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Colonial Beach State of the Beach Report: 2011

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Colonial Beach

State of the Beach Report: 2011



September 2011

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Data Summary Report
by

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September 2011

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1 Introduction

The Town of Colonial Beach occupies a peninsula between the Potomac River and Monroe Bay (Figure 1). Approximately 2.5 miles of the shoreline is publicly-owned. Two areas on the Potomac River have been enhanced as recreational beaches for swimming and sunbathing. Central Beach is located just south of the Town Pier and is the main recreational beach. Castlewood Beach is south of Central Beach near the entrance to Monroe Bay. Mean tide range is 1.64 ft while the spring range is 1.94 ft (NOAA, 2011).

In 1982, breakwater and beach fill systems were completed to abate erosion and restore the beach along the Town's shoreline. Four gapped breakwaters were constructed at Central Beach, and 50,000 cubic yards of sand was placed as part of an U.S. Army Corps of Engineers shore project. At Castlewood Beach, three gapped breakwaters and 16,000 cubic yards of sand were placed, and a terminal groin was constructed to reduce shoaling in the entrance channel to Monroe Bay. Sections of the shoreline had a rock revetment placed along it by 1986. A project in 1989 called for 1,250 cubic yards of sand, breakwater maintenance, and cleanup and removal of small rocks from the river bed at the toe of the beach at Central Beach. In the fall of 1992, the Town, in conjunction with the U.S. Army Corps of Engineers replenished Central Beach with 11,200 cy of sand. In the mid-1990s, the Virginia Department of Transportation put in additional riprap revetment along a large section of Colonial Beach's shoreline. Prior to that, a mix of different types of materials had been placed along the shore to abate erosion. In 1998, approximately 2,100 cubic yards of sand was placed primarily on Central Beach with some on Castlewood. Again in the winter of 1999, more sand was placed on Central and Castlewood Beaches. In September 2003, Hurricane Isabel severely impacted Colonial Beach (Milligan *et al.*, 2002). In May 2011, approximately 10,000 cy of beach fill was placed on Central Beach.

Specific shore change is addressed at Central Beach and Castlewood Beach through recent beach profiles. Beach profiles taken in January 2011 and July 2011 were compared to previous profiles. Change in beach volume was quantified. Aerial photography taken in February 2001 were rectified in GIS to compare to previous aerial photos.

2 Methods

The beaches at Colonial Beach were surveyed in January and July 2011. For Central Beach, the previous baseline was re-occupied and surveyed with a rod and level ([Figure 2](#)). The baseline at Castlewood Beach had to be re-created ([Figure 2](#)). However, because earlier survey data was taken with a real-time kinematic global positioning system (RTK-GPS), data from a past survey was exported to match the present baseline. Using this data, changes in beach volume could be calculated. Profile dates for Central Beach are shown in [Table 1](#). Profile dates for Castlewood Beach are shown in [Table 2](#). The profile data taken for this project are listed in [Appendix A](#). Vertical control for the survey data was set with the RTK-GPS. The profile data were converted to mean lower low water (MLLW), feet (1983-2001 tidal epoch). Accepted datums are listed in [Table 3](#).

Volume change was calculated along each profile from the top of bank to the -2 ft MLLW contour for two time periods for Central Beach, September 2004 to January 2011 and January 2011 to July 2011. The latter time period reflects the changes at Central Beach due to the beach nourishment. Castlewood Beach only was analyzed for the time period September 2004-January 2011. No beach fill was placed on Castlewood. The change in distance to mean high water (MHW) also was calculated.

Sediments were taken at Central and Castlewood Beach in January 2011 and analyzed for grain size. One sample of the fill material placed on the beach in May 2011 also was sampled and analyzed. These data are found in [Appendix B](#).

Low-level, near-vertical, aerial photos were taken along the Colonial Beach shoreline on 20 Oct 2003 and 6 Feb 2011. Individual photos were geo-rectified in ArcMap and mosaicked together. The approximate location of high water was digitized along the shoreline to show change through time.

Table 1. Beach profile data available for Central Beach in Colonial Beach.

Date	Survey Number	Profile Number	Comments
30 April 1998	100	1,3,5,7,9,11,13,15,17	Post-Twin Northeaster
26 May 1998	101	1,3,5,7,9,11,13,15,17,18	
28 October 1998	102	1,3,5,7,9,11,13,15,17,18	Post-Hurricane Dennis
23 April 1999	103	1,3,5,7,9,11,13,15,16,17,18	
23 September 1999	104	1,3,5,7,9,11,13,15,17,18	
2 June 2000	105	1,3,5,7,9,11,13,15,17,18	
3 October 2000	106	1-18	
25 June 2001	107	1-18	Baseline Reset
19 November 2001	108	1-18	
12 June 2002	109	1-18	Baseline Reset
1 October 2003	110	2-9,18	Post-Hurricane Isabel
21 September 2004	111	1-18	Elevation adjusted to MLLW
25 January 2011	112	1-18	
5 July 2011	113	1-18	

Table 2. Beach Profile data available for Castlewood Beach in Colonial Beach.

Date	Survey Number	Profile Number	Comments
25 February 2004	100	1-10, 5.5, 8.5	
13 January 2005	101	1-10, 5.5, 8.5	
25 January 2011	102	1-10, 5.5, 8.5	

Table 3. Accepted datums for Colonial Beach in feet for the 1983-2001 tidal epoch from the National Ocean Service website (NOAA, 2011). Values are relative to the station datum.

Datum	Value	Description
MHHW	4.58	Mean higher-high water
MHW	4.42	Mean high water
NAVD88	3.63	North American Vertical Datum of 1988
MSL	3.61	Mean sea level
MLW	2.78	Mean low water
MLLW	2.64	Mean lower-low water
STND	0.00	Station datum
HAT	5.10	Highest astronomical tide
LAT	2.12	Lowest astronomical tide
MN	1.63	Mean range of tide
GT	1.94	Great diurnal range

3 Beach Status Summary

3.1 Central Beach, Pre-Fill

Between October 2003 and February 2011, low-level aerial photography shows that the shoreline generally has receded in the embayments, but additional sand accumulated behind the breakwaters (Figure 3). Survey data shows that the net trend between 2000 and January 2011 (Table 4) was accretion behind the breakwaters at Profiles 3, 7, and 15 as indicated by the increase in the distance to MHW. The data also show that between 2000 and 2004, the position of MHW moved riverward for most profiles. This was due to sand eroding from the upper backshore region and moving to the intertidal beach on most profiles and to the base of the bank on some profiles (2, 3, 4, and 8) (Figure 4). Profile 11 eroded behind the breakwater between 2000 and 2004, but was accretionary between 2004 and Jan 2011. It should be noted that Hurricane Isabel severely impacted Colonial Beach in September 2003. Surveys taken by

VIMS personnel after the storm indicated that the storm surge and waves reached about 8.8 ft MLLW. During the storm increased water levels moved sand from the upper beach.

Overall, Central Beach lost -4,180 cubic yards (cy) of sand between 2000 and January 2011 (Table 5). The amount of volume change (in cy/ft) between 2004 and January 2011 is shown on each profile in Figure 4. The net volume change shown in Table 5 was calculated using the volume calculation cells and their along shore distances as shown in Figure 2.

Table 4. Distance to mean high water (MHW) from the baseline for several time periods.

Profile #	2000-2004 Distance to MHW (ft)	2004-2011 Distance to MHW (ft)	2000- Jan 2011 Distance to MHW (ft)	Jan 2011-Jul 2011* Distance to MHW (ft)
1	-3.0	-14.4	-17.3	
2	5.9	-11.5	-5.6	-3.0
3-BW	-8.7	15.6	6.9	-20.3
4	1.3	-15.9	-14.6	16.9
5	3.7	-16.5	-12.8	10.7
6	11.3	-21.7	-10.4	9.2
7-BW	-8.8	17.9	9.1	-17.9
8	4.4	-9.0	-4.6	15.9
9	2.7	-6.5	-3.8	11.5
10	9.8	-16.5	-6.6	9.4
11-BW	-12.8	5.8	-7.1	9.2
12	-0.9	-10.2	-11.1	15.7
13	-2.8	-7.1	-9.9	7.4
14	2.7	-13.9	-11.2	5.3
15-BW	-19.5	24.7	5.3	-50.0
16	-6.9	5.1	-1.8	-5.4
17	-4.8	-2.1	-6.9	2.1
18	9.5	-0.8	8.7	

*Pre-nourishment to Post-Nourishment

Table 5. Calculated net volume change per volume calculation cell (as shown on Figure 2) above -2 ft MLLW for three time periods.

VCC #	2000-2004 Net Vol Change above -2 MLLW (cy)	2004-Jan 2011 Net Vol Change above -2 MLLW (cy)	2000-Jan 2011 Net Vol Change above -2 MLLW (cy)	Jan 2011-Jul 2011* Net Vol Change above -2 MLLW (cy)
1	-81	-456	-537	
2	-9	-725	-734	779
3-BW	-181	167	-14	333
4	-84	-269	-353	773
5	-45	-230	-275	743
6	247	-383	-136	884
7-Bw	-128	387	259	424
8	-11	-194	-205	963
9	-59	-81	-139	574
10	57	-347	-290	782
11-BW	-253	-102	-355	1,070
12	-223	-282	-506	631
13	-177	-115	-292	166
14	26	-345	-318	229
15-BW	-362	151	-211	-613
16	-161	87	-73	-95
17	77	-255	-178	61
18	203	-24	179	
Total	-1,163	-3,016	-4,180	7,703

*Pre-nourishment to Post-Nourishment

3.2 Central Beach, January 2011 to July 2011

In May 2011, sand was placed on Central Beach (Figure 5). Due to the fill, most profiles had a gain in the distance to MHW (Table 4). The exceptions are the profiles behind the breakwaters and two profiles near the breakwater. This is likely due to the bulldozing of material during the beach fill project. Overall, the VIMS survey measured almost 8,000 cy of added material on the beach. This is slightly less than placed volume (Rob Murphy, *pers. communication*) and is probably due to the shifting and loss of fine material between the end of the project and when the beach was surveyed. In addition, data from profile 1 could not be used for

the analysis, and therefore, we cannot account for material on the most northern section of the beach. No material was placed on the southern section of the beach (profiles 15, 16, and 17). The sand was placed along the entire profile from the bank to low water. In particular, much of the asphalt bank that runs along the backshore was covered (Figure 6). The fill material was 88% sand with 4% gravel and 8% mud with a D_{50} of 0.44 millimeters.

3.3 Castlewood Beach

The position of approximate high water is shown on the 2003 and the 2011 photos (Figure 7). Most of the shoreline has eroded landward. In the area behind the first breakwater, a large stand of *Phragmites australis* has grown. The tombolo behind the second breakwater is completely detached at high water. Figure 8 shows the individual profile change along the shore with the net volume change above -2 ft MLLW and distance change to MHW between February 2004 and Jan 2011. Significant change has occurred on most profiles particularly below +3 ft MLLW. The region between about -2 ft MLLW and +3 ft MLLW has the most erosion. Some areas of the upper backshore accreted. Profiles 3, 5, and 6 had the most net volume change and profiles 3 and 5 also had the greatest change in the distance to MHW. Photos taken in January 2011 show the state of the beach at Castlewood (Figure 9).

4 References

Milligan, D.A., C.S. Hardaway, Jr., R.H. Brindley, G.R. Thomas, L.M. Meneghini, 2002. Public Beach Assessment Report: Central Beach and Castlewood Park Beach, Colonial Beach, Virginia. Technical Report prepared for the Board on Conservation and Development of Public Beaches. Virginia Institute of Marine Science, College of William & Mary, Gloucester Point, Virginia. http://web.vims.edu/physical/research/shoreline/docs/Public_Beaches/Final_Report-Central%20Beach.pdf

NOAA, 2011. http://tidesandcurrents.noaa.gov/data_menu.shtml?stn=8635150 Colonial Beach, Potomac River, VA&type=Datums

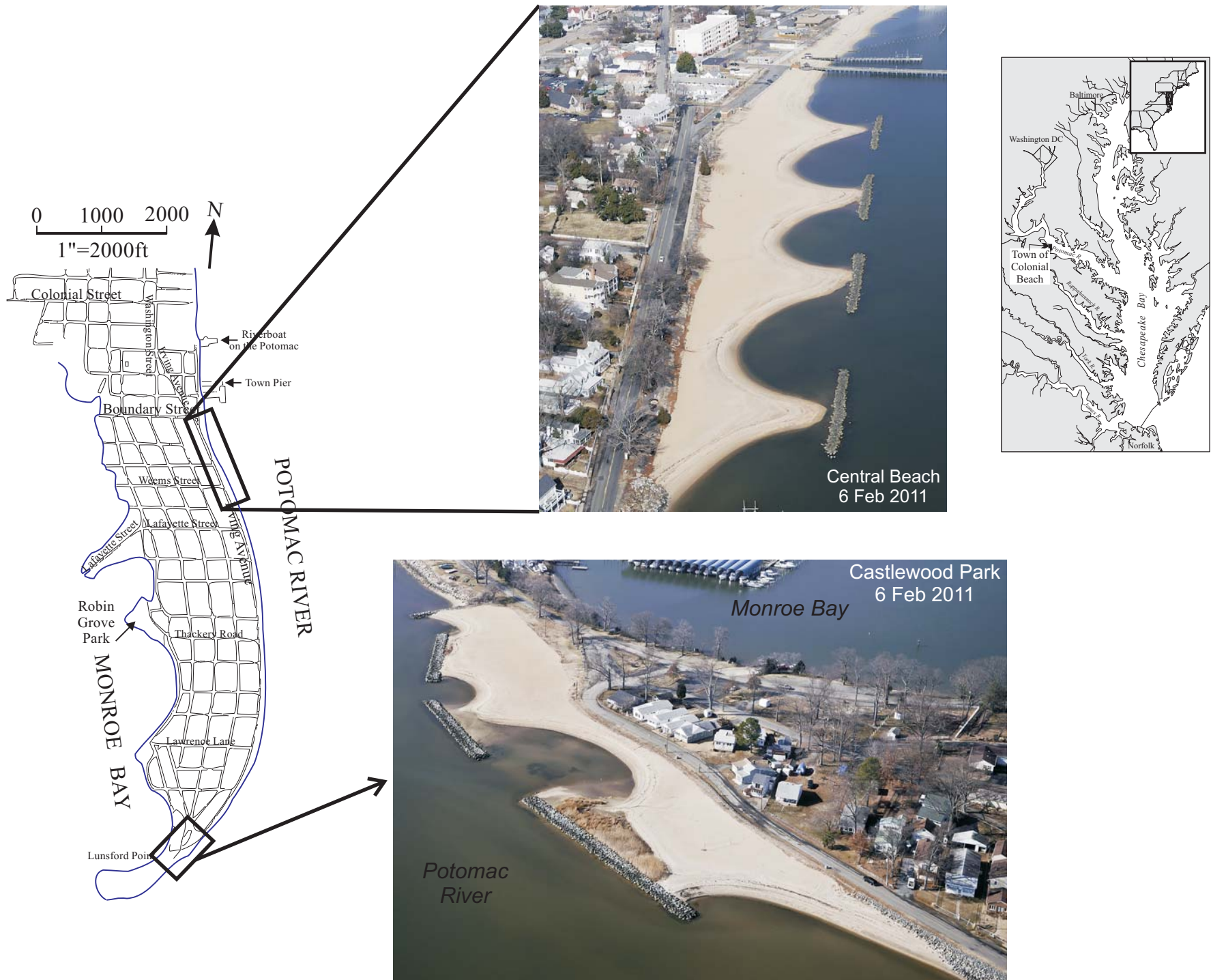
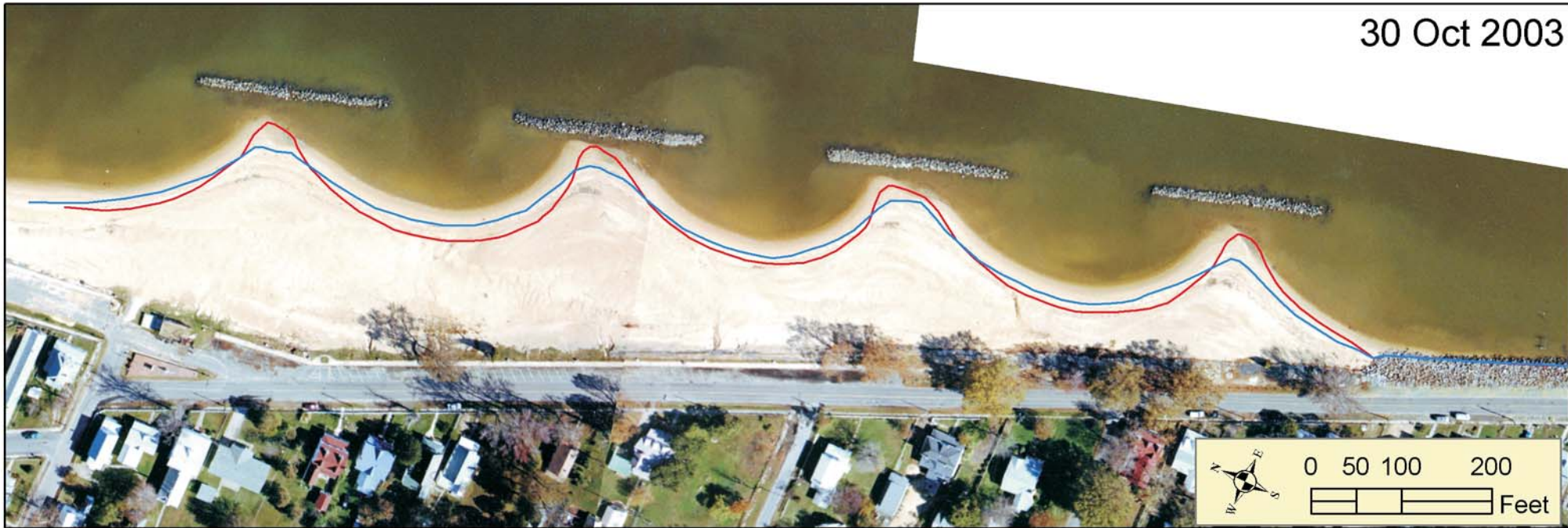


Figure 1. Location of Central and Castlewood Beaches along the Town of Colonial Beach's shore.



Figure 2. Profile baselines for Central Beach and Castlewood Beach in the Town of Colonial Beach. Also shown are the Volume Calculation Cells (VCC) for Central Beach.



30 Oct 2003



6 Feb 2011

Figure 3. Rectified low-level aerial photos of Central Beach in October 2003 and February 2011 with the approximate position of high water shoreline digitized.

— Oct 2003 Shoreline
 — Jan 2011 Shoreline

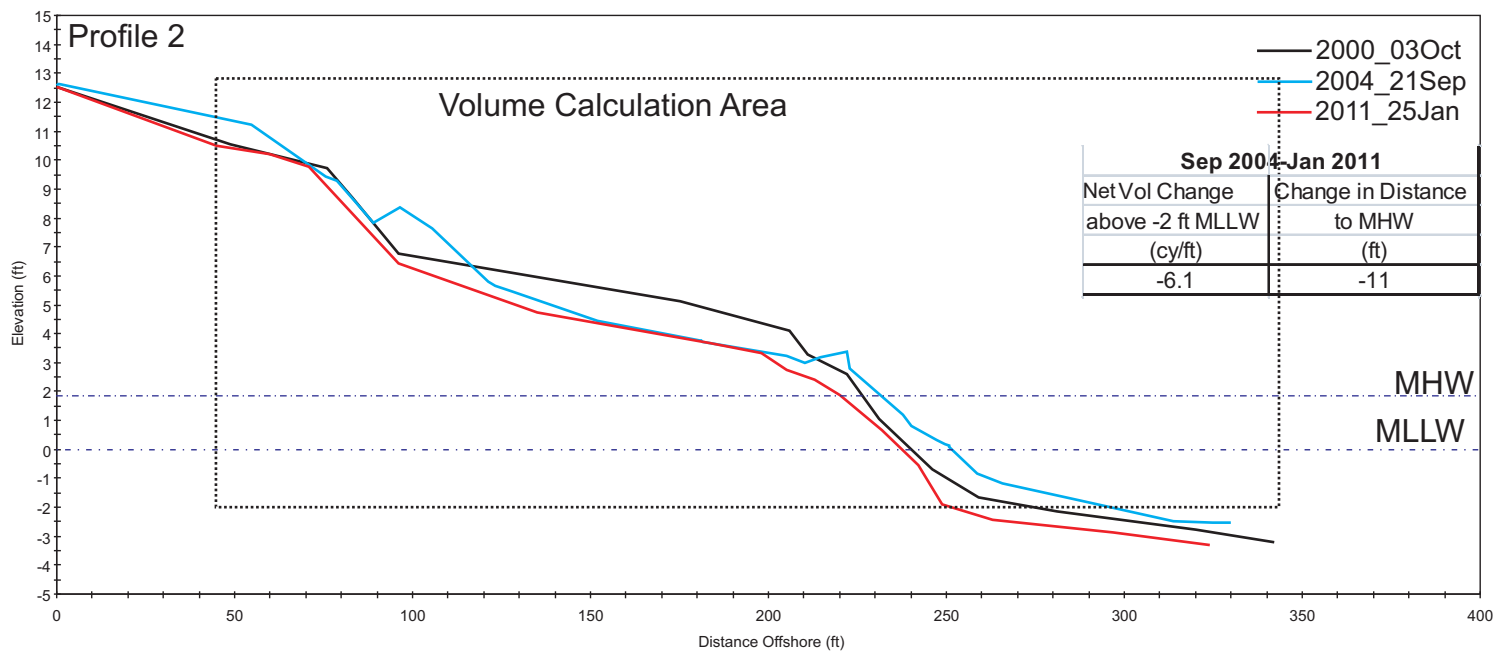
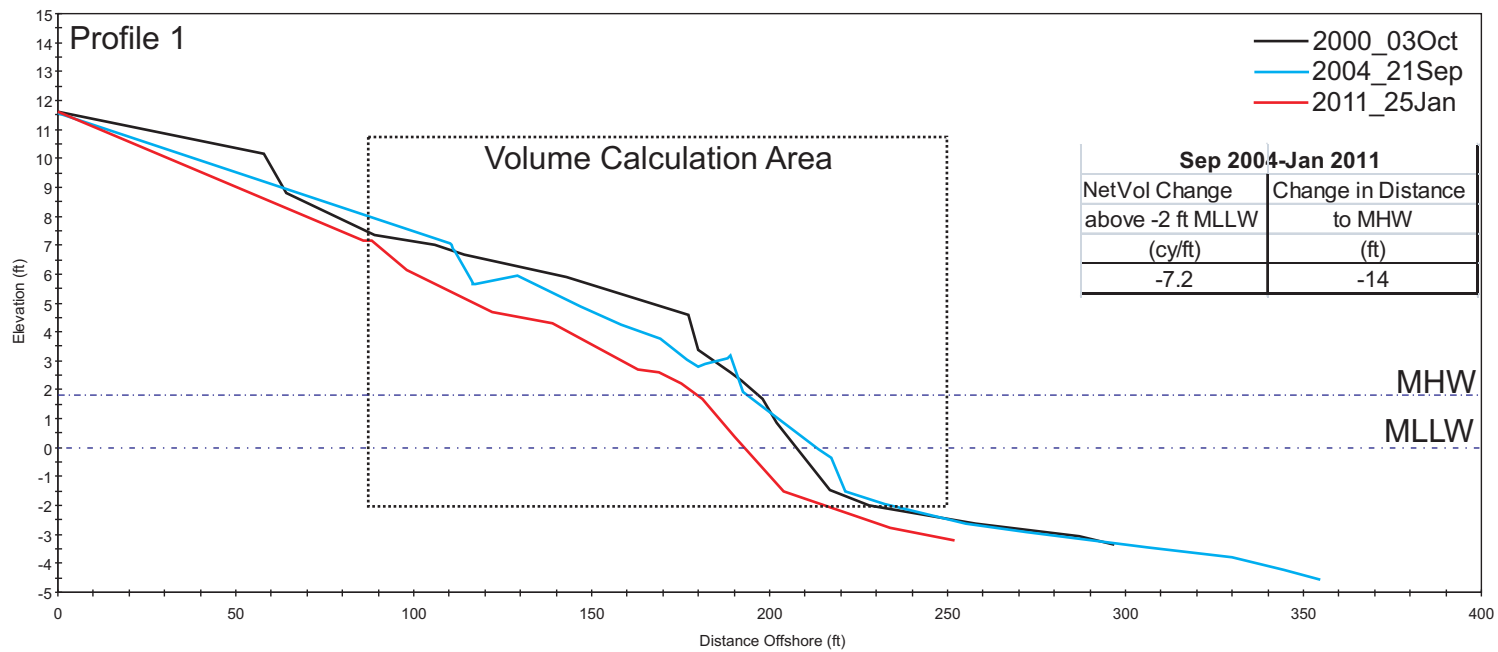


Figure 4. Central Beach profile cross-sections taken on 3 Oct 2000, 21 Sep 2004 and 25 Jan 2011. Also shown is the area on each profile that was used to calculate net volume change. Net volume change and change in the distance to MHW between 2004 and Jan 2011 is shown in the chart on each profile.

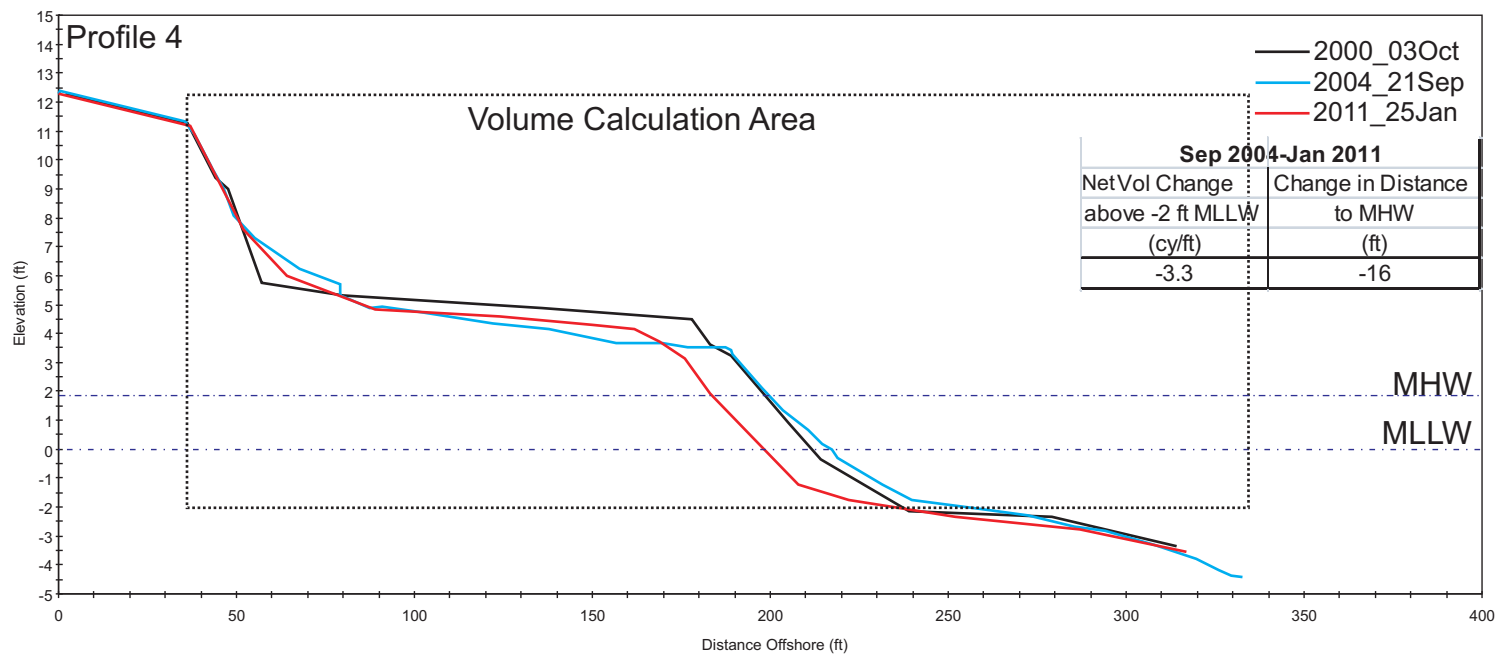
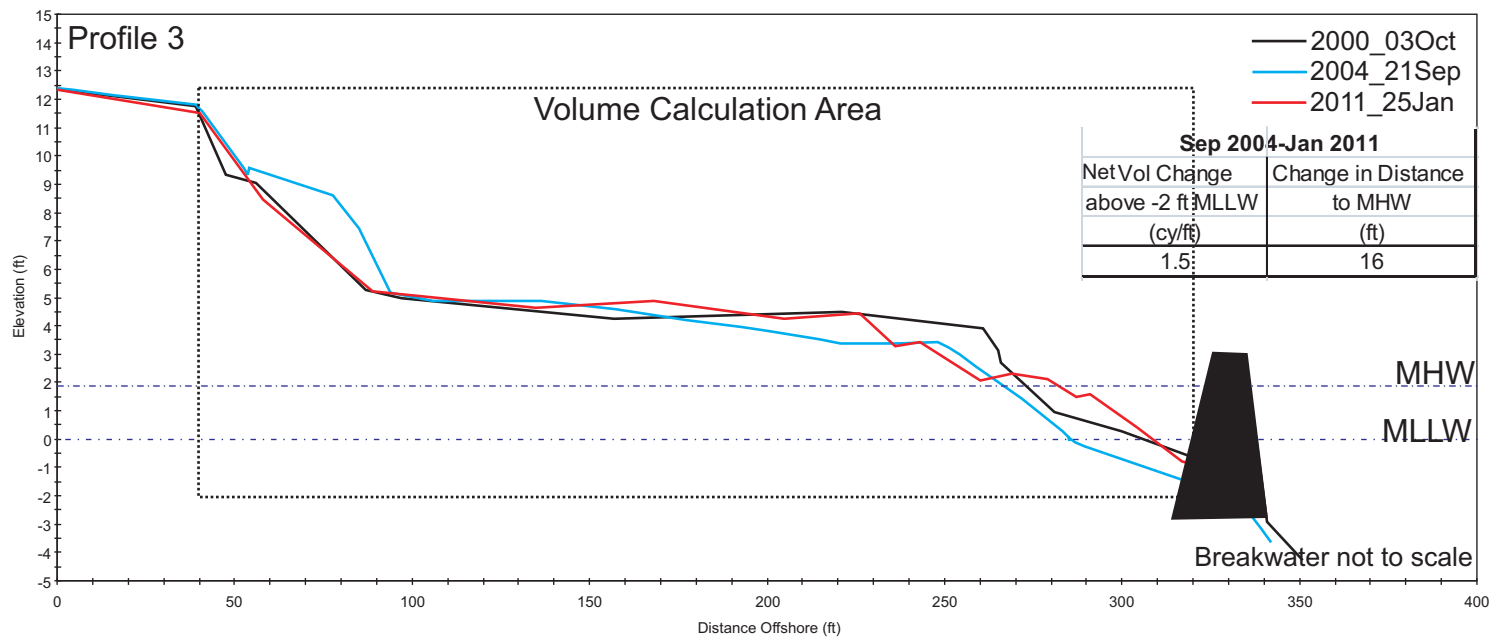


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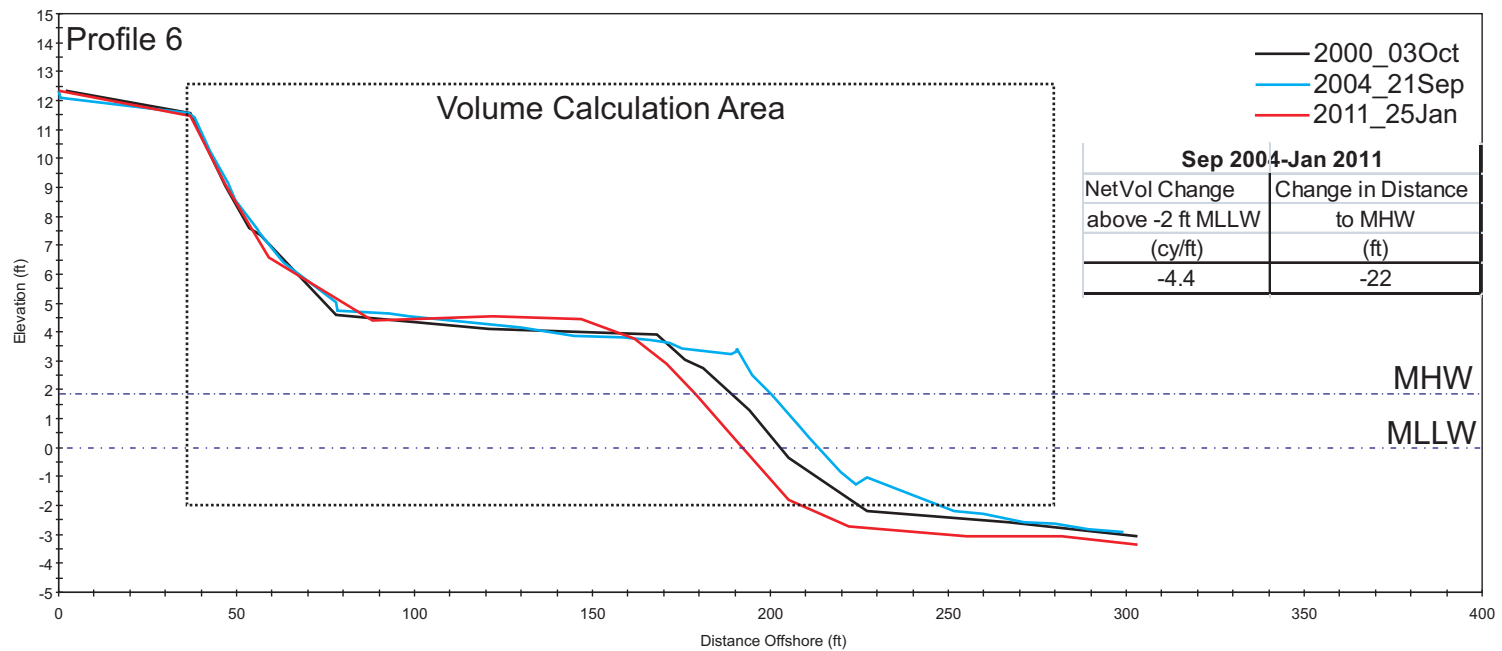
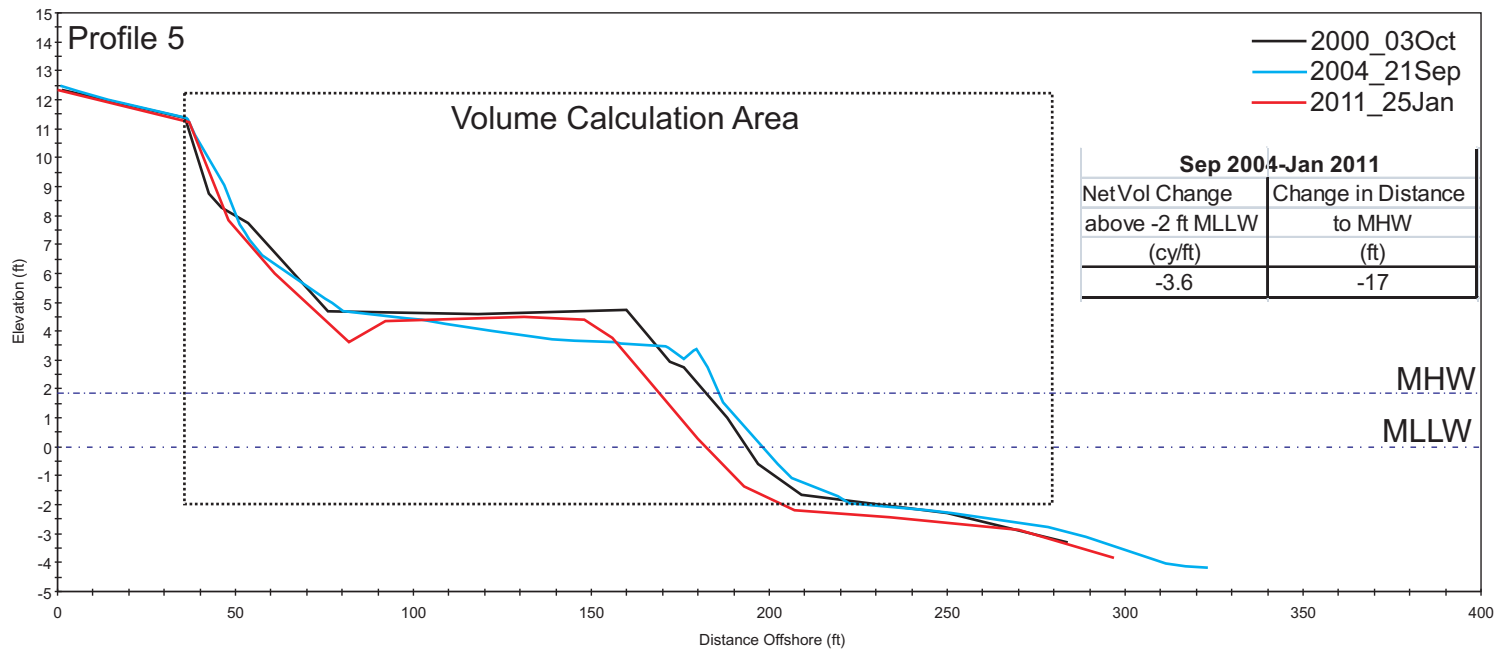


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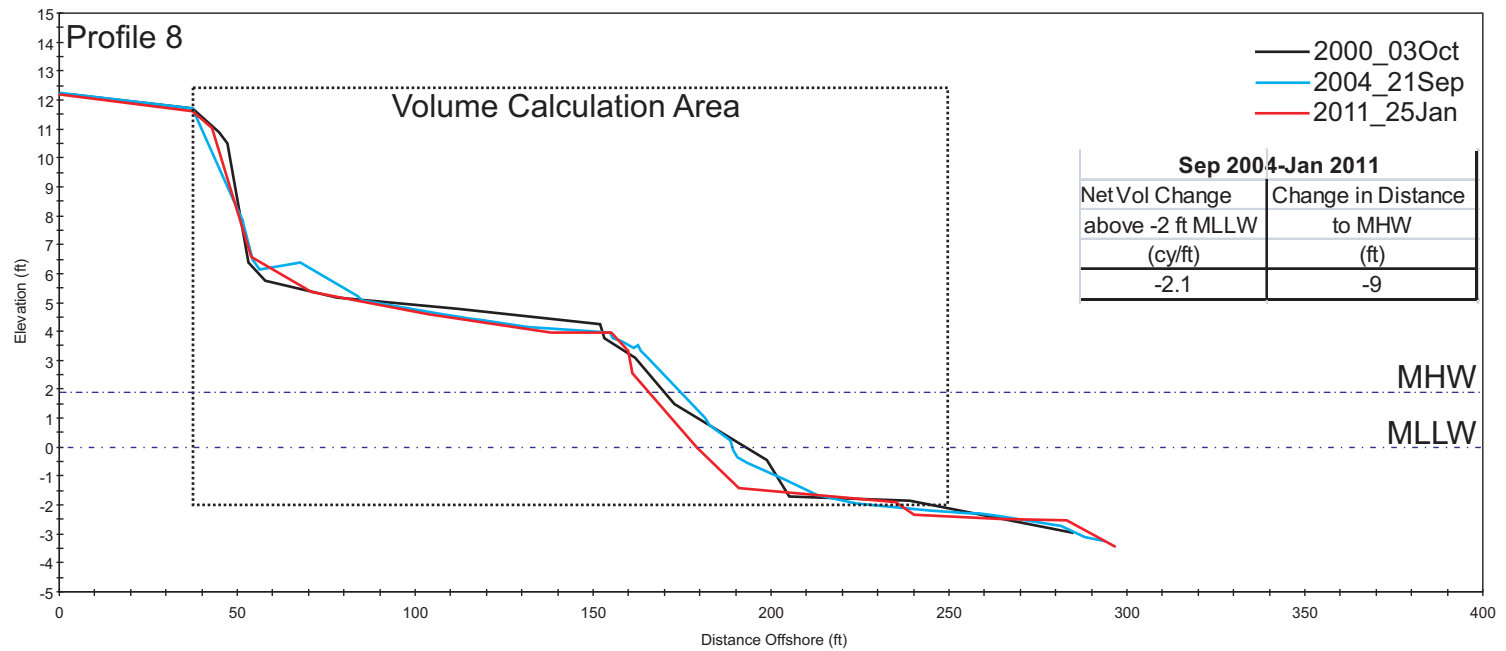
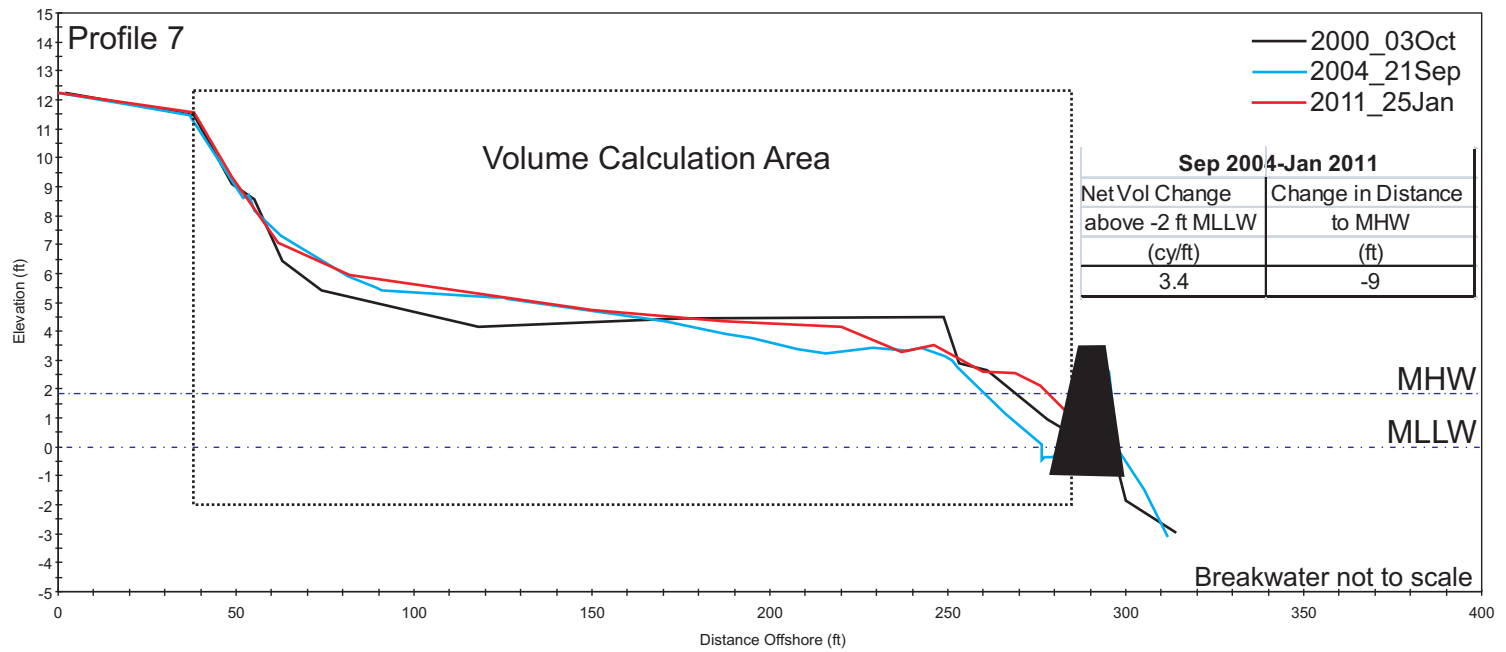


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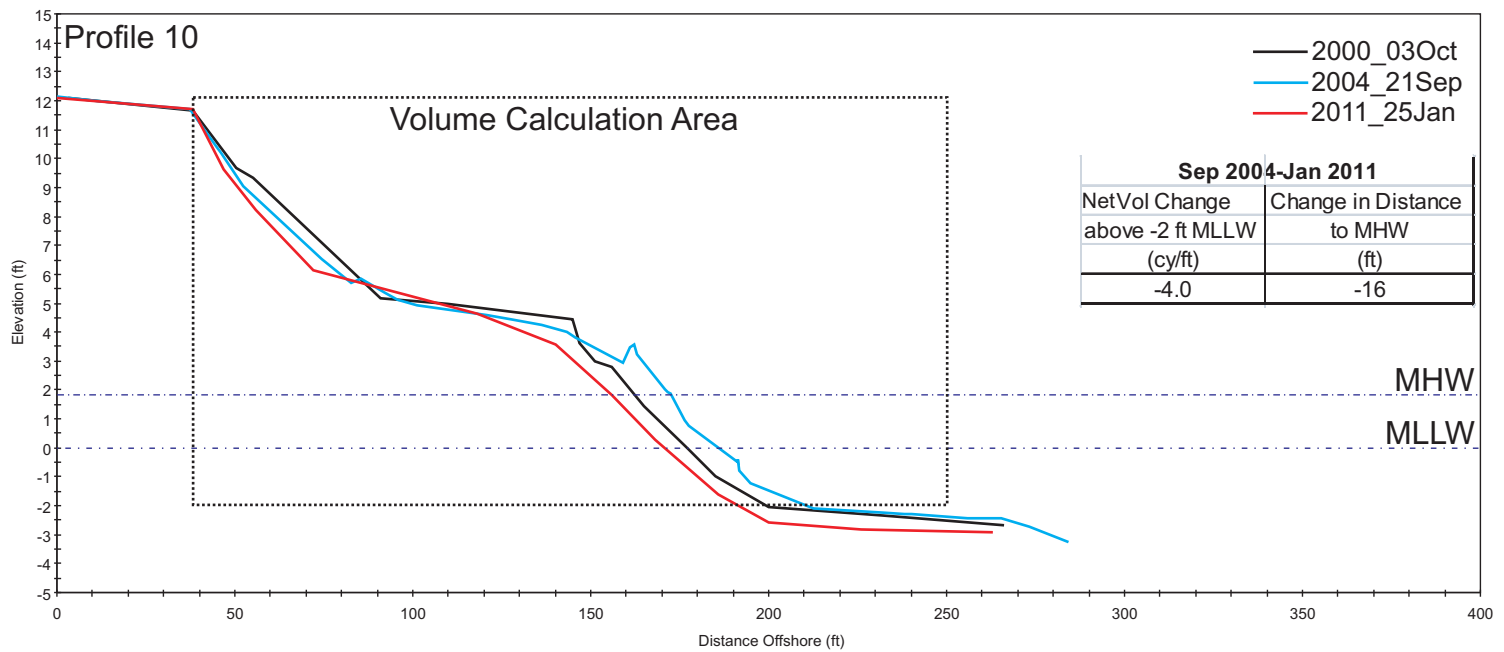
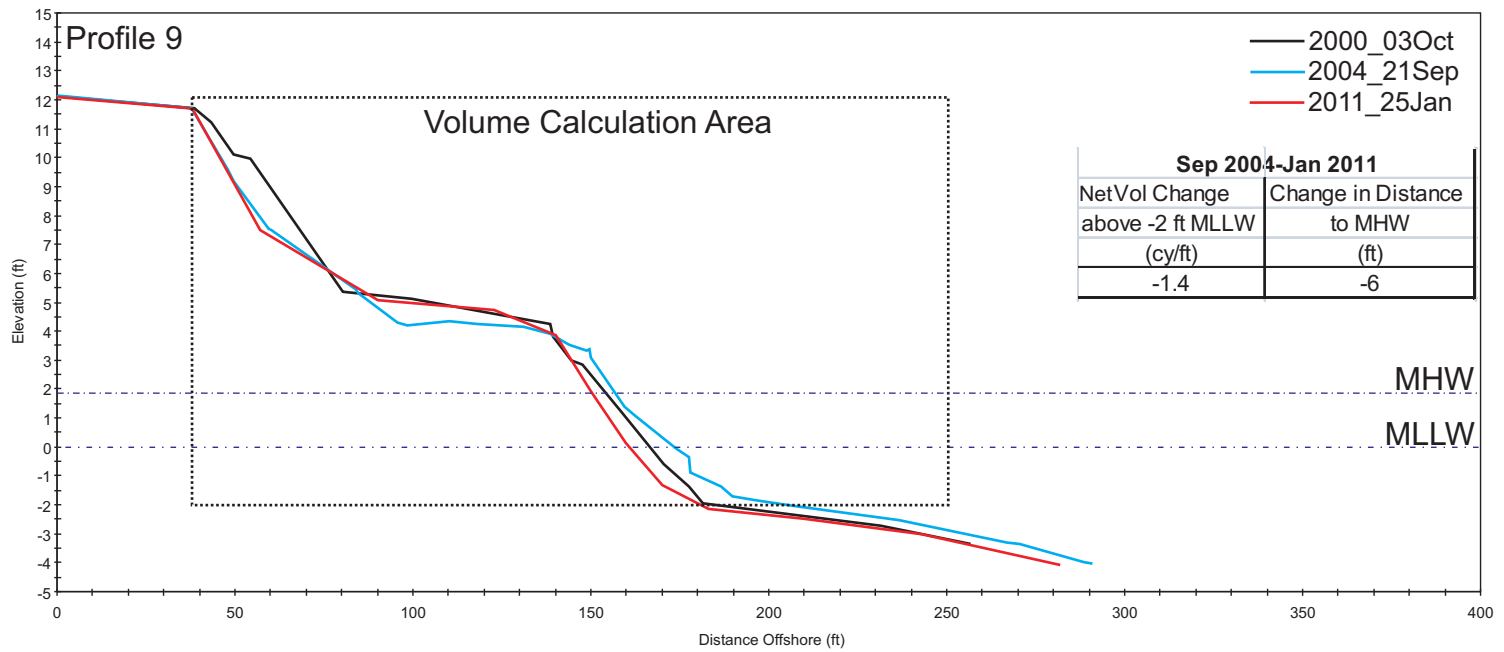


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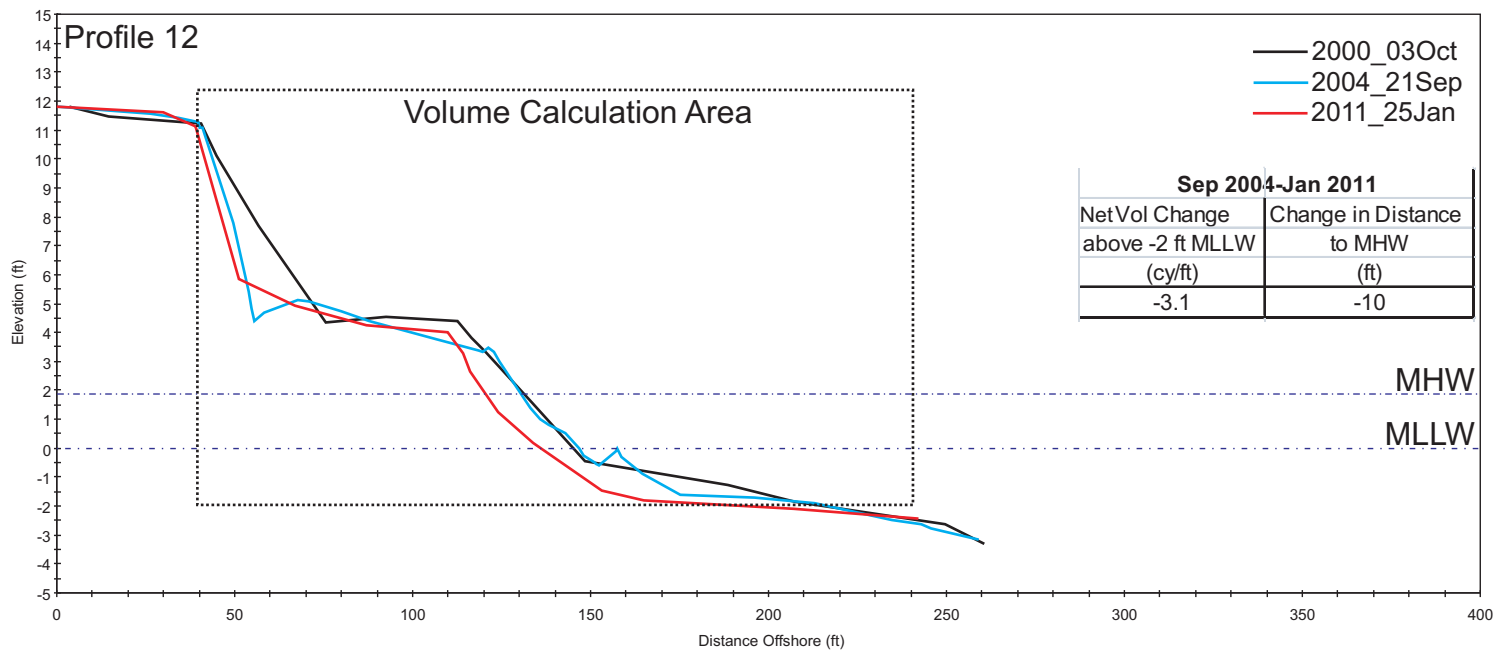
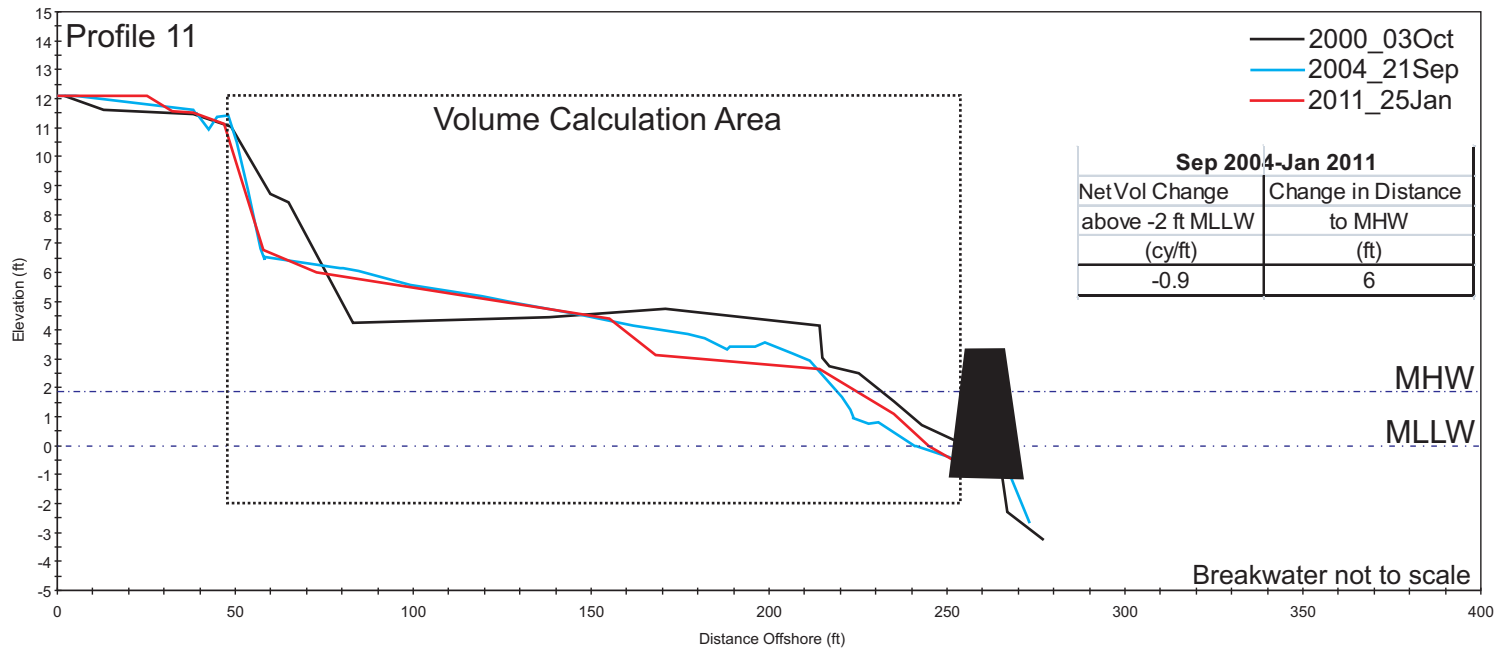


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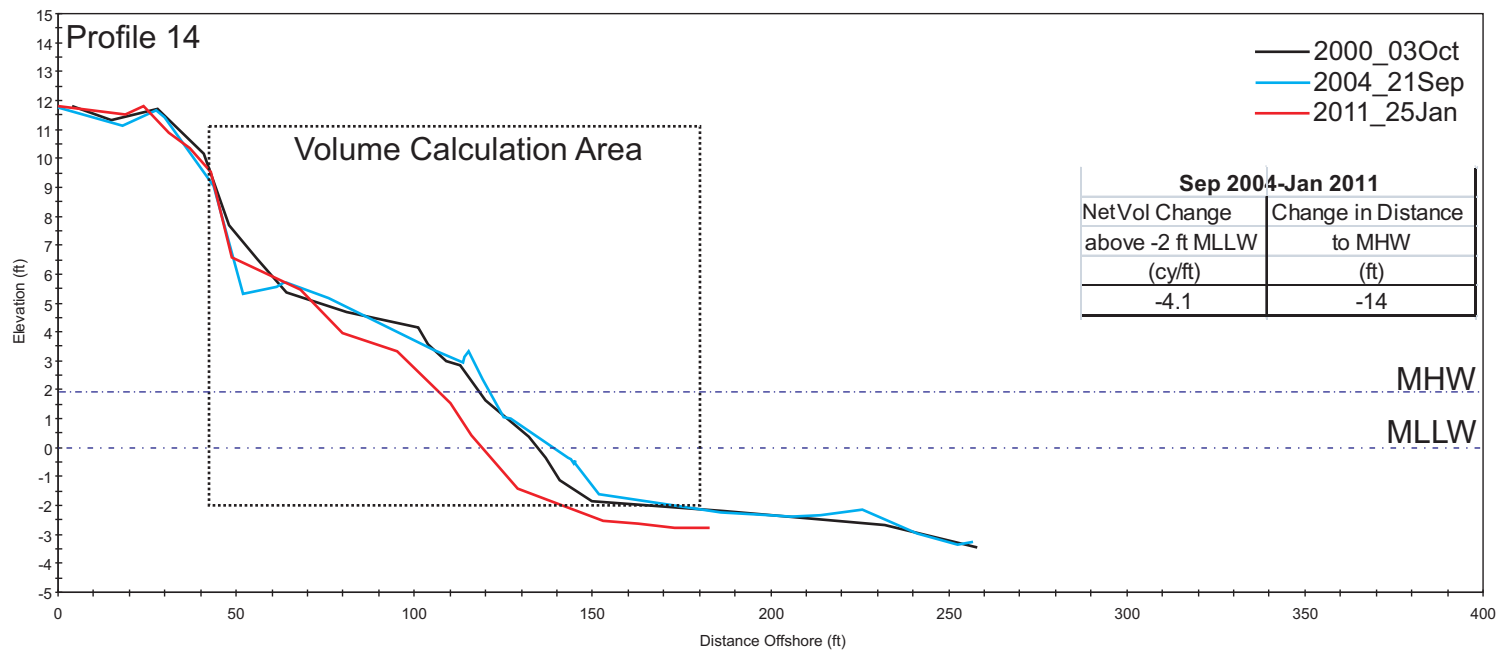
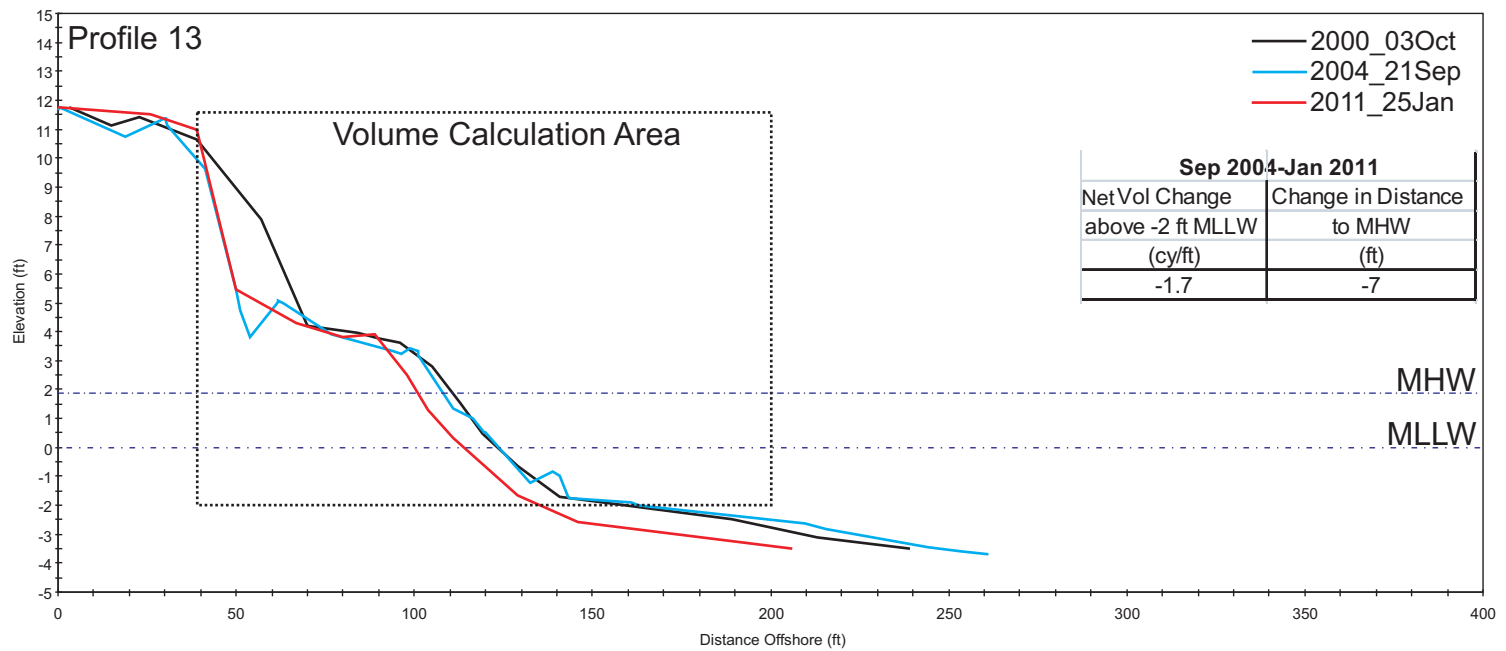


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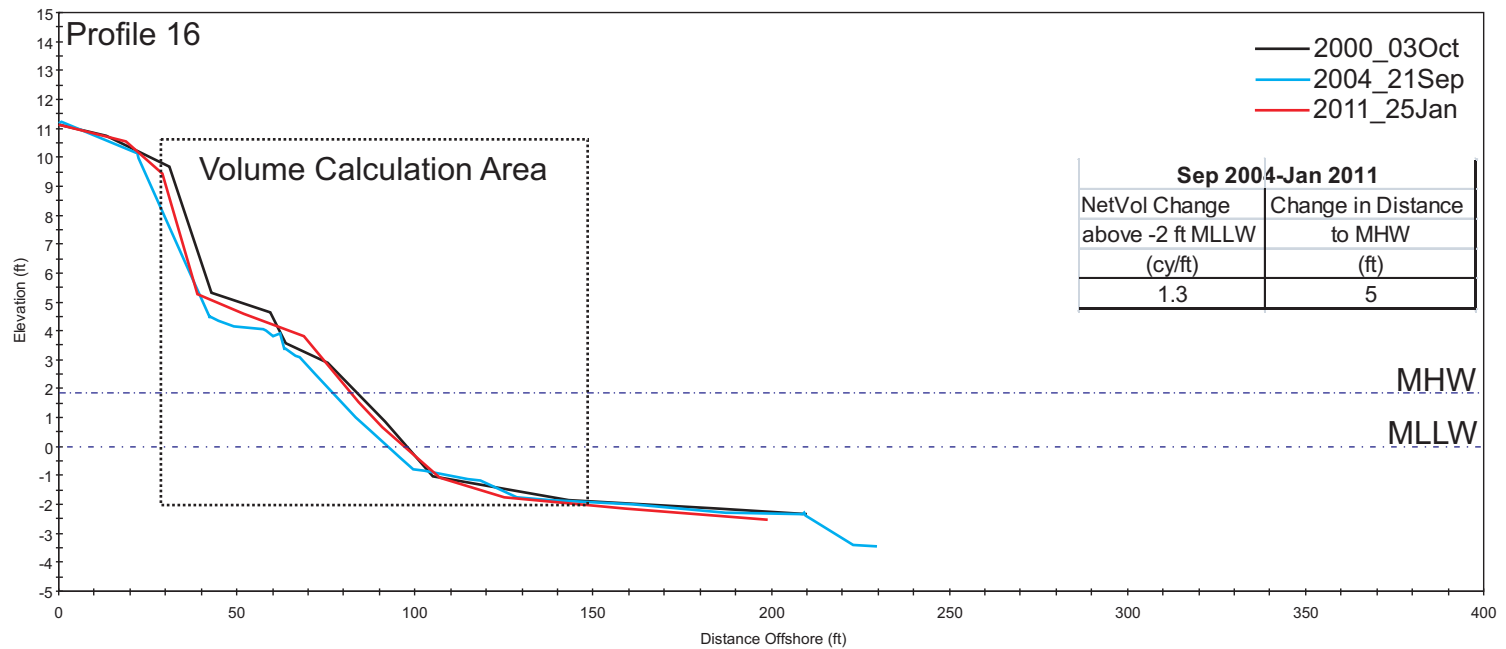
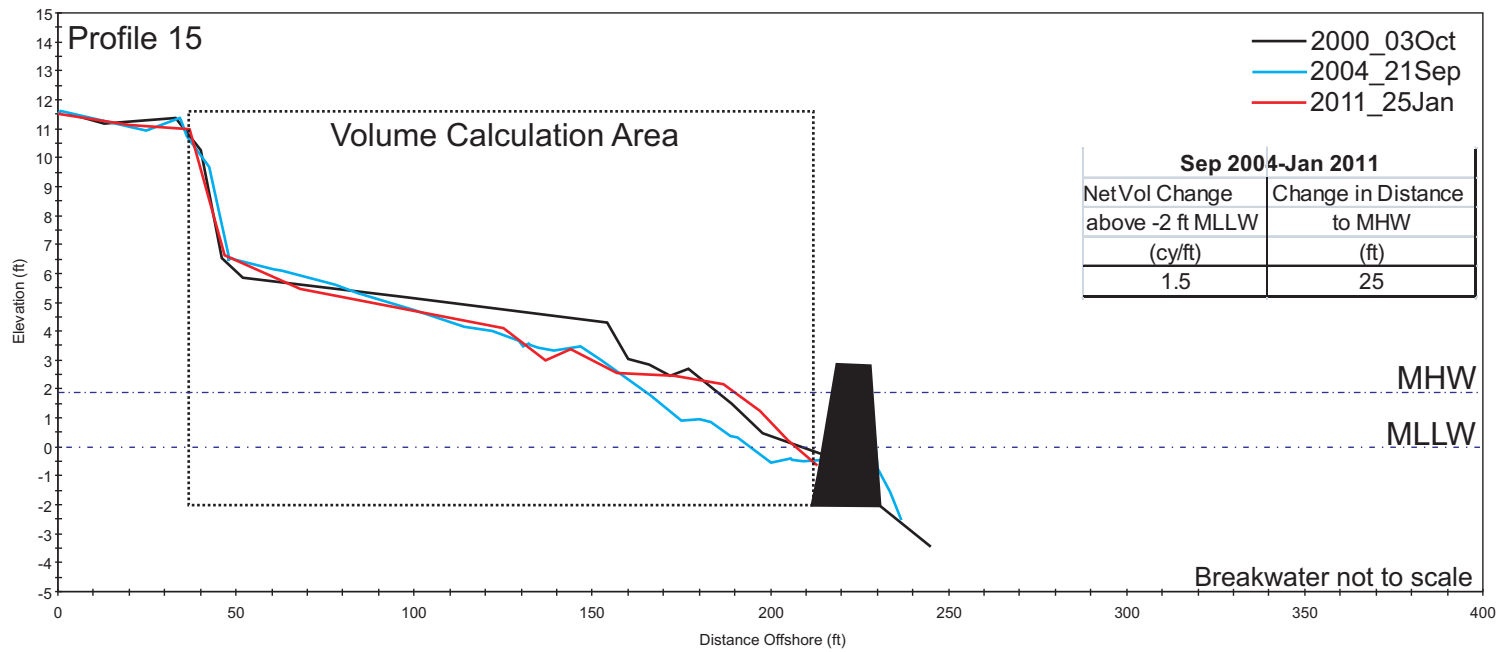


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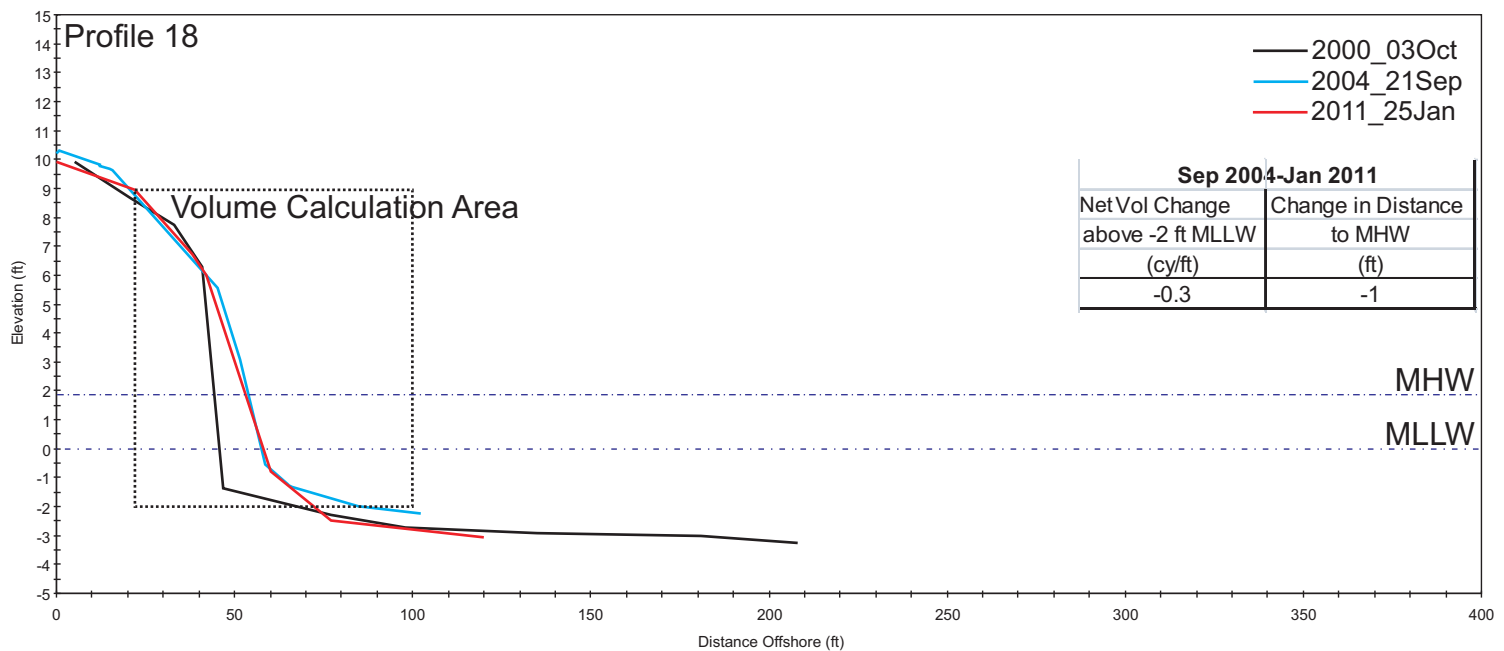
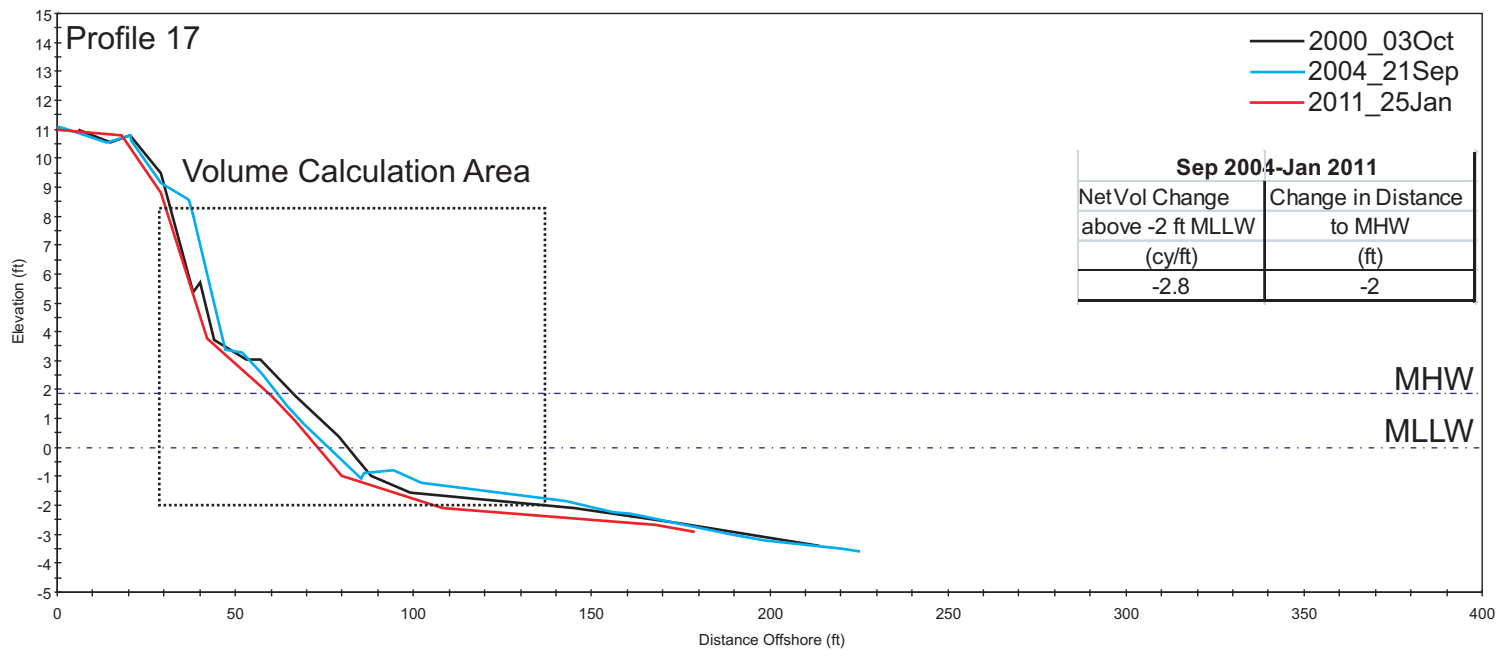


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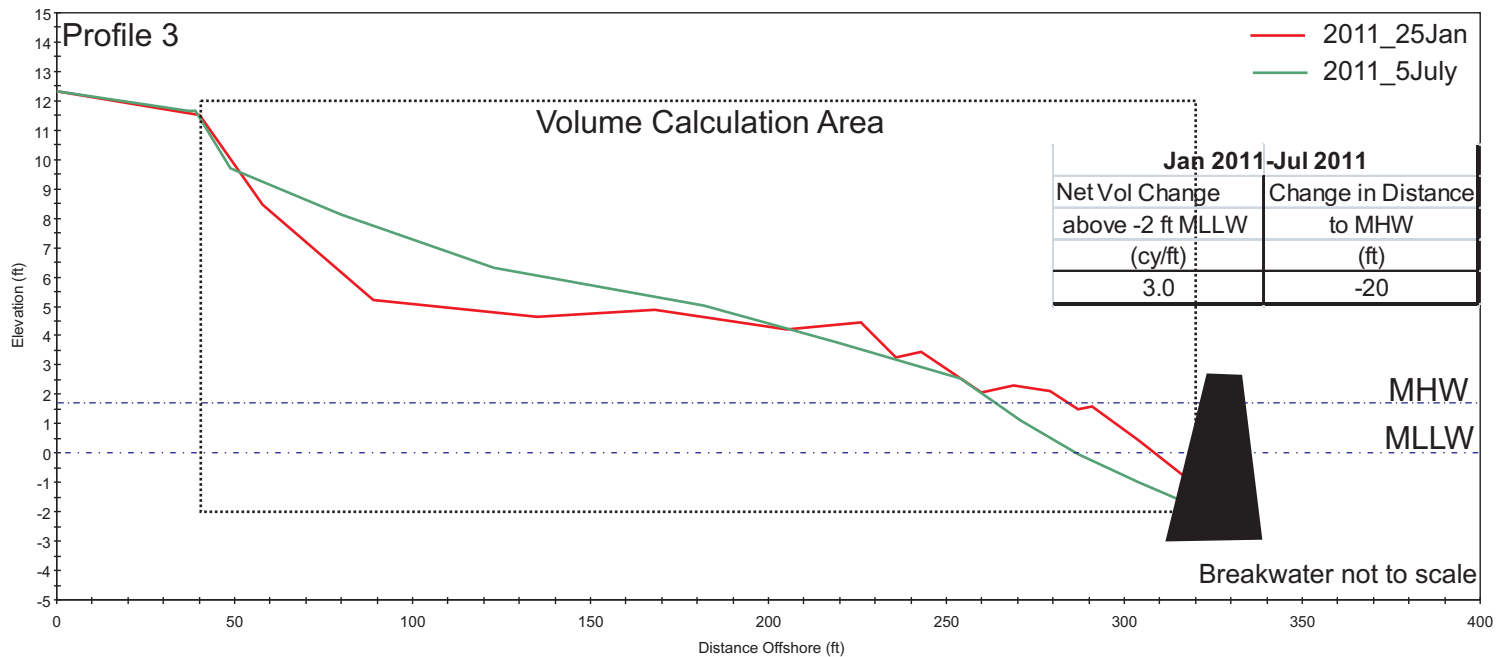
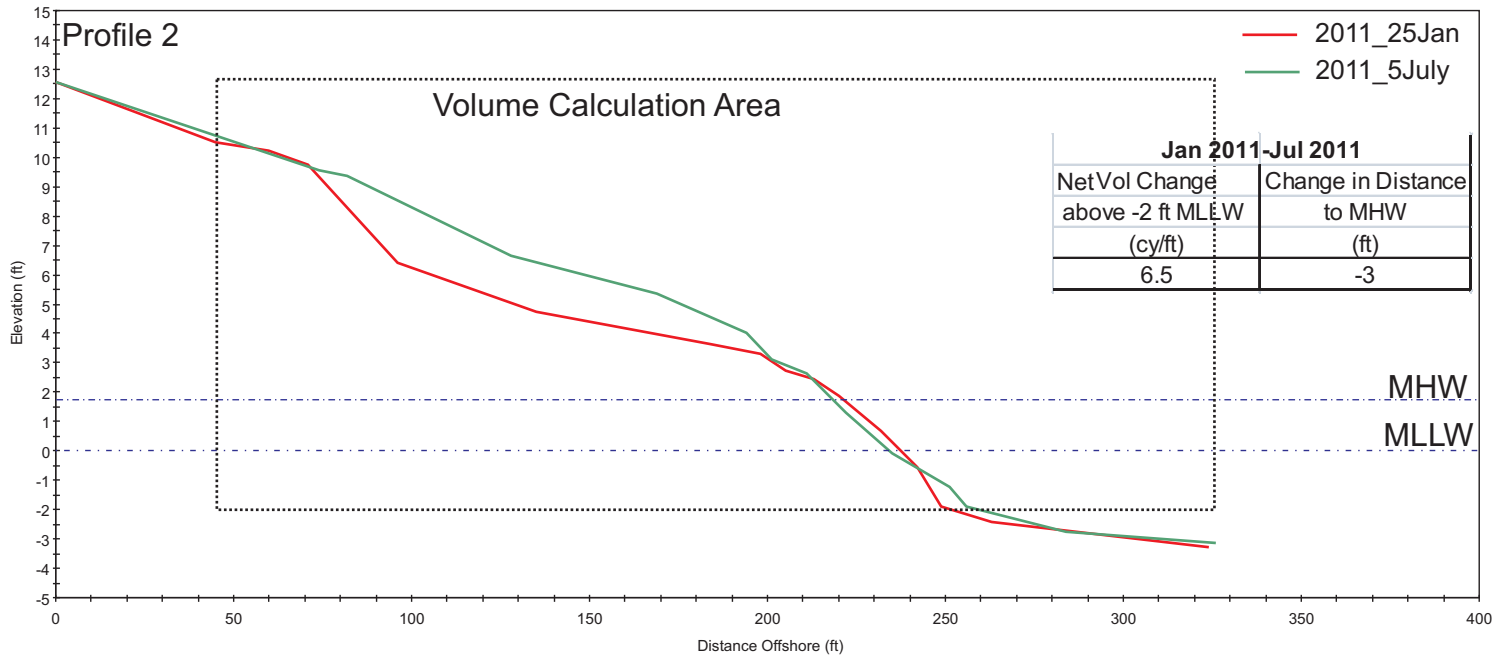


Figure 5. Central Beach profile cross-sections taken before the beach fill (25Jan2011) and after the beach fill (5Jul2011). Also shown is the area on each profile that was used to calculate net volume change. Net volume change and change in distance to MHW between Jan and July 2011 is shown in the chart on each profile.

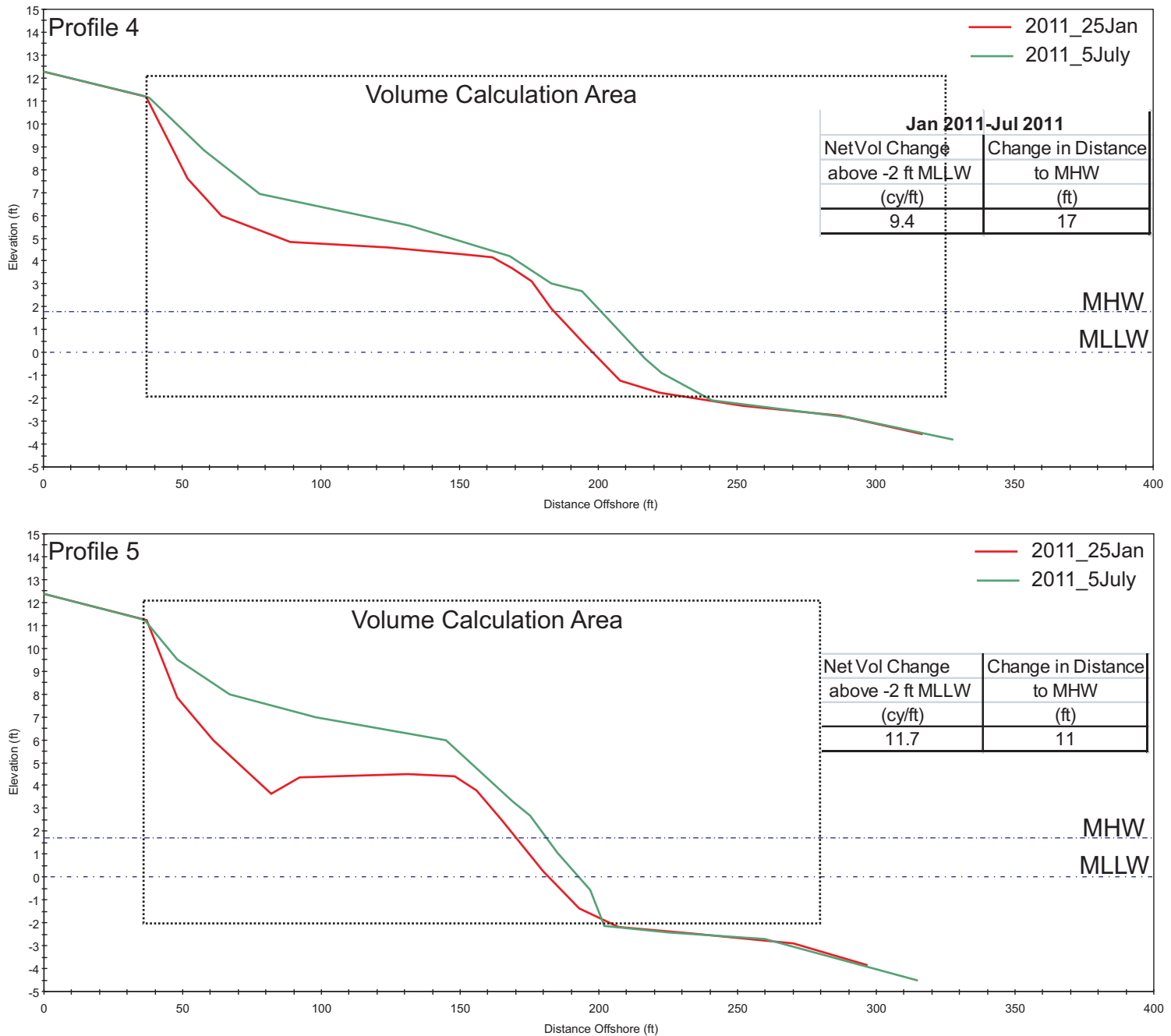


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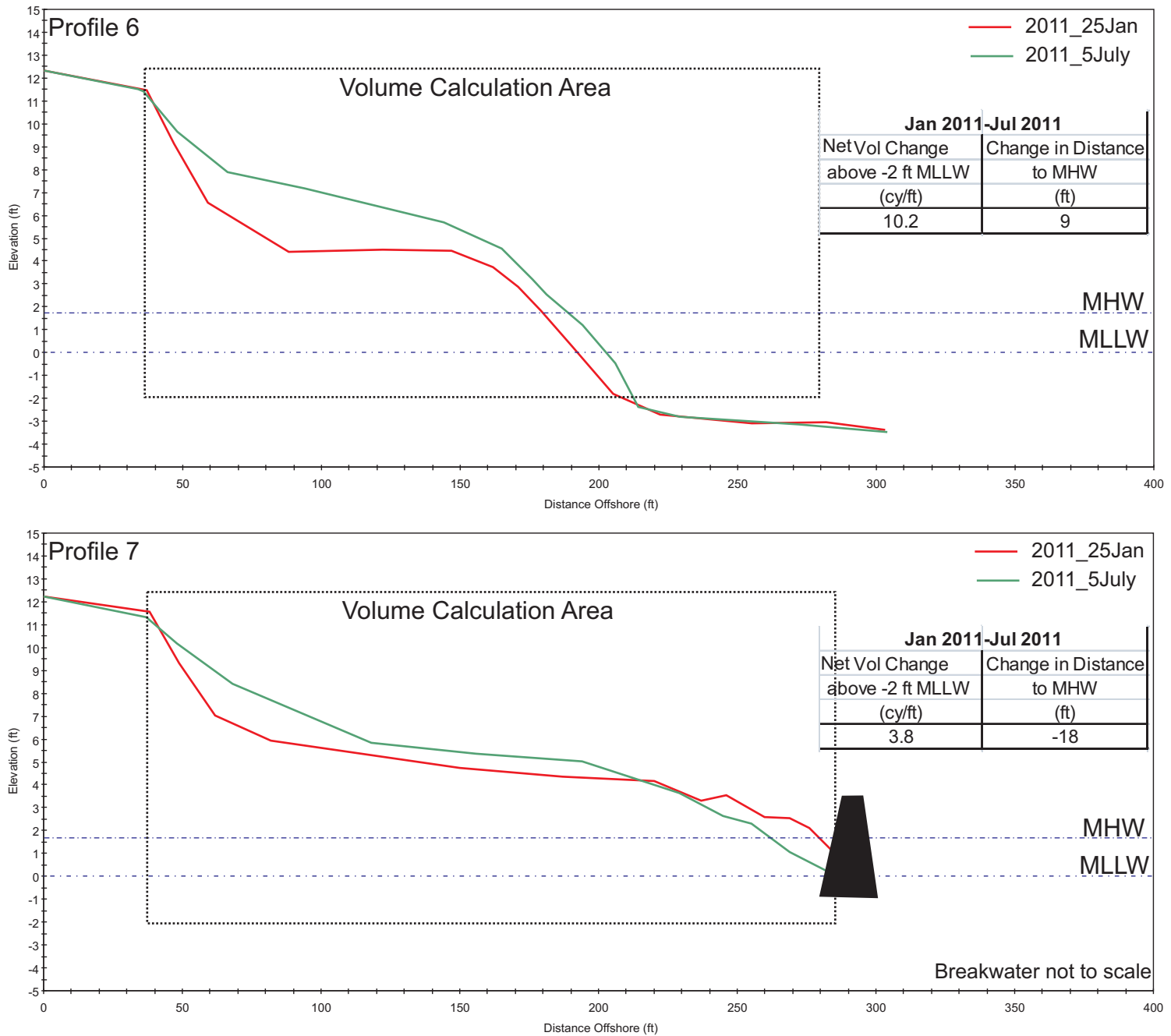


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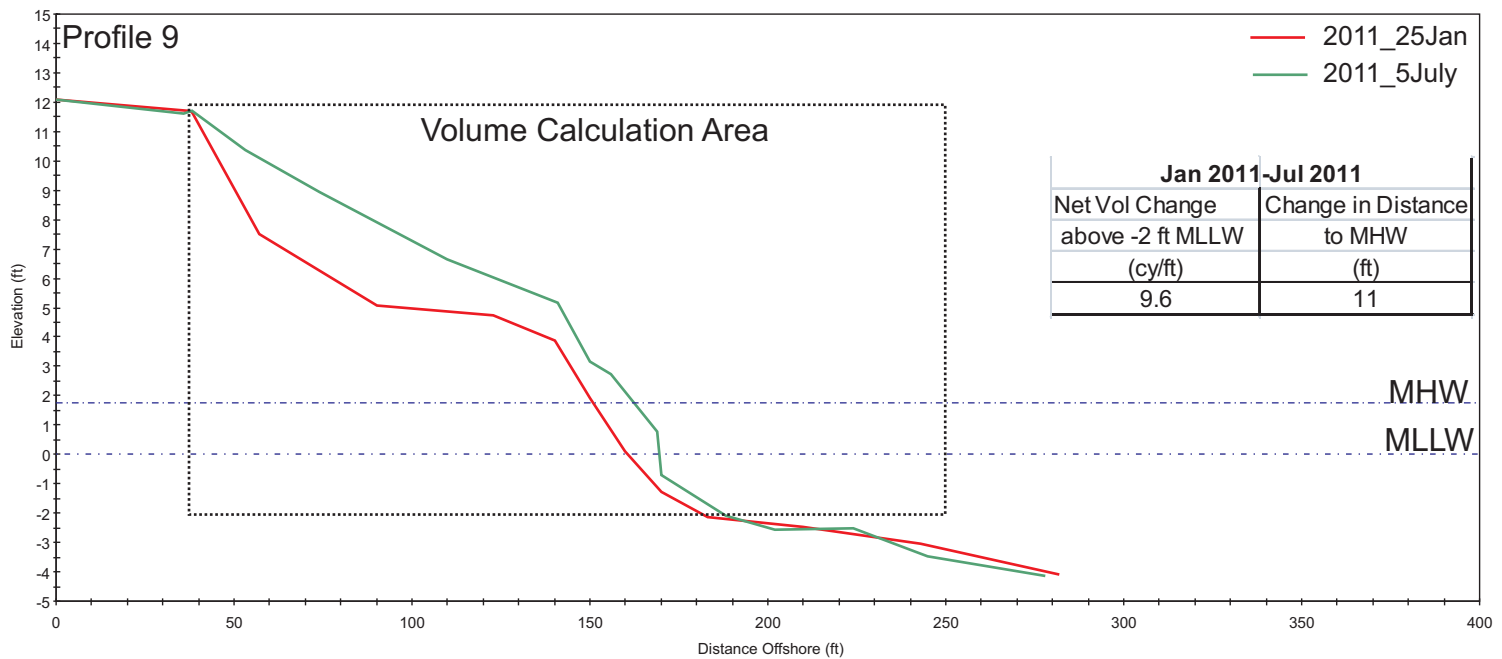
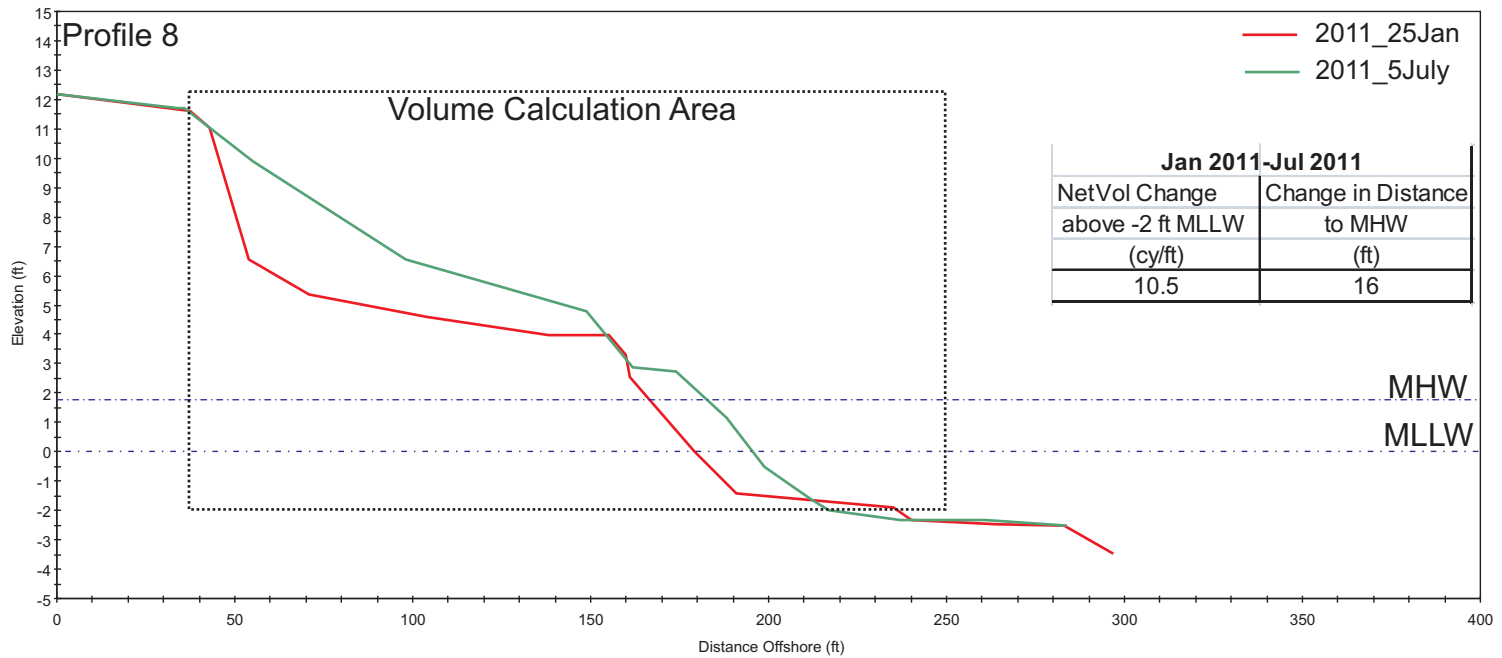


Figure 5. Central Beach profile cross-sections taken before the beach fill (25Jan2011) and after the beach fill (5Jul2011). Also shown is the area on each profile that was used to calculate net volume change. Net volume change and change in distance to MHW between Jan and July 2011 is shown in the chart on each profile.

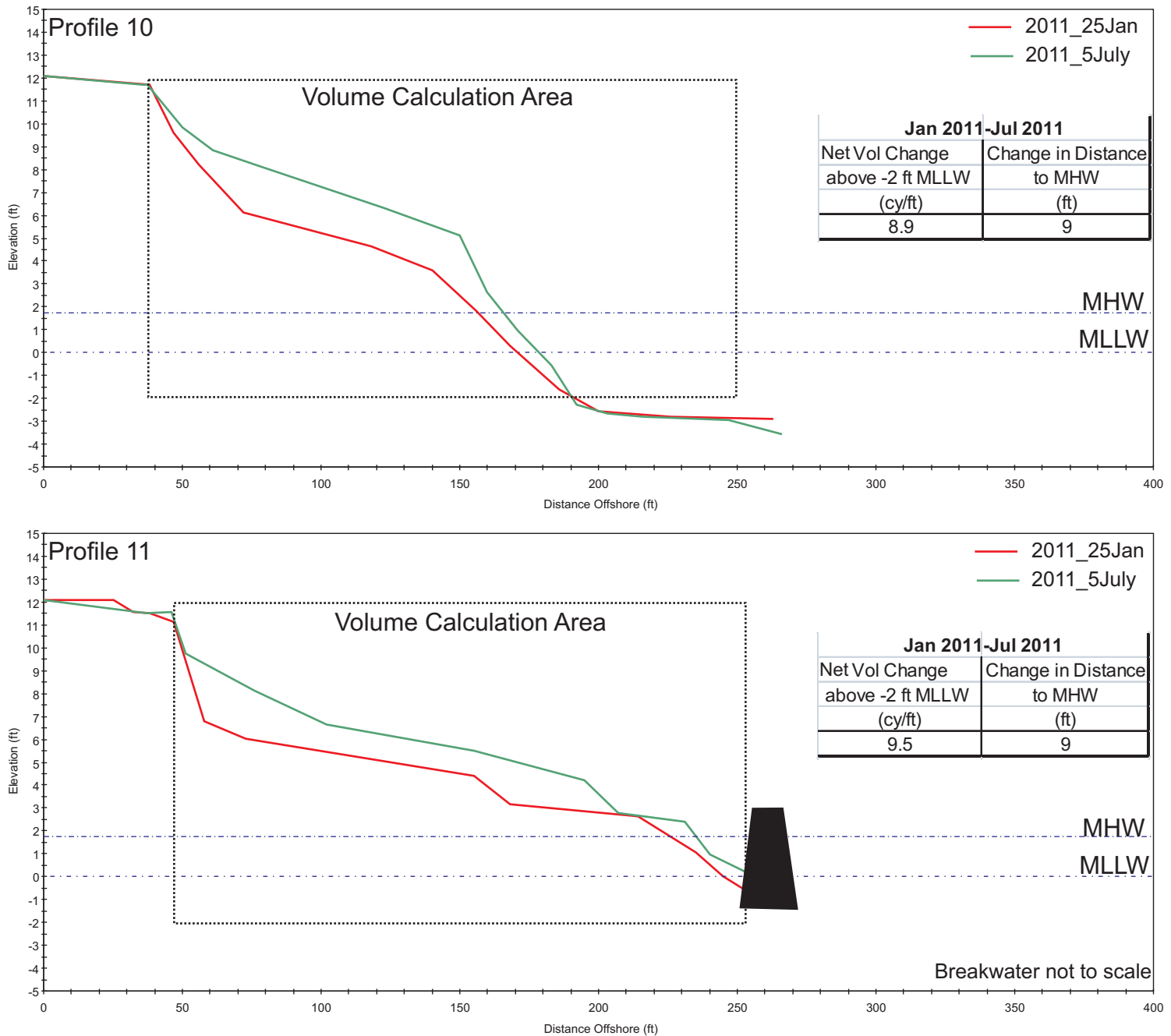


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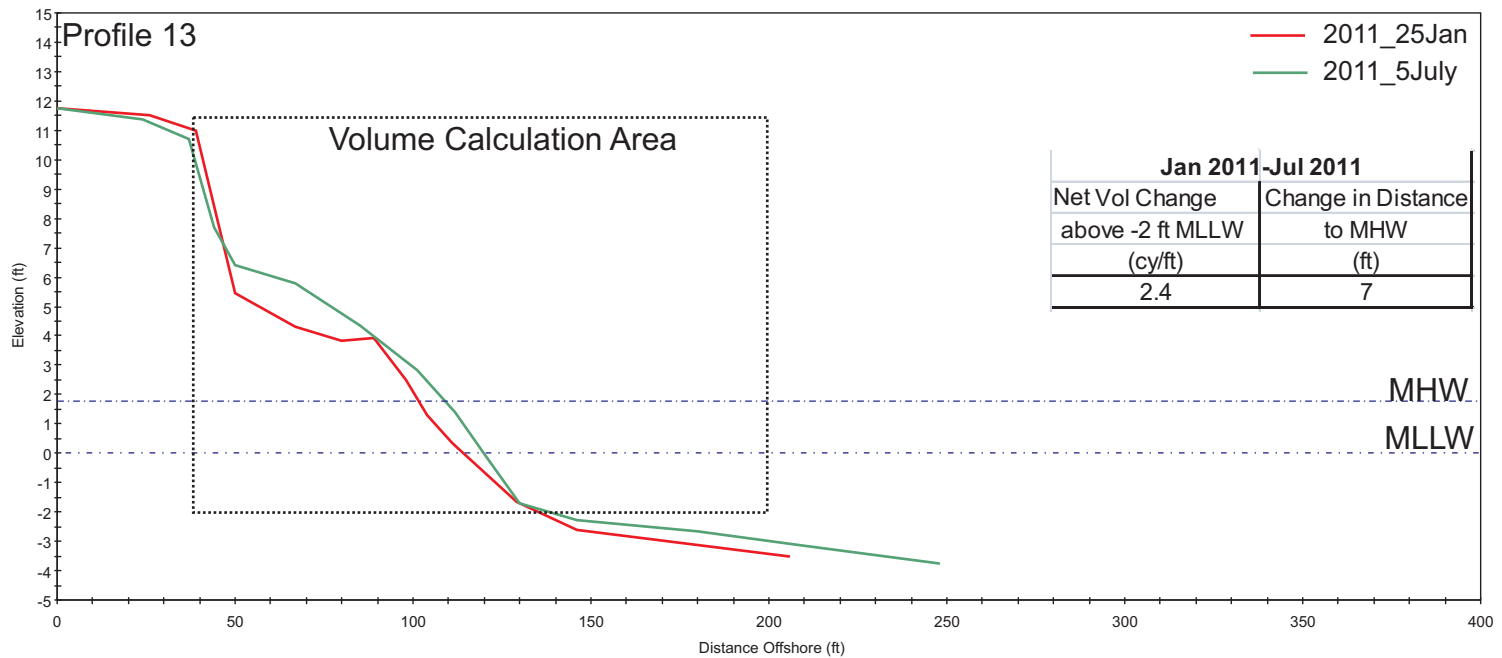
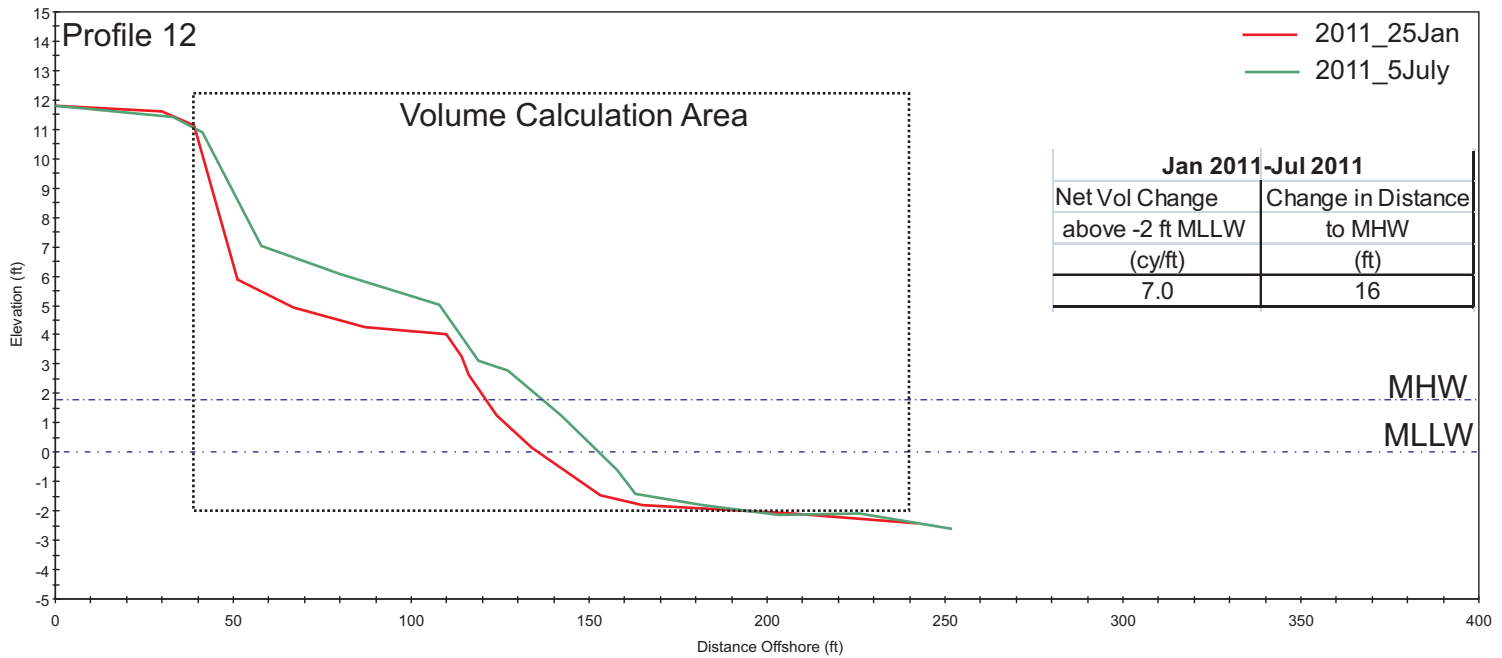


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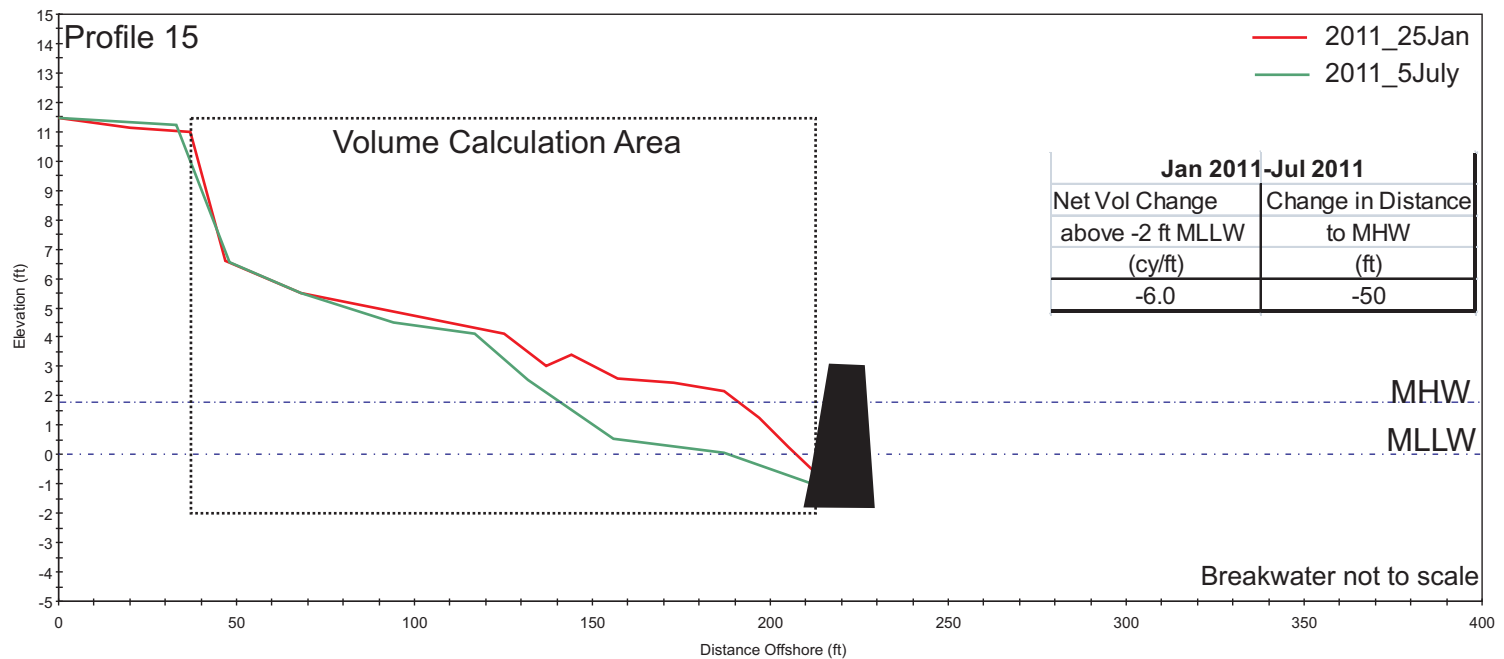
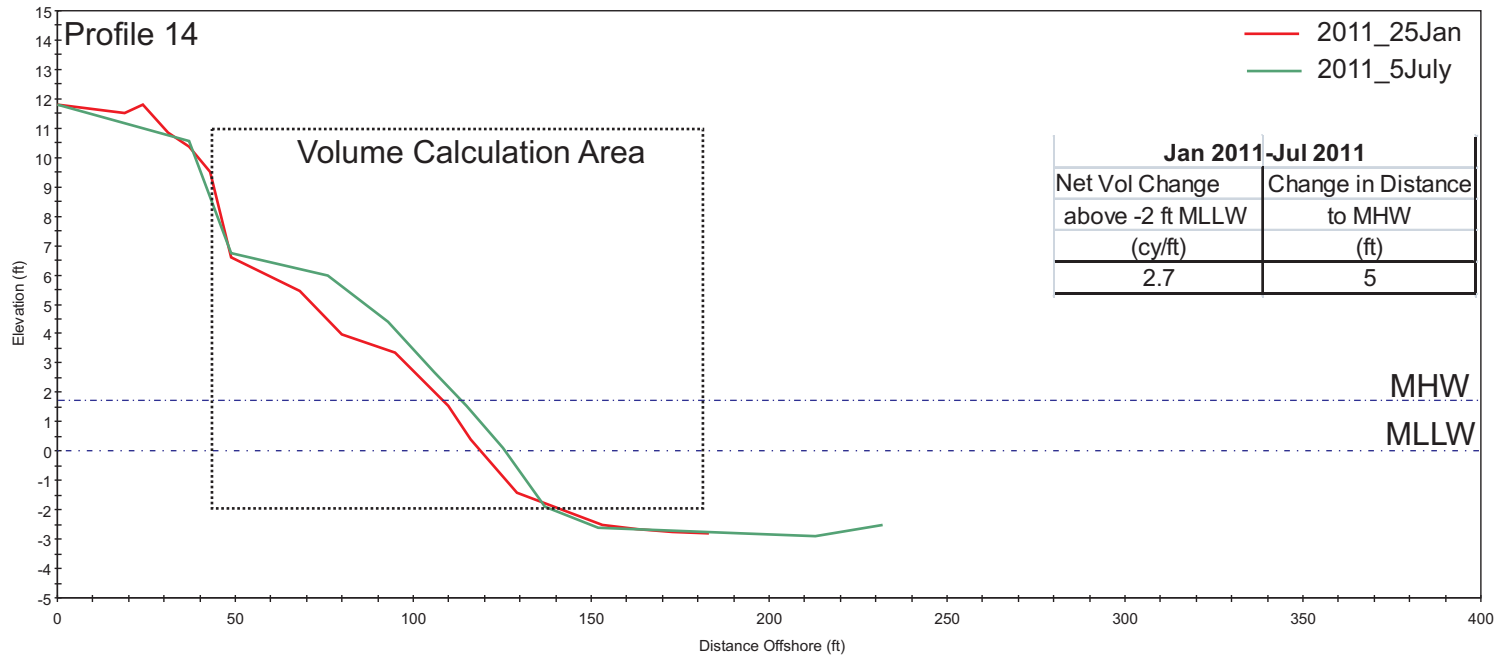


Figure 5. Central Beach profile cross-sections taken before the beach fill (25Jan2011) and after the beach fill (5Jul2011). Also shown is the area on each profile that was used to calculate net volume change. Net volume change and change in distance to MHW between Jan and July 2011 is shown in the chart on each profile.

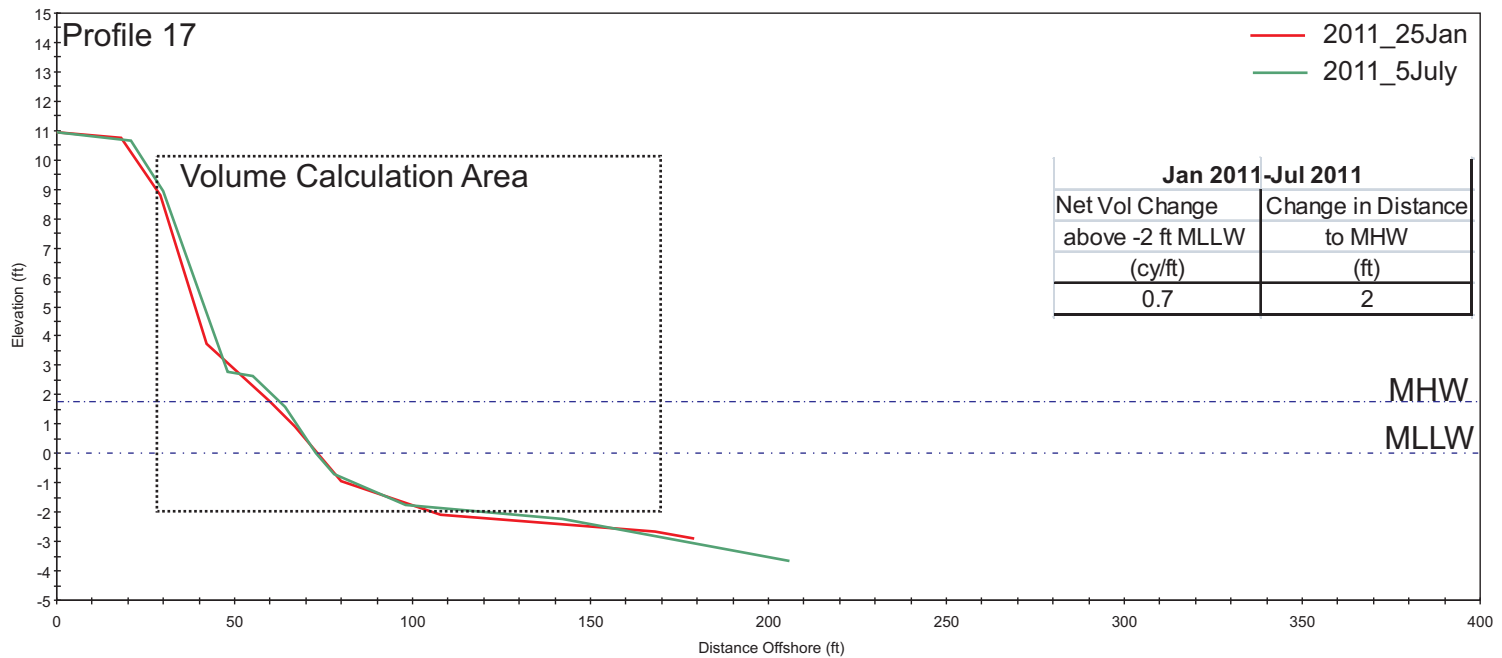
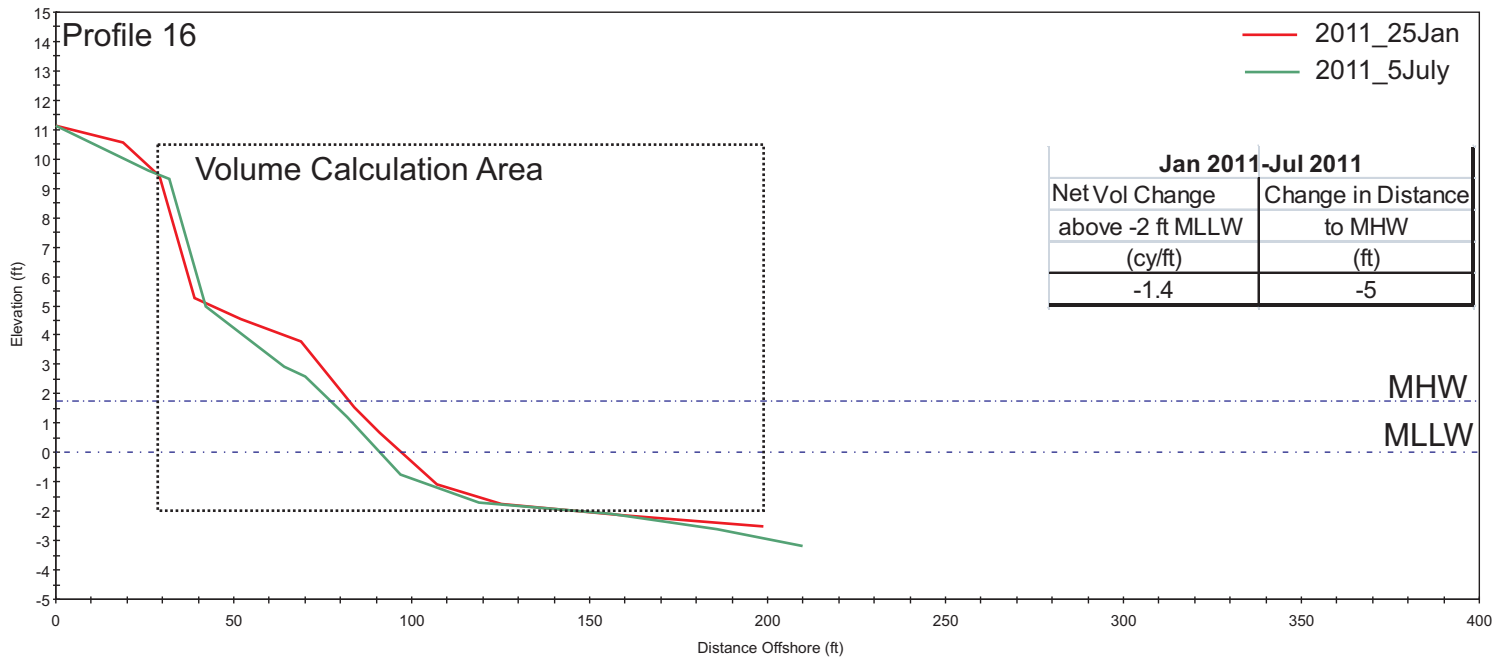


Figure 5. Central Beach profile cross-sections taken before the beach fill (25Jan2011) and after the beach fill (5Jul2011). Also shown is the area on each profile that was used to calculate net volume change. Net volume change and change in distance to MHW between Jan and July 2011 is shown in the chart on each profile.



Figure 6. Photos showing Central Beach before (25 Jan 2011) and after (8 Jun 2011) the beach fill.



Figure 7. Rectified low level aerial photos of Castlewood Beach, City of Colonial Beach taken in 2003 and 2011. The approximate high water shoreline was digitized.

— 30 Oct 2003 Shoreline
 — 11 Feb 2011 Shoreline

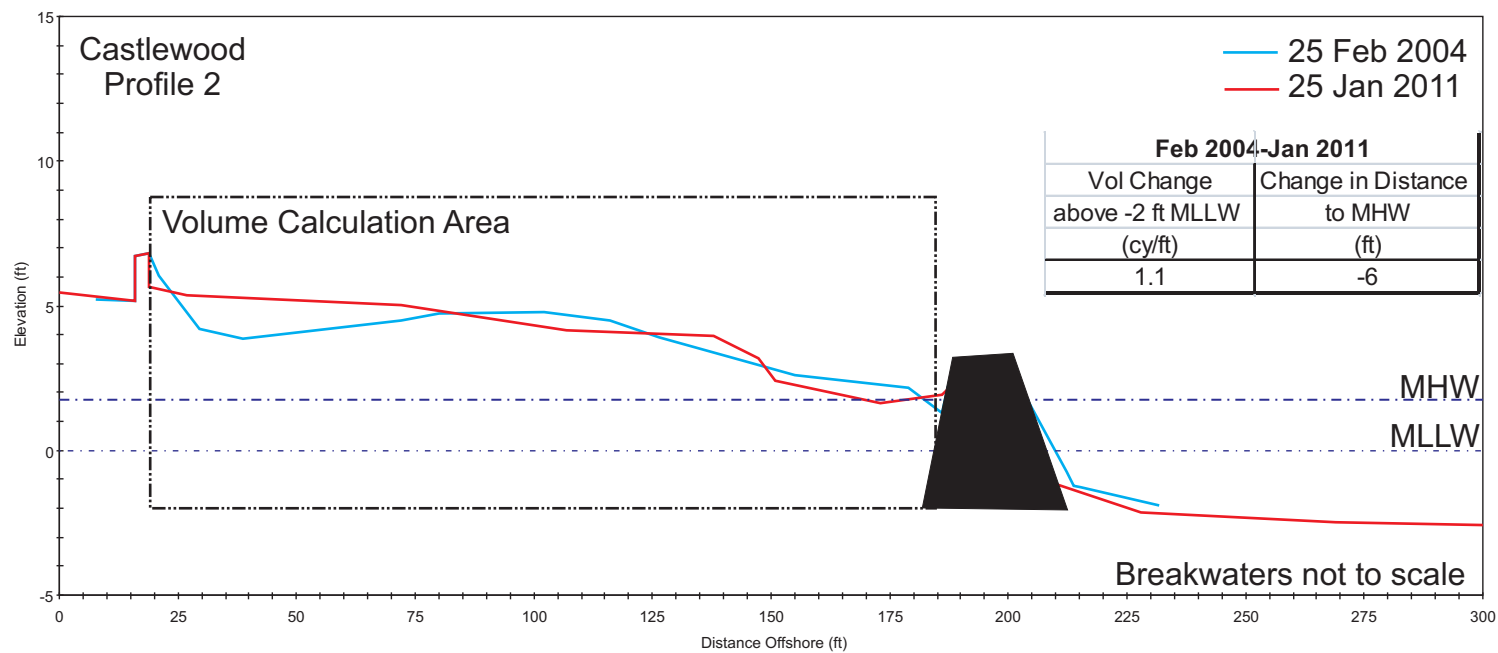
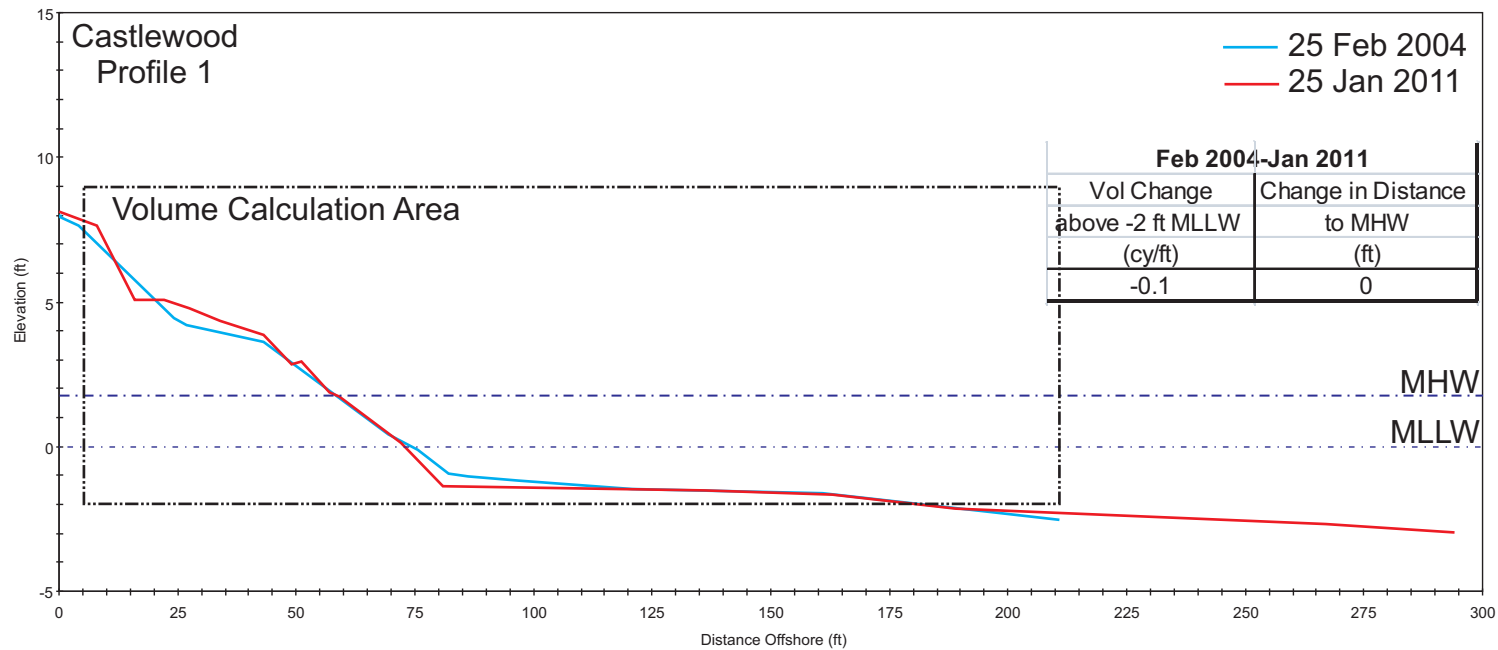


Figure 8. Castlewood Beach cross-sections taken in 2004 and 2011. Also shown is the area on each profile that was used to calculate net volume change. Net volume change and change in distance to MHW is shown in the chart on each profile.

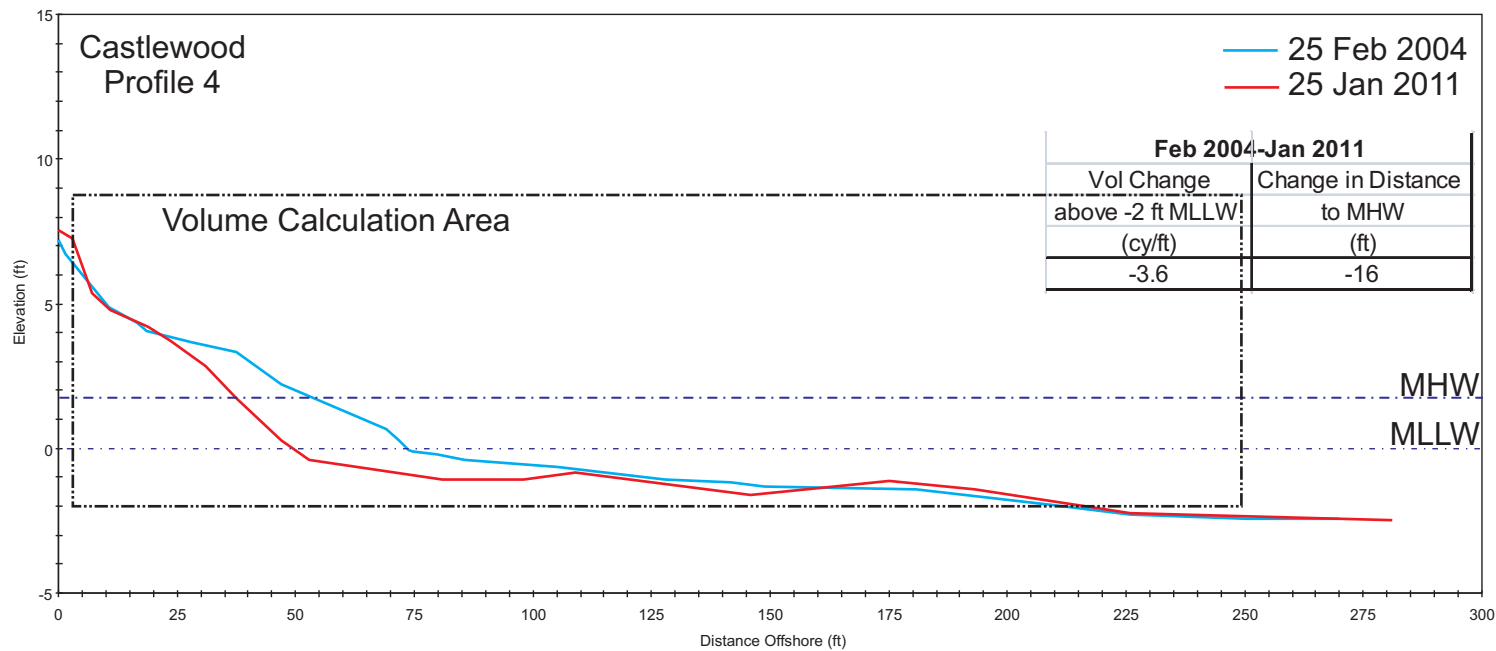
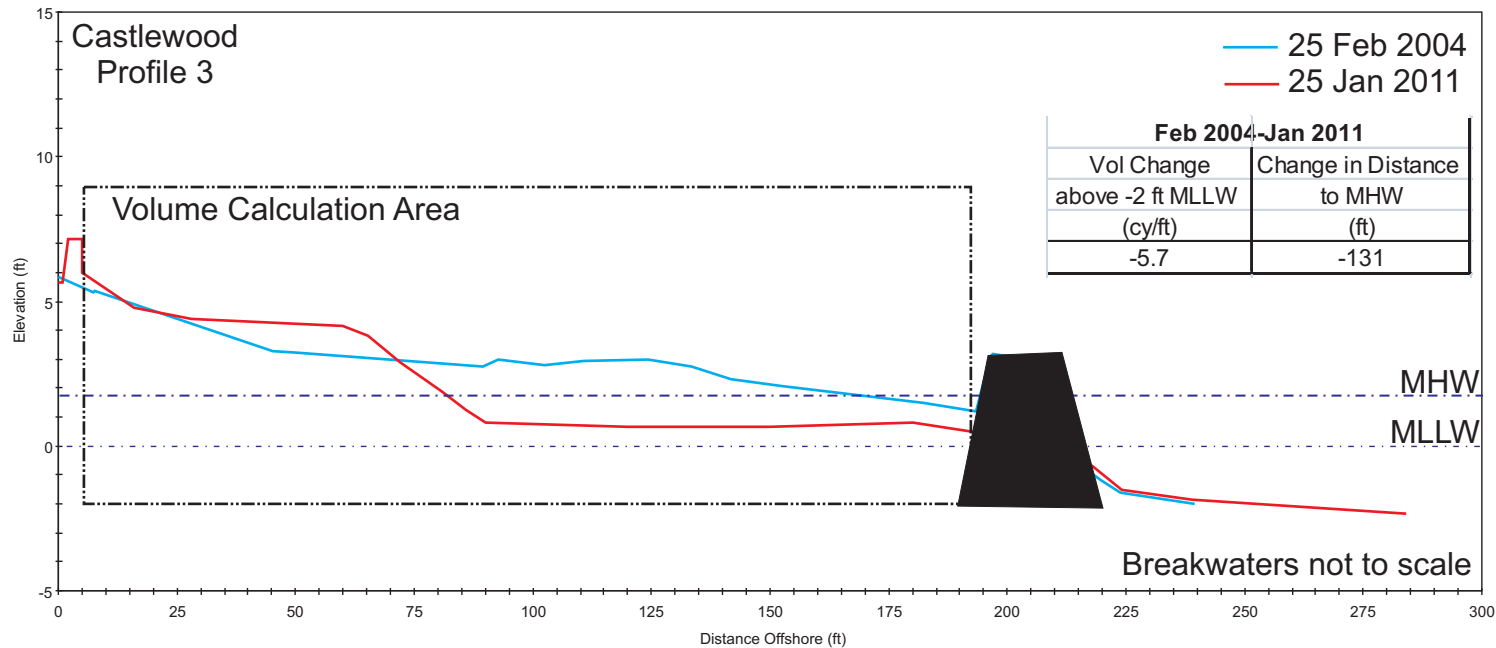


Figure 8. Castlewood Beach cross-sections taken in 2004 and 2011. Also shown is the area on each profile that was used to calculate net volume change. Net volume change and change in distance to MHW is shown in the chart on each profile.

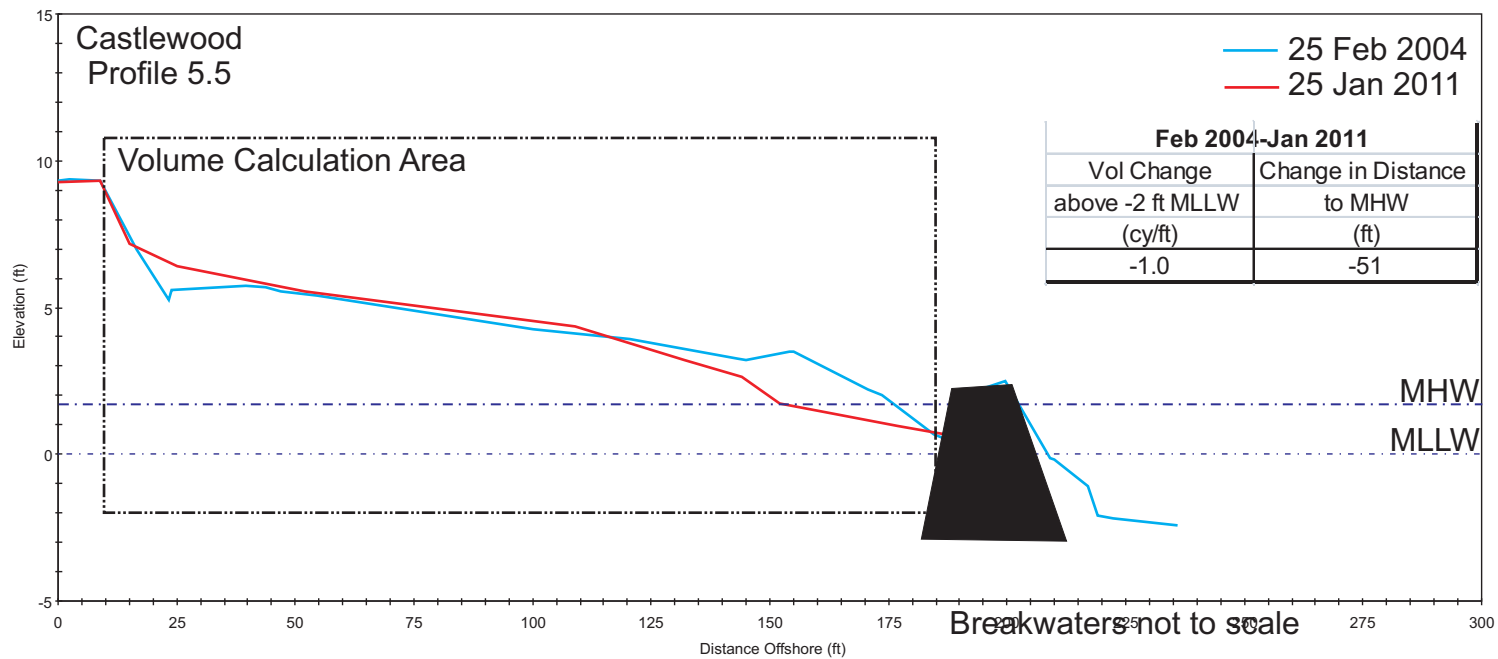
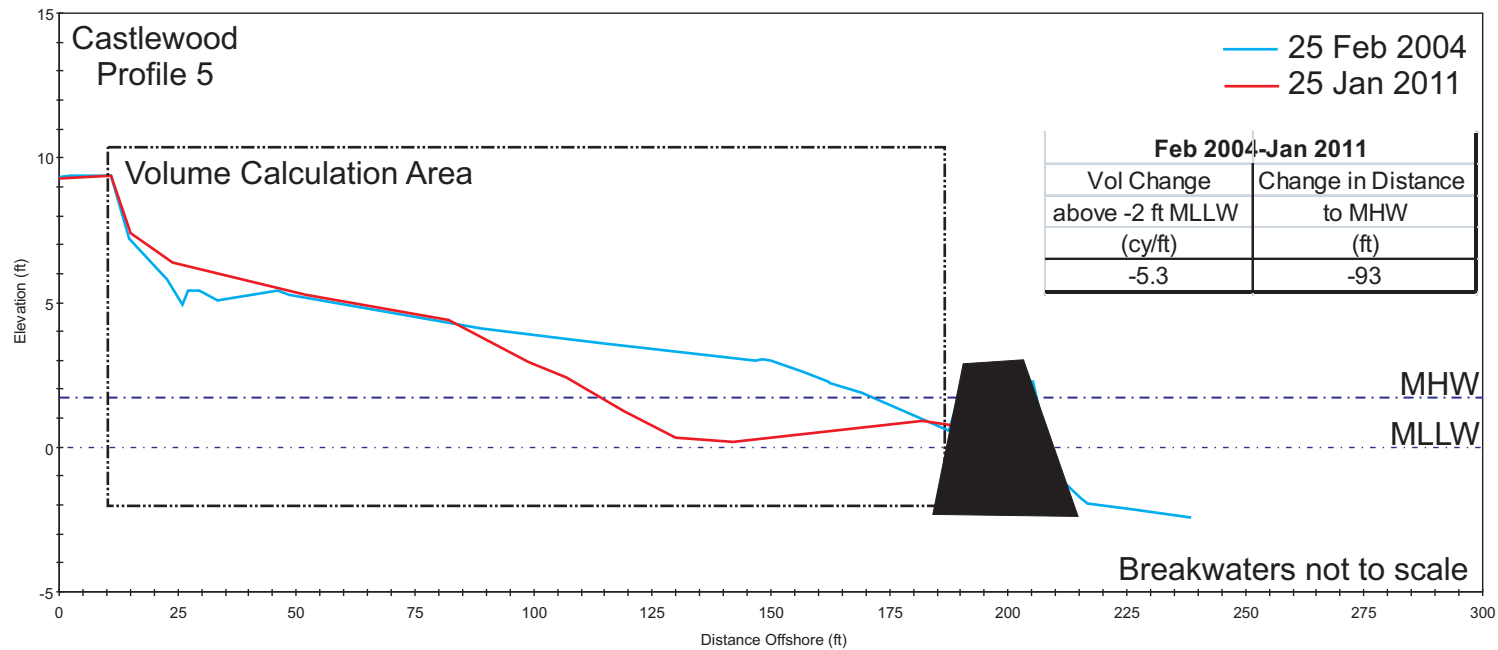


Figure 8. Castlewood Beach cross-sections taken in 2004 and 2011. Also shown is the area on each profile that was used to calculate net volume change. Net volume change and change in distance to MHW is shown in the chart on each profile.

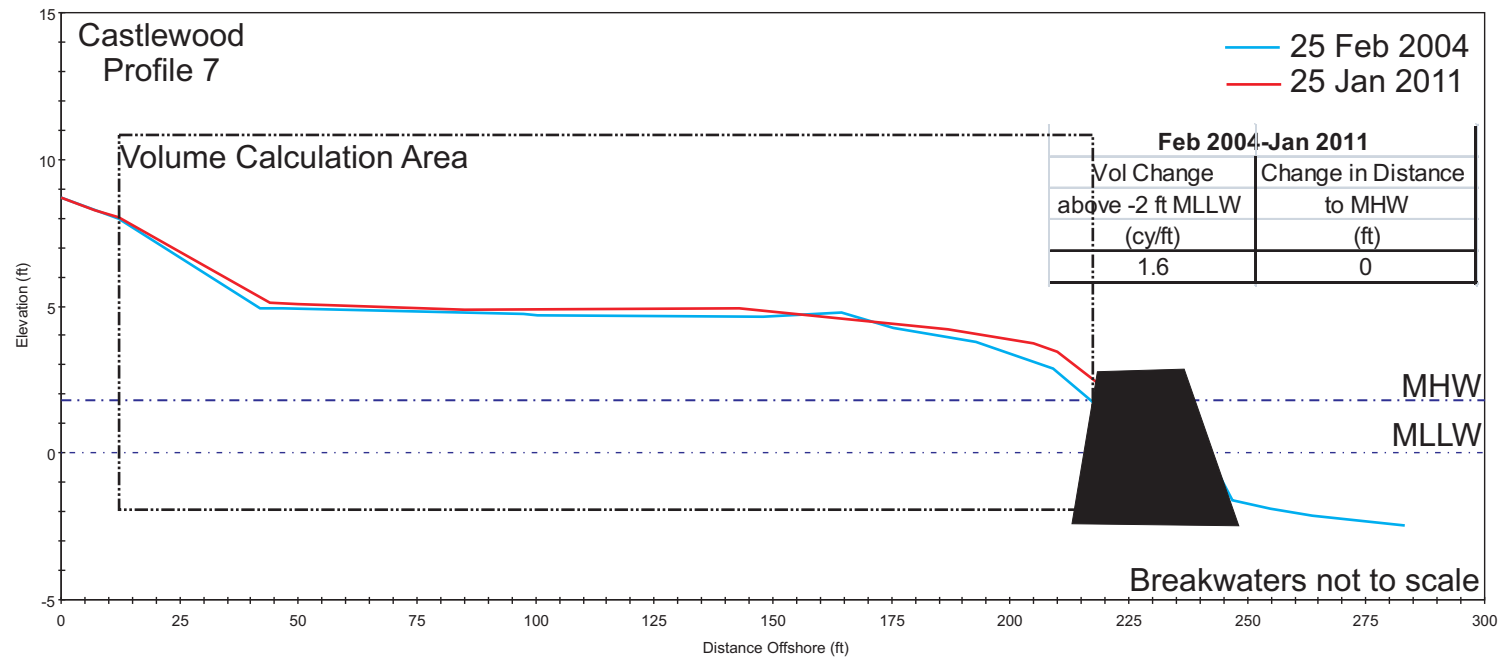
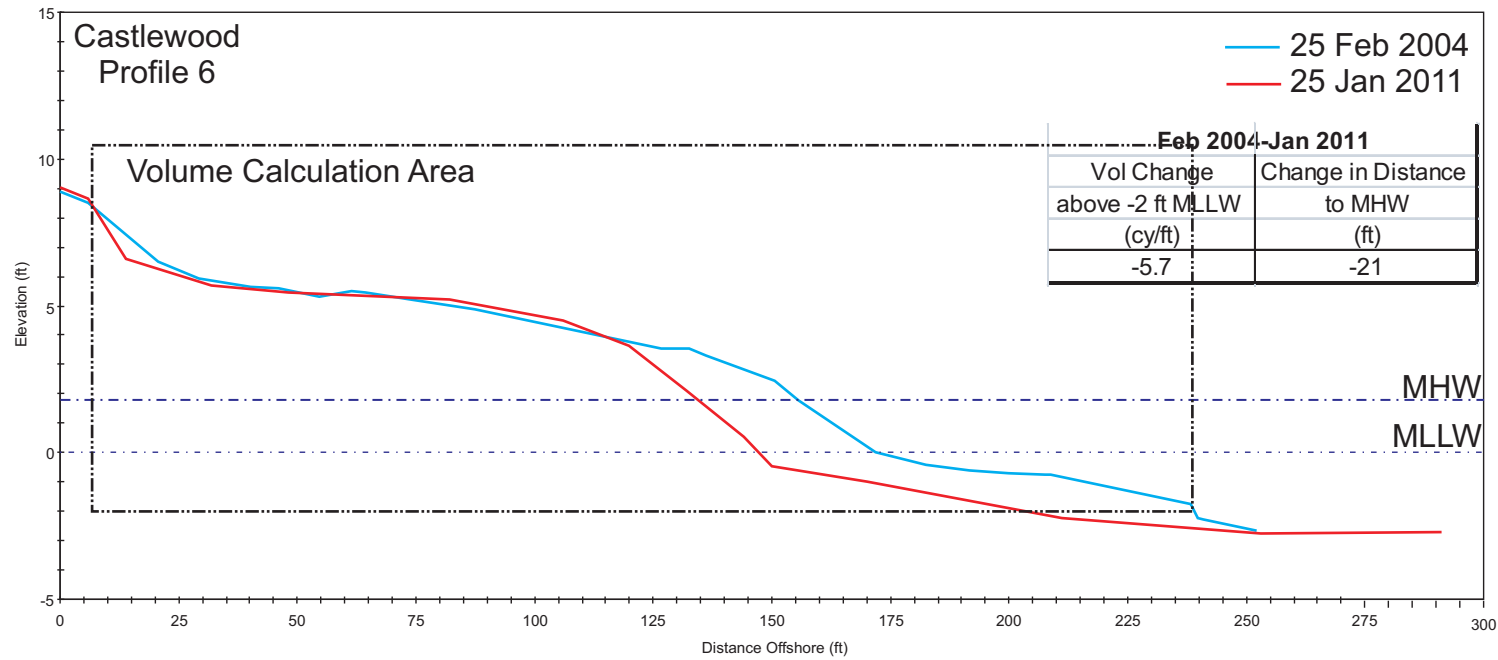


Figure 8. Castlewood Beach cross-sections taken in 2004 and 2011. Also shown is the area on each profile that was used to calculate net volume change. Net volume change and change in distance to MHW is shown in the chart on each profile.

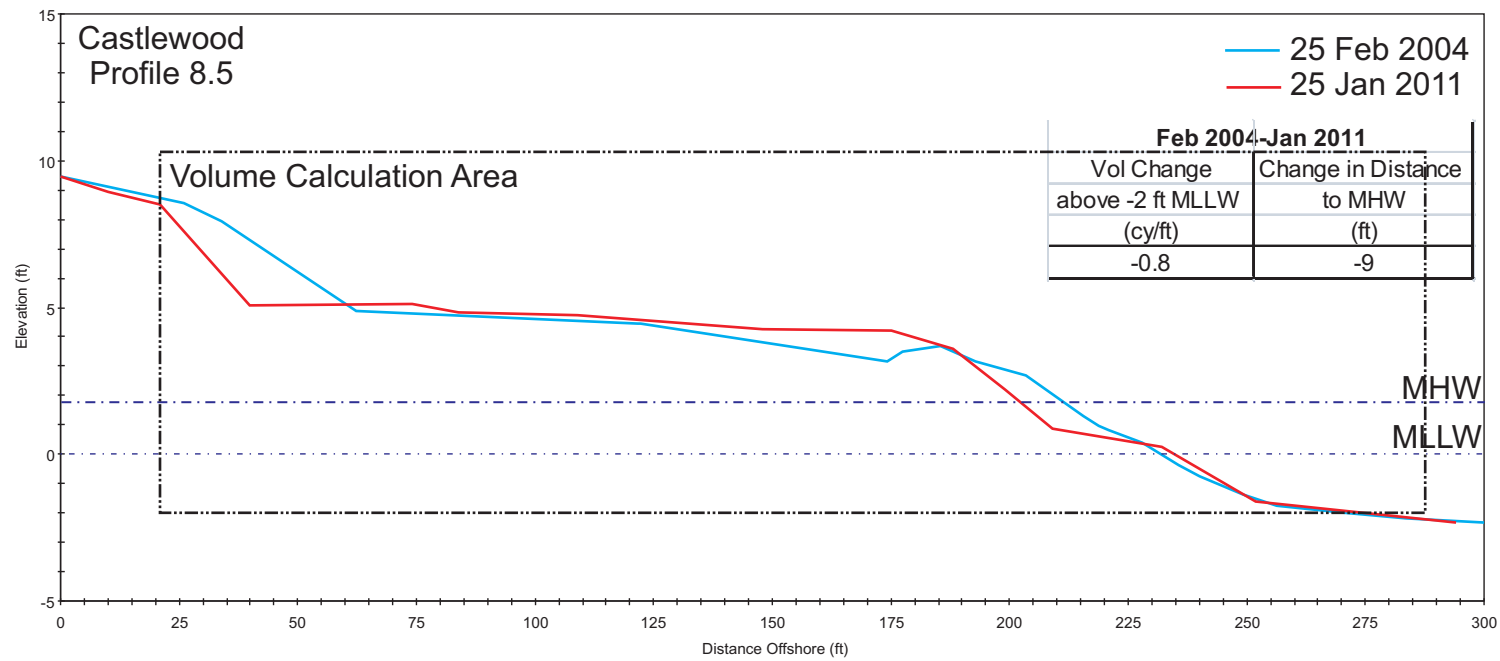
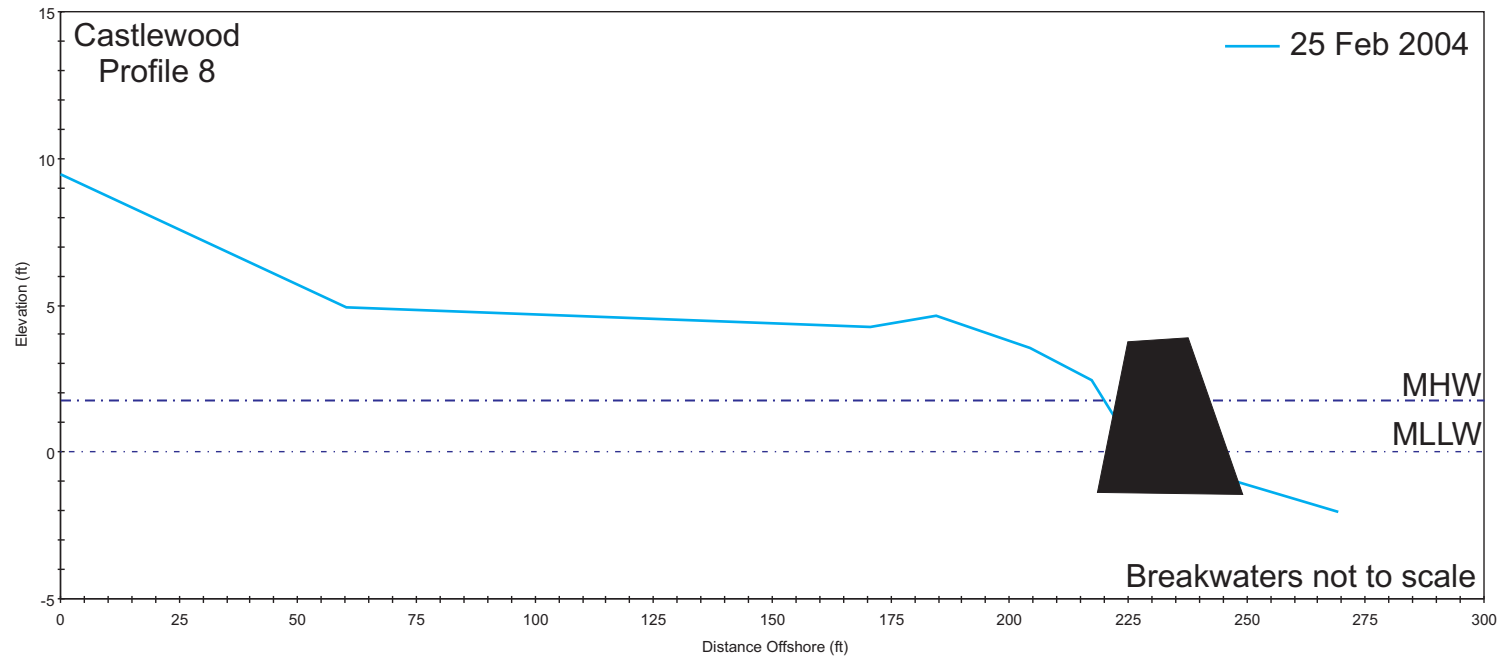


Figure 8. Castlewood Beach cross-sections taken in 2004 and 2011. Also shown is the area on each profile that was used to calculate net volume change. Net volume change and change in distance to MHW is shown in the chart on each profile.

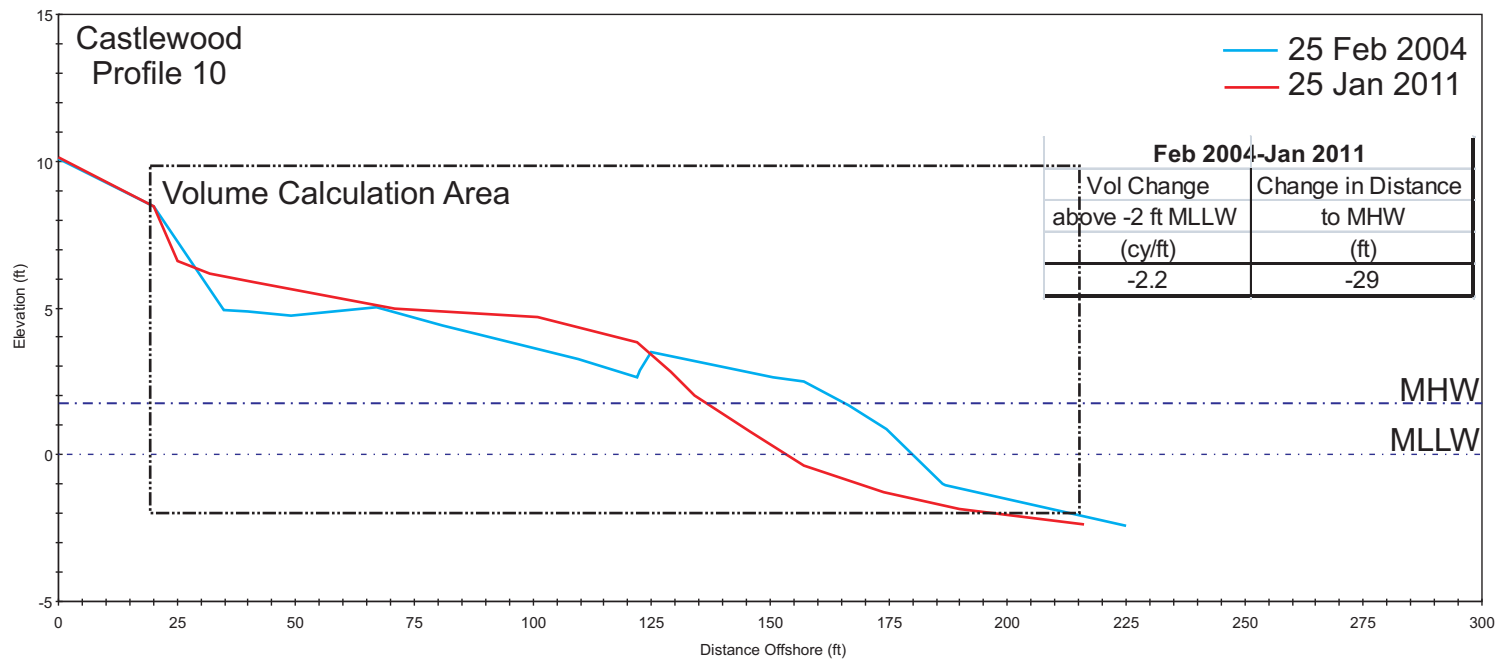
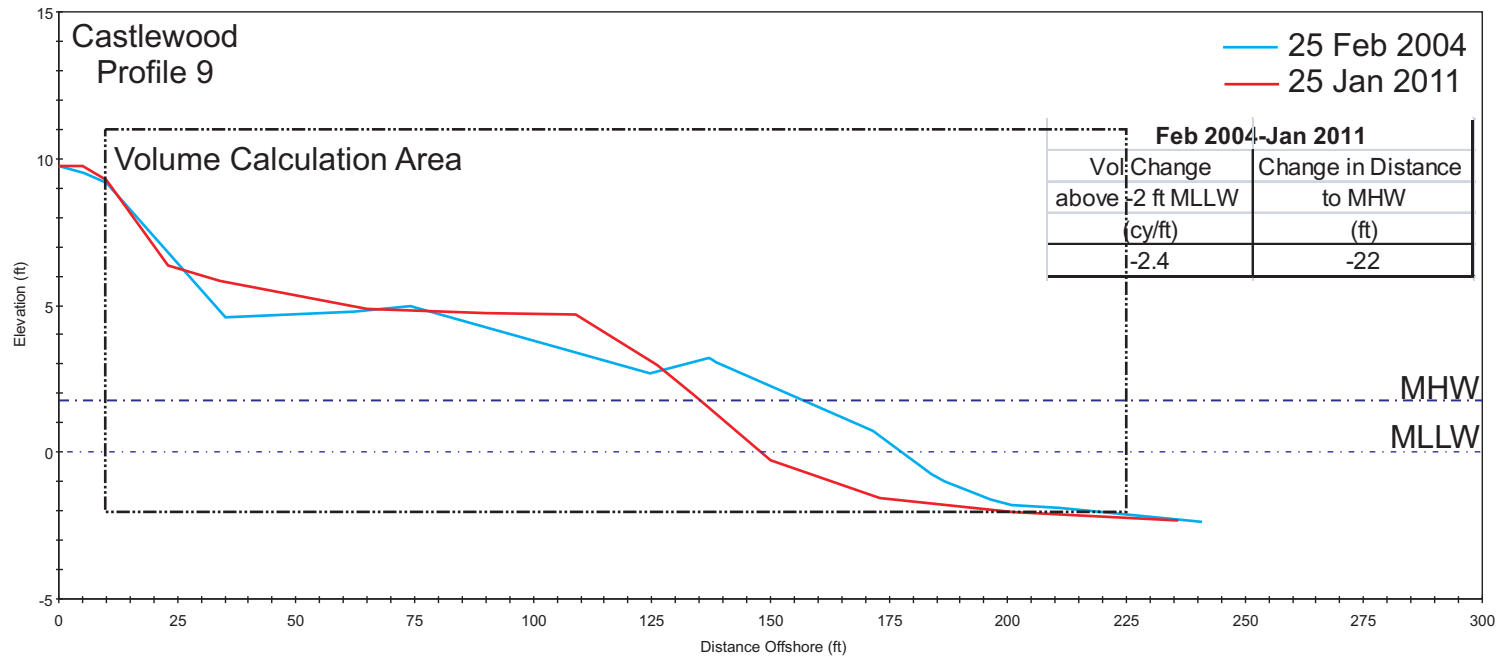


Figure 8. Castlewood Beach cross-sections taken in 2004 and 2011. Also shown is the area on each profile that was used to calculate net volume change. Net volume change and change in distance to MHW is shown in the chart on each profile.



Figure 9. Photos taken of Castlewood Beach on 25 Jan 2011.

Appendix A

Survey data from January 2011 and July 2011 for Central and Castlewood Beaches in the Town of Colonial Beach, Virginia

Central Beach			
Profile	UTM NAD83, zone 18, ift		Elevation ft
Number	Northing	Easting	MLLW 1983-2001
P1	13,895,526.69	1,077,375.43	11.6
P2	13,895,410.92	1,077,427.79	12.6
P3	13,895,309.65	1,077,473.29	12.3
P4	13,895,210.24	1,077,517.15	12.3
P5	13,895,161.01	1,077,539.85	12.4
P6	13,895,094.60	1,077,569.50	12.3
P7	13,895,002.36	1,077,610.66	12.2
P8	13,894,889.49	1,077,661.56	12.2
P9	13,894,835.74	1,077,685.73	12.1
P10	13,894,780.62	1,077,710.07	12.1
P11	13,894,675.69	1,077,757.52	12.1
P12	13,894,574.35	1,077,802.81	11.8
P13	13,894,510.11	1,077,831.50	11.8
P14	13,894,449.22	1,077,859.00	11.8
P15	13,894,355.94	1,077,900.67	11.5
P16	13,894,262.19	1,077,942.80	11.2
P17	13,894,230.18	1,077,956.72	11.0
P18	13,894,093.37	1,078,017.78	9.9

Castlewood			
Profile	UTM NAD83, zone 18, ift		Elevation ft
Number	Northing	Easting	MLLW 1983-2001
P1	13,889,404.46	1,077,865.94	8.1
P2	13,889,277.89	1,077,750.99	5.5
P3	13,889,183.90	1,077,667.30	5.7
P4	13,889,080.92	1,077,575.70	7.7
P5	13,888,957.44	1,077,465.71	9.3
P5.5	13,888,957.44	1,077,465.71	9.3
P6	13,888,935.28	1,077,397.33	9.1
P7	13,888,892.90	1,077,265.92	8.7
P8	13,888,866.29	1,077,186.65	9.5
P8.5	13,888,866.29	1,077,186.65	9.5
P9	13,888,748.94	1,077,108.16	9.7
P10	13,888,701.15	1,077,077.43	10.1

Abbreviation	Meaning
bm	benchmark
bo	base of
bob	base of bank
bs	backshore
cl bw	centerline of the breakwater
eo	edge of
eov	edge of vegetation
lht/lhw	approximate location of the last high tide
mb	midbeach
ns	nearshore
r/s	rock sand interface
r/s bw	rock sand interface at the breakwater
sw	sidewalk
to	top of
tob	top of bank
toe	toe of beach
tor	top of rock

P1			P2			P3			P4			P5			P6		
Dist	Elev		Dist	Elev		Dist	Elev		Dist	Elev		Dist	Elev		Dist	Elev	
(ft)	(ft MLLW)	Comments	(ft)	(ft MLLW)	Comments	(ft)	(ft MLLW)	Comments	(ft)	(ft MLLW)	Comments	(ft)	(ft MLLW)	Comments	(ft)	(ft MLLW)	Comments
0	11.62	bm	0	12.55	bm	0	12.33	bm	0	12.29	BM	0	12.36	bm	0	12.34	bm
86	7.15	Eo Sidewalk	45	10.5	Eo road	40	11.5	front eo sw	37	11.19	EO SW	37	11.23	eo sw	37	11.48	eo sw
88	7.17		60	10.22		58	8.46	eov	52	7.6		48	7.85		47	9.11	
98	6.15		71	9.76	TO slope	89	5.2	bo slope	64	5.97	EOV	61	5.99	eov	59	6.55	eov
122	4.7	Mid BS	96	6.43	EOV	135	4.65	bs	89	4.85		82	3.62	bo slope	88	4.41	bo slope
139	4.3		135	4.74		168	4.88		124	4.59		92	4.34		122	4.52	bs
163	2.72		184	3.66	storm berm	205	4.23		150	4.29		131	4.51		147	4.46	
169	2.62	Upper Berm	198	3.32		226	4.45		162	4.17		148	4.4		162	3.746	
175	2.21	HW1-1 Berm	205	2.75		236	3.27		169	3.7		156	3.78		171	2.87	
181	1.68	MB	213	2.43		243	3.44		176	3.12		165	2.48	lhw 5-1	179	1.81	
190	0.39	Toe	220	1.89		260	2.06		183	1.94		180	0.27	mb	190	0.3	mb
204	-1.51	NS	232	0.66		269	2.32		195	0.4		193	-1.39	toe	205	-1.82	toe
234	-2.76		242	-0.54		279	2.11		208	-1.23	TOE	207	-2.17	ns	222	-2.72	
252	-3.21		249	-1.89	toe	287	1.5		222	-1.75		234	-2.45		255	-3.08	
			263	-2.44	ns	291	1.61		252	-2.35		270	-2.89		282	-3.04	
			297	-2.88		304	0.44		287	-2.78		297	-3.85	cl	303	-3.36	r/s cl
			324	-3.3		317	-0.79	toe	317	-3.57	r/s cl bw						
						321	-0.91	r/s									
						326	1.86	to rock									
P7			P8			P9			P10			P11			P12		
Dist	Elev		Dist	Elev		Dist	Elev		Dist	Elev		Dist	Elev		Dist	Elev	
(ft)	(ft MLLW)	Comments	(ft)	(ft MLLW)	Comments	(ft)	(ft MLLW)	Comments	(ft)	(ft MLLW)	Comments	(ft)	(ft MLLW)	Comments	(ft)	(ft MLLW)	Comments
0	12.23	bm	0	12.2	bm	0	12.09	bm	0	12.1	bm	0	12.08	bm	0	11.8	bm
38	11.57	eo sw	37.4	11.61	eo sw	37	11.71	eo sw	38	11.71	eo sw	25	12.1	mulch	30	11.59	ip
49	9.32	mid bank	43	11.05	tp slope	38	11.66		47	9.61	sand/bank	32.3	11.55	gravel path	39	11.11	tob
62	7.05	bob/eov	54	6.57	bo asphalt	57	7.5	bob /eov	56	8.22	bob	38	11.53		51	5.87	bob
82	5.95		71	5.37	eov	90	5.05		72	6.12	bs	47	11.13	tob	67	4.94	bs
150	4.74		104	4.58		123	4.73		118	4.63		58	6.77	bob	87	4.26	
187	4.36		138	3.96		140	3.87	big berm	140	3.59	berm	73	6.01	bs	110	4.01	
220	4.15		155	3.98	bch berm	150	1.93	lhw 9-1	156	1.81	lht	155	4.41		114	3.28	to berm scarp
237	3.3		160	3.31		160	0.12	mb	168	0.3	mb	168	3.15		116	2.65	bo berm scarp
246	3.53		161	2.56	scarp	170	-1.3	boulder/toe	186	-1.61	toe	214	2.65		124	1.23	lht
260	2.6		179	0.01	mb	183	-2.13		200	-2.56		235	1.08	lht	134	0.17	mb
269	2.56		191	-1.42	toe	210	-2.47		226	-2.82		245	0	mb	153	-1.46	toe
276	2.12		235	-1.89		243	-3.03		263	-2.9	r/s bw	253	-0.61	r/s	165	-1.81	
284	1.16	r/s	240	-2.33		282	-4.07					255	2.35		207	-2.1	
288	2.6	to rock	264	-2.46											242	-2.43	cl bw
			283	-2.51	r/s cl												
			297	-3.46													

Central Beach 25 Jan 2011

P13			P14			P15			P16			P17			P18		
Dist	Elev		Dist	Elev		Dist	Elev		Dist	Elev		Dist	Elev		Dist	Elev	
(ft)	(ft MLLW)	Comments	(ft)	(ft MLLW)	Comments	(ft)	(ft MLLW)	Comments	(ft)	(ft MLLW)	Comments	(ft)	(ft MLLW)	Comments	(ft)	(ft MLLW)	Comments
0	11.77	bm	0	11.82	bm	0	11.49	bm	0	11.15	bm	0	10.96	bm	0	9.91	bm
26	11.51	gravel path	19	11.53	bo mulch	20	11.14		19	10.55	tree root	18	10.77		22	8.97	tor
39	10.97		24	11.79	to mulch	37	10.99	tob	29	9.43	tob	29	8.78	tor	38	6.7	on rock
50	5.46	bob	31	10.87	front mulch	47	6.6	bob	39	5.26	bob	42	3.75	r/s	42	5.98	on rock
67	4.29	bs	36.9	10.35	eo gravel path	68	5.48	bs	52	4.57	bs	60	1.79	lht 17-1	60	-0.77	r/s
80	3.81		43	9.53	bob	125	4.11		69	3.8	berm	67	0.91	mb	77	-2.48	
89	3.93	berm	48.8	6.59	bs	137	3		84	1.56	lht	80	-0.96	toe	120	-3.07	
98	2.51		68	5.45		144	3.4		91	0.69	mb	108	-2.08				
104	1.29	lht 13-1	80	3.97	berm	157	2.57		107	-1.1	toe	168	-2.66				
111	0.34	mb	95	3.33	lht	173	2.46		125	-1.74		179	-2.91				
129	-1.66	toe	110	1.53	mb	187	2.15		159	-2.15							
146	-2.59		116	0.41	toe	197	1.27	lht	199	-2.54	r/s bw						
206	-3.51	cl bw	129	-1.43		205	0.25	mb									
			153	-2.53		213	-0.65										
			163	-2.64													
			173	-2.77													
			183	-2.79													

Central Beach 25 Jan 2011

P1			P2			P3			P4			P5			P5.5		
Dist	Elev		Dist	Elev		Dist	Elev		Dist	Elev		Dist	Elev		Dist	Elev	
(ft)	(ft MLLW)	Comments	(ft)	(ft MLLW)	Comments	(ft)	(ft MLLW)	Comments	(ft)	(ft MLLW)	Comments	(ft)	(ft MLLW)	Comments	(ft)	(ft MLLW)	Comments
0	8.1	bm	0	5.47	bbgabions	0	5.65	bm	0	7.56	grnd	0	9.27	bm	0	9.27	bm
8	7.65	tor	15.9	5.18	btgabions	1	5.63	bb gabions	3	7.23	tob	11	9.4	tob	9	9.34	tob
16	5.05	bor	16	6.74	ftgabions	2	7.17	bt gabions	7	5.35	bob	15	7.42	bob	15	7.19	bob
22	5.06	r/s	18.9	6.84	fb gabions	5	7.15	ft gabions	11	4.79	eov	24	6.38		25	6.42	eov
27.6	4.77	backsho	19	5.64	eov	5.1	6	fb gabions	19	4.18	bs	52	5.26		52	5.57	
34	4.37		27	5.37	bs	16	4.76	eov	23.6	3.74	uberm	82	4.4		109	4.35	
43	3.86	old berm	72	5.04		28	4.41		31	2.85	berm	99	2.94		132	3.2	
49	2.84		107	4.15		60	4.17	uberm	37.5	1.72	lht 4-1	107	2.4	lht	144	2.65	
51	2.92	newer berm	138	3.95	berm	65.2	3.82	wrack	47	0.3	mb	119	1.23	mb	152	1.71	lht
57	1.88		147.3	3.19	wrack	72	2.88	lower berm	53	-0.41	toeish	130	0.33	toe	177	0.98	
59	1.73	lht 1-1	151	2.42	sand/frag	81	1.86	lht	81	-1.06		142	0.19		187	0.69	r/s
72	0.12	mb	173	1.63	mid frag	86	1.27	mb	98	-1.06		182	0.93				
81	-1.35	toeish	186	1.94	bbbw/frag	90	0.82	toe	109	-0.84	mid bar	192	0.66	r/s			
136	-1.52		194	3.17	top bw	120	0.66		146	-1.6							
163	-1.656		205	-0.86	ffbw	150	0.65		175	-1.14							
189	-2.15		228	-2.13		180	0.8	shoal behind	193	-1.43							
267	-2.69		269	-2.46		207	0.12	bbbw end	226	-2.23							
294	-2.962		346	-2.78		218	-0.71	mid bw end	281	-2.5							
						224	-1.52	ffbw									
						239	-1.86										
						284	-2.32										
P6			P7			P8.5			P9			P10					
Dist	Elev		Dist	Elev		Dist	Elev		Dist	Elev		Dist	Elev		Dist	Elev	
(ft)	(ft MLLW)	Comments	(ft)	(ft MLLW)	Comments	(ft)	(ft MLLW)	Comments	(ft)	(ft MLLW)	Comments	(ft)	(ft MLLW)	Comments	(ft)	(ft MLLW)	Comments
0	9.01		0	8.7	bm	0	9.46		0	9.74		0	10.11	bm			
6	8.64	tob	7	8.29		10	8.94	eo road	5	9.77	eo road	20	8.44	ob			
14	6.6	eov	12	8.04	tob	21	8.5	tob	10	9.27	tob	25	6.58	bob			
32	5.71		44	5.14		40	5.08	bob	23	6.36	bob	32	6.18				
48	5.47		50	5.07		74	5.11		34	5.83	eov	41	5.88	eov			
82	5.2		85	4.86		84	4.81	eov	65	4.86		71	5				
106	4.52		143	4.94		109	4.73		90	4.72		101	4.7				
120	3.66	berm	187	4.2		148	4.25		109	4.69		122	3.82	uberm			
132	2.09	lht 6-1	205	3.74		175	4.2		126	2.96		129	2.82				
144	0.54		210	3.46		188	3.59		134	1.9	lht 9-1	134	2.01	lht			
150	-0.48	toe	219	2.31	lht/ul scirpus	199	2.23	mb	142	0.81	mb	146	0.77	mb			
170	-0.99		221	2.18	r/s	209	0.88	toe	150	-0.26	toe	157	-0.39	toe			
211	-2.23	cl	224	3.44	top rock	232	0.24	r/s cl	173	-1.54		174	-1.26				
253	-2.77					252	-1.59		201	-2.04		190	-1.87				
291	-2.69					294	-2.35		236	-2.32		216	-2.38				

Castlewood Beach 25 Jan 2011

Appendix B

Graphs of Sediment Sample Analysis

Samples were taken on 25 Jan 2011 at mean high water along profiles 1, 5, 9, 13, and 17 at Central Beach and along profiles 1, 4, 6, and 9 at Castlewood Beach. The beach fill sample was taken at Central Beach in June 2011 near the end of the project.

The gravel portion of the samples were analyzed by sieve, the sand portion of the sample was analyzed with VIMS' Rapid Sediment Analyzer, and the silt and clay portion by pipette analysis. The overall sample statistics shown on the graph were calculated in MATLAB using procedures outlined by Blott and Pye (2001) in Earth Surf. Process. Landforms 26, 1237–1248 as shown below.

(a) Arithmetic method of moments

Mean	Standard deviation
$\bar{x}_a = \frac{\sum f m_m}{100}$	$\sigma_a = \sqrt{\frac{\sum f (m_m - \bar{x}_a)^2}{100}}$
Sorting (σ_g)	
Very well sorted	<1.27
Well sorted	1.27–1.41
Moderately well sorted	1.41–1.62
Moderately sorted	1.62–2.00
Poorly sorted	2.00–4.00
Very poorly sorted	4.00–16.00
Extremely poorly sorted	> 16.00

Sample Date	Location	Profile Number	sample #	Description	Total Sample Statistics							
					%>12.7 mm	Gravel % #4	% >2 mm	%Total Gravel	%Total Sand	%Total Mud	% Silt	% Clay
25-Jan-11	Central Beach	1	1	MHW	0.00	12.03	22.43	34.46	65.21	0.33	0.00	0.33
25-Jan-11	Central Beach	5	1	MHW	0	5.81	6.24	12.05	87.85	0.10	0.08	0.02
25-Jan-11	Central Beach	9	1	MHW	0	12.61	16.5	29.11	68.67	2.22	0.88	1.34
25-Jan-11	Central Beach	13	1	MHW	0	3.49	3.32	6.81	92.71	0.48	0.03	0.45
25-Jan-11	Central Beach	17	1	MHW	0	0	0	0.00	99.5	0.50	0.03	0.47
25-Jan-11	Castlewood	1	1	MHW	0	50.48	43.6	94.08	5.75	0.17	0.03	0.14
25-Jan-11	Castlewood	4	1	MHW	0	18.2	5.68	23.88	75.62	0.50	0.09	0.41
25-Jan-11	Castlewood	6	1	MHW	0	3.02	10.38	13.40	86.26	0.34	0.1	0.24
25-Jan-11	Castlewood	9	1	MHW	0	10.57	17.13	27.70	71.96	0.34	0.07	0.27

Sample Date	Location	Profile Number	sample #	Description	Total Sample Statistics				Overall Sample is	Total Sample Statistics	
					Mean		Median			Average Grain Size is	Sorting
				(Phi)		(mm)					
25-Jan-11	Central Beach	1	1	MHW	-0.46	1.38	0.69	0.62	sandy gravel	Very coarse sand	Poorly sorted
25-Jan-11	Central Beach	5	1	MHW	0.69	0.62	1.19	0.44	gravelly sand	Coarse sand	Moderately well sorted
25-Jan-11	Central Beach	9	1	MHW	-0.26	1.20	0.56	0.68	gravelly sand	Very coarse sand	Poorly sorted
25-Jan-11	Central Beach	13	1	MHW	0.9	0.54	1.19	0.44	gravelly sand	Coarse sand	Well sorted
25-Jan-11	Central Beach	17	1	MHW	1.46	0.36	1.44	0.37	sand	Medium sand	Very well sorted
25-Jan-11	Castlewood	1	1	MHW	-3.2	9.19	-3.64	12.47	gravel	Medium gravel	Very well sorted
25-Jan-11	Castlewood	4	1	MHW	0.09	0.94	0.94	0.52	sandy gravel	Coarse sand	Poorly sorted
25-Jan-11	Castlewood	6	1	MHW	0.24	0.85	0.56	0.68	gravelly sand	Coarse sand	Moderately well sorted
25-Jan-11	Castlewood	9	1	MHW	-0.57	1.48	-0.19	1.14	gravelly sand	Very coarse sand	Moderately sorted

