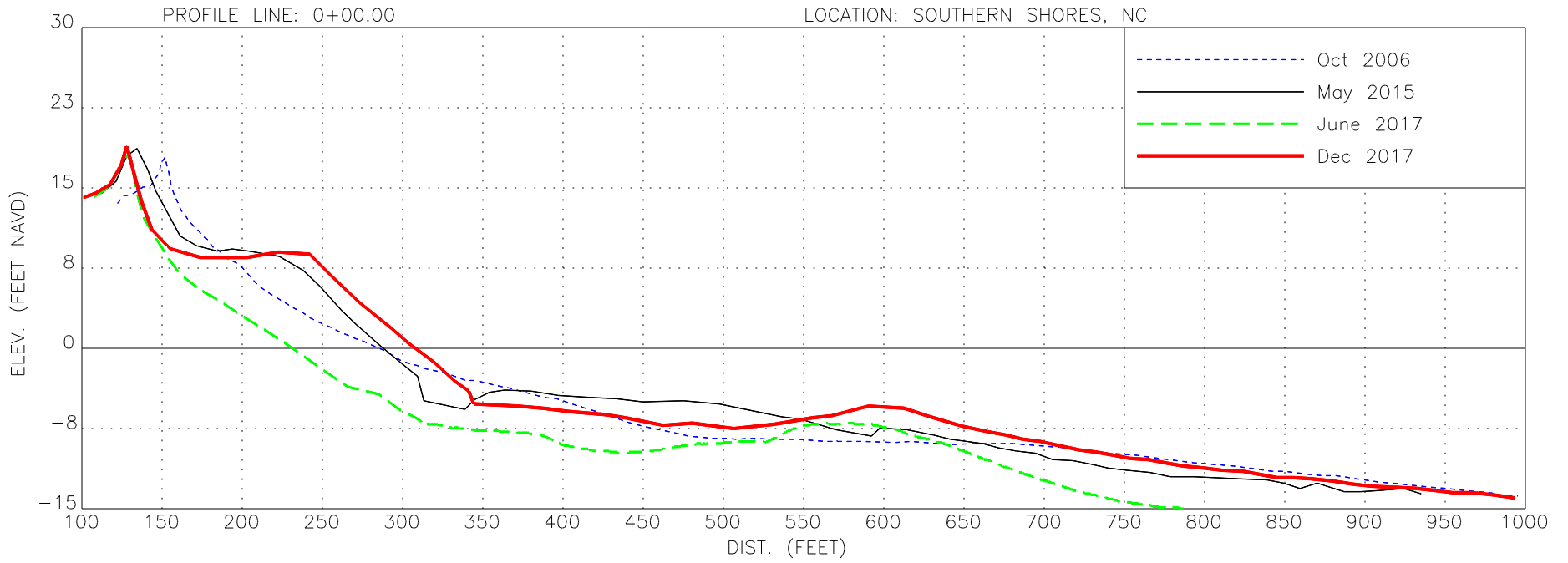












## APPENDIX 4

### GROUND DIGITAL PHOTOGRAPHY

APPENDIX 4: Southern Shores Ground Digital Photography  
(Individual High Resolution Images Included as Digital Copy)



**Ground Digital Photography  
Monument**

**D-34 (-197+12)**



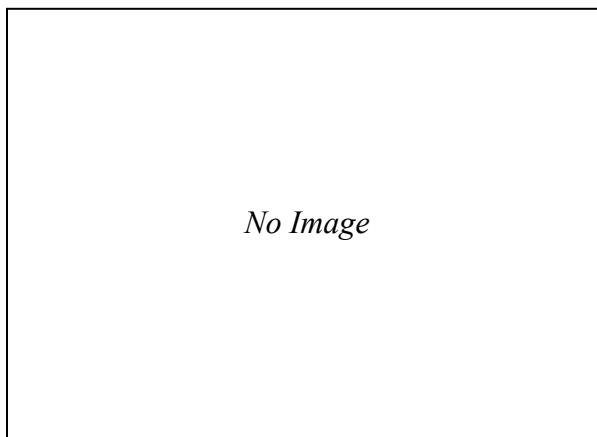
**North View**



**South View**



**Landward View**



**Monument – Reference Point**



**Ground Digital Photography  
Monument**

**-187+14**



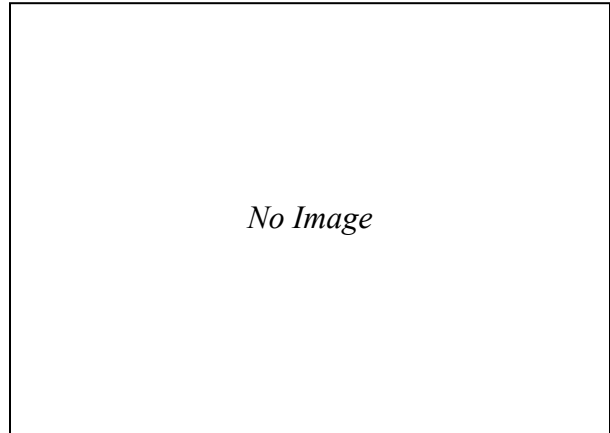
**North View**



**South View**



**Landward View**



**Monument – Reference Point**



**Ground Digital Photography  
Monument**

**-177+13**



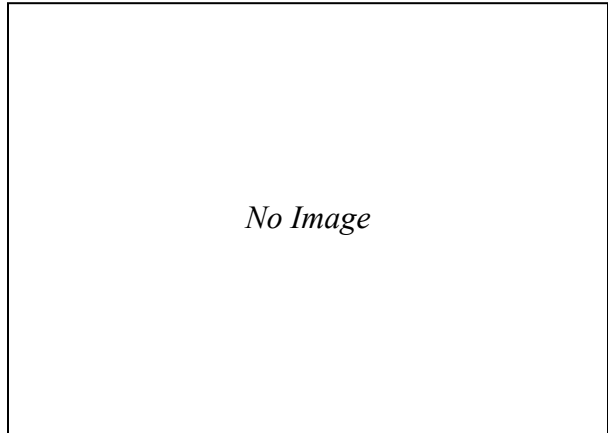
**North View**



**South View**



**Landward View**



**Monument – Reference Point**



**Ground Digital Photography  
Monument**

**-170+56**



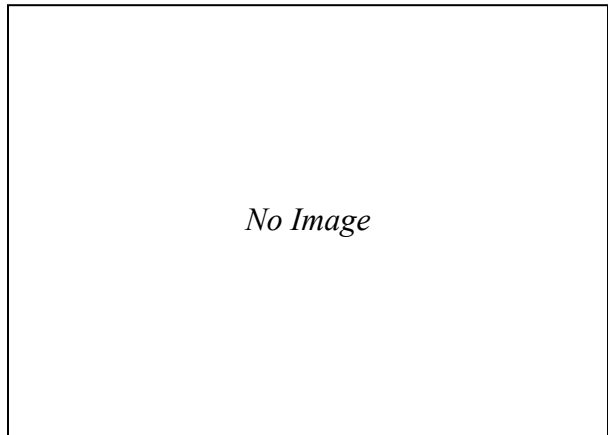
**North View**



**South View**



**Landward View**



**Monument – Reference Point**



**Ground Digital Photography  
Monument**

**-163+99**



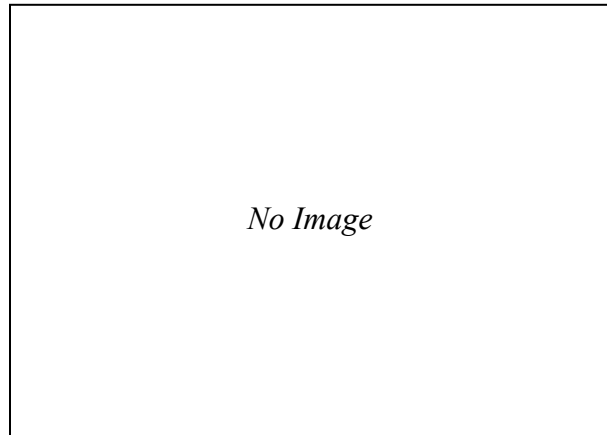
**North View**



**South View**



**Landward View**



**Monument – Reference Point**



**Ground Digital Photography  
Monument**

**-157+41**



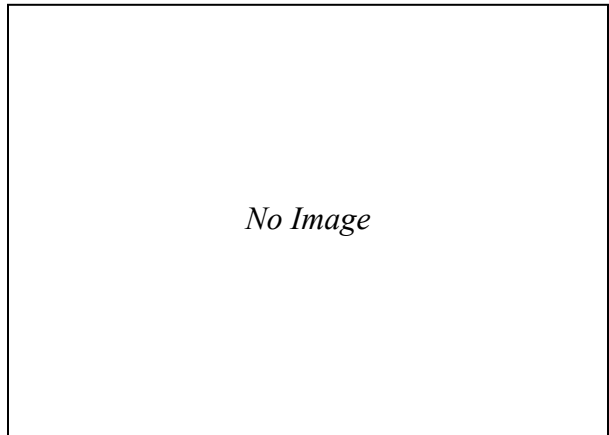
**North View**



**South View**



**Landward View**



**Monument – Reference Point**





**Ground Digital Photography  
Monument**

**-150+00**



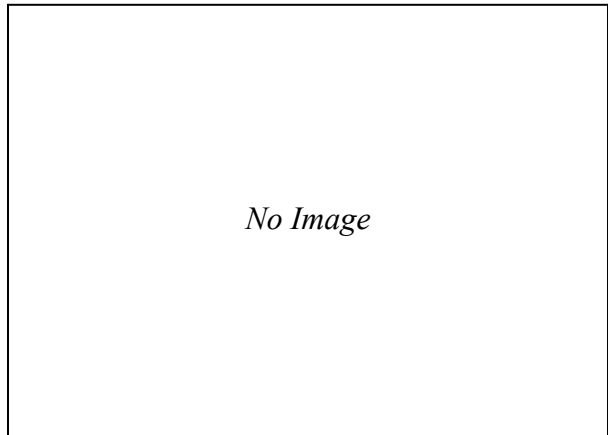
**North View**



**South View**



**Landward View**



**Monument – Reference Point**



**Ground Digital Photography  
Monument**

**-140+00**



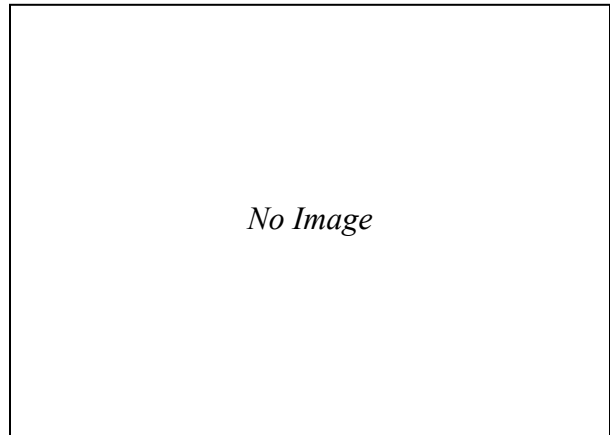
**North View**



**South View**



**Landward View**



**Monument – Reference Point**



**Ground Digital Photography  
Monument**

**-130+00**



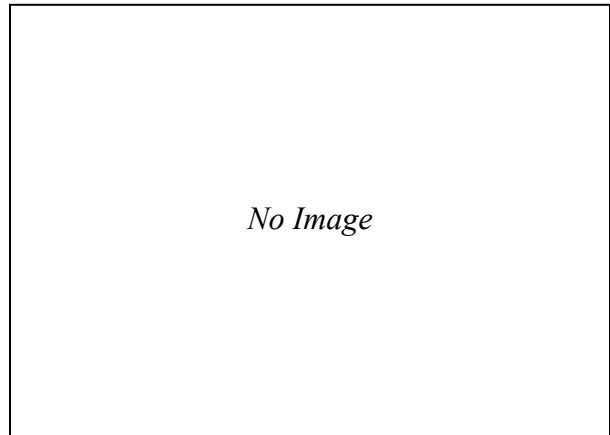
**North View**



**South View**



**Landward View**



**Monument – Reference Point**



**Ground Digital Photography  
Monument**

**-120+00**



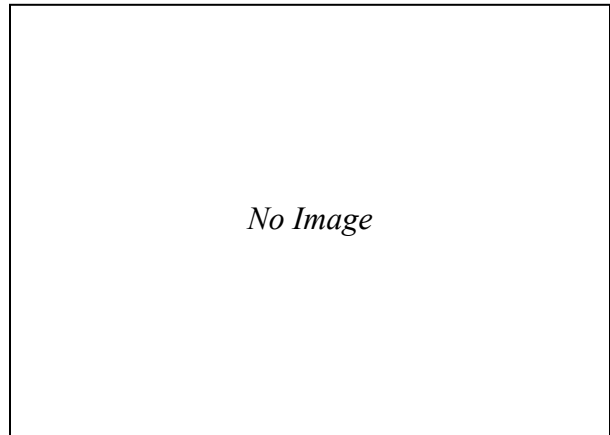
**North View**



**South View**



**Landward View**



**Monument – Reference Point**



**Ground Digital Photography  
Monument**

**-110+00**



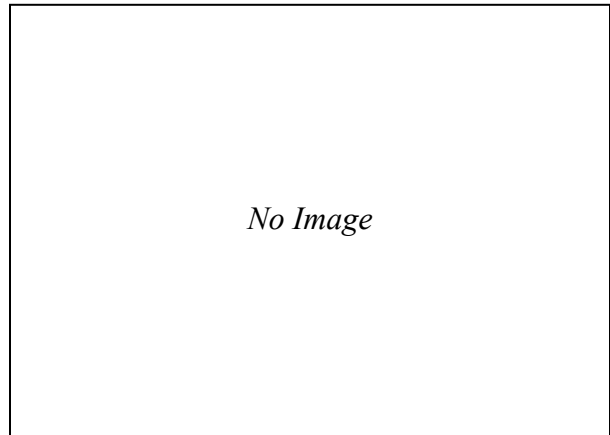
**North View**



**South View**



**Landward View**



**Monument – Reference Point**



**Ground Digital Photography  
Monument**

**-100+00**



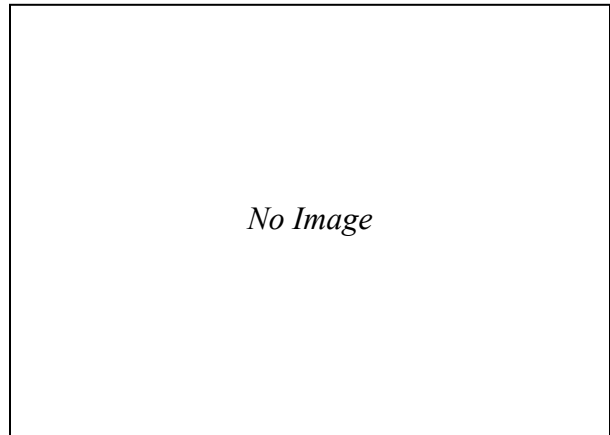
**North View**



**South View**



**Landward View**



**Monument – Reference Point**



**Ground Digital Photography  
Monument**

**-90+00**



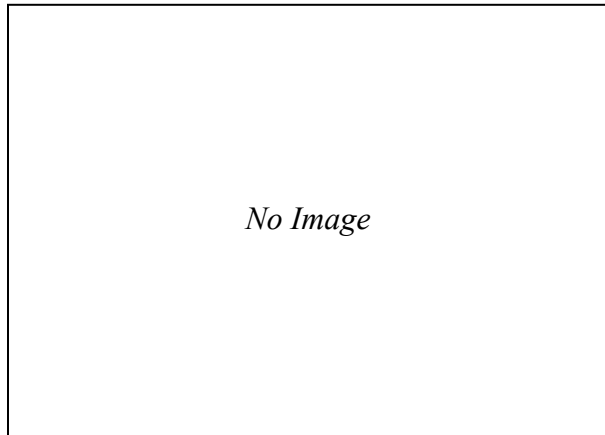
**North View**



**South View**



**Landward View**



**Monument – Reference Point**



**Ground Digital Photography  
Monument**

**-80+00**



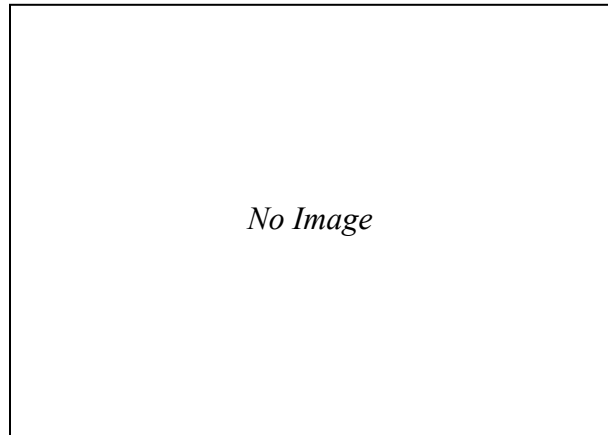
**North View**



**South View**



**Landward View**



**Monument – Reference Point**





**Ground Digital Photography  
Monument**

**-70+00**



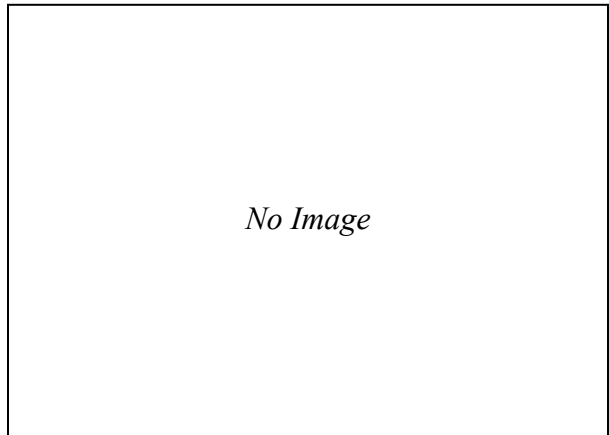
**North View**



**South View**



**Landward View**



**Monument – Reference Point**



**Ground Digital Photography  
Monument**

**-60+00**



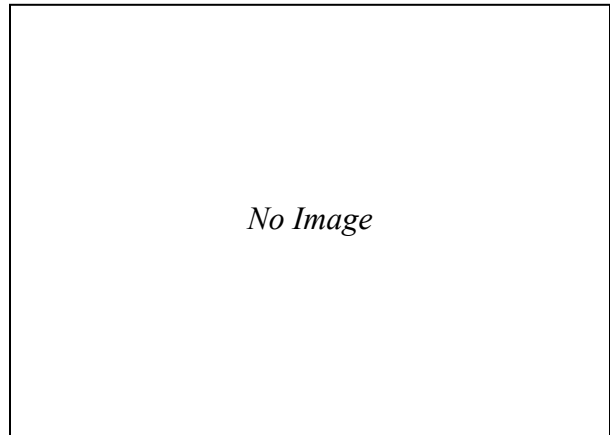
**North View**



**South View**



**Landward View**



**Monument – Reference Point**



**Ground Digital Photography  
Monument**

**-50+00**



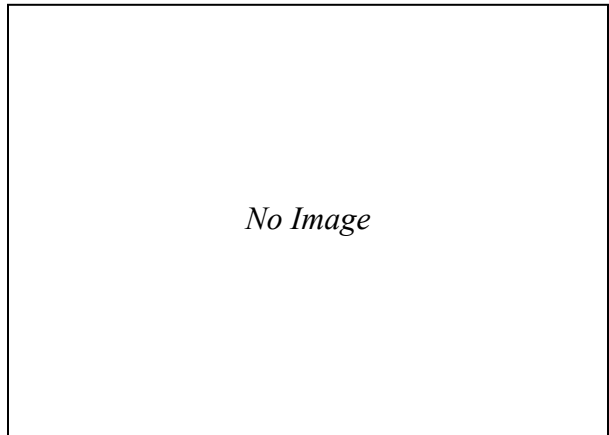
**North View**



**South View**



**Landward View**



**Monument – Reference Point**



**Ground Digital Photography  
Monument**

**-40+00**



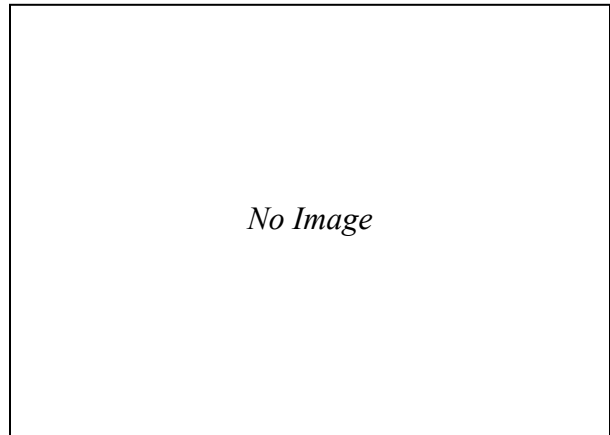
**North View**



**South View**



**Landward View**



**Monument – Reference Point**



**Ground Digital Photography  
Monument**

**-30+00**



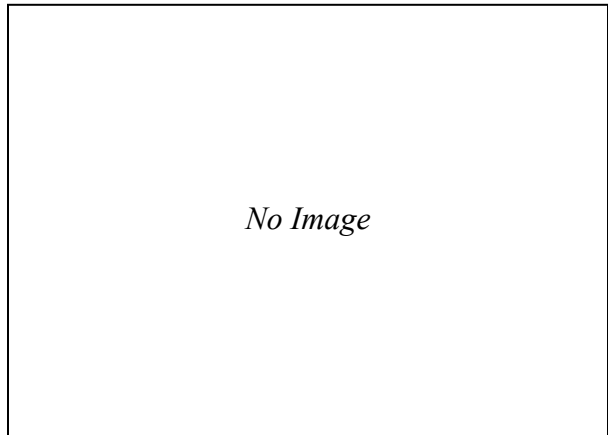
**North View**



**South View**



**Landward View**



**Monument – Reference Point**



**Ground Digital Photography  
Monument**

**-20+00**



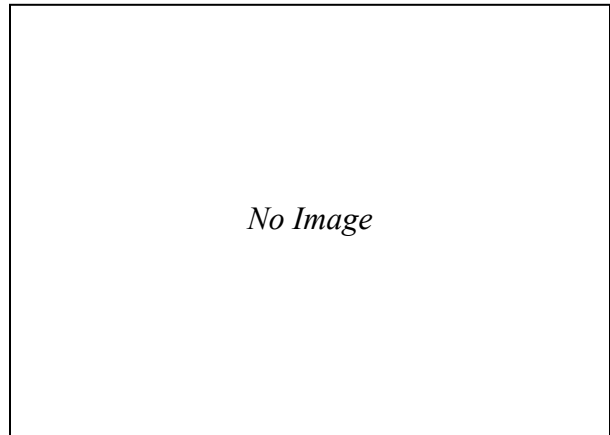
**North View**



**South View**



**Landward View**



**Monument – Reference Point**

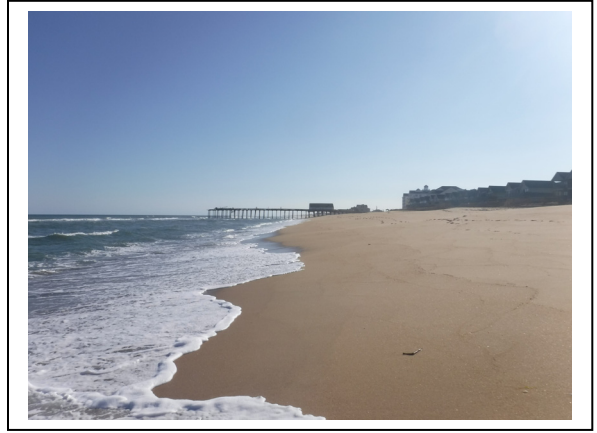


**Ground Digital Photography  
Monument**

**-10+00**



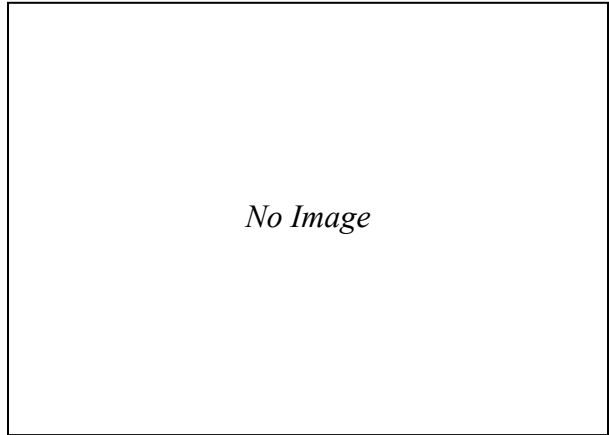
**North View**



**South View**



**Landward View**



**Monument – Reference Point**



**Ground Digital Photography  
Monument**

**0+00**



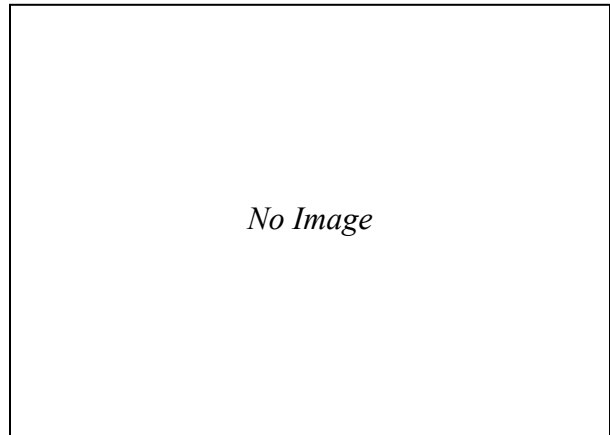
**North View**



**South View**



**Landward View**



**Monument – Reference Point**



APPENDIX 5

FIELD BOOK PAGES

*(Available in digital format only)*