Broward County Shore Protection Project - Segment III
Broward County, FL

5-Year Post-Construction
Physical Monitoring Report

December 2011

FDEP Permit No: 0163435-001-JC/0226688-001

EXECUTIVE SUMMARY

This report details the physical performance of the 2005/06 Broward County Federal Shore Protection Project – Segment III for the period February 2006 to April 2011 (i.e., 5.2 years) and summarizes shoreline and beach changes that have occurred along the entire Broward County shoreline for the latest monitoring period, April 2009 to April 2011. The report also includes a summary of bathymetric changes within the five offshore borrow areas and Port Everglades Inlet sand shoal, areas used as sand sources for the 2005/06 project, for the period April 2009 to July 2011.

The primary purposes of this report are (1) to meet regulatory requirements to evaluate Segment III beach renourishment performance, (2) to assess the potential effects, if any, of the John U. Lloyd Beach State Park groin field upon the downdrift shoreline and (3) to document the existing county-wide beach conditions as of April 2011 and changes over the most recent monitoring period.

Segment III - Shore Protection Project (February 2006 to April 2011) . The Broward County Segment III shoreline extends from the Port Everglades south jetty to the Miami-Dade County line (R128). Sub-reaches of the Segment III shoreline studies include the (1) northern John U. Lloyd Beach State Park (JUL) shoreline (R85.7 to R-92), (2) the southern JUL shoreline (R92 to R98.3), and (3) the Hollywood/Hallandale/Dania (HHD) shoreline (R98.3 to R128). The 2005/06 Broward County Shore Protection Project added sand to the northern JUL and HHD shorelines.

Northern John U. Lloyd (JUL). Between February 2006 and April 2011, 5.2 years following project completion, the JUL project area MHWL receded roughly 65 ft, on average. Relative to the benchmark Erosion Control Line (ECL) position, the April

2011 JUL MHWL position was 53 ft seaward of the ECL, on average. It is noted that the JUL project design was based upon the requirement to maintain the MHWL location seaward of the ECL (i.e., 0-ft design) over the six year project design life.

Shoreline conditions in the vicinity of the JUL groin field appear to have reached a general equilibrium and are generally equivalent to those predicted during project design. As of April 2011, the measured berm location within the northern groin cell was more or less located at the predicted position while the MHWL was generally situated *landward* of the design location, suggesting that the beach profile is steeper than anticipated. Within the southern beach cell (between the middle and southern groins) the April 2011 MHWL was *landward* of the design position while the berm was slightly *seaward*. Shoreline change patterns between April 2009 and April 2011 reveal a reasonably stable shoreline along the northern most 700 feet of the JUL project area (between Port Everglades south jetty and R-86.5). Immediately south of the structures, the shoreline continued to recede at rates generally consistent with expectations.

Between February 2006 and April 2011, the JUL project shoreline lost approximately 217,300 cy of sand. The equivalent average annual sand loss rate is approximately 41,800 cy/yr -- about 21% less than the pre-project prediction of 53,250 cy/yr. As of April 2011, a volume equivalent to approximately 62% of the fill volume placed in JUL remains within the project limits.

<u>Southern John U. Lloyd.</u> Between February 2006 and April 2011, the MHWL position along the unnourished southern area of John U. Lloyd Beach State Park (R-92 to R-98.3) advanced over 15 ft, on average. Note that this reach of shoreline did not receive direct sand placement as part of the 2005/06 project but has remained stable to accretional due to the synergistic benefits of sand losses from the shoreline to the north. Shoreline advance along this stretch was fairly consistent, with a maximum advance of nearly 37 ft at R-95 and a maximum retreat of almost 14 ft at R-98.

During this same period, this reach of shoreline gained approximately 83,200 cubic yards of sand, which is roughly equivalent to 13.2 cy/ft of shoreline, on average.

<u>Hollywood/Hallandale/Dania (HHD)</u> project area (R98.3 to R128) occupies the remainder of the Segment III shoreline. Between February 2006 and April 2011, the HHD MHWL retreated an average of 36 feet. As of April 2011, the HHD MHWL remained about 67 ft, on average, seaward of the Erosion Control Line (ECL) and about 45 ft seaward of the March 2005 (pre-construction) position. It is noted that the HHD

project design was intended to maintain the MHWL a minimum of 50 ft seaward of the ECL (i.e., 50-ft design) over the six year project design life.

Since project completion in February 2006, the HHD project shoreline has lost approximately 112,400 cy of sand. The equivalent average annual sand loss rate is approximately 21,600 cy/yr -- about 80% less than the pre-project predictions of 110,550 cy/yr. As of April 2011, a volume equivalent to approximately 90.5% of the fill volume placed in HHD remains within the project limits. A possible explanation for the lower than predicted sand loss rates for the first five post-construction years could be lower than normal wave energy conditions since completion of the project, improvements in fill density distribution -- compared to those for the 1991 project upon which the expected sand loss rates were developed --, and the addition of terminal tapers at the northern and southern end of the fill.

Since completion of the 2005/06 Broward County project (February 2006 to April 2011), the northern 4,300-ft reach of Miami-Dade County shoreline (R-128 to D-5) shoreline has gained approximately 33,500 cy (+8 cy/ft, on average). Alongshore sand diffusion from the HHD project is likely contributing to the increase in sand volume along the northern Miami-Dade County shoreline.

For the period April 2009 to April 2011, the latest monitoring period, shoreline change and beach volume change for each Broward County shoreline segments and sub-reaches along each are summarized in **Table EX.1**.

Figure EX.1: Broward County, FL MHW shoreline and beach volume change for the inter-survey period **April 2009 to April 2011**.

	April 2009 to April 2011	Reach Length (ft)	Average Shoreline Change (ft)	Average Volume Change (cy/ft)		Volume Change (cy)	
				Above MLW	Total Profile	Above MLW	Total Profile
SEGMENT I	Deerfield Beach (R-1 to R-6.7)	5,630	15.3	4.0	6.2	22,600	35,100
	Hillsboro Beach (R-6.7 to R-24)	16,940	67.1	21.7	24.1	367,600	407,500
	SEGMENT I TOTAL (R-1 to R-24)	**22,570**	**54.2**	**17.3**	**19.6**	**390,200**	**442,600**
SEGMENT II	Pompano Beach (R-25 to R-40)	14,650	7.4	2.5	6.3	36,800	92,900
	Lauderdale-by-the-Sea (R-40 to R-53)	12,819	16.3	5.7	4.5	73,400	57,900
	North Fort Lauderdale (R-53 to R-74)	21,025	7.3	2.7	4.4	57,700	92,300
	South Fort Lauderdale (R-74 to R-84.7)	11,065	7.7	3.2	6.5	35,100	71,900
	SEGMENT II TOTAL (R-25 to R-84.7)	**59,559**	**9.3**	**3.4**	**5.3**	**203,000**	**315,000**
SEGMENT III	John U. Lloyd Project (R-85.7 to R-92)	6,148	-1.3	-0.8	-4.9	-4,700	-30,100
	John U. Lloyd South (R-92 to R-98.3)	6,280	16.8	4.9	2.1	30,600	13,500
	Hollywood/Hallandale/Dania (R-98.3 to R-128)	30,312	6.4	1.9	0.7	58,500	20,800
	SEGMENT III TOTAL (R-85.7 to R-128)	**42,740**	**6.8**	**2.0**	**0.1**	**84,400**	**4,200**
	Miami-Dade (R-128 to D-5)	4,286	10.5	2.1	2.6	8,900	11,000

Offshore Borrow Areas. A portion of BA-I was dredged in 2011 to construct a beach fill along a chronically eroded section of southern Deerfield Beach and northern Hillsboro Beach approximately 6,067 ft in length. Approximately 356,000 cy of material were removed from BA-I and placed along the beach during the project. This dredging of BA-I was the only significant change (seabed elevation change greater than ± 0.5 ft) observed in the borrow areas over the most recent 24-month monitoring period (As depicted in the May 2009, August 2010, and April 2011 surveys).

Port Everglades Spoil Shoal. In addition to the five offshore borrow areas, a sand shoal along the north side of the Port Everglades Entrance Channel was dredged in 2005/06 and used as a supplemental sand source for the Segment III project. All sand from the shoal was placed on the JUL project beach. During construction, approximately 31,340 cubic yards of material were removed from the shoal, inclusive of sand, fines, rock rubble and debris. Of that quantity, approximately 26,650 cubic yards were beach quality sand. Rock rubble and debris were screened from the dredged material and disposed of offshore. Only clean beach quality sand was placed along the JUL shoreline.

During the sixty-two months following completion of the 2005/06 project, available surveys suggest that the shoal area has gained roughly 94,300 cubic yards of material around the general area of the dredge cut limits. The volume gain is equivalent to an average annual accretion rate of about 21,000 cy/yr. An analysis of sand shoaling rates for the period between 2001 and 2004 -- prior to the 2005/06 dredging -- indicated that this same general area gained sand at a rate of about 10,700 cy/yr.

Broward County Shore Protection Project - Segment III
Broward County, FL

5-Year Post-Construction
Physical Monitoring Report

December 2011

FDEP Permit No: 0163435-001-JC/0226688-001

TABLE OF CONTENTS

EXECUTIVE SUMMARY i

1.0 INTRODUCTION 2
- **1.1 Overview** 2
- **1.2 Physical Setting** 3

2.0 BACKGROUND - SEGMENT III PROJECT 5
- **2.1 Project Purpose** 5
- **2.2 Project Overview** 6
- **2.3 Project Permits** 10
- **2.4 Project Monitoring Plan** 11

3.0 SEGMENT III PROJECT PERFORMANCE (Feb 2006 to April 2011) 18
- 3.1 MHW Shoreline Position Change 19
- 3.2 Beach Volume Change 27

4.0 BEACH MONITORING RESULTS (April 2009 to April 2011) 33
- **4.1 SEGMENT III** 33
  - 4.1.1 MHW Shoreline Position Change 33
  - 4.1.2 Beach Volume Change 39
- **4.2 SEGMENT II** 43
  - 4.2.1 MHW Shoreline Position Change 43
  - 4.2.2 Beach Volume Change 46
- **4.3 SEGMENT I** 51
  - 4.3.1 MHW Shoreline Position Change 52
  - 4.3.2 Beach Volume Change 59

5.0 BORROW AREA MONITORING RESULTS 62
- **5.1 Background** 62
- **5.2 Project Construction (March 2005 to February 2006)** 67
- **5.3 Post-Construction Changes (February 2006 to July 2011)** 68
- **5.4 Port Everglades Spoil Shoal** 72

6.0 REFERENCES 75

APPENDIX A: Beach Profile Plots A-1
APPENDIX B: Shoreline Aerial Photography - 13 July 2011 ..... B-1
APPENDIX C: Inlet Dredging Records C-1
APPENDIX D: Borrow Area Plots D-1

Broward County Shore Protection Project - Segment III
Broward County, FL

5-Year Post-Construction Physical Monitoring Report

December 2011

FDEP Permit No: 0163435-001-JC/0226688-001

Report Prepared for:
Broward County Environmental Protection Department
Broward County, FL

Florida Department of Environmental Protection
Bureau of Beaches and Coastal Systems
Tallahassee, FL

Report Prepared by:
Olsen Associates, Inc.
2618 Herschel St.
Jacksonville, FL 32204
(904) 387-6114

1.0 INTRODUCTION

1.1 Overview

This report details the physical performance of the 2005/06 Broward County Federal Shore Protection Project – Segment III for the period February 2006 to April 2001 (i.e., 5.2 years) and summarizes shoreline and beach changes that have occurred along the entire Broward County shoreline for the latest monitoring period, April 2009 to April 2011 monitoring period. The report also includes a summary of bathymetric changes within the five offshore borrow areas and Port Everglades Inlet sand shoal used during construction of the 2005/06 project for the period April 2009 to July, 2011.

The primary purposes of this report is (1) to meet regulatory requirements to evaluate Segment III beach renourishment performance, (2) to assess the potential effects, if any, of the John U. Lloyd Beach State Park groin field upon the downdrift shoreline and (3) to document the existing county-wide beach conditions as of April 2011 and changes over the most recent monitoring period.

1.2 Physical Setting

Broward County is located on the southeastern coast of Florida and includes about 24 miles of coastline and two coastal inlets; Hillsboro Inlet and Port Everglades Inlet (see **Figure 1.1**). The County is located approximately 20 miles north of Miami and 30 miles south of West Palm Beach. The County borders Miami-Dade County to the south and Palm Beach County to the north. The coastal cities in Broward County, from north to south, are Deerfield Beach, Hillsboro Beach, Pompano Beach, Lauderdale-by-the-Sea, Fort Lauderdale, Dania Beach, Hollywood, and Hallandale Beach. Fort Lauderdale is the largest of these coastal cities. The Village of Sea Ranch Lakes occupies a 200-foot stretch of shoreline between two adjacent Lauderdale-by-the-Sea shoreline reaches (between R-46 and R-47).

The astronomical tides in the study area vicinity are semi-diurnal and have mean and spring ranges of approximately 2.6 ft and 3.2 ft, respectively. Tidal datums in the vicinity of the Port Everglades North Jetty are listed in **Table 1.1**. In this report, unless otherwise specified, all elevations are referenced to the North American Vertical Datum of 1988 (NAVD) and all horizontal coordinates are referenced to the Florida State Plane Coordinate System – East Zone, North American Datum of 1983 (NAD83).

Table 1.1: Tidal datums in the vicinity of the Port Everglades, North Jetty.

Datum	Abbreviation	Elevation (ft, NAVD88)
Mean Higher High Water	MHHW	0.53
Mean High Water	MHW	0.41
North American Vertical Datum (NAVD-1988)	NAVD	0.00
Mean Sea Level	MSL	-0.86
National Geodetic Vertical Datum (NGVD-1929)	NGVD	-1.60
Mean Low Water	MLW	-2.14
Mean Lower Low Water	MLLW	-2.30

Note: The above listed tidal datums were developed from the average of published datums for Port Everglades, Lake Mabel (Station 8722951) and Lauderdale-by-the-Sea (Station 8722899).

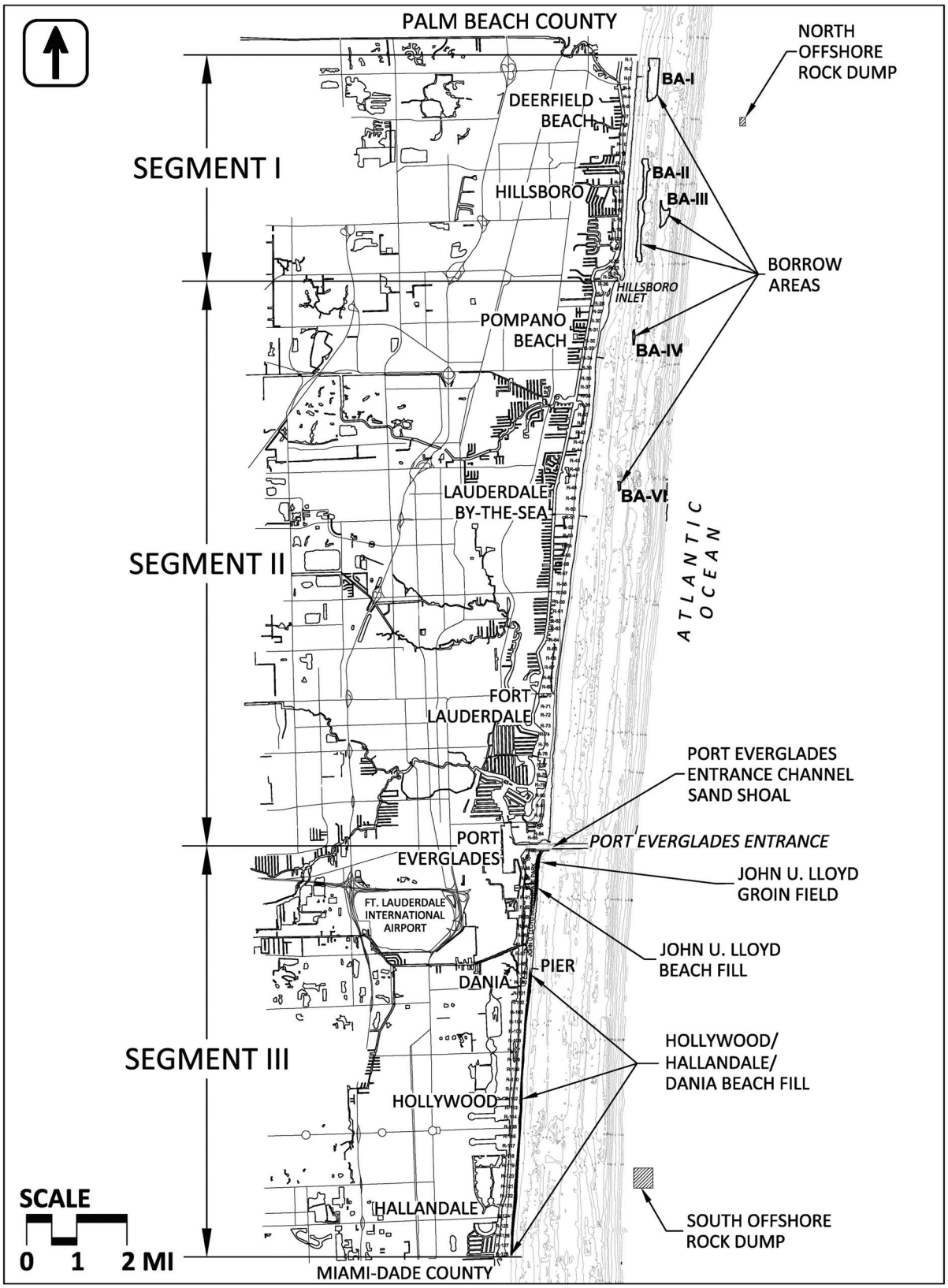


Figure 1.1: Location map and depiction of project elements associated with the Broward County Shore Protection Project - Segment III.

2.0 BACKGROUND - SEGMENT III PROJECT

2.1 Project Purpose

The purpose of the Broward County Shore Protection Project – Segment III was to renourish previously constructed shorefront reaches through the hydraulic placement of a protective berm and recreational beach and to construct features that reduce historical sand loss rates such as the beach fill taper along the Dania Beach shoreline and shore stabilizing structures at the north end of John U. Lloyd Beach State Park. Previous beach restoration projects implemented along the Segment III shoreline are summarized in **Table 2.1**.

The 2005/06 Segment III project was the second renourishment for previously constructed portions of the John U. Lloyd Beach State Park (JUL) (R-86 to R-92) and Hollywood (R-101 to R-124) project areas. It was the third renourishment for the Hallandale Beach shoreline (R-124 to R-128). The construction of the beach fill taper along the Dania Beach shoreline (R-98.3 to R-101) was the first beach fill event along that shoreline.

Table 2.1: Summary of beach restoration projects implemented along the Segment III shoreline.

Year	Project Area	Project Limits	Volume
1971	Hallandale	R-124 to R-128	350,000 cy
1976/77	John U. Lloyd Park	R-86 to R-93	1,090,000 cy
1979	Hollywood/Hallandale	R-101 to R-128	1,980,000 cy
1989	John U. Lloyd Park	R-86 to R-93	603,000 cy
1991	Hollywood/Hallandale	R-101 to R-128	1,110,000 cy
2005/06	John U. Lloyd Park Hollywood/Hallandale/Dania	R-86 to R-92 & R-98 to R-128	1,920,000 cy

2.2 Project Overview

The Segment III project was constructed between 15 May 2005 and 8 February 2006. The project consisted of beach fill placement along approximately 6.8 miles of shoreline between Port Everglades Inlet and the Miami-Dade County line (see **Figure 1.1**). The construction and post-construction condition of key project elements noted above were detailed in the report titled "*Broward County, Florida Shore Protection Project, Segment III: Post-Construction Engineering Summary Report* (OAI/CPE-J/V, 2007a) and are summarized below.

The project sponsor was the Broward County Board of County Commissioners. Funding for the project was provided by Broward County, the Florida Department of Environmental Protection Office of Beaches and Coastal Systems (FDEP OBCS), the US Army Corps of Engineers, and the Cities of Dania Beach, Hollywood, and Hallandale Beach, Florida. Great Lakes Dredge and Dock Company of Oak Brook, Illinois was the contractor selected for beach fill construction. Wilkinson and Jenkins of Tampa, Florida was a subcontractor to GLDD for construction of the three (3) rock groin structures. Olsen Associates, Inc. and Coastal Planning and Engineering Inc. operating as a Joint-Venture (OAI/CPE-J/V) was contracted by Broward County to develop the project's Federal General Reevaluation Report (GRR) as well as design, permit and monitor nearshore benthic communities before, during and after construction, and to provide construction observation services for the project.

The primary design objective of the Broward County Shore Protection Project – Segment III was to restore eroded sections of the authorized Federal project design berm, provide at least 6 years of advance nourishment, and improve fill performance through beach fill taper modifications at the northern end of Hollywood and southern end of Hallandale in concert with the construction of three shore-stabilizing structures at the northern end of the John U. Lloyd Beach State Park project reach.

In general, the project design called for sand placement along two reaches of the Segment III shoreline. These included the Hollywood/Hallandale/Dania (HHD) shoreline (R-98.3 to R-128) and John U. Lloyd Beach State Park (JUL) shoreline (Port Everglades South Jetty to R-92). Five (5) sand borrow areas located offshore of the Broward County's northern shoreline and a sand shoal within the Port Everglades Entrance Channel were used as the project's sand source. The project design also included the

construction of three shore stabilizing structures along the northern end of the JUL shoreline. The location and extent of these project features are depicted in **Figure 2.1**. The reach of coastline between monuments R-92 to R-98.3 (Dania Pier) was not filled as part of the project.

Specifically, the project design, based upon shoreline conditions in 2001, called for the placement of 1,100,000 cubic yards (cy) of sand along the HHD shoreline and the placement of 440,000 cy of sand along the JUL shoreline. Immediately prior to construction in the spring of 2005, a beach survey was conducted to document sand losses between 2001 and 2005 and represent immediate pre-fill conditions. Project construction included the placement of the original 2001 design sand volume and the replacement of sand lost from the Segment III shoreline between 2001 and 2005. Some of the sand lost from the Hollywood/Hallandale (R-101 to R-128) HHD shoreline between 2001 and 2005 was replaced under a separate contract by the Corps of Engineers as part of a PL-84-99 post-2004 hurricane season beach rehabilitation project. The Corps documented that the Hollywood/Hallandale shoreline between R-101 and R-128, lost 188,000 cy of sand. This sand was placed along that shoreline at the same time that construction of the Broward County Segment III project occurred. In sum, the two parallel contracts called for the placement of 1,288,000 cy and 522,600 cy of sand along the HHD and JUL shorelines, respectively.

Construction of the Segment III Shore Protection Project (SPP) and the Corps of Engineers' PL-84-99 Corps Project included the placement of the Segment III 2001 project design volume plus the volume of sand lost from the respective project shoreline between 2001 and 2005. In sum, the County paid for the placement of 549,704 cy of sand along the JUL shoreline and 1,104,752 cy of sand along the HHD shoreline. The Corps of Engineers paid for the placement of 188,000 cy of sand along the Hollywood/Hallandale[1] shoreline which was part of the PL-84-99 project[2]. Therefore, a total pay volume of 1,292,752 cubic yards was placed along the HHD project reach.

---

[1] The Corps' PL-84-99 project only included fill placement along the Hollywood/Hallandale shoreline (R-101 to R-128). The PL-84-99 sand was placed coincident with the SPP sand by GLDD but under a separate contract between the Corps of Engineers and GLDD.

[2] The Corps' PL-84-99 project volume exceeded the documented volume of material lost from the total beach profile between 2001 and 2005 by 84,500 cy. The PL-84-99 project volume was based upon sand volume losses during the 2004 hurricane season from the Corps' defined "design section". The design section commonly represents the upper areas of the beach profile and not the total profile from the back of berm to the seaward limit of the sand beach profile.

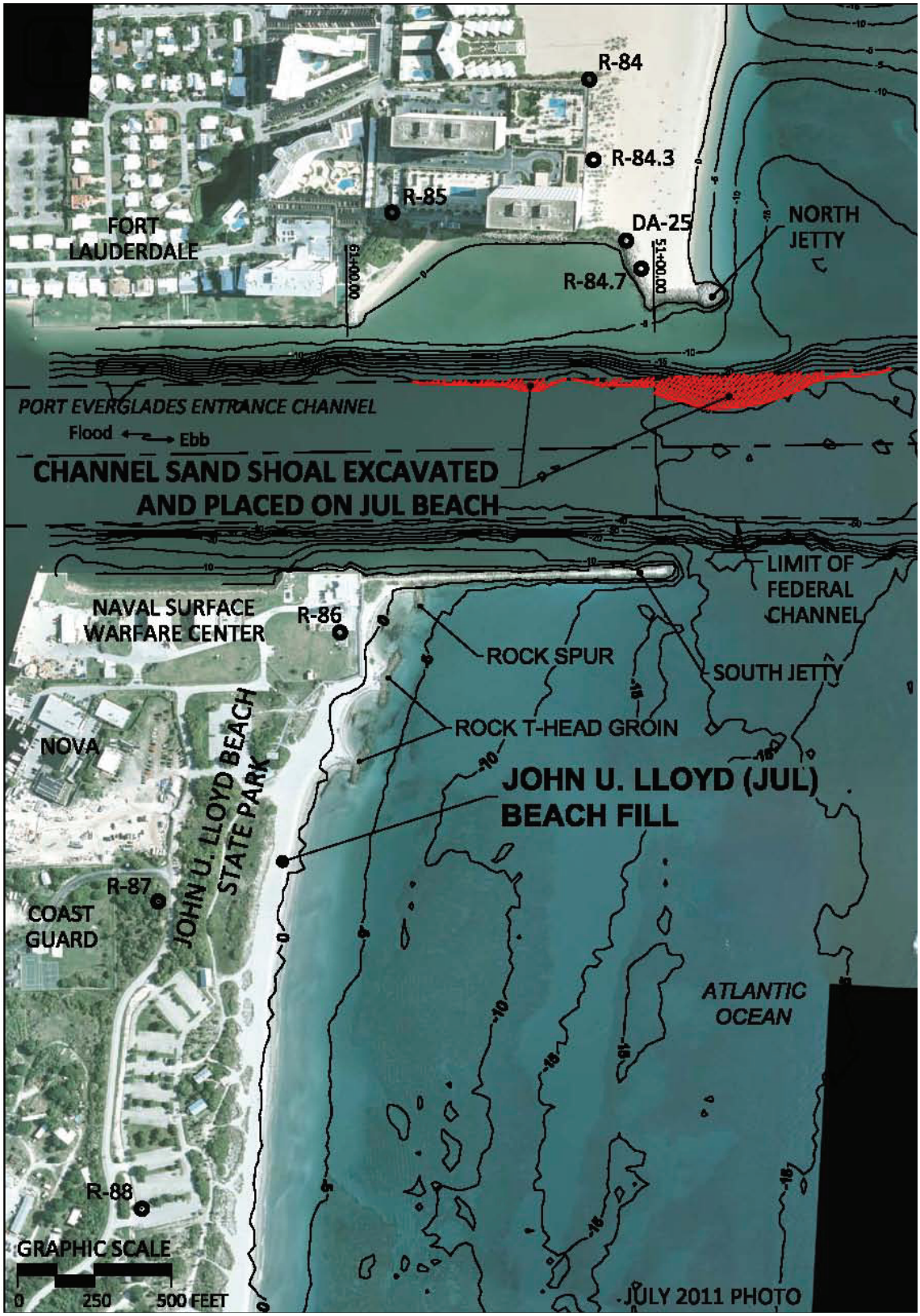


Figure 2.1: Location map and depiction of project elements associated with the Broward County Shore Protection Project - Segment III .

As a result of beach erosion before and during project construction, the *actual* volume placed by the contactor was larger than the *pay* volume. While typically a contractor continually works to minimize the amount of "non-pay" yardage placed along a beach it is common for a dredging contractor to place more sand along the beach fill area than is required in an attempt to meet the minimum contractually required fill requirements. Comparison of the March 2005 (pre-project) and February 2006 (post-project) beach monitoring surveys indicates that the beach fill volume along the JUL and HHD project shoreline reaches increased to 569,600 and 1,415,000 cy, respectively, over the eleven-month period (OAI/CPE-J/V, 2007a). This represents the total volume change, project related and otherwise, along the Segment III project shoreline reaches over the period in which project construction occurred.

Sand for the beach fill was excavated by hopper dredge from five borrow areas located offshore of northern Broward County as well as from a sand shoal located along the north side of the Port Everglades Entrance Channel. It was estimated that the offshore borrow areas contained approximately 3.48 million cubic yards of beach compatible sand while the Port channel sand shoal contained roughly 50,000 cubic yards of beach compatible sand (see **Figure 2.1**).

The structure field included a spur attached to the south jetty of Port Everglades and two T-head groins southward thereof. The structures were sited at a location that includes an extensive array of submarine cables that extend from the Naval Surface Warfare Center (NSWC), across the sand beach, to the offshore waters of southern Broward County.

2.3 Project Permits

The project was constructed in accordance with the following permits:

- *FDEP Bureau of Beaches and Coastal Systems*
  - Joint Coastal Permit No. 0163435-001-JC, Broward County
    - Broward County Beach Nourishment Project Segment III
    - Date of Issuance: May 12, 2003
    - Date of Expiration: May 12, 2008
  - Permit Modification No. 0163435-009-JC
    - Modification to Include Borrow Area I
    - Date of Issuance: June 22, 2005
  - Permit Modification No. 0163435-010-EM
    - Modification to Deepen a Portion of Borrow Area III
    - Date of Issuance: June 17, 2005
  - Permit Modification No. 0163435-011-EM
    - Added Pipeline Corridors and Operational Boxes to Permit and allowed a Modification to Pipeline Corridor No. 5
    - Date of Issuance: November 29, 2005
  - Permit Modification No. 0163435-013-EM
    - Modification of Borrow Area I and II Slope Cuts
    - Date of Issuance: January 13, 2006
  - Joint Coastal Permit No. 0226688-001-JC
    - Port Everglades Entrance Channel Shoal Removal
    - Date of Issuance: November 4, 2004
    - Date of Expiration: November 4, 2009
- *US Army Corps of Engineers – Jacksonville District*
  - Department of the Army (DOA) Permit No. SAJ-1999-5545 (IP-SLN) – (Date of Issuance: July 16, 2004)
  - Modification #1 of (DOA) Permit No. SAJ-1999-5545(IP-SLN) to allow removal of a Port Everglades Entrance Channel sand shoal and place the material along the John U. Lloyd Beach State Park project shoreline. (Date of Issuance: August 17, 2004)
  - Modification #2 of (DOA) Permit No. SAJ-1999-5545(IP-SLN) to allow placement of sand removed from the Port Everglades sand shoal along the entire Segment III project shoreline. (Date of Issuance: October 20, 2004).

- Modification #3 of (DOA) Permit No. SAJ-1999-5545(IP-SLN) to modify the vertical excavation limits of a portion of BA-III. (Date of Issuance: June 6, 2005).
- Modification #4 of (DOA) Permit No. SAJ-1999-5545 (IP-SLN) to modify the vertical excavation limits of portions of BA-I and BA-II (Date of Issuance: January 13, 2006).

2.4 Project Monitoring Plan

Broward County Shore Protection Project – Segment III Permits require a Physical Monitoring Plan be implemented as part of the overall project monitoring program. In general, the permitted Plan, dated March 18, 2005, consists of numerous elements that are intended to track the performance of the beach fill constructed along the Segment III shoreline, evaluate potential project related effects upon adjacent shorelines, document county-wide shoreline and beach changes, and develop guidance regarding future management of the project and County shorelines. Specifically, the principle purpose of the Broward County Shore Protection Project - Segment III Physical Monitoring Plan is to:

- meet the regulatory requirements of the Project Permits,
- evaluate the performance of the beach fill,
- evaluate the effects of the project upon the shoreline downdrift of the JUL groin field,
- evaluate the effects of the project borrow areas upon the shorelines of the City of Deerfield Beach and the Town of Hillsboro Beach,
- monitor County-wide beach conditions,
- make determinations with respect to the potential need for adjustments, modifications, or mitigative responses to documented project effects,
- function as an important database for future beachfront development, planning and/or management activities, and
- provide design guidance for future beach maintenance activities along the Segment III shoreline with specific emphasis on reducing the need for and costs of unnecessary work, as well as reducing environmental impacts.

The Physical Monitoring Plan includes the following basic work elements:

- beach profile surveys at all 128 Broward County primary FDEP R-monuments, 5 primary FDEP R-monuments in Miami-Dade County, 8 intermediate monuments immediately north of Port Everglades, and 13 intermediate monuments along the northern end of JUL,
- hydrographic surveys of the five (5) borrow sites and the Port Everglades Entrance Channel shoal by a qualified hydrographic surveyor,
- vertical stereoscopic color aerial photography,
- analysis of annual beach, borrow area, and shoal changes through the development of a cumulative comparative database,
- evaluation of potential project related effects to County shoreline reaches beyond the fill areas,
- evaluation of shoreline landward of Borrow Areas I and II and formulation of a contingency plan to address any potential project related impacts, and
- formulation of a detailed *Annual Report of Findings* for consideration by Broward County, State and Federal agencies, and the general public.

Data collected as part of the monitoring program is subject to the technical specifications of the FDEP BBCS and conditions of the FDEP Joint Coastal Permits #0163435-001-JC, #0163435-009-JC, and #0226688-001-JC. The overall Physical Monitoring Plan Schedule for the first five years subsequent to construction is summarized in **Table 2.2**. It is anticipated that monitoring will continue beyond the five years on a bi-annual basis as required by Permit.

Table 2.2: Schedule of physical monitoring tasks.

Task	Monitoring Period						
	Pre	**Post**	**Yr-1**	**Yr-2**	**Yr-3**	**Yr-4**	**Yr-5**
Beach Survey	X	X	X	X	X		X
Groin Field Survey	X	X	X	X	X		X
Borrow Area Survey (Areas I & II)	X	X		X		X	X
Borrow Area Survey (Areas III, IV & VI)	X	X				X	X
Port Everglades Shoal Survey	X	X		X		X	
Aerial Photography		X	X	X	X		X
Geotechnical		X					X
Analyses & Report		X	X	X	X	X	X

Note: This report represents the Year-5 monitoring event (shaded column).

In accordance with the project permit schedule, the following new data were acquired for purposes of performing the scheduled **Year Five** monitoring of the Broward County Shore Protection Project – Segment III project:

Beach profile survey

Beach profile surveys were performed between 13 April and 24 May 2011 from R-001 to R-128 of Broward County, including certain intermediate stations and profile monuments D-001 through D-005 in Miami-Dade County (see **Appendix A** for monument locations and profile). All profiles were surveyed by Coastal Planning and Engineering (CPE, 2011), of Boca Raton, FL during the following dates:

- Segment I (R-01 to R-24) – surveyed 21 May to 24 May 2011.
- Segment II (R-25 to R-85) – surveyed 13 April to 16 May 2011.
- Segment III (R-86 to R-128) – surveyed 17 May to 23 May 2011.

Table 2.3 lists the profiles with their respective survey dates. Although conducted between 13 April and 24 May 2011, this report will refer to the survey as the *April 2011 survey* because the majority of the profile set was surveyed in April.

Other surveys used throughout the post-project monitoring effort and in this report are listed in **Table 2.4**. All surveys were performed by Coastal Planning and Engineering, Inc. (CPE) of Boca Raton, FL.

Color orthorectified aerial photography

Digital aerial photography was flown on 13 July 2011 of the entire Broward County coastline and was produced by Southern Resource Mapping of Miami, Inc (see **Appendix B** for plots of the photography along the Segment I Shoreline).

Borrow area surveys

Although not in the physical monitoring schedule, annual bathymetric surveys of the five offshore borrow areas (BA-I, BA-II, BA-III, BA-IV & BA-VI) have been included in the scope-of-work for the County. The five-year monitoring survey was performed from 11 July to 13 July 2011 by Coastal Planning and Engineering (CPE, 2011), of Boca Raton, FL.

Table 2.3: April 2011 Broward County monitoring survey dates.

	Mon.	Upland	Beach	Offshore
Segment I	R-1	24-May-11	21-May-11	21-May-11
	R-2	24-May-11	21-May-11	21-May-11
	R-3	24-May-11	21-May-11	21-May-11
	R-4	24-May-11	21-May-11	21-May-11
	R-5	24-May-11	21-May-11	21-May-11
	R-6	24-May-11	21-May-11	21-May-11
	R-7	24-May-11	21-May-11	21-May-11
	R-8	24-May-11	21-May-11	21-May-11
	R-9	24-May-11	21-May-11	21-May-11
	R-10	24-May-11	21-May-11	21-May-11
	R-11	24-May-11	21-May-11	21-May-11
	R-12	24-May-11	21-May-11	21-May-11
	R-13	24-May-11	21-May-11	21-May-11
	R-14	24-May-11	21-May-11	21-May-11
	R-15	24-May-11	21-May-11	21-May-11
	R-16	24-May-11	21-May-11	21-May-11
	R-17	24-May-11	21-May-11	21-May-11
	R-18	24-May-11	21-May-11	21-May-11
	R-19	24-May-11	21-May-11	21-May-11
	R-20	24-May-11	21-May-11	21-May-11
	R-21	24-May-11	21-May-11	21-May-11
	R-22	24-May-11	21-May-11	21-May-11
	R-23	24-May-11	21-May-11	21-May-11
	R-24	24-May-11	21-May-11	21-May-11
Segment II	R-25	27-Apr-11	29-Apr-11	29-Apr-11
	R-26	27-Apr-11	29-Apr-11	29-Apr-11
	R-27	27-Apr-11	29-Apr-11	29-Apr-11
	R-28	27-Apr-11	29-Apr-11	29-Apr-11
	R-29	27-Apr-11	29-Apr-11	29-Apr-11
	R-30	27-Apr-11	29-Apr-11	29-Apr-11
	R-31	27-Apr-11	29-Apr-11	29-Apr-11
	R-32	27-Apr-11	29-Apr-11	29-Apr-11
	R-33	27-Apr-11	29-Apr-11	29-Apr-11
	R-34	27-Apr-11	29-Apr-11	29-Apr-11
	R-35	27-Apr-11	29-Apr-11	29-Apr-11
	R-36	27-Apr-11	29-Apr-11	29-Apr-11
	R-37	27-Apr-11	29-Apr-11	29-Apr-11
	R-38	27-Apr-11	29-Apr-11	29-Apr-11
	R-39	27-Apr-11	29-Apr-11	29-Apr-11
	R-40	27-Apr-11	29-Apr-11	29-Apr-11
	R-41	27-Apr-11	29-Apr-11	29-Apr-11
	R-42	27-Apr-11	29-Apr-11	29-Apr-11
	R-43	27-Apr-11	29-Apr-11	29-Apr-11
	R-44	27-Apr-11	29-Apr-11	29-Apr-11
	R-45	27-Apr-11	29-Apr-11	29-Apr-11
	R-46	27-Apr-11	29-Apr-11	29-Apr-11
	R-47	27-Apr-11	29-Apr-11	29-Apr-11

	Mon.	Upland	Beach	Offshore
Segment II	R-48	27-Apr-11	16-May-11	16-May-11
	R-49	27-Apr-11	16-May-11	16-May-11
	R-50	27-Apr-11	16-May-11	16-May-11
	R-51	27-Apr-11	16-May-11	16-May-11
	R-52	27-Apr-11	16-May-11	16-May-11
	R-53	27-Apr-11	16-May-11	16-May-11
	R-54	27-Apr-11	16-May-11	16-May-11
	R-55	27-Apr-11	16-May-11	16-May-11
	R-56	27-Apr-11	16-May-11	16-May-11
	R-57	27-Apr-11	16-May-11	16-May-11
	R-58	27-Apr-11	16-May-11	16-May-11
	R-59	27-Apr-11	16-May-11	16-May-11
	R-60	27-Apr-11	16-May-11	16-May-11
	R-61	27-Apr-11	16-May-11	16-May-11
	R-62	15-Apr-11	15-Apr-11	14-Apr-11
	R-63	15-Apr-11	15-Apr-11	14-Apr-11
	R-64	15-Apr-11	15-Apr-11	14-Apr-11
	R-65	15-Apr-11	15-Apr-11	14-Apr-11
	R-66	15-Apr-11	15-Apr-11	14-Apr-11
	R-67	15-Apr-11	15-Apr-11	14-Apr-11
	R-68	15-Apr-11	15-Apr-11	13-Apr-11
	R-69	14-Apr-11	14-Apr-11	13-Apr-11
	R-70	14-Apr-11	14-Apr-11	13-Apr-11
	R-71	14-Apr-11	14-Apr-11	13-Apr-11
	R-72	14-Apr-11	14-Apr-11	13-Apr-11
	R-73	14-Apr-11	14-Apr-11	13-Apr-11
	R-74	14-Apr-11	14-Apr-11	13-Apr-11
	R-75	14-Apr-11	14-Apr-11	13-Apr-11
	R-76	14-Apr-11	14-Apr-11	13-Apr-11
	R-77	13-Apr-11	13-Apr-11	13-Apr-11
	R-78	13-Apr-11	13-Apr-11	13-Apr-11
	R-79	13-Apr-11	13-Apr-11	13-Apr-11
	R-80	13-Apr-11	13-Apr-11	13-Apr-11
	R-81	13-Apr-11	13-Apr-11	13-Apr-11
	R-81.3	13-Apr-11	13-Apr-11	13-Apr-11
	R-81.7	13-Apr-11	13-Apr-11	13-Apr-11
	R-82	13-Apr-11	13-Apr-11	13-Apr-11
	R-82.3	13-Apr-11	13-Apr-11	13-Apr-11
	R-82.7	13-Apr-11	13-Apr-11	13-Apr-11
	R-83	13-Apr-11	13-Apr-11	13-Apr-11
	R-83.3	13-Apr-11	13-Apr-11	13-Apr-11
	R-83.7	13-Apr-11	13-Apr-11	13-Apr-11
	R-84	13-Apr-11	13-Apr-11	13-Apr-11
	R-84.3	13-Apr-11	13-Apr-11	13-Apr-11
	R-84.7	13-Apr-11	13-Apr-11	13-Apr-11
	R-85	15-Apr-11	15-Apr-11	13-Apr-11

Table 2.3 (continued): April 2009 Broward County monitoring survey dates.

	Mon.	Upland	Beach	Offshore		Mon.	Upland	Beach	Offshore
Segment III	R-85.7	17-May-11	17-May-11	16-May-11	Segment III	R-103	23-May-11	23-May-11	17-May-11
	R-86	17-May-11	17-May-11	16-May-11		R-104	23-May-11	23-May-11	17-May-11
	R-86.3	17-May-11	17-May-11	NA		R-105	23-May-11	23-May-11	17-May-11
	R-86.5	17-May-11	17-May-11	NA		R-106	23-May-11	23-May-11	17-May-11
	R-86.7	17-May-11	17-May-11	NA		R-107	23-May-11	23-May-11	17-May-11
	R-87	17-May-11	17-May-11	16-May-11		R-108	23-May-11	23-May-11	17-May-11
	R-87.2	17-May-11	17-May-11	NA		R-109	18-May-11	18-May-11	17-May-11
	R-87.5	17-May-11	17-May-11	NA		R-110	18-May-11	18-May-11	17-May-11
	R-87.7	17-May-11	17-May-11	NA		R-111	18-May-11	18-May-11	18-May-11
	R-88	17-May-11	17-May-11	16-May-11		R-112	18-May-11	18-May-11	18-May-11
	R-88.2	17-May-11	17-May-11	NA		R-113	18-May-11	18-May-11	18-May-11
	R-88.5	17-May-11	17-May-11	NA		R-114	18-May-11	18-May-11	18-May-11
	R-89	17-May-11	17-May-11	17-May-11		R-115	18-May-11	18-May-11	18-May-11
	R-89.5	17-May-11	17-May-11	NA		R-116	18-May-11	18-May-11	18-May-11
	R-90	17-May-11	17-May-11	17-May-11		R-117	18-May-11	18-May-11	18-May-11
	R-90.5	17-May-11	17-May-11	NA		R-118	18-May-11	18-May-11	18-May-11
	R-91	17-May-11	17-May-11	17-May-11		R-119	18-May-11	18-May-11	18-May-11
	R-91.5	23-May-11	17-May-11	NA		R-120	18-May-11	18-May-11	18-May-11
	R-92	23-May-11	17-May-11	17-May-11		R-121	18-May-11	18-May-11	18-May-11
	R-92.5	23-May-11	17-May-11	NA		R-122	18-May-11	18-May-11	18-May-11
	R-93	23-May-11	17-May-11	17-May-11		R-123	18-May-11	18-May-11	18-May-11
	R-94	23-May-11	17-May-11	17-May-11		R-124	18-May-11	18-May-11	18-May-11
	R-95	23-May-11	17-May-11	17-May-11		R-125	18-May-11	18-May-11	18-May-11
	R-96	23-May-11	17-May-11	17-May-11		R-126	18-May-11	18-May-11	18-May-11
	R-97	23-May-11	17-May-11	17-May-11		R-127	18-May-11	18-May-11	18-May-11
	R-98	17-May-11	17-May-11	17-May-11		R-128	18-May-11	18-May-11	18-May-11
	R-99	23-May-11	17-May-11	17-May-11	Miami-Dade	D-2	18-May-11	18-May-11	18-May-11
	R-100	23-May-11	17-May-11	17-May-11		D-3	18-May-11	18-May-11	18-May-11
	R-101	23-May-11	17-May-11	17-May-11		D-4	18-May-11	18-May-11	18-May-11
	R-102	23-May-11	17-May-11	17-May-11		D-5	18-May-11	18-May-11	18-May-11

Table 2.4: Beach profile surveys, Broward County Segment I shoreline.

Survey Date	Comment
September 2001[1]	42-Months Pre-Segment III Construction
March 2005[2]	Pre-Segment III Construction
February 2006[2]	Post-Segment III Construction
April 2007	14-Months Post-Segment III Construction
July 2008[3]	29-Months Post-Segment III Construction
April 2009[4]	38-Months Post-Segment III Construction
April 2011[5]	62-Months Post-Segment III Construction

Notes: (1) The September 2001 survey was conducted three years post-construction of the 1998 Deerfield-Hillsboro Beach Nourishment with 555,000 cy placed from R-6 to R-12.
(2) The Segment III project was constructed between May 2005 & February 2006. For monitoring purposes, the March 2005 survey is used to represent pre-construction conditions and the February 2006 survey is used to represent post-construction conditions.
(3) The 2008 survey was conducted between June and July 2008. However, to avoid confusion, this report will refer to the survey as the July 2008 survey because the majority of the Broward County profiles were surveyed in July.
(4) The 2009 survey was conducted between March and June 2009. However, to avoid confusion, this report will refer to the survey as the April 2009 survey because the majority of the Broward County profiles were surveyed in April.
(5) The 2011 survey was conducted between April and May 2011. However, to avoid confusion, this report will refer to the survey as the April 2011 survey because the majority of the Broward County profiles were surveyed in April.

Port Everglades Inlet sand shoal

A bathymetric survey of the Port Everglades inlet sand shoal was conducted in August 2010. The survey was performed by the USACE as part of the *Port Everglades Harbor, Broward County, Florida, Project Condition Survey*. Results of recent and other post-construction surveys of the borrow areas and shoal are presented and discussed in **Chapter 4** of this report.

2.5 Beach Monitoring Approach

Beach conditions are monitored principally through the inter-comparison of beach profile surveys collected through time at pre-determined beach monitoring stations (i.e., R-monuments).

Beach conditions are documented with transect surveys at all FDEP R-monument stations (spaced roughly 1,000 feet alongshore) and intermediate beach profile stations located immediately north and south of Port Everglades Inlet. A tabulated summary of the beach profile stations as well as plots of selected beach profile data at each station are presented in **Appendix A**. The 2011 Broward County shoreline aerial photography with

superimposed Mean High Water Line (MHWL, +0.41 ft-NAVD88) positions is included in **Appendix B**.

As will be discussed throughout this report, measured shoreline and beach volume changes exhibit a high level of variability, both temporally and spatially. In general, the changes are the result of several primary mechanisms:

- *Cross-shore equilibration of the beach fill*

Following completion of the constructed project berm, waves, tides, and currents will combine to reshape the construction berm into a more natural configuration. This process is termed "profile equilibration" and usually occurs over the first 12 to 18 months of the project life. Profile equilibration entails the offshore transport of sand from the initial construction fill berm to the submerged bar/trough areas, generally resulting in anticipated shoreline recession and volume loss along the upper beach and a corresponding accretion of sand at lower, submerged elevations of the profile.

- *Alongshore sand diffusion of the beach fill*

Likewise, the constructed project represents a shoreline perturbation. As wave action reduces the perturbation, sand is transported alongshore from the project ends, which experience increased losses. As anticipated, sand from both the eastern and western ends of the project has diffused to the adjacent shorelines. Typically, beach fills are designed to narrow, or "taper", to their ends over 1,000 to 2,000 feet to meet the pre-project shoreline. In this instance, to reduce the potential sand loss rates south of the JUL groin field immediately following construction, a sand fill taper was constructed through the groin field from the Port Everglades south jetty to a point just south of the southernmost groin (USACE, 2003).

- *Background erosion*

Background erosion refers to any naturally-occurring pre-project and non-project shoreline change. It is assumed that the processes that lead to any background shoreline change will continue during the nourishment project life and hence will be included in any measured shoreline or beach volume change in the monitoring program. Gradients in the net alongshore sediment transport, caused by the refraction of incident waves over irregular contours offshore of Broward County, result in a low level of chronic erosion along the County's shoreline. This rate, which is not uniform along the shoreline, includes localized areas of naturally occurring increased erosion and accretion areas caused by prominent shoal features and reef configurations.

- *Migration of offshore sandbars*

Beach profile data indicates significant cross-shore beach profile changes along the county shorelines. During the large storm events immediately following construction of the Segment III project, particularly Hurricanes Katrina and Wilma, large volumes of sand were transported from the upper beach to the lower portions of the profile. During the relatively mild wave climate experienced since the completion of the nourishment project, there appears to have been significant recovery of the profile from the onshore transport of sand. This has typically occurred in the trough area landward of the bar crest in water depths shallower than -4 to -8 ft NAVD88. The landward migration of sand and offshore sandbars is a relatively slow process that may only be notable over several years -- assuming that no other major storms impact the area during that timeframe.

- *Beach cusps, bar reattachment, and other alongshore-variable rhythmic features*

Monitoring data from 2009 and 2011 to a lesser degree reveals the presence of pronounced beach features that resemble beach cusps, bar reattachments, and other natural alongshore rhythmic variations in beach conditions that can affect shoreline and volume change analyses. In some areas, the data reveal atypical significant variability in shoreline location and beach volume change for the most recent monitoring period. Such changes have been shown to be indicative of the presence and movement of various scales of beach cusps and other alongshore-variable rhythmic features (van Enckevort et al., 2004, Browder and Reilly, 2008, among others). Aerial photography from 2009 and 2011 reveals the presence of generally small to medium scale beach cusps in the immediate nearshore ranging in size from about 50 to 1,000 feet in alongshore length. These cusps are also observed to weld and migrate with submerged sandbar features in the nearshore. This can lead to an artificial exaggeration of accretion or erosion measured along each of the fixed beach profile transects in the monitoring program.

Along the Broward County shoreline, all five of these mechanisms, and potentially others, affect computed results prescribed herein. In the following text, the measured data are assessed in the context of these mechanisms in order to better describe the shoreline and beach volume changes observed. In many instances, different segments of the beach are affected by different processes.

3.0 SEGMENT III PROJECT PERFORMANCE (February 2006 to April 2011)

This section of the report discusses the shoreline and beach volume changes which occurred along the Broward County Segment III shoreline between February 2006 (immediate post-project) and April 2011 (5.2 years post-project). It is noted that the design life of the 2005/06 project is six years. Accordingly, as of April 2011, the project was more than 87 percent through the expected design life. For purposes of this report, the Segment III shoreline is divided into three sub-reaches. These include the (1) northern John U. Lloyd Beach State Park (JUL) shoreline (R-85.7 to R-92), (2) the southern JUL shoreline (R-92 to R-98.3), and (3) the Hollywood/Hallandale Beach/Dania Beach (HHD) shoreline (R-98.3 to R-128). The 2005/06 Broward County Shore Protection Project added sand to the northern JUL and HHD shorelines.

3.1 MHW Shoreline Position Change

Table 3.1 summarizes the measured changes at the MHWL (+0.41 ft-NAVD88) that occurred between February 2006 and April 2011 at each Segment III beach monitoring monument and for the described beach reaches. Given the somewhat irregular spacing between R-monuments, the average MHWL change calculations presented in Table 3.1 were *spatially weighted* using an average end method based upon the alongshore distance between the monuments. This differs from the non-weighted "arithmetic" average shoreline changes presented in previous monitoring analyses including the 1-Year Post-Construction Physical Monitoring Report (OAI/CPE-J/V, 2007b). Due to this change in computational methodology, the spatially weighted average shoreline changes presented in this report differ slightly from the average values published in previous monitoring reports. Also note that there are small rounding discrepancies (±1.0 ft) between shoreline positions reported throughout this report and previous monitoring reports.

Figure 3.1 also depicts the surveyed locations of the MHWL for the JUL and HHD project shorelines relative to the March 2005 (pre-construction) position (*top*) and the Erosion Control Line (ECL) (*bottom*). The representation of the MHWL location in this format provides an opportunity to evaluate the April 2011 shoreline position relative to the two noted benchmark conditions.

Table 3.1: Broward County – Segment III shoreline change from February 2006 to April 2011 as measured at the MHWL (+0.41 ft-NAVD88).

Mon.	Distance from R-Monument (ft) February 2006	Distance from R-Monument (ft) April 2011	Δ (ft)	Mon.	Distance from R-Monument (ft) February 2006	Distance from R-Monument (ft) April 2011	Δ (ft)
R-85.7	204.4	203.6	-0.7	R-103	258.5	234.5	-24.0
R-86	197.1	86.8	-110.3	R-104	269.6	227.1	-42.5
R-86.3	311.0	199.4	-111.6	R-105	278.3	245.9	-32.4
R-86.5	391.6	343.6	-48.1	R-106	214.5	218.2	3.8
R-86.7	361.1	196.8	-164.3	R-107	221.7	211.1	-10.6
R-87	555.8	386.6	-169.2	R-108	167.6	169.1	1.5
R-87.2	340.1	166.0	-174.1	R-109	187.8	172.7	-15.1
R-87.5	332.0	171.3	-160.7	R-110	165.5	152.5	-13.0
R-87.7	426.9	293.5	-133.5	R-111	227.5	211.4	-16.1
R-88	539.7	399.0	-140.7	R-112	223.6	194.6	-29.0
R-88.2	376.1	285.1	-91.0	R-113	237.5	190.5	-47.1
R-88.5	267.0	178.1	-88.9	R-115	228.2	186.6	-41.6
R-89	410.7	354.4	-56.4	R-115	195.9	179.6	-16.3
R-89.5	348.1	321.6	-26.5	R-116	243.1	200.7	-42.4
R-90	368.3	358.6	-9.8	R-117	272.7	237.2	-35.5
R-90.5	240.6	228.7	-11.8	R-118	276.5	221.4	-55.1
R-91	279.7	260.4	-19.3	R-119	248.7	196.1	-52.7
R-91.5	115.5	135.8	20.3	R-120	182.5	143.0	-39.5
R-92	195.5	224.3	28.8	R-121	132.1	79.0	-53.0
R-92.5	108.1	117.7	9.6	R-122	114.3	63.7	-50.6
R-93	201.6	228.4	26.8	R-123	163.9	77.2	-86.8
R-94	146.0	169.3	23.3	R-124	299.6	217.6	-82.0
R-95	164.9	201.6	36.7	R-125	347.4	297.2	-50.2
R-96	176.8	178.1	1.3	R-126	204.0	119.2	-84.8
R-97	259.8	273.6	13.8	R-127	158.4	120.1	-38.3
R-98	244.7	231.1	-13.6	R-128	140.0	125.4	-14.6
R-99	149.6	116.7	-32.9	D-2	149.7	131.1	-18.6
R-100	169.1	134.8	-34.3	D-3	148.0	154.9	6.9
R-101	150.2	130.5	-19.7	D-4	299.8	280.4	-19.5
R-102	242.2	226.5	-15.7	D-5	130.1	120.7	-9.4

WEIGHTED AVERAGE: John U. Lloyd Project (R-85.7 to R-92)	-65.0
WEIGHTED AVERAGE: John U. Lloyd South (R-92 to R-98.3)	15.4
WEIGHTED AVERAGE: Hollywood/Hallandale/Dania (R-98.3 to R-128)	-35.9
WEIGHTED AVERAGE: SEGMENT III (R-85.7 to R-128)	-32.6
WEIGHTED AVERAGE: Miami-Dade (R-128 to D-5)	-10.7

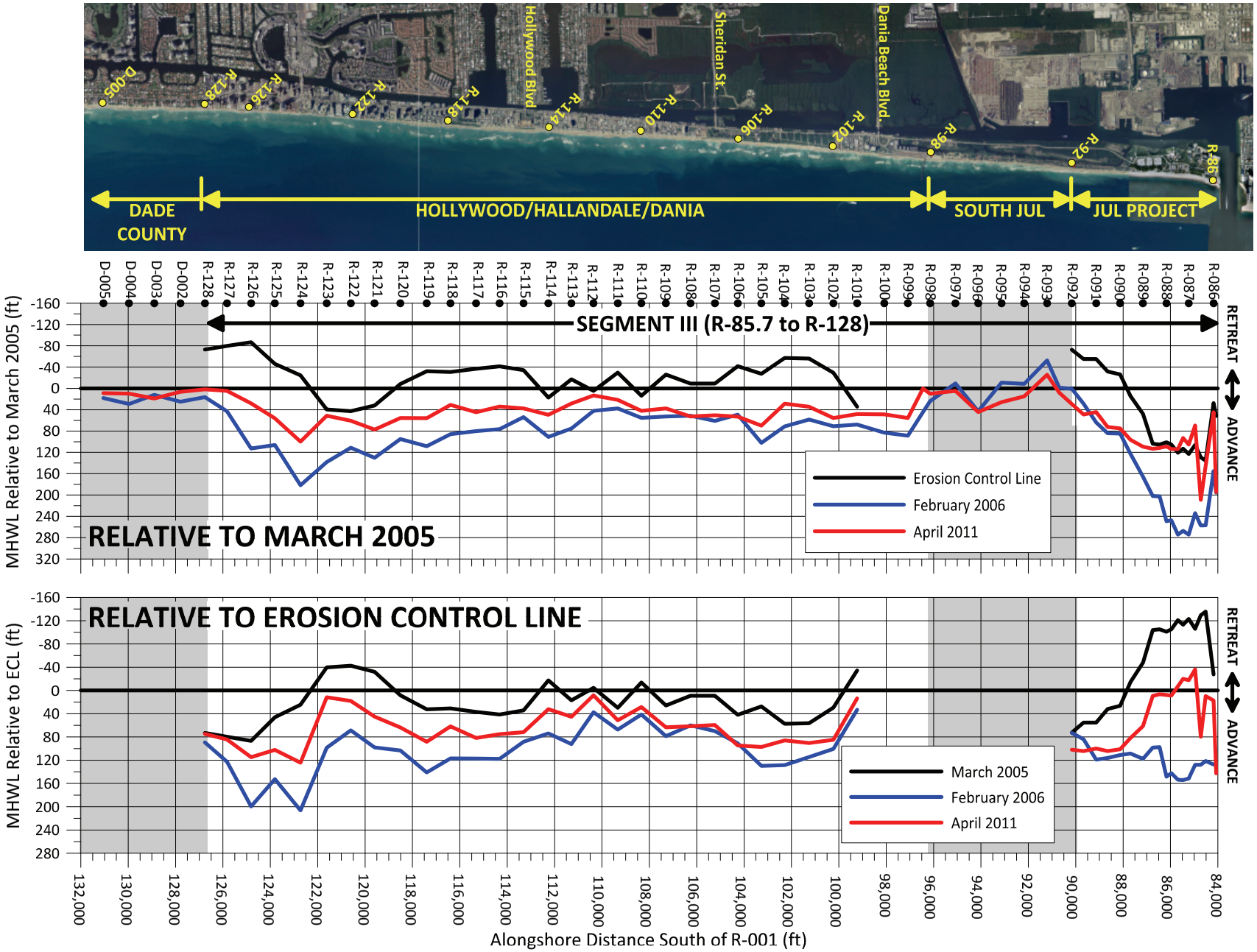


Figure 3.1: Segment III MHW shoreline location **relative to the March 2005** (pre-construction) **and the Erosion Control Line** (ECL).

Over the 62-month post-construction monitoring period between February 2006 and April 2011, (nominally from post-construction to five years post-construction of Segment III), the MHWL along the entire Segment III shoreline receded, on average, about 33 feet. This average advance, however, was the product of highly varied local MHWL changes along the Segment III shoreline. MHWL changes along this area varied from 174 ft of recession at R-87.2 within the JUL project area, to 37 ft of advancement at R-95 within the southern section of JUL where a beach fill was not constructed.

Over the same period, the MHWL within the JUL project area (R-85.7 to R-92) has receded roughly 65 ft, on average, with the most significant recession (an un-weighted average of 135 ft) occurring within and immediately downdrift of the groin field (R-86 to R-88). The southern section of the project area (R-89 to R-92) experienced only relatively minor erosion and some accretion during the same period. The accretion occurred at the southernmost reach of the project area (R-91 and R-92) and was related mostly to the large sand supply associated with losses from the beach to the north.

The area of largest shoreline recession and the relative change of shoreline positions between surveys is also seen in **Figure 3.2.** In this figure, the locations of the MHWL for the March 2005, February 2006, April 2007, July 2008, April 2009, and April 2011 surveys along the northern area of the JUL project are presented superimposed over the July 2011 aerial photograph of the area. The greatest rate of change occurred during the period immediately following construction of the project (as expected) and has gradually stabilized over each inter-survey period. Specifically, the average shoreline retreat during the first year following project completion (February 2006 to April 2007) was 33 ft, 21 ft during the second year (April 2007 to July 2008), 10 ft during the third year (July 2008 to April 2009), and only 1 ft between the third and fifth year (April 2009 to April 2011). The shoreline stability observed in the most recent inter-survey period is primarily due to effects of the T-head groin field as well as the overall shoreline planform adjusting to an equilibrated configuration.

As of April 2011, it appears that the shoreline and beach position within the groin field cells also has stabilized to an equilibrated shape. **Figure 3.3** depicts the approximate predicted design and the April 2007, July 2008, April 2009, and April 2011 measured location of the edge of berm (+7.0 ft-NAVD88) and the MHWL (+0.41 ft-NAVD88) along the northern end of the JUL project shoreline. This presentation suggests that the April 2011 MHWL and the upper berm location within the groin cells is

generally situated near the expected design position on average. The shoreline position within the northern cell is somewhat more landward than anticipate but the berm location remains seaward of the upland seawall which was a basic design parameter for the project. Overall, however, the post-project shoreline change within and immediately adjacent to the groin field has been generally equivalent to expected conditions. Minimal future change to the shoreline position within the cells is expected for typical weather conditions. Elevated storm activity could, however, could contribute to sand loss from the groin cells and an associated landward retreat of the MHWL and beam position.

As of April 2011 (5.2 years after project completion), the JUL MHWL remained seaward of the Erosion Control Line (ECL) by an average of 53 ft. The JUL project design was based upon the requirement to maintain the MHWL location at the ECL (i.e., 0-ft design) over the six year project design life. Prior to construction, along the JUL project reach, the weighted average MHWL position was 38 ft *landward* of the ECL. Along the most eroded portions of the JUL project shoreline, the pre-construction MHWL was nearly than 136 ft *landward* of the ECL position.

The MHWL position along the unnourished southern area of John U. Lloyd Beach State Park (R-92 to R-98.3) experienced average shoreline advance of over 15 ft during the post-construction monitoring period (February 2006 to April 2011). Note that this reach of shoreline did not receive direct sand placement as part of the 2005/06 project. Shoreline advance along this stretch does vary some alongshore, with a maximum advance of nearly 37 ft at R-95 and a maximum retreat of almost 14 ft at R-98.

The Hollywood/Hallandale/Dania (HHD) project area (R98.3 to R128) occupies the remainder of the Segment III shoreline. Between February 2006 and April 2011, the MHWL along the HHD project shoreline retreated an average of 36 feet. Localized MHWL change varied from 87 ft of recession at R-123 (southern Hollywood) to 4 ft of advance (north-central Hollywood). Over this period, the HHD shoreline was generally recessional with only two of the 30 profile transects in this reach experiencing advancement since project completion.

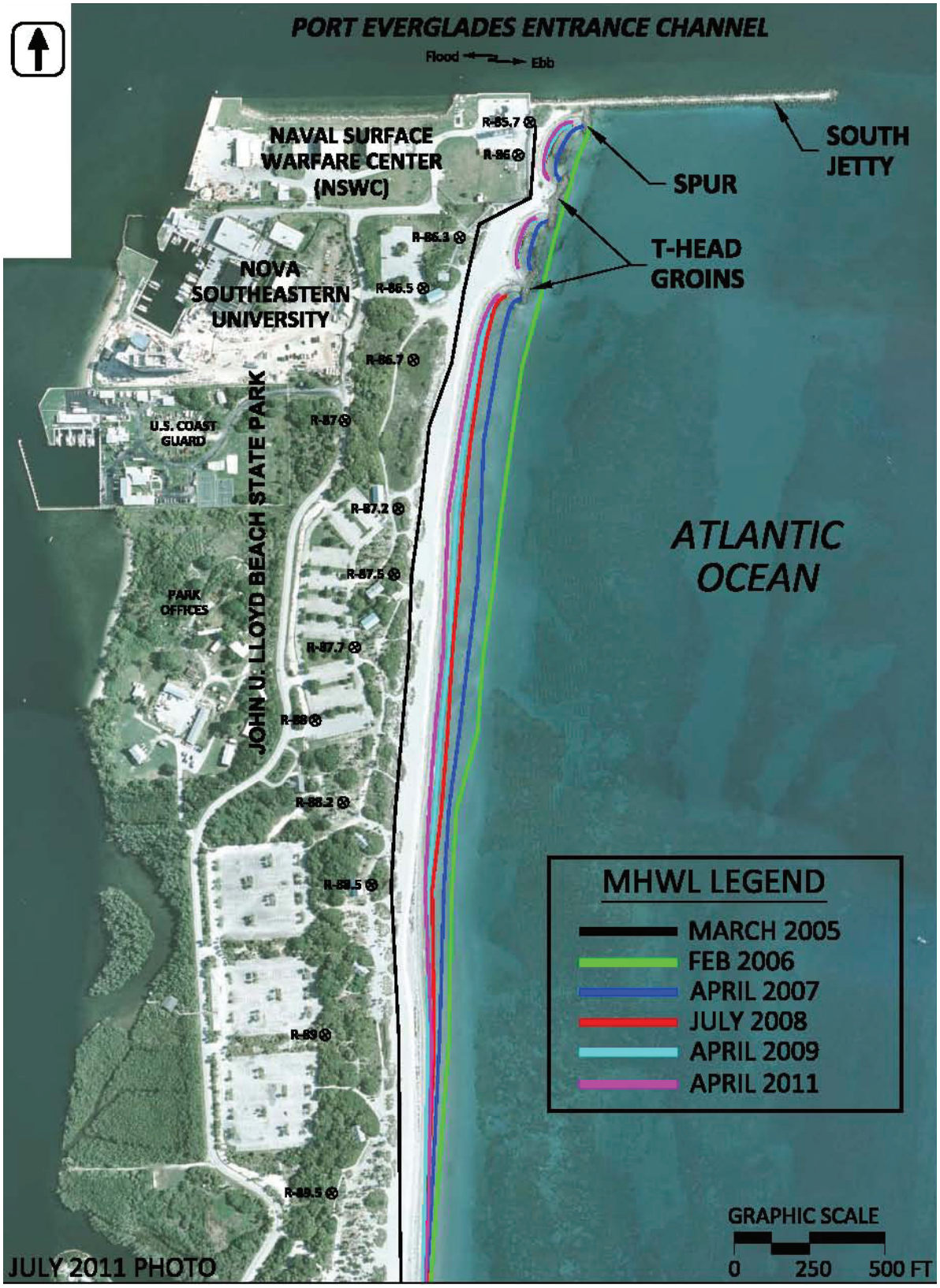
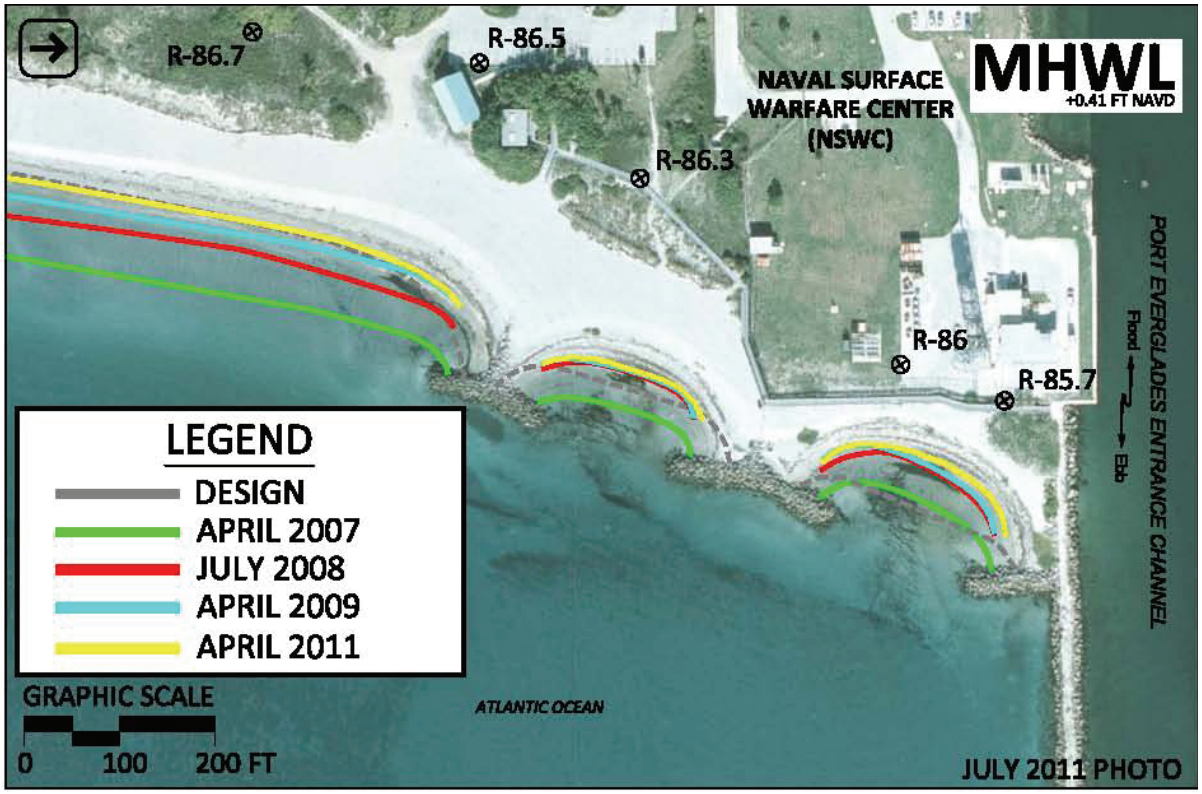


Figure 3.2: MHWL locations along the northern end of the JUL project shoreline.



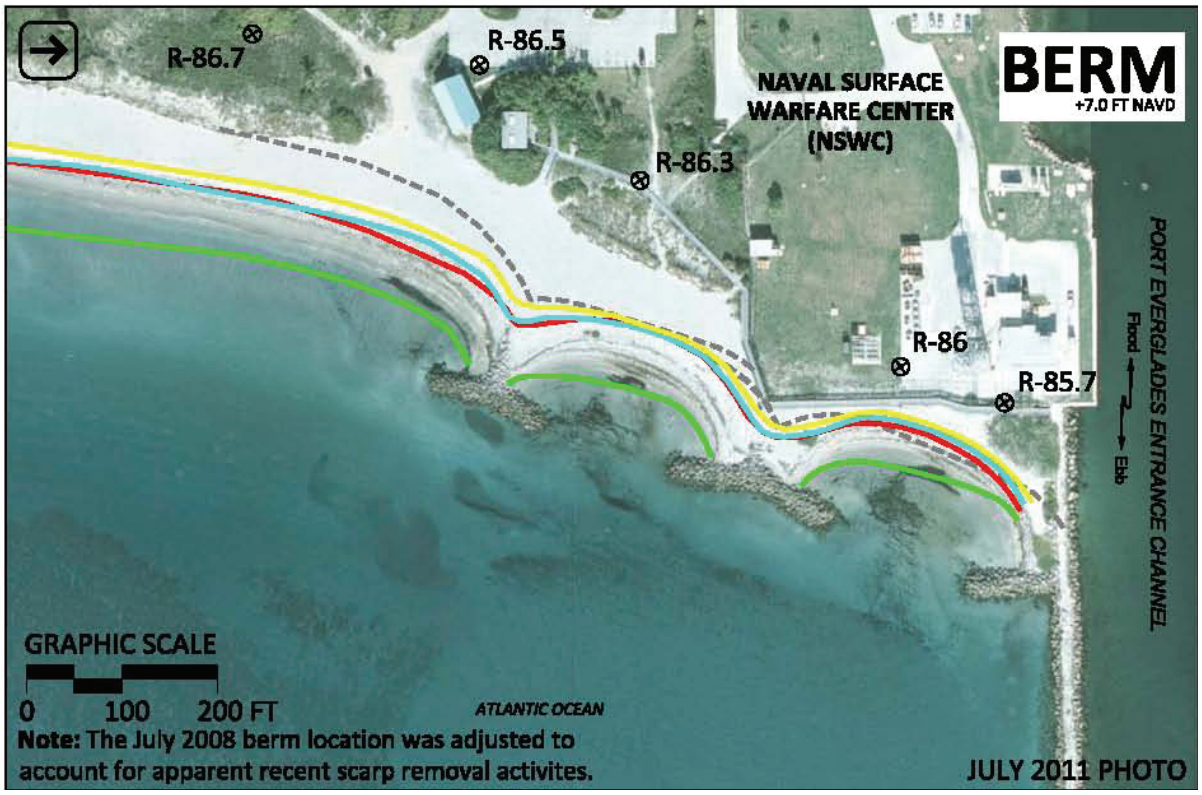


Figure 3.3: Predicted design and measured locations of the MHWL (top) and the BERM (bottom) along the northern end of the JUL project.

As of April 2011, the HHD MHWL remained seaward of the Erosion Control Line (ECL) by an average of 67 ft and 45 ft seaward of the March 2005 (pre-construction) position[3] (see **Figure 3.1**). The HHD project design was based upon the requirement to maintain the MHWL 50 feet seaward of the ECL (i.e., 50-ft design) over the six year project design life. As of April 2011 (5.2 years after project completion), the MHWL position varied from 8 (at R-112 in Hollywood) to 124 feet (at R-124 in Hallandale) seaward of the ECL. The April 2011 MHWL is less than 50 feet from the ECL at only 8 of the 28 monument locations (down from 13 monuments in April 2009 -- two years earlier). This occurred at three areas: (1) central Hollywood (R-110 and R-112 to R-114) where fill densities were the smallest of any along the HHD project and where historical erosion rates are less, (2) south Hollywood (R-121 to R-123) where erosion rates are the highest of any portion of the HHD shoreline , and (3) a highly localized area in north Hollywood (R-101), also a historically erosion area and a point where the ECL projects well seaward of the typical shoreline alignment. The variation in distance between the MHWL and ECL is not solely due to variations in shoreline position but also in part due to large alongshore variations in the location and alignment of the ECL (i.e., the ECL is not a straight line along the Hollywood/Hallandale shoreline).

[3] It is noted that the sand placement along the Hollywood/Hallandale/Dania shoreline occurred between May 15, 2005 and November 3, 2005. The first physical monitoring survey to represent post-project conditions along this shoreline was not performed until February 2006 – after completion of the JUL project reach. Therefore, significant cross-shore equilibration of the beach fill had occurred along the HHD shoreline at the time of project completion in February 2006. This is especially true for the southern area of the HHD project area which was constructed generally between May 15 and early August 2005.

3.2 Beach Volume Change

Table 3.2 and **Table 3.3** summarize Segment III beach volume changes from March 2005 (pre-construction) and February 2006 (post-construction) to April 2011 (five-year post-construction), respectively. **Figure 3.4** presents the local and cumulative beach volume changes, in cubic yards (cy), along the Segment III shoreline for the 62-month (5.2 year) post-construction monitoring period.

Volume changes were calculated from the back beach -- where the fill berm intersected the existing upland contour or seaward edge of vegetation -- to the seaward edge of sandy beach profile -- the beach toe/nearshore hardbottom interface[4]. Volume changes were also calculated above and below the Mean Low Water Line (MLWL) to demonstrate the cross-shore variation in sand volume changes.

In sum, the 42,740 feet of Segment III shoreline experienced a net loss of 246,500 cy of sand over the 5.2 year period between February 2006 and April 2011. This is equivalent to an overall average Segment III sand loss rate of about 47,400 cy/yr. Inspection of the localized beach volume changes, however, indicates a variety of localized gross beach changes consistent with that indicated by the MHWL change. Some of the losses from the fill areas were realized as gains along the southern JUL shoreline where no sand was placed.

Project design volumes were based upon four fill volume components. These include (1) design beach, (2) advance fill, (3) overfill, and (4) a sand volume to address fill end effect losses. The latter three fill volume elements are considered the "sacrificial" portion of the beach fill that protects the design beach. It is also these three fill volume components upon which fill performance predictions are based. It was anticipated from design analyses that the Segment III project areas, JUL and HHD, would loss approximately 163,800 cy/yr over the six year design life -- 53,250 cy/yr in JUL and 110,550 cy/yr in HHD, including a consideration of the overfill ratio of about 1.14 for the sand from the offshore borrow areas (USACE, 2003).

Again, these results reflect project conditions 5.2 years following project completion or about 87 percent through the six year project design life.

---

[4] The location of the nearshore edge of hardbottom used as the seaward beach volume computational limit was estimated from comparison of historical beach profile surveys and pre-and post-beach fill nearshore edge surveys. The computational limits for each profile are summarized in **Appendix A**.

Table 3.2: Broward County Segment III beach volume changes (March 2005 to April 2011).

		Monument		Length	Average Volume Change (cy/ft)		Volume Change (cy)	
		North	South	(ft)	Above MLW	Total Profile	Above MLW	Total Profile
SEGMENT III	JUL Project	R-85.7	R-86	160	11.7	30.3	1,900	4,900
		R-86	R-87	1,051	25.3	50.9	26,600	53,500
		R-87	R-88	940	42.1	72.8	39,600	68,400
		R-88	R-89	994	41.9	72.7	41,700	72,300
		R-89	R-90	964	33.3	63.9	32,100	61,600
		R-90	R-91	1,007	22.5	50.5	22,700	50,900
		R-91	R-92	1,032	13.1	41.4	13,500	42,700
		Subtotal		**6,148**	**29.0**	**57.6**	**178,100**	**354,300**
	JUL South	R-92	R-93	1,042	2.4	27.5	2,400	28,700
		R-93	R-94	967	0.7	9.4	700	9,100
		R-94	R-95	955	4.4	5.1	4,200	4,900
		R-95	R-96	986	7.0	20.6	6,900	20,300
		R-96	R-97	962	6.6	19.5	6,400	18,700
		R-97	R-98	1,069	2.8	9.2	3,000	9,900
		R-98	R-98.3	300	6.4	21.0	1,900	6,300
		Subtotal		**6,280**	**4.1**	**15.6**	**25,500**	**97,900**
	Hollywood / Hallandale / Dania	R-98.3	R-99	641	12.9	37.8	8,300	24,300
		R-99	R-100	993	16.6	41.2	16,500	40,900
		R-100	R-101	1,147	17.5	38.9	20,100	44,600
		R-101	R-102	1,004	20.2	53.9	20,300	54,100
		R-102	R-103	1,022	17.2	48.6	17,600	49,700
		R-103	R-104	1,029	11.9	22.2	12,200	22,800
		R-104	R-105	991	14.8	17.1	14,700	17,000
		R-105	R-106	992	16.8	23.7	16,600	23,500
		R-106	R-107	967	14.2	16.1	13,700	15,500
		R-107	R-108	1,029	12.6	25.8	13,000	26,500
		R-108	R-109	1,040	10.3	32.2	10,700	33,500
		R-109	R-110	1,034	9.7	32.8	10,000	33,900
		R-110	R-111	995	10.5	44.7	10,400	44,500
		R-111	R-112	1,029	5.9	44.5	6,100	45,800
		R-112	R-113	931	4.6	42.0	4,300	39,100
		R-113	R-115	974	11.3	61.5	11,000	59,900
		R-115	R-115	1,047	12.3	56.2	12,800	58,800
		R-115	R-116	1,012	10.3	35.3	10,400	35,700
		R-116	R-117	992	12.0	46.1	11,900	45,700
		R-117	R-118	1,081	10.5	33.9	11,400	36,700
		R-118	R-119	1,003	10.6	28.3	10,600	28,400
		R-119	R-120	1,113	15.0	48.2	16,700	53,700
		R-120	R-121	1,089	18.4	60.4	20,000	65,800
		R-121	R-122	1,000	16.9	70.9	16,900	70,900
		R-122	R-123	1,019	14.4	66.8	14,600	68,000
		R-123	R-124	1,107	20.8	58.5	23,000	64,700
		R-124	R-125	1,083	21.8	63.7	23,600	69,000
		R-125	R-126	1,001	13.1	47.6	13,100	47,600
		R-126	R-127	1,017	5.8	32.3	5,900	32,900
		R-127	R-128	933	2.1	28.8	1,900	26,800
		Subtotal		**30,312**	**13.1**	**42.2**	**398,300**	**1,280,300**
	TOTAL			**42,740**	**14.1**	**40.5**	**601,900**	**1,732,500**
Miami-Dade		R-128	D-2	1,035	1.3	17.0	1,400	17,600
		D-2	D-3	1,103	2.6	13.6	2,900	15,000
		D-3	D-4	1,071	2.9	27.2	3,100	29,100
		D-4	D-5	1,077	1.0	36.4	1,100	39,300
		Subtotal		**4,286**	**2.0**	**23.6**	**8,500**	**101,000**

Table 3.3: Broward County Segment III beach volume changes (Feb 2006 to April 2011).

		Monument		Length	Average Volume Change (cy/ft)		Volume Change (cy)	
		North	South	(ft)	Above MLW	Total Profile	Above MLW	Total Profile
SEGMENT III	JUL Project	R-85.7	R-86	160	-26.0	-56.3	-4,200	-9,000
		R-86	R-87	1,051	-46.2	-78.0	-48,500	-82,000
		R-87	R-88	940	-53.5	-83.0	-50,300	-78,000
		R-88	R-89	994	-33.0	-49.2	-32,800	-48,900
		R-89	R-90	964	-11.3	-14.8	-10,800	-14,200
		R-90	R-91	1,007	-3.5	1.3	-3,500	1,300
		R-91	R-92	1,032	4.1	13.1	4,300	13,500
		Subtotal		**6,148**	**-23.7**	**-35.3**	**-145,800**	**-217,300**
	JUL South	R-92	R-93	1,042	10.4	17.5	10,800	18,200
		R-93	R-94	967	7.6	14.1	7,300	13,600
		R-94	R-95	955	6.9	11.9	6,600	11,400
		R-95	R-96	986	4.0	11.2	3,900	11,000
		R-96	R-97	962	3.7	16.9	3,600	16,200
		R-97	R-98	1,069	3.9	11.9	4,200	12,800
		R-98	R-98.3	300	-1.2	-0.1	-400	0
		Subtotal		**6,280**	**5.7**	**13.2**	**36,000**	**83,200**
	Hollywood / Hallandale / Dania	R-98.3	R-99	641	-6.7	-11.2	-4,300	-7,200
		R-99	R-100	993	-8.9	-21.5	-8,800	-21,300
		R-100	R-101	1,147	-6.8	-20.9	-7,800	-24,000
		R-101	R-102	1,004	-3.6	-0.1	-3,600	-100
		R-102	R-103	1,022	-3.0	4.8	-3,000	4,900
		R-103	R-104	1,029	-5.3	-9.8	-5,500	-10,100
		R-104	R-105	991	-3.7	-5.6	-3,700	-5,600
		R-105	R-106	992	2.5	4.3	2,400	4,300
		R-106	R-107	967	2.4	-2.0	2,400	-1,900
		R-107	R-108	1,029	-0.3	0.4	-300	400
		R-108	R-109	1,040	-0.7	5.7	-700	5,900
		R-109	R-110	1,034	-1.9	9.2	-2,000	9,500
		R-110	R-111	995	-0.8	19.6	-800	19,500
		R-111	R-112	1,029	-2.3	22.6	-2,300	23,200
		R-112	R-113	931	-7.7	12.7	-7,200	11,900
		R-113	R-115	974	-8.0	6.3	-7,800	6,100
		R-115	R-115	1,047	-5.2	12.6	-5,400	13,200
		R-115	R-116	1,012	-7.3	-4.6	-7,400	-4,700
		R-116	R-117	992	-7.6	-10.3	-7,500	-10,200
		R-117	R-118	1,081	-6.6	-7.3	-7,100	-7,900
		R-118	R-119	1,003	-10.1	-15.5	-10,100	-15,600
		R-119	R-120	1,113	-10.7	-8.8	-11,900	-9,800
		R-120	R-121	1,089	-12.6	-9.4	-13,700	-10,300
		R-121	R-122	1,000	-14.6	-6.8	-14,600	-6,800
		R-122	R-123	1,019	-18.0	-8.8	-18,300	-9,000
		R-123	R-124	1,107	-21.2	-25.0	-23,400	-27,600
		R-124	R-125	1,083	-15.2	-18.0	-16,400	-19,500
		R-125	R-126	1,001	-14.3	-18.1	-14,300	-18,100
		R-126	R-127	1,017	-12.8	-11.0	-13,000	-11,200
		R-127	R-128	933	-6.1	10.3	-5,600	9,600
		Subtotal		**30,312**	**-7.3**	**-3.7**	**-221,700**	**-112,400**
TOTAL				**42,740**	**-7.8**	**-5.8**	**-331,500**	**-246,500**
	Miami-Dade	R-128	D-2	1,035	-3.3	0.8	-3,400	800
		D-2	D-3	1,103	1.2	2.2	1,300	2,500
		D-3	D-4	1,071	0.2	13.4	200	14,300
		D-4	D-5	1,077	-2.3	14.8	-2,500	15,900
		Subtotal		**4,286**	**-1.0**	**7.8**	**-4,400**	**33,500**

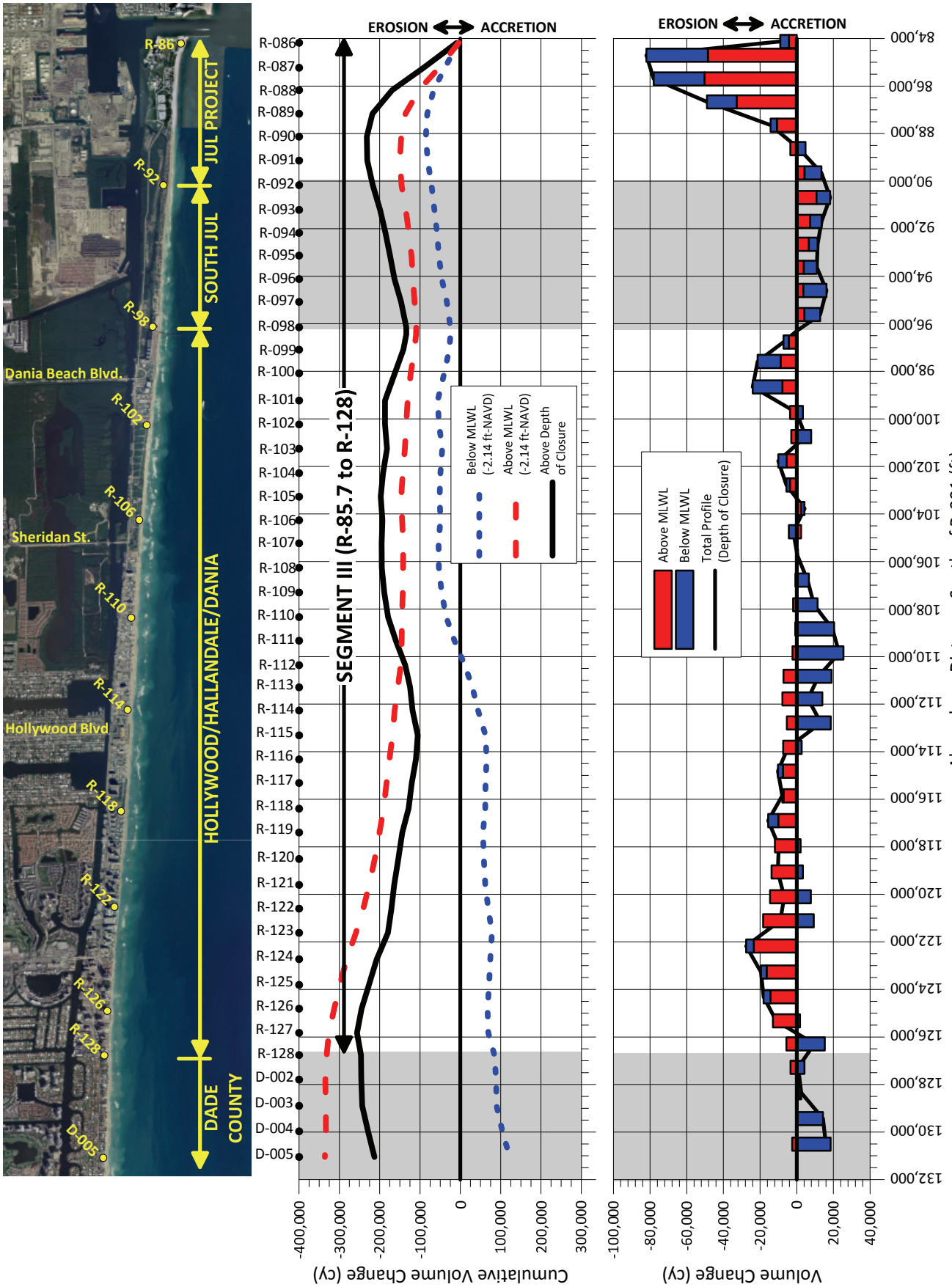


Figure 3.4: Segment III cumulative and local beach volume change between **February 2006 and April 2011**.

From February 2006 to April 2011, the JUL project shoreline (6,150 feet in length) lost roughly 217,300 cy of sand, the equivalent of about 41,800 cy/yr, over the 5.2 year post-project period. This is approximately 21.5 percent lower than the sand loss rate expected from design predictions. Most of the sand losses occurred in the northern two-thirds of the project shoreline (232,100 cy lost from R-85.7 to R-90, and 14,800 cy gained from R-90 to R-92). As of April, 2011, a sand volume equivalent to approximately 354,300 cy or 62.2 percent of the documented sand volume increase along the JUL during the 2005/06 construction year remained along the JUL project shoreline.

Along the unnourished beach along the southern JUL shoreline (6,280 feet in length), there was a net gain of 83,200 cy over the 62-month period between February 2006 and April 2011, with accretion occurring both above and below the MLWL. A portion of this gain in the total profile can be attributed to the continued diffusion of sand from the JUL project area. Each transect experienced accretion over total profile, with volume changes over the total profile varying from over 18 cy/ft gained at R-97 to nearly 6 cy/ft gained at R-98.

Along the HHD project shoreline (30,310 feet in length), the project area lost 112,400 cy of sand, the equivalent of about 21,600 cy/yr, over the 5.2 year post-project monitoring period between February 2006 and April 2011. This is approximately 80.0 percent lower than the sand loss rate expected from design predictions. Inspection of localized beach volume changes however, indicates a variety of beach change conditions over the 5.2 year period. The loss is made up of erosion of 221,700 cy of sand above the MLWL with an accompanying accretion of 109,300 cy below it down to the seaward limit of the sand beach profile. As of April 2011, a sand volume equivalent to approximately 1,280,300 cy or 90.5 percent of the documented sand volume increase along the HHD during the 2005/06 construction year remained along the HHD project shoreline. Although the average performance of the HHD project area is well above expectations, areas such as those along southern Hollywood and Hallandale have experience sand loss rates generally consistent with or slightly than expectations.

A possible explanation for the lower than predicted sand loss rates for the first five post-construction years could be that improvements in fill density distribution – compared to those for the 1991 project upon which the expected sand loss rates were developed -- and the addition of terminal tapers may be more effective than expected. Also, sand losses from the southern reaches of the project that may have occurred between fill placement completion and the February 2006 post-construction survey would not be captured through comparison of the February 2006 and subsequent surveys. That is, some areas along the HHD shoreline completed construction as much as nine months

prior to the February 2006 survey. It is believed that the below average storm conditions since the completion of the 2005/06 project and recovery of the beach system from the effects of the 2004 and 2005 hurricane season has contributed to the lower than expected sand loss rates. These factors are also believed to be related to the significant re-exposure of nearshore hardbottom along the Segment III shoreline over the same time period.

4.0 BEACH MONITORING RESULTS (April 2009 to April 2011)

This section summarizes the shoreline and beach volume changes along the three Broward County beach Segments for the period between April 2009 and April 2011, three to five years following construction of the Segment III project. In the following discussion, shoreline and beach volume conditions and recent changes are presented individually for each of the three Broward County shoreline segments. Segment III is presented initially as this details the changes associated with the Shore Protection Project constructed along that shoreline in 2005/06.

4.1 SEGMENT III

4.1.1 MHW Shoreline Position Change

Table 4.1 summarizes the measured MHWL (+0.41 ft-NAVD88) change that occurred between April 2009 and April 2011 along the Segment III shoreline. **Figure 4.1** presents these same results graphically and also presents the local volume changes at each beach profile station along the Segment III shoreline. The volume changes at each station are presented for beach sections above and below the MHWL. As expected some correlation between localized volume change above the MHWL and change in the MHWL location is evident in the figure. **Figure 4.2** depicts the surveyed locations of the MHWL for the JUL and HHD project shorelines relative to the March 2005 (pre-construction) position (*top*) and the Erosion Control Line (ECL) (*bottom*). The representation of the MHWL location in this format provides an opportunity to evaluate the April 2011 shoreline position relative to the two noted benchmark conditions.

Over the 24-month monitoring period between April 2009 and April 2011, (nominally three to five years post-construction of Segment III), the MHWL along the entire Segment III shoreline advanced, on average, about 7 feet. This average advance, however, was the product of highly varied local MHWL changes along the Segment III shoreline. MHWL changes along this area varied from 37 ft of recession at R-123 (southern Hollywood) to 46 ft of advancement at R-106 (central Hollywood).

Table 4.1: Broward County – Segment III shoreline change for the April 2009 to April 2011 monitoring period as measured at the MHWL (+0.41 ft-NAVD88).

Mon.	Distance from R-Monument (ft) April 2009	Distance from R-Monument (ft) April 2011	Δ (ft)	Mon.	Distance from R-Monument (ft) April 2009	Distance from R-Monument (ft) April 2011	Δ (ft)
R-85.7	200.6	203.6	3.0	R-103	228.0	234.5	6.6
R-86	91.1	86.8	-4.3	R-104	211.3	227.1	15.8
R-86.3	201.4	199.4	-1.9	R-105	223.1	245.9	22.8
R-86.5	342.8	343.6	0.8	R-106	172.0	218.2	46.2
R-86.7	211.9	196.8	-15.2	R-107	192.8	211.1	18.3
R-87	404.7	386.6	-18.1	R-108	146.8	169.1	22.3
R-87.2	192.2	166.0	-26.2	R-109	145.8	172.7	26.9
R-87.5	195.6	171.3	-24.3	R-110	156.8	152.5	-4.3
R-87.7	312.6	293.5	-19.1	R-111	221.7	211.4	-10.3
R-88	418.6	399.0	-19.6	R-112	226.2	194.6	-31.6
R-88.2	305.2	285.1	-20.1	R-113	152.0	190.5	38.5
R-88.5	188.2	178.1	-10.1	R-115	194.5	186.6	-7.8
R-89	342.1	354.4	12.3	R-115	160.4	179.6	19.2
R-89.5	309.4	321.6	12.2	R-116	194.3	200.7	6.4
R-90	345.4	358.6	13.2	R-117	243.0	237.2	-5.8
R-90.5	216.8	228.7	11.9	R-118	230.1	221.4	-8.7
R-91	259.2	260.4	1.2	R-119	190.6	196.1	5.5
R-91.5	130.1	135.8	5.7	R-120	148.1	143.0	-5.1
R-92	205.9	224.3	18.4	R-121	76.7	79.0	2.4
R-92.5	98.8	117.7	18.9	R-122	77.5	63.7	-13.9
R-93	207.9	228.4	20.4	R-123	114.5	77.2	-37.4
R-94	154.4	169.3	14.9	R-124	191.6	217.6	26.0
R-95	186.0	201.6	15.7	R-125	303.4	297.2	-6.2
R-96	171.8	178.1	6.3	R-126	121.1	119.2	-1.9
R-97	254.7	273.6	18.9	R-127	77.7	120.1	42.4
R-98	200.7	231.1	30.4	R-128	129.7	125.4	-4.3
R-99	117.4	116.7	-0.8	D-2	119.8	131.1	11.3
R-100	132.0	134.8	2.8	D-3	157.6	154.9	-2.7
R-101	120.3	130.5	10.2	D-4	222.7	280.4	57.7
R-102	209.8	226.5	16.8	D-5	165.1	120.7	-44.4

WEIGHTED AVERAGE: John U. Lloyd Project (R-85.7 to R-92)	-1.3
WEIGHTED AVERAGE: John U. Lloyd South (R-92 to R-98.3)	16.8
WEIGHTED AVERAGE: Hollywood/Hallandale/Dania (R-98.3 to R-128)	6.4
WEIGHTED AVERAGE: SEGMENT III (R-85.7 to R-128)	6.8
WEIGHTED AVERAGE: Miami-Dade (R-128 to D-5)	10.5

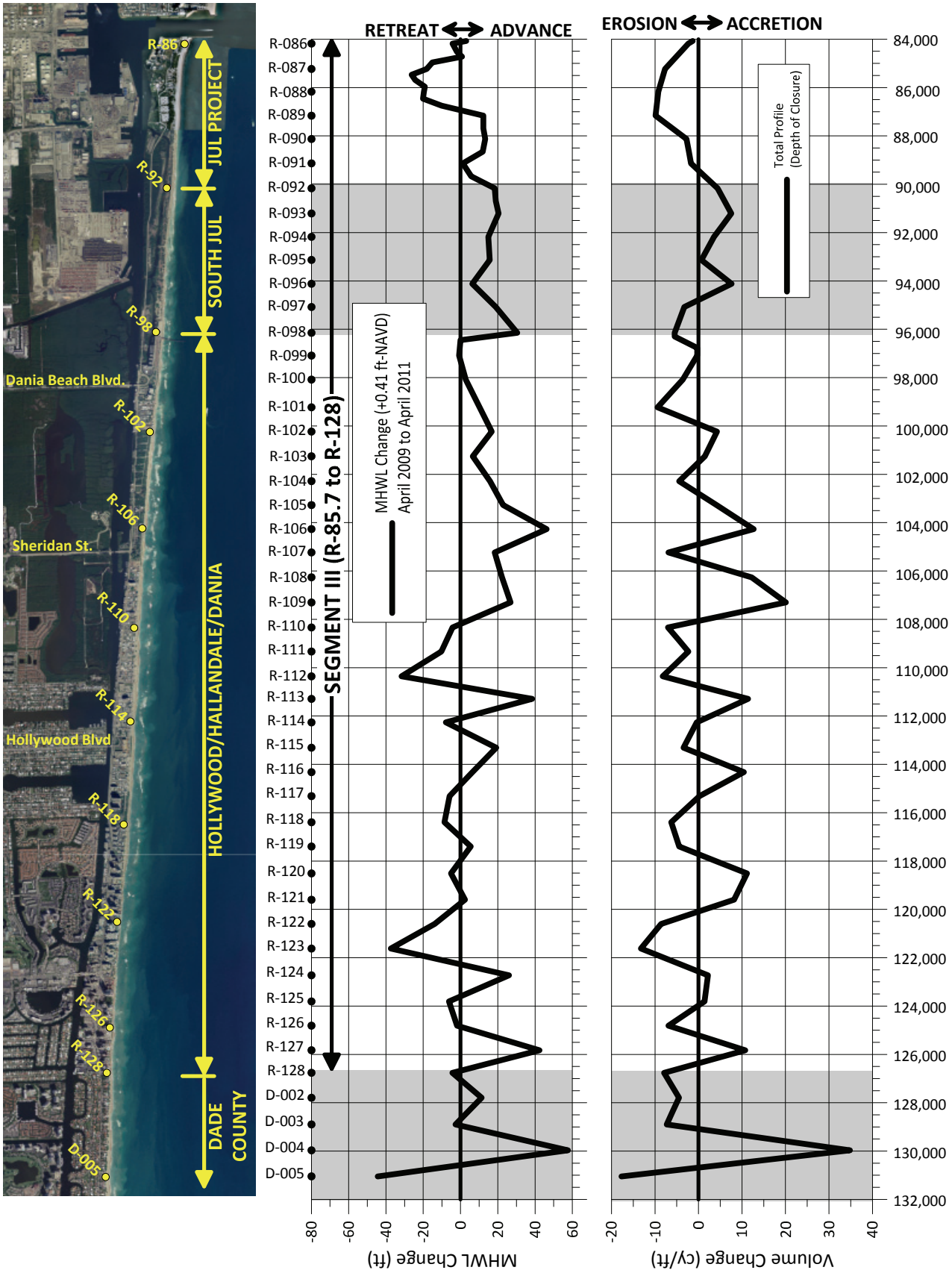


Figure 4.1: Segment III MHW shoreline and volume change for the inter-survey period **April 2009 to April 2011**.

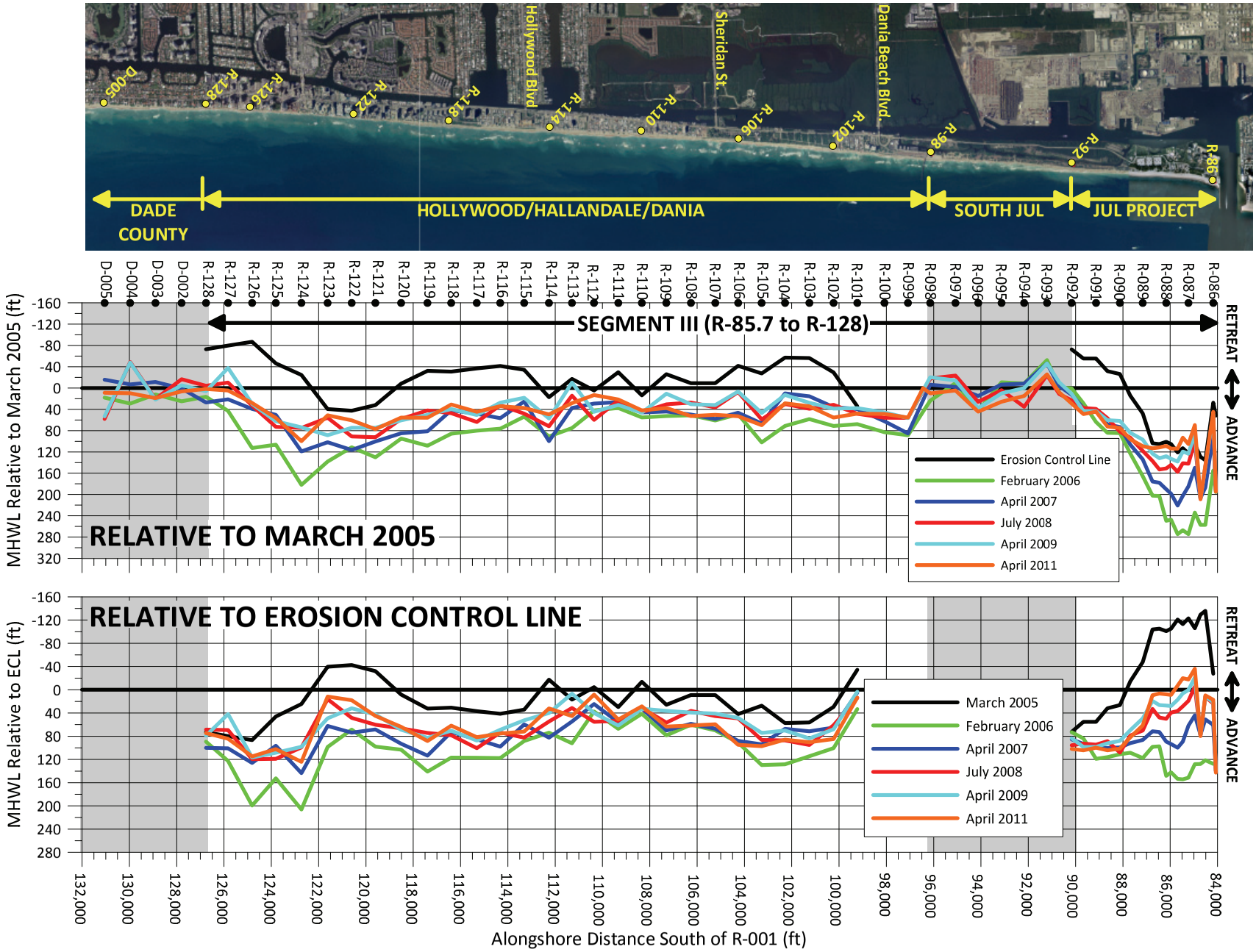


Figure 4.2: Segment III MHW shoreline locations **relative to the March 2005** (pre-construction) **and the Erosion Control Line** (ECL).

Over the same period, the MHWL within the JUL project area (R-85.7 to R-92) receded by an average of just over 1 ft, but shoreline change within this project reach also varied from recession of 26 ft at R-87.2 (just south of the groin field) to an advance of 18 feet at R-92 (southern project limit).

Shoreline change patterns between April 2009 and April 2011 reveal shoreline stability along the northernmost 700 feet of the JUL project area, the beach influenced most by the groin field. Some scarping of the beach is this area, however, was observed around the time of the April 2011 survey (see **Figure 4.3**). Immediately south of the structures, the shoreline receded about 19 ft, on average, along the area from R-86.5 to R-88.5. Along the southern end of the JUL project area, from R-89 to R-92, the shoreline was relatively stable to accretional, averaging about 13 ft of seaward advance. This accretion was likely due to the continued loss of sand from the beach to the north.

Figure 4.3: Beach conditions within the JUL groin field on 1 November 2010, depicting significant scarping in the northern and southern cells of the field (looking south). Shown at the bottom of the photo are the sink holes that have developed along the south side of the Port Everglades south jetty.

The MHWL position along the unnourished southern area of John U. Lloyd Beach State Park (R-92 to R-98.3) experienced average shoreline advance of nearly 17 ft during the April 2009 to April 2011 monitoring period. Note that this reach of shoreline did not receive direct sand placement as part of the 2005/06 project. Shoreline advance along this stretch was fairly consistent, with a maximum advance of over 30 ft at R-98 and a minimum advance of 6 ft at R-96. This average advance follows the previous monitoring period, during which this reach of shoreline receded by 6 ft, on average.

The Hollywood/Hallandale/Dania (HHD) project area (R98.3 to R128) occupies the remainder of the Segment III shoreline. Over the most recent 24-month monitoring period (April 2009 to April 2011), the MHWL along the HHD project shoreline advanced by an average of over 6 feet. Localized MHWL change varied from 37 ft at R-123 (southern Hollywood) of recession to 46 ft of advance at R-106 (central Hollywood). At R-122, adjacent to the point R-123 were the most recession was occurred, the MHW shoreline advanced by 26 ft. The variable shoreline observed is attributed to migrating bar formation alongshore and beach reshaping following the highly variable conditions that existed at the time of the April 2009 survey (Olsen Associates, Inc./CPE, 2009).

4.1.2 Beach Volume Change

Segment III beach volume changes as computed from comparison of the April 2009 (three-year post-construction) and April 2011 (five-year post-construction) surveys are summarized in **Table 4.2**. Also included in the table are the volume changes along the northern Miami-Dade County shoreline. **Figure 4.5** presents the local and cumulative beach volume changes, in cubic yards (cy), along the Segment III shoreline for the 24-month inter-survey period. The beach profile surveys document beach conditions along the entire Segment III shoreline, not just along the specific project fill reaches. Accordingly, comparison of these surveys captures potential project related changes from the Port Everglades south jetty to south of the Miami-Dade County line.

Volume changes were calculated from the back beach -- where the fill berm intersected the existing upland contour or seaward edge of vegetation -- to the seaward edge of sandy beach profile -- the beach toe/nearshore hardbottom interface[5]. Volume changes were also calculated above and below the Mean Low Water Line (MLWL) to demonstrate the cross-shore variation in sand volume changes.

In sum, the 42,740 feet of Segment III shoreline experienced a net accretion of only 4,200 cy over the 24-month period between April 2009 and April 2011. Inspection of the localized beach volume changes, however, indicates a variety of localized gross beach changes over the 24-month period.

From April 2009 to April 2011, the JUL project shoreline (6,150 feet in length) lost roughly 30,100 cy, most of it from the northern two-thirds of the project shoreline (28,900 cy lost from R-86 to R-90). As has been observed in past beach fill projects at JUL, it does not appear that a significant amount of cross-shore sand transport occurred over the post-construction period. Rather, sand volume is lost from across the entire beach profile at all but the most southern reaches of the project, where accretion occurred above MLW. While volume was gained above the MLWL from R-90 through R-92, each profile lost sand between MLW and the seaward limit of the project (R-92 is the only profile to experience a net gain over the total profile.

[5] The location of the nearshore edge of hardbottom used as the seaward beach volume computational limit was estimated from comparison of historical beach profile surveys and pre-and post-beach fill nearshore edge surveys. The computational limits for each profile are summarized in **Appendix A**.

Table 4.2: Broward County – Segment III beach volume changes (April 2009 to April 2011).

		Monument		Length	Average Volume Change (cy/ft)		Volume Change (cy)	
		North	South	(ft)	Above MLW	Total Profile	Above MLW	Total Profile
SEGMENT III	JUL Project	R-85.7	R-86	160	-0.8	-1.8	-100	-300
		R-86	R-87	1,051	-3.4	-5.0	-3,500	-5,300
		R-87	R-88	940	-4.7	-8.5	-4,400	-8,000
		R-88	R-89	994	-2.9	-9.6	-2,900	-9,500
		R-89	R-90	964	0.5	-6.3	500	-6,100
		R-90	R-91	1,007	2.2	-2.2	2,200	-2,300
		R-91	R-92	1,032	3.4	1.3	3,500	1,400
		Subtotal		**6,148**	**-0.8**	**-4.9**	**-4,700**	**-30,100**
	JUL South	R-92	R-93	1,042	4.6	6.0	4,800	6,200
		R-93	R-94	967	4.3	5.6	4,200	5,400
		R-94	R-95	955	4.4	2.1	4,200	2,000
		R-95	R-96	986	4.3	4.1	4,300	4,100
		R-96	R-97	962	5.2	2.2	5,000	2,100
		R-97	R-98	1,069	6.0	-4.4	6,400	-4,700
		R-98	R-98.3	300	5.6	-5.5	1,700	-1,600
		Subtotal		**6,280**	**4.9**	**2.1**	**30,600**	**13,500**
	Hollywood / Hallandale / Dania	R-98.3	R-99	641	3.2	-0.3	2,100	-200
		R-99	R-100	993	1.7	-2.0	1,700	-1,900
		R-100	R-101	1,147	1.4	-6.5	1,600	-7,500
		R-101	R-102	1,004	4.0	-2.6	4,000	-2,600
		R-102	R-103	1,022	3.4	2.9	3,500	2,900
		R-103	R-104	1,029	3.8	-1.5	3,900	-1,500
		R-104	R-105	991	5.2	-0.1	5,100	-100
		R-105	R-106	992	8.0	8.4	7,900	8,400
		R-106	R-107	967	7.1	2.9	6,900	2,800
		R-107	R-108	1,029	4.2	2.7	4,300	2,700
		R-108	R-109	1,040	6.3	16.2	6,500	16,800
		R-109	R-110	1,034	2.0	6.5	2,100	6,800
		R-110	R-111	995	-2.3	-4.7	-2,300	-4,600
		R-111	R-112	1,029	-6.3	-5.3	-6,400	-5,400
		R-112	R-113	931	-0.2	1.6	-200	1,500
		R-113	R-115	974	3.6	5.5	3,500	5,300
		R-115	R-115	1,047	-0.4	-1.9	-400	-2,000
		R-115	R-116	1,012	3.1	3.5	3,100	3,500
		R-116	R-117	992	1.3	5.4	1,300	5,300
		R-117	R-118	1,081	-0.3	-3.0	-400	-3,200
		R-118	R-119	1,003	2.1	-5.4	2,100	-5,400
		R-119	R-120	1,113	0.9	3.3	1,000	3,700
		R-120	R-121	1,089	-0.5	9.7	-600	10,500
		R-121	R-122	1,000	-1.8	-0.2	-1,800	-200
		R-122	R-123	1,019	-5.6	-10.9	-5,700	-11,100
		R-123	R-124	1,107	1.6	-5.5	1,800	-6,100
		R-124	R-125	1,083	3.9	1.8	4,200	1,900
		R-125	R-126	1,001	-1.2	-2.8	-1,200	-2,800
		R-126	R-127	1,017	5.3	1.9	5,400	2,000
		R-127	R-128	933	5.9	1.4	5,500	1,300
		Subtotal		**30,312**	**1.9**	**0.7**	**58,500**	**20,800**
	TOTAL			**42,740**	**2.0**	**0.1**	**84,400**	**4,200**
Miami-Dade		R-128	D-2	1,035	1.8	-6.2	1,900	-6,400
		D-2	D-3	1,103	1.0	-5.9	1,100	-6,500
		D-3	D-4	1,071	7.6	13.8	8,200	14,700
		D-4	D-5	1,077	-2.2	8.6	-2,300	9,200
		Subtotal		**4,286**	**2.1**	**2.6**	**8,900**	**11,000**

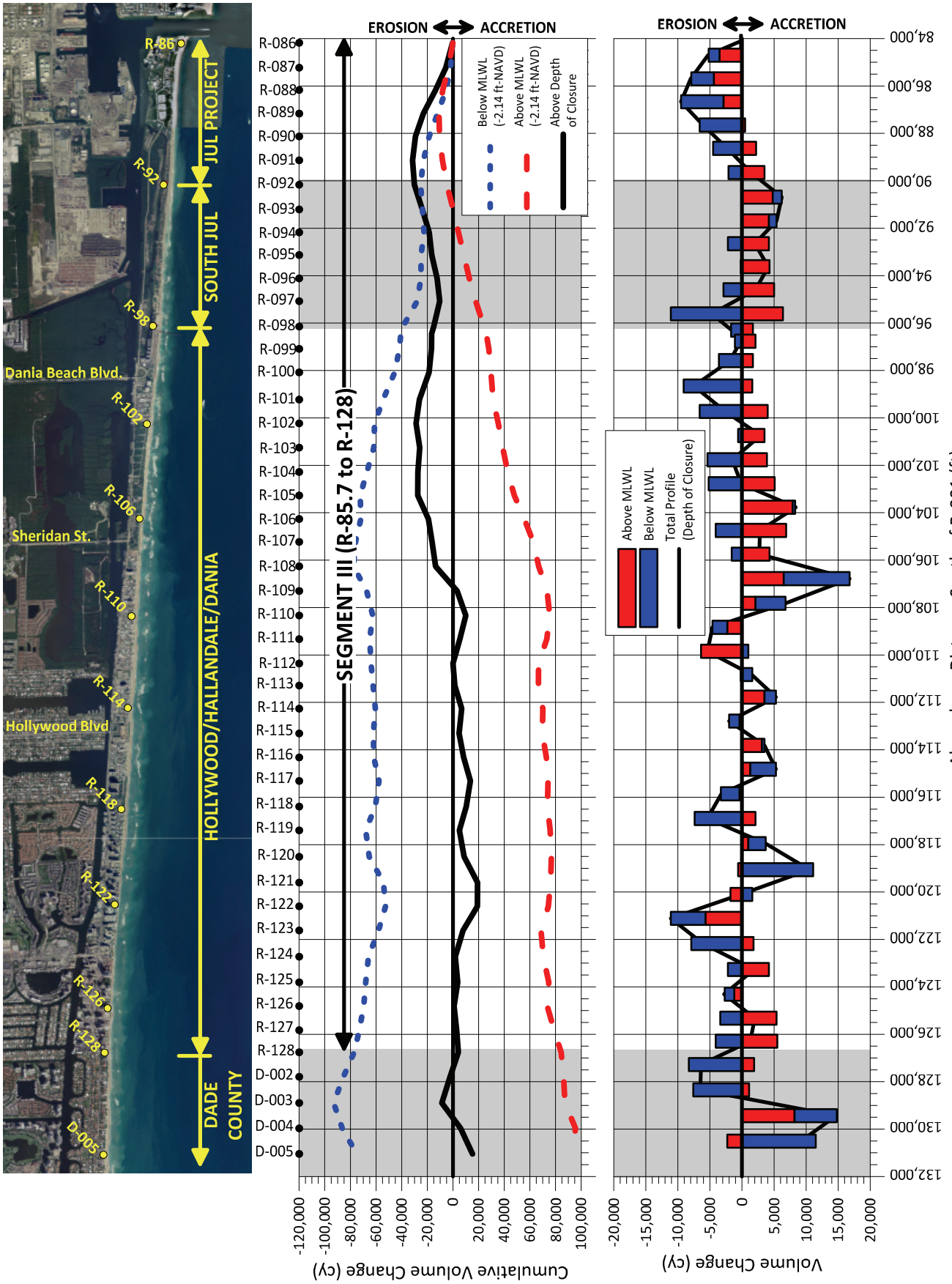


Figure 4.5: Segment III cumulative and local beach volume change between **April 2009 and April 2011**.

Along the unnourished beach along the southern JUL shoreline (6,280 feet in length), there was a net gain of 13,500 cy over the 24-month period between April 2009 and April 2011. The net gain was a balance of 30,600 cy gained above the MLWL and 17,100 cy lost below this elevation, a cross shore transport tending to steepen the beach. A portion of this gain in the total profile can be attributed to the continued diffusion of sand from the JUL project area. Volume changes over the total profile varied from 6 cy/ft gained at R-92 to nearly 6 cy/ft lost at R-98.

Along the HHD project shoreline (30,310 feet in length), the beach accreted by a volume of 20,800 cy over the inter-survey period between April 2009 and April 2011. Inspection of localized beach volume changes, however, indicates a variety of beach change conditions over the 24-month period. The small gain included a gain of 58,500 cy of sand above the MLWL with an accompanying loss of 37,700 cy below it down to the seaward limit of the sand beach profile. Volume changes varied from a 11 cy/ft loss at R-122 (southern Hollywood) to 16 cy/ft gained at R-108 (central Hollywood).

The observed gain of sand above the MLWL and the corresponding loss of sand below this elevation is indicative of low-wave energy recovery, causing steepening of the beach profile. Inspection of individual profiles reveals the presence of this trend at a few monitoring stations, but it is not seen consistently along the project reach. Instead, the variable change of beach volume measured appears to be the shifting sands of beach cusps and other alongshore-variable rhythmic nearshore features. Such features were widely prominent in 2009 along the HHD shoreline (Olsen Associates, Inc./CPE, 2009).

At minimal sand volume loss of 11,000 cy was observed to the south along the northern 4,300-ft reach of Miami-Dade County shoreline (R-128 to D-5). Since completion of the 2005/06 Broward County project (February 2006 to April 2011), this shoreline has gained approximately 33,500 cy (+8 cy/ft, on average). Alongshore sand diffusion and sand losses from the Hollywood and Hallandale beaches is believed to be the principal reason for any observed accumulation of sand along the northern Miami-Dade County shoreline.

4.2 SEGMENT II

This section of the report discusses the shoreline and beach volume changes which occurred along the Broward County Segment II shoreline during the most recent 24-month physical monitoring inter-survey period (April 2009 to April 2011). The overall changes for Segment II are presented along with the changes which occurred along four sub-reaches of the Segment II shoreline. These sub-reaches generally represent the extent of shoreline occupied by the major shorefront municipalities in Segment II. These include (1) Pompano Beach (R-25 to R-40.5), (2) Lauderdale-by-the-Sea (R-40.5 to R-53.3), northern Fort Lauderdale (FLL) (R-53.3 to R-74), and southern Fort Lauderdale (R-74 to the Port Everglades north jetty (R-84.7)). The shoreline changes along the 200 feet of Sea Ranch Lakes shoreline (between R-46 and R-47) are incorporated into the Lauderdale-by-the-Sea results.

4.2.1 MHW Shoreline Position Change

Table 4.3 summarizes and **Figure 4.10** depicts the measured changes at the MHWL (+0.41 ft-NAVD88) that occurred between April 2009 and April 2011. The volume changes at each station are presented for beach sections above and below the MHWL. As expected some correlation between localized volume change above the MHWL and change in the MHWL location is evident in the figure. **Figure 4.11** depicts the surveyed locations of the MHW position for the Segment II shoreline relative to the March 2005 condition (pre-construction - Segment III project).

Over the 24-month monitoring period, between April 2009 and April 2011 (the period that is between three and five years following completion of the Segment III project construction), the MHWL along the entire Segment II shoreline advanced, on average, about 9 feet. This average advance, however, resulted from a wide range of MHWL changes at individual transects along the Segment II shoreline. **Table 4.3** and **Figure 4.10** demonstrates the variability of MHW shoreline changes over the noted period. While shoreline change, in general, varied considerably from transect to transect, fairly consistent shoreline advance was observed across Lauderdale-by-the-Sea and in Pompano Beach (with the exception of very northern Pompano Beach adjacent to Hillsboro Inlet, which saw significant erosion). Local MHWL changes along the Fort Lauderdale shoreline were, with few exceptions, generally less than 15 ft.

Table 4.3: Broward County – Segment II shoreline change for the April 2009 to April 2011 monitoring period as measured at the MHWL (+0.41 ft-NAVD88).

Mon.	Distance from R-Monument (ft) April 2009	Distance from R-Monument (ft) April 2011	Δ (ft)	Mon.	Distance from R-Monument (ft) April 2009	Distance from R-Monument (ft) April 2011	Δ (ft)
R-25	210.7	136.4	-74.3	R-60	103.3	113.0	9.7
R-26	225.9	195.2	-30.7	R-61	118.1	126.6	8.5
R-27	183.7	204.8	21.0	R-62	208.1	208.9	0.9
R-28	341.5	346.9	5.4	R-63	107.7	120.8	13.0
R-29	391.8	406.3	14.5	R-64	75.8	82.3	6.6
R-30	372.2	393.4	21.3	R-65	98.1	96.7	-1.4
R-31	369.8	374.3	4.5	R-66	73.4	79.5	6.2
R-32	405.7	427.1	21.4	R-67	86.0	98.7	12.6
R-33	422.2	432.2	10.1	R-68	224.8	235.2	10.5
R-34	407.7	410.6	2.8	R-69	219.2	218.7	-0.4
R-35	303.5	318.5	15.0	R-70	148.5	142.1	-6.4
R-36	278.4	278.4	-0.1	R-71	199.7	208.6	8.9
R-37	226.9	238.2	11.3	R-72	180.7	184.9	4.2
R-38	170.1	186.6	16.5	R-73	151.2	154.2	3.0
R-39	138.0	156.8	18.8	R-74	191.5	198.5	6.9
R-40	193.3	194.7	1.4	R-75	212.1	220.0	7.9
R-41	184.3	188.6	4.3	R-76	227.4	229.3	1.9
R-42	172.6	191.8	19.2	R-77	250.2	264.7	14.5
R-43	231.9	234.2	2.3	R-78	250.7	258.0	7.2
R-44	278.4	293.6	15.2	R-79	408.6	419.8	11.2
R-45	328.2	341.1	12.9	R-80	356.2	362.0	5.8
R-46	212.4	226.1	13.6	R-81	340.3	354.7	14.3
R-47	286.6	315.1	28.5	R-81.3	309.0	329.2	20.2
R-48	292.7	333.1	40.4	R-81.7	391.9	391.5	-0.4
R-49	247.8	261.8	14.0	R-82	413.8	405.4	-8.3
R-50	152.2	164.0	11.8	R-82.3	427.8	418.7	-9.1
R-51	136.1	152.3	16.2	R-82.7	416.4	426.1	9.6
R-52	138.4	158.9	20.5	R-83	535.8	547.9	12.1
R-53	94.6	102.9	8.3	R-83.3	712.3	718.9	6.5
R-54	68.8	89.3	20.6	R-83.7	684.9	702.3	17.4
R-55	76.9	97.8	20.8	R-84	416.1	422.7	6.6
R-56	106.4	117.7	11.3	R-84.3	359.9	361.1	1.3
R-57	100.4	117.6	17.2	R-84.7	158.0	166.0	8.0
R-58	110.3	106.7	-3.6	R-85	177.2	122.5	-54.7
R-59	65.6	67.4	1.8				

WEIGHTED AVERAGE: Pompano Beach (R-25 to R-40)	7.4
WEIGHTED AVERAGE: Lauderdale by the Sea (R-40 to R-53)	16.3
WEIGHTED AVERAGE: North Fort Lauderdale (R-53 to R-74)	7.3
WEIGHTED AVERAGE: South Fort Lauderdale (R-74 to R-84.7)	7.7
WEIGHTED AVERAGE: SEGMENT II (R-25 to D-84.7)	9.3

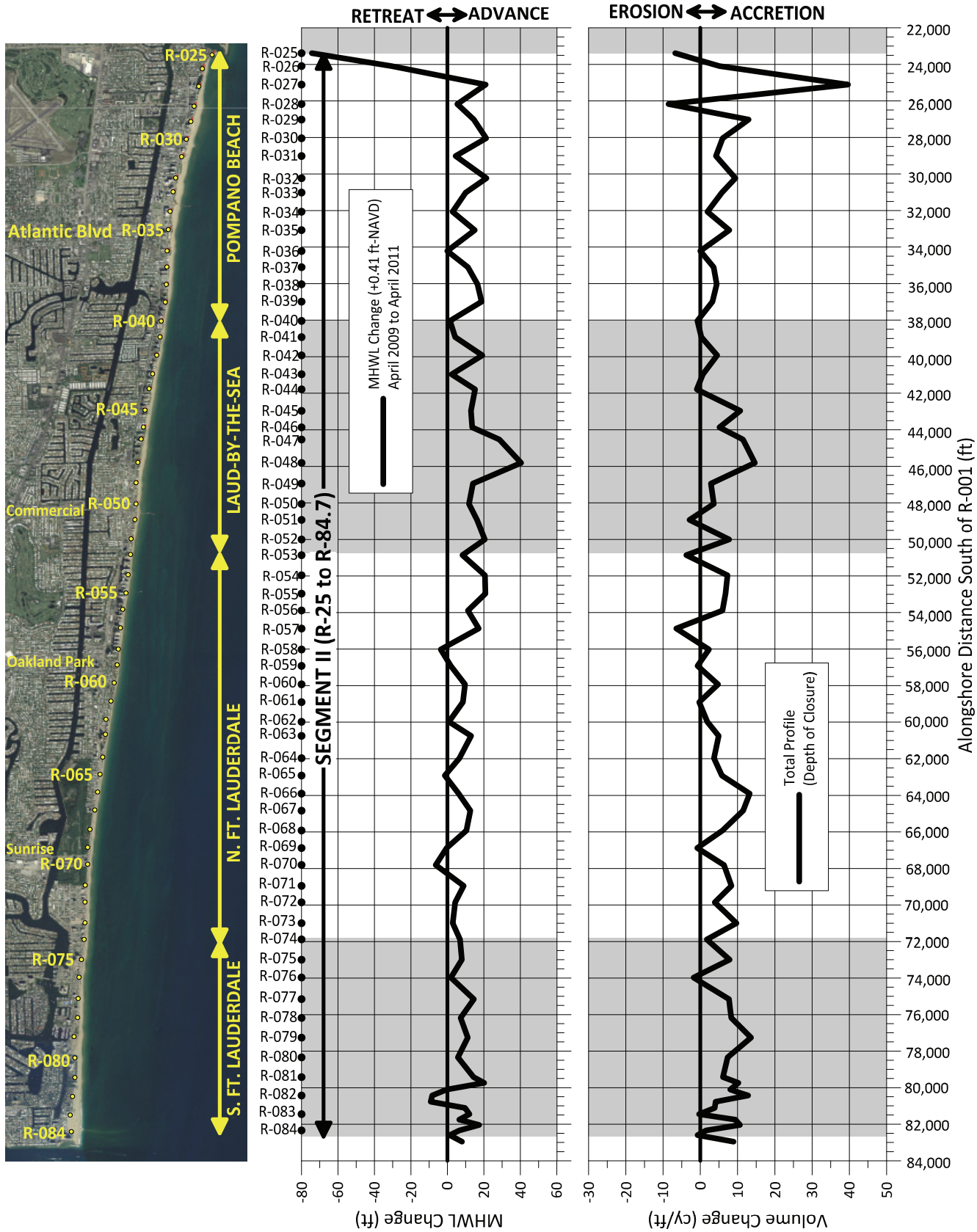


Figure 4.10: Segment II MHW shoreline and volume change for the inter-survey period **April 2009 to April 2011**.

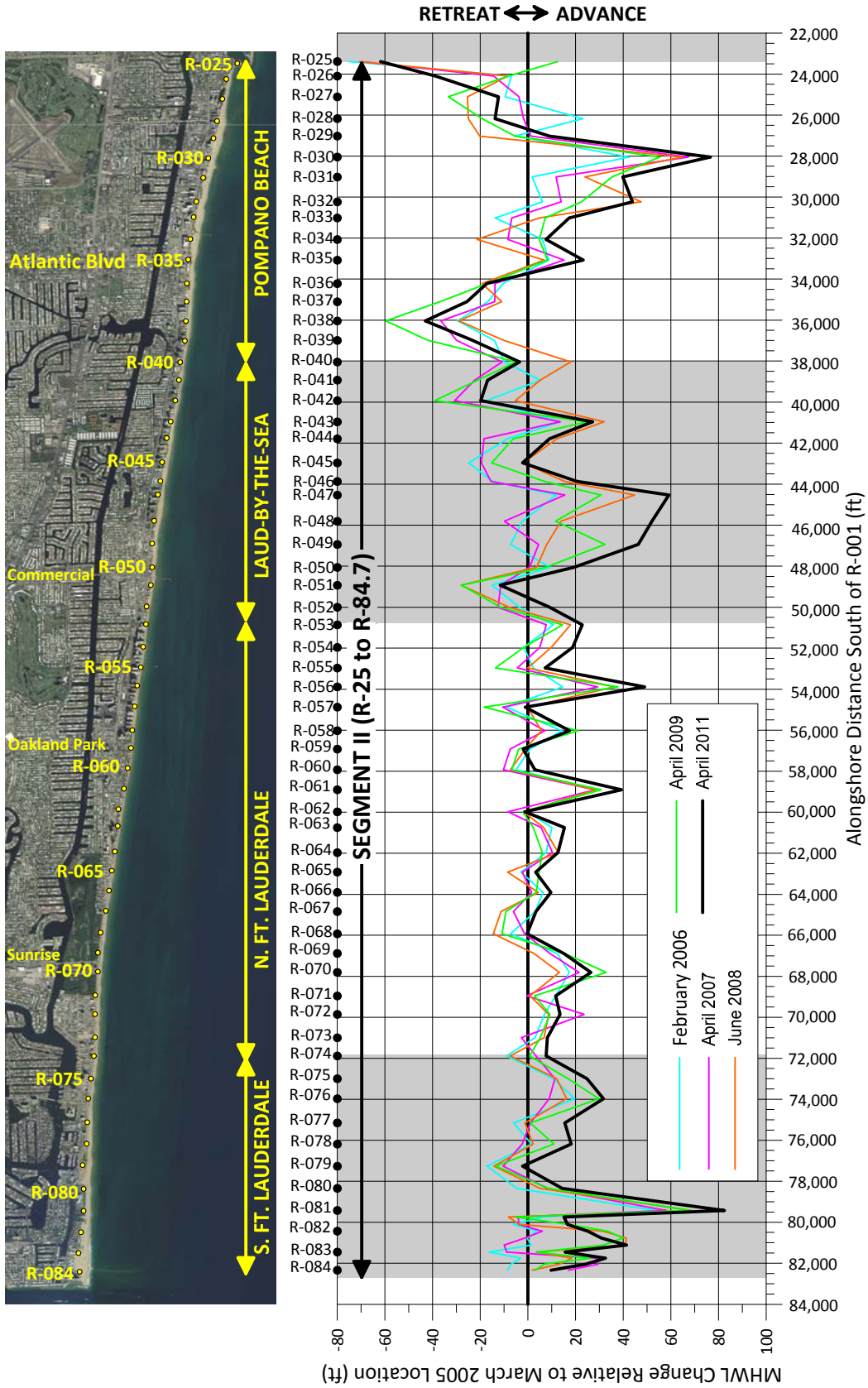


Figure 4.11: Segment II MHW shoreline locations relative to the March 2005 (pre-construction Segment III).

4.2.2 Beach Volume Change

Table 4.4 summarizes the Segment II beach volume changes as computed through comparison of the April 2009 and April 2011 surveys. **Figure 4.12** presents the local and cumulative beach volume changes, in cubic yards, along the Segment II shoreline for the same period.

Over the 24-month period between April 2009 and April 2011, the 59,560 feet of Segment II shoreline gained a net total of 315,000 cy of sand (over 5 cy/ft), on average. This gain was the balance of about 203,000 cy of accretion above the MLWL and 112,000 cy of sand volume gained between the MLWL and the estimated seaward limit of the sand beach profile. In Segment II, like Segment III, the seaward limit of the sand beach profile is generally the sand/rock interface and the edge of the nearshore hardbottom.

From April 2009 to March 2011[6], sand bypassing records indicate that about 36,050 cy of sand were bypassed across Hillsboro Inlet (**Appendix C**). According to historical records, the average bypass volume for this same period is about 81,110 cy. The averages are based upon the 1991 to 2011 dredging records (see **Appendix C**, **Table C.2**).

Along the Pompano Beach shoreline (14,650 feet in length), there was a total net sand volume gain of 92,900 cy (6 cy/ft) during this period. The total volume gain consisted of a 36,800 cy gained above the MLWL and a 56,100 cy gained between the MLWL and the seaward limit of the sand beach profile. It is noted that the large sand gains measured between R-26 and R-28 (+39,200 cy) contributed significantly to the documented gain during this period. The net increase in material here at the northern end of this segment is likely directly related to sand bypassing activities at Hillsboro.

[6] The total volume of sand bypassed between the two surveys was taken as the volume bypassed from the beginning of April 2009 through the end of March 2011. For the monitoring profiles along Segment I, the April 2009 survey was conducted in mid- to late-March while the April 2011 survey was conducted in late May.

Table 4.4: Broward County – Segment II beach volume changes (April 2009 to April 2011).

		Monument		Length	Average Volume Change (cy/ft)		Volume Change (cy)	
		North	South	(ft)	Above MLW	Total Profile	Above MLW	Total Profile
SEGMENT II	Pompano Beach	R-25	R-26	705	-11.8	-0.8	-8,300	-600
		R-26	R-27	1,014	-1.3	22.4	-1,300	22,700
		R-27	R-28	1,062	2.7	15.5	2,800	16,500
		R-28	R-29	852	1.5	2.2	1,200	1,900
		R-29	R-30	1,023	6.0	9.5	6,100	9,700
		R-30	R-31	972	5.2	5.1	5,100	4,900
		R-31	R-32	1,214	3.9	6.8	4,700	8,300
		R-32	R-33	785	4.1	7.6	3,200	6,000
		R-33	R-34	1,048	3.7	3.8	3,900	4,000
		R-34	R-35	1,008	4.4	4.8	4,500	4,900
		R-35	R-36	1,143	2.9	3.9	3,300	4,400
		R-36	R-37	886	2.2	1.8	2,000	1,600
		R-37	R-38	934	4.1	4.0	3,800	3,700
		R-38	R-39	952	4.1	3.8	3,900	3,600
		R-39	R-40	1,053	1.8	1.2	1,900	1,300
		Subtotal		**14,650**	**2.5**	**6.3**	**36,800**	**92,900**
	Lauderdale by the Sea	R-40	R-41	889	1.5	-0.3	1,300	-200
		R-41	R-42	997	3.8	2.4	3,800	2,400
		R-42	R-43	1,033	4.2	2.6	4,400	2,700
		R-43	R-44	826	4.0	-0.1	3,300	-100
		R-44	R-45	1,176	5.4	4.9	6,400	5,700
		R-45	R-46	904	6.5	7.9	5,900	7,100
		R-46	R-47	666	7.5	8.3	5,000	5,500
		R-47	R-48	1,279	10.6	13.0	13,500	16,700
		R-48	R-49	1,129	9.4	8.7	10,600	9,900
		R-49	R-50	1,118	6.2	3.2	6,900	3,600
		R-50	R-51	872	4.5	0.3	3,900	300
		R-51	R-52	1,074	4.2	2.4	4,600	2,600
		R-52	R-53	857	4.4	2.0	3,800	1,700
		Subtotal		**12,819**	**5.7**	**4.5**	**73,400**	**57,900**
	North Fort Lauderdale	R-53	R-54	1,100	3.7	1.8	4,100	1,900
		R-54	R-55	1,005	3.9	7.0	3,900	7,100
		R-55	R-56	921	3.1	6.3	2,900	5,800
		R-56	R-57	988	3.0	-0.3	3,000	-300
		R-57	R-58	1,147	3.0	-2.1	3,400	-2,400
		R-58	R-59	897	2.1	0.8	1,900	700
		R-59	R-60	1,008	2.7	2.0	2,700	2,000
		R-60	R-61	975	3.5	2.2	3,400	2,200
		R-61	R-62	1,076	2.2	0.8	2,400	800
		R-62	R-63	769	2.0	3.4	1,500	2,600
		R-63	R-64	1,221	2.9	4.3	3,500	5,200
		R-64	R-65	952	2.1	4.7	2,000	4,500
		R-65	R-66	988	1.8	9.5	1,800	9,400
		R-66	R-67	933	2.7	12.4	2,500	11,500
		R-67	R-68	1,085	3.6	8.7	3,900	9,500
		R-68	R-69	960	2.7	2.6	2,600	2,500
		R-69	R-70	925	1.3	2.8	1,200	2,600
		R-70	R-71	1,146	2.1	7.3	2,400	8,400
		R-71	R-72	901	2.4	6.1	2,200	5,500
		R-72	R-73	1,140	2.7	6.8	3,000	7,700
		R-73	R-74	887	3.9	5.7	3,400	5,100
		Subtotal		**21,025**	**2.7**	**4.4**	**57,700**	**92,300**

Continued on next page

Table 4.4 (continued): Broward County – Segment II beach volume changes (April 2009 to April 2011).

Continued from previous page

		Monument		Length	Average Volume Change (cy/ft)		Volume Change (cy)	
		North	South	(ft)	Above MLW	Total Profile	Above MLW	Total Profile
		Pompano Beach Subtotal		**14,650**	**2.5**	**6.3**	**36,800**	**92,900**
		Lauderdale by the Sea Subtotal		**12,819**	**5.7**	**4.5**	**73,400**	**57,900**
		Nort Fort Lauderdale Subtotal		**21,025**	**2.7**	**4.4**	**57,700**	**92,300**
SEGMENT II	South Fort Lauderdale	R-74	R-75	1,112	4.0	4.8	4,400	5,300
		R-75	R-76	974	3.5	3.0	3,400	2,900
		R-76	R-77	1,181	5.0	2.9	5,900	3,500
		R-77	R-78	1,030	5.8	8.0	5,900	8,200
		R-78	R-79	1,080	4.7	11.0	5,100	11,800
		R-79	R-80	1,080	3.0	10.5	3,200	11,300
		R-80	R-81	1,080	2.1	6.7	2,300	7,200
		R-81	R-81.3	318	4.1	8.2	1,300	2,600
		R-81.3	R-81.7	362	4.4	9.1	1,600	3,300
		R-81.7	R-82	326	2.5	10.4	800	3,400
		R-82	R-82.3	336	0.0	8.5	0	2,800
		R-82.3	R-82.7	347	-0.8	4.0	-300	1,400
		R-82.7	R-83	337	-2.6	1.7	-900	600
		R-83	R-83.3	300	-0.2	4.5	-100	1,400
		R-83.3	R-83.7	293	4.9	10.0	1,400	2,900
		R-83.7	R-84	295	2.6	6.1	800	1,800
		R-84	R-84.3	261	-0.2	0.4	0	100
		R-84.3	R-84.7	353	1.0	4.1	300	1,400
		Subtotal		**11,065**	**3.2**	**6.5**	**35,100**	**71,900**
		TOTAL		**59,559**	**3.4**	**5.3**	**203,000**	**315,000**

Over the 24-month inter-survey period between April 2009 and April 2011, the 12,800 feet of Lauderdale-by-the-Sea shoreline, there was a total net gain of 57,900 cy (5 cy/ft, on average). While the beach above the MLWL gained 73,400 cy in this segment, the lower beach (MLWL to the seaward limit of the sand beach profile) actually eroded by 15,500 cy. As expected from the pattern of shoreline advance across all transects noted above, all areas of the beach gained volume above the MLWL. However, because of losses below the MLWL, several sections (R-40 to R-41 and R-43 to R-44) experienced minor net erosion over the total profile. A significant portion of the sand gained along this reach of shoreline be attributed to the gains realized along the middle section of LBTS (R-47 to R-49), where there was a net increase of beach volume of 26,600 cy.

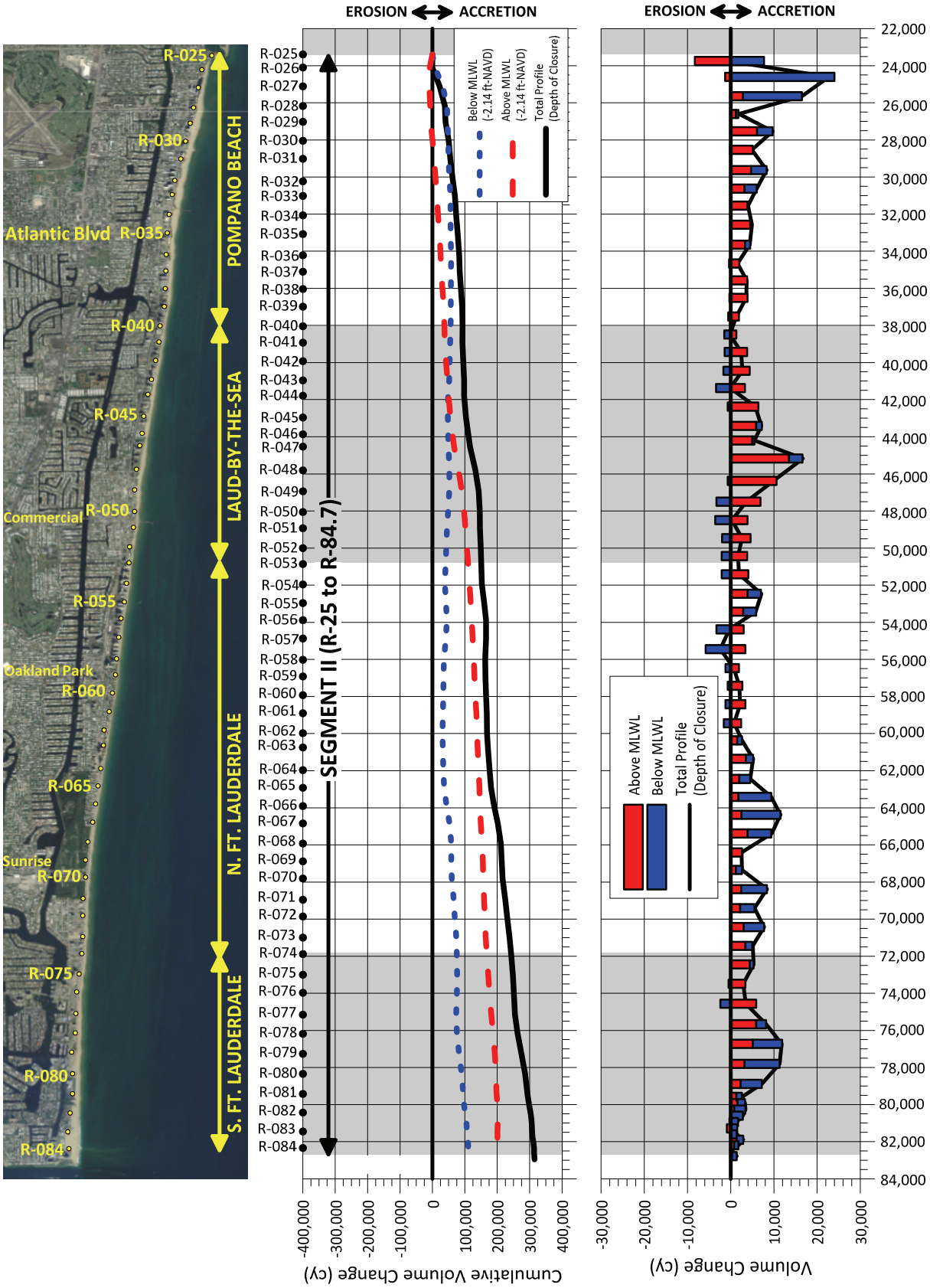


Figure 4.12: Segment II cumulative and local beach volume change between **April 2009 and April 2011**.

Fort Lauderdale shoreline (21,030 feet in length) gained approximately 92,300 cy (4 cy/ft, on average) during April 2009 to April 2011 monitoring period. Of this gain, 57,700 cy occurred above the MLWL, while 34,600 cy accreted between the MLWL and the seaward limit of the sand beach profile. As with LBTS, all sections of the northern Fort Lauderdale reach experienced accretion above the MLWL and most experienced accretion over the total profile, with the exception of R-56 to R-58, where a total of 2,700 cy of sand were lost. Volume changes were, for the most part, relatively small along this reach, with the exception of R-65 to R-68. This area gained nearly a third of the total volume added to this reach during this period. Just as with the shoreline changes, no real trends in beach volume change can be interpreted from the volume change data along this shoreline for this period. It appears the variable shoreline change and possibly the computed net gain of material may be related in part to the presence of minor beach cusps and other rhythmic nearshore features along this shoreline at the time of the April 2009 and April 2011 surveys.

The shoreline reach along southern Fort Lauderdale (11,070 feet in length), has been highly accretional in recent history, until the previous monitoring period. The historical accretion rate along this reach of shoreline -- considering data available between 1979 and 2006 – has been about +40,000 cy/yr OAI/CPE-J/V, 2007a). In the two years following Segment III project completion, between February 2006 and July 2008, the accretion rate has been similar, about +42,700 cy/yr. The largest gains in beach volume occurred between 5,000 and 9,000 feet north of the Port Everglades north jetty. The accretion along this shoreline is due principally to the impoundment effects of the Port Everglades north jetty and sand spoil shoal located 800 feet north of the jetty. The submerged shore perpendicular mound tends to function as a large groin, contributing to sand volume increases across the lower portions of the beach profile to the north.

With the most recent 24-month monitoring period (April 2009 to April 2011), this reach of the Segment II shoreline gained 71,900 cy (almost 7 cy/ft, or about 35,950 cy/yr) of sand, with a significant portion of the gains (38,500 cy) occurring from R-77 to R-81. All profiles in this segment gained volume during this 24-month period, though several lost (R-82.3 to R-83.3) sand or saw no significant change in volume (R-82 to R-82.3 and R-84 to R-84.3) above the MLWL. Sand impoundment on the north jetty appears to have nearly reached the jetties capacity. There have been recent large increases in the amount of sand accumulating along the north side of the Port Everglades Inlet channel. Sand volume change along the northern portion of the inlet channel is discussed in **Section 5.4**.

4.3 SEGMENT I

This section of the report discusses the shoreline and beach volume changes which occurred along the Broward County Segment I shoreline during the most recent 24-month physical monitoring inter-survey period (April 2009 to April 2011). The overall changes for Segment I are presented along with the changes which occurred along two sub-reaches of the Segment I shoreline. These sub-reaches generally represent the extent of shoreline occupied by the major shorefront municipalities in Segment I – Deerfield Beach (R-1 to R-6.7) and Hillsboro Beach (R-6.7 to about R-24). The northern end of the Deerfield Beach shoreline terminates at the border between Broward and Palm Beach Counties. The southern end of Hillsboro Beach is located at the Hillsboro Inlet north jetty.

It is noted that a beach fill project was constructed along the Segment I shoreline in 2011. This project called for the placement of 375,000 cy along a portion of southern Deerfield Beach and northern Hillsboro Beach approximately 6,067 feet long (extending from about 400 feet south of R-06 to 450 feet south of R-12). After a pre-construction survey, this fill volume was lowered to 327,594 cy of required material. Construction began on 12 March 2011 and was completed on 11 April 2011, with a final pay volume of 356,397 cy (out to -15' NAVD). Pre- and post-construction surveys indicate that the shoreline location was advanced by an average of 125.3 feet at the MHW shoreline. Construction activities were completed about a month and a half before the survey of the Segment I beach (while this survey set is referred to as the April 2011 survey, this particular segment was surveyed from 21 to 24 May 2011), allowing some time for equilibration of the beach fill. The effects of this beach fill are represented in the analysis of beach change conditions presented below.

4.3.1 MHW Shoreline Position Change

Table 4.5 summarizes and **Figure 4.13** depicts the measured changes at the MHWL (+0.41 ft-NAVD88) that occurred between April 2009 and April 2011. Also presented in **Figure 4.13** are the local volume changes at each beach profile station along the Segment I shoreline. The volume changes at each station are presented for beach sections above and below the MHWL. As expected some correlation between localized volume changes above the MHWL and change in the MHWL location is evident in the figure. **Figure 4.14** depicts the surveyed locations of the MHW position for the Segment I shoreline relative to the March 2005 condition (pre-construction - Segment III project).

Over the most recent 24-month monitoring period (April 2009 to April 2011), the MHWL along the Segment I shoreline accreted, on average, 54 ft. Within the 2011 fill area (R-07 to R-12) the shoreline advanced by an average of 134 ft, with a maximum advance of nearly 166 ft at R-09. Outside of the project area, MLWL change ranged from an advance of 55 ft at R-16 in the middle of Hillsboro Beach to a recession of 7 ft at R-06 in southern Deerfield Beach immediately adjacent to the beach fill. The large advances south of the beach fill, and lack of advances to the north, are mostly due to the downdrift diffusion of the fill material, which tends to move in a southerly direction along this stretch of beach.

As of April 2011, the average MHWL position along the entire Segment I shoreline was 39 ft seaward, on average, of the March 2005 shoreline position. There are, however, areas of significant localized accretion and erosion, and a significant amount of this shoreline advance can be attributed to the beach fill in spring 2011.

Along the Deerfield Beach shoreline (R-1 to R-6.7), the MHWL advanced by an average of 15 ft between April 2009 and April 2011, almost entirely due advances at R-01 and R-02, which advanced by an average of 41 ft. This localized advance appears to be a result of the movement of small-scale beach cusps, which were much more prominent during the previous survey (April 2009) than is typical. As of April 2011, the average MHWL position along Deerfield Beach was about 9 ft shoreward of the March 2005 location (pre-construction of Segment III project). Changes to the MHWL location at each monitoring station vary considerably over this timeframe, from advances of 56 ft at R-01 to recession of 16 ft at R-04.

Table 4.5: Broward County – Segment I shoreline change between April 2009 and April 2011 as measured at the MHWL (+0.41 ft-NAVD88).

Mon.	Distance from R-Monument (ft) April 2009	Distance from R-Monument (ft) April 2011	Δ (ft)	Mon.	Distance from R-Monument (ft) April 2009	Distance from R-Monument (ft) April 2011	Δ (ft)
R-01	286.9	340.9	54.1	R-13	88.3	139.7	51.4
R-02	243.1	270.8	27.7	R-14	72.3	107.0	34.7
R-03	224.4	225.7	1.3	R-15	122.0	143.3	21.3
R-04	180.6	192.0	11.4	R-16	138.3	193.5	55.2
R-05	124.6	123.6	-1.0	R-17	134.6	174.0	39.4
R-06	212.4	205.5	-6.9	R-18	80.3	126.5	46.2
R-07	68.6	193.7	125.1	R-19	96.5	115.2	18.7
R-08	57.1	184.1	126.9	R-20	87.3	127.9	40.6
R-09	115.3	281.1	165.8	R-21	90.2	125.6	35.5
R-10	109.3	244.0	134.7	R-22	134.6	147.4	12.8
R-11	97.2	248.9	151.7	R-23	115.1	115.6	0.5
R-12	76.9	179.3	102.4	R-24	110.1	104.0	-6.1
WEIGHTED AVERAGE: Deerfield Beach (R-1 to R-6.7)							15.3
WEIGHTED AVERAGE: Hillsboro Beach (R-6.7 to R-24)							67.1
WEIGHTED AVERAGE: SEGMENT I (R-1 to R-24)							54.2

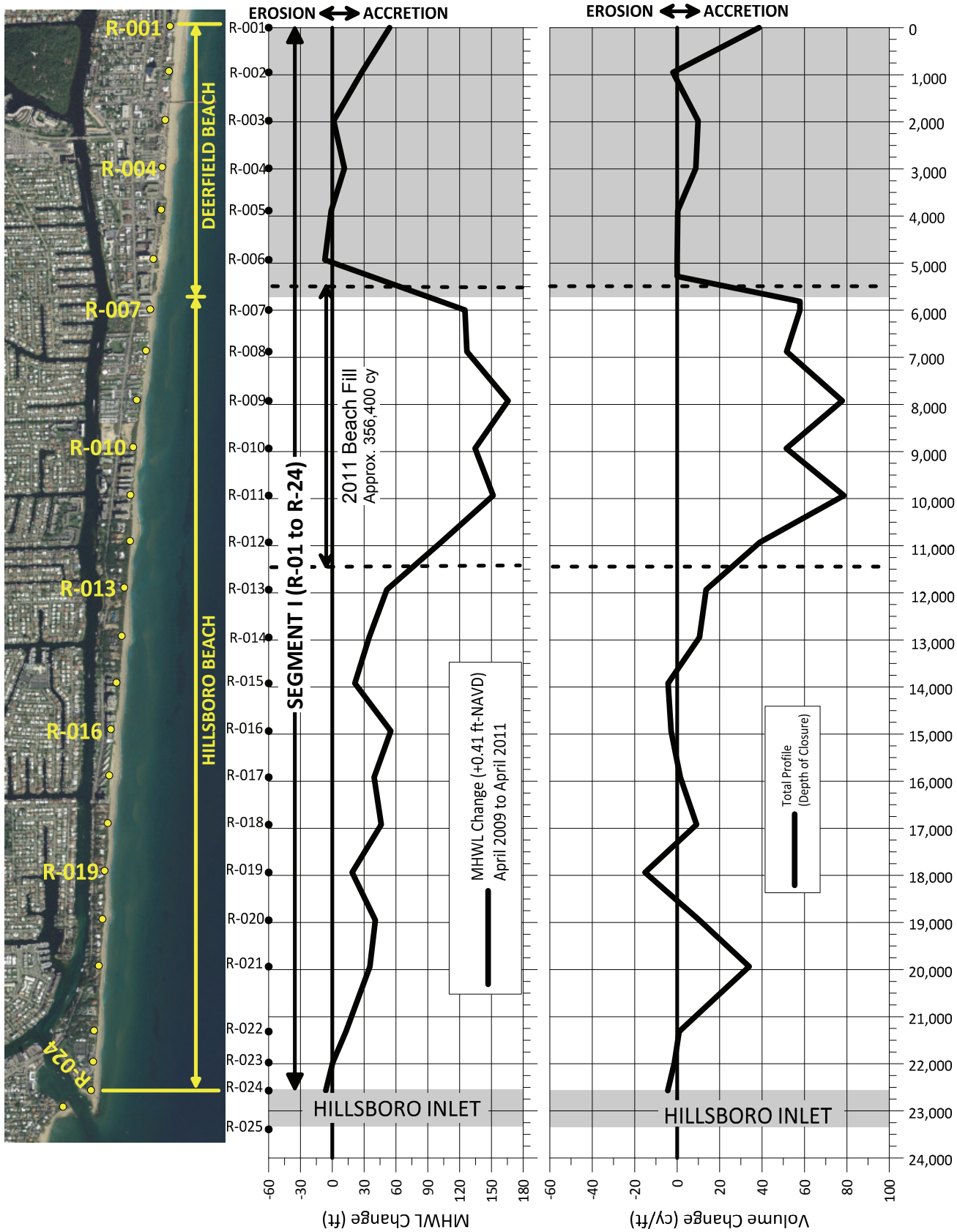


Figure 4.13: Segment I MHW shoreline and volume change for the inter-survey period **April 2009 to April 2011**.

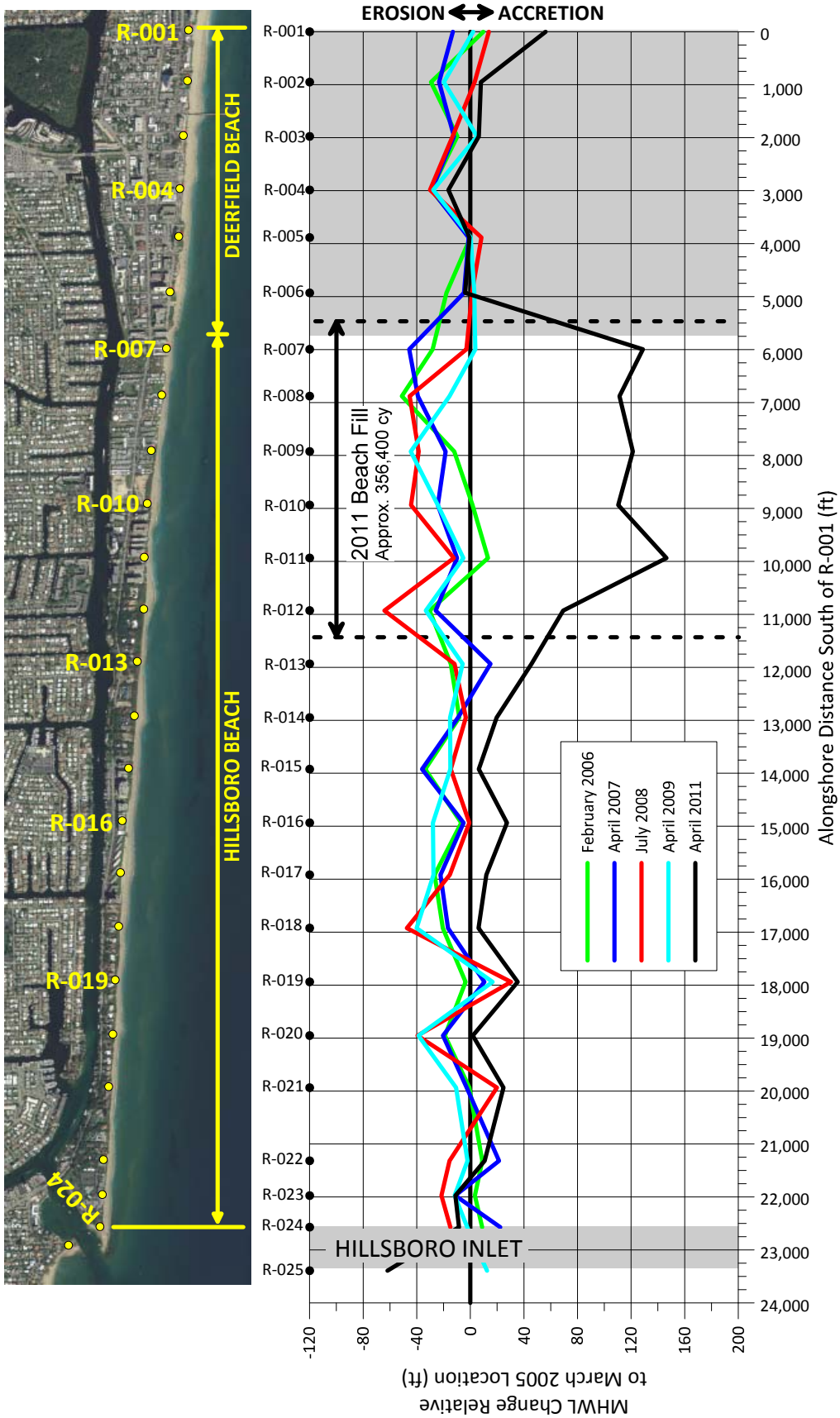


Figure 4.14: Segment I MHW shoreline locations **relative to the March 2005** location (pre-construction - Segment III).

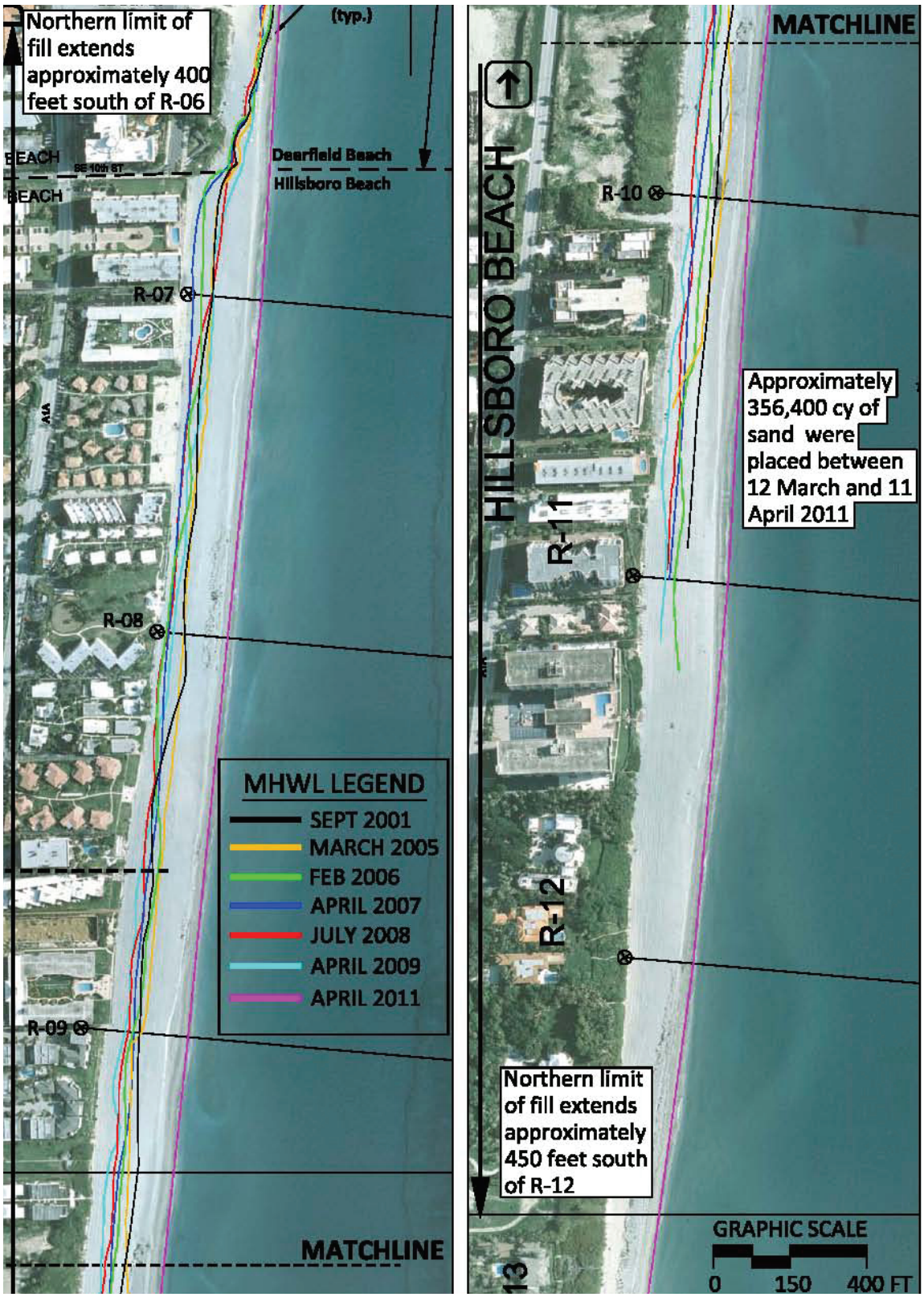


Figure 4.15: July 2011 aerial photography of the southern Deerfield Beach and northern Hillsboro Beach Atlantic coastline with superimposed MHWL locations.

Some of the variation in MHWL position change along the Segment I shoreline is likely related, in part, to sand bypassing activities at Hillsboro Inlet and Boca Raton Inlet. Approximately 5.3 miles of sandy shoreline resides between the two inlets. The southern limit of Segment I borders Hillsboro Inlet while the northern limit of the segment resides approximately 5,400 feet south of Boca Raton Inlet. Monthly dredging records for Hillsboro Inlet dating back to 1991 and records for Boca Raton Inlet dating back to 1979 are provided as **Appendix C**. The occurrence and frequency of sand bypassing activities at the inlets in relation to the timing of beach survey events may lead to the representation of irregular beach change conditions. However, no bypassed sand is placed directly on, nor taken directly off the Segment I shoreline.

From April 2009 to March 2011, sand bypassing records indicate that about 122,550 cy of sand were bypassed across Boca Raton Inlet (**Appendix C**). According to historical records, the average bypass volume for this length of time is about 118,900 cy (see **Appendix C**, **Table C.3**). It is noted that the typical transfer rate does not include the volume that is occasionally transferred to the downdrift shoreline by Boca Raton Inlet ebb tidal shoal dredging -- the last such event occurred in 2010. Between April 2009 and March 2011, approximately 183,800 cy of sand were added to the beaches south of Boca Raton Inlet due to the 2010 ebb shoal event. As such, a total of 306,350 cy of sand were added to the beaches south of the inlet during the 23 month period. During the same period, sand bypassing records for Hillsboro Inlet indicate that about 202,530 cy of sand were bypassed at that location, versus an expected volume of 213,700 cy.

Comparison of the sand transfer volumes at the two inlets suggests that there was a 103,820 cy surplus in sand input to the shoreline between Boca Raton and Hillsboro Inlets between April 2009 and April 2011. It is expected that the Broward County Segment I beaches may not yet be directly benefitting from this increase in sand placement south of Boca Raton Inlet but long-term benefits to the overall beach system area expected. It is noted that although this information is interesting and implies some expected long-term benefit to the Segment I shoreline, beach survey data evaluated in this investigation does not cover the entire shoreline between the two inlets. So, no definitive correlation can be made between the sand bypass volumes and documented beach changes along the Deerfield Beach and Hillsboro Beach shorelines. The 2011 Hillsboro Beach nourishment project would further complicate such an analysis.

4.3.2 Beach Volume Change

Table 4.6 summarizes the Segment I beach volume changes as computed for the period April 2009 to April 2011. **Figure 4.16** presents the local and cumulative beach volume changes, in cubic yards, for the 24-month inter-survey period. Again, these results include the influence of the 2011 beach nourishment project construction along portions of the Segment I shoreline.

Over the most recent 24-month monitoring period (April 2009 to April 2011), the 22,570 feet of Segment I beach gained roughly 442,600 cy of sand. The net gain of sand along Segment I over this period represents the sum of about 390,200 cy of sand gained above the MLWL and 52,400 cy gained between the MLWL and the defined beach toe. Most of this sand was placed ad beach fill.

Along the 5,630 feet of Deerfield Beach shoreline, there was a net gain of 35,100 cy of sand between April 2009 and April 2011. Changes in beach volume density ranged from 18 cy/ft of accretion at R-1 to no volume change at R-6. The Deerfield Beach segment was mostly stable in terms of beach volume during the most recent 24-month inter-survey period, with the exception of significant accretion at R-1 due to alongshore movement of sand from the north and possibly sand placement activities south of Boca Raton Inlet.

Along the 16,940 feet of Hillsboro Beach shoreline there was a net gain of about 407,500 cy of sand during the most recent 24-month inter-survey period. This net gain of sand was the sum of 367,600 cy gained above the MLWL and 39,900 cy gained across the lower area of the beach profile between the MLWL and defined beach toe. A significant majority (339,000 cy between R-6.7 and R-12.5) of the gains observed in Hillsboro Beach are due to the beach fill. Outside of the beach fill area, volume changes range from 34 cy/ft of accretion at R-21 to 15 cy/ft of erosion at R-19.

The beach fill construction and the effect of the Deerfield Beach groin field on shoreline and beach volume change makes it difficult to decipher volume change trends along the Segment I shoreline for this period.

Table 4.6: Broward County – Segment I beach volume changes (April 2009 to April 2011).

		Monument		Length	Average Volume Change (cy/ft)		Volume Change (cy)	
		North	South	(ft)	Above MLW	Total Profile	Above MLW	Total Profile
SEGMENT I	Deerfield Beach	R-01	R-02	951	10.5	18.3	10,000	17,400
		R-02	R-03	1,025	4.3	3.9	4,400	4,000
		R-03	R-04	1,011	5.0	9.3	5,000	9,400
		R-04	R-05	898	3.2	4.5	2,900	4,100
		R-05	R-06	1,045	0.4	0.2	400	200
		R-06	R-6.7	700	-0.2	0.0	-100	0
		Subtotal		**5,630**	**4.0**	**6.2**	**22,600**	**35,100**
	Hillsboro Beach	R-6.7	R-07	366	43.0	57.9	15,700	21,100
		R-07	R-08	884	44.4	54.7	39,200	48,400
		R-08	R-09	1,046	53.5	64.7	55,900	67,700
		R-09	R-10	1,010	47.9	64.6	48,400	65,300
		R-10	R-11	1,000	45.1	65.0	45,100	65,000
		R-11	R-12	993	45.8	58.8	45,400	58,300
		R-12	R-13	1,006	24.4	26.3	24,500	26,400
		R-13	R-14	1,015	12.2	12.1	12,400	12,300
		R-14	R-15	974	7.5	3.1	7,300	3,000
		R-15	R-16	1,013	10.2	-3.6	10,300	-3,600
		R-16	R-17	981	12.8	-0.7	12,600	-700
		R-17	R-18	1,006	10.3	5.3	10,300	5,400
		R-18	R-19	1,017	9.7	-3.0	9,900	-3,000
		R-19	R-20	1,014	8.8	-2.3	9,000	-2,300
		R-20	R-21	984	10.7	22.3	10,500	21,900
		R-21	R-22	1,380	7.4	17.5	10,200	24,100
		R-22	R-23	658	2.2	-0.2	1,500	-100
		R-23	R-24	595	-1.0	-2.8	-600	-1,700
		Subtotal		**16,940**	**21.7**	**24.1**	**367,600**	**407,500**
TOTAL				**22,570**	**17.3**	**19.6**	**390,200**	**442,600**

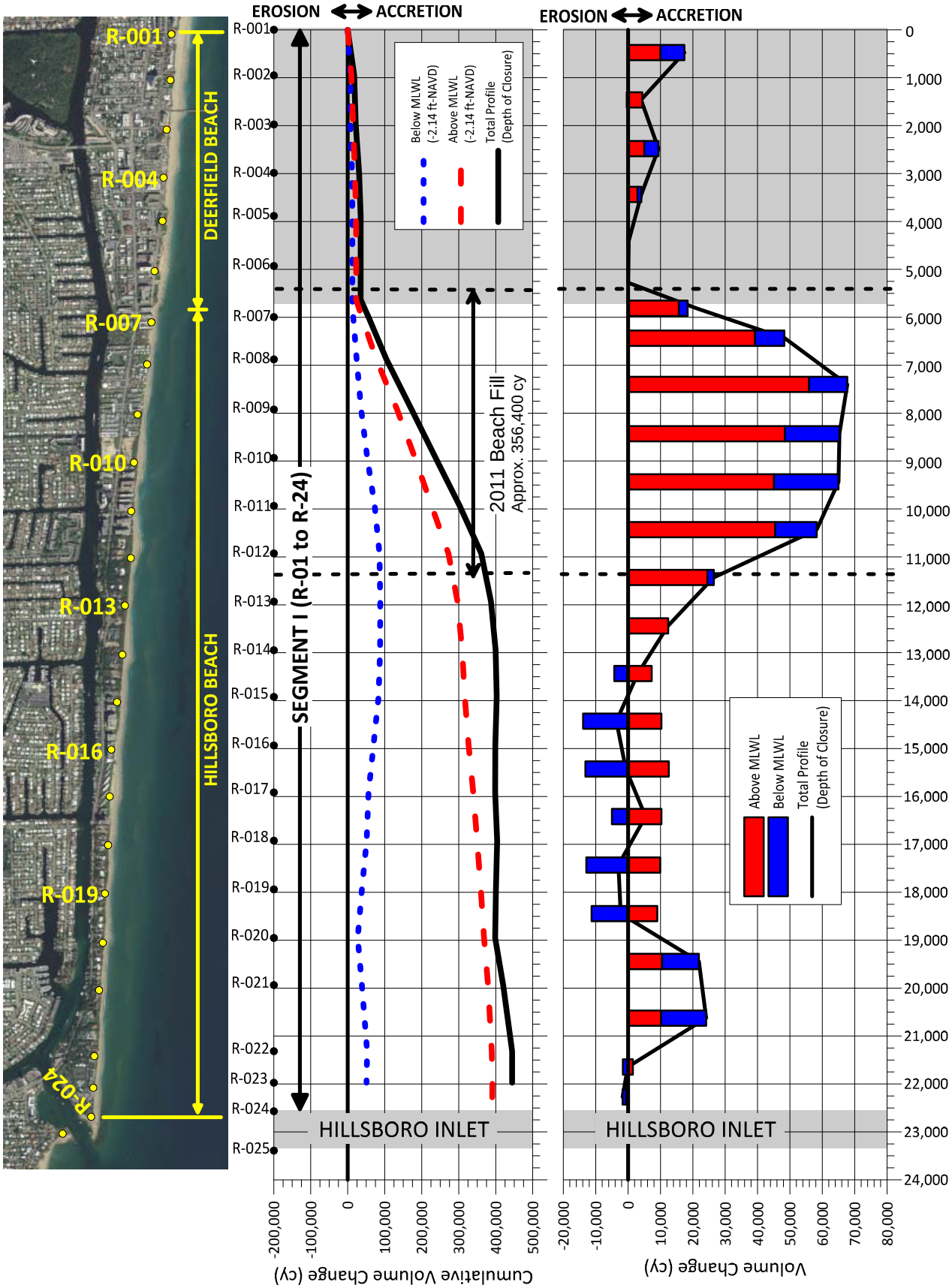


Figure 4.16: Segment I cumulative and local beach volume change between **April 2009 and April 2011.**

5.0 BORROW AREA MONITORING RESULTS

This section summarizes the July 2011 conditions and documented changes that have occurred within the project's five (5) offshore sand borrow areas (BA-I, BA-II, BA-III, BA-IV, and BA-VI) since construction of the Broward County Shore Protection Project - Segment III. For purposes of monitoring the physical changes of the five borrow areas, each site was surveyed immediately before and after construction of the Segment III project as well as 15-months (May 2007), 30-months (August 2008), 39-months (May 2009), 54-months (August 2010), and 65–months (July 2011) post-construction. Coastal Planning and Engineering, Inc. (CPE, 2011) performed all borrow area surveys to date. Plots depicting the survey results are available in **Appendix D**.

5.1 Background

A comprehensive analysis and discussion regarding the selection and use of the five borrow areas for construction of the Segment III project is provided in the *Post-Construction Engineering Summary Report* (OAI/CPE-J/V, 2007a). Beach quality sediments were dredged from five borrow areas located offshore of northern and north-central Broward County, between 0.25 and 1.0 miles offshore of the Broward County coast. The five sites are non-contiguous and extend from the Broward / Palm Beach County line (R-1) to Lauderdale-by-the-Sea (R-48) (see **Figure 5.1**). As part of the beach nourishment project, sand was also dredged from a shoal at the Port Everglades Entrance Channel and placed along the John U. Lloyd Beach State Park shoreline.

The available quantity of sand in each borrow area varied significantly (see **Table 5.1**), principally due to the broad variation in the dimensions and configuration of each site[8]. Additionally, the thickness of the sand deposits varied among and within each borrow area, resulting in varying operational plans and excavation elevation limits. **Figure 5.2** presents the allowable dredge elevations for BA-I, BA-II and BA-III. The same information for BA-IV and BA-VI is depicted in **Figure 5.3**.

[8] The available volume of clean sand listed in **Table 4.1** was estimated by calculating the total material volume available less an estimate of the rubble and silt fraction within each borrow area.

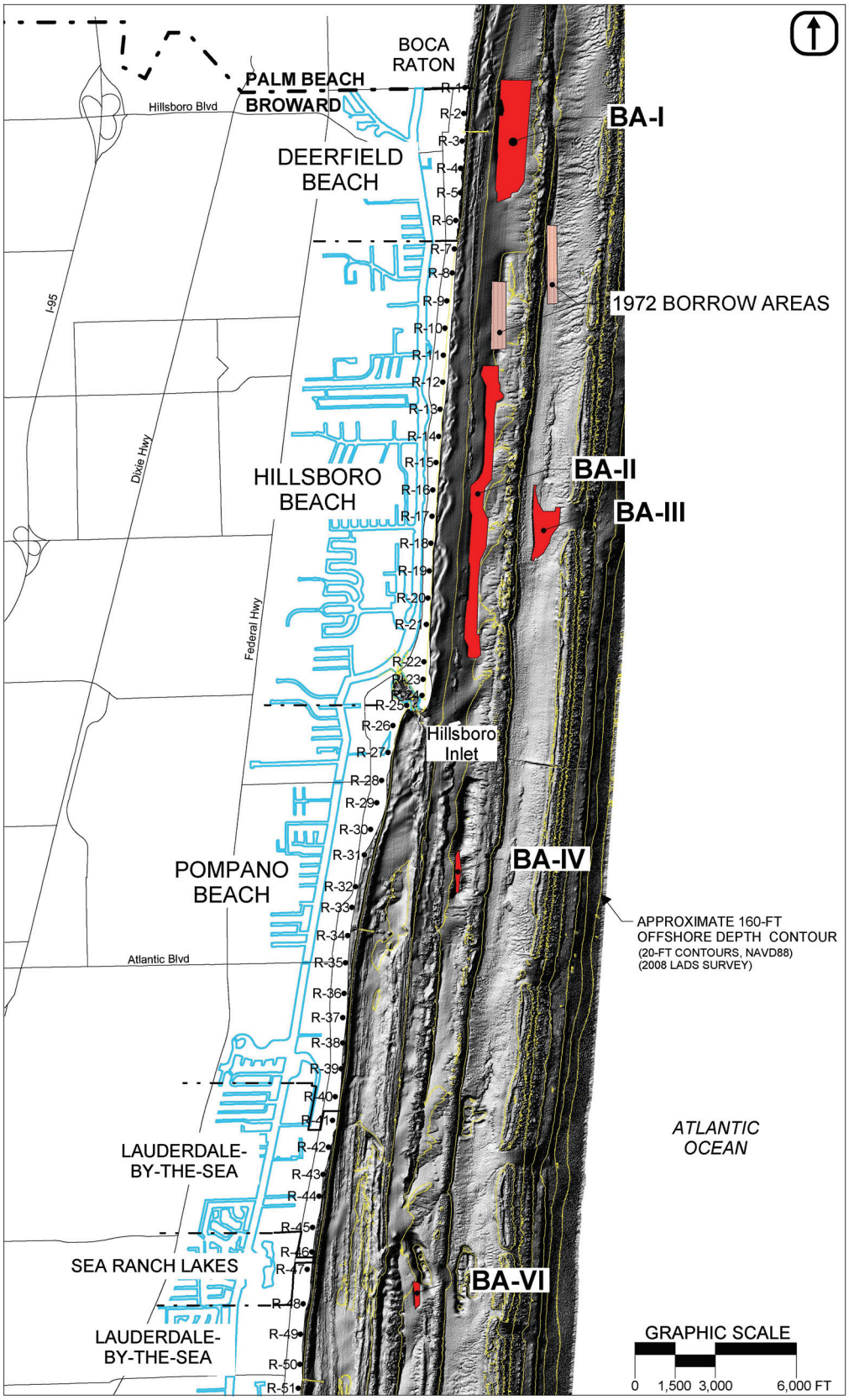


Figure 5.1: Location and configuration of the offshore borrow areas used for the Broward County Shore Protection Project - Segment III. The borrow areas used in the 1972 project are also displayed.

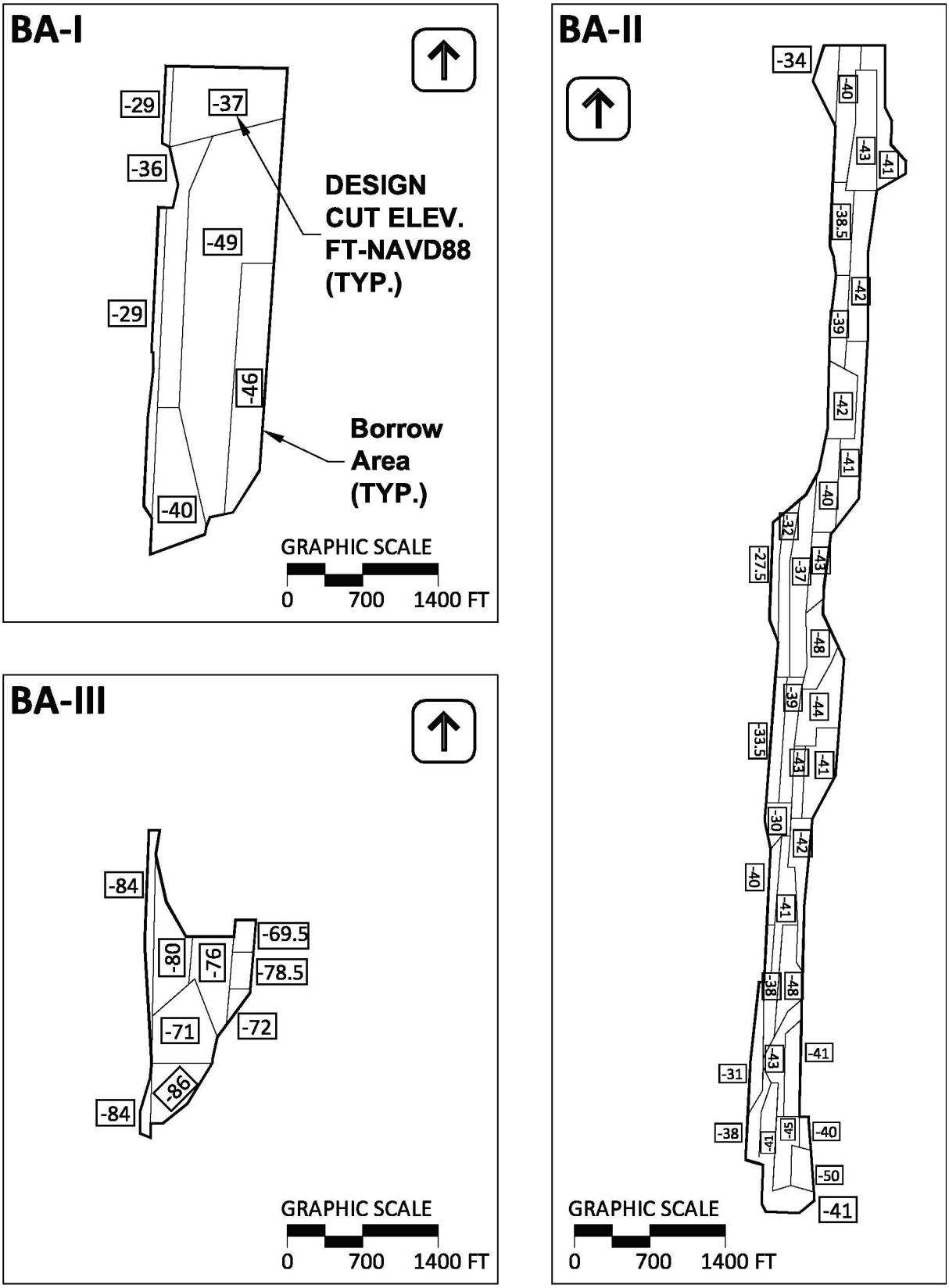


Figure 5.2: Maximum excavation depths to offshore borrow areas BA-I, BA-II and BA-III.

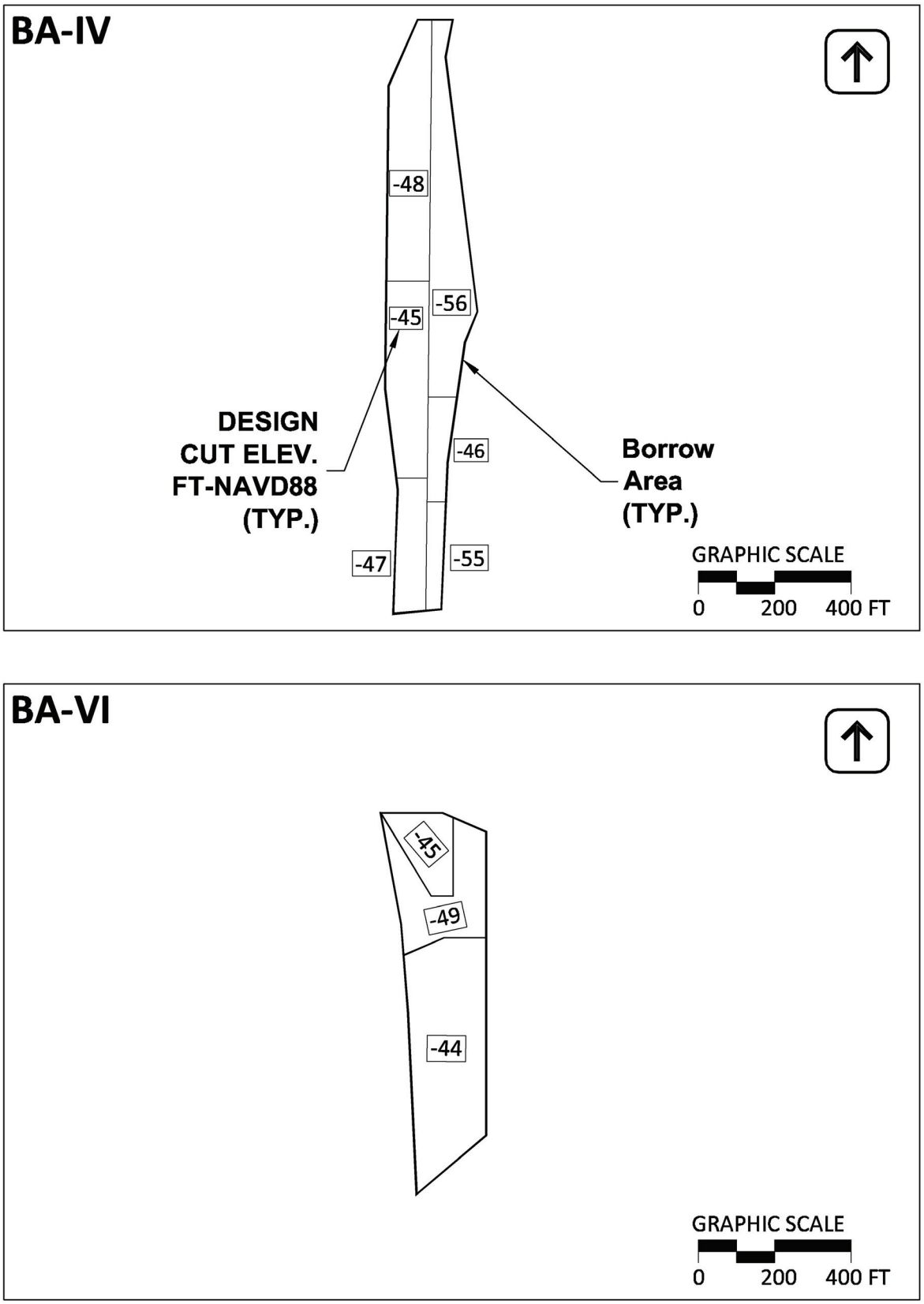


Figure 5.3: Maximum excavation depths to offshore borrow areas BA-IV and BA-VI.

Table 5.1: Estimated available sand volumes prior to construction in the five borrow areas prior to construction of the Broward County Shore Protection Project – Segment III.

Borrow Area	Area (acres)	Est. Total Material Available (cy)	Est. Fines Content (%)	Est. Rock Content (%)	Est. Total Sand Available (cy)
BA-I	86	2,209,900	2.0%	9.5%	1,960,000
BA-II	116	1,182,000	1.9%	6.0%	1,090,000
BA-III	33	411,600	4.4%	7.5%	364,000
BA-IV	6	54,800	2.6%	4.5%	51,000
BA-VI	4.5	55,600	2.1%	4.5%	52,000
Total	**245.5**	**3,913,900**			**3,517,000**

Note: Estimated volume quantities are based upon the March 2005 pre-construction survey and include 400-ft dredging buffers.

The pre-construction surveys indicate that the five borrow areas contained roughly 3,913,900 cy of material of which roughly 3,517,000 cy was estimated to be clean, beach compatible material (OAI/CPE-J/V, 2007a). The borrow areas also contained rubble and silt that were not beach compatible and were either removed via mechanical screening before beach placement or washed away during the dredging process. The available volume of clean sand listed in **Table 5.1** was estimated by calculating the total material volume available less an estimate of the rubble and silt fraction within each borrow area.

It is noted that a portion of BA-I was also dredged in 1998 and 2011. Both dredging operations were associated with renourishment projects along the southern end of Deerfield Beach and the northern end of Hillsboro Beach. Approximately 555,000 cy and 356,000 cy of material were removed from BA-I and placed along the beach during the 1998 and 2011 projects, respectively.

5.2 Project Construction (March 2005 to February 2006)

Table 5.2 summarizes the measured and estimated volumetric changes at the five offshore borrow areas of Segment I resulting from construction of the Segment III project as represented by the pre- and post-construction surveys (March 2005 to February 2006). A total of approximately 1,891,500 cy of material and 1,794,700 cy of beach compatible sand were removed from the borrow areas during construction. The quantity of sand removed was estimated as the measured total volume change within the borrow area less the estimated amount of rubble removed from each respective borrow area. The rubble quantities were estimated from measurements taken on the dredge following completion of each of the dredge loads of material.

Additionally, the post-construction survey (February 2006) was used to estimate the total volume of material that theoretically remains within the permitted limits of the borrow areas. Access to the theoretically remaining material in BA-I, and possibly in others, may be limited by an increase in the percentage of 'rubble vs. sand' caused by the dredge's inability to remove larger rubble. In addition, some remaining sand within the borrow sites will be in corner areas inaccessible to large dredging equipment.

Table 5.2: Estimated quantities of total material and beach compatible sand removed from the five Broward County – Segment III borrow areas.

Borrow Area	Est. Total Material Available (cy)	Total Material Removed (cy)	Rubble Content (%)	Sand Volume Removed (cy)	Est. Total Material Remaining (cy)	Est. Sand Volume Remaining (cy)
BA-I	2,209,900	783,300	4.9%	744,800	1,426,600	1,356,600
BA-II	1,182,000	886,400	5.0%	842,100	295,600	280,800
BA-III	411,600	169,900	6.3%	159,200	241,700	226,500
BA-IV	54,800	26,500	6.8%	24,700	28,300	26,400
BA-VI	55,600	25,400	5.9%	23,900	30,200	28,400
Total	**3,913,900**	**1,891,500**		**1,794,700**	**1,963,900**	**1,918,700**

5.3 Post-Construction Changes (February 2006 to July 2011)

The bathymetric conditions as represented by the five post-project surveys are depicted for each borrow area in **Appendix D**, **Figures D.2** to **D.6**. Additionally, the computed seabed elevation changes over three different time periods are graphically depicted in **Appendix D** as **Figures D.7** to **D.11**. The three time periods are Pre- to Post-Dredge (March 2005 to February 2006), Four to Five Years Post-Dredge (the most recent intersurvey period, August 2010 to July 2011), and Post- to Five Years Post-Dredge (February 2006 to April 2011). In the figures, the seabed elevation changes are contoured and shaded to indicate the spatial extent and magnitude of apparent areas of accretion and/or erosion within the borrow areas.

The 2011 Segment I beach fill, which was constructed between 12 March 2011 and 11 April 2011, placed a final pay volume of 356,397 cy (out to -15' NAVD) on the beach. This is the quantity of sand, at a minimum, that was removed from BA-I. The observed loss over the year five monitoring period (August 2010 to July 2011) of 258,806 cy indicates that some infilling occurred in BA-I over this period, most of which likely took place after post-dredging. The total loss of material over this period equates to a mean seabed elevation change within the borrow area of -1.53 ft, which significantly skews the mean seabed elevation change in BA-I over the entire post-construction period.

Table 5.3 summarizes the seabed elevation changes for the nominal year one (February 2006 to May 2007), year two (May 2007 to August 2008), year three (August 2008 to May 2009), year four (May 2009 to August 2010), and year five (August 2010 to July 2011) monitoring periods, as well as over the entire project period. In general, since project completion there have been no large-scale seabed elevation changes within BA-II BA-III, BA-IV, or BA-VI. BA-I had also not experienced significant elevation change over the course of post-construction monitoring until the 2011 dredging. Mean seabed elevation changes within the five borrow areas have been less than ± 0.5 ft during each post-dredging monitoring period, with the largest changes occurring in the first year after construction and significantly smaller changes occurring in subsequent monitoring periods (save for the BA-I during the most recent inter-survey period). This is expected, as a process of equilibration may occur within sand borrow areas immediately following dredging, resulting in some bathymetric changes. Accordingly, it can be expected that BA-I will experience larger (but still relatively minor) change over the next year than it has in years two, three, or four.

Within all five borrow areas and in particular in BA-I, BA-II, and BA-III, there were some localized areas of above-average seabed elevation change. The reason for these apparently abnormal localized changes is unclear since they generally do not occur along dredge cut boundaries, where the most significant seabed changes would be expected to occur. These changes are not regarded as important, since it is likely these changes are in part due to inherent issues associated with hydrographic surveying. These inherent issues are discussed in the following paragraphs. The borrow area surveys are designed and conducted with track lines spaced 250 feet apart. Therefore, in order to represent changes across the entire borrow area, the data along the survey lines must be interpolated. This approach can extend the representation of small localized differences in elevation near a survey track line across relatively large areas of a borrow area.

Table 5.3: Borrow seabed elevation changes since project completion.

Borrow Area	Post-Construction (February, 2006) to May 2007				May 2007 to August 2008				August 2008 to May 2009			
	Mean (ft)	Standard Deviation (ft)	Max Positive Change (ft)	Max Negative Change (ft)	Mean (ft)	Standard Deviation (ft)	Max Positive Change (ft)	Max Negative Change (ft)	Mean (ft)	Standard Deviation (ft)	Max Positive Change (ft)	Max Negative Change (ft)
BA-I	-0.29	0.35	2.43	-2.53	0.07	0.20	1.62	-1.10	0.14	0.26	1.79	-1.35
BA-II	-0.34	0.39	3.39	-2.93	0.03	0.28	2.24	-2.12	0.08	0.31	2.11	-1.23
BA-III	-0.41	0.36	1.47	-3.64	0.06	0.37	4.23	-1.34	0.11	0.35	1.88	-4.93
BA-IV	0.06	0.36	1.28	-1.37	-0.21	0.25	0.75	-0.87	0.06	0.36	0.88	-0.97
BA-VI	-0.46	0.35	0.79	-1.71	0.17	0.27	1.08	-0.45	0.09	0.30	0.97	-0.70

Borrow Area	May 2009 to August 2010				August 2010 to July 2011				Post-Construction (February, 2006) to July 2011			
	Mean (ft)	Standard Deviation (ft)	Max Positive Change (ft)	Max Negative Change (ft)	Mean (ft)	Standard Deviation (ft)	Max Positive Change (ft)	Max Negative Change (ft)	Mean (ft)	Standard Deviation (ft)	Max Positive Change (ft)	Max Negative Change (ft)
BA-I	-0.10	0.32	1.27	-1.56	-1.53	2.40	1.57	-10.20	**-1.71**	**2.55**	**3.01**	**-10.70**
BA-II	0.00	0.52	4.62	-1.96	0.04	0.24	1.41	-1.12	**-0.18**	**0.48**	**3.62**	**-2.70**
BA-III	-0.09	0.51	1.95	-3.78	0.02	0.39	2.85	-2.28	**-0.28**	**0.39**	**1.90**	**-2.14**
BA-IV	-0.01	0.29	0.68	-0.60	0.13	0.16	0.71	-0.90	**0.02**	**0.30**	**1.26**	**-1.15**
BA-VI	0.21	0.35	1.33	-0.55	-0.01	0.24	0.46	-0.83	**-0.05**	**0.28**	**1.48**	**-0.93**

Furthermore, small differences in the position of the survey vessel along a given transect from survey to survey can potentially result in apparent variations in seabed elevations when the two surveys are compared. This is especially true in the case of the Broward County borrow areas where it is known that the bottom elevations within the borrow areas are highly irregular. Although efforts are made to minimize this phenomenon by using the most sophisticated navigations systems available, varying sea state and current conditions and different boat operators can contribute to deviations in position along the survey line. Hydrographic survey standards provide for this possibility.

FDEP Monitoring Standards for Beach Erosion Control Projects (FDEP, 2004) state that the allowable horizontal positioning system accuracy for borrow sites shall be a maximum of +/-2.0 feet. The standards also allow a maximum off-line horizontal deviation of +/-30 feet. Therefore, when comparing two surveys, their horizontal discrepancy may be as much as 64 feet. In the case of the Broward County borrow areas, a difference in boat position of 64 ft could result in apparent significant changes in seabed elevation that are not real.

Inherent survey error is another phenomenon that could lead to questions regarding the significance of observed volume changes occur across the borrow areas. Such errors can occur from local geodetic datum errors, tide/stage modeling-extrapolation-interpretation errors, dynamic-latency/roll/pitch/heave errors, and acoustic measurement errors, including velocity, refraction, and beam forming errors (FDEP, 2004). The FDEP standards state that the vertical accuracy of hydrographic survey data collection offshore shall meet or exceed the GPS-derived heights standard of 0.2-0.5 feet. Applying this standard to borrow area BA-I, for example, the acceptable level survey error alone could indicate a potential change in total borrow area volume of +/-69,400 cy.

Table 5.4 summarizes the net volume changes within each borrow area since project completion. **Appendix D** contains net volume changes and seabed elevation change plots, which indicate the relatively insignificant bathymetric changes within the five borrow areas during the first four post-construction monitoring years, and significant change only in BA-I during the fifth. The net volume changes and seabed elevation changes are within the potential hydrographic survey inaccuracies and errors discussed above. Considering that the average vertical difference in <u>every</u> borrow area (excluding

the exception mentioned above) is within the hydrographic survey accuracy envelope, it is concluded that the observed volume changes within the borrow areas do not represent significant accumulations or movements of sediment.

Several apparently large differences exist between surveys at the survey boundaries -- as distinct from the borrow area boundaries. Determining seabed changes at the survey limits using standard data contouring techniques can also be misleading. Slight differences in respective survey line termination points can mean that considerable differences in seabed elevation are computed at the computational boundary. Therefore, it is recommended that survey and computed contour differences at the survey limits be disregarded as meaningful for the purposes of representing accurate seabed elevation changes.

Table 5.4: Borrow area volume changes since project completion.

Borrow Area	Borrow Site Acreage	Volume Change (cy)					
		Post-Construction (February, 2006) to May 2007	May 2007 to August 2008	August 2008 to May 2009	May 2009 to August 2010	August 2010 to July 2011	Post-Construction (February, 2006) to July 2011
BA-I	86	-48,430	11,530	23,450	-17,350	-258,806	-289,606
BA-II	116	-51,060	6,160	15,560	-260	6,943	-22,657
BA-III	33	-20,450	3,320	5,740	-4,700	1,268	-14,822
BA-IV	6	580	-2,060	600	-120	1,231	231
BA-VI	4.5	-3,700	1,290	690	1,550	-58	-228
Total	**245.5**	**-123,060**	**20,240**	**46,040**	**-20,880**	**-249,422**	**-327,082**

5.4 Port Everglades Inlet Sand Shoal

In addition to the five offshore borrow areas, a sand shoal along the north side of the Port Everglades Inlet channel was dredged in 2005/06 and used as a supplemental sand source for the Segment III project (see **Figure 2.1**). All sand from the shoal was placed on the JUL project beach. The sand deposit was located immediately south of the Port Everglades north jetty and occupied a significant portion of the northern half of the federally authorized navigation channel.

The 2005/06 project required the removal of all shoal material from within the Federal Navigation channel. During construction, approximately 31,340 cubic yards of material were removed from the shoal, inclusive of sand, fines, rock rubble and debris (OAI/CPE-J/V, 2007a). Of that quantity, approximately 26,650 cubic yards were beach quality sand. Rock rubble and debris were screened from the dredged material and disposed of offshore. Only clean beach quality sand was placed along the JUL shoreline.

Figure 5.4 depicts the immediate post-dredge (February 2006), 30-month post-dredge (August 2008), and 54-month post-dredge (August 2010) bathymetric conditions in the vicinity of the spoil shoal. **Figure 5.5** depicts the seabed elevation changes since construction (February 2006 to August 2010), from immediately post-dredge to 30-months post-dredge (February 2006 to August 2008), and from 30-months post-dredge to 54-months post-dredge (August 2008 to August 2010). During the fifty-four months following completion of the 2005/06 project, the shoal has gained roughly 94,300 cubic yards of material around the general area of the dredge cut limits. The volume gain is equivalent to an average annual accretion rate of about 21,000 cy/yr. An analysis of sand shoaling rates for the period between 2001 and 2004 -- prior to the 2005/06 dredging -- indicated that this same general area gained sand at a rate of about 10,700 cy/yr (OAI/CPE-J/V, 2007a).

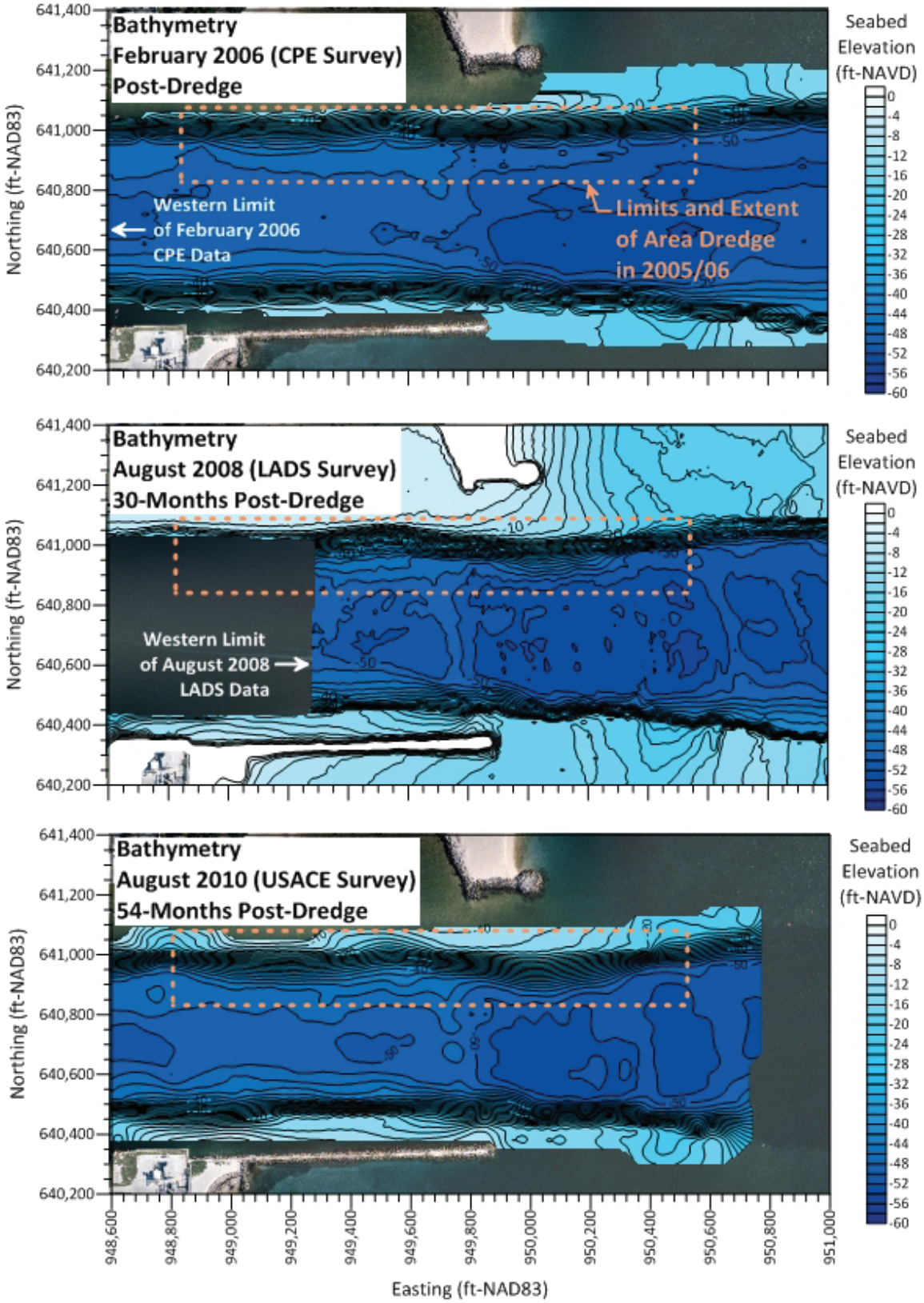


Figure 5.4: Immediate post-dredge, 30-month post-dredge, and 54-month post-dredge bathymetric conditions in the vicinity of the Port Everglades spoil shoal.

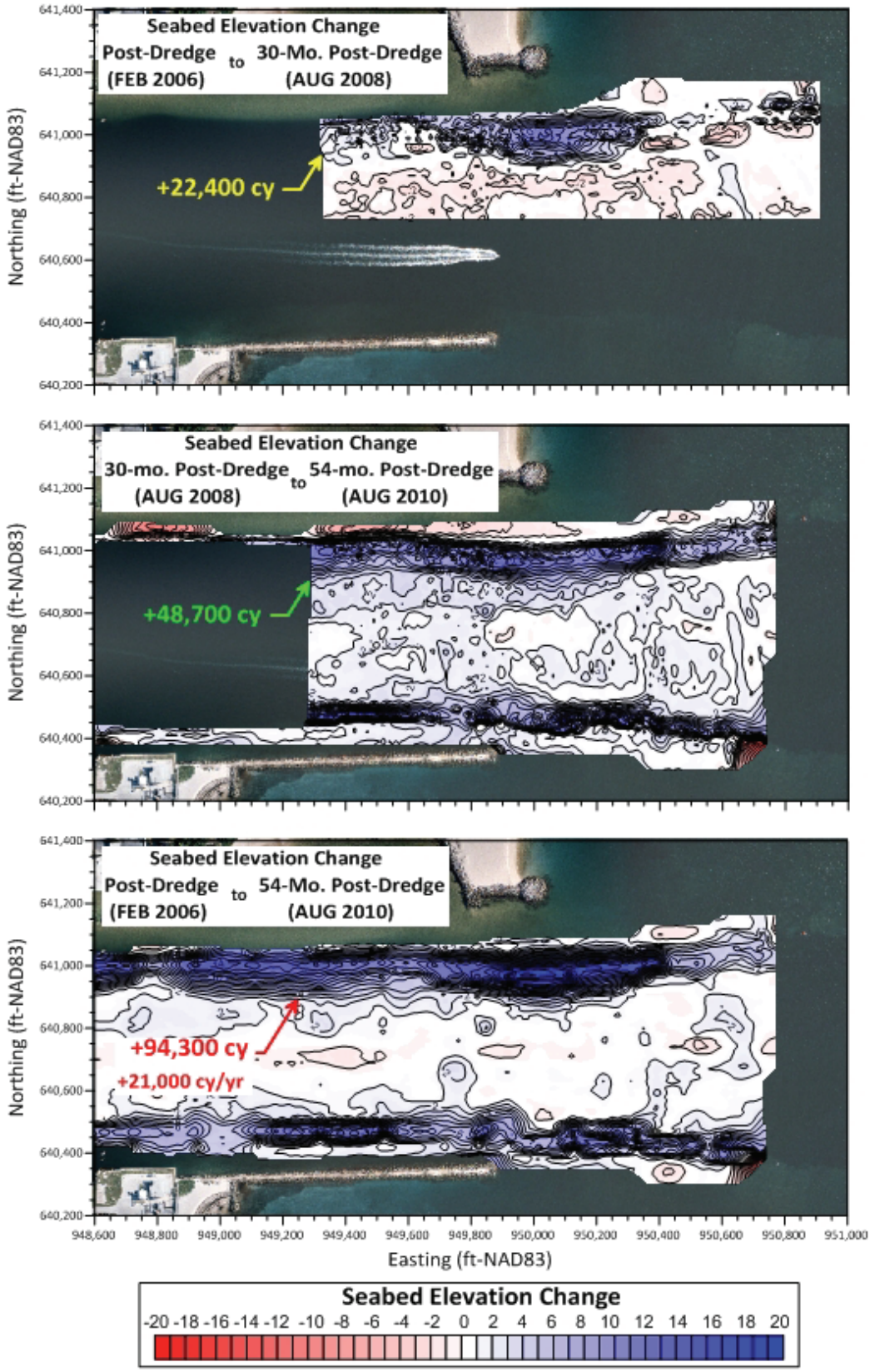


Figure 5.4: Seabed elevation change over the 54 months following dredging of the Port Everglades spoil shoal.

5.0 REFERENCES

Browder, A.E. and Reilly, W.L, (2008). *"Observations of Large-Scale Beach Cusps In the Florida Panhandle and Alabama,"* proceeding at the FSBPA 21st Annual National Conference on Beach Preservation Technology, January 28 – February 1, 2008 – Sarasota, FL.

Coastal Planning & Engineering (CPE), (2011). *"2011 Broward County Annual Monitoring Topographic and Hydrographic Survey Report,"* Report prepared for the Florida Department of Environmental Protection and the FDEP Bureau of Beaches and Coastal Systems, Tallahassee, FL. Report submitted by the Broward County Environmental Protection Department, Broward County, FL. Coastal Planning and Engineering, Inc., Boca Raton, FL, July 2011.

Florida Department of Environmental Protection (FDEP), (2004). *"Monitoring Standards for Beach Erosion Control Projects,"* Florida DEP Bureau of Beaches and Coastal Systems Division of Water Resources Management, Tallahassee, FL.

Olsen Associates, Inc./Coastal Planning & Engineering - Joint Venture (OAI/CPE-J/V), (2007a). *"Broward County, Florida Shore Protection Project, Segment III, Post-Construction Engineering Summary Report,"* Report submitted to the Broward County Environmental Protection Department, Broward County, FL, and the FDEP Bureau of Beaches and Coastal Systems, Tallahassee, FL. Olsen Associates, Inc., Jacksonville, FL, January 2007.

Olsen Associates, Inc./Coastal Planning & Engineering - Joint Venture (OAI/CPE-J/V), (2007b). *"Broward County, Florida Shore Protection Project, Segment III, 1-Year Post-Construction Physical Monitoring Report,"* Report submitted to the Broward County Environmental Protection Department, Broward County, FL, and the FDEP Bureau of Beaches and Coastal Systems, Tallahassee, FL. Olsen Associates, Inc., Jacksonville, FL,

Olsen Associates, Inc./Coastal Planning & Engineering - Joint Venture (OAI/CPE-J/V), (2009). *"Broward County, Florida Shore Protection Project, Segment III, 3-Year Post-Construction Physical Monitoring Report,"* Report submitted to the Broward County Environmental Protection Department, Broward County, FL, and the FDEP Bureau of Beaches and Coastal Systems, Tallahassee, FL. Olsen Associates, Inc., Jacksonville, FL, November 2009.

Personal Communication, (2009), Doug Mann, P.E., Coastal Planning and Engineering, Inc.

Personal Communication, (2011), Jack Holland, Chairman - Hillsboro Inlet District.

Personal Communication, (2011), Jennifer Bistyga, E.I., City of Boca Raton.

U.S. Army Corps of Engineers (USACE), (2003). *Broward County, Florida Shore Protection Project: Segment II and III, General Reevaluation Report, Appendices A through G,* prepared by Coastal Planning and Engineering, Inc./Olsen Associates, Inc. (Joint Venture), Boca Raton/Jacksonville, Florida.

van Enckevort, I.M.J., B.G. Ruessink, G. Coco, K. Suzuki, I.L. Turner, N.G. Plant, and R.A. Holman, (2004). "*Observations of Nearshore Crescentic Sandbars*," Journal of Geophysical Research, Vol. 109, C06028, 17 pp., American Geophysical Union, Washington, D.C.

APPENDIX A: Beach Profile Plots

This Appendix includes plots of beach profile surveys performed at the primary FDEP R-monuments along the entire Broward County shoreline, 5,000 feet of Miami-Dade County shoreline, and intermediate monuments along the shoreline immediately north and south of Port Everglades Inlet. A list of the specific monuments at which beach profiles were collected is provided as **Table A.1**. Monument coordinates are referenced to the Florida State Plane Coordinate System – East Zone, North American Datum of 1983 (NAD83). Elevations are referenced to the North American Vertical Datum of 1988 (NAVD88).

Also included in **Table A.1**, is a summary of the volume change computational limits applied to each profile at a given monument. The landward computation limit was estimated as the location where the fill berm intersects the existing upland contour or the seaward edge of vegetation. The seaward limit was assumed to be the estimated location of the beach toe/nearshore hardbottom interface. It is noted that the "beach toe" in Segment I is not specifically defined by a consistent edge of nearshore hardbottom like is typical along the Broward County Segment II and III shorelines. The "beach toe" in Segment I is described by the apparent "seaward limit of the sand beach profile" as identified by comparison of select historical beach profiles. There are, however, isolated outcroppings of rock across the active areas of the beach profile. These rock areas do not appear to significantly affect beach profile volume change. The active beach profile in Segment I typically extends from 500 to 1,000 feet seaward of the MHW shoreline and into water depths that typically range from about 25 to 30 feet.

The beach profile plots are provided as **Figures A.01** through **A.157**. Included in the plots are surveys from September 2001, March 2005 (Pre-Construction), February 2006 (Post-Construction), April 2007 (1-Year Post), July 2008 (2-Years Post), April 2009 (3-Years Post), and April 2011 (5-Years Post). All profiles were surveyed by Coastal Planning and Engineering (CPE), of Boca Raton, FL.

Table A.1: Physical limits used for volume change calculations at the primary FDEP R-monuments along the Broward County shoreline.

	Mon.	Easting (ft, NAD83)	Northing (ft, NAD83)	Azimuth	Elev. (ft, NAVD88)	Land Limit (ft)	Sea Limit (ft)
Segment I	R-01	959,068.0	723,426.0	95	14.53	0	700
	R-02	959,029.4	722,474.7	95	12.94	0	900
	R-03	958,967.6	721,451.5	95	12.7	0	620
	R-04	958,907.8	720,442.1	95	11.59	0	640
	R-05	958,901.0	719,541.5	95	14.12	0	350
	R-06	958,729.4	718,507.3	95	13.22	0	520
	R-07	958,676.5	717,444.8	95	10.7	0	650
	R-08	958,597.1	716,565.0	95	11.71	0	690
	R-09	958,397.2	715,533.5	95	14.06	0	840
	R-10	958,327.7	714,524.7	95	12.91	0	900
	R-11	958,266.9	713,526.5	95	17.22	0	970
	R-12	958,246.0	712,532.0	95	10.74	0	1070
	R-13	958,149.3	711,531.0	95	10.71	0	1120
	R-14	958,099.6	710,516.5	95	10.03	0	1140
	R-15	957,998.3	709,549.1	95	14.79	0	1200
	R-16	957,875.7	708,542.8	95	14.84	42	1300
	R-17	957,846.7	707,561.1	95	13.85	8	1240
	R-18	957,806.5	706,555.1	95	10.25	-12	1200
	R-19	957,749.0	705,540.9	95	10.36	-10	1220
	R-20	957,702.2	704,530.2	95	11.31	-10	1120
	R-21	957,637.6	703,547.5	95	19.84	32	1030
	R-22	957,545.9	702,172.3	95	20.45	10	1150
	R-23	957,519.1	701,514.6	95	15.5	0	1120
	R-24	957,478.0	700,921.0	95	11.48	0	800
Segment II	R-25	956,907.3	700,560.1	163	8.42	0	1340
	R-26	956,396.7	699,806.4	100	5.48	0	850
	R-27	956,212.9	698,811.3	100	7.7	0	1130
	R-28	955,977.6	697,775.6	100	8.39	15	1150
	R-29	955,799.4	696,944.9	100	9.43	120	1450
	R-30	955,570.2	695,954.6	100	11.42	5	1000
	R-31	955,333.3	695,014.4	100	13.34	0	1000
	R-32	955,007.9	693,840.7	100	12.18	0	1170
	R-33	954,881.4	693,066.1	100	11.61	0	750
	R-34	954,716.4	692,030.9	100	11.7	-8	810
	R-35	954,636.4	691,021.5	100	10.6	5	630
	R-36	954,584.9	689,877.0	100	10.97	0	640
	R-37	954,533.7	688,988.9	100	10.76	0	560
	R-38	954,533.5	688,046.9	100	10.35	100	500
	R-39	954,480.2	687,092.7	100	8.31	0	500
	R-40	954,256.4	686,062.1	100	10.64	0	580
	R-41	954,159.5	685,179.2	100	12.11	3	690
	R-42	954,009.9	684,192.9	100	9.76	30	440
	R-43	953,807.6	683,180.2	100	8.83	8	440
	R-44	953,653.0	682,367.2	100	11.79	0	570
	R-45	953,413.5	681,216.9	100	9.44	85	900
	R-46	953,388.2	680,304.3	100	7.06	130	600
	R-47	953,221.5	679,657.6	100	10.98	2	660
	R-48	953,070.3	678,388.2	100	10.92	0	590
	R-49	952,972.1	677,260.4	100	9.09	0	660
	R-50	952,949.6	676,133.9	100	10.48	0	715
	R-51	952,892.2	675,262.3	100	10.02	11	570

Notes: Monument coordinates are referenced to the Florida State Plane Coordinate System – East Zone, North American Datum of 1983 (NAD83). Elevations are referenced to the North American Vertical Datum of 1988 (NAVD88)

The above listed landward and seaward limits are offshore distances from the respective R-monument. The landward computation limit was estimated as the location where the fill berm intersects the existing upland contour or the seaward edge of vegetation. The seaward limit was assumed to be the estimated location of the beach toe/nearshore hardbottom interface. This was located through comparison of historical beach profile surveys.

Table A.1 (cont.): Physical limits used for volume change calculations at the primary FDEP R-monuments along the Broward County shoreline.

	Mon.	Easting (ft, NAD83)	Northing (ft, NAD83)	Azimuth	Elev. (ft, NAVD88)	Land Limit (ft)	Sea Limit (ft)
Segment II	R-52	952,717.4	674,202.8	100	8.29	-18	600
	R-53	952,654.6	673,343.5	100	9.06	3	530
	R-54	952,558.5	672,252.2	100	9.5	-17	510
	R-55	952,420.3	671,251.6	100	11.11	2	620
	R-56	952,245.2	670,330.9	90	11.42	22	630
	R-57	952,119.7	669,349.1	90	10.92	2	590
	R-58	952,018.2	668,216.2	95	11.67	0	520
	R-59	951,973.9	667,325.0	100	9.13	0	620
	R-60	951,818.5	666,339.3	105	13.68	6	610
	R-61	951,633.8	665,361.0	95	10.29	50	700
	R-62	951,389.4	664,340.6	105	9.73	120	760
	R-63	951,370.2	663,546.2	100	8.03	0	670
	R-64	951,222.2	662,333.2	100	8.82	0	590
	R-65	951,086.2	661,391.2	100	5.77	7	660
	R-66	950,953.2	660,411.2	100	5.42	6	760
	R-67	950,798.2	659,430.2	100	5.81	2	550
	R-68	950,546.7	658,374.6	100	10.98	100	730
	R-69	950,459.5	657,395.9	100	10.51	120	680
	R-70	950,460.2	656,481.2	100	5.94	30	650
	R-71	950,336.9	655,346.2	100	6.77	118	580
	R-72	950,315.8	654,440.1	95	6.7	88	520
	R-73	950,314.7	653,289.6	95	7.22	60	440
	R-74	950,236.8	652,407.5	100	10.15	82	510
	R-75	950,101.3	651,308.9	100	9.87	60	590
	R-76	949,992.4	650,345.3	100	9.81	55	690
	R-77	949,937.0	649,163.1	100	9.84	50	570
	R-78	949,927.8	648,132.3	100	12.14	8	590
	R-79	949,738.2	647,083.1	100	13.34	100	870
	R-80	949,773.1	645,961.9	95	9.95	210	660
	R-81	949,776.4	644,880.0	95	14.28	0	730
	R-81.3	949,783.9	644,532.4	90	7.45	70	720
	R-81.7	949,690.8	644,169.5	90	9.69	2	790
	R-82	949,652.2	643,844.1	90	8.48	4	1130
	R-82.3	949,643.6	643,508.0	90	8.16	-10	1010
	R-82.7	949,656.9	643,161.4	90	5.93	-34	1130
	R-83	949,541.8	642,825.0	90	9.15	4	1190
	R-83.3	949,359.4	642,524.7	90	8.3	400	1350
	R-83.7	949,360.7	642,231.8	90	8.29	520	1200
	R-84	949,602.3	641,935.2	90	7.65	0	500
	R-84.3	949,616.4	641,674.1	90	8.07	0	680
	R-84.7	949,771.2	641,320.9	90	6	0	700
	R-85	948,960.9	641,502.8	94	7.49	0	580
Segment III	R-85.7	948,858.7	640,252.8	94	NA	9	980
	R-86	948,820.9	640,143.7	94	8.36	38	1000
	R-86.3	948,625.9	639,870.9	94	8.14	-50	1110
	R-86.5	948,505.4	639,702.3	94	10	0	810
	R-86.7	948,472.9	639,464.7	94	11.43	0	610
	R-87	948,244.6	639,264.8	94	10.21	225	740
	R-87.2	948,422.7	638,971.9	94	7.35	-88	490
	R-87.5	948,408.6	638,754.2	94	7.27	0	500
	R-87.7	948,277.9	638,512.5	94	6.49	120	640

Notes: Monument coordinates are referenced to the Florida State Plane Coordinate System – East Zone, North American Datum of 1983 (NAD83). Elevations are referenced to the North American Vertical Datum of 1988 (NAVD88)

The above listed landward and seaward limits are offshore distances from the respective R-monument. The landward computation limit was estimated as the location where the fill berm intersects the existing upland contour or the seaward edge of vegetation. The seaward limit was assumed to be the estimated location of the beach toe/nearshore hardbottom interface. This was located through comparison of historical beach profile surveys.

Table A.1 (cont.): Physical limits used for volume change calculations at the primary FDEP R-monuments along the Broward County shoreline.

	Mon.	Easting (ft, NAD83)	Northing (ft, NAD83)	Azimuth	Elev. (ft, NAVD88)	Land Limit (ft)	Sea Limit (ft)
Segment III	R-88	948,146.6	638,270.6	94	5.59	205	670
	R-88.2	948,240.1	637,998.4	94	6.77	80	550
	R-88.5	948,333.9	637,725.2	94	6.45	0	450
	R-89	948,179.7	637,228.2	94	3.66	190	550
	R-89.5	948,202.2	636,703.4	94	4.16	0	520
	R-90	948,150.4	636,251.5	94	4.34	190	520
	R-90.5	948,245.5	635,732.6	94	6.93	0	410
	R-91	948,176.3	635,229.2	94	6.98	130	490
	R-91.5	948,270.9	634,704.5	94	8.67	-50	420
	R-92	948,139.8	634,194.6	94	6.65	120	470
	R-92.5	948,200.2	633,673.5	94	8.34	-50	300
	R-93	948,026.9	633,158.9	94	6.06	138	550
	R-94	947,945.8	632,194.9	94	8.02	92	640
	R-95	947,858.6	631,243.9	92	7.9	115	750
	R-96	947,832.8	630,255.4	92	7.62	90	590
	R-97	947,681.2	629,304.0	92	6.63	150	810
	R-98	947,707.0	628,227.3	100	8.21	130	670
	98.5	947,729.3	627,752.8	100		46	265
	R-99	947,751.5	627,278.3	100	5.22	1	700
	R-100	947,679.1	626,288.1	100	6.08	25	720
	R-101	947,568.1	625,146.2	95	8.35	5	790
	R-102	947,410.2	624,152.0	95	8.35	0	1020
	R-103	947,279.7	623,137.8	95	8.67	68	1010
	R-104	947,184.9	622,113.7	95	8.51	85	1000
	R-105	947,101.2	621,126.7	95	9.19	92	820
	R-106	947,069.5	620,134.0	95	7.71	80	940
	R-107	946,989.6	619,170.0	95	8.17	80	950
	R-108	946,957.1	618,139.6	95	8.45	40	880
	R-109	946,892.8	617,100.9	95	7.77	40	900
	R-110	946,828.4	616,034.1	95	7.56	40	880
	R-111	946,779.9	615,040.4	95	7.78	100	890
	R-112	946,730.3	614,013.0	95	5.83	95	770
	R-113	946,708.7	613,081.9	95	5.62	40	790
	R-114	946,635.3	612,110.9	95	6.37	80	900
	R-115	946,625.0	611,059.8	95	6.28	12	800
	R-116	946,561.1	610,055.9	95	6.18	92	940
	R-117	946,441.5	609,066.3	95	7.31	130	1080
	R-118	946,368.2	607,985.2	95	8.22	75	1060
	R-119	946,382.0	606,982.3	95	7.57	4	900
	R-120	946,307.9	605,867.6	95	8.79	0	810
	R-121	946,274.1	604,782.5	95	6.81	-10	850
	R-122	946,211.9	603,784.5	95	8.69	0	750
	R-123	946,132.2	602,768.5	95	7.32	0	810
	R-124	945,912.1	601,672.8	95	11.19	18	920
	R-125	945,729.1	600,600.8	95	6.35	175	1060
	R-126	945,861.1	599,589.8	95	7.66	2	950
	R-127	945,781.3	598,575.0	95	7.21	0	830
	R-128	945,749.5	597,642.6	95	7.95	-50	850
Dade	D-02	945,772.3	596,602.5	95	7.44	-20	800
	D-03	945,700.6	595,501.4	95	14.94	2	980
	D-04	945,582.6	594,436.8	95	11.37	40	1100
	D-05	945,665.3	593,353.5	95	8.7	0	840

Notes: Monument coordinates are referenced to the Florida State Plane Coordinate System – East Zone, North American Datum of 1983 (NAD83). Elevations are referenced to the North American Vertical Datum of 1988 (NAVD88)

The above listed landward and seaward limits are offshore distances from the respective R-monument. The landward computation limit was estimated as the location where the fill berm intersects the existing upland contour or the seaward edge of vegetation. The seaward limit was assumed to be the estimated location of the beach toe/nearshore hardbottom interface. This was located through comparison of historical beach profile surveys.

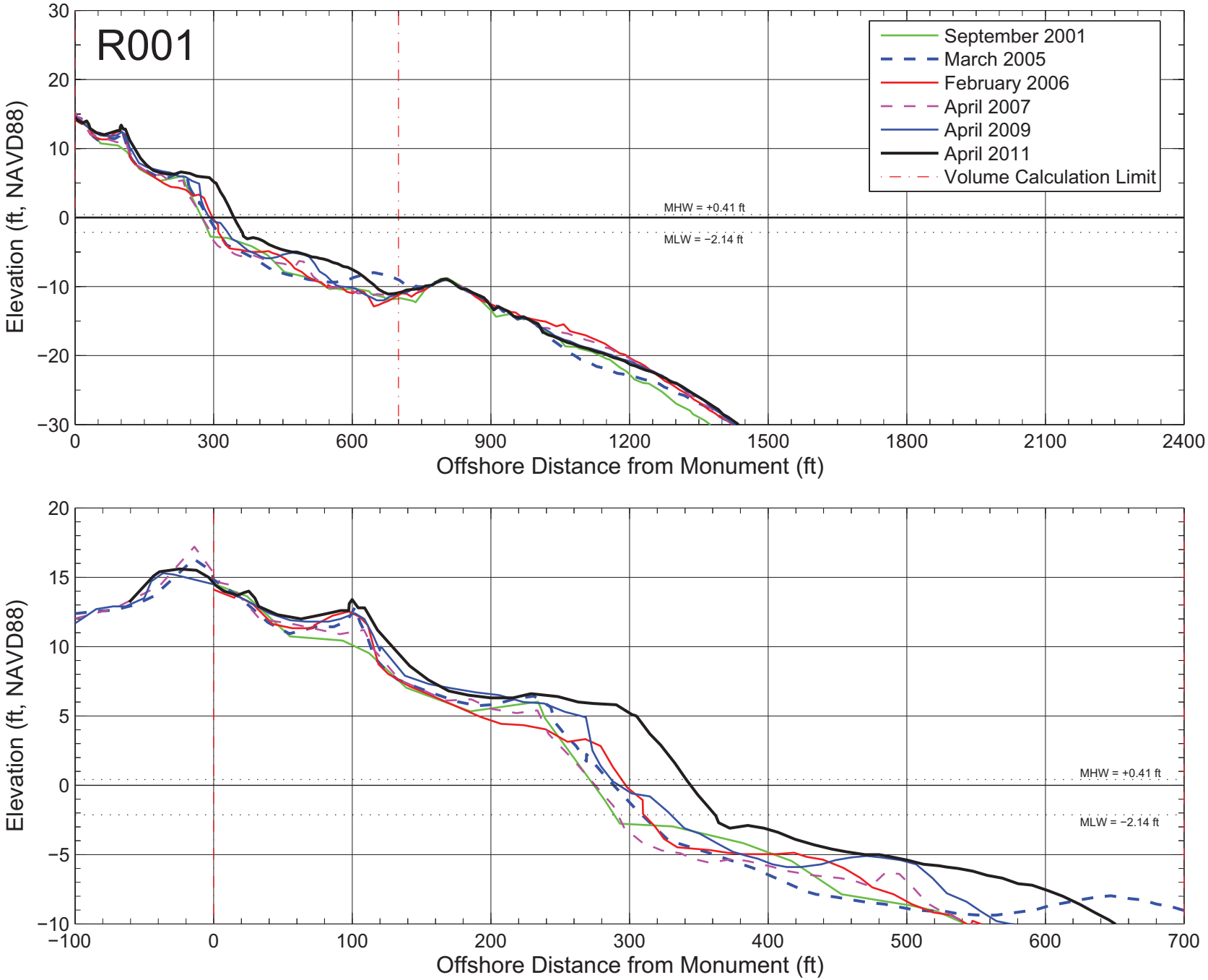


Figure A–001: Measured beach profiles at monument R001 Broward County, Florida.

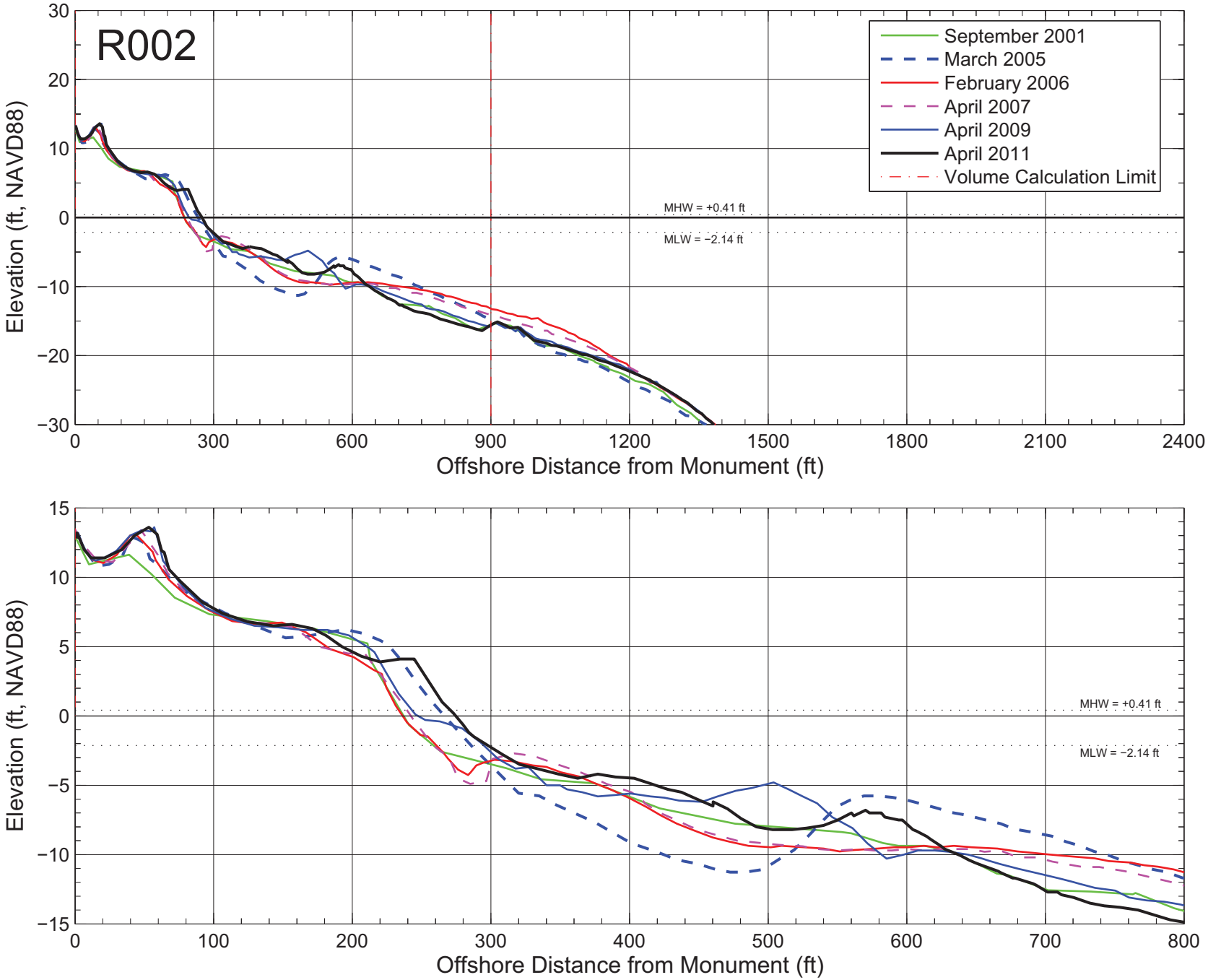


Figure A–002: Measured beach profiles at monument R002 Broward County, Florida.

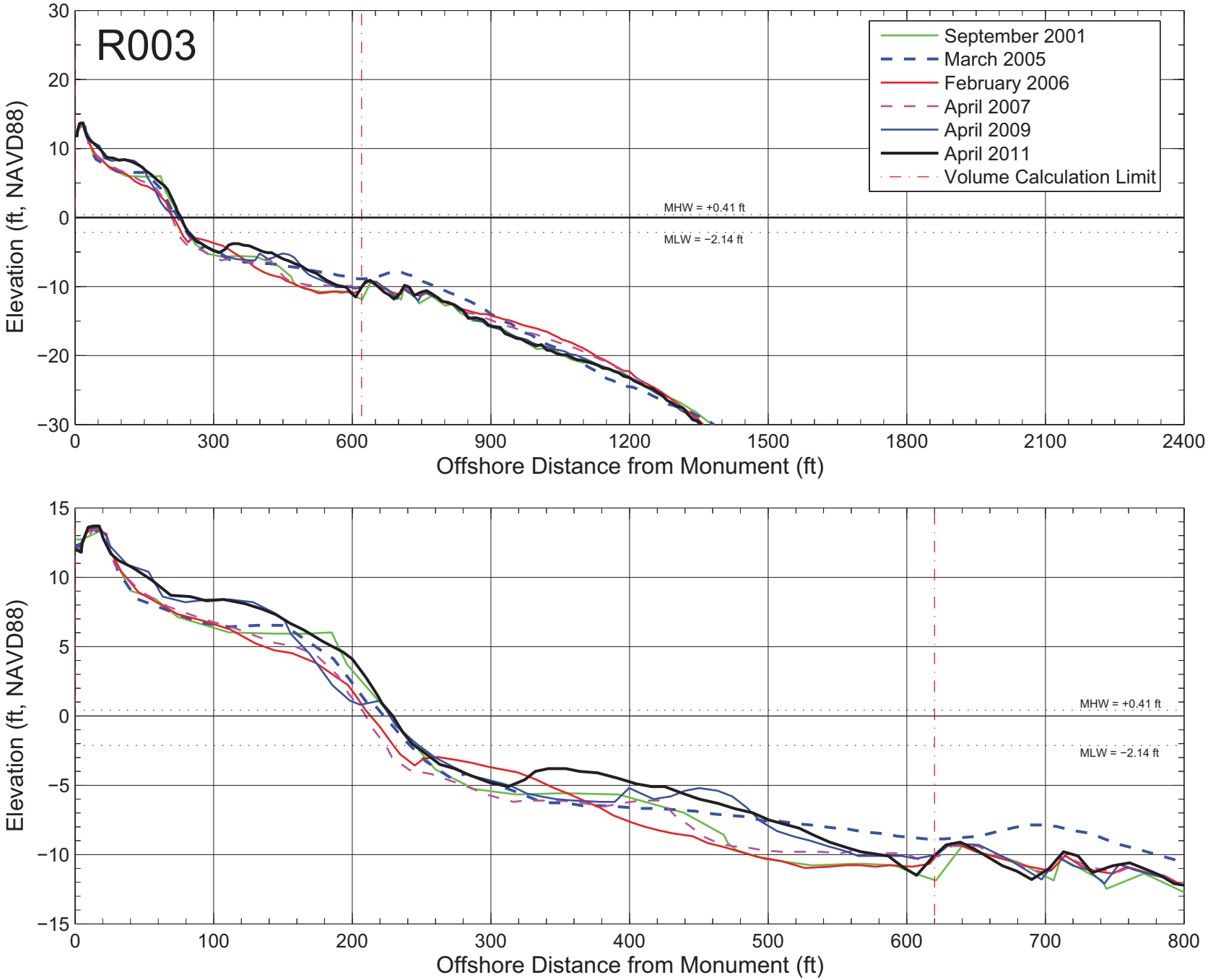


Figure A–003: Measured beach profiles at monument R003 Broward County, Florida.

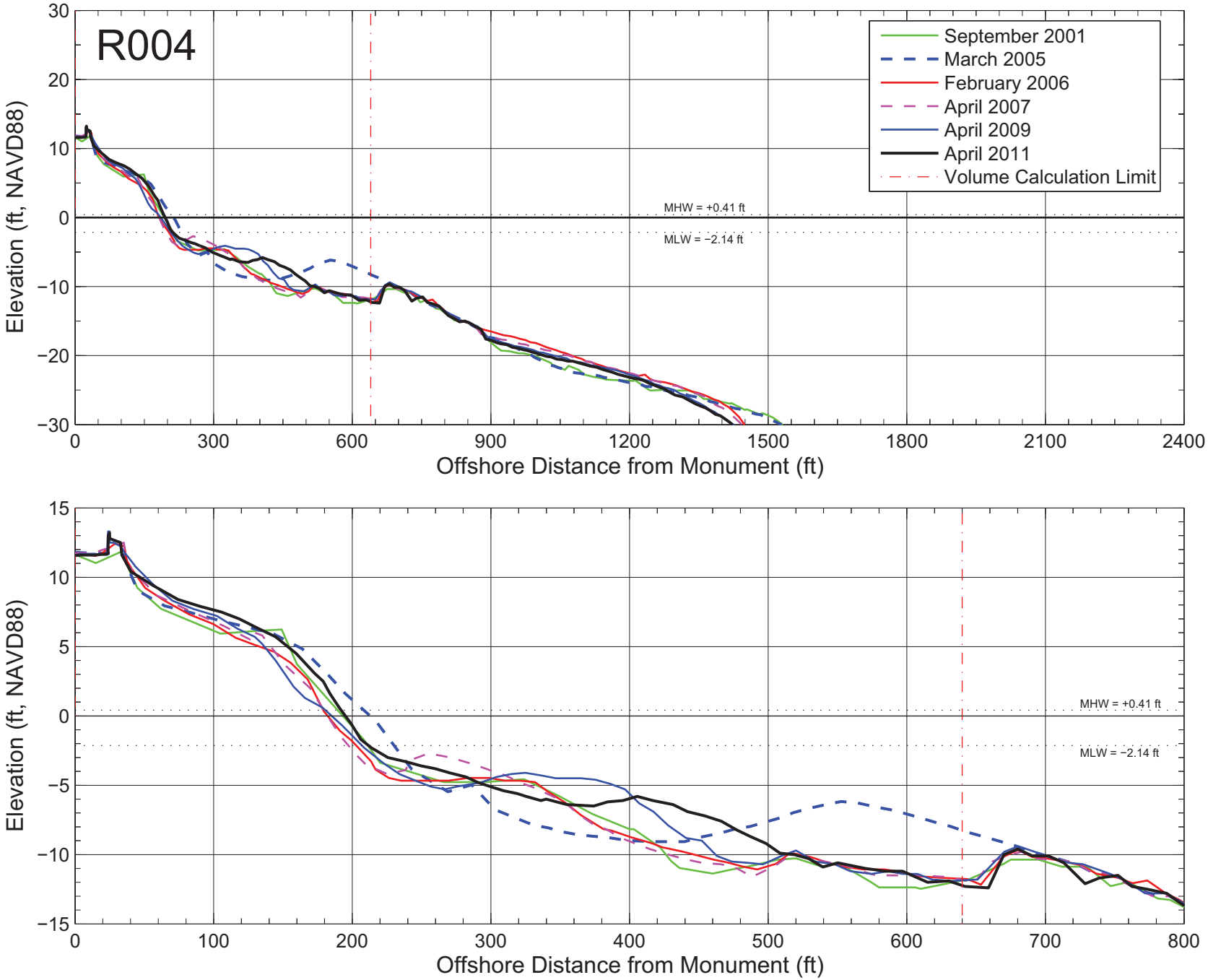


Figure A–004: Measured beach profiles at monument R004 Broward County, Florida.

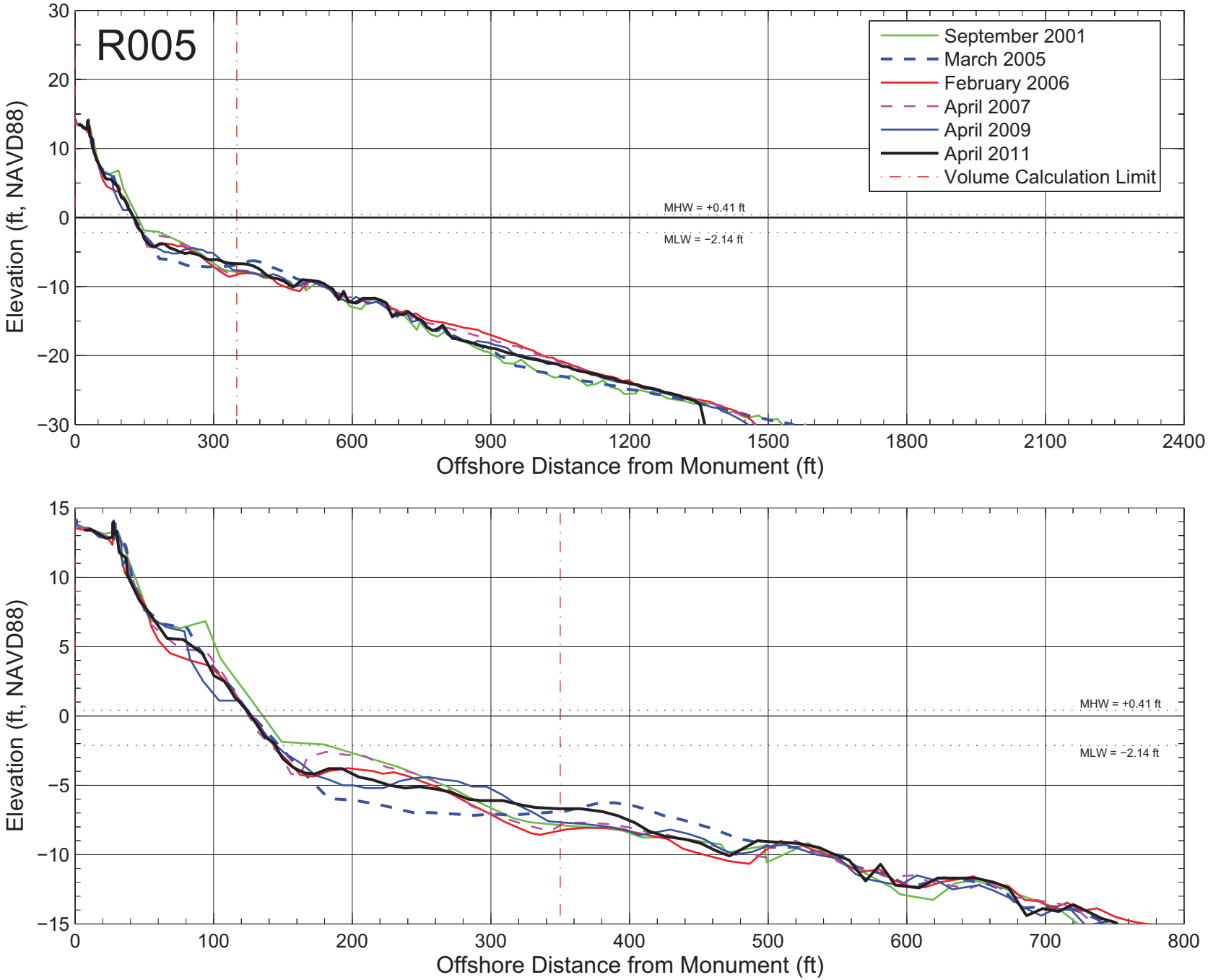


Figure A–005: Measured beach profiles at monument R005 Broward County, Florida.

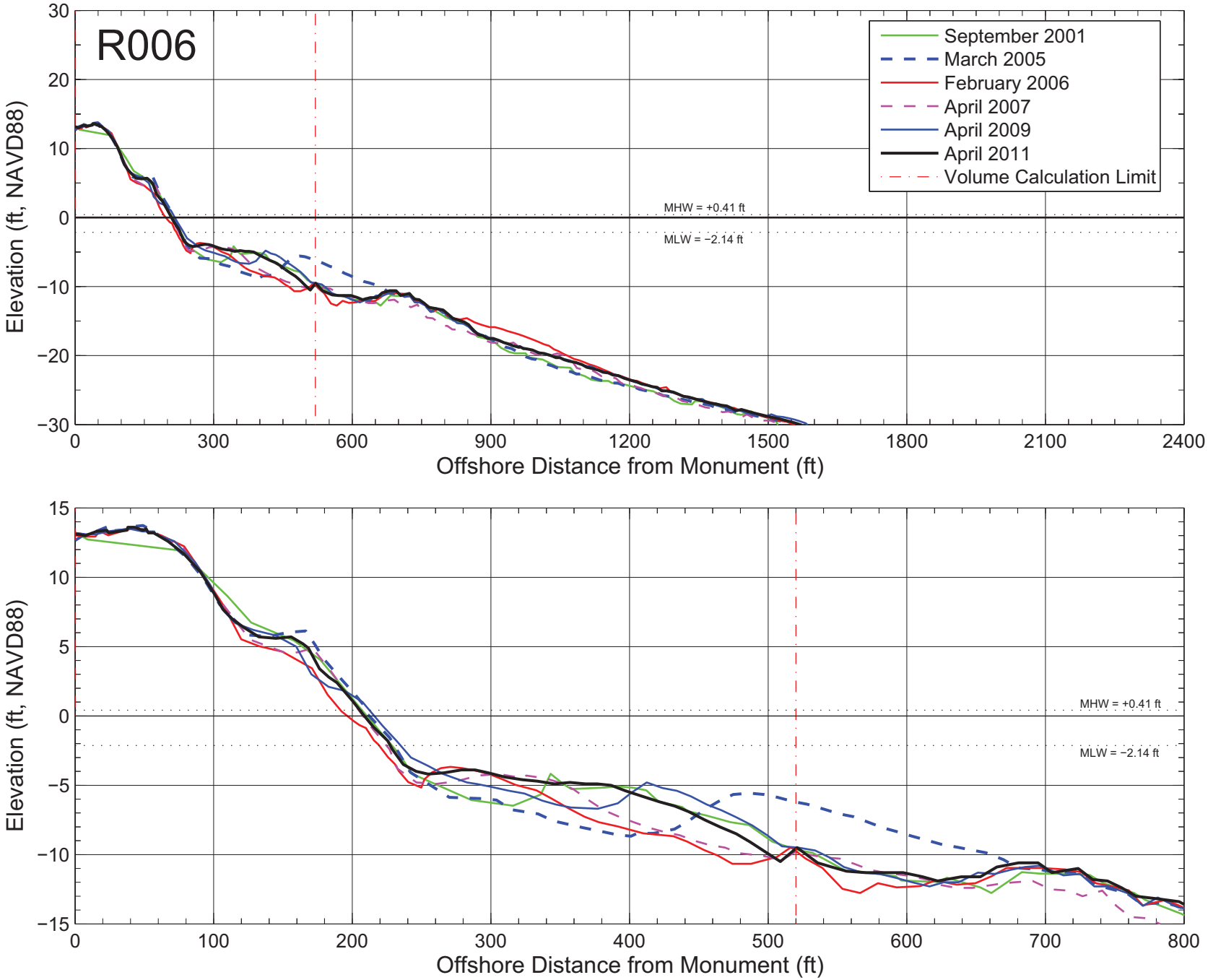


Figure A–006: Measured beach profiles at monument R006 Broward County, Florida.

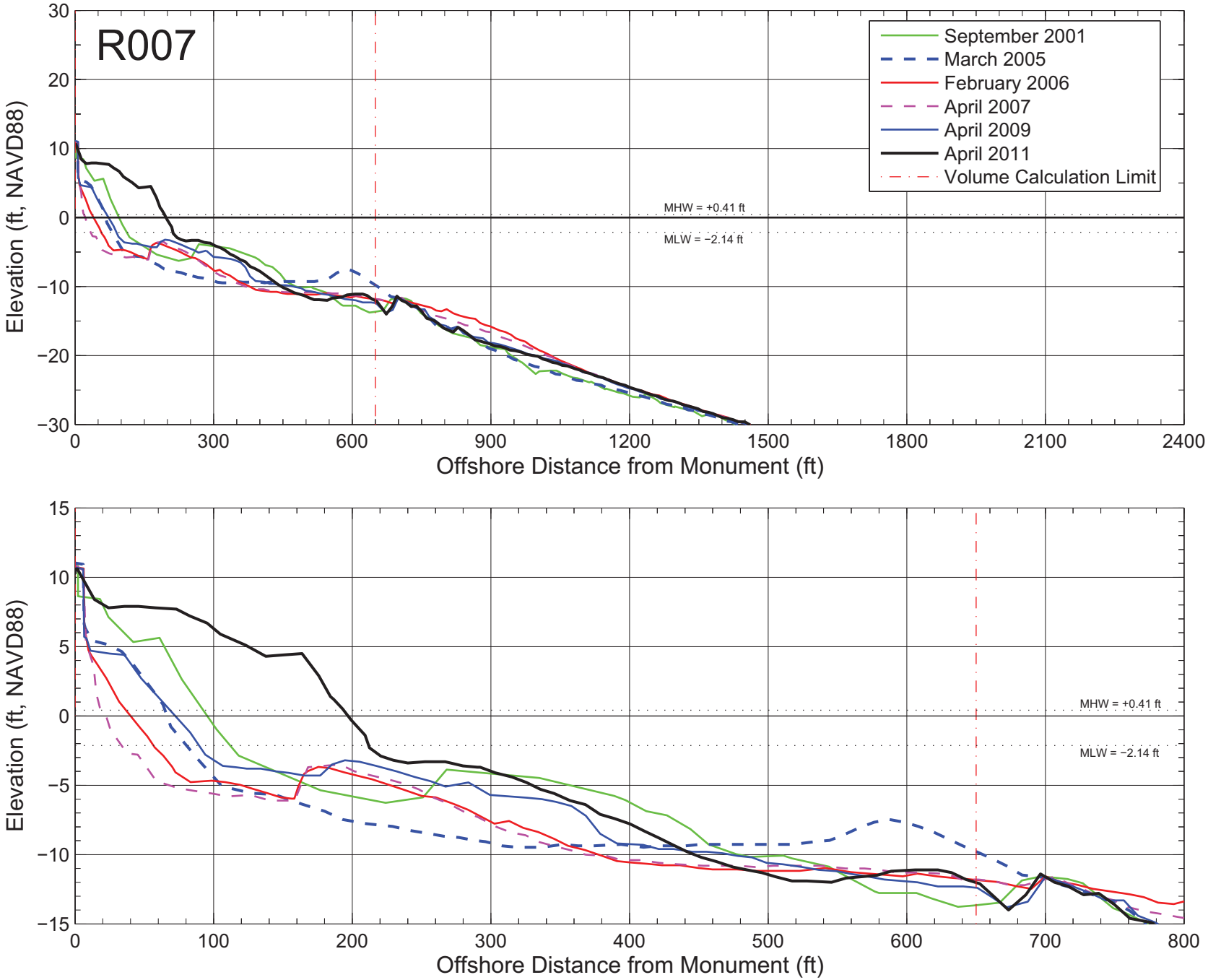


Figure A–007: Measured beach profiles at monument R007 Broward County, Florida.

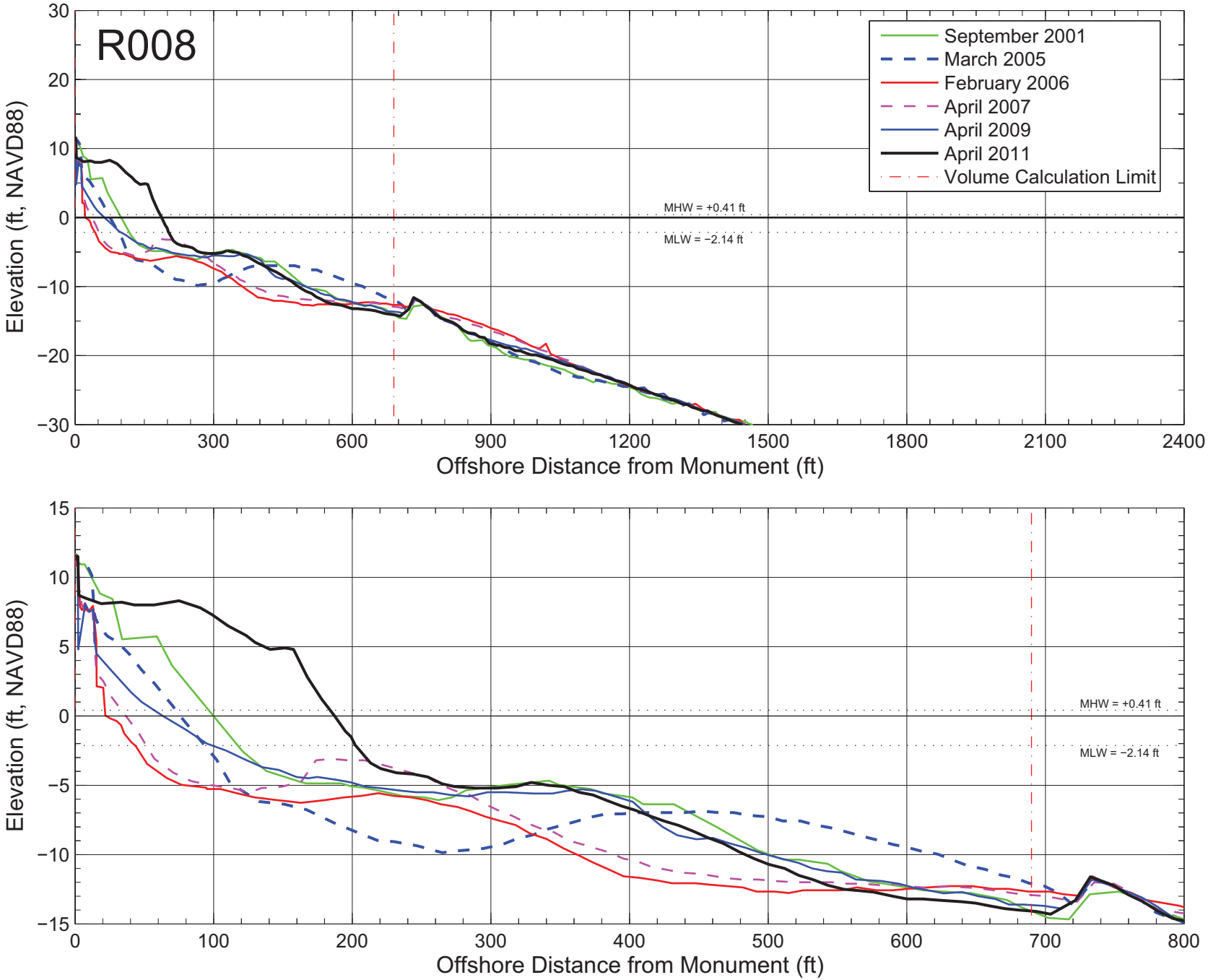


Figure A–008: Measured beach profiles at monument R008 Broward County, Florida.

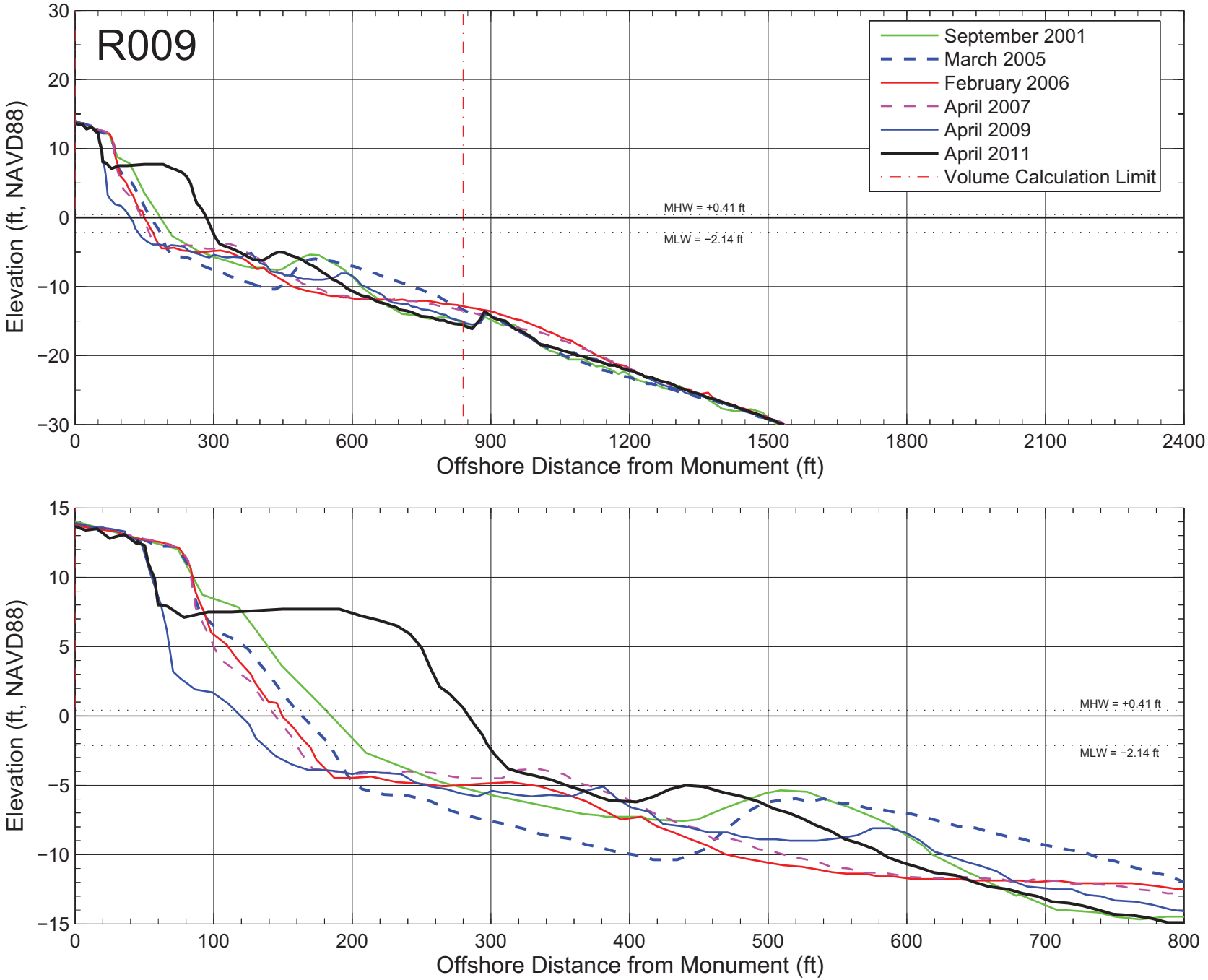


Figure A–009: Measured beach profiles at monument R009 Broward County, Florida.

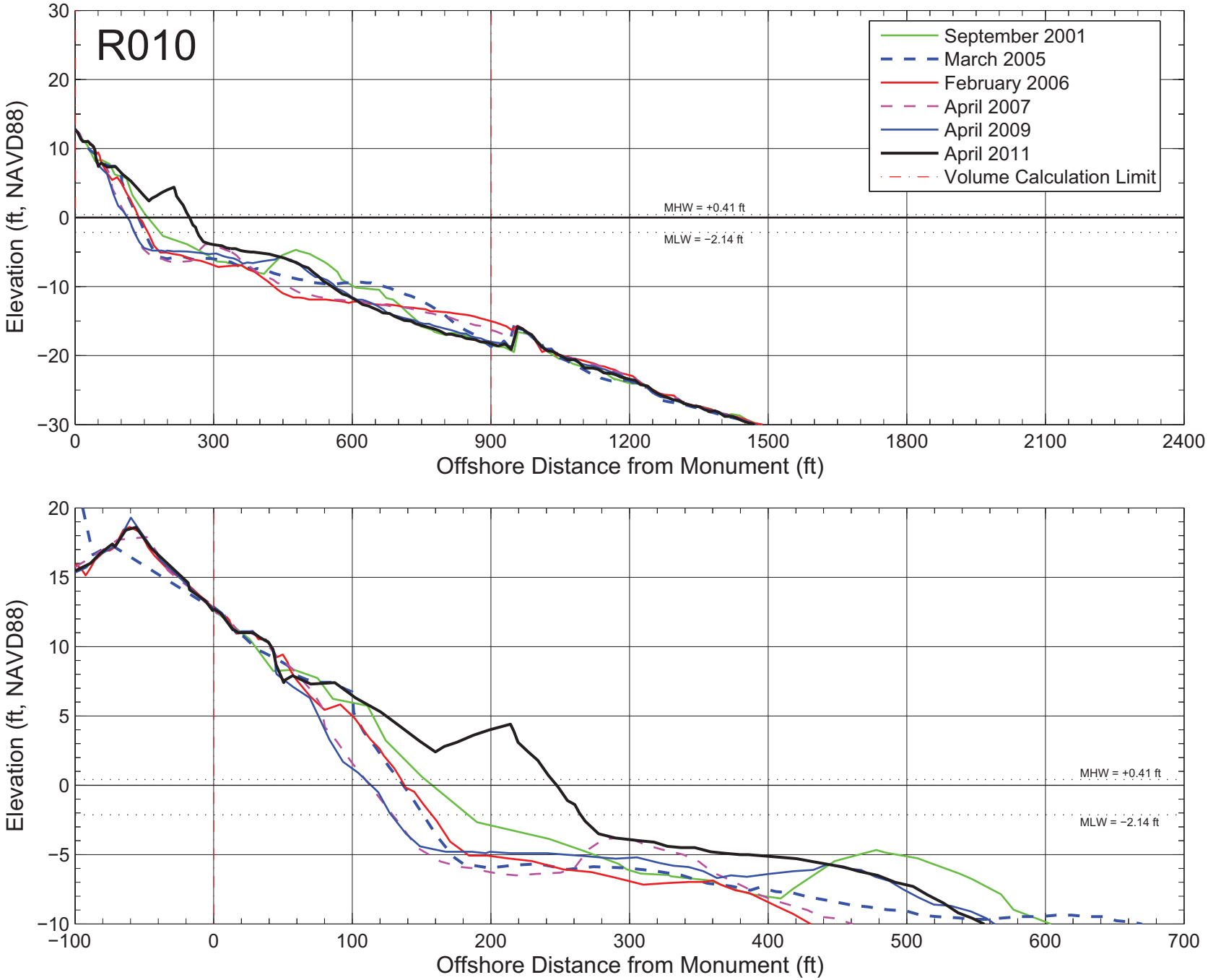


Figure A–010: Measured beach profiles at monument R010 Broward County, Florida.

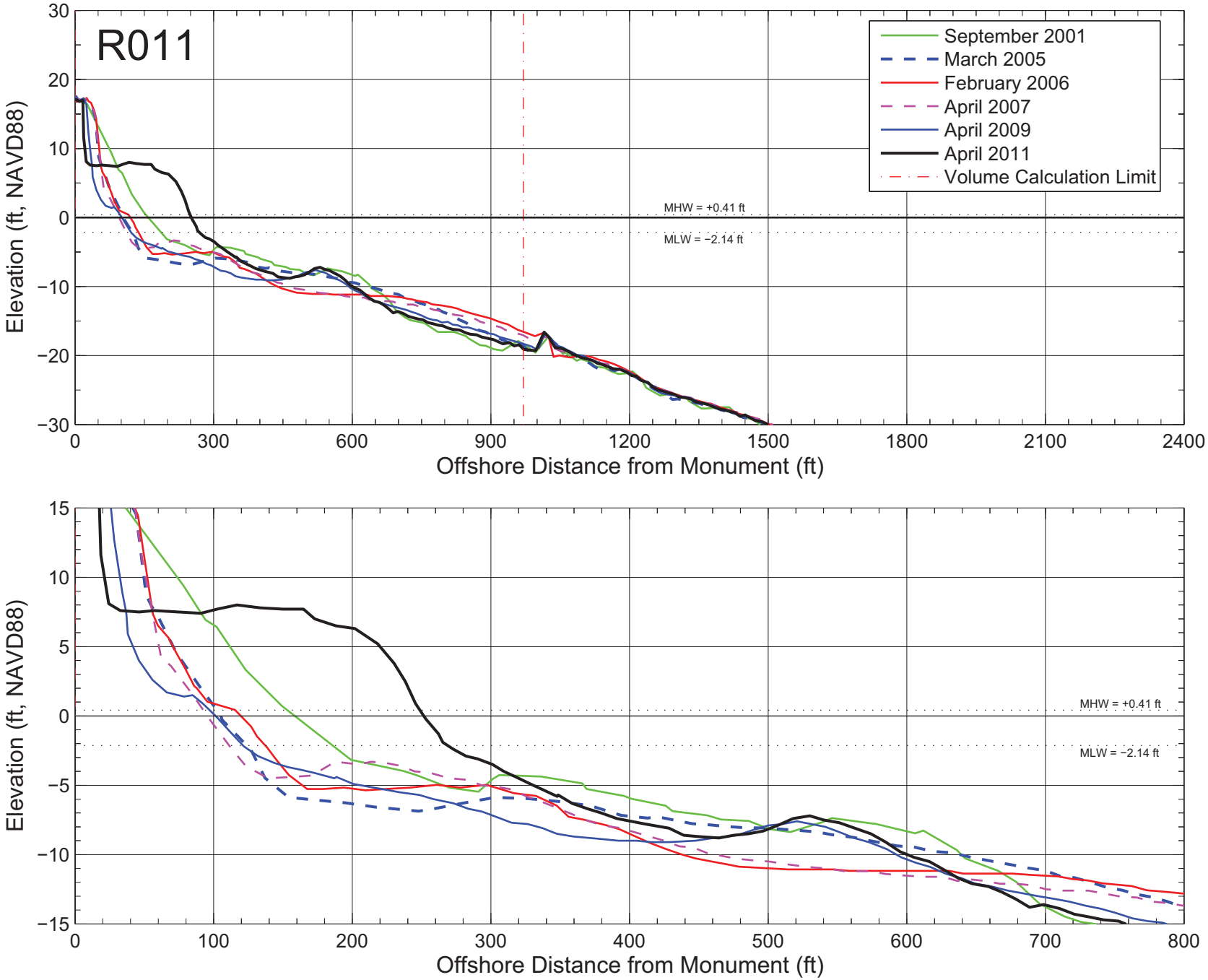


Figure A–011: Measured beach profiles at monument R011 Broward County, Florida.

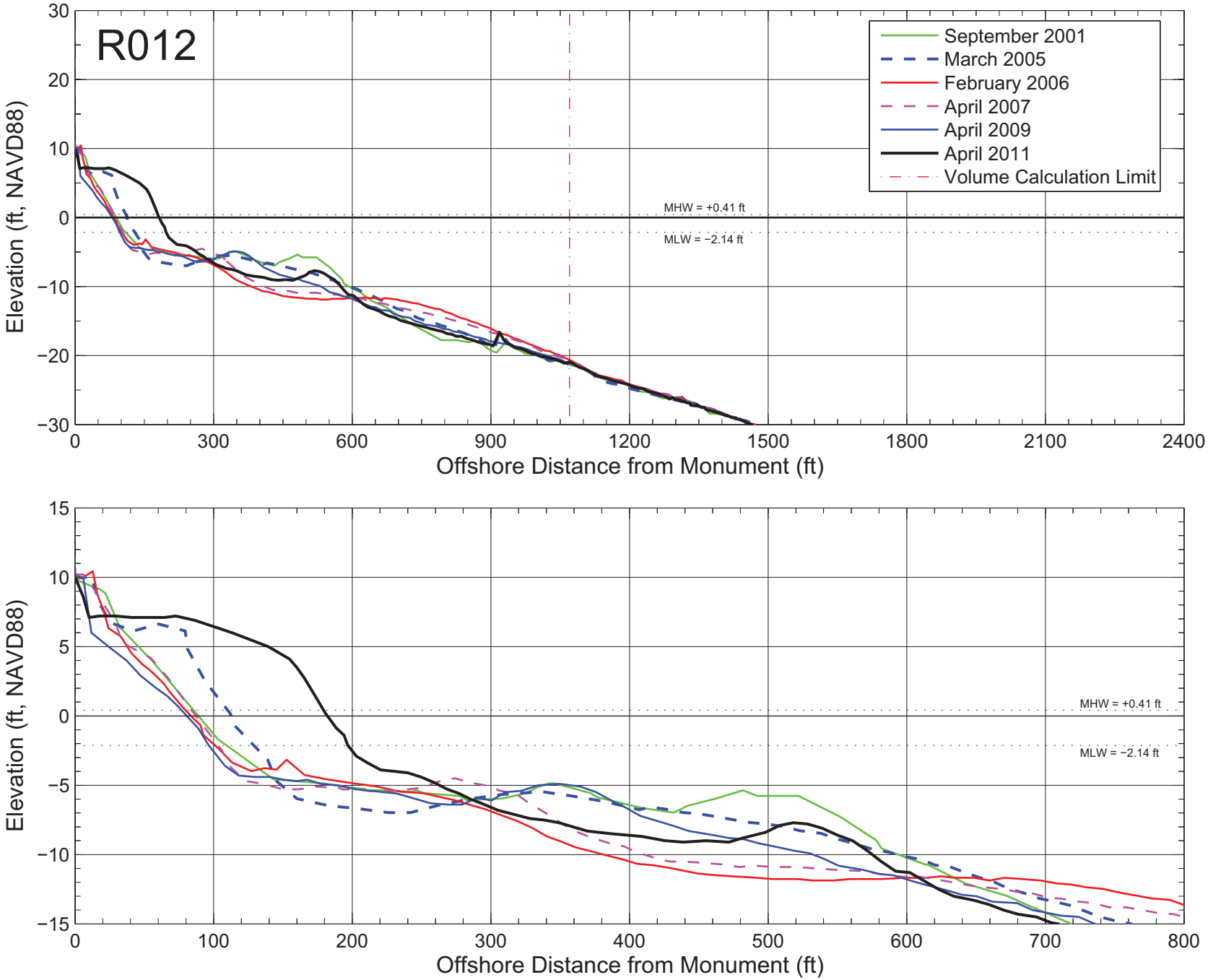


Figure A–012: Measured beach profiles at monument R012 Broward County, Florida.

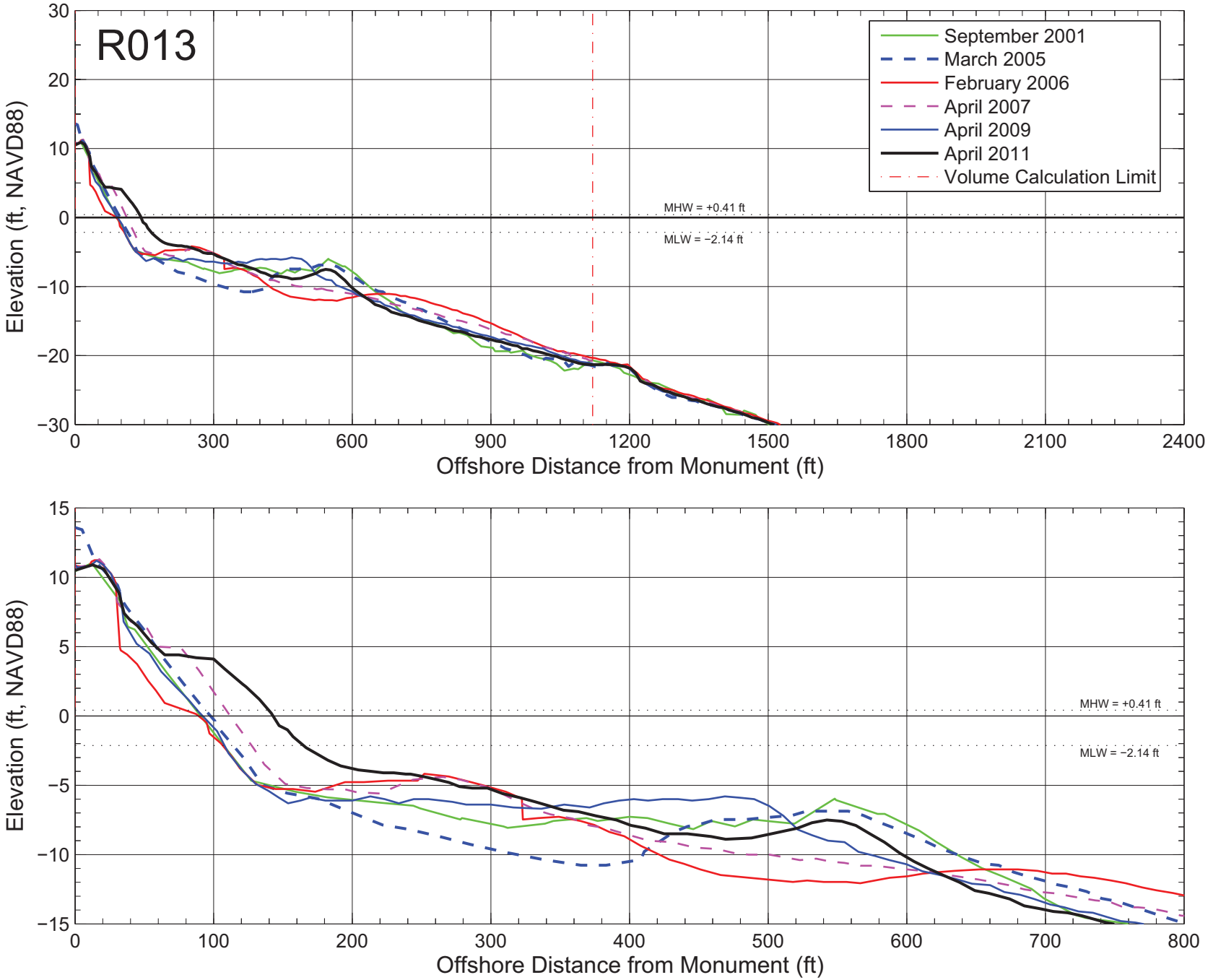


Figure A–013: Measured beach profiles at monument R013 Broward County, Florida.

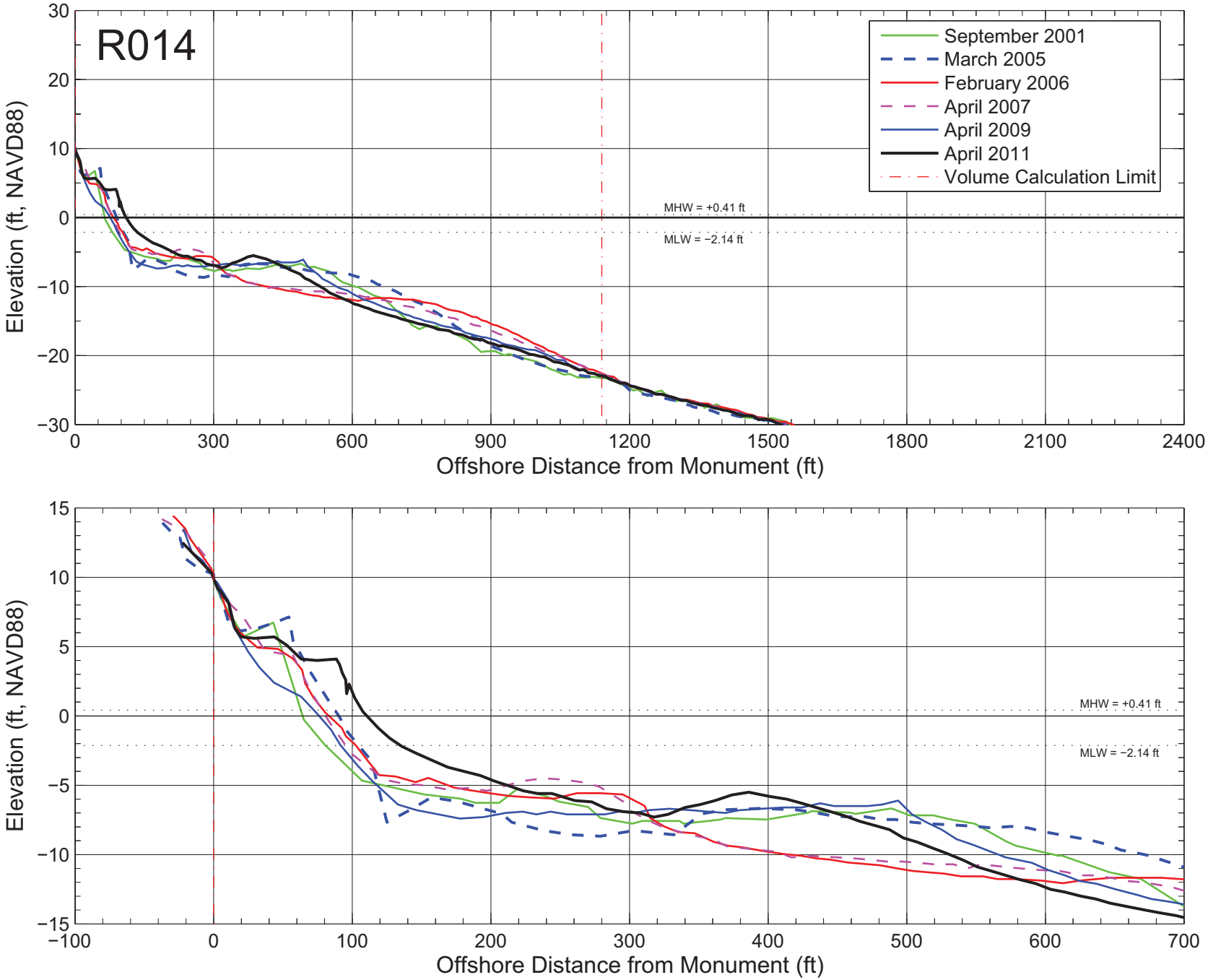


Figure A–014: Measured beach profiles at monument R014 Broward County, Florida.

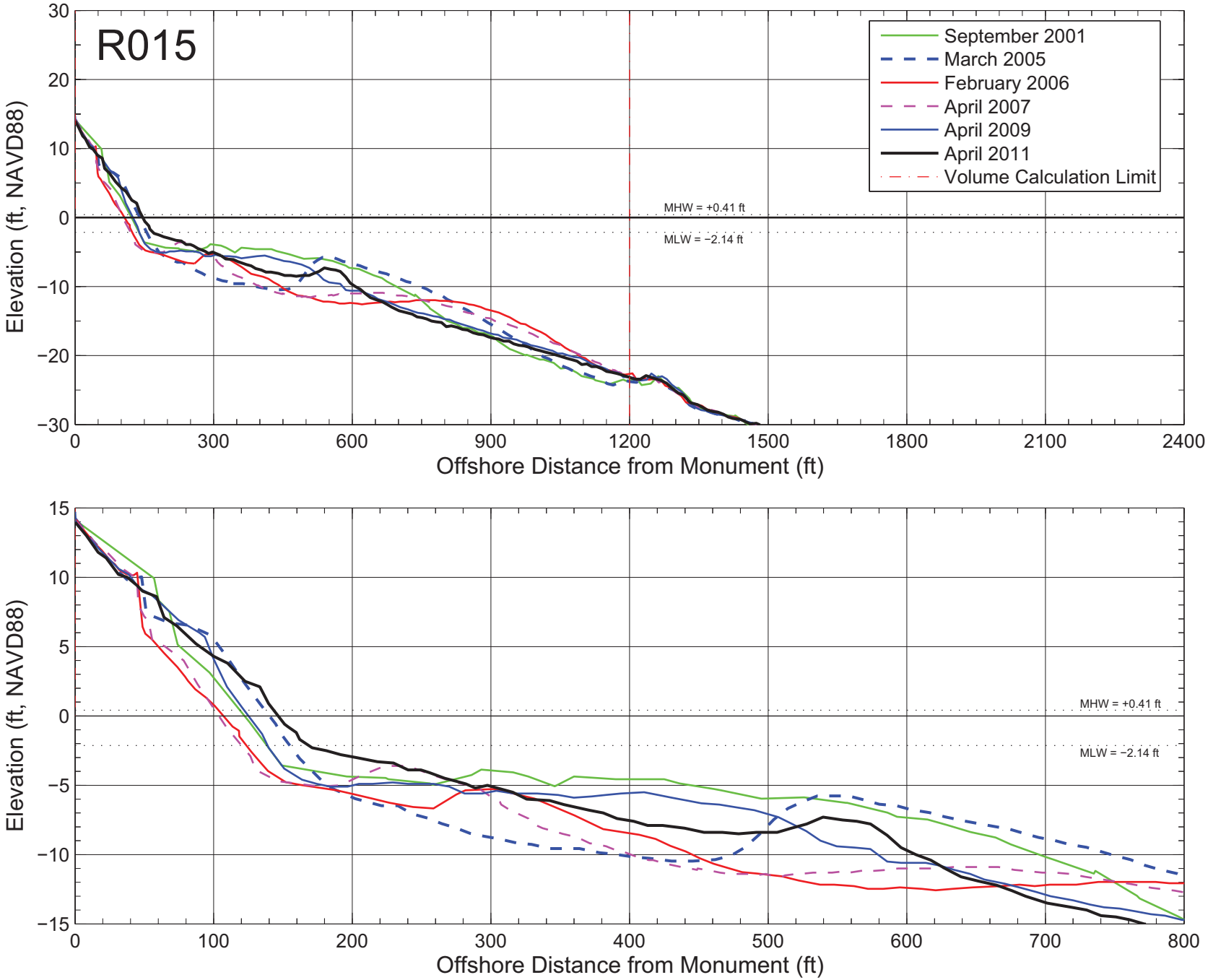


Figure A–015: Measured beach profiles at monument R015 Broward County, Florida.

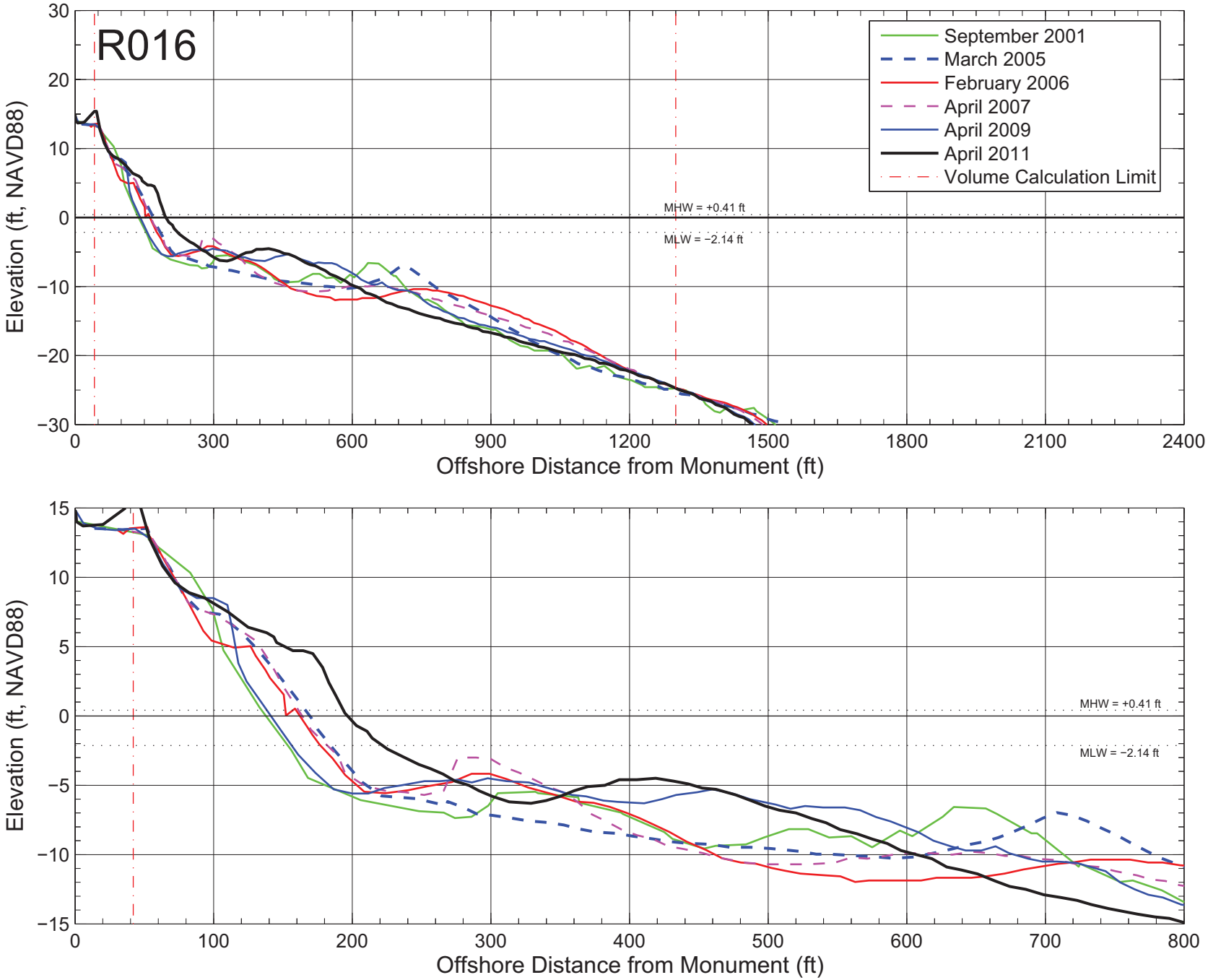


Figure A–016: Measured beach profiles at monument R016 Broward County, Florida.

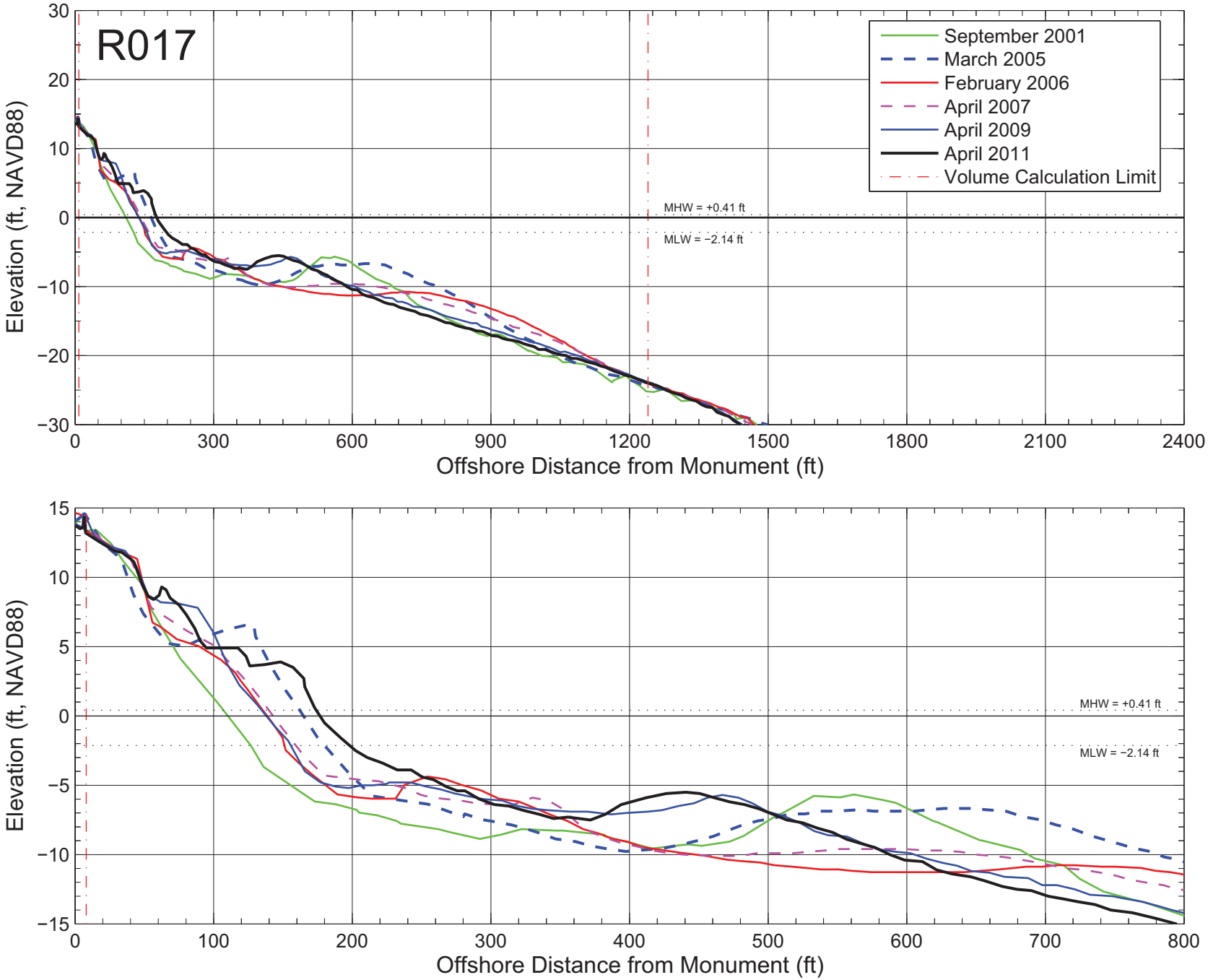


Figure A–017: Measured beach profiles at monument R017 Broward County, Florida.

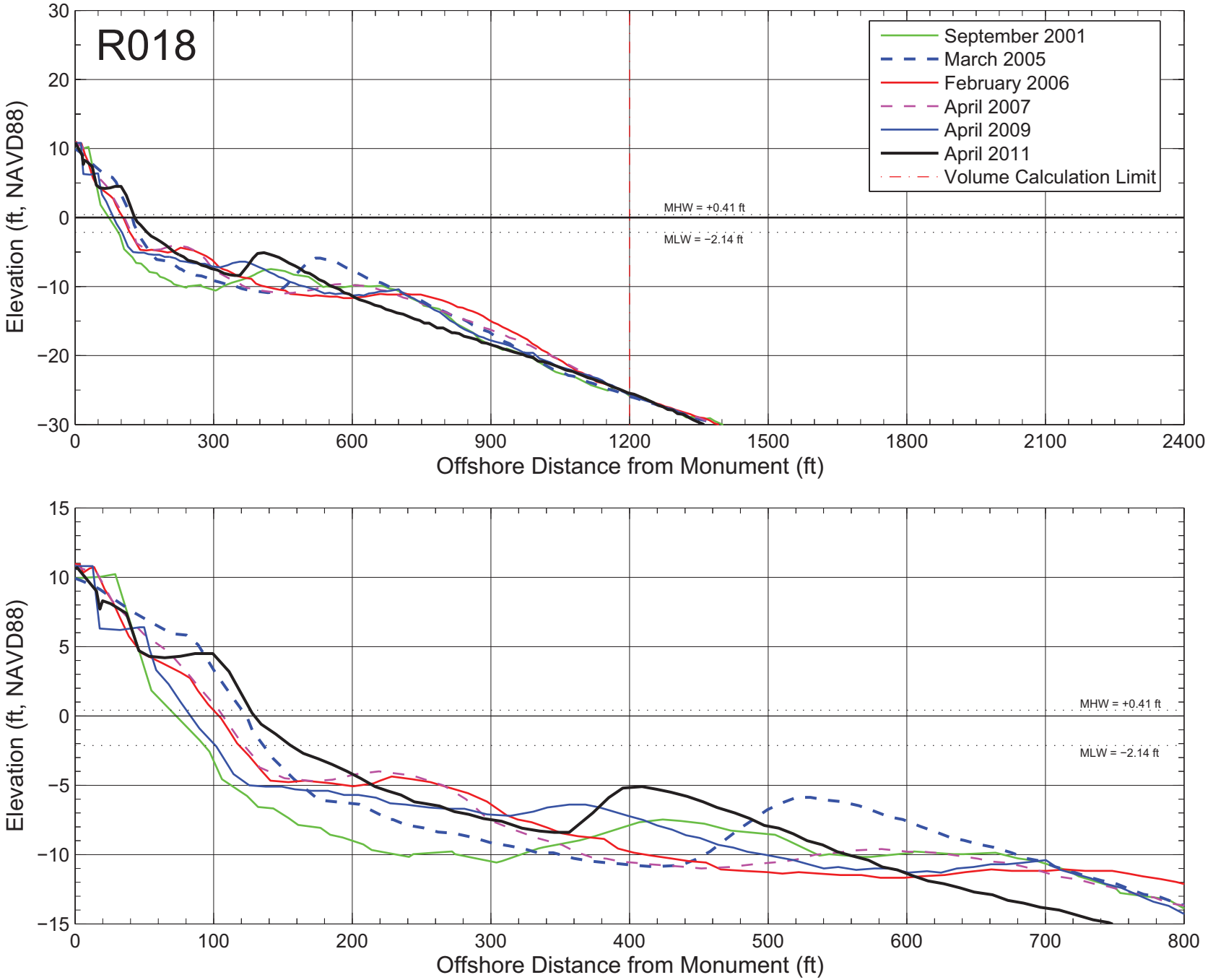


Figure A–018: Measured beach profiles at monument R018 Broward County, Florida.

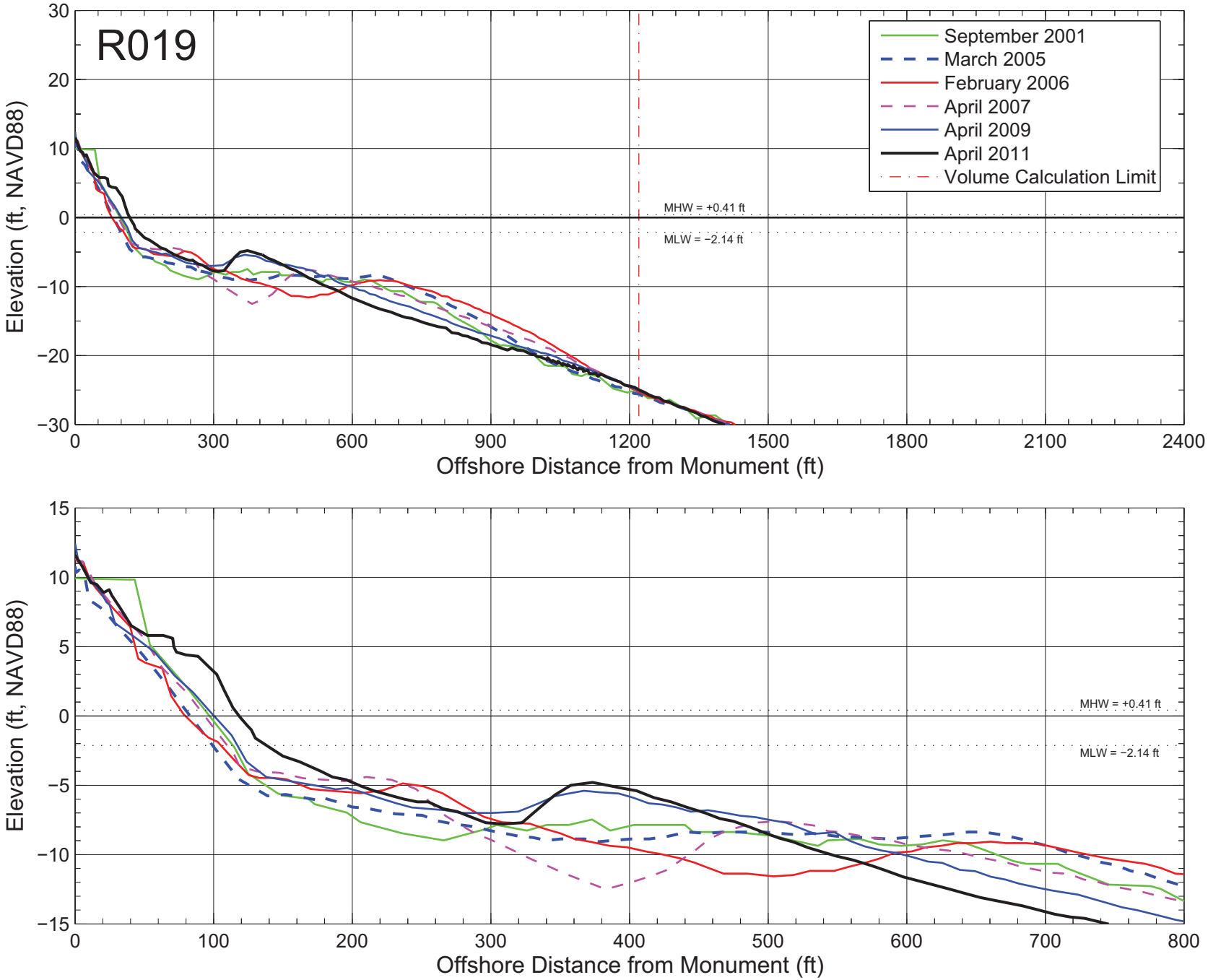


Figure A–019: Measured beach profiles at monument R019 Broward County, Florida.

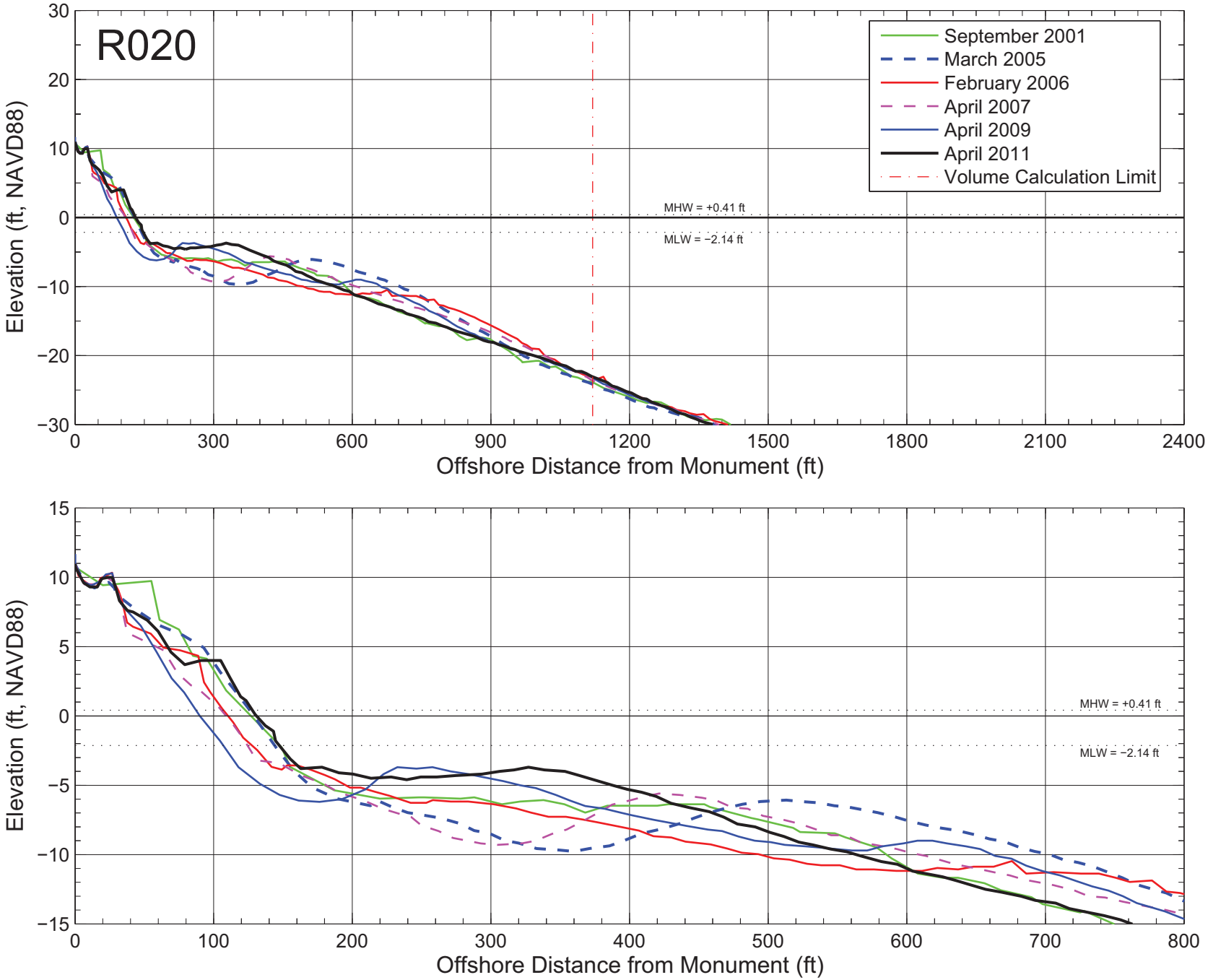


Figure A–020: Measured beach profiles at monument R020 Broward County, Florida.

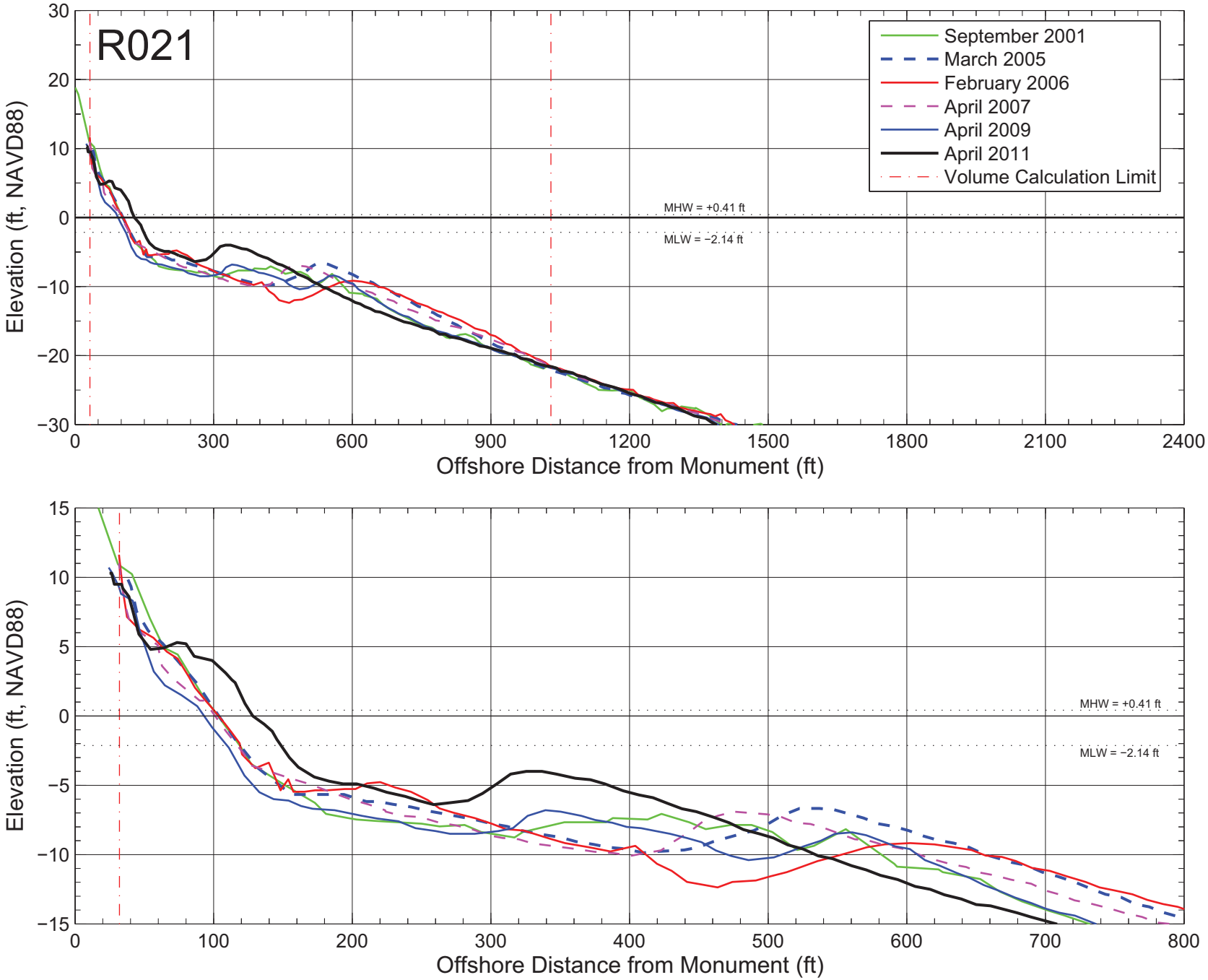


Figure A–021: Measured beach profiles at monument R021 Broward County, Florida.

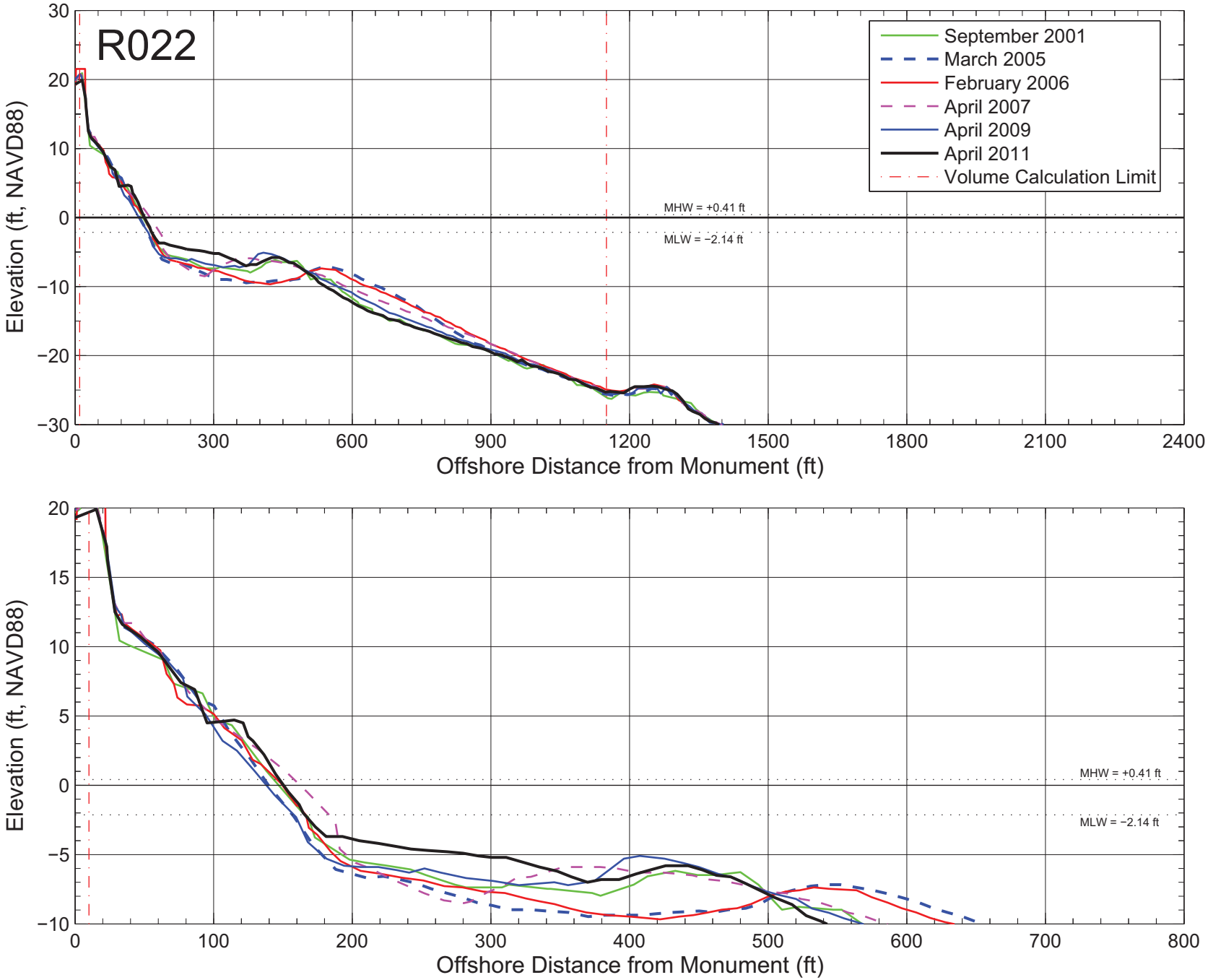


Figure A–022: Measured beach profiles at monument R022 Broward County, Florida.

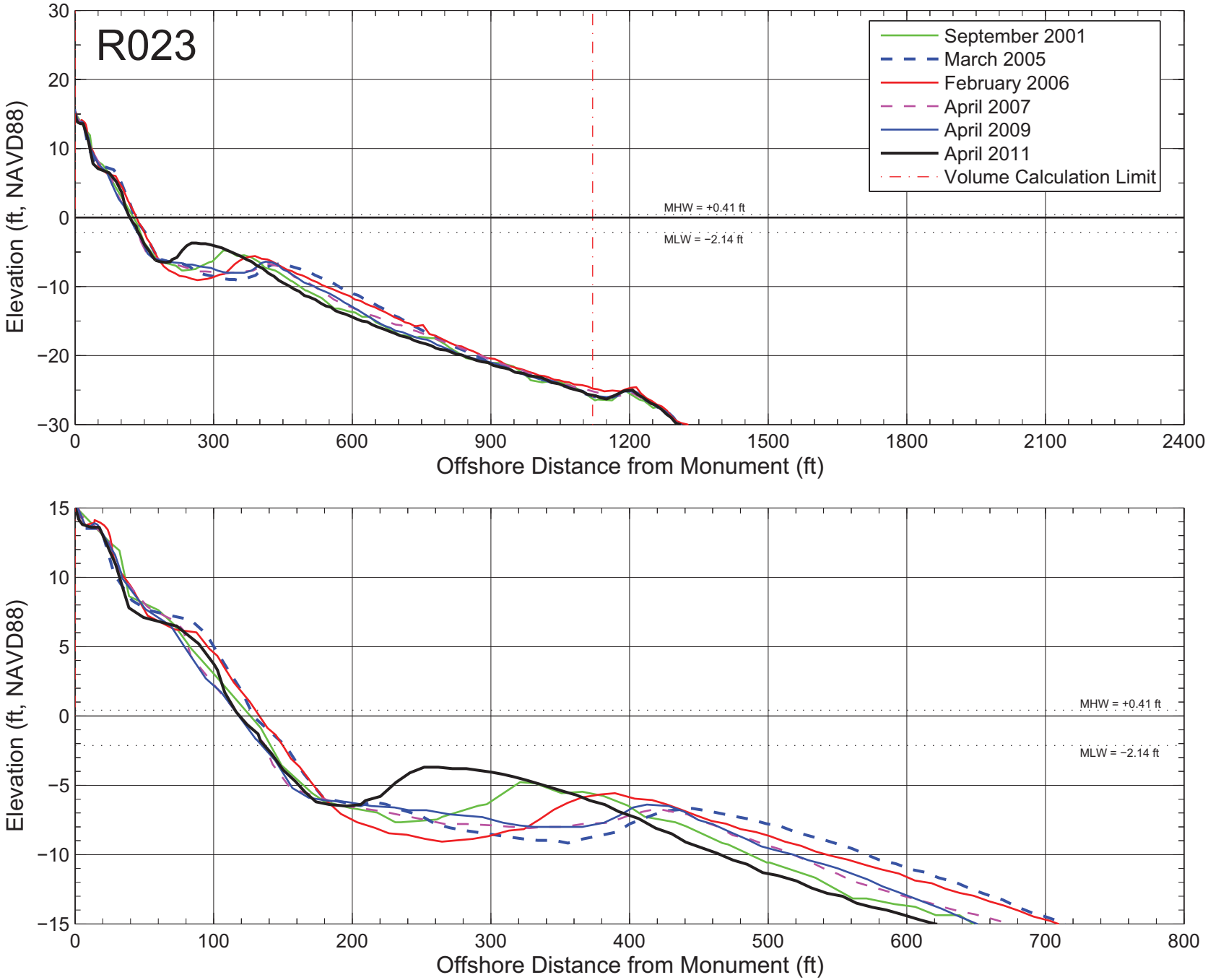


Figure A–023: Measured beach profiles at monument R023 Broward County, Florida.

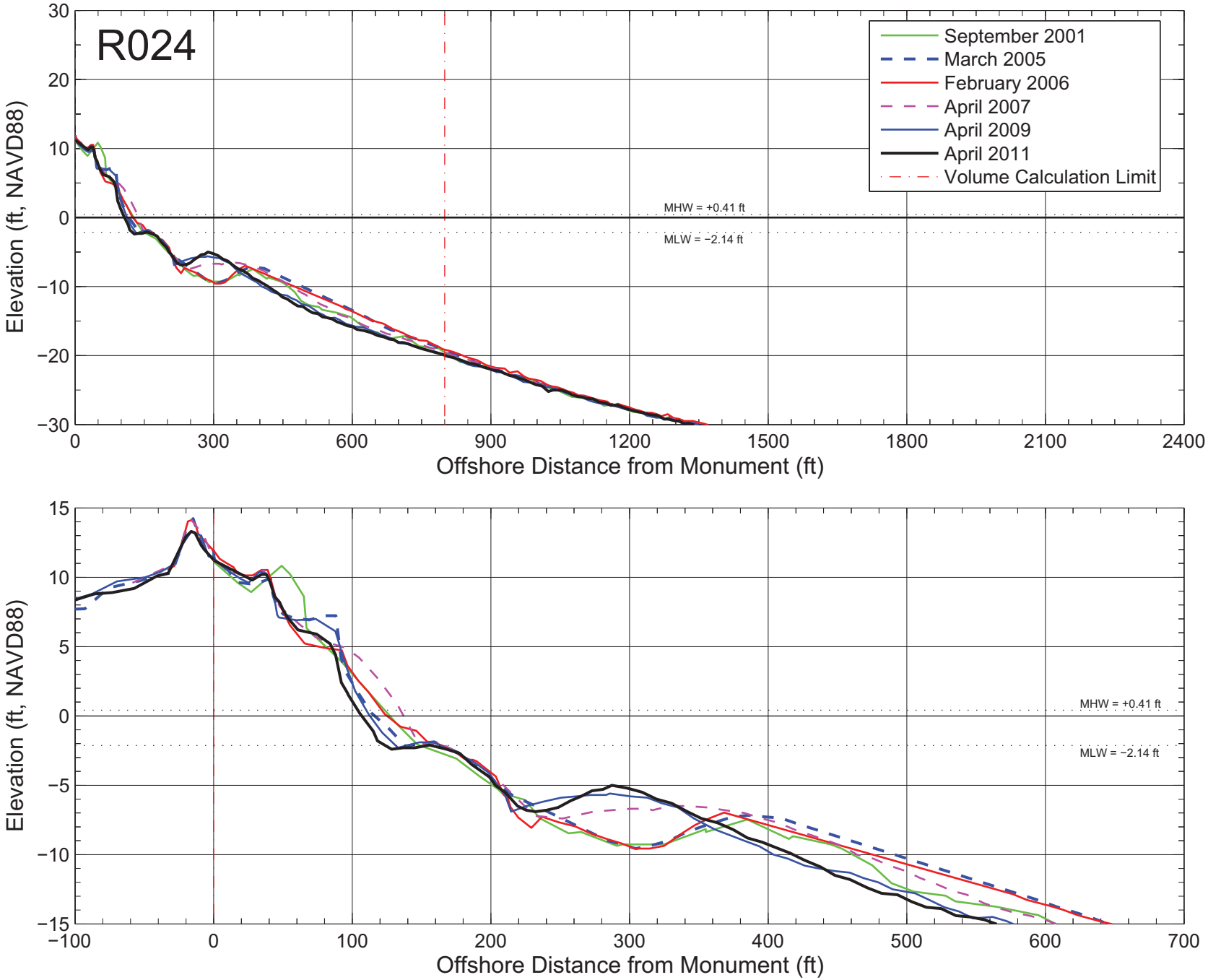


Figure A–024: Measured beach profiles at monument R024 Broward County, Florida.

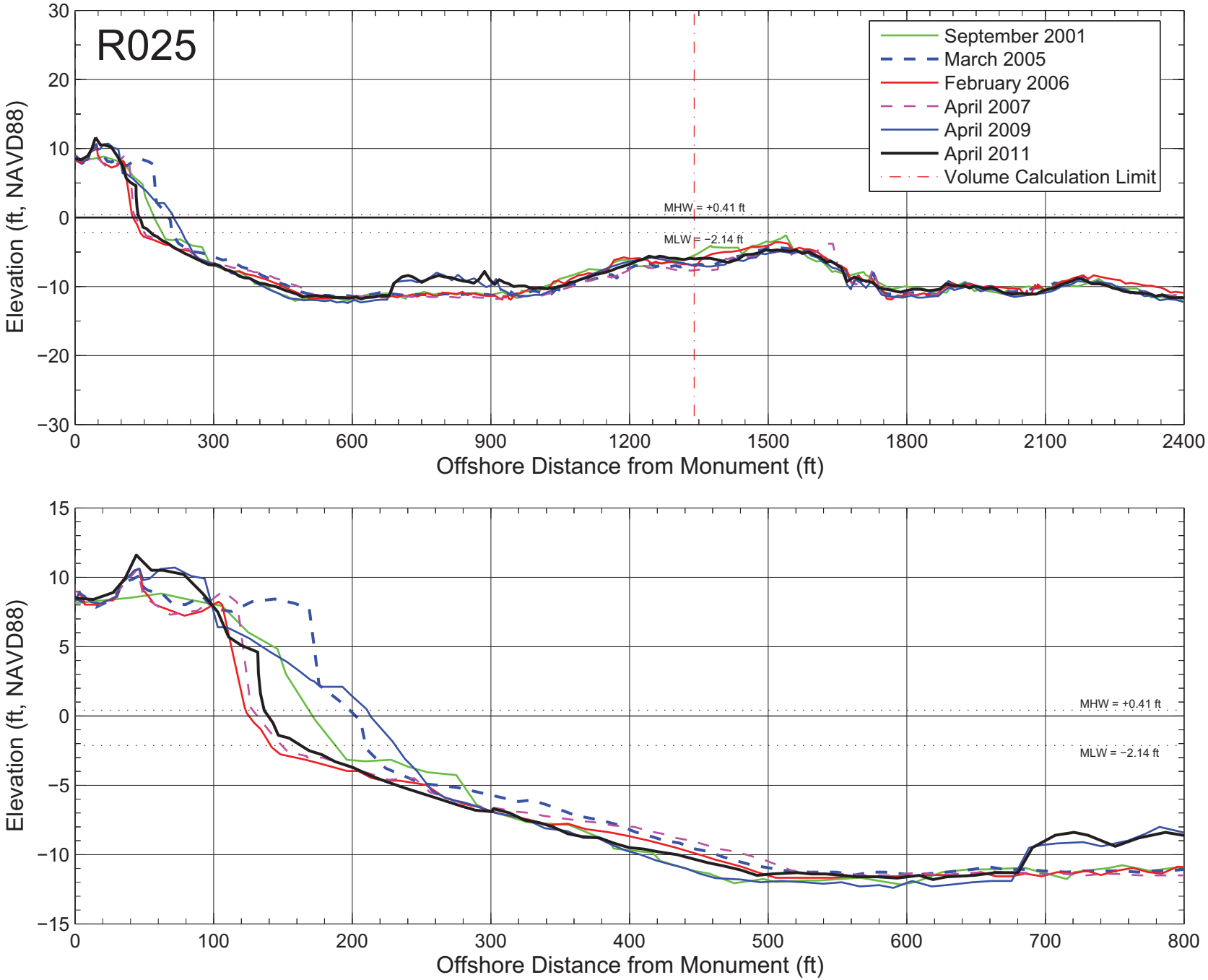


Figure A–025: Measured beach profiles at monument R025 Broward County, Florida.

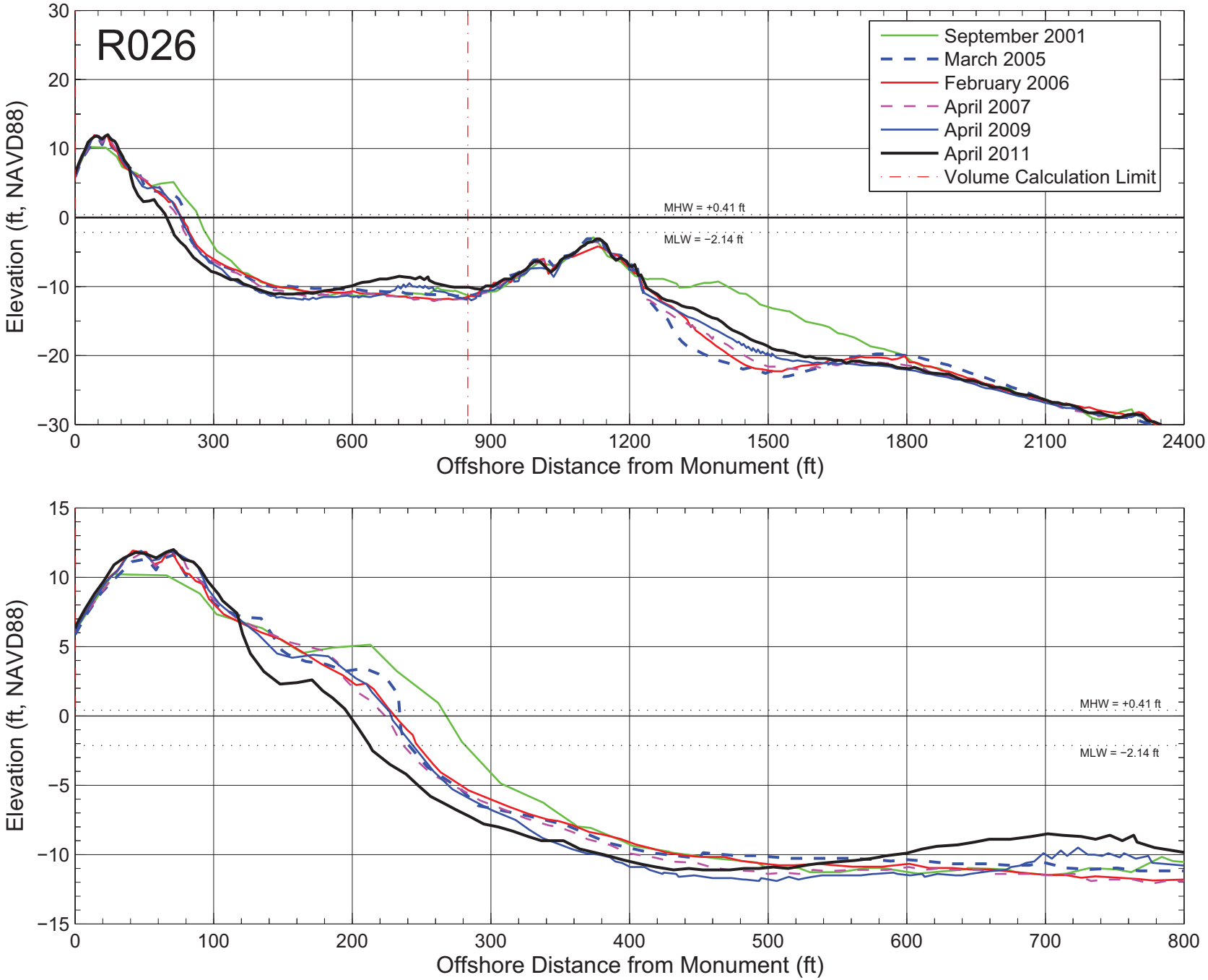


Figure A–026: Measured beach profiles at monument R026 Broward County, Florida.

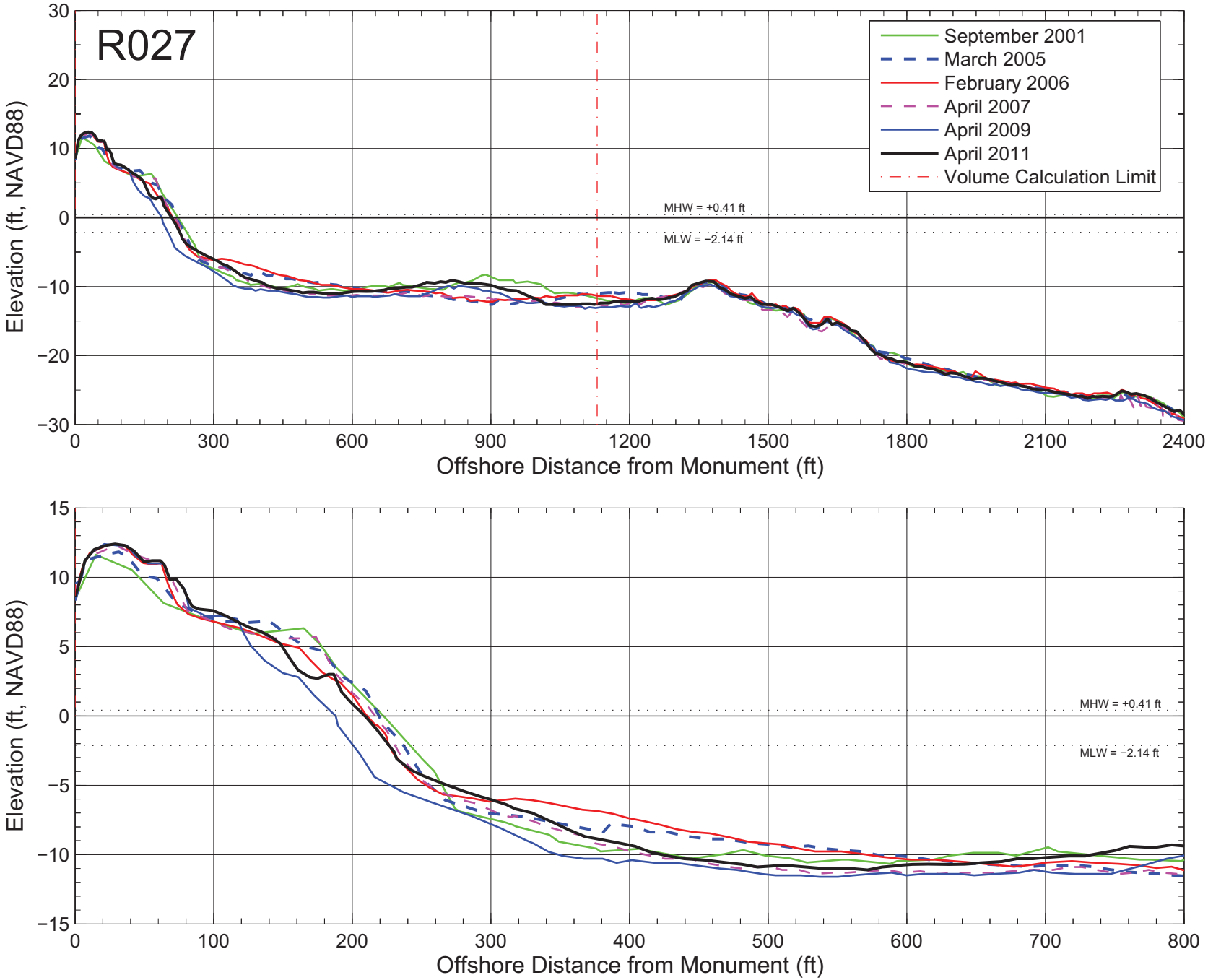


Figure A–027: Measured beach profiles at monument R027 Broward County, Florida.

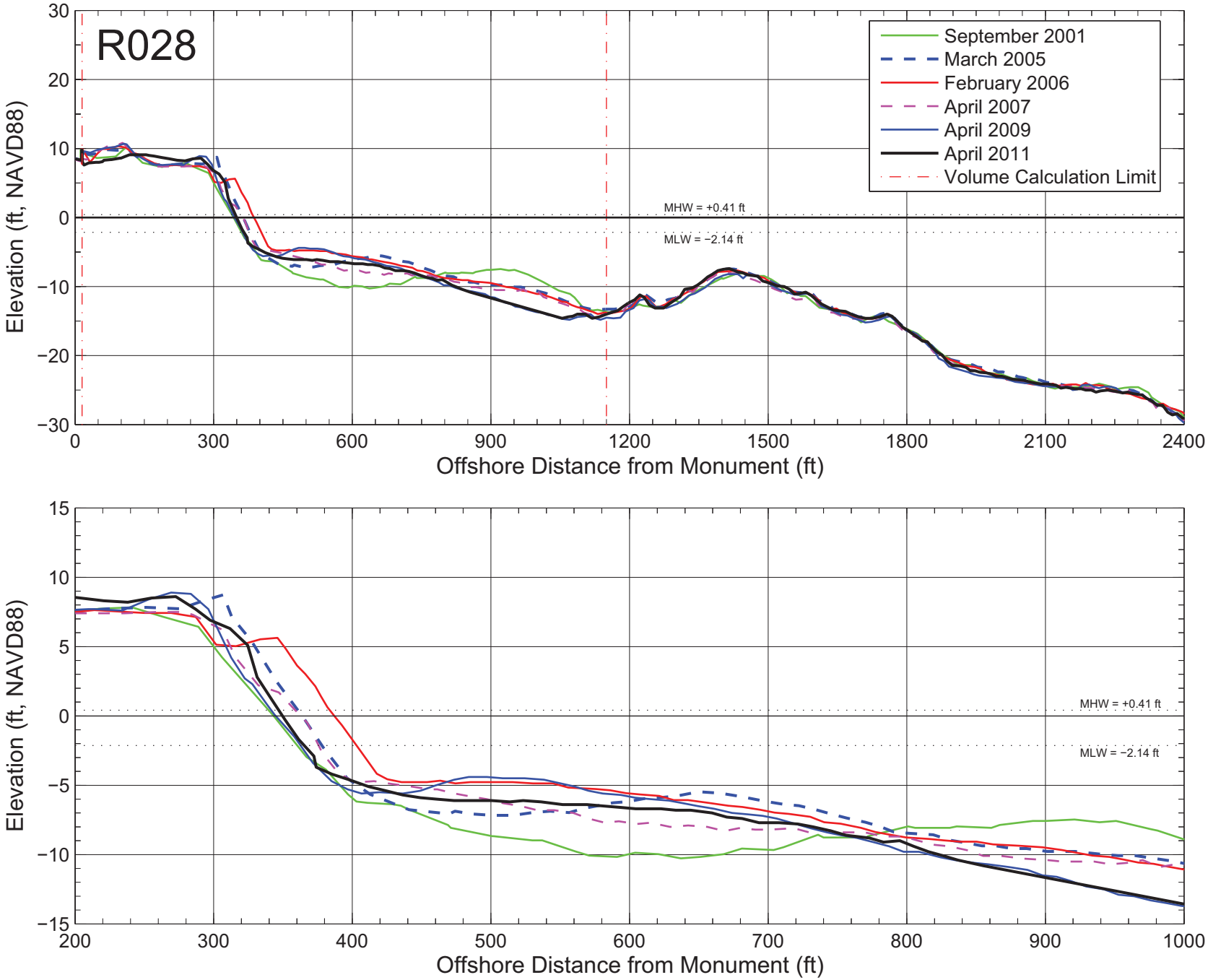


Figure A–028: Measured beach profiles at monument R028 Broward County, Florida.

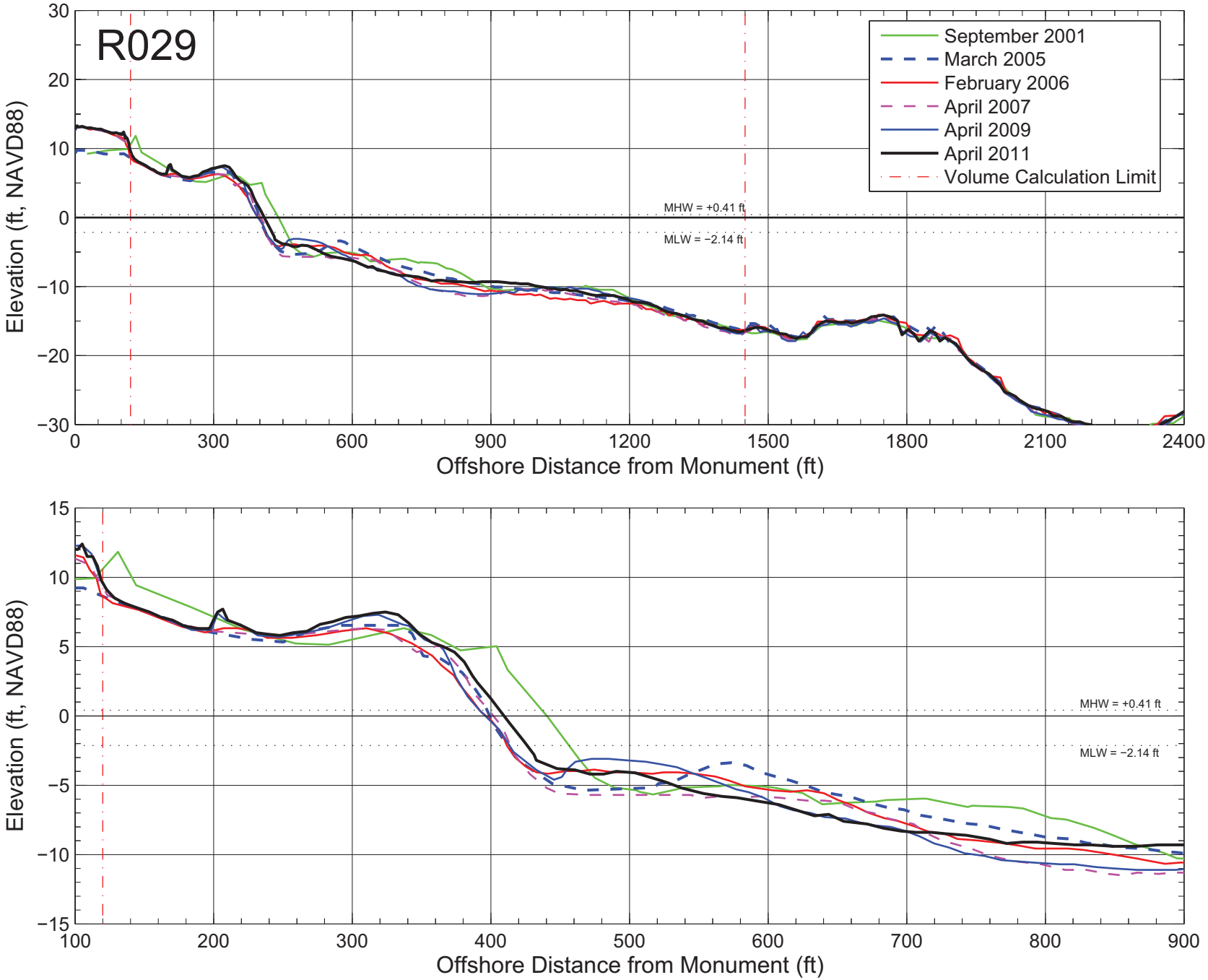


Figure A–029: Measured beach profiles at monument R029 Broward County, Florida.

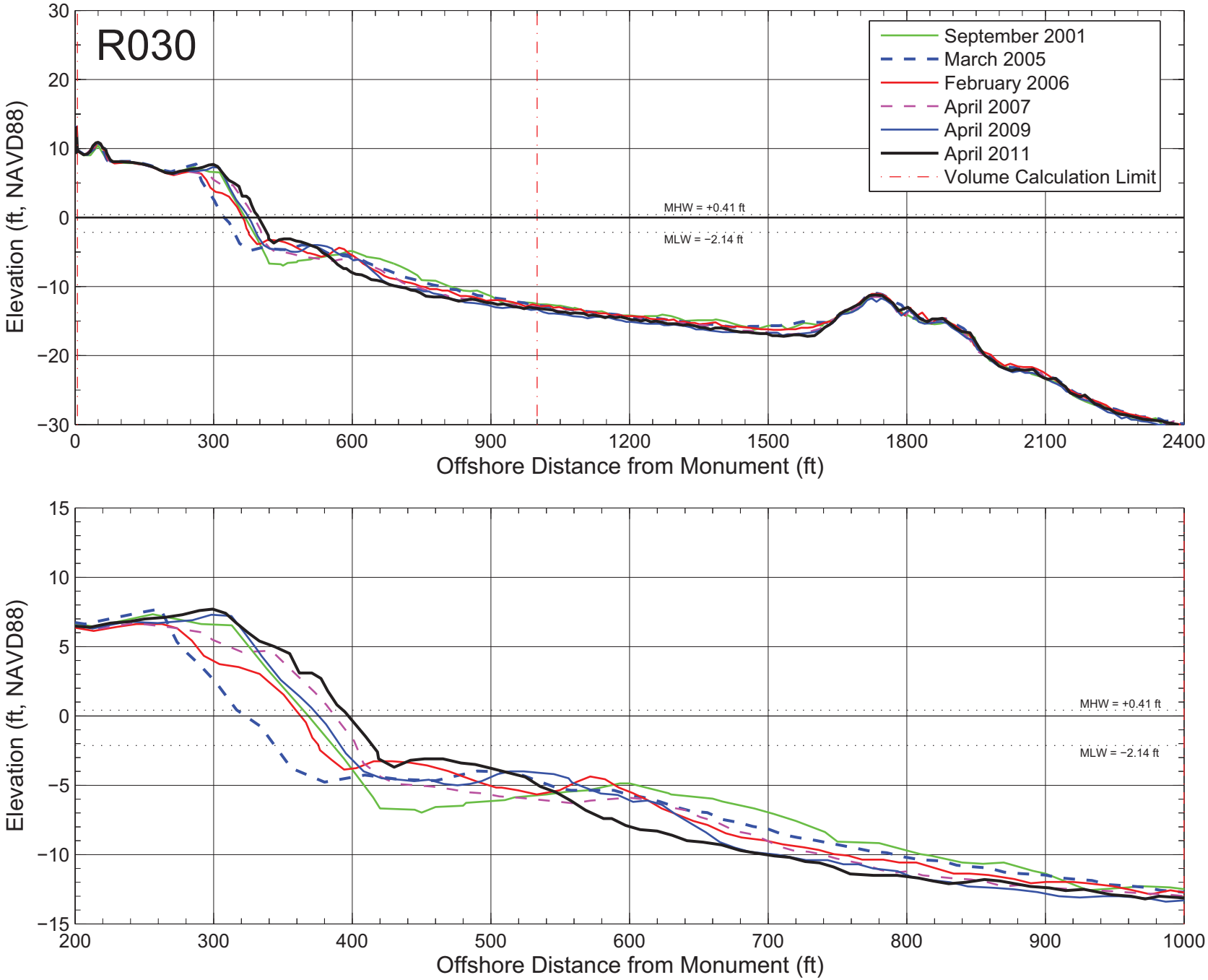


Figure A–030: Measured beach profiles at monument R030 Broward County, Florida.

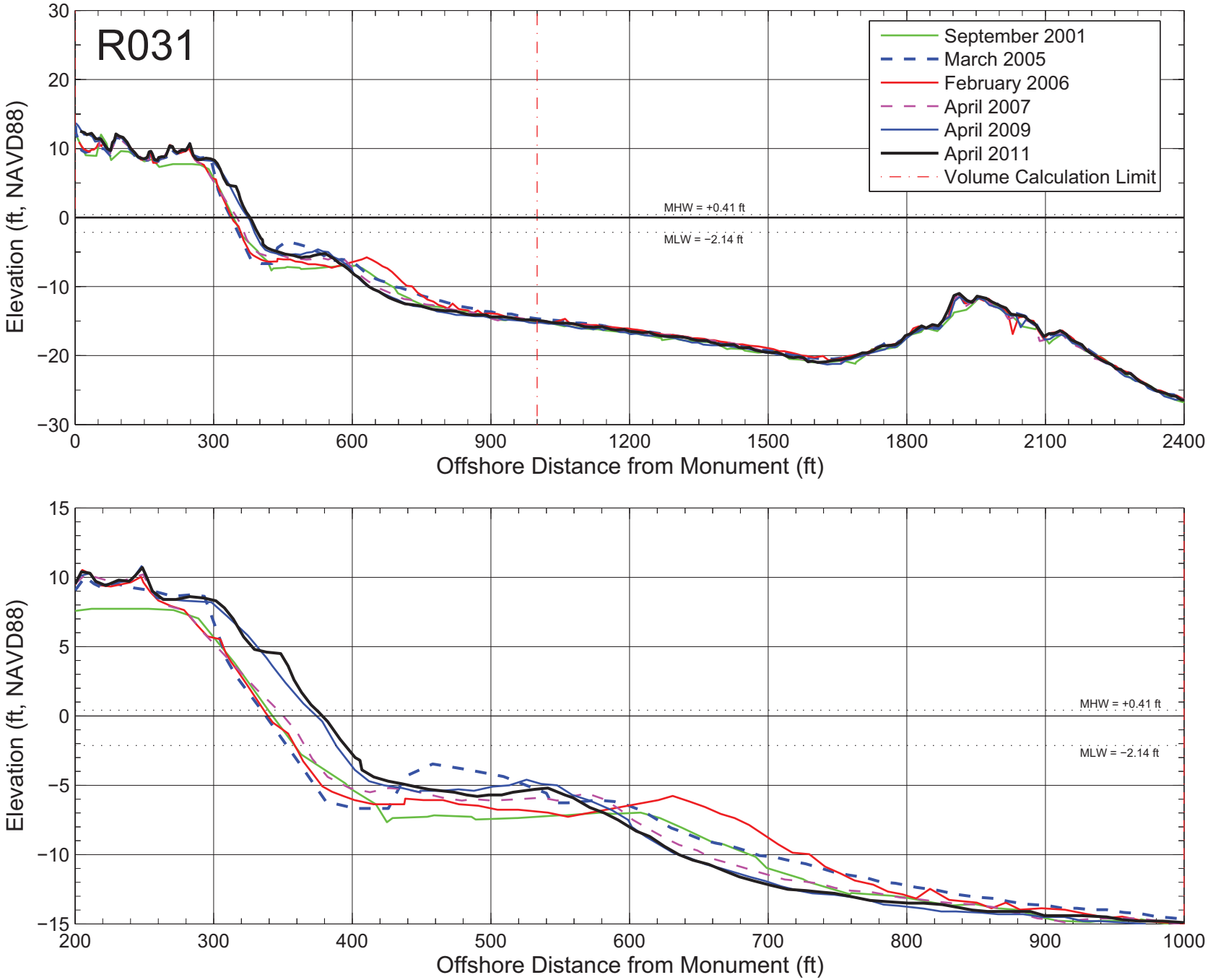


Figure A–031: Measured beach profiles at monument R031 Broward County, Florida.

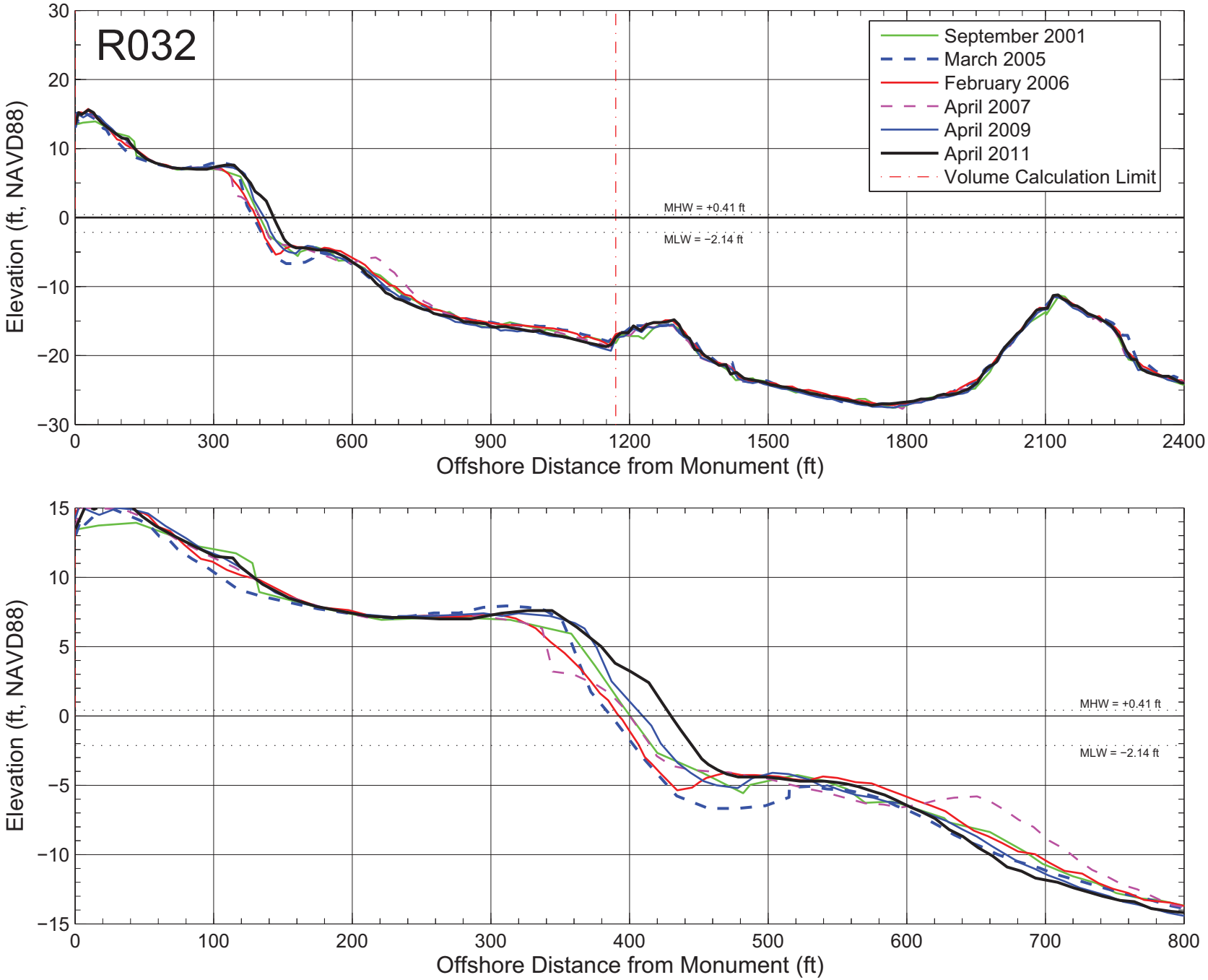


Figure A–032: Measured beach profiles at monument R032 Broward County, Florida.

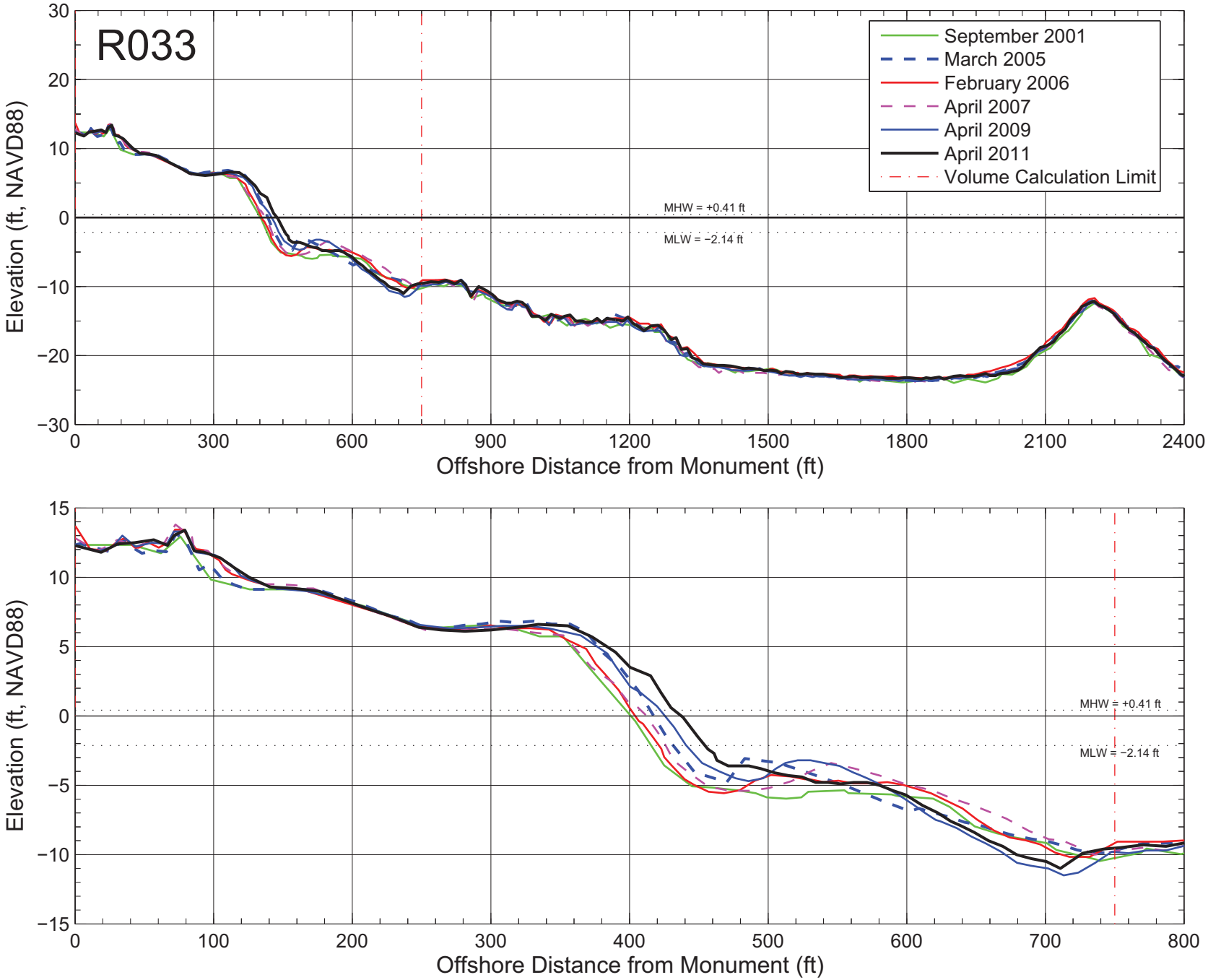


Figure A–033: Measured beach profiles at monument R033 Broward County, Florida.

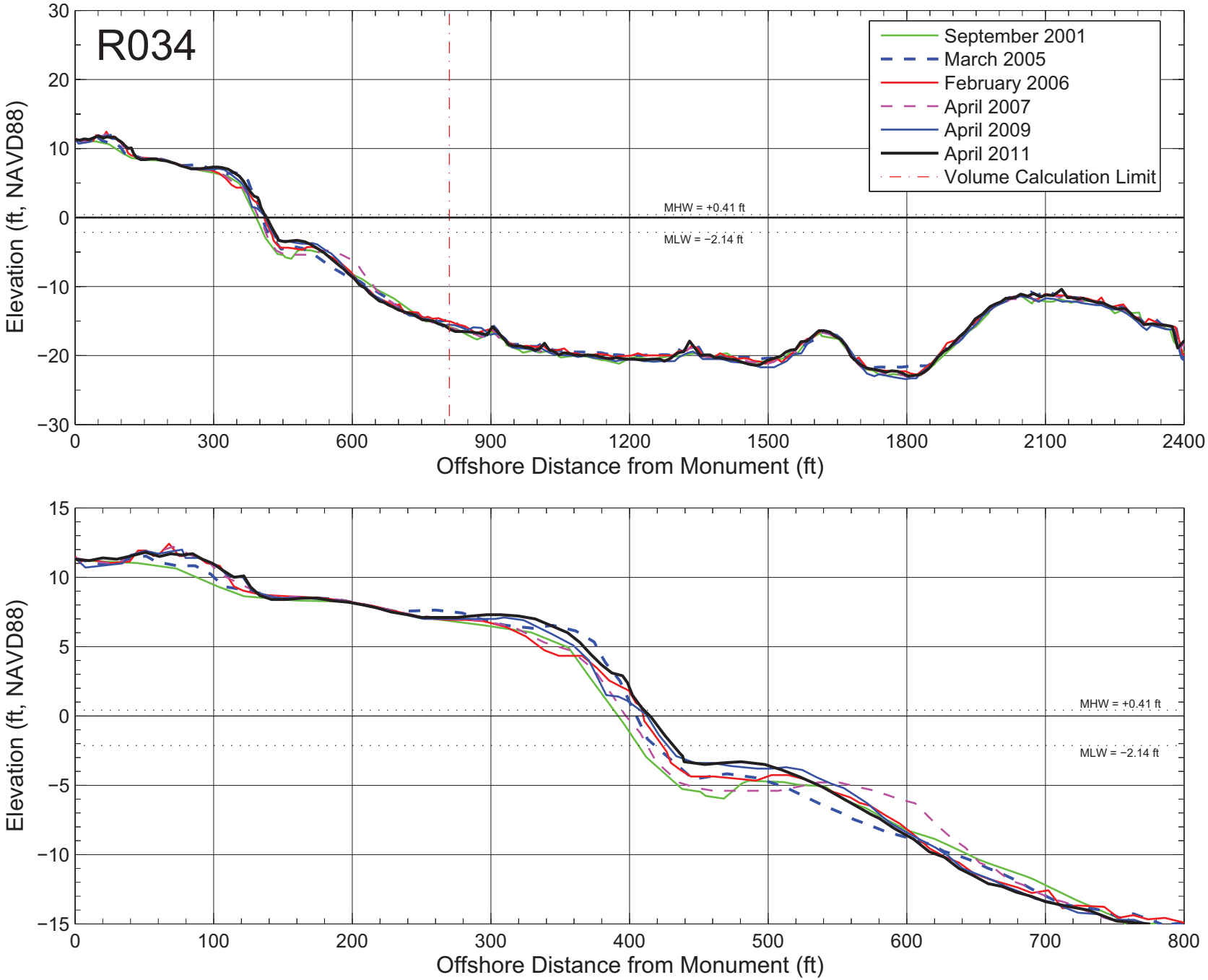


Figure A–034: Measured beach profiles at monument R034 Broward County, Florida.

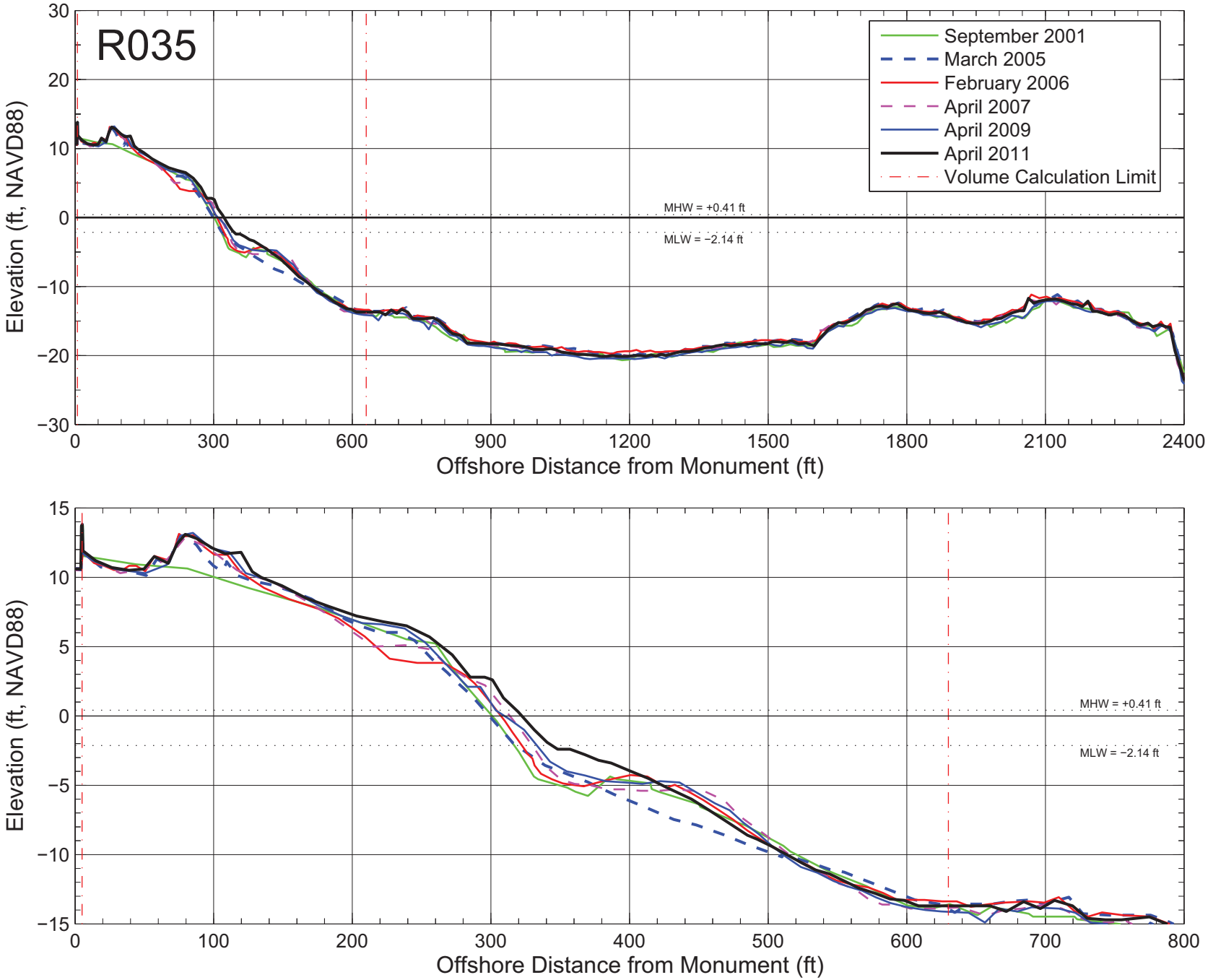


Figure A–035: Measured beach profiles at monument R035 Broward County, Florida.

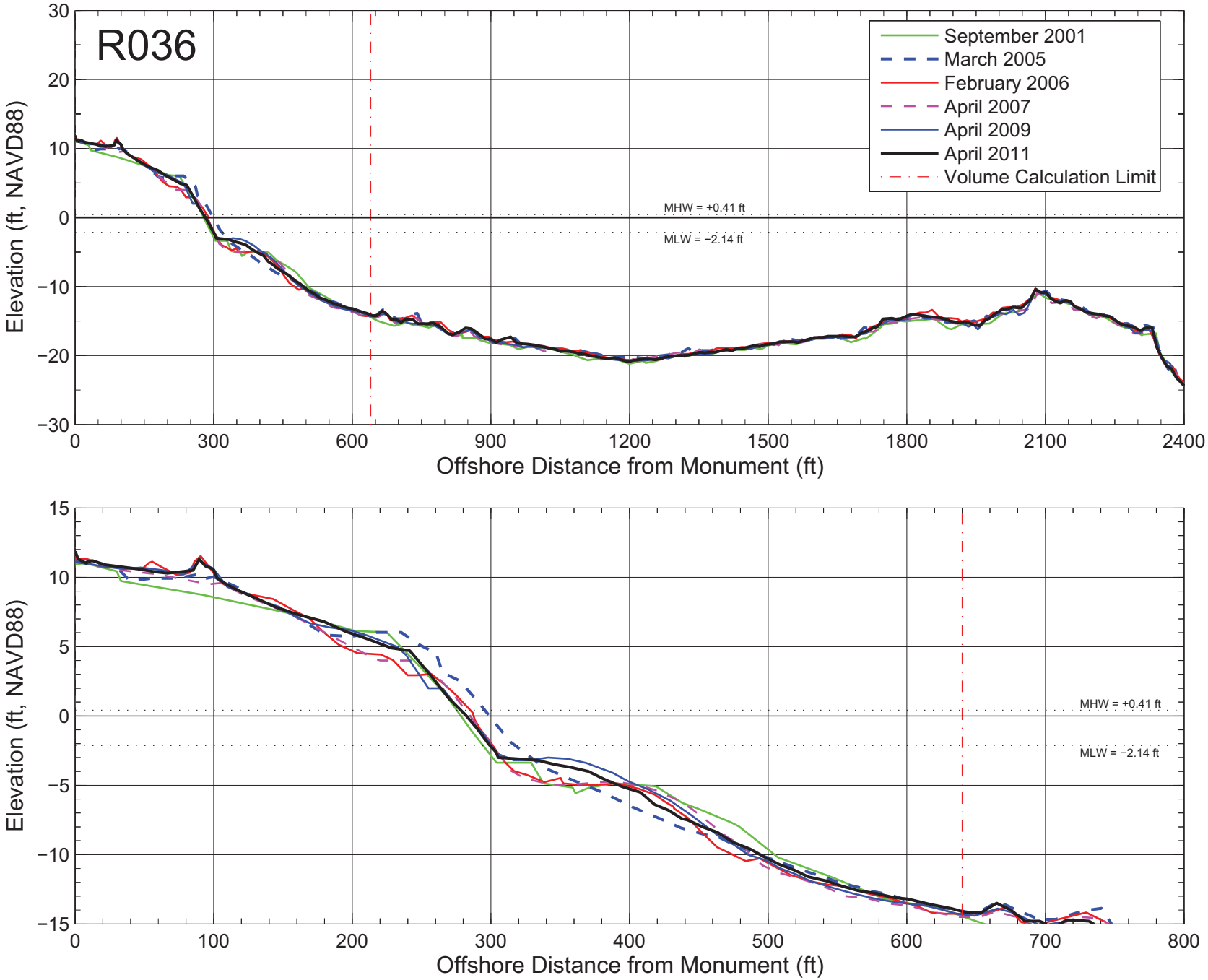


Figure A–036: Measured beach profiles at monument R036 Broward County, Florida.

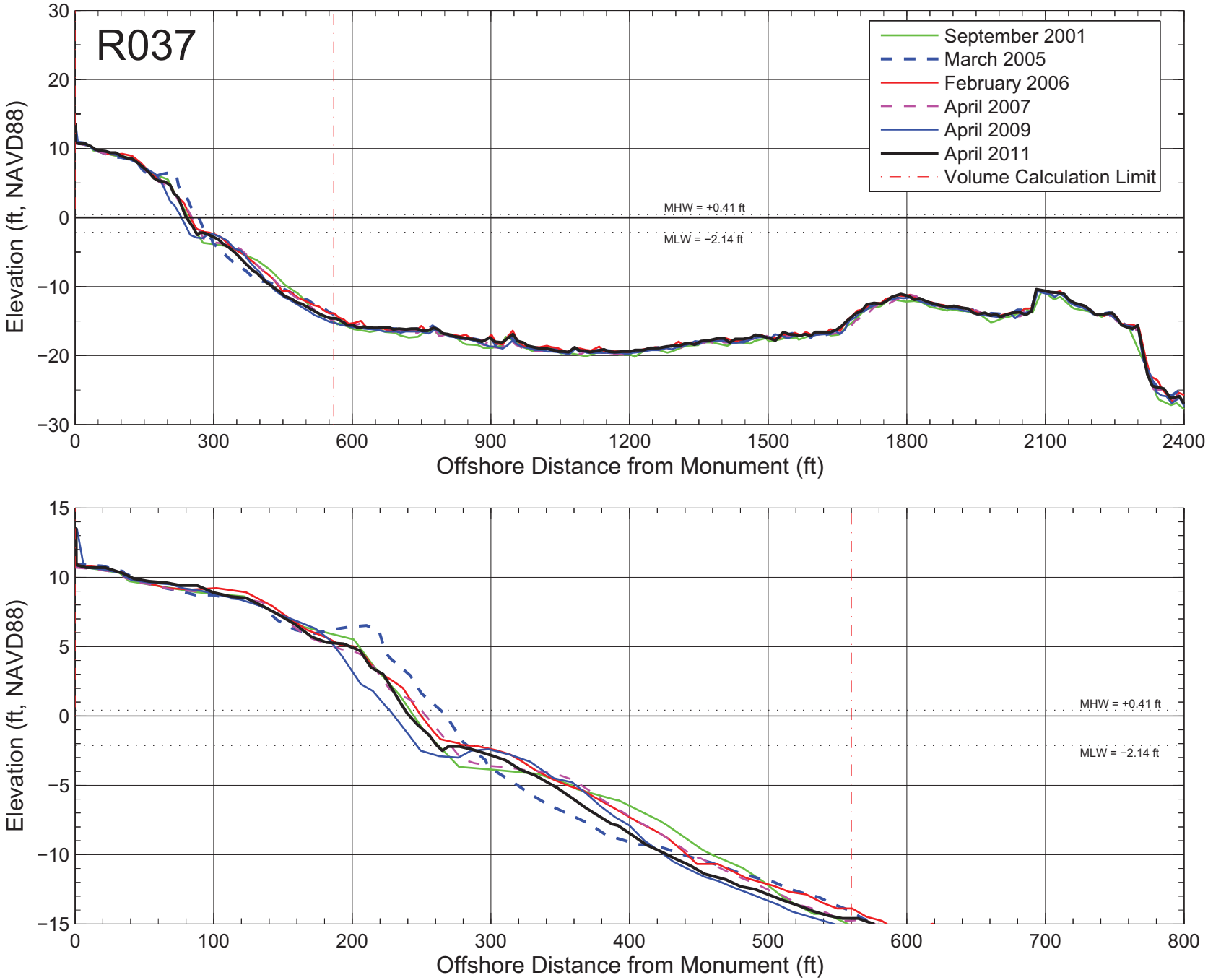


Figure A–037: Measured beach profiles at monument R037 Broward County, Florida.

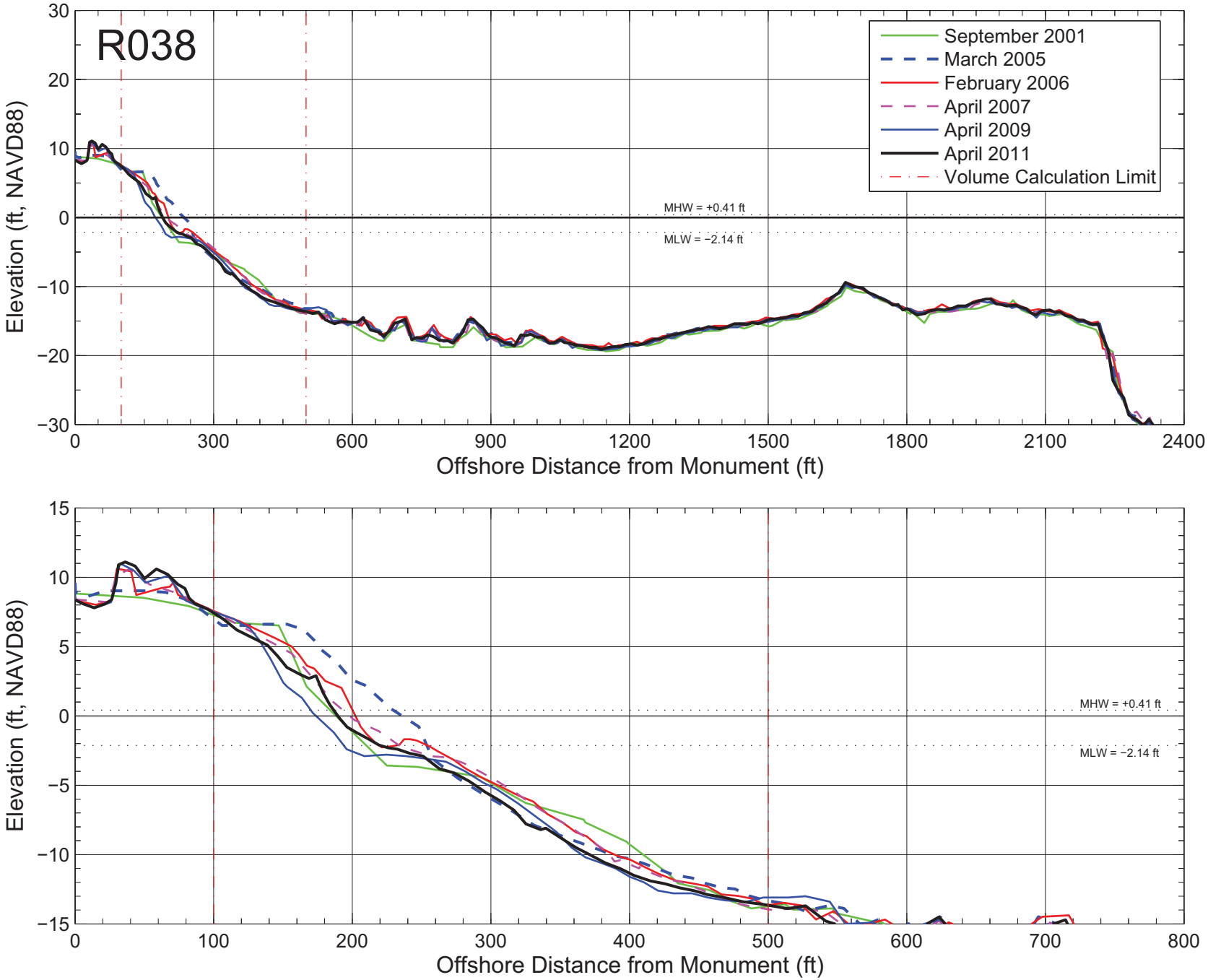


Figure A–038: Measured beach profiles at monument R038 Broward County, Florida.

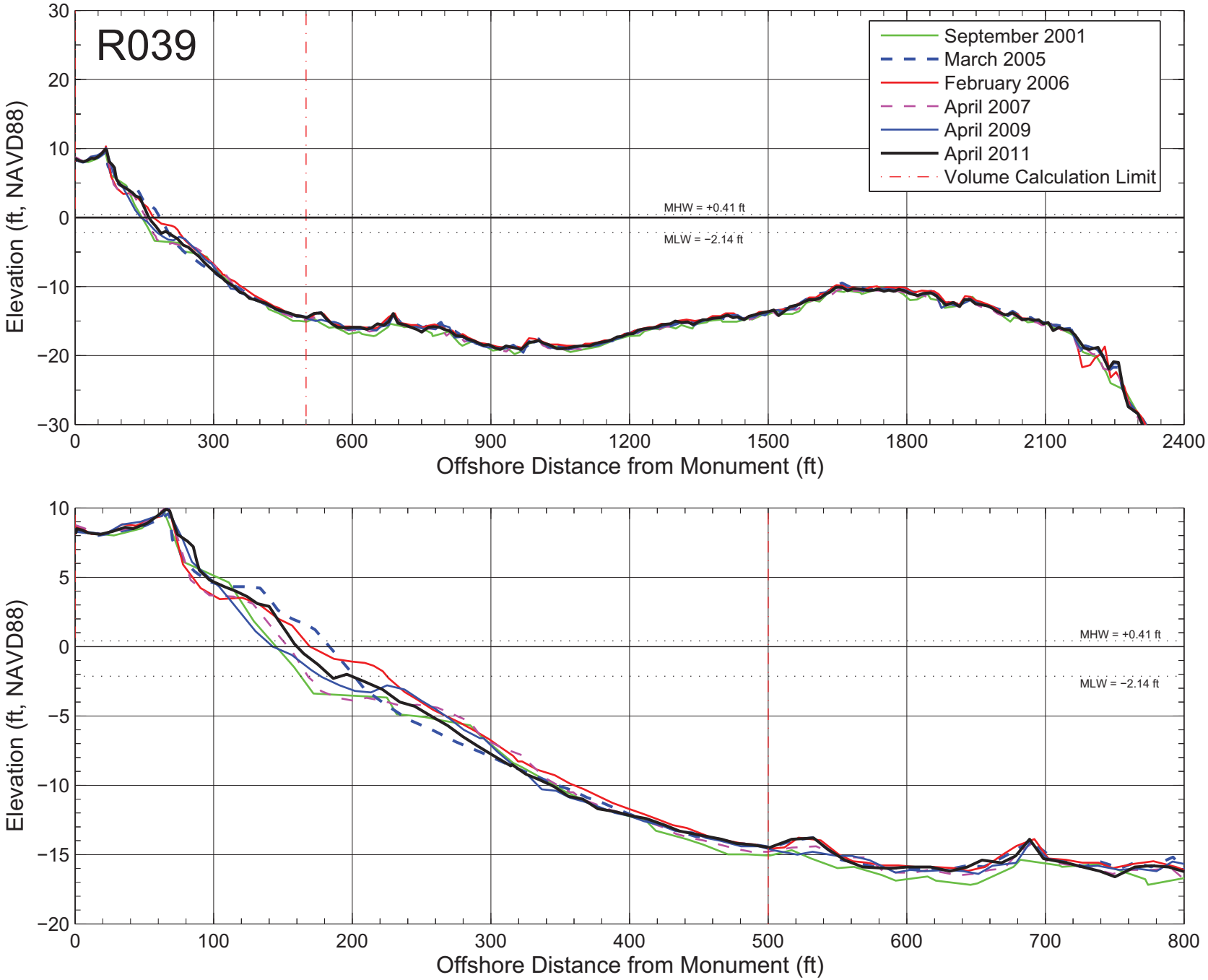


Figure A–039: Measured beach profiles at monument R039 Broward County, Florida.

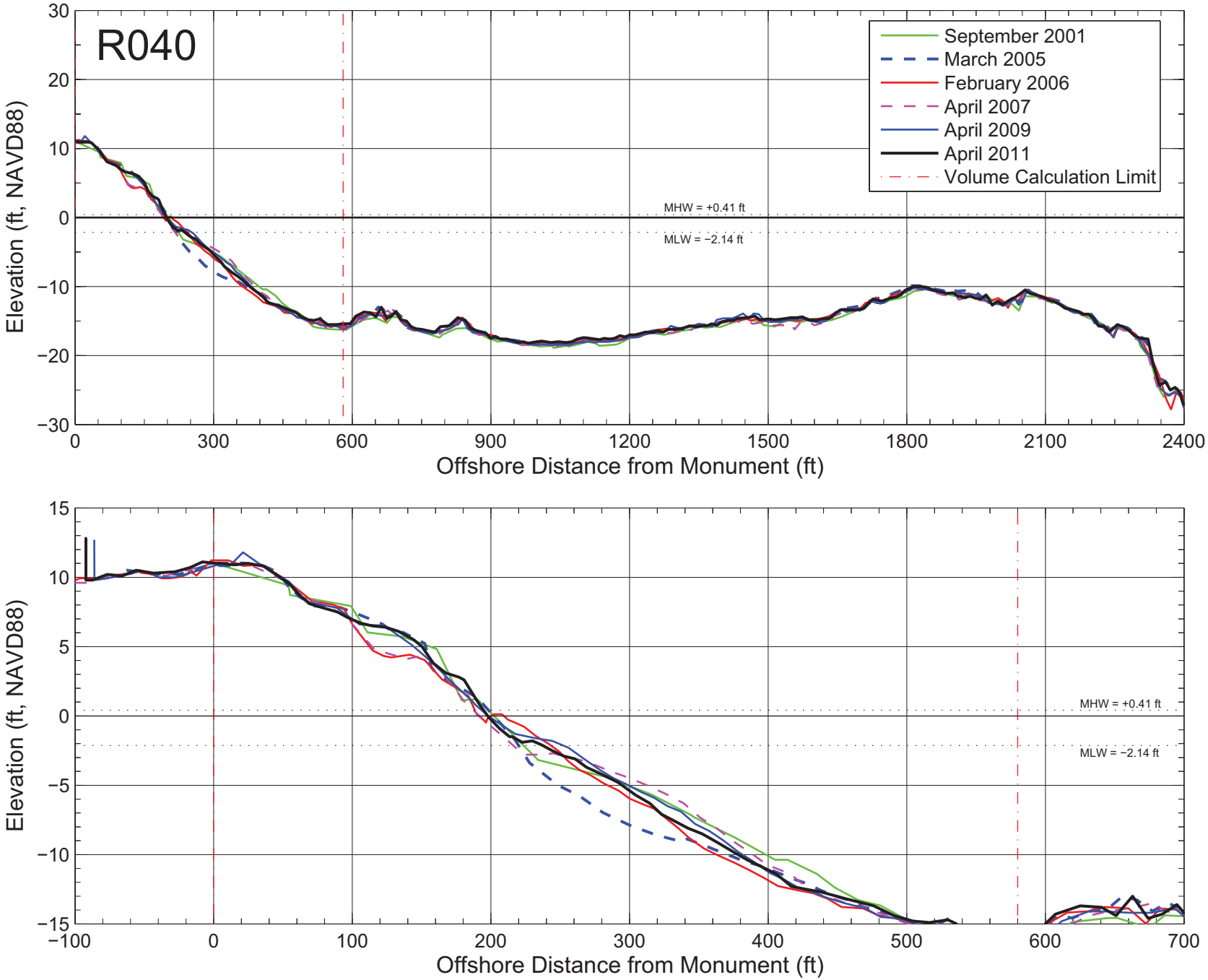


Figure A–040: Measured beach profiles at monument R040 Broward County, Florida.

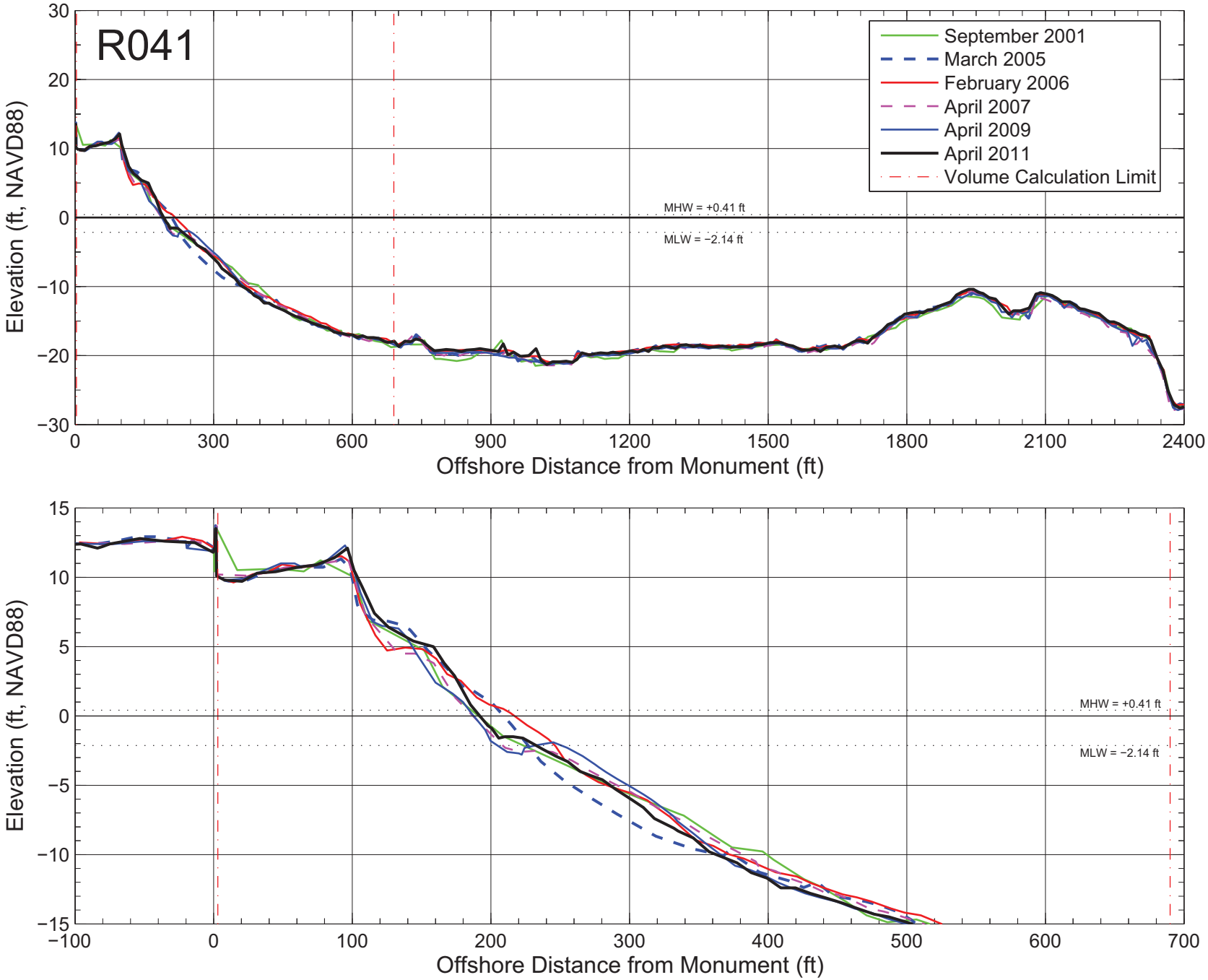


Figure A–041: Measured beach profiles at monument R041 Broward County, Florida.

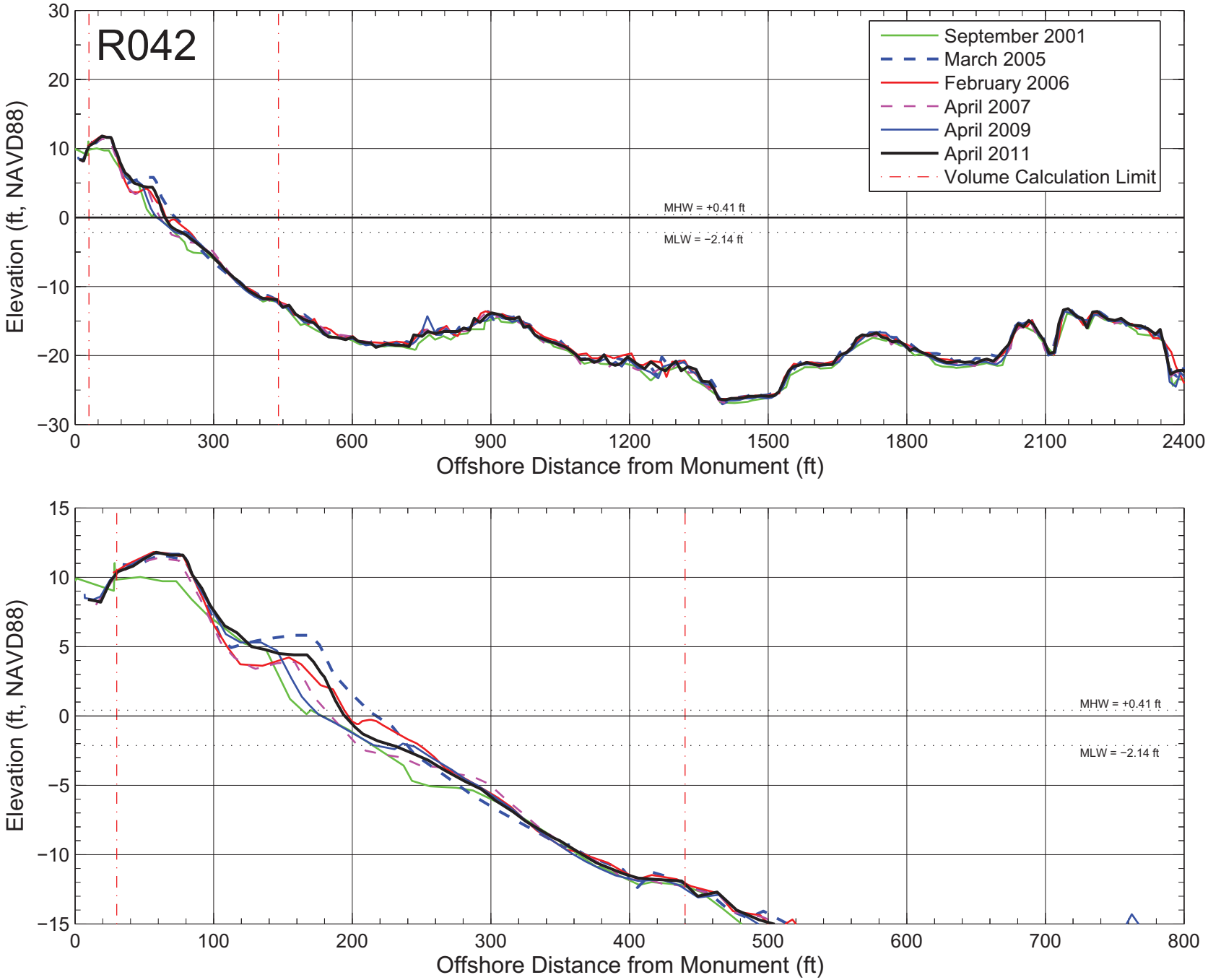


Figure A–042: Measured beach profiles at monument R042 Broward County, Florida.

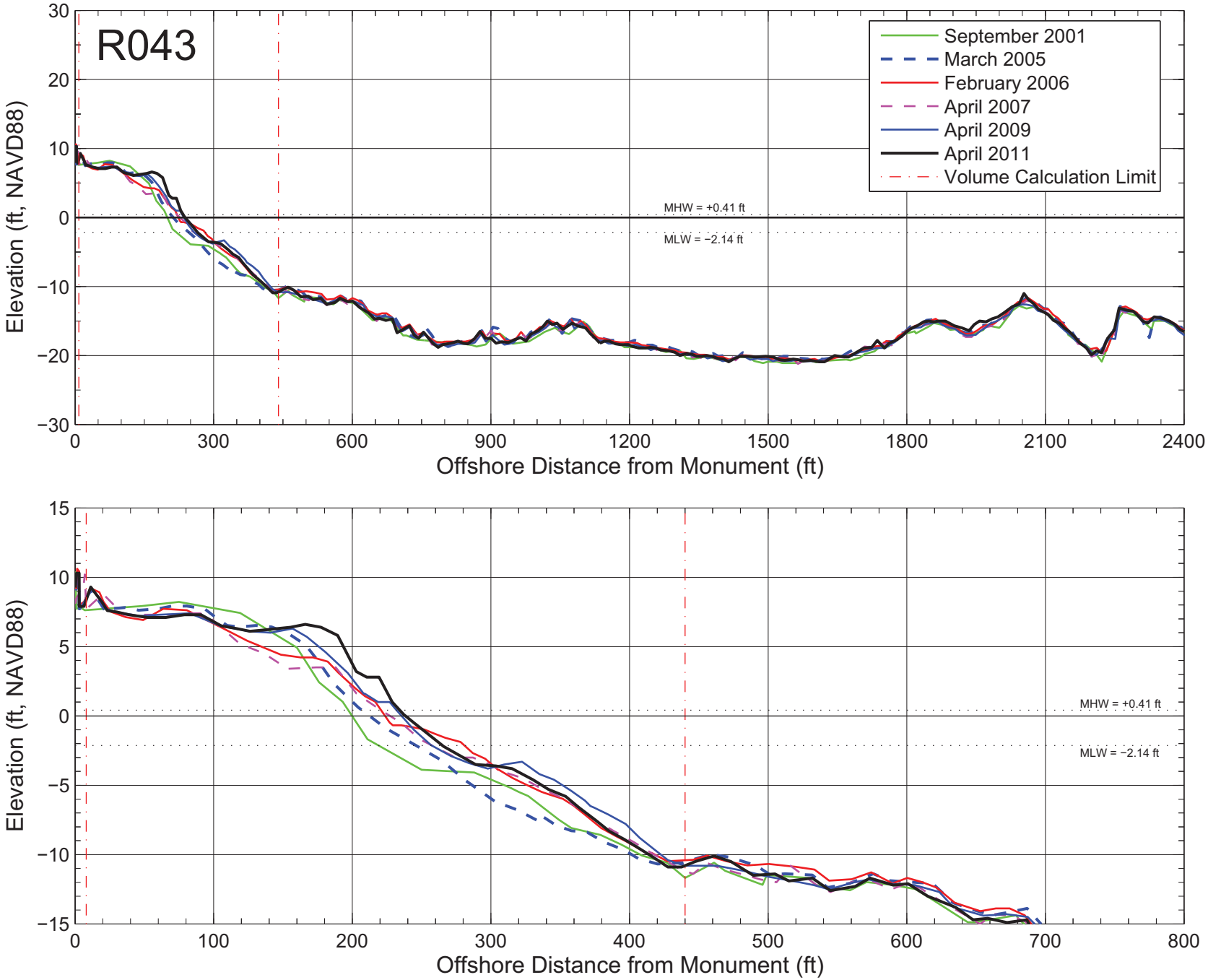


Figure A–043: Measured beach profiles at monument R043 Broward County, Florida.

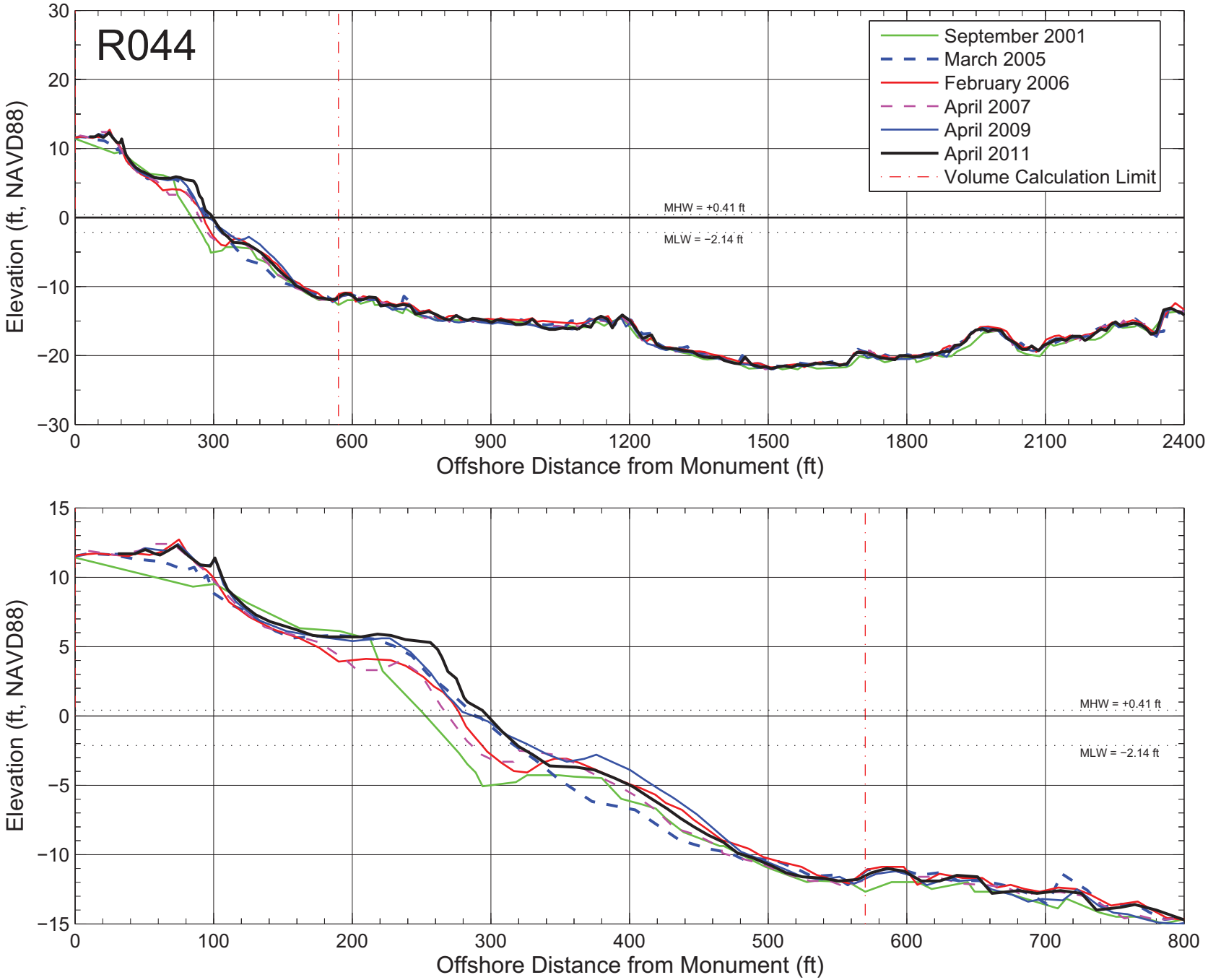


Figure A–044: Measured beach profiles at monument R044 Broward County, Florida.

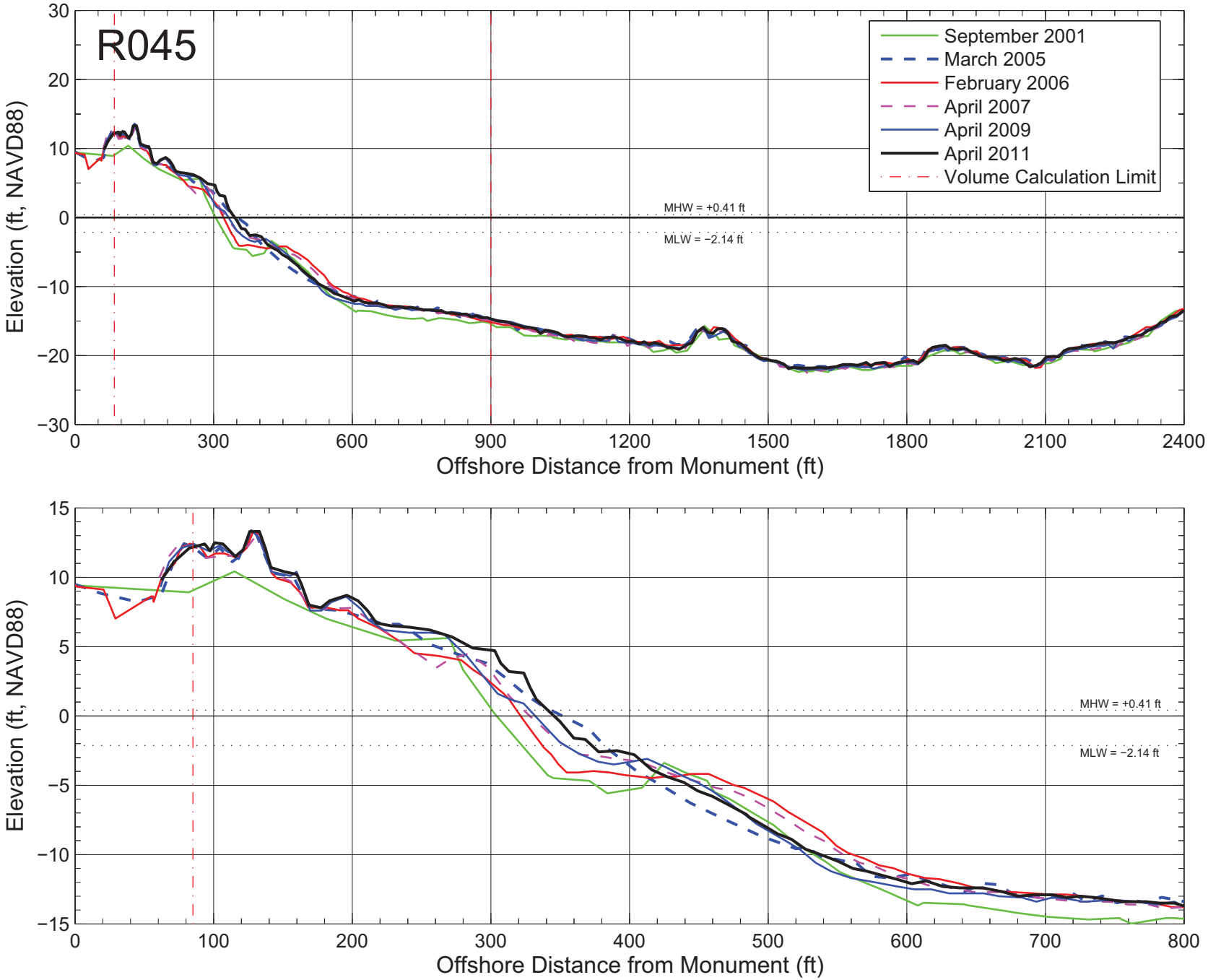


Figure A–045: Measured beach profiles at monument R045 Broward County, Florida.

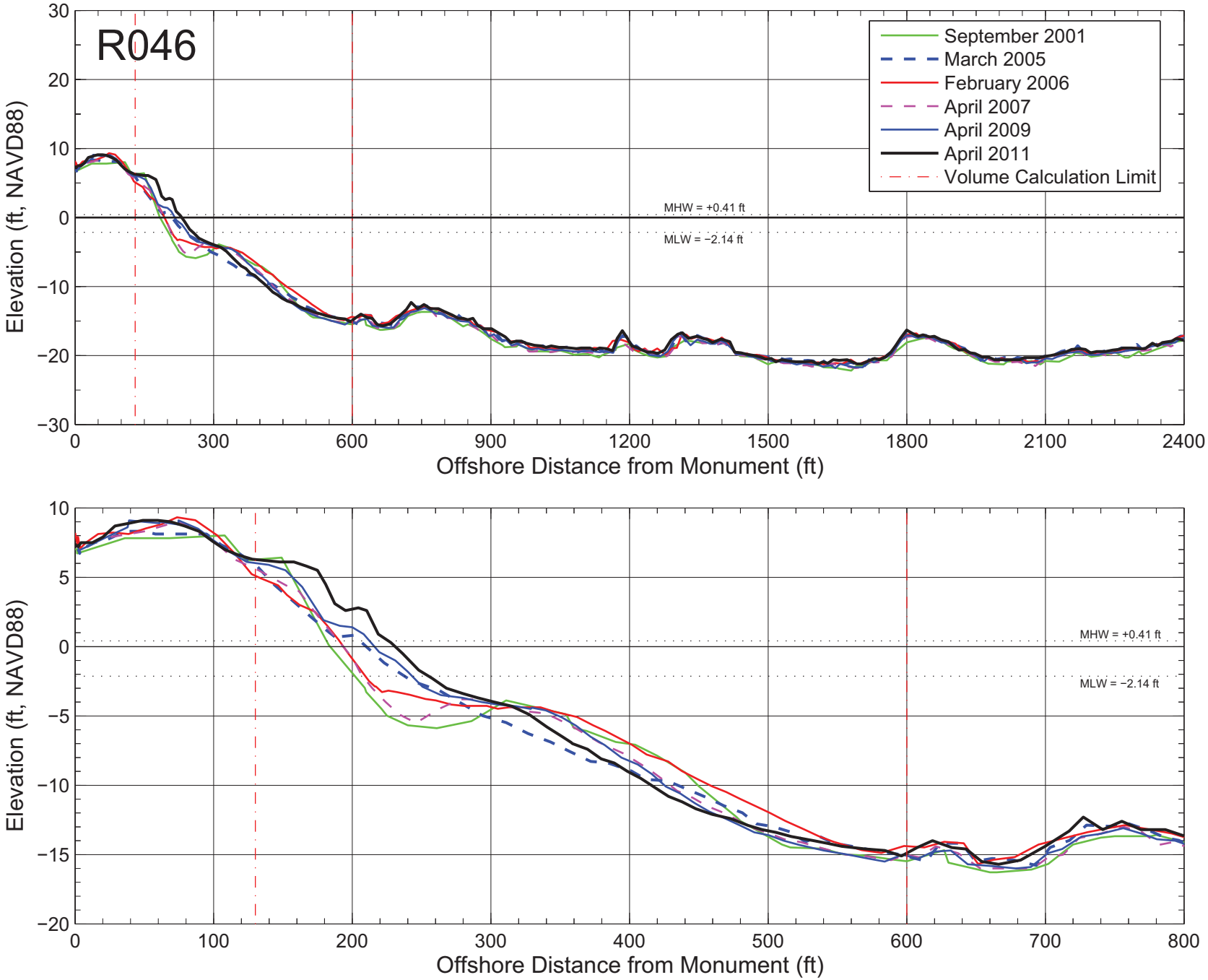


Figure A–046: Measured beach profiles at monument R046 Broward County, Florida.

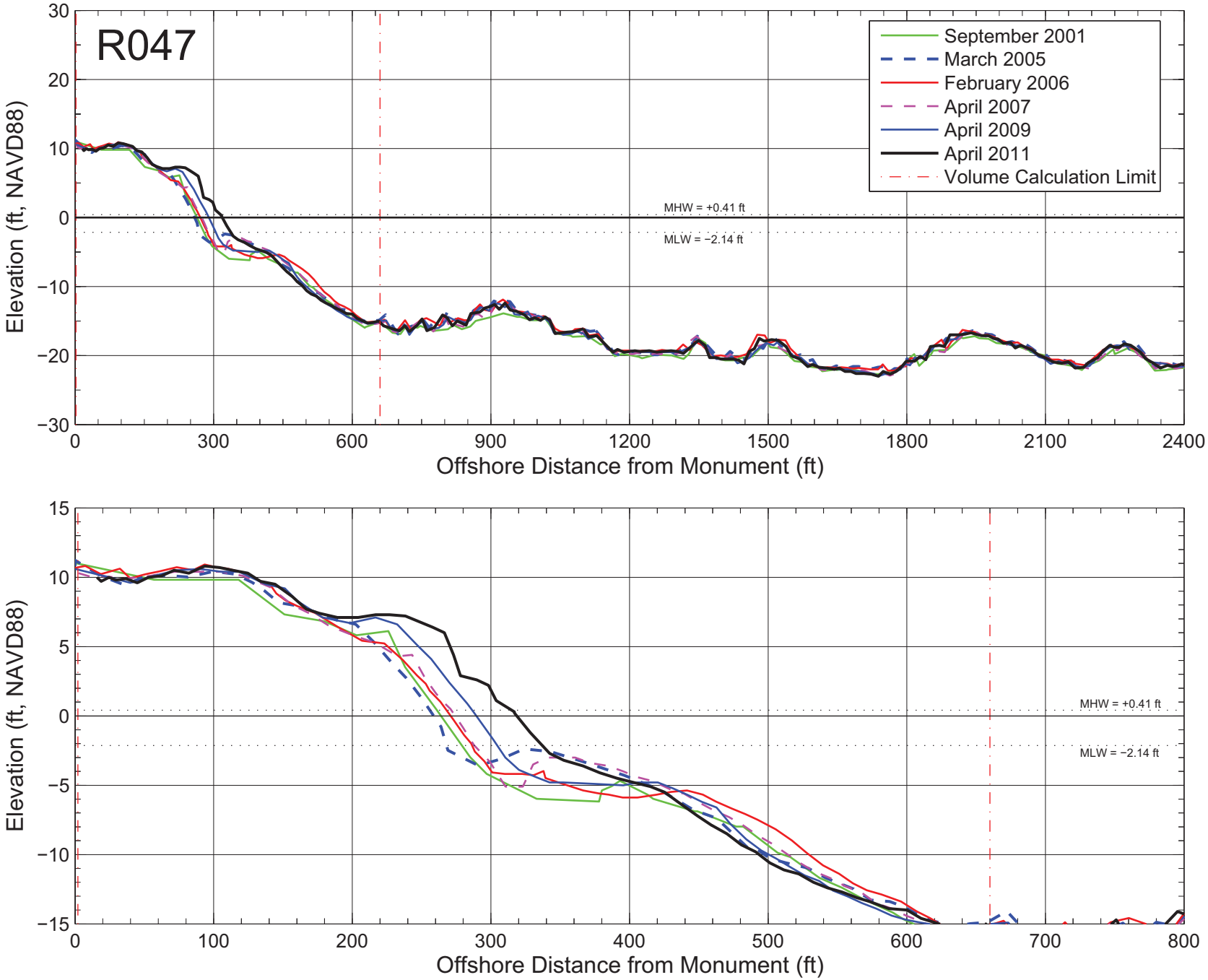


Figure A–047: Measured beach profiles at monument R047 Broward County, Florida.

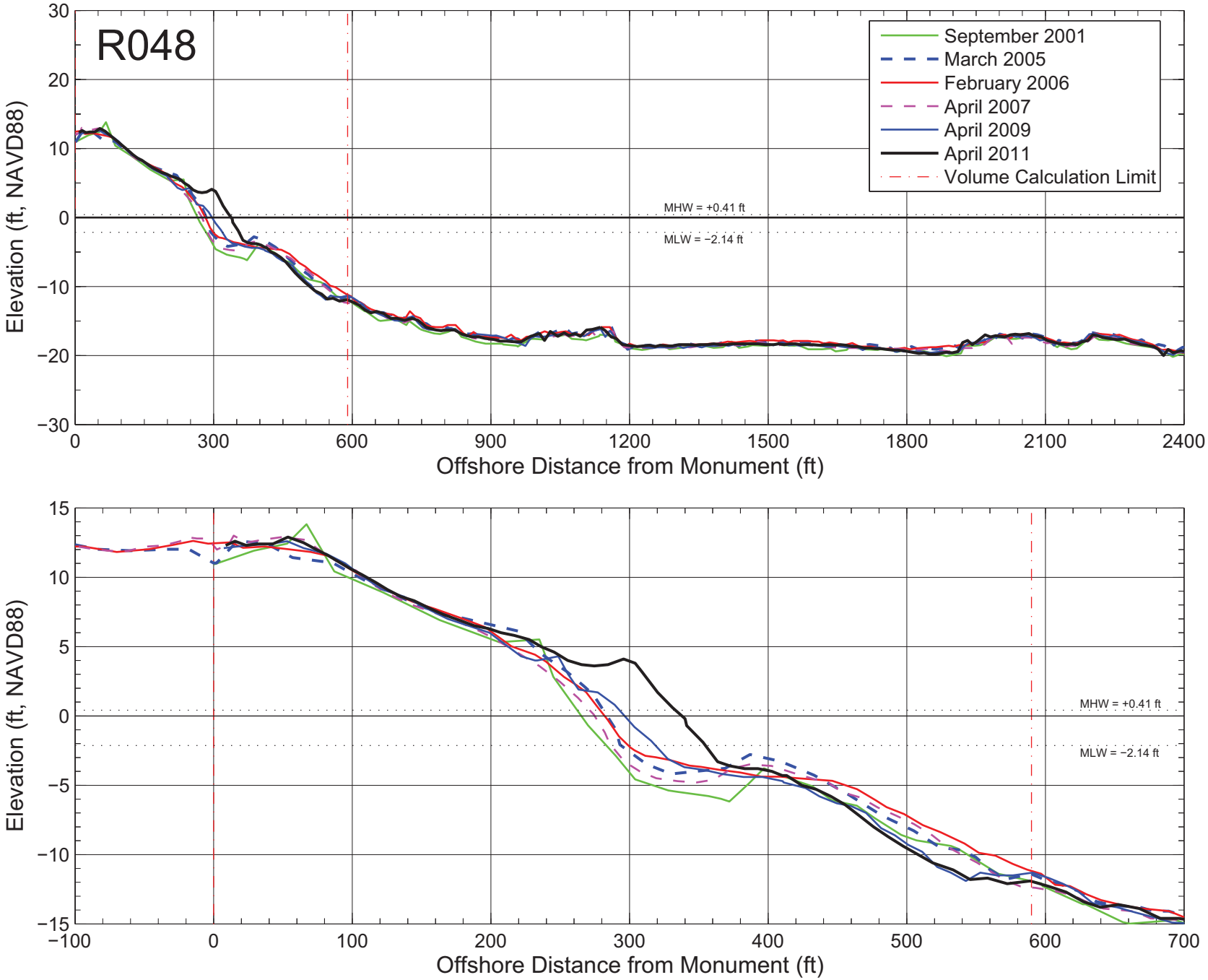


Figure A–048: Measured beach profiles at monument R048 Broward County, Florida.

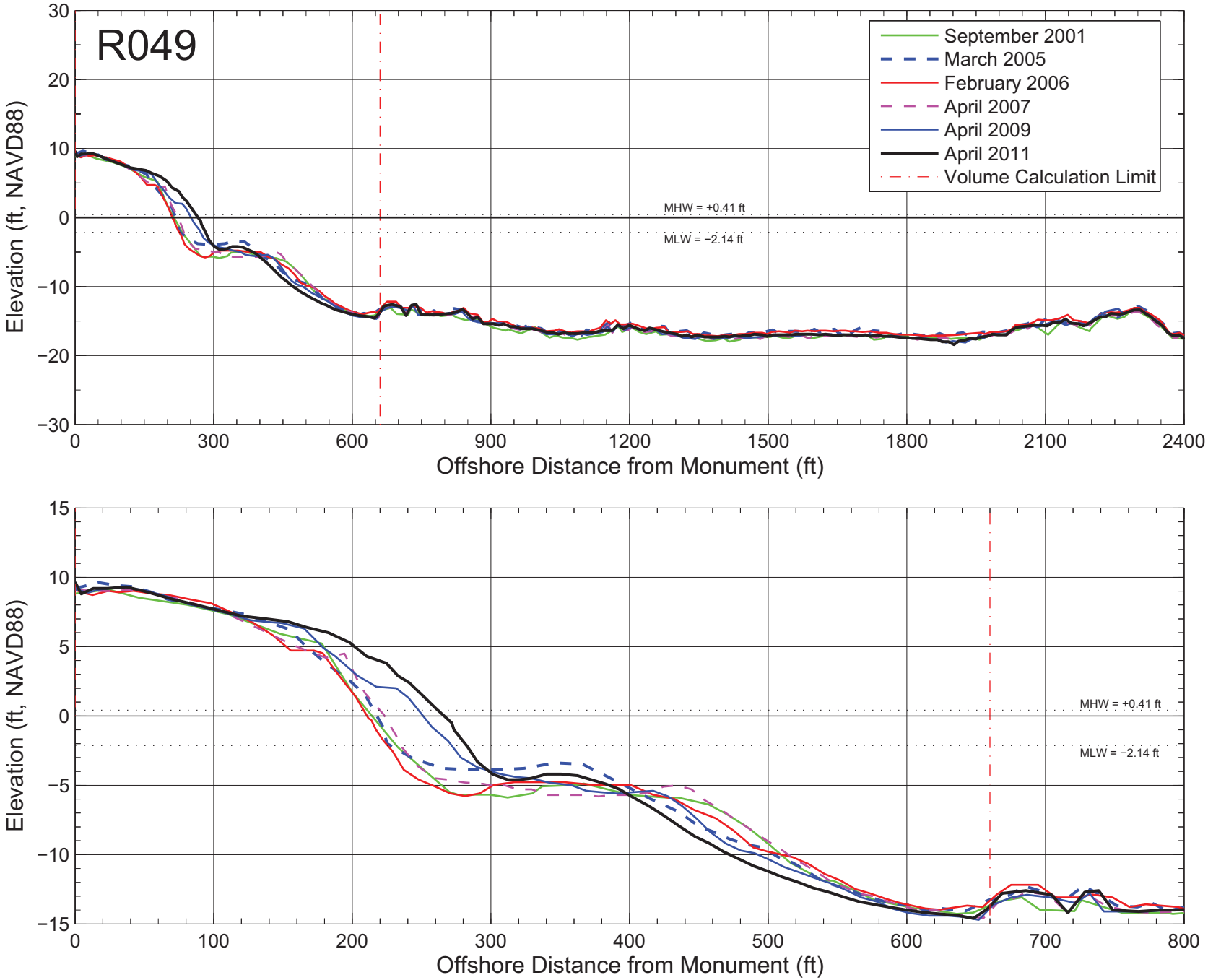


Figure A–049: Measured beach profiles at monument R049 Broward County, Florida.

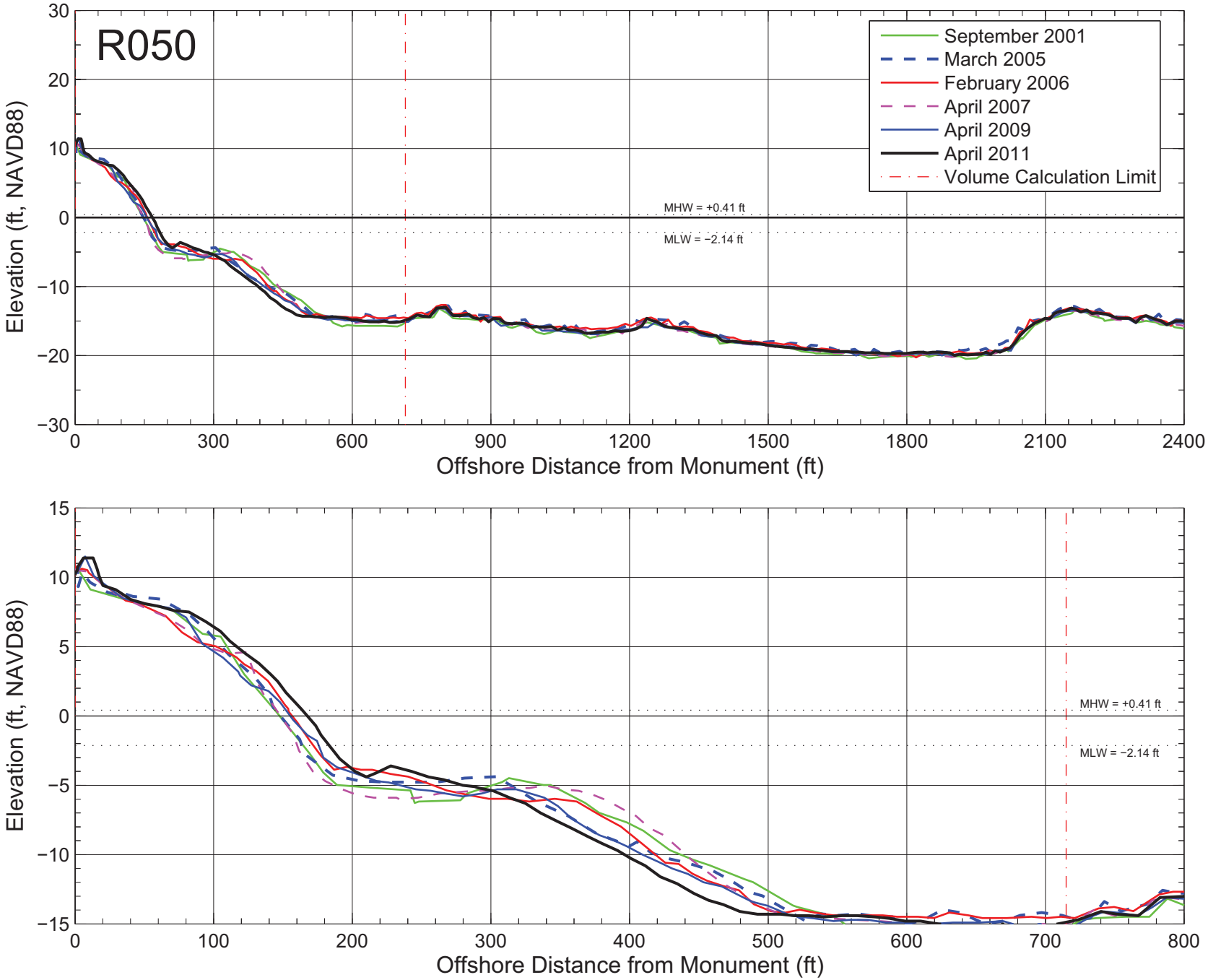


Figure A–050: Measured beach profiles at monument R050 Broward County, Florida.

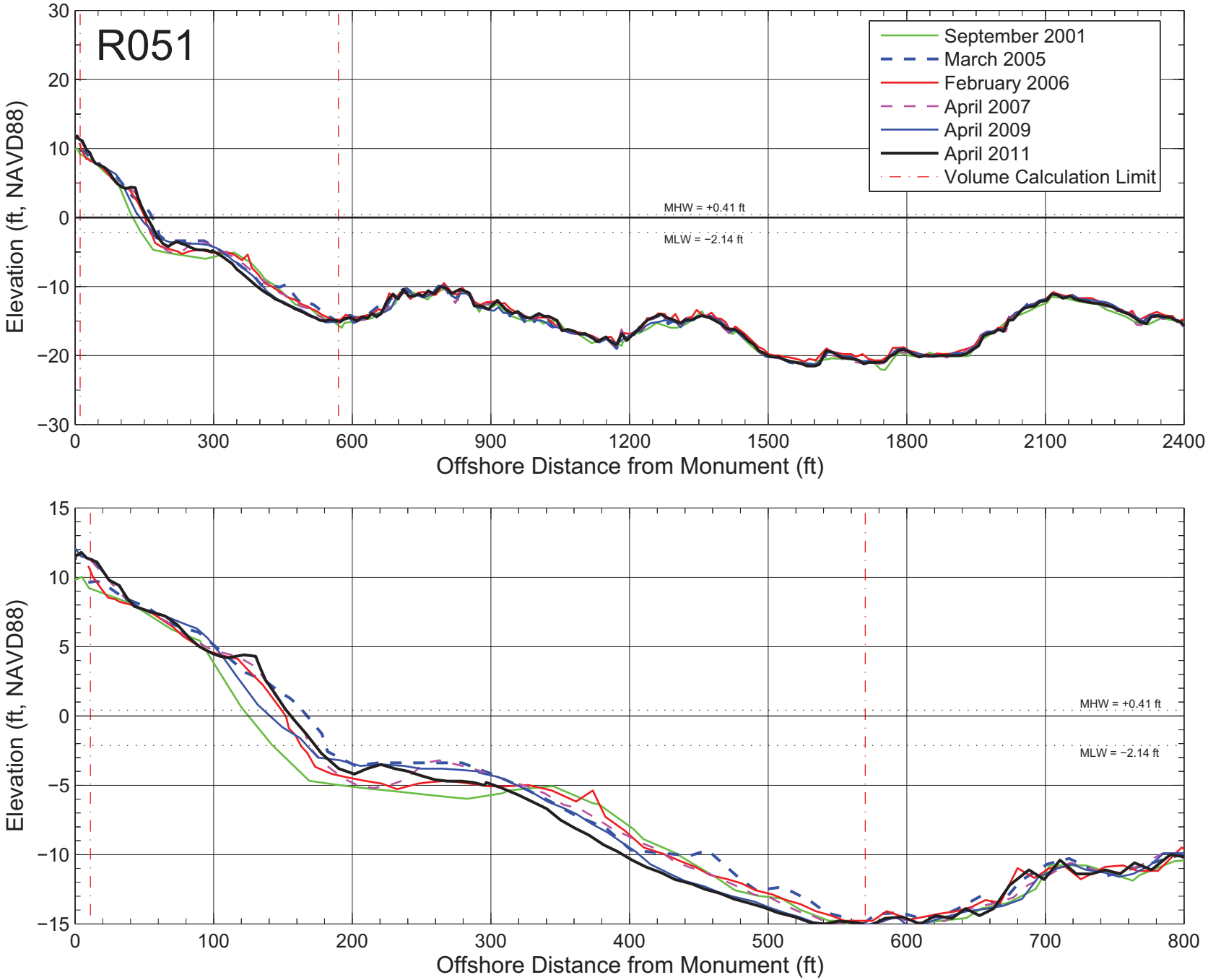


Figure A–051: Measured beach profiles at monument R051 Broward County, Florida.

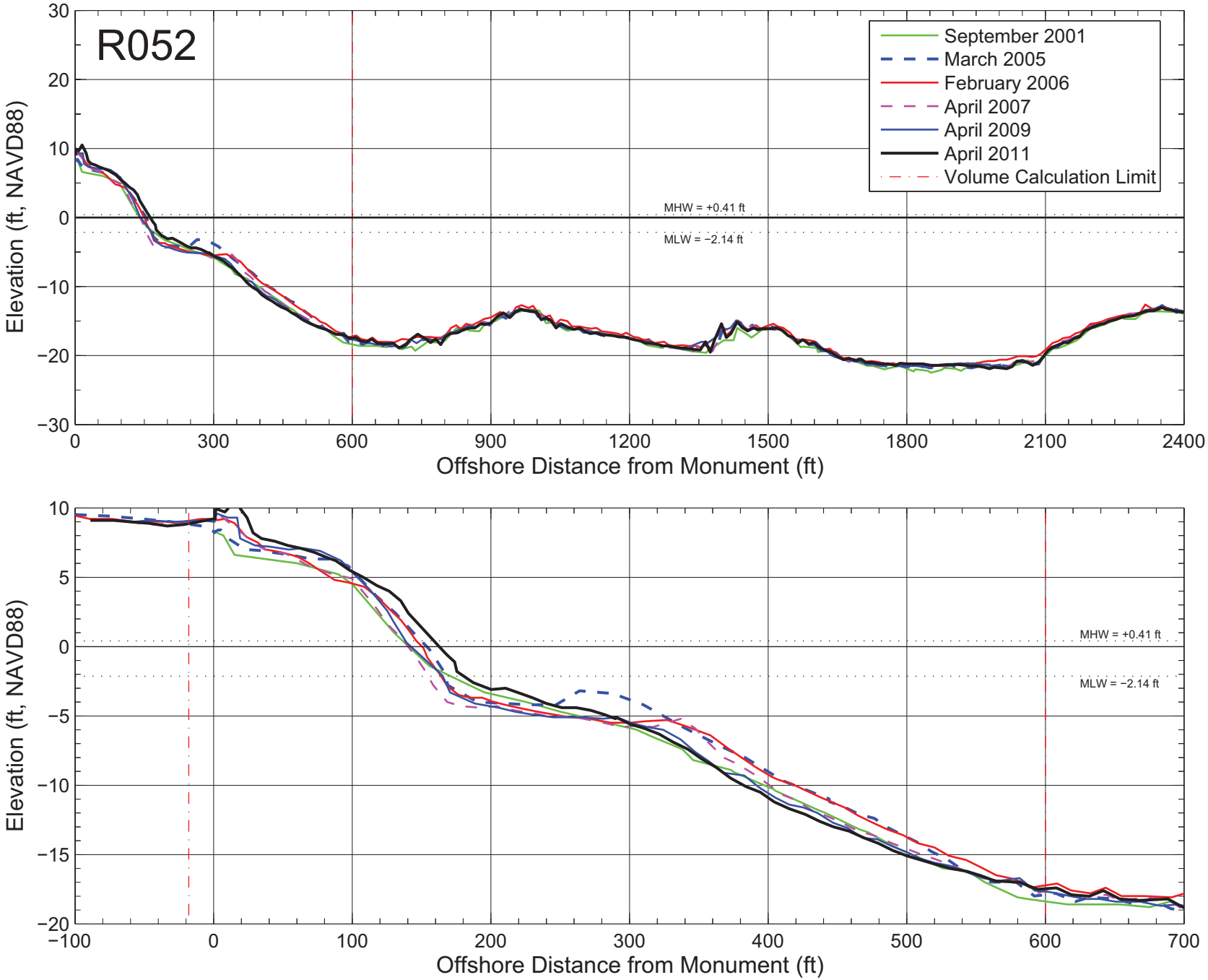


Figure A–052: Measured beach profiles at monument R052 Broward County, Florida.

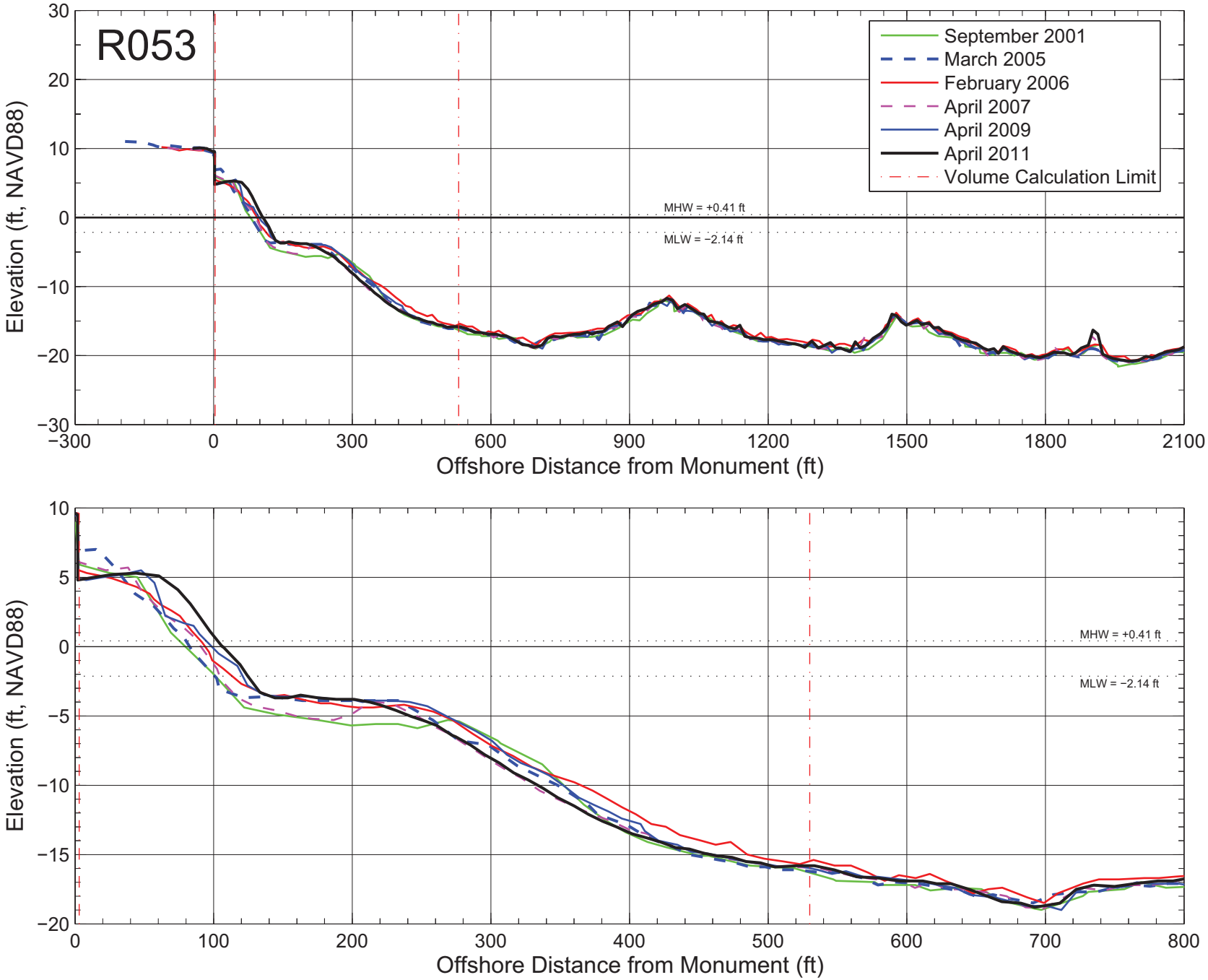


Figure A–053: Measured beach profiles at monument R053 Broward County, Florida.

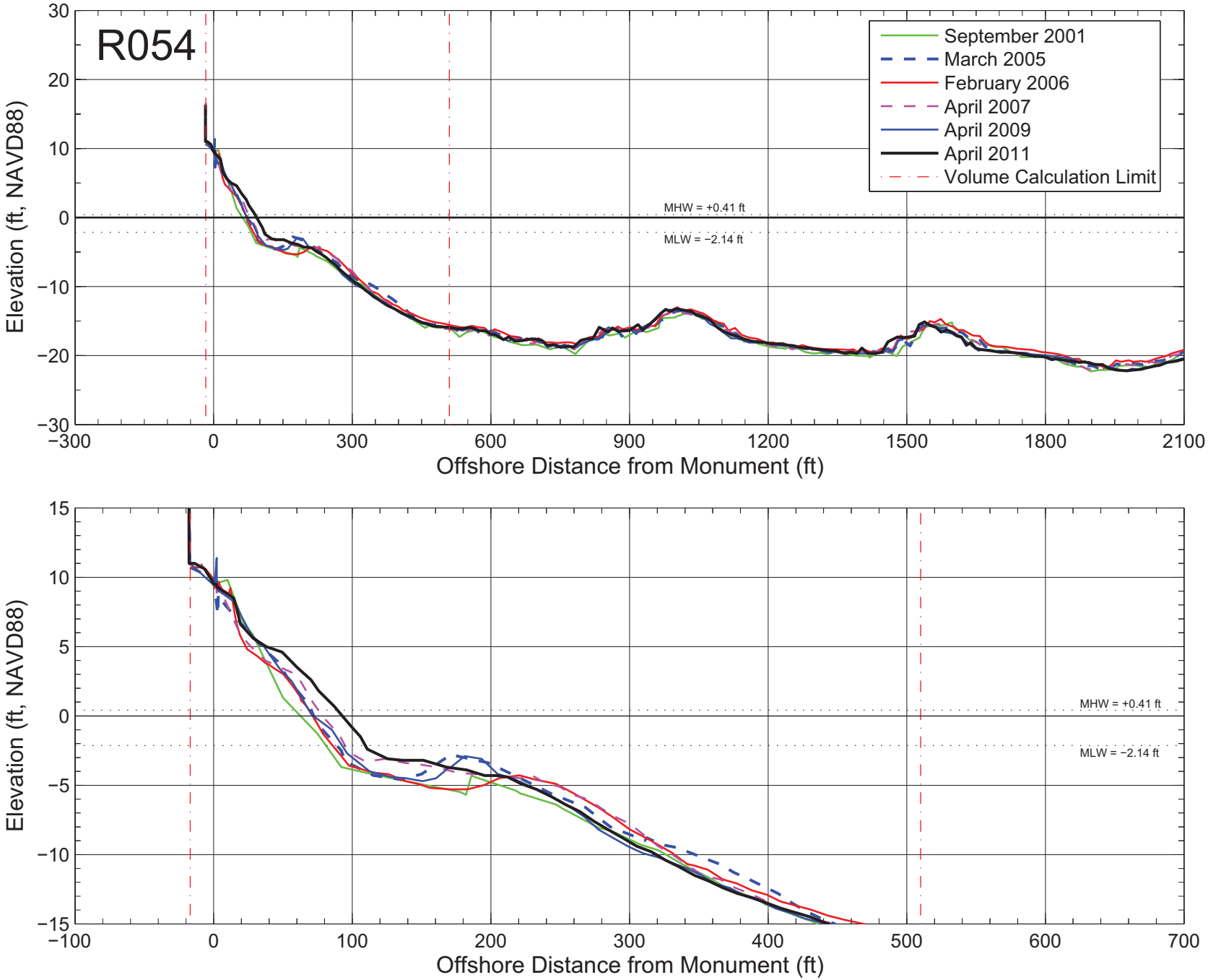


Figure A–054: Measured beach profiles at monument R054 Broward County, Florida.

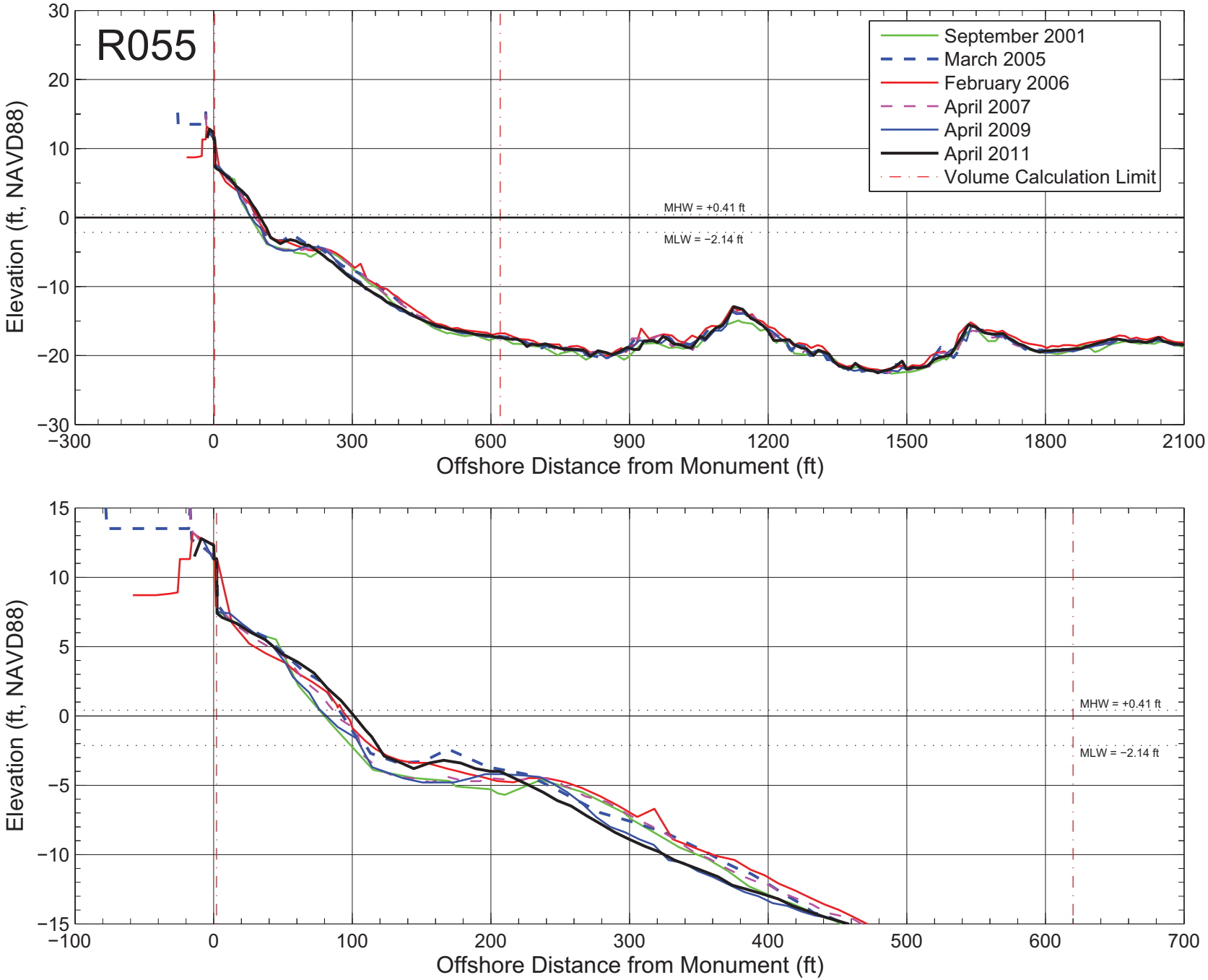


Figure A–055: Measured beach profiles at monument R055 Broward County, Florida.

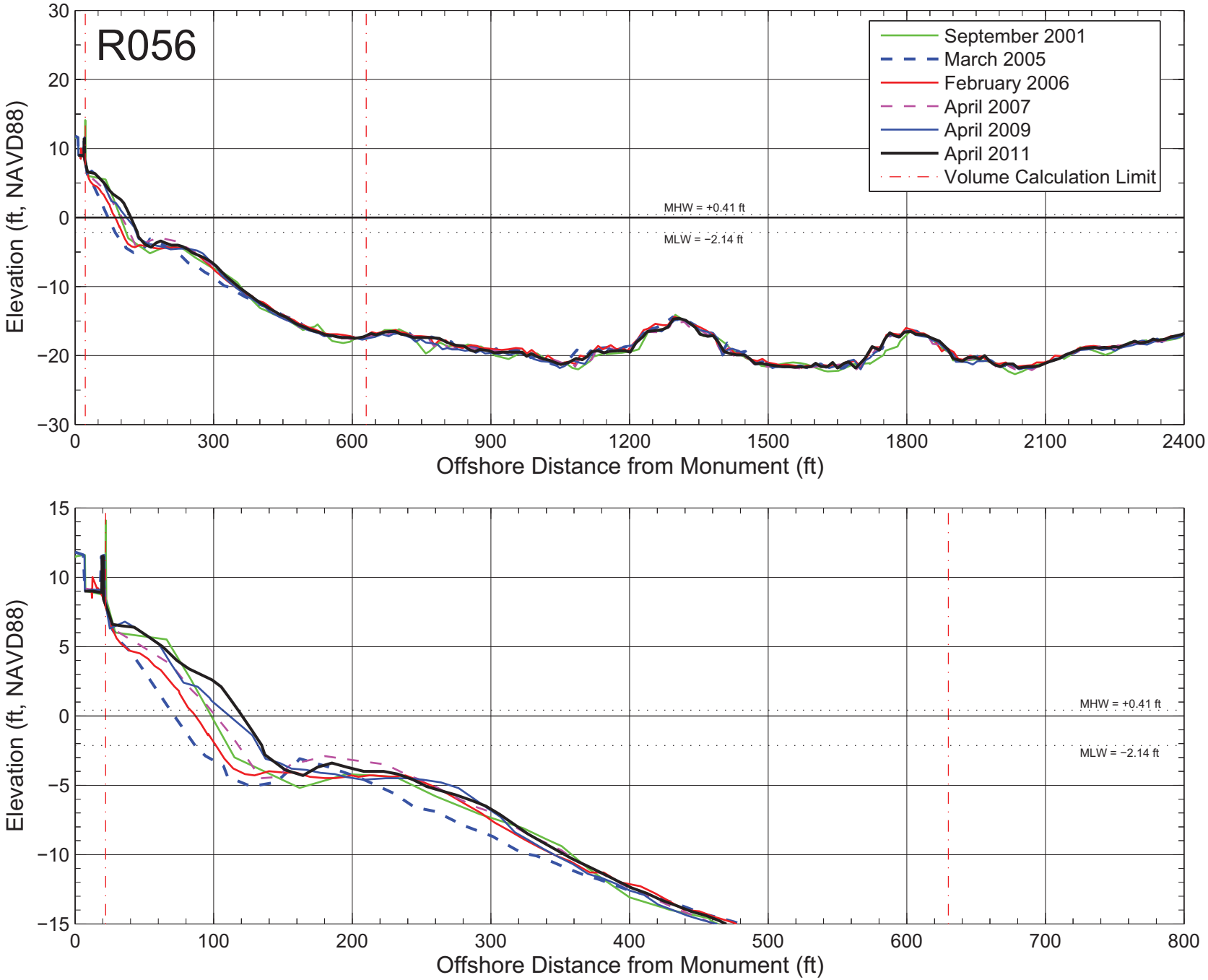


Figure A–056: Measured beach profiles at monument R056 Broward County, Florida.

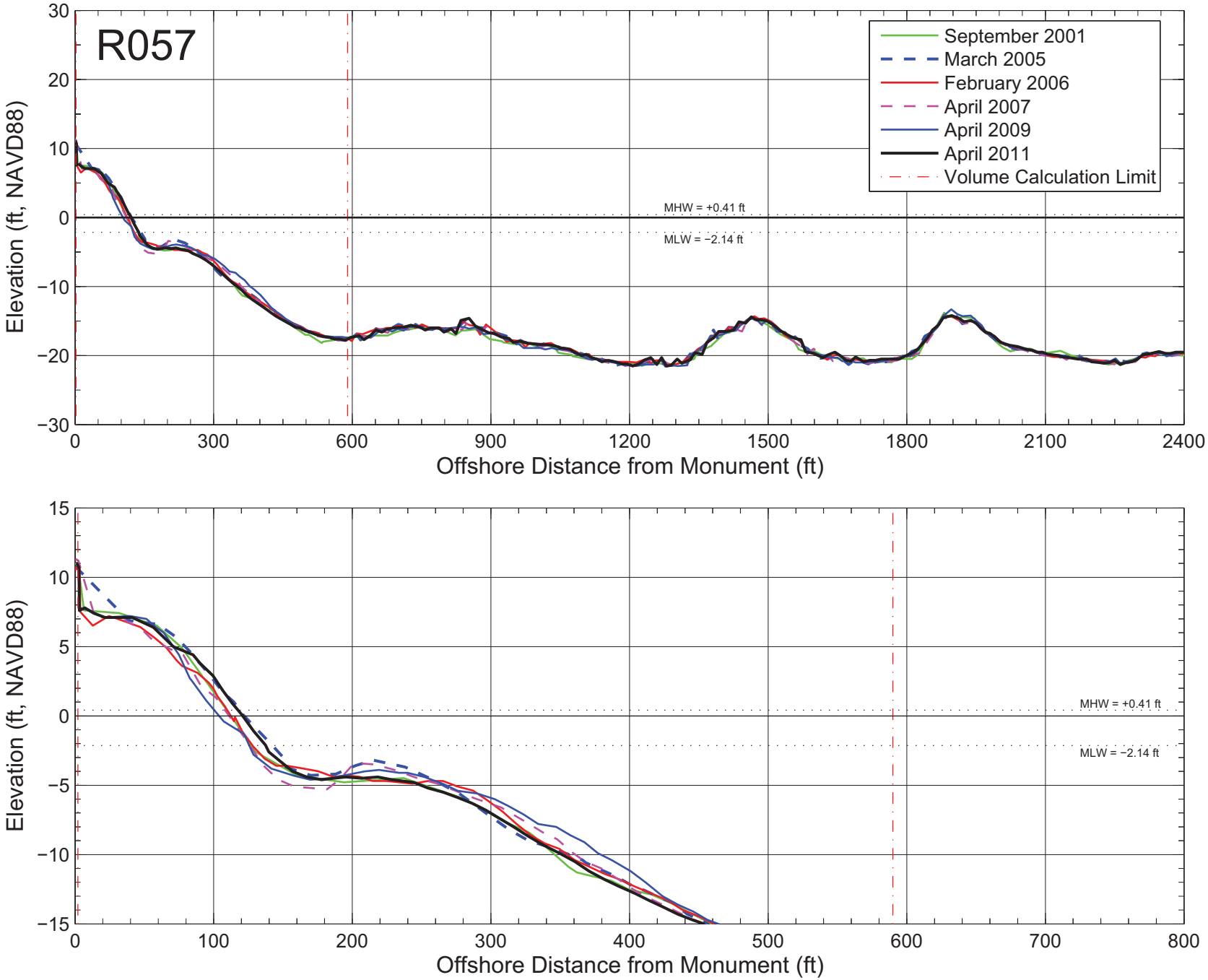


Figure A–057: Measured beach profiles at monument R057 Broward County, Florida.

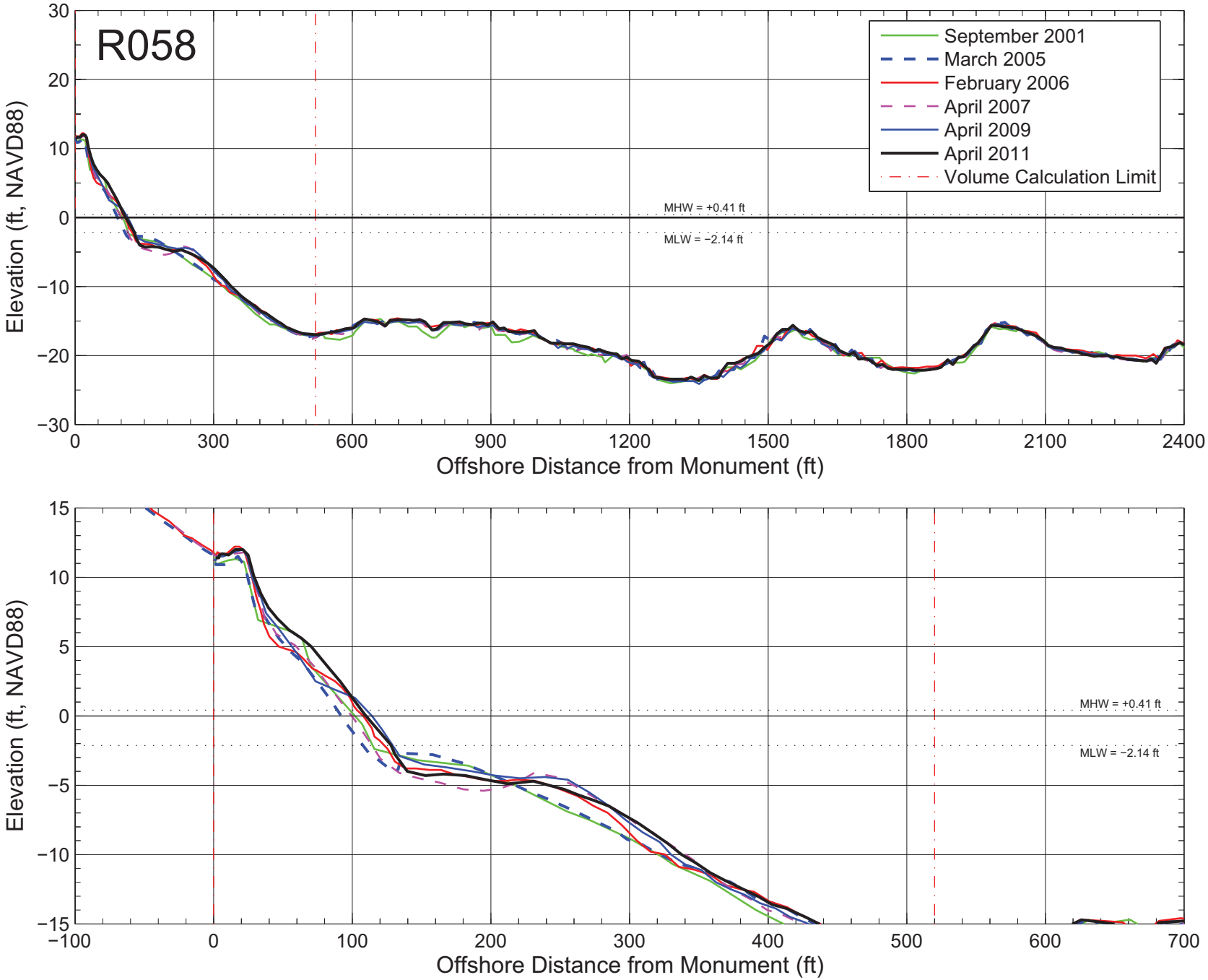


Figure A–058: Measured beach profiles at monument R058 Broward County, Florida.

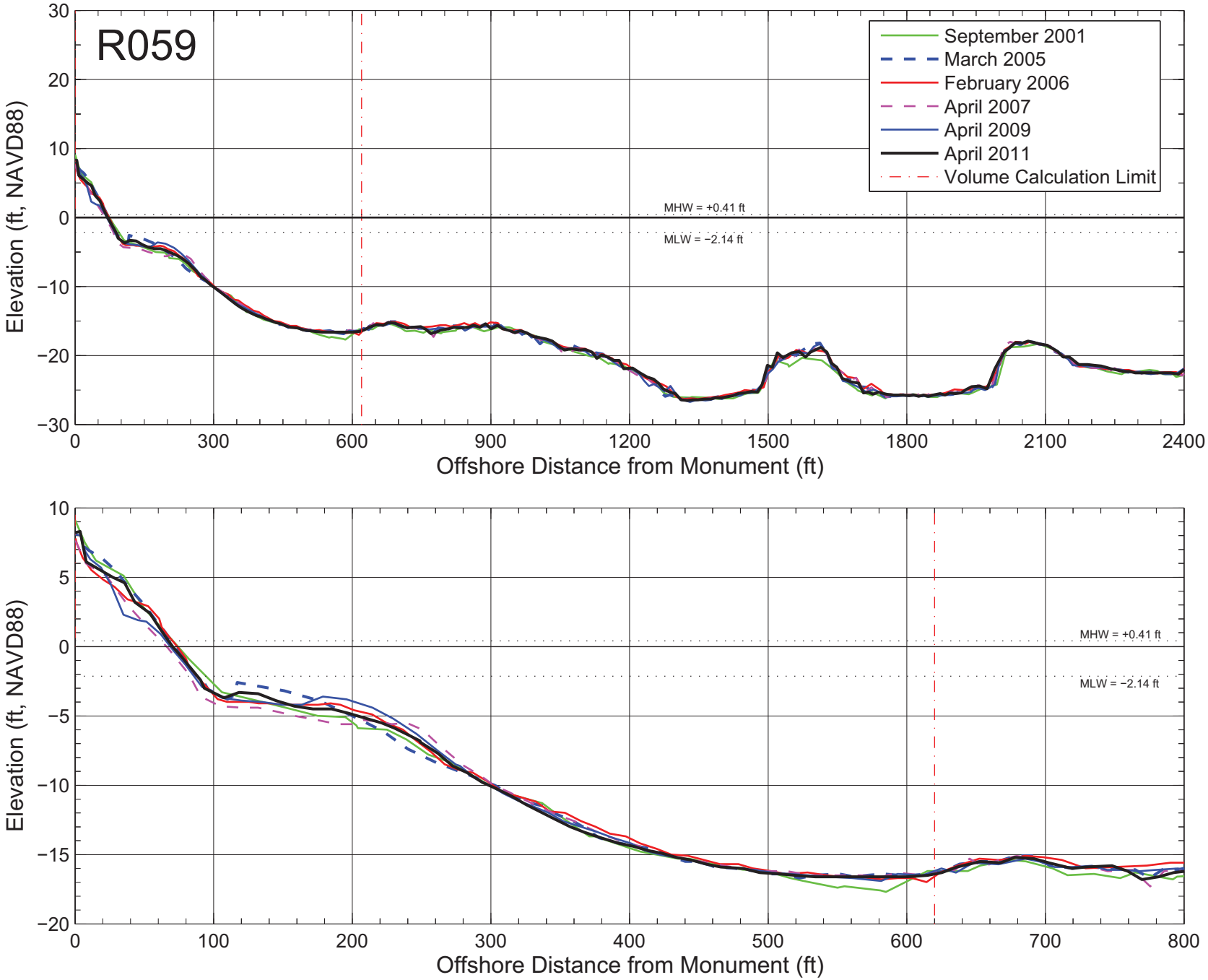


Figure A–059: Measured beach profiles at monument R059 Broward County, Florida.

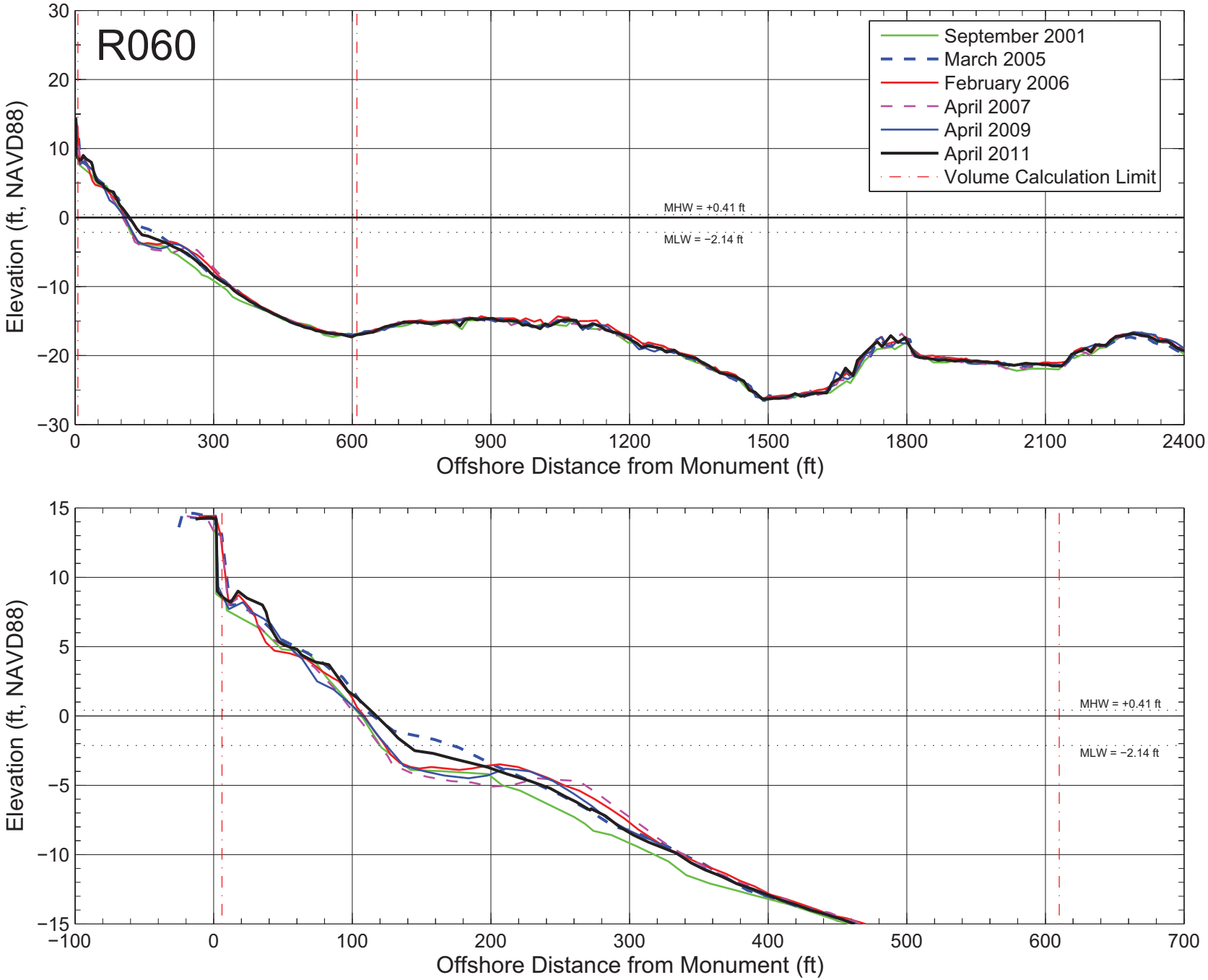


Figure A–060: Measured beach profiles at monument R060 Broward County, Florida.

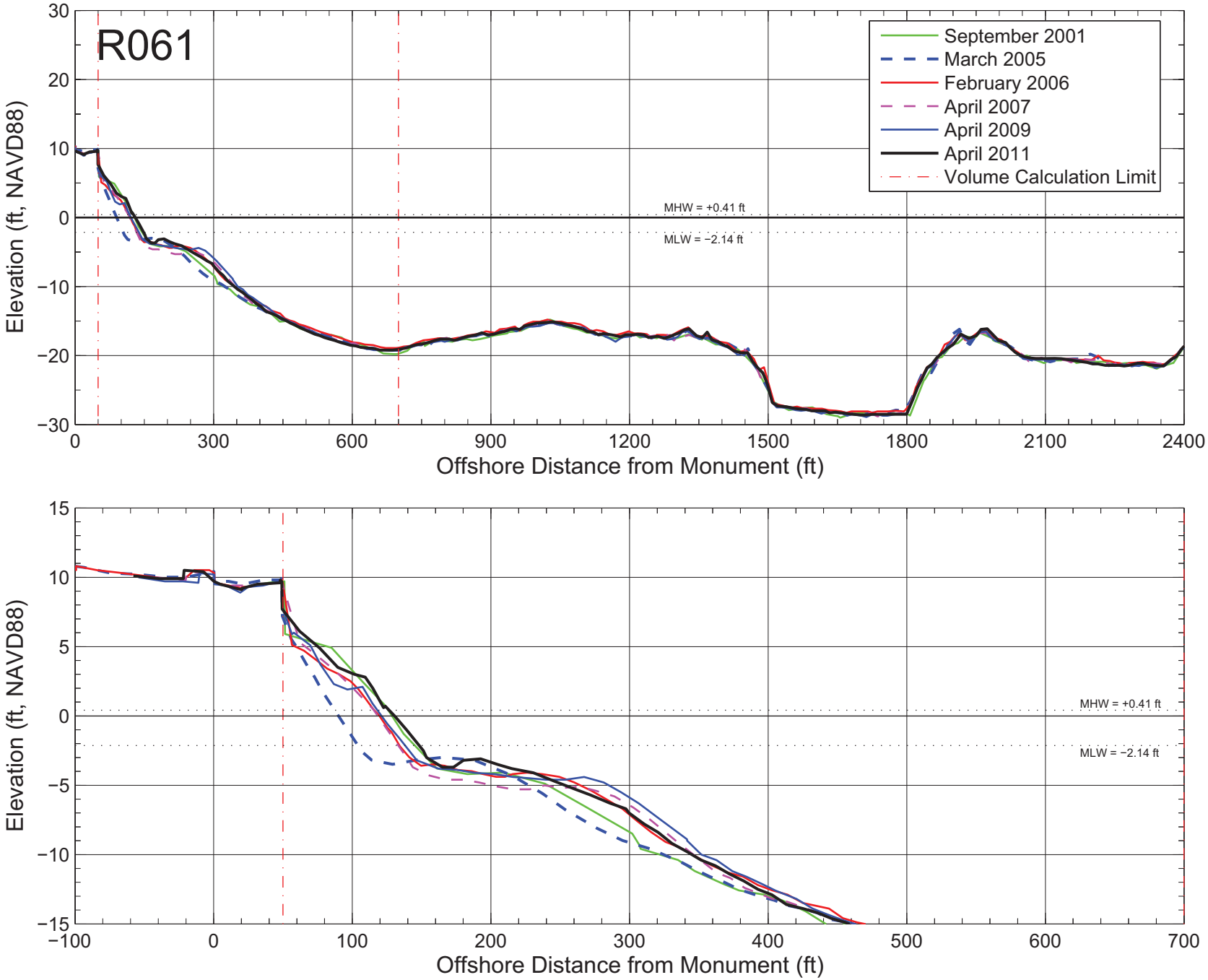


Figure A–061: Measured beach profiles at monument R061 Broward County, Florida.

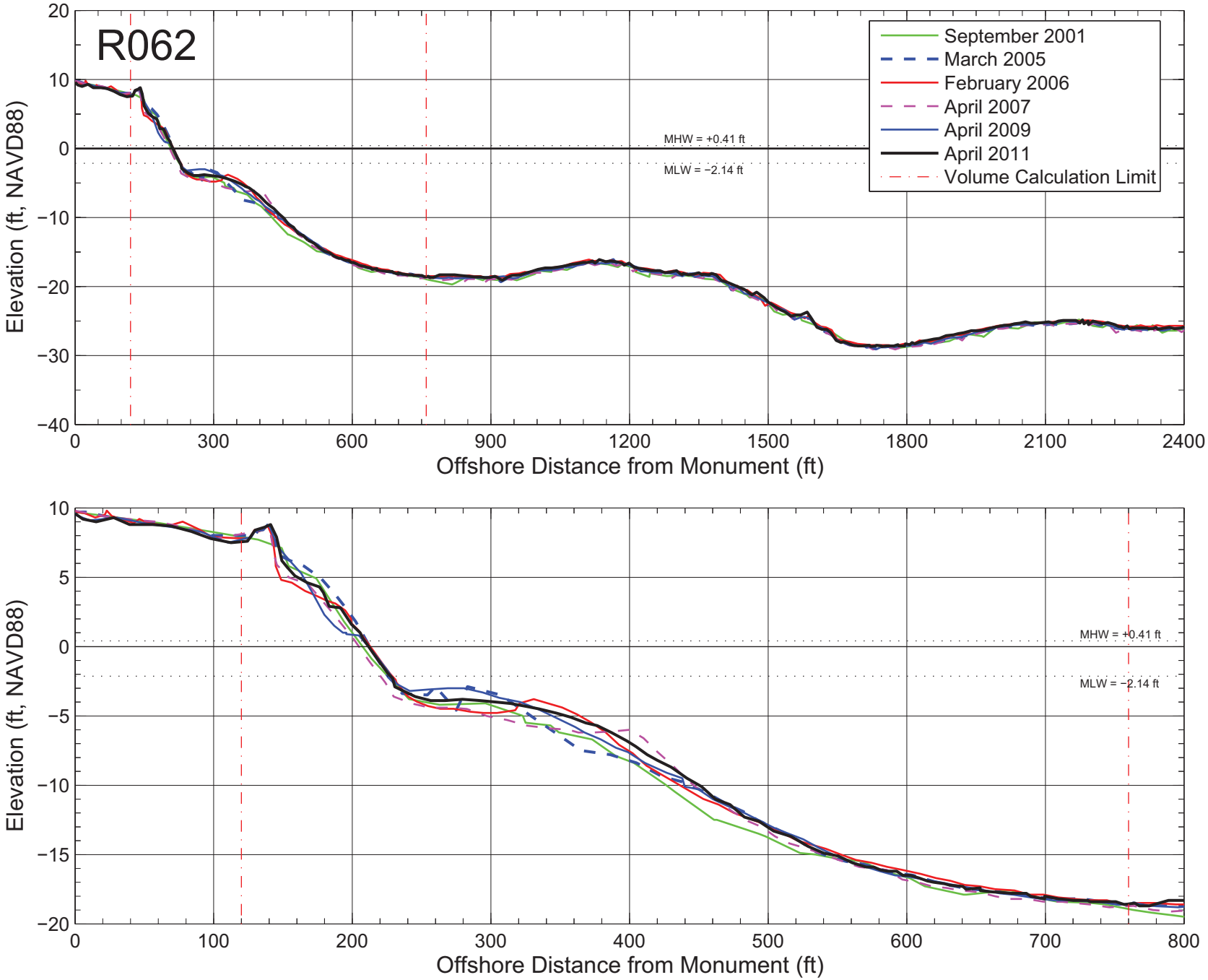


Figure A–062: Measured beach profiles at monument R062 Broward County, Florida.

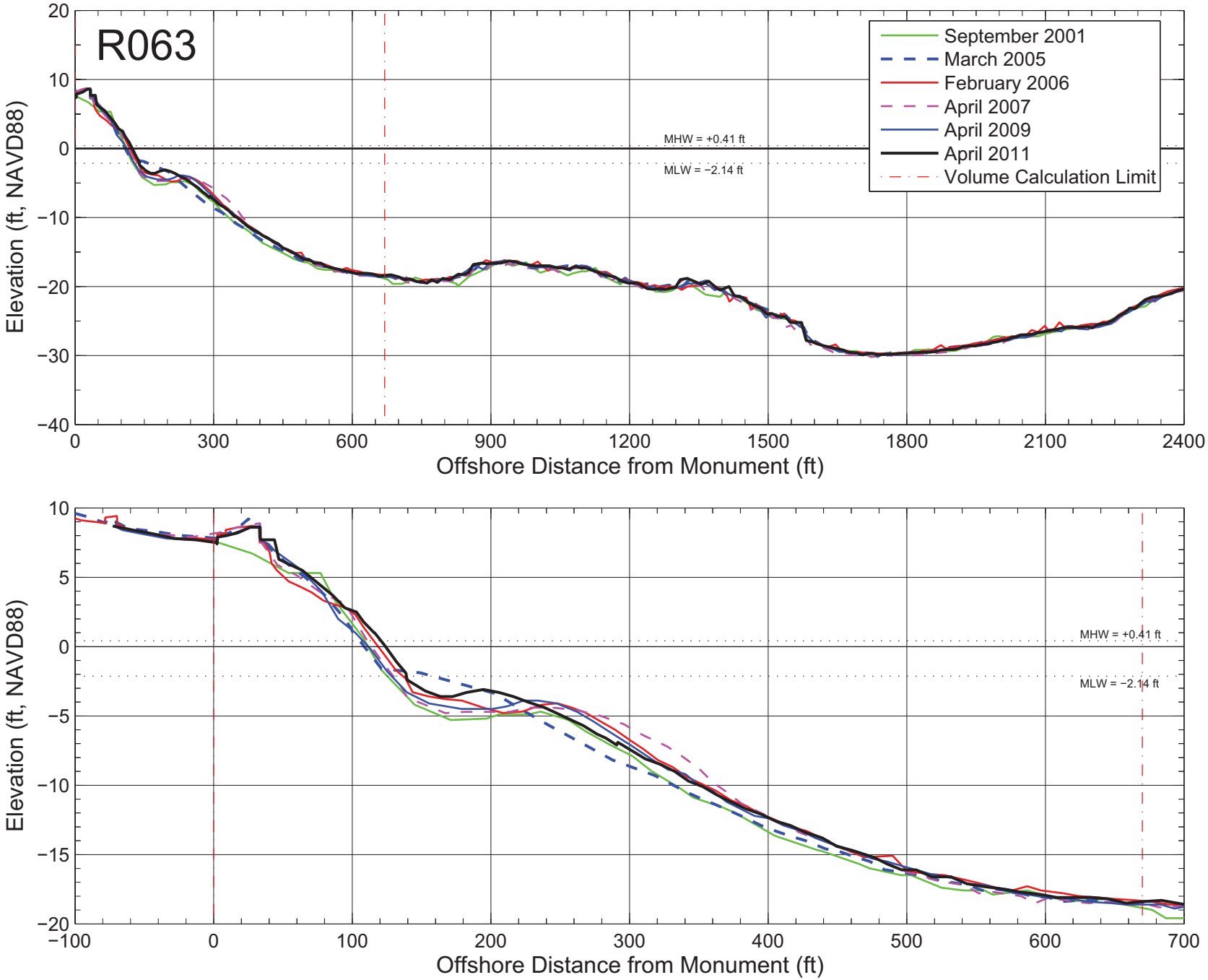


Figure A–063: Measured beach profiles at monument R063 Broward County, Florida.

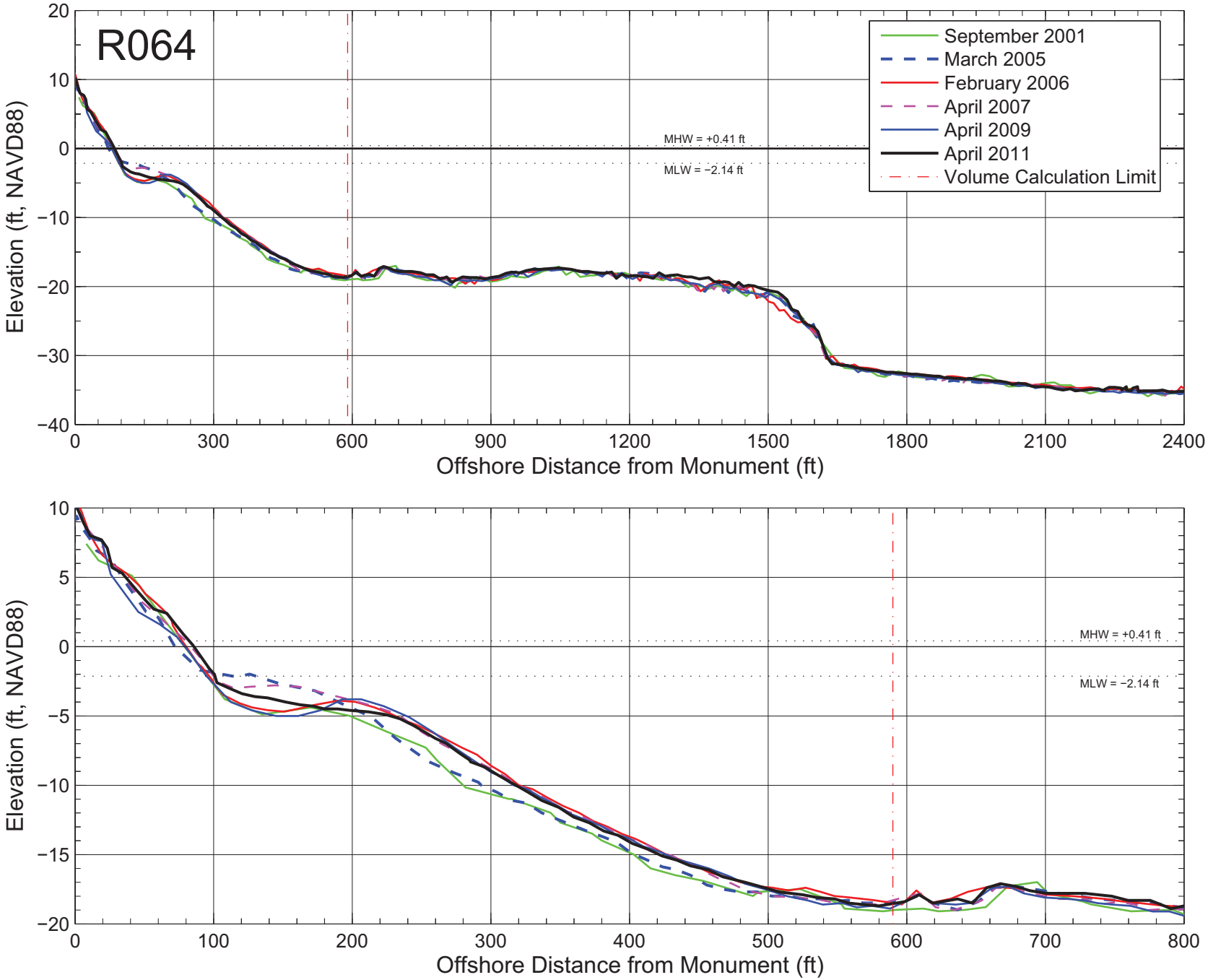


Figure A–064: Measured beach profiles at monument R064 Broward County, Florida.

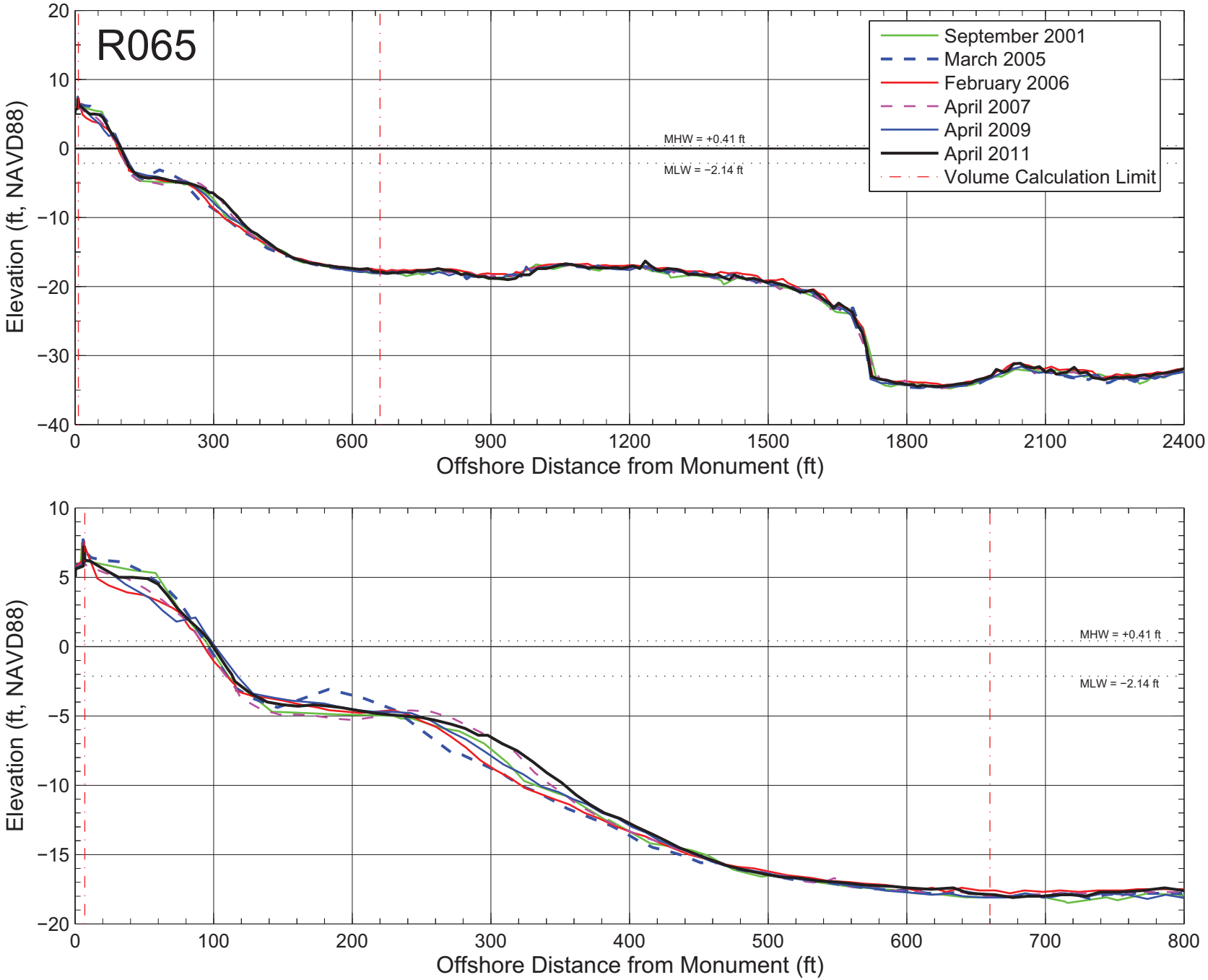


Figure A–065: Measured beach profiles at monument R065 Broward County, Florida.

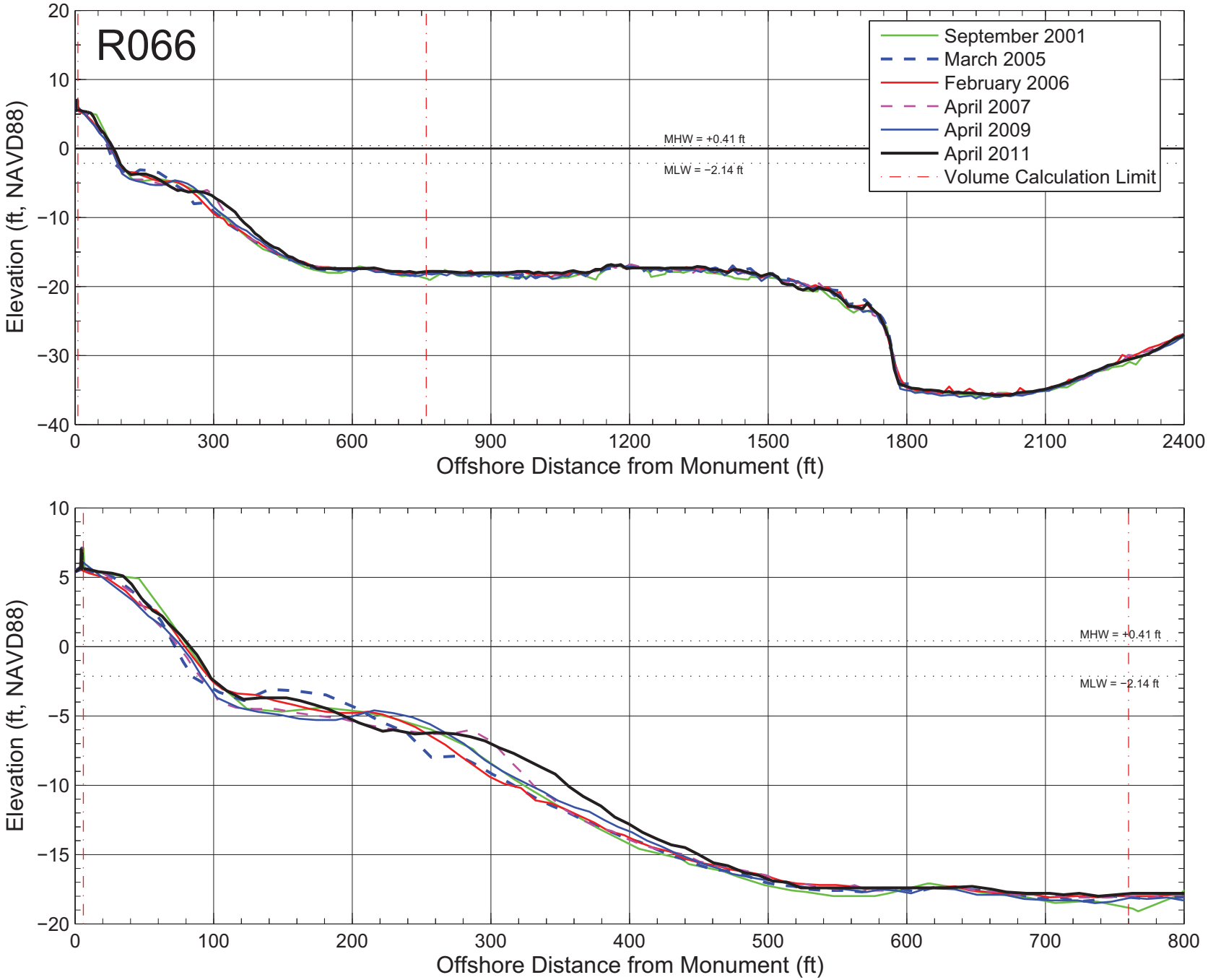


Figure A–066: Measured beach profiles at monument R066 Broward County, Florida.

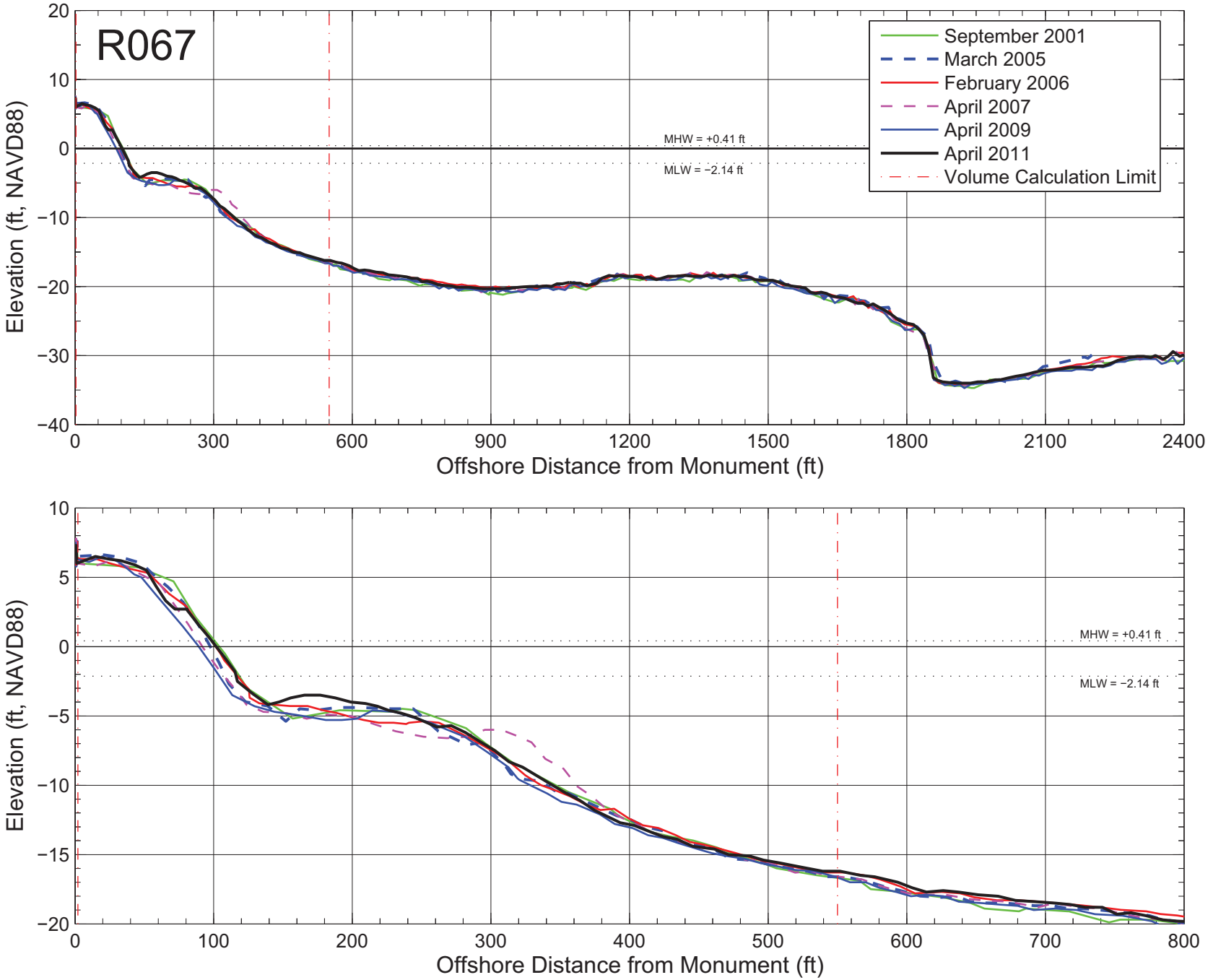


Figure A–067: Measured beach profiles at monument R067 Broward County, Florida.

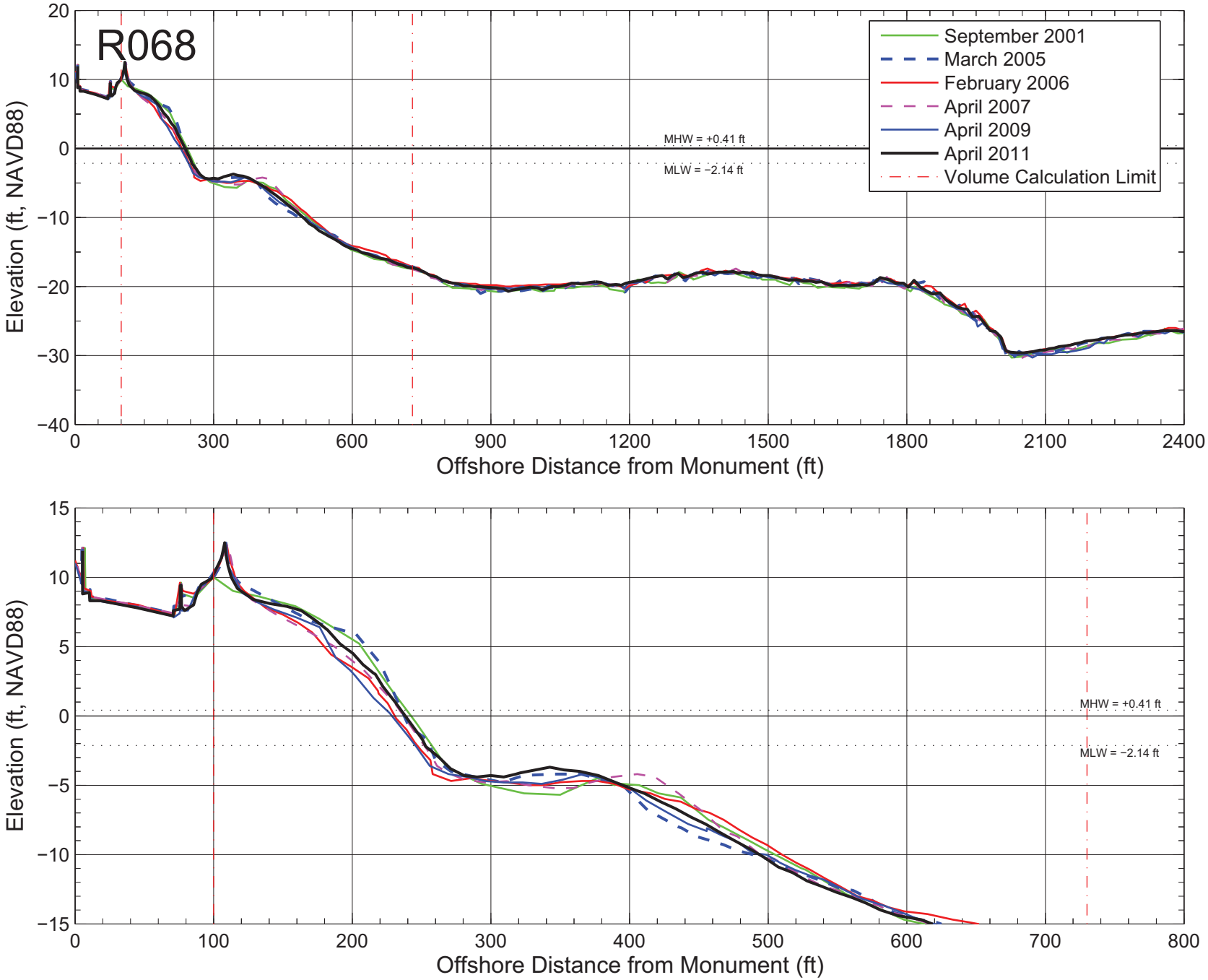


Figure A–068: Measured beach profiles at monument R068 Broward County, Florida.

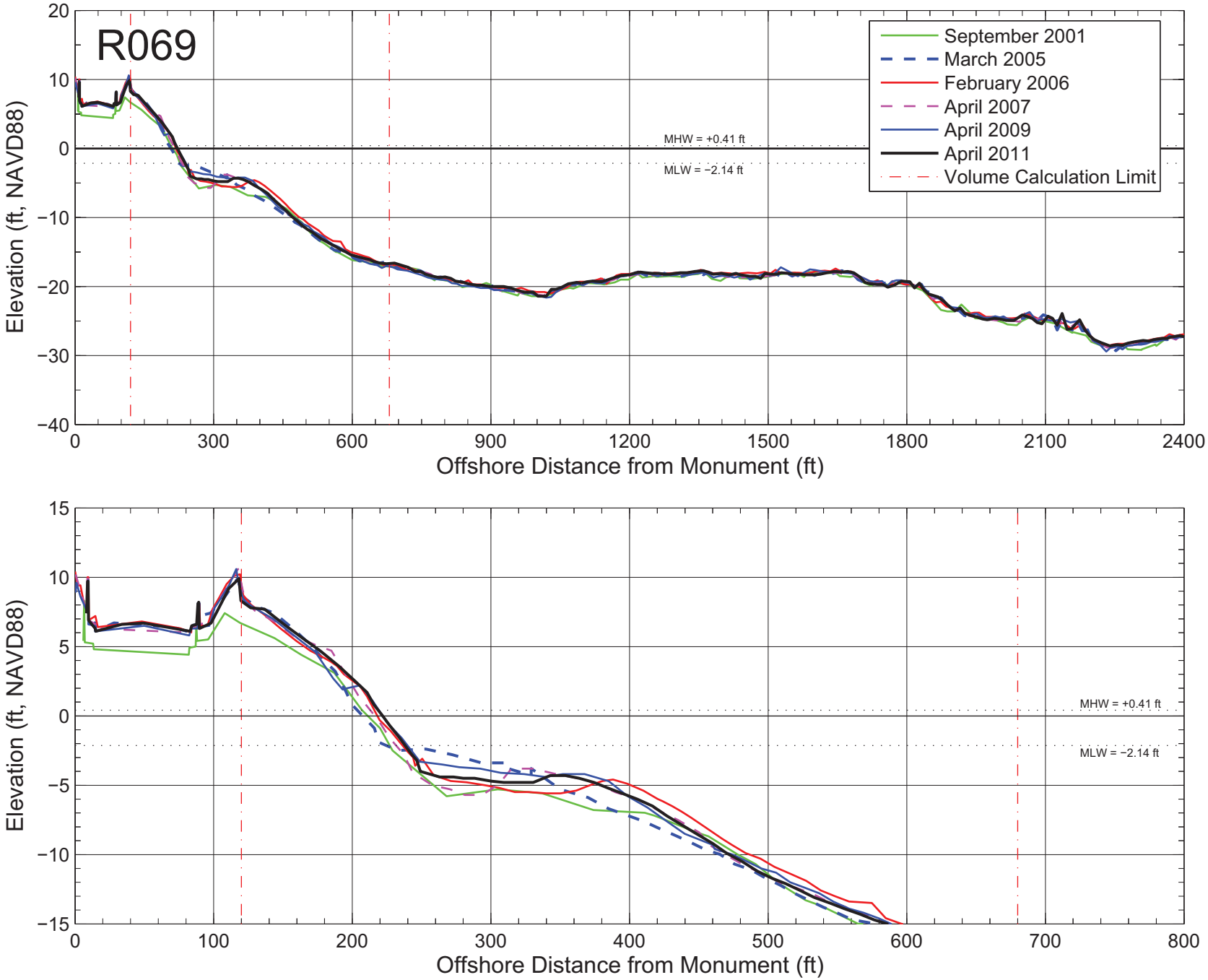


Figure A–069: Measured beach profiles at monument R069 Broward County, Florida.

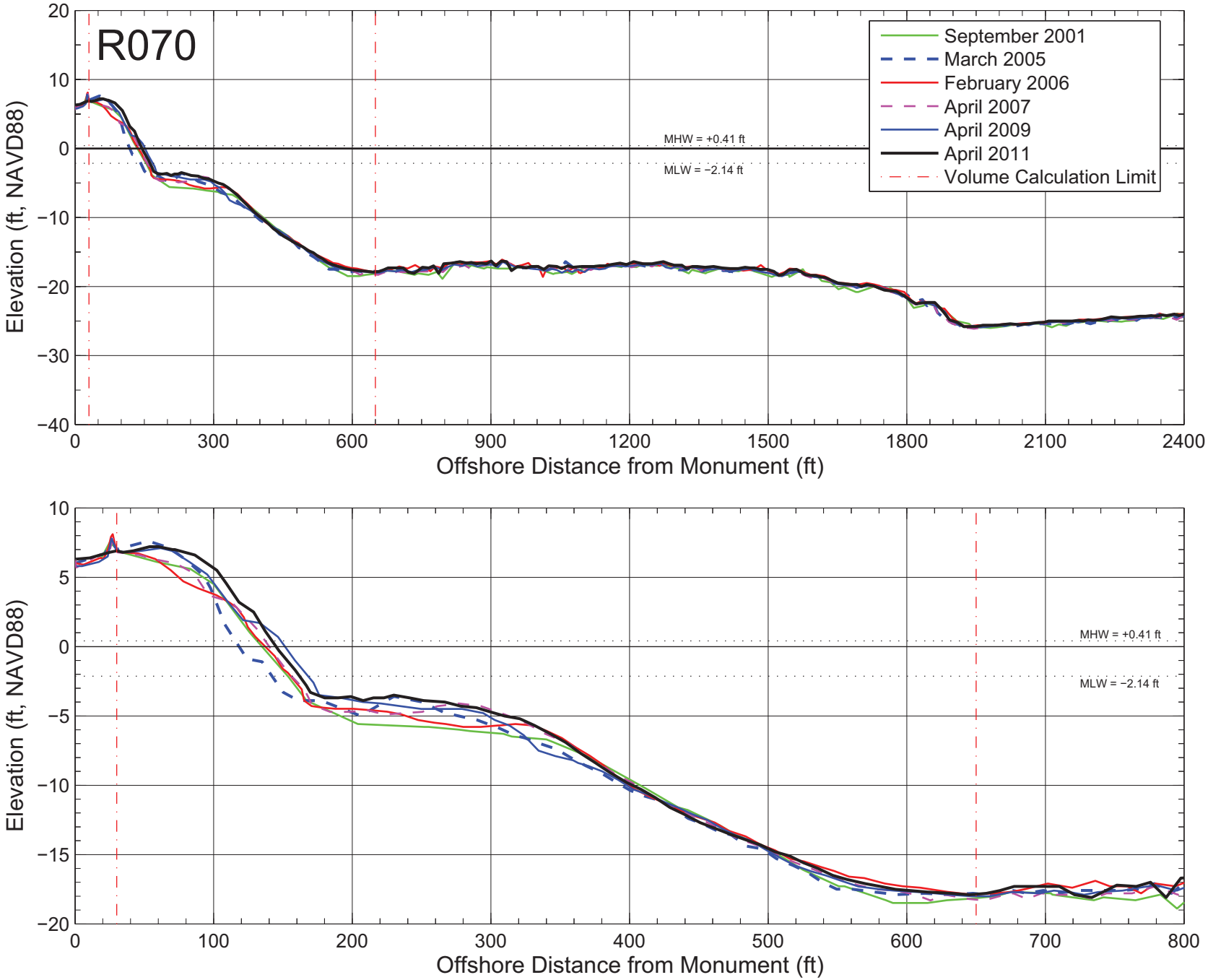


Figure A−070: Measured beach profiles at monument R070 Broward County, Florida.

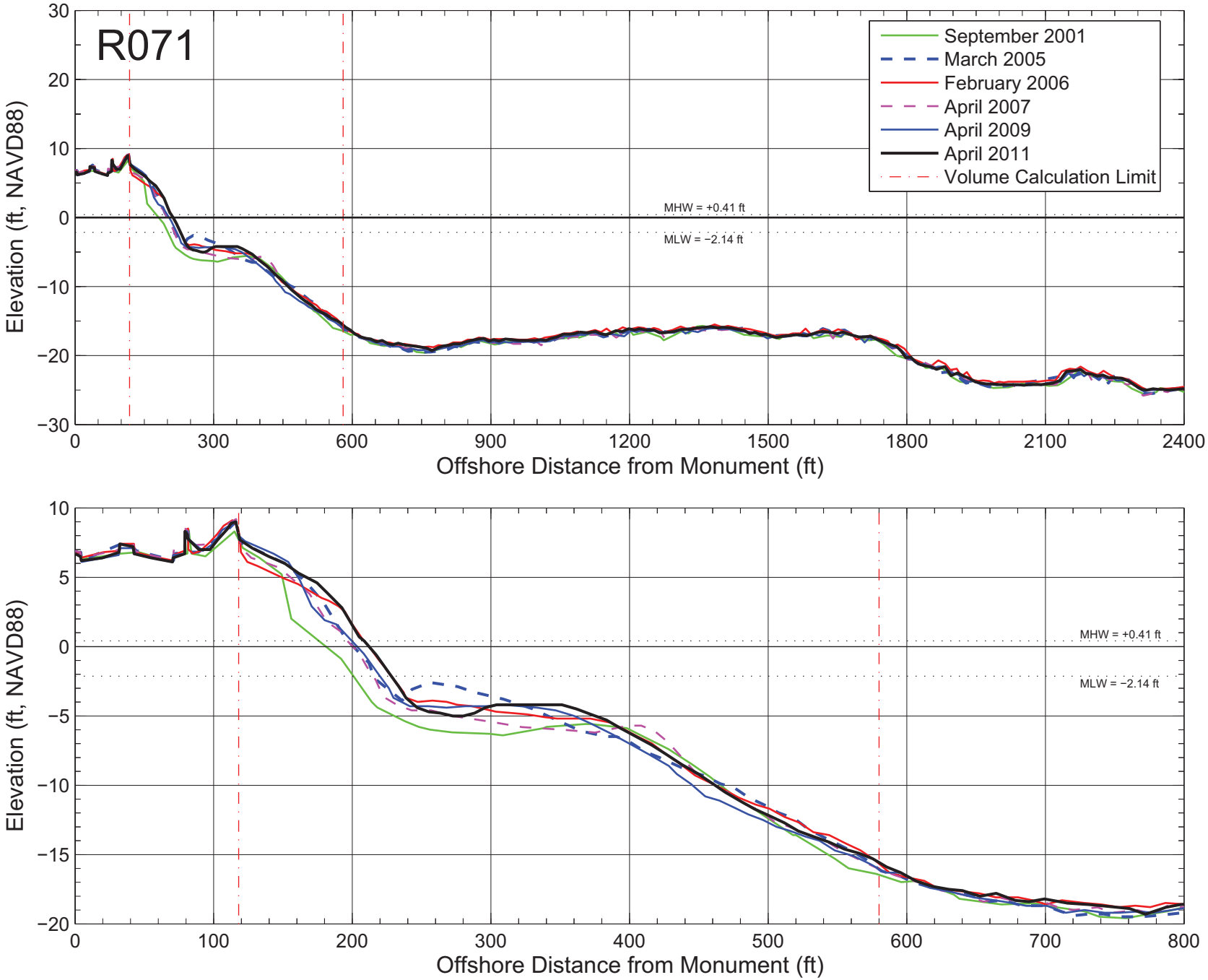


Figure A–071: Measured beach profiles at monument R071 Broward County, Florida.

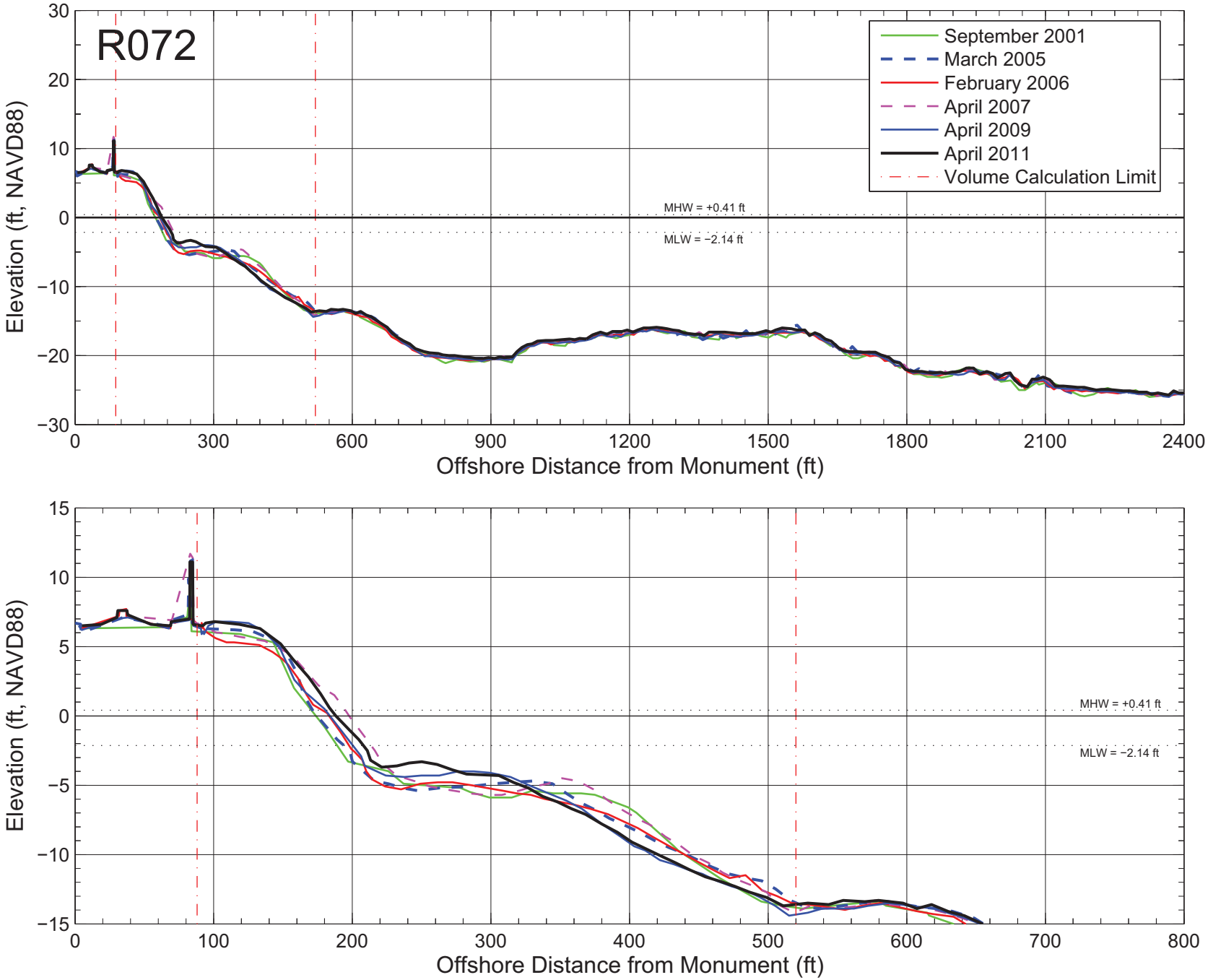


Figure A–072: Measured beach profiles at monument R072 Broward County, Florida.

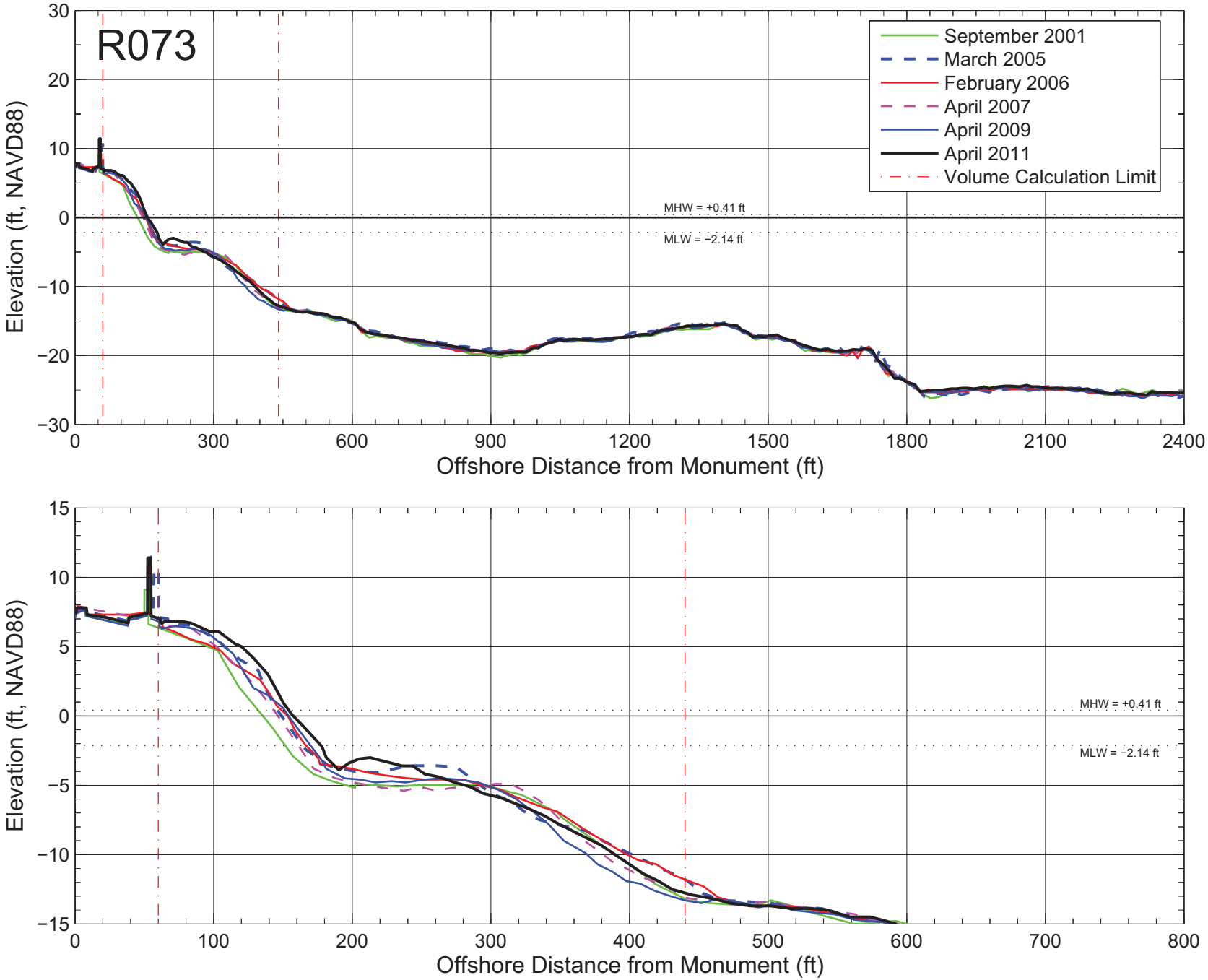


Figure A–073: Measured beach profiles at monument R073 Broward County, Florida.

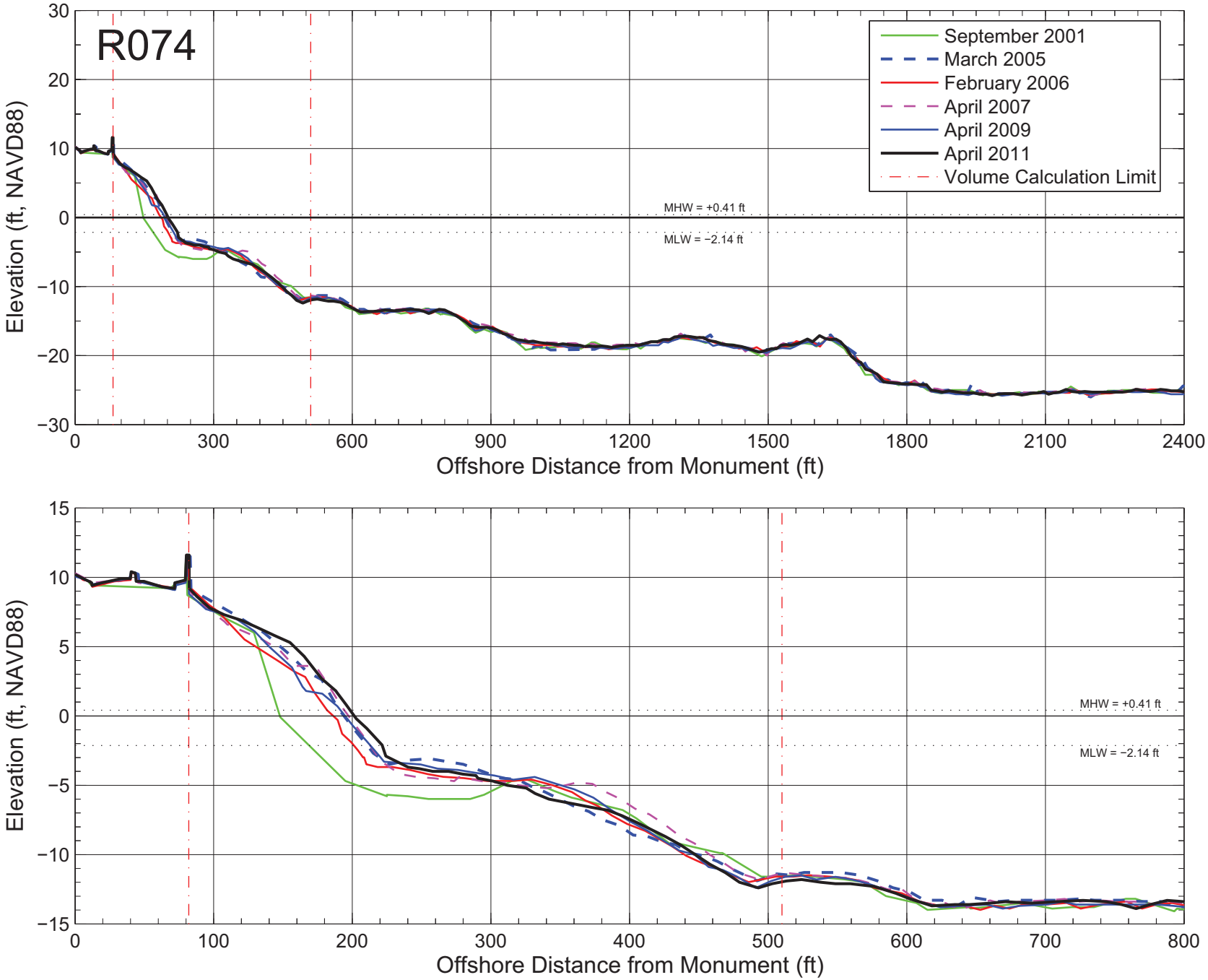


Figure A–074: Measured beach profiles at monument R074 Broward County, Florida.

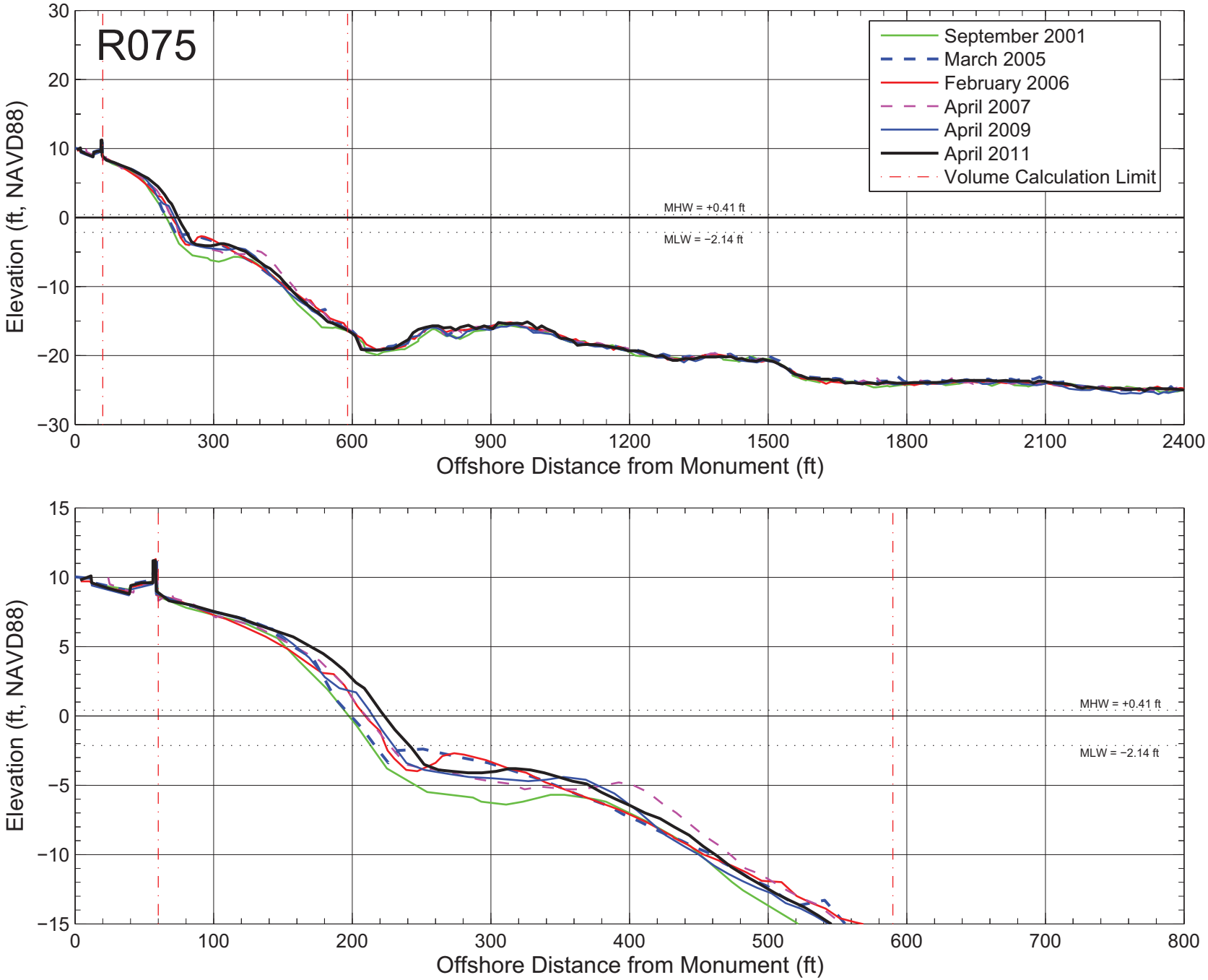


Figure A–075: Measured beach profiles at monument R075 Broward County, Florida.

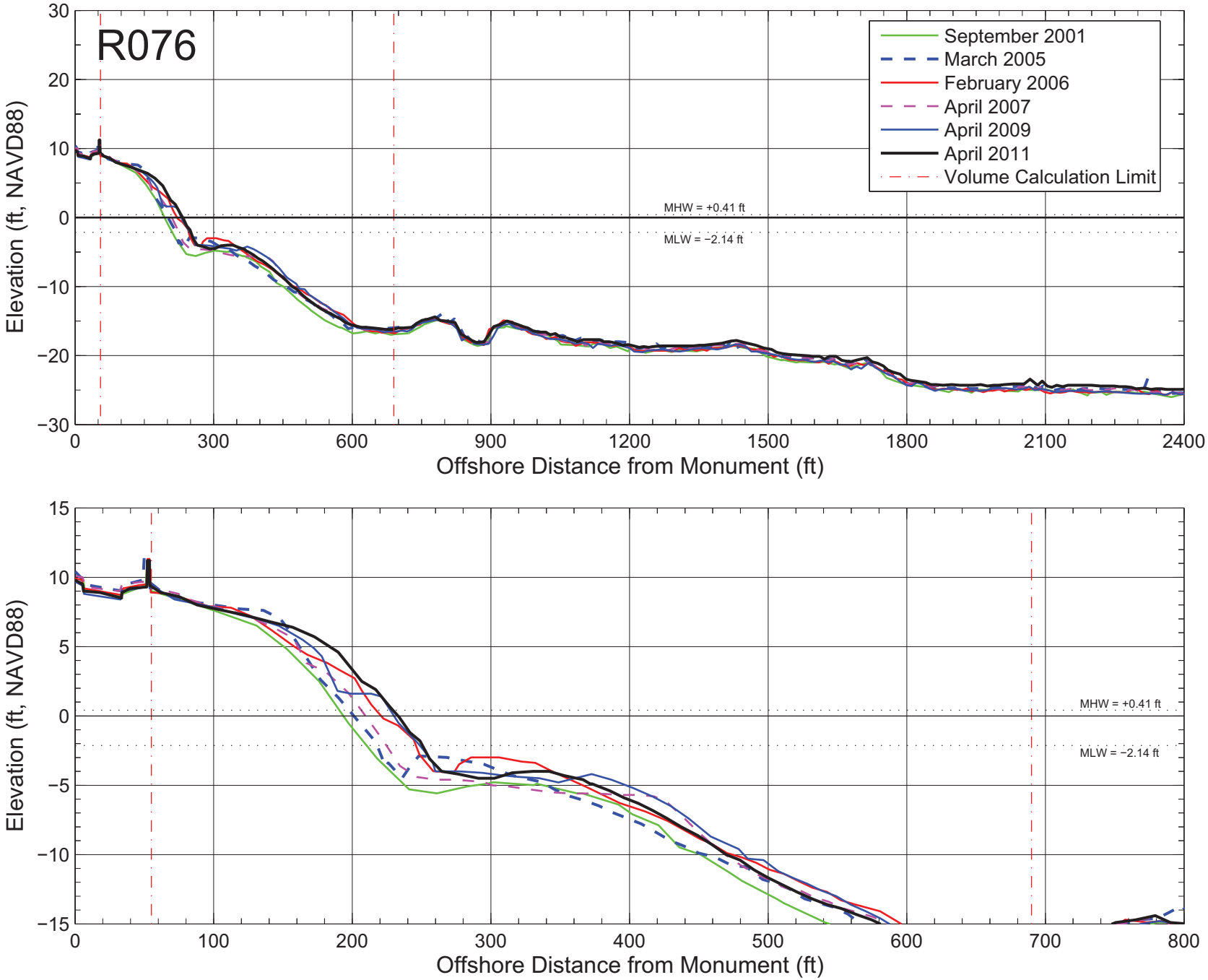


Figure A–076: Measured beach profiles at monument R076 Broward County, Florida.

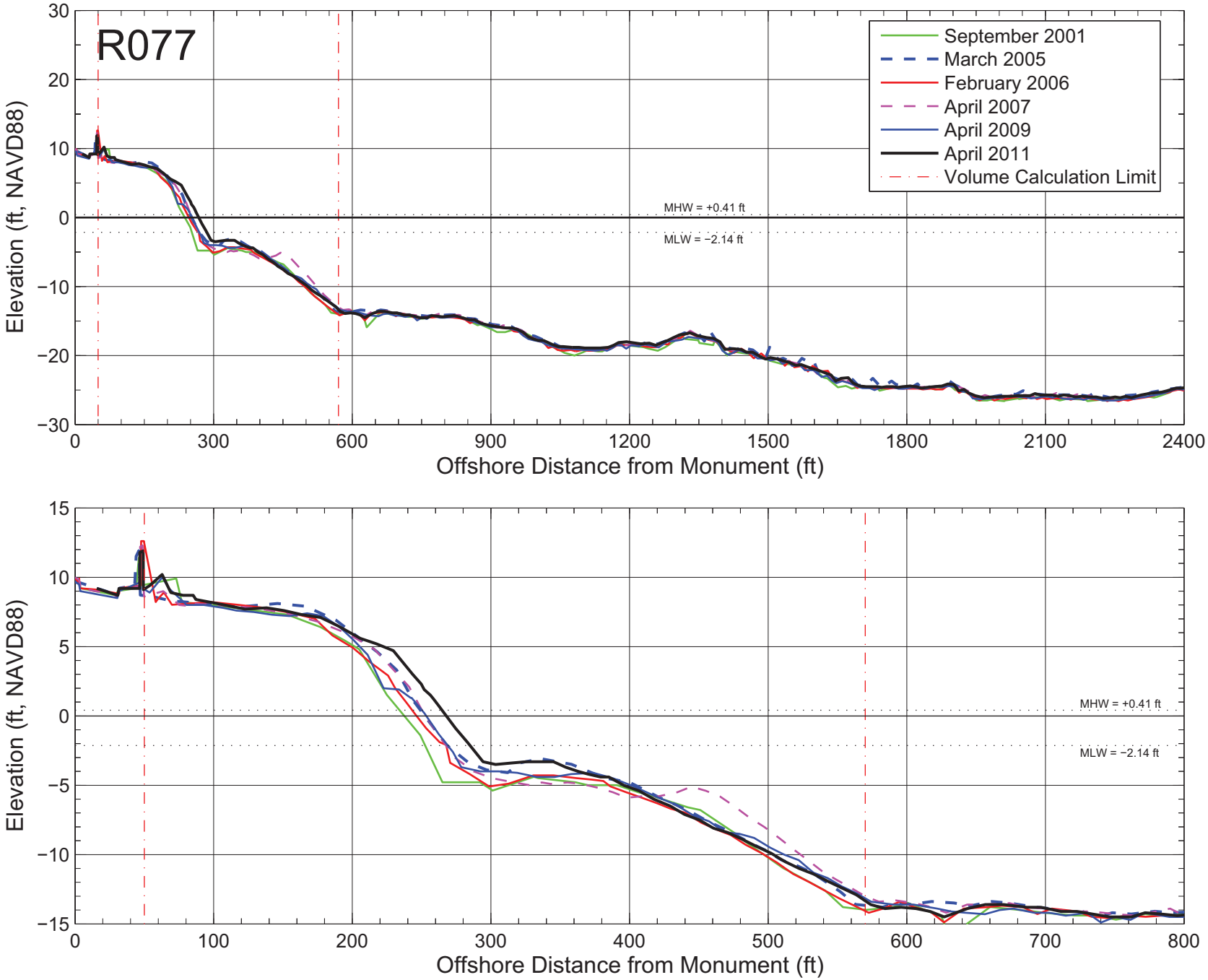


Figure A–077: Measured beach profiles at monument R077 Broward County, Florida.

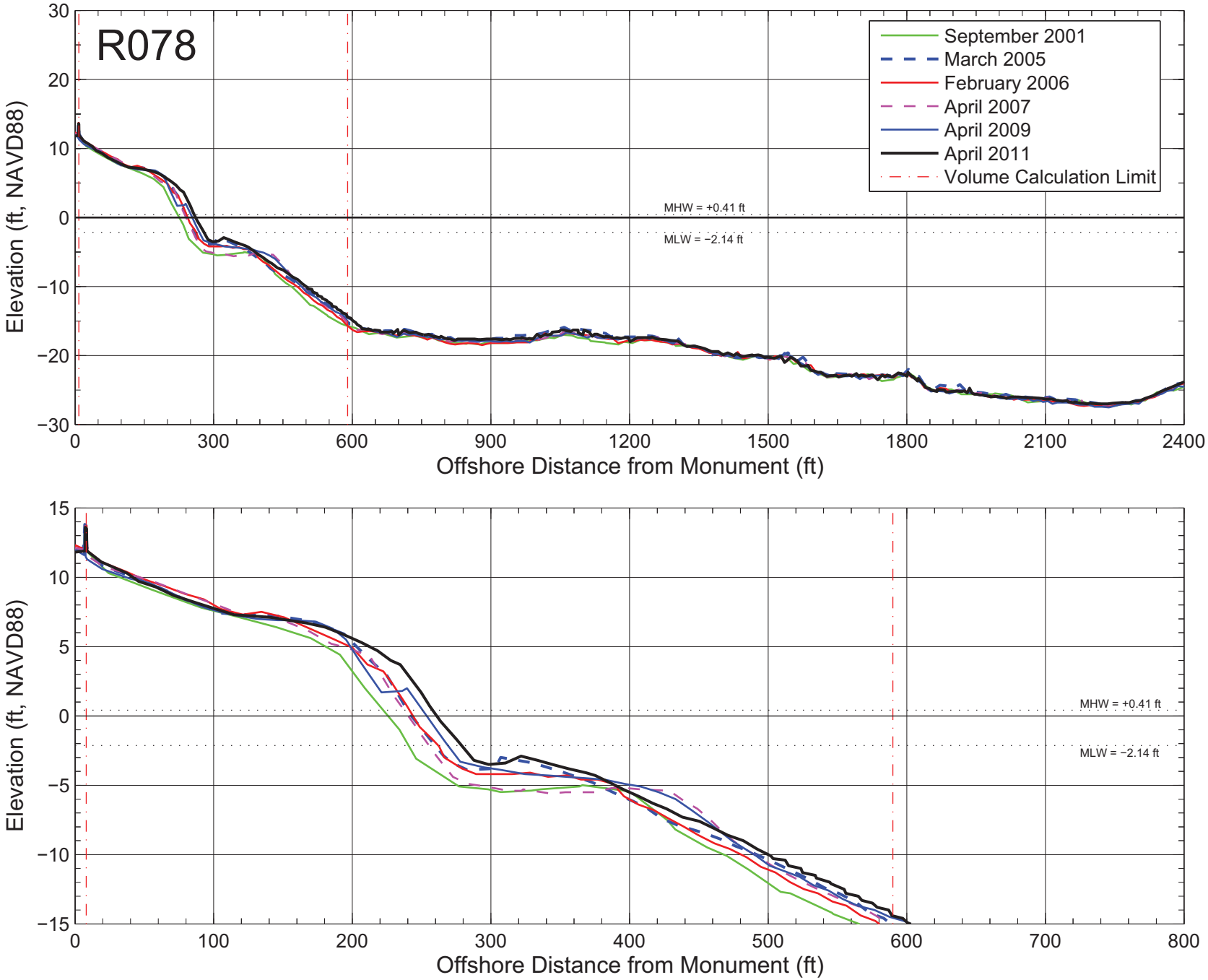


Figure A–078: Measured beach profiles at monument R078 Broward County, Florida.

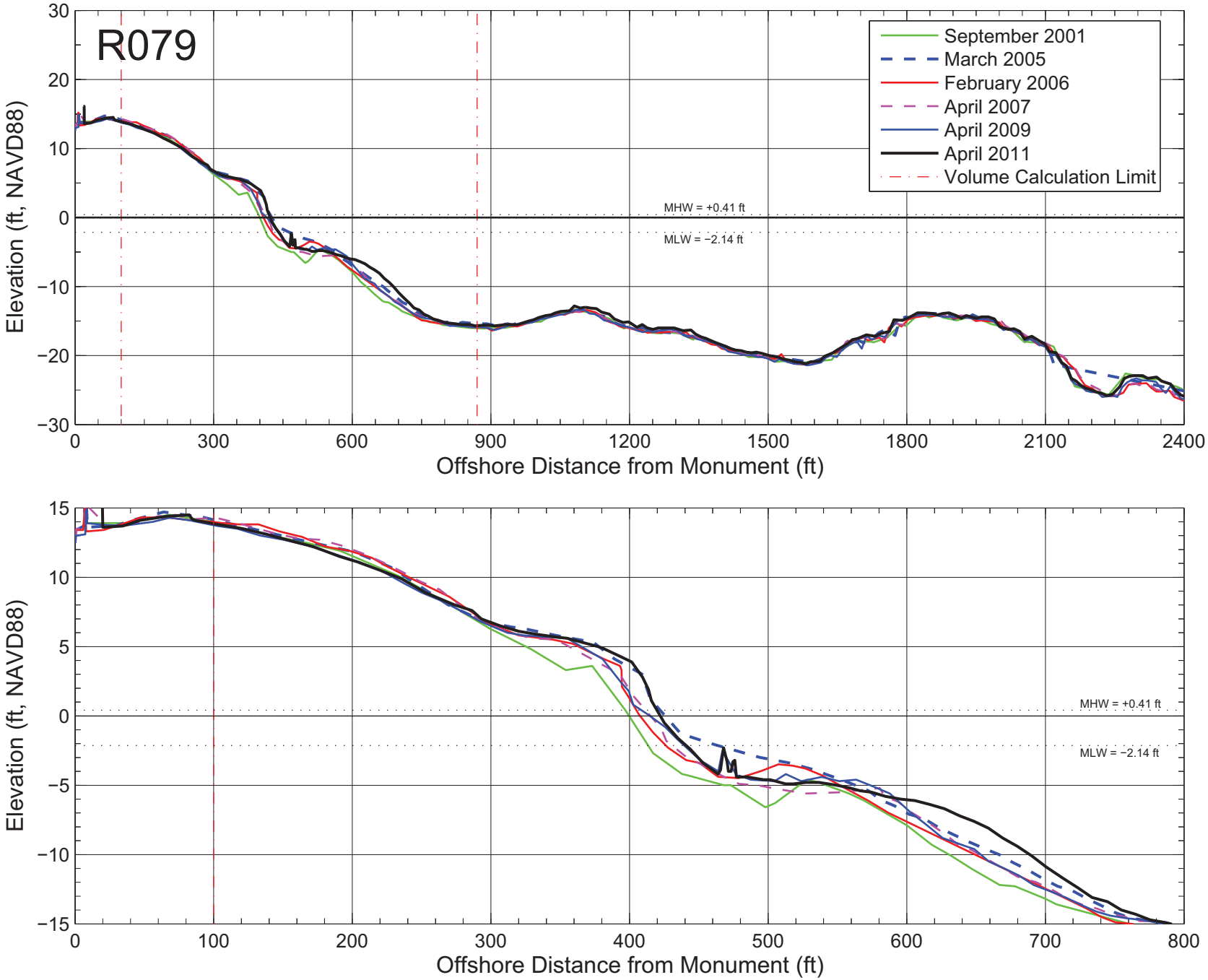


Figure A–079: Measured beach profiles at monument R079 Broward County, Florida.

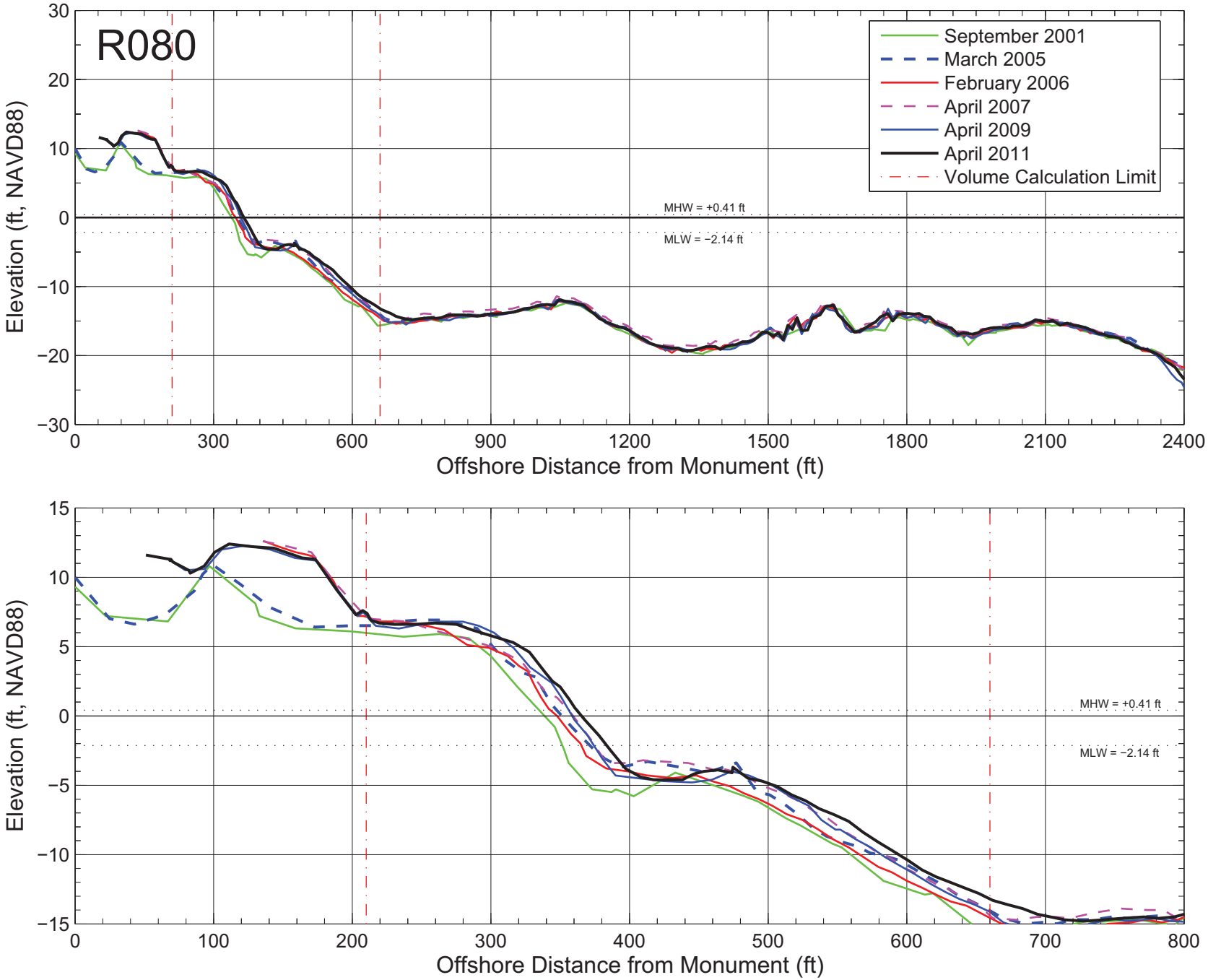


Figure A–080: Measured beach profiles at monument R080 Broward County, Florida.

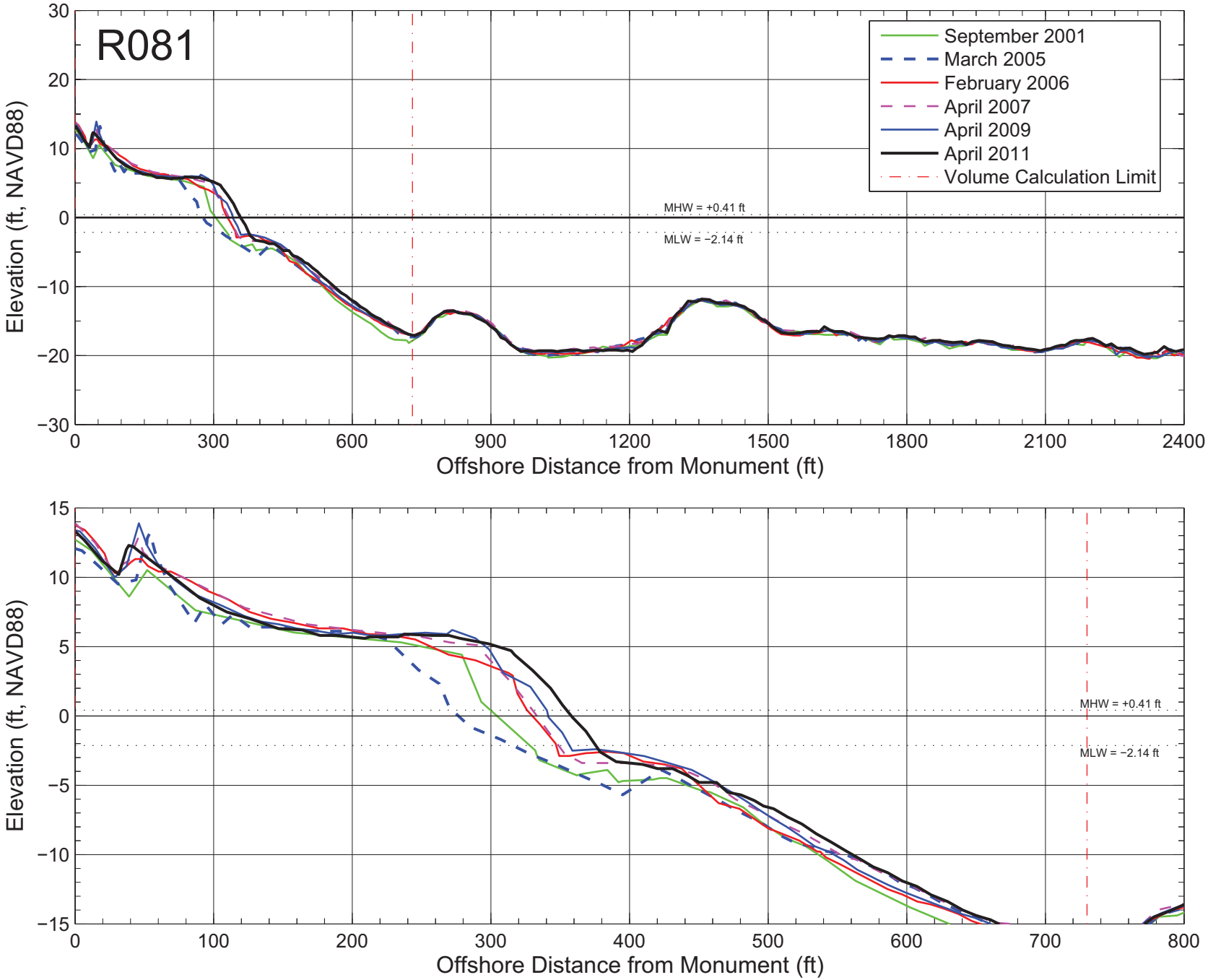


Figure A–081: Measured beach profiles at monument R081 Broward County, Florida.

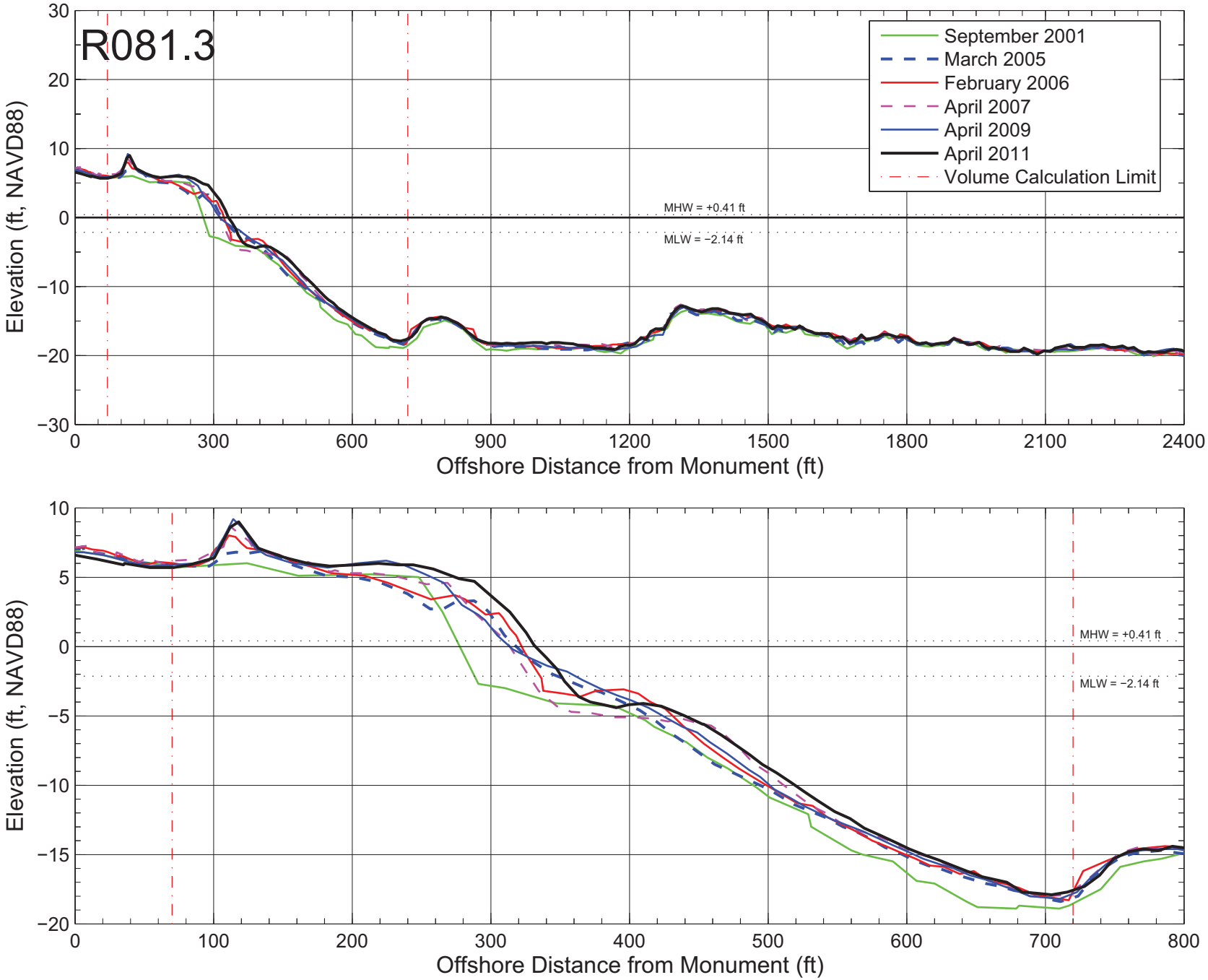


Figure A–082: Measured beach profiles at monument R081.3 Broward County, Florida.

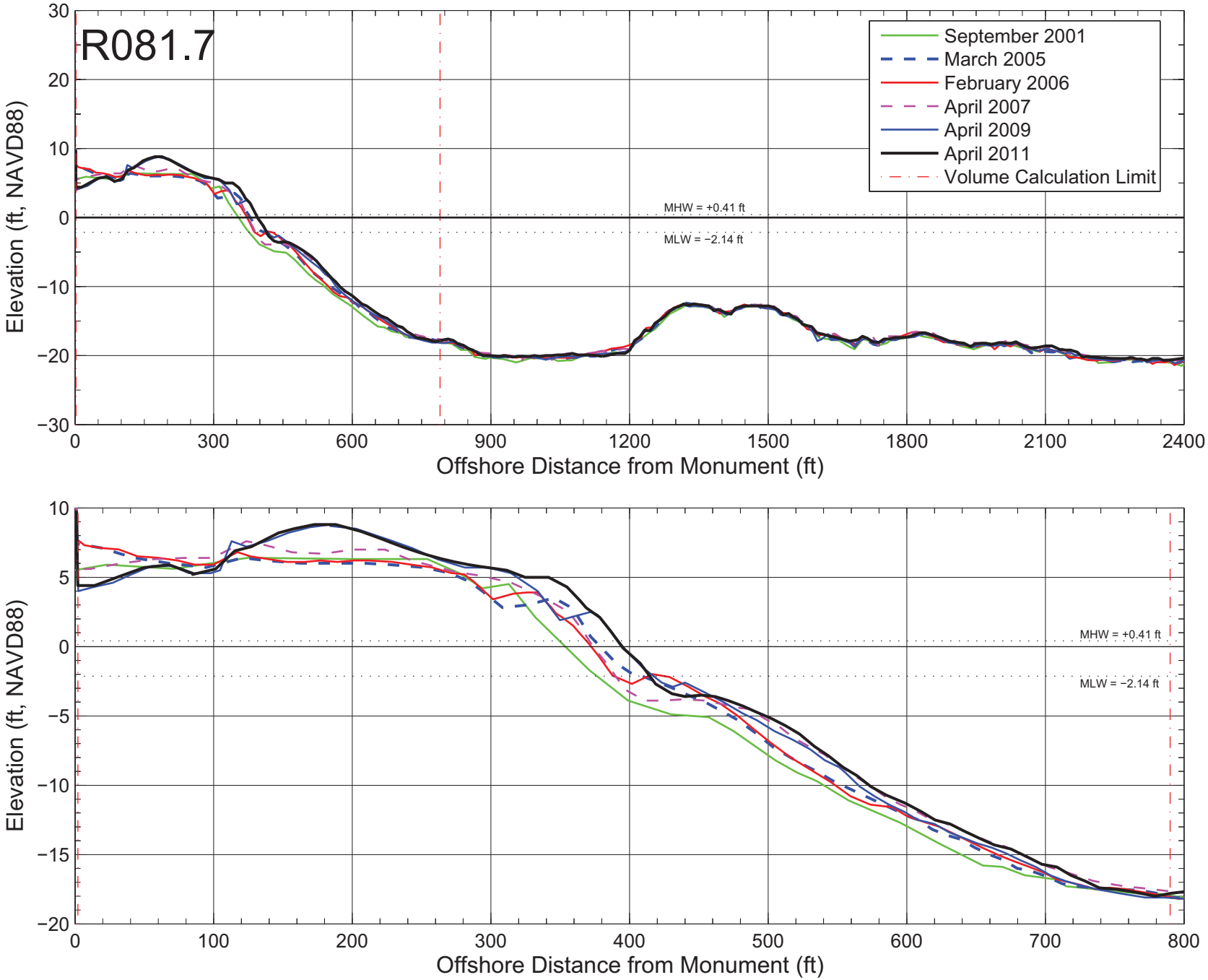


Figure A–083: Measured beach profiles at monument R081.7 Broward County, Florida.

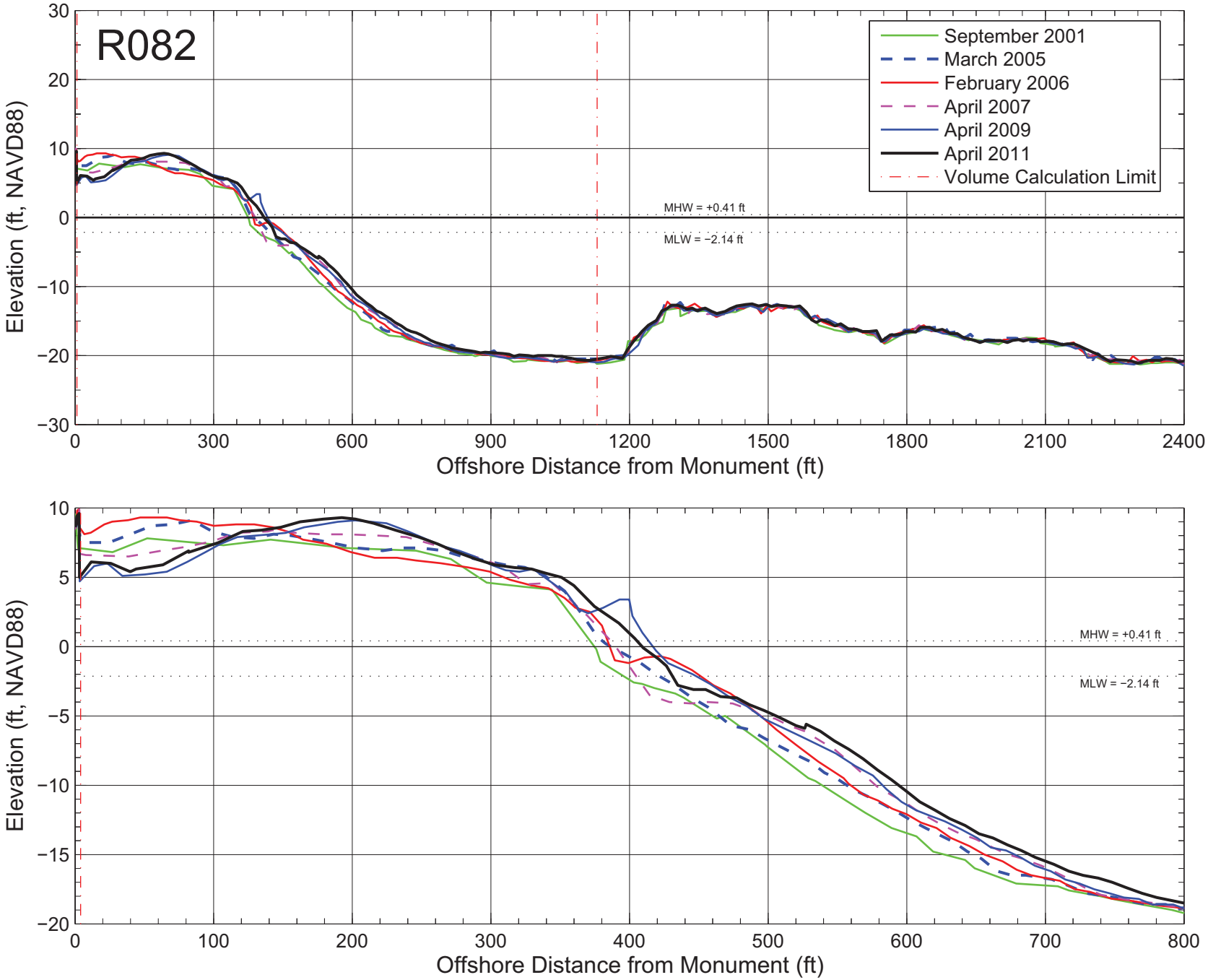


Figure A–084: Measured beach profiles at monument R082 Broward County, Florida.

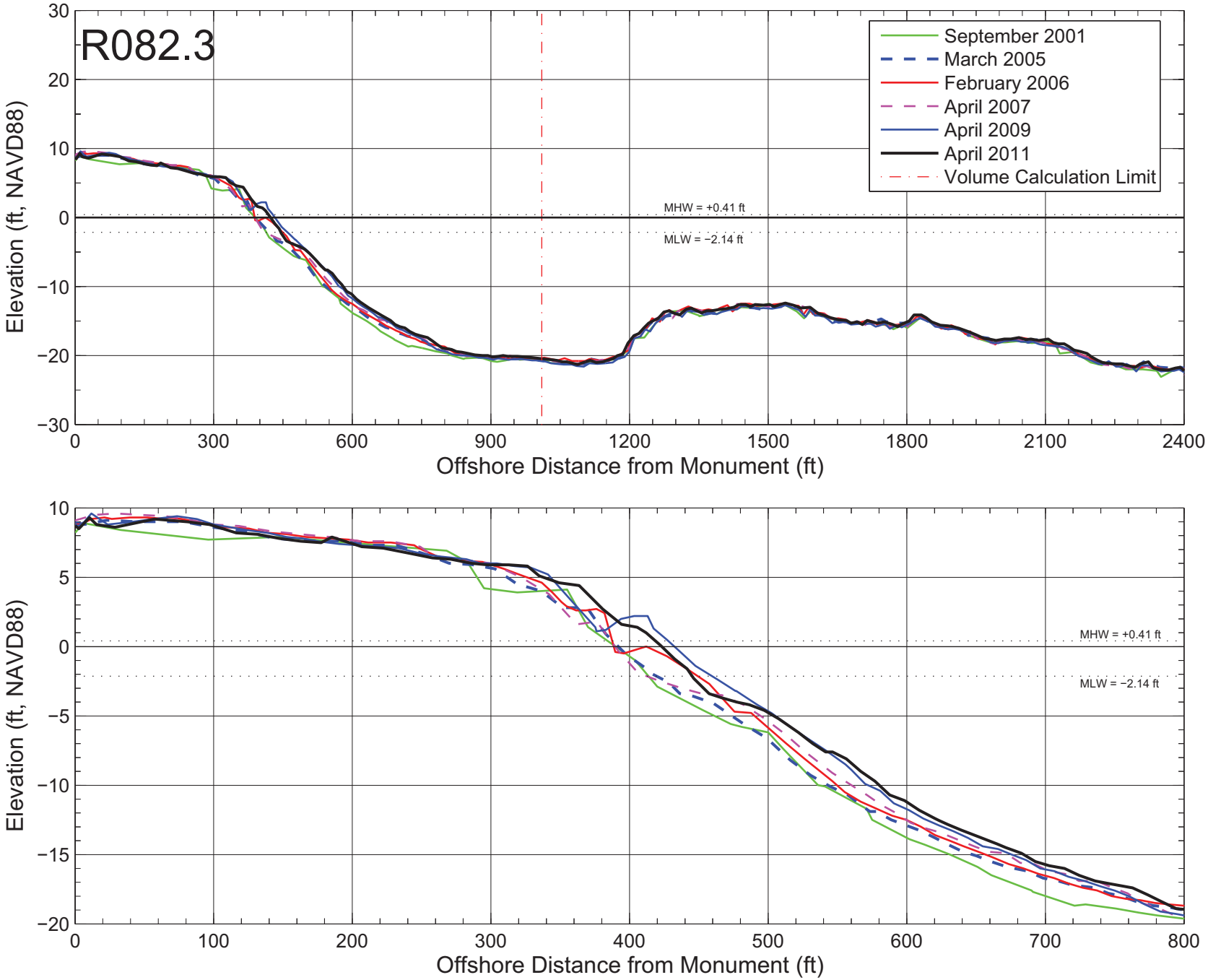


Figure A–085: Measured beach profiles at monument R082.3 Broward County, Florida.

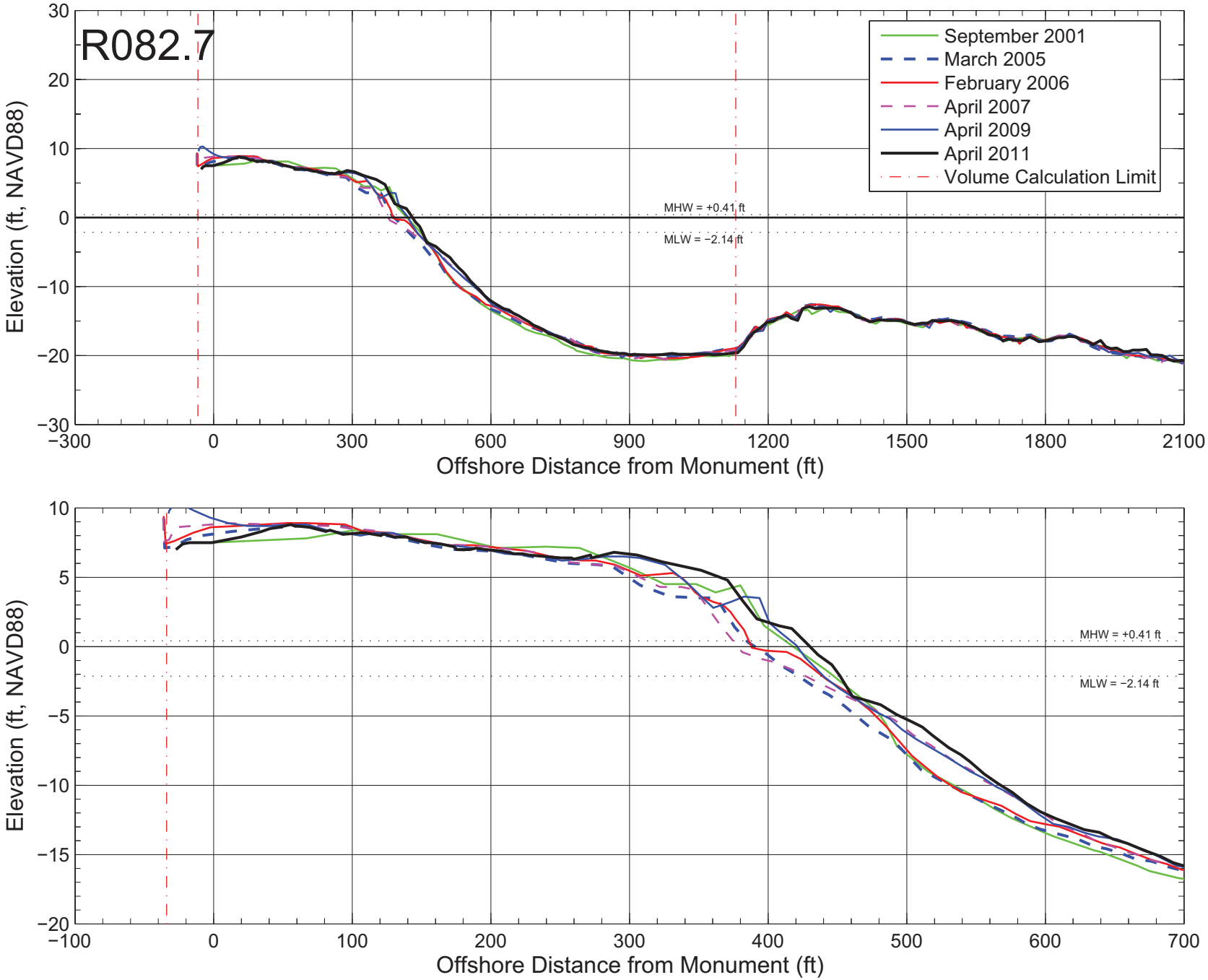


Figure A–086: Measured beach profiles at monument R082.7 Broward County, Florida.

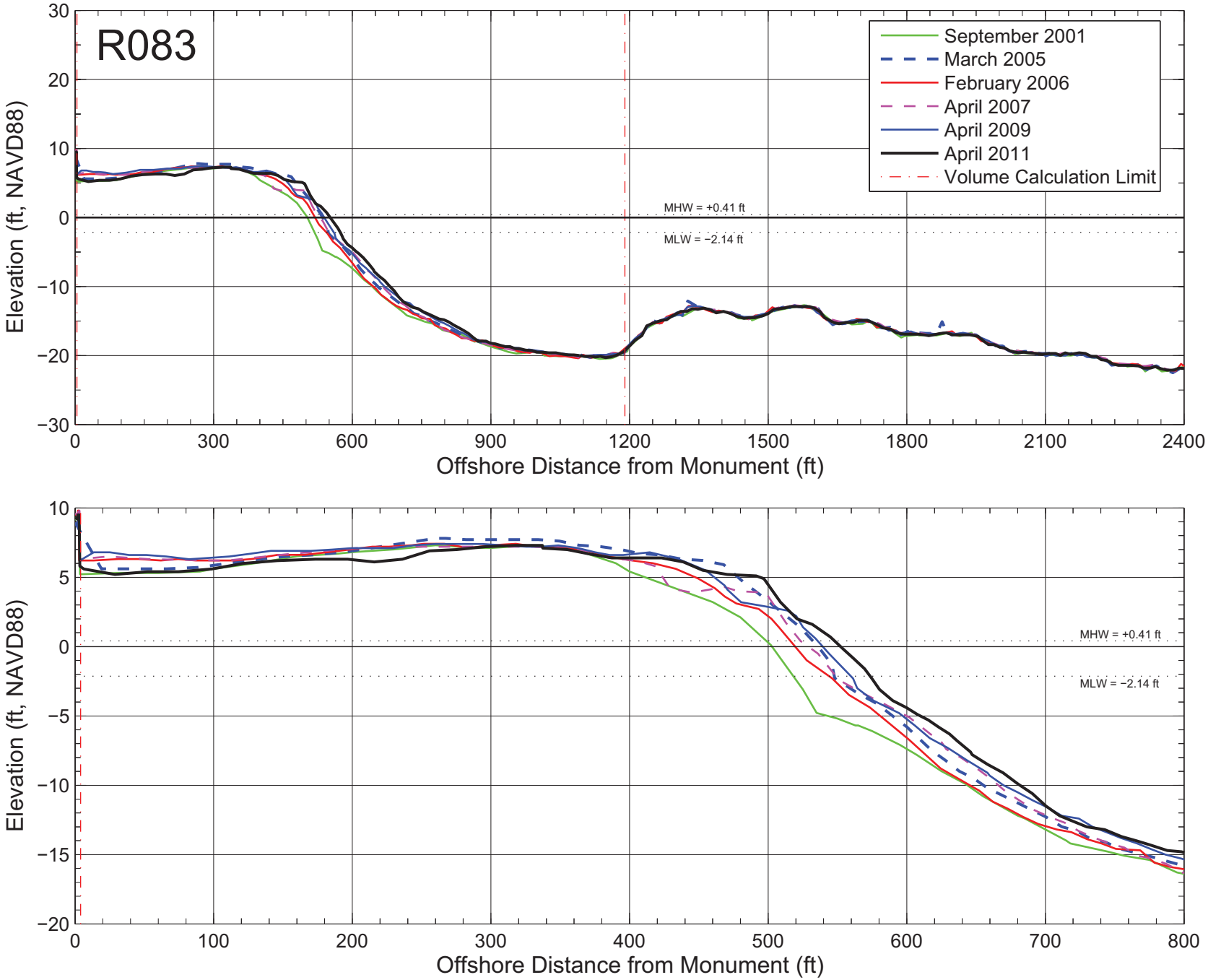


Figure A–087: Measured beach profiles at monument R083 Broward County, Florida.

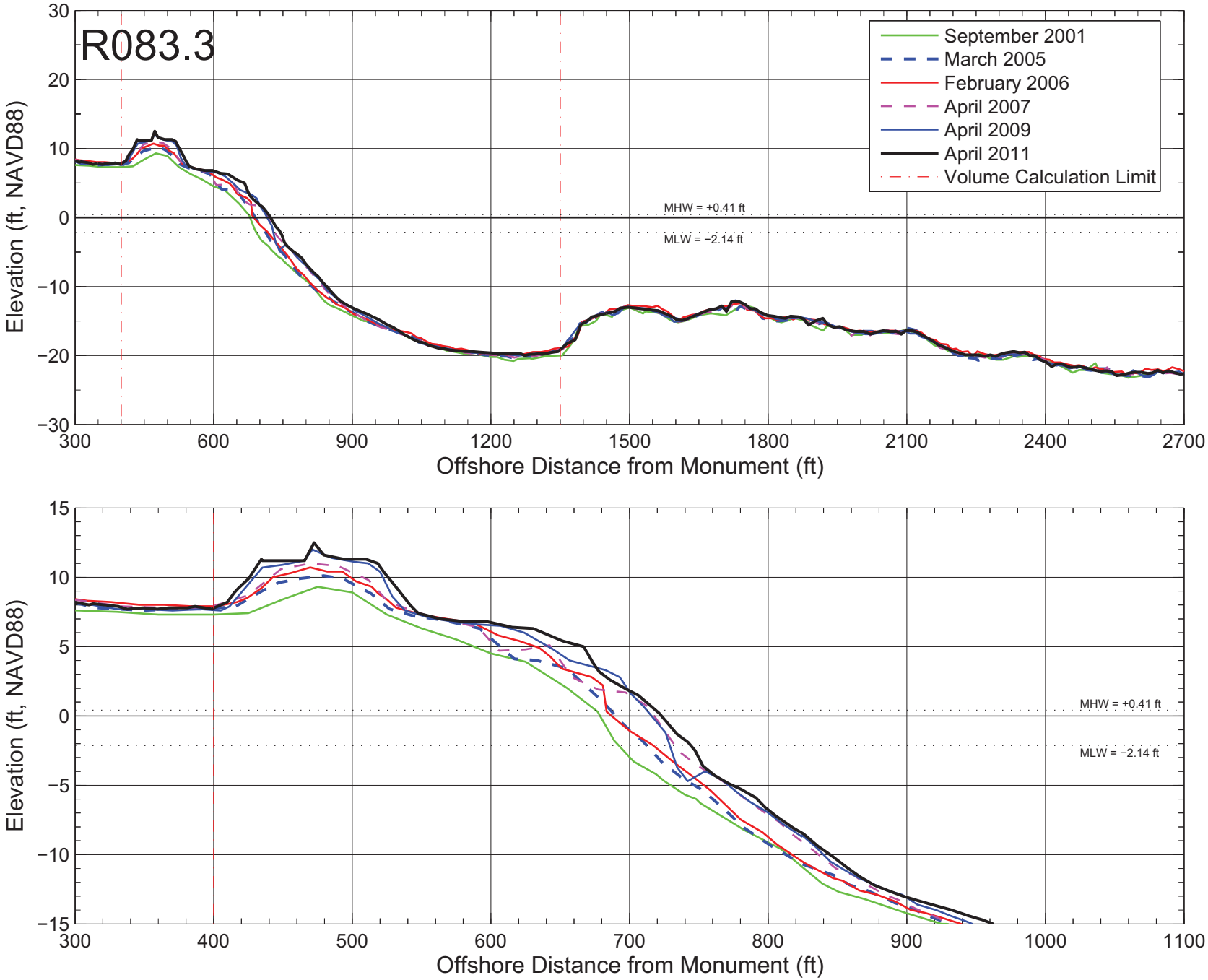


Figure A–088: Measured beach profiles at monument R083.3 Broward County, Florida.

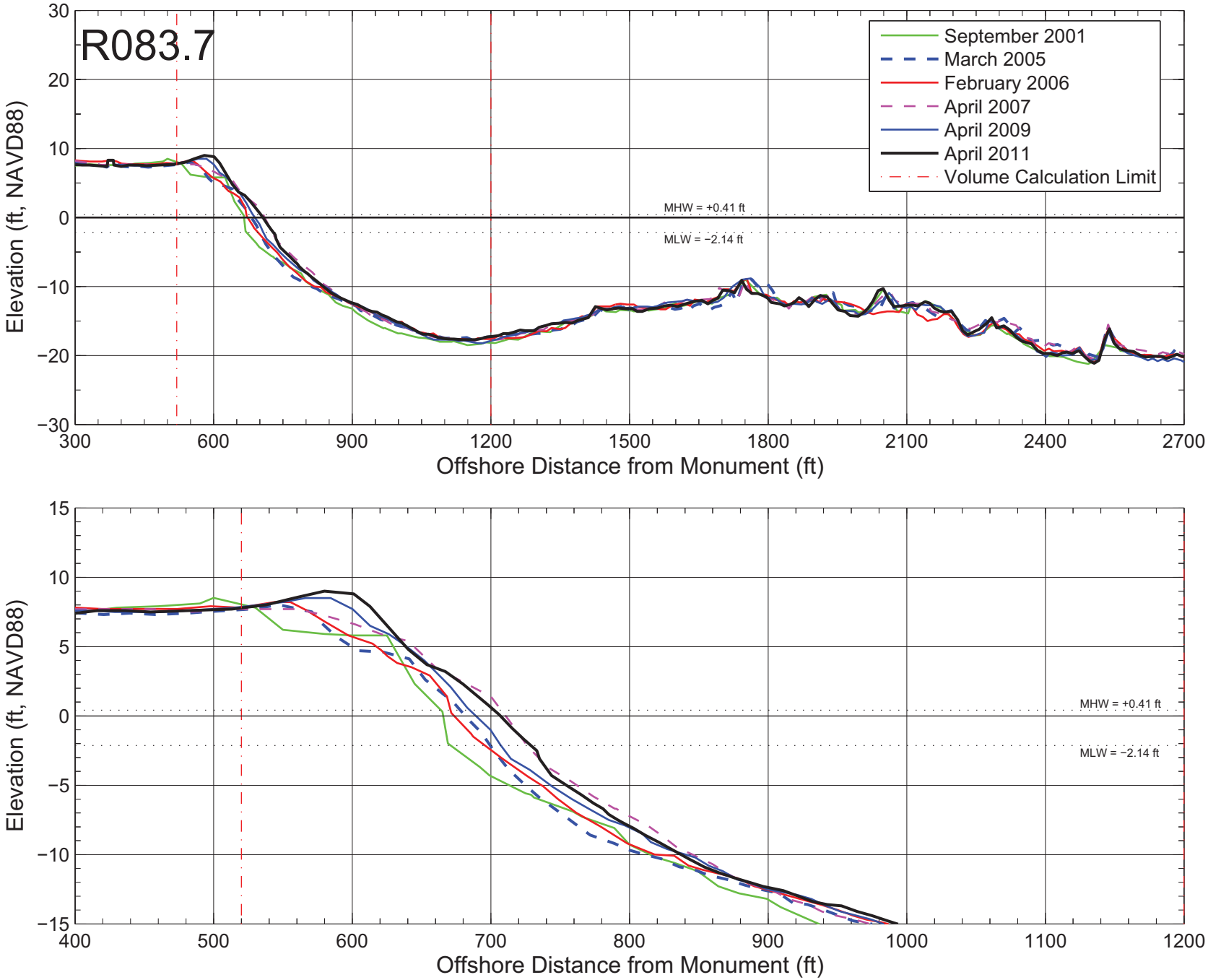


Figure A–089: Measured beach profiles at monument R083.7 Broward County, Florida.

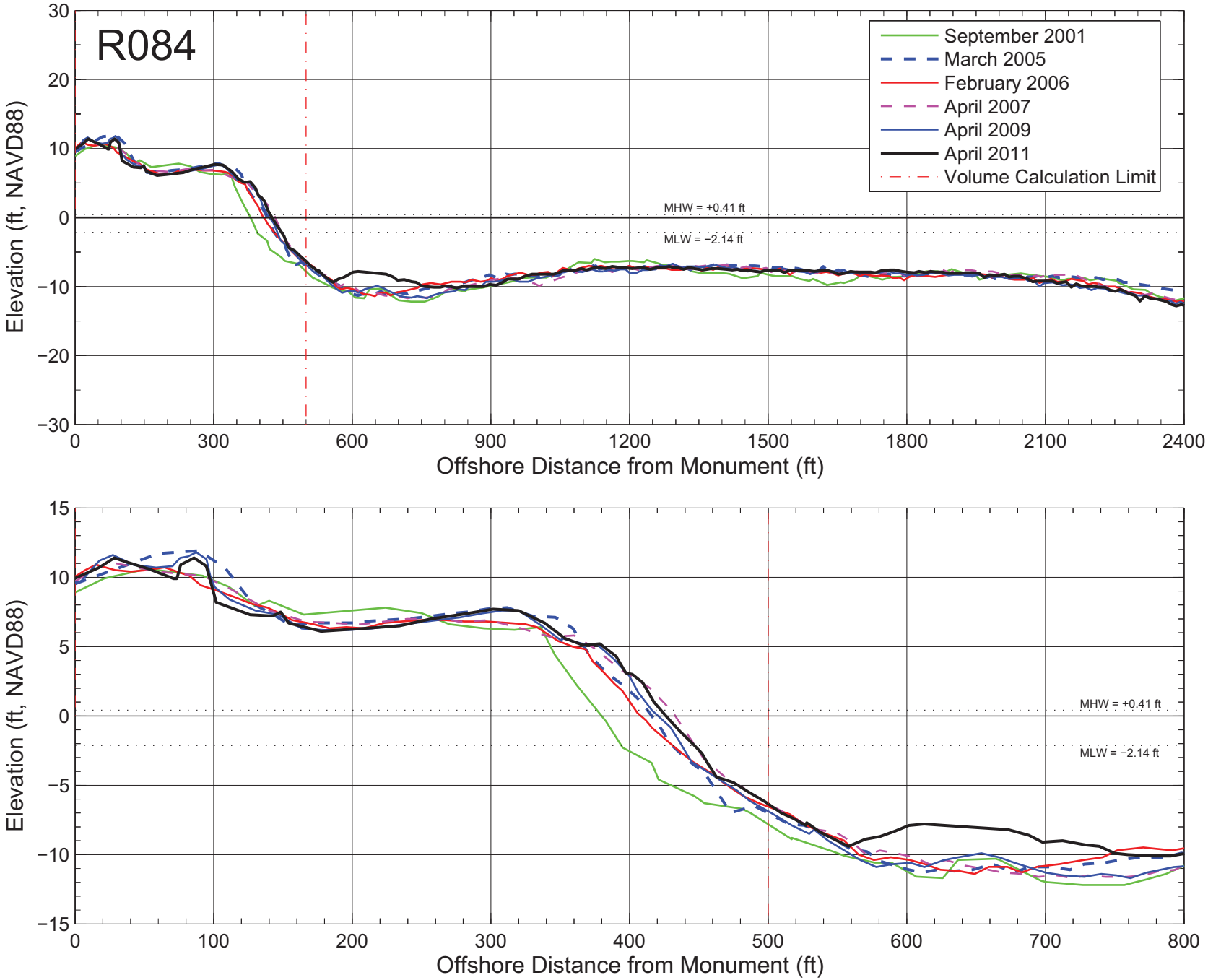


Figure A–090: Measured beach profiles at monument R084 Broward County, Florida.

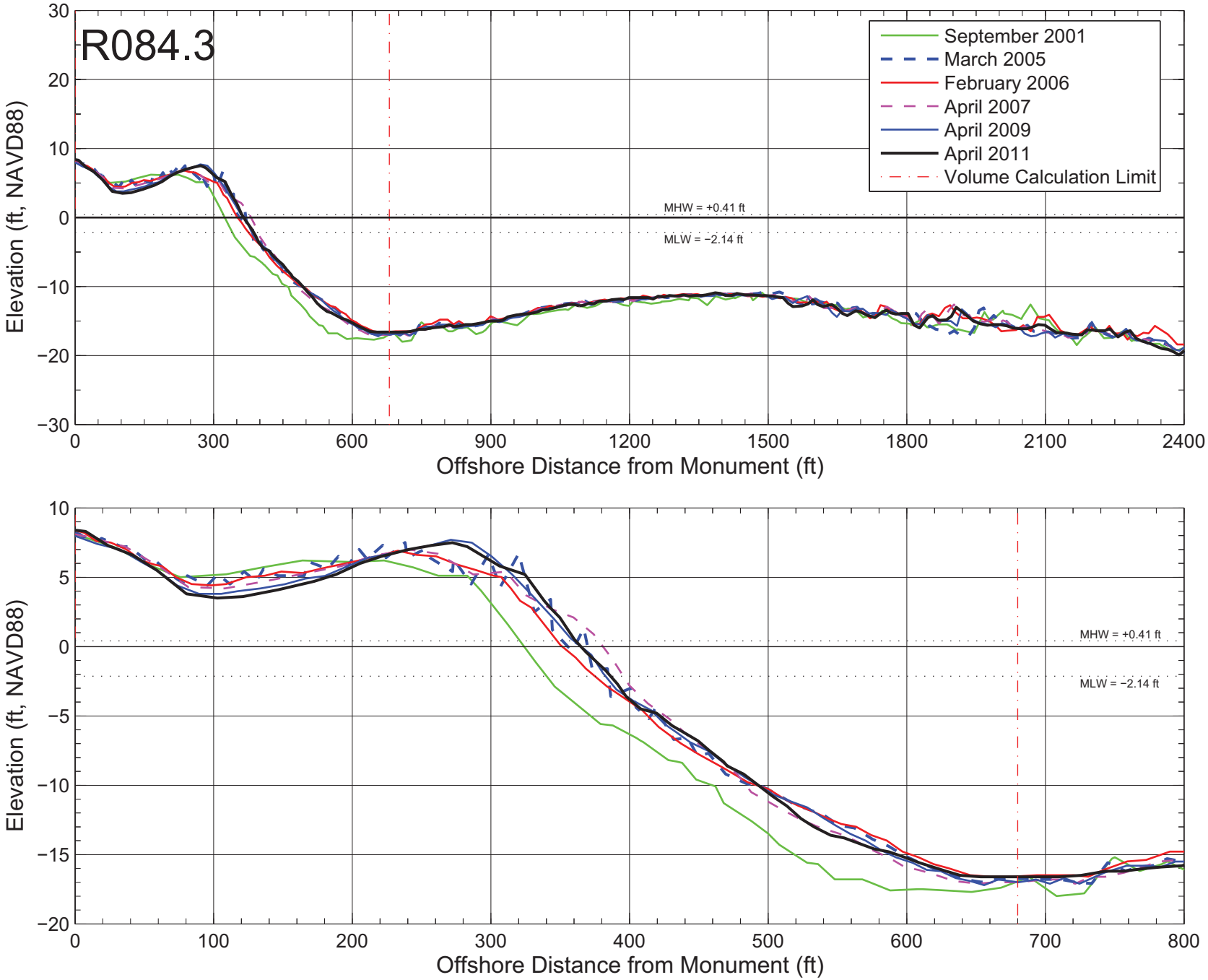


Figure A–091: Measured beach profiles at monument R084.3 Broward County, Florida.

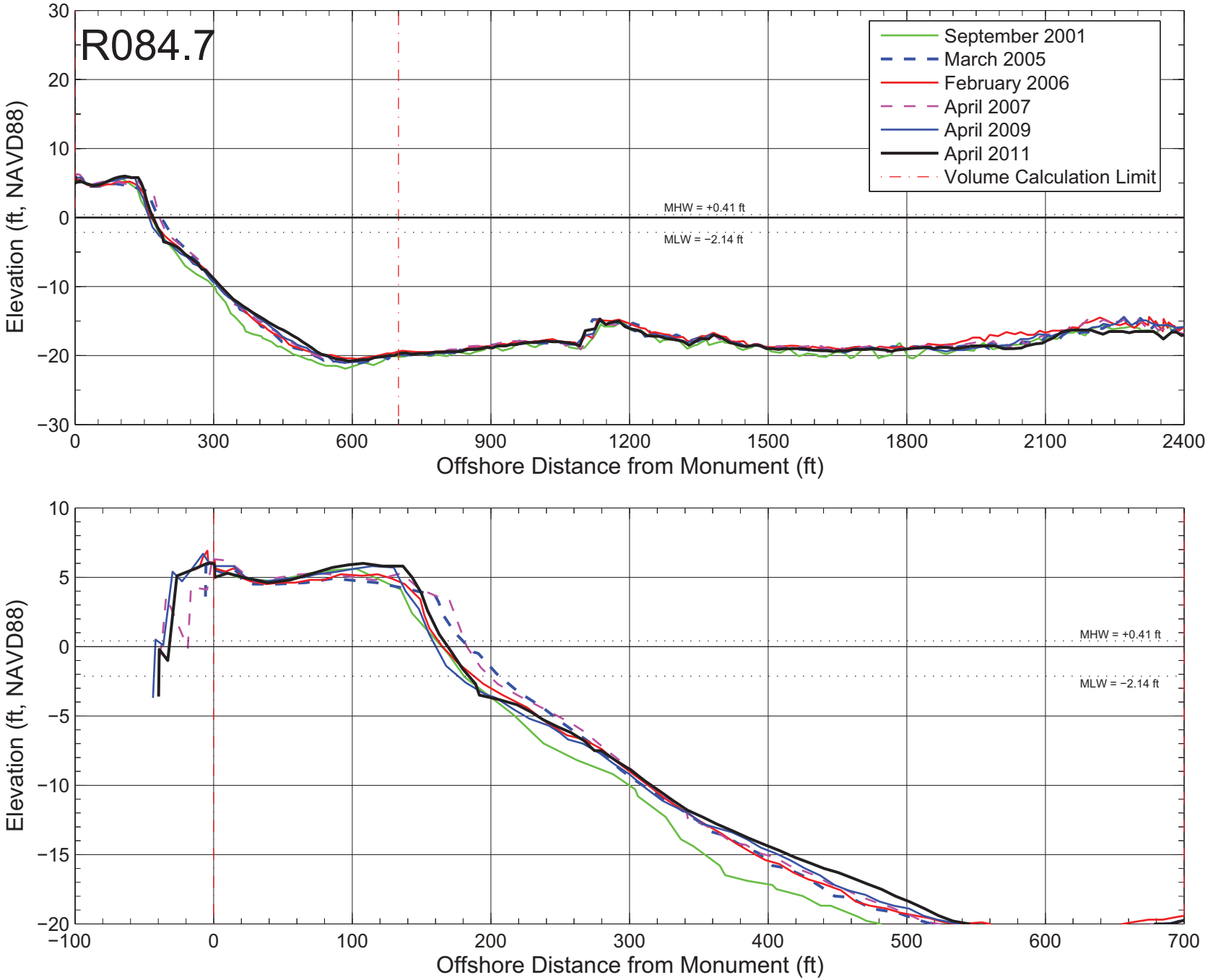


Figure A–092: Measured beach profiles at monument R084.7 Broward County, Florida.

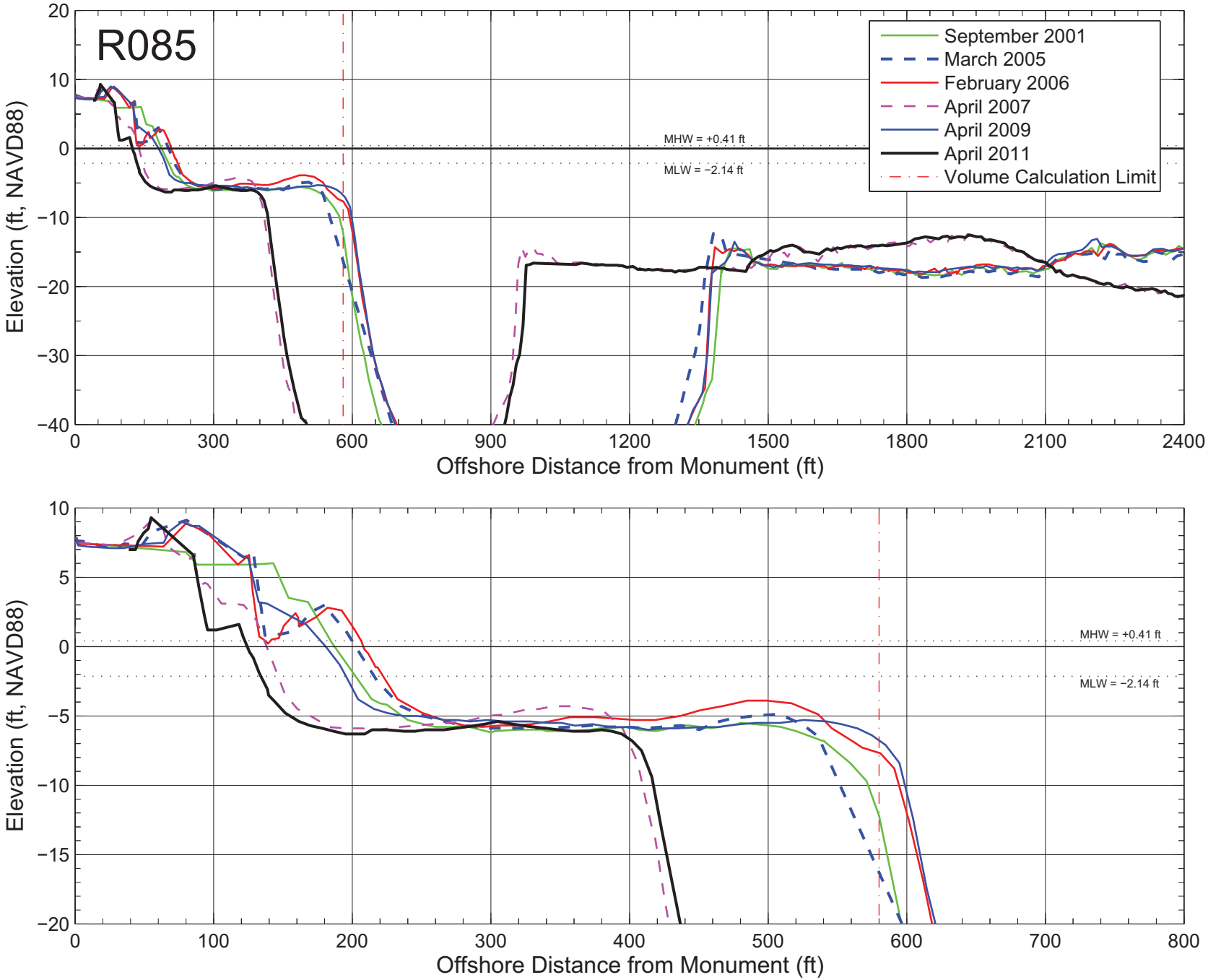


Figure A–093: Measured beach profiles at monument R085 Broward County, Florida.

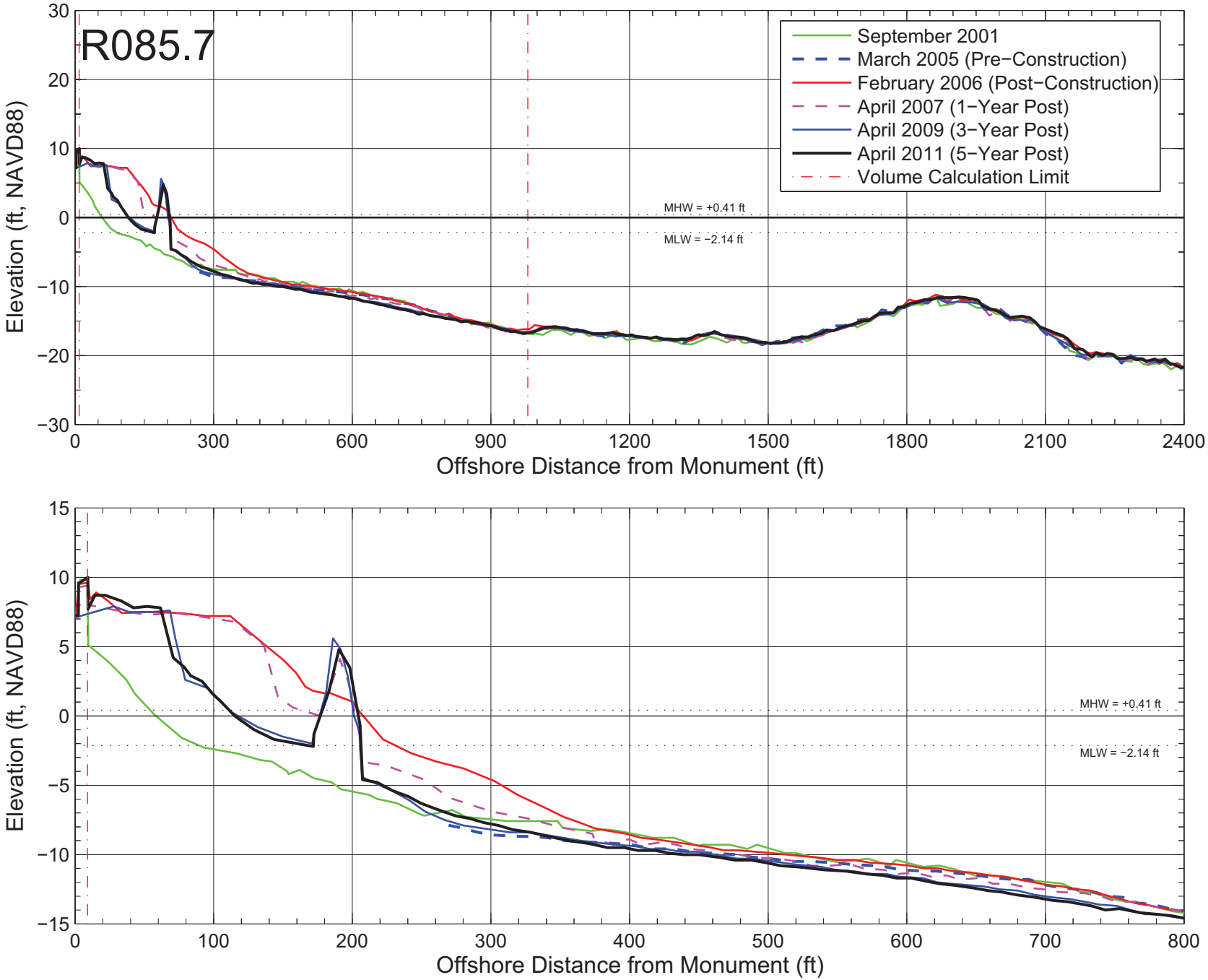


Figure A–094: Measured beach profiles at monument R085.7 Broward County, Florida.

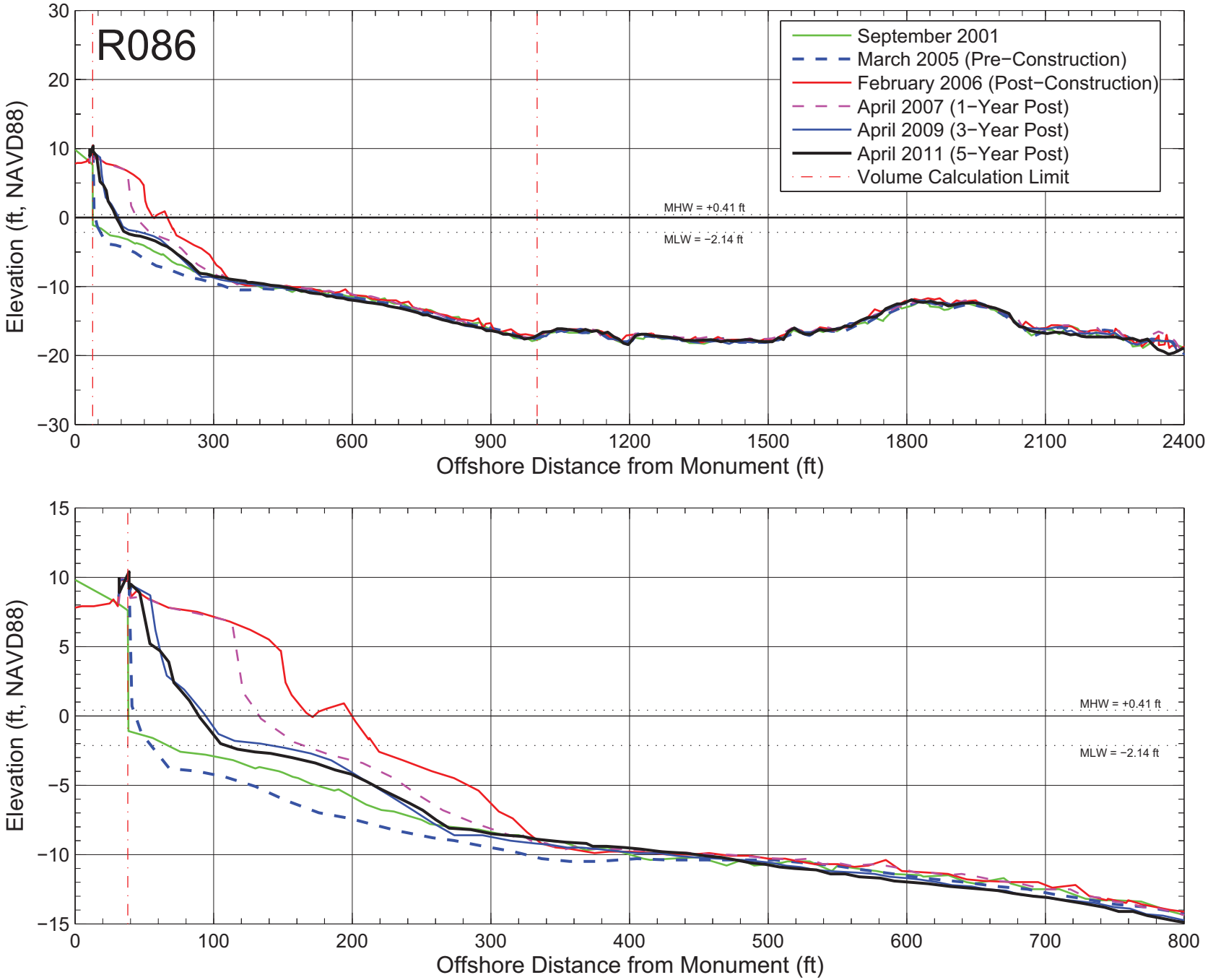


Figure A–095: Measured beach profiles at monument R086 Broward County, Florida.

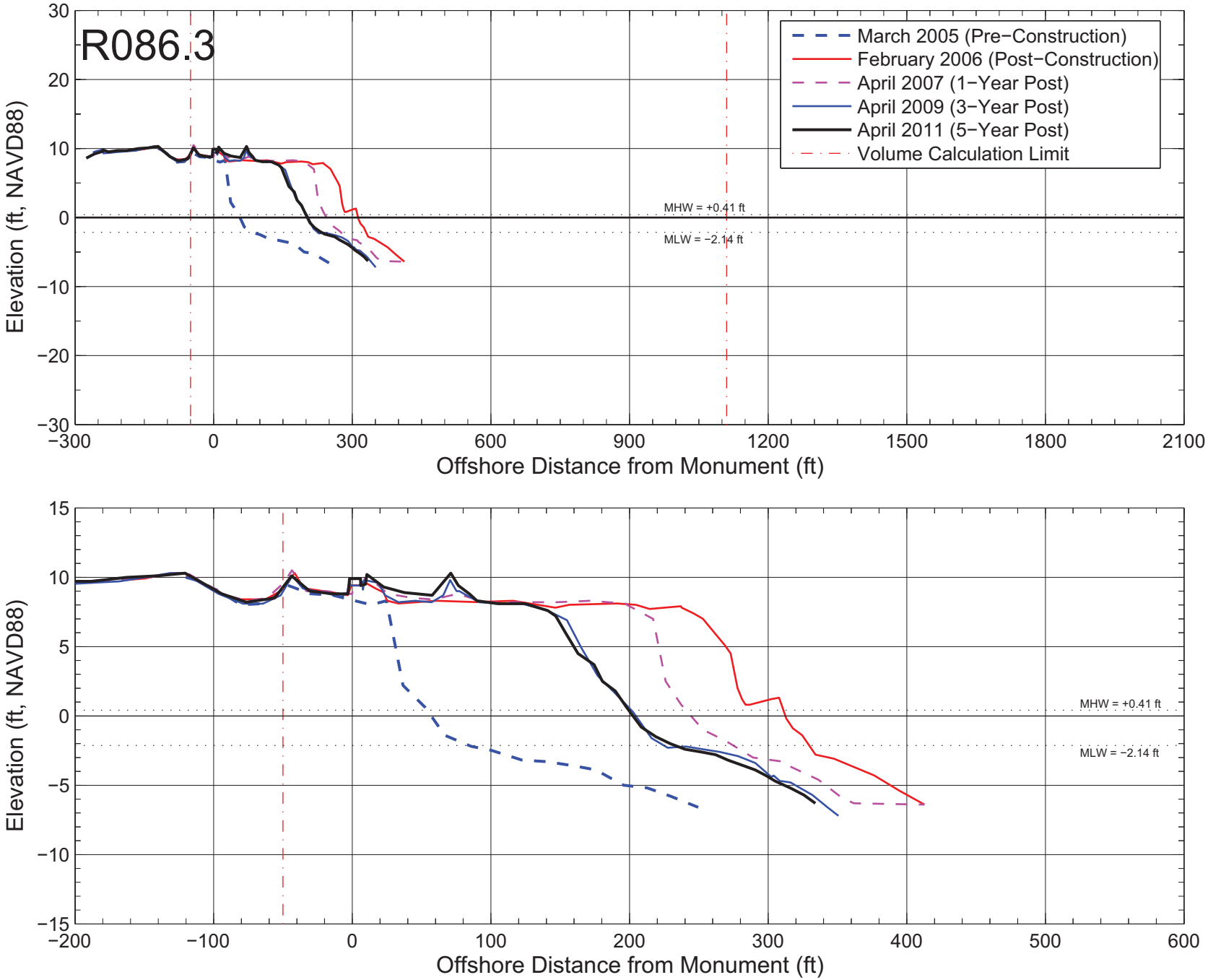


Figure A–096: Measured beach profiles at monument R086.3 Broward County, Florida.

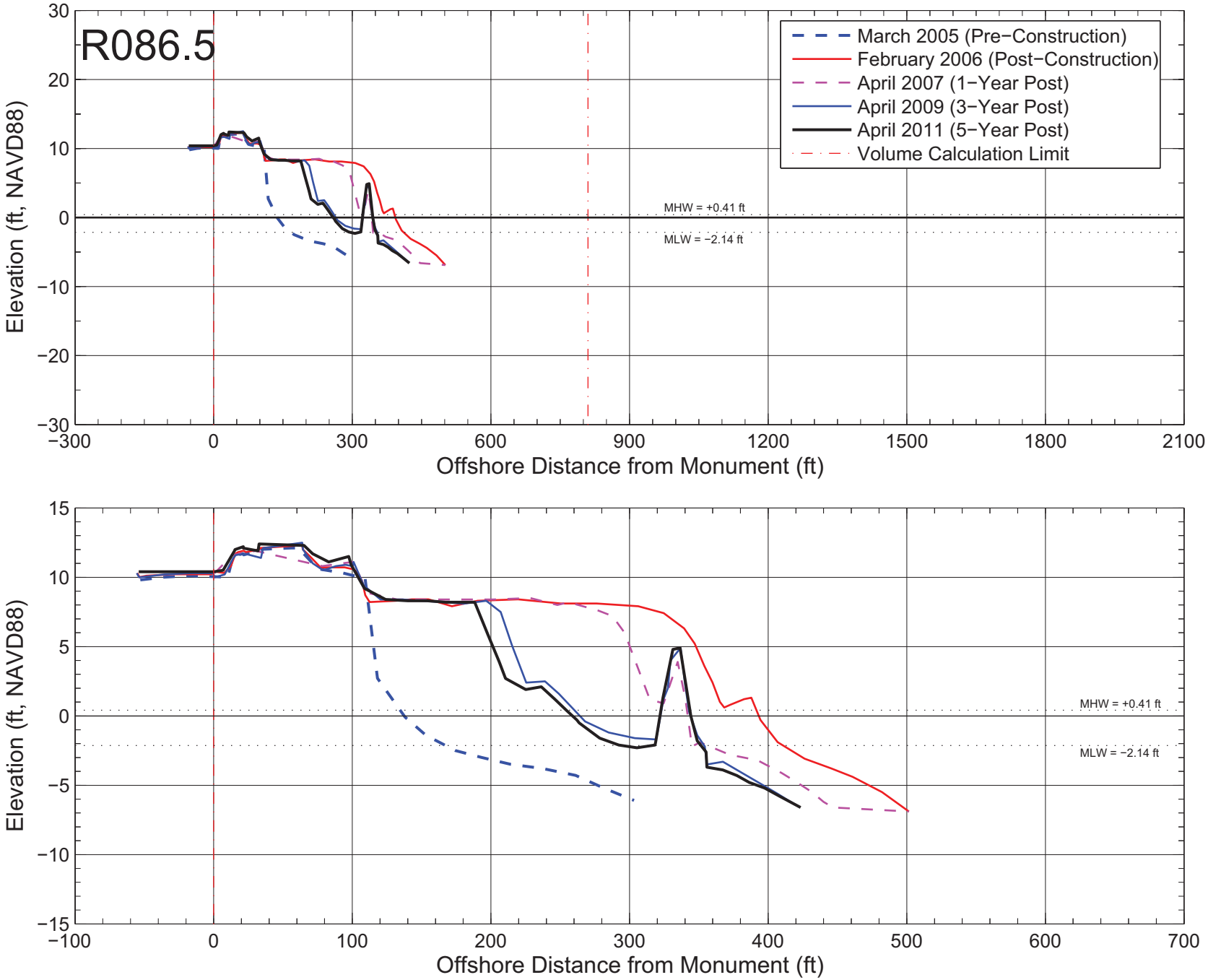


Figure A−097: Measured beach profiles at monument R086.5 Broward County, Florida.

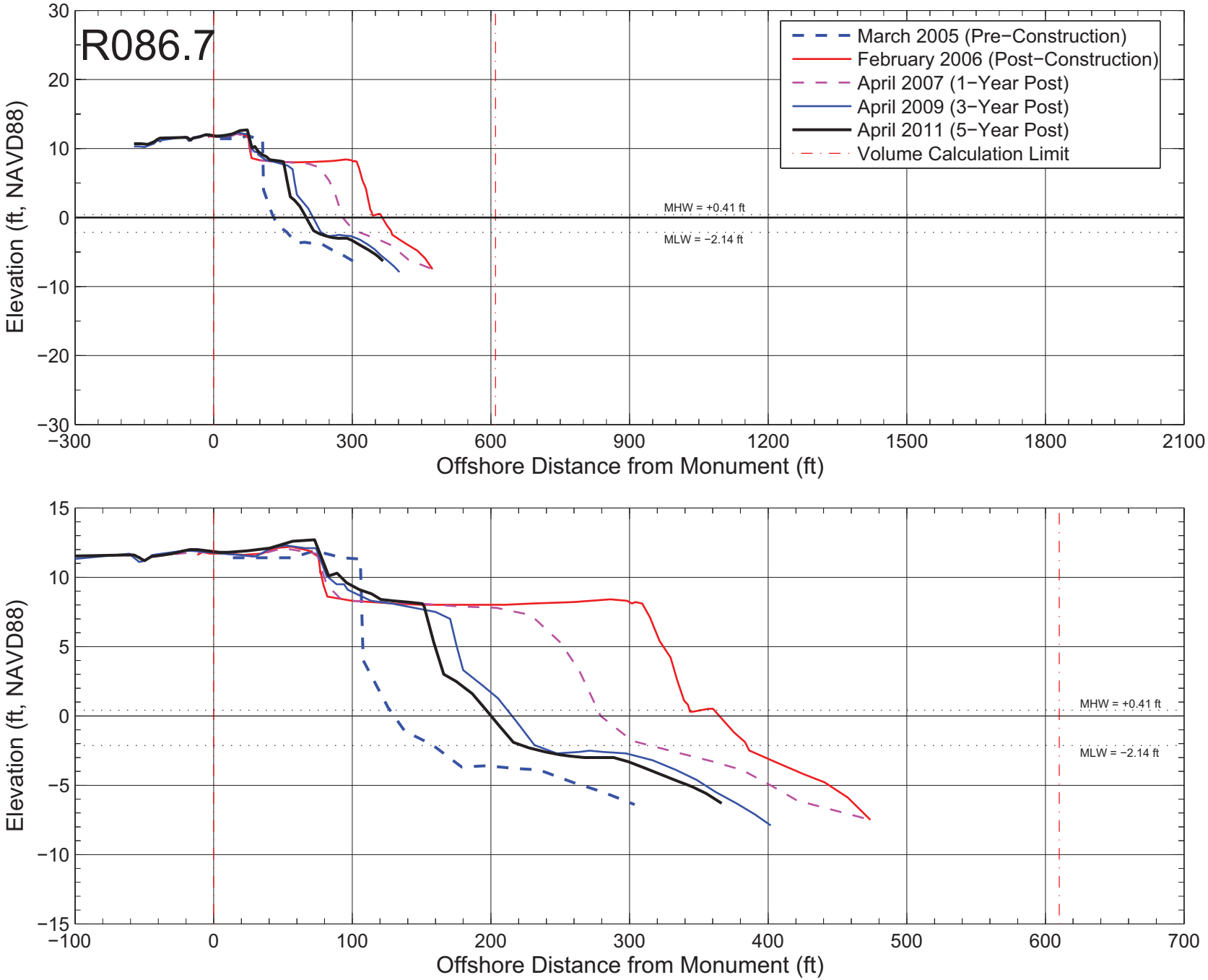


Figure A–098: Measured beach profiles at monument R086.7 Broward County, Florida.

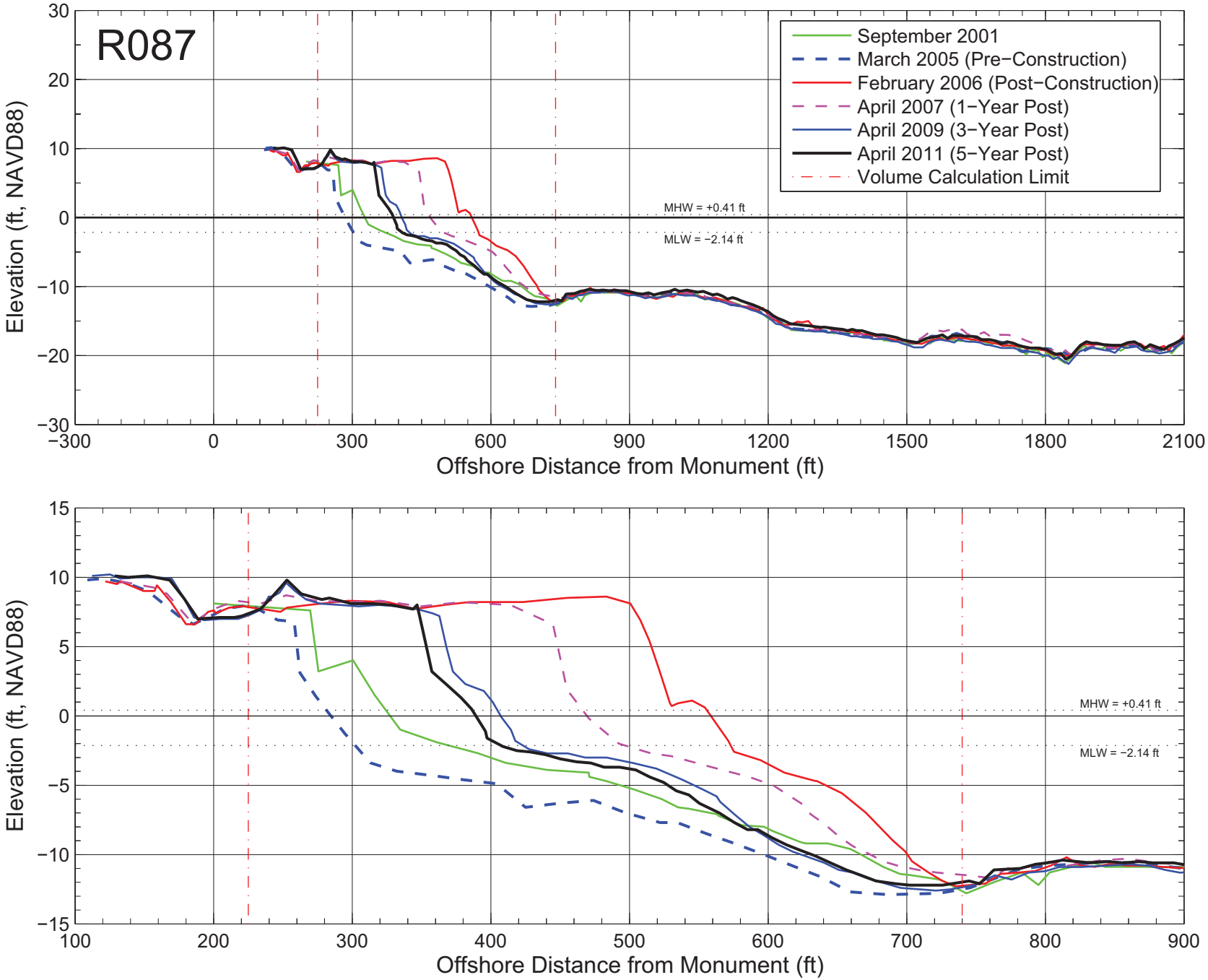


Figure A–099: Measured beach profiles at monument R087 Broward County, Florida.

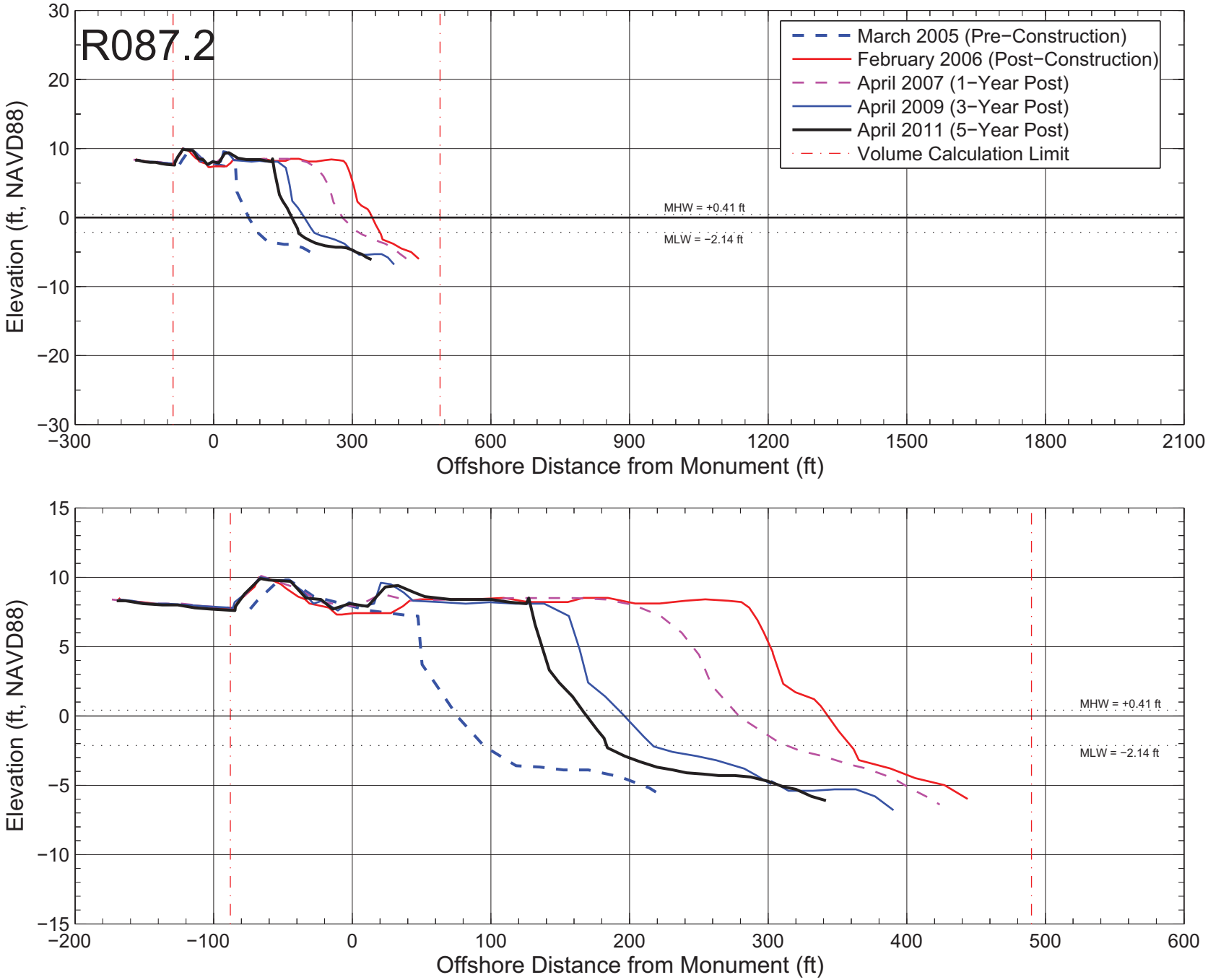


Figure A–100: Measured beach profiles at monument R087.2 Broward County, Florida.

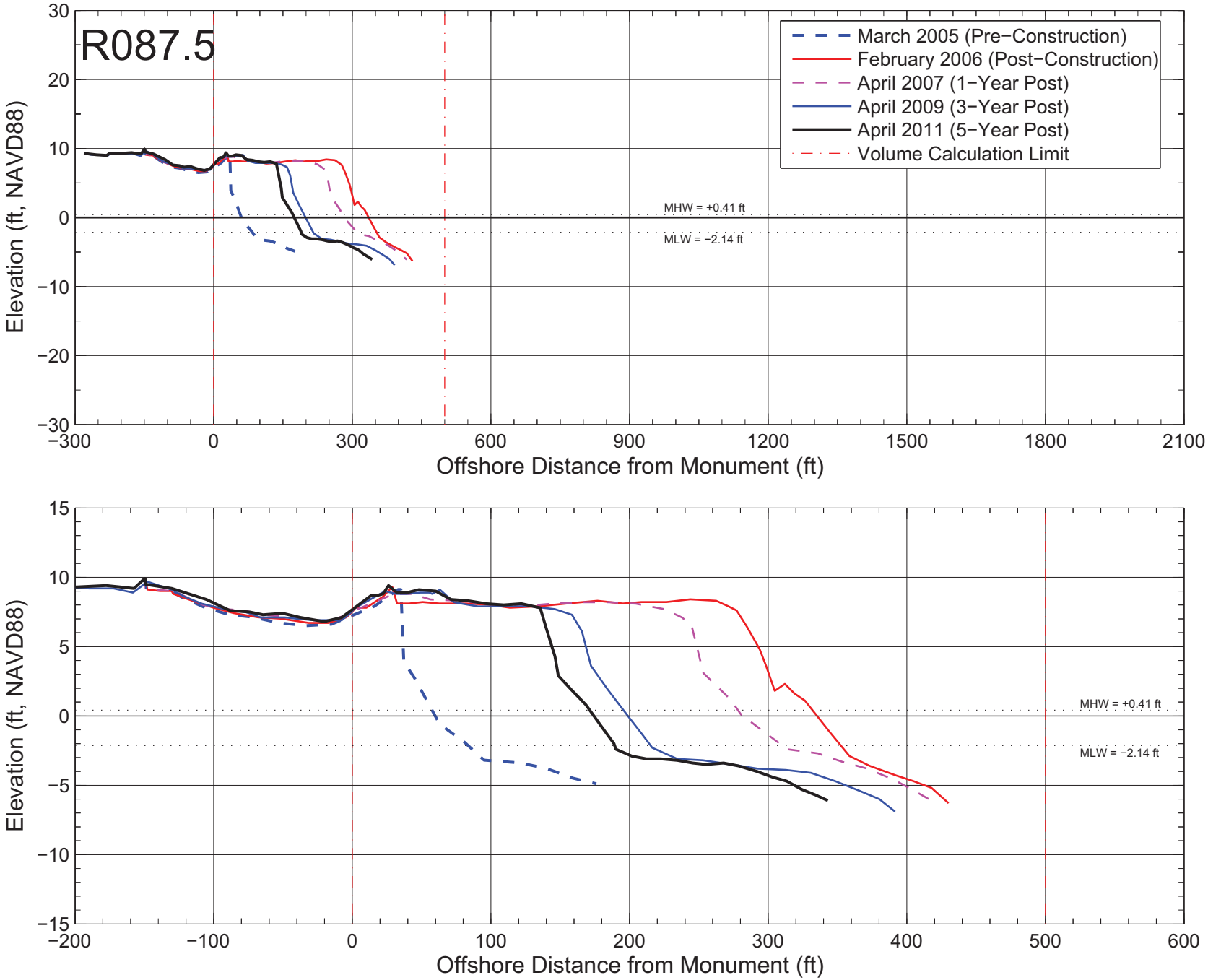


Figure A–101: Measured beach profiles at monument R087.5 Broward County, Florida.

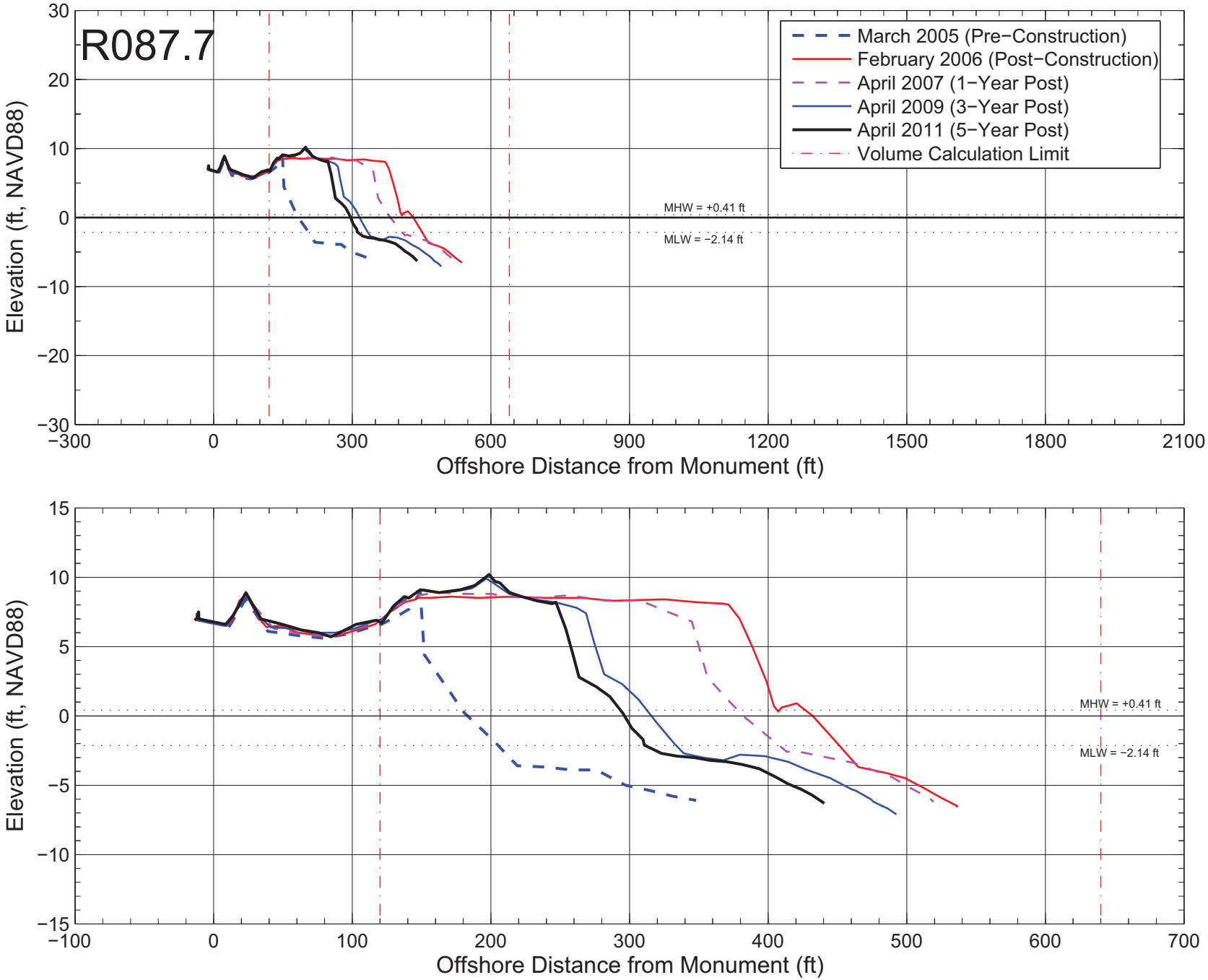


Figure A–102: Measured beach profiles at monument R087.7 Broward County, Florida.

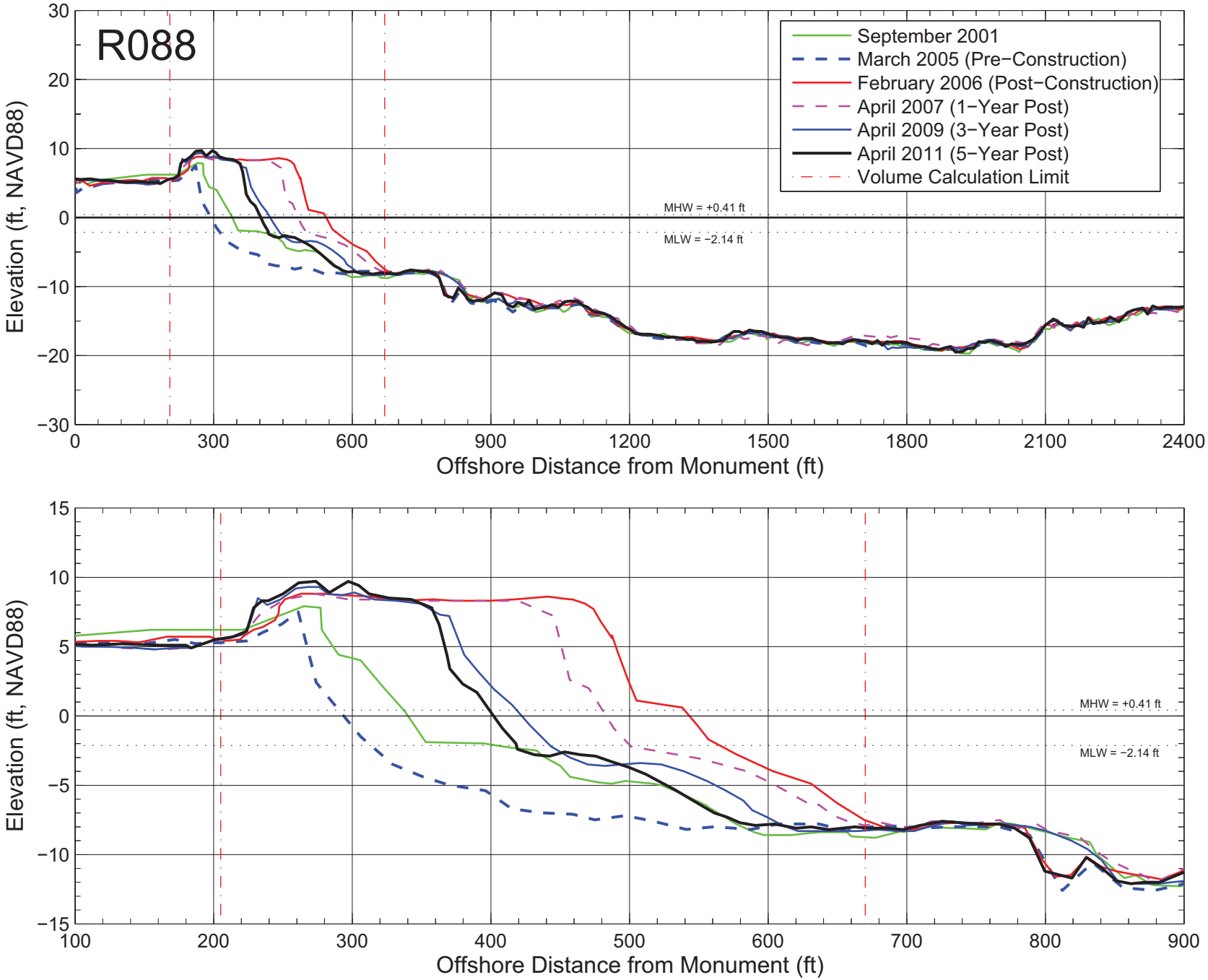


Figure A–103: Measured beach profiles at monument R088 Broward County, Florida.

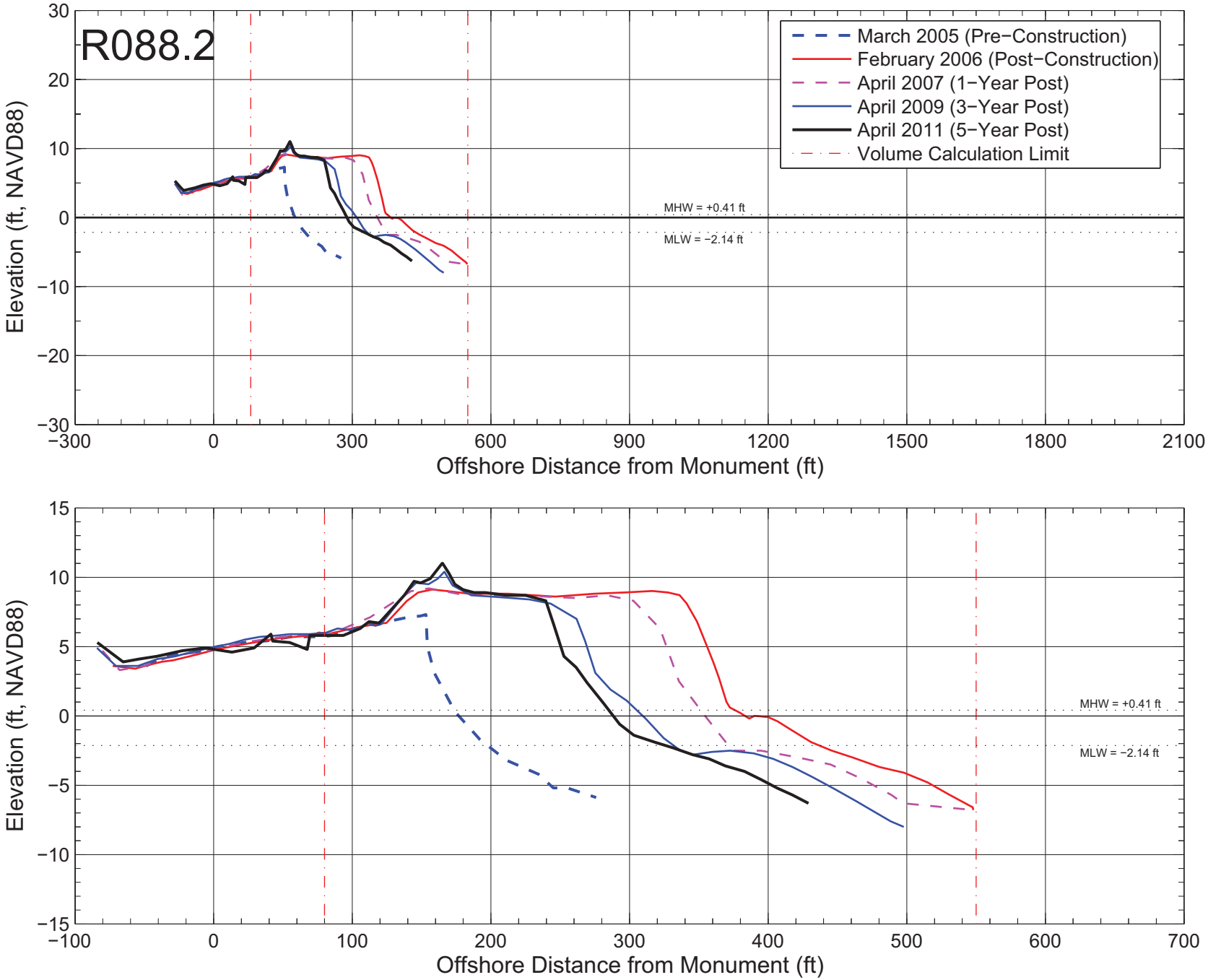


Figure A–104: Measured beach profiles at monument R088.2 Broward County, Florida.

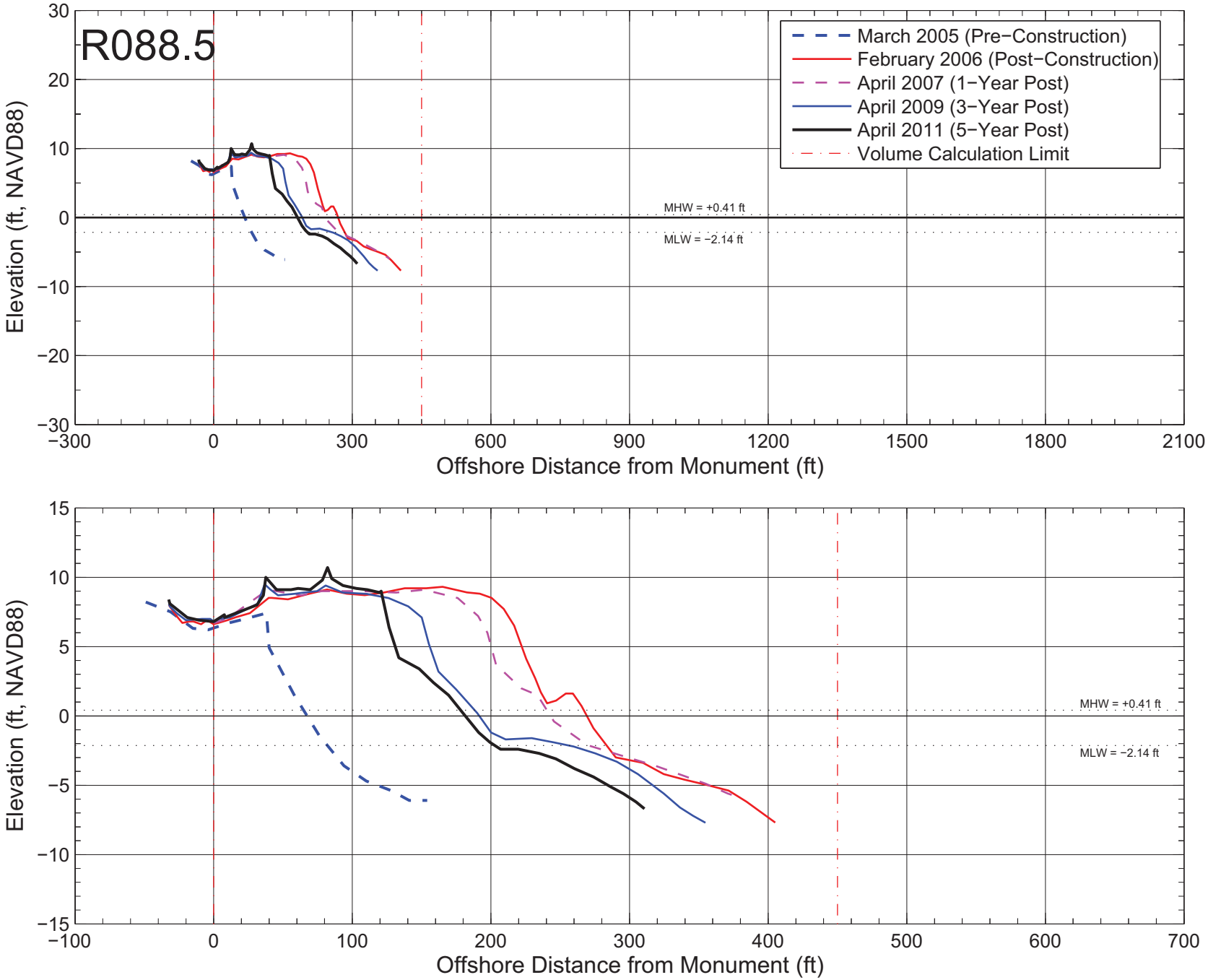


Figure A–105: Measured beach profiles at monument R088.5 Broward County, Florida.

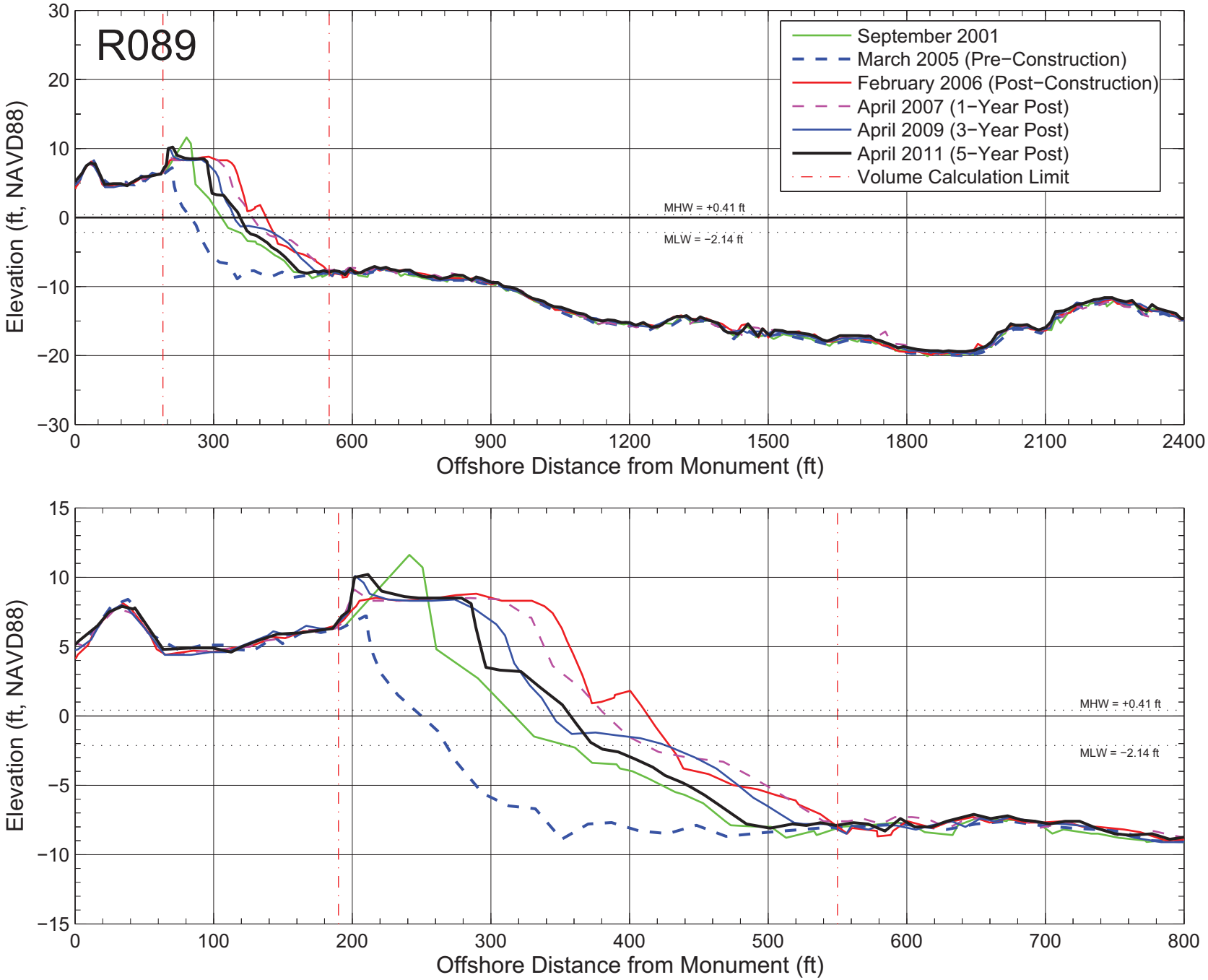


Figure A–106: Measured beach profiles at monument R089 Broward County, Florida.

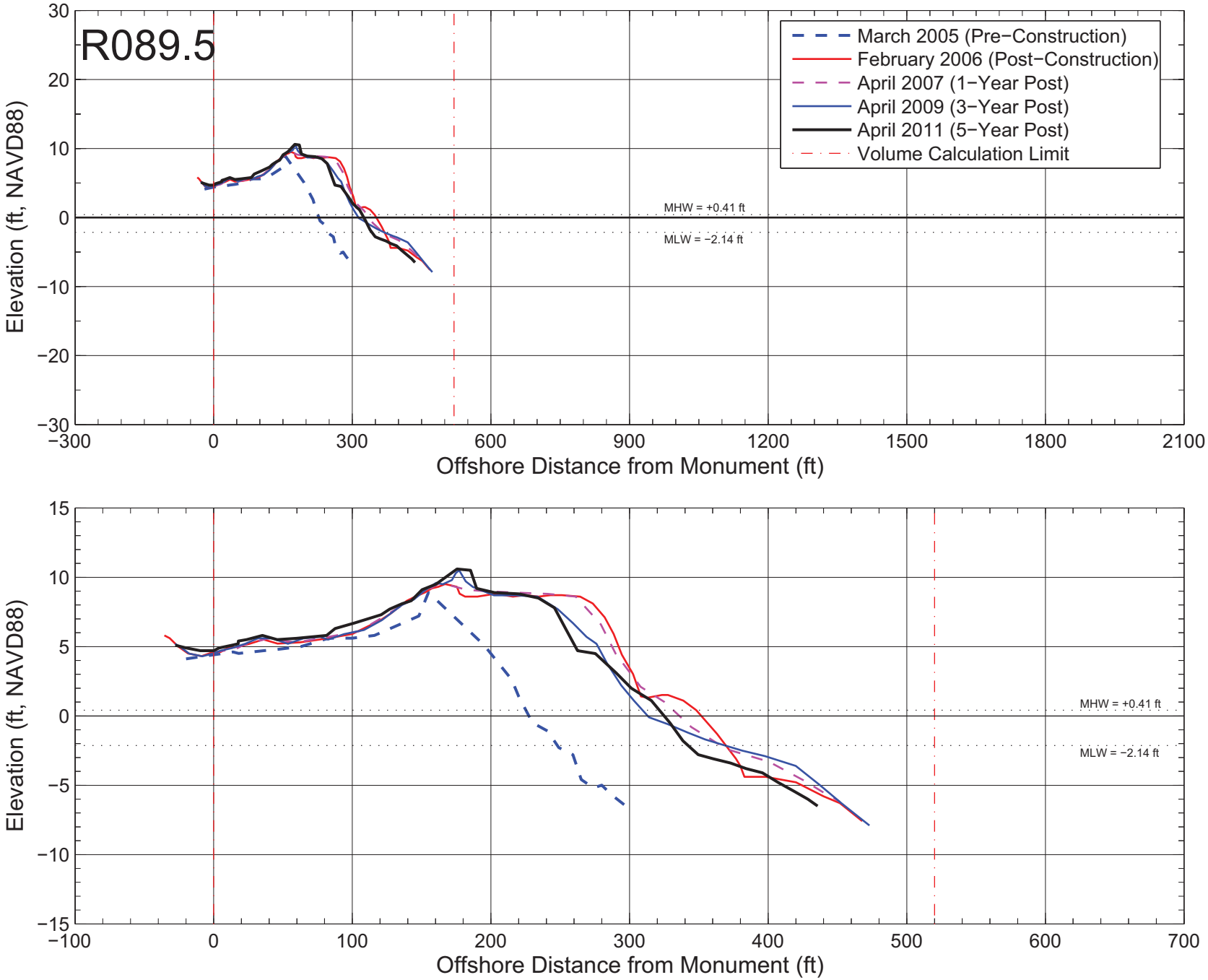


Figure A–107: Measured beach profiles at monument R089.5 Broward County, Florida.

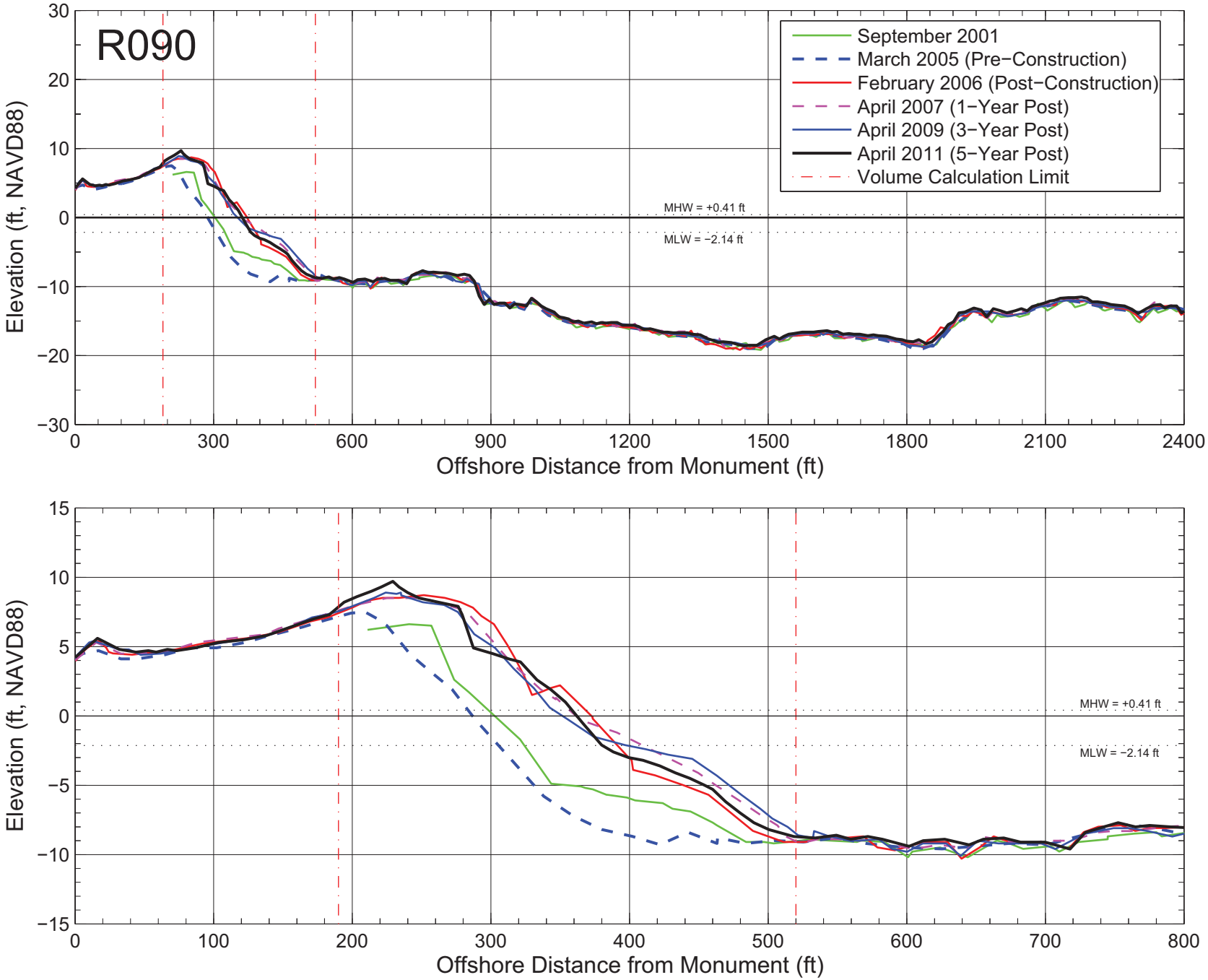


Figure A–108: Measured beach profiles at monument R090 Broward County, Florida.

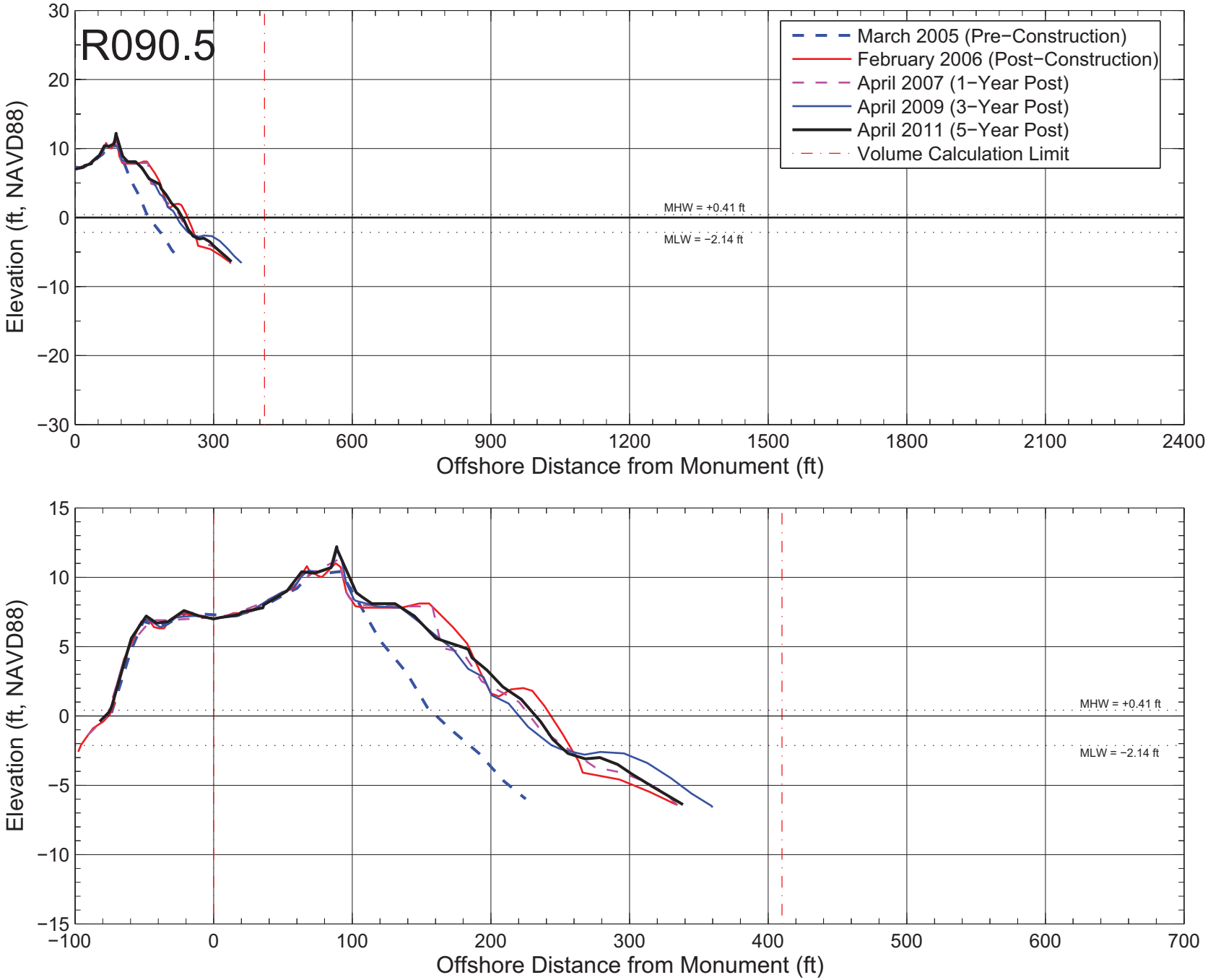


Figure A–109: Measured beach profiles at monument R090.5 Broward County, Florida.

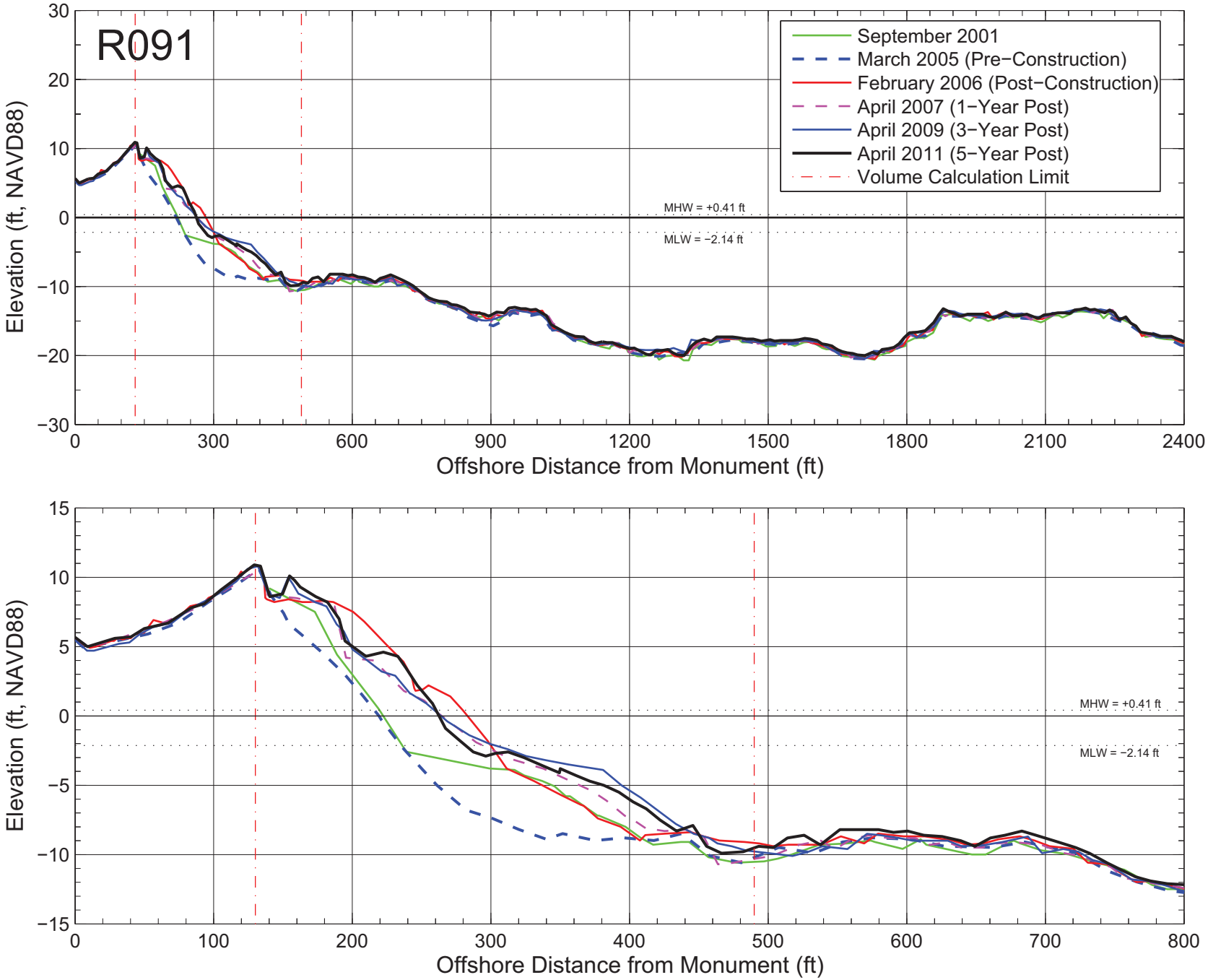


Figure A−110: Measured beach profiles at monument R091 Broward County, Florida.

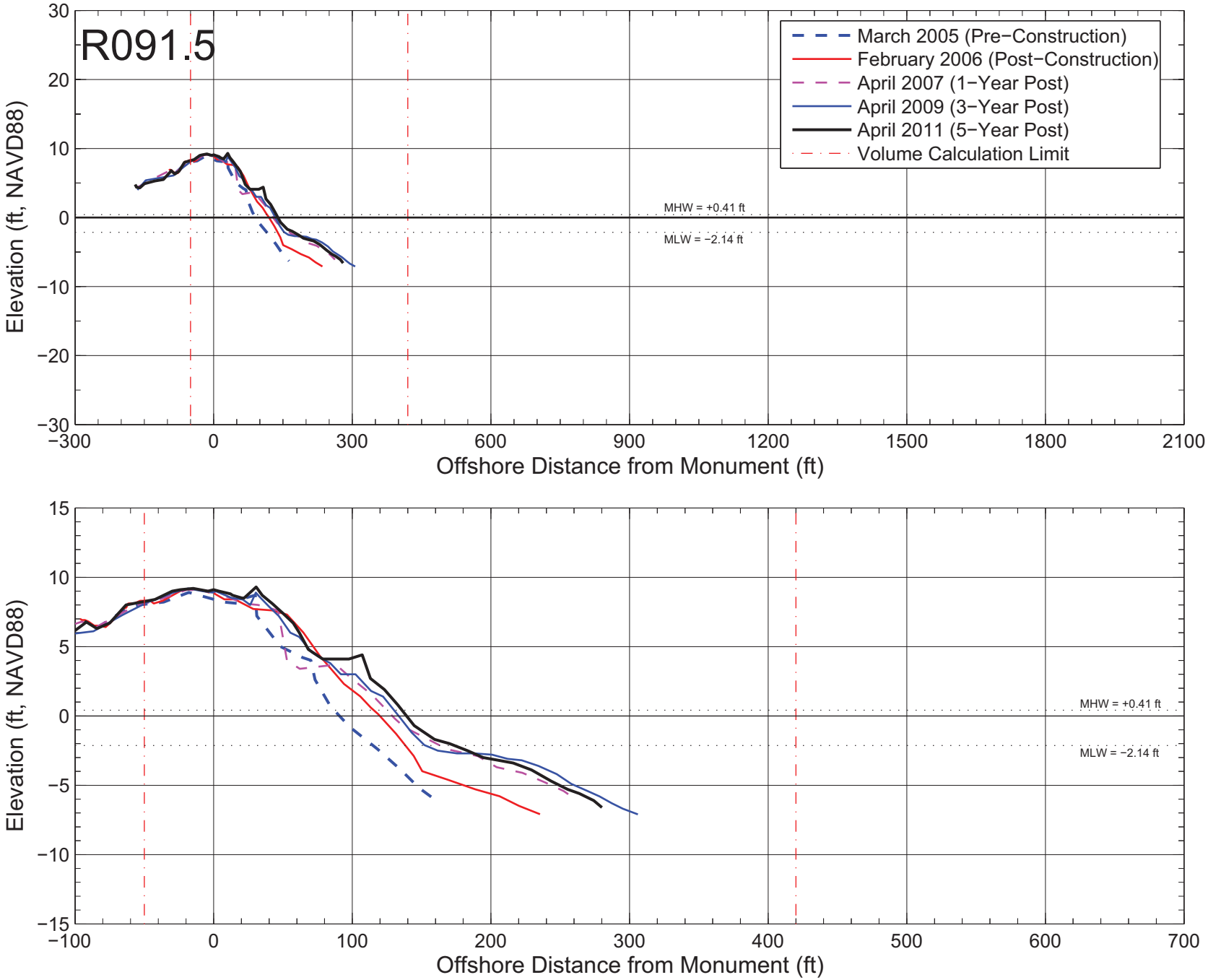


Figure A–111: Measured beach profiles at monument R091.5 Broward County, Florida.

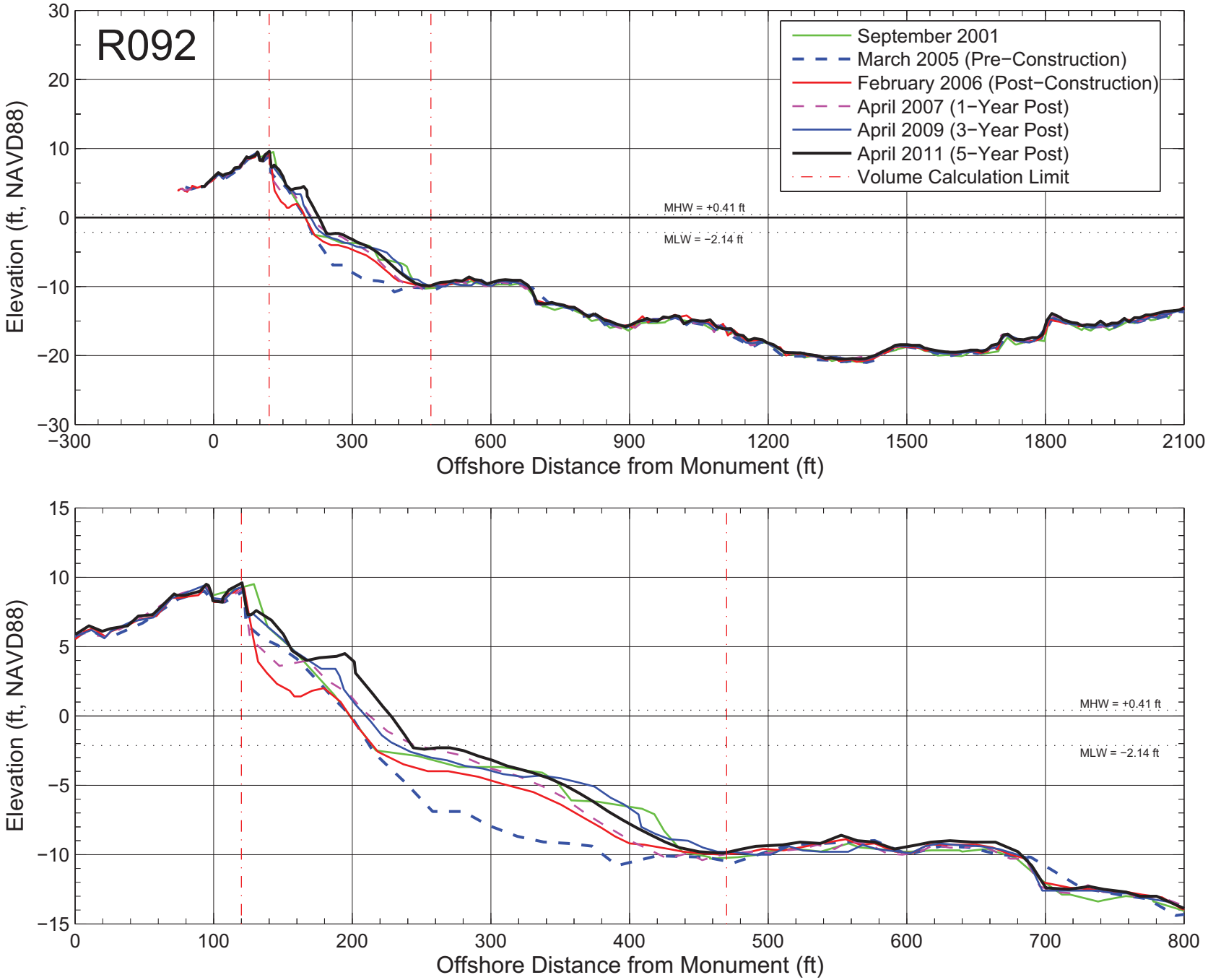


Figure A−112: Measured beach profiles at monument R092 Broward County, Florida.

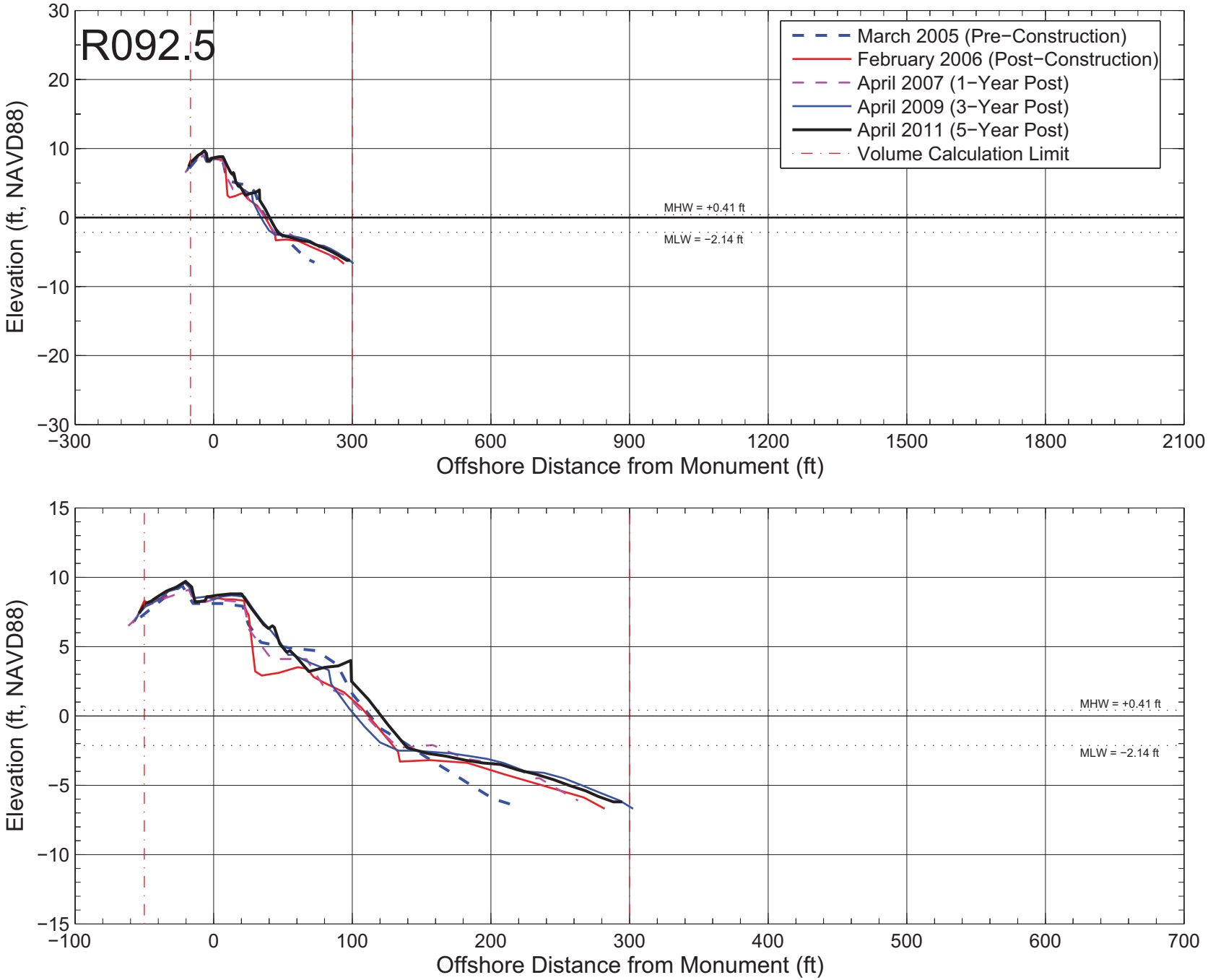


Figure A–113: Measured beach profiles at monument R092.5 Broward County, Florida.

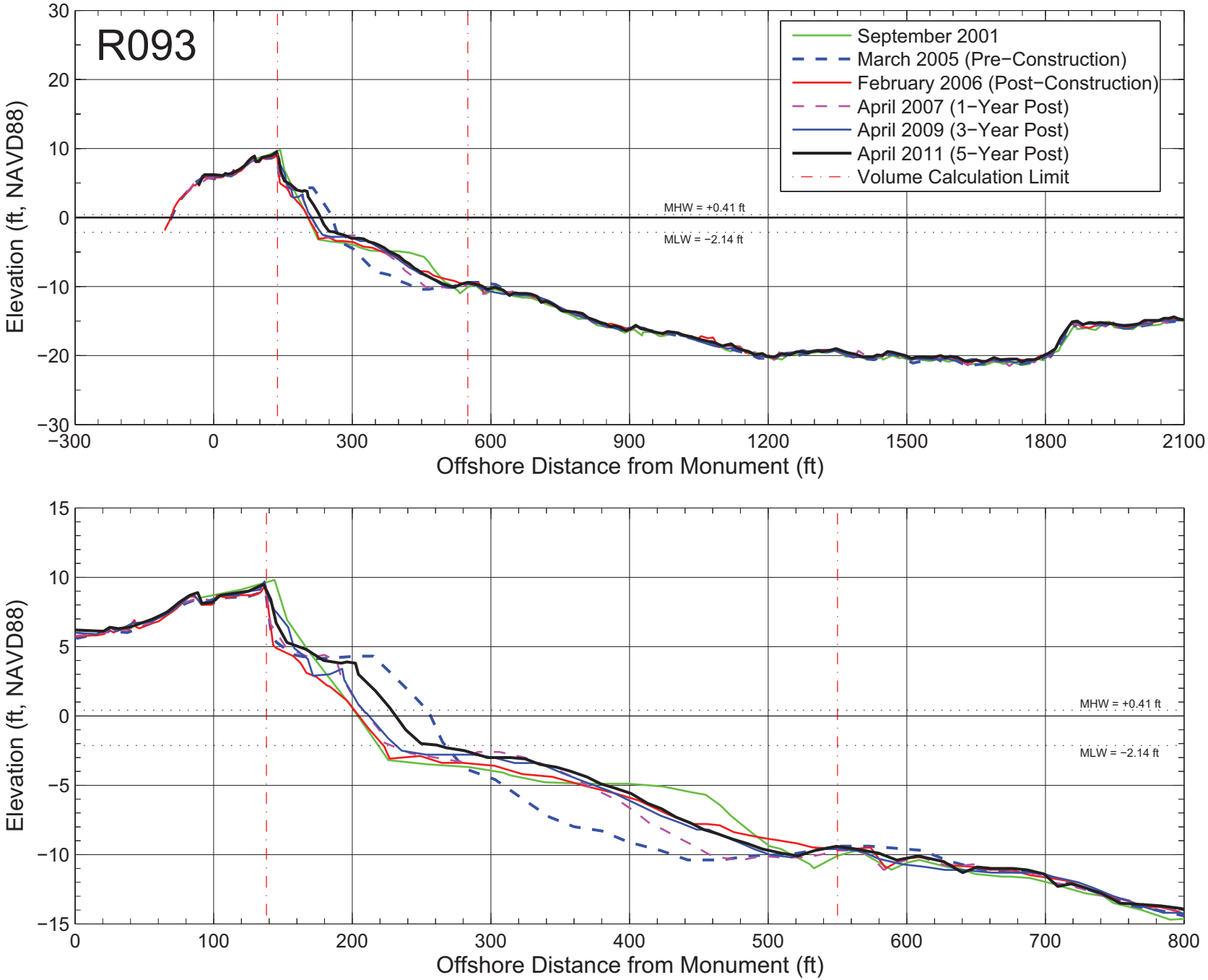


Figure A–114: Measured beach profiles at monument R093 Broward County, Florida.

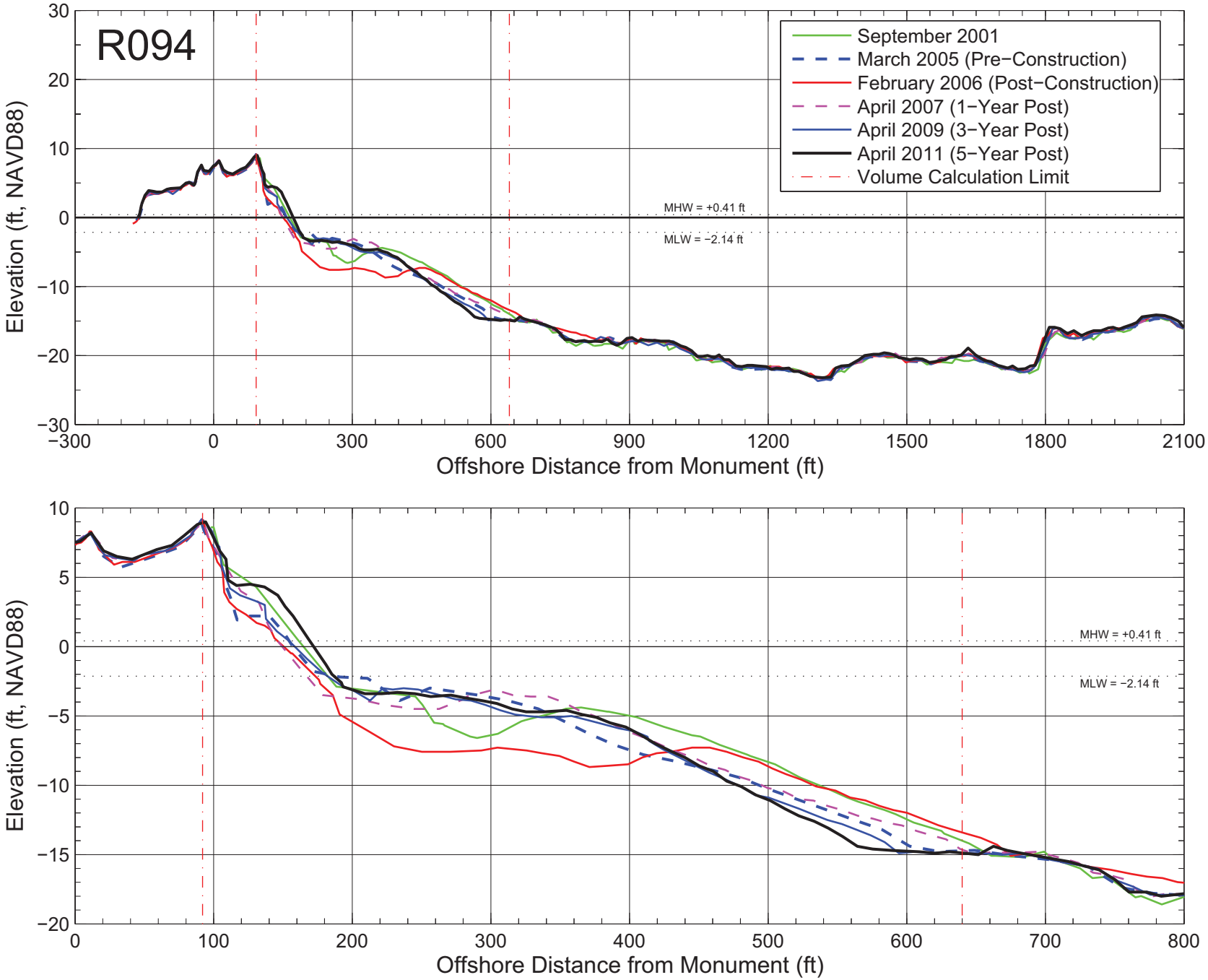


Figure A–115: Measured beach profiles at monument R094 Broward County, Florida.

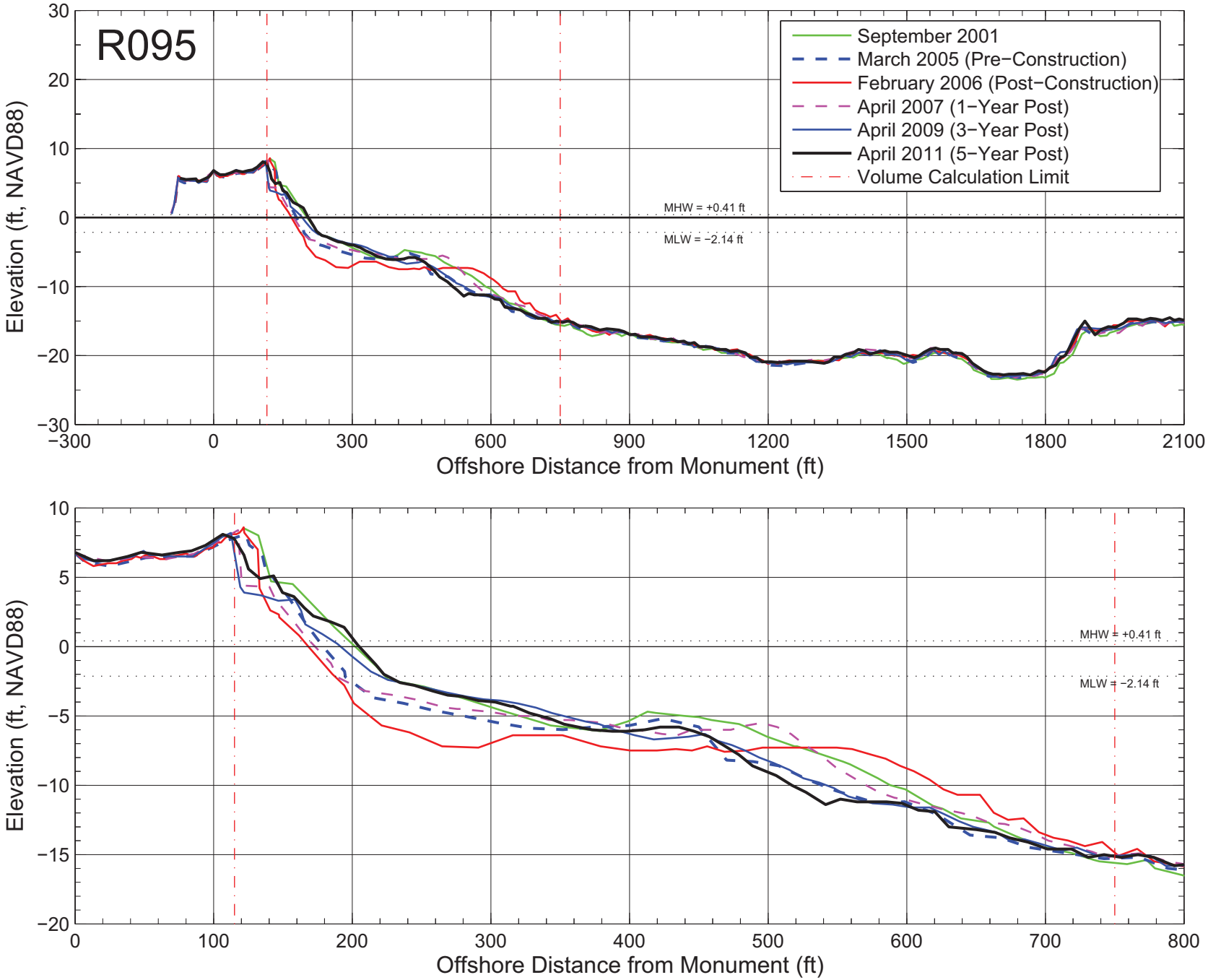


Figure A–116: Measured beach profiles at monument R095 Broward County, Florida.

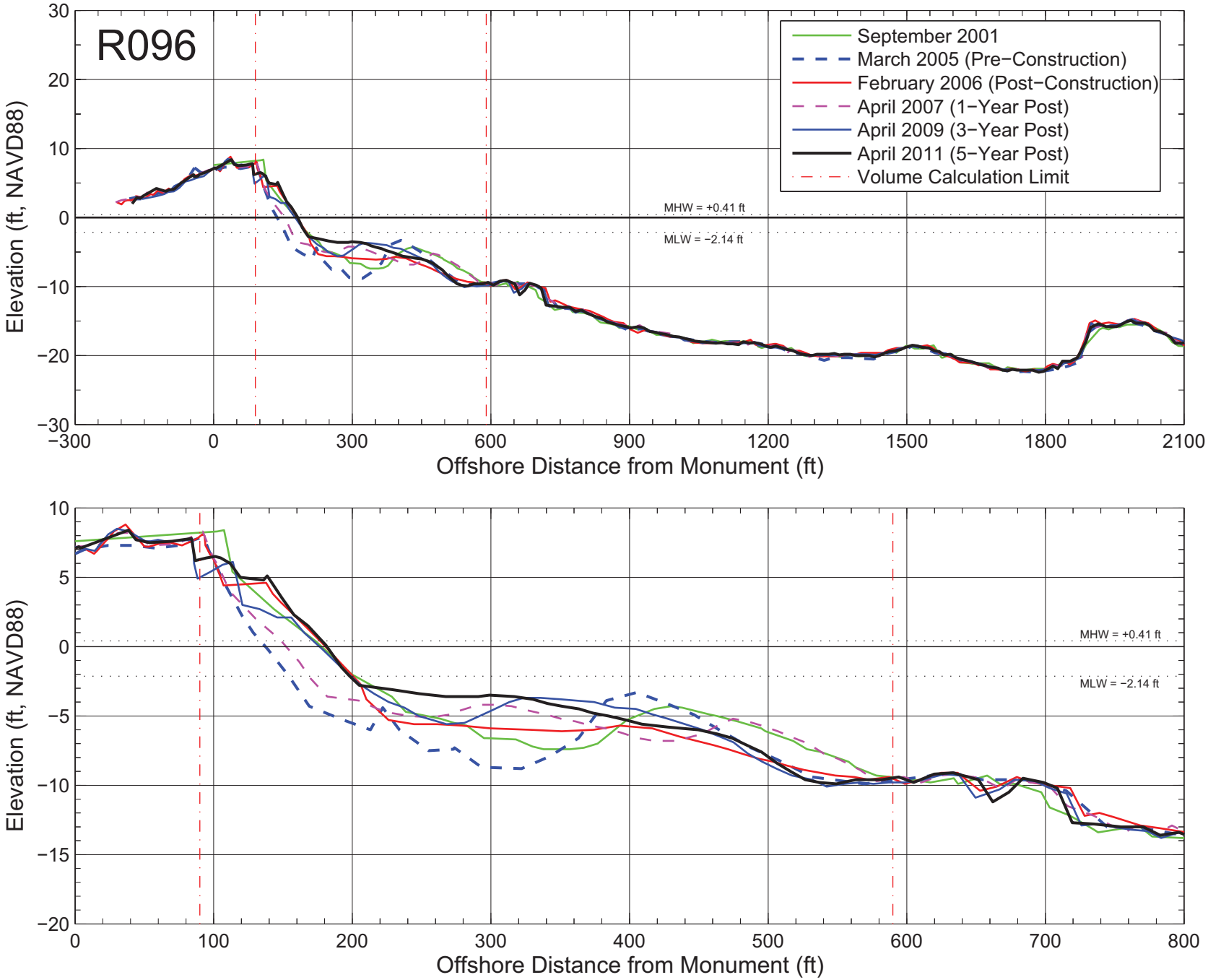


Figure A–117: Measured beach profiles at monument R096 Broward County, Florida.

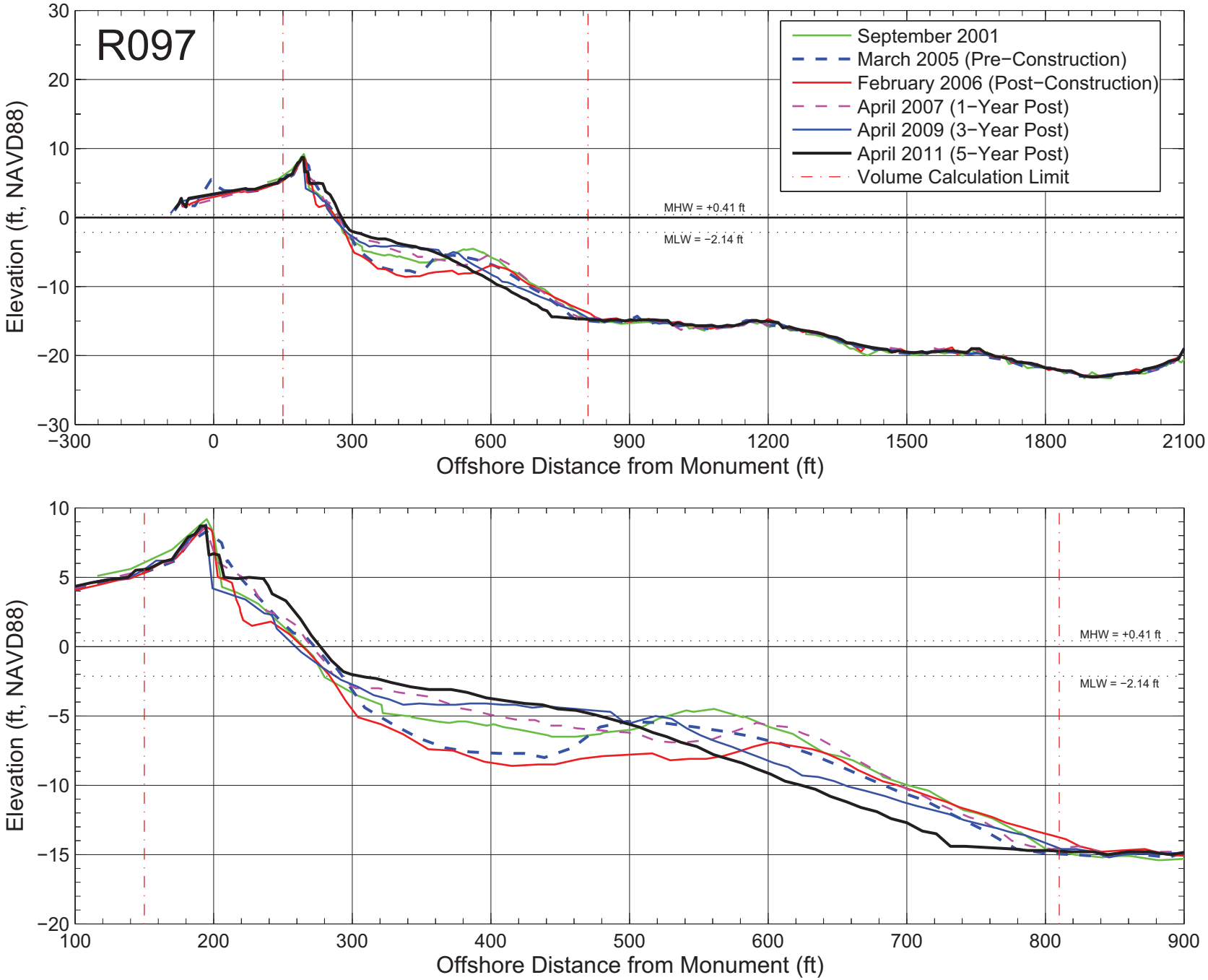


Figure A–118: Measured beach profiles at monument R097 Broward County, Florida.

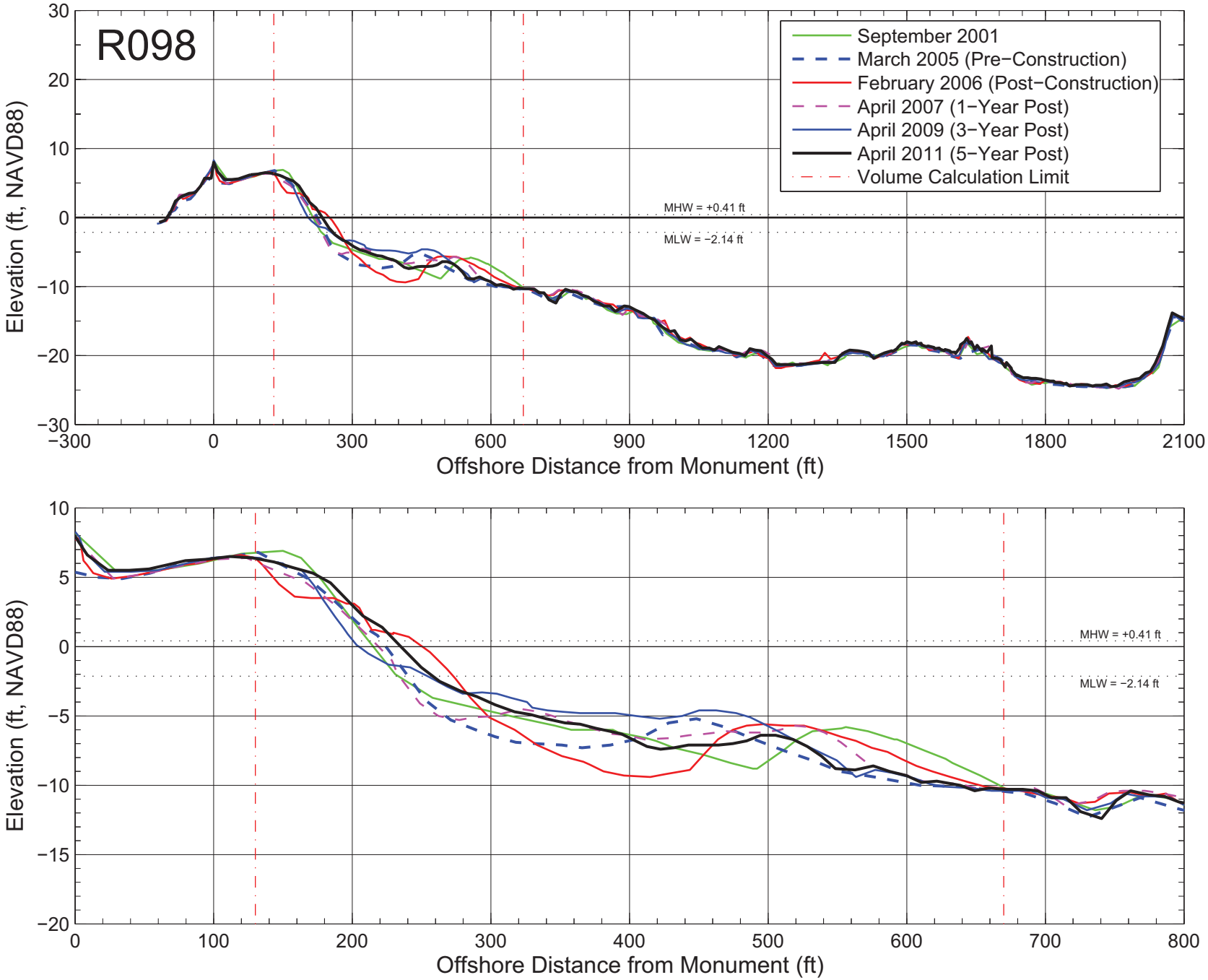


Figure A–119: Measured beach profiles at monument R098 Broward County, Florida.

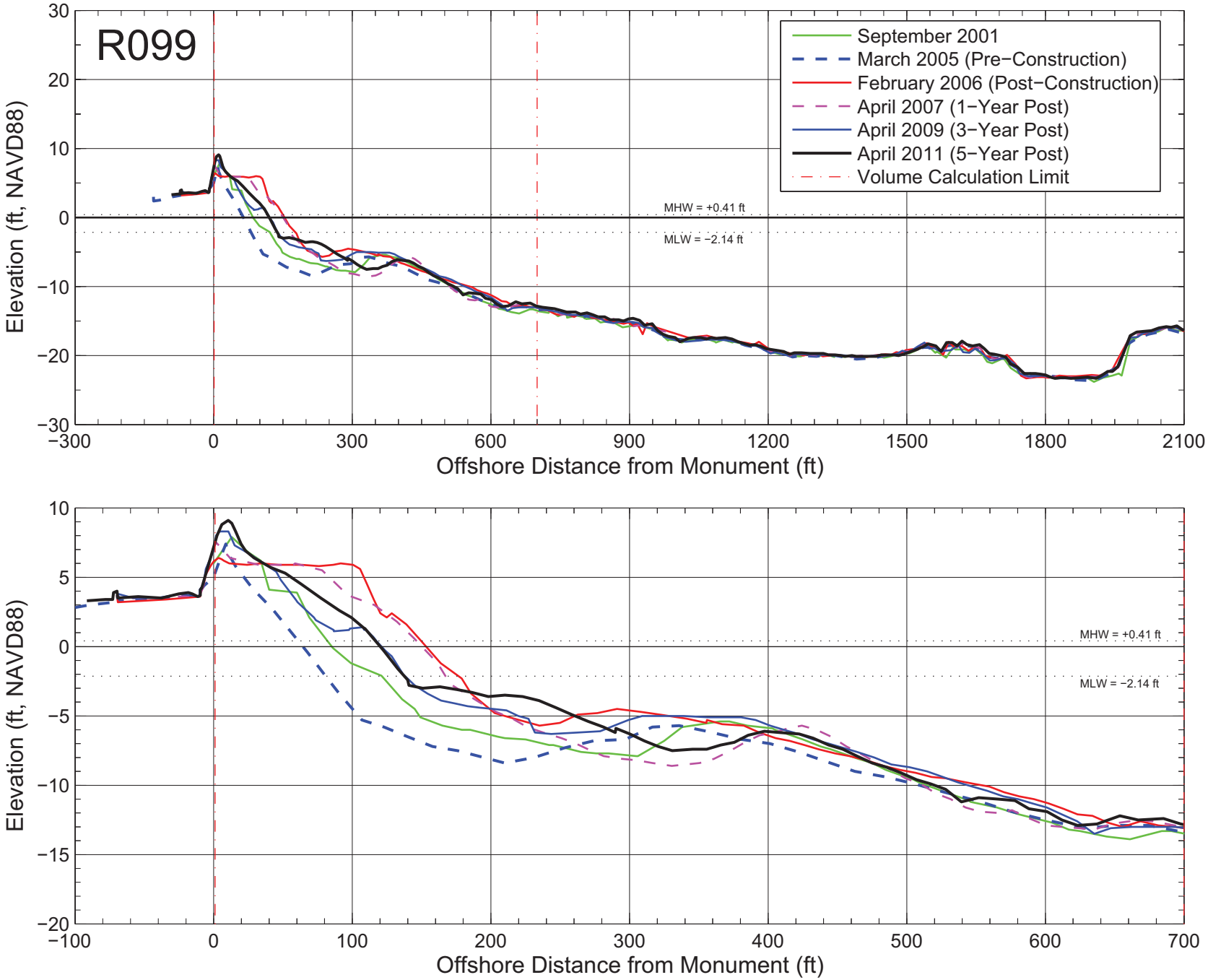


Figure A−120: Measured beach profiles at monument R099 Broward County, Florida.

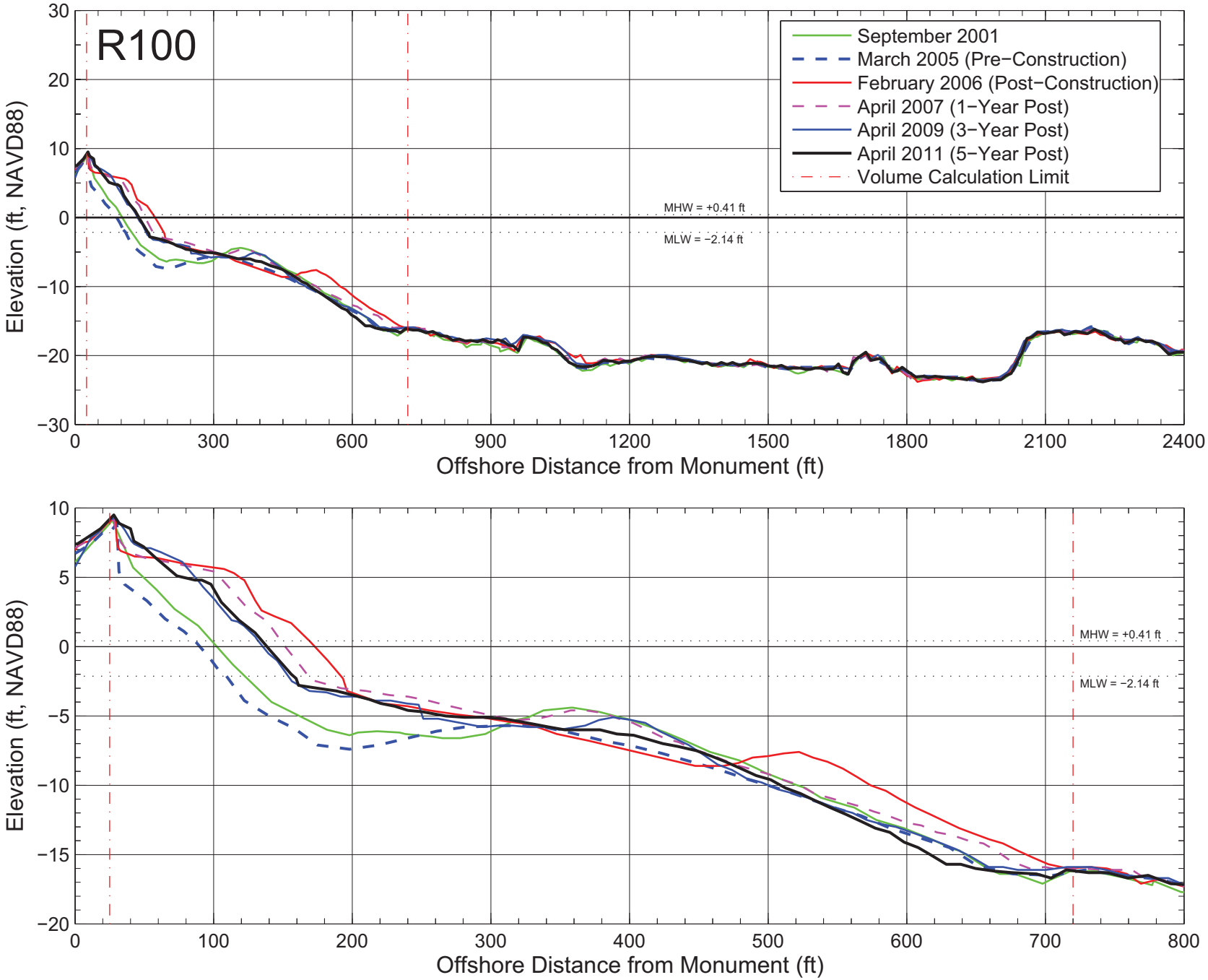


Figure A–121: Measured beach profiles at monument R100 Broward County, Florida.

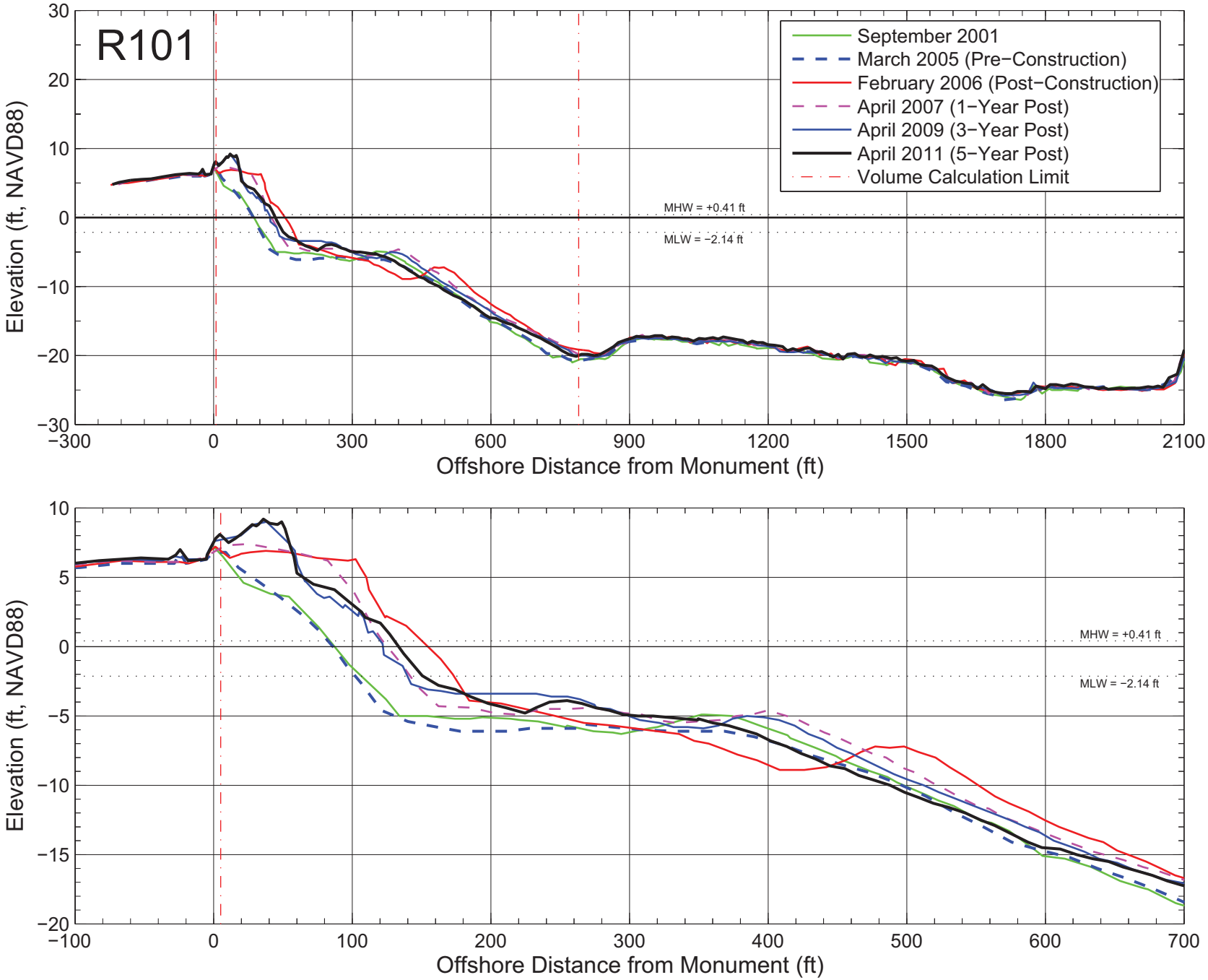


Figure A−122: Measured beach profiles at monument R101 Broward County, Florida.

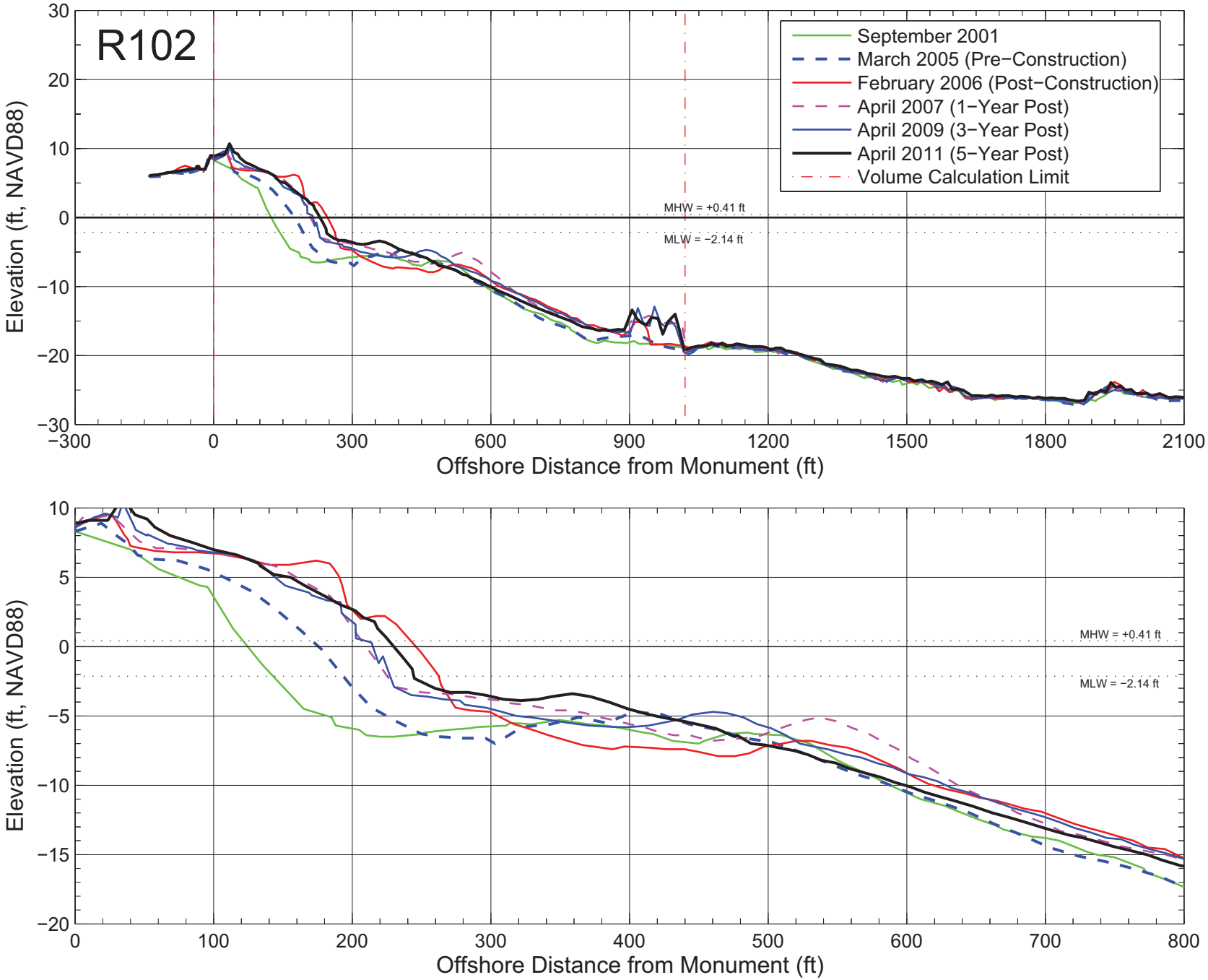


Figure A−123: Measured beach profiles at monument R102 Broward County, Florida.

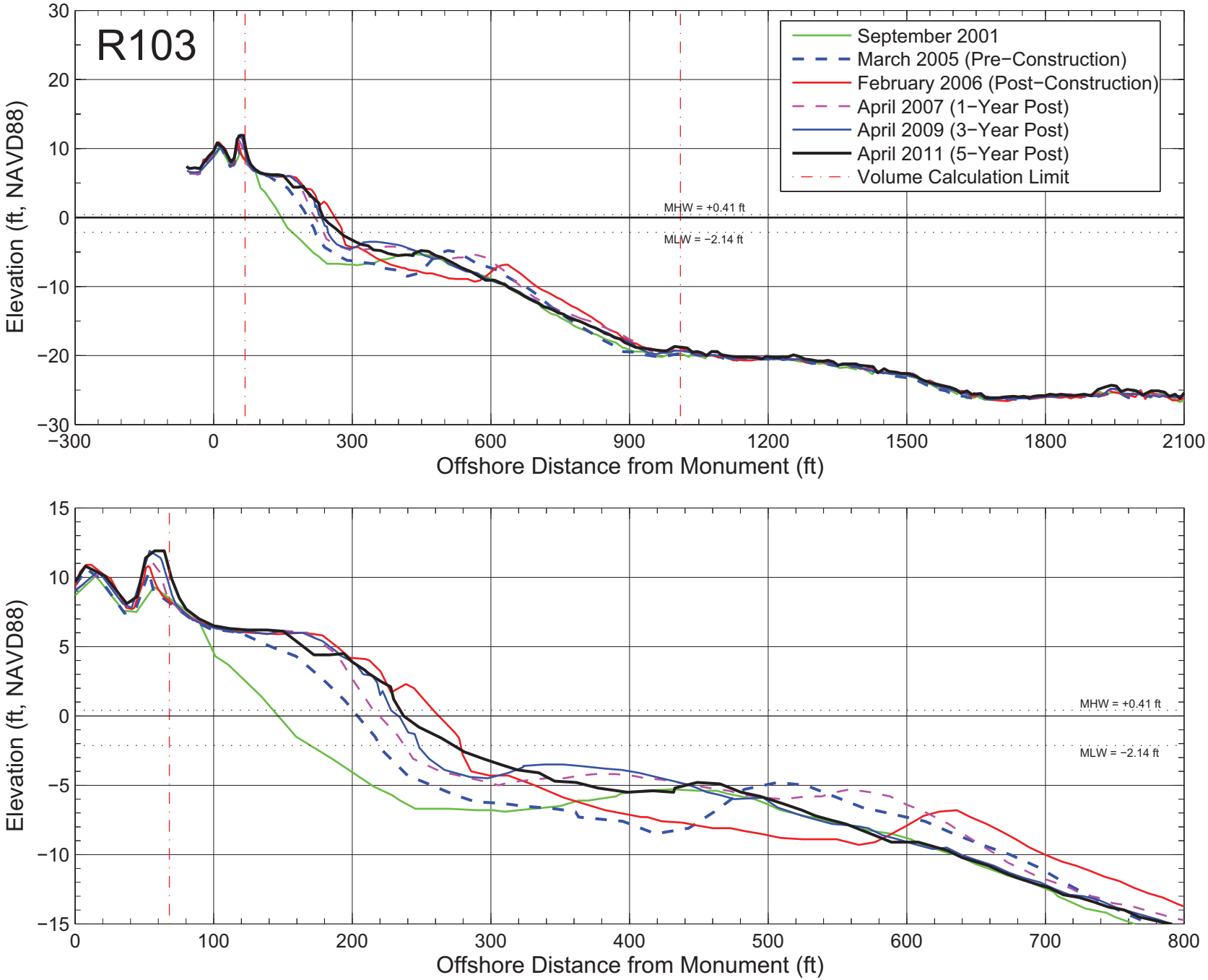


Figure A–124: Measured beach profiles at monument R103 Broward County, Florida.

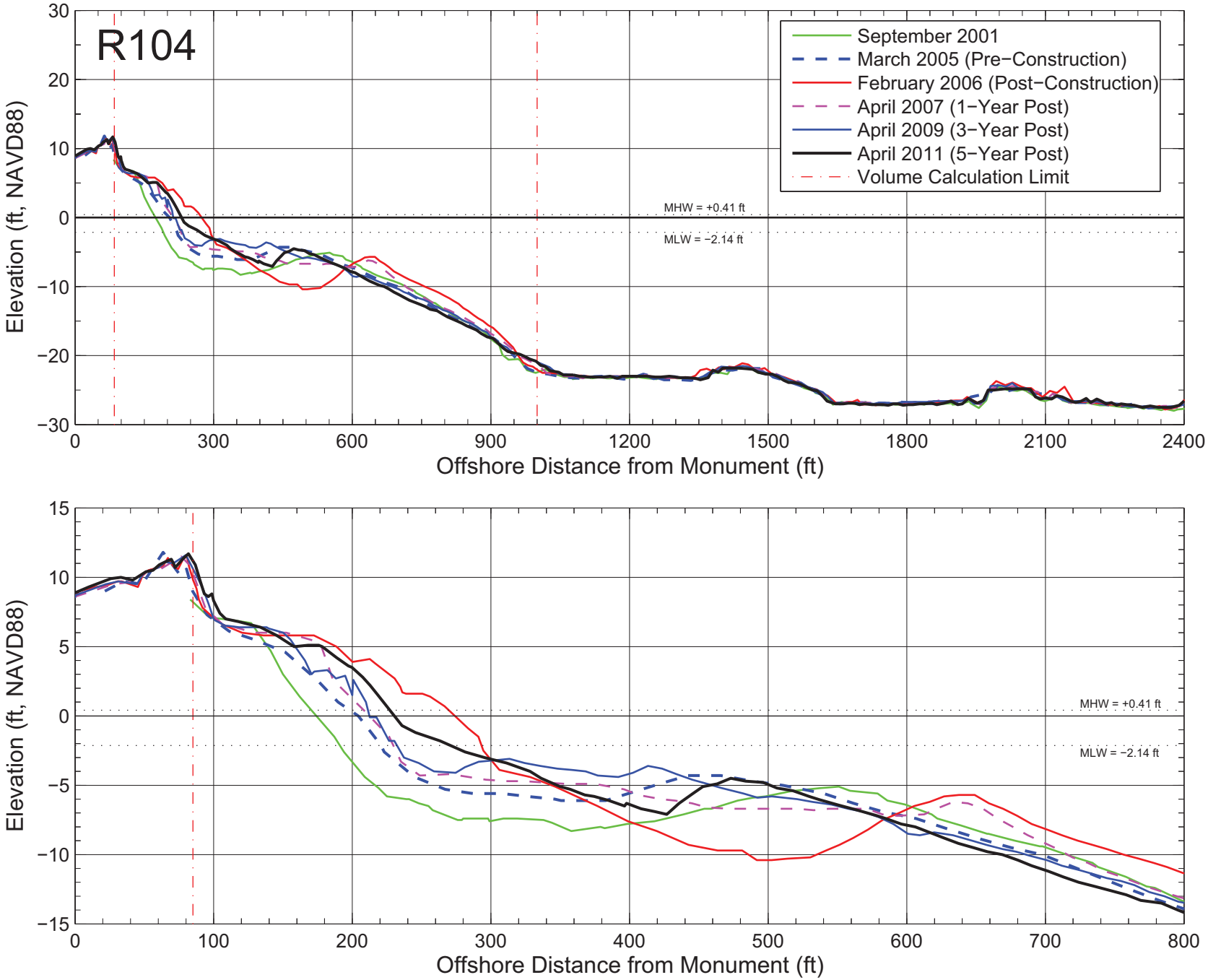


Figure A–125: Measured beach profiles at monument R104 Broward County, Florida.

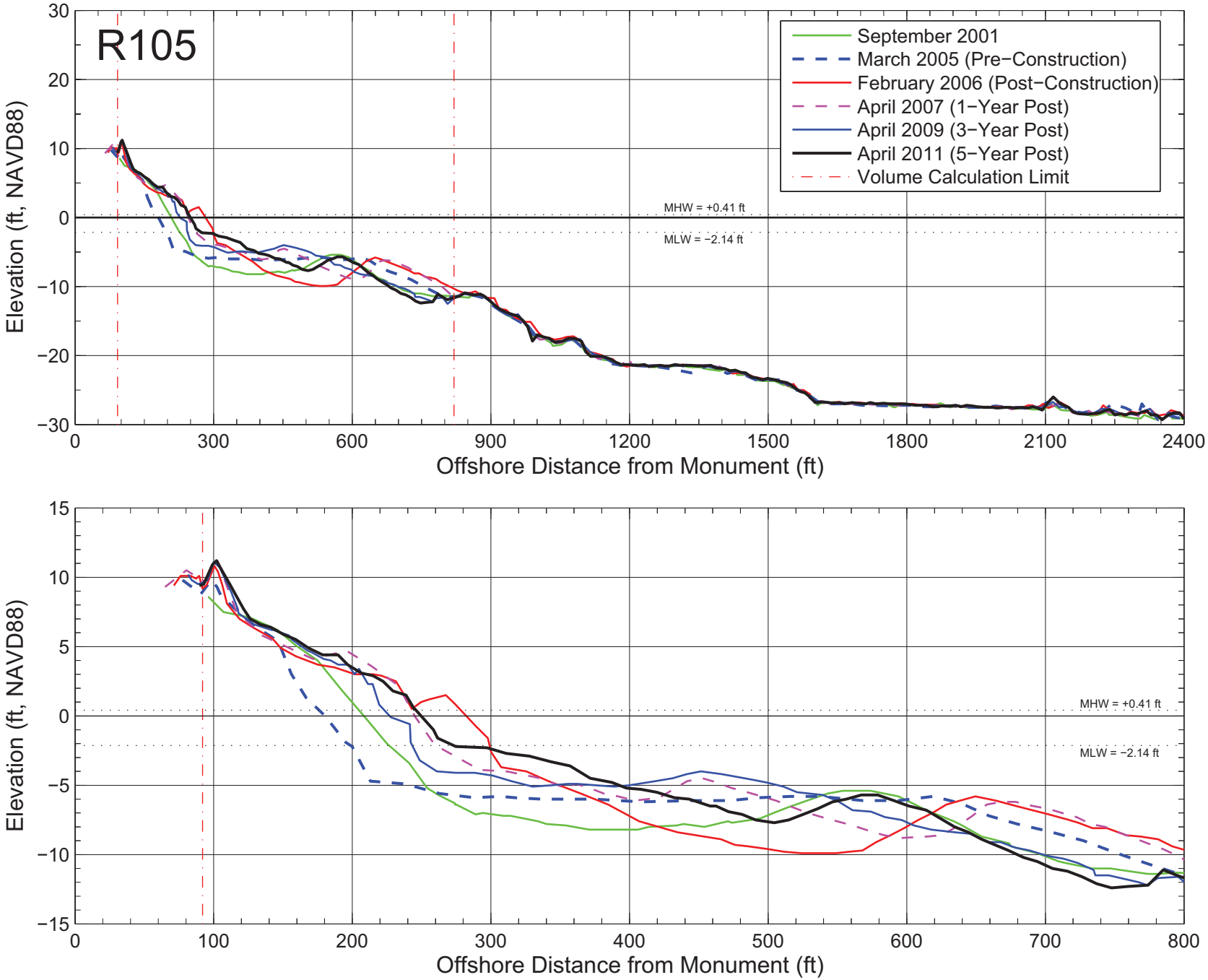


Figure A–126: Measured beach profiles at monument R105 Broward County, Florida.

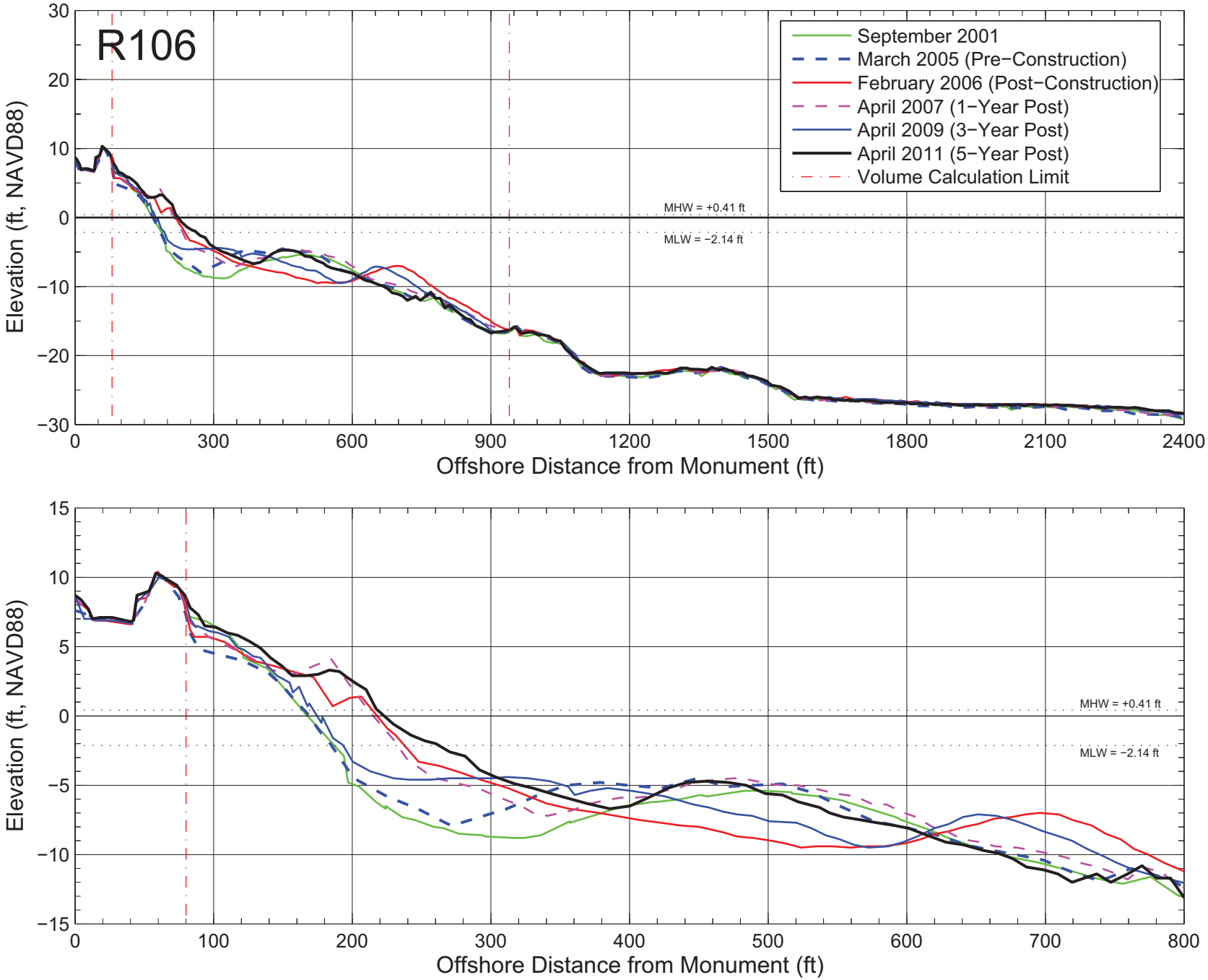


Figure A–127: Measured beach profiles at monument R106 Broward County, Florida.

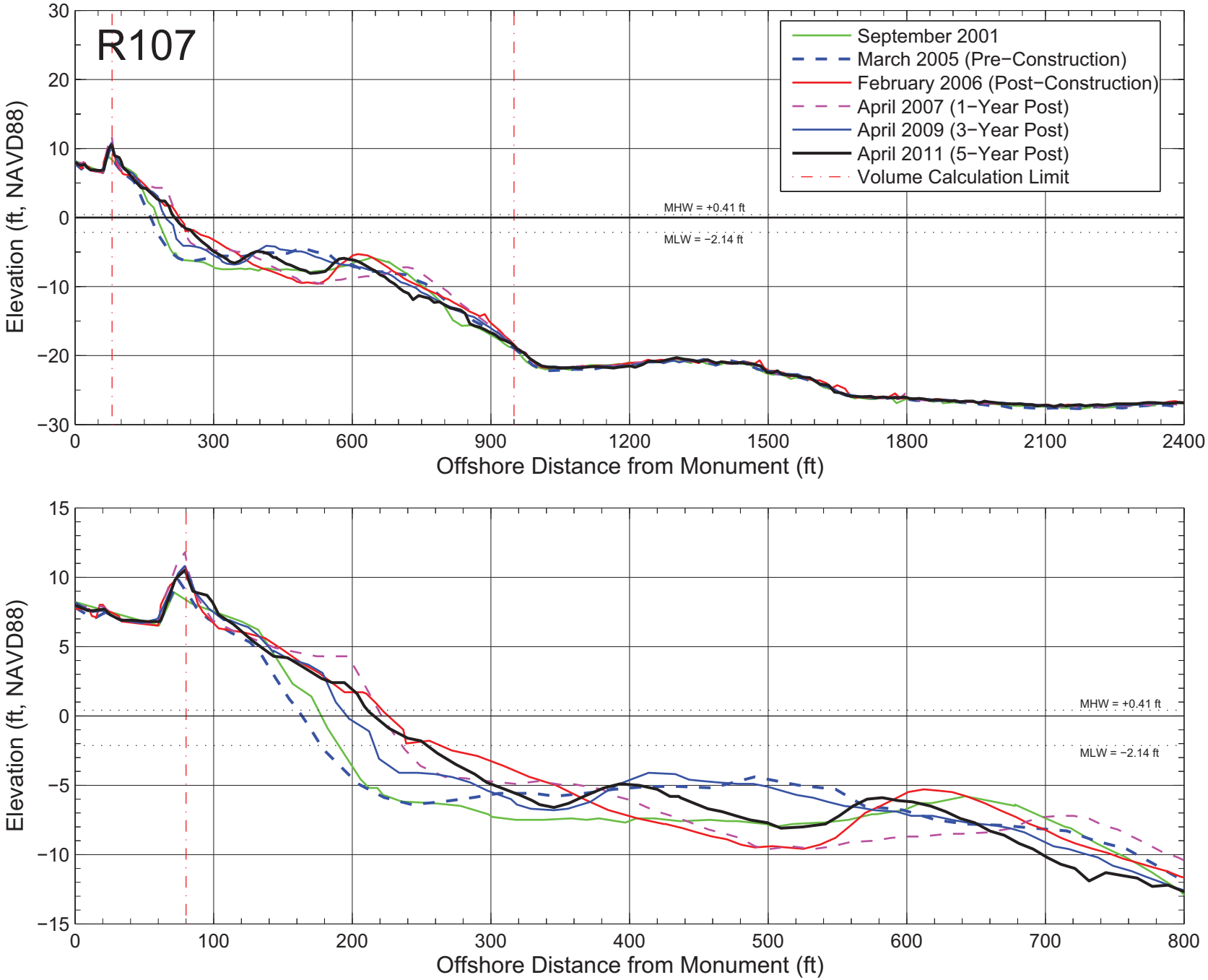


Figure A–128: Measured beach profiles at monument R107 Broward County, Florida.

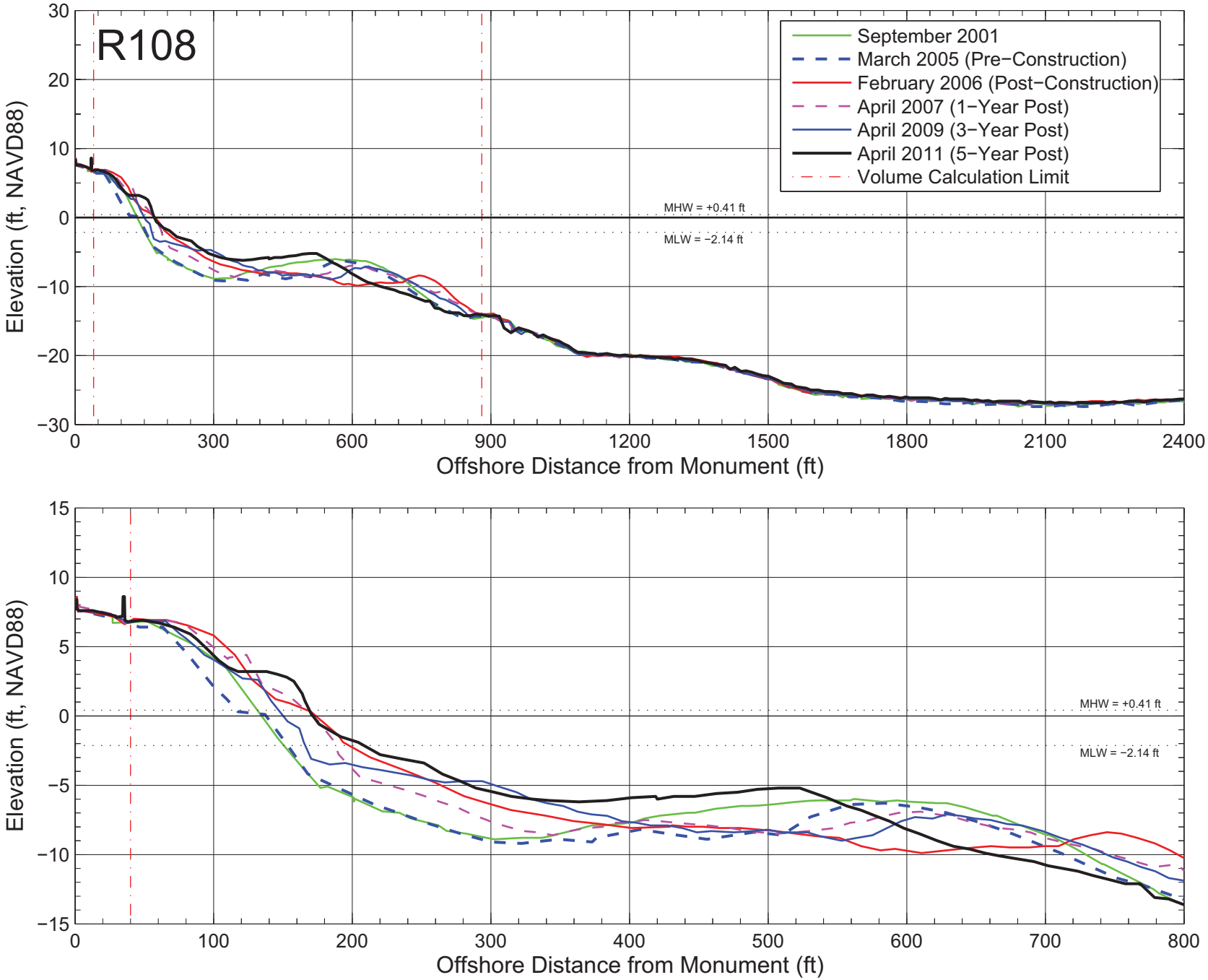


Figure A−129: Measured beach profiles at monument R108 Broward County, Florida.

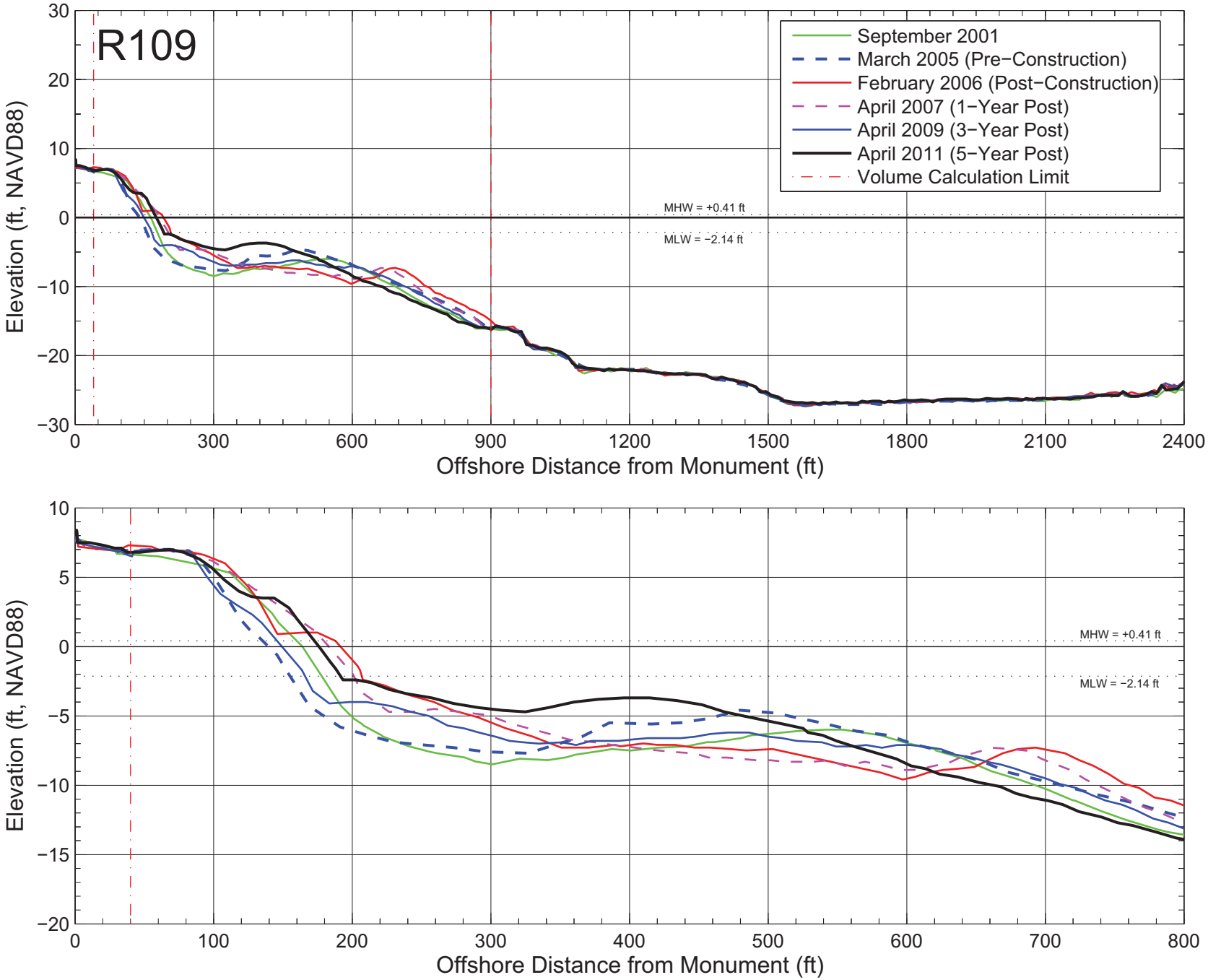


Figure A–130: Measured beach profiles at monument R109 Broward County, Florida.

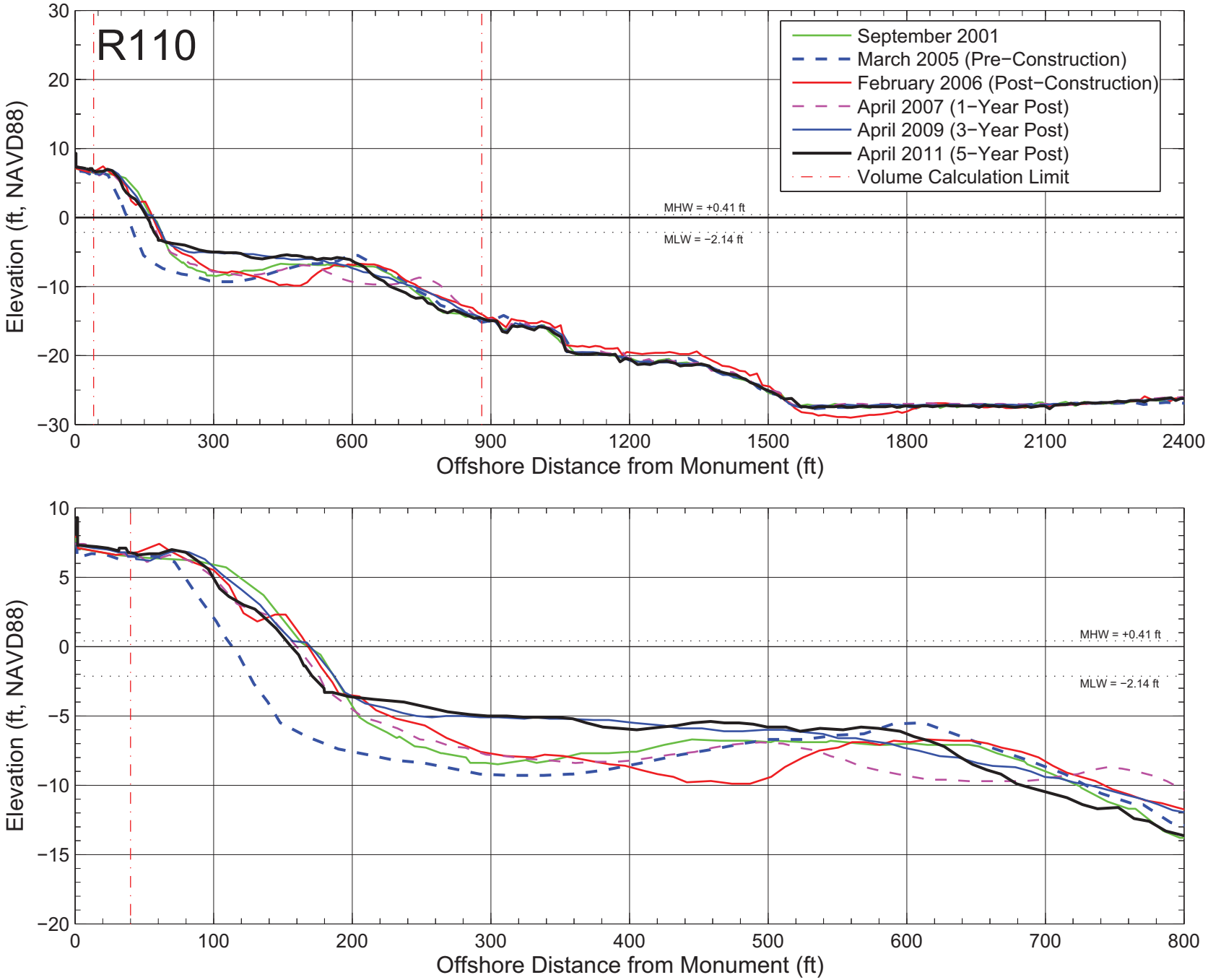


Figure A–131: Measured beach profiles at monument R110 Broward County, Florida.

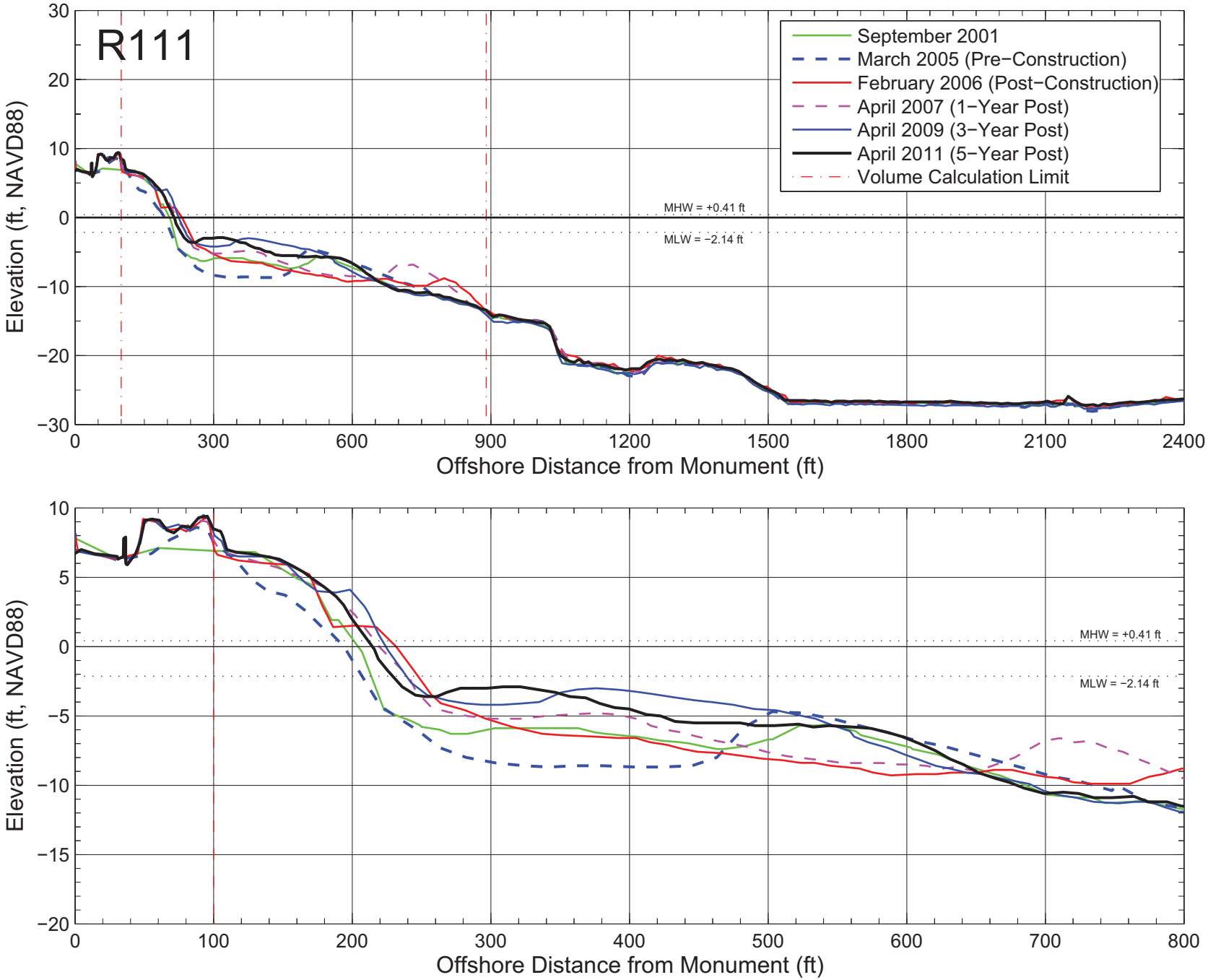


Figure A–132: Measured beach profiles at monument R111 Broward County, Florida.

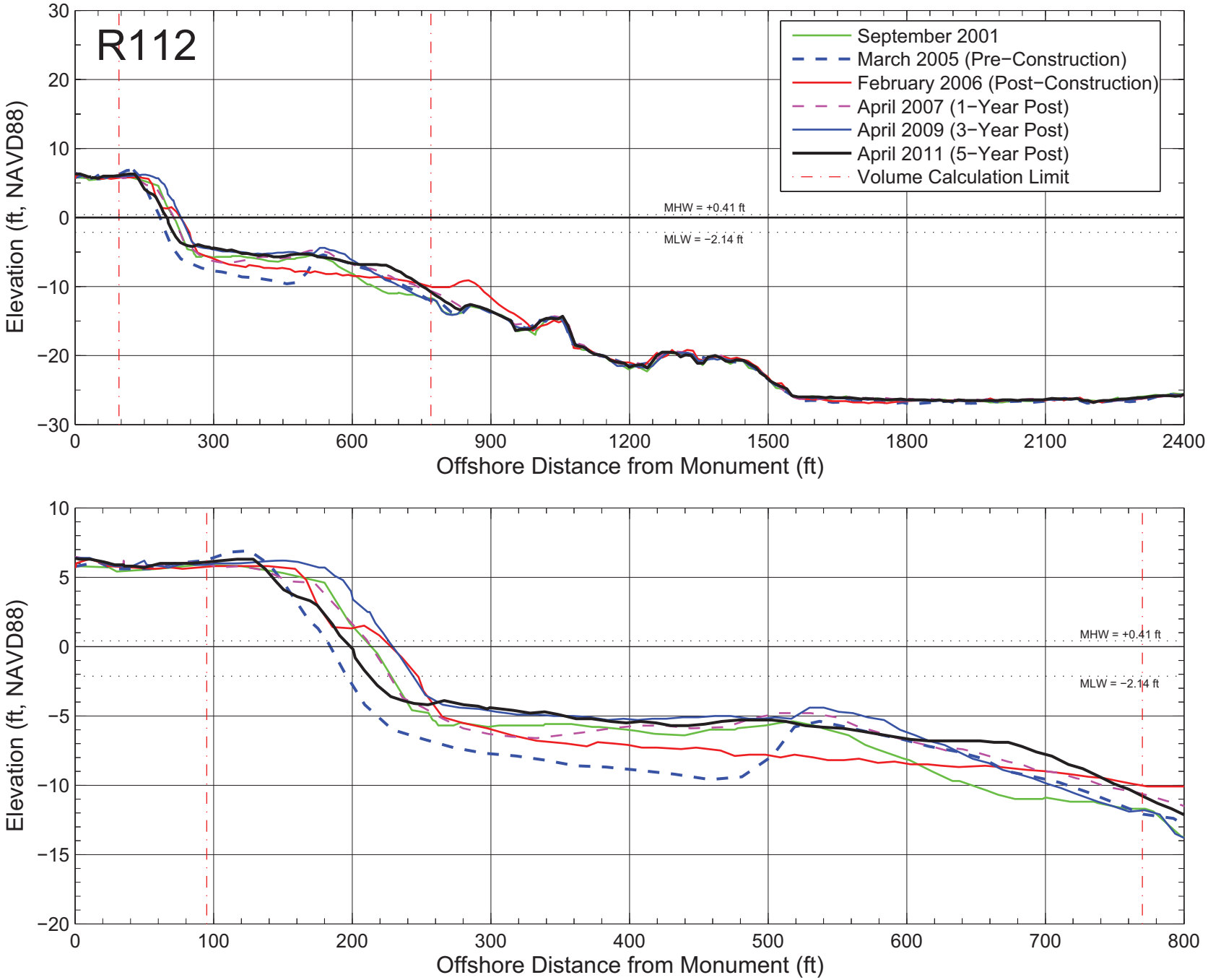


Figure A–133: Measured beach profiles at monument R112 Broward County, Florida.

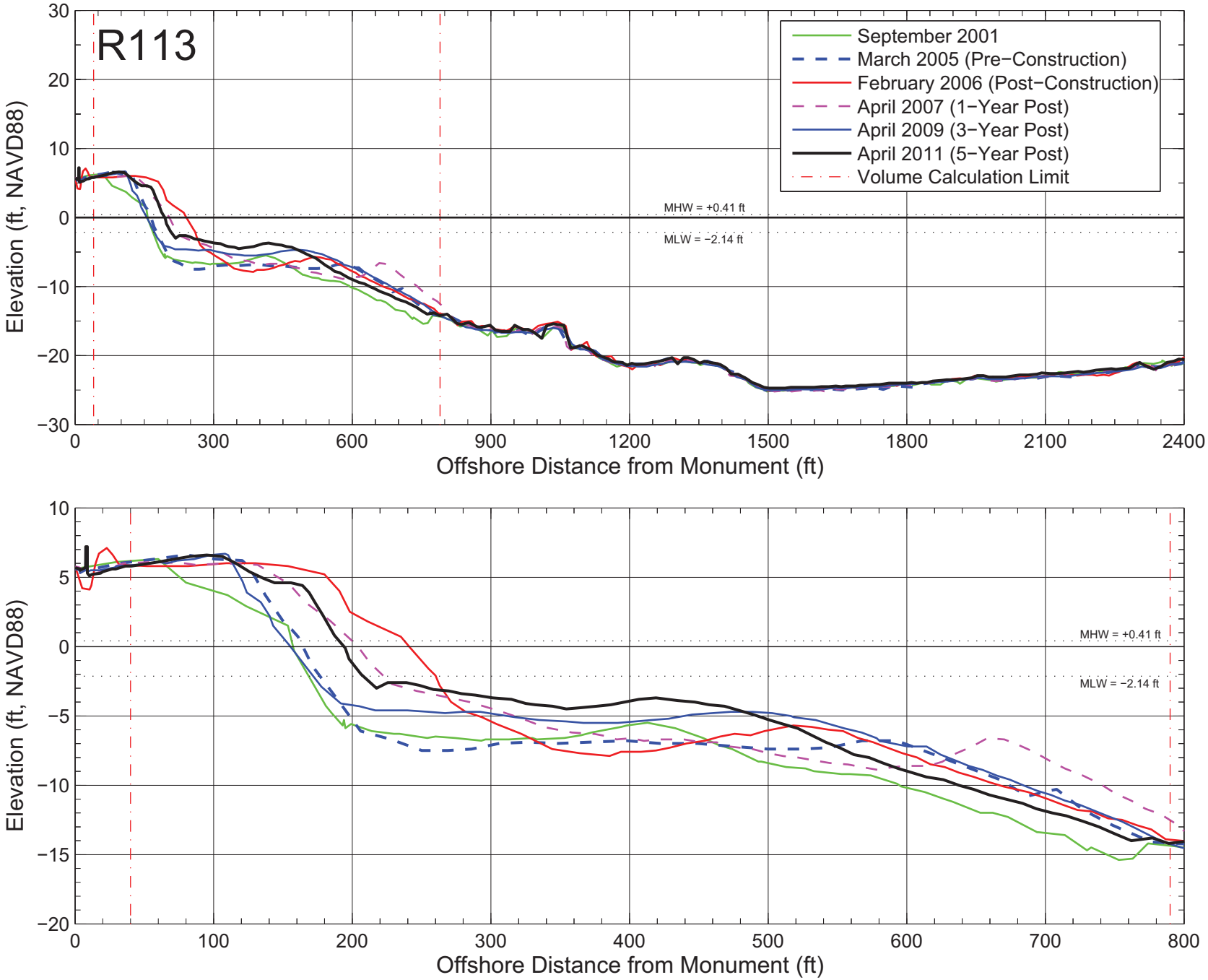


Figure A–134: Measured beach profiles at monument R113 Broward County, Florida.

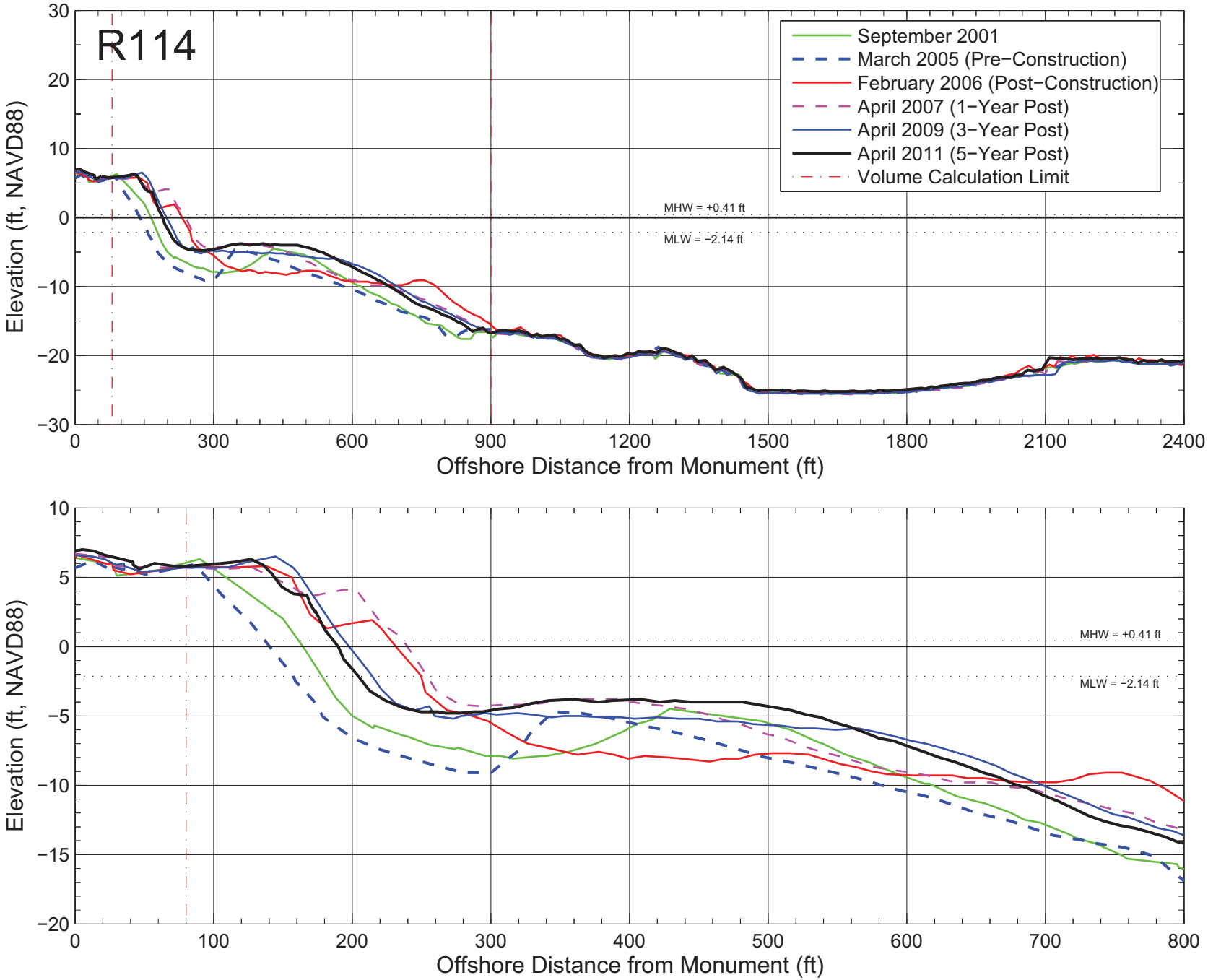


Figure A–135: Measured beach profiles at monument R114 Broward County, Florida.

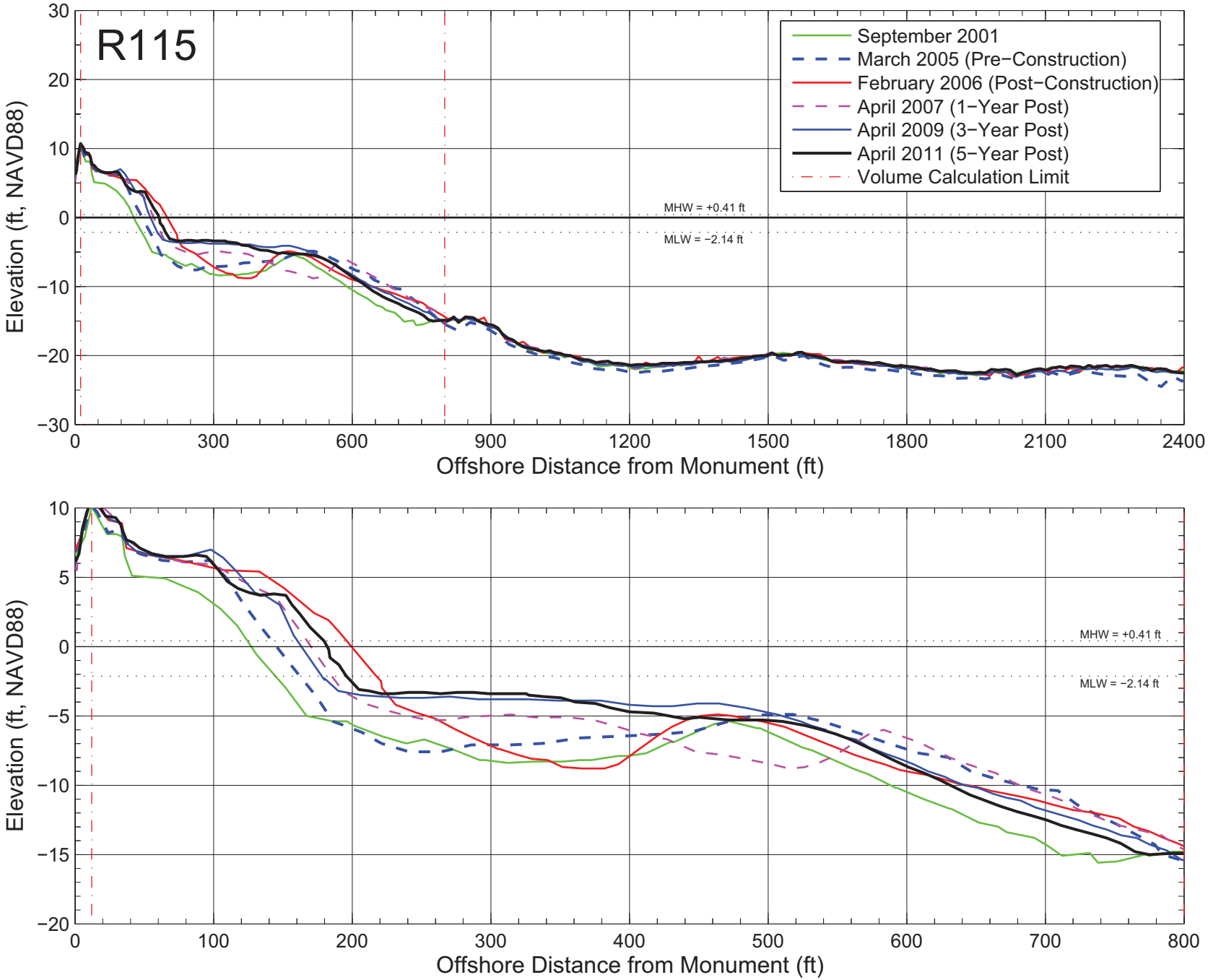


Figure A–136: Measured beach profiles at monument R115 Broward County, Florida.

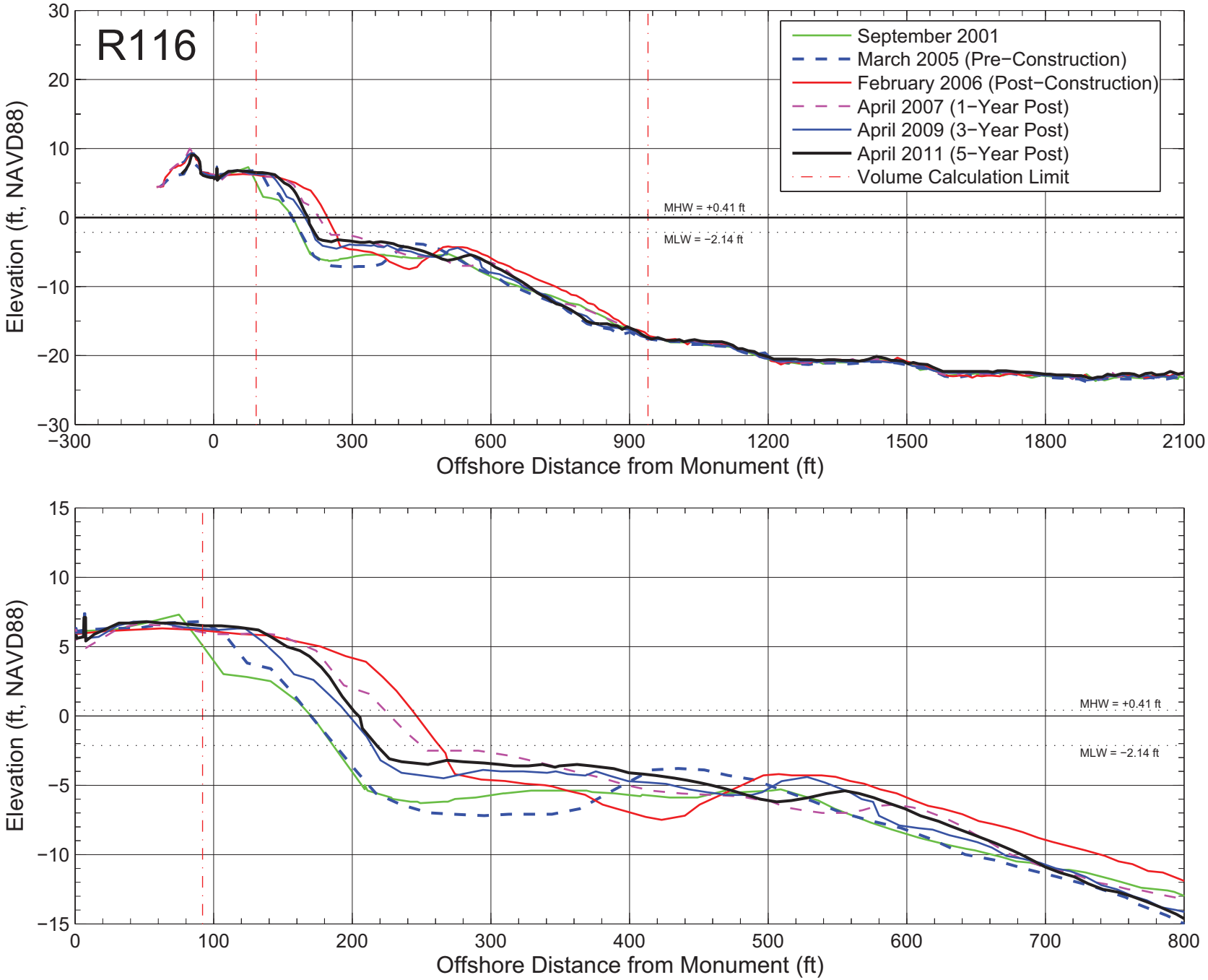


Figure A–137: Measured beach profiles at monument R116 Broward County, Florida.

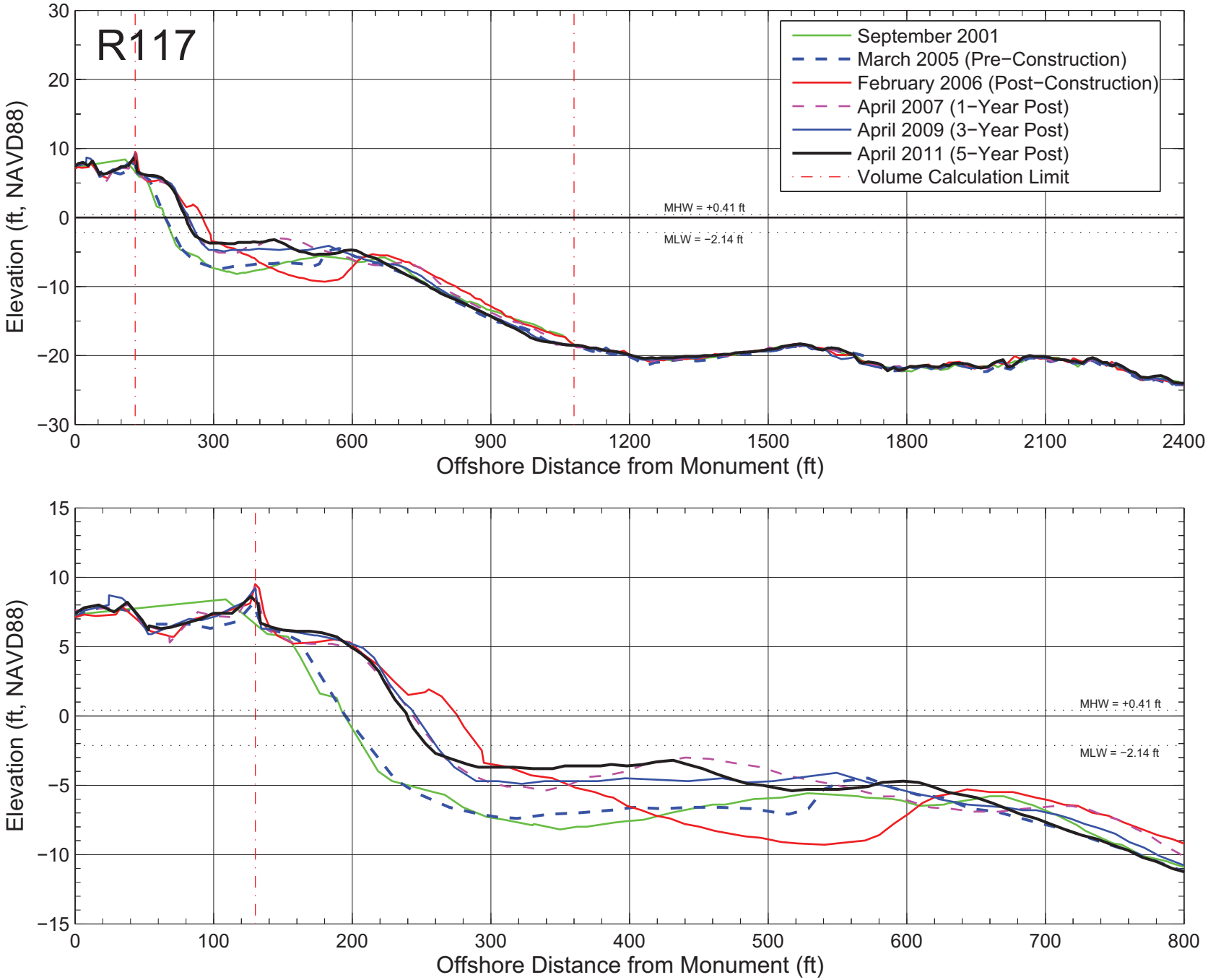


Figure A–138: Measured beach profiles at monument R117 Broward County, Florida.

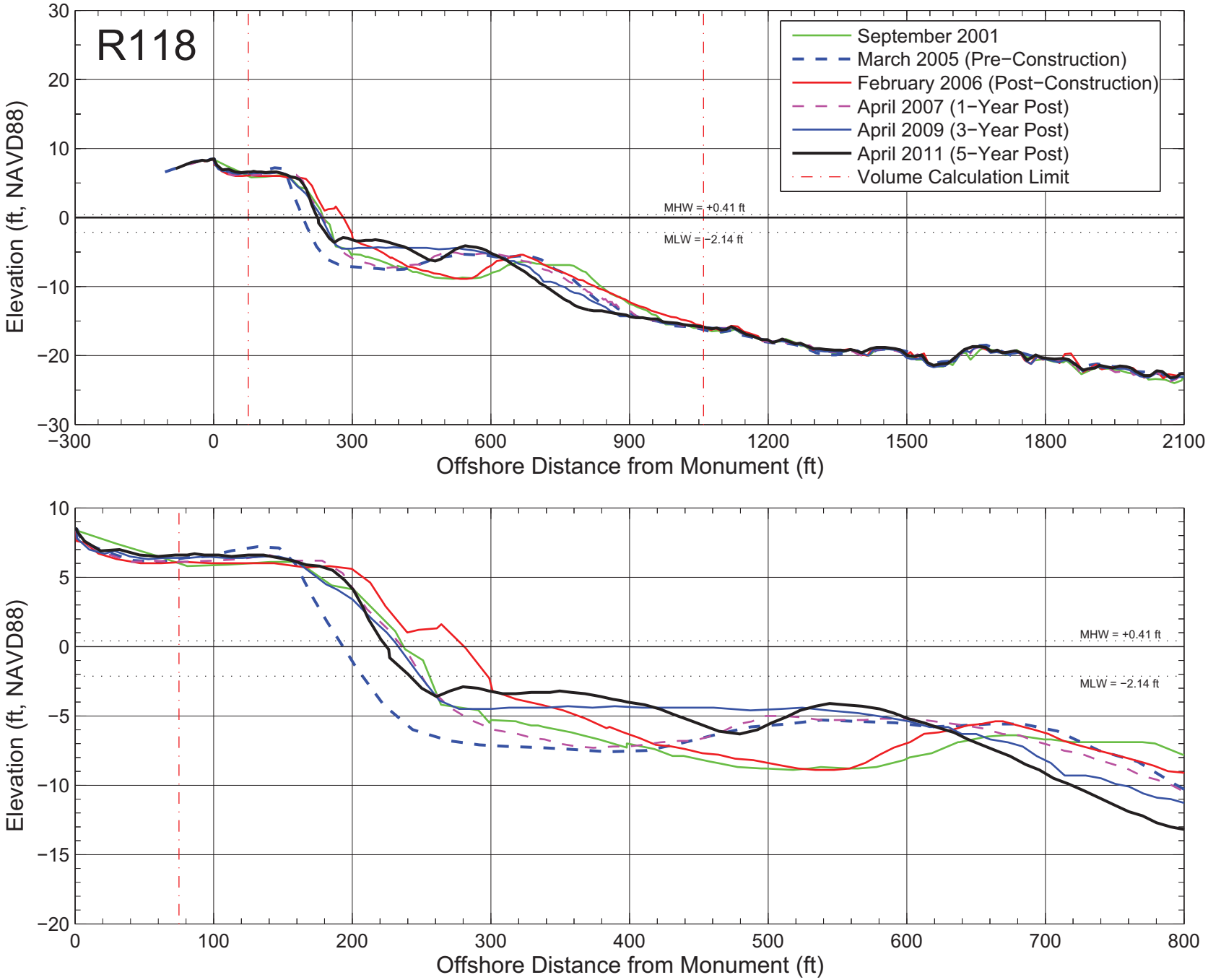


Figure A–139: Measured beach profiles at monument R118 Broward County, Florida.

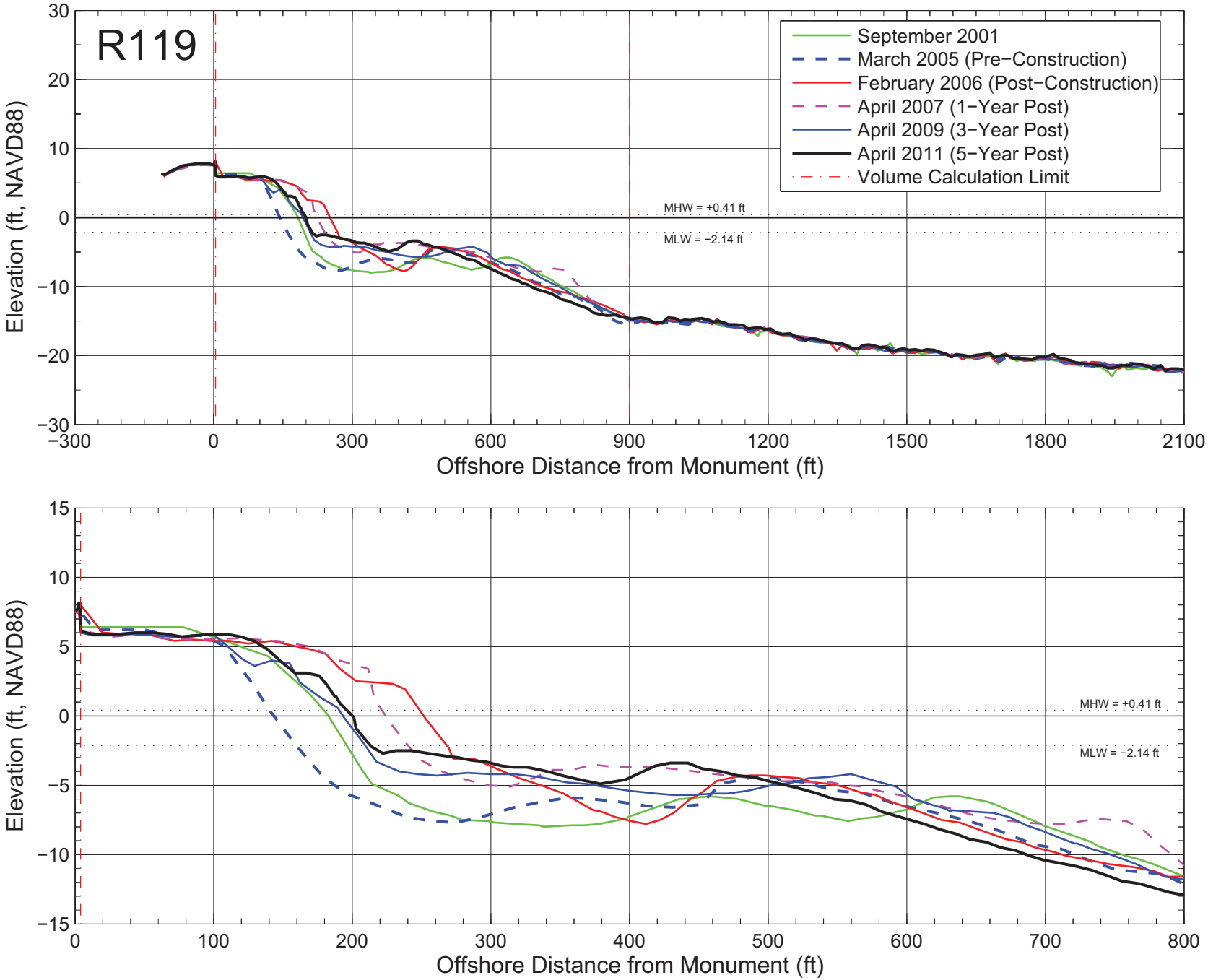


Figure A−140: Measured beach profiles at monument R119 Broward County, Florida.

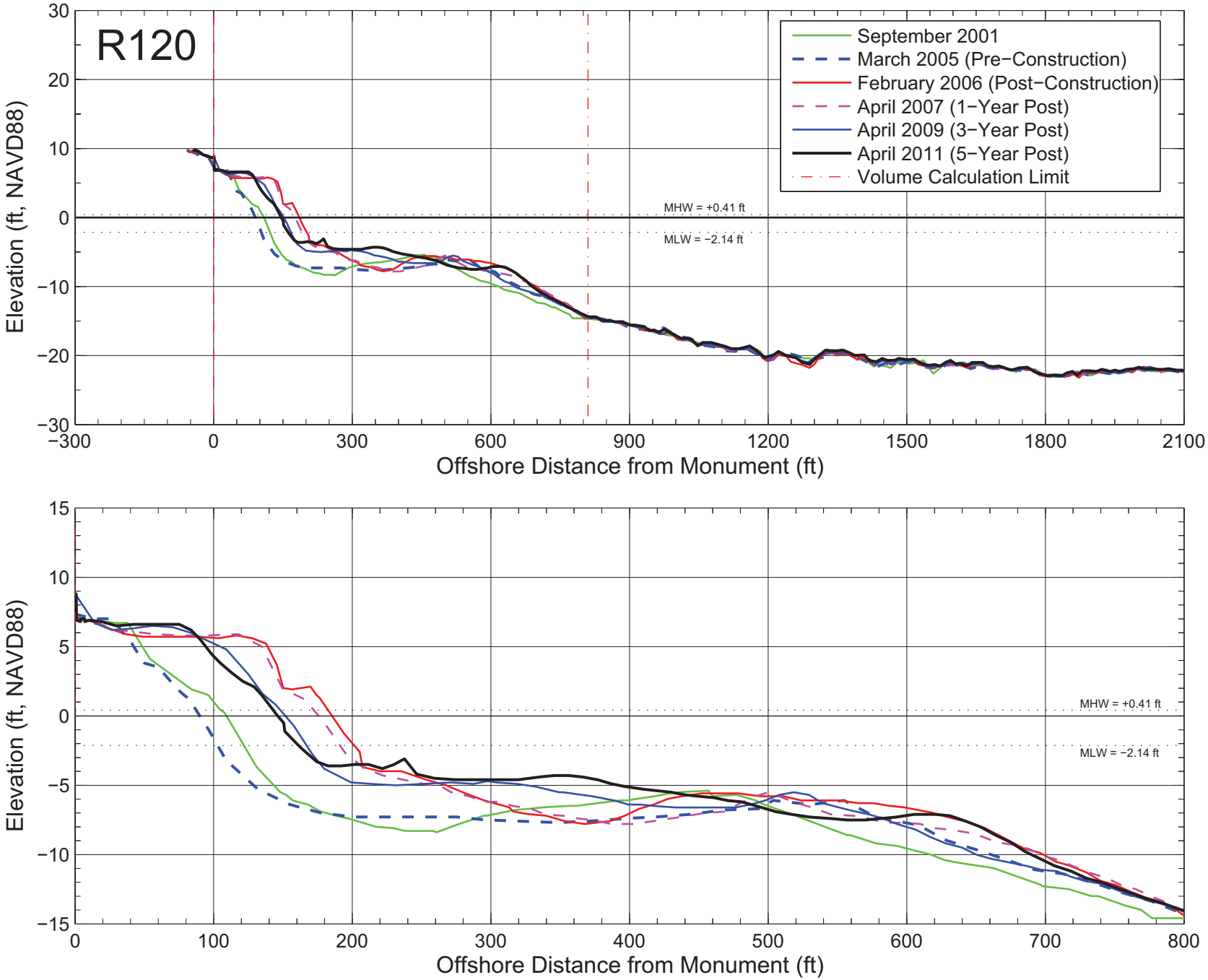


Figure A–141: Measured beach profiles at monument R120 Broward County, Florida.

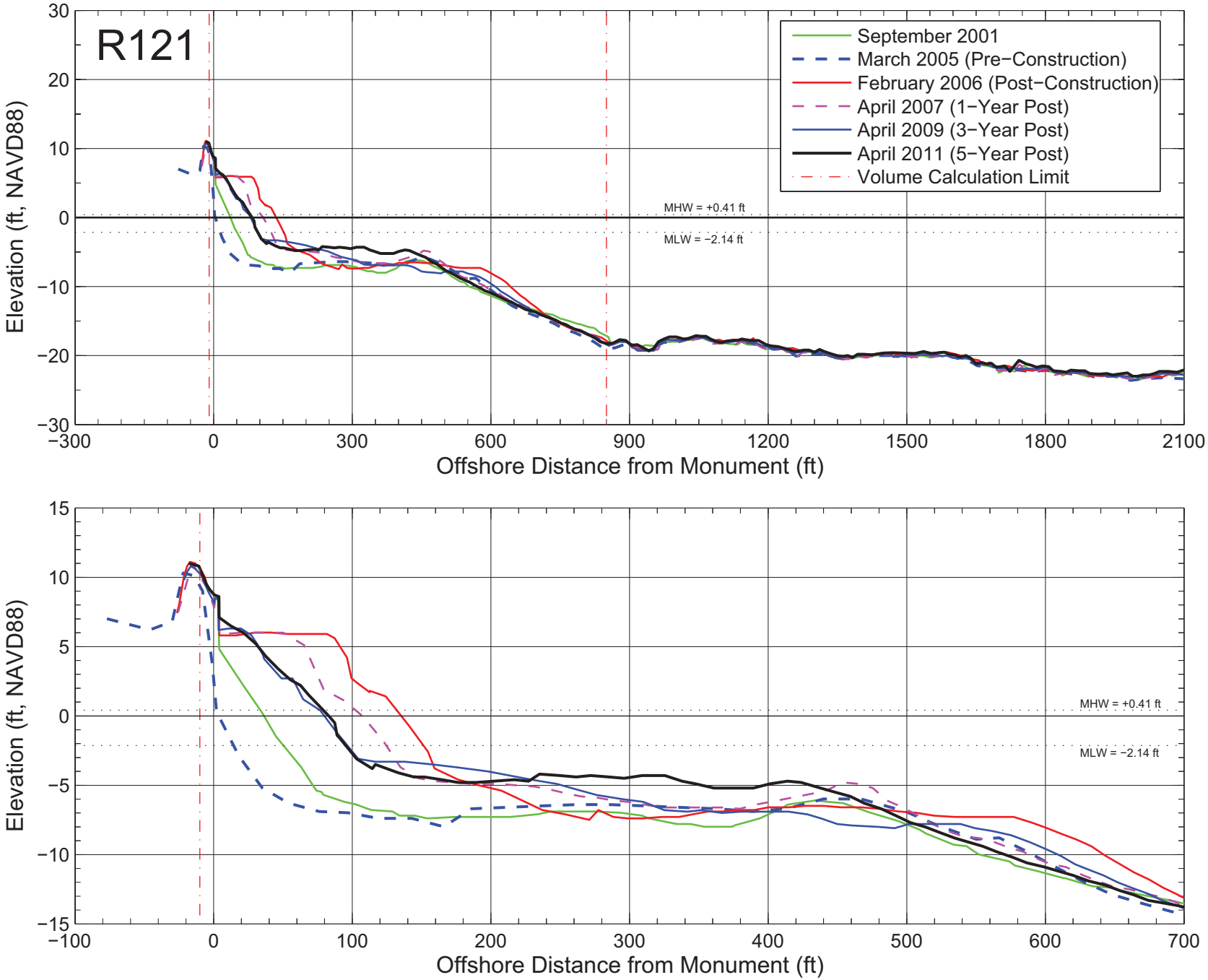


Figure A–142: Measured beach profiles at monument R121 Broward County, Florida.

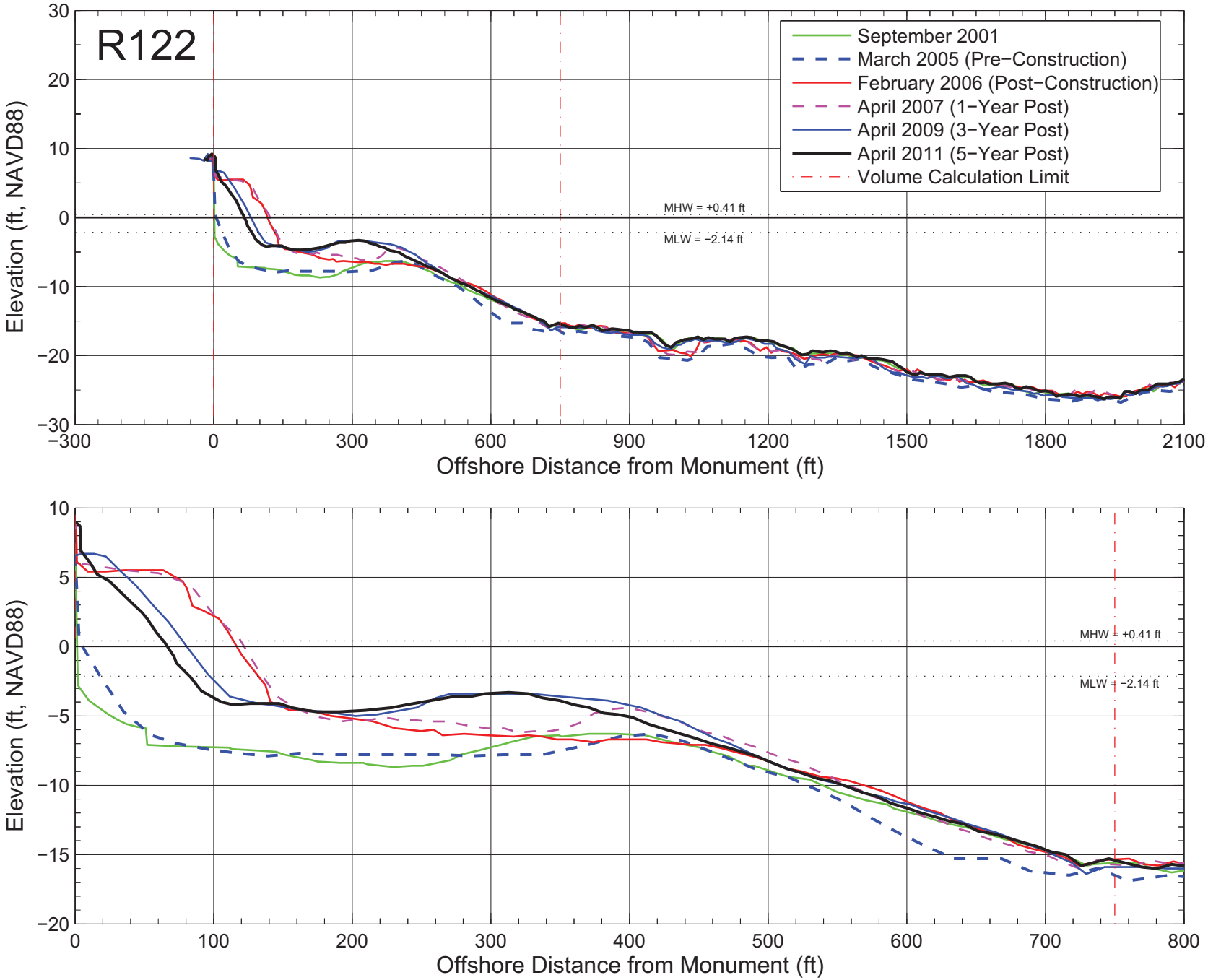


Figure A–143: Measured beach profiles at monument R122 Broward County, Florida.

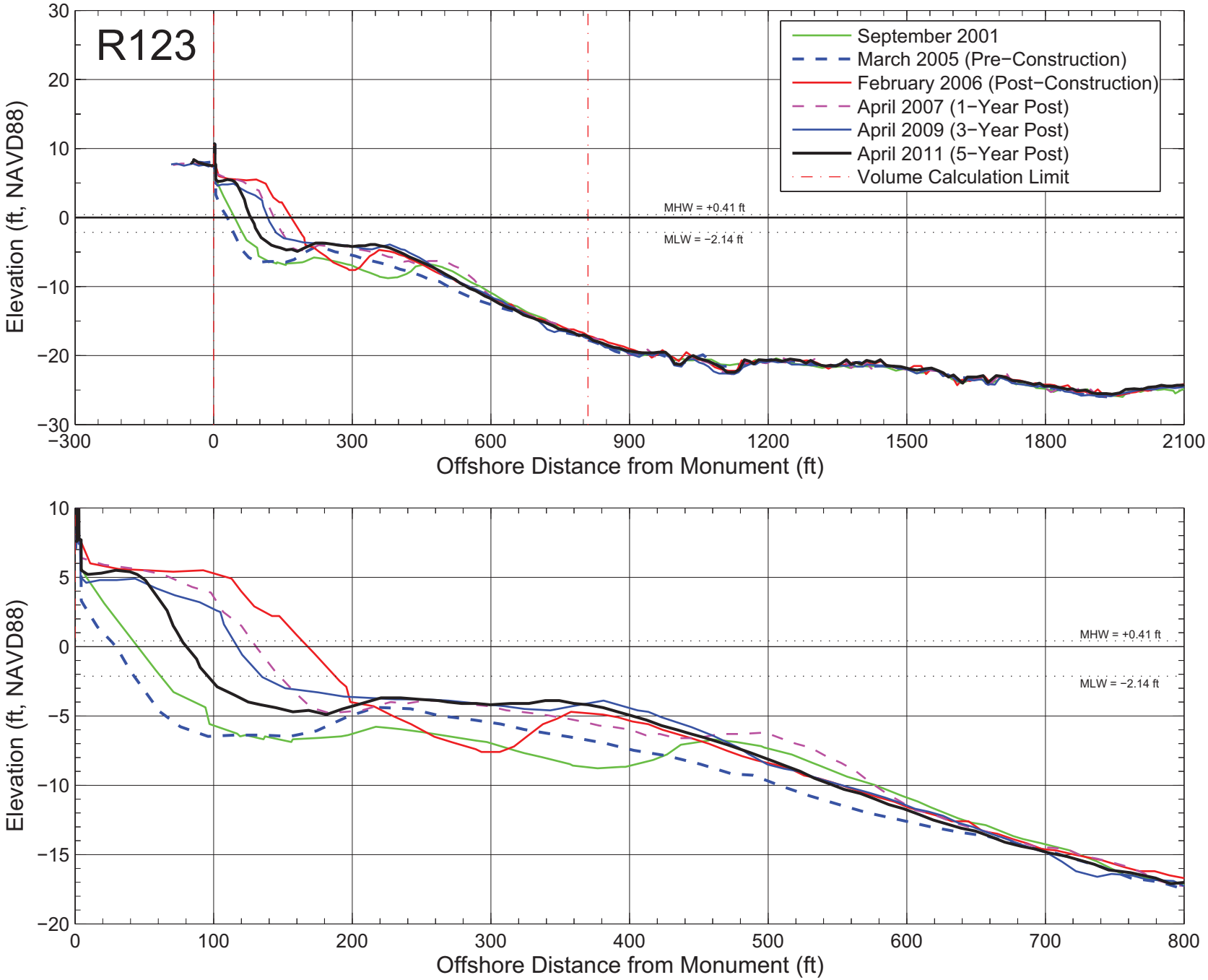


Figure A–144: Measured beach profiles at monument R123 Broward County, Florida.

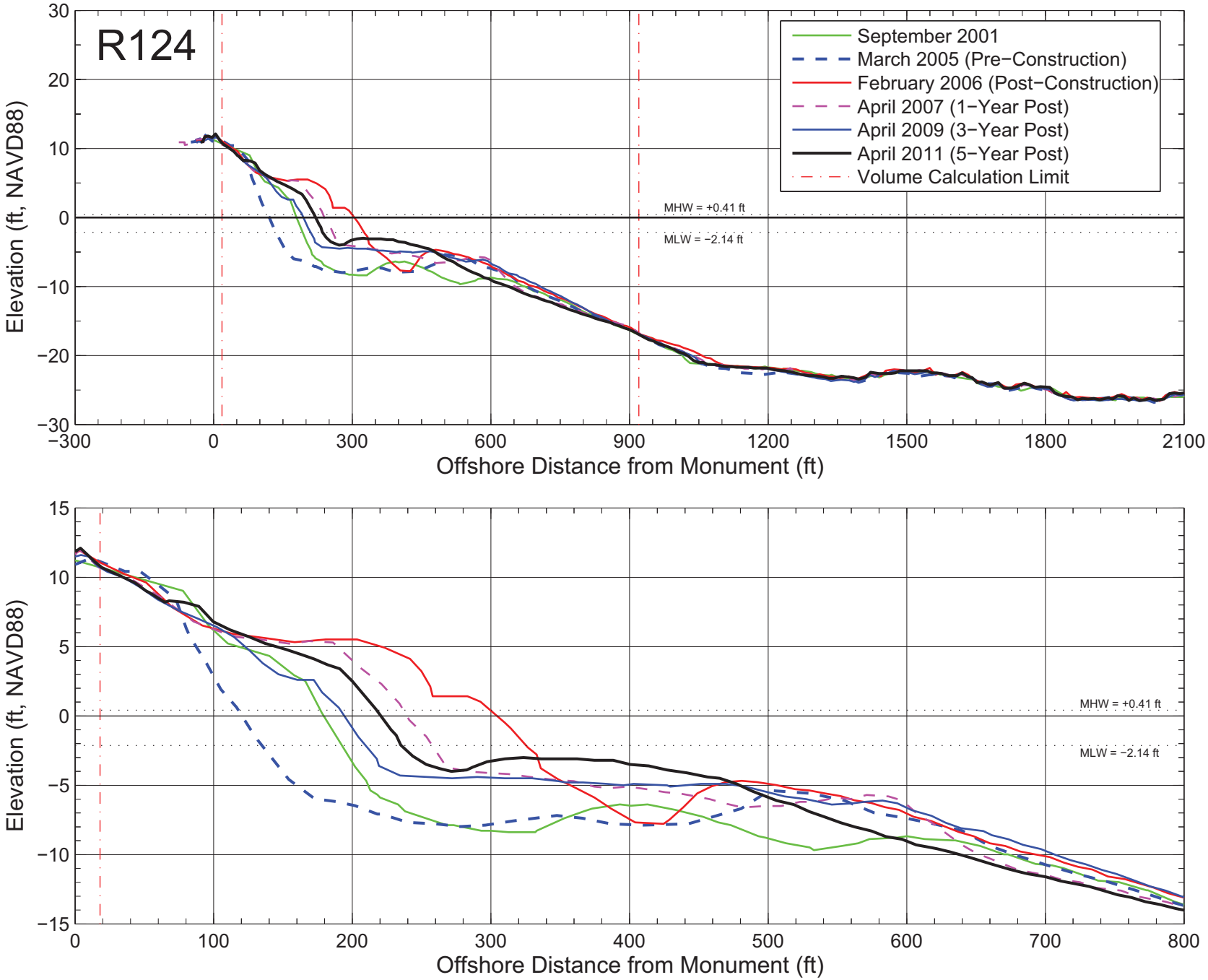


Figure A–145: Measured beach profiles at monument R124 Broward County, Florida.

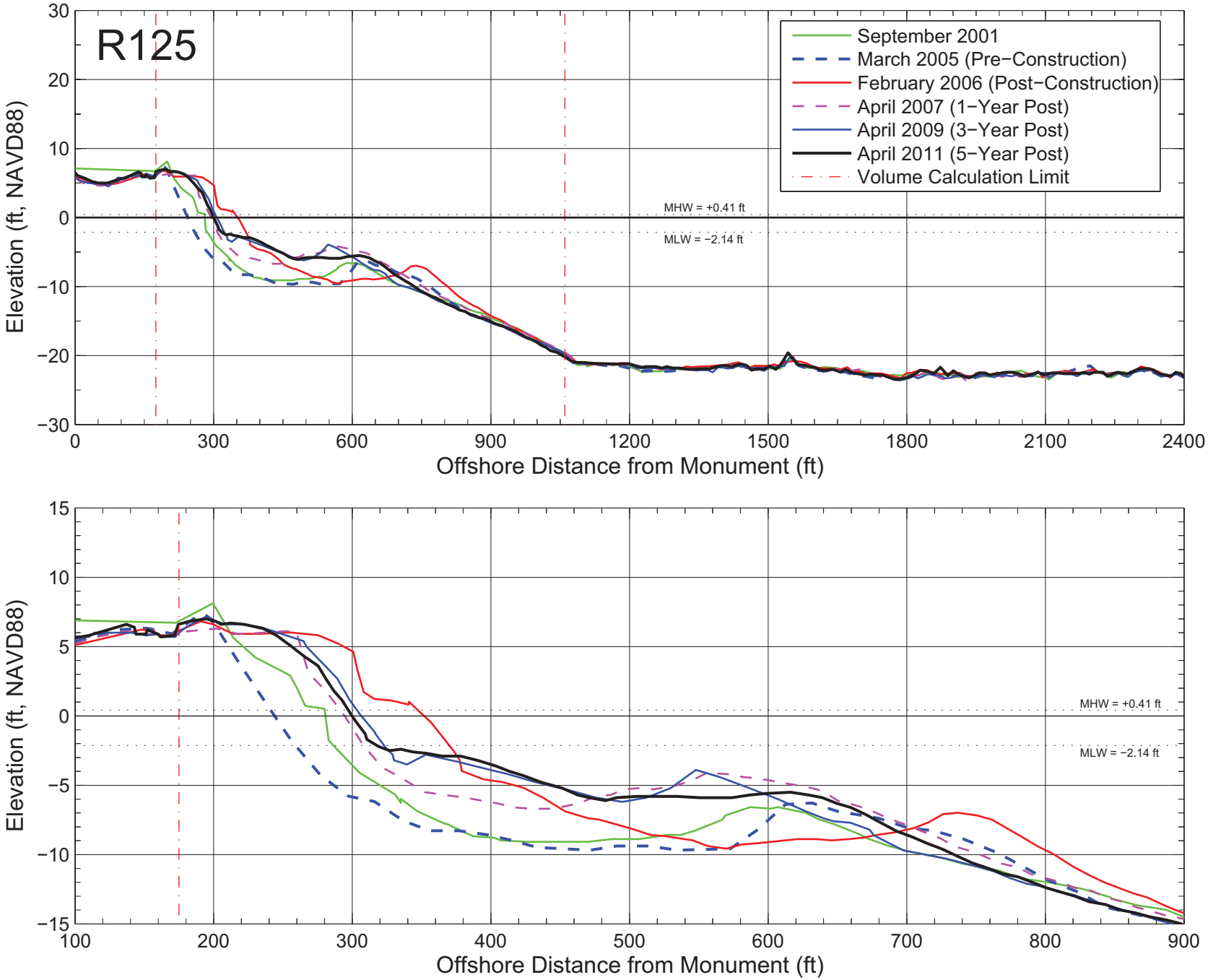


Figure A–146: Measured beach profiles at monument R125 Broward County, Florida.

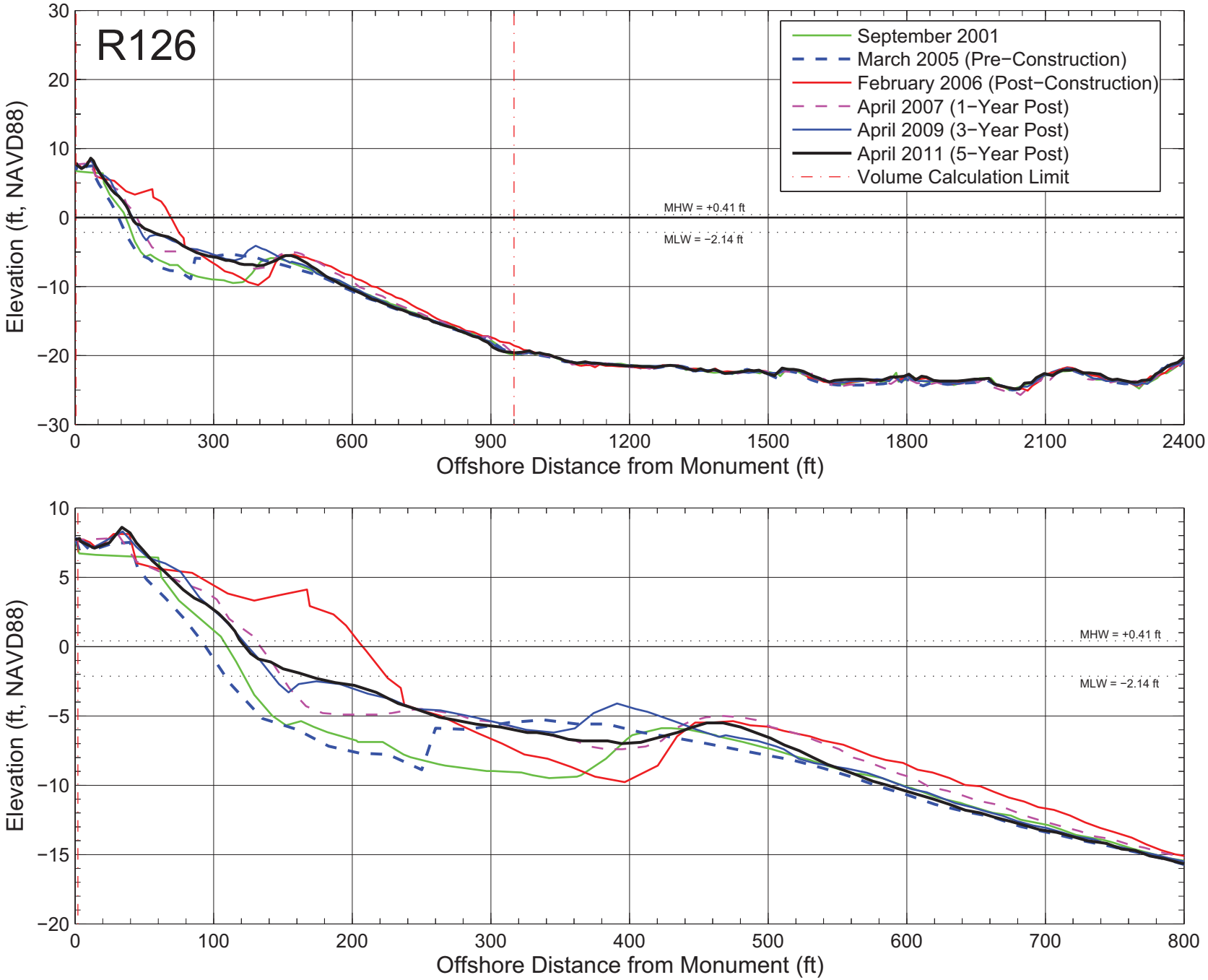


Figure A–147: Measured beach profiles at monument R126 Broward County, Florida.

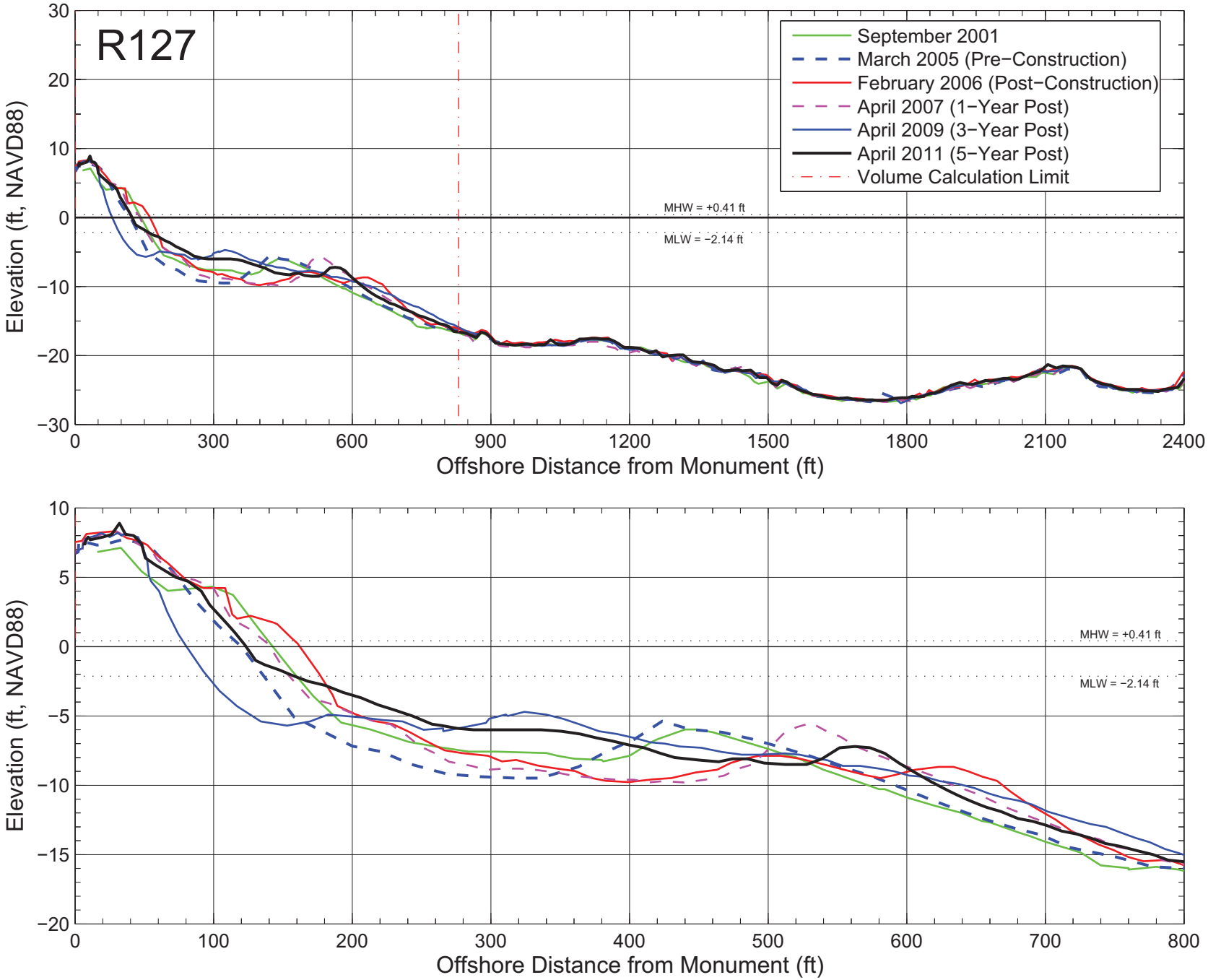


Figure A–148: Measured beach profiles at monument R127 Broward County, Florida.

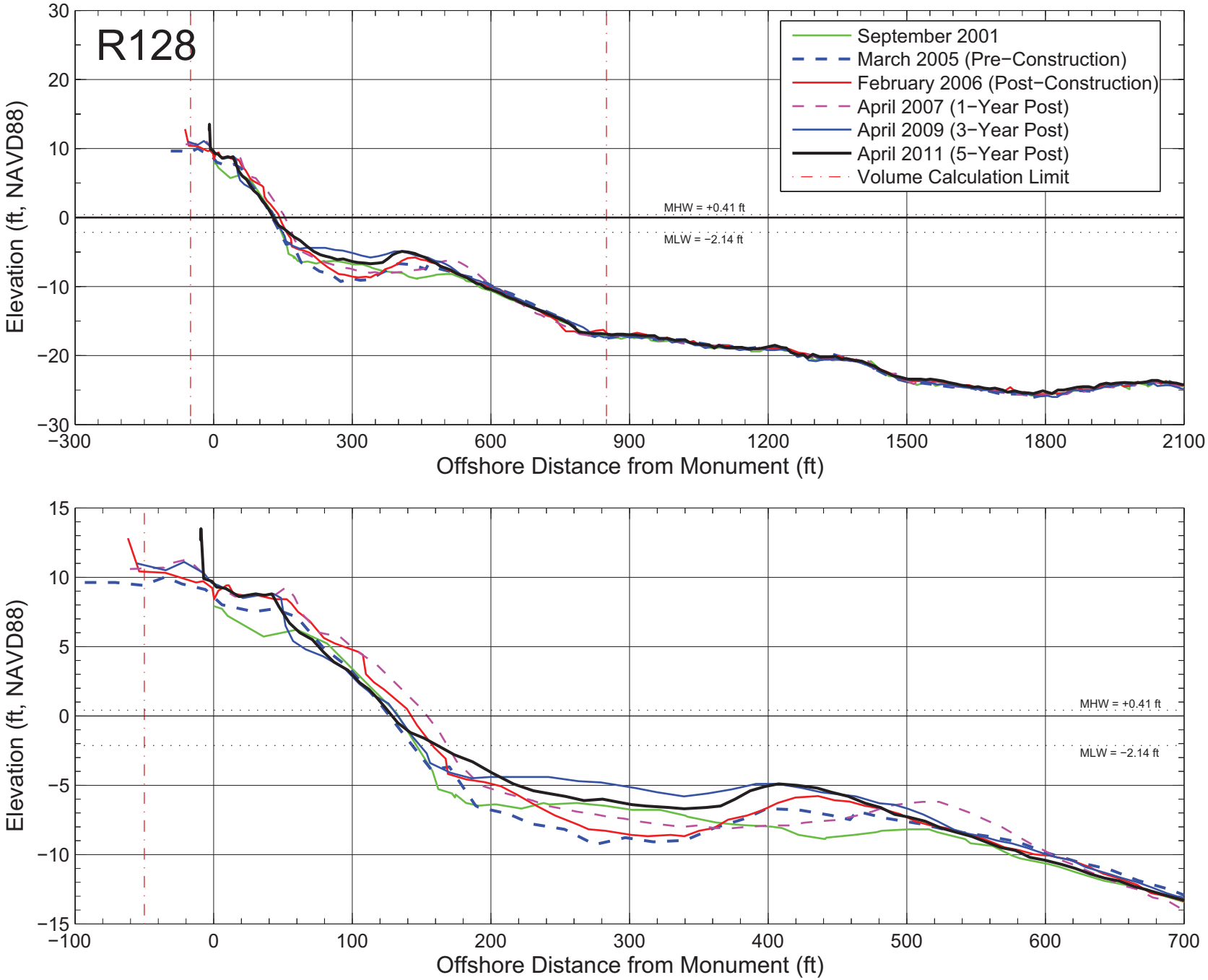


Figure A–149: Measured beach profiles at monument R128 Broward County, Florida.

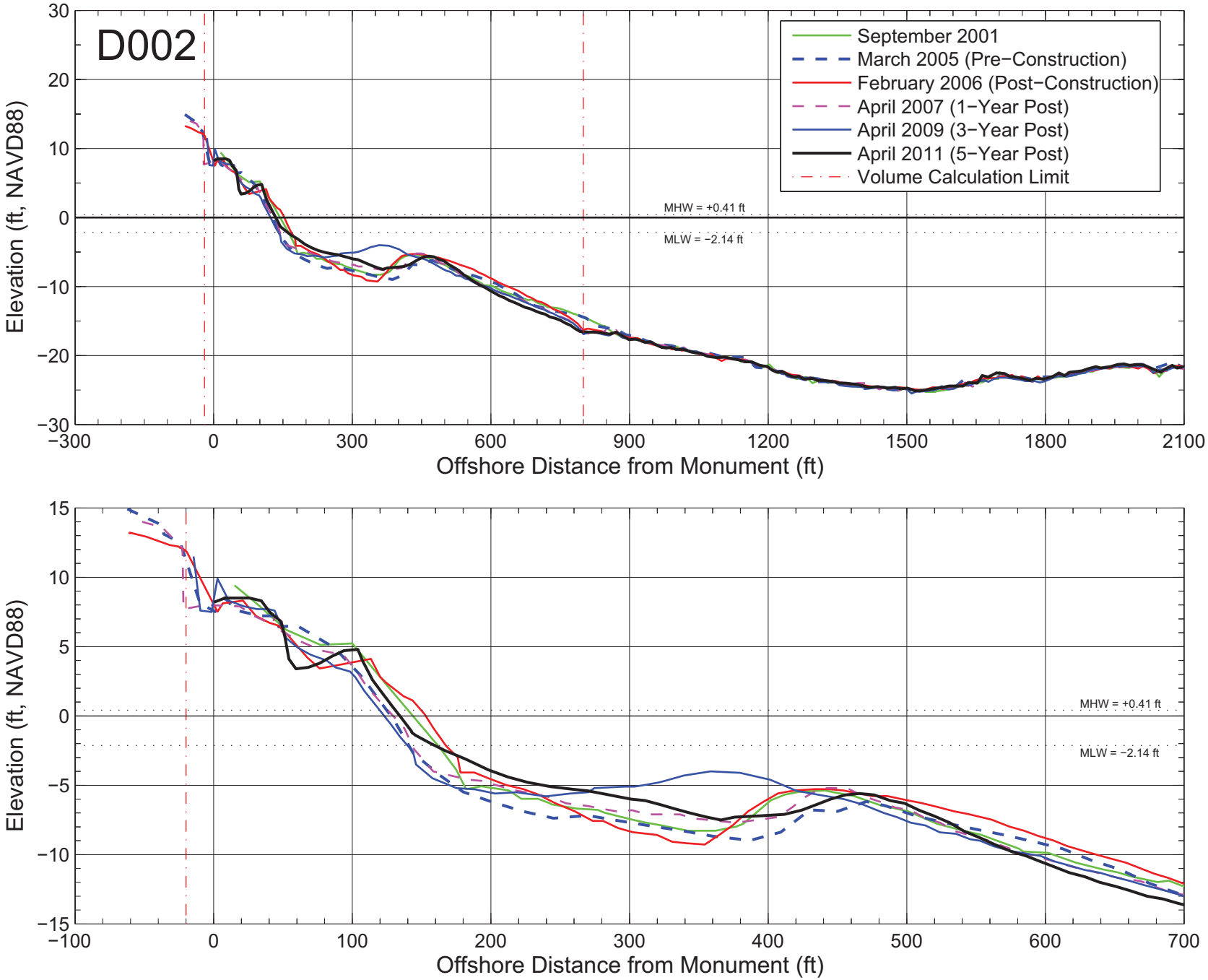


Figure A–150: Measured beach profiles at monument D002 Broward County, Florida.

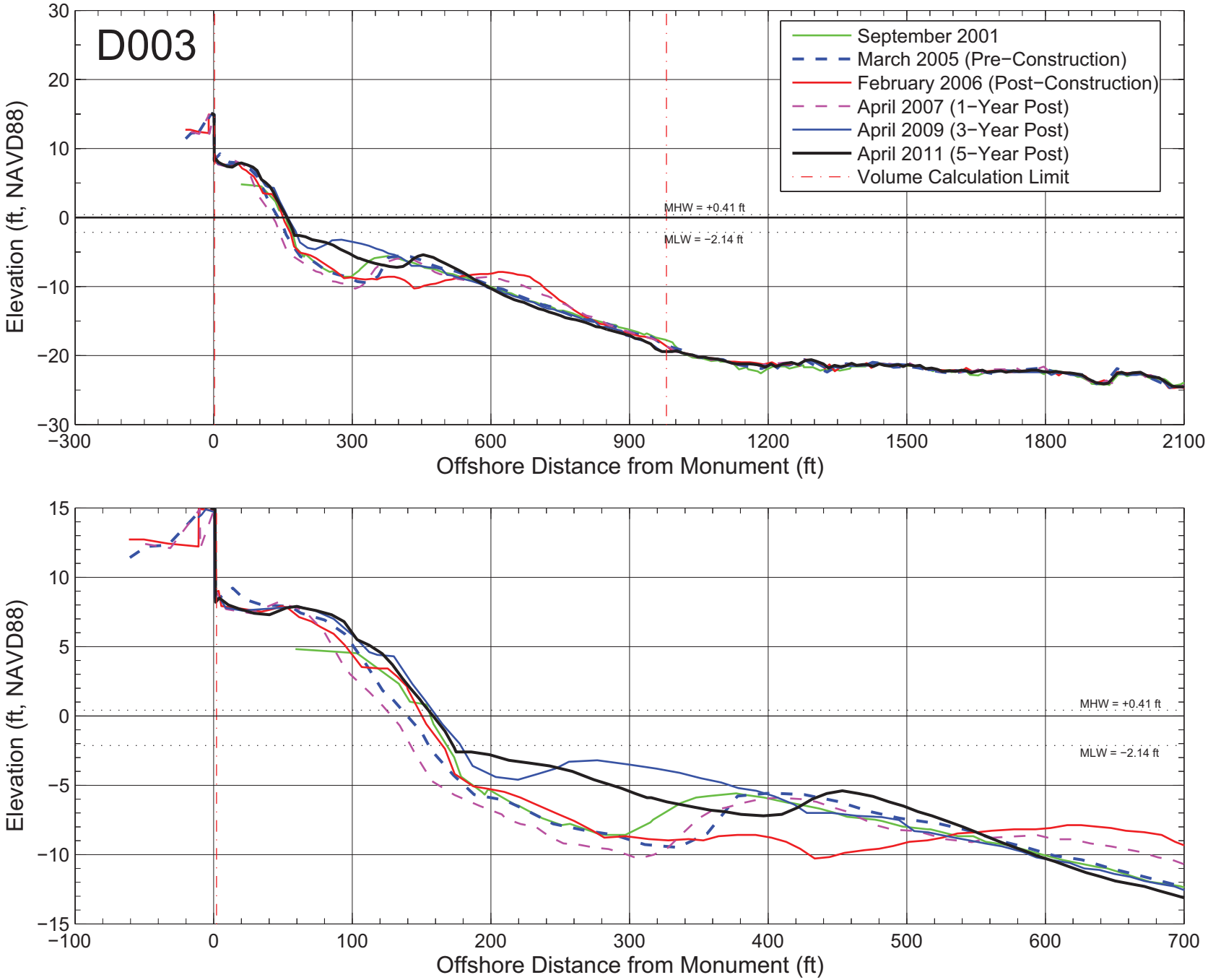


Figure A–151: Measured beach profiles at monument D003 Broward County, Florida.

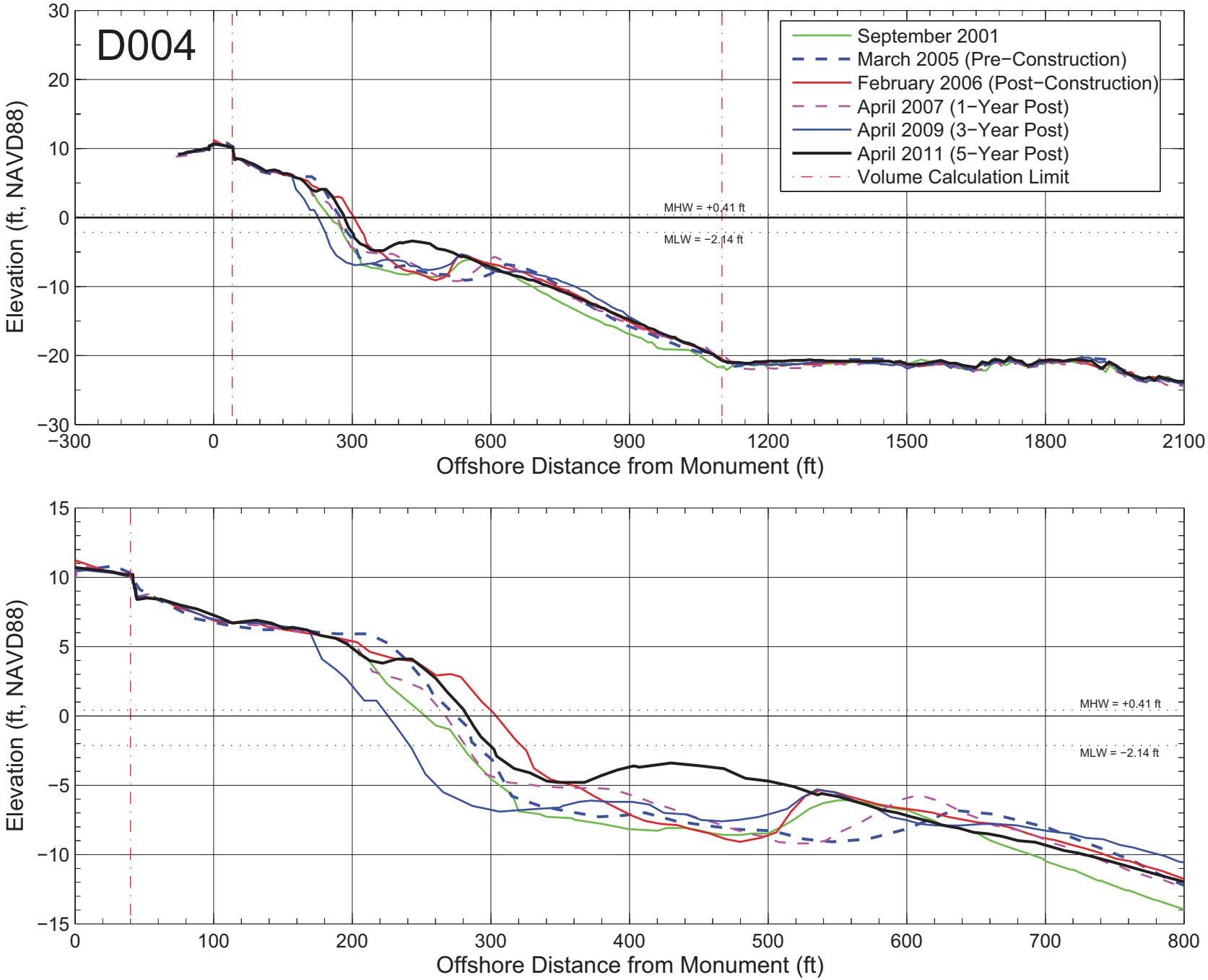


Figure A–152: Measured beach profiles at monument D004 Broward County, Florida.

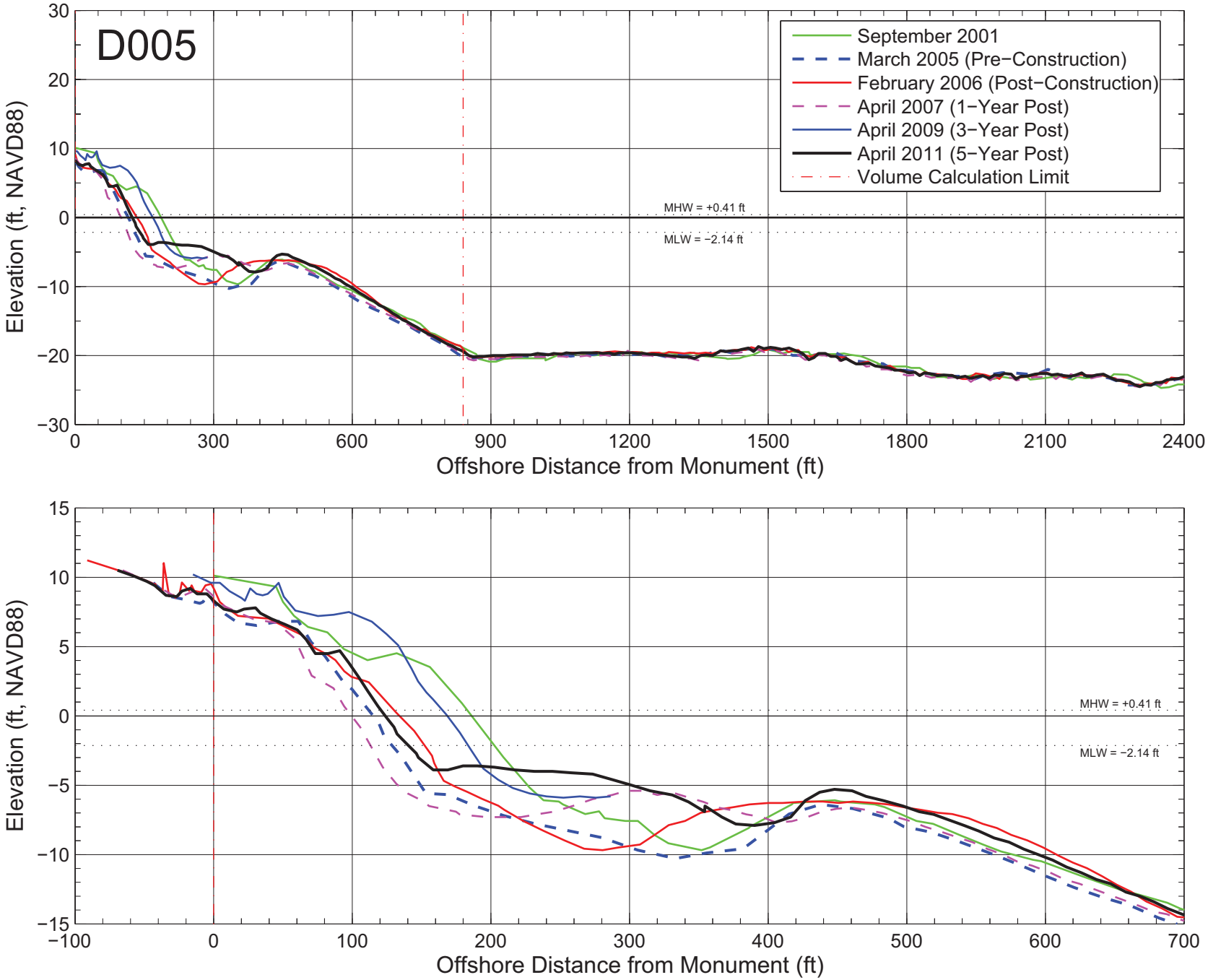


Figure A−153: Measured beach profiles at monument D005 Broward County, Florida.

APPENDIX B: Shoreline Aerial Photography - 13 July 2011

This appendix contains aerial photography of the Broward County shoreline flown on 13 July 2011 by Southern Resource Mapping of Miami, Inc. The photography is presented as **Figures B.01** to **B.31**. Also depicted on the aerials are the FDEP R-monument locations, the April 2011 survey elevations and recent Mean High Water Line locations (MHWL +0.41 ft-NAVD88). All elevations shown are referenced to the North American Vertical Datum of 1988 (NAVD88).

Figure B-01: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

Figure B-02: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2009. Survey elevations: April 2011 (ft, NAVD88).

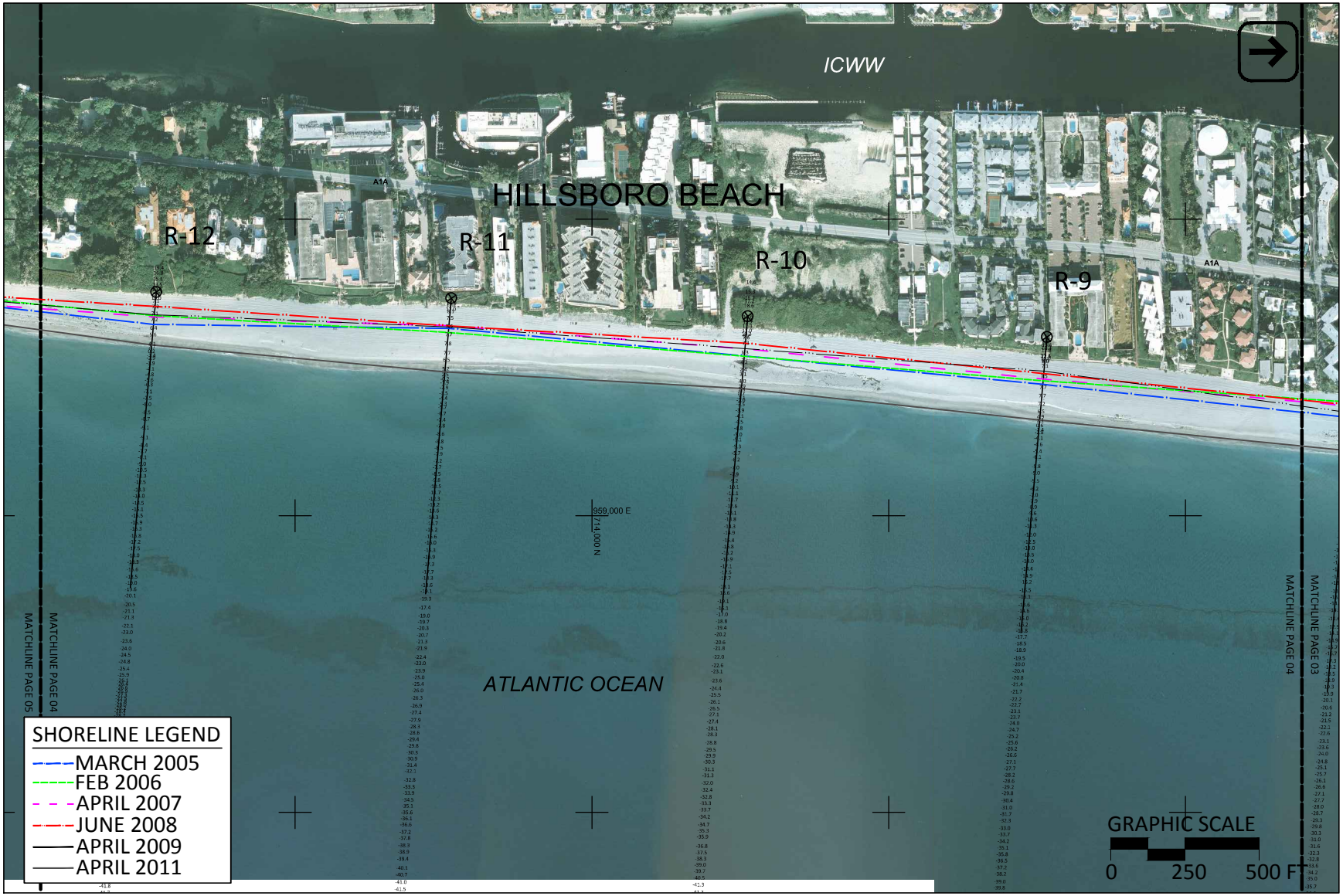


Figure B-03: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

Figure B-04: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

Figure B-05: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

Figure B-06: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

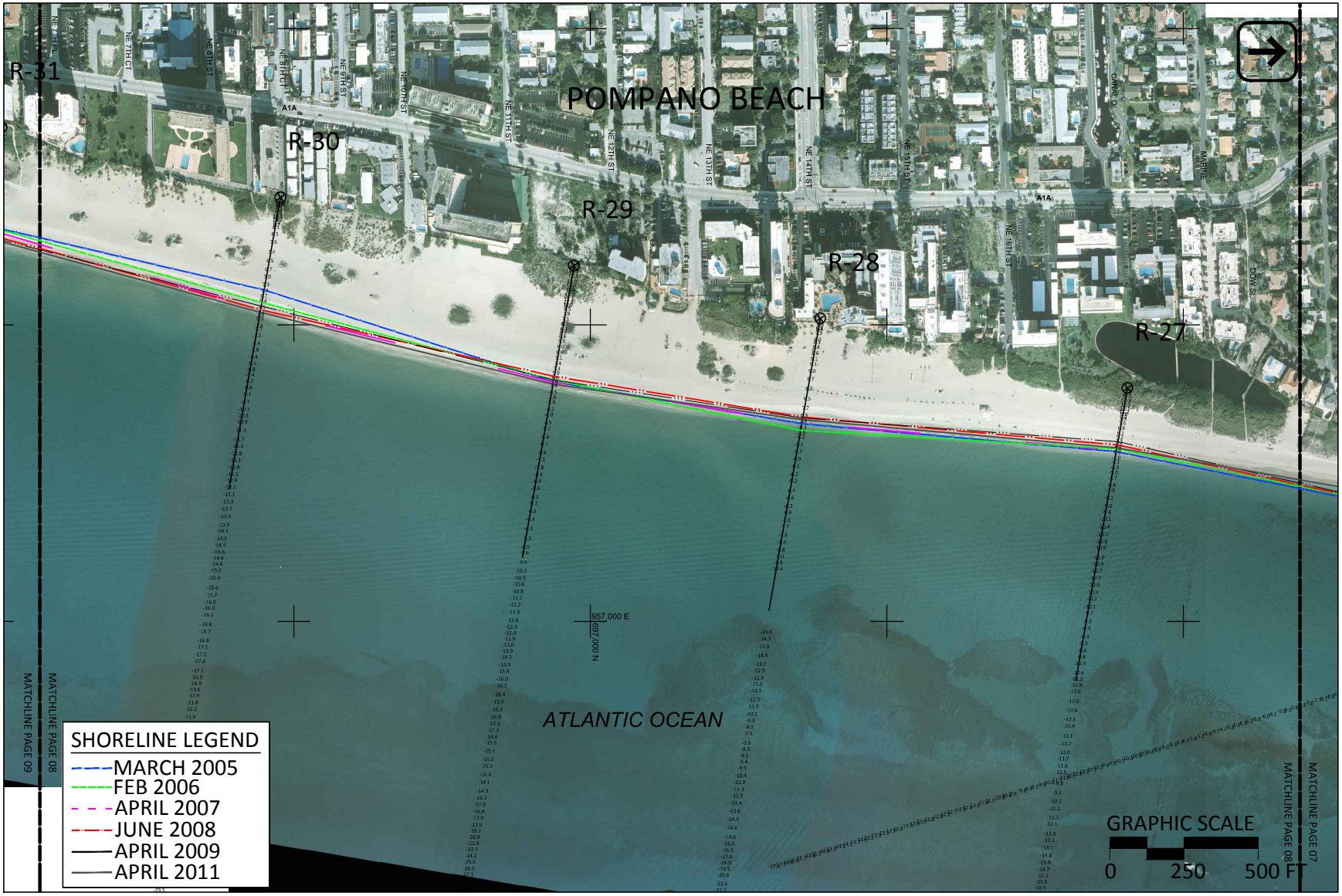


Figure B-07: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

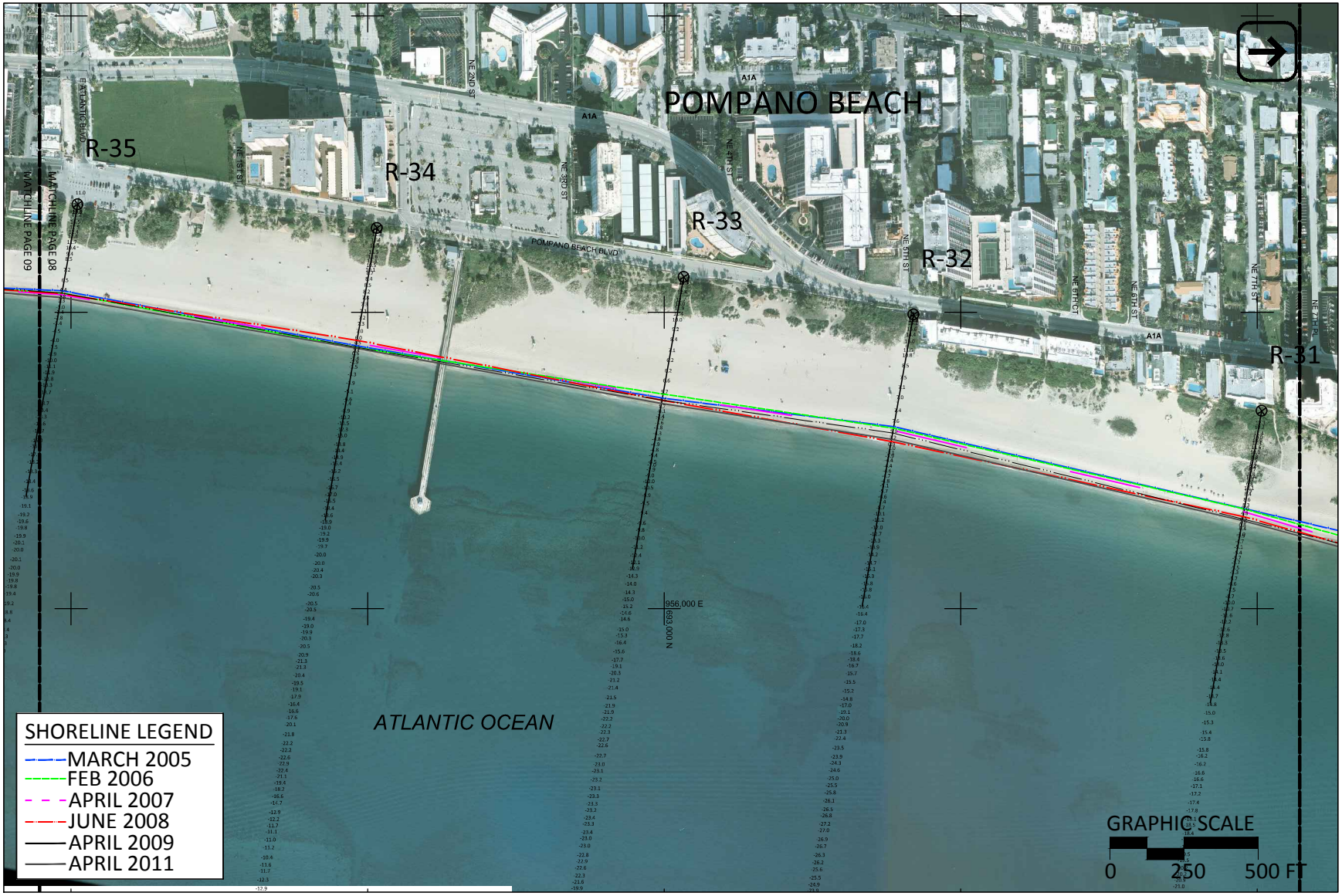


Figure B-08: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

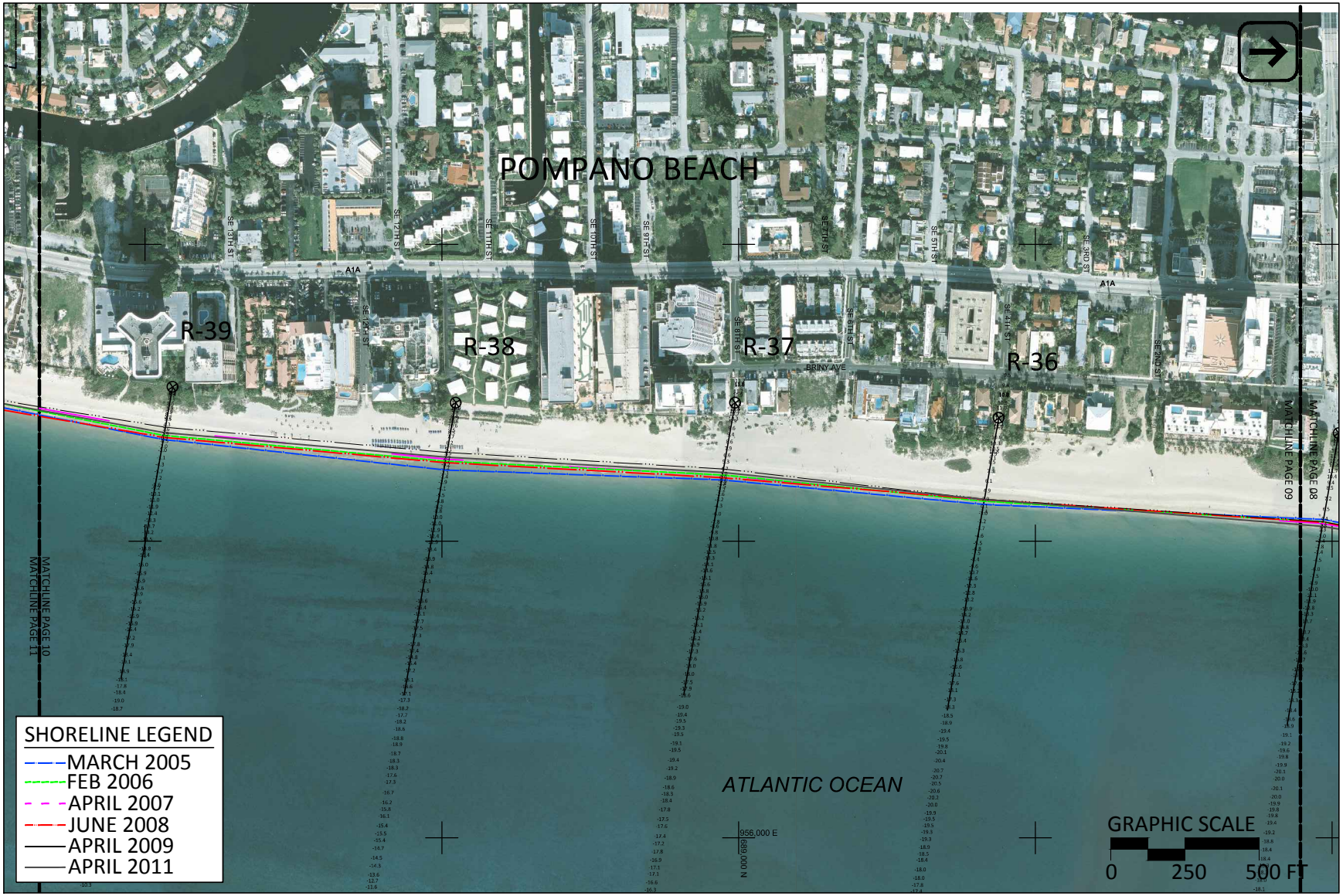


Figure B-09: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

Figure B-10: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

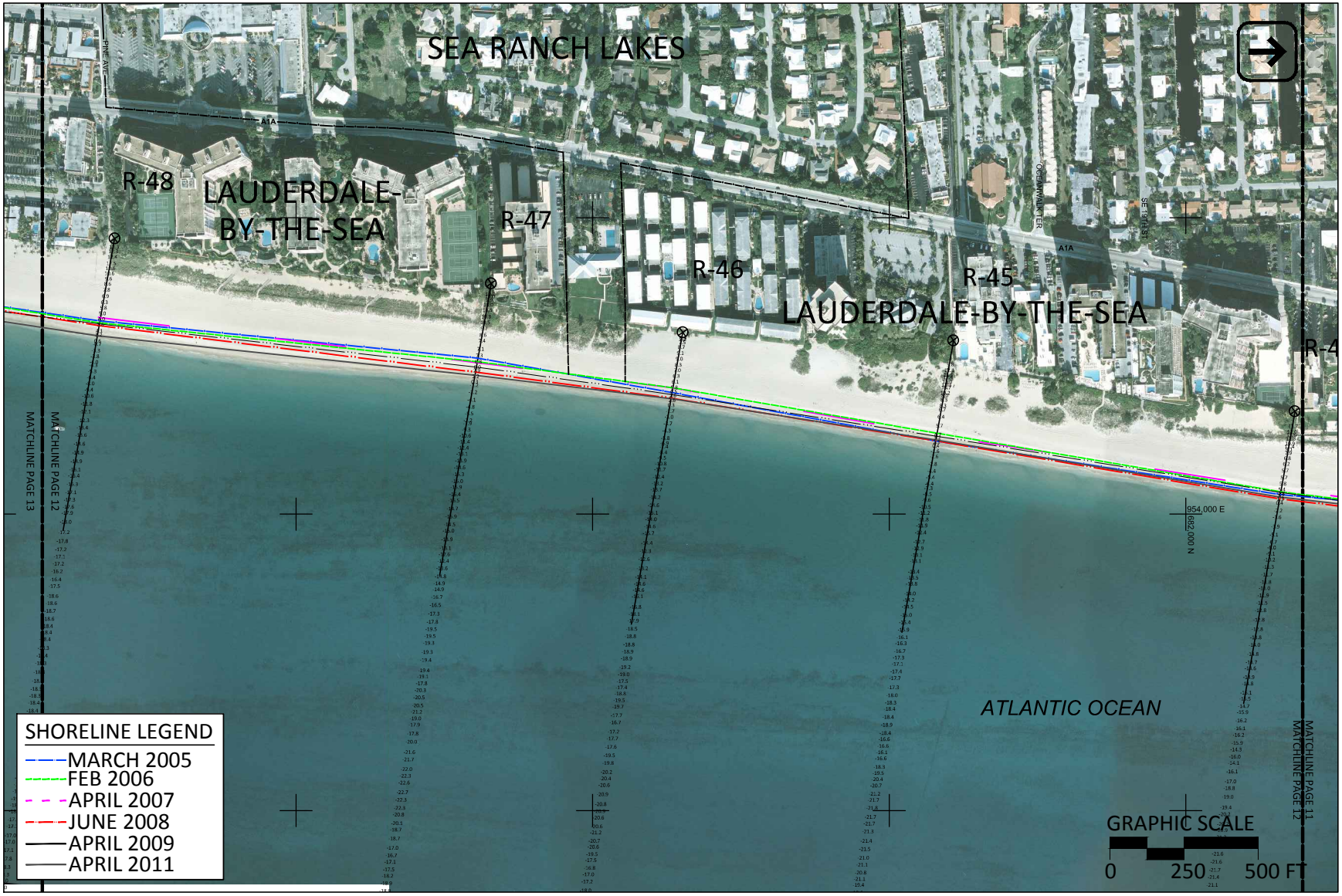


Figure B-11: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

Figure B-12: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

Figure B-13: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

Figure B-14: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

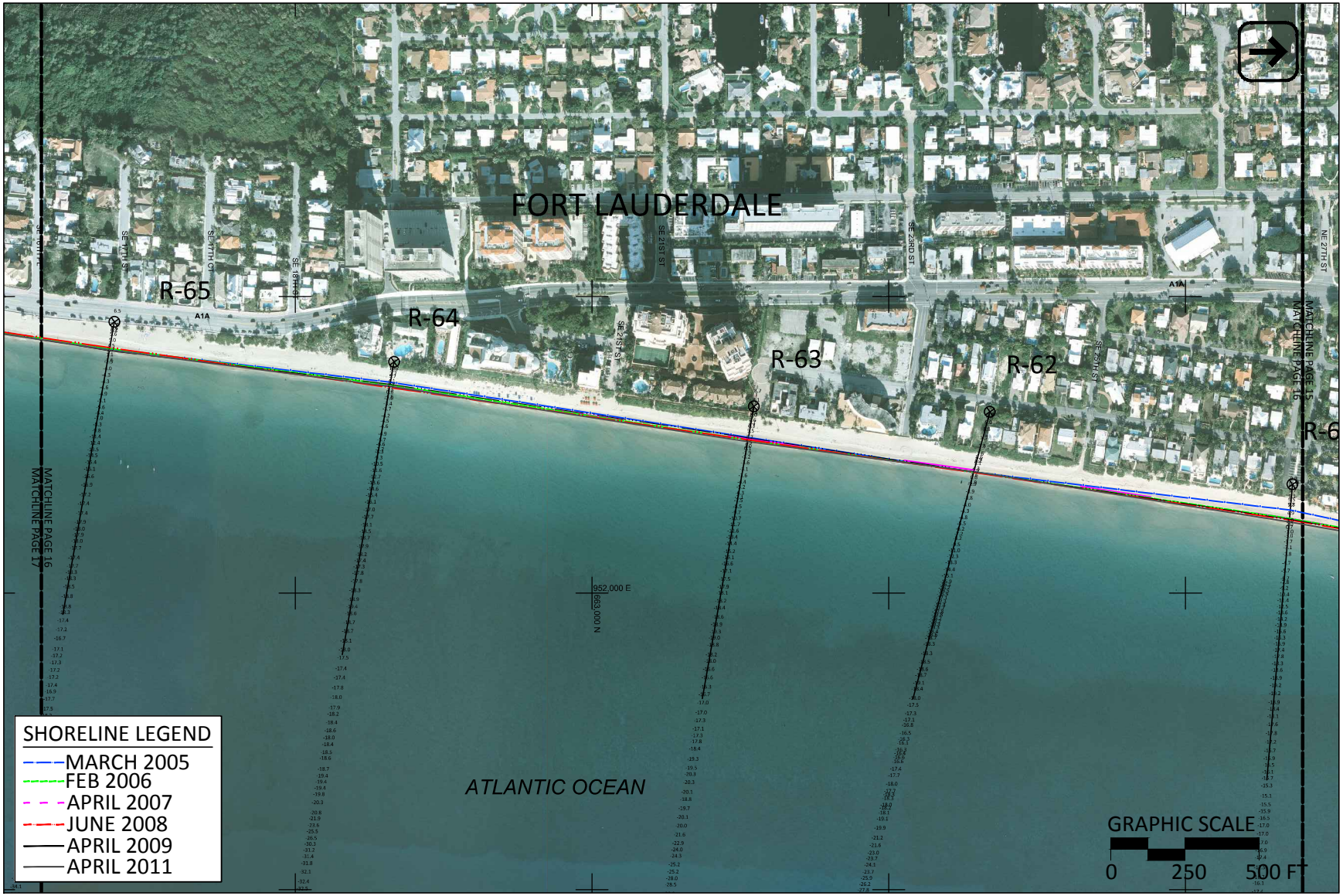


Figure B-15: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

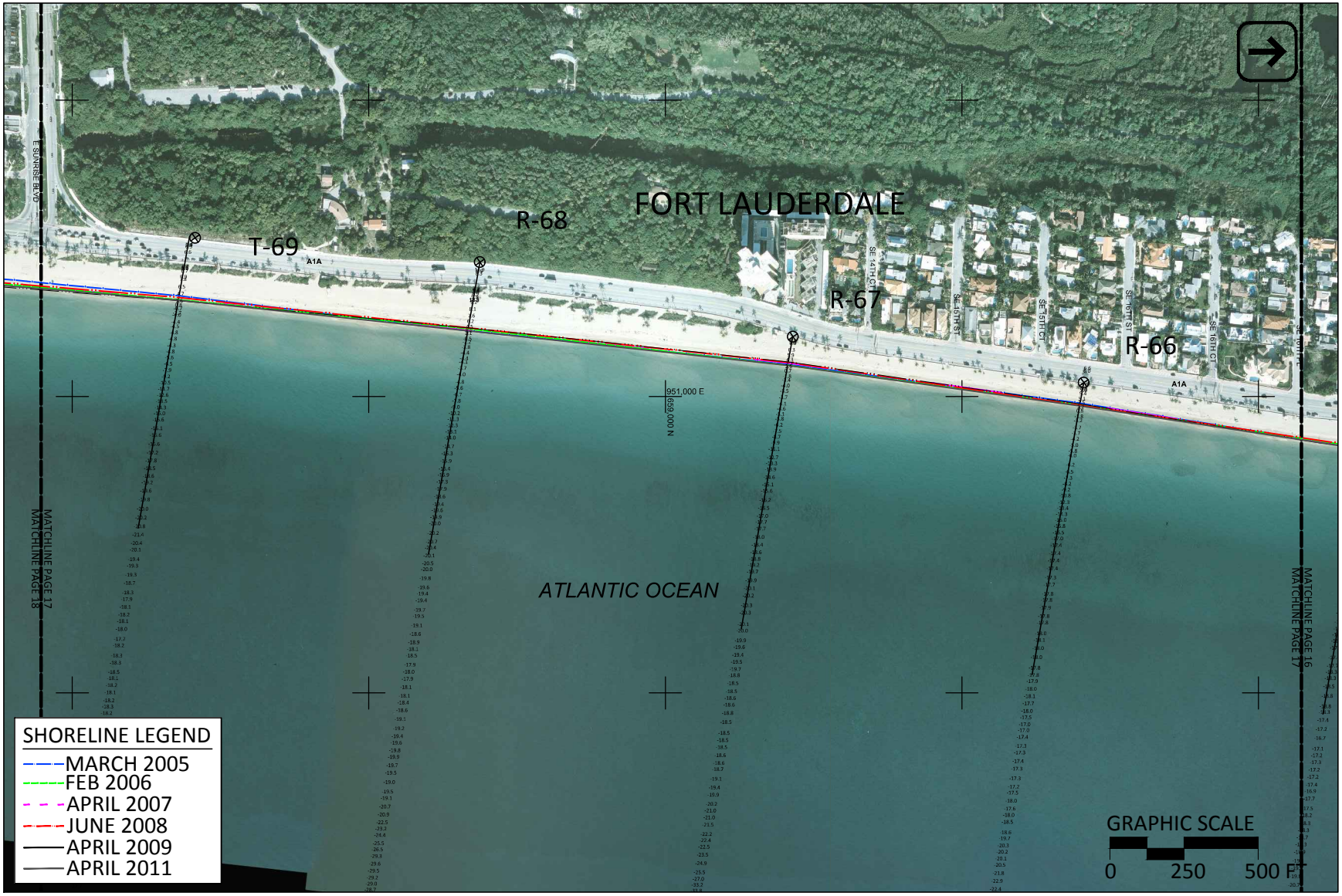


Figure B-16: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

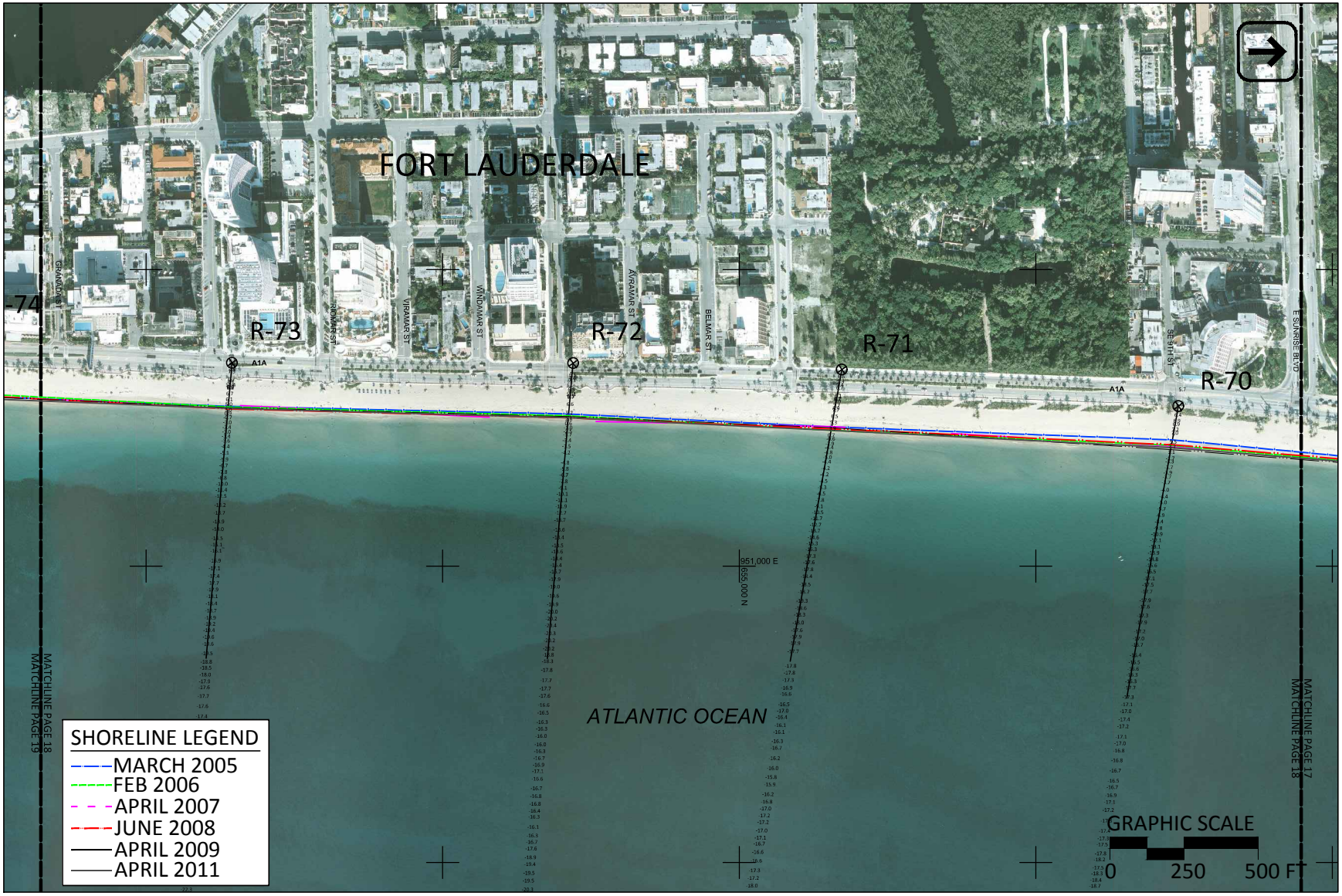


Figure B-17: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

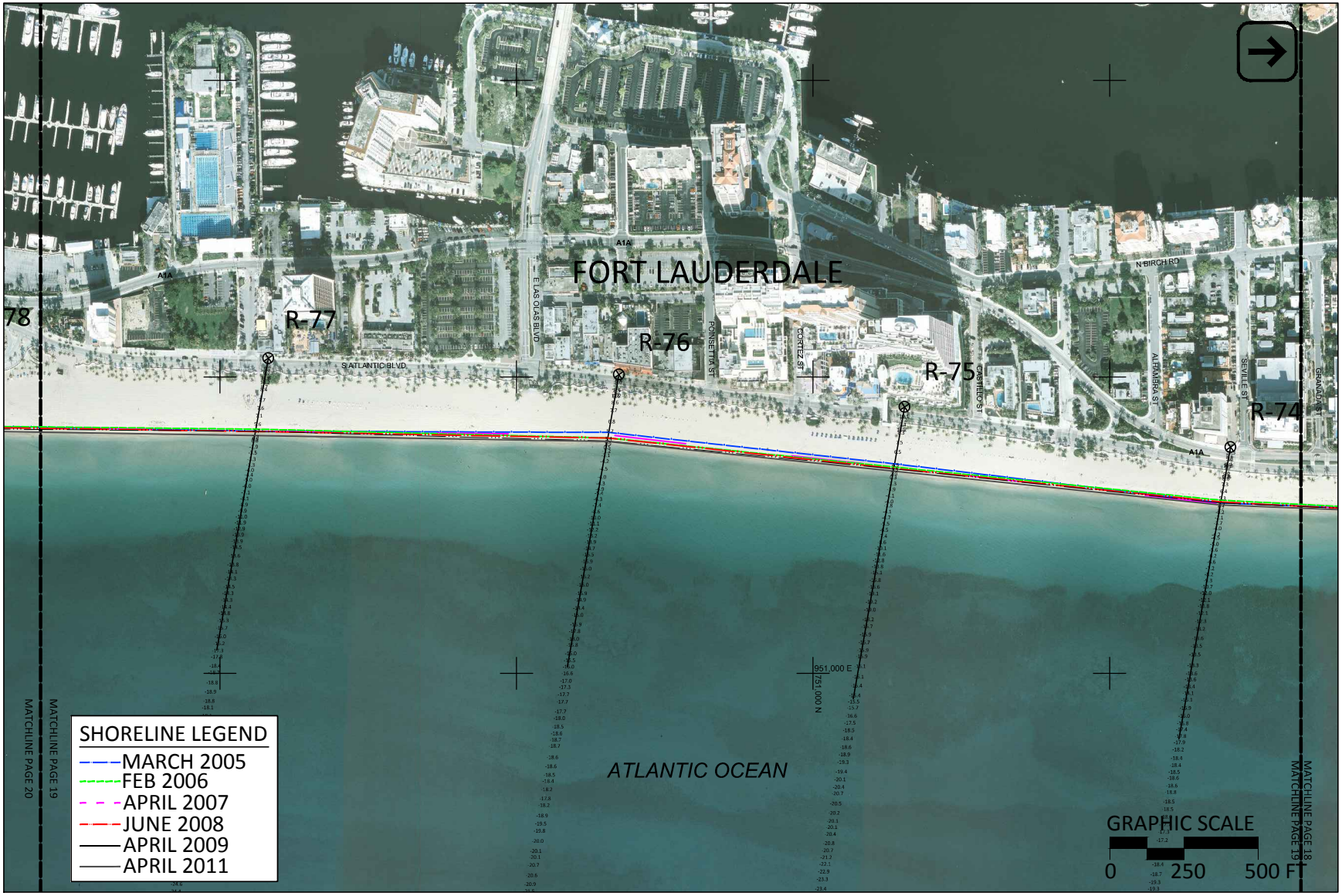


Figure B-18: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

Figure B-19: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

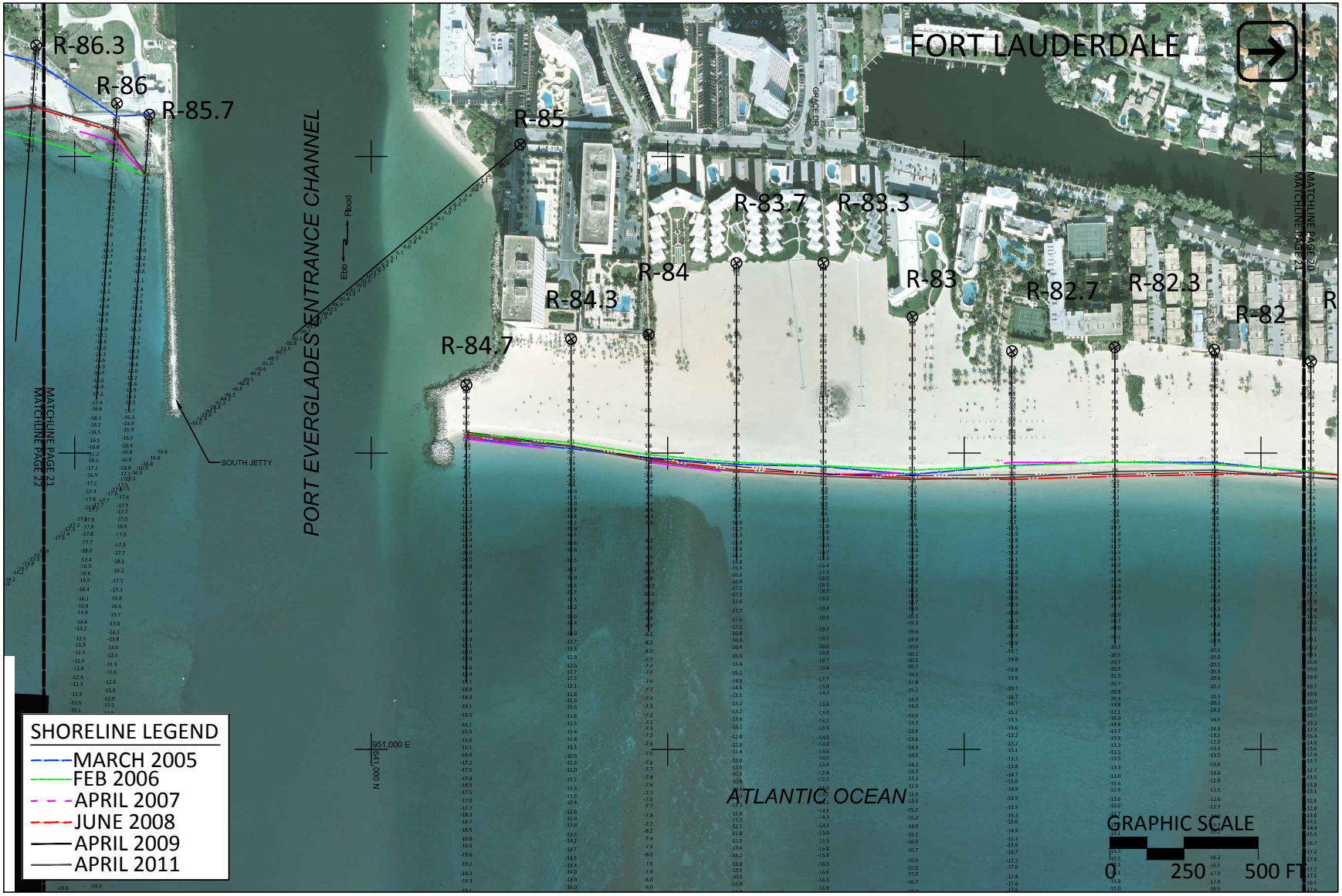


Figure B-20: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

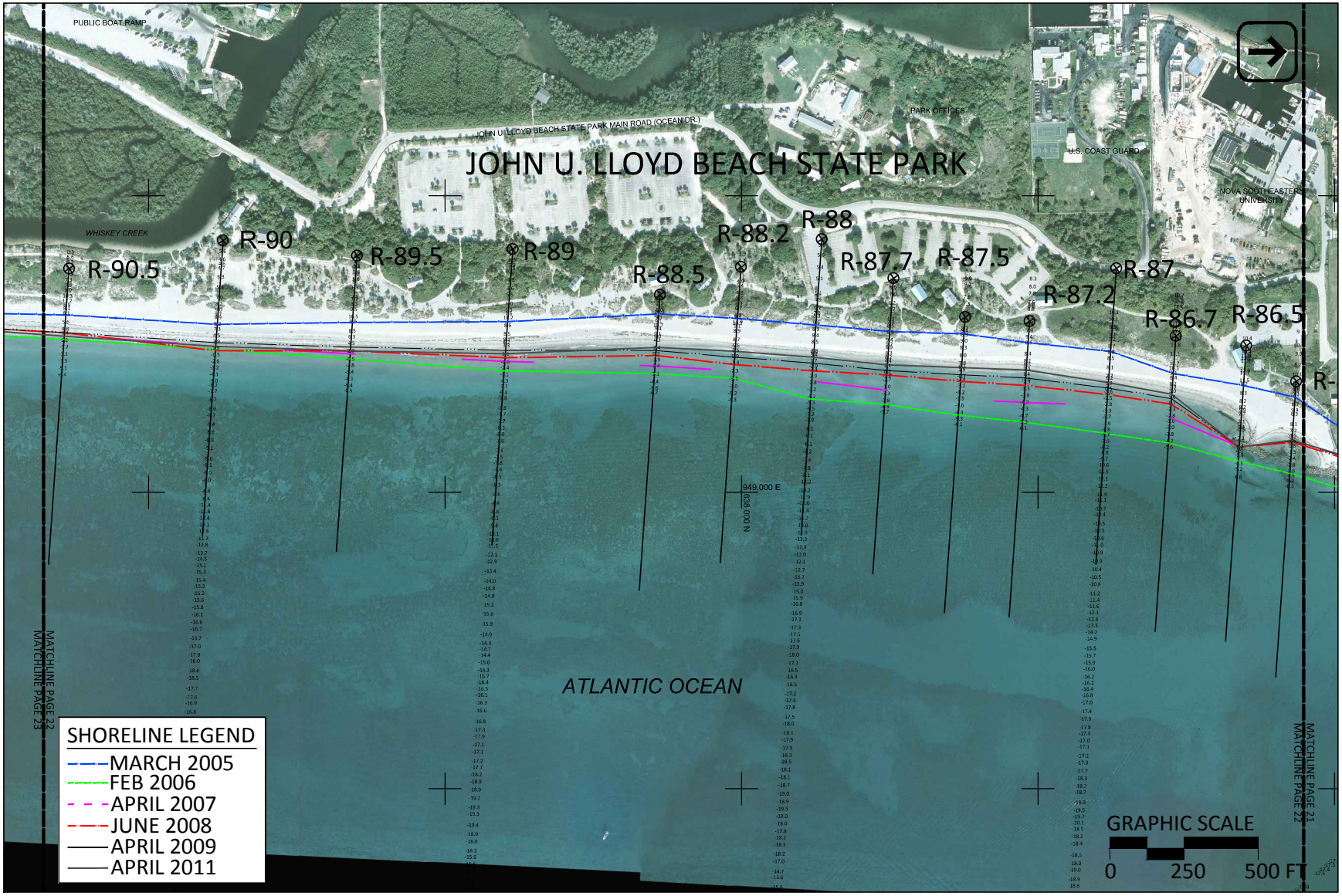


Figure B-21: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

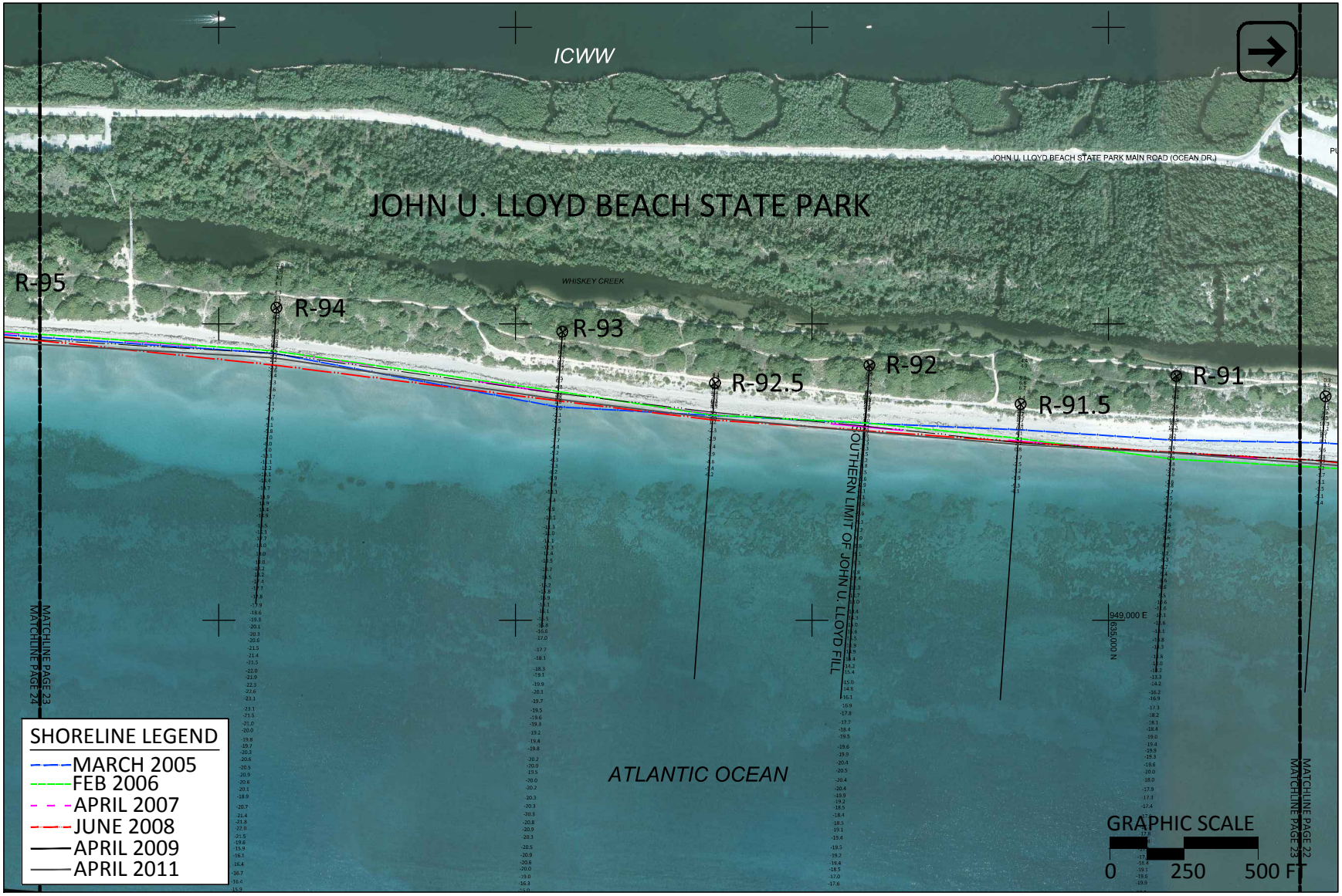


Figure B-22: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

Figure B-23: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

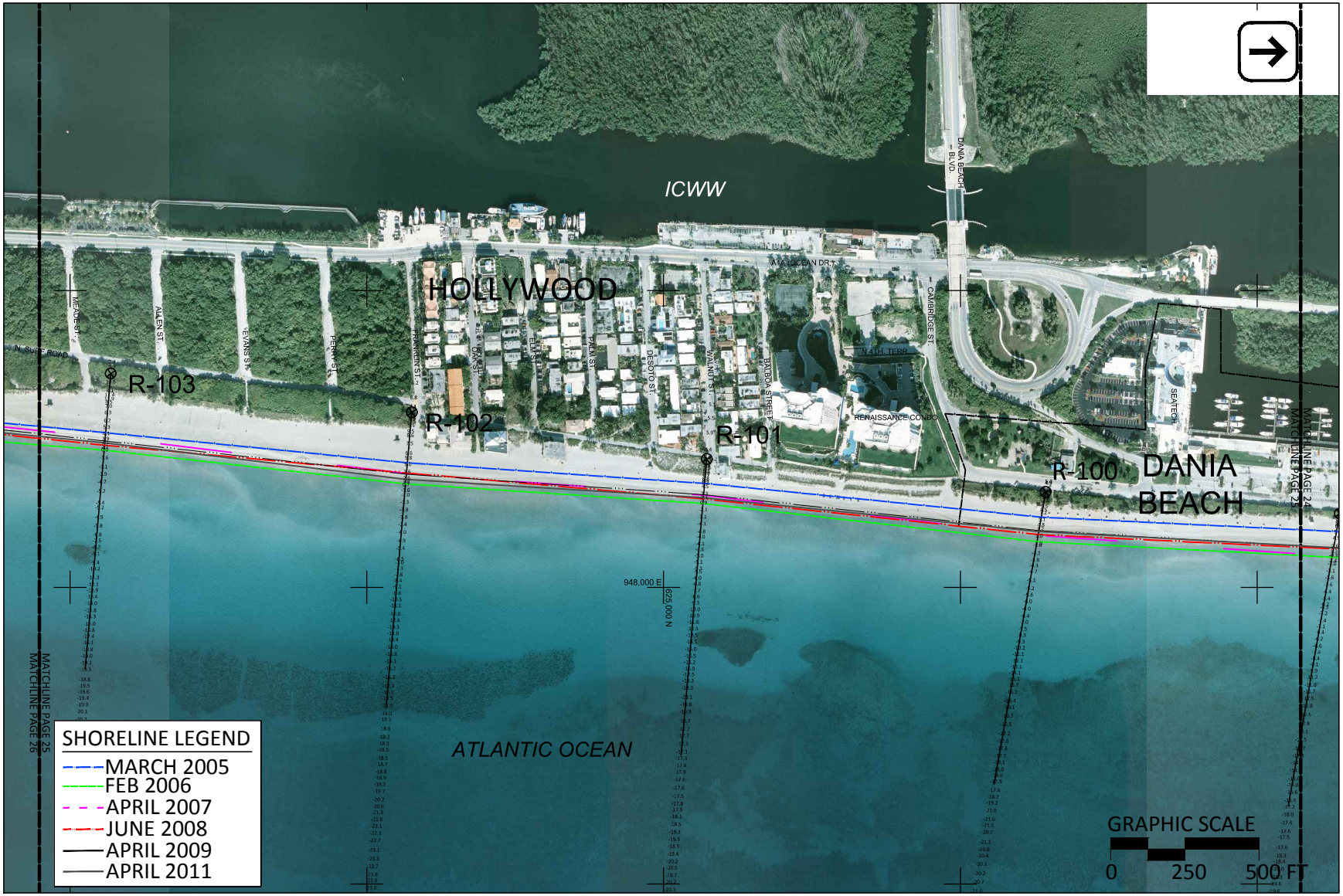


Figure B-24: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

Figure B-25: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

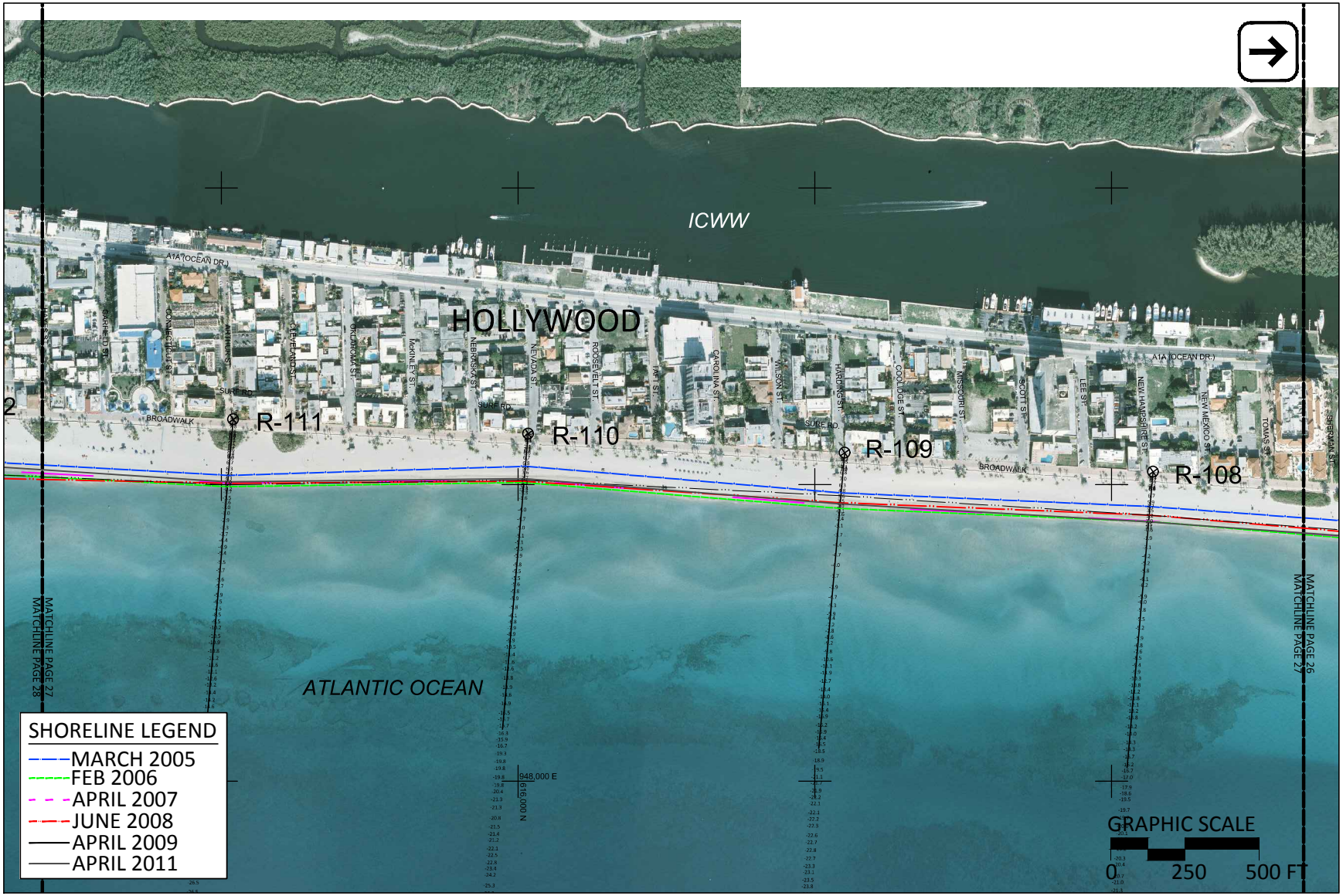


Figure B-26: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

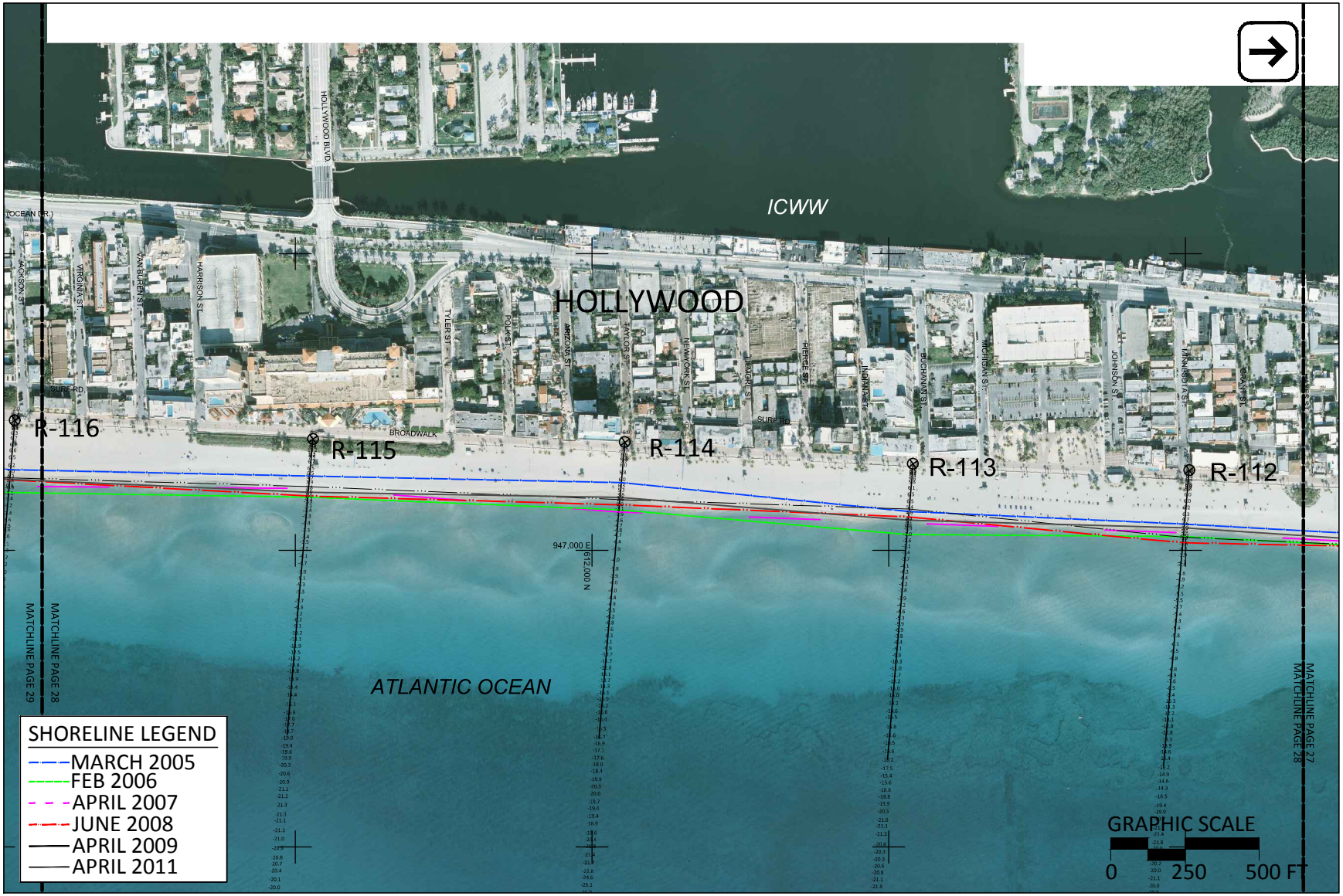


Figure B-27: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

Figure B-28: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

Figure B-29: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

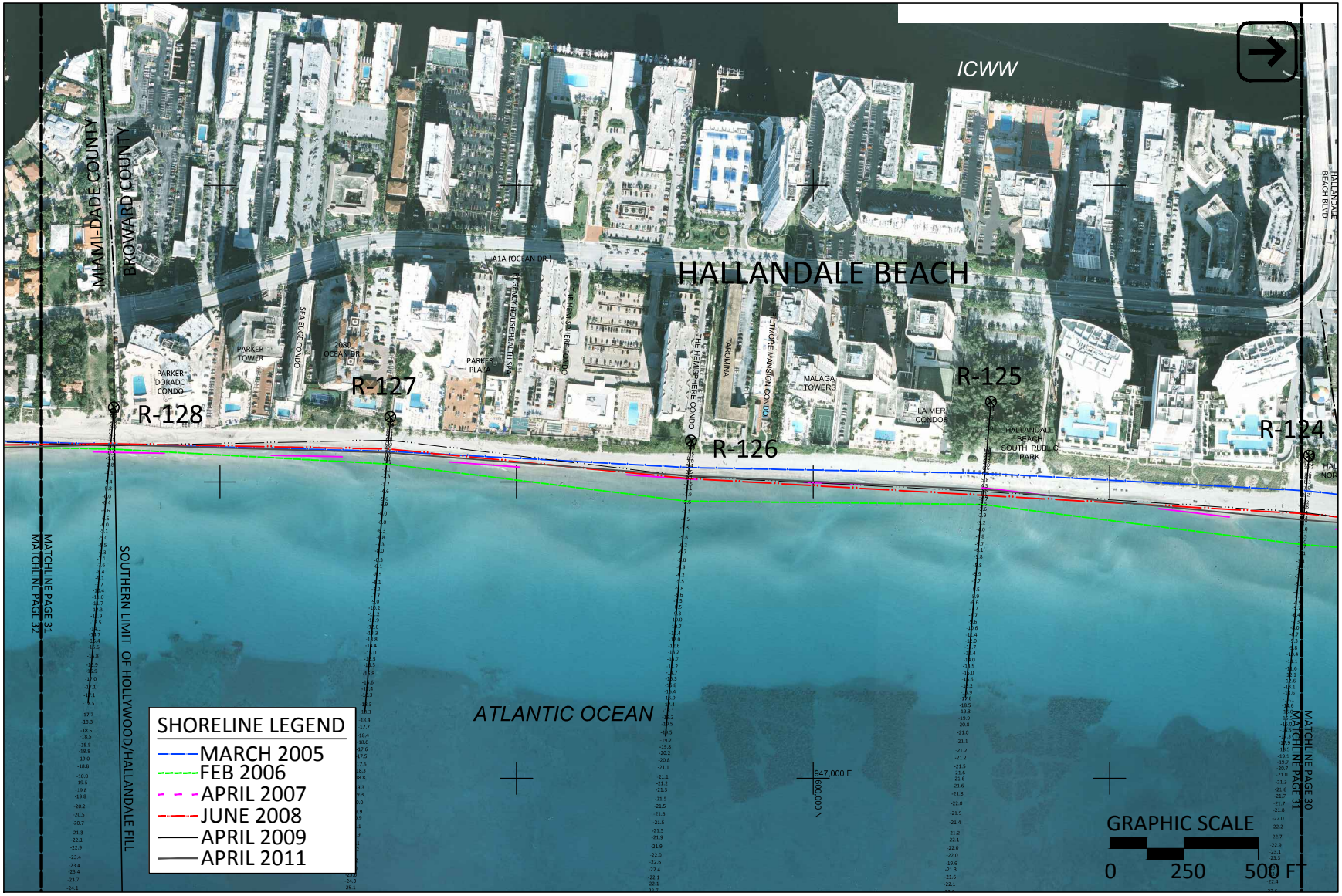


Figure B-30: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

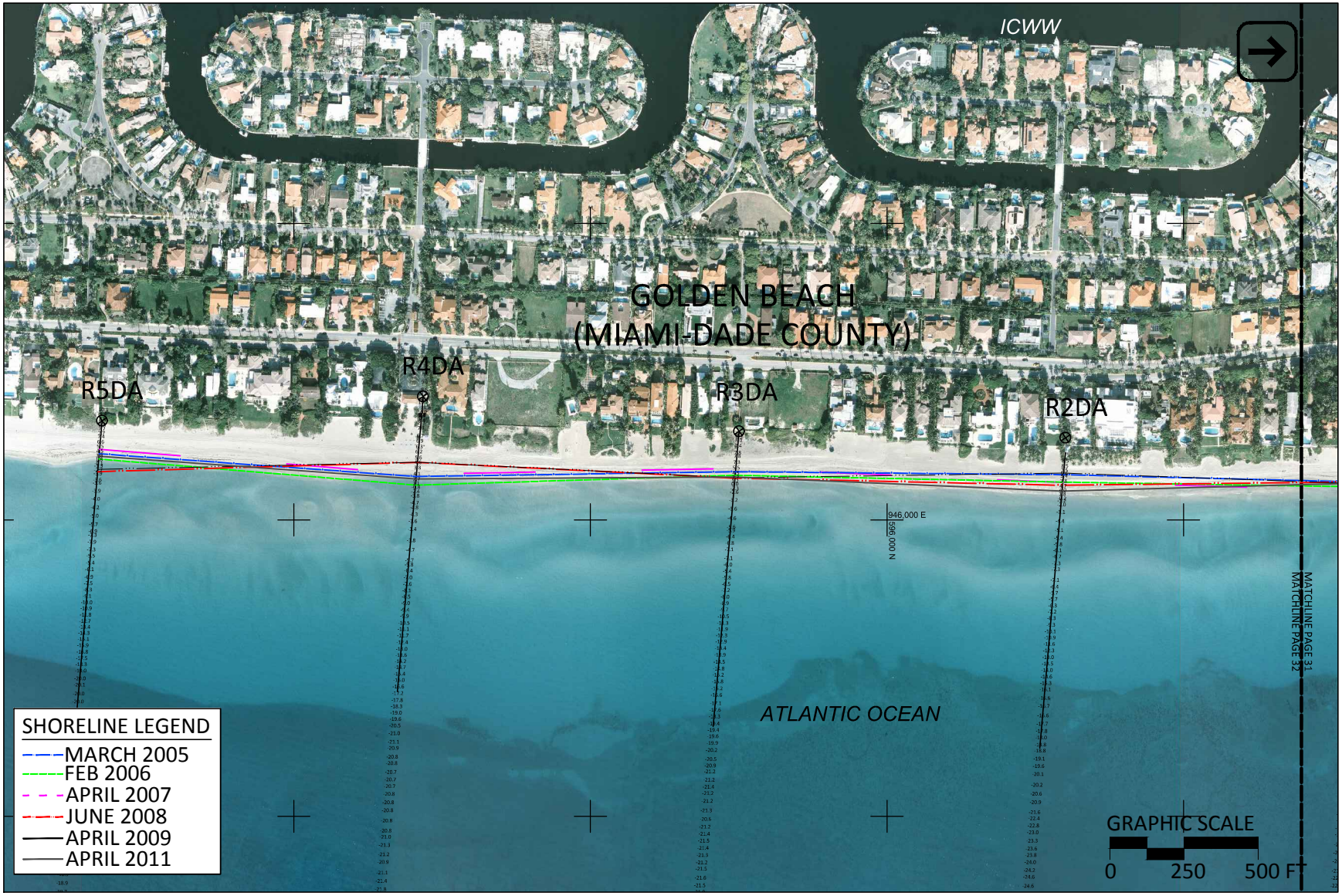


Figure B-31: April 2011 shoreline conditions five-years following the Broward County Shore Protection Project - Segment III. Broward County, FL. Date of aerial photograph: 13 July 2011. Survey elevations: April 2011 (ft, NAVD88).

APPENDIX C: Inlet Dredging Records

This Appendix includes the historical mechanical sand bypass dredging records for Boca Raton Inlet and Hillsboro Inlet. **Table C.1** summaries the expected and actual bypass volume totals for pre-, during-, and post-Segment III project construction time periods. The expected values are based upon the long-term historical average bypassing rates at each inlet. **Table C.2** presents the monthly and annual sand bypassing records for Hillsboro Inlet between January 1991 and August 2011 (Jack Holland, 2009 and 2011, personal communications). **Table C.3** presents the historical bypassing records for Boca Raton Inlet. The historical record is from fiscal year 1979/1980 to 2010/2011 (CPE 2006, Doug Mann, P.E., 2009, and Jennifer Bistyga, E.I., 2011, personal communication).

Table C.1: Mechanical sand bypass volumes for pre-, during-, and post-Segment III project construction time periods. Expected volumes are based upon historical monthly and annual rates.

Inlet		Bypass Volume (cubic yards)		
		Pre-Const. Sep 2001 to Feb 2005 (42-months)	During Const. Mar 2005 to Jan 2006 (11-months)	Post-Const. Feb 2006 to Mar 2011 (62-months)(4)
Hillsboro Inlet	*Expected* (1)	383,209	95,129	345,050
	Actual	363,475	91,875	534,500
Boca Raton Inlet	*Expected* (2)	539,828 (3)	51,550	290,555
	Actual	491,996	51,242	316,799

Notes: (1) Expected based upon historical average monthly mechanical bypassing rates at Hillsboro Inlet through March 2011. Dredging records through September 2011 were used to formulate monthly averages.
(2) Expected based upon historical average annual mechanical bypassing rate at Boca Raton Inlet through March 2011. Dredging records through June 2011 were used to formulate annual average.
(3) An additional 343,000cy added to the expected to account for ebb shoal dredging in 2002.
(4) Post-construction dredging records analyzed through March 2011. Dredging records were obtained through September 2011 for Hillsboro Inlet and through June 2011 for Boca Raton Inlet.

Table C.2: Hillsboro Inlet District monthly sand dredging volumes.

Year	Dredged Volume (cubic yards)												
	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1991	**74,900**	10,220	3,220	5,040	6,440	0	11,200	0	0	0	2,940	18,620	17,220
1992	**126,630**	10,360	16,660	7,980	21,770	9,380	5,040	12,250	0	0	14,700	16,800	11,690
1993	**129,500**	15,680	20,230	3,360	14,700	19,810	22,330	1,680	0	0	0	12,180	19,530
1994	**129,990**	14,770	13,650	18,900	19,950	11,690	0	0	0	0	8,260	15,540	27,230
1995	**110,810**	32,270	24,990	26,110	5,320	0	5,320	1,820	0	0	0	8,190	6,790
1996	**111,300**	11,410	7,140	15,680	9,520	9,590	3,850	3,010	0	560	5,740	13,930	30,870
1997	**80,360**	29,120	5,250	4,690	4,130	10,500	1,820	0	0	0	12,320	6,020	6,510
1998	**77,175**	18,463	15,750	0	0	0	0	0	0	0	11,900	20,825	10,238
1999	**112,438**	3,850	1,138	16,100	0	9,888	2,013	0	0	0	2,363	30,975	46,113
2000	**168,613**	9,275	9,275	35,963	18,113	18,900	17,238	4,025	6,038	13,913	11,813	6,475	17,588
2001	**156,363**	3,325	20,388	8,925	19,863	18,550	11,113	11,375	0	0	4,725	31,150	26,950
2002	**111,475**	20,738	15,575	18,550	10,150	19,513	13,650	0	0	0	0	0	13,300
2003	**41,738**	5,950	8,400	0	0	0	0	0	0	0	0	9,188	18,200
2004	**91,700**	13,825	263	10,588	15,050	2,100	14,788	15,925	0	0	0	13,125	6,038
2005	**128,538**	18,725	37,013	15,313	12,688	0	11,463	0	12,163	0	7,613	2,888	10,675
2006	**110,950**	19,075	6,563	12,425	14,000	16,713	5,250	0	0	0	875	12,250	23,800
2007	**156,975**	24,150	7,438	20,563	21,525	14,525	9,363	17,675	0	0	10,150	27,650	3,938
2008	**57,838**	14,088	10,500	12,775	5,338	4,375	0	5,950	0	0	4,813	0	0
2009	**85,050**	0	9,450	15,838	16,275	16,450	15,925	613	0	0	0	6,125	4,375
2010	**92,588**	13,275	0	1,125	6,075	0	0	0	10,913	0	17,213	13,950	30,038
2011	**53,325**	18,563	13,275	18,338	3,150	0	0	0	0	0	0	0	0
Total	**2,062,340**	**275,293**	**232,890**	**248,798**	**214,830**	**181,983**	**150,360**	**74,323**	**18,200**	**14,473**	**98,210**	**251,930**	**301,053**
Average	**106,851**	**14,625**	**11,722**	**12,774**	**10,669**	**8,666**	**7,160**	**3,539**	**1,386**	**689**	**5,771**	**13,294**	**16,555**

Notes: (1) Sand is bypassed to Pompano Beach just south of the South jetty. The sand is typically placed along the waterline below the high tide mark within 300 feet of the jetty. The dry beach is built up only during winter months.
(2) Since the District owns its' dredge, the dredging frequency is based on the need to clear the sand trap and/or channel and favorable weather conditions.
(3) Monthly averages include data through September 2011. Total average is based on sum of monthly averages.
(4) In July, August and November of 2002 the outer channel was deepened by a rock cutting dredge. Some of the sand over the rock was disposed of in the rock spoil area offshore rather than being bypassed to the beach to the south.
(5) During November 2008 through January 2009, sand bypassing was prevented by the new dredge gearbox problem and blocked submerged line.
(6)

Table C.3: Historical annual dredge volumes for Boca Raton Inlet.

Fiscal Year[1]	Dredge Volume (cubic yards)		
	Inlet Interior	East of Inlet Mouth	Total
1979/1980	37,600	0	37,600
1980/1981	57,500	0	57,500
1981/1982	57,500	15,600	73,100
1982/1983	47,600	24,900	72,500
1983/1984	33,800	25,900	59,700
1984/1985	30,600	26,700	57,300
1985/1986	23,200	16,200	39,400
1985 (Ebb Shoal Event)	0	221,000	221,000
1986/1987	16,200	12,200	28,400
1987/1988	27,400	7,700	35,100
1988/1989	16,600	6,700	23,300
1989/1990	31,800	6,000	37,800
1990/1991	37,000	12,500	49,500
1991/1992	50,500	21,600	72,100
1992/1993	34,900	17,300	52,200
1993/1994	50,300	23,700	74,000
1994/1995	37,300	20,700	58,000
1995/1996	46,700	18,900	65,600
1996 (Ebb Shoal Event)	0	220,000	220,000
1996/1997	41,900	0	41,900
1997/1998	27,600	1,900	29,500
1998/1999	63,400	8,600	72,000
1999/2000	119,500	14,300	133,800
2000/2001	75,400	17,300	92,700
2001/2002	40,400	3,600	44,000
2002 (Ebb Shoal Event)	0	343,000	343,000
2002/2003	27,500	800	28,300
2003/2004	44,000	0	44,000
2004/2005	NA	NA	59,930
2005/2006	NA	NA	48,848
2006/2007	NA	NA	61,726
2007/2008	NA	NA	64,817
2008/2009	NA	NA	70,272
2009/2010	NA	NA	61,025
2010 (Ebb Shoal Event)	0	183,800	183,800
2010/2011[2]	NA	NA	39,590
Total - Including Ebb Shoal Events (Oct 1979 - Jun 2011)			2,753,308
Annual Average - Including Ebb Shoal Events (Oct 1979 - Jun 2011)			86,718
Monthly Average - Including Ebb Shoal Events (Oct 1979 - Jun 2011)			7,227
Total - Excluding Ebb Shoal Events (Oct 1979 - Jun 2011)			1,969,308
Annual Average - Excluding Ebb Shoal Events (Oct 1979 - Jun 2011)			62,025
Monthly Average - Excluding Ebb Shoal Events (Oct 1979 - Jun 2011)			5,169

Notes:

(1) Fiscal year is October through September

(2) 2010/2011 available through June 2011 (9 months of data)

(3) Monthly and annual averages include data through June 2011.

APPENDIX D: Borrow Area Plots

This Appendix includes plots depicting the survey results for the pre-dredge (March 2005), post-dredge (February 2006), 15-months post-dredge (May 2007), 30-months post-dredge (August 2008), 39-months post-dredge (May 2009), 54-months post-dredge (August 2010), and 65–months post-dredge (July 2011) surveys. The borrow area surveys were performed by Coastal Planning and Engineering, Inc. (CPE) of Boca Raton, FL. All survey elevations and bathymetric contours are reported in feet relative to the North American Vertical Datum of 1988 (NAVD88). All horizontal coordinates are reported in feet relative to the Florida State Plane Coordinate System, East Zone, North American of 1983 (NAD83).

Figure D.1 depicts the location of the five (5) borrow areas relative to the Broward County shoreline. **Figures D.2** through **D.6** present the bathymetry at each borrow area for four of the surveys (March 2005, February 2006, May 2009, and July 2011). **Figures D.7** through **D.11** present the seabed elevation changes at each borrow site for the Pre- to Post-Dredge (March 2005 to February 2006), Four to Five Years Post-Dredge (August 2010 to July 2011), and Post- to Five Years Post-Dredge (February 2006 to July 2011) monitoring periods. **Table D.1** summarizes the volume changes for each borrow site since project construction.

Table D.1: Borrow area volume changes since project completion.

Borrow Area	Borrow Site Acreage	Volume Change (cy)					
		Post-Construction (February, 2006) to May 2007	May 2007 to August 2008	August 2008 to May 2009	May 2009 to August 2010	August 2010 to April 2011	Post-Construction (February, 2006) to April 2011
BA-I	86	-48,430	11,530	23,450	-17,350	-258,806	-289,606
BA-II	116	-51,060	6,160	15,560	-260	6,943	-22,657
BA-III	33	-20,450	3,320	5,740	-4,700	1,268	-14,822
BA-IV	6	580	-2,060	600	-120	1,231	231
BA-VI	4.5	-3,700	1,290	690	1,550	-58	-228
Total	**245.5**	**-123,060**	**20,240**	**46,040**	**-20,880**	**-249,422**	**-327,082**

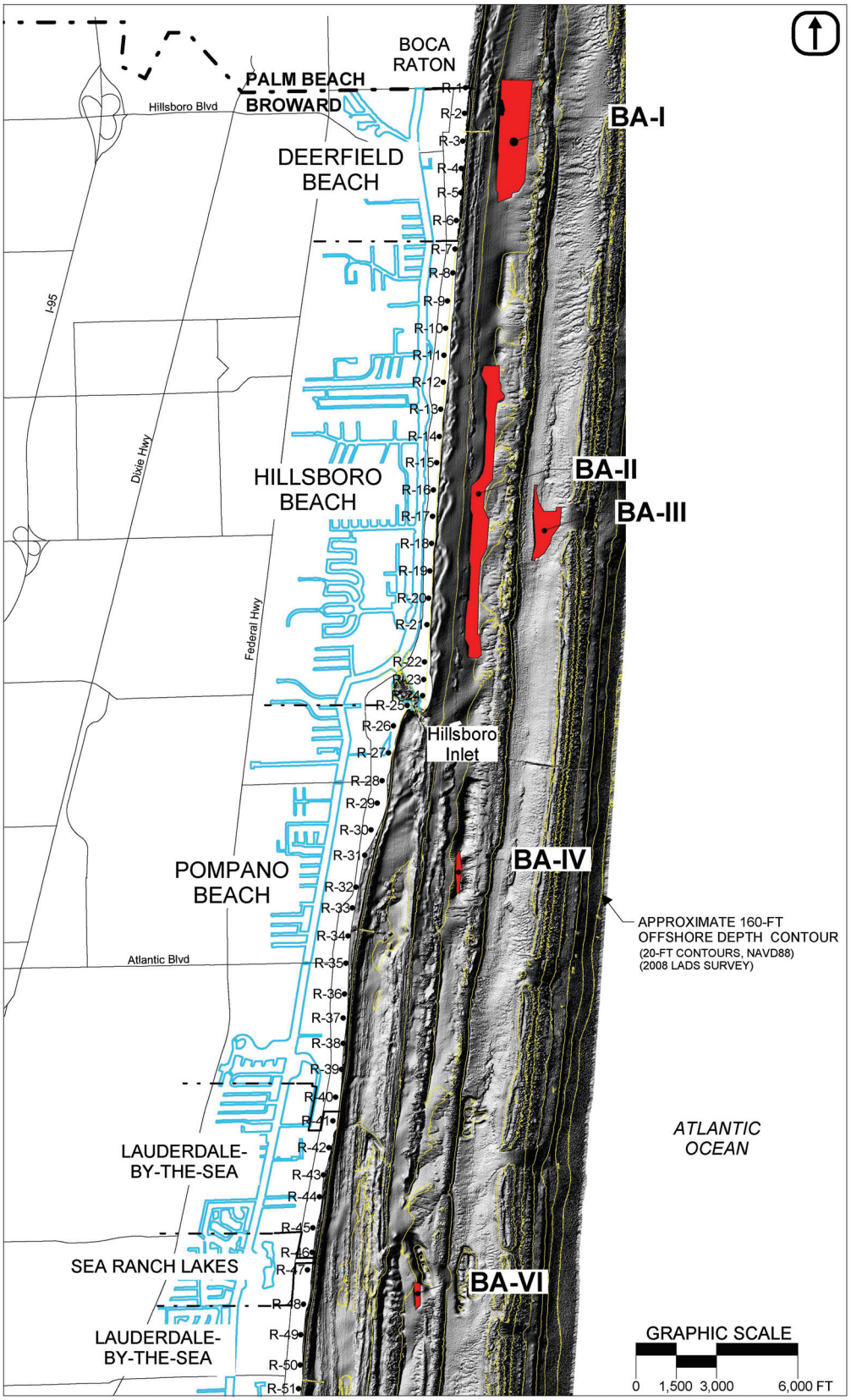
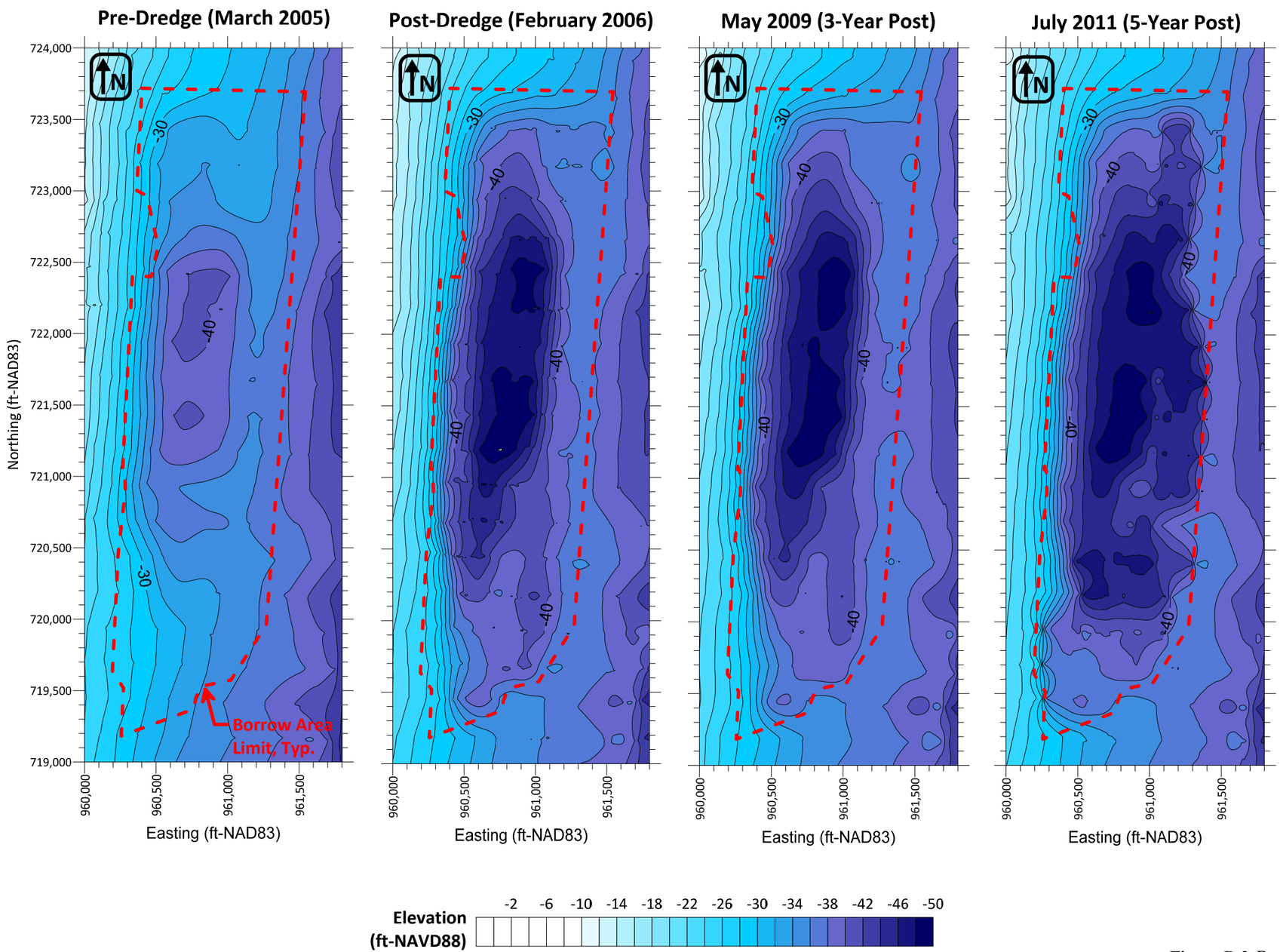
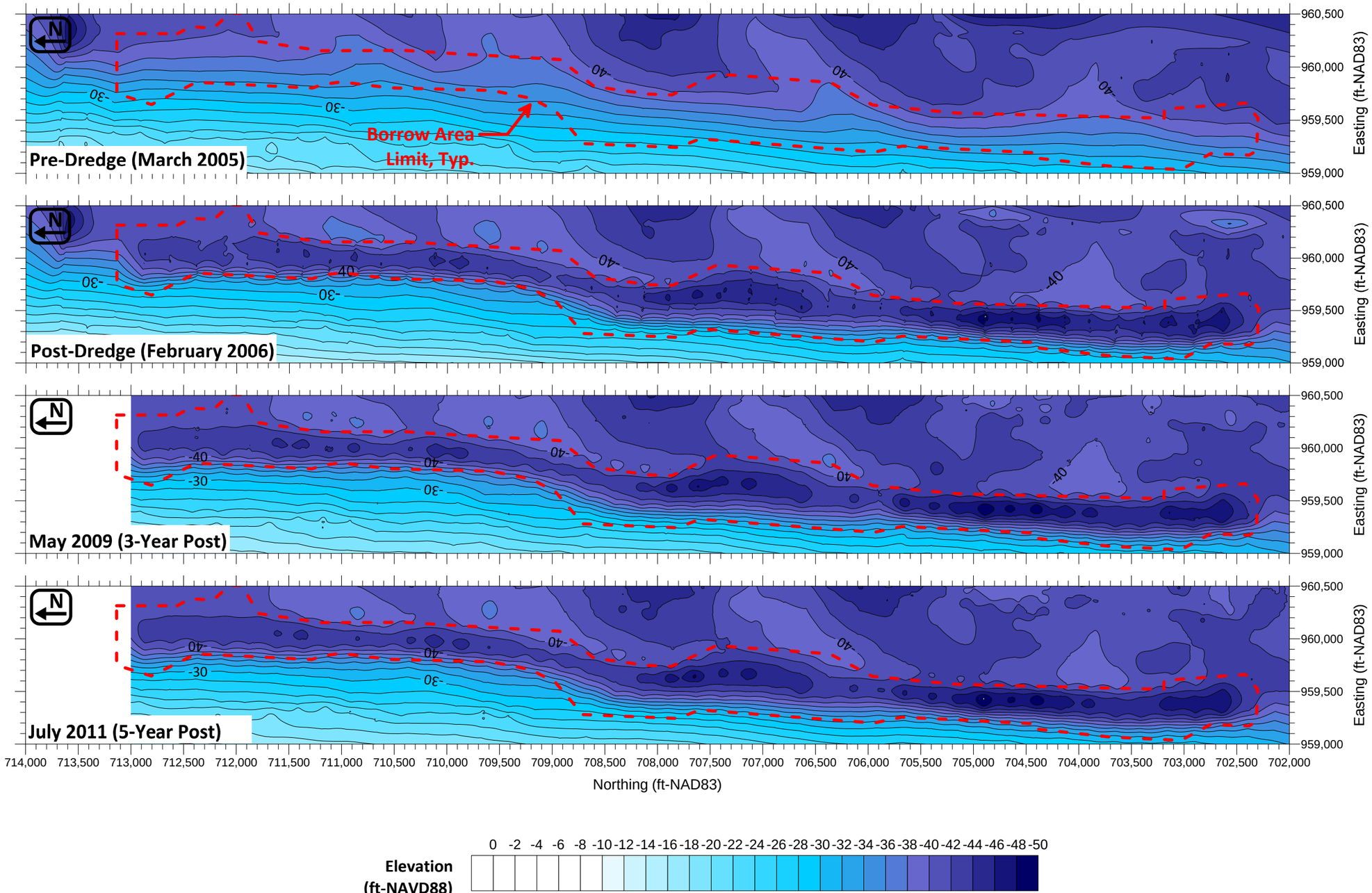


Figure D.1: Location and configuration of the offshore borrow areas used for the Broward County Shore Protection Project - Segment III.



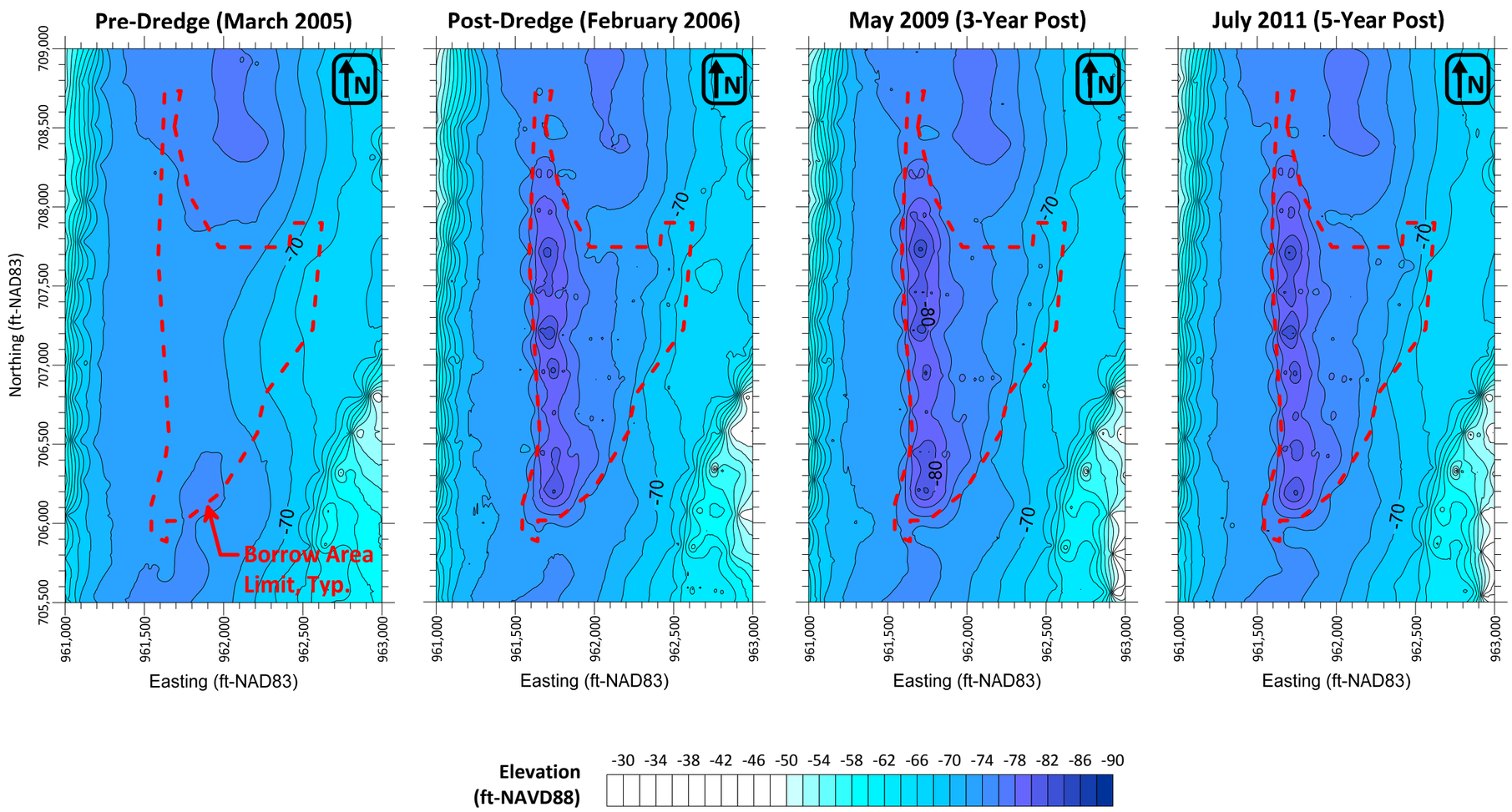
BA-I

Figure D.2: Borrow Area I (BA-I) bathymetery.



BA-II

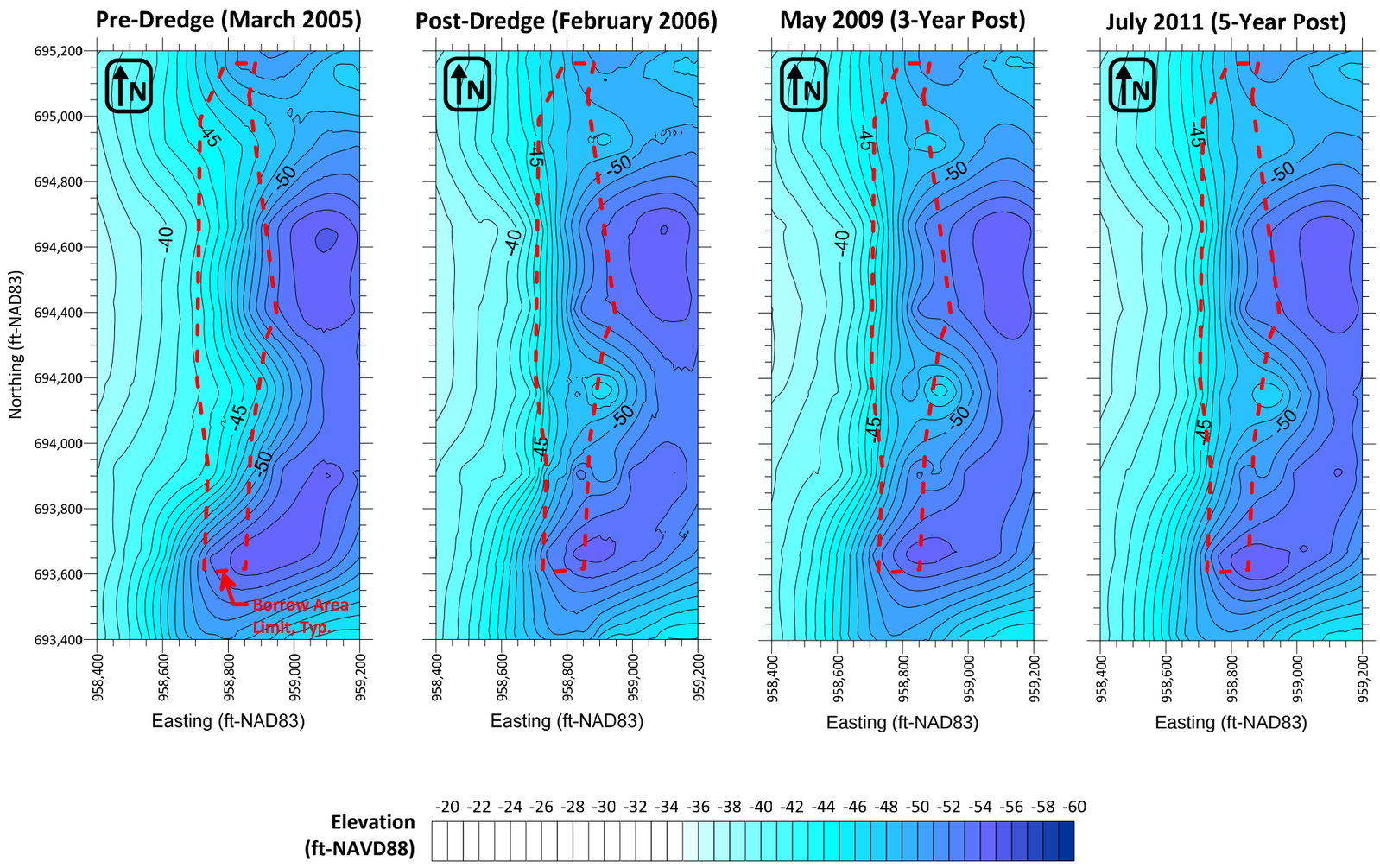
Figure D.3: Borrow Area II (BA-II) bathymetery.



BA-III

Broward County Shore Protection Project - Segment III
5-Year Post-Construction Physical Monitoring

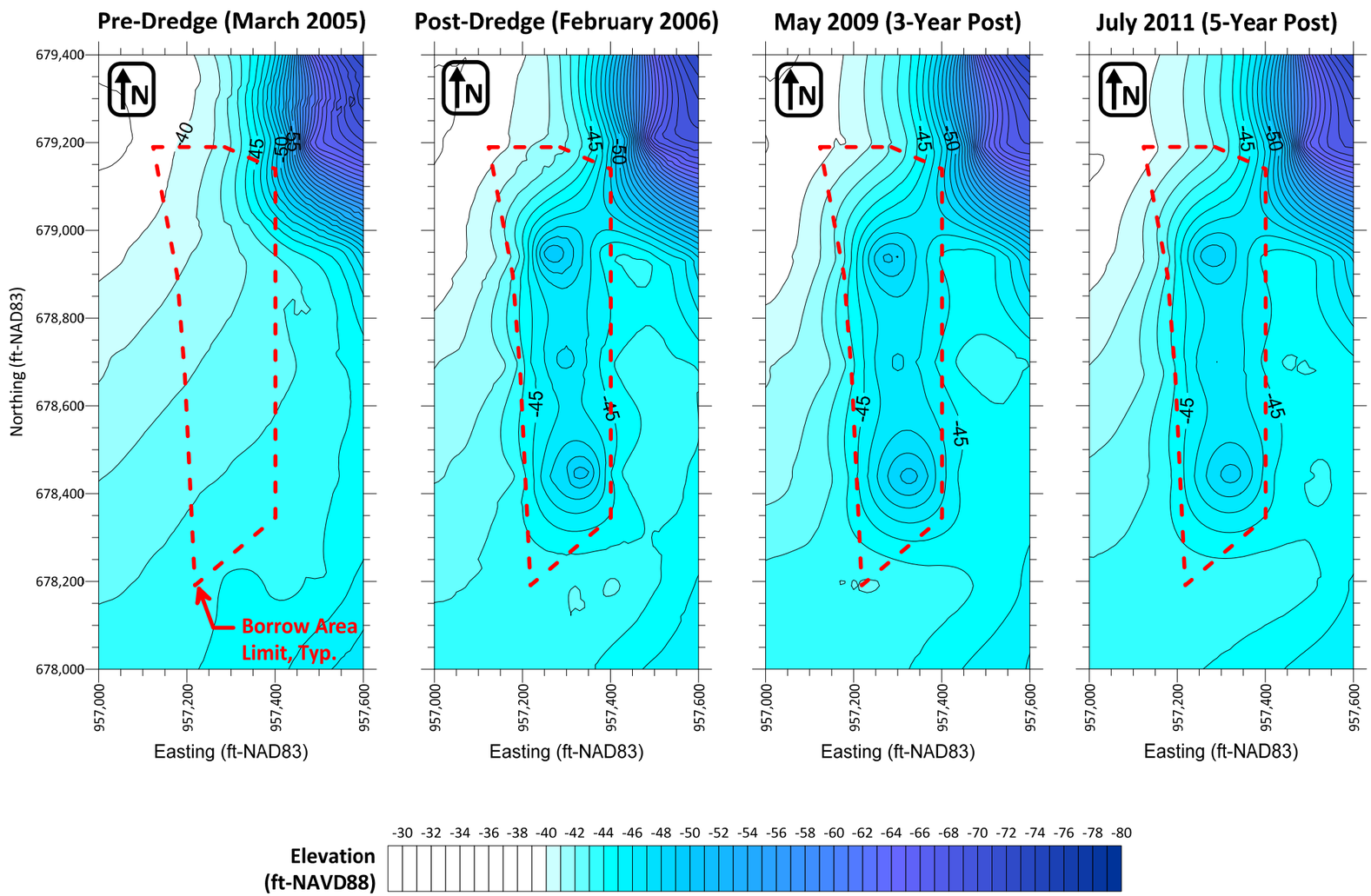
Figure D.4: Borrow Area III (BA-III) bathymetery.



BA-IV

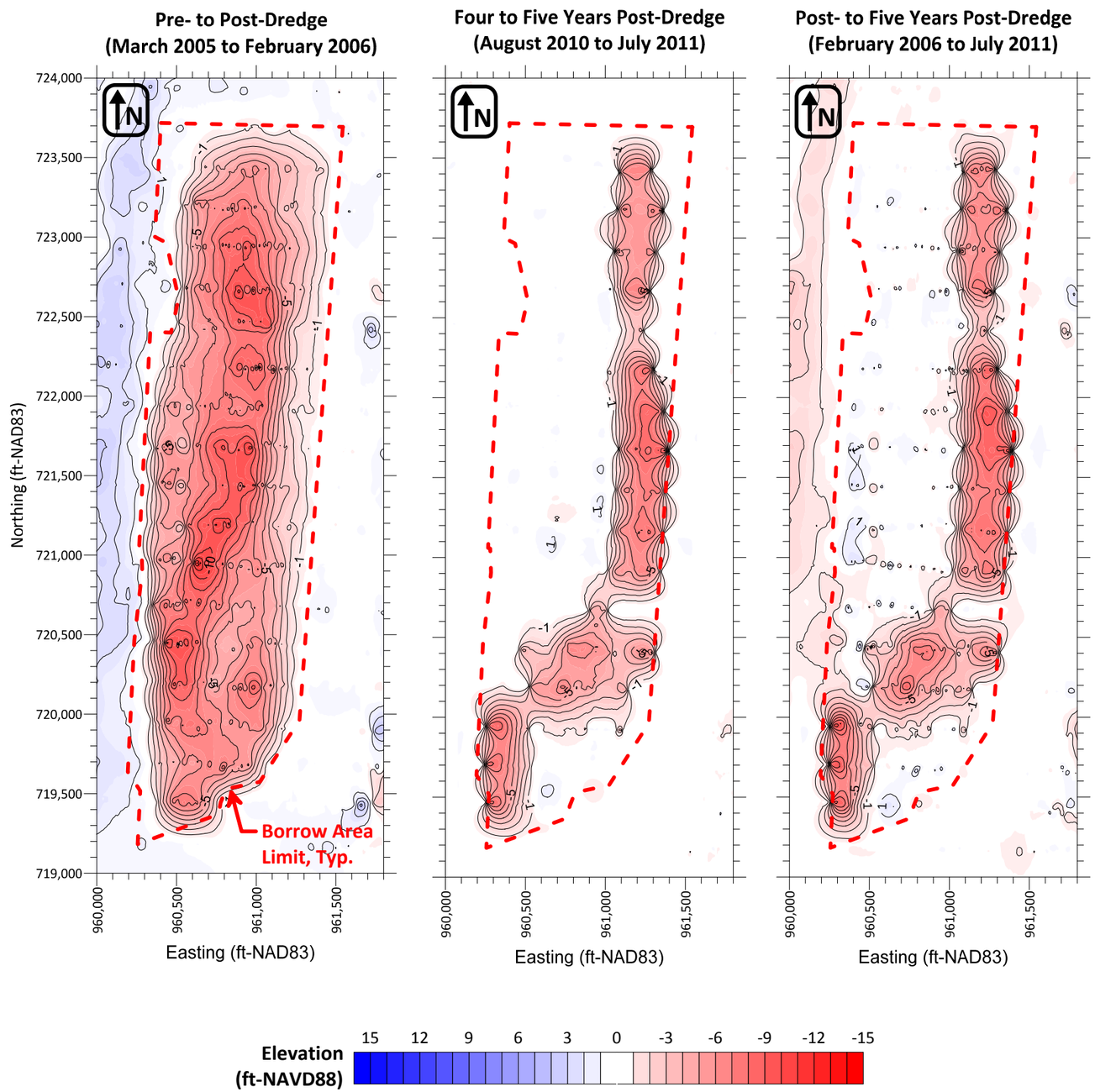
Broward County Shore Protection Project - Segment III
5-Year Post-Construction Physical Monitoring

Figure D.5: Borrow Area IV (BA-IV) bathymetery.



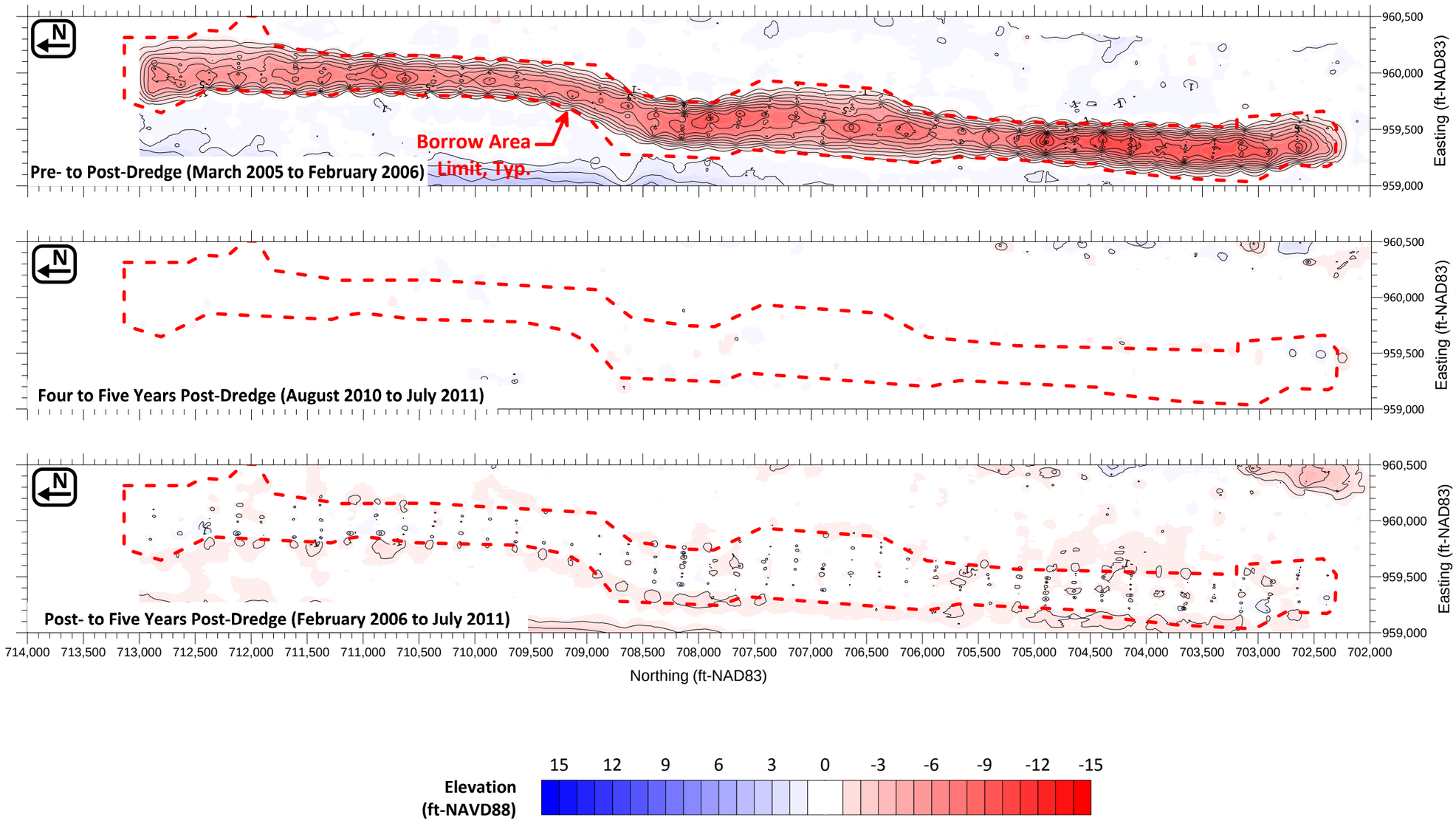
BA-VI

Figure D.6: Borrow Area VI (BA-VI) bathymetery.



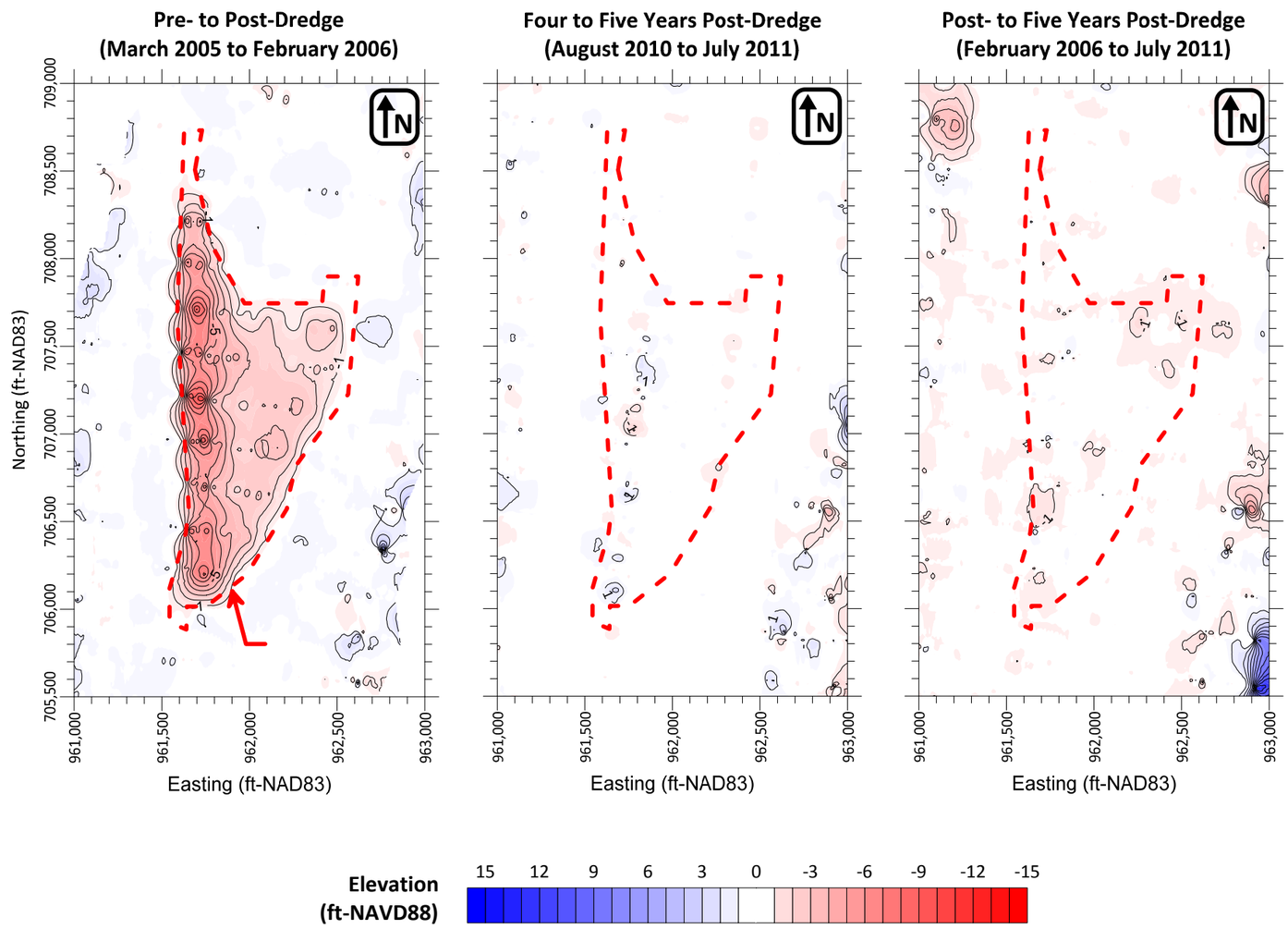
BA-I

Figure D.7: Borrow Area I (BA-I) seabed elevation change.



BA-II

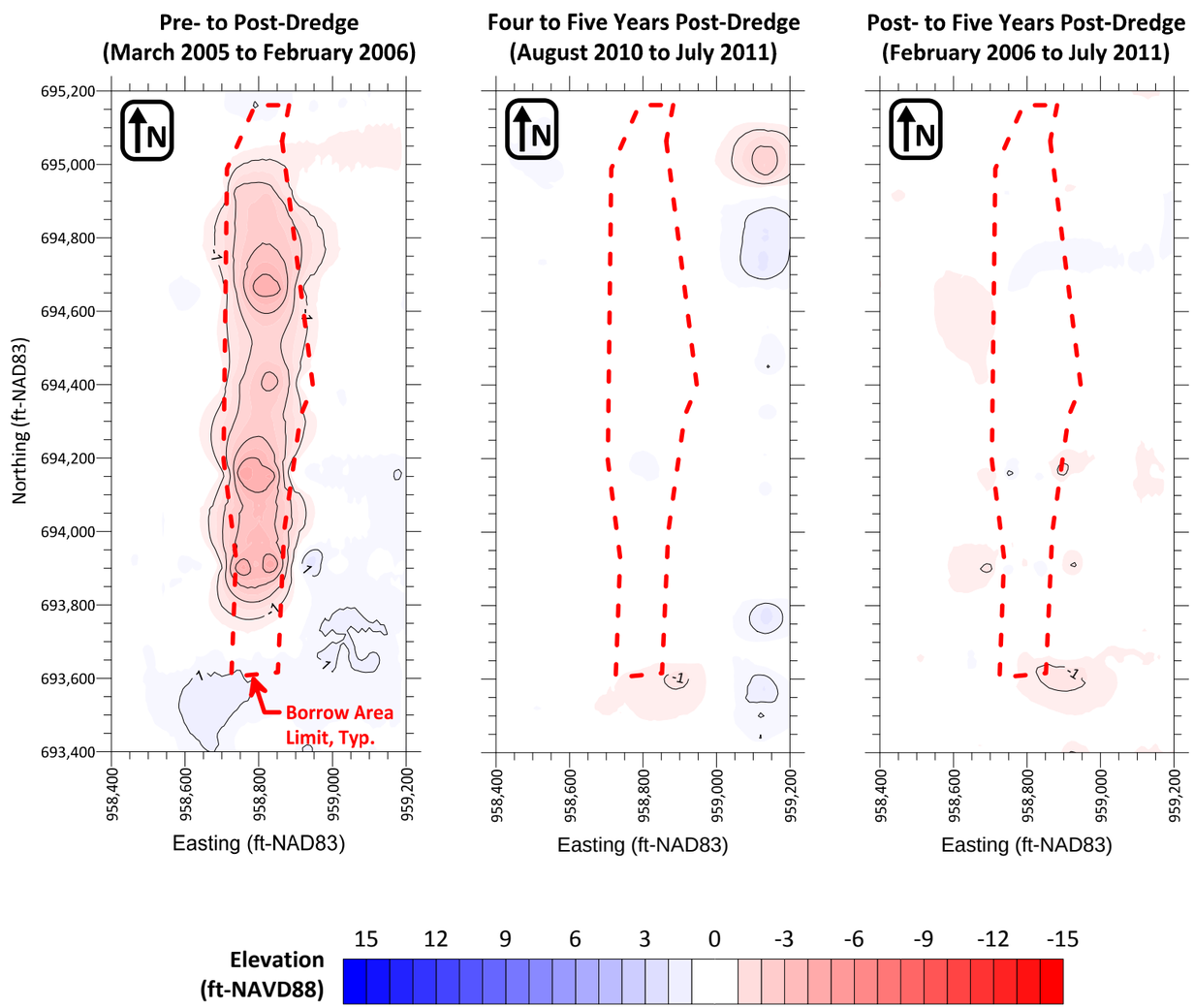
Figure D.8: Borrow Area II (BA-II) seabed elevation change.



BA-III

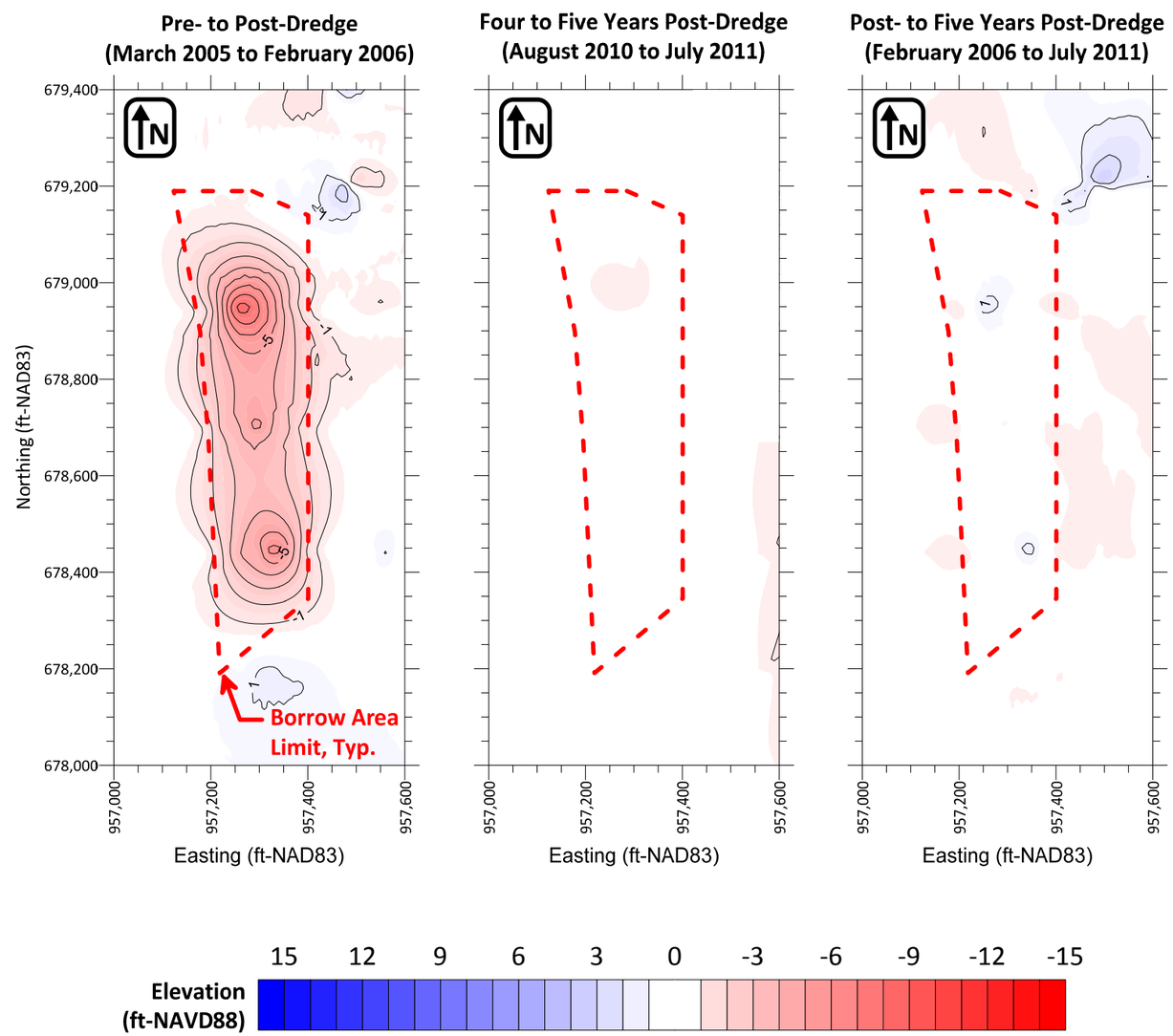
Broward County Shore Protection Project - Segment III
5-Year Post-Construction Physical Monitoring

Figure D.9: Borrow Area III (BA-III) seabed elevation change.



BA-IV

Figure D.10: Borrow Area IV (BA-IV) seabed elevation change.



BA-VI

Figure D.11: Borrow Area VI (BA-VI) seabed elevation change.