Technical Report TAMU-CC-CBI-05-01

Monitoring, Analysis and Interpretation of the Post-Construction Evolution of a Restored Beach at TAMU-CC

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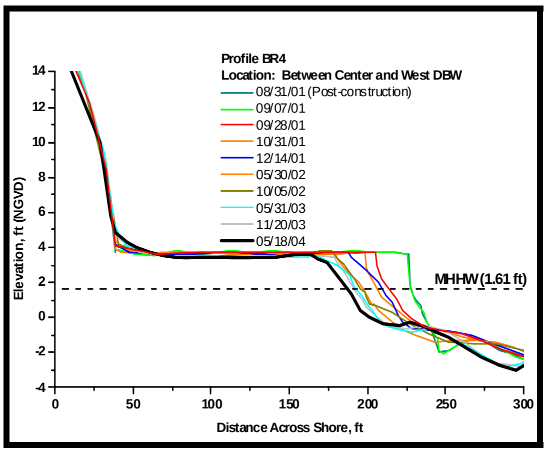

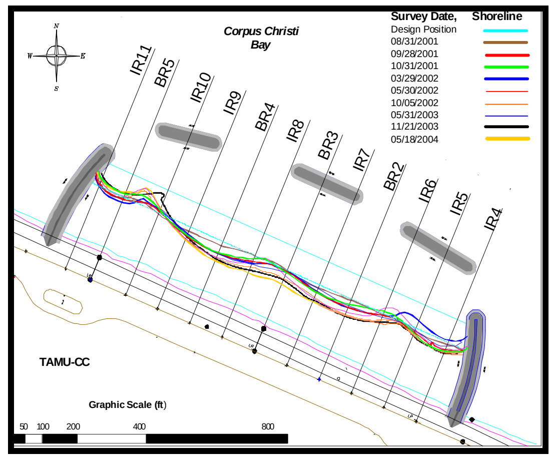

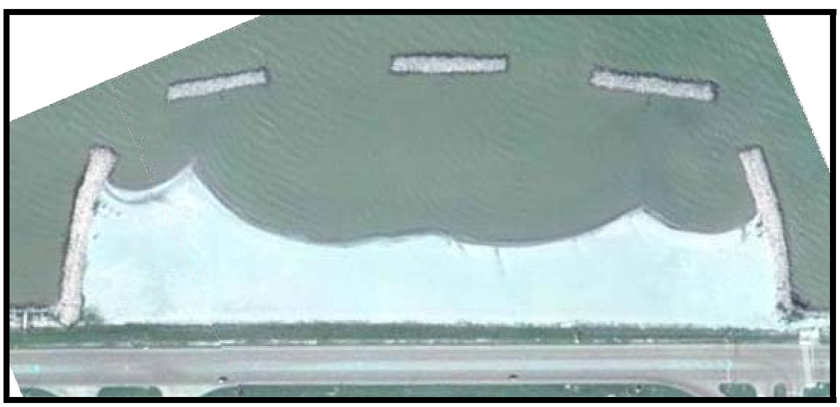

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Executive Summary

The evolution of a beach fill placed along Corpus Christi Bay was monitored to determine trends in shoreline change, sub-aerial and nearshore morphology, volumetric change, and sand grain size distribution. The monitoring program was initiated to document the evolution of a restored beach that was constructed during the summer of 2001. University Beach is located adjacent to Texas A&M University-Corpus Christi along the northern shoreline of Ward Island, Corpus Christi, Texas. The beach fill, consisting of 45,000 cu yd of beach-quality quarry sand, was placed to restore a 1,200 ft section of a beach that had eroded some 60 years ago. Prior to construction, the shoreline was completely devoid of a beach and consisted of a deteriorating timber bulkhead as well as discarded concrete and construction materials. The public recreational beach was completed in August 2001 after 5 months of construction and nearly 7 years of research and planning. The project was made possible through the cooperation and support of The Texas General Land Office (Coastal Management Program and Coastal Erosion Planning and Response Act), Texas A&M University Corpus Christi, The Conrad Blucher Institute for Surveying and Science, the City of Corpus Christi and Shiner Moseley and Associates as the lead engineers.

The monitoring program included seasonal beach profile surveys, shoreline position surveys and sediment sampling. Eleven surveys were conducted from Fall 2000 to Spring 2004 including four abbreviated surveys that were conducted immediately after construction to capture rapid post-construction change. The analysis of the extensive data set shows that University Beach is relatively stable with significant erosion (hot spots) presently occurring only in the 300 ft central region. A small section of this area will likely require nourishment within the next 3-4 years while the remainder of the beach experiencing net erosion is not anticipated to require nourishment for 11-18 years. The two hot spots are separated by a region of less critical retreat, thus it is recommended that at least 300 ft of alongshore region is nourished. This would require the placement of a minimum of 2,500 cu yd of sand on the beach to advance the shoreline 50 ft, at a 4.5 ft fill depth, and thereby maintain an advance position from the protective 50-ft minimum width recommended by the present research and previous studies.

Two options for replacement of the sand lost from the subaerial beach are recommended, 1) purchase and transport of a bulk volume of Nueces River quarry sand or 2) reclaim sand from within the beach cell in the lee of the western and central DBW for nourishment of hot spots on an as need basis. The data show that there is a growing resource of beach quality sand in these two areas. An expanded survey of these potential sand resources is planned for the Spring 2005. This will include the collection of additional sediment samples in key areas of interest to better define the extent of beach quality sand deposits. Additional elevation surveys between beach profile transects will help accurately define the extent of sand deposits. The survey data support the prediction that on the order of 1,400 to 1,500 cu yd of sand are potentially encumbered in the lee of the western and central DBWs, respectively. Thus, preliminary data indicate that there is enough sand (nearly 3,000 cu yd) encumbered in the lee of these DBWs to satisfy the most immediate nourishment needs anticipated within the next 3-4 years. These estimates will be confirmed by an expanded survey during Spring 2005. An additional benefit of mining these sand deposits located within the beach cell system is that the water depths within the beach cell will be increased in regions where deposition has reduced elevations by 1 to 3 feet.

1. Introduction

The evolution of a beach fill placed along Corpus Christi Bay was monitored to determine trends in shoreline change, sub-aerial and nearshore morphology, volumetric change, and sand dispersal. The monitoring was initiated to document the evolution of the beach fill that was constructed during the summer of 2001. University Beach is located adjacent to Texas A&M University-Corpus Christi along the northern shoreline of Ward Island, Corpus Christi, Texas (Figure 1). The beach fill, consisting of 45,000 cu yd of beach-quality quarry sand, was placed to restore a 1,200 ft section of a beach that had eroded some 60 years ago. Prior to construction the shoreline was completely devoid of a beach and consisted of a deteriorating timber bulkhead as well as discarded concrete and construction materials (Figure 2). The public recreational beach was completed in August 2001 after 5 months of construction and nearly 7 years of research (Williams 1999, Williams 2002) and planning (Figure 3). The project was made possible through the cooperation and support of The Texas General Land Office (Coastal Management Program and Coastal Erosion Planning and Response Act), Texas A&M University Corpus Christi, The Conrad Blucher Institute for Surveying and Science, the City of Corpus Christi and Shiner Moseley and Associates as the lead engineers.

As all beaches are ephemeral features they are anticipated to evolve and have periods of accretion and erosion that may be related to seasonal or annual meteorological changes. The beach monitoring program began in anticipation of construction during Fall 2000 and continued at a minimum of twice annually up to Fall of 2004. This report will describe the findings based on analysis of beach profile survey and sediment grain size data collected from Fall 2000 to Spring 2004 (Table 1). The data collected during Fall 2004 was not a deliverable under this

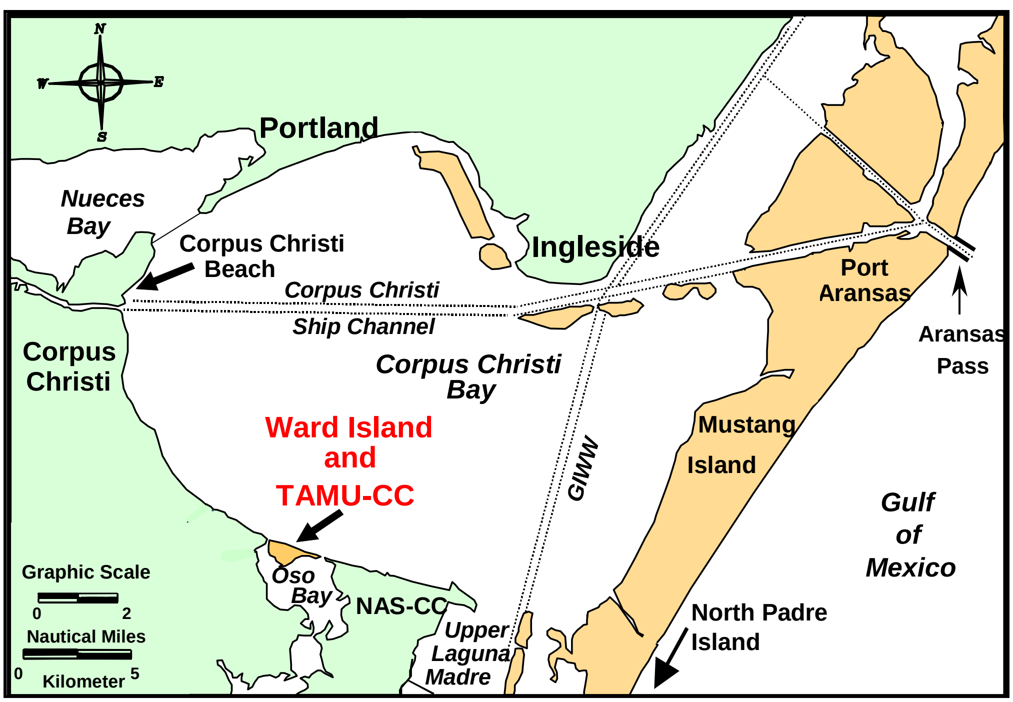

Figure 1. Site Map for University Beach located at TAMU-CC.

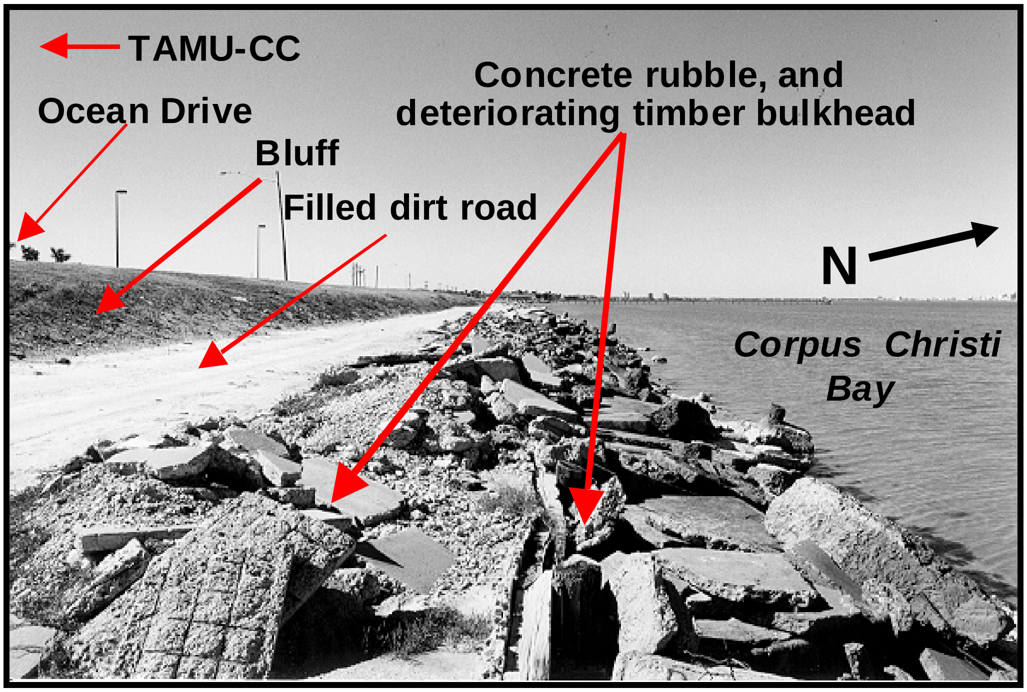

Figure 2. Shoreline prior to beach construction.

contract but will analyzed and submitted as a supplementary document as a courtesy to update the sponsor on recent changes.

The beach monitoring program serves four purposes; 1) to provide documentation of the evolution of a restored beach along a developed shoreline, 2) to anticipate and assess nourishment needs for planning purposes, 3) to determine the impact on the adjacent shoreline and 4) to serve as an example of post restoration care of a beach for other bayside communities with similar concerns related to loss of naturally occurring beaches. A primary goal of the monitoring program is to identify trends and assist resource managers in anticipating where when additional fill material should be placed along the existing beach to maintain its integrity and promote project longevity.

2. Monitoring Program

The key components of the monitoring program are shoreline position surveys, beach profile surveys, and sediment grain size analysis. In addition, aerial imagery provided from complementary projects is included to enhance visualization of changes occurring at the beach.

The surveys were conducted both immediately prior to construction and post construction up to October 2004. Several abbreviated surveys were conducted between August 2001 and February 2002 to monitor the rapid change in shoreline morphology anticipated immediately after placement. Thereafter, the surveys were conducted twice annually during the spring and fall of each year.

Figure 3. Panorama of the beach shortly after placement in August 2001.

2.1 Personnel and Equipment

All shoreline position surveys and beach profile surveys were conducted with a conventional Leica Total Station or Leica Robotic Total Station (RTS) (Williams 2002). Survey personnel included staff at the Conrad Blucher Institute and Division of Nearshore Research, professors and students from the TAMU-CC GIS program, and TAMU-CC students from many departments. In addition, Frontier Surveying Inc. offered support in form of surveyors and equipment and Easy Driver of San Antonio Texas donated equipment for use during surveys.

2.2 Definitions

This section of definitions clarifies terminology applied throughout this document. The following definitions are provided for the information of the potentially diverse reading audience.

Beach —The beach is composed of two primary regions; a subaerial ("dry") beach and a submerged or subaqueous ("wet") beach. Although the changes that occur on the dry beach are most noticeable to the typical observer, the changes in both the dry and wet beach must be investigated as a unit to determine performance of the beach over time. Much of the change in the beach is a redistribution of sand from the dry to the wet region of the beach and vice versa. This is a natural process that often culminates with the beach reaching a condition of equilibrium with the forces acting on it (i.e. typical waves, currents and changes in water level).

Design Beach — this is beach fill extents anticipated immediately after construction as depicted on the planview (looking down on the study area from above) image (Figure 4). Note the position of the design beach shoreline as the baseline for future reference.

Design Beach Toe — the position depicted on the planview image that denotes the seaward-most position of the submerged beach toe anticipated immediately after construction. This is the

Table 1. Survey Coverage and Date Information.				
Date	**Beach Profile Survey**		**Shoreline Position Survey**	***Special Notes**
	Full	**Abbrev.**		
10/13/2000	X		N/A*	Pre-construction survey
08/31/2001 and 09/07/2001		X*	Yes	Severe weather required additional survey day
09/28/2001		X*	Yes	Post-const. nearshore focus
10/31/2001		X*	Yes	Post-const. nearshore focus
12/14/2001		X*	Yes	Post-const. nearshore focus
05/30/2002	X		Yes	
10/05/2002	X		Yes	
05/31/2003	X		Yes	
11/20/2003	X		Yes	
05/18/2004	X		Yes	
10/15/2004	X		Yes	

location where the beach-fill material intersects the existing bay bottom in the nearshore (Figure 4).

Groin — a shore perpendicular structure typically placed at the terminus of a beach to stabilize the sand. Groins act to limit sand loss by blocking longshore sediment transport. Two groins were selected for this project to reduce the impact of longshore sediment transport that is strongly developed during frontal passage and during the extensive periods of strong southeasterly winds (Figure 4).

Detached Breakwaters (DBWs) — DBWs are roughly shore parallel structures placed at a specific distance offshore to dampen wave and current energy that would otherwise be directed on the beach. Waves and currents are diffracted at the ends of the DBWs causing the characteristic formation of a feature called a salient (see definition below) in the lee (behind) of each structure (Figure 4).

Beach Cell — the area defined as the beach and nearshore bounded by and including coastal structures (groins and DBWs) (Figure 4).

Shoreline Stabilization — University Beach was constructed with a combination of both soft (sand) and hard (groins and DBWs) methods of shoreline stabilization. For a more in depth description of the design and development of University Beach the reader is directed to (Williams 1999, Williams 2002). The source of the beach sand was a local quarry that mines a historic arm of the Nueces River. Both the groins and detached breakwaters were constructed out of stone with a smaller stone inner core.

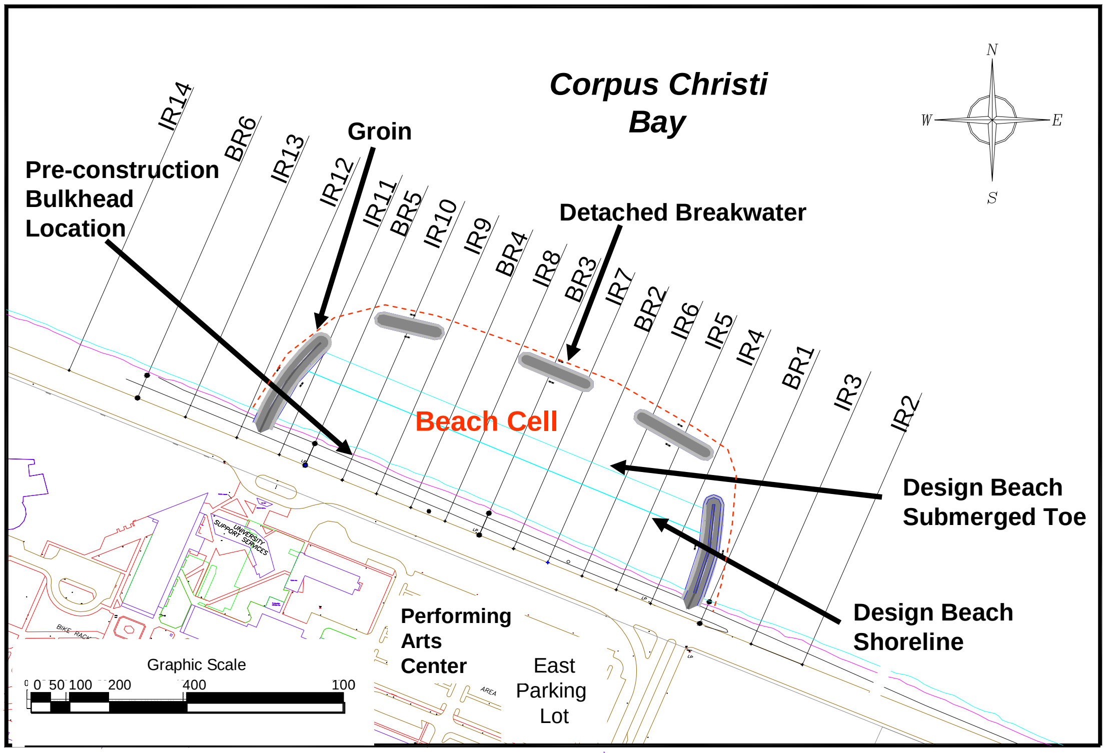

Figure 4. Monitoring area with transect (profile) identification and terms defined.

Salient — this protruding accretionary feature develops in response to a reduction in energy in the lee of a DBW and patterns of diffraction from coastal structures (Figure 5). The beach was designed such that the shoreline would develop a sinusoidal shape resulting in salient formation.

Tombolo — a tombolo forms when a salient continues to extend offshore until it touches a DBW or other limiting offshore structure (Figure 5). The beach was not designed to promote tombolo formation although periods of reduced energy may initiate such formation.

2.3. Monitoring Area and Survey Grid

The monitoring area is located along the north shore of Ward Island fronting Corpus Christi Bay (Figure 6). The 1,200-ft long beach is located in front of the TAMU-CC campus in the general vicinity of the east campus parking lot and the new Performing Arts Center. Data were collected within the confines of the beach cell and extending offshore to 1000 ft (> 6 ft NGVD 1929). In addition, data were collected over 500 ft to the west and over 300 ft east of the beach cell to define changes in nearshore morphology. The beach cell was divided into 12 beach profile transects at approximately 100 ft intervals along the length of the 1,200-ft beach (Figure 4). In addition, three transects were occupied to the east and west of the beach. Position and elevation were measured at 5 to10-ft intervals along each transect (spacing adjusted dependent on morphology) to the depth of closure (DOC). The DOC is defined as the maximum depth past which sediment transport is no longer significant. The depth of closure in the study area was determined as 4.25 ft (NGVD 1929) through comparison of historic survey data up to beach construction in 2001 (Williams, 2002).

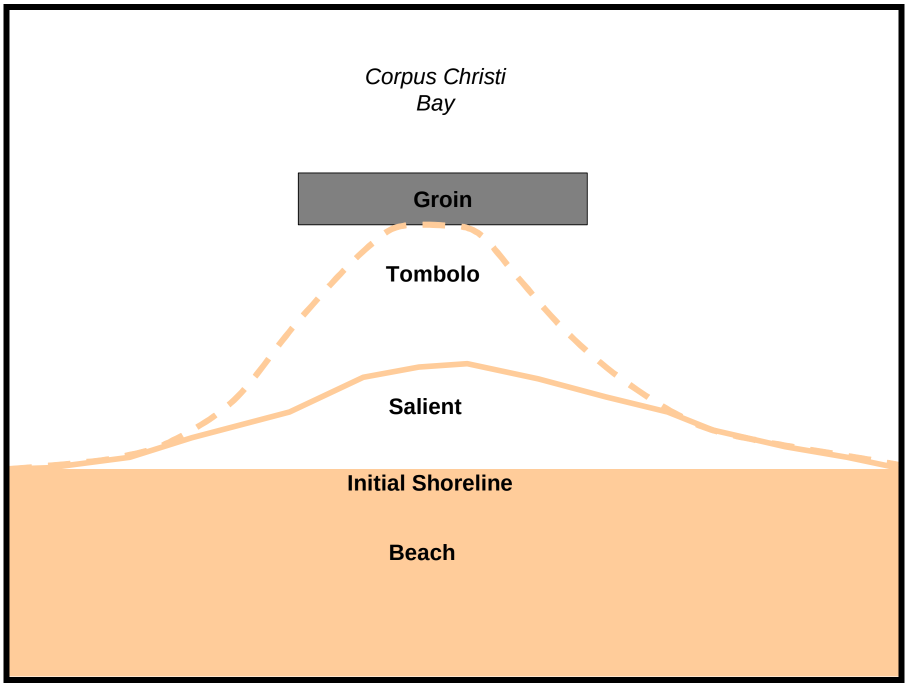

Figure 5. Definition of shape and extent of salient and tombolo features.

2.4 Datum

Data were collected and reported in two different datum. All survey data were collected relative to NGVD 1929 to remain consistent with previous data collection efforts. The beach profile plots are shown relative to NGVD 1929 with the position of Mean Higher High Water (MHHW) noted. For seasonal comparison, all shoreline position data were reported relative to MHHW. A precise level loop was conducted to define the initial position of the MHHW shoreline, relative to NGVD 1929, along Ward Island prior to construction of the beach. The level loop, conducted in 1996, initiated and terminated at the Naval Air Station Corpus Christi (NAS-CC) tide gauge (NAS-CC station now retired see: http://lighthouse.tamucc.edu/overview/001). During this survey all key benchmarks relative to the study area were occupied. MHHW was determined at 1.61-ft above the survey datum (NGVD 1929). The pre-construction MHHW shoreline was surveyed by Dr. Gary Jeffress (RPLS and TAMU-CC professor) in conjunction with C.B. Thomson (RPLS, LSLS TGLO Surveying Department) and the documents describing this survey are on file with the TGLO surveying department. The pre-construction MHHW shoreline corresponded approximately to the location of the timber bulkhead (extracted during demolition) that previously stabilized the northern Ward Island shoreline.

2.5 Initial Post-Construction Survey Challenges

The first beach profile and shoreline surveys were challenging as the beach face was raw and consisted of a nearly vertical wall at the waters edge (Figure 6 and 7). This vertical feature limited the measurement of shoreline position relative to an assigned datum such as MHHW. The shoreline quickly began to moderate as the beach came to equilibrium with the waves and currents thereby forming a more-gentle slope at the waters edge (Figure 6 and 8). The central section of the beach modified first followed by the west and east ends of the beach.

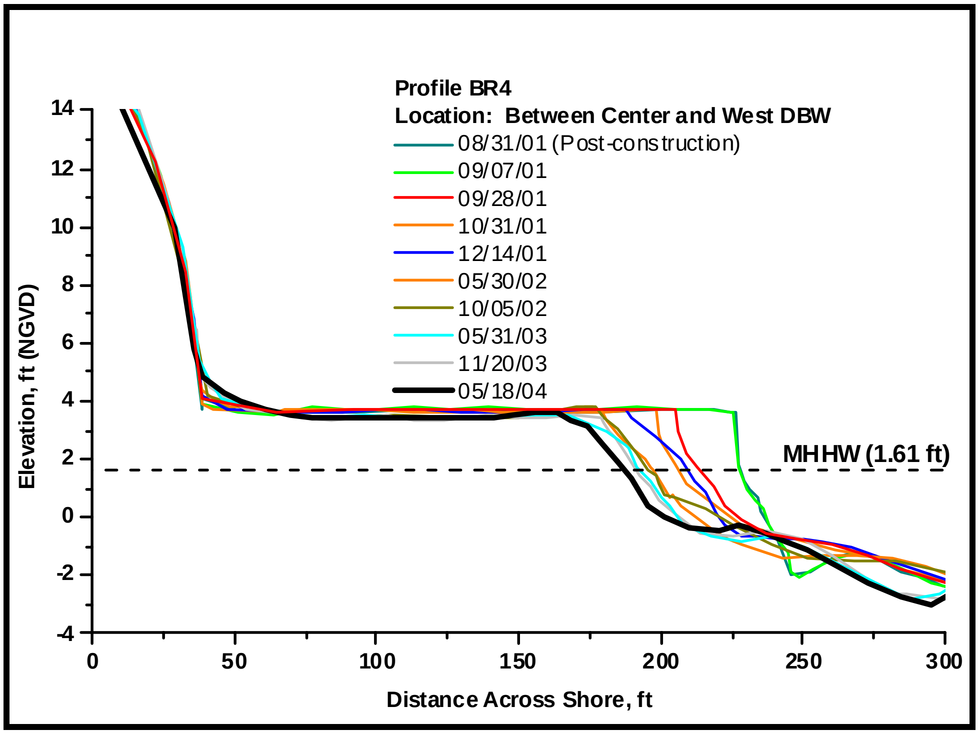

Figure 6. Modification of the beach slope from post-construction to 05/18/2004.

Figure 7. Nearly vertical wall of sand along shore immediately after beach placement 08/31/2001.

Figure 8. Gentle beach slope developed across entire shoreline after 5 months (01/07/2002).

3. Shoreline Position Change: Identification of General Trends

Shoreline position surveys assisted in identification of regions of peak accretion (seaward shoreline shift) and erosion (landward shoreline shift) as well as regions approaching equilibrium. Trends were identified by interpreting changes in shoreline position and shape. Regions with peak tendencies toward erosion or accretion remained consistent throughout the study period. In addition, regions of equilibrium were identified.

To allow a more accurate comparison of successive shoreline position data the shoreline was first measured and then shifted to the position of MHHW. Data were collected along the shoreline at 5-10 ft intervals to describe the general shape and position of the shoreline. Then the position of MHHW (1.61 ft) was measured at key points of inflection along the shoreline.

Shoreline position survey data provides information on the general shape of the shoreline and was applied to identify areas of accretion and erosion "hot spots" or areas of rapid erosion. Analysis of shoreline planform shape helped to identify trends in overall subaerial (dry) beach performance from construction to May 2004. The shoreline position data is complemented by beach profile survey data collected concurrently which provides information describing the subaqeous nearshore portion of the beach. In addition, aerial photography assisted in determining trends in shoreline change and feature development. For the complete aerial library the reader is directed to Appendix A. All aerial photography was provided by Lanmon Aerial Photography, Inc. unless otherwise noted.

Although the following discussion focuses on information gathered from analysis of planform shoreline position change (Figure 9) interpretation of beach profile survey data discussed in Section 4.0 was applied to support conclusions.

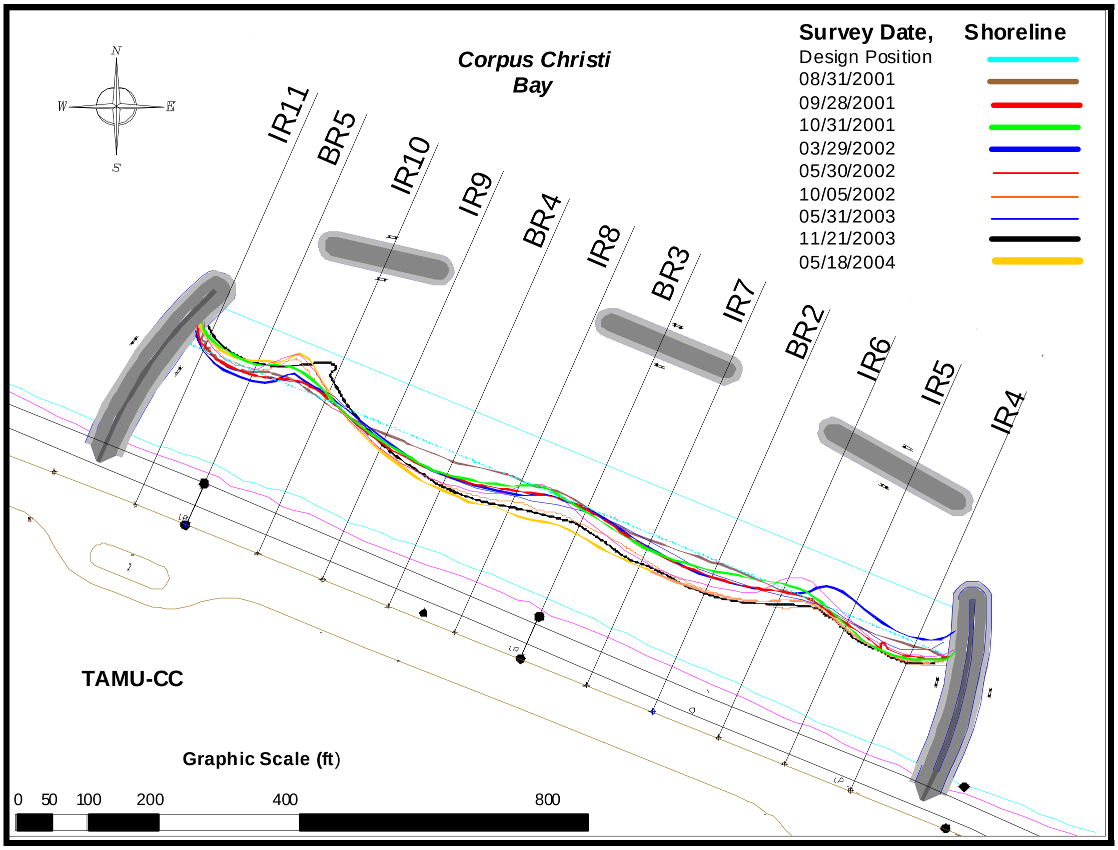

Figure 9. Shoreline position change from August 2001 to May 2004.

3.1 Post Construction-August 2001 to August 2002

The sinusoidal shape of the shoreline began to develop immediately upon placement of sand and simultaneous commencement of DBW construction. Aerial photographs taken in August 2001 show that by project completion the beach had already begun to respond to waves diffracted at the DBWs (Figure 10). These sinusoidal accretionary features observed in the lee of each DBW are salients. Salient development was a key parameter of beach design. During modeling of shoreline change beach cell designs that did not result in the formation of salients were discarded. Salient formation is an indicator of beach stability and that the DBWs are functioning to dampen wave and current energy on the beach (Rosati, 1990).

Salient formation was particularly developed and evident in the lee of the first constructed DBW at the west end of the beach (Figure 9). This trend of accretion on the western end of the beach continued up to the most recent Spring 2004 survey. Salient development in the lee of a DBW is indicative of effective offshore structure placement (Rosati 1990, McCormick et al 1993), thus the development of a salient in the lee of each DBW shows that the offshore placement of the DBW is effective in this beach design.

3.2 Regions of Equilibrium (minimal change)

Analysis of all available data, up to May 2004, indicates that the shoreline in the lee of the eastern DBW (IR5 and IR6) is approaching equilibrium (Figure 9). Prior to Fall 2002 the data

Figure 10. Salient development in the lee of DBWs occurred immediately after construction 08/26/2001.

shows that this region was shifting seaward. The shoreline may be approaching its maximum landward position as shown by the Fall 2002 and the two most recently analyzed surveys Fall 2003 and Spring 2004 agreeing in position. This is a general trend relative to long-term monitoring and does not anticipate changes related to extreme events such as tropical storms.

The survey data shows that the regions immediately east (BR2) and west (BR4) of the central DBW are also approaching an equilibrium position as of Spring 2002 (Figure 9). Although both of the regions initially showed the greatest landward shift in position from placement in August 2001 to Spring 2002, BR2 a 35-ft and BR4 a 34-ft shift, from Spring 2002 to Spring 2004 there was only a landward shift of approximately 10 ft for both regions.

3.3 Regions of Seaward Shoreline Advance (Accretion)

The survey data show that the maximum seaward (accretion) shoreline advance occurred in the lee of the western DBW from placement to Spring 2004 (Figure 9). The shoreline in this region has shifted over 27-ft seaward. With only two minor periods of retreat (Spring 2002/Fall 2002 and Spring 2003/Fall 2003) the data show that the beach in this region, defined by transects IR10, IR11, and BR5, is accreting. Looking at this region in conjunction with the beach profile survey data indicates that the beach growth in this region is not isolated to the subaerial portion of the beach but also continues in the nearshore extending offshore to the DBW (see section 3.0). A tombolo is anticipated to develop in this region within the next 5-8 years if trends in wave and current conditions remain as observed in the past.

3.4 Regions of Landward Shoreline Retreat (Erosion)

Although initial data from August 2001 to Fall 2002 showed that shoreline retreat dominated across the length of the beach, with the exception of the western end, the majority of the beach has slowed in retreat to the point that it may be approaching a state of equilibrium (Figure 9). The central region (defined by transects BR3, IR8, BR4 and IR9) is an exception. The data show that the central section of the shoreline in the lee of the central DBW has consistently shifted landward, with a few minor exceptions, since placement in August 2001 and continues to retreat as of the Spring 2004 survey. Over the study period, the shoreline in this region has retreated at an average rate of 9 to 17 ft per year.

3.5 Shoreline Position Change: Quantitative Analysis

Data collected during seasonal beach profile surveys was applied to determine changes in shoreline position (Table 2). All measurements were reported relative to MHHW for each profile. Although the beach initiates at the base of the bluff the change in width of the beach was calculated from a more seaward position (43 ft < x < 56 ft) associated with location of the bulkhead that existed along the preconstruction shoreline (Figure 4). This position is a critical baseline reference because as the beach approaches within 50 ft of this location action is recommended in the form of beach nourishment to protect the integrity of the beach and backshore (bluff). If the beach were to erode landward of this location waves and currents would then begin to act on the clay and fill material of the preconstruction shoreline of Ward Island. The plots show the entire beach width for each transect including the additional approximately 50 ft from the bulkhead to the bluff that was applied in the shoreline position change analysis. Thus, the actual measured beach width from bluff to MHHW is approximately 50 ft wider than indicated by the calculations in Table 2.

Beach profile survey data were applied to calculate changes in MHHW shoreline position along each transect (Table 2). The average initial (immediately post-construction) shoreline position (MHHW) was 156.40 ft with a minimum of 147.85 in the lee of the center DBW (BR3) and a maximum of 162.72 ft in the lee of the west DBW (IR10). The average shoreline position (MHHW) for May 2004 was 142.22 ft with a minimum of 112.58 ft in the lee of the center DBW (IR8) and a maximum of 179.87 ft at the far western end of the beach (IR11). The greatest overall landward shift (retreat) in position of 42.55 ft (IR8) and 40.58 ft (BR4) was observed in the region between the central and west DBWs. Figure 9 shows that this central region consistently retreated over the study period. The greatest overall seaward advance in shoreline position of 22.15 ft (BR5) and 27.3 ft (IR11) was observed at the far western end of the beach. The data show that this western region consistently experienced advance with only minor periods of retreat during the study period.

3.6 Shoreline Position Change: Compared to Model Predictions

During the functional design of University Beach shoreline change modeling was applied in conjunction with the monitoring and observation of local coastal processes to design the most effective configuration coastal structures for beach stabilization. The study applied the Generalized Model for Simulating Shoreline Change (GENESIS), developed at the U.S. Army Corps of Engineers Waterways Experiment Station, to predict shoreline change associated with longshore sand transport (Hanson and Kraus 1989). The model is capable of simulating shoreline response under a wide range of beach configurations, coastal structures, and beach fills. In particular, GENESIS has been demonstrated to accurately predict shoreline response associated with detached breakwaters (Kraus and Harikai 1983; Hanson and Kraus 1989).

Wave action is the mechanism for such transport and, therefore, a wave hindcast, a retrospective forecasting of waves, was applied to simulate future wave action in Corpus Christi Bay. A wave

Table 2. Shoreline Position and Difference, ft (origin = original bulkhead location)

Profile	Fall01/Sp02			Sp02/Fall02			Fall02/Sp03			Sp03/Fall03			Fall03/Sp04		
	Start	End	Diff.	Start	End	Diff.	Start	End	Diff.	Start	End	Diff.	Start	End	Diff.
IR4	172.07	160.07	-12.00	160.07	148.11	-11.96	148.11	158.72	10.61	158.72	144.99	-13.73	144.99	152.02	7.03
IR5	155.33	166.42	11.09	166.42	152.27	-14.15	152.20	170.14	17.87	170.14	149.6	-20.54	149.6	156.04	6.44
IR6	159.34	184.63	25.29	184.63	144.03	-40.60	144.03	173.81	29.78	173.81	136.77	-37.04	136.77	153.70	16.93
BR2	156.78	127.52	-29.26	127.52	122.21	-5.31	122.21	122.87	0.66	122.87	113.44	-9.43	113.44	118.44	5.00
IR7	147.85	125.15	-22.70	125.15	127.53	2.38	127.53	122.79	-4.74	122.79	110.69	-12.10	110.69	113.35	2.66
BR3	155.29	147.92	-7.37	147.92	136.66	-11.26	136.66	147.52	10.86	147.52	127.99	-19.53	127.99	121.45	-6.54
IR8	155.13	152.96	-2.17	152.96	132.86	-20.10	132.86	129.95	-2.91	129.95	126.84	-3.11	126.84	112.58	-14.26
BR4	155.25	124.38	-30.87	124.38	123.07	-1.31	123.07	119.90	-3.17	119.90	118.80	-1.10	118.80	114.67	-4.13
IR9	149.30	135.57	-13.73	135.57	129.56	-6.01	131.77	128.64	-3.13	128.64	138.57	9.93	138.57	128.87	-9.70
IR10	162.72	180.04	17.32	180.04	174.6	-5.44	174.60	177.64	3.04	177.64	187.6	9.96	187.60	178.27	-9.33
BR5	150.02	167.90	17.88	167.9	167.34	-0.56	167.34	181.08	13.74	181.08	173.42	-7.66	173.42	177.30	3.90
IR11	157.72	184.89	27.17	184.89	182.42	-2.47	182.42	194.60	12.22	194.64	195.02	0.38	195.02	179.87	-15.15
Avg.	156.40	154.79	-1.61	154.79	145.06	-9.73	145.24	152.31	7.07	152.31	143.64	-8.66	143.64	142.22	-1.43

hindcast is calculated from historic synoptic weather charts of the wave characteristics that probably occurred at some past time. For the functional design development, 10 years of continuous wave data were generated for 15 locations within a 50 km^2 area surrounding the study site. The 10-year wave hindcast was derived from wind and atmospheric pressure data obtained for the period of 1987 to 1997. Wind fields were created through analysis of wind and pressure data developed by the NOAA National Center for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAP) reanalysis effort. The wave data were developed from 10-m wind fields on a Gaussian-spaced latitude grid with an average spacing of 1.905 deg. The longitude grid spacing is constant at 1.875 deg. The wind data were interpolated to the nested grids used for wave modeling. The wave model was run so as to include generation across the entire Corpus Christi Bay nesting from a 2.5-min grid over the bay to 0.5-min grid around the study site. Wave conditions were hindcast by applying a discrete directional spectral wave model that is applicable in all water depths. The model includes a nonlinear wave-wave interaction source term and shallow water wave transformations.

The wave hindcast was applied to drive the model (GENESIS). GENESIS calculates wave transformation including shoaling, refraction, transmission, breaking, and diffraction from coastal structures. GENESIS was applied to determine which design alternative was best suited to the conditions along Ward Island. The design alternatives were evaluated based on the following quantitative performance criteria; 1) minimum dry beach width of 50 ft, 5 years after placement and 2) loss of less than 30% of material after 5 years. After the optimum design was selected, shoreline change was predicted over a 10 year post-construction interval to assist in anticipating when nourishment efforts would be necessary.

The reader is cautioned that model predictions serve as a reference of a range in potential change that can be expected over a project lifetime. Modeling is a tool to assist researchers and resource managers in anticipating trends in shoreline change. Predictions are not suggested as absolute because they rely on the wave hindcast data that approximates future wave conditions. Wave conditions will vary year to year, thus longer prediction periods increase in agreement with observed changes. The model has some limitations in that it can not quantify change due to the unstable slope of the newly placed beach, resulting in an underestimate of change during the first years after construction. In addition, storm events outside of typically observed conditions are not represented in the wave hindcast. Predictions will typically more closely match the observed shoreline position over time as the newly placed beach comes to equilibrium with the local waves and currents and is not experiencing such rapid change as seen the first few years as the beach approaches an equilibrium state.

The actual data at 1, 2, 3, and 3.5 year intervals were compared to the predicted shoreline change over a 10-year period. These predictions were based on an initial fill volume of 50,000 cu yd therefore some differences are anticipated due to a reduced volume of 45,000 cu yd actually placed. Note that the shoreline predicted for year three was an outlier year showing greater than average advance and retreat and was included to show the extremes that can occur under even typical conditions. Figure 11 shows that model accurately predicted accretion and development of a salient along the west end of the beach in the lee of the west DBW over the first year post construction. The magnitude of erosion that occurred along the central and eastern end of the beach was underestimated by the model, although the overall sinusoidal shape of the shoreline

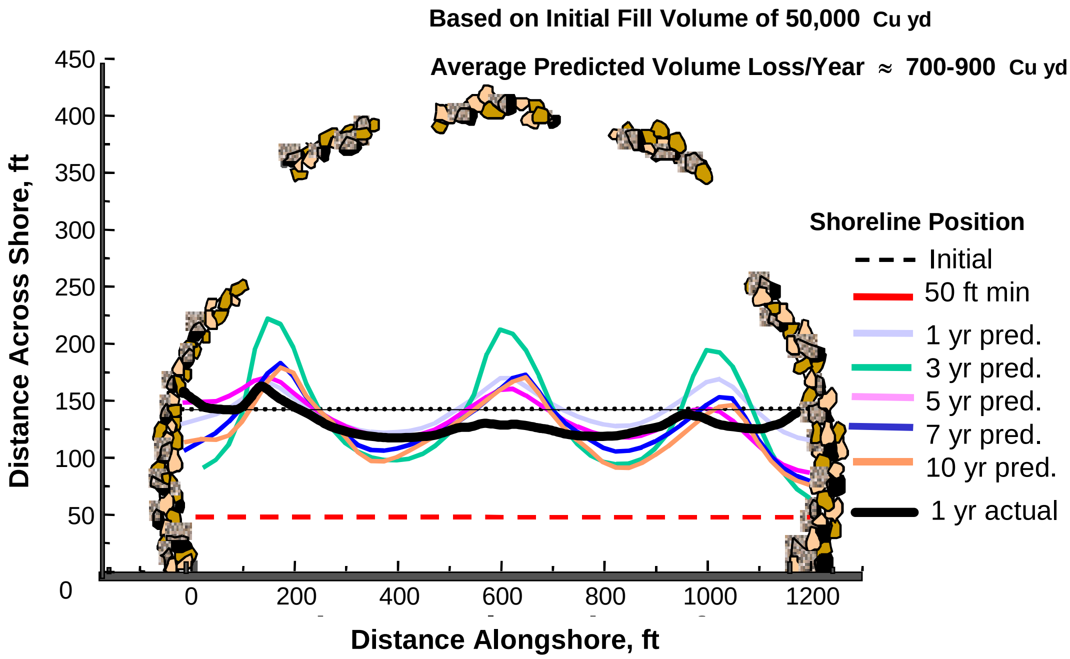

Figure 11. Comparison of a range of model predicted shoreline change to actual change 1.0 year after construction.

was captured by the model in a modified form. Figure 11 shows that the actual observed shoreline more closely followed the 5-year model prediction. Salient development on the east and west ends of the beach was captured by the model prediction. Although the central salient, observed during the Fall 2002 survey, was not as developed as predicted and the regions to the east and west of the salient retreated approximately 25 ft less than predicted. The 3-year and 3.5-year (most recent Spring 2004 survey) prediction showed a more exaggerated sinusoidal shoreline that became more modified by the 5-year prediction (Figure 12 and 13). Again, the actual observed shoreline in the central region showed greater retreat after 3 years than predicted with less shoreline retreat observed to the east and west of the salient than predicted.

Of particular interest is that the model consistently over-estimated shoreline retreat closest to the groins and between the salients. In addition, the maximum actual observed retreat in the central region (hot spot) is approximately 25 ft less than predicted. The overall maximum retreat in shoreline was overestimated by the model indicating that the overall shoreline position is reaching an equilibrium state more rapidly than anticipated by model predictions.

3.7 Prediction of Nourishment Schedule

The beach profile survey data were applied to predict a beach nourishment schedule based on time anticipated for the MHHW shoreline to retreat to the 50 ft minimum position. The rate of change in shoreline position (MHHW) was calculated from the measured change in position over time (Table 3). In Table 3, transects where the change in shoreline position was approaching equilibrium are denoted with a “C” for constant position. A constant shoreline position indicates

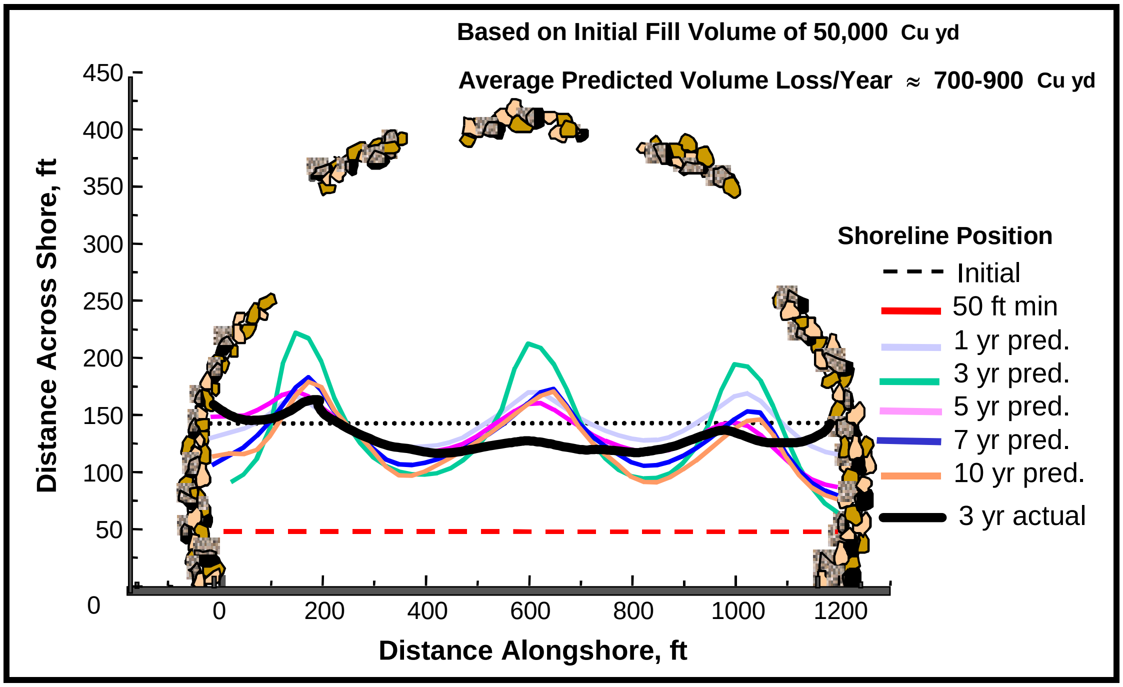

Figure 12. Comparison of a range of model predicted shoreline change to actual change 3.0 years after construction (Fall 2002).

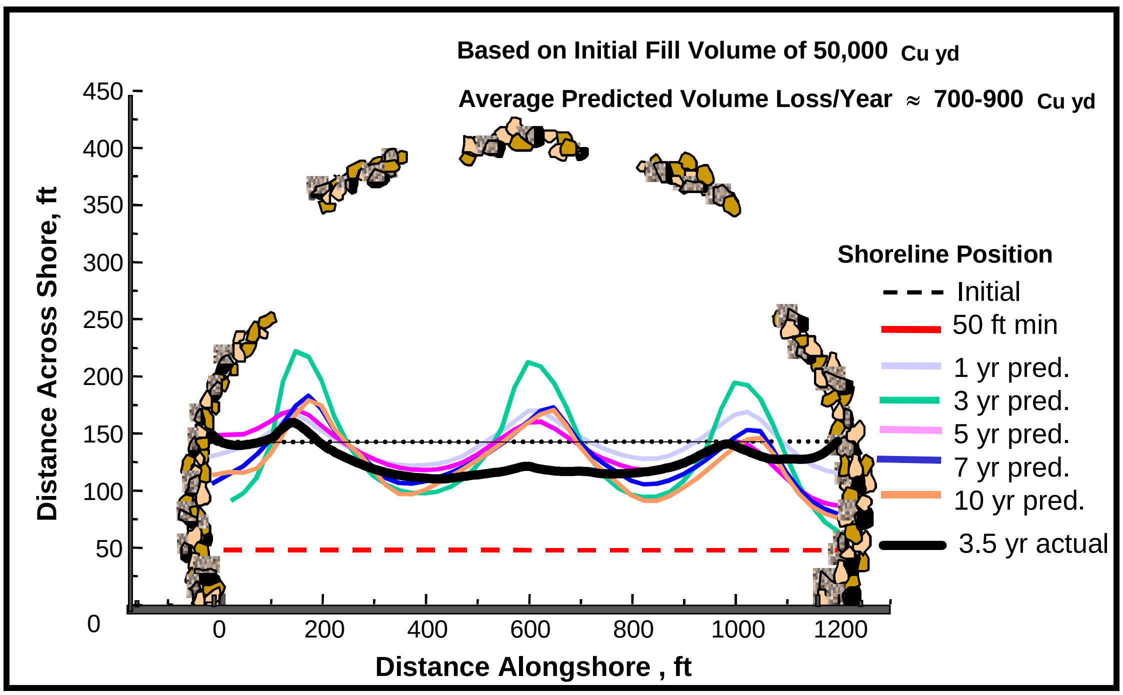

Figure 13. Comparison of a range of model predicted shoreline change to actual change 3.5 years after construction (May 2004).

Table 3. Predicted Nourishment Schedule (minimum beach width of 50 ft)						
(A = Accretion) (C = Constant Position) (# = number of years until needed)						
	Fall01/Sp02	**Sp02/Fall02**	**Fall02/Sp03**	**Sp03/Fall03**	**Fall03/Sp04**	**Avg.**
IR4	5	4	A	4	A	C
IR5	A	4	A	2	A	A
IR6	A	1	A	2	A	A
BR2	2	7	A	4	A	A
IR7	2	A	8	3	A	A
BR3	7	4	A	2	6	3
IR8	24	2	14	12	2	11
BR4	2	28	11	31	8	16
IR9	3	7	13	A	4	4
IR10	A	12	A	A	7	A
BR5	A	105	A	8	A	18
IR11	A	27	A	A	4	A

no net retreat and therefore nourishment is not anticipated in the predictable future (taking the wave/current conditions to be similar to those during the study period). Transect locations denoted with an "A" are regions showing net accretion over the study period, therefore no nourishment is anticipated in the predictable future assuming similar wave and current regime. The data show two potential hot spots of shoreline retreat in the region bounded between transects IR9 and BR3. Nourishment may be required in these locations within 3-4 years. The west-central section defined as from BR3 to IR9 will require nourishment within 11 to 16 years. Because the overall region of accelerated erosion is small (only 300 ft) alongshore, it is recommended that the entire area from BR3 to IR9 be nourished concurrently. This will reduce mobilization costs. Calculations indicate only one other region may require nourishment in the predictable, albeit distant (18 years), future and that is near transect BR5 but trends observed in this region (IR11 to IR10) do not support this as a concern in the foreseeable future.

4.0 Morphology and Trends in Accretion and Erosion

The beach profile data provides detailed information on changes in morphology of both the subaerial beach and submerged nearshore region. All profile plots, including those not specifically described in this section, are shown sequentially from east to west in Appendix C. The most striking change in features is observed in close proximity to the DBWs. Deposition in the lee of all three DBWs was observed within 8 months of construction and has consistently increased. The most striking observation is the extent of deposition in the lee of the central and western DBWs with water depths reduced 1-3 ft. (Figure 14 and 15). Analysis of the survey data supports the prediction that on the order of 1,400 to 1,500 cu yd of sand are potentially encumbered in the lee of the western and central DBWs, respectively. Thus, preliminary data indicate that there is enough sand (nearly 3,000 cu yd) encumbered in the lee of the west and central DBWs to satisfy the most immediate nourishment needs anticipated within the next 3-4 years (Table 3). These estimates will be confirmed by the Spring 2005 survey.

The beach profile data further describe the related salient development shown by the shoreline position data and described in Section 3.0. This large region of deposition in the lee of the west

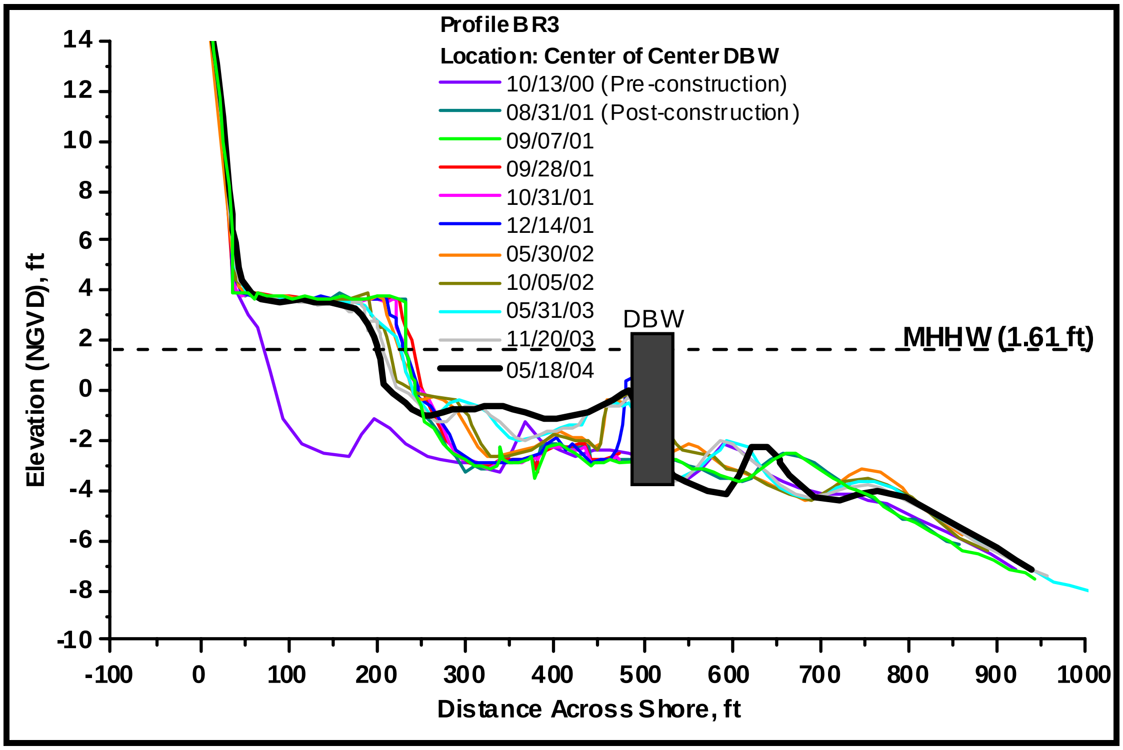

Figure 14. Accretion in lee of central DBW on transect BR3.

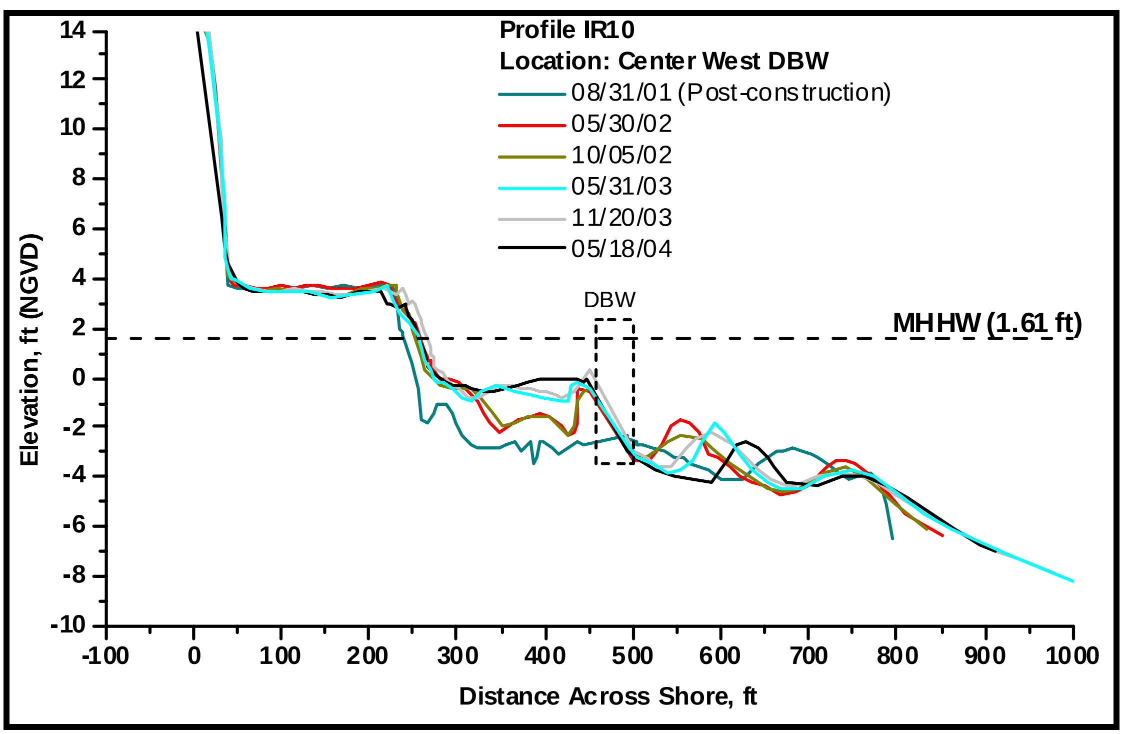

Figure 15. Significant accretion measured in the lee of west DBW on transect IR10.

DBW indicates that there is potential for tombolo formation in this area in the future. The tombolo would develop as the salient continued to extend offshore in position and would eventually meet and join the deposition occurring in the lee of the west DBW. Tombolo development is not anticipated in the lee of the central DBW as the salient in this region is not as developed, nor in the lee of the east DBW as deposition is not as extensive (Figure 16).

The intersection of the profile seaward of each DBW is often susceptible to accelerated erosion. Erosion near structures such as DBWs that may undermine stability is called scour. Up until Fall 2003, the region just offshore of the DBWs was stable showing no sign of erosion or scour. The May 2004 data show a localized area of erosion developing just offshore of the west and central DBWs (Figure 14 and 15). The morphology has changed seaward of the DBWs in that the bar that once was located adjacent to the DBWs shifted offshore approximately 50 ft from Fall 2003 to May 2004 and 100 ft from Spring 2002 to May 2004. This may be a temporary condition as bars in this area have been historically (Williams 2002) observed to shift onshore and offshore dependent on water level and wave action prior to surveys. A pattern of erosion is evident in the region between 500 and 600 ft offshore across the entire the length of the beach even in areas without DBWs. The areas of erosion observed in these two areas are most pronounced immediately offshore of the DBWs and may be enhanced by the proximity of the DBWs. Along the transects outside of the beach cell there is also an offshore shift in bar location of 500 to 600 ft indicating that this change in morphology may be related to area wide coastal processes. Future surveys will assist in determining the cause of this change in morphology.

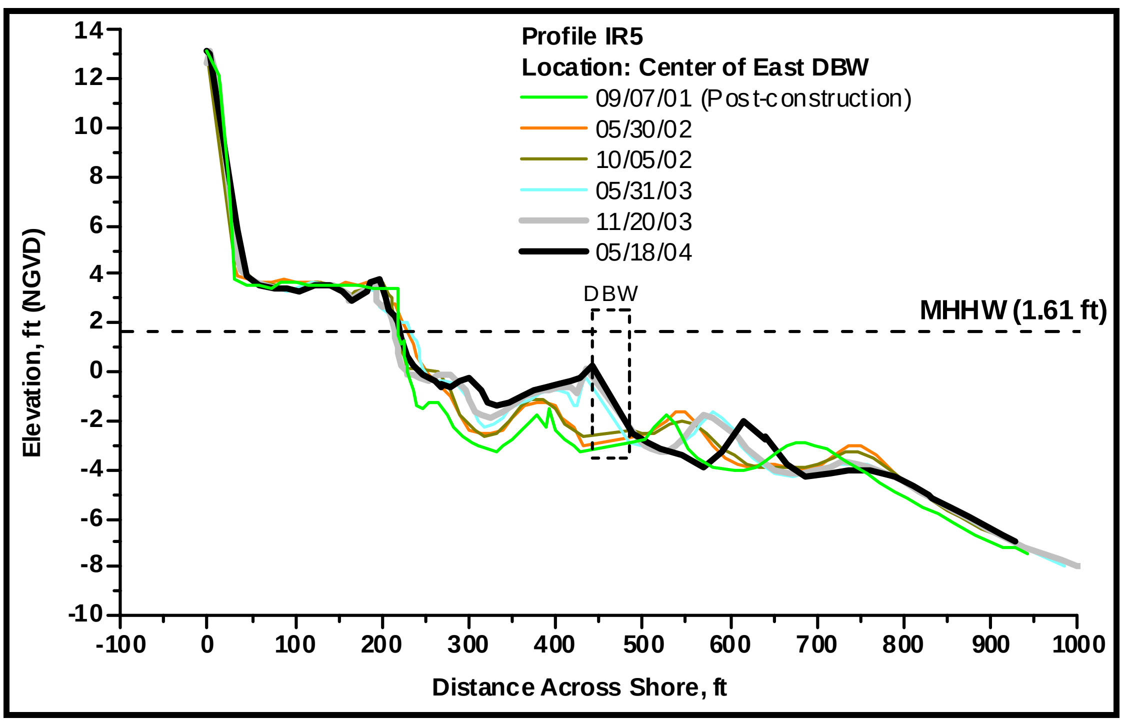

Figure 16. Limited accretion in the lee of IR5 located in the lee of the east DBW.

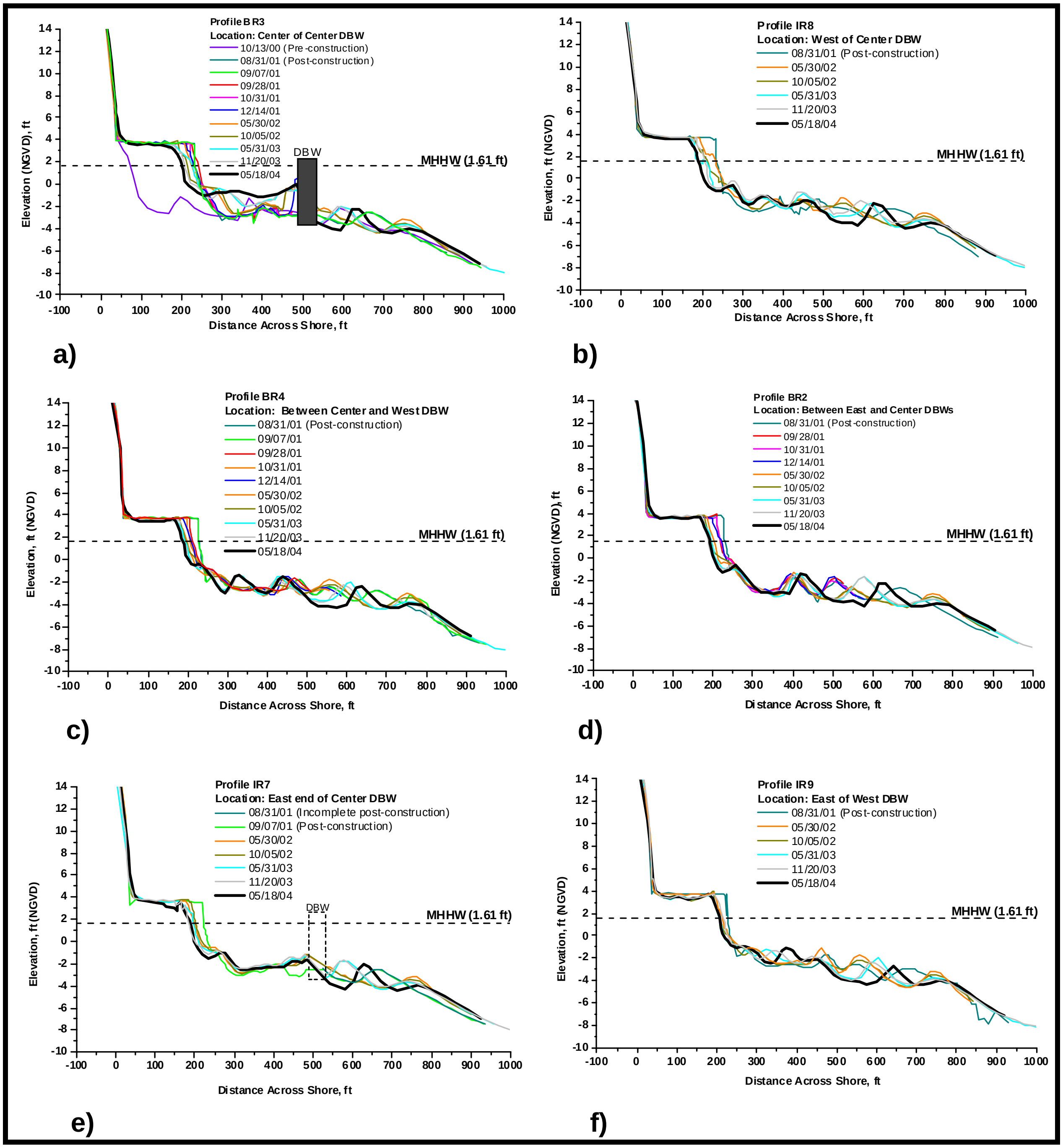

Figure 17. Extensive shoreline retreat observed along transects a) BR3, b) IR8, c) BR4 and to a lesser extent along transects d) BR2, e) IR7 and f) IR9.

The central region shows the greatest retreat in shoreline position as shown along transects BR3, IR8, BR4 and to a lesser degree on transects BR2, IR7 and IR9 (Figure 17). In contrast, there is little change in nearshore morphology along all transects except BR3 other than the typical transition of bars and the erosion or bar shift described in the preceding paragraph.

Beach profile surveys where conducted adjacent to the beach cell to determine the impact of waves and currents interacting with the new coastal structures. The profile data for the region defined from BR6 to IR14 show little or no change identifiable as related to placement of the beach cell (Figure 18 and 19). Figure 20 and 21 show accretion in the region from the shoreline offshore 250 ft along transects IR12 and IR13. IR12 had a net accretion of 6 cu yd/ft in the region from the shoreline offshore 250 ft. A net accretion of 6 cu yd/ft was also calculated in the area along Transect IR13 from the shoreline to 300 ft offshore. Both of these transects were characterized by net accretion across the entire transect of 3.6 and 7.2 cu yd/ft, respectively. The data indicate that accretion observed along Transect IR12 and IR13 is in response to forcing of native sand by strong storm waves and currents associated with northwesterly frontal systems. Deposition is enhanced by the groin acting as a barrier to transport to the east. Associated sediment analysis shows that the sand deposited in this region has an average grain size of 0.15 mm which is consistent with native sediment in the area.

The morphology and volumetric changes are similar on the east side of the beach cell. Transects IR2 and IR3 show little change in morphology with the sand bar system maintaining the same number of bars and relative placement along shore (Figure 22 and 23). Changes in morphology and volume appear to be restricted to the area nearest to shore and immediately adjacent to the east groin as described by transect BR1 (Figure 24). This area experienced net accretion of 5.0 cu yd/ft from the shoreline to approximately 300-ft offshore but maintained a net loss of -6.0 cu yd/ft along the entire profile**.** In addition, the bar system fluctuated widely along this profile indicating sediment response motivated by the altered hydrodynamics nearest to the groin.

The observations on the east and west sides of the beach cell indicate that the beach cell is not significantly impacting the nearshore region beyond IR13 to the west and BR1 to the east (Figures 21 and 24). The changes along the profiles closest to the beach cell are limited to the area within 200 to 300 ft offshore of the shoreline. The data indicate that the deposition in this region is due to forcing of native sediment by seasonal wind and waves with the groins acting as barriers to longshore sediment transport. In addition this trend of accretion close to shore is anticipated to continue and will be monitored to determine if this trend is initiating along transects located further from the beach cell.

Overall settling of the dry beach was identified as a lowered beach profile elevation and was observed throughout the study period. Consistent significantly (> 0.2 ft) lowered beach elevations were identified along transects IR4, IR5, IR7, BR4, and IR9 (Figures 25, 16, 17e, 17c and 17f). Changes in beach elevation typically ranged from 0.3 to 0.5 ft and appeared to be associated with regions that experienced pooling during high water or excessive rain and/or areas where runoff from the bluff often forms deep guts in the surface. Another contributing factor may be that the beach experienced several periods of inundation during higher than average water level where the beach was nearly submerged.

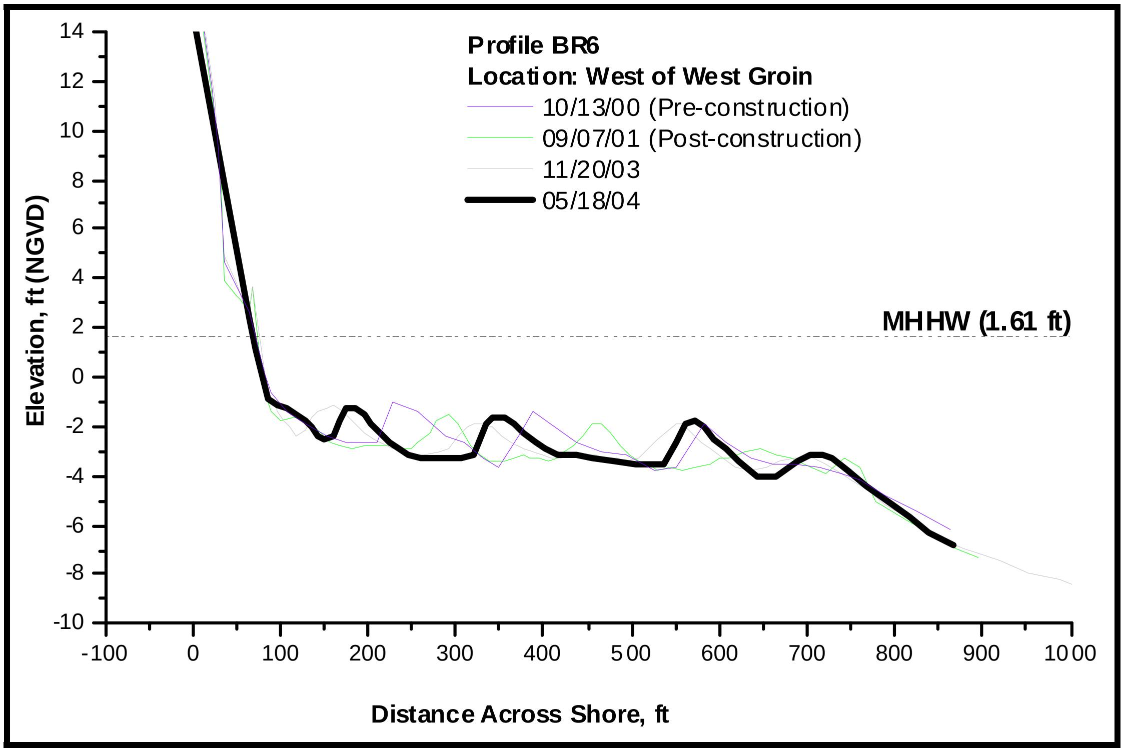

Figure 18. Limited change in morphology along Transect (Profile) IR14.

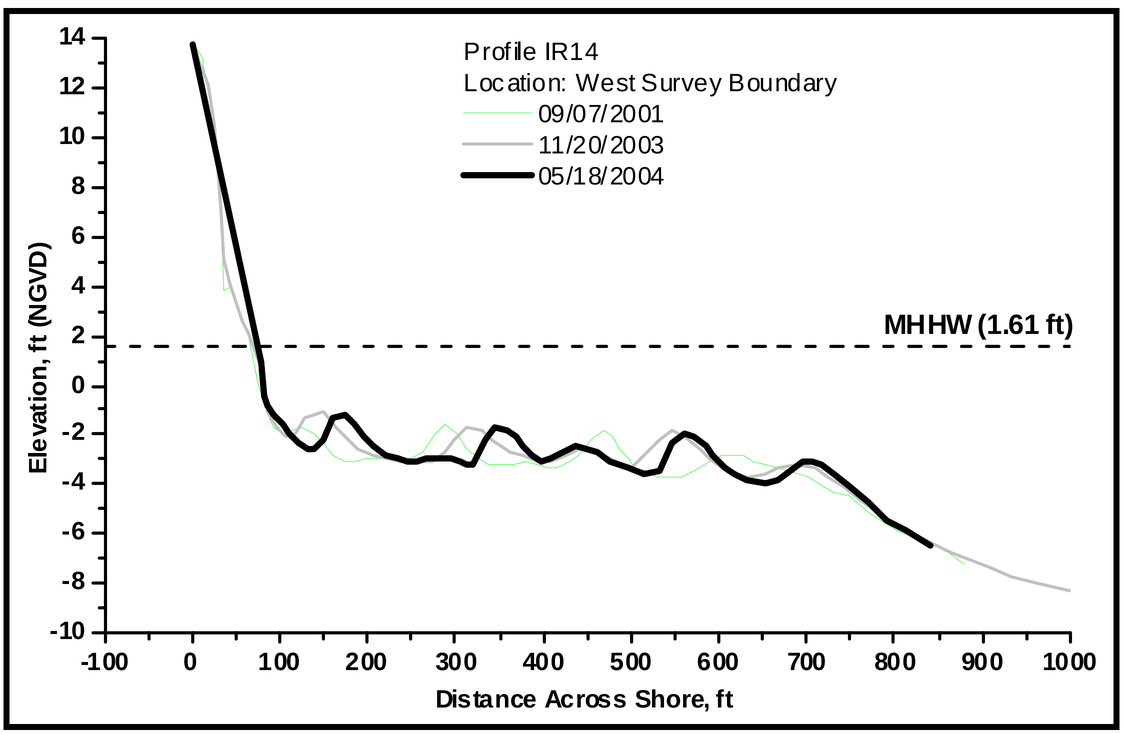

Figure 19. Limited change in morphology along Transect (Profile) IR14.

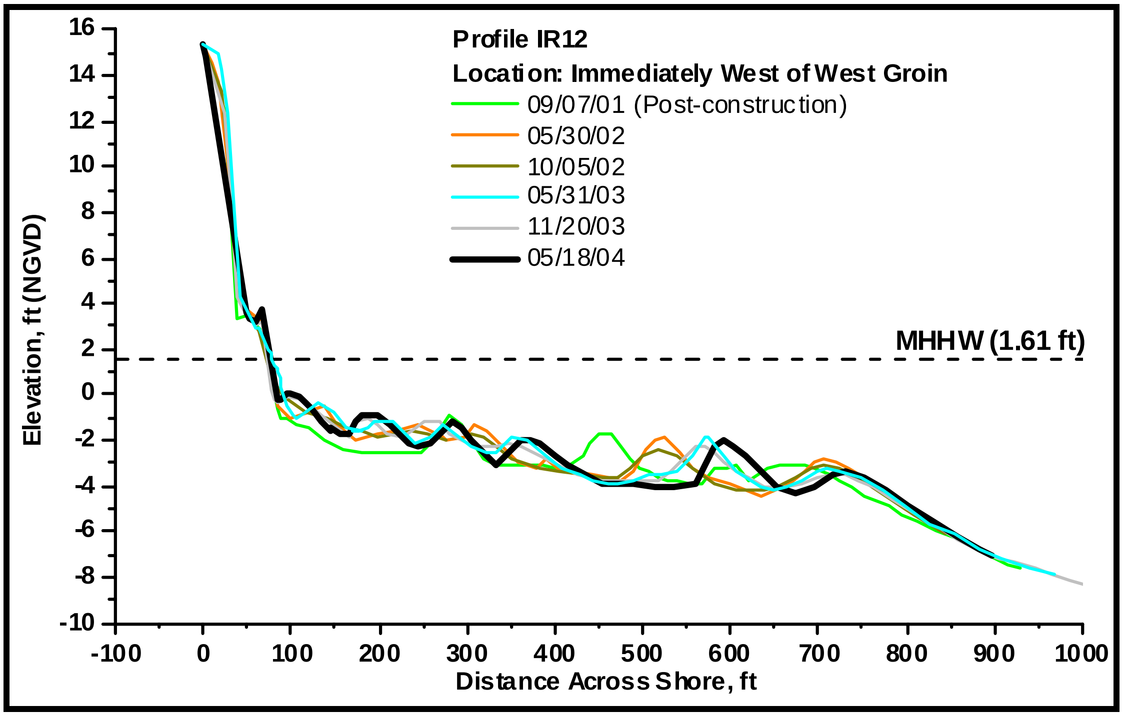

Figure 20. Accretion along Transect (Profile) IR12 occurs from across shore distance of 100 to 250 ft. Trend in offshore bar movement is seaward from 450 to 600 ft offshore.

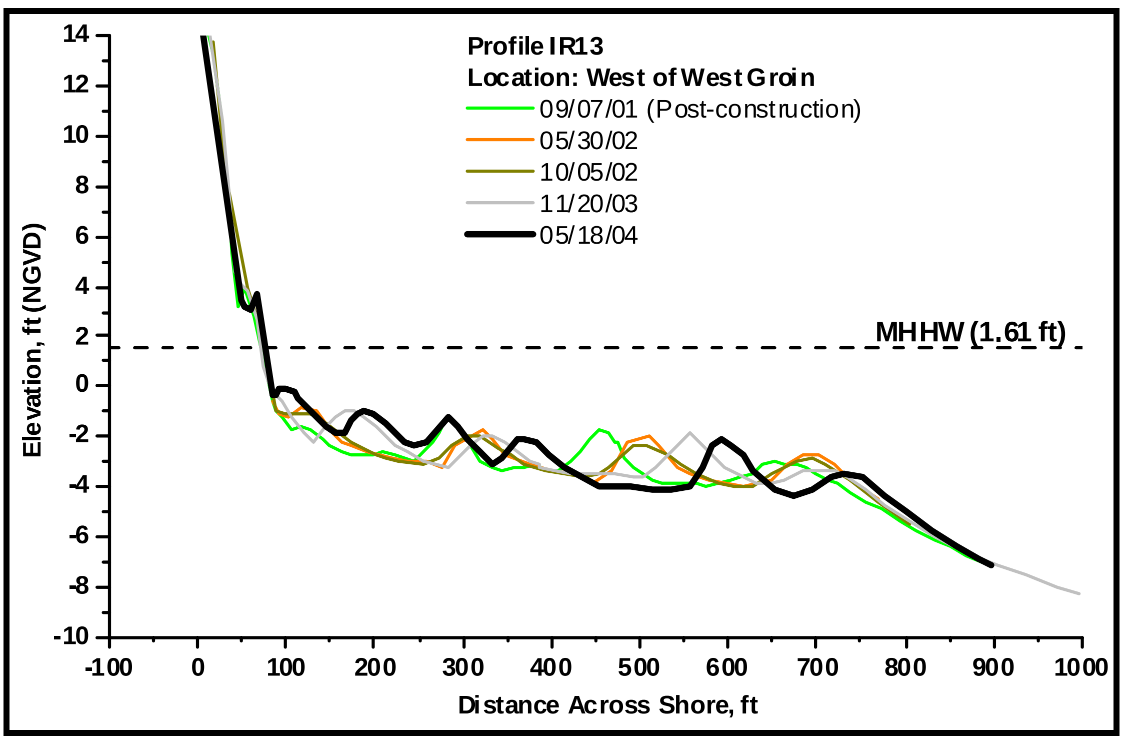

Figure 21. Accretion along Transect (Profile) IR13 occurs from across shore distance of 100 to 300 ft.

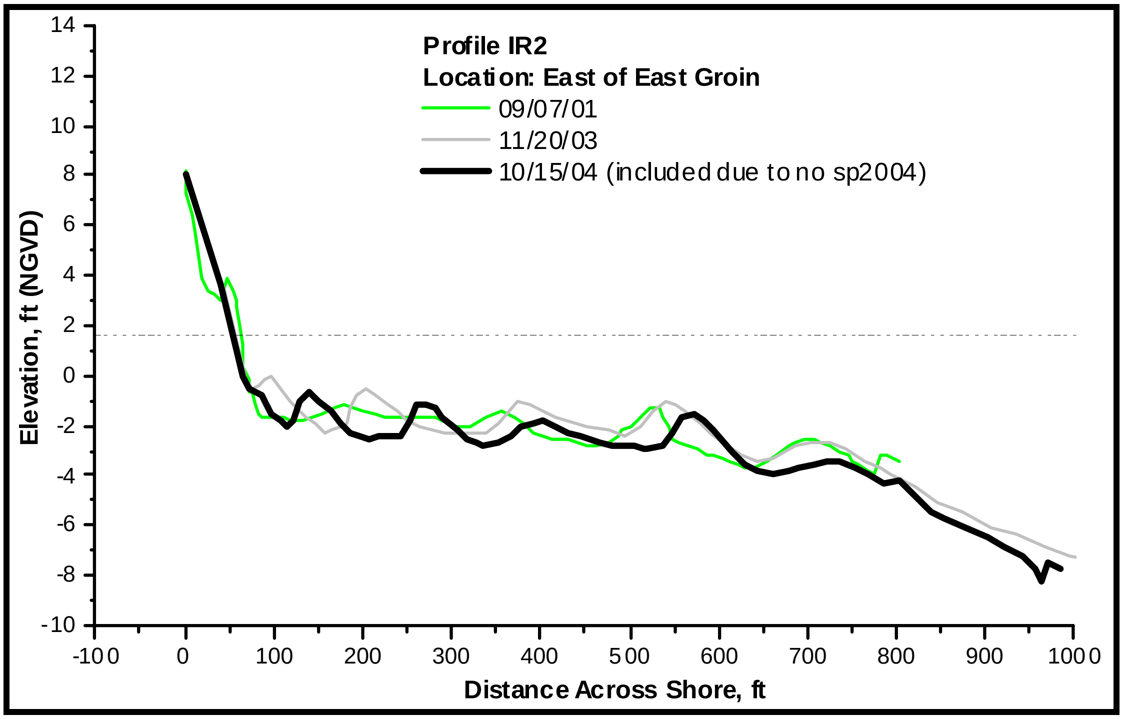

Figure 22. Limited change in morphology along Transect (Profile) IR2.

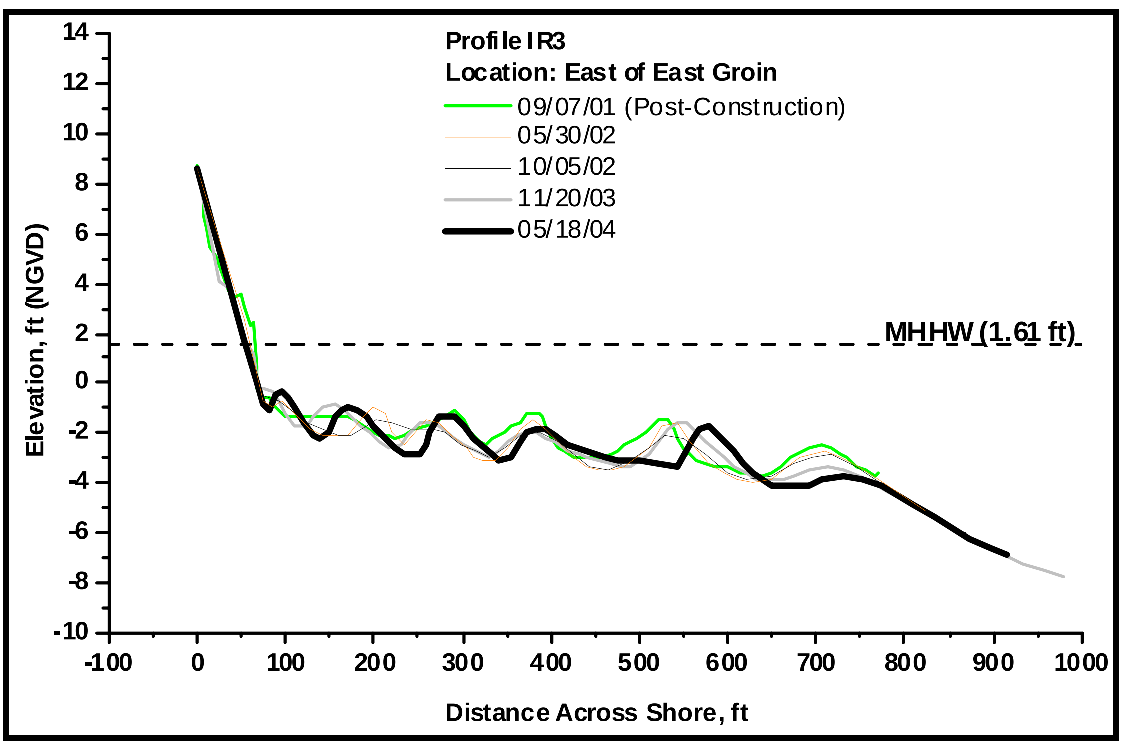

Figure 23. Limited change in morphology along Transect (Profile) IR3.

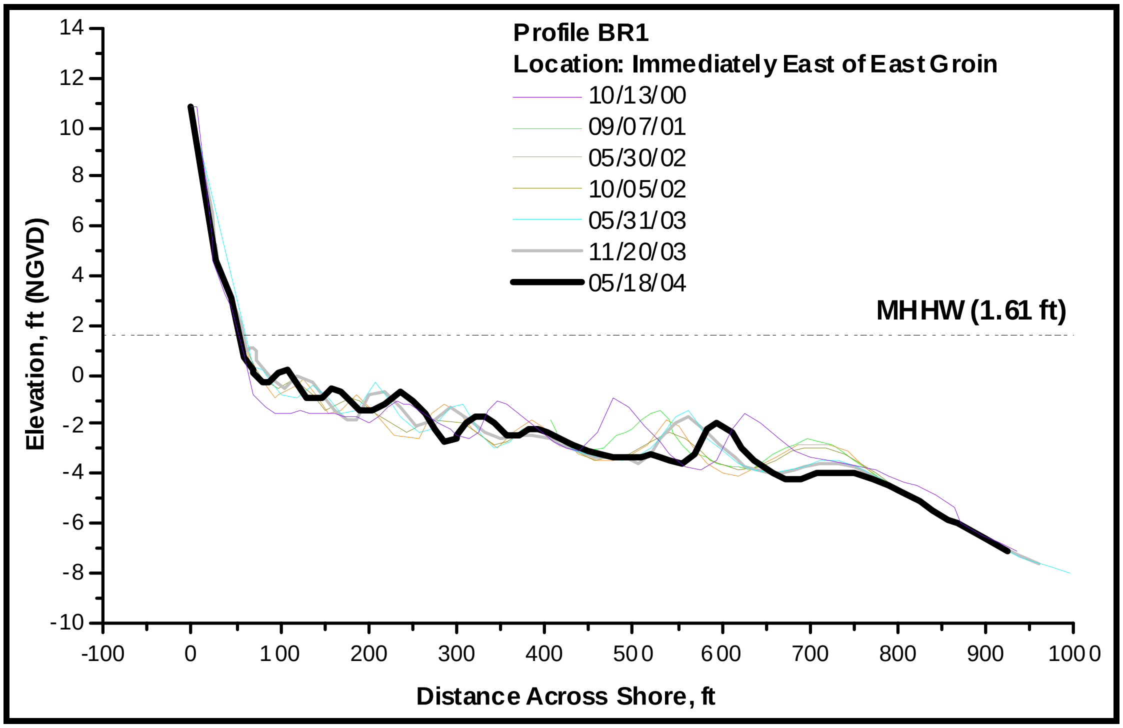

Figure 24. Transect (Profile) BR1 shows increased deposition from shoreline offshore 250 ft as well as changes in overall morphology of bar system.

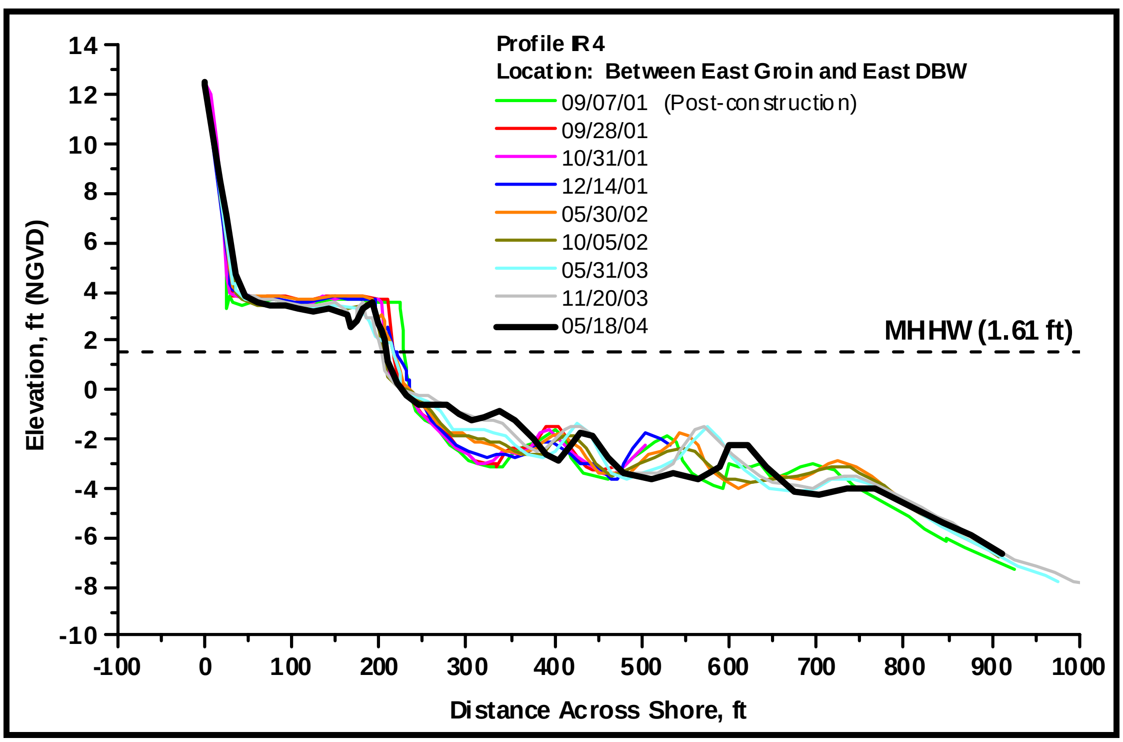

Figure 25. Settling of dry beach along Transect (Profile) IR4.

5.0 Volumetric Change

5.1. Baseline

During project development, predicted project performance was based upon a final beach-fill volume of 50,000 to 51,000 cubic yards. The actual fill volume placed was 45,000 cubic yards, thus upon completion the beach was in a sand deficit of 5,000 to 6,000 cu yd which is within the order of magnitude of an anticipated nourishment volume. Often the anticipated volume associated with the first predicted nourishment period is added to the initial placement volume to defray costs related to mobilization. Despite starting in a deficit, University Beach has performed well and shows signs of overall stability.

5.2. Methods

Volume change was calculated for the entire beach from the base of the bluff along Ocean Drive offshore to the Depth of Closure (DOC). The “average end-area method” was applied utilizing Excel spreadsheets to determine beach volume for each survey period. The average end-area method approximates the volume between every two transects (stations) by multiplying the average area of every two consecutive transects by the distance between the two transects. The results were then compared to determine overall volumetric change and to identify trends.

The first step in analysis was to verify the template and construction volume by applying the Beach Morphology Analysis Package (BMAP) to analyze the beach profile survey data. The boundaries of the template were defined as the toe of the bluff extending offshore to where the beach profile intersects the pre-existing nearshore profile, immediately after placement (Figure 26). The design template volume calculated from the beach profile data was 52,025 cu yd. The difference between the template volume and the actual fill volume placed (as per contractor specifications) was attributed to an approximately 50 ft wide area of pre-existing subsurface that was left intact during construction. The volume (7,025 cu yd) associated with this pre-existing area near the bluff was subtracted from the total template volume as it was not composed of beach fill material. Thus, the final design template volume (beach area less existing subsurface) calculated from survey data was 45,000 cu yd which agrees with contractor specifications. The boundaries of the construction template volume were defined as the toe of the bluff extending offshore to the DOC. Thus, the construction template encompassed the entire beach from the subaerial portion to the most offshore extent of sediment transport. The construction template volume was calculated based on the beach profile survey data collected immediately after project completion in August 2001. All volumes calculated from subsequent beach profile survey data were compared to this baseline volume.

The net-volume change between surveys was calculated to determine the rate and magnitude of sand lost from the beach system. The entire region from the bluff toe offshore to the DOC was included in these calculations not just the dry beach. This is a key concept as once the sand was placed it was redistributed from the subaerial beach to the submerged nearshore region. Some of the sand distributed in the submerged region of the beach was maintained in the immediate beach system and some was lost offshore or alongshore. The net changes given in Table 4 include losses from the beach fill and pre-existing nearshore as well as sediment introduced into the beach system from the surrounding bay. The amount of sand introduced into the area from other

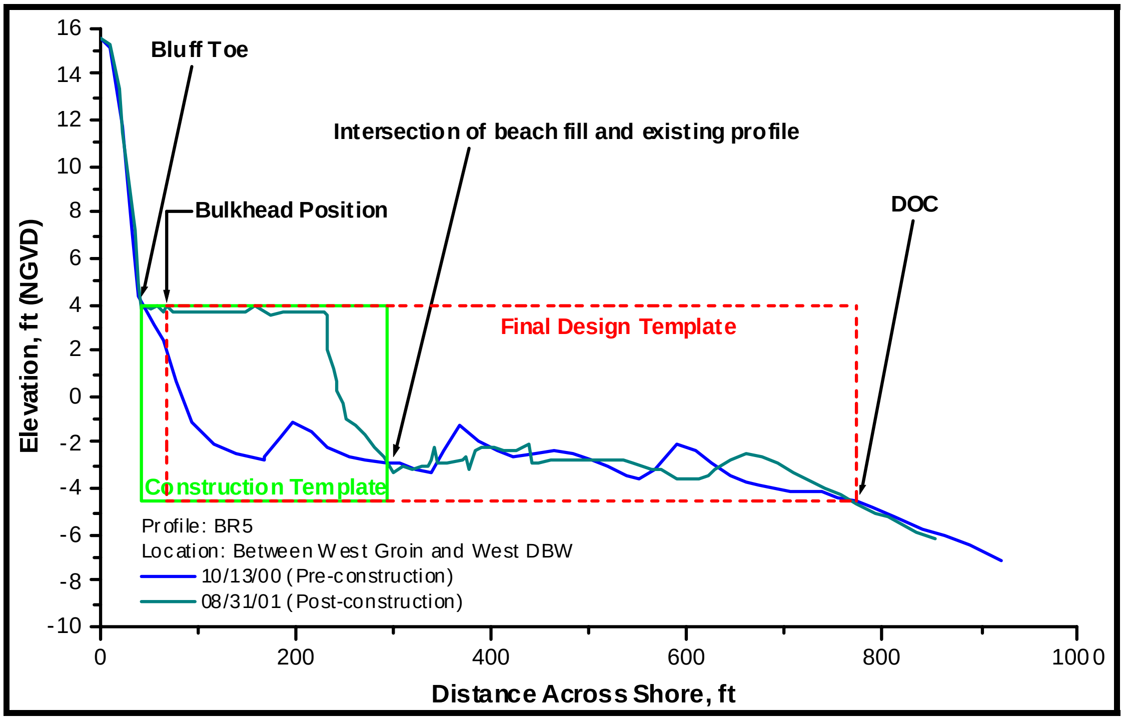

Figure 26. Definition of area applied to determine overall volumetric change of the beach.

sources can only be estimated as there is an exchange of sand from within the beach cell and the adjacent bay system. These volumes are not readily quantifiable.

5.3. Net Volume Change

The comparison of data from 08/31/2001 to 05/18/2004 indicates that the beach system is accreting with a net volume change of 1,678 cu yd (Table 4). Although the overall net change is positive for the entire study period, there was a net change of -2,859.80 from Spring 2002 to Fall 2002 and -3,629 cu yd during the last survey period from Fall 2003 to Spring 2004. Therefore, the beach should be monitored closely over the next few years to determine if a trend of net erosion is developing.

6.0. Sediment Grain Size Analysis

The beach fill material placed on University Beach was transported from a Nueces River quarry and placed along the shoreline during the summer of 2001. Sand was placed in conjunction with the construction of the DBWs and completion of the groins. Sediment analysis consisted of processing the samples and calculating statistics that were later applied to develop sediment contour maps to show the distribution of the sand within the system.

Table 4. Beach Volume Change		
Period		
Start	**End**	**Volume Change (cu. yd.)**
Fall 2002	Spring 2002	4785.41
Spring 2002	Fall 2002	-2859.80
Fall 2002	Spring 2003	1284.61
Spring 2003	Fall 2003	2096.37
Fall 2003	Spring 2004	-3628.99
Net Change		1677.60
Rate of Change/yr. (2.5 yr. observation period)		671.04

6.1. Methods

Sediment samples were collected along 9 transects (IR2, BR1, BR5, BR2, BR3, BR4, BR5, IR12 and BR6) in the study area during each beach profile survey. Samples were collected along 5 transects along the beach cell and along 2 transects to the east and 2 west of the beach. Approximately 100 samples were collected during each survey. Standard sample locations were selected based on morphology (base of bluff, mid-beach, mid-berm, shoreline, landward of DBW, seaward of DBW and DOC). Additional samples were collected to define areas of interest including regions of apparent siltation from bay sources and on sand bars and troughs. All samples were rinsed, dried and sieved at 0.25 Phi intervals according Folk (Folk 1977) procedures. Once the sieved fractions were weighed the data were applied to calculate statistics and then contour plots were developed to determine sediment distribution patterns.

6.2. Sediment Grain Size Statistics

Sediment grain size statistics (median grain size, mode, and inclusive graphic standard deviation) were calculated for each sampling location (Appendix B). Folk methods (Folk 1977) were applied to calculate statistics utilizing the ACES (Automated Coastal Engineering System) software (CEDAS). An average median grain size contour plot (Figures 22 to 28) was developed for each survey to assist in determining trends in sediment distribution within and adjacent to the beach cell. The contour plots reflect averages and trends therefore select contour values that were not representative of data collected in that region are not shown to focus the observer on the grain size of interest. These contour plots were compared to identify two primary locations 1) regions of coarse (> 0.20 mm) beach material and 2) locations of finer (≤ 0.15 mm) sediment within the beach cell. Locating regions of coarser sand deposition, as opposed to finer native sand, provides information on the pathways of migration of the beach fill material. These deposits of coarser sand are of interest as they may indicate potential on site sand reclamation areas for future beach nourishment. Significant coarse material sinks were identified in the lee of the central and west DBW (Figures 29, 31, 32 and 34). Subsequent surveys will add additional sediment collection locations along Transect IR10 in the lee of the west DBW. Beach profile survey data show that this region has the greatest potential for accumulating beach quality sand that has migrated offshore and could potentially be utilized as nourishment material in the future.

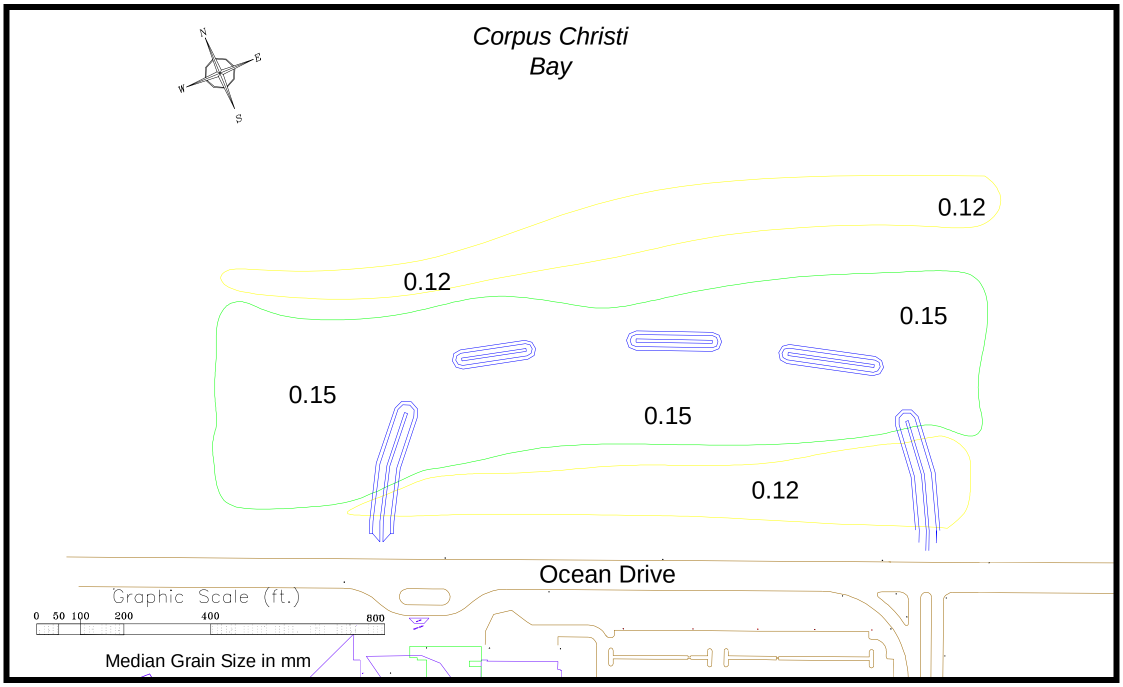

Figure 27. Average median grain size distribution prior to beach construction (10/13/2003).

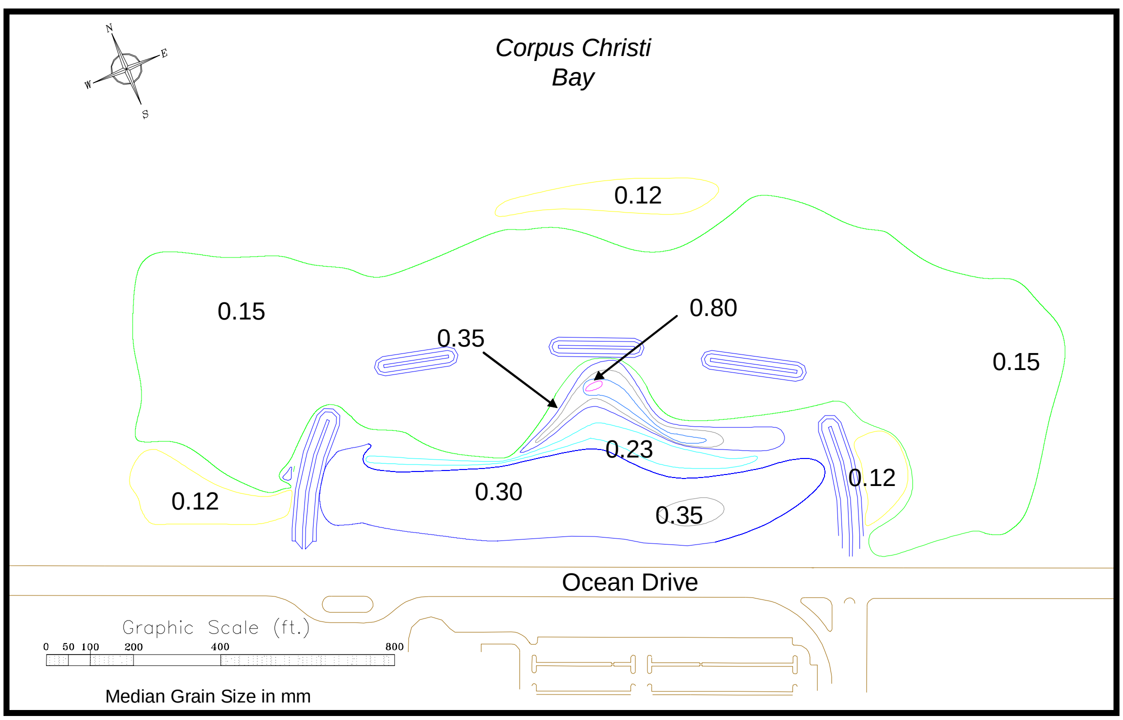

Figure 28. Average median grain size distribution immediately after beach construction (09/07/2001).

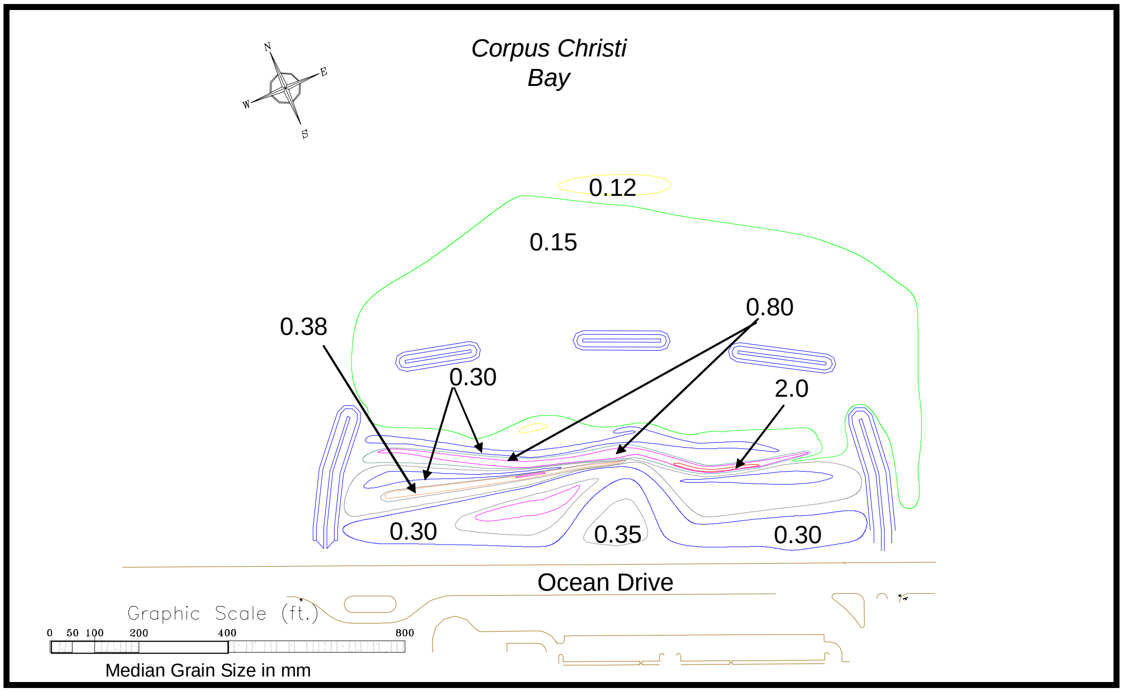

Figure 29. Average median grain size distribution (05/30/2002).

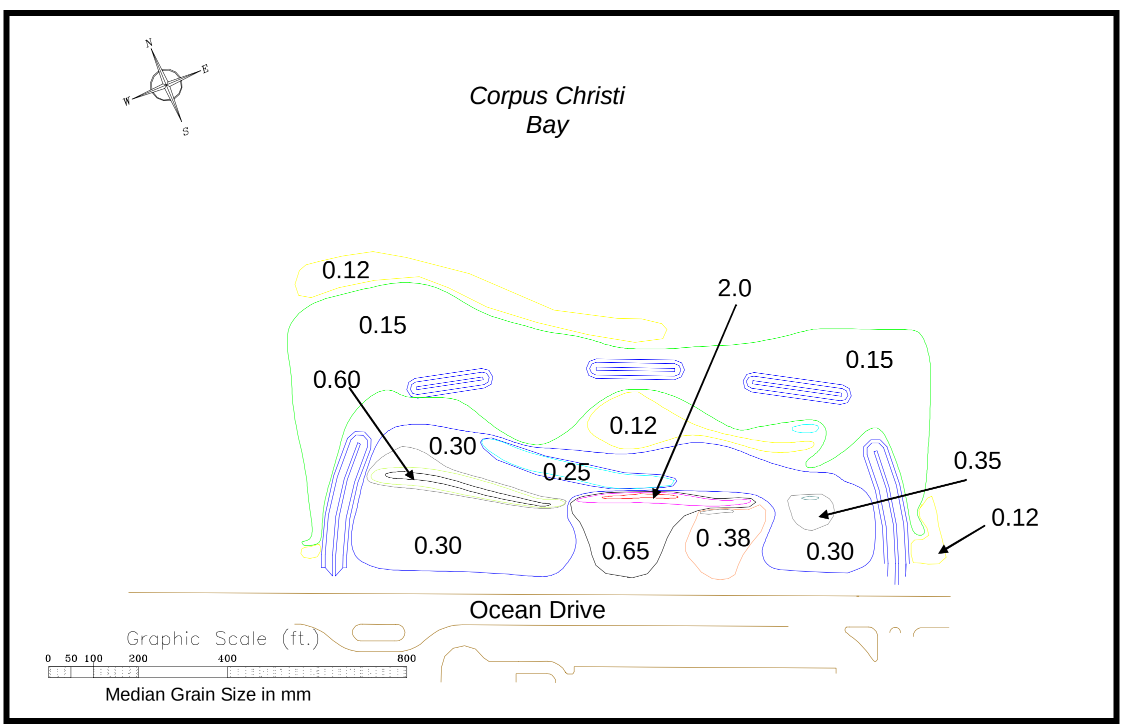

Figure 30. Average median grain size distribution (10/05/2002).

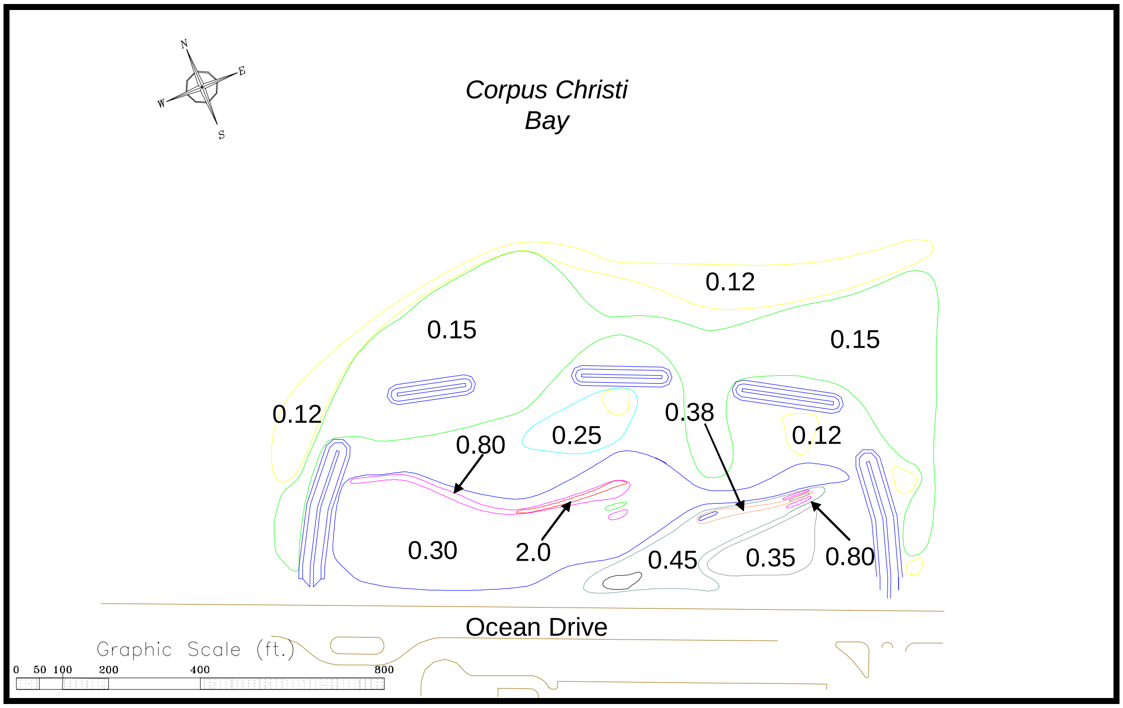

Figure 31. Average median grain size distribution (05/31/2003).

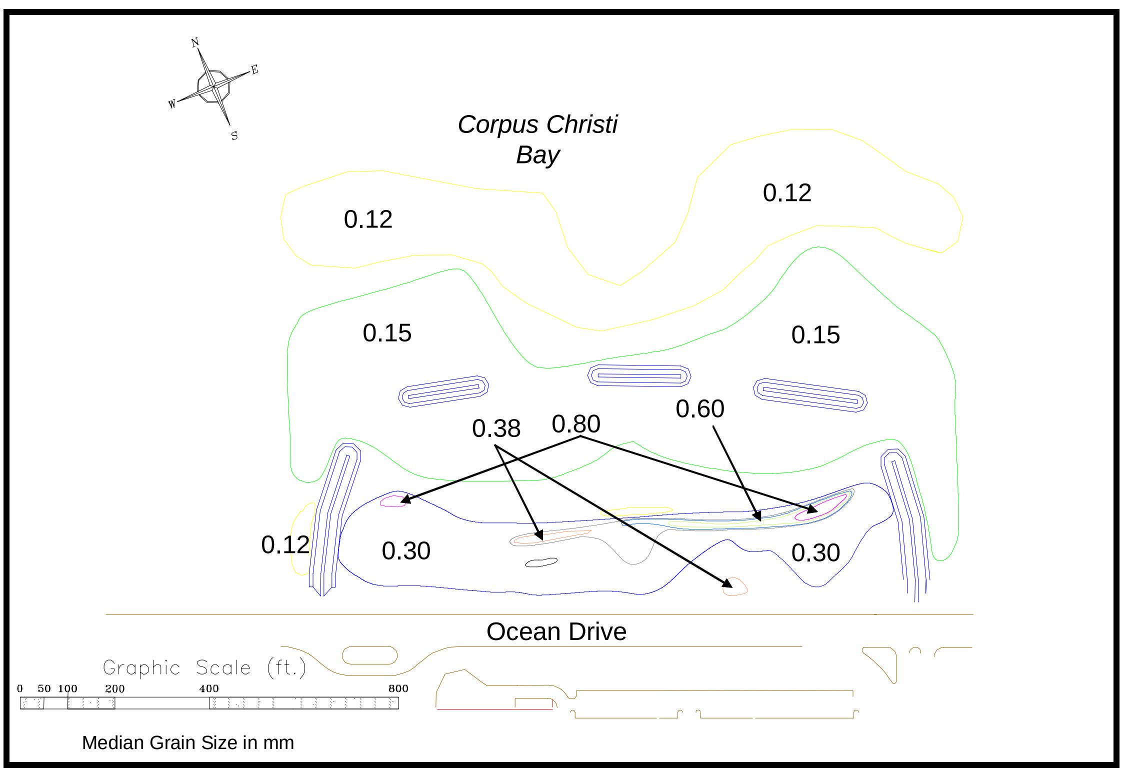

Figure 32. Average median grain size distribution (11/15/2003).

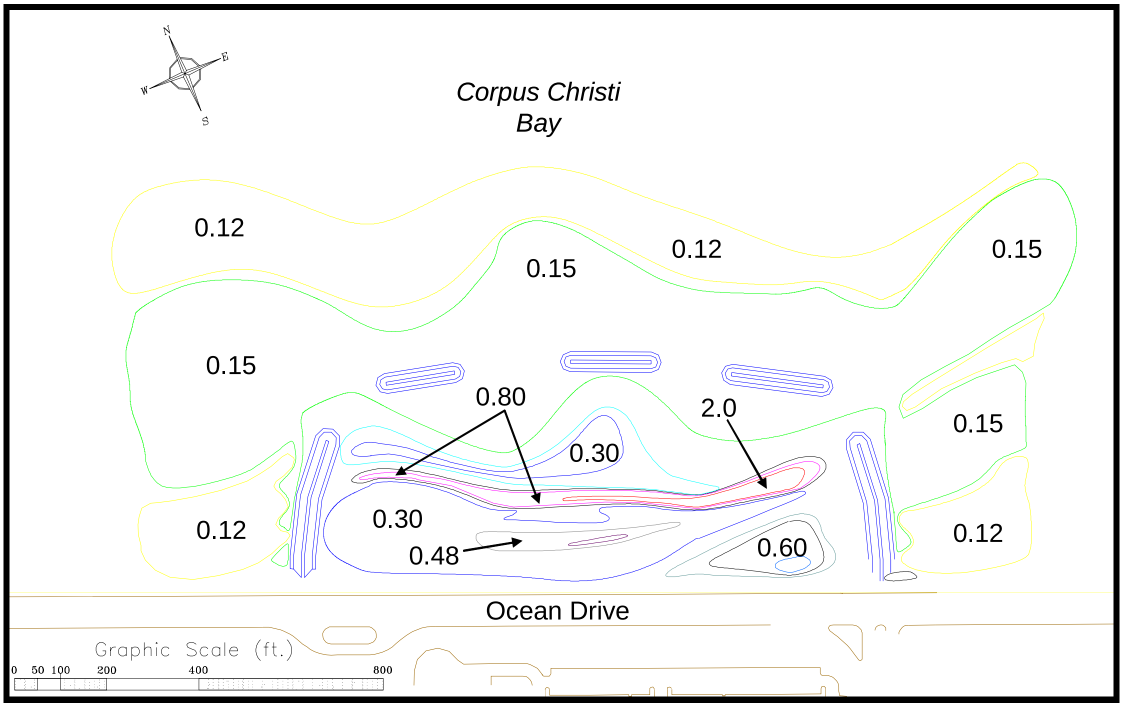

Figure 33. Average median grain size distribution (05/17/2004).

Comparison of the median grain size across the area through contour plots and statistics shows that the average median grain size for the nearshore region along Ward Island prior to beach placement was 0.15 mm (Figure 28 and Appendix B). The median grain size of the initial beach fill material ranged from 0.2 to 0.4 mm. The contour plots for all surveys (Figures 28-34) show that the median grain size for locations offshore of the detached breakwaters remained constant, ranging between 0.11 and 0.16 mm, during the study period.

Isolated occurrences of samples with larger than average (≥ 0.8 mm) median grain size were found along the beach shoreline and are attributed to selective sorting of pebbles by waves and currents (Figures 30-34). Pockets of less coarse (0.4 to 0.8 mm) material occur landward on the beach but are associated with the impact of rain, wind and settling of the fill material (Figures 30, 31, 33 and 34). These inland pockets of coarser material are attributed to selective sorting of the top layer of the sand by aeolian transport as well as due to the action of rain and pooling water.

6.3. Sediment Grain Size Distribution

Sediment distribution patterns reflect the changes that waves, currents and even wind have on selectively transporting sand within the beach and nearshore system. Sediment contour plots showing the general regions of sediment grain size can assist in determining patterns of sediment transport and aid in locating potential sand reclamation sites. Spatial changes in sediment grain size are anticipated as the beach face comes to a state of equilibrium with the coastal processes acting on the beach. Deposits of fine material are anticipated further offshore where the wave and current energy is lower. Deposits of coarser material are anticipated on the dry beach as well as in the immediate nearshore where the energy is higher. Some natural sorting of coarser pebble material along the shoreline is expected as well. The data shows that University beach also experiences changes in sediment grain size distribution, particularly on the dry beach landward of MHHW, due to natural settling of the sand after placement, sorting due to rain and runoff from the adjacent bluff, settling and sorting due to inundation by higher than average water levels. The latter caused extending pooling of water on the surface of the beach particularly on the western end, particularly during the first year.

Changes in grain size distribution are related to the transport of the sand by the forces described previously but there are also other factors impacting the grain size distribution along the subaerial region of University Beach. First, the beach from bluff to MHHW has been manually manipulated numerous times since it was placed during the summer of 2001. The beach was mechanically graded every one to three months by TAMU-CC Physical Plant dependent on need. The beach requires grading to clean both natural and anthropogenic debris and to smooth the surface after extreme rain events. Another reason for mechanical manipulation of the dry beach was that forces, particularly aeolian transport, left a coarse, crust-like surface on the beach in some areas (particularly well developed on the eastern end) during early 2002. The crust was composed of coarse material with a higher concentration of pebbles since the finer sand material had been selectively extracted. This extraction of the fine material on the surface of the beach was attributed to alternating periods of pooled water, drying, and high wind. This was considered a temporary condition but to promote more rapid deterioration of this condition the contractor manually redistributed sand within the dry beach by scraping off the crust, then mining sand from the subsurface of the beach and replacing the surface. The crusty surface layer that was removed was buried in the holes where the new surface sand was extracted. This process was completed on 06/07/2002 and 06/10/2002. No development of this type of surface has been observed since this time which may be attributable to regular grading of the beach surface and pedestrian usage.

Natural forces and mechanical manipulation have caused a varied grain size distribution to develop within the confines of the beach cell. The beach had a generally uniform composition when constructed in August 2001 but became more diverse as the beach evolved. The nearshore region outside of the beach cell has remained constant with little variation in grain size distribution. These observations indicate that the majority of the beach-fill material is being contained within the confines of the beach cell, most likely in the lee of the DBWs. This hypothesis is supported by the beach profile data.

7.0. Conclusions and Recommendations

The beach profile data and shoreline position data were analyzed concurrently to provide an overview of trends in erosion and accretion at University Beach. The data show that University Beach is a relatively stable beach with significant erosion presently occurring only in the 300 ft central region defined by transects BR3 to IR9. A small section of this area will likely require nourishment within the next 3-4 years while the remainder of the beach is not anticipated to require nourishment for 11-18 years based on minimal shoreline width requirements. Since these two hot spots are separated by a region of less critical retreat it is recommended that the entire 300 ft region from transect BR3 to IR9 is nourished. This would require the placement of a minimum of 2,500 cu yd of sand on the beach to advance the shoreline 50 ft (4.5 ft depth) and thereby maintain an advance position from the protective 50 ft minimum width recommended by the present research and previous studies (Williams 2000, Williams 2002).

The average observer notices change in the dry beach most readily and therefore reporting changes in shoreline position is meaningful. The average initial (immediately post-construction) shoreline position (MHHW) was 156.40 ft with a minimum of 147.85 in the lee of the center DBW (BR3) and a maximum of 162.72 ft in the lee of the west DBW (IR10). The average shoreline position (MHHW) for May 2004 was 142.22 ft with a minimum of 112.58 ft in the lee of the center DBW (IR8) and a maximum of 179.87 ft at the far western end of the beach (IR11). Only the central region is showing consistent shoreline retreat.

Shoreline position change measured over the 3.5 years after beach placement was compared to original model predictions of shoreline change to verify nourishment schedules. Originally a nourishment schedule of 5-10 years was predicted with a volume of 10,000 cu yd anticipated to maintain the 50 ft minimum baseline shoreline position. The observed shoreline shape agreed with the predicted shoreline shape with differences in extent of retreat and advance. The model over estimated retreat adjacent to the central beach and adjacent to the groins while overestimating shoreline advance in the lee of the DBWs. Model predictions assisted in developing the optimum configuration of coastal structures during the design process and in determining when the shoreline could retreat beyond an acceptable minimum. The data collected during the seasonal surveys assists in verifying these predictions and adjusting the nourishment schedule based on observed rates of retreat. Continuing seasonal surveys (fall and spring) is an integral component to effective and responsible management of this restored beach.

Analysis of beach profile survey data showed that the impact of the beach cell was isolated to the nearshore region nearest the groins and no observable change was identified beyond IR13 to the west and BR1 to the east. The changes along the profiles closest to the beach cell were limited to the area within 200 to 300-ft offshore of the shoreline. The data indicate that deposition in this region is due to forcing of native sediment by seasonal wind and waves with the groins acting as barriers to longshore sediment transport. This trend of accretion close to shore is anticipated to continue and will be monitored to determine if this trend initiates further away from the beach cell.

Natural forces and mechanical manipulation have caused a varied grain size distribution to develop within the confines of the beach cell. The beach had a generally uniform composition when constructed in August 2001 but became more diverse as the beach evolved. The nearshore region outside of the beach cell has remained constant with little variation in grain size distribution. These observations indicate that the majority of the beach-fill material is being contained within the confines of the beach cell, specifically in the lee of the DBWs. This hypothesis is supported by morphology identified in the beach profile data.

Two options for replacement of the sand lost from the subaerial beach are recommended, 1) purchase Nueces River quarry sand and have it transported to the site or 2) reclaim sand from within the beach cell in the lee of the western and central DBW for nourishment of hot spots on an as need basis. The data show that there is a growing resource of beach quality sand in these two areas. An expanded survey of these potential sand resources is planned for the Spring 2005. This will include additional sediment samples along IR10 and the nearshore region landward of IR9 and additional elevation data to more accurately define the extents of these areas of deposition. The survey data supports the prediction that on the order of 1,400 to 1,500 cu yd of sand are potentially encumbered in the lee of the western and central DBWs, respectively. Thus, preliminary data indicate that there is enough sand (nearly 3,000 cu yd) encumbered in the lee of the west and central DBWs to satisfy the most immediate nourishment needs anticipated within the next 3-4 years. These estimates will be confirmed by the Spring 2005 survey.

Although a cost analysis was beyond the scope of this report costs associated with initial beach fill material placement during construction indicate that the cost of reclaiming and redistributing the sand from within the nearshore to the dry beach is likely less expensive than purchasing new sand and transporting it to the site. Transportation of the sand was one of the most costly components of the original construction. Thus, the option of reclaiming sand from the nearshore for nourishment of hot spots of erosion on the dry beach is recommended to maintain the integrity of the beach and increase the nearshore water depths. An additional benefit of mining sand from within the system is that the water depths within the beach cell will be increased in regions where deposition has reduced elevations up to 1-3 ft.

The monitoring program at University Beach has provided an extensive data base for quantifying change in the subaerial and subaqueous beach and nearshore. This information will support informed management of this restored beach environment. This study recommends continuing support of this monitoring program to insure the continued success of this collaborative restoration project and to promote public awareness on coastal issues and coastal management of beach resources.

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Acknowledgments

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APPENDIX A:

Aerial Photography Taken From May 2001 to September 2004

Figure 1. Post-demolition/preconstruction aerial view taken on 05/02/2001 (Lanmon Aerial Photography, Inc.).

Figure 2. Mid-construction aerial view taken during construction of west DBW, 07/28/2001 (Lanmon Aerial Photography, Inc.).

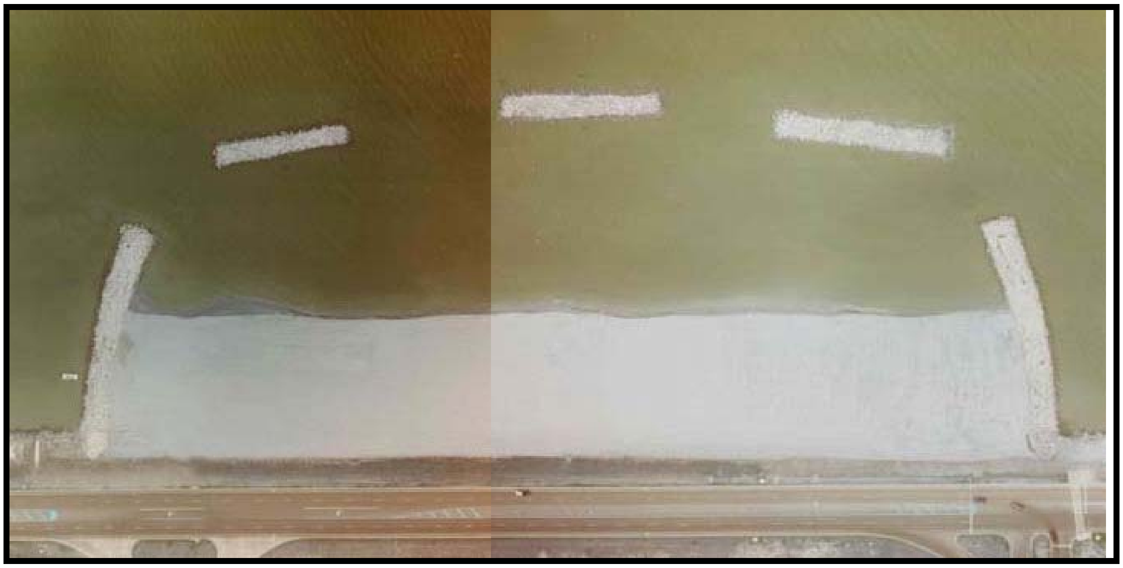

Figure 3. Post-construction aerial view of initial salient development taken on 08/26/2001 (Lanmon Aerial Photography, Inc.).

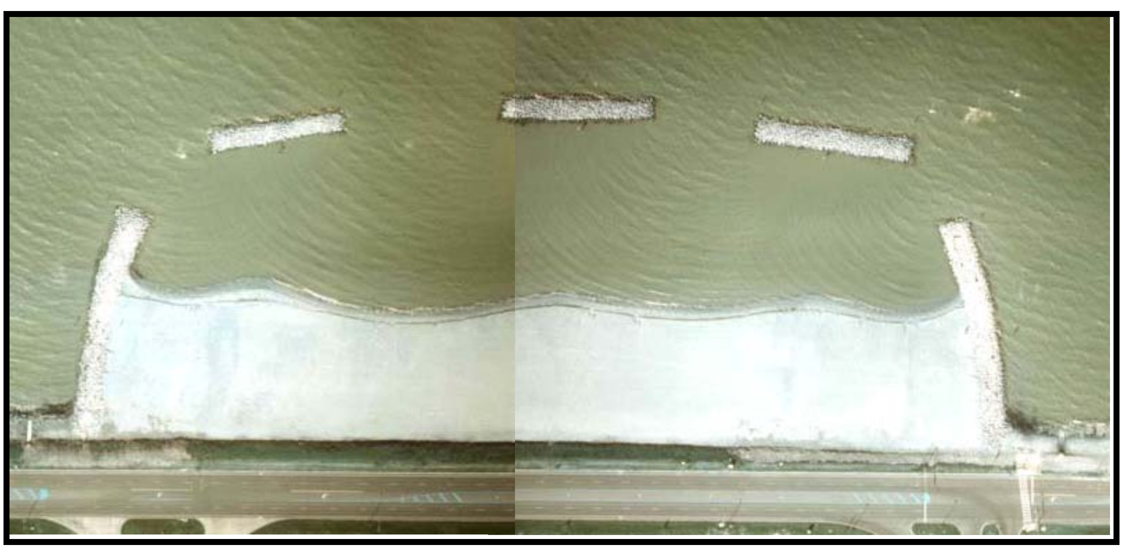

Figure 4. Aerial view showing strong salient development taken on 10/16/2001 (Lanmon Aerial Photography, Inc.).

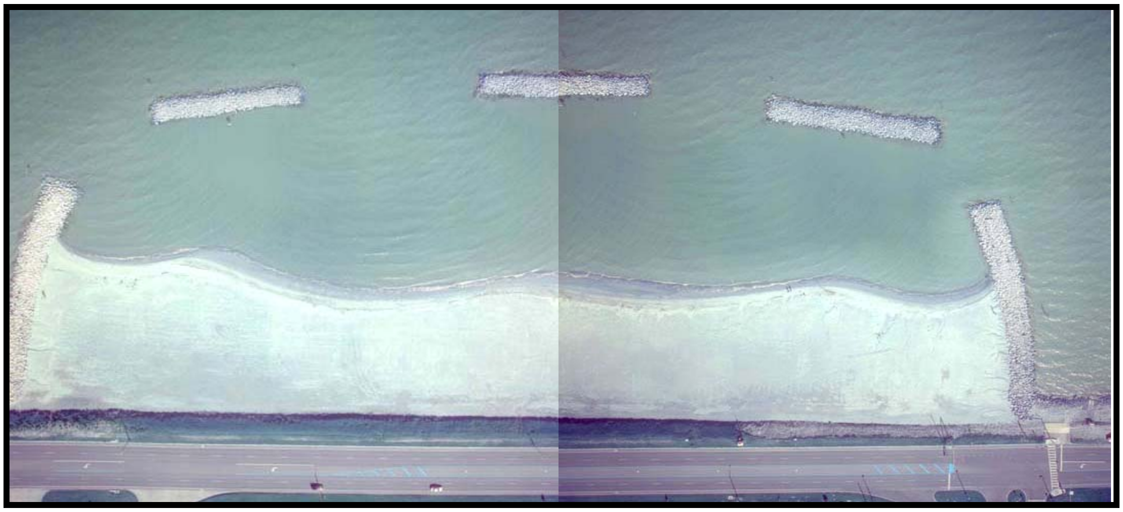

Figure 5. Aerial view showing increased accretion on west end of the beach taken on 11/24/2001 (Lanmon Aerial Photography, Inc.).

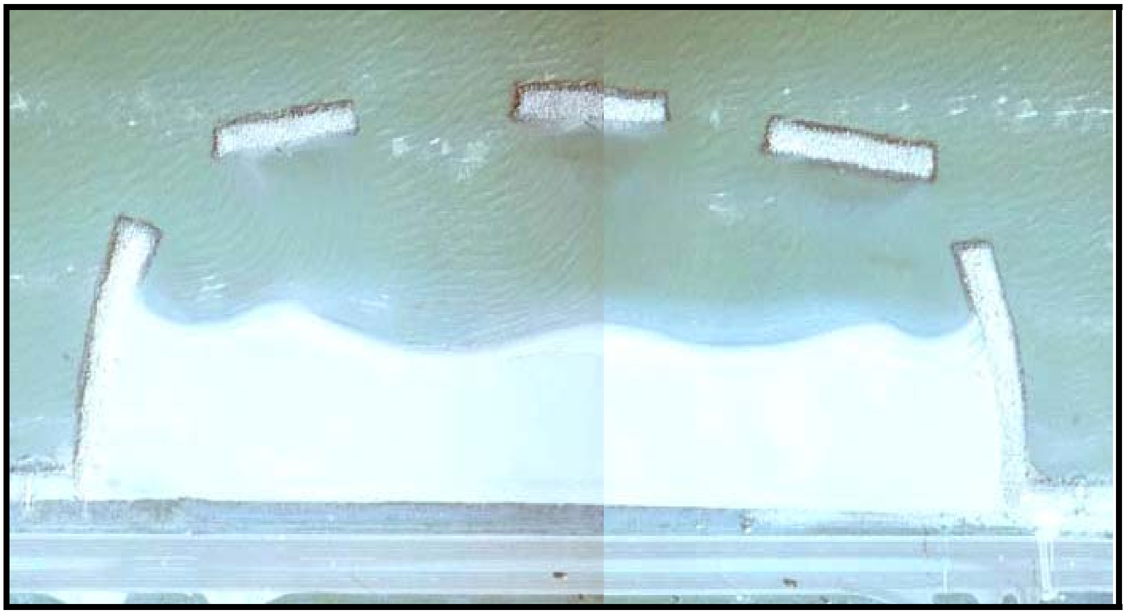

Figure 6. Aerial view showing continued salient development taken on 11/24/2001. Shadow areas in lee of DBWs are locations of enhanced deposition (Lanmon Aerial Photography, Inc.)

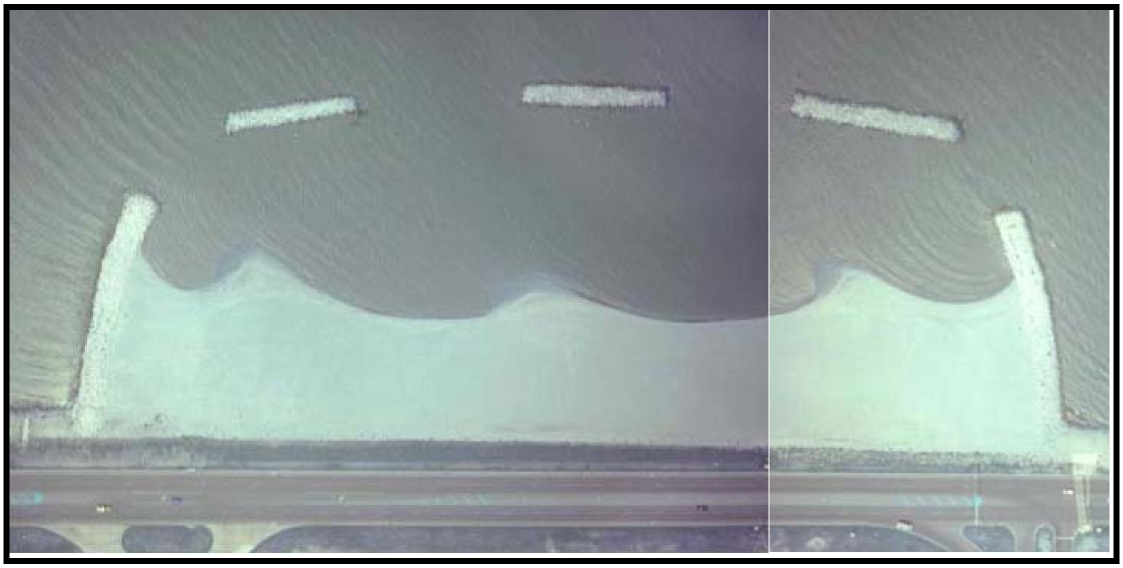

Figure 7. Aerial view showing maintained salient development and pronounced shoreline retreat west of the central DBW taken on 04/27/2002 (Lanmon Aerial Photography, Inc.)

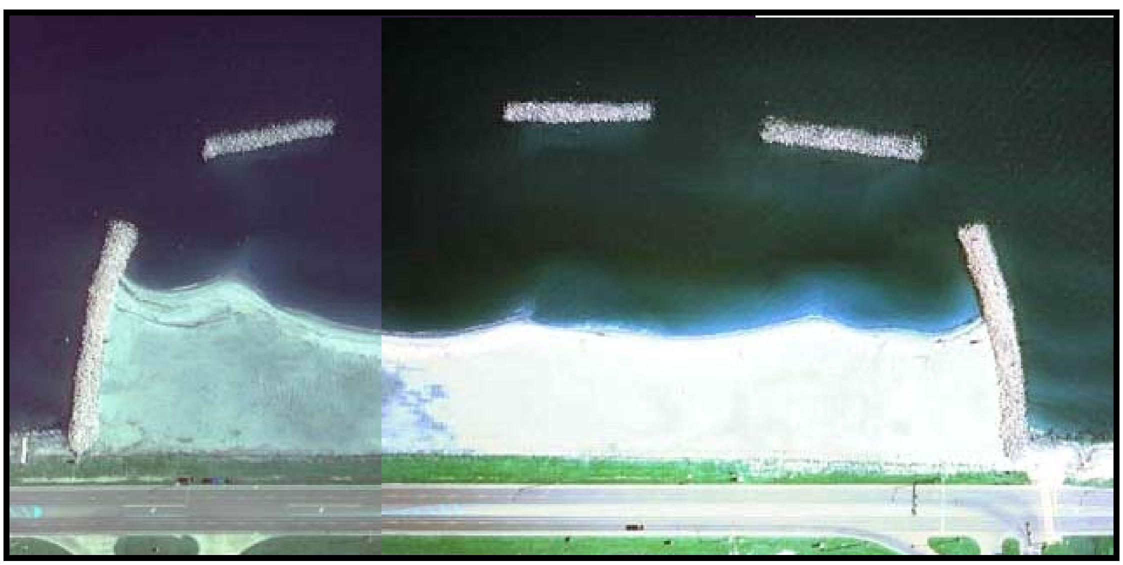

Figure 8. Aerial view showing moderation of salient development and shoreline retreat taken on 09/27/2002 (Lanmon Aerial Photography, Inc.)

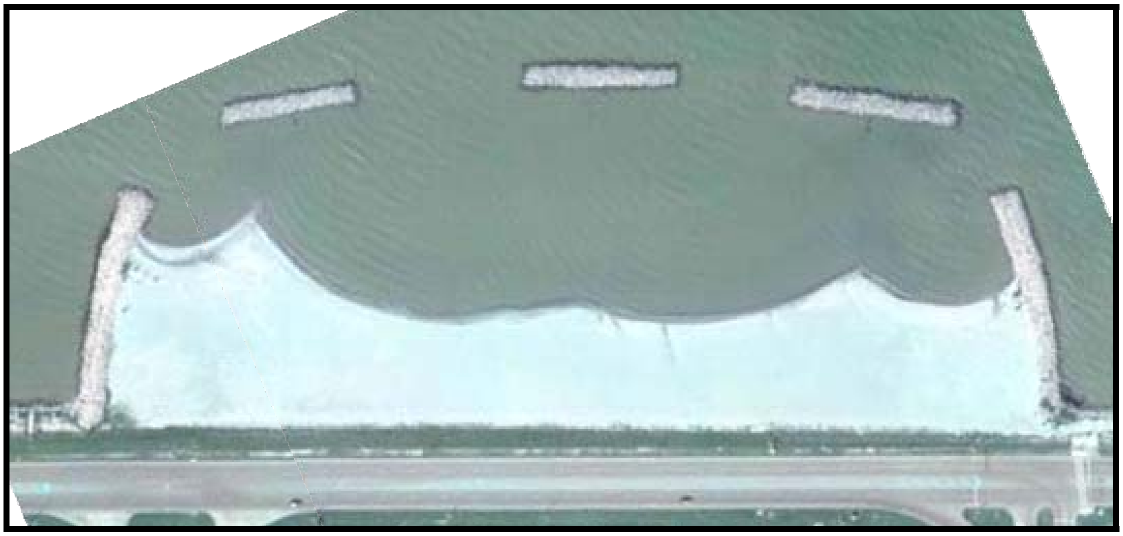

Figure 9. Aerial view showing maintained salient development on east end of beach, minimal salient development in lee of central DBW and pronounced accretion on the west end of the beach taken on 09/15/2004 (Tobin International LTD.).

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APPENDIX B:
Sediment Grain Size Statistics

The Coastal Engineering and Design System (CEDAS) software Automated Coastal Engineering System (ACES) was applied to determine statistical parameters describing grain size distribution (median, mode and inclusive graphic standard deviation). Statistical analysis followed methods described by Folk and Ward (1957), Mason and Folk (1958) and Folk (1976). Inclusive graphic standard deviation is a measure of sorting that has been applied to describe the sediments of Mustang Island (Mason and Folk, 1958) and is defined as:

$$\sigma_I = \frac{ø84 - ø16}{4} + = \frac{ø95 - ø5}{6.6};$$

Where ø = grain size (Phi)

This formula includes 90% of the distribution and is the best overall measure of sorting (Folk 1974). A classification system for sorting defined by the inclusive graphic standard deviation is given in Table A#-1.

Table A#-1. Sorting classification system for inclusive graphic standard deviation

σ_I	Classification
< 0.35	Very well sorted
0.35-0.50	Well sorted
0.50-0.71	Moderately well sorted
0.71-1.0	Moderately sorted
1.0-2.0	Poorly sorted
2.0-4.0	Very poorly sorted
> 4.0	Extremely poorly sorted

Table A2-1. Sediment Grain Size Statistics: Pre-construction Fall 2000

Date	Transect id.	Sample #	Median (mm)	Mode (mm)	IGSD
10/13/2000	BR 1	3	0.14	0.125	0.38
10/13/2000	BR 1	4	0.15	0.125	0.41
10/13/2000	BR 1	5	0.15	0.125	0.28
10/13/2000	BR 1	6	0.16	0.149	0.49
10/13/2000	BR 1	7	0.16	0.149	0.27
10/13/2000	BR 1	8	0.16	0.149	0.59
10/13/2000	BR 1	9	0.15	0.125	0.29
10/13/2000	BR 1	10	0.11	0.074	1.57
10/13/2000	BR 3	1	0.14	0.125	0.48
10/13/2000	BR 3	2	0.14	0.125	0.46
10/13/2000	BR 3	3	0.14	0.125	0.4
10/13/2000	BR 3	4	0.15	0.149	0.35
10/13/2000	BR 3	5	0.16	0.149	0.46
10/13/2000	BR 3	6	0.16	0.149	0.26
10/13/2000	BR 3	7	0.16	0.149	0.33
10/13/2000	BR 3	8	0.15	0.149	0.29
10/13/2000	BR 3	9	0.1	0.074	0.6
10/13/2000	BR 5	1	0.15	0.125	1.12
10/13/2000	BR 5	2	0.14	0.125	0.44
10/13/2000	BR 5	3	0.15	0.125	0.27
10/13/2000	BR 5	4	0.15	0.125	0.75
10/13/2000	BR 5	5	0.15	0.149	0.22
10/13/2000	BR 5	6	0.15	0.149	0.49
10/13/2000	BR 5	7	0.15	0.125	1.02
10/13/2000	BR 5	8	0.11	0.074	0.5
10/13/2000	BR 6	1	0.15	0.149	0.35
10/13/2000	BR 6	2	0.16	0.149	0.47
10/13/2000	BR 6	3	0.15	0.125	0.29
10/13/2000	BR 6	4	0.16	0.149	0.56
10/13/2000	BR 6	5	0.15	0.125	0.31
10/13/2000	BR 6	6	0.16	0.149	0.46
10/13/2000	BR 6	7	0.14	0.125	0.28
10/13/2000	BR 6	8	0.11	0.074	0.52

Table A2-2. Sediment Grain Size Statistics: Post-construction August 2001					
Date	**Transect id.**	**Sample #**	**Median (mm)**	**Mode (mm)**	**IGSD**
9/7/2001	IR 2	1	3.18	4	3.86
9/7/2001	IR 2	2	0.18	0.149	1.59
9/7/2001	IR 2	3	0.17	0.125	0.74
9/7/2001	IR 2	4	0.15	0.125	0.56
9/7/2001	IR 2	5	0.15	0.125	0.38
9/7/2001	IR 2	6	0.15	0.125	0.31
9/7/2001	IR 2	7	0.15	0.125	0.31
9/7/2001	IR 2	8	0.15	0.125	0.27
9/7/2001	IR 2	9	0.15	0.125	0.25
9/7/2001	IR 2	10	0.15	0.125	0.25
9/7/2001	IR 2	11	0.15	0.149	0.4
9/7/2001	IR 2	12	0.16	0.149	0.28
9/7/2001	IR 2	13	0.16	0.149	0.32
9/7/2001	IR 2	14	0.16	0.149	0.36
9/7/2001	IR 2	15	0.15	0.125	0.4
9/7/2001	BR 1	1	0.16	0.149	0.99
9/7/2001	BR 1	2	0.15	0.074	1.48
9/7/2001	BR 1	3	0.14	0.125	0.62
9/7/2001	BR 1	4	0.14	0.125	0.51
9/7/2001	BR 1	5	0.14	0.125	0.47
9/7/2001	BR 1	6	0.14	0.125	0.45
9/7/2001	BR 1	7	0.14	0.125	0.44
9/7/2001	BR 1	8	0.15	0.125	0.33
9/7/2001	BR 1	9	0.14	0.125	0.47
9/7/2001	BR 1	10	0.15	0.125	0.29
9/7/2001	BR 1	11	0.15	0.125	0.3
9/7/2001	BR 1	12	0.14	0.125	0.44
9/7/2001	BR 1	13	0.16	0.149	0.27
9/7/2001	BR 1	14	0.16	0.149	0.26
9/7/2001	BR 1	16	0.15	0.125	0.26
9/7/2001	BR 1	17	0.15	0.149	0.38
9/7/2001	BR 1	18	0.15	0.149	0.3
9/7/2001	IR 5	1	0.31	0.3	1.44
9/7/2001	IR 5	2	0.3	0.25	1.87
9/7/2001	IR 5	3	0.3	0.25	1.80
9/7/2001	IR 5	4	0.31	0.25	1.59
9/7/2001	IR 5	5	0.29	0.25	1.40
9/7/2001	IR 5	6	0.25	0.25	0.51
9/7/2001	IR 5	7	0.27	0.25	1.15
9/7/2001	IR 5	8	3.82	4	-0.58
9/7/2001	IR 5	9	3.25	4	-0.72
9/7/2001	IR 5	10	0.16	0.125	0.50
9/7/2001	IR 5	11	0.16	0.149	0.33
9/7/2001	IR 5	12	0.16	0.149	0.29
9/7/2001	IR 5	13	0.16	0.149	0.40
9/7/2001	IR 5	14	0.16	0.149	0.30
9/7/2001	IR 5	15	0.17	0.149	0.34
9/7/2001	IR 5	16	0.16	0.149	0.31
9/7/2001	IR 5	17	0.15	0.149	0.24
9/7/2001	IR 5	18	0.15	0.149	0.25
8/31/2001	BR 2	1	0.14	0.074	0.6

Table A2-2. Sediment Grain Size Statistics: Post-construction August 2001 (cont.)					
Date	**Transect id.**	**Sample #**	**Median (mm)**	**Mode (mm)**	**IGSD**
8/31/2001	BR 2	2	0.13	0.074	0.53
8/31/2001	BR 2	3	0.15	0.149	0.23
8/31/2001	BR 2	4	0.16	0.149	0.3
8/31/2001	BR 2	5	0.15	0.149	0.32
8/31/2001	BR 2	6	0.16	0.149	0.29
8/31/2001	BR 2	7	0.17	0.149	0.85
8/31/2001	BR 2	8	0.16	0.149	0.35
8/31/2001	BR 2	10	0.16	0.149	0.37
8/31/2001	BR 2	11	0.55	0.3	1.55
8/31/2001	BR 2	12	0.25	0.25	0.68
8/31/2001	BR 2	13	0.28	0.25	1.07
8/31/2001	BR 2	14	0.29	0.25	1.35
8/31/2001	BR 2	15	0.31	0.25	1.53
8/31/2001	BR 2	16	0.29	0.25	1.33
9/7/2001	BR 3	1	0.16	0.149	0.32
9/7/2001	BR 3	2	0.15	0.149	0.42
9/7/2001	BR 3	3	0.17	0.149	0.37
9/7/2001	BR 3	4	0.15	0.149	0.39
9/7/2001	BR 3	5	0.14	0.125	0.71
9/7/2001	BR 3	6	0.27	0.25	1.83
9/7/2001	BR 3	7	0.74	0.3	1.4
9/7/2001	BR 3	8	0.3	0.25	1.33
9/7/2001	BR 3	9	0.25	0.25	0.48
9/7/2001	BR 3	10	0.29	0.25	1.25
9/7/2001	BR 3	11	0.32	0.25	1.31
8/31/2001	BR 4	1	0.29	0.25	1.09
8/31/2001	BR 4	2	0.29	0.25	1.4
8/31/2001	BR 4	3	0.26	0.25	0.99
8/31/2001	BR 4	4	0.3	0.3	0.71
8/31/2001	BR 4	5	0.16	0.25	1.56
8/31/2001	BR 4	6	0.15	0.149	0.25
8/31/2001	BR 4	7	0.15	0.149	0.36
8/31/2001	BR 4	8	0.15	0.149	0.28
8/31/2001	BR 4	9	0.16	0.149	0.27
8/31/2001	BR 4	10	0.16	0.149	0.27
8/31/2001	BR 4	11	0.16	0.149	0.31
8/31/2001	BR 4	12	0.16	0.149	0.27
8/31/2001	BR 4	13	0.16	0.149	0.25
8/31/2001	BR 4	14	0.15	0.125	0.29
8/31/2001	BR 4	15	0.15	0.125	0.33
8/31/2001	BR 4	16	0.14	0.125	0.41
8/31/2001	BR 5	1	0.14	0.125	0.44
8/31/2001	BR 5	2	0.15	0.125	0.36
8/31/2001	BR 5	3	0.15	0.149	0.3
8/31/2001	BR 5	4	0.15	0.125	0.36
8/31/2001	BR 5	5	0.16	0.149	0.28
8/31/2001	BR 5	6	0.17	0.149	0.36
8/31/2001	BR 5	7	0.17	0.149	0.38
8/31/2001	BR 5	8	0.16	0.149	0.41
8/31/2001	BR 5	9	0.15	0.149	0.71
8/31/2001	BR 5	10	0.17	0.149	0.49

Table A2-2. Sediment Grain Size Statistics: Post-construction August 2001 (cont.)					
Date	**Transect id.**	**Sample #**	**Median (mm)**	**Mode (mm)**	**IGSD**
8/31/2001	BR 5	11	0.29	0.25	1.26
8/31/2001	BR 5	12	0.26	0.25	0.54
8/31/2001	BR 5	13	0.23	0.25	1.14
8/31/2001	BR 5	14	0.26	0.25	1.51
8/31/2001	BR 5	15	0.26	0.25	1.37
9/7/2001	IR 12	1	0.29	4	3.69
9/7/2001	IR 12	2	0.14	0.125	0.72
9/7/2001	IR 12	3	0.13	0.125	0.84
9/7/2001	IR 12	4	0.13	0.074	0.98
9/7/2001	IR 12	5	0.15	0.125	1.3
9/7/2001	IR 12	6	0.3	4	1.95
9/7/2001	IR 12	7	0.15	0.125	1.39
9/7/2001	IR 12	8	0.15	0.125	1.26
9/7/2001	IR 12	9	0.16	0.149	0.37
9/7/2001	IR 12	10	0.15	0.149	0.52
9/7/2001	IR 12	11	0.15	0.149	0.51
9/7/2001	IR 12	12	0.16	0.149	0.33
9/7/2001	IR 12	13	0.16	0.149	0.32
9/7/2001	IR 12	14	0.17	0.149	0.36
9/7/2001	IR 12	15	0.15	0.125	0.4
9/7/2001	IR 12	16	0.15	0.149	0.39
9/7/2001	IR 12	17	0.15	0.149	0.22
9/7/2001	BR 6	1	0.16	0.074	3.18
9/7/2001	BR 6	2	0.14	0.125	0.67
9/7/2001	BR 6	3	0.14	0.125	0.37
9/7/2001	BR 6	4	0.14	0.125	0.41
9/7/2001	BR 6	5	0.14	0.125	0.48
9/7/2001	BR 6	6	0.14	0.125	0.49
9/7/2001	BR 6	7	0.15	0.125	0.37
9/7/2001	BR 6	8	0.16	0.149	0.31
9/7/2001	BR 6	9	0.15	0.149	0.38
9/7/2001	BR 6	10	0.15	0.149	0.37
9/7/2001	BR 6	11	0.16	0.149	0.33
9/7/2001	BR 6	12	0.16	0.149	0.29
9/7/2001	BR 6	13	0.16	0.149	0.32
9/7/2001	BR 6	14	0.15	0.149	0.29
9/7/2001	BR 6	15	0.15	0.125	0.28

Table A2-3. Sediment Grain Size Statistics: Spring 2002					
Date	**Transect id.**	**Sample #**	**Median (mm)**	**Mode (mm)**	**IGSD**
5/30/2002	BR 1	1	0.12	0.074	0.46
5/30/2002	BR 1	2	0.16	0.125	0.32
5/30/2002	BR 1	3	0.16	0.149	0.41
5/30/2002	BR 1	4	0.15	0.149	0.47
5/30/2002	BR 1	5	0.14	0.125	0.29
5/30/2002	BR 1	6a	0.15	0.149	0.23
5/30/2002	BR 1	6b	0.16	0.149	0.31
5/30/2002	BR 1	7	0.15	0.125	0.28
5/30/2002	BR 1	8	0.16	0.149	0.32
5/30/2002	BR 1	9	0.18	0.177	0.37
5/30/2002	BR 1	10	0.16	0.149	0.29
5/30/2002	IR 5	1	0.16	0.149	0.25
5/30/2002	IR 5	2	0.16	0.149	0.29
5/30/2002	IR 5	3	NA	NA	NA
5/30/2002	IR 5	4	0.17	0.149	0.73
5/30/2002	IR 5	5	0.41	4	2.31
5/30/2002	IR 5	6	0.16	0.149	0.82
5/30/2002	IR 5	7	0.16	0.149	0.39
5/30/2002	IR 5	8	0.15	0.125	0.23
5/30/2002	IR 5	9	0.14	0.125	0.69
5/30/2002	IR 5	10	0.13	0.074	0.82
5/30/2002	IR 5	11	0.23	0.125	1.38
5/30/2002	IR 5	12	1.03	0.3	2.06
5/30/2002	IR 5	13	0.15	0.125	0.24
5/30/2002	IR 5	14	0.34	0.3	0.76
5/30/2002	IR 5	15	0.29	0.25	0.51
5/30/2002	IR 5	16	0.29	0.25	1.93
5/30/2002	IR 5	17	0.35	0.25	2.01
5/30/2002	IR 5	18	0.3	0.25	1.8
5/30/2002	IR 5	19	0.3	0.25	1.6
5/30/2002	IR 5	20	0.29	0.25	1.51
5/30/2002	BR 2	1	0.15	0.125	0.28
5/30/2002	BR 2	2	0.33	0.3	0.32
5/30/2002	BR 2	3	0.16	0.149	0.32
5/30/2002	BR 2	4	0.16	0.149	0.32
5/30/2002	BR 2	5	0.21	0.177	0.66
5/30/2002	BR 2	6	0.17	0.149	0.36
5/30/2002	BR 2	7	0.27	4	2.38
5/30/2002	BR 2	8	0.17	0.149	0.53
5/30/2002	BR 2	9	0.26	0.25	0.47
5/30/2002	BR 2	10	0.31	0.3	0.67
5/30/2002	BR 2	11	1.13	4	2.09
5/30/2002	BR 2	12	0.58	0.3	1.78
5/30/2002	BR 2	13	2.4	4	1.95
5/30/2002	BR 2	14	0.31	0.3	0.53
5/30/2002	BR 2	15	0.28	0.25	1.62
5/30/2002	BR 2	16	0.34	0.25	1.41
5/30/2002	BR 2	17	0.33	0.25	1.81
5/30/2002	BR 2	18	0.36	0.3	1.59
5/30/2002	BR 2	19	0.3	0.25	1.7
5/30/2002	BR 2	20	0.33	0.3	0.82

Table A2-3. Sediment Grain Size Statistics: Spring 2002 (cont.)					
Date	**Transect id.**	**Sample #**	**Median (mm)**	**Mode (mm)**	**IGSD**
5/30/2002	BR 3	1	0.14	0.125	0.29
5/30/2002	BR 3	2	0.16	0.149	0.32
5/30/2002	BR 3	3	0.16	0.149	0.35
5/30/2002	BR 3	4	0.16	0.149	0.54
5/30/2002	BR 3	5	0.15	0.125	0.31
5/30/2002	BR 3	6	0.16	0.149	0.4
5/30/2002	BR 3	7	0.17	0.149	0.38
5/30/2002	BR 3	8	0.17	0.149	0.47
5/30/2002	BR 3	9	0.18	0.177	0.74
5/30/2002	BR 3	10	5.75	4	2.7
5/30/2002	BR 3	11	0.15	0.125	1.49
5/30/2002	BR 3	12	0.13	0.074	1.54
5/30/2002	BR 3	13	0.14	0.125	1.25
5/30/2002	BR 3	14	0.16	0.149	0.59
5/30/2002	BR 3	15	0.33	0.3	0.83
5/30/2002	BR 3	16	0.28	0.25	0.58
5/30/2002	BR 3	17	0.83	4	2.15
5/30/2002	BR 3	18	0.86	4	2.34
5/30/2002	BR 3	19	0.33	0.25	1.45
5/30/2002	BR 3	20	0.7	4	1.93
5/30/2002	BR 3	21	0.36	0.3	1.01
5/30/2002	BR 3	22	0.28	0.25	1.59
5/30/2002	BR 3	23	0.28	0.25	1.19
5/30/2002	BR 3	24	0.33	0.25	1.87
5/30/2002	BR 3	25	0.34	0.25	1.96
5/30/2002	BR 3	26	0.31	0.25	1.62
5/30/2002	BR 3	27	0.34	0.3	0.87
5/30/2002	BR 4	1	0.16	0.149	0.32
5/30/2002	BR 4	2	0.16	0.125	0.39
5/30/2002	BR 4	3	0.16	0.149	0.32
5/30/2002	BR 4	4	0.16	0.149	0.34
5/30/2002	BR 4	5	0.17	0.149	0.33
5/30/2002	BR 4	6	0.18	0.149	0.36
5/30/2002	BR 4	7	0.16	0.149	0.3
5/30/2002	BR 4	8	0.16	0.149	0.37
5/30/2002	BR 4	9	0.19	0.149	1.19
5/30/2002	BR 4	10	0.16	0.149	0.35
5/30/2002	BR 4	11	0.13	0.074	0.88
5/30/2002	BR 4	12	0.29	0.25	1.32
5/30/2002	BR 4	13	1	4	2.2
5/30/2002	BR 4	14	0.29	0.25	1.6
5/30/2002	BR 4	15	1.8	4	2.17
5/30/2002	BR 4	16	0.57	0.3	1.31
5/30/2002	BR 4	17	0.39	0.3	0.93
5/30/2002	BR 4	18	0.31	0.25	1.19
5/30/2002	BR 4	19	0.29	0.25	1.33
5/30/2002	BR 4	20	1.16	4	2.29
5/30/2002	BR 4	21	0.32	0.25	2.07
5/30/2002	BR 4	22	0.29	0.25	1.32
5/30/2002	BR 4	23	0.3	0.3	0.86

Table A2-3. Sediment Grain Size Statistics: Spring 2002 (cont.)					
Date	Transect id.	Sample #	Median (mm)	Mode (mm)	IGSD
5/30/2002	BR 5	1	0.15	0.149	0.24
5/30/2002	BR 5	2	0.15	0.125	0.33
5/30/2002	BR 5	3	0.16	0.149	0.28
5/30/2002	BR 5	4	0.26	4	2.41
5/30/2002	BR 5	5	0.17	0.149	2.35
5/30/2002	BR 5	6	0.17	0.149	0.38
5/30/2002	BR 5	7	0.17	0.149	0.94
5/30/2002	BR 5	8	0.16	0.149	0.85
5/30/2002	BR 5	9	0.28	0.25	0.61
5/30/2002	BR 5	10	0.36	0.3	2.03
5/30/2002	BR 5	11	0.72	0.5	1.35
5/30/2002	BR 5	12	0.43	0.3	0.63
5/30/2002	BR 5	13	0.41	0.3	0.69
5/30/2002	BR 5	14	0.31	0.3	0.48
5/30/2002	BR 5	15	0.27	0.25	1.55
5/30/2002	BR 5	16	0.24	0.25	1.69
5/30/2002	BR 5	17	0.38	4	2.33
5/30/2002	BR 5	18	0.26	0.25	1.7
5/30/2002	BR 5	19	0.26	0.25	0.99

Table A2-4. Sediment Grain Size Statistics: Fall 2002					
Date	**Transect id.**	**Sample #**	**Median (mm)**	**Mode (mm)**	**IGSD**
10/5/2002	BR 1	1	0.11	0.074	0.45
10/5/2002	BR 1	2	0.13	0.074	0.42
10/5/2002	BR 1	3	0.14	0.125	0.4
10/5/2002	BR 1	4	0.13	0.125	0.44
10/5/2002	BR 1	5	0.15	0.125	0.29
10/5/2002	BR 1	6	0.15	0.149	0.23
10/5/2002	BR 1	7	0.16	0.149	0.28
10/5/2002	BR 1	8	0.15	0.125	0.28
10/5/2002	BR 1	9	0.16	0.149	0.31
10/5/2002	BR 1	10	0.16	0.149	0.29
10/5/2002	BR 1	11	0.16	0.149	0.25
10/5/2002	BR 1	12	0.15	0.149	0.22
10/5/2002	IR 5	2	0.32	0.250	1.56
10/5/2002	IR 5	3	0.29	0.250	0.69
10/5/2002	IR 5	4	0.41	0.149	1.5
10/5/2002	IR 5	5	0.29	4.000	1.61
10/5/2002	IR 5	6	0.26	0.250	0.59
10/5/2002	IR 5	7	0.15	0.149	0.76
10/5/2002	IR 5	8	0.11	0.074	0.51
10/5/2002	IR 5	9	0.25	0.177	1.19
10/5/2002	IR 5	10	0.15	0.149	0.35
10/5/2002	IR 5	11	0.14	0.149	0.73
10/5/2002	IR 5	12	0.17	0.149	0.3
10/5/2002	IR 5	13	0.16	0.149	0.29
10/5/2002	IR 5	14	0.16	0.149	0.29
10/5/2002	IR 5	15	0.16	0.149	0.31
10/5/2002	BR 2	0	0.39	0.5	0.77
10/5/2002	BR 2	1	0.39	0.25	1.71
10/5/2002	BR 2	2	0.31	0.3	0.36
10/5/2002	BR 2	3	0.37	0.5	0.73
10/5/2002	BR 2	4	0.7	0.5	0.65
10/5/2002	BR 2	5	1.03	0.5	1.3
10/5/2002	BR 2	6	0.3	0.25	0.92
10/5/2002	BR 2	7	0.35	0.3	0.54
10/5/2002	BR 2	8	NA	NA	NA
10/5/2002	BR 2	9	NA	NA	NA
10/5/2002	BR 2	10	NA	NA	NA
10/5/2002	BR 2	11	NA	NA	NA
10/5/2002	BR 2	12	NA	NA	NA
10/5/2002	BR 2	13	NA	NA	NA
10/5/2002	BR 2	14	NA	NA	NA
10/5/2002	BR 3	0	0.63	0.5	0.83
10/5/2002	BR 3	1	0.67	0.5	0.46
10/5/2002	BR 3	2	0.85	0.5	1.54
10/5/2002	BR 3	3	6.53	4	0.96
10/5/2002	BR 3	4	0.25	0.25	0.71
10/5/2002	BR 3	5	0.26	0.25	0.57
10/5/2002	BR 3	6	0.14	0.0625	0.95
10/5/2002	BR 3	7	0.1	0.074	0.59
10/5/2002	BR 3	8	0.13	0.125	0.67
10/5/2002	BR 3	9	0.12	0.125	0.73

Table A2-4. Sediment Grain Size Statistics: Fall 2002 (cont.)					
Date	**Transect id.**	**Sample #**	**Median (mm)**	**Mode (mm)**	**IGSD**
10/5/2002	BR 3	10	0.16	0.149	0.3
10/5/2002	BR 3	11	0.14	0.125	0.3
10/5/2002	BR 3	12	0.15	0.125	0.23
10/5/2002	BR 3	13	0.15	0.125	0.22
10/5/2002	BR 3	14	0.14	0.125	0.25
10/5/2002	BR 3	15	0.14	0.125	0.28
10/5/2002	BR 4	1	0.28	0.25	0.88
10/5/2002	BR 4	2	0.3	0.25	1.59
10/5/2002	BR 4	3	0.29	0.25	0.38
10/5/2002	BR 4	4	0.64	0.5	0.93
10/5/2002	BR 4	5	0.52	0.5	1.49
10/5/2002	BR 4	6	0.33	0.3	0.64
10/5/2002	BR 4	7	0.21	0.25	0.53
10/5/2002	BR 4	8	0.15	0.125	0.27
10/5/2002	BR 4	9	0.16	0.149	0.27
10/5/2002	BR 4	10	0.16	0.149	0.3
10/5/2002	BR 4	11	0.16	0.149	0.29
10/5/2002	BR 4	12	0.15	0.125	0.26
10/5/2002	BR 4	13	NA	NA	NA
10/5/2002	BR 4	14	NA	NA	NA
10/5/2002	BR 4	15	NA	NA	NA
10/5/2002	BR 4	16	0.15	0.125	0.41
10/5/2002	BR 5	1	0.26	0.25	1.18
10/5/2002	BR 5	2	0.3	0.25	2.12
10/5/2002	BR 5	3	0.29	0.25	1.58
10/5/2002	BR 5	4	0.39	0.3	0.6
10/5/2002	BR 5	5	0.55	0.5	0.64
10/5/2002	BR 5	6	0.63	0.5	1.21
10/5/2002	BR 5	7	0.56	0.5	0.73
10/5/2002	BR 5	8	0.33	0.3	0.58
10/5/2002	BR 5	9	0.3	0.3	0.56
10/5/2002	BR 5	10	0.15	0.125	0.29
10/5/2002	BR 5	11	0.15	0.125	0.3
10/5/2002	BR 5	12	0.14	0.125	0.23
10/5/2002	BR 5	13	0.15	0.125	0.23
10/5/2002	BR 5	14	0.15	0.125	0.28
10/5/2002	BR 5	15	0.14	0.125	0.27
10/5/2002	IR 12	1	0.11	0.074	0.5
10/5/2002	IR 12	2	0.15	0.125	0.33
10/5/2002	IR 12	3	0.15	0.125	0.35
10/5/2002	IR 12	4	0.16	0.149	0.3
10/5/2002	IR 12	5	0.14	0.125	0.73
10/5/2002	IR 12	6	0.14	0.125	0.25
10/5/2002	IR 12	7	0.15	0.125	0.32
10/5/2002	IR 12	8	0.15	0.125	0.33
10/5/2002	IR 12	9	0.14	0.125	0.33
10/5/2002	IR 12	15	0.15	0.125	0.26

Table A2-5. Sediment Grain Size Statistics: Spring 2003					
Date	**Transect id.**	**Sample #**	**Median (mm)**	**Mode (mm)**	**IGSD**
5/31/2003	BR 1	1	0.12	0.074	0.42
5/31/2003	BR 1	2	0.15	0.125	0.55
5/31/2003	BR 1	3	0.15	0.125	0.5
5/31/2003	BR 1	4	0.15	0.125	0.35
5/31/2003	BR 1	5	0.14	0.125	0.38
5/31/2003	BR 1	6	0.15	0.125	0.25
5/31/2003	BR 1	7	0.16	0.149	0.34
5/31/2003	BR 1	8	0.15	0.125	0.23
5/31/2003	BR 1	9	0.14	0.125	0.25
5/31/2003	BR 1	10	0.16	0.149	0.29
5/31/2003	BR 1	11	0.16	0.149	0.3
5/31/2003	BR 1	12	0.16	0.149	0.28
5/31/2003	BR 1	13	0.16	0.149	0.36
5/31/2003	BR 1	14	0.14	0.125	0.26
5/31/2003	BR 1	15	0.13	0.125	0.48
5/31/2003	IR 5	1	0.32	0.3	0.83
5/31/2003	IR 5	2	0.33	0.25	2.13
5/31/2003	IR 5	3	0.78	0.5	0.95
5/31/2003	IR 5	4	0.36	0.3	0.65
5/31/2003	IR 5	5	0.31	0.3	0.35
5/31/2003	IR 5	6	0.77	0.5	1.28
5/31/2003	IR 5	7	0.29	0.25	2.07
5/31/2003	IR 5	8	0.27	0.25	0.58
5/31/2003	IR 5	9	0.14	0.074	1.3
5/31/2003	IR 5	10	0.13	0.125	0.8
5/31/2003	IR 5	11	0.14	0.125	0.34
5/31/2003	IR 5	12	0.15	0.125	1.62
5/31/2003	IR 5	13	0.16	0.149	0.36
5/31/2003	IR 5	14	0.17	0.149	0.57
5/31/2003	IR 5	15	0.18	0.177	0.33
5/31/2003	IR 5	16	0.15	0.125	0.42
5/31/2003	BR 2	1	0.45	0.50	0.74
5/31/2003	BR 2	2	0.33	0.25	1.51
5/31/2003	BR 2	3	0.40	0.30	0.64
5/31/2003	BR 2	4	NA	NA	NA
5/31/2003	BR 2	5	0.30	0.30	0.58
5/31/2003	BR 2	6	0.48	4.00	2.28
5/31/2003	BR 2	7	0.26	0.25	0.53
5/31/2003	BR 2	8	0.18	0.15	0.46
5/31/2003	BR 2	9	0.15	0.15	0.88
5/31/2003	BR 2	10	0.16	0.15	0.45
5/31/2003	BR 2	11	0.17	0.15	0.30
5/31/2003	BR 2	12	0.16	0.13	0.37
5/31/2003	BR 2	13	NA	NA	NA
5/31/2003	BR 2	14	0.16	0.15	0.27
5/31/2003	BR 2	15	0.14	0.13	0.26
5/31/2003	BR 3	1	0.49	0.5	0.82
5/31/2003	BR 3	2	0.3	0.25	1.64
5/31/2003	BR 3	3	1	1	0.84
5/31/2003	BR 3	4	0.15	0.125	0.58
5/31/2003	BR 3	5	0.28	0.25	0.45

Table A2-5. Sediment Grain Size Statistics: Spring 2003 (cont.)					
Date	**Transect id.**	**Sample #**	**Median (mm)**	**Mode (mm)**	**IGSD**
5/31/2003	BR 3	6	0.3	0.25	0.56
5/31/2003	BR 3	7	1.11	1	1.3
5/31/2003	BR 3	8	1.12	0.5	1.3
5/31/2003	BR 3	9	5.77	4	1.63
5/31/2003	BR 3	10	0.24	0.25	0.89
5/31/2003	BR 3	11	0.28	0.25	0.53
5/31/2003	BR 3	12	0.21	0.25	0.45
5/31/2003	BR 3	13	0.13	0.074	0.8
5/31/2003	BR 3	14	NA	NA	NA
5/31/2003	BR 3	15	0.16	0.149	0.34
5/31/2003	BR 3	16	0.16	0.149	0.29
5/31/2003	BR 3	17	0.16	0.149	0.28
5/31/2003	BR 4	1	0.3	0.3	0.86
5/31/2003	BR 4	2	0.28	0.25	1.52
5/31/2003	BR 4	3	0.3	0.25	1.39
5/31/2003	BR 4	4	NA	NA	NA
5/31/2003	BR 4	5	0.53	0.5	1.11
5/31/2003	BR 4	6	NA	NA	NA
5/31/2003	BR 4	7	2.03	4	2.08
5/31/2003	BR 4	8	5.84	4	1.99
5/31/2003	BR 4	9	0.29	0.3	0.66
5/31/2003	BR 4	10	NA	NA	NA
5/31/2003	BR 4	11	0.23	0.3	1.33
5/31/2003	BR 4	12	0.16	0.149	0.28
5/31/2003	BR 4	13	0.17	0.177	0.3
5/31/2003	BR 4	14	0.16	0.149	0.34
5/31/2003	BR 4	15	0.16	0.125	0.35
5/31/2003	BR 4	16	0.16	0.149	0.22
5/31/2003	BR 4	17	0.13	0.125	0.58
5/31/2003	BR 5	1	0.14	0.125	0.38
5/31/2003	BR 5	2	0.17	0.149	0.27
5/31/2003	BR 5	3	0.17	0.125	1.49
5/31/2003	BR 5	4	0.15	0.125	0.7
5/31/2003	BR 5	5	NA	NA	NA
5/31/2003	BR 5	6	0.15	0.149	0.56
5/31/2003	BR 5	7	0.27	0.25	1.1
5/31/2003	BR 5	8	0.79	0.5	1.48
5/31/2003	BR 5	9	1.75	4	2.12
5/31/2003	BR 5	10	0.97	0.5	1.8
5/31/2003	BR 5	11	0.28	0.25	0.64
5/31/2003	BR 5	12	0.27	0.25	0.52
5/31/2003	BR 5	13	0.28	0.25	0.39
5/31/2003	BR 5	14	0.31	0.3	0.84
5/31/2003	BR 5	15	0.42	0.3	1.35
5/31/2003	BR 5	16	0.48	0.5	1.17
5/31/2003	BR 5	17	0.26	0.25	0.77
5/31/2003	IR 12	1	0.14	0.125	0.28
5/31/2003	IR 12	2	0.15	0.149	0.23
5/31/2003	IR 12	3	NA	NA	NA
5/31/2003	IR 12	4	0.15	0.125	0.45
5/31/2003	IR 12	5	0.15	0.125	0.25

Table A2-5. Sediment Grain Size Statistics: Spring 2003 (cont.)					
Date	**Transect id.**	**Sample #**	**Median (mm)**	**Mode (mm)**	**IGSD**
5/31/2003	IR 12	6	0.14	0.0372	1.08
5/31/2003	IR 12	7	0.15	0.125	0.28
5/31/2003	IR 12	8	0.16	0.149	0.37
5/31/2003	IR 12	9	0.14	0.125	0.36
5/31/2003	IR 12	10	0.16	0.149	0.38
5/31/2003	IR 12	11	0.15	0.125	1.68
5/31/2003	IR 12	12	0.13	0.125	0.45
5/31/2003	IR 12	13	0.14	0.125	1.78
5/31/2003	IR 12	14	0.11	0.074	0.63
5/31/2003	IR 12	15	0.54	0.125	2.44
5/31/2003	IR 12	16	NA	NA	NA
5/31/2003	IR 12	17	0.23	0.149	1.93
5/31/2003	IR 12	18	NA	NA	NA

Table A2-6. Sediment Grain Size Statistics: Fall 2003					
Date	**Transect id.**	**Sample #**	**Median (mm)**	**Mode (mm)**	**IGSD**
11/14/2003	BR1	1	0.14	0.125	1.58
11/14/2003	BR1	2	NA	NA	NA
11/14/2003	BR1	3	NA	NA	NA
11/14/2003	BR1	4	NA	NA	NA
11/14/2003	BR1	5	NA	NA	NA
11/14/2003	BR1	6	NA	NA	NA
11/14/2003	BR1	7	NA	NA	NA
11/14/2003	BR1	8	0.14	0.125	0.48
11/14/2003	BR1	9	0.15	0.149	0.54
11/14/2003	BR1	10	0.15	0.125	0.39
11/14/2003	BR1	11	0.15	0.125	0.28
11/14/2003	BR1	12	0.15	0.125	0.25
11/14/2003	BR1	13	0.14	0.125	0.19
11/14/2003	BR1	14	0.13	0.125	0.54
11/14/2003	BR1	15	0.10	0.063	0.63
11/14/2003	IR5	1	0.33	0.300	0.80
11/14/2003	IR5	2	0.29	0.250	1.34
11/14/2003	IR5	3	0.29	0.250	0.60
11/14/2003	IR5	4	1.03	1.000	1.39
11/14/2003	IR5	5	1.16	4.000	1.03
11/14/2003	IR5	6	0.95	4.000	0.08
11/14/2003	IR5	7	0.20	0.250	0.46
11/14/2003	IR5	8	0.08	0.063	0.78
11/14/2003	IR5	9	0.14	0.125	0.54
11/14/2003	IR5	10	0.15	0.125	0.33
11/14/2003	IR5	11	0.14	0.125	1.22
11/14/2003	IR5	12	0.17	0.149	0.35
11/14/2003	IR5	13	0.15	0.125	0.26
11/14/2003	IR5	14	0.13	0.125	0.53
11/14/2003	BR2	1	0.40	0.500	0.74
11/14/2003	BR2	2	0.27	0.250	0.78
11/14/2003	BR2	3	0.25	0.250	0.53
11/14/2003	BR2	4	0.60	0.500	1.40
11/14/2003	BR2	5	0.36	0.250	1.63
11/14/2003	BR2	6	0.29	4.000	2.48
11/14/2003	BR2	7	0.22	0.250	0.47
11/14/2003	BR2	8	0.16	0.149	0.49
11/14/2003	BR2	9a	0.18	0.125	1.26
11/14/2003	BR2	9b	0.16	0.149	0.49
11/14/2003	BR2	10	0.15	0.149	0.23
11/14/2003	BR2	11	0.17	0.149	0.51
11/14/2003	BR2	12	0.18	0.149	0.50
11/14/2003	BR2	13	0.15	0.125	0.24
11/14/2003	BR2	14	0.14	0.125	0.44
11/14/2003	BR2	15	0.13	0.063	1.56
11/14/2003	BR3	1	0.30	0.250	0.88
11/14/2003	BR3	2	0.32	0.250	1.34
11/14/2003	BR3	3	0.30	0.250	1.60
11/14/2003	BR3	4	0.28	0.250	0.47
11/14/2003	BR3	5	0.35	0.250	0.80
11/14/2003	BR3	6	0.52	0.500	1.62

Table A2-6. Sediment Grain Size Statistics: Fall 2003 (cont.)					
Date	**Transect id.**	**Sample #**	**Median (mm)**	**Mode (mm)**	**IGSD**
11/14/2003	BR3	7	0.14	0.125	0.97
11/14/2003	BR3	8	0.13	0.125	0.79
11/14/2003	BR3	9	0.17	0.149	0.33
11/14/2003	BR3	10	0.14	0.125	0.38
11/14/2003	BR3	11	0.07	0.063	0.68
11/14/2003	BR3	12	NA	NA	NA
11/14/2003	BR4	1	NA	NA	NA
11/14/2003	BR4	2	NA	NA	NA
11/14/2003	BR4	3	NA	NA	NA
11/14/2003	BR4	4	NA	NA	NA
11/14/2003	BR4	5	0.31	0.500	0.88
11/14/2003	BR4	6	0.47	0.250	1.90
11/14/2003	BR4	7	0.36	0.300	1.55
11/14/2003	BR4	8	0.29	0.250	0.76
11/14/2003	BR4	9	NA	NA	NA
11/14/2003	BR4	10	0.16	0.125	1.07
11/14/2003	BR4	11	0.17	0.125	0.75
11/14/2003	BR4	12	0.15	0.125	0.29
11/14/2003	BR4	13	0.15	0.149	0.46
11/14/2003	BR4	14	0.14	0.125	0.46
11/14/2003	BR4	15	0.07	0.063	0.58
11/14/2003	BR5	1	NA	NA	NA
11/14/2003	BR5	2	0.29	0.250	0.35
11/14/2003	BR5	3	0.73	0.500	0.76
11/14/2003	BR5	4	1.52	1.000	1.13
11/14/2003	BR5	5	0.30	0.300	0.69
11/14/2003	BR5	6	0.15	0.125	0.41
11/14/2003	BR5	7	0.15	0.125	0.60
11/14/2003	BR5	8	0.15	0.125	0.46
11/14/2003	BR5	9	0.13	0.125	0.42
11/14/2003	BR5	10	0.12	0.063	0.67
11/14/2003	BR5	11	0.12	0.125	0.72
11/14/2003	IR12	1	NA	NA	NA
11/14/2003	IR12	2	NA	NA	NA
11/14/2003	IR12	3	NA	NA	NA
11/14/2003	IR12	4	NA	NA	NA
11/14/2003	IR12	5	NA	NA	NA
11/14/2003	IR12	6	NA	NA	NA
11/14/2003	IR12	7	NA	NA	NA
11/14/2003	IR12	8	NA	NA	NA
11/14/2003	IR12	9	0.08	0.053	0.68
11/14/2003	IR12	10	0.13	0.125	0.55
11/14/2003	IR12	11	NA	NA	NA
11/14/2003	IR12	12	0.15	0.125	0.32
11/14/2003	IR12	13	0.16	0.149	0.30
11/14/2003	IR12	14	0.15	0.125	0.54
11/14/2003	IR12	15	0.15	0.125	0.29

Table A2-7. Sediment Grain Size Statistics: Spring 2004					
Date	**Transect id.**	**Sample #**	**Median (mm)**	**Mode (mm)**	**IGSD**
05/18/2004	IR 2	1	0.14	0.125	0.38
05/18/2004	IR 2	2	0.14	0.125	0.40
05/18/2004	IR 2	3	0.14	0.125	0.41
05/18/2004	IR 2	4	0.14	0.125	0.37
05/18/2004	IR 2	5	0.14	0.125	0.25
05/18/2004	IR 2	6	0.15	0.125	0.36
05/18/2004	IR 2	7	0.14	0.125	0.22
05/18/2004	IR 2	8	0.16	0.149	0.29
05/18/2004	IR 2	9	0.12	0.074	0.52
05/18/2004	IR 2	1	0.14	0.125	0.38
05/18/2004	BR 1	3	0.49	0.50	2.06
05/18/2004	BR 1	4	0.13	0.125	0.39
05/18/2004	BR 1	5	0.15	0.125	0.42
05/18/2004	BR 1	6	0.14	0.125	0.30
05/18/2004	BR 1	7	0.15	0.125	0.24
05/18/2004	BR 1	8	0.15	0.125	0.24
05/18/2004	BR 1	9	0.14	0.125	0.25
05/18/2004	BR 1	10	0.16	0.149	0.27
05/18/2004	BR 1	11	0.15	0.125	0.21
05/18/2004	BR 1	12	0.14	0.125	0.29
05/18/2004	IR 5	1	0.51	0.50	0.71
05/18/2004	IR 5	2	0.46	4.00	2.16
05/18/2004	IR 5	3	0.29	0.25	0.47
05/18/2004	IR 5	4	0.62	0.50	0.68
05/18/2004	IR 5	5	2.08	1.19	1.22
05/18/2004	IR 5	6	1.43	0.50	1.62
05/18/2004	IR 5	7	6.82	4.00	1.51
05/18/2004	IR 5	8	0.14	0.125	0.35
05/18/2004	IR 5	9	0.15	0.125	0.33
05/18/2004	IR 5	10	0.16	0.149	0.27
05/18/2004	IR 5	11	0.15	0.125	0.25
05/18/2004	IR 5	12	0.11	0.074	0.47
05/18/2004	BR 2	1	0.41	0.30	0.64
05/18/2004	BR 2	2	0.29	0.25	1.72
05/18/2004	BR 2	3	0.27	0.25	0.47
05/18/2004	BR 2	4	1.01	0.50	1.27
05/18/2004	BR 2	5	0.82	0.50	0.96
05/18/2004	BR 2	6	3.05	4.00	1.50
05/18/2004	BR 2	7	0.21	0.125	2.38
05/18/2004	BR 2	8	0.14	0.125	0.81
05/18/2004	BR 2	9	0.15	0.125	0.56
05/18/2004	BR 2	10	0.15	0.125	0.39
05/18/2004	BR 2	11	0.16	0.149	0.28
05/18/2004	BR 2	12	0.14	0.125	0.26
05/18/2004	BR 3	1	0.34	0.30	0.60
05/18/2004	BR 3	2	0.63	4.00	1.93
05/18/2004	BR 3	3	0.28	0.25	0.57
05/18/2004	BR 3	4	0.26	0.25	0.51
05/18/2004	BR 3	5	1.48	1.19	1.46
05/18/2004	BR 3	6	7.19	4.00	1.19
05/18/2004	BR 3	7	0.26	0.25	0.63

Table A2-7. Sediment Grain Size Statistics: Spring 2004 (cont.)					
Date	**Transect id.**	**Sample #**	**Median (mm)**	**Mode (mm)**	**IGSD**
05/18/2004	BR 3	8	0.13	0.125	0.75
05/18/2004	BR 3	9	0.16	0.149	0.29
05/18/2004	BR 3	10	0.15	0.125	0.29
05/18/2004	BR 3	11	0.10	0.074	0.43
05/18/2004	BR 4	1	0.28	0.25	0.84
05/18/2004	BR 4	2	0.33	0.25	1.57
05/18/2004	BR 4	3	0.27	0.25	0.57
05/18/2004	BR 4	4	0.26	0.25	0.51
05/18/2004	BR 4	5	1.14	1.00	1.02
05/18/2004	BR 4	6	0.22	0.177	0.43
05/18/2004	BR 4	7	0.14	0.125	0.39
05/18/2004	BR 4	8	0.15	0.125	0.27
05/18/2004	BR 4	9	0.15	0.125	0.36
05/18/2004	BR 4	10	0.15	0.125	0.21
05/18/2004	BR 4	11	0.14	0.125	0.35
05/18/2004	BR 4	12	0.14	0.125	0.27
05/18/2004	BR 5	1	0.26	0.25	0.81
05/18/2004	BR 5	2	0.28	0.25	1.48
05/18/2004	BR 5	3	0.29	0.25	0.37
05/18/2004	BR 5	4	0.83	0.50	0.56
05/18/2004	BR 5	5	0.89	0.50	0.97
05/18/2004	BR 5	6	0.46	0.50	0.73
05/18/2004	BR 5	7	0.29	0.25	0.45
05/18/2004	BR 5	8	0.24	0.25	0.58
05/18/2004	BR 5	9	0.14	0.125	0.81
05/18/2004	BR 5	10	0.15	0.125	1.10
05/18/2004	IR 12	1	0.15	0.125	0.28
05/18/2004	IR 12	2	0.13	0.125	0.59
05/18/2004	IR 12	3	0.15	0.125	1.41
05/18/2004	IR 12	4	0.14	0.125	0.24
05/18/2004	IR 12	5	0.16	0.125	0.51
05/18/2004	IR 12	6	0.14	0.125	0.30
05/18/2004	IR 12	7	0.15	0.149	0.23
05/18/2004	IR 12	8	0.14	0.125	0.34
05/18/2004	IR 12	9	0.15	0.125	0.22
05/18/2004	IR 12	10	0.11	0.125	0.59
05/18/2004	IR 12	12	0.99	0.50	1.90
05/18/2004	BR 6	1	0.13	0.074	0.41
05/18/2004	BR 6	2	0.14	0.125	0.40
05/18/2004	BR 6	3	0.14	0.125	0.36
05/18/2004	BR 6	4	0.15	0.125	0.31
05/18/2004	BR 6	5	0.15	0.125	0.24
05/18/2004	BR 6	6	0.15	0.125	0.24
05/18/2004	BR 6	7	0.13	0.074	0.54
05/18/2004	BR 6	8	0.14	0.36	0.38

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Appendix C:

Historic Overlay of Beach Profile Survey Plots

Note: Fall 2000 data available for BR6, BR5, BR3 and BR1 only.
Note: The first post-construction survey was conducted on two dates (08/31/2001 and 09/07/2001) due to electrical storms halting the survey. Several profiles were selected for replicate surveys to ensure that changes in morphology were minimal between survey dates.

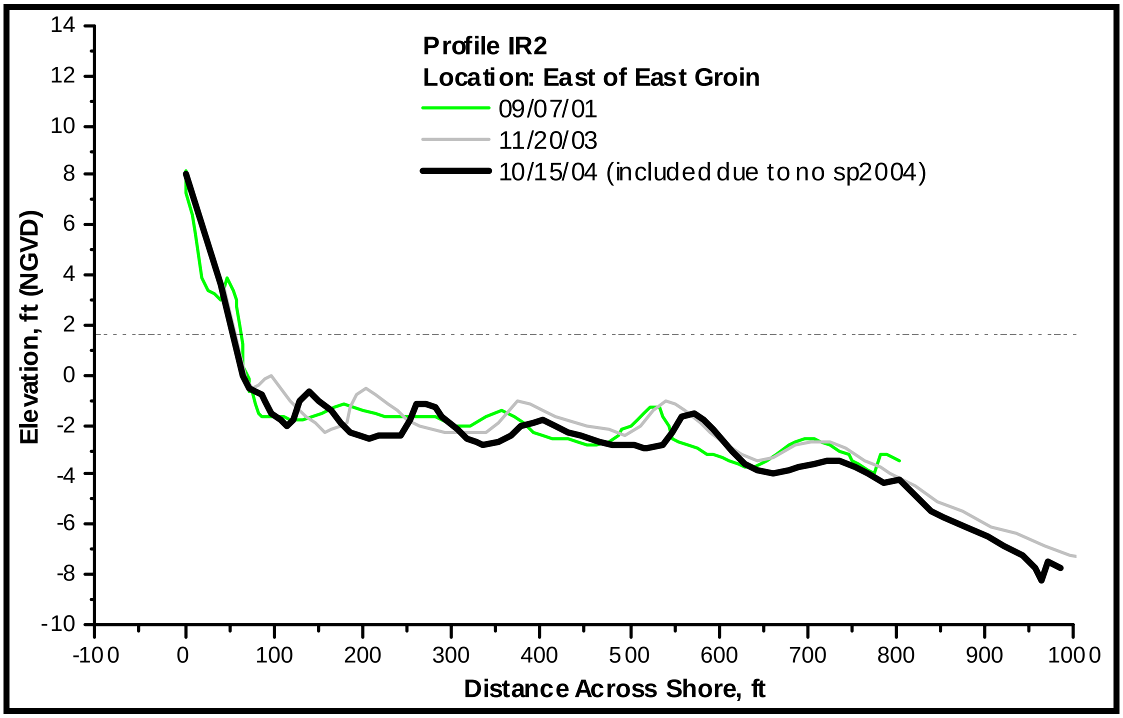

Figure 1. Profile IR2 located east of the east groin.

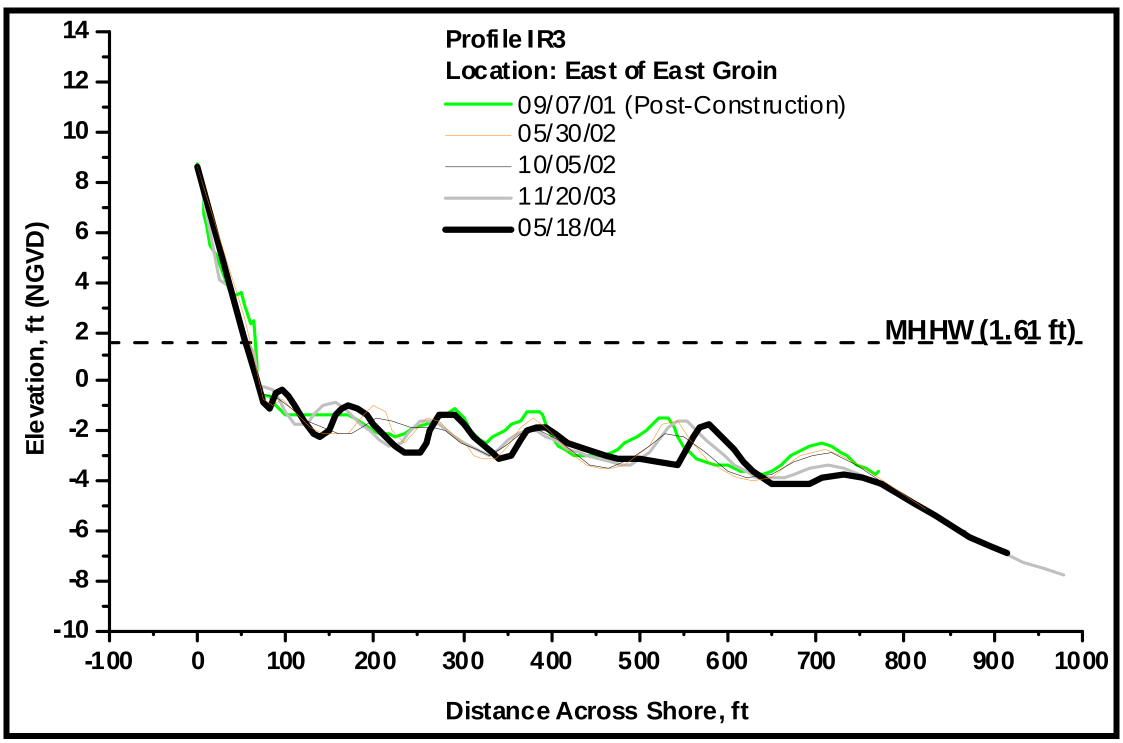

Figure 2. Profile IR3 located east of the east groin.

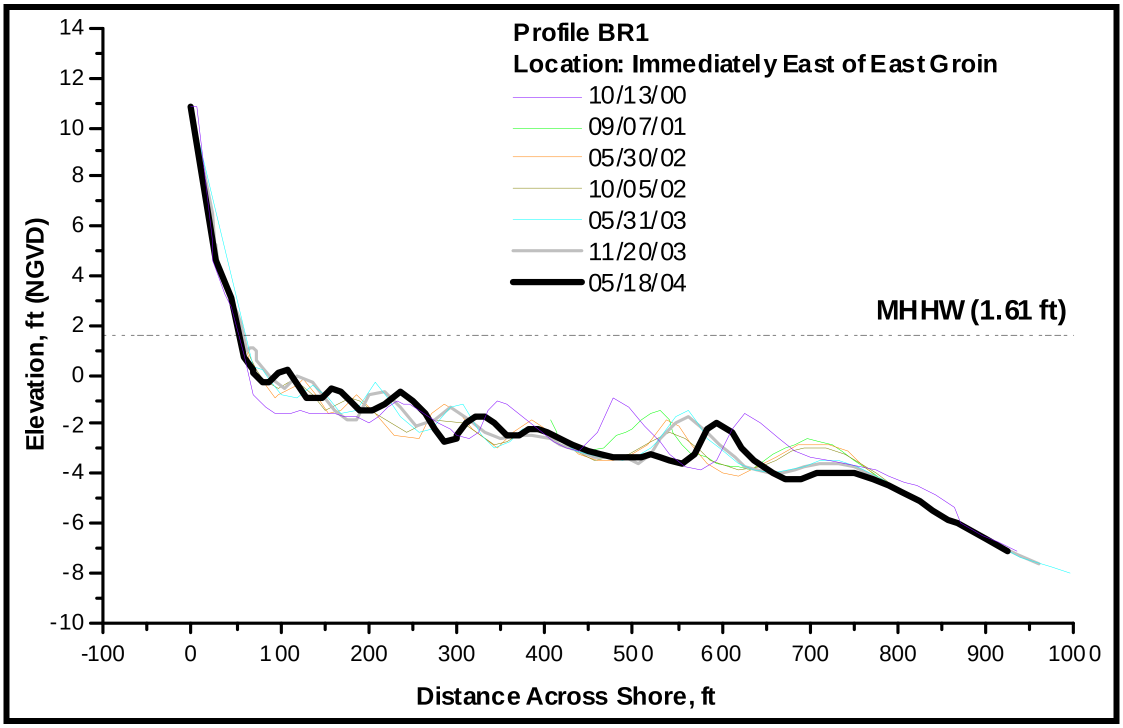

Figure 3. Profile BR1 located immediately east of the east groin.

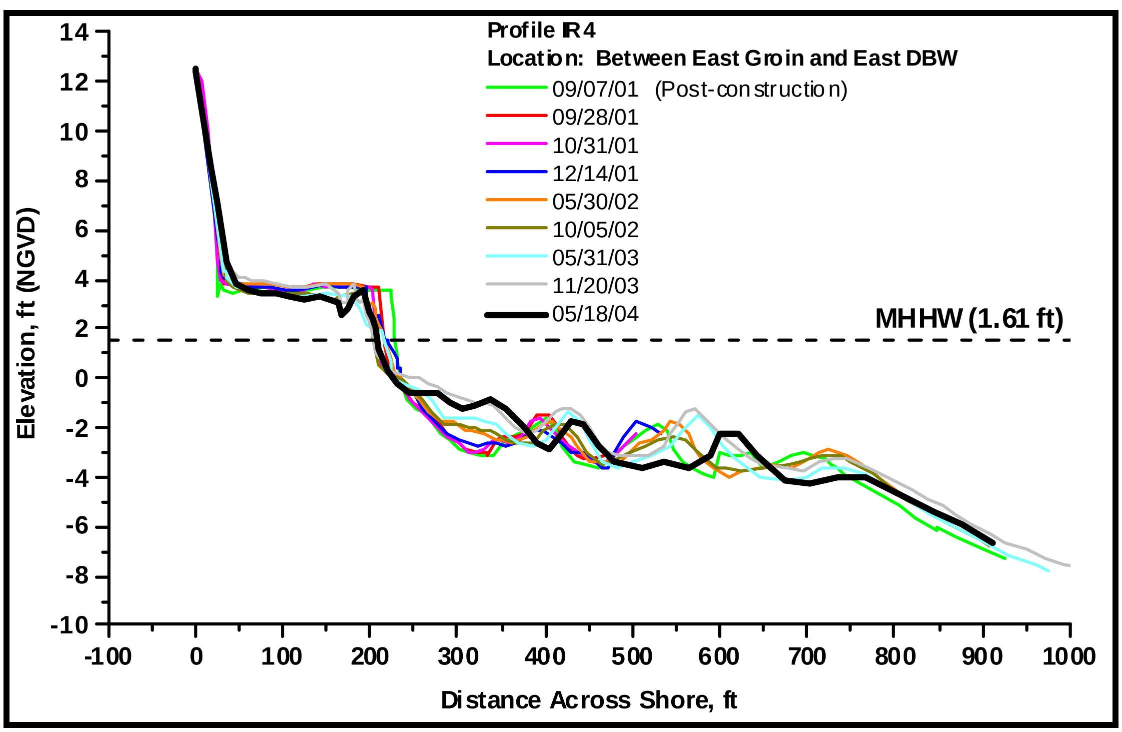

Figure 4. Profile IR4 located between the east groin and east DBW.

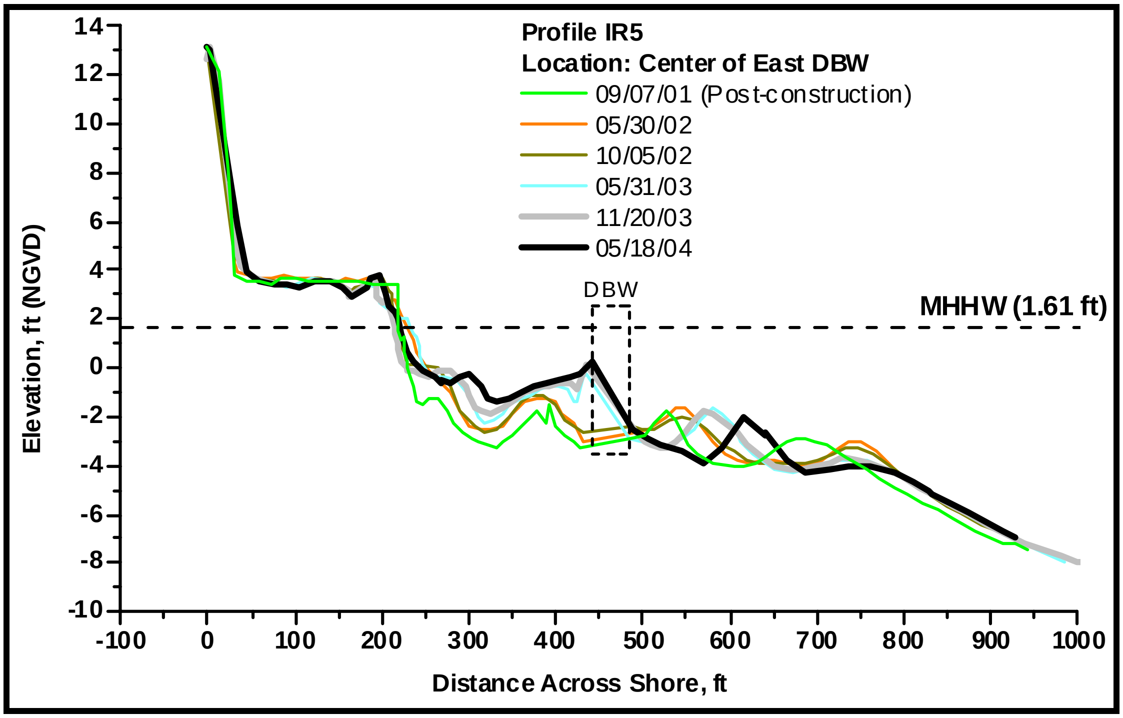

Figure 5. Profile IR5 located in the center of the east DBW.

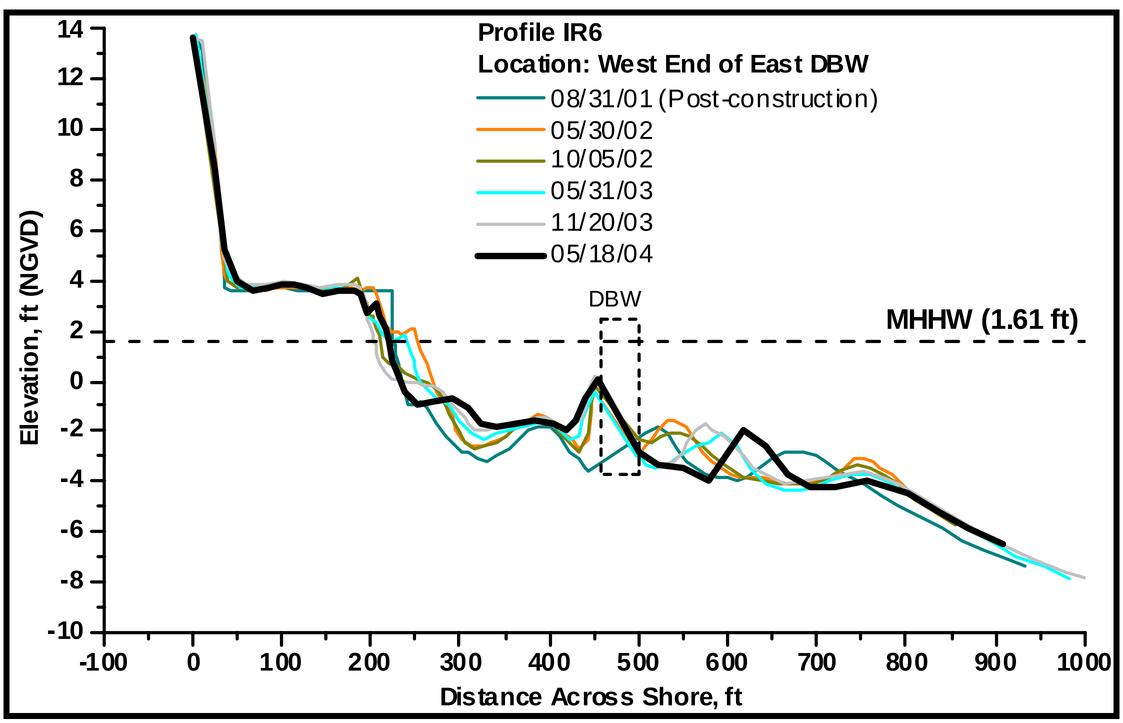

Figure 6. Profile IR6 located at the west end of the east DBW.

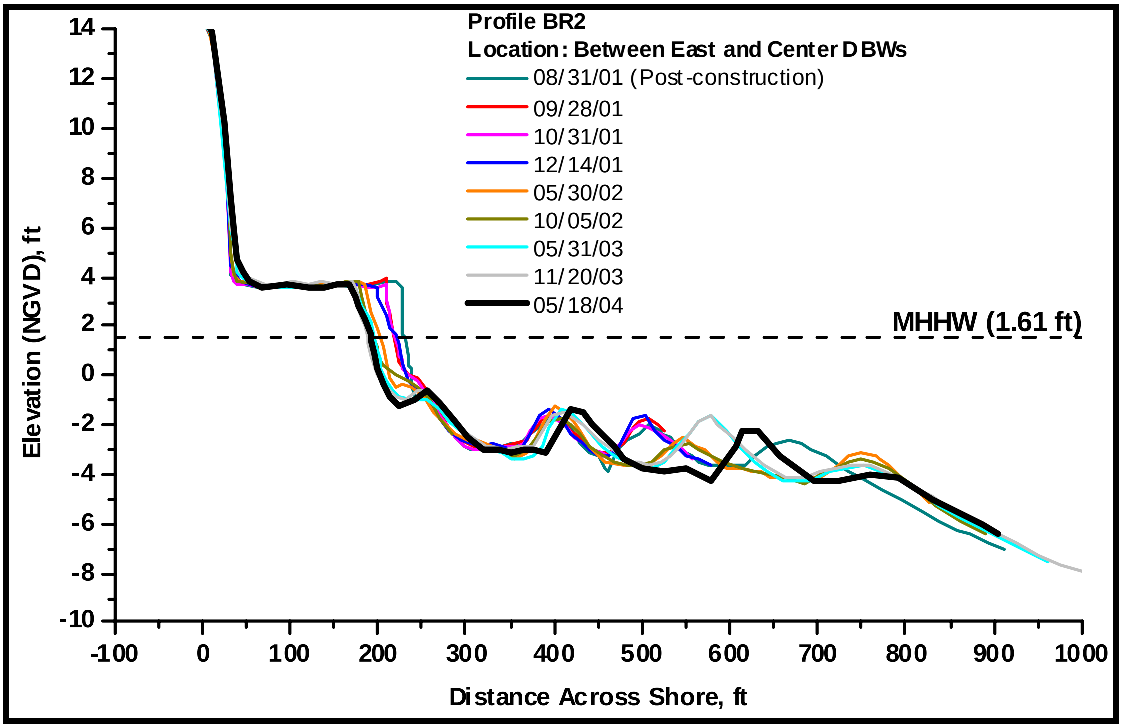

Figure 7. Profile BR2 located between the east and center DBWs.

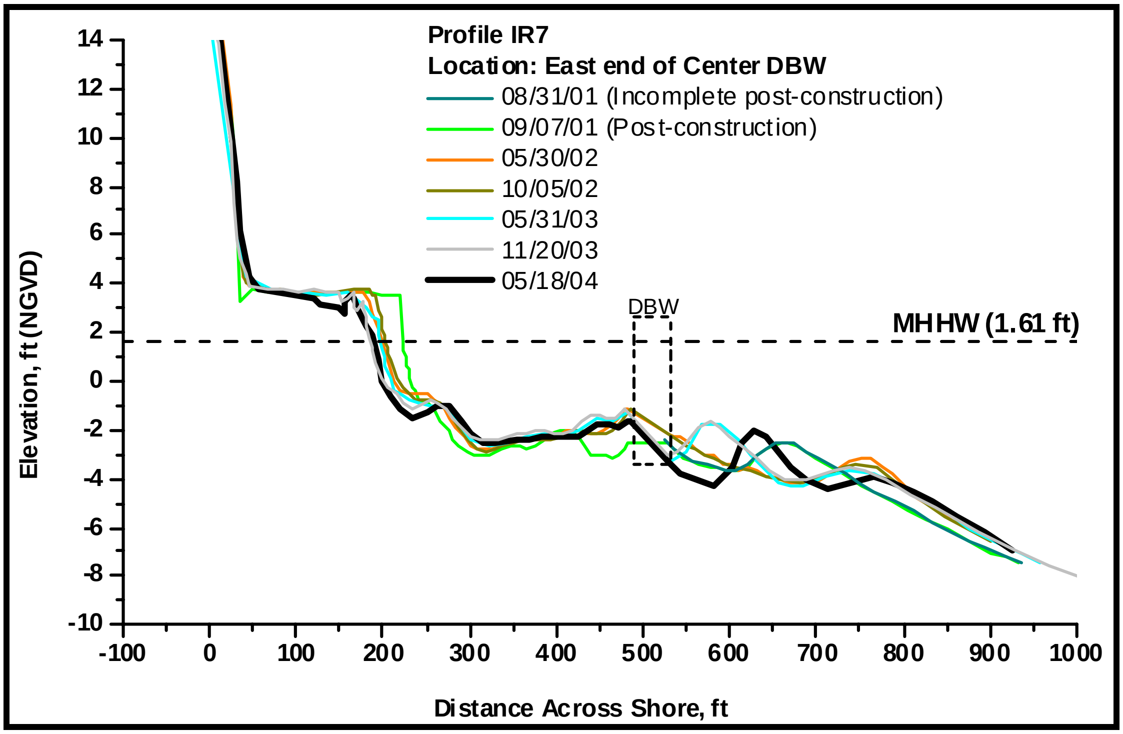

Figure 8. Profile IR7 located at the east end of the center DBW.

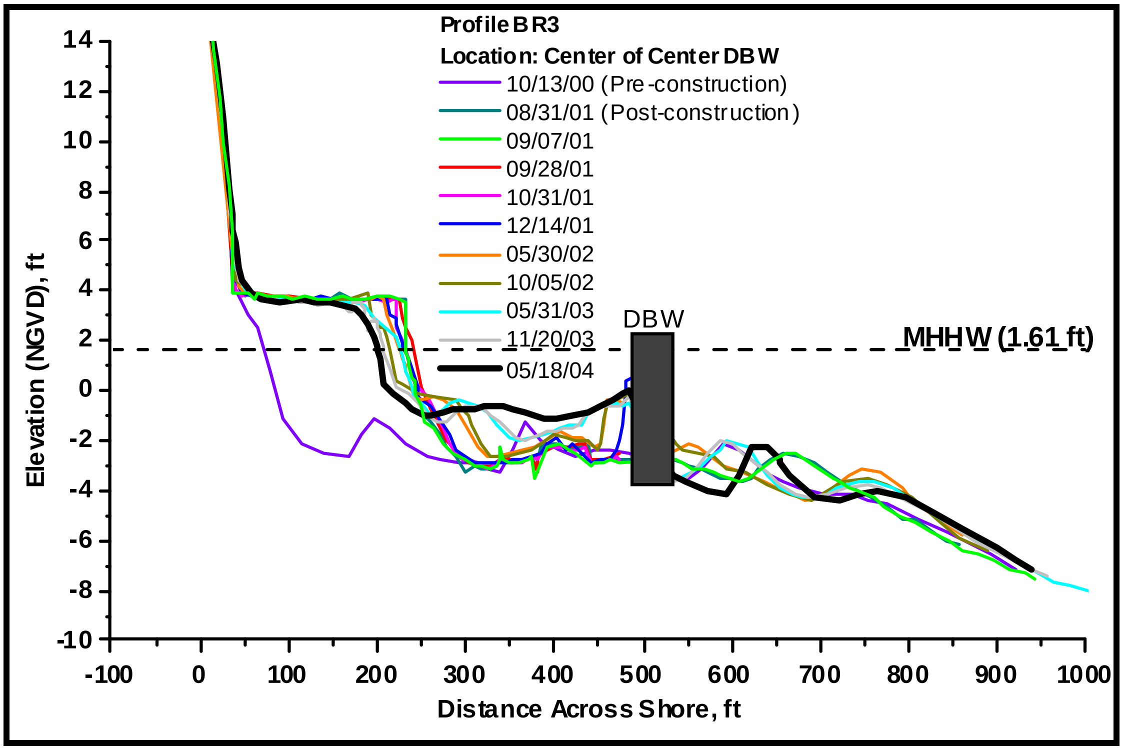

Figure 9. Profile BR3 located between the east and center DBWs.

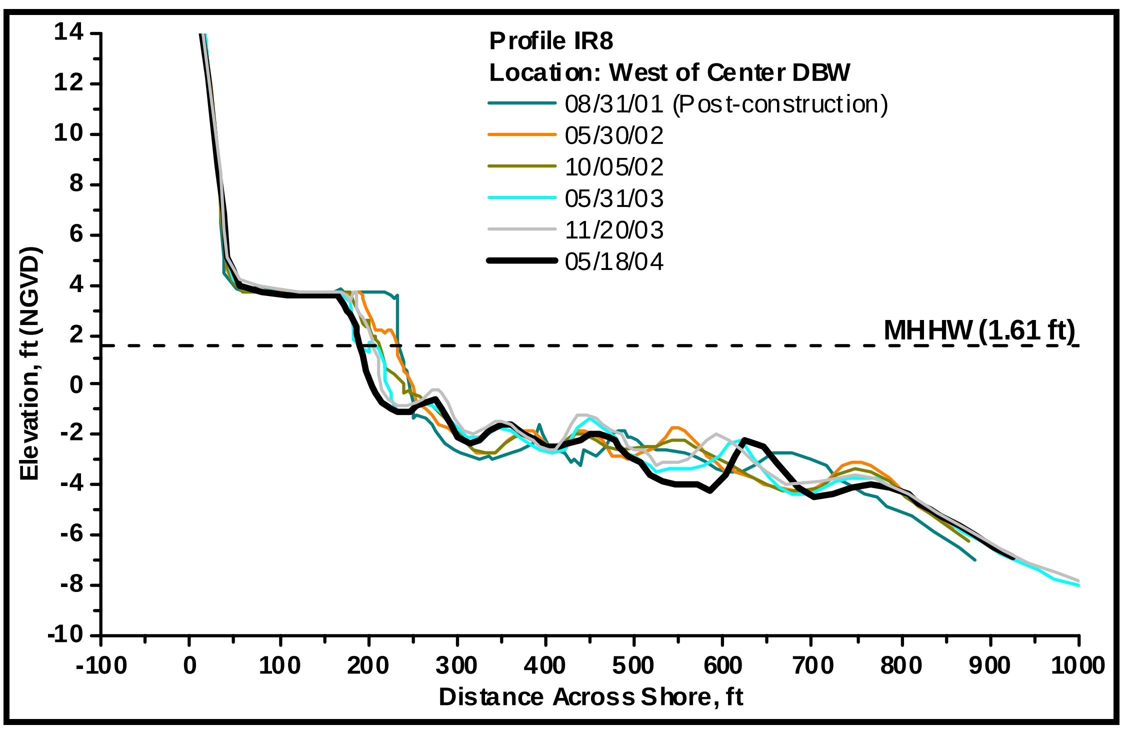

Figure 10. Profile IR8 located west of the center DBW.

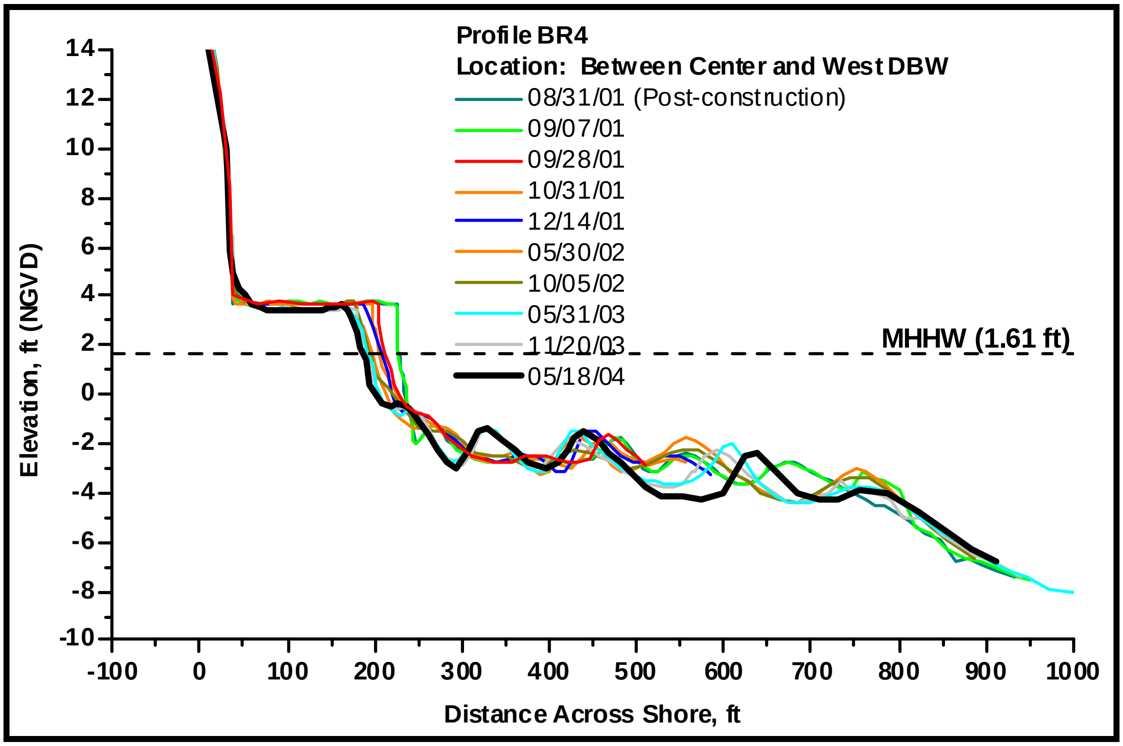

Figure 11. Profile BR4 located between the center and west DBW.

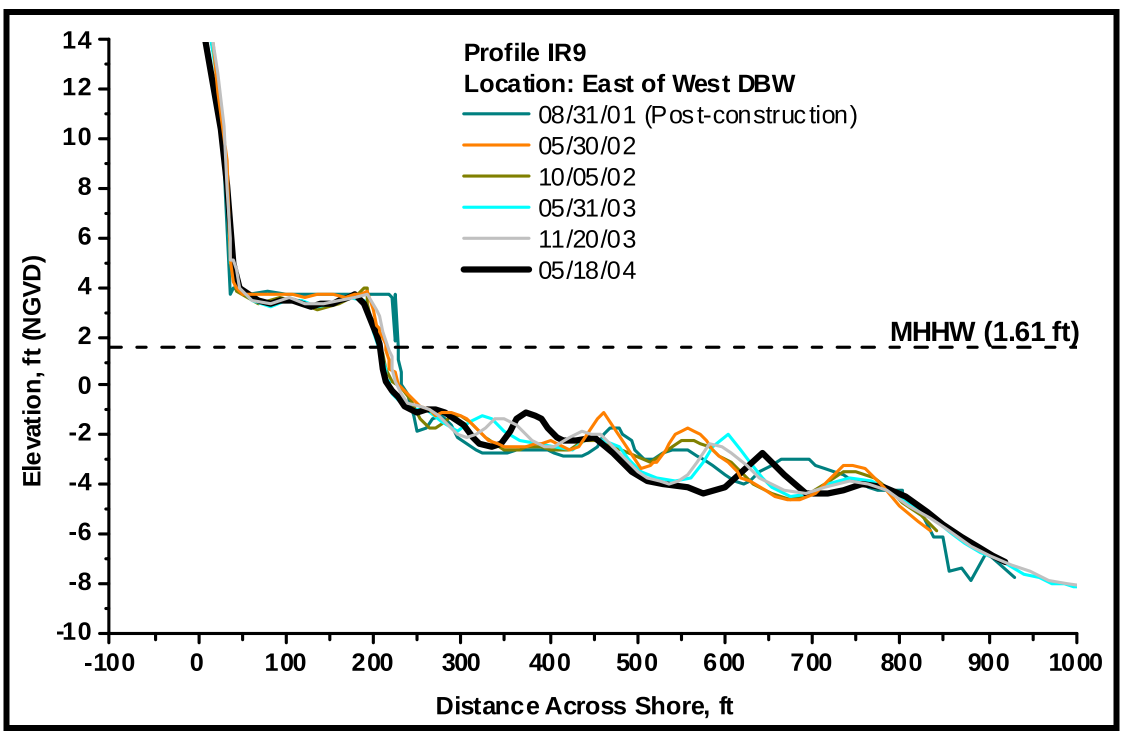

Figure 12. Profile IR9 located east of the west DBW.

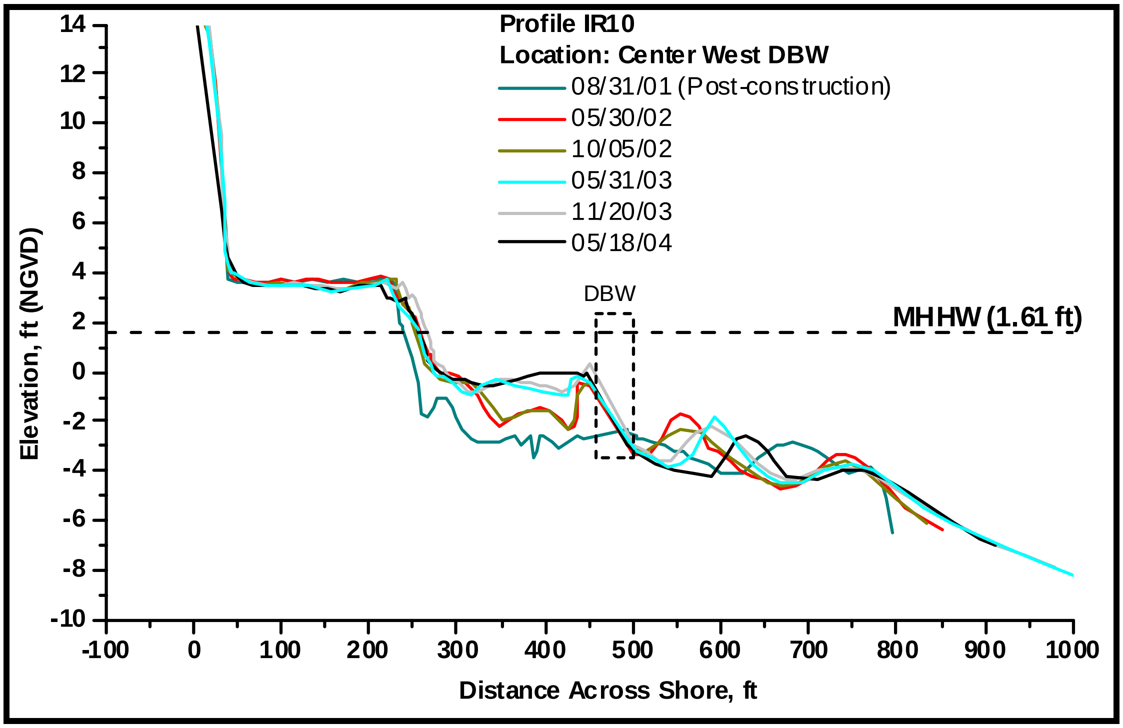

Figure 13. Profile IR10 located at the center of the west DBW.

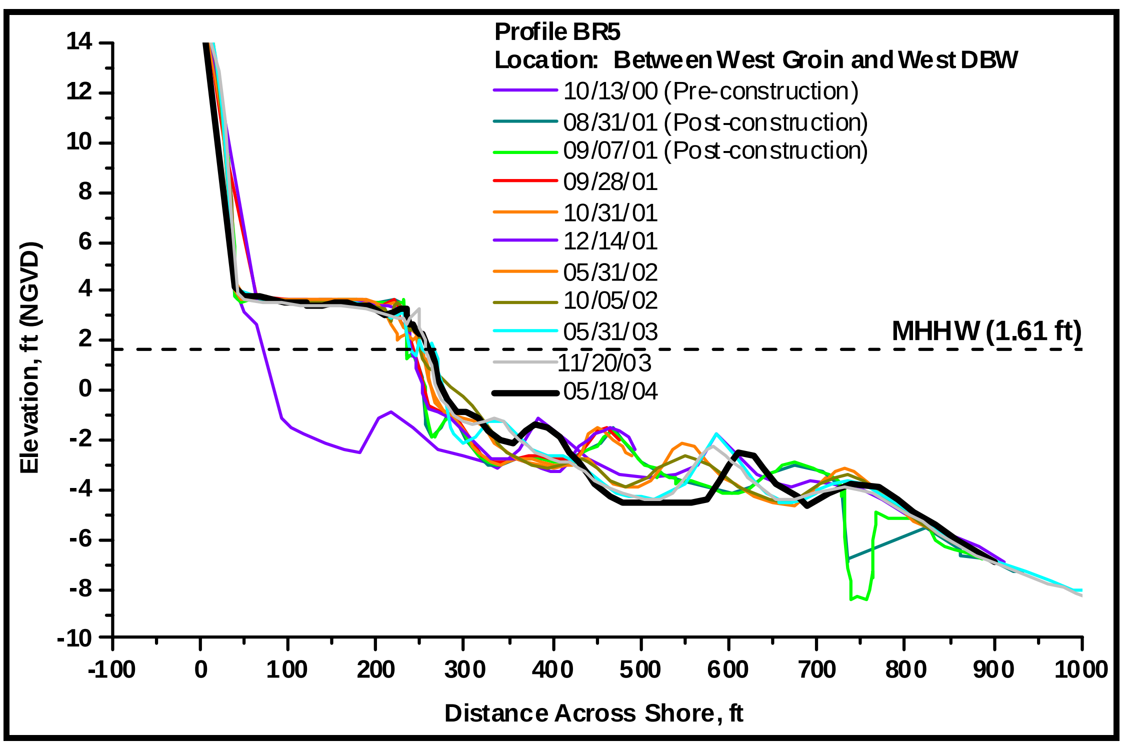

Figure 14. Profile BR5 located between the west groin and west DBW.

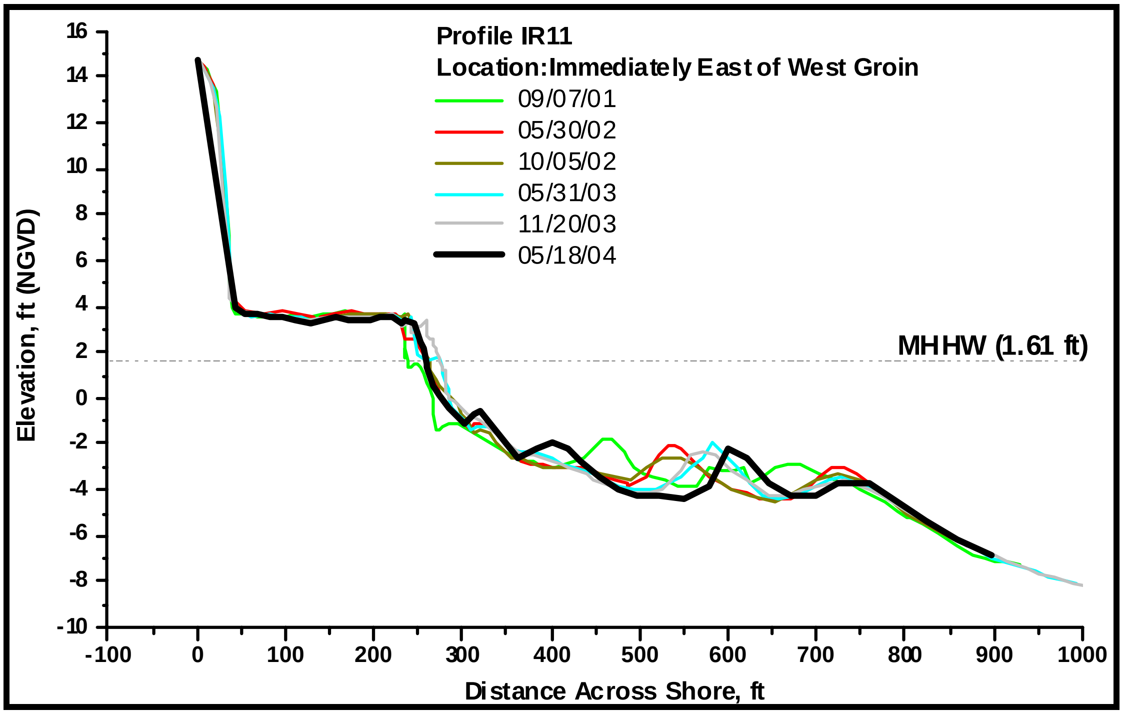

Figure 15. Profile IR11 located immediately east of the west groin.

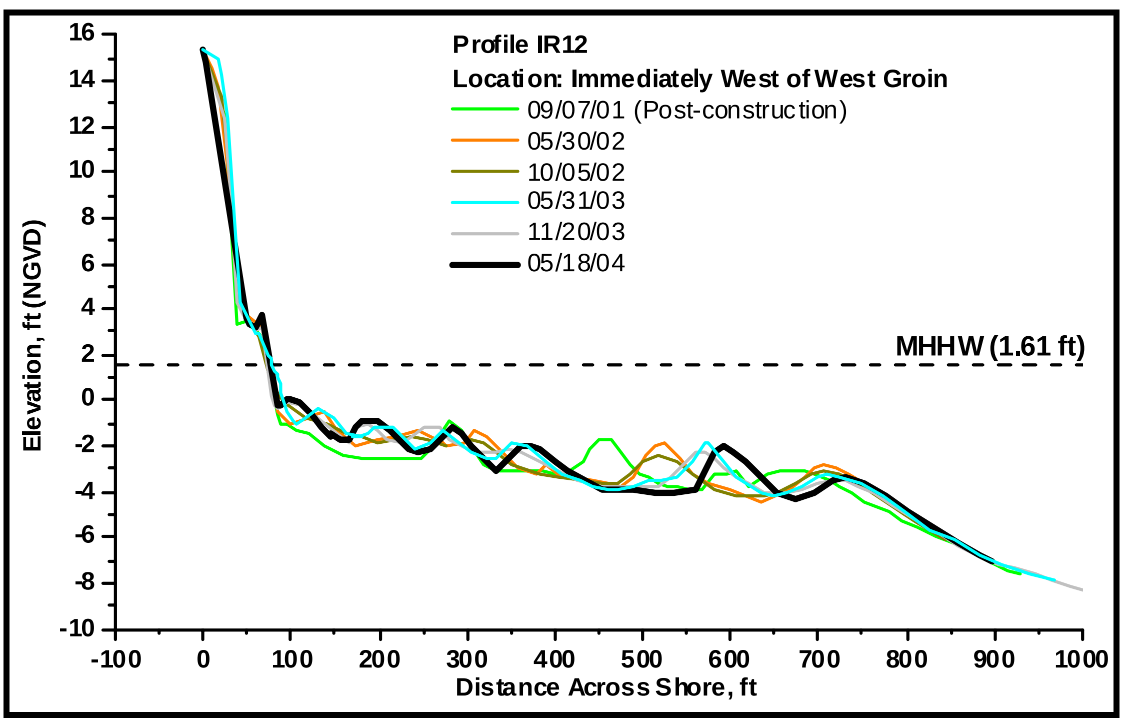

Figure 16. Profile IR12 located immediately west of the west groin.

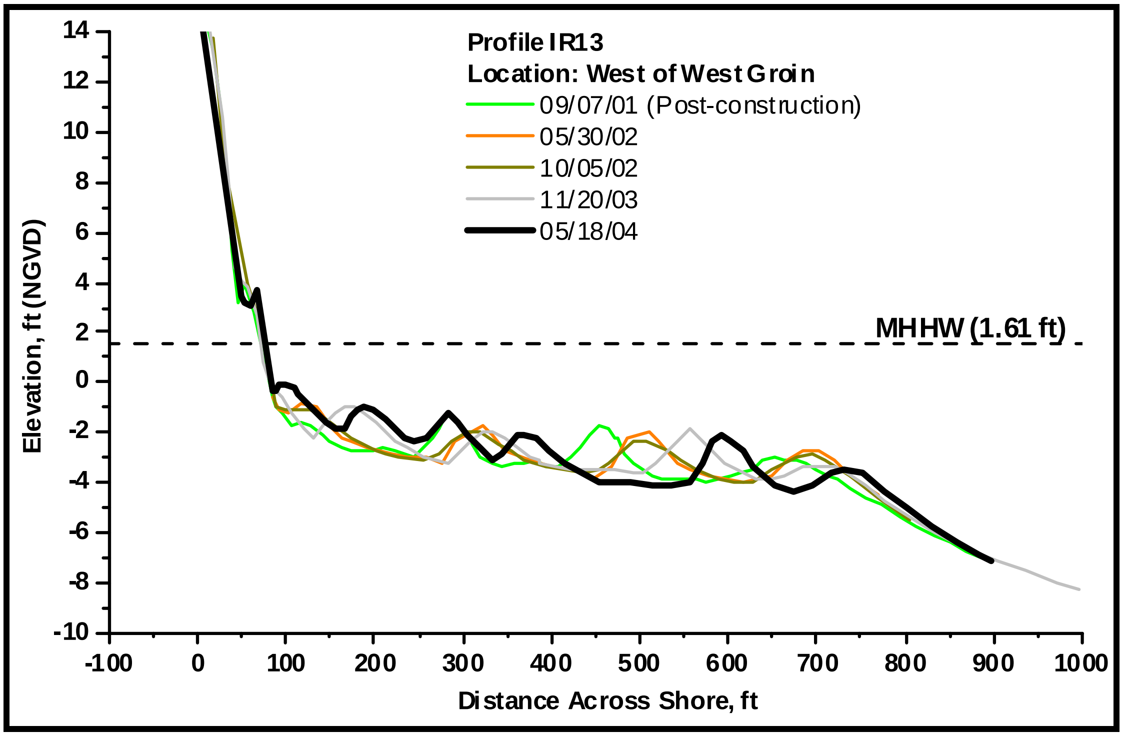

Figure 17. Profile IR13 located west of the west groin.

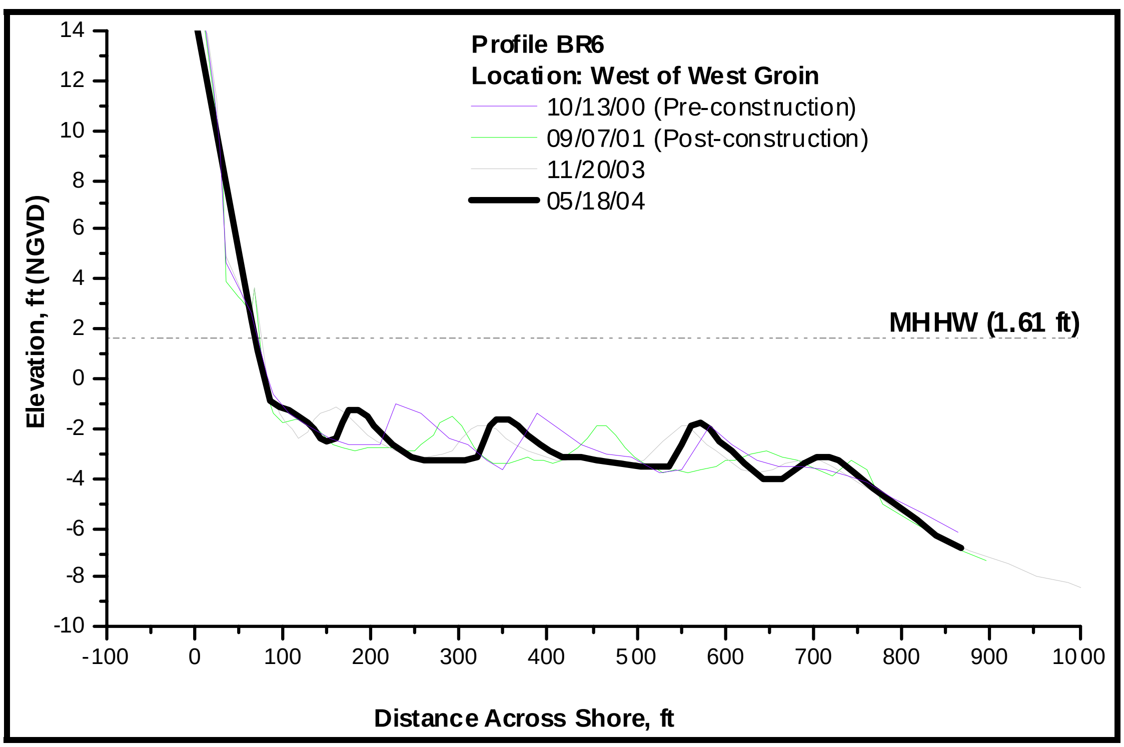

Figure 18. Profile BR6 located west of the west groin.

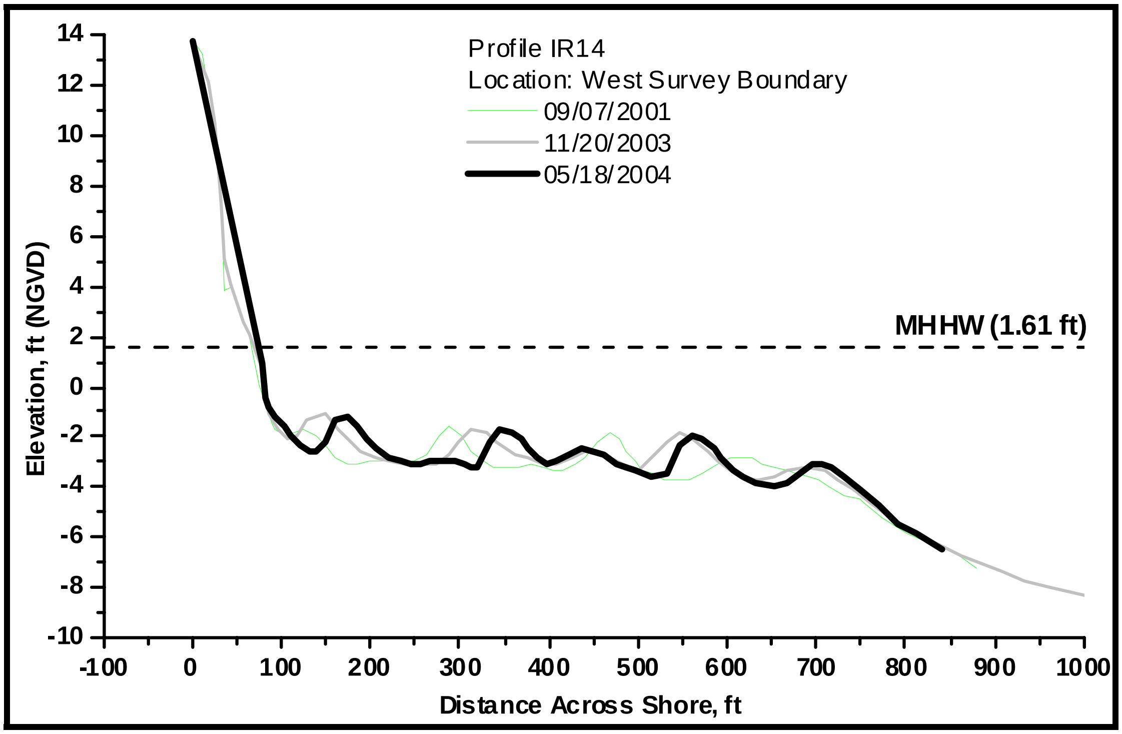

Figure 19. Profile IR14 located west of the west groin at studies western boundary.