PREPARED FOR:

MANATEE COUNTY & THE TOWN OF LONGBOAT KEY

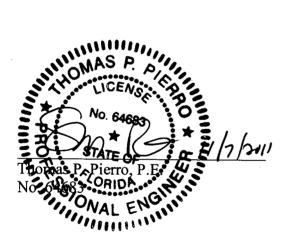
PREPARED BY:

COASTAL PLANNING & ENGINEERING, INC.

OCTOBER 2011

ENGINEERING CERTIFICATION

This report (main text) is a feasibility and planning study and the recommended plans will require arthitimal engineering prior to implementation.



ENGINEERING CERTIFICATION

This repor	t (main	text)	İS	a	feasibility	and	planning	study	and	the	recommende	ed j	plans	will
require add	itional	engine	eerir	ng	prior to in	plen	nentation.							

Douglas W. Mann, P.E.							
No. 44046							
Thomas P. Pierro, P.E.							

Executive Summary

Longboat Pass is a natural inlet that separates the barrier islands Anna Maria Island (to the north) from Longboat Key (to the south) and connects Sarasota Bay and the Gulf of Mexico. On both Anna Maria Island and Longboat Key, the shorelines adjacent to Longboat Pass are classified by the FDEP as critically eroded.

This report summarizes the history of Longboat Pass; the characteristics of the waves, tides, and currents at the inlet, the present erosion and shoaling patterns, the sediment transport patterns at Longboat Pass, the inlet's zone of influence, the natural resources at Longboat Pass, previous studies, and the development of a recommended plan for the management of the inlet and adjacent beaches.

Prior to the construction of the 1992 and 1993 beach nourishment projects on Anna Maria Island and Longboat Key, natural bypassing occurred at Longboat Pass via the inlet's ebb tidal shoal. In 1993, an inlet management plan was developed (ATM, 1993) and approximately 1,955,000 cubic yards of material was removed from the Longboat Pass ebb shoal to construct the Longboat Key Beach Restoration Project. Since that time, the borrow area has been refilling, and the ebb shoal complex as a whole has been gaining approximately 96,000 c.y./year without measureable bypassing. The net sediment transport responsible for this growth is estimated to be 73,000 c.y./year from Anna Maria Island and 23,000 c.y./year from the north end of Longboat Key. Therefore, Longboat Pass functions as a sediment sink, resulting in erosion of the adjacent beaches.

To address the erosion problems at Longboat Pass, an inlet management plan has been formulated using the information presented in this document and intergovernmental coordination between local stakeholders. The plan combines the following elements (see Figure E-1):

- An extension of the existing terminal groin on the south end of Anna Maria Island.
- The construction of a terminal groin on the north end of Longboat Key, plus two permeable adjustable groins near the 360 North Condominium and the public beach access at the end of North Shore Road.
- Dredging of the 1977 Authorized Channel with approximately 38,700 c.y. of advance maintenance on the north side of Cut 1 and placement of the spoil material on the southern mile of Anna Maria Island (R-35+790' to Longboat Pass) and the north end of Longboat Key between Greer Island and Gulfside Road on an as needed basis (R-44+48' to R-46A and R-48+722' to R-51).
- Dredging of Gulf Intracoastal Waterway Cut M5.

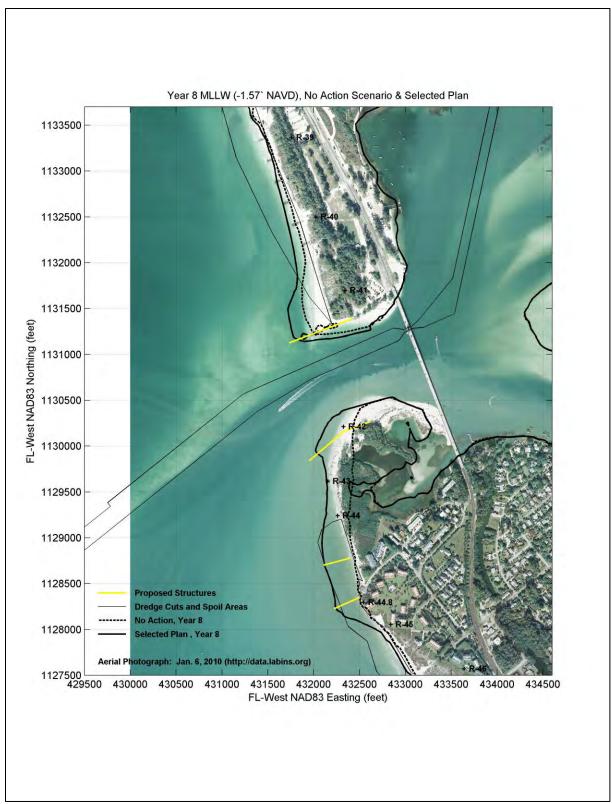


FIGURE E-1: Recommended Inlet Management Plan for Longboat Pass.

Under this plan,

- The extension and tightening of the existing terminal groin should be able to reduce the future erosion rates on the south end of Coquina Beach and maintain a fillet that extends approximately 2,000 feet north.
- The proposed terminal groin and permeable adjustable groins on the north end of Longboat Key should be able to reduce the erosion rates between Longboat Pass and Sea Pine Condominium (R46.5) and stabilize the beach.
- The channel dredging component should provide roughly 329,900 cubic yards of material, with subsequent channel refilling rates on the order of those that have occurred since the last dredging operation in 1997.

The recommended plan is feasible for permitting and implementation along with the ongoing beach nourishment programs of Manatee County and the Town of Longboat Key and is consistent with Florida Statutes for inlet management. The study suggests that maintenance dredging of the navigation channel will require dredging approximately 190,000 cy. every 8 years. Alternatively, maintenance dredging could be performed on a 4 year interval with each island receiving 100% of the dredge spoil every other dredging event. This would provide navigational maintenance dredging more frequently and allow Manatee County and the Town of Longboat Key the opportunity to tie the maintenance events to their regional beach nourishment programs on an approximate 8 year basis.

Further refinement of the components of the selected plan will be accomplished during the final design phases and as a result of the permitting processes. The results of this numerical modeling study should be used in conjunction with other coastal engineering assessments and prudent engineering judgment. Further engineering is recommended prior to implementation.

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1. INTRODUCTION

A. General Description

Longboat Pass is a natural inlet that separates the barrier islands Anna Maria Island (to the north) from Longboat Key (to the south) and connects Sarasota Bay and the Gulf of Mexico. Longboat Pass is the southernmost inlet within Manatee County, approximately 7 miles south of Tampa Bay Entrance and 10 miles north of New Pass (Figure 1-1). The inlet is bridged by State Road 789 (Gulf of Mexico Drive) which connects Anna Maria Island and Longboat Key. Manatee County extends until R-67.3 on Longboat Key where it abuts Sarasota County, which begins at R-1. On both Anna Maria Island and Longboat Key, the shorelines adjacent to Longboat Pass are classified by the FDEP as critically eroded.

Circulation of water between Sarasota Bay and the Gulf of Mexico through Longboat Pass maintains water quality within the bay and interior canals. The inlet was authorized as Federal navigation project by the Rivers and Harbors Act of July 1970 and approved by the Chief of Engineers on 20 April 1976 under section 107 of the Act. Longboat Pass was dredged for the first time by the U.S. Army Corps of Engineers (USACE) in 1977. The USACE has performed maintenance dredging of the Gulf entrance channel and the interior channel five times since its authorization - 1977, 1982, 1985, 1990-1991, and 1997. Both Manatee County and the Town of Longboat Key have allowed the disposal of dredged material from Longboat Pass on their shorelines. On Anna Maria, dredge spoil has been placed from profiles R-34 to R-35 (North Beach Disposal Area "A") and R-36.5 to R-38 (North Beach Disposal Area "B") (See Figure 1-1). On Longboat Key, dredge spoil has been placed between profiles R-47 and R-50.5 (South Beach Disposal Area "C", Figure 1-1).

Longboat Pass has one jetty, constructed in 1957, located on the northern side of the inlet on Anna Maria Island. The jetty is a permeable crib/rubble jetty approximately 475 feet in length. Manatee County is in the process of installing geotextile tubes on the north side of the jetty to test the effectiveness of sand tightening.

B. Authorization

In 1986 and 1987, the Florida legislature amended Section 161.161 and enacted Section 161.142 of the Florida Statutes to include inlet management planning into the statewide comprehensive beach management plan with the intention of mitigating erosion losses at coastal inlets, improving navigation at inlets and providing for net annual longshore sediment transport around inlets. During the 1991 legislative session, Longboat Pass was identified and recommended for study and the original Inlet Management Plan for Longboat Pass was developed in 1993 (ATM, 1993). Section 161 was further amended in 2008 to provide further guidance for addressing beach erosion related to Florida's inlets.

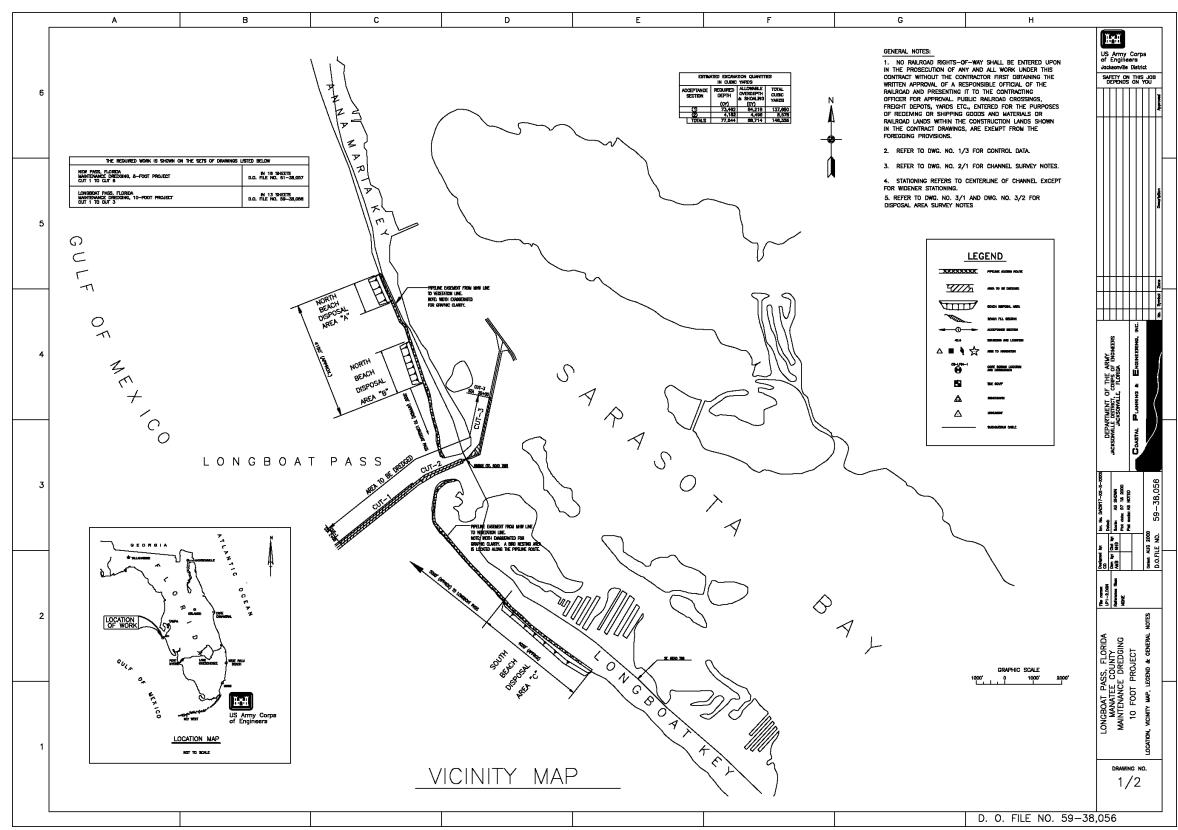


FIGURE 1-1: Longboat Pass Location Map (USACE/CPE, 2000).

The 2010 Inlet Management Study of Longboat Pass and Adjacent Beaches described in this document provides an update to the original Inlet Management Plan to address natural and anthropogenic changes that have occurred since completion of the 1993 plan. This new study was conceived and funded by the Town of Longboat Key and Manatee County in a joint effort to develop a mutually agreeable inlet management strategy for the future. The findings in this report are structured according to the State of Florida Inlet Management Plan guidelines (FL-DNR, 1990) and draw from elements of the original 1993 study as well as monitoring reports, management plans, evaluations and other studies that have been produced since the 1993 report was developed.

C. Purpose and Scope

The primary objective of this study is to assess the coastal processes at Longboat Pass and evaluate alternatives to improve inlet management and reduce inlet related erosion on Anna Maria Island and Longboat Key. The elements involved in this study include the following:

- Literature and data review (previous reports, hydrographic and bathymetric surveys, wave data, wave data, water level data, environmental resource data, etc.).
- Evaluation of erosion and accretion rates around Longboat Pass.
- An assessment of the inlet's history, physical characteristics and area of influence.
- Development of an updated sediment budget.
- Numerical modeling of wave transformation, circulation, sediment transport, and inlet morphology (erosion and deposition patterns) using SWAN and Delft3DFLOW.
- Identification and evaluation of alternatives for erosion reduction and inlet management.
- Assessment of the alternatives based on effectiveness, feasibility, natural resources, and the likelihood of obtaining permits.
- Recommended inlet management strategy.

Based on the various reports and data sets reviewed during study, profiles R-20 on Anna Maria and R-56 on Longboat Key mark the northern and southern ends of the study area. This stretch of shoreline has been influenced by the processes at Longboat Pass and represents the scope of the evaluation. The Delft3D numerical model was used to analyze the complex interaction between the waves and currents at the pass and sand movement at the adjacent beaches and on the shoals.

The information presented in this study has been developed to facilitate and integrate management of the Pass and the adjacent Gulf shore beaches between governments. The resulting plan integrates ongoing studies and beach designs near the pass and recommends strategies for inlet maintenance, inter-governmental sand sharing protocols, and the most effective methods for preserving the adjacent beaches according to State standards and initiatives.

D. Public Interest and Use

As Federal navigation project, Longboat Pass provides sufficient draft for recreational and commercial interests to access the Gulf of Mexico for fishing, and other watercraft activities. The

region's waterways experience a year-round boating season, with peak use between April and July and an off-peak period from December through February. (Sidman et al., 2007)

The interior basin of Longboat Pass is Sarasota Bay, which covers parts of Manatee and Sarasota Counties. Longboat Pass, New Pass, Big Sarasota Pass, and Venice Inlet provide tidal flushing of the bay. More than 1,400 different native species of plants and animals inhabit the Bay area. The Florida Administrative Code (Rule 17-302) has designated the waters of Sarasota Bay and the Gulf of Mexico, including Longboat Pass, as Class II waters. The designated uses of a Class II water body are shellfish propagation or harvesting. The Sarasota Bay estuarine system is included in the Special Waters category of Outstanding Florida Waters (OFW), which have special protection as determined by the Environmental Regulation Commission because of their natural attributes (ATM, 1992).

Primarily, the public interests are the Town of Longboat Key, the City of Anna Maria, Manatee County, Sarasota County, the West Coast Inland Navigation District (WCIND), the United States Army Corps of Engineers (USACE), and the State of Florida.

The USACE maintains the federally authorized navigational channel (small craft) from the Gulf of Mexico to the West Coast Inland Navigation Channel. The Federally authorized Longboat Pass navigation project provides for:

- An entrance channel with a 12 foot MLLW (-13.57 foot NAVD) design depth + 2 feet overdepth, and 150 foot bottom width from the Gulf to Longboat Pass Bridge (Cut 1 and first 1,500 feet of Cut 2, see Figures 1-1 and 1-2).
- A channel with a 10 foot MLLW (-11.57 foot NAVD) design depth + 1 foot overdepth, 100 foot bottom width from Longboat Pass Bridge to the Intracoastal Waterway (last 550 feet of Cut 2 and Cut 3, see Figures 1-1 and 1-2).
- Maintenance of the authorized channel (USACE, 2010 personal communication).

The WCIND is the local sponsor of the maintenance dredging of the pass and the USACE is the federal sponsor. The USACE and the Florida Department of Environmental Protection (FDEP) are the responsible permitting agencies for Anna Maria Island, Longboat Key and Longboat Pass.

E. History of the Inlet

Historical Changes

Longboat Pass is located between Anna Maria Island to the north and Longboat Key to the south. A map of the 1883 shoreline shows that Longboat Pass was approximately 3,500 feet wide with a small island in the middle of the pass (Figure 1-3). On the northern tip of Longboat Pass, a small spit began to grow towards the north (Finkl et al., 2007).

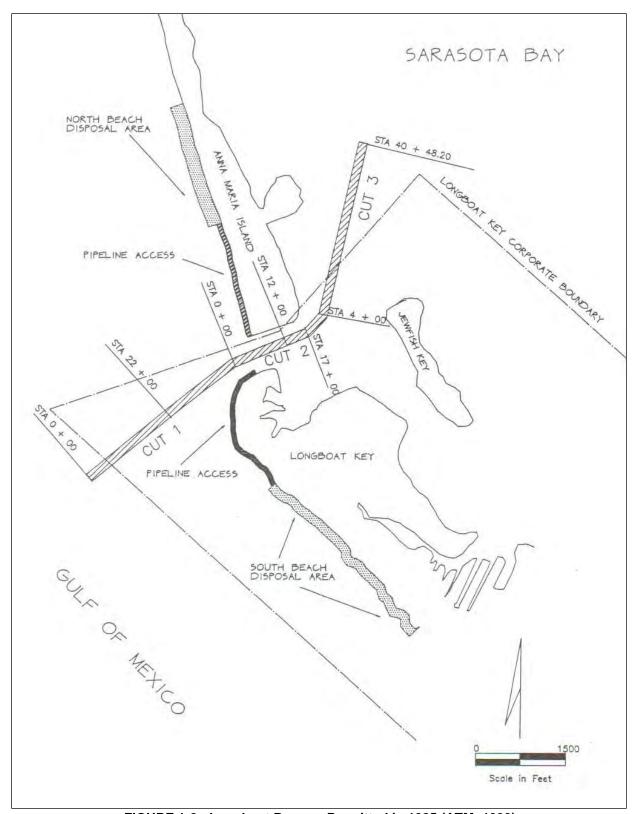


FIGURE 1-2: Longboat Pass as Permitted in 1985 (ATM, 1993).

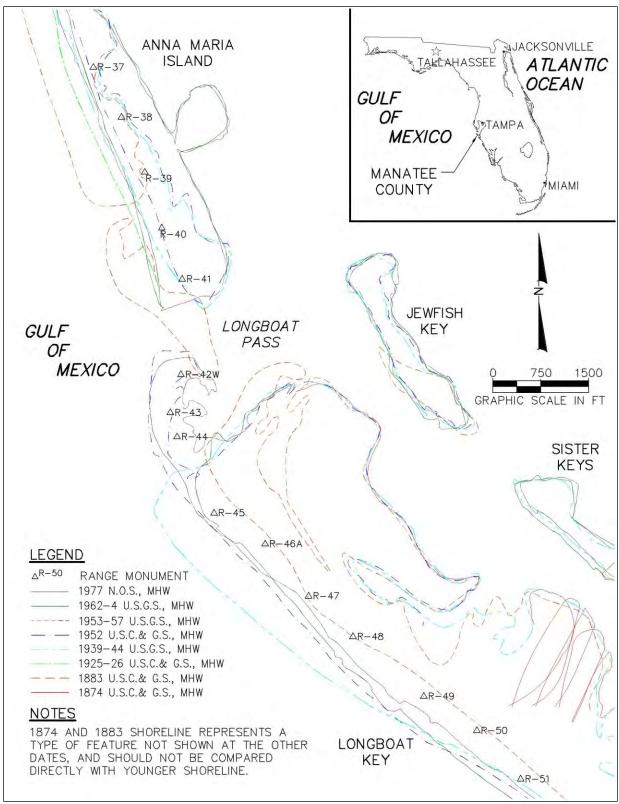


FIGURE 1-3: Historic shoreline change showing shoreline positions along the southern end of Anna Maria Island and the northern end of Longboat Key, for selected time intervals from 1874 to 1977.

In 1926 a wooden bridge was constructed which connected Anna Maria Island and Longboat Key. The bridge was washed away in a high tide in 1932 and was not replaced until 1957 (Coastal Engineering Consultants, 1987). By 1939, the island that was in the middle of the pass had attached to the south end of Anna Maria Island. The north end of the Longboat Key had moved seaward by approximately 700 feet. The spit that originally extended from the northern tip of Longboat Key into Longboat Pass was no longer present. The width of the pass had decreased to approximately 1,670 feet (Finkl et al., 2007).

During the construction of the Intracoastal Waterway in 1939, two islands located within the bay behind Longboat Pass (Jewfish and Pickett Keys) were joined using dredge spoil taken from the Intracoastal Waterway channel (Humiston & Moore, 2008). Prior to their joining, the north end of Longboat Key was characterized by a wide and rapidly accreting beach (ATM, 1993). After the joining of Jewfish and Pickett Keys, both the north end of Longboat Key and the south end of Anna Maria Island began to experience chronic erosion. Records indicate that since 1939, the beaches both north and south of Longboat Pass have experienced widely fluctuating beach widths.

By 1952, the spit that was at the northern end of Longboat Key in 1883 had reappeared and continued its northeastward growth. This spit is called Greer Island but is also referred to as Beer Can Island. The northern end of the island retreated landward approximately 600 feet (Finkl et al., 2007). In 1957, the jetty was constructed at the south end of Anna Maria Island. It is believed that these actions may have exacerbated the erosional losses on Longboat Key (Humiston & Moore, 2008). In 1983, the inlet separating Siesta Key and Casey Key, known as Midnight Pass, closed. The closure of this inlet contributed to changes in the tidal prism at Longboat Pass (Humiston & Moore, 2008).

Dredging History

Longboat Pass became a federally authorized in 1977 and was dredged by the U.S. Army Corps of Engineers in 1977, 1982, 1985, and 1991 (Table 1-1). The last dredging event took place in 1997.

TABLE 1-1
LONGBOAT PASS DREDGING HISTORY

Date Description		Dredge Disposal Quantities				
		Quantity	Anna Ma	ria Island	Longboat	
		(c.y.)	Beach	Bay	Key	Sources
1951	Navigation Maintenance	Unknown	Unknown	Unknown	Unknown	Humiston & Moore (2008, p. 35)
1959	Navigation Maintenance	Unknown	Unknown	Unknown	Unknown	Humiston & Moore (2008, p. 35)
1977	Initial Federal Dredging	307,516	187,758	36,000	83,758	ATM (1992, p. 38)
1981-1982	Navigation Maintenance	164,990	0	0	164,990	ATM (1992, p. 38)
1985	Navigation Maintenance	165,180	165,180	0	0	ATM (1992, p. 38)
1990-1991	Navigation Maintenance	200,000	100,000	0	100,000	ATM (1992, p. 38)

TABLE 1-1 (continued)

LONGBOAT PASS DREDGING HISTORY

Date	Date Description		Disposal Quantities Anna Maria Island Longboat				
		(c.y.)	Beach	Bay	Key	Sources	
1993	Ebb Shoal Dredging	1,955,000	0	0	1,955,000	12/1992 & 8/1993 surveys	
1993	Other Dredging (Unlikely)	300,000 (?)	Unl	known / Unlil	kely	Humiston & Moore (2008, p. 35)	
1997	Navigation Maintenance	168,000	59,000	0	109,000	CPE (2011), USACE (2010)	

The 1977 construction removed approximately 308,000 cubic yards of material from Longboat Pass. Based on the ATM (1992) Inlet Management Plan, which utilized dredge and spoil volume summaries from the U.S. Army Corps of Engineers, 36,000 cubic yards of dredge spoil was placed in Sarasota Bay near Anna Maria Island. The remainder was placed along the Gulf-front shorelines of Longboat Key and Anna Maria Island.

In the winter and spring of 1981 and 1982, approximately 165,000 cubic yards were dredged from Cuts 1 and 2 of the authorized channel and placed on 3,500 feet of beach along the north end of Longboat Key approximately 2,500 feet south of the pass (ATM, 1992). In 1985, a similar amount of material was dredged from Cuts 1, 2, and 3 (ATM, 1992). However, the dredge spoil was placed along a 2,500 foot beach segment on Anna Maria Island. In the winter and spring of 1990 and 1991, approximately 200,000 cubic yards were dredged from Cuts 1 and 2. Based on the post-construction surveys, half the dredge spoil was placed on Anna Maria Island, and half the dredge spoil was placed on Longboat Key (ATM, 1992).

In 1993, an inlet management study was completed by the Town of Longboat Key, which recommended the annual placement of 57,800 cubic yards on the adjacent beaches in the areas of greatest need (ATM, 1993). However, the study was not adopted by the State into an Inlet Management Plan.

An island-wide beach restoration project along the majority of Longboat Key also took place in 1993. The fill project was 9.3 miles long and placed approximately 3.34 million cubic yards of fine white sand fill between profile R-46 and New Pass. The fill material was obtained from the ebb shoals of Longboat Pass and New Pass, located to the immediate north and south of Longboat Key, respectively (ATM, 1993). The project also removed 5,751 tons of derelict groins and coastal structures and created two artificial reefs, covering 1.5 acres of seafloor (ATM, 1995). The *Regional Model for Sarasota Bay and Case Studies of Longboat Pass and Venice Inlet* (Humiston & Moore, 2008) stated that surveys "of the inlet from this period show that an additional amount of sand, estimated to be approximately 300,000 cubic yards, was dredged from the landward portion of the Longboat Pass ebb shoal ... however, no substantiating records have been found". The available survey data from 1992 and 1993 was reviewed and based on the coverage of that data, along with the lack of records, the 300,000 c.y. of additional dredging has not been substantiated.

Between April and September 1997, Hendry Corporation removed approximately 168,000 cubic yards of material from the Longboat Pass navigation channel (CPE, 2010; USACE, 2010). This

operation was sponsored by the USACE under a 481,600 cubic yard contract that also included New Pass (USACE, 2010). Based on the construction plans for the project (USACE, 1996) and other records, 109,000 cubic yards of this material were placed along profiles R-43.66 to R45.5 and R-48.5 to R-51 on Longboat Key. The remaining 59,000 cubic yards were placed along profiles R-34 to R-35 and R-36+511' to R-38+204' on Anna Maria Island. In early 1998, approximately 2,000 cubic yards were dredged from Beer Can Island (Greer Island) and placed on the dry beach north of North Shore Road (Near R-45).

Beach Nourishment

Since 1992, beach nourishment programs have been conducted on both Anna Maria Island (AMI) and Longboat Key to address critical beach erosion. Presently, both Manatee County and the Town of Longboat Key have ongoing programs to address beach erosion on the southern end of Anna Maria Island and northern end of Longboat Key, respectively.

Between March 1 and April 13, 2011, the Coquina Beach Restoration Project was constructed on Anna Maria Island by the Great Lakes Dredge & Dock Company, under contract to Manatee County. The length of the project was approximately 5,000 feet, extending from profiles R-35+790 to R-41+305. The volume of material placed was 204,800 c.y. (CPE, 2011a). In addition to the beach fill component, the permit for the 2011 Coquina Beach project also included the construction of three sand-filled geotextile containers/tubes adjacent to the Longboat Pass terminal groin to limit the loss of sand through the existing groin into Longboat Pass. The geotextile tube project is currently out to bid with an anticipated commencement date in November 2011.

Between March 23 and June 20, 2011, the Town of Longboat Key North End Beach Renourishment project was constructed by Jay Cashman, Inc., under contract to the Town. The length of the project was 2,685 feet, extending from profiles R-44-100 to R-46.6. The volume of material placed was 139,900 c.y. (CPE, 2011b).

In addition to the projects above, two additional ones are presently in the permitting stages:

- The Longboat Key North End Breakwaters project (FDEP permit file 0295923-001-JC). This project would involve the construction for 4 breakwaters near the North Shore Road seawall (R-44.8) to moderate the high erosion rates there. To pre-fill the salients created by the breakwaters and address erosional impacts on the adjacent beaches, 25,000 to 50,000 cubic yards of trucked fill would be placed. The Town has placed this application on hold pending the results of this study.
- The Longboat Key Nourishment Project (FDEP draft permit 0296464-001-JC). The first nourishment operation will place approximately 310,000 c.y. of material along profiles R-44 to R-46 and R-47.5 to R-50 on Longboat Key in Manatee County and profiles R-12 to R-17 in Sarasota County. The second nourishment operation will place approximately 865,000 c.y. of material along profiles R-44 to R-45.5, R-47 to R-50, and R-67 to R-67.5, and profiles R-1 to R-3, R-13 to R-17, and R-21 to R-29. The Notice of Intent to Issue a Joint Coastal Permit and Variance was released by FDEP on September 23, 2011.

2008 Case Study of Longboat Pass

In 2008, Humiston & Moore prepared a Regional Model Study for Sarasota Bay and Case Studies of Longboat Pass and Venice Inlet under a cooperative effort between the West Coast Inland Navigation District (WCIND) and the FDEP (Humiston & Moore, 2008). The objective of the study was to provide a better understanding of the evolution of the inlet shoal system and how that evolution has been influenced by various dredging events. The report used:

- Historic aerial photographs and surveys to document changes to the inlet since the late 1800s.
- The Advanced Circulation Model (ADCIRC, Luettich, et al. 1991) to evaluate circulation in Sarasota Bay, Anna Maria Sound, Tampa Bay, and Boca Ciega Bay as a whole. Specifically the ADCIRC model was used to predict currents and water level variations due to astronomical tides.
- The CMS 2D flow/sediment transport model (Buttolph, et al., 2006) to evaluate morphological changes in Longboat Pass and Venice Inlet. This model predicted currents, water level changes, wave transformation, sediment transport, erosion and deposition near the two inlets. Forcing on the model's offshore and bay boundaries was based on water levels predicted by the ADCIRC model, along with hindcast wave data offshore.
- The Inlet Reservoir Model (Kraus, 2000a, 2000b) to evaluate the long-term growth and adjustment of the beaches and shoals around Longboat Pass and Venice Inlet. This model predicted the shoal and beach volumes using an analytical approach. Inputs to the Inlet Reservoir Model were based on dredging records, surveys, and results from the CMS 2D model.

The 2008 study included evaluations of the evolution of the pass over time, the effects of a changing tidal prism, and the effects of sediment excavation from the pass. The majority of the information in the report was presented in a qualitative manner, rather than tables and figures listing quantitative values in c.y./year, feet, etc. The study included the following recommendations:

• Re-align Cuts 1 and 2 of the Federal navigation channel "to conform more closely to the natural tidal channel alignment." Although not specified in the 2008 study, the channel proposed by the U.S. Army Corps of Engineers (USACE) for future dredging in Longboat Pass appears in Figure 1-4. It should be noted, however, that during the next Federal dredging operation, the USACE is only planning to dredge Cut 3, the landward half of Cut 2, and the Gulf Intracoastal Waterway; dredging seaward of the Longboat Pass bridge will not take place. FDEP granted a Notice of Intent to Issue Permit and Variance for the upcoming Federal dredging operation on September 29, 2011.

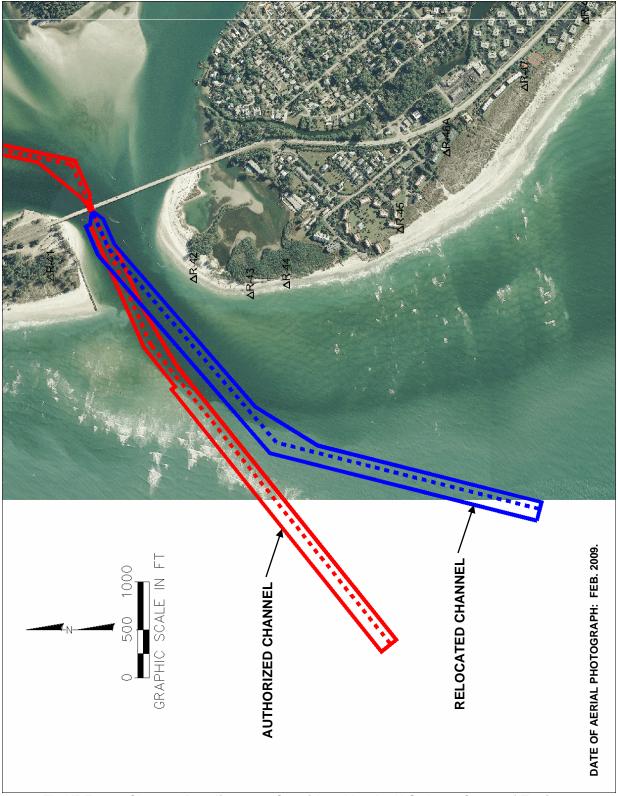


FIGURE 1-4: Channel Re-Alignment Considered by the U.S. Army Corps of Engineers (Mora, 2010).

- Refrain from using the ebb shoal as a large scale sand source.
- "If ongoing monitoring shows continued recovery of the ebb shoal, [allow] selective dredging of additional sand for beach restoration [as] ... an option in the future. Under such a scenario, the "quantities would be limited".
- Include additional advance dredging to maintain shoaling sections of the Gulf Intracoastal Waterway (IWW) near the northern and southern ends of Jewfish Key (see Figure 1-5). "This could be accomplished by increasing the channel width along those reaches where shoaling is a problem, so that material could accumulate there for a longer period of time before becoming a problem to navigation."
- Conduct periodic nourishment along Beer Can Island "using dredged material from the IWW and federal channel maintenance". In addition, construct permeable terminal structures where needed based on further modeling and analysis.
- Sand-tighten the terminal groin on the south end of Anna Maria Island.

Although the 2008 Humiston & Moore study does not comprehensively address the restoration and preservation of the adjacent beaches, which is a critical concern to both Manatee County and the Town of Longboat Key, the study provides several recommendations considered further in this report.

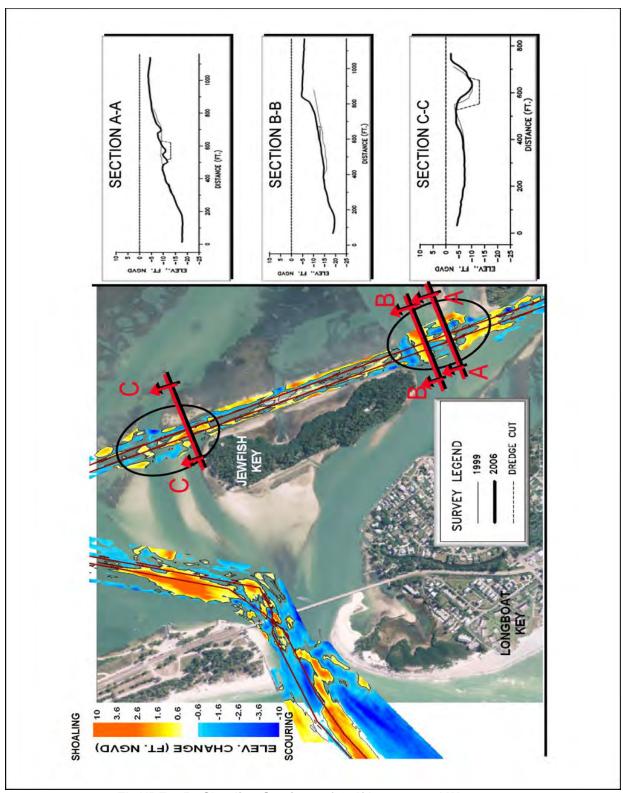


FIGURE 1-5: Shoaling Sections of Gulf Intracoastal Waterway (Humiston & Moore, 2008, p. 67).

2. PHYSICAL INLET CHARACTERISTICS

A. General

Geographic Setting

Longboat Pass separates Anna Maria Island from Longboat Key. Longboat Pass is a natural inlet which joins the Gulf of Mexico with Big Sarasota Bay and is approximately 7 miles south of Tampa Bay entrance and 10 miles north of New Pass. The inlet helps maintain the water quality within Big Sarasota Bay through tidal circulation and provides boating access to the Gulf of Mexico. However, Longboat Pass interrupts the natural alongshore sediment transport between the two islands, impacting the adjacent beaches.

Geologic Setting

The barrier islands along the central-west Florida coast are relatively young. They formed over the last 3000 years when the rates of Holocene sea-level rise did not exceed 0.04 cm/yr (Stapor et al., 1988). The rate of sea-level rise during the Holocene played a major role in barrier island development along this coast. During the early Holocene (e.g. 10,000 to 12,000 years ago) when rates of sea-level rise exceeded 1 centimeters/year (0.03 feet/year), the development of stable barrier islands was suppressed because this coast lacked major sediment sources. The coastal morphology that we observe today began to develop about 3000 years ago when favorable conditions included declining rates of sea-level rise that stabilized at 0.02 to 0.06 centimeters/year (0.0007 - 0.0020 feet/year). The oldest subaerial sediment accumulations on the barrier islands have been dated at 3000 YBP by Stapor et al. (1988). Holocene sediments beneath the barrier islands were dated from 4200 to 4500 YBP by Davis and Kuhn (1985). Because sea-level fluctuated around present eustatic conditions during the late Holocene (Fairbridge, 1961), sand bodies landward (beach ridges) and seaward (inner shelf sand ridges) of the present coastline developed during the last 4000 years of the Holocene. These sediments generally do not exceed 8 m in thickness and thin from the barriers to the offshore. Holocene sediments lie on top of pre-Holocene strata. Most of the Pleistocene record is absent on the inner shelf except for restricted areas where thin layers of Pleistocene clay have been mapped (e.g. Davis and Kuhn, 1985). According to Hine et al. (2001) the pre-barrier history of this area is characterized by multiple incursions and excursions of sea-level preserved in a range of estuarine to open marine sequences (Finkl et al., 2007). Among the barrier islands of the central-west Florida coast, Anna Maria Island is a typical drumstick barrier island, and Longboat Key is an elongated wave-dominated barrier island (Finkl et al., 2007).

Modern morphodynamics of the barrier/inlet system have been influenced by anthropogenic activities that have included inlet stabilization, the construction of causeways, shoreline armoring, and the construction of coastal structures (e.g. jetties, groins). The small tidal range in this area leads to limited tidal prisms and frequent inlet closures and migrations. Exceptions to this are the coastal inlets that have relatively large tidal prisms and large ebb shoals due to the large area occupied by the backbarrier water bodies that feed them (e.g. mouth of Tampa Bay and Charlotte Harbor estuaries) (Finkl et al., 2007).

Unconsolidated sand deposits that thicken towards the north, thinly mantle the Sarasota and Manatee County coasts. These sand deposits overlie the eroded limestones of the Arcadia and Peace River Formations (Campbell, 1985). The Arcadia Formation, a white to tan-colored quartz sandy limestone with a carbonate mud matrix of lower Miocene age (23 to 15.6 Ma) occurs as a near-subsurface layer throughout the area. The top of Arcadian limestone lies at approximate mean sea-level in northwestern Sarasota County (near Longboat Key) but dips to more than 30 m (100 ft.) depths in the southern-most part of Sarasota County (Campbell, 1985). The younger Peace River Formation (Middle to Upper Miocene – 16 to 5 Ma) is found near sea-level throughout southern Sarasota County (Campbell, 1985) (Finkl *et al.*, 2007).

Climate

The climate in the study area is sub-tropical. This area experiences mild winters with frequent southern moving cold dry fronts. The climate in the Gulf of Mexico is periodically affected by El Nino during the winter months. El Nino triggers cold fronts associated with strong low pressure systems in the Gulf of Mexico. These cold fronts may sit in the Gulf of Mexico for 7 to 10 days, generating waves that result in moderate to high erosion events along the Gulf coast (ATM, 1993). The cold fronts become weaker and push less further south during the beginning of spring. Winds become more easterly and rain showers begin to occur over Florida as the Gulf of Mexico and the Atlantic Ocean begin to warm and release their moisture (ATM, 1993).

The summer is characterized by generally light southerly winds with frequent, almost daily thunderstorms. Barrier islands are often missed by these storms as the thermal convection cycle takes its turn upward, carrying evaporated moisture from the Gulf, only about one or two miles inland over the mainland. Many storms do occur over the coastal barrier islands and nearshore areas. These storms may cause locally higher seas, but generally of short period and duration. In the fall, the storms and rains subside and the temperature drops (ATM, 1993).

Hurricanes and tropical storms from the North Atlantic Ocean and the Gulf of Mexico also influence Longboat Pass and vicinity. The hurricane season occurs from June to October. Hurricanes and tropical storms bring winds, waves, high tides, and storm surge, which cause flooding and erosion. This flooding and erosion causes property damage to low-lying barrier islands and interior bays.

B. Sediments

Along the Tampa Bay to Naples, FL region, sediments in nearshore and inlet environments are consistently composed of 90% to 95% by weight of fine to very fine quartz sand. The remaining fraction consists of gravel-sized shell fragments and a minor amount of biologically produced silt-plus-clay sized grains (Evans *et al.*, 1985). Higher shell contents occur in tidal channels that therefore have a coarser mean grain size than adjacent shorelines (Lynch-Blosse, 1977). No rivers provide new sediment to the coastal system, and unconsolidated sediment cover thins rapidly seaward (Davis and Kuhn, 1985) with the exception of offshore sand ridges (Finkl *et al.*, 2007).

Anna Maria Island

Sand samples were collected at the south end of Anna Maria Island in 2008 in support of the Anna Maria Island Coquina Beach nourishment project (CPE, 2009). The composite sediment characteristics for the Coquina Beach segment (R-36 to R-41, toe of dune to -20 feet NAVD) appear in Table 2-1.

TABLE 2-1
SELECTED AVAILABLE SEDIMENT PROPERTIES

Location	Average Shell Hash (%)	Carbonate Content (%)		ean n Size (phi)	Sorting (phi)	Silt (%)	Average Wet Munsell Color Value
Coquina Beach (R-36 to R-41) (CPE, 2009)	1.6	14	0.21	2.25	1.31	1.36	7
Longboat Key (R-46 to R-65) (ATM, 1989)	-N/A-	-N/A-	0.27	1.89	0.94	1.68	-N/A-
Channel (ATM, 1993)	-N/A-	-N/A-	1.03	-0.04	-N/A-	0.00	-N/A-
Flood Shoal (ATM, 1993)	-N/A-	-N/A-	0.15	2.77	-N/A-	0.00	-N/A-
Ebb Shoal (ATM, 1993)	-N/A-	-N/A-	0.18	2.50	0.79	-N/A-	-N/A-
Ebb Shoal, Channel, & IWW (CPE, 2009)	0 to 33	-N/A-	0.13 to 1.69	-0.76 to 2.94	0.30 to 2.34	0.83 to 6.76	6 to 8
Flood Shoal (Athena, 2009)	-N/A-	5 to 43	0.14 to 0.81	0.30 to 2.79	0.19 to 2.53	0.01 to 6.15	-N/A-

Notes:

- 1. All grain size statistics are based on the moment method.
- 2. Silt content is defined as percentage of material passing the #230 (0.0625 mm / 4.00 phi) sieve.
- 3. Shell hash is based on visual assessment of shell material retained on the #5 and #7 sieves (-2.0 and -1.5 phi)
- 4. Sources: (CPE, 2009), (ATM, 1989), (ATM, 1993), (Athena, 2009).

Longboat Key

Beach sediments along the entire length of Longboat Key were characterized in a geotechnical and sand source investigation that was conducted by ATM for the 1993 Longboat Key Beach Restoration Project. Native beach samples along the northern half of the island (R-46 to R-65, +8 to -16 feet NAVD) were collected in 1989 by ATM (ATM, 1989 as referenced in Finkl, 2009). The 1989 composite sediment characteristics for the northern half of Longboat Key appear in Table 2-1. In 2005 and 2006, the beach was renourished using fine-grained (0.20 mm) white sands along the entire beach which overlie medium-grained (0.45 mm) material that was placed in erosional hotspots (Finkl, et al., 2009).

The 1989 geotechnical study for the 1993 Longboat Key project found that the average phi size of the samples taken within the ebb shoal was 2.5 phi (0.18 mm) with a phi sorting of 0.79 (see Table 2-1). The fine fraction comprised less than 3 percent of the sub-area volumes (ATM, 1993). In March 1992, a total of 22 samples were collected within the channel and flood shoal of Longboat Pass. The mean grain size ranged from 1.03 mm in the center of Longboat Pass to 0.15 mm in the flood shoal (ATM, 1993).

Twenty (20) vibracores were collected from the Longboat Pass channel (including the ebb shoal) and the IWW behind Anna Maria Island in support of the Manatee County Coquina Beach Nourishment Project (CPE, 2009). The grain size of the samples collected from the vibracores ranges from 0.13 mm to 1.69 mm (average of 0.30 mm). The shell hash content is between 0 and 33% with an average of 7%. The content of fines (defined as material passing the #230 sieve) is between 0.83 and 6.76% (average of 1.73%). Sorting ranges from 0.30 to 2.34 (very well sorted to very poorly sorted). The color generally falls between 5Y 6/1 (gray) and 5Y 8/1 (white). The average wet Munsell Value is 7. Several samples have a hue of 2.5Y. Generally, the upper 8 to 10 ft of material is a light gray to white, fine-grained sand with trace silt and trace shell. Below approximately 10 ft, the color is significantly darker (Munsell Values of 4 and 5) and the material is a mix of fine-grained sand, clay and shell fragments.

On December 2, 2009, Humiston & Moore was granted a De Minimus Exemption from the FDEP to collect 12 vibracores throughout the Longboat Pass flood shoal to investigate sand quality for future establishment of a sand trap for periodic maintenance dredging (File No. 0298107-001-BE, Manatee). The vibracores were collected and analyzed by Athena Technologies, Inc. (2009). Sand characteristics based on the cores appear in Table 2-1. The color of the sand was not reported.

C. Tides

Tides at the project location are mixed tides. Typical observed tides near the Gulf shoreline (ATM, 1992, see Figure 2-1) appear in Figure 2-1. During the majority of the 14-day springneap cycle, there are two (2) high and two (2) low tides each day, with different high tide and low tide elevations. However, during a small portion of the 14-day cycle, there is only one high tide and one low tide each day. Published tidal datums at the locations in Figure 2-2 appear in Table 2-2. Differences between the published tidal datums (LABINS, 2003) and the observations in Figure 2-1 are probably due to local effects such as wind stress. Although the mean tidal range in the Gulf, based on the established tidal datums is 1.4 feet, the tide range during spring tides can exceed 3 feet, as shown in Figure 2-1. Within the bay, the tide range ranges from 1.3 to 1.5 feet.

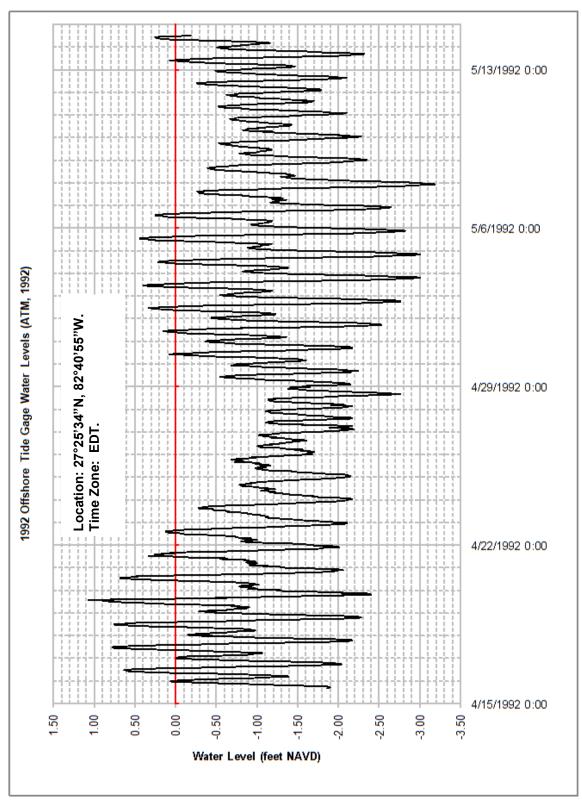
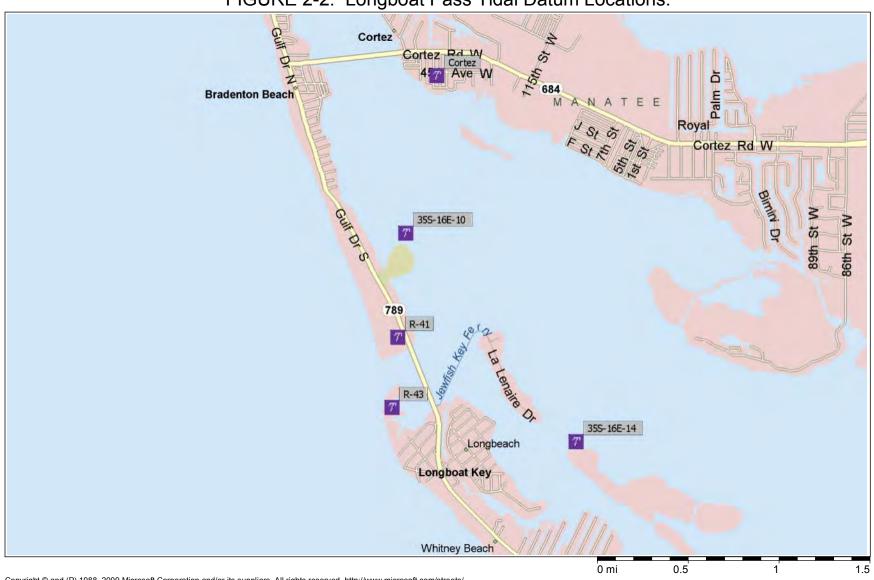


FIGURE 2-1: Typical Observed Gulf Tides (ATM, 1992).

FIGURE 2-2: Longboat Pass Tidal Datum Locations.



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TABLE 2-2
TIDAL DATUMS IN FEET NAVD LONGBOAT PASS, FL

	R-41 (Longboat Key)	R-43 (Anna Maria Island)	36S-17E-28 (Sar. R-27.5)	35S-16E-10 (Leffis Key)	35S-16E-14 (Sister Key)	Cortez (Mainland)
Mean Higher High Water (MHHW)	-N/A-	-N/A-	-N/A-	-N/A-	-N/A-	0.52
Mean High Water (MHW)	0.2	0.3	0.40	0.23	0.21	0.23
Mean Sea Level (MSL)	-N/A-	-N/A-	-N/A-	-N/A-	-N/A-	-0.48
Mean Tide Level (MTL)	-N/A-	-N/A-	-0.31	-0.50	-0.45	-0.50
Mean Low Water (MLW)	-N/A-	-N/A-	-1.01	-1.22	-1.10	-1.23
Mean Lower Low Water (MLLW)	-N/A-	-N/A-	-N/A-	-N/A-	-N/A-	-1.57
Tide Range (feet)			1.41	1.45	1.31	1.46
Latitude	27° 26' 43" N	27° 26' 23" N	27° 19' 52" N	27° 27' 14" N	27° 26' 13" N	27° 28' 00" N
Longitude	82° 41' 25" W	82° 41' 26" W	82° 35' 41" W	82° 41' 22" W	82° 40' 26" W	82° 41' 12" W
Source:	FDEP (2009)	FDEP (2009)	LABINS (2003)	LABINS (2003)	LABINS (2003)	NOAA (2003)

D. Waves

Wave statistics near Longboat Pass are based on the two wave hindcasts at WIS Station 272 (Figure 2-3):

- The U.S. Army Corps of Engineers (2003) Wave Information System (WIS) hindcast, from 1980 to 1999.
- The National Oceanographic and Atmospheric Administration (NOAA) WAVEWATCH hindcast, from 2000 to the present.

WIS Station 272 is located 14 miles offshore at 27.45155°N, 82.91727°W, at a nominal depth of 52.5 feet. The locations of the data sources used in the Delft3D modeling effort (Appendix A) and earlier model studies (CPE, 2008) appear with WIS Station 272 in Figure 2-3.

The directional and seasonal wave statistics at WIS Station 272 appear in Figures 2-4 to 2-8. Based on the NOAA (2009) wave hindcast, the prevailing wave directions are from the west, the west-northwest, the south, and the south-southeast. Although there are high percentages of oblique waves coming from the southerly direction bands, the waves coming from the northerly direction bands during average conditions tend to be higher (Figures 2-4). As a result, the prevailing sediment transport direction along most of Anna Maria Island and Longboat Key is from north to south. The highest and longest waves under average conditions occur during the winter months and during the peak of hurricane season, when distant storms can increase the wave height (Figures 2-5 and 2-6). The root mean square wave height is approximately 2.4 feet, with an average peak period of 4.5 seconds. During the fall and winter months, the prevailing waves are from the northerly direction bands. During the late spring and summer months, the prevailing waves are from the southerly direction bands.

The highest and longest waves under storm conditions occur during hurricane season. However, direct hits from hurricane and tropical storms are not necessary for the generation of large waves. The highest estimated wave of 20 feet (Figure 2-5) was generated by Hurricane Opal on October 4, 1995. Hurricane Frances (September 4, 2004) generated the highest estimated wave after 1999, which was 17 feet (Figure 2-5). The longest waves during the hurricane season are on the order of 16 seconds. During the winter months, storm waves range from 10 to 16 feet, with wave periods in ranging from 9 to 12 seconds.

E. Winds

Winds statistics at Longboat Pass are based on the wind velocities provided with the 1980 to 1999 wave hindcast at WIS Station 272 (USACE, 2003). Based on this data set, the prevailing winds come from the easterly direction bands (Figure 2-9). The average wind speed is approximately 13 mph, with an average direction of 68° (east-northeast). The maximum wind speed between 1980 and 1999 was 48 mph, occurring on November 23, 1988 during tropical storm Keith.

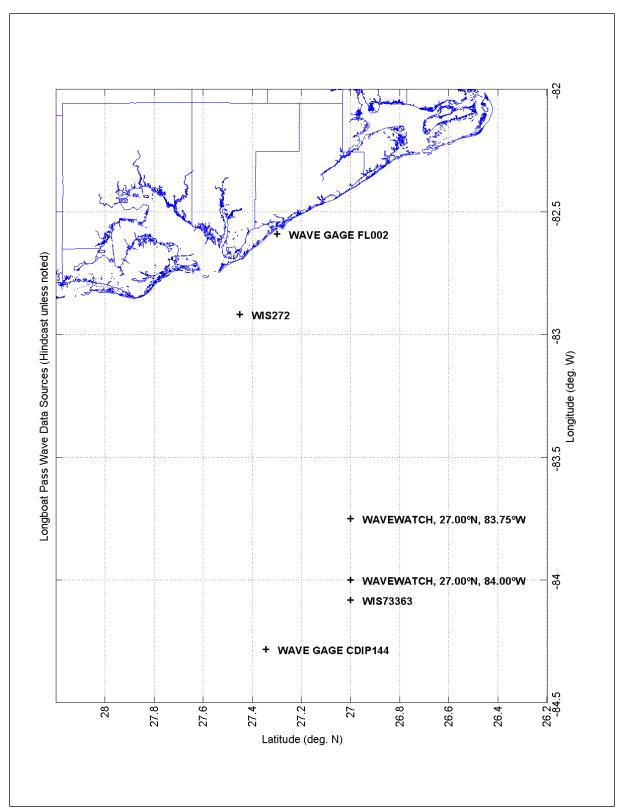
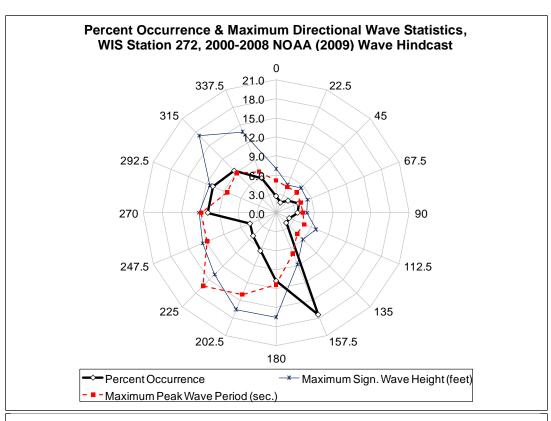


FIGURE 2-3: Longboat Pass Wave Data Sources.



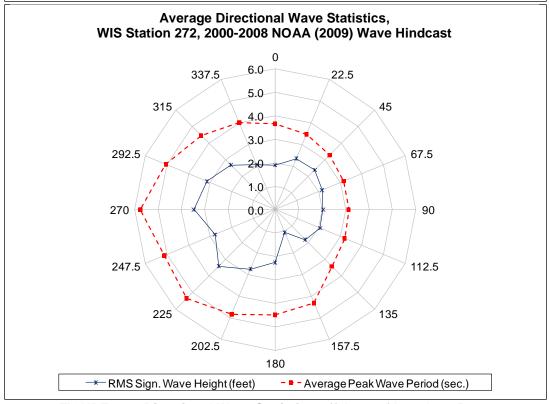


FIGURE 2-4: Directional Wave Statistics Offshore of Longboat Pass.

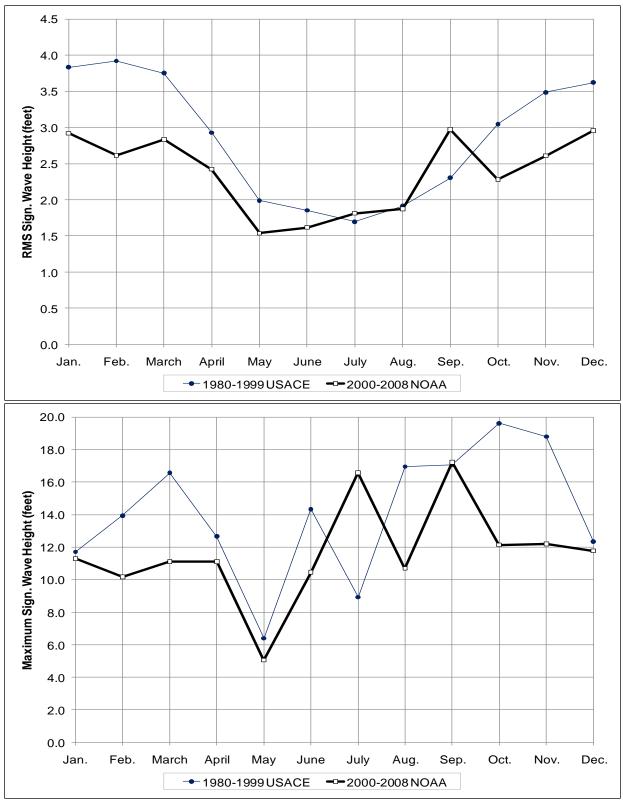


FIGURE 2-5: Monthly Wave Height Statistics Offshore of Longboat Key (WIS Station 272).

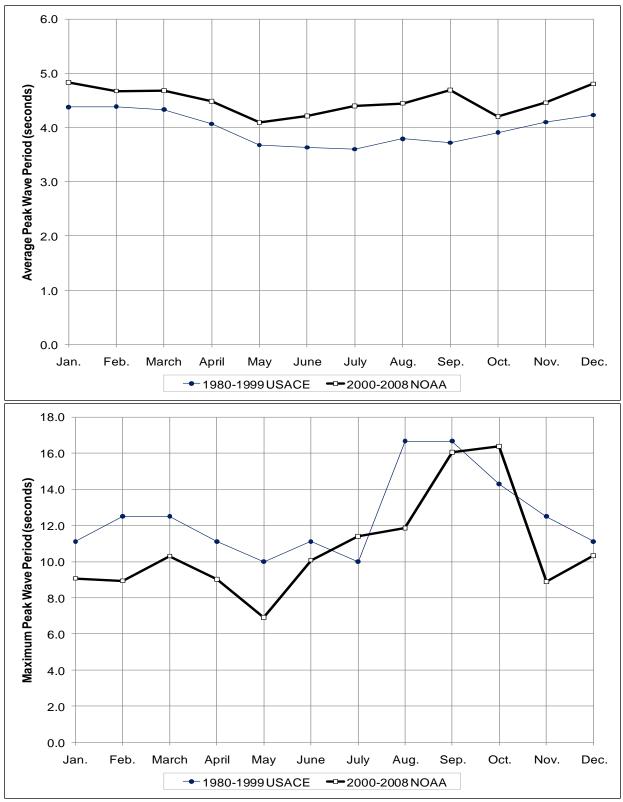


FIGURE 2-6: Monthly Wave Period Statistics Offshore of Longboat Key (WIS Station 272).

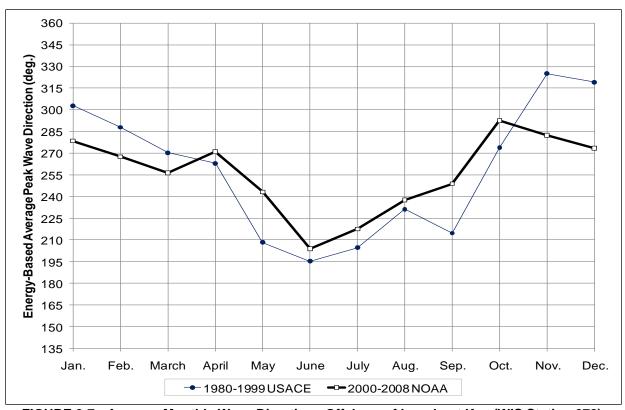


FIGURE 2-7: Average Monthly Wave Directions Offshore of Longboat Key (WIS Station 272).

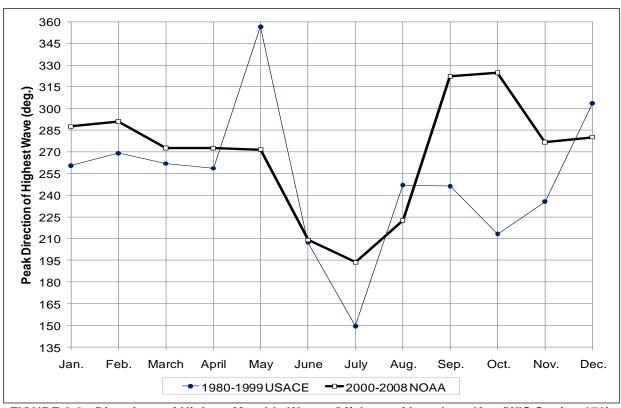


FIGURE 2-8: Directions of Highest Monthly Waves Offshore of Longboat Key (WIS Station 272).

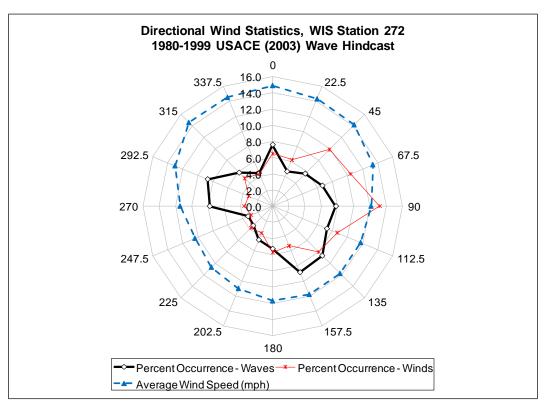


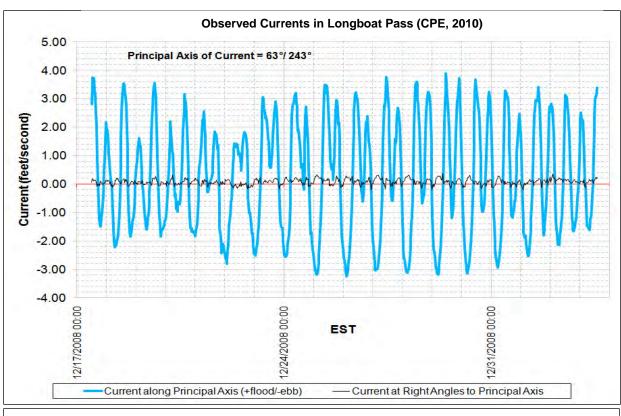
FIGURE 2-9: Directional Wind Statistics.

F. Currents

Current measurements were taken in Longboat Pass by CPE in 2008-2009 and by ATM in 1992 (Figures 2-10 to 2-11). Further information regarding current measurements appears in Appendix A. The 2008-2009 measurements indicate that the principal axis of the current is 63°/243° (east-northeast / west-southwest), which suggests a slight rotation from the 1992 measurements (83°/263°). During spring tides, maximum current speeds are on the order of 3.9 feet/second during flood and 3.1 feet/second during ebb. During neap tides, the maximum current speeds are on the order of 1.8 to 2.6 feet/second during flood and 1.9 feet/second during ebb.



FIGURE 2-10: Locations of 1992 and 2008-2009 Current Measurements.



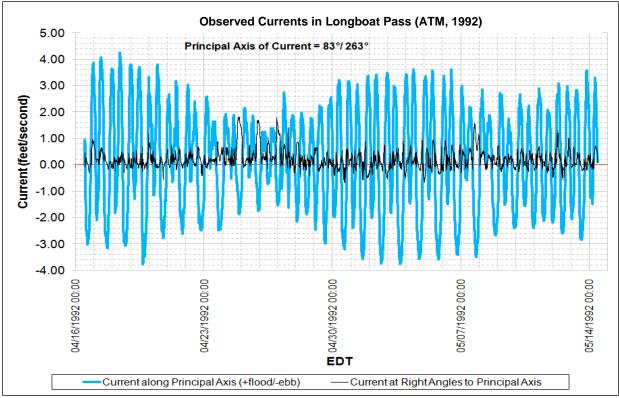


FIGURE 2-11: Typical Observed Currents in Longboat Pass.

G. Structures

Longboat Pass has one terminal groin, constructed in the 1957 at the south end of Anna Maria Island (Figure 2-12). To sand-tighten the structure, a 300 foot long series of geotextile tubes will be placed along the north side of the structure in late 2011 or early 2012. The crest elevation of this structure is approximately +3 feet NAVD.

In addition to the terminal groin, the southern portion of Anna Maria Island (from R-36 to R-40) has a groin field consisting of 18 groins approximately 100 feet in length, with crest elevations ranging from 2 to 2.4 feet NGVD (Figure 2-12). The spacing between the groins varies, but is typically 260 feet. These shore protection structures are made from concrete with rubble adjacent to the structures. There are also 3 permeable groins north of Coquina Beach constructed of concrete pile sections and decking, depicted and labeled as the Cortez Groins in Figure 2-12.

On Longboat Key, there are two major structures located near Longboat Pass – the North Shore Road seawall and the 6633 Gulf of Mexico Drive (GMD) seawall (Figure 2-13). The North Shore Road seawall is fronted by rubble toe scour protection. The crest elevation of this structure is +4.9 feet NAVD (Hyatt, 2010). The 6633 Gulf of Mexico Drive seawall does not feature any toe scour protection. The amount of beach width in front of the 6633 GMD seawall is presently negligible. In addition to these 2 structures, there are a number of buried seawalls and revetments near Gulfside Road (R50-R50.5) and profile R51-200' (ATM, 1991). These structures have been buried since the 1993 Longboat Key Beach Restoration Project. The crest elevations of the 6633 Gulf of Mexico Drive seawall and the buried structures range from 4.5 to 4.8 feet NAVD (ATM, 1991). The North Shore Road seawall is scheduled for maintenance and landward extension of the north return wall beginning in November 2011.

In May 2009, the Town of Longboat Key filed a Joint Coastal Permit application (0295923-001-JC) to construct 4 breakwaters in front of the North Shore Road seawall (see Figure 2-13). To address impacts on the adjacent beaches, trucked fill was also proposed behind the breakwaters and on the surrounding beaches. The permitting effort for this project was suspended at the Town's request at the initiation of this study to seek a more regional solution.

H. Morphology and Bathymetry

Although a variety of types of inlets exist, the same basic processes generally apply. Inlets may be classified based on their hydraulics, geometry/morphology and stability (Vincent and Corson, 1980). Inlets are unique to one another based on their local geology, morphology, specific hydrodynamic conditions and anthropogenic influences. Inlets may be classified as wave-dominated, tide dominated or mixed. Longboat Pass is classified as a tide-dominated inlet. Tide dominated inlets are characterized by ebb shoals with large channel margin bars similar to dual jetties.

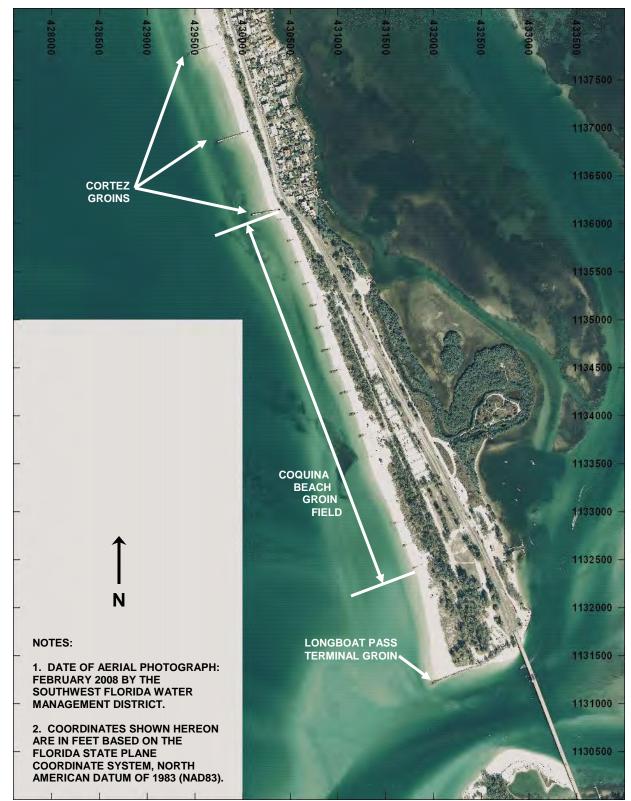


FIGURE 2-12: Structures on Anna Maria Island near Longboat Pass.



FIGURE 2-13: Structures on Longboat Key near Longboat Pass.

Bypassing at tide-dominated inlets can occur by tidal action (Bruun and Gerritsen, 1958), in which the sediment enters the channel on one side at flood tide and a portion eventually returns to the opposite side during the ebb tide. Reorientation of the outer channel is another mechanism of bar bypassing in tide-dominated inlets (Fitzgerald, et al. 2001). This was the mechanism that occurred at Longboat Pass around 1939, when the island that split Longboat Pass was joined to the pass's northern shoreline. Another mechanism of bypassing at tide-dominated inlets is the onshore movement of sand bodies over the shallower portion of the ebb shoal exposed to breaking waves. Bypassing may also occur during storms as portions of the channel-margin bars or other features of the ebb shoal may break off and migrate onshore (Gaudiano and Kana, 2001). For a relocated inlet, abandonment of the old ebb shoal can serve to nourish the downdrift beach (Kana and Mason, 1988). Interruptions in the flow of sediment between shorelines, through natural or anthropogenic mechanisms such as large scale ebb shoal dredging or improper structures, may lead to increased erosion of shorelines adjacent to the inlet.

A large ebb shoal is located at the mouth of the inlet at Longboat Pass and has been surveyed numerous times. The base elevation of this shoal varies from -25 to -27 feet NAVD and extends to a minimum depth of -4 feet NAVD along the northern margin of the navigation channel (Hearn and Erikson, 1993). Sand thickness decreases towards the west in direct proportion to the increase in water depth. The shoal is thickest at the mouth of the Pass; prior to 1993 it has been reported to contain an 18 foot thick layer of beach quality sand (Hearn and Erikson, 1993). In 1982, the volume of the shoal was estimated to be 8.2 million cubic yards. In 1991, the estimated volume of the ebb shoal was 6.6 million cubic yards (Hearn and Erikson, 1993). The volume of sediment within the flood shoal has been estimated at between 2.8 and 3.6 million cubic yards (Carr-Betts, 1999), based on the examination of nautical charts from 1977 and 1981.

Finkl et al., (2007) assessed the morphology of the ebb shoal at Longboat Pass through the evaluation of aerial photographs. Based on their analysis of aerial photographs from 1940 through 2007, the ebb shoal area has varied from between 13,000,000 sq. ft. (0.47 sq. miles) to 18,000,000 sq. ft. (0.65 sq. miles). They were also able to identify that the ebb shoal area has varied by only 0.18 sq. miles between 1960 and 2003. Though the area of the ebb shoal has not varied significantly, the shape of the ebb-tidal shoal has changed. In 1954, the ebb shoal stretched from approximately R-40 to R-46 (Figure 2-14). By 2009, the ebb shoal had shifted towards the south, extending from profiles R-41 to R-48 (Figure 2-15).

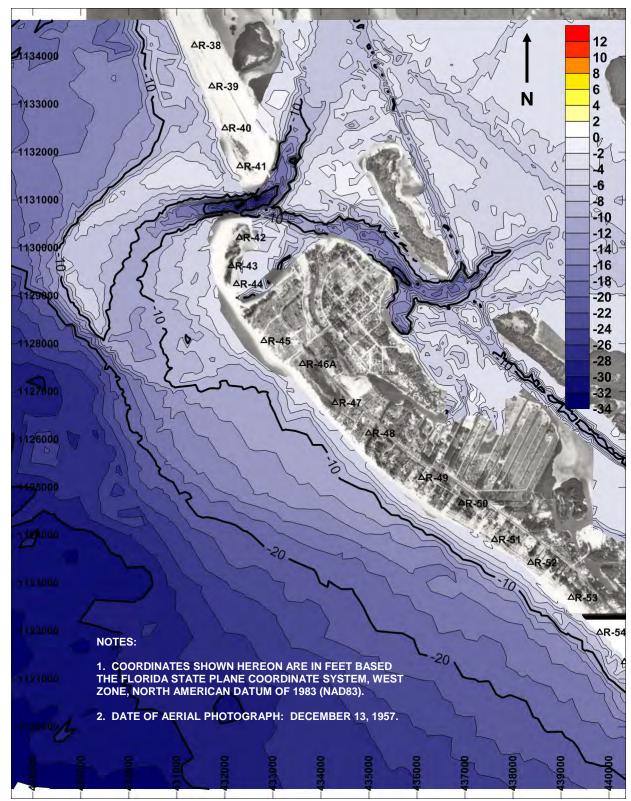


FIGURE 2-14: Longboat Pass 1954 Bathymetry (feet NAVD).

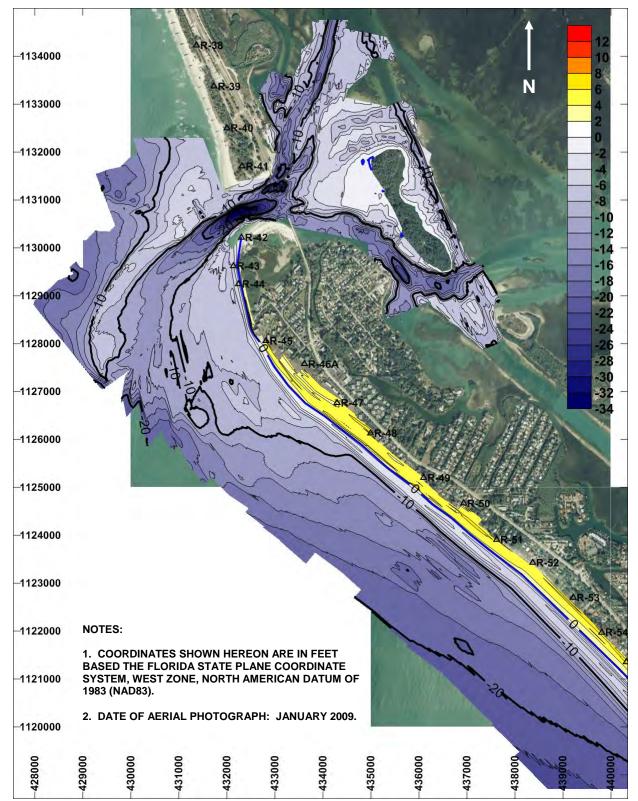


FIGURE 2-15: Longboat Pass March-October 2009 Bathymetry (feet NAVD).

As noted in Table 1-1, the southwest portion of the ebb shoal was dredged in 1993 to nourish the northern half of Longboat Key. This removal of material decreased the horizontal extent of the ebb shoal. In additional, it may have contributed to the shifting of the ebb shoal towards the south (Finkl, et al, 2007). In 1991, the ebb shoal covered an area of approximately 18,000,000 sq. ft. (0.65 sq. miles). In 1995, the ebb shoal covered an area of 15,000,000 sq. ft. (0.54 sq. miles), and by 2001 the ebb shoal only covered an area of 13,000,000 sq. ft. (0.47 sq. miles). By 2003, the ebb shoal appeared to be recovering, covering an area of 16,000,000 sq. ft. (0.57 sq. miles). The 1983 closure of Midnight Pass, which separated Siesta Key and Casey Key, may have also contributed to these changes by increasing the flow through Sarasota Bay's other inlets, including Longboat Pass (Humiston & Moore, 2008).

The Federally Authorized depth in the Longboat Pass navigation channel ranges from -11.57 to -13.57 feet NAVD (-10 to -12 feet MLLW). However, the actual channel depth varies from -12 feet NAVD to -33 feet NAVD (see Figures 2-14 and 2-15). The deepest sections of the channel are located between the Longboat Pass bridge and seaward end of the terminal groin on Anna Maria Island. East of the bridge, the channel splits into two. The southern branch runs from west-northwest to east-southeast, with depths ranging from -12 to -22 feet NAVD. This branch is not part of the Federal navigation project and is not dredged on a regular basis. The typical depths within this branch have existed since the 1800s (see Humiston & Moore, 2008, p. 26). The northern branch runs from south-southwest to north-northeast, with depths ranging from -12 to -22 feet NAVD. This branch is part of the Federal navigation project, which is largely responsible for its present depth. Prior to the establishment of the Federal navigation project (1977), the northern branch was much shallower (see Figure 2-14).

I. Previous Estimates of Sediment Transport in the Vicinity of Longboat Pass

The main source of littoral material for the beaches of Anna Maria Island and Longboat Key are the barrier islands themselves, portions of the interior channels, and the adjacent offshore shoals. Prior to 1992/1993 when the first federal nourishment of the Anna Maria Island shoreline (R-12 to R-36) occurred, there were multiple revetments and groins exposed along AMI. This indicates that the beach profiles were likely sand starved and limited sediment was being transported toward Longboat Pass. The following is a historical description of previous sediment budgets and sediment transport estimates. An updated sediment budget produced for this study is presented later in this section.

Walton & Dean (1973)

Walton and Dean (1973) used littoral drift roses for us in predicting transport rates along a shoreline as a function of the orientation of the shoreline. Wave data used to compute the alongshore transport rates was compiled from the Summary of Synoptic Meteorological Observations (SSMO). Because the transport computation is sensitive to an individual's interpretation of shoreline orientation, an 11.5 degree range of shoreline orientation was used in reading the littoral drift roses. Walton and Dean (1973) determined the range of net sediment transport on either side of the inlet to be between 30,000 and 45,000 cubic yards per year to the south (ATM, 1993) (see Table 2-3).

TABLE 2-3
PREVIOUS ESTIMATES OF SEDIMENT TRANSPORT

Author, Date	Net Alongshore Transport (c.y./year) Anna Maria Is.	Net Alongshore Transport (c.y./year) Longboat Key	Method of Determination
Walton & Dean, 1973	30,000 - 45,000	30,000 - 45,000	Littoral drift roses using
in ATM, 1993	to the south	to the south	wave data
ATM, 1993	(See Figure 2-16)	(See Figure 2-16)	1974-1986 Volume Changes + 1986-1991 Volume Changes
ATM, 1993	(See Figure 2-17)	(See Figure 2-17)	1974-1991 Volume Changes
CPE, 1995		17,300 to the south at R-43 0 at R-50.5	1974-1987 volumetric changes above -15 feet NGVD
CPE, 1995		38,000 to the north at R-43 68,000 to the south at R-50.5	1993-1995 volumetric changes above -15 feet NGVD
CPE, 2000	53,000 to the south at R-41		1993-1998 volumetric changes above -18 feet NGVD
CPE, 2004		23,400 to the north at R-42 11,600 to the south at R-48	1995-2003 volumetric changes above -15 feet NGVD
CPE, 2006		113,500 to the north at R-42 8,800 to the south at R-48	2003-2005 volumetric changes above -5 feet NGVD
CPE, 2007	98,300 to the south at R-41		2002-2006 volumetric changes above -12 feet NGVD

1993 Longboat Pass Inlet Management Plan

The 1993 Longboat Pass Inlet Management Plan (ATM, 1993) indicates that the net direction of sand transport along the coast of Manatee County is generally north to south. At Longboat Pass, there is an area of localized sediment transport from south to north. Evidence of this is the formation of the spit referred to as Beer Can Island or Greer Island on the northern tip of Longboat Key. The area 5,000 to 8,000 feet south of Longboat Pass (between R-48 and R-51) is described as a "nodal point", from which the net alongshore transport is in both directions. The nodal point at Longboat Key develops as northerly directed waves refract around and over the ebb shoal (ATM, 1993). The 1993 Longboat Pass Inlet Management Plan calculated the volumetric change along Anna Maria Island and Longboat Key using surveys from 1974, 1986 (FDNR) and 1991/92 (USACE). Since there were differences in the length of each profile line surveyed in 1974, 1986, and 1991/92, ATM developed two distinctly different sediment budgets for the 1974-1991 time period.

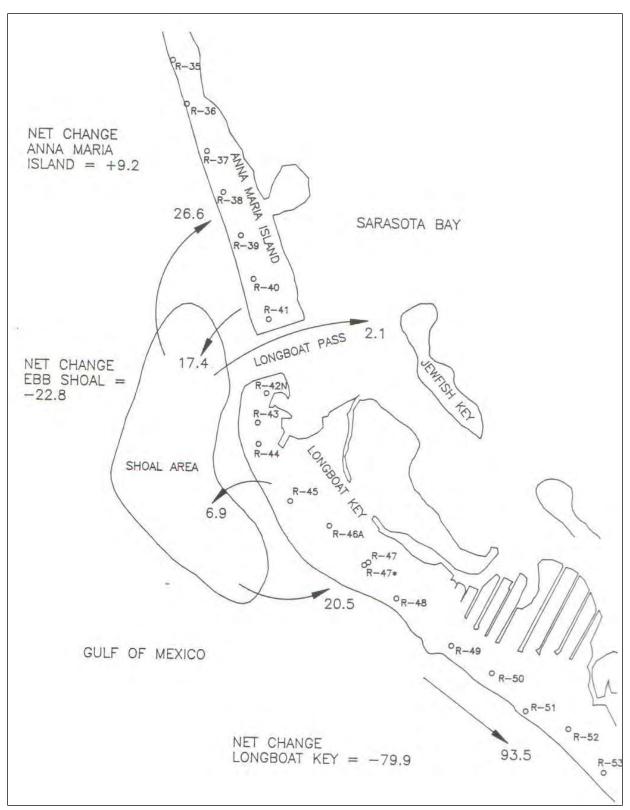


FIGURE 2-16: ATM (1993) Sediment Budget Based on 1974-1986 Volume Changes + 1986-1991 Volume Changes.

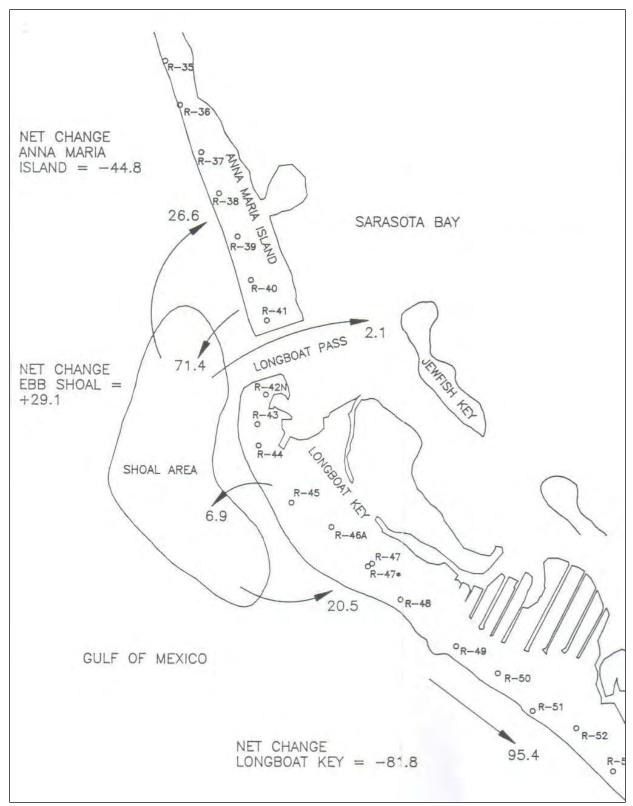


FIGURE 2-17: ATM (1993) Sediment Budget Based on 1974-1991 Volume Changes.

The first approach to the sediment budget estimated the 1974 to 1991 sediment transport by separately calculating the 1974-1986 and 1986-1991 volume changes, and subsequently taking the sum of the two. Using this approach, the net change to Anna Maria Island was +9,200 cubic yards per year, the net change in the ebb shoal was -22,800 cubic yards per year, and the net change to Longboat Key was -79,900 cubic yards per year. Based on these changes, there was a total of 26,600 cubic yards per year transported from the shoal to Anna Maria Island, and 17,400 cubic yards were transported from Anna Maria Island to the shoal annually. Likewise, on Longboat Key, 20,500 cubic yards were transported from the shoal to Longboat Key annually, and 6,900 cubic yards were transported from Longboat Key to the shoal. A total of 2,100 cubic yards per year were transported from the shoal into Longboat Pass (See Figure 2-16).

The second approach compares only the 1974 and 1991 surveys. The two methods produce very different results for the Anna Maria Island shoreline and the shoal, but not as much for the Longboat Key shoreline. The 1991/92 USACE surveys were not long enough to capture the entire offshore area (approximately -10 ft NGVD to beyond -20 feet NGVD). Thus, when the 1974 survey was directly compared to the 1991/92 survey any changes occurring in the offshore were not captured due to the limited length of the 1991/92 surveys. Based on this approach, the net change to Anna Maria Island was -44,800 cubic yards per year, the net change in the ebb shoal was +29,100 cubic yards per year, and the net change to Longboat Key was -81,800 cubic yards per year. Based on these changes, 26,600 cubic yards per year were transported from the shoal to Anna Maria Island, and 71,400 cubic yards were transported from Anna Maria Island to the shoal annually. Likewise, 20,500 cubic yards were transported from the shoal to Longboat Key annually, and 6,900 cubic yards per year were transported from Longboat Key to the shoal (see Figure 2-17). Net transport from the shoal into Longboat Pass was assumed to be the same as the first approach. The first method predicted a net annual loss to the "shoal system" (the region between the jetty on Anna Maria Island and R-45 on Longboat Key, including material transported into the Pass), while the second method predicted a net gain (ATM, 1993).

Additional Estimates for Longboat Key

Additional sediment budgets have been developed for the Town of Longboat Key. These include the following:

- Town of Longboat Key Comprehensive Beach Management Plan (CPE, 1995) 1974-1987 and 1993-1995 sediment budgets. These sediment budgets accounted for alongshore transport, dredge spoil placement, and cross-shore transport between the Longboat Pass ebb shoal and the beaches on the north end of Longboat Key.
- Greer Island Erosion Analysis (CPE, 2004) 1995-2003 sediment budget. These sediment budgets accounted for alongshore transport, dredge spoil placement, and a small degree of overwash on Greer Island.
- Town of Longboat Key North End Groins Permit Application 0259926-001-JC, Request for Additional Information #1, Attachment No. 33 2003-2005 sediment budget. These sediment budgets accounted for alongshore transport, a small degree of overwash on Greer Island, and various groin and renourishment scenarios.

Anna Maria Island Sediment Budgets (CPE, 2000 & 2007)

Two sediment budgets were developed for Anna Maria Island – the 1993 to 1998 sediment budget and the 2002 to 2006 sediment budget. The 1993 to 1998 sediment budget was developed for the October 2000 Limited Re-Evaluation Report for the Federal shore protection project on Anna Maria Island. This sediment budget was based on volume changes above -18 feet NGVD (-19 feet NAVD) between the February 1993 and February 1998, and assumed a nodal point between profiles R-20 and R-21. The 2002 to 2006 sediment budget was developed for the 2006-2007 Anna Maria Island Feasibility Study (CPE, 2007). This sediment budget was based on volume changes above -12 feet NGVD between May 2002 and May 2006, and assumed a nodal point near the same location. It also accounted for the fill volume placed in 2005 and 2006 by Goodloe Marine, Inc. Estimates provided by Goodloe (2006) indicated that the fill volume was approximately 224,600 cubic yards. However, the 2002 to 2006 sediment budget assumed 200,000 cubic yards of fill from profiles R-12 to R-29. Based on the two sediment budgets (Figure 2-18), the amount of material entering Longboat Pass at profile R-41 ranged from 53,000 to 98,300 c.y./year. The 2003-2009 sediment transport rates, which appear in Figure 2-18, will be discussed later in this report.

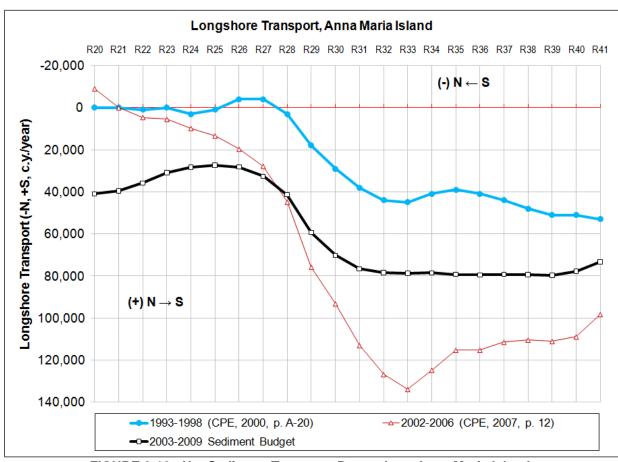


FIGURE 2-18: Net Sediment Transport Rates along Anna Maria Island.

Regional Model for Sarasota Bay and Case Studies of Longboat Pass and Venice Inlet (Humiston & Moore, 2008)

Although Humiston and Moore (2008) did not present a formal sediment budget as part of their regional modeling study, they utilized the Inlet Reservoir Model to calculate sediment transport and bypassing rates based on dredging records and volume changes over the areas shown in Figure 2-19. Using the reservoir model, the volume contained in each cell was projected to the year 2010 (Table 2-4).

TABLE 2-4

ESTIMATED 1880-2010 VOLUME CHANGES IN THE AREAS SHOWN IN FIGURE 2-8 BASED ON THE RESERVOIR MODEL

HUMISTON & MOORE (2008)

Cell	Estimated Volume (cubic yards)					
Location	Minimum	Mean	Maximum			
Anna Maria Beach	1,700,000	1,850,000	2,100,000			
Jetty Impoundment	690,000	710,000	750,000			
Anna Maria Bar	420,000	500,000	550,000			
Flood Shoal	1,900,000	2,000,000	2,000,000			
Ebb Shoal North	400,000	750,000	1,250,000			
Ebb Shoal South	50,000	300,000	550,000			
Ebb Shoal Total	4,100,000	5,250,000	5,950,000			
Ebb Channel	-N/A-	-N/A-	-N/A-			
Flood Channel North & South	1,950,000	2,000,000	2,000,000			
Beer Can Shoal	520,000	580,000	585,000			
Beer Can Island	850,000	900,000	900,000			
Longboat Bar	1,000,000	1,125,000	1,250,000			
Longboat Beach	1,750,000	1,800,000	1,850,000			

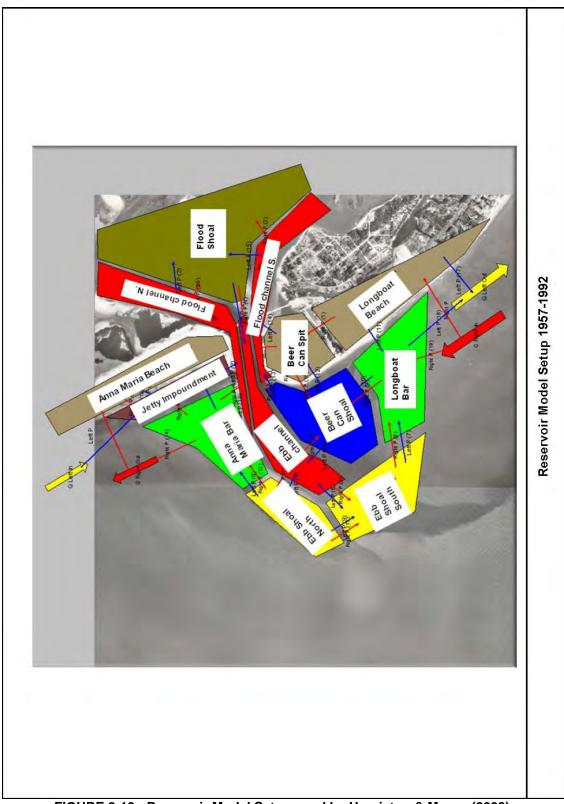


FIGURE 2-19: Reservoir Model Setup used by Humiston & Moore (2008).

J. Shoreline and Volume Changes

Shoreline change can be determined through the qualitative evaluation of aerial photographs or, quantitatively through surveys. Both methods have been utilized to study the shoreline change along Anna Maria Island and Longboat Key. Shoreline changes based on surveys assume a shoreline elevation of +0.1 feet NAVD / +1.1 feet NAVD on Longboat Key (CPE, 2010) and +0.2 feet NAVD / +1.2 feet NGVD on Anna Maria Island (USACE, 1991).

General

Based on historical records, the shoreline between R-45 and R-46 lost approximately 650 feet in 1932 (Hearn and Erikson, 1993). In 1935, the "Labor Day Hurricane" caused approximately 75 feet of accretion overnight near R-48 (Hearn and Erikson, 1993). According to the early residents of Longboat Key, the area known as Whitney Beach (R-47 to R-49), accreted 220 feet between 1935 and 1939 (Hearn and Erikson, 1993). In 1939, Jewfish and Pickett Keys were joined during the construction of the Intracoastal Waterway, which altered flow patterns through the inlet (Hearn and Erikson, 1993). Prior to 1939, the north end of Longboat Key was characterized by a wide and rapidly accreting beach. After the Pickett Key joined itself to Jewfish Key, erosion rates on the north end of Longboat Key and the south end of Anna Maria Island began to increase. Nevertheless, aerial photographs collected in 1940 and 1951 show a wide beach at the northern end of Longboat Key (Finkl et al., 2007).

Between 1940 and 1951, sand from the eroding beaches to the south contributed to the development of a 2,000 foot long spit that extended into Longboat Pass (Figure 2-20). In the early 1960's the spit was breached (Figure 2-21). At that time, the reach of shoreline between R-42 and R-44 was bordered by two tidal channels and became known as Beer Can Island. The second channel ran parallel to North Shore Road (R-44.5). In 1966, the Town of Longboat Key dredged a boat channel from the southern end of the bridge into the main channel. The dredged channel diverted tidal flow and caused southern channel to close (Figure 2-22). The spit curved south at approximately R-42 and continued to grow south until the early 1980's (Figure 2-23). Since then, a second spit has developed and curved south. Currently, sand moves to the island's terminus and is either transported into Longboat Pass or wraps around the spit into the bay at the bridge (Figure 2-24). The active spit is positioned east of the historic spit (CPE, 2006).

Anna Maria Island

Since 1993, shoreline changes on Anna Maria Island have been characterized by variable trends on Holmes Beach (R-20 to R-25), moderate to high retreat rates on Bradenton Beach (R-25 to R-30), mild to moderate retreat rates on Cortez Beach (R-30 to R-36), and mild retreat rates on Coquina Beach. Four projects have been constructed on the island during this period:



FIGURE 2-20: November 1951 Aerial Photograph of Longboat Pass (Source: Inlets Online).



FIGURE 2-21: November 1960 Aerial Photograph of Longboat Pass (Source: Inlets Online).

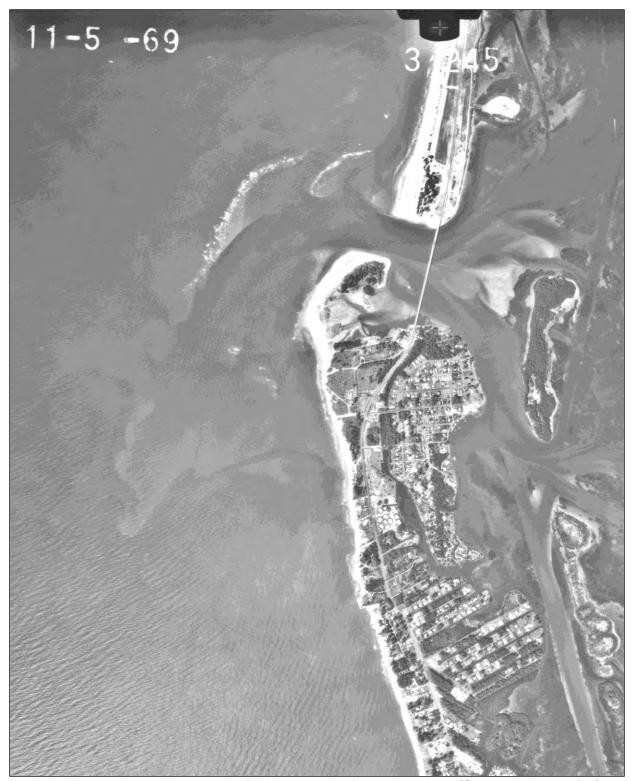


FIGURE 2-22: November 1969 Aerial Photograph of Longboat Pass (Source: Inlets Online).



FIGURE 2-23: October 1980 Aerial Photograph of Longboat Pass (Source: Inlets Online).

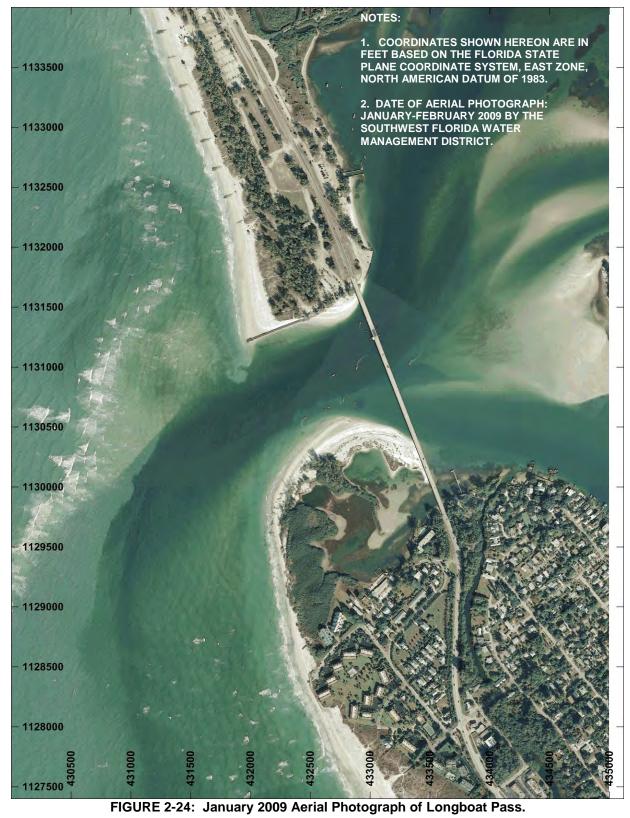


FIGURE 2-24: January 2009 Aerial Photograph of Longboat Pass.

- The 1992-1993 Anna Maria Island Beach Restoration Project. This project placed 2.32 million cubic yards of fill from profiles R-12 to R-36.
- The 2002 Anna Maria Island Beach Renourishment Project. This project placed 1.8 million cubic yards of fill from profiles R-7 through R-10 and R-12 through R-36.
- The Anna Maria Island 2005-2006 Storm Damage Repair Project. This project placed approximately 224,600 cubic yards of material from R11+901' to R29+452'. This project was characterized by numerous delays and a very uneven distribution of fill.
- The 2011 City of Anna Maria Beach Nourishment and the 2011 Coquina Beach Restoration Project. The City of Anna Maria Beach Nourishment project placed 24,700 c.y. of material between profiles R-7 and R-10, and the Coquina Beach project placed 204,800 c.y. of material between profiles R-35+790 and R-41+305.

In addition to these projects, 59,000 cubic yards of dredge spoil from Longboat Pass were placed on profiles R-34 to R-35 and R-36+511' to R-38+204' in 1997.

Shoreline changes since 1993 appear in Table 2-5 and Figure 2-25. In general, retreat rates have been decreasing since 1992. On Holmes Beach (R-20 to R-25), the spreading of the fill placed in 2005 and 2006 has led to advancing shorelines, reversing the erosional pattern prior to 2002. On the Bradenton Beach erosion hotspot (R-25 to R-30), the average retreat rate dropped 27% after the 2002 project, and declined further after the 2005-2006 project. On Cortez Beach, the average retreat has exhibited similar decreases.

On Coquina Beach (R-36 to R-41), shoreline retreat rates have been relatively low. However, it should be noted that shoreline retreat rates do not provide a complete picture of the erosion problem on Coquina Beach. Some of the profiles along this reach indicate deflation of the profile since 2006 due to recent storms in the Gulf of Mexico such as Hurricane Ike (see Spadoni, et al, 2009 and Figure 2-25A). Nevertheless, the eroded condition of the beach has been largely due to the fact that beach nourishment did not occur there until the recent 2011 project. As shown in Figure 2-7, net sediment transport rates along Coquina Beach do not exhibit large variations with respect to distance. This may be due to the presence of the groins in Figure 2-12. Between profile R-39 and Longboat Pass, the net sediment transport tends to slow down under the present conditions (Figure 2-18). This effect is due to the terminal groin.

Volume changes on Anna Maria Island appear in Table 2-6 and Figure 2-26. On Bradenton Beach (R-25 to R-30), erosion rates increased after the 2002 project was constructed. This segment had the highest fill densities during the 2002 project, ranging from 55 to 138 c.y./foot. The higher concentration of fill resulted in spreading losses, which increased the erosion on the Bradenton Beach (R-25 to R-30), decreased the erosion rate on Cortez Beach (R-30 to R-36), and reversed the net erosion on Holmes Beach (R-20 to R-25) and Coquina Beach (R-36 to R-41).

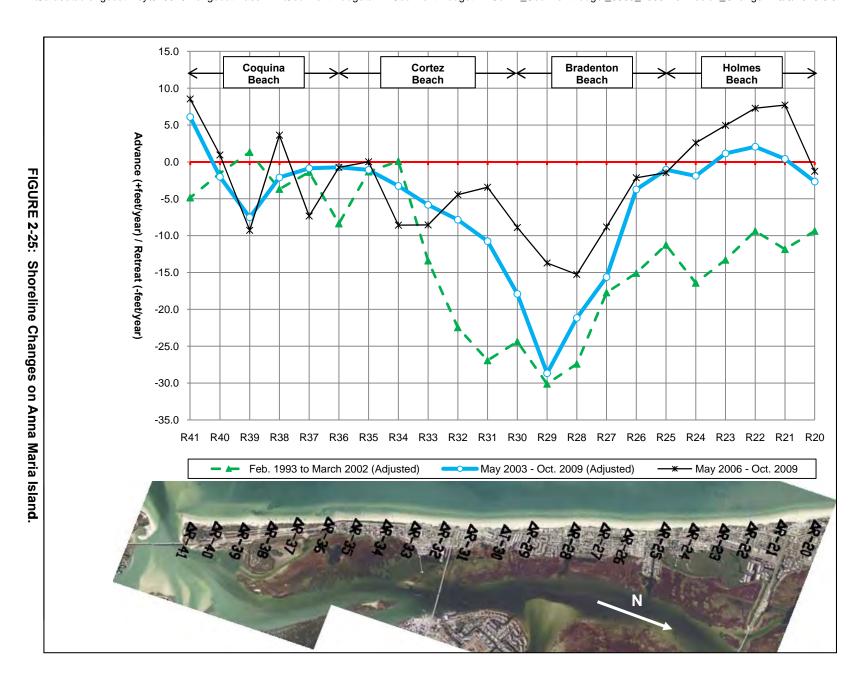


TABLE 2-5 RECENT SHORELINE CHANGES ANNA MARIA ISLAND, FL

	Dist. From	Beach	Feb. 1993 to	March 2002	1993-2002	May 2003 t	o Oct. 2009	2003-2009	May 2006 t	o Oct. 2009
Profile	Inlet	Length	Shoreline	e Change	Adjusted	Adjusted Shoreline Change (feet)		Adjusted	justed Shoreline Change	
Line	(feet)	(feet)	Surveyed	Adjusted	(feet/year)	Surveyed	Adjusted	(feet/year)	(feet)	(feet/year)
R5	35,939	505	-102	-102	-11.3	430	430	67.0	275	80.3
R6	34,930	1,069	-50	-50	-5.5	344	344	53.6	179	52.2
R7	33,801	1,032	-37	-37	-4.1	118	118	18.4	16	4.5
R8	32,867	1,002	-13	-13	-1.4	12	12	1.9	2	0.5
R9	31,798	1,016	-27	-27	-3.0	-20	-20	-3.1	9	2.6
R10	30,835	1,006	3	3	0.4	9	9	1.3	-16	-4.7
R11	29,787	1,079	12	12	1.3	74	74	11.5	7	2.1
R12	28,678	1,045	-144	-144	-15.8	23	-11	-1.6	-11	-3.2
R13	27,698	983	-132	-132	-14.5	-26	-60	-9.3	-20	-5.7
R14	26,713	1,078	-177	-177	-19.5	-33	-84	-13.1	-24	-7.1
R15	25,543	1,022	-154	-154	-16.9	11	-22	-3.5	62	18.2
R16	24,670	903	-154	-154	-17.0	-29	-47	-7.3	-13	-3.8
R17	23,737	939	-118	-118	-13.0	-3	-3	-0.5	3	0.7
R18	22,793	984	-97	-97	-10.7	14	14	2.2	41	12.0
R19	21,769	980	-116	-116	-12.8	30	30	4.6	39	11.5

TABLE 2-5 (continued) RECENT SHORELINE CHANGES ANNA MARIA ISLAND, FL

DEll.	Dist. From	Beach	Feb. 1993 to		1993-2002	May 2003 to		2003-2009		o Oct. 2009
Profile	Inlet	Length	Shoreline	_	Adjusted	Shoreline C		Adjusted	Shoreline	
Line	(feet)	(feet)	Surveyed	Adjusted	(feet/year)	Surveyed	Adjusted	(feet/year)	(feet)	(feet/year)
R20	20,834	1,034	-85	-85	-9.4	-16	-17	-2.7	-4	-1.3
R21	19,701	1,063	-108	-108	-11.8	3	3	0.4	26	7.7
R22	18,709	963	-85	-85	-9.4	13	13	2.1	25	7.3
R23	17,776	971	-121	-121	-13.3	16	7	1.2	17	5.0
R24	16,767	988	-149	-149	-16.4	2	-12	-1.9	9	2.6
R25	15,801	1,086	-102	-102	-11.3	0	-7	-1.1	-5	-1.5
R26	14,596	1,004	-137	-137	-15.1	-19	-24	-3.7	-7	-2.2
R27	13,794	903	-161	-161	-17.7	-82	-100	-15.6	-30	-8.8
R28	12,791	1,200	-249	-249	-27.4	-125	-136	-21.2	-52	-15.3
R29	11,394	1,153	-273	-273	-30.1	-149	-184	-28.7	-47	-13.7
R30	10,485	1,017	-221	-221	-24.4	-115	-115	-17.9	-30	-8.9
R31	9,360	1,017	-244	-244	-26.9	-69	-69	-10.8	-12	-3.4
R32	8,452	934	-204	-204	-22.5	-50	-50	-7.8	-15	-4.4
R33	7,492	956	-122	-122	-13.4	-37	-37	-5.8	-29	-8.5
R34	6,540	985	27	1	0.1	-21	-21	-3.3	-29	-8.6
R35	5,522	970	14	-12	-1.3	-7	-7	-1.1	0	0.0
R36	4,600	975	-76	-76	-8.4	-5	-5	-0.7	-3	-0.7
R37	3,572	954	14	-12	-1.4	-6	-6	-0.9	-25	-7.3
R38	2,692	905	-7	-33	-3.7	-14	-14	-2.1	12	3.6
R39	1,763	918	12	12	1.3	-48	-48	-7.5	-32	-9.3
R40	857	882	-14	-14	-1.5	-13	-13	-2.0	3	0.9
R41	0	429	-44	-44	-4.8	39	39	6.1	29	8.5
R5-R20		15,105	-86	-86	-9.4	51	39	6.1	28	8.2
R20-R25	Homes	5,033	-111	-111	-12.2	5	0	-0.1	14	4.2
R25-R30	Bradenton	5,316	-199	-199	-21.9	-88	-103	-16.0	-32	-9.2
R30-R36	Cortez	5,885	-114	-123	-13.6	-42	-42	-6.5	-17	-5.0
R36-R41	Coquina	4,600	-11	-22	-2.4	-13	-13	-2.0	-6	-1.8
	2	.,						0	Ğ	
TOTAL		35,939	-101	-104	-11.5	1	-7	-1.1	5	1.6
		55,550		101			'			1.0
	<u> </u>									

NOTES:

^{1.} Shoreline elevation = +0.2' NAVD = +1.2' NGVD (USACE, 1991).

^{2. -}Retreat, +Advance.

Adjustments are based on 1997 dredge spoil and 2005/2006 fill volumes assuming a berm elevation of +4' NAVD and depth of closure of -19' NAVD.

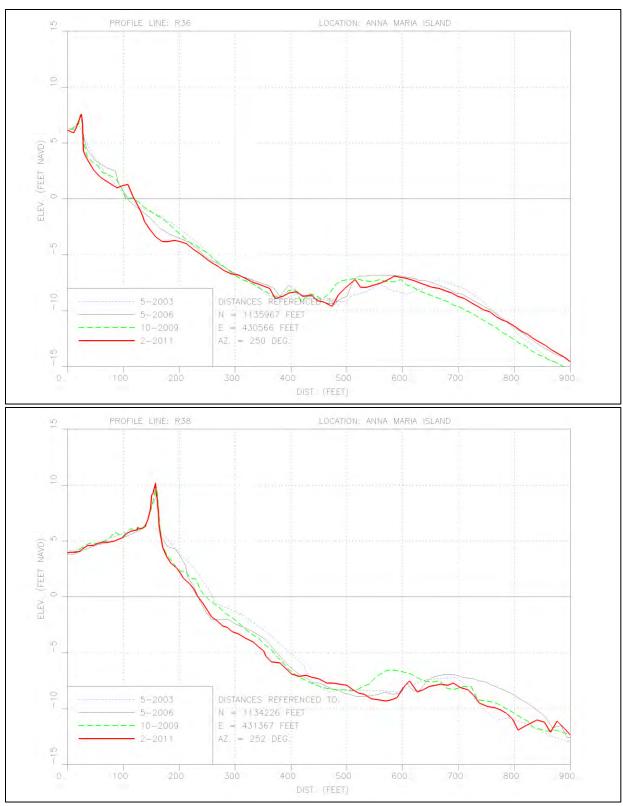


FIGURE 2-25A: Typical Beach Profiles along Coquina Beach.

TABLE 2-6
EROSION RATE COMPARISON
ANNA MARIA ISLAND, FL

	Distance	Beach	Volume Changes (c.y./year)*					
Profile	Profile Inlet		8/1993 to	5/2003 to	5/2006 to			
Line	(feet)	Length (feet)	12/2001	10/2009	10/2009			
R20	20,834							
K20		1,133	-2,100	1,500	-1,300			
R21	19,701	992	-1,100	3,600	1,700			
R22	18,709							
R23	17,776	933	-700	4,900	2,400			
R24	16,767	1,009	-3,700	2,500	1,600			
R25	15,801	966	-900	1,000	-1,300			
		1,205	1,400	-800	-4,000			
R26	14,596	802	-2,400	-4,400	-3,100			
R27	13,794	1,003	-7,400	-8,800	-6,500			
R28	12,791	1,397	-13,800	-18,000	-12,100			
R29	11,394	909	-9,700	-10,900	-8,000			
R30	10,485							
R31	9,360	1,125	-11,000	-6,400	-6,700			
R32	8,452	908	-6,700	-1,800	-1,800			
R33	7,492	960	-2,400	-200	-2,000			
		952	2,000	100	-5,600			
R34	6,540	1,018	-1,300	-700	-4,700			
R35	5,522	922	-1,900	-200	-2,300			
R36	4,600	1,028	-1,500	300	-4,200			
R37	3,572							
R38	2,692	880	-2,400	-200	-3,000			
R39	1,763	929	-1,900	-200	-4,700			
R40	857	906	-2,200	1,900	-6,400			
		857	-3,600	4,500	-9,400			
R41	0							
R20-R25	Homes	5,033	-8,500	13,500	3,100			
R25-R30	Bradenton	5,316	-31,900	-42,900	-33,700			
R30-R36	Cortez	5,885	-21,300	-9,200	-23,100			
R36-R41	Coquina	4,600	-11,600	6,300	-27,700			
TOTAL		20,834	-73,300	-32,300	-81,400			

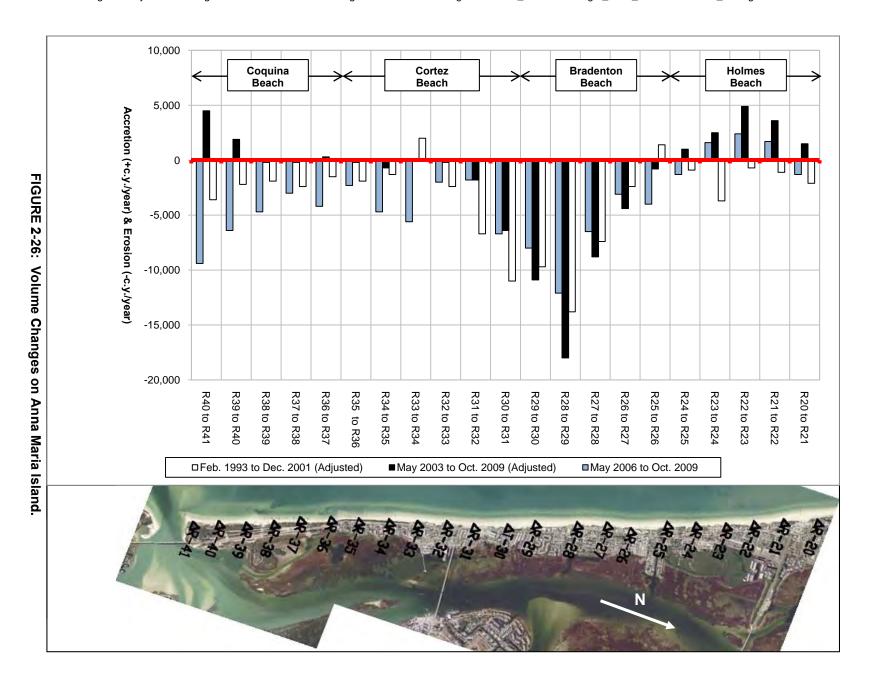
^{*} NOTES:

^{1. -} Erosion / + Accretion.

^{2.} For 1993-2001 and 2006-2009 changes, depth of closure = -19' NAVD = -18' NGVD.

^{3.} See Table 2-10 for 2003-2009 seaward calculation limit.

^{4.} Includes adjustments based on 1997 dredge spoil and 2005/2006 fill volumes.



Since the completion of the 2005-2006 project, erosion rates on Bradenton Beach (R-25 to R-30) have decreased. The density of fill placed on this segment during the 2005-2006 project was relatively low (3-35 c.y./foot), and the spreading of fill from the 2002 project has slowed down. The lower spreading rate from Bradenton Beach (R-25 to R-30) since 2006 has resulted in lower accretion rates on Holmes Beach (R-20 to R-25), higher erosion rates on Cortez Beach (R-30 to R-36), and a resumption of the erosional trend on Coquina Beach (R-36 to R-41) at higher rates than those prior to 2001 (see Table 2-6). Further details regarding erosion along Coquina Beach appear in Spadoni, et al (2009).

Longboat Key

Since August 1993, erosional patterns on Longboat Key have been dominated by moderate to high erosion on the northern end of the island (R-42 to R-51) and mild erosion to accretion between profile R-51 and the county line (R-67) (see Tables 2-7 to 2-8 and Figures 2-27 to 2-28). Three major beach fill projects have been constructed on the island during this period:

- The 1996-1997 Town of Longboat Key Mid-Key Interim Nourishment Project. This project only covered profiles R-65 in Manatee County to R-14 in Sarasota County.
- The 2005/2006 Longboat Key Beach Nourishment Project. This project covered almost the entire island, extending from profile R-44 in Manatee County to R-29 in Sarasota County. This project consisted of 1,051,600 cubic yards of fine (~0.20 mm), white sand fill, laid over 737,700 cubic yards of coarse-grained (~0.51 mm) fill at the high erosion areas and the existing beach elsewhere.
- The 2011 Town of Longboat Key North End Beach Renourishment. This project placed approximately 139,900 c.y. of material between profiles R-44-100 to R-46.6.

In addition to these projects, 109,000 cubic yards of dredge spoil from Longboat Pass were placed along profiles R-43.66 to R45.5 and R-48.5 to R-51 in 1997. In 1998, another 2,000 cubic yards of dredge spoil from the Beer Can Island (Greer Island) channel were placed on the dry beach north of North Shore Road (R-44.5).

Reaches 1N, 1S, and 2 (R-42 to R-51) have experienced some of the highest retreat and erosion rates on Longboat Key. The primary beneficiaries of the eroded material from these segments are the Longboat Pass ebb shoal and the accreting area south of profile R-51. Since 2003, the highest erosion rates within these 3 segments has shifted from Reach 2 (R-47 to R-51) to Reach 1S (R-44 to R-47) (see Table 2-8).

Since 2006, the combined erosion rate on Reaches 1N, 1S, and 2 (R-42 to R-51) has decreased. The decline in storm activity after 2006 is the most likely reason for this change. However, shoreline retreat rates have accelerated, most likely due to the shift of material from the construction template to the submerged portion of the beach profile. Reaches 1S and 2 were

TABLE 2-7
RECENT SHORELINE CHANGES
NORTHERN LONGBOAT KEY, FL

	Dist. From	Beach	Aug. 1993 to	April 2003	1993-2003	April 2003 t	o Oct. 2009	2003-2009	July 2006 t	o Oct. 2009
Profile	Inlet	Length	Shoreline C	hange (feet)	Adjusted	Shoreline C	hange (feet)	Adjusted	Shoreline C	hange (feet)
Line	(feet)	(feet)	Surveyed	Adjusted	(feet/year)	Surveyed	Adjusted	(feet/year)	(feet)	(feet/year)
		Ì				•	•			
R42	0	194	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)
R43	388	334	-40	-40	-4.2	-73	-73	-11.2	-53	-16.4
R44	667	738	-25	-28	-2.9	-204	-204	-31.3	-107	-32.7
R45	1,864	1,074	107	79	8.2	-274	-325	-50.0	-134	-41.1
R46A	2,814	984	-215	-215	-22.3	53	24	3.7	-28	-8.7
R47	3,832	978	-262	-262	-27.1	155	74	11.4	-77	-23.8
R48	4,770	1,193	-197	-207	-21.4	81	-58	-8.9	-90	-27.6
R49	6,217	1,213	-149	-189	-19.6	41	-64	-9.8	-119	-36.6
R50	7,196	996	-171	-208	-21.5	70	1	0.2	-41	-12.6
R51	8,209	948	-21	-33	-3.4	73	59	9.0	47	14.4
R52	9,092	998	26	26	2.7	83	77	11.9	62	19.2
R53	10,205	1,024	26	26	2.7	88	85	13.1	59	18.2
R54A	11,140	870	4	4	0.4	91	79	12.2	55	17.0
R55	11,945	880	13	13	1.4	64	43	6.6	20	6.2
R56	12,899	967	8	8	0.8	39	22	3.4	-21	-6.4
R57	13,879	949	14	14	1.4	28	19	2.9	-4	-1.1
R58	14,798	919	1	1	0.1	36	22	3.5	-3	-0.8
R59	15,717	988	-6	-6	-0.6	33	26	4.0	15	4.7
T60	16,774	1,031	-49	-49	-5.0	32	15	2.4	10	2.9
R61	17,778	1,098	-28	-28	-2.9	34	24	3.7	2	0.6
R62A	18,969	1,106	-22	-22	-2.3	46	30	4.6	4	1.2
R63	19,991	1,033	-15	-15	-1.5	27	11	1.7	-2	-0.7
R64	21,034	1,002	-35	-35	-3.6	44	27	4.2	-26	-8.0
R65	21,995	1,039	-14	-24	-2.5	51	34	5.2	16	4.9
R66	23,112	1,012	10	-26	-2.7	37	8	1.3	-11	-3.3
R67	24,020	454	-11	-59	-6.1	27	-10	-1.5	-48	-14.8
R42-R44	Reach 1N	667	-36	-37	-3.8	-111	-111	-17.1	-69	-21.2
R44-R47	Reach 1S	3,165	-77	-87	-9.0	-90	-129	-19.9	-87	-26.6
R47-R51	Reach 2	4,377	-165	-188	-19.4	75	-18	-2.8	-70	-21.4
R51-R56	Reach 3N	4,690	13	12	1.3	77	66	10.1	42	13.1
R56-R67	Reach 3S	11,121	-14	-20	-2.1	37	20	3.1	-3	-0.8
TOTAL		24,020	-45	-54	-5.6	32	0	0.0	-19	-5.7

NOTES:

^{1.} Shoreline elevation = +0.1' NAVD = +1.1' NGVD (CPE, 2010).

^{2. -}Retreat, +Advance.

^{3.} Profile R42 was completely submerged during the 2003 and 2006 surveys.

Adjustments are based on 1997 dredge spoil, and the 1996/1997 and 2005/2006 fill volumes assuming a berm elevation of +5' NAVD and depth of closure of -16' NAVD.

TABLE 2-8 EROSION RATE COMPARISON LONGBOAT KEY, FL

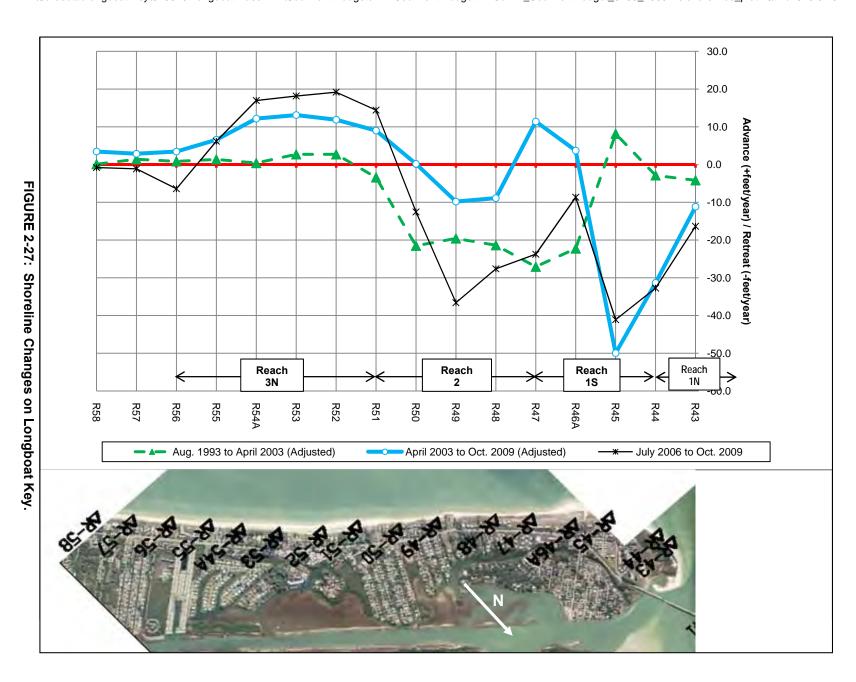
	Distance	Danah	Volume Changes (c.y./year)*					
Profile	from Inlet	Beach Length	8/1993 to	4/2003 to	7/2006 to			
Line	(feet)	(feet)	4/2003	10/2009	10/2009			
	, ,	, ,						
R42	0	388	1,900	-1,600	6,100			
R43	388	300	1,900	-1,000	0,100			
		279	-3,000	-3,200	-900			
R44	667	1,197	-600	-28,400	-22,800			
R45	1,864	1,197	-000	-20,400	-22,000			
		950	-1,800	-6,200	3,700			
R46A	2,814	1,018	-11,600	3,400	-900			
R47	3,832	1,010	11,000	3,400	300			
		938	-9,600	-1,600	-4,900			
R48	4,770	1,447	-15,000	-8,300	-11,400			
R49	6,217	.,	.0,000	3,333	11,100			
	- 400	979	-9,500	-5,400	-2,500			
R50	7,196	1,013	-1,900	-400	6,500			
R51	8,209							
DEO	0.000	883	5,600	3,200	6,100			
R52	9,092	1,113	8,300	5,100	6,100			
R53	10,205							
R54A	11,140	935	6,500	3,200	6,500			
NO4A	11,140	805	4,800	1,900	3,100			
R55	11,945	054	F 200	000	4 200			
R56	12,899	954	5,200	900	-1,200			
1.00								
R42-R44	Reach 1N	667	-1,100	-4,800	5,200			
R44-R47	Reach 1S	3,165	-14,000	-31,200	-20,000			
R47-R51	Reach 2	4,377	-36,000	-15,700	-12,300			
R51-R56	Reach 3N	4,690	30,400	14,300	20,600			
TOTAL		12,899	-20,700	-37,400	-6,500			
			,					

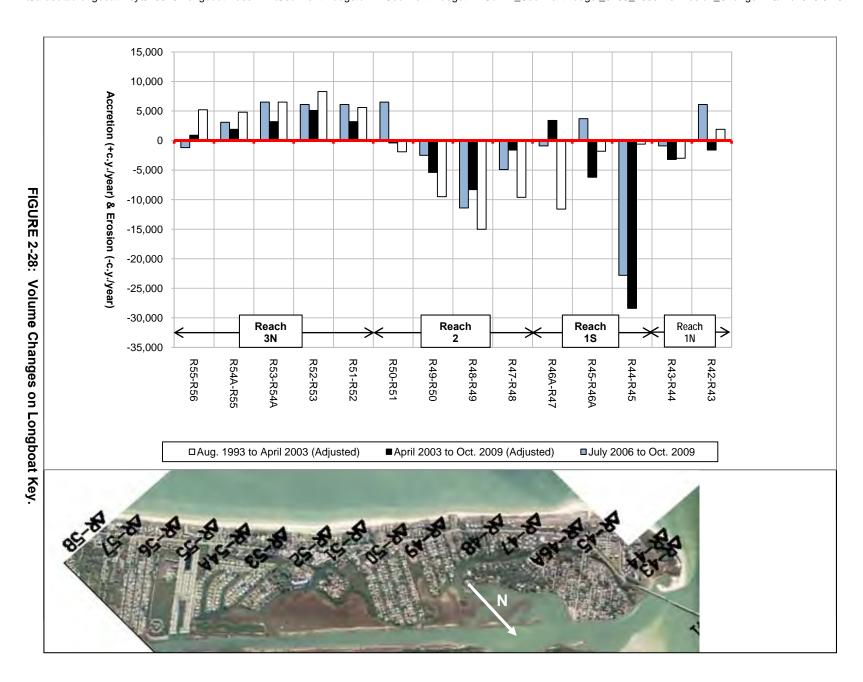
* NOTES:

^{1.} All volume changes are adjusted for the placement of beach fill & dredge spoil.

Erosion / + Accretion.
 R-42 to R-51 depth of closure = Landward limit of ebb shoal or hardbottom.
 R-52 to R-56 depth of closure = -16' NAVD = -15' NAVD.

^{5.} Source of 2006-2009 changes: CPE (2010).
6. See Table 2-11 for further details regarding 2003-2009 changes.





filled with approximately 316,000 cubic yards of coarse fill and 203,000 cubic yards of fine, white sand fill. As noted in Day (2004), construction cross-sections with finer material tend to change their shape more quickly than those with coarse material. The layered cross-section has generally performed better than the material placed in 1993 (CPE, 2010).

K. Sediment Budget – 2003 to 2009

Time Period

The time period for the analysis is from 2003 to 2009. The end of the study period coincides with the most recent surveys available at the time, and do not include the 2011 fill placements on Anna Maria Island and Longboat Key. The beginning of the study period was selected to be prior to the 2004 hurricane season. As shown in Figure 2-29, rapid retreat occurred during the 2004 hurricane season. For this reason, it was necessary to include the 2004 hurricane to properly account for the various processes governing erosion over the past several years. Although Light Detection and Ranging (LIDAR) Surveys were flown in May-June 2004, the LIDAR data was not very accurate below the water line (see Figure 2-30). The last conventional surveys before the 2004 hurricane season were taken between January and May 2003. Accordingly, 2003 was selected as the beginning of the study period.

Sediment Budget Cells

Sediment budget cells are presented in Figure 2-31 and Table 2-9. Sediment budget cells along Anna Maria Island and Longboat Key are based on the limits of the fill placed in 2005 and 2006, prior reach delineations (i.e.: CPE, 1995, 2000) and the computational limits of the volume change estimates (i.e. depth of closure). Sediment budget cells in the interior Longboat Pass are based on the boundaries of Cuts 1, 2, and 3 as shown on the July 2009 survey drawings (USACE, 2009) and the areas covered by the 1992-1992 and 2009 surveys. The limits of the Northern Ebb Shoal are based on the boundaries of the adjacent cells. The limits of the Southern Ebb Shoal are roughly based on the boundaries of the adjacent cells and the -15 foot NAVD contour. Beach and inlet profiles along Anna Maria Island, Longboat Key, and Longboat Pass Cuts 1-3 appear in Appendix B.

Anna Maria Island

Beach profile changes along Anna Maria Island were based on the May 2003 and October 2009 surveys (Table 2-10). The offshore calculation limits were selected to avoid the hardbottom area at profile R-23, the 1992-1993 borrow areas, and zones characterized by survey uncertainty. These limits defined the shapes of the sediment budget cells along Anna Maria Island. Based on pay volume estimates by Goodloe (2006), 27,360 cubic yards of fill were placed between profiles R-20 and R-25, and 68,971 cubic yards of fill were placed between profiles R-25 and R-30. During the study period, Bradenton Beach (R-25 to R-30) experienced the highest erosion

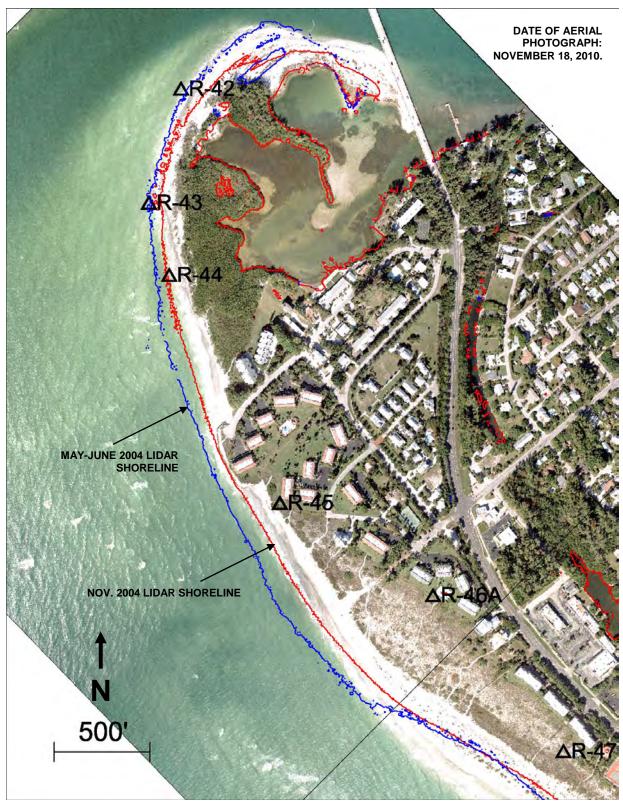


FIGURE 2-29: 2004 Mean High Water (+0.1 feet NAVD) Positions Based on Light Detection and Ranging (LIDAR) Surveys.

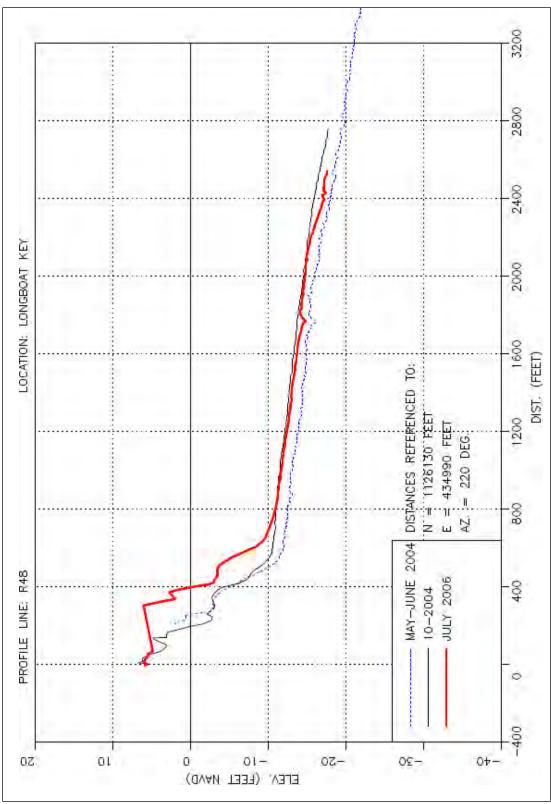


FIGURE 2-30: Typical Profile Based on the April-May 2004 LIDAR Survey, with other Surveys Taken by Conventional Methods for Comparison.

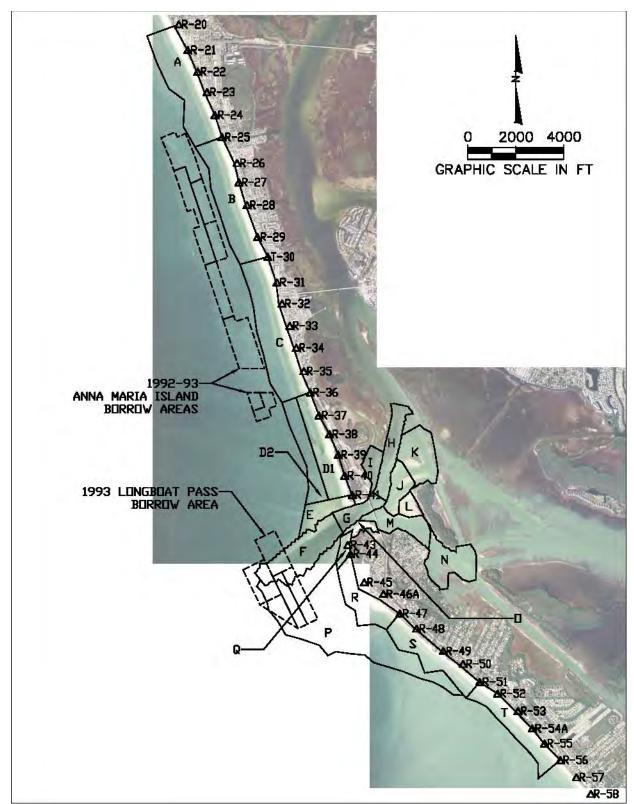


FIGURE 2-31: Sediment Budget Cells.

TABLE 2-9
SUMMARY OF VOLUME CHANGES
LONGBOAT PASS, FL & VICINITY

Cell	Area	Profiles	Surveyed Volume Change (c.y.)	Beach Fill (c.y.)	Start Date	End Date	Time (years)	Surveyed Volume Change (c.y./year)*	Beach Fill (c.y./year)*	Adjusted Volume Change (c.y./year)
А	Homes Beach	R20-R25	114,556	27,360	May. 2003	Oct. 2009	6.4	18,000	4,000	14,000
В	Bradenton Beach	R25-R30	-205,788	68,971	May. 2003	Oct. 2009	6.4	-32,000	11,000	-43,000
С	Cortez Beach	R30-R36	-59,819	0	May. 2003	Oct. 2009	6.4	-9,000	0	-9,000
D	Coquina Beach: D1 - Dry Beach (> 0' NAVD) D2 - Offshore (< 0' NAVD)	R36-R41	40,044 -9,720 49,764	0 0 0	May. 2003 May. 2003 May. 2003	Oct. 2009 Oct. 2009 Oct. 2009	6.4 6.4 6.4	6,000 -2,000 8,000	0 0 0	6,000 -2,000 8,000
Е	Northern Ebb Shoal	-N/A-	19,957	0	Jun. 2004	Mar. 2009	4.7	4,000	0	4,000
F	Longboat Pass Channel Cut 1	00+00 to 40+20	130,295	0	Jan. 2003	Jul. 2009	6.5	20,000	0	20,000
G	Longboat Pass Channel Cut 2	00+00 to 21+18	-4,138	0	Jan. 2003	Jul. 2009	6.5	-1,000	0	-1,000
Н	Longboat Pass Channel Cut 3	00+00 to 40+48	670	0	Jan. 2003	Jul. 2009	6.5	0	0	0
I	Leffis Key Basin	-N/A-	-2,726	0	1991-1992	Sep. 2009	17.0	0	0	0
J	Western Flood Shoal	-N/A-	30,563	0	1991-1992	Sep. 2009	17.0	2,000	0	2,000
К	Eastern Flood Shoal	-N/A-	-34	0	1991-1992	Sep. 2009	17.0	0	0	0
L	Jewfish Key Shoal	-N/A-	10,863	0	1991-1992	Sep. 2009	17.0	1,000	0	1,000
М	Outer South Channel	-N/A-	-92,021	0	1954	Mar. 2009	55.0	-2,000	0	-2,000
N	Inner South Channel	-N/A-	5,473	0	1991-1992	Sep. 2009	17.0	0	0	0
0	Beer Can Island	-N/A-	-3,810	0	Jun. 2004	FebJuly 2007	2.9	-1,000	0	-1,000
Р	Southern Ebb Shoal	-N/A-	382,807	0	Jun. 2004	Oct. 2009	5.3	72,000	0	72,000
Q	Reach 1N	R42-R44	-30,990	0	Apr. 2003	Oct. 2009	6.5	-5,000	0	-5,000
R	Reach 1S	R44-R47	-39,487	163,000	Apr. 2003	Oct. 2009	6.5	-6,000	25,000	-31,000
S	Reach 2	R47-R51	218,255	321,000	Apr. 2003	Oct. 2009	6.5	34,000	49,000	-15,000
Т	Reach 3N	R51-R56	127,666	35,000	Apr. 2003	Oct. 2009	6.5	20,000	5,000	15,000
NOTE: Rates in	a last 3 columns rounded to nearest 1,000 c.y./	year.			I		TOTAL	121,000	94,000	27,000

TABLE 2-10
MAY 2003 – OCTOBER 2009 VOLUME CHANGES ON ANNA MARIA ISLAND

PROFILE LINE	BEACH LENGTH (FEET)	SEAWARD CALC. LIMIT (FEET)	PROFILE CHANGE (C.Y./FOOT)	SURVEYED VOL. CHANGE (C.Y.)	FILL PLACEMENT (C.Y.)
R20		1,400	4.3		
R21	1,133	1,400	12.7	9,653	63
R22	992	1,400	34.1	23,224	0
R23	933	1,000	36.4	32,909	1,206
	1,009			29,946	13,577
R24	966	1,400	22.9	18,824	12,515
R25	1,205	1,200	16.0	2,397	7,434
R26	802	1,200	-12.1	-19,084	9,334
R27	1,003	1,200	-35.5	-46,604	9,577
R28	1,397	1,200	-57.4	-86,790	28,602
R29	909	1,200	-66.8	-55,708	14,025
R30		1,200	-55.7		14,025
R31	1,125	1,200	-17.5	-41,192	
R32	908	1,200	-8.4	-11,759	
R33	960	1,400	5.7	-1,312	
R34	952	1,400	-4.7	441	
R35	1,018	1,500	-4.1	-4,478	
R36	922	1,250	0.8	-1,519	
R37	1,028	1,300	2.4	1,645	
R38	880		-5.0	-1,108	
	929	1,400		-1,327	
R39	906	1,400	2.1	12,052	
R40	857	1,600	24.5	28,781	
R41		2,000	42.7		
R20-R25 R25-R30 R30-R36 R36-R41	5,033 5,316 5,885 4,600			114,556 -205,788 -59,819 40,044	27,360 68,971 0 0

losses, despite the placement of beach fill. Although Coquina Beach (R-36 to R-41) experienced gains, most of these gains occurred offshore. The dry beach at R-36 to R-41 lost 2,000 c.y./year between 2003 and 2009. The sediment budget cell for Coquina Beach (Cell D) was split into an onshore (Cell D1) and offshore (Cell D2) component to properly address this observation (see Figure 2-31).

Longboat Key

Beach profile changes along Longboat Key were based on the April 2003 and October 2009 surveys (Table 2-11). The offshore calculation limits were selected to avoid the hardbottom areas at profiles R-50 to R-51 and the areas in which the changes were related to ebb shoal development. These limits defined the shapes of the sediment budget cells along Longboat Key. Based on fill volume estimates by CPE (2007), 163,000 cubic yards of fill were placed between profiles R-44 and R-47, 321,000 cubic yards of fill were placed between profiles R-47 and R-51, and 35,000 cubic yards of fill were placed between profiles R-51 and R-56. During the study period, profiles R-44 to R-45 (North Shore Road) experienced the highest erosion losses, despite the placement of beach fill. Profiles R-48 to R-50 also experienced high erosion losses. Both of these locations featured seawalls that protruded seaward of the surrounding vegetation lines.

Longboat Pass Cuts 1, 2, and 3

Volume changes in Longboat Pass Cuts 1, 2, and 3 were based on the January 2003 and July 2009 surveys by the U.S. Army Corps of Engineers. The volume change estimates were based on survey lines with a maximum spacing of 100 feet. Calculation limits were based on the areas covered by both surveys, and determined the shapes of the sediment budget cells. No dredging took place between January 2003 and July 2009. Volume changes in Longboat Pass Cuts 1, 2, and 3 appear in Table 2-12. The largest changes occur in the form of a 20,000 c.y./year gain in Cut 1, which is part of the ebb shoal.

Northern Ebb Shoal

Volume changes in the northern ebb shoal were based on the May-June 2004 LIDAR survey and the March 2009 ebb shoal survey. Due to the survey control problem below the waterline (see Figure 2-30), the May-June 2004 LIDAR data was adjusted based on a comparison with the October 2004 beach survey. Below -5 feet NAVD, the LIDAR data points were raised by 0.7 feet. Above 0 feet NAVD, the LIDAR data points were used as-is. Between -5 and 0 feet NAVD, the LIDAR data points were adjusted on a sliding scale based on the reported elevation (i.e.: a point with a reported elevation of -2.5 feet NAVD was raised 0.35 feet). Since the March 2009 survey was taken using conventional methods, no adjustments were made. Volume changes between the two surveys were based on grid surfaces with a spacing of 10 feet (Figures 2-32 and 2-33). The volume change in the northern ebb shoal between May-June 2004 and March 2007 was a 19,957 cubic yard gain.

TABLE 2-11

APRIL 2003 – OCTOBER 2009 VOLUME CHANGES ON LONGBOAT KEY

PROFILE LINE	BEACH LENGTH (FEET)	SEAWARD CALC. LIMIT (FEET)	PROFILE CHANGE (C.Y./FOOT)	SURVEYED VOL. CHANGE (C.Y.)	FILL PLACEMENT (C.Y.)
R42_240		567	10.8	40.404	
R43	388	884	-64.5	-10,434	
R44	279	888	-82.8	-20,556	01 000
R45	1,197 950	1,203	-73.6	-93,616 -16,206	91,000 24,000
R46A	1,018	1,415	39.5	70,336	48,000
R47	938	873	98.7	76,424	87,000
R48	1,447	1,157	64.3	71,805	126,000
R49	979	1,195	35.0	37,707	73,000
R50	1,013	830	42.0	32,318	35,000
R51	883	880	21.8	26,033	5,000
R52	1,113	691	37.2	38,186	5,000
R53	935	831	31.4	26,666	6,000
R54A	805	787	25.6	20,236	8,000
R55 R56	954	716 1,189	24.7 10.0	16,545	11,000
	007	1,109	10.0	20.000	
R42-R44 R44-R47	667 3,165			-30,990 -39,487	0 163,000
R47-R51 R51-R56	4,377 4,690			218,255 127,666	321,000 35,000

TABLE 2-12

JANUARY 2003 – JULY 2009 VOLUME CHANGES IN LONGBOAT PASS

Cut	Channel Length (feet)	Scour (c.y.)	Deposition (c.y.)	Net Change (c.y.)	
CUT 1	4,020	-124,371	254,665	130,295	
CUT 2	2,118	-43,698	39,560	-4,138	
CUT 3	4,048	-31,197	31,866	670	
TOTAL	10,186	-199,266	326,091	126,826	

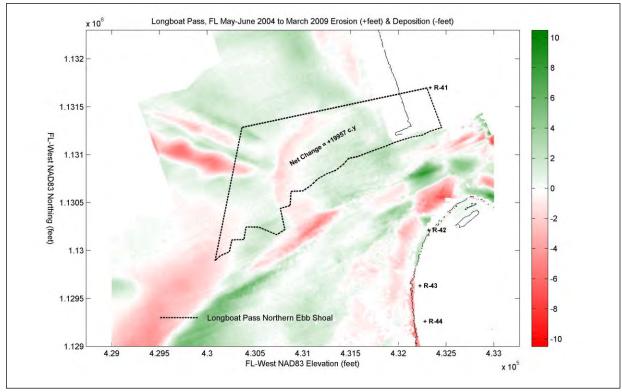


FIGURE 2-32: May-June 2004 to March 2009 Bathymetric and Volume Changes on the Northern Ebb Shoal.

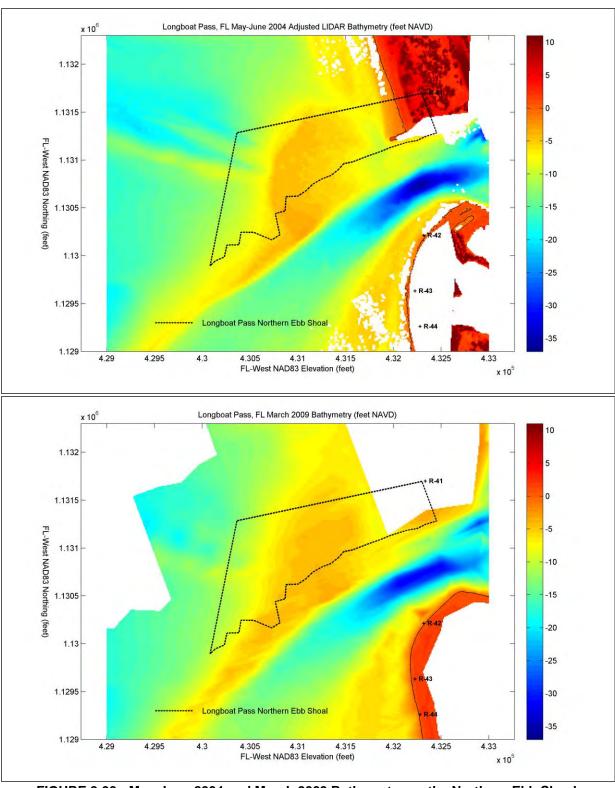


FIGURE 2-33: May-June 2004 and March 2009 Bathymetry on the Northern Ebb Shoal.

Inlet Interior

Volume changes in the Leffis Key Basin (Cell I), the Western Flood Shoal (Cell J), the Eastern Flood Shoal (Cell K), the Jewfish Key Shoal (Cell L), and the Inner South Channel (Cell N) were based on the 1991-1992 survey (ATM, 1993) and the September 2009 survey by Sea-Diversified (see Figures 2-34 to 2-36). Over the past 17 years, these 5 areas gained a net volume of approximately 44,000 c.y. (see Table 2-9), equal to 3,000 c.y./year. The majority of these changes occurred on the Jewfish Key Shoal and the Western Flood Shoal.

The Eastern Flood Shoal and the Inner South Channel include the 3 shoaling areas highlighted in Figures 1-5. Elevations in Shoaling Areas A and B have increased 2-3 feet since 1991-1992. These 2 areas are part of the Inner South Channel, which has experienced a small gain of material. Deposition near Shoaling Area C has been smaller and more localized. This area is part of the Eastern Flood Shoal, over which the net volume change is nearly zero.

In the Outer South Channel (Cell M), the 1991-1992 and September 2009 surveys did not offer complete coverage. Accordingly, volume changes in Cell M were based on the 1954 survey by NOAA and the March 2009 survey by CPE (see Figure 2-37). This area has lost approximately 92,000 c.y. since 1954, equal to a rate of 2,000 c.y./year. Most of this loss is concentrated near its border with Cut 2.

Greer Island

Volume changes on Greer Island (Cell O) were based primarily on the July 2007 LIDAR survey by the Florida Division of Emergency Management and the May-June 2004 LIDAR survey. The July 2007 LIDAR survey was originally distributed as a "bare-earth" data set, but only covered the areas above wading depth. The 2007 surface was extended below wading depth using the February 2007 inlet survey by CPE. The May-June 2004 LIDAR survey was not distributed as a "bare-earth" data set. Thus, it was necessary to filter out vegetated areas from the 2004 surface. A gap in the May-June 2004 LIDAR survey near the eastern end of the cell was also filled using the November 2004 LIDAR survey. Final adjustments to the 2004 surface below the waterline were identical to those performed for the Northern Ebb Shoal.

Based on the 2007 and 2004 surfaces, the Greer Island cell (Cell O) lost approximately 1,000 c.y./year (Figure 2-38). Although deposition occurs at the inland end of the sand spit, losses along the seaward face were larger. Overall, the behavior of this area were characterized by the following:

- Erosion along the area facing the Gulf.
- Partial deposition of the lost material on the inland end of the sand spit.
- Transport of the remaining material into Cut 2.

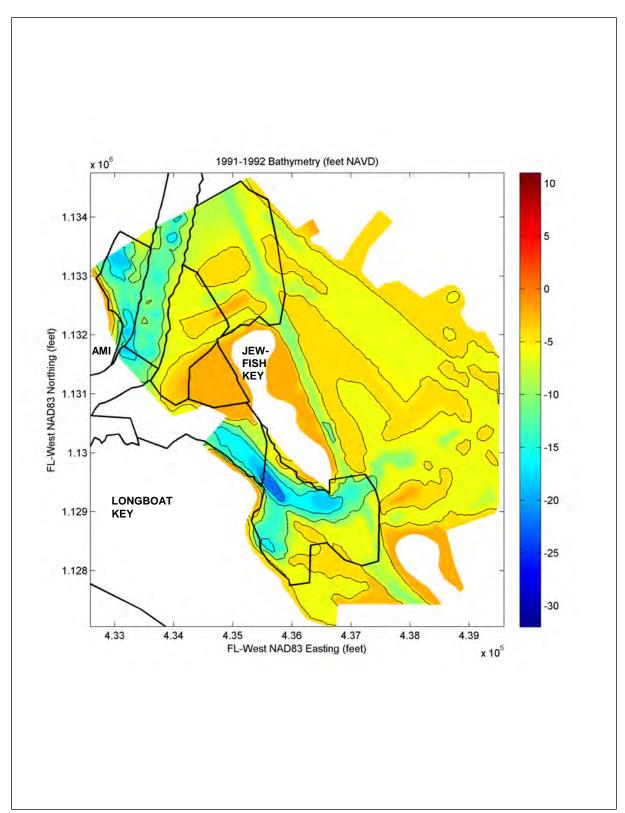


FIGURE 2-34: 1991-1992 Bathymetry in the Interior of Longboat Pass.

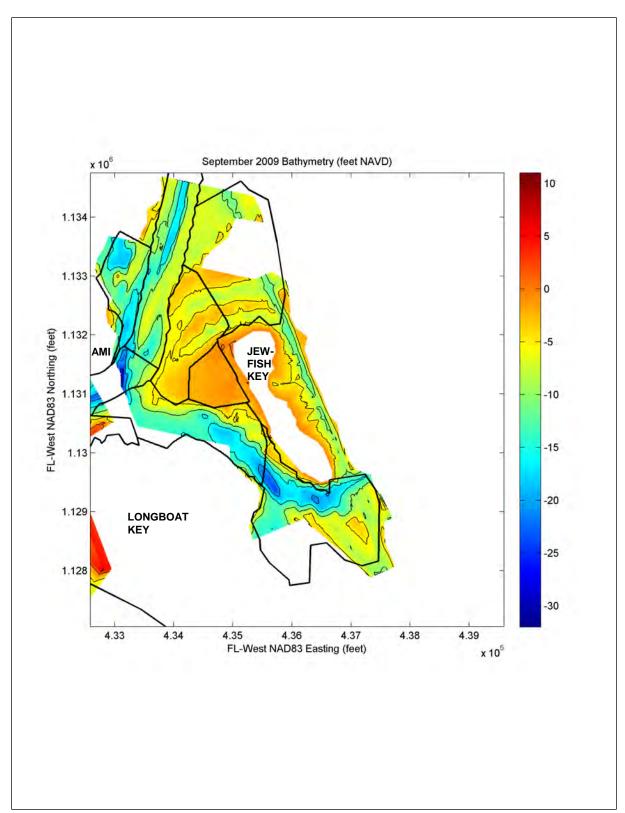


FIGURE 2-35: September 2009 Bathymetry in the Interior of Longboat Pass.

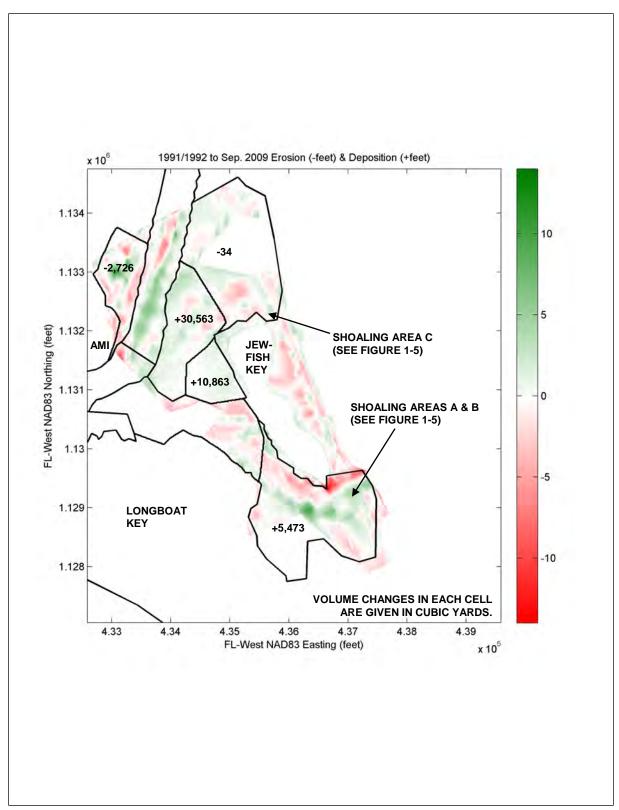


FIGURE 2-36: 1991-1992 to September 2009 Bathymetric and Volume Changes in the Interior of Longboat Pass.

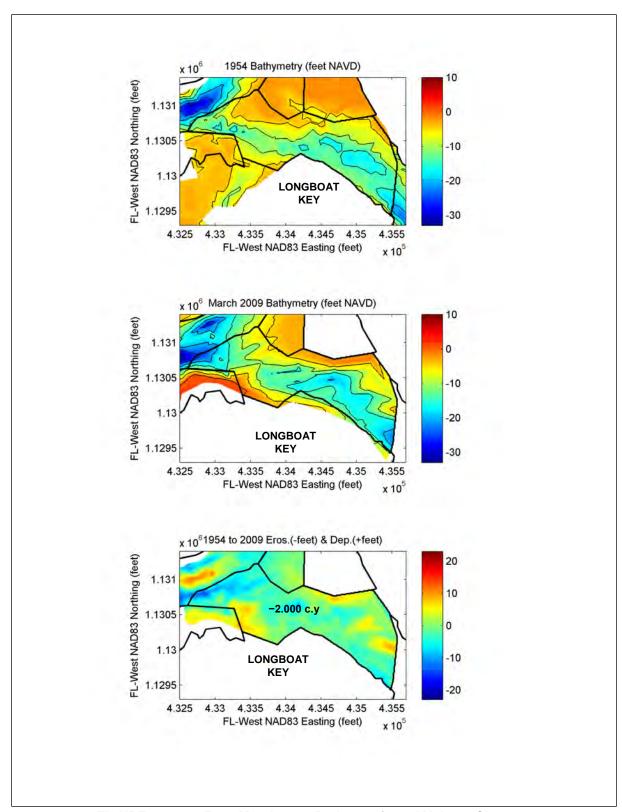


FIGURE 2-37: 1954 to March 2009 Bathymetric and Volume Changes in the Outer South Channel.

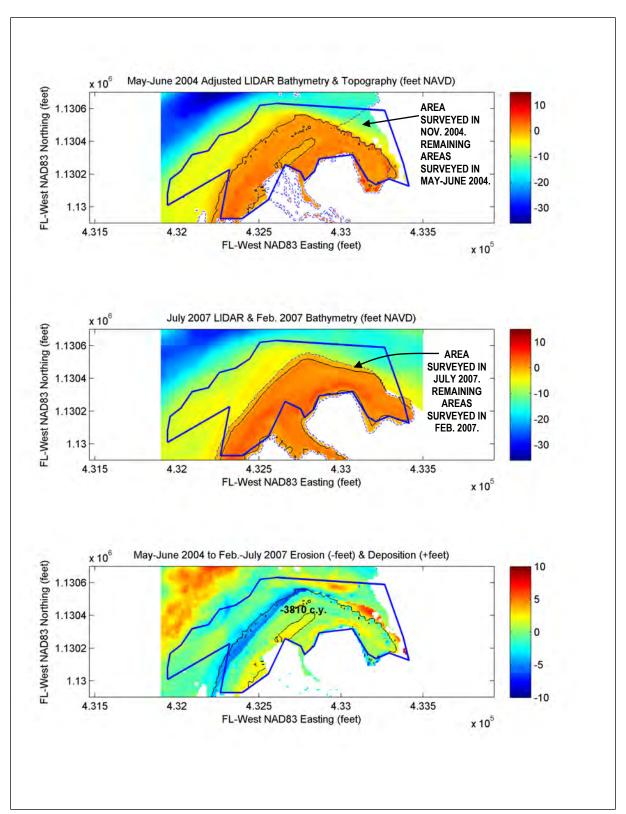


FIGURE 2-38: 2004-2007 Bathymetric and Volume Changes on Beer Can Island.

Southern Ebb Shoal

Volume changes in the Southern Ebb Shoal were based on the May-June 2004 LIDAR survey and the October 2009 ebb shoal survey. Due to the survey discrepancies below the waterline, the May-June 2004 LIDAR data was adjusted using the method employed for the Northern Ebb Shoal. The October 2009 survey did not cover the entire cell. Accordingly, the data was extended to the north using March 2009 ebb shoal survey. Based on the 2004 and 2009 surfaces, the volume change in the southern ebb shoal was a 382,807 cubic yard gain (Figures 2-39 and 2-40).

Although the May-June 2004 LIDAR survey required adjustment (see Figure 2-30), average deposition rates in the Southern Ebb Shoal are similar to Cut 1. The Southern Ebb Shoal covers 14,324,828 square feet. Given the 72,000 c.y./year gain, the average deposition rate is 0.14 feet/year. In comparison, Cut 1 gains 20,000 c.y./year over an area covering 4,419,330 square feet. Based on these values, the average deposition rate in Cut 1 is 0.12 feet/year based on hydrographic surveys. Given the similarity between the average deposition rates in the two adjacent cells, the estimated gains are comparable.

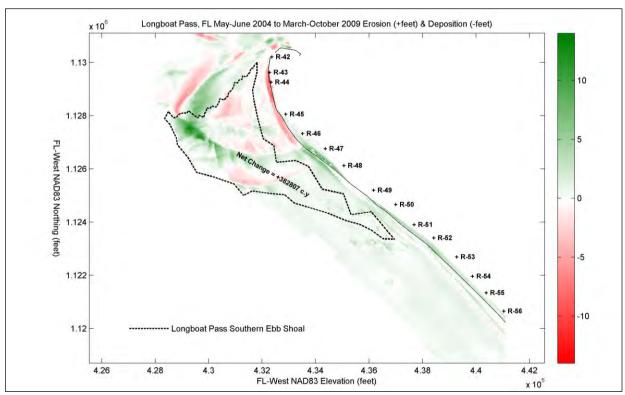


FIGURE 2-39: May-June 2004 to March-October 2009 Bathymetric and Volume Changes on the Southern Ebb Shoal.

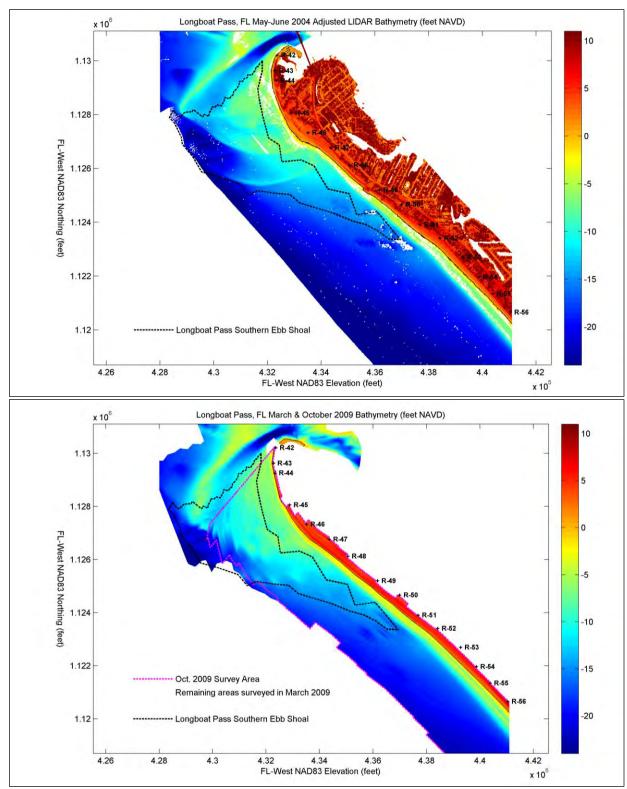


FIGURE 2-40: May-June 2004 and March-October 2009 Bathymetry on the Southern Ebb Shoal.

Sediment Budget

The volume changes described above were combined with the fill quantities and annualized, as shown in Table 2-9. To develop a sediment budget, this information was compared with the following:

- The GENESIS modeling results developed for the permitted design of the 2005-2006 Longboat Key Beach Nourishment Project specifically, the alongshore transport estimates near profile R-56. The GENESIS results have generally followed the observed performance of the project to date (CPE, 2010).
- The Delft3D modeling results developed for the Longboat Key North End Breakwaters project (CPE, 2010) (Figure 2-41). The predicted sediment transport patterns around Longboat Pass were used to establish the general trends in sediment transport near North Shore Road, the mouth of the inlet, and the interior boundaries of the Leffis Key Basin, Cut 3, the Eastern Flood Shoal, and the Inner South Channel.

Regional Sediment Transport Pattern

The 2003-2009 sediment budget appears in Figures 2-42 to 2-45. Overall, Longboat Pass and the adjacent beaches gained an average of 121,000 c.y./year. However, 94,000 c.y./year of this amount is beach fill. Excluding the beach fill, the natural changes are 27,000 c.y./year. Based on the GENESIS modeling for the 2005-2006 project on Longboat Key, approximately 14,000 c.y./year leave the area at profile R-56. This value is comparable to the sediment budgets in the Comprehensive Beach Management Plan (CPE, 1995). On the landward boundaries of the Leffis Key Basin, Cut 3, the Eastern Flood Shoal, and the Inner South Channel, the Delft3D model suggests low or negligible sediment transport (see Figure 2-41). Given the natural changes in the system as a whole (27,000 c.y./year) and the southerly transport at R-56 (14,000 c.y./year), the amount of material entering the system from the north at profile R-20 is 41,000 c.y./year.

Anna Maria Island

On Anna Maria Island, 41,000 c.y./year enters the Holmes Beach segment (R-20 to R-25). Given the observed volume change of 18,000 c.y./year and the fill placed in 2005 and 2006 (4,000 c.y./year), 27,000 c.y./year crosses the southern boundary (R-25) into the Bradenton Beach segment (R-25 to R-30). Although the rate of beach fill placement on Bradenton Beach is 11,000 c.y./year, 70,000 c.y./year leaves the cell at R-30, resulting in a loss of 32,000 c.y./year.

On Cortez Beach (R-30 to R-36), the erosion rate is on the order of 9,000 c.y./year. Given the incoming transport of 70,000 c.y./year at R-30, the amount of material crossing into the Coquina Beach cells at R-36 is 79,000 c.y./year. Along Coquina Beach (R-36 to R-41), the dry beach loses 2,000 c.y./year, but the submerged areas gain 8,000 c.y./year. Given amount of material

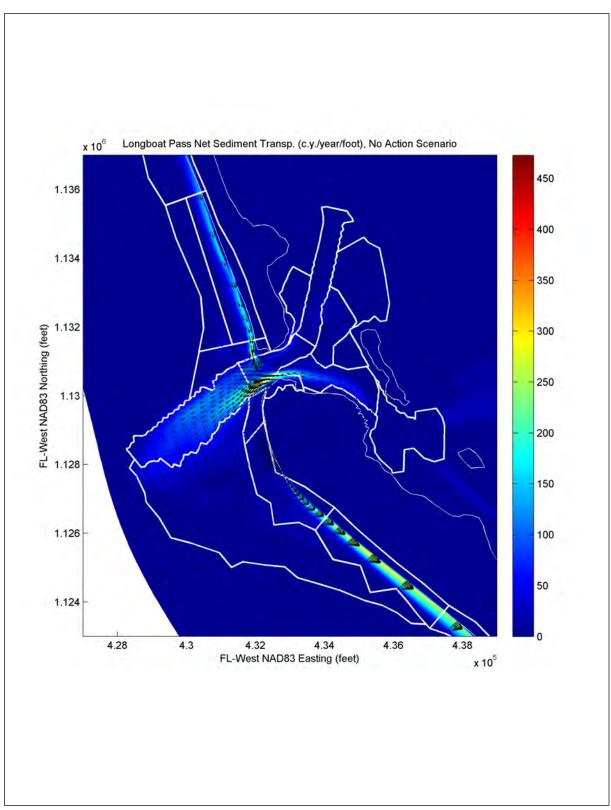


FIGURE 2-41: Delft3D Sediment Transport Patterns near Longboat Pass, Longboat Key North End Breakwaters Project (CPE, 2010), No Action Alternative.

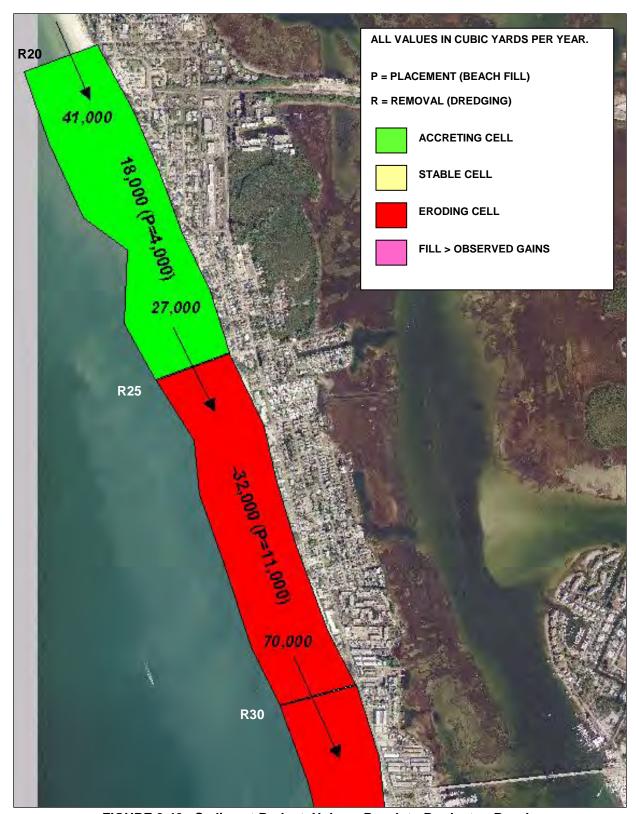


FIGURE 2-42: Sediment Budget, Holmes Beach to Bradenton Beach.

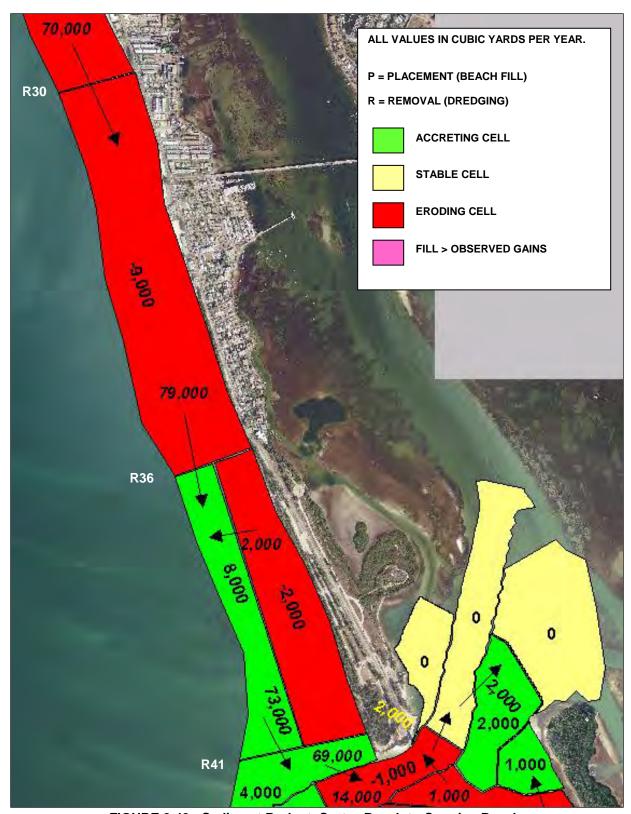


FIGURE 2-43: Sediment Budget, Cortez Beach to Coquina Beach.

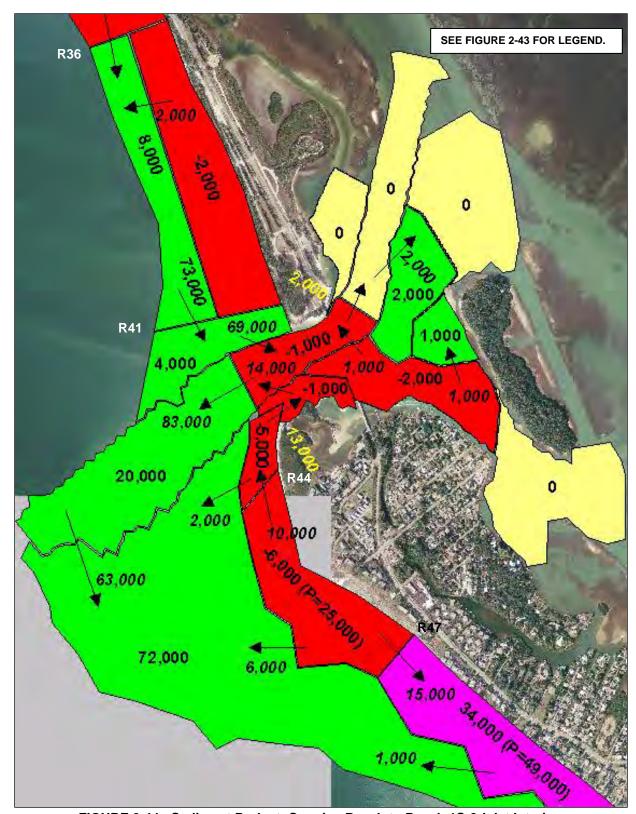


FIGURE 2-44: Sediment Budget, Coquina Beach to Reach 1S & Inlet Interior.

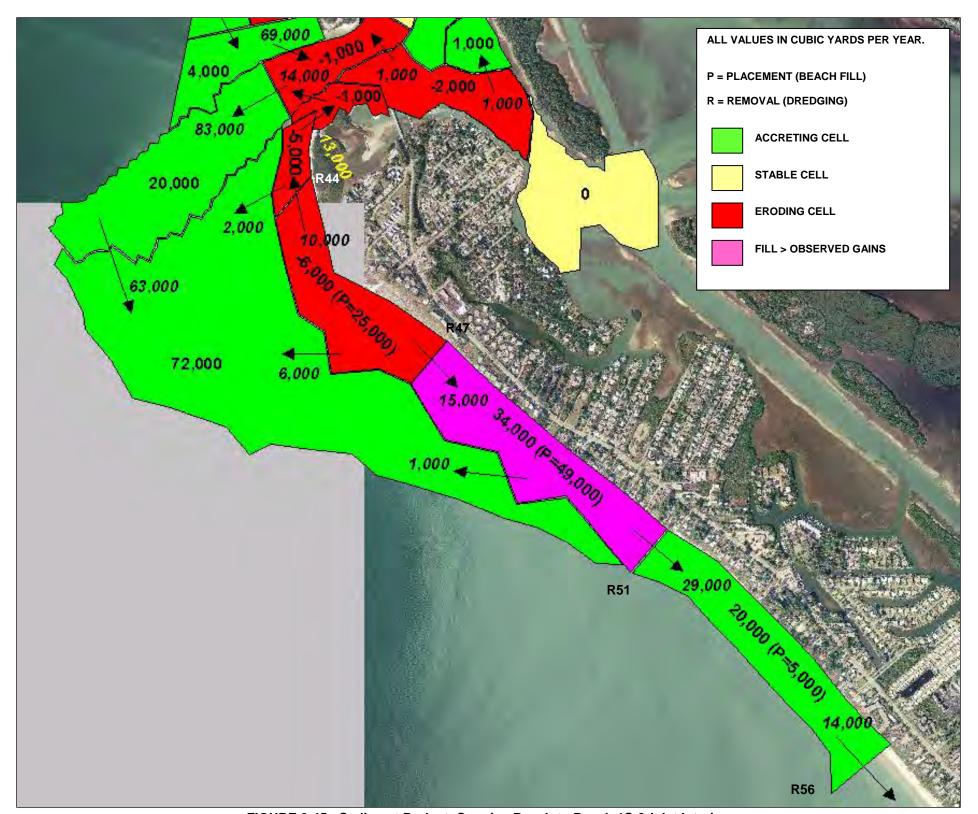


FIGURE 2-45: Sediment Budget, Coquina Beach to Reach 1S & Inlet Interior.

entering Coquina Beach at R-36 (79,000 c.y./year), the loss from the dry beach (2,000 c.y./year), and the gains below the waterline (8,000 c.y./year), the net littoral drift at profile R-41 is 73,000 c.y./year. This represents the approximate volume of sediment being transferred from Anna Maria Island to the inlet system each year.

The Northern Ebb Shoal of Longboat Pass adjoins Anna Maria Island, and gains roughly 4,000 c.y./year. Given these gains and the incoming transport of 73,000 c.y./year, the outgoing sediment transport is 69,000 c.y./year. Delft3D model results indicate the most of the outgoing transport occurs close to the shoreline, and goes primarily into Cut 2, rather than Cut 1 (see Figure 2-41).

Longboat Pass Interior

In the interior of Longboat Pass, the Jewfish Key shoal and the Western Flood Shoal generally function as sediment sinks, while Cut 2 and the Outer South Channel serve as sediment sources. Nevertheless, the changes in these 4 areas occur slowly. Based on the erosion and deposition patterns in Figures 2-36 and 2-37, the source of the gains in the Jewfish Key shoal appears to be the Outer South Channel. Figure 2-36 also suggests that the gains in the Western Flood Shoal appear to come from the transfer of material from Cut 2 via Cut 3. In the other interior cells, incoming and outgoing sediment transport rates are close to zero, resulting in volume changes on the same order of magnitude.

Longboat Pass Outer Channel and Ebb Shoal

Volume changes seaward of the bridge are dominated by gains in Cut 1 and the Southern Ebb Shoal. These two cells gain 92,000 c.y./year. The sources of the gains are:

- The volume of material (69,000 c.y./year) that enters the ebb shoal via Cut 2 (see Figure 2-44).
- Losses from Greer Island, Reach 1N, Reach 1S, and Reach 2. The combined volume of material from these sources is 23,000 c.y./year (see Figure 2-44).

Overall, the gains on the ebb shoal and the losses on Reaches 1N, 1S, and 2 suggests that the net sediment transport between these zones is in the offshore direction. This finding differs from earlier sediment budgets, which indicate net sediment transport in the onshore direction, ranging from 13,600 to 32,000 c.y./year (Figures 2-16 to 2-17 and CPE, 1995). However, the major difference between the 2003-2009 sediment budget and earlier sediment budgets is the presence of the 1993 Longboat Pass borrow area. As detailed later in this study, the borrow area has been refilling at an average rate of 69,000 c.y./year, relatively constantly since 1993. It should also be noted Reaches 1N, 1S, and 2 experience some of the highest erosion rates on the island (see CPE, 2010). Given these two factors, net sediment transport from the beach to the ebb shoal has been the more evident trend in recent years, rather than the onshore transport of previous decades.

Longboat Key

Volume changes on the north end of Longboat Key are dominated by the rapid loss of material from Reach 1S (R-44 to R-47), which exhibits some of the highest erosion rates on the island. The Delft3D results in Figure 2-41 support the assumption that Reach 1S contains a nodal point. When the observed volume change of 6,000 c.y./year is combined with 25,000 c.y./year of beach fill, the effective erosion rate is 31,000 c.y./year. Of this amount, approximately 15,000 c.y./year are transported into Reach 2 (R-47 to R-51), with 10,000 c.y./year moving into Reach 1N (R-42 to R-44). The remaining 6,000 c.y./year moves into the Southern Ebb Shoal offshore.

On the north end of the island, Reach 1N (R-42 to R-44) receives 10,000 c.y./year from the neighboring beach cell to the south. However, due to the movement of 2,000 c.y./year offshore and 13,000 c.y./year into Greer Island, this segment erodes 5,000 c.y./year. The Greer Island area has experienced spit growth since 2004 (see Figures 2-29 and 2-38). However, since erosion occurs along the seaward shoreline of the spit, cell exhibits a 1,000 c.y./year loss. Given the incoming transport from Reach 1N and the net loss of material, the net transport out of Greer Island into Cut 2 is 14,000 c.y./year.

Reach 2 (R-47 to R-51) is located downdrift of Reach 1S, and receives 15,000 c.y. from the beach cell to the north. When the observed gain of 34,000 c.y./year is combined with 49,000 c.y./year of beach fill, the effective erosion rate is 15,000 c.y./year. When combined with the incoming material from the north, the amount of material leaving the segment is 30,000 c.y./year. A small percentage of this material (1,000 c.y./year) moves into the Southern Ebb Shoal offshore. The rest (29,000 c.y./year) moves towards the south into Reach 3N (R-51 to R-56). This volume effectively represents the transport rate to the south from the inlet system.

Reach 3N benefits from the erosion taking place further to the north. With 29,000 c.y./year of material entering the cell at profile R-51, and 14,000 c.y./year leaving the cell at R-56, the natural accretion rate is approximately 15,000 c.y./year. Combined with 5,000 c.y./year of white sand beach fill, the observed gain on Reach 3N is 20,000 c.y./year.

Comparison to Humiston & Moore (2011) Sediment Budgets

Humiston & Moore (September 2011) recently prepared a number of sediment budgets for Longboat Pass covering various time periods from 1957 to 2010. On Anna Maria Island, the sediment transport rates near profiles R-36 and R-41 (see Figure 2-43) are similar to those of Humiston & Moore (2011). On Longboat Key, the net longshore transport rates near profiles R-49 to R-51 (see Figure 2-45) are roughly half those of Humiston & Moore (2011). This is primarily because the sediment budget in Figure 2-45 assumes that there is a nodal point along Reach 1S (R-44 to R-47). In contrast, the Humiston & Moore (2011) sediment budget assumes that from profiles R-42 to R-49, the net longshore transport is towards the south at all locations. Given the observed erosion and accretion patterns along the north end of Longboat Key (Figure 2-28) and Beer Can Island (Figure 2-38), the assumption of a nodal point in Reach 1S (R44-R47) and northward transport from tip of Longboat Key best describes the trends of the 2003 to 2009 sediment budget used in this study.

Summary

Overall, the 2003-2009 sediment budget suggests that the Longboat Pass ebb shoal functions as a sediment sink. The three sections of the ebb shoal (Cells E, F, and P) trap approximately 96,000 c.y./year of material, including 73,000 c.y./year of alongshore transport from Anna Maria Island and 23,000 c.y./year of alongshore and cross-shore transport from the north end of Longboat Key (Cells O, Q, R, S, and T). The refilling of the 1993 Longboat Pass borrow area represents the majority of these gains. Given the amount of material entering the ebb shoal and fill placed on the adjacent beaches, it is likely that there is little natural bypassing at the present time.

L. Inlet Influence

Area of Influence

A common method for assessing the impact of an inlet is the Even-Odd analysis. The purpose of the Even-Odd analysis is to separate the shoreline and volume changes that occur symmetrically about the inlet (e.g., storm erosion, erosion and accretion due to relative sea level change) from changes which are anti-symmetric (e.g., updrift impoundment at jetties and groins, downdrift erosion) (Rosati and Kraus, 1997):

$$f(x) = f_e(x) + sign(x)f_o(x)$$

where

f(x) = observed shoreline or volume change

$$f_e(x) = \text{even function} = [f(x) + f(-x)]/2$$

$$f_o(x) = odd function = [f(x) - f(-x)]/2$$

x = distance from the distance from the inlet (-west, +east)

An Even-Odd analysis was conducted using the shoreline changes in Tables 2-5 and 2-7. Over a 9-10 year time frame (1993 to 2002/2003), the area influenced by Longboat Pass lies within 15,000 to 16,000 feet of the inlet's northern and southern banks (see Figure 2-46) (R-25 to R-59). Over a shorter time frame (2003-2009 or 2006-2009), the area influenced by Longboat Pass lies within 15,000 feet of inlet (see Figures 2-47 and 2-48) (R-25.5 to R-58).

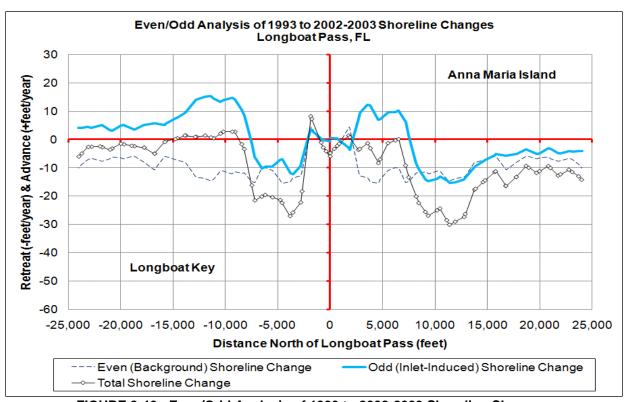


FIGURE 2-46: Even/Odd Analysis of 1993 to 2002-2003 Shoreline Changes.

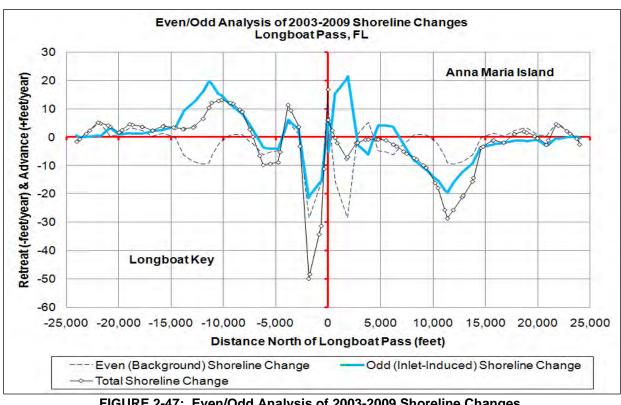


FIGURE 2-47: Even/Odd Analysis of 2003-2009 Shoreline Changes.

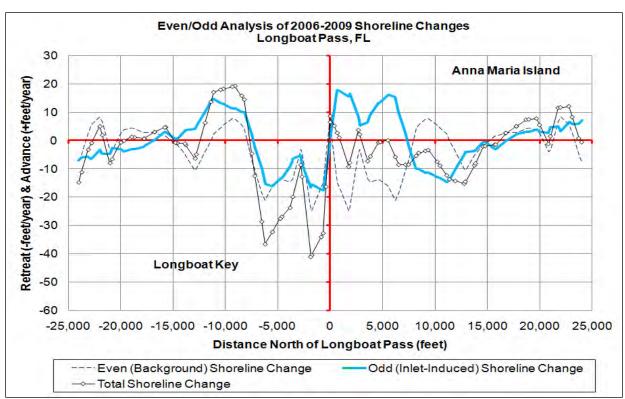


FIGURE 2-48: Even/Odd Analysis of 2006-2009 Shoreline Changes.

Ebb Shoal and 1993 Longboat Pass Borrow Area

The presence of Longboat Pass interrupts the alongshore sediment transport from Anna Maria Island (north) to Longboat Key (south) as sediment from the adjacent beaches enters the channels and shoals. As shown in the previous section, the ebb shoal is a sediment sink that absorbs much of the net sediment transport between Anna Maria Island and Longboat Key.

The refilling of the 1993 Longboat Pass borrow area appears to be contributing to this effect. Bathymetric changes in the 1993 Longboat Pass borrow area appear in Appendix C. Based on the December 1992 and August 1993 surveys, approximately 1,955,000 c.y. were removed from the borrow area during the construction of the Longboat Key Beach Restoration Project. Between August 1993 and March 2009, the net volume change within the borrow area was 1,074,000 c.y. (see Figure 2-49), equal to a rate of 69,000 c.y./year. It should be noted that the refilling has been relatively constant since 1993 and has recovered about 55% thus far. Given present rates, the borrow area is expected to refill by 2021 or 2022. As noted in the previous section, the ebb shoal is currently gaining 96,000 c.y./year. The refilling rate of 69,000 c.y./year represents 72% of this gain.

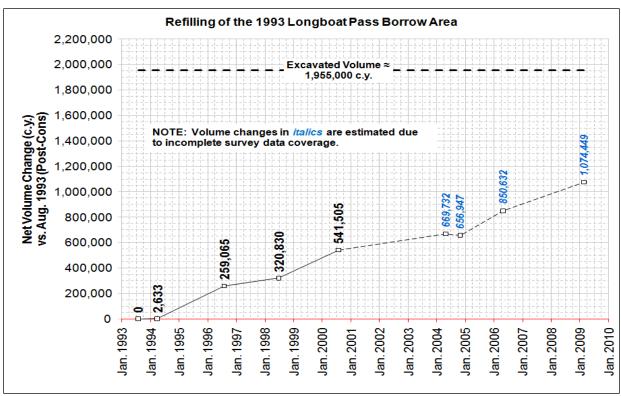


FIGURE 2-49: Refilling of the 1993 Longboat Pass Borrow Area.

Shoreline changes before and after the 1993 Longboat Key Beach Restoration Project appear in Figure 2-50. Shoreline changes prior to the project were based on the September 1986 and January 1993 surveys. This time period was selected based on the available survey data. Shoreline changes after the project were based on the August 1993 and August 1999 surveys, to cover a similar period of time. Prior to the 1993 project, the area between Broadway (R46) and Gulfside Road (R50) was either stable or accretional, while the area to the north was erosional. After the 1993 project, all beaches north of Gulfside Road (R50) were erosional, with the exception of profile R45 (Seabreeze Avenue).

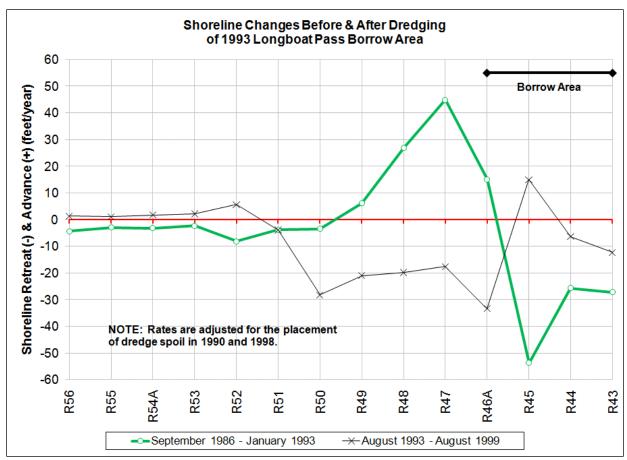


FIGURE 2-50: Shoreline Changes Before and After the Construction of the 1993 Longboat Key Beach Restoration Project.

Changes in the erosion patterns on the north end of the island appear to have been influenced by a combination of factors:

- Alongshore spreading of the beach fill material. The northern end of the 1993 project was located at profile R46 (Broadway). As noted by Dean and Yoo (1991) and others, the spreading of beach fill alters the shoreline retreat rate near the ends of a beach fill project. Beaches just inside the fill area exhibit accelerated erosion rates, with either gains or lower erosion rates just outside the fill area.
- <u>Cross-shore spreading of beach fill material.</u> Because sand is placed by the dredge mostly in the dry at a steep slope, waves will transport sand offshore to achieve a more natural beach slope. The rate at which this process occurs depends on the grain size of the fill material, with finer materials adjusting more quickly (Day, 2004). The 1993 fill material was fine sand, with a grain size in the 0.19 mm range (CPE, 1995).
- The influence of the borrow area. When the dredging of a borrow area represents a significant change to the bathymetry, it can alter wave propagation, currents, and the resulting sediment transport. Also, if a borrow area refills at a rapid rate (Figure 2-49), it can act as a sediment sink, taking material that would otherwise remain within the

nearshore littoral system. To investigate the influence of the borrow area on the erosion rates after the 1993 project, simulations were conducted using the Delft3D model given the excavated, 1993 bathymetry and the 1992 pre-construction bathymetry (CPE, 2011). These simulations suggest that the dredging of the borrow area could have accelerated the erosion rate near Beachwalk (R47) and lowered the accretion rate near North Shore Road (R44.7), although the effect may be indirectly related as the overall system adjusted to the dredging event.

Channel Stability, Position, and Orientation

Stability

A detailed discussion of the inlet's stability appears in the *Morphodynamics of Longboat Pass, Manatee County, Florida: Historic Channel Locations and Shoreline Positions Based on a Time Series Analysis of Aerial Photographs* (Finkl, et al, 2007). This analysis notes that the "position of the inlet centerline was most variable from 1940 to 1977. During this time, it migrated within a 900 foot swath. Federal maintenance of the inlet began in 1977. From 1980 to 1997 and from 2000 to 2006 the inlet centerline position was relatively stable, migrating within an approximately 250 ft. wide swath. Inlet stability appears to have increased since 1977." As noted earlier, 1977 was year in which the Longboat Pass Federal navigation project was authorized. The relative stability of the inlet since this date can be partly attributed to the maintenance of an established inlet channel cross-section.

North Shore Road (R44.8) Erosion Hotspot

The general area between Longboat Pass (R42) and Gulfside Road (R50) has been a chronic erosion hotspot since 1993 (see Figures 2-27, 2-28, 2-50 and Tables 2-7 and 2-8). Within this segment, the North Shore Road seawall began to experience rapid losses in beach width around 2003 (see Figure 2-51). Based on the 2010 aerial photograph (Figure 2-29), there was almost no sandy beach in front of this structure, necessitating the closure of the public access.

At some inlets, the pathway of the inlet channel through the ebb shoal has a strong influence on the adjacent beaches' erosional patterns (i.e. Cleary and Jackson, 2004). To determine whether this was the case at North Shore Road (R44.8), the pathway of the outer inlet channel was digitized based on aerial photographs and bathymetric contours between 1993 and 2009 (see Appendix C). Using the same data sources, plus additional surveys and photographs, the distance between the mean high water line and the seawall at profile R44.8 was determined (Figure 2-51). The pathway of the inlet channel through the ebb shoal was measured in terms of its orientation at its seaward terminus (Figure 2-51).

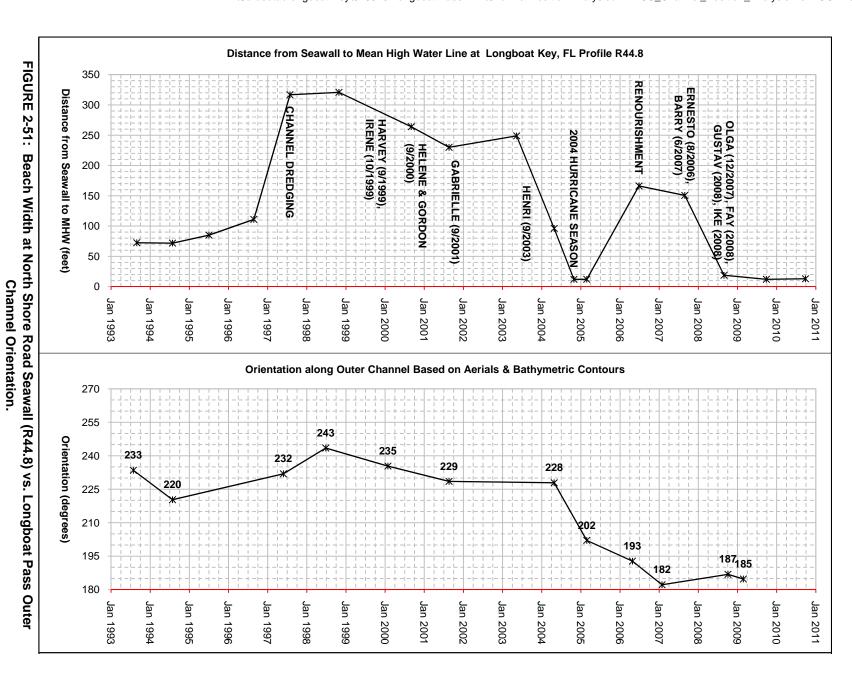


Figure 2-51 shows several distinct periods between 1993 and the present:

- 1993-1997: This was the period between the Longboat Key Beach Restoration Project and the 1997 maintenance dredging project. During this period, the channel orientation varied from 220 to 233° (southwest). The overall position of the channel as shown in Appendix C did not change substantially. The beach near North Shore Road was either stable or accretional. This period ended with the placement of dredge spoil in front of the North Shore Road seawall in 1997 (USACE, 1994 construction plans, sheet 3/2).
- 1997-2003: Between 1997 and 2003, the beach near North Shore Road experienced either stability or mild erosion. During this period, several tropical storms and hurricanes made landfall along the Florida gulf coast. None of these exceeded Category 1 strength while in the Gulf of Mexico. However, their effect may have contributed to the erosion that occurred between 1998 and 2001. The channel orientation between 1997 and 2003 varied from 228 to 243°, with a decrease in orientation during the 1998-2001 storm period.
- 2003-2004: During the 2003 and 2004 hurricane seasons, rapid erosion occurred near North Shore Road, combined with a shift in the channel towards its present position and orientation. The notable storms during the period were Tropical Storm Henri (September 2003), Bonnie (August 2004), Charley (August 2004), Frances (September 2004), Ivan (September 2004), and Jeanne (September 2004). Although Henri was primarily considered a rain event (Wikipedia, 2010), it made landfall in Pinellas County, and may have been responsible for the rapid erosion between 2003 and early 2004. The other storms made landfall further from Longboat Pass than Tropical Storm Henri. However, their combined effect was the cause of the rapid erosion between May and November of 2004. By November 2004, no sandy beach was left in front of the North Shore Road seawall (see Figure 2-29).
- 2004-2009: Since November 2004, it has been difficult to maintain a sandy beach in front of the North Shore Road seawall (see Figures 2-29 and 2-51). During this period, the channel continued to change position and orientation. Although the beach was renourished in 2005 and 2006, the fill in front of the seawall only lasted for about a year. Between September 2007 and September 2008, rapid erosion removed most of the remaining beach width, which may have been related to hurricane activity in the Gulf of Mexico.

Overall, Figure 2-51 and Appendix C suggest that storm activity is a major contributor to the erosion patterns near North Shore Road (R44.8). Erosion at the North Shore Road seawall has generally coincided with elevated hurricane and tropical storm activity in the Gulf of Mexico. However, the position and orientation of the Longboat Pass outer channel may also influence beach width at North Shore Road. During the times at which there has been little or no sandy beach at this location, the channel has generally followed a curved path, with an orientation near 180° at its seaward terminus (Figure 2-52). During the times in which there has been a wide

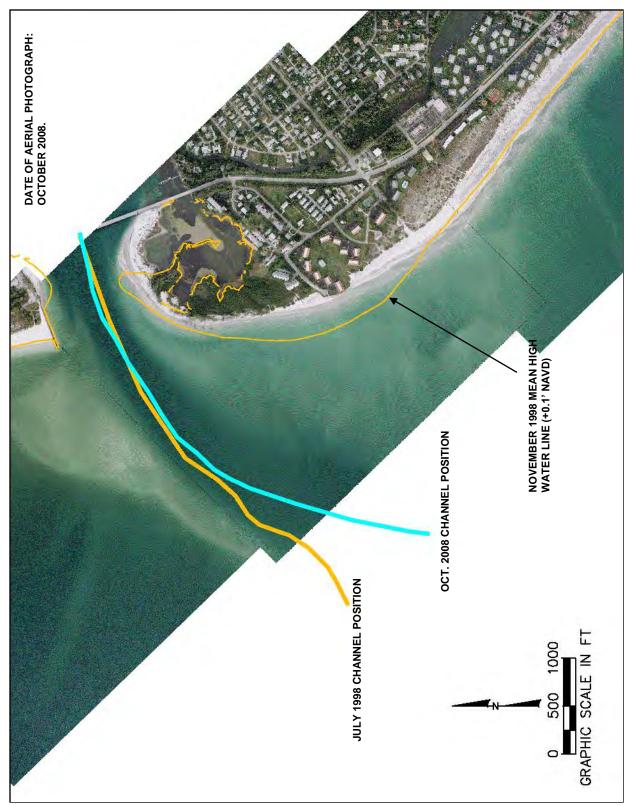


FIGURE 2-52: Comparison of Widest and Narrowest Beach at North Shore Road versus Channel Position at Longboat Pass.

beach at North Shore Road, the channel has followed a straighter path, with an orientation near 240° (Figure 2-52). The shift of the channel location also coincides with a rotation of the ebb shoal complex, which affects the location of wave impacts on the coast and the point at which the ebb shoal reconnects with the beach.

Size of Inlet (Escoffier Analysis)

The stability of Longboat Pass in terms of its size and its likelihood of closure was evaluated using the Escoffier (1940, 1977) and O'Brien curves (Keulegan, 1967). The Escoffier curve is a theoretical relationship between the tidal current velocity and the cross-sectional area. The O'Brien curve is an empirical relationship between tidal prism and the cross-sectional area at the throat of the inlet. In most cases, the two curves will cross (see Figure 2-53). The two crossing points represent an inlet whose channel is stationary in size. The crossing point that corresponds to the smaller area represents an unstable equilibrium – "any deviation from that point immediately sets into action forces which tend to further increase or aggravate the deviation" (Escoffier, 1940). A reduction in that cross-sectional area would lead to its closure, while an increase would expand the inlet. The crossing point that corresponds to the larger area represents a stable equilibrium – "any deviation from that point sets into action forces which tend to restore the channel to its initial condition" (Escoffier, 1940).

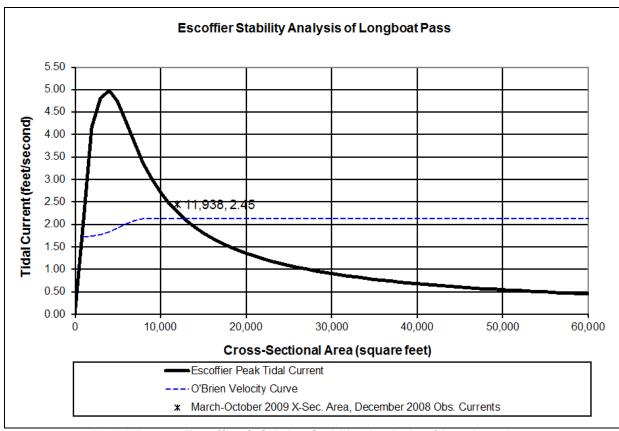


FIGURE 2-53: Escoffier & O'Brien Stability Analysis of Longboat Pass.

The Escoffier and O'Brien curves for Longboat Pass appear in Figure 2-53, and assume the following:

Tidal amplitude = 0.71 feet (Table 2-2, 4th column).

Inlet length = 1,575 feet (Bayfront shorelines to seaward end of terminal groin).

Wetted perimeter = 909 feet (Cut 2 profile 7+00, 2009 surveys).

Effective bay area = $329,000,000 \text{ feet}^2$.

Chezy's friction coefficient = 75 m $^{1/2}$ /s = 118 feet $^{1/2}$ /s (see Appendix A).

Tidal period = 24 hours.

O'Brien cross-sectional area in $m^2 \approx 0.56 \times 10^{-4} \text{ x}$ (tidal prism in m^3) (Van de Kreeke, 1992).

Typical tidal current = 2.45 feet/second (Figure 2-11).

Present cross-sectional area = 11,938 feet² (Cut 2 profile 7+00, 2009 surveys).

The effective bay area accounts for the multiple entrances into Sarasota Bay: Longboat Pass, New Pass, Big Sarasota Pass, Little Sarasota Bay, and Anna Maria Sound. Excluding these entrances, Sarasota Bay covers 945,905,000 square feet between the Cortez Road and State Road 72 bridges. Based on the modeling in Appendix A, Longboat Pass carries approximately 35% of the flow into the bay, with the remainder being carried by other the inlets and waterways. Given this proportion of flow, the corresponding bay area is roughly 329,000,000 feet².

As shown in Figure 2-53, the Escoffier curve is consistent with recent current measurements and hydrographic surveys. Based on Escoffier and O'Brien curves, Longboat Pass is slightly smaller than its stable equilibrium (12,750 feet²). This suggests that aside from maintenance dredging, changes over the next few years will be limited to minor scouring around the throat of the inlet (Cut 2). This small increase in size would ease the flow through Cut 2, gradually reducing the current velocities and scouring rates until the controlling cross-section reached its equilibrium size. Overall, this finding is consistent with the volume changes in Table 2-12 and Figure 2-44, which are characterized by low scouring rates in Cut 2.

3. NATURAL RESOURCES

A. General

Longboat Pass is directly connected to the Sarasota Bay estuary system, which is a small, subtropical estuary classified as an Outstanding Florida Water. Sarasota Bay was designated an "estuary of national significance" by the U.S. Congress in 1988 as part of the Water Quality Act of 1987. It is a coastal lagoon system formed by a chain of barrier islands to the west and the mainland of Sarasota and Manatee Counties to the east. The area surrounding Longboat Pass supports extensive seagrass beds, and is dotted with mangrove keys. The region is home to a variety of coastal and marine wildlife, including dolphins and manatees, sea turtles, shore and wading birds, and many recreationally and commercially important fish species.

B. Beach and Dune System

The sandy Gulf coast beaches surrounding Longboat Pass are characteristic of low energy shorelines, having a relatively gentle, shallow offshore slope. These beaches provide resting and foraging habitat for shore and wading birds. Species commonly observed in these areas include pelicans, herons, egrets, gulls, terns, plovers, sandpipers, and small passerine species. The beaches also provide foraging habitat for a few terrestrial mammals, such as raccoons and squirrels. Other organisms inhabiting the beach zone include amphipods, isopods, coquina clams (*Donax variabilis*), polychaete worms, and various crabs such as mole crabs (*Emerita talpoida*) and the common ghost crab (*Ocypode* sp.). The beaches also provide nesting habitat for sea turtles (CPE, 2010).

The beaches in the project area are part of a barrier island system. Barrier islands are dynamic environments, with topographic and vegetation profiles dictated by the interaction of plant growth and physical processes such as wind-driven sand movement and salt spray, and wave-driven erosion and accretion (Myers and Ewel, 1990). High temperatures, strong winds, and varying wet and dry conditions typical of a dune environment along south Florida's barrier island system provide unique conditions for plant species with specific adaptations. These specific adaptations include extensive root systems, which allow for prolific growth in unconsolidated beach sand. Sand dunes and vegetation that comprise the dune system are important recreational and wildlife habitat areas and provide coastline protection from storm surge. Dunes are important reservoirs for sand, replacing beach material lost through erosion. Dunes also provide important protection to the island from storms and hurricanes.

Anna Maria Island

Anna Maria Island, on the north side of Longboat Pass, has miles of pristine white sand beaches. One of the largest of these beaches, Coquina Beach, is located at the southern end of the island at the entrance to Longboat Pass. Native dune vegetation is present along Coquina, as well as numerous non-native Australian pines (*Casuarina equisetifolia*).

Dunes on Anna Maria Island provide habitat for a variety of wildlife and important storm protection for the island. The backshore dune system of Anna Maria Island shoreline acts as a

habitat for ghost crabs (*Ocypode quadrata*), raccoons (*Procyon lotor*), the threatened eastern indigo snake (*Drymarchon corais couperi*) and, in some areas, the threatened gopher tortoise (*Gopherus polyphemus*). Along portions of the Anna Maria Island shoreline, the edge of vegetation marks the landward limits of historical beach fill placement. Dune vegetation mainly consists of salt tolerant sea oats (*Uniola paniculata*), railroad vine (*Ipomoea pes-caprae*) and beach elder (*Iva imbricata*). These plants function as stabilizers for the dune and beach system and create additional habitat and nesting area for many shore animals. Sea oats have been designated as a protected plant by the FDEP. This designation specifies that sea oat seeds cannot be collected without a permit, and the plants cannot be cut back or removed. In accordance with FDEP guidelines, all native dune vegetation is required to be protected from pedestrian traffic, pruned only as necessary and replanted as necessary (CPE, 2007).

At the southern end of Anna Maria Island, dune construction occurred in 1994/95, with placement of vegetation. Another dune vegetation project was constructed in the spring of 2004. However, storm surge associated with the 2004 hurricane season washed away some of the newly planted vegetation. Based on 2005 FDEP aerial photos and field verification, low relief vegetation is present along the upper berms and dunes found within the study area (CPE, 2007).

Leffis Key

Leffis Key is a preserve located on the east side Anna Maria Island, just north of Longboat Pass. Once a spoil island overgrown with non-native vegetation, significant restoration efforts have created a more natural setting on Leffis Key. The uplands were planted with native dune and coastal ridge plants such as sea oats (*Uniola paniculata*), beach elder (*Iva imbricata*) and dune sunflower (*Helianthus debilis*) (MC-NRD, 2010).

The Coquina Baywalk at Leffis Key provides boardwalks and footpaths for visitors to view the restored tidal lagoons and mangrove shoreline. This site is part of a larger program to restore portions of the mangrove shoreline that once fringed much of Sarasota Bay. The Florida Fish and Wildlife Conservation Commission (FWC) lists this site as a great Florida birding and wildlife viewing trail, where at high tide, the tidal lagoons attract blue crabs (*Callinectes sapidus*), whelks, conchs, ragged sea hares (*Bursatella leachii*), and many fish species. Low tide brings fiddler crabs (*Uca pugnax*) and many wading birds, including great white herons (*Ardea alba*), little blue herons (*Egretta caerulea*), tricolored herons (*Egretta tri-color*), black-crowned and yellow-crowned night herons (*Nycticorax nycticorax; Nyctanassa violacea*), snowy egrets (*Egretta thula*), and glossy and white ibis (*Plegadis falcinellus; Eudocimus alba*). Magnificent frigatebirds (*Fregata magnificens*) are common in the summer, and brown pelicans (*Pelicanus occidenatalis*) and osprey (*Pandion haliaetus*) can be seen year-round (FWC, 2010).

Longboat Key

The north end of Longboat Key is known as Beer Can (Greer) Island. This is an undeveloped hooked sand spit that has a history of being separated from and subsequently reconnected to Longboat Key (see Figures 2-20 to 2-22 and corresponding text). It is primarily vegetated by sea grapes (*Coccoloba uvifera*) and red mangroves (*Rhizophora mangle*). The red mangroves dominate the interior of the spit as well as the shoreline leading up to the northern end.

Australian pines are also found at the northern tip of the island; however, many have fallen due to erosion. Other vegetative species present include sea oats (*U. paniculata*), saltmeadow cordgrass (*S. patens*), railroad vine (*I. pes-caprae*), and beach elder (*I. imbricata*).

The developed section of Longboat Key extends from North Shore Road (R44.7) to New Pass and lies south of Greer Island. Most of the areas landward of the vegetation line consist of developed, landscaped parcels. However, several sections, such the Sea Pines to Whitney Beach segment, feature natural vegetation zones between the sandy beach and the developed, landscaped areas. The plant and animal communities in these zones are similar to those on Anna Maria Island.

C. Estuarine Wetlands

Estuarine wetlands are present within the interior of Longboat Pass along the east side of the barrier island within the Intracoastal Waterway. These wetlands provide a number of benefits to Sarasota Bay, including food and shelter for marine life, filtration of pollutants and sediments, and regulation of freshwater flow into Sarasota Bay (SBNEP, 1995). The estuarine habitats surrounding Longboat Pass primarily include mangroves and seagrass meadows (see Figure 3-1). However, on Leffis Key, in addition to native dune and beach plantings there, extensive saltmarsh vegetation was also installed along the banks of a tidal pond, including smooth cordgrass (*Spartina alterniflora*), saltmeadow cordgrass (*Spartina patens*), and salt jointgrass (*Paspalum vaginatum*) (MC-NRD, 2010).

D. Nearshore Areas and Hardbottom

The nearshore Gulf of Mexico in the area of Longboat Pass includes the littoral (intertidal) zone and the sublittoral (offshore) zone. The littoral zone is inhabited by organisms such as polychaete worms, crustaceans, and bivalves. Organisms common to the sublittoral zone include annelid worms, crustaceans, echinoderms, pelecypod and gastropod mollusks, and various species of crabs and shrimp. In addition, the coastal waters contain a variety of commercial and sport fishes including snook (*Centropomus undecimalis*), pompano (*Trachinotus carolinus*), spotted seatrout (*Cynoscion nebulosus*), groupers (*Epinephelus* and *Mycteroperca* spp.), snappers (*Lutjanus* spp.), redfish (*Sciaenops ocellatus*) and flounders (*Bothus* spp.) (CPE, 2010).

The nearshore Gulf floor consists of a mosaic of carbonate sand, small areas of low-relief exposed hardbottom, and thin layers of carbonate sand over hardbottom. In general, the sand-silt substrate supports a low-diversity, low density soft bottom assemblage. Organisms frequently associated with the soft bottom include pen shells (*Atrina rigida*), tube worms (*Chaetopterus variopedatus*), fighting conch (*Strombus alatus*) and various echinoderms (*Lytechinus variegatus*, *Mellita quinquiesperforata*, *Astropecten* sp., and *Luidia senegalensis*) (CPE, 2010).

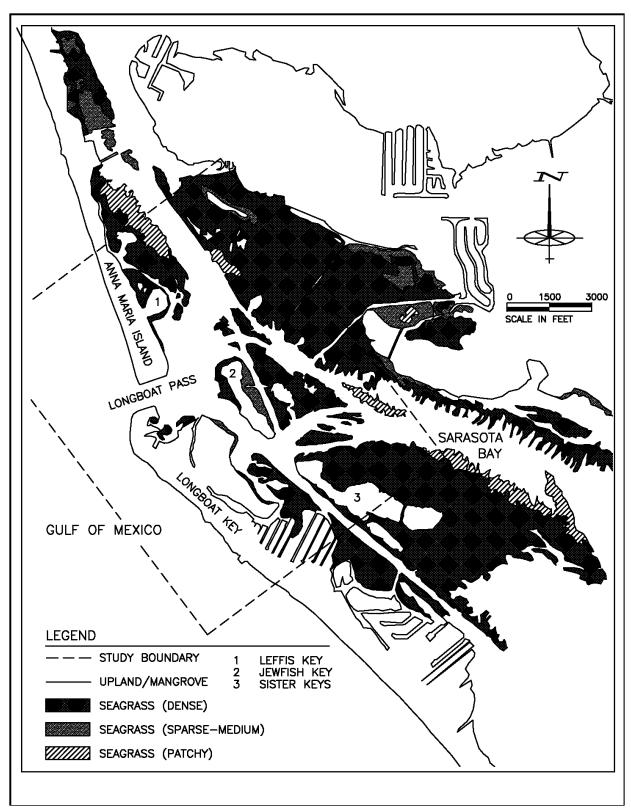


FIGURE 3-1: Sarasota County 1988 – Sarasota Bay Seagrass Assessment (1984 Aerial with 1987 Ground Truth) (ATM, 1993).

CPE has conducted extensive inventories of the benthic habitat surrounding Longboat Pass, including the hardbottoms of both Anna Maria Island and Longboat Key. The term "hardbottom" refers to areas of rock or consolidated sediments in temperate, subtropical, and tropical regions, generally located in the ocean rather than in the estuarine system. Hardbottom habitats provide food, shelter, spawning and nursery areas to a wide variety of fish, invertebrate, coral and algal species.

Nearshore hardbottom habitat is present along the southern shoreline of Anna Maria Island between FDEP monuments R-35 and R-39, offshore of Coquina Beach. The ephemeral hardbottom resources have been mapped on multiple occasions, and the benthic communities associated with these resources have been assessed, monitored and documented in association with previous Anna Maria Island beach nourishment projects (1992/93, 2002, and 2005/06). Most recently, the hardbottom resources were delineated and characterized by CPE marine biologists in September 2009. Data have shown that the nearshore hardbottom resources located off of Coquina Beach are ephemeral, experiencing frequent burial and re-exposure. These hardbottom resources are comprised primarily of scattered limestone outcroppings ranging from low-relief, well-scoured areas to some offshore isolated areas of higher relief (up to 2 feet). The benthic community is typically dominated by turf algae and macroalgae, with moderate tunicate and sponge cover. The octocorals Leptogorgia virgulata and L. hebes are commonly found in this habitat; these colonies remain small (<5 cm) on areas which experience frequent burial, and may grow to 20-30 cm in isolated areas of higher relief farther offshore. Stony corals such as Solenastrea hyades and Phyllangia americana are occasionally observed on the exposed hardbottom, but are restricted to offshore areas of higher relief that escape sedimentation. Several fish utilize the nearshore hardbottom resources off of Anna Maria Island, including sheepshead (Archosargus probatocephalus), red grouper (Epinephelus morio), and belted sandfish (Serranus subligarius).

In addition to the natural nearshore hardbottom resources, three artificial reefs, totaling approximately 14.5 acres have been constructed offshore of the Anna Maria Island shoreline to mitigate for hardbottom burial associated with beach nourishment. One of these reefs is located in approximately 22 feet of water, approximately 6,700 feet offshore of Anna Maria Island. The other two artificial reefs are located in 10 to 15 feet of water, approximately 900 – 1000 feet offshore of Coquina Beach, just north of Longboat Pass. The County is currently constructing an additional 4.87 acres of limestone boulder artificial reefs north of Longboat Pass in conjunction with the 2011 Coquina Beach project.

Hardbottom formations are also present in the nearshore of Longboat Key. Fourteen acres of nearshore hardbottom habitat were documented and characterized within the 2005/06 beach renourishment project area. The Town of Longboat Key constructed 1.5 acres of artificial reef as required mitigation for anticipated impacts to 1.5 acres of nearshore natural hardbottom. Four years of bi-annual monitoring surveys were conducted on the artificial reef and nearshore natural hardbottom habitats between 2005 and 2009. Monitoring revealed a community dominated by turf and macroalgae species. The macroalgae community primarily consisted of *Hypnea*, *Gracilaria*, *Codium*, and *Sargassum* species. *Dictyota*, *Caulerpa*, and *Padina* were also frequently observed. A total of 21 macroalgae genera were identified on the nearshore natural hardbottom throughout monitoring.

Tunicates and sponges dominate the invertebrate community. The sponge community mainly consists of bioeroding sponges *Cliona celata* and *Pione lampa*. Coral cover in the nearshore benthic community is generally less than 1%. *Leptogorgia virgulata* and *Leptogorgia hebes* are the primary octocoral species. The stony coral community is dominated by *Solenastrea* spp., but also includes *Siderastrea siderea*, *Phyllangia americana*, *Oculina robusta*, and *Cladocora arbuscula*. The average size of stony coral colonies in the nearshore habitat is small (< 3cm).

4. INLET MANAGEMENT ALTERNATIVES

A. General

Based on the erosion rates, the sediment budget, the 1993 borrow area analysis presented in Section 2, and the intergovernmental coordination between local stakeholders, the management of Longboat Pass should address the following:

- High erosion rates on the south end of Anna Maria Island at Coquina Beach (R36-R41).
- The location of the navigation channel through the Longboat Pass ebb shoal.
- High erosion rates on the north end of Longboat Key (Reaches 1 and 2, R42 to R51).
- Dredged material placement sites for the periodic maintenance of Longboat Pass.

Conceptual alternatives were developed and discussed with the inlet stakeholders in a design charette on November 5, 2010. Results of the charette were presented to a joint meeting of the Town and County commissions on November 30, 2010. A finalized list of alternatives to be evaluated was developed and presented to the Town and the County on December 14, 2010. These alternatives included:

- 1. No Action.
- 2. Anna Maria Island Terminal Groin Extension (Figure 4-1).
- 3. Longboat Key terminal groin options:
 - a. Single groin (Figure 4-2).
 - b. Twin terminal groins (Figure 4-3).
- 4. Longboat Key Terminal Groin Plus Breakwater (Figure 4-4).
- 5. Longboat Key Terminal Groin Plus Two Permeable Adjustable Groins (Figure 4-5).
- 6. Inlet channel dredging options:
 - a. Authorized Channel (Figure 4-6).
 - b. Relocated Channel proposed by U.S. Army Corps of Engineers (Figure 4-7).
 - c. Relocated Channel following the recommendation of Humiston & Moore (Figure 4-8)
 - d. Authorized Channel with Advance Maintenance (Figure 4-9).
- 7. Dredging of Gulf Intracoastal Waterway Cut M5 (near Jewfish Key) (Figure 4-10).
- 8. Combinations of the above alternatives into a comprehensive plan.

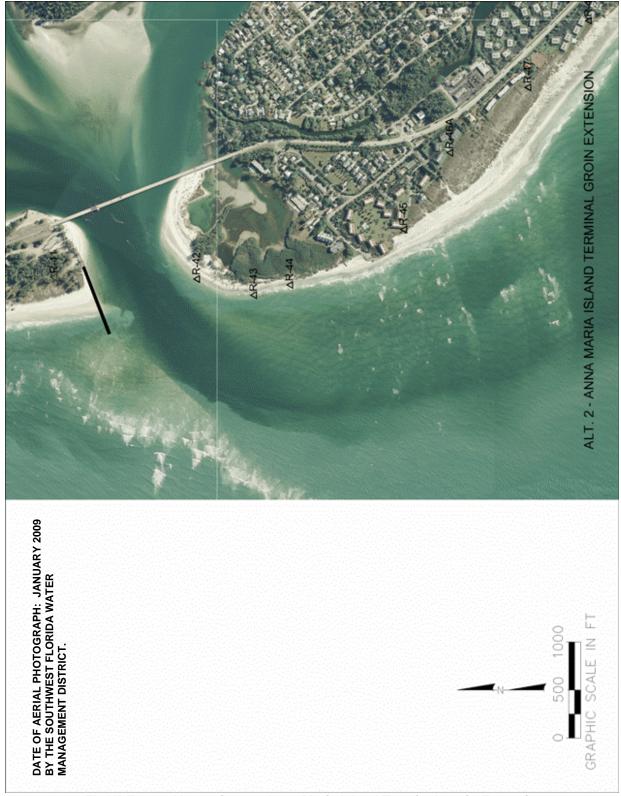


FIGURE 4-1: Alternative 2 – Anna Maria Island Terminal Groin Extension.

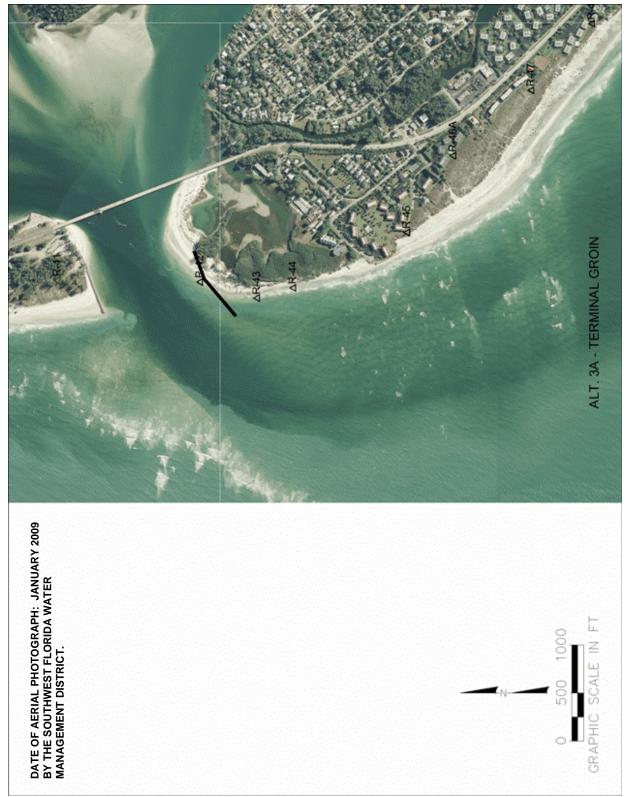


FIGURE 4-2: Alternative 3A – Longboat Key Single Terminal Groin.



FIGURE 4-3: Alternative 3B – Longboat Key Twin terminal groins.



FIGURE 4-4: Alternative 4 – Longboat Key Terminal Groin Plus Breakwater.



FIGURE 4-5: Alternative 5 – Longboat Key Terminal Groin Plus Two Permeable Adjustable Groins.



FIGURE 4-6: Alternative 6A - Authorized Channel.



FIGURE 4-7: Alternative 6B – Relocated Channel Proposed by U.S. Army Corps of Engineers.

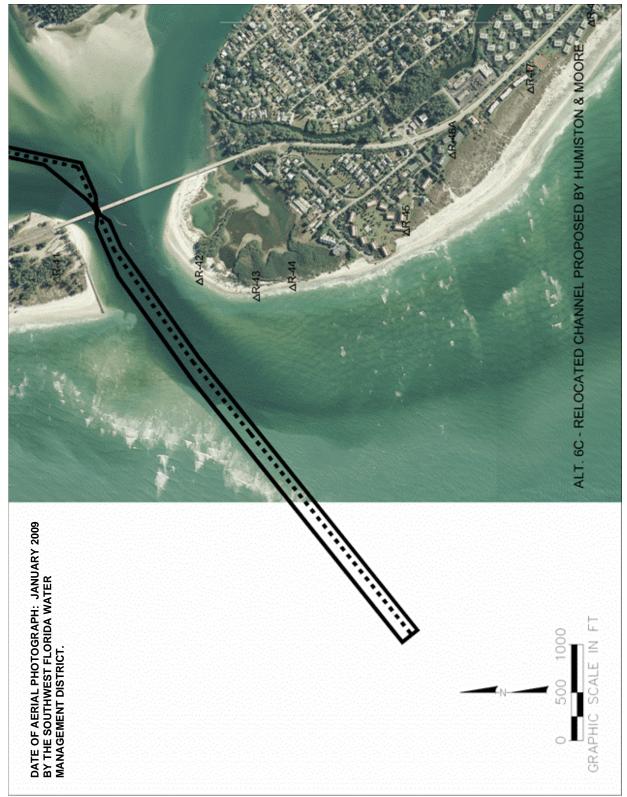


FIGURE 4-8: Alternative 6C – Relocated Channel Proposed by Humiston & Moore.



FIGURE 4-9: Alternative 6D - Authorized Channel with Advance Maintenance.

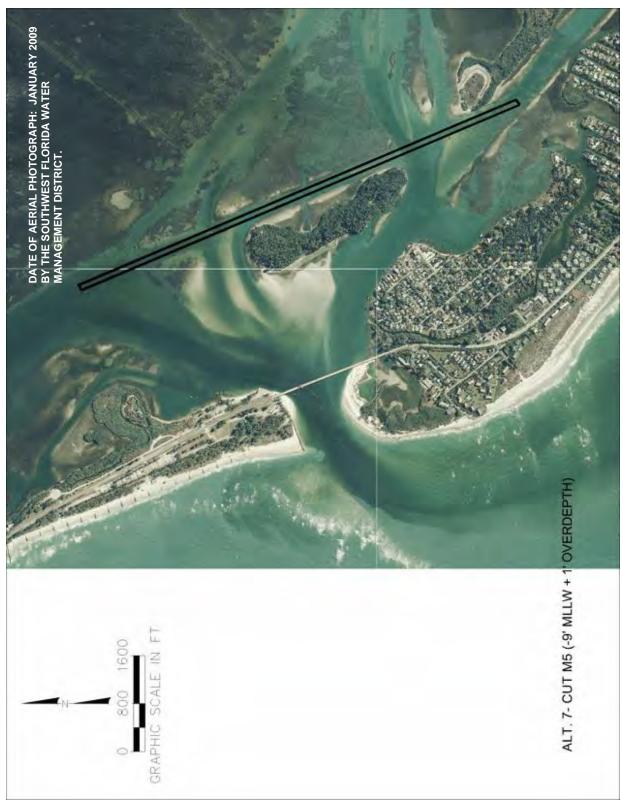


FIGURE 4-10: Alternative 7 – Dredging of Gulf Intracoastal Waterway Cut M5.

B. Engineering Approach

Each of the alternatives was developed using traditional engineering approaches. Each alternative was designed to a preliminary level sufficient for description in the numerical model and for comparison of the effects on the beach with the no action alternative. It is recognized that any recommended alternative will require final engineering, which is outside the scope of this study.

A numerical model, Delft3D, was setup, and calibrated for the Longboat Pass area. This state of the art hydrodynamic and sediment transport model allows the simulation of various alternatives to determine the positive and negative effects of the alternative on the beach and inlet system. The details of the model setup and calibration are provided in Appendix A. Each of the alternatives, identified above, was simulated in the Delft3D numerical model. Detailed results and technical discussions are presented in Appendix A. Summarized results are provided below.

C. Alternative Descriptions

Alternative 1 – No Action

Under this alternative, no projects to maintain Longboat Pass or the adjacent shorelines were included. This scenario is unlikely to occur. Construction of the City of Anna Maria Nourishment and Coquina Beach Restoration and the Longboat Key North End Beach Nourishment Project were completed in 2011. Due to high erosion rates on the north end of Longboat Key, maintenance will probably continue. On Coquina Beach, beach fill is expected to be tied into the island-wide program in the future.

In Longboat Pass itself, a no-action scenario is more likely to occur. As noted in the sediment budget (Figure 2-44), the interior of Longboat Pass (Cut 1 and Cut 2) is not a sediment sink. This behavior is one of the reasons that the channel was not dredged between 1997 and 2011. Recent discussions between the U.S. Army Corps of Engineers, Manatee County, and the Town of Longboat Key have suggested that "future dredging ... would be the town and the county's responsibility" (Schultheis, www.yourobserver.com, 2010).

Under a no-action scenario, the model (Appendix A) suggests that over 8 years, the main channel of Longboat Pass will assume an inverted L-shape as the ebb shoal rotates south, bringing the inlet's entrance channel closer to the shoreline of Longboat Key. The model also indicates that on Anna Maria Island, the swash channel adjacent to the existing terminal groin could deepen. Due to the continued formation of that swash channel, the net volume change on coquina beach would likely be erosional. Nevertheless, the model also suggests that slight fillet growth could occur above the water line at the existing terminal groin.

On Longboat Key, the migration of the channel and ebb shoal in the model results in high erosion rates on the island's north end, with estimated rates on the order of 13 c.y./foot/year north of Broadway (R46). The calculated shoreline retreat over 8 years approaches 280 feet on Greer Island (between profiles R42 and R43) and 180 feet near Seabreeze Avenue (R45.5) (Appendix A).

The No Action alternative fails to meet the objectives of improving inlet management for Longboat Pass.

Alternative 2 – Anna Maria Island Terminal Groin Extension

To reduce the erosion rate on Coquina Beach, the terminal groin on Anna Maria Island is proposed to be sand tightened and extended. By extending the groin 250 feet seaward, the beach width is expected to increase. The sand tightening of the groin will reduce losses to Longboat Pass by slowing the transport of material into Longboat Pass near the shoreline (see Figure 2-41). Overall, the extension is expected to reduce future nourishment needs, increase storm protection and increase potential nesting area for sea turtles and shorebirds.

If the terminal groin on Anna Maria Island is extended 250 feet, the model suggests that the structure's fillet will widen 335 feet over 8 years, approaching the seaward end of the structure (see Figure 4-11). Nevertheless, the structure extension would not eliminate the swash channel formation; it would only divert it further offshore (see Sub-Appendix A-1), and erosion of the submerged beach profile would continue near profiles R39-R41. The northern limit of the structure's beach widening effects would be located approximately 2000 feet north of the inlet between profiles R38 and R39.

On Longboat Key, the extension of the terminal groin could increase the erosion and retreat rates along Greer Island and 360 North (R42-R44.7) (see Figure 4-11). Since the structure would retain more material, the transport of sediment towards Longboat Key would be reduced, resulting in higher erosion and retreat rates north of North Shore Road (R44.8). South of North Shore Road (R44.8), erosion along the submerged part of the profile could increase. However, shoreline retreat rates will be similar to those of the No Action Scenario (Appendix A).

Alternative 3 – Longboat Key Terminal Groin Options:

a. Single Groin

To slow the alongshore transport of sand from the north end of Longboat Key into Longboat Pass, a terminal groin is considered. The total length of the groin, as simulated, is 800 feet, with a 500 foot long section beginning at the existing shoreline. The terminal groin will be constructed of rubble-mound quarry stone. The beach width is anticipated to increase immediately adjacent to the groin and be stabilized north of North Shore Road (R44.7).

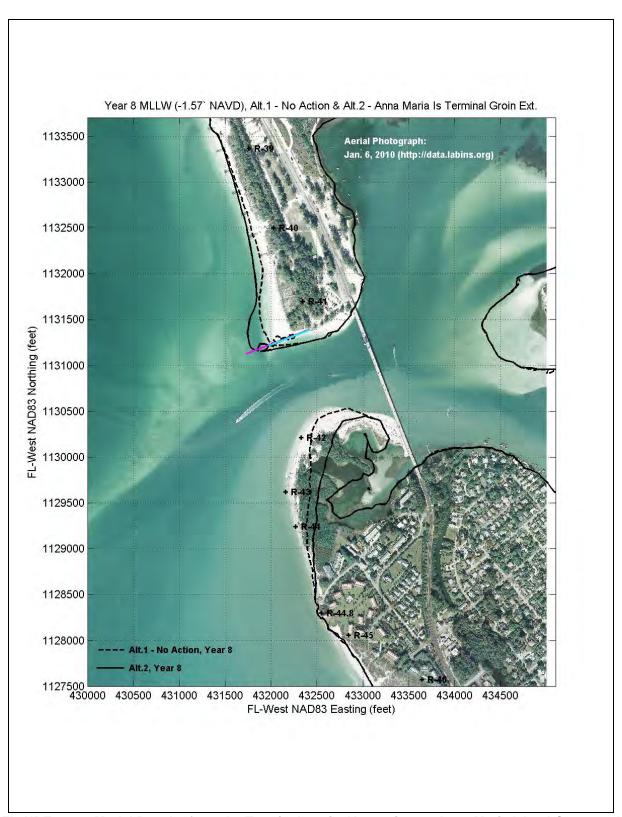


FIGURE 4-11: Model Results from the Terminal Groin Alternative on Anna Maria Island Compared to the No Action Alternative.

If a single terminal groin is constructed on the north end of Longboat Key, the Delft3D model suggests that the shoreline at the immediate north end of Longboat Key will be stabilized (Figure 4-12). However, the 8-year fillet growth will likely be limited to Greer Island (R42-R44.5). The benefits of the structure are not likely to extend into the developed section of the beach (near North Shore Road). On Anna Maria Island, the structure could have a negative impact south of R38.5 (Figures 4-12), possibly due to the reduction in northerly sediment transport off Greer Island.

As shown in Figure 4-12, the model suggests that sediment could also accumulate on the northern, or downdrift side of the terminal structure. Similar behavior occurs at the terminal groin on the west end of Fire Island, NY, and at the south end of Amelia Island, FL, where the structure was intentionally designed to be porous (Olsen, 2009).

b. Two Groins

To block the alongshore transport of sand from the north end of Longboat Key into Longboat Pass and to possibly increase the beach width seaward near the North Shore Road beach access and the 360 North Condominiums, two terminal groins were considered. The groins, as simulated, were 420 feet and 500 feet in length. If two terminal groins are constructed on the north end of Longboat Key, the Delft3D model also suggests that the shoreline at the north end of Longboat Key will be stabilized (Appendix A). However, by constructing two groins instead of a single groin, this option may be able to extend the benefits of the structures further south, just reaching the 360 North Condominium (R44.7), though little benefit would be seen at the property (Figure 4-13). At North Shore Road, the groins would not widen the beach.

On Anna Maria Island, the potential impacts of the structures are similar to those of the single groin option. Like the single groin option, the deflection of the sediment transport around the two groins results in the accumulation of material on the northern side of the northern groin.

Alternative 4 – Longboat Key Terminal Groin Plus Breakwater

The combination of a breakwater seaward of North Shore Road and the terminal groin at the north end of Longboat Key is anticipated to slow the alongshore transport around the headland created by the North Shore Road seawall and prevent the loss of sand from the beach into Longboat Pass. The simulated terminal groin is 800 feet long, similar to Alternative 3A. The shore-parallel breakwater, as simulated, is 250 feet long, and located 400 feet offshore of the North Shore Road seawall. Both structures would be constructed of rubble-mound quarry stone. Analytical engineering methods suggest that a salient is expected to form landward of the breakwater. The analytical methods also suggest that the shoreline width will increase by 90 to 130 feet and should be able to maintain the Town's design beach seaward of North Shore Road, the 360 North Condominiums, and Longbeach Village.

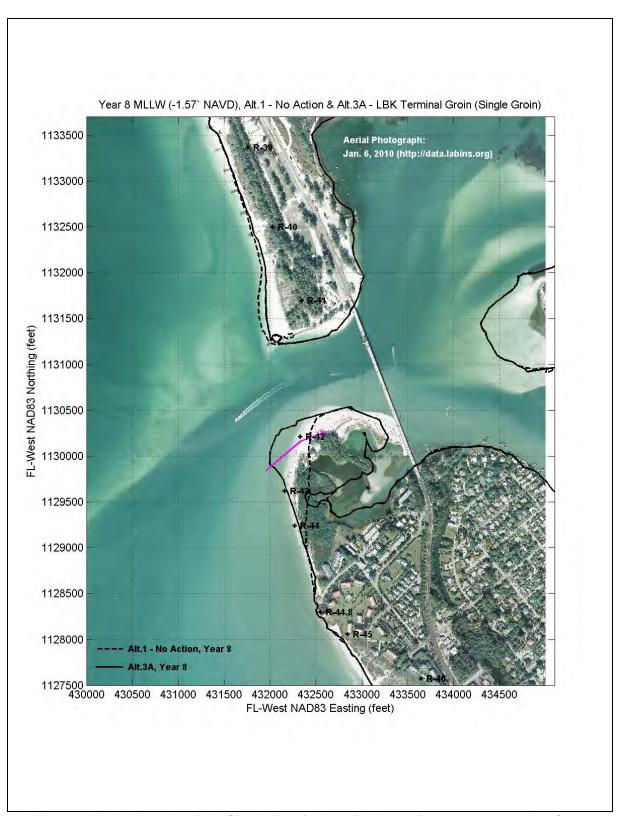


FIGURE 4-12: Model Results of the Single Terminal Groin Alternative on Longboat Key Compared to the No Action Alternative.

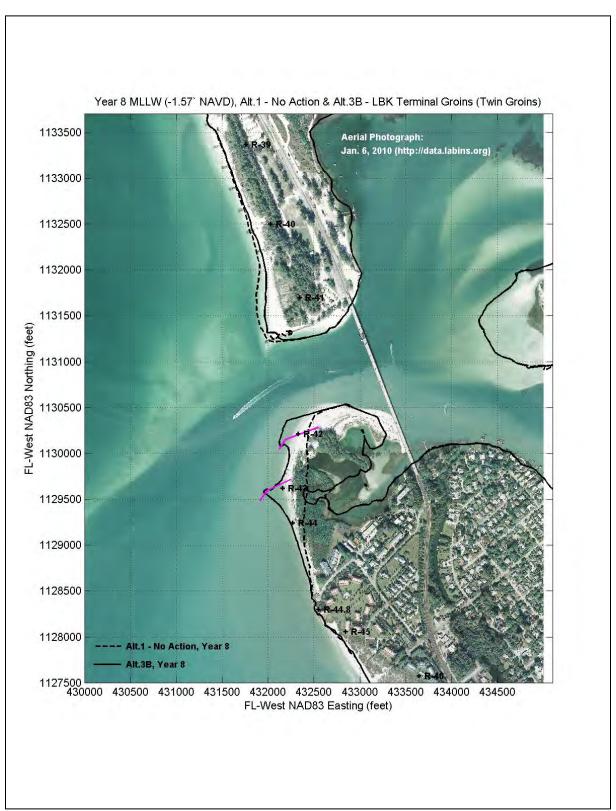


FIGURE 4-13: Model Results of the Two Terminal Groin Alternative on Longboat Key Compared to the No Action Alternative.

The Delft3D model suggests a smaller morphological response than the analytical methods (Appendix A). While substantial reductions in erosion rates from Longboat Pass to Seabreeze Avenue (R45) will occur, and while the breakwater would be able to accumulate sediment in its lee, the deposition of material may not be substantial enough to generate a visible salient (Figure 4-14). In addition, scour in front of the existing seawall could continue, although the degree of scour may be exaggerated due model limitations (see CPE, 2010, for a further discussion of this issue). At the breakwater itself, the migration of the inlet entrance channel towards Longboat Key could cause the structure to settle or become unstable (Appendix A).

On Anna Maria Island, the model suggests that the potential impacts of the structures are similar to those of the single groin option (Figure 4-14). Similar to the single terminal groin alternative (3A), the deflection of the sediment transport around the proposed terminal groin results in the accumulation of material on its northern side (Appendix A).

Alternative 5 – Longboat Key Terminal Groin Plus Two Permeable Adjustable Groins

The combination of two permeable adjustable groins near the North Shore Road access, along with a terminal groin, is anticipated to maintain the Town's beach design width seaward of vulnerable properties and allow continuous access along the north end of Longboat Key to Greer Island. The permeable adjustable groins allow sand to pass through while trapping enough sand to maintain the desired design beach width. Based on model results, the groins are expected to increase the beach width by 80 to 200 feet, significantly increasing the storm protection to North Shore Road and the 360 North Condominiums. The design of the permeable adjustable groins follows that of the Islander Club Condominium (Mann, 2011). The two permeable groins are designed to be 280 feet long. The length of the terminal groin, as simulated, is 800 feet, similar to Alternative 3A. During the initial simulation of this alternative, the model suggested that modifications could improve the stability of the beach at the south end of the North Shore Road seawall (Figure 4-15).

In response to the initial alternative simulation, a revised alternative (5S) was simulated to assess the performance if the southern permeable adjustable groin were moved 94 feet south. As shown in Figure 4-16, Alternative 5S is expected to hold a combined fillet extending from Longboat Pass to the south end of the North Shore Road seawall (R42 to R45). South of the seawall, erosion below the waterline could increase by a small amount. However, this erosion would likely be addressed by the Town's overall nourishment program. South of Whitney Beach (R48), the effect of the structures would be either small or negligible. On Anna Maria Island, the structures could have a negative impact between Longboat Pass and R38.5 related to the retention of sand in northern Longboat Key and reduced sediment transport off Greer Island. Similar to Alternative 3A, the deflection of the sediment transport around the proposed terminal groin results in the accumulation of material on its northern side (Appendix A). Of the structural alternatives considered for Longboat Key, Alternative 5S offers the most widespread benefits based on the model results (Appendix A), but should be considered in conjunction with jetty modifications on Anna Maria Island to offset any potential impacts to Coquina Beach.

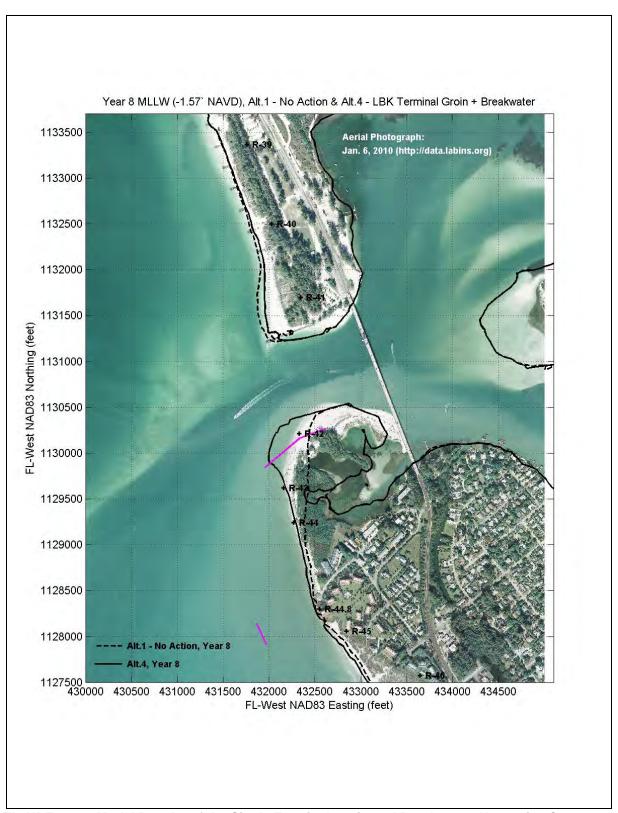


FIGURE 4-14: Model Results of the Single Terminal Groin and Breakwater Alternative Compared to the No Action Alternative.

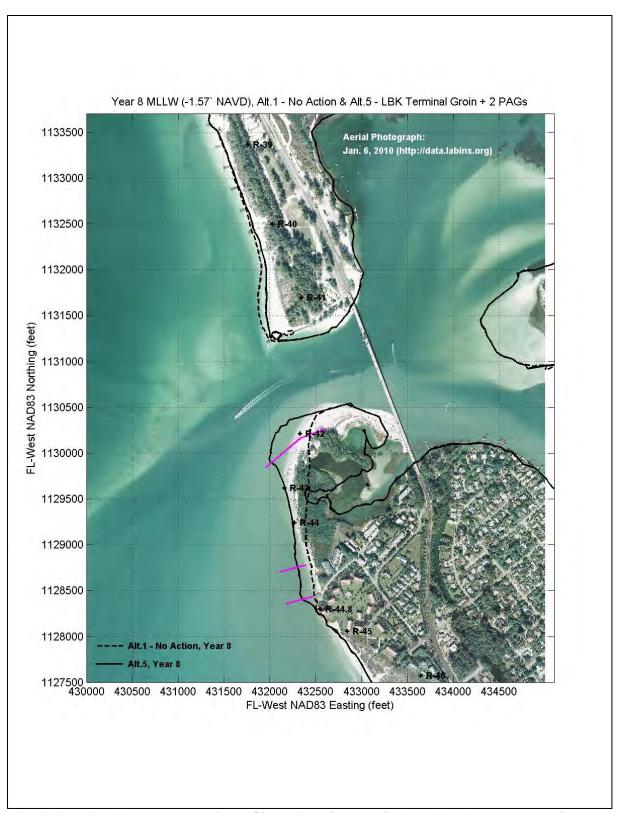


FIGURE 4-15: Model results of the Single Terminal Groin Plus Two Permeable Adjustable Groins alternative compared to the No Action alternative. Note little beach stabilized at the seaward end of North Shore Road.

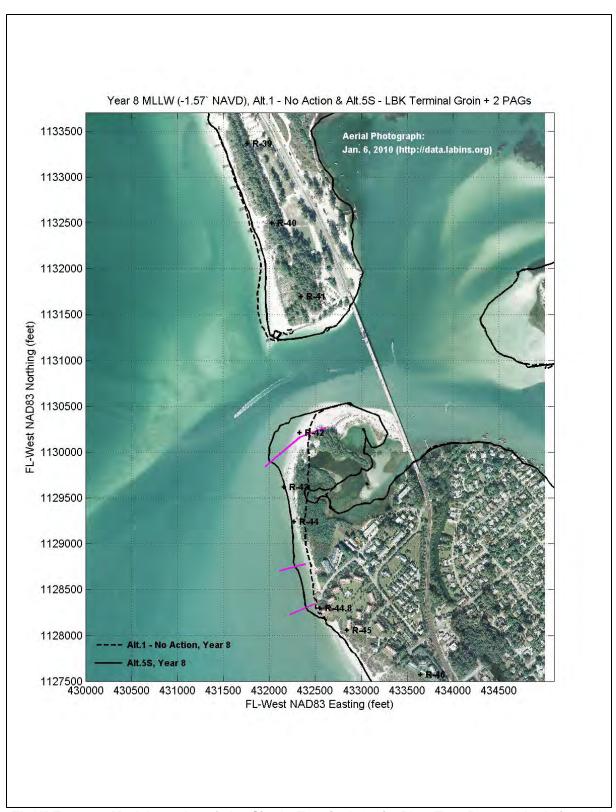


FIGURE 4-16: Model results of the Single Terminal Groin Plus Two Permeable Adjustable Groins alternative (5S) compared to the No Action alternative. Note that there is beach stabilized at the southern end of North Shore Road in this alternative (5S).

Alternative 6 – Inlet Channel Dredging Options

To ensure the navigability of Longboat Pass and provide an additional source of material to maintain Cortez Beach, Coquina Beach, and the north end of Longboat Key, four dredging options were proposed. Similar to Alternatives 1-5S, each dredging option was simulated in the Delft3D model for a period of 8 years. During these model simulations, beach fill activity and navigational dredging after the initial excavation and spoil placement were not included. However, it should be noted that this assumptions was conservative. Between 1977 and 1997, the average interval between maintenance dredging operations was 5 years (see Table 1-1).

Initial dredging volumes appear in Figure 4-17 and Table 4-1. The primary differences between the dredging options are the configurations of the channel west of the Longboat Pass bridge (Cut 1 00+00 to Cut 2 16+00). East of the bridge, the dredging options are identical. For each simulation the dredge spoil was evenly split between the two adjacent islands.

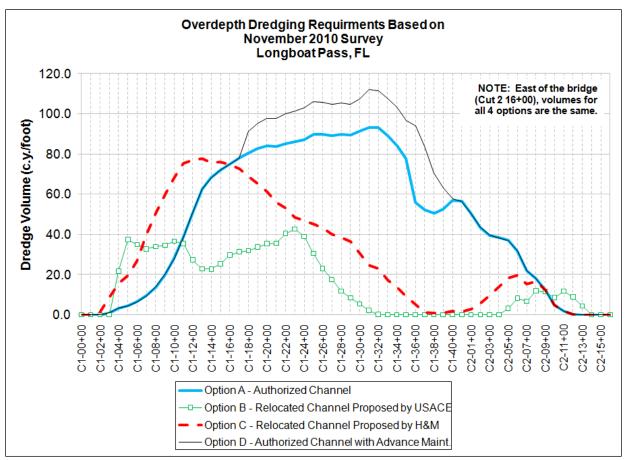


FIGURE 4-17: Distribution of Initial (Year 0) Inlet Channel Dredging along the Channel for Each Alternative.

TABLE 4-1

INITIAL (YEAR 0) DREDGING VOLUMES
BASED ON NOV. 2010 CHANNEL SURVEY
LONGBOAT PASS, FL

Alt.	Description	Cut / Profiles		Volume (cubic yards)	Design Depth			
7			Design Overdepth Total		Total	(feet MLLW)		
6A	Authorized Channel	Cut 1 Cut 2 Cut 3 TOTAL	176,300 21,200 15,100 212,600	58,500 13,500 6,600 78,600	234,800 34,700 21,700 291,200	-12 + 2' overdepth varies -10 + 1' overdepth		
		Cut 1-00+00 to Cut 2-16+00 Cut 2-16+00 to Cut 3-40+48 TOTAL	197,100 15,500 212,600	70,500 8,100 78,600	267,600 23,600 291,200	-12 + 2' overdepth -10 + 1' overdepth		
6B	Relocated Channel	Cut 1 Cut 2 Cut 3 TOTAL Cut 1-00+00 to Cut 2-16+00 Cut 2-16+00 to Cut 3-40+48	27,700 3,200 15,100 46,000 30,500 15,500	50,700 6,200 6,600 63,500 55,400 8,100	78,400 9,400 21,700 109,500 85,900 23,600	-12 + 2' overdepth varies -10 + 1' overdepth -12 + 2' overdepth -10 + 1' overdepth		
		TOTAL	46,000	63,500	109,500			

TABLE 4-1 (continued)

INITIAL (YEAR 0) DREDGING VOLUMES BASED ON NOV. 2010 CHANNEL SURVEY LONGBOAT PASS, FL

Alt.	Description	Cut / Profiles		Volume (cubic yards)	Design Depth		
7			Design			(feet MLLW)	
6C	Relocated Channel Proposed by	Cut 1	103,300	51,700	155,000	-12 + 2' overdepth	
	Humiston & Moore	Cut 2 Cut 3	6,200 15,100	7,800 6,600	14,000 21,700	varies -10 + 1' overdepth	
		TOTAL	124,600	66,100	190,700		
		Cut 1-00+00 to Cut 2-16+00 Cut 2-16+00 to Cut 3-40+48	109,100 15,500	58,000 8,100	167,100 23,600	-12 + 2' overdepth -10 + 1' overdepth	
		TOTAL	124,600	66,100	190,700		
6D	Authorized Channel with Advance Maintenance	Cut 1 Cut 2 Cut 3	206,900 21,200 15,100	66,600 13,500 6,600	273,500 34,700 21,700	-12 + 2' overdepth varies -10 + 1' overdepth	
		TOTAL	243,200	86,700	329,900		
		Cut 1-00+00 to Cut 2-16+00 Cut 2-16+00 to Cut 3-40+48	227,700 15,500	78,600 8,100	306,300 23,600	-12 + 2' overdepth -10 + 1' overdepth	
		TOTAL	243,200	86,700	329,900		

During the 1997 dredging operation, there were 4 designated disposal sites: R34 to R35 and R36+511' to R38+204' on Anna Maria Island and R44+48' to R46A and R48+722' to R51 on Longboat Key (USACE, 1996). This disposal plan was assumed for the Delft3D model simulations of Alternatives 6A, 6B, 6C, and 6D. Given the erosion that has occurred at North Shore Road (R44.8), the 1997 disposal plan would be well suited to the present conditions of the Longboat Key beaches. For purposes of the Delft3D modeling, the disposal sites were simulated with a berm elevation of +3' NAVD (+4 feet NGVD).

a. Authorized Channel

This option would continue the maintenance of the original channel authorized by Congress and constructed by the U.S. Army Corps of Engineers in 1977. Based on the November 2011 survey, this option would require dredging 291,200 cubic yards of sand (Appendix A).

This option has several advantages. It does not involve any major design changes, it has been permitted previously by the State, and the quantities required during the initial dredging operation would be similar to past dredging volumes (Table 1-1). In addition, it would also promote the stability of the inlet. As noted by Finkl, et al. (2007), "from 1980 to 1997 and from 2000 to 2006, the inlet centerline was relatively stable, migrating within an approximately 250 ft. wide swath. Inlet stability appears to have increased since 1977." By maintaining the design established in 1977, this option would increase the likelihood of the inlet remaining within the stable configuration observed by Finkl, et al. (2007) between 1977 and 1997.

One disadvantage of this option is the larger volume and cost relative to the other dredging options. However, by placing more sand on the eroding shorelines of Anna Maria Island and Longboat Key, some of the higher costs will be offset through reductions in the volumes required for other forms of beach maintenance undertaken by the County and Town.

If the 1977 Authorized Channel is dredged, the model suggests that the outer entrance channel will have two branches by Year 8; the primary channel runs along the northern shoreline of Longboat Key, with a second that runs at a 10-20° angle to the south of the design dredge cut (Figure 4-18). The model suggests that the branch running close to Longboat Key does not scour as quickly as it would under the No Action scenario (Appendix A). Likewise, the seaward edge of the ebb shoal would also be located further seaward after several years than it would under the No Action scenario, thus reducing the impacts of channel and shoal migration on Longboat Key.

On Longboat Key, most of dredge spoil is expected to spread towards the south, although a small amount would spread to the north. Near Whitney Beach (R48), the model suggests a small erosional impact on the order of 2-3 c.y./year/foot. At other locations on the island, the impacts of dredging the 1977 Authorized Channel will be small or negligible.

On Anna Maria Island, the dredging of the Authorized Channel may result in additional erosion along Coquina Beach between R39 and Longboat Pass (Appendix A). The impact is estimated to be within the 10-12 c.y./year/foot range at R41 tapering to zero near R39. The futher development of the swash channel near the existing terminal groin is expected.

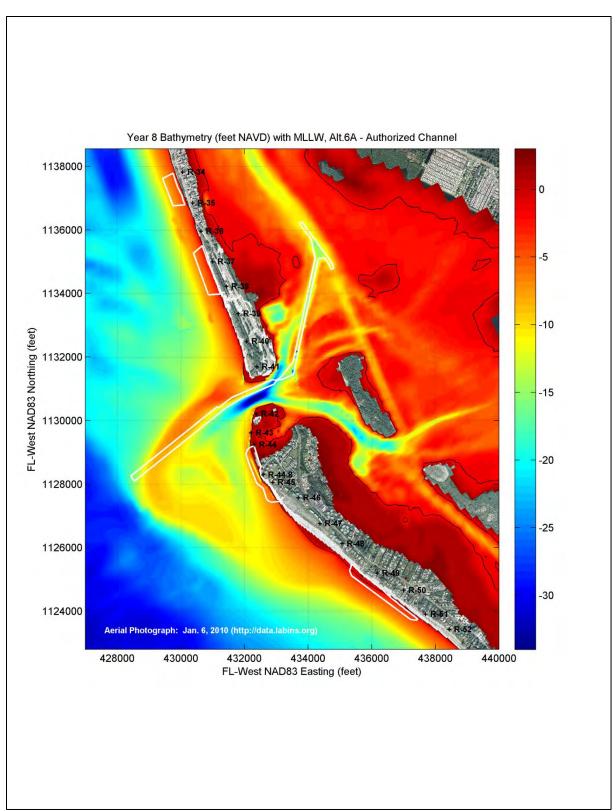


FIGURE 4-18: Predicted bathymetry 8 years after the dredging of the Authorized Channel (Alternative 6A). White polygons along the beach show the dredge spoil placement areas as simulated.

Shoaling within the design dredge cuts is also of interest. The model suggests that the redredging volume at the end of Year 8 is 195,900 c.y., which is equivalent to an average shoaling rate of 24,500 c.y./year (Table 4-2, last column). This simulated rate is similar to the observed rate from 1997 to 2010, which is 22,400 c.y./year. Additional discussion of dredging requirements is provided in Appendix A.

b. Relocated Channel Proposed by the U.S. Army Corps of Engineers (Mora, 2010)

This option would relocate the outer channel to near the flow pathway that has been developing since 2004 (Figure 4-19). The primary advantage of this option is that it has the smallest dredging requirement and is the least-cost option. However, it also poses some disadvantages. First, it does not provide a large amount of material to assist with the maintenance of Cortez Beach, Coquina Beach, or the north end of Longboat Key. Second, there is the risk that erosion rates at the North Shore Road hotspot would continue to remain high or increase. Due to these factors, the Town of Longboat Key does not favor this option (Schultheis, www.yourobserver.com, 2010).

Model results given the dredging of the Relocated Channel into the present (2009) bathymetry appear in Figures 4-19 and Appendix A. Overall, the Relocated Channel offers only minor differences (≤ 2 c.y./foot/year) compared to the No-Action scenario. This is because the amount of material in the design cuts is relatively low. If the Relocated Channel were constructed, the maintenance dredging requirement would increase each year, reaching 173,300 c.y. at Year 8 (Table 4-2, last column). The maintenance dredging requirement at Year 8 would be significantly higher than the initial dredging requirement given the present (2009-2010) conditions. The reason that this quantity is larger than the present requirement is that the model suggests that the outer channel is expected to migrate landward, resulting in ebb shoal buildup near the outer leg of the design cut and scour closer to the beach. Appendix A provides additional discussion of these results.

c. Relocated Channel Following Recommendation of Humiston & Moore (2008)

This option was similar to the Authorized Channel (6A). However, the channel design cut was shifted 200 feet to the south "to conform more closely to the natural tidal channel alignment", as recommended by Humiston & Moore (2008). This allows the outer design cut to take partial advantage of the natural channel alignment along the landward third of Cut 1 and the seaward half of Cut 2. East of the Longboat Pass bridge, the dredging requirements are the same as the Authorized Channel (see Figures 4-6 and 4-8). While this option reduces the initial (Year 0) dredging requirements by approximately 100,500 c.y. (see Table 4-1), the amount of dredge spoil available for placement on the beach remains within the range of previous dredging operations (see Table 1-1).

Of the 4 channel dredging options, the model suggests that Alternative 6C is expected to have the lowest maintenance dredging requirement at Year 8 (Table 4-2), although this is not the case at Years 2 or 4 (see also Appendix A). This may be due the location of the design cut relative to the ebb shoal growth areas depicted by the model (Figure 4-20).

TABLE 4-2

MAINTENANCE DREDGING REQUIREMENTS BASED ON DELFT3D MODEL RESULTS

Alternative		Profiles	Design Depth	+ Over- depth	Design Dredging Requirement (c.y.) at Year				Overdepth Dredging Requirement (c.y.) at Year				
			(ft. MLLW)	(feet)	2	4	6	8	2	4	6	8	
6A	Authorized Channel	Cut 1-00+00 to Cut 2-16+00	-12	2	130,700	96,300	101,400	116,800	198,800	160,100	163,200	180,100	
		Cut 2-16+00 to Cut 3-40+48	-10	1	7,700	7,700	7,600	7,200	17,400	16,700	16,400	15,800	
		TOTAL			138,400	104,000	109,000	124,000	216,200	176,800	179,600	195,900	
6B	Relocated Channel	Cut 1-00+00 to Cut 2-16+00	-12	2	73,300	82,100	88,200	101,300	126,300	136,400	144,100	157,800	
		Cut 2-16+00 to Cut 3-40+48	-10	1	7,600	7,600	7,600	7,000	17,300	16,400	16,300	15,500	
		TOTAL			80,900	89,700	95,800	108,300	143,600	152,800	160,400	173,300	
6C	Relocated Channel	Cut 1-00+00 to Cut 2-16+00	-12	2	111,000	109,100	96,600	96,100	167,300	160,000	142,100	143,700	
	Proposed by H&M	Cut 2-16+00 to Cut 3-40+48	-10	1	7,700	7,500	7,600	7,000	17,500	16,500	16,400	15,800	
		TOTAL			118,700	116,600	104,200	103,100	184,800	176,500	158,500	159,500	
6D	Authorized Channel	Cut 1-00+00 to Cut 2-16+00	-12	2	114,700	96,500	88,900	101,600	183,700	169,800	158,100	171,300	
	with Advance Maint.	Cut 2-16+00 to Cut 3-40+48	-10	1	7,700	7,700	7,600	7,200	17,300	16,700	16,400	16,000	
		TOTAL			122,400	104,200	96,500	108,800	201,000	186,500	174,500	187,300	
7	Dredging of GIWW Cut M5	M5-00+00 to M5-79+35	-9	1	600	600	700	1,000	1,100	1,400	2,300	3,500	

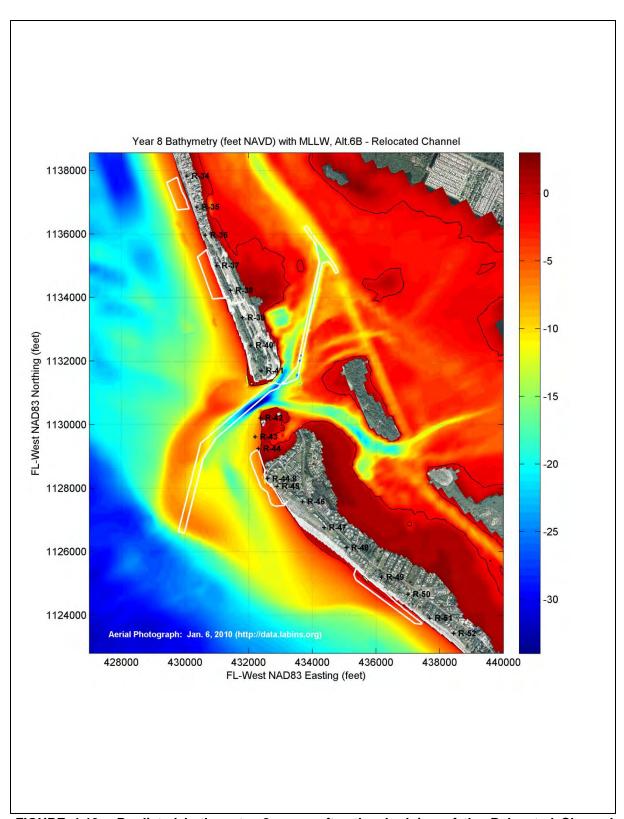


FIGURE 4-19: Predicted bathymetry 8 years after the dredging of the Relocated Channel (Alternative 6B). White polygons along the beach show the dredge spoil placement areas as simulated.

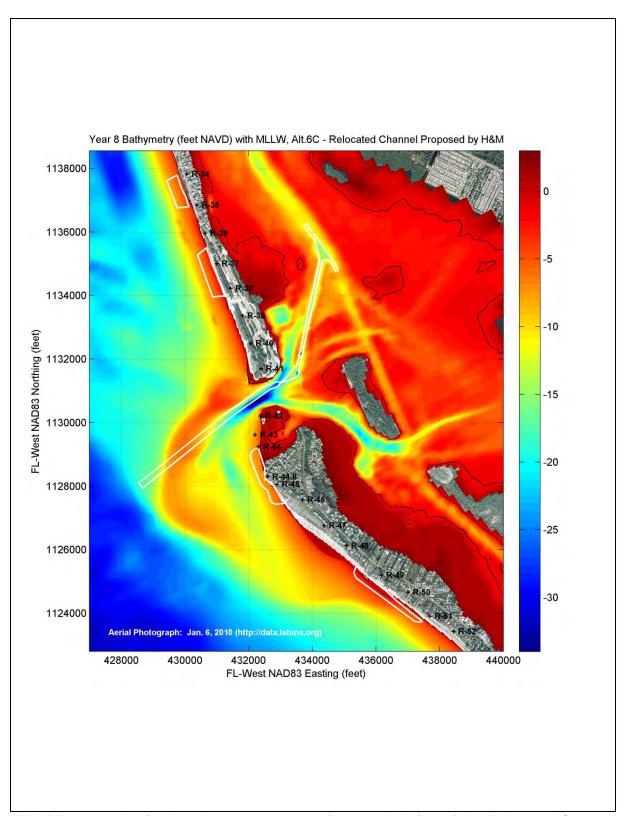


FIGURE 4-20: Predicted bathymetry 8 years after the dredging of the Relocated Channel Following the Recommendation of Humiston & Moore (2008) (Alternative 6C). White polygons along the beach show the dredge spoil placement areas as simulated.

d. Authorized Channel with Advance Maintenance

This option (Alternative 6D) removes an additional 38,700 c.y. from a 50 foot wide deposition area on the north side of the Authorized Channel (6A). The deposition area will allow the design cross-section to be maintained for a somewhat longer period of time than Option 6A. The primary advantage of this option is that it provides the most material to assist with the maintenance of Cortez Beach, Coquina Beach, and the north end of Longboat Key, and slows the projected infilling of the channel. The other advantages of this option are similar to Option 6A. The primary disadvantage of this option is that it is the most expensive dredging option due to its volume requirement. However, similar to Option 6A, the higher costs will be offset through reductions in the volumes required for other forms of beach maintenance.

In general, the performance of Alternative 6D is similar to Alternative 6A (Figure 4-21). The primary differences between the two are the larger changes on the simulated erosion/accretion rates at Whitney Beach (R48) and the smaller projected maintenance dredging requirements at Years 2, 6, and 8 (Table 4-2 and Appendix A). Further refinement of the Advanced Maintenance cut may reduce shoaling and improve performance of the channel.

Alternative 7 – Dredging of Gulf Intracoastal Waterway Cut M5

Gulf Intracoastal Waterway Cut M5 (Figure 4-10) includes the critical shoaling areas identified Humiston & Moore (2008) in Figure 1-5. This cut features a bottom width of 100 feet and a design depth of -9 feet MLLW (-10.57' NAVD) with a 1 foot over-dredge allowance. Based on the September 2009, May 2008, and September 1999 surveys by Sea Diversified, Inc. and the U.S. Army Corp of Engineers, approximately 40,800 c.y. are available for excavation.

Alternative 7, as simulated, removes 40,800 cubic yards of material from the Gulf Intracoastal Waterway behind Jewfish Key with a disposal of sediment outside the study area. This alternative has been incorporated into a larger dredging plan by the U.S. Army Corps of Engineers under FDEP permit application 0305363-001-JC. In general, the model suggests little to no shoaling within the M5 cut with slight shoaling north of Jewfish Key. This is consistent with the dredging history of Intracoastal Waterway near Longboat Pass when no dredging occurred between the 1960s and 2007 (Appendix A).

The Delft3D model results suggest that Alternative 7 could results in somewhat more scour through the swash channel around the existing terminal groin on the north side of Longboat Pass (see Sub-Appendix A-1). This would occur due to the small increase in tidal prism resulting from the deeper bathymetry near the Cut M5. Otherwise, the effects of this alternative on the Gulf-front erosion rates are minimal.

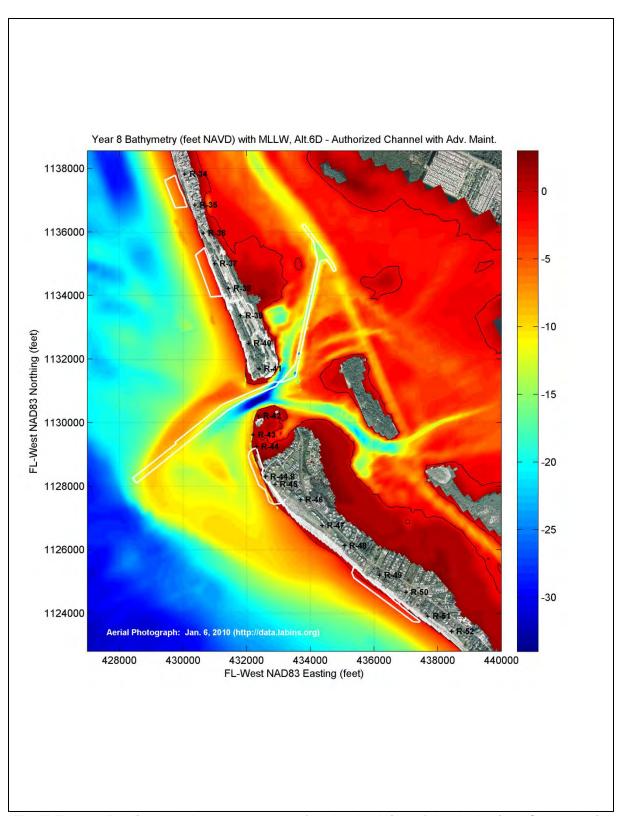


FIGURE 4-21: Predicted bathymetry 8 years after the dredging of the Authorized Channel with Advance Maintenance Dredging (Alternative 6A). White polygons along the beach show the dredge spoil placement areas as simulated.

4.8 Individual Alternative Findings

Overall, the model results of the various alternatives suggest the following:

- Longboat Pass is a complex and integrated system. Structural interventions/modifications on one side of the pass can affect the opposite side. Likewise, channel maintenance can result in impacts to the adjacent beaches both north and south of the pass.
- The present outer channel of Longboat Pass is likely to migrate landward over the next 8 years, resulting in high erosion rates on the north end of Longboat Key. This migration is expected to be coincident with a southerly rotation of the ebb shoal complex, which further exposes the north end of Longboat Key to erosion.
- The model suggests the development of a swash channel into the inlet near the existing terminal groin on the south end of Anna Maria Island, which is expected to continue to erode. Extension of the Longboat Pass North jetty on Anna Maria Island would partially offset these losses and push the swash channel further offshore.
- High erosion rates at the immediate north end of Longboat Key can be addressed through the construction of a terminal groin. Among the structural alternatives considered, Alternative 5S, which adds two permeable adjustable groins at the 360 North Condominium (R44.5) and the North Shore Road seawall (R44.7), benefits the longest stretch of beach on Longboat Key (R42-R44.9).
- Dredging the Authorized Channel (Alternative 6A) is likely to reduce the amount of channel scour close to the northern shoreline of Longboat Key and move the fringe of the ebb shoal further seaward. These processes should be able to reduce the erosional impacts of channel and shoal migration on along the northern end of Longboat Key.
- Dredging 38,700 c.y. on the northern side of the Authorized Channel as Advance Maintenance (i.e., Alternative 6D), will provide additional material for beach maintenance and may be able to offer a small reduction in the amount of maintenance dredging. Over the 8 year planning period, the average refilling rates given the Authorized Channel with Advance Maintenance will be similar to those that have occurred since 1997.
- Dredge spoil placed on Longboat Key should benefit the eroded beaches on the north end of the island. On Anna Maria Island, dredge spoil may spread in both directions due to sediment transport reversals, with the middle of Cortez Beach (R31-R34) receiving the greatest benefit.
- The high erosion rates on the south end of Anna Maria Island can be partially addressed by tightening and extending the terminal groin 260 feet. The proposed modification of the structure may also be a viable means of addressing the increased erosion that could occur on Coquina Beach if navigational dredging takes place, or if groins are constructed

on the north end of Longboat Key. Although the structure is not likely to completely eliminate the erosion along the south end of Anna Maria Island, the modifications are expected to benefit the beach approximately 2,000 feet to the north of the inlet.

• No one alternative addresses the needs of the inlet and both adjacent beaches. Structural alternatives on one beach appear to cause small impacts to the opposite beach. A combination of alternatives is required.

4.9 Combination of Alternatives

Based on the findings of the individual alternatives, the following combination of alternatives was simulated as the selected inlet management plan strategy:

- Anna Maria Island Terminal Groin Extension (Alternative 2).
- Longboat Key Terminal Groin Plus Two Permeable Adjustable Groins (Alternative 5S).
- Dredging of the 1977 Authorized Channel with Advance Maintenance (Alternative 6D). To reflect Manatee County's current beach management strategy, the designated spoil areas on Anna Maria Island have been combined into a single spoil site extending from R-35+790' to Longboat Pass. This spoil site coincides with the fill area used during the 2011 Anna Maria Island Beach Nourishment Project Coquina Beach Segment. On Longboat Key, the spoil sites are identical to those used in 1997.
- Dredging of Gulf Intracoastal Waterway Cut M5 (Alternative 7).

The simulation of the selected inlet management plan assumes that all components of the plan are constructed simultaneously. The simulation also assumes that pass maintenance dredging will take place in Year 8 (after the simulation period) and that no other nourishment activities on either island occur during the simulation period for comparison purposes.

The performance of the combined alternative is presented in Figure 4-22, with additional details provided in Appendix A. Implementing the combined alternative will maintain the channel along the northern lobe of the ebb shoal and temporarily widen the beaches along the southern end of Anna Maria Island and the northern end of Longboat Key. Between Years 2 and 8, the outer channel may develop two branches – one running near the location of the existing channel close to the beach and another which is located closer to the design dredge cut.

Between the north end of Longboat Key and Beachwalk (R47), erosion along the active beach profile will occur with scour further offshore, but it will likely be less than the No-Action scenario. In addition, the placement of the dredge spoil and the new structures should be able to prevent or minimize shoreline retreat past the 2009 shoreline north of R45 (Longbeach Village).

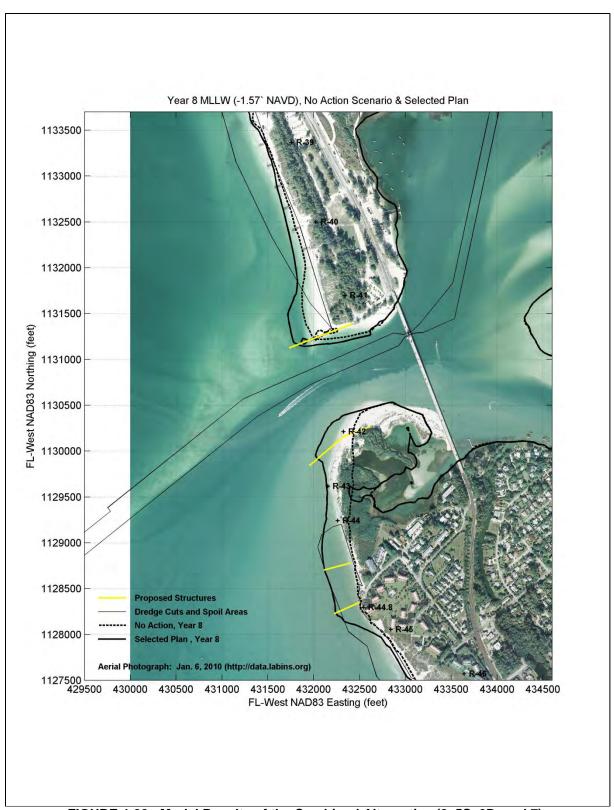


FIGURE 4-22: Model Results of the Combined Alternative (2, 5S, 6D, and 7).

On Anna Maria Island, the model suggests that placement of the dredge spoil and the extended terminal groin will be able to prevent or minimize erosion into the present beach profile north of R40. In addition, it will also promote the development of a fillet that will approach the seaward end of the extended groin (Figures 4-22). Erosion near the groin (R40 – R41) will continue to occur due to the development of the swash channel into Longboat Pass. However, the degree of erosion will be less, and it will largely occur below the waterline.

Shoaling within the channel dredge cuts will occur at approximately 24,000 cy/yr (Appendix A). As discussed earlier, the maintenance dredging requirements will depend on the adjustment of the ebb shoal to the post-dredging conditions and variations in wave activity. Within Cut M5 of the GIWW, the maintenance dredging requirements are predicted to be similar to those of Alternative 7 alone.

Overall this alternative meets the goals of the inlet management study better than any other alternative and is recommended for further consideration as the comprehensive management strategy. It is expected that the details of the plan and its implementation will be refined based on final design consideration and permit requirements.

5. COMPREHENSIVE MANAGEMENT PLAN

A. Plan

The results of Delft3D alternative screening simulations suggest the selected inlet management plan should include the following components:

- An extension of the existing terminal groin on the south end of Anna Maria Island (Alternative 2).
- The construction of a terminal groin on the north end of Longboat Key, plus two permeable adjustable groins near the 360 North Condominium and the public beach access at the end of North Shore Road (Alternative 5S).
- Dredging of the 1977 Authorized Channel with approximately 38,700 c.y. of advance maintenance on the north side of Cut 1 and placement of the spoil material on the south end of Anna Maria Island (R-35+790' to Longboat Pass) and the north end of Longboat Key (R-44+48' to R-46A and R-48+722' to R-51) (Alternative 6D).
- Dredging of Gulf Intracoastal Waterway Cut M5 (Alternative 7).

Under the selected inlet management plan,

o Projected erosion rates on the south end of Coquina Beach are likely to decrease with the extension and tightening of the existing terminal groin, which should be able to push the swash channel further offshore and maintain a fillet that extends approximately 2,000 feet north.

- The proposed terminal groin and permeable adjustable groins on the north end of Longboat Key should be able to reduce the 8 year erosion rates between Longboat Pass and R46 5 and stabilize a beach
- o Within Gulf Intracoastal Waterway Cut M5, the rates of refilling will be very slow, consistent with historical trends.
- The adjustment of the ebb shoal to the 1977 Authorized Channel will be most pronounced in the first 2 years, but may take 4-6 years to complete. After the 4-6 year adjustment period, the design cuts will exhibit gradual refilling rates over time. The bulk of the maintenance dredging requirements will be concentrated west of the Longboat Pass bridge. Overall, the average refilling rate over the 8 year planning period (24,000 cy/yr) will be similar to the average rate since 1997 (22,400 cy/yr).
- O Dredging the 1977 Authorized Channel plus 38,700 c.y. of advance maintenance should be able to divert some of the inlet's flow away from the beaches of Longboat Key. It will also provide dredge spoil that can be placed along Anna Maria Island and Longboat Key to address higher erosion rates adjacent to the inlet. Modifications to the specific advance maintenance cut location may improve performance.
- O Dredging the Authorized Channel may increase shoaling rates on the northwestern fringe of the ebb shoal, which could increase dredging requirements in the future. However, the potential increases in future dredging requirements would also provide beach quality sand to offset inlet effects on adjacent beaches. The cost of maintenance dredging requirements would be offset by the benefits to the beach management programs along Anna Maria Island and Longboat Key.

B. Maintenance

The terminal groins are intended to be rubblemound structures. These structures, when properly designed and constructed require minimal maintenance. For longer term planning purposes, a 1% annual damage estimate is usually recommended. This indicates that 1% of the structure (by tonnage) will require replacement per year. In practice, the need for maintenance is deferred until 10 to 25 years has elapsed and substantive damage has occurred.

The permeable adjustable groins may require adjustment in their porosity in order to achieve the correct balance of sand retention and sand bypassing. It is likely one maintenance event within 10 years may be necessary to adjust the structural porosity.

As indicated previously, the model suggests that maintenance dredging of the navigation channel will require dredging approximately 190,000 cy. every 8 years. Alternatively, maintenance dredging could be performed on a 4 year interval with each island receiving 100% of the dredge spoil every other dredging event. This would provide navigational maintenance dredging more frequently and allow Manatee County and the Town of Longboat Key the opportunity to tie the

maintenance events to their regional beach nourishment programs on an approximate 8 year basis.

C. Natural Resources

The selected plan is not anticipated to significantly impact natural resources in the area. All components of the selected plan will require permits from the State and Federal governments. Thus, the plan will be subject to a NEPA review and Section 7 consultations under the Endangered Species Act.

It is recognized that the landward terminus of the terminal groin on Longboat Key, and the proposed permeable adjustable groins may be located immediately adjacent to the mangroves within Greer Island. The need for impacts, and the ability for avoidance and minimization of impacts will be incorporated into the final design and permitting.

Impacts to Sarasota Bay associated with the GIWW Cut M5 have been coordinated under separate permits.

D. Navigation and Public Safety

The reestablishment of the navigation channel in its authorized location will provide a straight channel to the seaward portion of Longboat Pass. At the time of permitting and construction, the applicant will coordinate with the USACE and the U.S. Coast Guard regarding responsibility for management of the navigation markers.

The addition of coastal structures to an existing beach has the potential to modify the nearshore currents and affect public safety. It is not anticipated that the proposed structures will cause hazards to public safety. Additional interrogation of the Delft3D model results will occur during final design to document changes in nearshore currents. This will be documented within the Joint Coastal Permit application in accordance with 62B-41, F.A.C.

E. Economics

To date, the economic planning of the improvements has been limited to budgetary estimates. For the terminal groin on Anna Maria Island, Manatee County is working with a budget estimate of approximately \$4.6 million to reconstruct and extend the terminal groin. Similarly, Longboat Key created a budgetary estimate of \$6.0 million for the north end structures. State funding requests have been applied for.

The re-dredging of Longboat Pass channel (Alternative 6D) is expected to cost approximately \$3.5 million. No financing plan has been developed to date.

F. Permitting Considerations

Based on prior experience, the various components of the selected plan are feasible for permitting and implementation. Specific considerations include the following:

- Alternative 2: The extension of the terminal groin on the south side of Anna Maria Island (Alternative 2) will be similar in scope to the 1998 terminal groin extension at New Pass. More recently, the terminal groin at the north end of Captiva was reconstructed and extended in 2006. As part of the 2011 Coquina Beach project, the FDEP required Manatee County to test sand tightening of the existing structure with geotextile tubes.
- Alternative 5S: Two permeable adjustable groins were recently permitted and constructed near the Islander Club Condominium on Longboat Key (Sarasota Co. Profile R-13). In addition, a number of new terminal groins have been constructed and permitted throughout the state of Florida, including the terminal groin at the south end of Amelia Island (Olsen, 2009). The permitting efforts associated with the new terminal groin at the north end of Longboat Key and the permeable adjustable groins near North Shore Road will likely be similar to those of the Islander Club and Amelia Island groin projects.
- <u>Alternative 6D:</u> The re-dredging of Longboat Pass channel (Alternative 6D) follows the previously permitted dredging cut, except for the 38,700 c.y. advance dredging on the northern side of Cut 1. The main channel location has been federally authorized since 1977 and the advance maintenance is expected to improve performance.
- <u>Alternative 7:</u> A Notice of Intent to issue a permit for the dredging of Gulf Intracoastal Waterway Cut M5 has already been released by FDEP (draft permit 0305363-001-BI). As such, this component of the selected plan is nearing the completion of its permitting phase.

As discussed above, each component of the selected plan would be similar to previously permitted projects at Longboat Pass, Longboat Key, and elsewhere in the state. Based on the considerations above, the selected plan is feasible from a permitting perspective and the County/Town should seek long term multi-use permits from the FDEP and USACE for inlet channel maintenance dredging.

G. Implementation Schedule

The Town of Longboat Key will be initiating additional engineering and permitting in 2011 for the three structures on the south side of the Pass. Construction is planned for early 2013.

There are no plans for the joint dredging of the authorized channel at the time of writing of this document, although discussions among stakeholders are ongoing.

Manatee County has received a permit to install a sand filled geotextile tube groin parallel to the existing terminal groin and the same length as the existing groin. The construction is planned for fall 2011. Construction of the terminal groin reconstruction with possible extension is planned for 2014/2015.

H. Plan Element Refinements

Further refinement of the components of the selected plan will be accomplished during the final design phases and as a result of the permitting processes. The results of this numerical modeling study should be used in conjunction with other coastal engineering assessments and prudent engineering judgment. Further engineering is recommended prior to implementation.

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APPENDIX A

DELFT3D MODELING STUDY

INLET MANAGEMENT STUDY OF LONGBOAT PASS AND ADJACENT BEACHES

INLET MANAGEMENT STUDY OF LONGBOAT PASS AND ADJACENT BEACHES

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- A-2 Engineering Analysis of Single Terminal Groin on the North End of Longboat Key

INLET MANAGEMENT STUDY OF LONGBOAT PASS AND ADJACENT BEACHES

1. MODELING OBJECTIVES

1.1. Objectives

Longboat Pass is a natural inlet that separates the barrier islands Anna Maria Island (to the north) from Longboat Key (to the south) and connects Sarasota Bay and the Gulf of Mexico. Longboat Pass is the southernmost inlet within Manatee County, approximately 7 miles south of Tampa Bay Entrance and 10 miles north of New Pass (Figure 1-1). The inlet is bridged by State Road 789 (Gulf of Mexico Drive) which connects Anna Maria Island and Longboat Key. On both Anna Maria Island and Longboat Key, the shorelines are classified by the FDEP as critically eroded.

The overall objective of the inlet management study is to evaluate coastal processes at Longboat Pass and recommend alternatives to provide for the equitable allocation of sand resources on Anna Maria Island and Longboat Key. The information presented in the inlet management study will be used to improve regional sediment management in order to better conserve the sediment resources of the area, improve the efficiencies of the erosion control programs, maintain navigation through the pass, and protect the local natural resources. To assist with the inlet management study, the Delft3D modeling package is being applied. The objectives of the numerical modeling effort are to evaluate:

- The general erosion and sediment transport patterns near Longboat Pass.
- Various structural alternatives to stabilize the southern end of Anna Maria Island and the northern end of Longboat Key.
- Dredging options for the maintenance of the Federal navigation channel, along with the interior channels running between the Longboat Pass bridge and the Intracoastal Waterway (IWW).

1.2 Summary of the Study Area's Coastal Environment

Longboat Pass is a tide-dominated inlet, with an ebb-shoal covering 13 to 18 million square feet (Finkl, 2007) and a Federal navigation channel. The base elevation of the ebb shoal is approximately -20 feet NAVD and extends to a minimum depth of -4 feet NAVD along the northern margin of the navigation channel (Hearn and Erikson, 1993). The Federally Authorized depth in Longboat Pass ranges from -11.57 to -13.57 feet NAVD (-10 to -12 feet MLLW). However, the actual channel depth varies from -12 feet NAVD to -33 feet NAVD (see Figures 1-2 and 1-3).

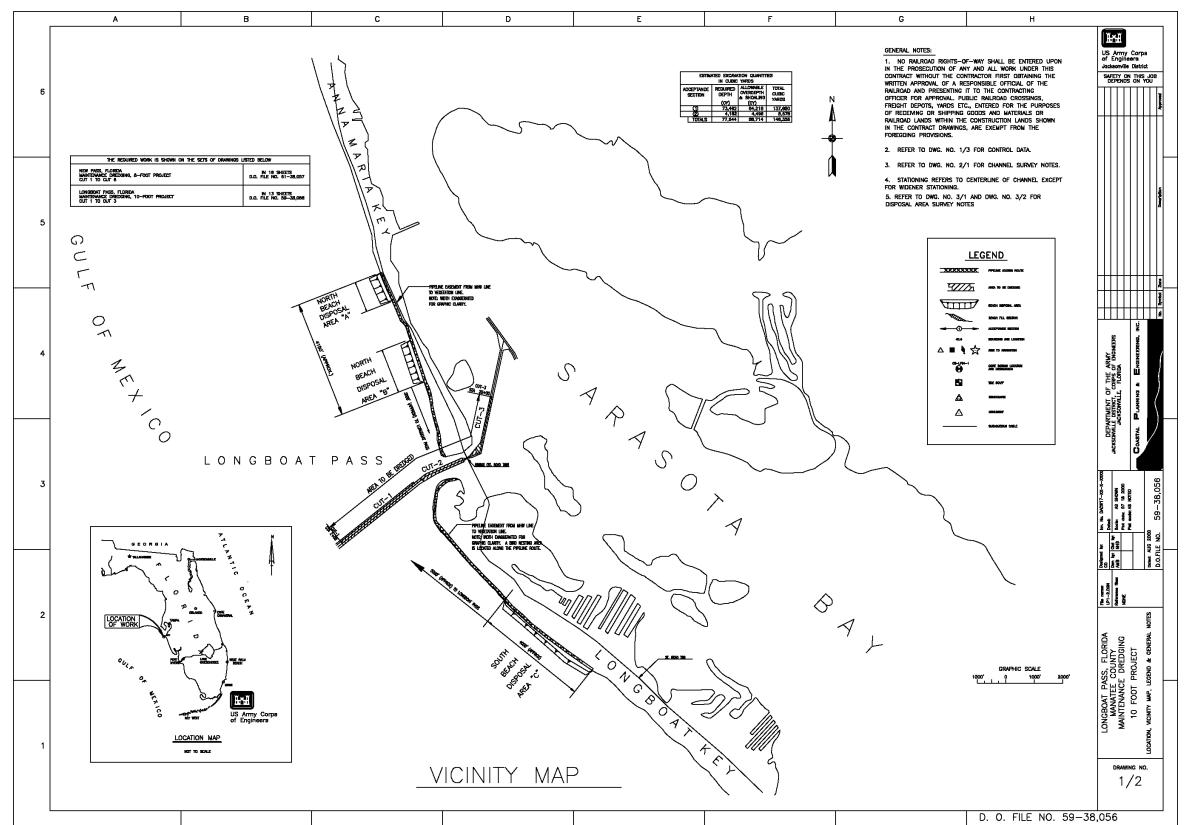


FIGURE 1-1: Longboat Pass Location Map (USACE/CPE, 2000).

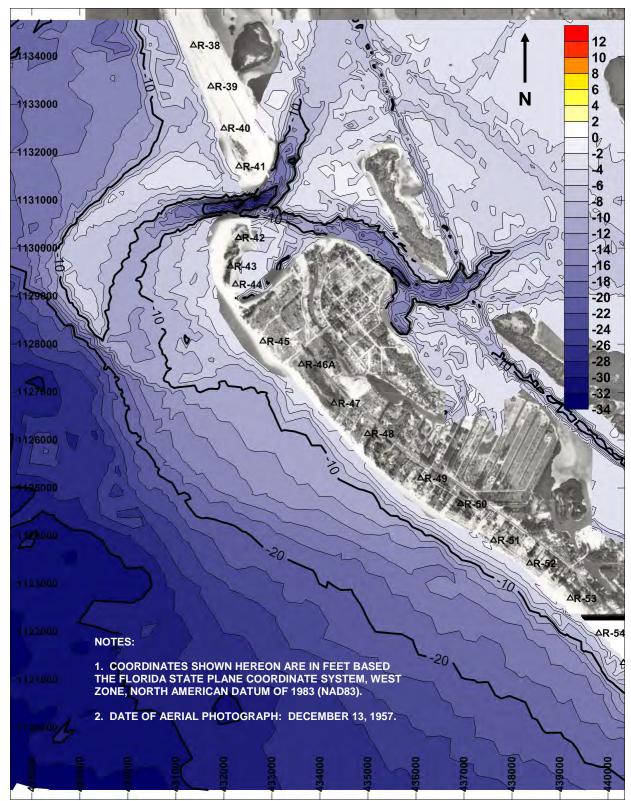


FIGURE 1-2: Longboat Pass 1954 Bathymetry (feet NAVD).

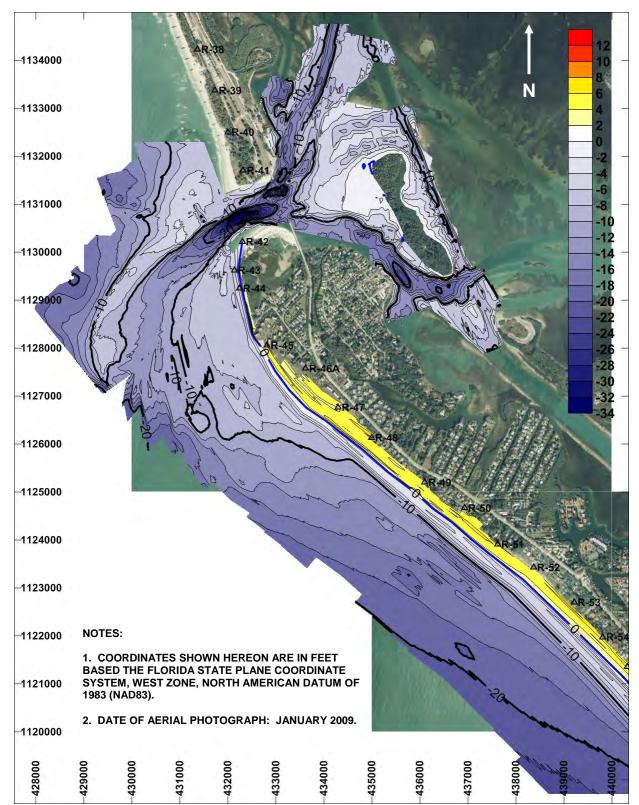


FIGURE 1-3: Longboat Pass March-October 2009 Bathymetry (feet NAVD).

Gulf-front beaches on both sides of Longboat Pass are critically eroded (FDEP, 2009, p. 66). The southern end of Anna Maria Island has been erosional since 2006, and the northern end of Longboat Key has been a chronic erosion hotspot since about 2003. The natural bypassing of sediment from Anna Maria Island to Longboat Key has historically occurred via the Longboat Pass ebb shoal (ATM, 1993). However, in 1993, 1,955,000 cubic yards of material were excavated from the ebb shoal to construct the northern half of the 1993 Longboat Key Beach Restoration Project. Since that time, the ebb shoal borrow area has been refilling at a rate of 69,000 c.y./year.

1.3 Methods

The primary tool in this investigation is the Delft3D morphological model (Deltares, 2011). This model determines changes in a topographic and bathymetric surface based on the effects of waves, water levels, winds, and currents. Wave transformation from the offshore to the nearshore area is simulated using the SWAN wave transformation model (Booij, et al, 2004, Deltares, 2009). The SWAN model (version 40.72ABd) is coupled with the Delft3D-Flow model (version 3.60.01.7844), which simulates currents, water levels, and sediment transport. Based on the sediment transport estimates at each flow time step, the Delft3D-Flow model calculates the subsequent elevations of the topographic and bathymetric surface. Typical time steps in Delft3D-Flow range from 1 second to 60 seconds. Water levels, currents, and bottom grade elevations are then sent to the SWAN model at each wave time step, which is on the order of 1 to 3 hours.

Given this study's objectives, Delft3D is the best means of evaluating the various strategies to manage Longboat Pass. By linking waves, currents, sediment transport, erosion, and deposition, Delft3D can provide valuable information regarding all of these processes within a single set of outputs. Stand-alone flow models or stand-alone wave transformation models do not offer this sort of combined capability. Delft3D also can accommodate curvilinear grids, which allows the grids to be better fitted to offshore contours and shorelines than the rectangular grids used by other models.

This inlet study will examine structural alternatives for erosion control at the inlet, along with channel dredging options. For this reason, it will be necessary to use a 3 dimensional flow and sediment transport formulation to resolve the bottom return flows at the existing and proposed structures.

1.4 Model Application

While the Delft3D model is a processed based model capable of replicating the morphological evolution of complex bathymetries, the strength of the model is in its ability to show the relative differences between alternatives. The model should not be solely relied on to predict the (absolute) shoreline position, currents, and morphological implications of a specific alternative. The model results must also be used in conjunction with analytic models, prototype performance of similar projects, and sound coastal engineering judgment.

2. MODEL DATA

2.1 Bathymetry

The bathymetric data sources used in this model study appear in Table 2-1. The grids used in the study were constructed in meters using the Florida State Plane Coordinate System, West Zone, North American Datum of 1983 (FL-West NAD83). The bathymetric surfaces used in the model were compiled in meters relative to the North American Vertical Datum of 1988 (NAVD).

TABLE 2-1 BATHYMETRIC AND TOPOGRAPHIC SURVEYS USED IN THE DELFT3D MODELING OF LONGBOAT PASS

Date	Source	Vertical Datum	Horizontal Datum	Horiz. Accuracy (feet)	Vertical Accuracy (feet)	Location
Nov 2010	USACE-SAJ	feet MLLW	FL-West NAD83 feet	2	0.5	Longboat Pass Federal Navigation Channel
Oct 2010	CPE	feet NAVD	FL-West NAD83 feet	FDEP (2004	1) Standard*	Longboat Key Gulf Beaches
Oct 2009	CPE	feet NAVD	FL-West NAD83 feet	FDEP (2004	1) Standard*	Anna Maria Island Gulf Beaches
Oct 2009	CPE	feet NAVD	FL-West NAD83 feet	FDEP (2004	1) Standard*	Longboat Key Gulf Beaches
Sep 2009	Sea Diversified	feet NAVD	FL-West NAD83 feet	2	0.5	Longboat Pass Flood Shoal
Jul 2009	USACE-SAJ	feet MLLW	FL-West NAD83 feet	2	0.5	Longboat Pass Federal Navigation Channel
Mar 2009	CPE	feet NAVD	FL-West NAD83 feet	FDEP (2004	1) Standard*	Longboat Pass Ebb Shoal, Channel, & Flood Shoal
Dec 2008	CPE	feet NAVD	FL-West NAD83 feet	FDEP (2004	1) Standard*	Anna Maria Island Gulf Beaches
Sep 2008	CPE	feet NAVD	FL-West NAD83 feet	FDEP (2004	1) Standard*	Longboat Key Gulf Beaches
Sep 2008	USACE-SAJ	feet MLLW	FL-West NAD83 feet	2	0.5	Longboat Pass Federal Navigation Channel
May-June 2004	USACE/NOAA	feet NAVD	FL-West NAD83 feet	See Appe	ndix A text	Manatee & Sarasota County Gulf Beaches
Apr 2004	USACE-SAJ	feet MLLW	FL-West NAD83 feet	2	0.5	Longboat Pass Federal Navigation Channel
May 2003	CPE	feet NGVD	FL-West NAD83 feet	FDEP (2004	1) Standard*	Anna Maria Island Gulf Beaches
Apr 2003	CPE	feet NGVD	FL-West NAD83 feet	FDEP (2004	1) Standard*	Longboat Key Gulf Beaches
Jan 2003	USACE-SAJ	feet MLLW	FL-West NAD83 feet	2	0.5	Longboat Pass Federal Navigation Channel
Jan 1993	FDEP	feet NAVD	FL-West NAD83 feet	2	0.5	Longboat Key Gulf Beaches
Dec 1992	FDEP	feet NAVD	FL-West NAD83 feet	2	0.5	Anna Maria Island Gulf Beaches
Dec 1992	ATM	feet NGVD	FL-West NAD27 feet	2	0.5	Longboat Pass 1993 Ebb Shoal Borrow Area
Dec 1992	ATM	feet NGVD	FL-West NAD83 feet	2	0.5	Longboat Pass Adjacent Gulf Beaches
1984	USGS/LABINS	feet NGVD	UTM-17N NAD27 m	10	1.0	Manatee & Sarasota County 30m Digital Elevation Models
1953-1955	NOAA	m MLLW	UTM-17N NAD27 m	10	1.0	Sarasota Bay 30m Digital Elevation Model
1950-2004	NOAA	m MLLW	Lat./Long. NAD83	10	1.0	Southwest Florida Gulf Coast (GEODAS Database)
1950-2004	NOAA	m MLLW	Lat./Long. NAD83	10	1.0	Southwest Florida Gulf Coast (Design-a-Grid)

*NOTE: FDEP (2004) standard is:

This level of accuracy was also assumed for the 2003 CPE beach surveys, which were taken using similar methods.

^{±0.16} feet vertically and ±0.66 feet horizontally above the wading depth. ±0.5 feet vertically and ±2 feet horizontally below wading depth.

Conversions to the FL-West NAD83 coordinate system were performed using Corpscon 6.0 (USACE, 2005). Conversions between feet and meters assumed a ratio of 1200.0 m to 3937.0 U.S. Feet. The elevation of the National Geodetic Vertical Datum of 1929 (NGVD) was assumed to be -0.99 feet NAVD. Conversions between Mean Lower Low Water (MLLW) and NAVD depended on the data set being used:

- <u>July 2009 and September 2008 channel surveys</u>: MLLW = -1.78 feet NAVD, based on the USACE (2009) survey drawings.
- <u>April 2004 and January 2003 channel surveys</u>: MLLW = -0.79 feet NGVD = -1.78 feet NAVD, based on the USACE (2004, 2003) survey drawings.
- <u>NOAA datasets</u>: MLLW = -1.6 feet NAVD, based on the average elevation among the NOAA tidal benchmark sheets in and near Sarasota Bay.

The May-June 2004 survey by USACE/NOAA was a Light Detection and Ranging Survey (LIDAR). However, elevation values below wading depth were 0.7 feet lower than surveys taken by conventional methods around the same time. To remedy this discrepancy:

- Points with a reported elevation above 0 feet NAVD were used as-is. Based on the metadata for the May-June 2004 LIDAR survey, the accuracy above wading depth was on the order of ±0.5 feet in the horizontal and vertical directions.
- Points with a reported elevation below -5 feet NAVD were raised 0.7 feet.
- Points with a reported elevation between 0 and -5 feet NAVD were adjusted on a sliding scale based on the reported elevation.

The accuracy of the other surveys appears in Table 2-1. Shoreline positions are based on the location of the +0.1 foot NAVD contour, which is commonly used as the shoreline elevation on Longboat Key in annual monitoring studies (see CPE, 2010). However, volume changes are the primary basis for evaluating the model results in terms of erosion and deposition. Accordingly, the shoreline locations appearing in this document are shown primarily for visual reference.

2.2 Structures

A number of buried seawalls are located between profiles R-50 and R-51. These structures have not been exposed since 1993 and have not had any significant effect on the coastal processes. Accordingly, they are not included in the model simulations. Other coastal structures are included in the model simulations and appear later in this document.

2.3 Bottom Sediments

Information regarding the grain sizes and sediment densities used in the Delft3D model is discussed later in this document (see Section 3.4.4).

2.4 Waves

2.4.1 Wave Data Inventory

The sources of wave data used in this modeling study and earlier modeling studies (CPE, 2010, 2008) appear in Figure 2-1 and Table 2-2. The primary sources of wave data in this study were:

- <u>1980-1997</u>: Wave Information System (WIS) hindcast at Station 73363 (USACE, 2003/2010).
- 1997-2005: NOAA Global Wavewatch hindcast at 27.00°N, 83.75°W (1.0° x 1.25° grid).
- <u>2005-Present</u>: NOAA High Resolution Global Wavewatch hindcast at 27.00°N, 84.00°W (0.5° x 0.5° grid).

TABLE 2-2
WAVE DATA SOURCES
LONGBOAT PASS, FL

SOURCE	LAT. (deg. N)	LONG. (deg. W)	DEPTH (ft. NAVD)	TIME PERIOD	DATA TYPE
CDIP144	27.34530	84.28090	-329	2007-Present	Measured
FL002	27.30000	82.59000	-25	1993-1996	Measured
WAVEWATCH (Global)	27.00000	83.75000	-200	1999-Present	Hindcast
WAVEWATCH (Global)	27.00000	84.00000	-279	2005-Present	Hindcast
WAVEWATCH (WNA*)	27.00000	84.00000	-279	1999-2007	Hindcast
WIS272	27.45155	82.91727	-53	1980-1999	Hindcast
WIS73363	27.00000	84.08000	-314	1980-1999	Hindcast

^{*} WNA = Western North Atlantic Model, 0.25° x 0.25° grid.

All wave data was provided in SI units, with times referenced to Greenwich Mean Time (GMT). The WIS data was given hourly. Wavewatch data was given every 3 hours. The observed data at CDIP144 was given every 30 minutes.

2.4.2 Offshore Wave Statistics

Typical wave statistics offshore appear in Figure 2-2. As discussed in the next section, the prevailing winds come from the east. As a result, a large proportion of the wave energy (47%) at 27.00°N, 84.00°W comes from the landward direction bands (N to SE). Closer to the shoreline, at WIS Station 272, that percentage drops to 19% (CPE, 2010).

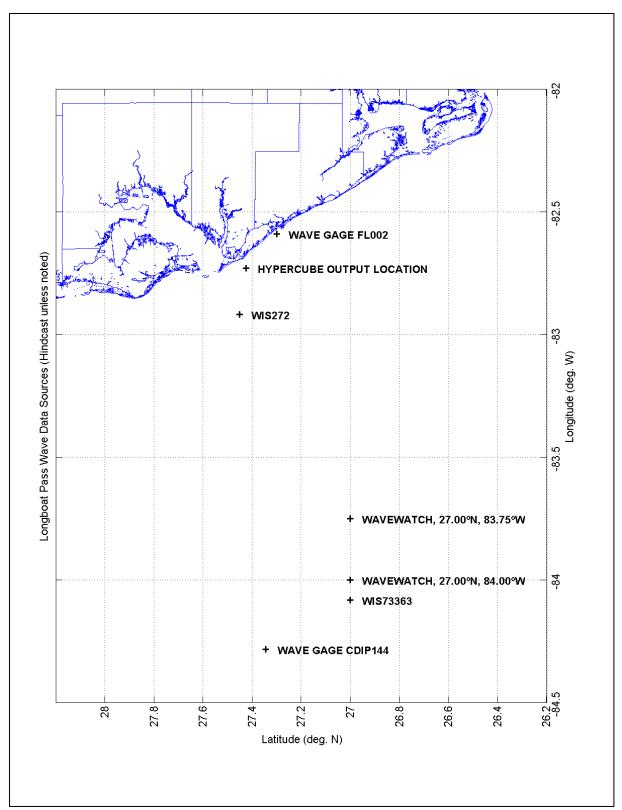
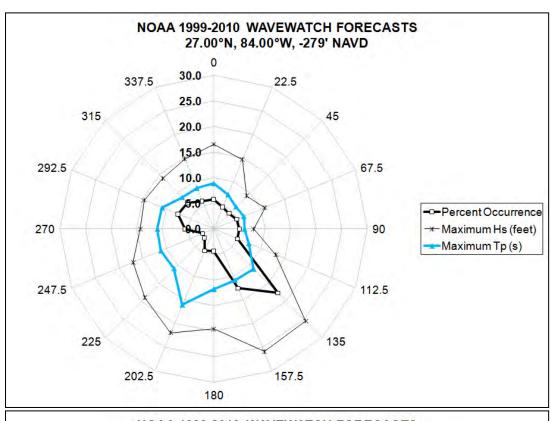


FIGURE 2-1: Longboat Pass Wave Data Sources.



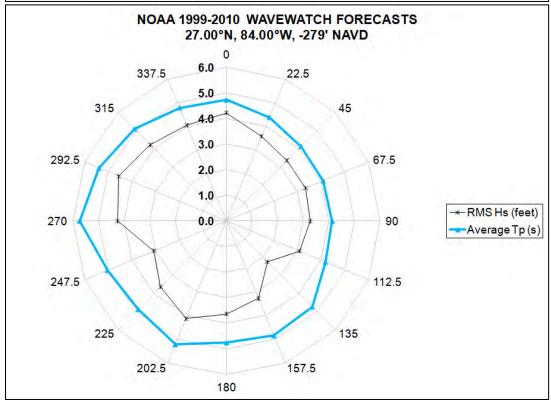


FIGURE 2-2: Directional Wave Statistics at 27.00°N, 84.00°W.

2.4.3 Quality of the Offshore Wave Hindcasts

Comparisons between the observed waves at CDIP144 and the Wavewatch hindcast waves at 27.00°N, 84.00°W appear in Figures 2-3 to 2-5. In general, the hindcast waves are consistent with the observed waves, and accommodate the full range of wave conditions that affect the region. By using hindcast instead of observed waves to drive the SWAN model, it is possible to simulate periods during which there is no measured data (i.e.: prior to 2007 or September 2008 gage malfunction).

As noted in CPE, 2010, the WIS hindcast generally depicts more wave energy coming from the landward direction bands than the Wavewatch forecasts. Given this characteristic, the WIS hindcast is mainly reserved for periods during which no other wave data is available.

2.5 Winds

To account for wind-generated wave development, wind stress was activated in the SWAN model. The primary sources of wind data were the wind fields used in the WIS and Wavewatch hindcasts (see previous section). All wind velocities were provided in meters per second, with times referenced to Greenwich Mean Time (GMT). The WIS wind velocities were given hourly. The Wavewatch wind fields were given every 3 hours.

Long-term wind statistics are summarized in Figure 2-6. In general, the prevailing wind direction is from the east. The high percentage of winds from the east and northeast are the primary reason why a large percentage of waves in deep water propagate from the landward direction bands.

2.6 1992 ATM Current and Water Level Measurements

Water levels and currents were measured by ATM (1993) to support its 1993 inlet management study for Longboat Pass. The locations of these measurements appear in Table 2-3 and Figure 2-7. Water levels were tabulated in feet NGVD every 20 minutes relative to Eastern Daylight Time (EDT); the data was subsequently converted to NAVD assuming NGVD = -0.99 feet NAVD (Figures 2-8 to 2-9). Currents were tabulated in feet/second every 10 minutes relative to EDT (Figure 2-10). The offshore water levels were comparable to the predicted tides at Clearwater Beach. The differences between the two were similar to the residual tide at the St. Petersburg tide gage (NOAA, 2010). Water levels at the Bayside Tide Gage appeared to be 1 foot lower than those at the Offshore Tide Gage. Although their variation appeared to be correct, there may have been an error regarding the referencing of the water levels to NGVD. At the 1992 Current Gage, peak flood and ebb currents were on the order 1.2 to 4.2 feet/second, with a principal current axis of 83°/ 263°.

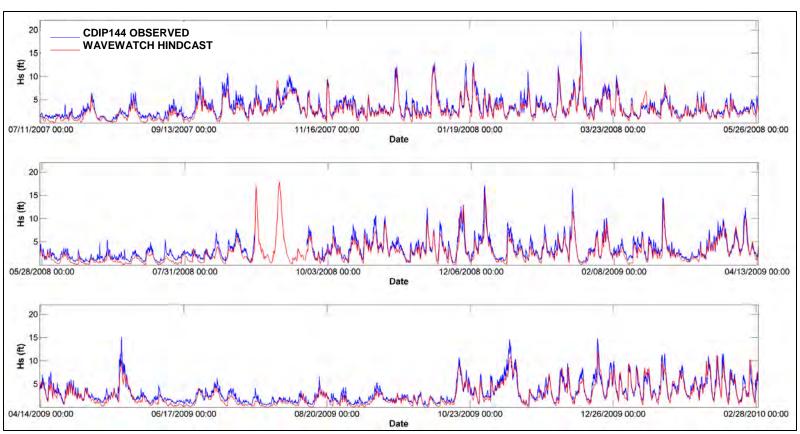


FIGURE 2-3: Observed Wave Height at CDIP144 vs. Wavewatch Forecast at 27.00°N, 84.00°W (Time Zone = GMT).

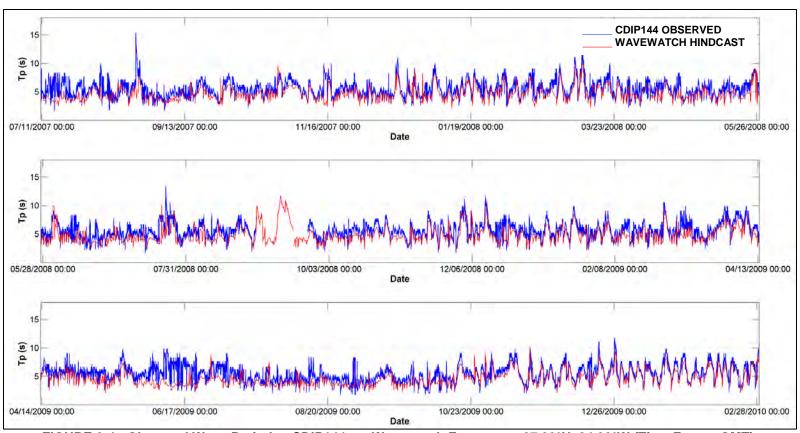


FIGURE 2-4: Observed Wave Period at CDIP144 vs. Wavewatch Forecast at 27.00°N, 84.00°W (Time Zone = GMT).

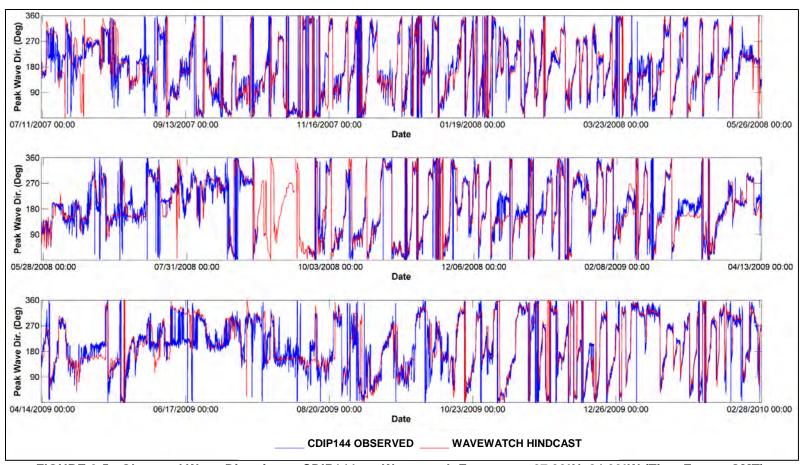


FIGURE 2-5: Observed Wave Direction at CDIP144 vs. Wavewatch Forecast at 27.00°N, 84.00°W (Time Zone = GMT).

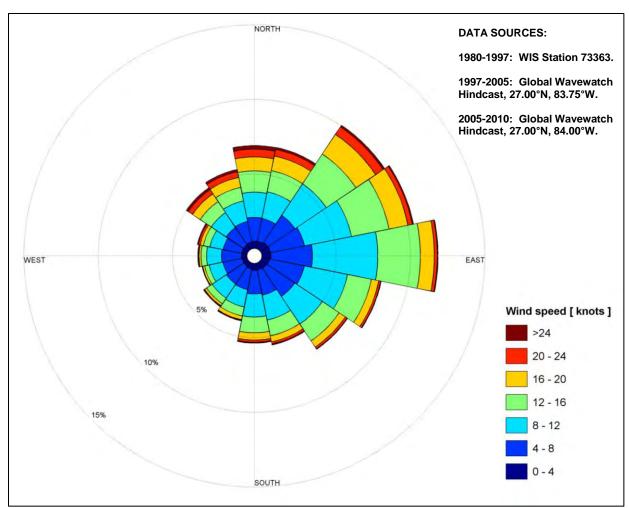


FIGURE 2-6: January 1980 – February 2010 Wind Rose.

TABLE 2-3

LOCATION OF ATM (1993) CURRENT AND WATER LEVEL MEASUREMENTS

LONGBOAT PASS, FL

Station	Latitude	Longitudo	Depth	Time Period Measured (EDT)		
	Latitude	Longitude	(feet NAVD)	End		
Offshore Tide Gage	27°25'34"N	82°40'55"W	-12.7	4/15/1992 16:25	5/14/1992 12:05	
Bayside Tide Gage	27°26'21"N	82°40'47"W	-7.2	4/15/1992 15:30	5/14/1992 11:00	
Current Gage	27°26'36"N	82°41'22"W	-28 (approx.)	4/16/1992 12:00	5/14/1992 11:00	

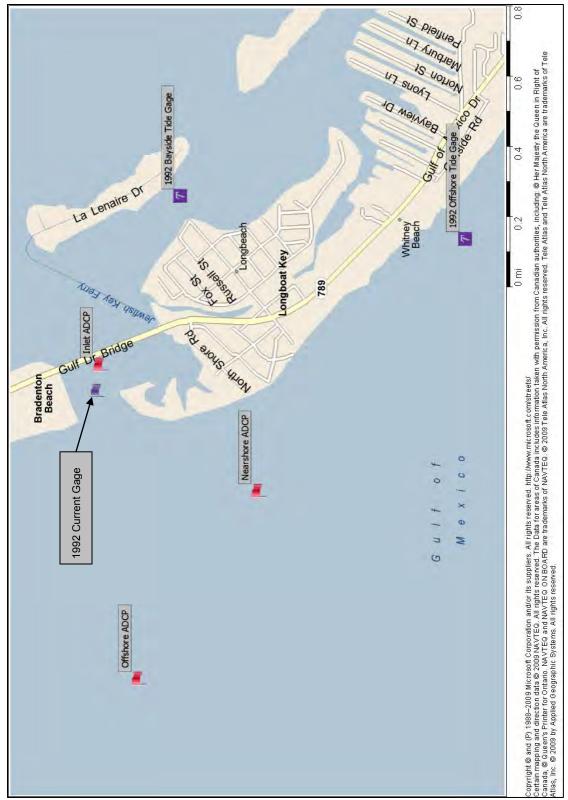


FIGURE 2-7: Location of ATM (1993) and CPE (2010) Tide Gages, Currents Gages, and ADCPs.

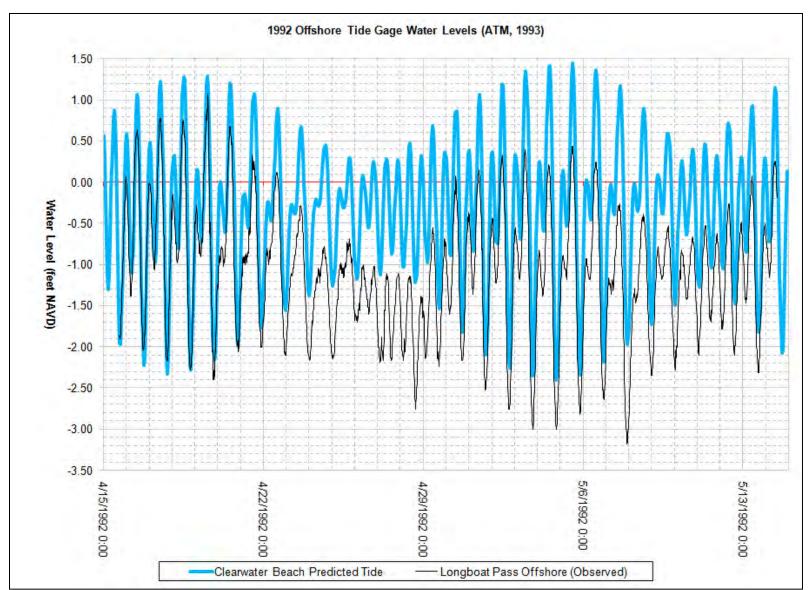


FIGURE 2-8: ATM (1993) Offshore Water Levels (Time Zone = EDT).

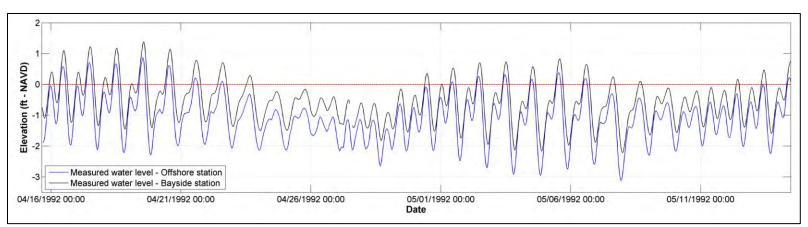


FIGURE 2-9: ATM (1993) Bayside Water Levels (Time Zone = EDT).

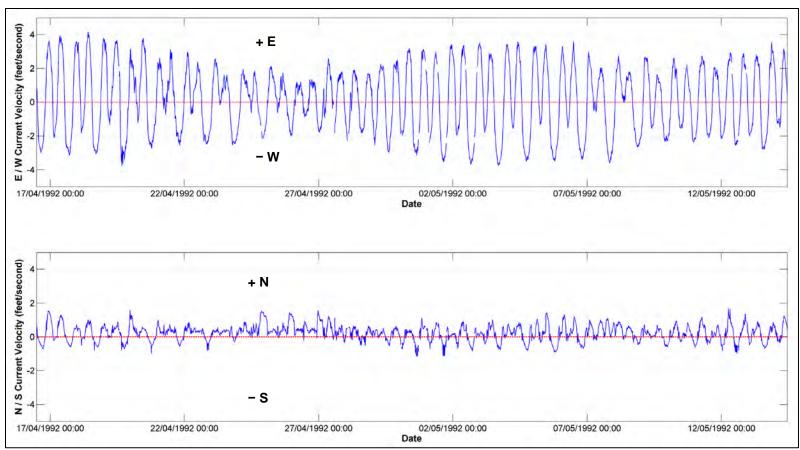


FIGURE 2-10: ATM (1993) Observed Currents in Longboat Pass (Time Zone = EDT).

2.8 ADCP Measurements

Three Acoustic Doppler Current Profilers (ADCPs) were deployed between December 17, 2008 and February 6, 2009. The ADCPs were removed from the water during a maintenance event on January 12, 2009 and were placed back in the water near their original deployment locations (within 20 feet) on January 13, 2009. The batteries were changed and the collected data was downloaded during the maintenance event to ensure that the ADCPs were collecting quality data at a sampling interval sufficient for modeling purposes. Seven moderate storm events passed through the Gulf of Mexico during their deployment. The locations of the ADCPs appear in Figure 2-7 and Table 2-4.

TABLE 2-4

LOCATION OF CPE (2010) ADCP MEASUREMENTS

LONGBOAT PASS, FL

Station	Latitude	Longitudo	Depth	Time Period Measured (EST)			
	Latitude	Longitude	(feet NAVD)	Start	End		
Offshore ADCP	27°26'29.2"N	82°42'15.3"W	-30 (approx.)	12/17/2008 12:10	2/6/2009 8:10		
Nearshore ADCP	27°26'09.4"N	82°41'40.5"W	-10.6	12/17/2008 12:35	2/6/2009 8:35		
Inlet ADCP	27°26'35.4"N	82°41'17.1"W	-20.6	12/17/2008 12:00	2/6/2009 7:00		

ADCP setup and processing settings appear in Tables 2-5 and 2-6. Raw binary data files from the instruments were processed and converted to ASCII files utilizing the Nortek software STORM. The ADCPs current data for cells beyond the surface were removed from the record. The upper layer can contain scatterers (i.e.: bubbles, flotsam, etc.) that can overwhelm the side lobe suppression of the transducers. Therefore, the processing software removed the current data from the upper layer of the water column. Formatted output data included the following: significant wave height, mean wave period, mean wave direction, water level, and current velocities for each cell

During the initial deployment on December 17, 2008, the Inlet ADCP was placed approximately 200 feet west of the bridge in the center of the inlet. During the maintenance event on January 12, 2009, the instrument was found approximately 200 feet east of the bridge. The pitch and roll measurements collected by the Inlet ADCP show that the instrument was disturbed around January 3, 2009. Remnants of netting around the Inlet ADCP suggested that it was dragged by a boat trawling through the center of the inlet. The Inlet ADCP was repositioned to its original deployment location during the January 12, 2009 maintenance event.

TABLE 2-5
2008-2009 ADCP DEPLOYMENT SETTINGS (CPE, 2010)

	Offshore		Nearshore		Inlet	
	Deployment 1	Deployment 2	Deployment 1	Deployment 2	Deployment 1	Deployment 2
Currents						
Number of Cells	20	20	45	10	25	25
Cell Size (ft)	1.6	1.6	0.3	1.0	1.6	1.6
Blanking Distance (ft)	1.6	1.6	0.3	1.3	1.6	1.6
Sampling Interval (s)	3600	3600	1800	1800	1800	3600
Averaging Interval (s)	600	600	300	300	600	300
Compass Update Rate (s)	3600	3600	1800	1800	1800	3600
Waves						
Sampling Rate (Hz)	2	2	2	2	N/A	N/A
Sampling Interval (s)	3600	3600	1800	1800	N/A	N/A
Averaging Interval (s)	1024	1024	1024	1024	N/A	N/A
Deployment						
Estimated Depth (ft)	33	33	15	11	43	43
Estimated Salinity (ppt)	35	35	35	35	35	35
Vertical Velocity Precision (ft/s)	0.02	0.02	0.03	0.02	0.02	0.02
Horizontal Velocity Precision (ft/s)	0.06	0.06	0.08	0.07	0.06	0.07
Assumed Duration (days)	50	50	50	40	50	30
Battery Required (Wh)	307.8	307.8	227.5	129	84.5	17.5
Memory Required (MB)	56.7	56.7	113.6	90.3	0.6	0.2

Time Zone: Eastern Standard Time.

TABLE 2-6
2008-2009 ADCP PROCESSING SETTINGS
(CPE, 2010)

Currents	Offshore ADCP	Nearshore & Inlet ADCPs		
SNR Threshold Level (dB)	3	3		
SNR Spike Rejection Level (dB)	70	70		
Statistical Threshold (Std)	5	5		
Surface Detection Method	Pressure	Pressure		
Surface Layer Rejection (%)	10	5		
Beams Used	All	All		
Map to Vertical	Yes	Yes		
Waves	Offshore ADCP	Nearshore & Inlet ADCPs		
Method	MLMST (AWAC/AST)	PUV (Aquadopp/Vector)		
Spectrum	Pressure	Pressure		
Beams Used	All	All		
Smoothing	High (128 Bins)	High (128 Bins)		
Minimum Frequency (Hz)	0.05	0.25		
Maximum Frequency (Hz)	0.5	1		
Frequency Bin Size (Hz)	0.01	0.01		
Pressure Offset (ft)	0	0		
Compass Offset (ft)	0	0		
Mounting Height (ft)	3.7	2.3		

Time Zone: Eastern Standard Time.

The waves measured during the two month deployment were representative of those expected during winter months where weekly cold front cycles are typical. The average significant wave height measured during the two month deployment at the Offshore ADCP was 1.7 feet coming from the west-southwest (252°) with a corresponding mean period of 5.5 seconds. The average significant wave height measured during the two month deployment at the Nearshore ADCP was 1.5 feet coming from the southwest (238°) with a corresponding mean period of 5.4 seconds. Seven wave events occurred during the two month deployment (see Hs in Figure 2-11). Waves during these storm events came from the west-northwest. Wave parameters measured at the Offshore ADCP appear in Figure 2-11 while the wave parameters measured at the Nearshore ADCP appear in Figure 2-12.

The currents measured in the inlet (Figure 2-13) are tidally influenced with both the east (U) and north (V) current velocities being slightly out of phase with the water levels. The inlet currents are also influenced by the spring-neap tide cycle. The east current velocity measured in the inlet fluctuates between -3.3 and 3.3 feet/second with smaller ranges (-1.6 to 1.6 feet/second) occurring at neap tide, and larger ranges (-3.3 to 3.3 feet/second) occurring at spring tide. The north current velocity measured in the inlet fluctuates between and -0.7 and 1.3 feet/second and does not appear to be influenced by the spring-neap tide cycle.

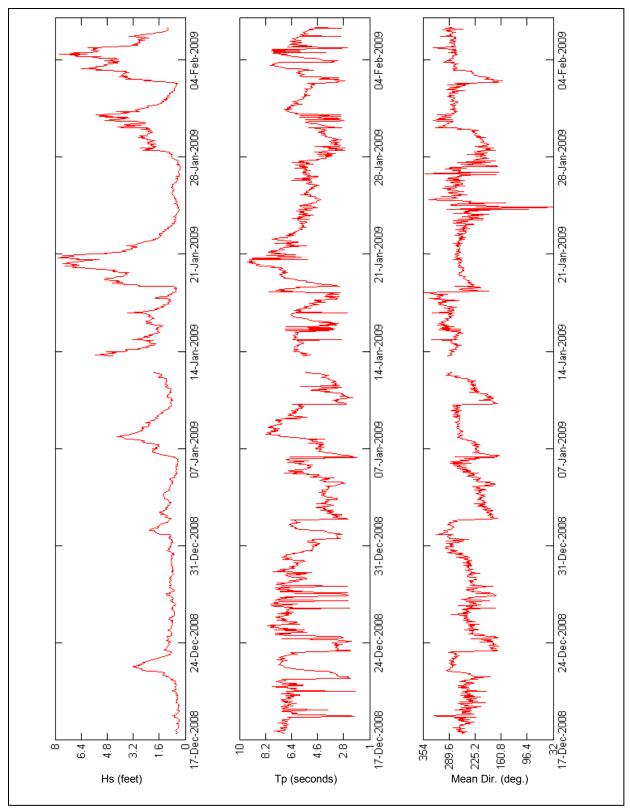


FIGURE 2-11: Offshore ADCP Wave Measurements (Time Zone = EST).

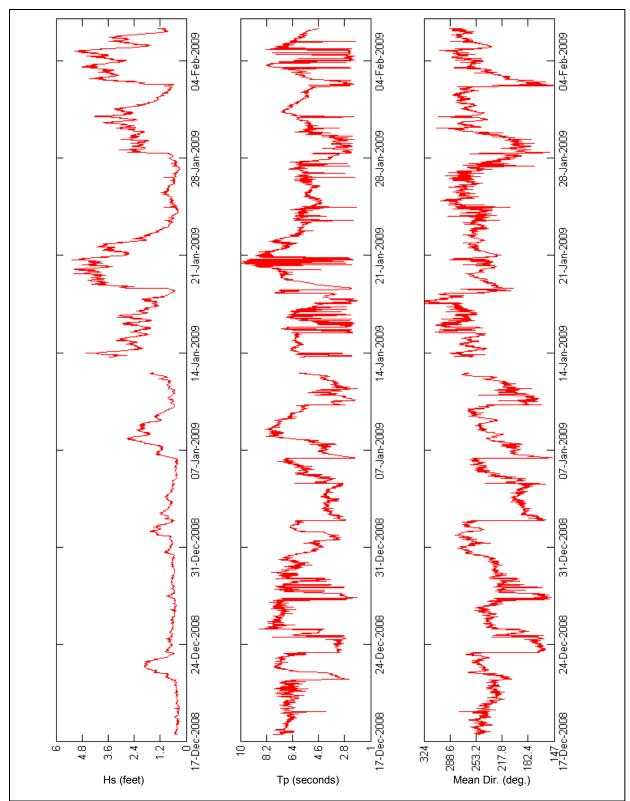


FIGURE 2-12: Nearshore ADCP Wave Measurements (Time Zone = EST).

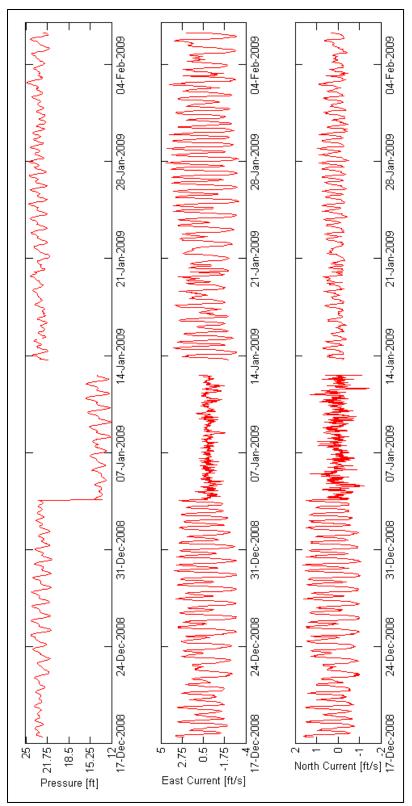


FIGURE 2-13: Inlet ADCP Depth-Averaged Current Measurements (Time Zone = EST).

The primary application of the 2008-2009 ADCP measurements was the calibration of the SWAN model used in this study. Further details regarding the ADCP measurements appear in Appendix A of Longboat Key North End Breakwaters, Numerical Modeling of Breakwater and Beach Fill Performance (CPE, 2010).

3. MODEL CONFIGURATION, CALIBRATION, AND PARAMETER SELECTION

3.1 Grids

Several computational grids have been created to simulate wave propagation within the Florida Gulf Coast and the study area. The Regional Wave Grid extends from the west coast of Florida to the break of the continental shelf (Figure 3-1). The northern limit of this grid is the coastline of Franklin County, and the southern limit of this grid is the Florida Keys. The other wave grids are the Intermediate and Local Wave Grids (Figure 3-2), which are intended to simulate wave propagation closer to the study area. The properties of the wave modeling grids appear in Table 3-1. All wave grids meet the recommended standard for orthogonality, or the angles between the longshore and cross-shore grid lines. The grids also meet the recommended standards for grid smoothness, or the change in grid spacing between two adjacent rows of grid cells. A smoothness value of 1.15 indicates a 15% change in grid spacing between two rows of grid cells.

Two computational grids were originally created to simulate flows into and out of the bays near Longboat Pass. The Regional Flow Grid was designed to simulate depth-averaged flows over the multiple inlet system that constitutes Sarasota Bay and Tampa Bay. A Local Flow Grid was then nested within the Regional Flow Grid (Figures 3-3 and 3-4) to simulate three-dimensional flows using the 1992 water level and current measurements (Figures 2-8 to 2-10). This grid was subsequently refined to simulate three-dimensional flows, sediment transport, erosion, and deposition between 2003 and 2009 (see Figure 3-5). Boundary conditions on both Local Flow Grids were based on water levels estimated using the Regional Flow Grid. All 3 flow grids met the recommended standards for orthogonality and grid smoothness. The only exceptions were a small number of grid cells within the Local Flow (2003) Grid, which were located on dry areas of the mainland. The properties of the grids appear in Table 3-1.

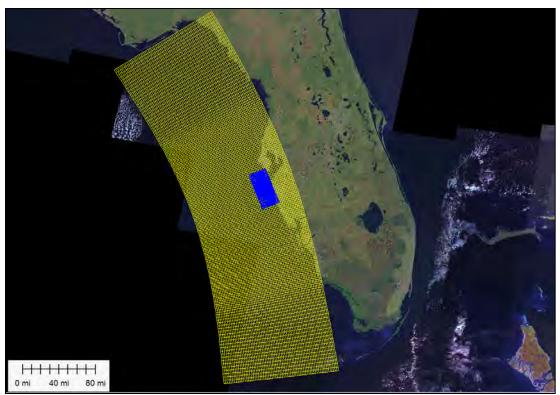


FIGURE 3-1: Regional Wave Grid (yellow) and Intermediate Wave Grid (blue).

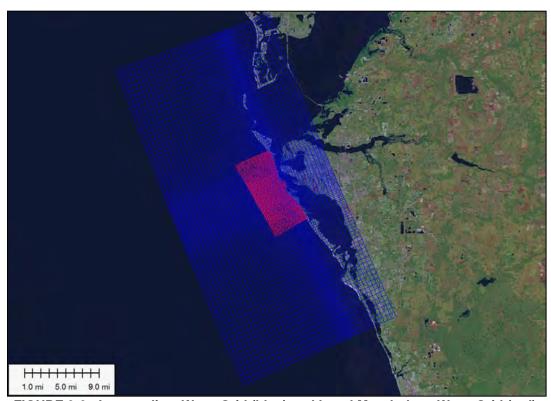


FIGURE 3-2: Intermediate Wave Grid (blue) and Local Morphology Wave Grid (red).

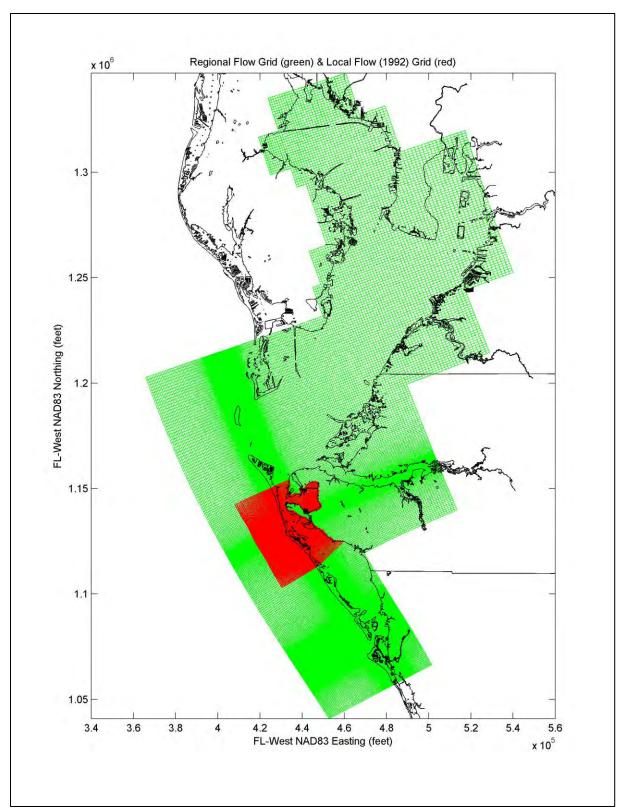


FIGURE 3-3: Regional Flow Grid (green) and Local Flow (1992) Grid (red).

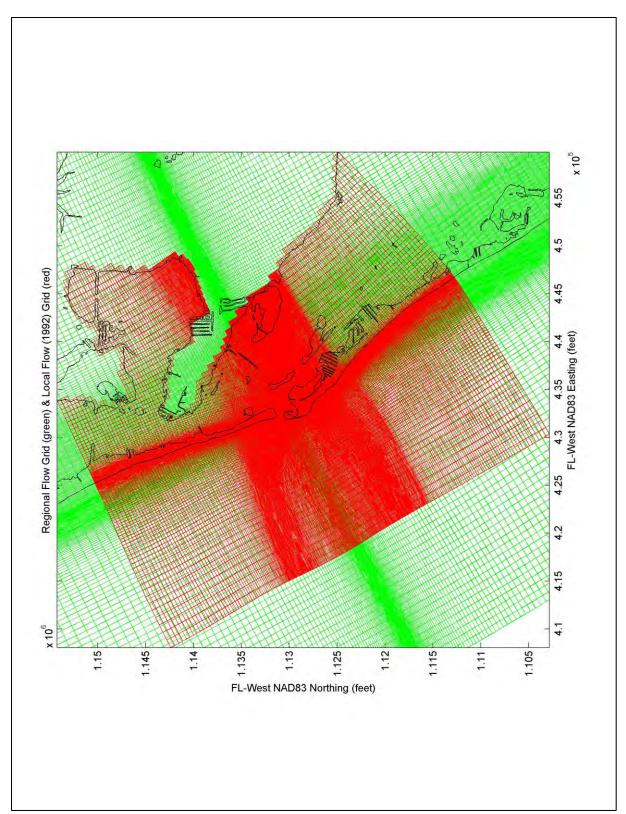


FIGURE 3-4: Closeup of Regional Flow Grid (green) and Local Flow (1992) Grid (red).

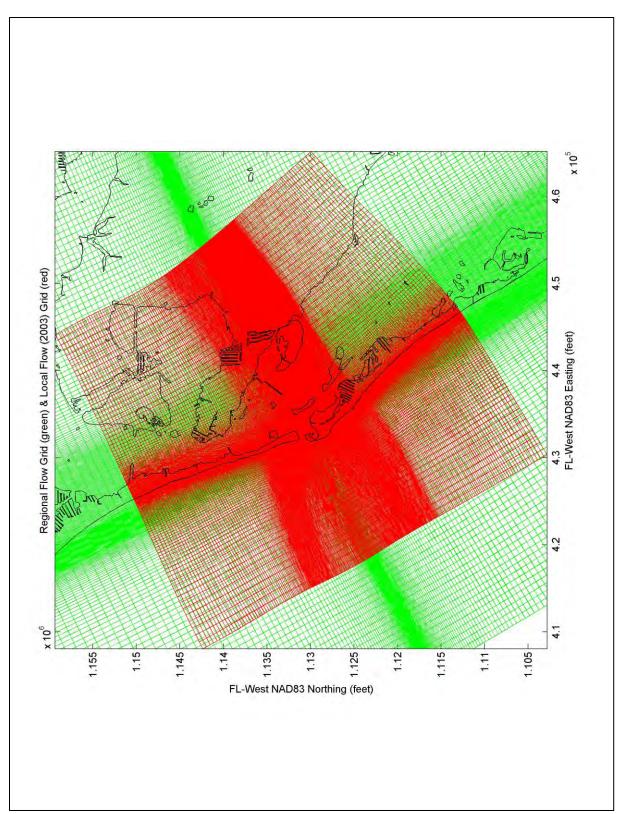


FIGURE 3-5: Closeup of Regional Flow Grid (green) and Local Flow (2003) Grid (red).

TABLE 3-1

GRID PROPERTIES
LONGBOAT PASS, FL

Grid	Orthog-	Smoothness		Spacing (feet)		Number of Cells	
	onality (deg.)	Long- shore	Cross- shore	Long- shore	Cross- shore	Long- shore	Cross- shore
Regional Wave	89.2 to 90.0	1.00 to 1.07	1.00 to 1.01	9,200 to 21,370	8,049 to 10,831	160	69
Intermediate Wave	89.9 to 90.0	1.00 to 1.06	1.00 to 1.14	759 to 3,149	695 to 2,836	123	63
Local Morphology Wave	88.3 to 90.0	1.00 to 1.14	1.00 to 1.13	34 to 635	29 to 948	387	119
Local Calibration Wave	87.5 to 90.0	1,00 to 1.16	1.00 to 1.14	33 to 636	29 to 1022	387	109
Regional Flow	88.3 to 90.0	1.00 to 1.11	1.00 to 1.08	35 to 1339	58 to 1846	563	343
Local Flow (1992)	88.0 to 90.0	1.00 to 1.14	1.00 to 1.16	26 to 487	29 to 904	374	140
Local Flow (2003)	87.1 to 90.0	1.00 to 1.14	1.00 to 1.16	23 to 487	29 to 904	374	165
Recommended (WL Delft, 2005)	> 87.4	< 1.2	< 1.2				''

3.2 SWAN Model Calibration

3.2.1 Boundary Conditions and Forcing

Calibration of the SWAN model was based on wave measurements at the Nearshore and Offshore ADCPs between December 17, 2008 and January 12, 2009. The offshore boundary condition on the Regional Wave Grid was based on observed waves at Wave Gage CDIP144 (Figures 3-6 to 3-8). Input to the model was specified using 9 band wave spectra provided by Scripps Institute of Oceanography (SIO, 2009) (see Figure 3-8). Wind velocities were based on wind fields provided as part of the Global Wavewatch Forecast. These wind fields were specified over a 0.5° x 0.5° grid at 3 hour intervals. Gaps in the wind fields over land areas were filled using the NOAA (2010) Gaussian Wind Field Grids. A typical input wind field appears in Figure 3-9. Water levels during the calibration period were based on measurements at the Anna Maria Island pier (Figure 3-10) and assumed to be uniform over the model grid.

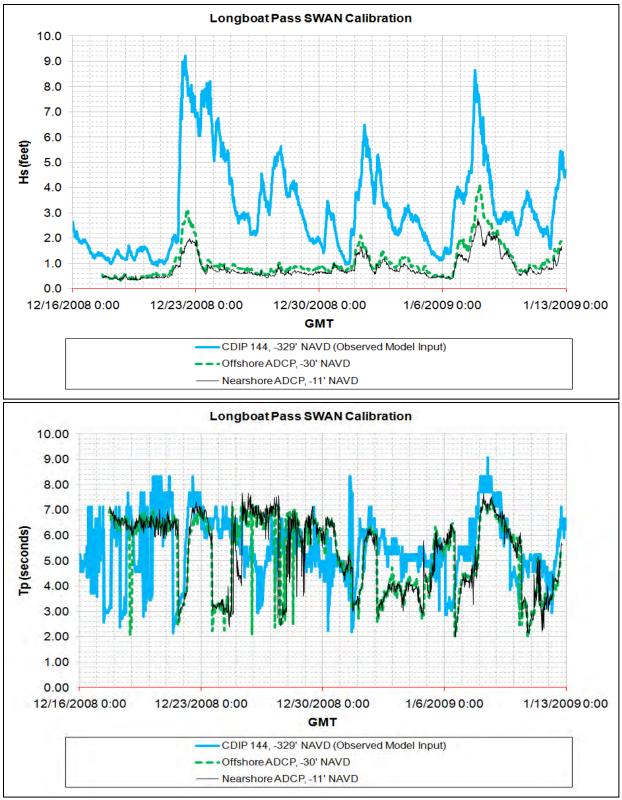


FIGURE 3-6: Observed Waves during the Calibration Period.

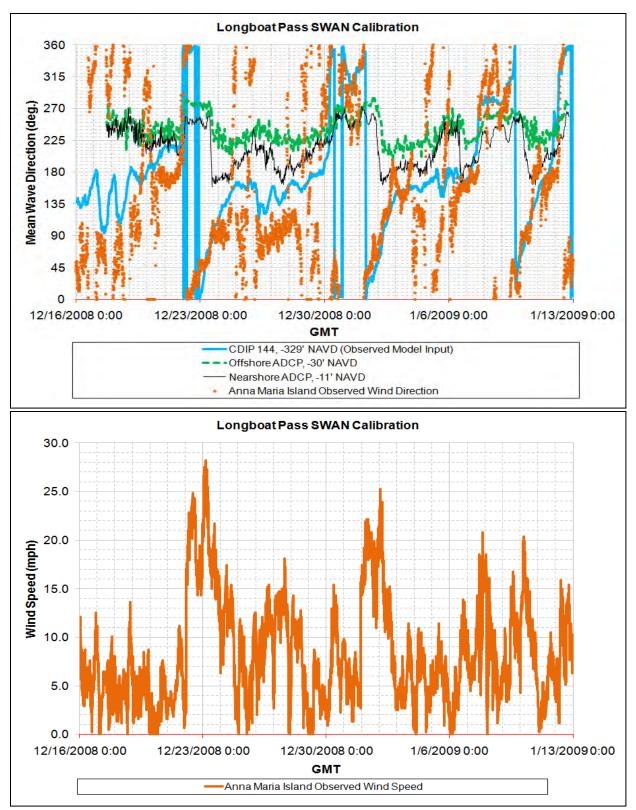
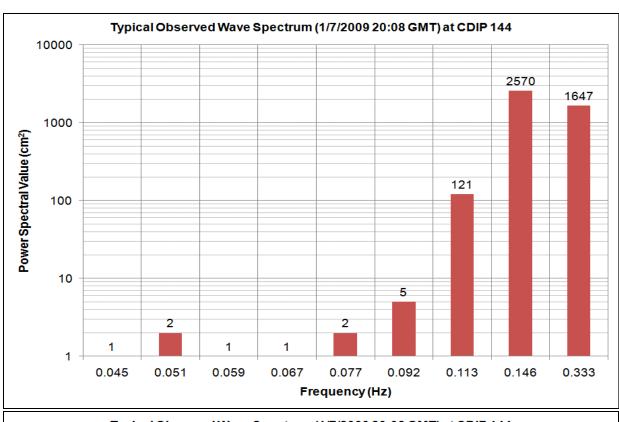


FIGURE 3-7: Observed Waves and Winds during the Calibration Period.



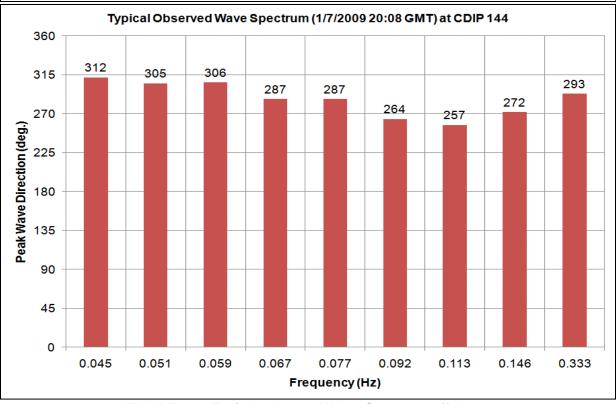


FIGURE 3-8: Typical Observed Wave Spectrum Offshore.

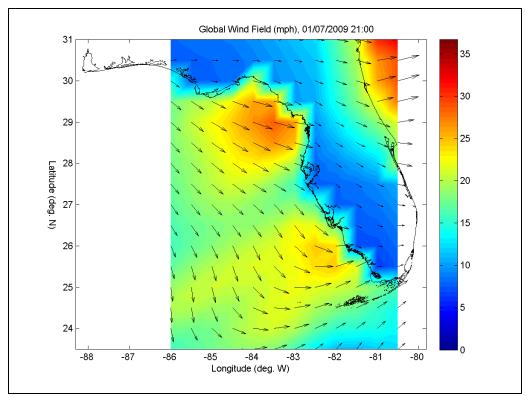


FIGURE 3-9: Typical Wind Field during the Calibration Period (Time Zone = GMT).

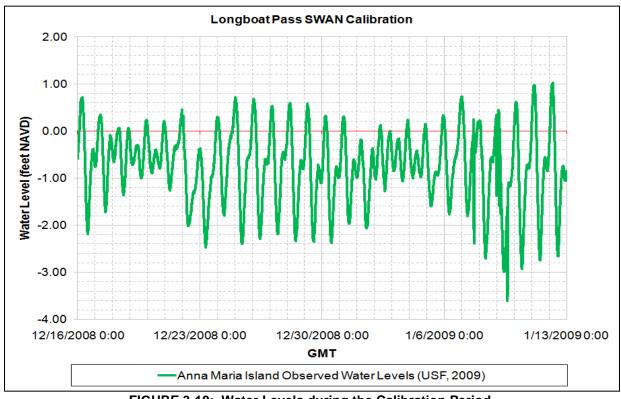


FIGURE 3-10: Water Levels during the Calibration Period.

3.2.2 Bathymetry

The bathymetry used in the calibration of the SWAN model was based on the bathymetric data sets between 1950 and 2008 (see Table 2-1). The 2008 surveys were used as the primary data source. Grid points outside the 2008 survey areas were filled using older data sets, beginning with the 2004 LIDAR survey and ending with the "Design-a-Grid" as the data set of last resort. In this manner, bathymetric surfaces used in the model utilized the most recent survey available at a given location. Bathymetric surfaces used in the model appear in Figures 3-11 through 3-13.

3.2.3 Representation of Structures

The terminal groin on Anna Maria Island was simulated as a "dam" with a crest height of +3 feet NAVD, with overtopping transmission coefficients equal to those of a caisson structure (α = 2.2, β = 0.4). The 18 Coquina Beach groins (R-36 to R-40) and the North Shore Road seawall (R-44.8) were also simulated as dams. Crest elevations were assumed to be +2.2 feet NAVD at the Coquina Beach groins and +4.9 feet NAVD at the North Shore Road seawall, with transmission coefficients equal those of a sloped structure (α = 2.6, β = 0.15). The 6633 Gulf of Mexico Drive (GMD) seawall was simulated as a dam with a crest elevation of +4.8 feet NAVD, with transmission coefficients equal to those of a vertical wall (α = 1.8, β = 0.1). While represented in the SWAN model as described above, the reflection coefficient at each structure was assumed to be negligible since most of the structures were of rubble mound construction. The seawall at 6633 GMD is usually in shallow water such that reflection contributes to a localized standing wave pattern that breaks.

3.2.4 Model Calibration

The primary parameter examined during the SWAN calibration process was the bottom friction. This parameter had the most influence on the results at the locations of the ADCPs. To account for local wave development due to wind, SWAN's wind stress formulation was used in all calibration runs, along with the default diffraction formulation. All other model parameters, including the directional spreading within each frequency band (25°), were set to their default values. To account for the travel time between the offshore model boundary and Longboat Pass (~3 to 4 hours), the model was run in non-stationary mode. The time step during the calibration period for the SWAN model was 10 minutes.

Comparisons between the simulated and observed waves at the ADCPs appear in Figures 3-14 to 3-17 and Table 3-2. Three different JONSWAP coefficients for bottom friction dissipation were tested: 0.038, 0.067, and 0.096 m²/s³. At the Nearshore ADCP, the model tended to over-predict the wave heights given the lowest friction coefficient (0.038 m²/s³). At the Offshore ADCP, the model tended to under-predict the wave heights given the highest friction coefficient (0.096 m²/s³). Based on these findings, a bottom friction coefficient of 0.067 m²/s³ was selected for use in subsequent simulations. Typical wave patterns over the 3 grids used in the model appear in Figures 3-18 to 3-21.

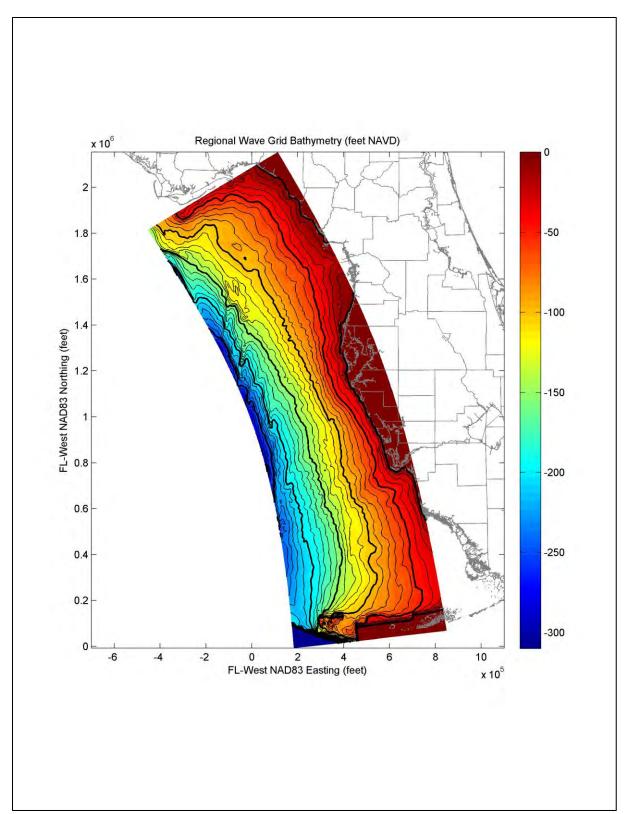


FIGURE 3-11: Bathymetry over the Regional Wave Grid.

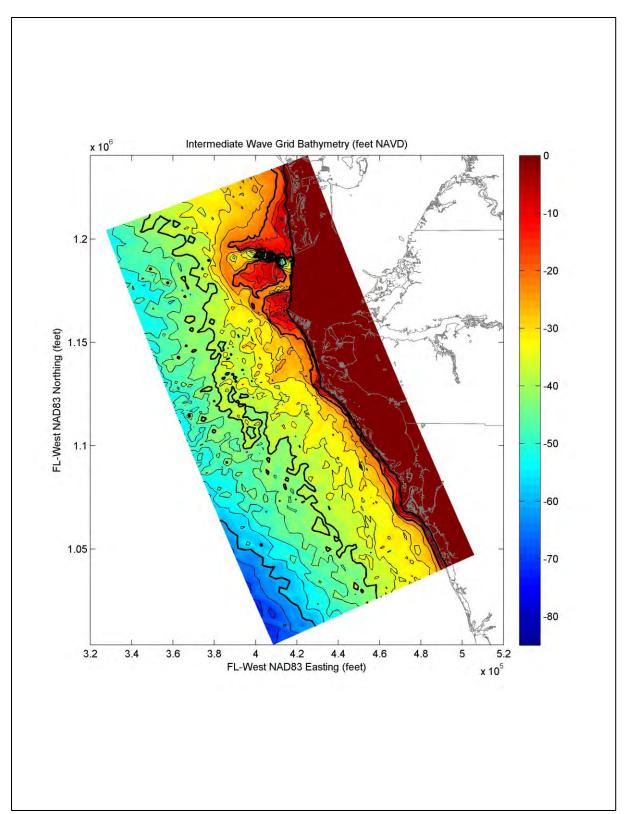


FIGURE 3-12: Bathymetry over the Intermediate Wave Grid.

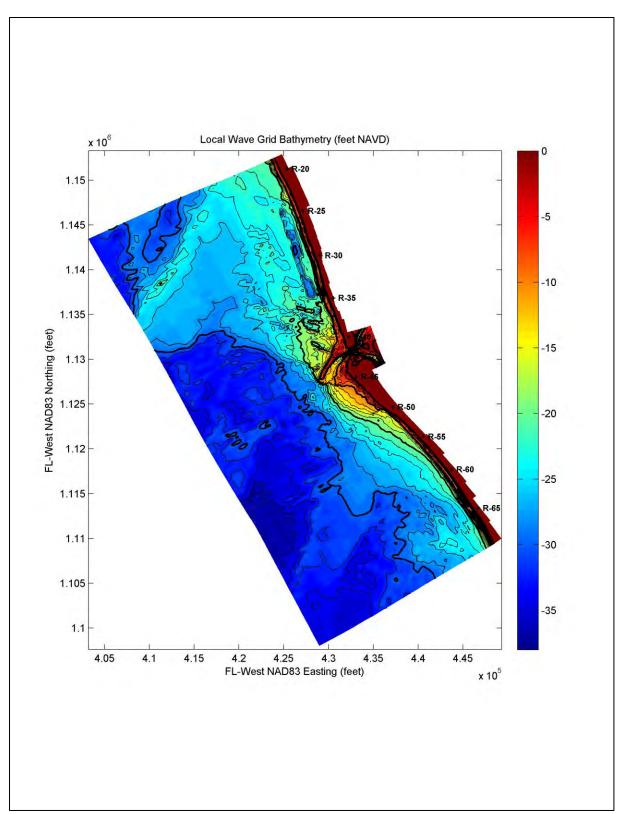


FIGURE 3-13: Bathymetry over the Local Calibration Wave Grid through December 2008.

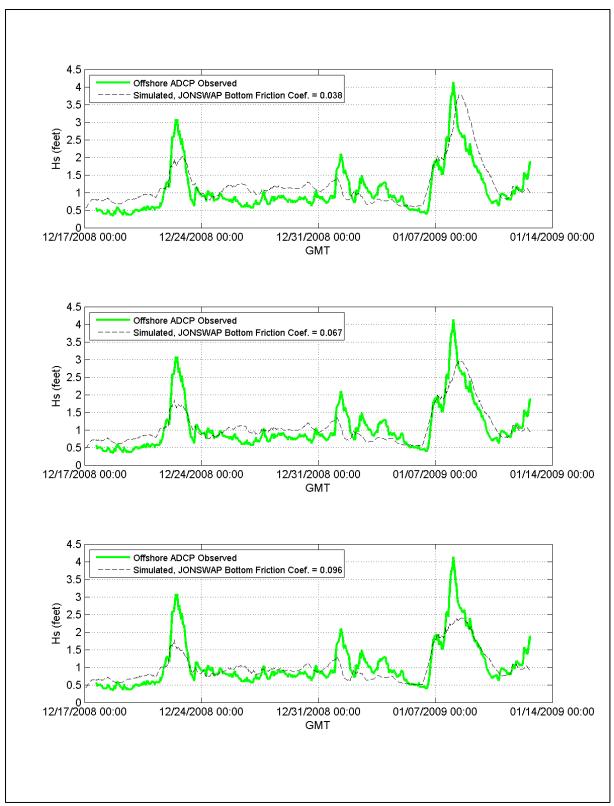


FIGURE 3-14: SWAN Model Results at the Offshore ADCP.

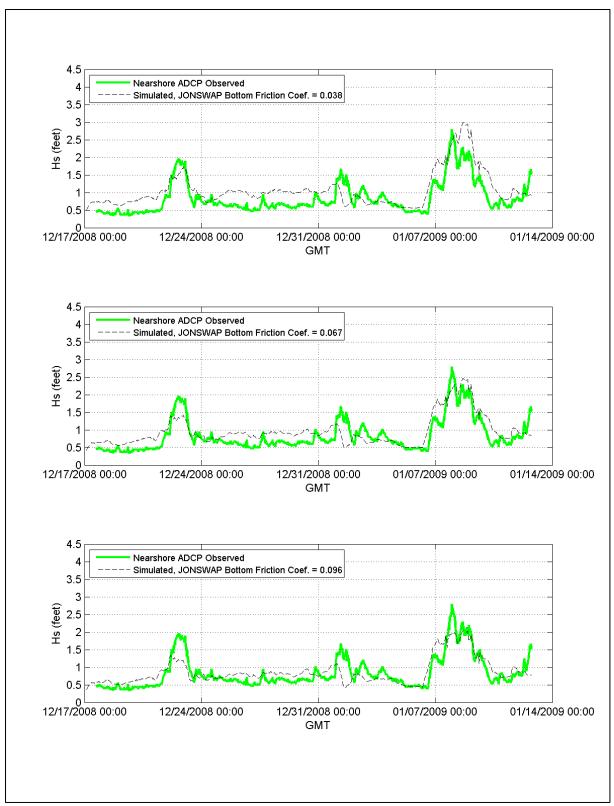


FIGURE 3-15: SWAN Model Results at the Nearshore ADCP.

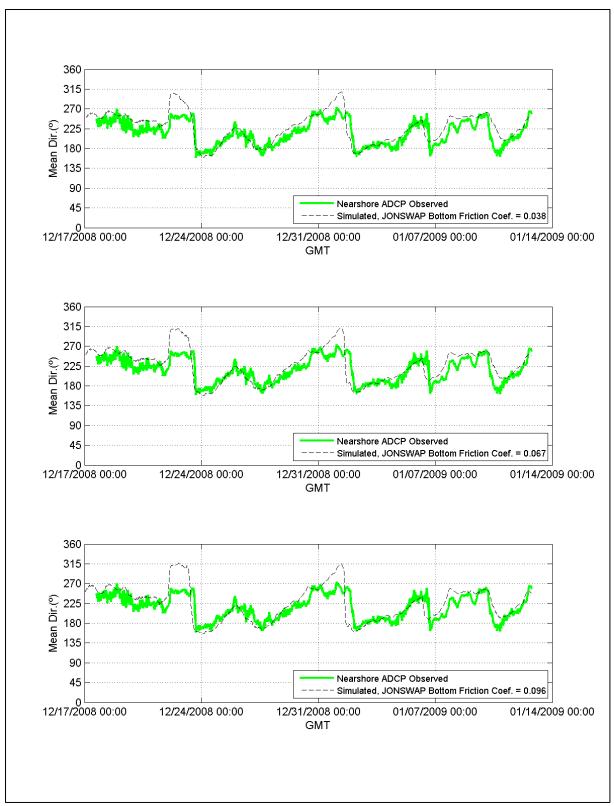


FIGURE 3-16: SWAN Model Results at the Nearshore ADCP.

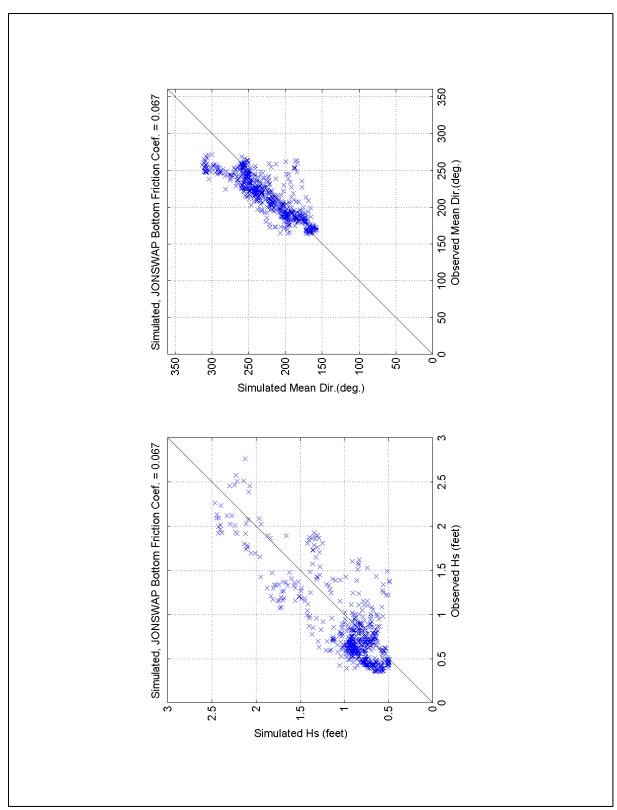


FIGURE 3-17: Scatter Plot of SWAN Model Results at the Nearshore ADCP.

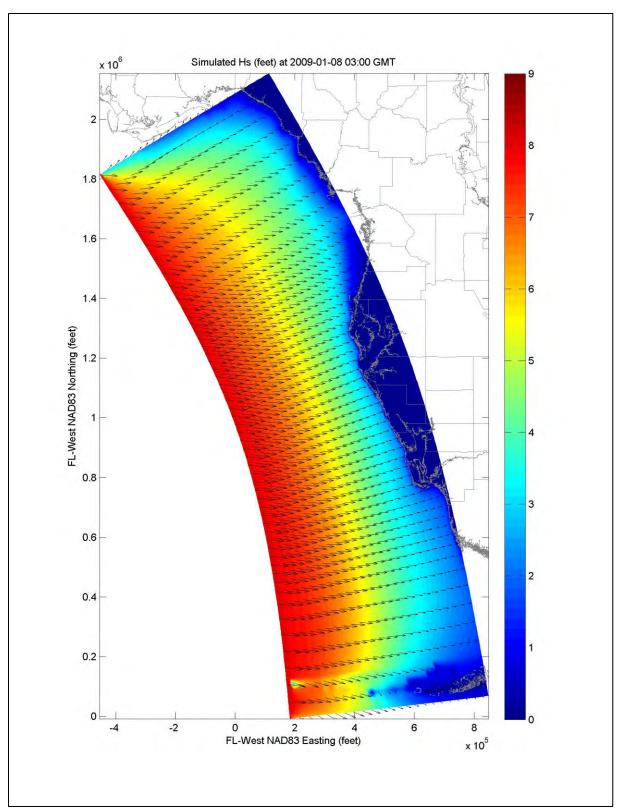


FIGURE 3-18: Typical SWAN Results during the Calibration Period over the Regional Wave Grid.

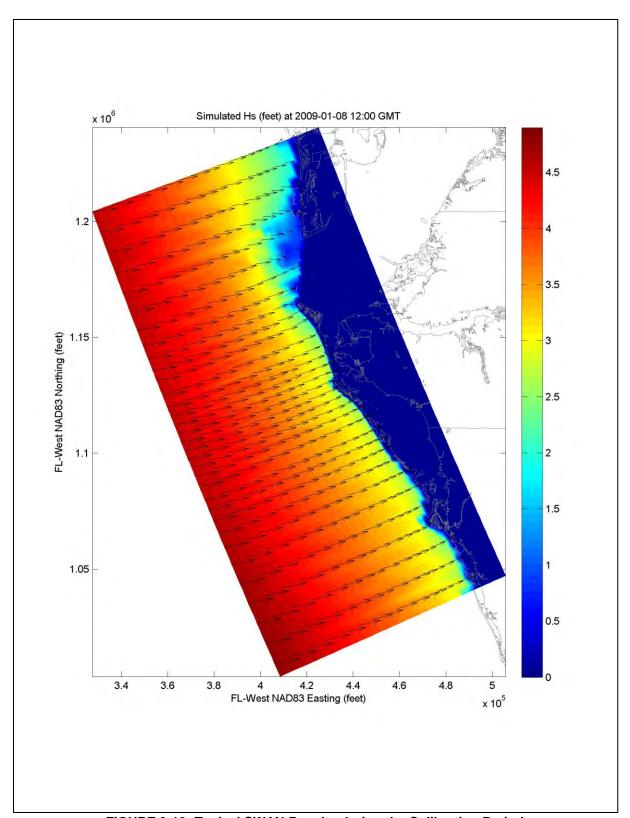


FIGURE 3-19: Typical SWAN Results during the Calibration Period over the Intermediate Wave Grid.

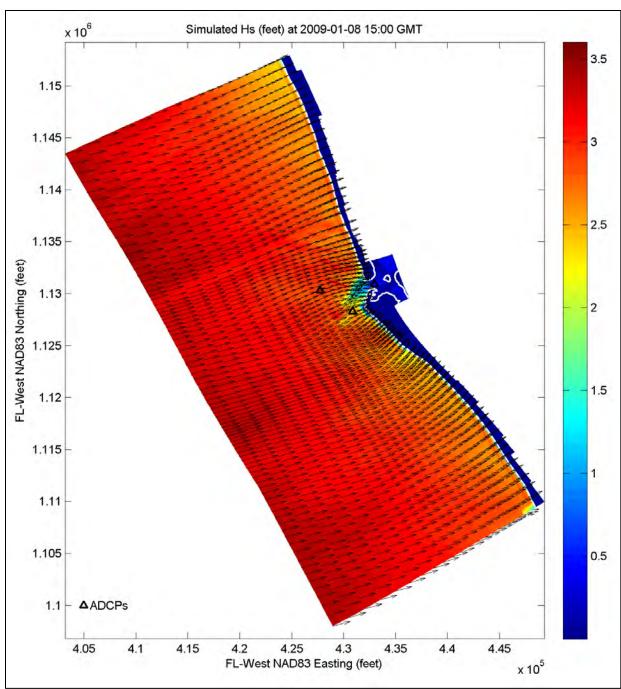


FIGURE 3-20: Typical SWAN Results during the Calibration Period over the Local Wave Grid.

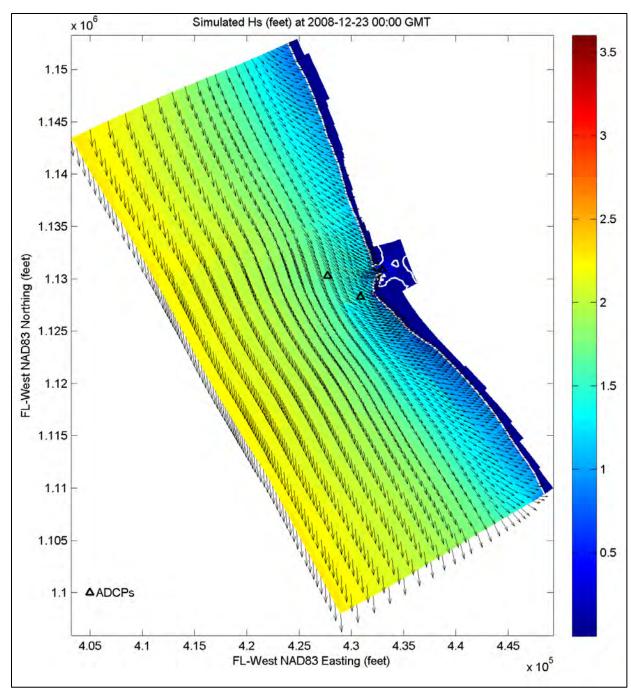


FIGURE 3-21: Typical SWAN Results Showing Offshore-Directed Waves.

TABLE 3-2
SWAN CALIBRATION SUMMARY
LONGBOAT PASS, FL

JONSWAP BOTTOM FRICTION COEFFICIENT	0.038	0.067	0.096
OFFSHORE ADCP			
Hs(simulated) – Hs(observed) (feet)			
Mean	0.2	0.0	0.0
Root-Mean-Square	0.4	0.4	0.4
Mean Dir.(simulated) – Mean Dir.(observed) (°)			
Mean	-18	-18	-18
Root-Mean-Square	37	38	40
NEARSHORE ADCP			
Hs(simulated) – Hs(observed) (feet)			
Mean	0.2	0.1	0.0
Root-Mean-Square	0.4	0.3	0.3
Mean Dir.(simulated) – Mean Dir.(observed) (°)			
Mean	12	10	8
Root-Mean-Square	21	23	25
·			

During several portions of the calibration period, wave energy in deeper water was directed offshore, while wave energy in shallow water was directed onshore (see Figure 3-21). As noted in previous model studies (see CPE, 2010), the Wave Information System hindcast (USACE, 2003) showed that a significant percentage of the wave energy in the offshore areas was directed towards the open Gulf, rather than the shoreline. On the other hand, observed wave records closer to the shoreline showed that near the beach, the majority of wave energy was directed towards the shoreline (CPE/USACE, 2001). The model results in Figure 3-21 reflected this process.

Overall, the model results show that the SWAN model is able to realistically predict the wave height and direction in the nearshore areas. These predicted wave patterns are consistent with observations where the majority of sediment transport occurs. In addition, the large-scale wave propagation patterns estimated by the model are reasonable in comparison to the overall wave statistics for the region.

3.3 Delft3D-FLOW Hydrodynamic Calibration

3.3.1 Boundary Conditions and Forcing

Inlet flows were calibrated based on the 1992 current and water level measurements (Figures 2-8 to 2-10). The calibration period was from April 15 to May 14, 1992. Two grids were utilized during the calibration – the Regional Flow Grid and the Local Flow (1992) Grid (Figures 3-3 and 3-4). The offshore boundary condition on the Regional Flow Grid was based on the observed water levels in Figure 2-8. Zero-gradient boundary conditions were applied on the upcoast and downcoast boundaries of the Regional Flow Grid. In other words, currents and water levels just outside the grid were assumed to be equal to water levels just inside. Flows within the Regional

Flow Grid were estimated using a depth-averaged flow formulation. The water levels based on these results provided the offshore, upcoast, and downcoast boundary conditions on the Local Flow (1992) Grid. Since the calibration was primarily focused on velocities in the channel of the inlet, winds and waves were not included during the calibration of the inlet flows. As shown in Figures 3-20 and 3-21, wave heights in the inlet channel tend to be low (~ 1 foot or less).

3.3.2 Bathymetry

The bathymetry used in the calibration of the inlet flow was based on the bathymetric data sets between 1950 and 1993 (Table 2-1). The 1992 and 1993 surveys were used as the primary data sources. Grid points outside the 1992-1993 survey areas were filled using older data sets in a manner similar to that of the SWAN calibration (see Section 3.2.2). Bathymetric surfaces used in the model appear in Figures 3-22 to 3-24.

3.3.3 Representation of Structures

During the preliminary simulations, the Coquina Beach groins and the Longboat Pass terminal groin were simulated as "thin dams" (Deltares, 2011), except for 3 partially buried structures near R-38, R-39, and R-40. The North Shore Road seawall (R-44.8) was not included in the flow calibration. This structure was fronted by approximately 70 feet of dry beach width in 1992, and did not affect the tidal flow patterns. The 6633 Gulf of Mexico Drive seawall was not included. Although this structure was exposed in 1992, its impacts on the tidal currents in Longboat Pass itself were not significant. The buried seawalls further to the south were not included in the preliminary efforts.

During the final calibration run, all 18 groins at Coquina Beach were included in the model as "thin dams", along with the Longboat Pass terminal groin, the North Shore Road seawall (R-44.8), and the 6633 Gulf of Mexico Drive seawall. These updates had a negligible effect on the results of the flow calibration as expected. However, they were necessary to ensure that wave-driven currents were properly represented when Delft3D-FLOW was coupled with SWAN to simulate sediment transport.

3.3.4 Model Calibration

The primary parameter examined during the calibration of the inlet flows was Chezy's friction coefficient C:

$$C = h^{1/6} / n$$

where

h = water depth in meters

n = Manning's n

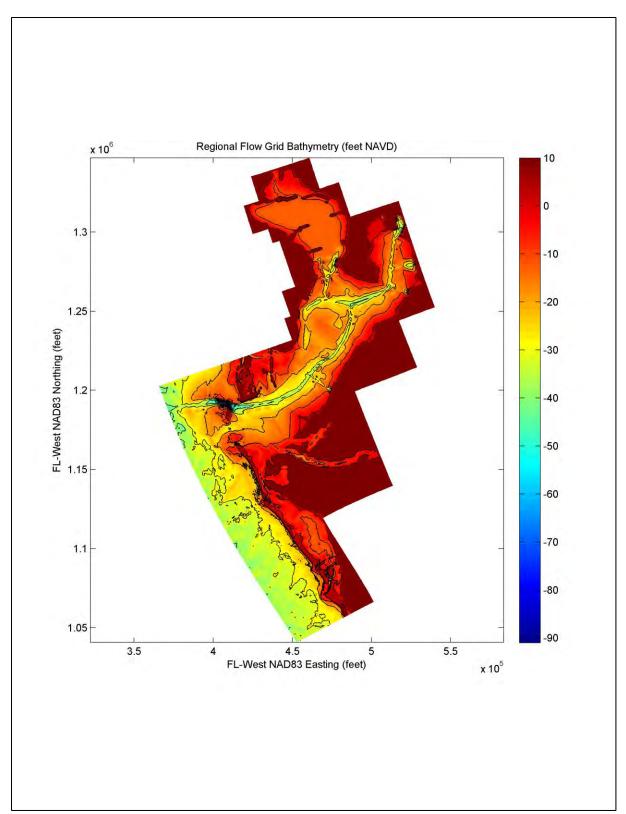


FIGURE 3-22: Bathymetry over the Regional Flow Grid.

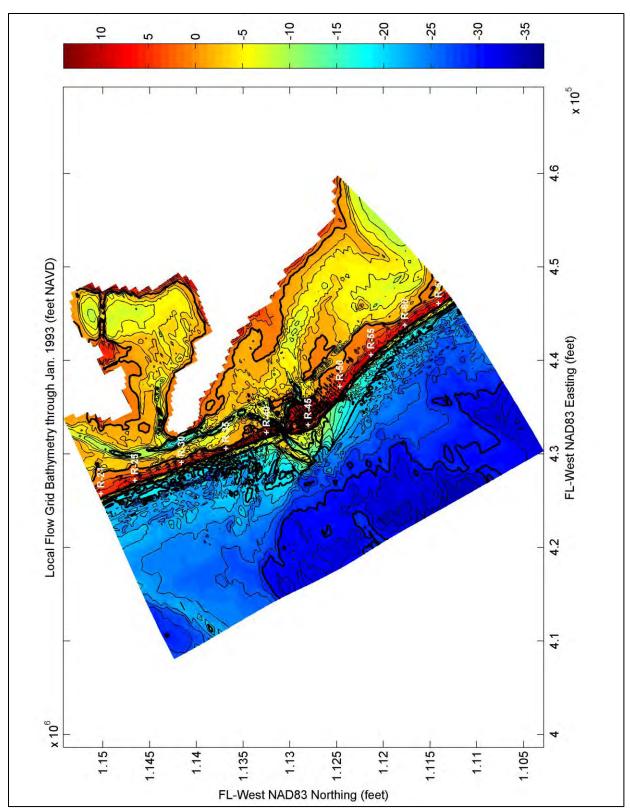


FIGURE 3-23: Bathymetry over the Local Flow (1992) Grid in feet NAVD.

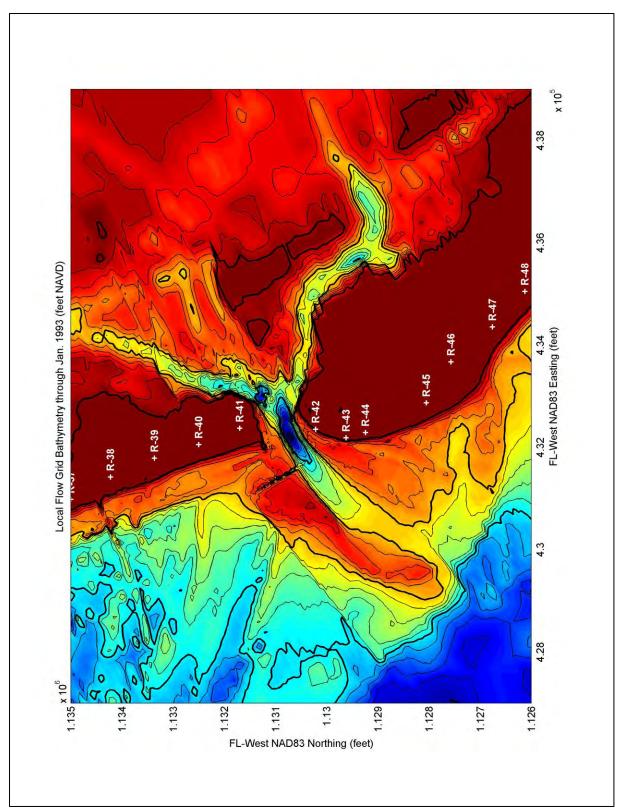


FIGURE 3-24: Bathymetry over the Local Flow (1992) Grid in feet NAVD (Close-up).

A lower Chezy friction coefficient corresponds with a larger bottom roughness and thus a larger resistance; conversely a higher value corresponds with smaller roughness and less bed resistance. Three values of C were tested outside of the submerged aquatic vegetation areas: 55, 65 (default), and 75.

Within the submerged aquatic vegetation areas, the Chezy friction coefficient was lowered to 17 m^{1/2}/s in each calibration run. Seagrasses were located inside the bay and would influence the currents by increasing the bed roughness. Seagrass locations were based on:

- 1) SHEDA Ecological Associates Technical Memorandum (2009) Submerged aquatic vegetation is mapped in the region close to Jewfish Key. The flora composition (species and density) are described.
- 2) Seagrass Survey of Longboat Pass Field Observation Report (CPE, 2010)
- 3) Google Earth Images.

This value was based on the empirical equations of Klopstra, et al, 1997 and the characteristics of the vegetation and the environment. A typical friction map based on the sources above appears in Figure 3-25.

Comparisons between the simulated and observed currents at the 1992 Current Gage appear in Figures 3-26 to 3-30. Based on the average differences between the simulated and observed currents, a Chezy friction coefficient of 75 was selected for use in subsequent simulations (Table 3-3). Typical flow patterns during peak flood and peak ebb appear in Figures 3-31 and 3-32.

INLET FLOW CALIBRATION SUMMARY
DELFT3D-FLOW MODEL
LONGBOAT PASS, FL

TABLE 3-3

Chezy Friction	East / We	Observed st Current econd)	Simulated – Observed North / South Current (feet/second)				Simulated – Observed Bayside Water Level (feet)**	
Value*	Mean	RMS	Mean	RMS	Mean	RMS	Mean	RMS
55	-0.03	0.53	-0.16	0.53	-0.02	0.50	0.00	0.10
65	-0.01	0.48	-0.16	0.56	-0.01	0.45	0.00	0.11
75	0.00	0.44	-0.15	0.58	0.01	0.44	0.00	0.11

IOTES: * Outside submerged aquatic vegetation areas. Within the submerged aquatic vegetation areas, the Chezy Friction value was 17.

^{**} Due to datum referencing problems at the Bayside Tide Gage (see Figure 2-9), the Mean and Root-Mean-Square values are based on the water levels in feet MTL.

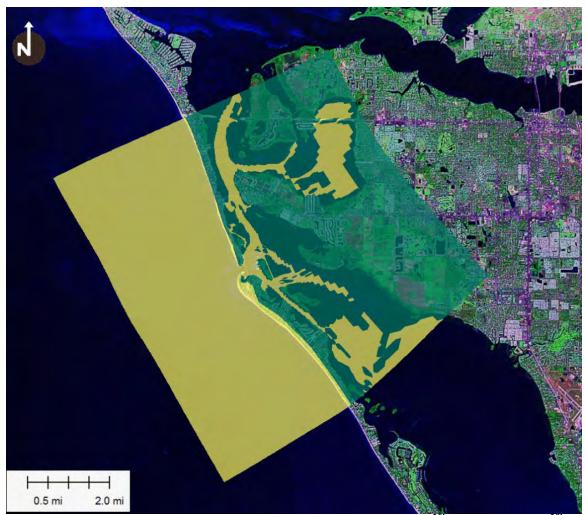


FIGURE 3-25: Variation of Chezy Friction Coefficient; green = 17 m^{1/2}/s; yellow = 75 m^{1/2}/s.

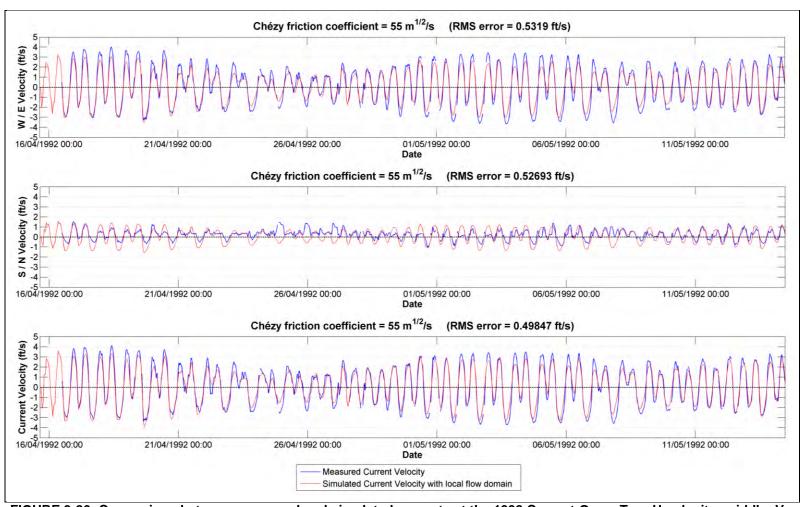


FIGURE 3-26: Comparison between measured and simulated currents at the 1992 Current Gage. Top: U-velocity; middle: V-velocity; bottom: Velocity magnitude (flood currents positive, ebb currents negative). Chezy friction coefficient = 55 m^{1/2}/s (Time Zone = EDT).

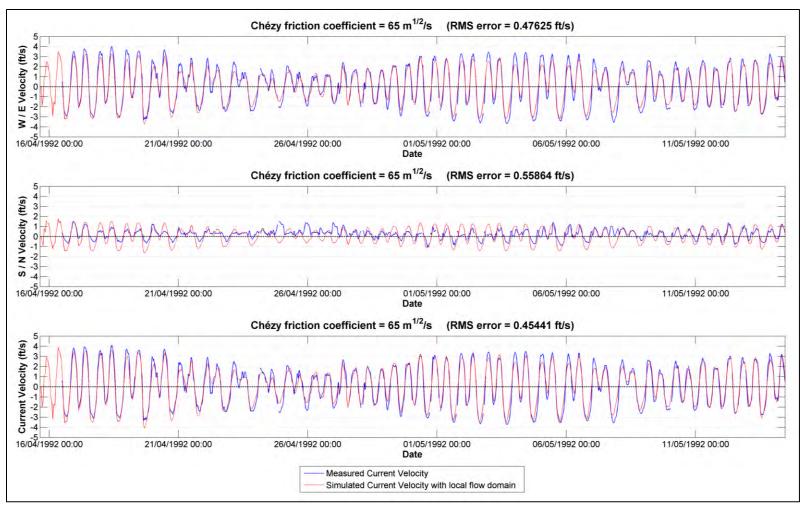


FIGURE 3-27: Comparison between measured and simulated currents at the 1992 Current Gage. Top: U-velocity; middle: V-velocity; bottom: Velocity magnitude (flood currents positive, ebb currents negative). Chezy friction coefficient = 65 m^{1/2}/s (Time Zone = EDT).

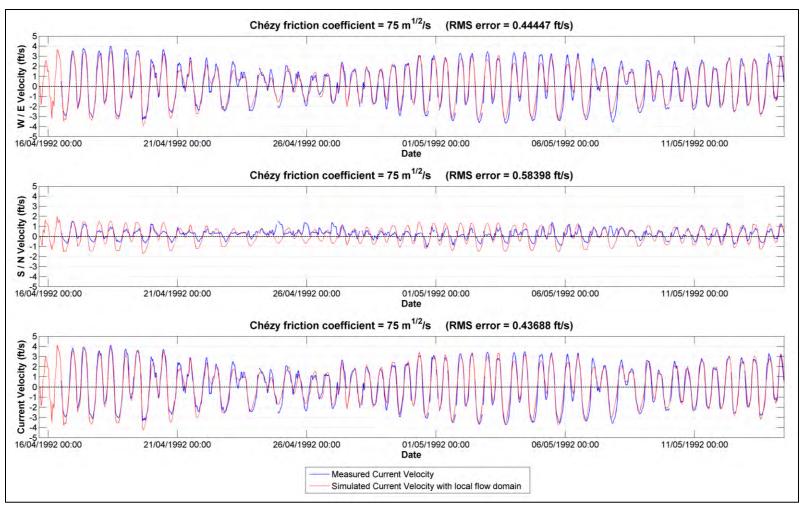


FIGURE 3-28: Comparison between measured and simulated currents at the 1992 Current Gage. Top: U-velocity; middle: V-velocity; bottom: Velocity magnitude (flood currents positive, ebb currents negative). Chezy friction coefficient = 75 m^{1/2}/s (Time Zone = EDT).

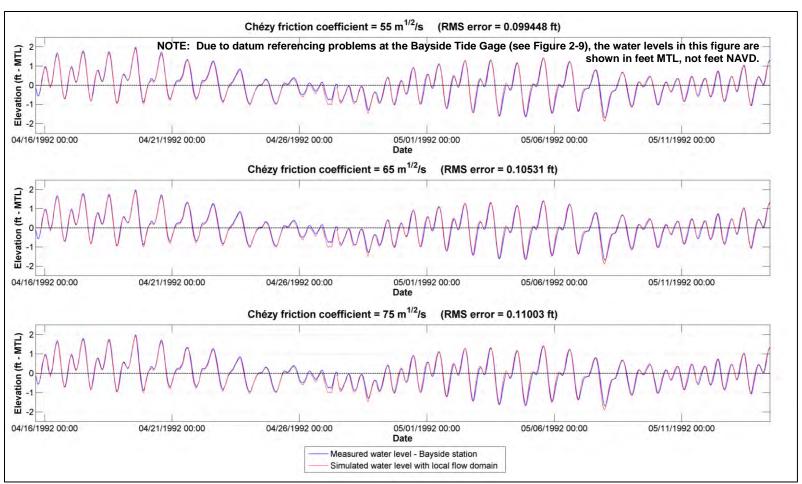


FIGURE 3-29: Simulated vs. Observed Water Levels at the 1992 Bayside Tide Gage (Time Zone = EDT).

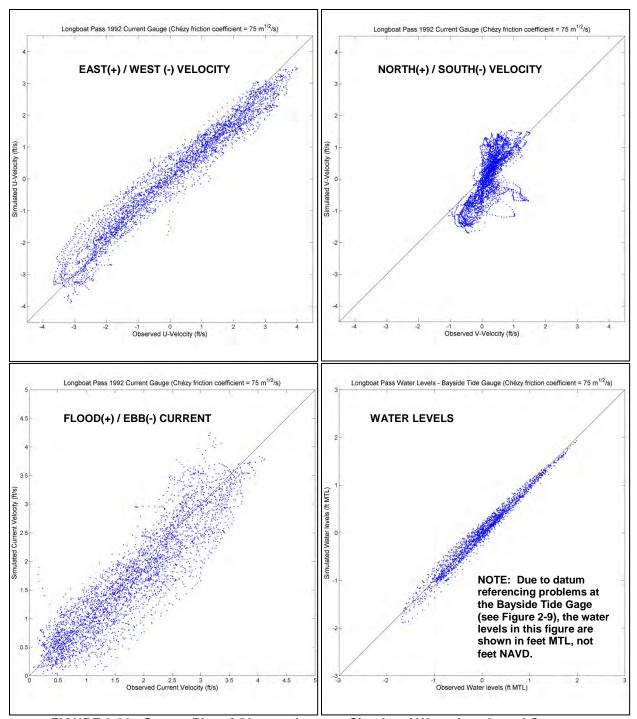


FIGURE 3-30: Scatter Plot of Observed versus Simulated Water Levels and Currents.

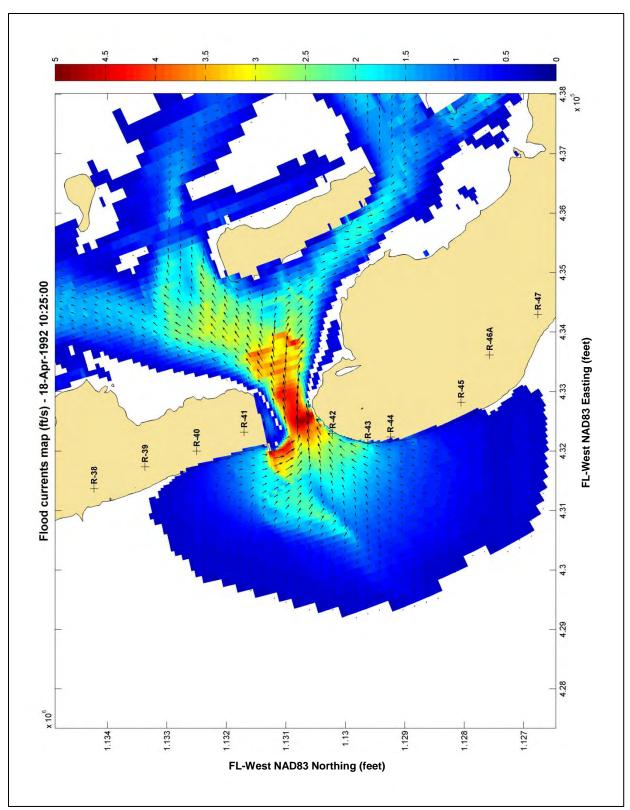


FIGURE 3-31: Typical Peak Flood Flow during the Calibration Period (Time Zone = EDT).

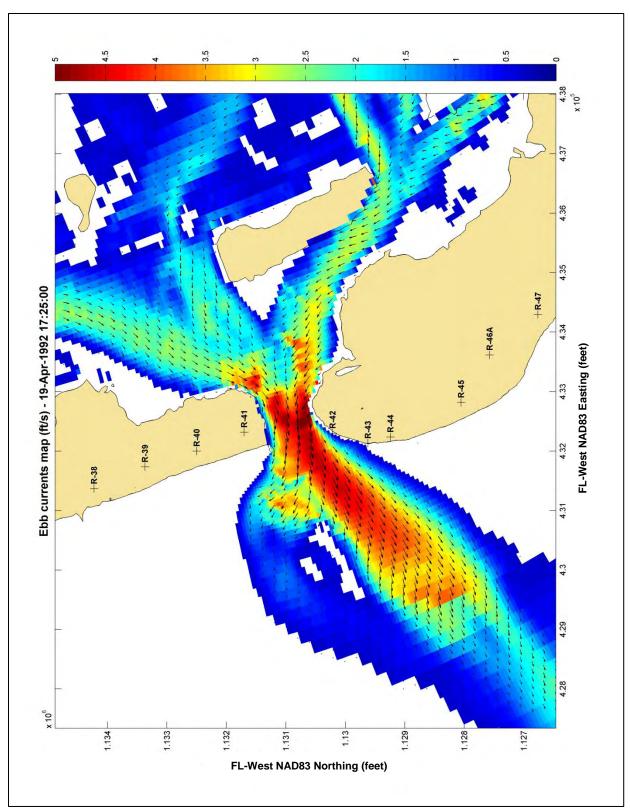


FIGURE 3-32: Typical Peak Ebb Flow during the Calibration Period (Time Zone = EDT).

3.4 Delft3D-FLOW Morphology Calibration

Sediment transport, erosion, and deposition were calculated within the Delft3D-FLOW model, which was coupled with SWAN. These processes were calibrated based on the beachfront volume changes on Longboat Key and Anna Maria Island between April-May 2003 and October 2009.

3.4.1 Initial Condition Bathymetry

The initial condition for the model was based on the following sources (see Table 2-1):

- 1. The April 2003 beach survey of Longboat Key.
- 2. The May 2003 beach survey of Anna Maria Island.
- 3. The April 2004 channel survey by the U.S. Army Corps of Engineers.
- 4. The NOAA Digital Elevation Models of Sarasota Bay and Tampa Bay.
- 5. USGS Digital Elevation Models of the land areas surrounding Sarasota Bay and Tampa Bay.
- 6. The May-June 2004 LIDAR survey.
- 7. The NOAA GEODAS database.
- 8. The NOAA "Design-a-Grid".

Grid cells within the Local Flow (2003) Grid were filled using the first data source. Cells outside the area covered by the first data source were filled using the other sources, beginning with #2 above and ending with #8 as the data source of last resort. The resulting bathymetry appears in Figure 3-33.

3.4.2 Representation of Structures

All 18 groins at Coquina Beach were included in the Delft3D-FLOW model as "thin dams", along with the Longboat Pass terminal groin, the North Shore Road seawall (R-44.8), and the 6633 Gulf of Mexico Drive seawall. Within the SWAN model, the representation of the structures was identical to the selected SWAN model calibration run (see Section 3.2.3).

3.4.3 Model Forcing

3.4.3.1 Hypercube Method for Estimating Nearshore Waves

During each morphology calibration run, the input wave cases were given on the western boundary of the Regional Wave Grid in Figure 3-1. The wave cases were selected from a composite time series extending from 1980-2010 (see Section 2.5.1 and Figure 2-1):

- 1980-1997: Wave Information System (WIS) hindcast at Station 73363.
- 1997-2005: NOAA Global Wavewatch hindcast at 27.00°N, 83.75°W.
- 2005-2010: NOAA High Resolution Global Wavewatch hindcast at 27.00°N, 84.00°W.

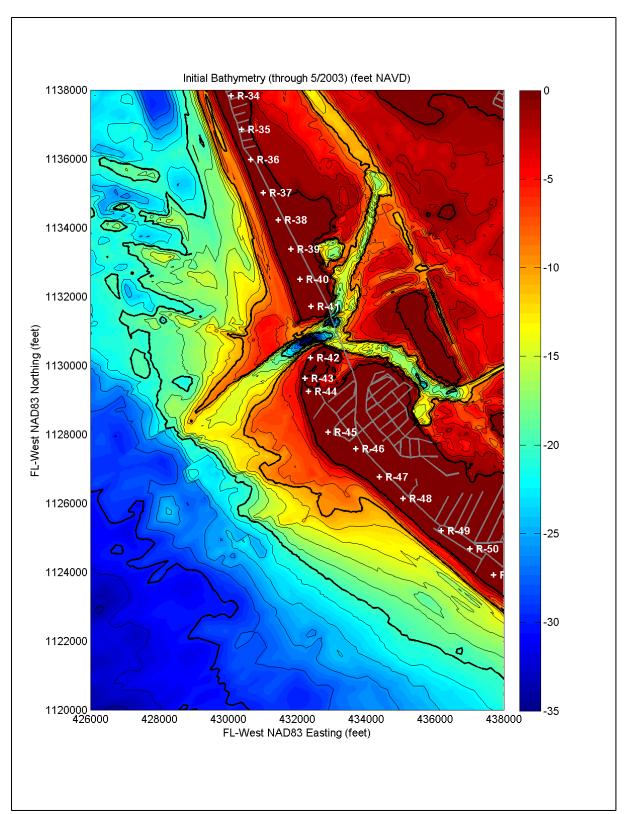


FIGURE 3-33: Initial Bathymetry for Morphology Calibration.

Wave cases were selected based on the wave energy flux:

```
\begin{split} E_p &\approx 1.56 \ T_p \rho g H_s^{\ 2} \, / \, 16 \\ \end{split} where \begin{split} E_p &= \text{energy flux} \\ T_p &= \text{peak wave period (seconds)} \\ \rho &= \text{sea water density (1025 kg/m}^3) \\ g &= \text{gravitational acceleration (9.81 m/s}^2) \\ H_s &= \text{significant wave height (m)} \end{split}
```

However, due to the large distances across the Regional Grid, the wave height and wave energy on the offshore boundary was not always representative of the wave energy close to the shoreline. To estimate the wave energy closer to the shoreline, it was necessary to transform the time series from the western boundary of the Regional Wave Grid to the nearshore zone.

Due to the length of the time series, transforming every wave record at 1-3 hour intervals is not practical. As an alternative, the Hypercube technique has been developed by the Environmental Hydraulic Institute of the University of Cantabria, Spain (Instituto de Hidraulica Ambiental de la Universidad de Cantabria - IH Cantabria). It consists of simulating a large number of deepwater wave cases in SWAN using different combinations of wave height, period, and direction that cover the entire ranges of these parameters. Using three-dimensional ("cube"), linear interpolation, a multi-year time series of the waves closer to the shoreline can be constructed based on the concurrent wave record further offshore and the SWAN results for each wave case (see Figure 3-34). This procedure is similar to the lookup method used to couple GENESIS to an external wave transformation model (Hanson & Kraus, 1989, p. 74). However, the number of wave cases is larger (300 to 400 Hypercube vs. 50-100 GENESIS). Using the Hypercube method, it is possible to transform a long record (i.e. 1-30 years) of waves from the offshore zone to the nearshore zone by analyzing 300-400 wave cases rather than 50,000 to 150,000 individual records.

The Hypercube evaluation for Longboat Pass utilized the grids in Figures 3-1 and 3-2, the SWAN model settings in Section 3.2, and the wave direction, wave period, and wave height classes in Table 3-4. To construct Table 3-4, the 1980-2010 wave record was divided into 16 direction bands. Within each direction band, the wave record was further subdivided into the 5 period classes and 5 height classes. The widths of the height and period class were not uniform. Instead, they were spaced so that within each direction band, each height or period class would contain the same amount of wave energy. Overall, the total number of wave cases for Longboat Pass was $400 (16 \times 5 \times 5)$.

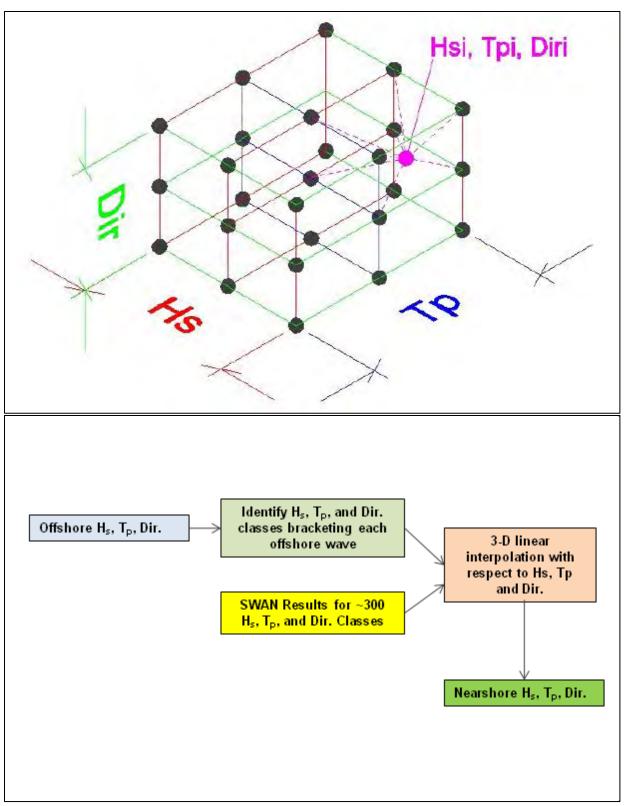


FIGURE 3-34: Schematic representation of the Hypercube methodology. The wave height, period, and direction can be obtained for a selected nearshore point through linear interpolation of the SWAN results for a large number of deepwater wave cases.

TABLE 3-4

HYPERCUBE WAVE CASE SUMMARY
LONGBOAT PASS, FL

Direction Band (degrees)		Tp (sec.) Classes within	Hs (feet) Classes within
Avg.	Range	Direction Band, Avg. Values	Direction Band, Avg. Values
11	0 to 22.5	2.0, 3.6, 4.8, 6.9, 12.5	0.03, 1.4, 3.5, 7.2, 20.3
34	22.5 to 45	2.0, 3.6, 4.7, 6.7, 11.0	0.03, 1.6, 3.5, 7.0, 16.4
56	45 to 67.5	2.0, 3.4, 4.3, 5.9, 9.5	0.03, 1.6, 3.1, 5.7, 16.4
79	67.5 to 90	2.0, 3.4, 4.2, 5.5, 9.0	0.03, 1.6, 2.8, 5.0, 16.4
101	90 to 112.5	2.0, 3.4, 4.1, 5.3, 10.5	0.03, 1.4, 2.6, 4.6, 23.0
124	112.5 to 135	2.0, 3.4, 4.2, 5.4, 10.5	0.03, 0.8, 1.9, 4.1, 23.0
146	135 to 157.5	2.0, 3.5, 4.5, 5.8, 11.5	0.03, 0.8, 1.8, 4.3, 24.9
169	157.5 to 180	2.0, 3.5, 4.4, 5.9, 15.5	0.03, 1.0, 2.4, 5.3, 30.8
191	180 to 202.5	2.0, 3.6, 4.7, 6.6, 15.5	0.03, 1.1, 2.7, 5.9, 30.8
214	202.5 to 225	2.0, 3.6, 4.6, 6.7, 16.0	0.03, 1.2, 2.7, 6.0, 30.8
236	225 to 247.5	2.0, 3.6, 4.6, 7.2, 16.0	0.03, 1.1, 2.4, 6.2, 24.3
259	247.5 to 270	2.0, 3.7, 4.9, 7.7, 16.0	0.03, 0.8, 2.1, 5.7, 21.7
281	270 to 292.5	2.0, 3.7, 5.0, 7.5, 13.0	0.03, 0.9, 2.4, 6.6, 21.7
304	292.5 to 315	2.0, 3.6, 4.8, 6.9, 13.0	0.03, 0.9, 2.5, 6.6, 21.7
326	315 to 337.5	2.0, 3.5, 4.7, 6.7, 12.5	0.03, 1.0, 2.7, 6.8, 20.3
349	337.5 to 360	2.0, 3.6, 4.9, 6.9, 12.5	0.03, 1.3, 3.4, 7.3, 20.3

As a first approximation, water level changes, tidal currents, and wind stress were not included in the various cases summarized in Table 3-4. These processes were included in the subsequent model runs discussed later in this report. The inclusion of wind stress would have required the delineation of wind speed and direction cases, in addition to wave height, wave period, and wave direction cases. Depending on how the winds were classified (8-16 direction bands and 5 speed classes), this would have multiplied the number of wave cases by a factor of 40 to 80, offsetting any gains in computational efficiency.

Using the SWAN model, the 400 wave cases in Table 3-4 were transformed from the offshore boundary of the Regional Wave Grid to the Hypercube Output Location (27°25'25.3568"N, 82°43'41.1189"W) shown in Figure 2-1. Typical results based on the Hypercube method appear in Figures 3-35 and 3-36.

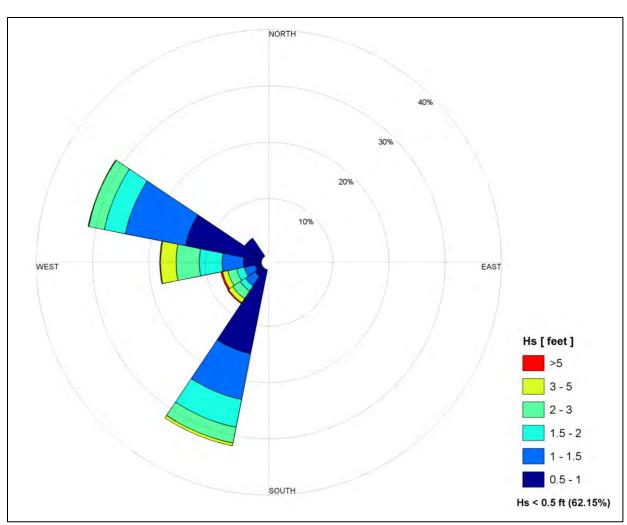


FIGURE 3-35: Wave Rose Based on the Estimated 1980-2010 Wave Record at the Hypercube Output Location (27°25'25.3568"N, 82°43'41.1189"W).

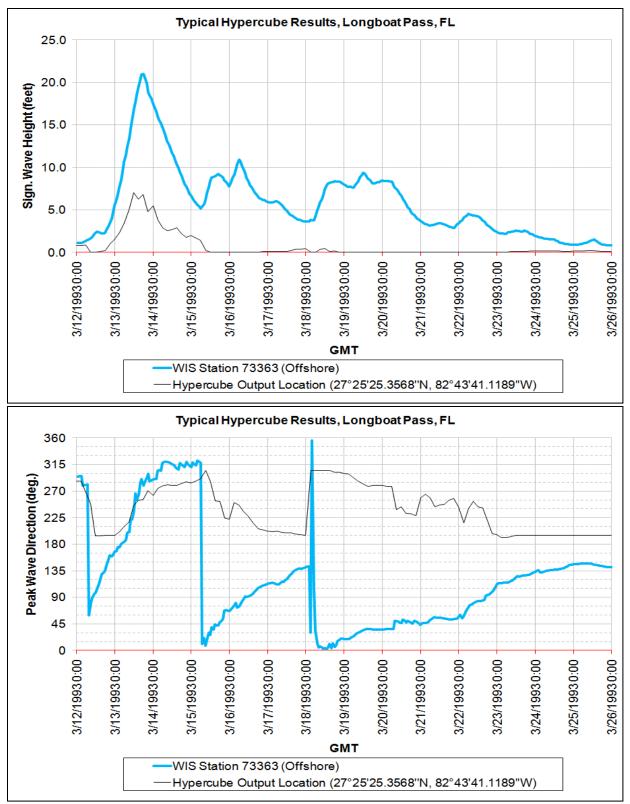


FIGURE 3-36: Typical Hypercube Wave Transformation Results.

3.4.3.2 Wave Cases

The final wave cases used in the morphological calibration runs were developed using the composite time series on the seaward edge of the Regional Wave Grid. The offshore wave height, peak period, and offshore wave direction for each wave case were averaged from the wave records at the offshore hindcast locations (27.00°N, 83.75°W and 27.00°N, 84.00°W). However, the energy flux corresponding to each offshore wave record was the nearshore wave energy flux based on the concurrent waves at the Hypercube Output Location (27°25'25.3568"N, 82°43'41.1189"W). All wave cases used as input to the SWAN model during the morphological calibration were given at the seaward edge of the Regional Wave Grid.

To develop the final wave cases, the wave records offshore and at the Hypercube Output Location were divided into 3 groups – January 2003 to April 2005, April 2005 to August 2007, and August 2007 to December 2009. The 3 groups were then filtered to eliminate all waves that would result in nearshore wave energy coming from the landward direction bands (blue bars in Figure 3-37), along with all low waves (i.e. < 1 foot). Afterwards, the remaining wave records in each group were divided into 4 direction classes and 3 height classes, resulting in 12 offshore wave cases each (Table 3-5). The offshore water wave cases were selected based on the nearshore wave energy flux. Each offshore wave case represented an equal amount of wave energy at the Hypercube Output Location. Although the 36 wave cases (3 x 3 x 4) represented approximately 95% of the onshore wave energy, they only covered 40% of the study period (2003-2009). To account for the remaining 60%, an additional case was added to represent calm conditions onshore, bringing the total number of wave cases to 37.

To decrease the time needed for the morphological computation, morphological acceleration factors (Morfacs) were used, as described in Lesser et al (2004) and Benedet and List (2008). The morphological acceleration factor "M" was estimated according to the following procedure:

$$M = T_{\text{study period}} / T_{\text{model period}}$$

where

 $T_{\text{study period}} = \text{(length of the study period)} \times \text{(percent occurrence for each wave case)}$ $T_{\text{model period}} = \text{duration of the wave case in the model simulation}$

For example, a wave case that occurs 14 days a year can be simulated over 24 hours with a morfac value of 14. With the Delft3D modeling community, it is common practice to use lower M values for high wave cases, when the most significant morphological changes occur, and higher M values for smaller wave cases, where little change takes place.

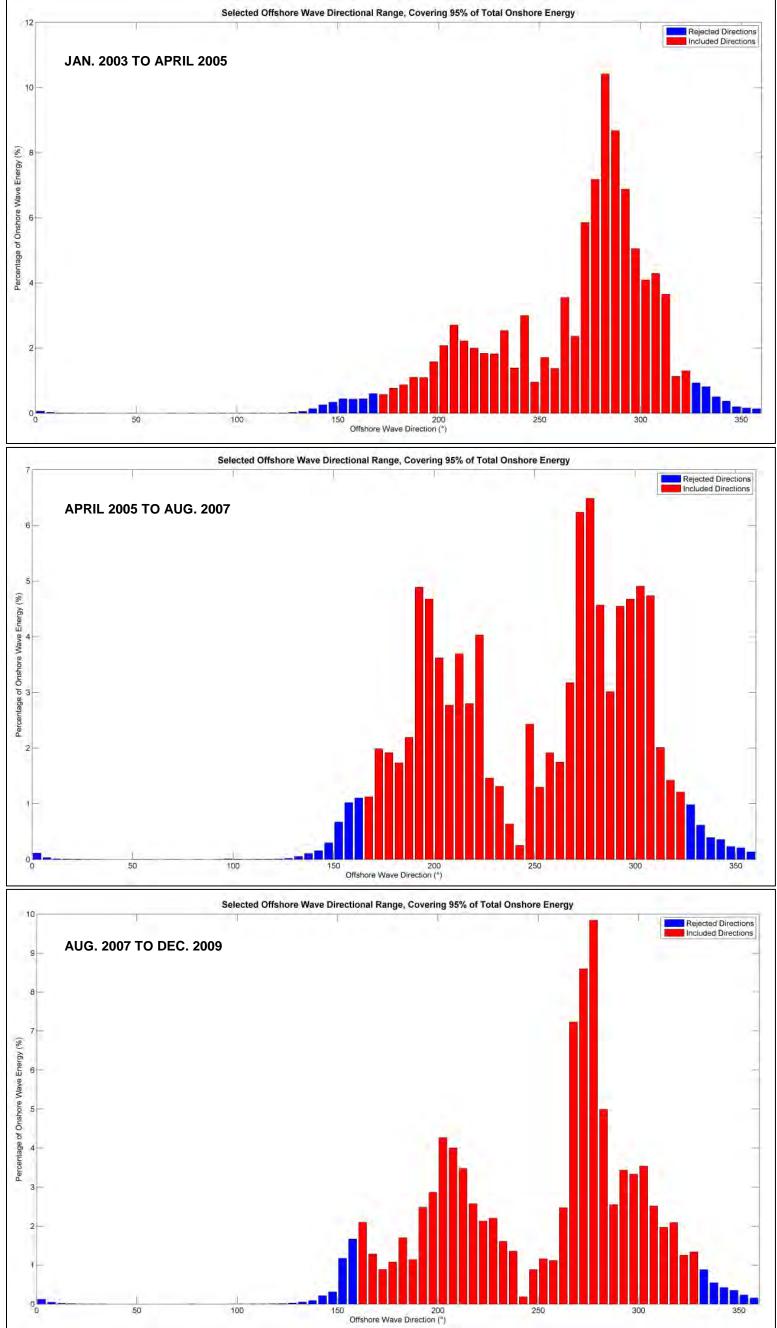


FIGURE 3-37: Selected Offshore Directional Ranges that Cover 95% of Total Onshore Energy.

TABLE 3-5
SIMULATED WAVE CASES AND THEIR CORRESPONDING MORFAC VALUES LONGBOAT PASS, FL

	Wave case	Sign. Wave Height (feet)	Peak Wave Period (sec.)	Peak Wave Dir. (deg.)	Directional Spreading (deg.)	Wind speed (mph)	Wind Dir. (deg)	Morfac
	#1	2.5	4.9	265	25	3.2	304	92.7
	#2	2.9	5.1	307	25	4.5	335	110.0
	#3	7.7	7.8	285	14	10.4	351	11.9
	#4	2.2	4.4	202	25	3.5	210	67.4
20	#5	10.1	7.7	309	14	16.1	353	12.9
2003-2005	#6	9.6	8.4	269	11	10.6	262	11.7
-20	#7	6.1	6.8	269	14	9.3	302	29.3
05	#8	10.2	7.2	223	14	11.6	237	2.2
	#9	6.7	6.8	306	14	12.9	3	35.4
	#10	10.9	8.2	287	11	17.4	318	9.3
	#11	4.5	5.6	203	25	7.6	233	11.1
	#12	3.3	5.5	286	25	3.1	327	76.1
	#13	2.7	4.9	231	25	4.2	244	34.6
	#14	11.2	8.1	302	11	23.4	320	10.1
	#15	6.8	7.9	277	14	9.3	327	17.2
	#16	2.9	4.9	185	25	5.1	182	76.5
20	#17	7.3	7.0	306	14	16.0	335	33.2
2005-2007	#18	11.9	10.1	232	11	18.4	145	8.0
.20	#19	2.8	4.6	309	25	5.2	324	142.9
07	#20	8.5	8.2	187	11	14.3	155	4.2
	#21	6.8	7.5	233	14	9.5	223	3.7
	#22	9.6	8.5	279	11	13.4	306	9.8
	#23	2.6	5.1	278	25	2.5	269	80.5
	#24	14.6	9.9	189	11	20.8	133	1.6
	#25	2.6	4.5	309	25	4.2	322	145.8
	#26	13.9	9.3	182	11	20.2	121	2.5
	#27	7.8	8.3	275	11	8.1	319	10.1
	#28	2.3	4.7	183	25	4.8	195	100.3
20	#29	10.3	7.9	306	14	21.3	333	13.1
2007-2009	#30	11.6	9.1	258	11	12.1	281	5.3
.20	#31	6.3	7.1	239	14	5.9	271	4.9
09	#32	6.1	6.1	185	14	13.3	180	11.1
	#33	7.0	6.8	309	14	14.7	341	24.9
	#34	11.8	8.8	277	11	18.7	306	4.7
	#35	2.3	5.1	239	25	3.2	244	50.0
	#36	2.7	5.7	276	25	1.7	345	59.9
	CALM	0.7	5.0	255	25	2.2	75	95.4

3.4.3.3 Tides

Tides at Longboat Pass are mixed semidiurnal tides, with both a non-uniform amplitude and non-uniform tidal period (see Figure 2-8). Simulating each wave cases for a portion of the spring-neap tidal cycle introduces biases that negatively affect the model results, since the tidal component of the sediment transport would not be the same for each wave case. Ideally, each wave case could be simulated over a full, 14-day, spring-neap tidal cycle. However, given the number of wave cases, this would inflate the model's run time to unacceptable levels (i.e. 1 month).

To address this issue, the accepted practice is to schematize the tides using one or two sinusoidal harmonics only. The schematized tide approach may reproduce the morphological effects associated with the observed tides or all the astronomical constituents estimated for a given location. Three different simplified tides were tested (Table 3-6):

- 1. A semidiurnal tide (period of 12 hours) oscillating between mean high water and mean low water;
- 2. A diurnal tide (period of 24 hours) oscillating between mean high water and mean low water;
- 3. A combination of a semidiurnal component (M2) and a diurnal component (C1). This last methodology was proposed by Lesser (2009) to better represent the tidal fluxes associated with the full tide by using a simplified tidal signature with two sinusoidal harmonics.

TABLE 3-6
TIDE SCHEMES TESTED LONGBOAT PASS, FL

Scheme		Amplitude (feet)	Period (hours)	Phase (deg.)
# 1	MHW - MLW (semidiurnal)	0.64	12	0
# 2	MHW - MLW (diurnal)	0.64	24	0
# 3	C1	0.71	24	242.9
#3	M2	0.60	12	358.0

The approach used to identify which tide scheme was appropriate consisted of simulating six months of morphology changes. The offshore boundary condition for this model run was the observed water level in Figure 2-8. The initial condition was the bathymetry in Figure 3-33. To simulate 6 months of changes using the 1 month record length, a morphological acceleration factor of 6 was used. Similar simulations were conducted using the schematized tides in Table 3-6. In order to focus on tidal effects only, waves were not included in these 4 simulations and default sediment transport parameters were used. The morphological responses of Tide Schemes 1-3 (Table 3-6) were then compared with those of the observed tides in Figure 2-8. The results appear in Figures 3-38 to 3-41.

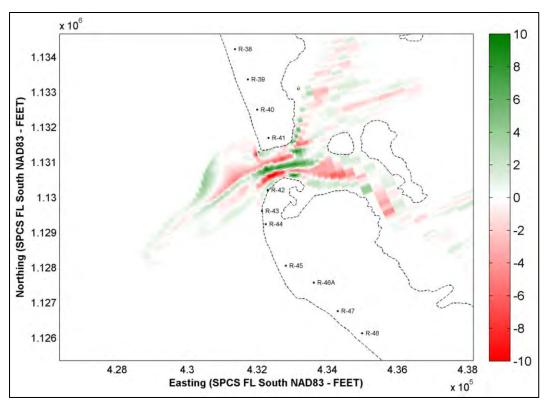


FIGURE 3-38: Six Month Erosion (-feet) and Deposition (+feet) Given the Observed Tides in Figure 2-8.

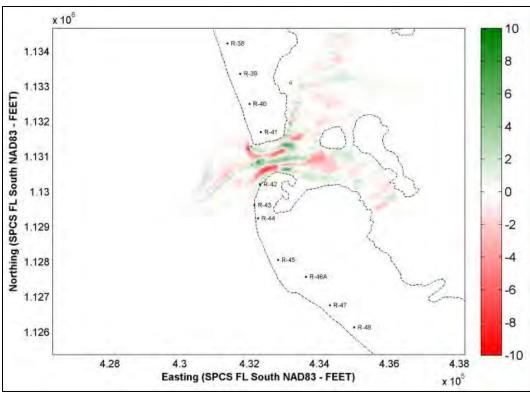


FIGURE 3-39: Six Month Erosion (-feet) and Deposition (+feet) Given Tide Scheme #1 in Table 3-6.

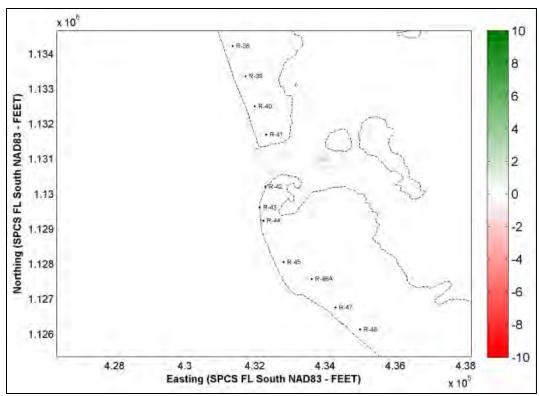


FIGURE 3-40: Six Month Erosion (-feet) and Deposition (+feet) Given Tide Scheme #2 in Table 3-6.

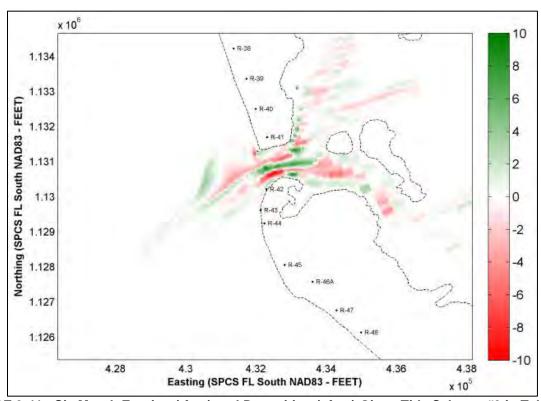


FIGURE 3-41: Six Month Erosion (-feet) and Deposition (+feet) Given Tide Scheme #3 in Table 3-6.

The results presented in Figures 3-38 to 3-41 indicated that Tide Schemes #1 and #2 (diurnal or semi-diurnal oscillation between MLW and MHW) were unable to reproduce the morphology changes associated with the observed tides at the inlet. Tide Scheme #3 (M2 + C1 approach) presented results more similar those associated with the observed tides. Nevertheless, the morphological changes based on this schematization were slightly underestimated. To address this difference, two additional tests were conducted with the tidal amplitudes increased by 5% and 10%. The 10% increase brought the changes associated with the schematized tide (Figures 3-42 and 3-43) into consistency with the observed tides (Figures 2-8 and 3-38). The 10% increase of Tide Scheme #3 was selected for all subsequent model applications, and appears in Table 3-7 and Figure 3-42.

TABLE 3-7
FINAL SCHEMATIZED OFFSHORE TIDE FOR LONGBOAT PASS, FL

Constituent	Amplitude (feet)	Period (min)	Phase (deg.)
C1	0.78	1440	242.9
M2	0.66	720	358.0

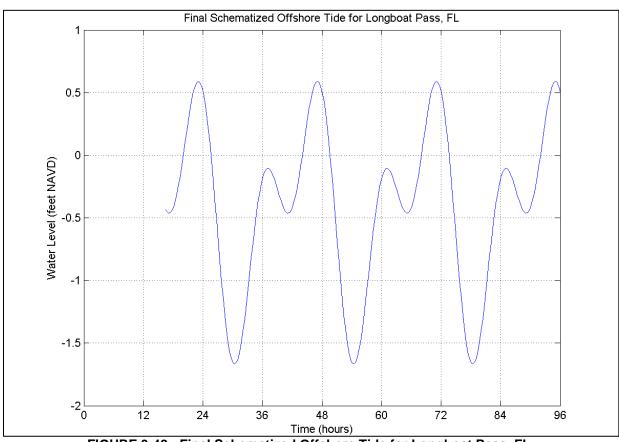


FIGURE 3-42: Final Schematized Offshore Tide for Longboat Pass, FL.

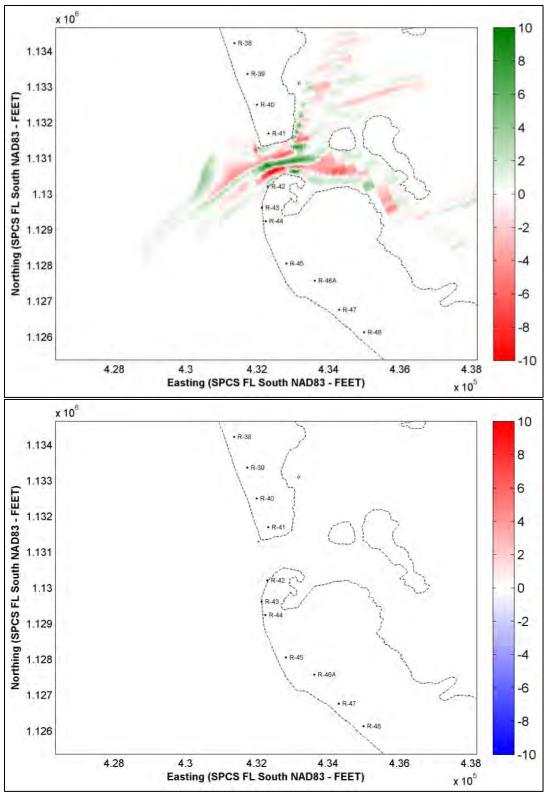


FIGURE 3-43: Six Month Erosion (-feet) and Deposition (+feet) Given the Final Tide Scheme (top), and Differences in Comparison with the Bathymetric Changes in feet Given the Observed Tides (bottom).

3.4.4 Bottom Sediments

The observed grain sizes of the bed material at the study area varied from 0.13 to 1.80 mm. To account for this variability, an initial model run was conducted using 5 sediment fractions. The assumed density of the sediment grains was 2,650 kg/m³ (165 lbm/foot³), with a dry bed densities ranging from 1,600 to 1,732 (kg/m³), depending on grain size. The purpose of this model run was to generate an initial distribution of the median grain size that would reflect the morphodynamics of the inlet. During this simulation, bed level changes and waves were turned off, but the sediment transport formulations within Delft3D-FLOW were activated. The sediment distribution at the end of the model run was then adjusted based on the observed samples, and the number of sediment fractions was reduced from 5 to 4 (see Table 3-8). The resulting grain size distribution appears in Figure 3-44.

TABLE 3-8
FINAL GRAIN SIZE SCHEMATIZATION FOR LONGBOAT PASS, FL

Grain Size Fraction	Density Area (see also Figure 3-44	
0.28 mm	1,600 kg/m ³ (100 lbm/foot ³)	Adjacent Beaches, Inner North Channel, & Bay
0.60 mm	1,644 kg/m ³ (103 lbm/foot ³)	Main & Inner South Channel
1.20 mm	1,688 kg/m ³ (105 lbm/foot ³)	Main & Inner South Channel
1.80 mm	1,732 kg/m ³ (108 lbm/foot ³)	Main & Inner South Channel

3.4.5 Beach Fills

Midway through the calibration period, beach fill projects took place on both Longboat Key and Anna Maria Island. The Longboat Key Beach Nourishment Project was constructed between April 2005 and July 2006. To account for this project, each model run was split into two parts – the first part covered the first 2 years of the calibration period, and the second covered the remaining 4 years. The beach fill placed on Longboat Key was inserted into the model between the end of the first part and the beginning of the second. The distribution of the fill was based on the pay surveys conducted by Manson Construction Company. The Anna Maria Island (Manatee County) Shore Protection Project Beach Renourishment was constructed between July 2005 and June 2006. However, the project area did not extend into the Local Flow (2003) Grid. The treatment of the Anna Maria project is discussed below.

3.4.6 Morphology Calibration

The overall goals of the morphology calibration were to approximate the observed erosion patterns along the beach and provide a realistic estimate of the sediment transport at the south end of Anna Maria Island. Over 21 calibration runs were conducted. These runs examined the following calibration parameters:

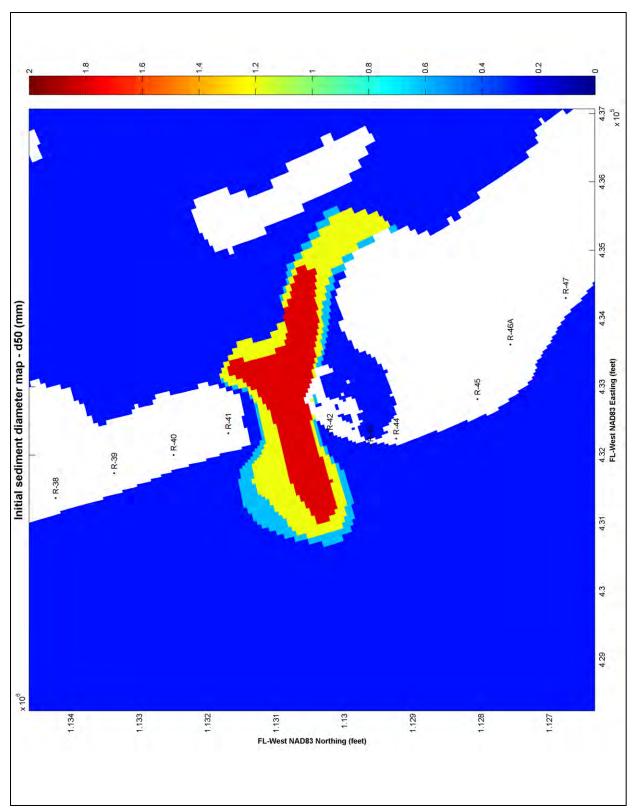


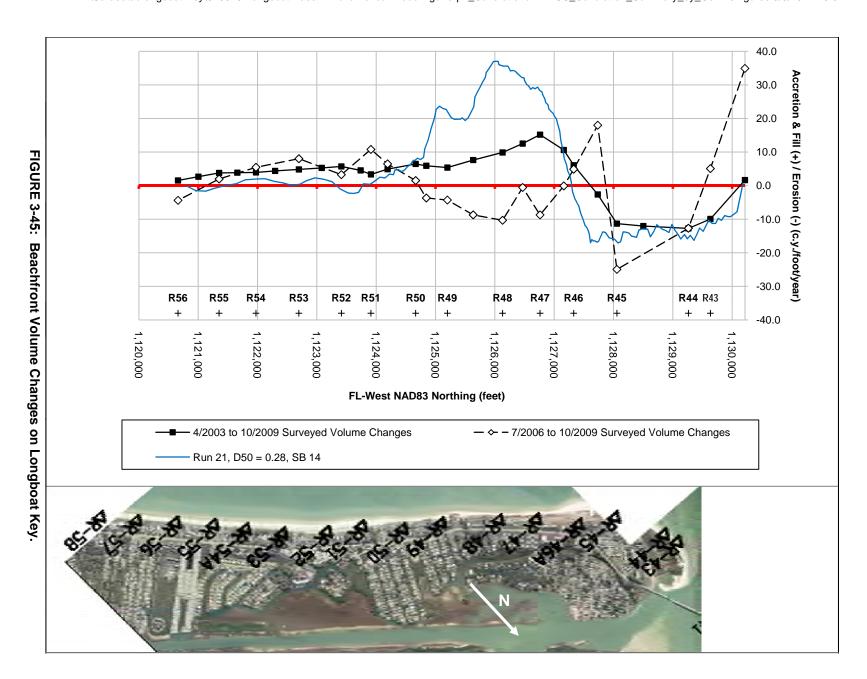
FIGURE 3-44: Grain Size Distribution at the Beginning of the Final Calibration Run.

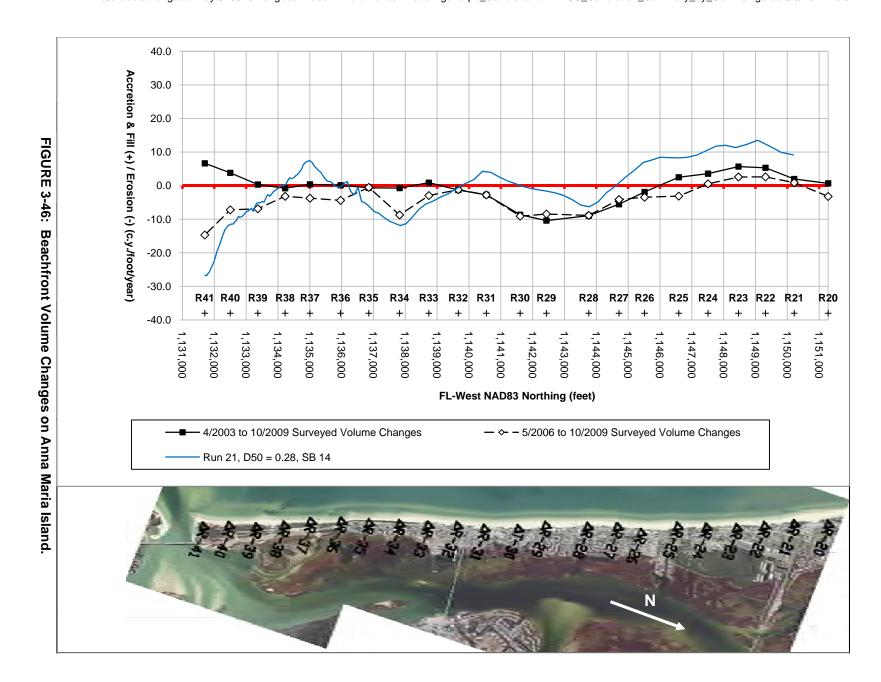
- Suspended sediment transport factor "SUS".
- Bedload sediment transport factor "BED".
- Wave-related suspended sediment transport factor "SUSW".
- Wave-related bedload sediment transport factor "BEDW".
- Dry cell erosion factor θ SD.
- Median grain size outside the inlet channel (blue areas in Figure 3-37).
- Morphological acceleration factors associated with waves from the north.
- Treatment of the 2005-2006 Anna Maria Island fill project.

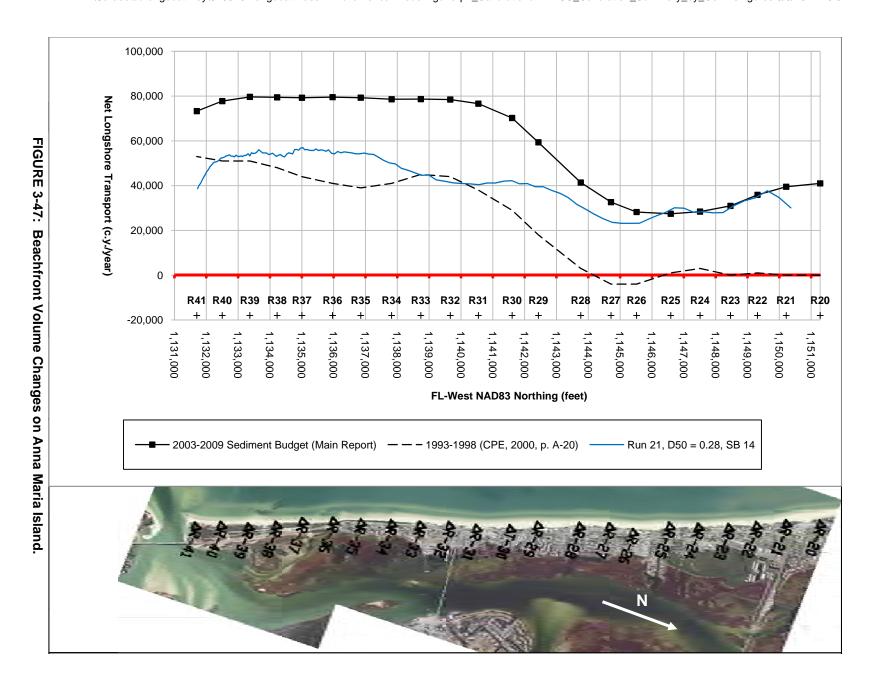
Overall, the calibration process revealed the following:

- Smaller grain sizes outside the inlet channel led to higher sediment transport rates at the southern end of Anna Maria Island. Larger values of BED and SUS had a similar effect on the model results.
- Increasing the morphological acceleration factors of the northerly waves by 10% also led to higher sediment transport rates at the southern end of Anna Maria Island. They also improved the fit between the observed beachfront erosion rates and the simulated rates. However, similar improvements could be achieved without increases in the morphological acceleration factors by making small adjustments to the median grain size (~0.03 to 0.05 mm).
- Beach fill placed along Anna Maria Island in 2005 and 2006 could be simulated by placing the material along profile lines R-20 to R-30. Although the contractor stated that 224,632 c.y. of material were placed (Goodloe, 2006), the construction of the project was affected by numerous delays and mechanical problems. As a result, the pay surveys and the documentation of the project volumes were not representative of the total volume. Borrow area surveys suggested that a much larger quantity material (at least 449,000 c.y.) was removed from the borrow area and placed on the beach. During the final calibration run, approximately 449,000 c.y. of material were placed along R-20 to R-30. The longshore spreading of this material was on the order of 3,000 feet, which was consistent with the historical observations summarized in CPE 2009. Placing the fill along profiles R-20 to R-30 during the final calibration allowed the model to approximate the 2003-2009 sediment transport along profiles R-31 to R-41.

The results of the final calibration run appear in Figures 3-45 to 3-48. It is important to note that since the model run includes the insertion of beach fill, comparisons between the model results and the observations do not require adjustments for beach fill.







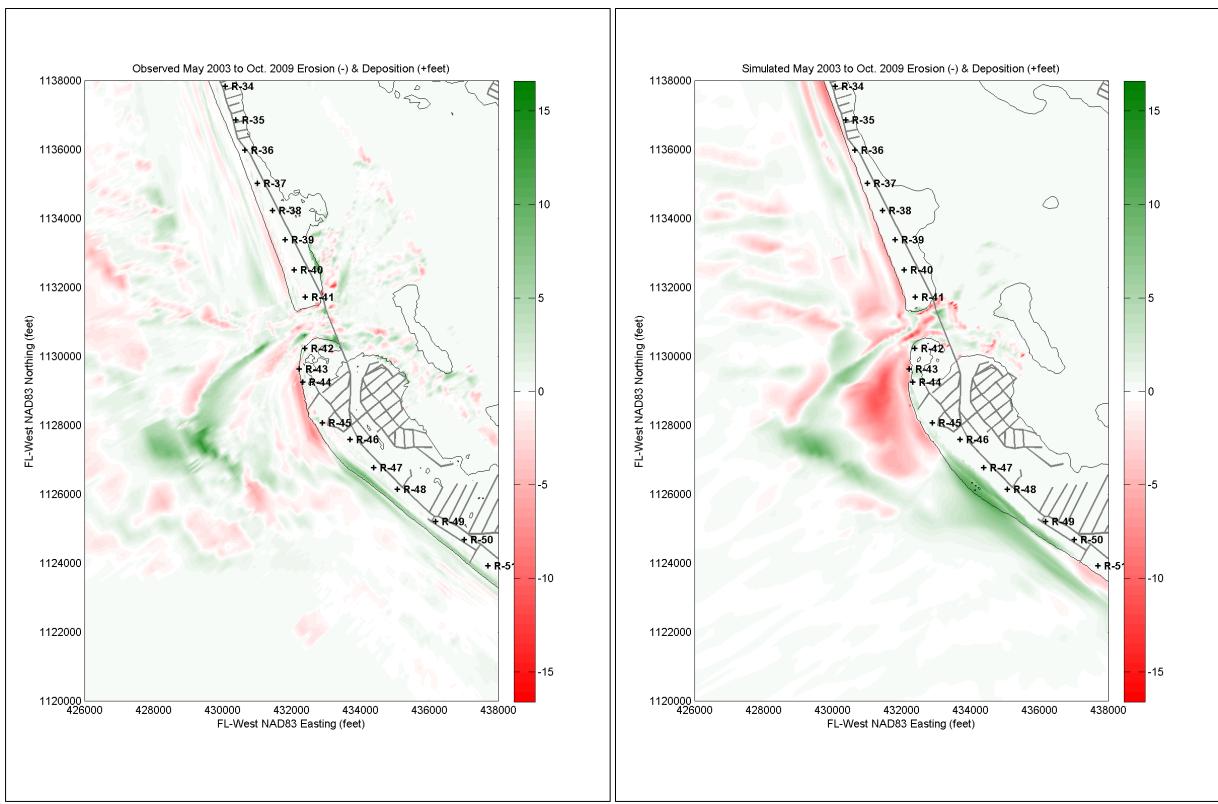


FIGURE 3-48: Comparison of Observed and Simulated Erosion and Deposition Patterns between 2003 and 2009.

TABLE 3-9
DELFT3D CALIBRATION PARAMETERS
LONGBOAT PASS, FL

	Min.	Default	Max.	Selected Value				
	1911111	Doladit	max.	Ocicoted Value				
SWAN Wave Transformation Model Parameters:								
Breaking Parameter γ (Hb/db)	0.55	0.73	1.20	0.73				
Breaking Parameter α	0.1	1.0	10.0	1.0				
Bottom Friction Coef. for Waves (Optional):								
JONSWAP Friction Value (m ² /s ³)	0.000	0.067	None	0.067				
Collins Friction Value	0.000	0.015	None	Not used				
Madsen Roughness Scale (m)	0.0000	0.0500	None	Not used				
Triads - Energy Transfer from low to high frequencies in shallow water	-N/A-	Off	-N/A-	Off				
Diffraction:	-N/A-	Off	-N/A-	On				
Diffraction Smoothing Coefficient	0	0.2	1.0	0.5				
Diffraction Smoothing Steps	1	5	999	200				
Wind Growth	-N/A-	On	-N/A-	Off				
JONSWAP Peak Enhancement Factor (for input waves specified in terms of height, period, and direction)	-N/A-	3.3	-N/A-	3.3				
Delft3D-FLOW Model, Flow Parameters:								
Bottom Friction Coef. for Flow:								
Chezy's Friction Coef. C	0	65	1000	(see Figure 3-25)				
Manning's n	0.000	None	0.040	Not Used				
Horiz. Eddy Viscosity (m ² /s)	0	10	100	2				
Vertical Eddy Viscosity (m ² /s)	0	1 x 10 ⁻⁶	100	0				
Delft3D-FLOW Model,	Sediment Tr	ansport Para	meters:					
Spin-up Interval - # of hours between the start of the simulation and the initiation of erosion & deposition estimates	0	6	None	12 hours				
Density of sediment grains (kg/m ³)	100	2650	4000	2650				
Dry bed density (kg/m³)	Mud 100 Sand 500	Mud 500 Sand 1600	3000	(see Table 3-8)				
Median Grain Size (mm)	0.064	0.200	2.000	(see Table 3-8 & Figure 3-44)				
Horiz. Eddy Diffusivity (m ² /s)	0	10	1000	15				
Vertical Eddy Diffusivity (m ² /s)	0	1 x 10 ⁻⁶	1000	0				
Dry Cell Erosion Factor	0	0	1	0.75				
BED - Current-Related Bedload Transport Factor (including wave-driven currents)	0	1	100	1.4				
SUS - Current-Related Suspended Load Transport Factor (including wave-driven currents)	0	1	100	1.4				
BEDW - Wave-Related Bedload Transport Factor	0	1	100	0.18				
SUSW - Wave-Related Suspended Load Transport Factor	0	1	100	0.18				

4. PERFORMANCE OF INLET MANAGEMENT ALTERNATIVES

Alternatives for the management of Longboat Pass were developed to address the following concerns:

- High erosion rates on the south end of Anna Maria Island at Coquina Beach (R36-R41).
- The location of the navigation channel through the Longboat Pass ebb shoal.
- High erosion rates on the north end of Longboat Key (Reaches 1 and 2, R42 to R51).
- Dredged material placement sites for the periodic maintenance of Longboat Pass.

In response to these concerns, the following alternatives were developed:

- 1. No Action.
- 2. Anna Maria Island Terminal Groin Extension.
- 3. Longboat Key terminal groin options:
 - a. Single groin.
 - b. Twin terminal groins.
- 4. Longboat Key Terminal Groin Plus Breakwater.
- 5. Longboat Key Terminal Groin Plus Two Permeable Adjustable Groins.
- 6. Inlet channel dredging options:
 - a. Authorized Channel.
 - b. Relocated Channel proposed by U.S. Army Corps of Engineers.
 - c. Relocated Channel proposed by Humiston & Moore (2008).
 - d. Authorized Channel with Advance Maintenance.
- 7. Dredging of Gulf Intracoastal Waterway (GIWW) Cut M5 (near Jewfish Key).

4.1 Grids and Bathymetry

All simulations utilized the Regional Wave Grid, the Intermediate Wave Grid, the Local Morphology Wave Grid, and the Local Flow (2003) Grid. The initial bathymetry used for Alternatives 1-5 was based on the bathymetric data sets between 1950 and 2009 (see Table 2-1). The 2009 surveys were used as the primary data sources. Grid points outside the 2009 survey areas were filled using older data sets, beginning with the 2008 surveys and ending with the "Design-a-Grid" where no other data was available (see Table 2-1). In this manner, bathymetric surfaces for Alternatives 1-5 utilized the most recent survey available at a given location. Initial (Year 0) surfaces for Alternatives 1-5 appear in Sub-Appendix A-1.

The initial surfaces for Alternatives 6A-7 were similar to those of Alternatives 1-5, except for the dredge cuts and spoil areas. Within the dredge cuts, the initial elevation was equal to the overdepth dredging limits:

- Alternatives 6A-6D:
 - \circ -14' MLLW = -15.57' NAVD west of bridge.
 - \circ -11' MLLW = -12.57' NAVD east of bridge.
- Alternative 7: -10' MLLW = -11.57' NAVD.

Dredge quantities for Alternatives 6A-6D appear in Table 4-1. The simulations for Alternatives 6A-6D assumed that the dredge spoil would be placed in the 4 disposal sites used in the 1997 dredging operation, as illustrated later in this document. The dredge spoil was distributed as a layer with a uniform thickness over the 4 disposal sites, capped at the design berm elevation of +3' NAVD (+4' NGVD) (USACE, 1994) (See Figure 4-1). The combined volume of material in the 4 disposal sites was equal to the overdepth quantities in Table 4-1. The dredge quantity for Alternative 7 consisted of approximately 19,900 c.y. in the design cross-section plus 20,900 c.y. of overdepth dredging, for a total of 40,800 c.y. Simulations for Alternative 7 assumed that the dredge spoil would be placed offshore of Egmont Key, similar to the plan described in FDEP Permit Application No. 0305363-001-JC (USACE, 2011). This site was located outside the model domain of the Local Flow (2003) Grid. Initial (Year 0) surfaces for Alternatives 6A-7 appear in Sub-Appendix A-1.

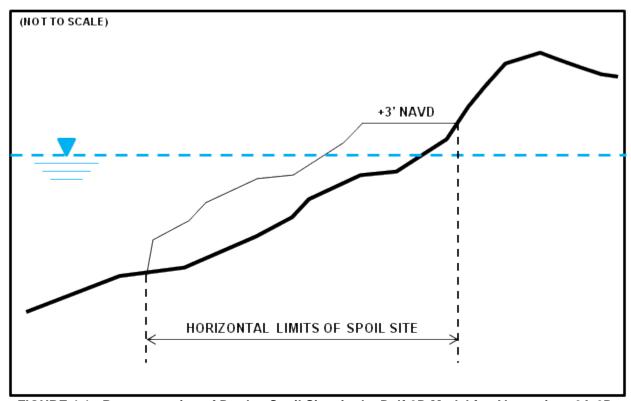


FIGURE 4-1: Representation of Dredge Spoil Sites in the Delft3D Model for Alternatives 6A-6D.

TABLE 4-1

CHANNEL MAINTENANCE ALTERNATIVES
LONGBOAT PASS, FL

Alt.	Description	Cut / Profiles	Design	Volume (cubic yards) Overdepth	Total	Design Depth (feet MLLW)	
6A	Authorized Channel	Cut 1 Cut 2 Cut 3 TOTAL Cut 1-00+00 to Cut 2-16+00 Cut 2-16+00 to Cut 3-40+48	176,300 21,200 15,100 212,600 197,100 15,500 212,600	13,500 6,600 78,600 70,500 8,100	234,800 34,700 21,700 291,200 267,600 23,600 291,200	varies -10 + 1' overdepth -12 + 2' overdepth	
6B	Relocated Channel	Cut 1 Cut 2 Cut 3 TOTAL Cut 1-00+00 to Cut 2-16+00 Cut 2-16+00 to Cut 3-40+48 TOTAL	27,700 3,200 15,100 46,000 30,500 15,500 46,000	6,200 6,600 63,500 55,400 8,100	78,400 9,400 21,700 109,500 85,900 23,600 109,500	varies -10 + 1' overdepth -12 + 2' overdepth -10 + 1' overdepth	

TABLE 4-1 (continued)

CHANNEL MAINTENANCE ALTERNATIVES LONGBOAT PASS, FL

Alt.	Description	Cut / Profiles	Design	Volume (cubic yards) Overdepth	Total	Design Depth (feet MLLW)	
6C	Relocated Channel Proposed by Humiston & Moore	Cut 1 Cut 2 Cut 3 TOTAL Cut 1-00+00 to Cut 2-16+00 Cut 2-16+00 to Cut 3-40+48	103,300 6,200 15,100 124,600 109,100 15,500 124,600	7,800 6,600 66,100 58,000 8,100	155,000 14,000 21,700 190,700 167,100 23,600 190,700	varies -10 + 1' overdepth -12 + 2' overdepth	
6D	Authorized Channel with Advance Maintenance	Cut 1 Cut 2 Cut 3 TOTAL Cut 1-00+00 to Cut 2-16+00 Cut 2-16+00 to Cut 3-40+48	206,900 21,200 15,100 243,200 227,700 15,500 243,200	13,500 6,600 86,700 78,600 8,100	273,500 34,700 21,700 329,900 306,300 23,600 329,900	varies -10 + 1' overdepth -12 + 2' overdepth -10 + 1' overdepth	

4.2 Representation of Structures

The representation of the existing structures was identical to that of the final morphology calibration run (see Section 3.4.2 above). The proposed structures in Alternatives 2-4 were simulated as "Thin Dams" in the Delft3D-FLOW model and "Sheets" in the SWAN model, with negligible wave reflection and transmission.

The permeable adjustable groins in Alternative 5 were simulated as porous plates in the Delft3D-FLOW model (Deltares, 2011), with a loss coefficient of 24, which was equivalent to a permeability of approximately 30%. The same structures in the SWAN model were treated as "Sheets" with a transmission coefficient of 30% and negligible wave reflection (Deltares, 2009). The terminal groin in Alternative 5 was modeled in the same manner as the proposed structures in Alternatives 2-4

4.3 Model Forcing

For all simulations, the model forcing was identical to the final calibration run (see Table 3-5 and Figure 3-42). Years 0-6 were simulated using wave cases 1-36, plus the "Calm" wave case. Years 6-8 were simulated using wave cases 25-36, plus the "Calm Case".

Overall, the sequencing of wave cases used was:

- Years 0-2: Cases 1-12 (2003-2005)
- Years 2-4: Cases 13-25 (2005-2007)
- Years 4-6: Cases 25-36 (2007-2009)
- Years 6-8: Cases 25-36 (2007-2009)

4.4 **Bottom Sediments**

For all simulations, 4 sediment fractions were used as defined in the model calibration. The sediment fractions were as defined in Table 3-8, and their initial distribution was equal to that of Figure 3-44.

4.5 Additional Assumptions

For Alternatives 1-5, beach fill activity and navigational dredging was not included in order to evaluate the specific effects of the modeled alternatives. For Alternatives 6A-7, beach fill activity and navigational activity after the initial dredging/placement was not included. Prior to the construction of the 2011 fill project on Coquina Beach, Longboat Pass was most recently dredged in 1997. Within northern Sarasota Bay, there was no dredging of the Intracoastal Waterway between the 1960s and 2007 (SBNEP, 1995; Cruiser's Net, 2007; Schultheis, 2009; Listowski, 2011). Finally, on Anna Maria Island (1993 to 2002) and northern Longboat Key (1997 to 2005), beach nourishment intervals have exceeded 8 years.

4.6 Modeling Results

Each Alternative was simulated for a period of 8 years. The results of the model for each alternative appear in Sub-Appendix A-1. Results are presented in terms of bathymetry, bathymetric changes ("Delta plots"), the impacts and benefits versus the No Action scenario, and the volumetric changes along the beach.

4.6.1 Alternative 1 – No Action

Under a no-action scenario, the model suggests that over 8 years, the main channel of Longboat Pass will assume an inverted L-shape as the ebb shoal rotates south, bringing the inlet's entrance channel closer to the shoreline of Longboat Key (see Figure 4-2). The model also indicates that on Anna Maria Island, a swash channel could form. Due to the formation of that swash channel, the net volume change south of R39 would likely be erosional (see Figure 4-3). Nevertheless, the model also suggests that slight fillet growth could occur above the water line at the existing terminal groin (see Figures 4-2 and 4-4).

On Longboat Key, the migration of the channel and ebb shoal in the model results in high erosion rates on the island's north end, with estimated rates on the order of 13 c.y./foot/year north of Broadway (R46) (see Figure 4-5). The calculated shoreline retreat over 8 years approaches 280 feet between profiles R42 and R43 and 180 feet near Seabreeze Avenue (R45.5).

4.6.2 Alternative 2 – Anna Maria Island Terminal Groin Extension

If the terminal groin on Anna Maria Island is extended 260 feet, the model suggests that the structure's fillet will widen 335 feet over 8 years, approaching the seaward end of the structure (see Figure 4-4). Nevertheless, the structure extension would not eliminate swash channel formation; it would only divert it further offshore (see Sub-Appendix A-1), and erosion of the submerged beach profile would continue near profiles R39-R41 (see Figure 4-5). The northern limit of the structure's increased fillet would be located between profiles R38 and R39. As a result, the southern 2,000 feet of Anna Maria Island would experience beach widening as a benefit of the groin extension.

On Longboat Key, the extension of the terminal groin could increase the erosion and retreat rates along Greer Island and 360 North (R42-R44.7) (see Figures 4-4 and 4-5). Since the structure would retain more material, the transport of sediment towards Longboat Key would be reduced, resulting in higher erosion and retreat rates north of R44.8. South of R44.8, erosion along the submerged part of the profile could increase (see Figure 4-5). However, shoreline retreat rates will be similar to those of the No Action Scenario (see Figure 4-4).

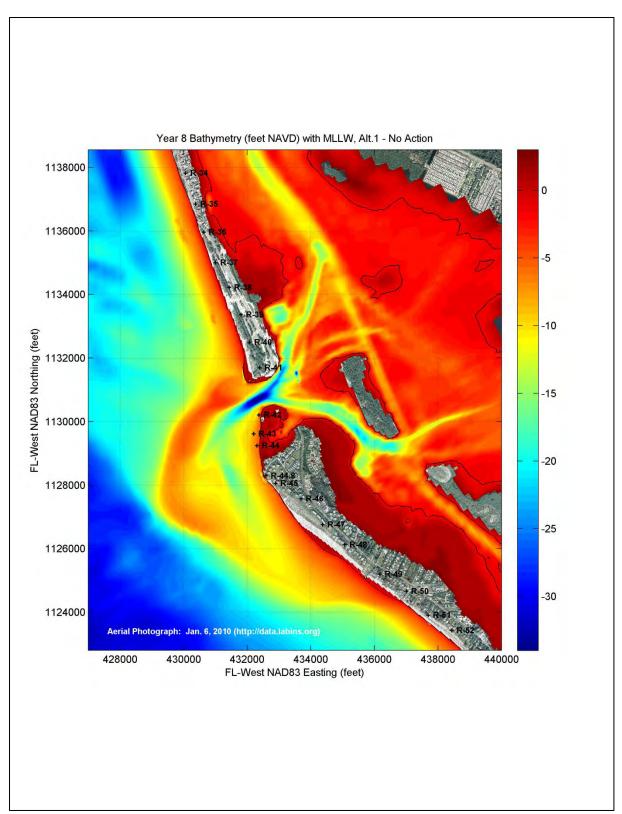


FIGURE 4-2: Simulated Bathymetry Given the No-Action Scenario at Year 8.

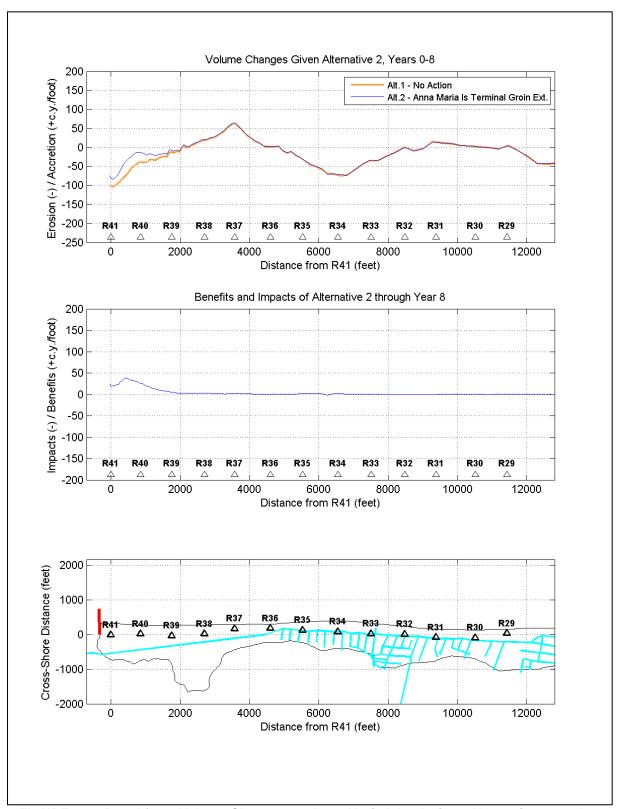


FIGURE 4-3: Beachfront Volume Changes on Anna Maria Island Given Alternatives 1 and 2.

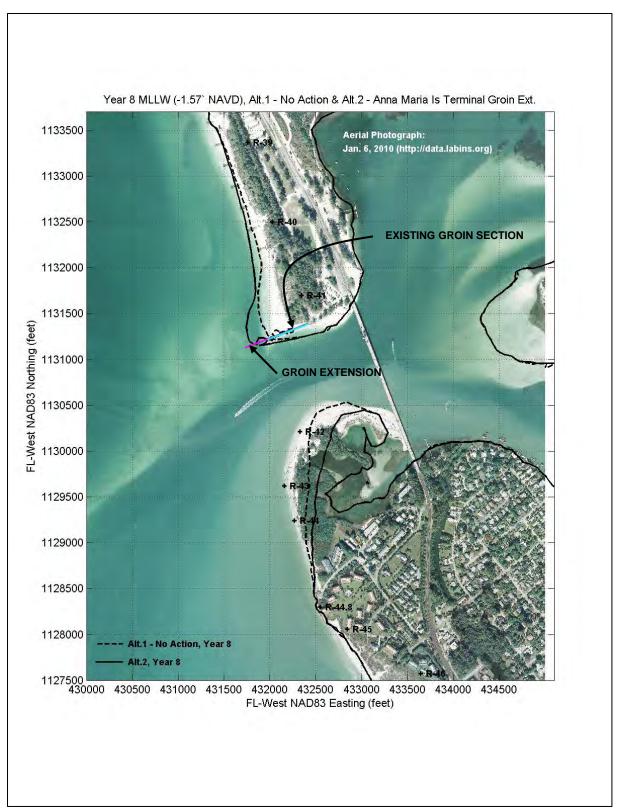


FIGURE 4-4: Simulated MLLW Positions Given Alternatives 1 and 2.

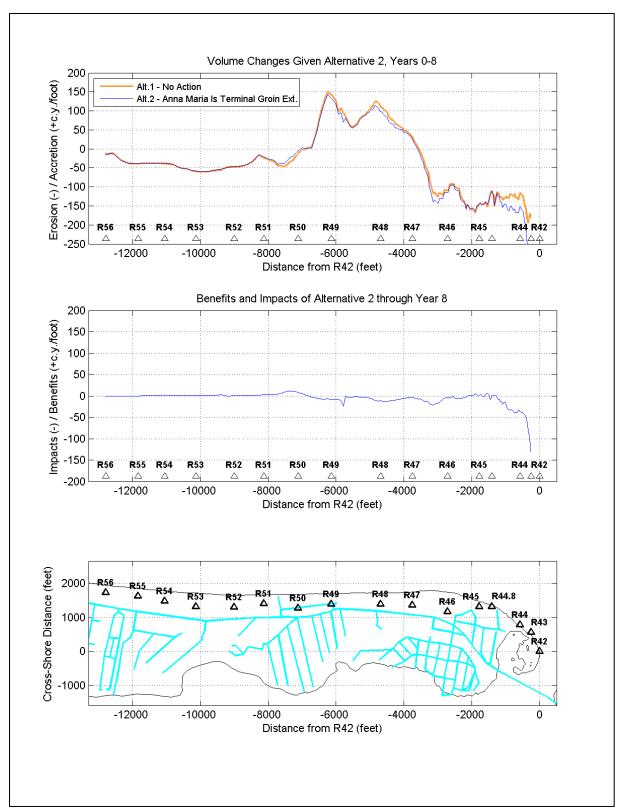


FIGURE 4-5: Beachfront Volume Changes on Longboat Key Given Alternatives 1 and 2.

4.6.3 Alternative 3 – Longboat Key Terminal Groin Options

A. Single Groin

If a single terminal groin is constructed on the north end of Longboat Key, the Delft3D model suggests that the shoreline at the immediate north end of Longboat Key will be stabilized (see Figure 4-6 and 4-7). However, the 8-year fillet growth will likely be limited to Greer Island (R42-R44.5). The benefits of the structure are not likely to extend into the developed section of the beach (R44.8 southward) (see Figures 4-6 and 4-7). On Anna Maria Island, the structure could have a negative impact south of R38.5 (see Figures 4-6 and 4-8), possibly due to the reduction in northerly sediment transport off Greer Island.

As shown in Figure 4-6, the model suggests that sediment could accumulate on the northern, or downdrift side of the structure. Similar behavior occurs at the terminal groin on the west end of Fire Island, NY (see Figure 4-9). The sediment transport rates along Fire Island are approximately 3-5 times higher than those at Longboat Pass. However, in both cases, the sediment transport that is deflected past the terminal groin results in the deposition of sediment along its downdrift side. Similar results have been observed at the south end of Amelia Island, FL (Olsen, 2009).

B. Twin Terminal Groins

If two terminal groins are constructed on the north end of Longboat Key, the Delft3D model also suggests that the shoreline at the north end of Longboat Key will be stabilized (see Figure 4-10 and 4-11). However, by constructing two groins instead of a single groin, this option may be able to extend the benefits of the structures further south, reaching the 360 North condominium (R44.7). South of this property, the structures are unlikely to offer a significant benefit. On Anna Maria Island, the potential impacts of the structures are similar to those of the single groin option (see Figures 4-8 and 4-12). Like the single groin option, the deflection of the sediment transport around the two groins results in the accumulation of material on the northern side of the northern groin (see Figure 4-10).

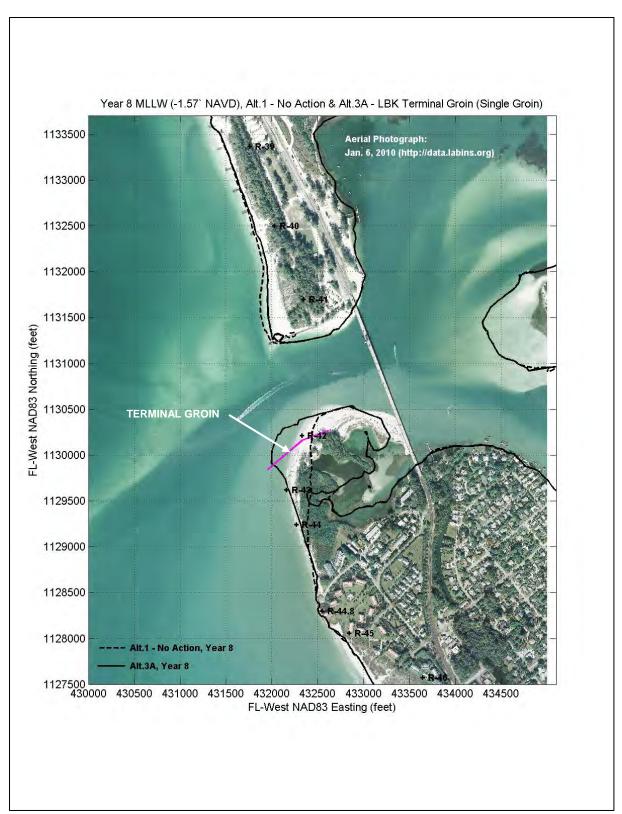


FIGURE 4-6: Simulated MLLW Positions Given Alternatives 1 and 3A.

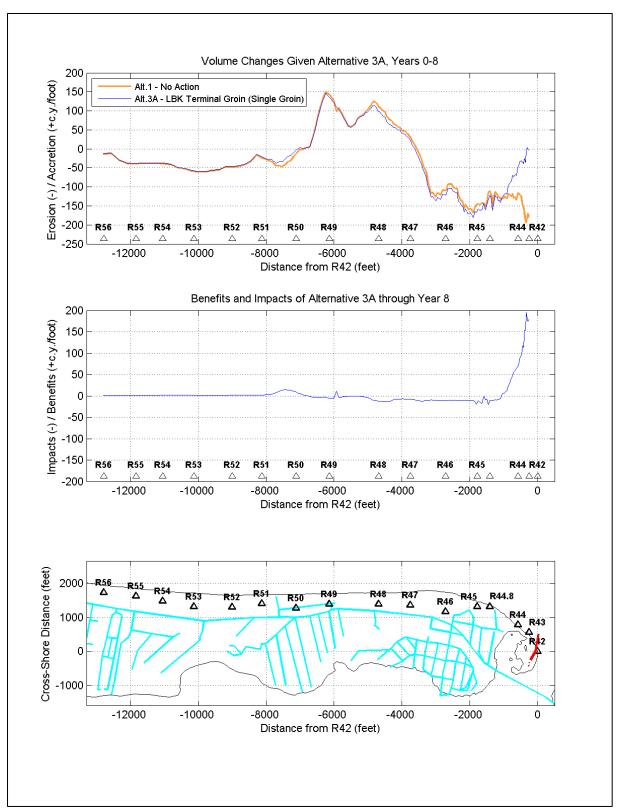


FIGURE 4-7: Beachfront Volume Changes on Longboat Key Given Alternatives 1 and 3A.

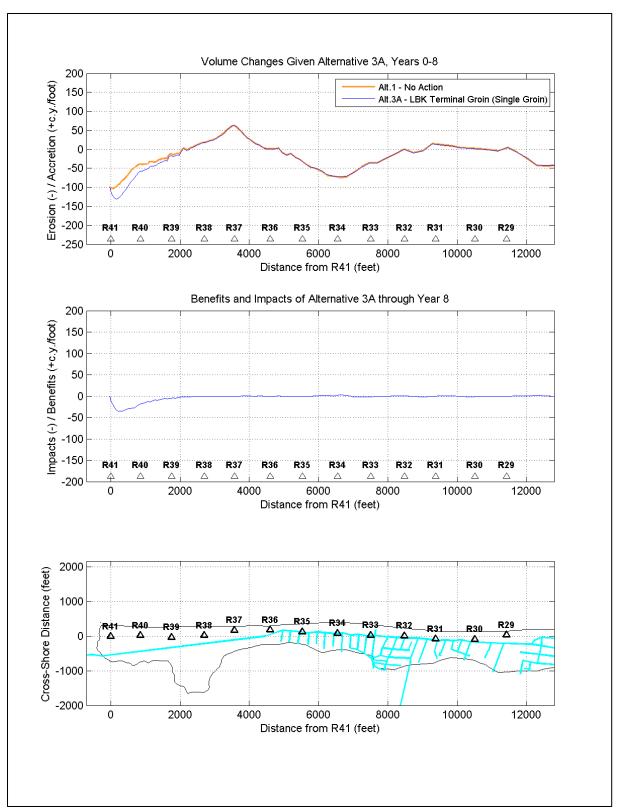


FIGURE 4-8: Beachfront Volume Changes on Anna Maria Island Given Alternatives 1 and 3A.

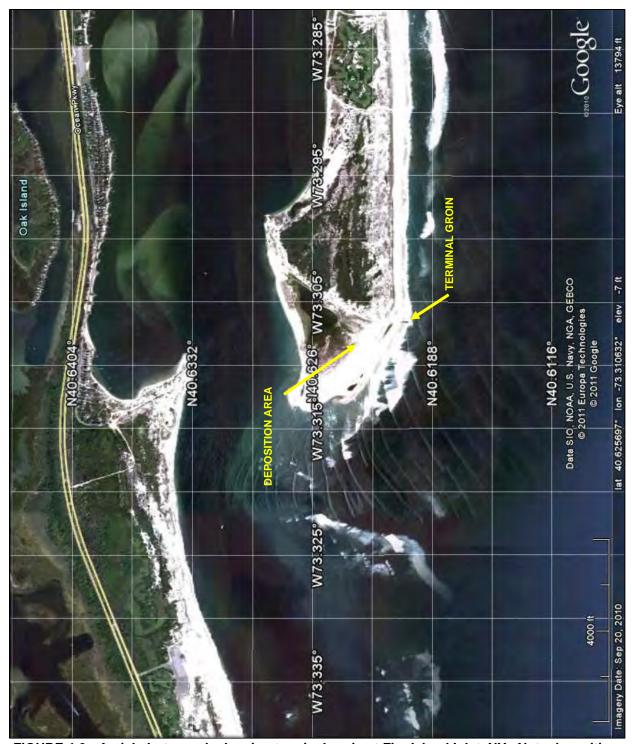


FIGURE 4-9: Aerial photograph showing terminal groin at Fire Island Inlet, NY. Note deposition on the downdrift, western side of the structure.

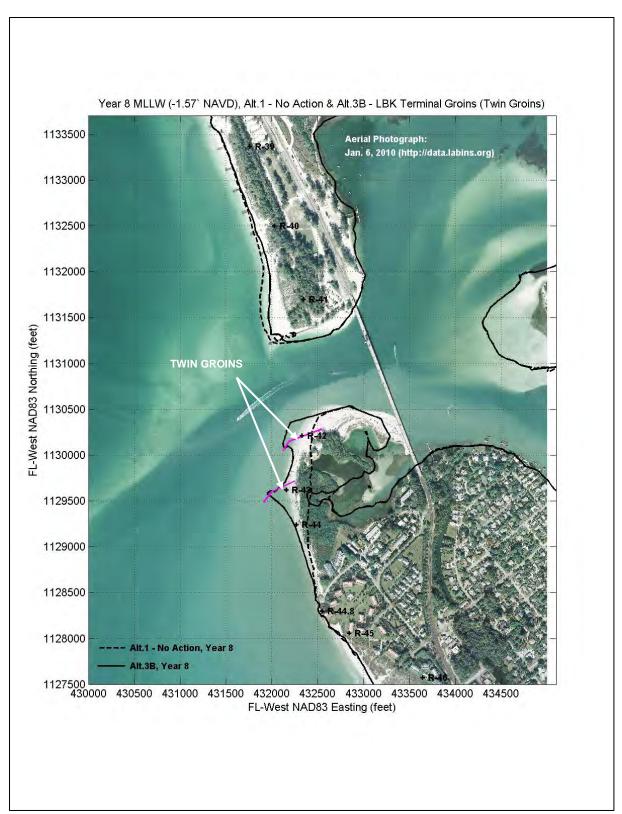


FIGURE 4-10: Simulated MLLW Positions Given Alternatives 1 and 3B.

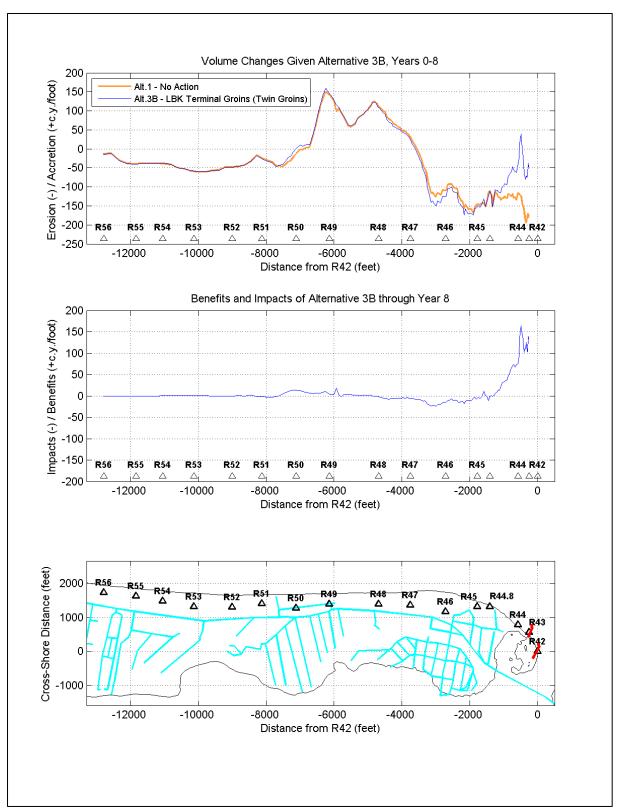


FIGURE 4-11: Beachfront Volume Changes on Longboat Key Given Alternatives 1 and 3B.

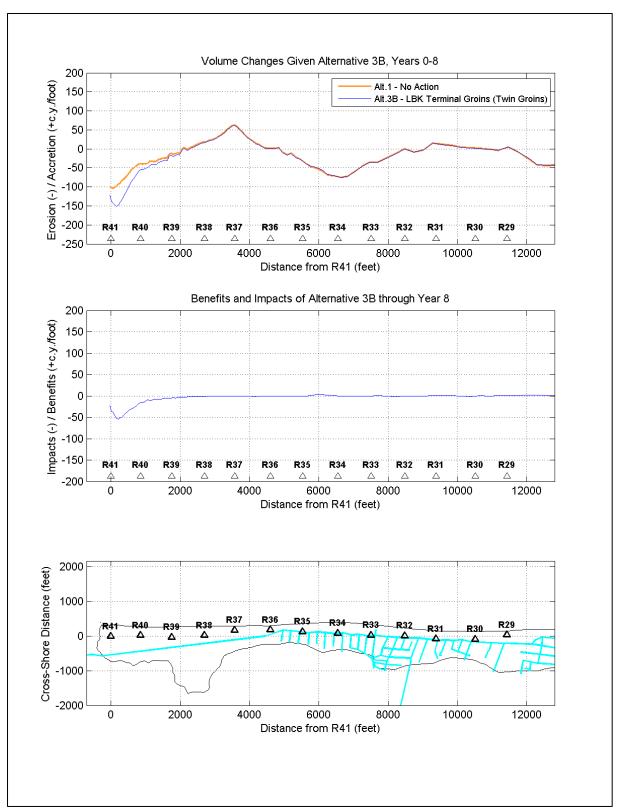


FIGURE 4-12: Beachfront Volume Changes on Anna Maria Island Given Alternatives 1 and 3B.

4.6.4 Alternative 4 – Longboat Key Terminal Groin Plus Breakwater

If a terminal groin is constructed with a breakwater on the north end of Longboat Key, the Delft3D model suggests substantial reductions in erosion rates from Longboat Pass to Seabreeze Avenue (R45), along with relatively stable shorelines (see Figures 4-13 and 4-14). The breakwater would be able to accumulate sediment in its lee (see Figure 4-15). However, the deposition of material may not be substantial enough to generate a visible salient (see Figure 4-12). In addition, scour in front of the existing seawall could continue, although the degree of scour may be exaggerated due model limitations (see *Longboat Key North End Breakwaters, Numerical Modeling of Breakwater and Beach Fill Performance*, CPE, 2010, for a further discussion of this issue). At the breakwater itself, the migration of the entrance channel towards Longboat Key could cause the structure to settle or become unstable (see Figure 4-15). On Anna Maria Island, the potential impacts of the structures are similar to those of the single groin option (see Figures 4-8 and 4-16). Similar to Alternative 3A, the deflection of the sediment transport around the proposed terminal groin results in the accumulation of material on its northern side (see Figures 4-9, 4-12, and 4-15 and Olsen, 2009).

4.6.5 Alternatives 5 and 5S - Longboat Key Terminal Groin Plus Two Permeable Adjustable Groins

Alternative 5 includes a terminal groin at the north end of Longboat Key and two permeable adjustable groins (PAG's) at the 360 North condominium and North Shore Road (R44.5 to R44.8). The PAG structures would be similar to the recently constructed groins at the Islander Club Condominium on Longboat Key (Sarasota County R13). The performance of Alternative 5 is summarized in Figures 4-17 to 4-20.

As noted in Figure 4-17, the estimated 8 year fillet from Alternative 5 benefits the northern half of the North Shore Road seawall (R44.8). To extend the benefits of this alternative over a longer section of the seawall, the southernmost groin was moved 94 feet to the south-southeast. This revised plan was named Alternative 5S. Under Alternative 5S, the estimated 8 year fillet benefits the entire length of the existing seawall, and is still able to maintain a moderately-wide beach at the 360 North property (see Figure 4-18).

Of the structural alternatives considered for Longboat Key, Alternative 5S offers the most widespread benefits based on the model results. As shown in Figure 4-18, Alternative 5S should be able to hold a combined fillet extending from Longboat Pass to the south end of the North Shore Road seawall (R42 to R45). South of the seawall, erosion below the waterline could increase by a small amount. However, this erosion would likely be addressed by the Town's overall nourishment program. South of Whitney Beach (R48), the effect of the structures would be either small or negligible. On Anna Maria Island, the structures could have a negative impact between Longboat Pass and R38.5 (see Figures 4-18 and 4-20) related to the retention of sand in northern Longboat Key and reduced sediment transport off Greer Island. Similar to Alternative 3A, the deflection of the sediment transport around the proposed terminal groin results in the accumulation of material on its northern side (see Figure 4-18).

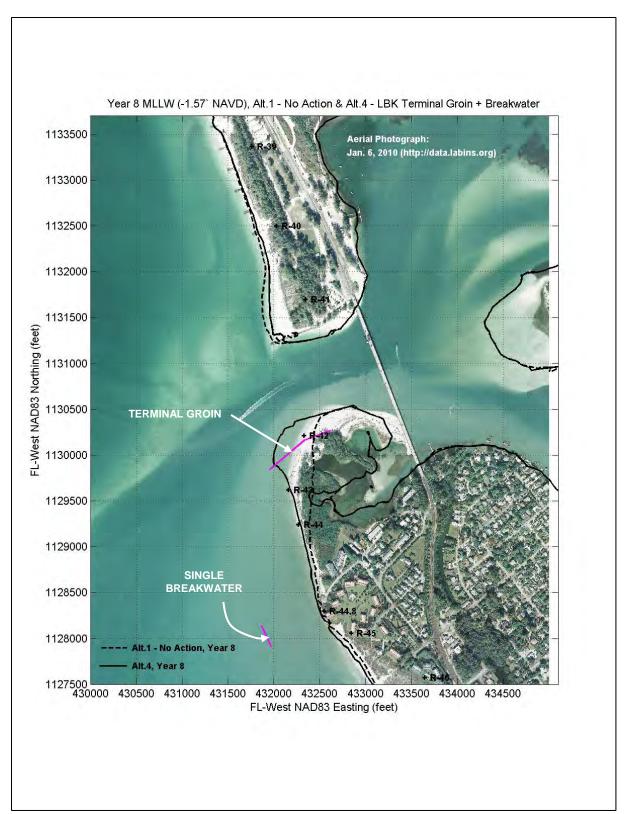


FIGURE 4-13: Simulated MLLW Positions Given Alternatives 1 and 4.

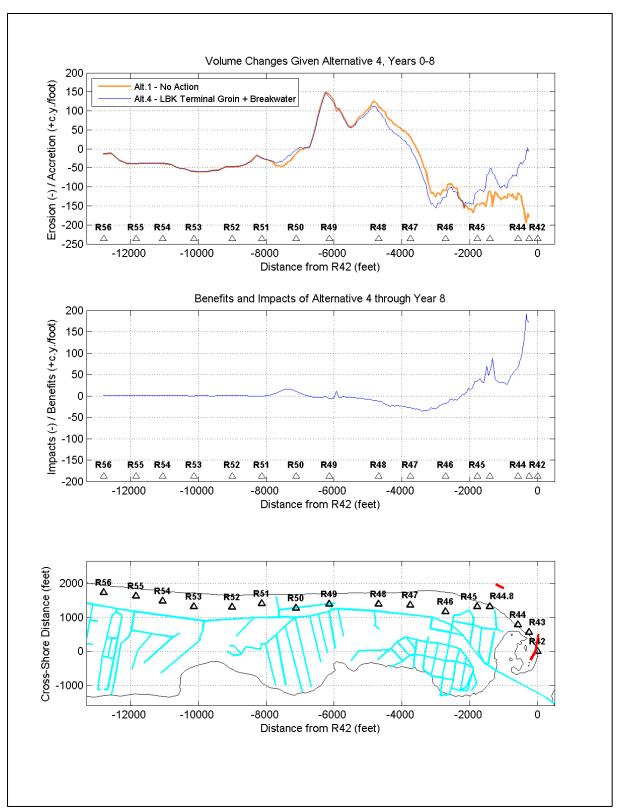


FIGURE 4-14: Beachfront Volume Changes on Longboat Key Given Alternatives 1 and 4.

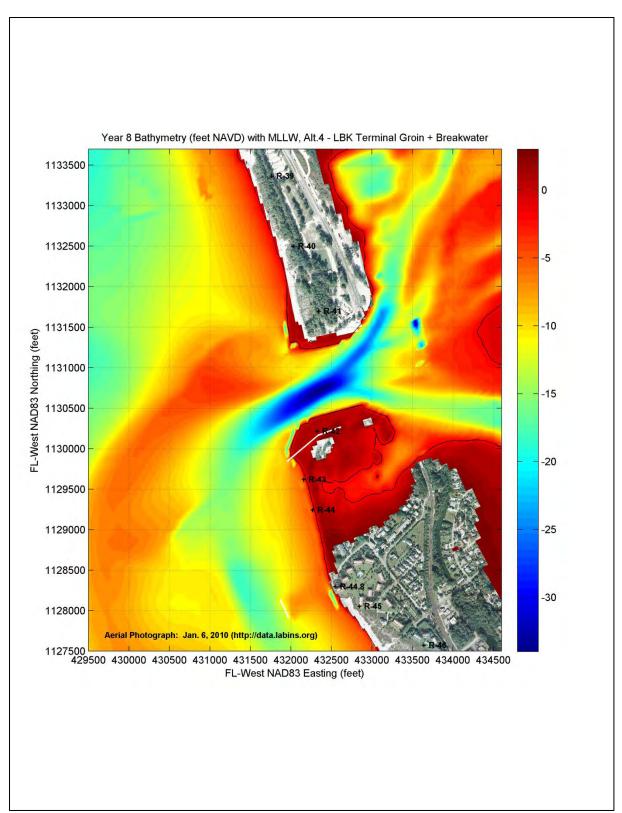


FIGURE 4-15: Simulated Bathymetry Given the Alternative 4 at Year 8.

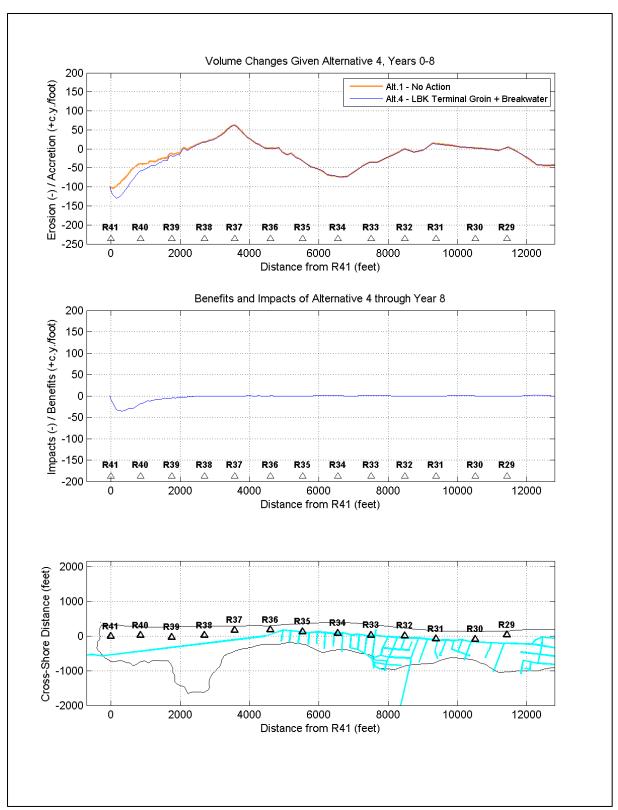


FIGURE 4-16: Beachfront Volume Changes on Anna Maria Island Given Alternatives 1 and 4.

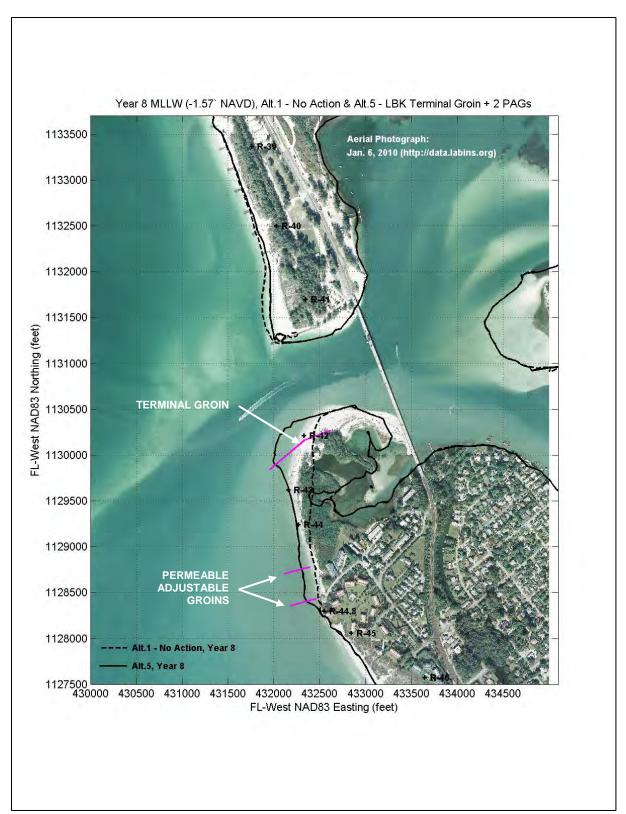


FIGURE 4-17: Simulated MLLW Positions Given Alternatives 1 and 5.

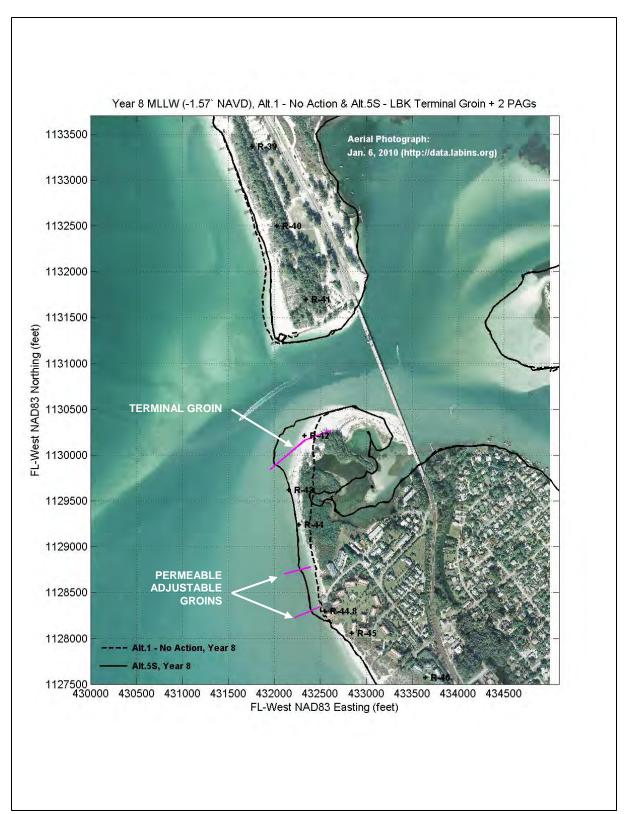


FIGURE 4-18: Simulated MLLW Positions Given Alternatives 1 and 5S.

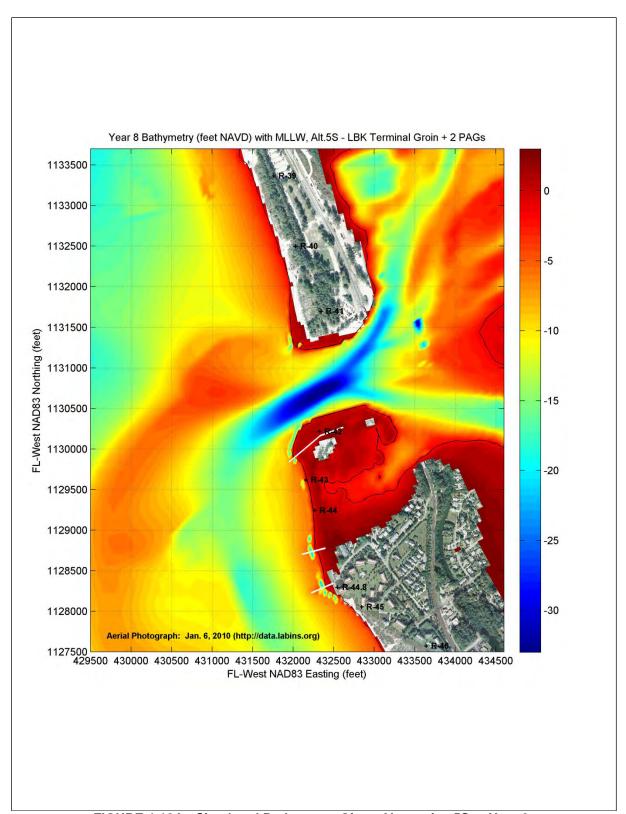


FIGURE 4-18A: Simulated Bathymetry Given Alternative 5S at Year 8.

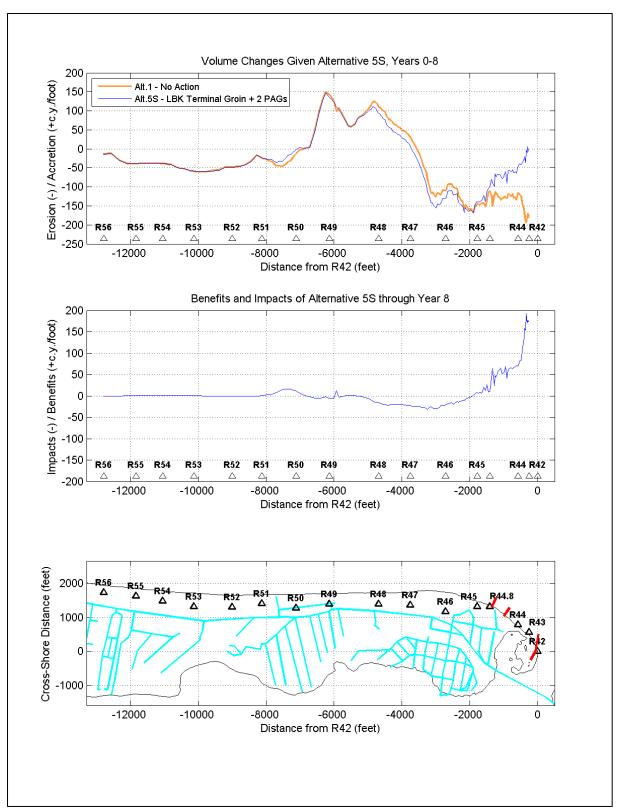


FIGURE 4-19: Beachfront Volume Changes on Longboat Key Given Alternatives 1 and 5S.

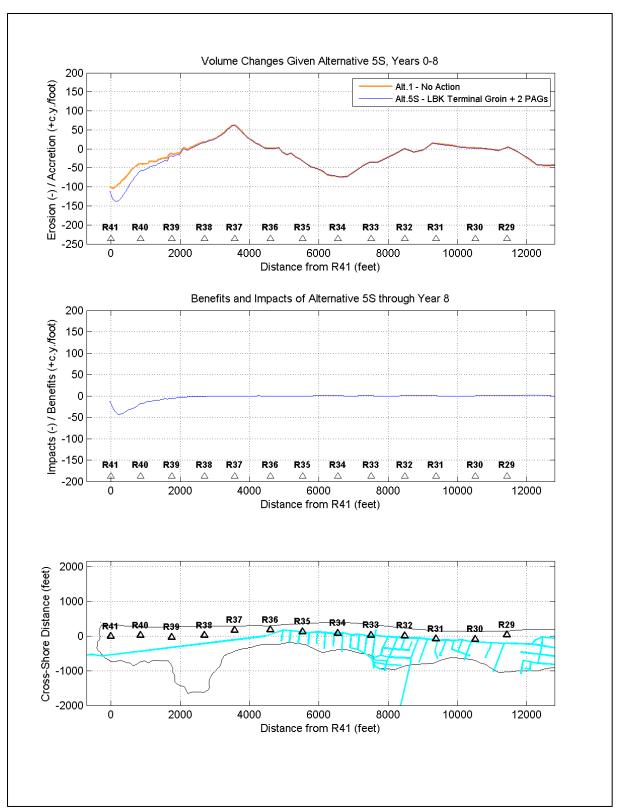


FIGURE 4-20: Beachfront Volume Changes on Anna Maria Island Given Alternatives 1 and 5S.

4.6.6 Alternative 6 – Inlet Channel Dredging Options

A. Authorized Channel

Model results given the dredging of the Authorized Channel into the present (2009) bathymetry appear in Figures 4-21 to 4-24, Table 4-2, and Sub-Appendix A-1.

If the 1977 Authorized Channel is dredged, the model suggests that the outer entrance channel will have two branches by Year 8, the primary channel runs along the northern shoreline of Longboat Key, with a second that runs at a 10-20° angle to the south of the design dredge cut (Figure 4-21). The model suggests that the branch running close to Longboat Key does not scour as quickly as it would under the No Action scenario (Figure 4-22). Likewise, the edge of the ebb shoal would also be located further seaward after several years than it would under the No Action scenario (Figure 4-23), thus reducing the impacts of channel and shoal migration on Longboat Key.

On Longboat Key, most of dredge spoil is expected to spread towards the south, although a small amount would spread to the north (Figure 4-24). Near Whitney Beach (R48), the model suggests a small impact on the order of 2-3 c.y./year/foot. At other locations on the island, the impacts of dredging the 1977 Authorized Channel will be small or negligible.

On Anna Maria Island, the dredging of the Authorized Channel may result in additional erosion along Coquina Beach between R39 and Longboat Pass (Figure 4-24). The impact is estimated to be within the 10-12 c.y./year/foot range at R41 tapering to zero near R39. The development of the swash channel near the existing terminal groin could be the cause of this increased erosion at R41.

Shoaling within the design dredge cuts can be evaluated in terms of bathymetric changes (Figure 4-22 and Sub-Appendix A-1) and maintenance dredging requirements at various times following initial construction (Table 4-2). Between Years 0 and 4, the dredge cuts experience changes as the bathymetry adjusts to the dredged conditions. After Year 4, the maintenance dredging requirements gradually increase due to shoaling and migration. Much of the maintenance dredging requirement is concentrated on the outer ebb shoal in Cut 1 (Figure 4-22, brown area), with moderate shoaling in Cut 2 at the inflection point in the main channel (Figure 4-21, orange area). Overall, the 195,900 c.y. re-dredging volume at Year 8 (Table 4-2, last column) is equivalent to an average shoaling rate of 24,500 c.y./year. This simulated rate is similar to the observed rate from 1997 to 2010, which is 22,400 c.y./year based on the present overdepth dredging requirement of 291,200 c.y. (see Table 4-1).

It should be noted that the maintenance dredging volumes in Table 4-2 are partly governed by the sequencing of wave cases (see Table 3-8 and Section 4.4) in the model. In particular, the highest wave case (#24, 15 feet, 189°) occurs near the end of Year 4. The bathymetric changes that occur during this wave case are reflected in the slightly lower maintenance dredging requirement that the model suggests at Year 4. Overall, the maintenance

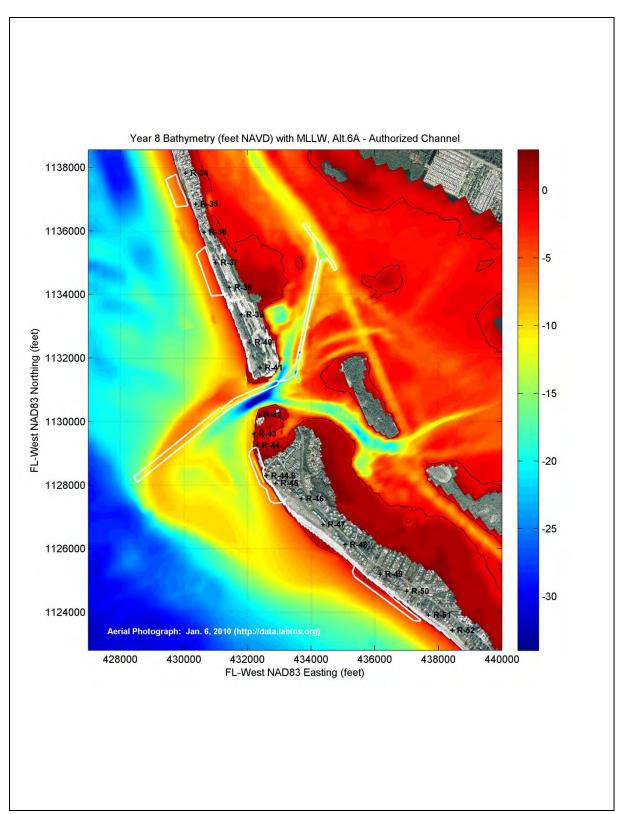


FIGURE 4-21: Simulated Bathymetry at Year 8 Given Alternative 6A.

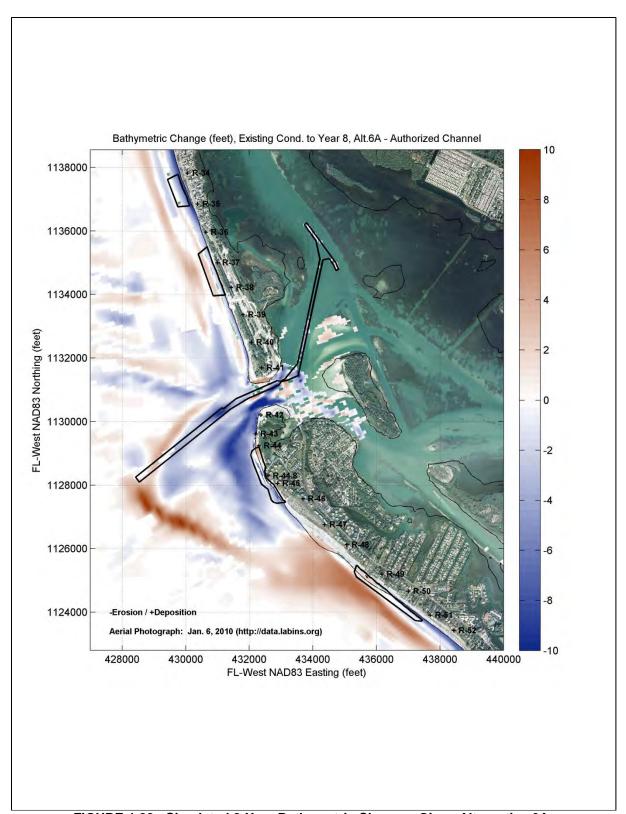


FIGURE 4-22: Simulated 8-Year Bathymetric Changes Given Alternative 6A.

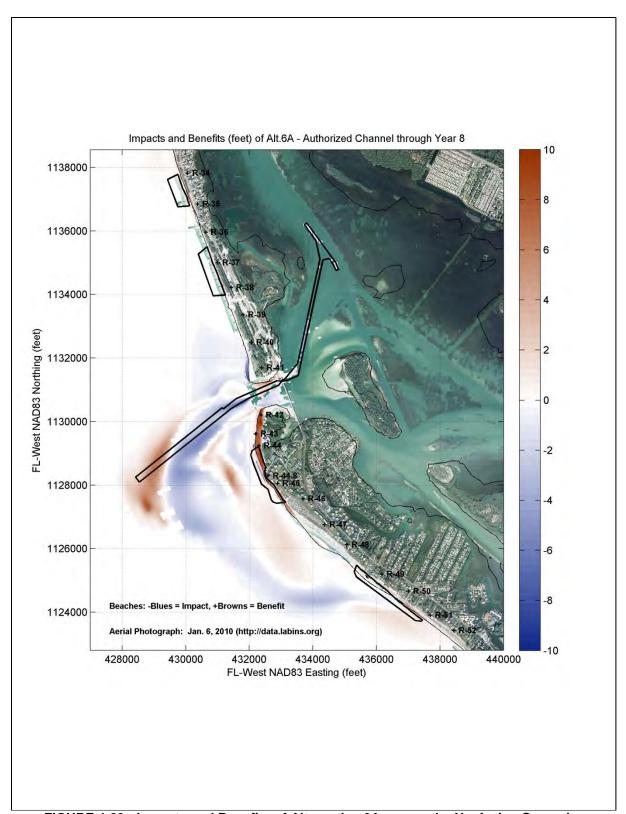


FIGURE 4-23: Impacts and Benefits of Alternative 6A versus the No-Action Scenario.

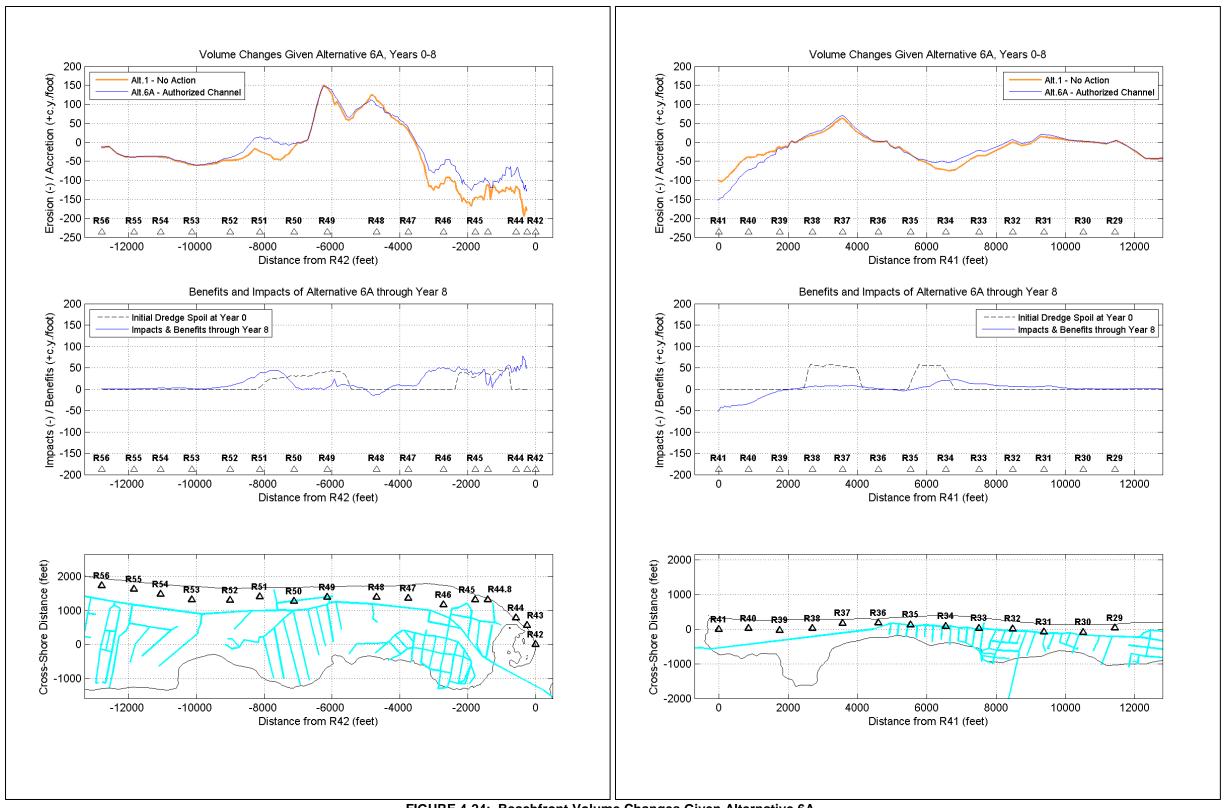


FIGURE 4-24: Beachfront Volume Changes Given Alternative 6A.

TABLE 4-2

MAINTENANCE DREDGING REQUIREMENTS BASED ON DELFT3D MODEL RESULTS

	Alternative	Profiles	Design Depth	+ Over- depth	Design	Dredging Requ	uirement (c.y.) a	at Year	Overdepth	Dredging Re	quirement (c.y.) at Year
			(ft. MLLW)	(feet)	2	4	6	8	2	4	6	8
6A	Authorized Channel	Cut 1-00+00 to Cut 2-16+00	-12	2	130,700	96,300	101,400	116,800	198,800	160,100	163,200	180,100
		Cut 2-16+00 to Cut 3-40+48	-10	1	7,700	7,700	7,600	7,200	17,400	16,700	16,400	15,800
		TOTAL			138,400	104,000	109,000	124,000	216,200	176,800	179,600	195,900
6B	Relocated Channel	Cut 1-00+00 to Cut 2-16+00	-12	2	73,300	82,100	88,200	101,300	126,300	136,400	144,100	157,800
		Cut 2-16+00 to Cut 3-40+48	-10	1	7,600	7,600	7,600	7,000	17,300	16,400	16,300	15,500
		TOTAL			80,900	89,700	95,800	108,300	143,600	152,800	160,400	173,300
6C	Relocated Channel	Cut 1-00+00 to Cut 2-16+00	-12	2	111,000	109,100	96,600	96,100	167,300	160,000	142,100	143,700
	Proposed by H&M	Cut 2-16+00 to Cut 3-40+48	-10	1	7,700	7,500	7,600	7,000	17,500	16,500	16,400	15,800
		TOTAL			118,700	116,600	104,200	103,100	184,800	176,500	158,500	159,500
6D	Authorized Channel	Cut 1-00+00 to Cut 2-16+00	-12	2	114,700	96,500	88,900	101,600	183,700	169,800	158,100	171,300
	with Advance Maint.	Cut 2-16+00 to Cut 3-40+48	-10	1	7,700	7,700	7,600	7,200	17,300	16,700	16,400	16,000
		TOTAL			122,400	104,200	96,500	108,800	201,000	186,500	174,500	187,300
7	Dredging of GIWW Cut M5	M5-00+00 to M5-79+35	-9	1	600	600	700	1,000	1,100	1,400	2,300	3,500

dredging requirements shown in Table 4-2 are intended as rough estimates for planning purposes based on the region's wave climate since 2003. The future maintenance dredging requirements will vary based on the actual wave climate in the area.

B. Relocated Channel

A Relocated Channel was considered by the U.S. Army Corps of Engineers in 2010 (Mora, 2010), but was withdrawn after consultation with Manatee County and the Town of Longboat Key (Schulteis, www.yourobserver.com, 2010). The primary advantage of the Relocated Channel would have been the 62% reduction in the overdepth dredging requirement versus the Authorized Channel (see Table 4-1). Model results given the dredging of the Relocated Channel into the present (2009) bathymetry appear in Figures 4-25 to 4-26, Table 4-2, and Sub-Appendix A-1.

Overall, the Relocated Channel offers only minor differences (≤ 2 c.y./foot/year) compared to the No-Action scenario (see Figure 4-26). This is because the amount of material in the design cuts is relatively low. The predicted bathymetry at Year 8 (Figure 4-25) is similar to that of the No Action Scenario (Figure 4-2).

If the Relocated Channel were constructed, the maintenance dredging requirement would increase each year, reaching an estimated value of 173,300 c.y. at Year 8 (Table 4-2). The reason that this quantity is larger than the present requirement is that the outer channel is expected to migrate landward, resulting in ebb shoal buildup near the outer leg of the design cut and scour closer to the beach (see Figures 4-2 and 4-25 and Sub-Appendix A-1). As a result, the maintenance dredging requirement at Year 8 would be significantly higher than the initial dredging requirement given the present (2009-2010) conditions.

C. Relocated Channel Proposed by Humiston & Moore

The relocated channel proposed by Humiston & Moore (2008) is similar to the 1977 Authorized Channel. However, "to conform more closely to the natural tidal channel alignment", (Humiston & Moore, 2008) the design cut was shifted 200 feet to the south. The volumetric dredging requirement of this option is midway between the Authorized Channel and the Relocated Channel (see Table 4-1). The performance of this option is summarized in Figures 4-27 to 4-30 and Sub-Appendix A-1.

Although the design cuts for Alternative 6C are similar to the 1977 Authorized Channel, the model suggests that it would actually perform in a manner similar to the Relocated Channel in Alternative 6B. As shown in Figures 4-27 and 4-28, the predicted bathymetry for Year 8 is similar to that of the No Action scenario (Figure 4-2) and the Relocated Channel (Figure 4-24). On Anna Maria Island, the benefits of dredge spoil placement under Alternative 6C would be relatively small, and likely diminish after Year 2 (see Figure 4-28 and Sub-Appendix A-1). On Longboat Key, the dredge spoil would probably migrate towards the south, eventually providing a small benefit to the Broadway to Whitney Beach (R46-R48) and Gulfside Road (R50-R51) segments.

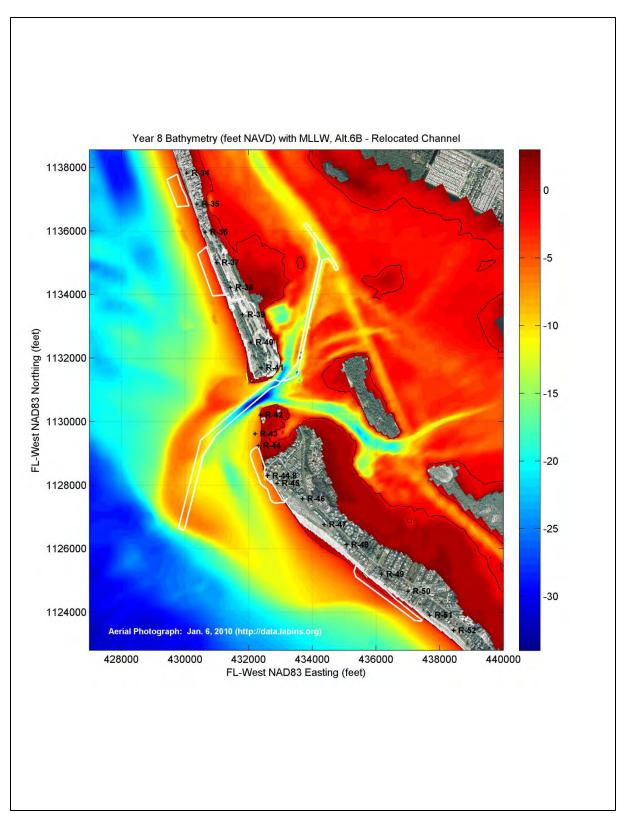


FIGURE 4-25: Simulated Bathymetry at Year 8 Given Alternative 6B.

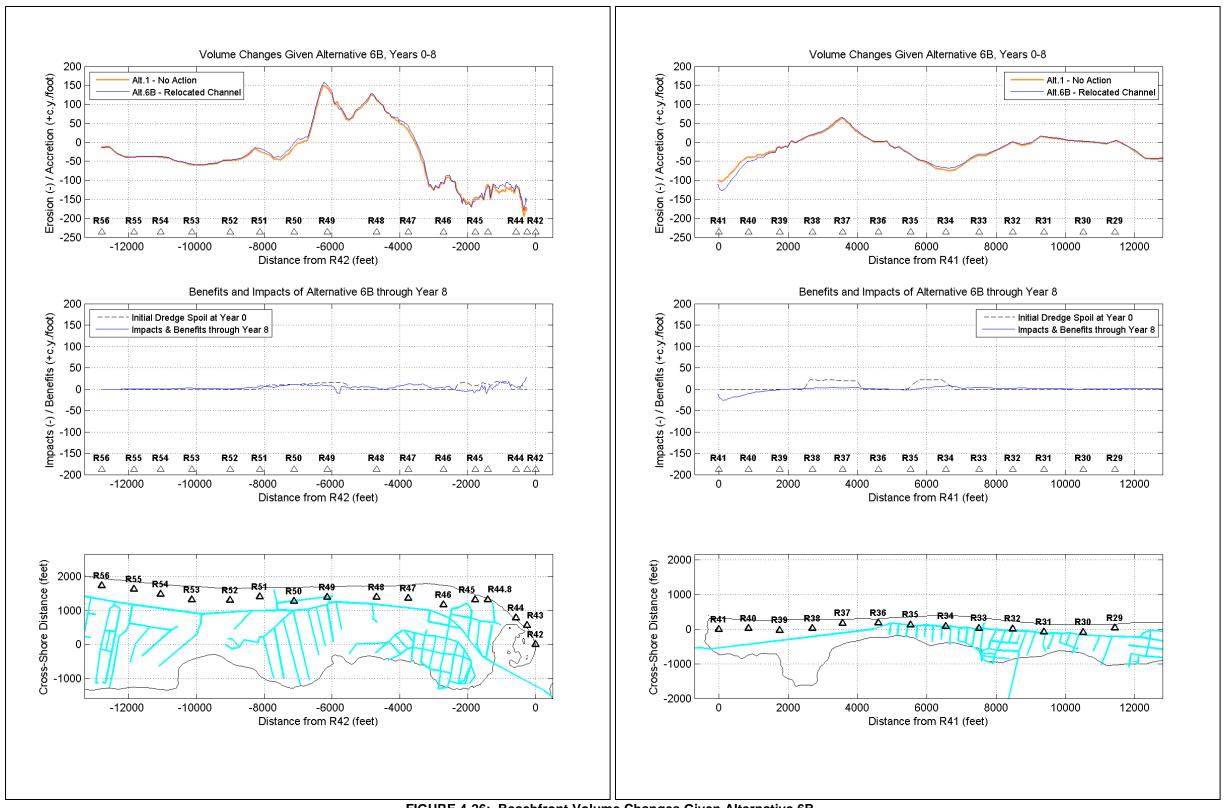


FIGURE 4-26: Beachfront Volume Changes Given Alternative 6B.

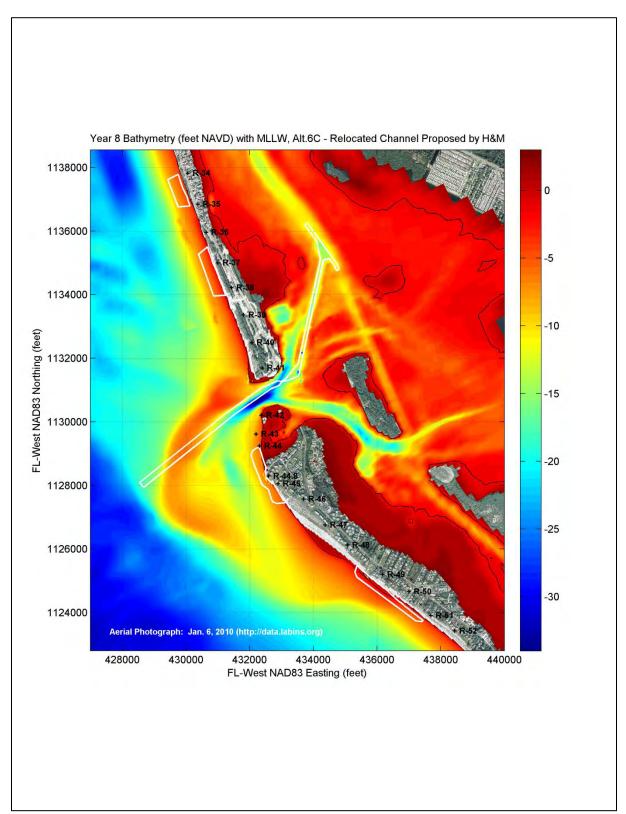


FIGURE 4-27: Simulated Bathymetry at Year 8 Given Alternative 6C.

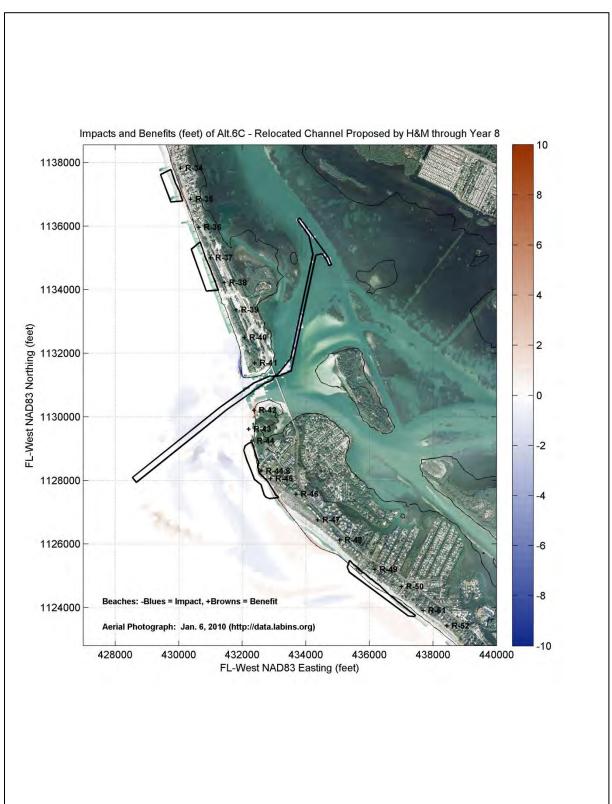


FIGURE 4-28: Impacts and Benefits of Alternative 6C versus the No-Action Scenario.

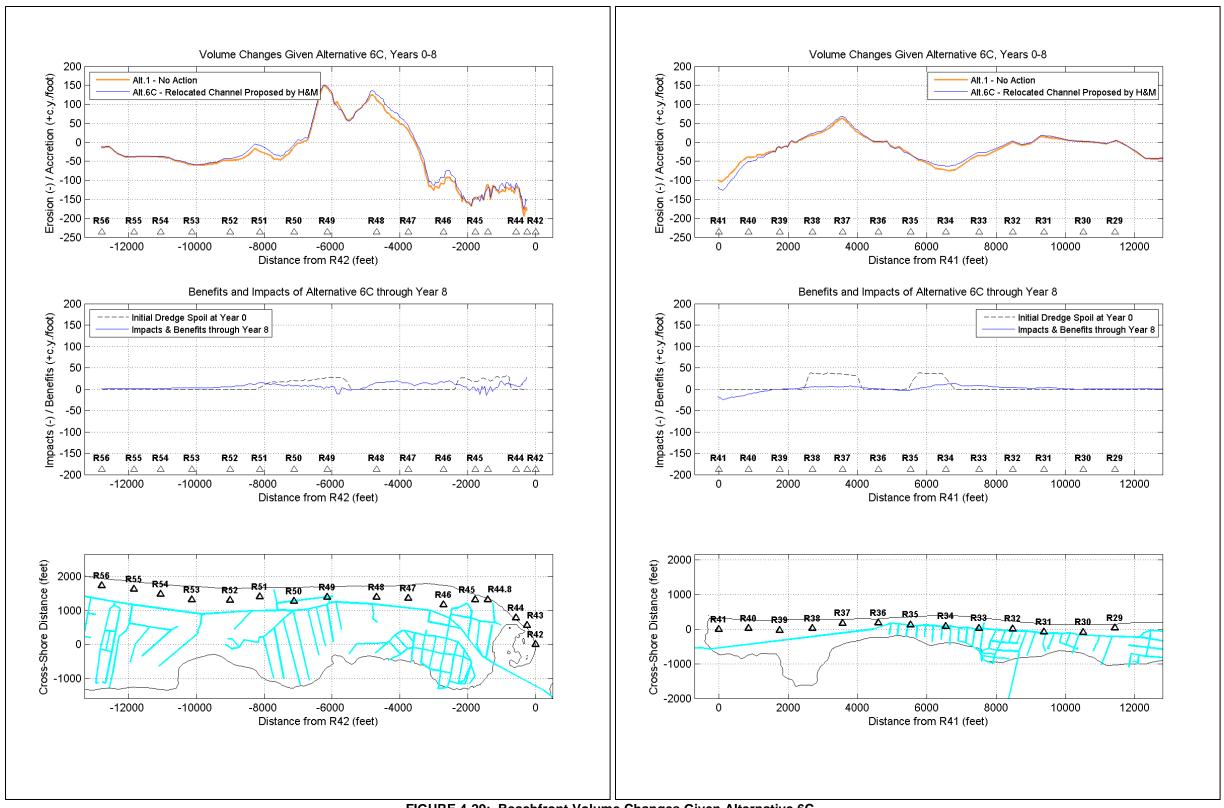


FIGURE 4-29: Beachfront Volume Changes Given Alternative 6C.

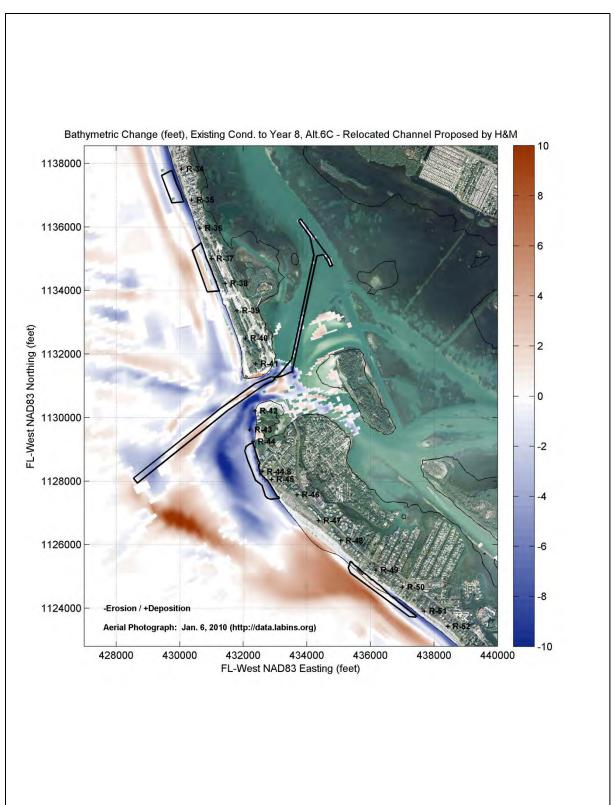


FIGURE 4-30: Predicted Bathymetric Changes Given Alternative 6C.

Of the 4 channel dredging options, Alternative 6C is expected to have the lowest maintenance dredging requirement at Year 8, although this is not the case at Years 2 or 4. This may be due the location of the design cut relative to the ebb shoal growth areas depicted by the model. As shown in Figure 4-30, the west end of the design cut for Alternative 6C is located over an area that is shown to lose material, whereas for Alternatives 6A and 6B, the west end of the design cut is located over an area that is shown to gain material (see Figure 4-21 and Sub-Appendix A-1).

D. Authorized Channel with Advance Maintenance

This option is similar to Alternative 6A. However, to maintain the channel for a somewhat longer period of time, this option includes dredging of an additional 38,700 c.y. from the north side of the Authorized Channel along the eastern half of Cut 1 as Advanced Maintenance. The performance of the Authorized Channel with advance maintenance is summarized in Figures 4-31 to 4-34 and Sub-Appendix A-1.

In general, the performance of Alternative 6D is similar to Alternative 6A. The primary differences between the two are the larger changes on the simulated erosion/accretion rates at Whitney Beach (R48) and the smaller projected maintenance dredging requirements at Years 2, 6, and 8. The larger impact at Whitney Beach is due to the bulge in the shoreline updrift near Beachwalk (R47) (see Figure 4-31). The greater volume of fill placed in the spoil area to the north creates a slightly larger bulge. The slightly larger bulge leads to a perceived larger impact at profile R48. The smaller maintenance dredging requirements in certain years are a potential benefit of the advance dredging. The wider cross-section in the landward half of Cut 1 appears to result in more scour along that section of the channel, as seen by the depth of the blue tones in Figures 4-23 and 4-33. Further refinement of the Advanced Maintenance cut may reduce shoaling and improve performance of the channel.

4.6.7 Alternative 7 – Dredging of Gulf Intracoastal Waterway Cut M5

Alternative 7, as simulated, removes 38,800 to 40,800 cubic yards of material from the Gulf Intracoastal Waterway behind Jewfish Key. This alternative has been incorporated into a larger dredging plan by the U.S. Army Corps of Engineers under FDEP permit application 0305363-001-JC.

The performance of Alternative 7 is summarized in Figure 4-35 and Table 4-2. In general, very little shoaling is expected in the design dredge cut except off the north end of Jewfish Key. This predicted shoal area is located a few hundred feet north of an area that has experienced shoaling in the past (Humiston & Moore, 2007, p. 67 and Figure 1-5 of main report). However, it should be noted that overall, the rate of shoaling in the design dredge cut is very low (see Table 4-2). This is consistent with the dredging history of Intracoastal Waterway near Longboat Pass when no dredging occurred between the 1960s and 2007.

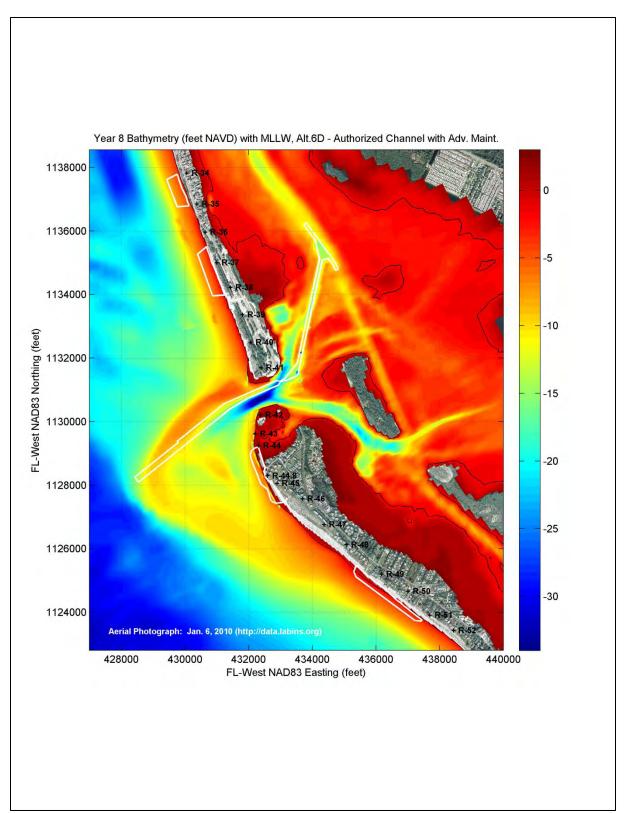


FIGURE 4-31: Simulated Bathymetry at Year 8 Given Alternative 6D.

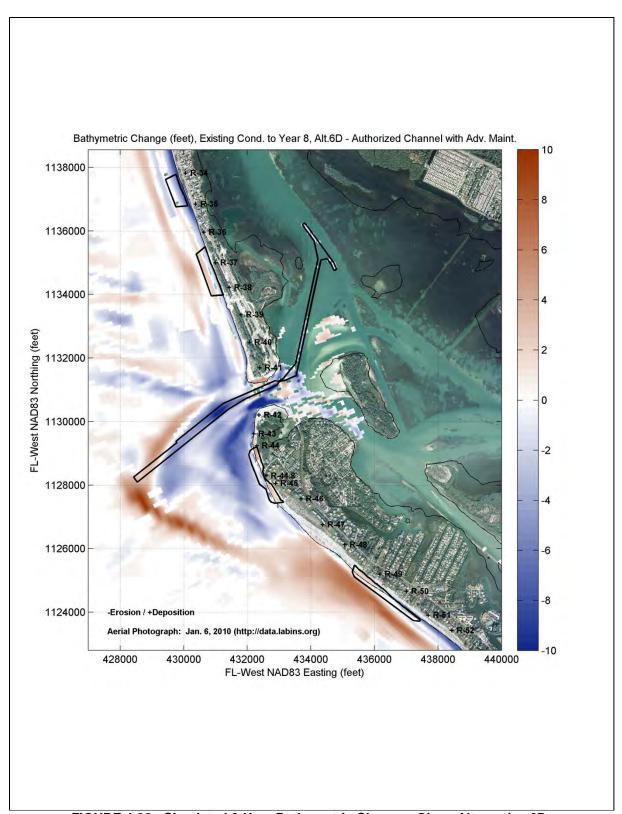


FIGURE 4-32: Simulated 8-Year Bathymetric Changes Given Alternative 6D.

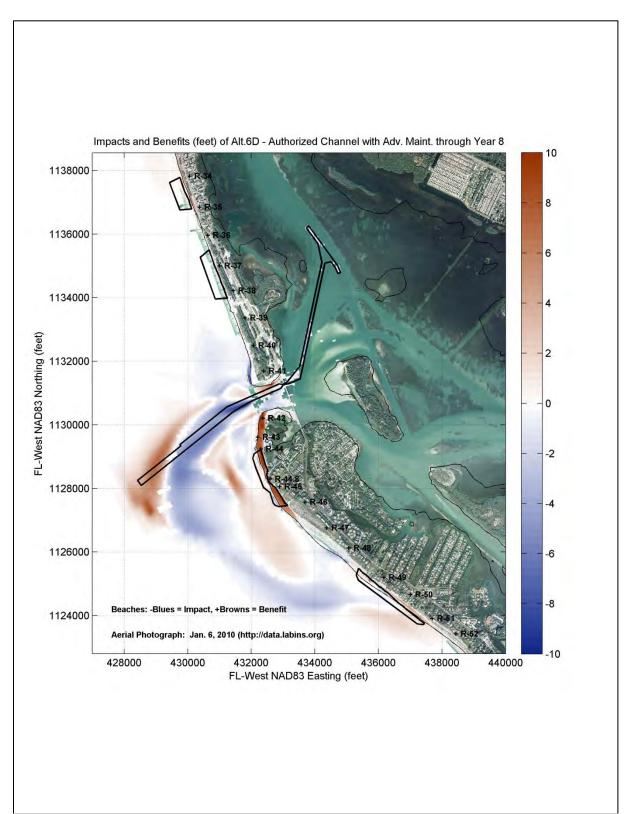


FIGURE 4-33: Impacts and Benefits of Alternative 6D versus the No-Action Scenario.

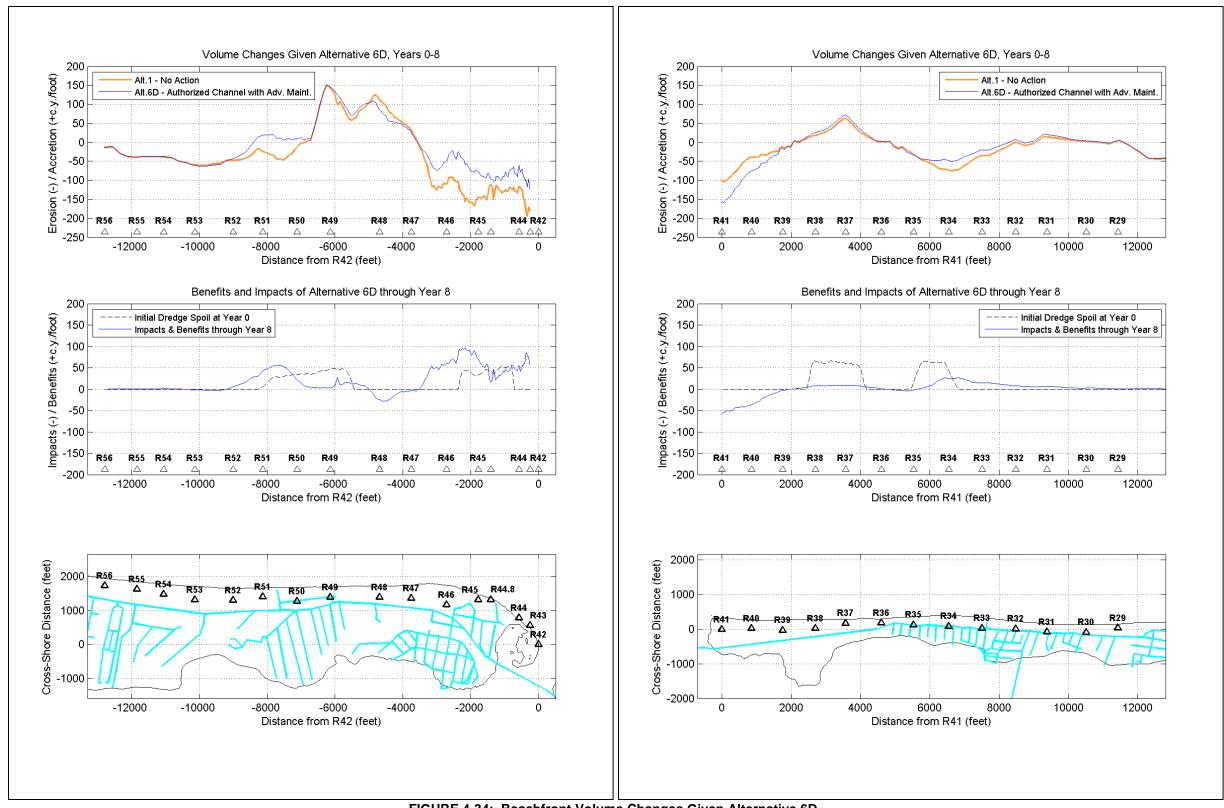


FIGURE 4-34: Beachfront Volume Changes Given Alternative 6D.

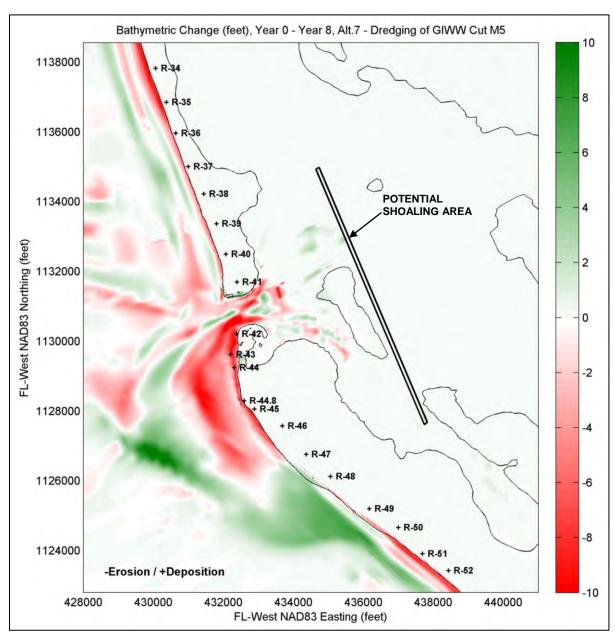


FIGURE 4-35: Simulated 8-Year Bathymetric Changes Given Alternative 7.

4.7 Additional Terminal Groin Alternatives

An additional alternative was simulated, which consisted of various extensions of the terminal groin being proposed in Alternative 3A. The purpose of these simulations was to evaluate whether a longer terminal groin at the north end of Longboat Key could provide the benefits of Alternative 5S without the construction of permeable adjustable groins near the 360 North condominium and North Shore Road. The results of these simulations appear in Sub-Appendix A-2. These simulations suggest that this alternative is not able to provide a benefit equivalent to Alternative 5S. Further details appear in Sub-Appendix A-2.

4.8 Study Findings

Overall, the model results of the various alternatives suggest the following:

- Longboat Pass is a complex and integrated system. Structural interventions/modifications on one side of the pass can affect the opposite side. Likewise, channel maintenance can result in impacts to the adjacent beaches both north and south of the pass.
- The outer channel of Longboat Pass is likely to migrate landward over the next 8 years, resulting in high erosion rates on the north end of Longboat Key. This migration is expected to be coincident with a southerly rotation of the ebb shoal complex, which further exposes the north end of Longboat Key to erosion. The model suggests the development of a swash channel into the inlet near the existing terminal groin on the south end of Anna Maria Island, which is expected to further erode. Extension of the Longboat Pass North jetty on Anna Maria Island would partially offset these losses and push the swash channel further offshore.
- High erosion rates at the immediate north end of Longboat Key can be addressed through the construction of a terminal groin. Among the structural alternatives considered, Alternative 5S, which adds two permeable adjustable groins at the 360 North condominium (R44.5) and the North Shore Road seawall (R44.7), benefits the longest stretch of beach on Longboat Key (R42-R44.9).
- Dredging the Authorized Channel (Alternative 6A) is likely to reduce the amount of channel scour close to the northern shoreline of Longboat Key and move the fringe of the ebb shoal further seaward. These processes should be able to reduce the erosional impacts of channel and shoal migration on along the northern end of Longboat Key. Dredging 38,700 c.y. on the northern side of the Authorized Channel as Advance Maintenance (i.e., Alternative 6D), will provide additional material for beach maintenance at Year 0 and may be able to offer a small reduction in the amount of maintenance dredging. Over the 8 year planning period, the average refilling rates given the Authorized Channel with Advance Maintenance will be similar to those that have occurred since 1997. Further refinement of the Advance Maintenance cut may reduce shoaling and improve overall performance of the channel.
- Dredge spoil placed on Longboat Key should be able to benefit the eroded beaches on the
 north end of the island. However, it should be noted that most of that dredge spoil will
 spread towards the south. On Anna Maria Island, dredge spoil may spread in both
 directions due to sediment transport reversals, with the middle of Cortez Beach (R31R34) receiving the greatest benefit.
- The high erosion rates on the south end of Anna Maria Island can be partially addressed by tightening and extending the terminal groin 260 feet. The proposed modification of the structure may also be a viable means of addressing the increased erosion that could occur on Coquina Beach if navigational dredging takes place, or if groins are constructed on the north end of Longboat Key. Although, the structure is not likely to completely

eliminate the erosion along the south end of Anna Maria Island, the modifications are expected to benefit the beach approximately 2,000 ft to the north of the inlet.

5. PERFORMANCE OF THE SELECTED INLET MANAGEMENT PLAN

Based on the study findings and model results, the selected inlet management plan for Longboat Pass includes the following components:

- Anna Maria Island Terminal Groin Extension (Alternative 2).
- Longboat Key Terminal Groin Plus Two Permeable Adjustable Groins (Alternative 5S).
- Dredging of the 1977 Authorized Channel with Advance Maintenance (Alternative 6D). To better accommodate Manatee County's beach management strategy, the designated spoil areas on Anna Maria Island have been combined into a single spoil site extending from R-35+790' to Longboat Pass. This spoil site coincides with the fill area used during the 2011 Anna Maria Island Beach Nourishment Project Coquina Beach Segment. On Longboat Key, the spoil sites are identical to those used in 1997.
- Dredging of Gulf Intracoastal Waterway Cut M5 (Alternative 7).

The formulation of the plan is based on the needs of Manatee County and the Town of Longboat Key and the study findings above. The simulation of the selected inlet management plan assumes that all components of the plan are constructed simultaneously. They also assume that maintenance dredging will take place in Year 8 (after the simulation period) for comparison purposes. However, economic, permitting, and planning considerations may result in some of the components, such as GIWW Cut M5, being implemented before the others. In addition, maintenance dredging may be performed on a more frequent basis (i.e. every 4 years) to dovetail with the beach management programs on Anna Maria Island and Longboat Key.

The performance and impact of the selected inlet management plan is presented in Figures 5-1 to 5-13. Implementing the selected plan will maintain the channel along the northern lobe of the ebb shoal and temporarily widen the beaches along the southern end of Anna Maria Island and the northern end of Longboat Key. Between Years 2 and 8, the outer channel may develop two branches – one running near the location of the existing channel close to the beach and another which is located closer to the design dredge cut (Figures 5-3 to 5-5). Between the north end of Longboat Key and Beachwalk (R47), erosion along the active beach profile (see also Figures 5-6 and 5-7) will occur with scour further offshore, but it will likely be less than the No-Action scenario (see Figures 5-12 and 5-13). In addition, the placement of the dredge spoil and the new structures should be able to prevent or minimize shoreline retreat past the present shoreline north of R45 (Longbeach Village), based on the results in Figures 5-8 to 5-11.

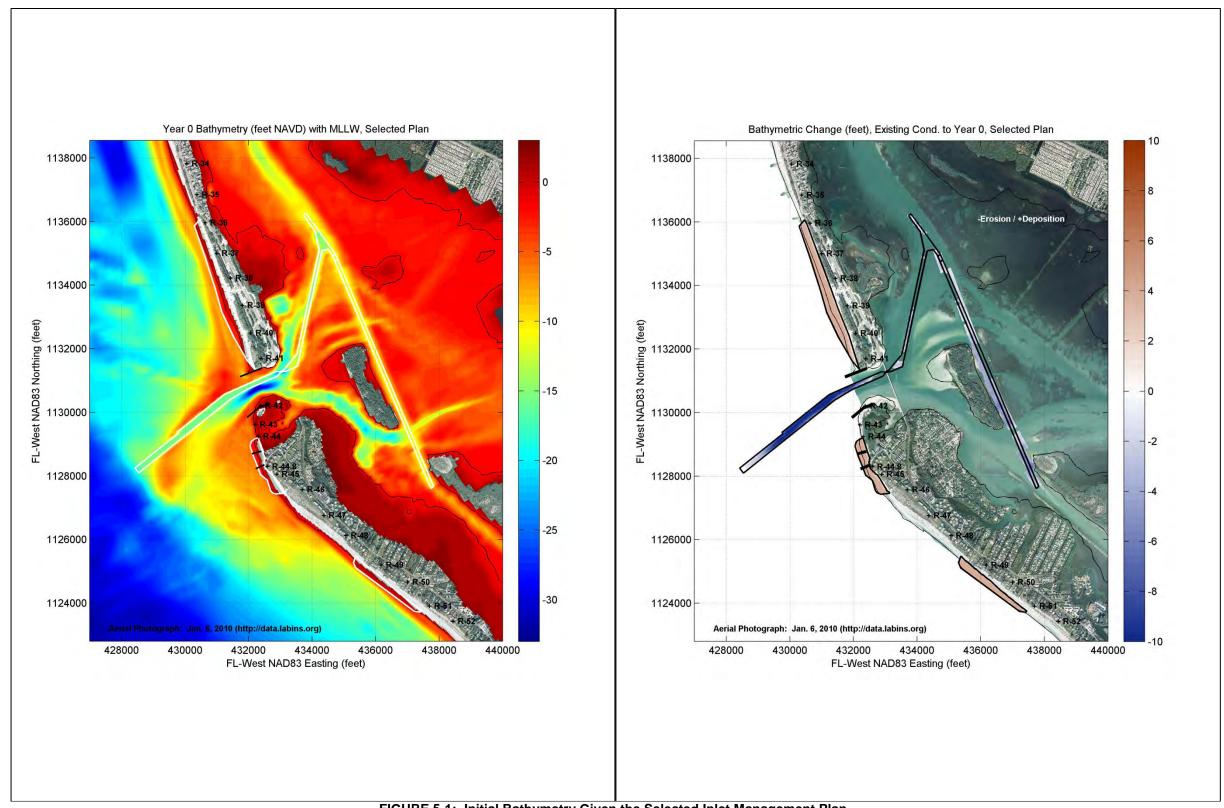


FIGURE 5-1: Initial Bathymetry Given the Selected Inlet Management Plan.

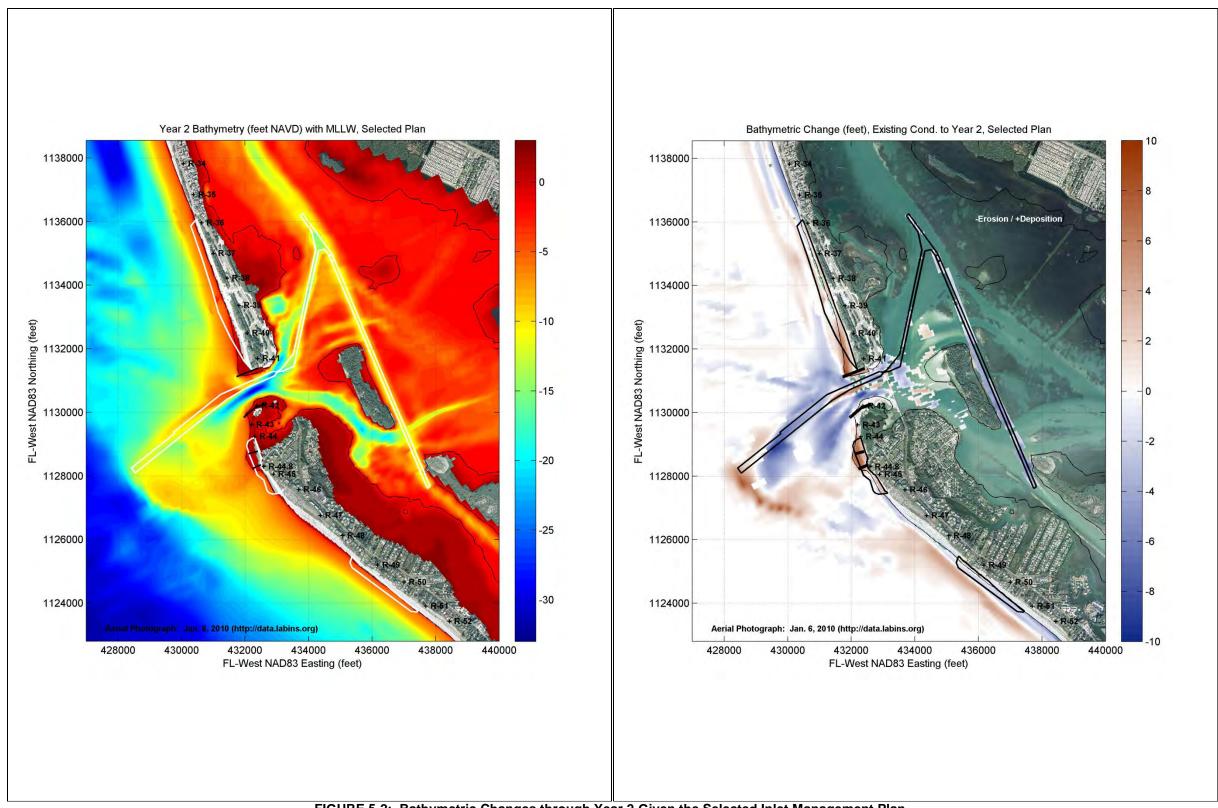


FIGURE 5-2: Bathymetric Changes through Year 2 Given the Selected Inlet Management Plan.

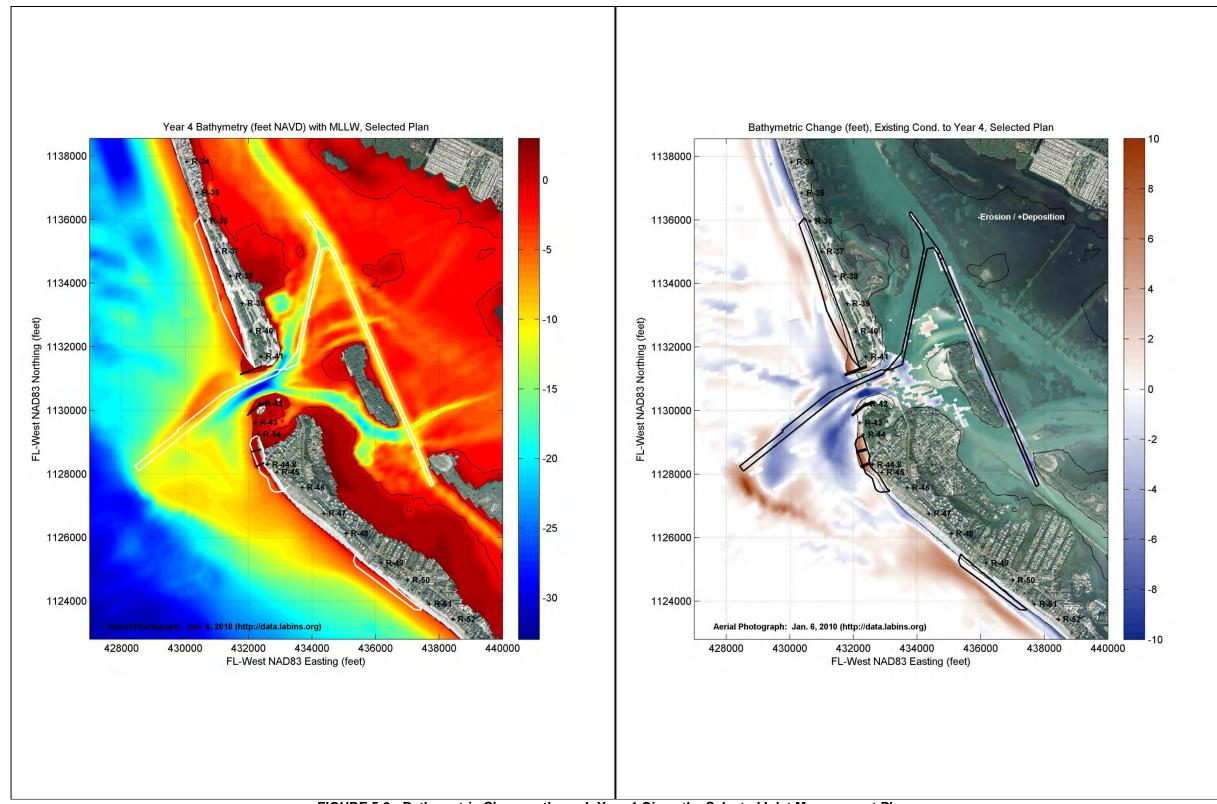


FIGURE 5-3: Bathymetric Changes through Year 4 Given the Selected Inlet Management Plan.

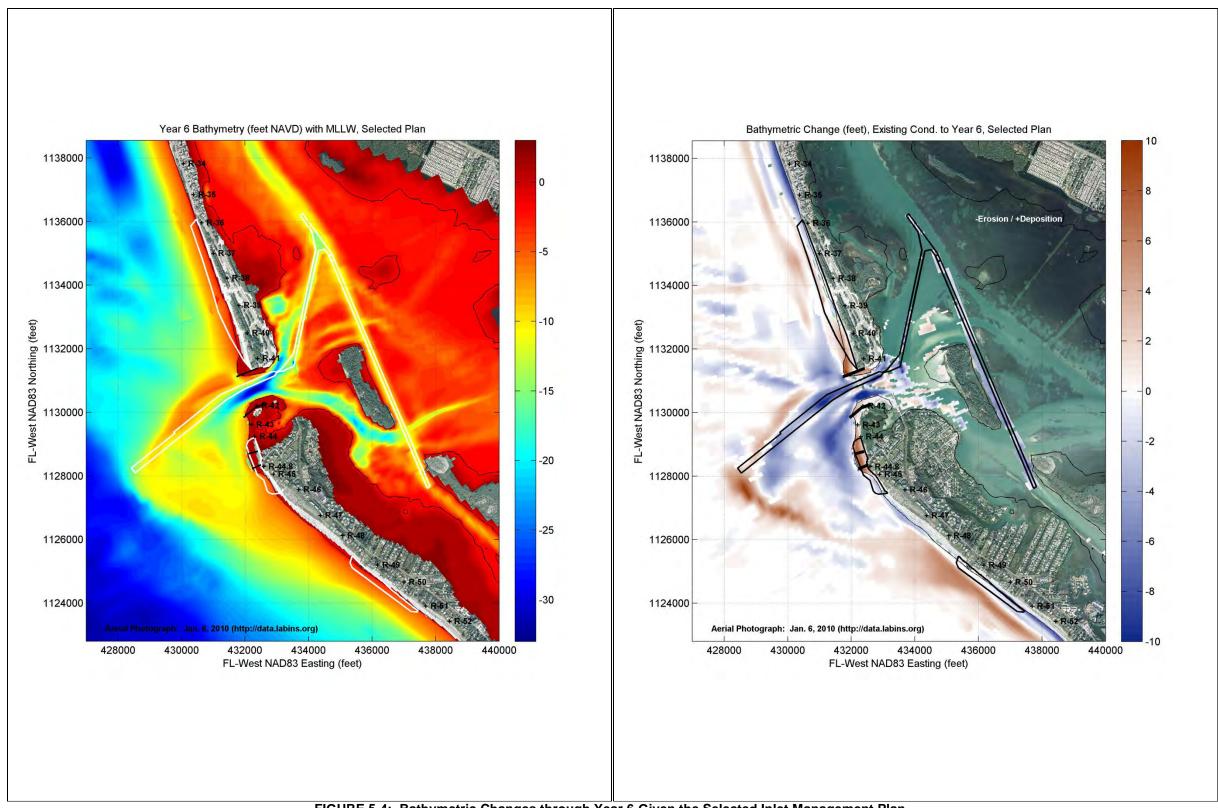


FIGURE 5-4: Bathymetric Changes through Year 6 Given the Selected Inlet Management Plan.

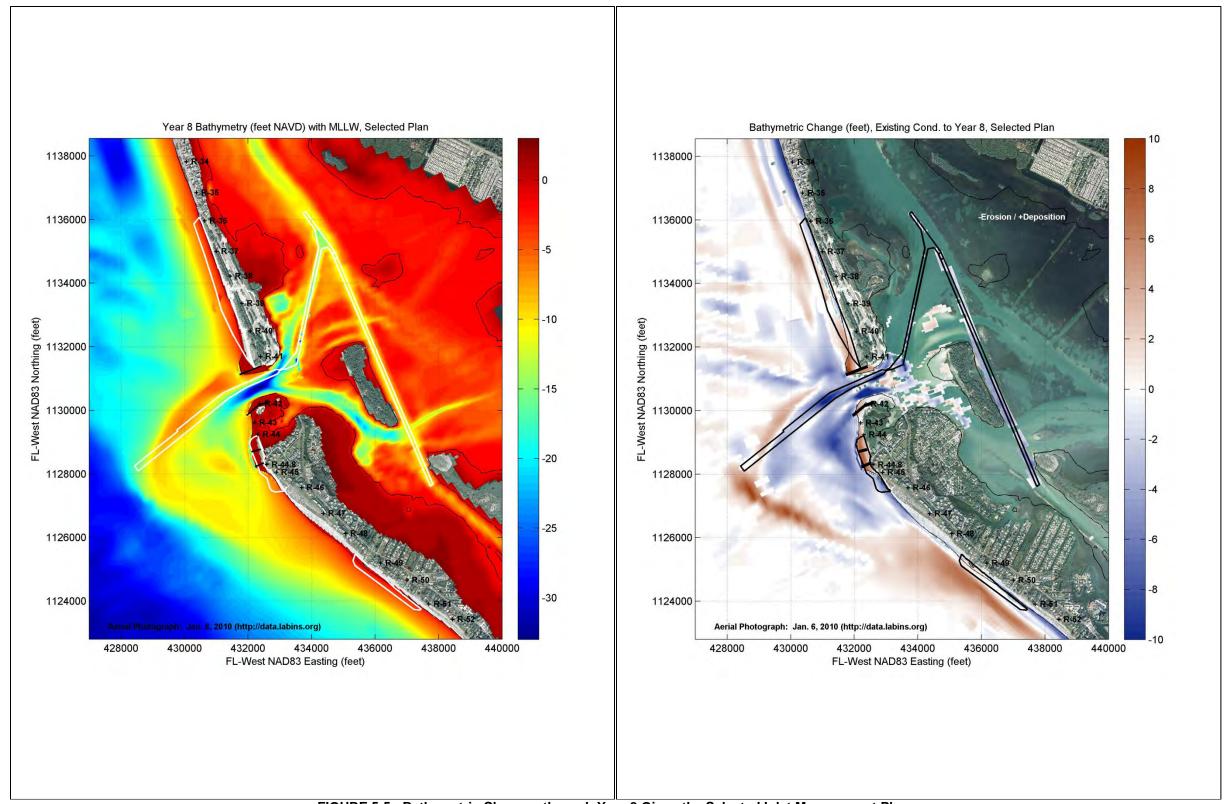


FIGURE 5-5: Bathymetric Changes through Year 8 Given the Selected Inlet Management Plan.

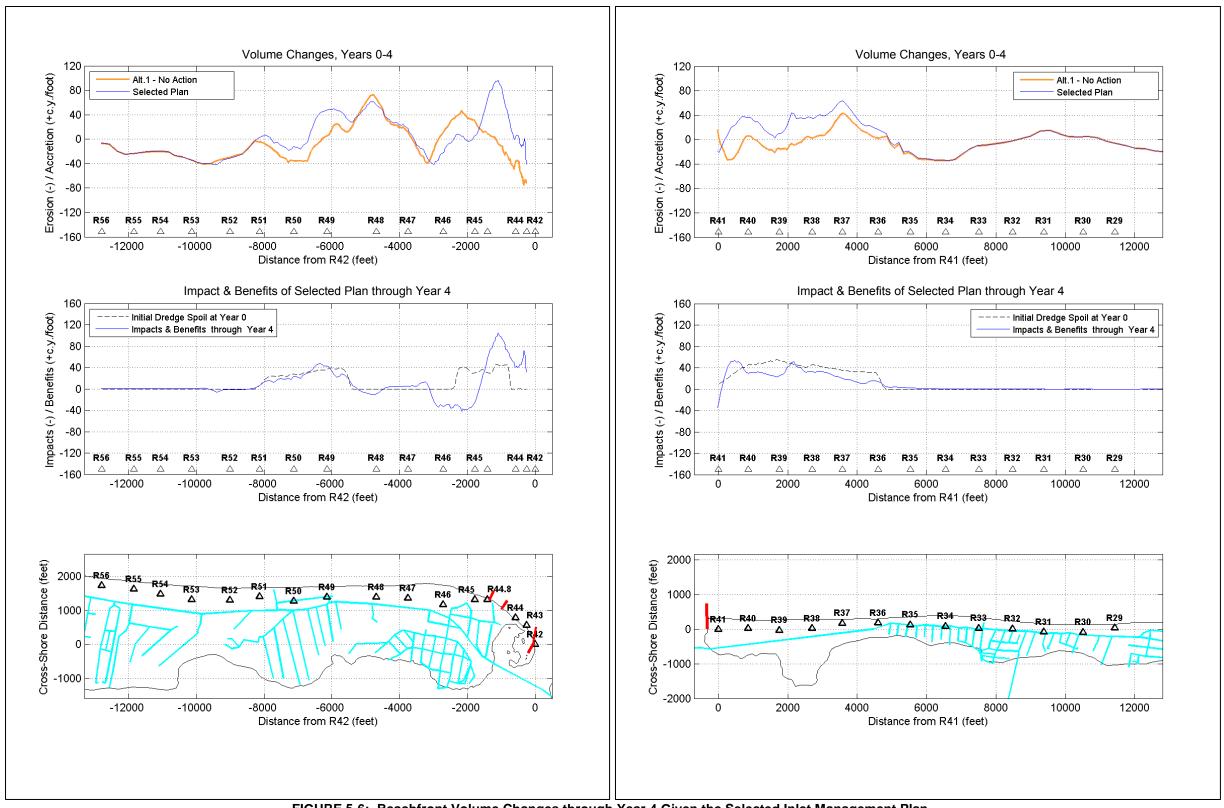


FIGURE 5-6: Beachfront Volume Changes through Year 4 Given the Selected Inlet Management Plan.

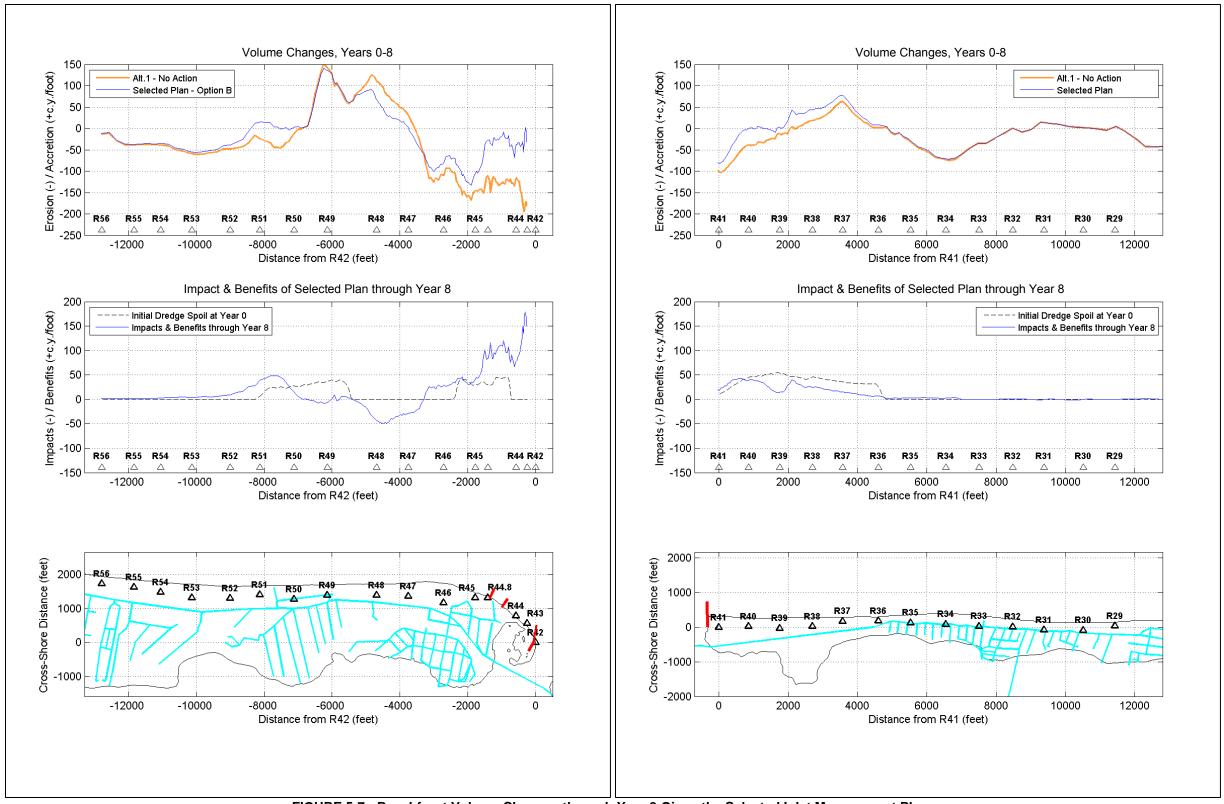


FIGURE 5-7: Beachfront Volume Changes through Year 8 Given the Selected Inlet Management Plan.

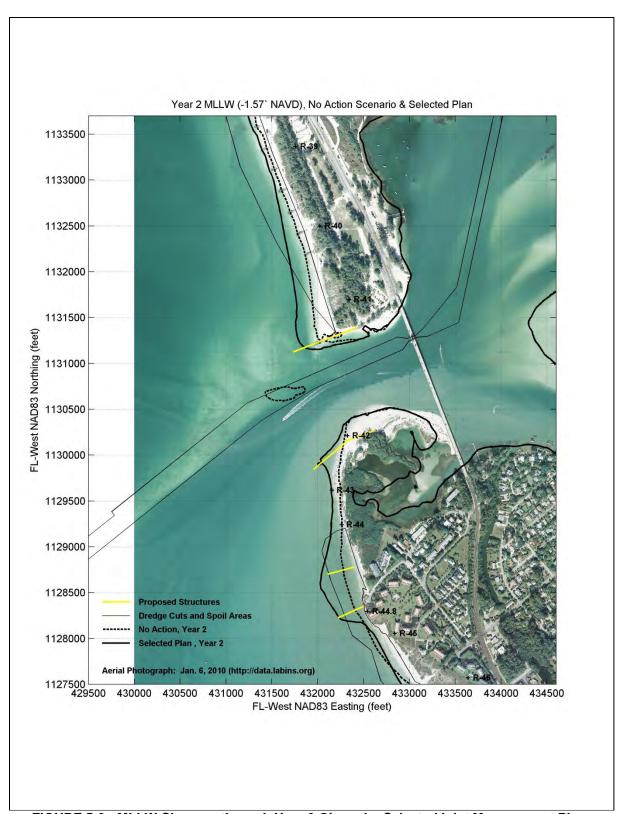


FIGURE 5-8: MLLW Changes through Year 2 Given the Selected Inlet Management Plan.

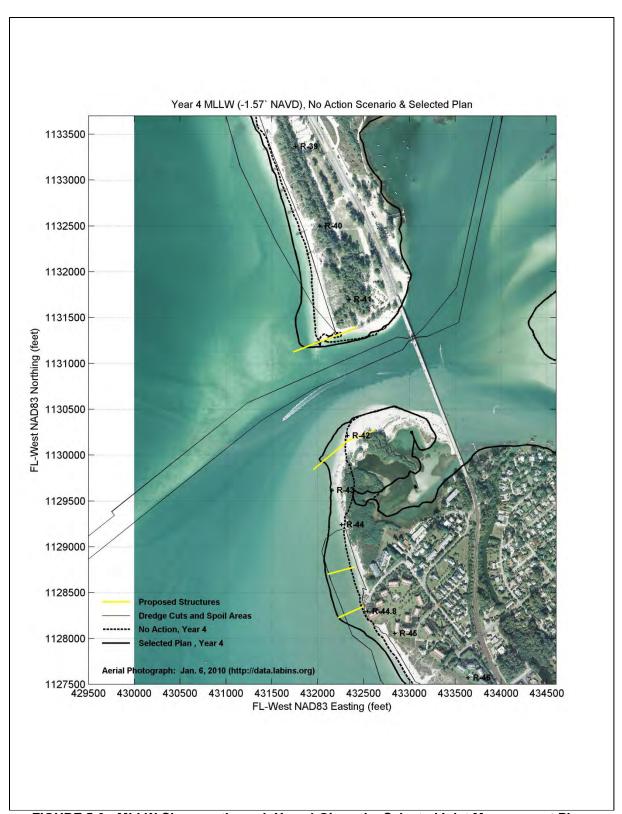


FIGURE 5-9: MLLW Changes through Year 4 Given the Selected Inlet Management Plan.

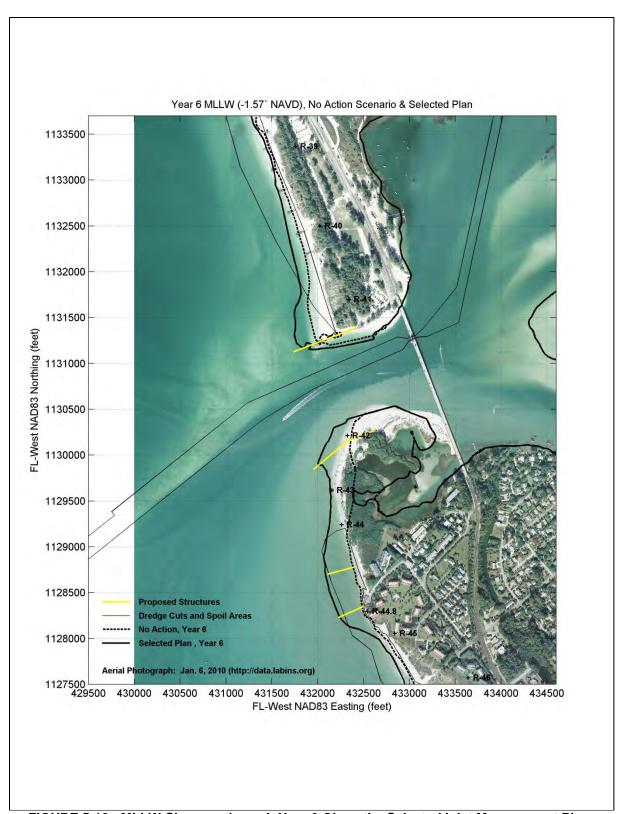


FIGURE 5-10: MLLW Changes through Year 6 Given the Selected Inlet Management Plan.

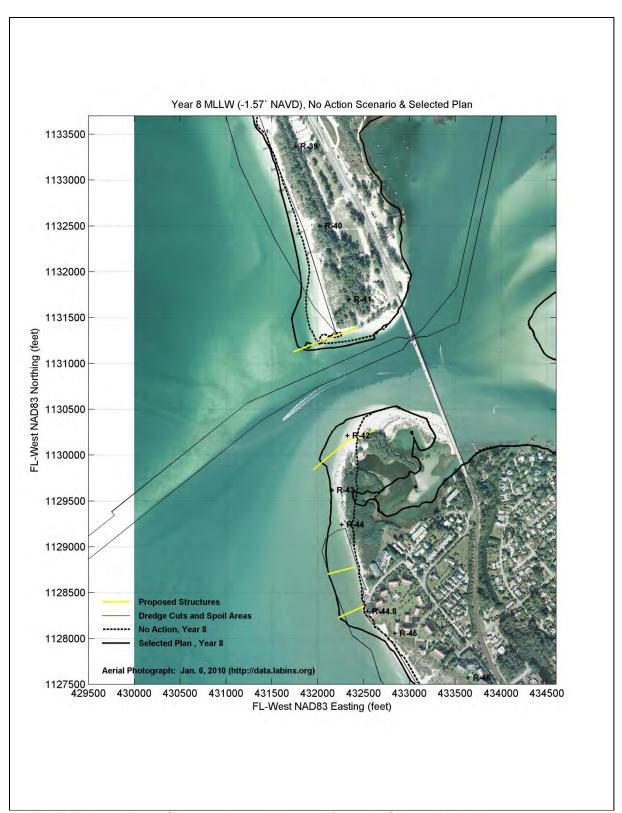


FIGURE 5-11: MLLW Changes through Year 8 Given the Selected Inlet Management Plan.

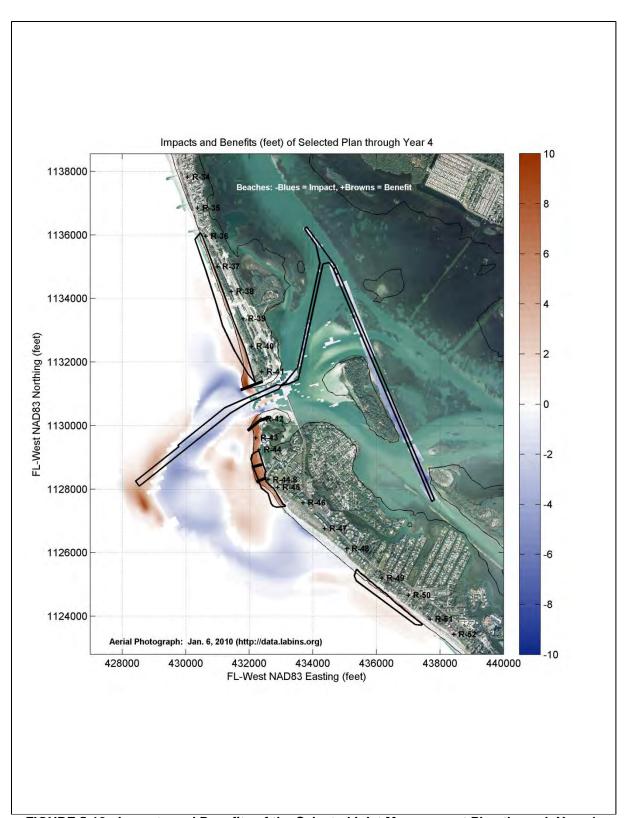


FIGURE 5-12: Impacts and Benefits of the Selected Inlet Management Plan through Year 4.

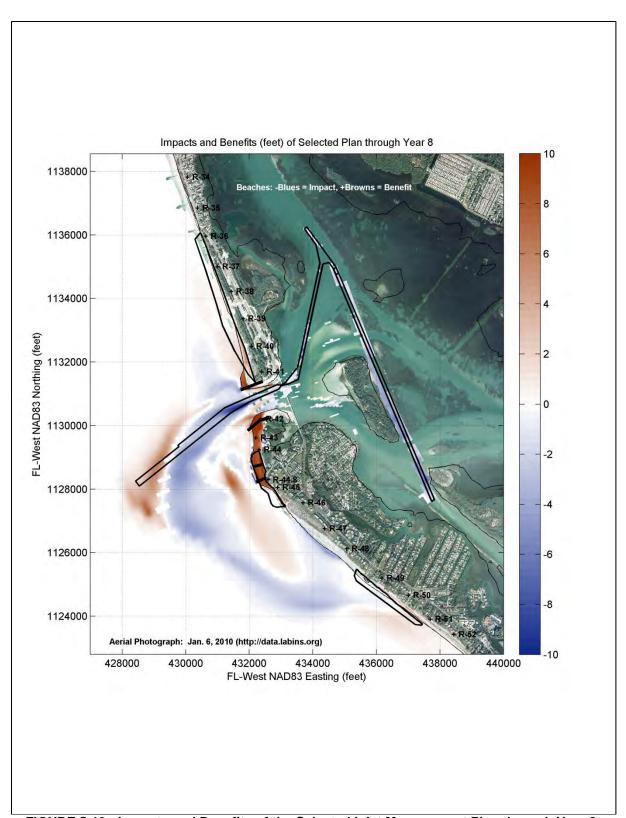


FIGURE 5-13: Impacts and Benefits of the Selected Inlet Management Plan through Year 8.

On Anna Maria Island, the model suggests that placement of the dredge spoil and the extended terminal groin will be able to prevent or minimize erosion into the present beach profile north of R40 (see Figures 5-6 and 5-7). In addition, it will also promote the development of a fillet that will approach the seaward end of the extended groin (see Figures 5-8 to 5-11). Erosion near the groin (R40 – R41) will continue to occur due to the development of the swash channel into Longboat Pass (see Figures 5-2 to 5-7). However, the degree of erosion will be less, and it will largely occur below the waterline.

Shoaling within the dredge cuts is summarized in Figures 5-14 to 5-15 and Table 5-1. As discussed earlier (see Section 4.6.6.A), the maintenance dredging requirements will likely depend on the adjustment of the ebb shoal to the post-dredging conditions and variations in wave activity. Similar to Table 4-2, the values in Table 5-1 should be considered rough estimates for planning purposes.

TABLE 5-1

MAINTENANCE DREDGING REQUIREMENTS FOR THE SELECTED INLET MANAGEMENT PLAN BASED ON THE DELFT3D MODEL RESULTS

Profiles	Design Depth (feet	+ Over- depth	Design Dredging Requirement (cubic yards)			
	MLLW)	(feet)	Year 2	Year 4	Year 6	Year 8
Cut 1-00+00 to Cut 2-16+00	-12	2	138,900	118,600	101,600	113,300
Cut 2-16+00 to Cut 3-40+48	-10	1	6,500	6,400	6,800	6,200
LONGBOAT PASS TOTAL			145,400	125,000	108,400	119,500
GIWW Cut M5 00+00 to 79+35	-9	1	600	600	800	1,300
Profiles	Design Depth (feet	+ Over- depth	Overdepth Dredging Requirement (cubic yards)			
	MLLW)	(feet)	Year 2	Year 4	Year 6	Year 8
Cut 1-00+00 to Cut 2-16+00	-12	2	214,300	190,500	170,200	178,600
Cut 2-16+00 to Cut 3-40+48	-10	1	15,600	14,900	15,100	14,300
LONGBOAT PASS TOTAL			229,900	205,400	185,300	192,900
GIWW Cut M5	-9	1	1,100	1,400	2,500	3,700

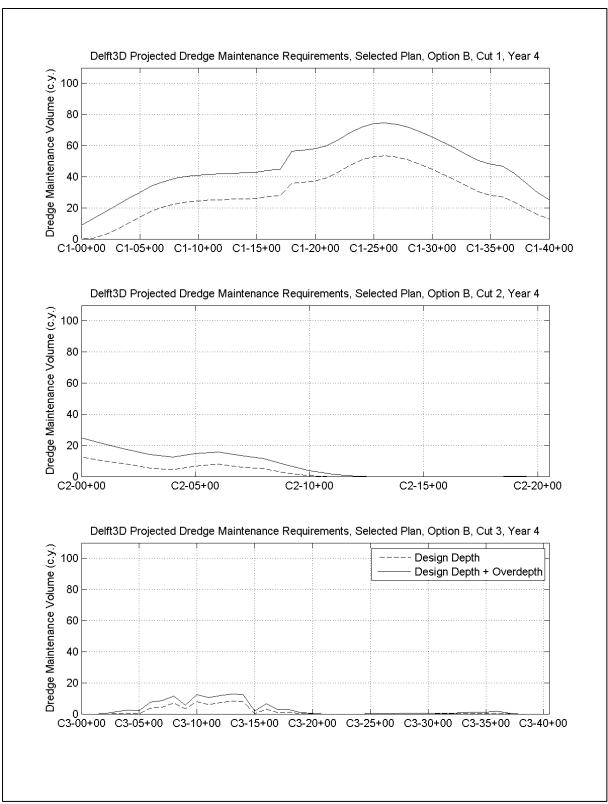


FIGURE 5-14: Projected Dredge Maintenance Requirements at Year 4.

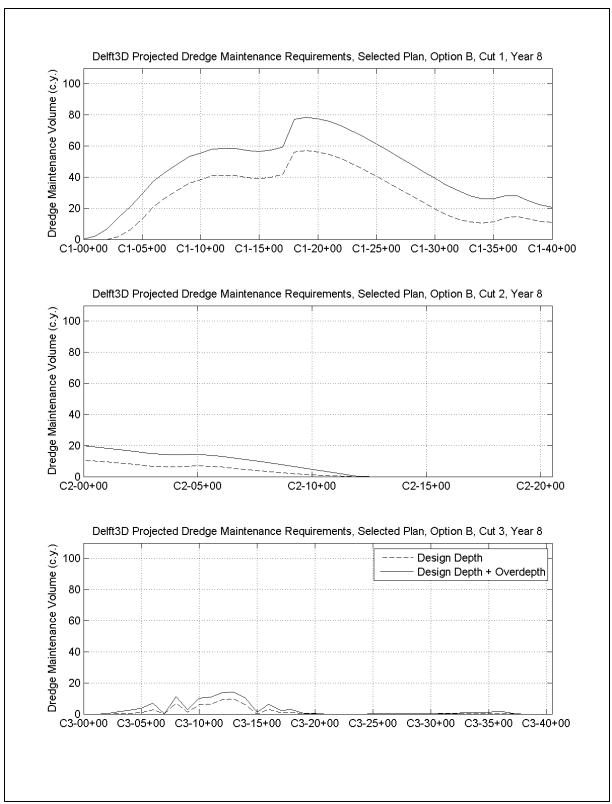


FIGURE 5-15: Projected Dredge Maintenance Requirements at Year 8.

Between Year 0 and 2, the inlet's dredge cuts experience rapid changes as the bathymetry adjusts to the dredged conditions (see Figures 5-1 and 5-2). Although many of the changes occur within with the first two years, the maintenance dredging projections suggest that full adjustment may require up to 6 years (see Table 5-1), after which the maintenance requirements begin to increase slowly with time. The bulk of the inlet's maintenance dredging requirements (79-88%) will be concentrated in Cut 1, with the remainder split between Cut 2 (7-15%) and Cut 3 (5-6%). Within Cut M5 of the GIWW, the maintenance dredging requirements are predicted to be similar to those of Alternative 7 alone.

6. CONCLUSIONS

To assist in the formulation of a management plan for Longboat Pass, the Delft3D-FLOW and SWAN models were applied. These models were utilized to examine wave propagation, sediment transport, beach erosion, shoal development, and dredging requirements given the existing conditions and a number of potential alternatives to address the erosion and shoaling issues at the inlet.

The Delft3D modeling package was setup using a large collection of survey data from FDEP, NOAA, USACE, USGS, and other sources. Grids were delineated to examine wave propagation and flow on both a regional and local basis. Structures were incorporated into the model based on recent aerial photographs, survey drawings, and other sources. Wave propagation within the SWAN model was calibrated using measured wave spectra offshore, observed water levels, regional wind fields, and recently collected wave measurements close to the inlet. Currents and water levels within the Delft3D-FLOW model were calibrated using water level and current measurements collected during a 1992 study, along with data summarizing the extent of the submerged aquatic vegetation near Longboat Pass. Finally, sediment transport, erosion, and deposition were calibrated using the 2003, 2004, and 2009 beach and inlet surveys, concurrent wave and wind data, and numerous test runs to examine the most appropriate values of the tidal amplitude, the sediment transport coefficients, and distribution of the bottom sediment.

Following the calibration effort, the Delft3D modeling package was applied to evaluate various alternatives to address the erosion and shoaling issues at Longboat Pass. These included terminal groins, breakwaters, permeable adjustable groins, and various dredge cuts. The results of alternative screening runs were then utilized to formulate the selected inlet management plan, which has the following components:

- An extension of the existing terminal groin on the south end of Anna Maria Island (Alternative 2).
- The construction of a terminal groin on the north end of Longboat Key, plus two permeable adjustable groins near the 360 North condominium and the public dune overwalk at the end of North Shore Road (Alternative 5S).
- Dredging of the 1977 Authorized Channel with approximately 38,700 c.y. of advance maintenance on the north side of Cut 1 and placement of the spoil material on the south

end of Anna Maria Island (R-35+790' to Longboat Pass) and the north end of Longboat Key (R-44+48' to R-46A and R-48+722' to R-51) (Alternative 6D).

• Dredging of Gulf Intracoastal Waterway Cut M5 (Alternative 7).

Comparison of the selected inlet management plan and the No-Action simulations suggest the following:

- Under a No-Action scenario, the outer channel of the inlet is likely to migrate landward as the ebb shoal rotates southward over the next 8 years, accompanied by the development of swash channel around the terminal groin at the south end of Anna Maria Island. Both processes are likely to result in erosion along the south end of Coquina Beach and the north end of Longboat Key.
- Under the selected inlet management plan,
 - O Projected erosion rates on the south end of Coquina Beach are likely to decrease with the extension and tightening of the existing terminal groin, which should be able to push the swash channel further offshore and maintain a fillet that extends approximately 2,000 ft north (Figures 5-5, 5-7, 5-11).
 - The proposed terminal groin and permeable adjustable groins on the north end of Longboat Key should be able to reduce the 8 year erosion rates between Longboat Pass and R46.5 (Figure 5-7).
 - Within Gulf Intracoastal Waterway Cut M5, the rates of refilling will be very slow, consistent with historical trends (Table 5-1).
 - The adjustment of the ebb shoal to the 1977 Authorized Channel will be most pronounced in the first 2 years, but may take 4-6 years to complete. After the 4-6 year adjustment period, the design cuts will exhibit gradual refilling rates over time (Table 5-1). The bulk of the maintenance dredging requirements will be concentrated west of the Longboat Pass bridge, specifically in Cut 1 (Figures 5-14 and 5-15). Overall, the average refilling rate over the 8 year planning period (24,000 8 Year, Table 5-1 last column) will be similar to the average rate since 1997 (22,400 cy/yr).
 - O Dredging the 1977 Authorized Channel plus 38,700 c.y. of advance maintenance should be able to divert some of the inlet's flow away from the beaches of Longboat Key. It will also provide dredge spoil that can be placed along Anna Maria Island and Longboat Key to address higher erosion rates adjacent to the inlet.
 - o Dredging the Authorized Channel may increase shoaling rates on the northwestern fringe of the ebb shoal, which could increase dredging requirements in the future (Figures 5-12 and 5-13). However, the potential increases in future

dredging requirements would also provide beach quality sand to offset inlet effects on adjacent beaches. The cost of maintenance dredging requirements would be offset by the benefits to the beach management programs along Anna Maria Island and Longboat Key.

• Further refinement to the components of the selected design will be needed in the final design phase and as a result of the permitting process.

The results of this numerical modeling study should be used in conjunction with other coastal engineering assessments and prudent engineering judgment. Further engineering is recommended prior to implementation.

Christanhan M. Davy D.E.

Christopher M. Day, P.E. Florida P.E. 60052

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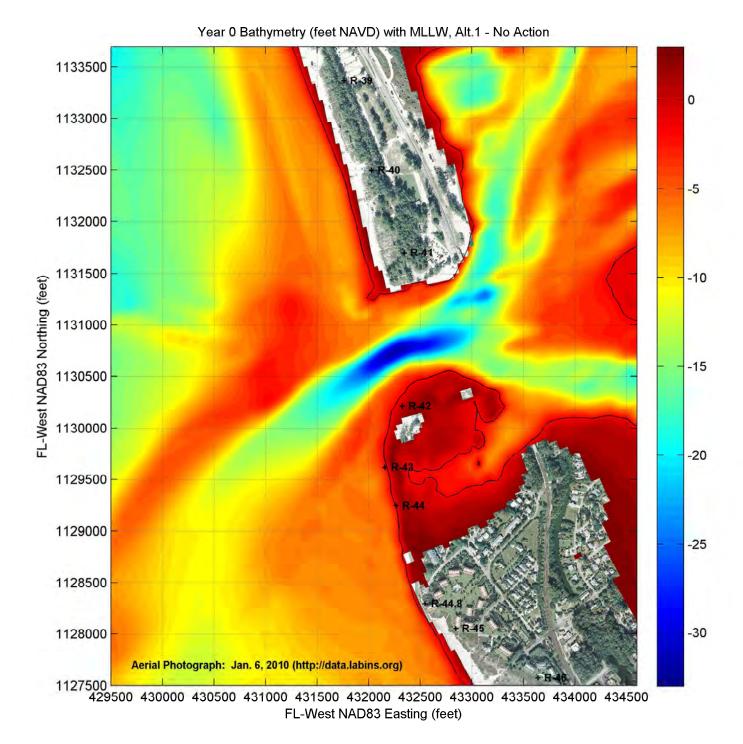
Sub-Appendix A-1

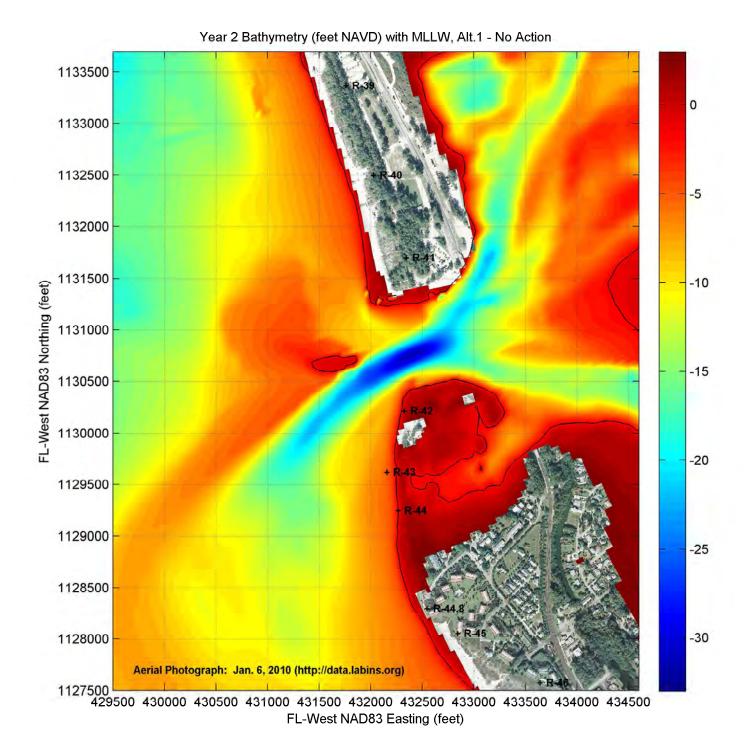
Model Results for Alternatives 1-7:

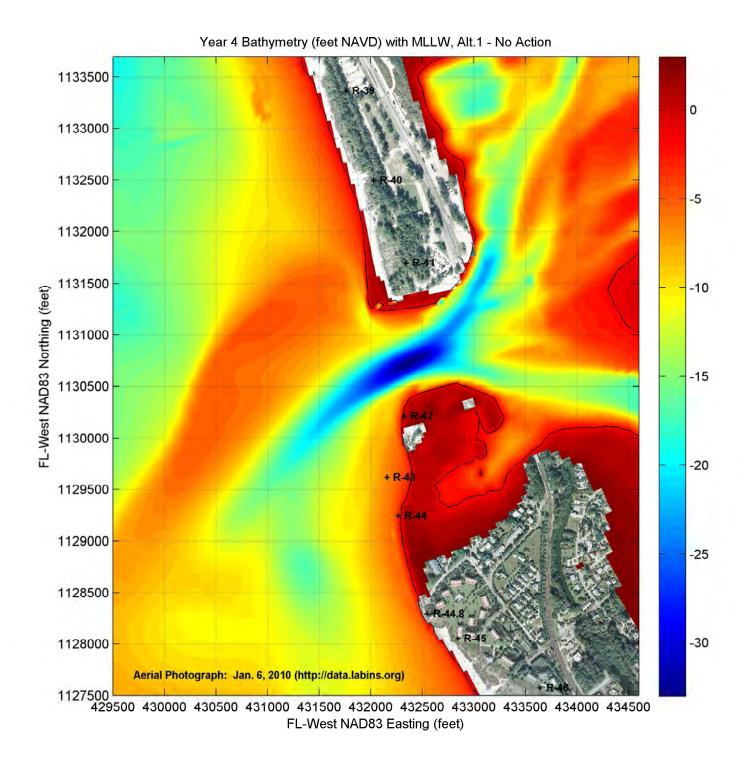
- Bathymetry at Years 0, 2, 4, 6, 8
- Bathymetric Changes
- Impacts and Benefits
- Beachfront Volumetric Changes

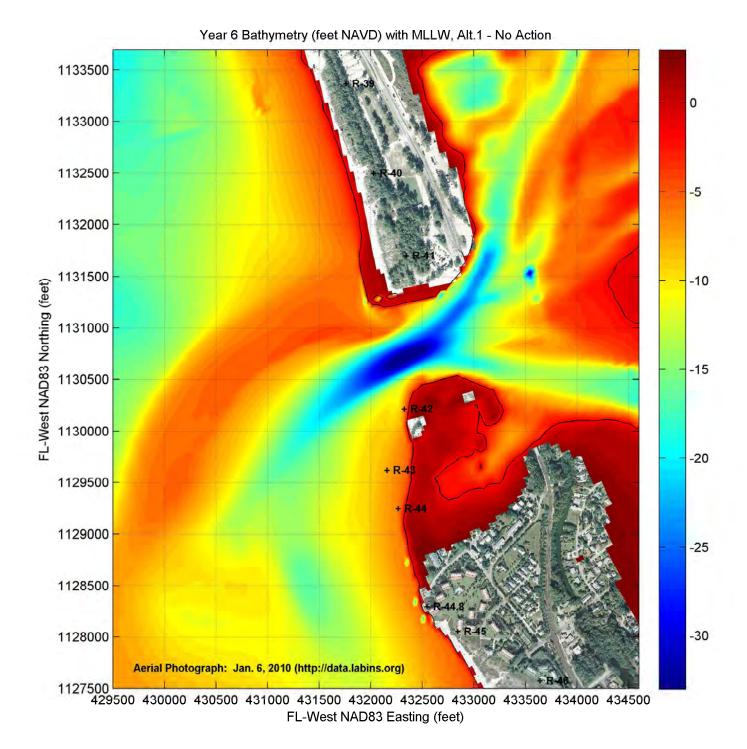
Typical Current Plots for No Action and Selected Plan

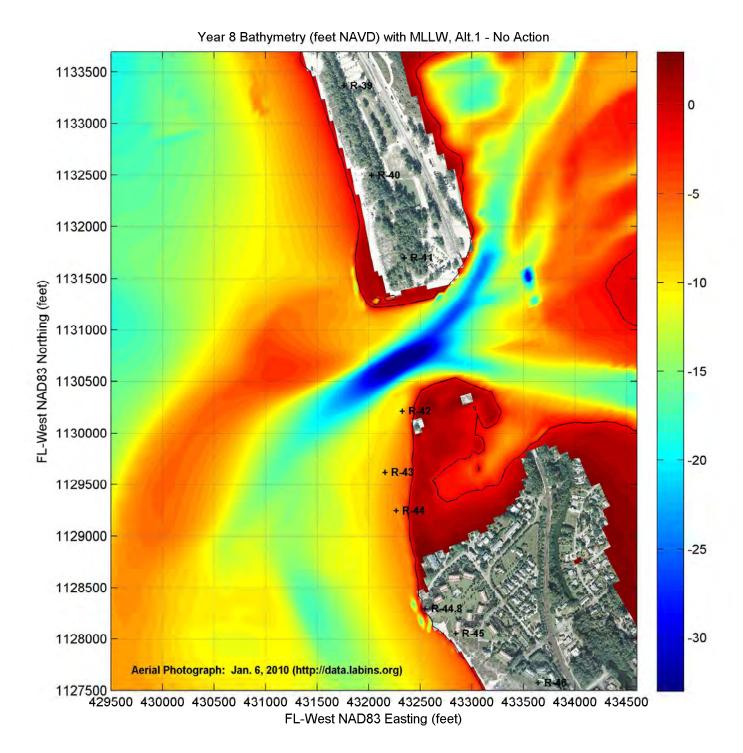
(Note: Results provided in electronic PDF format only)

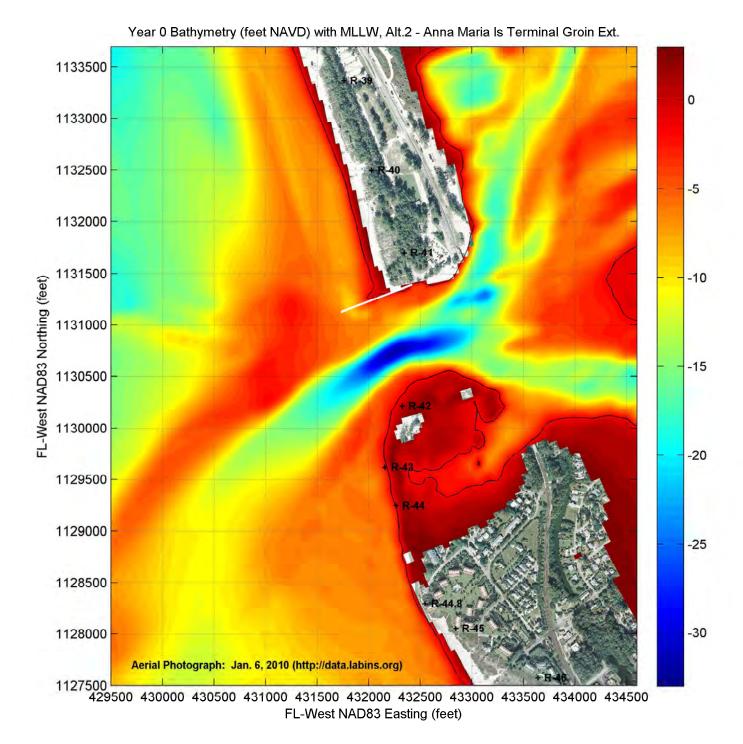


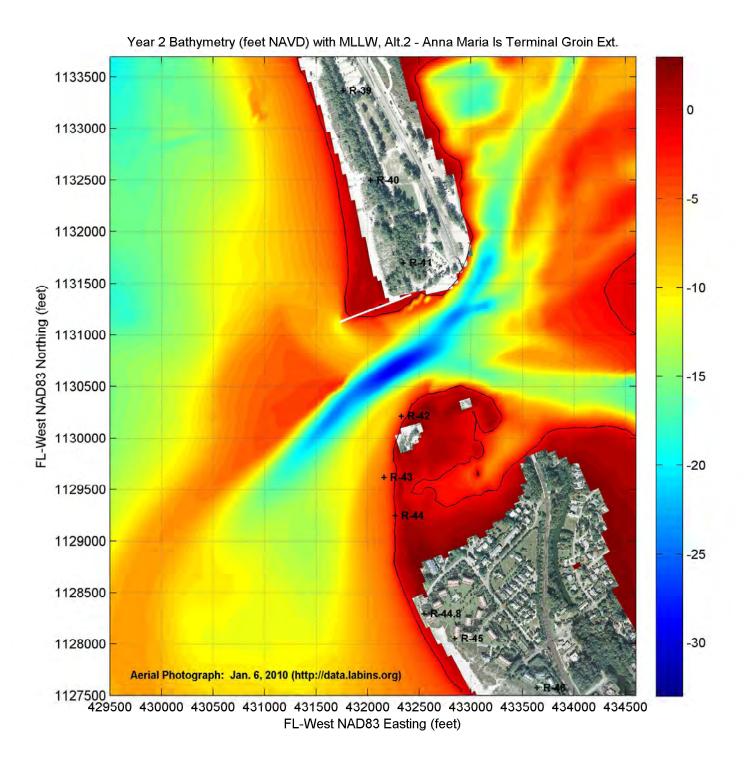


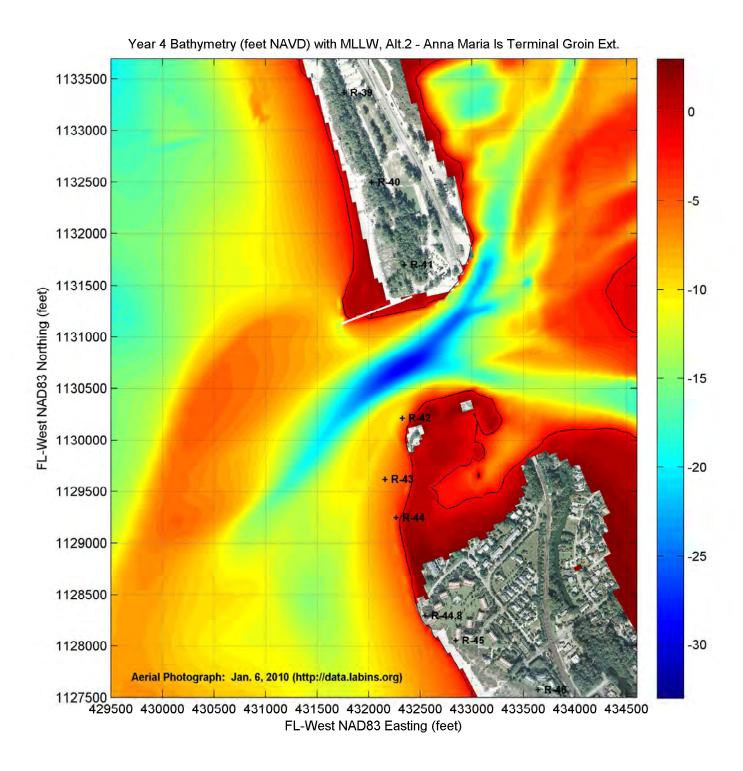


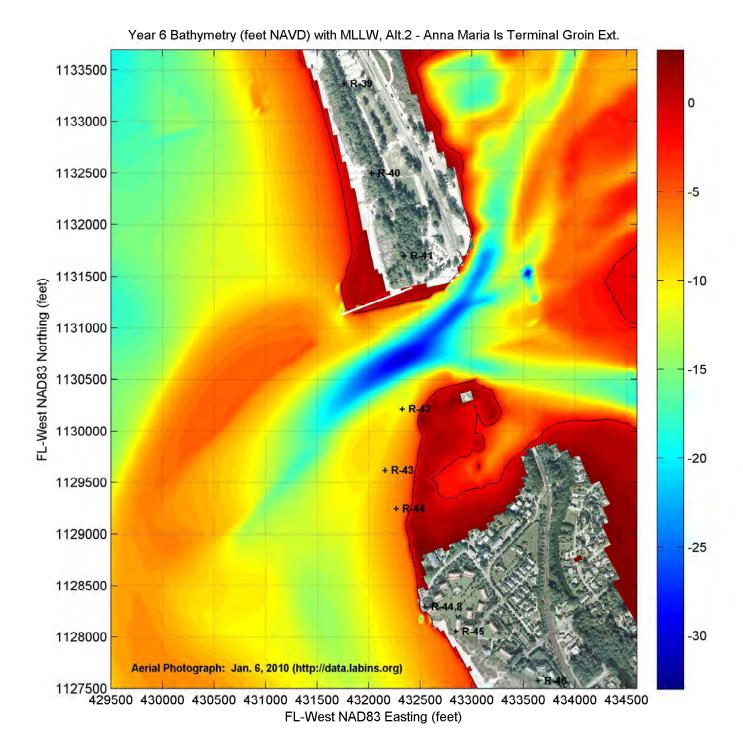


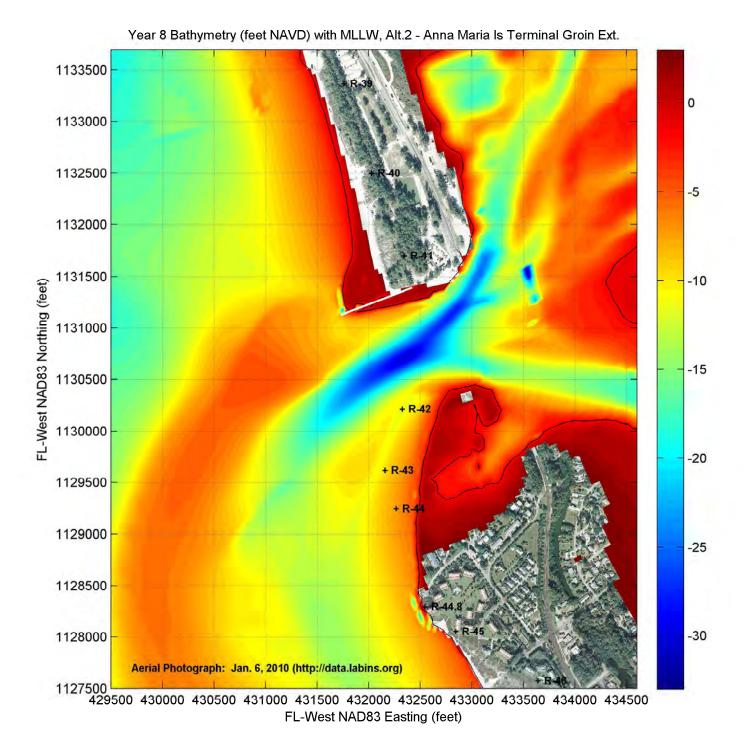


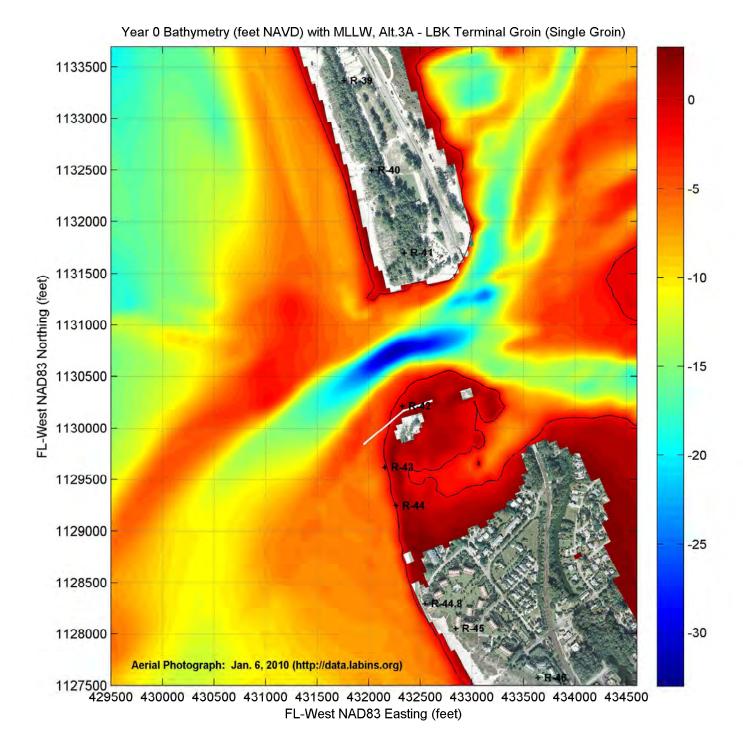


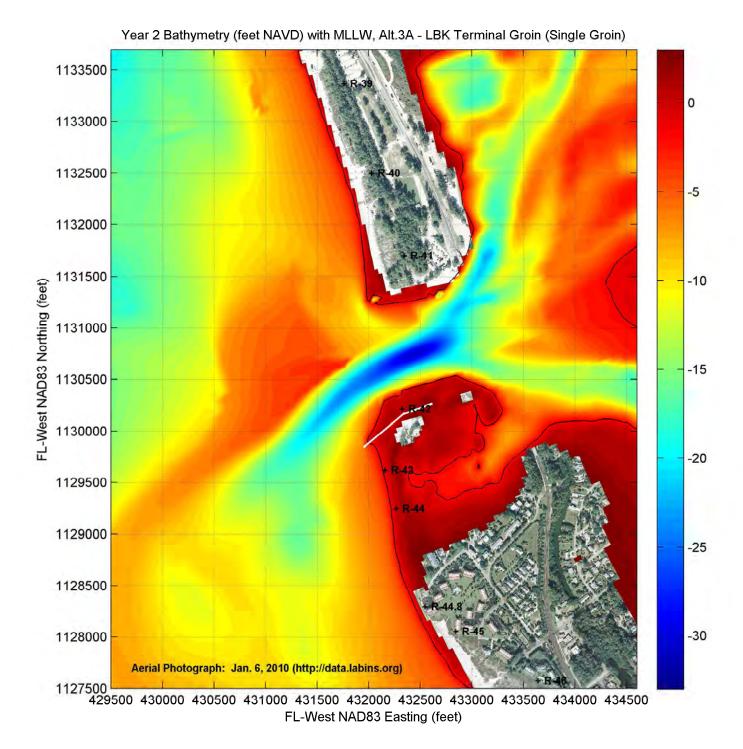


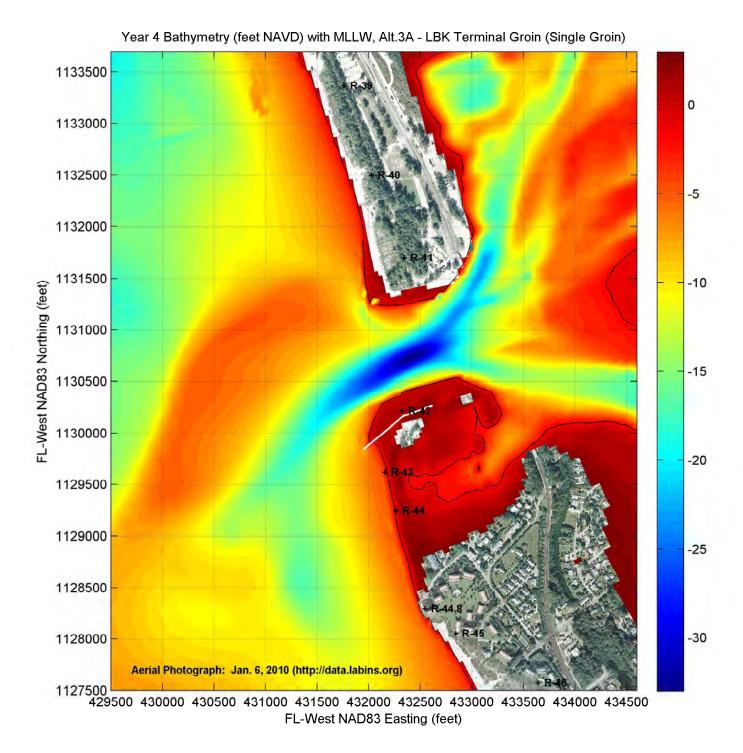


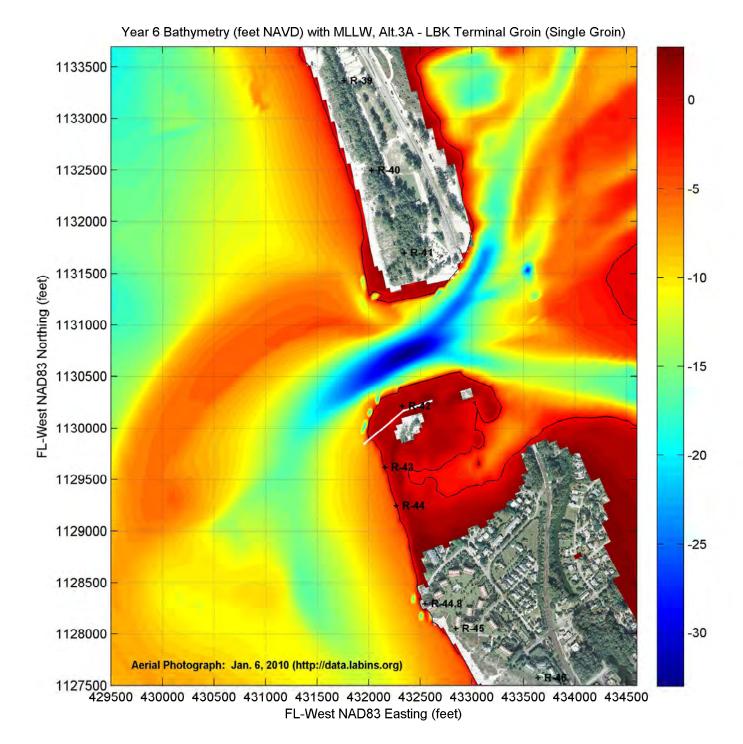


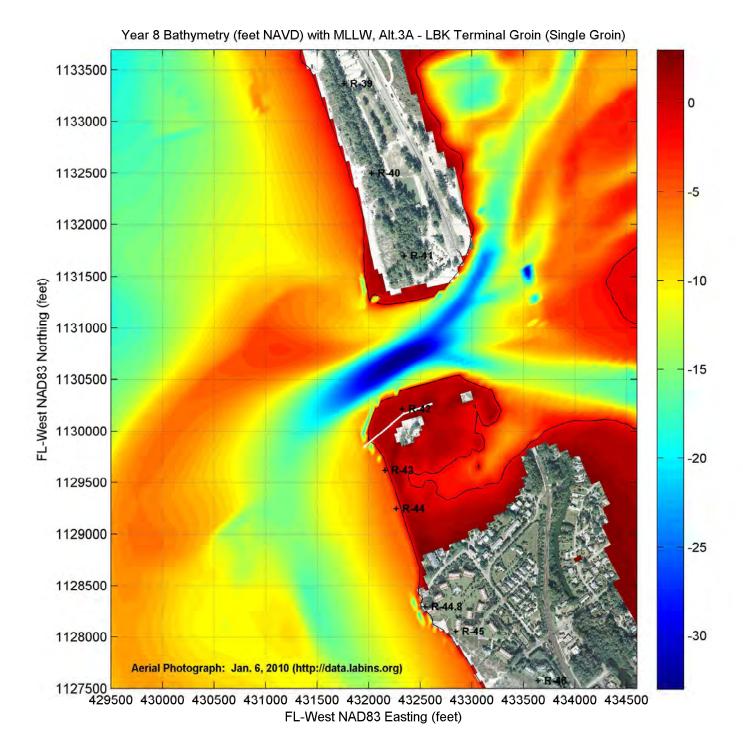


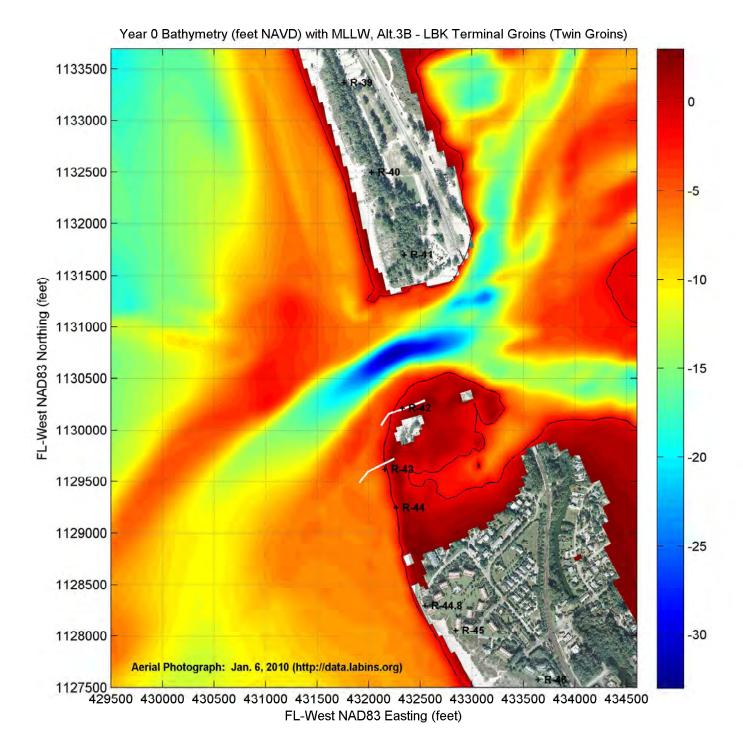


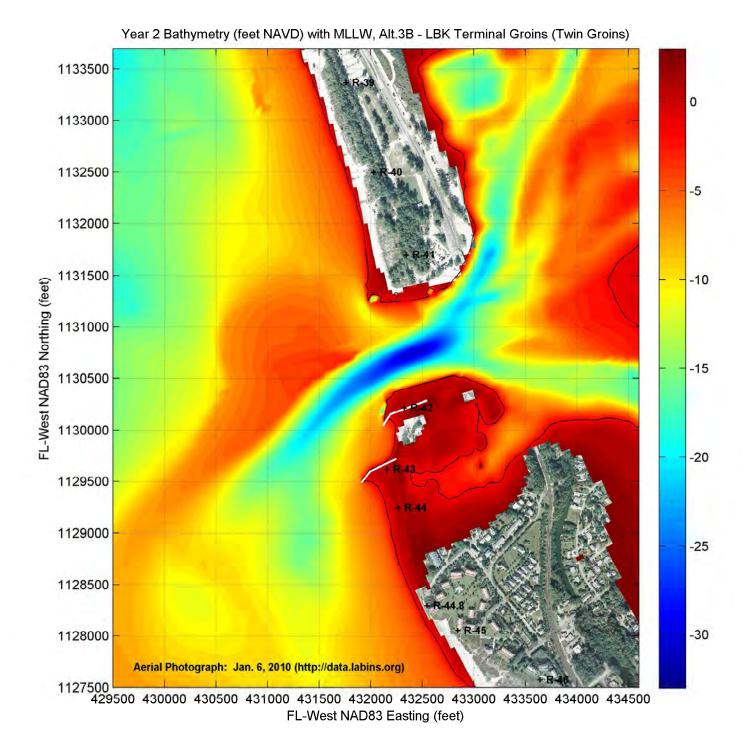


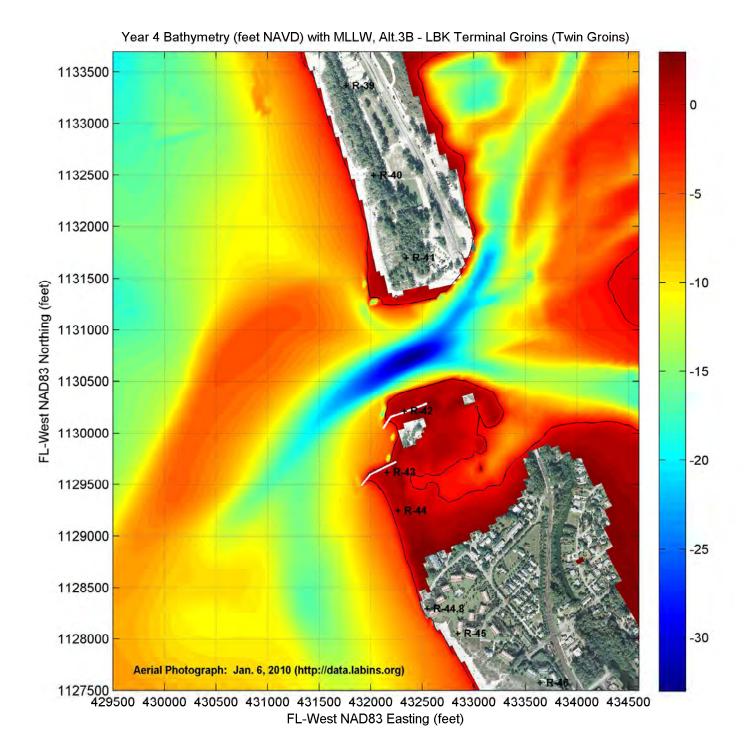


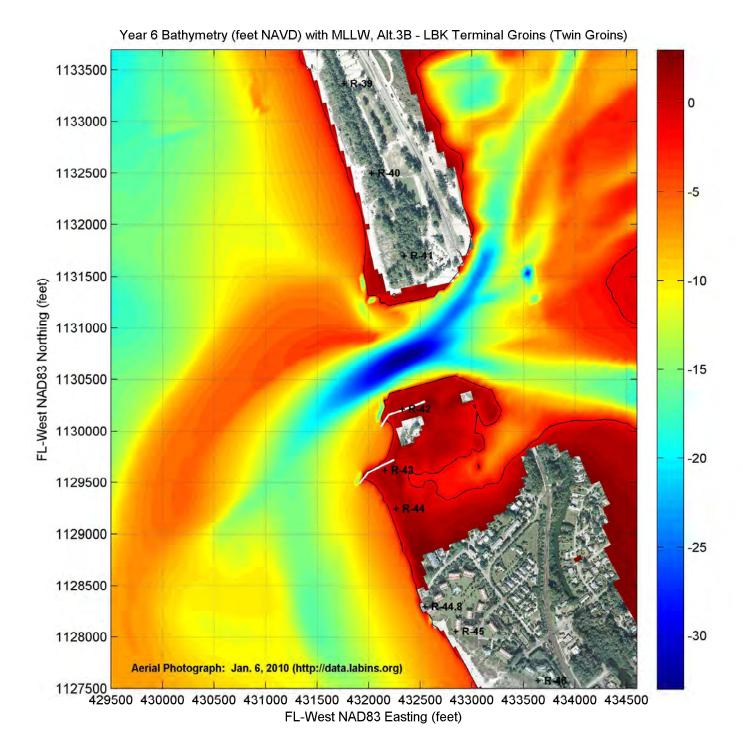


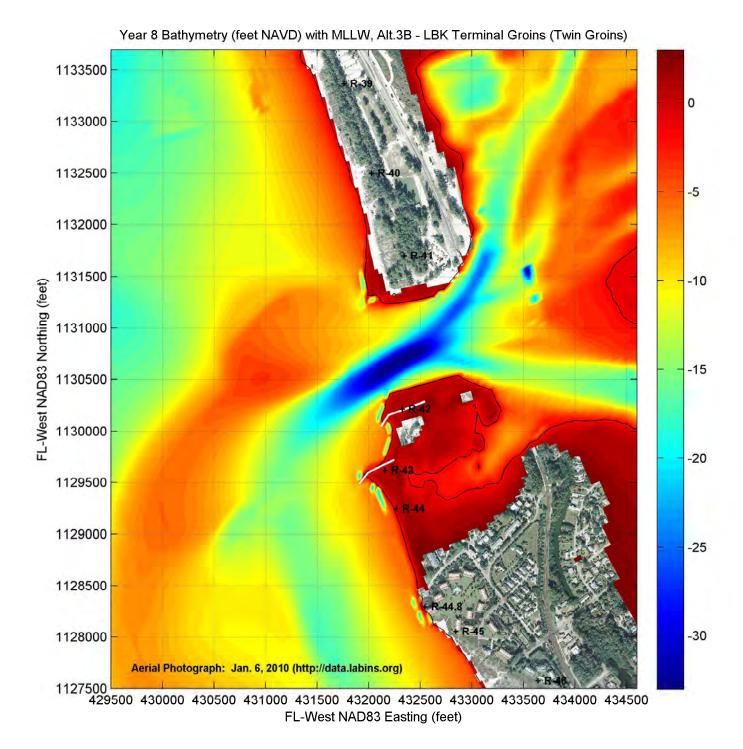


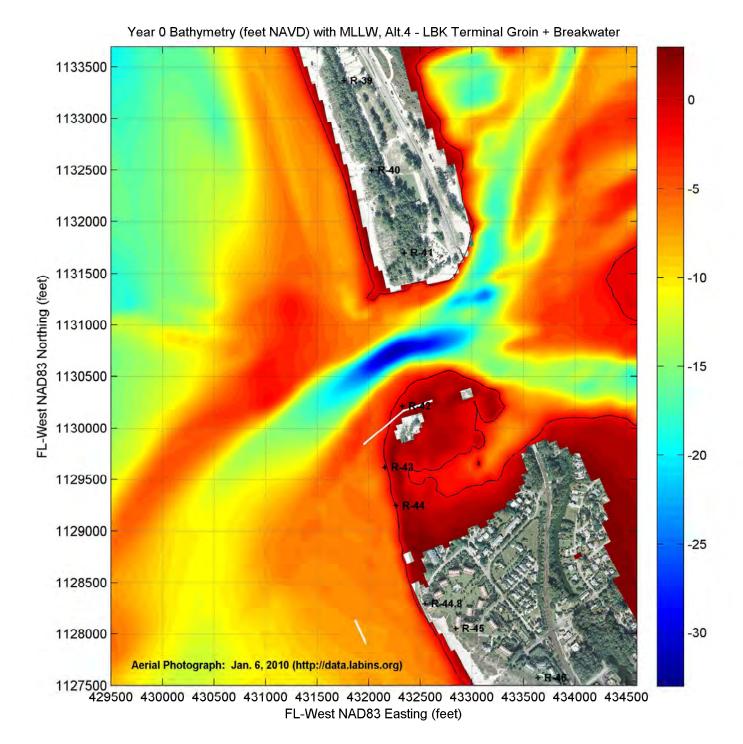


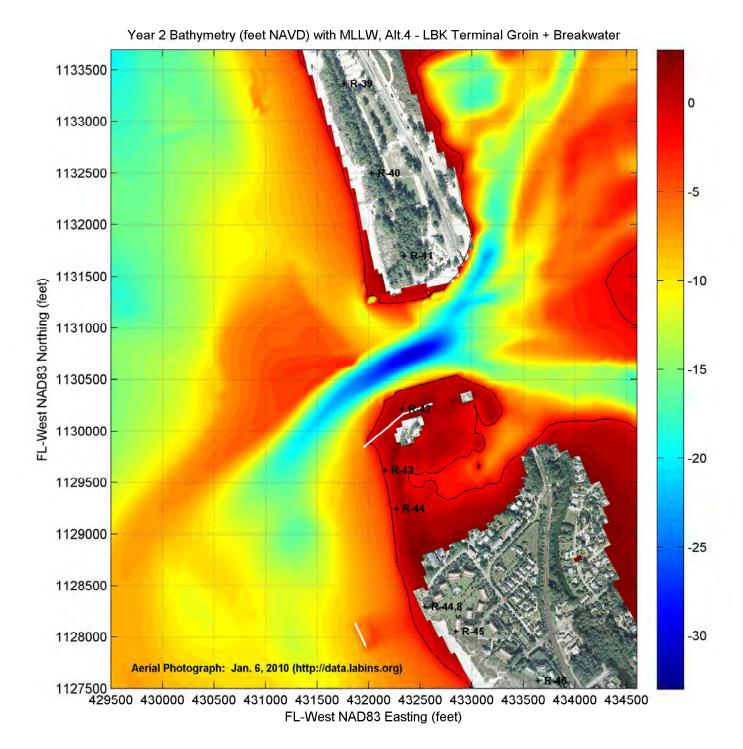


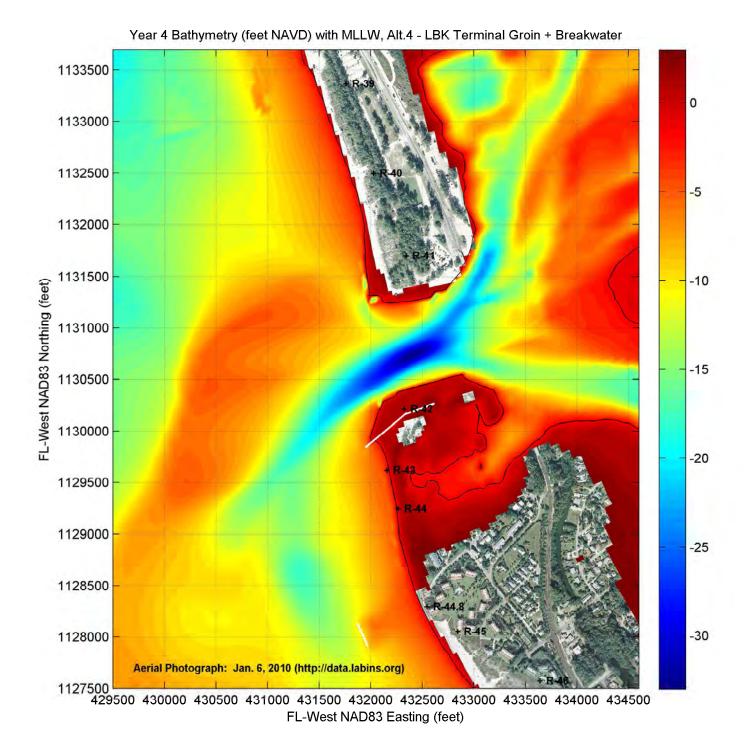


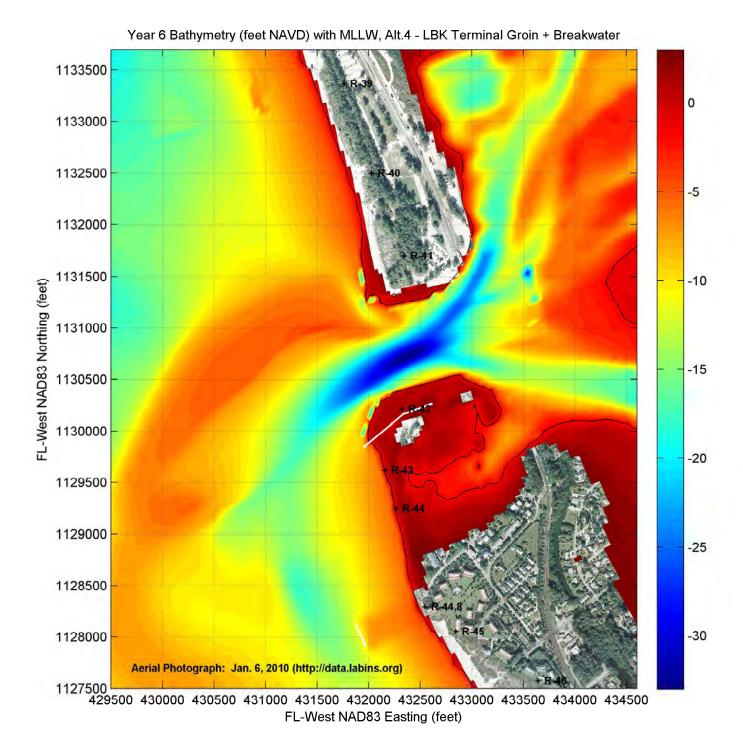


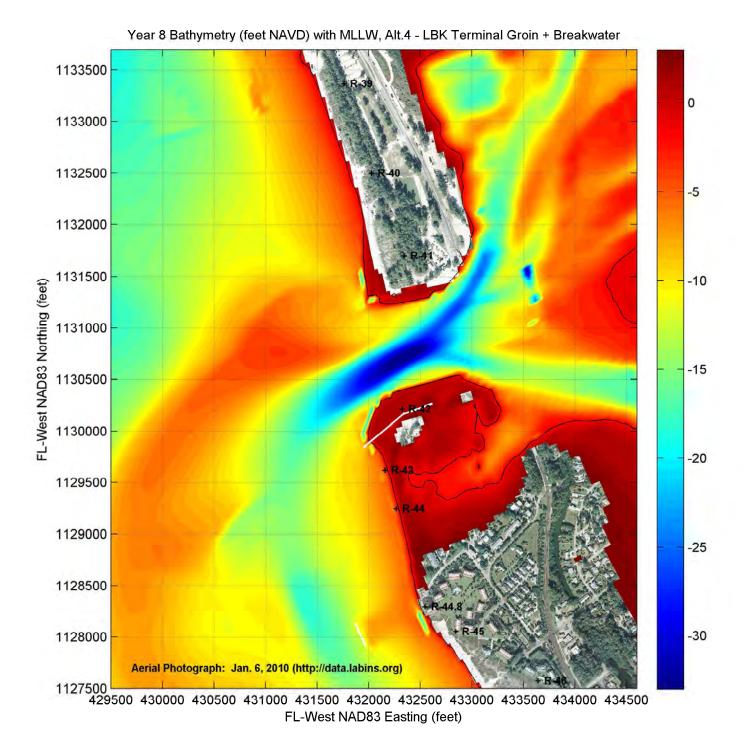


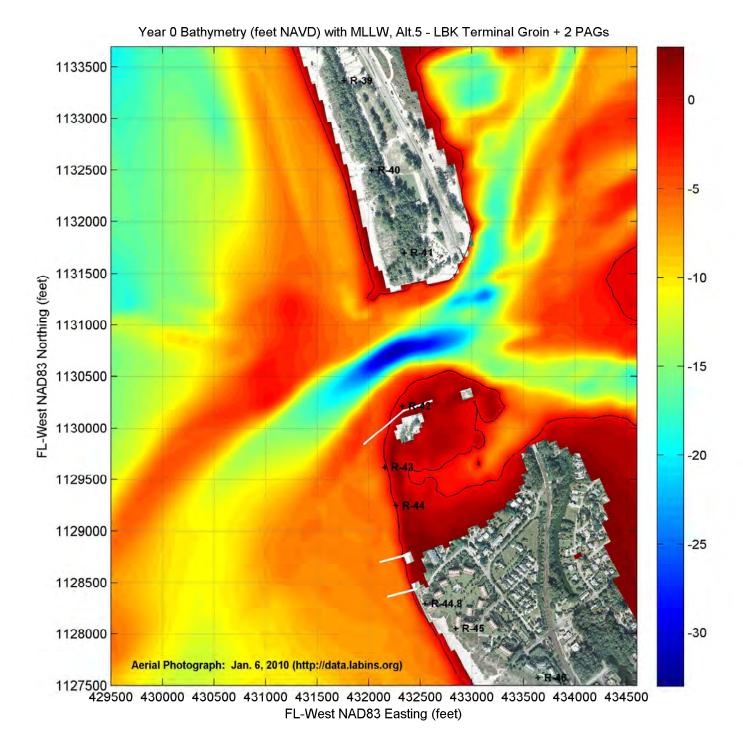


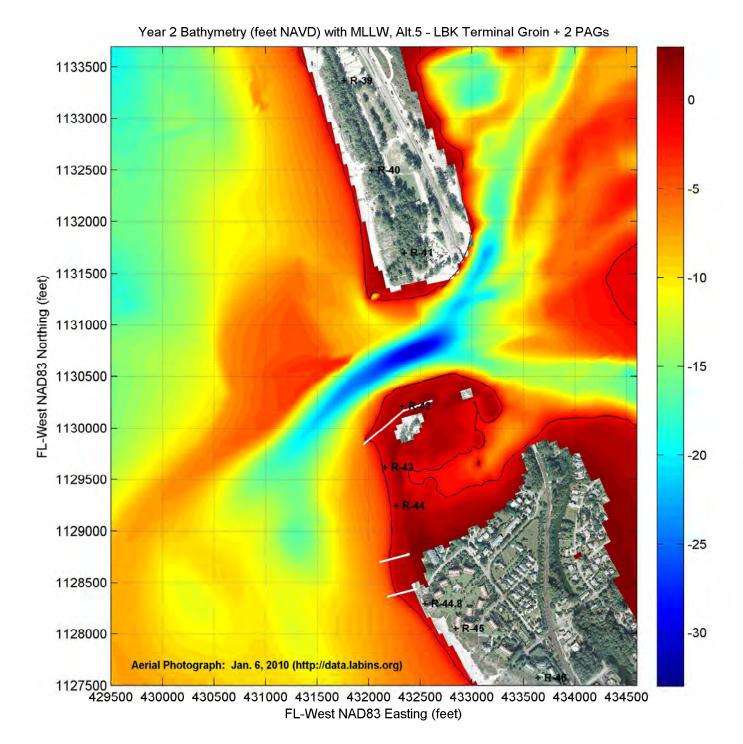


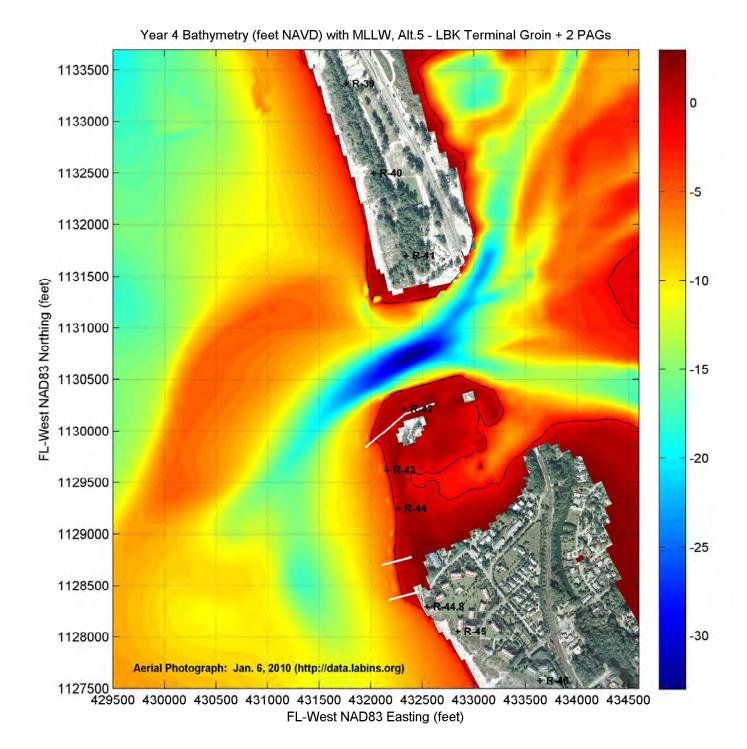


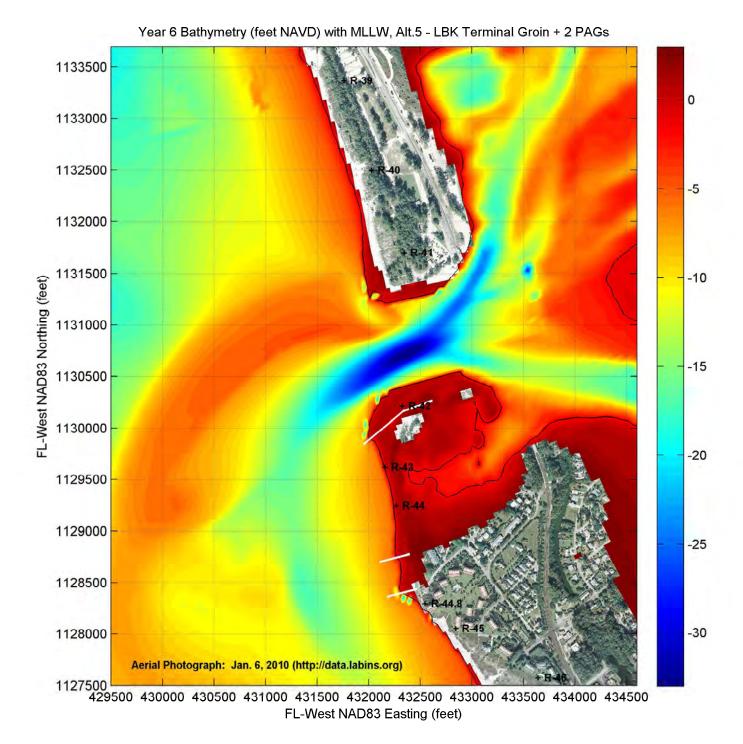


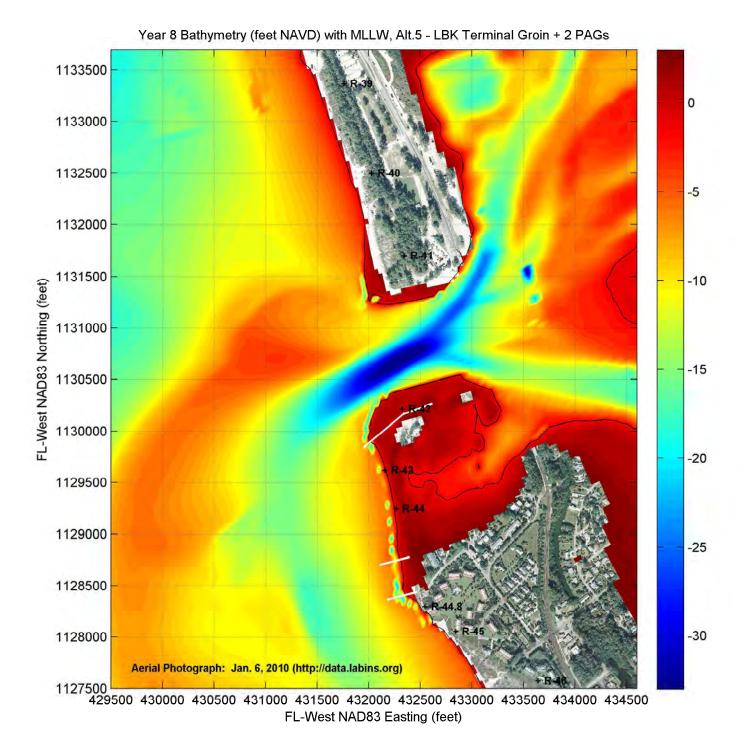


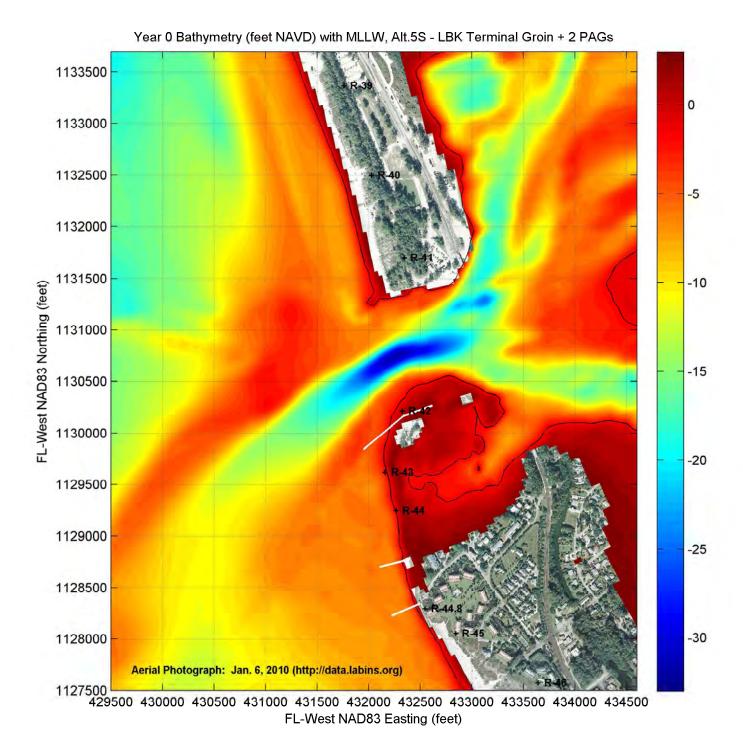


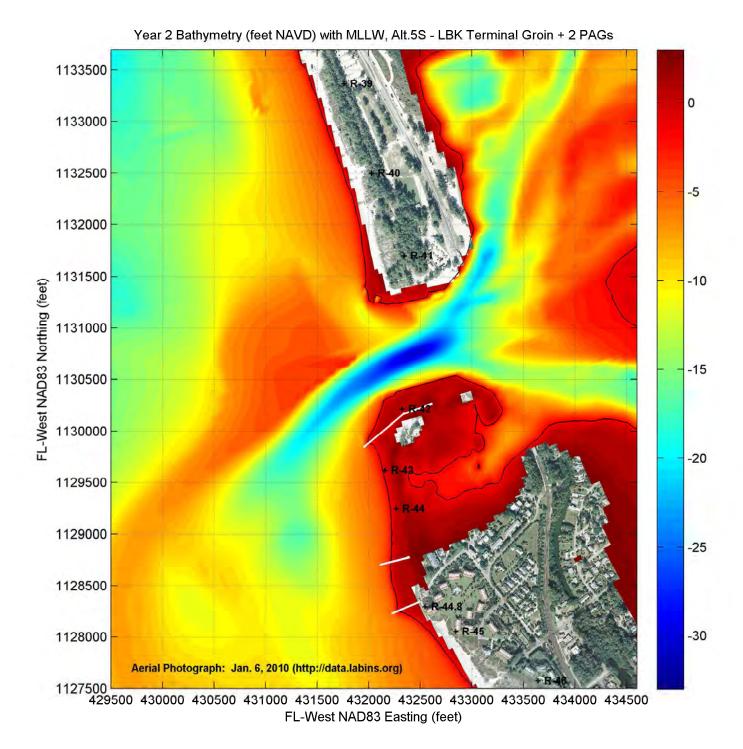


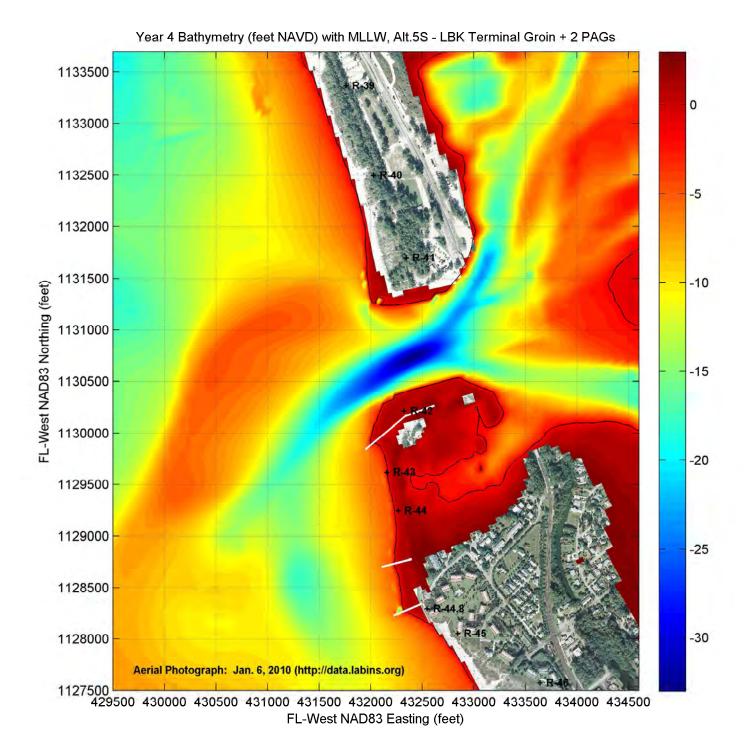


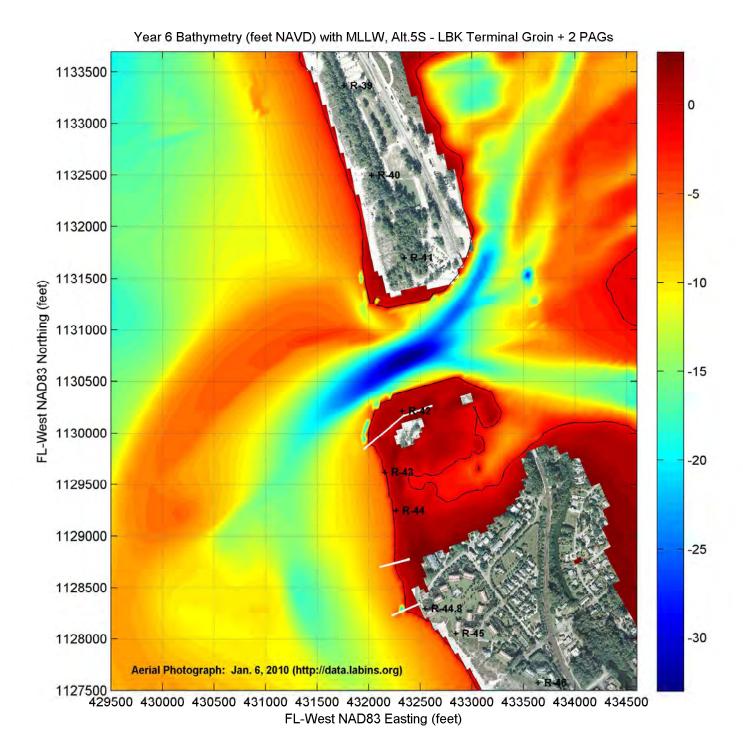


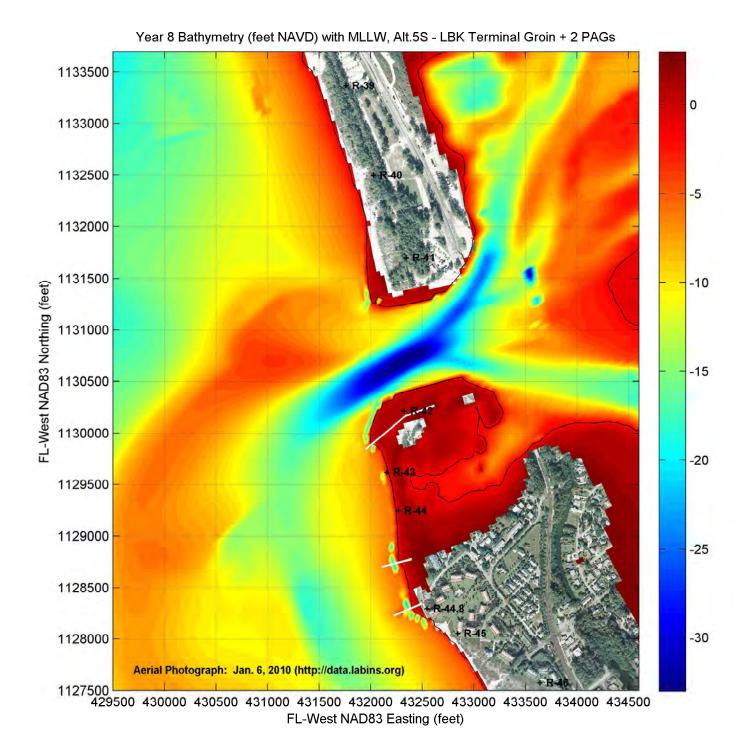




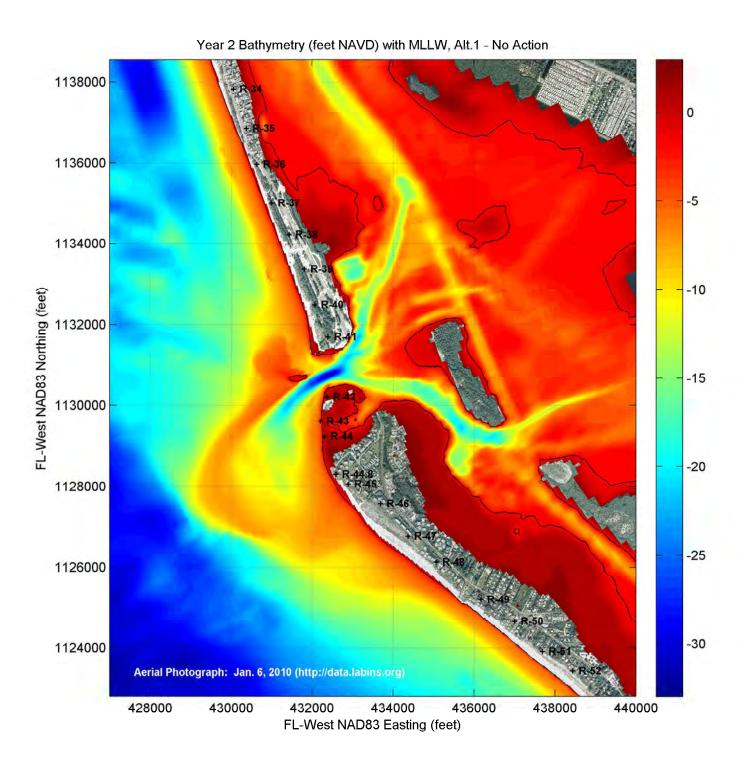


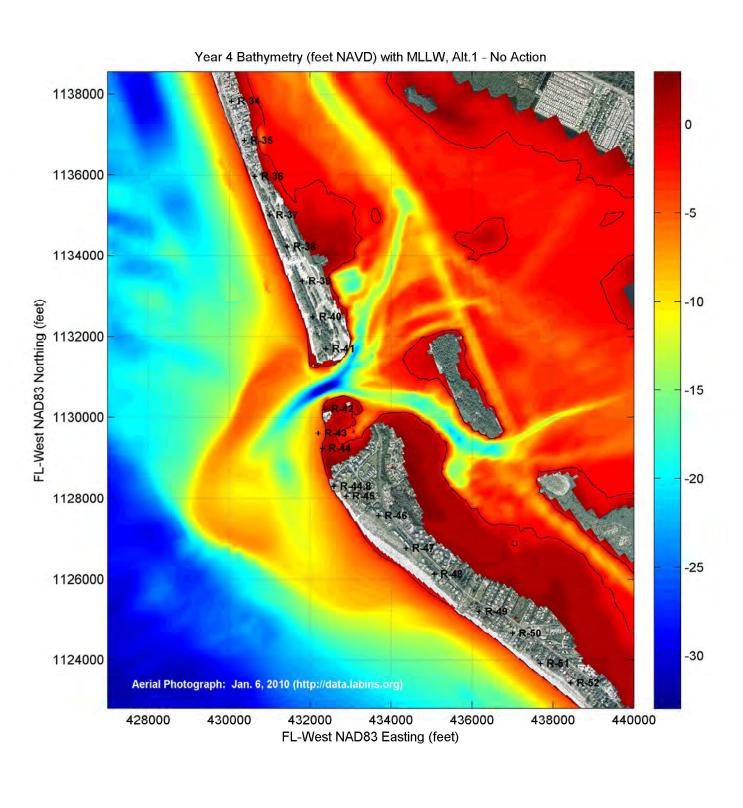


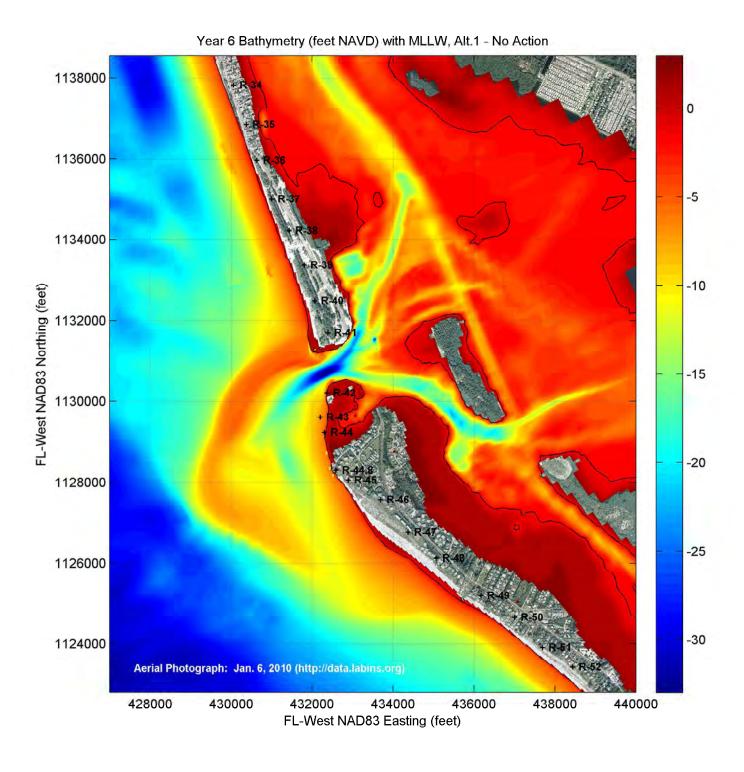




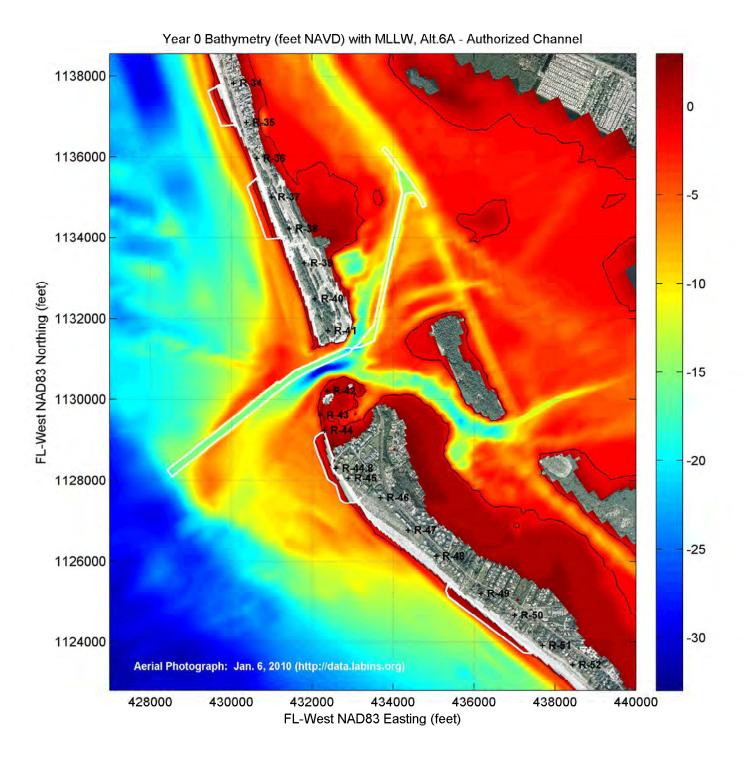
Year 0 Bathymetry (feet NAVD) with MLLW, Alt.1 - No Action -5 -10 FL-West NAD83 Northing (feet) -15 -20 -25 -30 Aerial Photograph: Jan. 6, 2010 (http://data.labins.org) FL-West NAD83 Easting (feet)

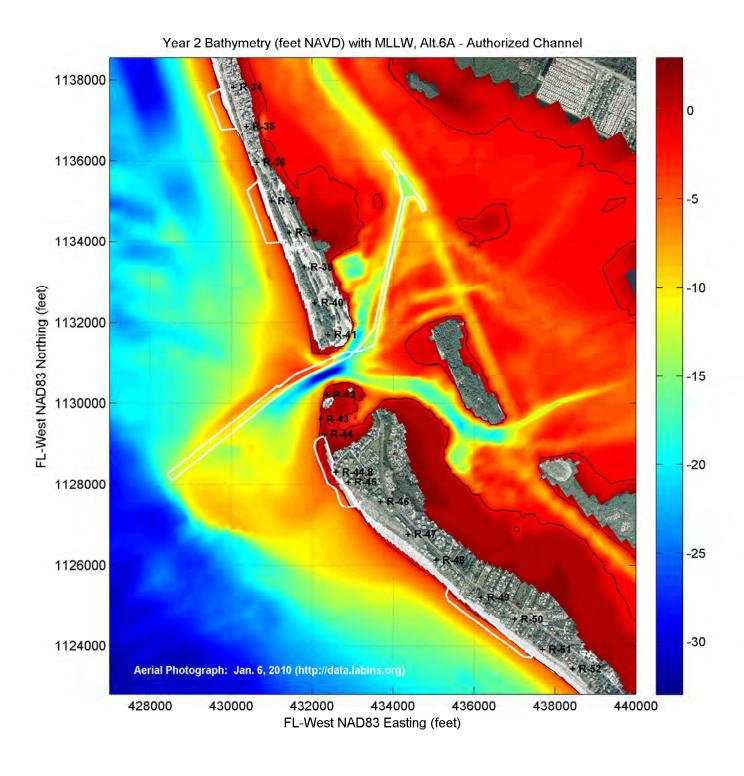


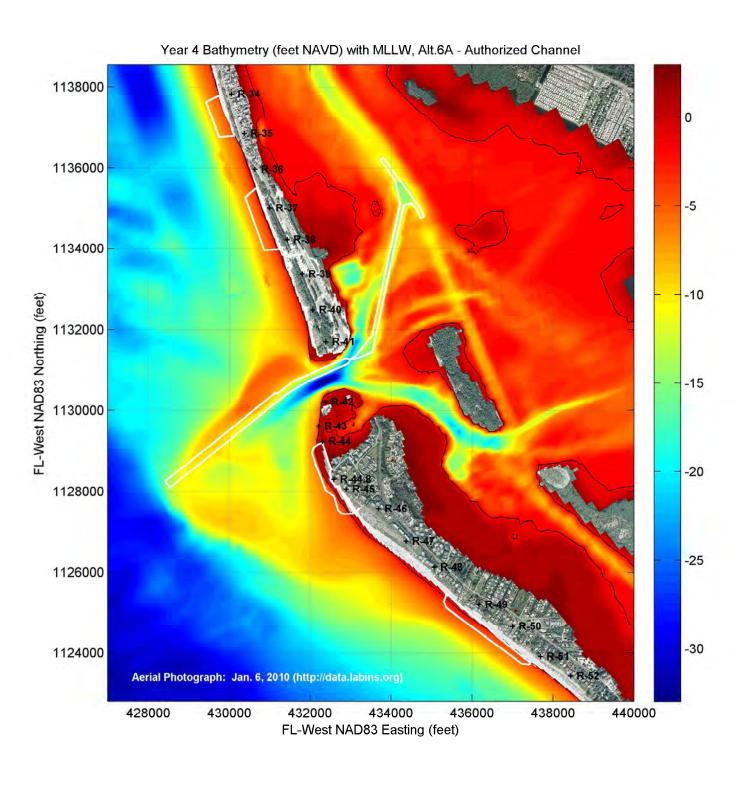


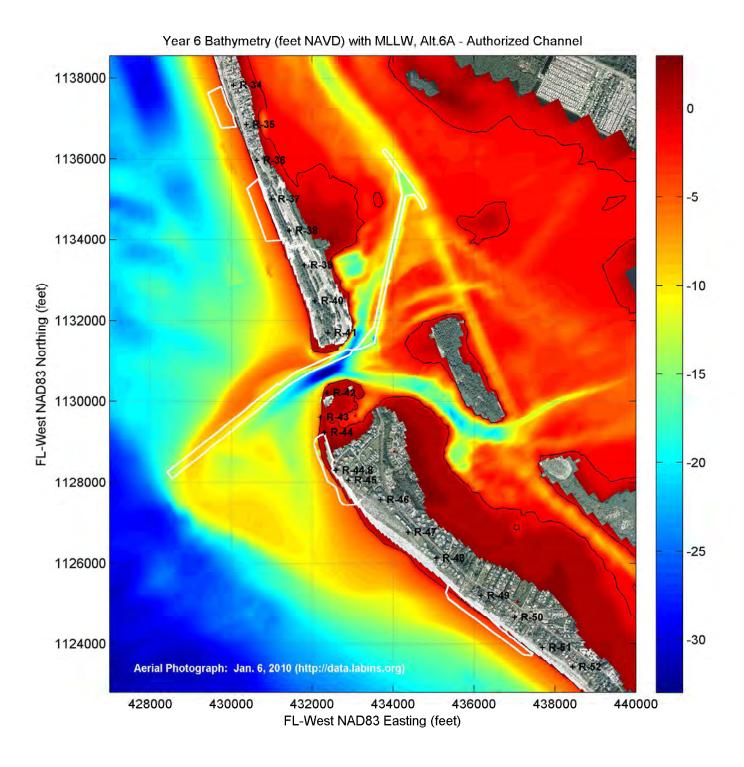


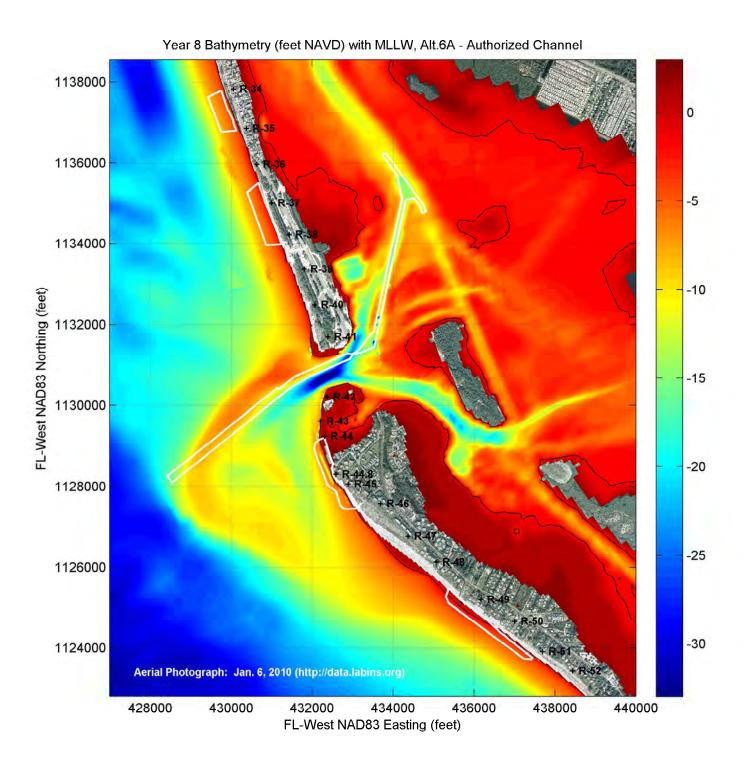
Year 8 Bathymetry (feet NAVD) with MLLW, Alt.1 - No Action -5 -10 FL-West NAD83 Northing (feet) -15 -20 -25 -30 Aerial Photograph: Jan. 6, 2010 (http://data.labins.org) FL-West NAD83 Easting (feet)

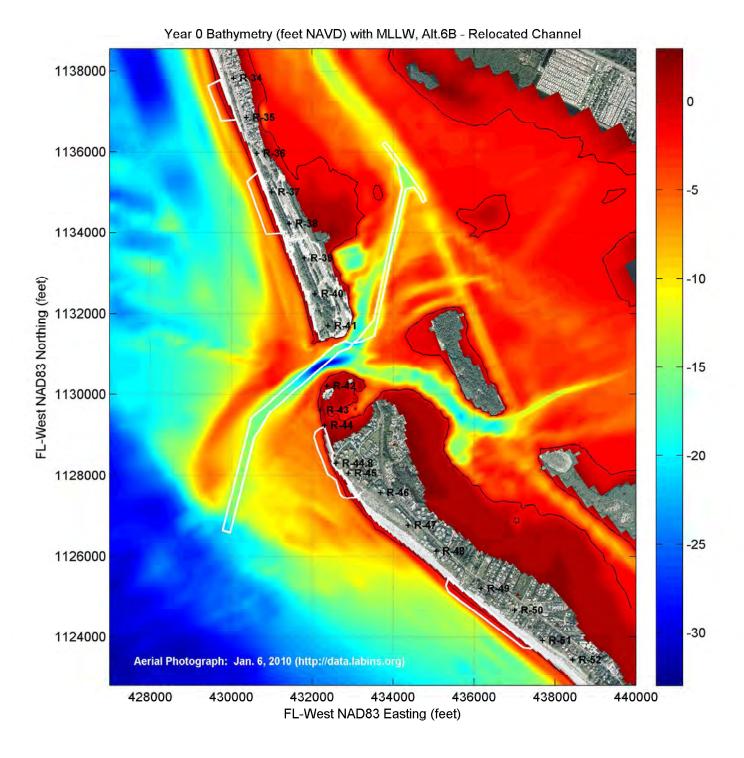


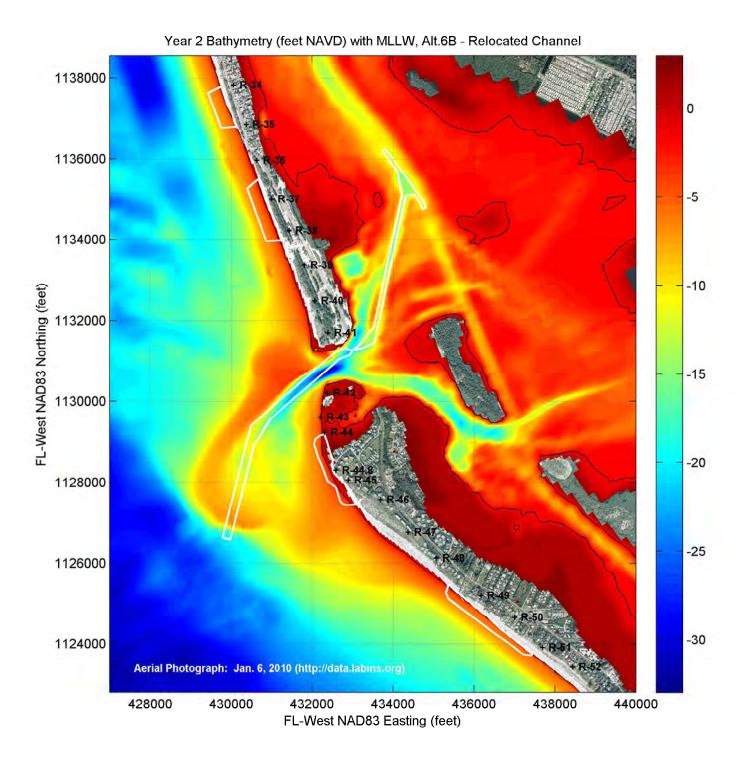


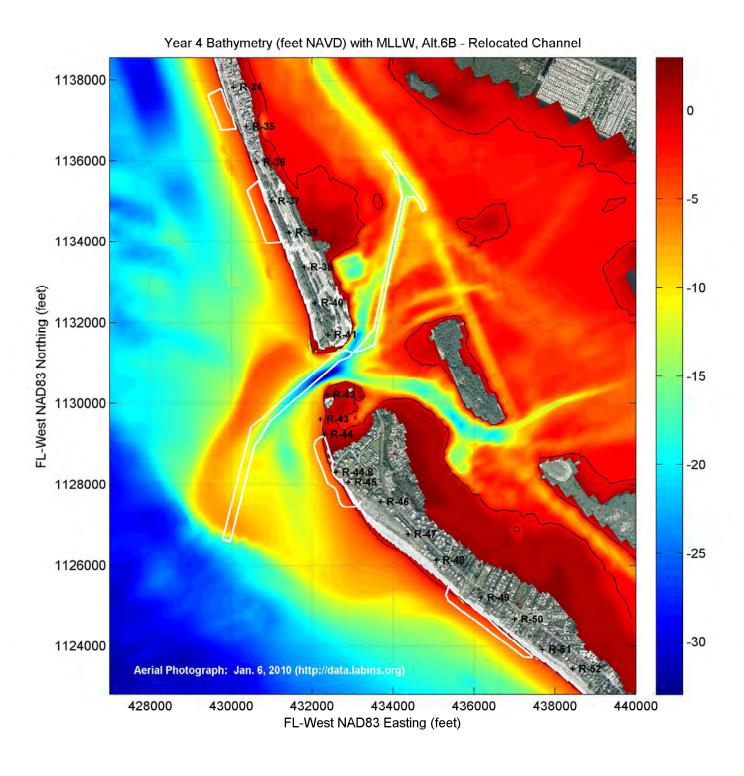


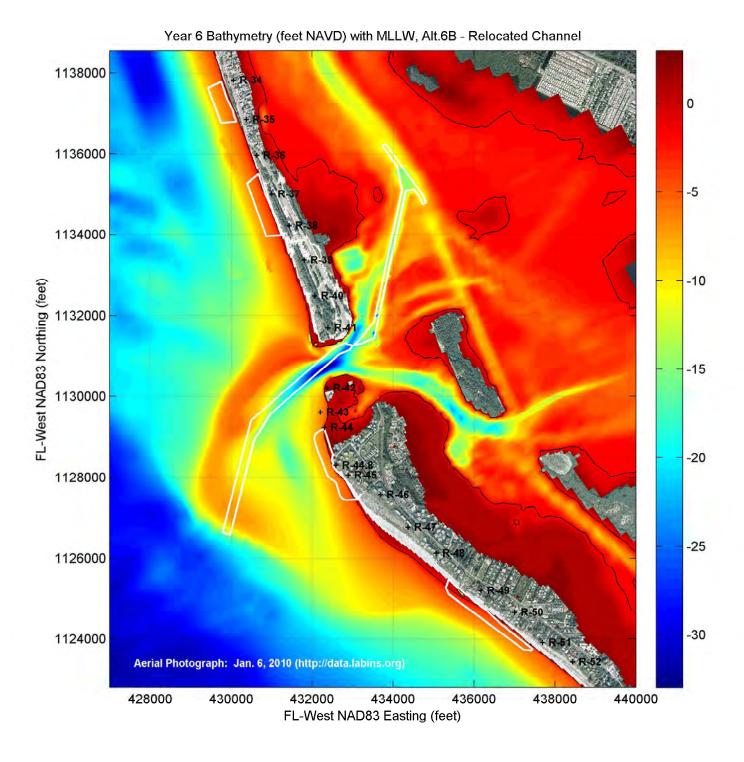


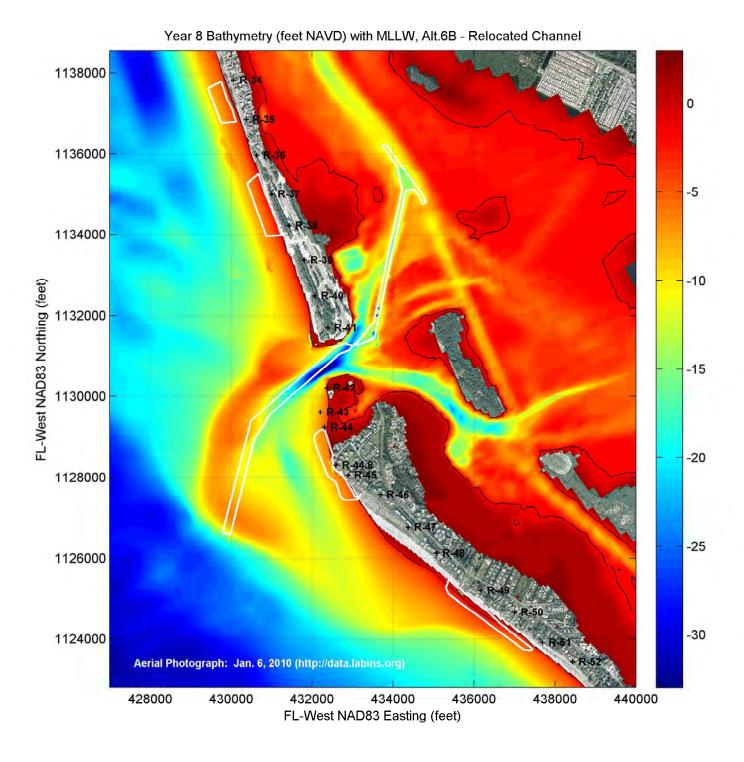


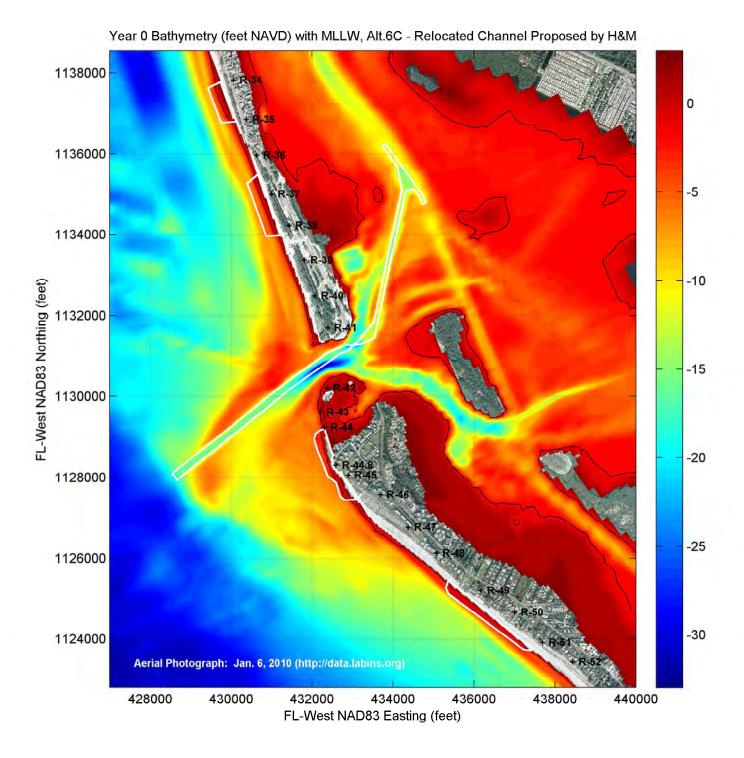


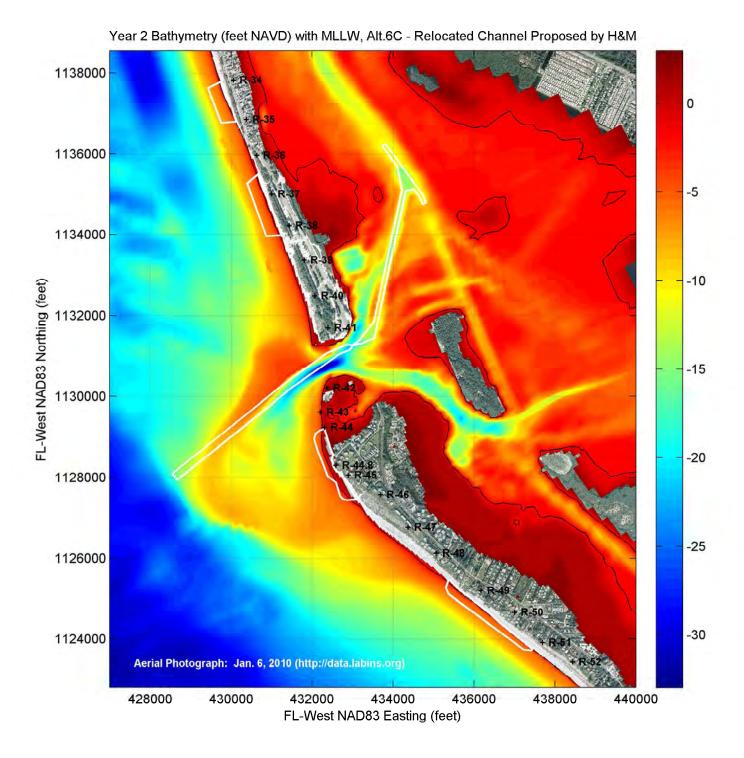


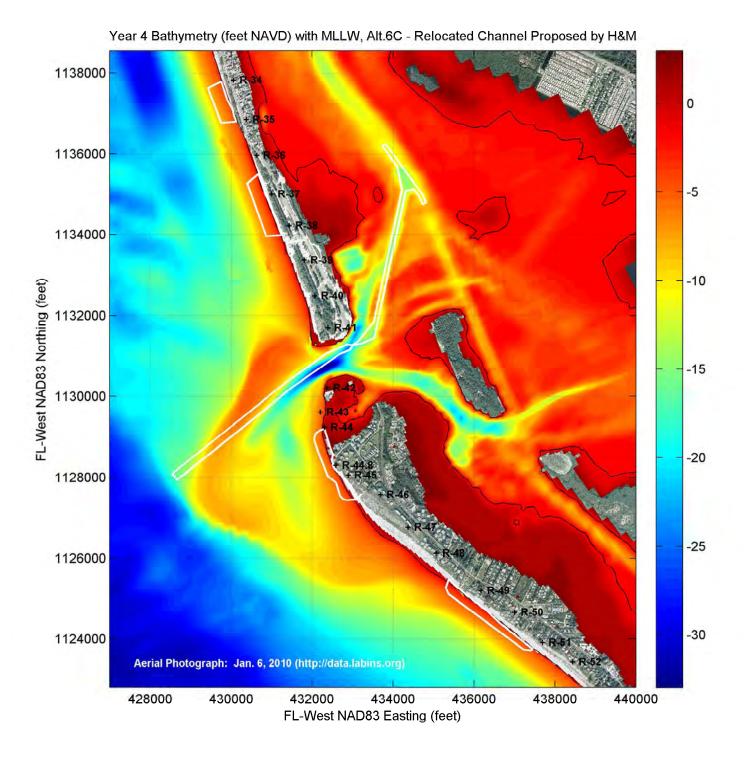


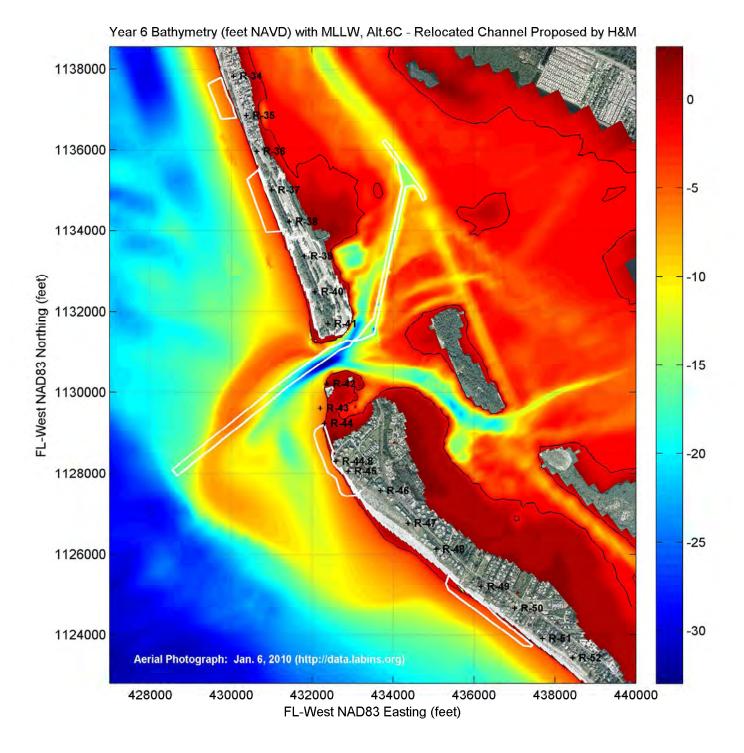


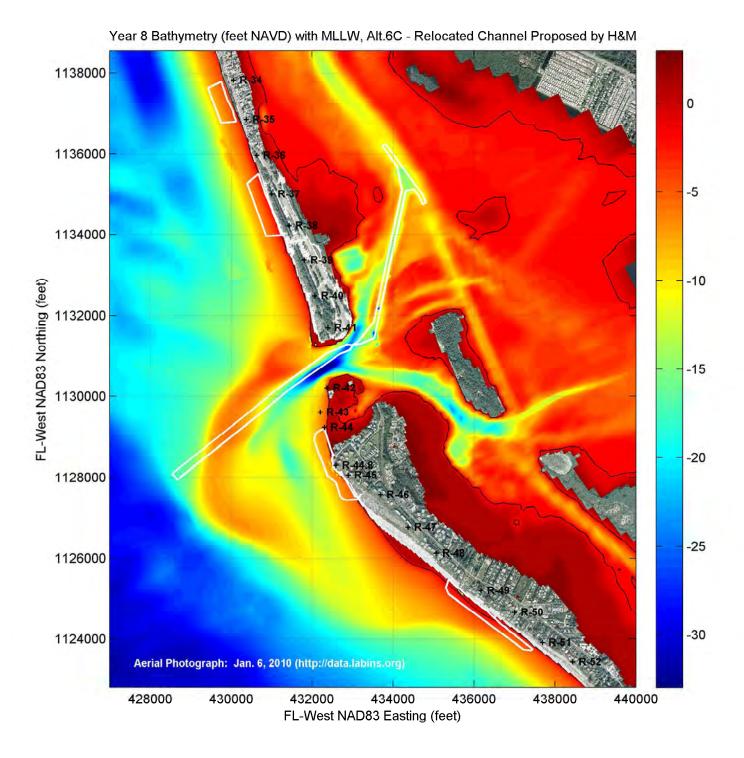


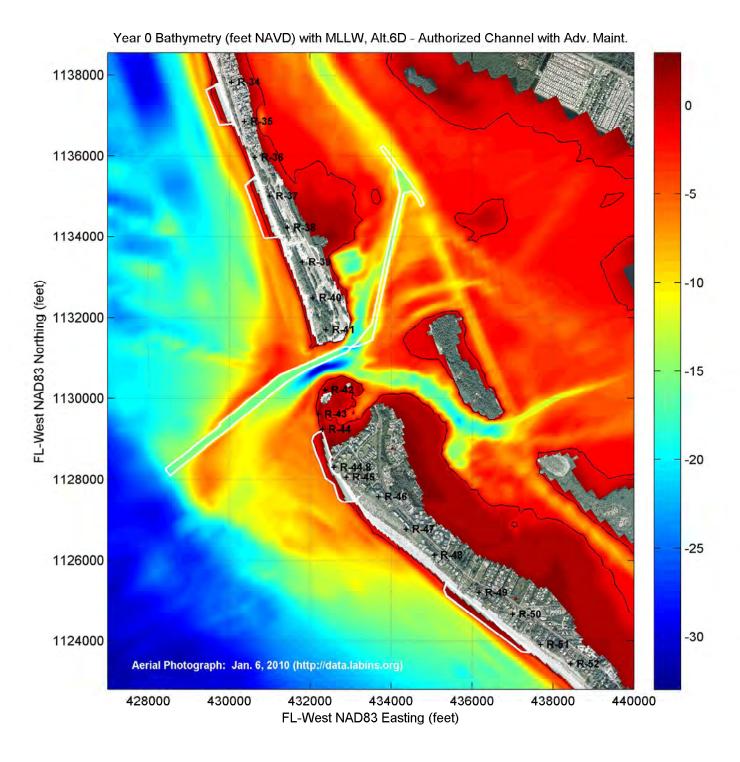


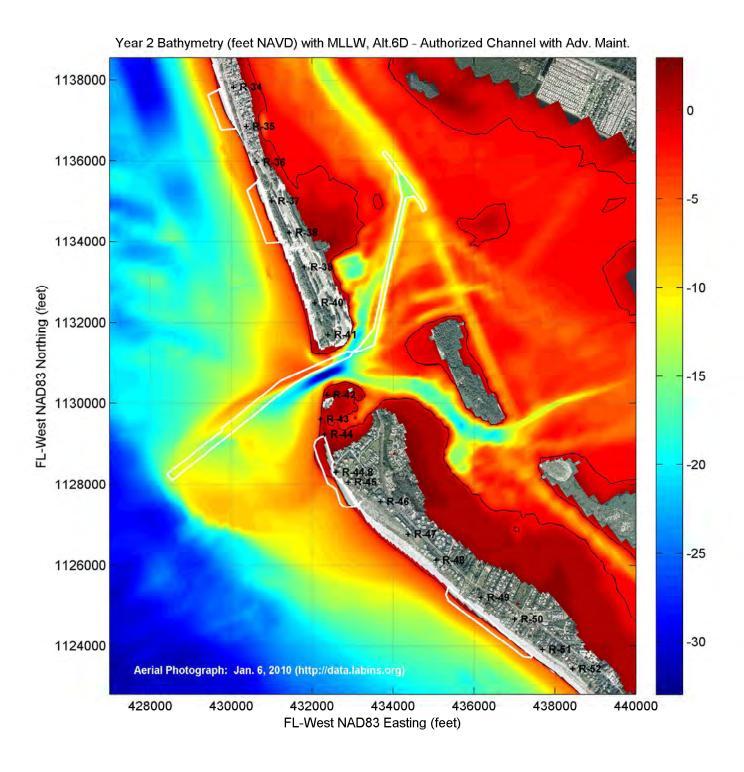


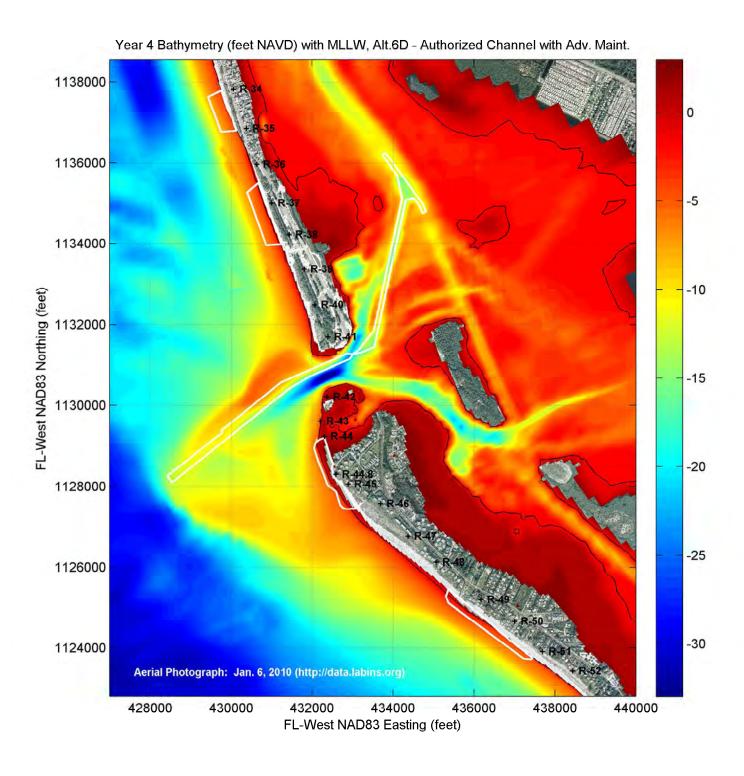


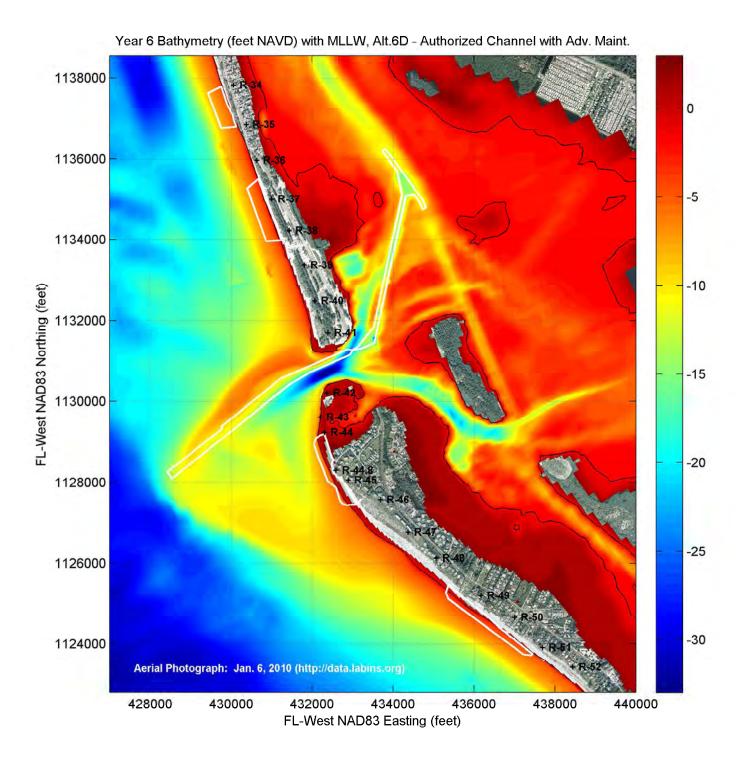


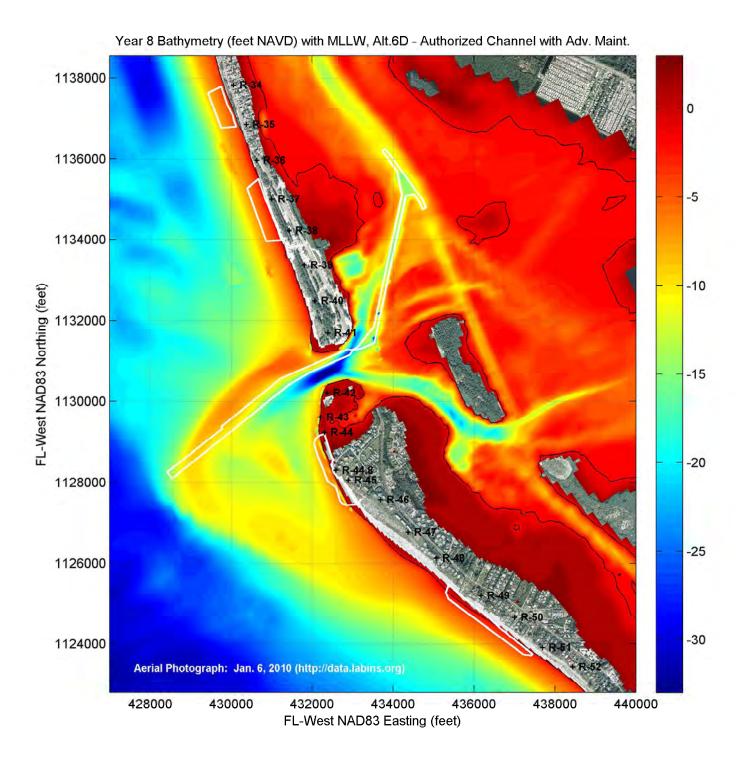


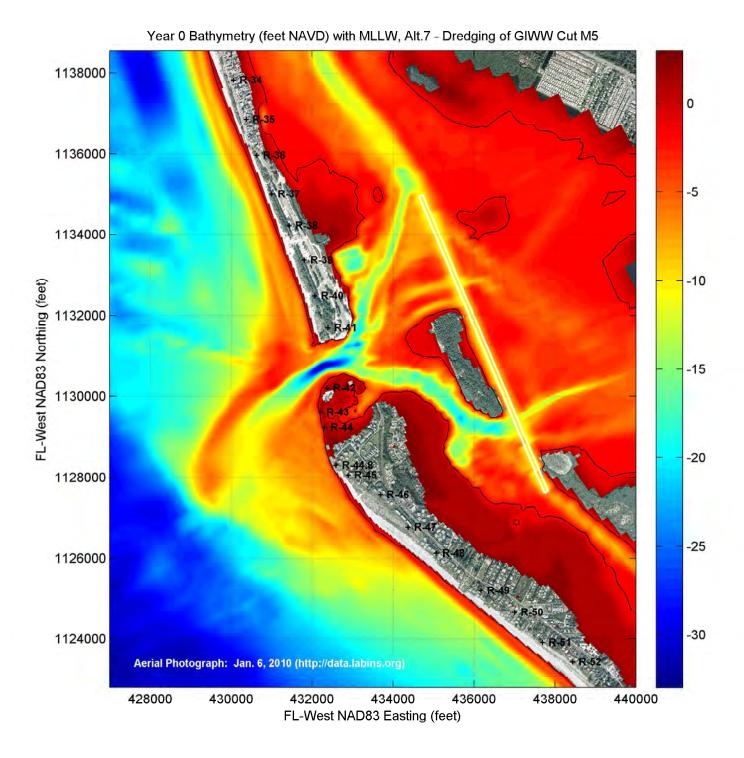


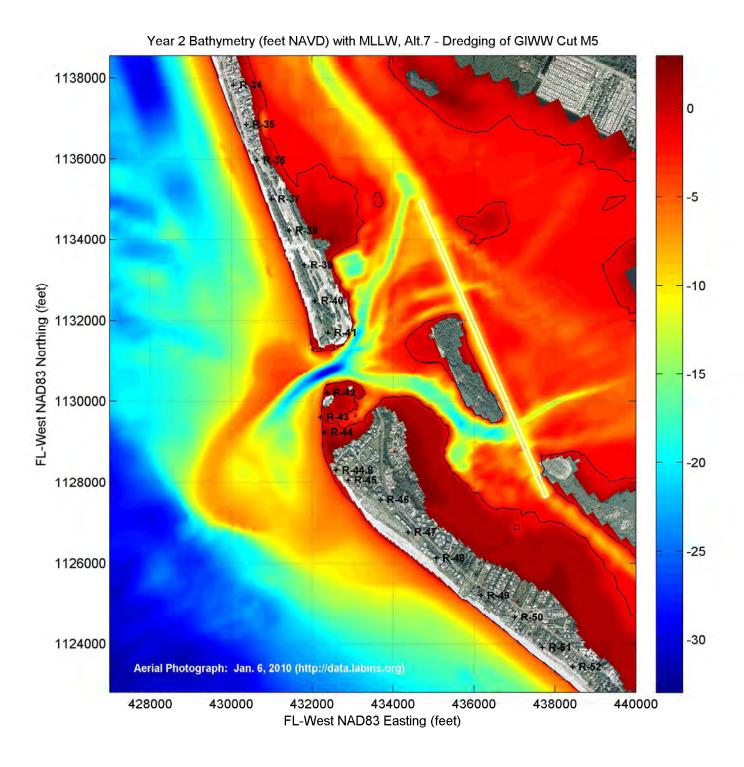


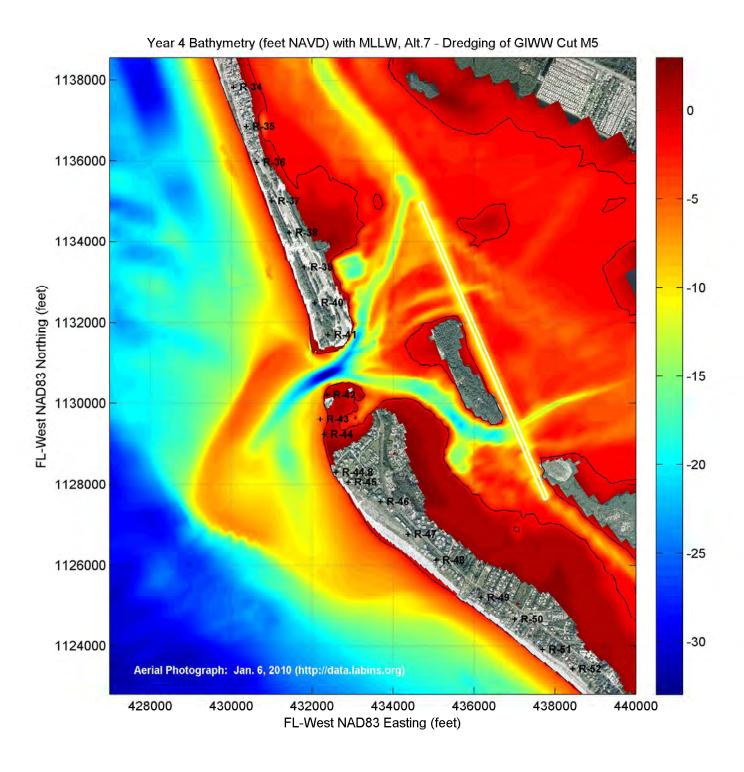


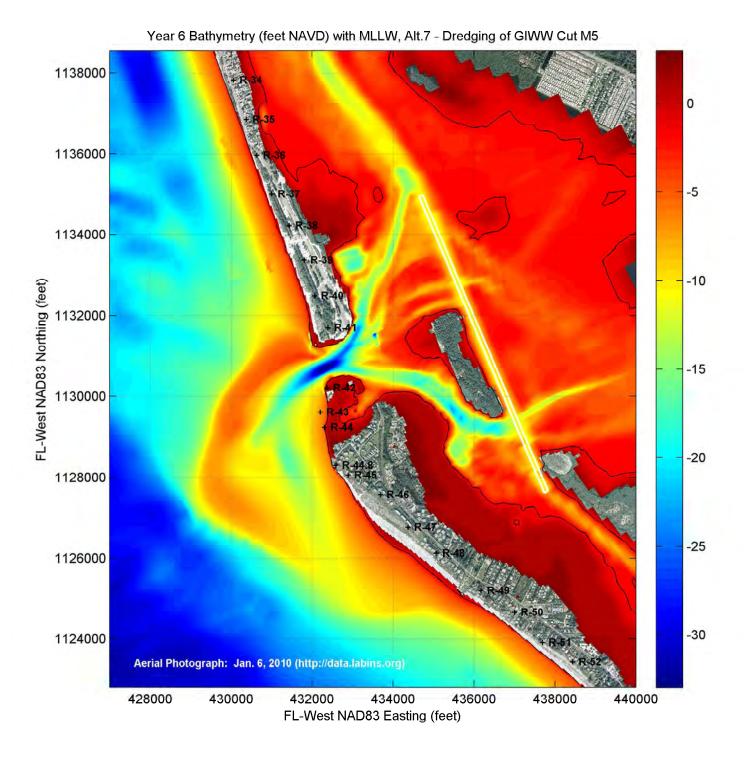


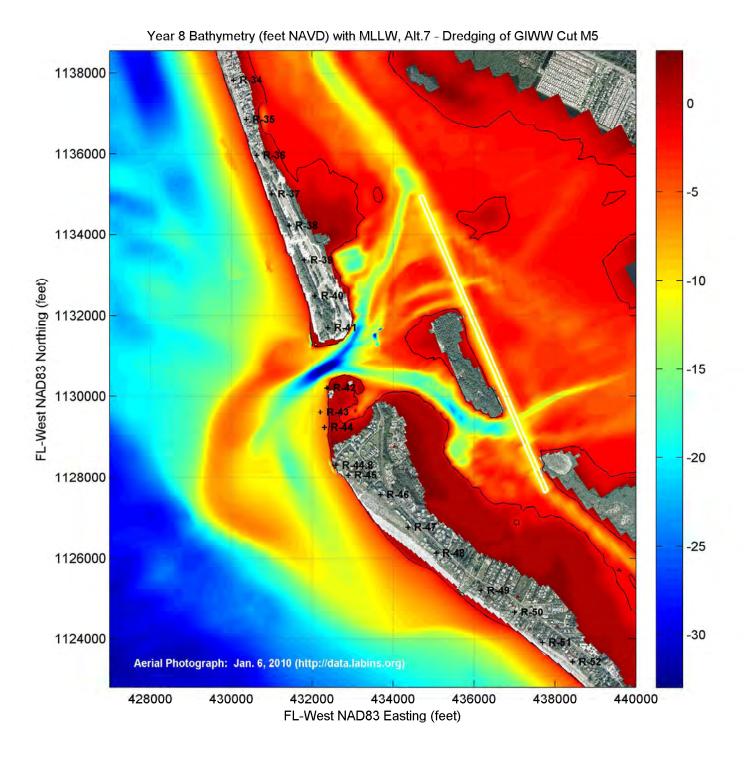


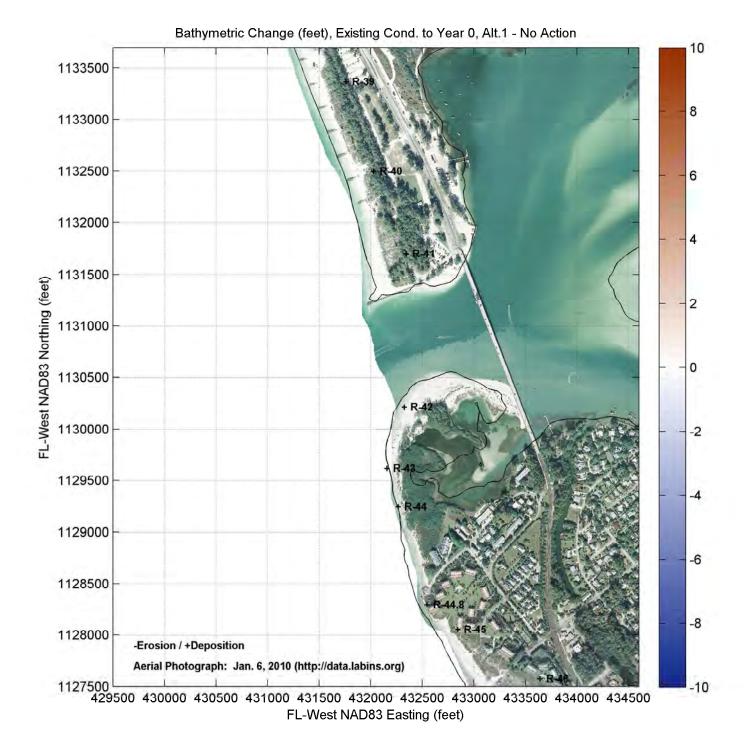


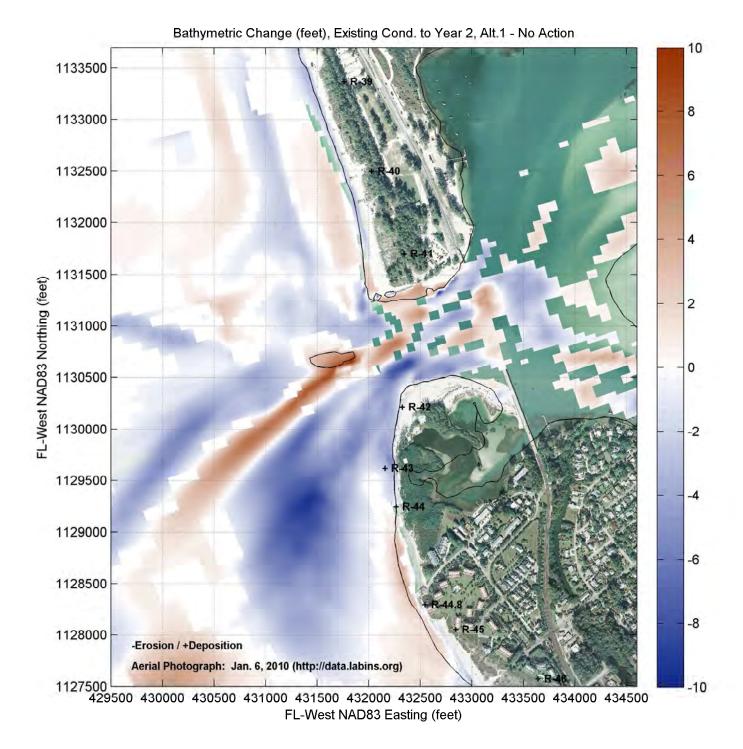


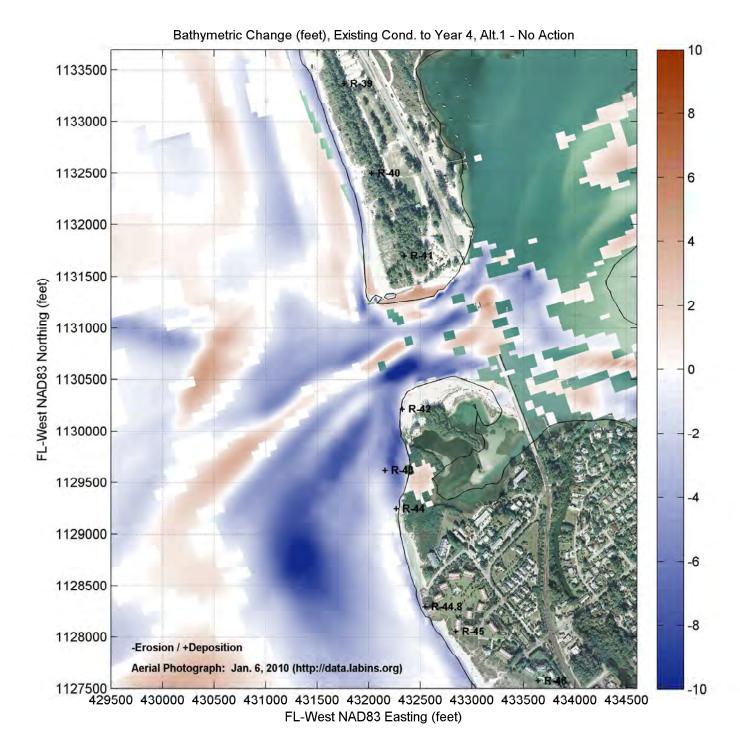


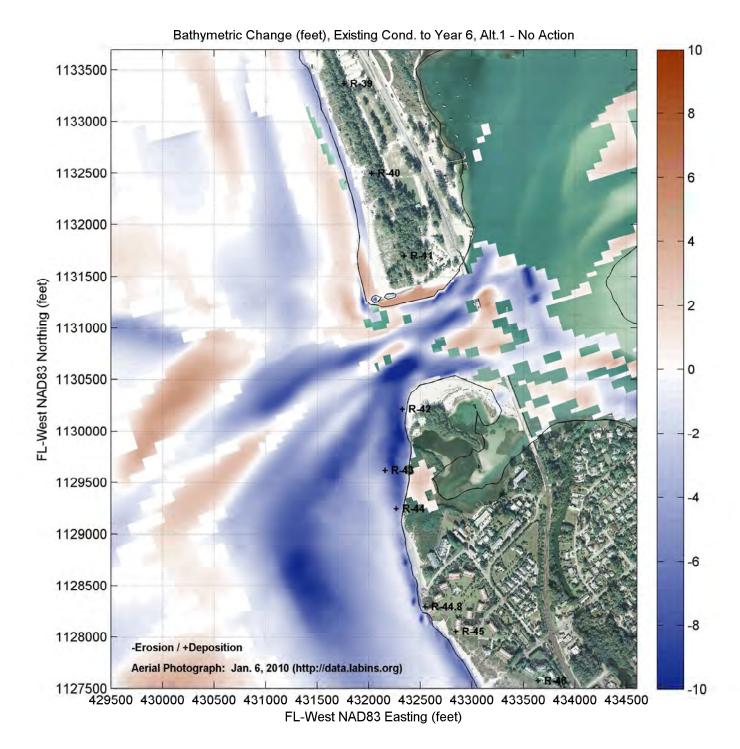


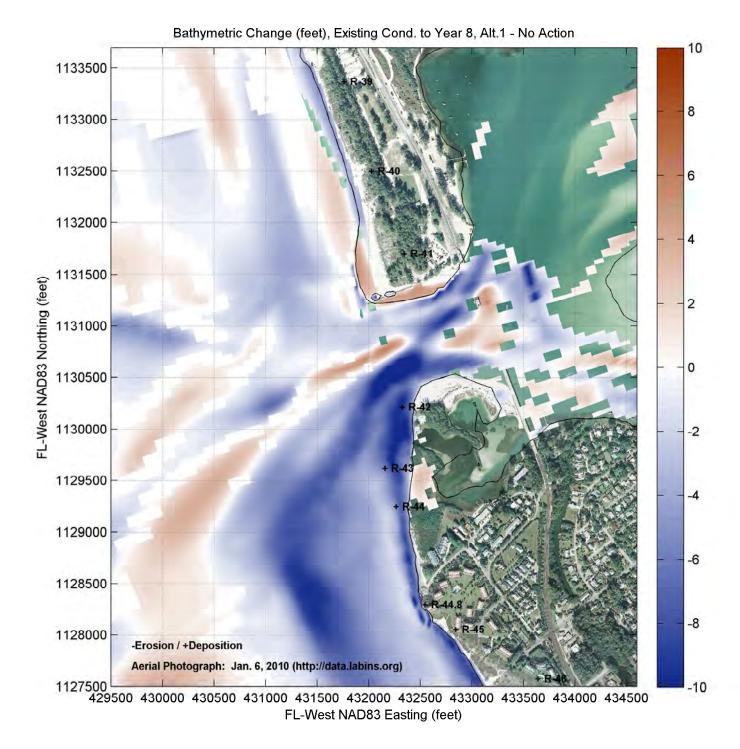


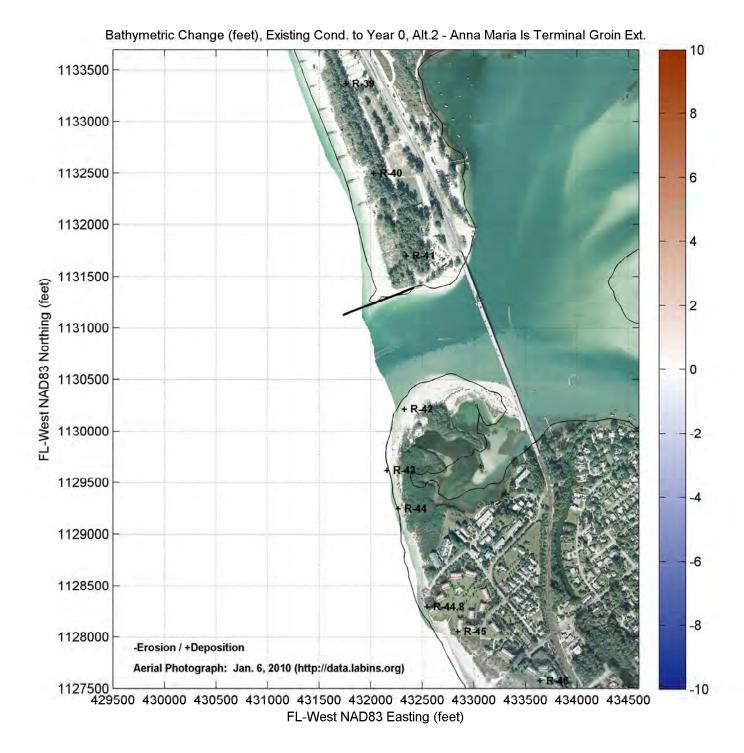


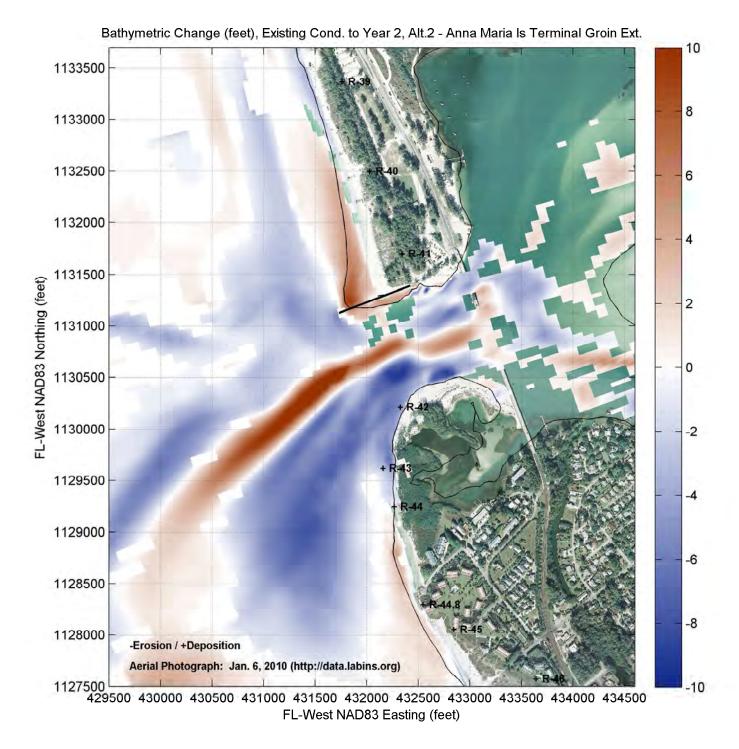


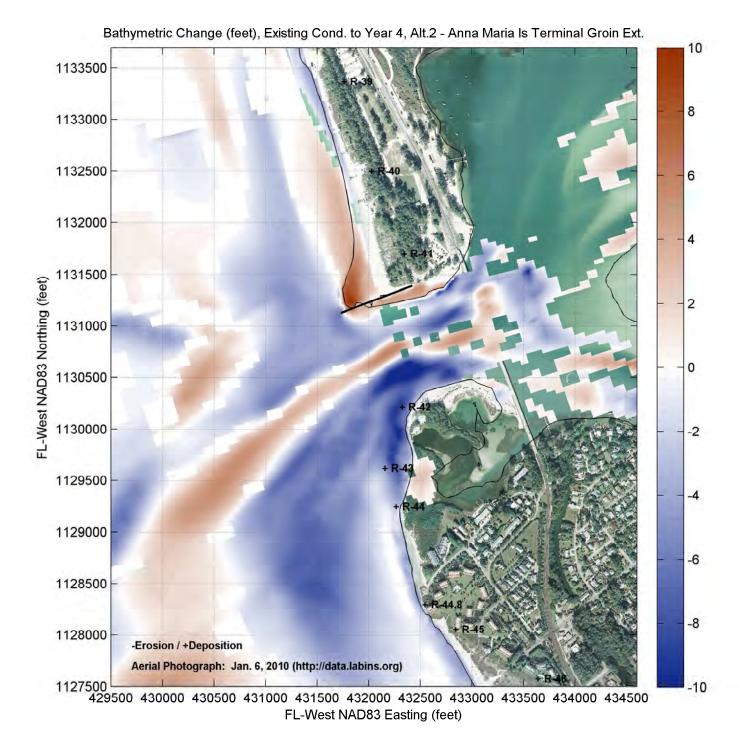


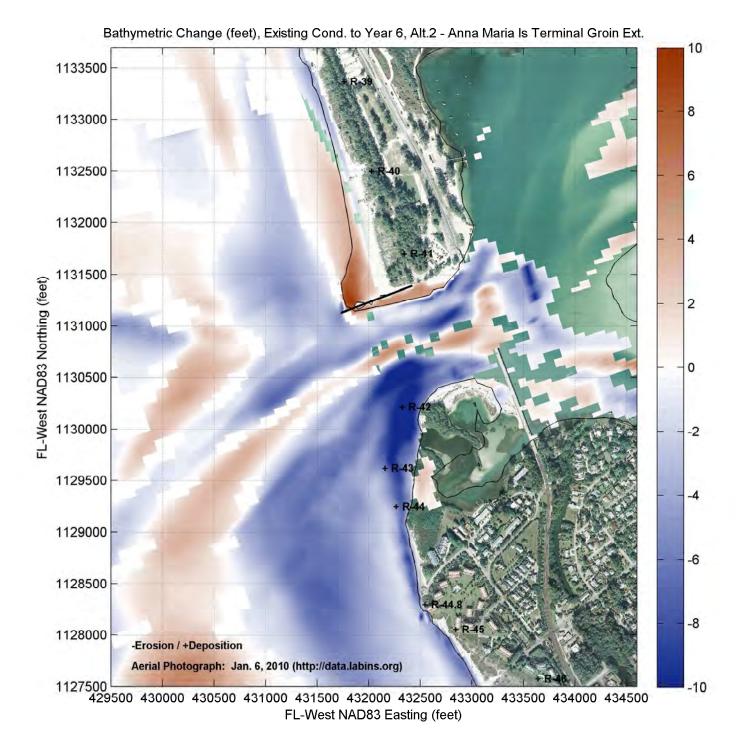


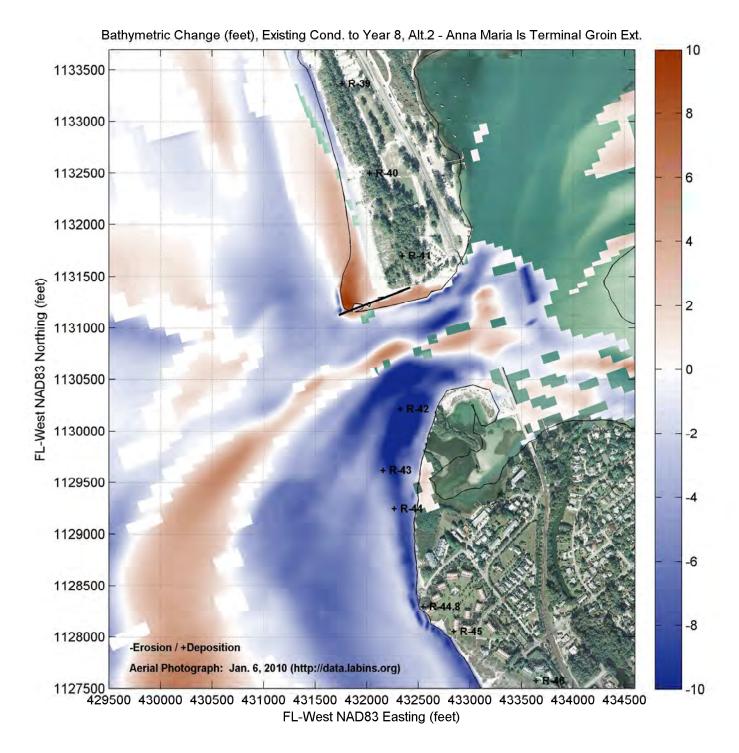


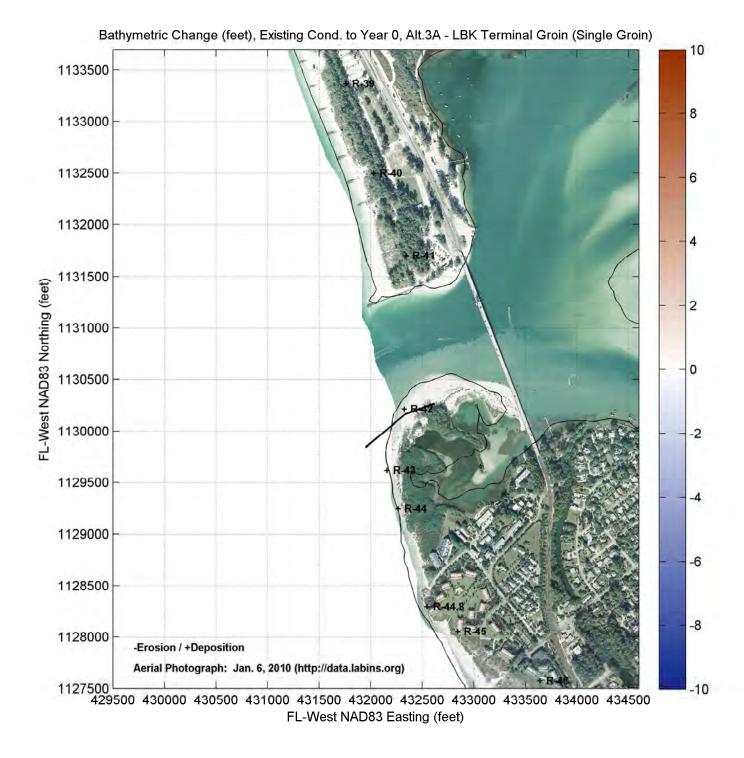


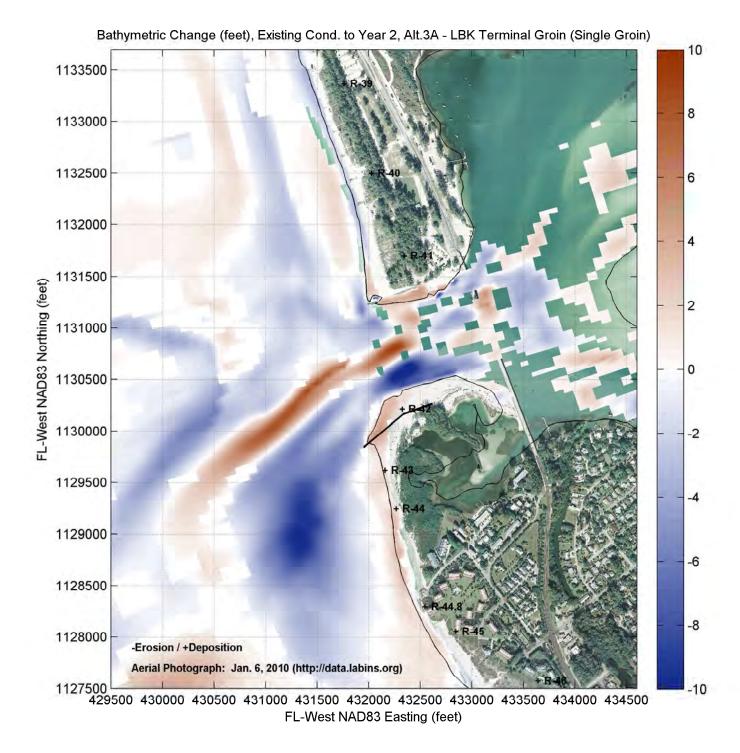


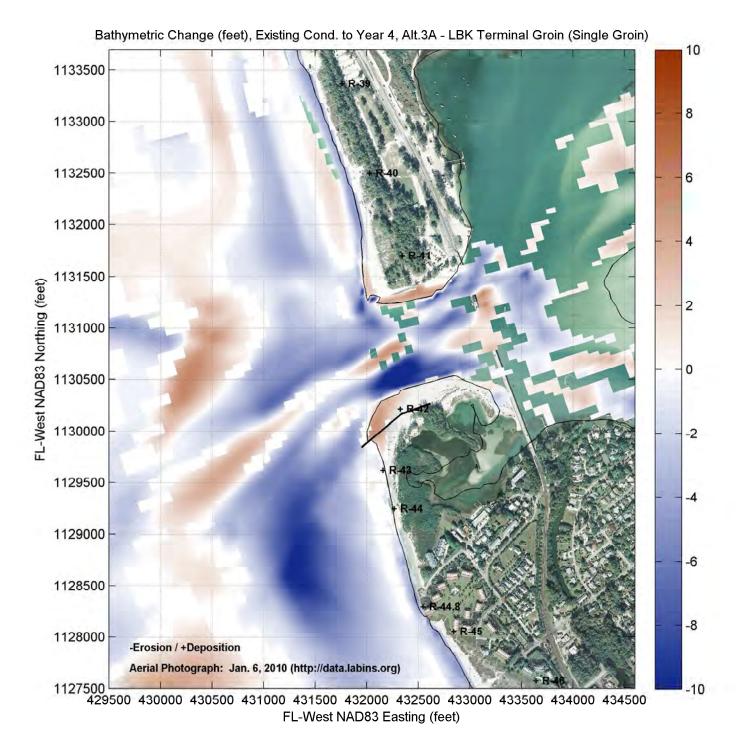


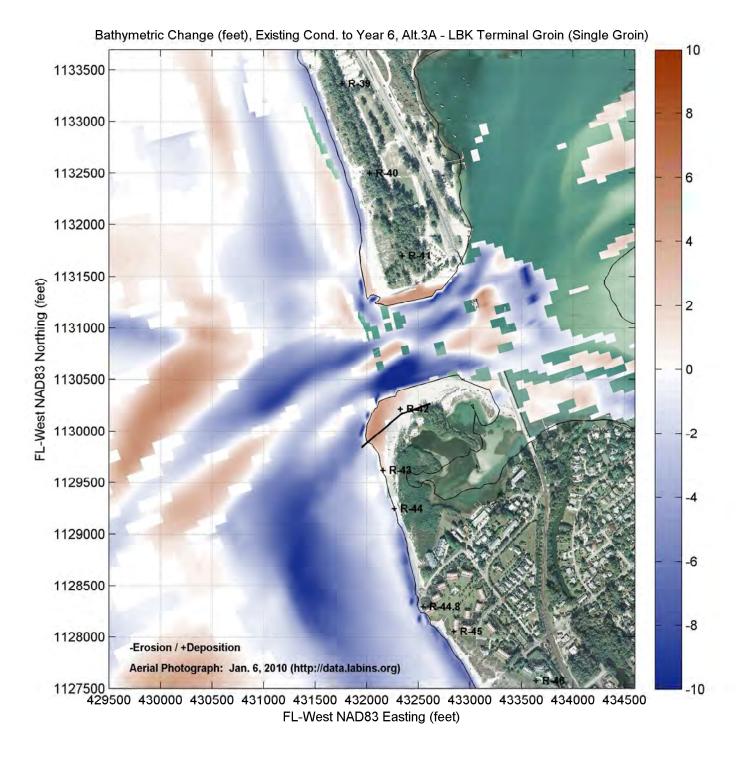


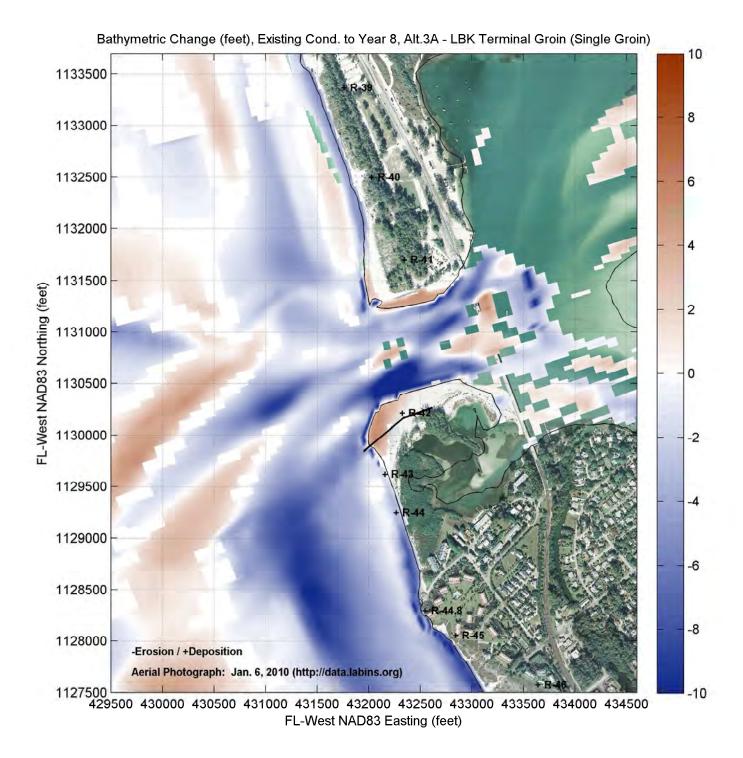


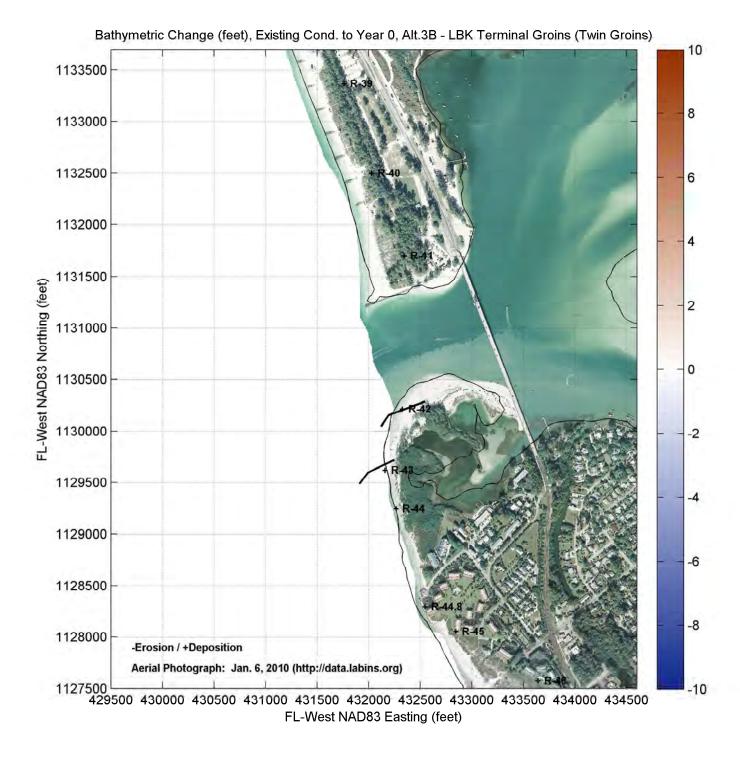


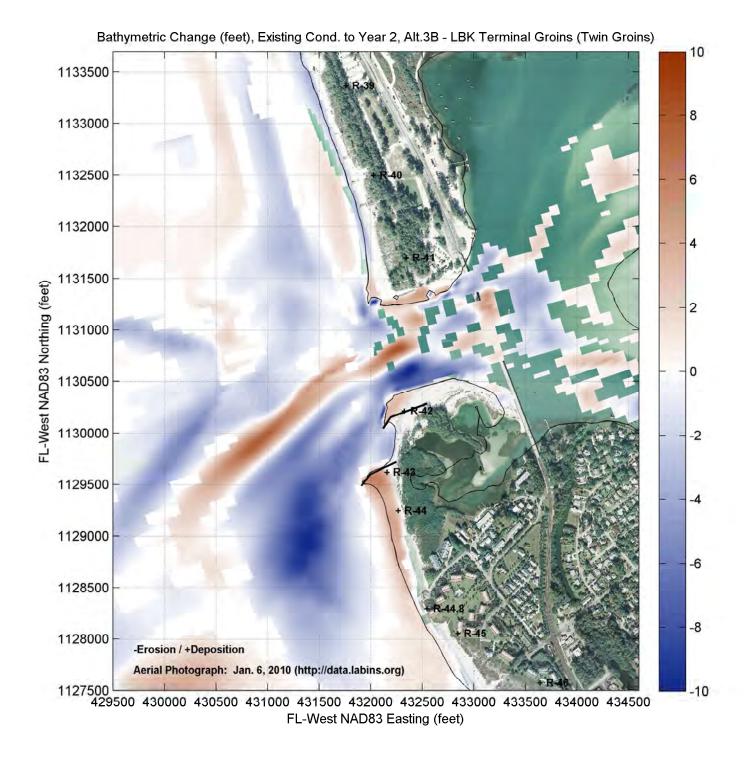


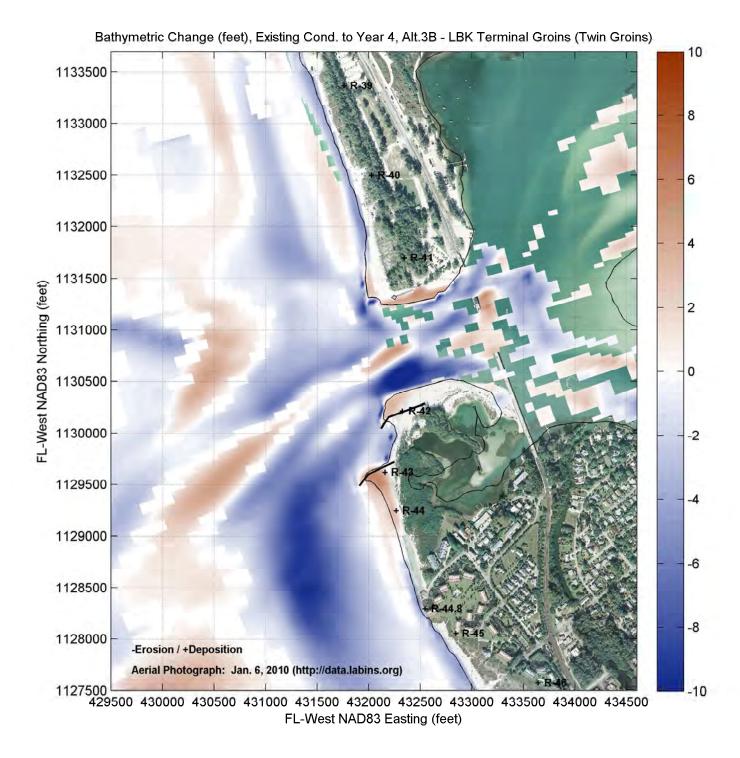


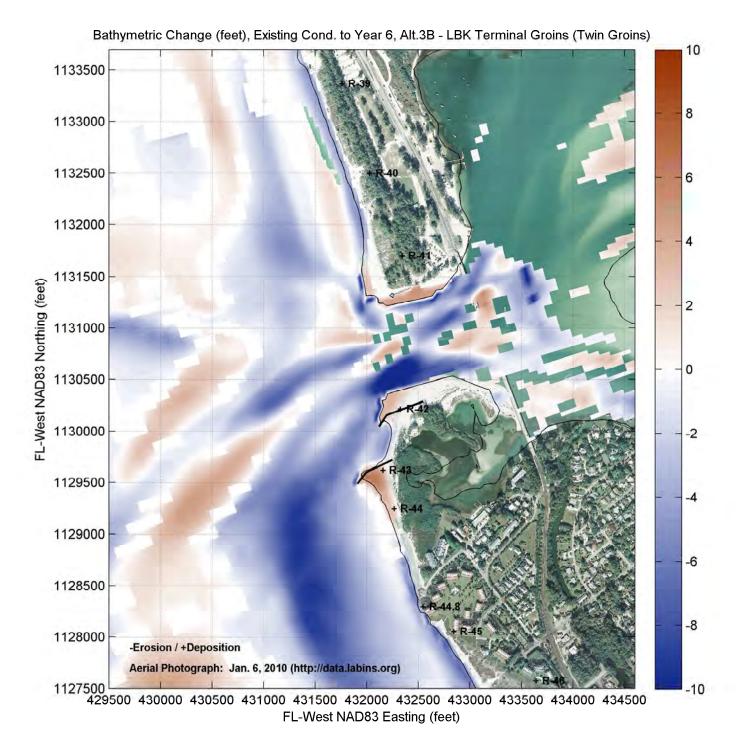


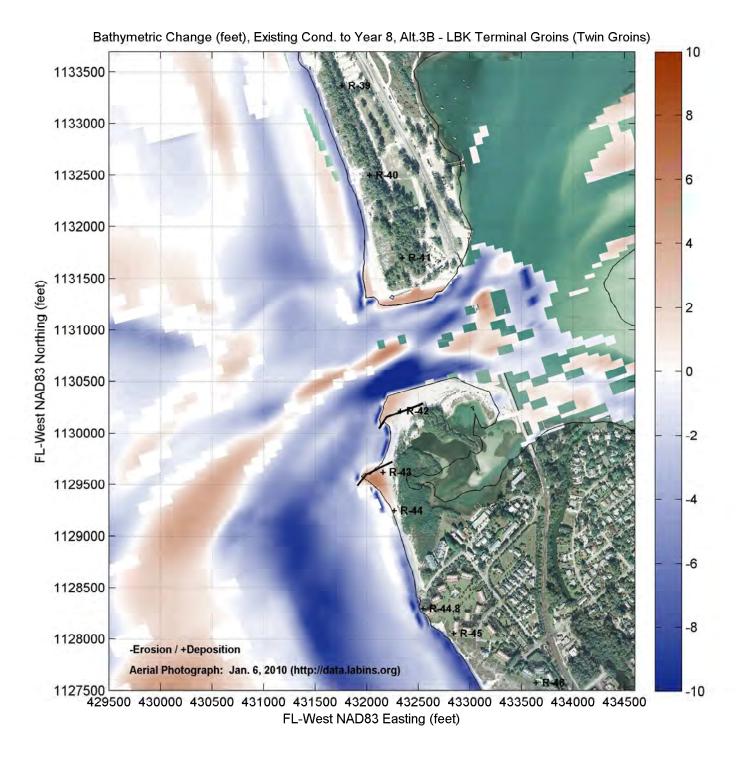


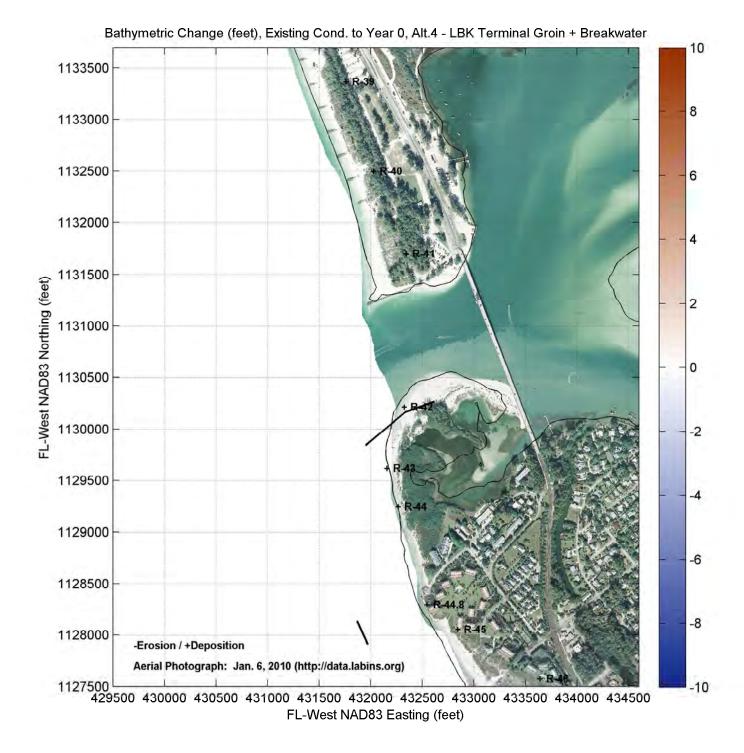


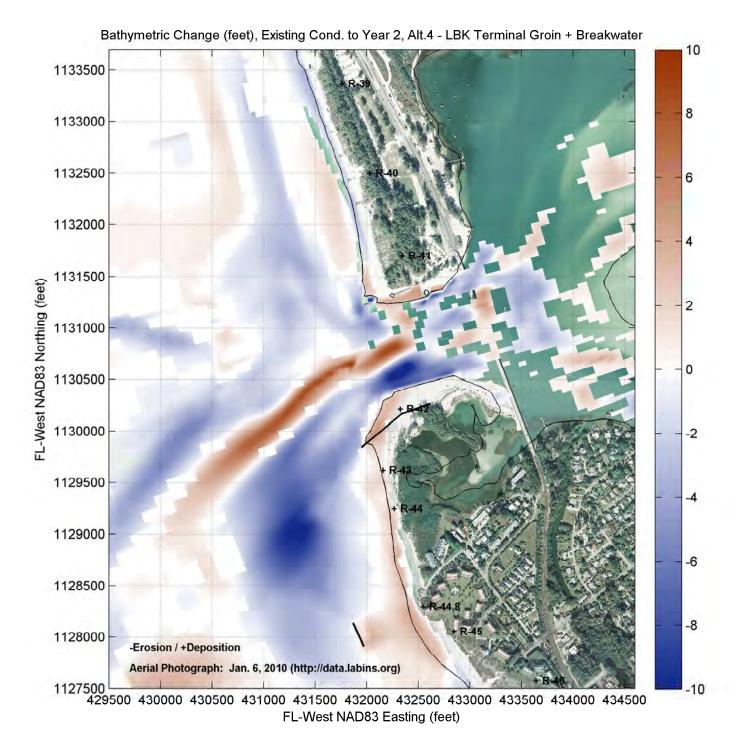


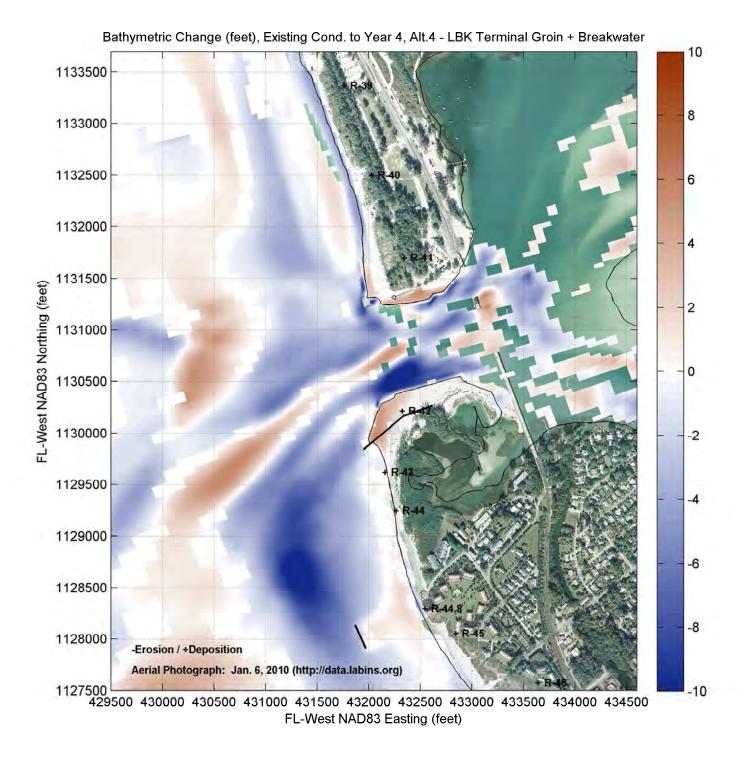


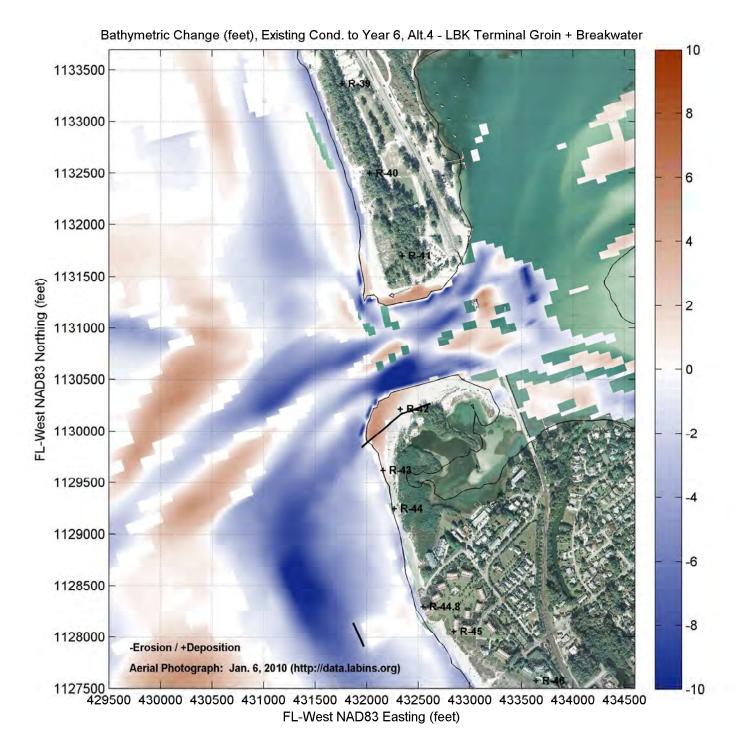


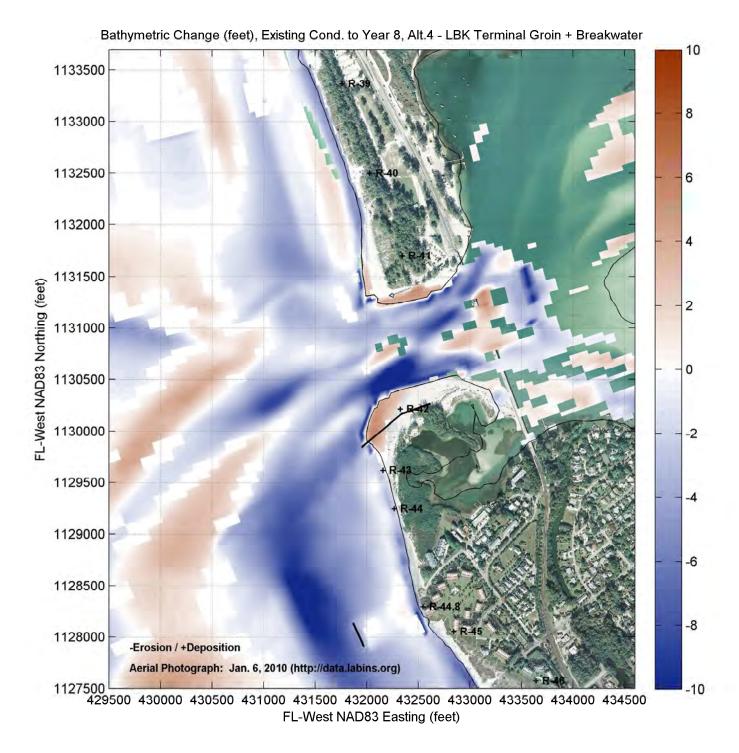


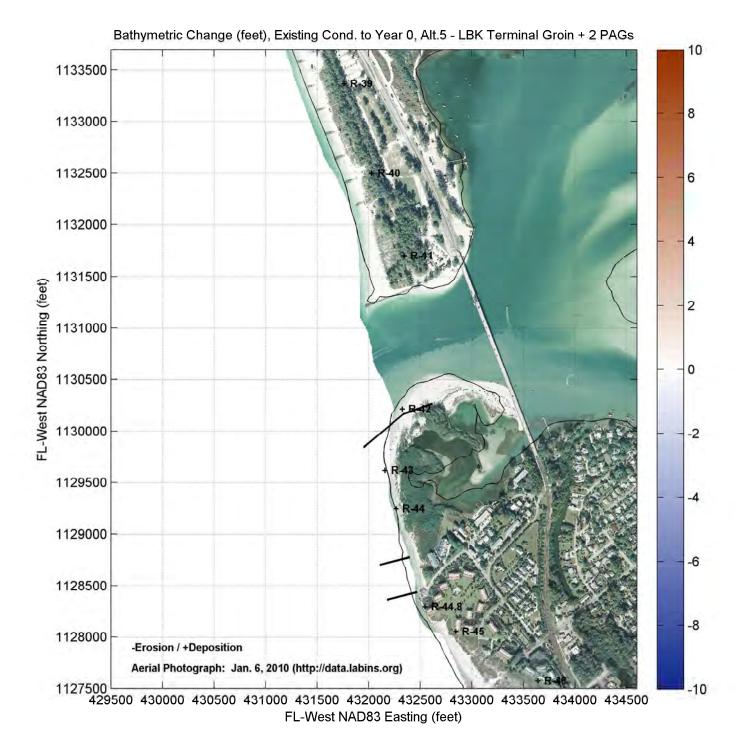


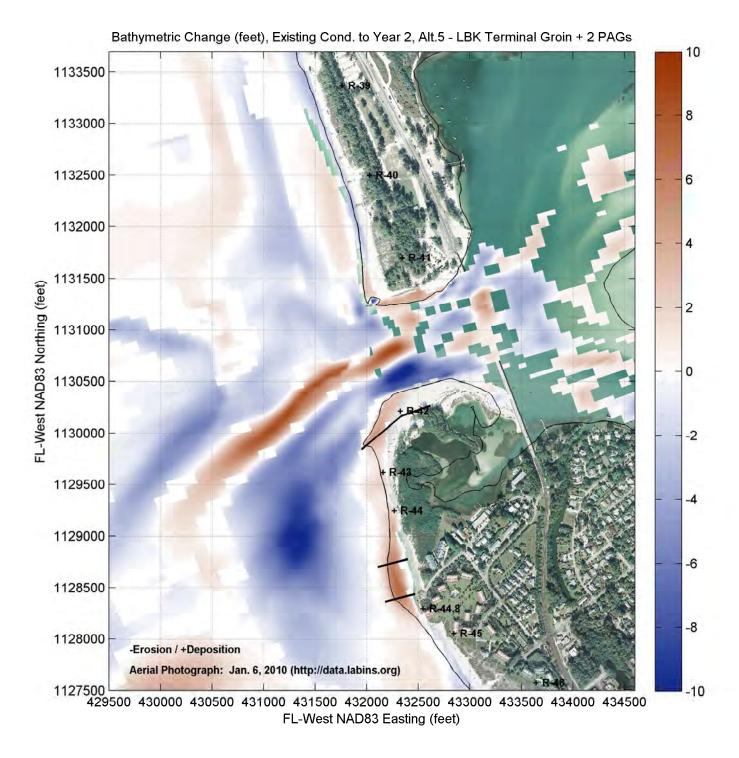


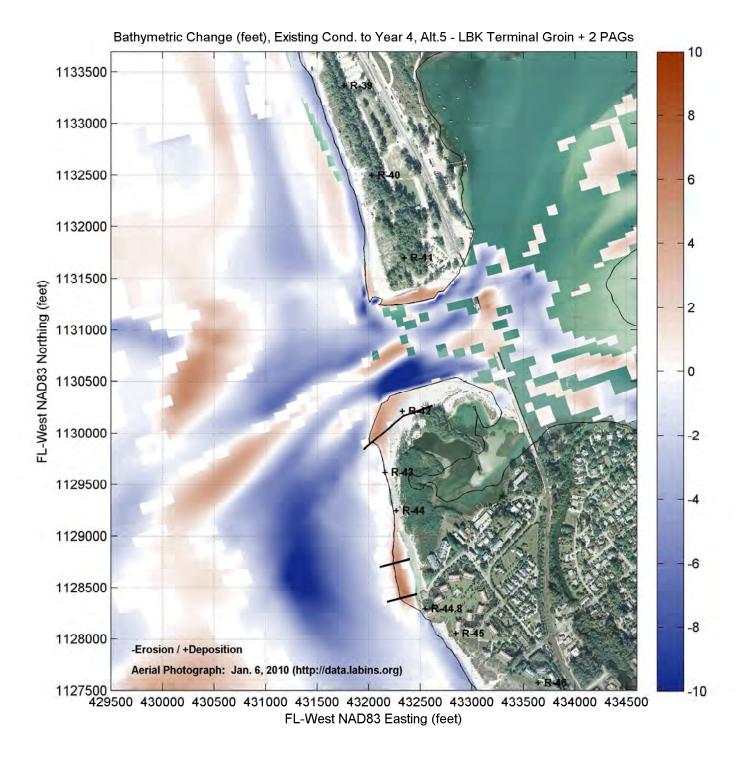


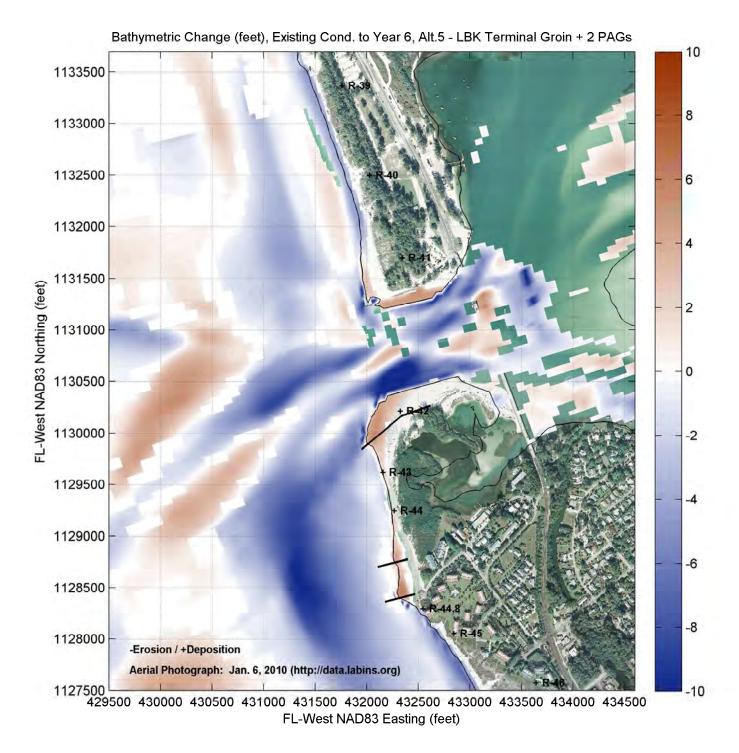


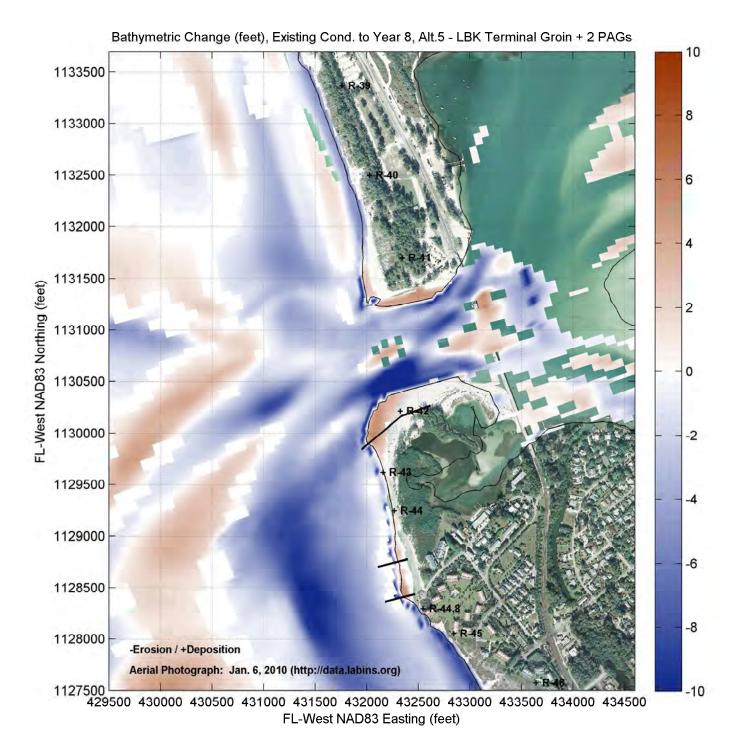


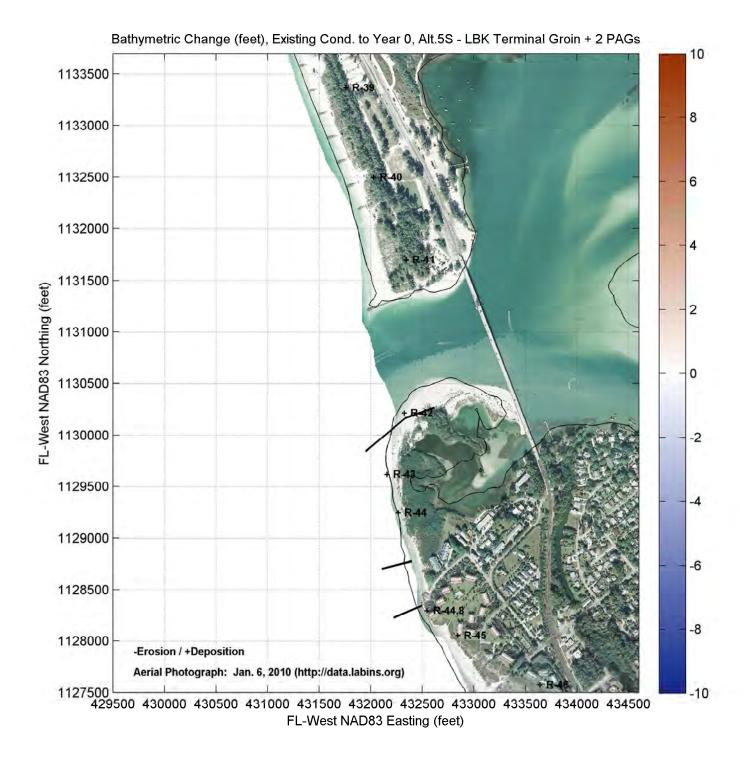


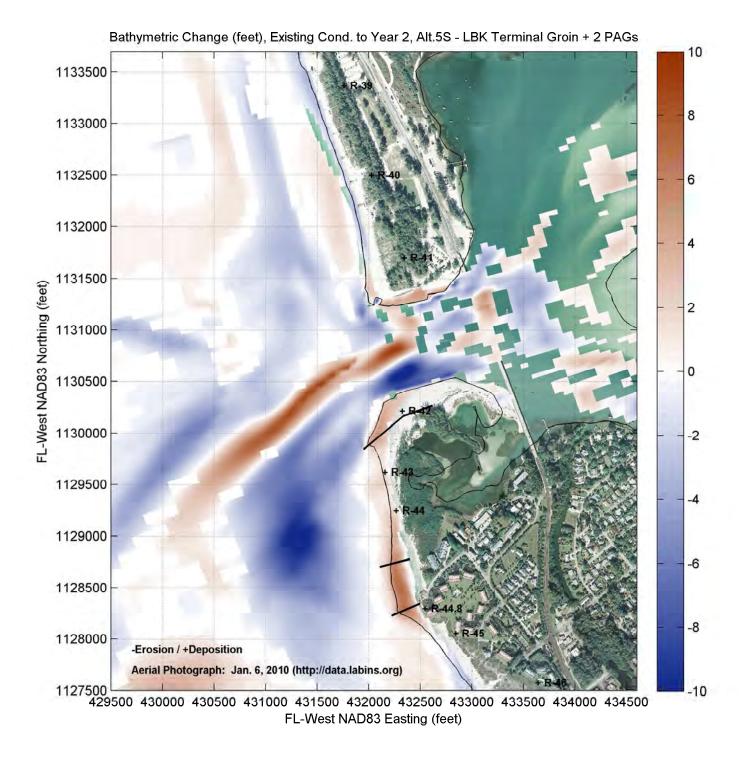


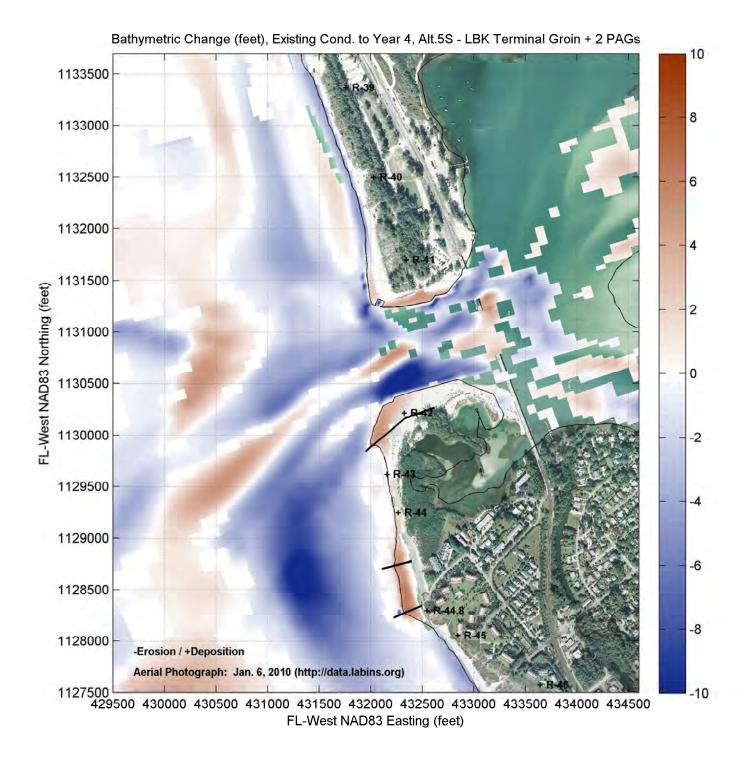


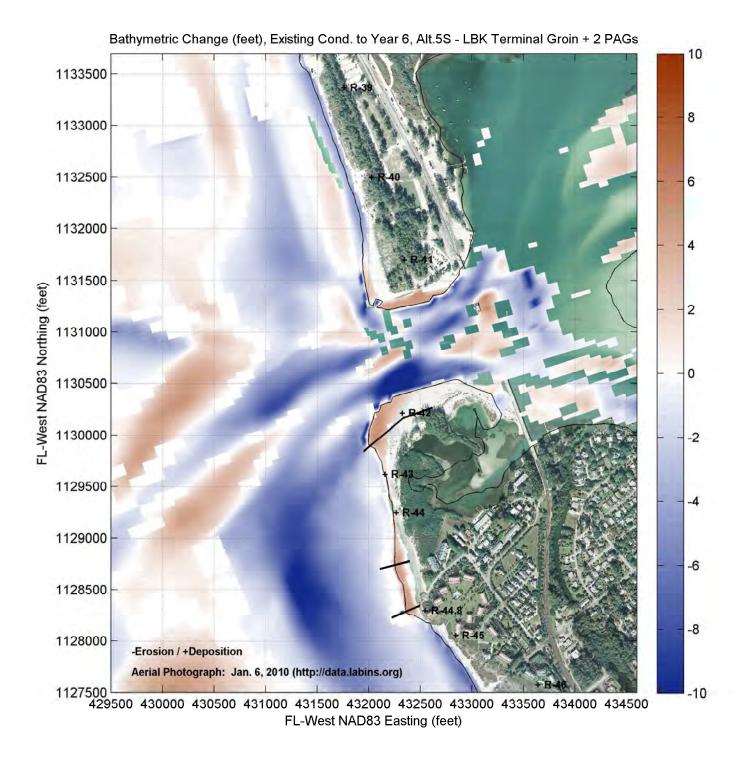


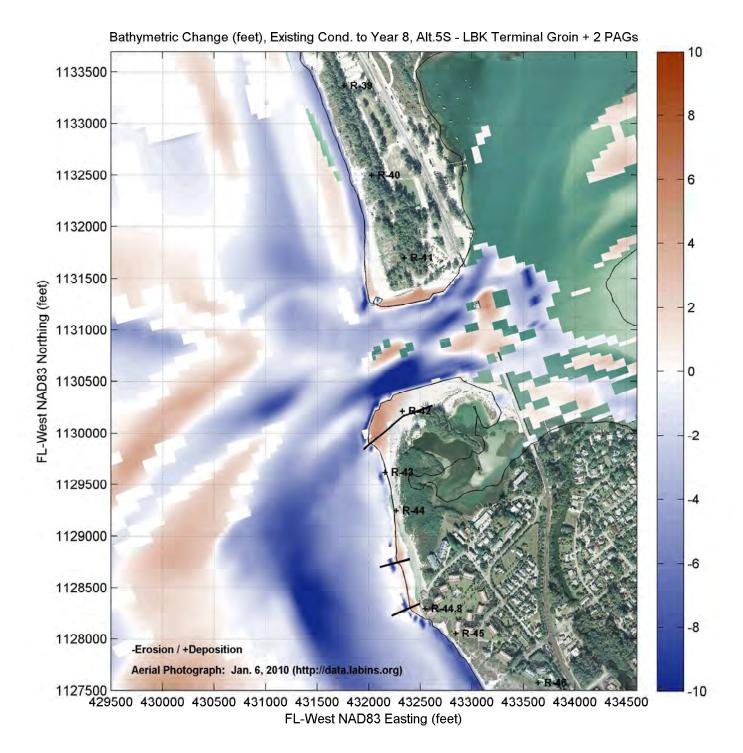


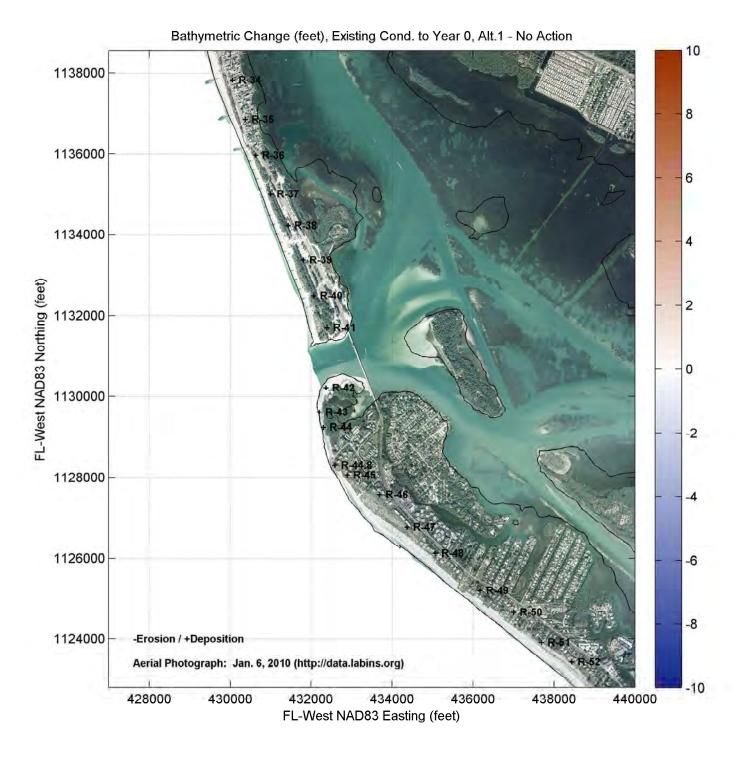


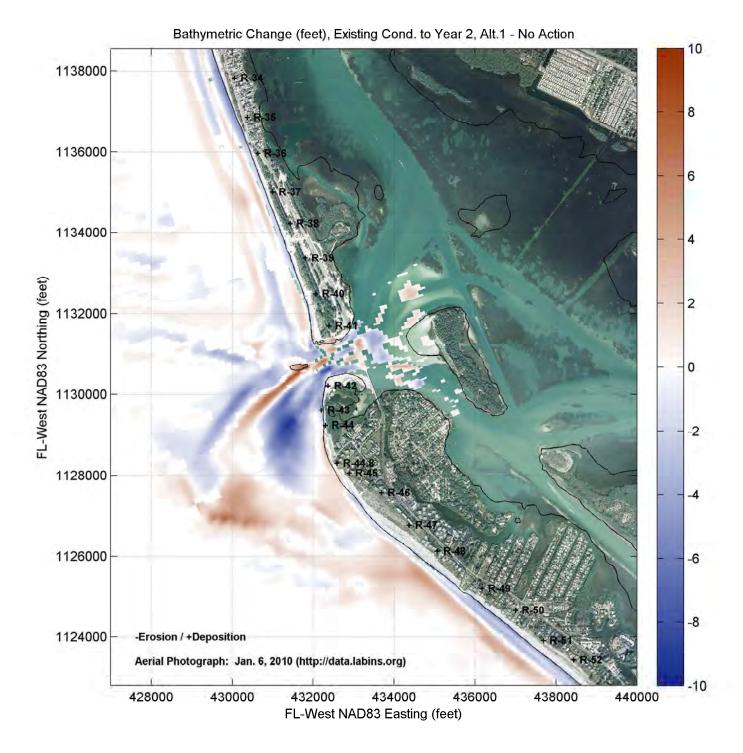


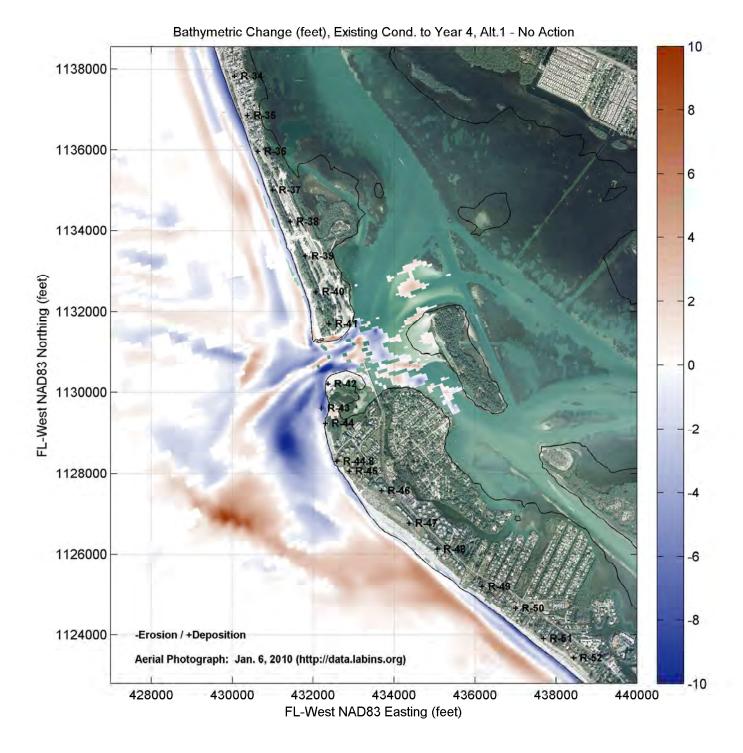


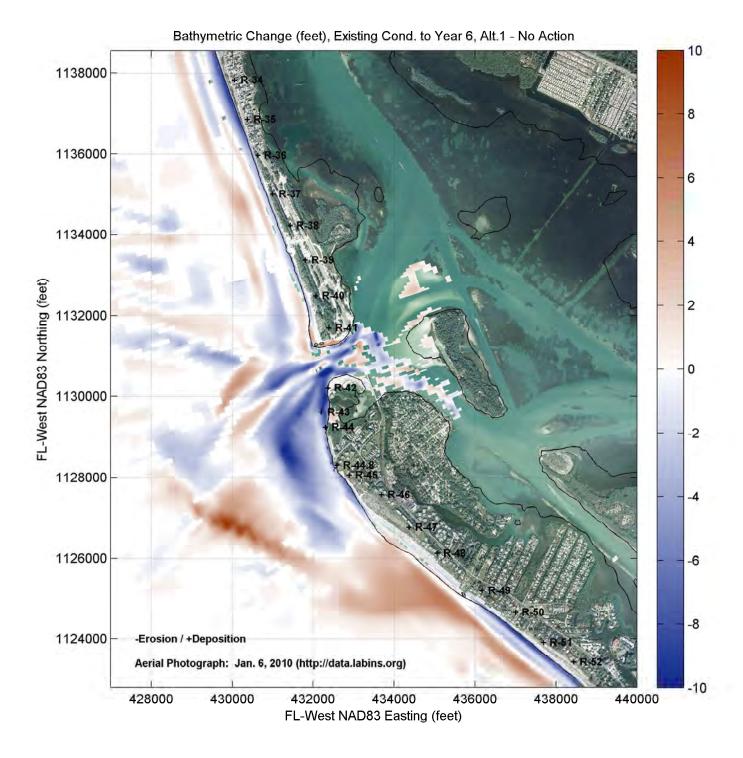


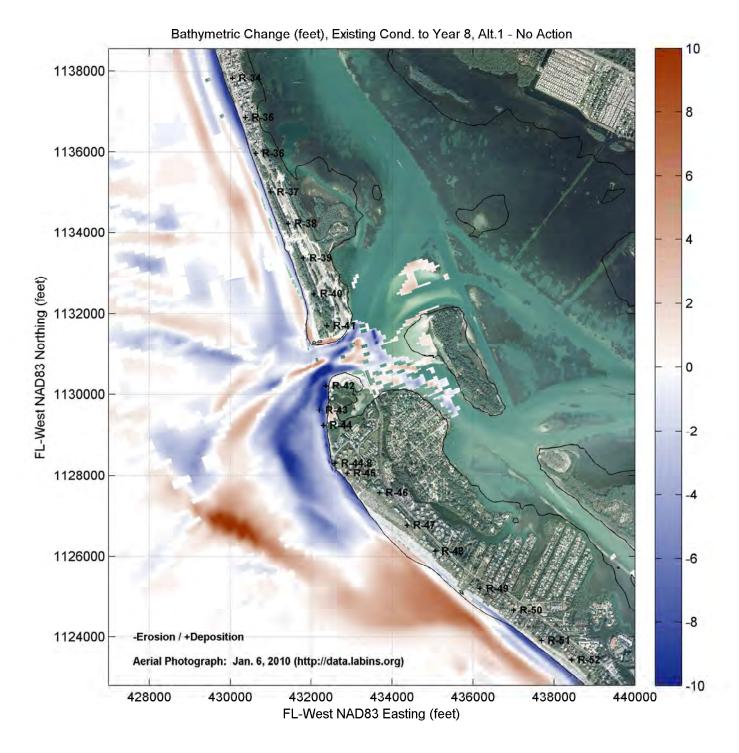


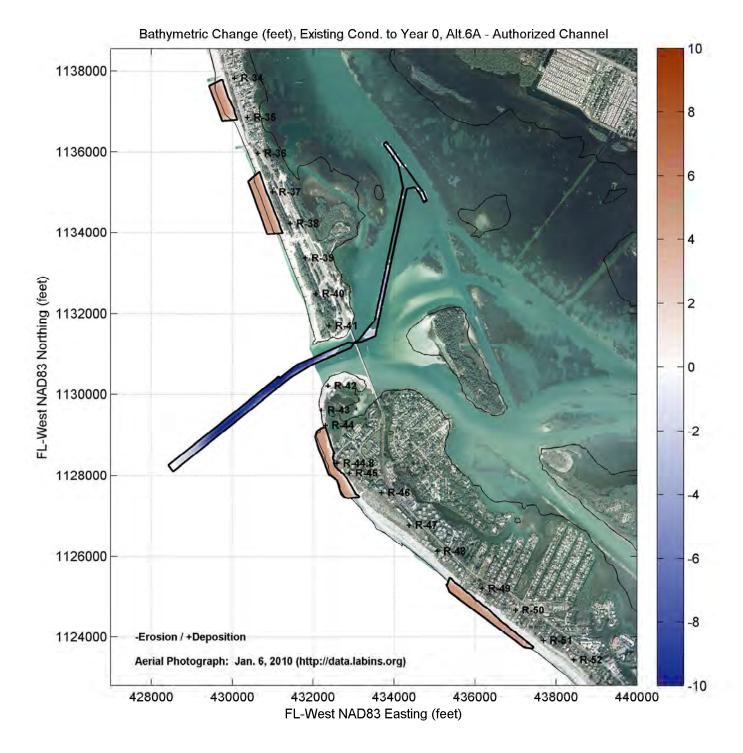


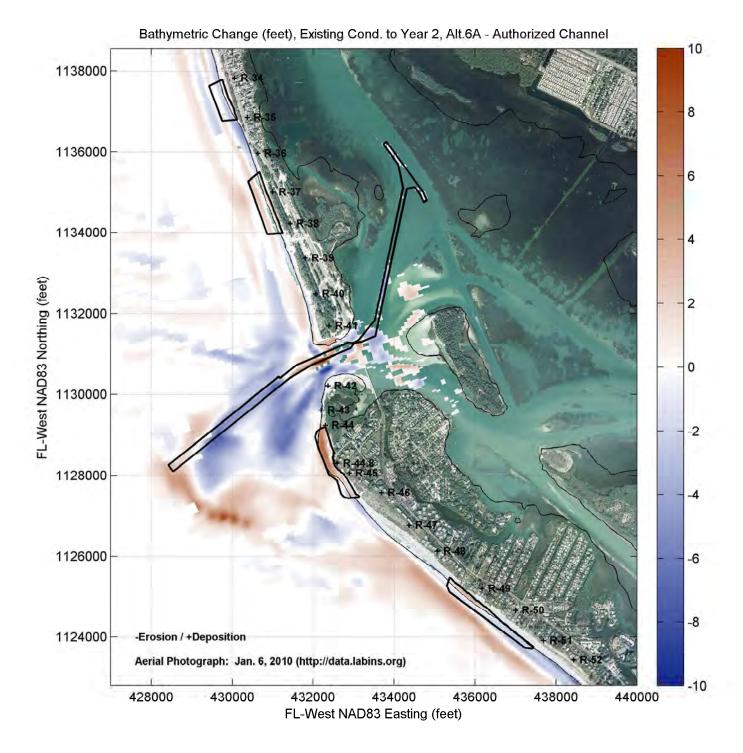


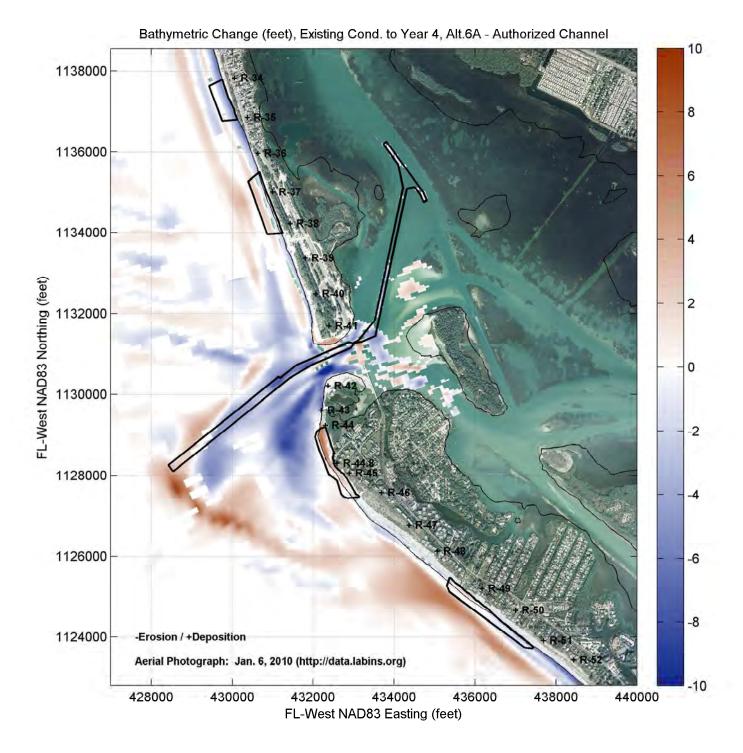


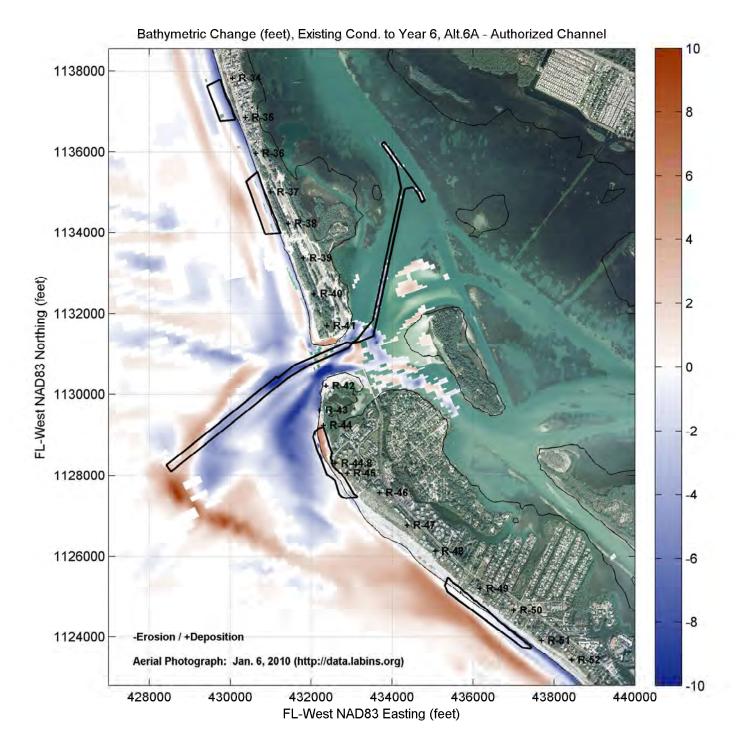


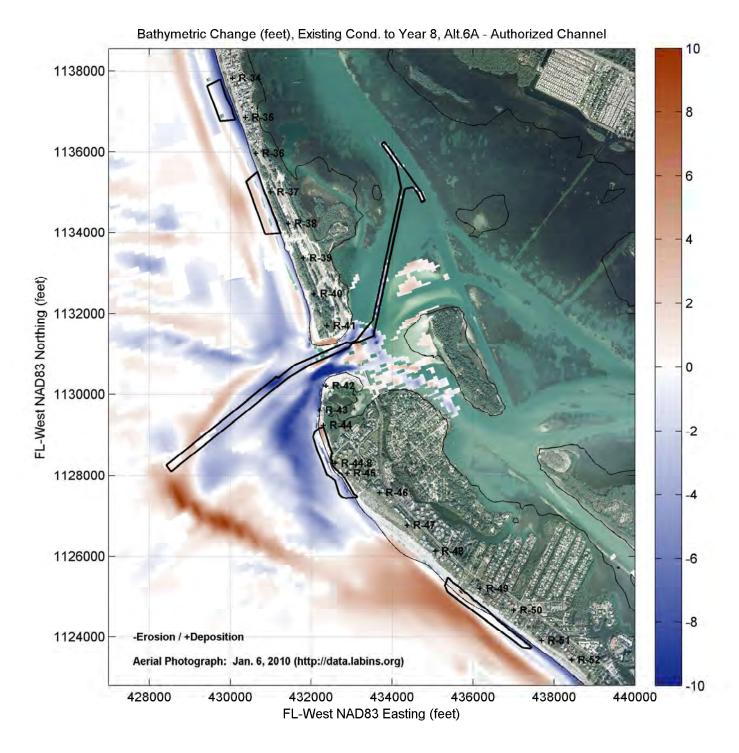


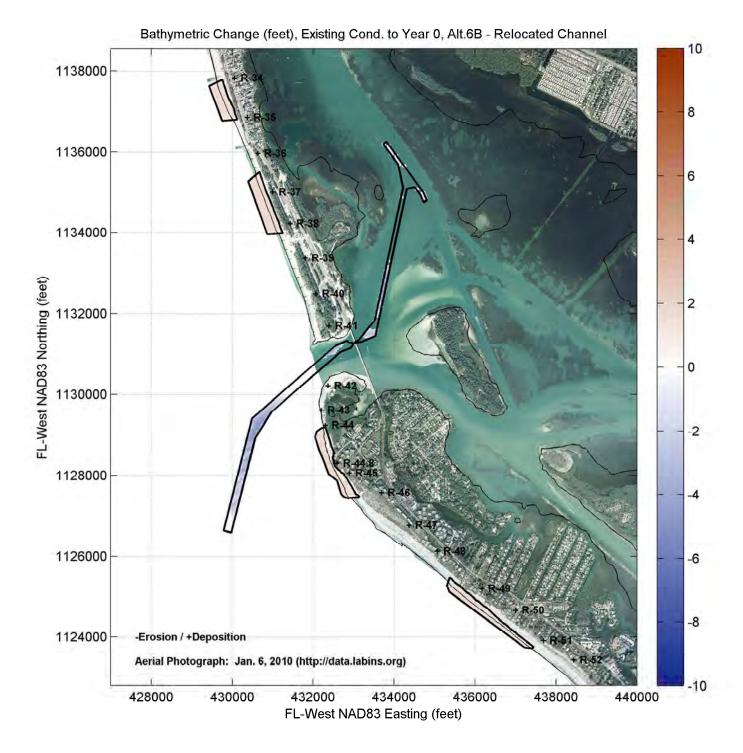


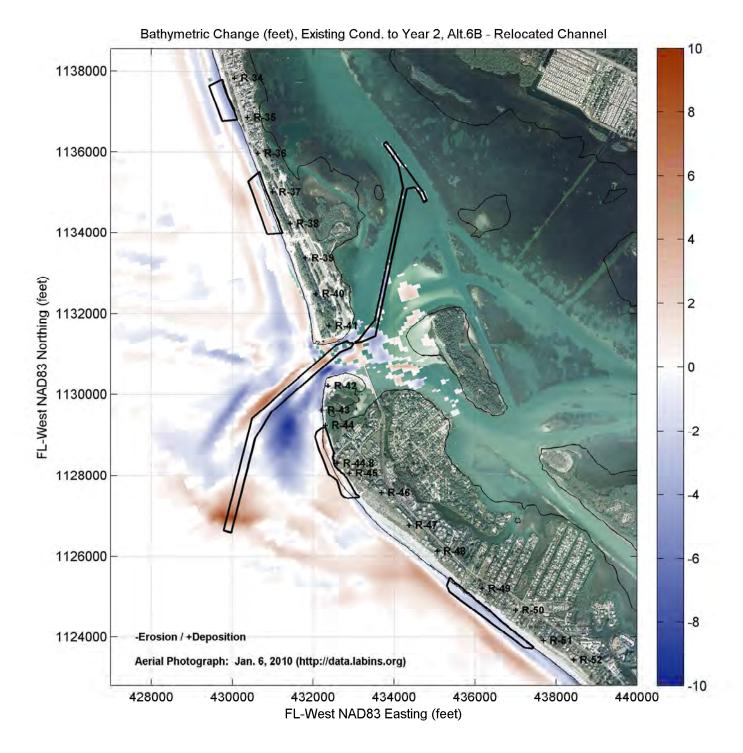


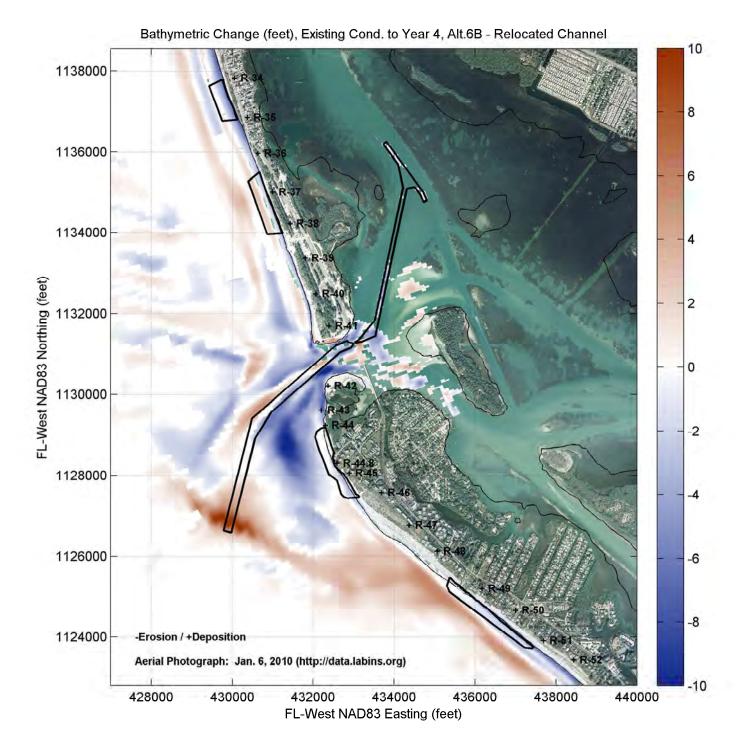


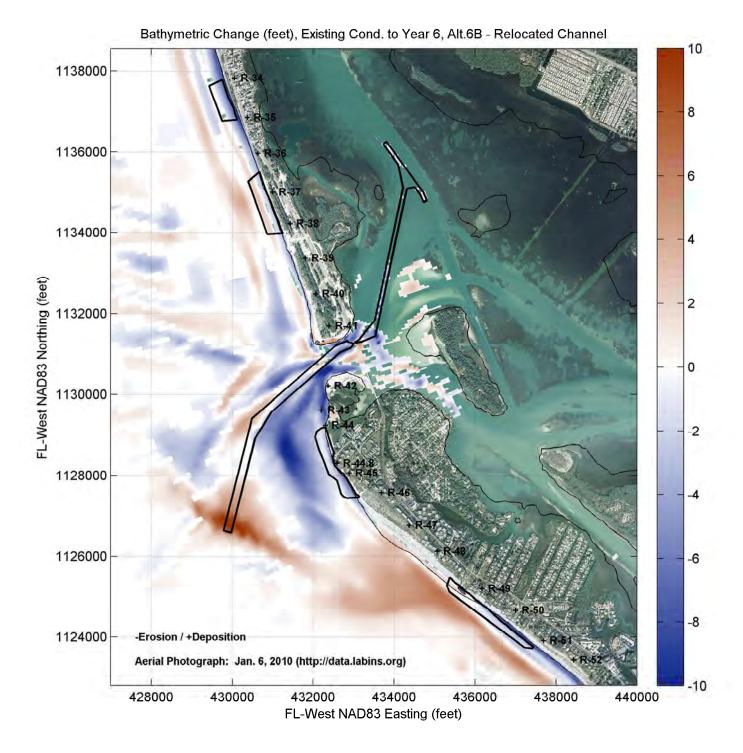


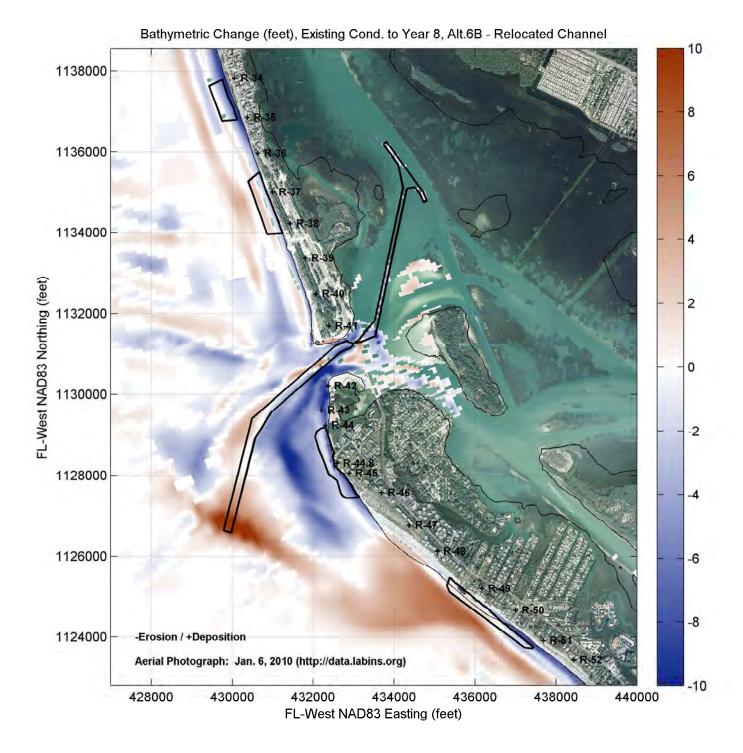


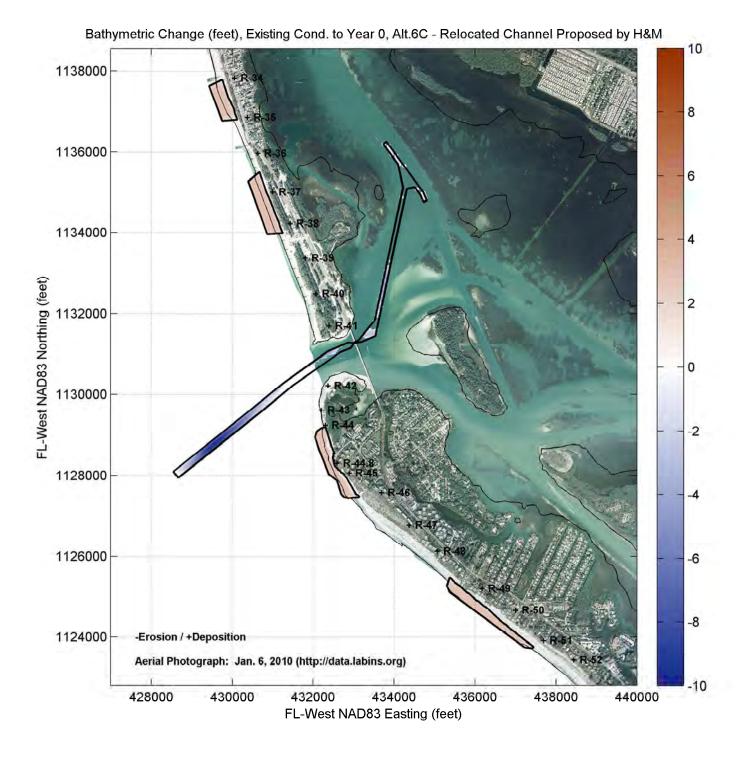


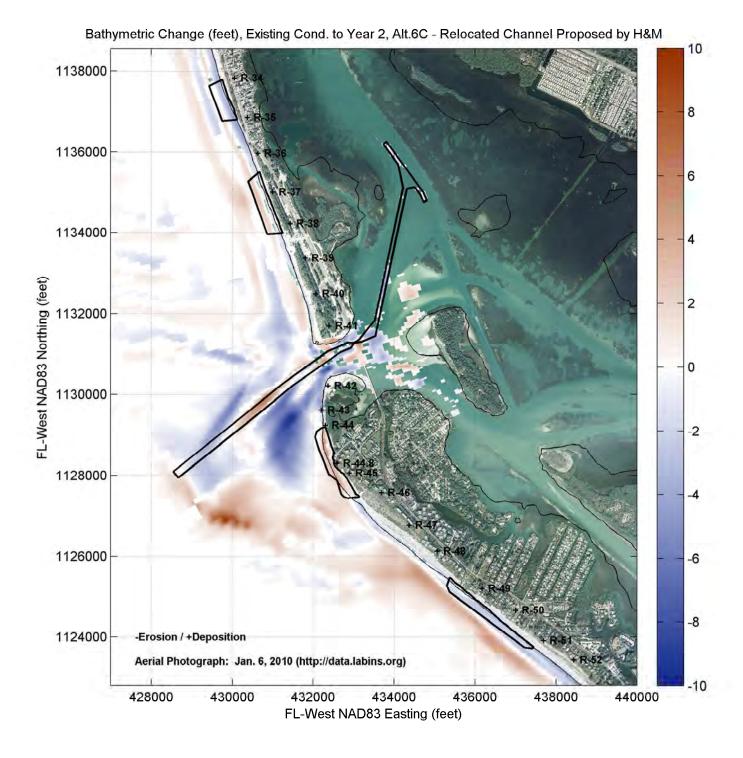


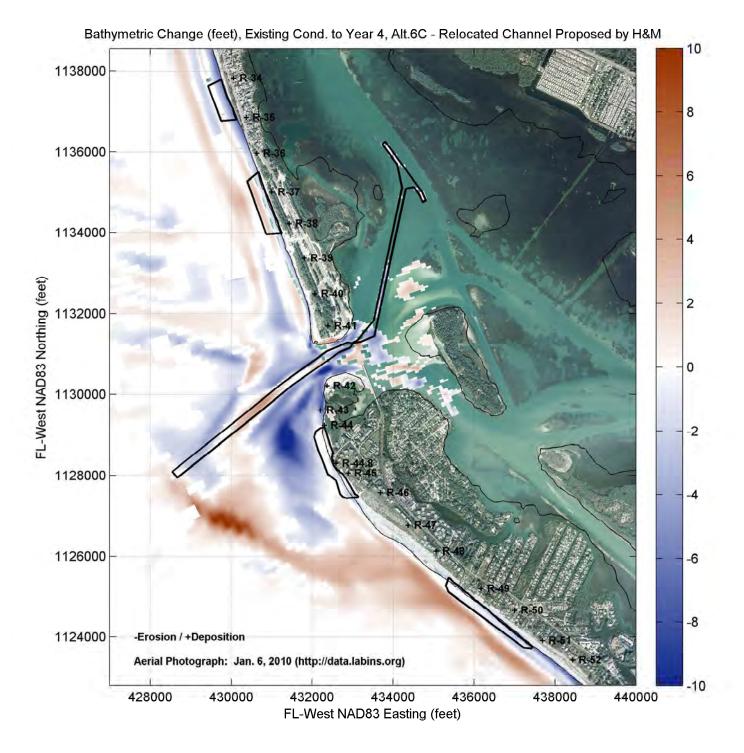


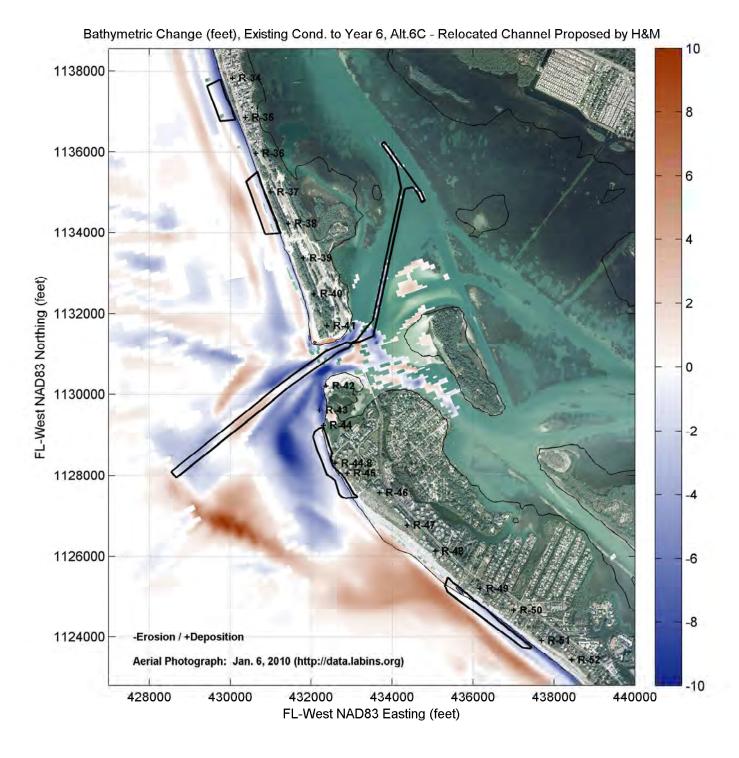


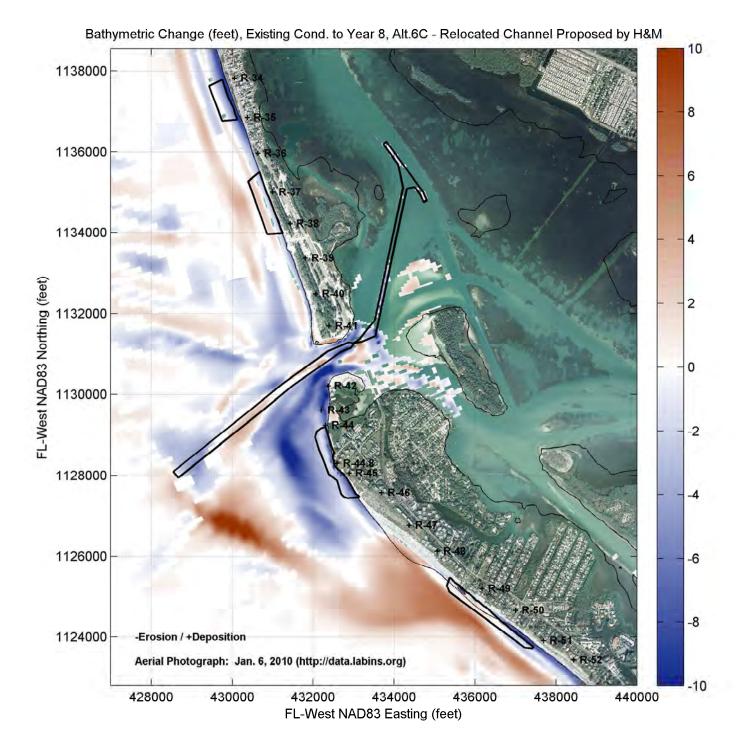


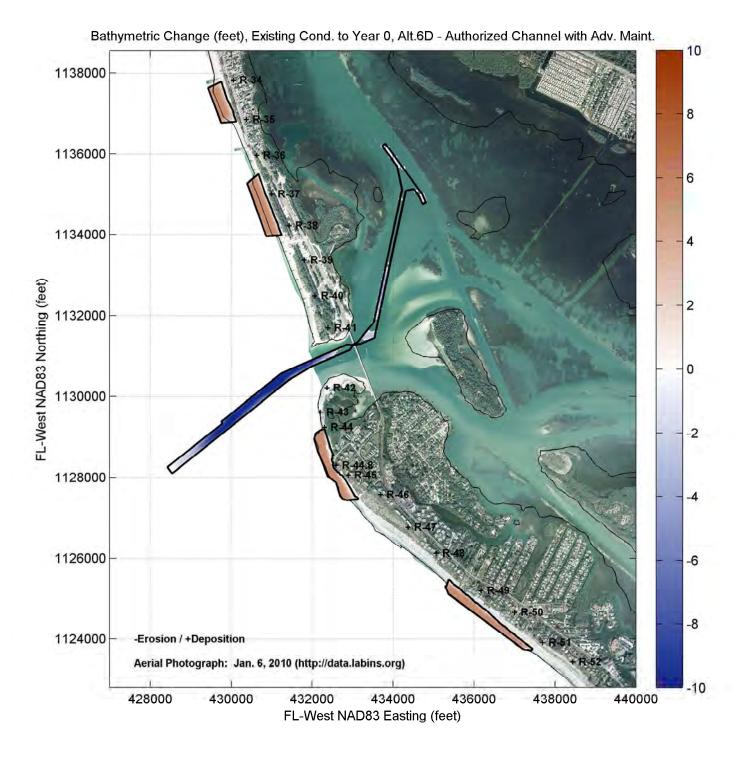


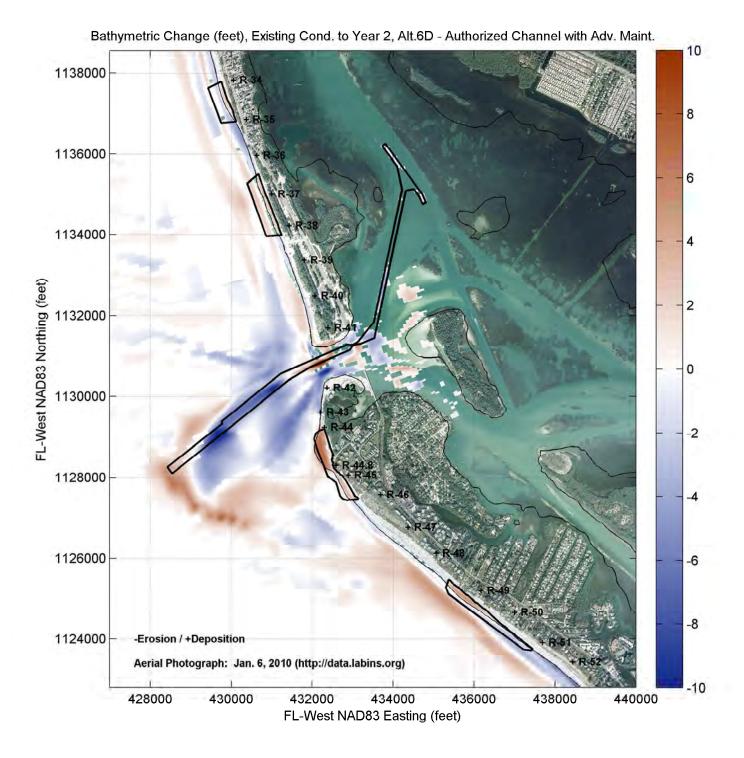


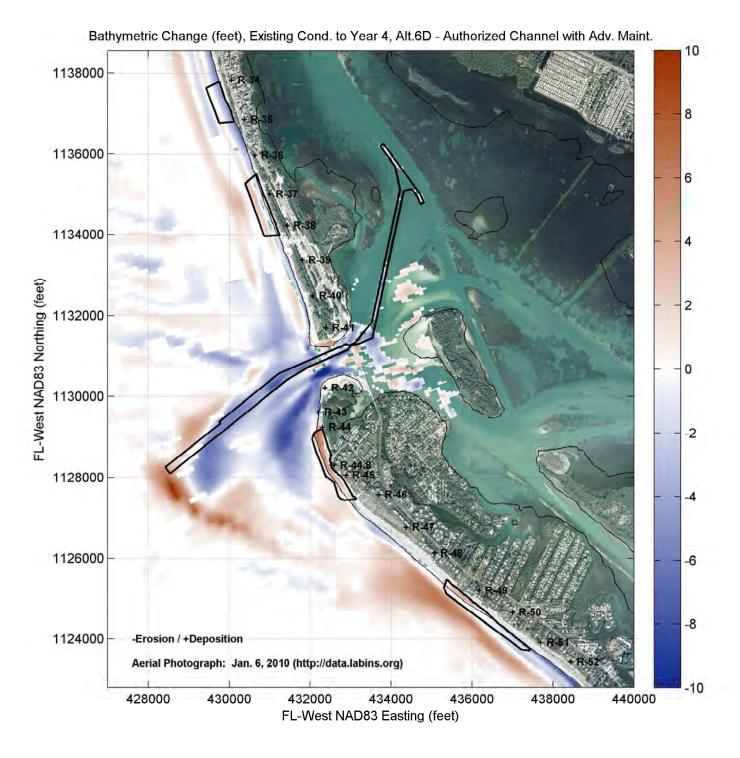


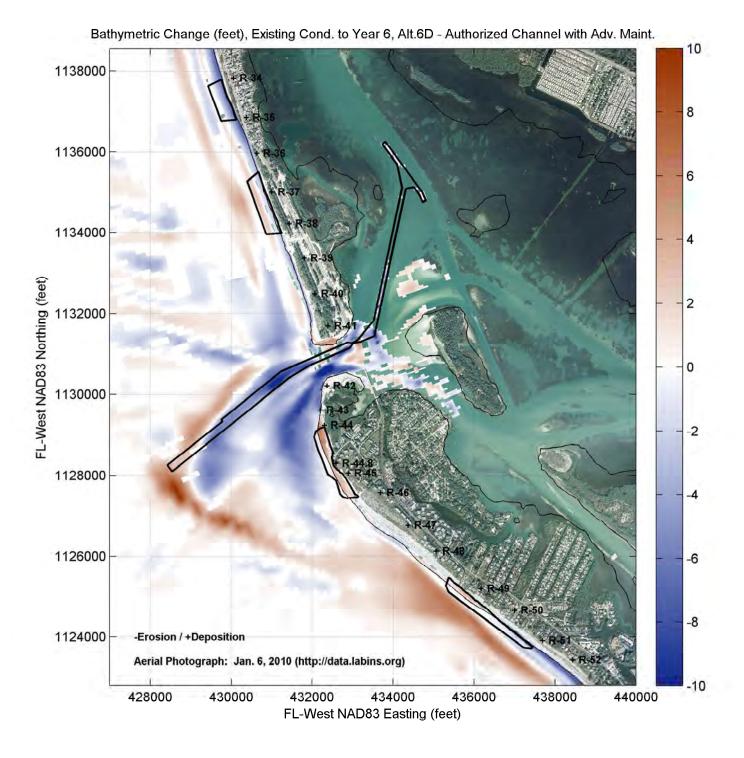


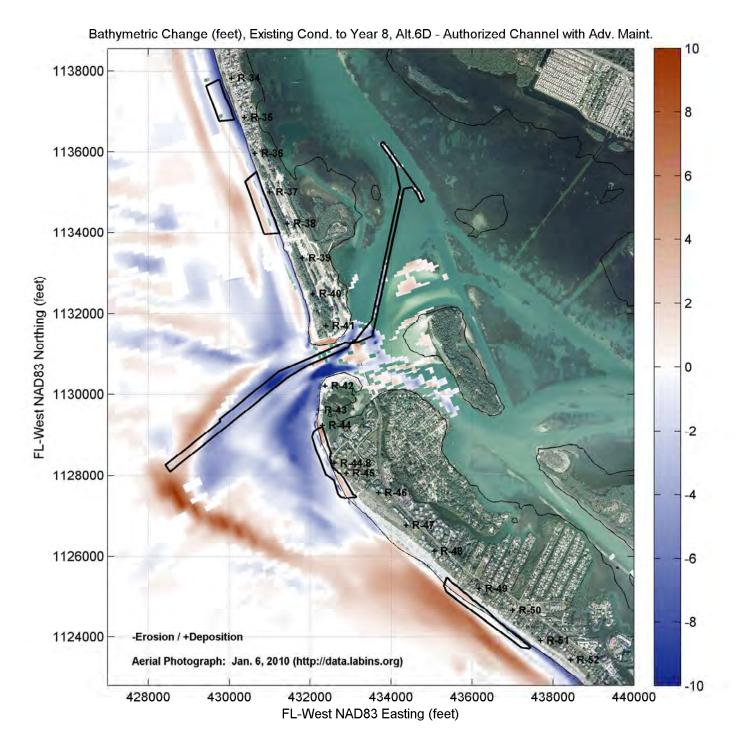


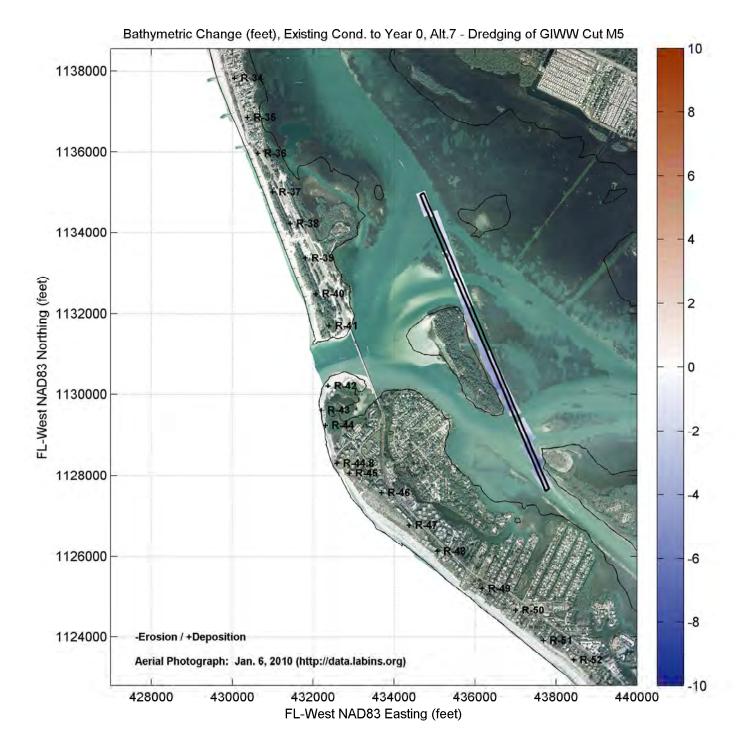


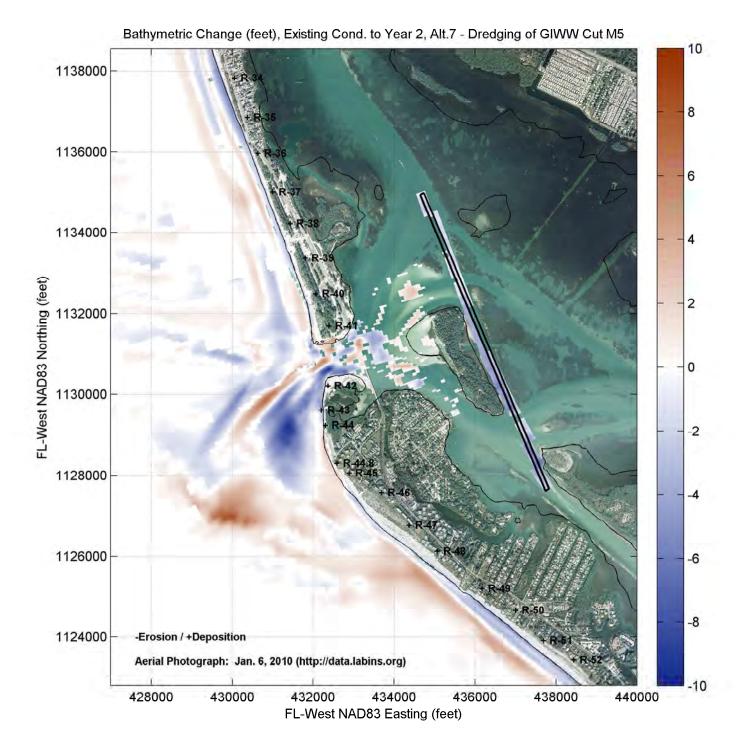


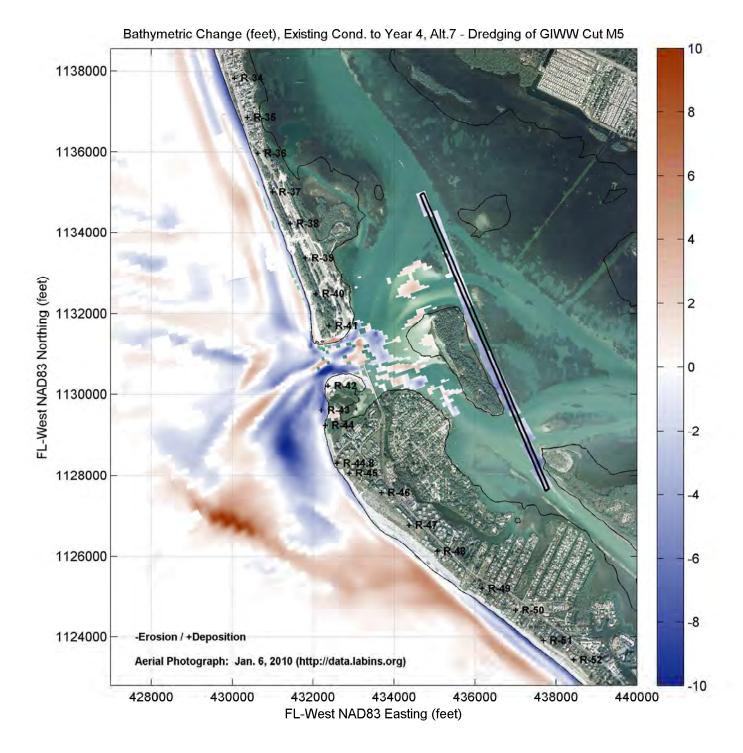


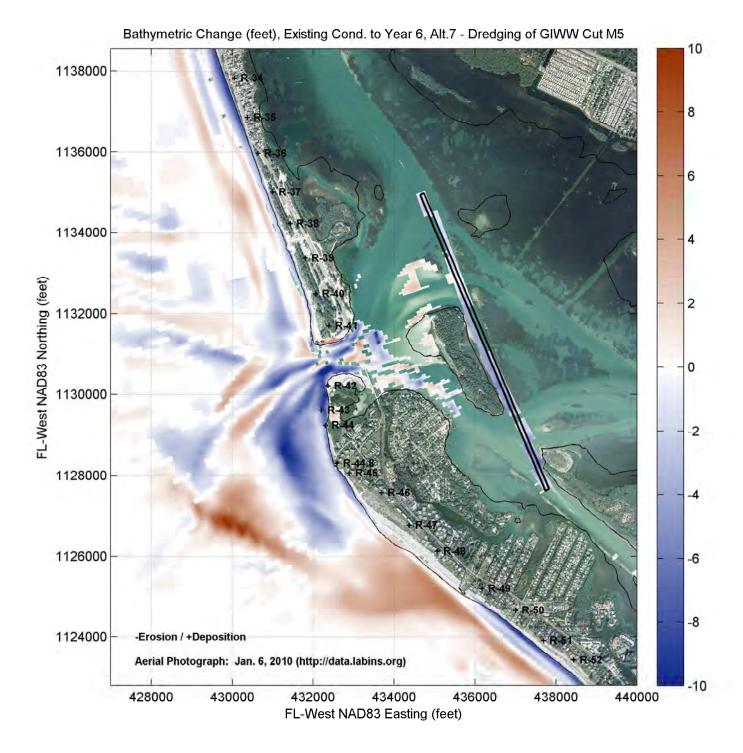


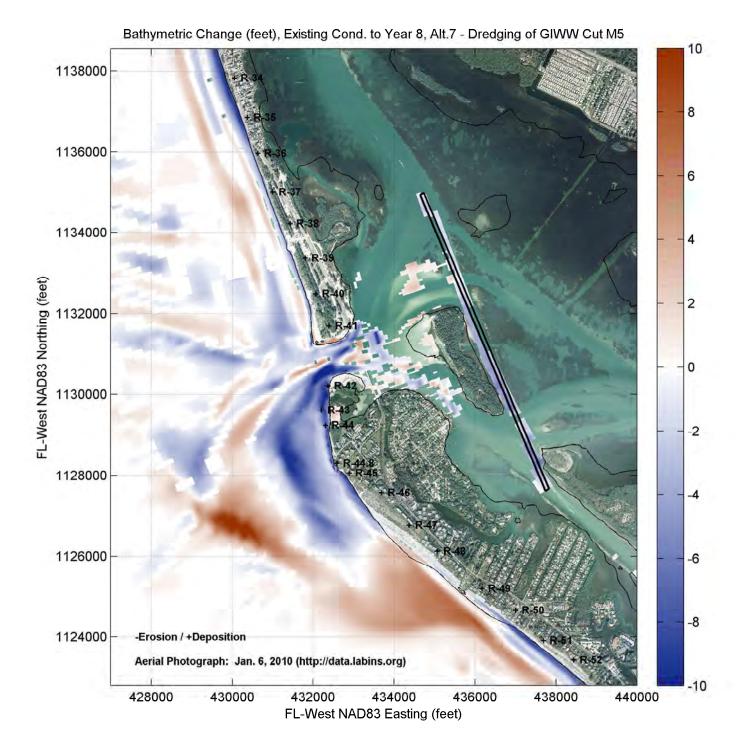


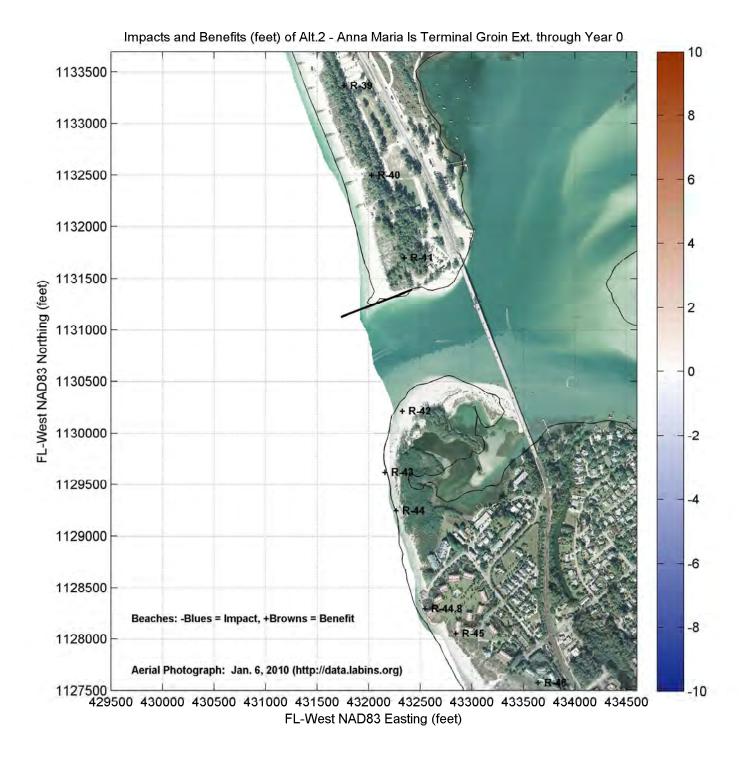


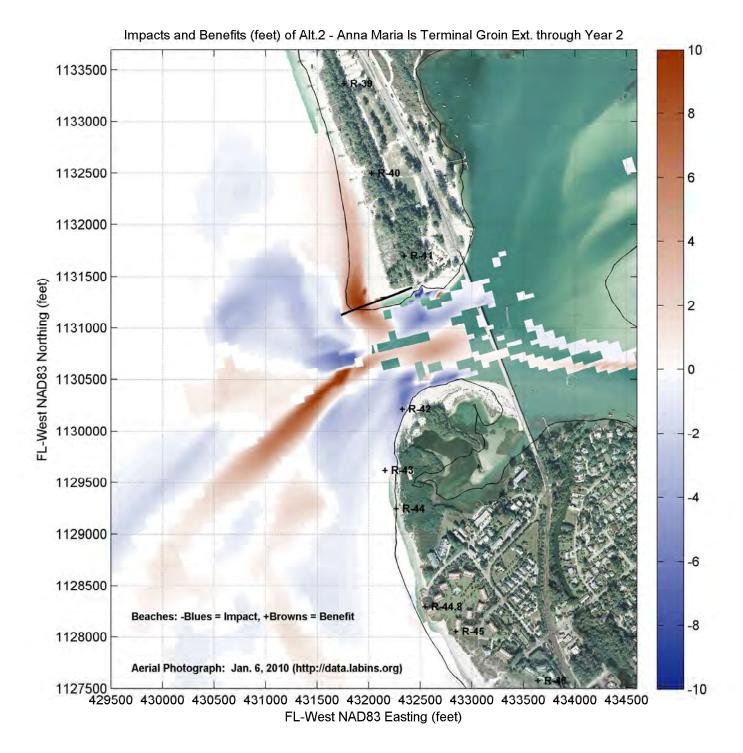


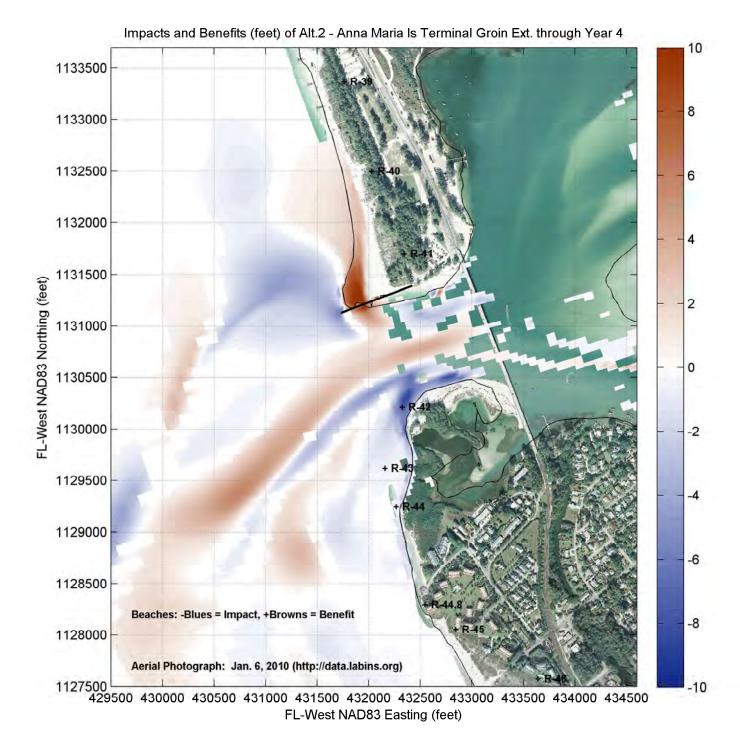


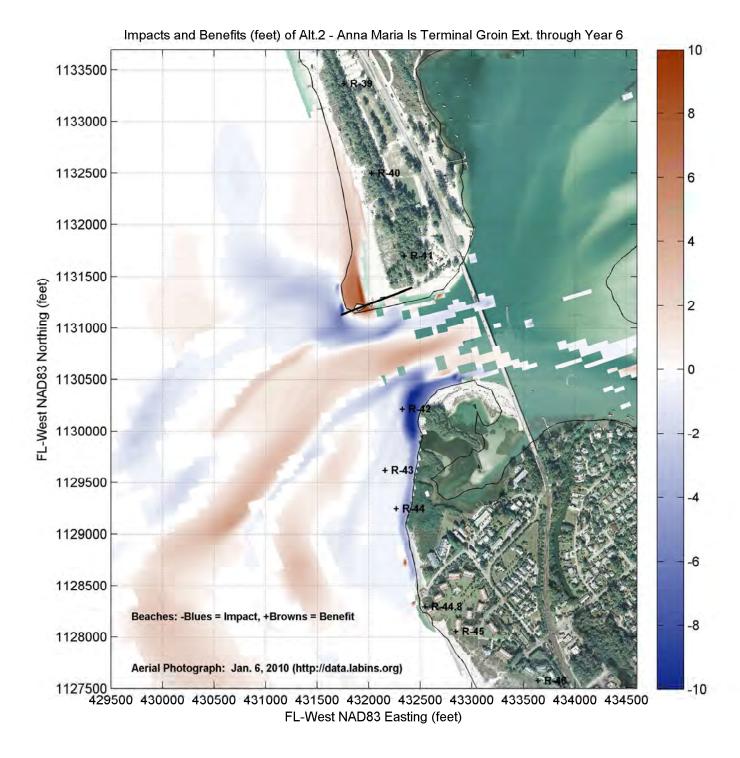


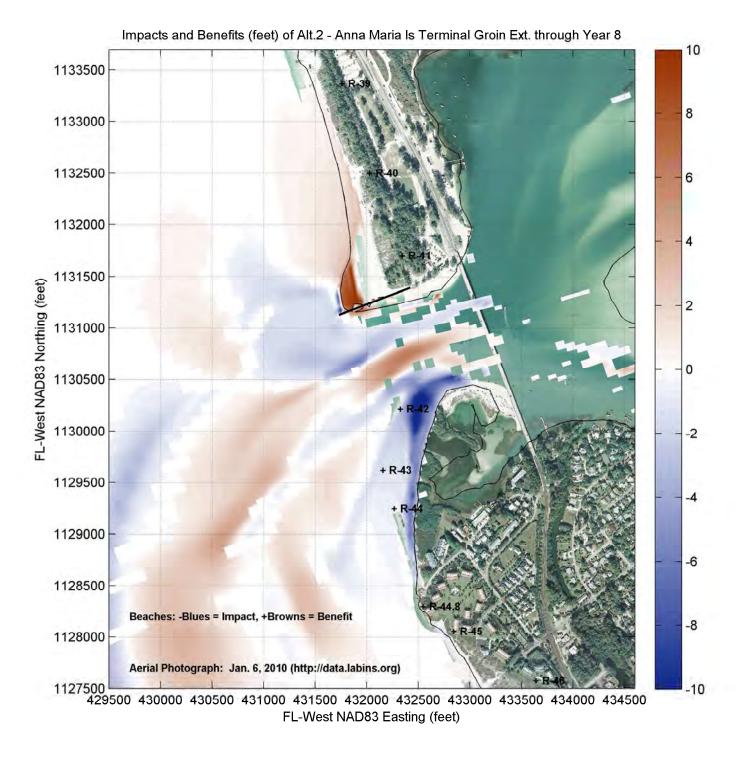


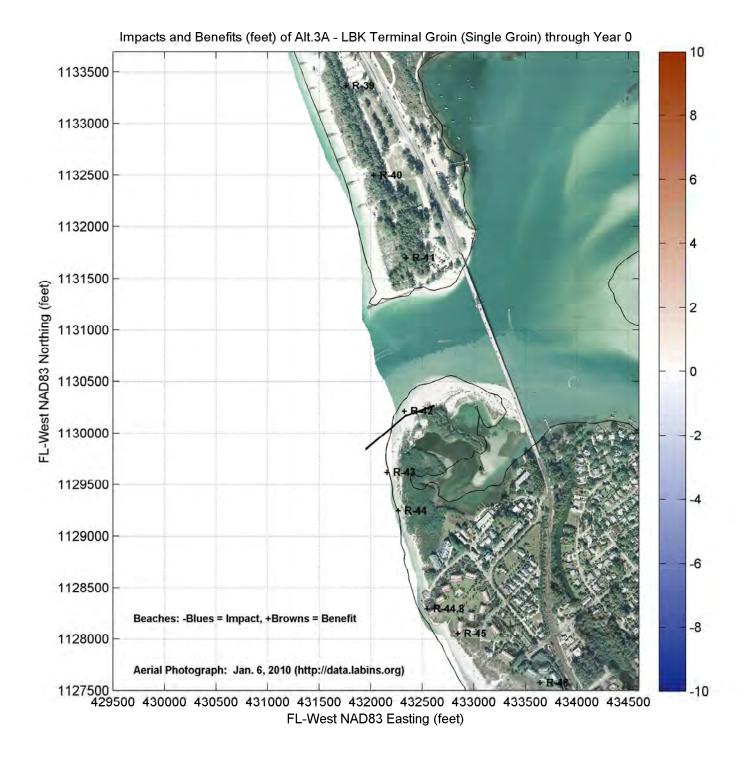


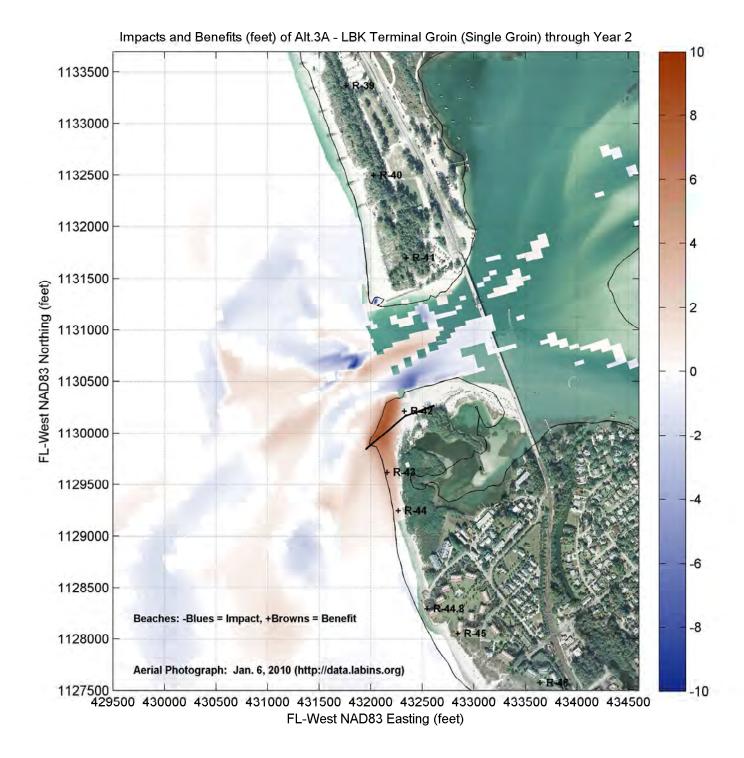


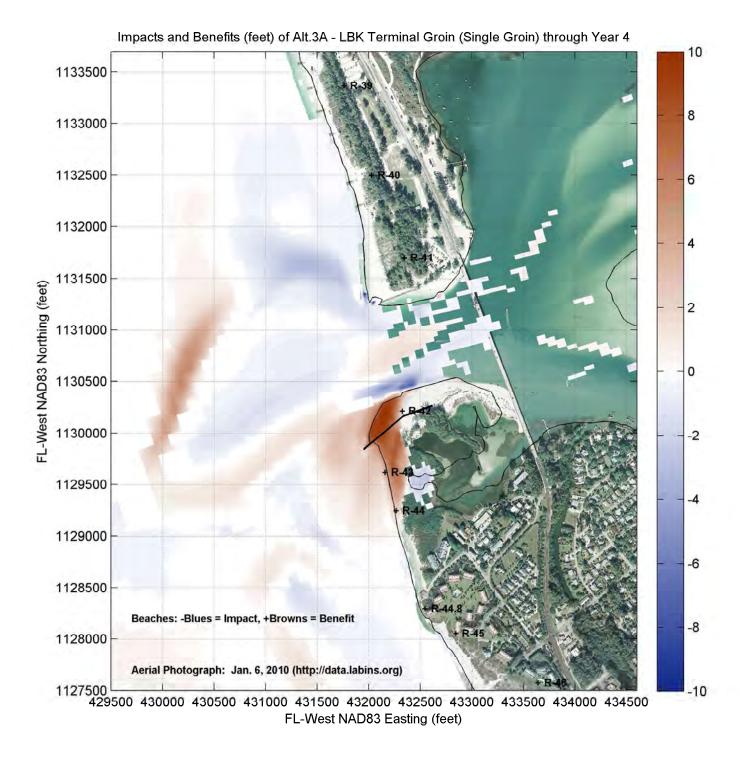


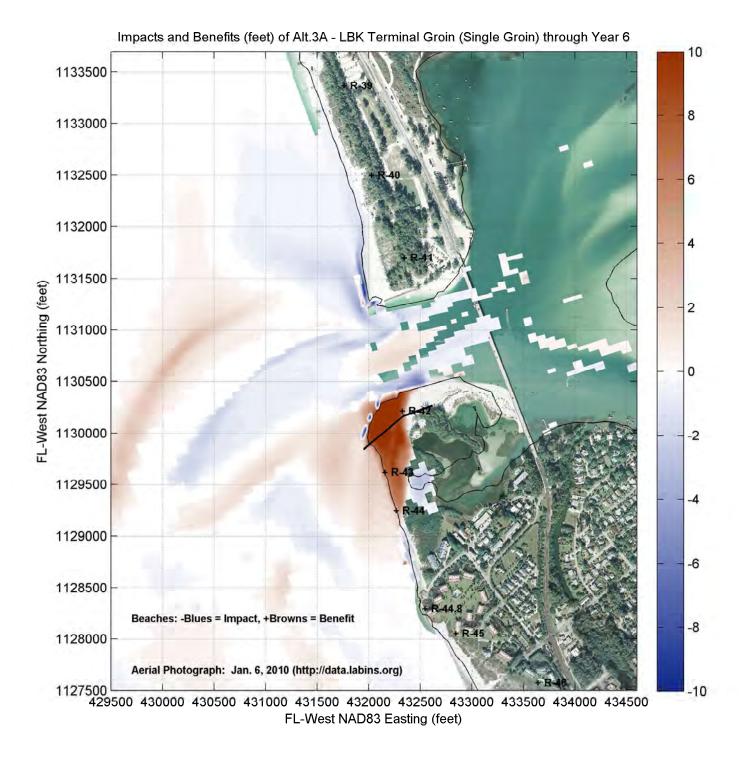


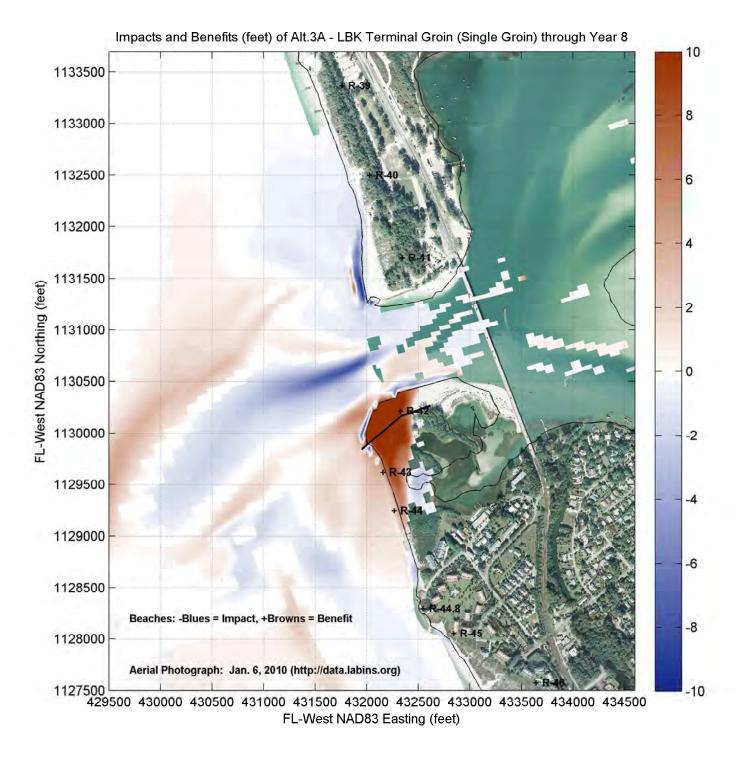


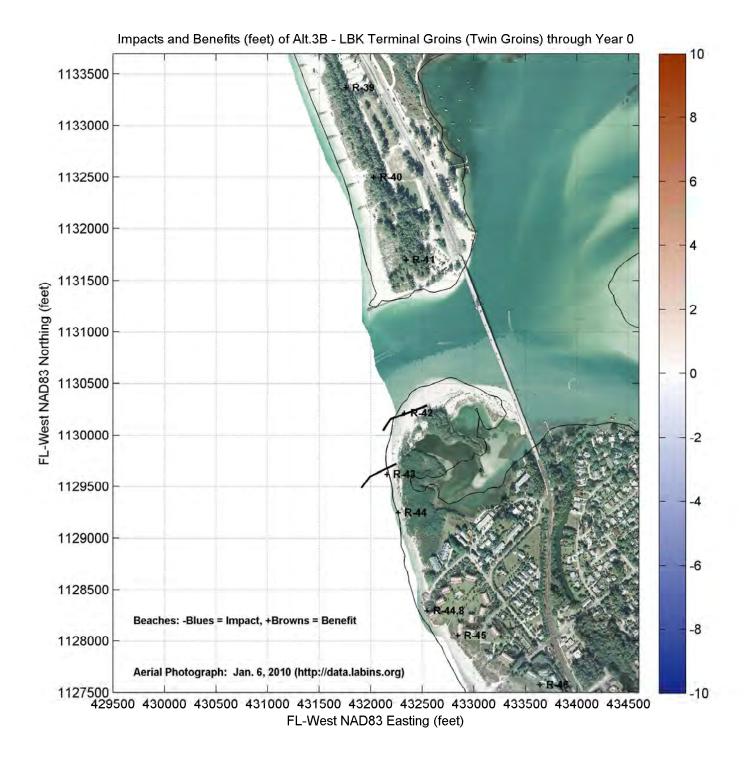


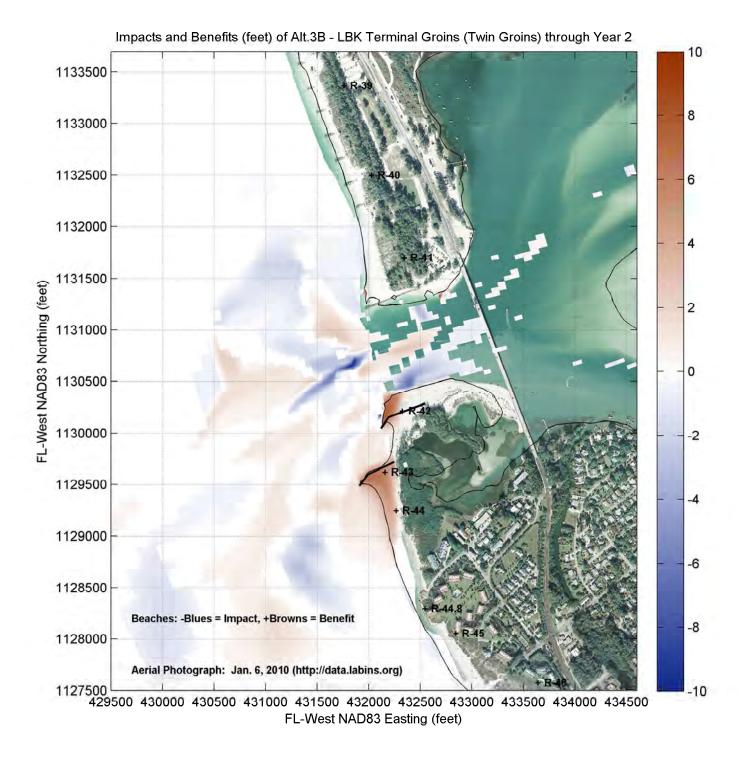


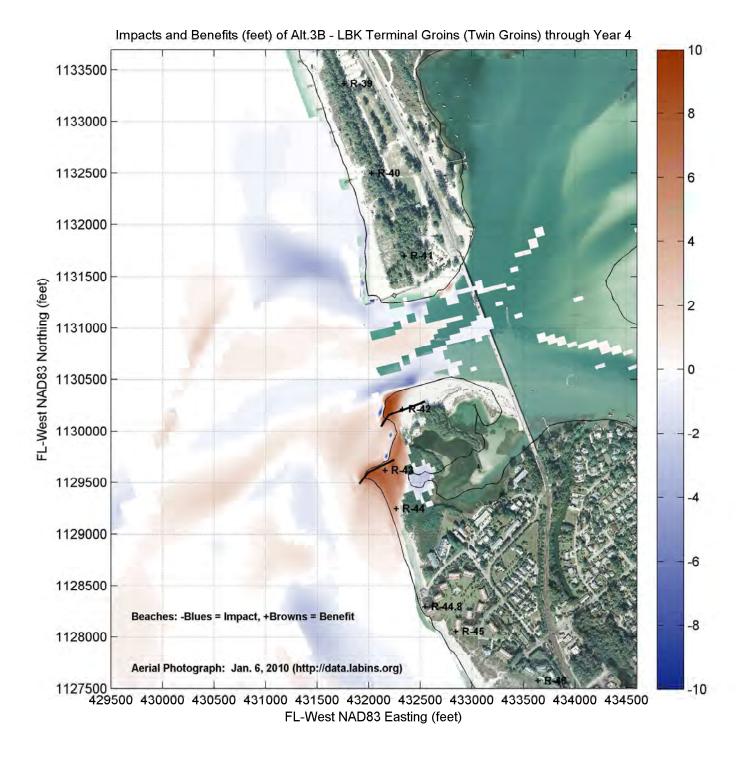


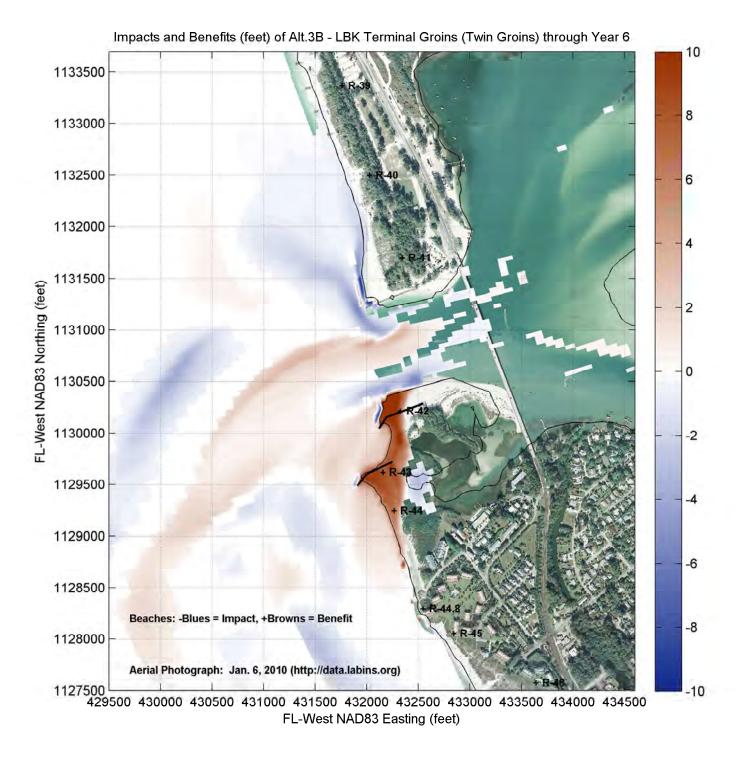


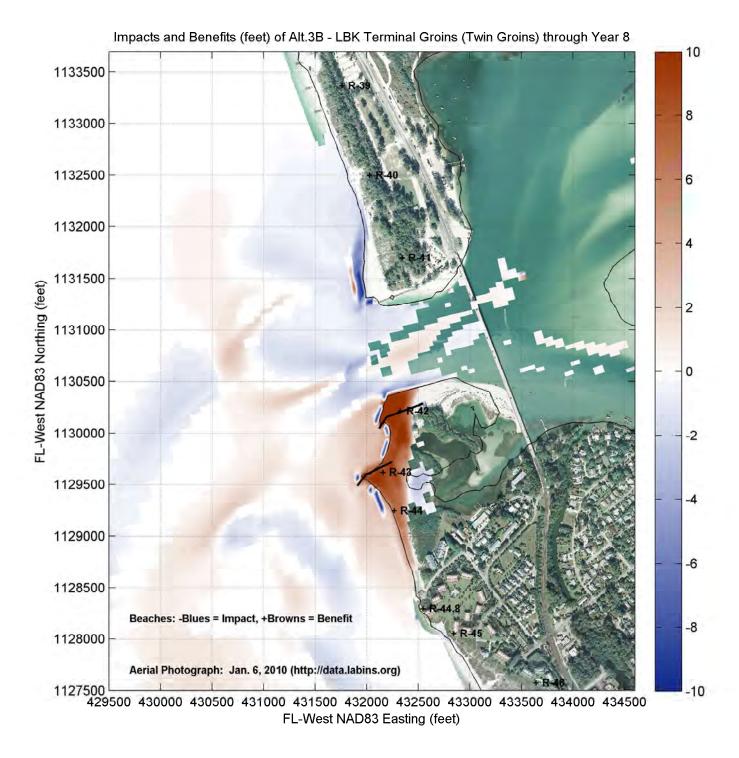


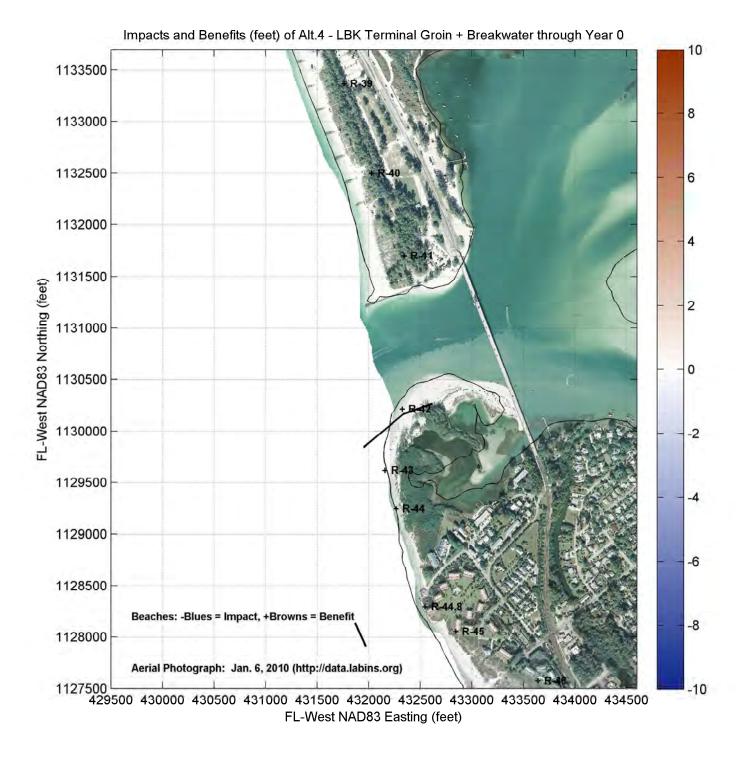


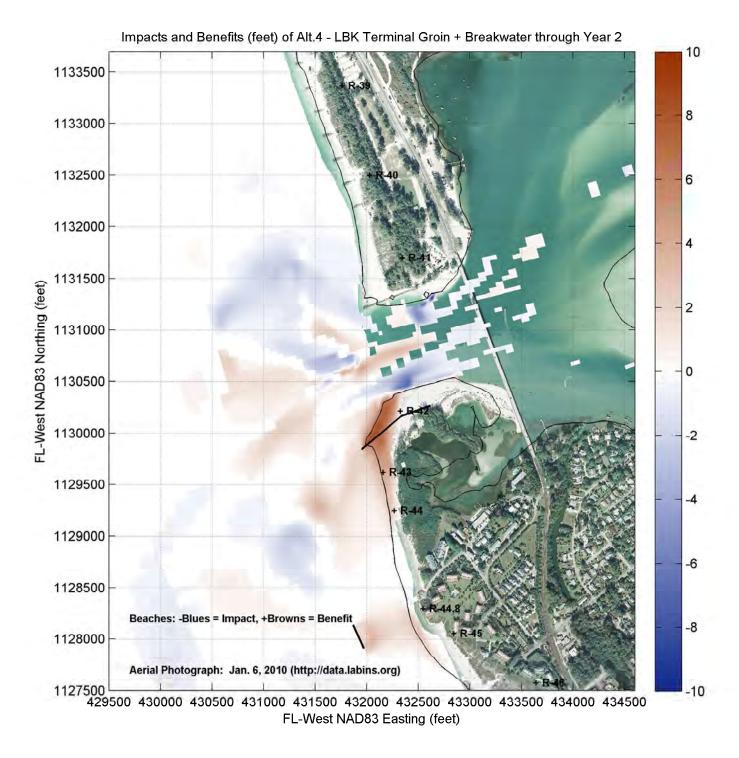


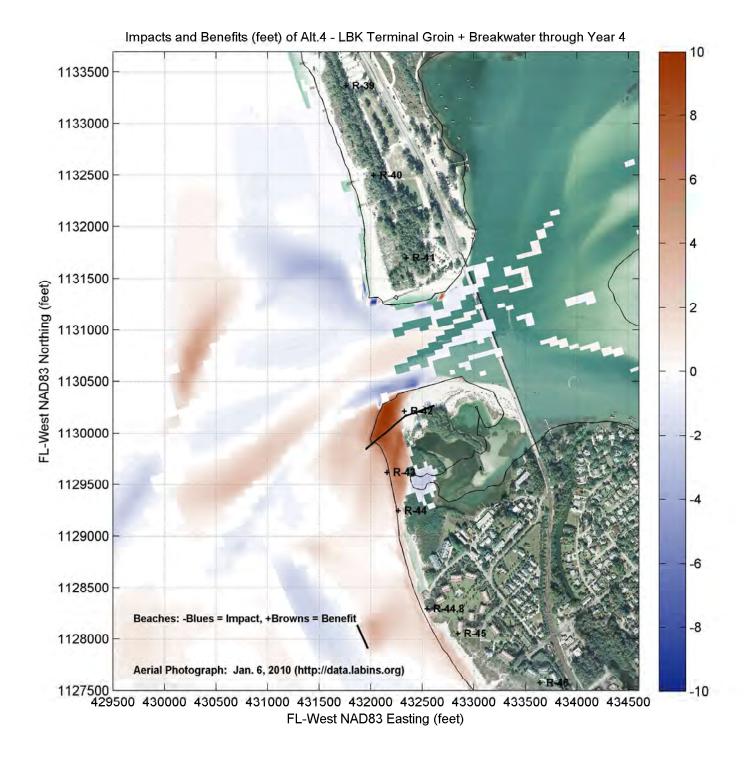


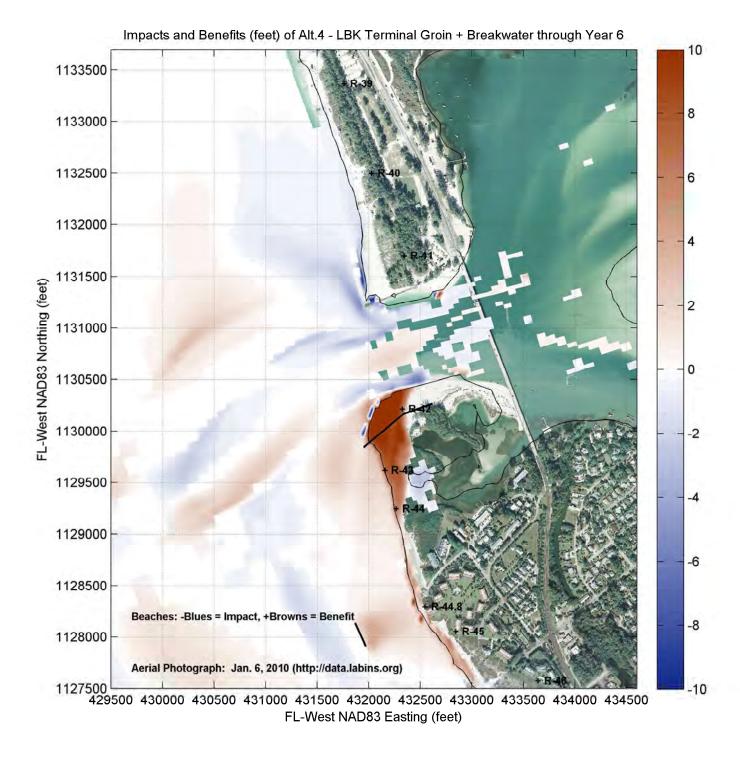


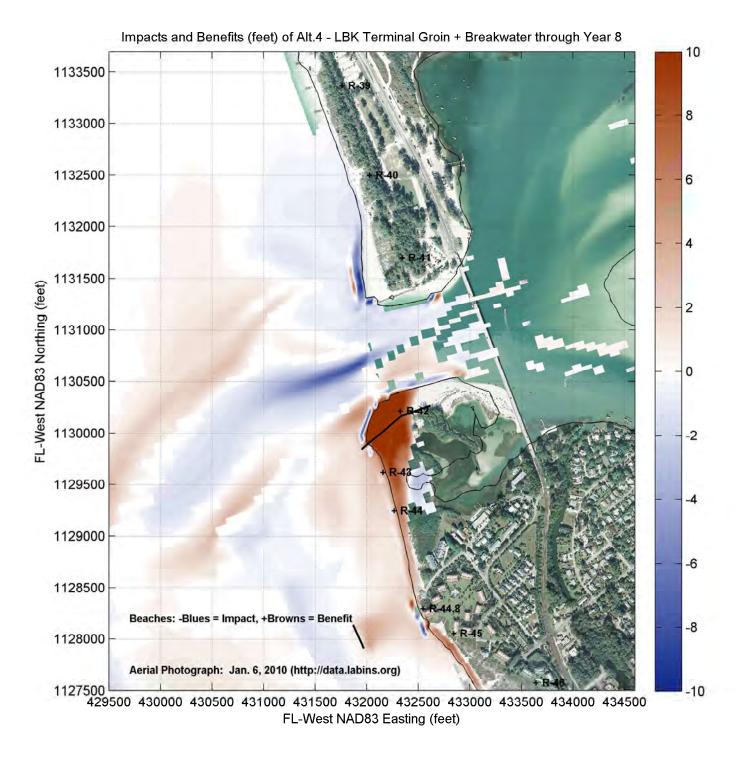


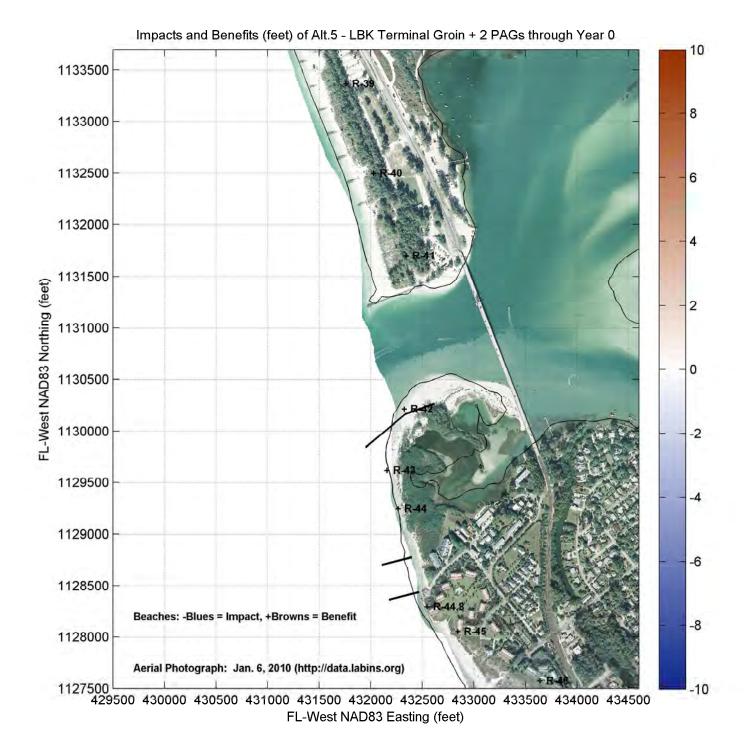


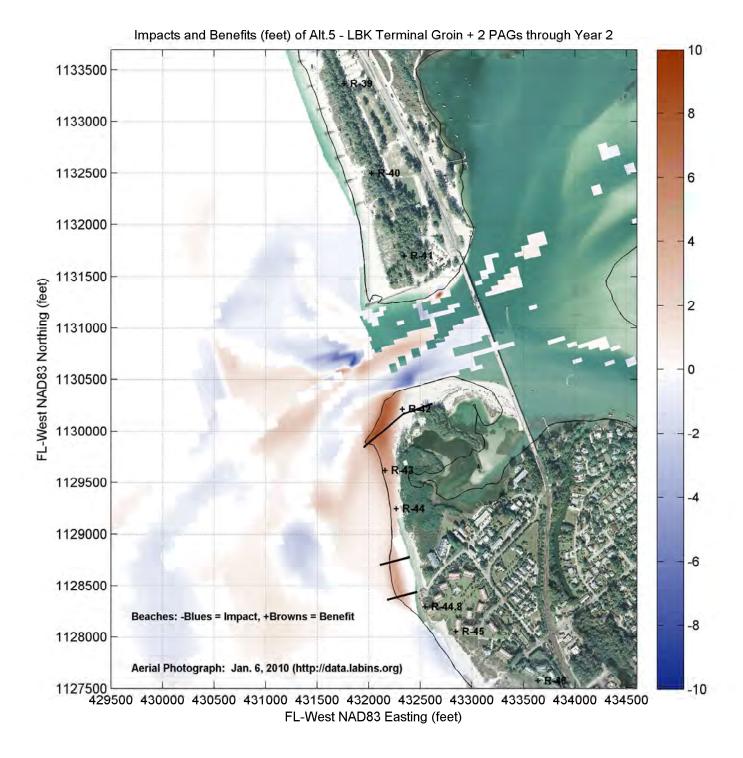


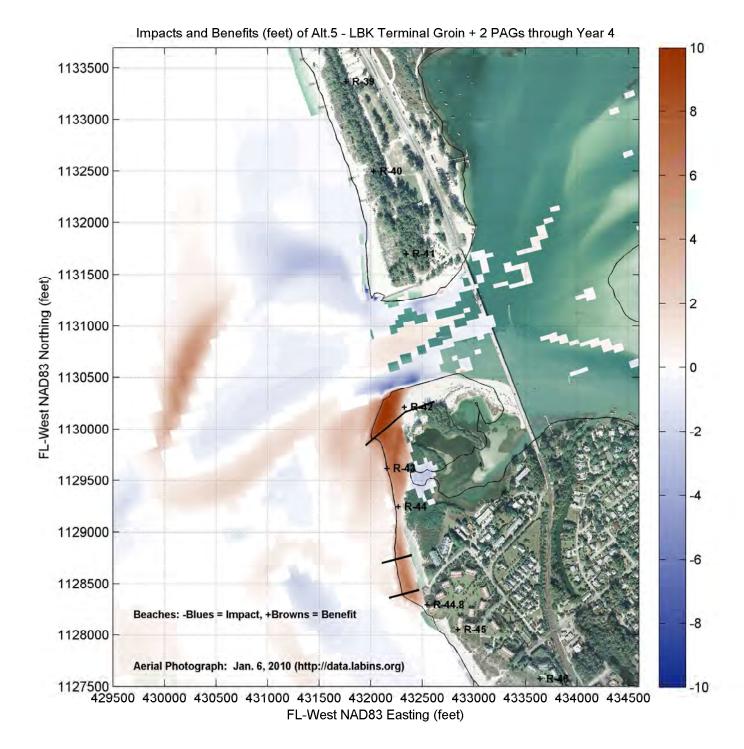


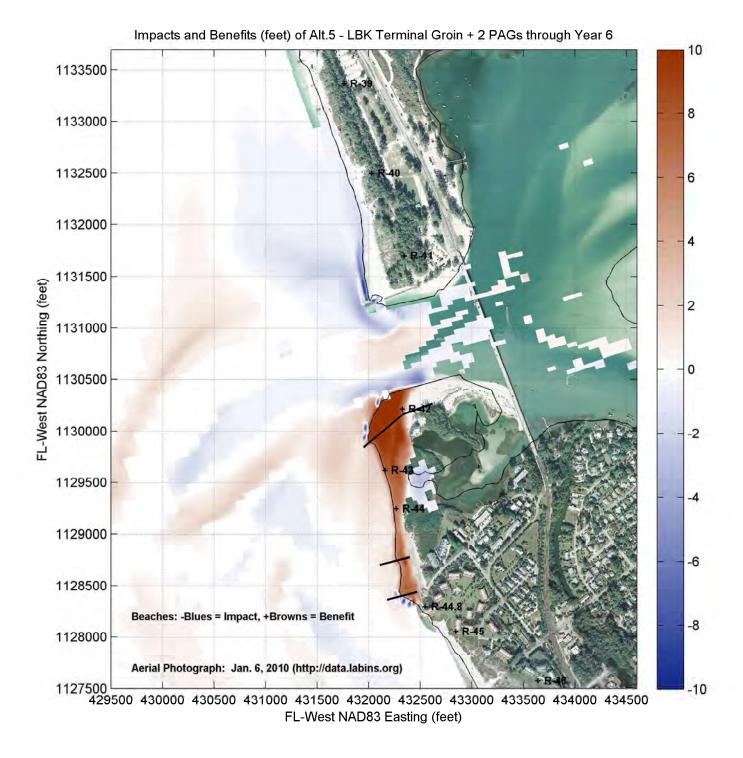


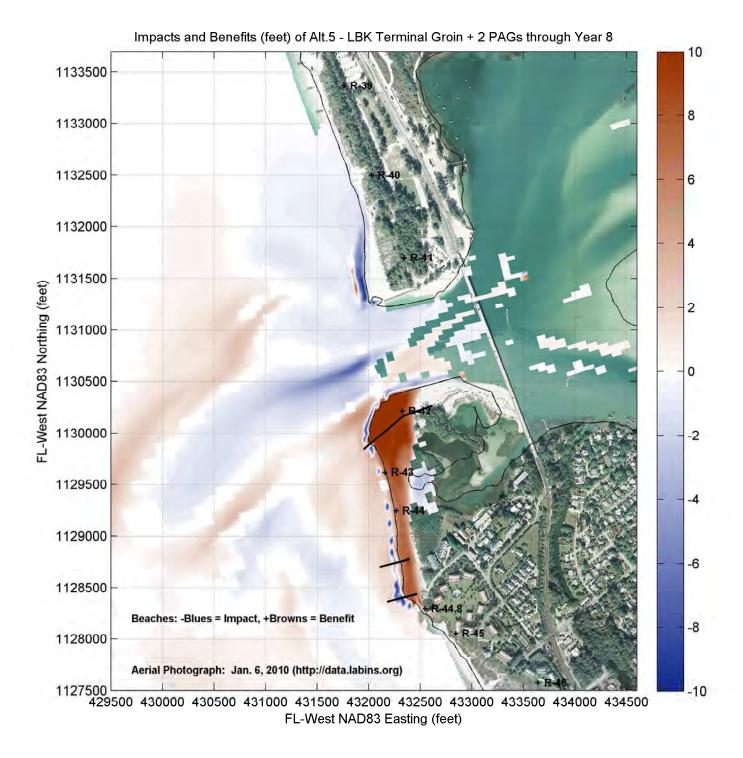


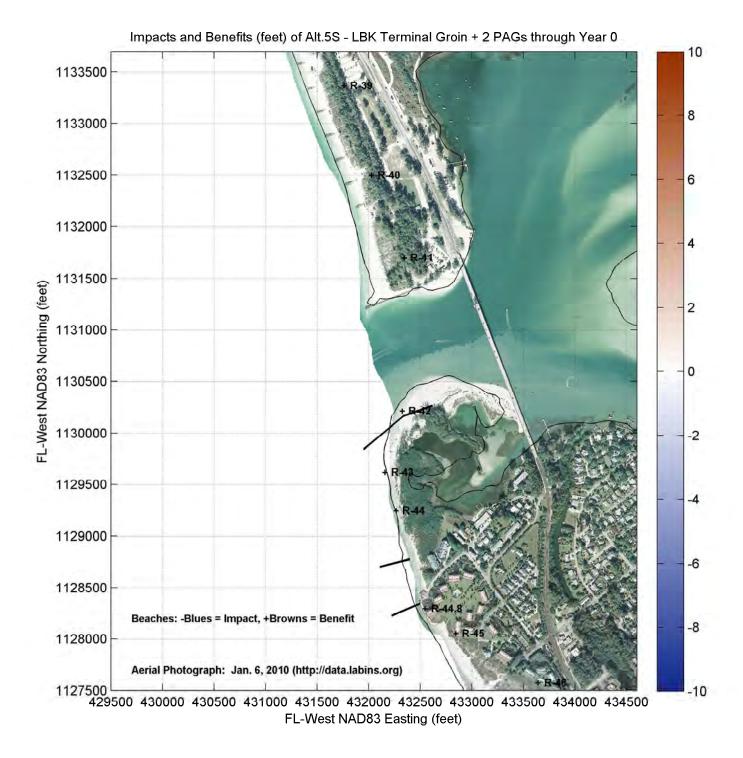


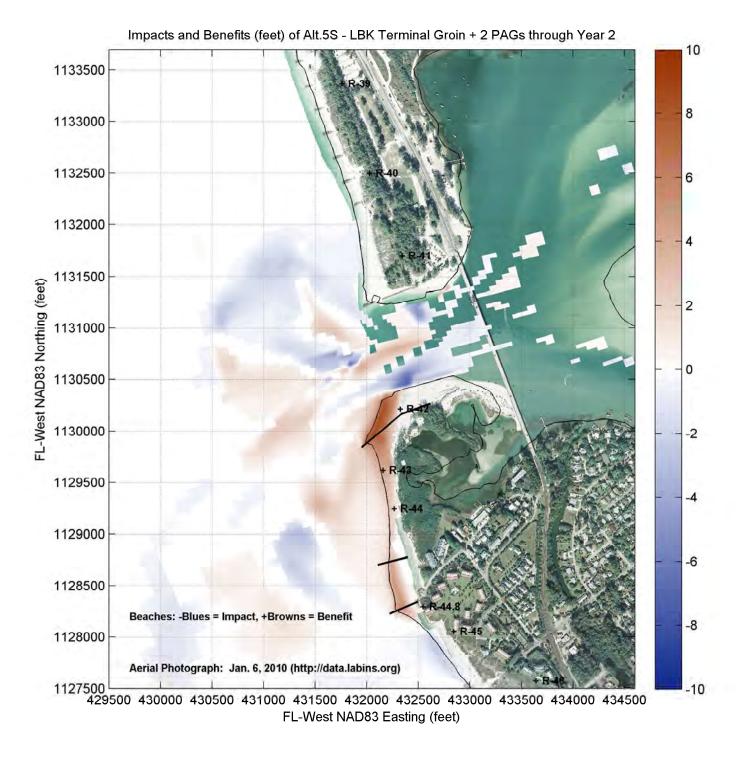


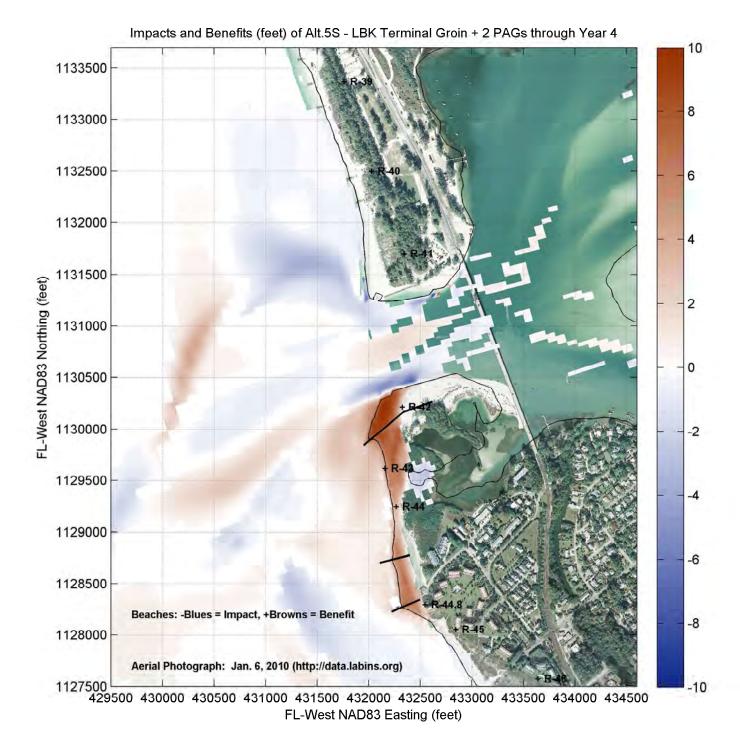


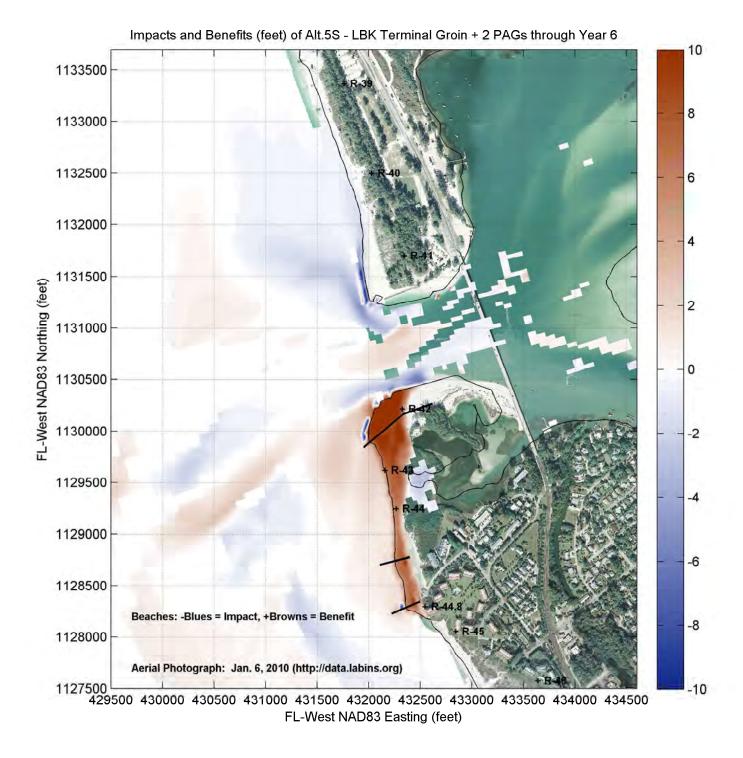


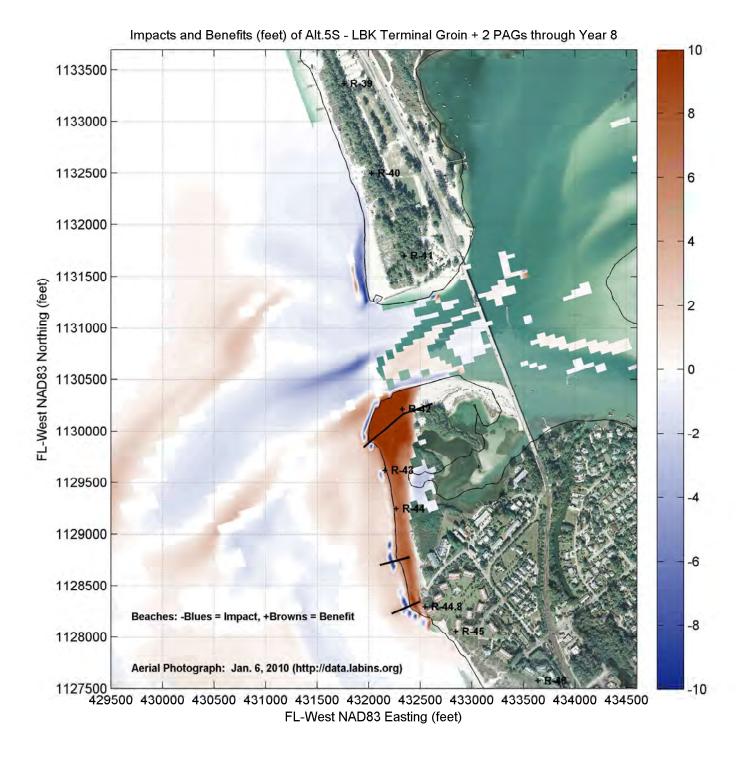


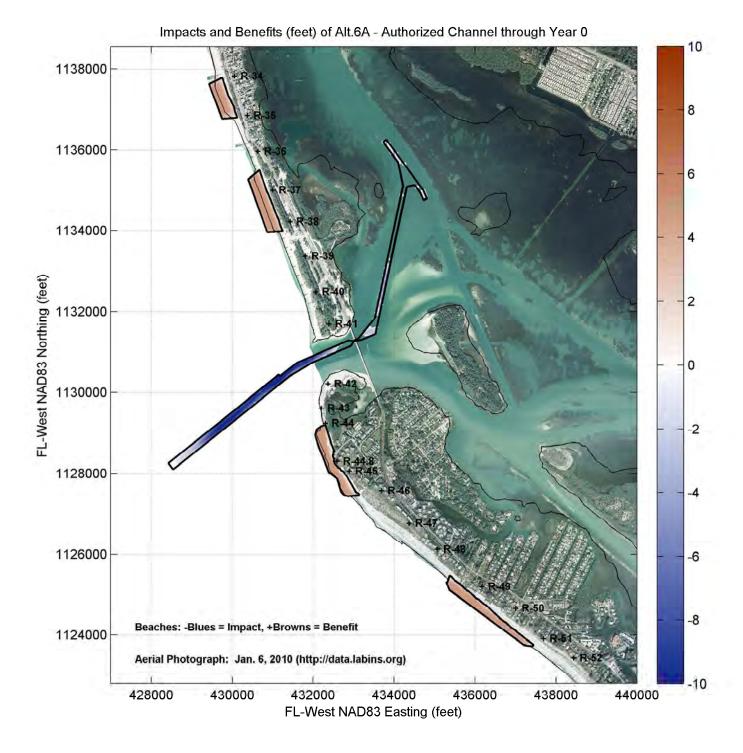


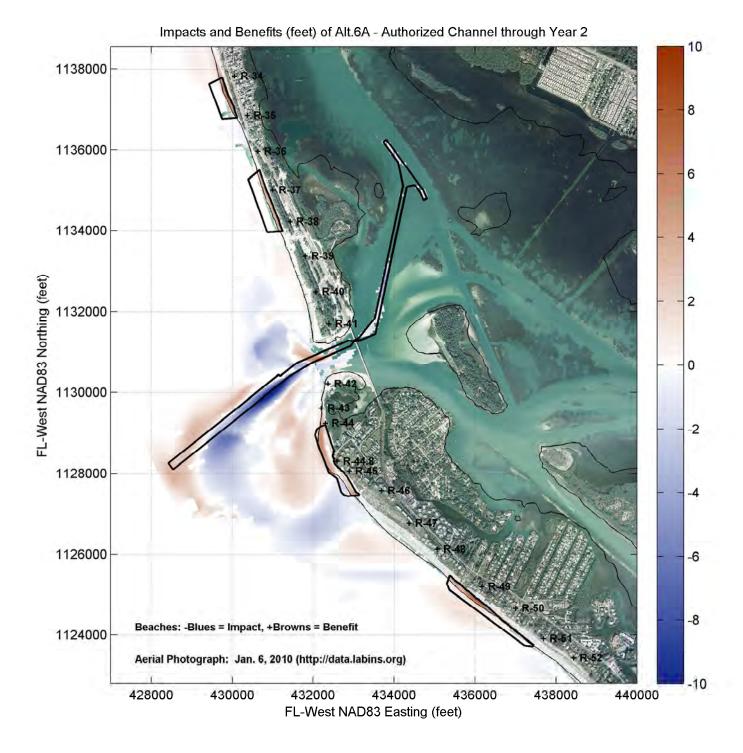


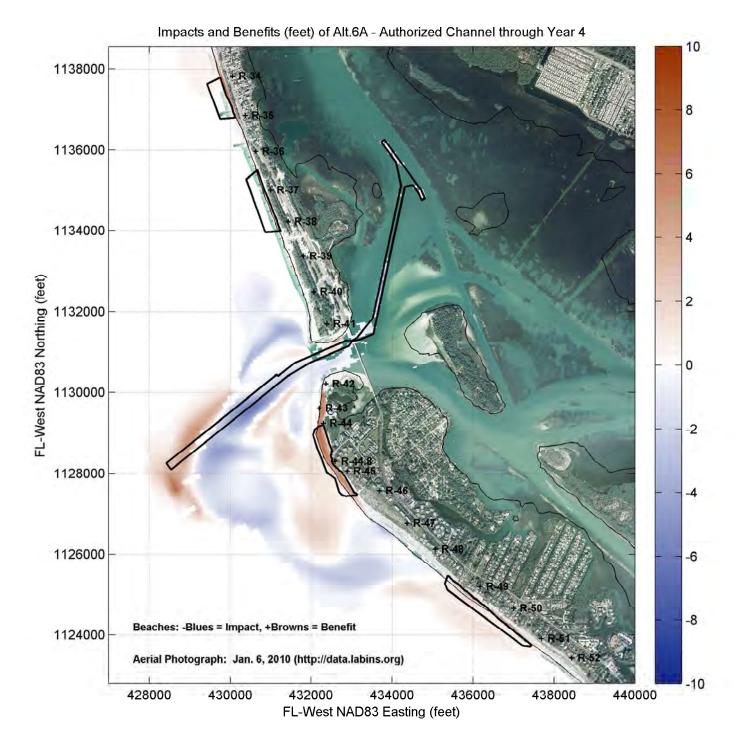


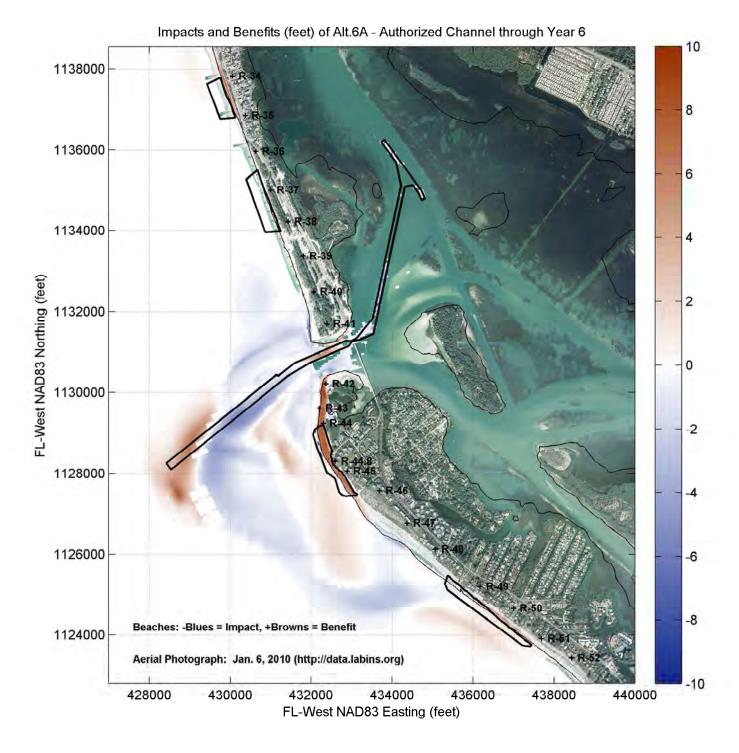


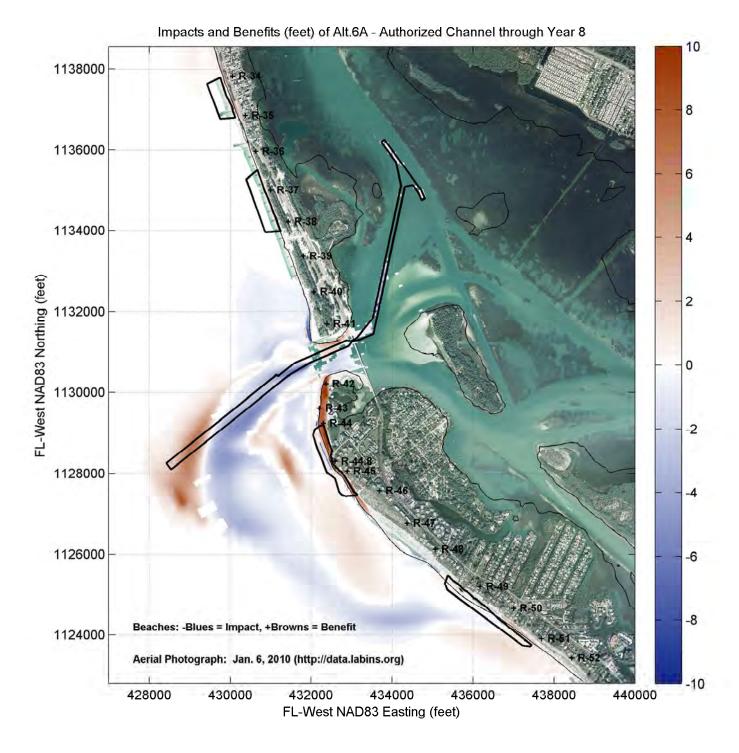


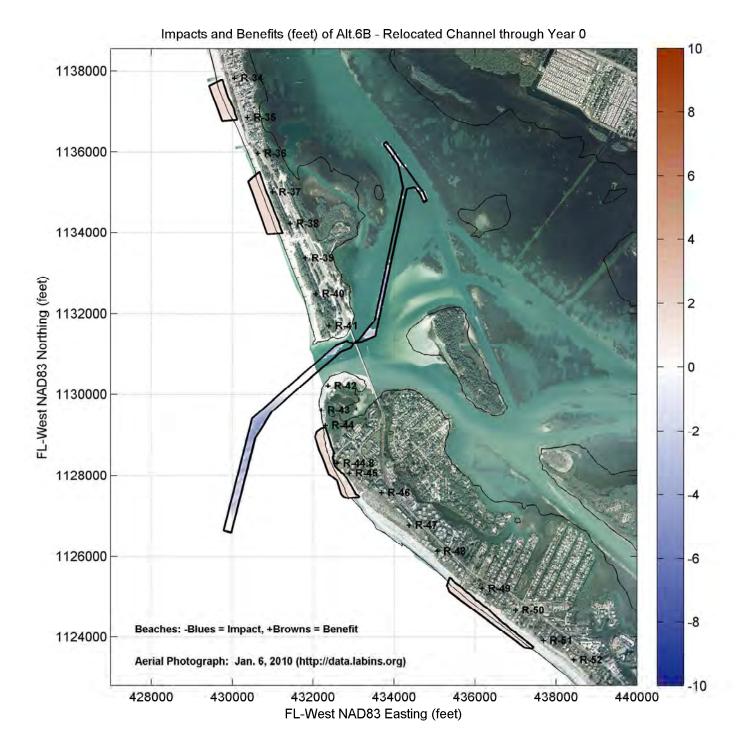


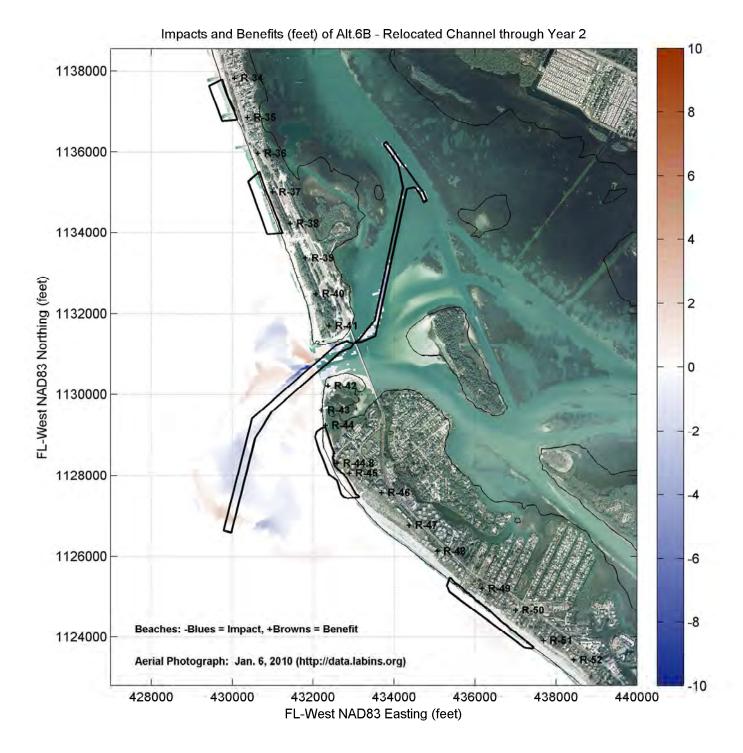


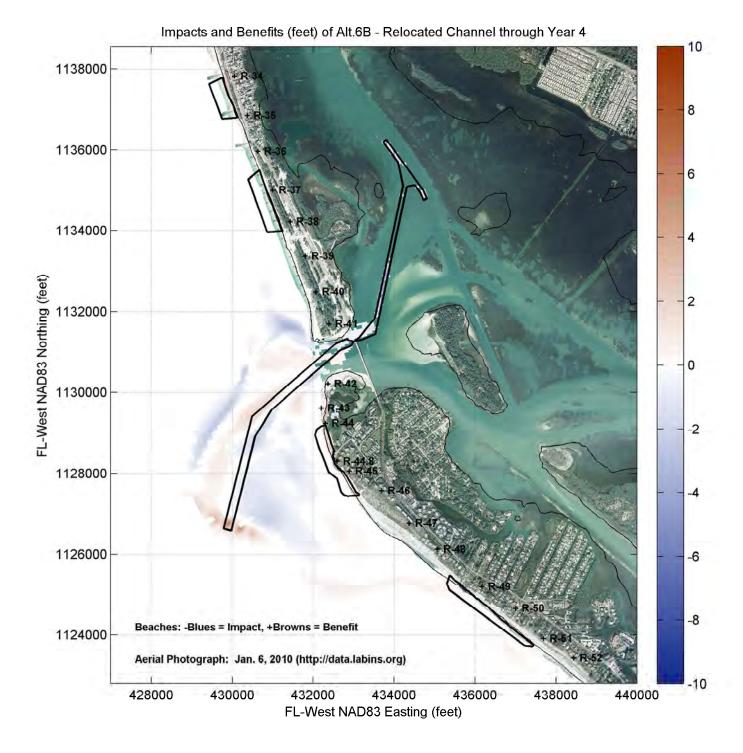


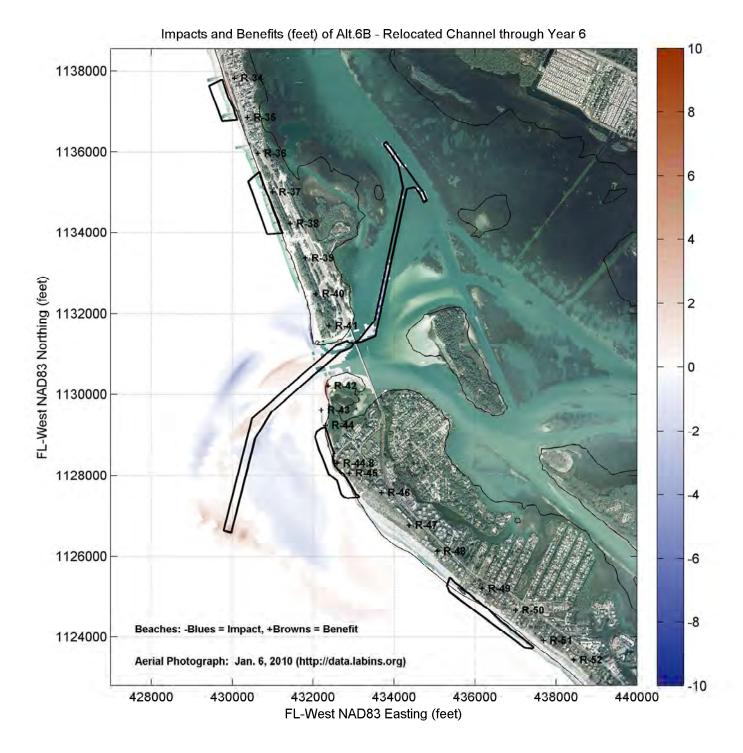


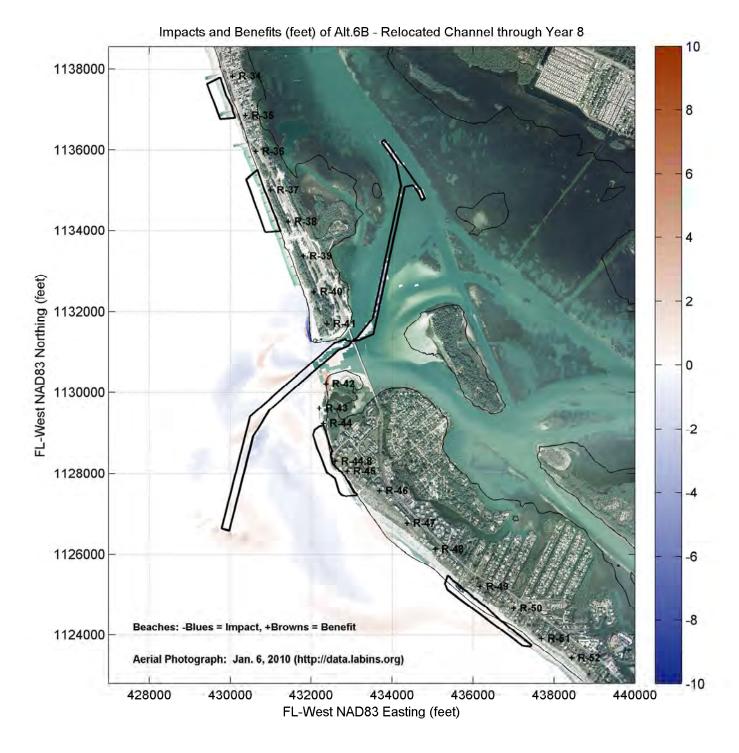


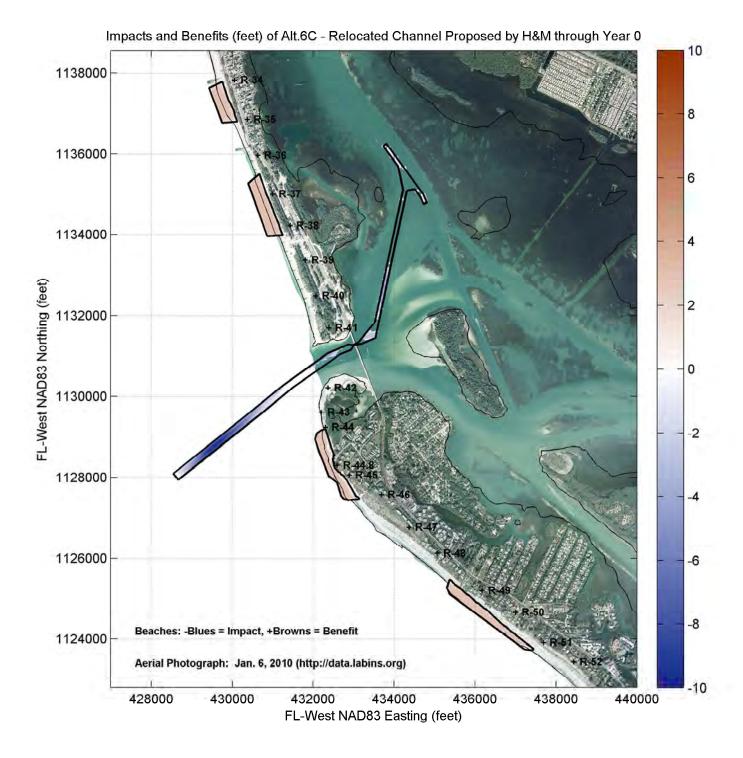


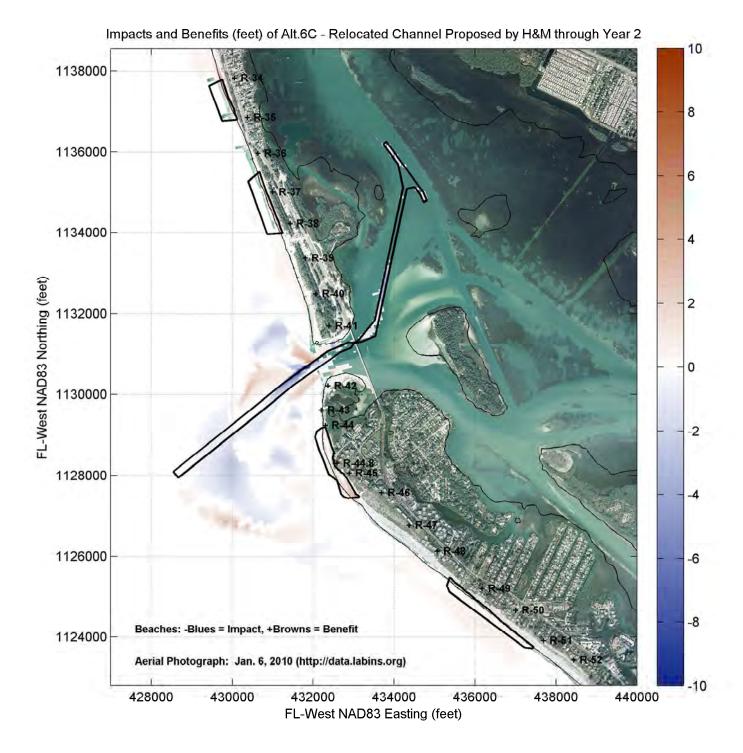


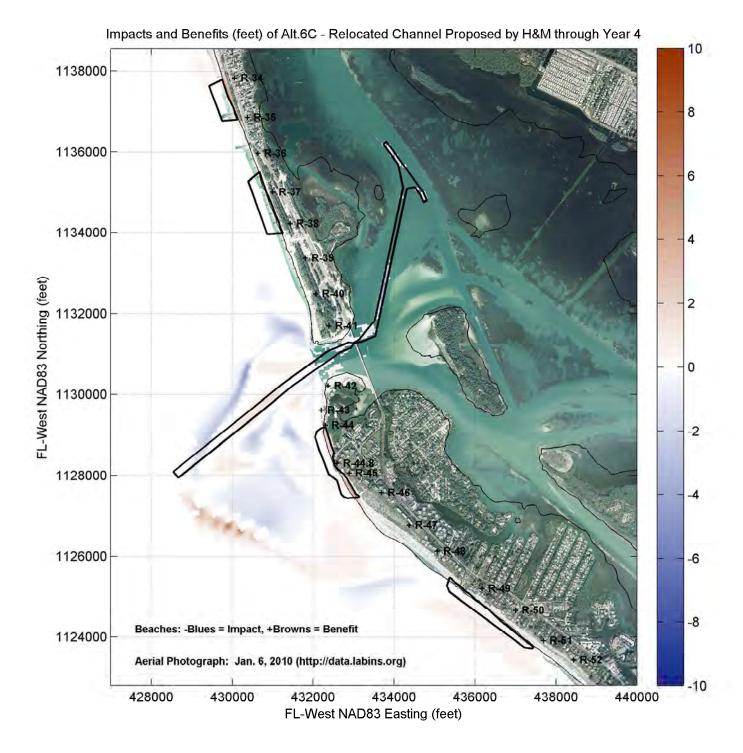


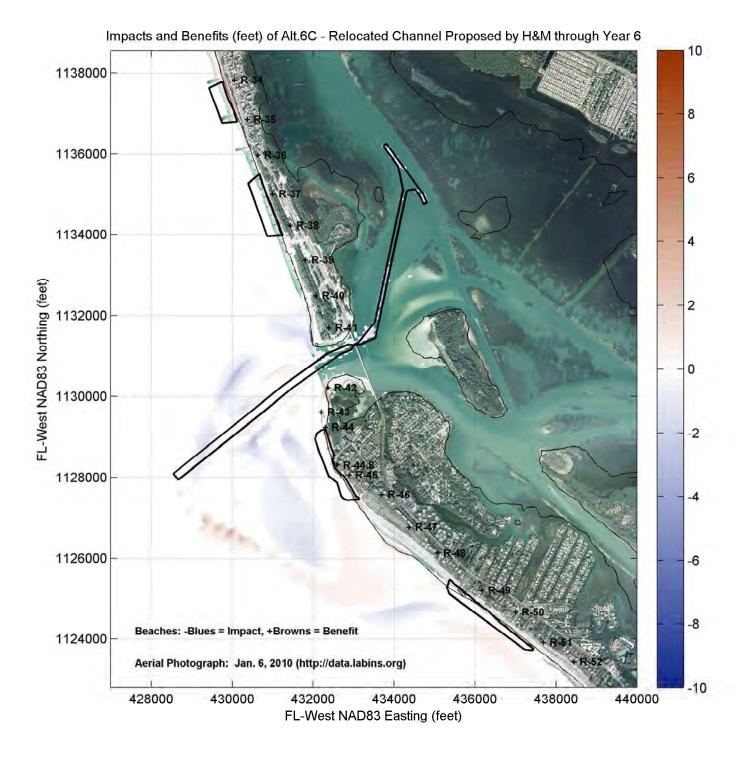


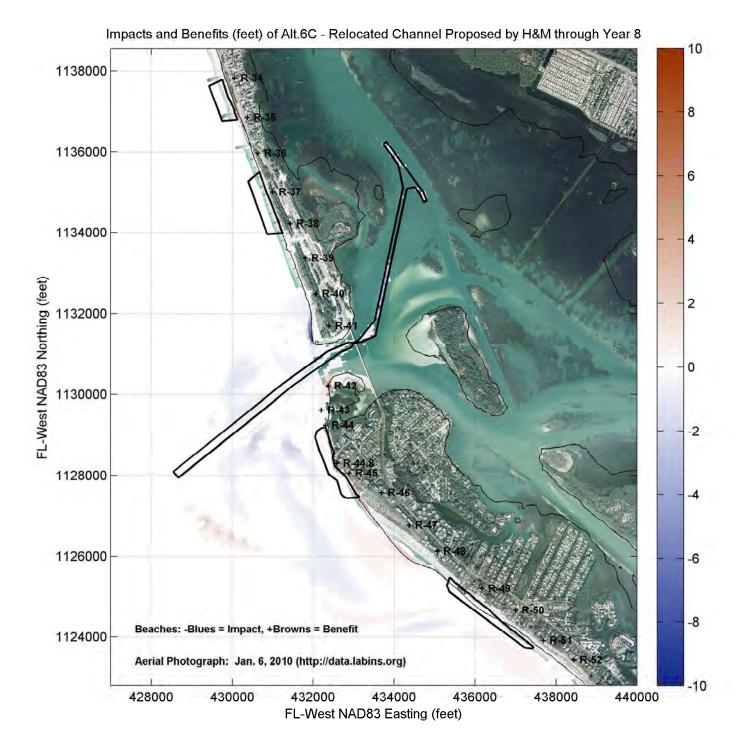


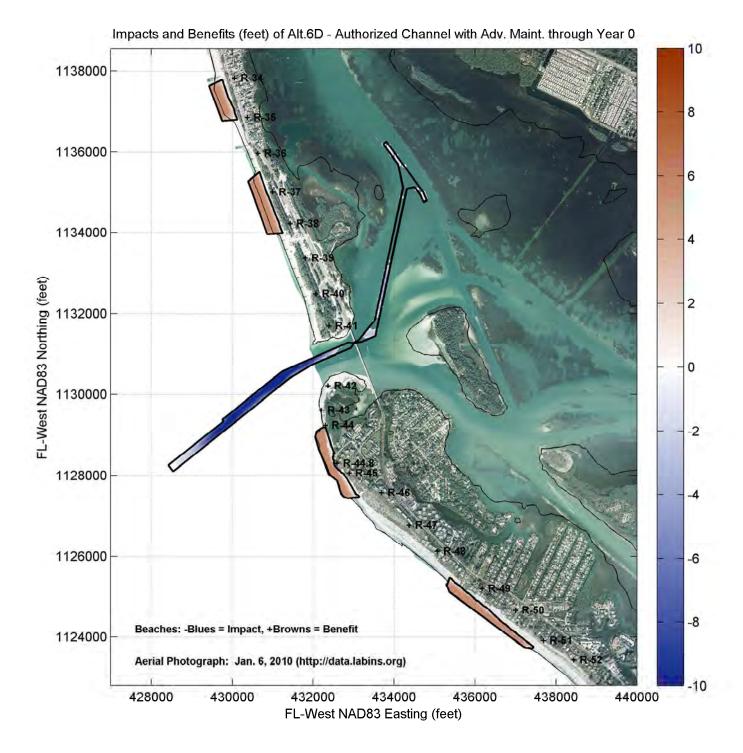


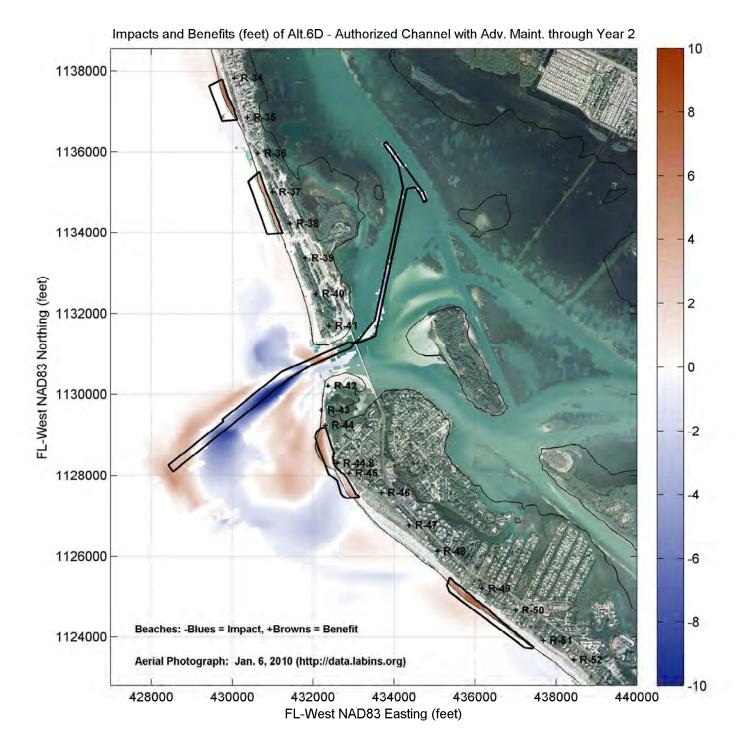


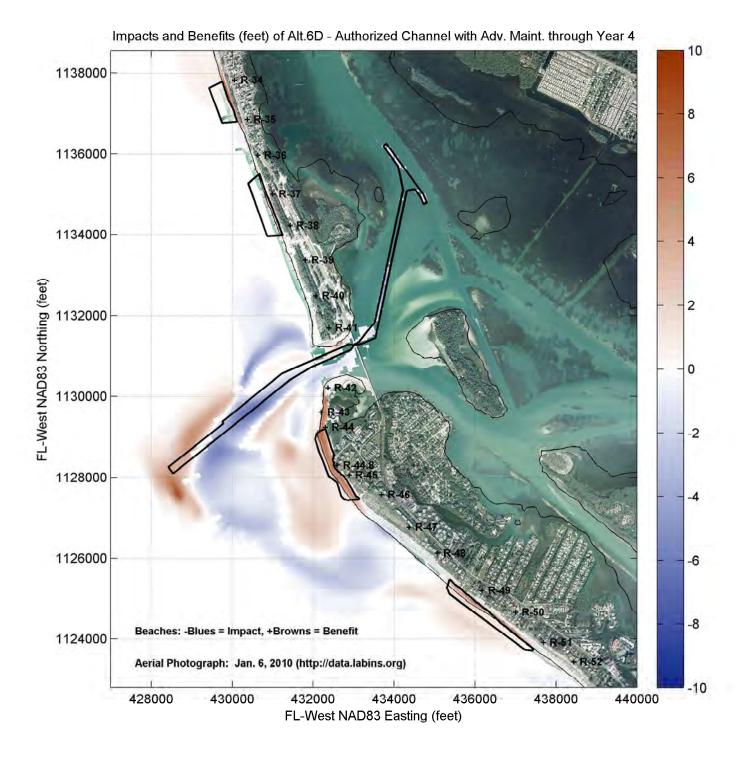


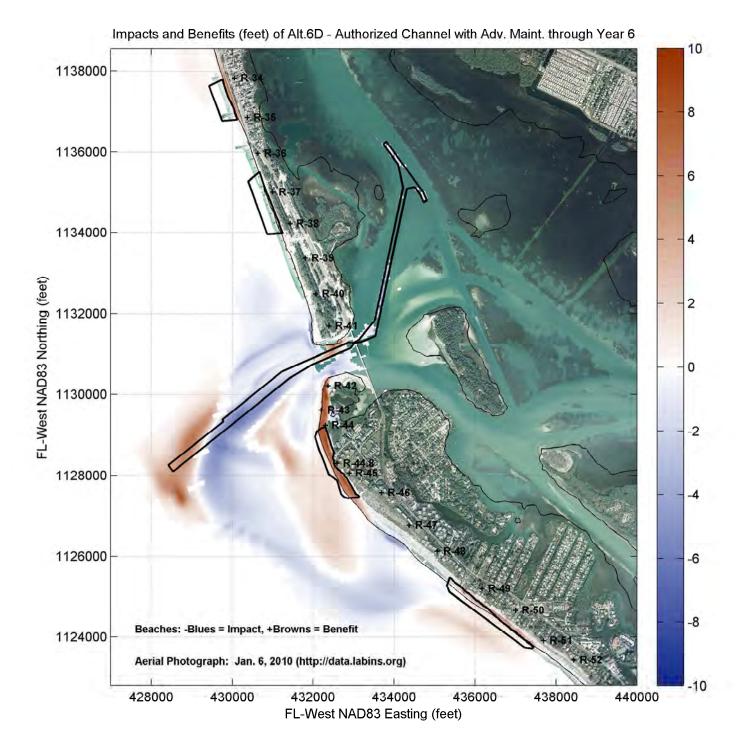


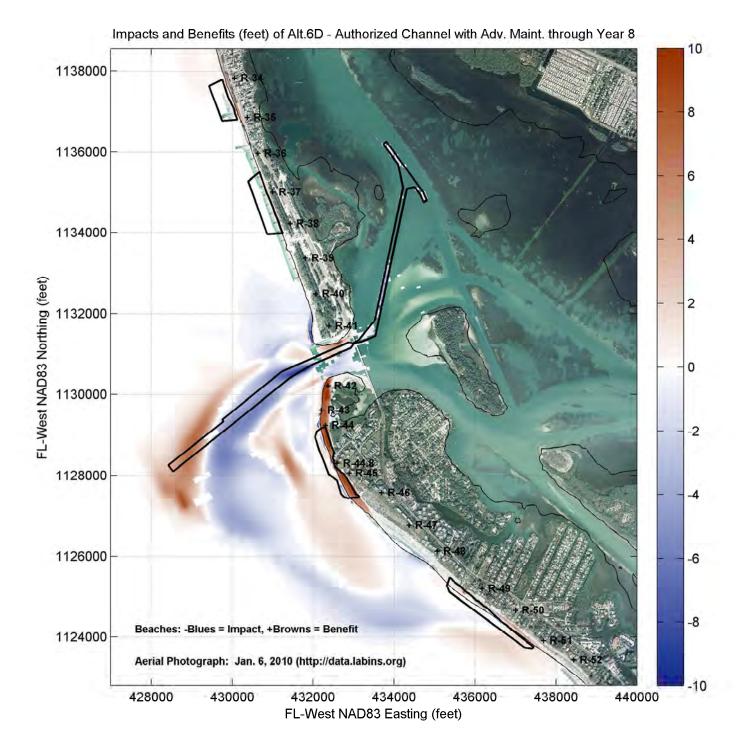


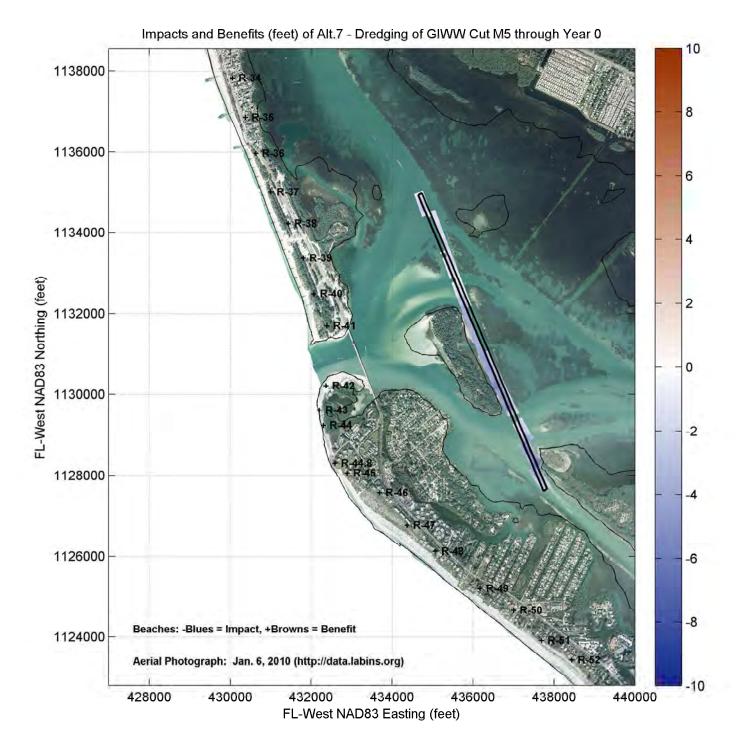


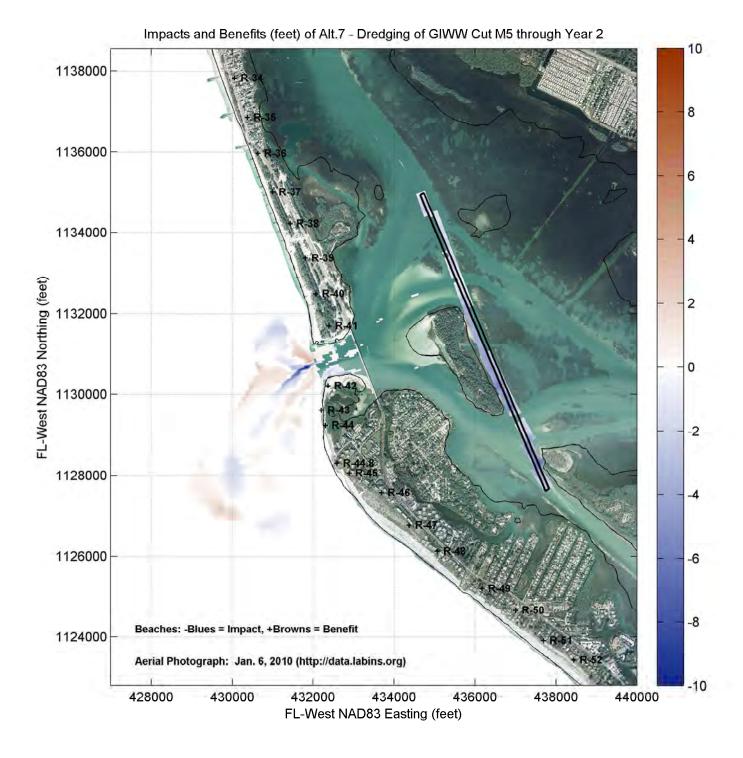


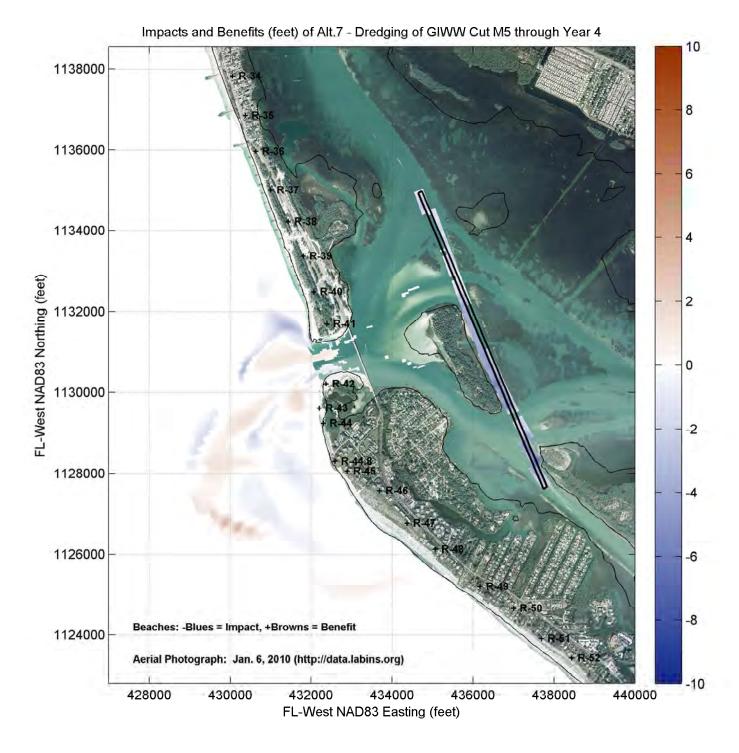


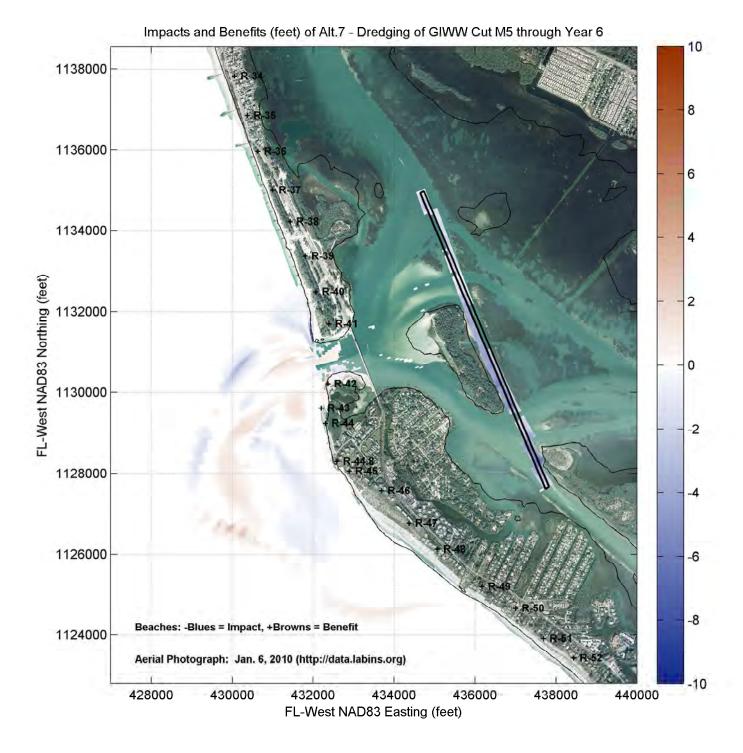


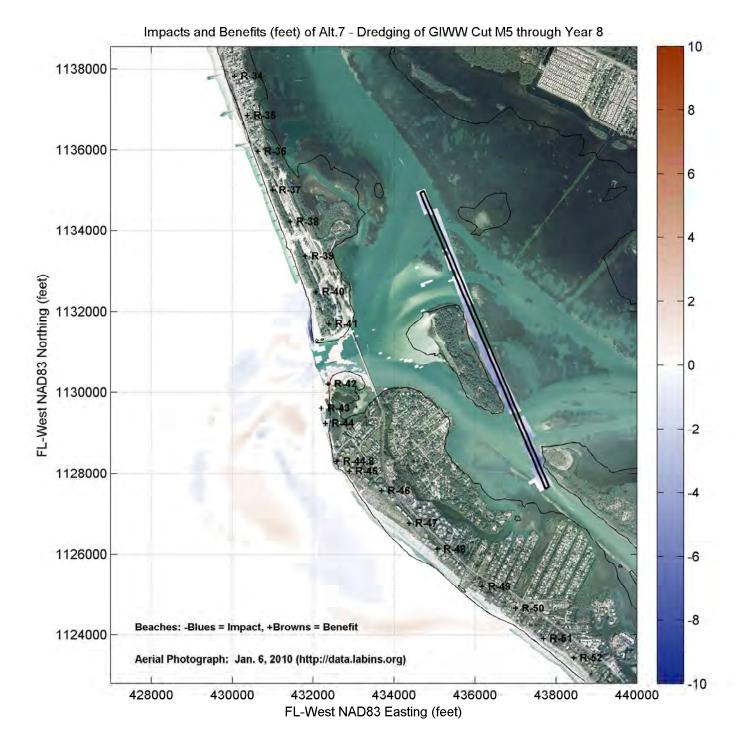


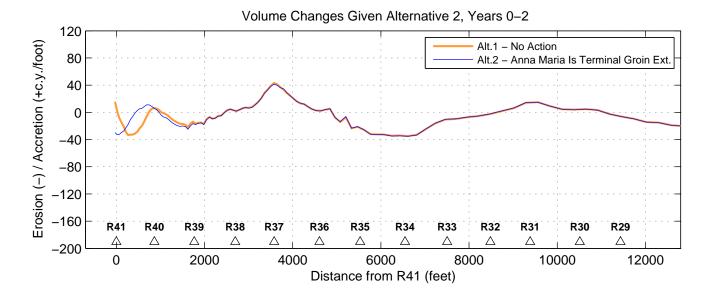


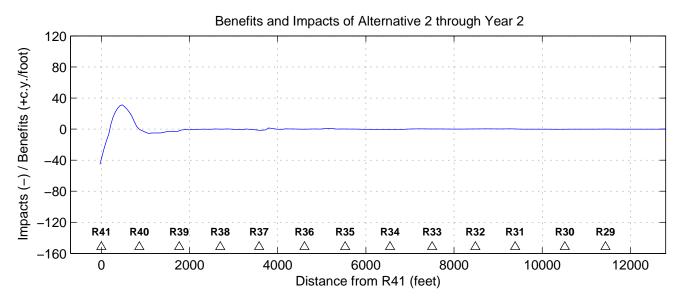


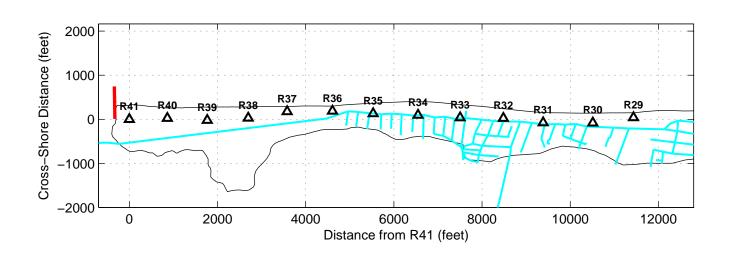


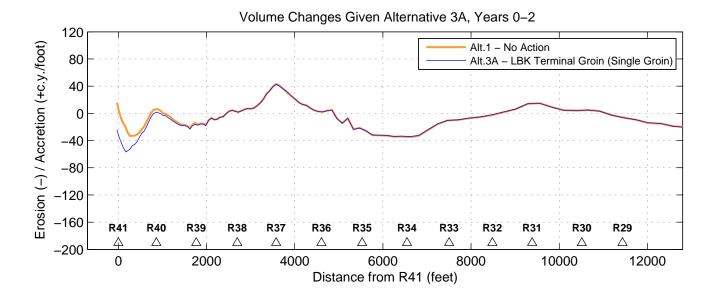


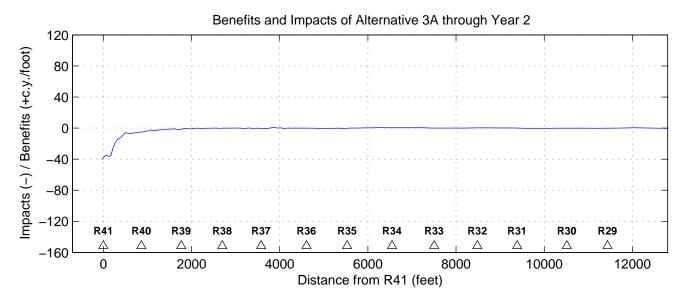


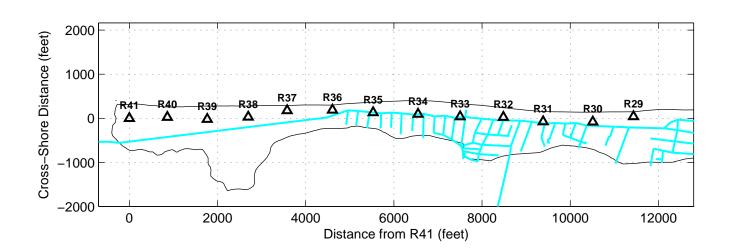


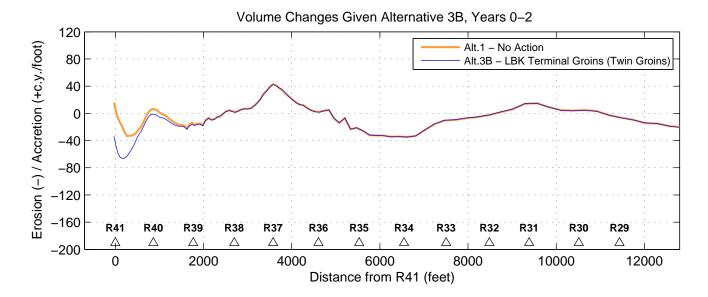


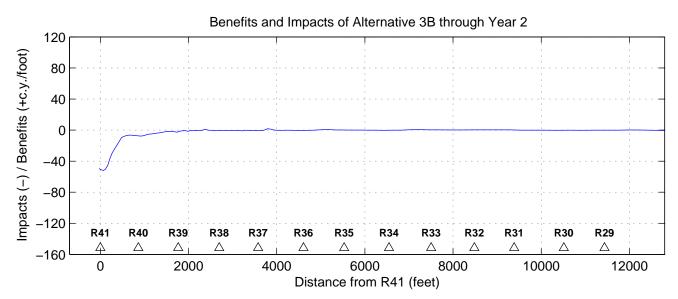


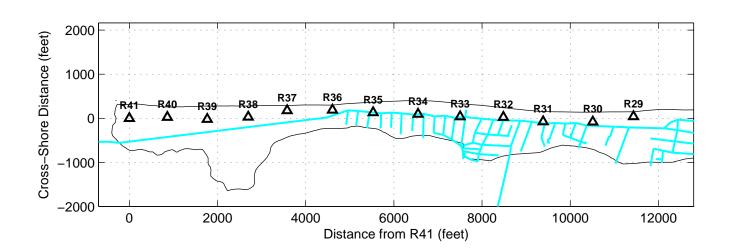


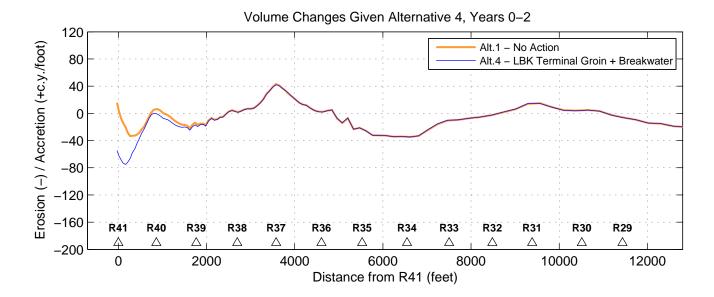


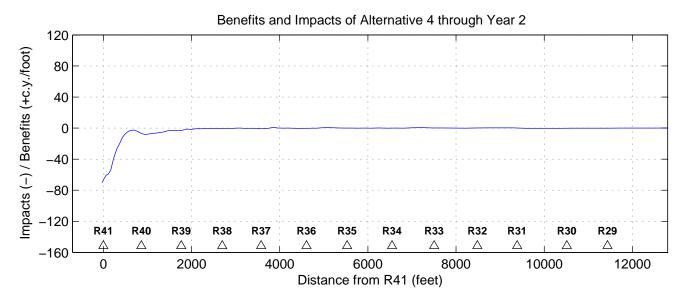


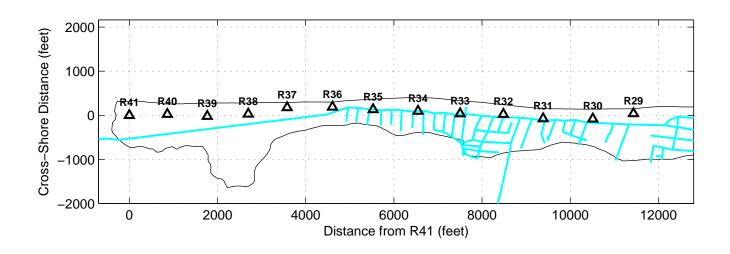


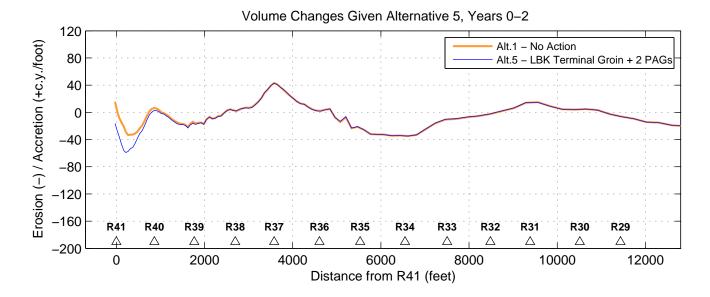


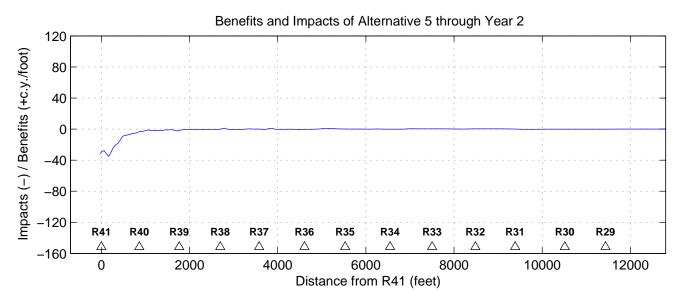


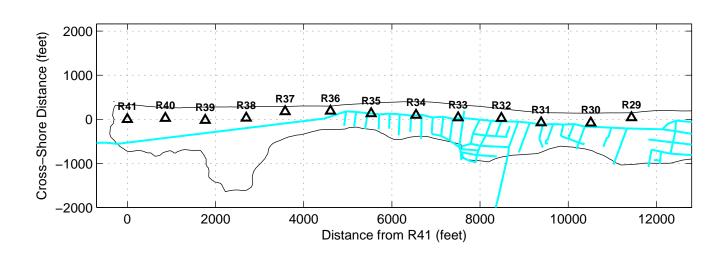


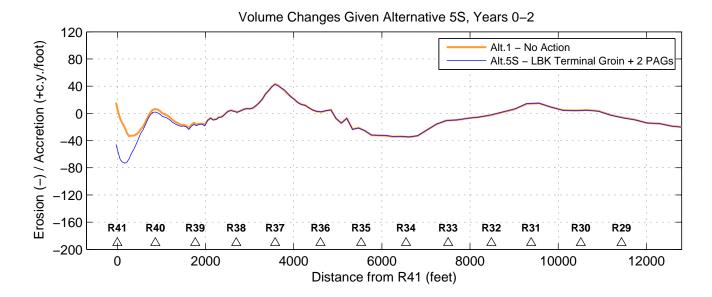


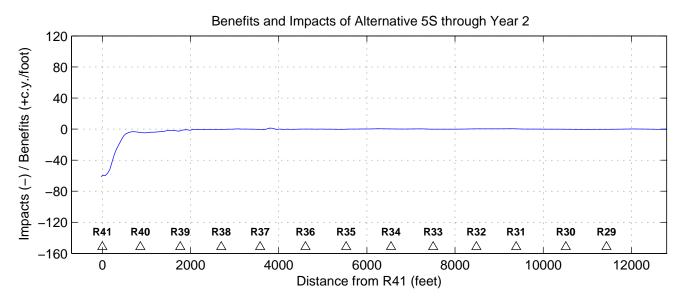


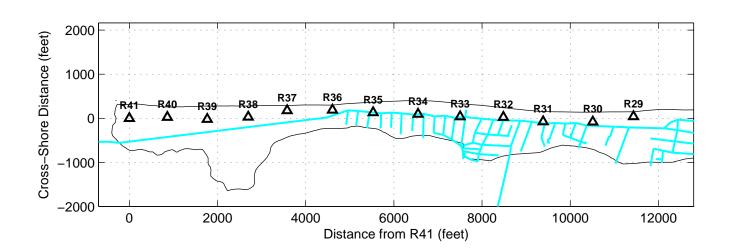


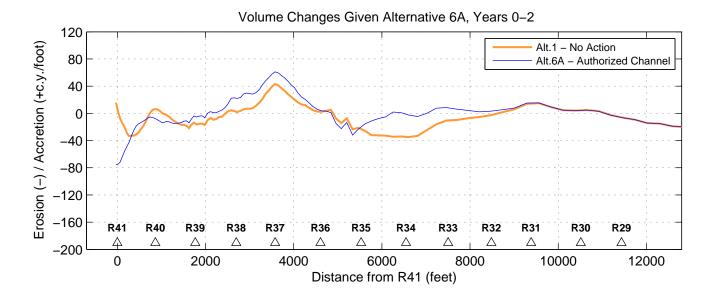


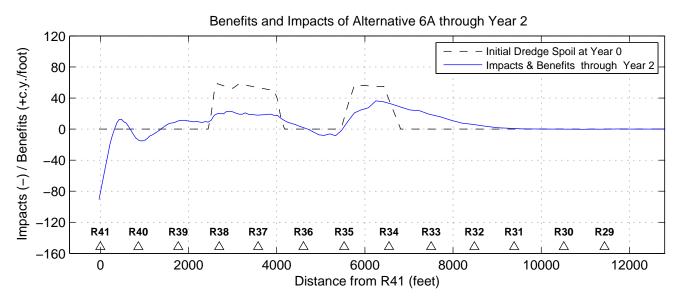


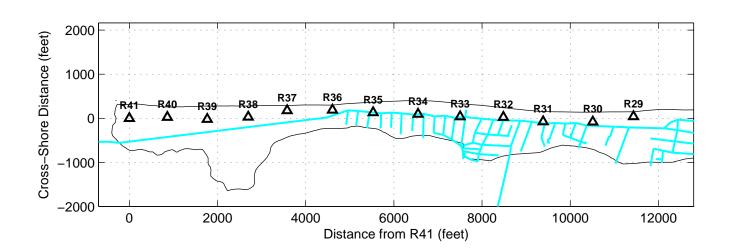


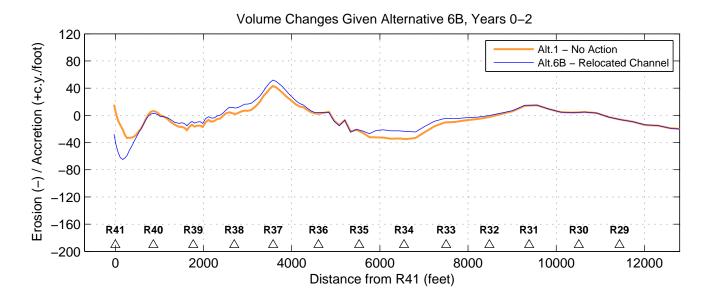


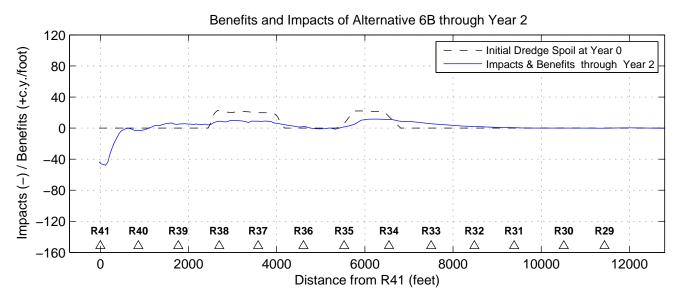


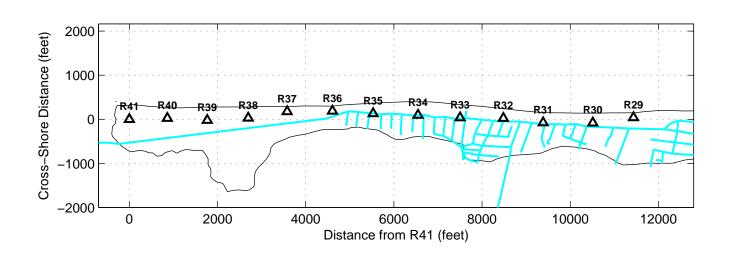


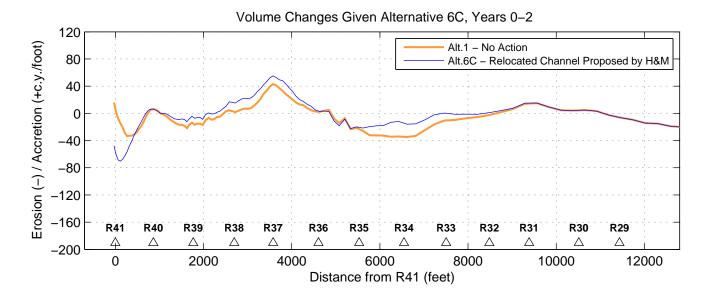


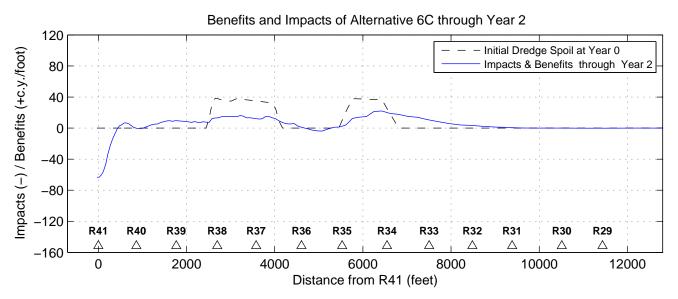


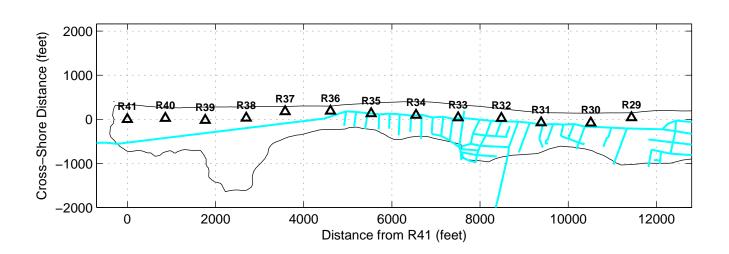


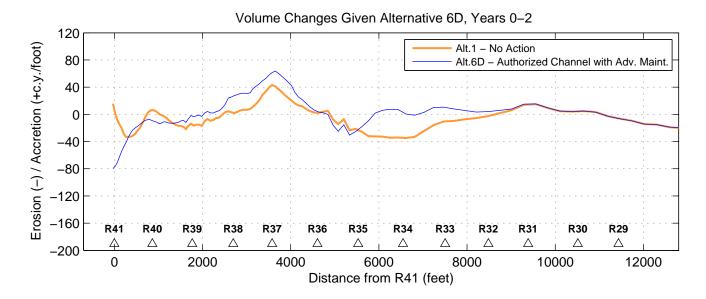


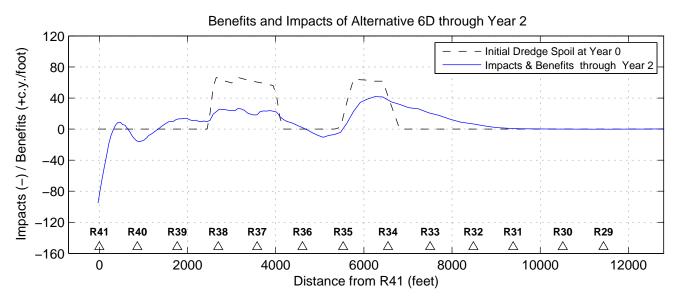


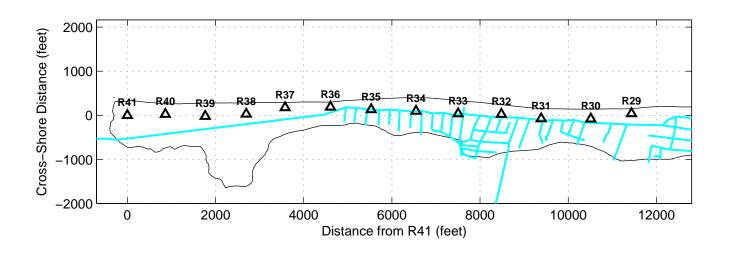


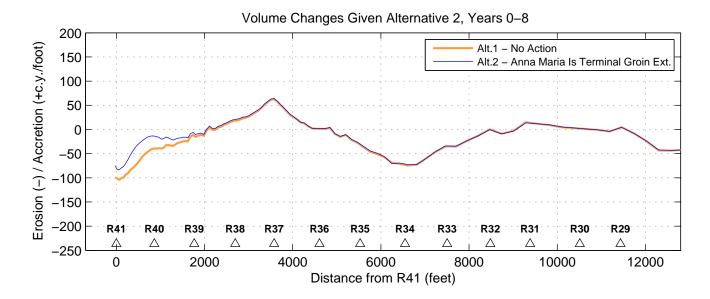


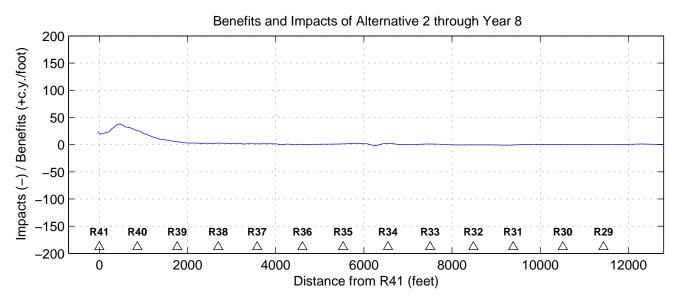


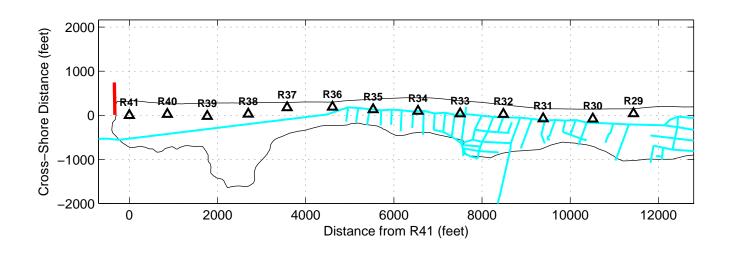


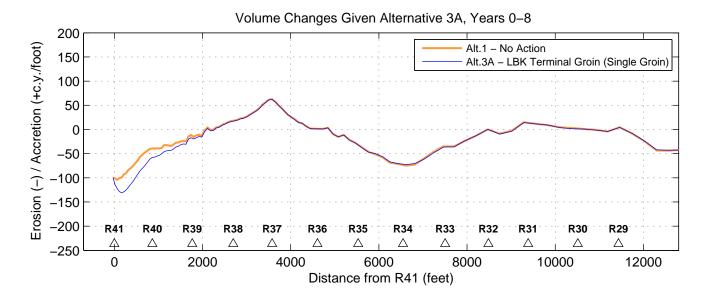


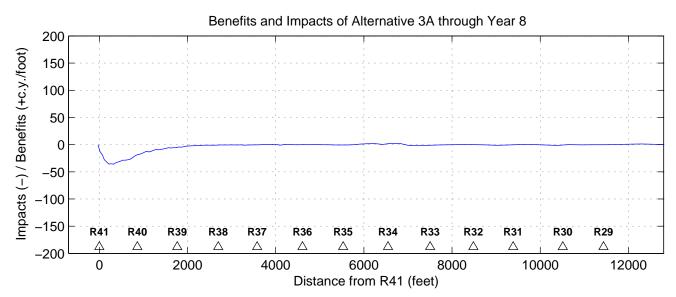


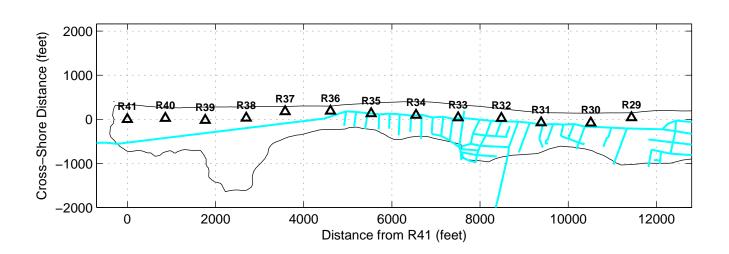


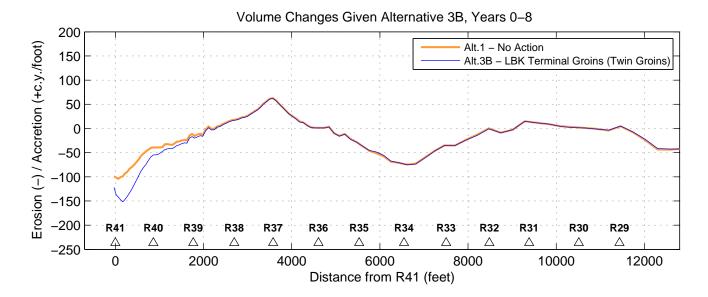


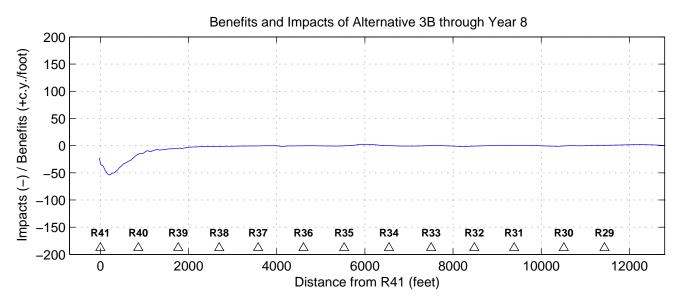


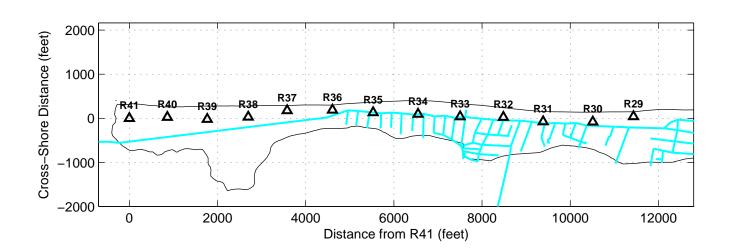


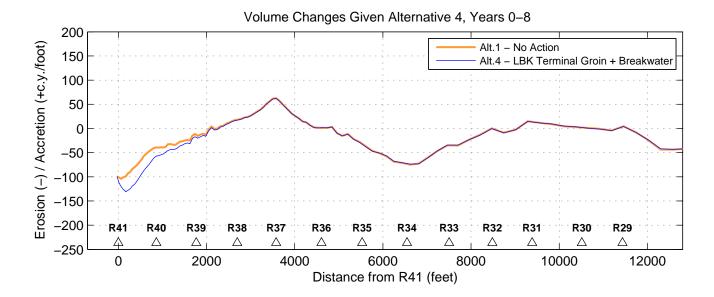


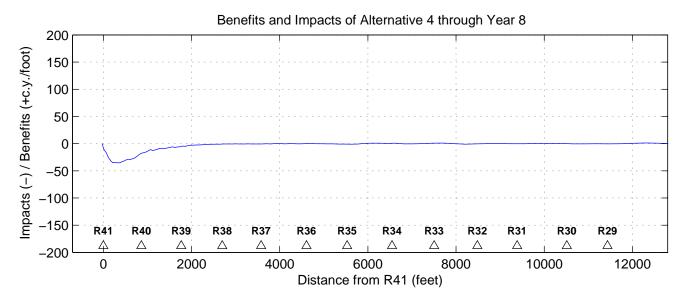


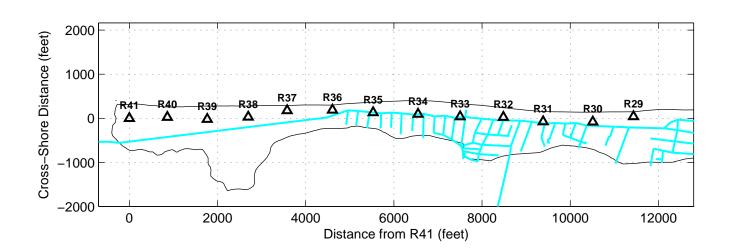


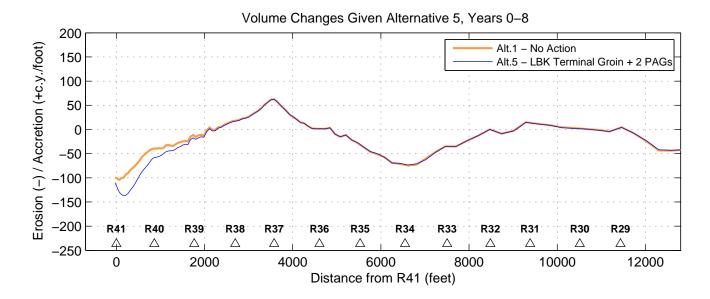


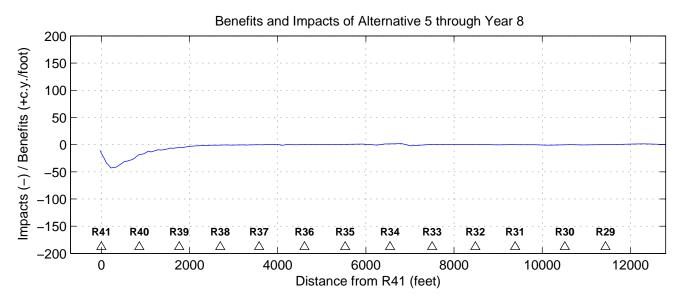


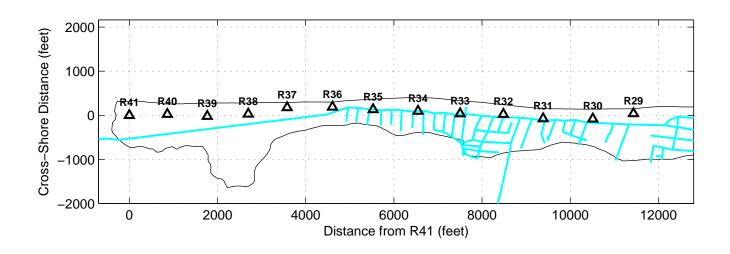


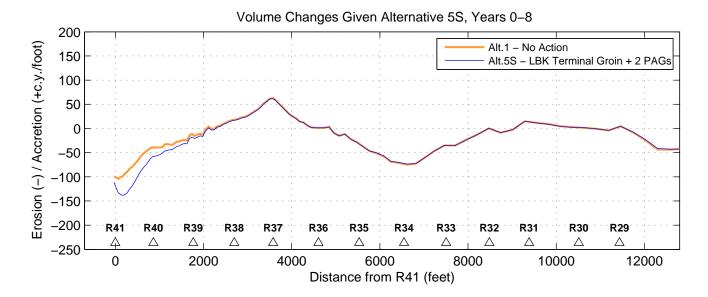


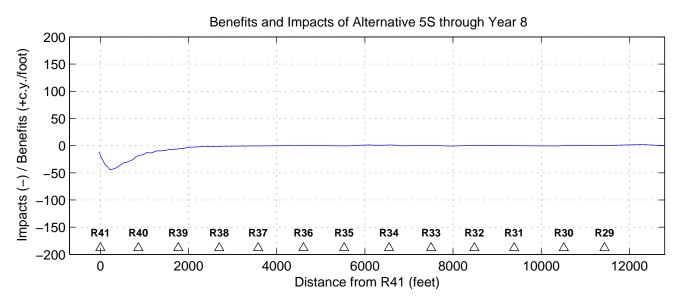


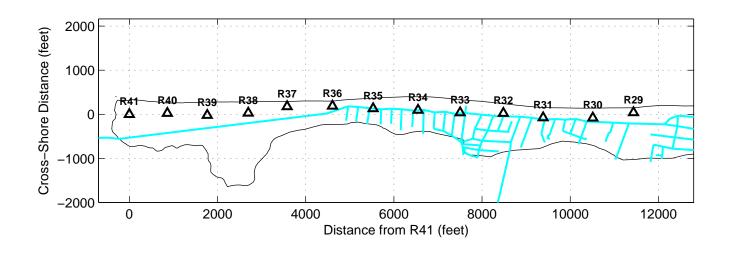


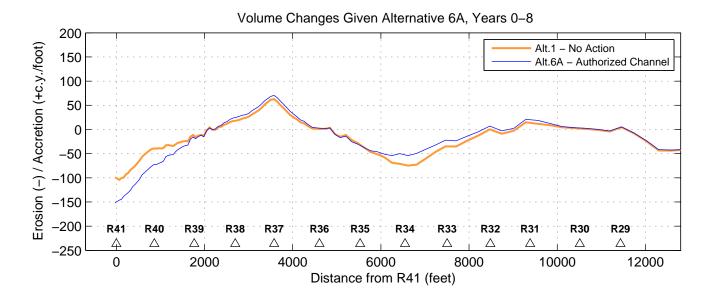


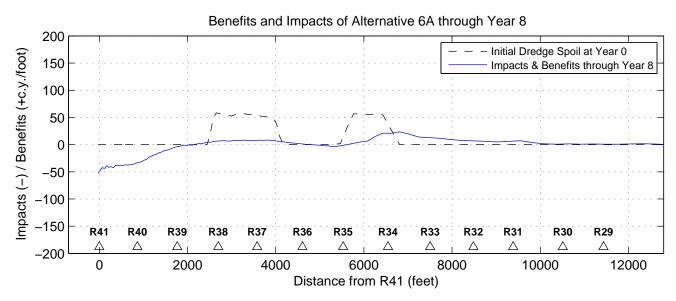


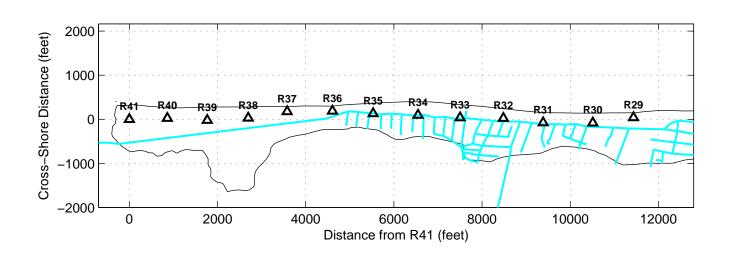


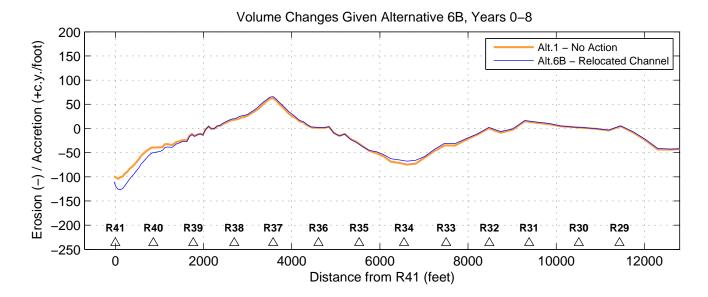


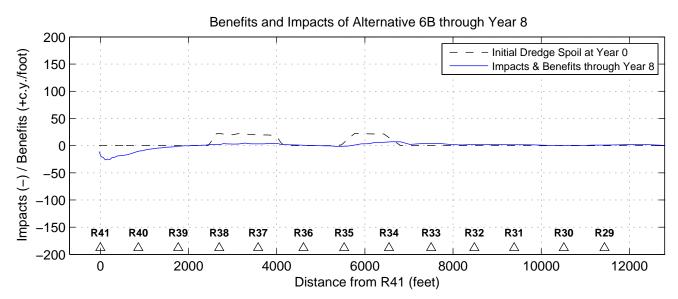


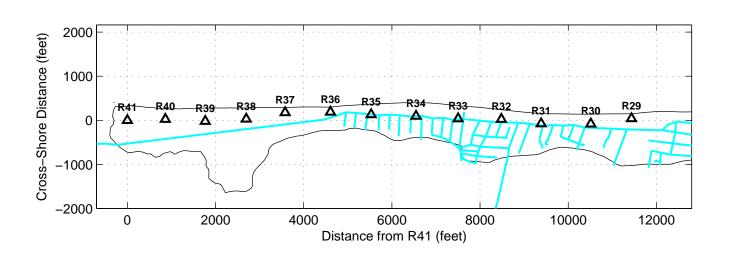


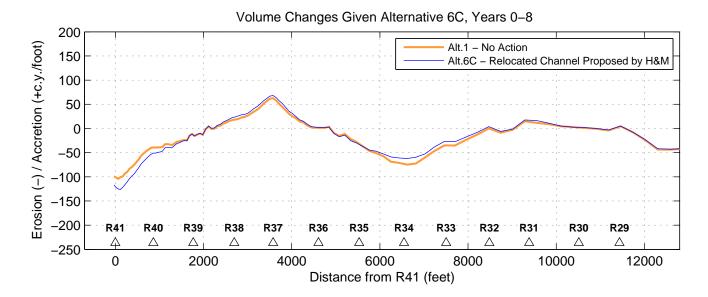


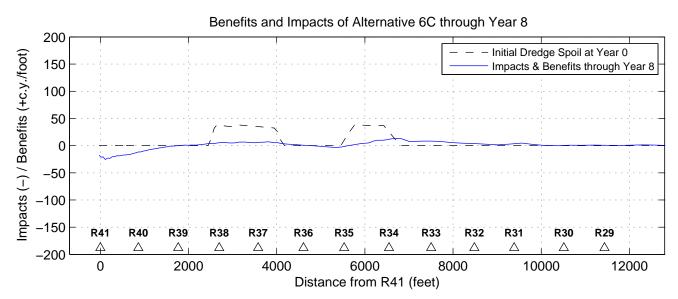


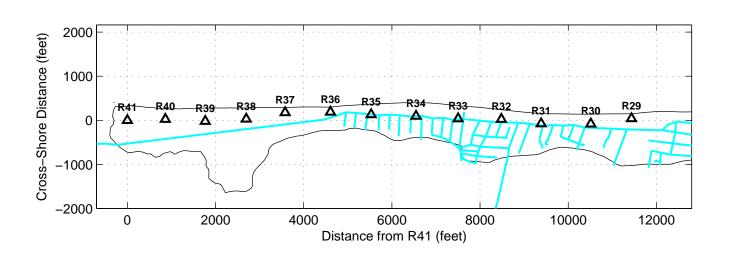


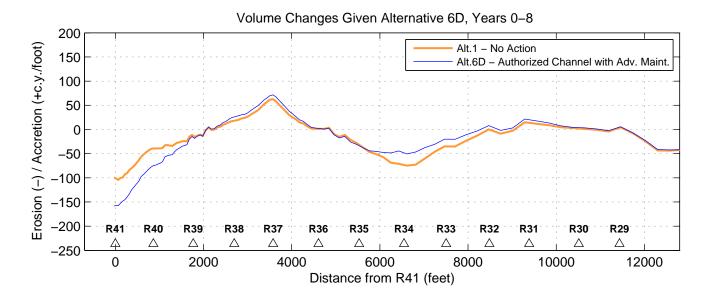


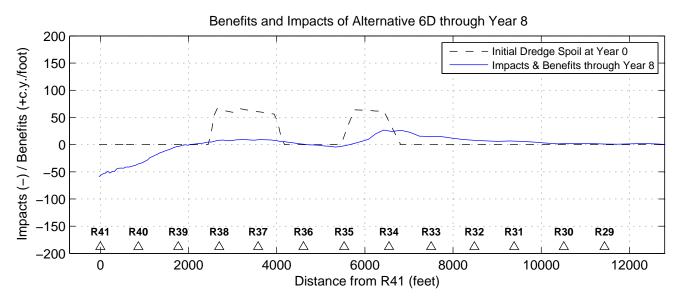


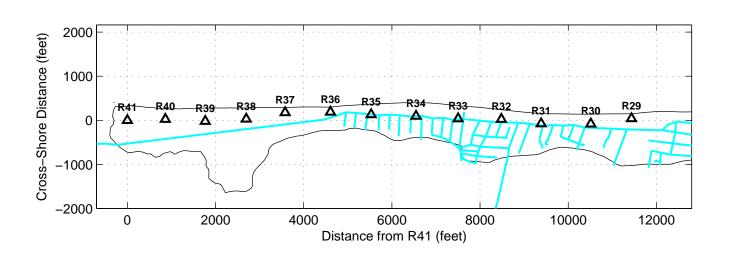


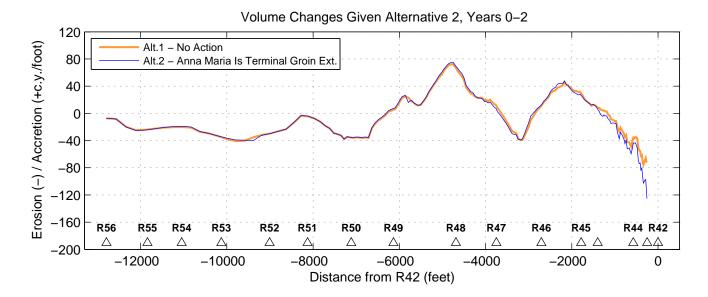


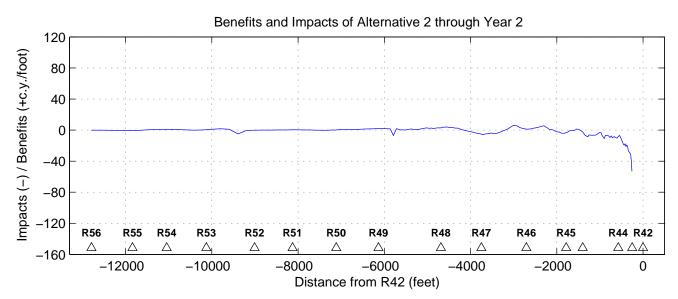


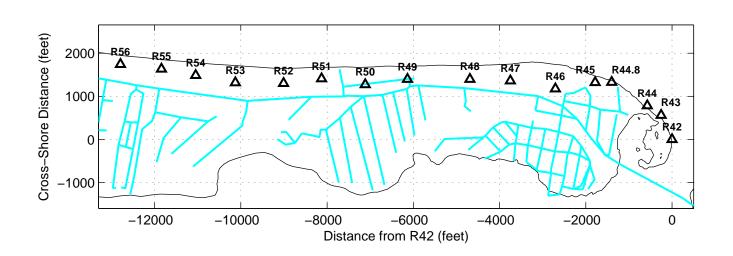


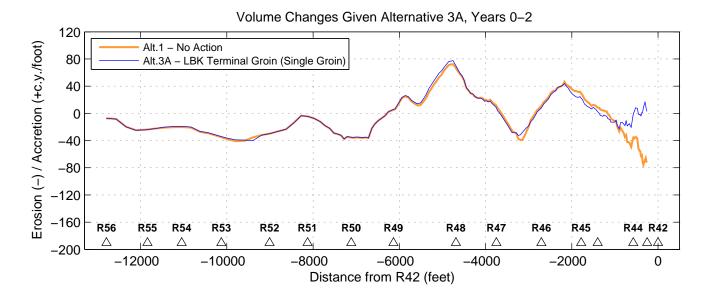


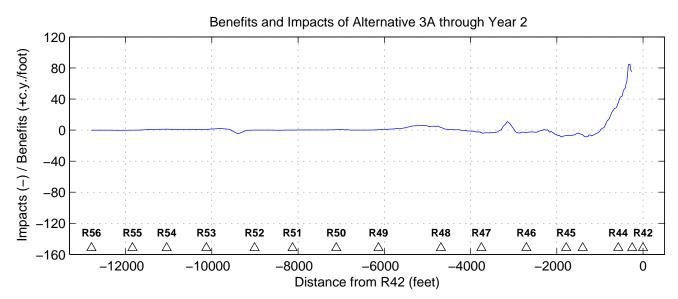


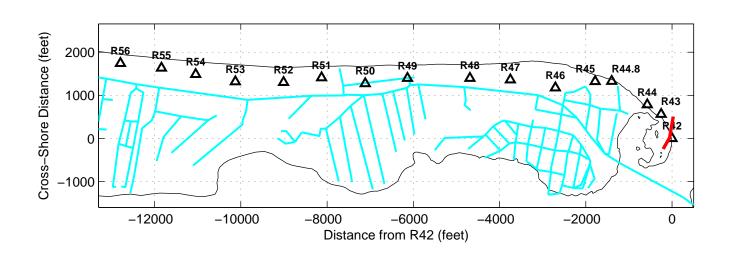


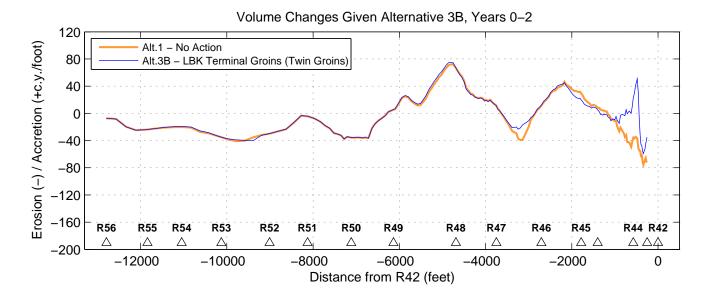


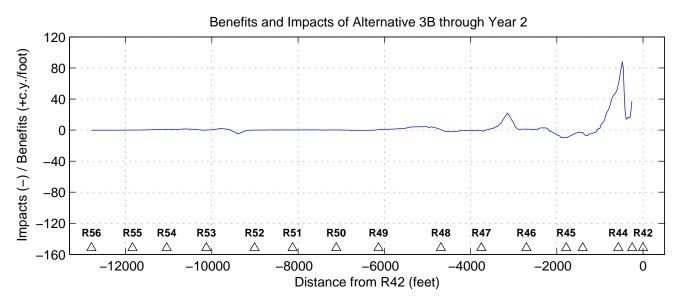


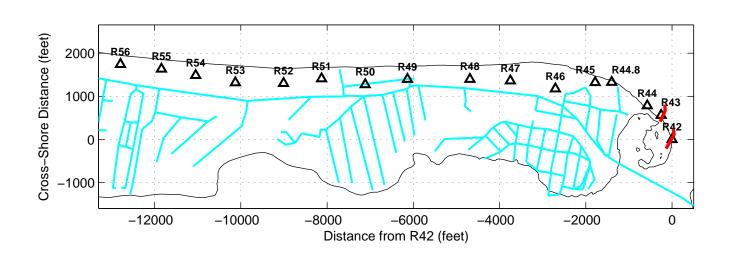


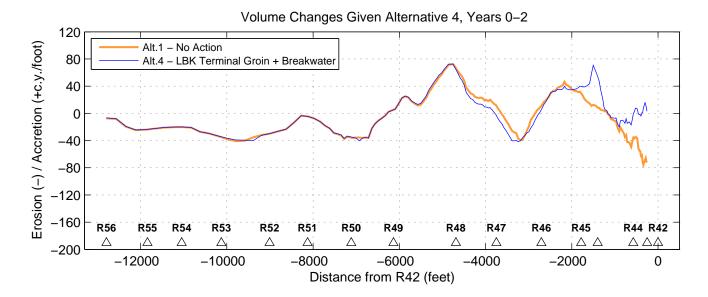


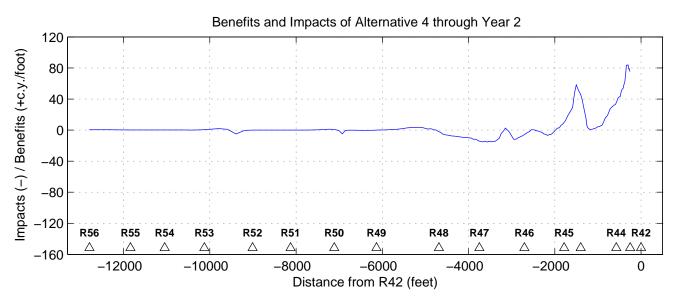


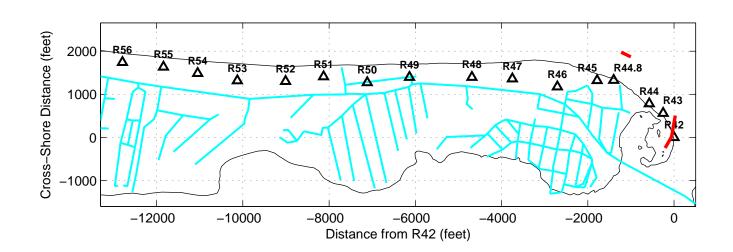


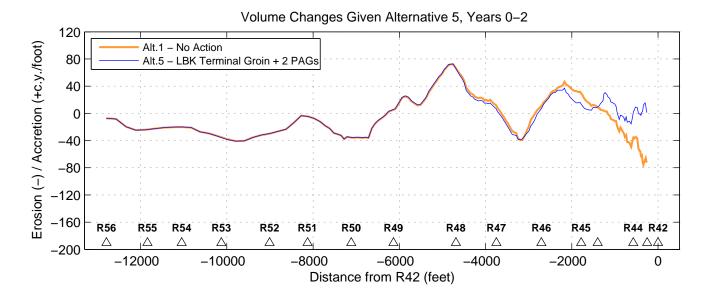


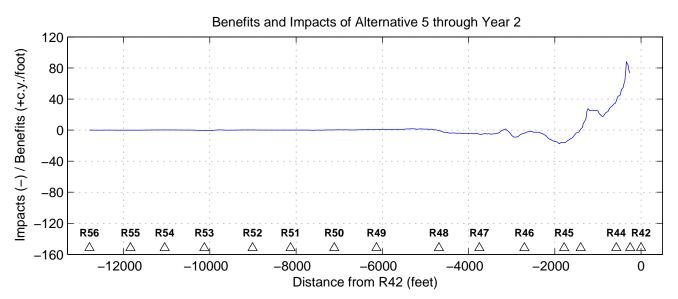


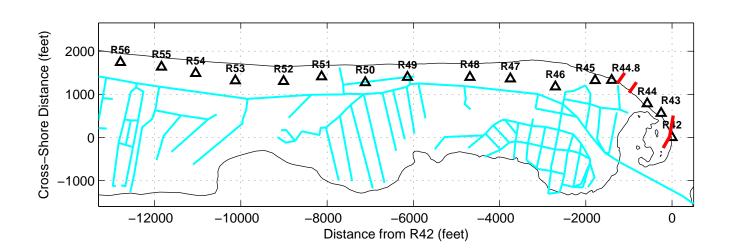


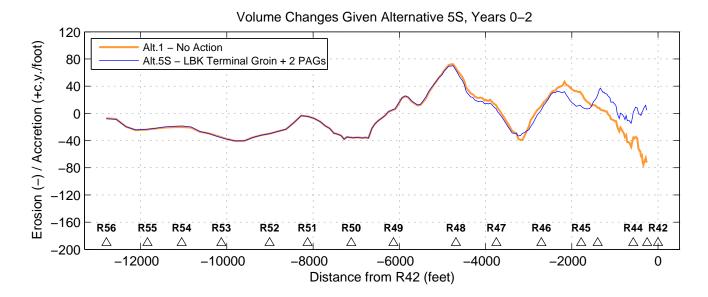


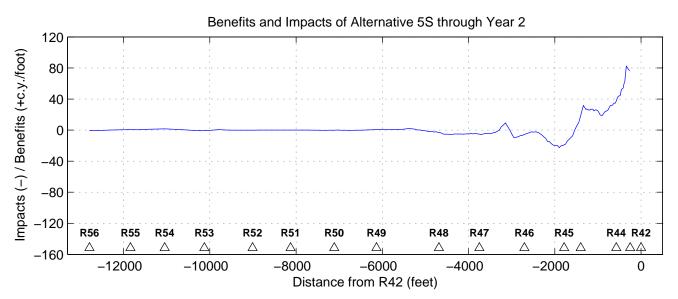


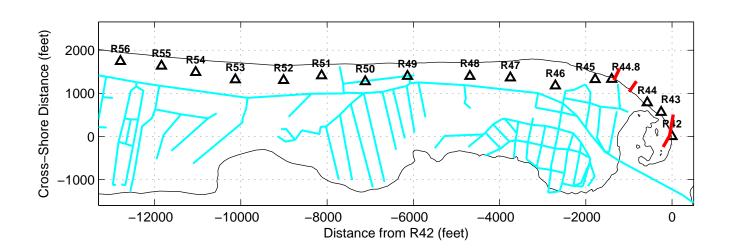


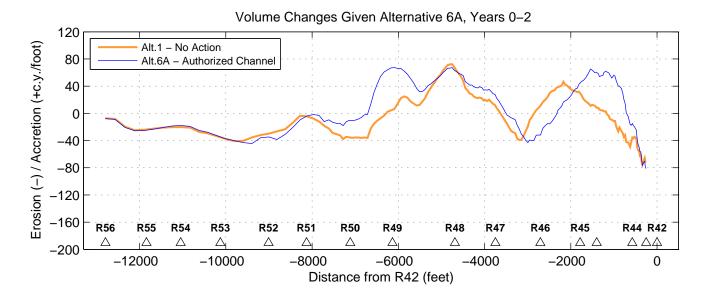


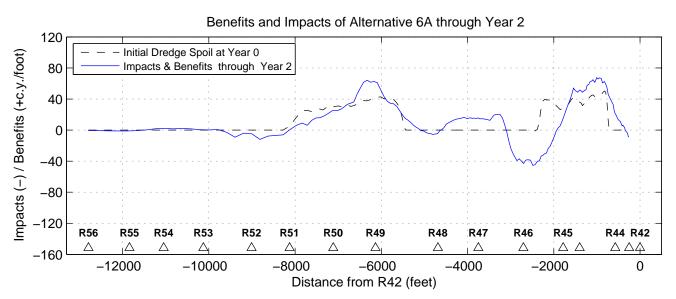


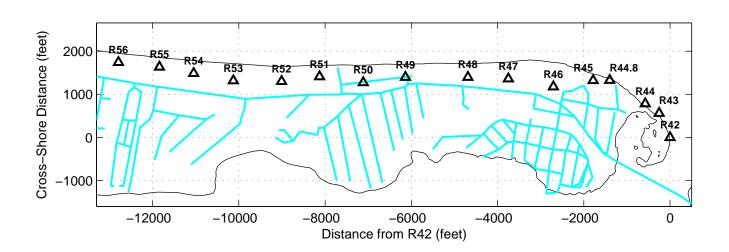


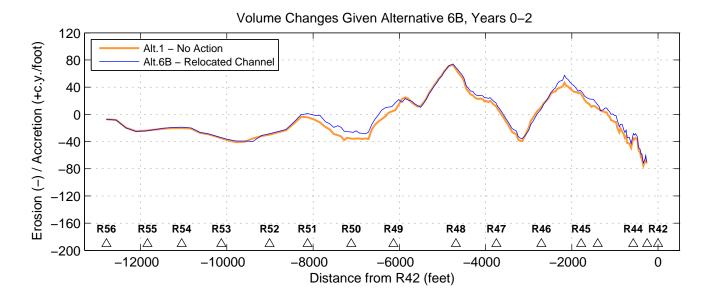


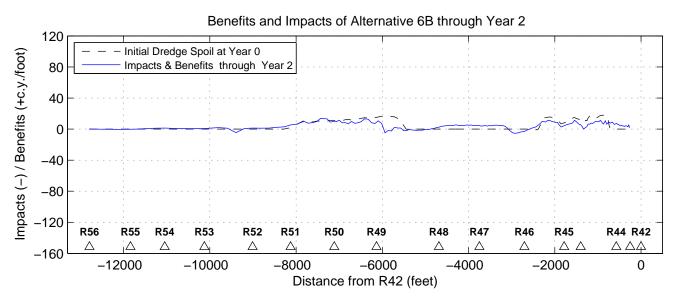


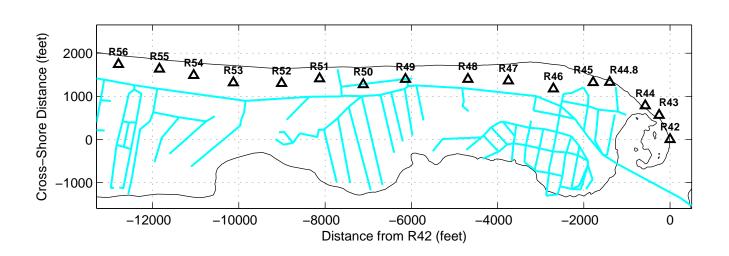


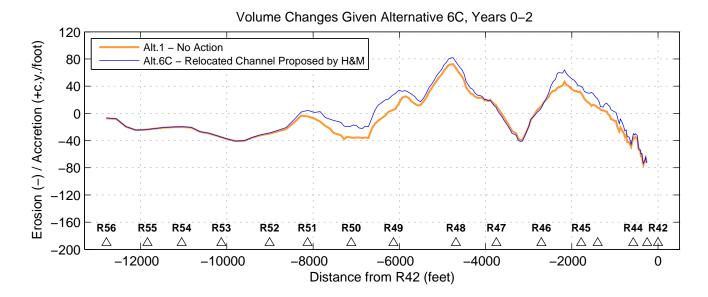


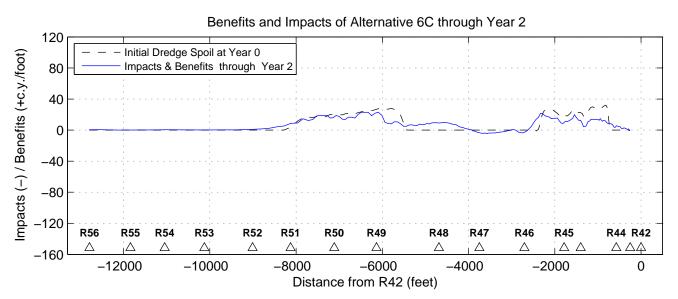


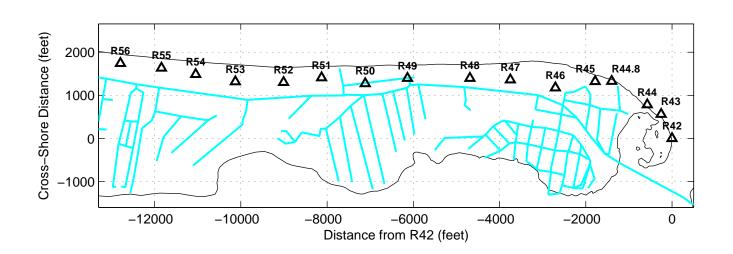


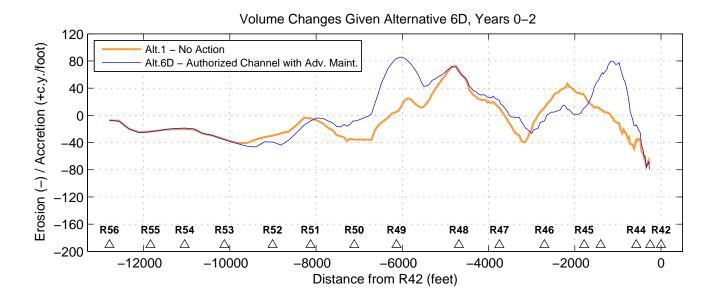


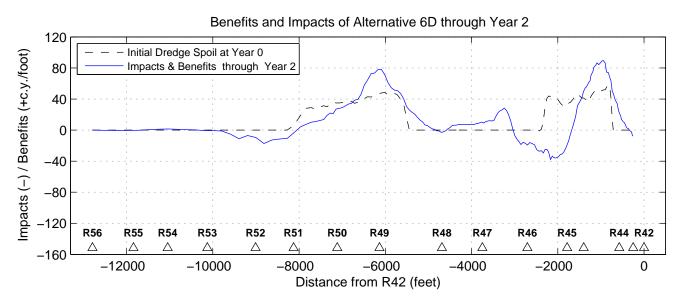


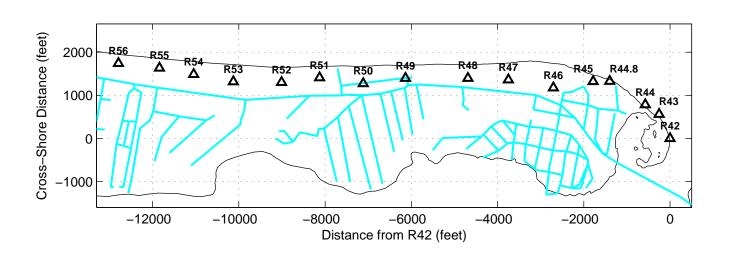


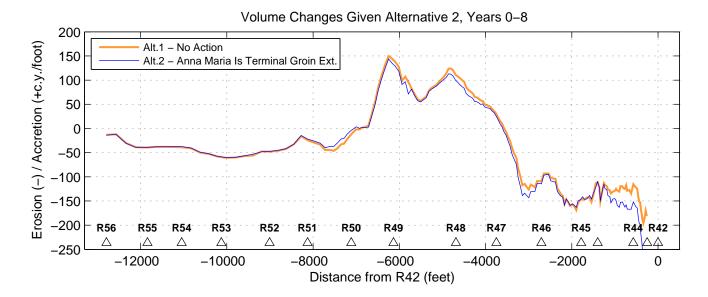


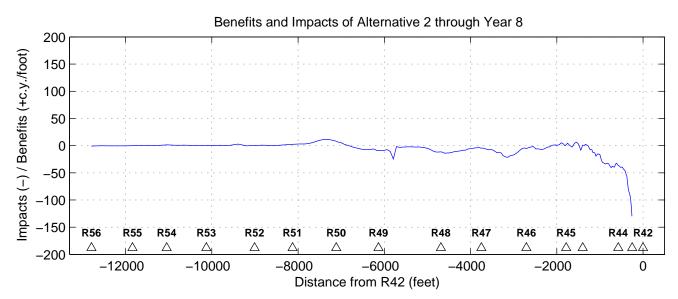


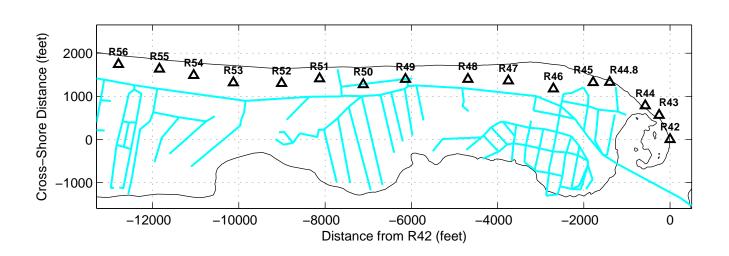


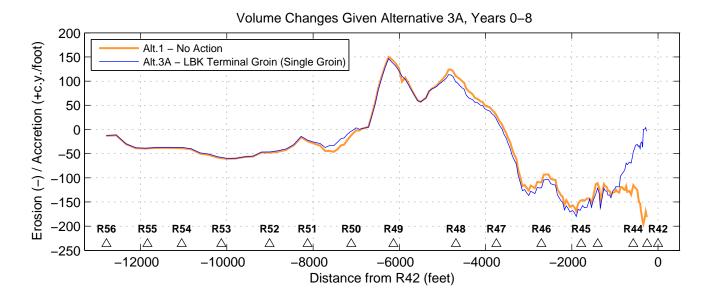


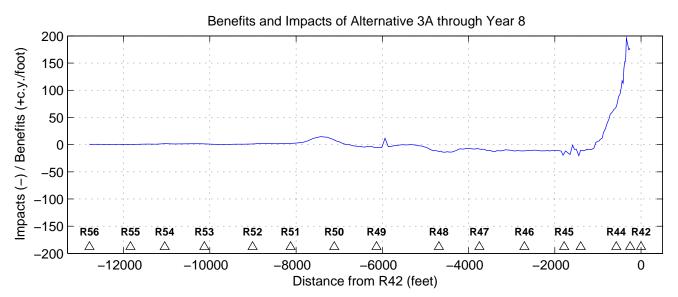


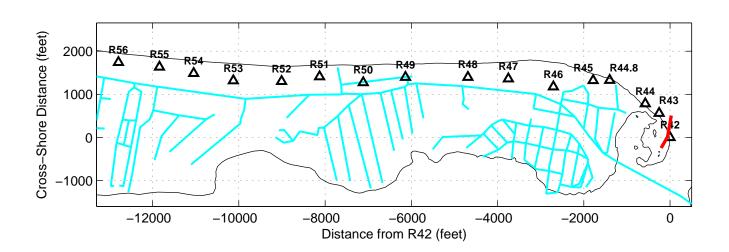


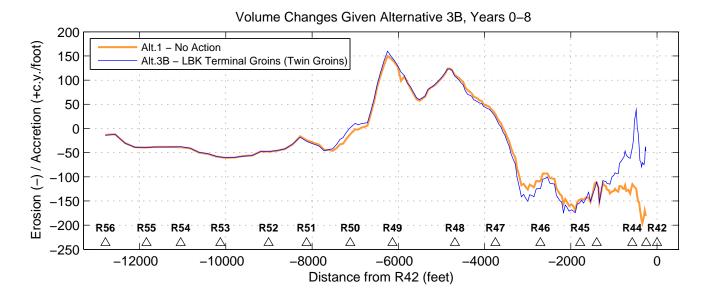


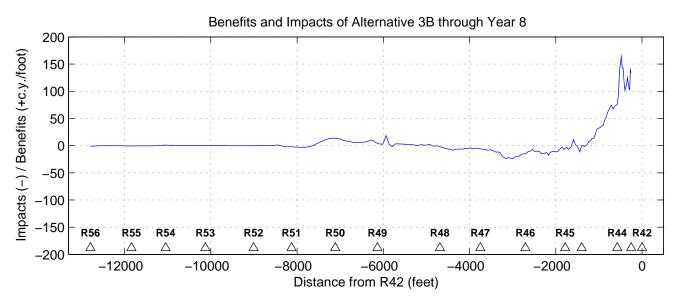


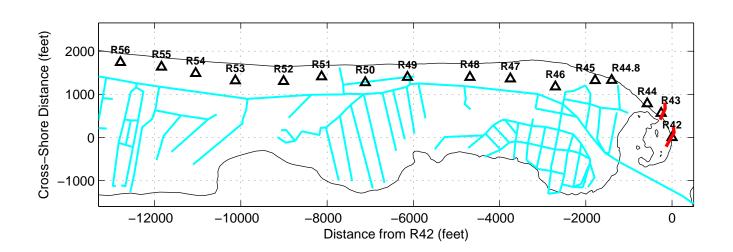


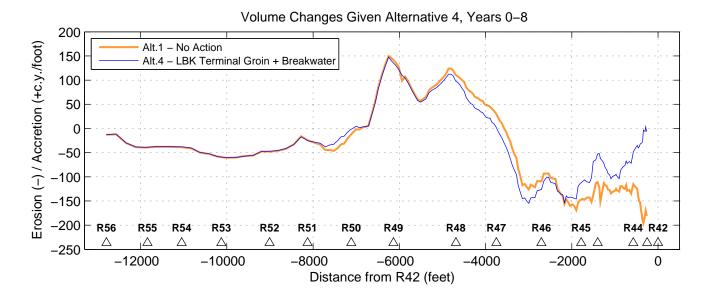


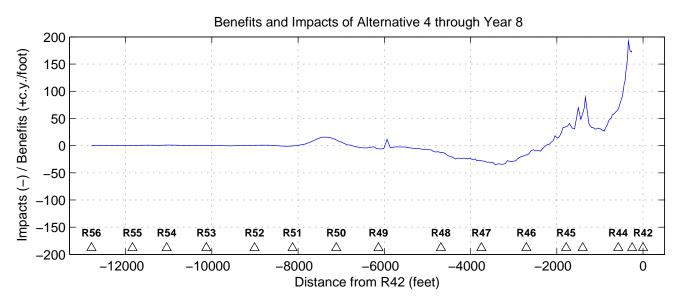


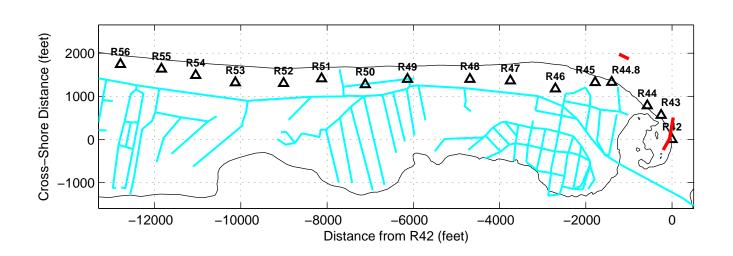


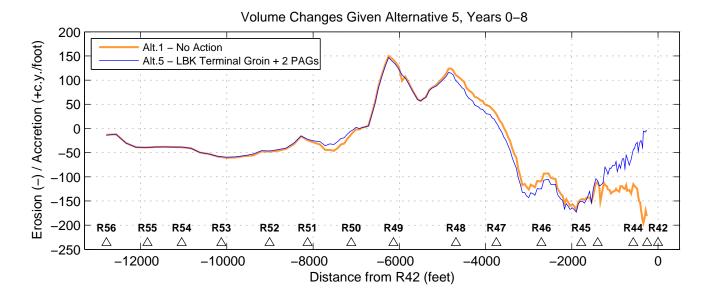


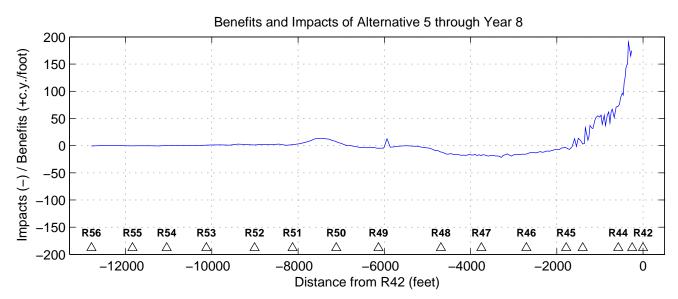


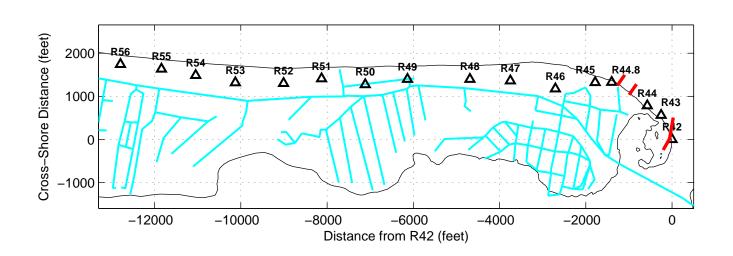


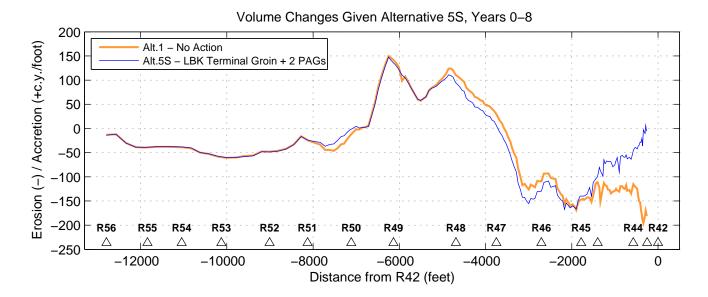


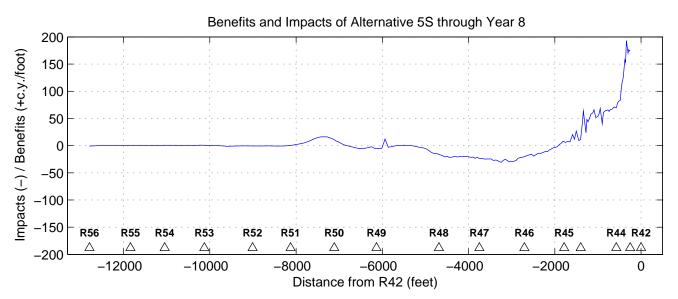


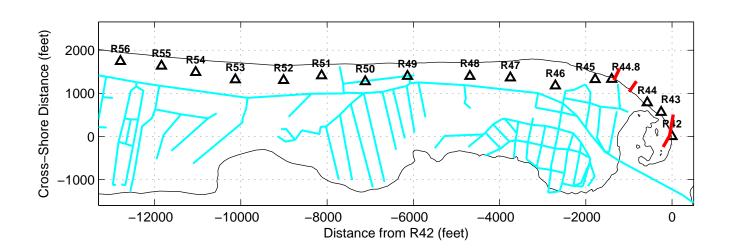


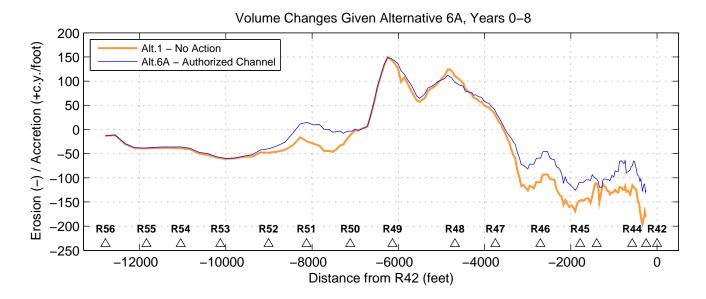


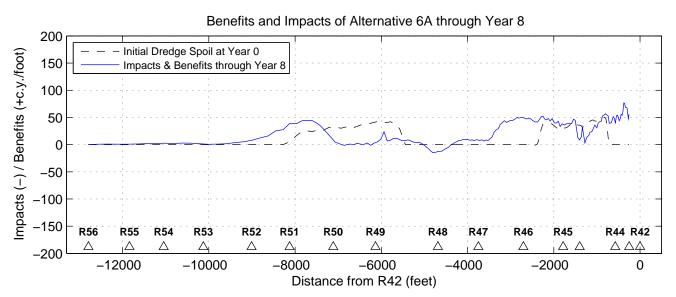


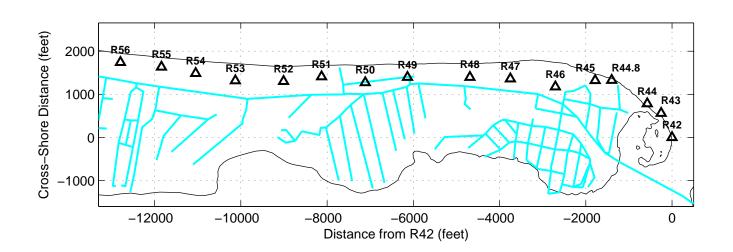


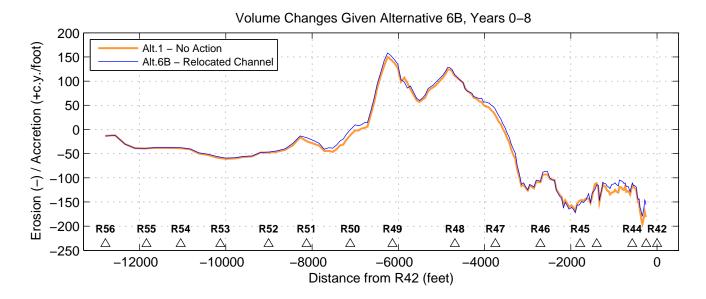


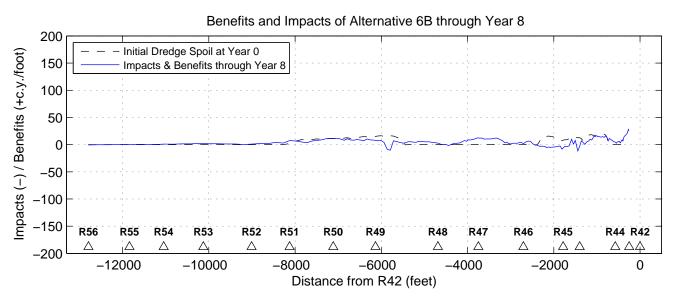


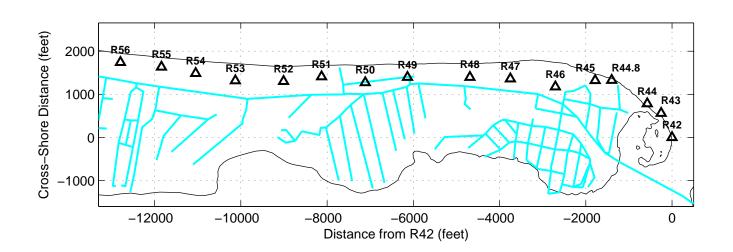


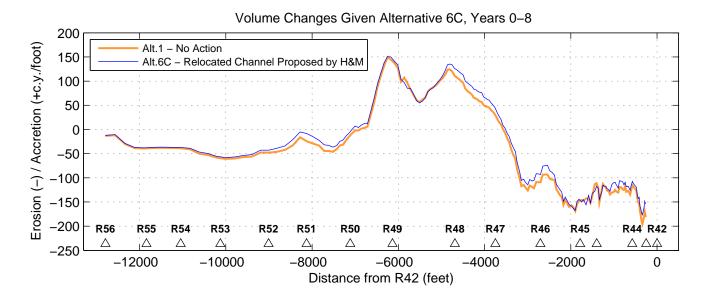


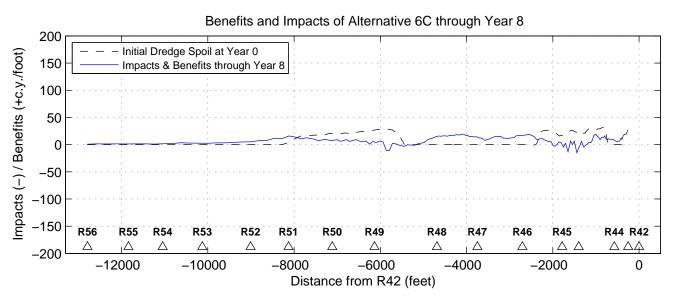


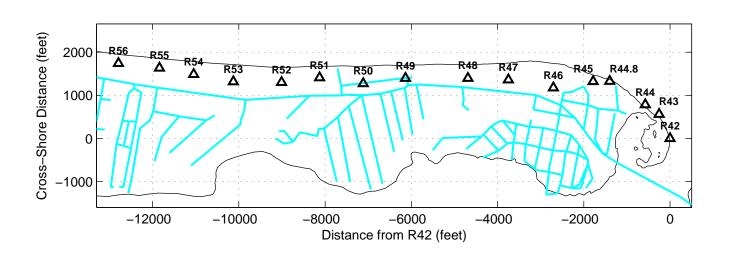


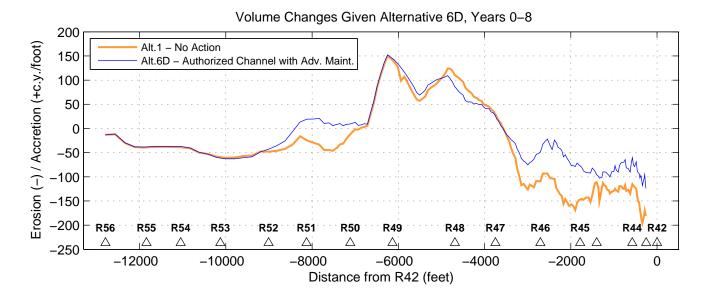


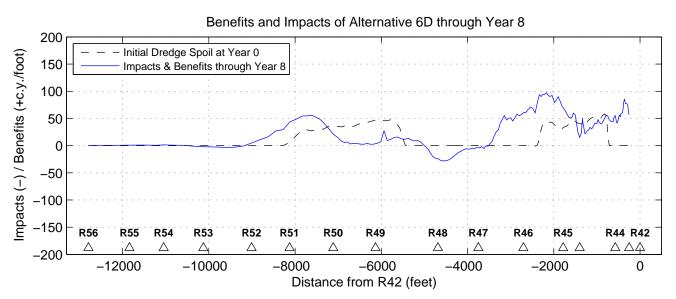


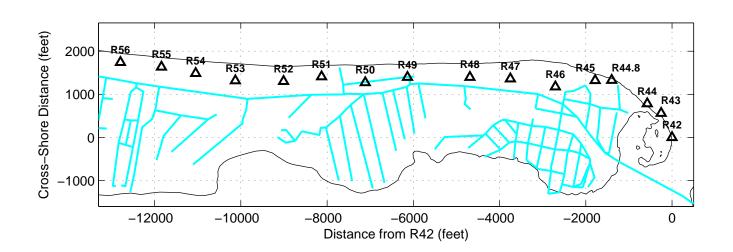


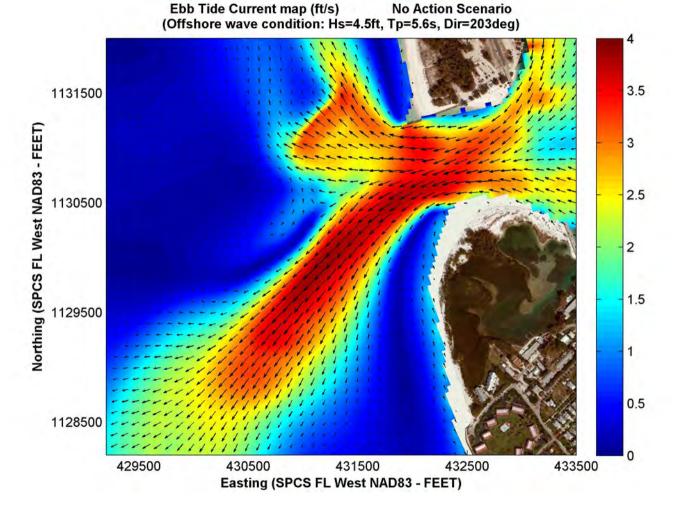


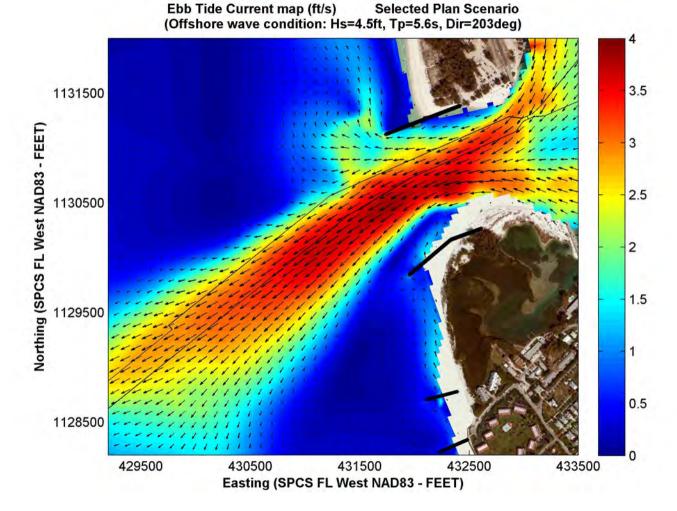


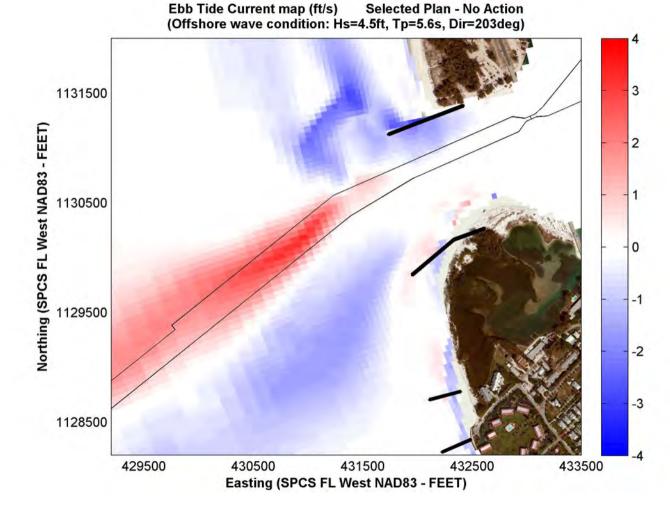


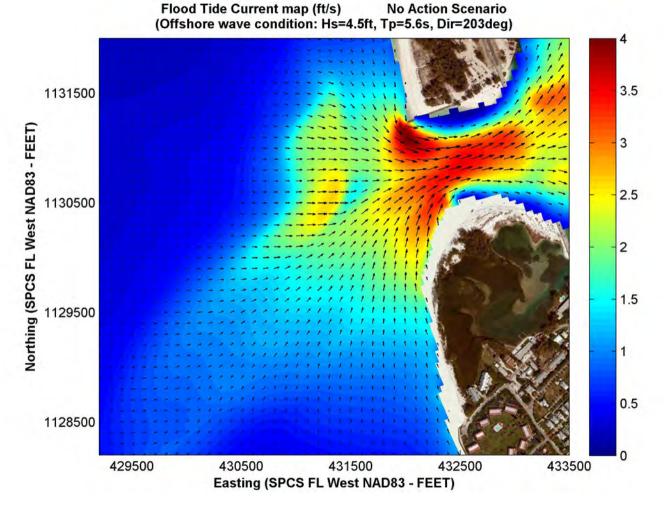












Flood Tide Current map (ft/s) **Selected Plan Scenario** (Offshore wave condition: Hs=4.5ft, Tp=5.6s, Dir=203deg) 3.5 1131500 Northing (SPCS FL West NAD83 - FEET) 3 2.5 1130500 2 1.5 1129500 0.5 1128500 429500 430500 431500 432500 433500 Easting (SPCS FL West NAD83 - FEET)

Flood Tide Current map (ft/s) Selected Plan - No Action (Offshore wave condition: Hs=4.5ft, Tp=5.6s, Dir=203deg) Northing (SPCS FL West NAD83 - FEET) -2 -3 Easting (SPCS FL West NAD83 - FEET)

Sub-Appendix A-2

Engineering Analysis of Single Terminal Groin on the North End of Longboat Key

(Extended Version of Alternative 3A)

COASTAL PLANNING & ENGINEERING, INC.

2481 N.W. Boca Raton Boulevard, Boca Raton, FL 33431 Telephone: (561) 391-8102 Fax: (561) 391-9116

TECHNICAL MEMORANDUM

TO: Juan Florensa

Public Works Director Town of Longboat Key 600 General Harris Longboat Key, FL 34228

FROM: Douglas W. Mann, P.E., D.CE.

CC: Tom Campbell, P.E., D.CE., CPE

Rick Spadoni, CPE

Beau C. Suthard, P.G., CPE Tom Pierro, P.E., D.CE., CPE

Lindino Benedet, CPE

Christopher M. Day, P.E., D.CE., CPE

RE: Feasibility of Using a Single Terminal Structure to Stabilize Shoreline at North Shore

Road / Longbeach Village Seawall

DATE: October 11, 2011

TECHNICAL MEMORANDUM

FEASIBILITY OF USING A SINGLE TERMINAL STRUCTURE TO STABILIZE SHORELINE AT NORTH SHORE ROAD / LONGBEACH VILLAGE SEAWALL

1. Introduction

Longboat Pass is a natural inlet that separates the barrier islands Anna Maria Island (to the north) from Longboat Key (to the south) and connects Sarasota Bay and the Gulf of Mexico. Longboat Pass is the southernmost inlet within Manatee County, approximately 7 miles south of Tampa Bay Entrance and 10 miles north of New Pass. The inlet is bridged by State Road 789 (Gulf of Mexico Drive) which connects Anna Maria Island and Longboat Key.

On both Anna Maria Island and Longboat Key, the shorelines are classified by the FDEP as critically eroded. On Longboat Key, the area between profiles R-44 and R-45 (Greer Island to Palmetto Avenue) has experienced some of the highest erosion rates on Longboat Key, losing 35 to 131 c.y./foot between July 2006 and October 2010 (CPE, 2011). To address the high erosion rates near Longboat Pass, a number of structural and channel dredging alternatives have been proposed as part of the *Inlet Management Study of Longboat Pass and Adjacent Beaches* (Main Report, Section 4 and Appendix A, Section 4). These include the following:

- 1. No Action.
- 2. Anna Maria Island Terminal Groin Extension.
- 3. Longboat Key terminal groin options:
 - A. Single groin.
 - B. Twin terminal groins.
- 4. Longboat Key Terminal Groin Plus Breakwater.
- 5. Longboat Key Terminal Groin Plus Two Permeable Adjustable Groins.
- 6. Inlet channel dredging options:
 - A. Authorized Channel.
 - B. Relocated Channel proposed by U.S. Army Corps of Engineers.
 - C. Relocated Channel proposed by Humiston & Moore (2008).
 - D. Authorized Channel with Advance Maintenance.
- 7. Dredging of Gulf Intracoastal Waterway (GIWW) Cut M5 (near Jewfish Key).

This Technical Memorandum discusses an additional alternative: the use of a single, longer terminal groin to stabilize the shoreline in front of the seawall located at North Shore Road and Longbeach Village (profiles R-44.7 to R-44.9).

2. Methods

The primary tool in this investigation is the Delft3D morphological model (Deltares, 2011). This model determines changes in a topographic and bathymetric surface based on the effects of waves, water levels, winds, and currents. Wave transformation from the offshore to the nearshore area is simulated using the SWAN wave transformation model (Booij, et al, 2004; Deltares, 2009). The SWAN model (version 40.72ABd) is coupled with the Delft3D-Flow model (version 3.60.01.7844), which simulates currents, water levels, and sediment transport. Based on the sediment transport estimates at each flow time step, the Delft3D-Flow model calculates the subsequent elevations of the topographic and bathymetric surface. Typical time steps in Delft3D-Flow range from 1 second to 60 seconds. Water levels, currents, and bottom grade elevations are then sent to the SWAN model at each wave time step, which is on the order of 1 to 3 hours.

The calibration of the Delft3D model is detailed in Appendix A of the *Inlet Management Study* of Longboat Pass and Adjacent Beaches. The wave cases, calibration coefficients, water levels, wind velocities, and input bathymetry are identical to those used in that report. As with Appendix A of the *Inlet Management Study*, the duration of each simulation in this analysis is 8 years.

3. Results

3.1 Alternative 3A – Longboat Key Terminal Groin (Single Groin)

Alternative 3A constructs a single, 800 foot long terminal groin on the north end of Longboat Key near profile R-42. As shown in Figure 1, and presented in detail in Appendix A, the benefits of the structure are limited to the area between Longboat Pass and R-44+200' only. The benefits of the structure are not likely to extend into the developed section of the beach.

3.2 800 Foot Extension of the Alternative 3A Groin, Total Length = 1,600 Feet

To determine whether a longer terminal groin could benefit the developed section of Longboat Key, the Alternative 3A groin was doubled in length. Model results given the 800 foot extensions of the Alternative 3A groin appear in Figure 2. These results suggest that if the groin length is doubled, the 360 North property will have a wider, more stable beach. However, the North Shore Road seawall will receive little benefit from the structure except at its far northern end. Because of this, the 1,600 foot long terminal groin is not likely to achieve its intended objective.

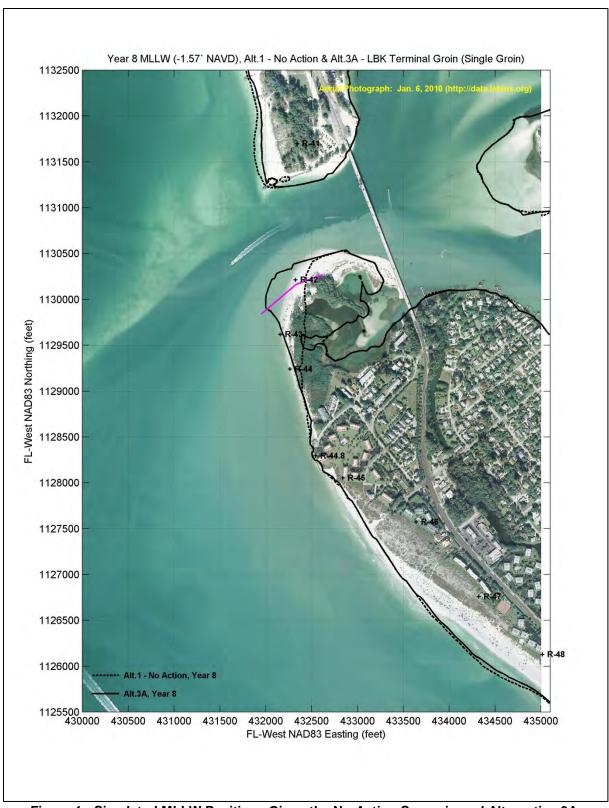


Figure 1: Simulated MLLW Positions Given the No-Action Scenario and Alternative 3A.

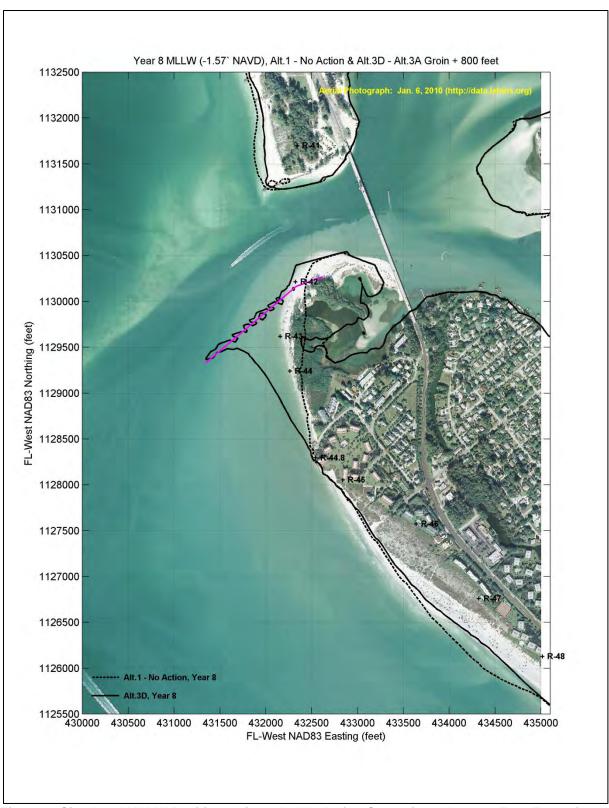


Figure 2: Simulated MLLW Positions Given the No-Action Scenario and an 800 Foot Extension of the Alt. 3A Groin.

3.3 1,000 Foot Extension of the Alternative 3A Groin, Total Length = 1,800 Feet

Based on the results above, the terminal groin was extended an additional 200 feet. Model results given the 1,000 foot extension of the Alternative 3A groin appear in Figure 3. As with the 800 foot groin extensions, the 1,000 foot extension does not appear to provide any significant benefit beyond the north end of the North Shore Road seawall. As such, it is unlikely to achieve the intended objective.

3.4 Longer Extensions of the Alternative 3A Groin

Model results given 1,200 to 1,800 foot extensions of the Alternative 3A groin appear in Figure 4 through Figure 7. These model results suggest that none of the extensions will stabilize a beach in front of the North Shore Road seawall.

4. Discussion

Two mechanisms may be occurring with the implementation of longer terminal groins. These are offshore transport and limited sand availability. As noted in the *Inlet Management Study of Longboat Pass and Adjacent Beaches* (main report), there appears to be nodal point between profiles R-44 (Greer Island) and R-47 (Beachwalk). North of the nodal point, the net longshore transport is towards the north; south of the nodal point, the net longshore transport is towards the south. In addition to these longshore transport components, there is a cross-shore transport component that is directed offshore.

The existence of the nodal point limits the length of the groin fillet by limiting the volume of sand available for transport to the terminal groin fillet. Longer terminal groins may require prefilling with sand or renourishment of the beach in order to achieve a wide stable fillet.

As the groin is extended beyond 1600 feet (total), the seaward end of the structure occurs in water depths greater than -6 feet NAVD. The model may be limiting fillet growth with an increase in transport to offshore. Similarly, the increase in effective depth of closure for the fillet may result in significantly more sand being required in the offshore profile in order to widen the dry beach. This in combination with potential sediment supply may limit the effectiveness of long terminal groins at Longboat Pass.

5. Cost Implications

In developing Alternative 3A, the depth of the structure was considered. Adjacent to Longboat Pass, there is a relatively flat bathymetric feature around elevation -6 feet NAVD (Figure 8). If a terminal groin is extended beyond this bathymetric feature, depths increase as the evolved outer channel is encountered which has maximum depths of -12 feet NAVD (Figure 8).

For conceptual design purposes, a rubblemound groin that is trapezoidal in shape with a constant top width of about 15 feet and a top elevation of +5 feet NAVD (height of the beach berm) was considered. A cross section in -6 feet of water will require about 30 tons of stone per linear foot of structure. If the depth increases to -10, the cross section will require 50 tons of stone per foot.

For a 2000 foot long (total length) structure, the approximate cost will be \$8 million which is uneconomical relative to other structural alternatives and outside the Town's existing budget.



Figure 3: Simulated MLLW Positions Given the No-Action Scenario and a 1,000 Foot Extension of the Alt. 3A Groin.



Figure 4: Simulated MLLW Positions Given the No-Action Scenario and a 1,200 Foot Extension of the Alt. 3A Groin.

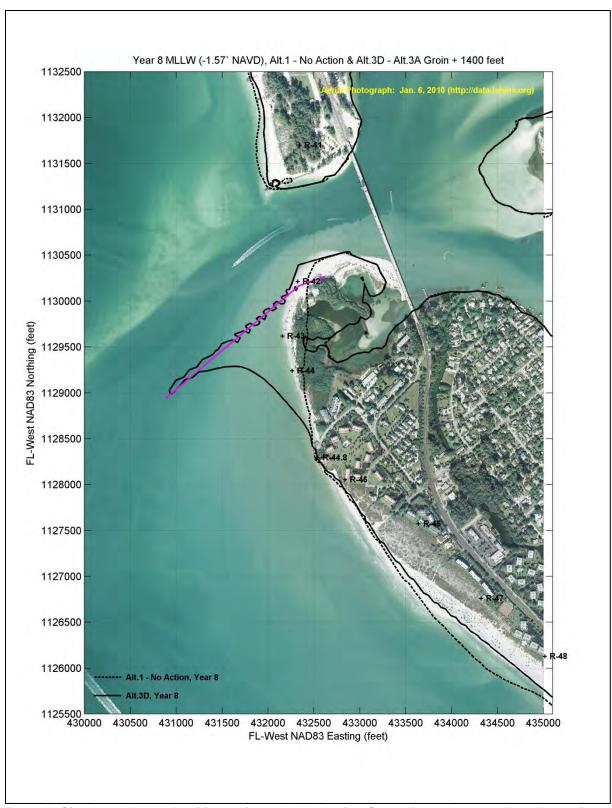


Figure 5: Simulated MLLW Positions Given the No-Action Scenario and a 1,400 Foot Extension of the Alt. 3A Groin.



Figure 6: Simulated MLLW Positions Given the No-Action Scenario and a 1,600 Foot Extension of the Alt. 3A Groin.

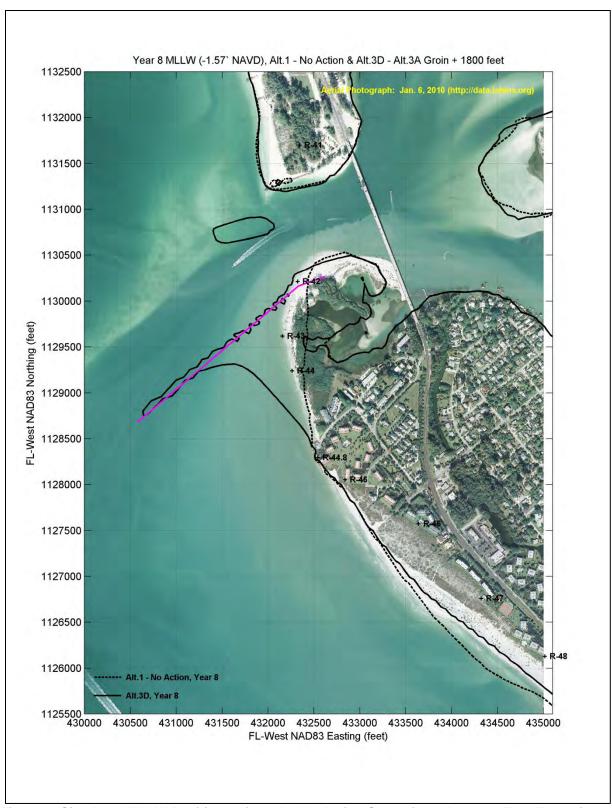
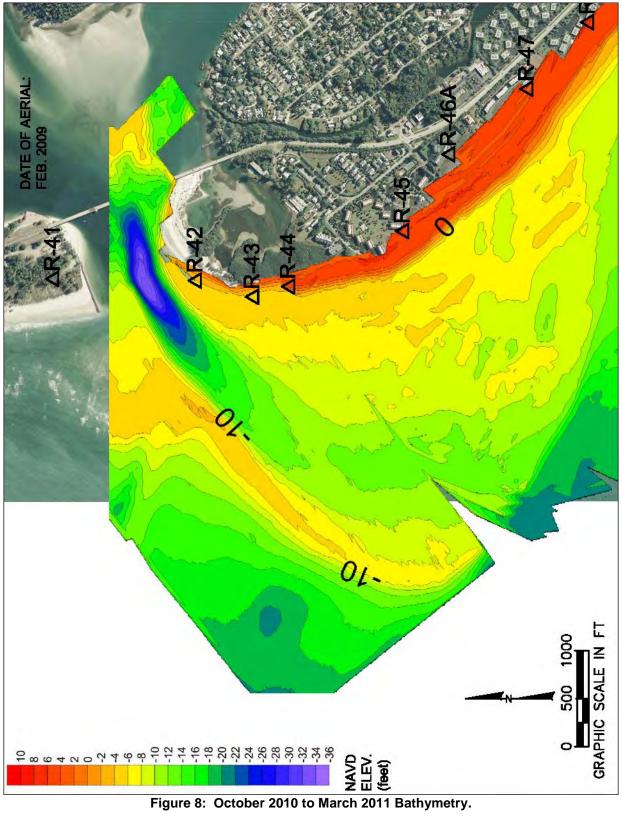


Figure 7: Simulated MLLW Positions Given the No-Action Scenario and a 1,800 Foot Extension of the Alt. 3A Groin.



6. Conclusion

To evaluate whether a single, longer terminal groin could stabilize the shoreline in front of the North Shore Road seawall (profiles R-44.7 to R-44.9). Alternative 3A was lengthened. Eight year simulations were performed using the Delft3D modeling package, with the model setup being identical that of the *Inlet Management Study of Longboat Pass and Adjacent Beaches*.

Based on the modeling results, none of the longer versions of Alternative 3A will achieve a stable beach at North Shore Road. These results were due to the existence of a nodal point near the North Shore Road seawall, which would limit the length of the fillet adjacent to the structure. The beach may also need to receive significant nourishment to establish the fillet. Increasing depth at the structure toe may also restrict dry fillet growth. Due to the high costs associated with the lengthened structure, these alternatives would not be feasible, and were not considered further as part of the Selected Plan for managing Longboat Pass.

7. References

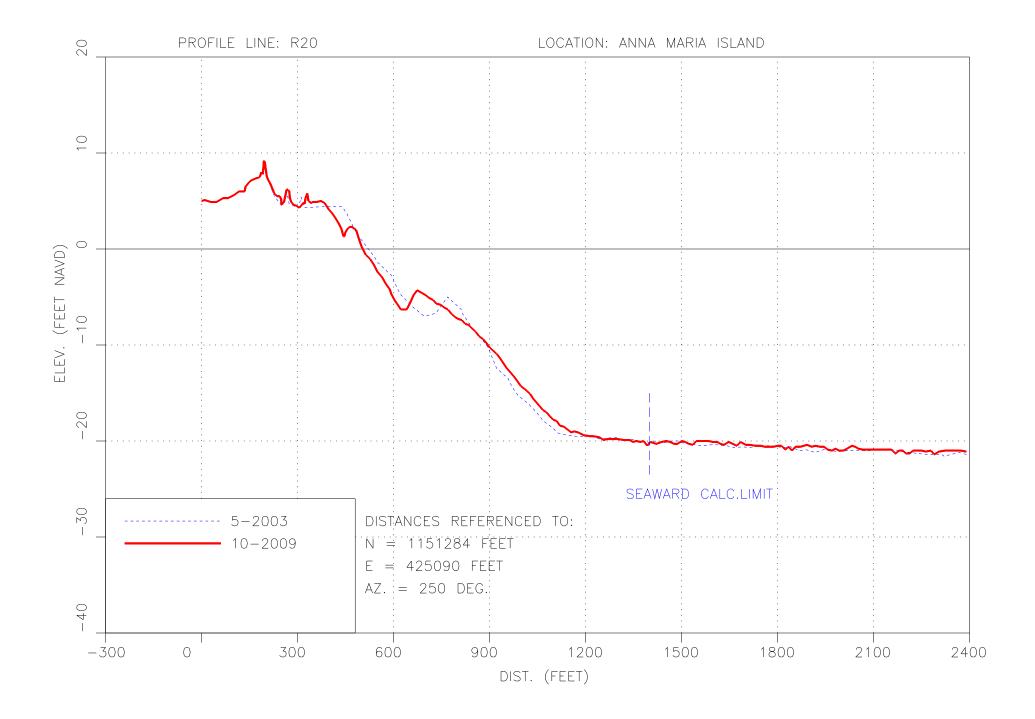
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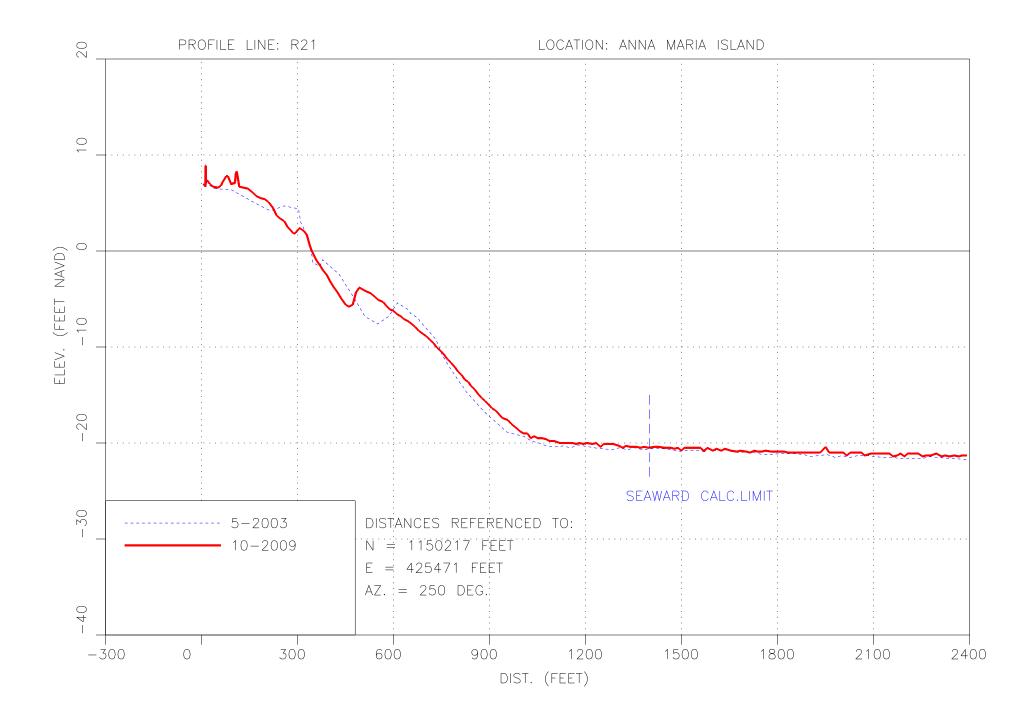
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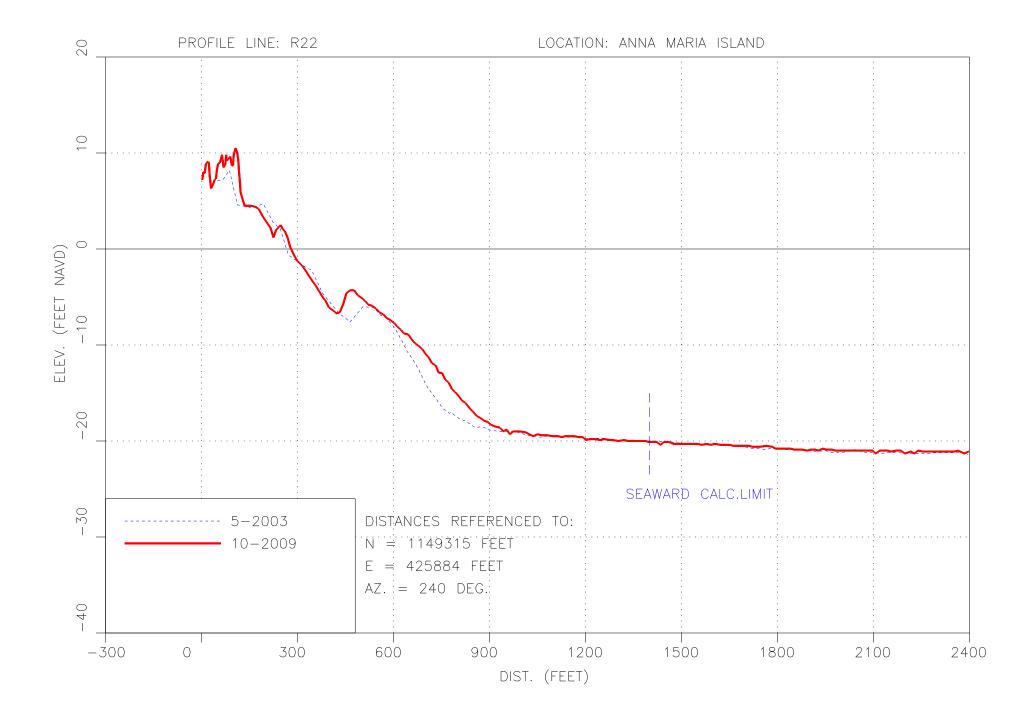
APPENDIX B

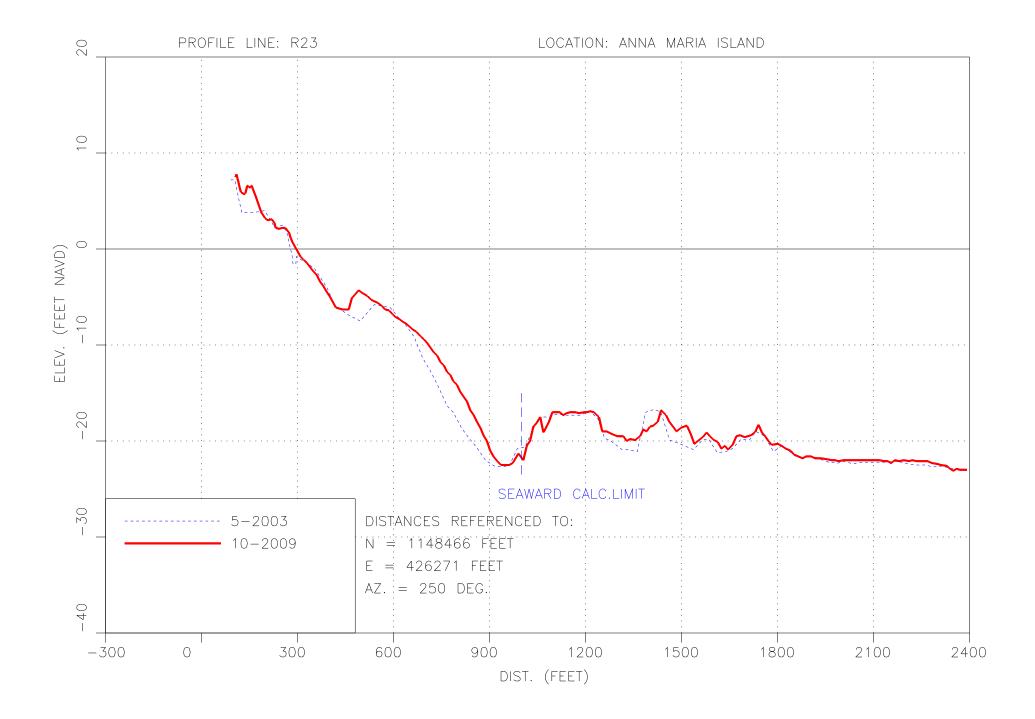
2003 AND 2009 BEACH AND INLET PROFILES

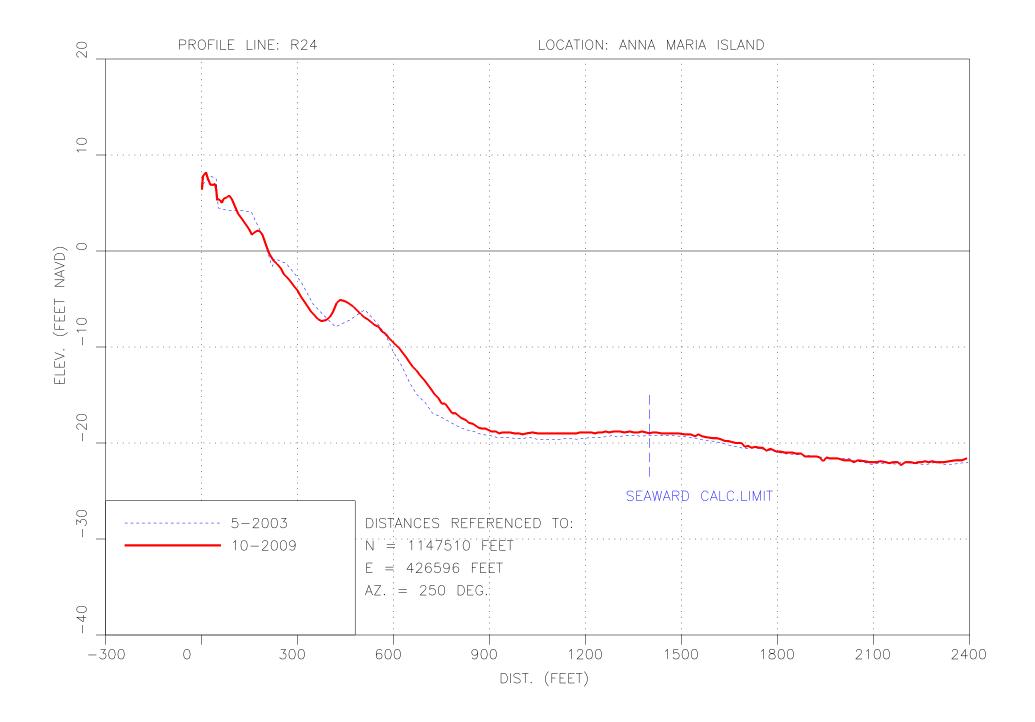
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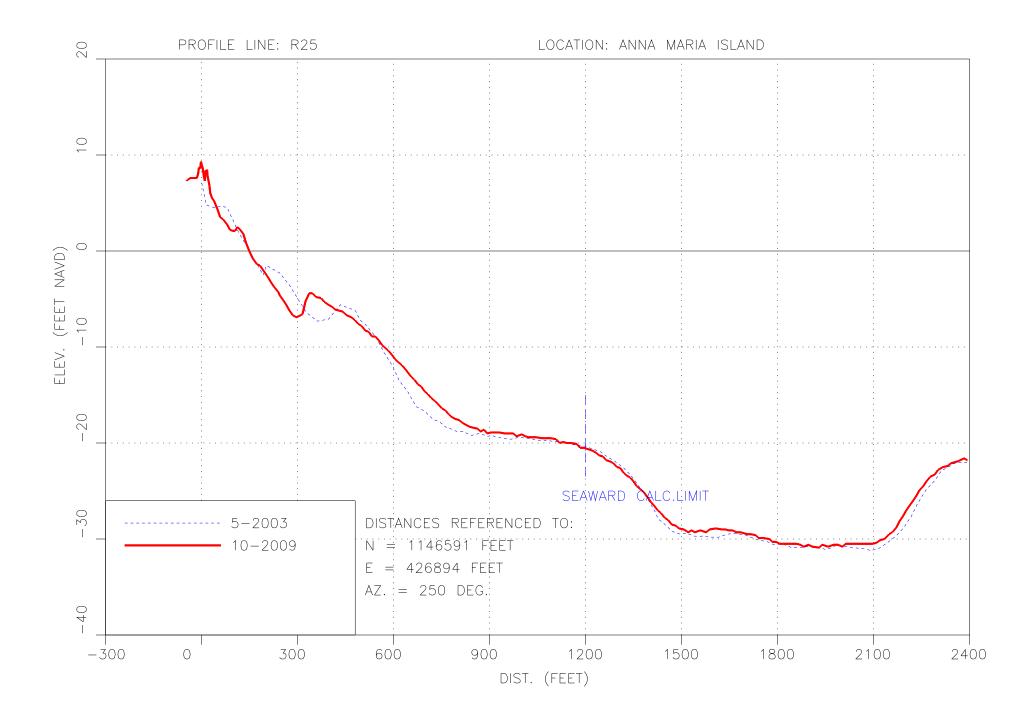


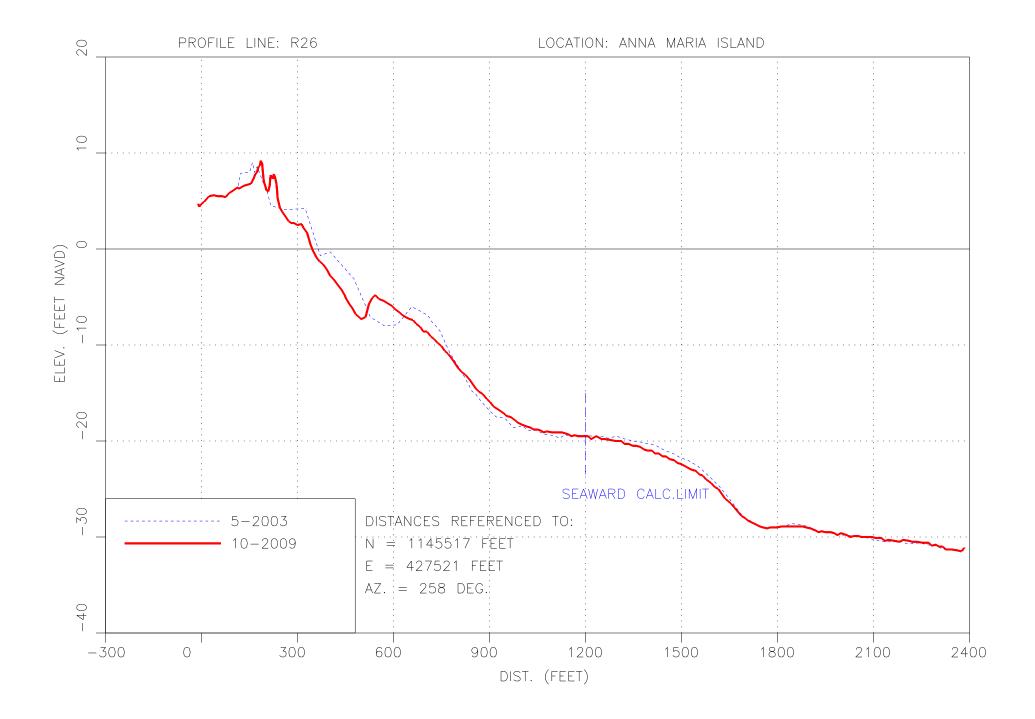


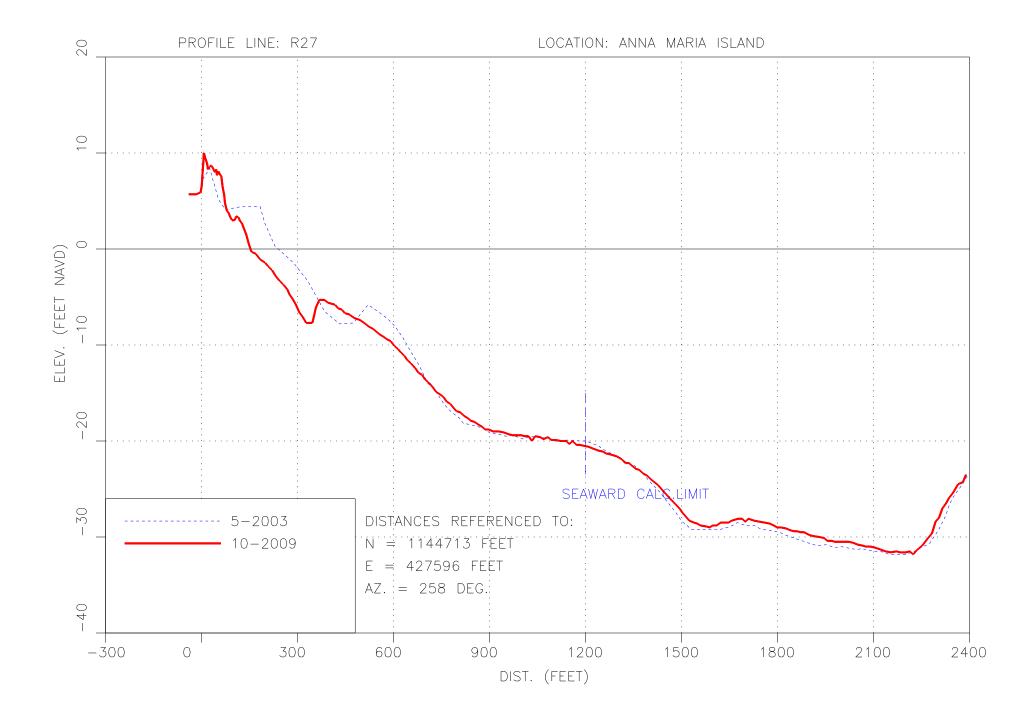


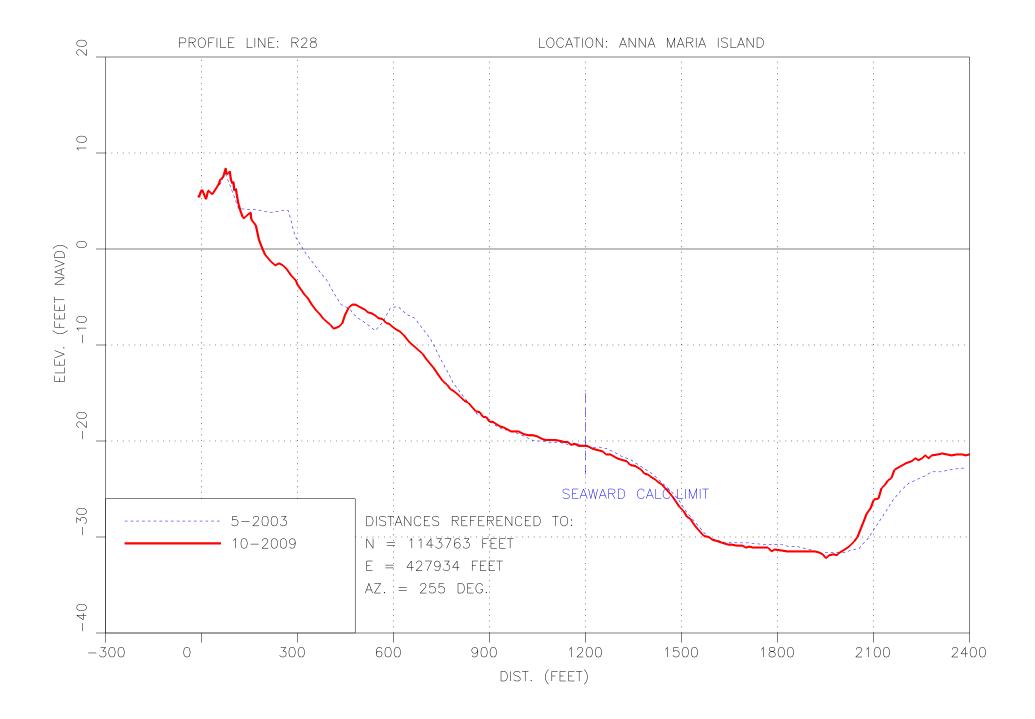


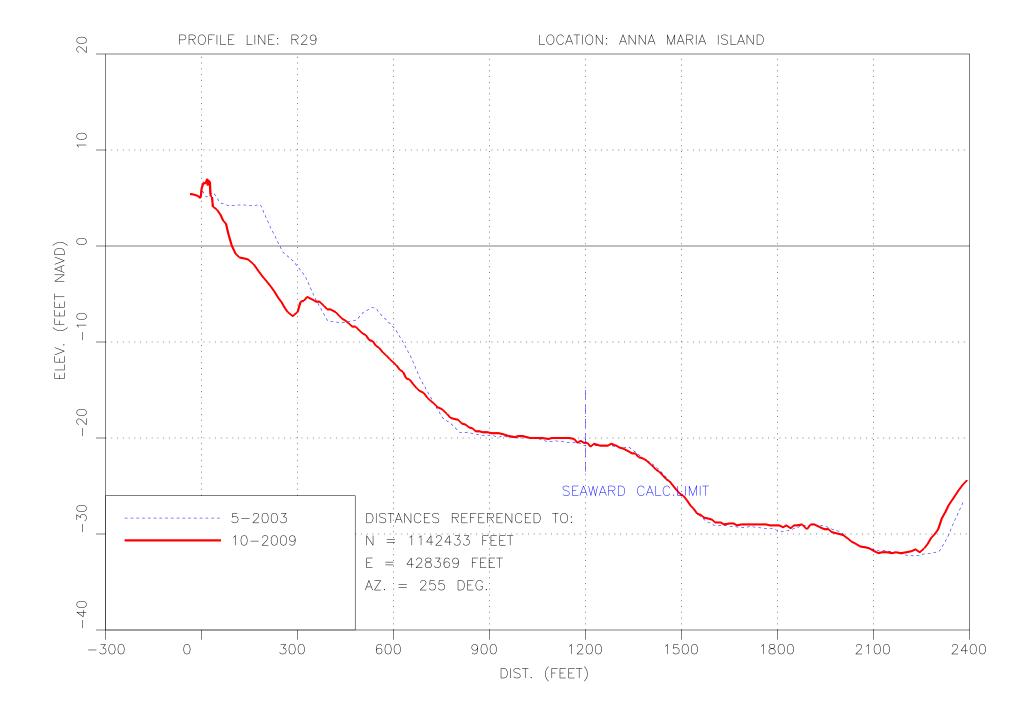


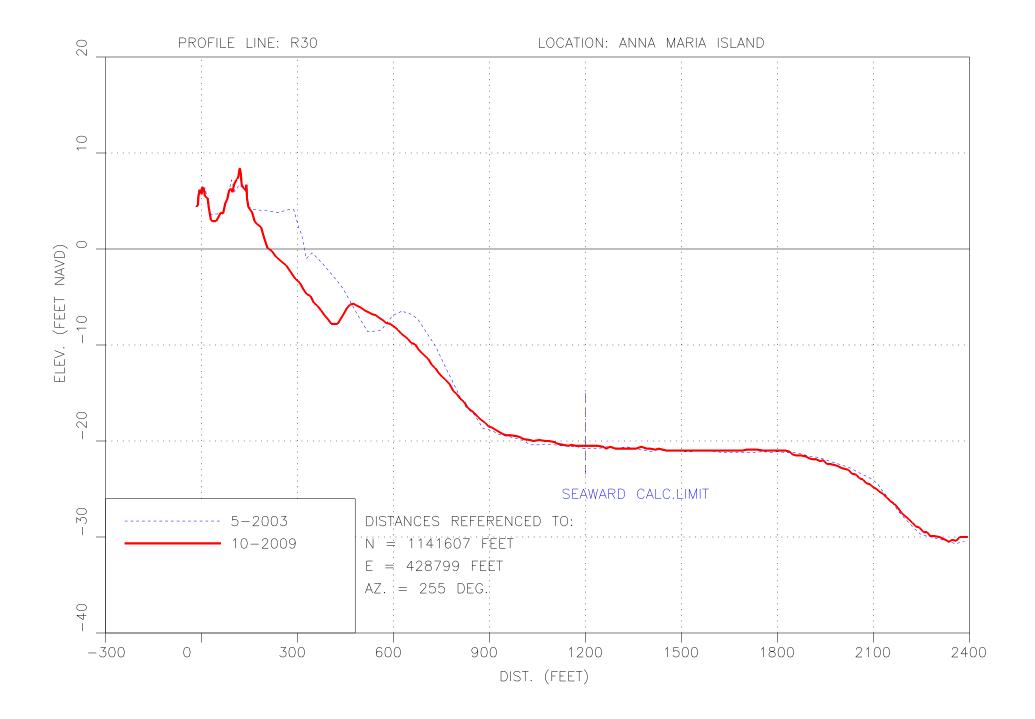


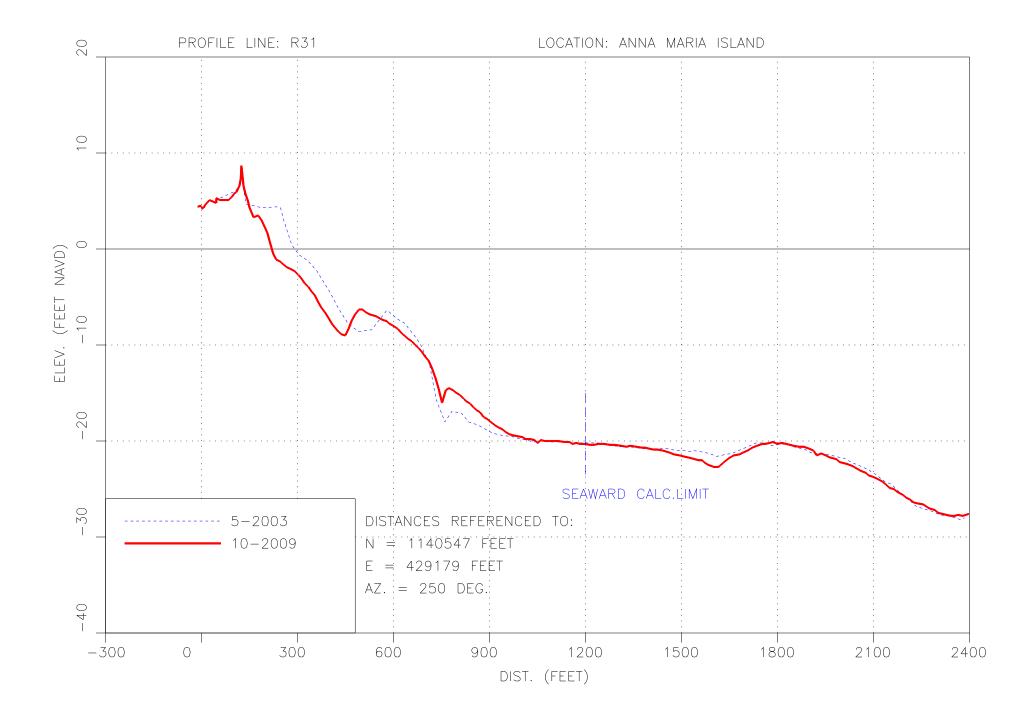


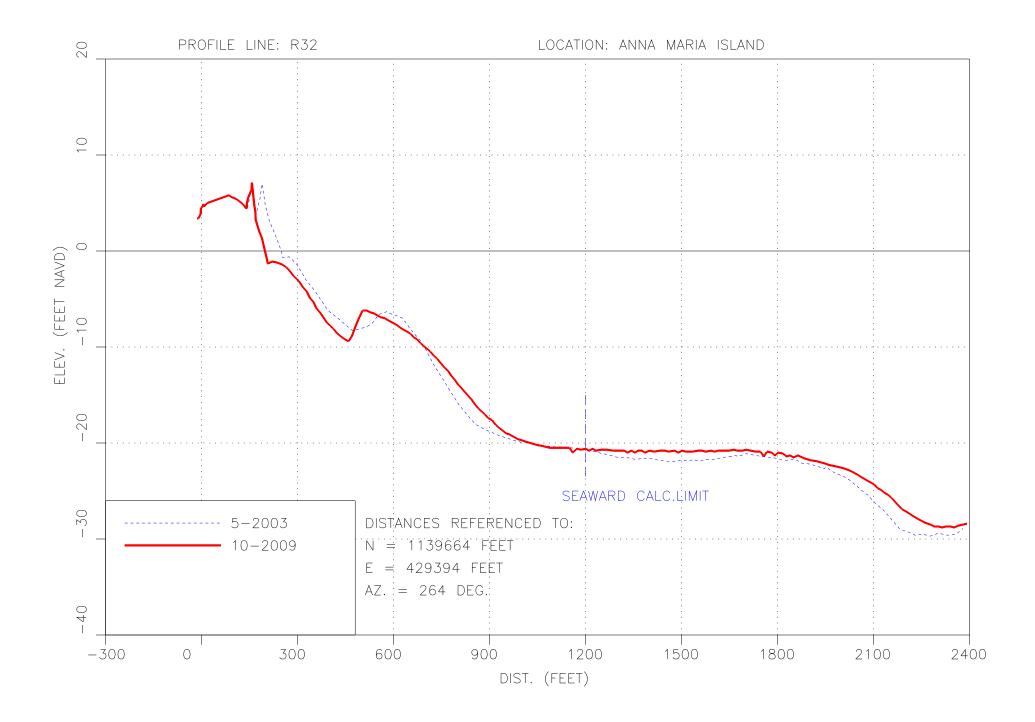


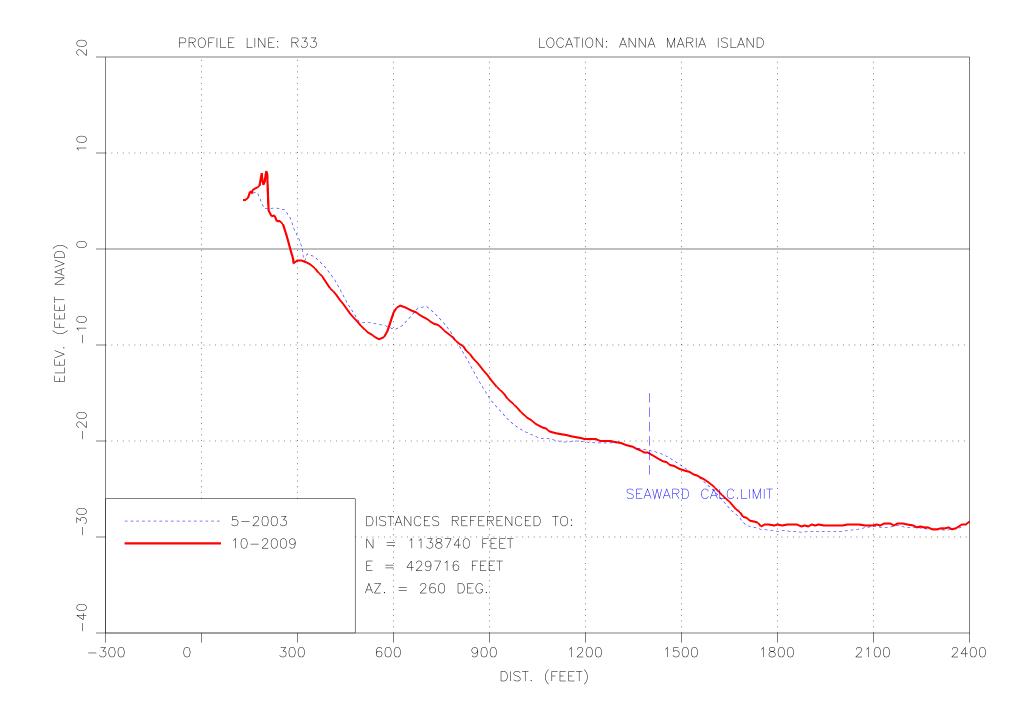


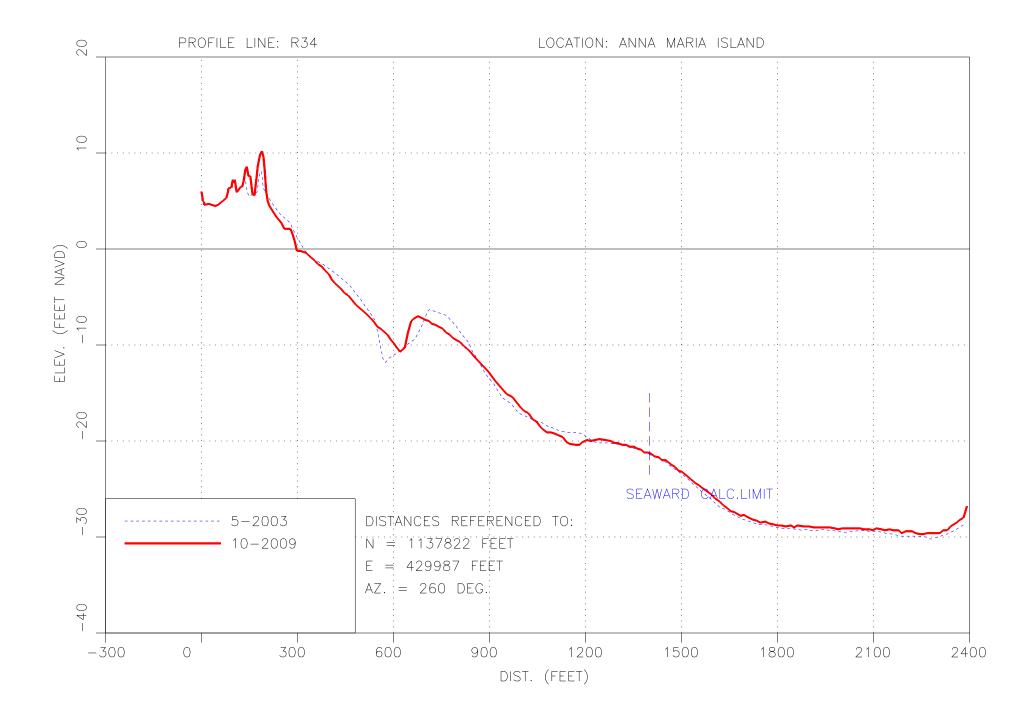


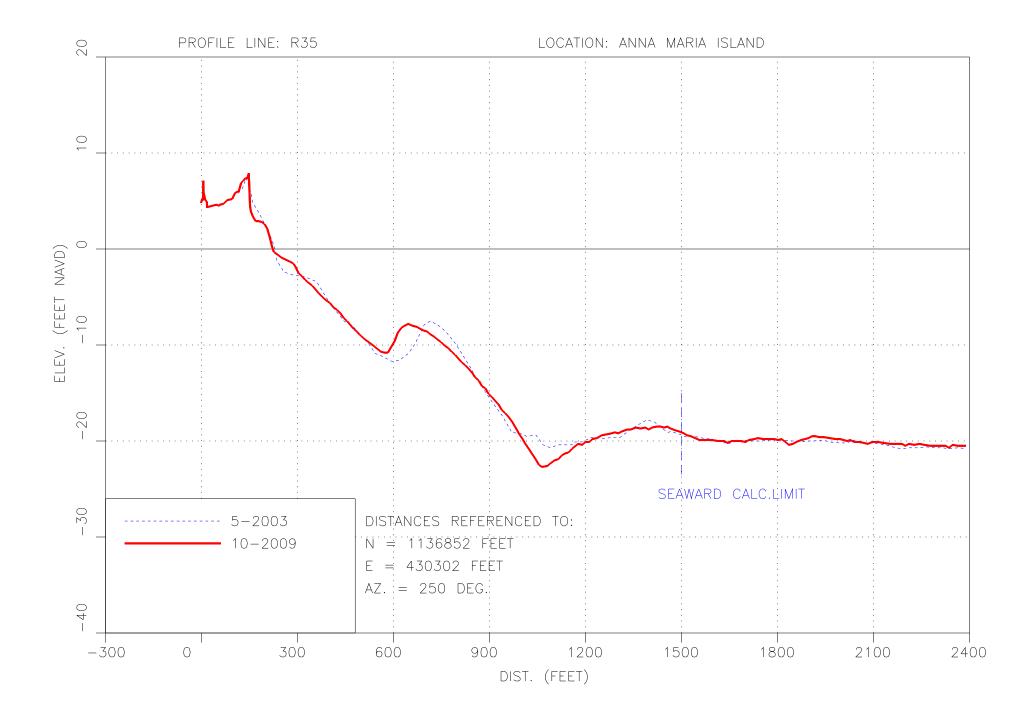


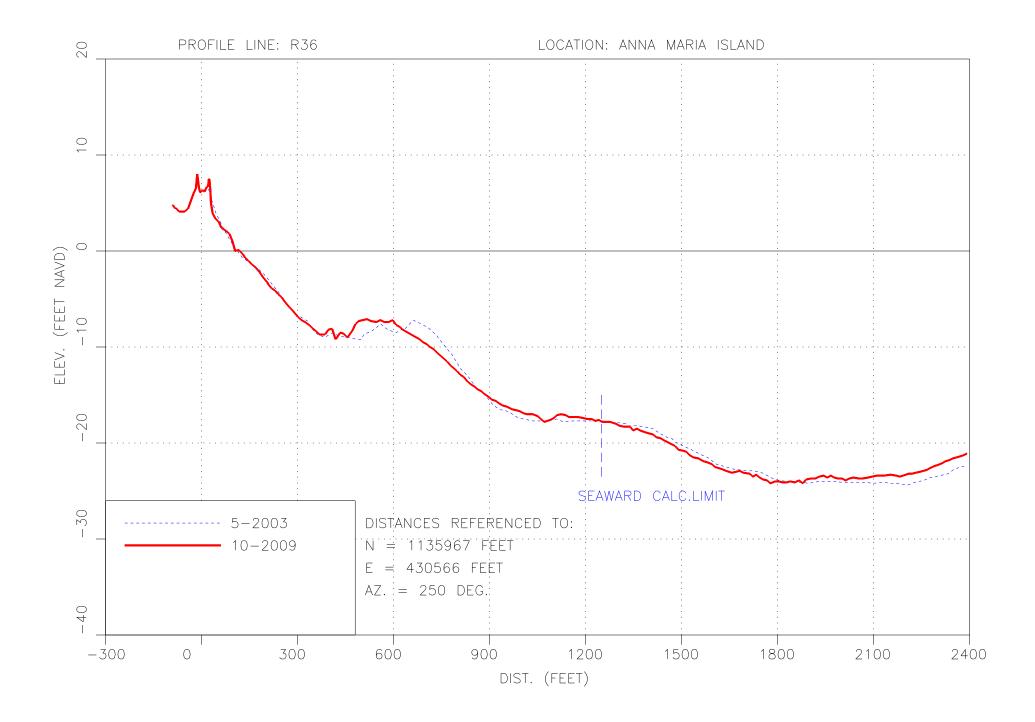


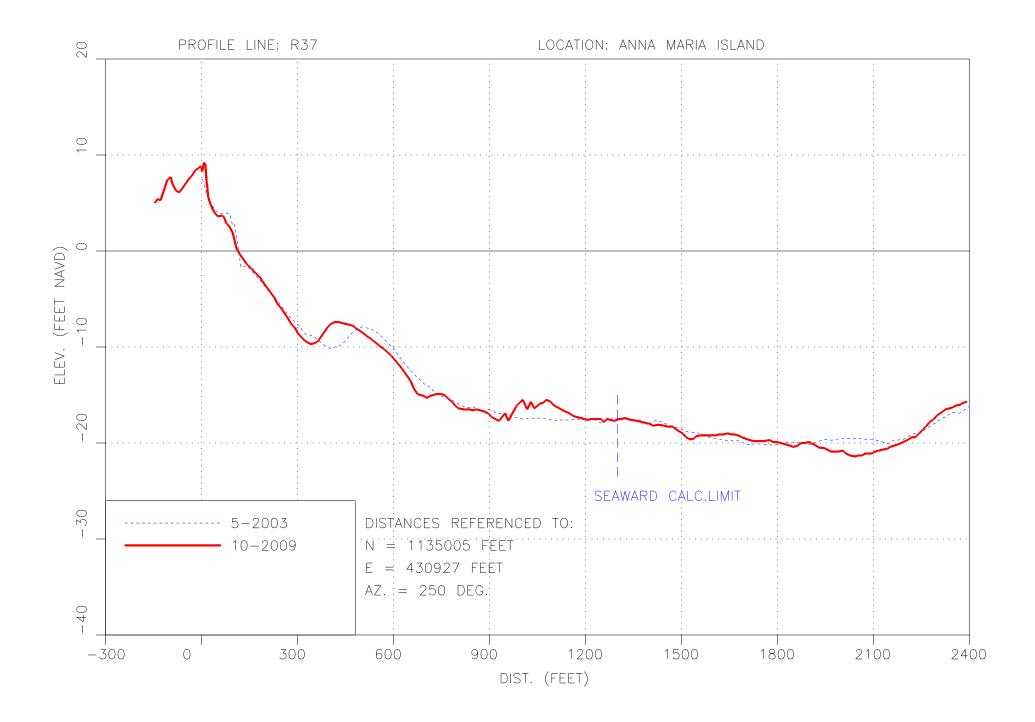


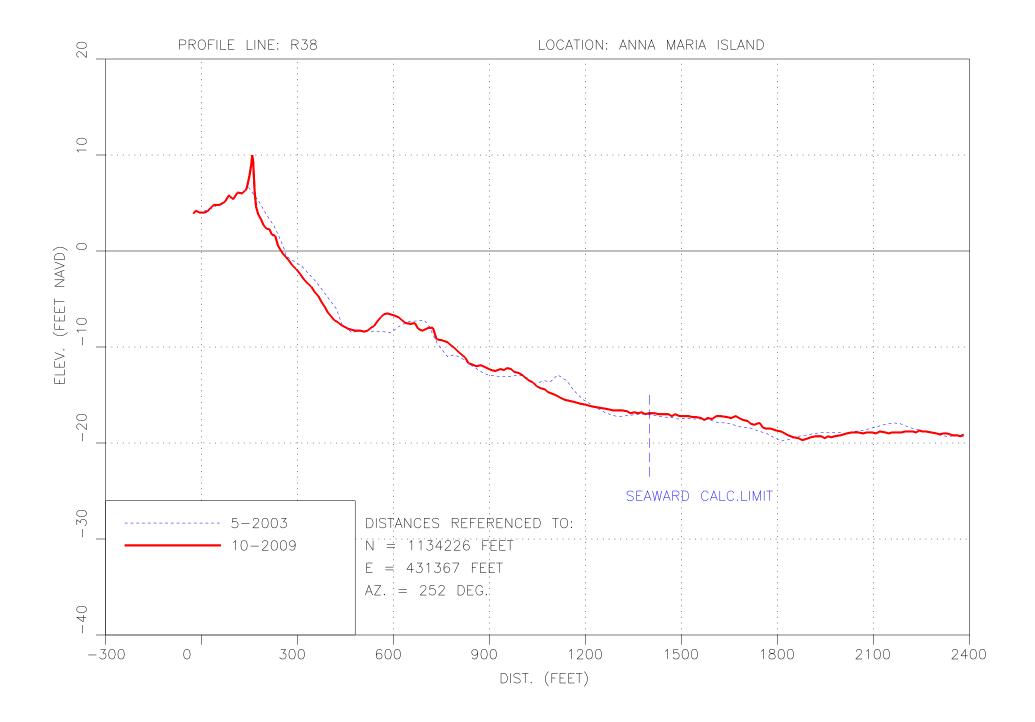


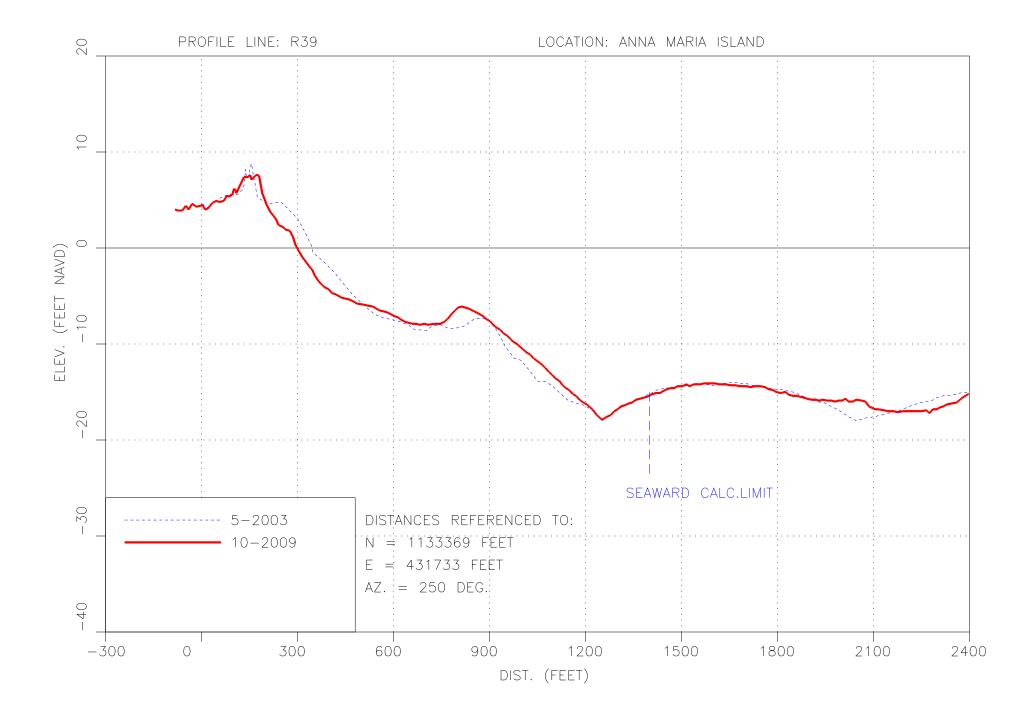


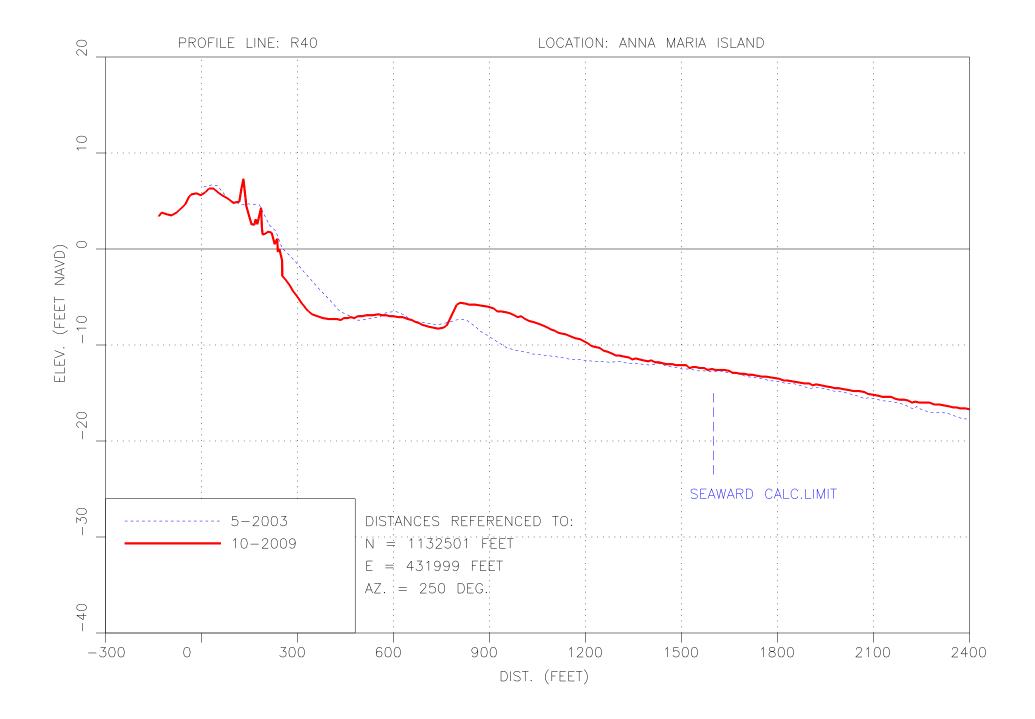


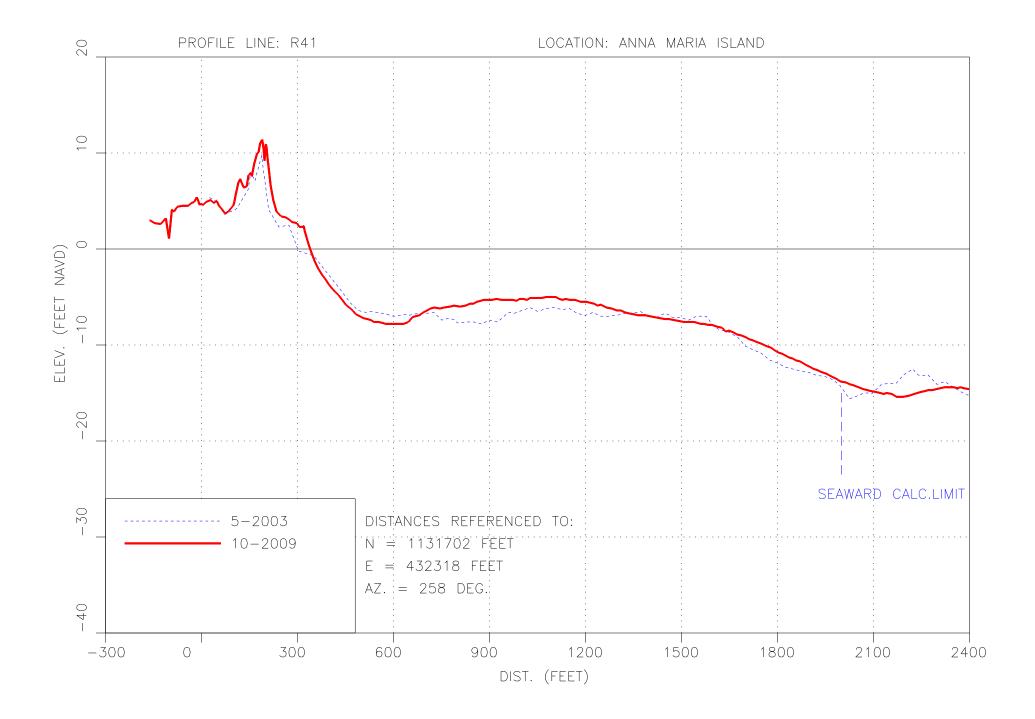


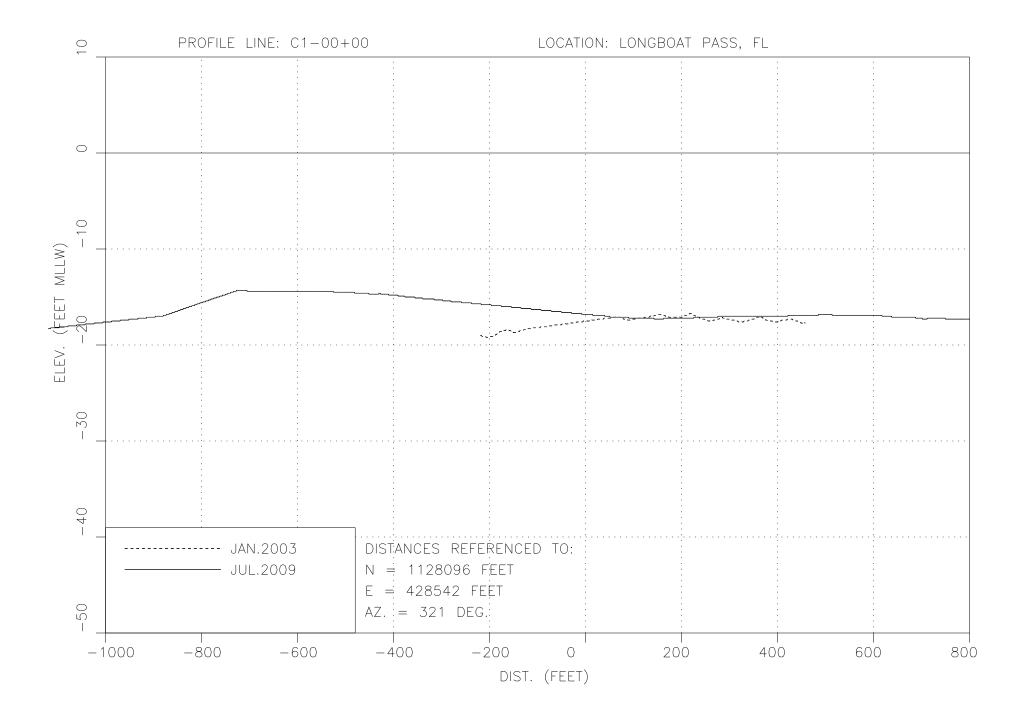


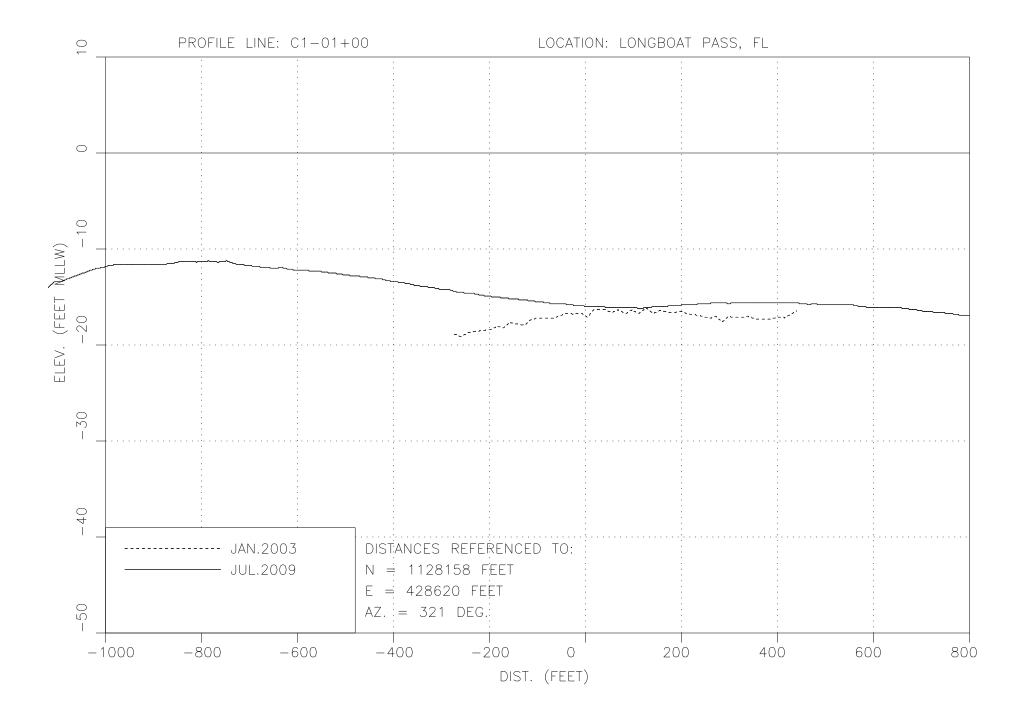


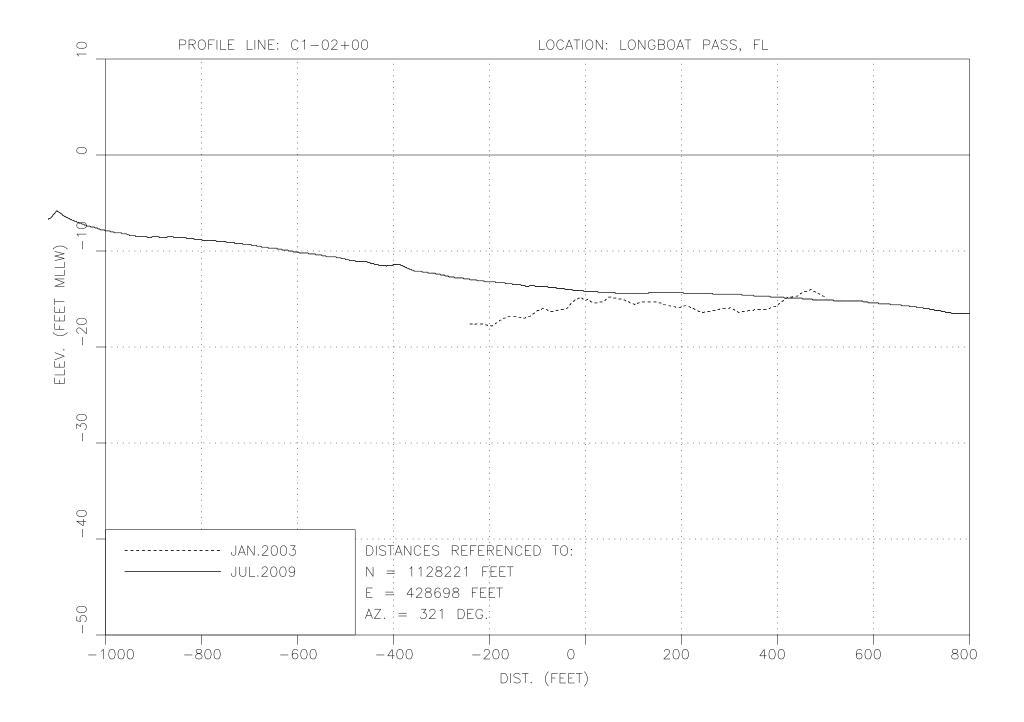


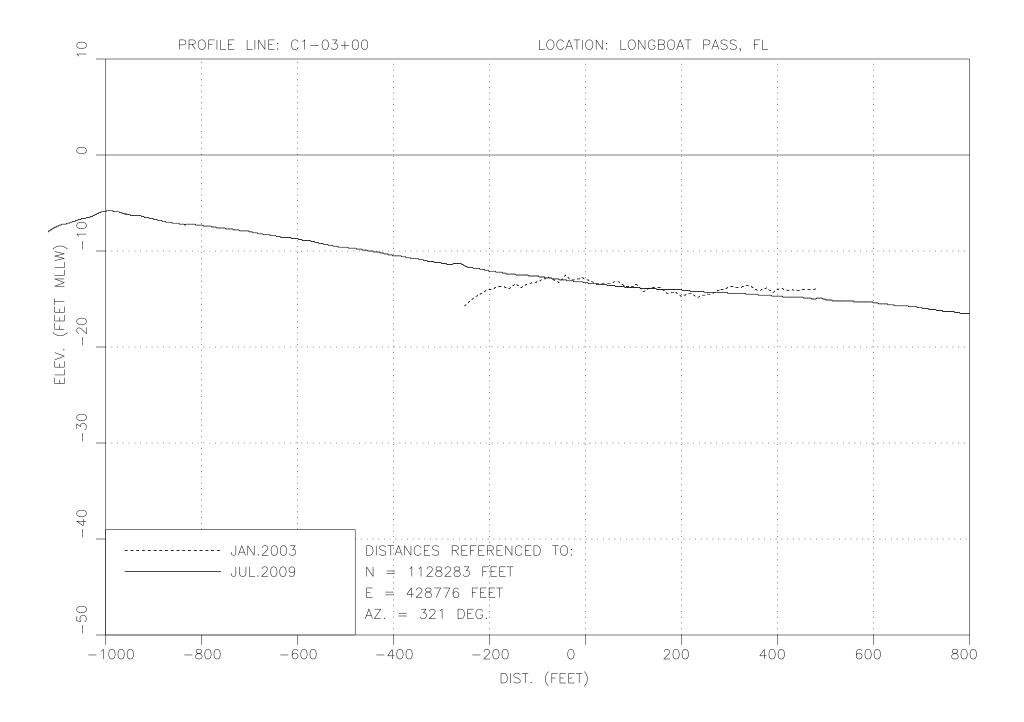


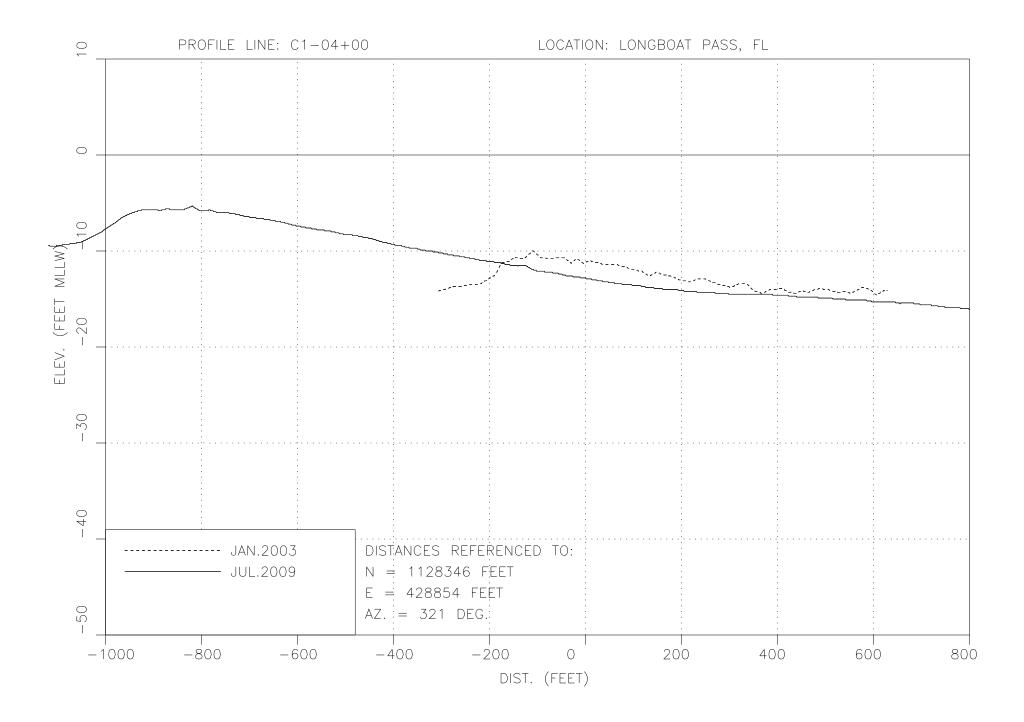


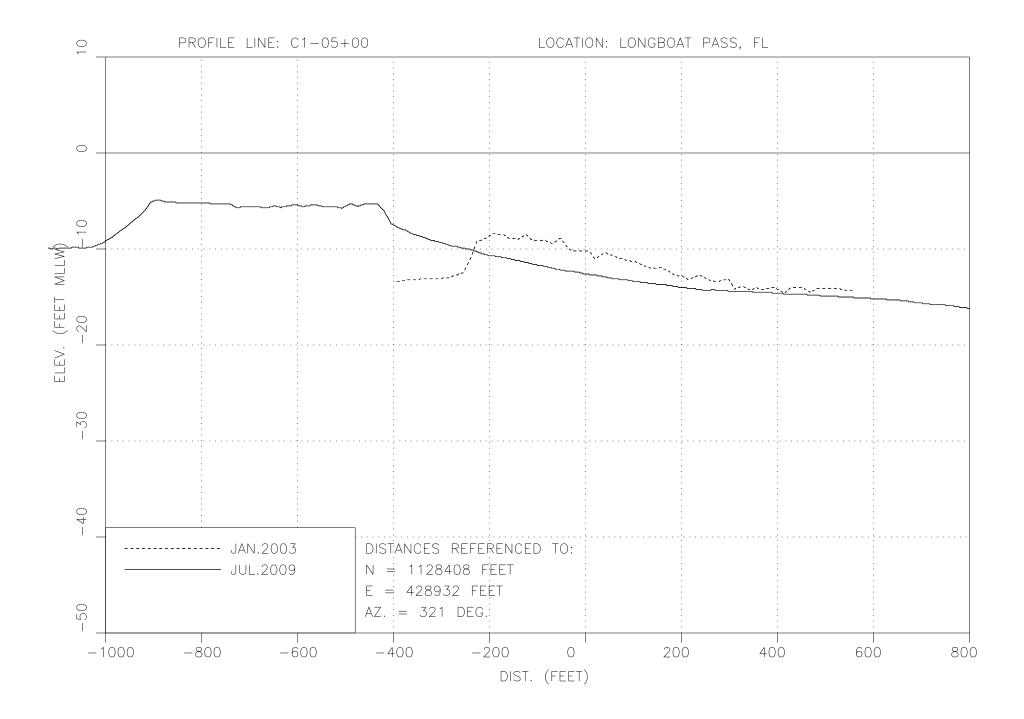


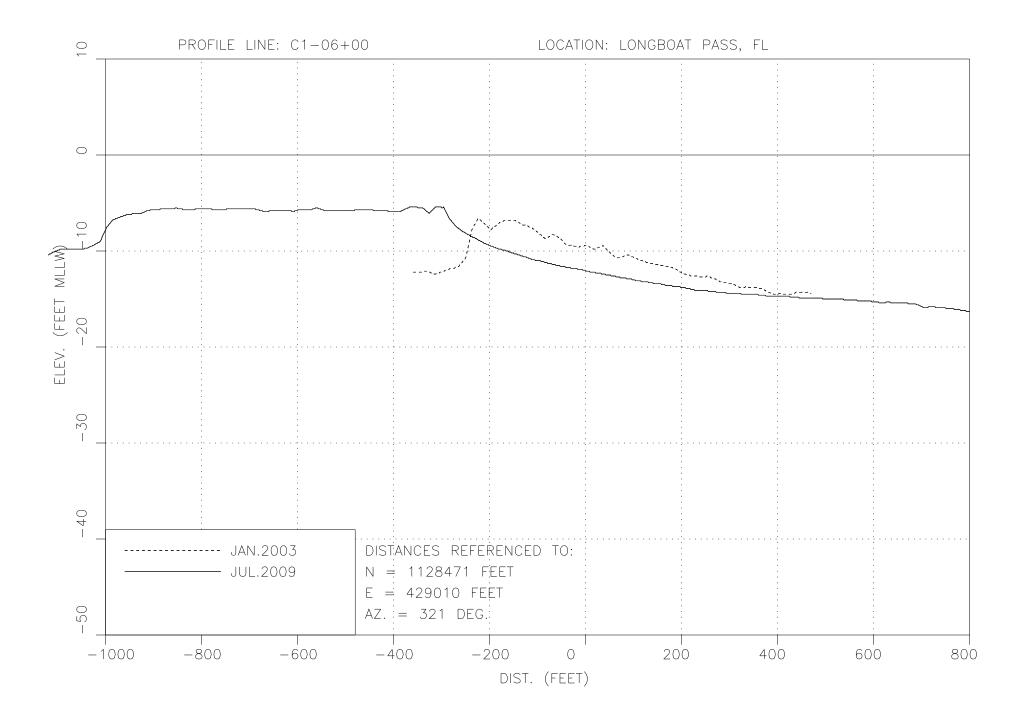


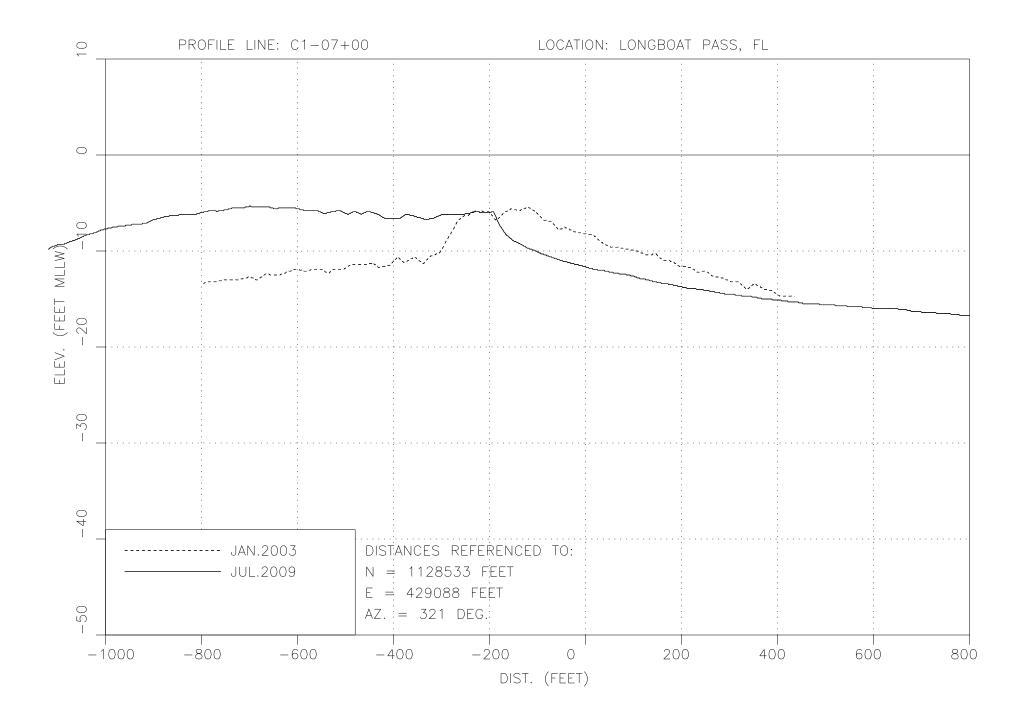


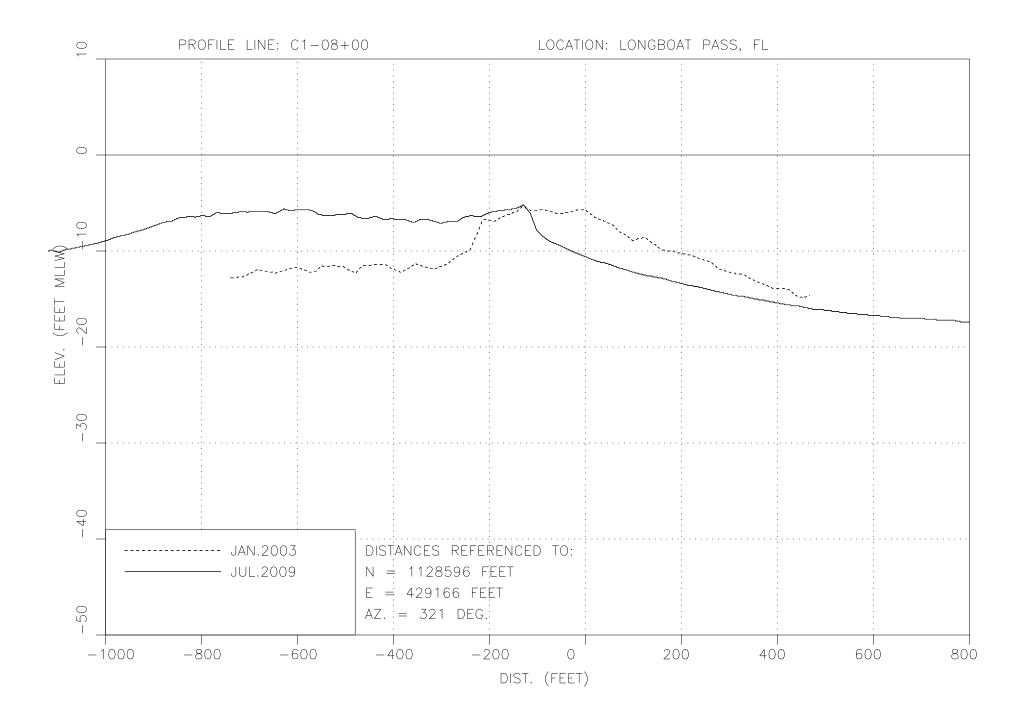


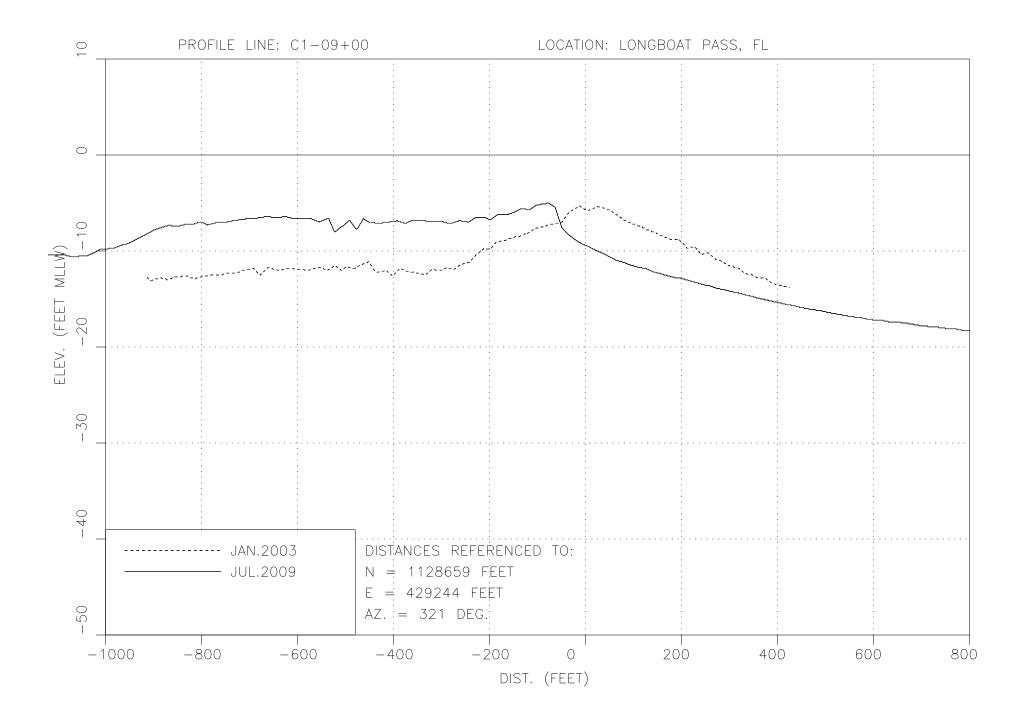


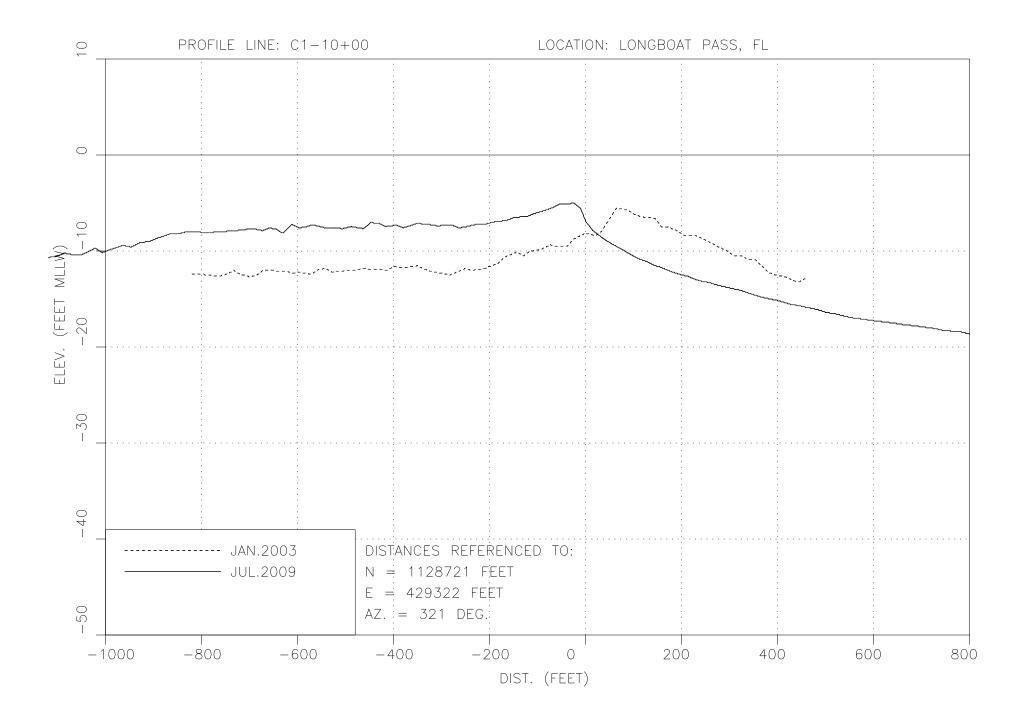


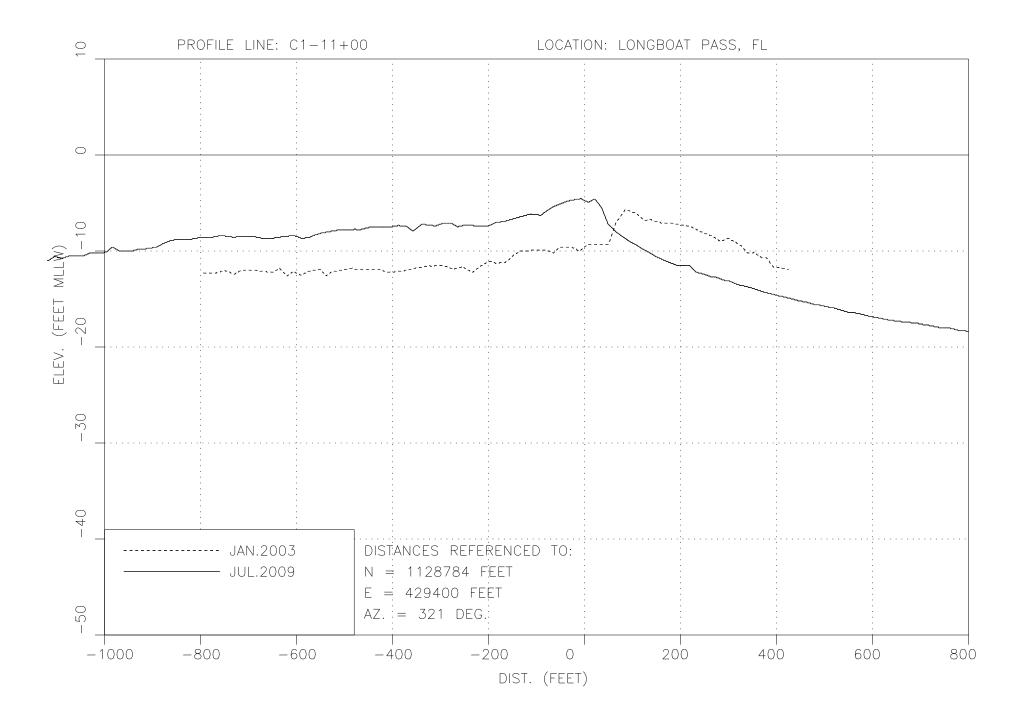


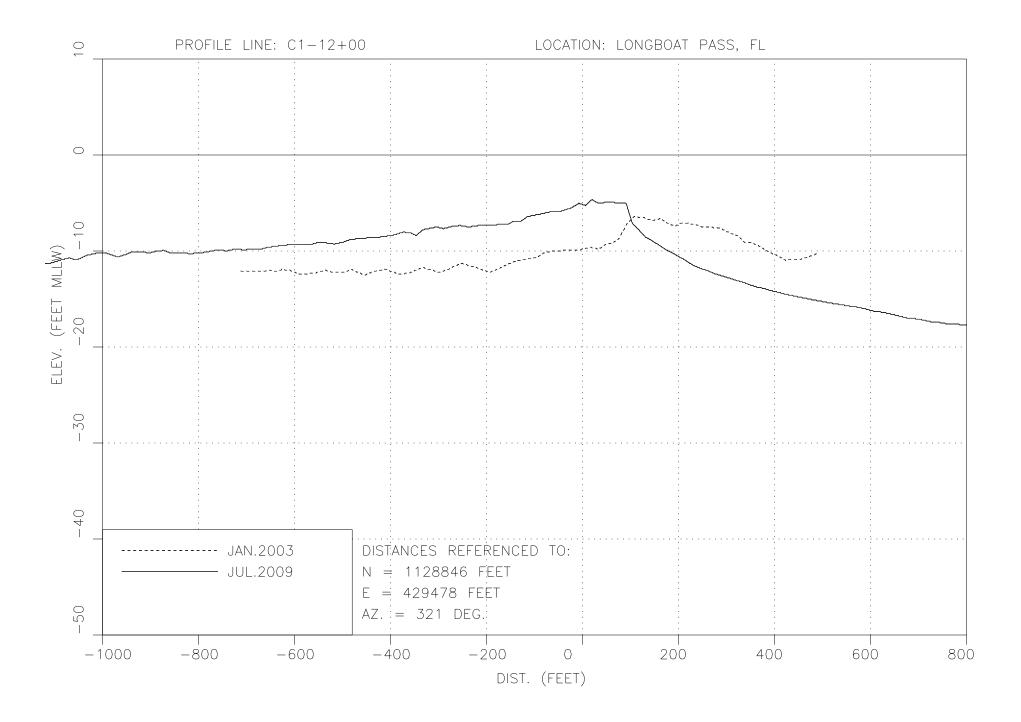


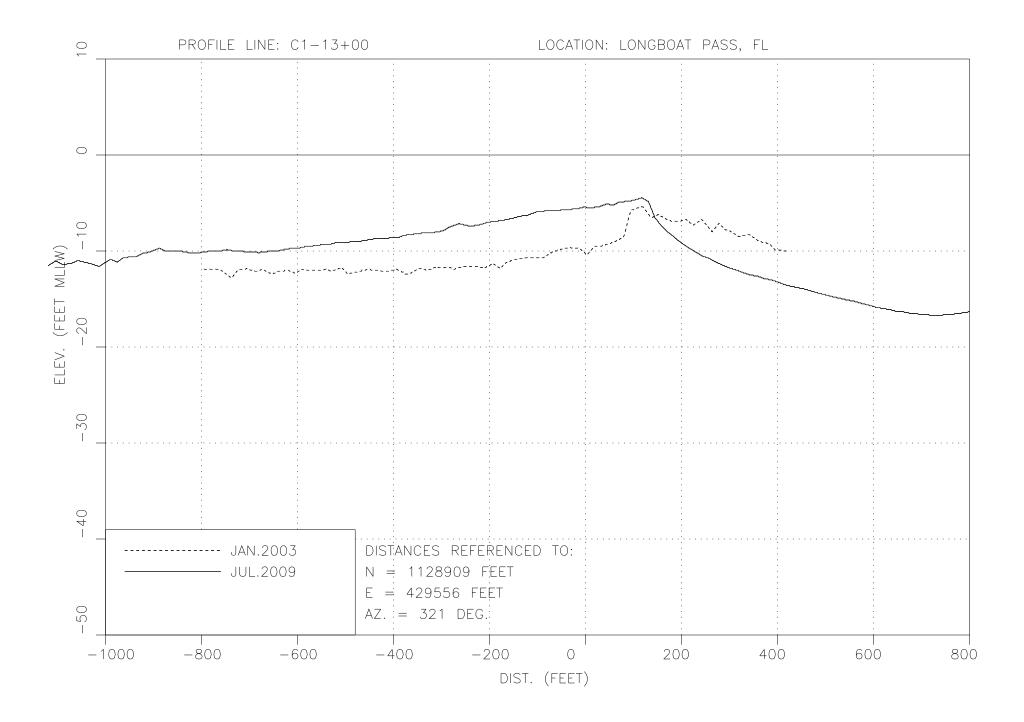


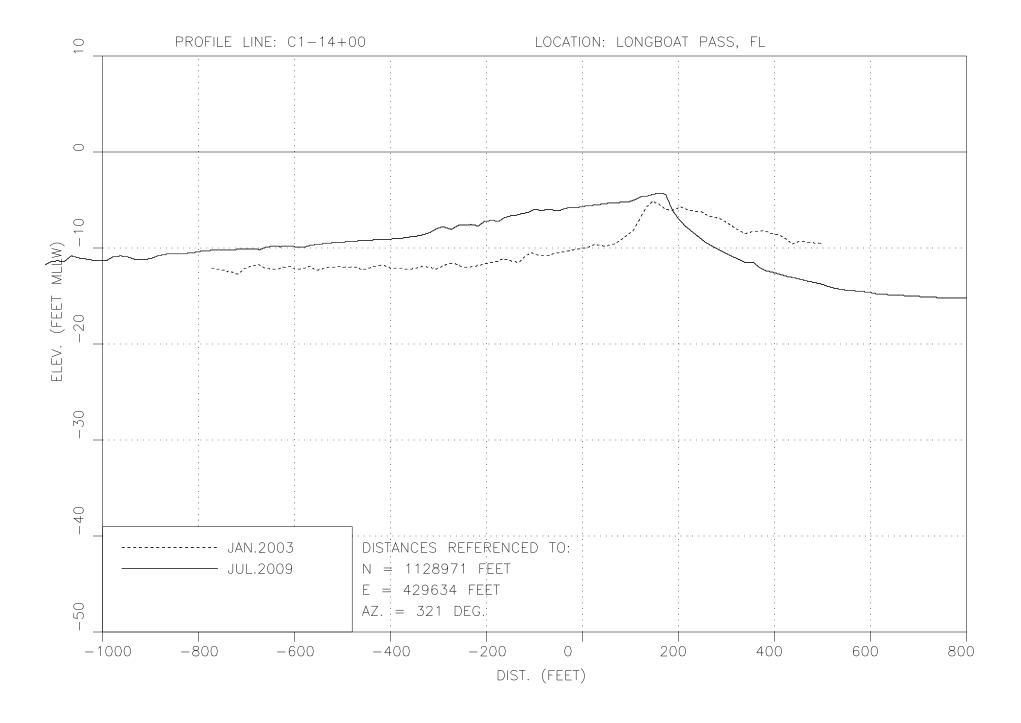


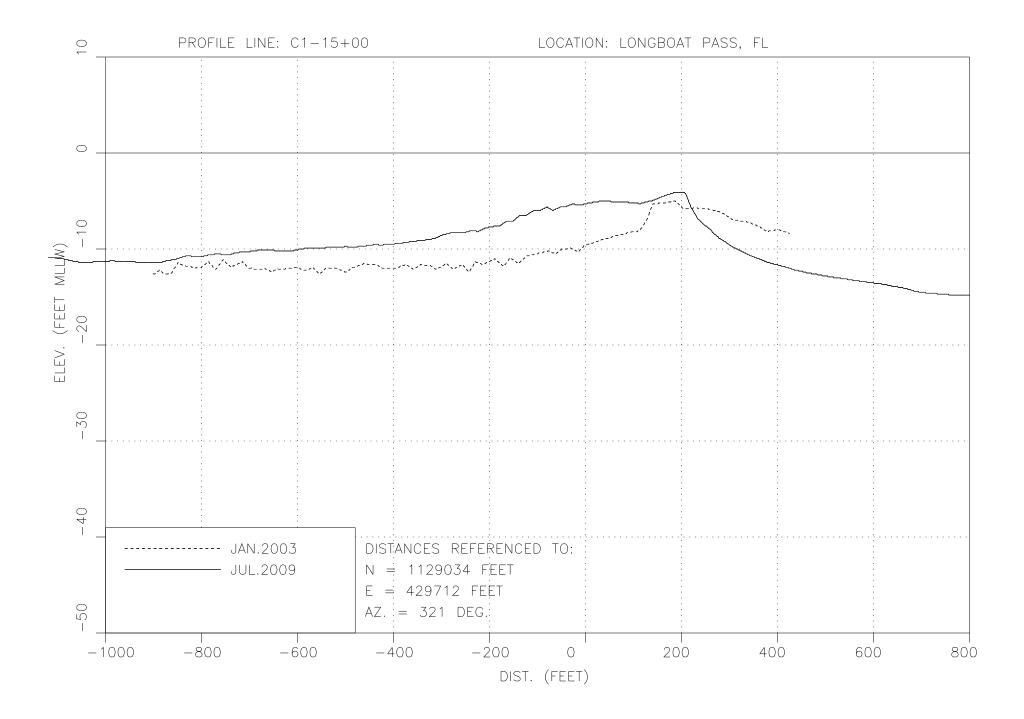


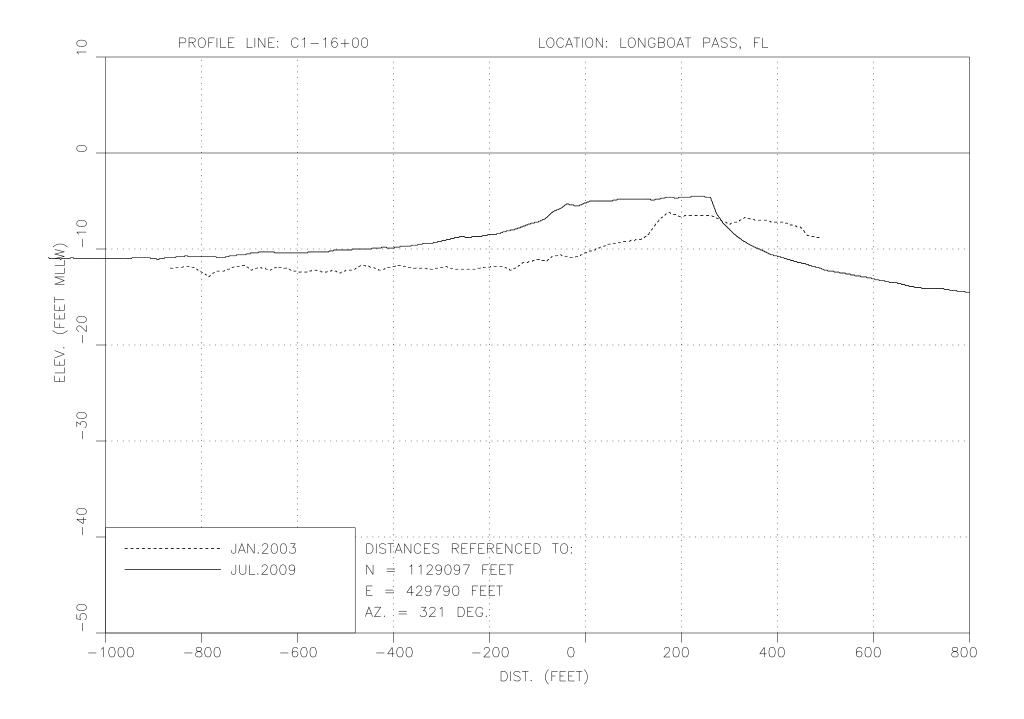


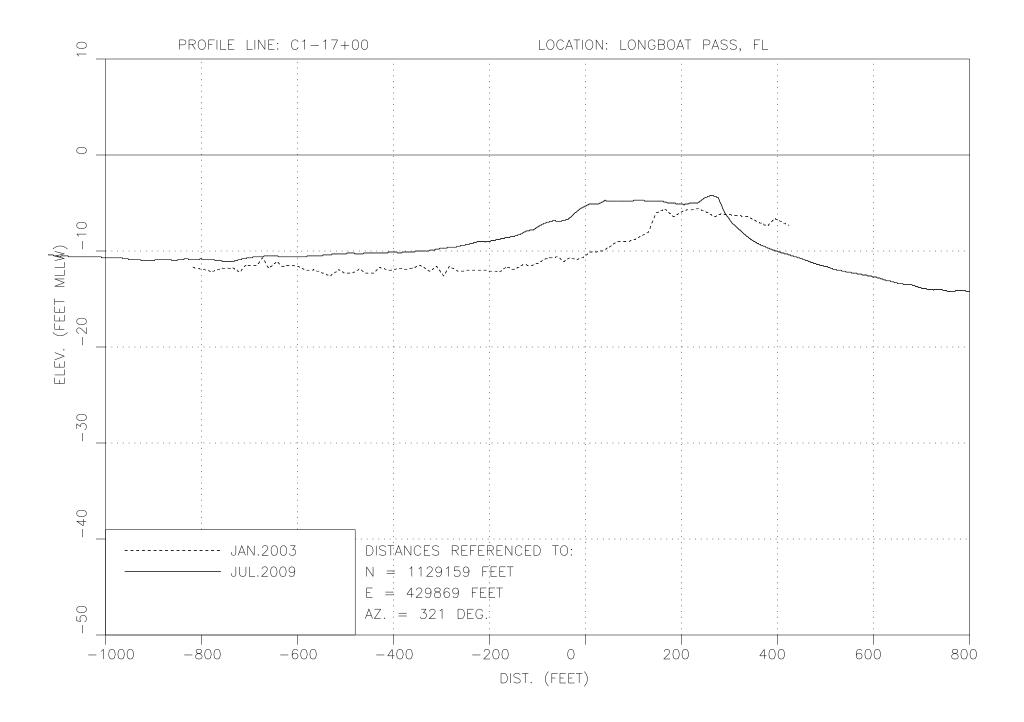


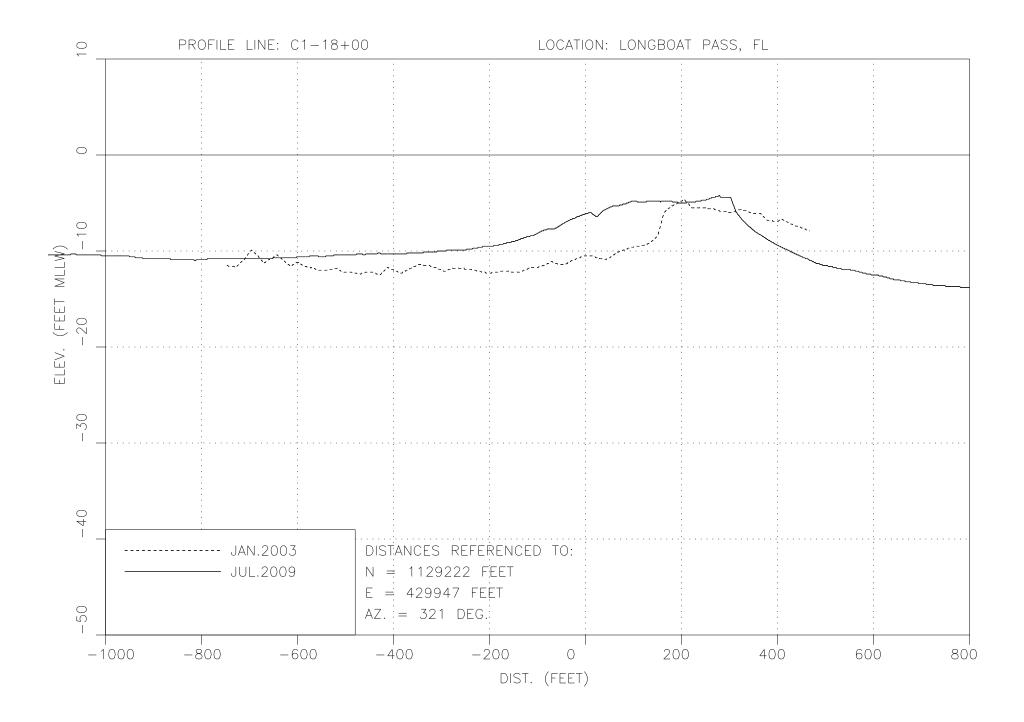


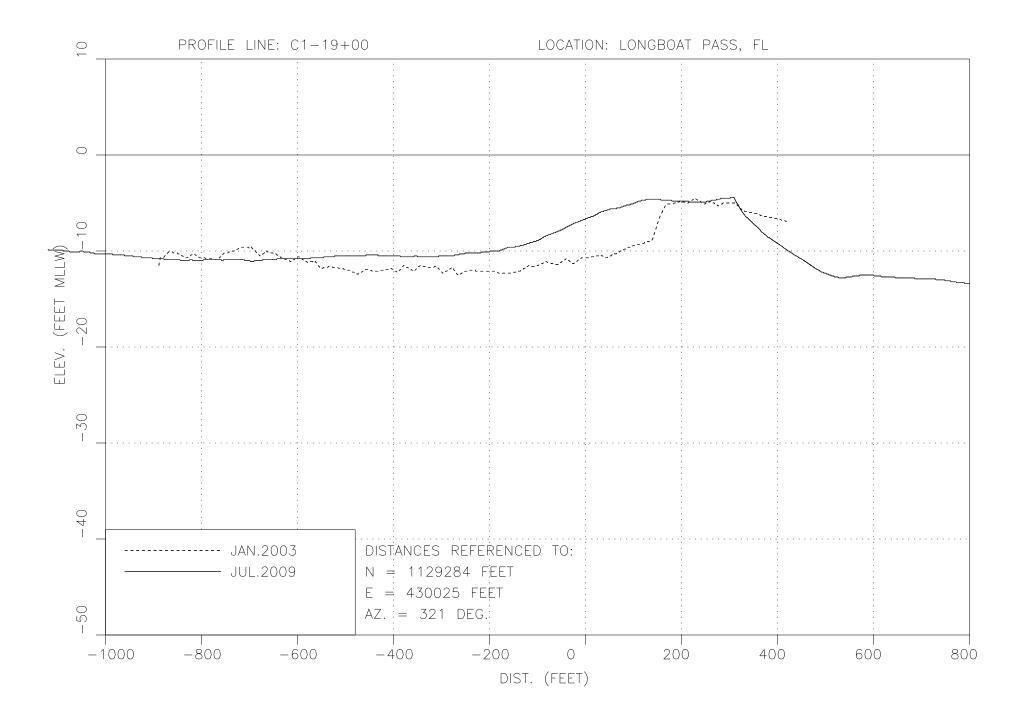


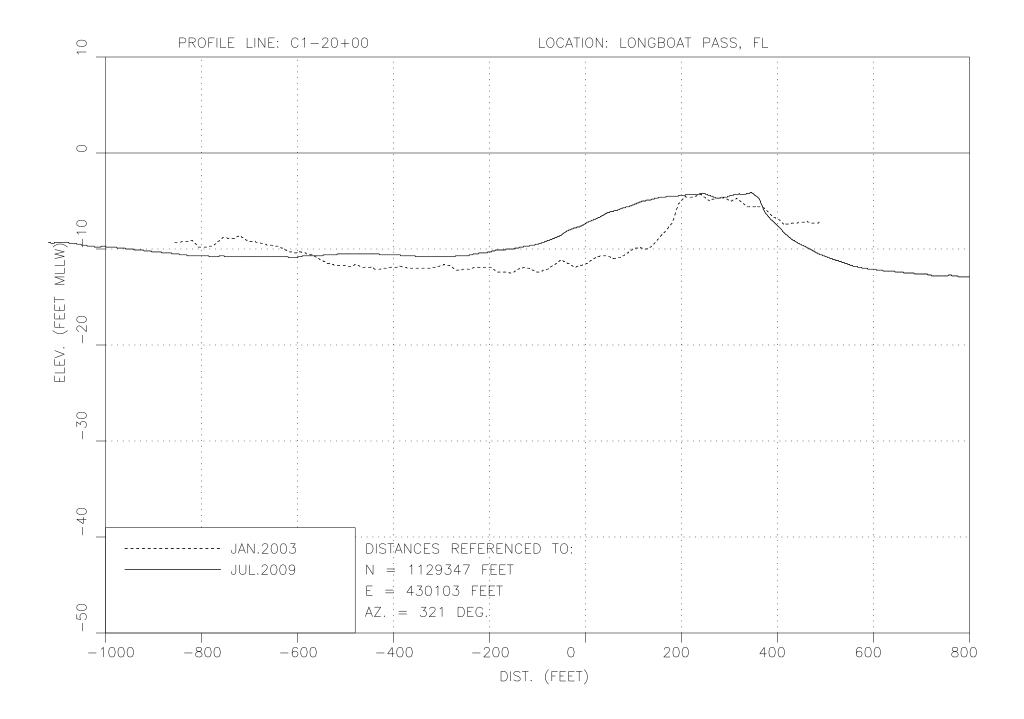


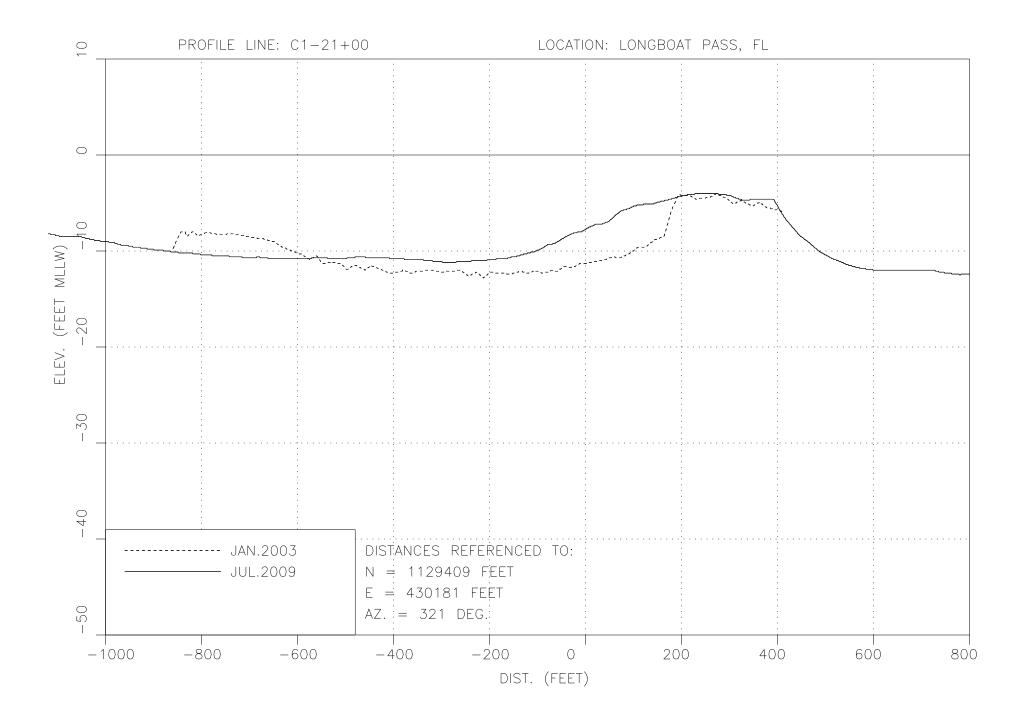


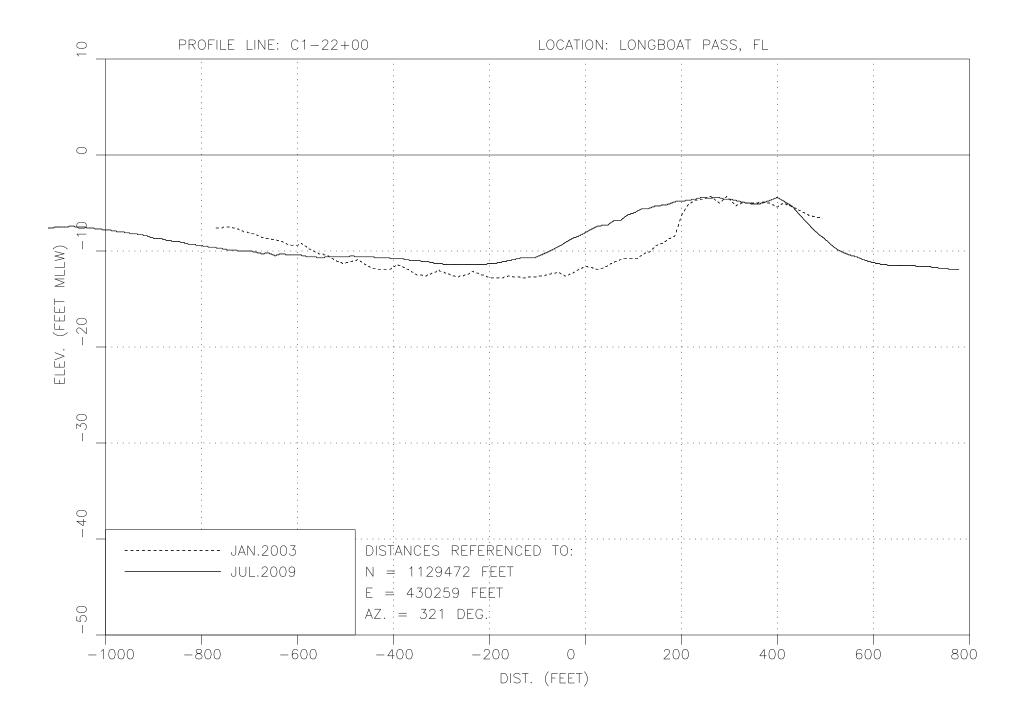


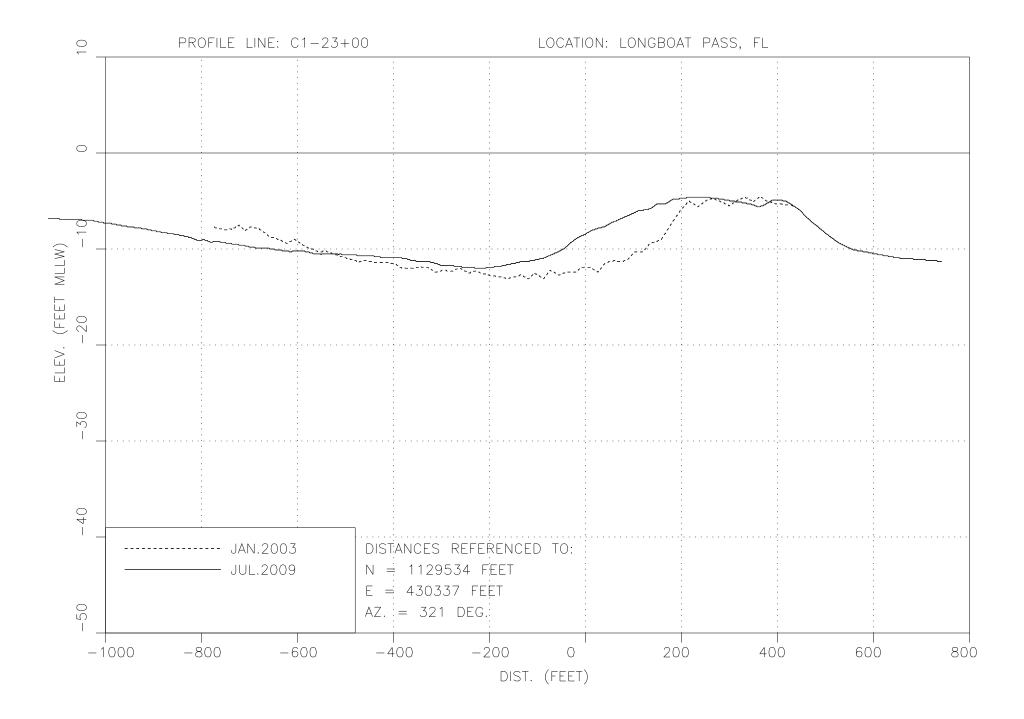


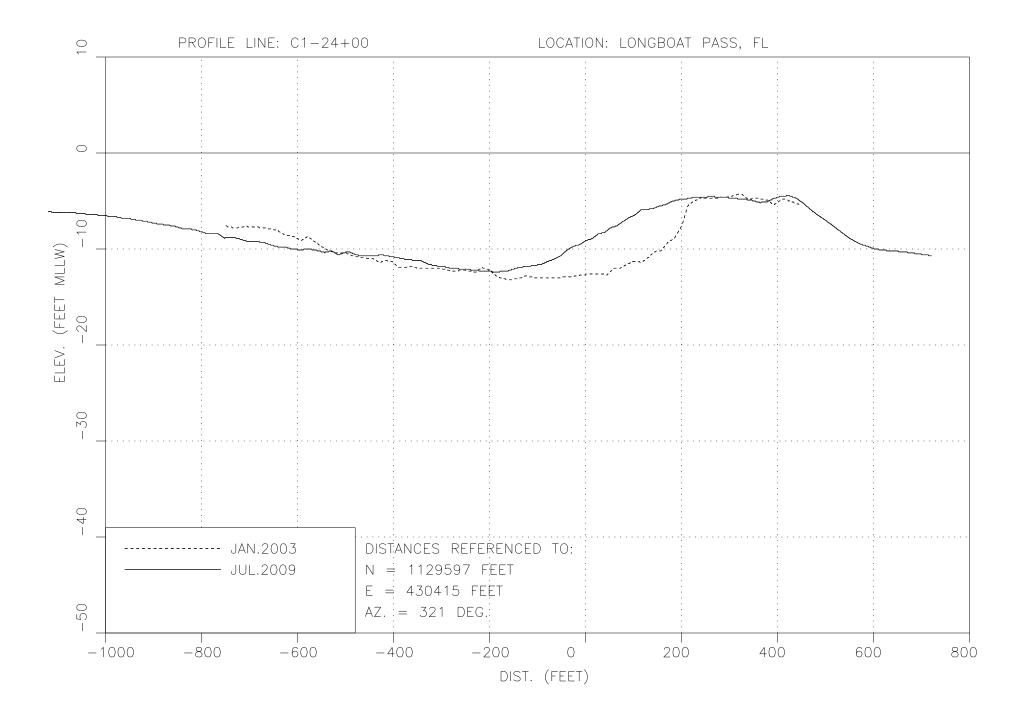


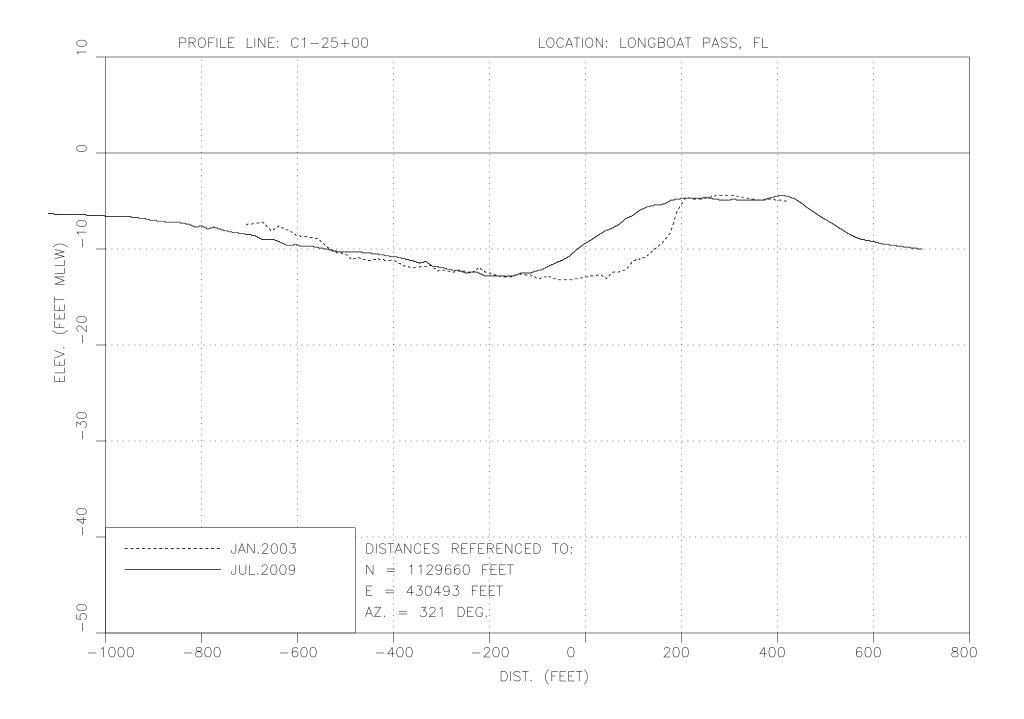


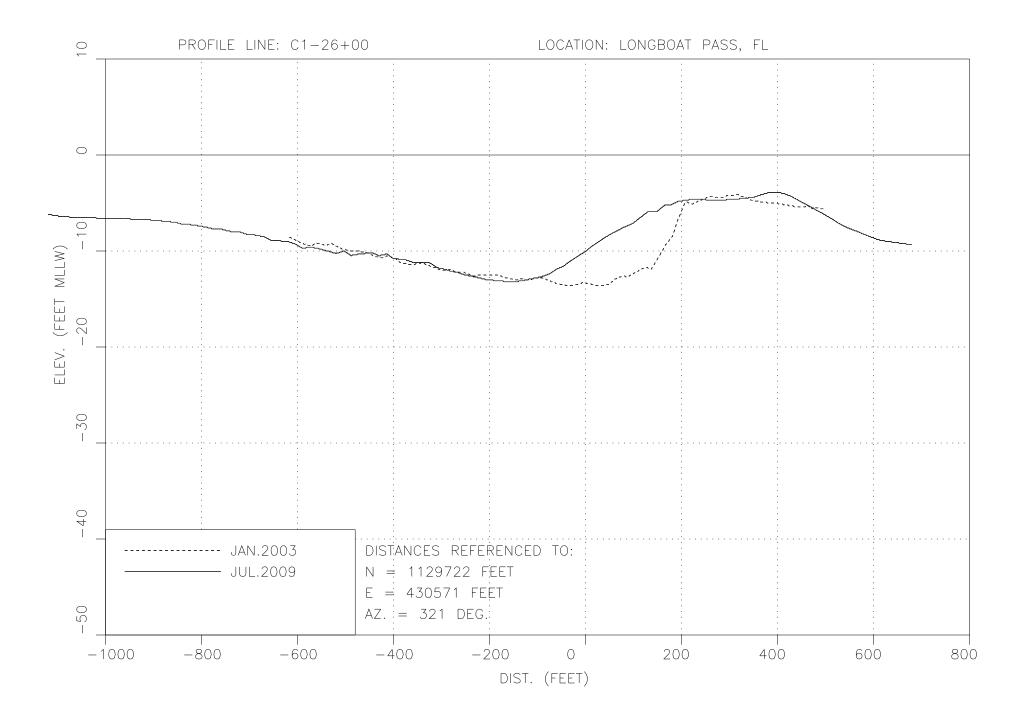


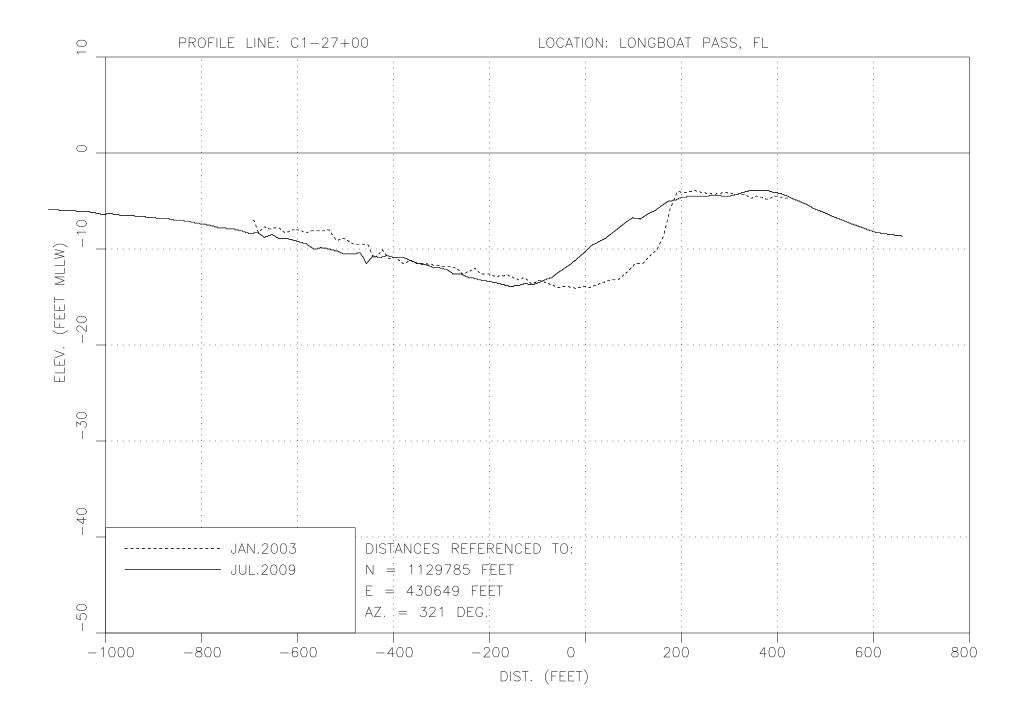


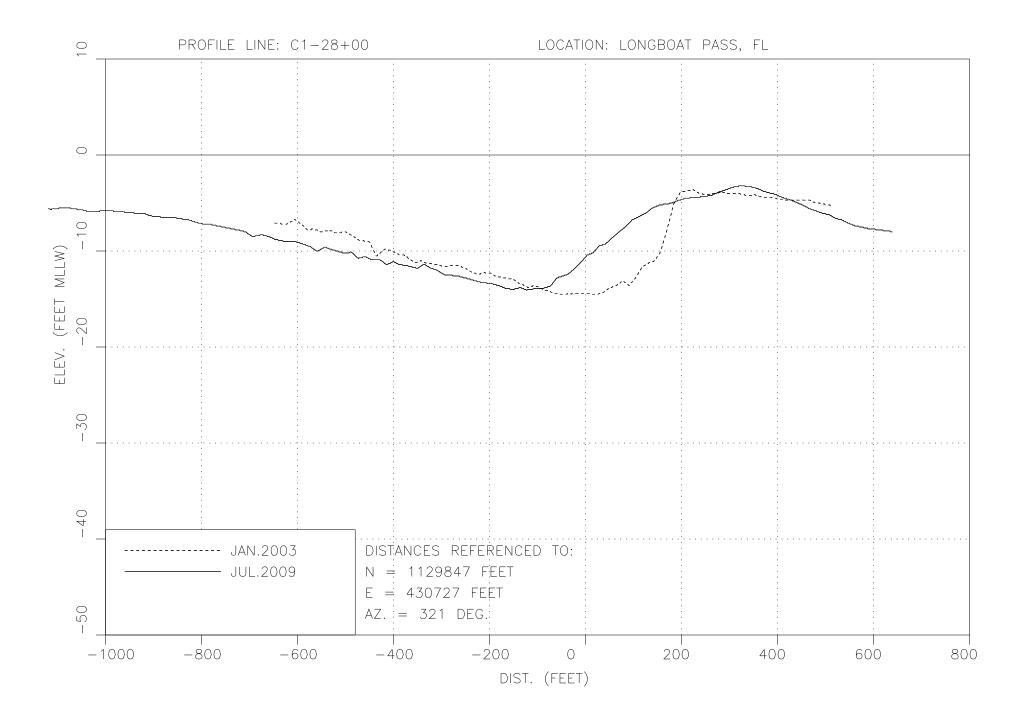


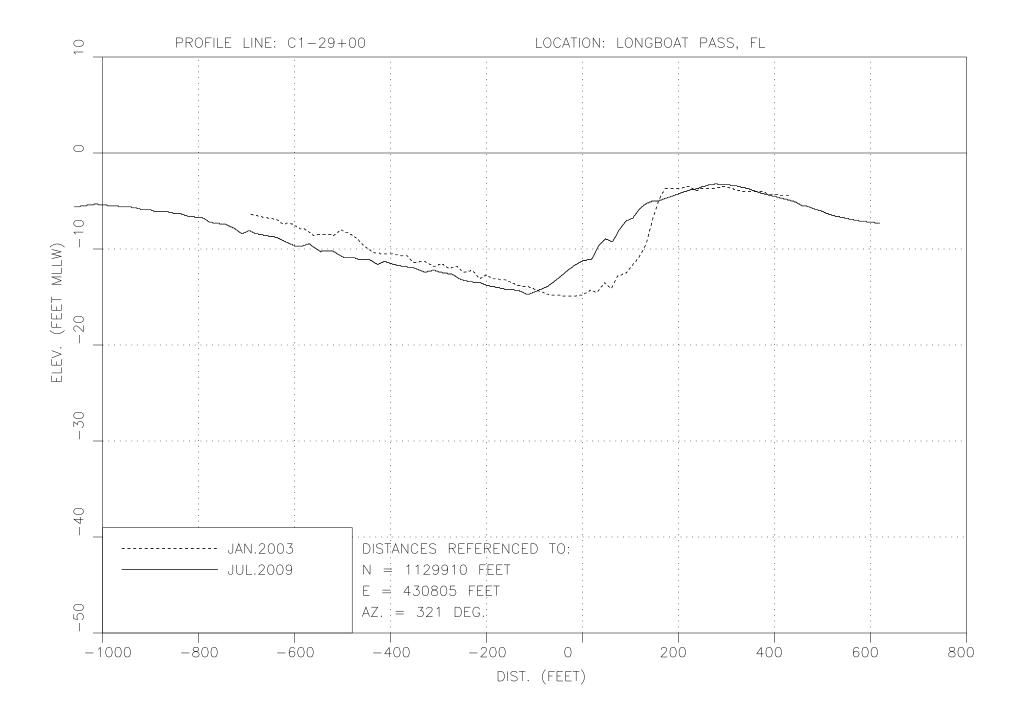


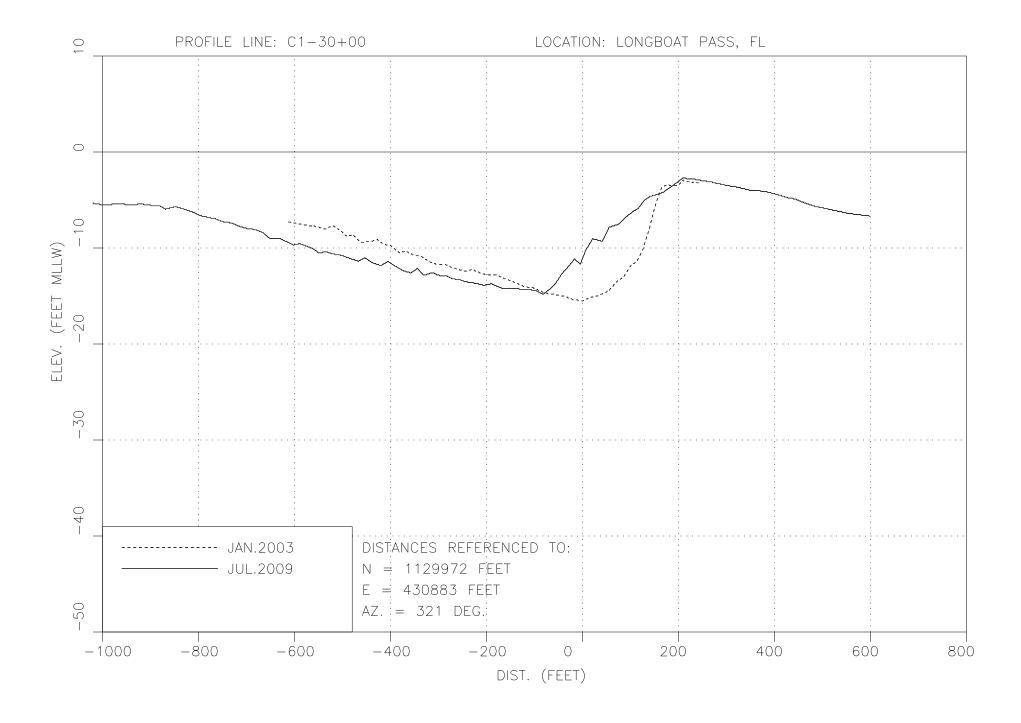


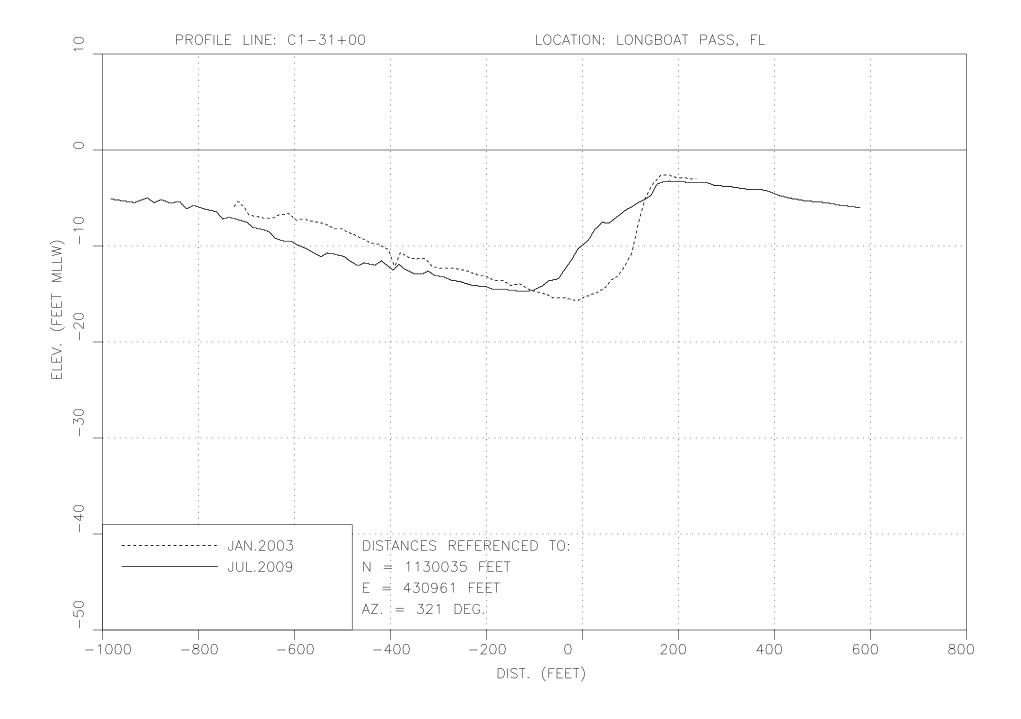


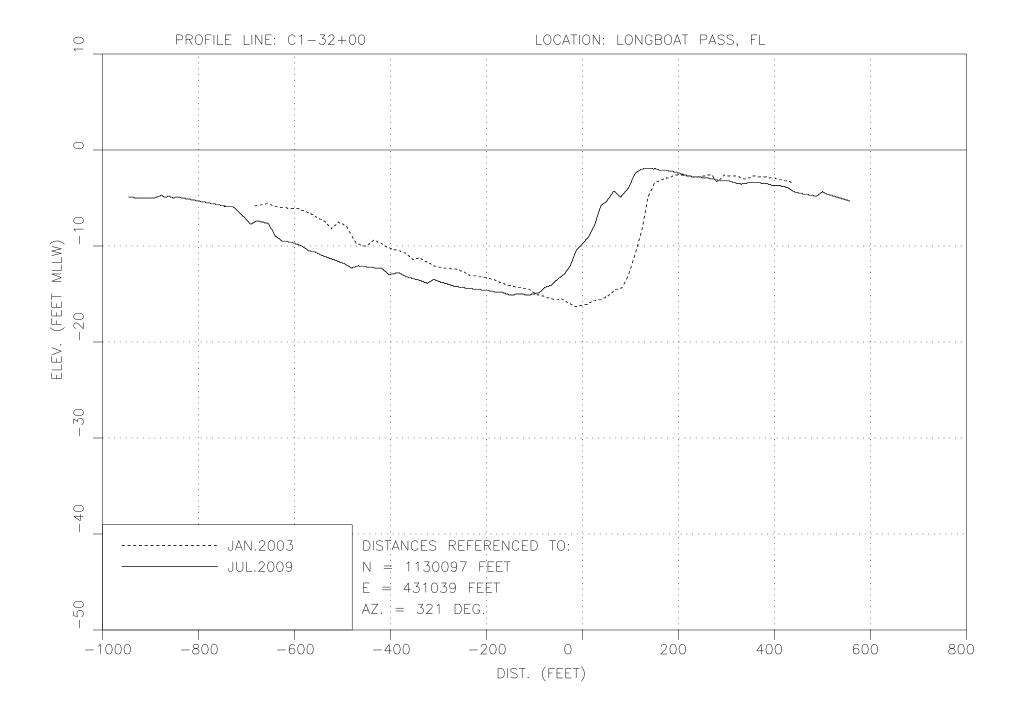


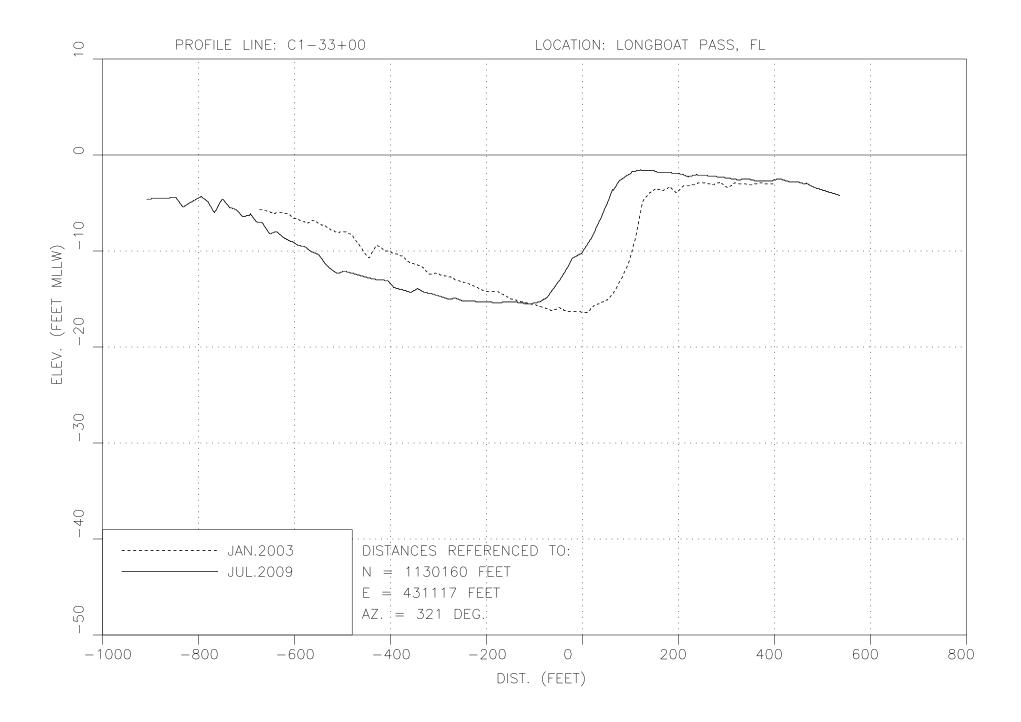


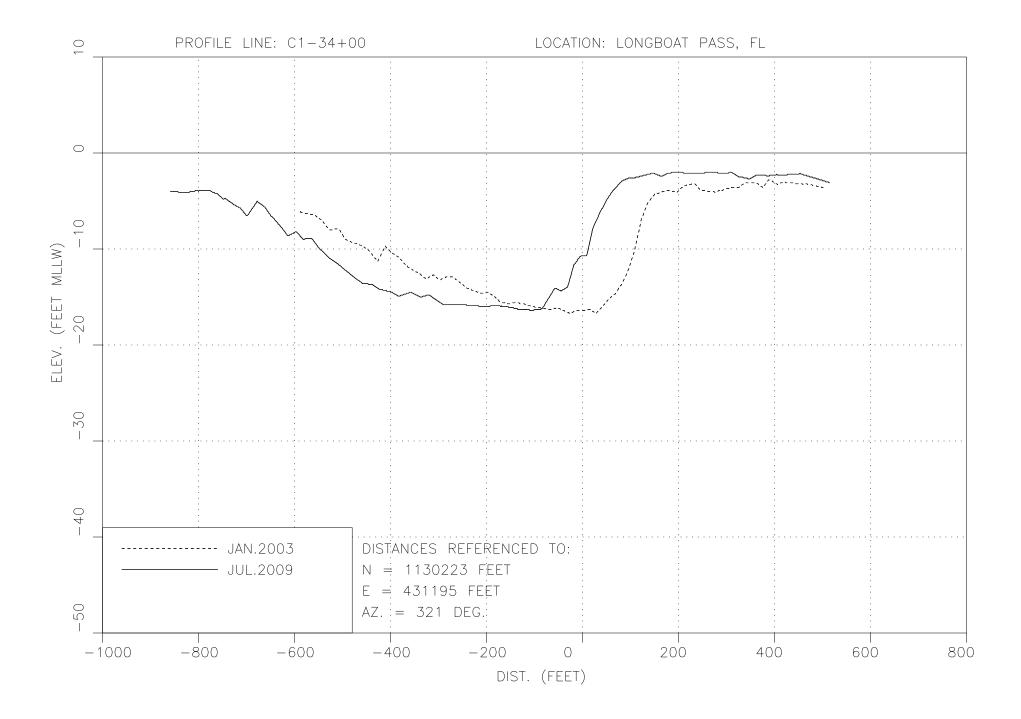


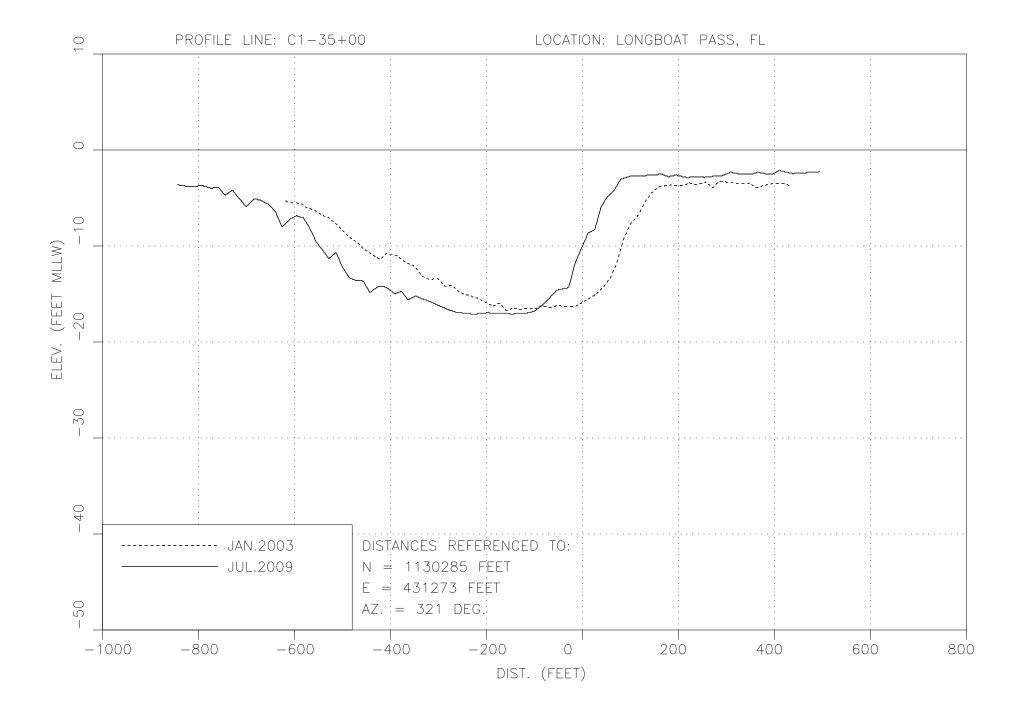


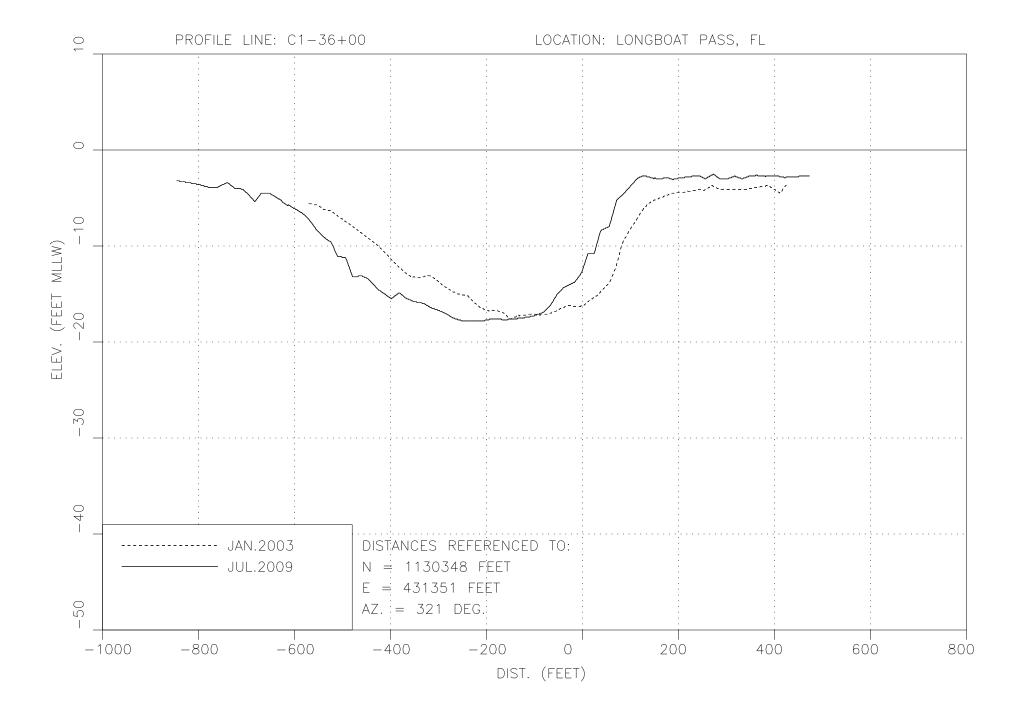


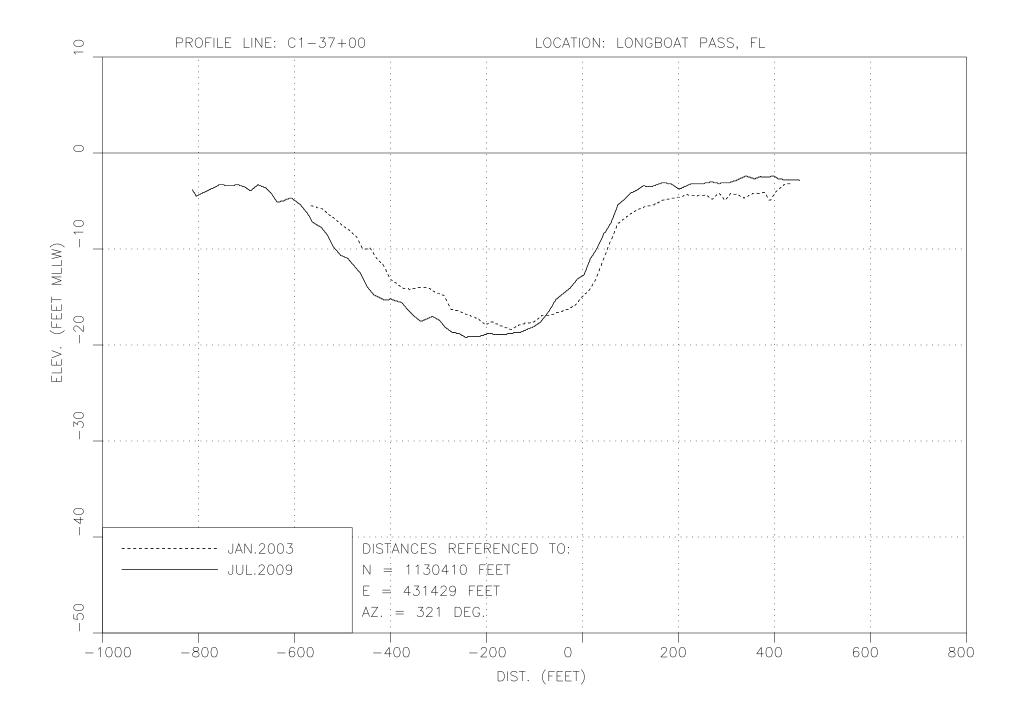


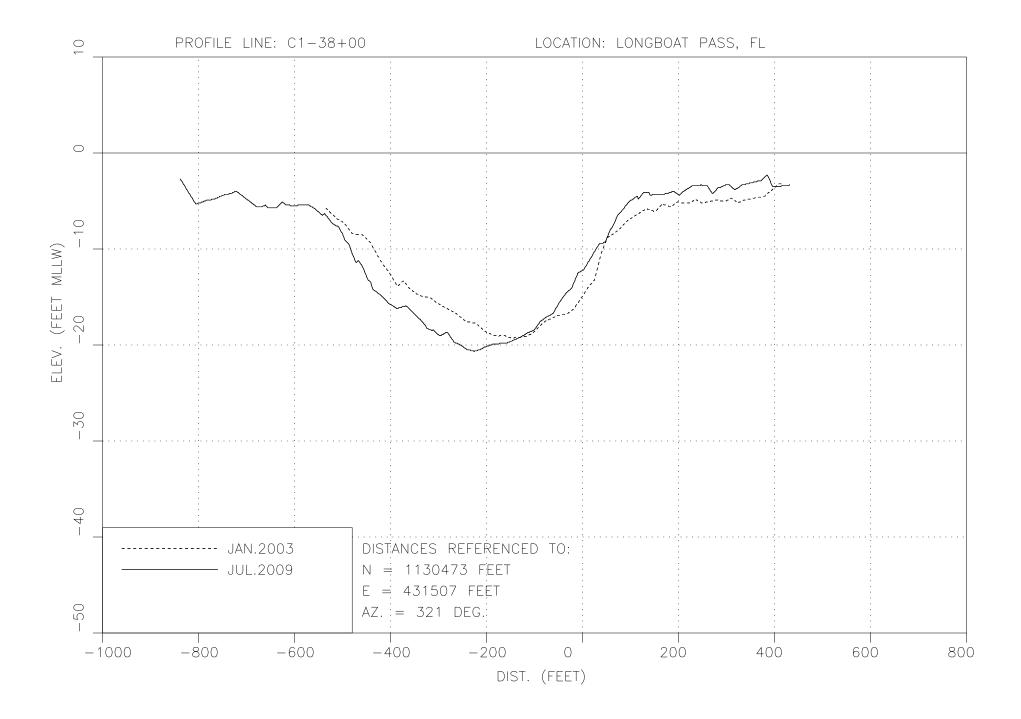


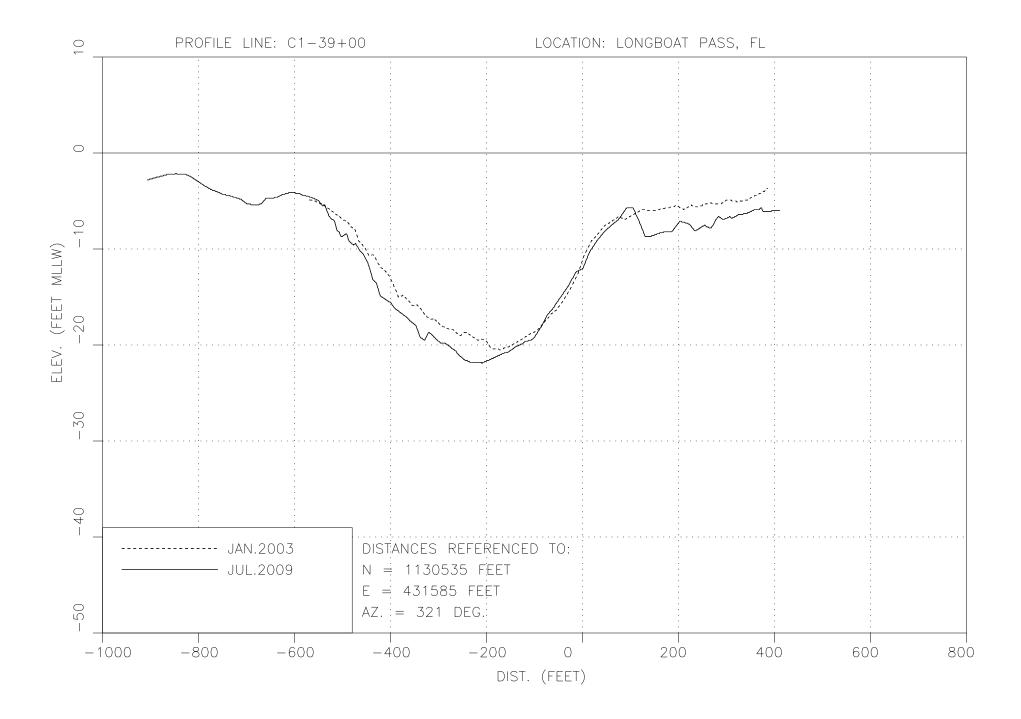


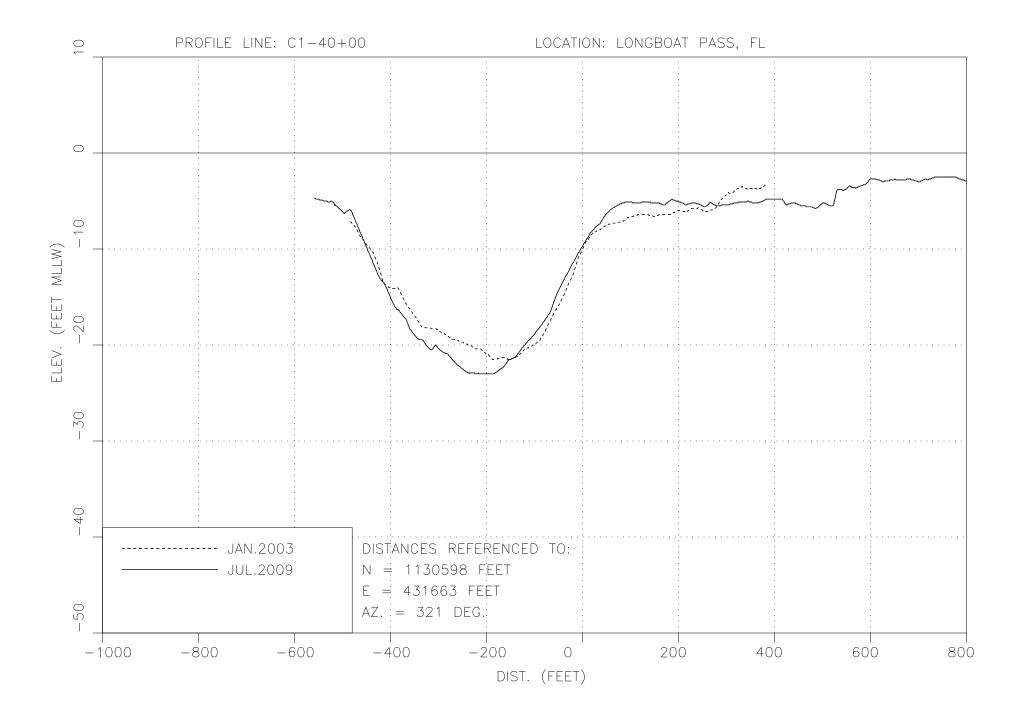


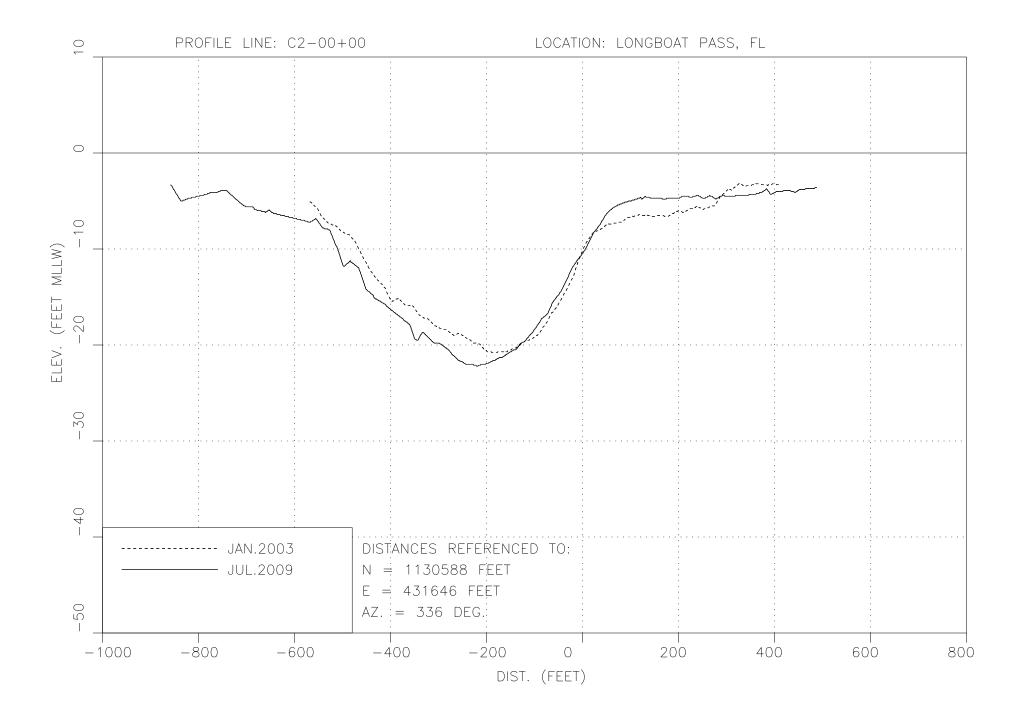


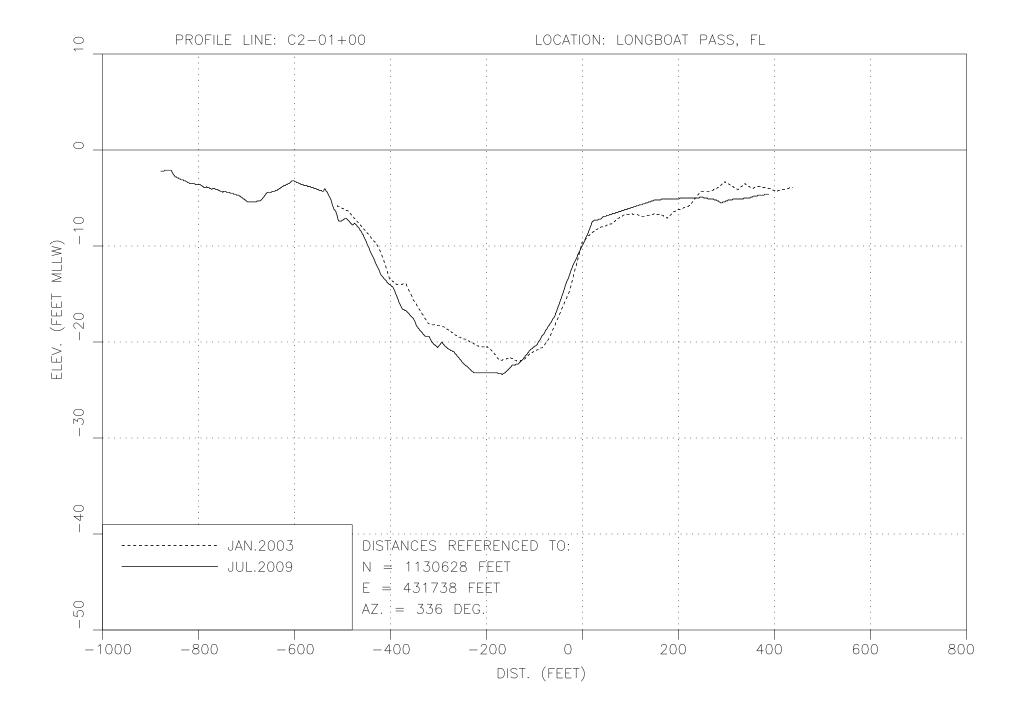


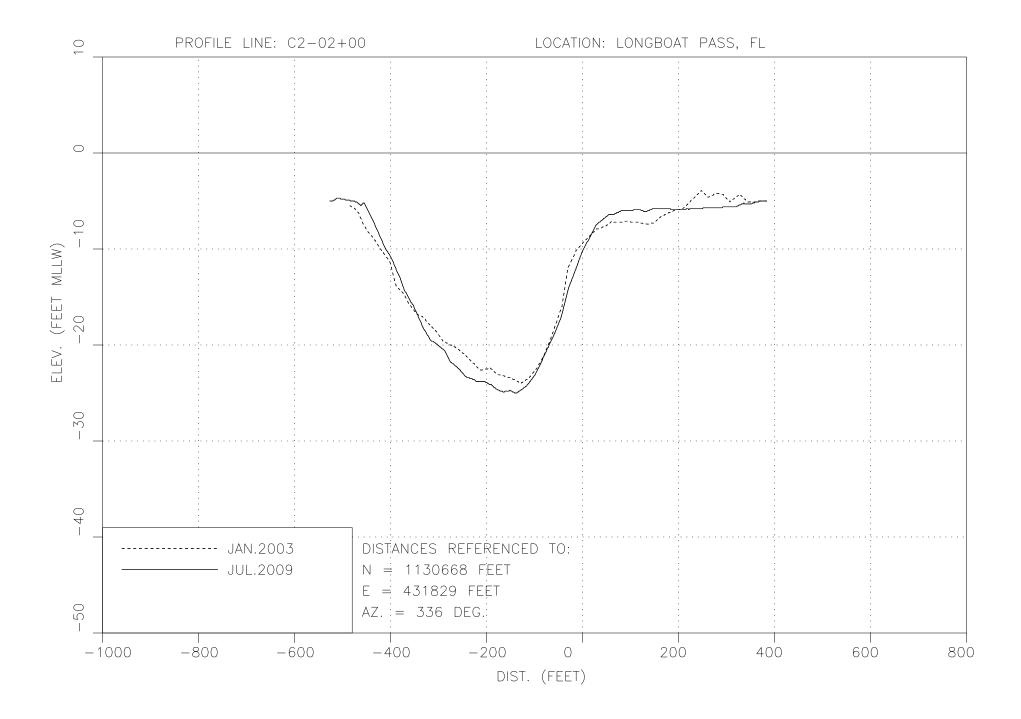


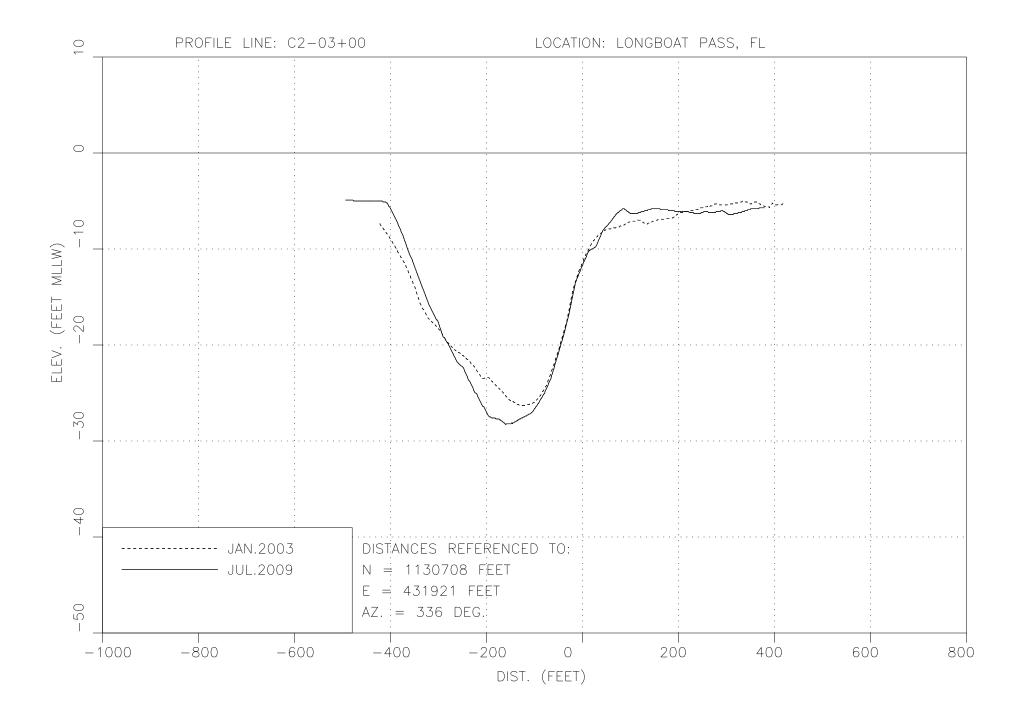


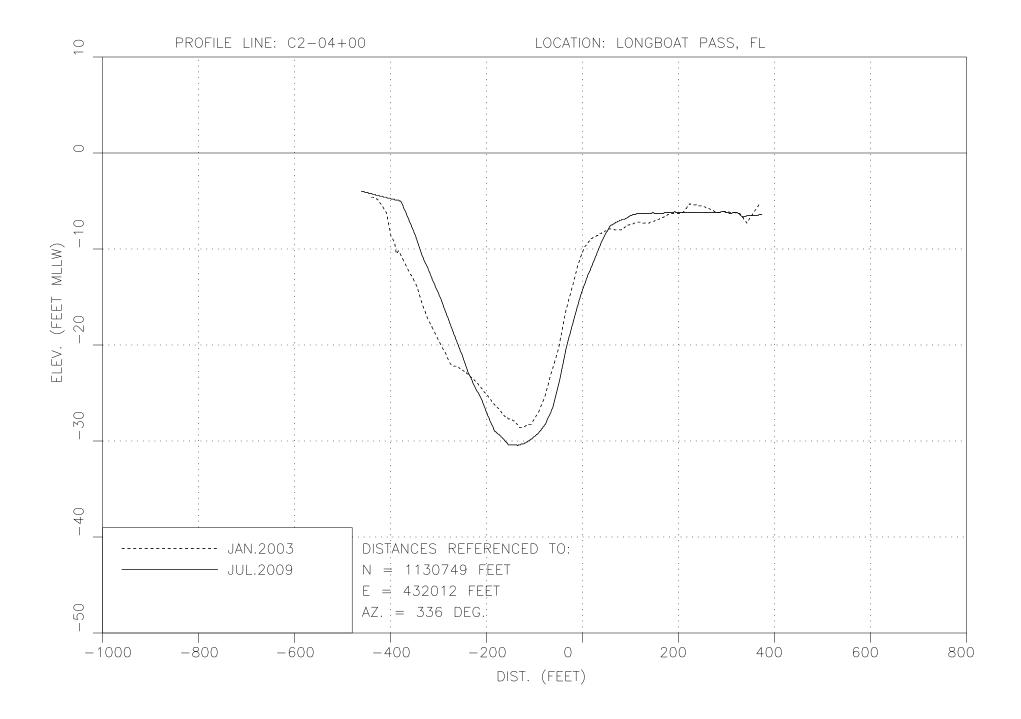


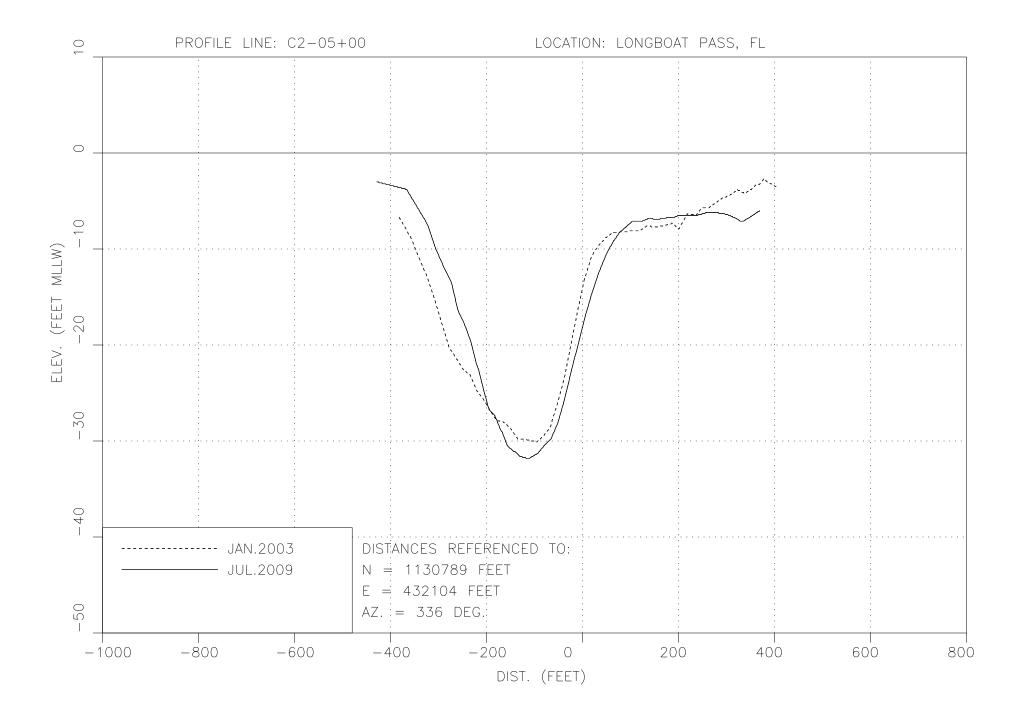


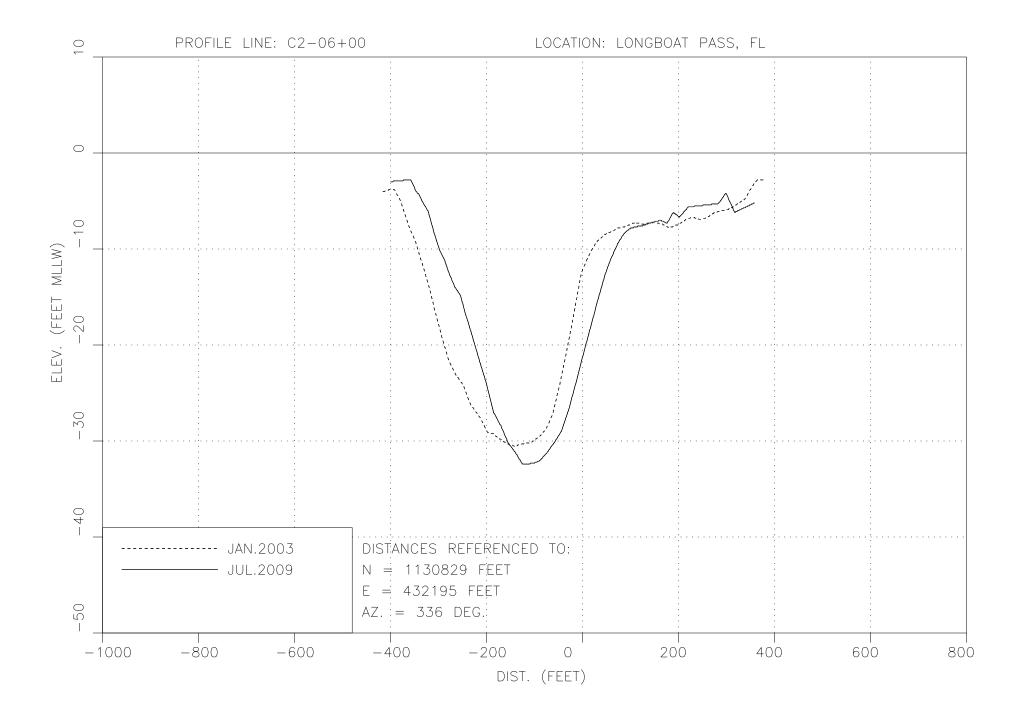


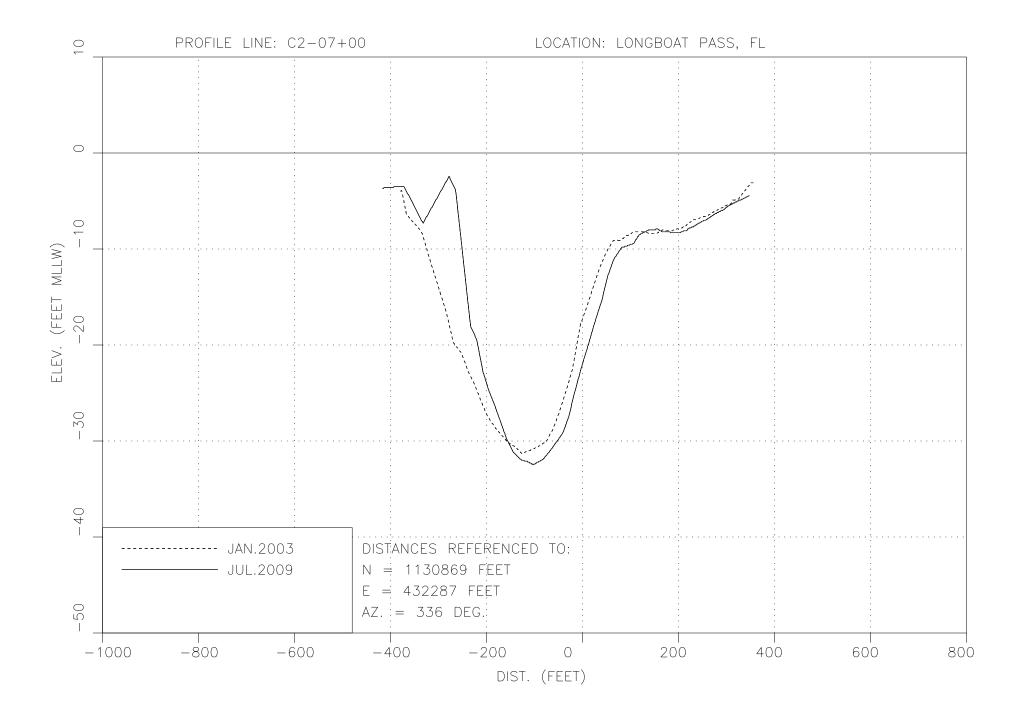


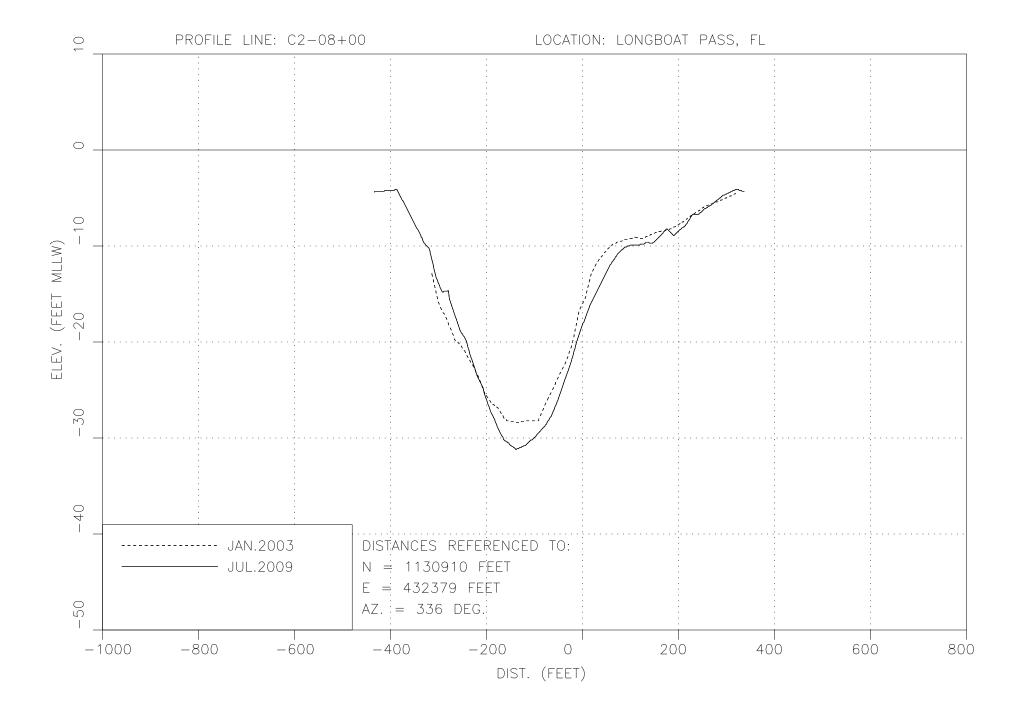


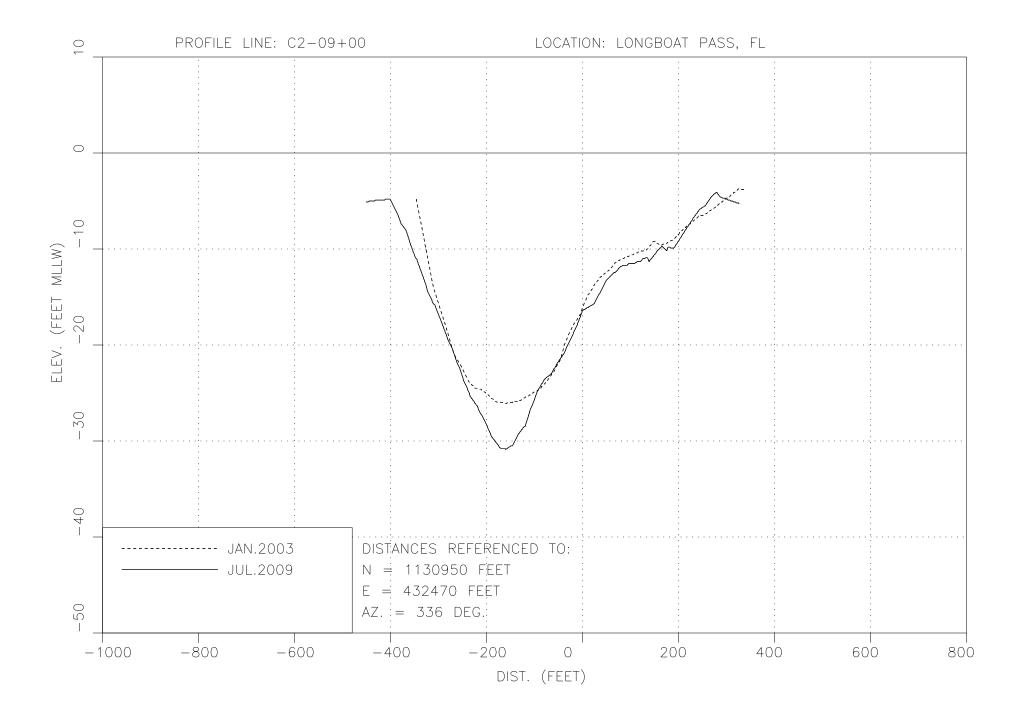


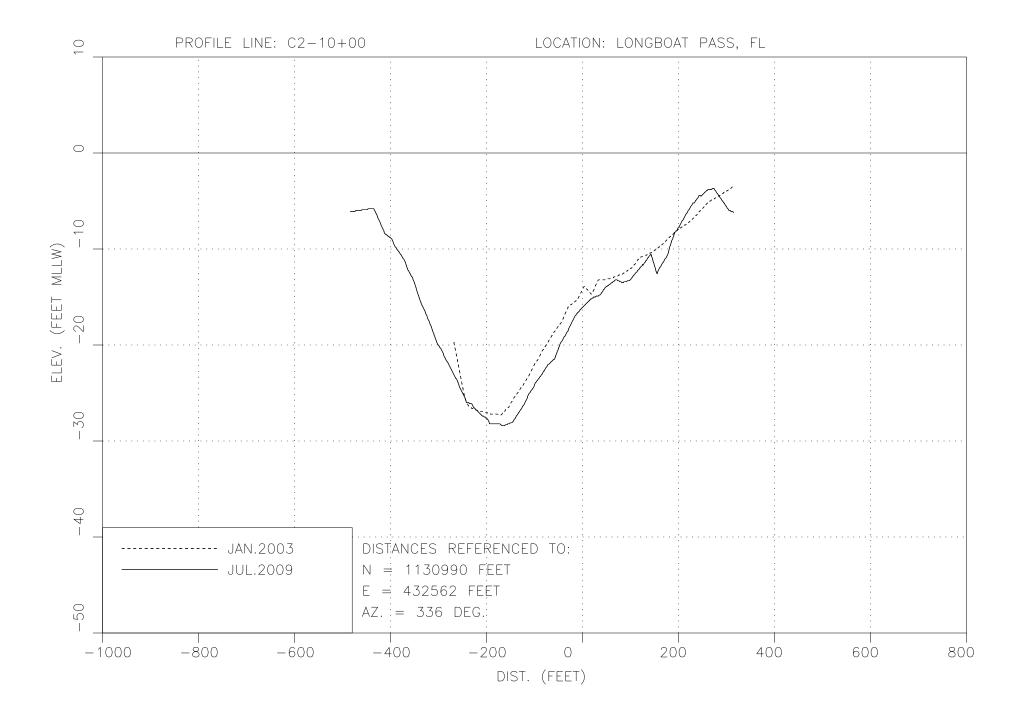


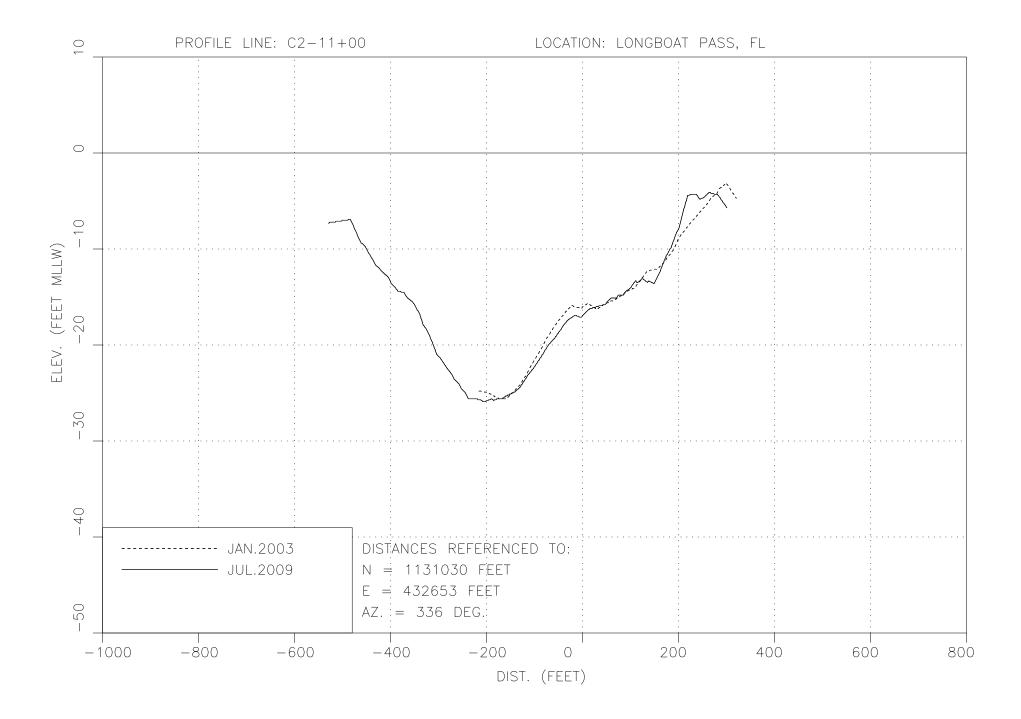


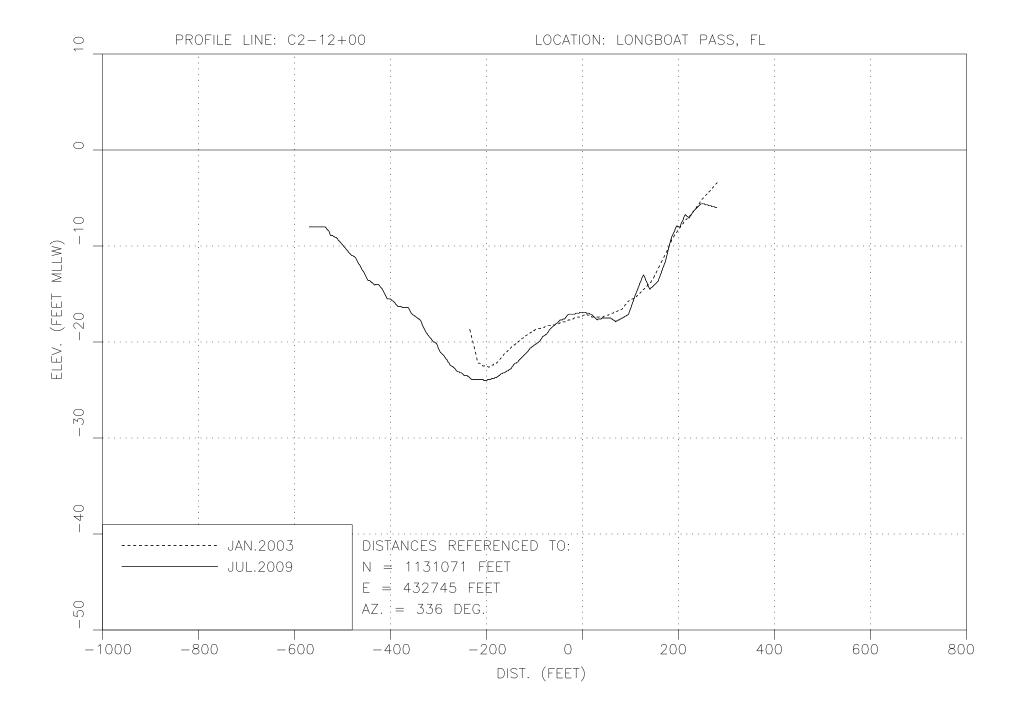


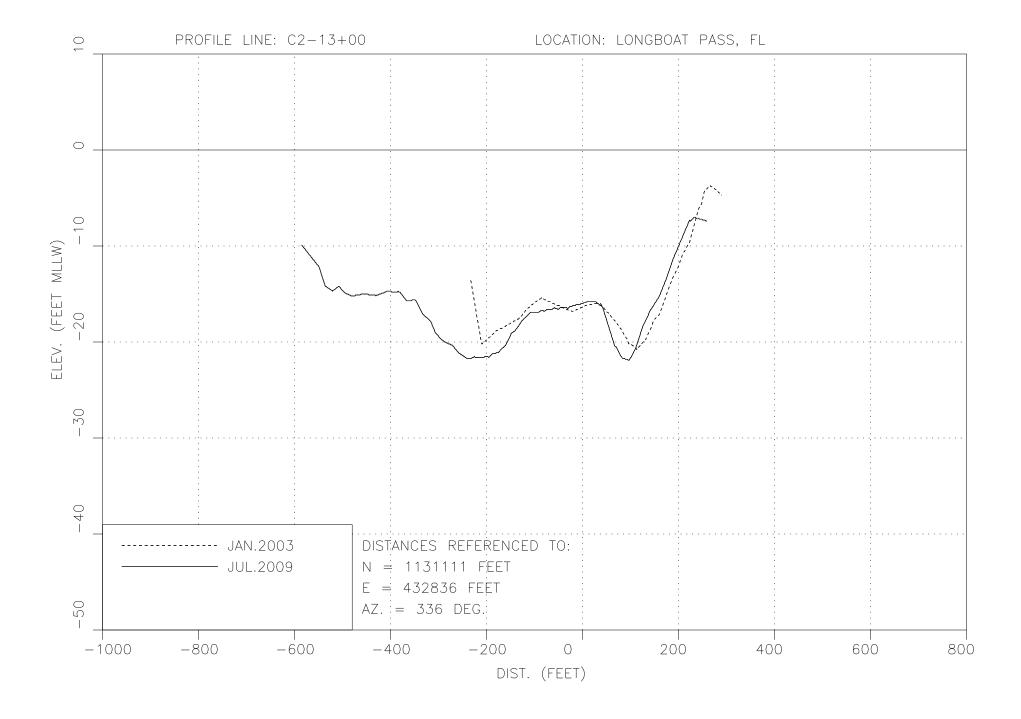


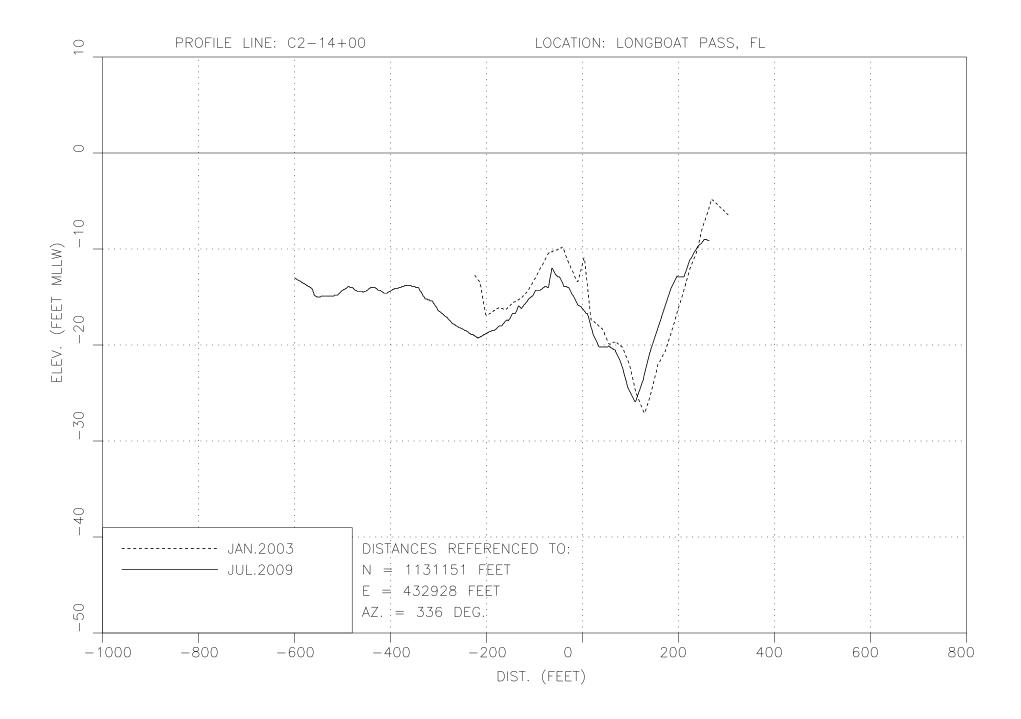


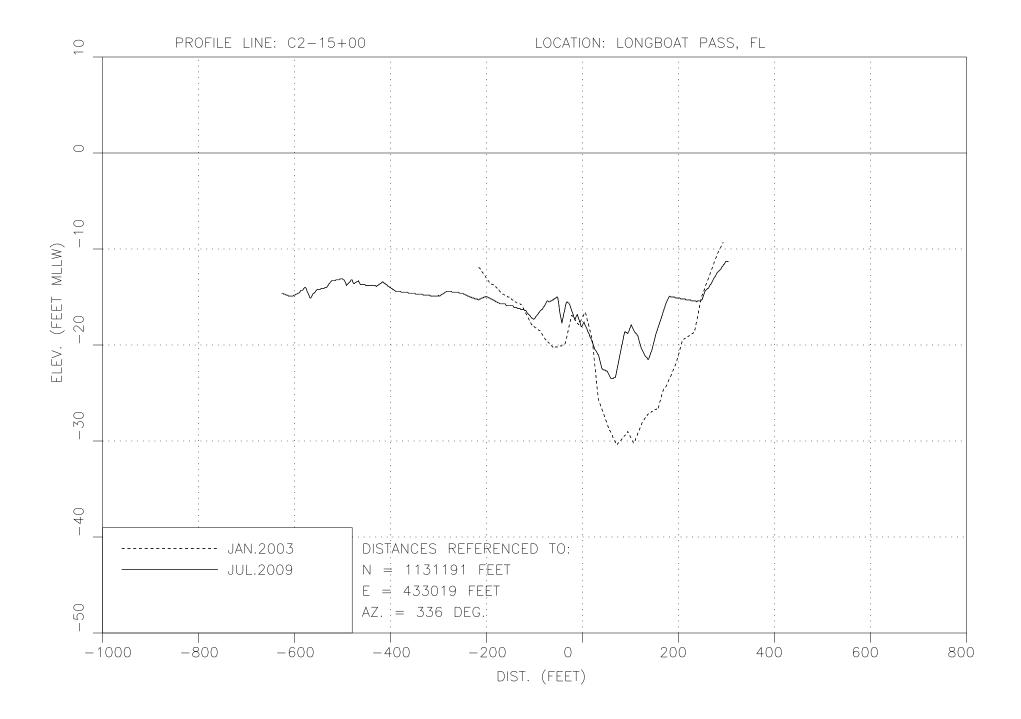


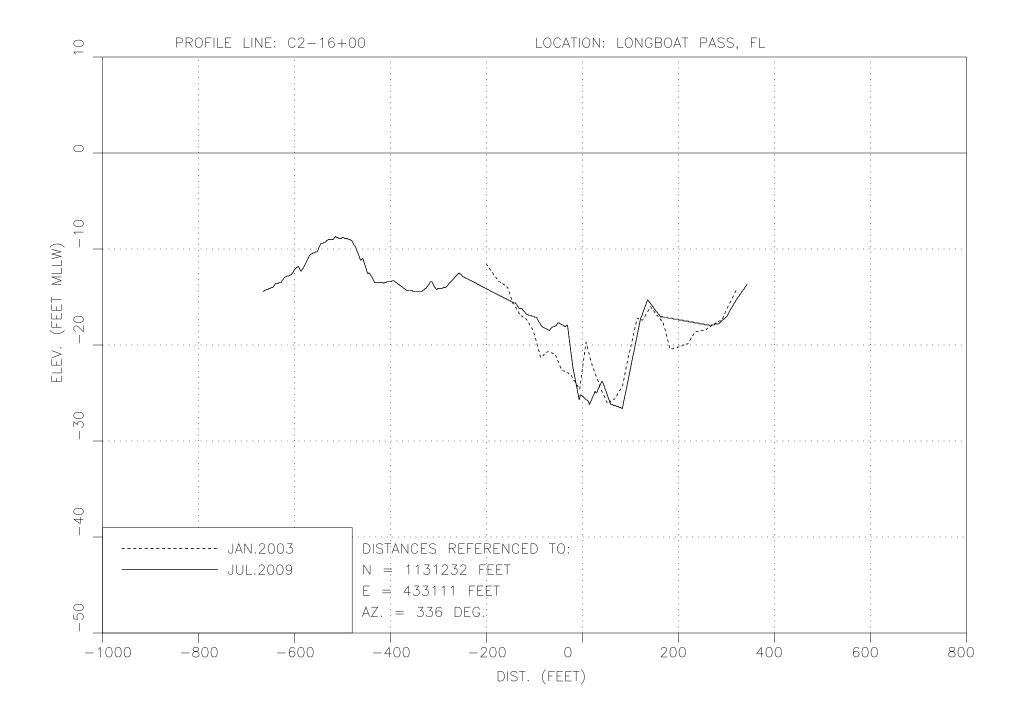


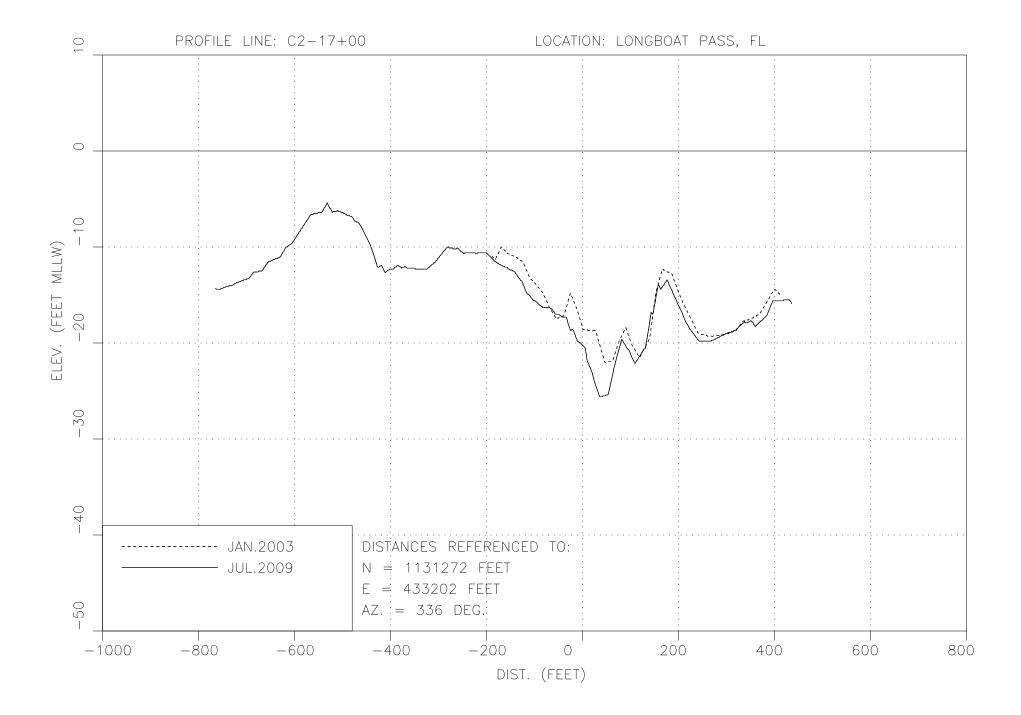


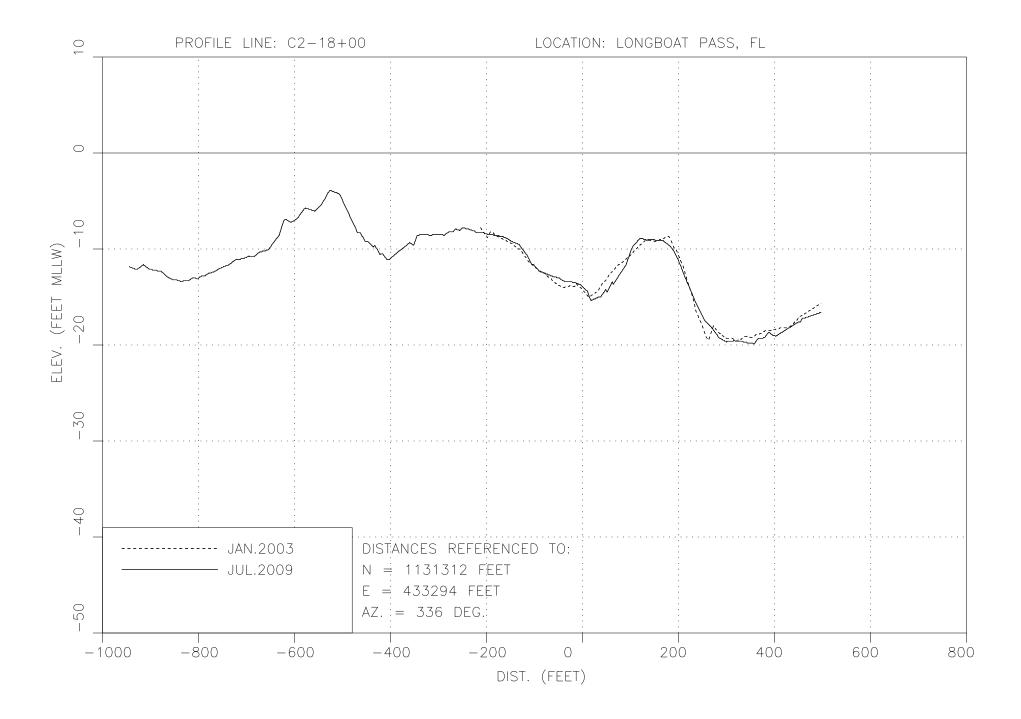


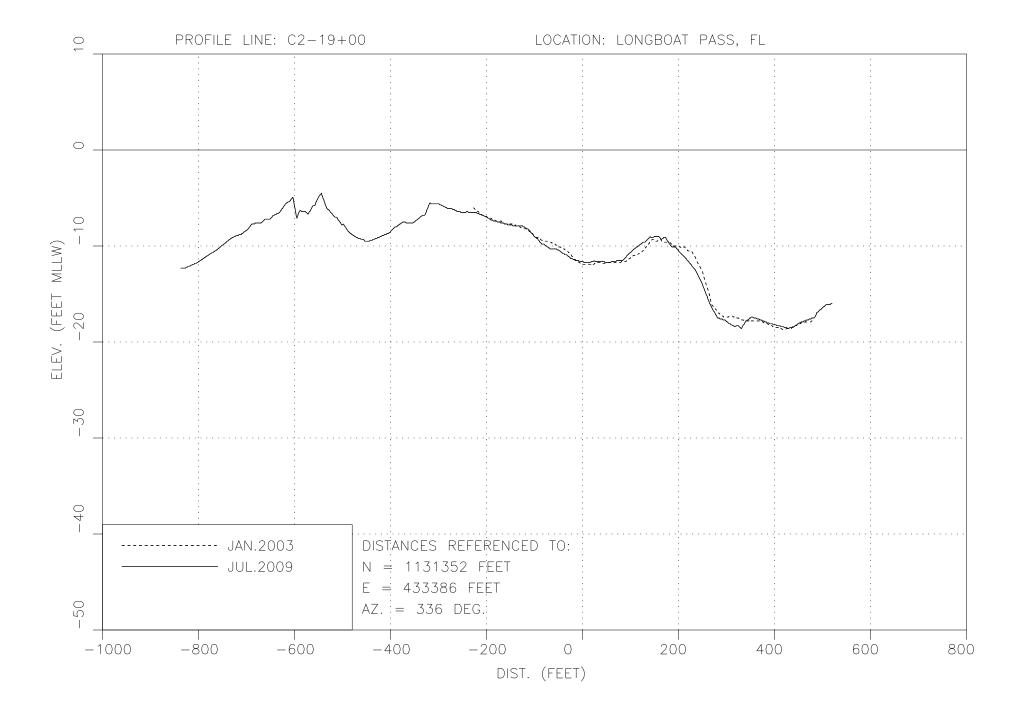


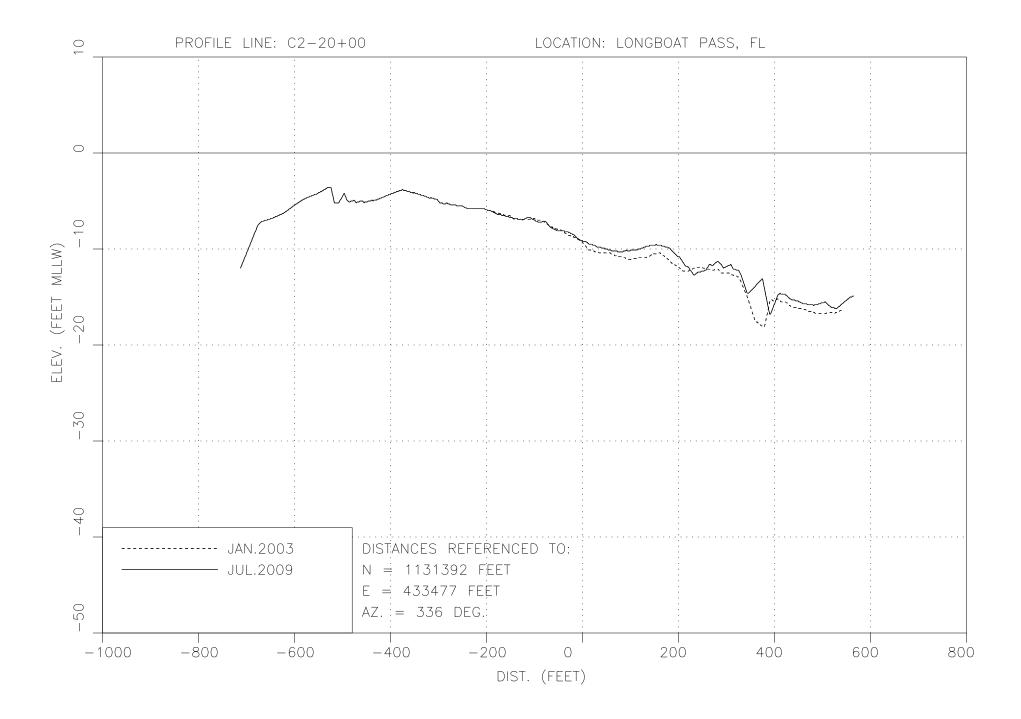


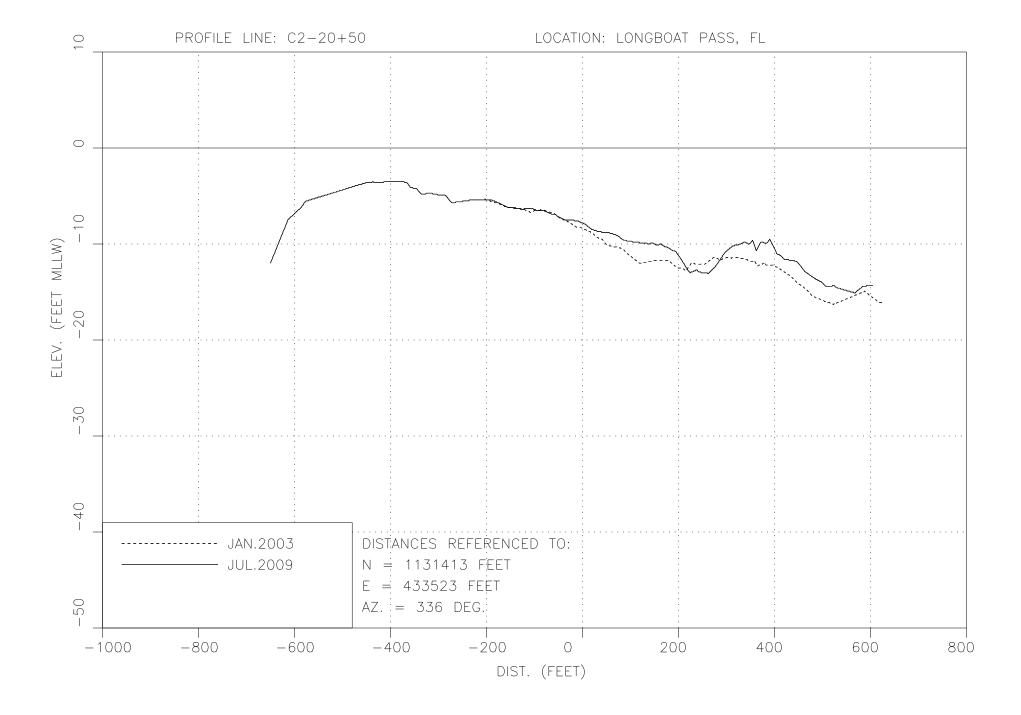


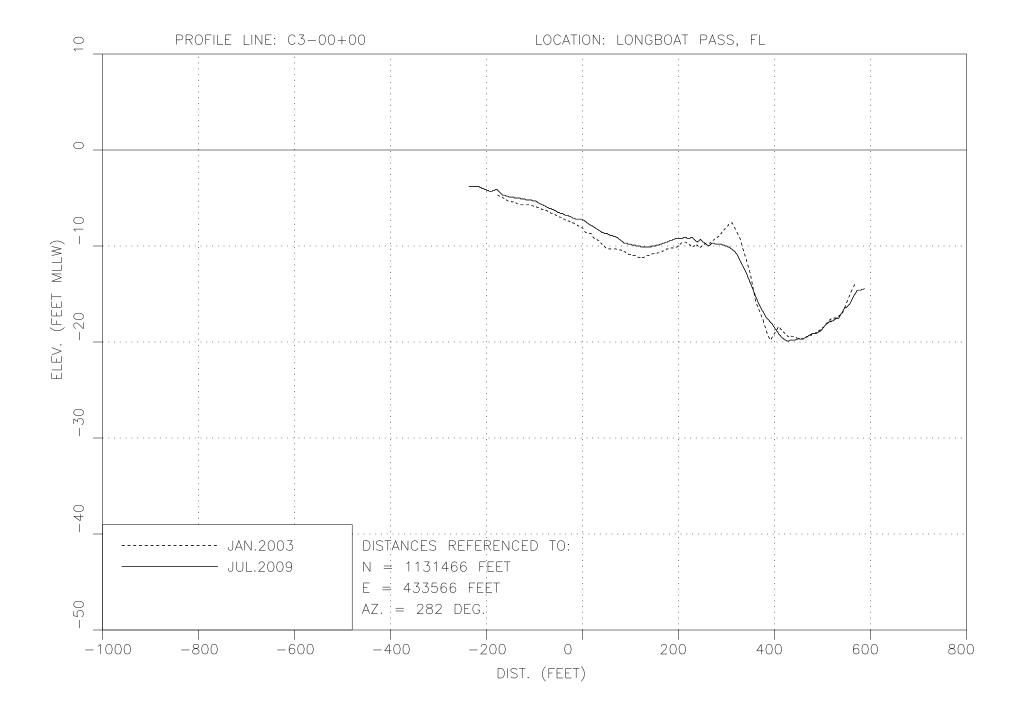


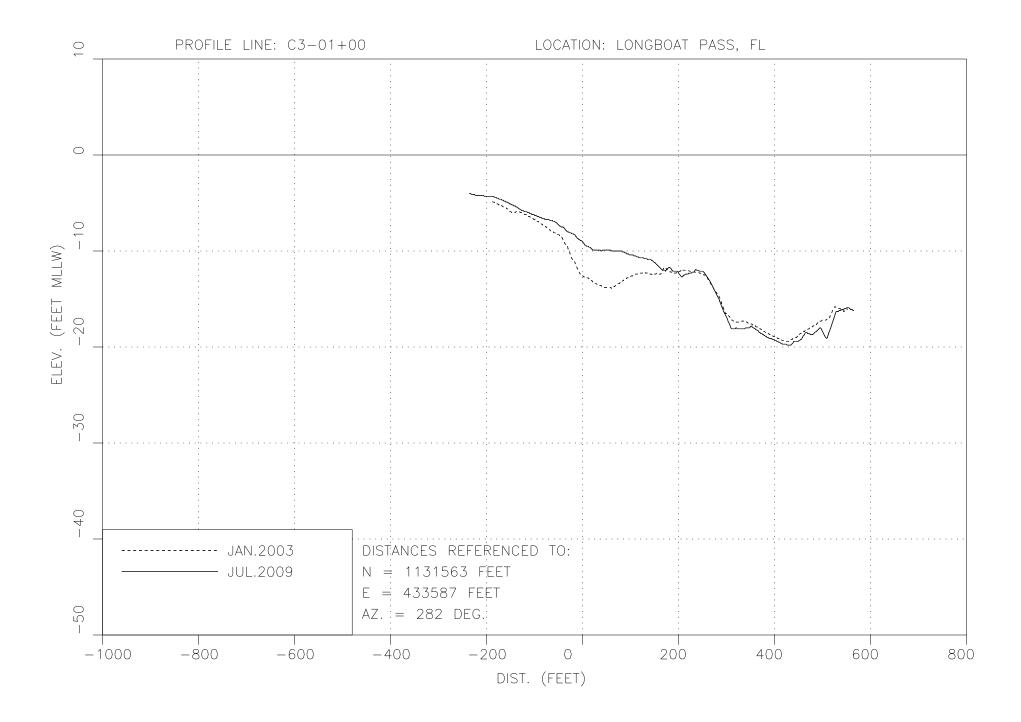


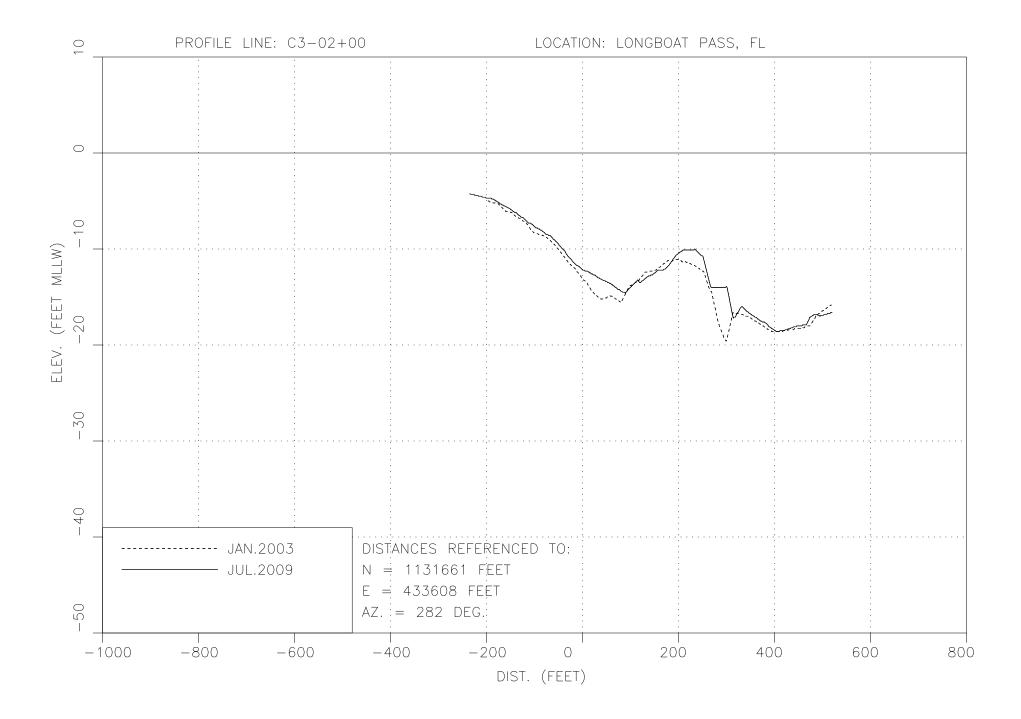


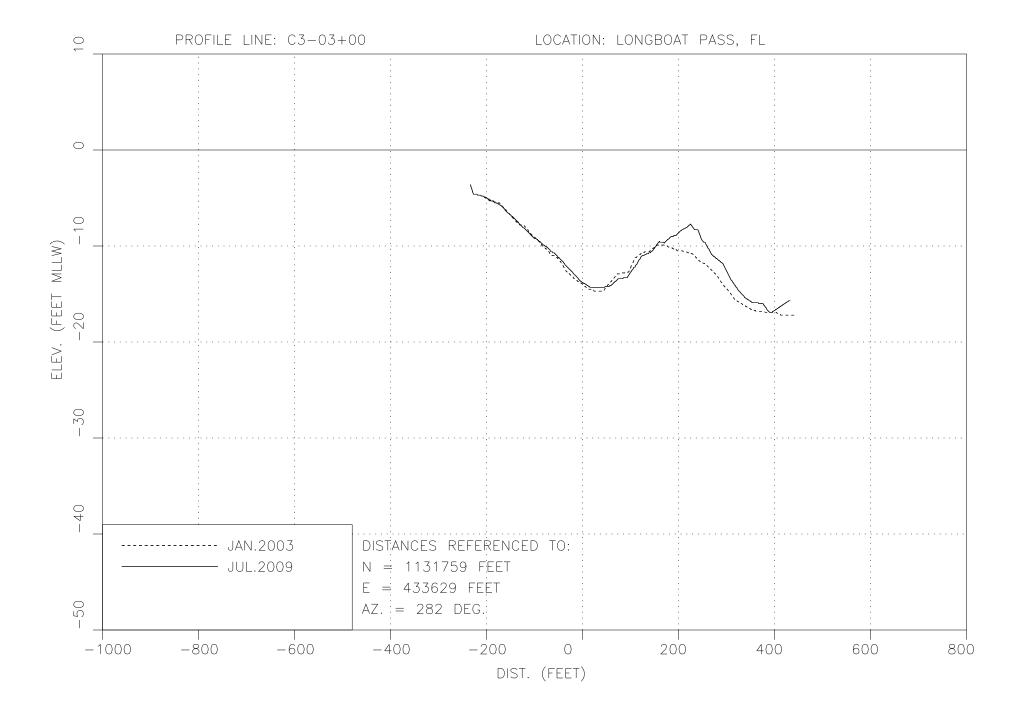


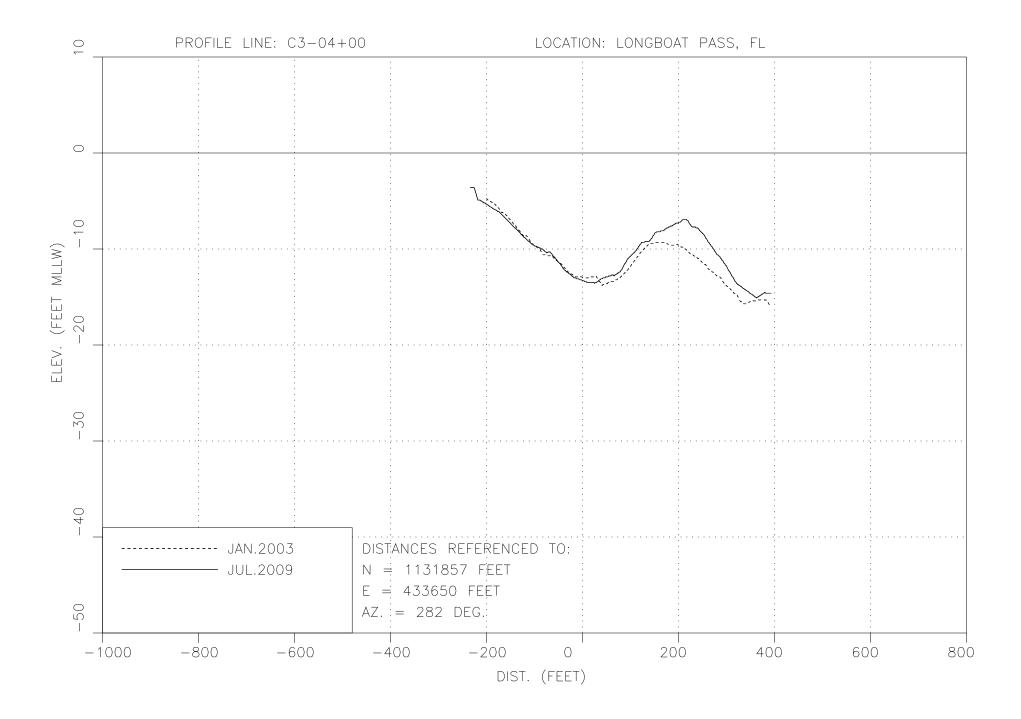


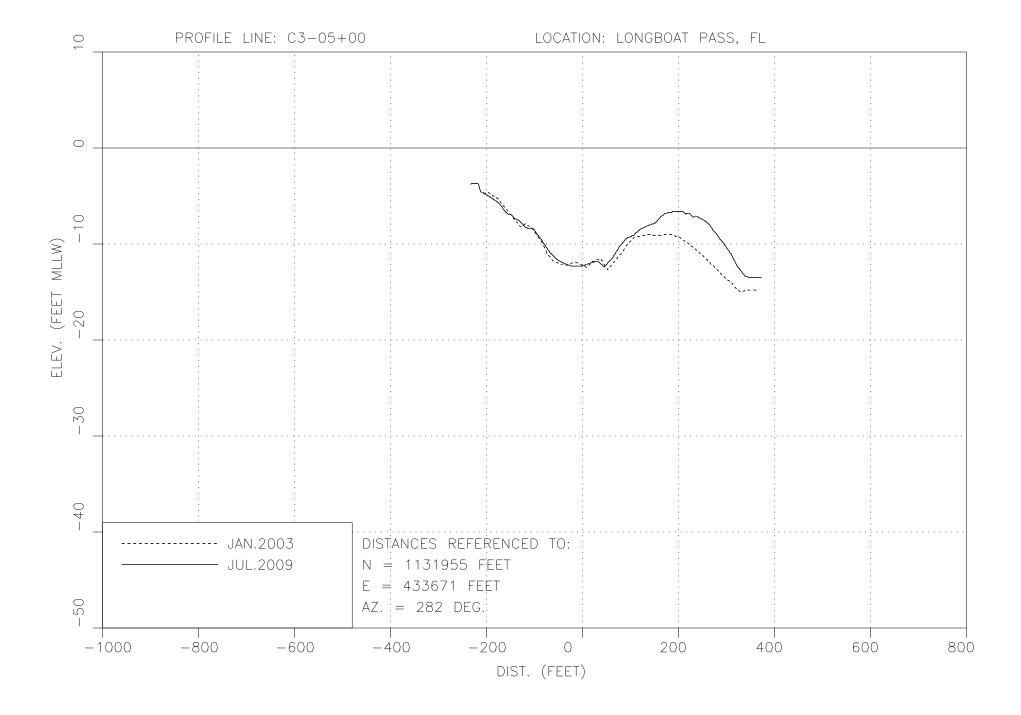


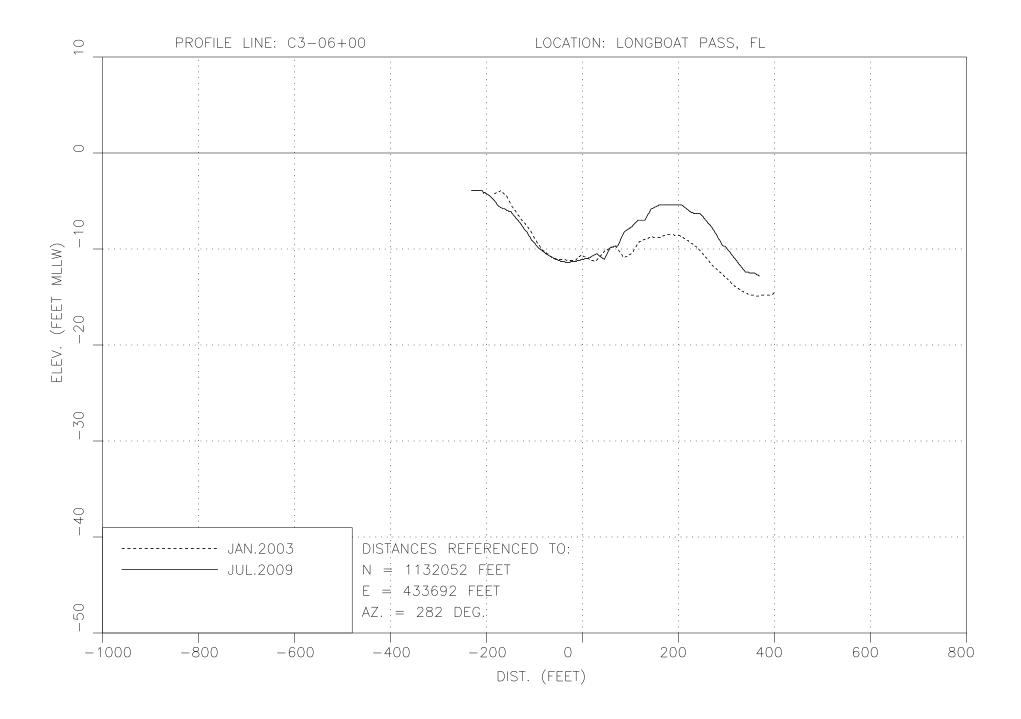


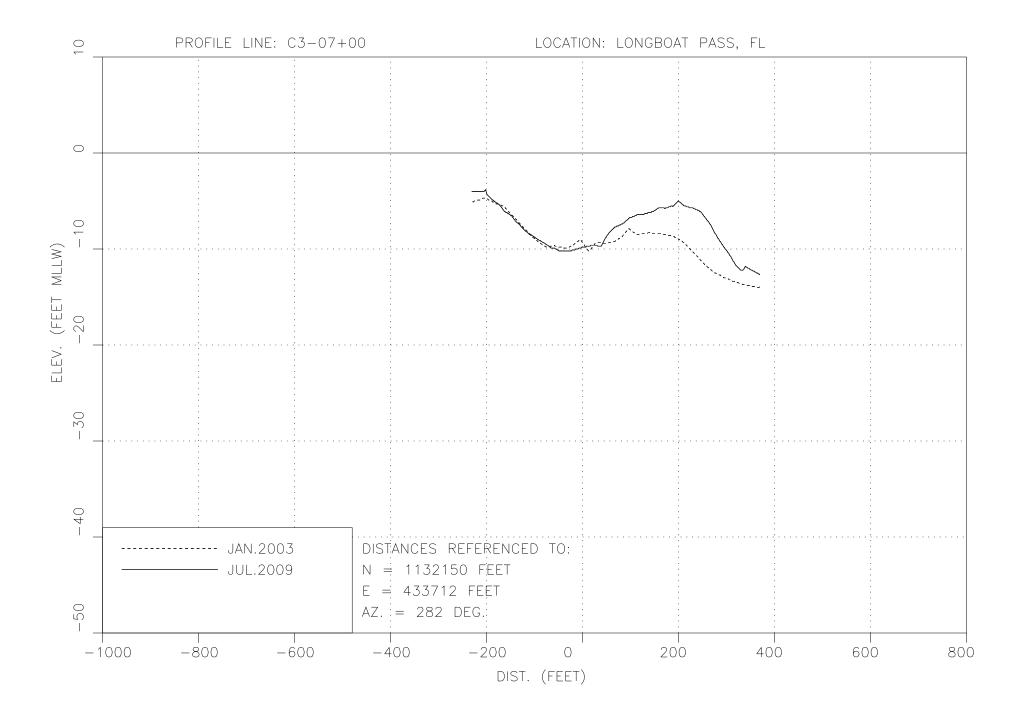


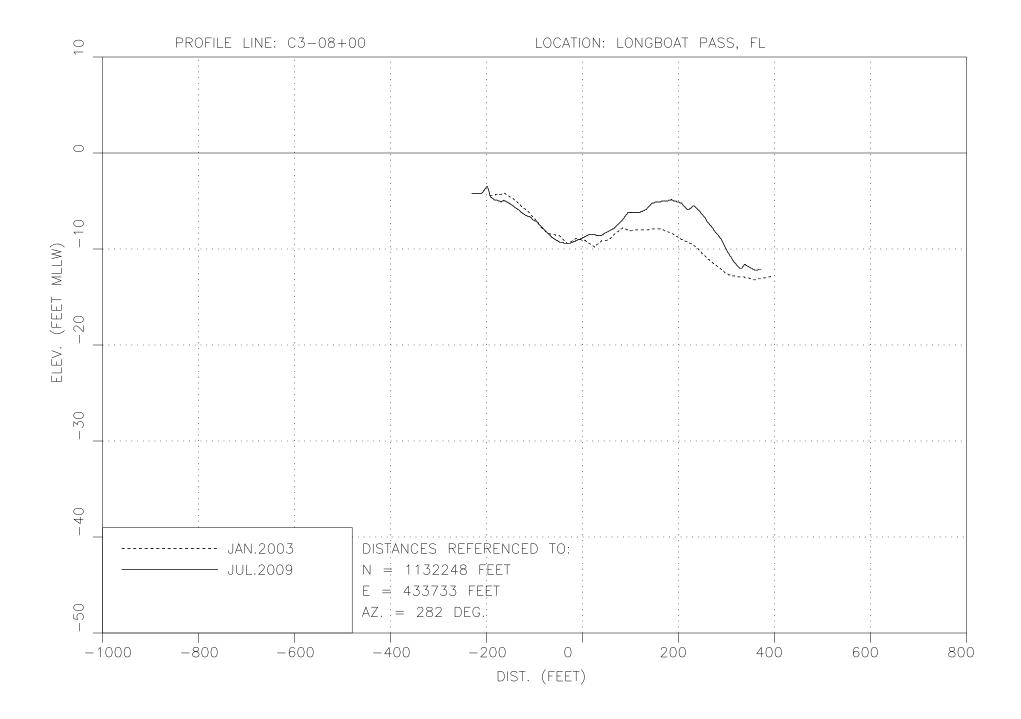


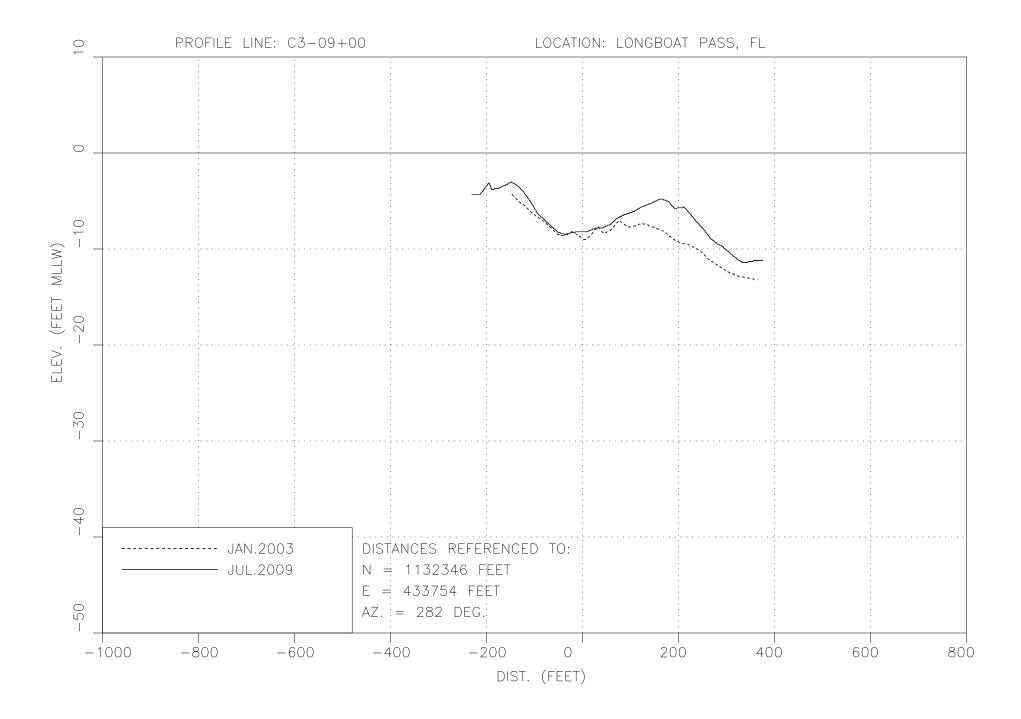


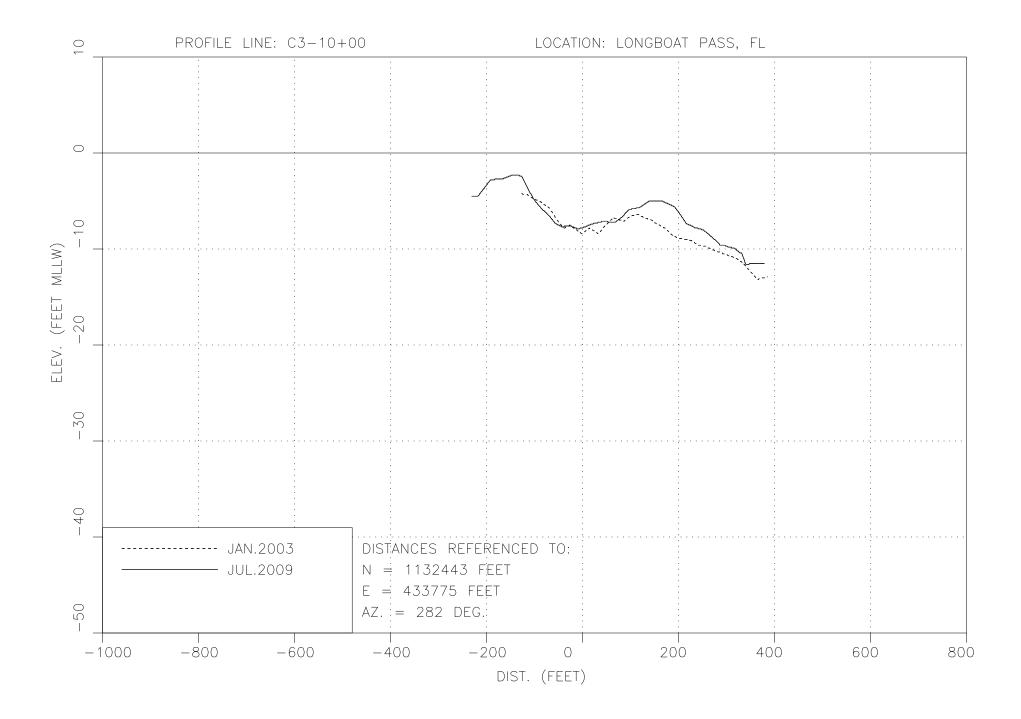


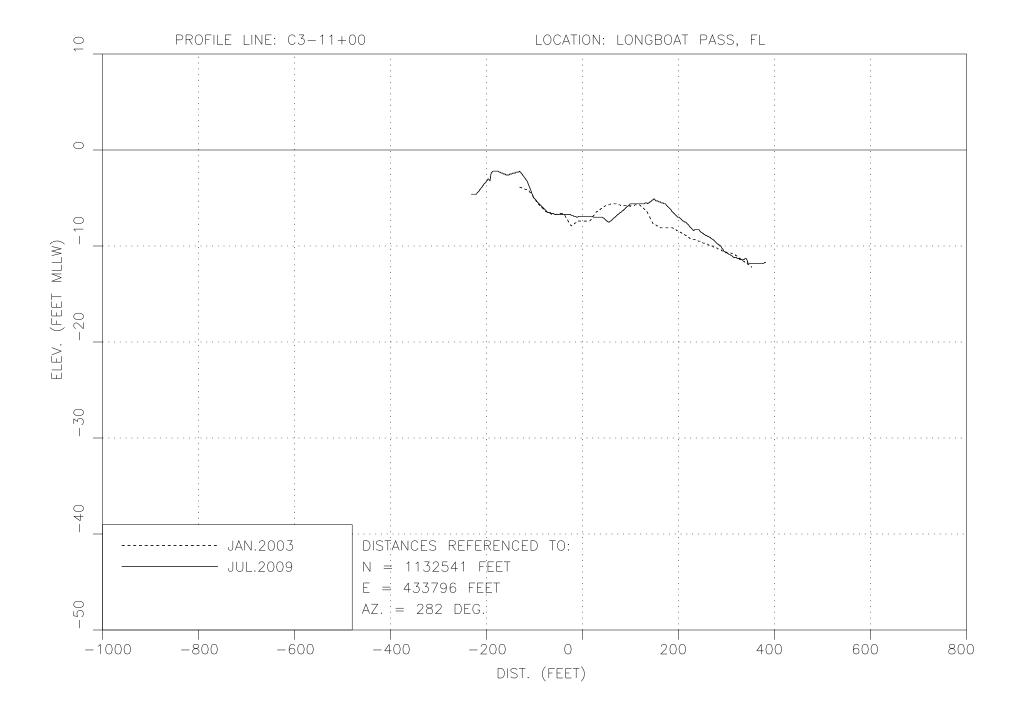


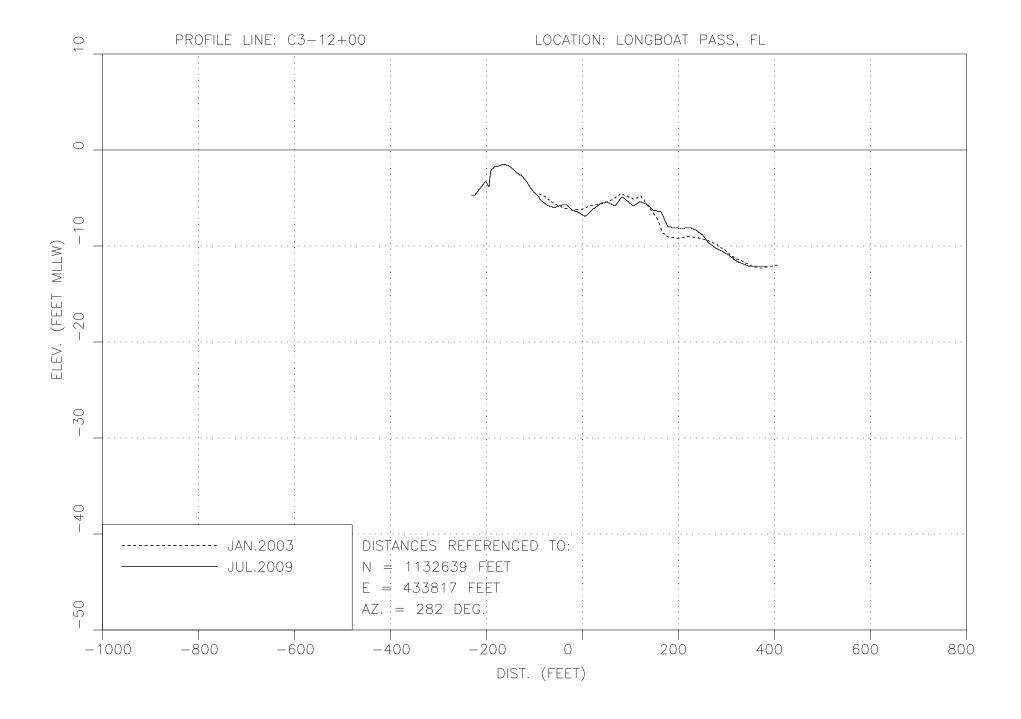


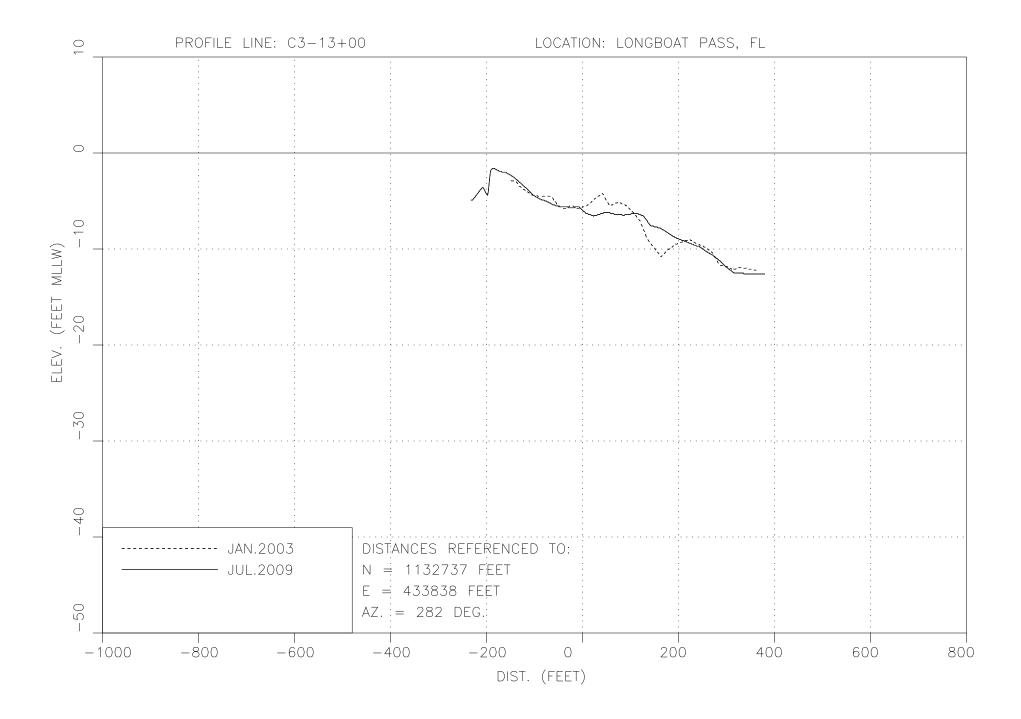


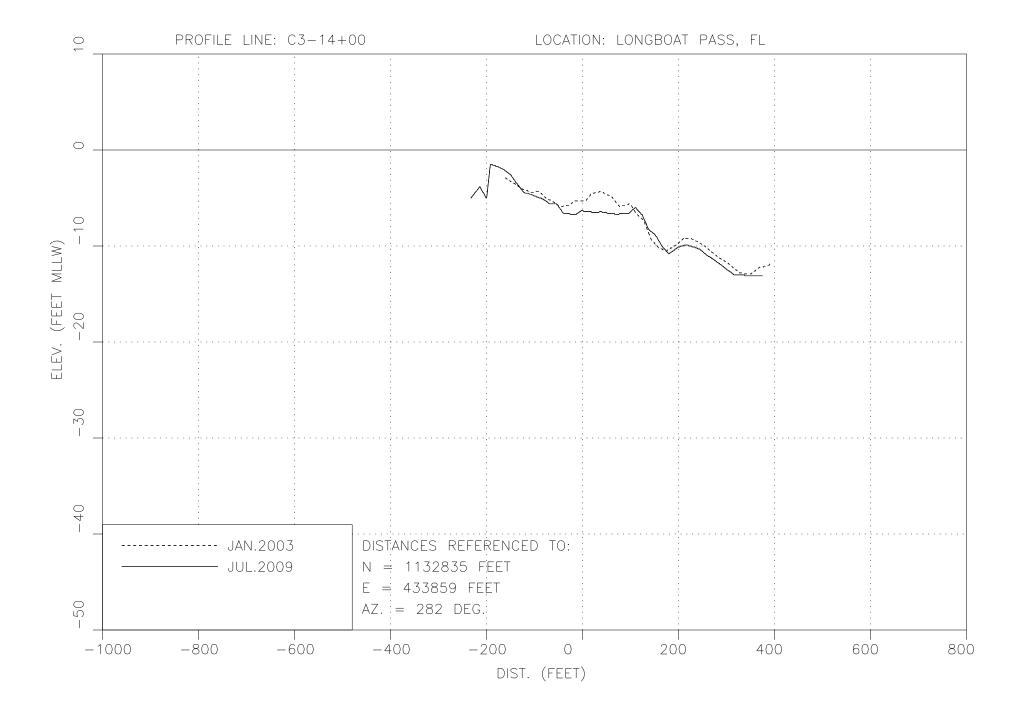


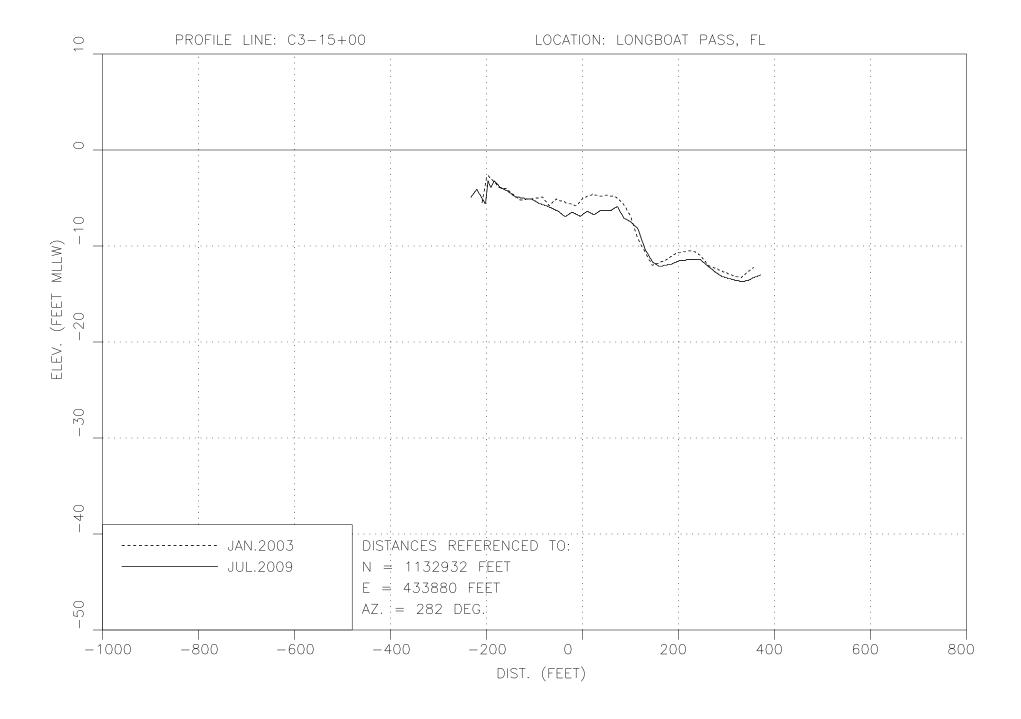


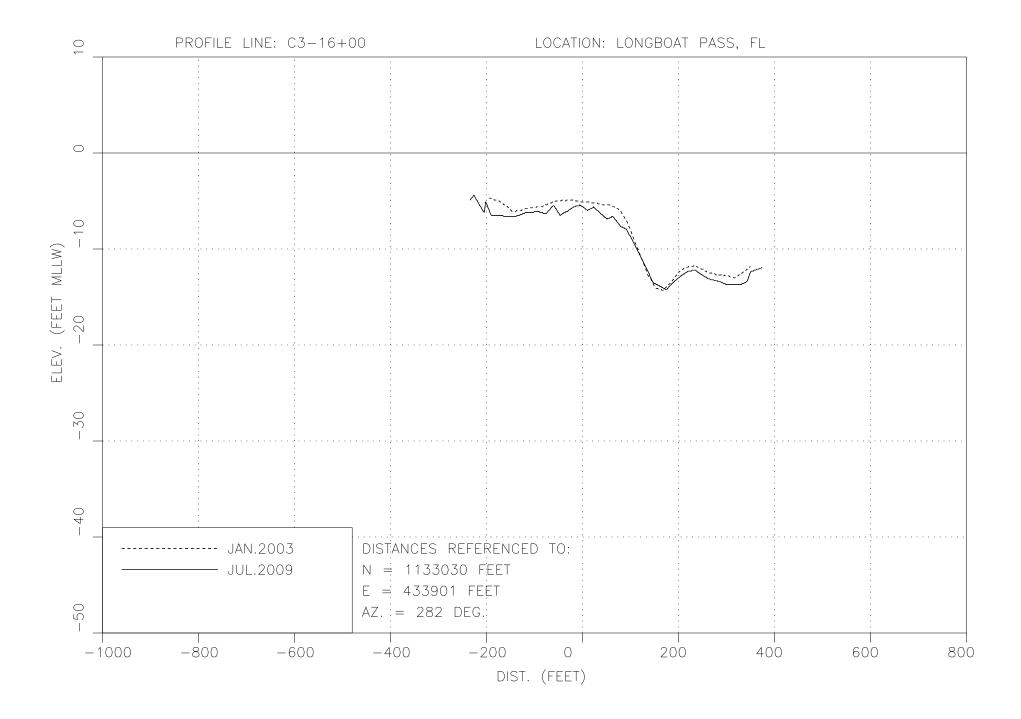


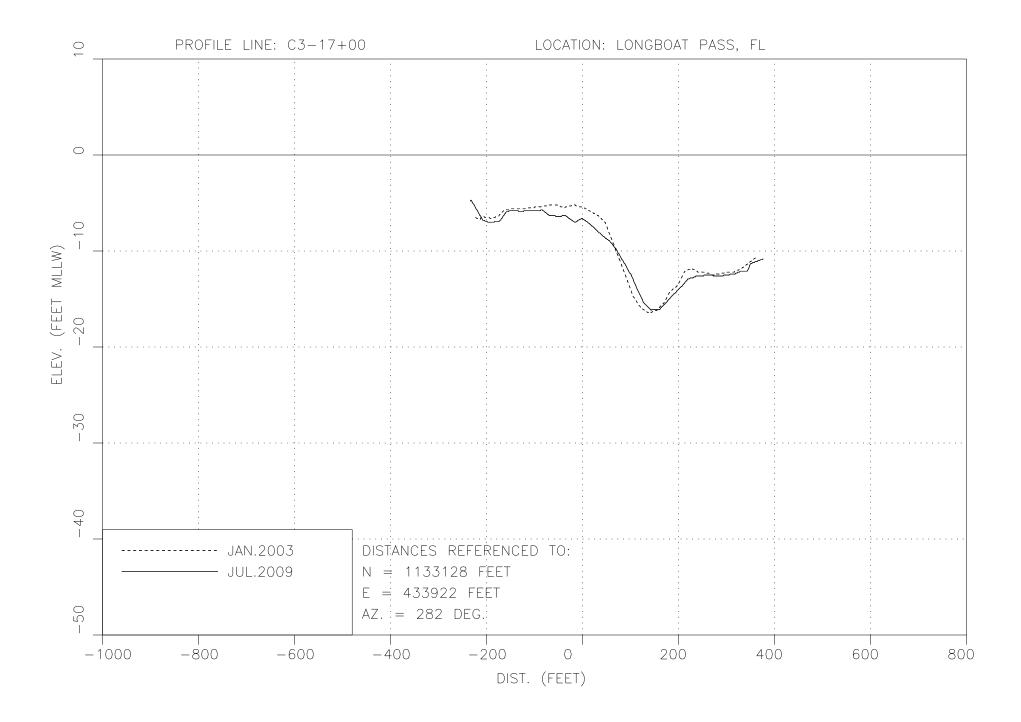


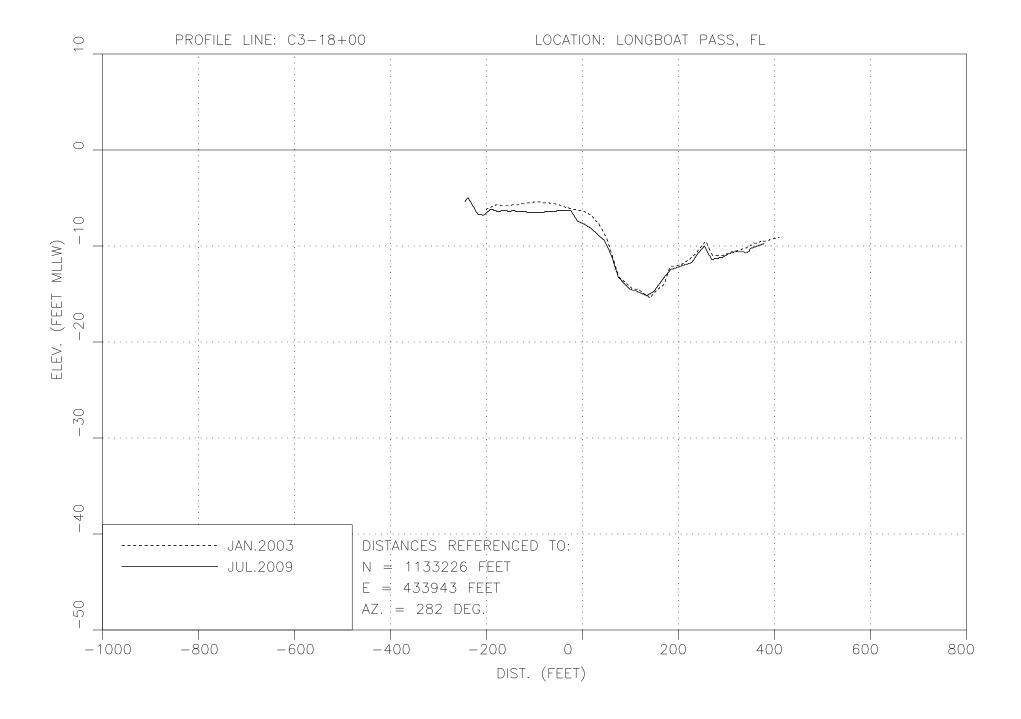


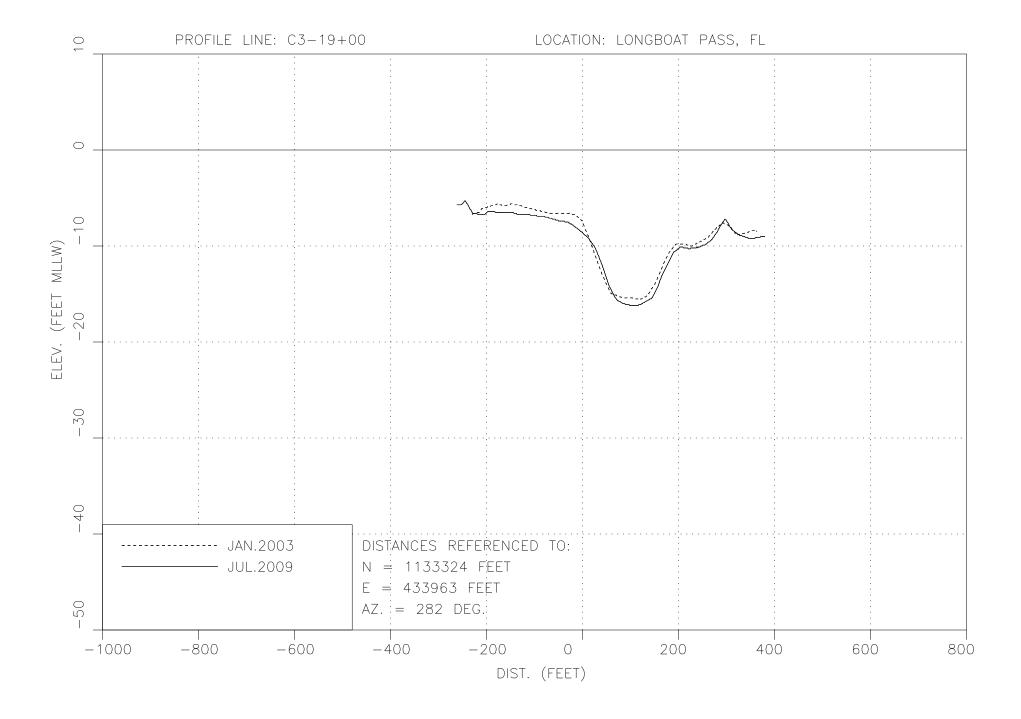


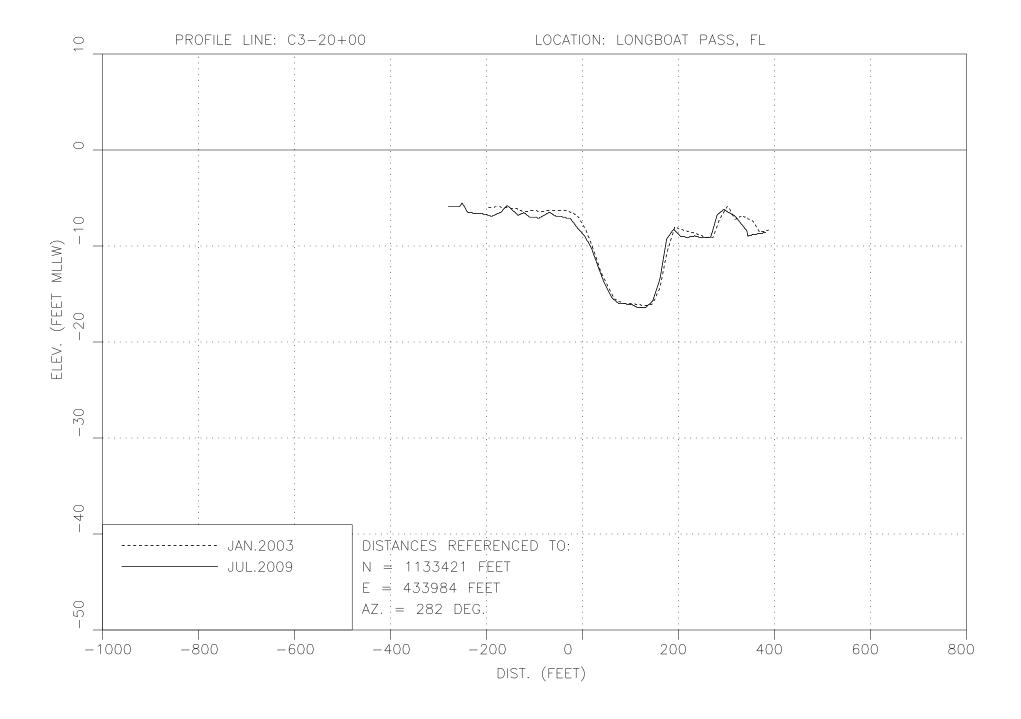


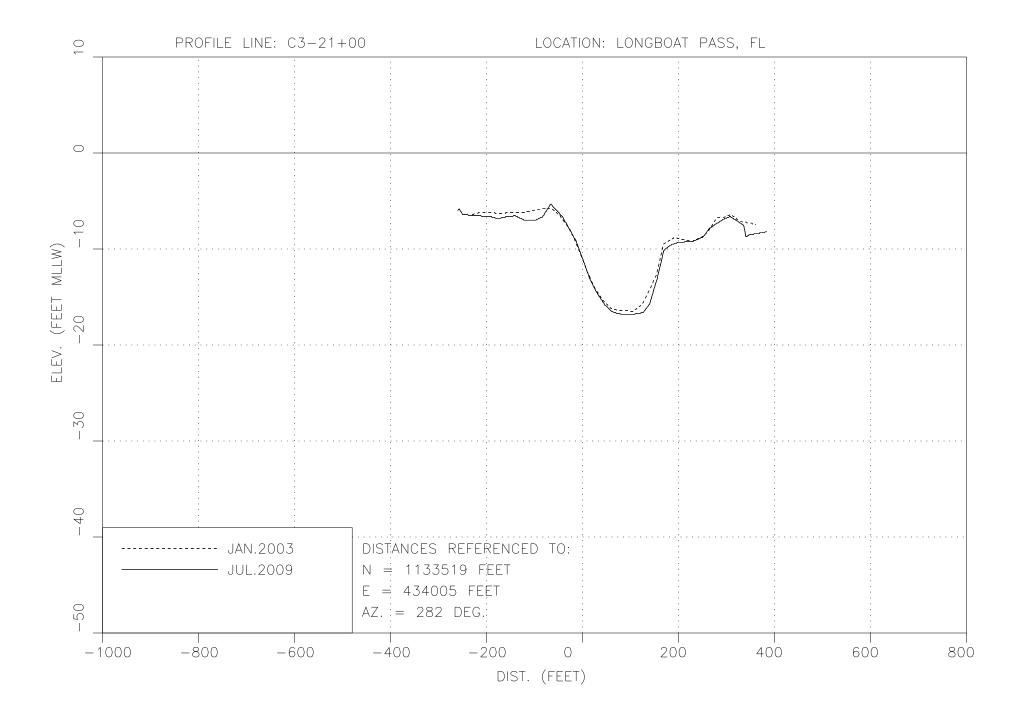


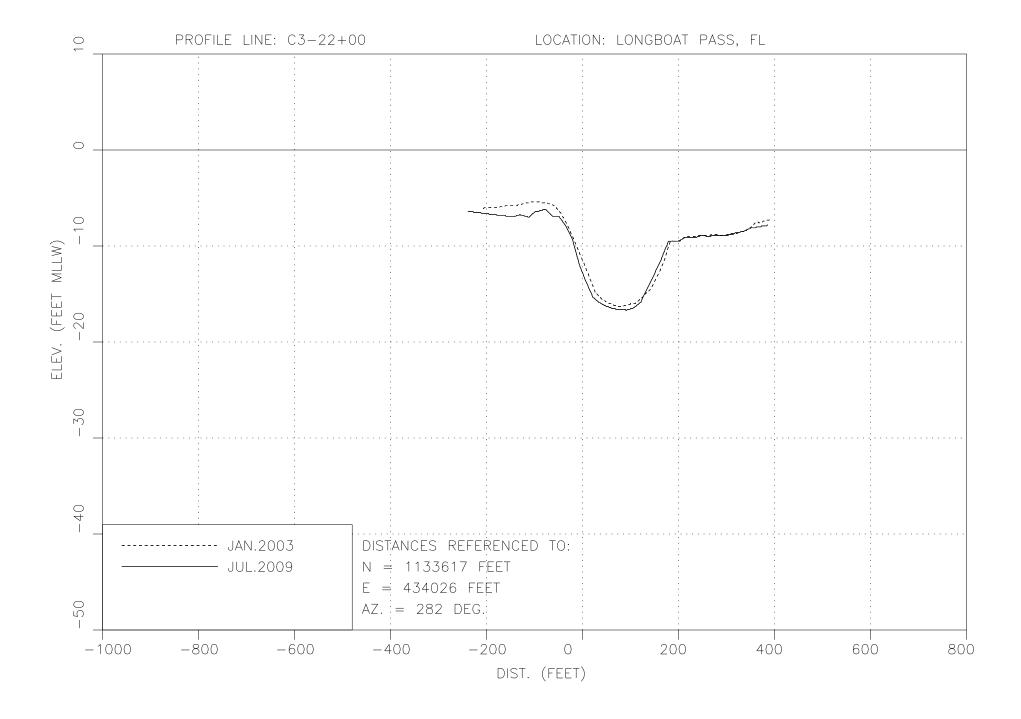


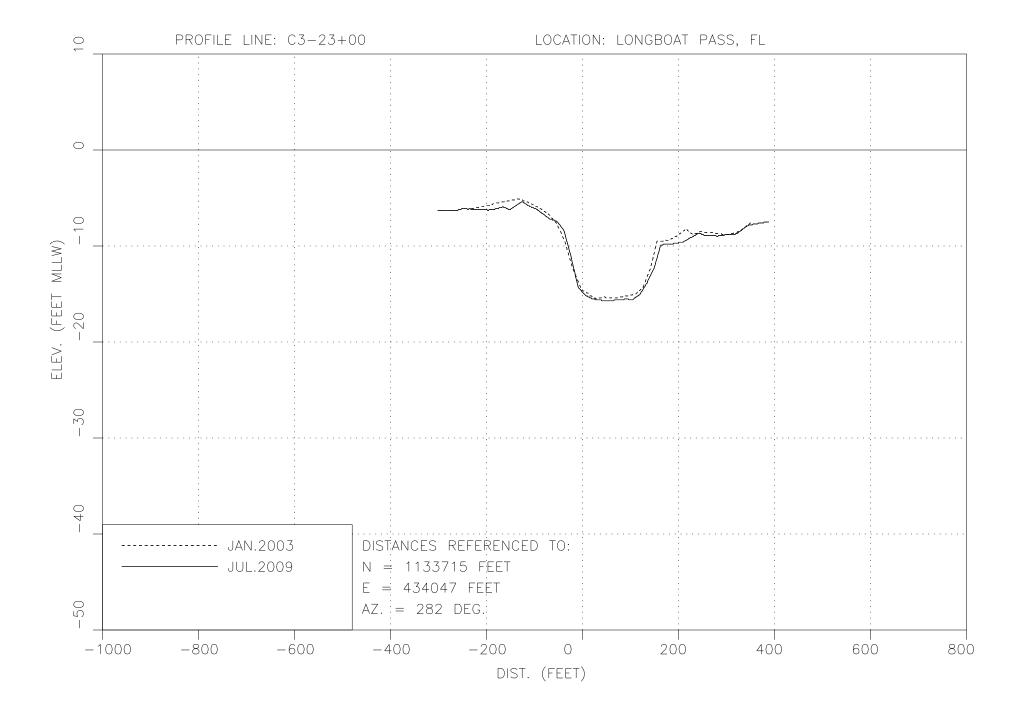


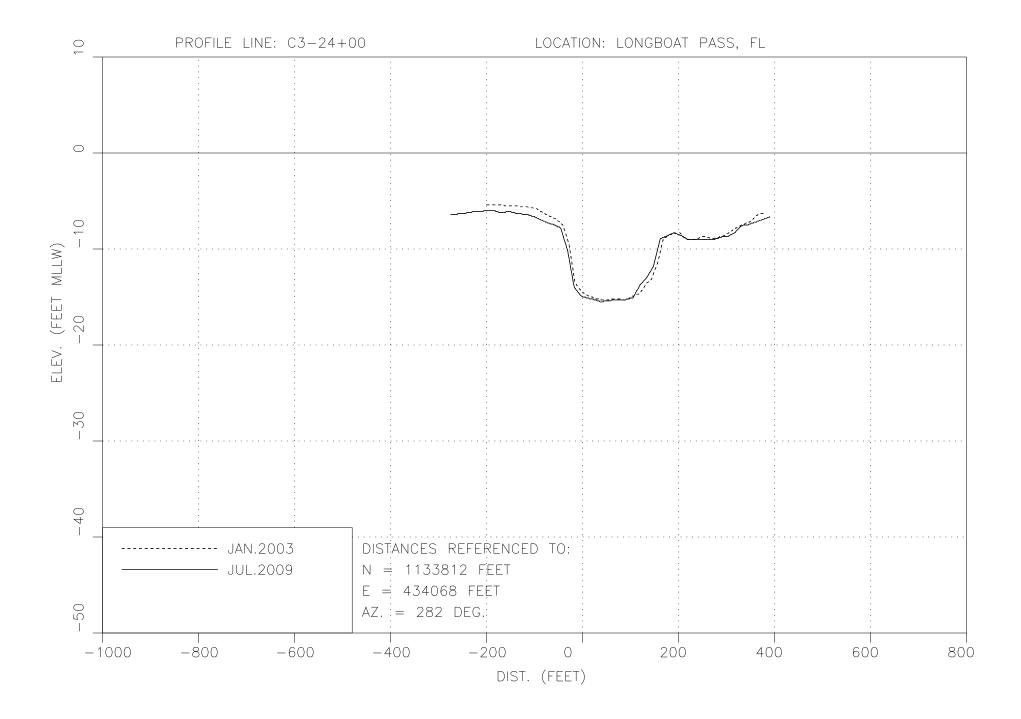


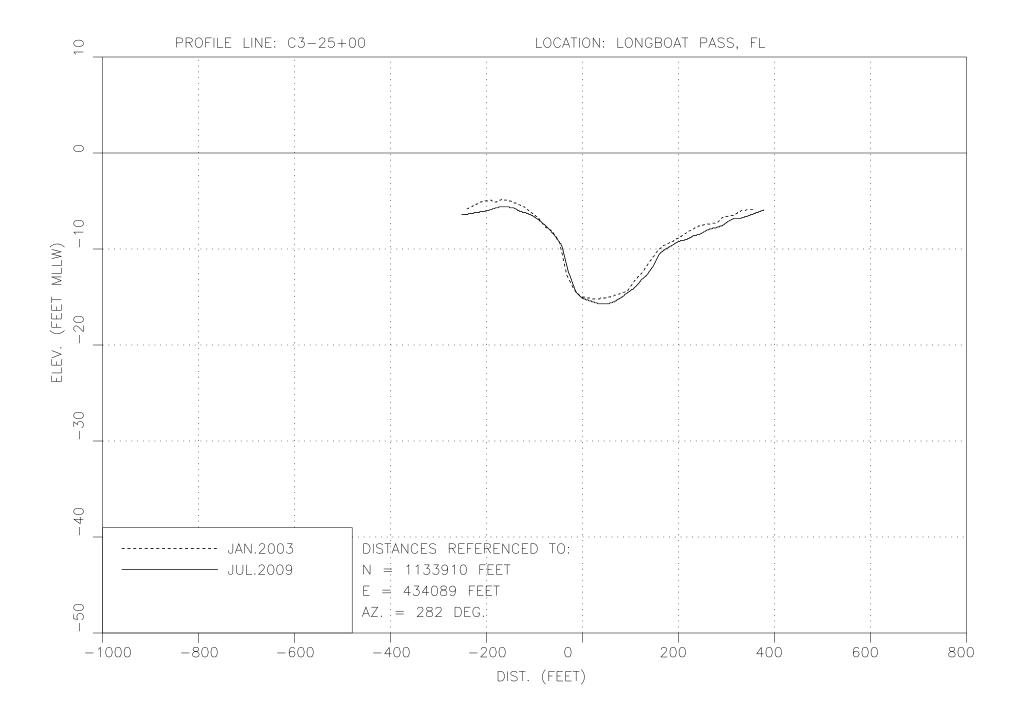


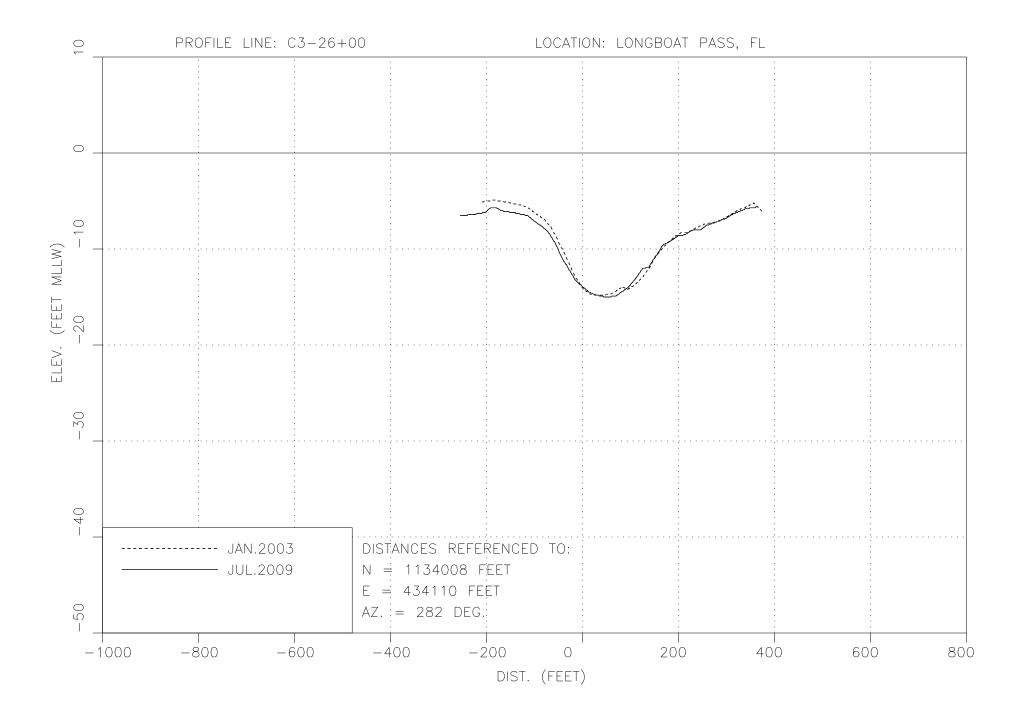


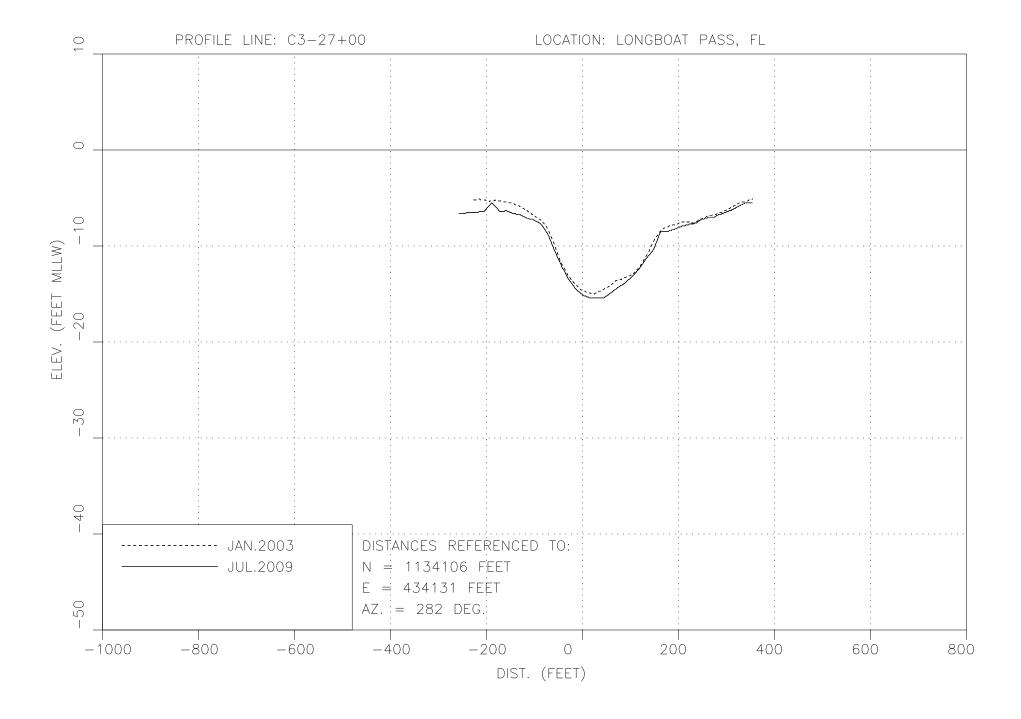


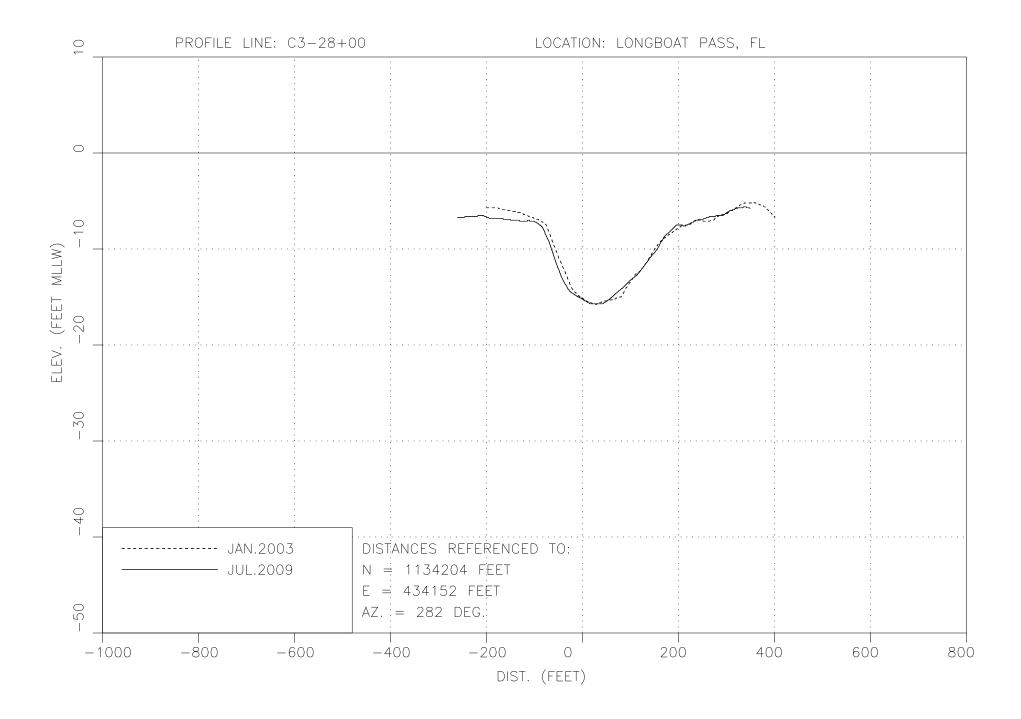


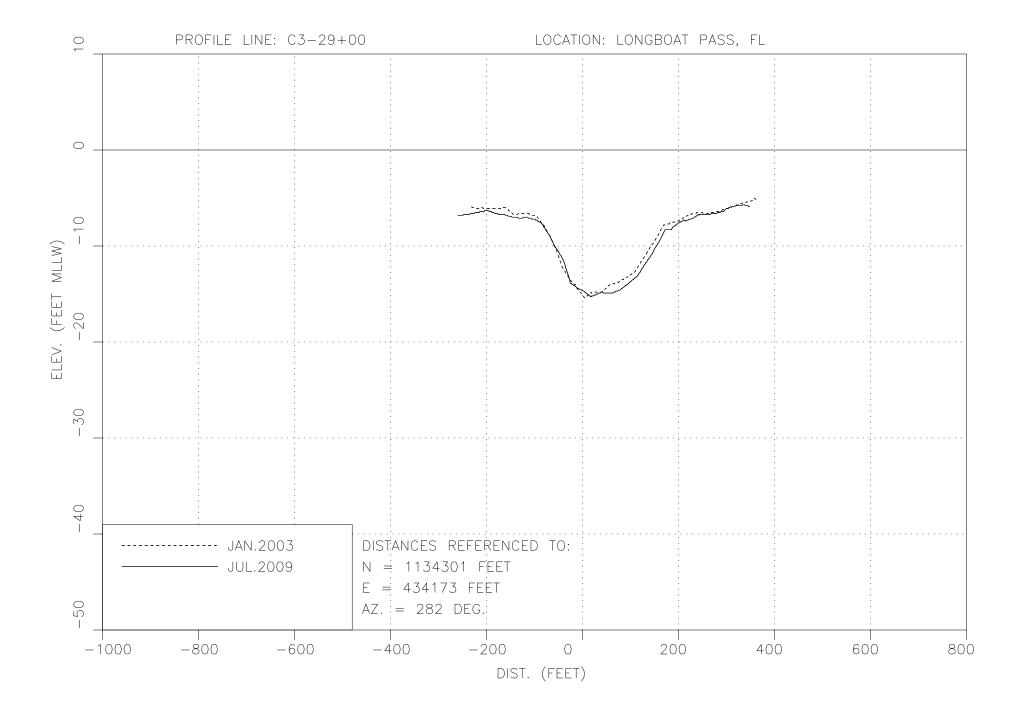


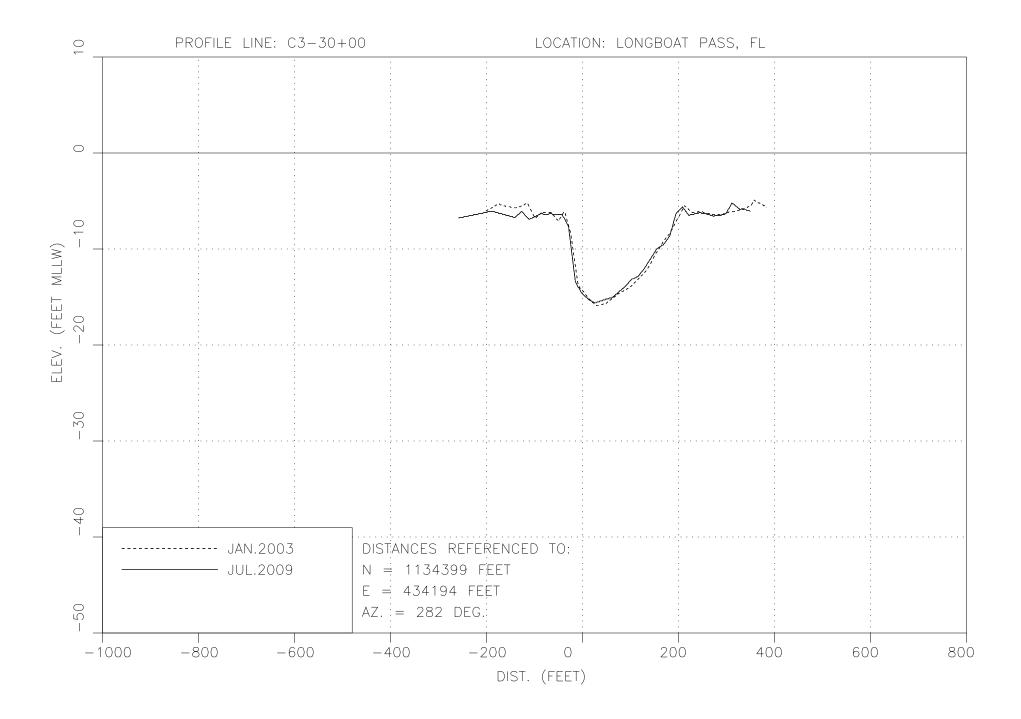


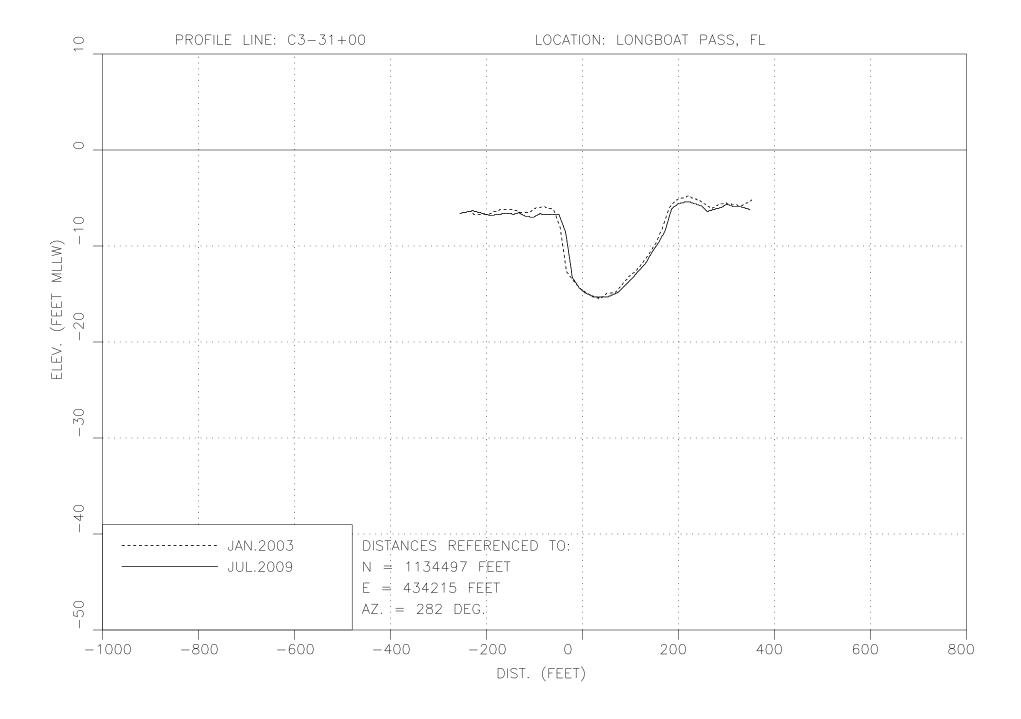


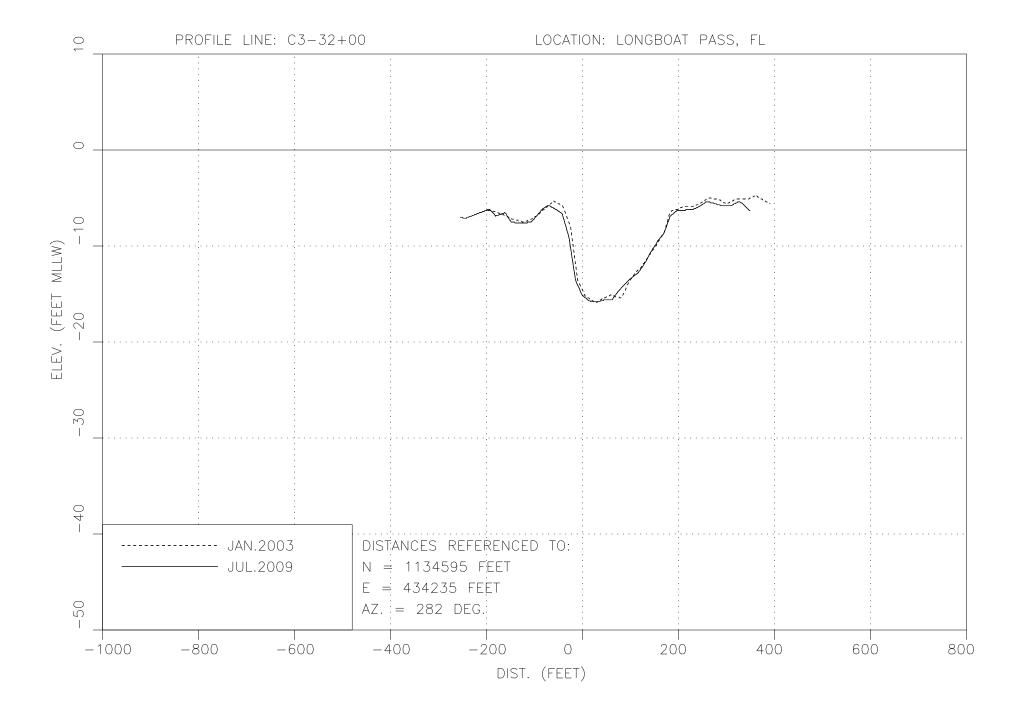


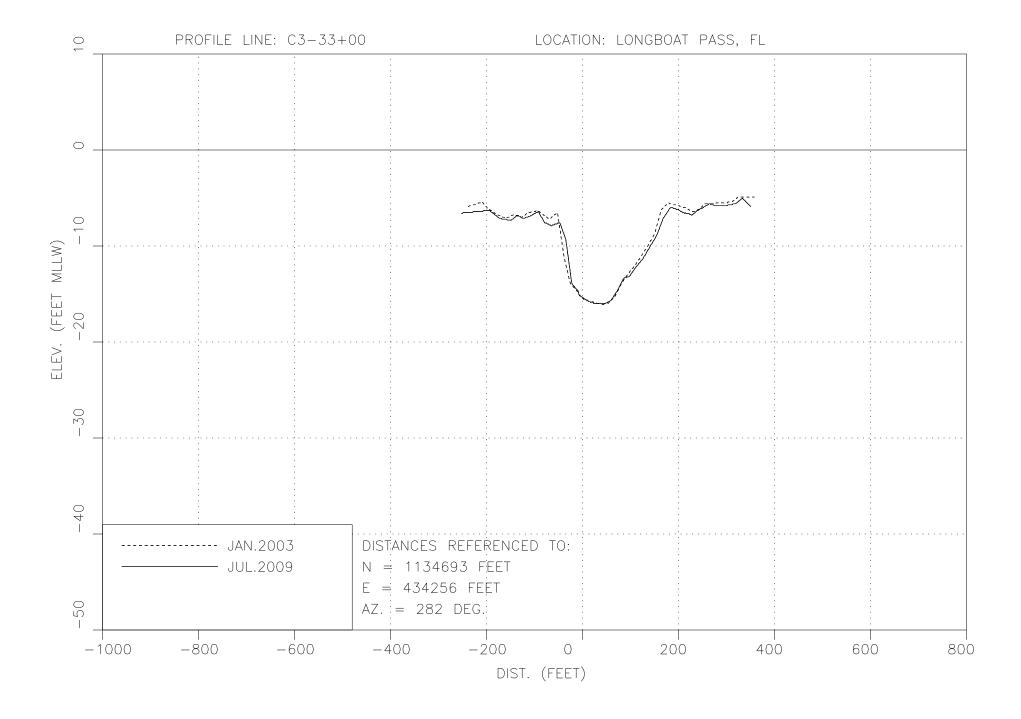


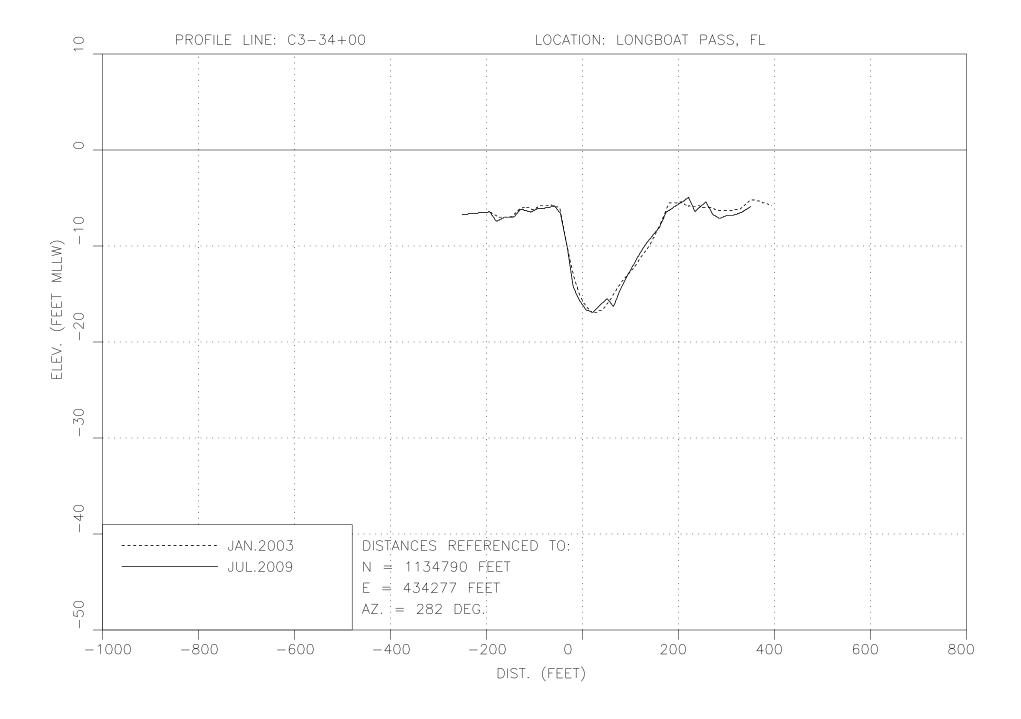


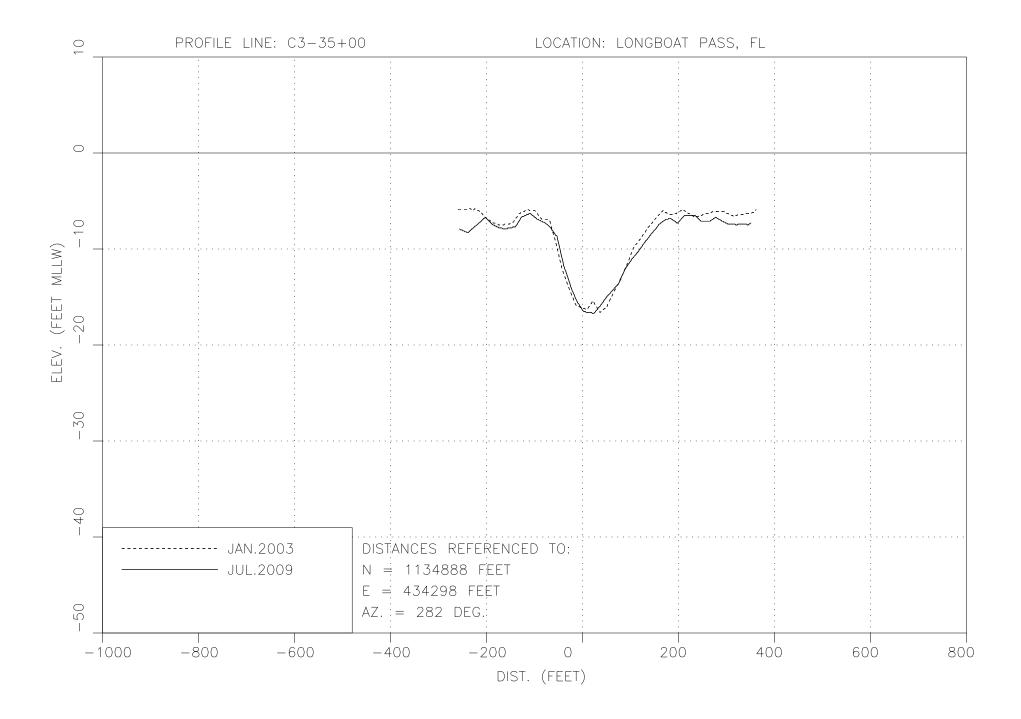


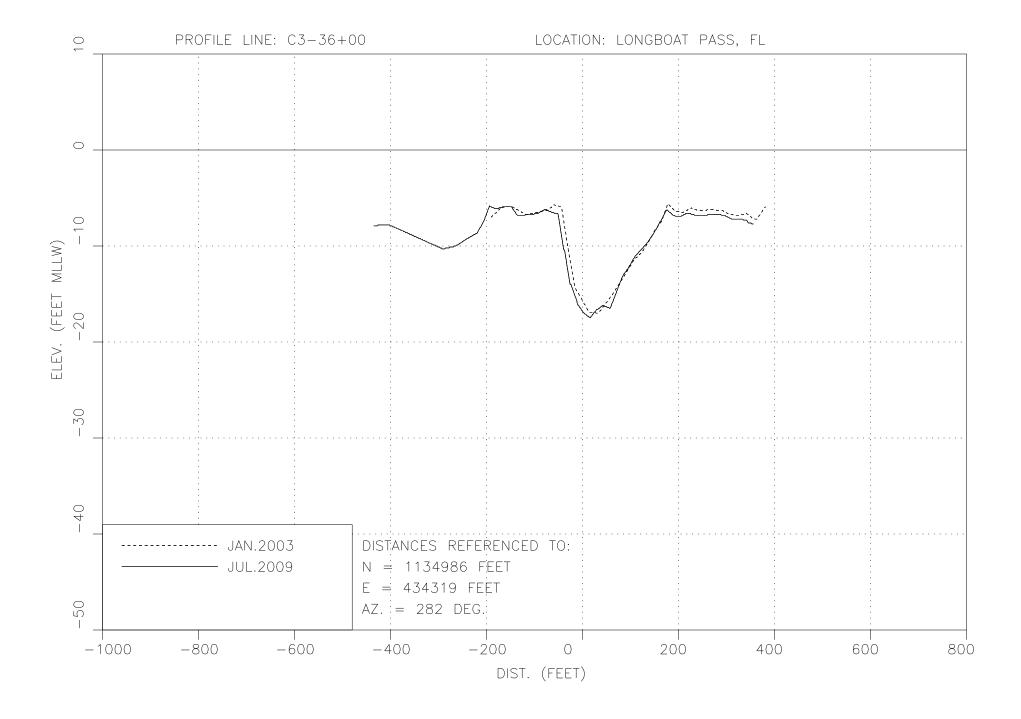


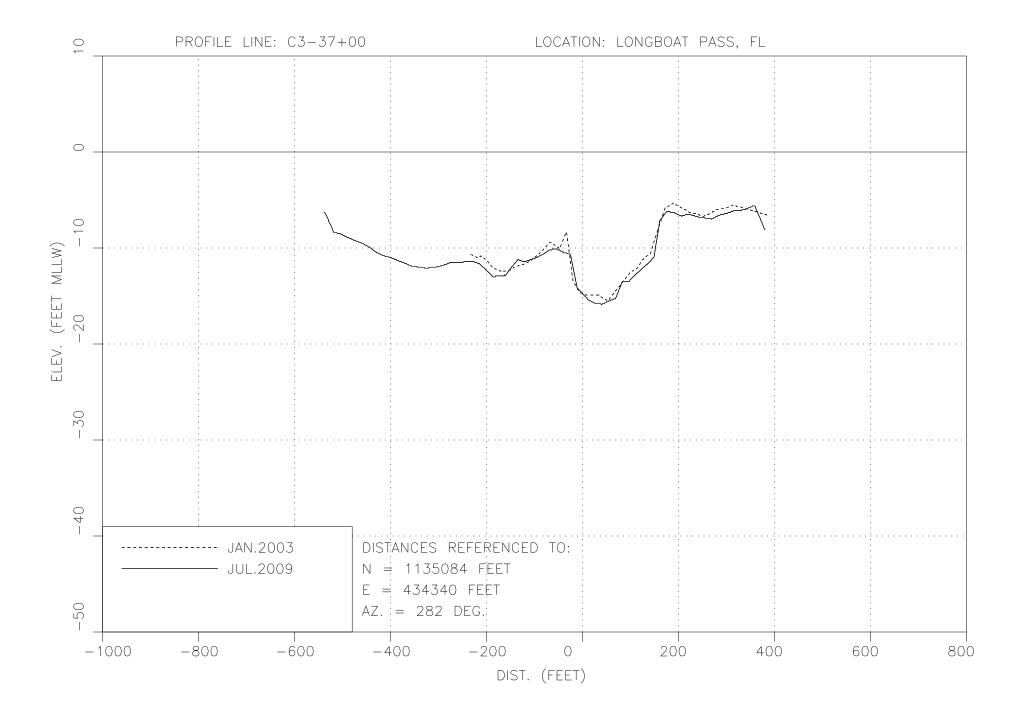


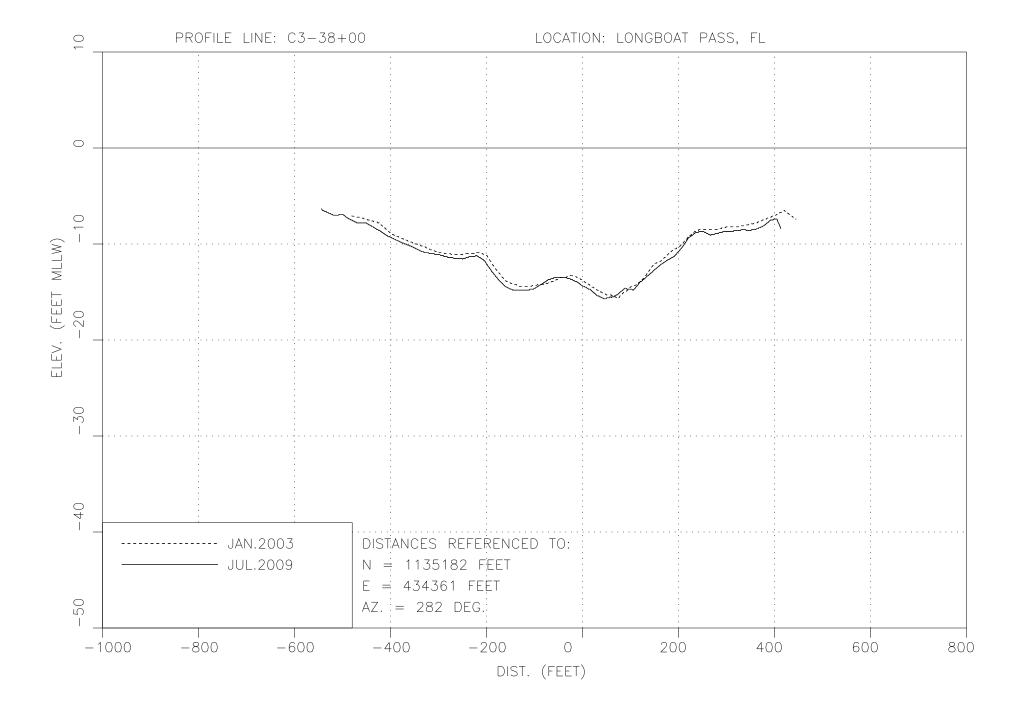


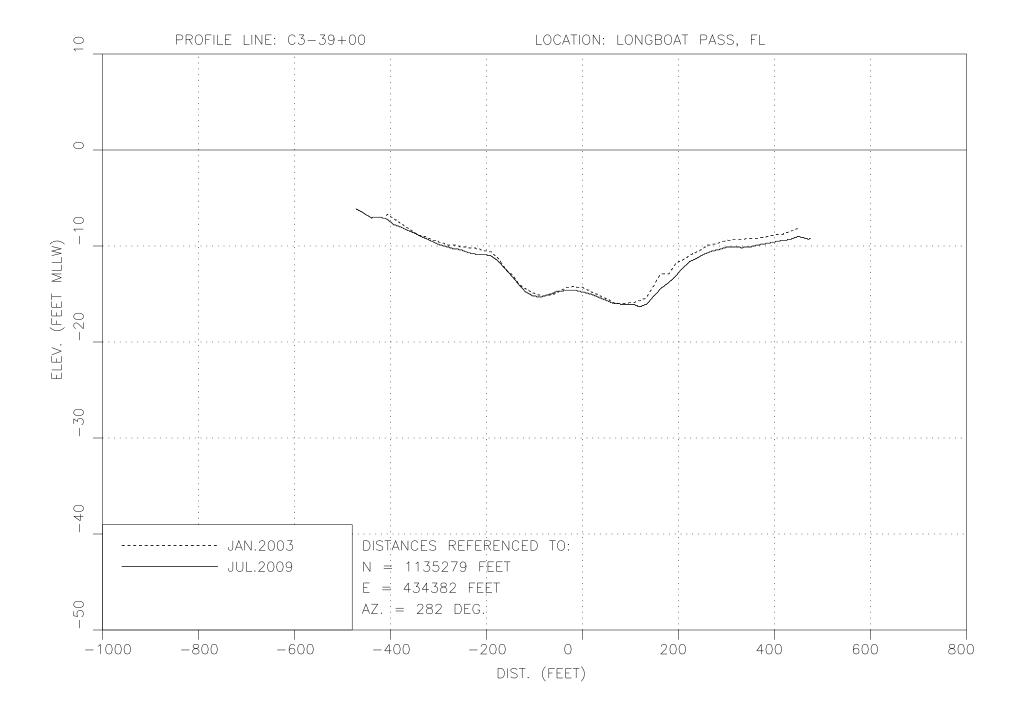


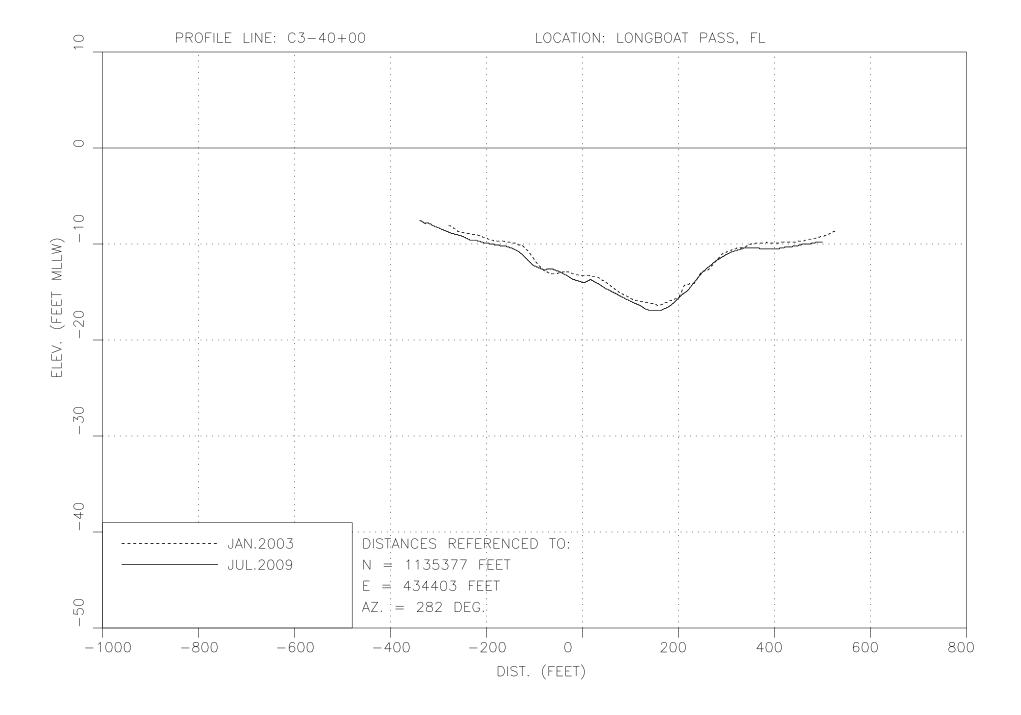


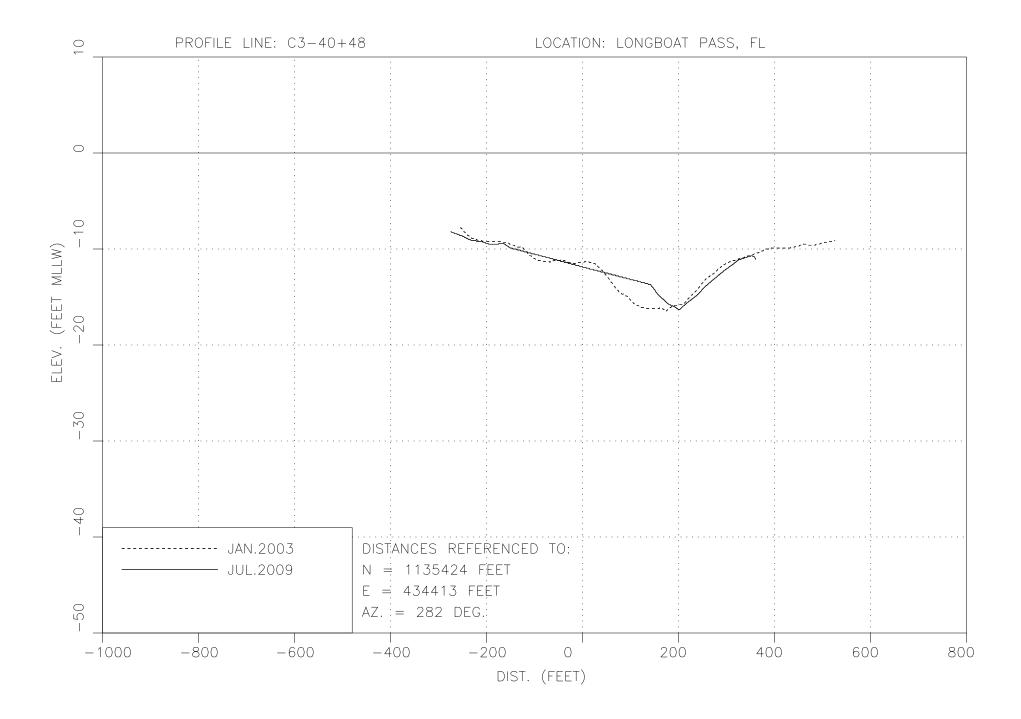


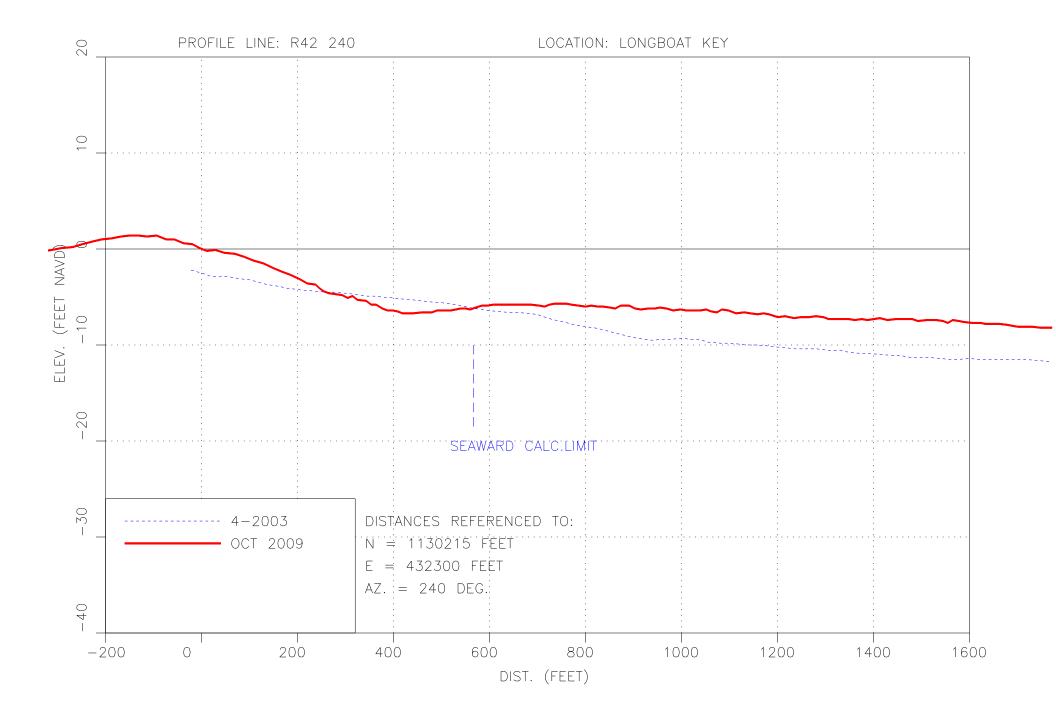


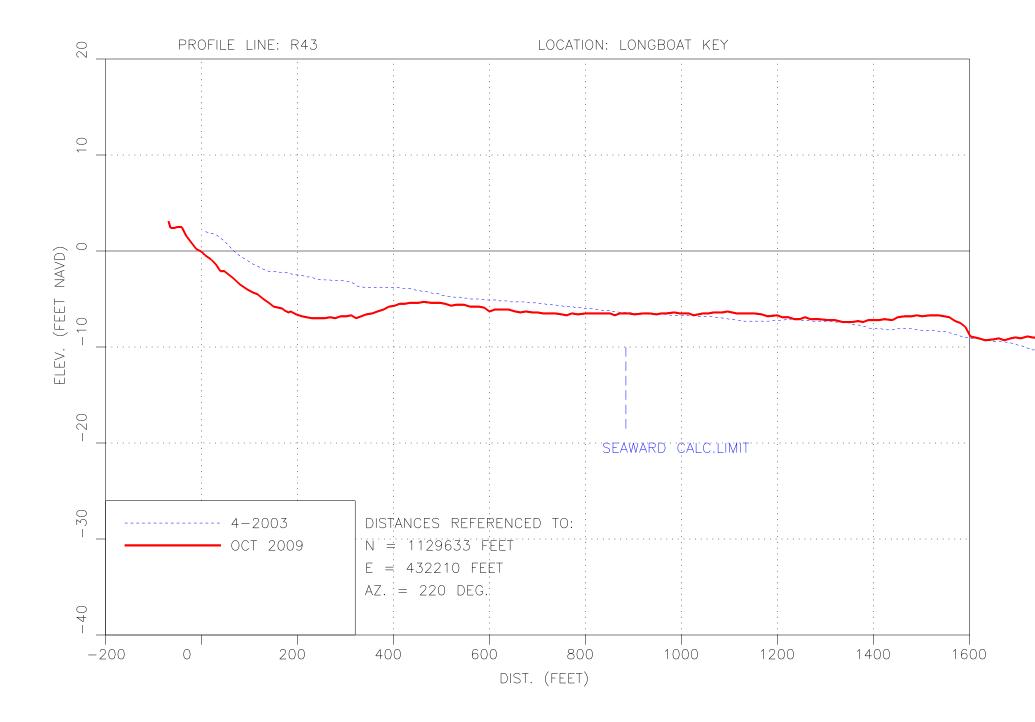


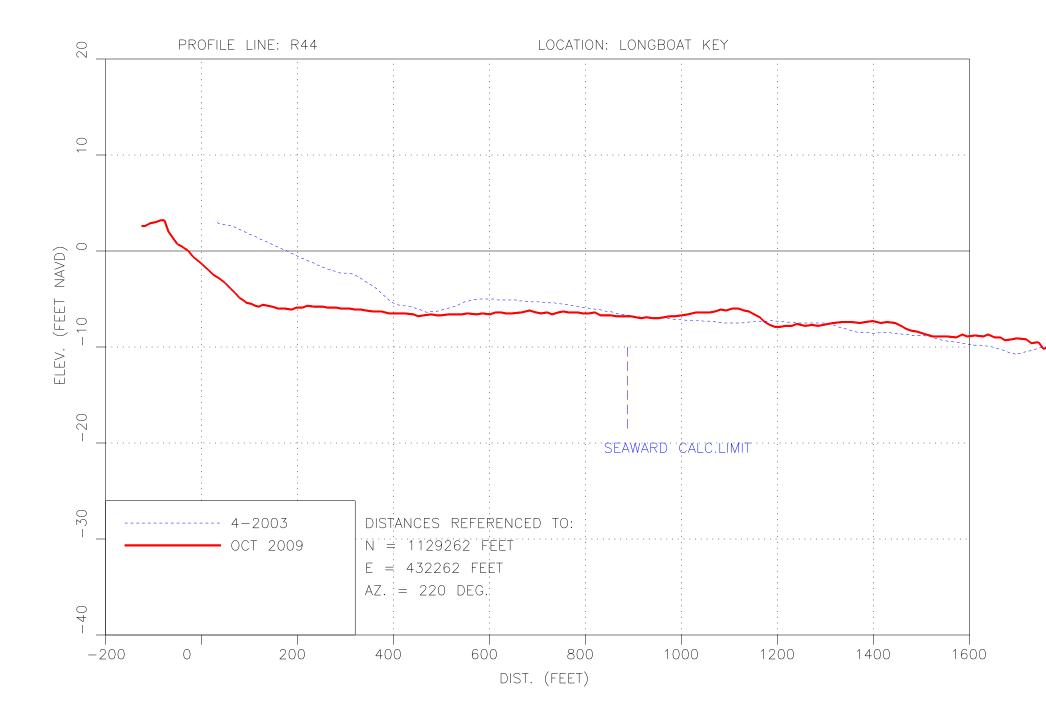


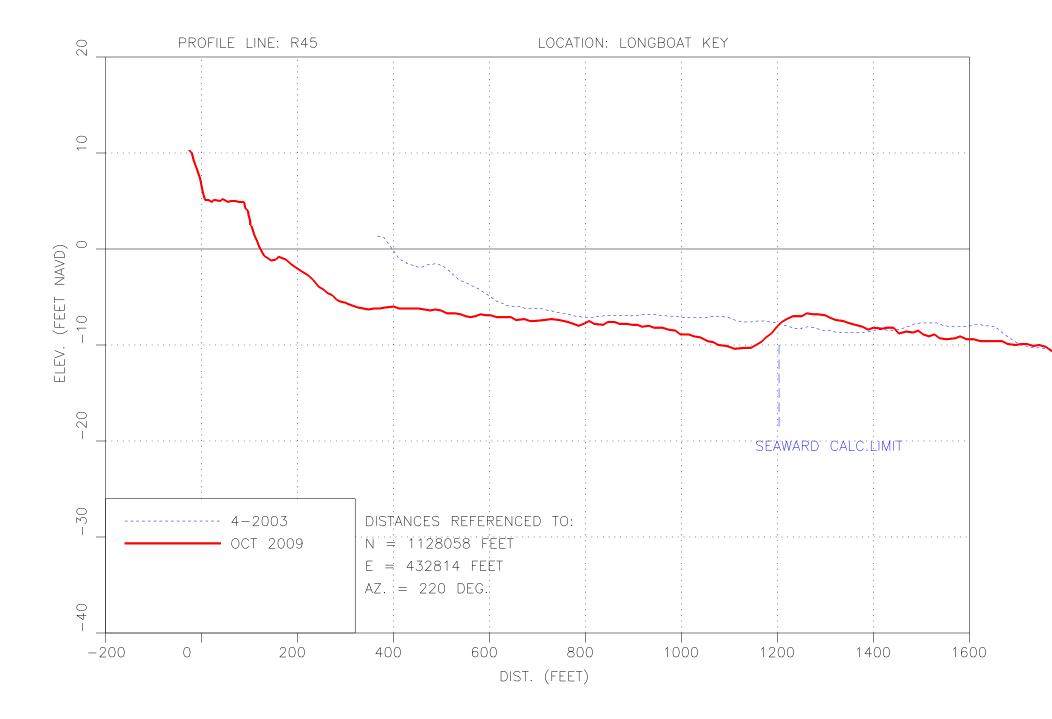


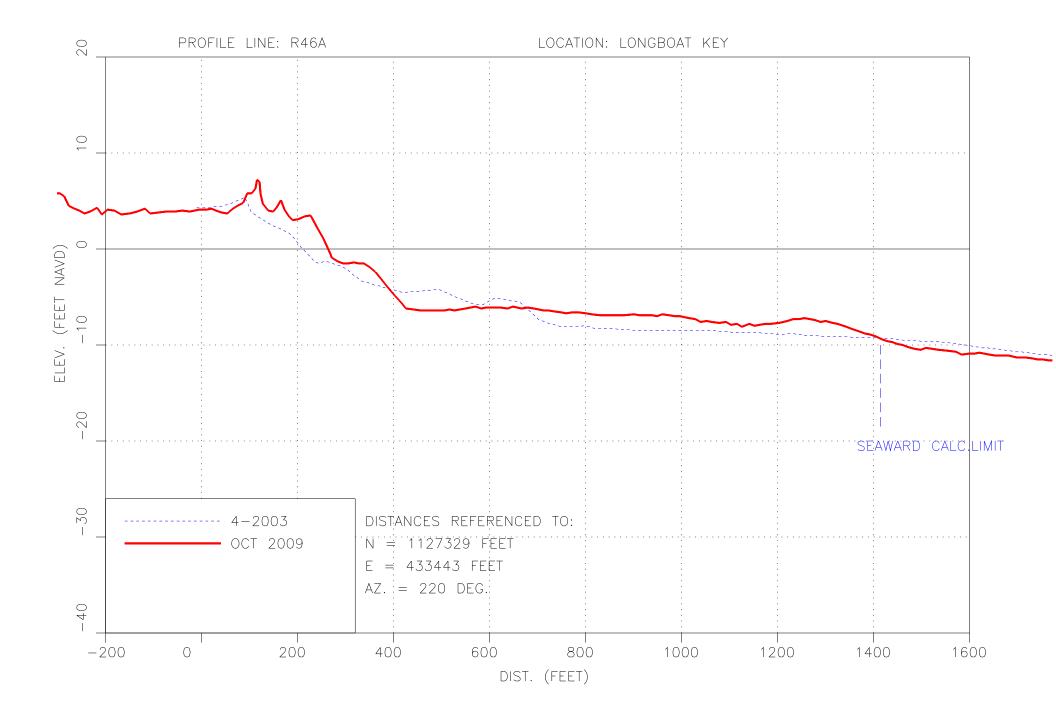


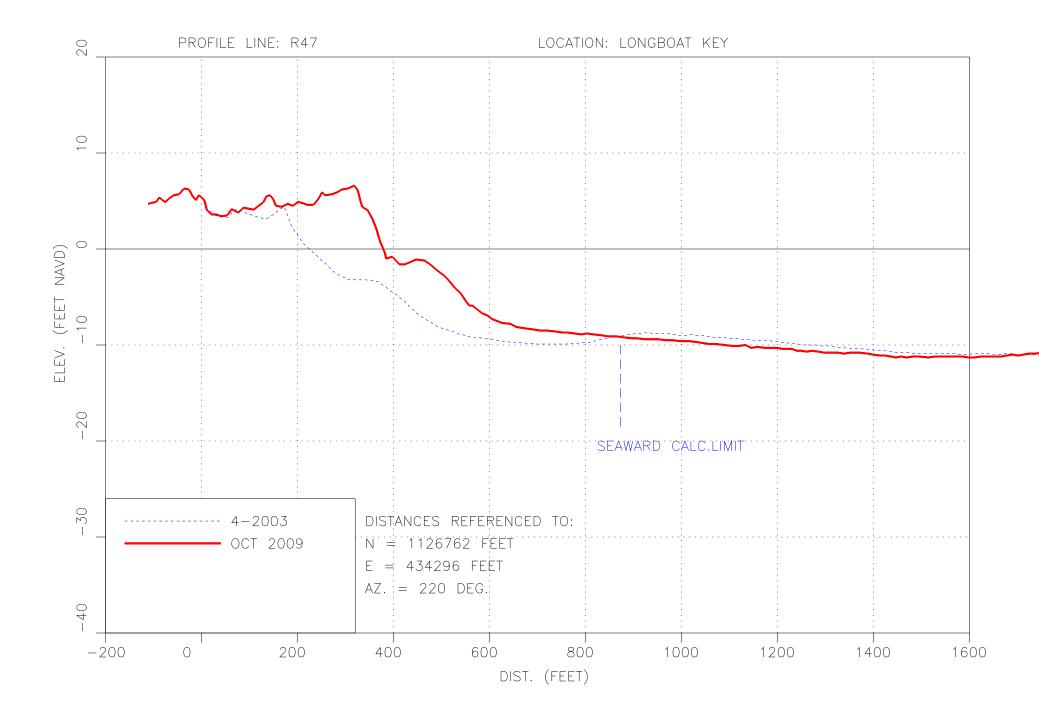


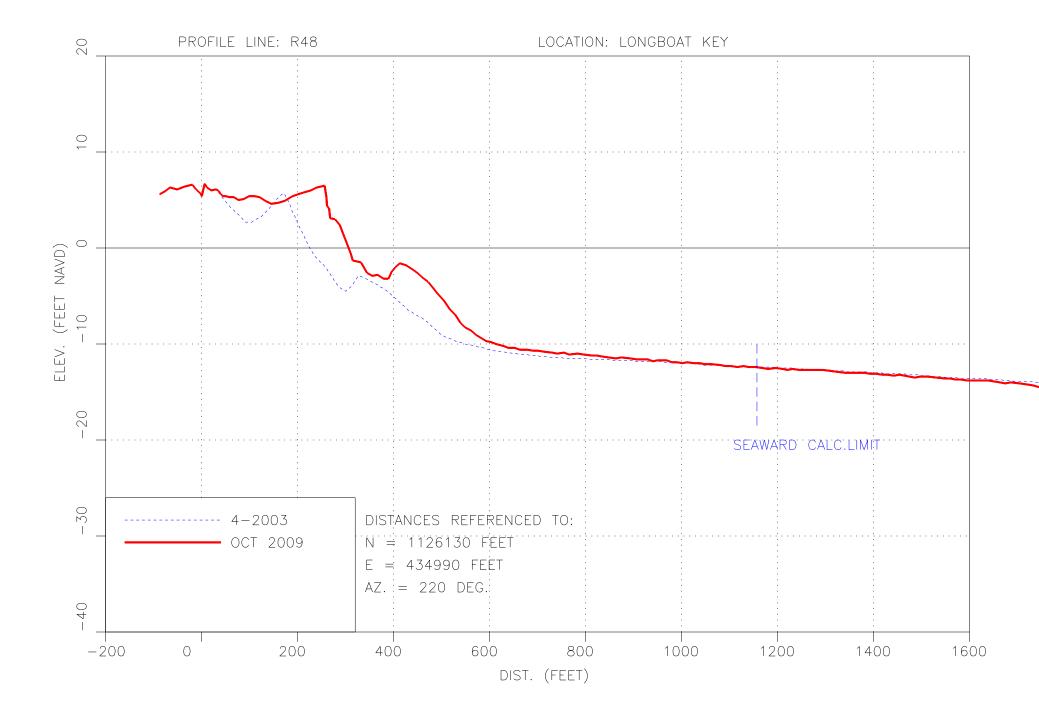


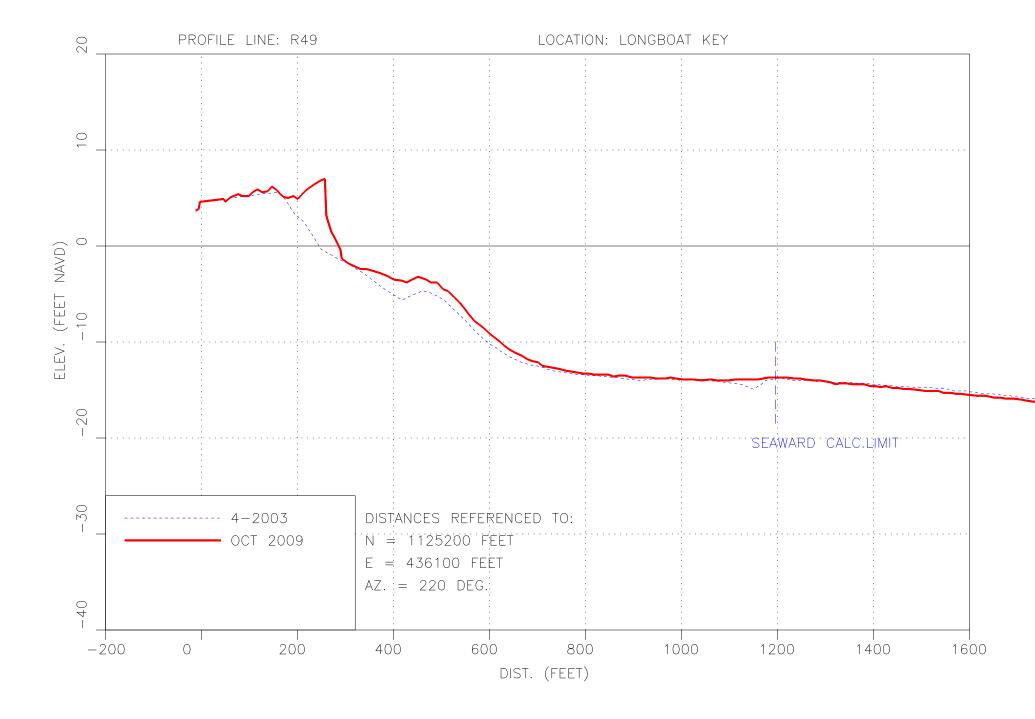


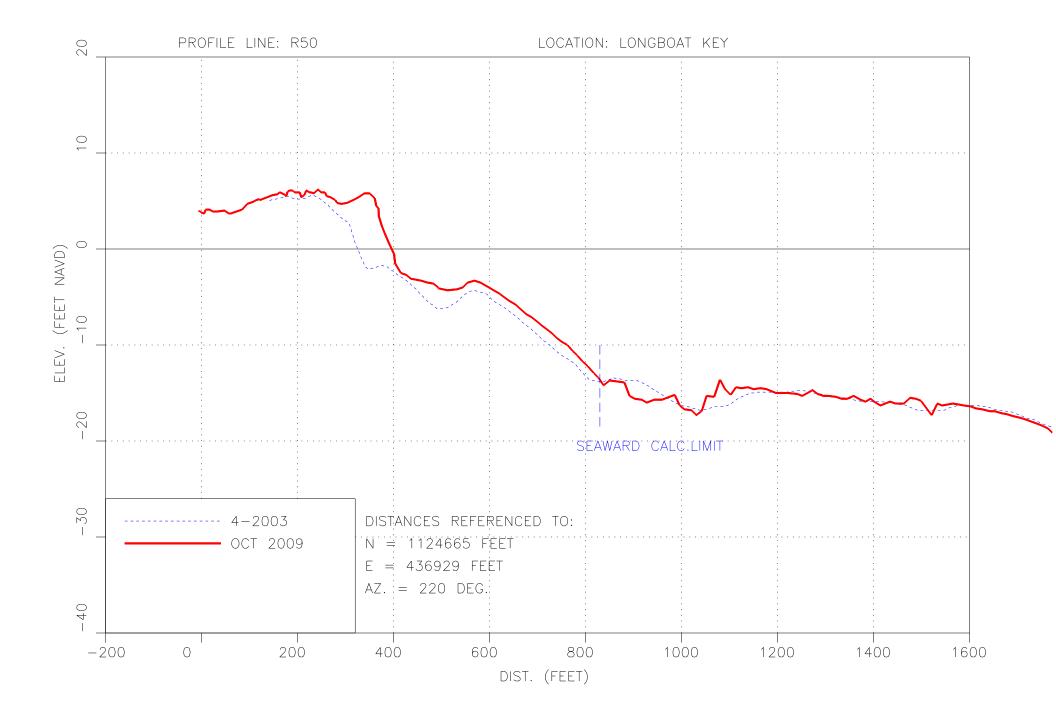


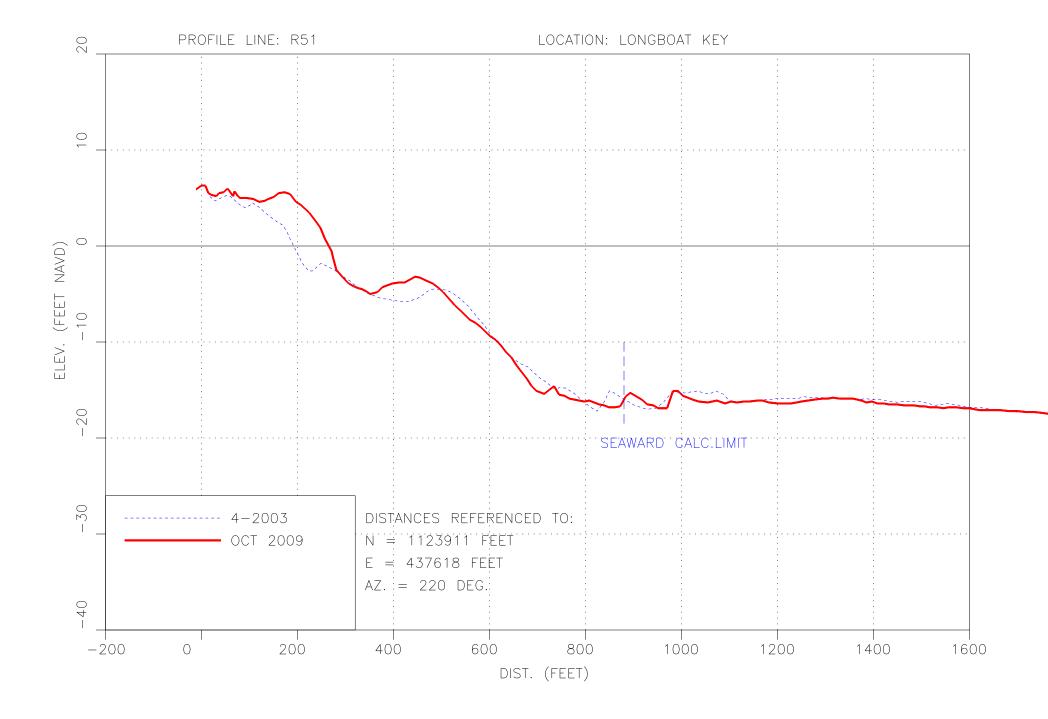


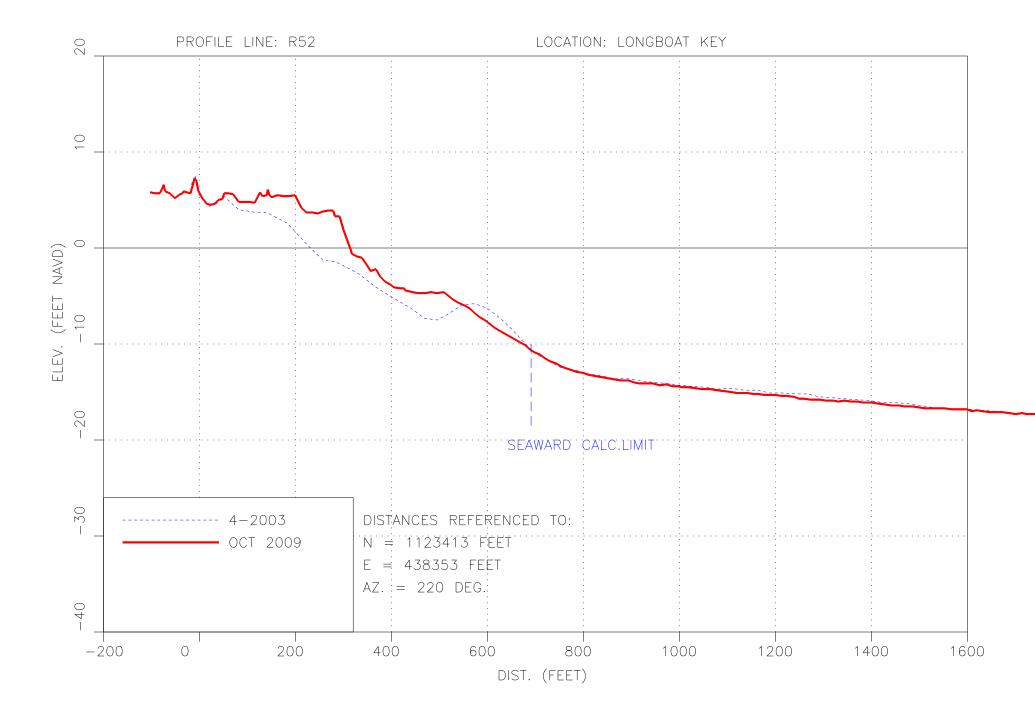


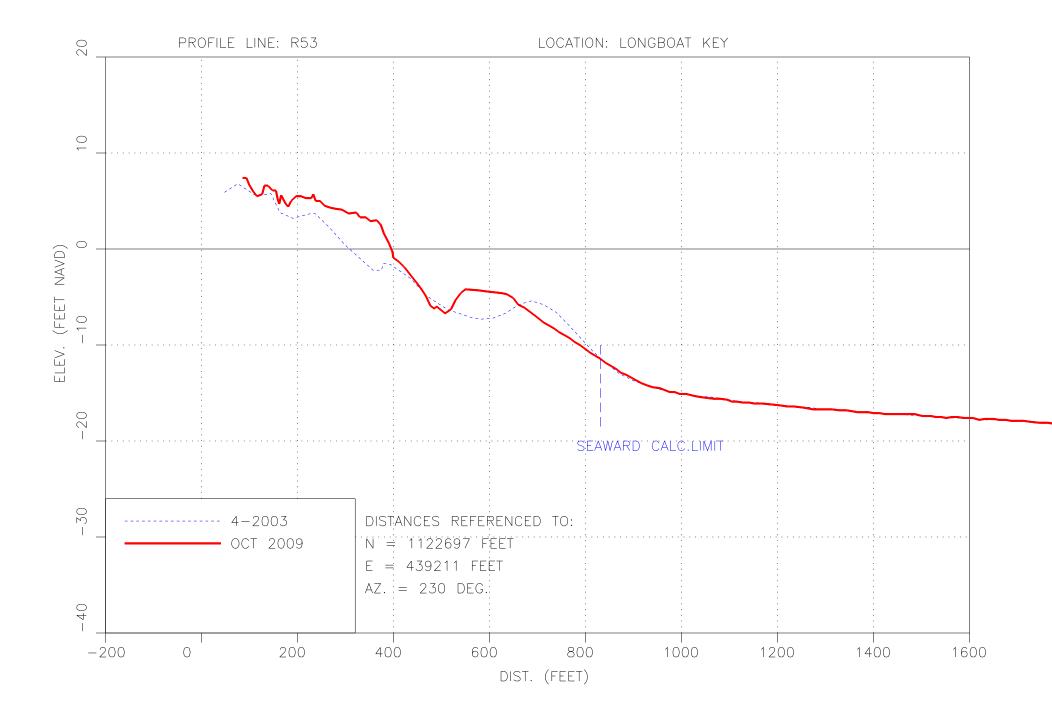


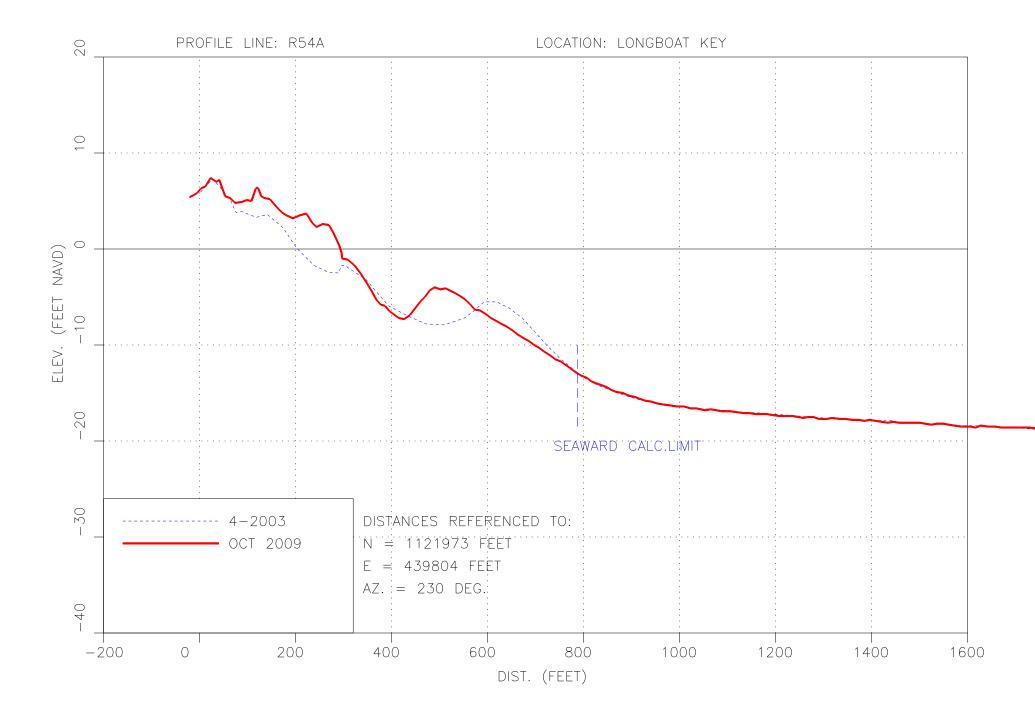


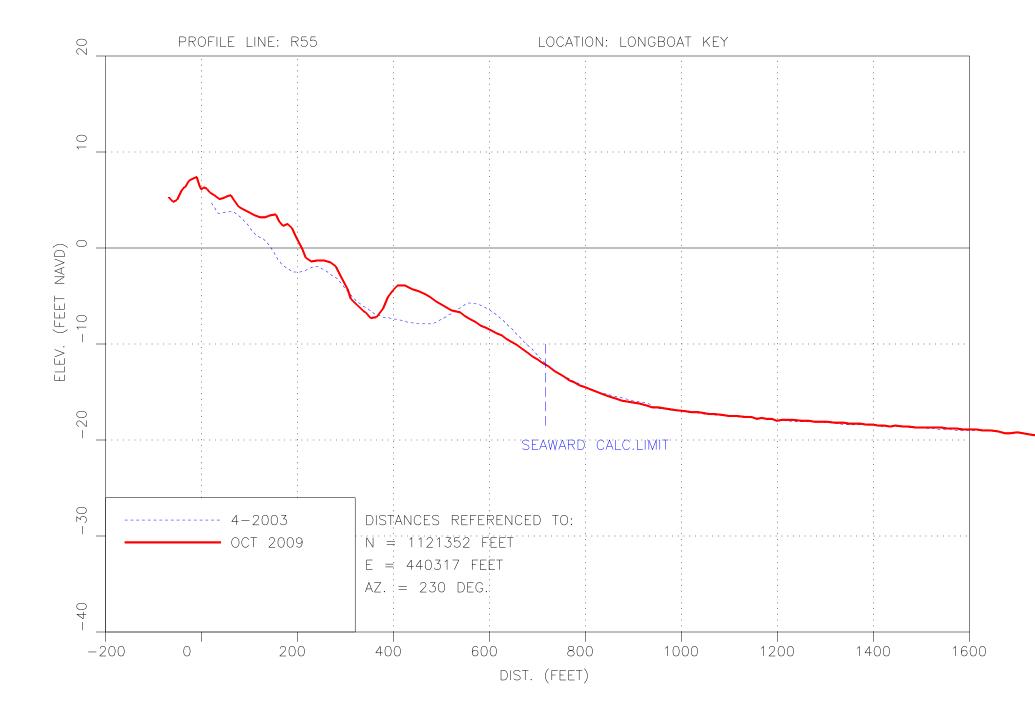


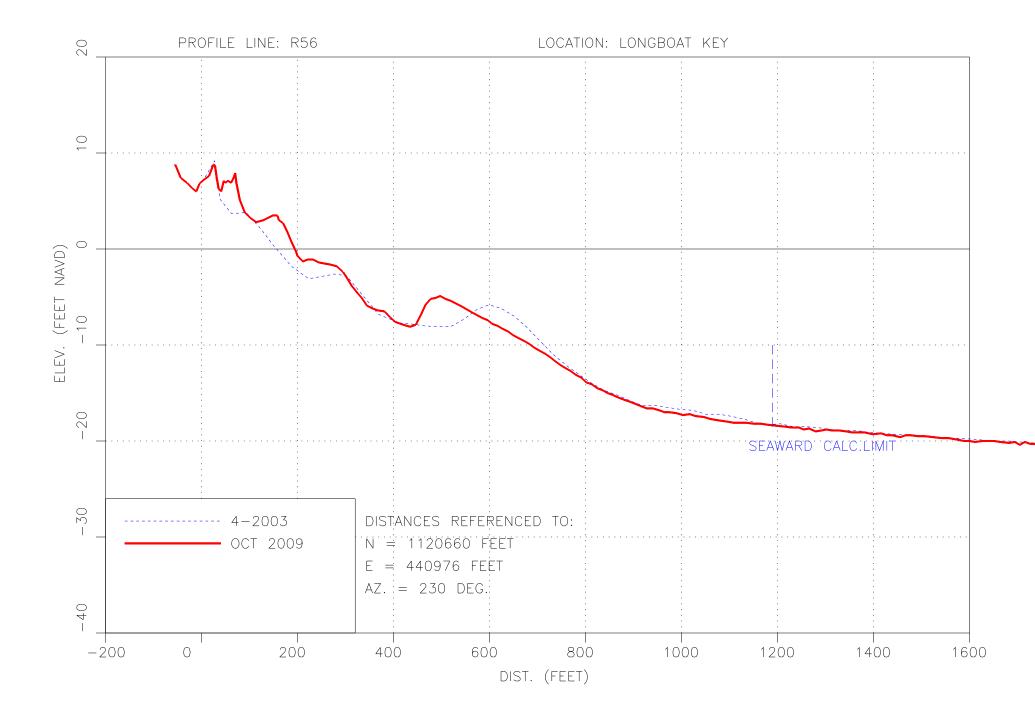












APPENDIX C

LONGBOAT PASS CONTOUR MAPS WITH CONCURRENT AERIALS AND CHANNEL CENTERLINES

Note:

For all maps:

Thick blue contour = 0' NAVD.

Spacing between thick contour lines = 5 feet.

Spacing between thin contour lines = 1 foot.



FIGURE C-1: Longboat Pass August 1993 Bathymetry (feet NAVD).

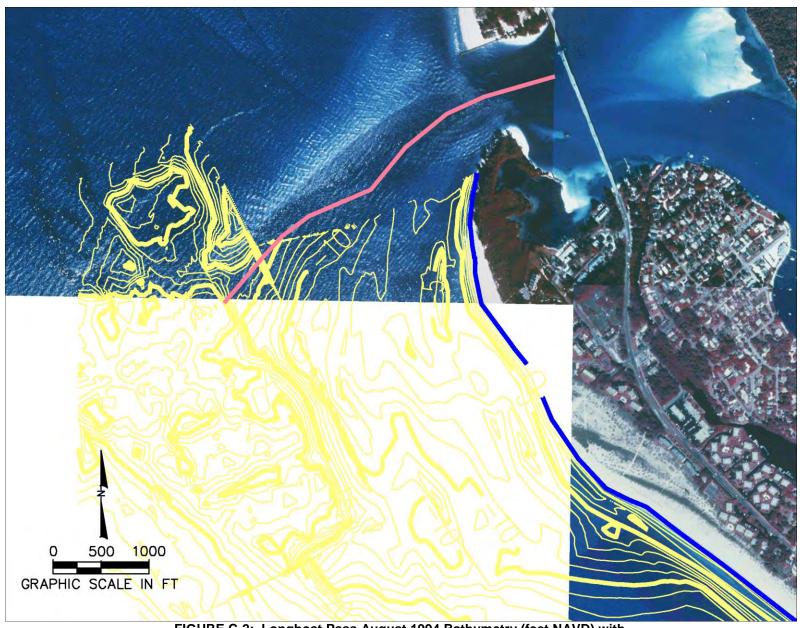


FIGURE C-2: Longboat Pass August 1994 Bathymetry (feet NAVD) with Feb. 1994 / Jan. 1995 Aerial Photographs (http://data.labins.org).

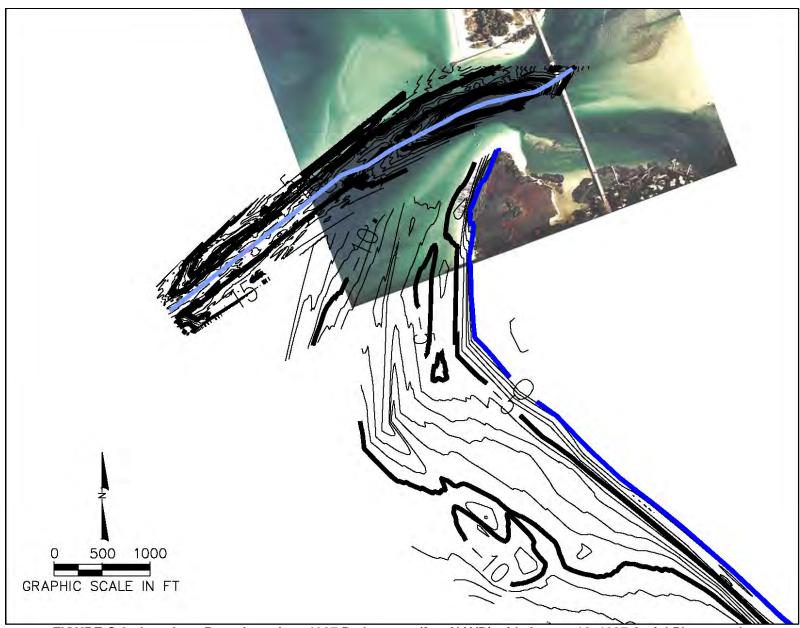


FIGURE C-3: Longboat Pass June-Aug. 1997 Bathymetry (feet NAVD) with August 12, 1997 Aerial Photograph.

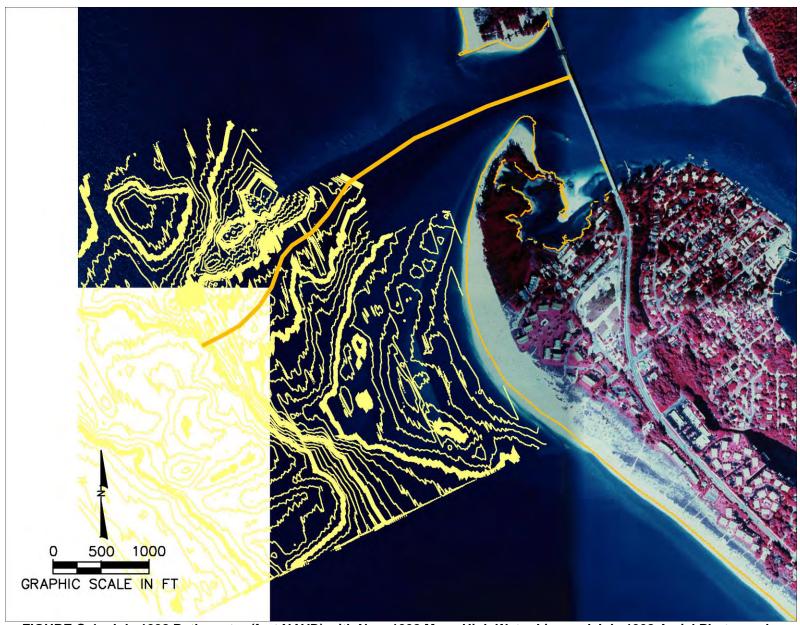


FIGURE C-4: July 1998 Bathymetry (feet NAVD) with Nov. 1998 Mean High Water Line and July 1998 Aerial Photograph.

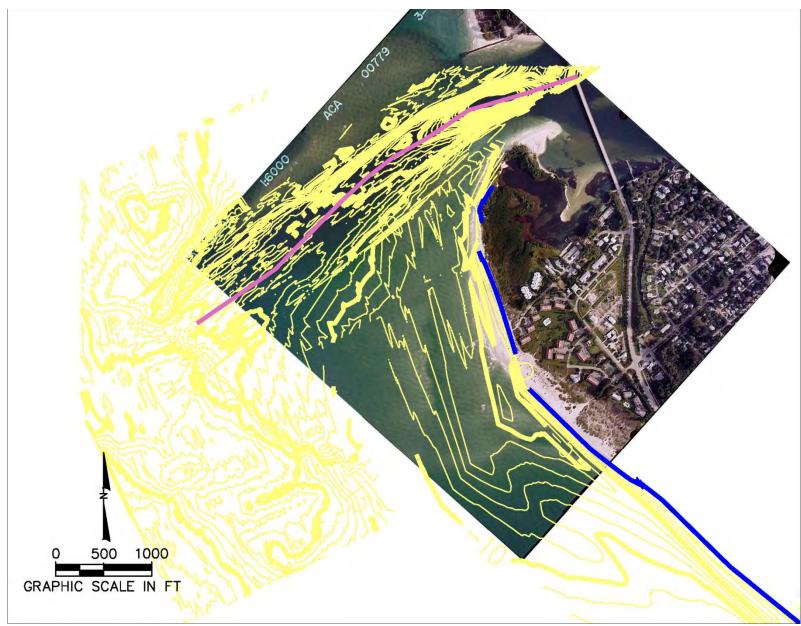
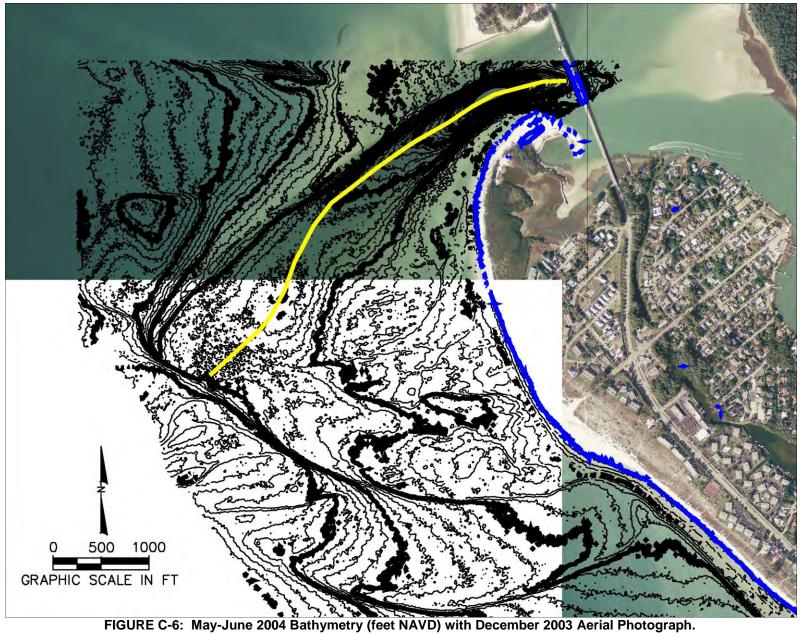


FIGURE C-5: February-August 2000 Bathymetry (feet NAVD) with September 2000 Aerial Photograph.



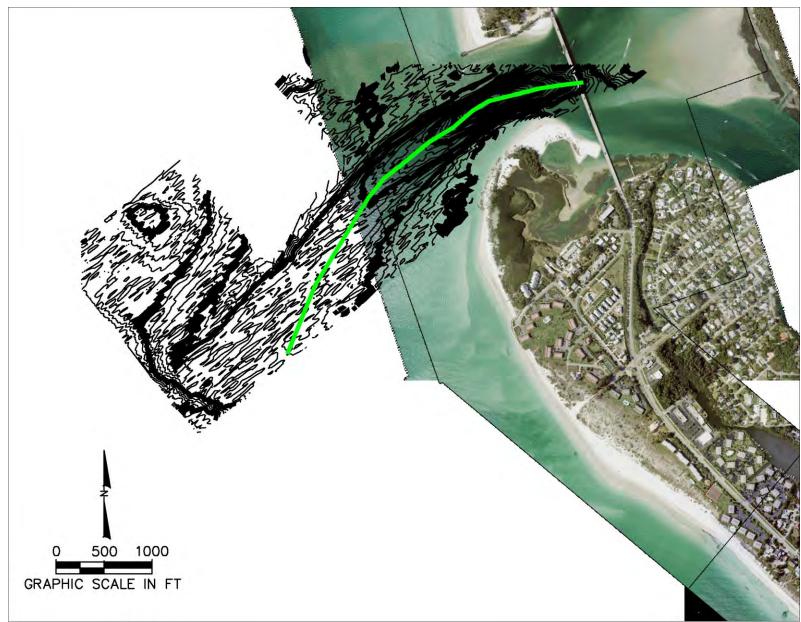
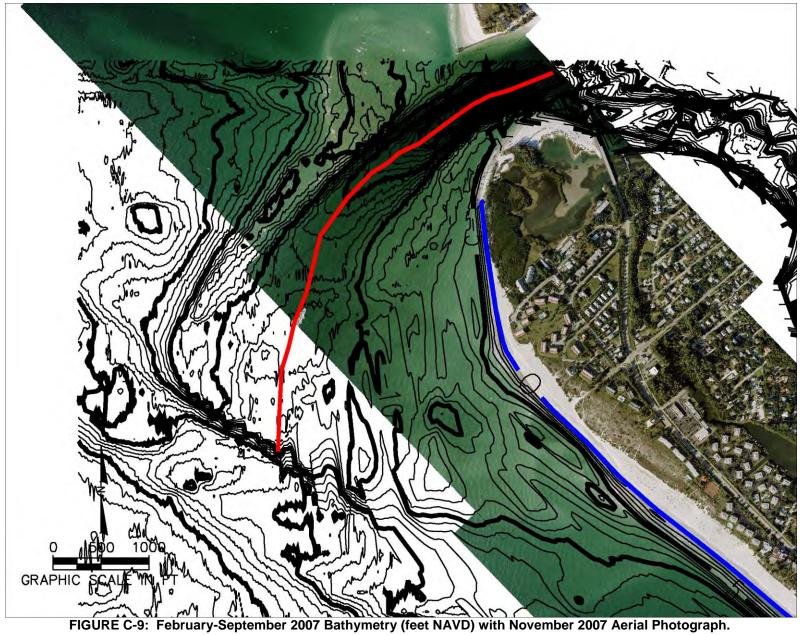


FIGURE C-7: March 2005 Bathymetry (feet NAVD) with May 2005 Aerial Photographs.



FIGURE C-8: May-June 2006 Bathymetry (feet NAVD) with February 2006 Aerial Photograph.



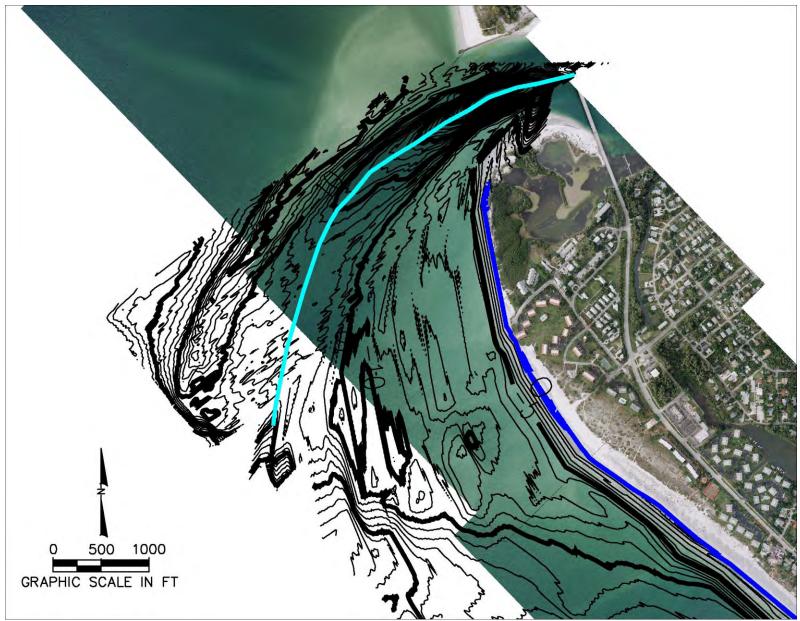


FIGURE C-10: September 2008 Bathymetry (feet NAVD) with October 2008 Aerial Photograph.

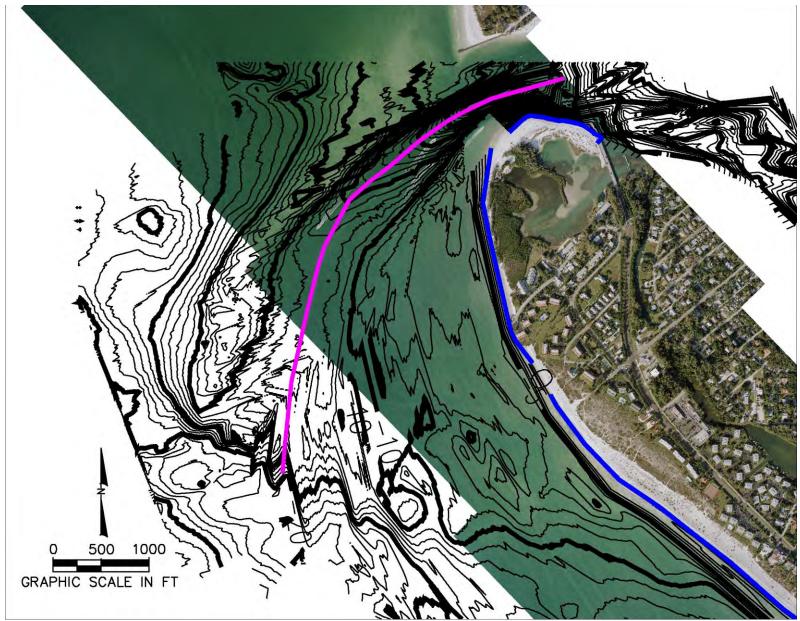


FIGURE C-11: March-October 2009 Bathymetry (feet NAVD) with December 2009 Aerial Photograph.



Telephone: (941) 373-6460

January 17, 2012

Mr. David Bullock Town Manager Town of Longboat Key 501 Bay Isles Road Longboat Key, FL 34228

RE:

Longboat Pass - Proposed Inlet Management Plan (IMP)

ECE Review and Comments

Dear Mr. Bullock,

As you are aware, ECE represents the interests of the Longbeach Condominium Association and in this capacity conducted a review of the Draft IMP for Longboat Pass dated October 2011. On their behalf, we greatly appreciate the opportunity to submit our review comments and suggested changes to the Draft Plan for your consideration as summarized herein.

While the State DEP and the Town and County will conduct both internal and formal reviews of the IMP over the upcoming months, we believe there are changes that should be incorporated as soon as practical. We are available to discuss our suggestions at your convenience. For clarity, we refer to each section of the report that the reference statements first appear to avoid duplicity.

Comments on Draft Plan:

1. Executive Summary: Paragraph 3 states that "prior to the construction of the 1992 and 1993 beach nourishment projects on Anna Maria Island and Longboat Key, natural bypassing occurred at Longboat Pass via the inlet's ebb tidal shoal."

Comment: The construction of the beach nourishment project was February 1993 to August 1993 with no work occurring in 1992. Please correct the dates of construction.

The above sentence infers that sand bypassing across the inlet was not adversely impacted by the Longboat Pass channel dredging and/or that sand bypassing occurred benefiting Longboat Key's beaches. Longboat Key's beaches experienced substantial



erosion that occurred from the Gulfside Road shoreline south along the entire island. This erosion wave commenced at the north end and continued south prior to the Town's first nourishment event. The cause of this erosion was Longboat Pass functioning as a sand sink and a barrier to sand bypassing to Longboat Key's beaches, without "measurable bypassing." Notably the deficits in sand bypassing extended from Tampa Bay entrance channel to Anna Maria and Longboat Key. We recommend rewording this paragraph to correct and clarify these statements, as the data and sediment budget documents a nominal 81,800 CY deficit of sand bypassing from the ebb shoal to Longboat Key prior to the 1993 beach nourishment project.

2. Executive Summary: Paragraph 4, Bullet 2 states that that the Plan combines the following elements: "The construction of a terminal groin on the north end of Longboat Key, plus two permeable adjustable groins near the 360 North Condominium and the public beach access at the end of North Shore Road."

Comment: Remove the word "permeable" as most groins provide varying degrees of permeability. Further, rock rubble groin structures are semi-permeable with greater or less permeability based on the design of the core, elevation(s) along the crest, weir and construction materials. The IMP recommends three groin structures that are shown at a conceptual design level. In the design development and permitting phases of the project, these structures will be refined in terms of their geometry, orientation, lengths, materials, and potentially phasing and sequence of construction. For these reasons, statements as to a specific type of construction material and/or the permeability are not necessary. After the Plan is adopted by the State, the Town's future decisions to modify or change these structure(s) creates costly and time-consuming work from either the USACE or FDEP who will likely take issue conflicts.

It is well understood and agreed that the net direction of sand movement is nearly unidirectional, i.e. strongly from south to north, along the northerly 3000+ feet of Longboat Key and that the inlet's erosive impact on the beaches between North Shore Road and the north end of the island requires a terminal groin structure to shift the strong currents further seaward. Further, the influence of the recommended "terminal" structure on the shoreline extending south towards North Shore Drive cannot be readily predicted with certainty and a high level of accuracy. For this reason, optimal locations for the second and third groin(s) will be known after the terminal groin is constructed and monitored. Many structures projects perform better (i.e. hold



more sand and effect a longer length of shoreline) than the models or analytical methods predict, which is often the case for structures that are adjacent to inlets. For this reason, the second groin location, that we agree needs to be included in the initial permit application, should be sequenced with construction occurring approximately a year after the terminal groin is constructed. The final groin #2 location would be based upon actual observations and performance of the terminal groin.

Should the Town decide that construction of the second groin must occur at the same time as the terminal groin, this structure is best situated near to or immediately north of the 360 Condominium and constructed using rock material(s). This location will provide the greatest level of protection for this condominium property and the Town's road end (also structurally hardened with a seawall). There are many advantages of building a rock structure as opposed to a pier/pile structured groin such as those built at the Colony and the Islander Club. Rock structures may be raised and lowered in nominal 3 feet lifts (stone layers) and these types of structures are readily constructed with or without cores to increase permeability, while the height and length are readily modified to increase (or decrease) the longshore stabilizing influence. Rock structures are less costly and are preferred where the direction of longshore sand movement is strongly in one direction such as near inlets. The second groin's performance would determine the need for, and location of a third structure, and/or whether modifications to the second groin would be the optimal solution to increase the stabilizing influence of this structure along the Longbeach Condominiums.

 Section 1: Sub-Section C (Purpose and Scope) states the purpose and scope of the study..."to assess the coastal processes at Longboat Pass and evaluate alternatives to improve inlet management and reduce inlet related erosion on Anna Maria Island and Longboat Key".

Comment: The Plan does not state the goals and objectives for the recommended Plan within Section 1 or Section 5, although a scope of study is described in Section 1C. In Section 1C, the last two bulleted items read "an assessment of alternatives will be performed and a recommended inlet management strategy will be developed". Stating the Plan's objectives will benefit the public and the agencies in their review of the Plan and justification for the Plan's recommendations.



We recommend adding a new Section F in Section 1 or Section A to Section 5 that identifies the "Goals and Objectives" for the Plan. Goals and objectives and justification for each element of the recommended Plan may be stated as:

- a. Shoreline structures are needed to stabilize the north beach and reduce high sand losses to the Pass channel and the ebb shoal.
- b. Stabilization is recommended for "two shoreline segments" strongly influenced by the inlet, including (1) the re-curved shoreline fronting the low lying, undeveloped Greer Island and the (2) a developed shoreline fronting the 360 Condominium to Longbeach Condominium.
- c. Evaluation of alternative structure(s) configurations to include a (1) terminal groin to block strong longshore currents and prevent sand losses to the inlet channel and (2) additional structure(s) to widen the beaches a nominal 100 feet fronting the 360 Condominium-North Shore Road Beach Access-Longbeach Condominium beach segment.
- d. Channel re-alignment to reduce strong tidal currents and secondary "flodd" tidal channel development that results in severe erosion at the north shoreline of LBK.
- e. Channel maintenance dredging or capture sand within a widened segment of the channel that prevents losses to the flood tidal shoal to control channel migration toward Longboat Key.
- f. Channel dredge maintenance sediments placed in the requisite quantities on both Longboat Key and Anna Maria Island to ameliorate the impacts of the channel on the adjacent Longboat Key beaches (nominally at a ratio of 70:30 for LBK:AMI).
- 4. Sections 1E, 2B, 2I, etc. References to the 1993 (ATM) Longboat Pass draft Inlet Management Plan.

Comment: Numerous references and figures are taken from the 1993 (ATM) Longboat Pass IMP without the benefit of the data to review and cross reference. As such, we recommend including the 1993 IMP as an appendix to the current Plan. The ability to review the two plans concurrently will allow for a full understanding of the complexities of the inlet system as well as minimize the potential for statements to be taken out of context.



Section 2A Sediments, Pages 15-17. Sediment data composites for the Longboat Pass Ebb Shoal complex.

Comment: Two geotextile reports were issued by ATM characterizing the sediment characteristics of the ebb shoal. The first, the Geotechnical and Sand Source Investigation Report dated October 1989, characterized the composite mean grain size of the ebb shoal complex as being equal to 1.96 phi (0.26mm) with a sorting of 1.09 phi (0.47mm). The second report, Attachment D to the Longboat Key Sand Source Investigation report dated June 1991, characterized the composite mean grain size of the ebb shoal borrow site as being equal to 2.5 phi (0.18mm) with a sorting of 0.79 phi (0.58mm). Since the value(s) reported in the 1989 report provides the composite value for the ebb shoal complex as a whole, rather than the sediment composite that was limited to the borrow site for the planned nourishment project (situated in deeper water and thus finer), a mean grain size of 1.96 phi (0.26 mm) with a sorting of 1.09 phi (0.47mm) should be the value reported in Table 2-1 of the Plan and the text in the following paragraph.

6. **Section 4.9:** States that the modeling simulations assume that all components of the Plan are constructed simultaneously.

Comment: The model simulations are based on a set of assumed wave conditions that in nature are, at best, an approximation of the conditions that will occur in future years. It is well recognized that seasonal weather conditions, wave regimes and hurricane generated winds and wave regimes vary considerably, from expectations and predictions on an annual basis. For these reasons and based on the performance of groins near inlets that sequencing the construction in two phases would result in an improved location for the groins progressing away from the Pass channel and the orientation as the shoreline planform adjusts to the first structure. We recognize the dominant south to north longshore currents which suggest the use of less permeable groins, and a varying crest elevation to reduce sand losses to the channel and to prevent secondary tidal channels forming parallel to the shoreline, observed at this site. Why were these types of rock structures eliminated from the modeling, review and consideration?

The optimal approach will depend upon the 60% design phase drawings and plans; however, discounting or recommendations against phasing may result in a less than optimal spacing and, or may prove to be short-sighted.



7. Section 5.0 The Comprehensive Management Plan, Pages 140 to 144.

Comment: The recommend Plan is described in three pages with no information as to the baseline design assumptions such as width, lengths, volumes, costs, expected sand holding capacity, typical conceptual section views and related basis design information. Neither was this information described or provided in Section 4 (Inlet Management Alternatives) to allow for comparison of viable alternatives but rather all decisions are based on the results of a series of numerical models predictions.

Given the uncertainties for these models, the engineers need to provide their analytical methods and the associated design tools that were applied to develop the expected shoreline response to the proposed structures. This information was not included in the IMP. Typical design development phases for engineering projects follow at 30%, 60%, 90% and 100% submittal phase with permit applications at the 60% design phase. The Plan, Section 5H states what refinement of the selected plan will be accomplished during the final design phases. When will the 30% and 60% design phase work be complete for review of the draft drawings, plans and design basis documentation?

8. Technical Comments and General Changes:

- a. Erosion rates at the north end of Longboat Key exceeded 10 feet per year from 1925 to 1990, causing long term chronic erosion, as seen along Anna Maria Island due to the dredging of Tampa Bay entrance channel. These impacts, and reduced bypassing resulted in the nearly 68% of the island's shoreline armored prior to the 1993 beach nourishment project. The cause of the long term sediment deficits and erosion at the north end of Longboat Key is not clearly stated. Further the impacts of rebuilding the groins at the south end of Anna Maria Island were not discussed in terms of the impact to Longboat Key.
- b. The stable shoreline and wide beach widths for the shoreline adjacent to R-46 to R-47 strongly suggests a nodal area, referred to as a divergence in sand transport located along the shoreline between R-47 and R-49. This divergence would result in net northerly sand movement at R-47 not southerly transport as shown on Figure 2-44. The beach profile section data given in Appendix B do not appear to support the assumptions in the sediment budget along this segment of



shoreline (refer to attached Figure 1). The source of the sand gains on the ebb tidal shoal are likely greater from Longboat Key's beaches, than represented in the proposed sediment budget with less sand moving south from Anna Maria Island due to the effects of their groin field.

- c. Reference to Longboat Pass Inlet Management Plan (1993) prepared by Hearn and <u>Erikson</u> should be changed to Hearn and <u>Erickson</u>.
- d. The Table of Contents lists 5 report sections and excludes all further sub-sections and page numbers for the 144 page IMP, which is difficult to review and to understand the organization of the report to locate information. The figures are large and many could be reduced to improve readability. Please include further section sub-divisions in a manner that is similar to the list of figures.

Please contact me if you have questions concerning the comments provided herein or need additional information.

Sincerely,

ERICKSON CONSULTING ENGINEERS, INC.

Karyn Erickson, P.E., D.CE.

President

Cc: Mr. Robert Appel, Longbeach Condominium

Juan Florensa, Public Works Director

Town of Longboat Key Town Council

Erickson Consulting Engineers, Inc.

SEDIMENT CPE BUDGET ГОИ СВЕЕСН СОИ БОИ КЕУ, FLORIDA

LONGBOAT KEY, FLORIDA

AERIAL FLIGHT: 2009

0,000 CYNR 6,000 CYNR TO EBB SHOAL

Jan 19, 2012-4:28pm

2,000 CY/YR TO EBB SHOAL

2003 - 2009 BEACH FILL (CY/YR) SURVEY VOLUME CHANGE (CYN'R) -5,000 34,000 R42 - R44 R44 - R47 R47 - R51 R51 - R56 R-MON REACH 1N SEDIMENT BUDGET CELL REACH 2 REACH 3

1,000 CY/YR
TO EBB
SHOAL

ADJUSTED VOLUME CHANGE (CY/YR)

-31,000 -15,000 -5,000

NOTE: REACH 1S TOTAL SAND PLACEMENT IS 163,000 CY BETWEEN 2003-2009

Trish Granger

From: Karyn Erickson [karyn@ericksonconsultingengineers.com]

Sent: Wednesday, January 25, 2012 4:40 PM

To: Dave Bullock

Cc: rja1940@comcast.net; Juan Florensa
Subject: Longboat Pass IMP Comments

Subject: Longboat Pass IMP Comments

Attachments: ECE Longbeach Condominium Longboat Pass IMP Review Comments 01252012.pdf

Hello Dave,

Our review comments to the Longboat Key IMP are attached. Please let us know if you have questions or comments after you've completed your review of our letter and how the Town plans to proceed with respect to formal submittal to the State DEP. We look forward to working with you on this important project.

Best regards, Karyn



Karyn M. Erickson, P.E., D.CE., President Erickson Consulting Engineers, Inc. 7201 Delainey Court Sarasota, Florida 34240 941.373.6460 941.356.2162 (mobile) karyn@ericksonconsultingengineers.com

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