



2018 Town of Duck Annual Monitoring Beach Profile Survey Report

Prepared for:

Town of Duck, North Carolina

Prepared by:

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

September 2018



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ABSTRACT

Aptim Coastal Planning & Engineering of North Carolina, Inc. (APTIM) was contracted by Duck, North Carolina to provide a topographic and hydrographic survey for the 2018 Annual Monitoring Beach Profile Survey. The 2018 annual monitoring consisted of thirty-six (36) profile stations. APTIM surveyors conducted the beach and hydrographic surveys June 13, 2018 through June 16, 2018.

The physical monitoring of the Town of Duck 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 (EM 1110-2-1003).

This survey is in accordance with Chapter 56.1606 of the North Carolina Administrative Code (NCAC) specifications established by The North Carolina Engineering and Land Surveying Act (GS89C). In addition, 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 seven (7) maps visualizing profiles, one (1) project location map, and six (6) 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). Profile data is presented in xyz format relative to The North American Vertical Datum of 1988 (NAVD88) in **Appendix 2**. 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 2nd order monuments, specifically C255 and TIDAL C 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 2nd 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 2nd 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. Offshore data at the pier was obtained from the U.S Army Corps of Engineers Field Research Facility.

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 elevations but enough to give an accurate depiction of the cross sections. The survey maps display profile data and control monument locations plotted against United States Army Corps of Engineers (USACE) 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.

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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



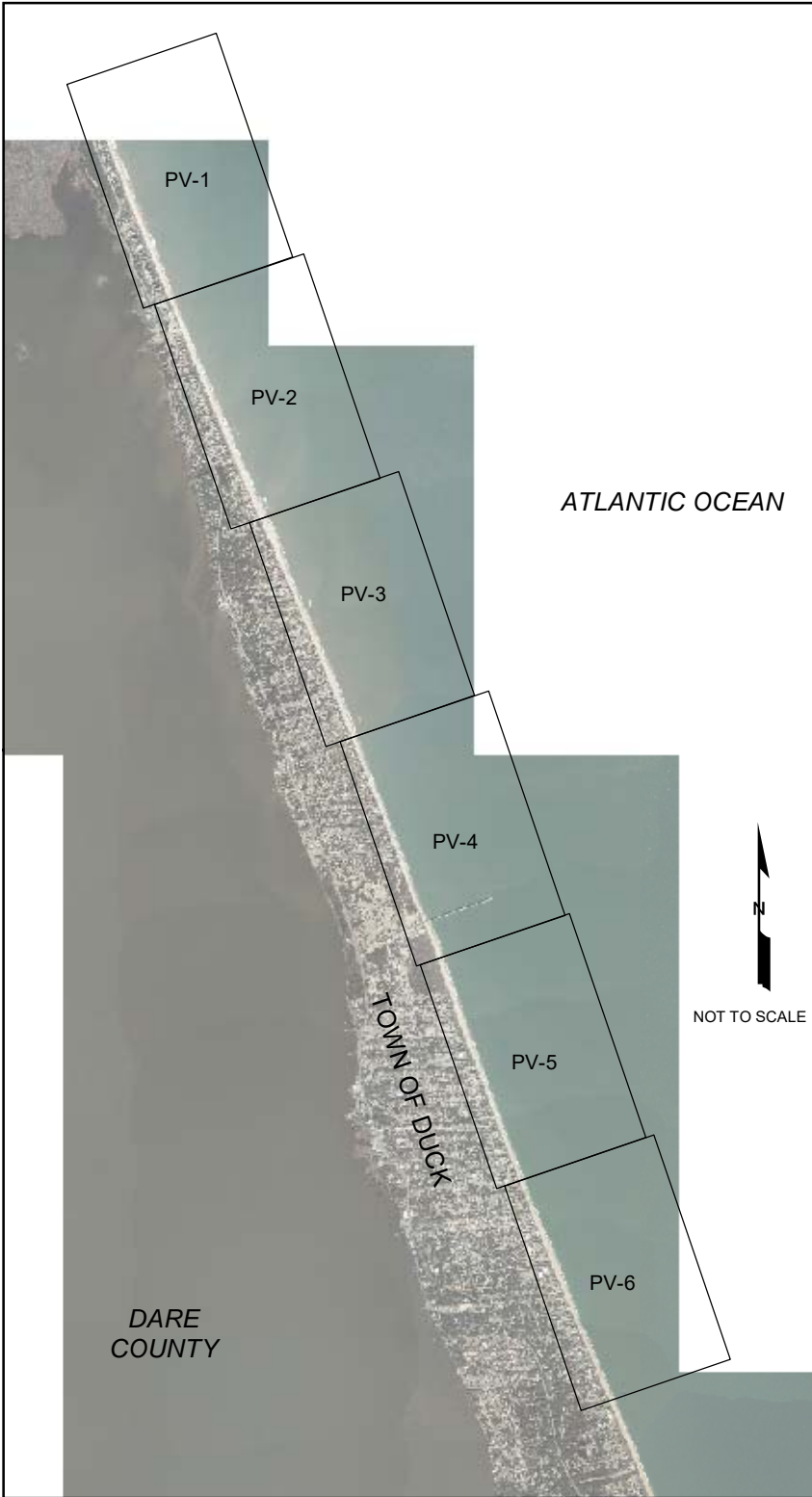
2018 TOWN OF DUCK ANNUAL MONITORING BEACH PROFILE SURVEY REPORT

INDEX TO SHEETS

- 1 COVER SHEET AND PROJECT LOCATION MAP
2-7 PROJECT PLAN VIEWS

CONTROL USED BY APTIM 2018 SURVEY			
DATUMS: NAD83/2011 / NAVD88			
STATION	NORTHING	EASTING	AZIMUTH
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
D-33	890553.20	2962439.40	70.00
D-34	889616.10	2962839.60	70.00

DARE COUNTY A-MON CONTROL			
MON STAMPING	NORTHING	EASTING	M. ELEV.
Y167	871368.17	2970021.75	30.85
C255 1981	900856.11	2958600.06	16.89
865 1370 C TIDAL	900621.51	2957662.02	18.46



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

4038 MASONBORO LOOP RD.
WILMINGTON, NC 28409
PH: (910) 791-9494
FAX (910) 791-4129
COL #C2331

2018 TOWN OF DUCK ANNUAL MONITORING
BEACH PROFILE SURVEY REPORT

COVER SHEET

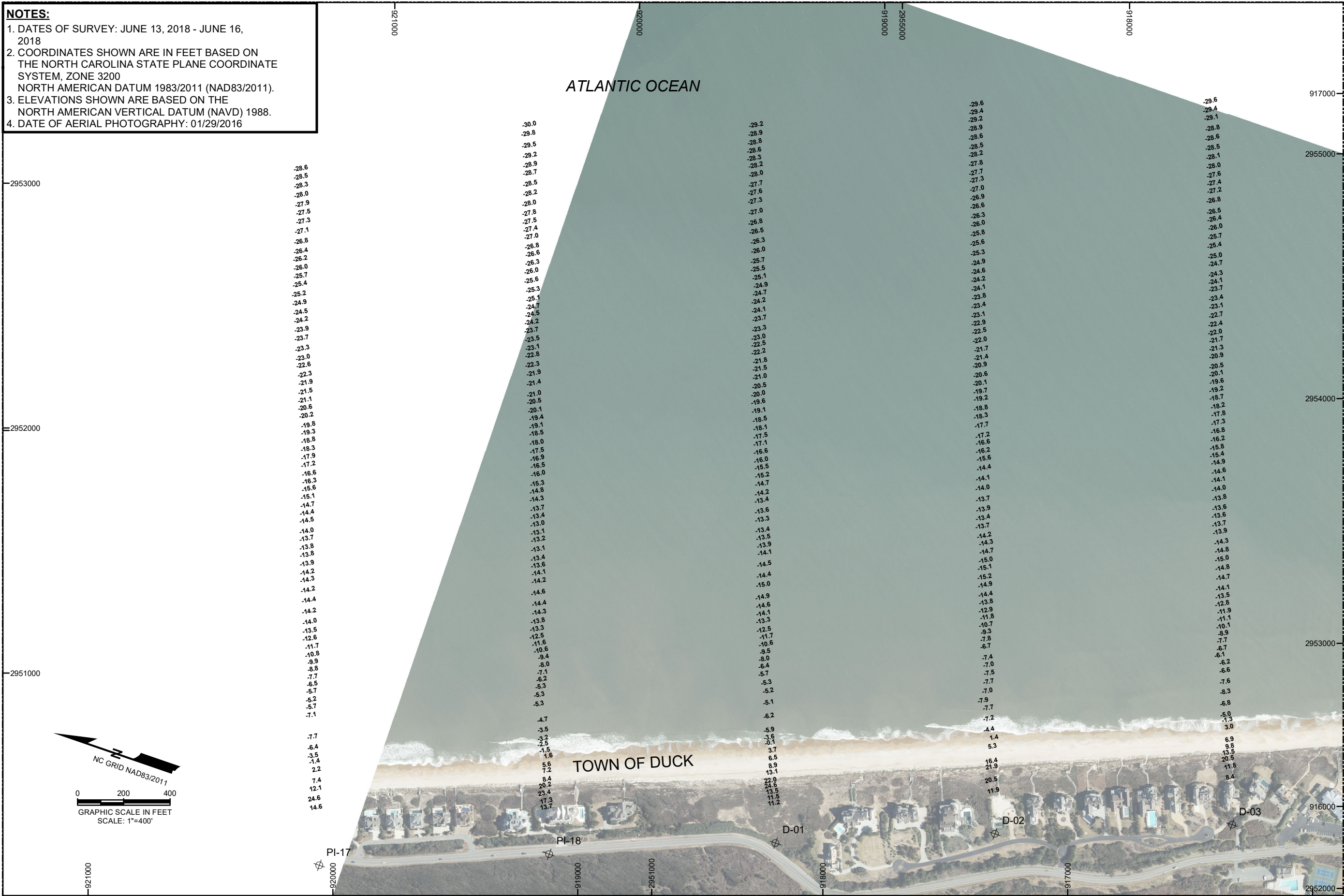
DRAWING NO.

CS

SHEET 1 OF 7

Document Path: G:\Enterprise\NorthCarolina\636226485 486 487 Dare 1YRPOST\Survey Charts\MXD\IDuck PV1.mxd

- NOTES:**
- DATES OF SURVEY: JUNE 13, 2018 - JUNE 16, 2018
 - COORDINATES SHOWN ARE IN FEET BASED ON THE NORTH CAROLINA STATE PLANE COORDINATE SYSTEM, ZONE 3200
NORTH AMERICAN DATUM 1983/2011 (NAD83/2011).
 - ELEVATIONS SHOWN ARE BASED ON THE NORTH AMERICAN VERTICAL DATUM (NAVD) 1988.
 - DATE OF AERIAL PHOTOGRAPHY: 01/29/2016



MATCHLINE SHEET 3 OF 7

2018 TOWN OF DUCK ANNUAL MONITORING
BEACH PROFILE SURVEY REPORT

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

Reference Files:		Checked by:		Reviewed by:		Submitted by:		Comm. No.:		Description	
Designed by:	M. Lowrie	Checked by:	M. Lowrie	Reviewed by:	J. Samburg	Submitted by:	M. Lowrie	Comm. No.:	636226485	No.	Date
Drawn by:	J. Walker	Drawn by:	J. Walker	Drawn by:	J. Walker	Drawn by:	J. Walker	Drawn by:	J. Walker		
Date:	September 2018	Date:	September 2018	Date:	September 2018	Date:	September 2018	Date:	September 2018		
Plot Scale:	AS NOTED	Plot Scale:	AS NOTED	Plot Scale:	AS NOTED	Plot Scale:	AS NOTED	Plot Scale:	AS NOTED		

DRAWING NO.
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SHEET 2 OF 7

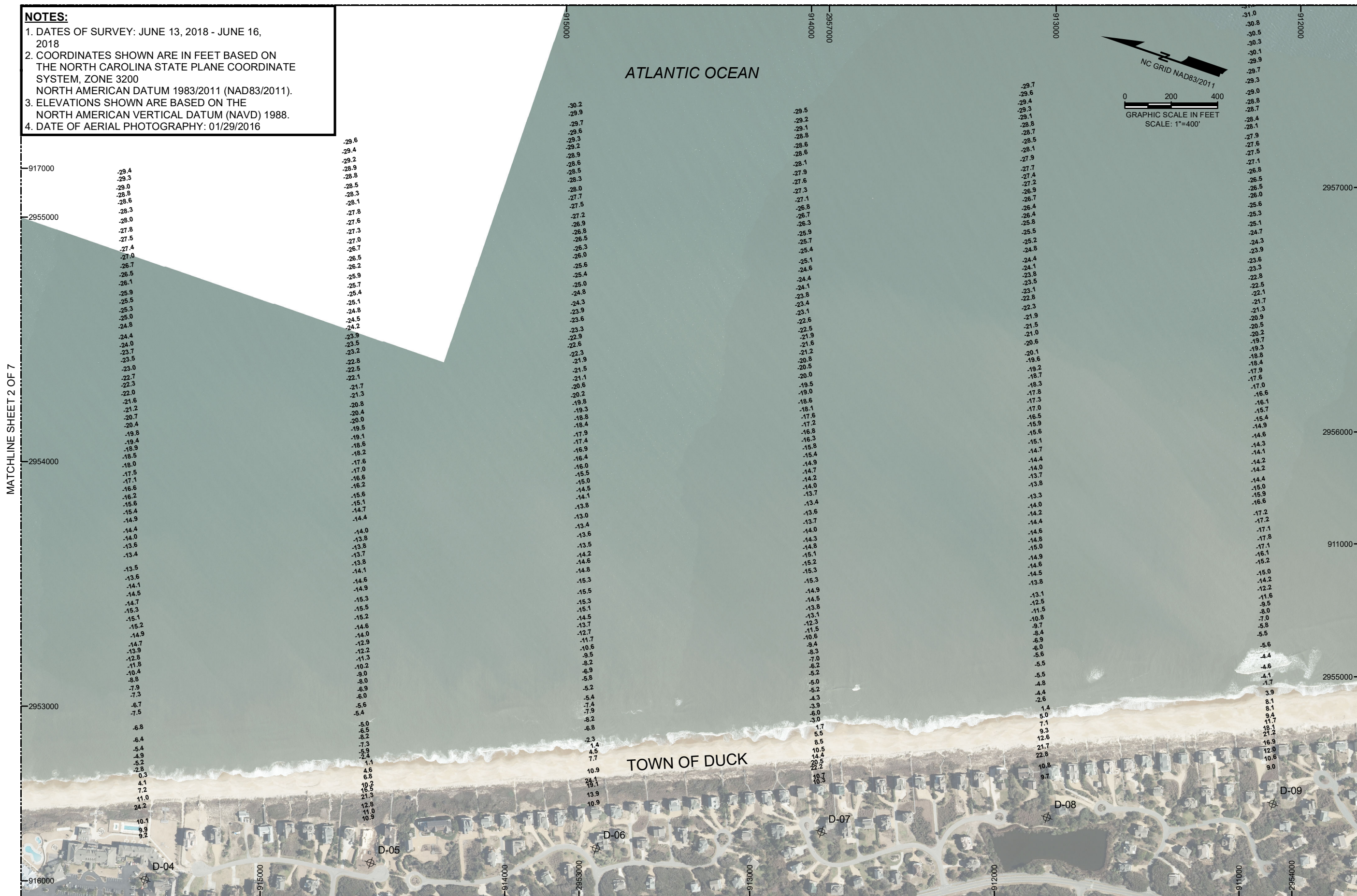
PH: (910) 791-9494
FAX: (910) 791-4129

4038 MASONBORO LOOP RD.
WILMINGTON, NC 28409

COL #C2331

NOTES:

1. DATES OF SURVEY: JUNE 13, 2018 - JUNE 16, 2018
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. DATE OF AERIAL PHOTOGRAPHY: 01/29/2016



MATCHLINE SHEET 4 OF 7

2018 TOWN OF DUCK ANNUAL MONITORING
BEACH PROFILE SURVEY REPORT

DRAWING NO.

PV-2

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

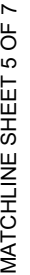
4038 MASONBORO LOOP RD.
PH. (910) 791-9494

4038 MASONBORO LOOP RD.

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SHEET 4 OF 7

WILMINGTON, NC 28409

- NOTES:**
1. DATES OF SURVEY: JUNE 13, 2018 - JUNE 16, 2018
 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. DATE OF AERIAL PHOTOGRAPHY: 01/29/2016



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OF NORTH CAROLINA, INC.

PH: (910) 791-9494
FAX: (910) 791-4129
COL #C2331

4038 MASONBORO LOOP RD.
WILMINGTON, NC 28409

Designed by:	Checked by:	No.	Date	Description
W. Lowrie	W. Lowrie			
J. Walker	J. Walker			
September 2018	Submitted by:			
Plot Scale:	Comm. No.:			
AS NOTED	636226485			

2018 TOWN OF DUCK ANNUAL MONITORING
BEACH PROFILE SURVEY REPORT

PLAN VIEW

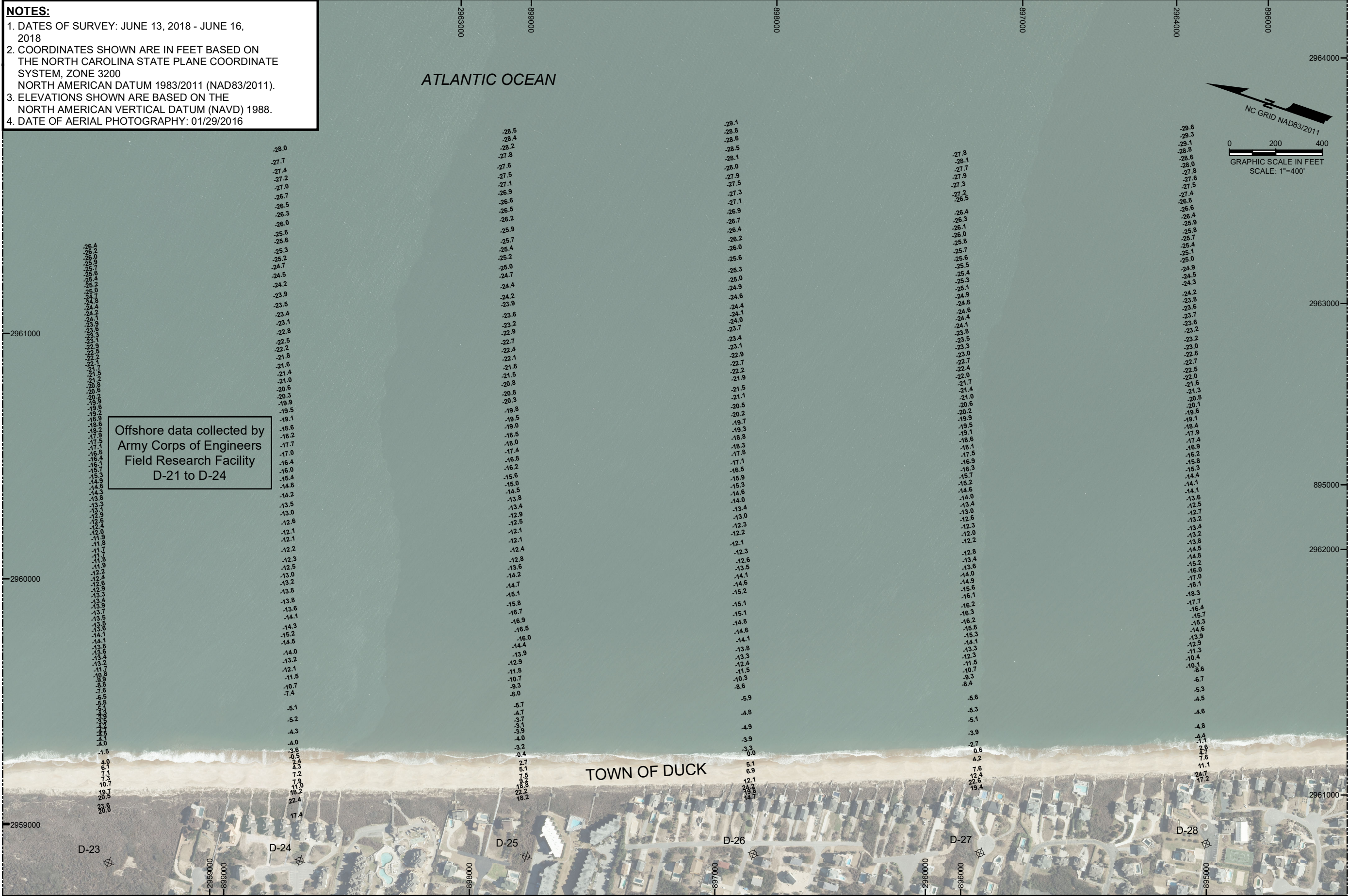
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PV-4

SHEET 5 OF 7

- NOTES:**
1. DATES OF SURVEY: JUNE 13, 2018 - JUNE 16, 2018
 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. DATE OF AERIAL PHOTOGRAPHY: 01/29/2016

MATCHLINE SHEET 5 OF 7



Offshore data collected by
Army Corps of Engineers
Field Research Facility
D-21 to D-24

MATCHLINE SHEET 7 OF 7

2018 TOWN OF DUCK ANNUAL MONITORING
BEACH PROFILE SURVEY REPORT

**APTIM COASTAL PLANNING & ENGINEERING
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PH: (910) 791-9494
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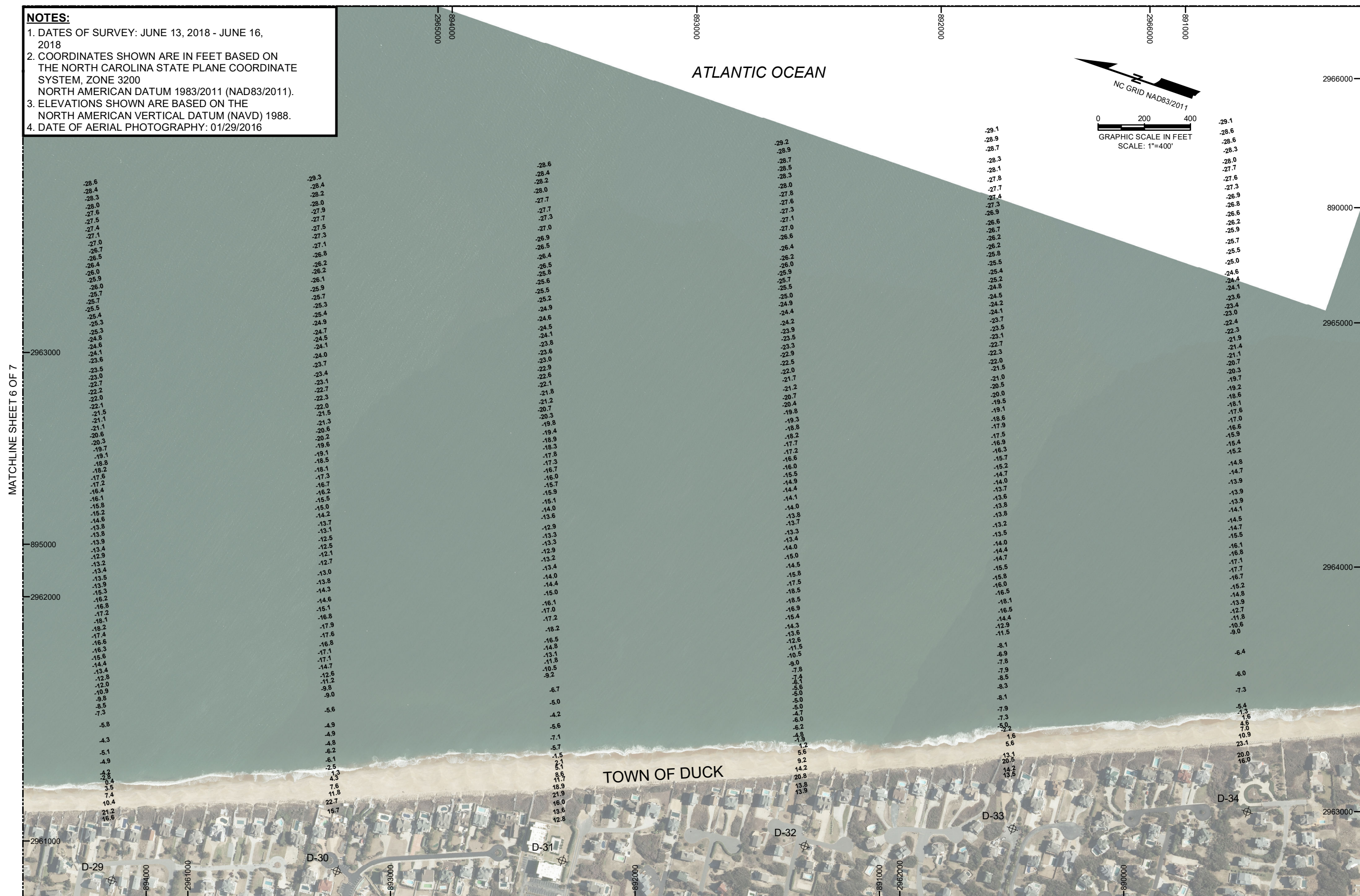
Reference Files:		Checked by:		Reviewed by:		Submitted by:		Comm. No.:		Description	
Designed by:	M. Lowrie	Checked by:	M. Lowrie	Reviewed by:	J. Samburg	Submitted by:	M. Lowrie	Comm. No.:	636226485	No.	Date
Drawn by:	J. Walker	Drawn by:	J. Walker	Drawn by:	J. Walker	Drawn by:	J. Walker	Drawn by:	J. Walker		
Date:	September 2018	Date:	September 2018	Date:	September 2018	Date:	September 2018	Date:	September 2018		
Plot Scale:	AS NOTED	Plot Scale:	AS NOTED	Plot Scale:	AS NOTED	Plot Scale:	AS NOTED	Plot Scale:	AS NOTED		

DRAWING NO.
PV-5

SHEET 6 OF 7

PLAN VIEW

1. DATES OF SURVEY: JUNE 13, 2018 - JUNE 16, 2018
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. DATE OF AERIAL PHOTOGRAPHY: 01/29/2016



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WILMINGTON, NC 28409

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BEACH PROFILE SURVEY REPORT

DRAWING NO.

PV-6

SHEET 7 OF 7



Survey Report Notes

Survey Title: 2018 Town of Duck Annual Monitoring Beach Profile Survey Report

Prepared Date: September 2018

Prepared For: Town of Duck, NC

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

Dates of Survey: June 13, 2018 through June 16, 2018

Survey Location: Town of Duck PI-17 through D-34

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).
4. Vertical measurements are based on second order monuments C255 and TIDAL C per published NGS coordinates.

5. Bearings are based on a bearing of South 255° 57' 31" East between NGS second order monuments C255 and TIDAL C 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 OBX 2018 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 Town of Duck 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) Profile 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 survey data 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 OBX 2018 for the onshore portion. Navigation field book No. 50 for the offshore survey.

APPENDIX 1

MONUMENT INFORMATION REPORT

TOWN OF DUCK STATION INFORMATION

June 2018

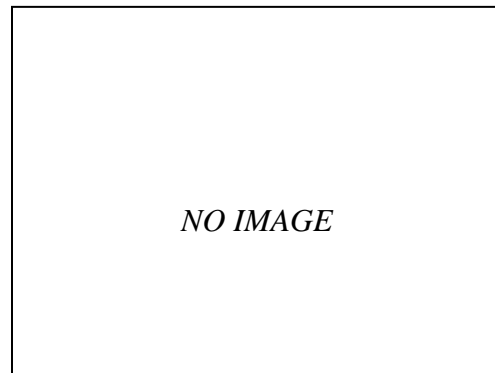
DATUMS: NAD83/2011 & NAVD88

STATION	NORTHING	EASTING	AZIMUTH
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
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D-17	903863.92	2957333.66	70
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D-22	900228.83	2958754.03	70
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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

CONTROL MONUMENT USED BY APTIM FOR 2018 DARE COUNTY ANNUAL MONITORING TOPOGRAPHIC AND HYDROGRAPHIC SURVEY REPORT JUNE 2018	
DATUMS: NAD83/2011 - NAVD1988	
Designation	C255
Stamping	C255 1981
Northing	900856.11
Easting	2958600.06
Horizontal Root Mean Square Error	0.230
Elevation	16.89
Vertical Root Mean Square Error	0.114
Description	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



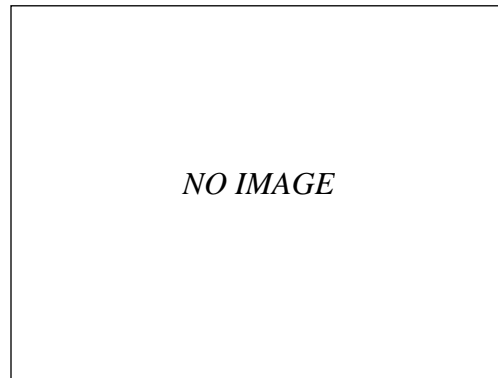
Location Verification: C255

Mean of Inverse Shots - Published Versus APTIM Found				
Monument	No. of Shots	ΔN	ΔE	ΔZ
C255	10	-0.10	-0.04	0.09

CONTROL MONUMENT USED BY APTIM FOR 2018 DARE COUNTY ANNUAL MONITORING TOPOGRAPHIC AND HYDROGRAPHIC SURVEY REPORT JUNE 2018	
DATUMS: NAD83/2011 - NAVD1988	
Designation	TIDAL C
Stamping	865 1370 1977
Northing	900621.51
Easting	2957662.02
Horizontal Root Mean Square Error	0.229
Elevation	18.46
Vertical Root Mean Square Error	0.015
Description	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

Mean of Inverse Shots – OPUS Solution Versus APTIM Found				
Monument	No. of Shots	ΔN	ΔE	ΔZ
TIDAL C	10	0.05	0.12	0.00

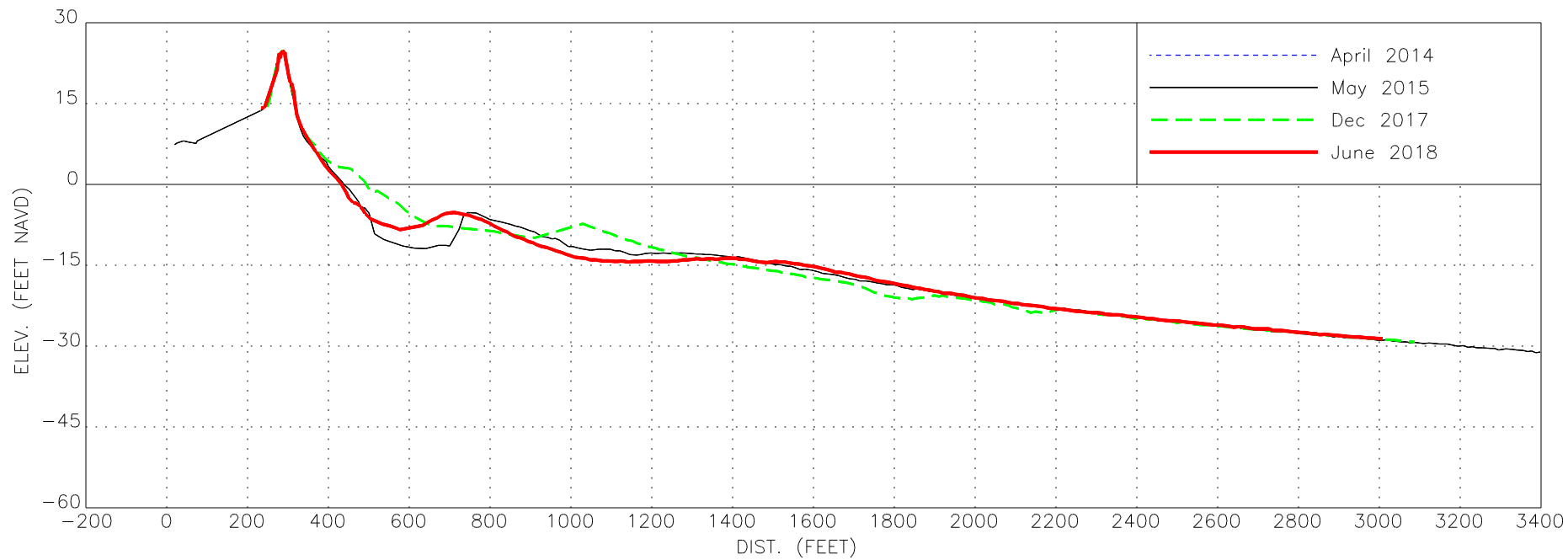
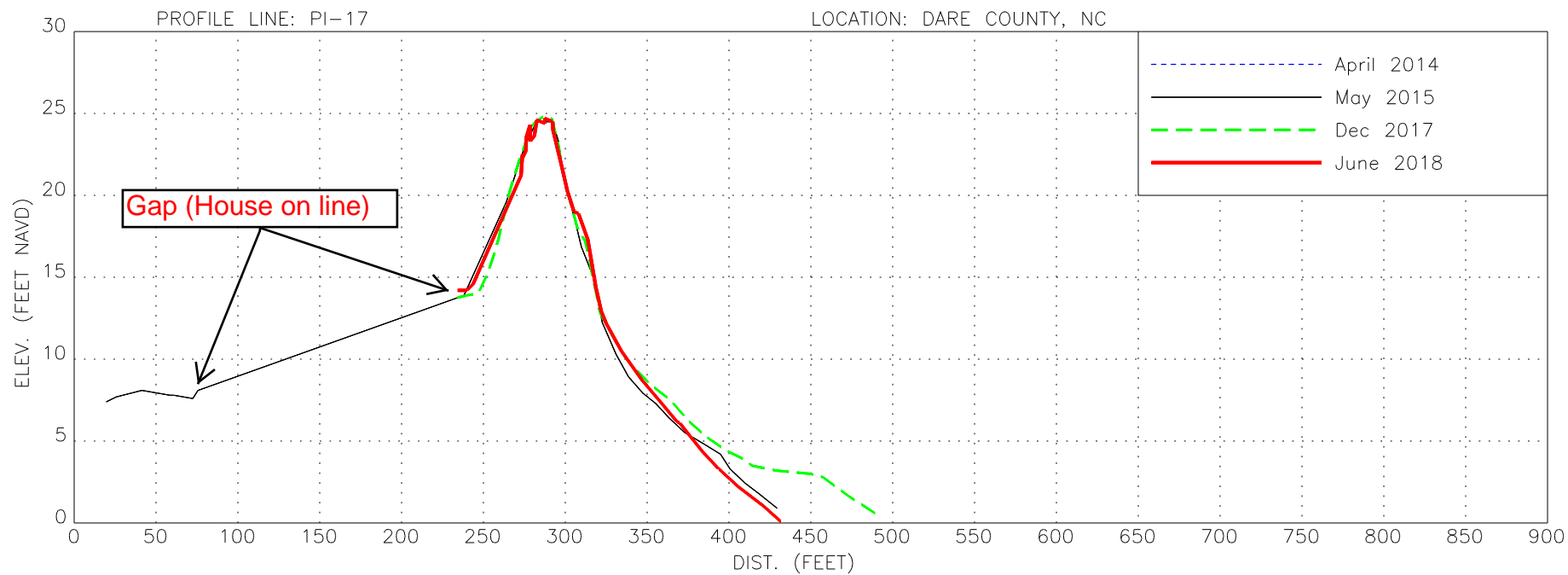
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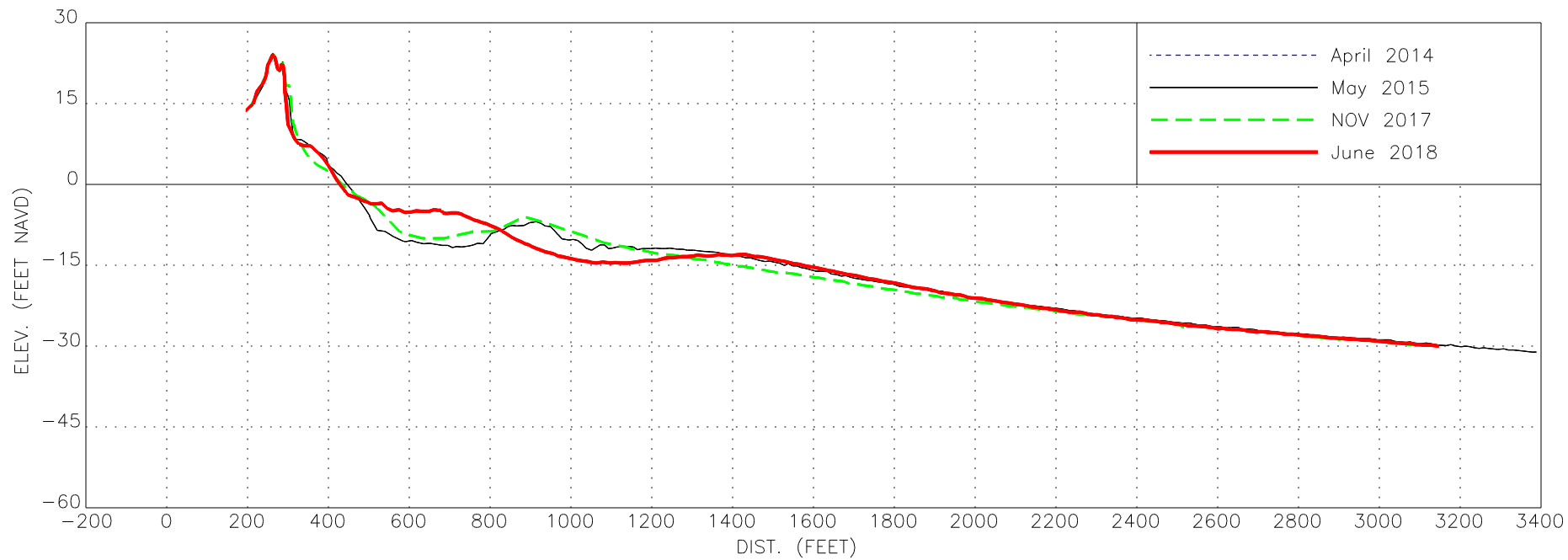
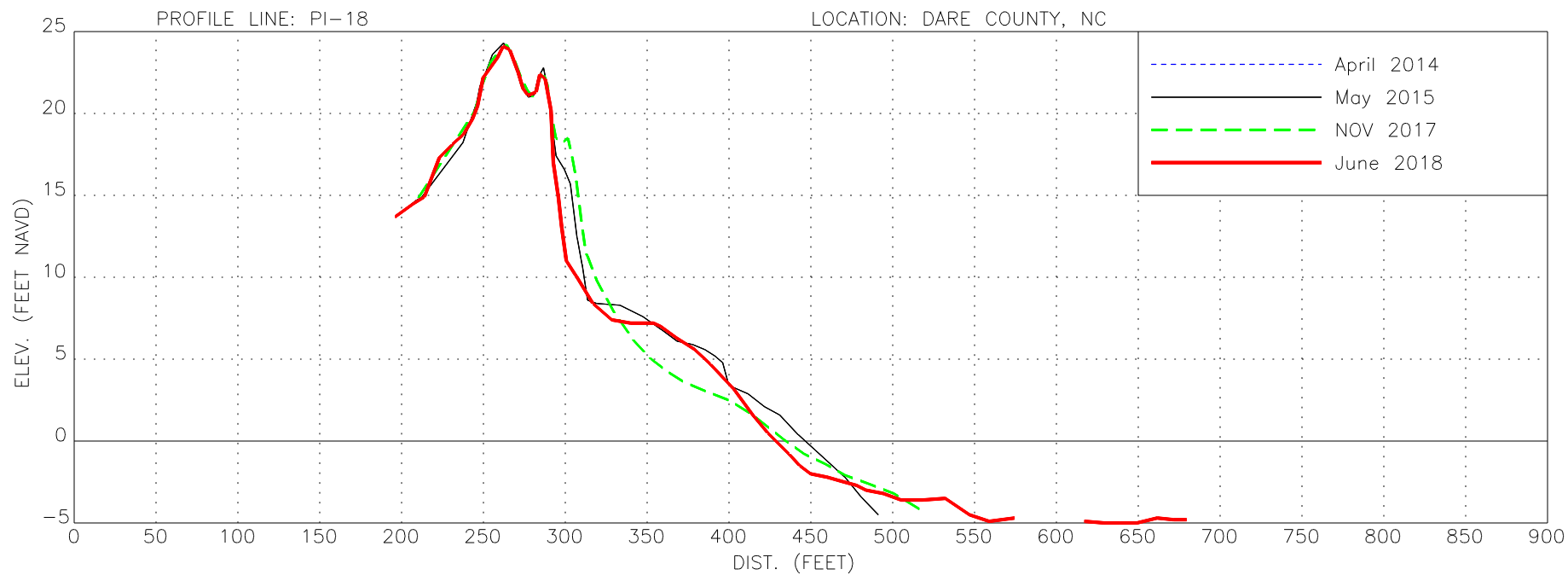
PROFILE XYZ DATA

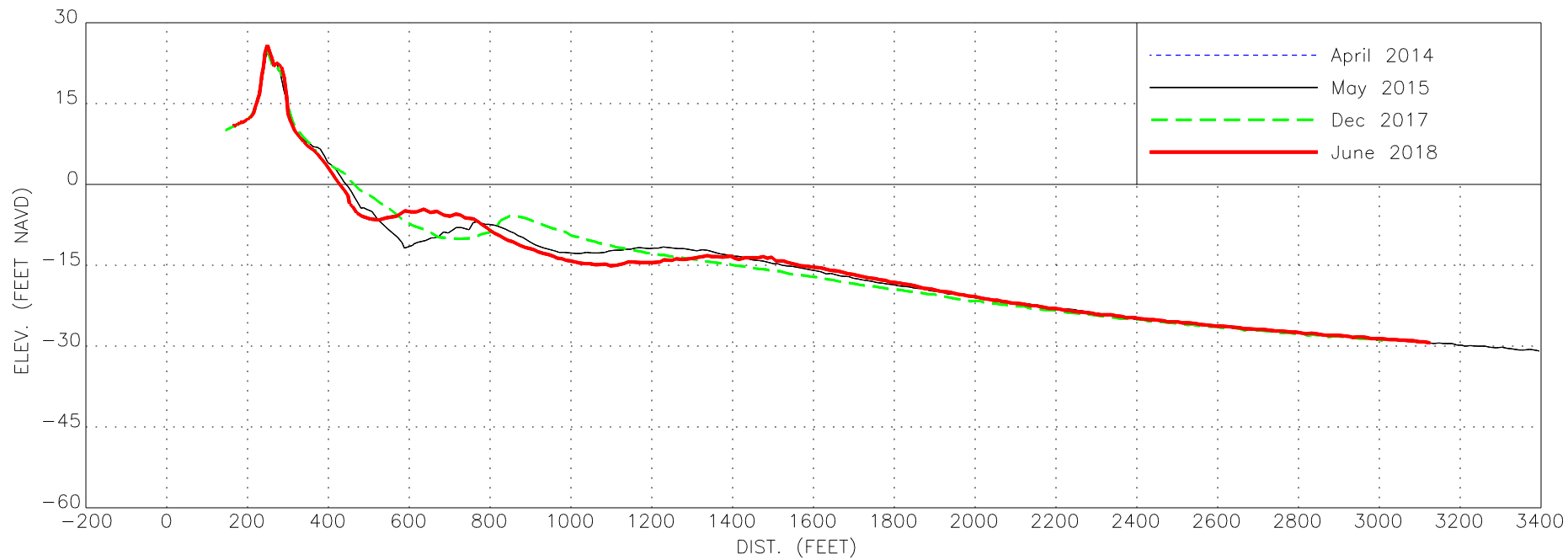
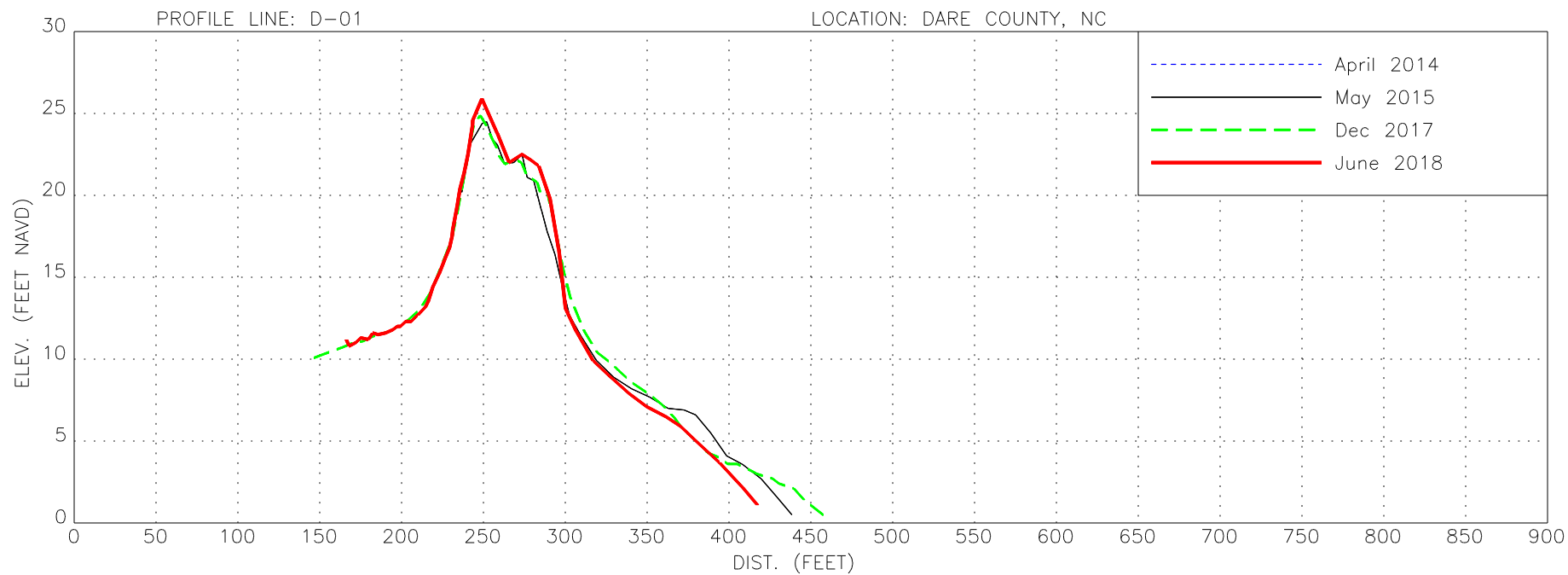
(Available in digital format only)

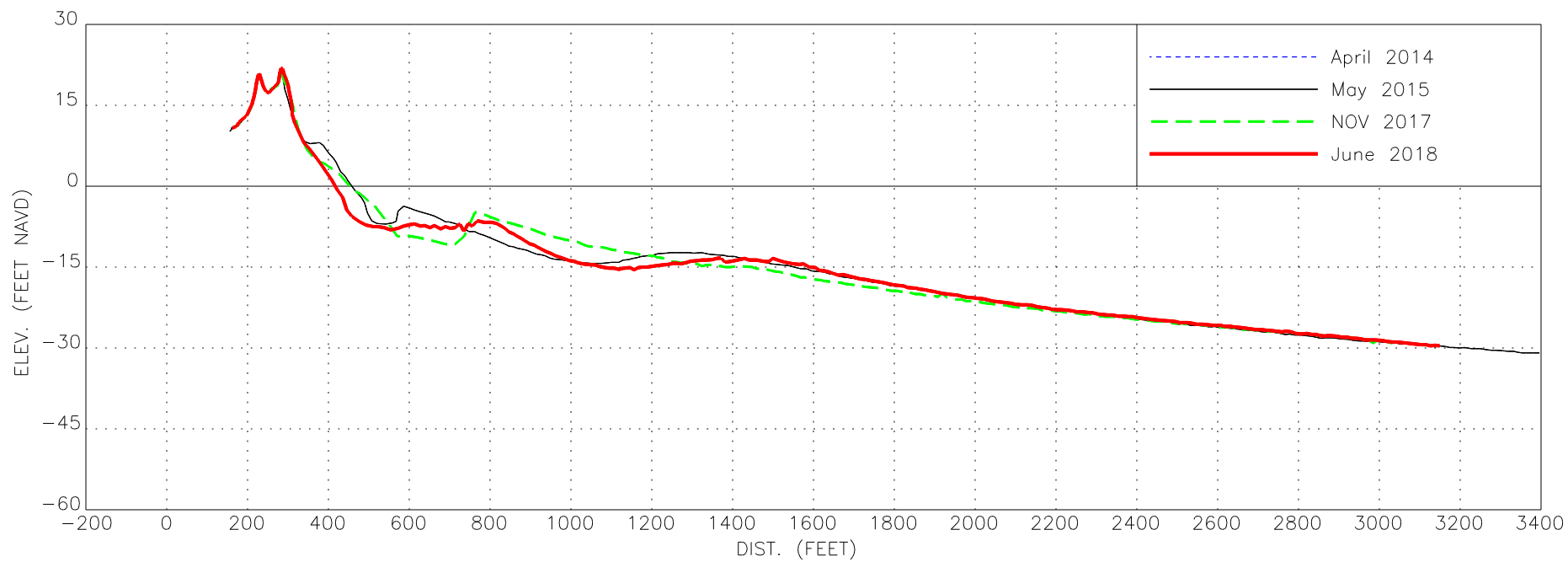
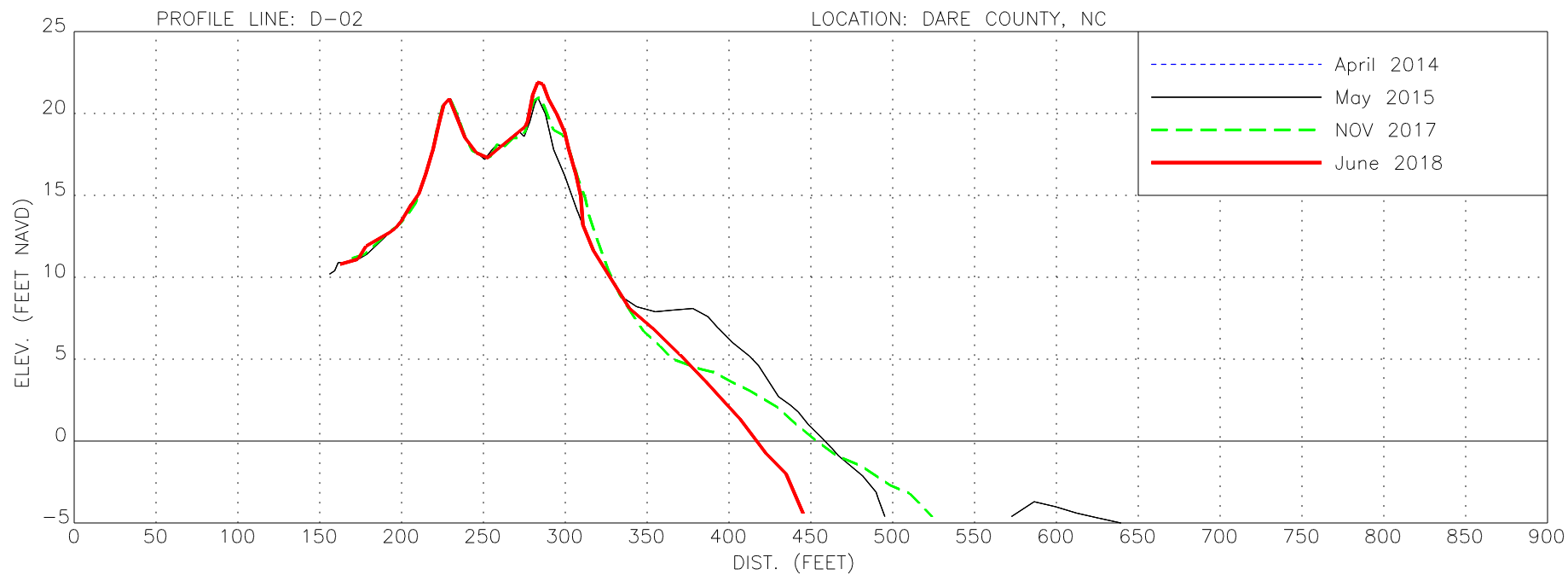
APPENDIX 3

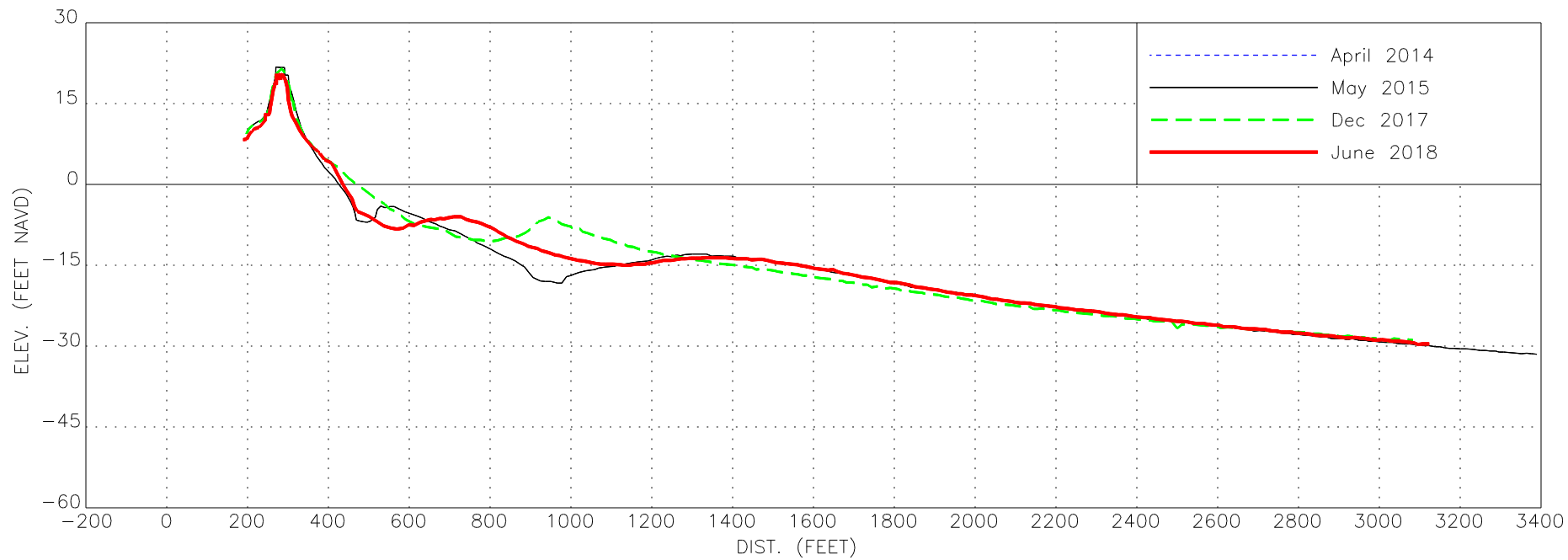
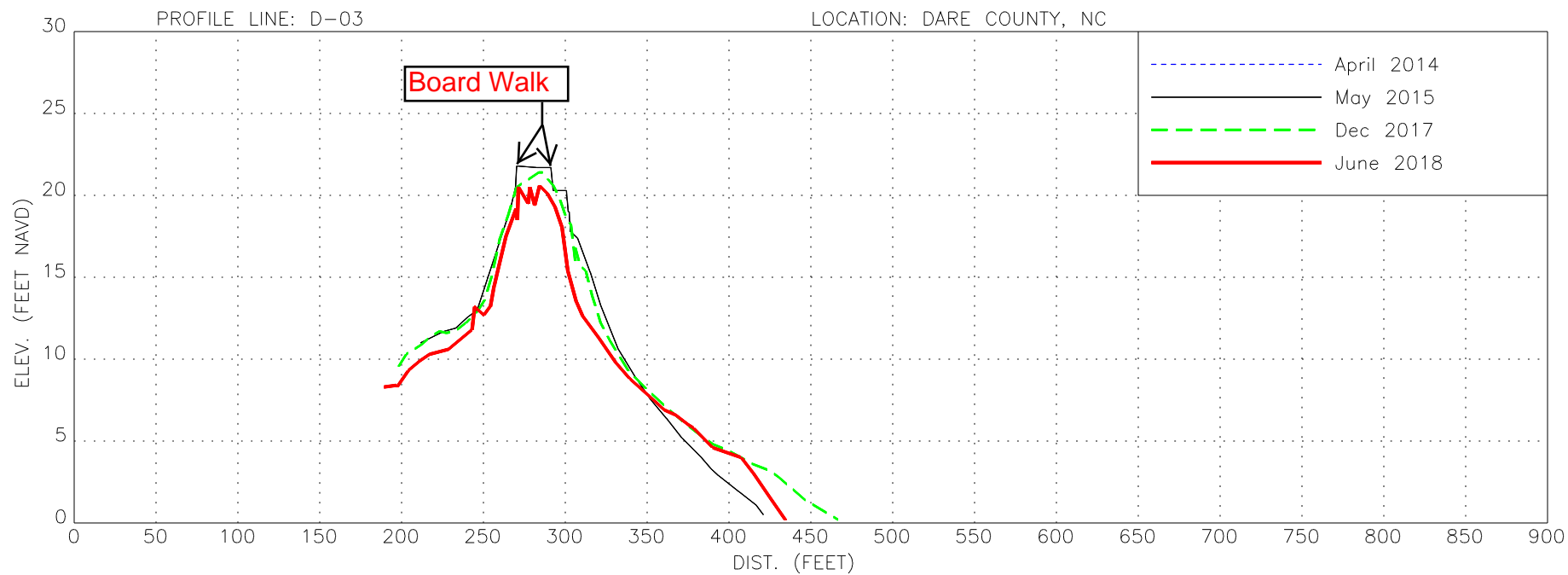
PROFILE PLOTS

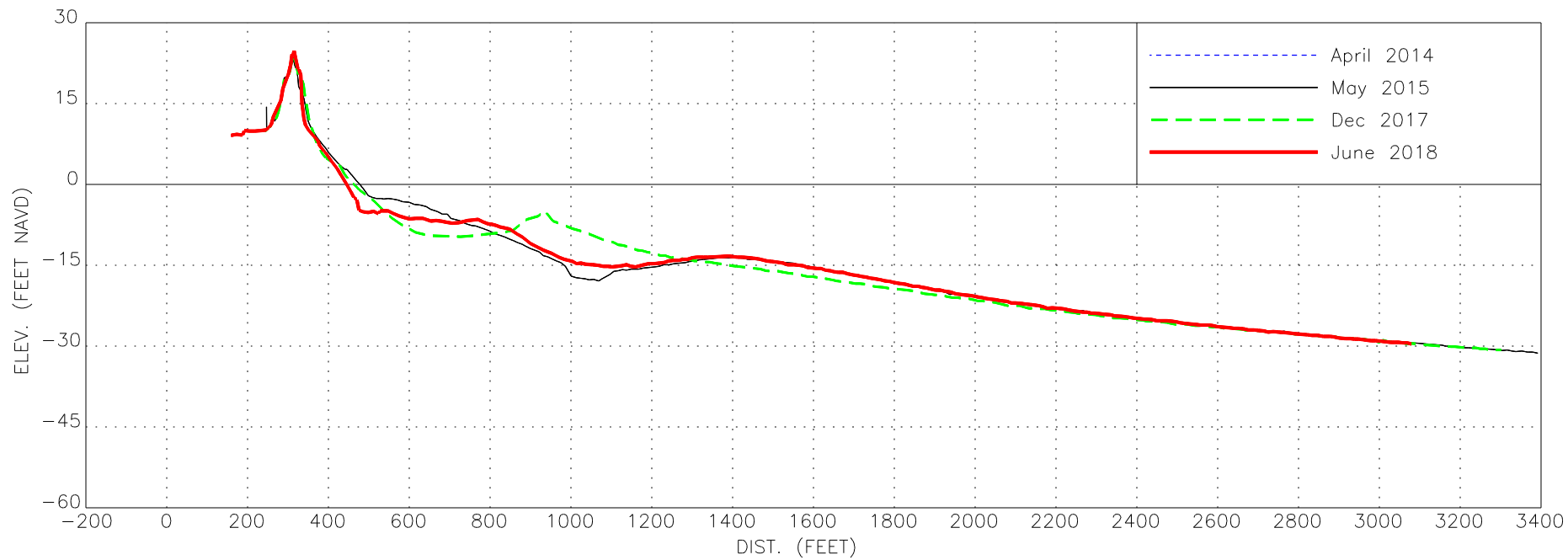
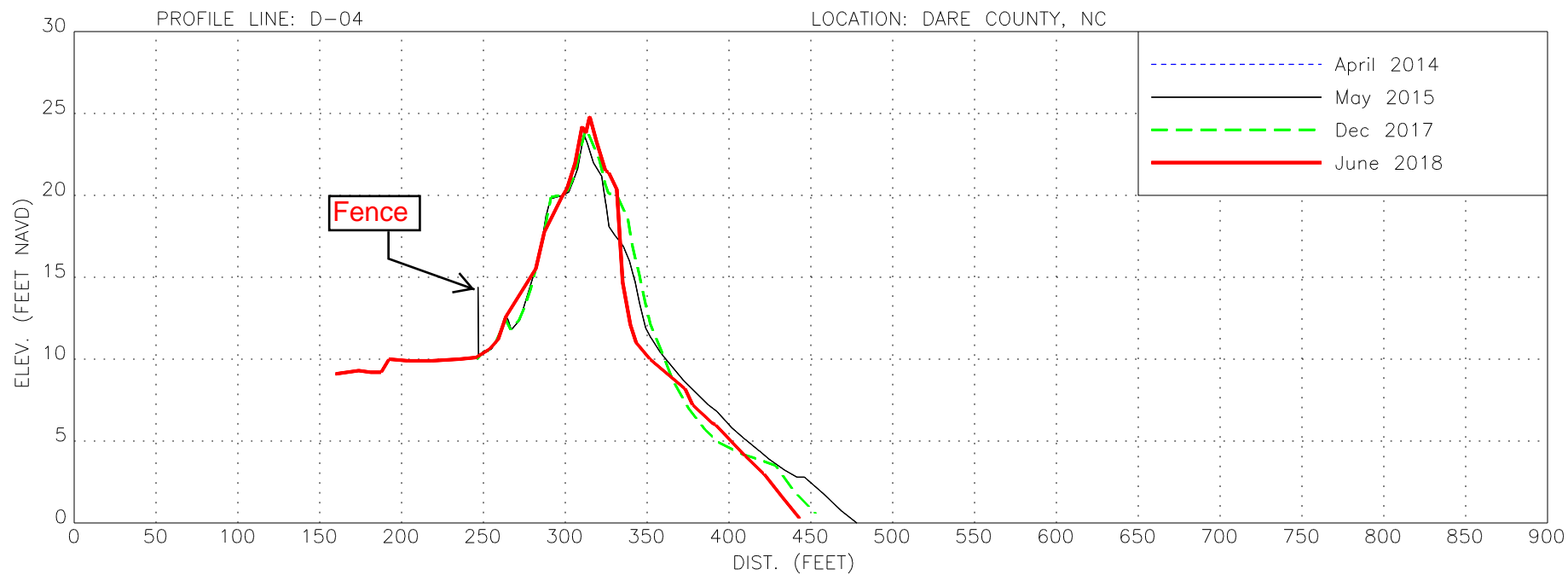


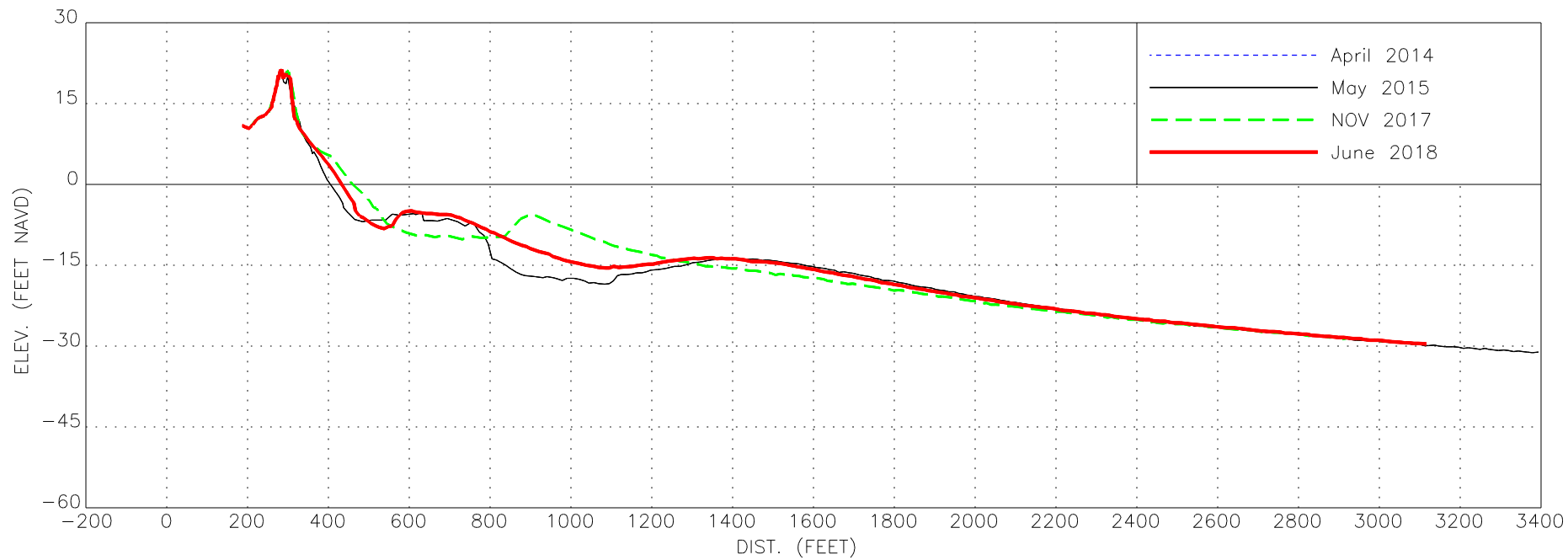
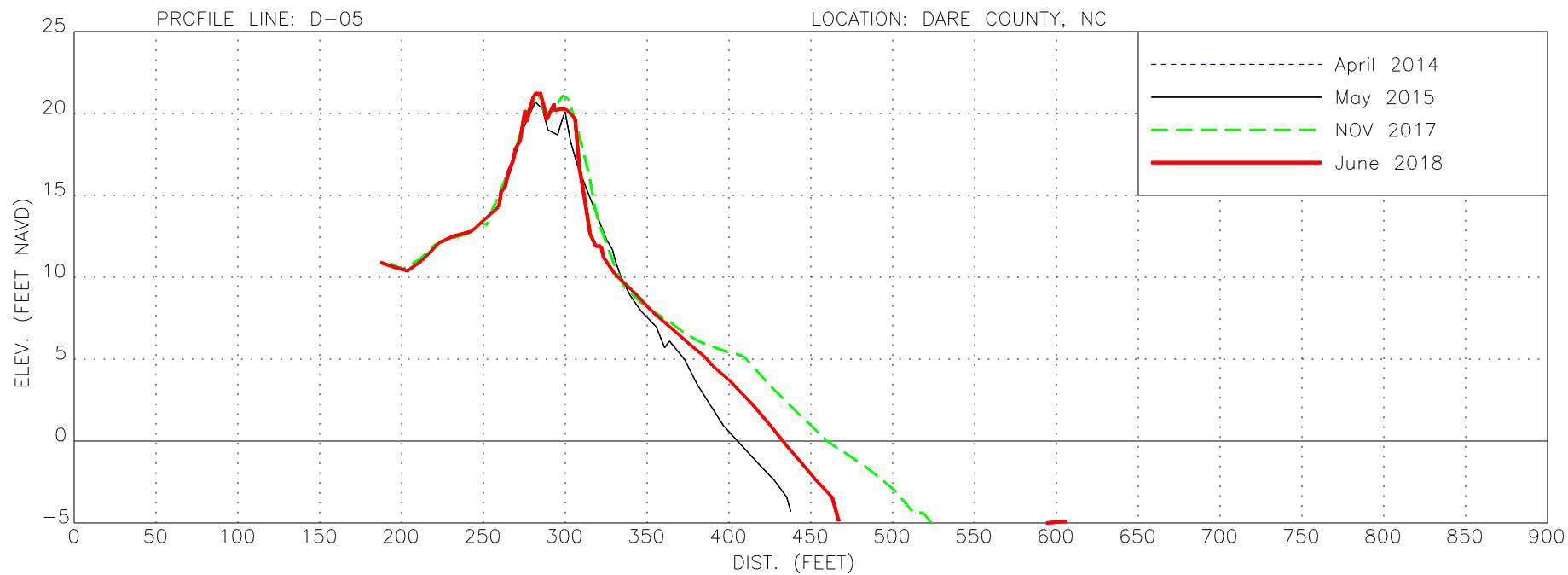


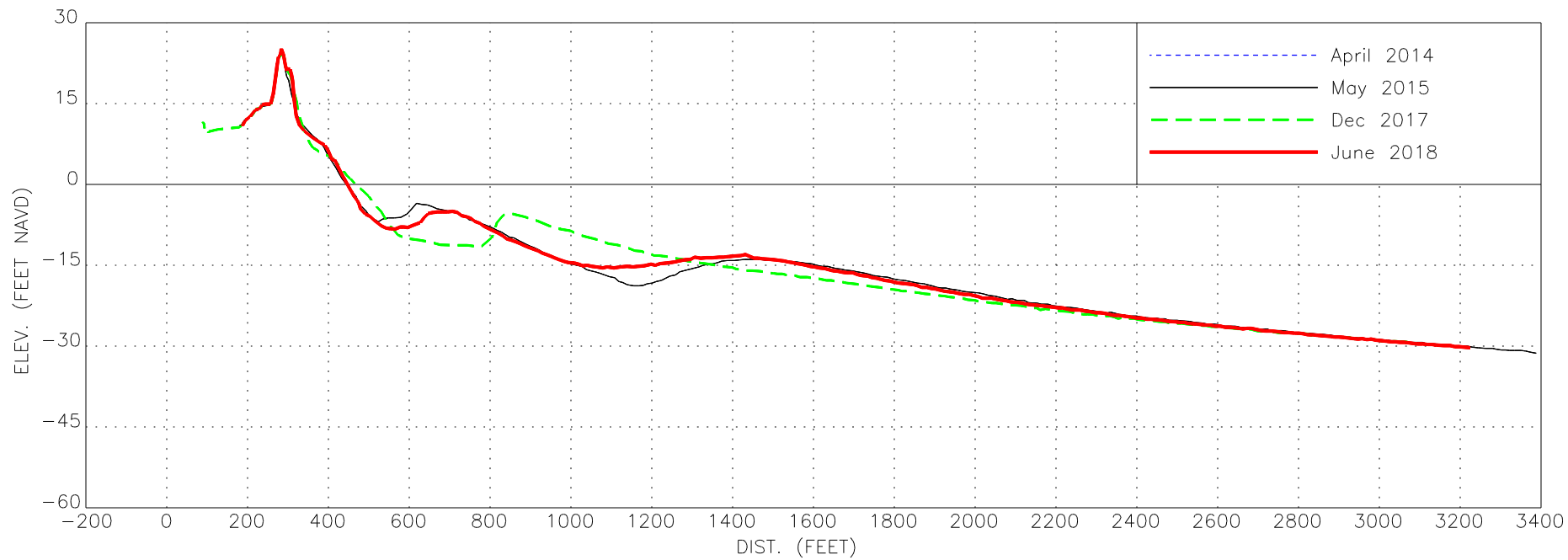
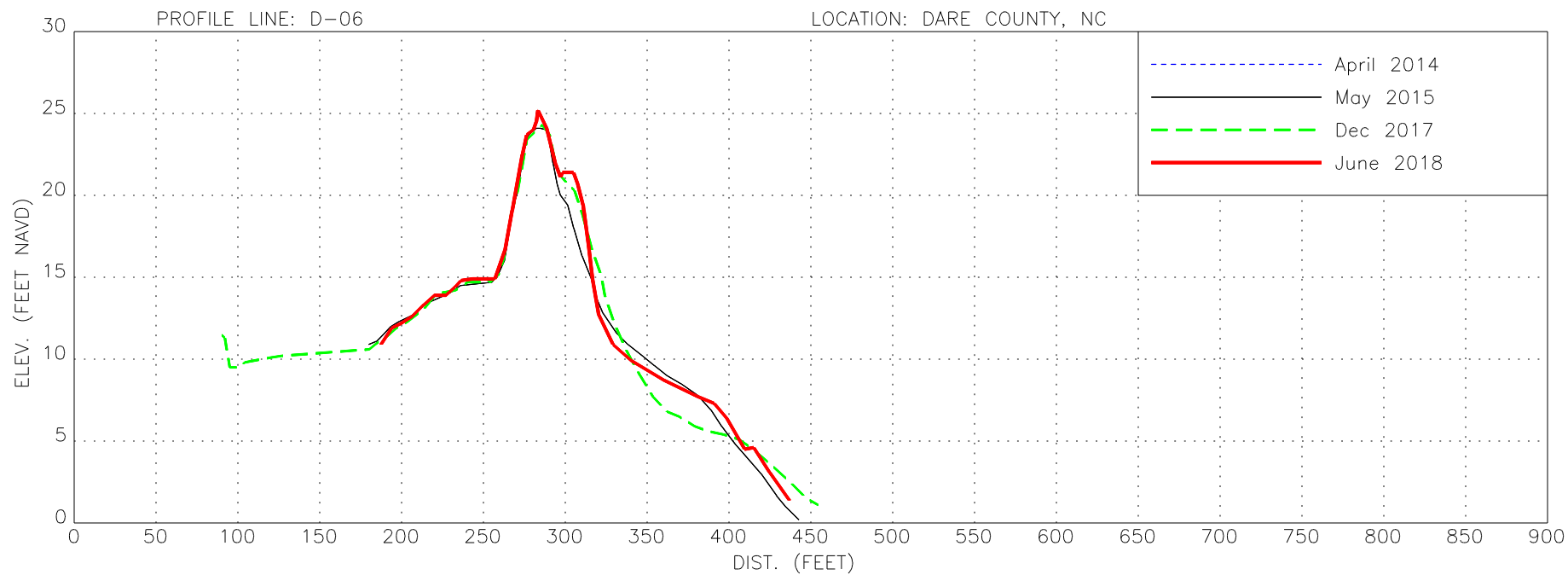


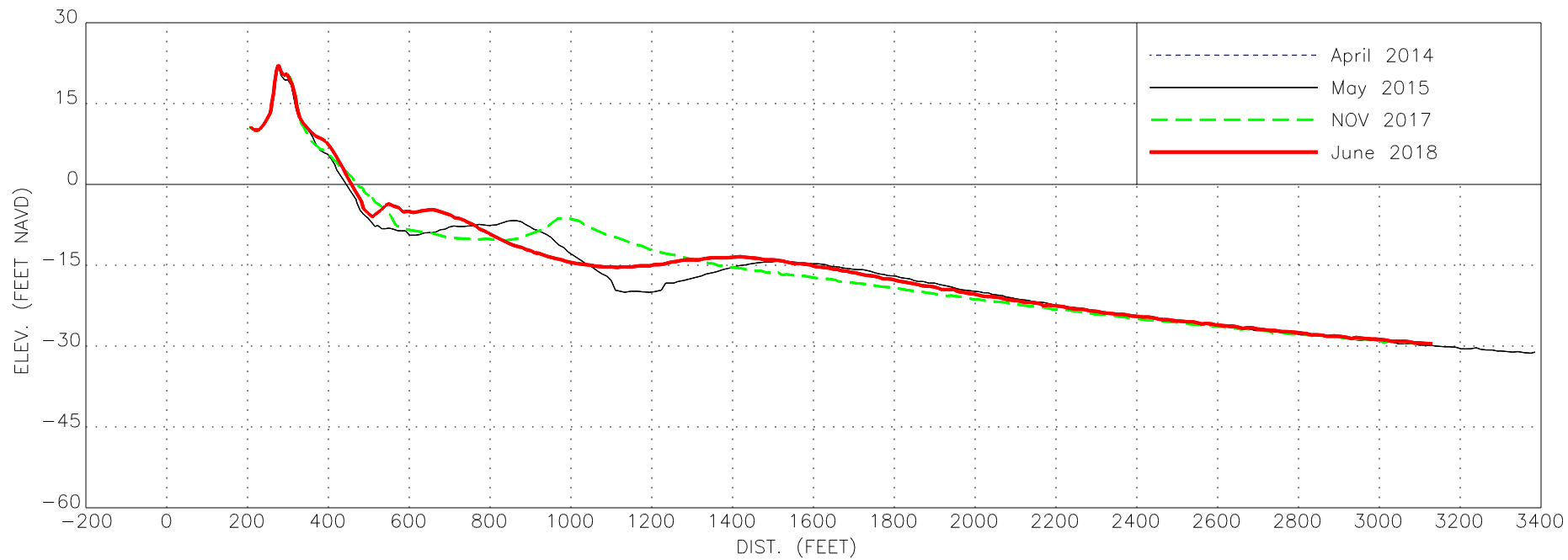
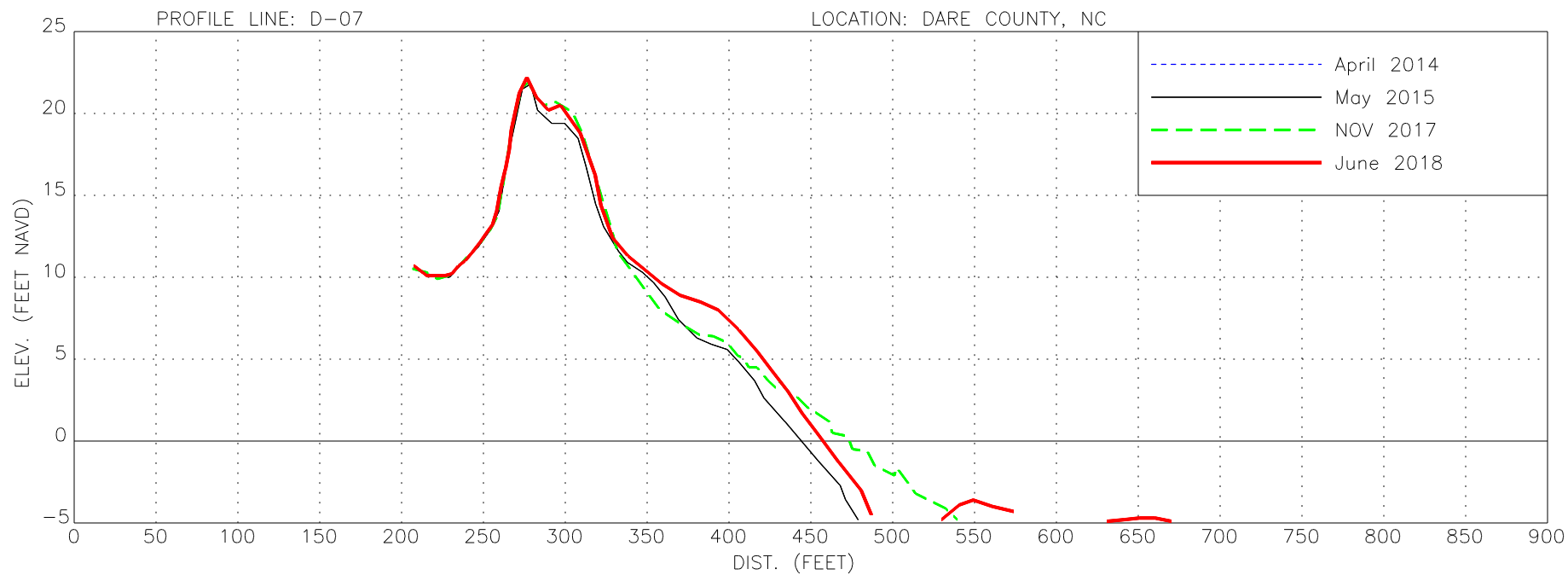


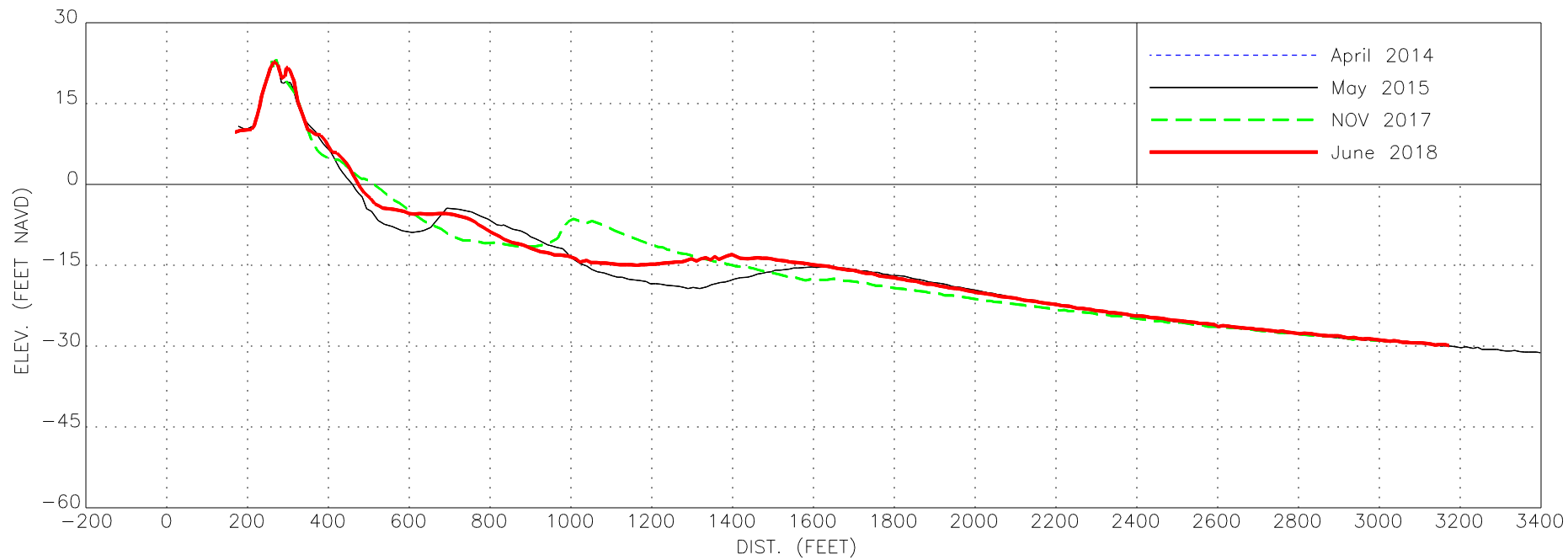
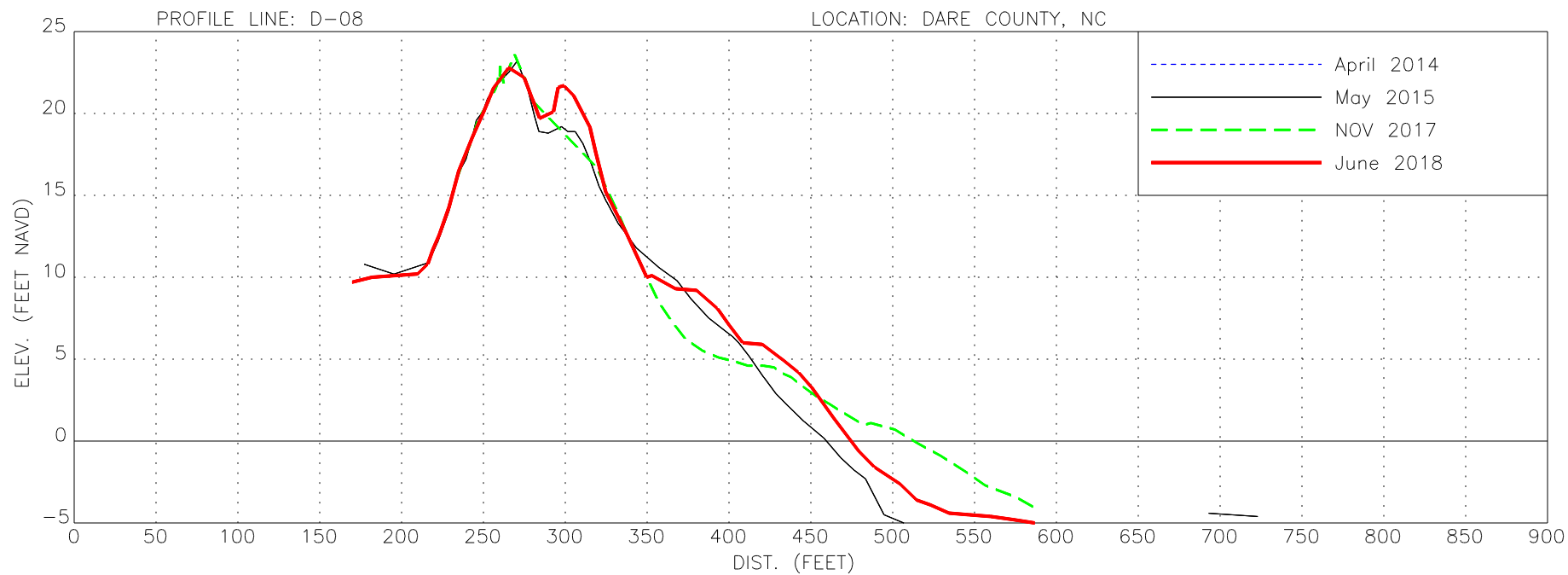


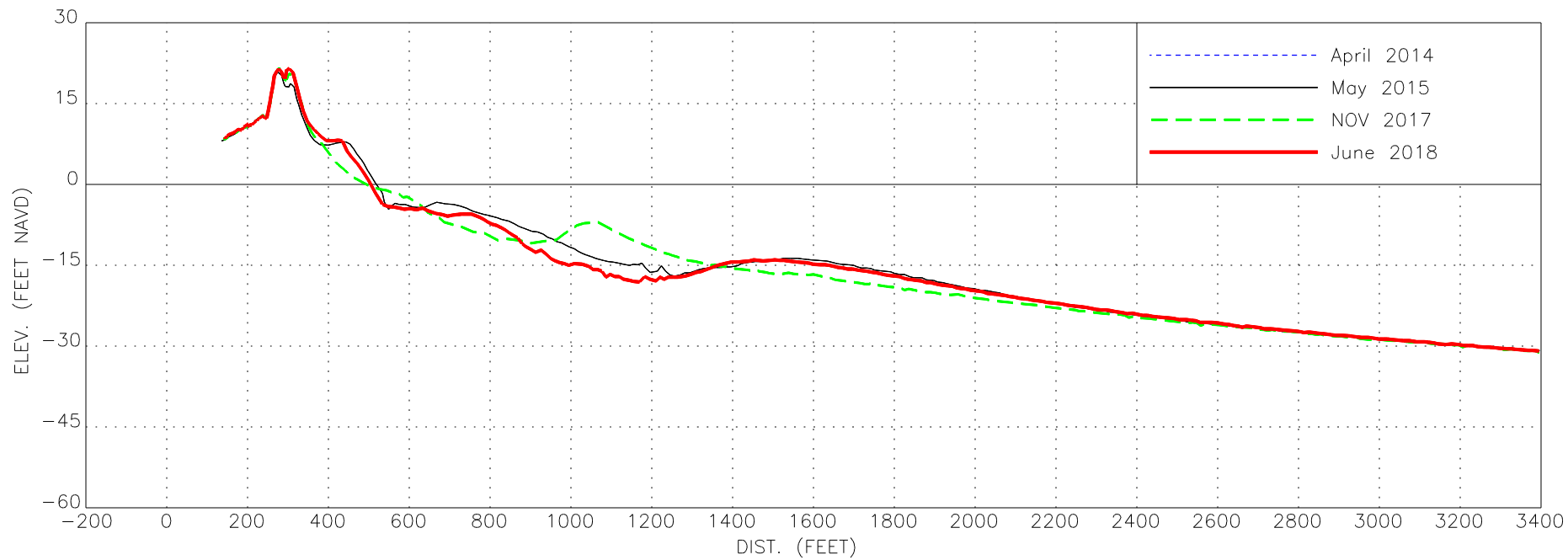
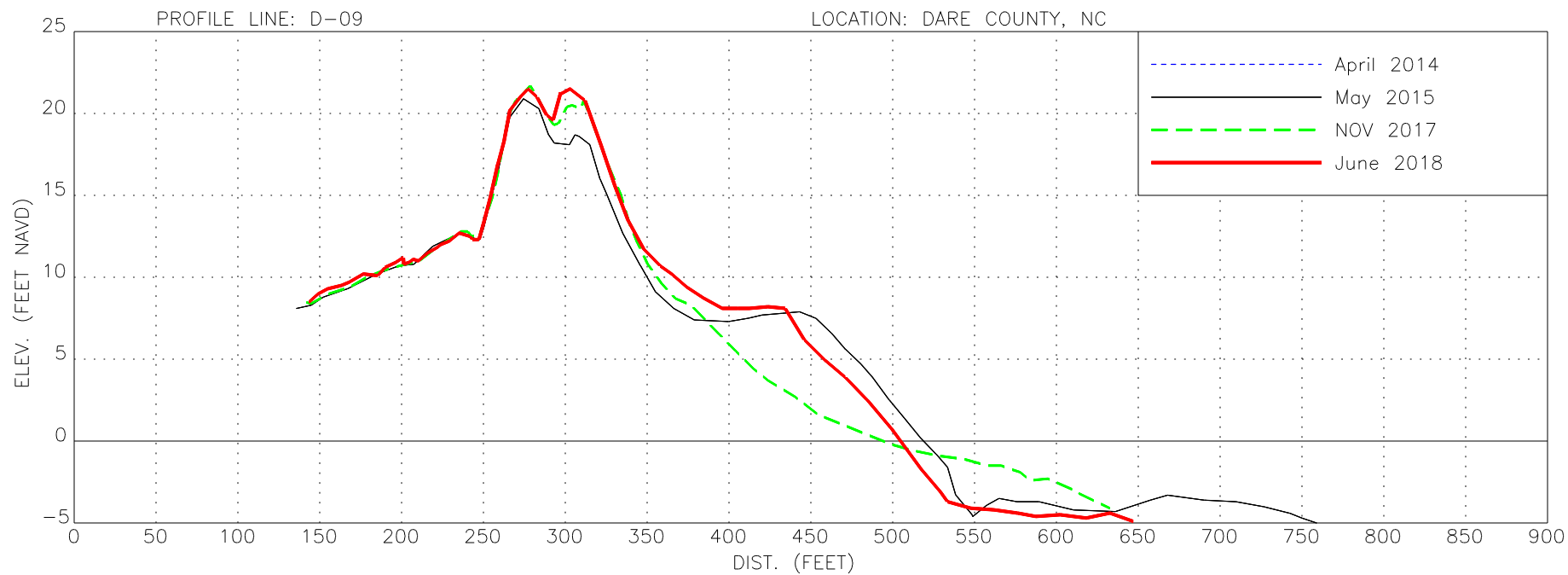


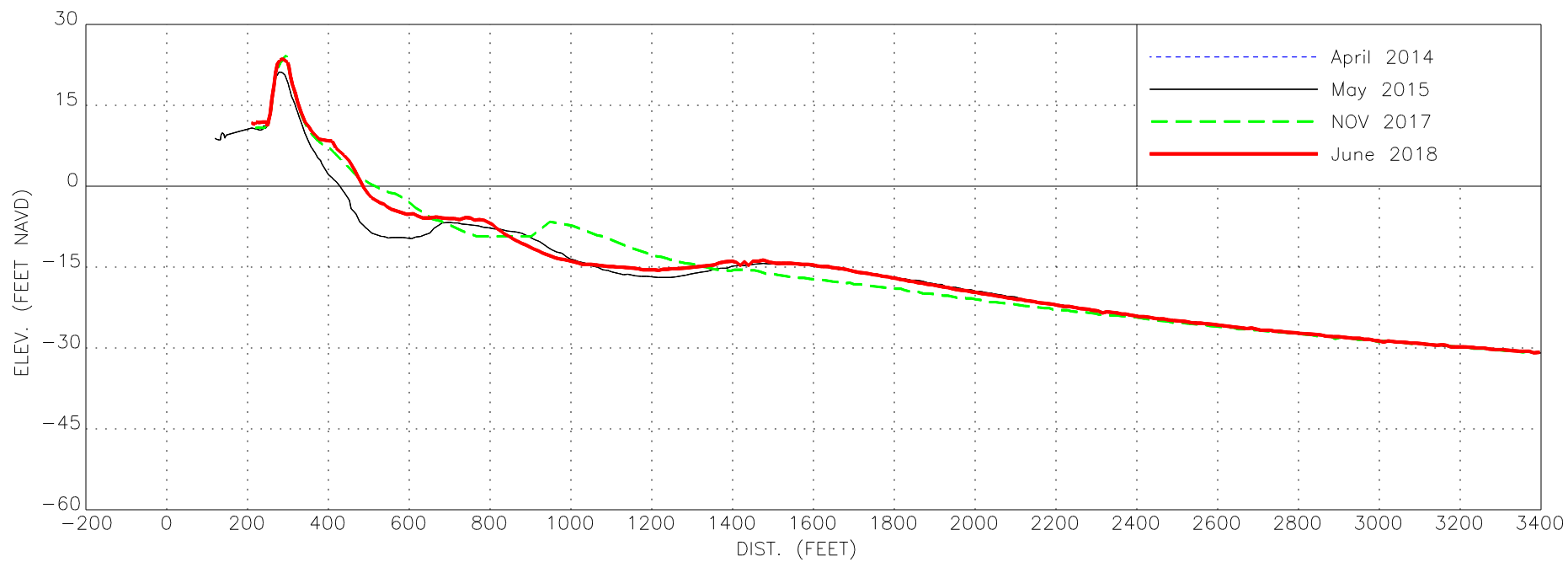
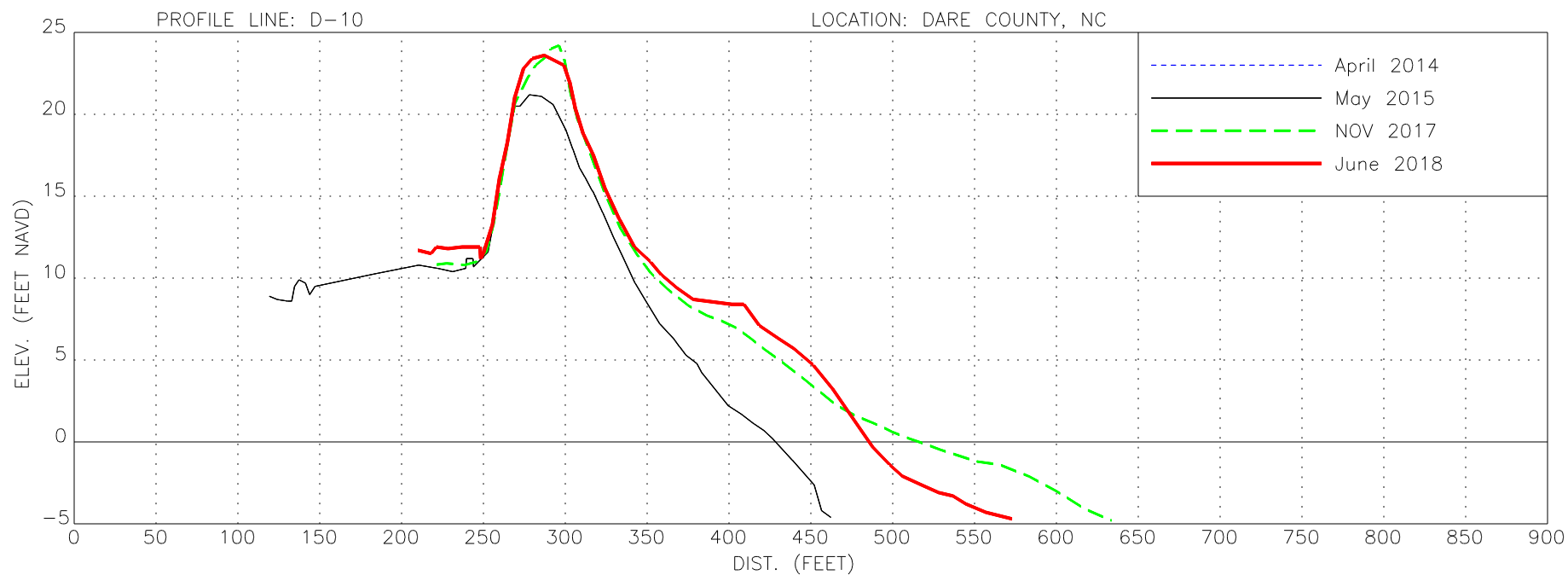


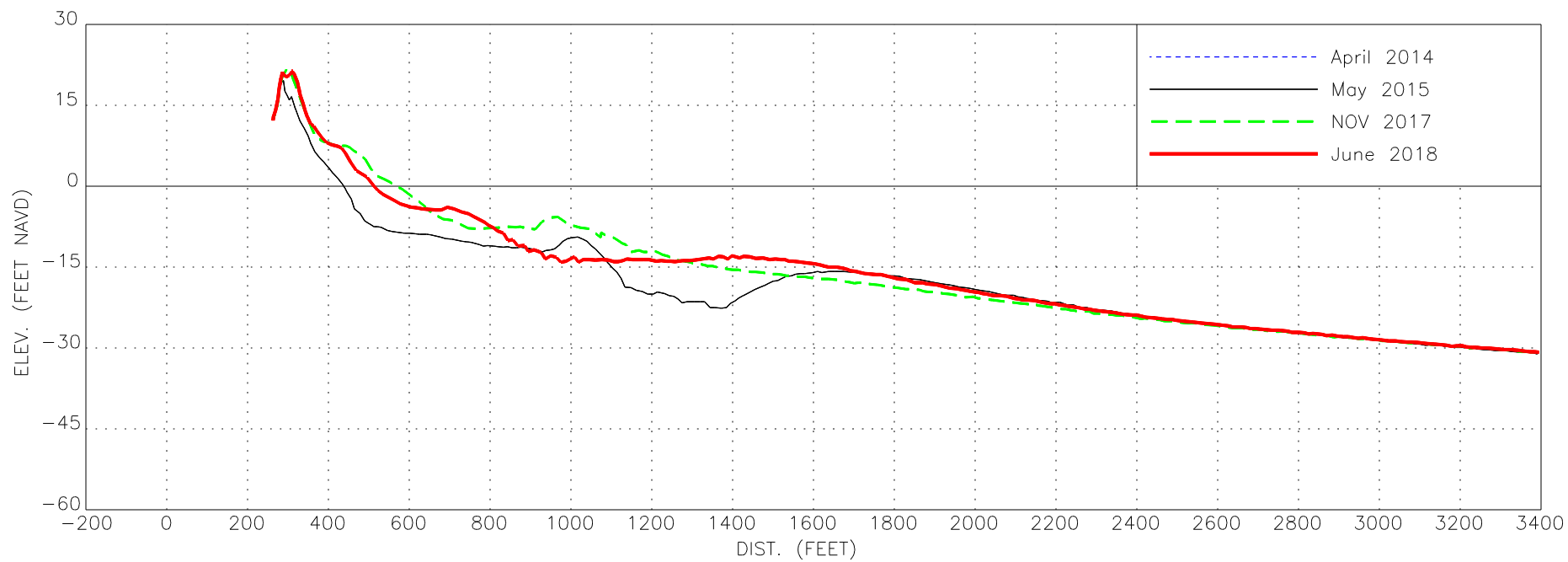
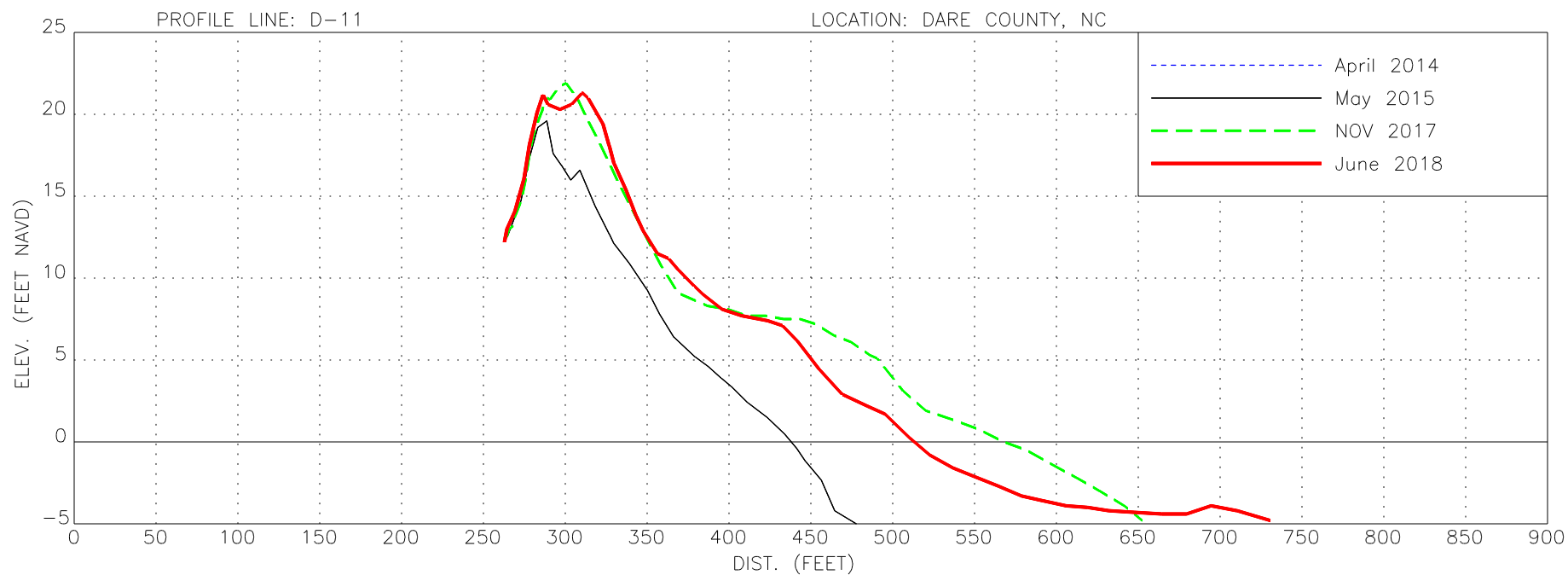


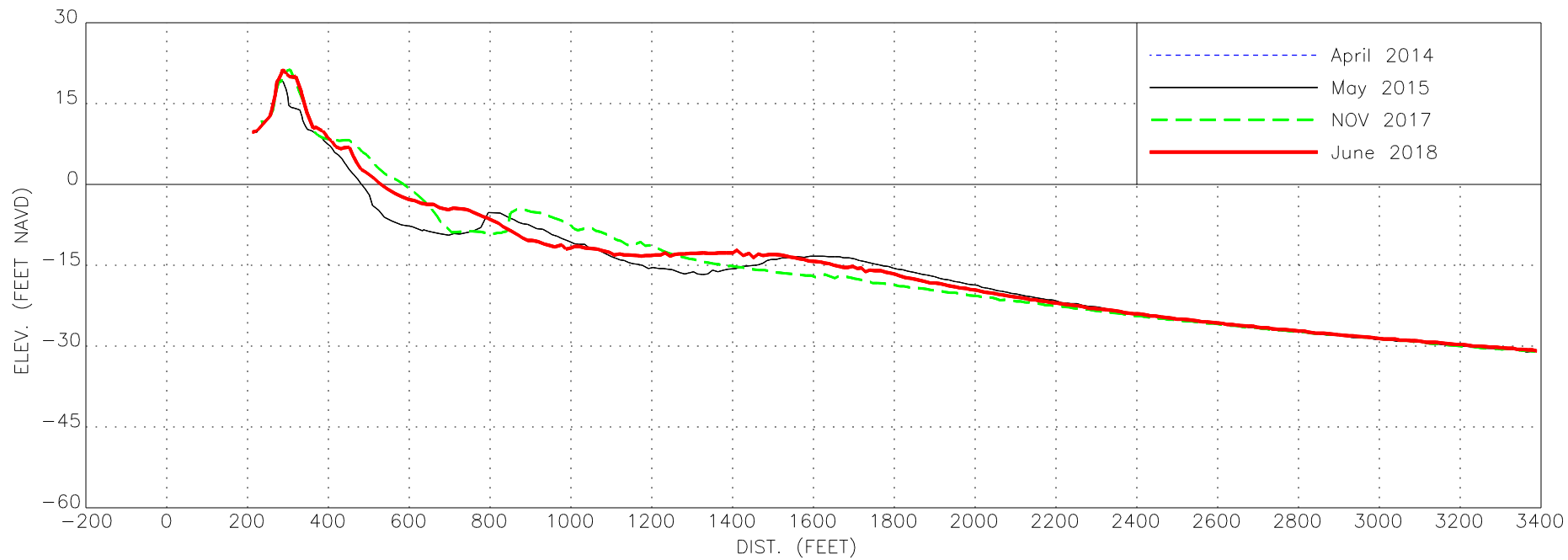
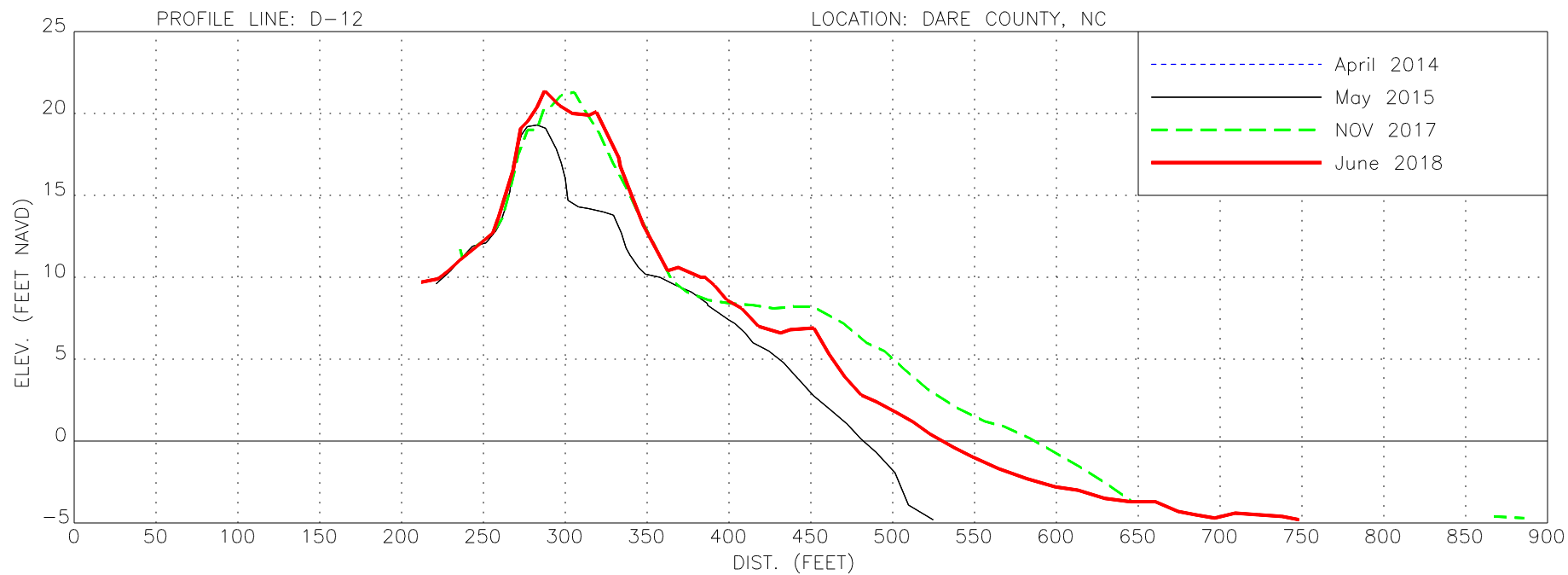


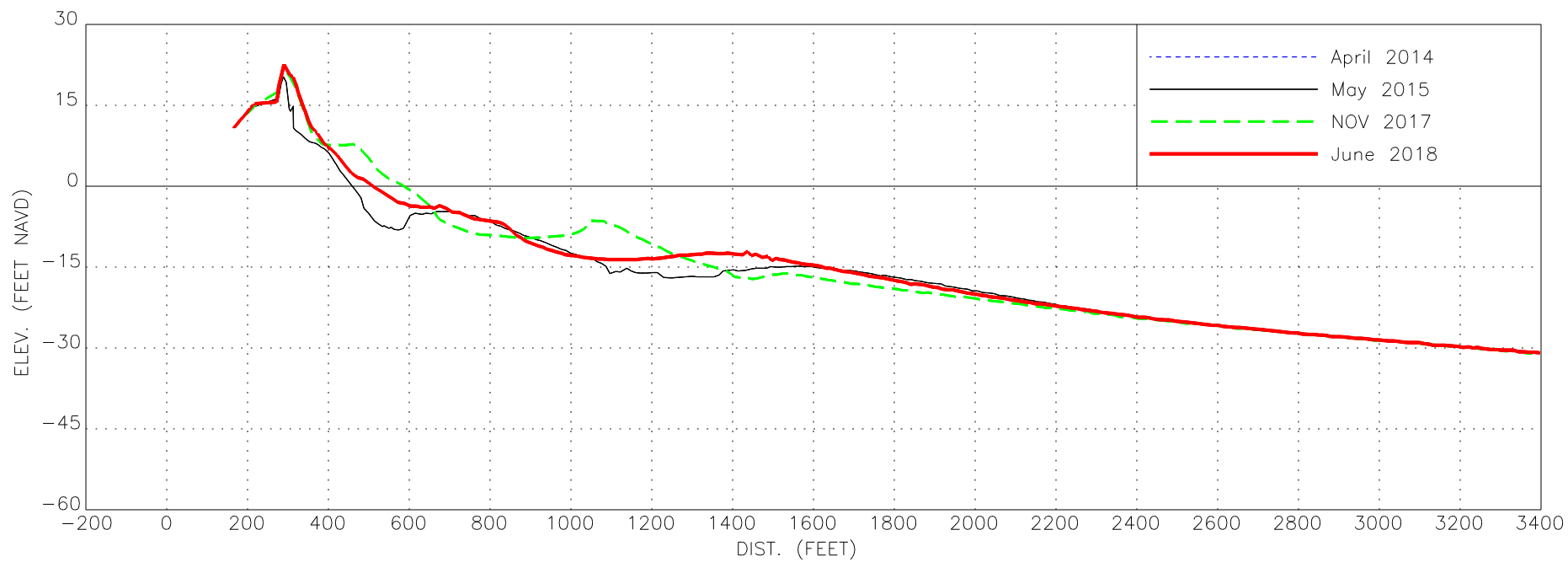
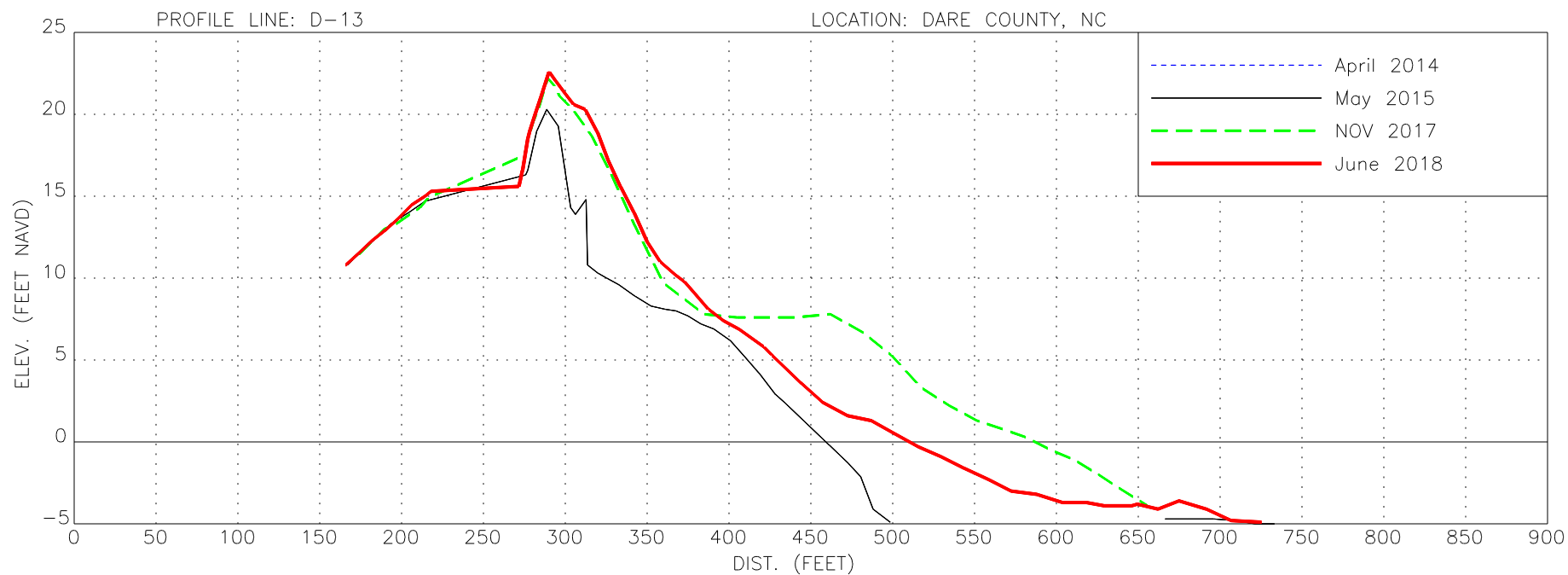


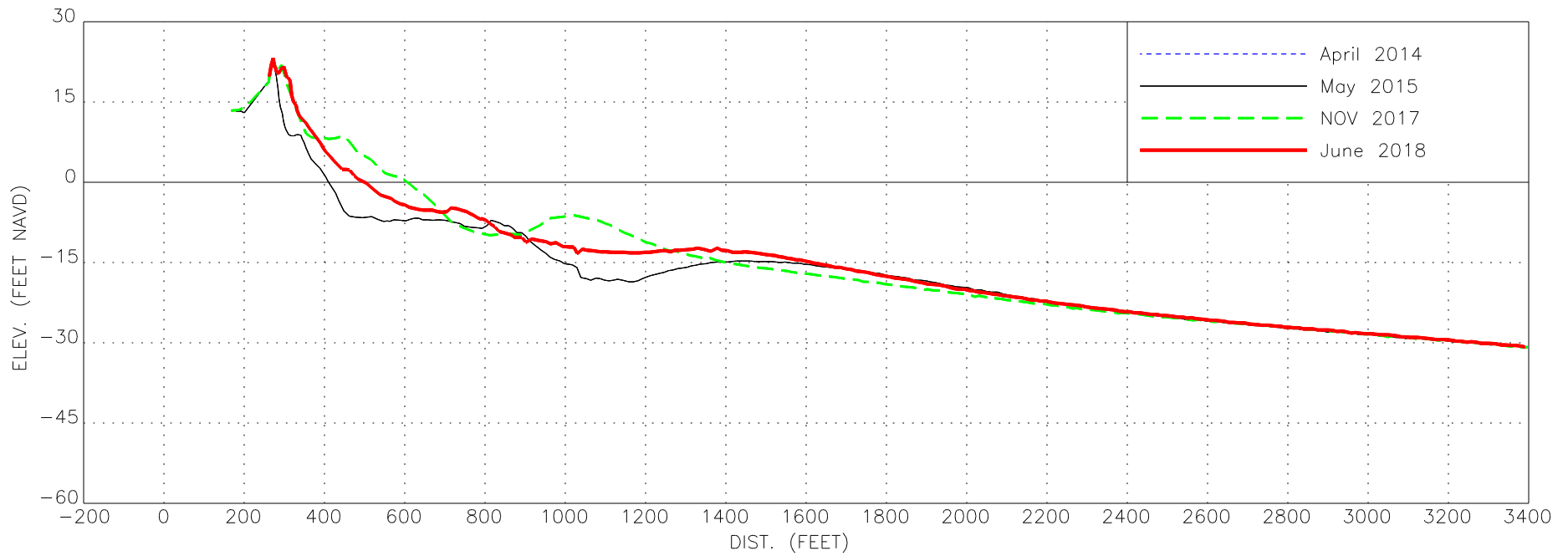
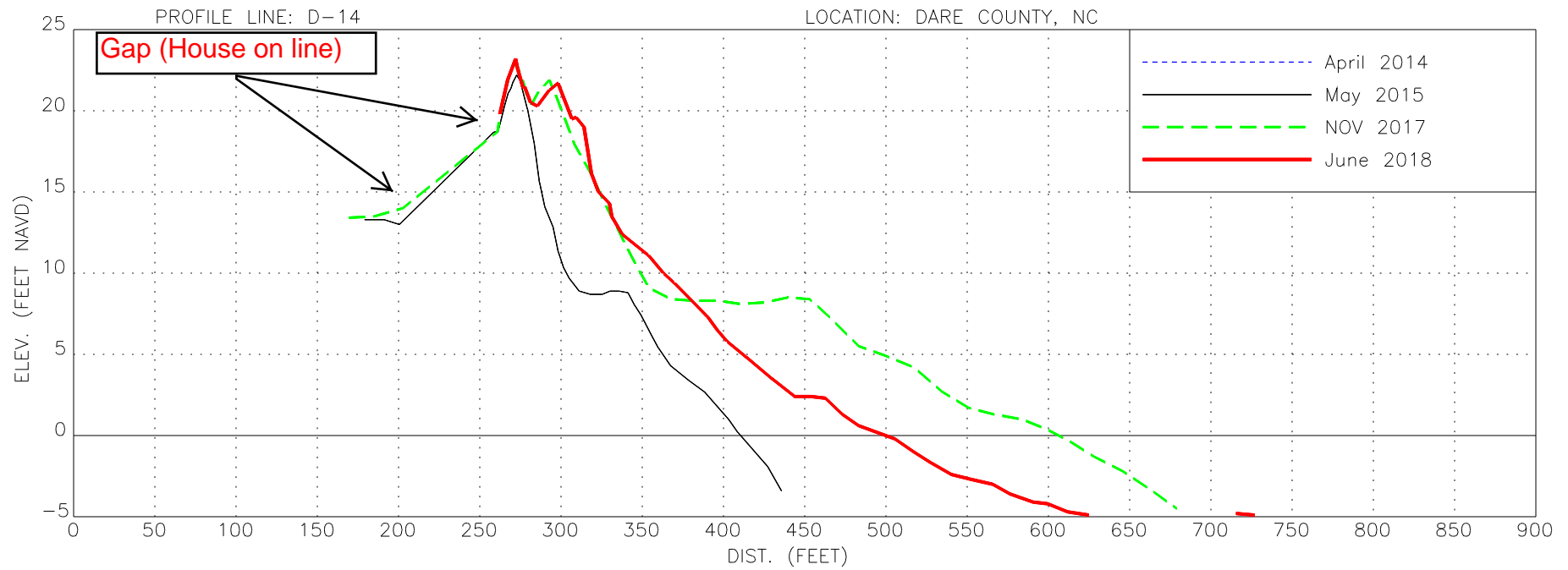


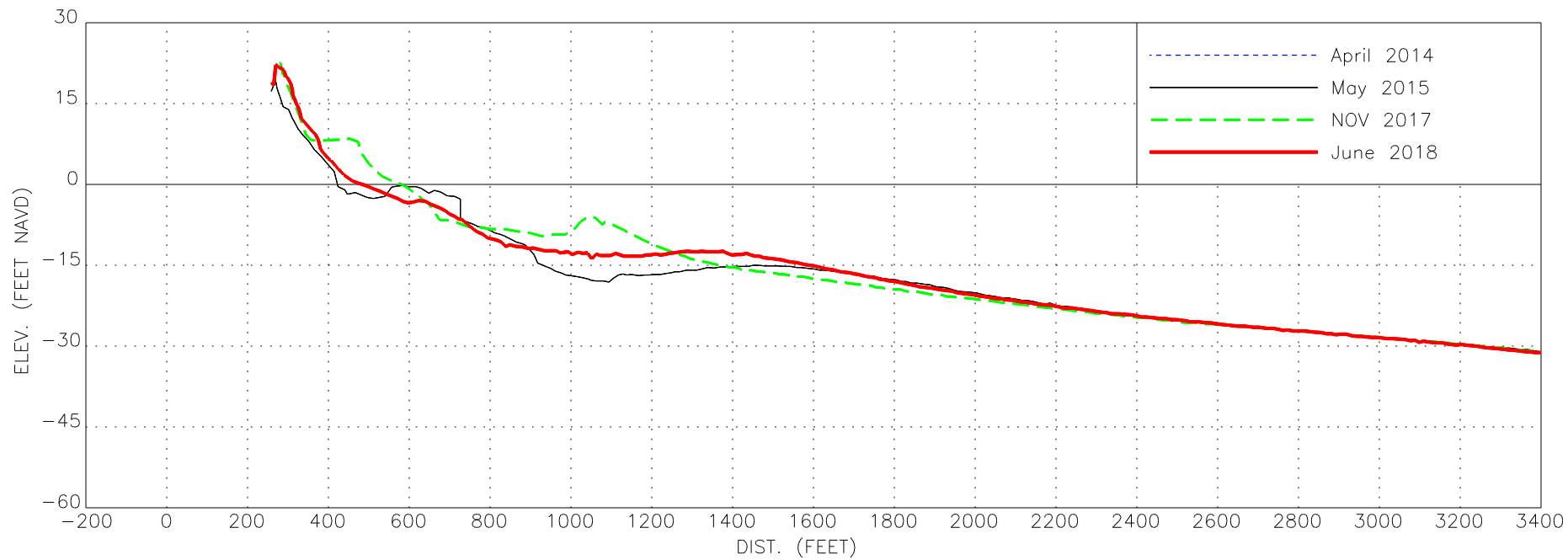
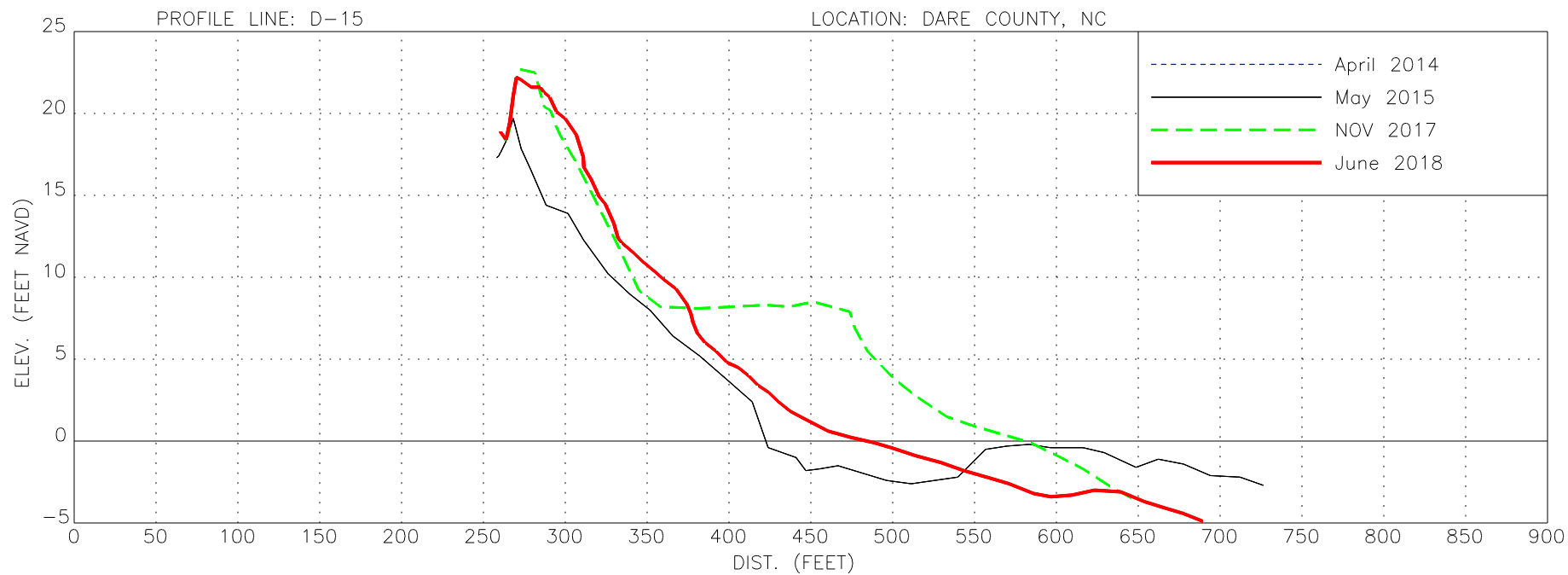


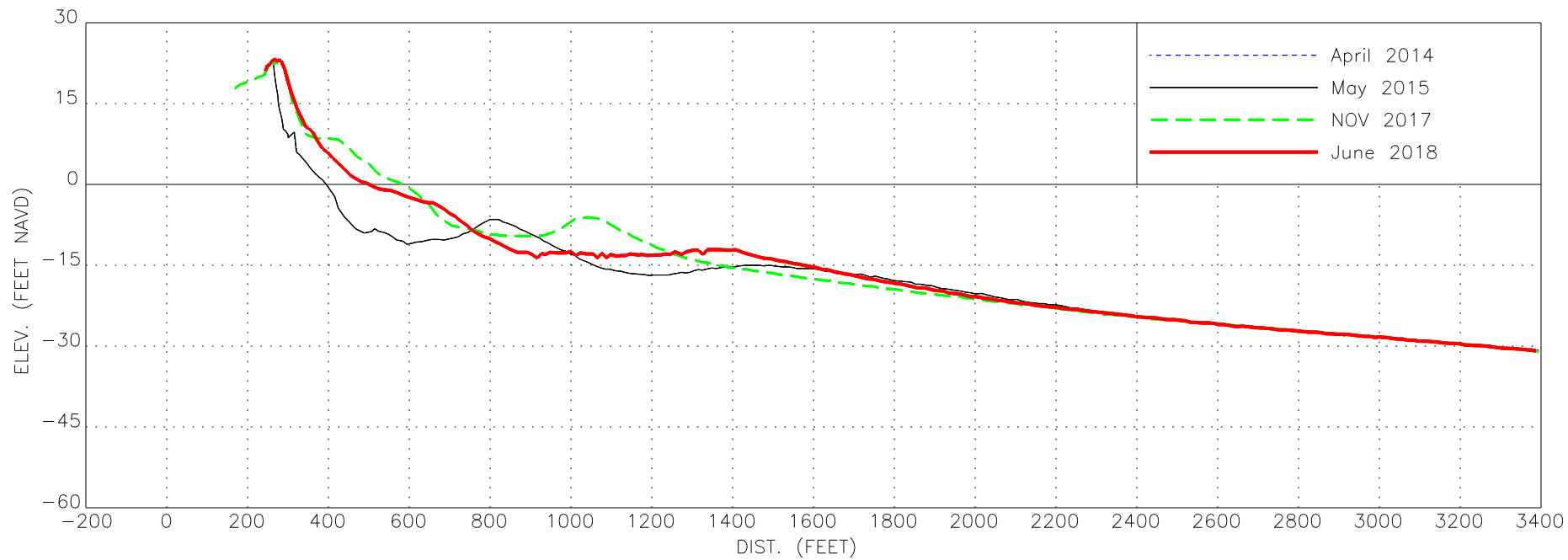
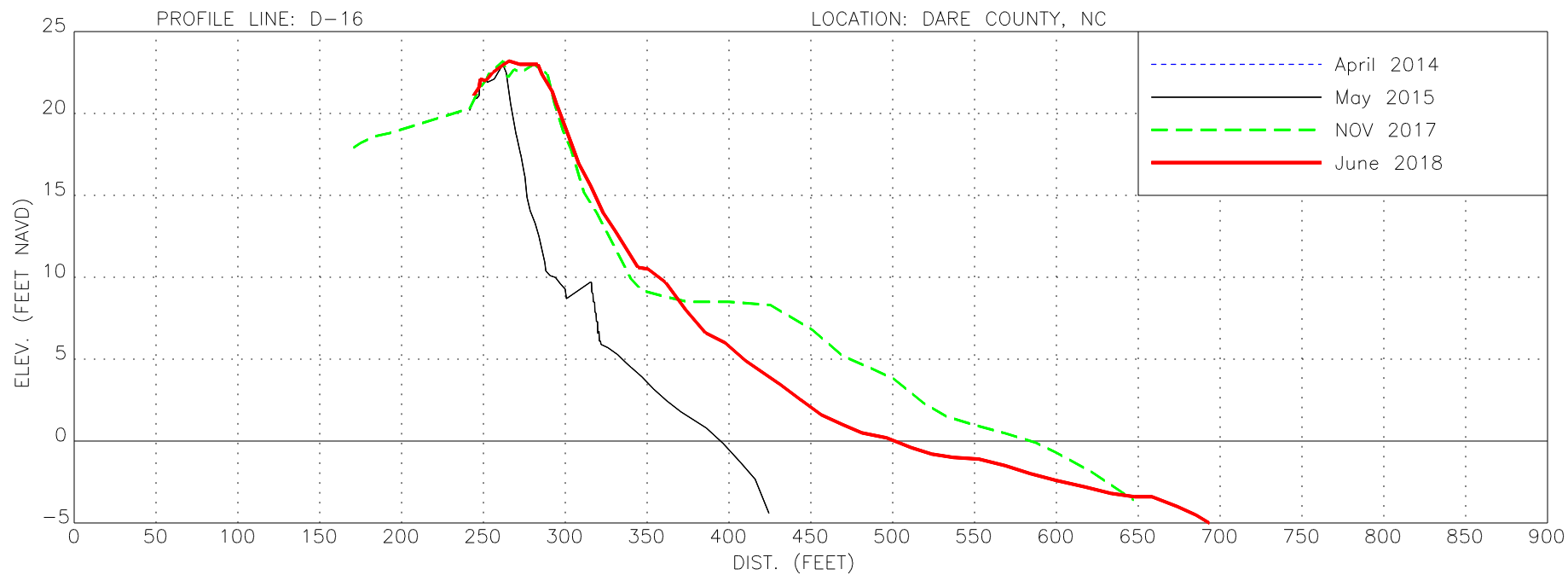


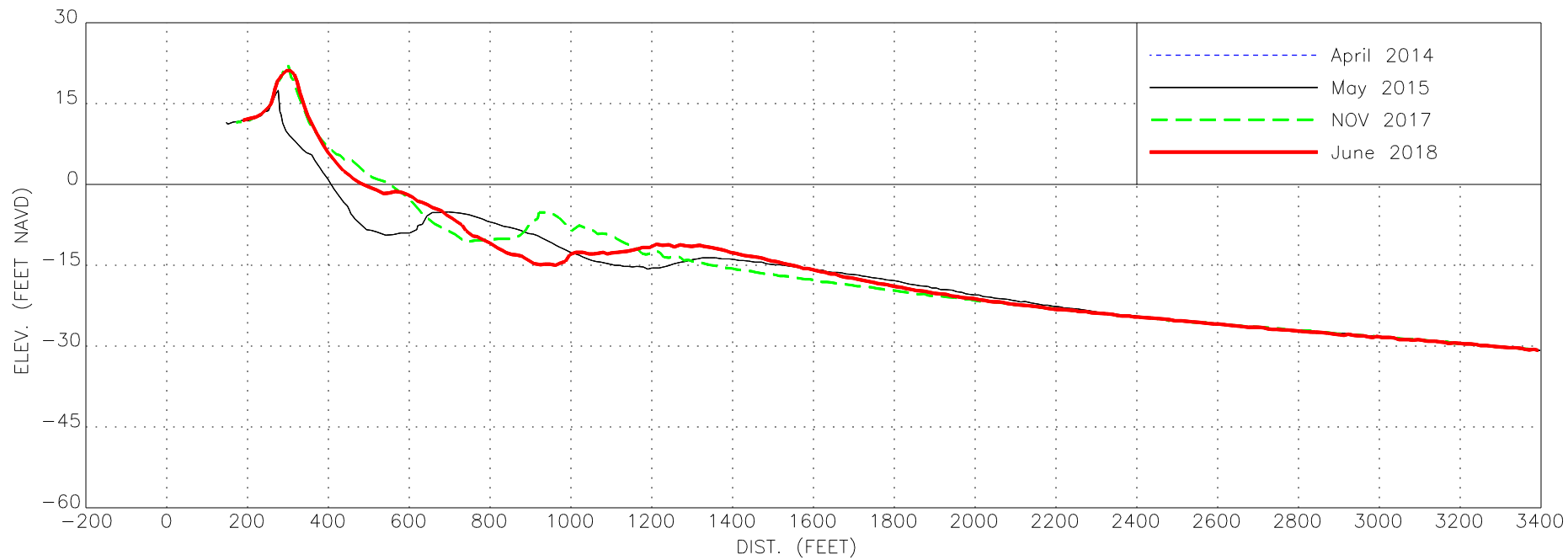
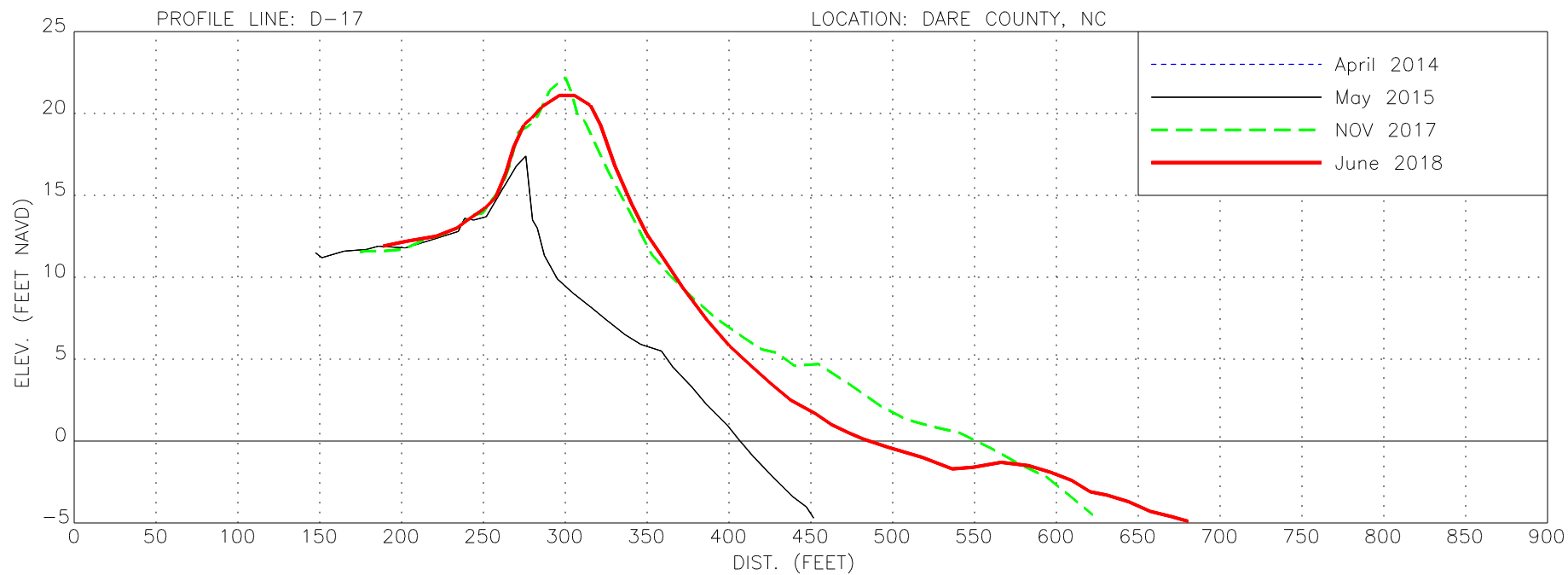


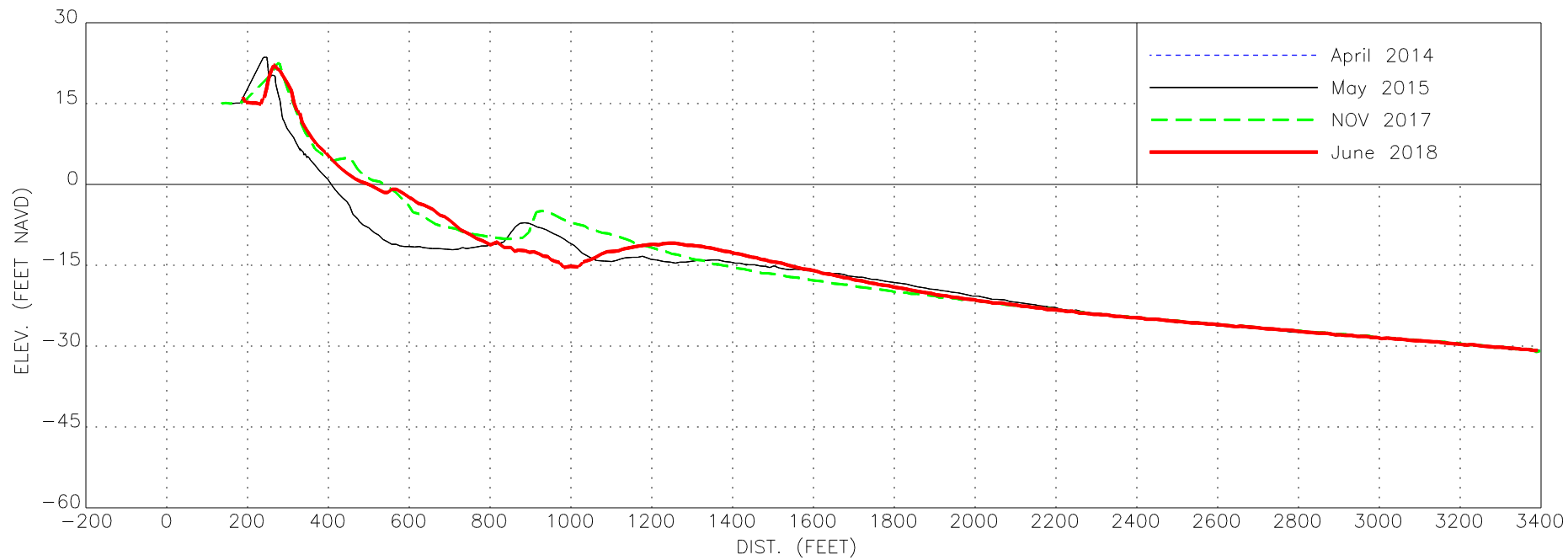
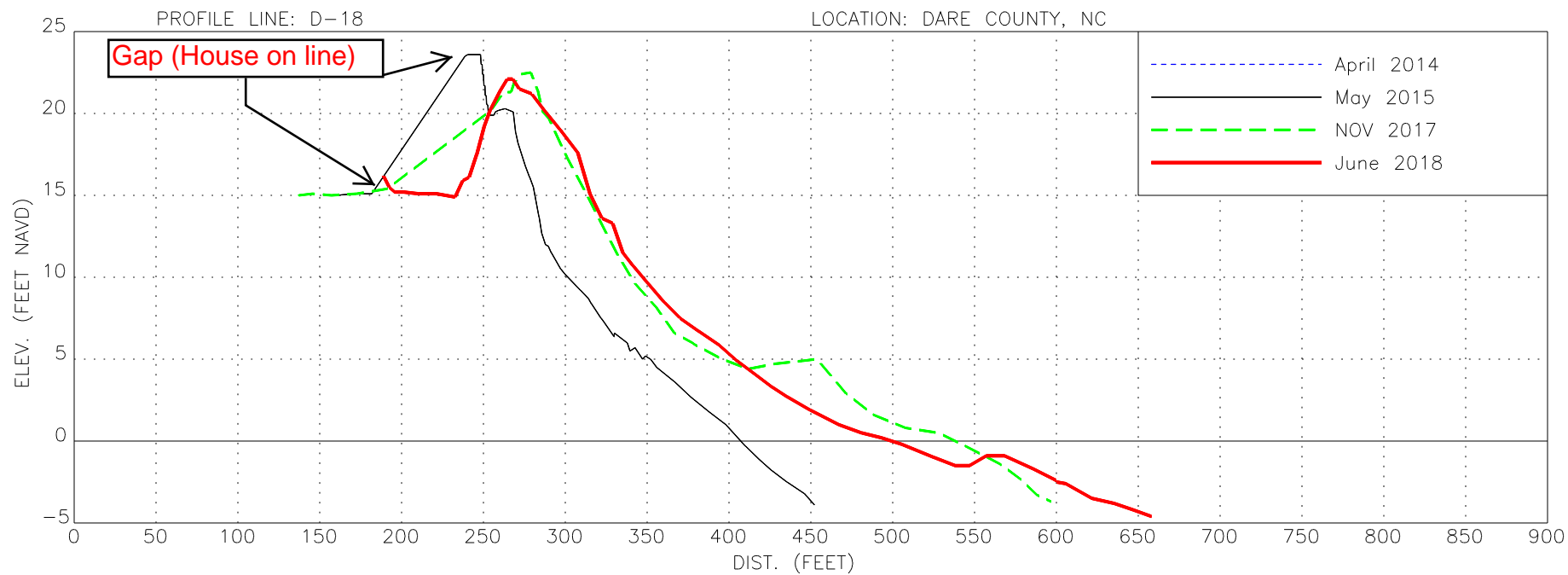


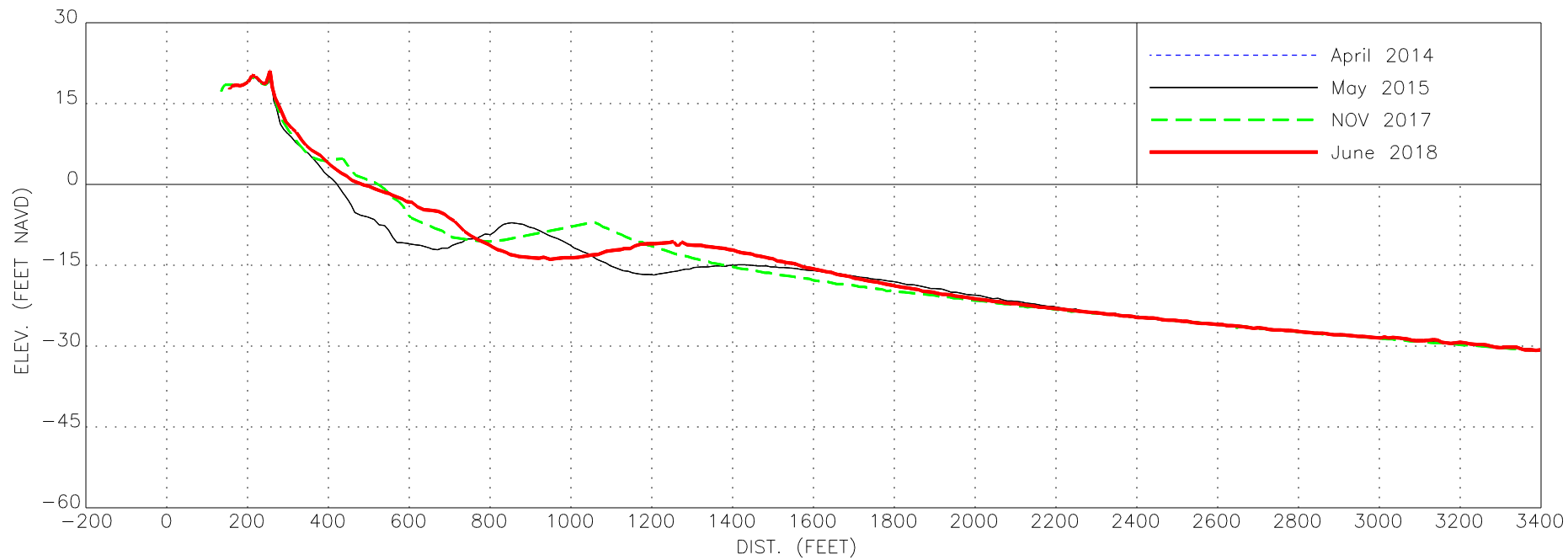
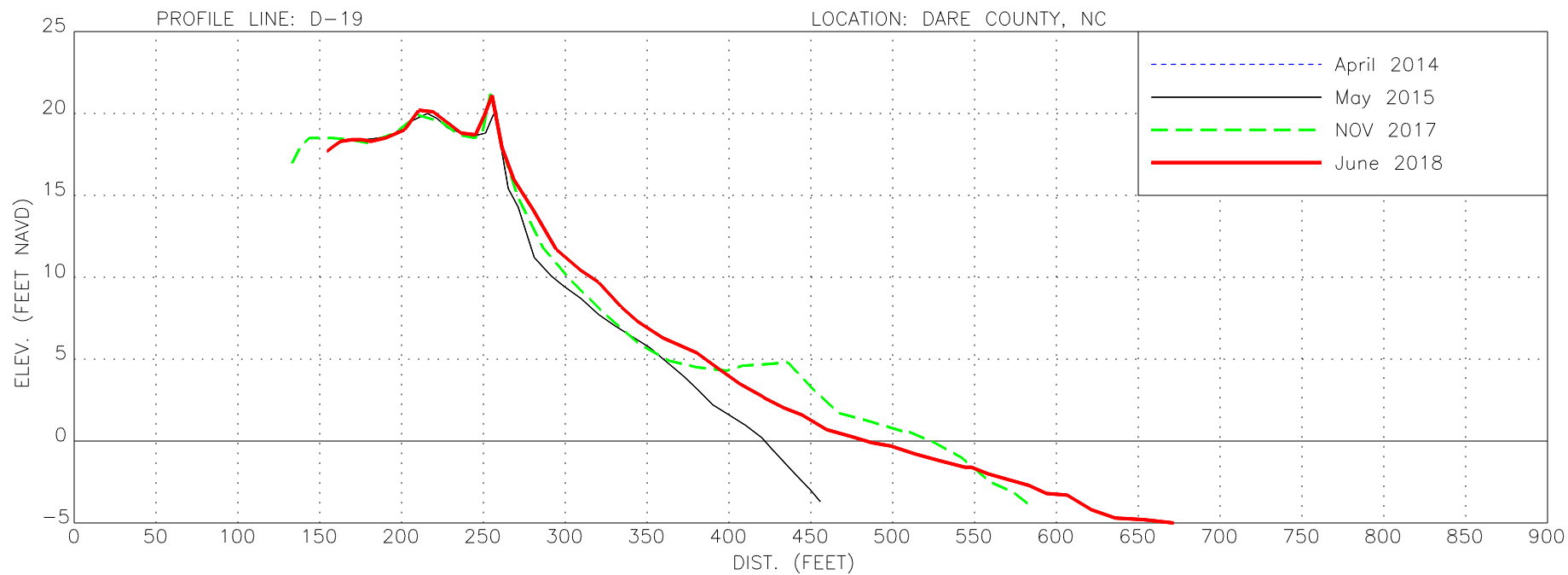


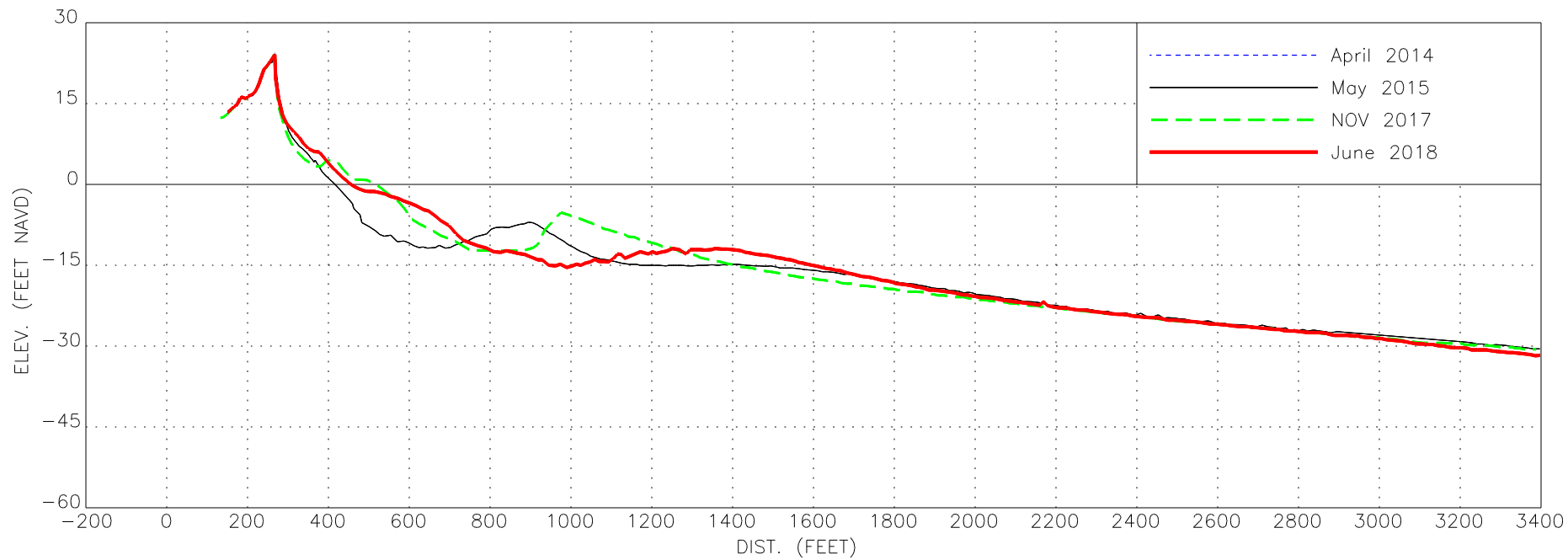
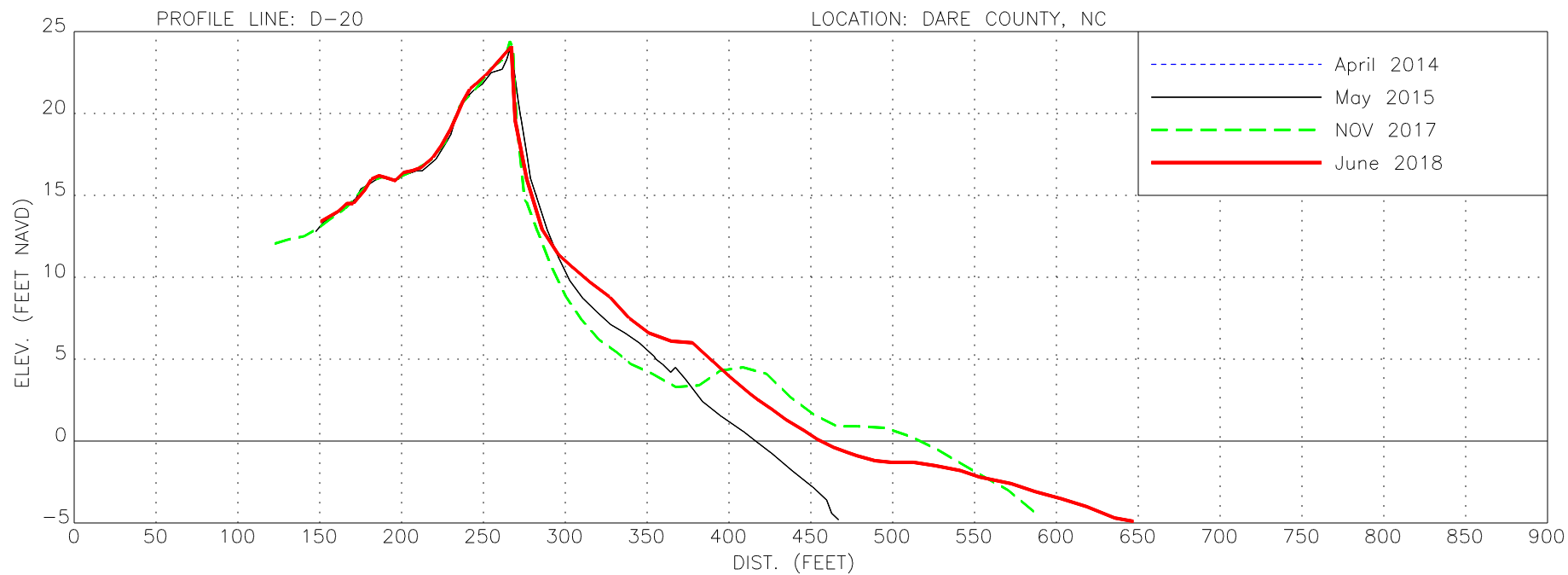


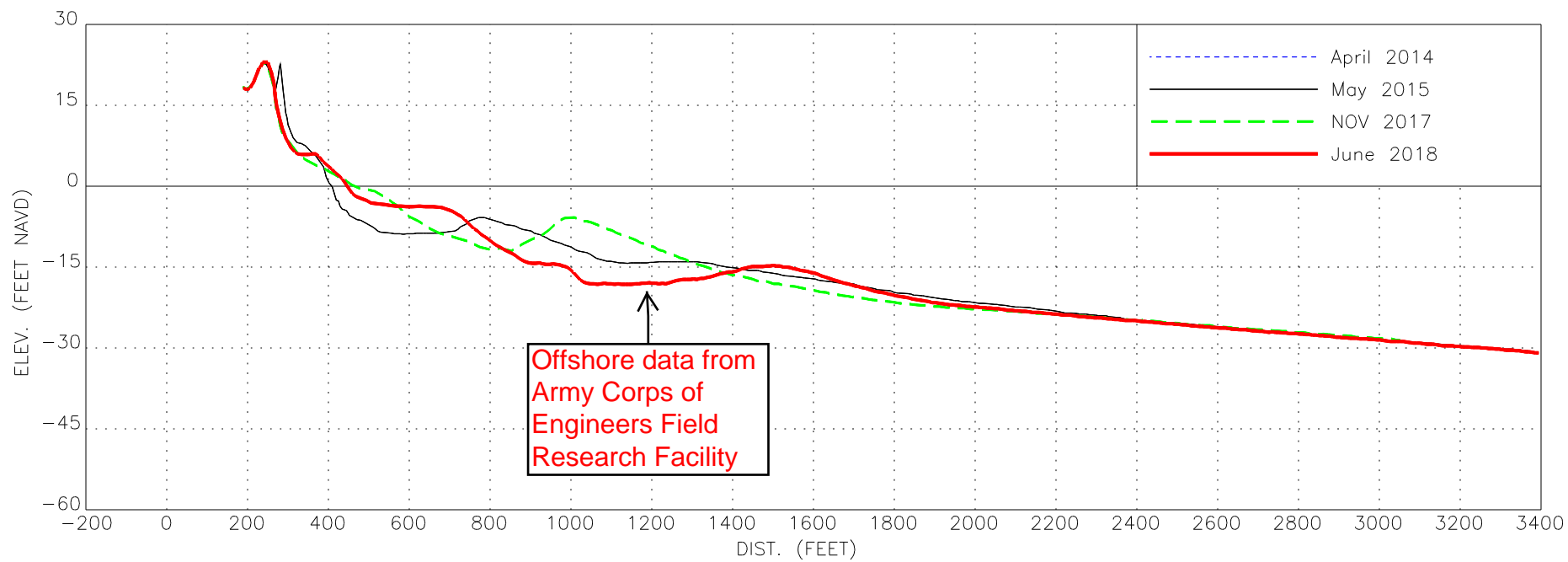
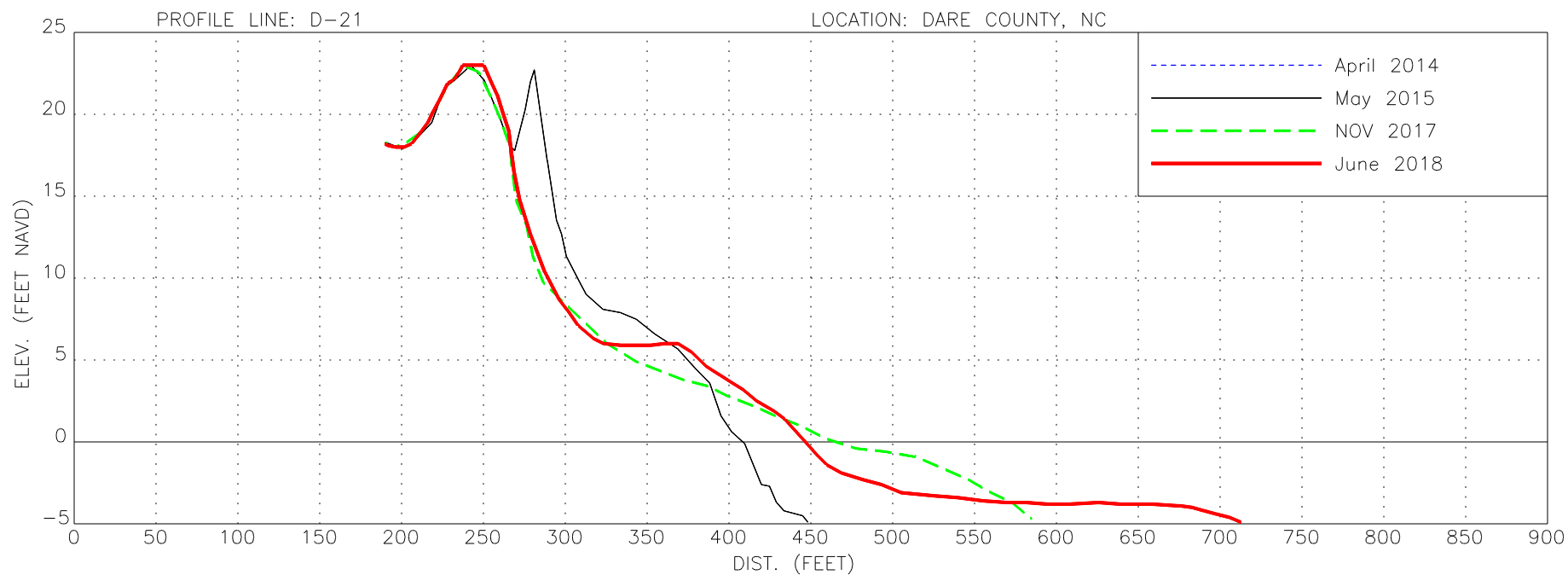


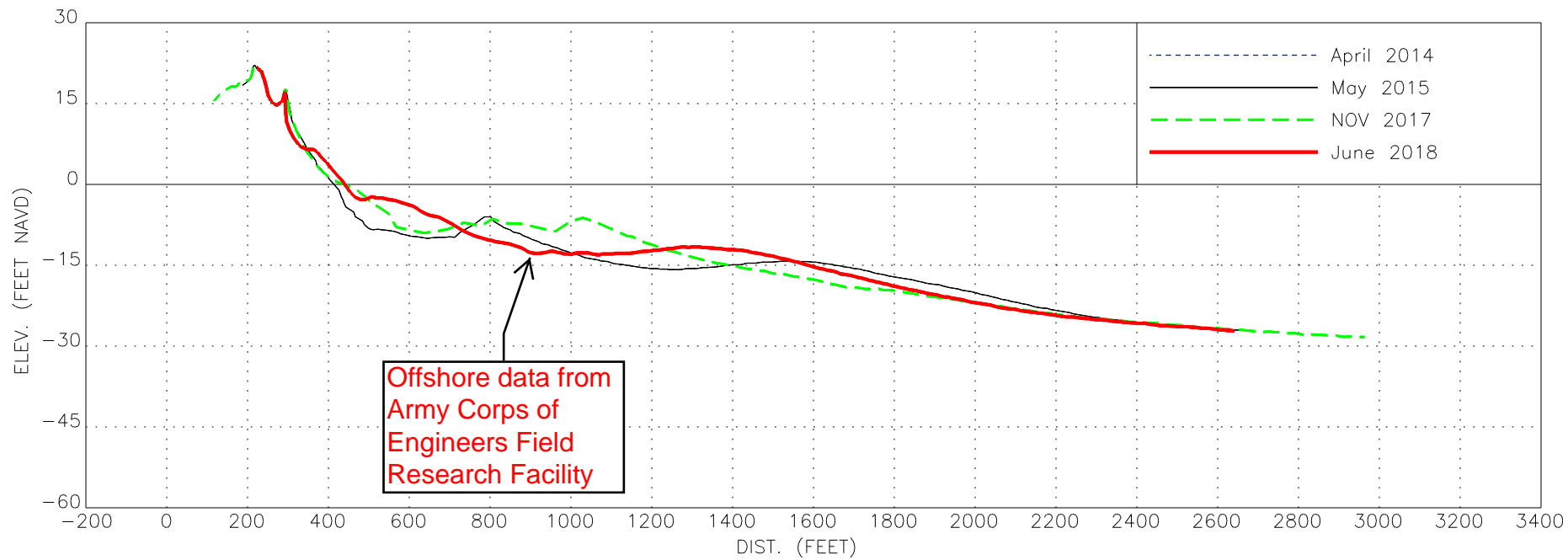
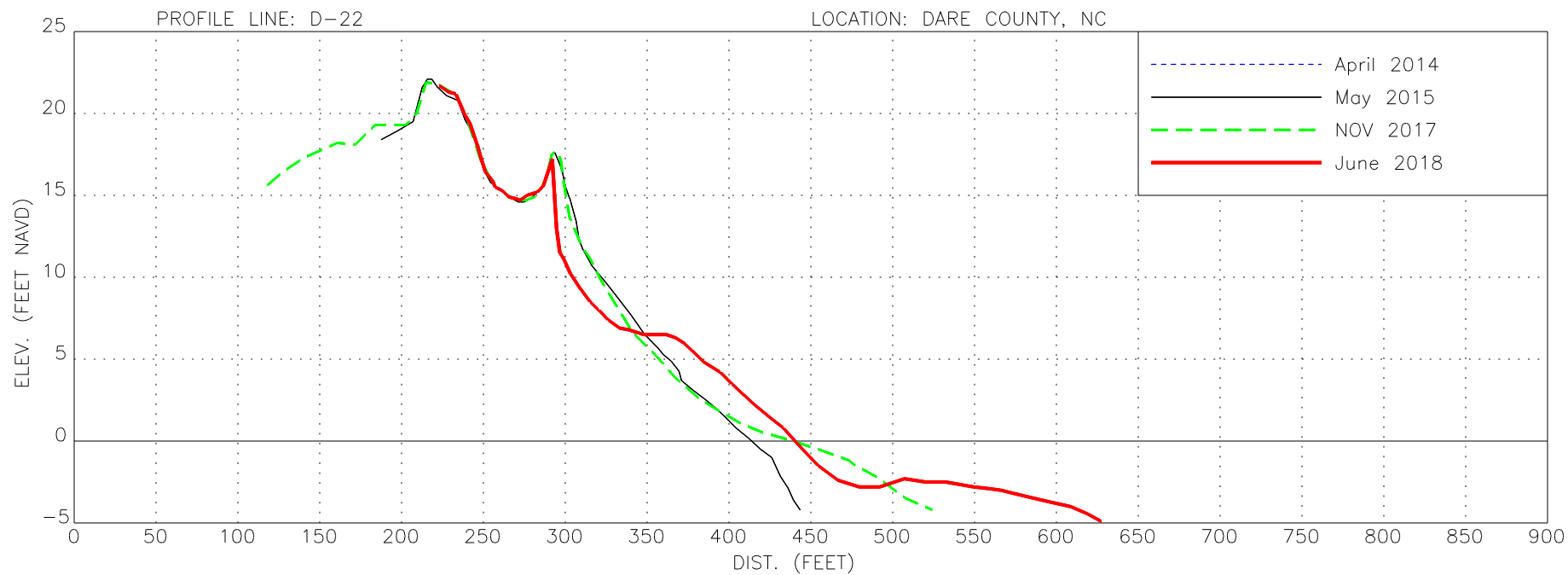


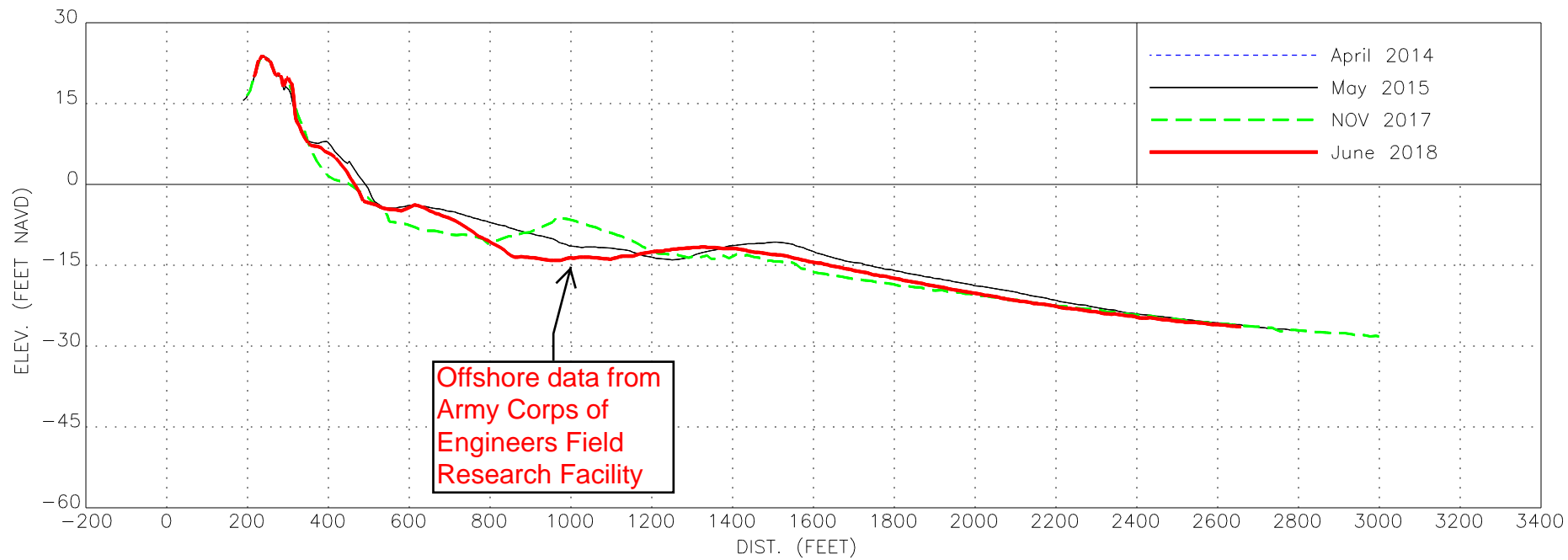
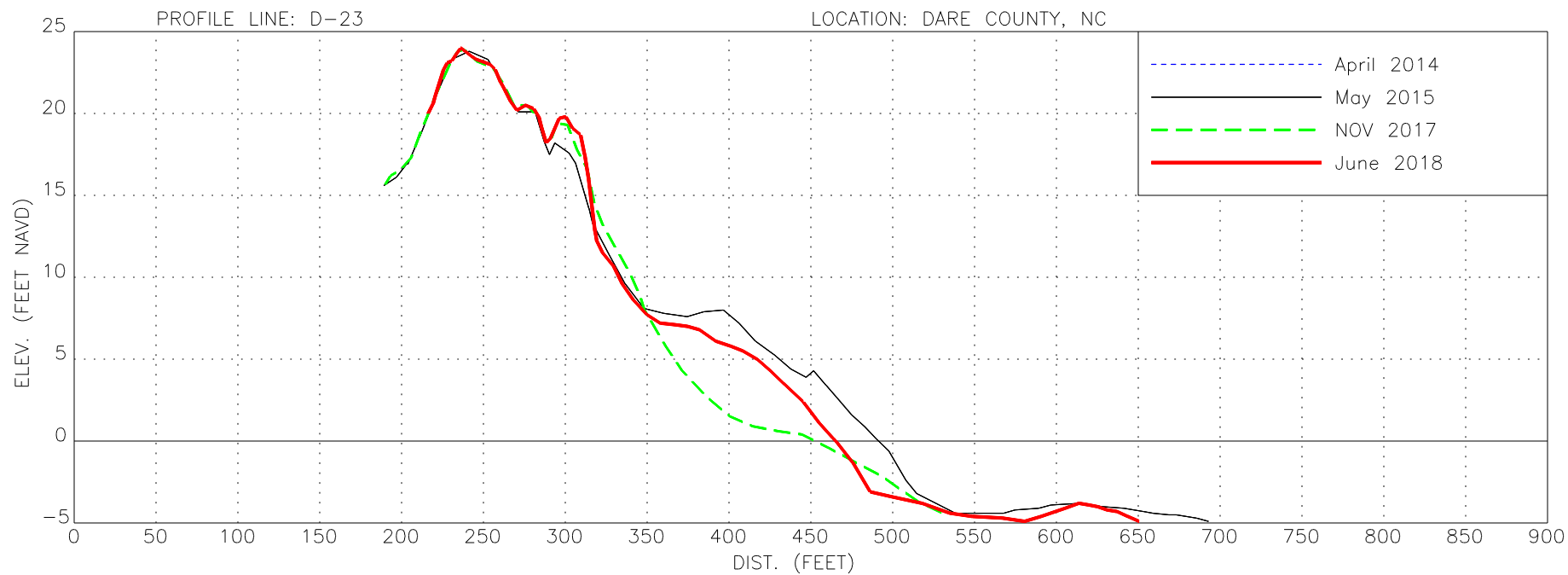


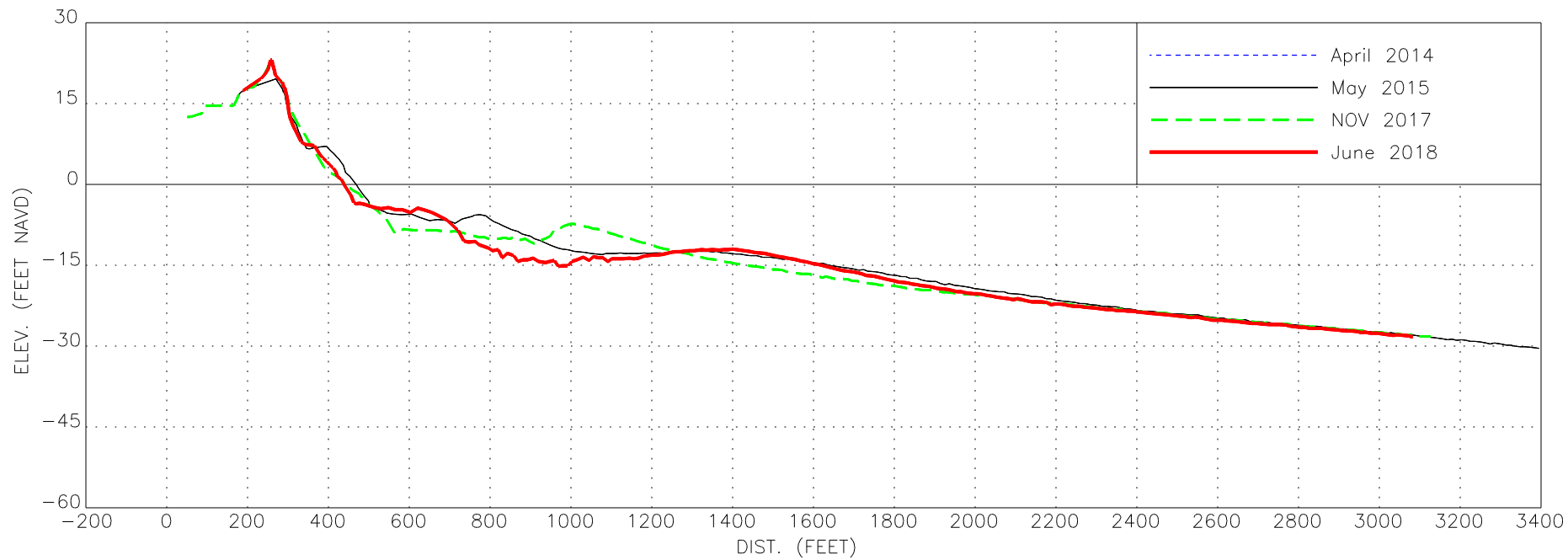
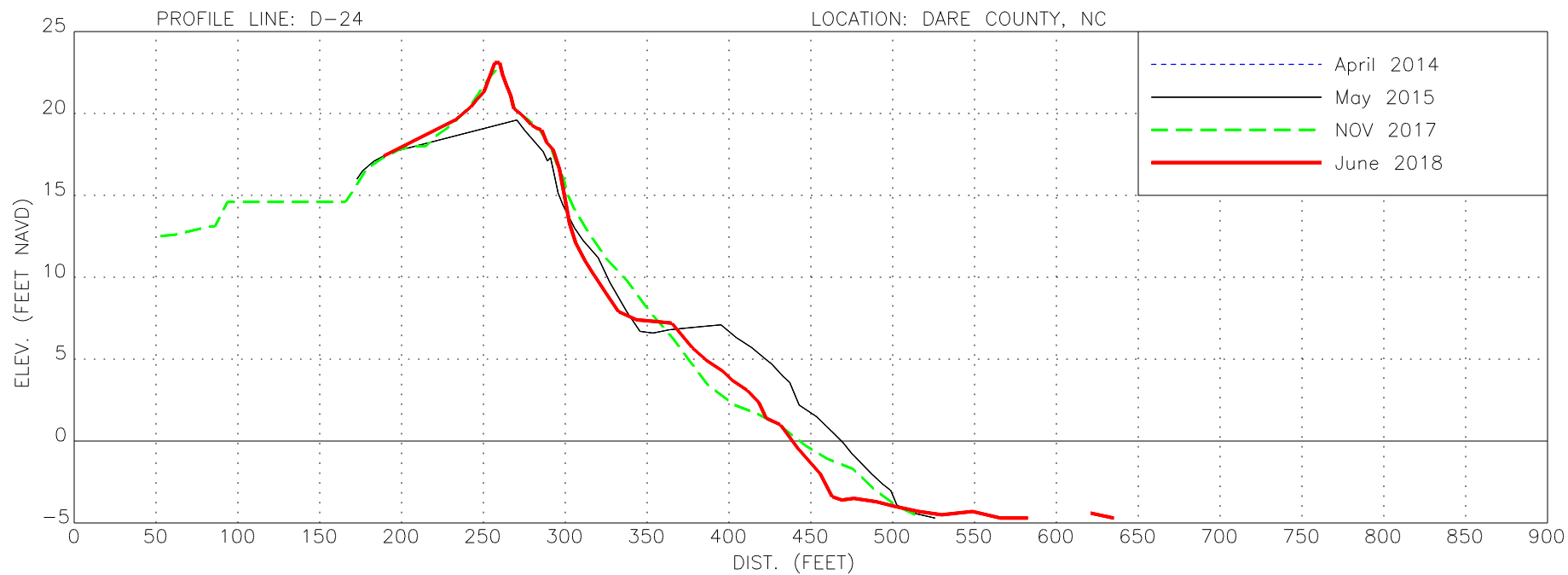


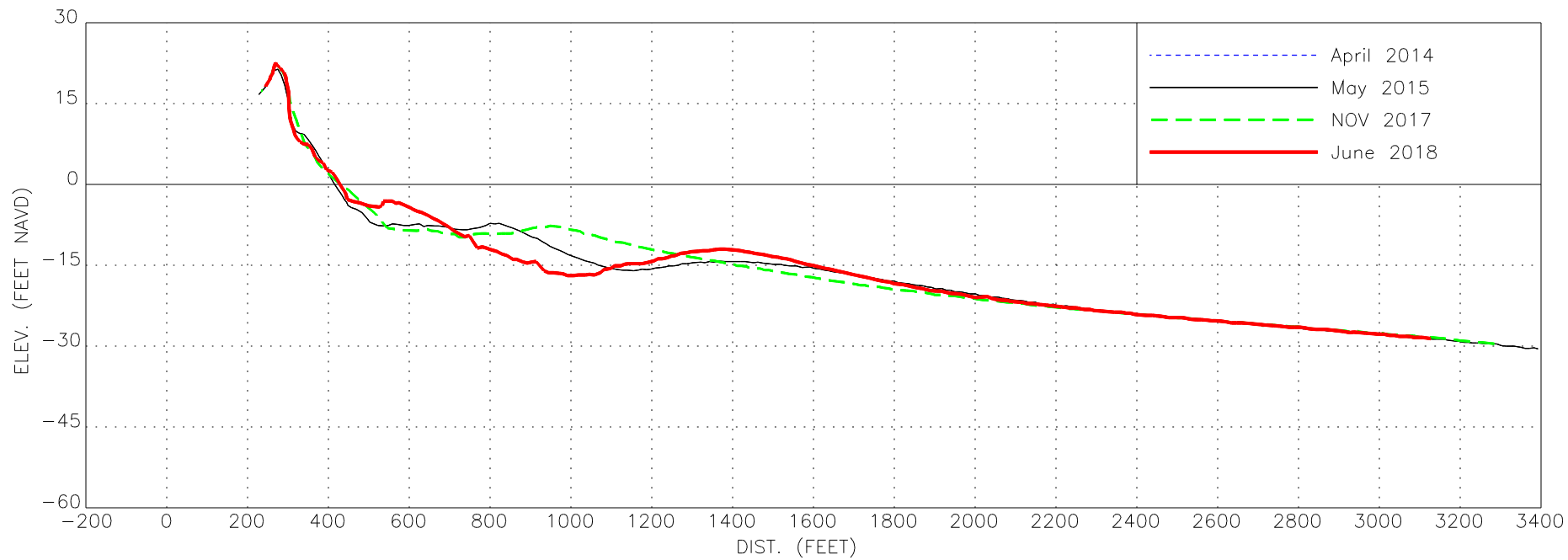
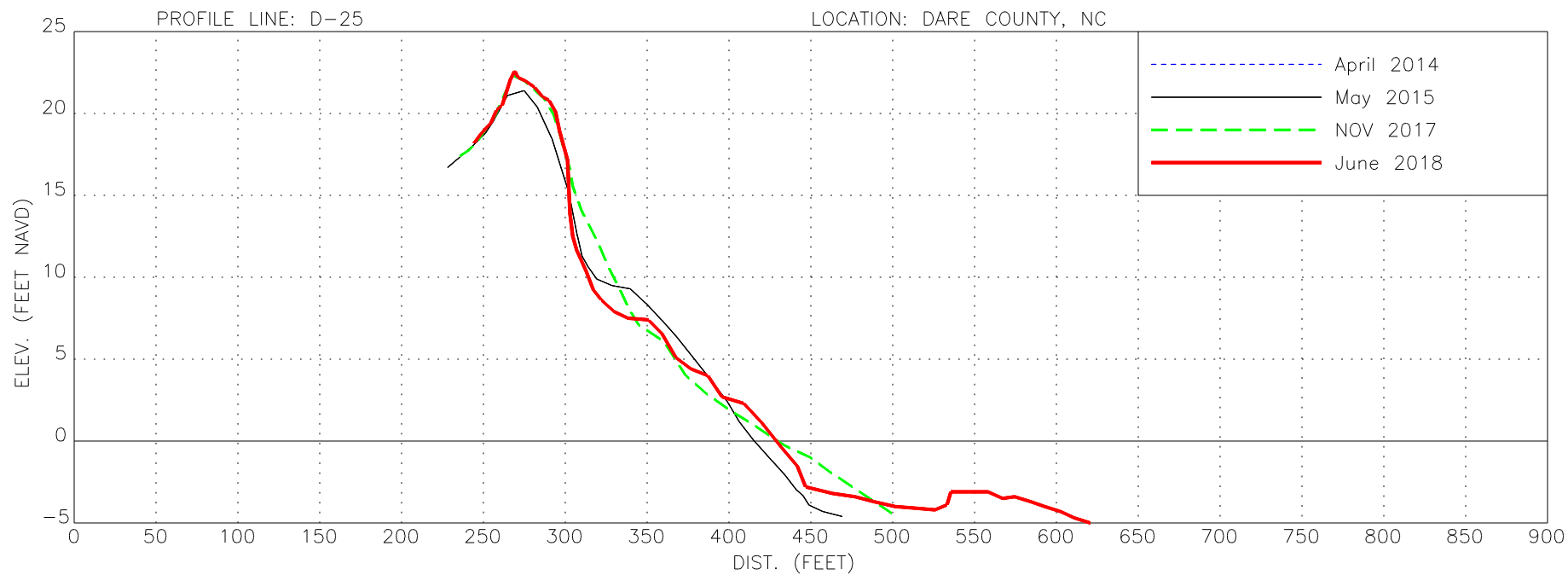


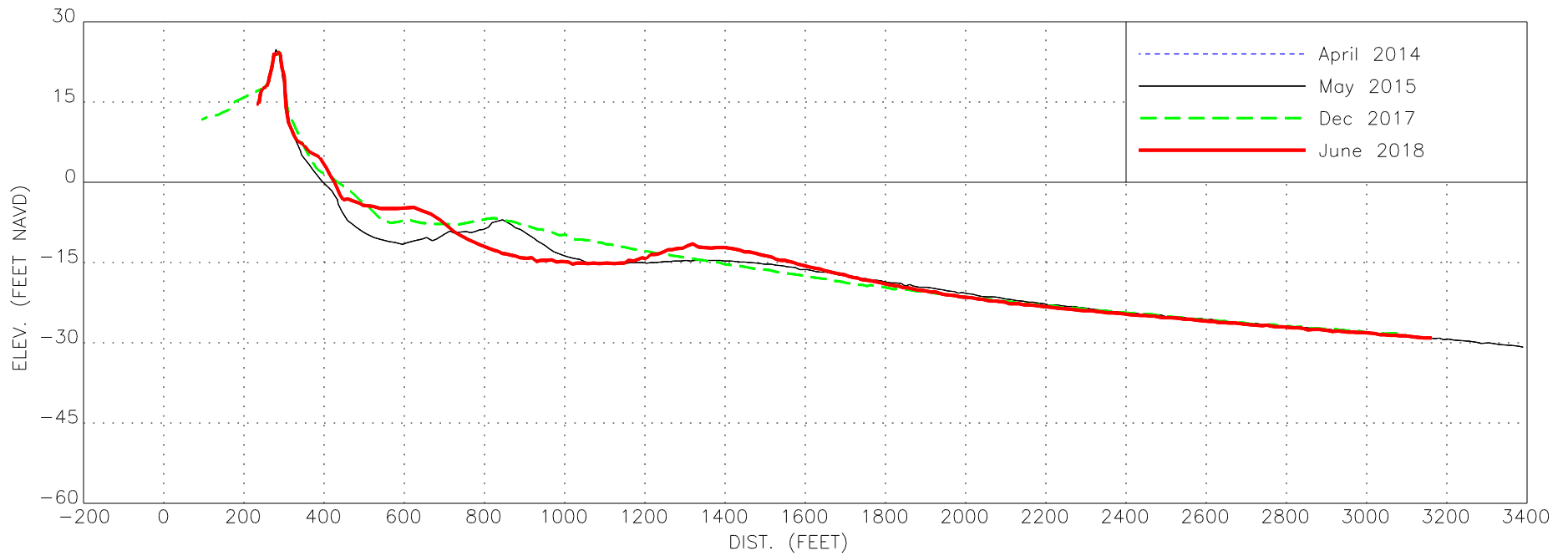
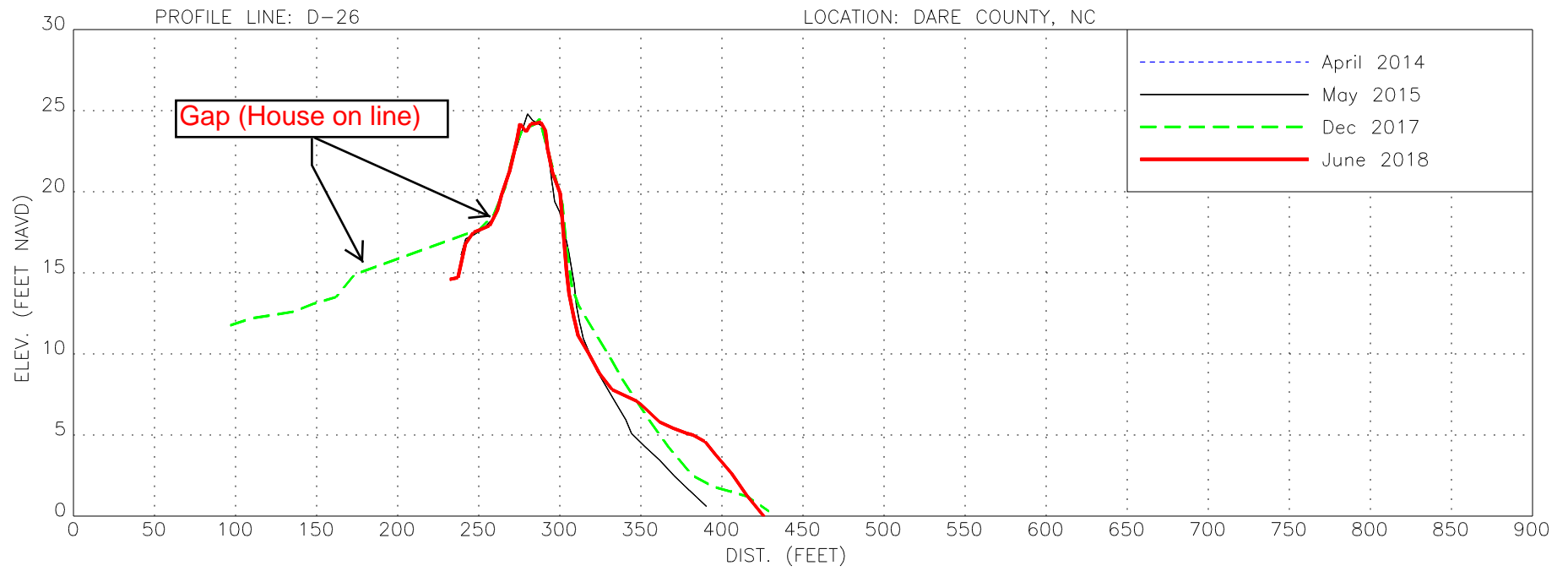


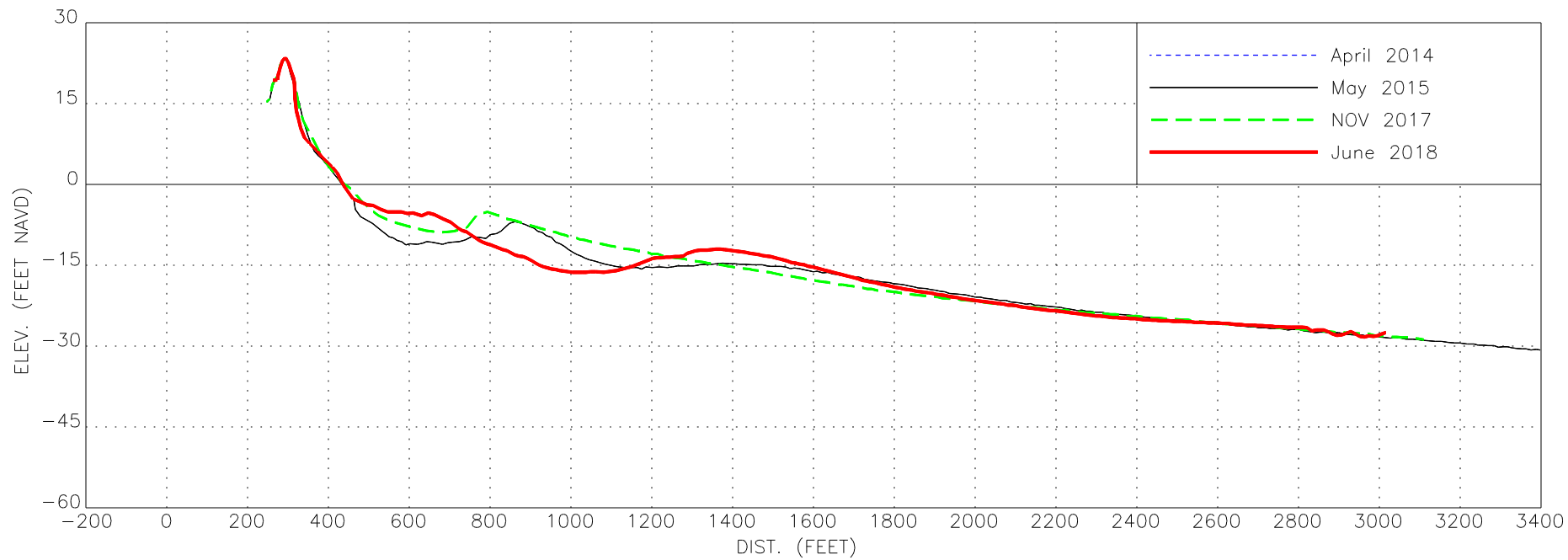
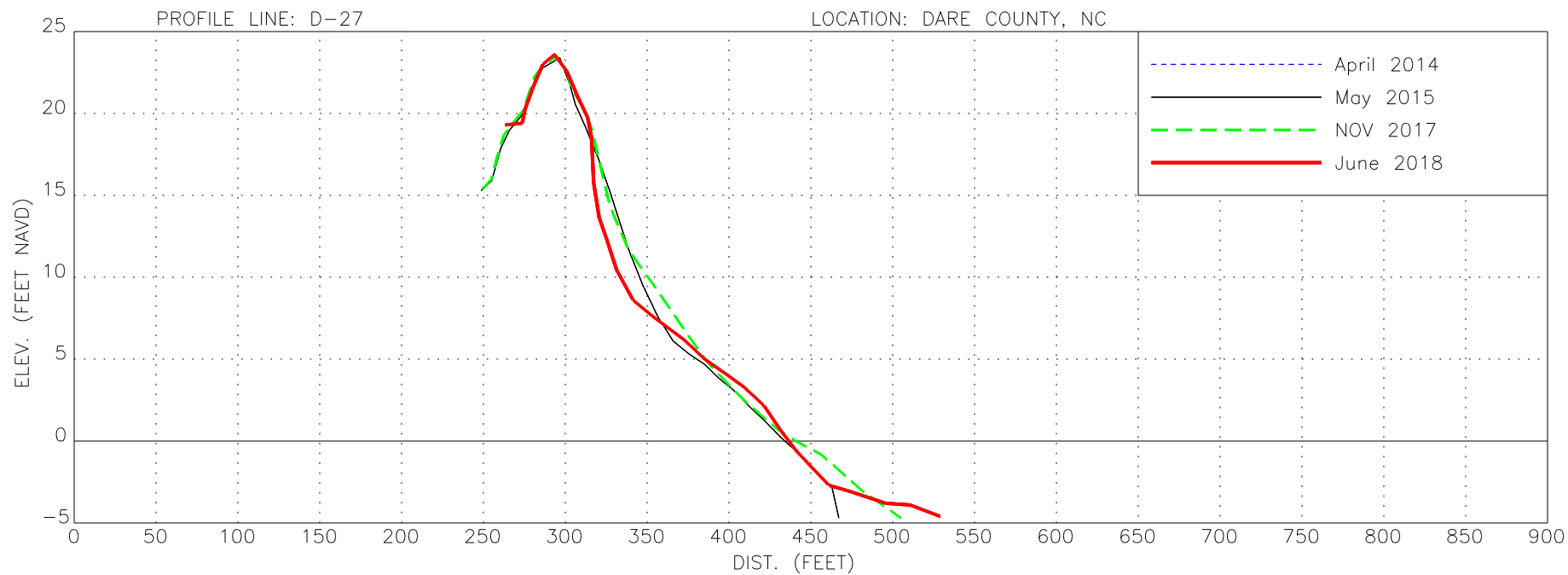


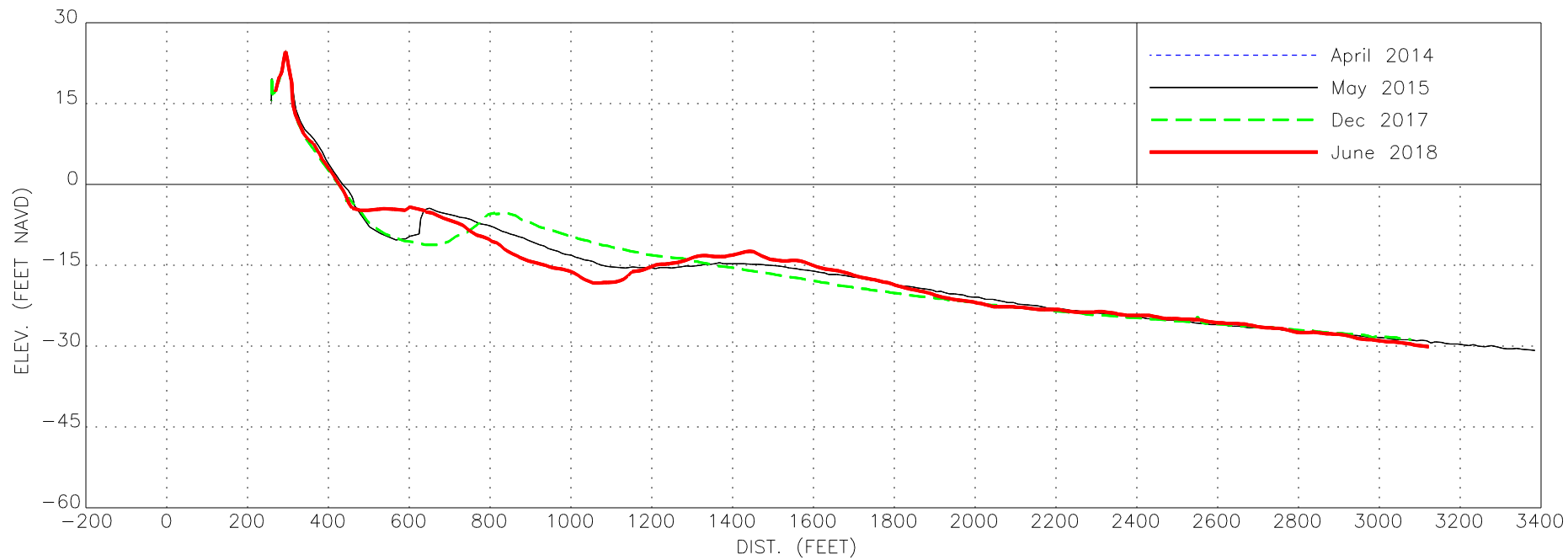
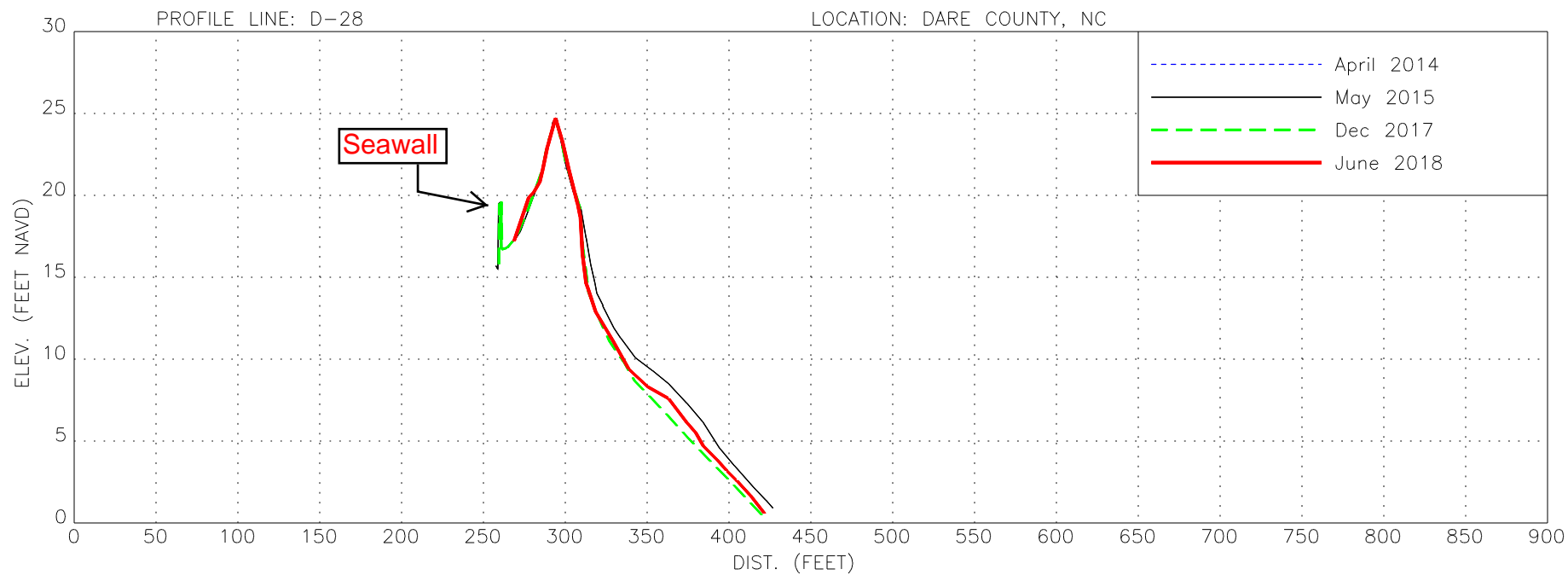


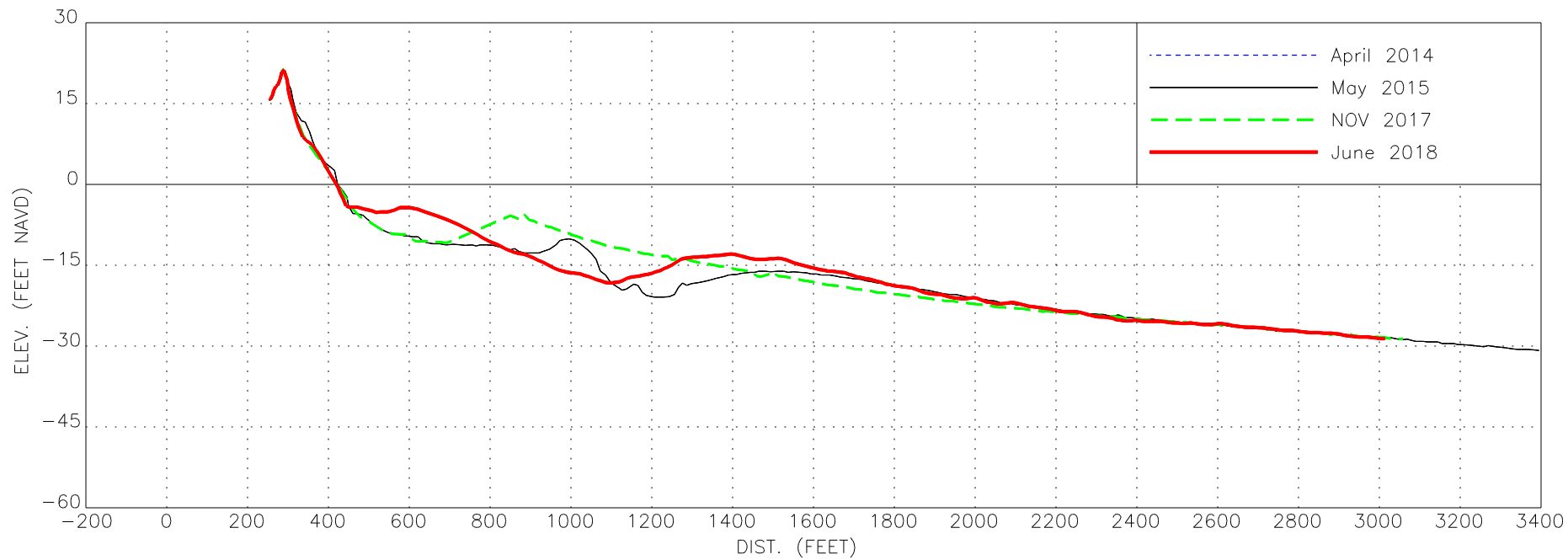
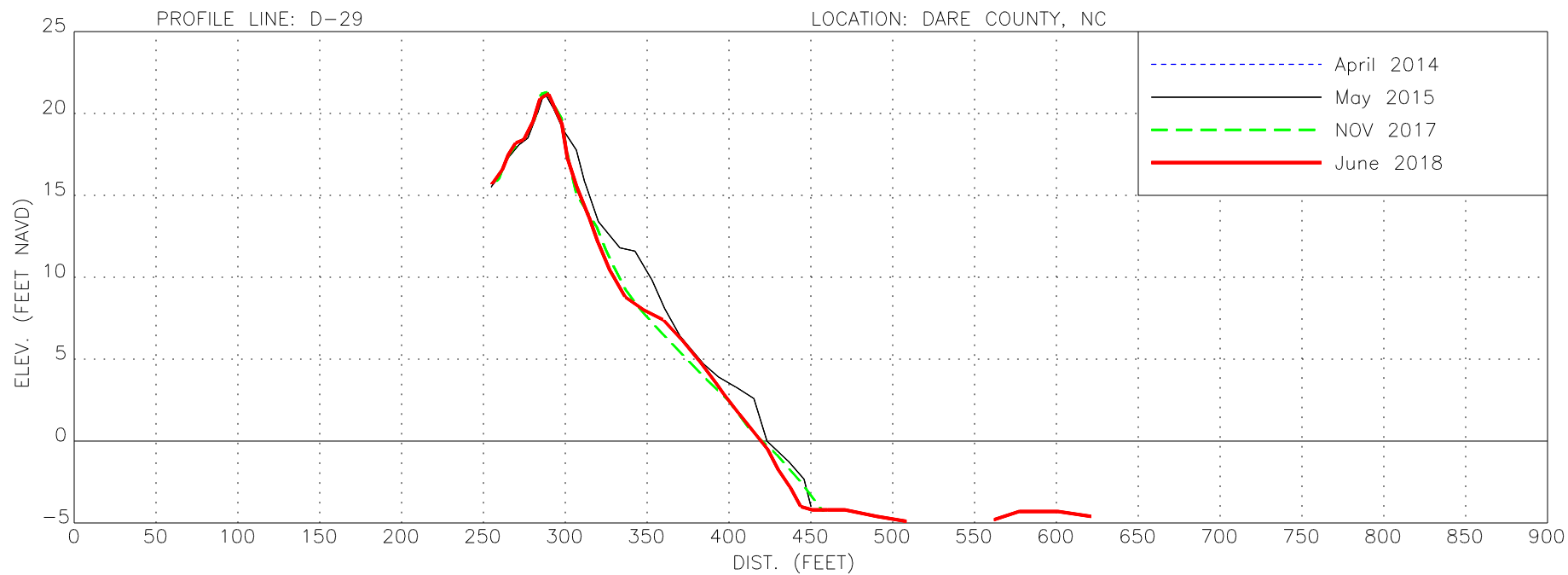


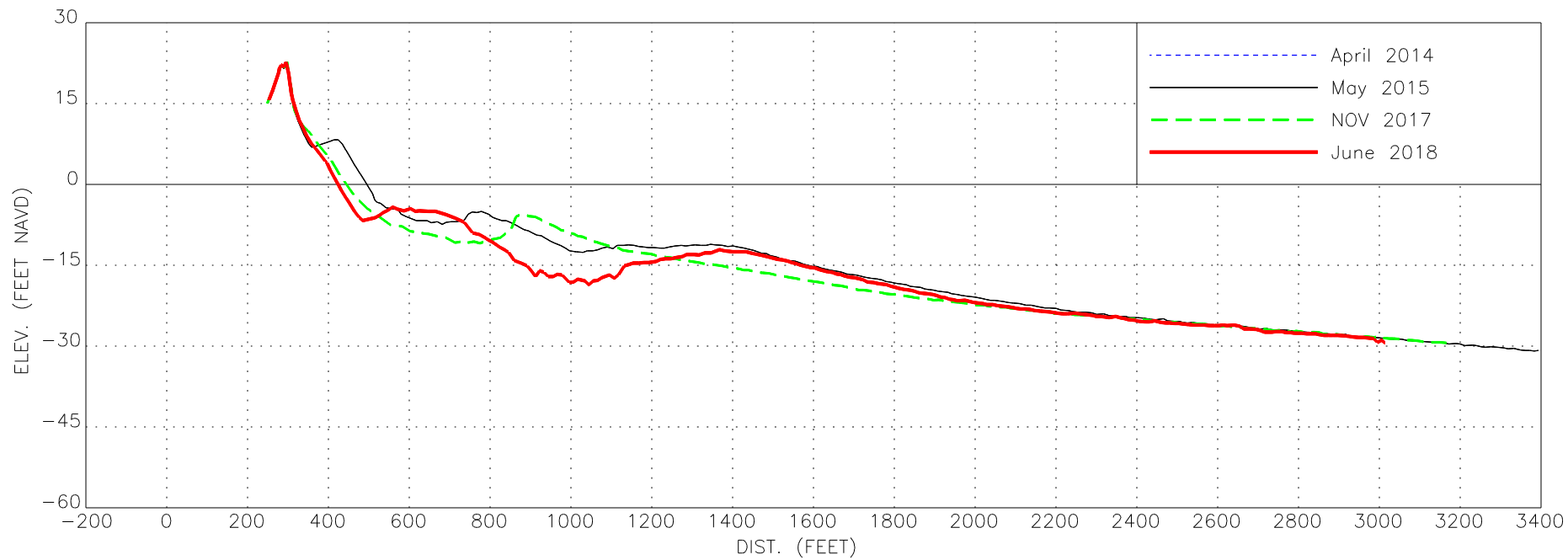
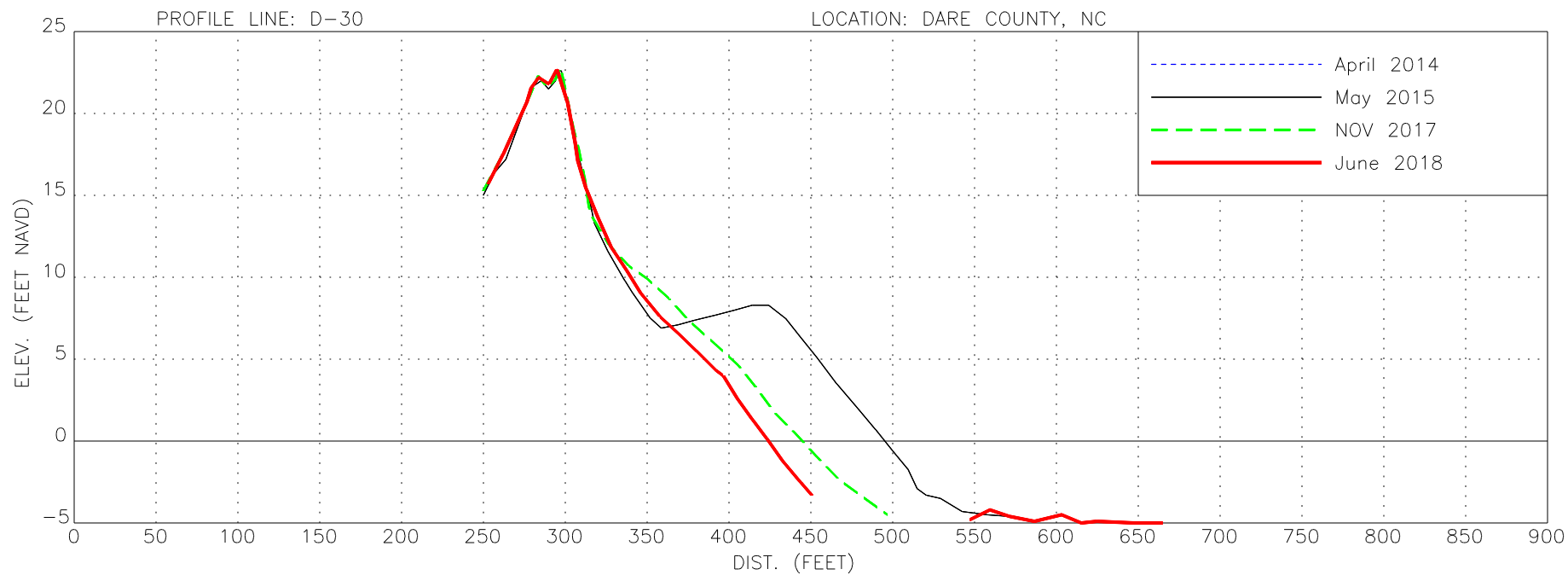


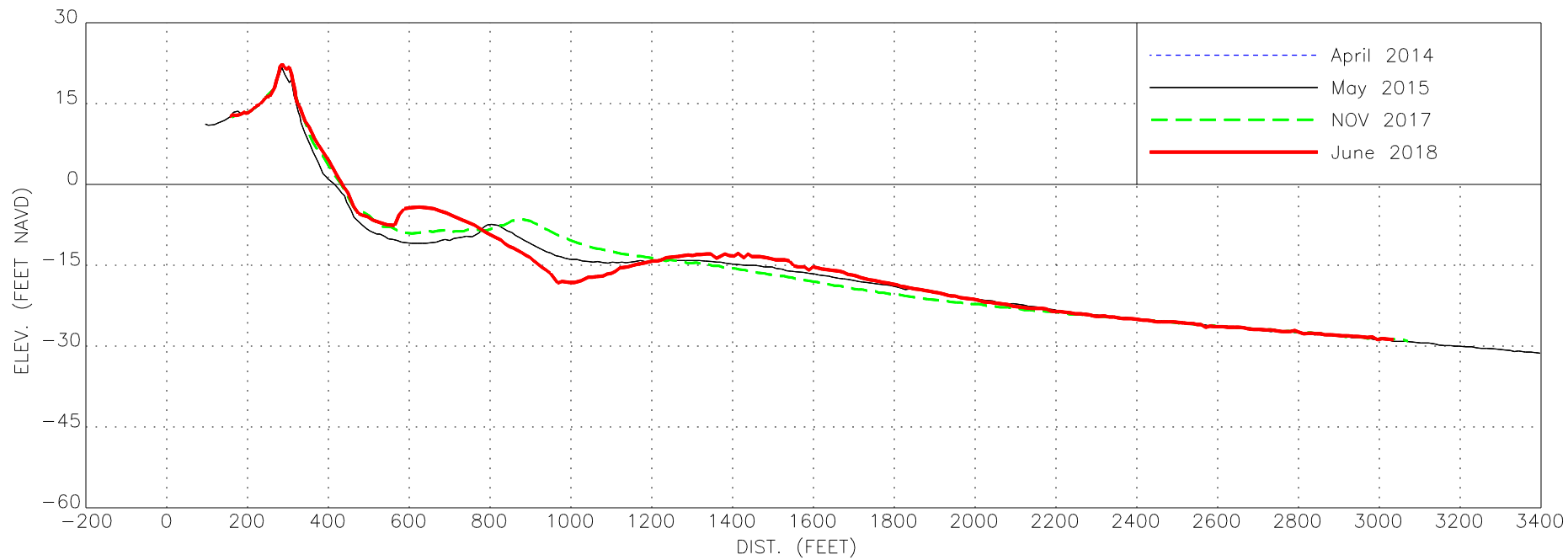
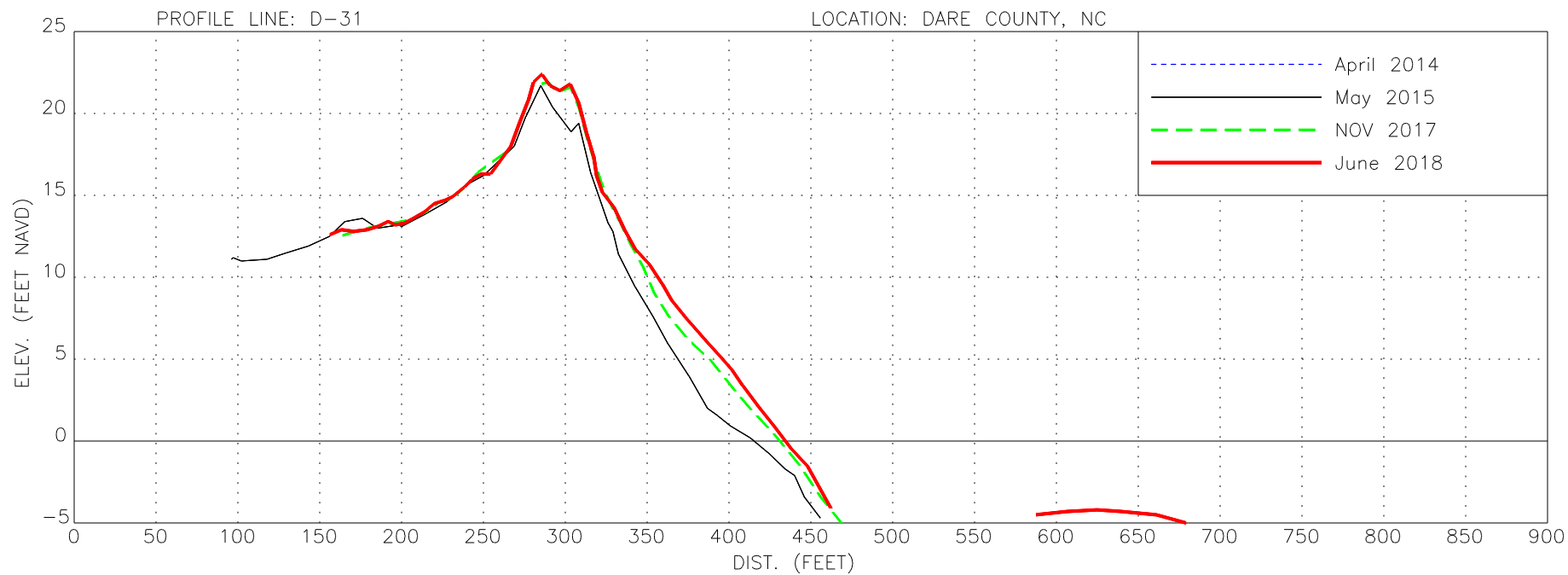


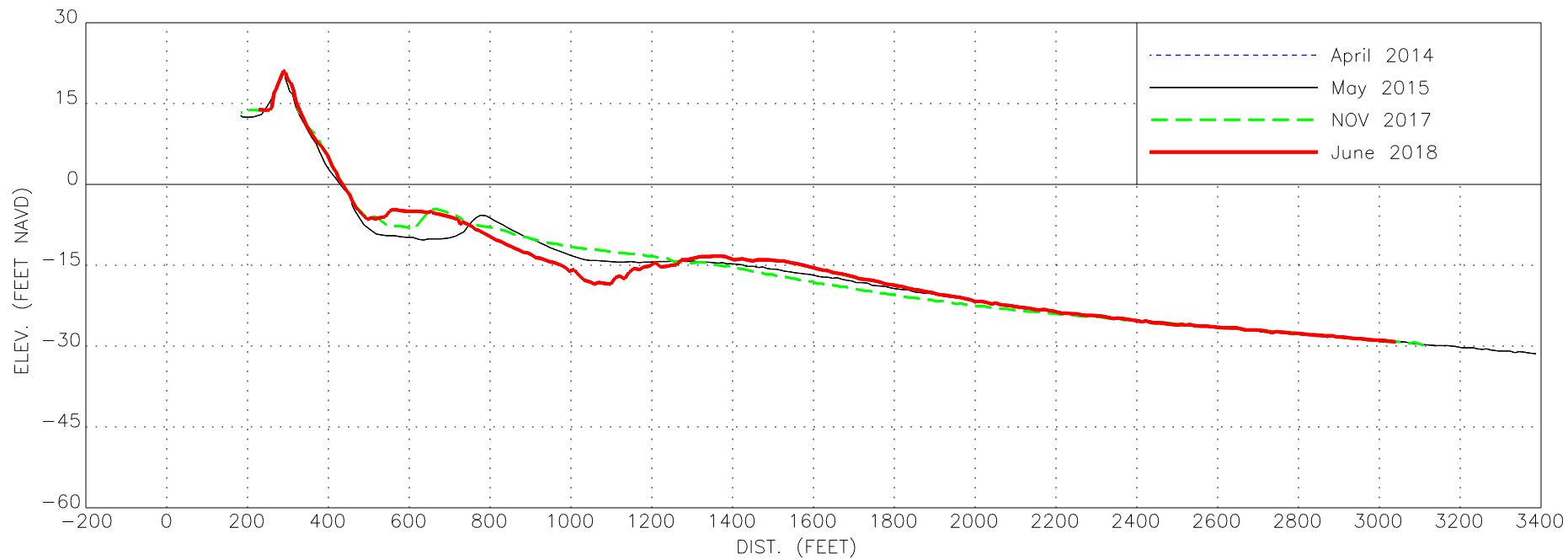
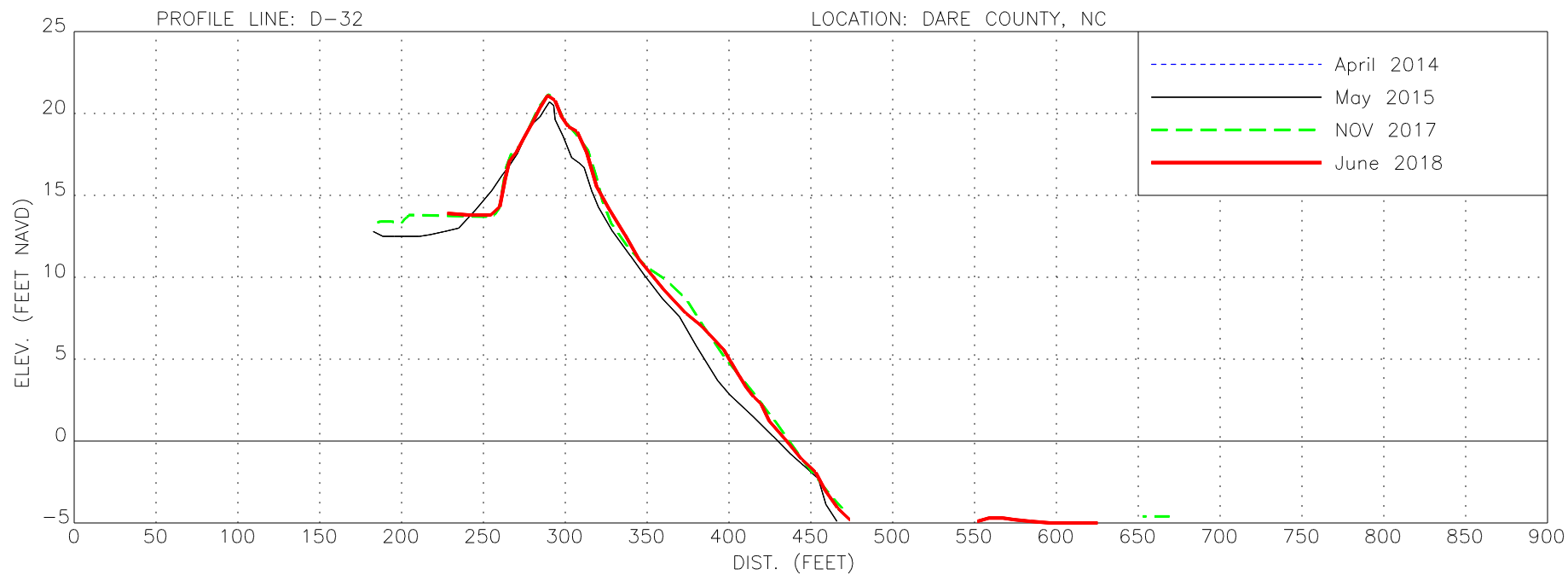


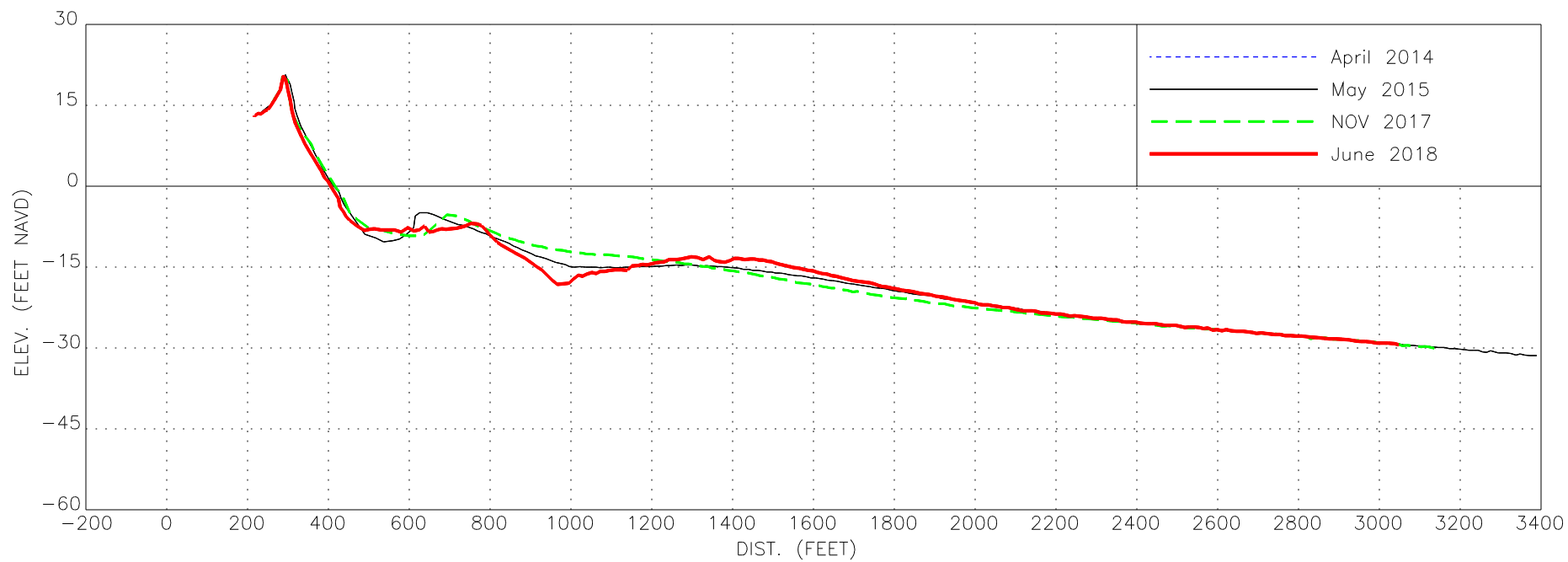
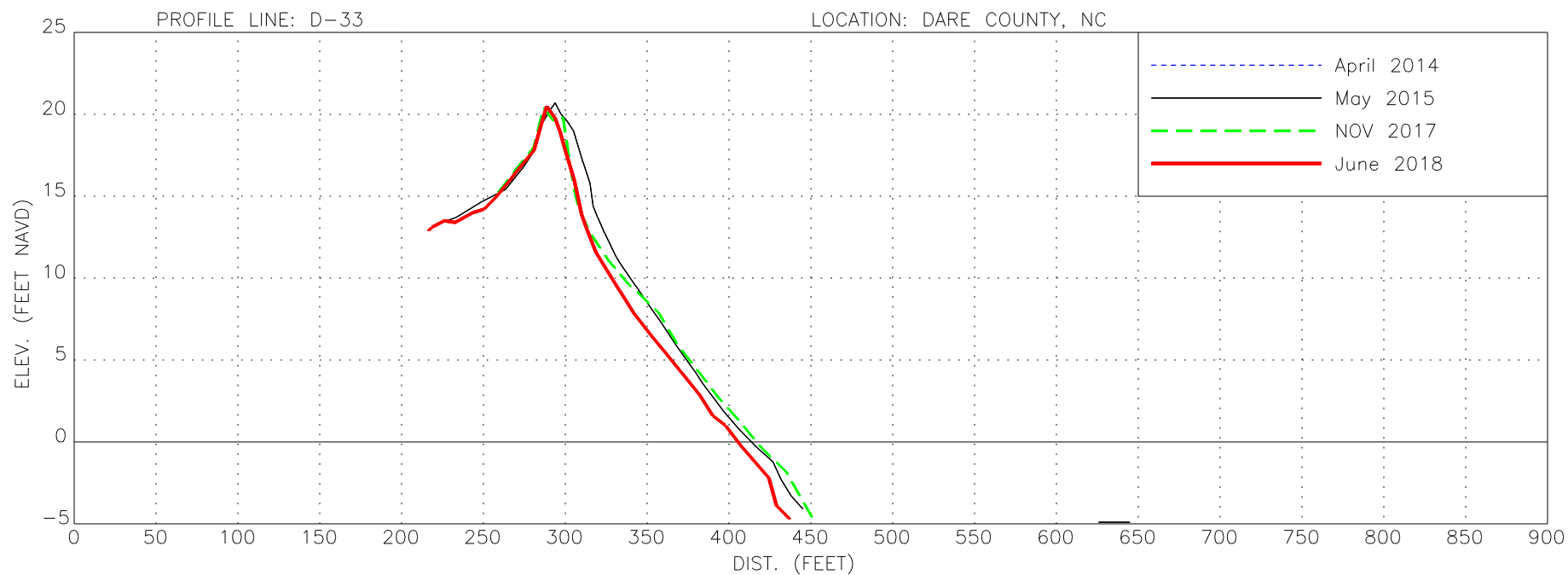


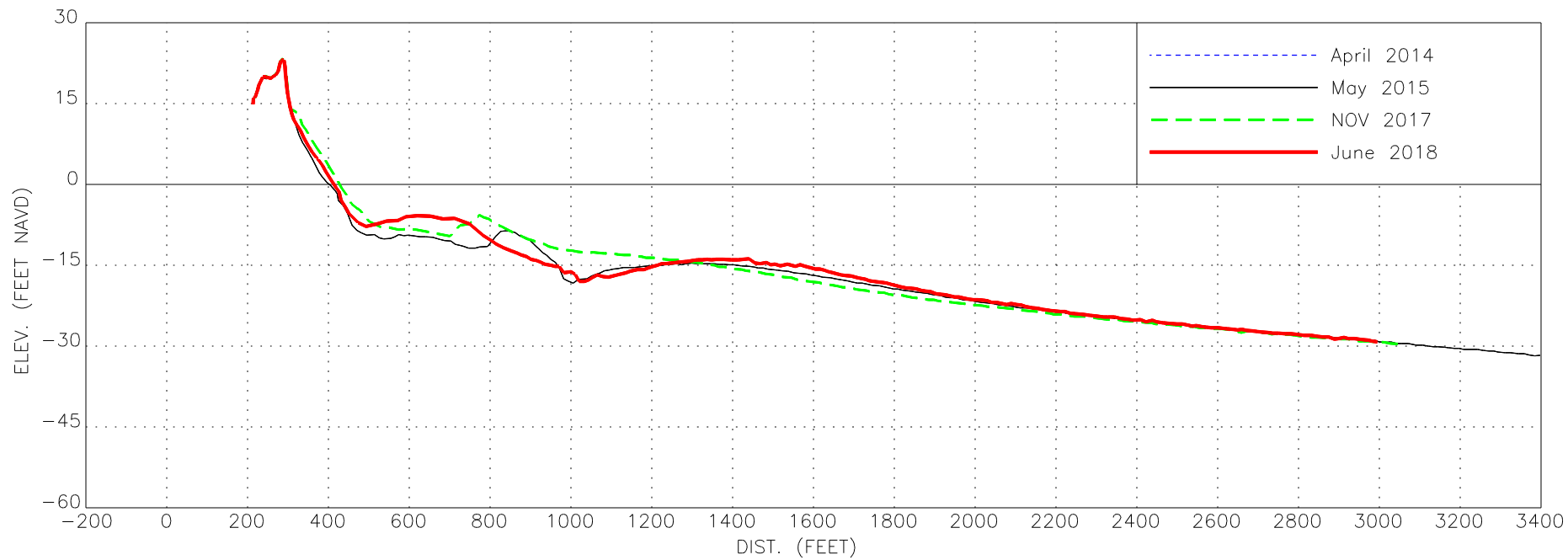
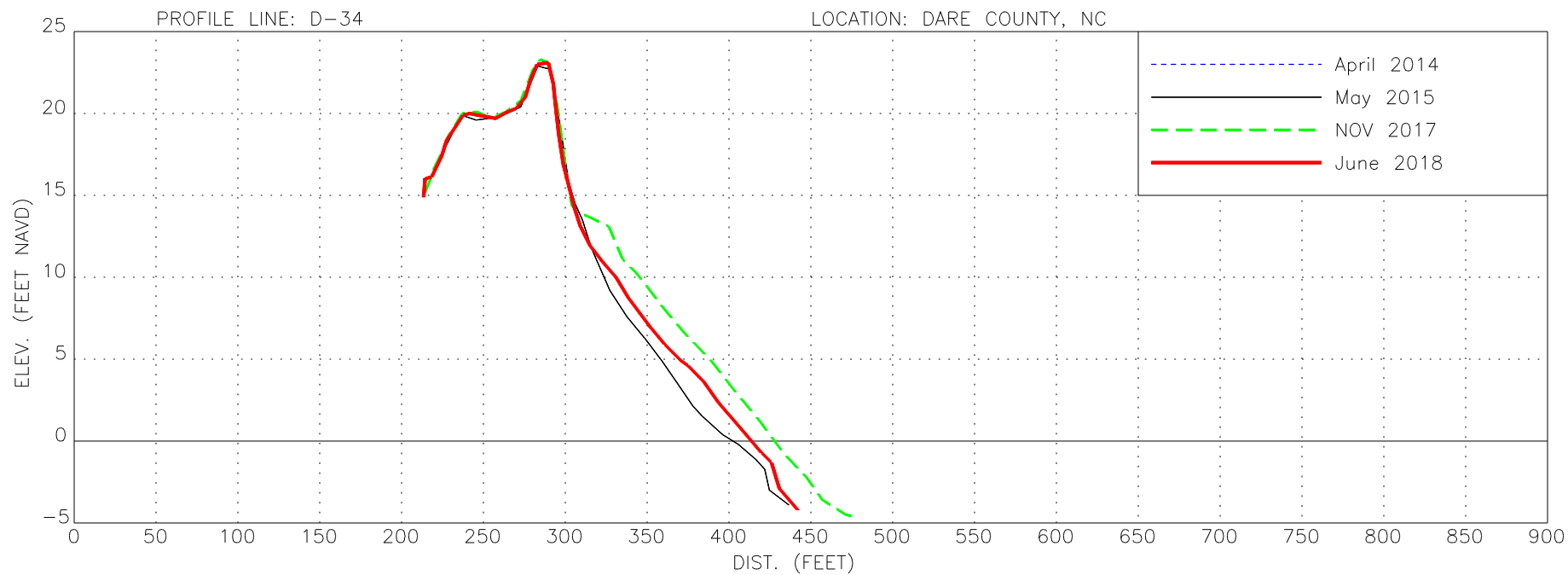












APPENDIX 4

GROUND DIGITAL PHOTOGRAPHY

**Ground Digital Photography
Monument**

PI-18



North View



South View



Landward View



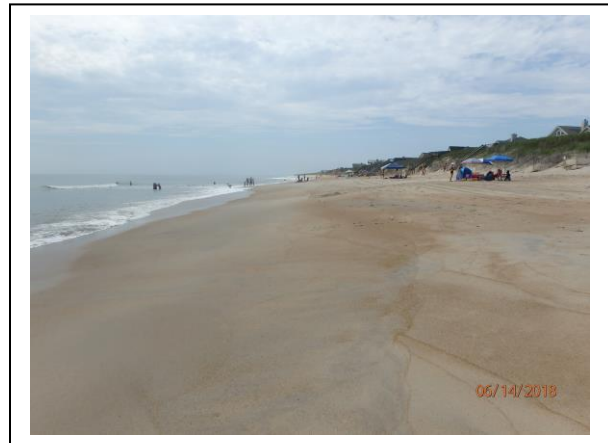
Monument – No RTK

**Ground Digital Photography
Monument**

PI-17



North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-01



North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-02



North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-03



North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-04



North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-05



North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-06



North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-07



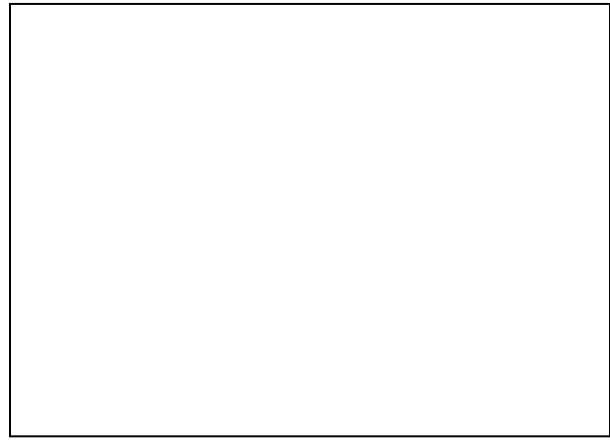
North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-08



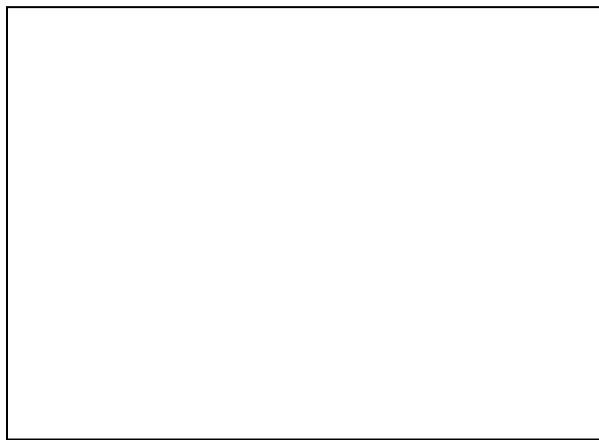
North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-09



North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-10



North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-11



North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-12



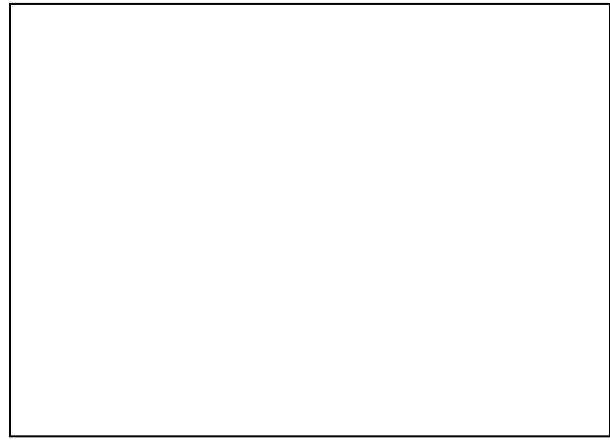
North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-13



North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-14



North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-15



North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-16



North View



South View



Landward View



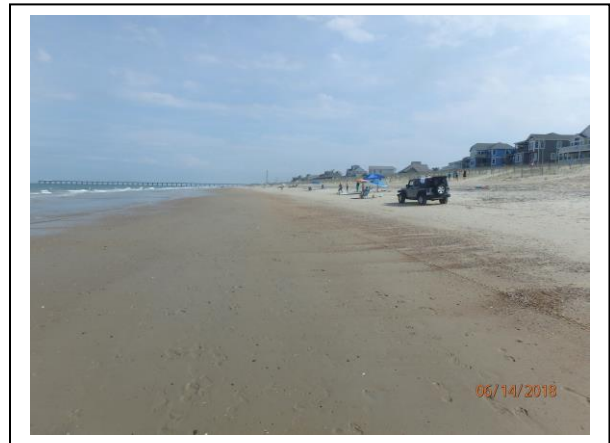
Monument – No RTK

**Ground Digital Photography
Monument**

D-17



North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-18



North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-19



North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

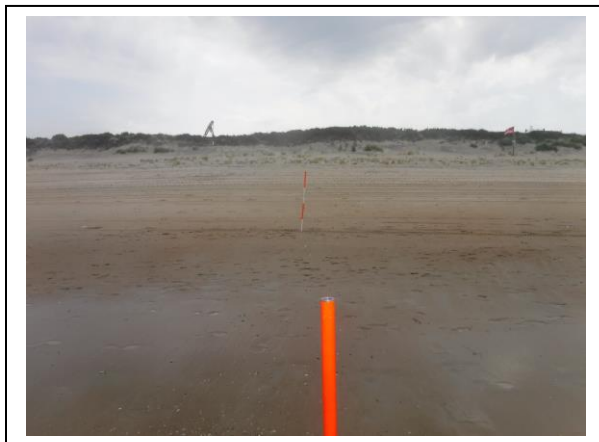
D-20



North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-21



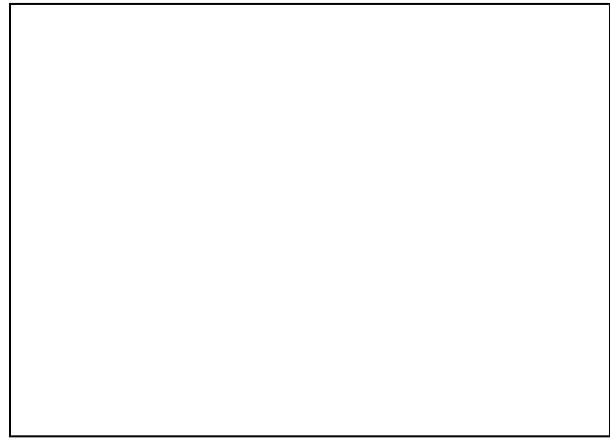
North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

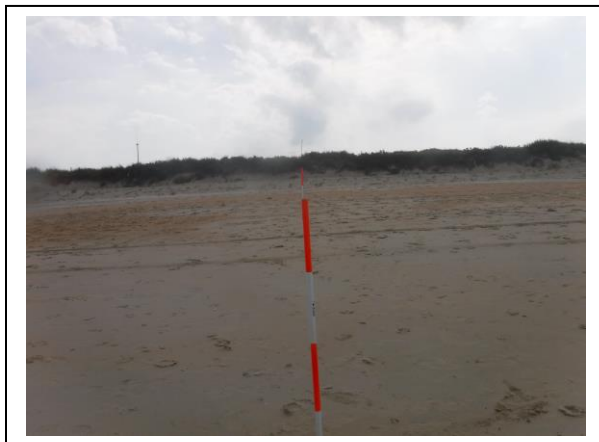
D-22



North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-23



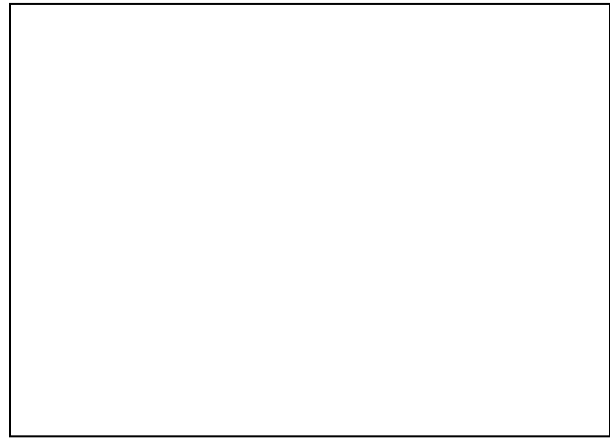
North View



South View



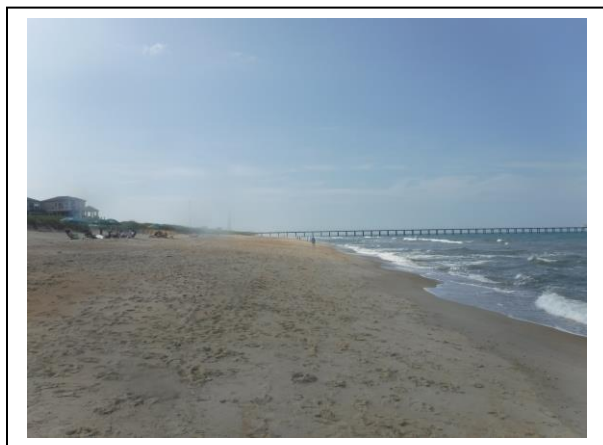
Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-24



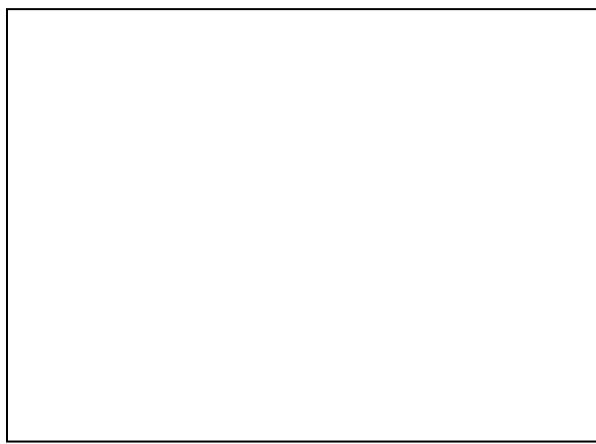
North View



South View



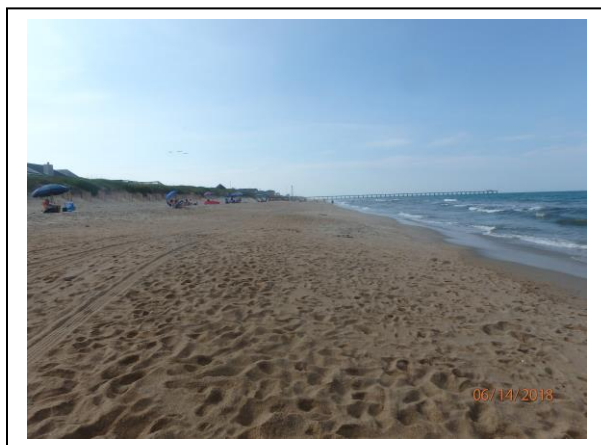
Landward View



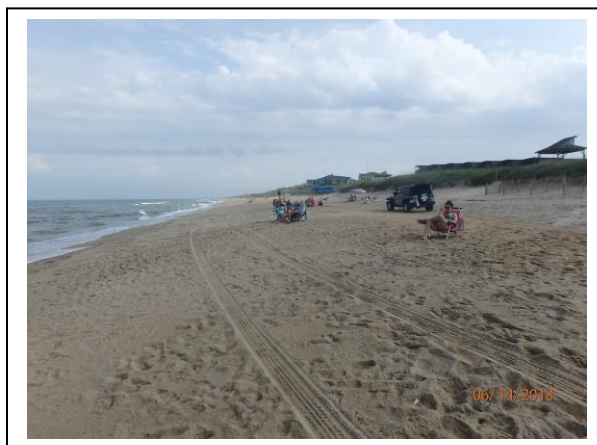
Monument – No RTK

**Ground Digital Photography
Monument**

D-25



North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-26



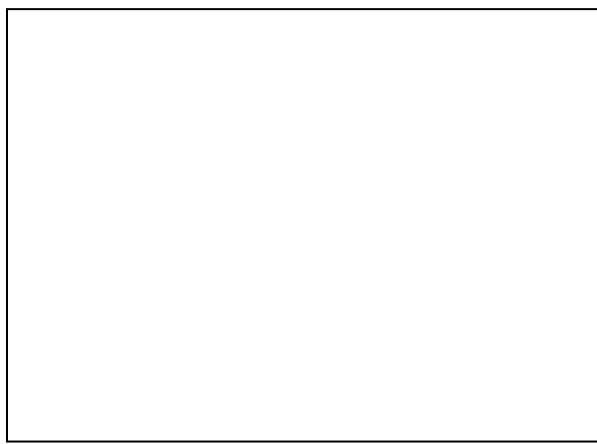
North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-27



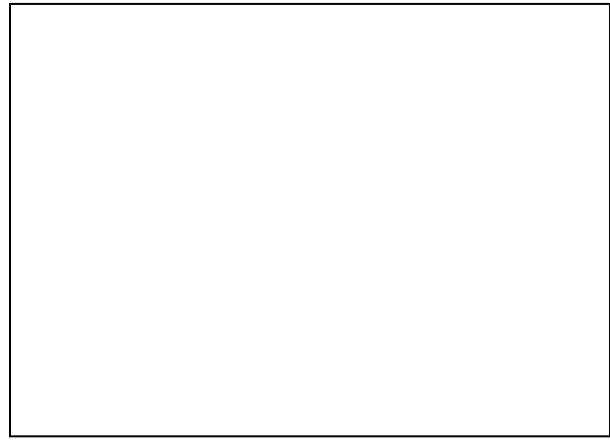
North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-28



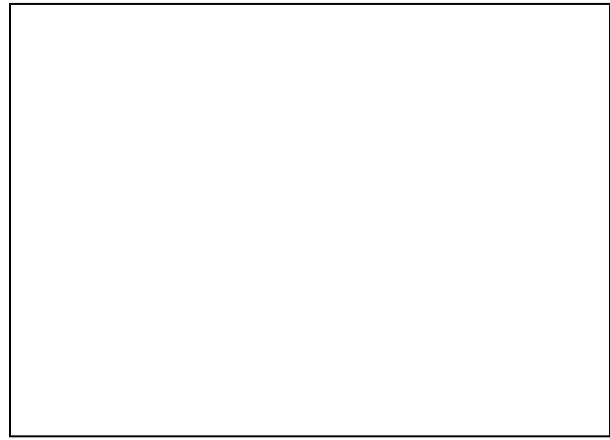
North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-29



North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-30



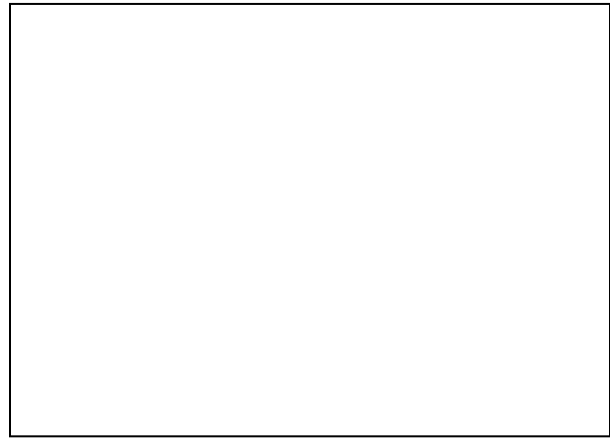
North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-31



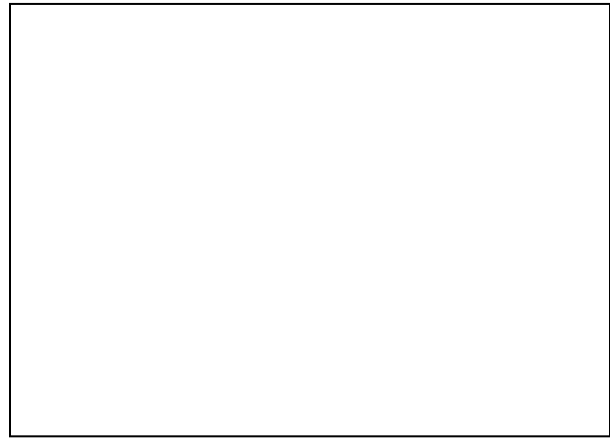
North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

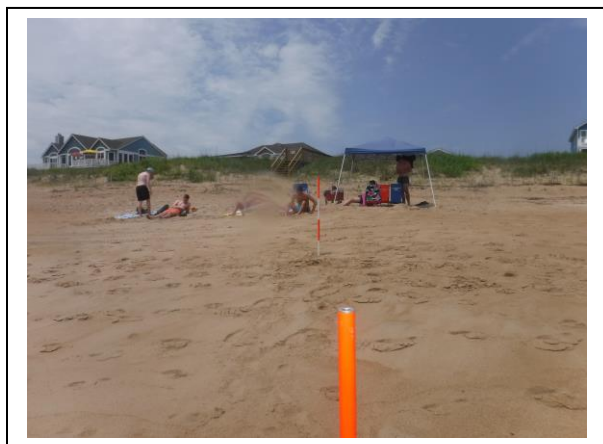
D-32



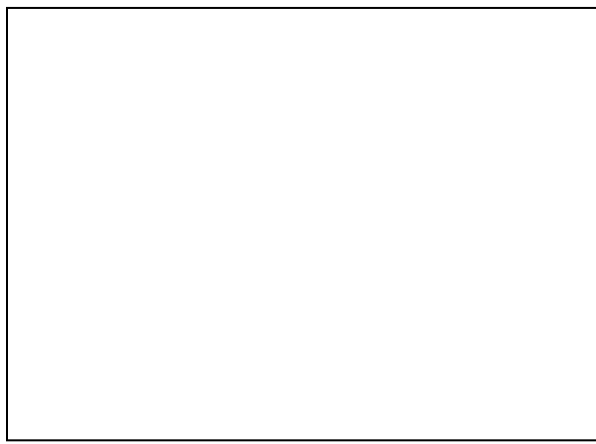
North View



South View



Landward View



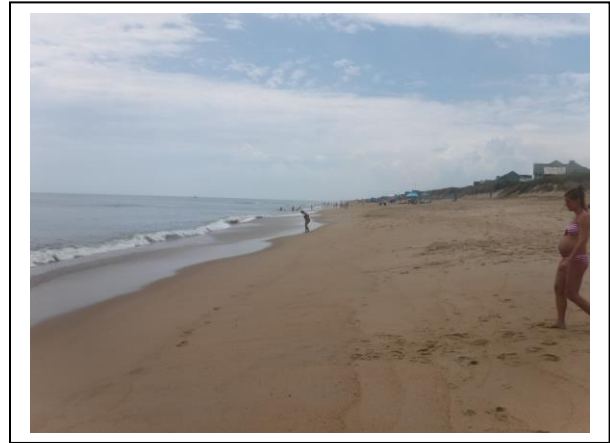
Monument – No RTK

**Ground Digital Photography
Monument**

D-33



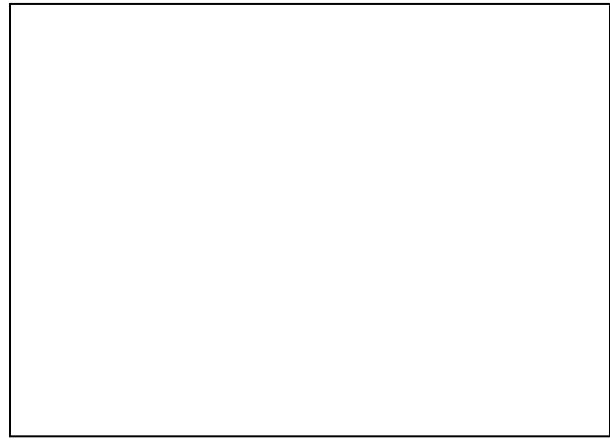
North View



South View



Landward View



Monument – No RTK

**Ground Digital Photography
Monument**

D-34



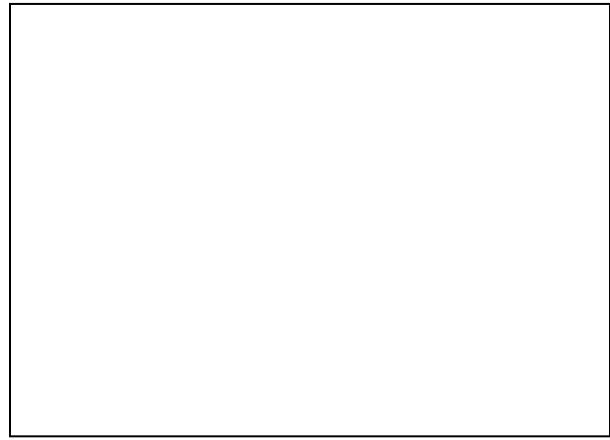
North View



South View



Landward View



Monument – No RTK

APPENDIX 5

FIELD BOOK PAGES

(Available in digital format only)