Blind Pass Restoration Project

Design Report
May 2006

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BLIND PASS RESTORATION PROJECT DESIGN REPORT

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1.0 Purpose

The Blind Pass Restoration Project Design Report, provided herein, has been developed to provide Lee County with a recommended Project plan and design ("Preferred Alternative") to implement the Project and to provide state and federal agencies with a Project Design Report and a preliminary assessment of the environmental and technical impacts of the Project. The Preferred Alternative will restore a direct tidal connection between the Gulf of Mexico and Roosevelt Channel, Wulfert Channel, Dinkins Bayou, and Pine Island Sound and provide a high quality sand source and shoreline protection for Sanibel and Captiva Islands. Goals and objectives that guided the design development phase of the Project include: (a) provide a stable pass channel that minimizes adverse impacts to the environment and the adjacent shoreline, whilst addressing the socioeconomic and environmental impacts on the public and the marine ecosystem, (b) placement of compatible material on the adjacent beaches to ameliorate the severe erosion downdrift on Sanibel Island and (c) restore circulation and flushing to the interior marine systems thus allowing the Pass to function naturally in an equilibrium state.

1.1 Need for Corrective Actions

Over the past 8 years, Blind Pass has remained closed as the result of instabilities in the channel geometry caused by storm induced shoaling and infilling. Since severe shoaling occurred at the Pass, the rates of erosion at Sanibel Island have increased and reduced tidal flows and flushing of Dinkins Bayou, Roosevelt Channel and Wulfert Channel have created conditions that has impaired light transmission and disturbed the historically pristine marine ecosystem. (See Figure 1-1, Current Conditions.)

The closing of the Pass also resulted in the associated loss of the ebb shoal causing the convex shoreline to erode at higher rates causing the loss of recreational beaches and storm protection to upland development.

1.2 Project Objectives

The primary objective of the Project is to restore significant portions of the many disturbed coastal ecosystems within the Wulfert Channel, Dinkins Bayou and Roosevelt Channel marine complex that have been adversely affected by the loss of a direct tidal connection to the Gulf of Mexico. This Project will also provide significantly enhanced flushing and water quality benefits to those systems which existed prior to the shoaling and closure of the Pass. Secondary benefits associated with direct channel access to the Gulf will enhance recreational benefits to the public.

The design goals and objectives for the Project include: (1) provide a natural, stable pass channel, (2) minimize future maintenance requirements, (3) minimize adverse impacts to the biological resources, and (4) maximize benefits by placing beach compatible material on the adjacent shoreline.

To develop the Preferred Alternative, several Pass channel geometries were evaluated to determine the recommended depths, widths and alignments of the channel to restore the Pass. To evaluate these alternatives, habitat resource studies, sediment analyses, and hydrodynamic model studies were conducted and assessed to determine which alternative would maximize overall performance while meeting the design criteria for the Project as described in Sections 2 and 3 of this report.

1.3 Planning and Design Development

To develop a recommended design to restore Blind Pass, field investigations and hydrodynamic model studies were conducted to supplement available scientific data and information and provide necessary data to formulate and evaluate alternative plans. Field investigations that were conducted include: hydrographic and topographic surveys, geotechnical surveys (core borings and sediment testing), continuous water level and acoustic doppler current (ADCP) measurements, wetland resource mapping and assessments, fisheries and shellfish resource assessment, and benthic sampling and analysis.

The above field investigations, along with hydrodynamic model studies and empirical analyses, were conducted to provide design tools to aid in formulating the Project's engineering design by evaluation of design alternatives. They will also provide a framework for the potential evaluation of Project induced environmental changes.

Figure 1-1 Current Conditions

2. EXISTING ENVIRONMENT

2.1. Tidal Hydraulics

Before Redfish opened in 1921, Blind Pass was a more substantial inlet as seen in historic photographs of the pass. In the 1920's, the tidal prism of Blind Pass was reduced when Redfish Pass opened and as a direct result of the "new" inlet, became a smaller, less stable inlet. Blind Pass migrated along the northern end of Sanibel Island and, also, intermittently opened and closed over several decades. The most prevalent natural influence on the inlet is wave regime driven by the wind between north and west directions and resulting sediment movement into the Pass's shoal system. Because of continuous exposure to the local wave climate, the net southerly longshore sediment movement intermittently formed a spit across Blind Pass, deflecting the channel to south. As the channel became less and less hydraulically efficient, the conditions at the northern end of the spit became more conducive to tidal breakthroughs and the formation of a new inlet location. This cycle had been repeated by the local longshore transform, wave action, and hurricane events until the pass closure in the beginning of 2000.

Blind Pass is closed and Wulfert Channel and Roosevelt Channel convey tidal flows between the Pine Sound and Clam Bayou. Currently, the west most segment of Wulfert Channel is filled with sediments and bottom elevations are generally shallower than -3 ft (NAVD88) based on surveys performed in May 2005.

2.1.1. Water Elevations, Current Velocities and Flows

Tides in the Project area are mixed with diurnal and semi-diurnal tides through the month. The mean tidal range is 1.35 ft with a spring tide range of approximately 3 ft. Erickson Consulting Engineers (ECE) measured water surface elevations at 3 locations in 2005 including the offshore site fronting Blind Pass and interior sites at Wulfert Channel and Roosevelt Channel as shown in Figure 2-1. The coordinates of these locations are listed in Table 2-1.

Table 2-1 Location of gauges to measure the water surface elevation

		ADCP #1	ADCP #2	Offshore Tidal Gauge
Geographic Coordinate	Latitude	26.49264	26.49018	26.48
	Longitude	82.17659	82.18330	82.19
State Plane NAD83 Florida West (0902)	Northing(ft)	784789.12	783898.03	780200.97
	Easting(ft)	598409.64	596213.73	594016.85

Additionally, Coastal Engineering Consultants (CEC) deployed a pressure gauge to measure water surface elevations offshore of the Pass location from March 30, 2005 to May 10, 2005.

ECE measured the water surface elevations at 6 minute intervals using two Sontek side-looking Acoustic Doppler Current Profile (ADCP) gauges at Wulfert Channel and Roosevelt Channel from February 15, 2005 to May 6, 2005. These ADCP gauges recorded both current velocity and water surface elevations in these three tidal channels. The measured water levels and current velocities for these stations are shown in Figure 2-2, Figure 2-3, and Figure 2-4, respectively. Table 2-2 shows the major tidal harmonics determined at the three stations.

Table 2-2 Harmonics of Measured Tide at Gulf of Mexico, Wulfert Channel, and Roosevelt Channel during April, 2005

Location	Constituent	Frequency (cph)	Amplitude (ft)	Phase (degree)
Gulf of Mexico	Q1	0.0372185	0.100	276
	O1	0.0387307	0.504	285
	K1	0.0417807	0.503	282
	N2	0.0789992	0.101	330
	M2	0.0805114	0.670	350
	S2	0.0833333	0.329	335
Wulfert Channel	Q1	0.0372185	0.068	299
	O1	0.0387307	0.245	316
	K1	0.0417807	0.425	318
	N2	0.0789992	0.208	32
	M2	0.0805114	0.463	47
	S2	0.0833333	0.303	20
Roosevelt Channle	Q1	0.0372185	0.109	305
	O1	0.0387307	0.464	319
	K1	0.0417807	0.408	320
	N2	0.0789992	0.153	37
	M2	0.0805114	0.477	51
	S2	0.0833333	0.283	27

The data shows damping of the primary tidal constituents which included the luni-solar diurnal (K1), principal lunar diurnal (O1), and principal lunar semidiurnal (M2) constituents as the tide progressed from the Gulf of Mexico to Wulfert Channel and Roosevelt Channel. The peak currents in Wulfert Channel and Roosevelt Channel were approximately 0.3~0.4 ft/s and 0.1 ft/s, respectively. Because measured current velocities in the shallow channel was generally affected by the local wind, some recorded velocity peaks are greater than other peaks.

2.1.2 Tidal Prisms

The tidal prism for the mixed tide diurnal/semi-diurnal type of tide is not a constant value, which changes depending on the tidal conditions each day. Currently, Blind Pass does not have a tidal flow through the Pass as the Pass closed in 2000 due to heavy shoaling. The tidal boundary from the period between April 3 and April 17 was applied to determine the tidal prism calculations. The averaged tidal prisms of Redfish Pass based upon hydrodynamic numerical simulations conducted by ECE are 688×10^6 ft^3 and 991×10^6 ft^3 at flood tide and ebb tide, respectively.

2.2. Waves and Littoral Processes

2.2.1. Wind and Wave Condition

To estimate long term wind and wave conditions, hindcast wave data (WIS) is the most reliable information to characterize the wave and wind climate at offshore from the project site. Hindcast wave data is generated by numerical simulations of past wind and wave conditions and provides the wave climate data to apply to design projects located in coastal zones. WIS hindcast data (http://frf.usace.army.mil/wis/wis_main.html) have been updated and uses a finer grid spacing, superior wind field, and higher resolution bathymetry for the period of 1980~1999 than older hindcast methods. Wind data was compiled for the WIS hindcast station #290 in Gulf of Mexico. This station is located at the offshore (26.42N and 82.33W, 16m depth) approximately 11 miles west of Blind Pass which is mapped in Figure 2-1. Figure 2-5 provides the wind rose for the most recently available twenty year (1980~1999) period.

At the site, the most prevalent wind directions were from the northeast through southeast. The seasonal wind trends are distinguished between the summer season from June to August and winter season from December to February as shown in Figure 2-6 and Figure 2-7, respectively. The winds from the east through the south dominate during the summer season whereas the primary wind direction during the winter season is from the north through the east (representing an offshore wind direction). Overall, the wind trends shift from the northeast to the southeast between winter and summer seasons.

Waves are generated by the local wind and weather disturbances and create the driving force for the coastal processes which include the longshore transport and the resulting beach erosion/accretion. The predominant offshore winds produce waves that travel away from land into the Gulf of Mexico, leaving the project area free of wave activity. For this reason, waves directed at the project site are the focus of this analysis. Wave roses of significant wave height and peak wave period are shown in Figure 2-8 to Figure 2-9, respectively, using the recent hindcast wave data for the twenty-year period (1980~1999) at WIS station #290 which is mapped in Figure 2-1. The approximate shoreline alignment at Blind Pass is also superimposed onto the wave rose diagram. The primary direction of wave is between the northwest and the west-northwest. The peak wave period of 4~6 seconds is dominant for most wave directions from the west, and in turn drive the sediment transport which effects the coastal process in the project area. The seasonal wave roses of significant wave height and peak wave period are shown in Figure 2-10 through Figure 2-13. Figure 2-10 and Figure 2-11 present the seasonal wave roses of significant wave height for summer and winter seasons, respectively. The northwest and west-northwest waves are dominant for both summer and winter seasons, but wave energy is higher in the winter season than the summer season. The wave peak period of 2~4 seconds prevails during both seasons as shown in Figure 2-12 and Figure 2-13. The long period (>10 seconds) swells occur from the west-northwest during the winter season causing the strongest longshore currents and sediment movement along the west coast of Florida. The most frequently occurring waves along the study area were from the northwest and west-northwest, with a peak wave period 4 ~ 6 seconds.

2.2.2. Littoral Transport

Littoral transport in the Blind Pass Restoration area is primarily controlled by fluctuations in wave height and direction. Tidal and local wind-driven currents represent a secondary sediment transport mechanism, but generally require initial suspension of the sandy sediments by wave action followed by current transport. It is generally accepted that the littoral transport along Florida's southwest coast is predominately from north to south because of predominant waves from the northwest and west-northwest. Upon wave breaking, these waves induce a longshore transport that is related to the wave energy and breaking angle. Surrounding Blind Pass, the shoreline orientation of the coastline is aligned approximately 150 degrees to 330 degrees from north. Estimates for the littoral transport at the project area vary widely. Applied Technology and Management (1987) estimated that the net longshore sediment transport in the southward direction was approximately 100,000 CY. Using the empirical equations (Shore Protection Manual, 1984), net longshore transport volume ranged from 60000 to 138000 CY per year in the south direction (CPE, 1995).

2.3. Geomorphology and Pass Migration

Blind Pass is bounded on the north by Captiva Island and the south by Sanibel Island and connects Pine Island Sound to the Gulf of Mexico. The survey taken in 1859 indicates that Blind Pass was open at that time, far to the south of the interior tidal channel (CPE, 1993). Since Redfish Pass was formed by the Hurricane of 1921, Blind Pass lost a significant portion of Pine Island Sound's tidal prism, which led to it's characterization as a wave-dominated inlet. Before Redfish Pass opened, Blind Pass was an inlet with a mixed-energy downdrift offset form. The flood-tidal delta, developed under the pre-Redfish Pass condition, was large and well-defined. Underlying the "Gilbert" theory, the southward longshore sediment transport has formed a barrier island progressively as a spit extending in a downdrift direction from Blind Pass. The longshore sediment transport caused a sand spit to grow southward from Captiva Island to north Sanibel Island across Blind Pass, deflecting the channel to the south. An ongoing beach nourishment program that provides a significant source of sediments to the Gulf shore of Captiva Island which has continued to feed the existing south-trending spit. Continued spit growth and placement of beach sand on northern Sanibel Island in 1996 contributed to the most recent closure of the inlet. Historical pass migration and morphological changes are shown in Figure 2-14 through Figure 2-20. Its recent history is varied: the inlet closed in 1960, opened in 1972 and closed again in 2000.

2.4. Sediments

2.4.1. Geographic and Geologic Setting

The presently closed Blind Pass is located in Lee County between Captiva Island and Sanibel Islands between Redfish Pass to the north and San Carlos Bay and Matanzas Pass to the south. The Blind Pass Restoration Project would reopen the closed Pass approximately 5 miles south of Redfish Pass.

The peninsula of Florida is the emergent eastern half of the great continental platform, Floridian Plateau. This partially submerged platform separates the deepwater of the Gulf of Mexico from the deepwater of the Atlantic Ocean. The great continental platform is nearly 500 miles long and ranges from 20 to 450 miles wide.

Since the beginning of the Pleistocene period, (approximately 1.6 million years ago) the coastline of Florida has periodically and repeatedly been submerged and drained during fluctuations in sea level. These oscillations appear to be correlated with the Pleistocene glacial and interglacial stages during which great quantities of water were alternately withdrawn and returned to the sea by freezing and melting of the continental ice sheets.

2.4.2. Sediment Characteristics

Coastal Engineering Consultants (CEC) under subcontract to ECE conducted supplemental investigation of the Project area, extracting 9 core borings within the potential areas of excavation. Additionally, 13 previous cores taken in 2004 by CEC which provided the information and data for analysis of sediment characteristics within areas of potential excavation. Both geotechnical investigations of the areas (i.e. channel alignments), were designed to collect cores where dredging is most likely to occur, and were conducted to determine the material composition within the proposed area. The borings were taken to define the material characteristics at varying depths and locations suitable to develop Project plans and design features and to prepare permit applications to state and federal agencies.

A total of 22 sediment core borings (13 taken in 2004, and 9 taken in 2005) were performed along the areas where the primary tidal channel may be located. All cores were located (x, y, z) using survey quality GPS equipment and referenced vertically to NAVD 88. Core locations are shown in Figure 2-21. Samples were taken from each core for grain size testing and analysis. Cores were catalogued using standard core log forms and sediment testing and analysis performed to characterize the sediments using standard statistical methods (mean, standard deviation, etc). The core logs and grain size distribution data are provided in The Final Geotechnical Report January 2006 Blind Pass Ecosystem Restoration attached under separate cover to the State of Florida JCP Permit Application submittal.

The sediments within the proposed channel inlet corridor are comprised mostly of well sorted fine grained shelly quartz-rich sand. The material is comprised of fine to medium grained sized sand and shell with a silt and clay fraction generally less than four percent (4%) above a depth of -10 to -12 ft, NAVD.

Soil tests indicate these sediments are SP type soils as identified by the Unified Soil Classification System. Layers of clayey sands can be found at differing depths and thicknesses within the Tidal Channel further inland of the bridge location. The percentage of material passing the #230 sieve was found to be less than three percent (3%) for the composites of the samples at the Preferred Alternative cut depths and volumes. Data from all of the cores indicate that the shell content ranges from zero to thirty percent based on the cut depths established for the alternative, where shell material is classified as the percent retained on the #4 sieve. Additionally, fine sand sized sediment, between 0.250 mm and 0.125 mm, are present throughout the study area.

Composites representing the sediment characteristics, as represented by cumulative grain size distributions, have been developed and evaluated for the preferred design alternative and evaluated in Sections 3 and 4 of this report. A representative longitudinal section view between the Gulf and Wulfert Channel was developed to provide a conceptual representation of the core locations and the elevations of the existing bay bottom (refer to Figure 2-22, 2-23, 2-24 and 2-25).

2.4.3. Historic Sediment Information for Beaches adjacent to Blind Pass

Historic native beach sediment along Captiva and Sanibel Island dates back to before 1981. Captiva Island has been re-nourished four times with large quantities of sediment placed in 1981, 1989, 1996 and in 2006. The 1981 project was centered at the South Seas Plantation and involved the placement of 655,000 cy of material. The largest re-nourishment took place in 1989 when 1.595 million cy were placed from R-84 (Redfish Pass) to R-109 at Blind Pass. In 1996, 817,000 cy of material was placed from R-85 to R-114.

Results show a decrease in mean grain size from the native (pre-1981) dry beach sediment to the 2001 dry beaches (South Captiva and Sanibel) sediment at the project area. The sorting values for the beaches are all within the poorly sorted range and the silt content for the dry beaches (pre-1981, and 2001) are less than 5%.

Table 2-3 Historical Native Sediment Characteristics

Areas	Date	Mean Grain Size (mm)
Native Beach Composite	Pre-1981 project	0.57
Native Dry Beach	Pre-1981 project	0.64
Redfish Pass	Used 1981 & 1988 projects	0.57
BA III	Used in 1995/96 project	0.37
Captiva Beach Composites 2001	2001 samples	0.44
Captiva Dry Beach 2001	2001 samples	0.42
Sanibel Dry Beach Composites 2001	2001 samples	0.42
Sanibel Offshore 2001*	2001 samples	0.39

* MHW line to the -12 ft contour

2.5 Biological Resources

2.5.1 Introduction

The local biologic resources, in the vicinity of Blind Pass, consist primarily of marine habitats, seagrass beds, and wetland habitats which provide for a wide range of fish, shellfish, and other macro invertebrate ecosystems. Several protected species are known to frequent the areas adjacent to Blind Pass including sea turtles, West Indian manatees and the bald eagle. Comprehensive field investigations within the study area were conducted in the summer of 2005 to supplement available scientific data and information and provide the necessary data to formulate and evaluate design alternatives.

2.5.2 Methodology

The biologic surveys were conducted to document the distribution, occurrence, abundance and density of sea grasses within the study area as well as occurrences of other resources, such as oyster beds, rocks, sand, marine algae, as well as mixed assemblages. Survey sampling was aided by use of ArcView

GIS software. Transects and targets were located in the field using Trimble navigational software, and a snorkel point-intercept survey was performed. Time of observation, water depth, species composition, and percent coverage were recorded. For benthic macrofaunal analyses, conducted according to FDEP protocol as of their July 27, 2005 memo, sixteen (16) core samples were taken utilizing a petite ponar sampling device. Each Sample was washed through a 0.5 mm (No. 35) sieve. Wetland delineation of mangroves and other state protected flora and fauna or their habitat was determined.

2.5.3 Seagrass and Other Marine Habitats

A biologic study of the seagrass, as well as other resource presence, was conducted during May 11-13, 2005 and late September 2005 by Dial Cordy & Associates. This survey was conducted during recovery from the 2004 hurricane season and exhibited several stress indicators, such as turbid water, recovering sea grasses, and heavy algae cover. The closer to Blind Pass and more shallow the seagrass bed, the greater the algal cover.

2.5.4 Benthic Analysis

A benthic survey was performed on September 1, 2005 by Lee County Natural Resources Division in the vicinity of the proposed project. Those areas with high species population generally had low species diversity and conversely those areas with low species populations generally exhibited high species diversity. The more diverse species populations were found in deeper waters along the northern end of the study area, farthest from Blind Pass, and the less diverse more populated areas were closer to Blind Pass.

2.5.5 Wetland Habitat

A delineation survey was conducted of the mangrove and other state protected wetland species. These areas were categorized as either mature, historically established, mangrove habitat or immature, recently colonized, mangrove habitat. Mature mangrove communities are established along the shorelines of the study area including a narrow fringe between the established residential communities on Captiva Island. The immature red mangrove seedlings have become established on the newly accreted sand that extends on the northern side of the bridge. The most recently accreted areas have the shortest and most sparse populations of mangroves. As the established accreted sand remains established, the mangrove communities will continue to grow and mature.

2.5.6 Fish and Shellfish

Seagrass habitats along the Gulf coast of Florida typically have a high diversity of fish species, although no fish species were observed during the seagrass study. Historically, the area has been noted for it's populations of redfish, snook, and sea trout. All of which provide both recreational and commercial sport fishing resources. During the seagrass study two oyster beds were observed in the study area, each of which provides habitat for several species of crab.

2.5.7 Protected Species

The West Indian Manatee distribution in Lee County includes substantial sightings in Pine Island Sound throughout the year, but substantially lower numbers occur during the colder months. Only four reported manatee fatalities were recorded near the study area between 1976 and 2002. Two deaths were watercraft related, one was perinatal, and one was undetermined. Sea turtles nesting data provided by Lee County Natural Resources Division showed sea turtles regularly nest on both Sanibel and Captiva Islands. The historical data shows several nests over the four year study period.

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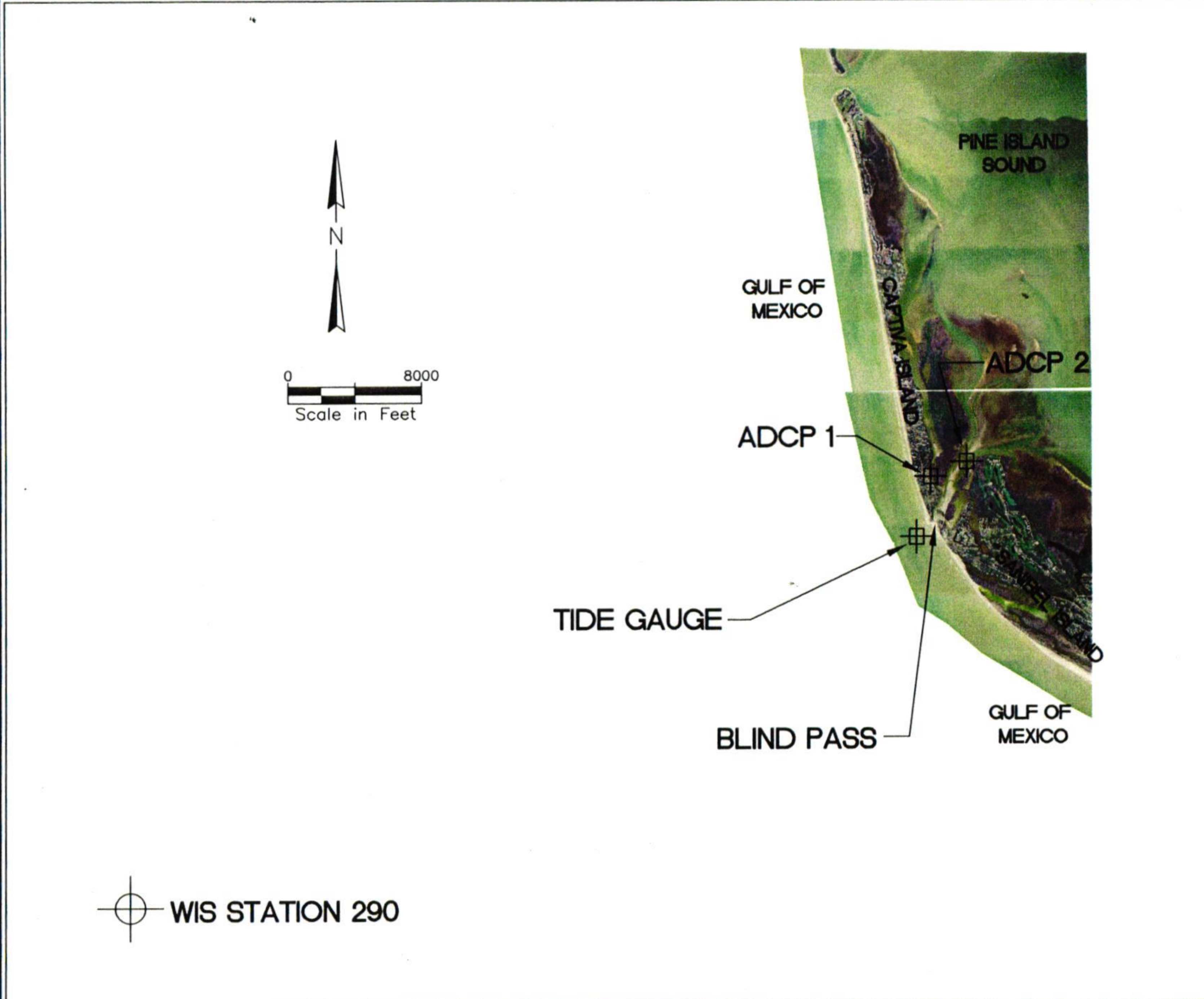

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FIGURE 2-1 LOCATION OF WAVE AND TIDAL GAUGES

Blind Pass Restoration
Lee County

REVISIONS

PROJECT 05-129	CHECKED BY WJ
DATE 04/25/06	DRAWN BY JE
SCALE As Shown	SHEET: 1 of 1

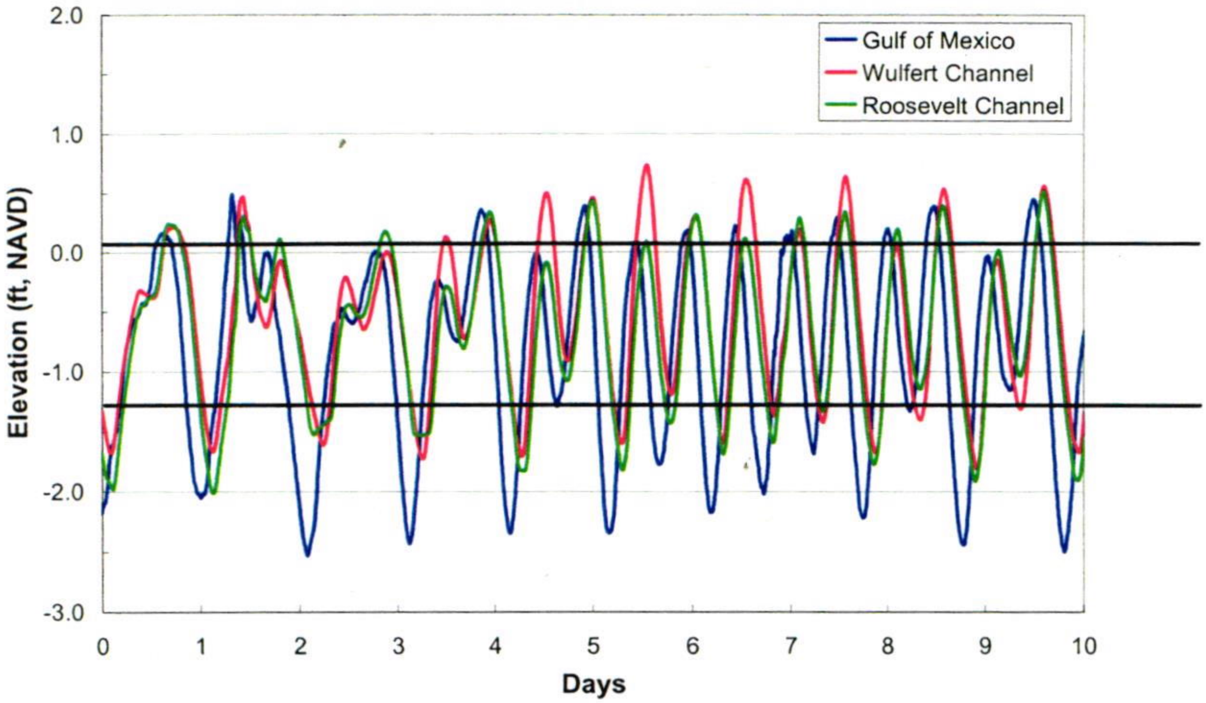


Figure 2-2 Measurement of Tidal Elevation

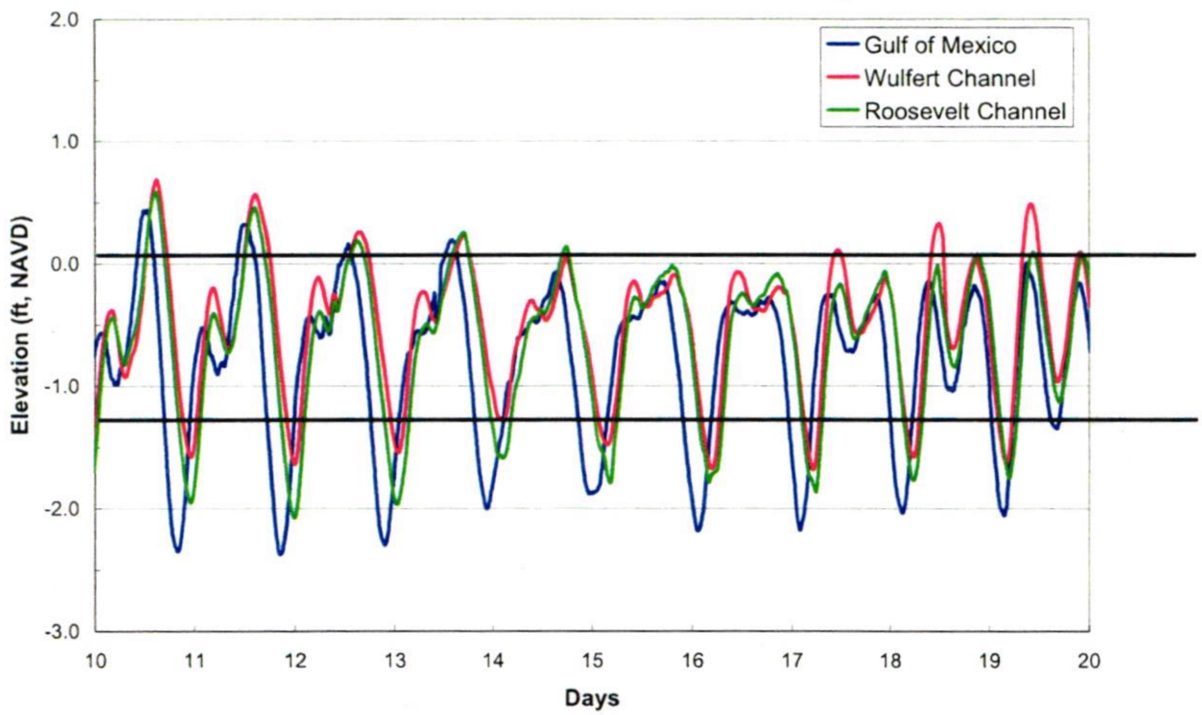
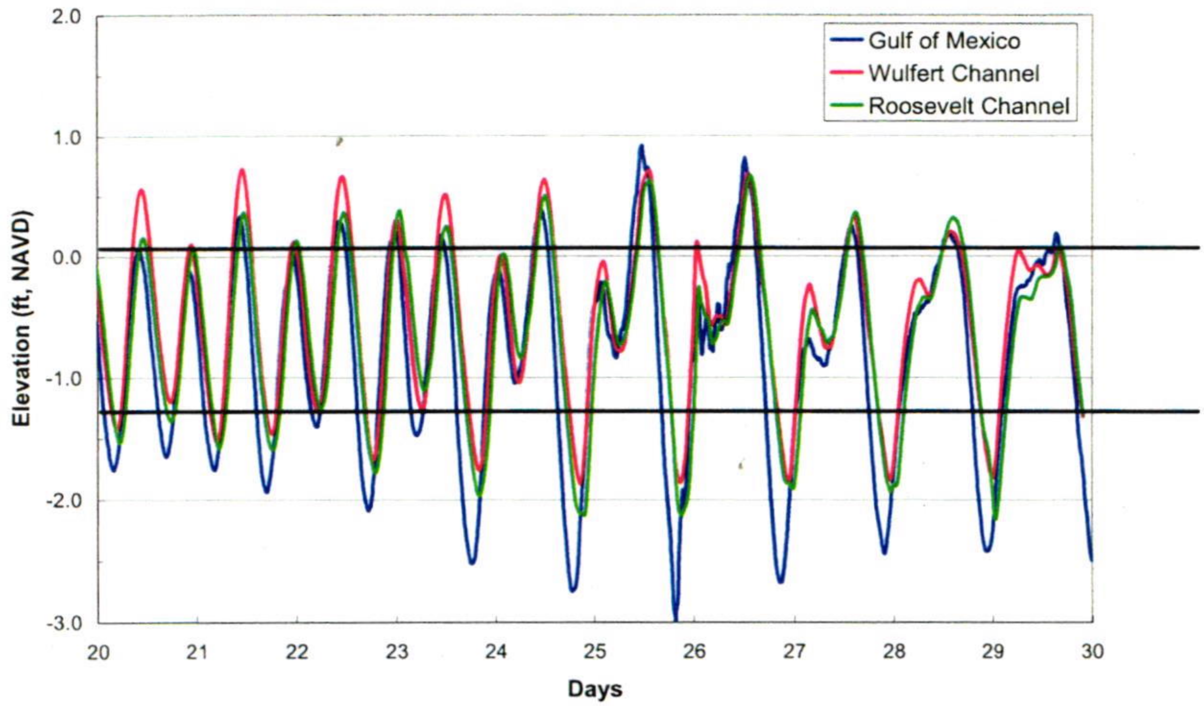


Figure 2-2 Continued



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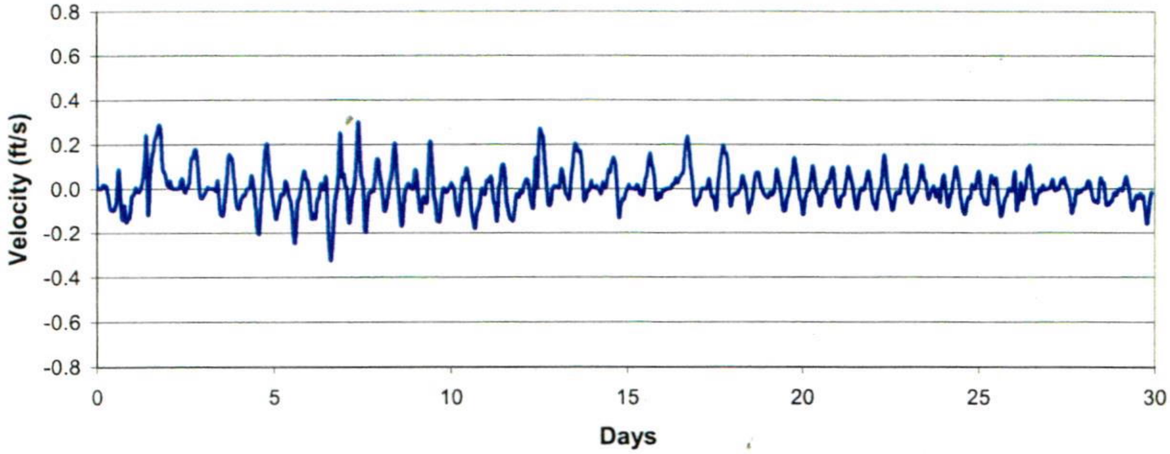


Figure 2-3 Current Velocity at Roosevelt Channel

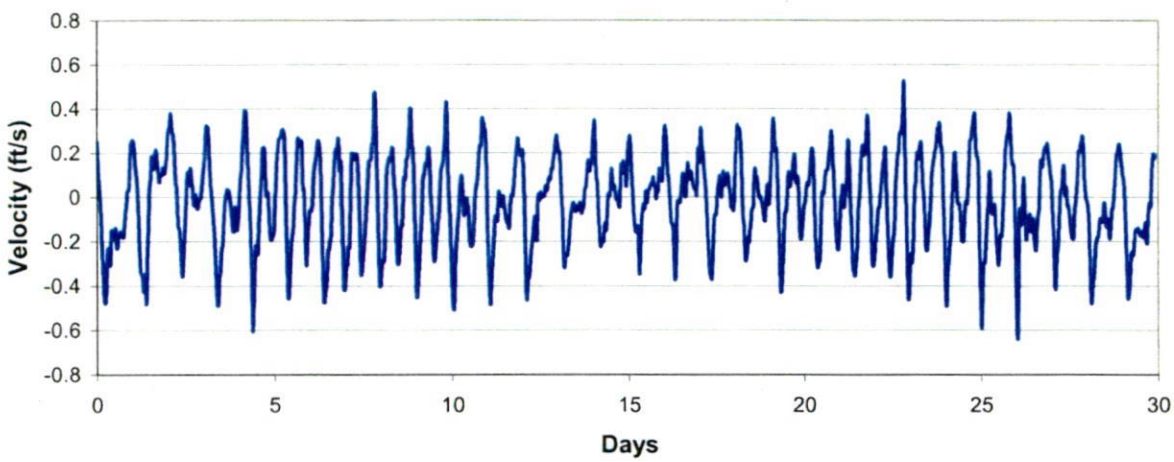


Figure 2-4 Current Velocity at Wulfert Channel

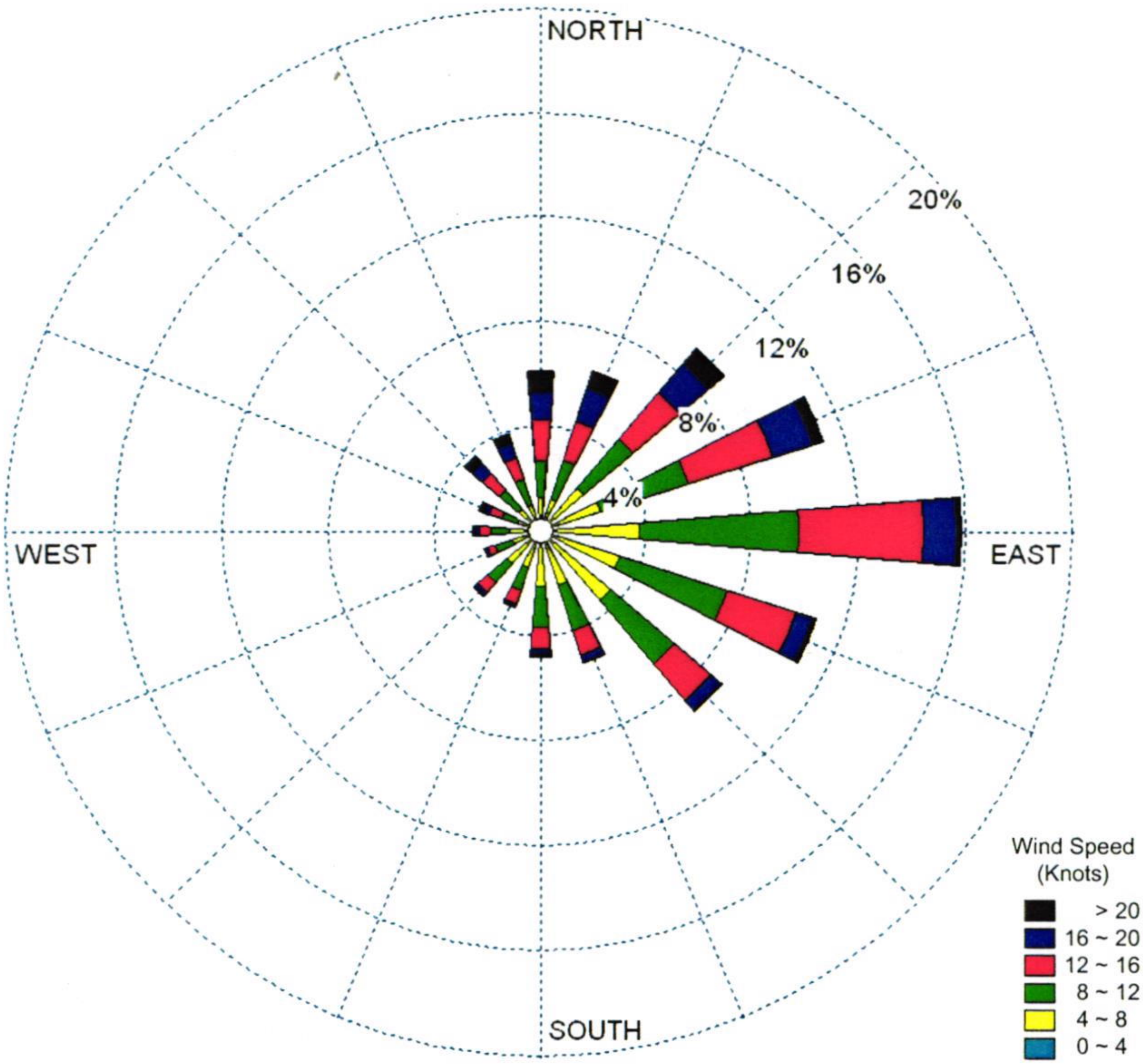


Figure 2-5 Wind Rose during the 20-years period at WIS Station #290

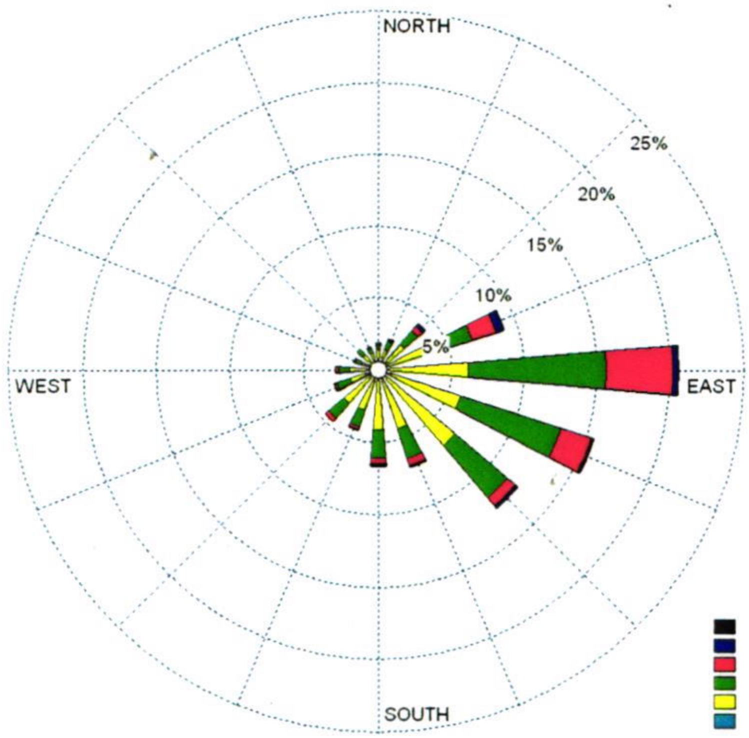


Figure 2-6 Wind Rose during the summer season at WIS Station #290

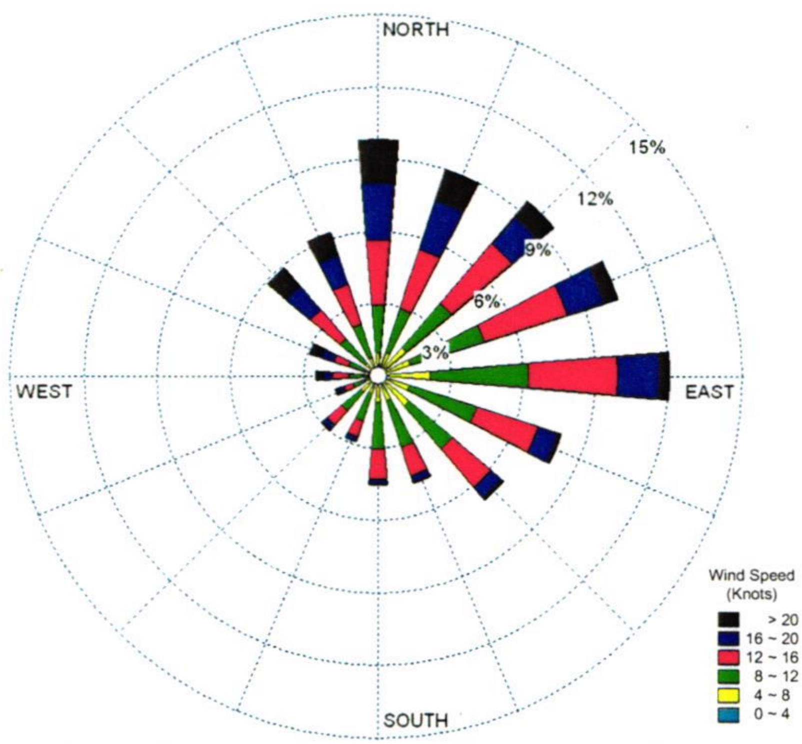


Figure 2-7 Wind Rose during the winter season at WIS Station #290

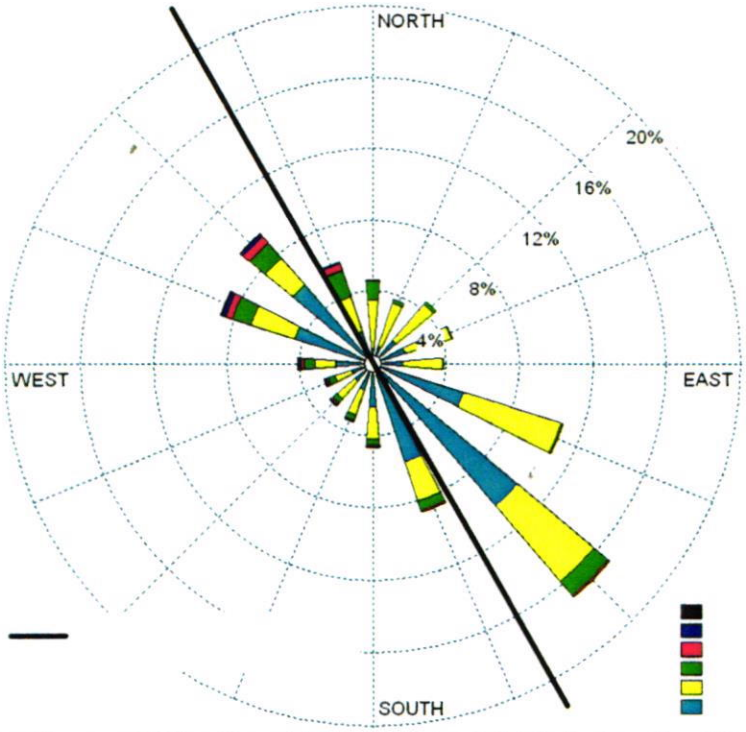


Figure 2-8 Wave Rose of Significant Wave Height (H_S) during the 20-years period at WIS Station #290

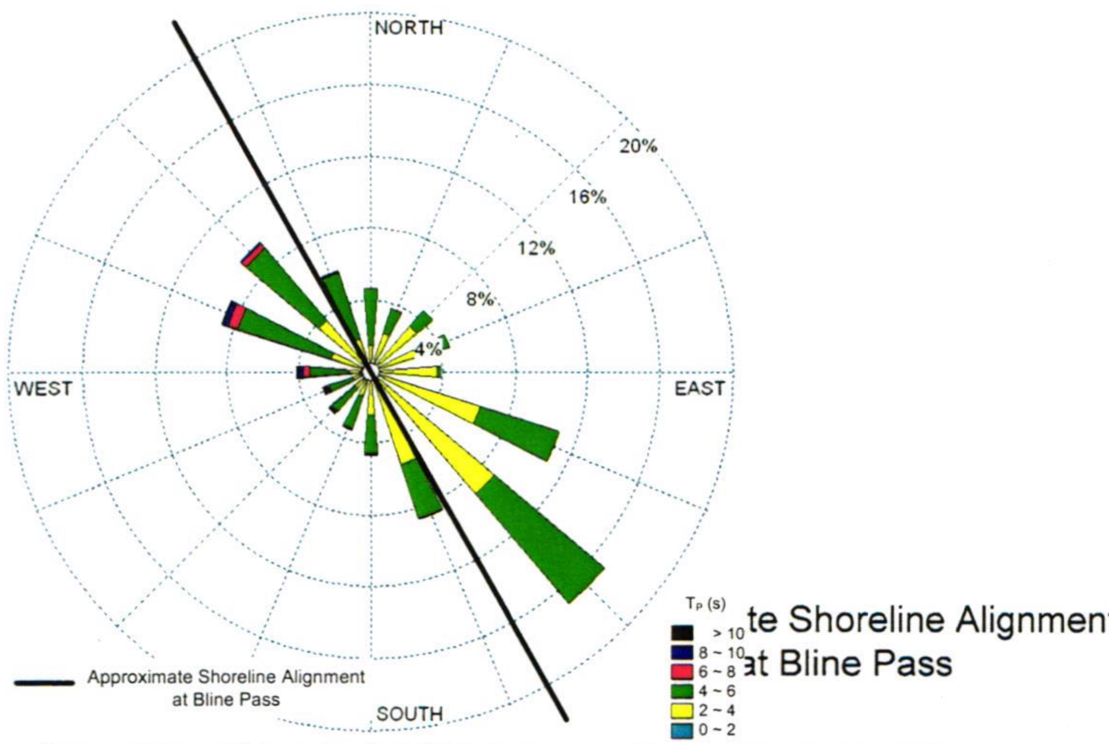


Figure 2-9 Wave Rose of Peak Wave Period (T_P) during the 20-years period at WIS Station #290

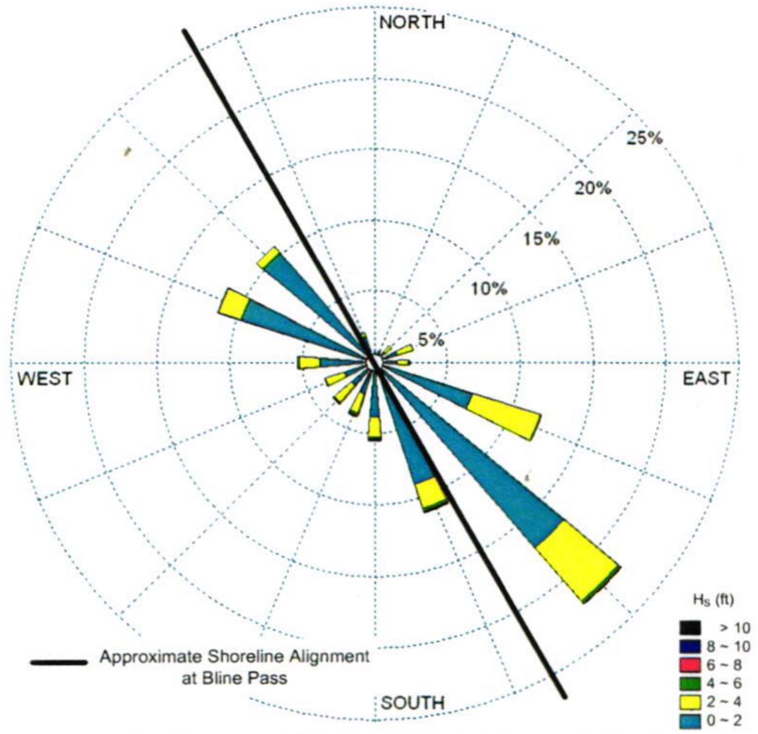


Figure 2-10 Wave Rose of Significant Wave Height (H_S) during the summer season at WIS Station #290

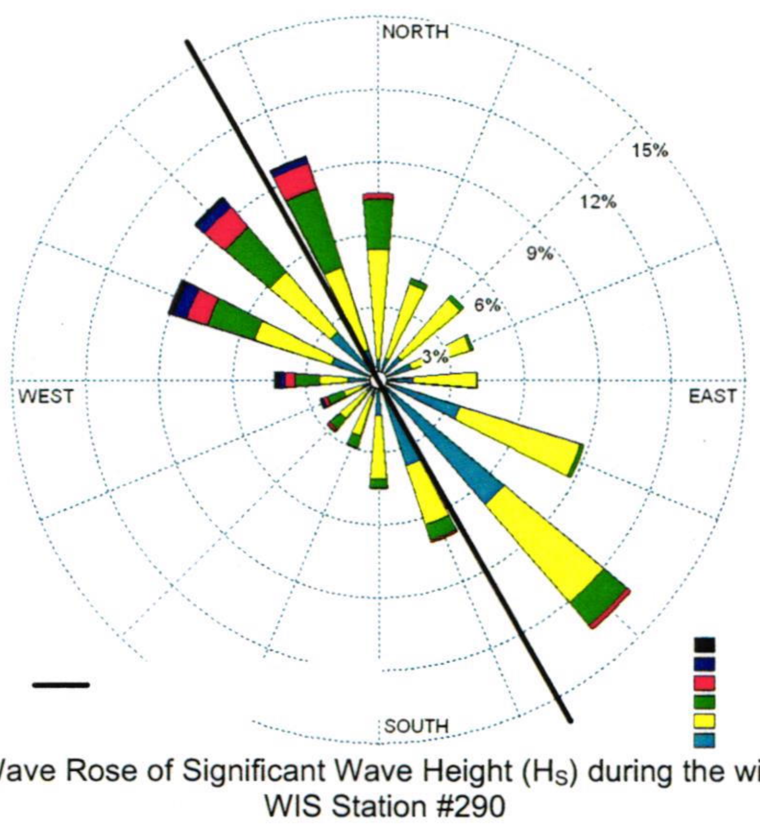


Figure 2-11 Wave Rose of Significant Wave Height (H_S) during the winter season at WIS Station #290

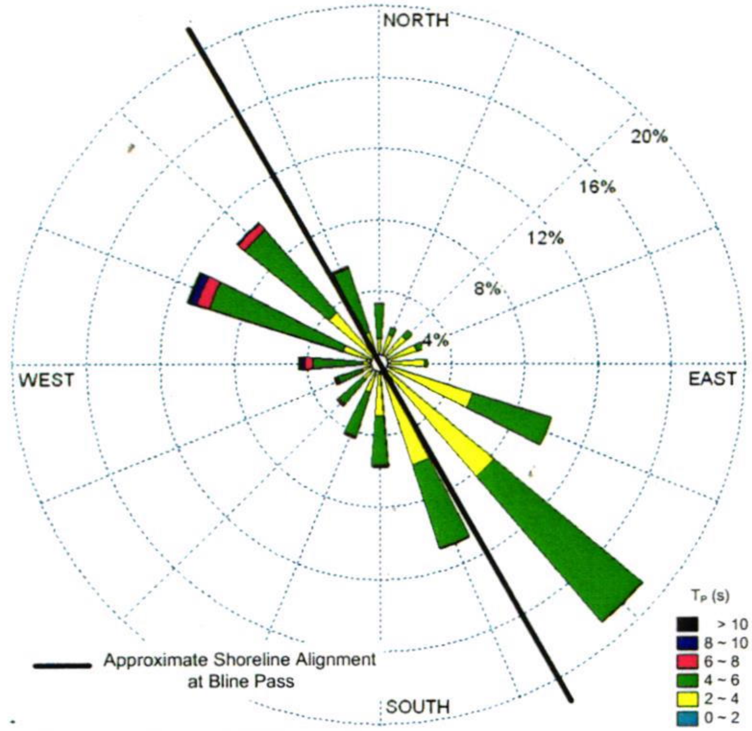


Figure 2-12 Wave Rose of Peak Wave Period (T_P) during the summer season at WIS Station #290

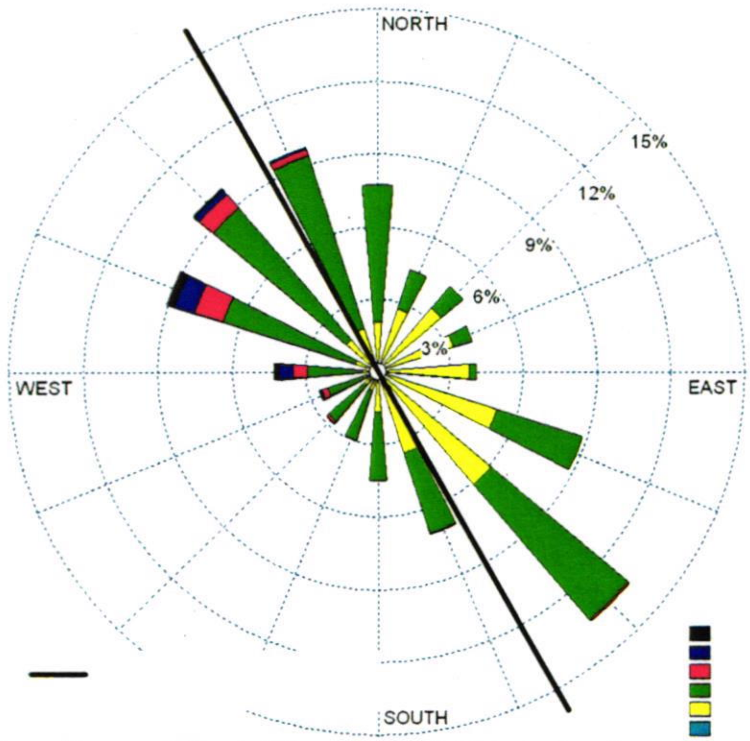


Figure 2-13 Wave Rose of Peak Wave Period (T_P) during the winter season at WIS Station #290

Figure 2-14 Blind Pass in 1944

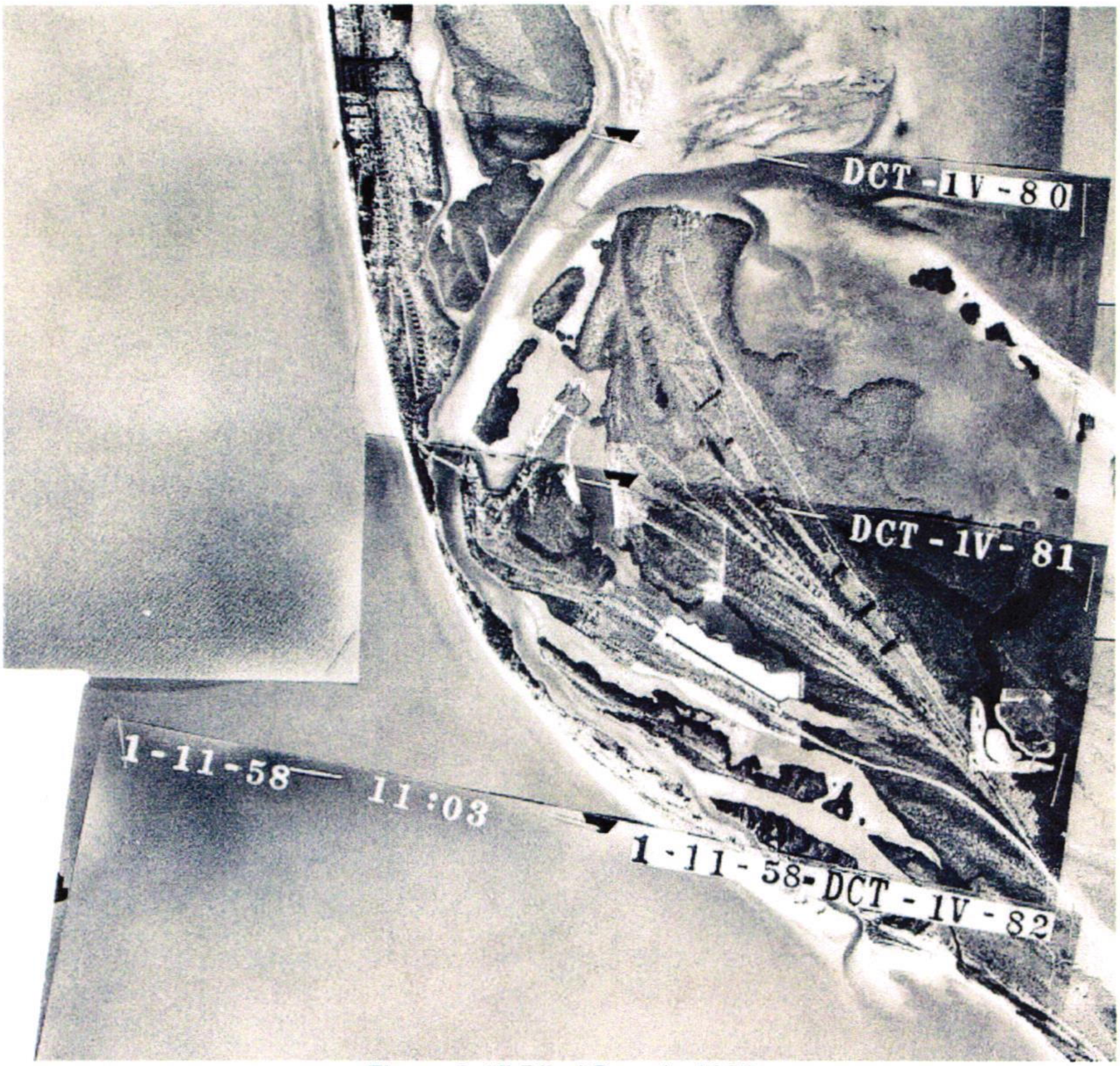


Figure 2-15 Blind Pass in 1958


Figure 2-16 Blind Pass in 1970

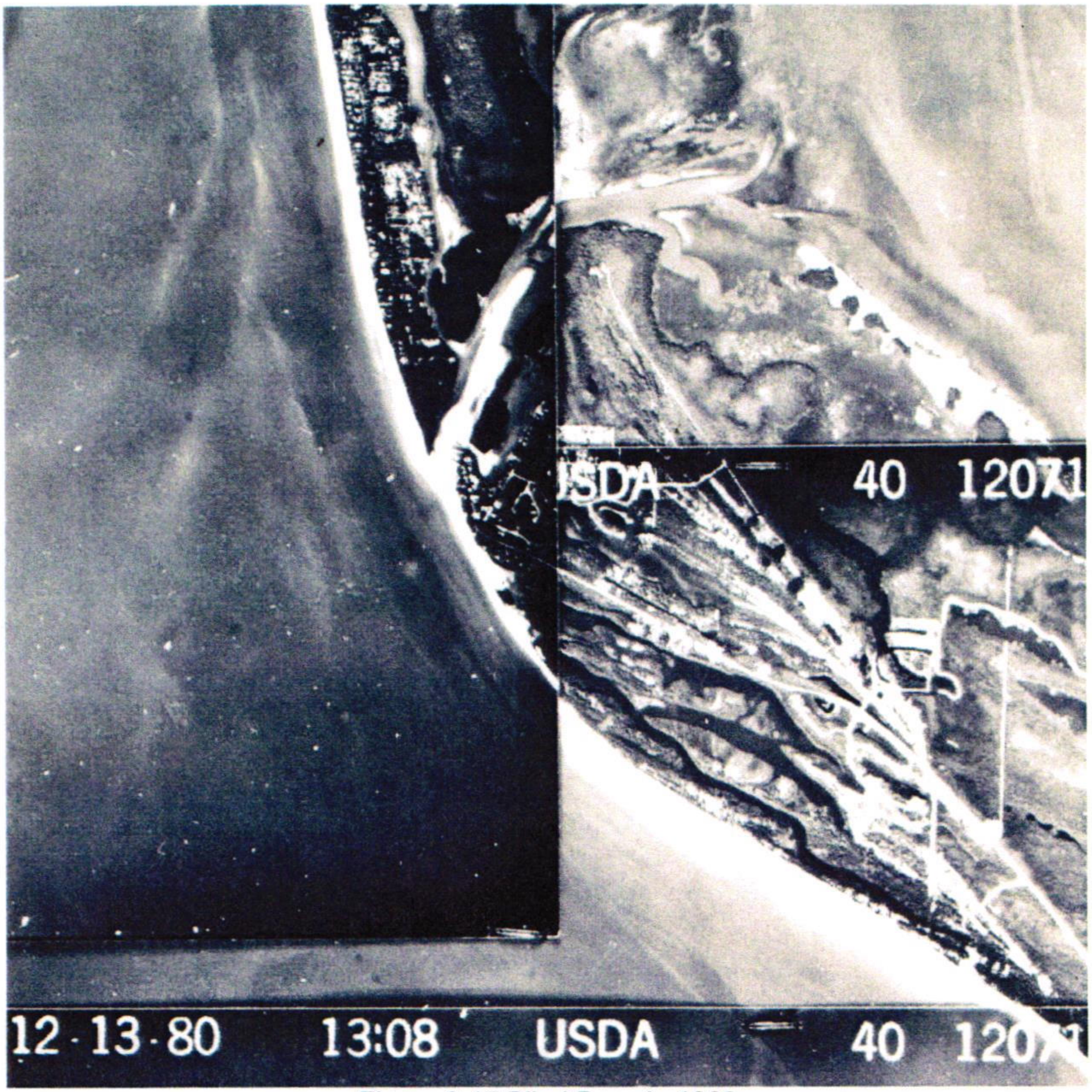


Figure 2-17 Blind Pass in 1980

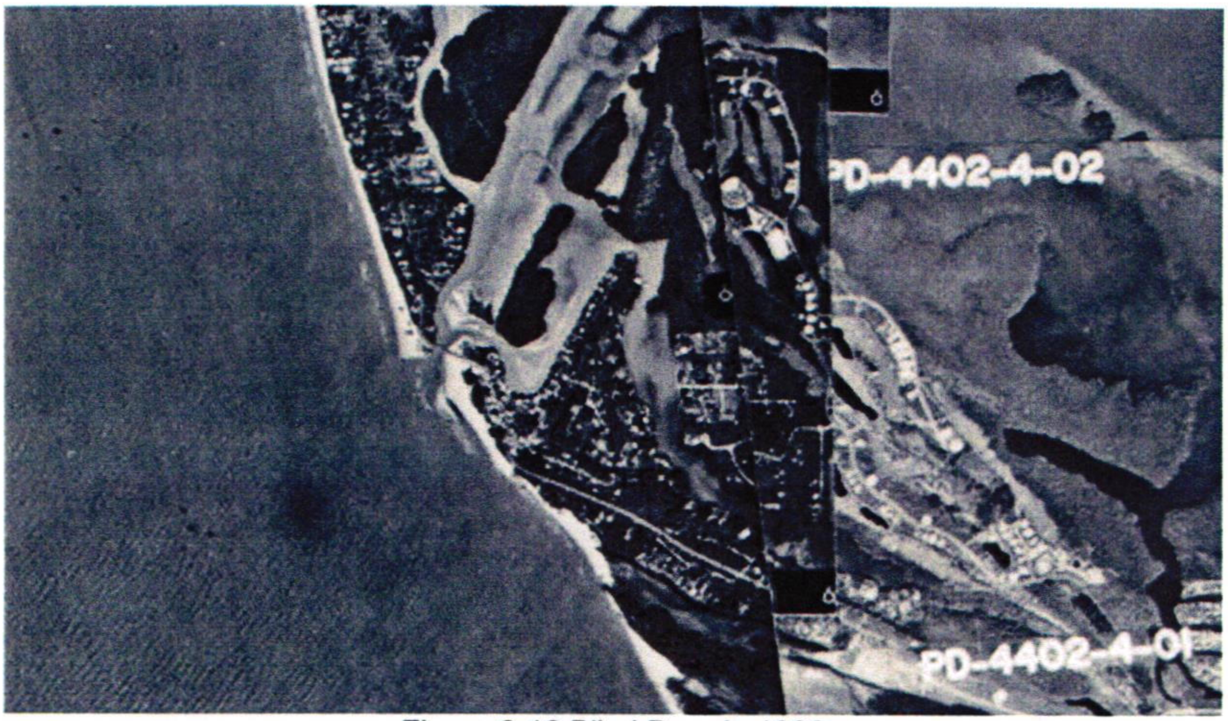


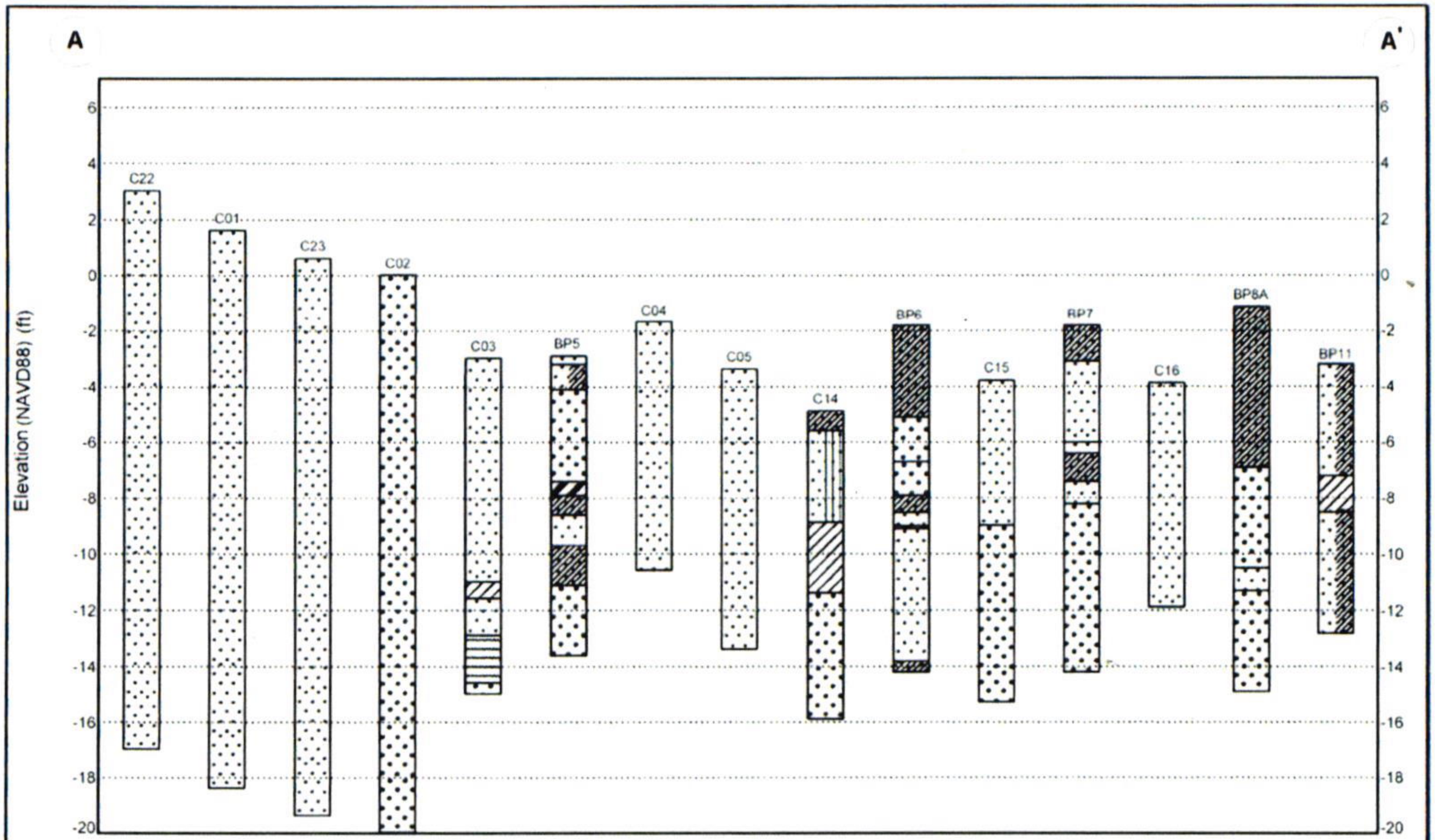
Figure 2-18 Blind Pass in 1996

Figure 2-19 Blind Pass in 1999

Figure 2-20 Blind Pass in 2005

Figure 2-21 Plan view of core locations and geologic cross sections within the study area.

Figure 2-22



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Blind Pass
Decompacted Cores
Horizontal Baseline Not to Scale

Figure 2-23

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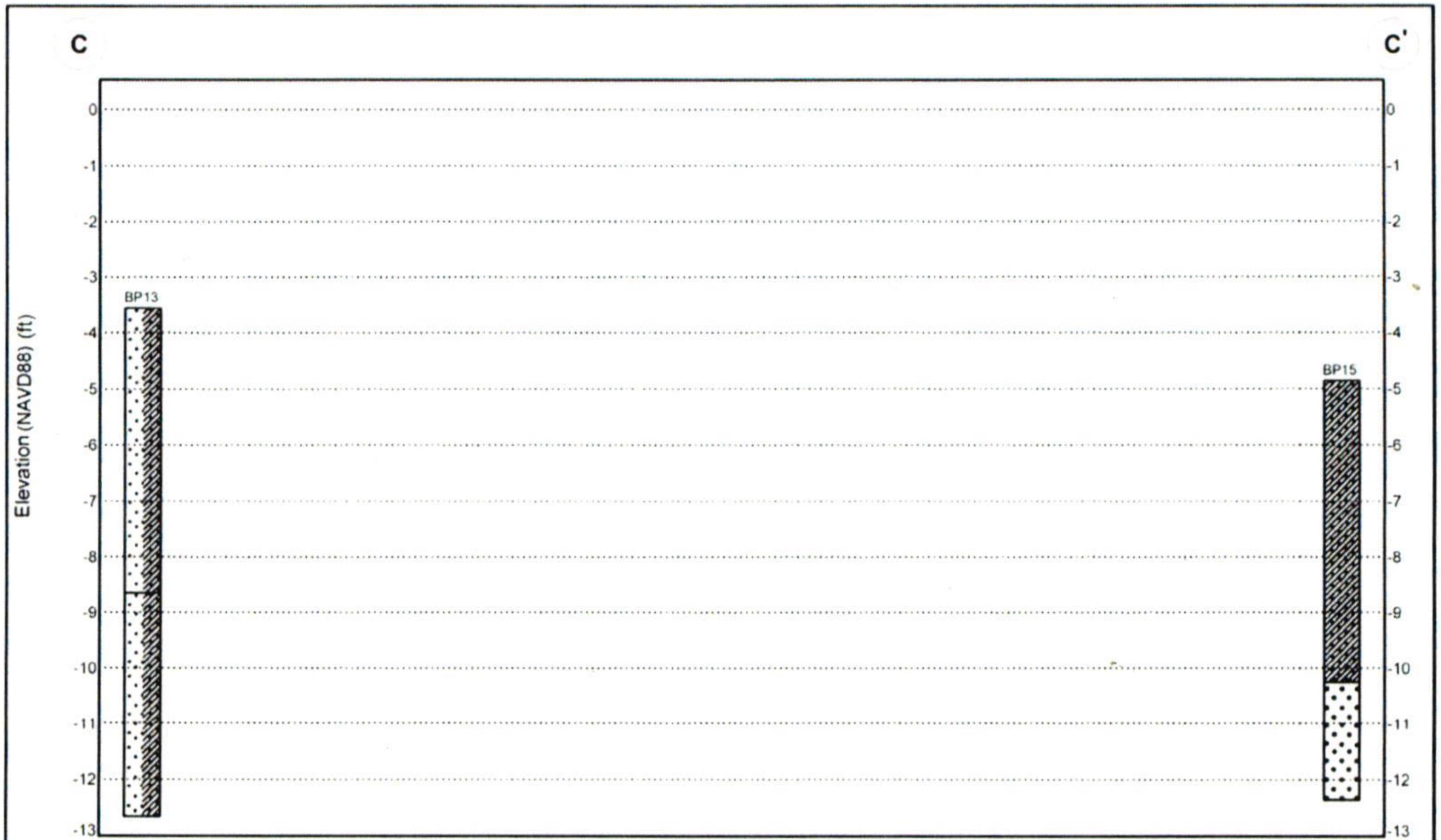
Blind Pass
Decompacted Cores
Horizontal Baseline Not to Scale

Figure 2-24



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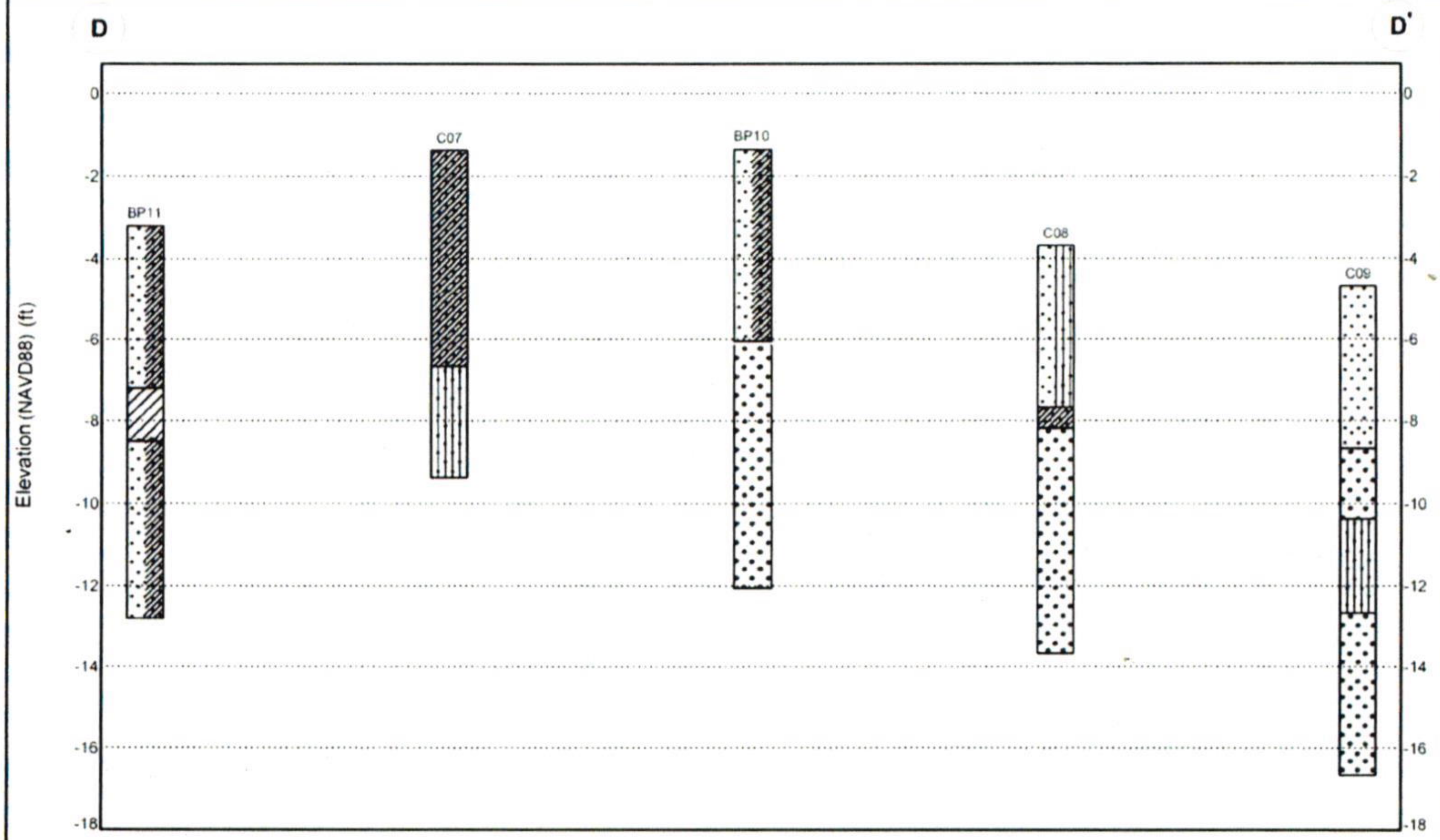
Fax (321) 751-2343

Blind Pass
Decompacted Cores
Horizontal Baseline Not to Scale

Figure 2-25



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Blind Pass
Decompacted Cores
Horizontal Baseline Not to Scale

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ECE Erickson Consulting Engineers 1819 Main St., Suite 402 Sarasota, FL 34236 (941) 952-0487	FIGURE 2-26 NATURAL COMMUNITIES Blind Pass Restoration Lee County, Florida	REVISIONS	PROJECT 05-129 DATE 04/27/06 SCALE 1"=400'	CHECKED BY JG DRAWN BY JE SHEET: of

3. ALTERNATIVES

To determine the preferred channel geometry and alignment for the Blind Pass Restoration Project, an evaluation of alternative design features was conducted using numerical and empirical analysis methods. The design goals that guided the development of the Preferred Alternative include: (1) provide a natural, stable channel, (2) minimize future maintenance requirements, (3) minimize adverse impacts to biological resources, (4) maximize beneficial changes that improve flushing of the interior bay waters, and beneficial impacts to the hydrodynamic regime at Redfish Pass. Nine alternative geometric configurations were developed and evaluated to determine which alternative best met the Project's design goals and objectives.

To evaluate these alternatives and to provide a framework for the evaluation of potential Project due to environmental changes, hydrodynamic model studies, natural resource studies, geotechnical testing, and sediment analyses were conducted to aid in the engineering design of the Preferred Alternative. A two-dimensional numerical hydrodynamic model (ADCIRC) was set up and calibrated to simulate the water surface elevations and current velocities in the project area to provide a framework for evaluation of different design alternatives. Analyses of these alternatives, based on the ADCIRC model simulations, reflect the existing hydrodynamic conditions and the projected hydrodynamic conditions which will result from the Project.

The Preferred Alternative is based on an evaluation of each alternative, in terms of the expected inlet cross-sectional and planform location stability, tidal prism and current velocities, environmental impacts, expected permitting constraints, estimated maintenance requirements and anticipated performance.

3.1 Geometry of Alternatives

Alternatives were analyzed to restore Blind Pass in the configuration that is designed to minimize biological impacts and minimize future maintenance at the pass as well as provide a hydraulically stable pass, and utilize channel widths and cut depths to provide compatible dredged sediment characteristics for beach placement. These alternatives are comprised of the following components (Figure 3-1):

- Deepen and widen the Gulf Entrance of Blind Pass varying amounts to achieve a tidal prism to minimize the problem of future pass cross-section instability.

- Vary the depth and width of the Transition Tidal Channel to design a stable tidal channel and minimize the adverse impacts on wetland communities.

- Deepen and widen of the Interior tidal channel to improve the tidal flushing in Roosevelt Channel and Wulfert Channel.

In evaluating the alternative channel geometries to determine the Preferred Alternative, detailed hydrodynamic numerical model studies were performed for alternative channel geometries. Channel depths varied from -10 ft to -14 ft (NAVD 88) at the Gulf Entrance, from -6 ft to -14 ft (NAVD 88) at the Transition Tidal Channel, and -8 ft (NAVD 88) at the Interior Tidal Channel (as shown in Figure 3-1). Channel widths vary from 100 ft to 220 ft at Bridge section and 100 ft to 160 ft at Critical Section as shown in Figure 3-1. Channel alignments are designed to be bended at Critical Section to minimize the impact on mangrove wetlands. Cross sectional areas at the bridge section are changed from 960 ft^2 to 2500 ft^2. These alternatives are summarized in Table 3.1. Figure 3-2 shows alternatives of smallest, preferred, largest cross sections at Bridge Section with the existing bridge feature. Hydrodynamic modeling results of these alternatives are described in Section 3.2.

To further reduce the potential for adverse impacts along the channel margins, the interior tidal channel follows along a west to east orientation coincident with the historical pass channel. Equilibrated slope of the channel margins are assumed to follow a 3:1 (H:V) side slope at Interior Tidal Channel and Transient Tidal Channel, and a 5:1 (H:V) side slope at Gulf Entrance in the Gulf of Mexico. The channel widths, for each alternative, would be excavated to the depth and width necessary to convey the design tidal prism at Blind Pass to reduce the potential for migration and to provide cross-section stability for the Pass channel. It is recommended that beach quality sediments dredged from the tidal channel is placed along the adjacent beached in either south Captiva Island or north Sanibel Island to provide the sediment forming the ebb tidal shoal.

3.2 Hydrodynamic Analysis using Numerical Model Results

ADCIRC (Advanced Circulation Model) is a state of the art (2-D, 3-D) numerical model for use in hydrodynamic evaluations of marine environments. The ADCIRC model equations formulated with the traditional hydrostatic pressure and Boussinesq approximations discretely defined using the Finite Element Method (FEM) in space and using the Finite Difference Method (FDM) in time. ADCIRC was run as a 2-Dimensional depth integrated (2DDI) model that allows adjustment of the model grid resolution. The model was applied to the model domain which extends from the Gulf of Mexico to Pine Island Sound and includes Captiva Pass and Redfish Pass to the north and San Carlos Pass to the south. The northern and southern boundaries are located at a sufficient distance from the project area, thus the project area and adjacent inlets are not influenced by the north and south boundaries. The open ocean boundary in the Gulf of Mexico is located sufficiently seaward (approximately 43 miles from the project location) where the water surface elevations at the boundary locations are not influenced by inlets.

A two-dimensional finite element mesh system was generated using National Ocean Service (NOS) bathymetry and shoreline data provided by NOAA and the most recent (May 2005) hydrographic and topographic survey data conducted by Mckim&Creed, Inc. Boundary conditions for the model consist of a seaward boundary, a mainland shoreline, and a number of barrier islands. To simulate the hydrodynamic conditions at the project area, the tidal forcing was imposed by time as well as spatially varying water levels along the open ocean boundary of the model. The ADCIRC model can represent the Newtonian tidal potential and correction due to the effect of the Earth tides, ocean tide loading and self-attraction. For the model calibration simulations, the major tidal constituents of K1, O1, Q1, K2, M2, N2, and S2 listed in Table 3.2 were imposed along the ocean boundary.

The numerical model calibration verified the methodical application and evaluation of a model to predict field data for a specific domain with existing conditions. Details of the model calibration were described in Hydrodynamic Model Calibration Report (Appendix A). To provide a qualitative evaluation of numerical model, the numerical simulation results were compared with the observed data at three locations (see Figure 2-1) during one month (April, 2005). The quantitative comparisons included comparisons of the harmonic constituents of the observed data (i.e. performing a harmonic analysis of the tidal constituents of the observed data) to model predictions. The calibration results found good agreement of the hydrodynamic numerical model accuracy with measured accuracy.

Nine channel alternatives, described previously in Section 3.1, were simulated using the hydrodynamic numerical model (ADCIRC) to evaluate the hydrodynamic changes associated with varying geometries for the channel alternatives to design the Blind Pass Restoration Project. The numerical model was applied to determine hydrodynamic changes in tidal elevations and current velocities associated with varying tidal channel and pass geometry (as listed in Table 3.1).

A goal in the development of the design of the Preferred Alternative was to minimize the impact on natural environments and maximize stability of the pass. Numerical and empirical methods were applied to evaluate impacts to wetlands, tidal hydrodynamics, ebb shoal volume, and longshore sediment transport processes. The approach in the design development of Preferred Alternative was to obtain the ebb and flood tidal flow of sufficient strength and orientation at the pass channel and minimize the impact on mangroves in southern Wulfert Channel.

Alternatives varied channel depths from -6 ft to -14 ft (NAVD 88) and channel widths from 100 ft to 220 ft at the Bridge Section (shown in Figure 3-1). Cross sectional areas at the bridge section varied from 960 ft^2 to 2500 ft^2. Channel geometries of each alternative are listed in Table 3.1. The averaged peak current velocities (V_{peak}) at Bridge Section and Critical Section were used to evaluate pass stability of each alternative, because maximum velocities of these two locations are important for the stable inlet to ensure the capability to flush out the sediment shoaled in the tidal channel.

The averaged peak current velocity is the average of the maximum velocity during the daily tidal cycle over a 14 days tidal cycle at the Bridge Section and Critical Section. The tidal boundary for the period between April 3 and April 17 (2006) was used to determine the average peak current velocity. The model results of average peak current velocity at these two sections is summarized in Table 3.3. For a stable inlet, the maximum velocity over a tidal cycle is evaluated in order to determine if currents are sufficient to scour out the sediment carried into the inlet by waves and the incoming tidal currents.

Alternative A has a channel depth (-12 ft, NAVD88) and width (100 ft) at Bridge Section and varies depth to Critical Section (-8 ft, NAVD88). This alternative is the smallest tidal channel at the Bridge Section and the Critical Section. This cross section area is close to the critical sectional area (860 ft^2) in the hydraulic curve of inlet stability presented by Mehta (1991). If any storm transports a large amount of sediment into the tidal channel, the cross section is reduced thus causing instabilites. Moving to the left side of the critical section area, the peak maximum velocity of the hydraulic curve indicates that a smaller cross section will result in reduced current velocities. Thus, the tidal inlet has less capability to flush out the sediment and eventually will close unless it is dredged. The highest current velocity (5.6 ft/s for flood tide and 6.6 ft/s for ebb tide) at the Critical Section would be expected to cause impacts to the mangrove wetland at the east side of the tidal channel.

Alternative H represents the largest cross section (220 ft wide and 14 ft deep) at the Bridge Section and a reduced section of 100 ft wide and 10 ft deep at the Critical Section. The averaged peak current velocity is 2.0 ft/s and 2.2 ft/s for the flood tide and ebb tide conditions, respectively. These current velocities are not sifficient to flush out the sediment from the tidal inlet. The fast current velocity (6.4 ft/s for flood tide and 7.6 ft/s for ebb tide) at Critical Section may cause the impact on mangrove wetland at the ease side of the tidal channel.

Based on these numerical results, and the inlet's expected stability and environmental impacts of each alternative, Channel Alternative "F" was determined to be the Preferred Alternative. A plan view of the Preferred Alternative is presented in Figure 3-1 and, Figure 3-2 shows the cross sectional area (160 ft width) at the Bridge Section for the Preferred Alternative, the smallest (100 ft width) and largest (220 ft width) cross sections of Alternatives A and H. The entrance is designed with a trapezoidal geometry of 330 ft width and -10 ft depth (NAVD88) assuming side slopes of 5:1 (H:V) at the end of channel cut in the Gulf of Mexico. The Bridge Section and Critical Section are designed at 160 ft width and -10 ft depth (NAVD88) with a 3:1 (H:V) side slope. The Interior Tidal Channel has the dimension of a 100 ft width and -8 ft depth (NAVD88) at a 3:1 (H:V) side slope, and the cross sectional area at the Bridge Section is 1500 ft^2. Mehta (1991) presented the cross section area for a stable inlet estimated at 1345 ft^2 and 1615 ft^2 (by Keulegan method). As seen, these values are close to the historical cross section area of Blind Pass in 1966 and 1974.

Figure 3-3 shows the relationship between the averaged peak velocity and the cross sectional area at Bridge section. Based on the inlet stability argument, Figure 3-3 indicates that channel alternatives belong to the stable regime. When the cross section area is reduced by the sediment carried into the pass due to wave action, the current velocity increases at the pass and hence results in an increased ability of the inlet to scour out the sediment. The averaged peak ebb and flood velocities of 4.3 ft/s and 3.3 ft/s were determined by the numerical model, which will provide sufficient flow rate to maintain a stable pass cross-section under the immediate post-construction condition. Actual maximum average current velocities are expected to increase upon equilibration of the pass as the cross section area will be reduced.

3.3 Characteristics and Quantities of Sediments

Sediment quantities and composites of the dredge material are compared for the Preferred Alternative and Alternative H (the largest cross sectional area and deepest cut depth). The Pass Channel and Tidal Channel have been divided into sub areas to account for the differing sediment characteristics found within the cores for each varying region or sub area. The Sub Areas are shown in Figure 3-4 for the Preferred Alternative and again in Figure 3-6 for Alternative H. Corresponding cross sections for the Alternative analyzed where used to determine the volume of sediment within the sub area. A volumetric composite of the sediment characteristics for the overall dredge material was obtained by weighting the cores within each sub area.

Preferred Alternative Characteristics and Quantities of Sediments

An estimated volume of 115,184 cubic yards (CY) of material will be excavated to form the Preferred Alignment to restore Blind Pass (see Table 3.3). Existing elevations within the channel configuration range from +5 to -10 ft (NAVD 88). Composites of the material found in sub areas 1 and 2 resulted in 0.8 and 0.6 percent passing the 4ϕ sieve, respectively. The material (approximately 74,000 CY) within these sub areas are highly beach compatible and will be placed directly on the beach as nourishment. Composites of approximately 17,500 CY of material within sub area 3 show approximately 5% fines or passing the 4ϕ sieve. This material is beach compatible; however, a detailed sediment QA/QC plan shall be implemented to ensure that only beach compatible material is placed on the beach. Overall composites of the material within sub area 4 resulted in 7.7% fines. The 24,000 CY of material from sub area 4 will be placed in a sediment containment area and sorted. The unsuitable material (approximately 1,900 CY) will be disposed of at an approved upland site. Detailed sediment grain size distribution composites are shown in Tables 3-5 to 3-9 and graphically in Figure 3-4.

Alternative H Characteristics and Quantities of Sediments

An estimated volume of 163,663 cubic yards (CY) of material will be excavated to form the Alternative H Alignment to restore Blind Pass (see Table 3.10). Composites of the material found in sub areas 1 and 2 resulted in less than 1 percent passing the 4ϕ sieve. The material (approximately 119,000 CY) within these sub areas are highly beach compatible. Composites of approximately 21,200 CY of material within sub area 3 show approximately 6.2% fines or passing the 4ϕ sieve. This indicates the deeper cut resulted in material composite that were not beach compatible. Overall composites of the material within sub area 4 resulted in 7.4% fines. Detailed sediment grain size distribution composites of Alternative H are shown in Tables 3-11 to 3-13 and graphically in Figure 3-6.

Results of the sediment composites show compatible material in sub areas 1, 2, and 3 for the Preferred Alternative and compatible material only in sub areas 1 and 2 for Alternative H. Both Alternatives resulted in unsuitable material composites in sub area 4 (greater than 5% fines).

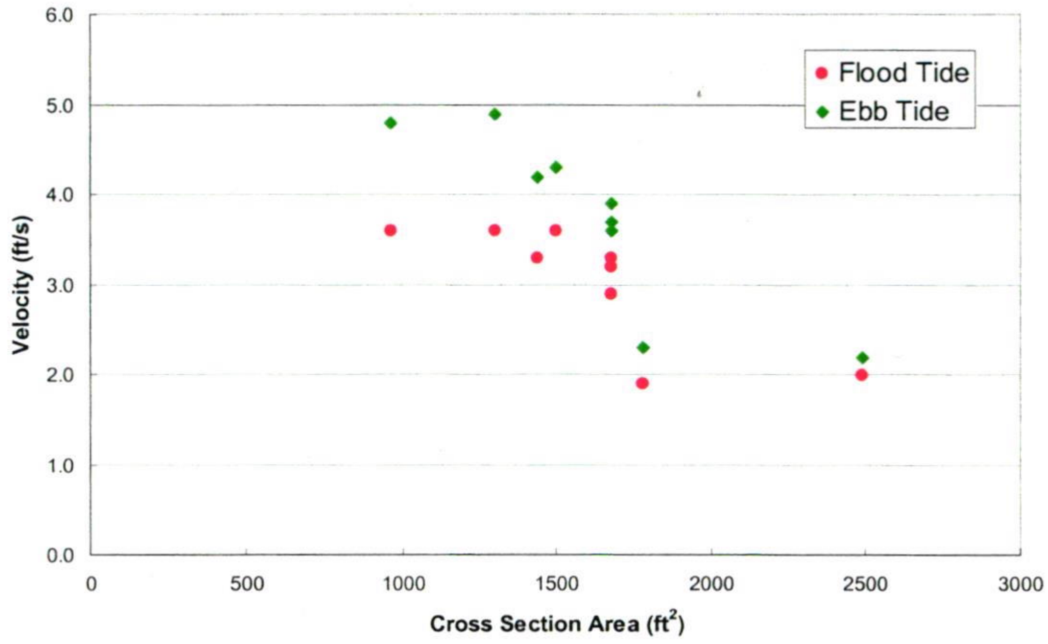

Figure 3-3 Averaged peak velocity at Bridge Section as a function of cross sectional area.

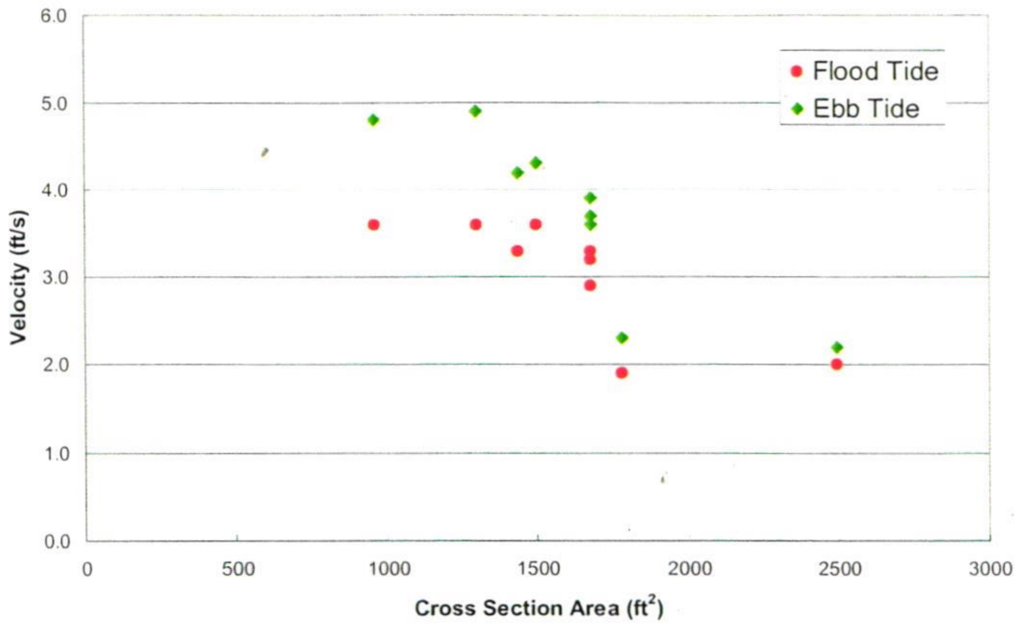

Figure 3-3 Averaged peak velocity at bridge section as a function of cross sectional area.

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Karyn M. Erickson, P.E. Date
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ECE Erickson Consulting Engineers 1819 Main St., Suite 402 Sarasota, FL 34236 (941) 952-0487	FIGURE 3-4 PLAN VIEW PREFERRED ALT. SUB AREAS Blind Pass Reopening Lee County, FLorida	REVISIONS	PROJECT 05-129	CHECKED BY JG
			DATE 04/28/06	DRAWN BY JE
			SCALE 1"=500'	SHEET: 1 of 1

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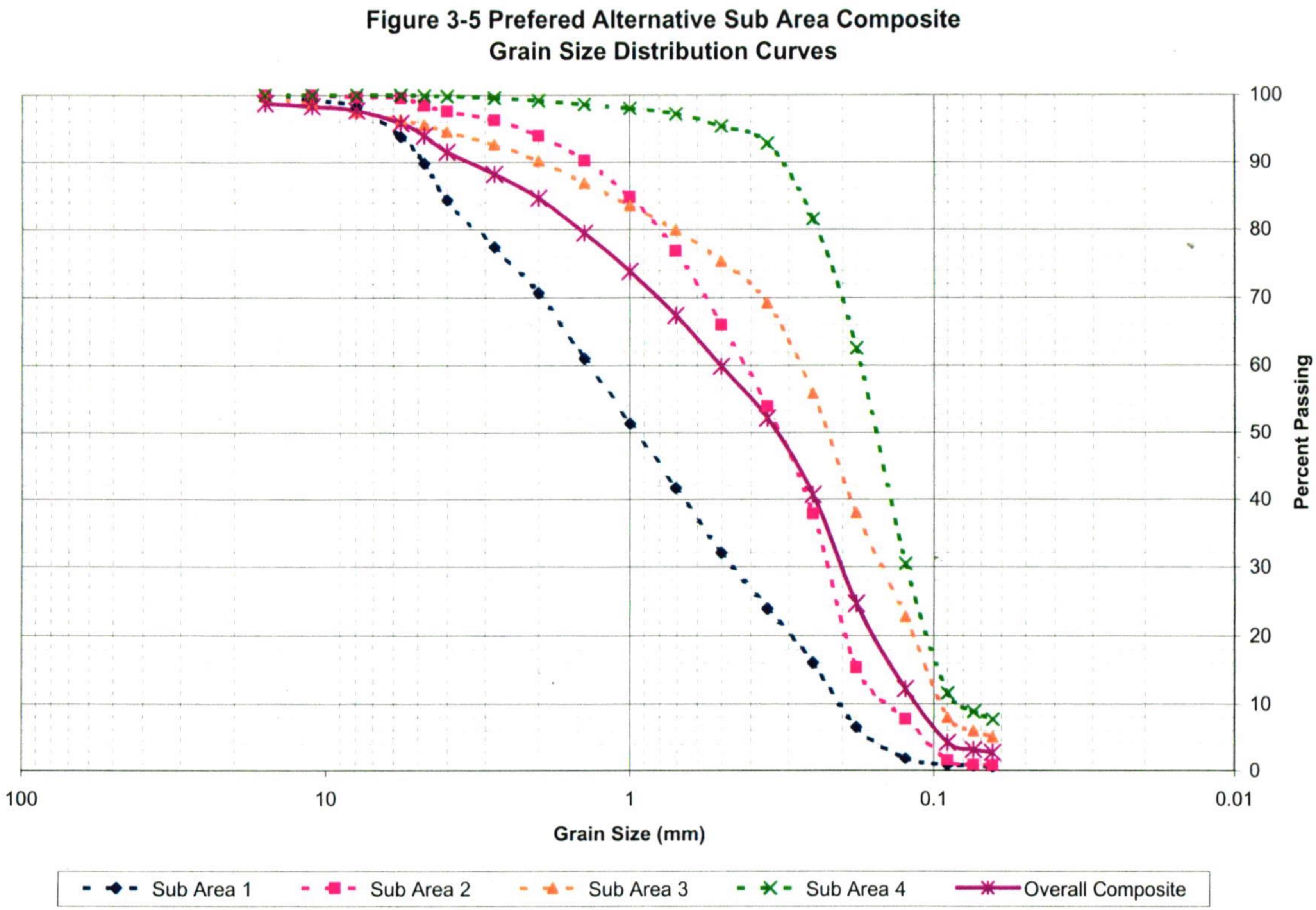
Figure 3-5 Prefered Alternative Sub Area Composite
Grain Size Distribution Curves
100
90
80
70
60
50
40
30
20
10
0
Percent Passing
100
10
1
0.1
0.01
Grain Size (mm)
Sub Area 1
Sub Area 2
Sub Area 3
Sub Area 4
Overall Composite

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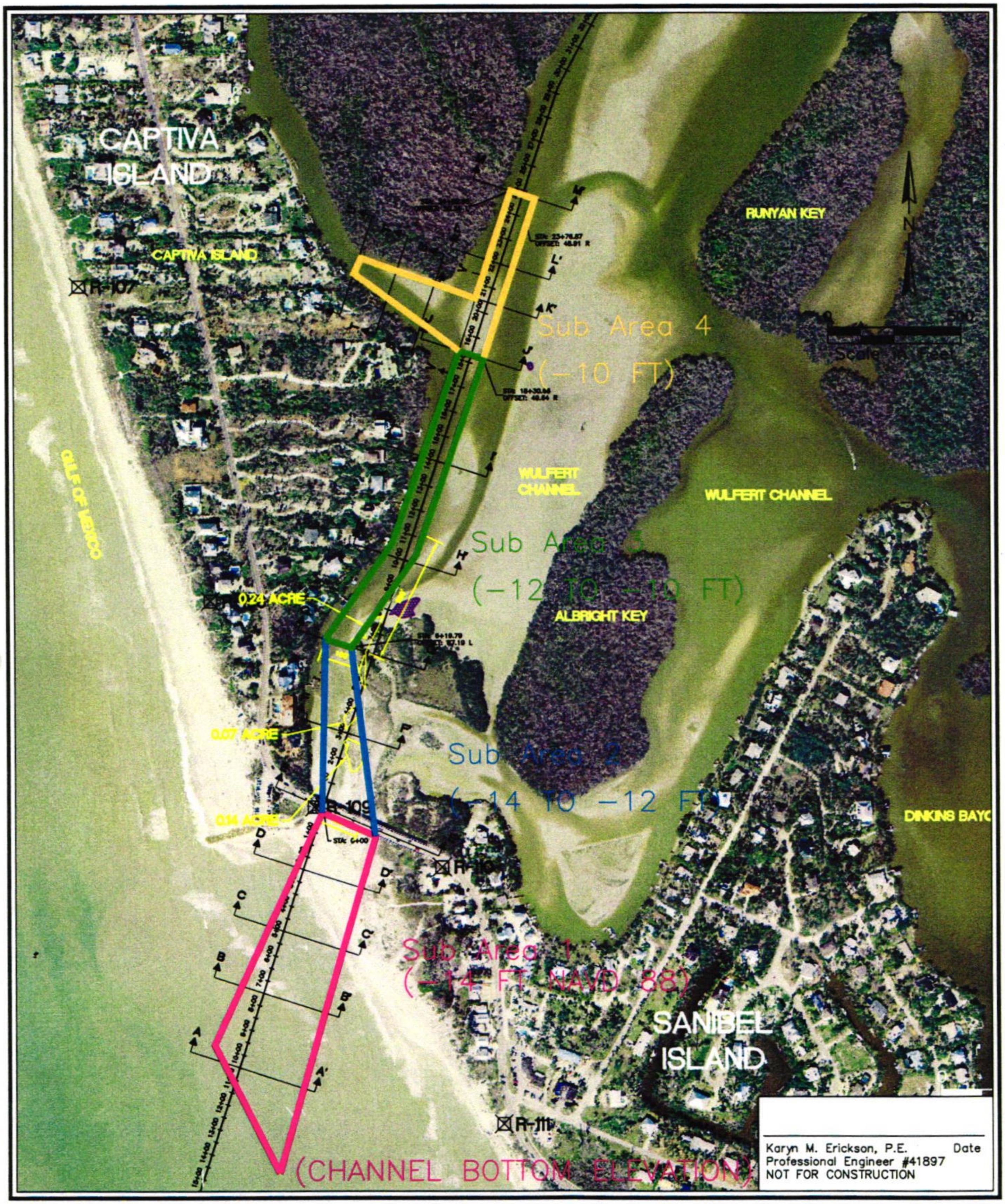


Karyn M. Erickson, P.E. Date
Professional Engineer #41897
NOT FOR CONSTRUCTION

ECE Erickson Consulting Engineers 1819 Main St., Suite 402 Sarasota, FL 34236 (941) 952-0487	FIGURE 3-6 PLAN VIEW ALTERNATE H SUB AREAS Blind Pass Reopening Lee County, FLorida	REVISIONS	PROJECT 05-129 DATE 04/28/06 SCALE 1"=500'	CHECKED BY JG DRAWN BY JE SHEET: 2 of

Figue 3-7 Alternative H Sub Area Composite Grain Size Distribution Curves

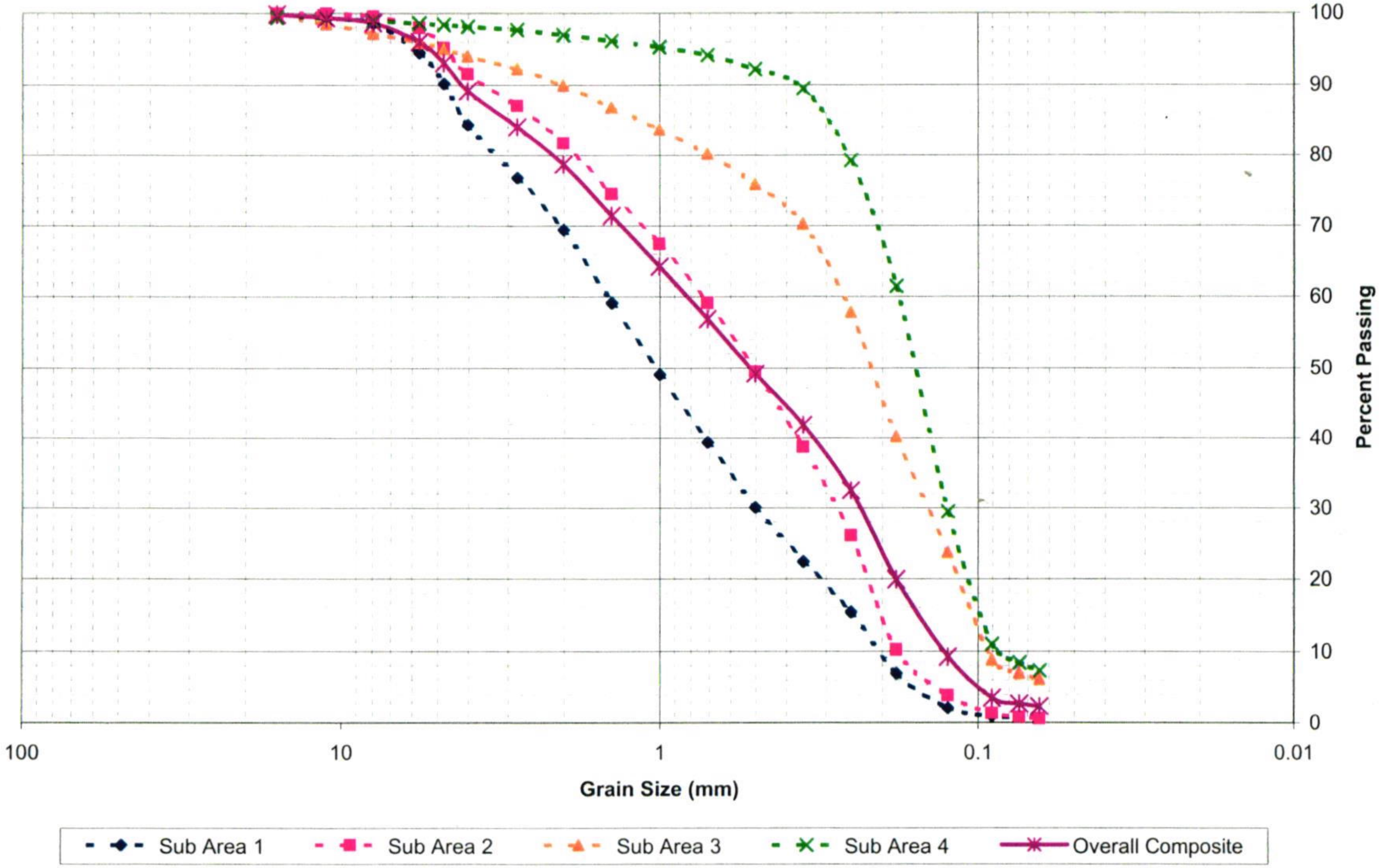


Table 3.1 Channel Alternatives - Blind Pass Restoration

Channel Alternatives	Description							Remark
	Depth (ft, NAVD)			Width (ft)			Cross Section Area (ft^2) at Bridge Section	
	Interior Section	Critical Section	Bridge Section	Interior Section	Critical Section	Bridge Section		
A	8	8	12	100	100	100	960	
B	8	8	12	100	120	140	1440	
C	8	8	12	100	140	160	1680	
D	8	10	12	100	140	160	1680	
E	8	10	12	100	160	160	1680	
F	8	10	10	100	160	160	1500	Preferred Design
G	8	8	8	100	160	160	1300	
H	10	10	14	100	100	220	2500	
I	6	6	10	100	100	220	1800	

Table 3.2 Constituents of Tidal Forcing Along the Ocean Boundary

Symbol	Name	Period (hr)
K_1	Luni-solar diurnal	23.93
O_1	Principal lunar diurnal	25.82
Q_1	Larger lunar elliptic	26.87
K_2	Luni-solar semidiurnal	11.97
M_2	Principal lunar	12.42
N_2	Larger lunar elliptic	12.66
S_2	Principal solar	12.00

* Diurnal and semidiurnal constituents are denoted by the subscripts “1” and “2”, respectively, in their symbols.

Table 3.3 Current Velocity at Bridge Section and Critical Section of Channel Alternatives

Channel Alternatives	Averaged Peak Current Velocity (V_{peak}, ft/s)				Remark
	Bridge Section		Critical Section		
	Flood	Ebb	Flood	Ebb	
A	3.6	4.8	5.6	6.6	
B	3.3	4.2	4.9	5.9	
C	2.9	3.6	4.9	6.1	
D	3.2	3.9	4.6	4.9	
E	3.0	3.7	3.9	4.3	
F	3.3	4.3	3.8	4.1	Preferred Alternative
G	3.6	4.9	4.2	4.4	
H	2.0	2.2	6.4	7.6	
I	1.9	2.3	6.6	7.5	

Table 3.4 Volumetric Determination for Sub Areas

				Prefered Alternative					
Sub Area	**Station**	**Cross Section**	**Length**	Cut Elev.	Cross Sec. Area	Cell Volume	Cum. Sub Area Volume	Percent Total	Sub Area Percent
			(ft)	(NAVD 88)	(ft^2)	(ft^3)	(ft^3)	(%)	(%)
1	0+00	START		-10	0				37%
	1+07.38	A-A	107.38		671	36,026	36,026	1%	
	3+26.38	B-B	219		956	178,157	214,182	6%	
	5+39.83	C-C	213.45		780	185,275	399,457	6%	
	7+60.69	D-D	220.86		2284	338,358	737,815	11%	
	9+67.32	E-E	215.63		1555	413,902	**1,151,716**	13%	
2	9+67.32	$E\text{-}E_2$	1	-10	1555	1,555	1,555	0%	27%
	13+12.41	F-F	345.09		1143	465,526	467,081	15%	
	16+42.18	G-G	329.77		1107	370,991	**838,073**	12%	
3	16+42.18	$G\text{-}G_2$	1	-8	1107	1,107	1,107	0%	15%
	18+94.49	H-H	252.31		637	220,014	221,121	7%	
	21+46.76	I-I	252.27		355	125,126	346,247	4%	
	25+06.73	J-J	359.97		342	125,450	**471,697**	4%	
4	25+06.73	$J\text{-}J_2$	1	-8	342	342	342	0%	12%
	28+64.21	K-K	357.48		390	130,838	131,180	4%	
	30+76.64	L-L	212.43		442	88,371	219,551	3%	
	32+33.55	M-M	156.91		343	61,587	281,138	2%	
	33+75.01	N-N	141.46		328	47,460	328,598	2%	
	END		141.45		200	37,343	**365,940**	1%	
			3279.63			**2,827,426**		**91%**	
4	0+00	O-O		-8	1047				9%
	1+70.75	P-P	170.75		776	155,639	155,639	5%	
	3+23.65	Q-Q	152.9		442	93,116	248,755	3%	
	4+76.54	R-R	152.89		0	33,789	282,543	1%	
	END		50.97		0	0	**282,543**	0%	
						282,543		**9%**	**100%**

Total	**3,109,970**	(ft^3)
	115,184	(yd^3)

Table 3.5 Preferred Alternative Overall Composite			Total Volume (ft³) 3,109,970	Total Volume (yds³) 115,184																
Sieve Size (Phi)	-4	-3.5	-3	-2.5	-2.25	-2	-1.5	-1	-0.5	0	0.5	1	1.5	2	2.5	3	3.5	3.75	4
Sieve Size (mm)	15.875	11.125	7.925	5.664	4.75	4	2.794	2	1.41	1	0.706	0.5	0.353	0.25	0.18	0.124	0.09	0.074	0.064
Blind Pass Core Composite Preferred Alternative	**98.77**	**98.31**	**97.70**	**95.84**	**93.95**	**91.52**	**88.23**	**84.66**	**79.47**	**73.82**	**67.36**	**59.81**	**52.11**	**40.64**	**24.63**	**12.21**	**4.23**	**3.14**	**2.71**

Table 3.6	Dredge Elevation (ft, NAVD)	Core Number			Sub Area Volume (ft³)								Blind Pass Restoration Project - Sediment Composites								
Sub-Area 1	-10				1,151,716																
		CEC-1 Core Composite	0.00	0.00	0.98	7.39	12.77	20.44	29.60	37.89	48.74	59.13	69.36	79.34	87.03	92.56	96.70	98.83	99.44	99.56	99.67
		CEC-1 Composite % Passing	**100.00**	**100.00**	**99.02**	**92.61**	**87.23**	**79.56**	**70.40**	**62.11**	**51.26**	**40.87**	**30.64**	**20.66**	**12.97**	**7.44**	**3.30**	**1.17**	**0.56**	**0.44**	**0.33**
CEC-1																					
		CEC-22 Core Composite	0.00	1.59	2.51	5.03	7.53	10.77	15.59	20.81	29.28	38.23	47.33	56.58	65.21	75.30	90.22	97.50	98.86	99.02	99.18
		CEC-22 Composite % Passing	**100.00**	**98.41**	**97.49**	**94.97**	**92.47**	**89.23**	**84.41**	**79.19**	**70.72**	**61.77**	**52.67**	**43.42**	**34.79**	**24.70**	**9.78**	**2.50**	**1.14**	**0.98**	**0.82**
CEC-22		**Sieve Size (Phi)**	**-4**	**-3.5**	**-3**	**-2.5**	**-2.25**	**-2**	**-1.5**	**-1**	**-0.5**	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**3.75**	**4**
		Sieve Size (mm)	**15.875**	**11.125**	**7.925**	**5.664**	**4.75**	**4**	**2.794**	**2**	**1.41**	**1**	**0.706**	**0.5**	**0.353**	**0.25**	**0.18**	**0.124**	**0.09**	**0.074**	**0.064**
	37.0%	**Sub Area 1 Composite**	**100.00**	**99.20**	**98.25**	**93.79**	**89.85**	**84.40**	**77.40**	**70.65**	**60.99**	**51.32**	**41.65**	**32.04**	**23.88**	**16.07**	**6.54**	**1.83**	**0.85**	**0.71**	**0.57**

Table 3.7	Dredge Elevation (ft, NAVD)	Core Number			Sub Area Volume (ft^3)						Blind Pass Restoration Project - Sediment Composites										
Sub Area 2	-10				838,073																
		CEC-2 Core Composite	0.00	0.00	0.56	0.56	1.93	2.95	4.50	7.49	11.33	16.18	22.50	32.37	45.67	61.15	80.27	86.52	97.65	98.87	98.87
		CEC-2 Composite % Passing	**100.00**	**100.00**	**99.44**	**99.44**	**98.07**	**97.05**	**95.50**	**92.51**	**88.67**	**83.82**	**77.50**	**67.63**	**54.33**	**38.85**	**19.73**	**13.48**	**2.35**	**1.13**	**1.13**
CEC-2																					
		CEC-23 Core Composite	0.00	0.00	0.00	0.23	1.03	1.82	2.96	4.55	8.15	14.08	23.73	35.67	46.48	63.16	88.93	98.00	99.23	99.41	99.55
		CEC-23 Composite % Passing	**100.00**	**100.00**	**100.00**	**99.77**	**98.97**	**98.18**	**97.04**	**95.45**	**91.85**	**85.92**	**76.27**	**64.33**	**53.52**	**36.84**	**11.07**	**2.00**	**0.77**	**0.59**	**0.45**
CEC-23		**Sieve Size (Phi)**	**-4**	**-3.5**	**-3**	**-2.5**	**-2.25**	**-2**	**-1.5**	**-1**	**-0.5**	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**3.75**	**4**
		Sieve Size (mm)	**15.875**	**11.125**	**7.925**	**5.664**	**4.75**	**4**	**2.794**	**2**	**1.41**	**1**	**0.706**	**0.5**	**0.353**	**0.25**	**0.18**	**0.124**	**0.09**	**0.074**	**0.064**
	26.9%	**Sub Area 2 Composite**	**100.00**	**100.00**	**99.72**	**99.61**	**98.52**	**97.61**	**96.27**	**93.98**	**90.26**	**84.87**	**76.88**	**65.98**	**53.93**	**37.84**	**15.40**	**7.74**	**1.56**	**0.86**	**0.79**

Table 3.8	Dredge Elevation (ft, NAVD)	Core Number			Sub Area Volume (ft^3)																
Blind Pass Restoration Project - Sediment Composites																					
Sub Area 3	-8				471,697																
		CEC-15 Core Composite	0.00	0.00	0.00	0.00	0.00	0.13	0.19	0.44	0.87	1.54	2.81	5.24	9.89	48.29	83.06	97.68	99.30	99.40	99.40
		CEC-15 Composite % Passing	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**99.87**	**99.81**	**99.56**	**99.13**	**98.46**	**97.19**	**94.76**	**90.11**	**51.71**	**16.94**	**2.32**	**0.70**	**0.60**	**0.60**
CEC-15																					
		CEC-14 Core Composite	0.00	0.00	0.00	0.32	0.55	0.87	1.50	2.60	4.03	5.87	8.18	11.90	17.37	25.68	39.92	43.51	79.32	82.55	84.15
		CEC-14 Composite % Passing	**100.00**	**100.00**	**100.00**	**99.68**	**99.45**	**99.13**	**98.50**	**97.40**	**95.97**	**94.13**	**91.82**	**88.10**	**82.63**	**74.32**	**60.08**	**56.49**	**20.68**	**17.45**	**15.85**
CEC-14																					
		CEC-4 Core Composite	0.00	0.00	0.00	0.43	0.54	0.88	1.45	2.06	2.82	3.70	4.78	6.68	10.17	19.81	48.17	79.80	95.77	97.23	98.04
		CEC-4 Composite % Passing	**100.00**	**100.00**	**100.00**	**99.57**	**99.46**	**99.12**	**98.55**	**97.94**	**97.18**	**96.30**	**95.22**	**93.32**	**89.83**	**80.19**	**51.83**	**20.20**	**4.23**	**2.77**	**1.96**
CEC-4																					
		CEC-3 Core Composite	0.00	4.21	6.43	8.64	10.71	12.93	16.56	21.41	28.66	36.31	44.63	54.20	63.96	73.96	84.05	90.92	96.41	97.20	97.90
		CEC-3 Composite % Passing	**100.00**	**95.79**	**93.57**	**91.36**	**89.29**	**87.07**	**83.44**	**78.59**	**71.34**	**63.69**	**55.37**	**45.80**	**36.04**	**26.04**	**15.95**	**9.08**	**3.59**	**2.80**	**2.10**
CEC-3																					
		CEC-5 Core Composite	0.00	0.00	0.00	0.20	0.41	0.71	1.07	1.82	2.92	4.54	7.00	10.20	15.08	22.82	35.11	58.19	87.02	93.00	95.46
		CEC-5 Composite % Passing	**100.00**	**100.00**	**100.00**	**99.80**	**99.59**	**99.29**	**98.93**	**98.18**	**97.08**	**95.46**	**93.00**	**89.80**	**84.92**	**77.18**	**64.89**	**41.81**	**12.98**	**7.00**	**4.54**
CEC-5																					
		BP-5 Core Composite	0	1.008958	3.77806939	7.117591	8.139601	9.728613	14.32832	19.38171	25.75779	31.63239	37.35478	43.6117	51.18746	60.49582	71.10258	84.52102	91.69995	92.71185	93.08402
		BP-5 Composite % Passing	**100.00**	**98.99**	**96.22**	**92.88**	**91.86**	**90.27**	**85.67**	**80.62**	**74.24**	**68.37**	**62.65**	**56.39**	**48.81**	**39.50**	**28.90**	**15.48**	**8.30**	**7.29**	**6.92**
BP-5																					
		BP-6 Composite % Passing	1.437191	3.934404	7.21796245	8.99866	10.55693	12.82288	16.28084	20.75818	26.25956	31.09455	35.80559	40.98464	47.70905	58.01179	72.45121	85.66496	94.41356	95.975	96.51333
		BP-6 Composite % Passing	**98.56**	**96.07**	**92.78**	**91.00**	**89.44**	**87.18**	**83.72**	**79.24**	**73.74**	**68.91**	**64.19**	**59.02**	**52.29**	**41.99**	**27.55**	**14.34**	**5.59**	**4.02**	**3.49**
BP-6		**Sieve Size (Phi)**	**-4**	**-3.5**	**-3**	**-2.5**	**-2.25**	**-2**	**-1.5**	**-1**	**-0.5**	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**3.75**	**4**
		Sieve Size (mm)	**15.875**	**11.125**	**7.925**	**5.664**	**4.75**	**4**	**2.794**	**2**	**1.41**	**1**	**0.706**	**0.5**	**0.353**	**0.25**	**0.18**	**0.124**	**0.09**	**0.074**	**0.064**
	15.2%	**Sub Area 3 Composite**	**99.79**	**98.69**	**97.51**	**96.33**	**95.58**	**94.56**	**92.66**	**90.22**	**86.95**	**83.62**	**79.92**	**75.31**	**69.23**	**55.85**	**38.02**	**22.82**	**8.01**	**5.99**	**5.07**

Blind Pass Restoration Project - Sediment Composites

Table 3.8	Dredge Elevation (ft, NAVD)	Core Number			Sub Area Volume (ft³)																
Sub Area 3	-8				471,697																
		CEC-15 Core Composite	0.00	0.00	0.00	0.00	0.00	0.13	0.19	0.44	0.87	1.54	2.81	5.24	9.89	48.29	83.06	97.68	99.30	99.40	99.40
		CEC-15 Composite % Passing	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**99.87**	**99.81**	**99.56**	**99.13**	**98.46**	**97.19**	**94.76**	**90.11**	**51.71**	**16.94**	**2.32**	**0.70**	**0.60**	**0.60**
CEC-15																					
		CEC-14 Core Composite	0.00	0.00	0.00	0.32	0.55	0.87	1.50	2.60	4.03	5.87	8.18	11.90	17.37	25.68	39.92	43.51	79.32	82.55	84.15
		CEC-14 Composite % Passing	**100.00**	**100.00**	**100.00**	**99.68**	**99.45**	**99.13**	**98.50**	**97.40**	**95.97**	**94.13**	**91.82**	**88.10**	**82.63**	**74.32**	**60.08**	**56.49**	**20.68**	**17.45**	**15.85**
CEC-14																					
		CEC-4 Core Composite	0.00	0.00	0.00	0.43	0.54	0.88	1.45	2.06	2.82	3.70	4.78	6.68	10.17	19.81	48.17	79.80	95.77	97.23	98.04
		CEC-4 Composite % Passing	**100.00**	**100.00**	**100.00**	**99.57**	**99.46**	**99.12**	**98.55**	**97.94**	**97.18**	**96.30**	**95.22**	**93.32**	**89.83**	**80.19**	**51.83**	**20.20**	**4.23**	**2.77**	**1.96**
CEC-4																					
		CEC-3 Core Composite	0.00	4.21	6.43	8.64	10.71	12.93	16.56	21.41	28.66	36.31	44.63	54.20	63.96	73.96	84.05	90.92	96.41	97.20	97.90
		CEC-3 Composite % Passing	**100.00**	**95.79**	**93.57**	**91.36**	**89.29**	**87.07**	**83.44**	**78.59**	**71.34**	**63.69**	**55.37**	**45.80**	**36.04**	**26.04**	**15.95**	**9.08**	**3.59**	**2.80**	**2.10**
CEC-3																					
		CEC-5 Core Composite	0.00	0.00	0.00	0.20	0.41	0.71	1.07	1.82	2.92	4.54	7.00	10.20	15.08	22.82	35.11	58.19	87.02	93.00	95.46
		CEC-5 Composite % Passing	**100.00**	**100.00**	**100.00**	**99.80**	**99.59**	**99.29**	**98.93**	**98.18**	**97.08**	**95.46**	**93.00**	**89.80**	**84.92**	**77.18**	**64.89**	**41.81**	**12.98**	**7.00**	**4.54**
CEC-5																					
		BP-5 Core Composite	0	1.008958	3.77806939	7.117591	8.139601	9.728613	14.32832	19.38171	25.75779	31.63239	37.35478	43.6117	51.18746	60.49582	71.10258	84.52102	91.69995	92.71185	93.08402
		BP-5 Composite % Passing	**100.00**	**98.99**	**96.22**	**92.88**	**91.86**	**90.27**	**85.67**	**80.62**	**74.24**	**68.37**	**62.65**	**56.39**	**48.81**	**39.50**	**28.90**	**15.48**	**8.30**	**7.29**	**6.92**
BP-5																					
		BP-6 Composite % Passing	1.437191	3.934404	7.21796245	8.99866	10.55693	12.82288	16.28084	20.75818	26.25956	31.09455	35.80559	40.98464	47.70905	58.01179	72.45121	85.66496	94.41356	95.975	96.51333
		BP-6 Composite % Passing	**98.56**	**96.07**	**92.78**	**91.00**	**89.44**	**87.18**	**83.72**	**79.24**	**73.74**	**68.91**	**64.19**	**59.02**	**52.29**	**41.99**	**27.55**	**14.34**	**5.59**	**4.02**	**3.49**
BP-6		**Sieve Size (Phi)**	**-4**	**-3.5**	**-3**	**-2.5**	**-2.25**	**-2**	**-1.5**	**-1**	**-0.5**	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**3.75**	**4**
		Sieve Size (mm)	**15.875**	**11.125**	**7.925**	**5.664**	**4.75**	**4**	**2.794**	**2**	**1.41**	**1**	**0.706**	**0.5**	**0.353**	**0.25**	**0.18**	**0.124**	**0.09**	**0.074**	**0.064**
	15.2%	**Sub Area 3 Composite**	**99.79**	**98.69**	**97.51**	**96.33**	**95.58**	**94.56**	**92.66**	**90.22**	**86.95**	**83.62**	**79.92**	**75.31**	**69.23**	**55.85**	**38.02**	**22.82**	**8.01**	**5.99**	**5.07**

Table 3.9 — Blind Pass Restoration Project - Sediment Composites

Table 3.9	Dredge Elevation (ft, NAVD)	Core Number	Sub Area Volume (ft^3)
Sub Area 4	-8		611,141

Core																				
CEC-15	CEC-15 Core Composite	0.00	0.00	0.00	0.00	0.00	0.13	0.19	0.44	0.87	1.54	2.81	5.24	9.89	48.29	83.06	97.68	99.30	99.40	99.40
	CEC-15 Composite % Passing	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**99.87**	**99.81**	**99.56**	**99.13**	**98.46**	**97.19**	**94.76**	**90.11**	**51.71**	**16.94**	**2.32**	**0.70**	**0.60**	**0.60**
CEC-16	CEC-16 Core Composite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.17	0.31	0.64	3.66	5.79	8.13	13.44	59.73	91.20	96.04	97.86
	CEC-16 Composite % Passing	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**99.89**	**99.83**	**99.69**	**99.36**	**96.34**	**94.21**	**91.87**	**86.56**	**40.27**	**8.80**	**3.96**	**2.14**
BP-11	BP-11 Composite	0	0	0	0.002482	0.066647	0.108596	0.167858	0.288991	0.632217	1.064117	1.964964	3.605931	6.618923	14.18149	38.55065	70.02076	82.03158	83.95821	84.79379
	BP-11 Composite % Passing	**100.00**	**100.00**	**100.00**	**100.00**	**99.93**	**99.89**	**99.83**	**99.71**	**99.37**	**98.94**	**98.04**	**96.39**	**93.38**	**85.82**	**61.45**	**29.98**	**17.97**	**16.04**	**15.21**
BP-7	BP-7 Composite	0	0	0	0.015121	0.035158	0.052377	0.083846	0.235211	0.415662	0.713775	1.197287	2.018459	3.484489	8.197937	26.67328	62.92318	85.70528	89.28208	90.70677
	BP-7 Composite % Passing	**100.00**	**100.00**	**100.00**	**99.98**	**99.96**	**99.95**	**99.92**	**99.76**	**99.58**	**99.29**	**98.80**	**97.98**	**96.52**	**91.80**	**73.33**	**37.08**	**14.29**	**10.72**	**9.29**
BP-8A	BP-8A Composite	0	0	0	0	0.415022	0.638496	1.63459	3.035268	4.907593	6.269324	7.465006	8.721732	10.31639	13.54066	25.60948	57.48382	83.74476	87.11115	88.74797
	BP-8A Composite % Passing	**100.00**	**100.00**	**100.00**	**100.00**	**99.58**	**99.36**	**98.37**	**96.96**	**95.09**	**93.73**	**92.53**	**91.28**	**89.68**	**86.46**	**74.39**	**42.52**	**16.26**	**12.89**	**11.25**
	Sieve Size (Phi)	**-4**	**-3.5**	**-3**	**-2.5**	**-2.25**	**-2**	**-1.5**	**-1**	**-0.5**	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**3.75**	**4**
	Sieve Size (mm)	**15.875**	**11.125**	**7.925**	**5.664**	**4.75**	**4**	**2.794**	**2**	**1.41**	**1**	**0.706**	**0.5**	**0.353**	**0.25**	**0.18**	**0.124**	**0.09**	**0.074**	**0.064**
19.7%	**Sub Area 4 Composite**	**100.00**	**100.00**	**100.00**	**100.00**	**99.90**	**99.81**	**99.58**	**99.18**	**98.60**	**98.02**	**97.18**	**95.35**	**92.78**	**81.53**	**62.53**	**30.43**	**11.60**	**8.84**	**7.70**

Table 3.10 Volumetric Determination for Sub Areas Alternative H

				Alternative H					
Sub Area	Station	Cross Section	Length	Cut Elev.	Cross Sec. Area	Cell Volume	Cum. Sub Area Volume	Percent Total	Sub Area Percent
			(ft)	(NAVD 88)	(ft^2)	(ft^3)	(ft^3)	(%)	
	(-)10+50	A-A			604	0	0	0%	
	(-)7+50	B-B	300		2118	408,300	408,300	9%	
	(-)5+00	C-C	250		1640	469,750	878,050	11%	
	(-)2+50	D-D	250		3469	638,625	1,516,675	14%	
1	0+00	E-E	250	-14	2495	745,500	**2,262,175**	17%	51%
	0+01	$E-E_2$	1		2495	2,495	2,495		
	3+00	F-F	300		1518	601,950	604,445	14%	
2	6+19.79	G-G	319.79	-14	590	337,059	**941,504**	8%	21%
	6+19.79	G-G2	1		516	553	553	0%	
	10+00	H-H	380.21		495	192,196	192,749	4%	
	14+00	I-I	400		434	185,800	378,549	4%	
3	18+30.66	J-J	430.66	-10	462	192,936	**571,485**	4%	13%
	18+30.66	J-J2	1		462	462	462		
	20+50	K-K	219.34		523	108,025	108,487	2%	
	22+00	L-L	150		431	71,550	180,037	2%	
4	24+82.93	M-M	282.93	-10	407	118,548	**298,585**	3%	7%
			3535.93			**4,073,748**		**92%**	
	51 N	V-V			1360				
	221 N	S-S	170		935	195,075	195,075	4%	
	373 N	T-T	150		533	110,100	305,175	2%	
4	525 N	U-U	150	-10	0	39,975	**345,150**	1%	8%
						345,150		**8%**	**100%**

Total	**4,418,898**	(ft^3)
	163,663	(yd^3)

Table 3.11 Alternative H
Overall Composite

Total Volume (ft^3)	Total Volume (yds^3)
4418898	163663

Sieve Size (Phi)	-4	-3.5	-3	-2.5	-2.25	-2	-1.5	-1	-0.5	0	0.5	1	1.5	2	2.5	3	3.5	3.75	4
Sieve Size (mm)	15.875	11.125	7.925	5.664	4.75	4	2.794	2	1.41	1	0.706	0.5	0.353	0.25	0.18	0.124	0.09	0.074	0.064
Blind Pass Core Composite Alternative H	99.87	99.40	98.70	96.09	93.12	89.18	84.06	78.74	71.41	64.21	56.87	49.21	41.86	32.47	19.92	9.27	3.53	2.72	2.33

Table 3.12	Dredge Elevation	Core Number	Volume (ft^3)	Blind Pass Restoration Project - Sediment Composites
Sub-Area 1	-14		2,262,175	

	CEC-1 Core Composite	0.00	0.00	0.83	6.85	13.26	21.73	31.83	40.76	52.33	62.89	72.77	81.95	88.73	93.47	96.96	98.80	99.40	99.51	99.64
	CEC-1 Composite % Passing	100.00	100.00	99.17	93.15	86.74	78.27	68.17	59.24	47.67	37.11	27.23	18.05	11.27	6.53	3.04	1.20	0.60	0.49	0.36
CEC-1																				
	CEC-22 Core Composite	0.00	1.22	1.92	3.99	6.32	9.55	14.53	20.39	29.42	38.94	48.47	57.87	66.43	75.74	89.07	97.04	98.70	98.90	99.09
	CEC-22 Composite % Passing	100.00	98.78	98.08	96.01	93.68	90.45	85.47	79.61	70.58	61.06	51.53	42.13	33.57	24.26	10.93	2.96	1.30	1.10	0.91
CEC-22	Sieve Size (Phi)	-4	-3.5	-3	-2.5	-2.25	-2	-1.5	-1	-0.5	0	0.5	1	1.5	2	2.5	3	3.5	3.75	4
	Sieve Size (mm)	15.875	11.125	7.925	5.664	4.75	4	2.794	2	1.41	1	0.706	0.5	0.353	0.25	0.18	0.124	0.09	0.074	0.064
51.2%	**Sub Area 1 Composite**	**100.00**	**99.39**	**98.63**	**94.58**	**90.21**	**84.36**	**76.82**	**69.43**	**59.13**	**49.08**	**39.38**	**30.09**	**22.42**	**15.40**	**6.99**	**2.08**	**0.95**	**0.79**	**0.64**

Table 3.13	Dredge Elevation	Core Number			Volume (ft^3)	Blind Pass Restoration Project - Sediment Composites																
Sub Area 2	-14				941,504																
		CEC-2 Core Composite	0.00	0.00	0.81	3.29	7.67	13.37	20.35	28.29	38.00	45.82	53.01	60.71	71.22	81.27	90.66	94.88	98.48	99.34	99.53
		CEC-2 Composite % Passing	**100.00**	**100.00**	**99.19**	**96.71**	**92.33**	**86.63**	**79.65**	**71.71**	**62.00**	**54.18**	**46.99**	**39.29**	**28.78**	**18.73**	**9.34**	**5.12**	**1.52**	**0.66**	**0.47**
CEC-2																					
		CEC-23 Core Composite	0.00	0.00	0.00	0.53	1.77	3.36	5.42	8.11	12.85	19.29	28.67	40.26	51.24	66.52	88.83	97.29	98.78	99.03	99.26
		CEC-23 Composite % Passing	**100.00**	**100.00**	**100.00**	**99.47**	**98.23**	**96.64**	**94.58**	**91.89**	**87.15**	**80.71**	**71.33**	**59.74**	**48.76**	**33.48**	**11.17**	**2.71**	**1.22**	**0.97**	**0.74**
CEC-23		**Sieve Size (Phi)**	**-4**	**-3.5**	**-3**	**-2.5**	**-2.25**	**-2**	**-1.5**	**-1**	**-0.5**	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**3.75**	**4**
		Sieve Size (mm)	**15.875**	**11.125**	**7.925**	**5.664**	**4.75**	**4**	**2.794**	**2**	**1.41**	**1**	**0.706**	**0.5**	**0.353**	**0.25**	**0.18**	**0.124**	**0.09**	**0.074**	**0.064**
	21.3%	**Sub Area 2 Composite**	**100.00**	**100.00**	**99.59**	**98.09**	**95.28**	**91.63**	**87.12**	**81.80**	**74.57**	**67.44**	**59.16**	**49.52**	**38.77**	**26.10**	**10.26**	**3.92**	**1.37**	**0.81**	**0.61**

Table 3.14	Dredge Elevation	Core Number	Volume (ft^3)	Blind Pass Restoration Project - Sediment Composites																		
Sub Area 3	-10		571,485																			

	CEC-15 Core Composite	0.92	1.33	2.62	3.62	3.71	4.27	4.87	5.68	6.63	7.76	9.36	12.27	16.91	50.21	81.36	96.76	99.05	99.25	99.31
	CEC-15 Composite % Passing	**99.08**	**98.67**	**97.38**	**96.38**	**96.29**	**95.73**	**95.13**	**94.32**	**93.37**	**92.24**	**90.64**	**87.73**	**83.09**	**49.79**	**18.64**	**3.24**	**0.95**	**0.75**	**0.69**
CEC-15																				
	CEC-14 Core Composite	0.00	0.00	0.00	0.27	0.46	0.72	1.25	2.21	3.46	5.01	7.01	10.15	14.83	21.97	34.61	40.43	73.11	76.08	77.61
	CEC-14 Composite % Passing	**100.00**	**100.00**	**100.00**	**99.73**	**99.54**	**99.28**	**98.75**	**97.79**	**96.54**	**94.99**	**92.99**	**89.85**	**85.17**	**78.03**	**65.39**	**59.57**	**26.89**	**23.92**	**22.39**
CEC-14																				
	CEC-4 Core Composite	0.00	0.00	0.00	0.33	0.41	0.67	1.20	1.77	2.51	3.39	4.46	6.41	10.22	20.62	49.47	78.81	96.06	97.34	98.06
	CEC-4 Composite % Passing	**100.00**	**100.00**	**100.00**	**99.67**	**99.59**	**99.33**	**98.80**	**98.23**	**97.49**	**96.61**	**95.54**	**93.59**	**89.78**	**79.38**	**50.53**	**21.19**	**3.94**	**2.66**	**1.94**
CEC-4																				
	CEC-3 Core Composite	0.00	4.73	7.88	10.92	13.70	16.62	20.91	26.28	33.92	41.63	49.59	58.38	67.07	76.09	85.48	92.11	97.25	97.91	98.44
	CEC-3 Composite % Passing	**100.00**	**95.27**	**92.12**	**89.08**	**86.30**	**83.38**	**79.09**	**73.72**	**66.08**	**58.37**	**50.41**	**41.62**	**32.93**	**23.91**	**14.52**	**7.89**	**2.75**	**2.09**	**1.56**
CEC-3																				
	CEC-5 Core Composite	0.00	0.00	0.00	0.31	0.46	0.85	1.23	2.27	3.86	6.23	9.57	13.90	20.15	30.08	44.47	65.95	90.30	94.86	96.72
	CEC-5 Composite % Passing	**100.00**	**100.00**	**100.00**	**99.69**	**99.54**	**99.15**	**98.77**	**97.73**	**96.14**	**93.77**	**90.43**	**86.10**	**79.85**	**69.92**	**55.53**	**34.05**	**9.70**	**5.14**	**3.28**
CEC-5																				
	BP-5 Core Composite	0	0.724745	2.9084053	5.314426	6.07553	7.240362	10.62434	14.36149	19.11496	23.53422	27.86496	32.65185	38.54381	46.19279	58.06944	77.64284	89.4435	91.25311	91.86419
	BP-5 Composite % Passing	**100.00**	**99.28**	**97.09**	**94.69**	**93.92**	**92.76**	**89.38**	**85.64**	**80.89**	**76.47**	**72.14**	**67.35**	**61.46**	**53.81**	**41.93**	**22.36**	**10.56**	**8.75**	**8.14**
BP-5																				
	BP-6 Composite % Passing	1.20094	3.287653	6.11229181	7.600476	8.90397	10.79764	13.69658	17.45889	22.10593	26.20827	30.21379	34.65377	40.46839	49.66181	64.66633	82.18181	92.37306	93.95906	94.54148
	BP-6 Composite % Passing	**98.80**	**96.71**	**93.89**	**92.40**	**91.10**	**89.20**	**86.30**	**82.54**	**77.89**	**73.79**	**69.79**	**65.35**	**59.53**	**50.34**	**35.33**	**17.82**	**7.63**	**6.04**	**5.46**
BP-6	**Sieve Size (Phi)**	**-4**	**-3.5**	**-3**	**-2.5**	**-2.25**	**-2**	**-1.5**	**-1**	**-0.5**	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**3.75**	**4**
	Sieve Size (mm)	**15.875**	**11.125**	**7.925**	**5.664**	**4.75**	**4**	**2.794**	**2**	**1.41**	**1**	**0.706**	**0.5**	**0.353**	**0.25**	**0.18**	**0.124**	**0.09**	**0.074**	**0.064**
12.9%	**Sub Area 3 Composite**	**99.70**	**98.56**	**97.21**	**95.95**	**95.18**	**94.12**	**92.32**	**90.00**	**86.91**	**83.75**	**80.28**	**75.94**	**70.26**	**57.88**	**40.27**	**23.73**	**8.92**	**7.05**	**6.21**

Table 3.15	Dredge Elevation	Core Number			Volume (ft³)	Blind Pass Restoration Project - Sediment Composites															
Sub Area 4	-10				643,735																
		CEC-15 Core Composite	0.92	1.33	2.62	3.62	3.71	4.27	4.87	5.68	6.63	7.76	9.36	12.27	16.91	50.21	81.36	96.76	99.05	99.25	99.31
		CEC-15 Composite % Passing	**99.08**	**98.67**	**97.38**	**96.38**	**96.29**	**95.73**	**95.13**	**94.32**	**93.37**	**92.24**	**90.64**	**87.73**	**83.09**	**49.79**	**18.64**	**3.24**	**0.95**	**0.75**	**0.69**
CEC-15																					
		CEC-16 Core Composite	0.00	0.00	0.00	0.00	0.02	0.05	0.07	0.19	0.29	0.50	1.22	4.09	6.63	9.56	16.44	60.74	91.56	96.14	97.87
		CEC-16 Composite % Passing	**100.00**	**100.00**	**100.00**	**100.00**	**99.98**	**99.95**	**99.93**	**99.81**	**99.71**	**99.50**	**98.78**	**95.91**	**93.37**	**90.44**	**83.56**	**39.26**	**8.44**	**3.86**	**2.13**
CEC-16																					
		BP-11 Composite	0	0	0	0.035915	0.113459	0.150177	0.259518	0.408733	0.787425	1.222955	2.069342	3.470977	5.967702	12.02993	32.53318	66.29533	81.09855	82.93711	83.81849
		BP-11 Composite % Passing	**100.00**	**100.00**	**100.00**	**99.96**	**99.89**	**99.85**	**99.74**	**99.59**	**99.21**	**98.78**	**97.93**	**96.53**	**94.03**	**87.97**	**67.47**	**33.70**	**18.90**	**17.06**	**16.18**
BP-11																					
		BP-7 Composite	2.063744	2.063744	2.62216853	3.446197	3.826123	4.244384	5.139537	6.279404	7.501199	8.789731	10.1578	11.72282	13.9144	19.28794	36.0347	68.29008	87.71601	90.67693	91.80873
		BP-7 Composite % Passing	**97.94**	**97.94**	**97.38**	**96.55**	**96.17**	**95.76**	**94.86**	**93.72**	**92.50**	**91.21**	**89.84**	**88.28**	**86.09**	**80.71**	**63.97**	**31.71**	**12.28**	**9.32**	**8.19**
BP-7																					
		BP-8A Composite	0	0	0	0	0.321759	0.495014	1.276324	2.416589	3.972329	5.177504	6.244886	7.445641	9.039721	12.69428	26.3579	60.44862	85.69479	88.87985	90.41604
		BP-8A Composite % Passing	**100.00**	**100.00**	**100.00**	**100.00**	**99.68**	**99.50**	**98.72**	**97.58**	**96.03**	**94.82**	**93.76**	**92.55**	**90.96**	**87.31**	**73.64**	**39.55**	**14.31**	**11.12**	**9.58**
BP-8A		**Sieve Size (Phi)**	**-4**	**-3.5**	**-3**	**-2.5**	**-2.25**	**-2**	**-1.5**	**-1**	**-0.5**	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**3.75**	**4**
		Sieve Size (mm)	**15.875**	**11.125**	**7.925**	**5.664**	**4.75**	**4**	**2.794**	**2**	**1.41**	**1**	**0.706**	**0.5**	**0.353**	**0.25**	**0.18**	**0.124**	**0.09**	**0.074**	**0.064**
	14.6%	**Sub Area 4 Composite**	**99.40**	**99.32**	**98.95**	**98.58**	**98.40**	**98.16**	**97.68**	**97.00**	**96.16**	**95.31**	**94.19**	**92.20**	**89.51**	**79.25**	**61.46**	**29.49**	**10.98**	**8.42**	**7.36**

4. "PREFERRED ALTERNATIVE" BLIND PASS RESTORATION PLAN

Channel Alternatives were considered in the development of the Preferred Alternative for Blind Pass Restoration Project. These alternatives, as described in Section 3, evaluated varying channel geometry to determine the preferred tidal channel. To determine the preferred channel geometry and alignment for the Blind Pass Restoration, an evaluation of alternative design features was conducted using numerical and empirical analysis methods. Each alternative was evaluated in terms of their expected performance in meeting the design goals for the Project. The two primary design goals were to: (1) provide a stable channel cross-section, and (2) minimize adverse impacts to biological resources while maximizing flushing of the interior bay waters.

The Preferred Alternative is based on an evaluation of each alternative, in terms of their expected inlet cross-sectional and planform location stability, tidal prism and current velocities, environmental impacts expected permitting constraints, maintenance requirements and anticipated performance. Based on hydrodynamic model analysis which evaluated inlet cross-section and direct impacts to wetland habitats, Channel Alternative "F" was determined to be the Preferred Alternative of the nine alternatives evaluated.

A plan view drawing depicting the channel alignment and width(s) of the Preferred Alternative is presented in Figure 4-1. The channel width at the west most boundary of the Gulf of Mexico is designed as a trapezoidal geometry at 330 ft width (NAVD88) and -10 ft depth (NAVD88) with side slopes of 5:1 (H:V). The Bridge section and Critical Section are designed at a 160 ft width and -10 ft depth (NAVD88) with a 3:1 (H:V) side slopes. The Interior Tidal Channel has the dimensions of 100 ft width and -8 ft depth (NAVD88) with a 3:1 (H:V) side slopes. Figure 4-2 (sheets 1-9) depict the proposed excavation for channel commencing at cross sections Section A'-A east to Section Q'-Q along the proposed Pass and Tidal channels. The cross-sectional area at the Bridge Section is 1500 ft^2 which is approximately the mid-range (1350 ft^2 and 1600 ft^2) area for a stable inlet (also as reported by Mehta, 1991).

The key components of the Preferred Alternative recommended to restore Blind Pass include:

- The Pass Channel reach through the historical location between Captiva Island and Sanibel Island at dimension of -10 ft (NAVD 88) depth and 160 ft width through the bridge with side slopes 3:1 (H:V) to provide sufficient hydraulic capacity for inlet stability.

- The Transition Tidal Channel reach aligned to avoid mangrove wetlands to minimize the impact on wetland community and follow the natural historic location.

- The Interior Tidal Channel, reach dimensioned to an -8ft (NAVD88) depth and 100 ft width, to provide conveyance of the requisite tidal prism to provide cross-sectional stability and improve the tidal flushing in Roosevelt Channel and Wulfert Channel.

The total excavated quantity of sediment is estimated at 115,000 cubic yards based on the May 2005 survey. This volume includes all material to the design channel depths and widths including material within the side slopes. The Preferred Alternative impacts 0.5 Acre of mangrove wetland and the Transition Tidal Channel between the Bridge Section and the Critical Section.

4.1 Sediment Quantities and Quality

The Preferred Alternative (as specified in this Project Design Report) is the baseline design. The total excavated quantity of sand for the Preferred Alternative is estimated at 115,000 cubic yards, based on the May 2005 surveys, which includes all material to the design depths and widths including material within the side slopes. The Preferred Alternative would require removal of approximately 43,000 cubic yards from excavating the restored Pass channel (Sub Area 1), 31,000 cubic yards of sediment from the Pass tidal channel bayside of the bridge (Sub Area 2), 17,500 cubic yards of material from the Pass Tidal Channel to Roosevelt Channel (Sub Area 3), and 24,000 cubic yards from the sedimentation basin (Sub Area 4).

Beach compatible material will be hydraulically excavated and transferred via floating and fixed pipeline to adjacent beaches on Captiva and Sanibel Island between DEP monuments R-108 and R-118. Material from Sub Area 4 will be placed in a sediment containment area, separated and the unsuitable material will be disposed of at an approved site.

4.2 Ebb Tidal Shoal at the Pass

When Blind Pass Channel is dredged and tidal flows are restored in the Project area, the ebb tidal shoal will form as a function of the new tidal hydraulics and longshore sediment transport conditions. The channel dimensions are designed to provide sufficient ebb tidal flows to scour and flush out the sediments deposited within the Pass as the net southerly sediment transport forms the ebb shoal between Captiva Island and Sanibel Island. Strong ebb tidal flows will move sediment seaward to the Pass and subsequent ebb flows will carry sediment from the pass throat and interior shoals to the ebb shoal and adjacent beaches. Sediment that is not moved seaward will be carried onto the flood shoal and deposit sediment within the interior tidal channel, which over time could reduce the tidal prism.

Qualitatively, there will be a period of time immediately following the pass restoration when the new ebb shoal will be forming. During this period, it is assumed that littoral material from the net southerly drift will be "filling in" the Pass and be flushed out to form the ebb shoal. This should not result in a negative impact to the shoreline adjacent to the Pass if, during construction of the Project, a sufficient quantity of sediment is placed on the beaches to serve as a feeder beach to form the shoal.

The ebb shoal volume of Blind Pass is determined by the relationship (Walton and Adams, 1976) between the tidal prism and the ebb shoal volume using the linear regression method.

$$V_E = a\,P^b$$

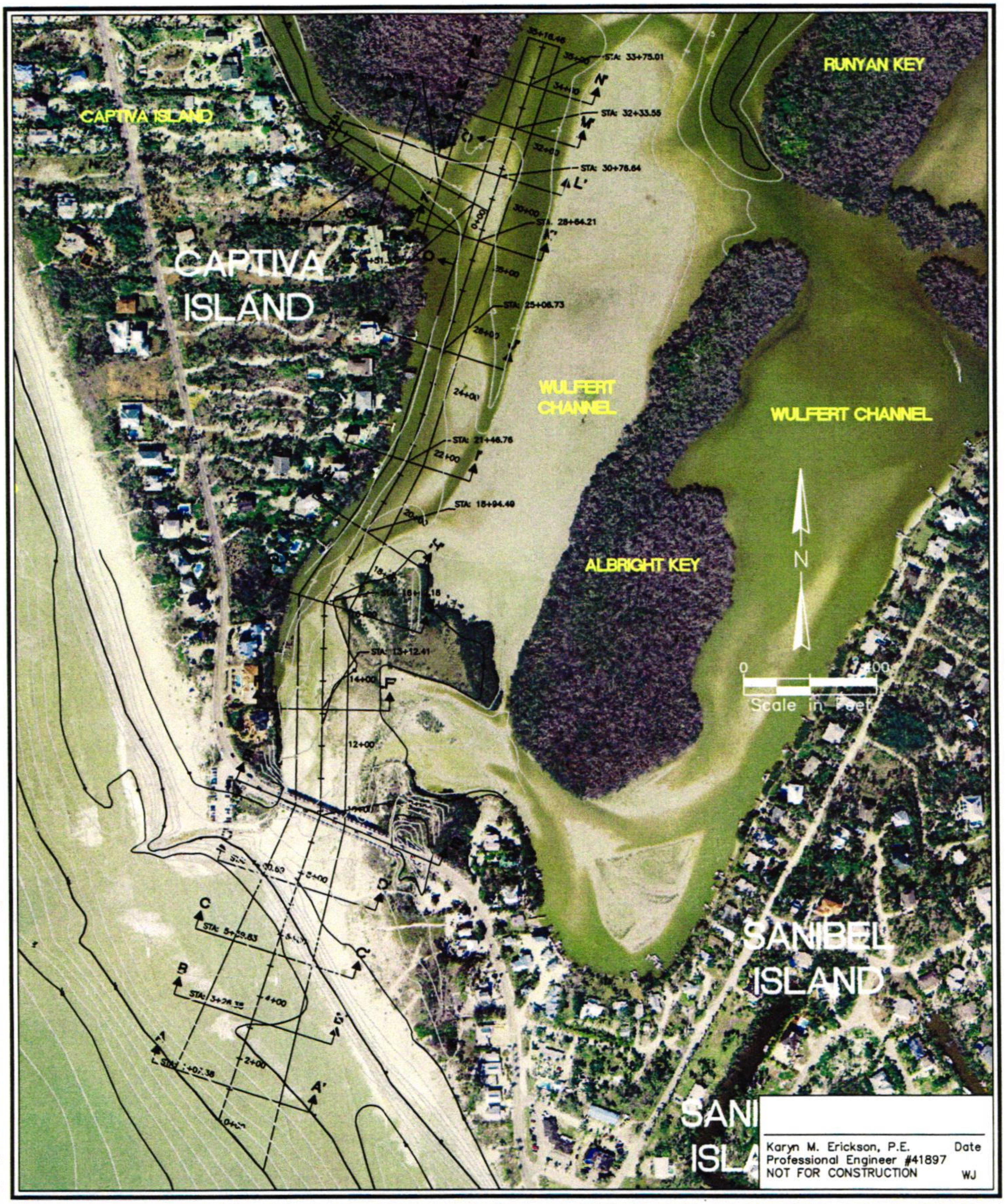
where

V_E = Volume of sediment in the ebb shoal of the inlet

P = Tidal prism of inlet

a and b = Correlation coefficients

Based on results of relationship between ebb shoal volume and tidal prism for 44 inlets, correlation coefficients a and b were determined 10.7 and b=1.23, respectively. The ebb shoal volume of Blind Pass is expected to range from 0.79 to 0.83 MCY (million cubic yards). The design ebb shoal volume is 0.82 MCY for purposes of beach stabilization and Pass maintenance planning. The volume change of sediment in ebb shoal is estimated using the reservoir model (Kraus, 2002) until it reaches an equilibrium volume according to the hydrodynamic conditions as shown in Figure 4-11. The ebb tidal shoal of the inlet is expected to form over a period of 40 to 50 years before reaching the equilibrium volume of 0.82 MCY. Figure 4-12 shows the ebb tidal shoal will be reached at 90% of equilibrium volume approximately 30 years after tidal flows through the Pass are restored.



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NOT FOR CONSTRUCTION WJ

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FIGURE 4-1 PLAN VIEW OF PREFERRED ALTERNATIVE

Blind Pass Restoration
Lee County, Florida

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PROJECT 05129	CHECKED BY	
DATE 04/27/06	DRAWN BY JE	
SCALE Scale	SHEET: 1 of 1	

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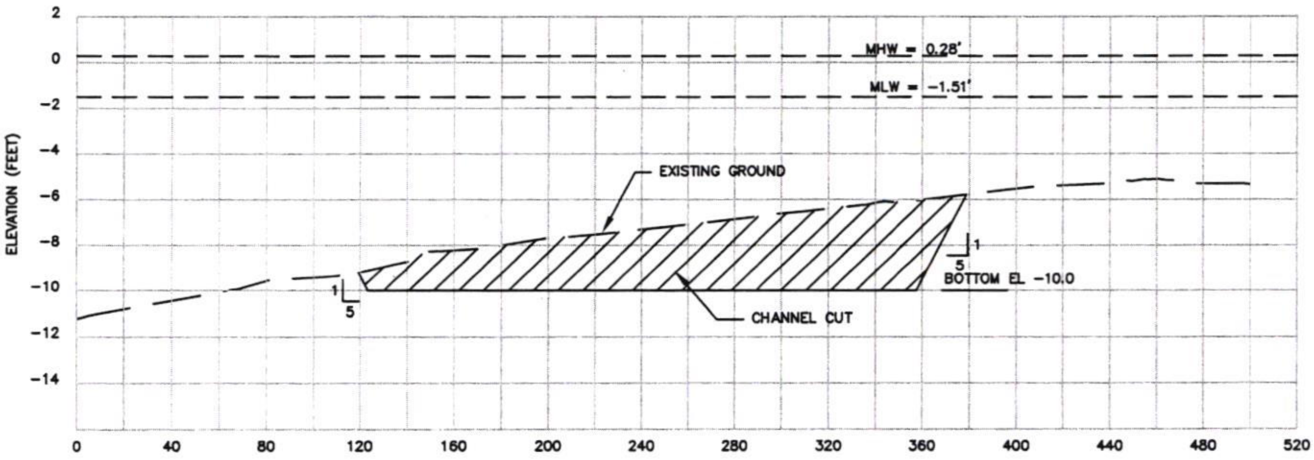
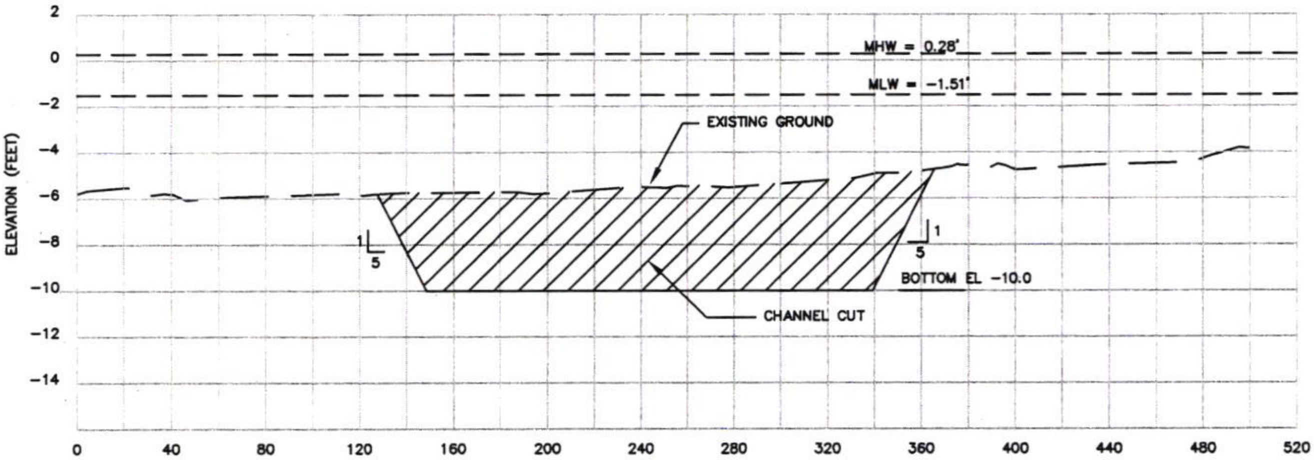


SECTION A–A'
SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET



SECTION B–B'
SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET

NOTES:
1. CHANNEL CROSS SECTIONS BASED ON SURVEY BY MCKIM AND CREED, MAY 2005. ELEVATIONS IN FEET, NAVD 88.

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FIGURE 4–2 CHANNEL CROSS SECTIONS
SECTIONS A–A' AND B–B'

Blind Pass Restoration
Lee County, Florida

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SCALE As Shown	SHEET: of

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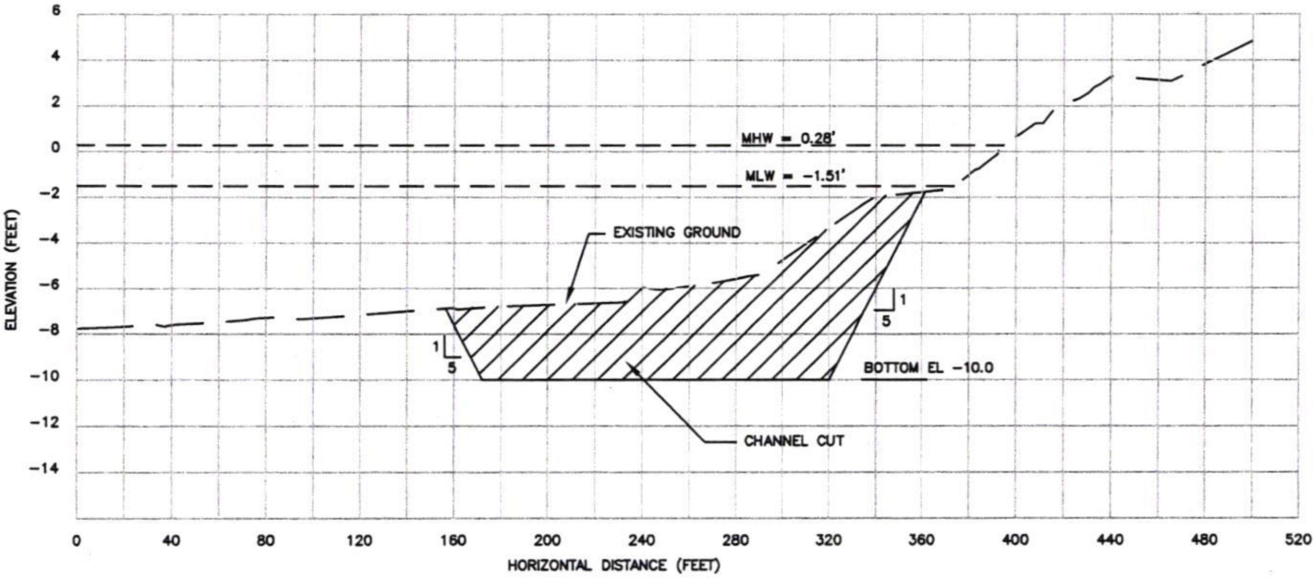
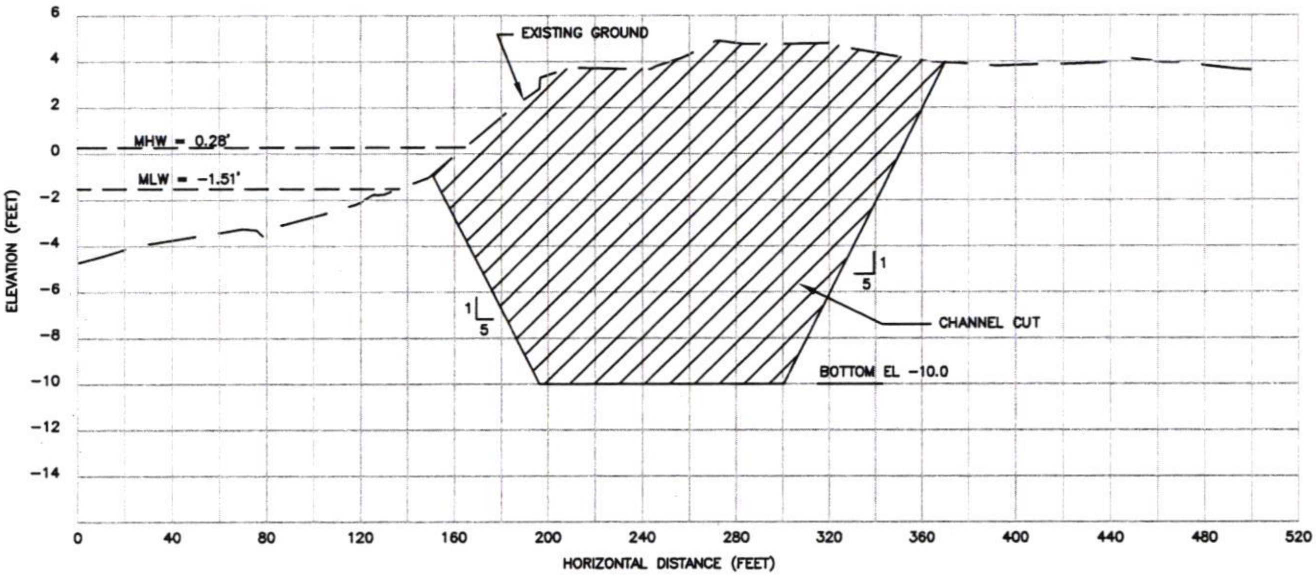


CROSS SECTION C–C'

SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET



SECTION D–D'

SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET

NOTES:
1. CHANNEL CROSS SECTIONS BASED ON SURVEY BY MCKIM AND CREED, MAY 2005. ELEVATIONS IN FEET, NAVD 88.

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FIGURE 4–3 CHANNEL CROSS SECTIONS
SECTIONS C–C' AND D–D'

Blind Pass Restoration
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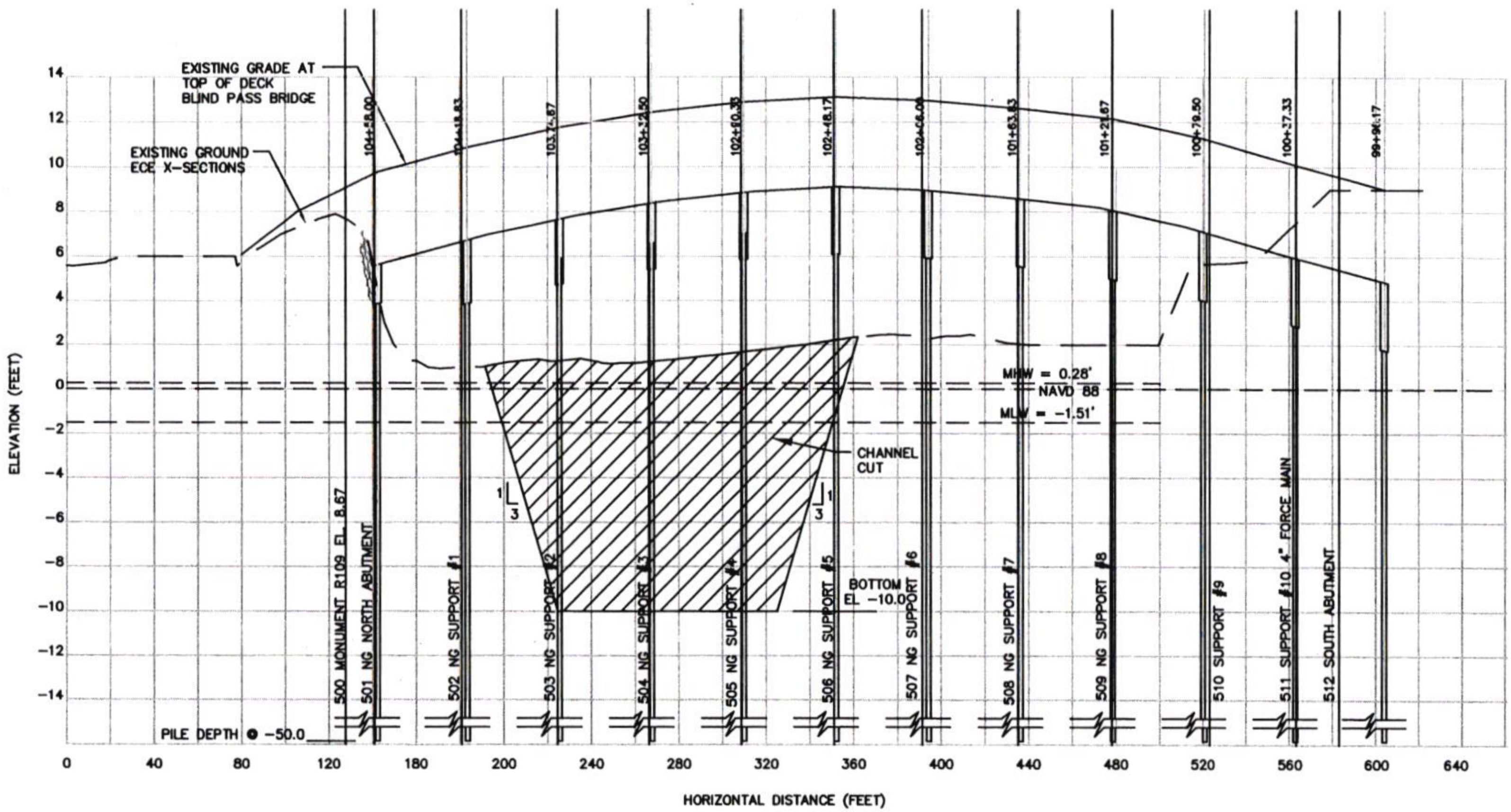
SCALE As Shown	SHEET: 2 of 9



CHANNEL SECTION E-E' AT EXISTING BRIDGE

SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET

NOTES:

1. CHANNEL CROSS SECTIONS BASED ON SURVEY BY MCKIM AND CREED, MAY 2005. ELEVATIONS IN FEET, NAVD 88.
2. BRIDGE PROFILE TAKEN FROM RECORD DRAWINGS B-2, B-6 & B-7, BLIND PASS BRIDGE REPLACEMENT, DATED FEB. 26, 1991 BY JENKINS & CHARLAND, INC.

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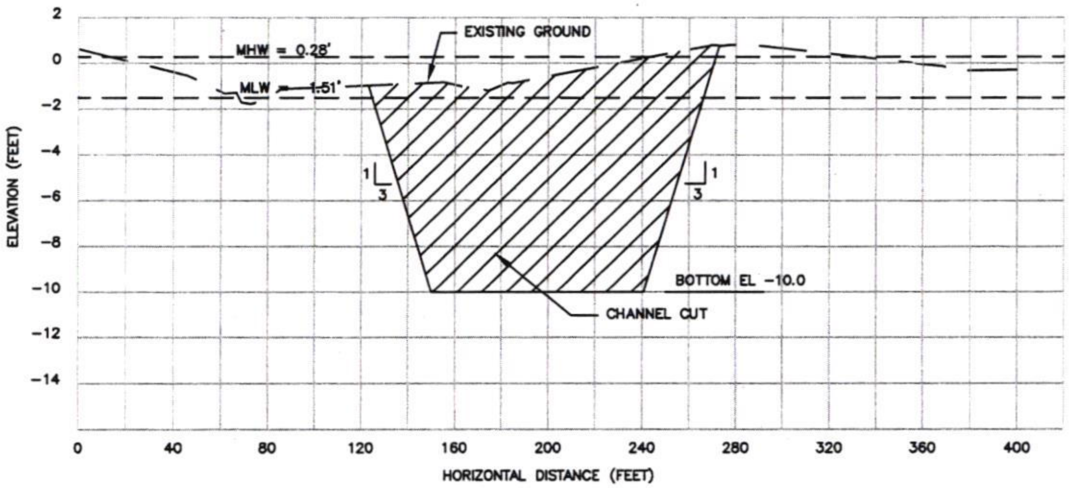
FIGURE 4-4 CHANNEL CROSS SECTIONS
SECTIONS E-E'

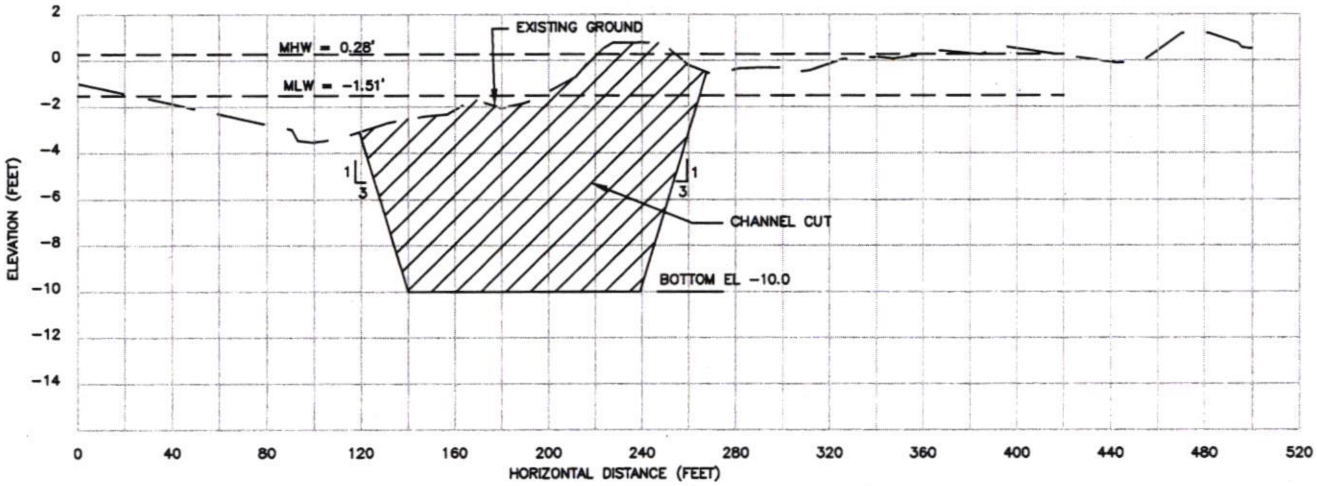
Blind Pass Restoration
Lee County, Florida

REVISIONS

PROJECT 05-129	CHECKED BY WJ
DATE 01/12/06	DRAWN BY JE
SCALE As Shown	SHEET: 3 of 9



SECTION F–F'
SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET



SECTION G–G'
SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET

NOTES:
1. CHANNEL CROSS SECTIONS BASED ON SURVEY BY MCKIM AND CREED, MAY 2005. ELEVATIONS IN FEET, NAVD 88.

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FIGURE 4–5 CHANNEL CROSS SECTIONS
SECTIONS F–F' AND G–G'

Blind Pass Restoration
Lee County, Florida

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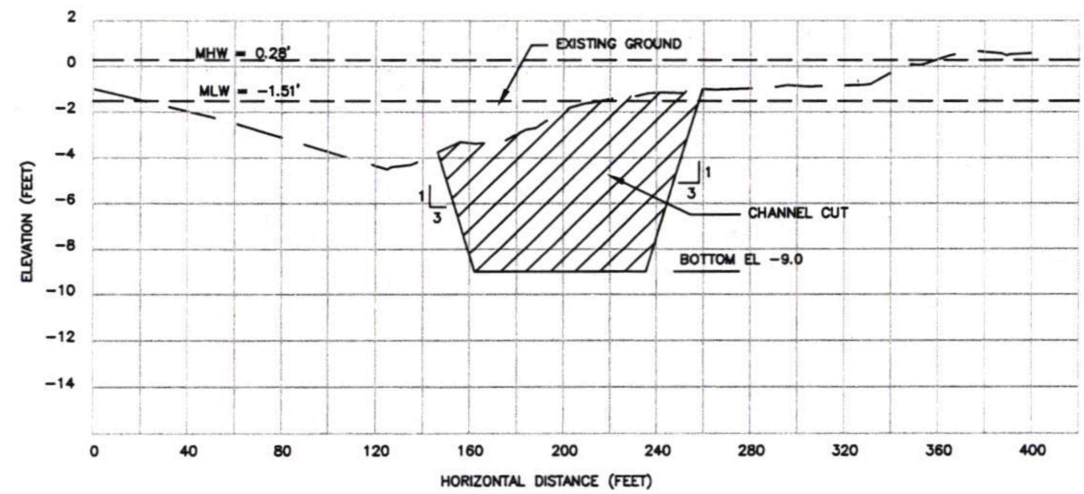

SECTION H–H'
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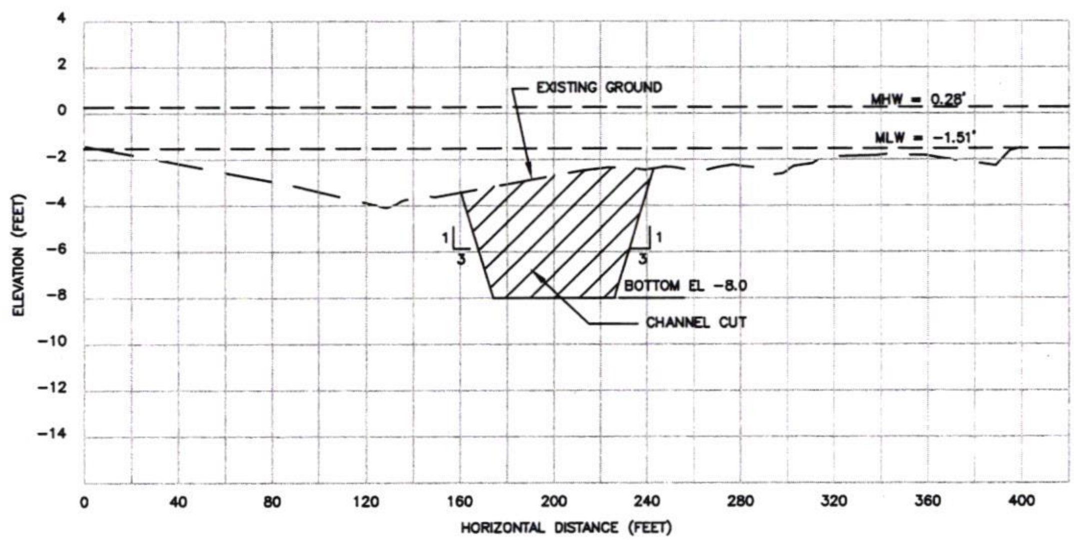
VERT. 1"= 8 FEET



SECTION I–I'
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VERT. 1"= 8 FEET

NOTES:
1. CHANNEL CROSS SECTIONS BASED ON SURVEY BY MCKIM AND CREED, MAY 2005. ELEVATIONS IN FEET, NAVD 88.

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FIGURE 4–6 CHANNEL CROSS SECTIONS
SECTIONS H–H' AND I–I'

Blind Pass Restoration
Lee County, Florida

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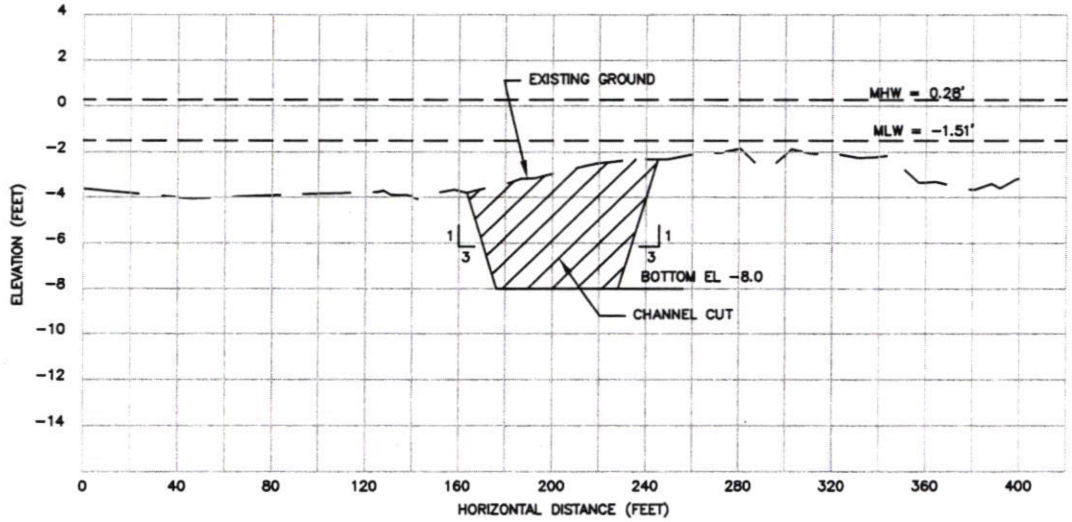

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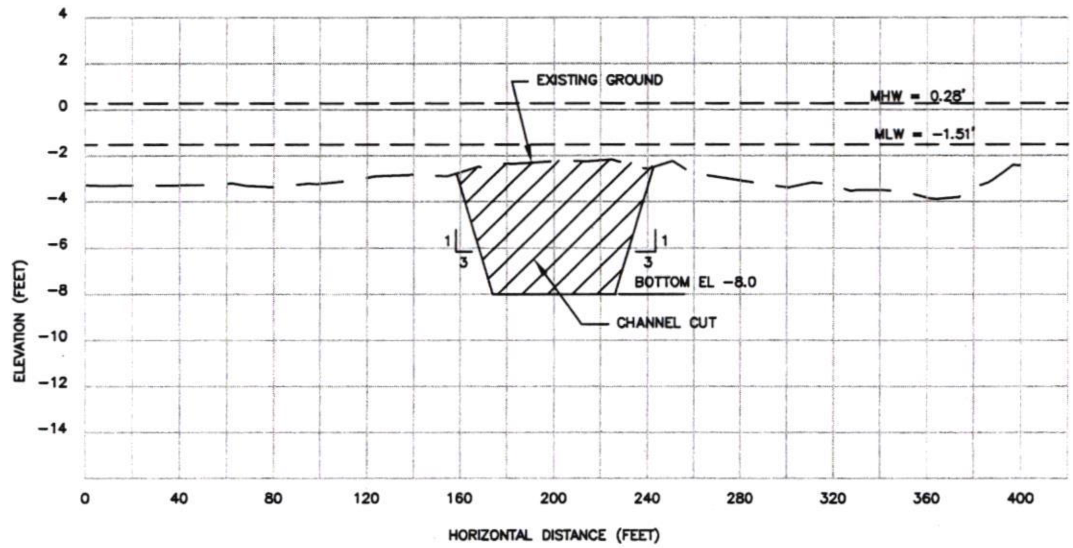

SECTION K–K'
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NOTES:
1. CHANNEL CROSS SECTIONS BASED ON SURVEY BY MCKIM AND CREED, MAY 2005. ELEVATIONS IN FEET, NAVD 88.

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FIGURE 4–7 CHANNEL CROSS SECTIONS
SECTIONS J–J' AND K–K'

Blind Pass Restoration
Lee County, Florida

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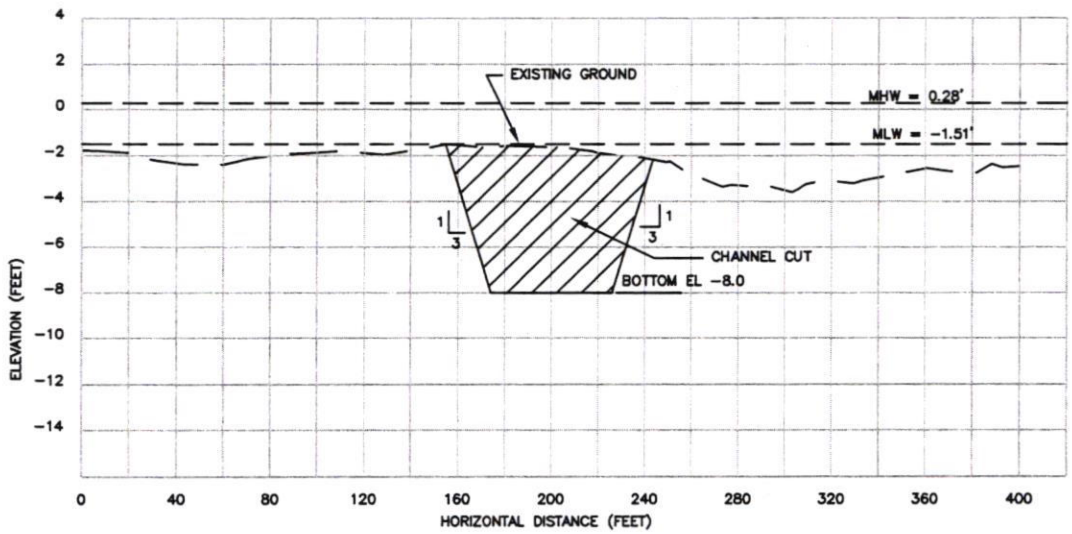

SECTION L–L'

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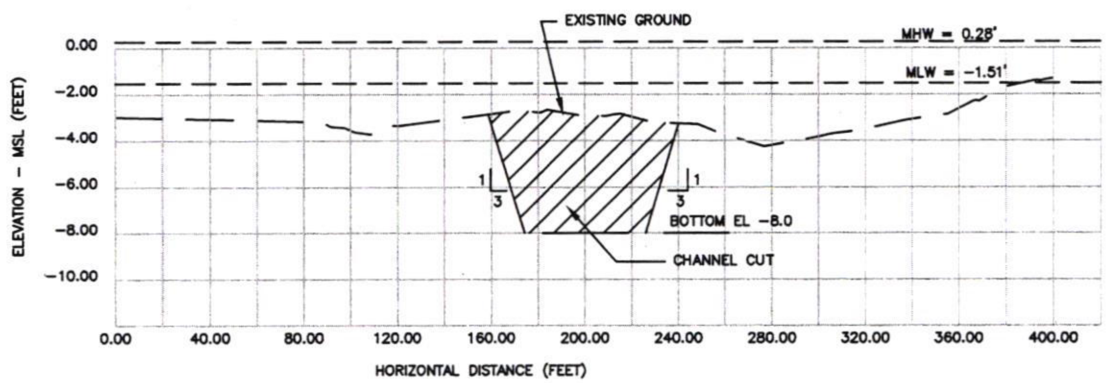

SECTION M–M'

SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET

NOTES:
1. CHANNEL CROSS SECTIONS BASED ON SURVEY BY MCKIM AND CREED, MAY 2005. ELEVATIONS IN FEET, NAVD 88.

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FIGURE 4–8 CHANNEL CROSS SECTIONS
SECTIONS L–L' AND M–M'

Blind Pass Restoration
Lee County, Florida

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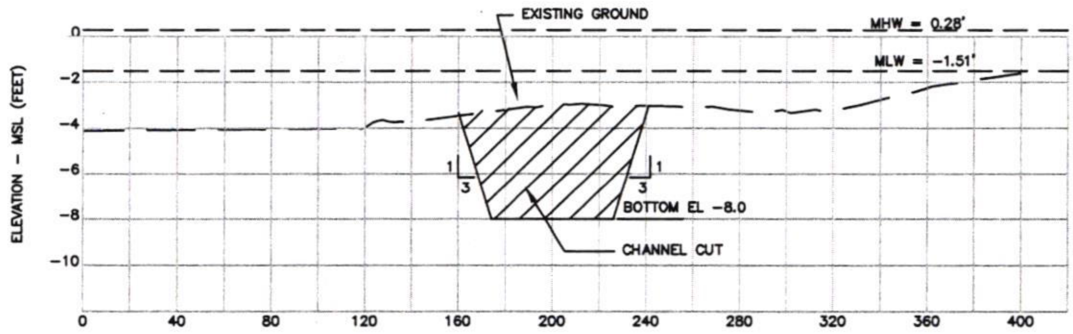
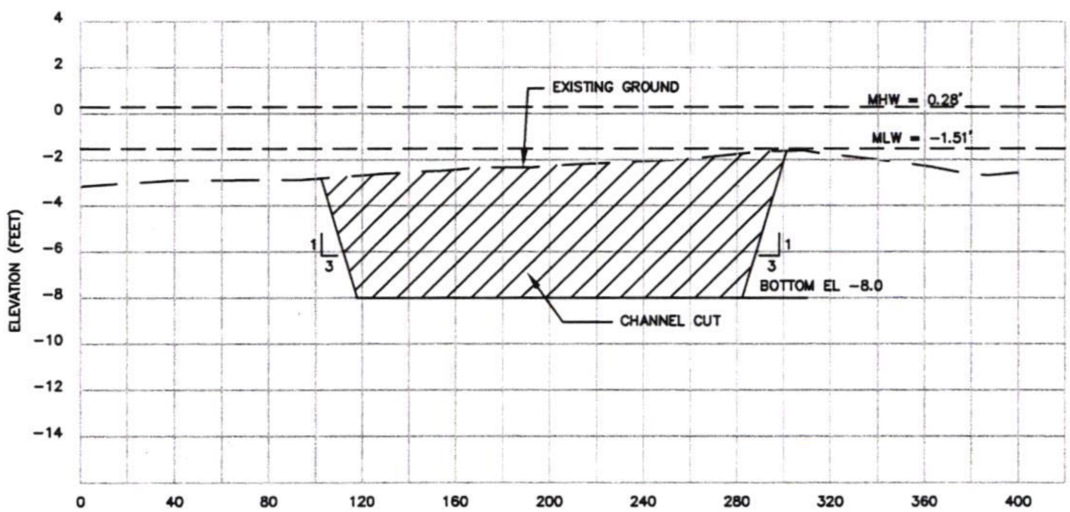


HORIZONTAL DISTANCE (FEET)

SECTION N–N'
SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET



HORIZONTAL DISTANCE (FEET)

SECTION O–O'
SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET

NOTES:
1. CHANNEL CROSS SECTIONS BASED ON SURVEY BY MCKIM AND CREED, MAY 2005. ELEVATIONS IN FEET, NAVD 88.

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FIGURE 4–9 CHANNEL CROSS SECTIONS
SECTIONS N–N' AND O–O'

Blind Pass Restoration
Lee County, Florida

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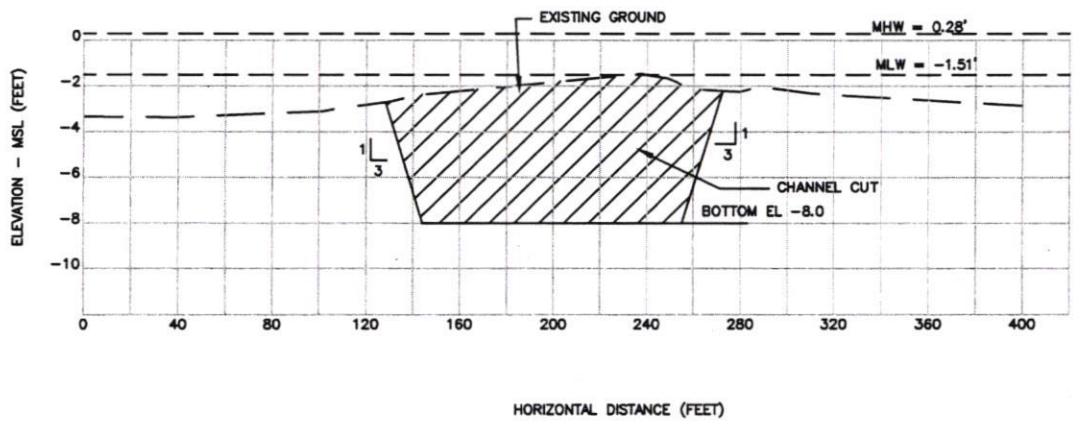

SECTION P-P'
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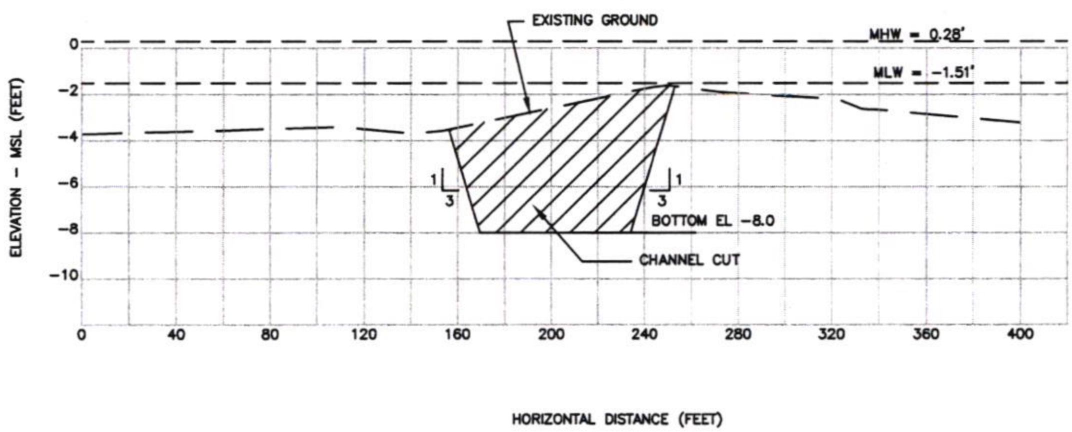
VERT. 1"= 8 FEET



SECTION Q-Q'
SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET

NOTES:
1. CHANNEL CROSS SECTIONS BASED ON SURVEY BY MCKIM AND CREED, MAY 2005. ELEVATIONS IN FEET, NAVD 88.

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FIGURE 4-10 CHANNEL CROSS SECTIONS
SECTIONS P-P' AND Q-Q'

Blind Pass Restoration
Lee County, Florida

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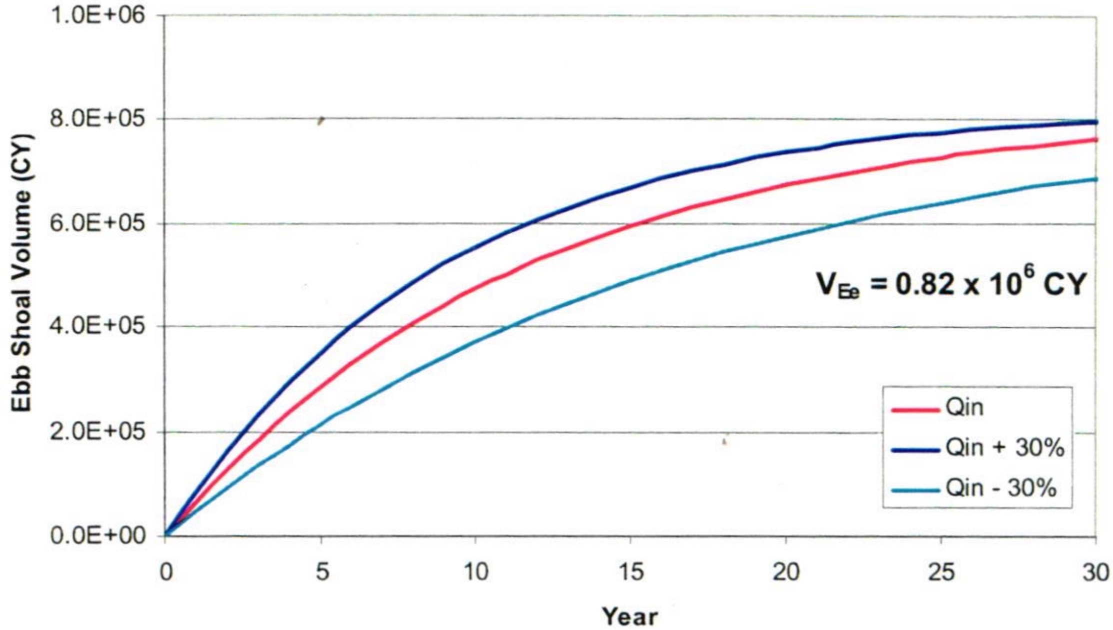


Figure 4-11 Volume Growth of Ebb Shoal at Blind Pass following Pass Restoration

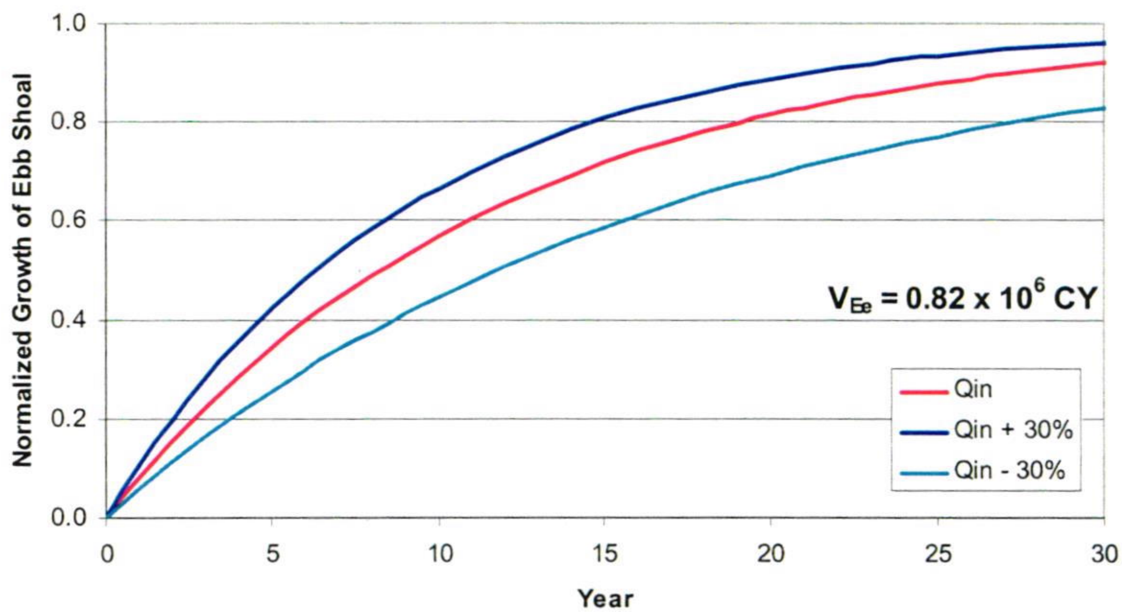


Figure 4-12 Normalized Volume Growth of Ebb Shoal at Blind Pass following Pass Restoration

5. ENVIRONMENTAL AFFECTS

5.1 Tidal Hydraulics

Blind Pass, which is presently closed, is located between Captiva Island and Sanibel Islands between Redfish Pass to the north and Matanzas Pass to the south. Because of continuous exposure to waves and a loss of tidal prism, the net southerly longshore sediment infilled the Pass and interior channels resulting in closure with intermittent break-throughs. The Pass channel closed due to cross-sectional instabilities which resulted from shoaling and hydraulic inefficiencies. Due to continued shoaling and several hurricane events the Pass closed in the beginning of 2000. Blind Pass is presently closed, as a result Wulfert Channel and Roosevelt Channel convey tidal flows between Pine Sound and Dinkins Bayou and Clam Bayou. The west most reaches of Wulfert Channel are filled with sediments and bottom elevations are shallow with depths nominally less than -3 ft (NAVD88) based on surveys performed in May 2005. Tides in the project area are mixed with diurnal and semi-diurnal tides through the month and the mean and spring tide range is 1.35 ft and 3 ft, respectively, spring tide range.

The hydrodynamic changes associated with varying channel dimensions to construct the Blind Pass Restoration Project, were evaluated using a hydrodynamic model. The hydrodynamic model "ADvanced CIRCulation Model (ADCIRC)" was used to simulate the existing system and each proposed alternative. This model was applied to determine changes in water elevations, tidal flows, channel velocities, and flow distribution to the interior channels associated with varying tidal channel geometry. A Model calibration (refer to Appendix A) was based on adjusting model variables to achieve agreement with measured water elevations and current velocities. These measured data were collected in March through May in 2005 using two ADCPs to measure tidal flows and one tidal gauge to record tidal elevation as described in Section 2. Nine alternatives were simulated using the model to evaluate varying channel geometries to determine the optimal design dimensions of the Pass and tidal channels to restore Blind Pass.

The Preferred Alternative is referred to as Channel Alternative F, described in greater detail in Section 3. The hydrodynamic analysis of the environmental changes (tidal prism, circulation and currents) resulting from the construction of the "Preferred Alternative" was evaluated using the ADCIRC and analytical engineering tools and methods. Variations on this design were also modeled to provide insight into the sensitivity of the inlet system to changes in channel depth, width and channel alignment configuration(s). A summary of the project alternative scenarios modeled in this study is provided in Table 5-1.

A quantitative analysis of the of the "Preferred Alternative" hydrodynamic changes was performed for several parameters:

- Tidal prism(s) at Blind Pass
- Tidal prism(s) at Redfish Pass
- Flow distributions (tidal prism) to adjacent channels with in the Blind Pass hydrodynamic regime/system
- Average maximum velocities in the Bridge Section (Blind Pass)
- Average maximum velocities at the Critical Section (Transition Channel at Mangroves)

The model is set up as a two dimensional, analytical simulation, therefore the predicted velocities are depth averaged.

Tidal prism is defined as the volume of water that passes through a channel cross-section during the course of a tidal cycle. Tidal prisms were calculated at Blind Pass, Redfish Pass, Roosevelt Channel, and Wulfert Channel, which were compared between the Preferred Alternative and the Existing Condition. The tidal prism for the mixed tide diurnal/semi-diurnal type of tide is not a constant value, and as a result changes depending on the tidal conditions (i.e. daily variation). Therefore, for this analysis, the tidal prism was defined as the average daily tidal prism over a 14-day spring/neap tidal cycle. The tidal conditions for the period between April 3 and April 17 in 2006 were the basis for the tidal prism computations.

A comparison of the simulated tidal prisms at the adjacent interior tidal channels and Blind Pass for the Preferred Alternative and the Existing Condition are summarized in Table 5-2. The model results show that the inlet will be ebb tide dominant and that the tidal prisms will be significantly increased through Wulfert Channel, Roosevelt Channel, and Dinkins Bayou by constructing the Blind Pass Restoration Project as proposed. At Wulfert Channel, the tidal prisms will increase approximately ten times during the ebb tide and twenty times during the flood tide phases of the tidal cycle. Also, tidal prisms will increase more than 4 to 6 times in Roosevelt Channel and Dinkins Bayou after the Pass is dredged. These model simulations show that Blind Pass will be an ebb dominant inlet, which significantly reduces the tendency for shoaling in the interior channels. Figure 5-1 compares tidal prisms at each channel resulting from the Blind Pass Restoration Project. Note that numbers shown in parentheses represent existing conditions. Significantly greater tidal prisms will improve the circulation and flushing in Wulfert Channel, Roosevelt Channel, and Dinkins Bayou.

At Redfish Pass, characterized by a prism approximately ten times larger tidal prism than Blind Pass, the model simulations predict that the restoration of Blind Pass will result in negligible changes at Redfish Pass. The changes in tidal prisms of Redfish Pass are expected to be less than one percent (1%) by the Blind Pass channel dredging.

The peak current velocities at the throat of the restored Blind Pass are an important variable that affects the stability of the inlet. A minimum of 3.5 ft/s current velocity during peak velocity conditions are required to scour sediments out of the inlet throat and maintain a stable inlet cross-section. Figure 5-2 summarizes the simulated depth averaged current velocity at the throat of Blind

Pass for the Preferred Alternative. The averaged peak current velocities are 3.3 ft/s during flood tide and 4.3 ft/s during ebb tide. When the cross-section area at the pass throat is reduced by the sediment carried into the pass due to wave action and flood current flows during each tidal cycle, the ebb current velocity increases at the pass throat cause turbulence and initiation of sediment transport and hence results in stability of the inlet as scour moves the sediment seaward to the ebb shoal or downdrift beaches. The averaged peak ebb and flood velocities of 4.3 ft/s and 3.3 ft/s are expected to provide sufficient flow rate to maintain a stable pass cross-section under the immediate post-construction condition.

5.2 Littoral Processes and Geomorphology

Littoral transport reversals are common in the vicinity of inlets primarily due to seasonal shifts in wave direction and sheltering and refractive effects of the ebb shoal feature. Both of these phenomena will affect the restored Blind Pass. As an ebb tidal shoal feature forms, and sand bypasses the inlet around the ebb tidal shoal feature, wave refraction along the ebb tidal shoal may cause a reversal in the direction of sand transport south of the inlet. As sand moves north (along Sanibel Island) towards the inlet, sand will deposit along the protected beaches in the lee of the ebb shoal, thus these shoreline segments tend to accrete, exhibiting a classic convex shoreline shape.

The section seaward of the inlet throat, at the entrance section to the ocean, is subjected to the combined forces of tidal flows and wave action. Sand carried by ebb tidal flows deposited in the ebb shoals will have less likelihood of reentering the channel, whereas sand carried by flood tidal flows deposit within the interior and flood shoals. Further, future sand placement onto the adjacent beaches will follow recommendations based on the findings of the monitoring program.

The principal forcing mechanism for littoral transport (i.e. sand movement) in the project area is the action of waves and wave breaking on the beach and nearby shoals. Initially the waves that are incident to the newly restored Pass will interact with the ebb tidal jet resulting in increased entrainment of sediments and development of our ebb tidal shoal surrounding the Pass. Until the ebb shoal fully develops, which is expected to occur over a period of 40 to 50 years, the typical sheltering and refractive effect of waves breaking on the shoals may result in beach erosion immediately south and north of the reopened pass (i.e. 1,000 ft). To ameliorate these losses, sand will be placed immediately updrift and downdrift of the Pass to "supply" the requisite sand volume, as the ebb shoal develops. It is expected that the beaches south of the pass will develop the classic convex shoreline shape upon development of the ebb tidal shoal as seen at the north end of Siesta Key (ECE, 2004). The major contributors to the sediment budget are the background longshore transport, the beach sand gains and losses, deposition in the maintained pass channel and the ebb shoal, sediment bypassing bar at the Pass.

The conceptual sediment budget is based on the sediment volume change (as shown in Table 5.3) using observed beach profiles since the beach nourishment performed between 1988 and 1989 on Captiva Island and north Sanibel Island. These analyses are based on the historic beach profile data obtained by Florida DEP between 1989 and 2004. The north and south limits of this analysis extends from R-100 at the north, about 8,460 ft north of the Pass (Captiva Island) to R-120 at the south, about 10,300 ft to the south of the Pass (Sanibel Island).

Four littoral cells, $LC_{Captiva}$, $LC_{Sanibel}$, LC_{Pass}, and LC_{Ebb}, are defined for the conceptual sediment budget as shown in Table 5.3 and Figure 5-3. Annual volumetric changes are initially estimated at -17,000 CY in $LC_{Captiva}$ and -26,000 CY in $LC_{Sanibel}$ based on these historic data sets. Because beaches adjacent to the restored pass will feed sand to form the ebb shoal, the higher volumetric change is used for the conceptual sediment budget. Sediment transport from north is assumed at 43,000 CY which was estimated during a period of 1988 and 1991 by CPE (1993).

Upon opening the Pass, some portion of the gross littoral transport will be trapped within the ebb shoal and pass channel until an equilibrium shoal and channel configuration is achieved. The annualized sand volume required to form the new ebb shoal is estimated at 57,000 cubic yards (CY) of sand based on the ebb shoal accretion from 0 to 5 years. The sand volume shoaling into the Pass is estimated at a minimum of 11,000 CY/year under the present assumption of the Pass infilling rate. Thus, maintenance will only occur at intervals whereby a minimum of 50,000 CY of sediment has deposited in the Pass and tidal channels.

Graphic representations of the conceptual sediment budget after the Blind Pass Restoration are shown in Figure 5.3 based on historical volumetric changes along the beaches and the estimation of ebb shoal development. The sand volumes from the adjacent beaches to form the ebb shoal are based upon a general longshore transport ratio (70% from north and 30% from south) along the west coast line in Florida.

From these the conceptual sediment budget, a 28,000 CY/YR net transport to the south is estimated after the Blind Pass Restoration Project.

5.3 Natural Resources

The Project design described in this report is expected to have direct and indirect impacts on natural resources within the footprint of the project and in the surrounding waters. A general summary of both adverse and beneficial impacts of various alternatives is summarized below. A more in -depth analysis of these impacts will be assessed in the forthcoming NEPA document, including a comparative analysis between the existing status quo, (No Action Alternative), and the alternative project designs described in Section 3 of this report. Figure 5-4 presents the natural resources that exist within the project area and the potential impacts. The "Preferred" project will not directly impact seagrass beds or marine resources identified in this study. Seagrass beds within the study area closest to the bridge are sparse and consist almost exclusively of shoal grass (*Halodule wrightii*), while the seagrass beds furthest to the east are dominated by turtle grass (*Thalassia testudinum*). However, a mapping effort conducted by Lee County Natural Resources Division in July 2004 identified sparse shoal grass within the project footprint. Conditions within the study area, particularly within the shallower areas nearest to the bridge are subject to rapid change due to environmental influences. Conditions within this area will most likely continue to change in the immediate future.

Benthic resources (approximately 8 acres) will be impacted with the project. Benthic resources within the footprint of the project show no apparent differences with stations outside of the project footprint. Benthic diversity and density within the entire sampling area were dominated by annelids, arthropods, and mollusks. Once the project has been constructed, it is expected that the benthic community will quickly recolonize the area.

Mangrove wetlands will be impacted by the project. Two small areas of recent sand accretion (0.07 acres and 0.15 acres) will be removed with the project, and a portion (0.24 acres) of another newly formed mangrove area will be impacted. However, these areas contain sparse, immature red mangrove seedlings that have only recently colonized the area. The individual mangrove seedlings are less than 36 inches in height. The mangrove area will likely continue to grow and expand until the project has been constructed.

Fish and shellfish resources will not be directly impacted by the project. Some disruption of habitat will occur with project construction, but this will be minor and temporary. Once the project has been constructed, the open channel and deeper water will likely be utilized by many fish that currently do not frequent the shallow waters near the bridge. The current fish community structure in the immediate vicinity of the project is limited, particularly to typical juvenile species of southwest Florida. Opening of Blind Pass will have minimal negative direct impacts on finfish, and most likely will result in positive impacts on finfish diversity as a result of opening migratory access to offshore waters. Enhancement in flushing rates will allow for increased utilization of marine vegetative habitats by finfish. The value in terms of Essential Fish Habitat (EFH) will be described in detail in the NEPA document, for the project. Impacts to shorebirds and wading birds and their habitat are not expected. Utilization by these species is limited, at least in part by the amount of human activity.

Impacts to the West Indian manatee populations within the Bay are not expected. Much of the immediate project area is very shallow and not suitable for manatee utilization. Once the channel has been opened, the area may provide an additional passage between Pine Island Sound and the gulf. Indirect impacts may occur due to additional boating traffic in the project area, but the additional traffic would only be small, recreational craft that can access the shallow channel. Blind Pass has been historically open in the past, and vessel related mortality data previously discussed has been low for this area, so it is not likely that the project will adversely affect the manatee. Appropriate protection measures will be implemented to insure the safety of any manatees within the area during construction. Sea turtles will not likely be directly affected by the project. Construction activities should occur outside of the nesting season (May 1 through October 31) as to avoid impacts to nests or nesting turtles. Approximately 1.3 acres of potential nesting habitat will be lost with the project, resulting in a "take" of sea turtle habitat under the Endangered Species Act. Approval for this take will require a "take" permit from the U.S. Fish and Wildlife Service (USFWS). Only minor nesting (one nest in 2003) has occurred in the project area, while the majority of the nesting in recent years has occurred south of the project.

Table 5.1 Channel Geometry of Project Alternatives - Blind Pass Restoration

Channel Alternatives	**Description**									**Remark**
	Depth (ft, NAVD)			Width (ft)			Side Slope (H:V)			
	Interior Section	Critical Section	Bridge Section	Interior Section	Critical Section	Bridge Section	Interior Channel	Transition Channel	Gulf Entrance	
A	8	8	12	100	100	100	3:1	3:1	5:1	
B	8	8	12	100	120	140	3:1	3:1	5:1	
C	8	8	12	100	140	160	3:1	3:1	5:1	
D	8	10	12	100	140	160	3:1	3:1	5:1	
E	8	10	12	100	160	160	3:1	3:1	5:1	
F	8	10	10	100	160	160	3:1	3:1	5:1	Preferred Design
G	8	8	8	100	160	160	3:1	3:1	5:1	
H	10	10	14	100	100	220	3:1	3:1	5:1	
I	6	6	10	100	100	220	3:1	3:1	5:1	

Table 5.2 Tidal Prism Comparisons between Preferred Alternative and Existing Condition

Location	Tide	Tidal Prism ($\times 10^6$ ft^3)		Percent Change
		Existing Condition	Preferred Alternative	
Blind Pass	Flood	0	90	
	Ebb	0	110	
Wulfert Channel	Flood	4	80	+1900%
	Ebb	8	90	+1013%
Roosevelt Channel	Flood	3	13	+333%
	Ebb	2	13	+550%
Dinkins Bayou	Flood	1	4	+300%
	Ebb	1	5	+400%
Redfish Pass	Flood	688	683	-0.7%
	Ebb	991	993	+0.2%

Table 5.3 Historical Shoreline Change and Sediment Volume Change in the Project Area

		Intervening Distance (ft)	Shoreline Change (cy/ft)		Volumatric Change Rate(cy/ft)		Annual Volumatric Change Rate(cy/ft)		Annual Volumetric Change (CY/yr)	
			1989 ~ 1995	1996 ~ 2004	1989 ~ 1995	1996 ~ 2004	1989 ~ 1995	1996 ~ 2004	1989 ~ 1995	1996 ~ 2004
Captiva Island	R100		-2.1	-0.8	1.1	0.6	0.2	0.1		
	R101	977	-3.2	-4.6	3.8	3.0	0.6	0.4	399	220
	R102	1,201	2.0	-2.4	-0.1	17.1	0.0	2.1	378	1,511
	R103	832	6.2	-3.1	-1.9	15.0	-0.3	1.9	-136	1,671
	R104	1,023	5.1	-3.1	-11.6	25.2	-1.9	3.2	-1,150	2,570
	R105	1,118	-3.2	-8.8	-21.3	6.8	-3.6	0.9	-3,066	2,239
	R106	958	-8.5	-14.3	-33.7	-18.8	-5.6	-2.3	-4,390	-713
	R107	1,070	-11.1	-13.3	-45.4	-18.9	-7.6	-2.4	-7,049	-2,516
	R108	1,282	1.5	-8.2	25.7	-19.7	4.3	-2.5	-2,099	-3,093
	Average		-1.5	-6.5	-9.3	1.2	-1.5	0.1	-2139.1	236.3
	Total	8,460							-17,113	1,890
Ebb Shoal Area	R109	838	-1.2	0.1	16.6	-21.6	2.8	-2.7	2,959	-2,165
	Blind Pass									
	R110		4.7		48.3	41.8	8.1	5.2		
	R111	1,007	-4.9	-10.6	87.3	-113.7	14.6	-14.2	11,382	-4,524
	R112	792	-19.5	-6.7	-5.5	-77.1	-0.9	-9.6	5,401	-9,445
Sanibel Island	R113	1,204	-29.0	9.2	-66.6	22.1	-11.1	2.8	-7,236	-4,141
	R114	800	-23.0	0.6	-69.4	-18.4	-11.6	-2.3	-9,069	186
	R115	1,162	-15.1	-15.1	-47.4	32.2	-7.9	4.0	-11,312	1,006
	R116	1,135	-11.0	-11.0	56.4	-102.9	9.4	-12.9	853	-5,017
	R117	1,063	-4.5	-4.5	4.7	-90.8	0.4	-11.3	5,186	-12,872
	R118	1,058	-1.0	-1.0	N/A	-74.3		-9.3		-10,915
	R119	1,034	6.6	6.6	N/A	23.3		2.9		-3,297
	R120	1,038	9.1	9.1	-63.1	122.8	-4.9	15.3		9,476
	Average		-9.2	-2.3				-2.7		
	Total	10,295								-25,574

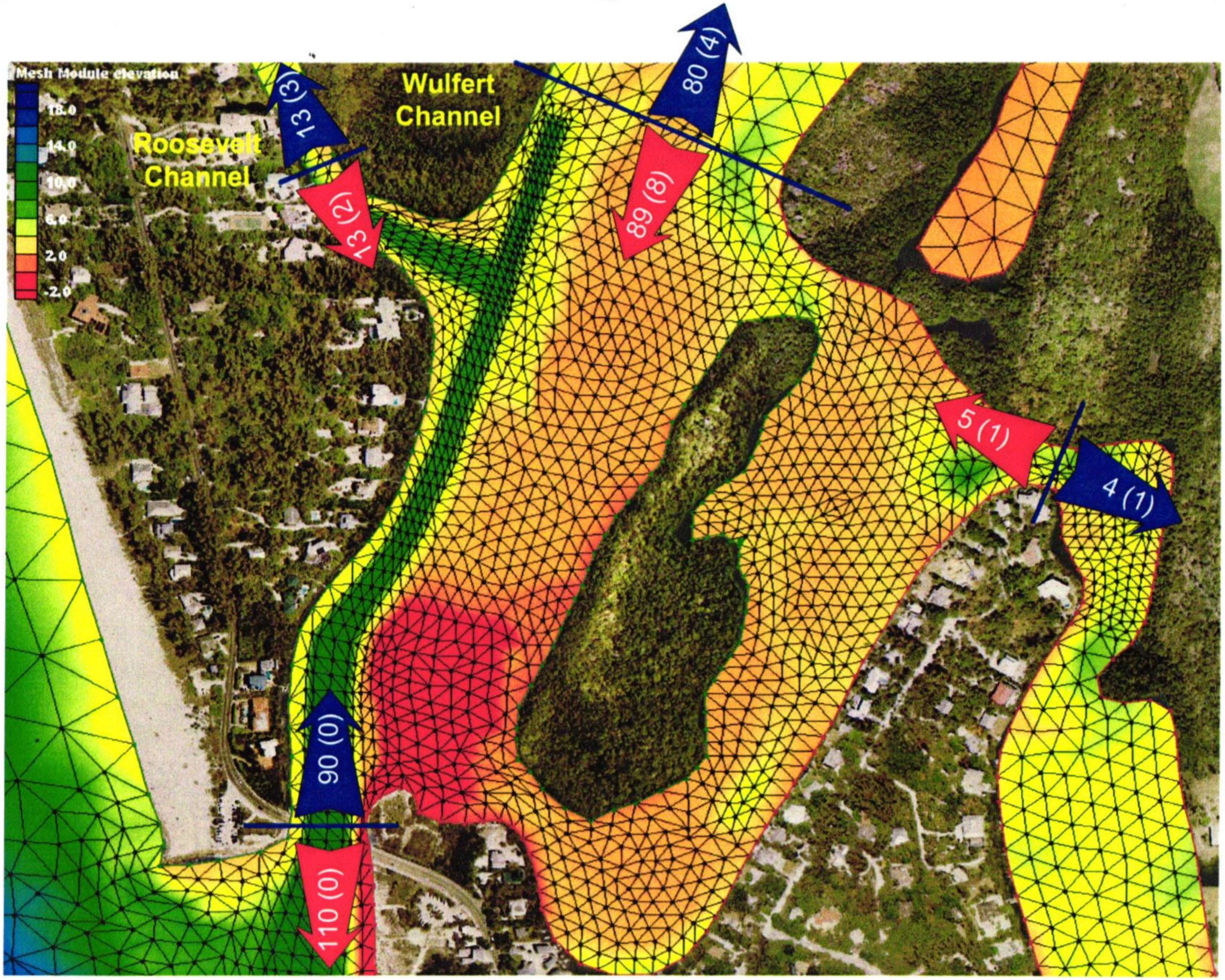


Figure 5-1 Tidal Prism Comparisons between Preferred Alternative and Existing Condition
(Tidal Prism: Preferred Alternative (Existing Condition), Unit: 10^6 ft^3)

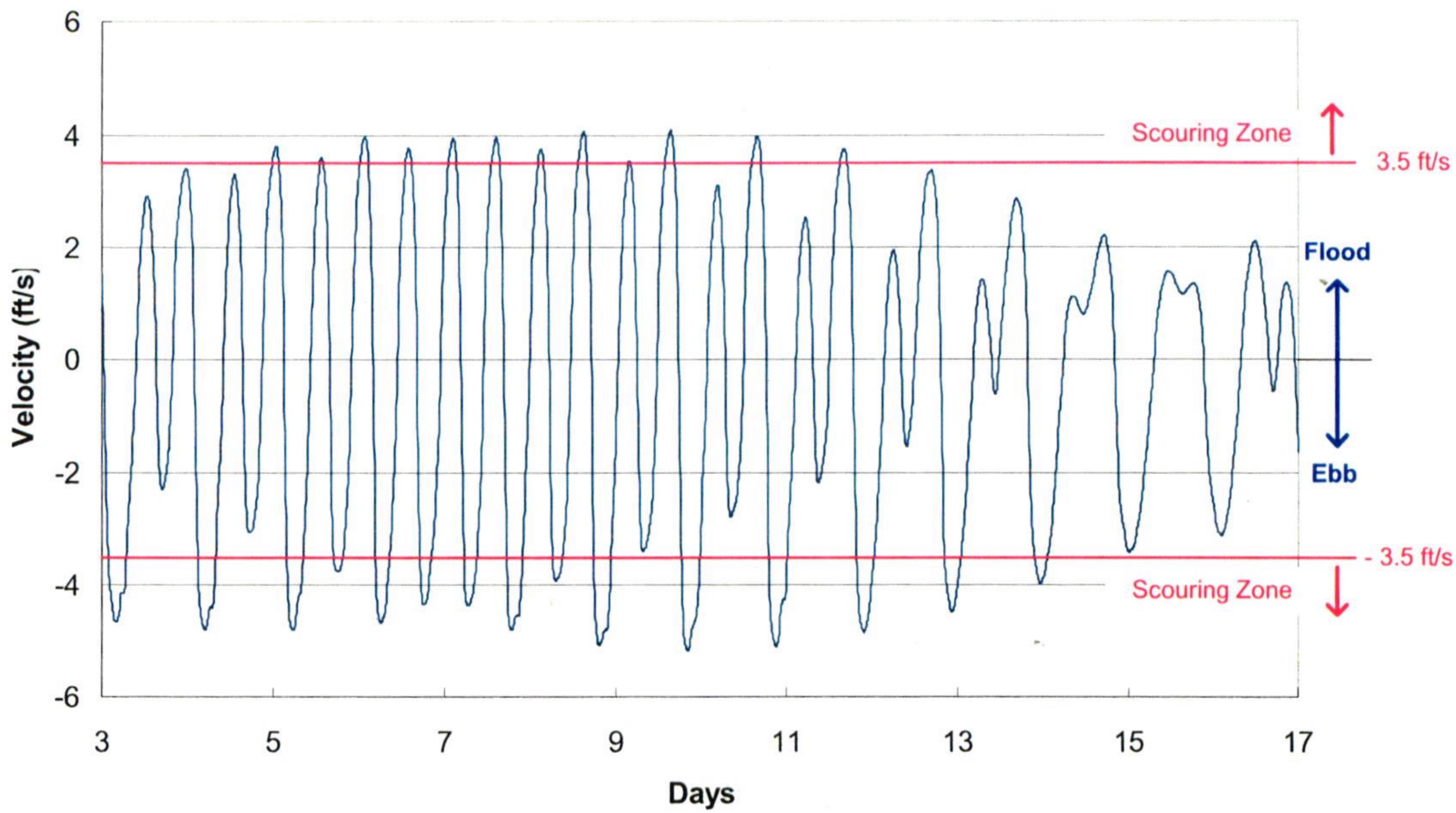


Figure 5-2 Current Velocity at Blind Pass after Dredging (Alternative Pass)

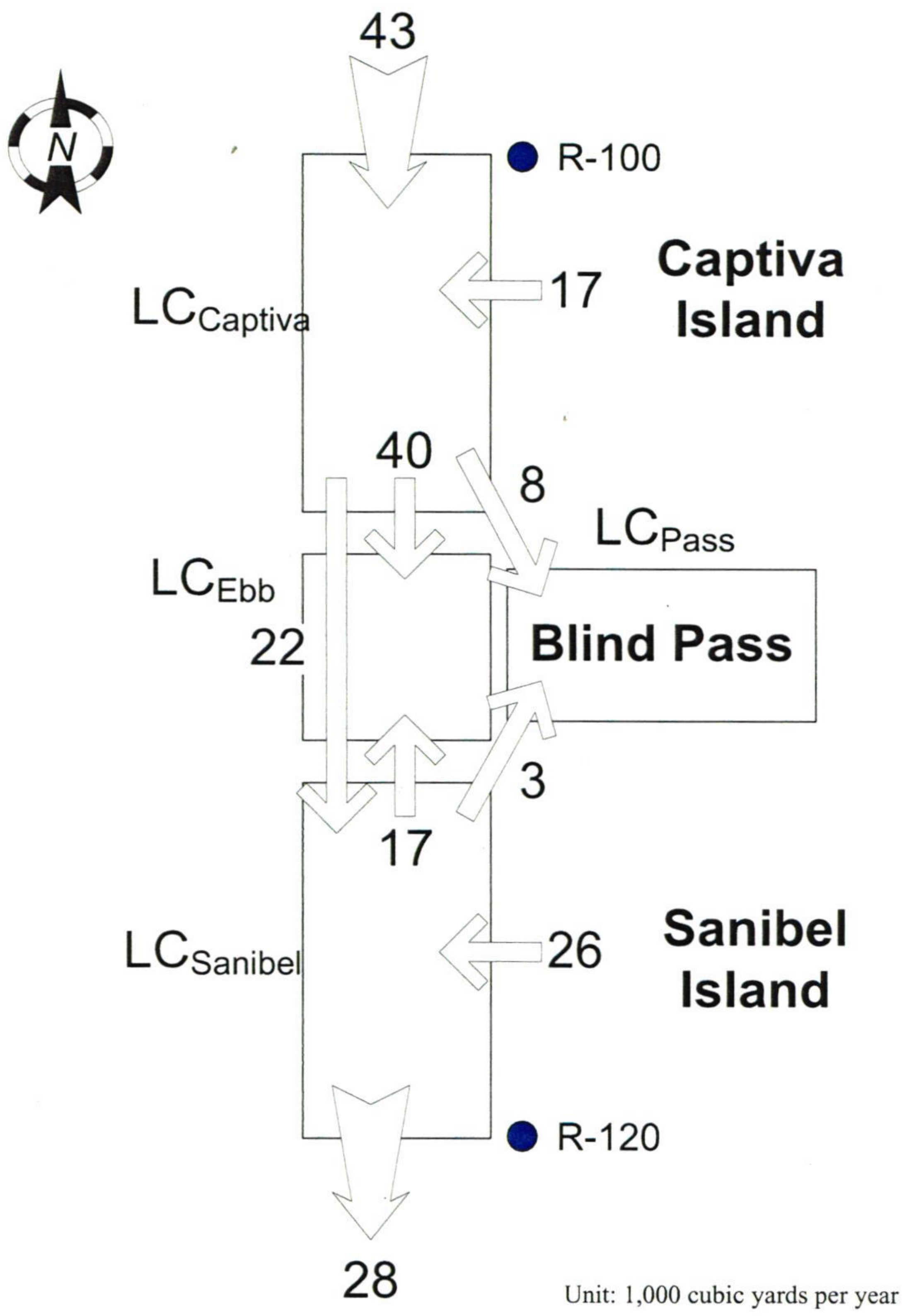
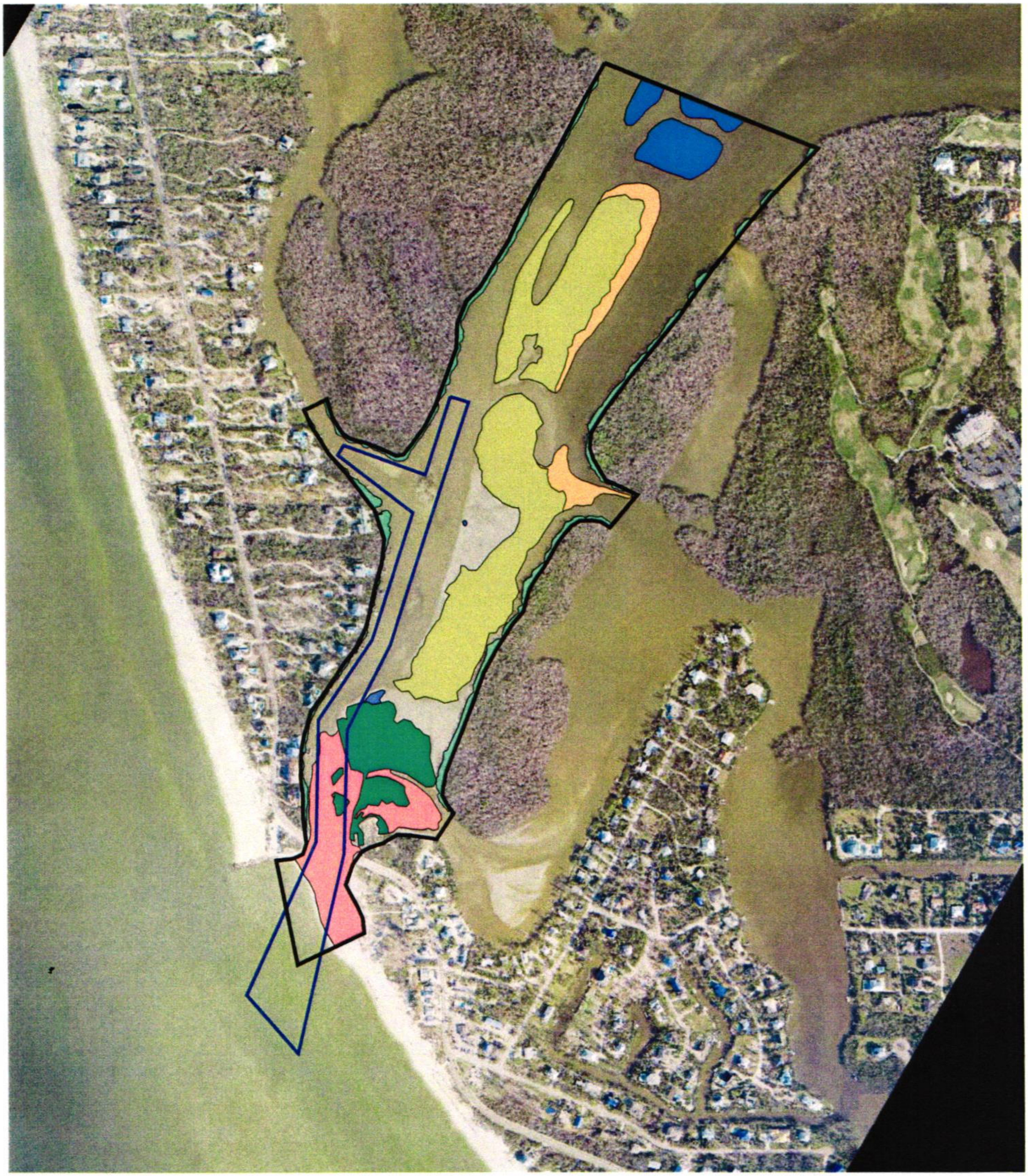


Figure 5-3 Conceptual Sediment Budget after Blind Pass Restoration Project



Extent of Survey Area
Plan View Channel Alignment
Option A
Blind Pass Resource Characterization
Halodule wrightii
Thalassia testudinum
Mixed seagrasses
Oyster
Mangrove
Fringe Mangrove
Accreted Sands

750 0 750 1500 Feet

Natural Resource Impact Assessment	
Blind Pass Restoration Project Design Report **Blind Pass, Lee County, FL**	
Scale: 1 inch = 750 feet	**Drawn By: MR**
Date: April 2006	**Approved By: LS**
DIAL CORDY AND ASSOCIATES INC Environmental Consultants	**J05-828** Figure 5-4

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HYDRODYNAMIC MODEL CALIBRATION

BLIND PASS RESTORATION

1.0 Introduction

Erickson Consulting Engineers, Inc. (ECE) conducted a hydrodynamic model study to support the Blind Pass Opening Project. The model study is (a) to provide a tool to aid in the engineering design by the evaluation of design alternatives and optimization of the inlet and interior channel dimensions and (b) to provide a framework for the evaluation of potential project induced environmental changes. This report describes the model set-up and calibration.

2.0 Study Methodology

The study utilized the (ADCIRC) model. ADCIRC is a state of the art (2-D, 3-D) numerical model for use in hydrodynamic evaluations of marine environments. The model was applied to the model domain which extends from the Gulf of Mexico to Pine Island Sound and includes Captiva Pass and Redfish Pass to the north and San Carlos Pass to the south.

The ADCIRC model equations formulated with the traditional hydrostatic pressure and Boussinesq approximations discretely defined using the Finite Element Method (FEM) in space and using the Finite Difference Method (FDM) in time. ADCIRC was run as a 2-Dimensional depth integrated (2DDI) model that allows adjustment of the model grid resolution.

Following the calibration, the model will be applied to simulate project alternatives identified based upon the baseline environmental data and information provided by recent field investigations and prior studies. The methodical application, testing and evaluation of a model to predict field data for a specific study domain is referred to as model calibration. The numerical model calibration verifies the methodical application and evaluation of a model to predict field data for a specific domain with existing conditions. The calibration results are a good assessment of the hydrodynamic numerical model accuracy. The model calibration process is an organized procedure to select model coefficients such that the best agreement is obtained between the model predictions and the measured data.

The calibration process for the hydrodynamic model focused on reproducing water surface elevation at 3 locations where water surface measurements were taken over a 30 day period. The primary parameter that can be adjusted is the bottom friction. The quality of the numerical model calibration is assessed using qualitative and quantitative evaluations. The most direct way to provide a qualitative evaluation is to plot the numerical simulation and the observed data at selected locations over the chosen time period. The quantitative comparisons include comparisons of the harmonic constituents of the observed data (i.e. performing a harmonic analysis of the tidal constituents of the observed data) to the model predictions.

3.0 Hydrodynamic Model Set-up

Model Area

The model domain included the passes, barrier islands, and embayments adjacent to the location of Blind Pass Restoration Project as shown in Figure 1. The northern and southern boundaries are located at a sufficient distance from the Blind Pass project area and the adjacent inlets that the project area and adjacent inlets are not influenced by the north and south boundaries. The open ocean boundary in the Gulf of Mexico is located sufficiently seaward where the water surface elevations at the boundary locations are not influenced by the inlets.

Grid Generation

A two-dimensional finite element mesh system was generated using National Ocean Service (NOS) bathymetry and shoreline data provided by NOAA and the most recent (May 2005) hydrographic and topographic survey data conducted by Mckim&Creed, Inc. The spacing of the grid nodes increased with depth and with distance from the project location as shown in Figure 1. The fine grid was generated in the Blind Pass project area including the Wulfert Channel and Roosevelt Channel based on the hydrographic and topographic surveys performed in May 2005 as shown in Figure 2. Grid nodes are separated by approximately 26,000 ft and 70 ft at the open ocean boundary and the project area for the Gulf of Mexico areas of the grid, respectively. The distance between grid nodes was about 50 ft at Wulfert Channel and Roosevelt Channel.

Boundary Conditions

Boundary conditions for the model consist of a seaward boundary, a mainland shoreline, and a number of barrier islands. To simulate the hydrodynamic conditions at the project area, the tidal forcing occurred along the open ocean boundary. The open ocean boundary in the Gulf of Mexico was located approximately 43 miles from the project location. The tidal forcing in the model is imposed by time as well as spatially varying water levels along the open ocean boundary of the model. The ADCIRC model can represent the Newtonian tidal potential and correction due to the effect of the Earth tides, ocean tide loading and self-attraction. For the model calibration simulations, the major tidal constituents of K_1, O_1, Q_1, K_2, M_2, N_2, and S_2 listed in Table 1 were imposed along the ocean boundary. This numerical model was run for 30 days from April 1 to April 30, 2005 to compare the simulation results to the observed data.

Table 1. Constituents of Tidal Forcing Along the Ocean Boundary

Symbol	Name	Period (hr)
K_1	Luni-solar diurnal	23.93
O_1	Principal lunar diurnal	25.82
Q_1	Larger lunar elliptic	26.87
K_2	Luni-solar semidiurnal	11.97
M_2	Principal lunar	12.42
N_2	Larger lunar elliptic	12.66
S_2	Principal solar	12.00

* Diurnal and semidiurnal constituents are denoted by the subscripts "1" and "2", respectively, in their symbols.

Model Calibration Parameters

The model was calibrated by adjusting the model bottom friction coefficient and the computational time step as well as the grid generation. For the model calibration, the parameters are assigned as shown in Table 2 below.

Table 2. Parameters from Model Calibration Process

Computational time step	2 seconds
Bottom friction coefficient	0.0025
Lateral viscosity	32.3 ft^2/s (3.0 m/s)
Wave continuity factor	0.01
Minimum angle for tangential flow	90°
Minimum water depth for wetting and drying	0.16 ft (0.05m)

The lateral viscosity governs the turbulent and viscous energy dissipation. The bottom friction coefficient and wave continuity factor govern the energy dissipation by bottom friction.

Measurements of Water Surface Elevation

Water surface elevations were measured at 3 locations including the offshore site fronting Blind Pass, and the interior sites at Wulfert Channel and Roosevelt Channel as shown in Figure 2. The coordinate locations are listed in Table 3. Coastal Engineering Consultants (CEC) measured the water surface elevations using a tidal gauge at the offshore location from March 30, 2005 to May 10, 2005 and Erickson Consulting Engineers (ECE) measured the water surface elevations using acoustic Doppler current profiling and pressure sensor instruments (ADCPs) at Wulfert Channel and Roosevelt Channel from February 15, 2005 to May 6, 2005.

Table 3. Locations of gauges to measure the water surface elevation

		ADCP #1	ADCP #2	Offshore Tidal Gauge
Geographic Coordinate	Latitude	26.49264	26.49018	26.48
	Longitude	82.17659	82.18330	82.19
State Plane NAD83 Florida West (0902)	Northing(ft)	784789.12	783898.03	780200.97
	Easting(ft)	598409.64	596213.73	594016.85

4.0 Model Calibration Results

A thirty (30) day time series of model simulated versus measured water surface elevations for varying bottom friction coefficients (C_F = 0.0015, 0.0025, and 0.0035) is shown in Figure 3 for three locations in the model domain. The corresponding main tidal harmonics of measured and simulated water elevation are listed in Table 4.

Low frequency water surface variations that result from meteorological occurrences are often observed in measured data (e.g. sustained winds cause low frequency increases or decreases in the mean water surface elevations along the coastline). Also, gauges can record false variations in water level resulting from fluctuations in barometric pressure. The barometric fluctuations are relatively small, but they add to the uncertainties in the measured data. For these reasons, the low frequency water surface variations were removed from measured water elevation data using the high pass filter.

After applying a high pass filter to the measured data, a comparison of water surface elevations over the April 2005 sample period, shows good agreement between the measured and simulated water surface elevations for the offshore gauge for the given boundary conditions and tidal forcing at the open ocean boundary. As seen in the comparison, the model slightly overpredicts all components of the main constituents. Overall, the bottom friction coefficient variation has little effect on the amplitudes and phases of each tidal constituent for the coefficients selected, which vary by two percent or less as a result of changing the bottom friction coefficient.

In the two tidal channels where measured water surface elevations were taken, the phases of the simulated *diurnal* constituents led those of the measured constituents; whereas the observed *semidiurnal* constituents were followed by the simulated results. The diurnal tidal components propagate through the bay with less damping in comparison to the semidiurnal tidal components because they occur over a time period that is twice as long. Thus, these results indicate that the bottom friction coefficients may be high. For these reasons, further sensitivity analysis was performed as described in the following paragraph.

Applying a bottom friction coefficient of C_F=0.0035, the comparison of measured to observed data indicates water elevations during the low tidal phases in Wulfert Channel and Roosevelt Channel were underpredicted as shown in the time series comparison (Figure 3). To assess the effect of reducing bottom friction on the model simulations, two lower bottom friction coefficients (C_F =0.0015 and 0.0025) were evaluated. The resulting simulated water surface elevations compare more closely to the measured data for both coefficients.

For the case where the bottom friction was decreased to 0.0015, the best agreement for the *phases* of the diurnal and semi-diurnal tidal constituents for the simulated and the observed data was obtained. Thus, the bottom friction coefficient of C_F=0.0015 yields the best agreement for the tidal constituent *phases*. In comparing tidal constituent *amplitudes*, the bottom friction coefficient of 0.0025 yields better agreement. Based on these simulations, the amplitudes of Q_1, O_1, K_1, and M_2 in Wulfert Channel and K_1, M_2, and S_2 in Roosevelt Channel using a bottom friction coefficient of C_F=0.0025 compare more closely to the measured data than the results using the bottom friction coefficient of C_F=0.0015.

In conclusion, a comparison of the amplitudes and phases of each tidal constituent of the simulated data, using a bottom friction coefficient of C_F=0.0025 shows the best overall agreement to those of the measured data. As well, the time series of water level shows very good overall agreement between the model simulations and the observations for the calibration period. Accordingly, the hydrodynamic model calibration coefficients are considered valid to simulate and evaluate existing hydrodynamic and circulation conditions and changes in the these conditions within the interior waters of Pine Island Sound, Dinkins Bayou, Wulfert Channel, and Roosevelt Channel that will result from opening Blind Pass.

Table 4. Comparison of Tidal Harmonics with the Simulated and Observed Data

(a) Offshore in Gulf of Mexico

Constituent	Frequency (cph)	Amplitude (ft)				Phase (degree)			
		Measured	Simulated			Measured	Simulated		
			C_F=0.0025	C_F=0.0015	C_F=0.0035		C_F=0.0025	C_F=0.0015	C_F=0.0035
Q1	0.0372185	0.100	0.101	0.100	0.101	276	280	280	281
O1	0.0387307	0.504	0.538	0.535	0.538	285	293	292	293
K1	0.0417807	0.503	0.529	0.527	0.529	282	288	288	288
N2	0.0789992	0.101	0.126	0.125	0.126	330	313	313	313
M2	0.0805114	0.670	0.737	0.735	0.737	350	325	324	325
S2	0.0833333	0.329	0.392	0.391	0.391	335	314	314	315

(b) Wulfert Channel

Constituent	Frequency (cph)	Amplitude (ft)				Phase (degree)			
		Measured	Simulated			Measured	Simulated		
			C_F=0.0025	C_F=0.0015	C_F=0.0035		C_F=0.0025	C_F=0.0015	C_F=0.0035
Q1	0.037219	0.068	0.075	0.076	0.072	299	324	318	326
O1	0.038731	0.245	0.432	0.445	0.403	316	327	323	331
K1	0.041781	0.425	0.461	0.477	0.430	318	327	322	331
M2	0.080511	0.463	0.467	0.509	0.428	47	18	12	18
S2	0.083333	0.303	0.276	0.299	0.259	20	9	3	13

(c) Roosevelt Channel

Constituent	Frequency (cph)	Amplitude (ft)				Phase (degree)			
		Measured	Simulated			Measured	Modeling		
			C_F=0.0025	C_F=0.0015	C_F=0.0035		C_F=0.0025	C_F=0.0015	C_F=0.0035
Q1	0.037219	0.109	0.075	0.077	0.072	305	324	318	325
O1	0.038731	0.464	0.432	0.450	0.409	319	327	322	330
K1	0.041781	0.408	0.461	0.483	0.436	320	327	322	330
N2	0.078999	0.153	0.067	0.074	0.065	37	7	360	9
M2	0.080511	0.477	0.467	0.515	0.434	51	18	13	19
S2	0.083333	0.283	0.276	0.301	0.262	27	9	3	12

* The model result in filled columns shows the best agreement with tidal constituents of measured water elevation.

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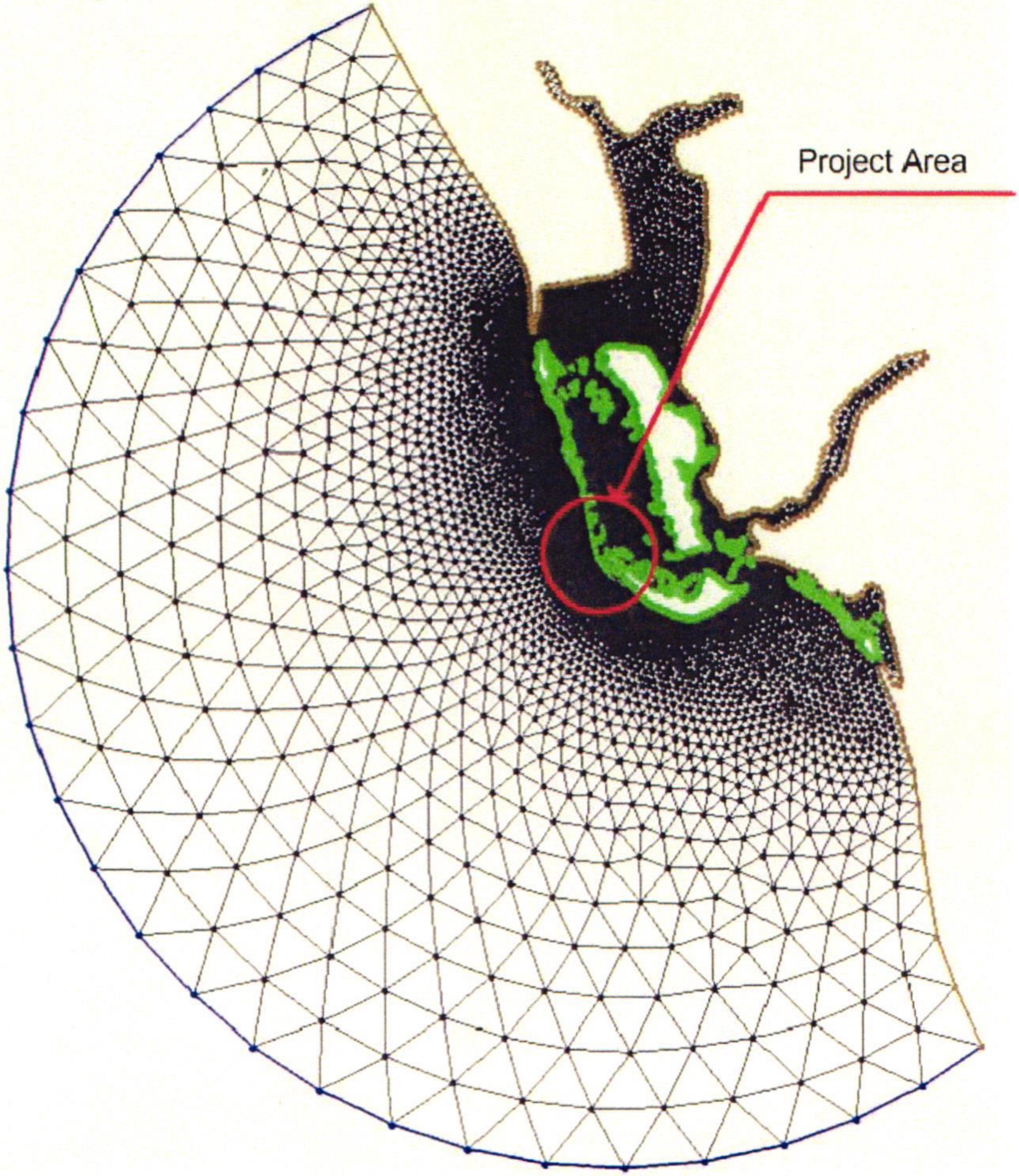

Karyn M. Erickson, P.E. Date
Professional Engineer #41897
NOT FOR CONSTRUCTION

ECE Erickson Consulting Engineers 1819 Main St., Suite 402 Sarasota, FL 34236 (941) 952-0487	FIGURE 1 GRID GENERATION Blind Pass Restoration Lee County, Florida	REVISIONS	PROJECT 05-129	CHECKED BY WJ
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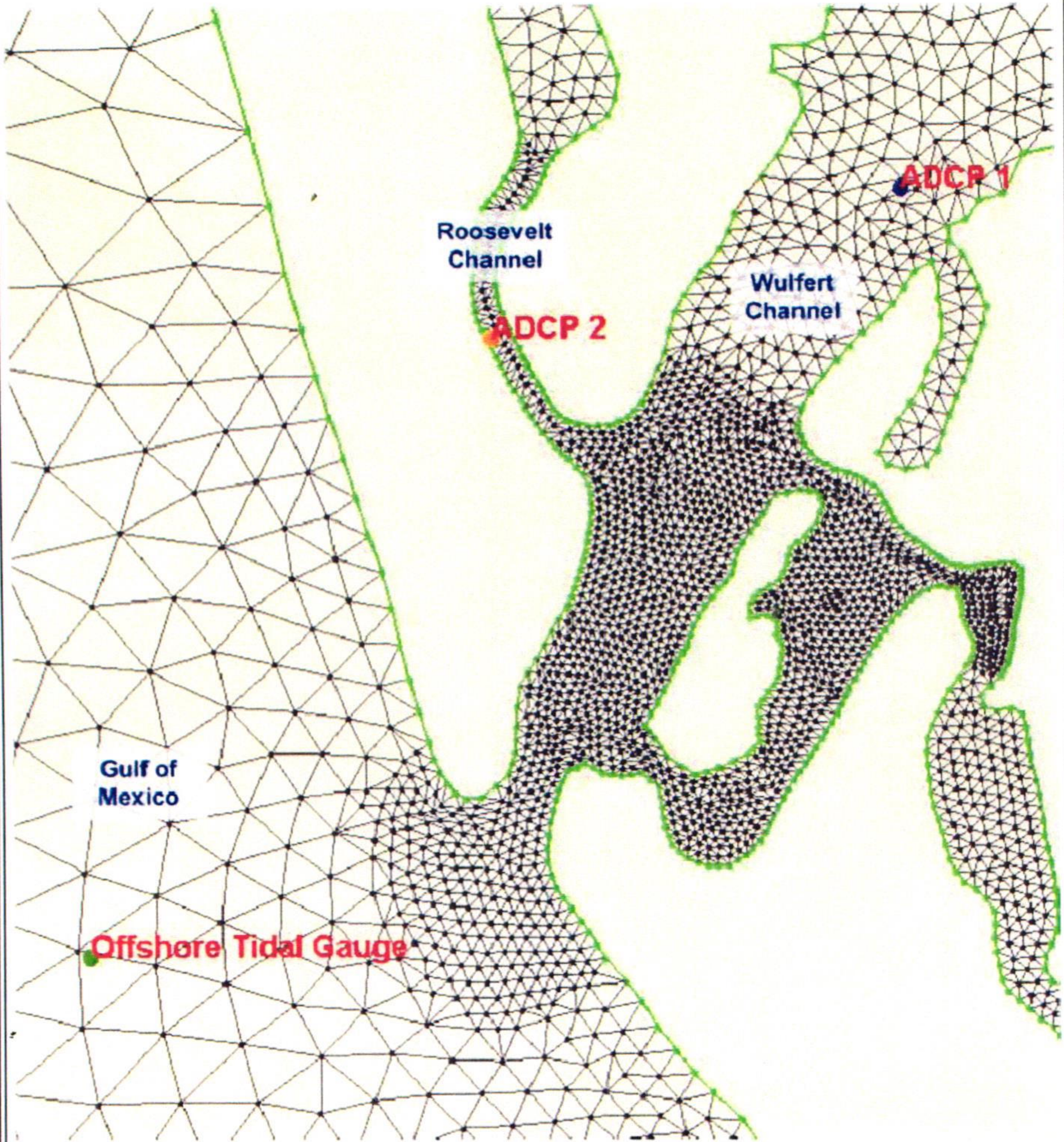

Karyn M. Erickson, P.E. Date
Professional Engineer #41897
NOT FOR CONSTRUCTION

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ECE
Erickson Consulting Engineers
1819 Main St., Suite 402
Sarasota, FL 34236
(941) 952-0487

FIGURE 2 – GRID GENERATION AT PROJECT SITE WITH GAUGE LOCATIONS

Blind Pass Restoration
Lee County, Florida

REVISIONS		
	PROJECT 05-129	CHECKED BY WJ
	DATE 06/10/05	DRAWN BY JE
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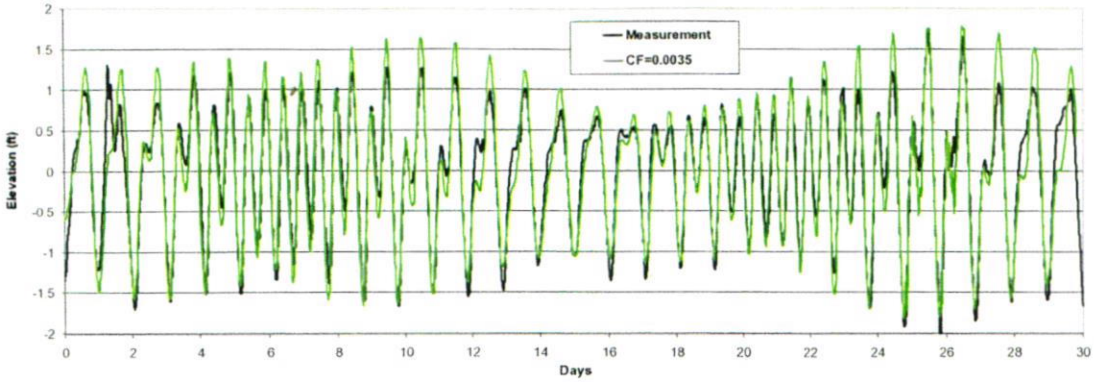
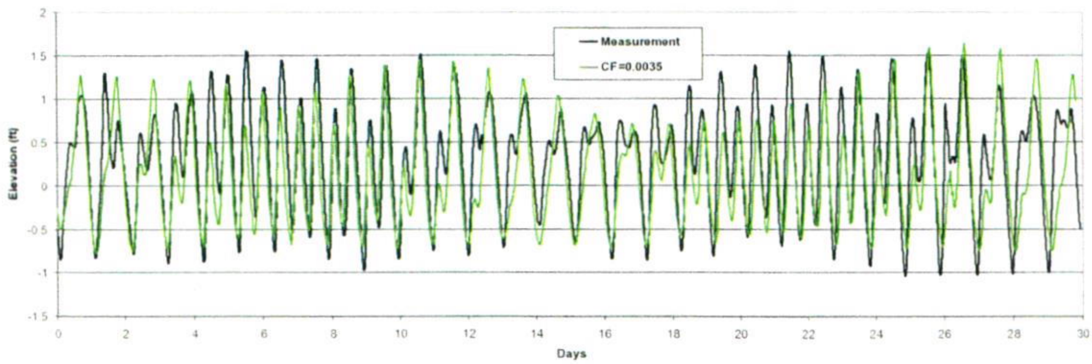
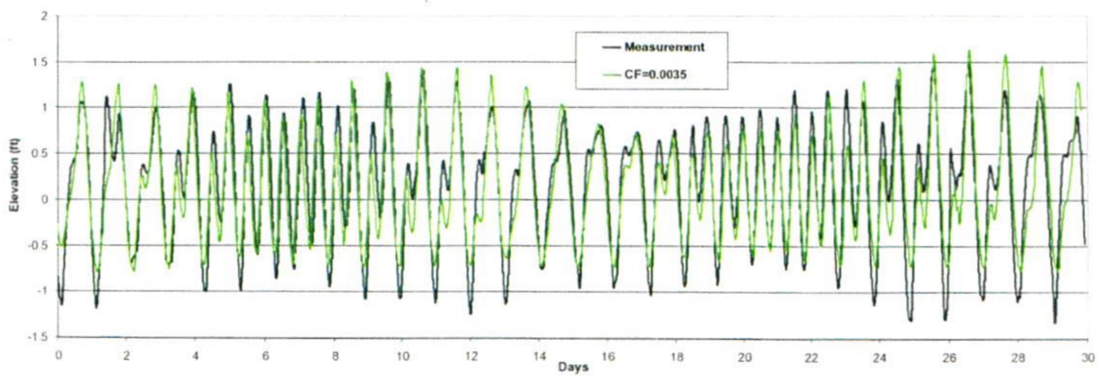


(a) Offshore in Gulf of Mexico

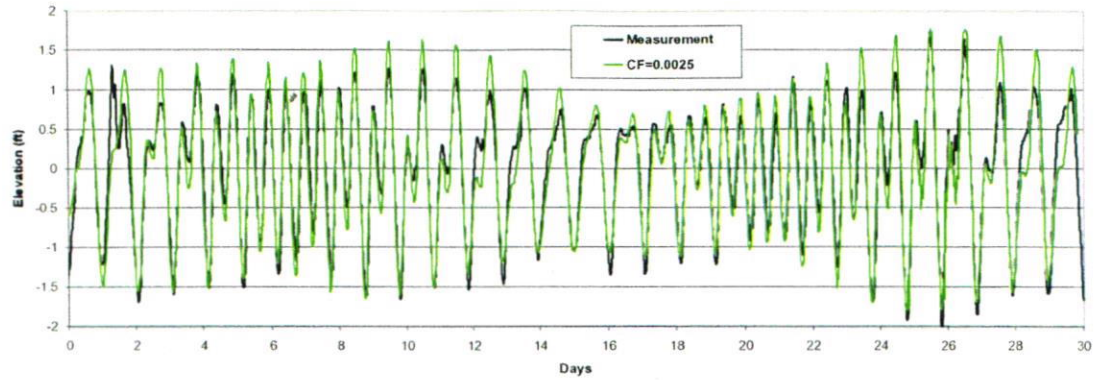


(b) Wulfert Channel

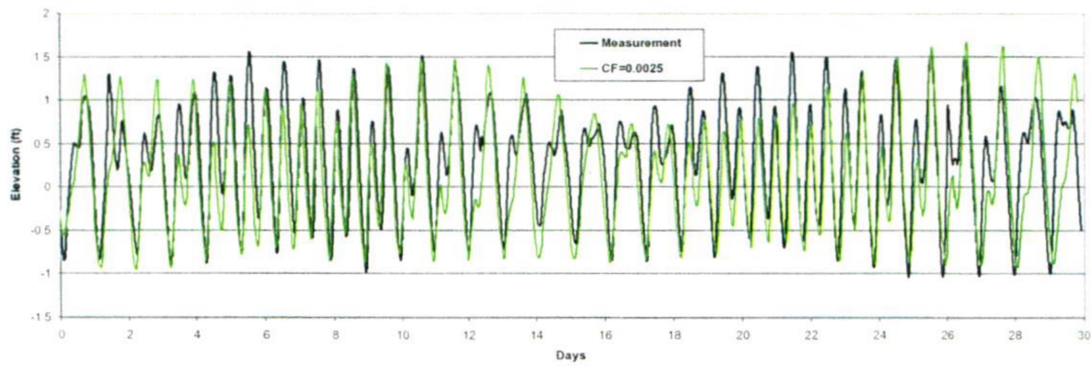


(c) Roosevelt Channel

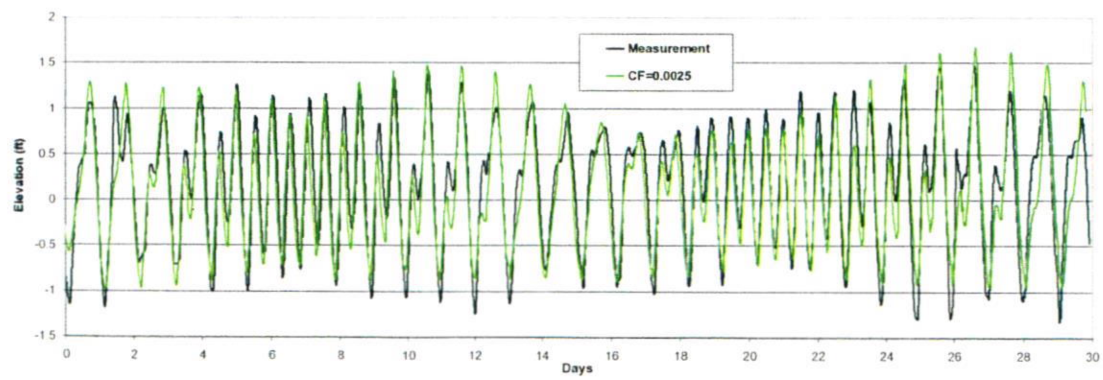
Figure 3. Comparisons of water surface elevation time series (C_F=0.0035)



(a) Offshore in Gulf of Mexico

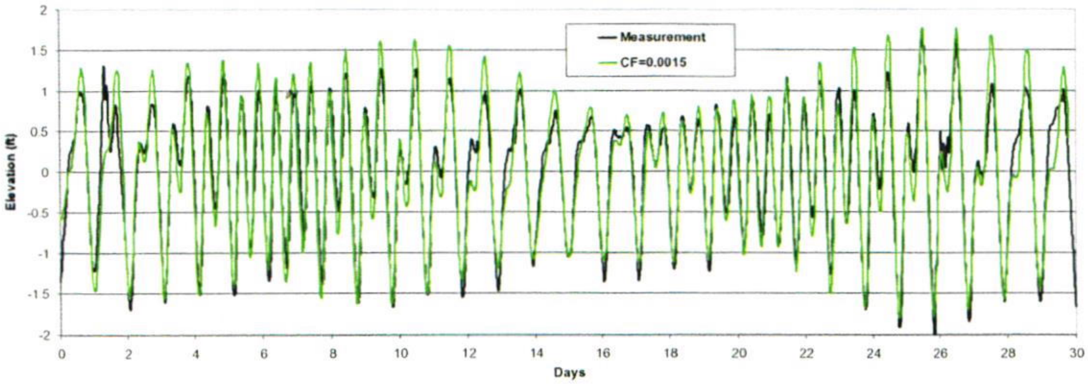


(b) Wulfert Channel



(c) Roosevelt Channel

Figure 3. Continued (C_F=0.0025)



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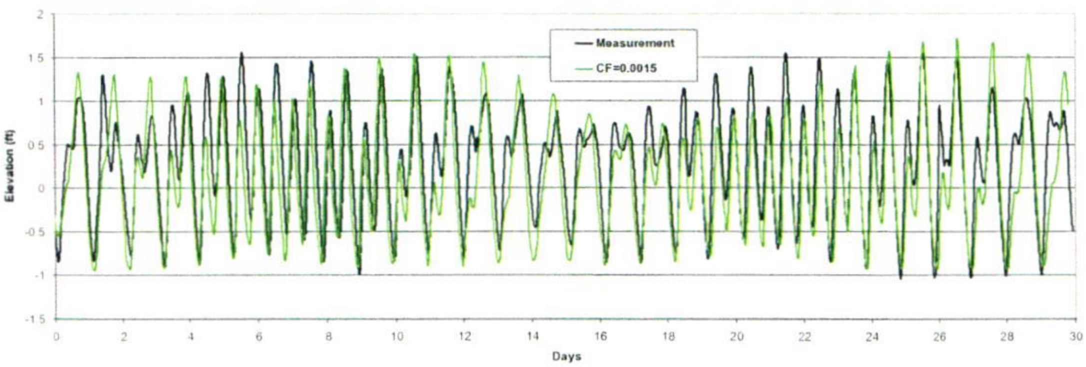
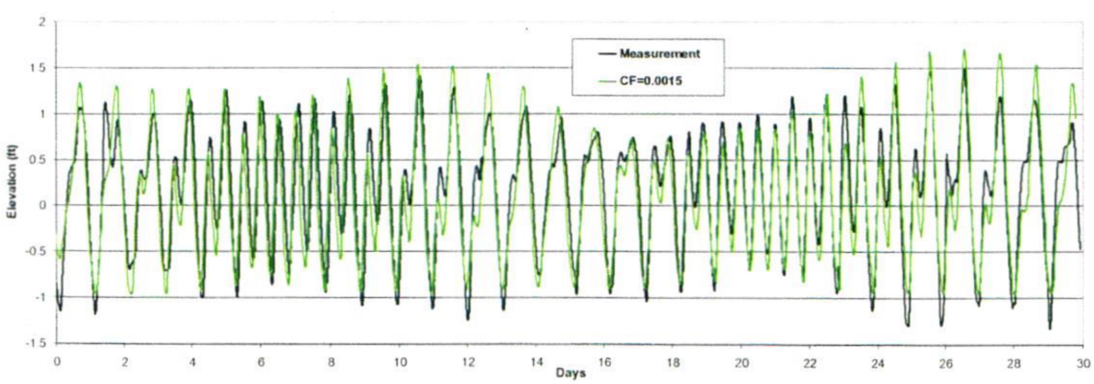


(b) Wulfert Channel



(c) Roosevelt Channel

Figure 3. Continued (C_F=0.0015)

INLET STABILITY STUDY AT BLIND PASS, LEE COUNTY, FLORIDA

Ashish J. Mehta
Say-Chong Lee
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University of Florida

November, 1991

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INLET STABILITY STUDY AT BLIND PASS, LEE COUNTY, FLORIDA

SUMMARY

This investigation was motivated by the need to examine the stability of Blind Pass inlet in conjuction with a study to develop options for the management of the inlet and the nearby beaches. The study efforts entailed using analytical models based on Keulegan-type inlets to attempt to characterize the long-term stability of Blind Pass, and a numerical model based on one-dimensional integrated momentum and flow and sediment continuity equations to model its short-term stability. Interpretation of photographic records coupled with a review of published reports was vital in assessing the morphological development of Blind Pass.

Based on these efforts, it may be concluded that the rate of sediment supply to the inlet has reduced measurably, principally a result of jetty construction and its subsequent extension. From long-term stability criteria, Blind Pass is found to be marginally stable based on present configuration. At this stage of its continuing development, this inlet is apparently still adjusting to an equilibrium state. Other than external factors such as variation in wave-induced sediment transport and the relative well-being of adjacent inlets especially Redfish Pass, the apparent reluctance to gravitate toward equilibrium may be the result of the lateral restraint imposed by bridge abutments. The altered morphological response manifests in a greater than expected depth at the inlet cross-section. However, further excursion of the depth due to scour is likely to be met with increased soil strength and reduced scouring power of the flow, thereby preventing the adjustment of the inlet section to the predicted equilibrium state. In terms of short-term stability, it is suggested that the critical rate of deposition in the inlet for which the inlet is just in a self-flushing condition is about 250 cu.m/day, which is in qualitative agreement with the volumetric computation based on the growth of the flood tidal shoal.

To the extent that two geographically close inlets can interact mutually, theoretical considerations indicate that one of the inlets will exhibit tendency toward shoaling and eventual closure. Based on past documented developments of Blind Pass and Redfish Pass, it is apparent that Redfish Pass is the dominant inlet in the analogous twin-inlet system considered. While Blind Pass has undergone alternate closure and reopening, underscoring its susceptibility to instability, the chronic shoreline erosion prevalent along Captiva Island appears to have helped reduce the sediment loading that would otherwise have gained ingress into the inlet. Furthermore, the interruption of longshore sediment transport by the jetty and the efficient bar-bypassing mechanism across the inlet further mitigate against any tendency toward permanent closure.

The analytical and numerical efforts yield a "potential" representation of the inlet in a simplified setting. Combining the idealized scenario considered with field experience derived from published reports, it is suggested that the efforts at shore protection, especially jetty construction, may have given a new lease of life to Blind Pass. However, some engineering improvements such as channel dredging in the interior may be required to ensure the continuous presence of the inlet.

Chapter 1

INTRODUCTION

1.1 Background

Blind Pass is one of many inlets that punctuate the southwest coast of Florida facing the Gulf of Mexico. Located in Lee County, it separates the Captiva Island to the north and Sanibel Island to the south and connects a part of Pine Island Sound to the Gulf. The inlet was first opened naturally around three hundred years ago and for quite a while behaved as a tide-dominated inlet with a prograding ebb-tidal shoal. Since the opening of Redfish Pass to the north in 1926, the inlet has gravitated toward a wave-dominated one, and is less stable. The capture by Redfish Pass of a substantial portion of the tidal prism that had kept Blind Pass active since its inception by the Redfish Pass is evidenced by the alternate closure and opening that has typified its existence up to at least the middle 1980s. Its emphemeral existence is also evidenced by the disintegration of the once stable ebb tidal shoal to relative insignificance. Concern, for instance, regarding the water quality in the part of Pine Island Sound that abuts the inlet has prompted studies on the morphological development of the inlet and its longevity. The present study is motivated by the need to examine the stability of the inlet in conjunction with a study to develop options for the management of the inlet and the nearby beaches.

1.2 Scope of Study

The scope of study as embodied in this report is confined to the physical inlet response using both analytical and numerical approaches to inlet hydraulics. The report outlines the approaches and calibration process and presents the computation results in an effort to characterize the inlet stability. The report consists of the following main elements:

a) collation and review of all the available study reports on Blind Pass in order to reconstruct the morphological development of the inlet with the aim of obtaining input parameters for subsequent analysis;

b) analysis of primary and secondary data;

c) detailing the use of analytical and numerical approaches to characterize the inlet stability behavior with a view to predicting its response under different scenarios; and

d) preliminary conclusions and recommendation for refinement.

The numerical model used is a one-dimensional code that describes the response of a Keulegan-type inlet-bay system to sinusoidal tidal forcing. The model includes the effect of precipitation and has been applied to Phillips Inlet south of Panama City [Lin, 1988].

Chapter 2

MORPHOLOGICAL STUDY

2.1 Morphological Changes

In addition to the relevant study reports, the authors have relied on the collection of old aerial photographs in the Coastal Engineering Archives and monitoring reports associated with the Captiva Island Beach Nourishment Project [Coastal Planning & Engineering, Inc., 1990 & 1991] and the associated photographic records supplied by Coastal Planning and Engineering, Inc. This store of documented and photographic information was converted into a chronology of events and description of temporal morphological changes to facilitate better understanding of the morphological development of the inlet as summarized in Tables 2.1 and 2.2, respectively.

It is apparent from Table 2.1 that Blind Pass has undergone a series of closures and reopenings as a consequence of the predominant southerly drift. The alternate inlet closure and opening represent an efficient pathway whereby sediments are fed to the south, i.e., Sanibel Island. Prior to 1926, the inlet section at Blind Pass measured 200 m across by 5 m deep due to the appreciable water surface area it commanded in the Pine Island Sound. Following the opening of Redfish Pass in 1926, the tidal prism that had maintained Blind Pass shrunk considerably due to flow diversion through Redfish Pass, which grew to a size about twenty times that of Blind Pass with significant development of the ebb-tidal shoal. Subsequently, there has been at least three episodes of downdrift migration, closure, and reopening. While the first two phases of the cycle may occur over time, the reopening is usually an episodic phenomenon that occurs during storm events. Since severe storm events are always accompanied by storm surges, some as much as 2 m above the mean water level, it is likely that the sand bar was breached by the overtopping water from the sea and the subsequent enlargement of the initial breach was aided by scouring of the pilot channel by outflowing water from the bay side. Consequently, the time of occurrence of inlet closure is easier to trace, normally being narrowed down to the particular hurricane that occurred in the year concerned. Examples are 1960 (Hurricane Donna), 1972 (Hurricane Agnes) and

Table 2.1: A Chronology of Events, Blind Pass

Year	*Event*	*Remarks*
995 BP -655 BP	Original pass opened.	ref. CPE. Inc.
300 BP	Pass broke through barrier island.	ref. Winton et al.
1883	Inlet broke through near the current podition.	ref. CPE. Inc.
1888	Inlet @ throat = 200 m x 5 m. Downstream offset of 250 m.	ref. US Army COE.
1926	Opening of Redfish Pass.	A substantial portion of tidal prism captured.
1941	New inlet opened near current position. Possibly the result of hurricane.	ref. CPE. Inc.
1953	Inlet width at throat = 60 m.	ref. 5.
1958	Inlet width at throat = 20 m.	ref. 5.
8/29-9/13/ 1960	Hurricane Donna reopened pass.	ref. CPE. Inc.
1961	Direct inlet closed. Flow exit further south.	ref. CPE. Inc.
1962	Gulf entrance reportedly closed by storm action.	ref. US Army COE.
1964	Inlet closed by spit.	ref. CPE. Inc.
1966	Historical flow area = 95 m^2.	ref. Winton et al.
1970	Historical flow area = 160 m^2.	ref. Winton et al.
1972	Hurricane Agnes reopened pass.	ref. Hine.
1972	Short rip-rap jetty constructed on the north side.	ref. CPE. Inc.
1974	Historical flow area = 140 m^2.	ref. Winton et al.
1975	Historical flow area = 42 m^2.	ref. Winton et al.
11/76	Gradual inlet narrowing in the past several months closed inlet to boat traffic.	ref. Island Rept.
May 1977	Inlet closed by tidal accretion.	ref. Larson.
1979	Inlet closed.	ref. Davis & Gibeaut.
6/1982	Subtropical 'No-Name' storm reopened pass. Minimum Cross-sectional area = 56 m^2.	ref. Hine.
12/1987	Inlet closed	ref. Dean & O'Brien.
1988	Inlet remained open.	ref. Davis & Gibeaut.
11/88	Terminal groin lengthened by 31 m.	ref. CPE. Inc.
8/1991	Throat Cross-section below NGVD = 64 m^2.	Computed based on field data.

1982 (Subtropical Storm 'No Name'). On the other hand, the estimation of the time of closure is very rough indeed and is usually given in interval of years in published reports. The preparation of Table 2.2 is in part aimed at arriving at a better estimate of an actual closure event so that its replication by the numerical model will yield the values of the relevant calibrating parameters for predictive purposes.

As apparent from Table 2.2, there are gaps in the sequence of aerial photographs and at other times there is a cluster of closely spaced shots in time. While this irregular temporal coverage does help elucidate some of the processes, the static and gapped coverage does not reveal substantially more information as regards the timing of the closure events. However, the lateral migration of the inlet channel and the timing of the construction and completion of the north jetty are apparent from the photographic records. The jetty is believed to have been constructed within a several-month period from July to November, 1972. The episodic nature of the inlet opening is also borne out, this paricular one occuring within the three-week period from June 23 to July 15, 1972. Prior to the inlet opening, the southward extending inlet channel was observed to be clogged with wave overwash deposits. The clogged waterway may have helped to concentrate bay water in the wave-created pilot channel, and hence to scour out a more or less equilibrium inlet channel as evident from the progressive widening of the inlet from time-lapsed photographs.

2.2 Longshore Sediment Transport

An estimation of the longshore sediment transport is a necessary input to the numerical model. A concomitant input is the estimated percentage of the amount of longshore drift that enters the inlet during the ebb, the amount that deposits on the flood tidal shoal, the amount that leaves the inlet in the ensuing flood, the amount of the ejected material that deposits on the ebb-tidal shoal or rejoins the longshore transport system, and the amount that returns in the next ebb-flood cycle. A sediment budget balance will then enable an estimate of the amount of littoral materials that actually settle out during each ebb-flood cycle and deposit in the inlet section to be made.

A relatively simple way of computing littoral drift along the coastline of Florida based on visually observed waves from ships has been presented by Walton [1973]. The method uses the SSMO (Summary of Synoptic Meteorological Observations) wave data, which are a compilation of meteorological and sea state observations made from ships plying through "Data Squares" defined by their longitudes and latitudes, as input in computing longshore energy flux and consequent littoral drift based on linear wave theory. The basic equation used is:

$$Q_l = C\frac{\gamma}{8}H_o^2 C_{go} \cos\alpha_o \sin\alpha_b K_f^2 \frac{24.(3600)}{10^6} \tag{2.1}$$

where

Table 2.2: Temporal Morphological Changes at Blind Pass

Date	*Observation*	*Record Type*
1859	Wide inlet channel flanked by south-growing sand spit and exit far to the south of interior channel.	Fig. 1.3 in ref. Winton et al.
1883	Inlet broke through the spit.	Air photo.
1944	Direct inlet closed. Inlet flow exit about 2.0 km south of interior channel.	Airphoto. (ref. 13)
Early 1950s	Direct Inlet closed. Inlet flow exit south of interior channel and was flanked on the left by southward growing sand spit with vegetation on its northern half.	Airphoto.
1958	Inlet has migrated about 2.8 km to the south.	Fig. 1.3 in ref. Winton et al.
1960	Hurricane Donna opened a new gap at the spit.	Air photo.
1961	Gap closed and inlet exit far to the south.	Air-photo.
2/66	Direct inlet closed. Inlet flow exit further south outside record confines. Closure bar not vegetated.	Slide.
2/14/70	Inlet completely closed. Closure bar not vegatated.	Airphoto.
4/72	Direct inlet closed. No jetty yet. Inlet flow exit further south outside record confines. However, closure bar has thinned.	Slide.
6/23/72	Direct inlet essentially closed. Wave overwash deposits clogged up exit channel. Rock outcrops/partial jetty (?) visible.	Airphoto.
7/15/72	Direct inlet partially open. (size = $\frac{1}{3}$ of bridge span.)	Airphoto.
11/30/72	Inlet size = $\frac{1}{2}$ of bridge span. Jetty in place. Updrift fillet began to form. Rivermouth bar deflected close to left bank.	Airphoto.
7/73	Inlet open. Jetty in place. Updrift accretion fillet just visible.	Oblique photo.
1975	Inlet open.	Fig. in ref. CPE. Inc.
May(?)/78	Inlet partially open. ($\frac{1}{3}$ of bridge span.)	Airphoto.
1978	Inlet completely closed.	Fig. 1.3 in ref. Winton et al.

Table 2.2: Temporal Morphological Changes at Blind Pass (continued)

Date	*Observation*	*Record Type*
10/25/78	Inlet completely closed. Updrift fillet full.	Airphoto.
11/1/78	Inlet completely closed. Updrift fillet full. Downdrift beach straight.	Airphoto.
11/2/78	Inlet completely closed. Updrift fillet full.	Airphoto.
11/12/78	Inlet completely closed. Updrift fillet full.	Airphoto.
12/80	Inlet completely closed. Updrift fillet full.	Slide.
5/14/85	Inlet open. Updrift fillet full.	Airphoto.
10/8/85	Inlet open. Updrift fillet receded slightly behind jetty head.	Airphoto.
2/25/86	Inlet open. Updrift fillet full.	Airphoto.
5/9/86	Inlet open. However, sediment bypassed jettyand recurved into inlet mouth. Inlet channel deflected southeastward.	Airphoto.
10/3/86	Inlet open. Updrift fillet receded behind jetty head. Downdrift deposition disappeared and bulge appeared on right bank of mouth.	Airphoto
1/87	Inlet open. Updrift fillet full. Flow confined by linear ebb-shoal bar.	Slide.
4/1/87	Inlet open.	Blown up airphoto.
2/90	Inlet open. Updrift fillet full. (Jetty extended by 31 m by end of 1988.)	Slide.
5/1/90	Inlet open. Updrift fillet receded slightly behind jetty head.	airphoto.
12/13/90	Inlet open. Updrift fillet about 15 m behind jetty head.	Blown up airphoto.
12/30/90	Inlet open. Updrift accretion full and sediment bypassed jetty and deposited immediately downdrift.	Airphoto
4/9/91	Inlet open. Updrift fillet receded behind jetty head. Downstream deposition disappeared. Right bank of inlet mouth deflected southward forming funnel shape followed by a planform bulge.	Airphoto.

Q_l = littoral drift rate ($\frac{yd^3}{day}$);

C = a constant correlation coefficient equalling 125;

γ = specfic weight of sea water (= 64 $\frac{lbs}{ft^3}$);

H_o = deepwater wave height (ft);

C_{go} = deepwater wave group velocity (ft/s);

α_o = deepwater wave approach angle;

α_b = breaking wave angle; and

K_f = friction-percolation coefficient (= 0.01).

While the method contains numerous assumptions, which is a necessary outcome of the simplicity of approach adopted, the magnitudes of net drift computed are in reasonable agreement with other estimates. Hence, the annual drift values for Blind Pass, which lies within the physiographic reach from San Carlos to Boca Grande, are taken from the littoral drift roses in the above report [Walton, 1973] based on the local azimuth of the shore normal. The azimuth angles are an average of the shoreline trends at several different times, care being taken to disregard local variations in order to reflect the more regional shore orientation. A follow-up work by Walton [1976] has included the monthly drift roses and the same were extracted to yield monthly drift values for Blind Pass as summarized in Table 2.3.

Blind Pass is situated at the break in shoreline orientation, which signifies the abrupt end of the north-western terminus of Sanibel Island. The major change in shore configuration at this point is controlled by a subsurface structure formed in the geologic past [Hine, 1987]. From Table 2.3 it is noticed that there are two distinct drift patterns, predominant northerly from March to September and the reverse for the balance of the year. The high northerly transport tends to coincide with the hurricane seasons, which usually occur during the third quadrant of the year and the hurricane route generally veers to follow a direction in the north-east sector after tracking through the lower half of the Florida peninsula.

On the other hand, the southerly transport is a consequence of winter wave action. Combined with the photographic interpretation in previous sections, it is suggested that the northerly drift is the agent that tends to close Blind Pass while the hurricanes are responsible for the reopening episodes, primarily associated with storm surges generated in the process. Other relevant volumetric rates have been computed for the flood tidal shoal; these being being 14,000 $yd^3/year$ for the period 1956 - 1960 and 2200 $yd^3/year$ for 1960 - 1989 respectively [Coastal Planning & Engineering, Inc., 1990]. While the reduction in the growth of the flood tidal shoal may be linked to the repeated closure of the inlet,

Table 2.3: Longshore Transport Rate at Blind Pass

Month	*Transport South* $\Theta_n = 255°N$ (m^3/day)	*Transport North* $\Theta_n = 220°N$ (m^3/day)	*Gross* (m^3/day)	*Net* (m^3/day)
Annual	350	230	580	120 S
January	840	90	920	750 S
February	750	150	900	600 S
March	410	250	660	160 S
April	50	400	450	350 N
May	80	240	320	160 N
June	20	300	320	280 N
July	100	120	220	20 N
August	50	170	220	120 N
September	90	250	340	160 N
October	220	160	380	60 S
November	320	100	420	220 S
December	240	210	450	30 S

longshore transport system is relatively easily and rapidly carried southward across the inlet and passed on to the downdrift [Hine, 1987], an efficient bar-bypassing process.

For comparison purposes, Davis & Gibeaut [1990] have reported a net southerly drift of 84,000 m^3/yr compared to about 44,000 m^3/yr based on Table 2.3. On the other hand, Coastal Planning & Engineering, Inc. [1991] gives the net longshore transport at Blind Pass as about 31,000 m^3/yr for the period 1974 - 1989 while the corresponding figures for the periods 1955 - 1974 and 1941 - 1955 are given as about 54,000 and 82,000 m^3/yr, respectively. Considering the usually large differences that attend sediment transport prediction, the above values can be deemed as close, the discrepancies at least in part arising from the subjective interpretation of the shoreline azimuth for the former two since they are both based on littoral drift roses of Walton [1973].

Chapter 3

FIELD DATA ANALYSIS

The following field data collected in July/August 1991 by Coastal Planning & Engineering, Inc. were analysed to obtain geometric and hydraulic data required for the subsequent portion of the study:

a) cross-sectional survey covering the inlet and a substantial part of the flood shoal;

b) one continuous point current measurement at about one-third depth located at the throat section;

c) two surface current measurements using drogues; and

d) spot tidal elevation measurements at selected locations and times.

3.1 Tides

While simultaneous measurement of both ocean and bay tides is desirable, the scant tide data collected in the field necessitates recourse to predicted tides by National Ocean Service (NOS), which was found to be in general agreement with the few measured spot tidal elevations. Hence, the NOS Tide Tables are used to generate the Gulf tide required in the analysis.

These tides are generated numerically using the tidal constituents reported in Winton et al [1981], which are then plugged into the general equation:

$$\eta_n = a_0 + \sum_{i=1}^{N} a_i \cos(\frac{2\pi t}{T_i} - \delta_i) \tag{3.1}$$

where η_n is the resultant tidal variation at time t, being composed of N constituents. The amplitude, phase, and period of the i^{th} constituents are a_i, δ_i, and T_i, respectively. a_0 denotes the displacement from the reference datum, in this case the 1965 Mean Low Water,

Table 3.1: Tidal Constituents used in Generating Gulf Tide (a_0=0.18 m)

Constituent	*Period, T_i (solarhr.)*	*Amplitude, a_i (m)*	*Phase, δ_i (degree)*
M_2	12.421	0.1869	77.8219
S_2	12.000	0.1001	99.6483
N_2	12.658	0.0299	194.7250
K_1	23.934	0.0528	185.8221
O_1	25.819	0.1079	115.1912
P_1	24.066	0.0601	132.1366
K_2	11.967	0.1351	342.0671
ν_2	12.626	0.0157	145.0242
M_1	24.833	0.0082	248.4851
J_1	23.099	0.0088	238.9296
Q_1	26.868	0.0298	221.5013
L_2	12.191	0.0461	140.3845
M_{tm}	219.191	0.0539	62.4574
M_f	327.869	0.0578	81.6405
M_{sf}	354.365	0.0690	225.0921
M_m	661.230	0.0161	193.1122

to the mean water level. Table 3.1 lists the 16 tidal constituents with their respective periods, amplitudes and phases, the latter two being obtained by harmonic analysis of a 35-day period continuous tidal data collected in Oct/Nov 1978 and conducted by Winton et al [1981].

Fig. 3.1 shows a plot of the generated tide, which exhibits a mixed state with two unequal highs and lows in a day. The mean tide range is about 0.50 m while the mean diurnal range is 0.80 m as reported in the NOS Tide Tables. Fig. 3.2 shows the variation of Gulf tidal range that will be used as input for the numerical model.

The generated tides are reduced to National Geodetic Vertical Datum (1929) by using the following tidal datums for the open coast gage at South Captiva Island (Station I.D.: 5383) [Balsillie et al, 1987]:

Mean Higher High Water = 0.46 m NGVD;

Mean High Water = 0.39 m NGVD;

Mean Tide Datum = 0.13 m NGVD;

Mean Lower Low Water = -0.13 m NGVD;

Mean Low Water = -0.29m NGVD; and

Mean Tide Range = 0.52 m.

Another source has placed the MHW on adjacent beaches at 0.52 m NGVD [Coastal Engineering & Planning, Inc., 1991]. Judging from the simplicity of approach and the many assumptions inherent in the study approach, the discrepancy was deemed tolerable and no effort was made to reconcile the difference. As an added simplification, the NGVD was used as the reference datum to compute the geometric properties of the inlet as elaborated in subsequent sections. The difference in the mean tide level between the Gulf and the bay is taken from Winton et al [1981], being 0.10 m, and is used in the model.

3.2 Currents

The measured current, which is mainly tide-driven and shown in Fig. 3.3, shows a similar pattern of change to the tidal variation. Current deflection from the inlet axis is apparent from Fig. 3.4, where the ebb and flood flow directions are each modified by the inlet exit and entrance geometry. The peak ebb current is stronger than the peak flood current, being about 1.3 m/s and 0.9 m/s respectively. The corresponding peak surface currents are about 1.6 m/s and 1.3 m/s based on surface drogue measurements. Assuming a theoretical logarithmic velocity distribution and accounting for variation in the transverse direction, the mean cross-sectionally averaged velocity is taken to be about 1.1 m/s for calibration purposes. This value is also consistent with those indicated in coastal charts, which indicate that velocities up to 1.1 m/s may be expected to occur in inlet throats.

3.3 Geometric Data

The survey data were analysed to yield the geometric data as summarized in Table 3.2 and graphically depicted in Fig. 3.5 and 3.6.

It is noted that while the throat flow depth, h_c, occurs at Section 4, the throat flow area, Ac, occurs at section 10. In the field, Section 10 is located at a constricted part of the flow channel due to the presence of an island that bifurcates the flow. This island most likely originated as a part of the flood tidal shoal the subaerial part of which became colonized by vegetation and eventually the entire complex became a stable feature. There are other mangrove-covered islands within the channel that connects Pine Island Sound to the Gulf. Immediately downstream of Section 10 is a branch channel that serves as an escape conduit for the incoming flood flow that would otherwise pile up against the constricted Section 10. Hence, for the present purpose, the inlet channel is considered to be stretching from Sections 1 to 7, and the water area thereafter is considered part of the

Table 3.2: Geometric Data for Blind Pass

Cross-section No.	Distance (m)	Cross-section Area (m^2)	Mean Depth (m)
1	0	125	0.8
2	29	91	1.0
3	60	64	1.5
4	76	64	2.1
5	116	94	1.8
6	134	74	1.2
7	163	78	0.9
10	259	52	1.4
11	312	57	1.2
12	648	76	0.8
13	984	189	0.7
14	1296	313	0.9
15	1548	234	0.7
16	1747	275	0.5

bay area. Confining the analysis to the first seven sections, h_c and A_c are found to be 2.1 m and 64 m^2, respectively.

The equivalent length of the inlet, L_e, is next computed using the following expression [Bruun, 1978]:

$$L_e = A_c^2 h_c^{\frac{4}{3}} \sum_{i=1}^{7} \frac{\Delta x_i}{h_i^{\frac{4}{3}} A_i^2} \tag{3.2}$$

where A_i and h_i are the individual cross-sectional areas and mean flow depths below Mean Water Level as summarized in Table 3.2 and Δx_i is the channel length of the ith segment. In this way, the equivalent length is found to be 194 m, i.e., longer than the measured length due to the irregular geometric shape of the inlet that increases flow resistance.

Chapter 4

ANALYTICAL STUDY

4.1 Inlet Hydraulics

The first part of the analytical study entails using the one dimensional model equation developed for the Keulegan-type bay to obtain parameters that characterize the hydraulic behavior of the inlet. The principal assumptions inherent in the analysis are:

a) the forcing tidal variation is sinusoidal in time;

b) effects of tides dominate over wave-induced effects;

c) negligible spatial variation in water surface elevation and velocity within the inlet channel; and

d) the bay is a small and deep body of water in which the kinetic energy of the flow issuing from the channel is dissipated, and the instantaneous water surface is horizontal throughout.

Combining the resulting momentum and continuity equations leads to the following second-order ordinary differential equation as the governing equation of motion [Bruun, 1978]:

$$\frac{d^2\eta_B}{dt^2} + \frac{F}{2L_c}\frac{d\eta_B}{dt}\left|\frac{d\eta_B}{dt}\right| + \frac{gA_c}{L_cA_B}\eta_B = \frac{gA_c}{L_cA_B}\eta_o \tag{4.1}$$

where

η_o = ocean elevation;

η_B = bay elevation;

A_B = bay surface area;

A_c = cross-sectional area at throat;

L_c = equivalent channel length;

g = acceleration due to gravity; and

F = impedance given by:

$$F = k_{en} + k_{ex} + \frac{f L_c}{4h_c} \tag{4.2}$$

where

k_{en} = entrance loss;

k_{ex} = exit loss; and

f = Darcy-Weisbach friction factor.

A relatively simple solution to the non-dimensional form of the governing equation of motion based on the describing function technique can be found in Bruun [1978]. The resulting solutions as used in the present study are reproduced below:

$$\tilde{\eta}_o = \sin \alpha \tilde{t} \tag{4.3}$$

$$\tilde{\eta}_B = \tilde{a}_B \sin(\alpha \tilde{t} - \epsilon) \tag{4.4}$$

$$\tilde{u} = \tilde{u}_{max} \cos(\alpha \tilde{t} - \epsilon) \tag{4.5}$$

$$\tilde{a}_B = \left\{ \frac{[(1-\alpha^2)^4 + \mu^2]^{\frac{1}{2}} - (1-\alpha^2)^2}{\frac{1}{2}\mu^2} \right\}^{\frac{1}{2}} \tag{4.6}$$

$$\epsilon = \tan^{-1}\left[\frac{\mu \tilde{a}_B}{2(1-\alpha^2)}\right] \tag{4.7}$$

$$\tilde{u}_{max} = \tilde{a}_B \tag{4.8}$$

where

$\tilde{\eta}_o = \frac{\eta_o}{a_o}$; $\tilde{\eta}_B = \frac{\eta_B}{a_o}$; $\tilde{t} = \left[\frac{gA_c}{L_c A_B}\right]^{\frac{1}{2}} t$; $\tilde{u} = \frac{\bar{u}A_c}{a_o \sigma A_B}$;

α = dimensionless tidal frequency $= \left[\frac{L_c A_B}{gA_c}\right]^{\frac{1}{2}} \sigma$;

$\tilde{a}_B = \frac{a_B}{a_o}$;

a_B = bay tidal amplitude;

a_o = ocean tidal amplitude;

$\bar{u}$ = depth-averaged flow velocity;

$\mu = \frac{16\beta\alpha^2}{3\pi}$;

β = dimensionless damping coefficient $= \frac{FA_B}{2L_cA_c}a_o$; and

σ = tidal frequency

In addition, an additional correction to L_c in the dimensional tidal frequency, α, is included via the following equations:

$$L'_c = \frac{W_c}{\pi}\ln\left[\frac{2\alpha\sqrt{gh_c}}{\sigma W_c}\right] \tag{4.9}$$

$$L_{c1} = L_c + L'_c \tag{4.10}$$

where

L'_c = correction;

W_c = width of idealized inlet; and

L_{c1} = value to be used in evaluating α.

Since α also appears in Equation 4.9 above, the correction is obtained iteratively.

4.2 Long-term Stability

The second part of the analytical study involves computation of the relation between the repletion coefficient, K, and the maximum flow velocity at the throat, u_{max}, which enables a qualitative assessment of the hydraulic stability of the inlet to be made. This is followed by the use of the O'Brien relationship linking the tidal prism, Ω, and the minimum flow area, A_c, from which the sedimentary regime of the inlet can be derived. The superposition of the hydraulic and sedimentary stability criteria then yields the inlet stability diagram for Blind Pass.

The various analytical expressions required for the above analysis are well-documented in the literature [Bruun, 1978; Escoffier & Walton, 1979; Mehta & Bruun, 1983] and are reproduced below:

Hydraulic Stability:

$$K = \frac{A_cF_n\sqrt{2gT}}{2\pi A_B\sqrt{a_o}} \tag{4.11}$$

$$F_n = (\frac{2gLn^2}{R^{\frac{4}{3}}} + m)^{-\frac{1}{2}} \tag{4.12}$$

where F_n is a dimensionless head loss parameter. The value of K is then obtained iteratively using the following equation:

$$K = \sqrt{e}\tilde{a}_B \left\{1 - \left[1 - \alpha_i^2(\frac{K_i}{K})^p\right]^2 \tilde{a}_B^2\right\}^{-\frac{1}{4}} \tag{4.13}$$

where

$$e = \frac{4}{\pi}[\frac{1}{3}\cos\theta_n(2 + \sin^2\theta_n) + \theta_n \sin\theta_n] \tag{4.14}$$

$$\theta_n = \sin^{-1}(\frac{Tq}{2\pi a_o A_B \tilde{a}_B}] \tag{4.15}$$

$$\alpha^2 = \alpha_i^2(\frac{K}{K_i})^{-p} \tag{4.16}$$

$$A_c = A_{ci}(\frac{K}{K_i})^p \tag{4.17}$$

$$U_{max} = \frac{2\pi a_o A_B \tilde{a}_B}{TA_c}(1 + \sin\theta_n) \tag{4.18}$$

where q is the tributary inflow and other parameters are as defined earlier.

The above set of equations, which is described in Escoffier & Walton [1979], incorporates the effects of inertia through the dimensionless tidal frequency term, α, and of tributary inflow through q found in the equation containing e. Equations 4.16 and 4.17 are assumed variations of α and A_c relative to K where the subscript i denotes initial values before accretion or erosion. The value of the parameter p lies between 0.6 for the condition when the wetted perimeter is assumed to vary but not R, the hydraulic radius, and 1.0 for the opposite condition in response to sedimentary processes. It is used here as a calibrating parameter to reproduce the measured flow velocity.

Sedimentary Stability

$$\Omega = \frac{U_{max}A_c T}{\pi C_k} \tag{4.19}$$

$$\Omega = a^{-\frac{1}{m}} A_c^{\frac{1}{m}} \tag{4.20}$$

Combining the above two equations leads to the following equation describing the relationship between U_{max} and A_c:

$$U_{max} = \frac{\pi C_k}{T} a^{-\frac{1}{m}} A_c^{\frac{1-m}{m}} \tag{4.21}$$

where C_k varies between 0.811 and 0.999 and is taken as 0.86 here. Values of a and m have been published for the Gulf of Mexico for "*Zero, One & Two*" and "*Zero & One*" jetty conditions [Bruun, 1978]. It was found that the two set of values yield $U_{max} \propto A_c$ relationships that are not far from each other in the present case. Hence, the values for the "*Zero & One*" jetty condition, i.e, a=3.51×10^{-4} and m=0.86, are used in this study.

Chapter 5

NUMERICAL MODELING

5.1 Model Description

The model is a one-dimensional dynamic model that is based on integrated momentum equation for flow and DuBoys formula for sediment transport. The model first computes the flow discharge and water depth in each numerical cell along the axis of the inlet using an iterative approach based on a given Gulf tide, bay area, bed resistance represented by the Manning's n, and exit and entrance losses. The integrated momentum equation that governs the tidal flow along the inlet is:

$$\eta_o - \eta_B = \frac{u_{m_i}^2}{2g}(k_{ex} + k_{en}) + \sum_{i=1}^{N} \Delta H_i \tag{5.1}$$

where

u_m = flow velocity in cell i;

ΔH_i = heat loss due to friction in cell i; and

N = total number of cells.

The values of η_o are specified from the generated Gulf tide mentioned earlier while the values of η_B are computed from the values of $\tilde{a}_B$ and ϵ computed from the analytical study. So is A_B, which is the result of the flow calibration exercise in the analytical study. The friction head loss in each cell is computed based on the Manning's Equation:

$$u_m = \frac{1}{n}(\Delta h)^{\frac{1}{2}} h^{\frac{2}{3}} \tag{5.2}$$

where both the uniform flow condition ($\Delta h = S$, the slope of the energy grade line) and the wide channel assumptions ($R \approx h$) have been invoked.

Once the flow conditions have been computed, the sediment fluxes entering and leaving each cell are computed by the DuBoys formula for given hydraulic conditions and sediment properties. The Duboys formula expresses the volumetric sediment transport rate per unit width, q_s, in terms of the excess shear stress as follows:

$$q_s = C_s \tau_o (\tau_o - \tau_{cr.h}) \tag{5.3}$$

where

τ_o = average bed shear stress = γRS;

$\tau_{cr.h}$ = critical shear stress for incipient motion on a horizontal bed;

Duboys'$C_s = \frac{0.173}{d^{\frac{3}{4}}}$

d = sediment size in mm; and

γ = unit weight of water.

$\tau_{cr.h}$ is computed from the Shields Diagram assuming that the flow is in the turbulent rough range (Roughness Reynolds Number, R_e $(= \frac{u_* d}{\nu}) > 70$) where the dimensionless Shear Stress, Θ_t, is a constant at 0.06. A metric conversion factor of 4.05×10^{-5} need to be incorporated into the expression for C_s, which is taken from Graf [1984].

The sediment conservation equation for each compartment is then:

$$\int_{t_1}^{t_2} q_{s_{in}} W\,dt - \int_{t_1}^{t_2} q_{s_{out}} W\,dt - m[(Wh)_{t_1} - (Wh)_{t_2}] = 0 \tag{5.4}$$

where the subscripts in and out denote fluxes into and out of the compartment, and m and W are the porosity of the sediment and the cross-sectional width, respectively. In order for the computation to proceed, initial conditions are ascribed for q_s, W and h, and boundary conditions assigned to q_s in terms of M, the fraction of littoral drift that enters the inlet, and ξ, the composite factor that represents the fraction of M that deposits during flood and the subsequent ebb in each time increment of the tidal cycle. An implict assumption is that bed erosion and deposition occur uniformly throughtout the entire inlet.

The flow area then adjusts to the sediment scour or deposition by changing the width to suit the new flow depth. Based on an examination of a large number of inlets, an empirical relation that expresses the gemetric relationship between W and h for the minimum flow area of the following form has been in use [Bruun, 1978]:

$$h = aW^b \tag{5.5}$$

Values of a and b used in the model are 0.087 and 0.88, respectively, for W and h in meters, based on the trend line for jettied inlet [Bruun, 1978].

Table 5.1: Calibrated Parameters from Analytical Method

T (hr)	a_o (m)	f	A_B (m^2)	$\tilde{a}_B$	ϵ
12.42	0.20	0.025	2.80 $\times 10^6$	0.86	33.3
12.42	0.25	0.025	2.10 $\times 10^6$	0.92	26.0
12.42	0.30	0.025	1.70 $\times 10^6$	0.94	21.5
12.42	0.35	0.025	1.43 $\times 10^6$	0.96	18.1
12.42	0.40	0.025	1.25 $\times 10^6$	0.97	15.9

5.2 Preliminary Runs

A series of run was first conducted using the same input data as for Phillips Inlet, except the geometric data which were based on conditions at Blind Pass. The runs always terminated early due to the exponential growth of the inlet cross-section, even under the condition of appreciable sediment input. After a few more runs, it was found necessary to reduce the C_s coefficient in Eq. 5.3 by 100-fold. The next series of runs were for different values of the bay area, A_B, calibrated againest different values of a_o to achieve an average flow velocity of about 1.1 m/s as shown in Table 5.1

The range of a_o selected encompasses the mean tide range on one end and the mean diurnal range on the other end. As observed, higher values of a_o lead to lower A_B and ϵ but higher $\tilde{a}_B$ values. Fig. 5.1 shows the results of comparative runs for the case of the fraction of littoral drift that enters the inlet, M, equalling 1,000 m^3/day, which indicates that lower values of η_o, and hence, higher A_B values, result in inlet widening. Since the chosen emphasis here is on inlet closure, the largest value of η_o, i.e., 0.40 m, was adopted for all subsequent runs.

The next preliminary test runs involved inputting various arbitrary values of M to assess the response of inlet under different scenarios. As indicated in Fig. 5.2, the inlet demonstrated no tendency to close even at M = 2,900 m^3/day, a very large figure indeed that is unlikely to be realized at the site. This is interpreted as the overwhelming effect of the erosion algorithm in the model. Fig. 5.3 indicates two comparative runs with the q_s reduction coefficient of 0.01 and 0.001, which is equivalent to reducing the C_s coefficient in Eq. 5.3 by another 10 times, for the case of M = 1,000 m^3/day. The latter case seemed to perform as expected, i.e,. exhibiting tendency to close. Hence, the value of 0.001 was adopted for subsequent runs.

With these input data, the model was run to simulate conditions after a week as indicated in Fig. 5.4 (a) and (b). While the output for the flow area is reasonable other than some initial high-frequency oscillations, which is not unusual for model start-up, the

Table 5.2: Final Input Values for Numerical Model Runs

L	$194\ m$	h	$64\ m$	n	0.05	n_p	0.4
d	$0.26\ mm$	K_{en}	1.00	K_{ez}	0.05	a_o	$0.40\ m$
T	$12.00\ hr.$	$\tilde{a}_B$	0.64	ϵ	51	A_B	$1.9 \times 10^6 m^2$
ξ	0.3	RF_{q_s}	0.001	RF_{η_o}	0.75	$\tau_{cr.h}$	$0.88\ \frac{N}{m^2}$

output for velocity is too excessive. It was then decided to increase the roughness to reduce the flow velocity to a more realistic level, being achieved by increasing the value of Manning's n from 0.03 to 0.05.

The relevant input parameters were recomputed from the analytical method using the revised n value. The value of friction factor, f, which is an input in the analytical method, was computed using the following relationship:

$$n = h^{\frac{1}{6}} \left[\frac{f}{8g}\right]^{\frac{1}{2}} \tag{5.6}$$

Table 5.2 lists all the inputs to the numerical model for the final runs where n_p, the only unexplained parameter thusfar, is the sediment porosity. The only varying input is M, which ranges from 200 to 2000 m^3/day.

In Table 5.2, RF_{q_s} and $RF_{\eta o}$ denote the reduction factors for the flow-induced bottom erosion rate computed using DuBoys formulation, and the forcing tide amplitude in the Gulf, respectively. The critical shear stress for incipient motion, $\tau_{cr.h}$, is computed from the graph for metric units (Fig. 7.2) in Graf [1984]. The average sediment size, d, is taken from the US Army Corps of Engineers Report [1969], which lists the representative beach sediment for beaches adjacent to Blind Pass.

Chapter 6

RESULTS AND DISCUSSION

In the literature on inlet stability, a distinction between long-term and short-term stability is frequently made. The former refers to the gradual deterioration of the inlet due to shoaling and may occur over several months or even decades. On the other hand, short-term stability is associated with storm events, which can result in inlet closure. Hence, while the former considers average conditions, the latter is necessarily linked to the intensity and duration of storm events.

6.1 Long-term stability

One of the frequently used criteria for long-term stability is the sedimentary and hydraulic stability diagram discussed in Chapter 4 : Analytical Study. Since there is substantial temporal variation in the tide conditions, two stability diagrams were prepared: one based on the mean tide condition (average of the two daily tides) and the other one based on the same parameter inputs for the numerical model, which represents a more extreme condition associated with the average of the higher daily tides only. This was done in the hope that the two conditions would envelope the expected behavioral range of the inlet.

The inlet performance for the mean tide condition is shown in Fig. 6.1, which indicates that the K value for the present inlet configuration (1.19) is more than K_c (0.74 in this case), indicating that the inlet is stable under the scenario considered. On the other hand, K-curve for the more extreme condition indicates that the K value for the present inlet (0.73 in this case) is very close to the corresponding K_c, which ranges from 0.42 to 0.74 depending on the p value used, as shown in Fig. 6.2. The figure also shows a lower peak velocity, which is expected due to the higher resistance coefficent used ($n = 0.05$). Hence, while Blind Pass may be deemed as stable under mean tide condition, it is only marginally stable under the more extreme tidal forcing scenario. Escoffier & Walton [1979] have recommended that the value of K for an inlet should always be considerably larger than K_c for stability. In a more quantitative sense, Oliveira [1976] has stated that a tidal inlet characterized by $K < 0.6$ is in a condition of non-steady alluvial equilibrium, which means that shoaling may be in progress there.

Perhaps a more complete picture may be gleaned from Fig. 6.3 and 6.4, which includes sedimentary regime as well. In both figures, curves for three different p values, which is the exponent characterizing the variation of the critical flow area, A_c, with K as discussed previously, have been drawn. The curve for $p = 0.7$ corresponds to that shown in Fig. 6.1. As indicated, higher p values lead to a shift to smaller A_c. However, the recession part of the curves remains relatively constant. Hence, the stable flow area, which is the point of interception of the two stability curves, is about 125 m^2 and 150 m^2 based on averaged and more extreme conditions respectively. These values are close to the historical flow area of Blind Pass in 1966, 1970, and 1974 (Table 2.1).

Based on both Fig. 6.3 and 6.4, the critical flow area ranges from 25 to 80 m^2, depending on the value of p used. The fact that the present cross-sectional area at the inlet throat (64 m^2) under mean conditions is between the critical and stable flow areas quoted above seems to indicate that the inlet is within the stable side of the stability diagram. However, the proximity of the present A_c value to the critical flow area, even disregarding the more extreme conditions where the present A_c value lies to the left of the critical flow area, does reflect the uncertainty on which the above interpretation is based, given possible errors in the field data collection and the simplicity of the approach adopted. Without distinguishing between the tidal conditions as was done here, Foster [1991] has characterized Blind Pass as a marginally stable inlet.

It should be noted that long-term criteria, as established from the above methodolody, presuppose adequate sand supply to satisfy the sedimentary regime. Hence, its application to improved inlets where sediment pathways are interrupted by human intervention as is the case in Blind Pass, requires judicious interpretation. Conceivably, the north jetty cuts off some of the natural flow of the littoral drift, thereby alleviating the shoaling tendency at Blind Pass. As pointed out by Hine [1987], the inlet jetty, although constructed to function as a terminal groin to retain beach nourishment to the north, has provided a measure of stability for this comparatively unstable inlet.

6.2 Short-term Stability

The results of the numerical runs are shown in Fig. 6.5 to Fig. 6.16 for M values ranging from 200 to 2000 m^3/day, a ten-fold increase. The length of run duration was chosen such that it would encompass an entire spring-neap tidal cycle, a period of approximately a month. Since the model was run each time with a constant M value, the duration of about a month more or less fits in with the strong monthly variation in littoral transport exhibited in Table 2.4.

In general, the model outputs in the form of temporal variations of flow area and flow velocity follow the same trend as that of the Gulf tide, which would be expected since the tide is the primary forcing agent. The variation reflects the influence of the two unequal tides in a day typical of a strongly mixed tide. Where the two daily tides approach each other in magnitude (day 7 to day 11), the variation is a smooth oscillation. At other times, the lower of the two tides is almost non-existent and the water level is sustained at almost the same elevation for hours. The horizontal trend of the variation (day 16 to day 18) is indicative of the tideless condition, which also appears in the velocity plots.

The flow area reaches a maximum of about 150 m^2, which is within the historical flow area reported. On the other hand, the simulation of flow velocity is perhaps less satisfactory, occasionally reaching a maximum of about 3 m/s during ebb flow, except for the M = 200 m^3/day run. However, most of the flows are within the 2 m/s cap. Flows of such magnitudes are not entirely unrealistic, if they occur only during part of the tidal cycle when spring, or even perigean spring, conditions prevail.

It is seen that up to about M = 600 m^3/day, the inlet exhibits either stable or slight accreting conditions. From M = 700 m^3/day to 800 m^3/day, the shoaling trend is clearly noticeable, but the inlet still remains open at the one-month cut-off point. The inlet closes in about a month for M = 900 m^3/day and thereafter the time of closure is more rapid as the M value increases to 2000 m^3/day where the inlet closes in twelve days. These outputs, therefore, are in qualitative agreement with the expected behavior of Blind Pass under increasing sediment loading.

As supported by photographic interpretation and qualitative observations made in published reports on the survivability of Blind Pass, the closure takes place over a period of months. Bearing this observation in mind, it is suggested that the critical M value for which the inlet is just in a self-flushing condition is probably around 700 - 900 m^3/day. Multiplying M by the ξ factor (= 0.3) used in the model, which is a reasonable estimate of the actual fraction of sediment that ultimately desposits on the bed of the inlet over a flood-ebb cycle from the total amount of sediments that enter the inlet, results in an actual rate of deposition of about 250 m^3.

There are no field data available on the rate of littoral drift that enters the inlet, other than the figures obtained from volumetric difference of the temporal growth of the flood tidal shoal. Since it has been acknowledged that the value computed for the period 1960 - 1965 is conservative, implying low, a reasonable estimate of the rate of deposition is probably three times the computed figure ($\approx$ 30 m^3/day), i.e., about 100 m^3/day. Considering the prevailing thinking that sediment transport predictions can differ by $\pm$ 200%, the M value based on numerical model is perhaps not too far-fetched.

The corresponding figure for post-1965 period is about one-sixth of the earlier value. Hence, by the same token, there is quite a reduction in the amount of littoral material that entered the inlet after the 1960s. The change is attributed mainly to the presence of the north jetty as explained earlier. Hence, it is possible that any southerly transport that manages to bypass the jetty is jettisoned to deeper water and subsequently brought back to shore at a point further downdrift beyond the inlet by the process of bar bypassing. In trying to explain the role of northerly transport, which can be appreciable in the middle of the year (about half of the maximum monthly southerly transport) based on computation, it can be argued that the littoral drift roses actually represent potential transport, i.e., solely based on the sediment transporting power of the waves. Hence, the realization of the actual transport is contingent upon the availability of mobile material. Looking at the regional scale of the shoreline orientation south of Blind Pass, it is apparent that the reach of shoreline immediately south of Blind Pass, the azimuth of which was used in computing littoral transport, is a relatively short transition that joins with the major shoreline of the Sanibel Island that trends roughly 280° N. Hence, it is conceivable that the nearshore bathymetry around this area may cause the waves to arrive at a more normal incidence, and hence result in a less sediment transport capacity.

Another aspect of inlet closure of Blind Pass is the southerly growth of the inlet channel south of its interior channel. This type pf lengthening of the inlet channel almost always precedes inlet closure. It increases flow resistance and hence, reduces the tidal prism. As the channel lengthens, it becomes hydraulically less efficient up to a point where the wave-induced transport just out-balances the tidal flow and closes the inlet at its southerly exit position. The closed channel then shoals from within until a storm event breaches across the enclosed sand bar, usually at the end of the interior channel. The encircling sand bar can also act to obstruct northerly drift from gaining entry into the inlet proper, in a way supporting the premise that the northerly drift may not feature strongly in the inlet closure process. The strong directional preference of ebb flow at Blind Pass also mitigates against any significant sediment movement to the north as suggested by Foster [1991].

It is intersting to note that in the sediment budget prepared by Coastal Engineering & Planning, Inc. [1991], the stretch of shoreline immediately south of Blind Pass ($\approx$ 1,800 m long) has lost about 17,000 m^3/yr for the period 1859 - 1941, 38,000 m^3/yr for 1955 - 1974, 30,000 m^3/yr for 1974 - 1978, and again 38,000 m^3/yr for 1978 - 1988. While these losses may be linked to the inlet sink, it is more likely the result of interruption in southerly drift by first the evolution of the ebb-tidal shoal at Redfish Pass and later the jetty and other protection works along the Captiva Island. The report also indicates the successive reduction in net southerly transport to the south of Redfish Pass for the three periods, 1941 - 1955, 1955 - 1974 and 1974 - 1989. In every case, no losses to the Blind Pass was indicated in the littoral budget established. Again, this may be construed as insignificant sediment supply to the inlet.

While Blind Pass has undergone alternate closure and reopening, the chronic shoreline erosion prevalent along Captiva Island appears to have helped reduce the sediment loading that would otherwise have gained ingress into the inlet. Analysis by Walton [1977] has shown that from 1859 to 1967, the shoreline of the sand bulge seaward of the interior channel of Blind Pass has progressively receded close to about 550 m. While this loss may reflect an efficient mode of sand transfer to the south, it does help mitigate against any tendency toward closure by removing sand from the region immediately offshore of the inlet via alongshore littoral transport.

6.3 Limitations of Approach Methodology

A drawback of the present approach is that it does not account for the presence of multiple inlets that share a common bay of water. Theoretical considerations by van de Kreeke [1985] for a twin- inlet system, albeit with certain simplifying assumptions, has shown that the condition for the existence of stable equilibrium flow area for both inlets is that the enhanced parts of the equilibrium flow curves computed based on the stability analysis of Escoffier [1940] intersect. In the event that no such intersection occurs, then a combination of individual flow area for which both inlets are in equilibrium with the flow conditions does not exist. In other words, one of the two inlets will survive; the other will close eventually.

The significance of the inter-relationship among the inlets is already attested to by the effect of the opening of Redfish Pass on the behavior of Blind Pass. Winton et al [1981], using a numerical approach, has attempted to investigate one facet of the problem, that being the effect of different inlet sizes of Blind Pass on the overall tidal response of Pine Island Sound. They concluded that these changes (up to an inlet cross-sectional area of 1400 m^2), did not significantly change the overall tidal response. However, they did acknowledge that there will be water interchange.

The effect of closing Redfish Pass was also simulated and they found no significant changes in flows through the other inlets. Specifically, their results indicated that the closing of Redfish Pass caused a slight decrease in the flows and in the maximum velocities through Blind Pass and Captiva Pass. However, Foster [1991] has cited Blind Pass, in qualitative terms, as an example whereby changes in the amount of tidal prism, as shared among a group of geographically close inlets, is a strong factor controlling inlet throat cross-section and stability. Nevertheless, these surprising results of Winton et al [1981] may be explained on the premise that the system may have equilibrated to such an extent that it has become irreversible. In fact, this finding may be used to support the premise of the present approach, i.e, treating it as essentially a single inlet system. The other major discrepancy between theirs and the present study is in the maximum velocity through the inlet. For the present configuration, their model predicted a maximum spring velocity of about 0.6 m/s, compared to the measured velocity of about 1.1 m/s used in the present study. They also attributed the very weak dependence of flow velocities on inlet cross-section area and flow depth, which their results indicated, on the fact that the tidal prisms through Redfish Pass and through the southern model boundary (San Carlos Bay) provide a tidal head difference between the inner and outer ends of Blind Pass, and hence, is the dominant factor which controls the flows through Blind Pass.

The constant inlet length assumption employed in the model is also not reflective of the actual tendency of the inlet to increase its length with time. As explained, inlet lengthening increases flow resistance, and the resulting reduced flow velocity makes the inlet more prone to closure. Another complicating element appears in the form of flow constriction imposed by structures. The fact that a bridge spans across Blind Pass implies that the inlet cross-section will not be able to adjust according to the pre-determined $h \propto W$ relationship. In this case, the restriction imposed by the bridge abutments appears to have resulted in a deeper section than expected based on the morphological relation.

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Fig. 3.1 GENERATED GULF TIDES, BLIND PASS

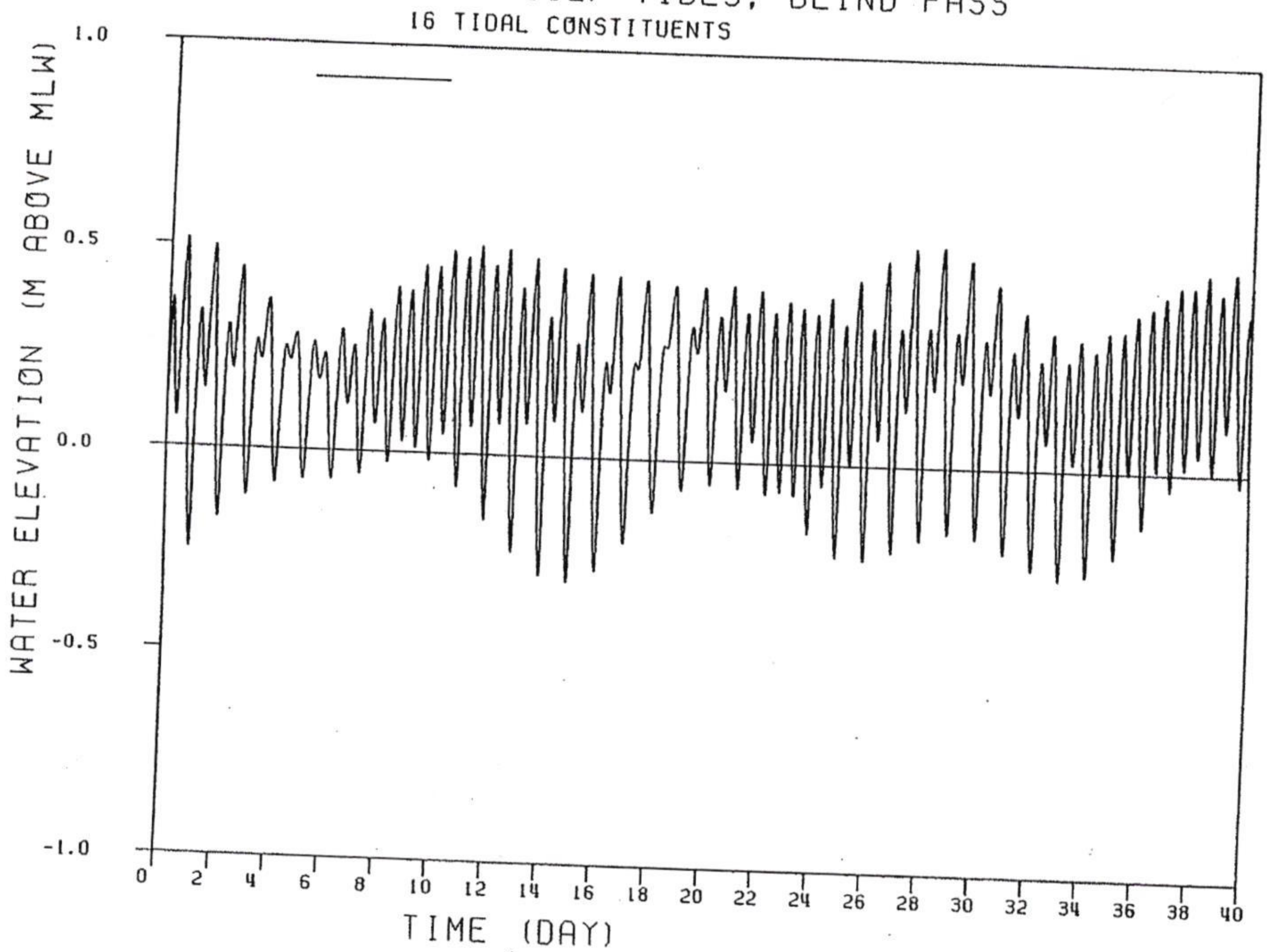


Fig.3.2 VARIATION OF GULF TIDAL RANGE
(MIXED TIDE)

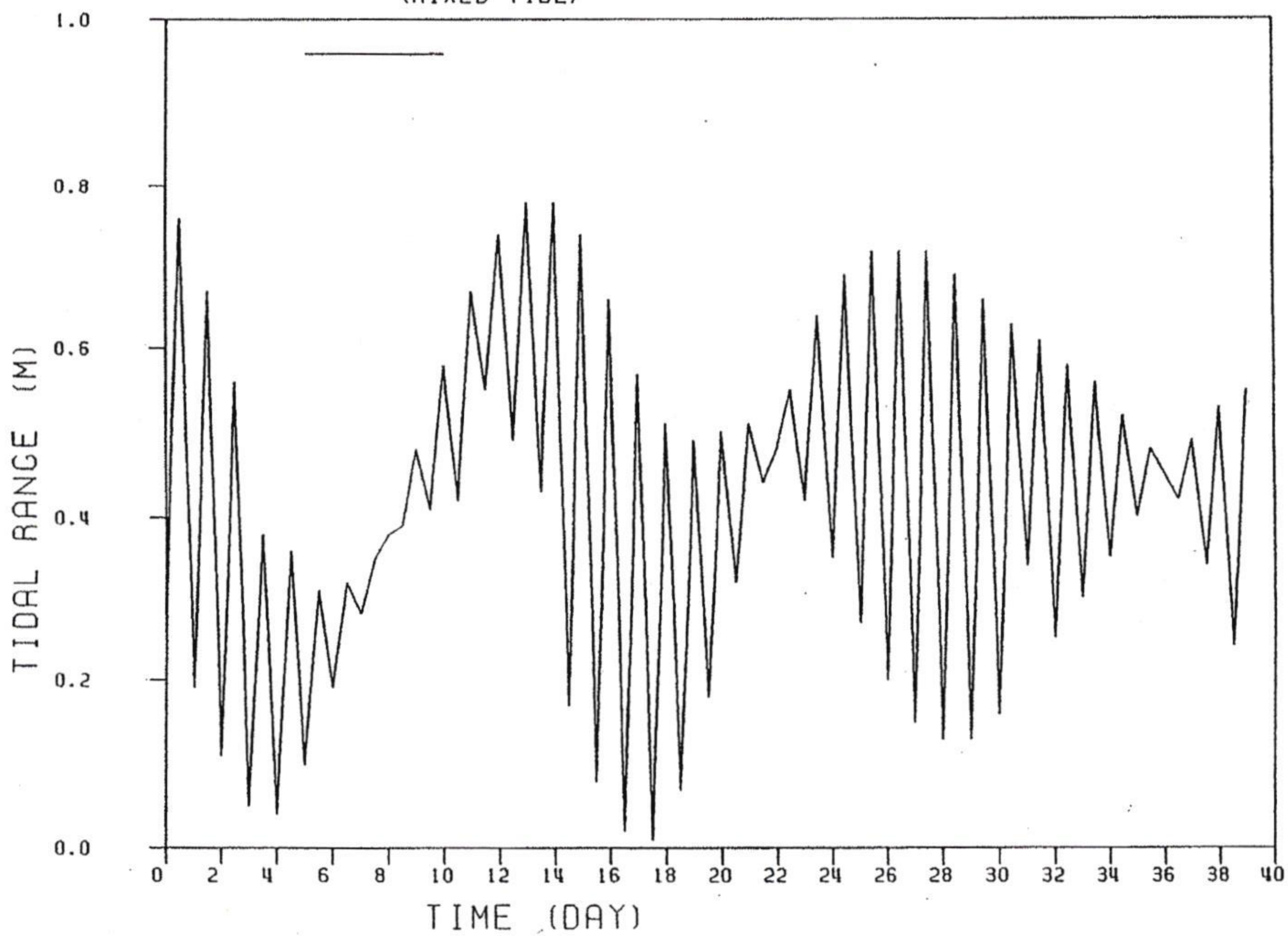


Fig. 3.3 MEASURED POINT VELOCITY AT BLIND PASS
(STARTING TIME: 3.21 PM, 31/7/91)

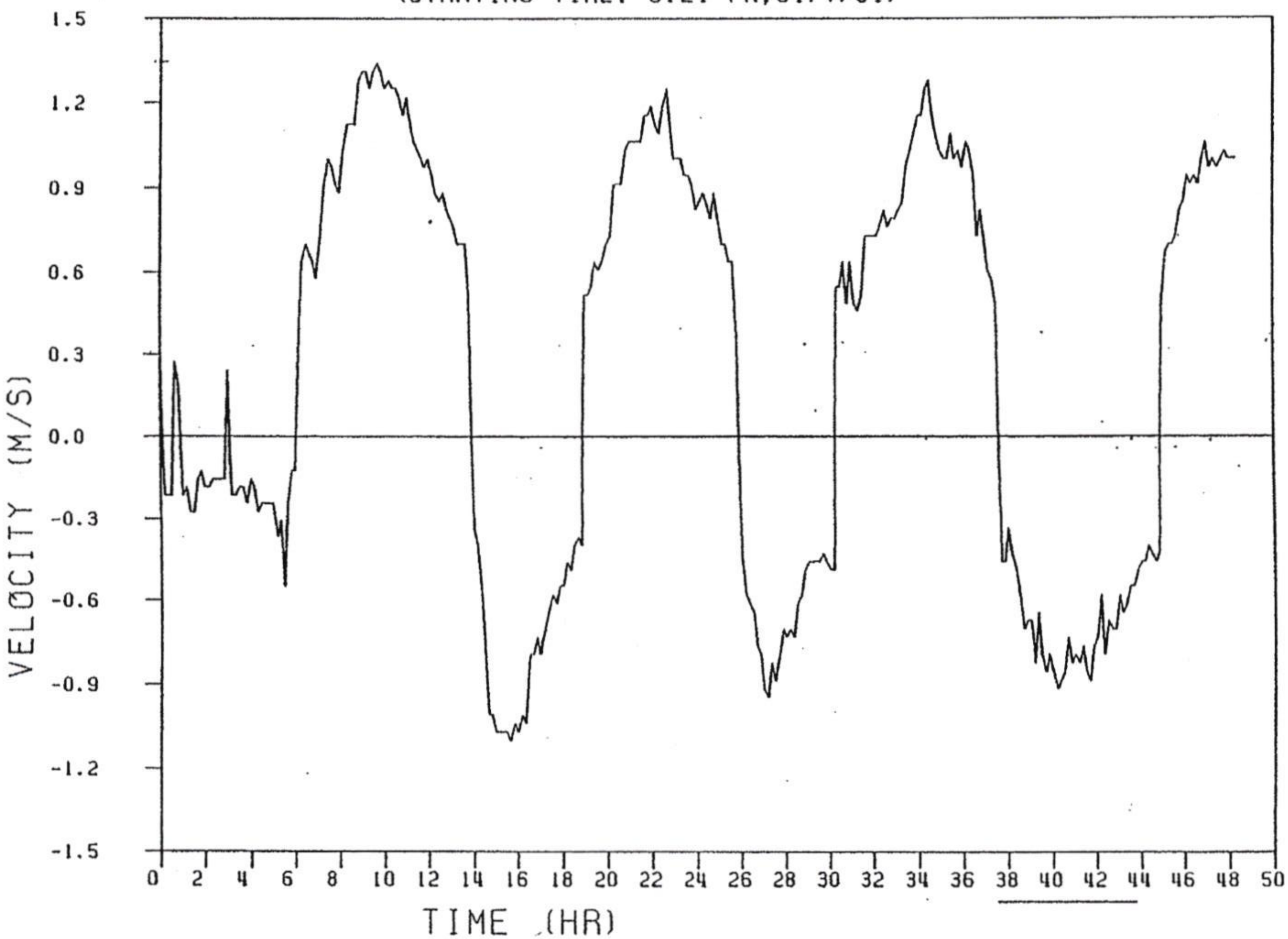


Fig.3.4 MEASURED POINT VELOCITY AT BLIND PASS

POSITIVE = EBB FLOW

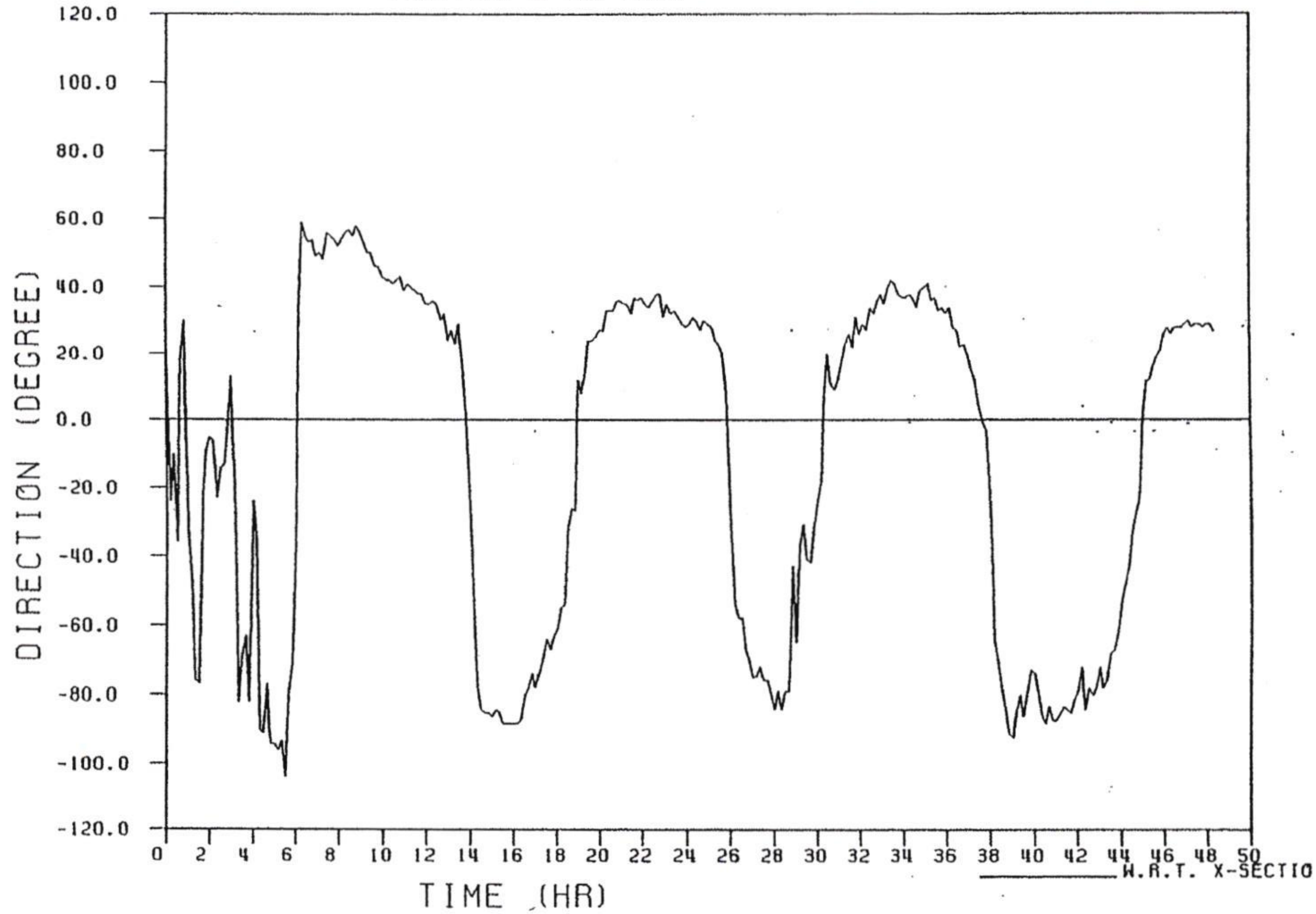


Fig.3.5 INLET GEOMETRY OF BLIND PASS, LEE COUNTY

VARIATION OF X-SECTION AREA A(X) WITH X

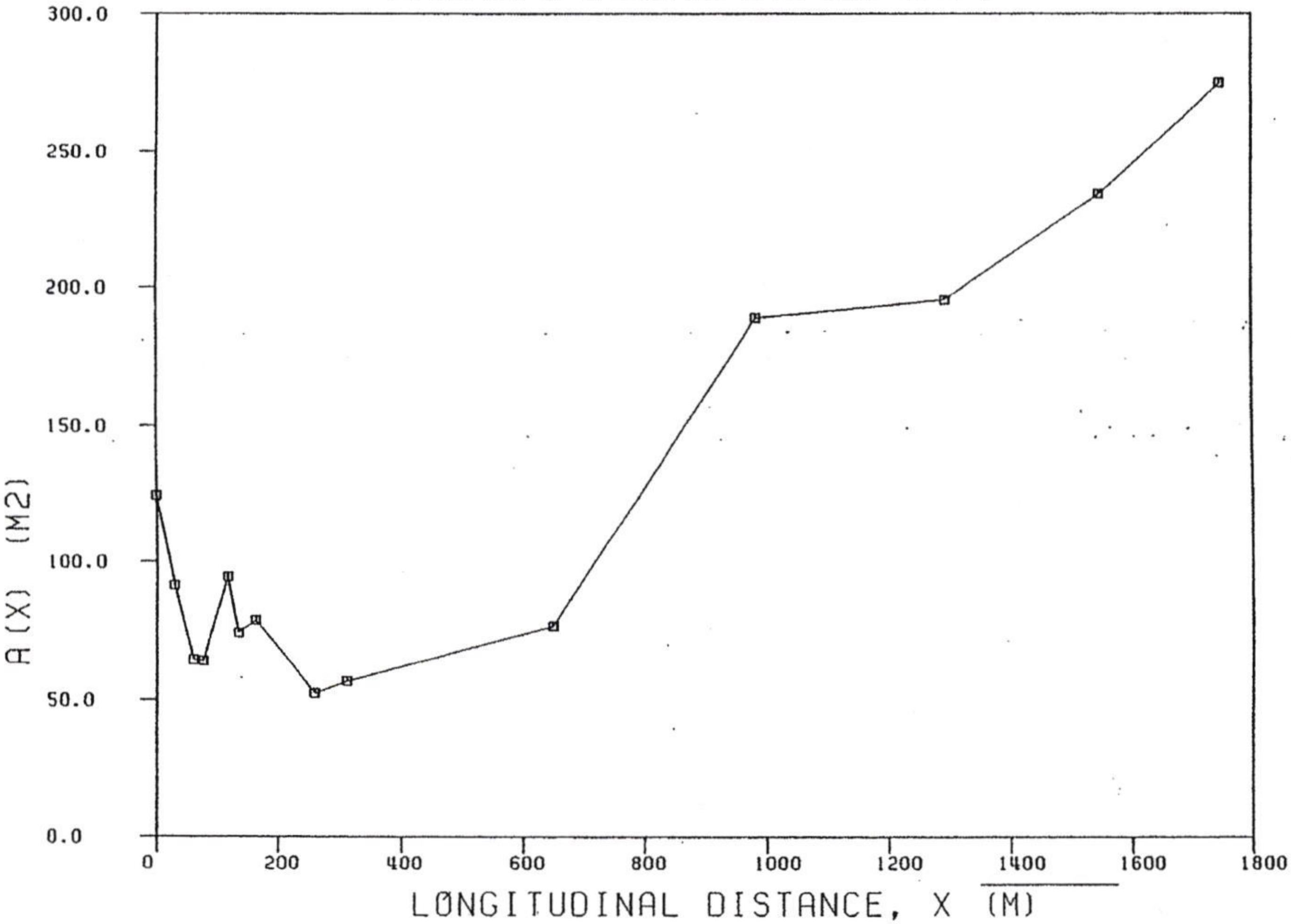


Fig.3.6

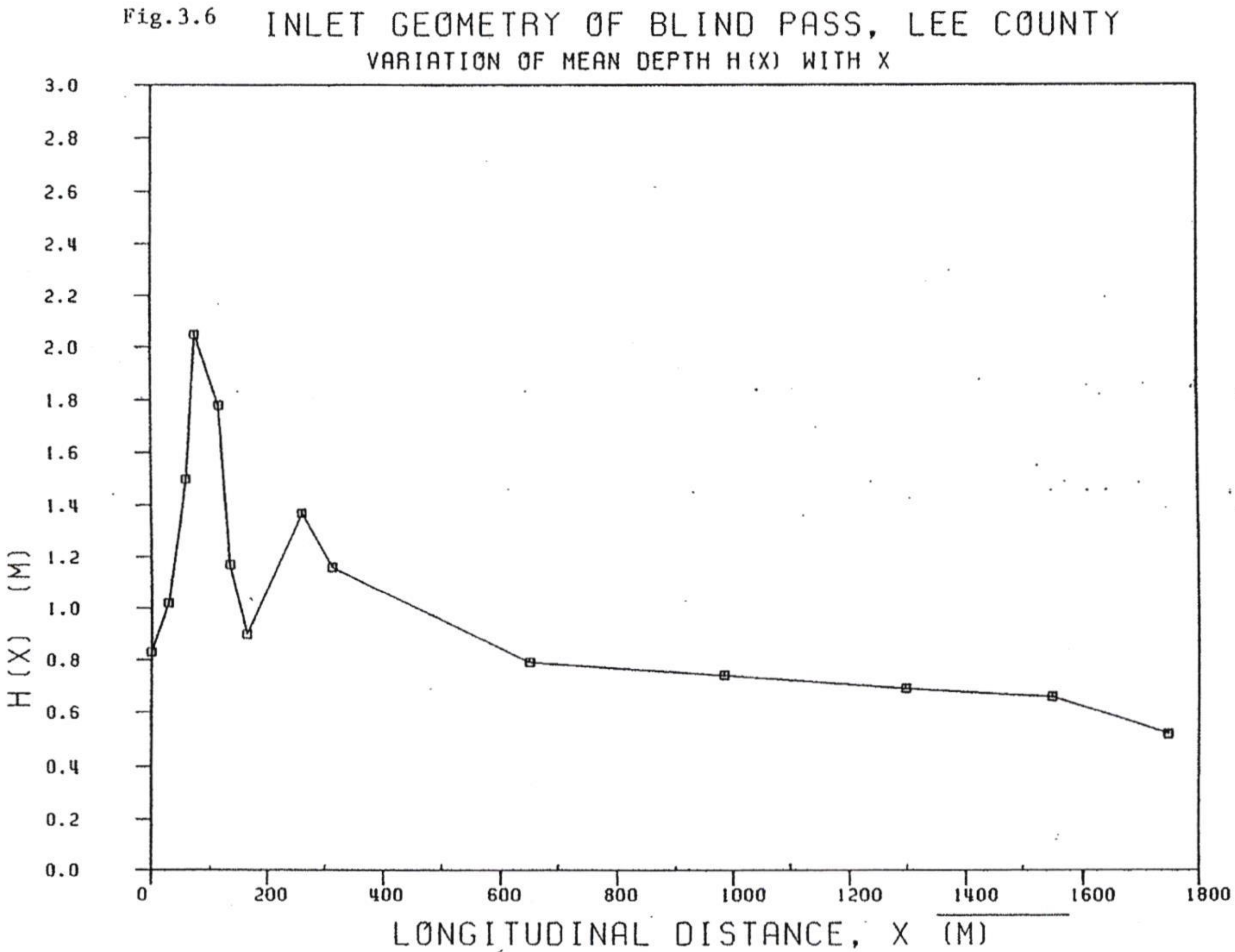

INLET GEOMETRY OF BLIND PASS, LEE COUNTY
VARIATION OF MEAN DEPTH H(X) WITH X
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
H(X) (M)
0
200
400
600
800
1000
1200
1400
1600
1800
LONGITUDINAL DISTANCE, X (M)

Fig. 5.1 Variation of Flow Area with Time
(Different Gulf Tide Ranges)

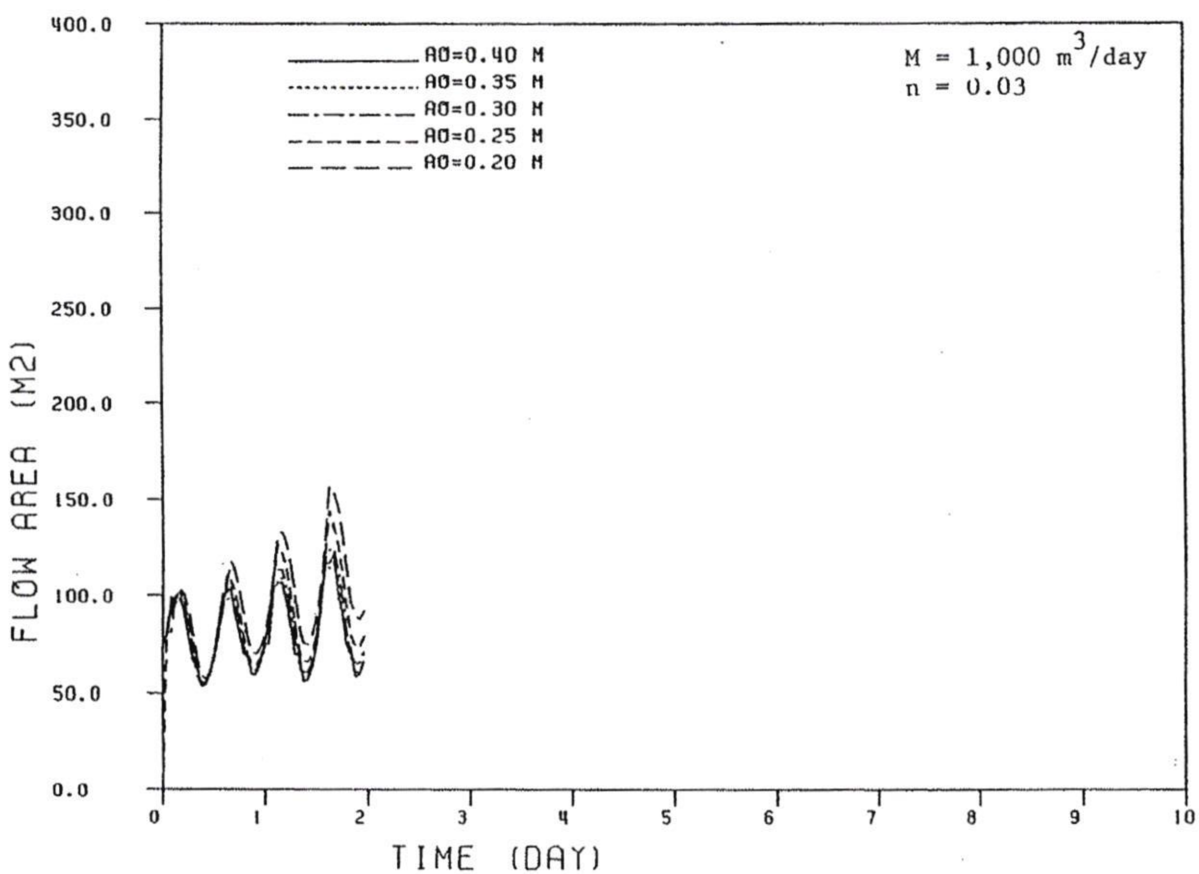


Fig. 5.2 Variation of Flow Area with Time
(Different M Values)

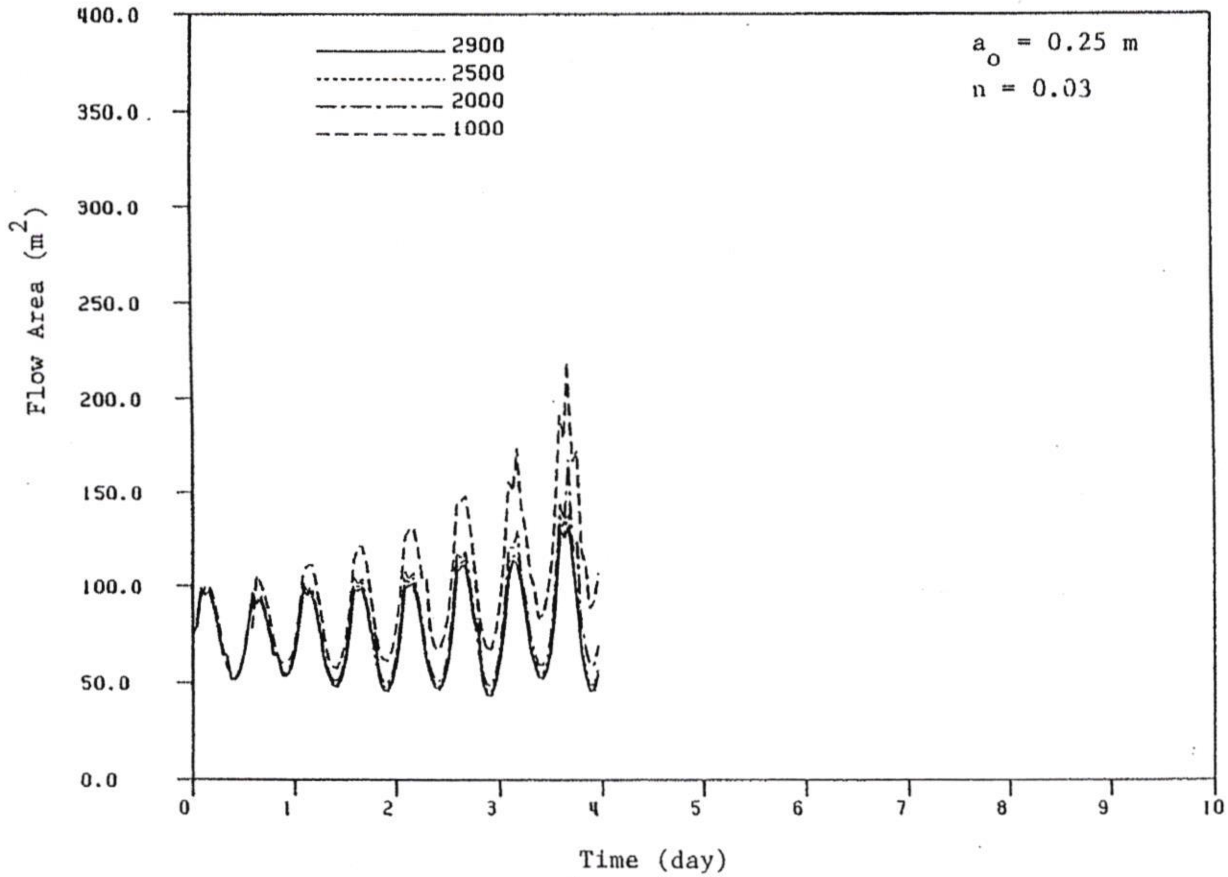
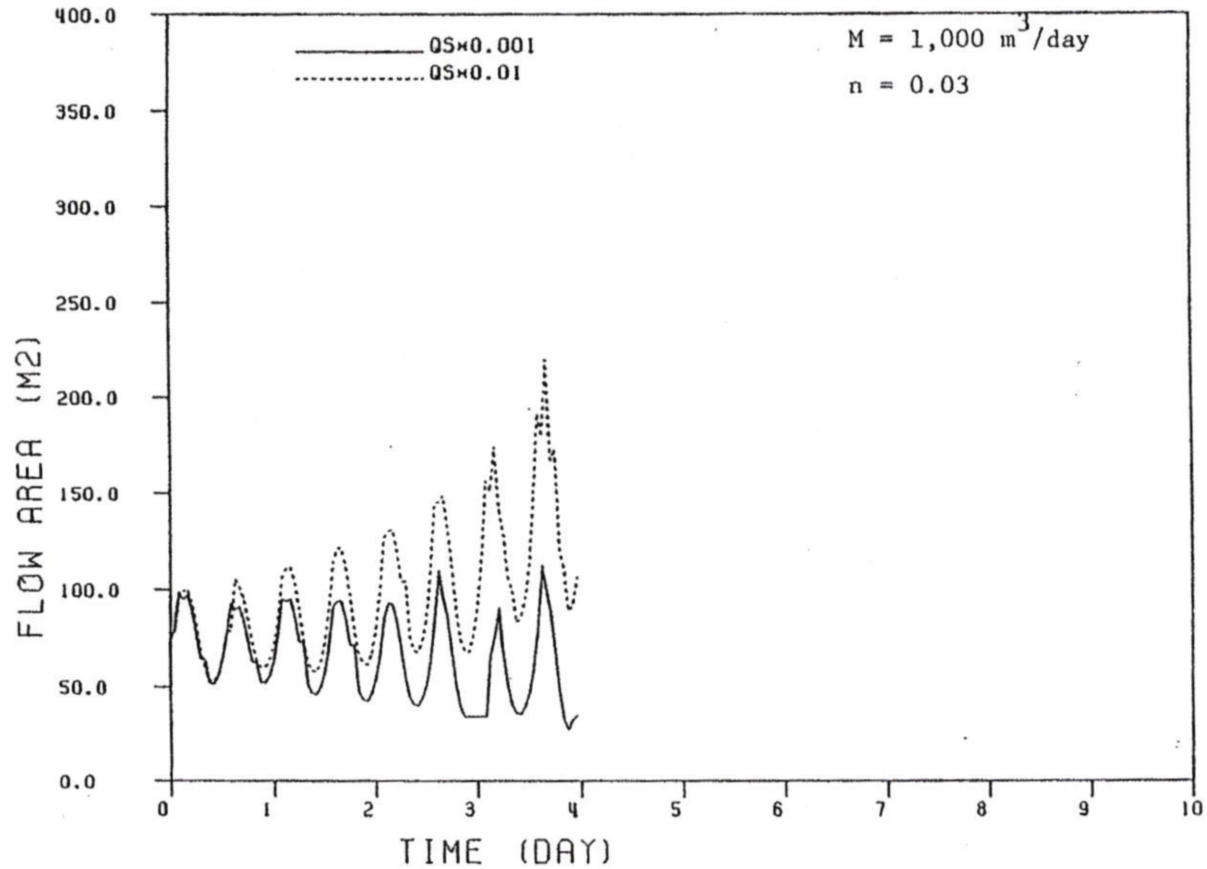


Fig. 5.3 Variation of Flow Area with Time
(Different Q_s Reduction Factors)



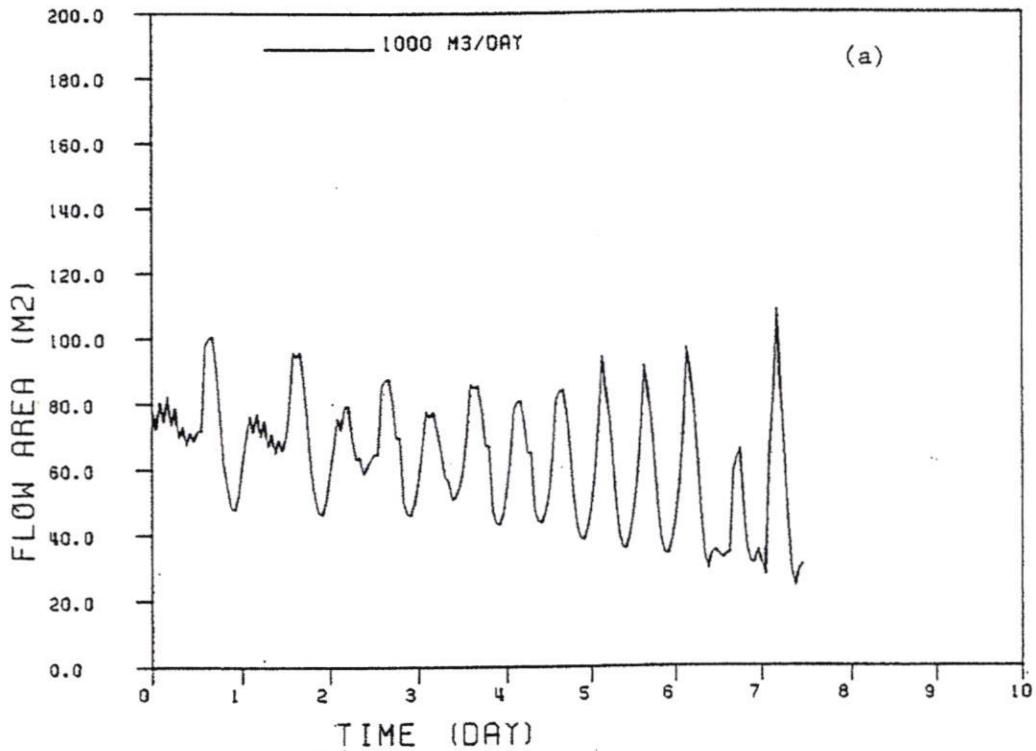


Fig. 5.4 Variation of Flow Area/Velocity with Time
($M = 1000\ m^3/day$; $n = 0.03$)

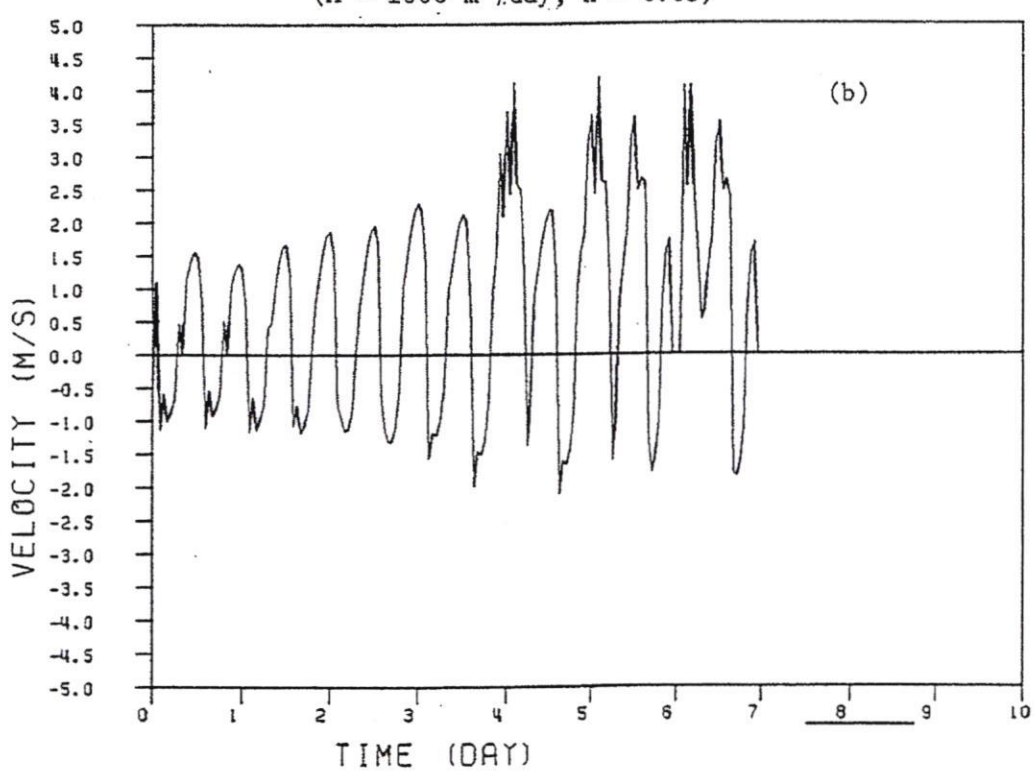


FIG.6.1: CRIT. K VALUE, BLIND P
(MEAN TIDE CONDITION)

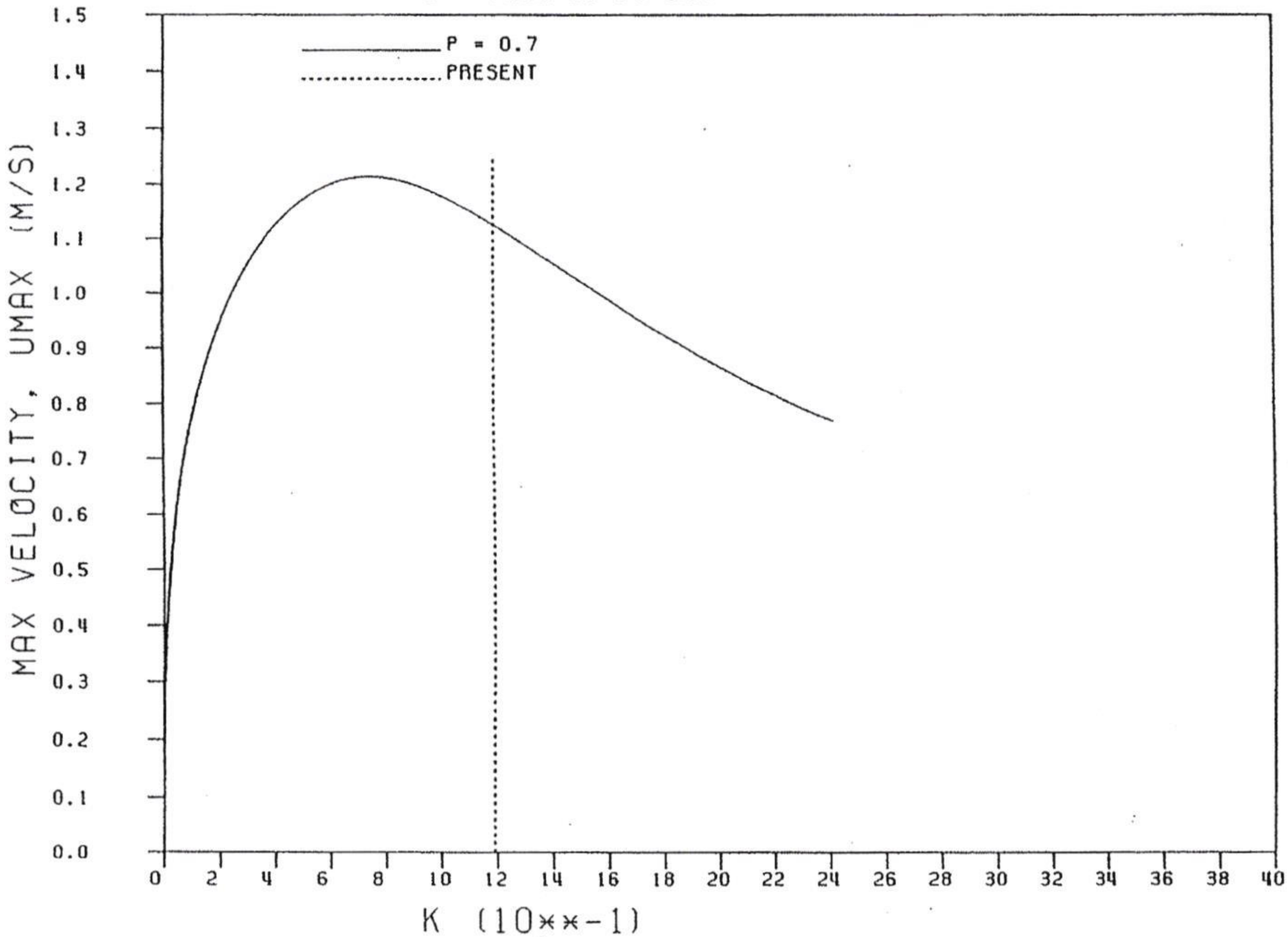


FIG.6.2:CRIT. REPLETION COEFF., BLIND P.

(MEAN DIURNAL TIDE CONDITION)

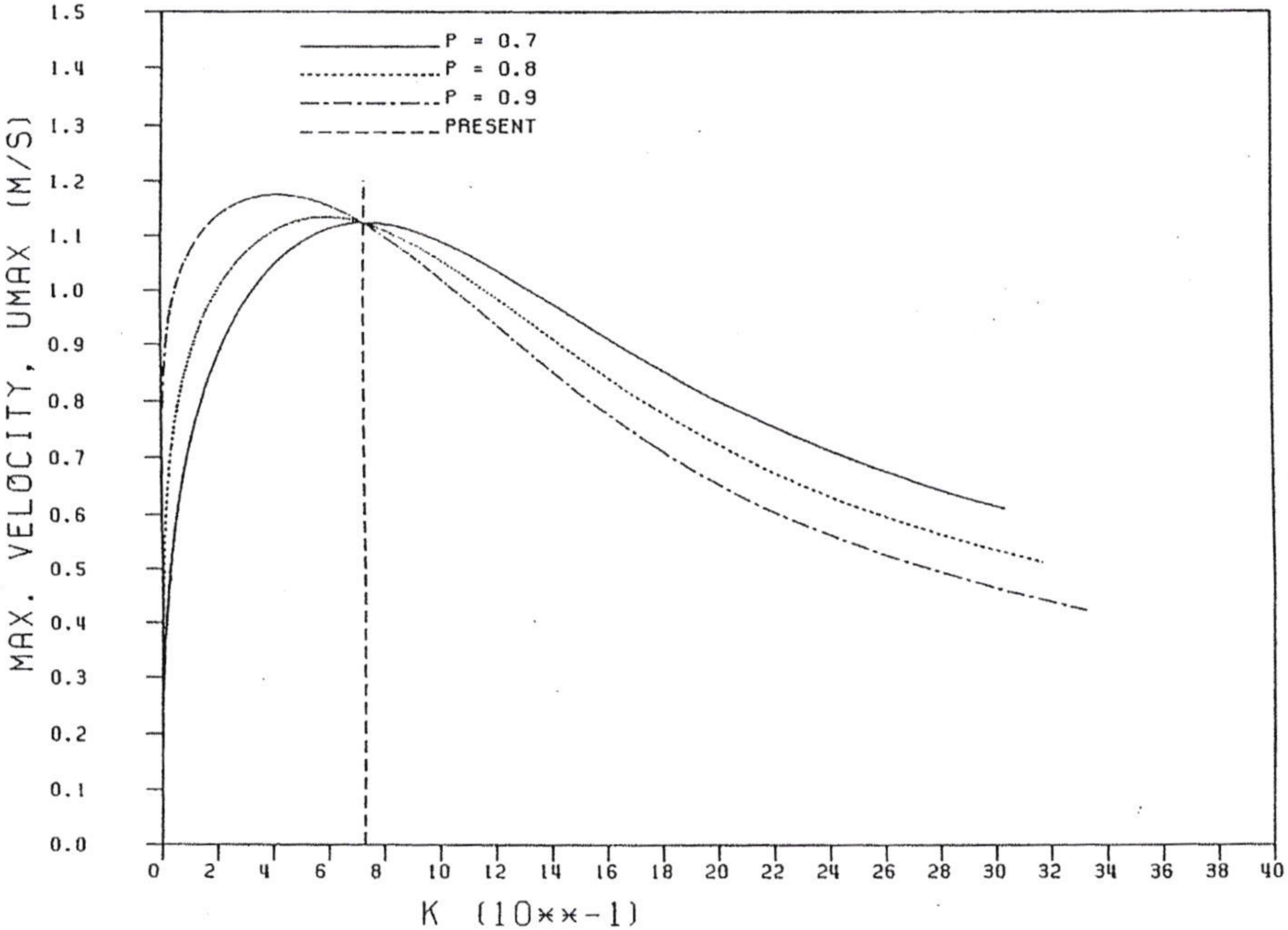


FIG. 6.3: STABILITY DIAGRAM, BLIND P.
(MEAN TIDE CONDITION)

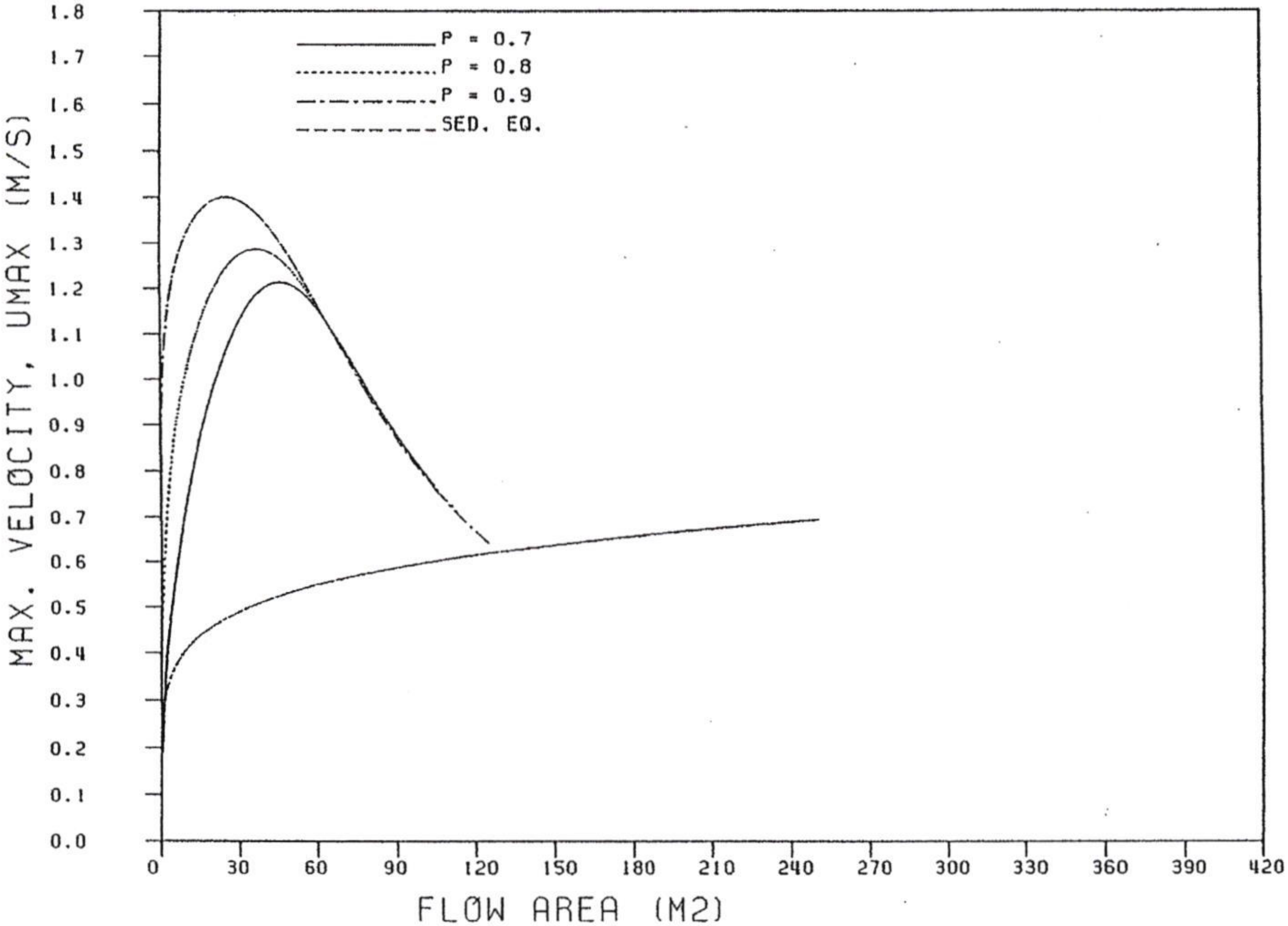
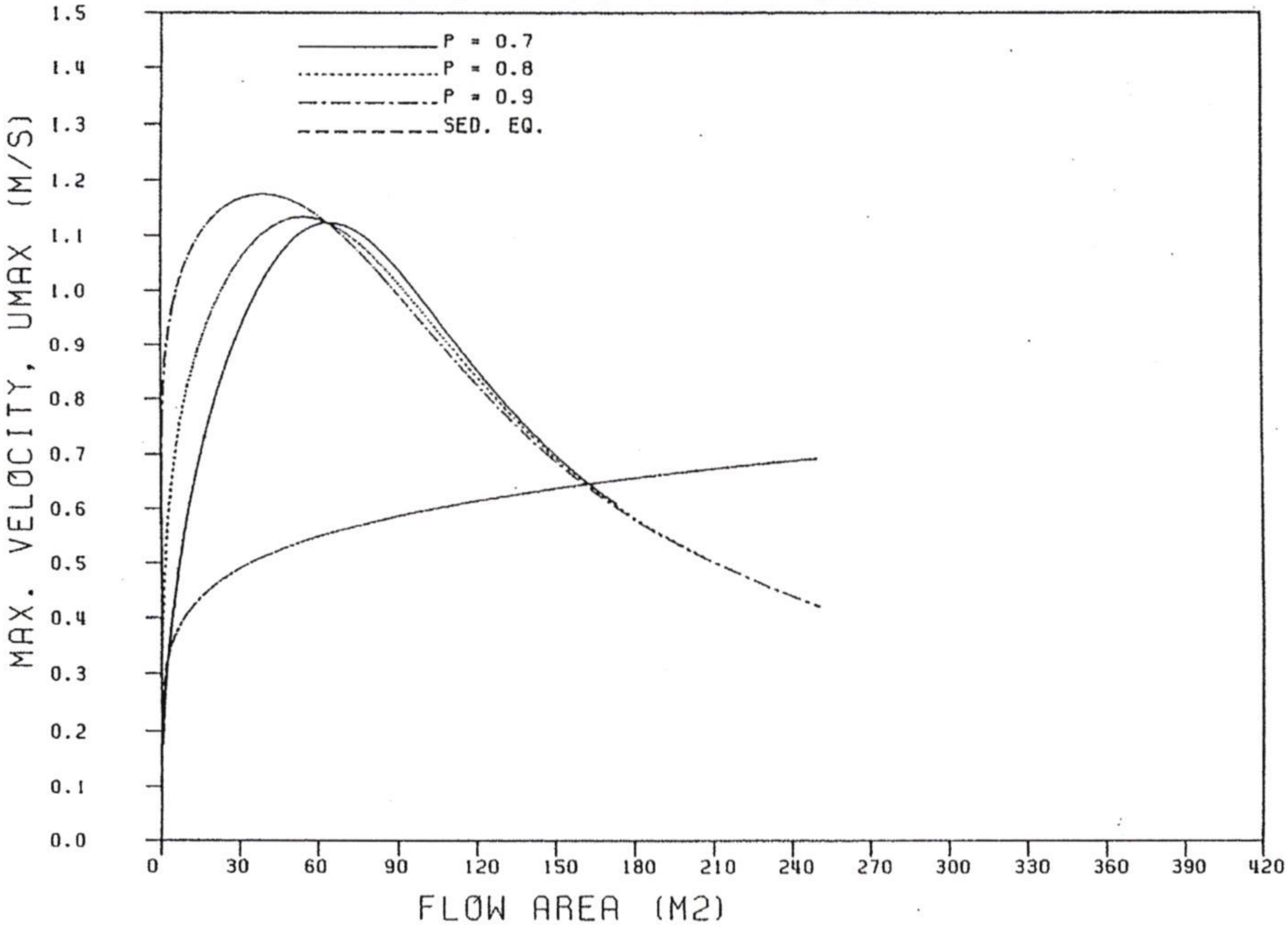


FIG.6.4: STABILITY DIAGRAM, BLIND P.

(SAME PARAMETER INPUTS AS MODELS)



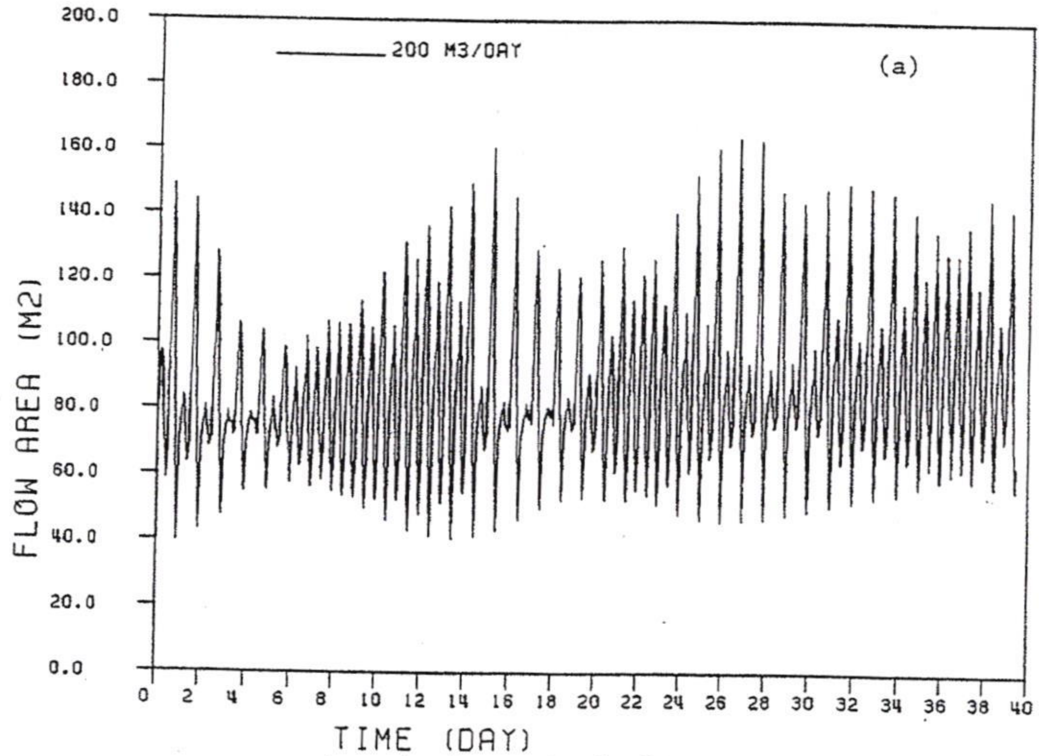
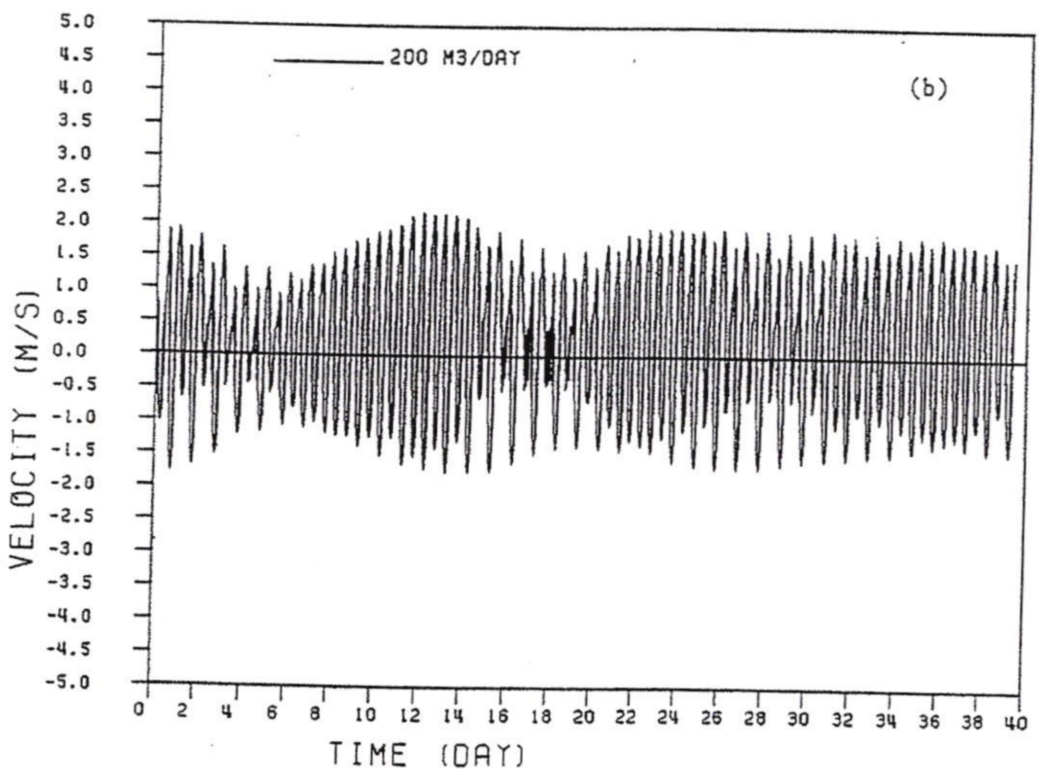


Fig. 6.5 Variation of Flow Area/Velocity with Time
($M = 200\ m^3$/day)



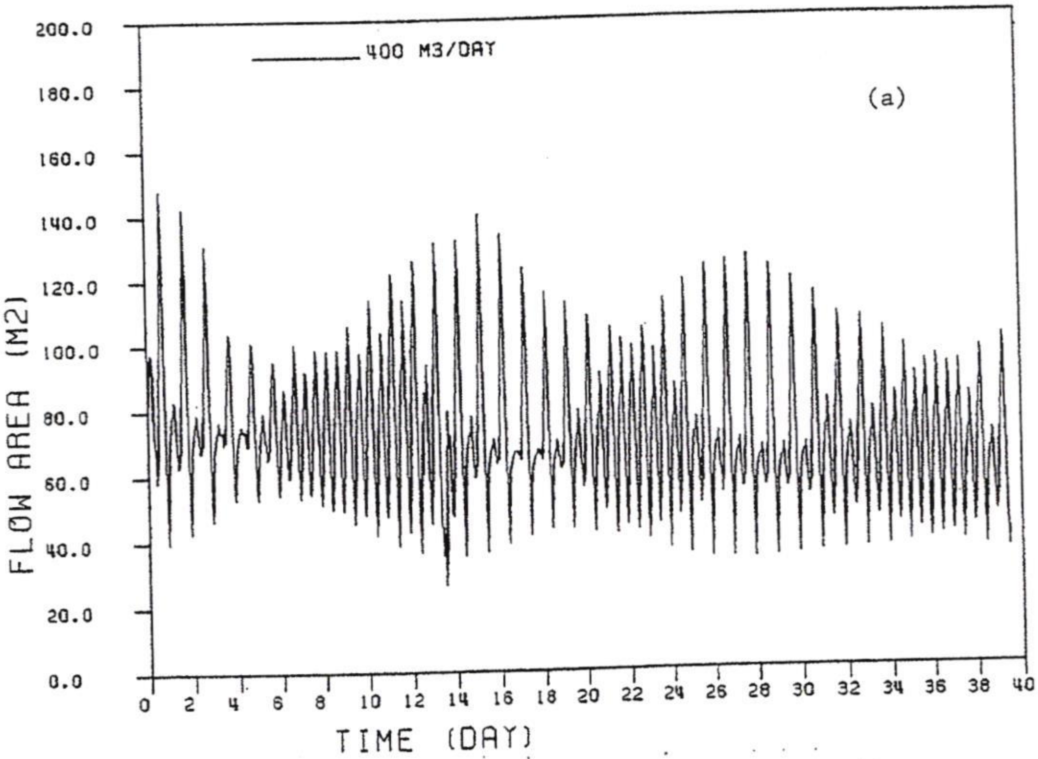
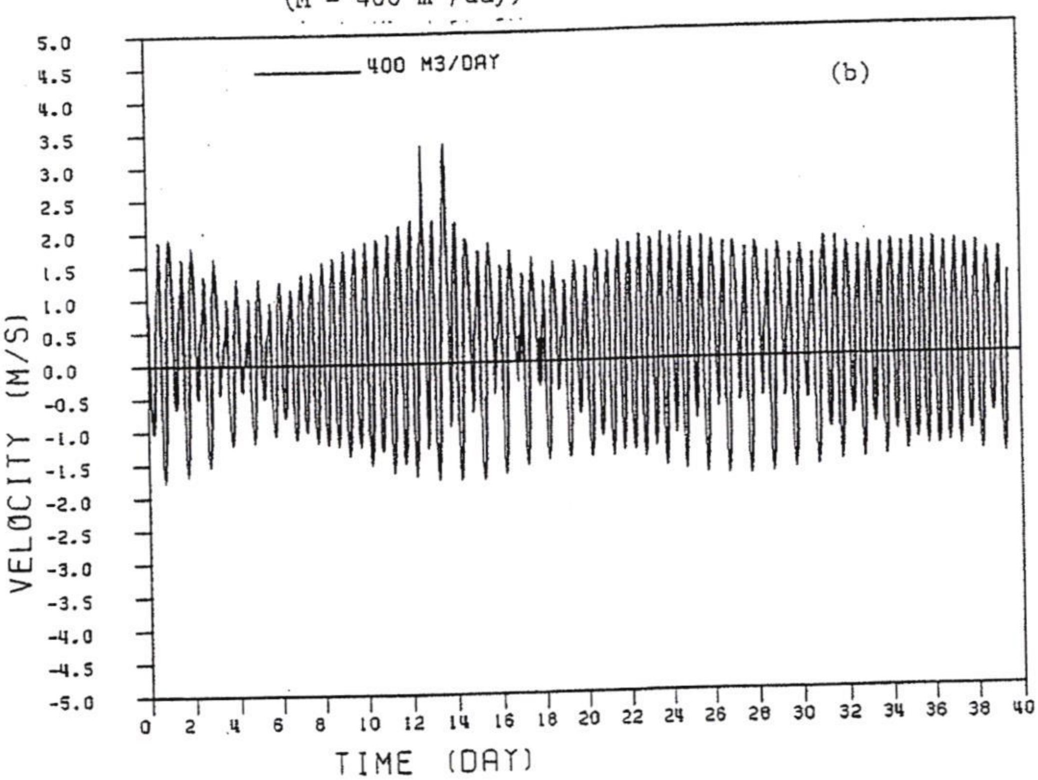


Fig. 6.6 Variation of Flow Area/Velocity with Time

($M = 400\ m^3/day$)



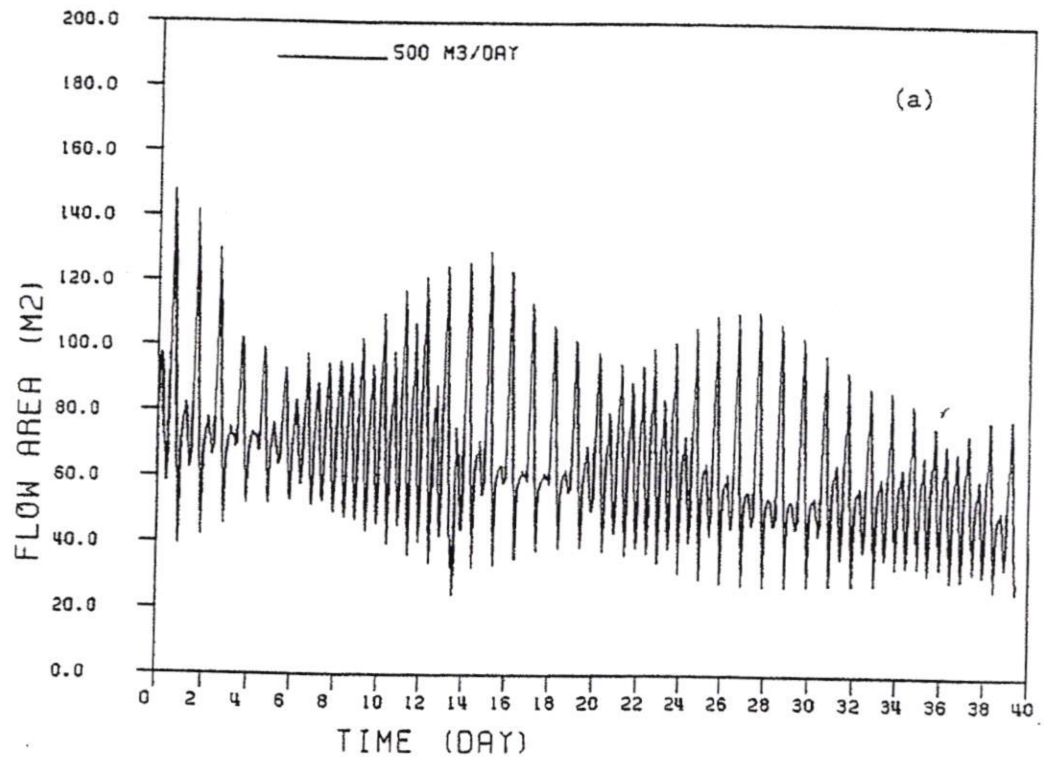
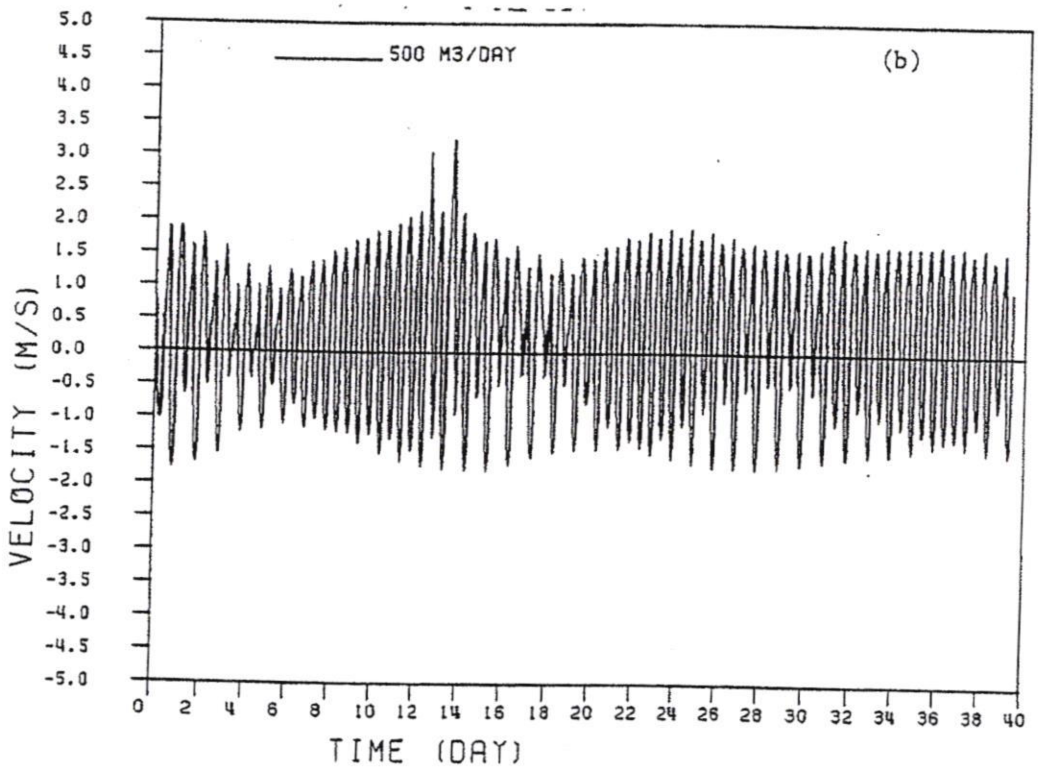


Fig. 6.7 Variation of Flow Area/Velocity with Time

(M = 500 m^3/day)



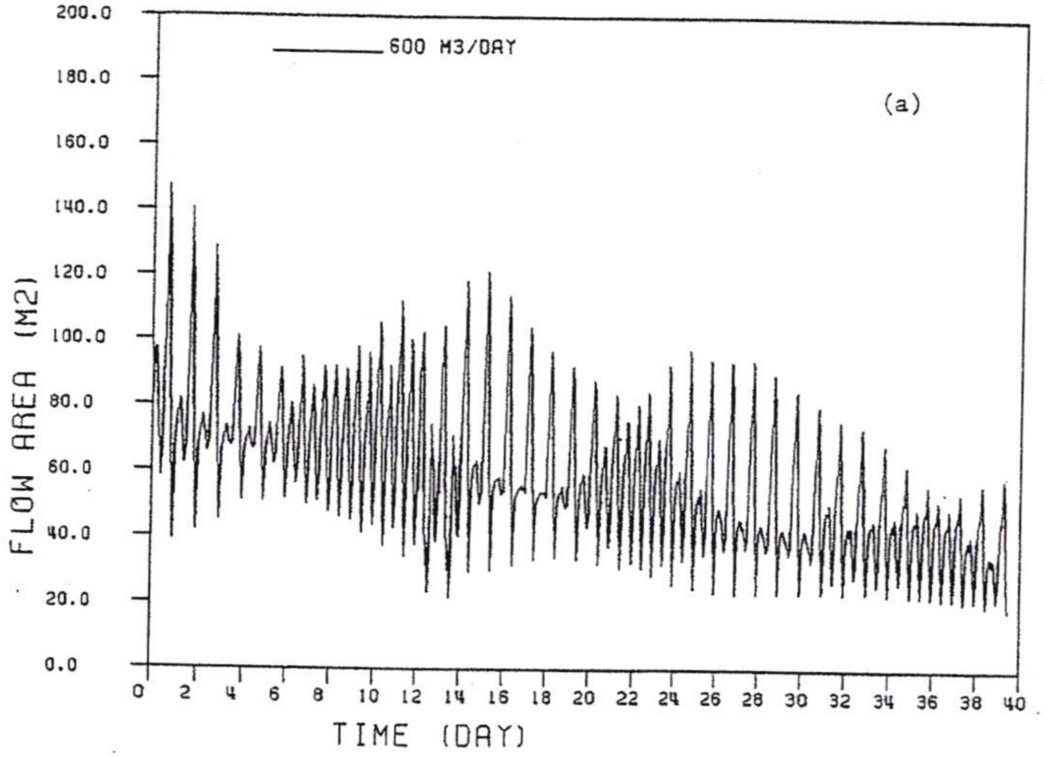
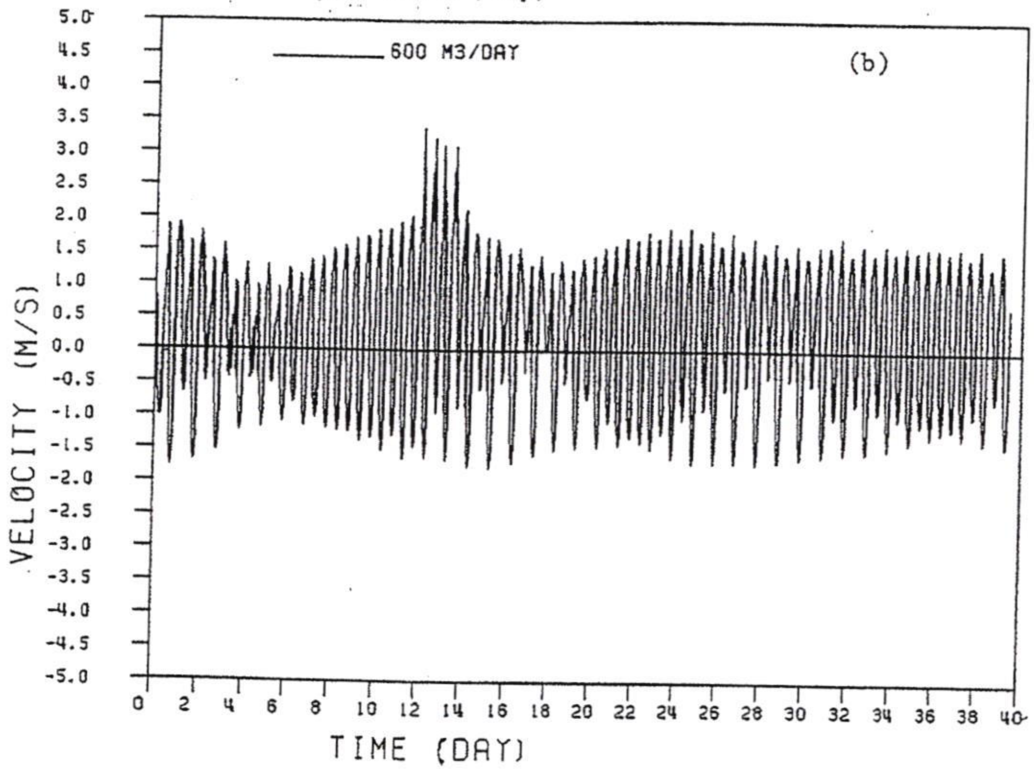


Fig. 6.8 Variation of Flow Area/Velocity with Time

($M = 600\ m^3/day$)



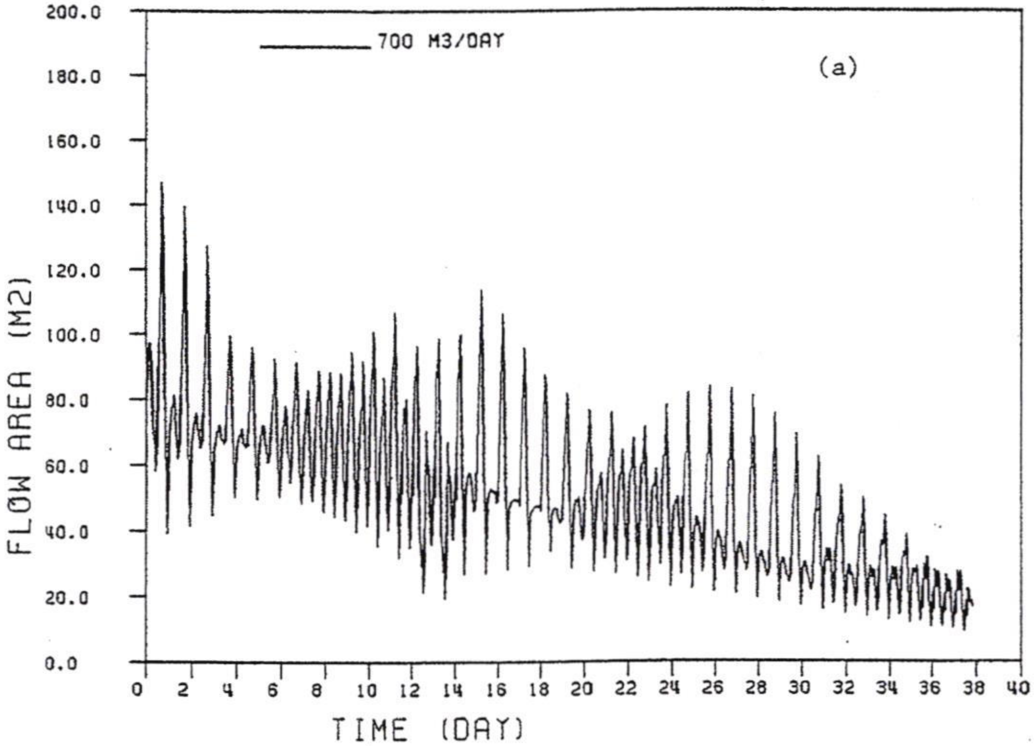
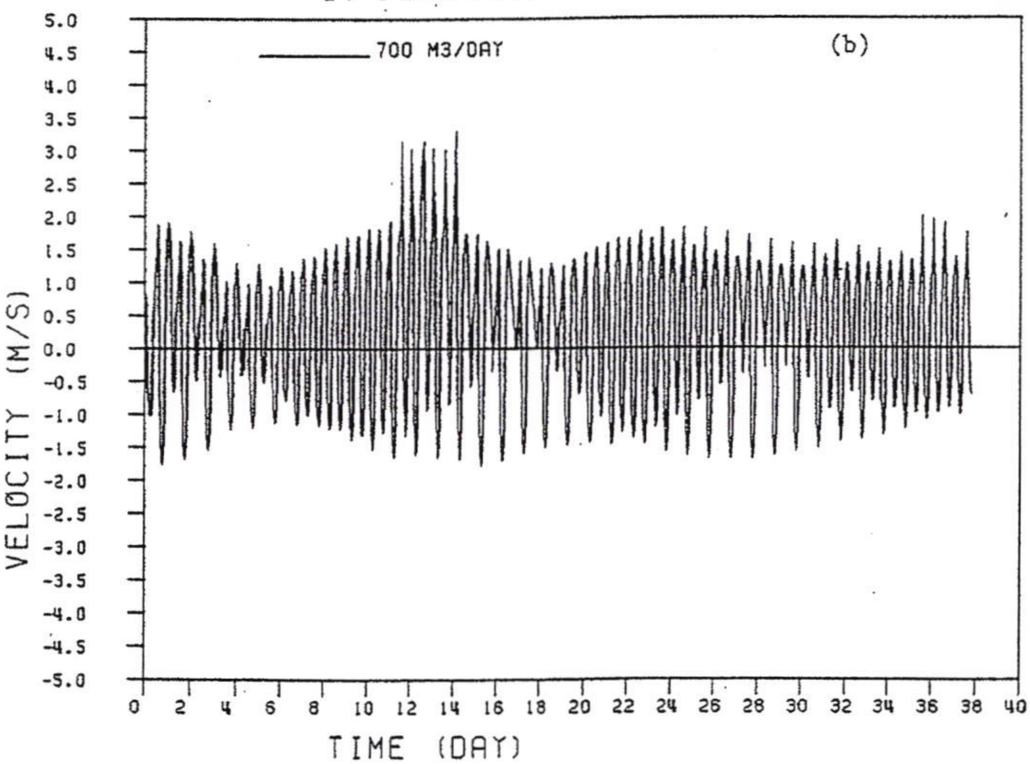


Fig. 6.9 Variation of Flow Area/Velocity with Time

($M = 700\ m^3/day$)



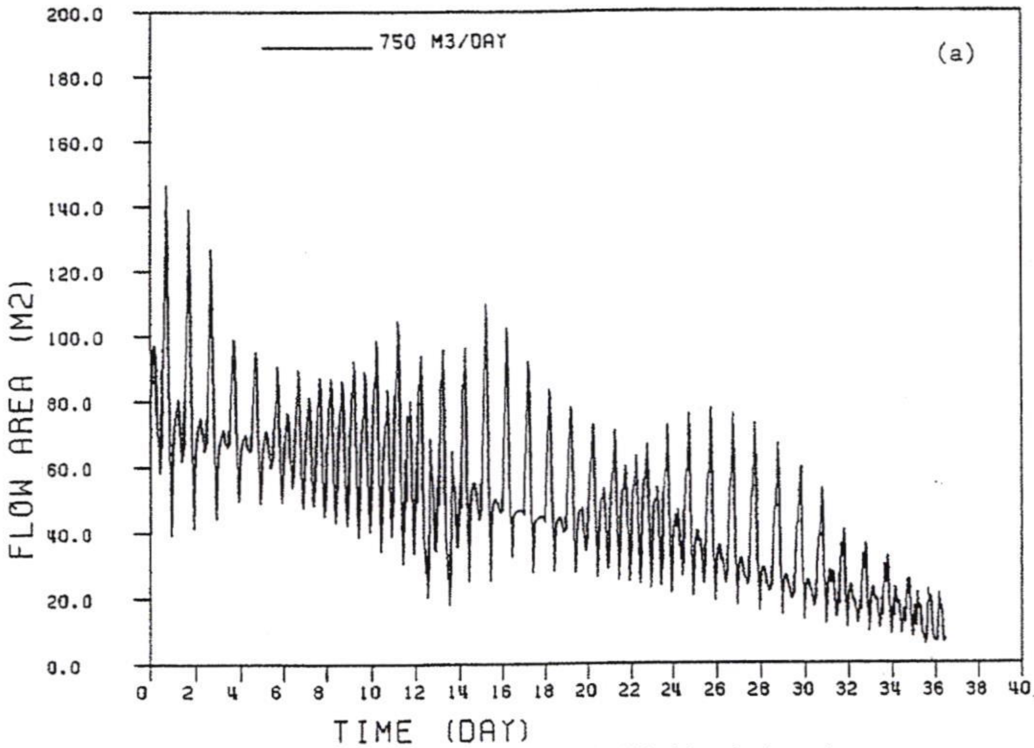
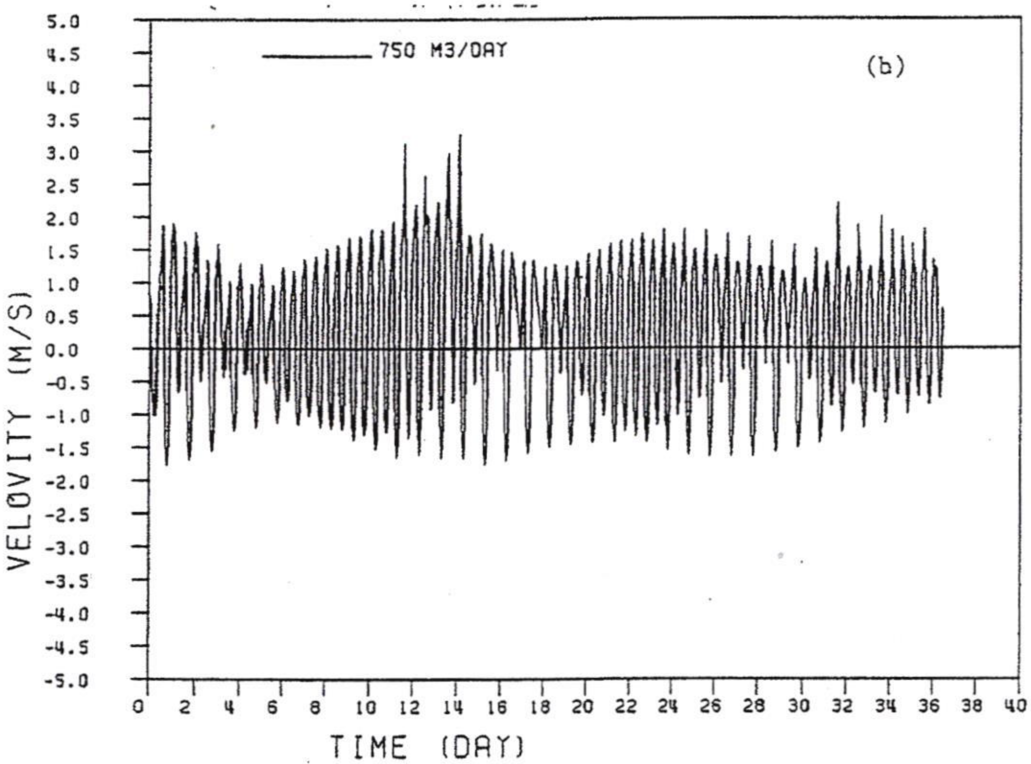


Fig. 6.10 Variation of Flow Area/Velocity with Time

($M = 750\ m^3/day$)



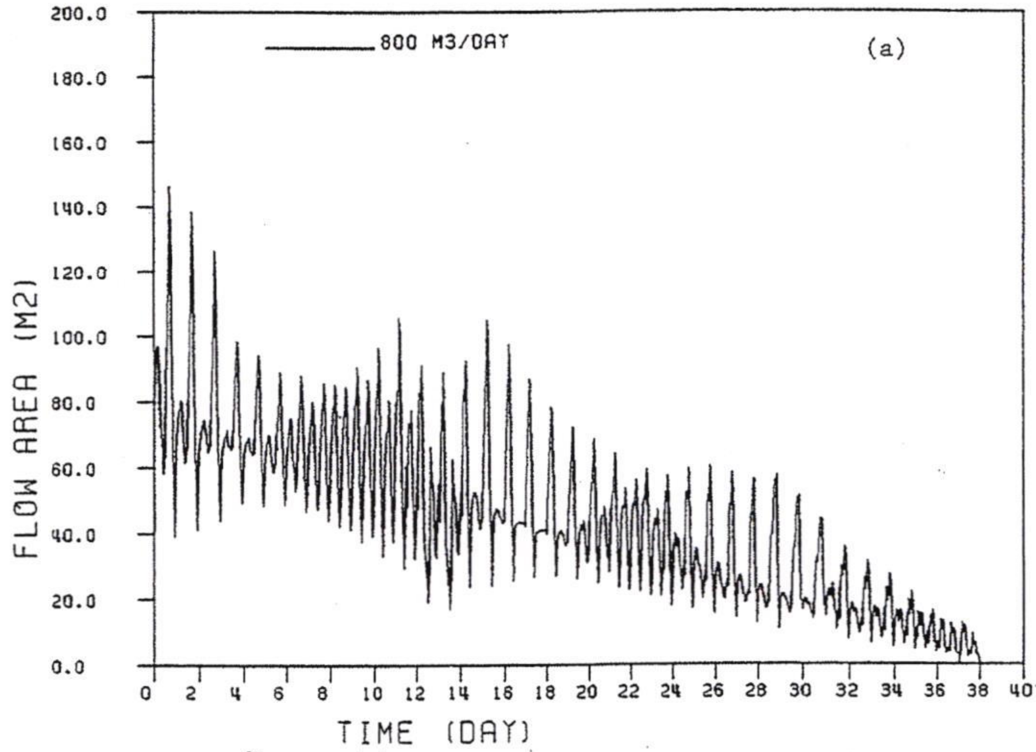
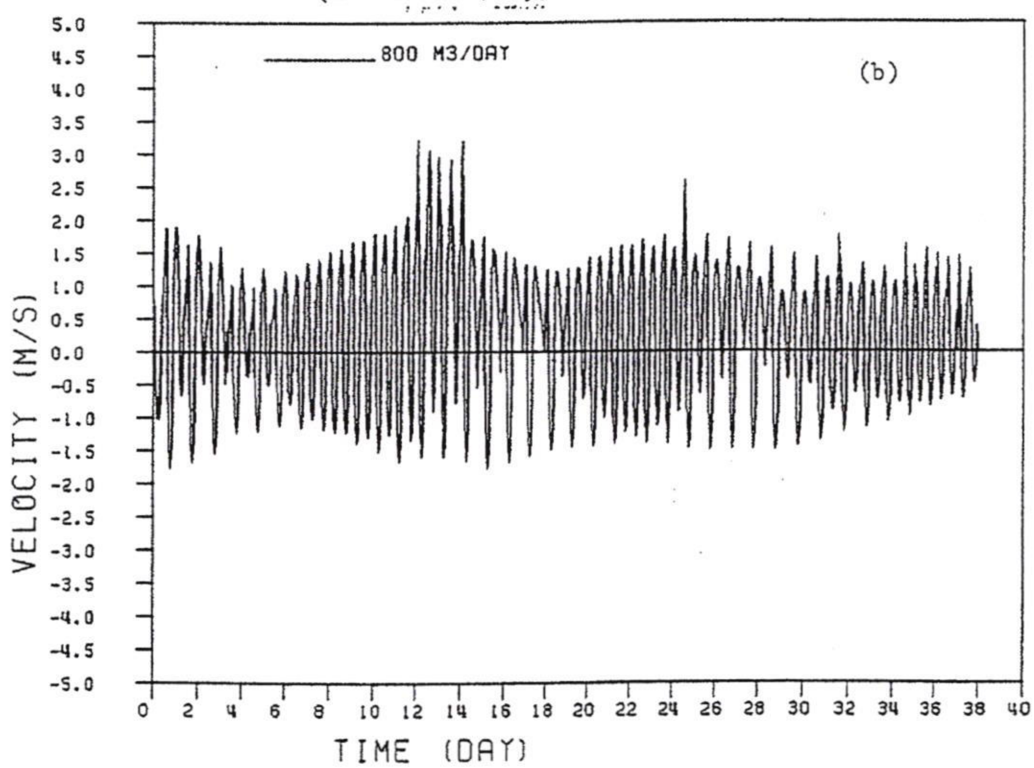


Fig. 6.11 Variation of Flow Area/Velocity with Time

($M = 800\ m^3/day$)



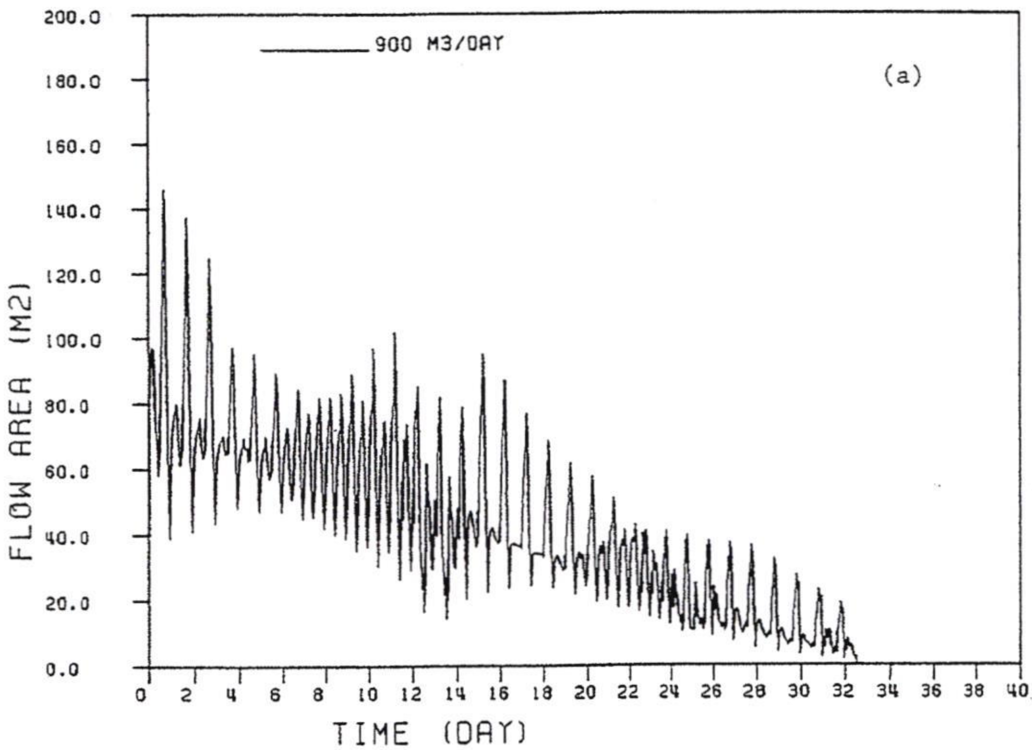
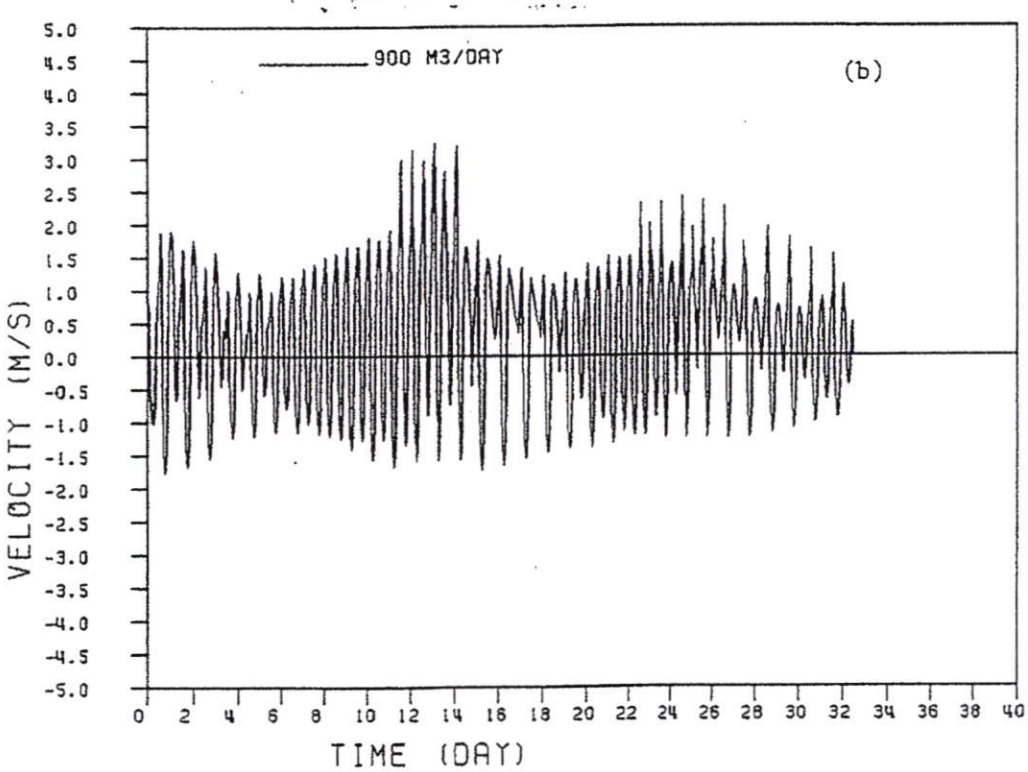


Fig. 6.12 Variation of Flow Area/Velocity with Time
($M = 900\ m^3/day$)



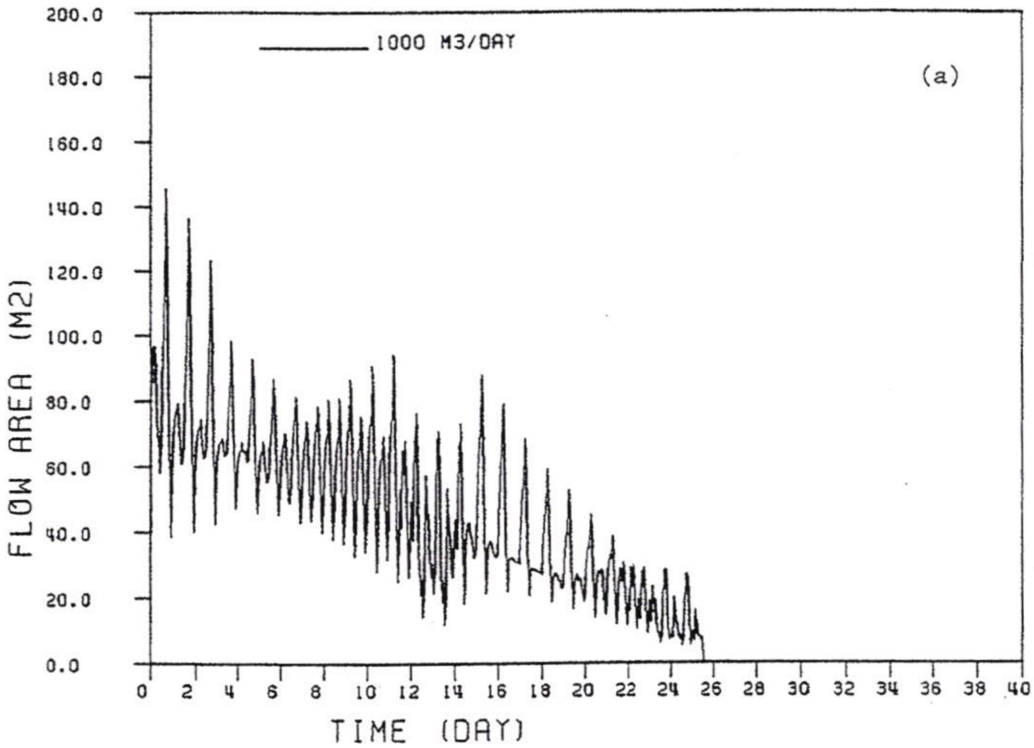
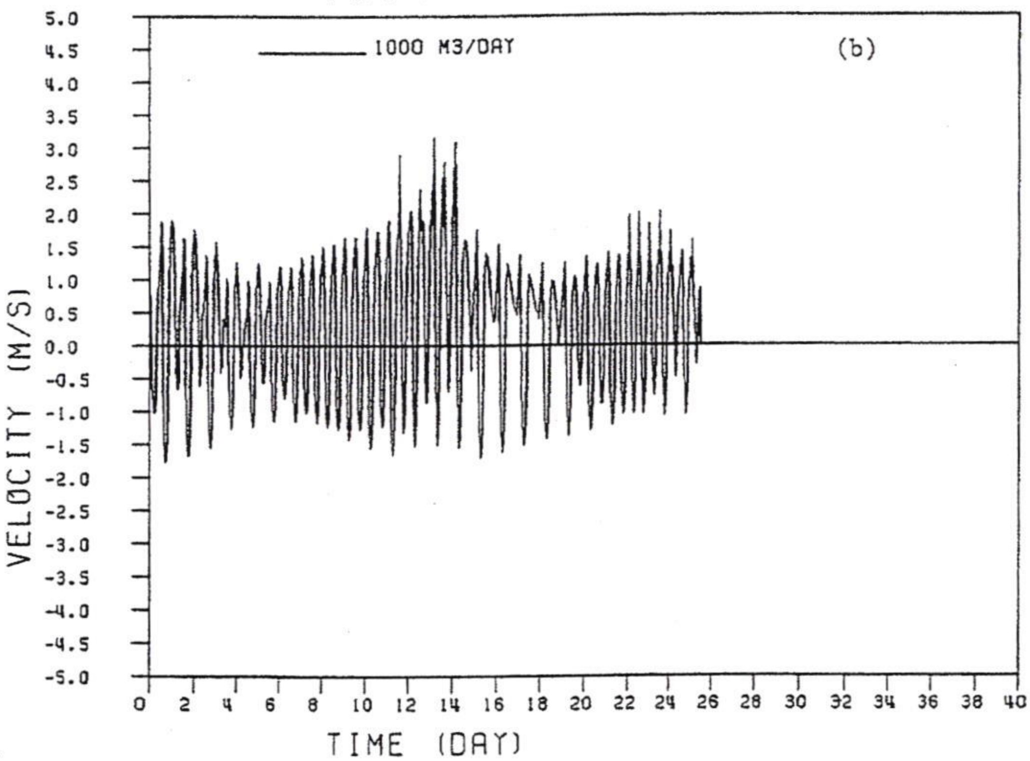


Fig. 6.13 Variation of Flow Area/Velocity with Time
($M = 1000\ m^3$/day)



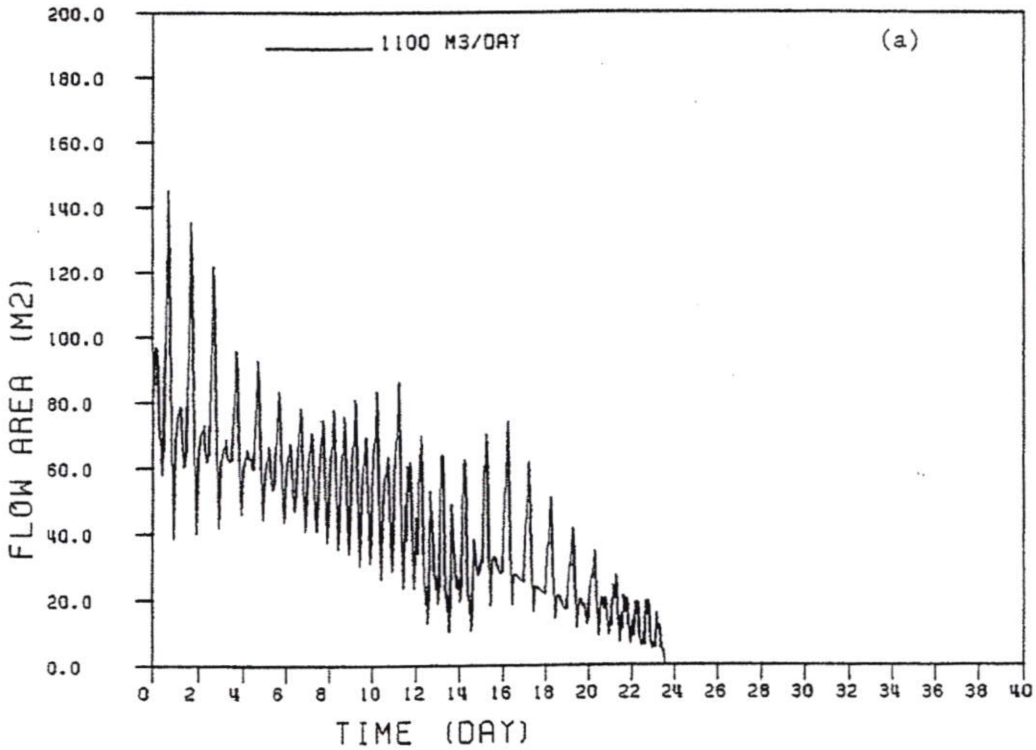
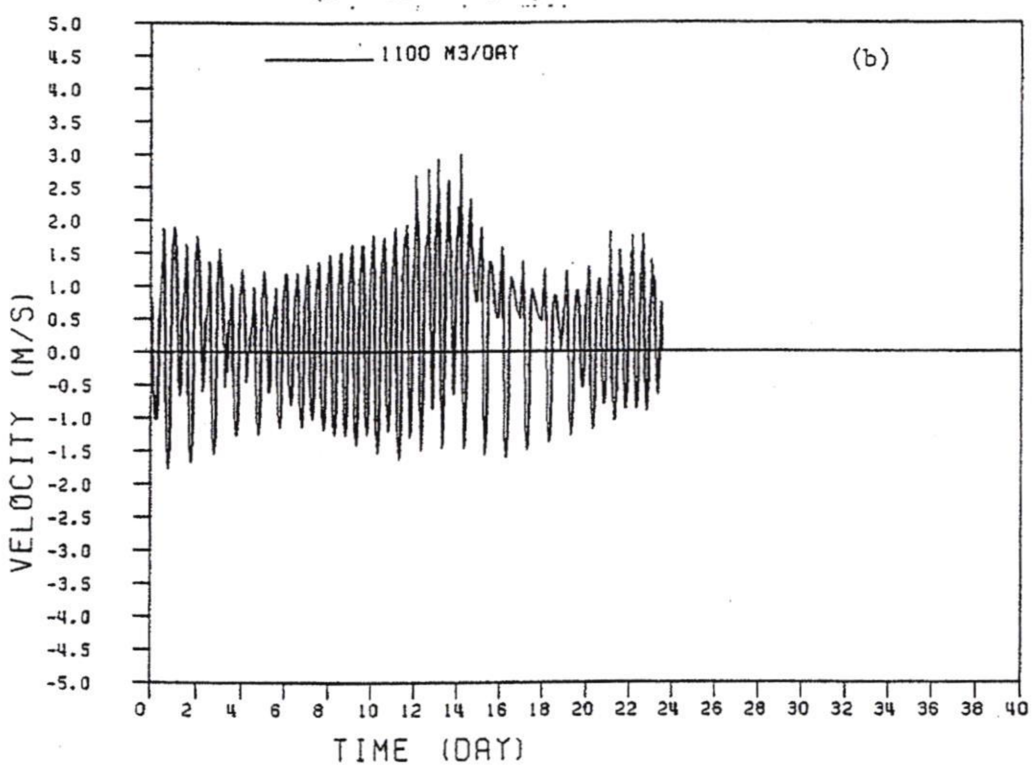


Fig. 6.14 Variation of Flow Area/Velocity with Time
(M = 1100 m^3/day)



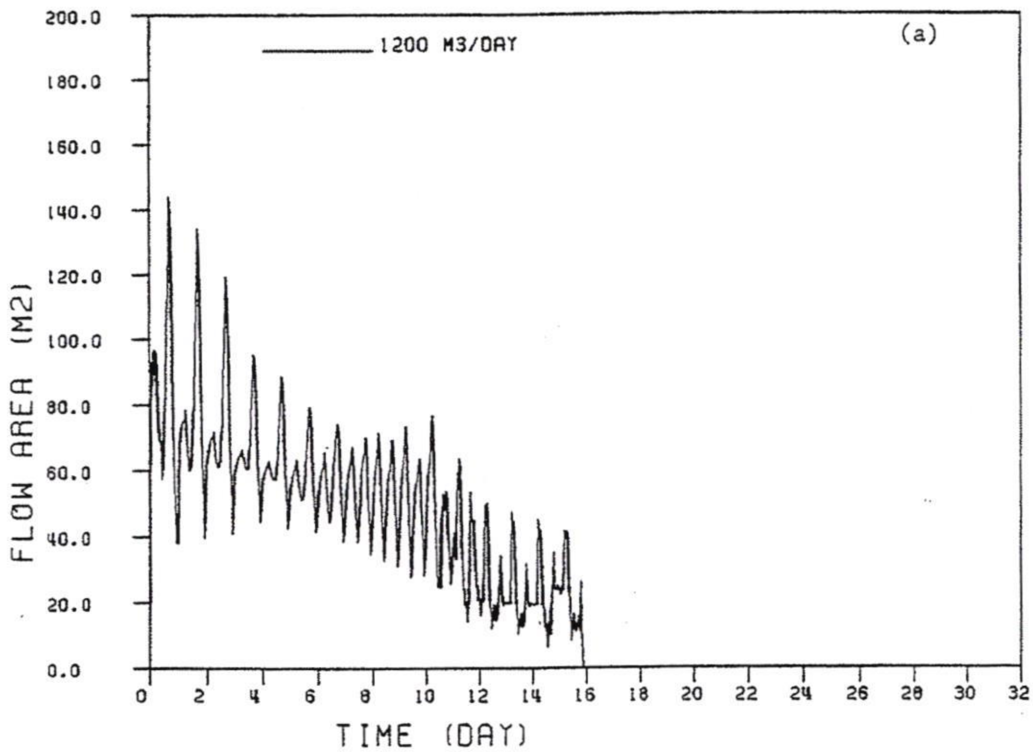
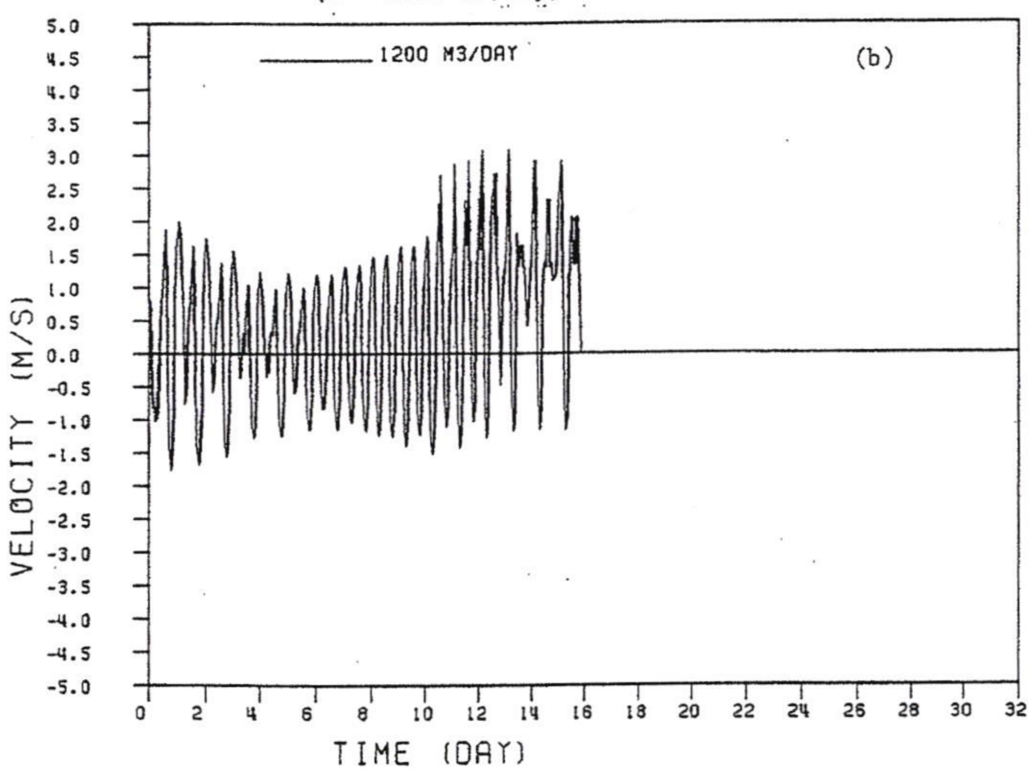


Fig. 6.15 Variation of Flow Area/Velocity with Time
($M = 1200\ m^3/day$)



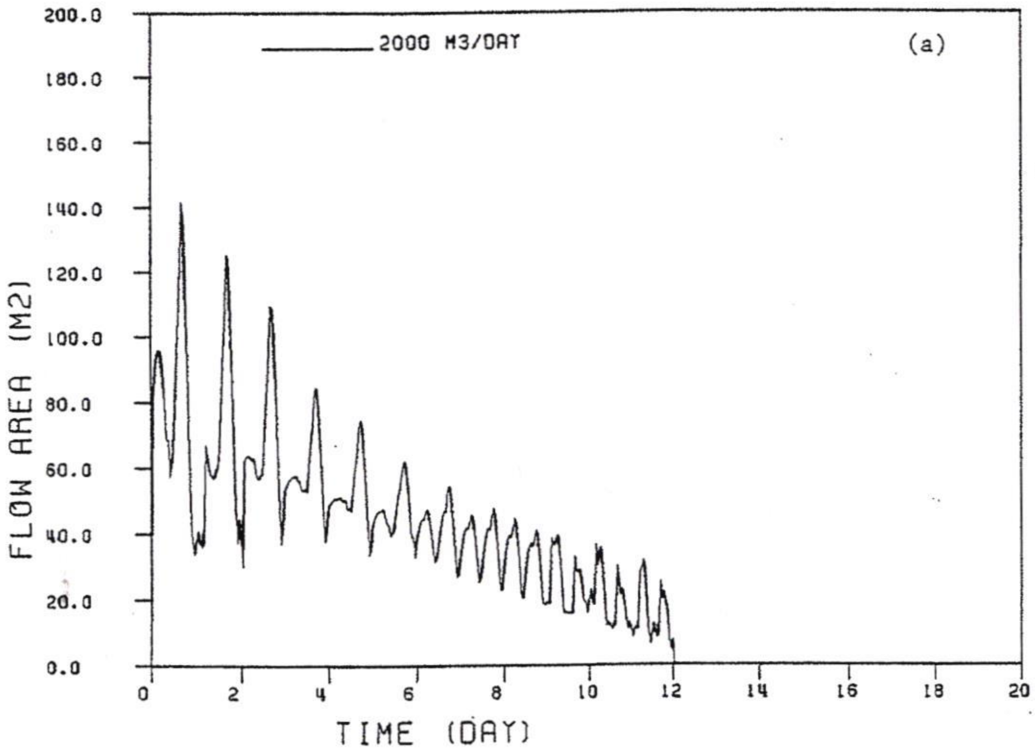
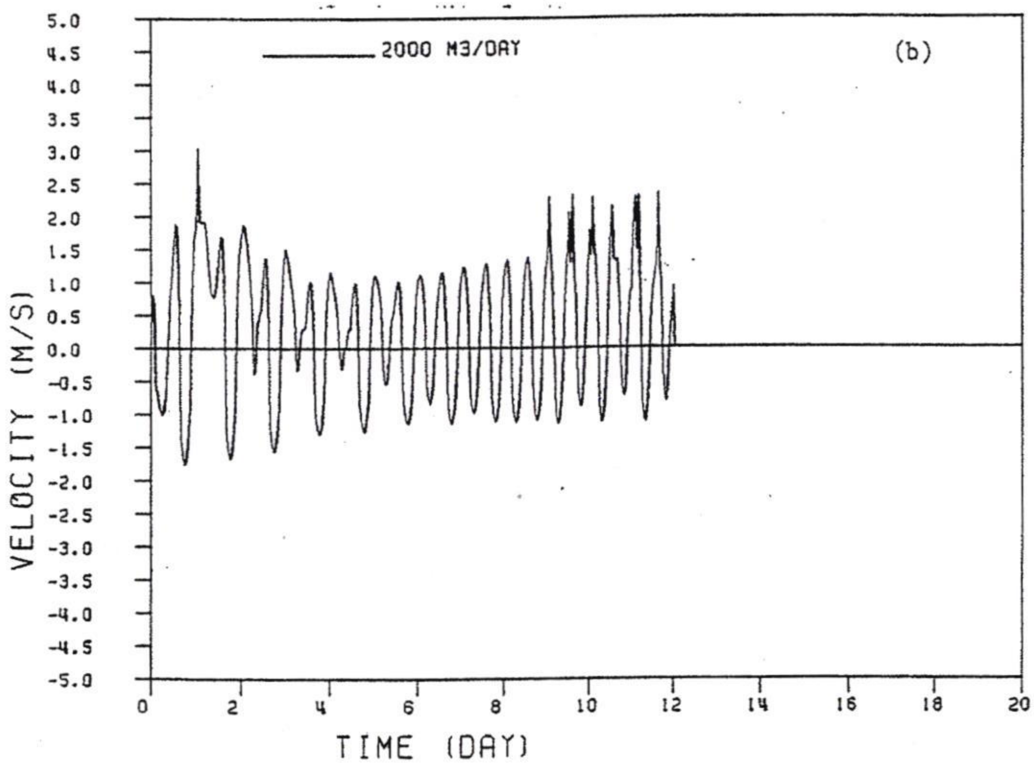


Fig. 6.16 Variation of Flow Area/Velocity with Time ($M = 2000\ m^3/day$)



LEE COUNTY
SOUTHWEST FLORIDA

Blind Pass Restoration
Design Synopsis

DEP Permit 0265943-JC

May 2006
Revised January 2008

Prepared By: Lee County Division of Natural Resources
1500 Monroe Street
P.O. Box 398
Fort Myers, FL 33902-0398

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Blind Pass Restoration
Design Synopsis
Updated January 16, 2008

Introduction

Lee County, with the cooperation from the Captiva Erosion Prevention District and the City of Sanibel, is the applicant for the project known as the Blind Pass Restoration. A Joint Coastal Permit application (JCP) and Design Report were submitted to the State of Florida Department of Environmental Protection, Bureau of Beaches and Coastal Systems (FDEP) and the U.S. Army Corps of Engineers (USACE) in May 2006.

The restoration involves the maintenance dredging of Blind Pass with the placement of beach compatible material on the adjacent shoreline and non-compatible material in an upland disposal site. The project is consistent with the state-approved Local Comprehensive Plan (The Lee Plan), the statewide strategic beach management plan, and the draft inlet management plan. (The inlet management plan is labeled as draft because the State has adopted only portions of the plan and not the plan in its entirety.) Below is a summary of the permit contents and design features. Unless otherwise referenced, all the information is available in the actual permit application; including the design report, sediment QA/QC report, mitigation plan, shorebird monitoring plan, biological monitoring plan and physical monitoring plan.

Project Goals

The Blind Pass Restoration application is submitted under Florida Administrative Code 62B-41.005 (11) for maintenance dredging. The pass is located in Lee County Florida, between Sanibel and Captiva Islands. A photo showing current conditions of the pass is provided below.

Blind Pass Current Conditions

Photo Provided by the City of Sanibel

472
2365

The project entails the maintenance dredging of Blind Pass, in addition to portions of Wulfert and Roosevelt Channel. The goals of the project are to (a) provide a stable pass opening while minimizing environmental impacts, (b) conserve and enhance the sand supply for the adjacent shoreline by placement of beach compatible material, (c) restore the naturally functioning inlet system, and (d) relieve a public hardship created by the pass closure.

Stable Opening

A conceptual layout of the channel alignment was developed during the feasibility phase. The alignment provided an improved connection into Dinkins and Sunset Bayou from Wulfert Channel and Blind Pass. It also provided an enhanced pathway between the Intracoastal Waterway and the Gulf of Mexico by connecting an existing navigation channel to Blind Pass. This alignment is shown in Figure 1 below.

During the design phase, the alignment was reduced due to sediment quality and resource protection. A hydrodynamic modeling analysis utilizing the ADvanced CIRCulation (ADCIRC) software was conducted to aid in the project's engineering design. A total of 9 additional alternatives were evaluated to determine the least impactive alignment for a relatively stable opening. Table 3.1 of the design report, and included herein as Table 1, shows the descriptions of each alignment. For the modeling analysis, the alignments were divided into 3 sections each. As shown in Figure 2 titled "General Plan View of Channel Sections", the Gulf section entails the area seaward of the Blind Pass Bridge. Also shown are the Transition Section (Critical Section) and Interior section, located inside or landward of the bridge. Both the Transition Section and Interior Section are located within the Pine Island Sound Aquatic Preserve, part of the greater Charlotte Harbor complex (Aquatic Preserve G-13). The alignment for Alternative F is found to be the most practical alignment modeled and is shown in Figure 2.

The Preferred Alternative, designated as Alternative F, extends from the -10 (NAVD88) contour in the Gulf of Mexico at a maximum width of 330 ft narrowing down to 160 ft width entering the Transitional Section. The dimensions are held constant progressing approximately midway through the Transitional Section; then reducing monotonically until reaching a 100 ft. width and -8 (NAVD88) depth at the Interior Section. This section is held constant within the Wulfert Channel alignment, but reduces from approximately a 213 ft width to roughly a 70 ft. width in Roosevelt Channel. The section termination is proposed as a boxcut, to be equilibrated under post construction conditions. The side slopes of the Transitional and Interior sections are designed at 3H:1V. The Gulf Section is designed at 5H:1V side slopes translating to the 3:1 ratio over the landward most +/- 227 feet from the bridge. The side slope designs are based on the Engineers experience with similar soil characteristics on alternate projects. Small scaled profile section views are shown in Appendix B. (All channel widths reference the dimensions at 0 NAVD88, or approximately mean high water.)

The cross-sectional area of the Preferred Alternative was compared with results from a previous study conducted by the University of Florida. Mehta et.al, conducted a study on the stability of Blind Pass in 1991. The study concluded a cross sectional area of 125 m^2 (1,345 ft^2) and 150 m^2 (1615 ft^2), depending on mean tide conditions and mean higher tide conditions in diurnal situations, would provide a stable pass. The Preferred Alternative proposes a maximum cross sectional template of 1500 ft^2 (139 m^2) within Wulfert Channel and a 1,624 ft^2 (151 m^2) cross-section in Roosevelt Channel. These results provide consistency between the reports, since each analysis was conducted using different methods and assumptions.

Modeling results indicate the Preferred Alternative will have average peak velocities at 3.3 ft/s for flood tide and 4.3 ft/s for ebb tide. A goal of 3.5 ft/s for ebb tide was targeted.

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NATURAL RESOURCES DIV

1500 Monroe St. Fort Myers, Florida 33901
Ph. (239) 479-8109/10 Fax. (239) 479-8108

TITLE:

FIGURE 1

BLIND PASS RESTORATION
CONCEPTUAL DESIGN
PLAN VIEW

Table 1 Channel Alternatives - Blind Pass Restoration

Channel Alternatives	Description							Remark
	Depth (ft, NAVD)			Width (ft)			Cross Section Area (ft^2) at Bridge Section	
	Interior Section	Critical Section	Bridge Section	Interior Section	Critical Section	Bridge Section		
A	8	8	12	100	100	100	960	
B	8	8	12	100	120	140	1440	
C	8	8	12	100	140	160	1680	
D	8	10	12	100	140	160	1680	
E	8	10	12	100	160	160	1680	
F	8	10	10	100	160	160	1500	Preferred Design
G	8	8	8	100	160	160	1300	
H	10	10	14	100	100	220	2500	
I	6	6	10	100	100	220	1800	

ECE 1819 Main St., Suite 402 Sarasota, FL 34236 (941) 952-0487	FIGURE 2 GENERAL PLAN VIEW OF CHANNEL ALTERNATIVES Blind Pass Restoration Lee County, Florida	REVISIONS	PROJECT 05129 DATE 04/28/06 SCALE Scale	CHECKED BY DRAWN BY JE SHEET: 1 of 1

H:\CADD_Graphics\Blind Pass Restoration\Planning & Permiting\Preferred Design\05-129 Plan View Preferred Design.dwg 5/18/2006 1:49:28 PM EDT

This is the engineers recommended minimum velocity required to scour sediment, or hydraulically force sediment out of the pass. The reported velocities are predicted at the Blind Pass Bridge where the area of water flow will be the smallest. Because this area is the smallest, it would be expected to be the most susceptible to shoaling impacts. The prediction that higher velocities will be pushing sediment out of the pass (ebb tide), than into the pass (flood tide), supports the pass will be relatively stable.

Tidal prisms were also compared between pre- and post-construction conditions. This was done to identify potential impacts at neighboring Redfish Pass and to evaluate how much sediment may flow into or out of Blind Pass. Potential change to the Redfish Pass tidal prism were found to be less than 1% and therefore considered negligible.

The evaluation of sediment flow relates to the stability of the pass. Results show more water will be traveling out of the pass during ebb events than into the pass during flood events. Figure 3 shows 110 $\times 10^6$ cubic feet of water travels through Blind Pass during ebb tides and 90$\times 10^6$ cubic feet during flood tides. The combination of higher velocities and greater volumes of water available to scour sediment into the Gulf of Mexico characterizes the pass as ebb dominate and increases the potential for pass stability.

Maintenance events are anticipated to provide long term stability to the pass. Blind Pass has historically migrated along the Sanibel shoreline, closing intermittently 23 of the 46 years between 1960 and 2006. The longshore sediment transport is estimated at 28,000 cubic yards / year (cy/yr) to the south after construction with a minimum of 11,000 cy/yr expected to deposit in the pass. A maintenance goal of a 5 year minimum or 8 year optimal interval is desired. The 8 year interval would allow maintenance projects to be conducted in conjunction with the Captiva nourishment. The ebb dominant characteristics of the design should minimize the maintenance dredging requirement; however, the DEP has suggested maintenance would be allowed during the 5 year permit lifespan.

Restore the Naturally Functioning System

Blind Pass was historically a relatively stable inlet dating back to 300 BP (Missimer, 1973). After Redfish Pass opened in the 1920's, Blind Pass periodically closed and reopened due to a loss in tidal prism (CPE, 1993). A combination of factors in the vicinity of Blind Pass contributed to the most recent closure in 2000. The proposed project combined with continued maintenance will restore the system to its natural condition. The alignment follows the historic position of the channel, as shown in Appendix A. The channel cross section also mimics conditions of 1966, 1970, and 1974 (Mehta et al, 1991). Current velocities are also predicted to reflect historic conditions. The velocities measured in 1991 by Mehta et al., were about 1.3 m/s (4.3 ft/s) for ebb flow and 0.9 m/s (3.0 ft/s) for flood events. Modeling results indicate the restored flows for ebb events will be 4.3 ft/s (1.3 m/s) and 3.3 ft/s (1.0 m/s).

Relief of Public Hardship

Although not created by a natural disaster, a public hardship would be relieved by the restoration of Blind Pass. The pass closure has taken away a prominent fishing location noted for it's abundance of snook. Residents wish to have the pass restored for improved water conditions and recreational fishing opportunities. Minor boating enhancements are

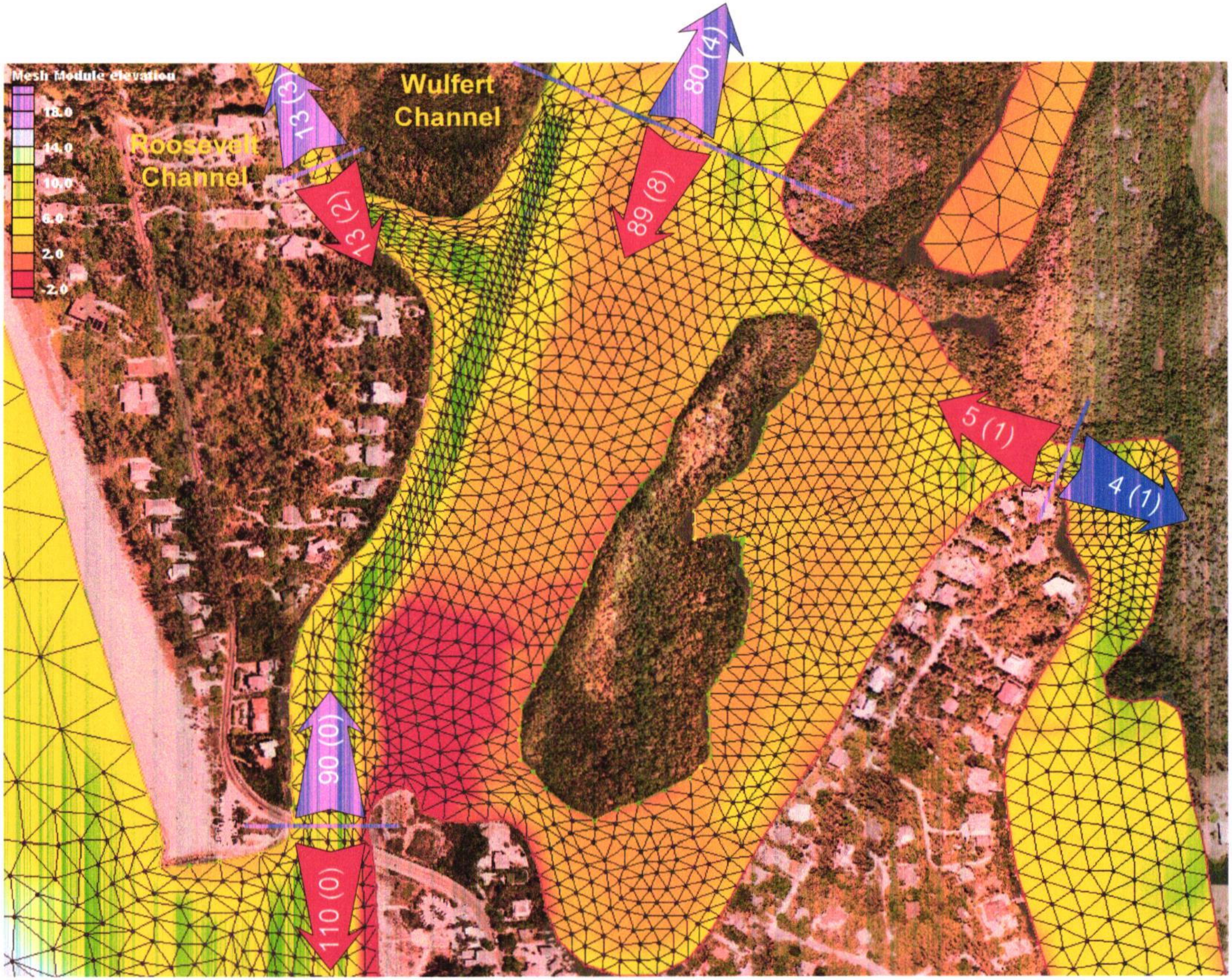


Figure 3 Tidal Prism Comparisons between Preferred Alternative and Existing Condition
(Tidal Prism: Preferred Alternative (Existing Condition), Unit: 10^6 ft^3)

Note: Figure is a duplicate of Figure 5-1 from Design Report provided by ECE.

also anticipated, however not a project goal. Citizens on Captiva and Sanibel Islands appear to be overwhelmingly in support of the project. Demonstration of the support has been provided to DEP in the form of 159 supporting letters. Personnel from the adjacent J.N. Ding Darling National Wildlife Refuge and the Sanibel-Captiva Conservation Foundation, also a property owner in the project area, have also been cooperative and supportive throughout the development of the project.

Environmental Impacts

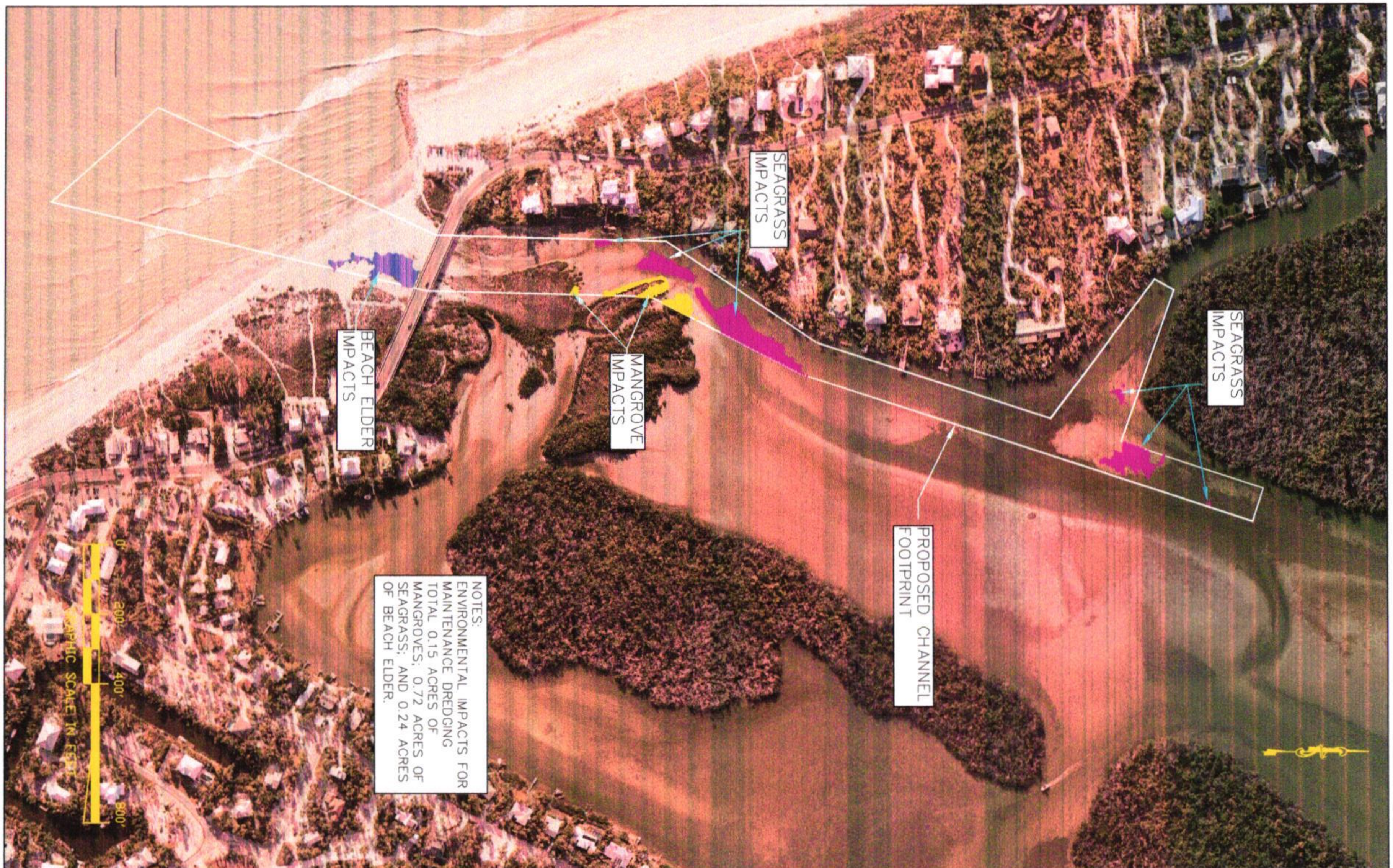
The proposed alignment was designed to avoid direct impacts with environmental habitats. The alignment follows the existing channel along the northern side of Blind Pass. The intent is to avoid the mangrove colony present inside the pass on the historic flood shoal. An impact of 0.157 acres was unavoidable to achieve the necessary cross section. The area of impact is shown below on Figure 4 titled "Environmental Resources". Also shown is 0.72 acres of seagrass located within the proposed channel alignment. This, in addition to 0.24 acres of Beach Elder from within the dredge footprint, will be removed to meet the minimum design standards.

Other resources that were avoided include two oyster beds and an extensive seagrass bed. Most of the seagrass bed and the historic flood shoal is utilized as foraging bird habitat. The seagrass bed is exposed during lower tide events, and many species of birds forage within the area. Obvious impacts will occur within the construction footprint, however, large portions were avoided to minimize the loss of habitat. FWC protocol for turbidity monitoring will be followed to avoid indirect impacts to seagrass beds during construction.

Sea turtle nesting habitat and benthic invertebrate habitat will be impacted. Approximately 1.3 acres of turtle nesting habitat will be lost. In addition, +/- 8.0 acres of benthic invertebrate habitat will be impacted. The turtle habitat is located seaward of the Blind Pass bridge along the sandy beach, and the benthic habitat is within the submerged portion of the construction footprint. FWC protocol shall also be followed for monitoring seaturtle nesting activities if construction occurs during season, which for southwest Florida extends from May 1st to October 31st. Benthic invertebrates are expected to recolonize the dredge footprint after construction.

Potential negative fish and manatee impacts are possible during construction. To minimize the likelihood for impacts, FWC protocol will be followed for construction within manatee habitats. Navigation through the restored pass will be limited to small vessels due the physical constraints of the Blind Pass Bridge. Clearance under the bridge is approximately 10 feet at low tide. The interior of Blind Pass is also designated as a manatee zone on the Sanibel side of the construction footprint. Slow speed is required for all vessels in this area. The north side of the footprint is designated as a seasonal manatee zone, requiring slow speed from April 1 to November 15. The actual footprint or navigation channel currently would be regulated for speeds under 25 mph during season (April 1 to November 15). The project footprint west of Roosevelt channel will also be designated as an idle speed zone per the Lee County Vessel Control Ordinance (02-14).

Restoring the pass will increase recreational fishing activities compared to current conditions. Historically, the pass has been used heavily for recreational fishing, but



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TITLE:

FIGURE 4
BLIND PASS RESTORATION
RESOURCE IMPACTS
PLAN VIEW

current conditions do not support the activities. Additional potential impacts include the disturbance of shorebird foraging and nesting during construction. Monitoring efforts to avoid or minimize disturbance will be conducted in accordance with the DEP approved shorebird monitoring plan.

Environmental Mitigation

Proposed mitigation efforts to improve the project and offset the loss of habitat will be conducted for the loss of nesting beach potential, the loss of mangrove habitat and the loss of seagrass habitat.

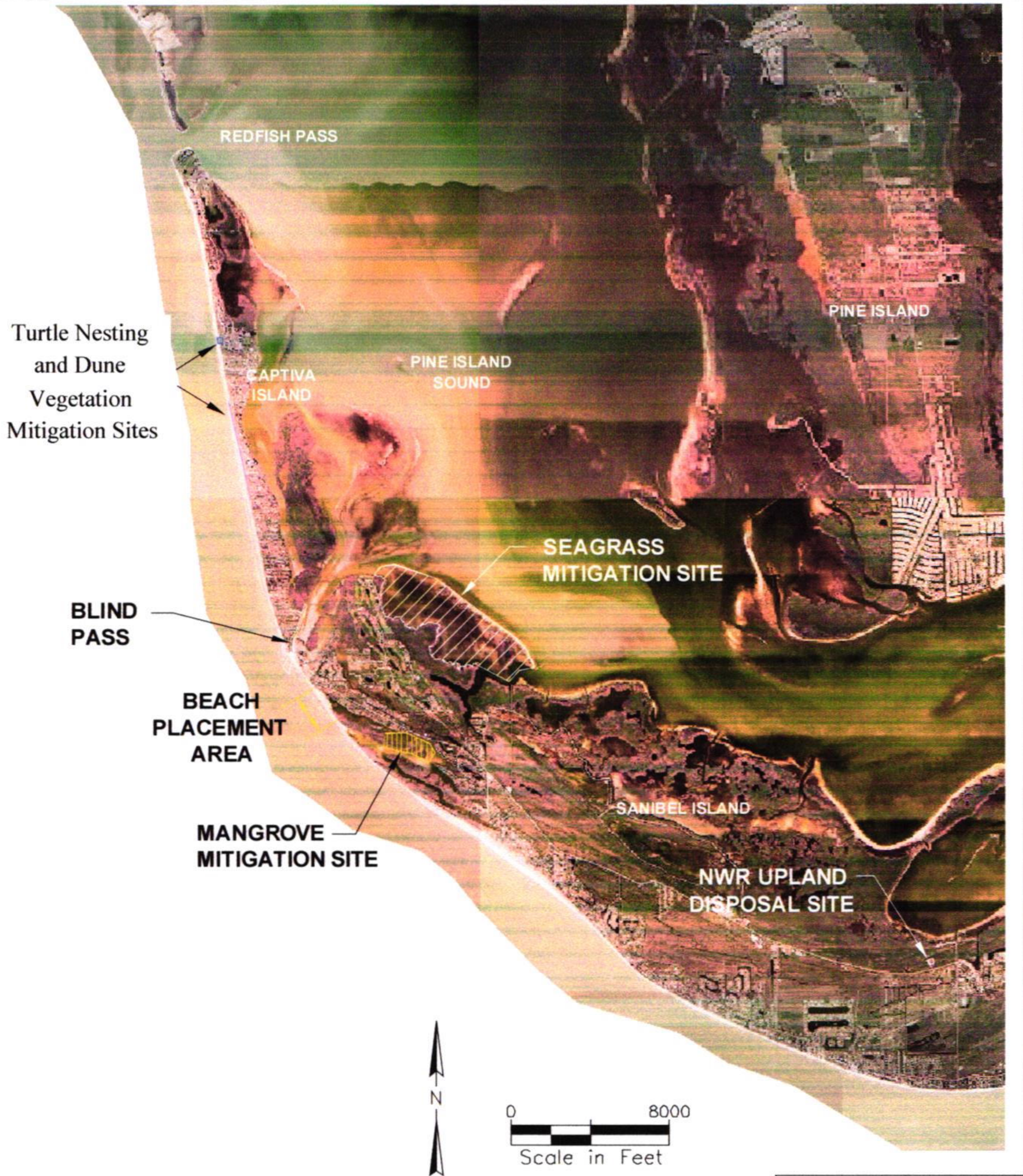
Efforts to offset the loss of nesting habitat, including the removal of beach elder, will be conducted in two (2) locations. The County will remove the existing Australian pines from approximately 11.7 acres of dunes along Captiva Drive. The area, located about 1.5 miles north of Blind Pass, is approximately 4,900 feet in length and varies in width. The dune has recently been invaded by Australian pines, perhaps as a result of seed dispersal from the hurricane seasons of 2004 and 2005. The County proposes to eradicate the Australian pines to prevent further infestation and remove the local seed source. If the pines cannot be removed without disturbing desirable dune vegetation, they will be cut down, and the stumps treated with appropriate herbicide by licensed applicators. Approximatley 100 trees averaging 5 feet in height were present in December 2006.

Lee County and the CEPD will also restore the dune at the northwest terminus of Captiva Drive located about 3 miles north of Blind Pass. The area in question is adjacent to a public access parking lot and has been a problem location for unauthorized vehicles accessing and driving on the beach. The only existing vegetation is mature Australian pines. The County will remove the pines, regrade the area and plant native dune vegetation sufficient to buffer the beach from the parking lot and associated vehicular lights. Plants will include a row of sea grapes along the parking lot border, and a combination of beach elder, sea oats and panic grass to fill a planting area approximately 35' in width. Finally, a locked barricade will be installed to prevent unauthorized vehicular access to the beach at this location. The mitigation sites are shown on Figure 5.

Additionally, the County will continue to enforce an existing lighting restriction in the Sea Turtle Conservation Code in unincorporated areas of Lee County. This code includes the standards for the prohibition of beach lighting that could cause disorientation of turtle hatchlings. More stringent code is in place and will be enforced on Sanibel Island as well.

Mangrove

The Uniform Mitigation Assessment Methodology (UMAM) was used to quantify the mangrove impact. The project results in the loss of 0.157 acres of mangroves. As mitigation, mangroves will be planted in the area of Clam Bayou shown in Figure 5. The UMAM formula results in calculated offsetting mitigation of 0.245 acres (see Mitigation Plan Section 8) resulting in a minimum of 851 seedlings.



NOTE
1. AERIAL PHOTOGRAPHY FLOWN 2005, PROVIDED BY LEE COUNTY.

Karyn M. Erickson, P.E. Date
Professional Engineer #41897
NOT FOR CONSTRUCTION

ECE	FIGURE 5 GENERAL LOCATION MAP	REVISIONS	PROJECT 05-129	CHECKED BY KE
7201 Delainey Court Sarasota, FL 34240 (941) 373-6460	BLIND PASS RESTORATION LEE COUNTY, FLORIDA	DEC 2007	DATE 12/31/07	DRAWN BY JE
			SCALE As Shown	SHEET: 2 of 36

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Drawing provided by ECE and has been edited by Lee County

Seagrass

The County intends to mitigate for seagrass impacts by implementing actions to protect the damaged grassbeds near Wulfert Keys. Because portions of the project are in the Pine Island Sound Aquatic preserve, there is sensitivity to the need to provide benefits that go beyond what is required from a regulatory perspective and propose to also meet the additional public interest requirements within the Wulfert Keys area.

Lee County will work with the J. N. Ding Darling National Wildlife Refuge (NWR) to establish a seagrass protection zone near Wulfert Keys (see Figure 5) where the operation of combustion engines will not be allowed ("no motor zone"). This managed area will be referred to as the No Motor Zone. The details will be spelled out in a management plan which the County will prepare for the Refuge's use. The management plan will address sign installation to identify zone boundaries, maintenance of signs, enforcement of no motor restrictions and public education.

The Uniform Mitigation Assessment Methodology (UMAM) was used to quantify the amount of mitigation required for direct impacts to seagrass (see Mitigation Plan Section 8). The Department determined that the UMAM calculation of 4.80 acres of compensatory mitigation was to be measured as the actual area of propeller scars within the no motor zone at the time of establishment. Based on the GIS analysis of the FWC 2003 data, it is projected that the area shown in Figure 10 will contain at least 5.88 acres of propeller scars. Actual scar areas of the preconstruction (pre-No Motor Zone establishment) and recovery conditions will be confirmed using high resolution aerial photography and ground truthing as described in the Biological Monitoring Plan.
In the event less than 4.8 acres of scarred area is present, additional mitigation efforts will be conducted in accordance with the contingency plans described in the DEP approved Mitigation Plan.

Conserve and Enhance the Sand Supply on Adjacent Beaches

Beach compatible material removed during the maintenance event will be placed on the adjacent shoreline. The potential placement area extends from R112 located approximately 2,000 feet south of the pass, to R114. This area is shown in Figure 5.

Sediment Concerns

Material content is a concern for placing the dredged material on the beach. Approximately 127,000 cubic yards of material will be removed from the pass and interior system to complete the restoration. Suitable spoil will be placed on the downdrift beach and nearshore area with unsuitable material being transported to an upland disposal site. Placement of the beach compatible material will help achieve a goal to bypass 37,250 cubic yards annually that was adopted by the Department. The goal was originally proposed in the draft Blind Pass Inlet Management Plan and later adopted into the State's strategic Beach Management Plan.

The following measures shall be taken to assure appropriate construction techniques and supervisory activities are utilized to protect the natural ecosystem during project completion.

Description Of Work

The dredge footprint has been divided into subareas based on the quality of sediment, the authorized dredge depth, and the sediment disposal location. Seven (7) subareas have been identified and are shown on Figure 6 with the location of all sediment tests conducted for this project. Samples with unsuitable material are labeled by elevation range on the figure. All the material in Subarea 1 may be placed directly on the beach and all of Subarea 6 may be placed in the nearshore. Subareas 2 thru 5 and 7 contain a mixture of material in which some is eligible for beach or nearshore placement and some must be disposed upland.

The suitable material in subareas 4, 5 and 7 may be placed in the nearshore region, and in subareas 2 & 3 it may be placed directly on the beach. The unsuitable material encompasses approximately 10,275 cyds and is defined by the Unified Soil Classification System (USCS) as Clay. The material is distributed throughout the interior dredge cut, but is generally located below the -7 NAVD contour.

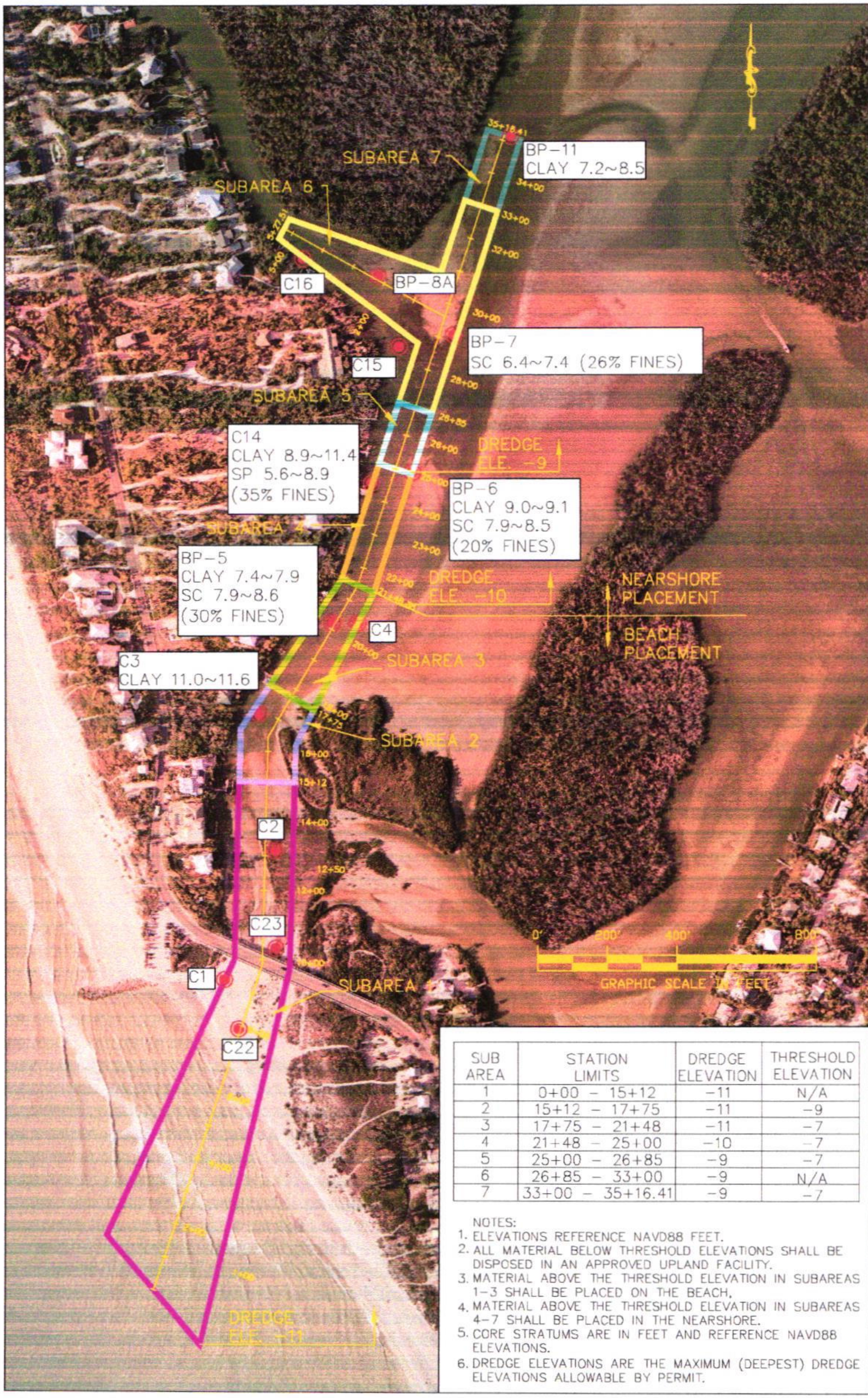
Table 2 below shows the designated subareas and volumes of material estimated for each respective placement location. Preconstruction surveys shall be used to establish actual project volumes

TABLE 2 VOLUME ESTIMATES AND PLACEMENT LOCATIONS

Subarea	Length (ft)	Beach / Nearshore Suitable Material			Unsuitable Material	Total	Placement Location for Suitable Material
		Design	Overdredge	Subtotal			
1	1,512	57,353	10,362	67,715	0	67,715	Beach
2	263	8,760	1,463	10,222	2,101	12,324	Beach
3	373	5,223	1,493	6,715	4,299	11,014	Beach
4	352	2,878	1,065	3,943	2,151	6,094	Nearshore
5	185	1,550	559	2,109	795	2,904	Nearshore
6	1,142	19,680	4,186	23,866	0	23,866	Nearshore
7	216	1,798	643	2,441	928	3,369	Nearshore
Total	4,043	97,241	19,770	117,011	10,275	127,286	

Material designated for beach or nearshore placement may be pumped directly to the respective placement site. The material designated for upland disposal shall be placed in a containment area for dewatering prior to transporting to the upland disposal site. The upland site is approximately 7 miles southeast of Blind Pass and is shown in Figure 5.

A threshold elevation has been identified for each subarea that contains clay material. The Contractor shall be provided a 1-foot tolerance above the threshold elevation for excavating material for beach or nearshore placement. The 1-foot tolerance shall serve as a transition layer (overdredge allowance) between the material designated for beach or nearshore placement and the material that must be disposed upland or unsuitable material. The threshold elevation shall serve as a definitive line between the unsuitable



SUB AREA	STATION LIMITS	DREDGE ELEVATION	THRESHOLD ELEVATION
1	0+00 – 15+12	-11	N/A
2	15+12 – 17+75	-11	-9
3	17+75 – 21+48	-11	-7
4	21+48 – 25+00	-10	-7
5	25+00 – 26+85	-9	-7
6	26+85 – 33+00	-9	N/A
7	33+00 – 35+16.41	-9	-7

NOTES:
1. ELEVATIONS REFERENCE NAVD88 FEET.
2. ALL MATERIAL BELOW THRESHOLD ELEVATIONS SHALL BE DISPOSED IN AN APPROVED UPLAND FACILITY.
3. MATERIAL ABOVE THE THRESHOLD ELEVATION IN SUBAREAS 1-3 SHALL BE PLACED ON THE BEACH.
4. MATERIAL ABOVE THE THRESHOLD ELEVATION IN SUBAREAS 4-7 SHALL BE PLACED IN THE NEARSHORE.
5. CORE STRATUMS ARE IN FEET AND REFERENCE NAVD88 ELEVATIONS.
6. DREDGE ELEVATIONS ARE THE MAXIMUM (DEEPEST) DREDGE ELEVATIONS ALLOWABLE BY PERMIT.

TITLE: FIGURE 6
BLIND PASS RESTORATION
SUBAREAS
PLAN VIEW

NATURAL RESOURCES DIV
1500 Monroe St. Fort Myers, Florida 33901
Ph. (239) 533-8109/10 Fax. (239) 485-8408

LEE COUNTY
SOUTHWEST FLORIDA

FILE: S:\NATRES\MARINE\BEACHMANAGEMENT\BLINDPASS\DRAWINGS\BP_SUBAREA.dwg
DESIGN:
DRAWN:
APPROVED:

SCALE: 1"=400'

SHEET: 01 OF 01

material and the 1-foot tolerance. The Contractor shall make all reasonable attempts and precautions to remove the suitable material above the threshold elevation for beach and nearshore placement. The threshold elevation is defined for each subarea on Figure 6 and shown below in Table 3 along with the station limits, and maximum dredge elevation for each subarea. Cross sections of the dredge cut showing the limiting elevations area provided in Appendix B.

TABLE 3 VERTICAL AND HORIZONTAL LIMITS FOR EACH SUBAREA

Subarea	Station Limits (Feet)	Max. Dredge Elevation (NAVD88 FT)(1)	Threshold Elevation (NAVD88 FT)(2)
1	0+00 to 15+12	-11	n/a
2	15+12 to 17+75	-11	-9
3	17+75 to 21+48	-11	-7
4	21+48 to 25+00	-10	-7
5	25+00 to 26+85	-9	-7
6	26+85 to 33+00	-9	-7
7	33+00 to 35+16	-9	-7

(1) The Maximum Dredge Elevation includes a 1-foot vertical tolerance BELOW the design elevation (overdredge). No payment shall be made for material excavated below this elevation.

(2) The Contractor shall be provided a 1-foot vertical tolerance ABOVE the threshold elevation as a transitional layer between material designated for beach or nearshore placement and material designated for upland disposal.

Criteria For Disposal Location

Spoil shall be placed in accordance with FAC 62B-41.007(k). Material with up to 10% fines by weight, as defined by passing the #230 sieve, shall be placed directly on the beach. Material with more than 10% but less than 20% fines by weight will be placed in the nearshore region of the placement area. Material with clay or excessive fine content shall be disposed in an upland site. All debris and cleared vegetation shall also be disposed in the upland site. Table 4 shows the specifications for the placement areas.

The Contractor shall dispose of all materials not meeting the specifications for beach or nearshore placement in an approved upland site. The material shall be surface dry during transportation by vehicular means (dump truck).

The Contractor shall be required to construct and maintain a containment cell for dewatering of the unsuitable material. The following information specifies the requirements for cell construction and the method of payment for removing and disposing of the material in the upland facility. It is only expected unsuitable material will have to be removed from the Containment cell once. However, the Contractor shall be allowed to remove material as determined necessary by the Contractor in accordance with the Handling Plan.

TABLE 4 PLACEMENT SPECIFICATIONS

Placement Location	Placement Criteria	Sediment Characteristic
Beach	D < 10% by Weight Passing 230 Sieve	Silt Content
	D < 5% by Weight Retained on 4 Sieve	Fine Gravel
Nearshore	20% < D < 10% by Weight Passing 230 Sieve	Silt Content
	D < 5% by Weight Retained on 4 Sieve	Fine Gravel
Upland	D > 20% by Weight Passing 230 Sieve	Silt Content
	D > 5% by Weight Retained on 4 Sieve	Fine Gravel
	D > 3/4″	Wood, Rock, Debris or Other Foreign Material
	Material resulting in Cementation on the beach	Clay, Excessive Silt or Fines, Wood, Rock, Debris or Other Foreign Material

Containment Cell Construction

The Contractor shall construct the containment area as shown in Appendix C and in the plans and specifications. The walls shall be constructed of steel sheet pile on a within the containment cell limits as shown on the construction drawings. Sand may only be used to construct an access point as shown on the plans. However, the sand wall shall not contain clay material. The walls shall be constructed to prevent collapse. The discharge point shall be a weir structure constructed of water tight material and shall be capable of being dismantled and reassembled at 12 inches (1 foot) vertical intervals or less at a time. A baffle or screen system shall be installed across the discharge point to prohibit floating materials from leaving the containment area.

Conclusion

This information is being provided to assist in the permit review and distribution of the design information for the Blind Pass Restoration. It is also included in greater detail within the JCP application and supporting documentation.

References

Coastal Planning & Engineering, Inc. (CPE) (1993). Blind Pass Inlet Management Plan. Boca Raton, Florida

Mheta, A. J., Lee, S-C., Feng, J. (1991).Inlet Stability at Blind Pass, Lee County, Florida. Coastal & Oceanographic Engineering Department University of Florida.

Missimer, T. (1973). The Depositional History of Sanibel Island. (Thesis). University of Florida.

Appendix A – Historical Aerials

Figure 2-14 Blind Pass in 1944

Source: (http://web.uflib.ufl.edu/digital/collections/FLAP/)

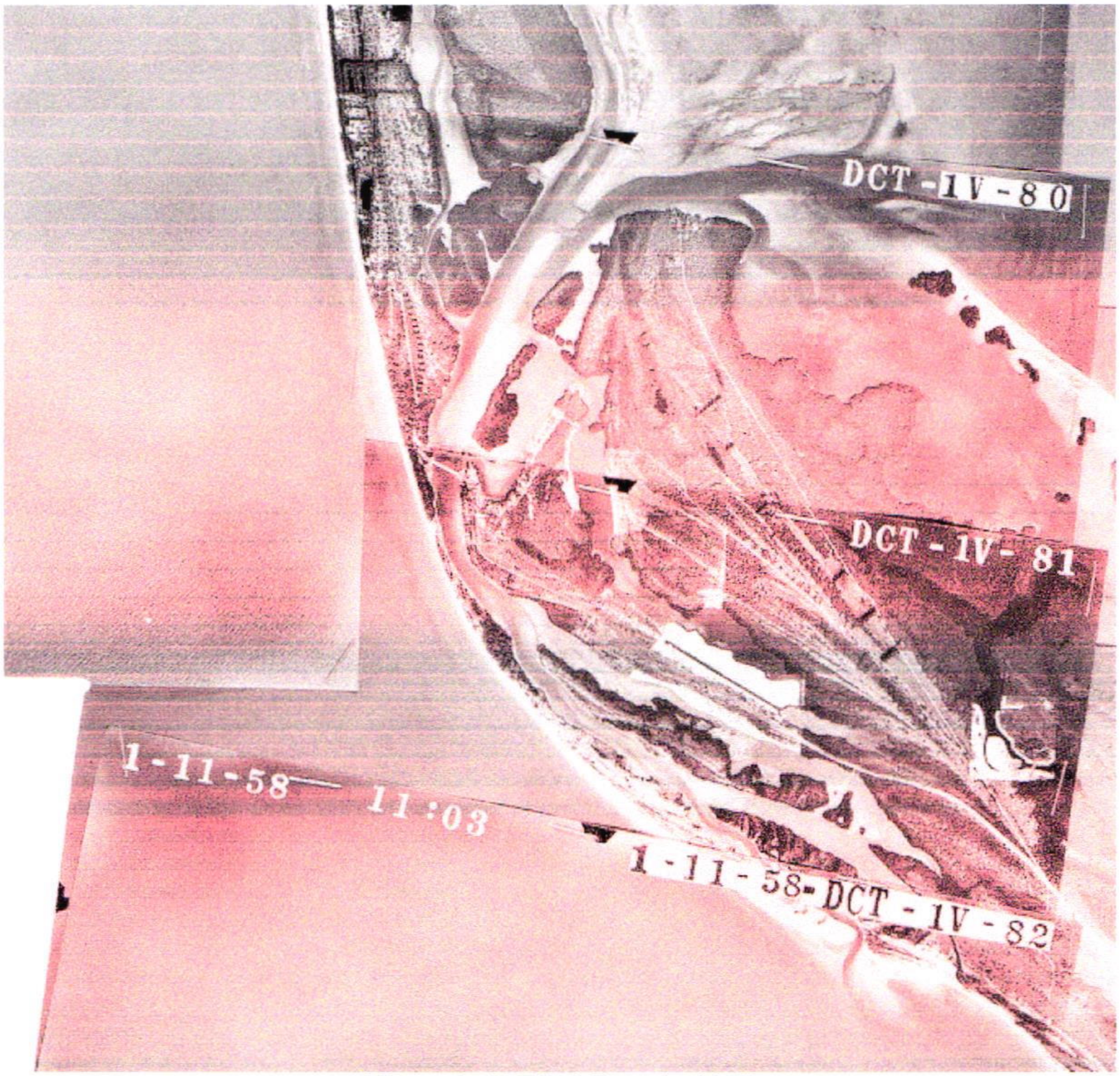


Figure 2-15 Blind Pass in 1958

Source: (http://web.uflib.ufl.edu/digital/collections/FLAP/)

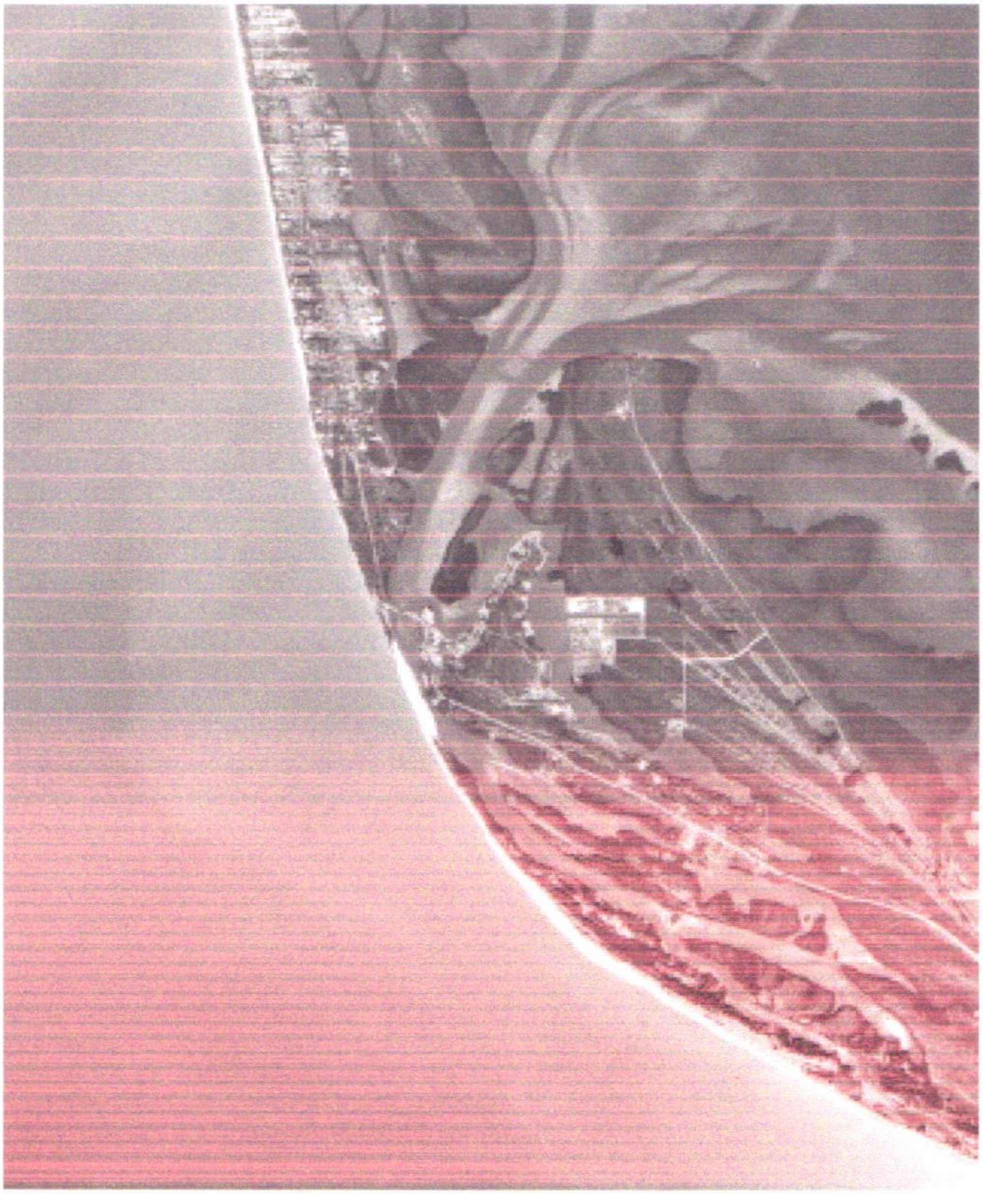


Figure 2-16 Blind Pass in 1970

Source: (http://web.uflib.ufl.edu/digital/collections/FLAP/)

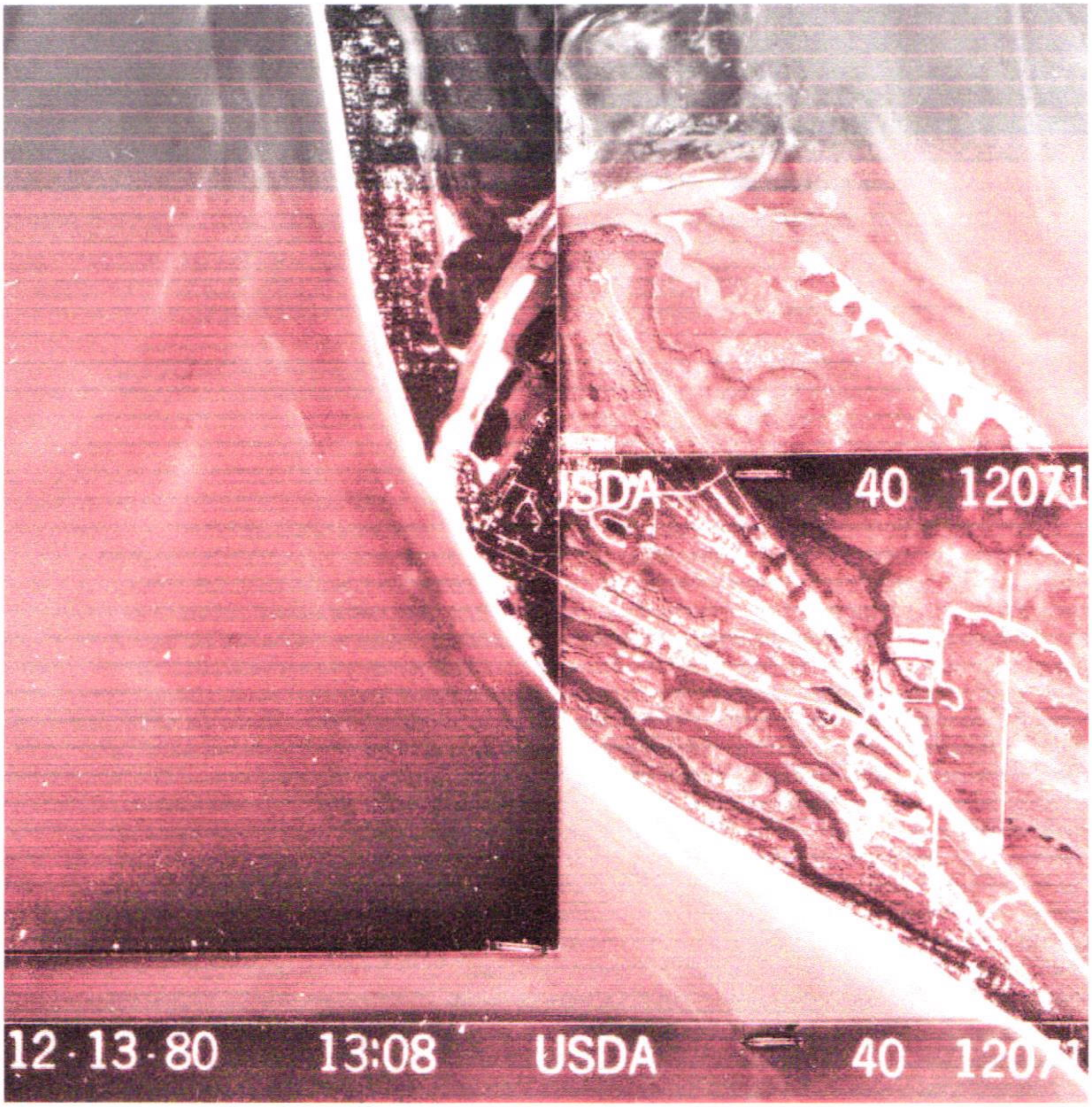


Figure 2-17 Blind Pass in 1980

Source: (http://web.uflib.ufl.edu/digital/collections/FLAP/)

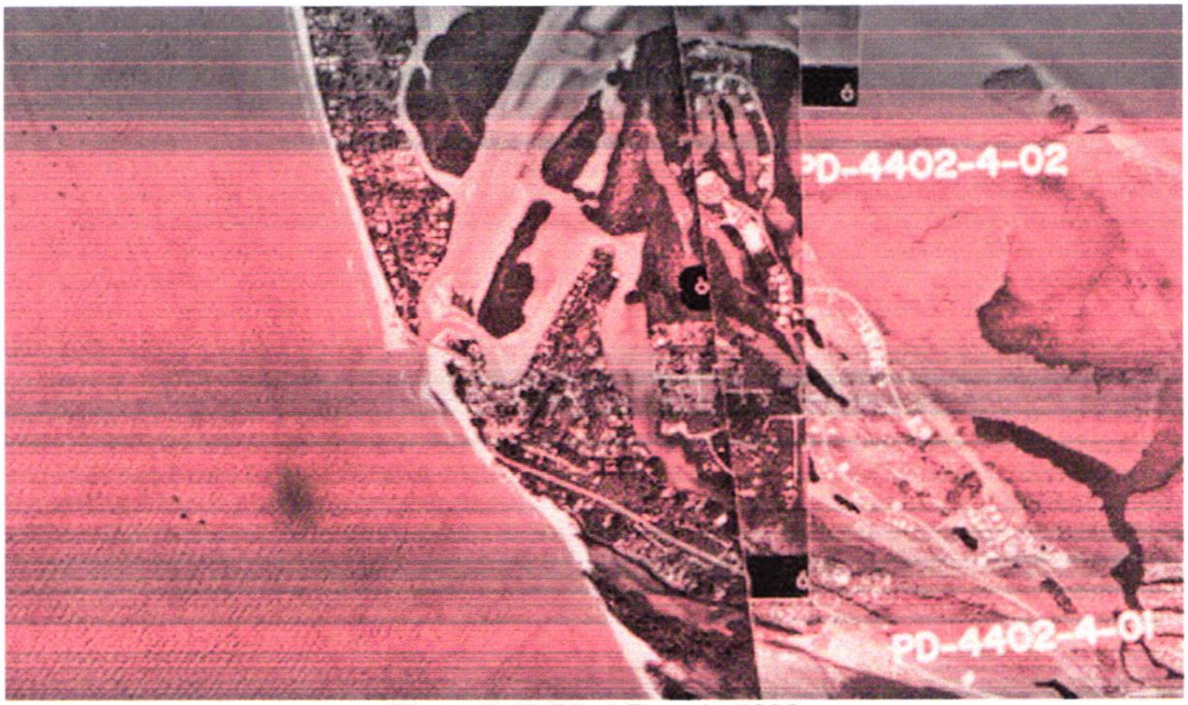


Figure 2-18 Blind Pass in 1996

Source: (http://web.uflib.ufl.edu/digital/collections/FLAP/)

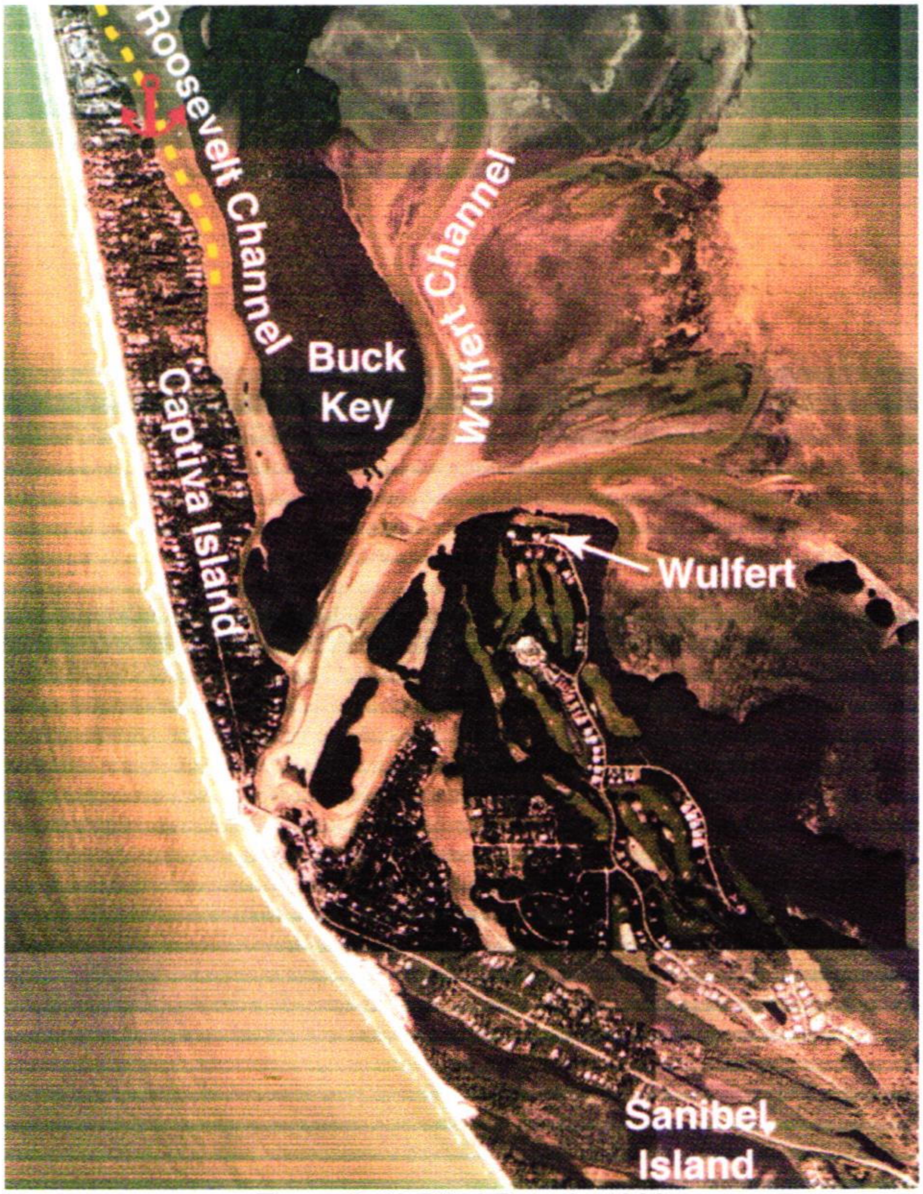


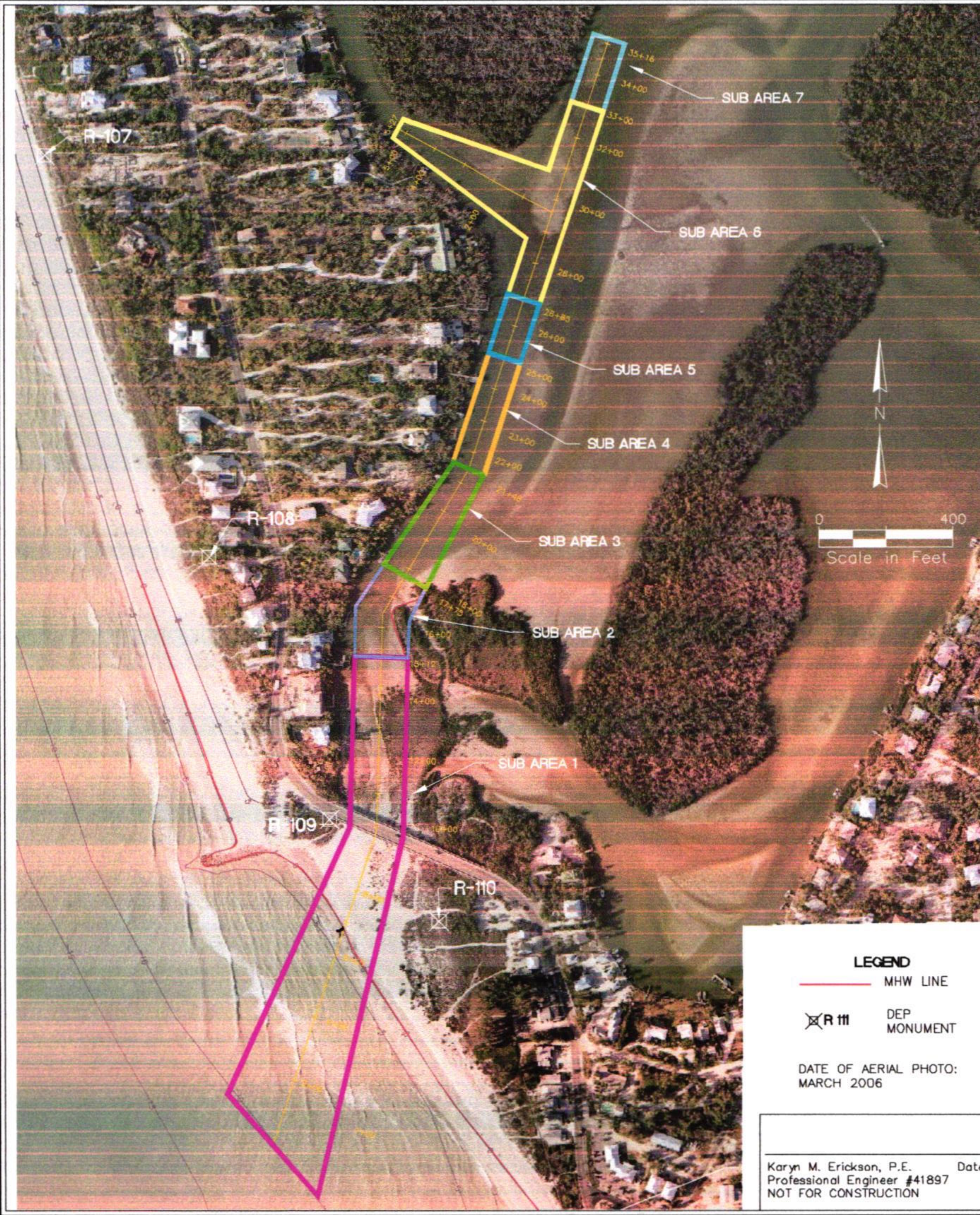
Figure 2-19 Blind Pass in 1999

Source: (http://web.uflib.ufl.edu/digital/collections/FLAP/)

Figure 2-20 Blind Pass in 2005

Source: (http://web.uflib.ufl.edu/digital/collections/FLAP/)

Appendix C – Permit Sketches of Containment Cell



LEGEND

MHW LINE

R 111 DEP MONUMENT

DATE OF AERIAL PHOTO: MARCH 2006

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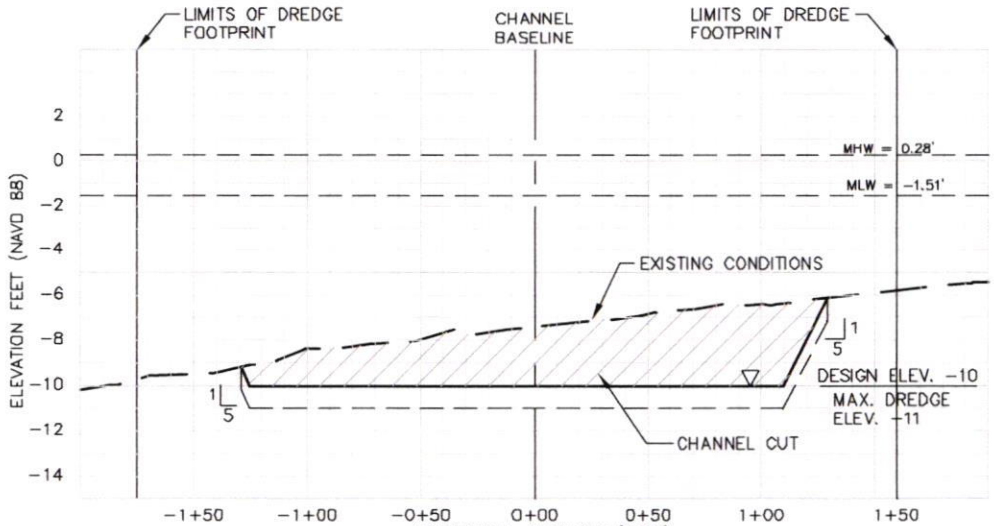
ECE 7201 Delainey Court Sarasota, FL 34240 (941) 373-6460	PLAN VIEW – CHANNEL DREDGING SUB AREAS	REVISIONS DEC 2007	PROJECT 05-129	CHECKED BY KE
	BLIND PASS RESTORATION LEE COUNTY, FLORIDA		DATE 11/05/07	DRAWN BY JE
			SCALE 1"=100'	SHEET: 8 of 36



STA 1+00 AREA 1

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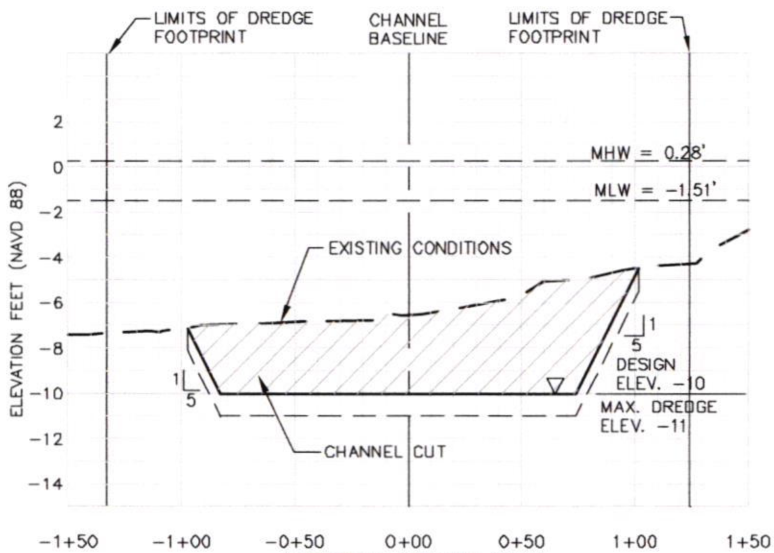
VERT. 1"= 8 FEET



STA 5+00 AREA 1

SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET

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Professional Engineer #41897
NOT FOR CONSTRUCTION

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CHANNEL CROSS SECTION
STATIONS 1+00 AND 5+00

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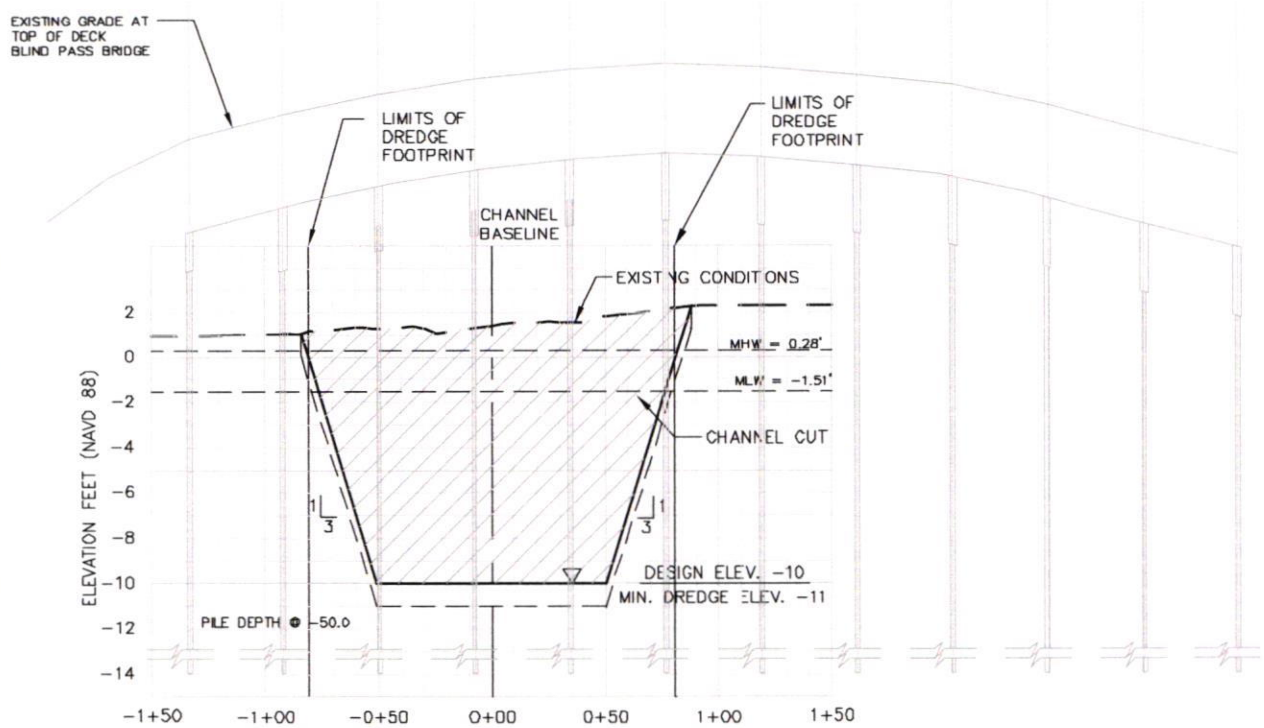

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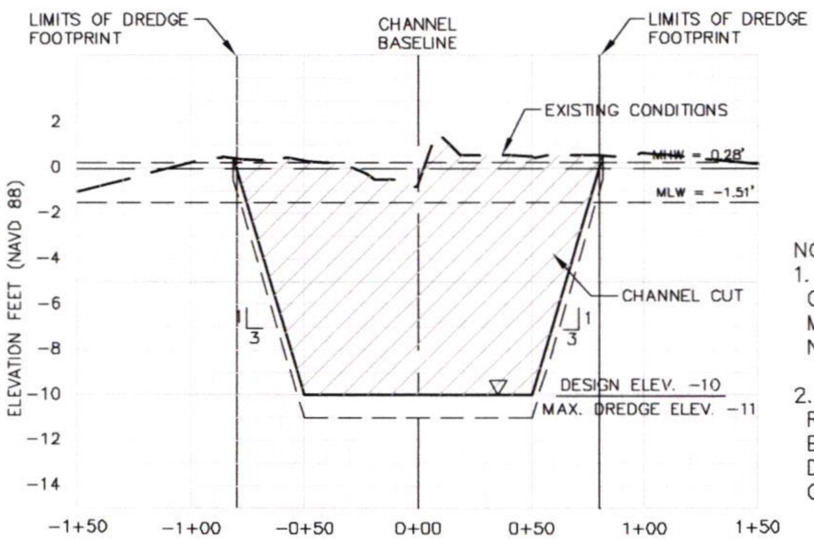

STA 12+50 AREA 1

SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET

NOTES:

1. CHANNEL CROSS SECTIONS BASED ON SURVEY BY MCKIM AND CREED, MAY 2005. ELEVATIONS IN FEET, NAVD 88.

2. BRIDGE PROFILE TAKEN FROM RECORD DRAWINGS B-2, B-6 & B-7, BLIND PASS BRIDGE REPLACEMENT, DATED FEB. 26, 1991 BY JENKINS & CHARLAND, INC.

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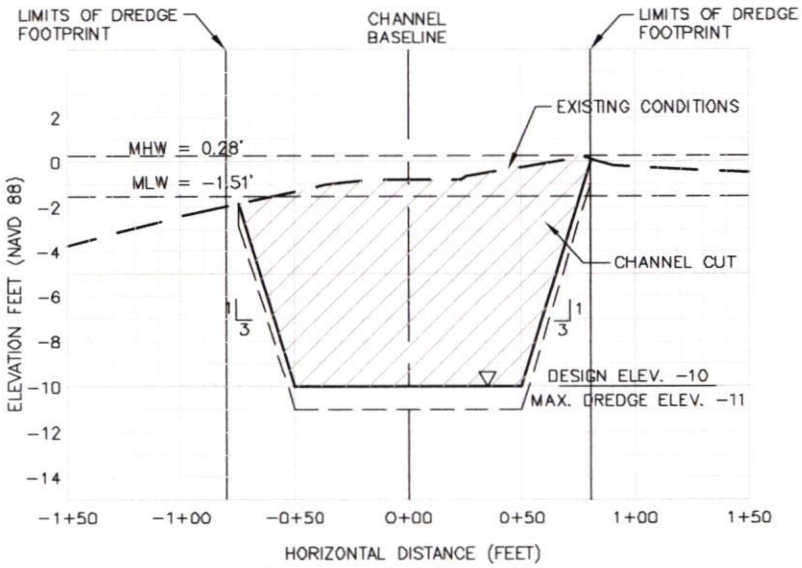

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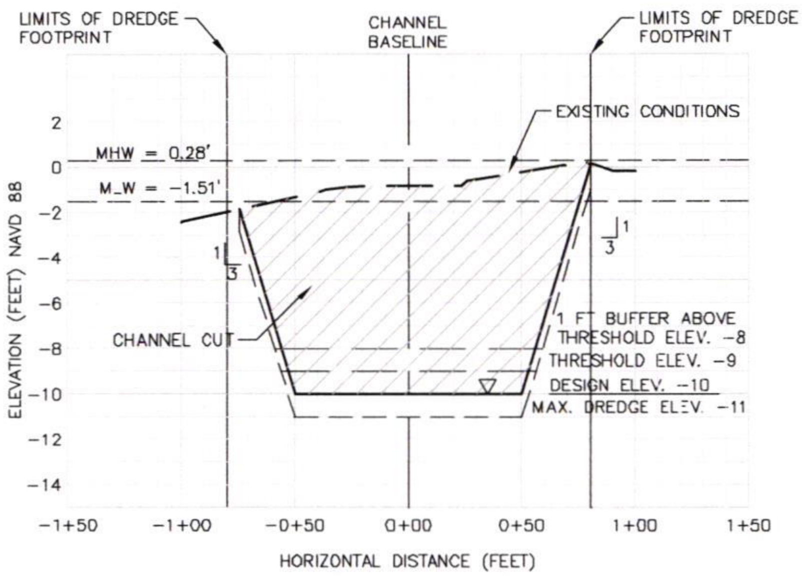
VERT. 1"= 8 FEET



STATION 15+12 AREA 2 (NORTH)
SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET

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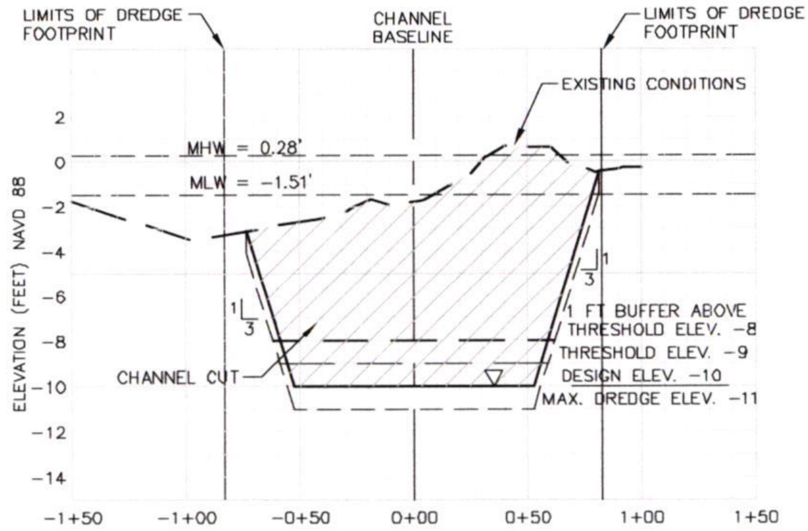

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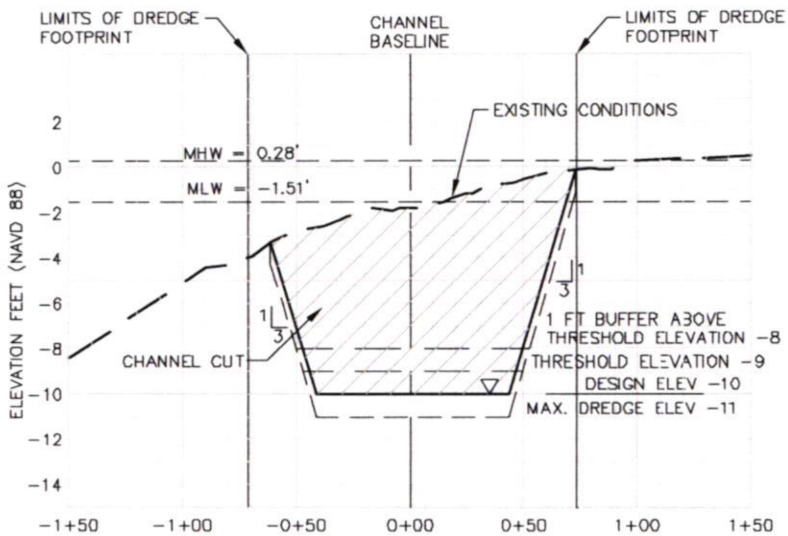

STATION 17+75 AREA 2 (SOUTH)
SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET

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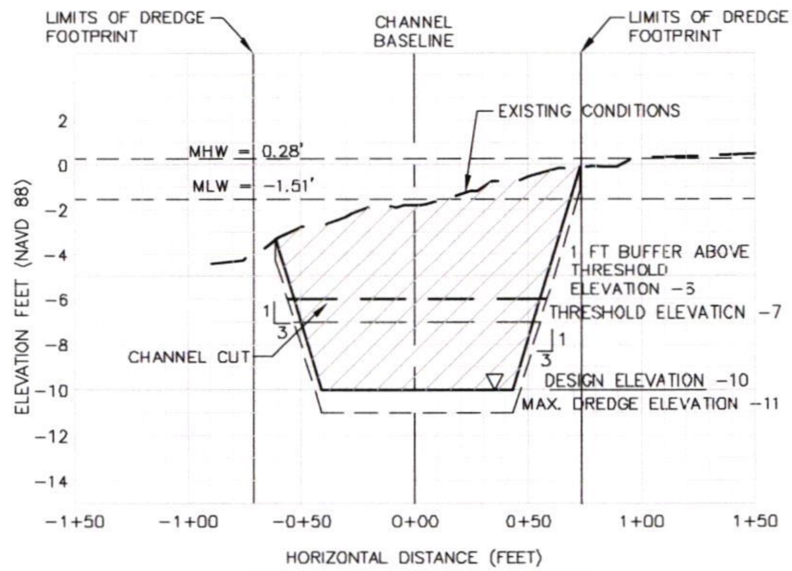

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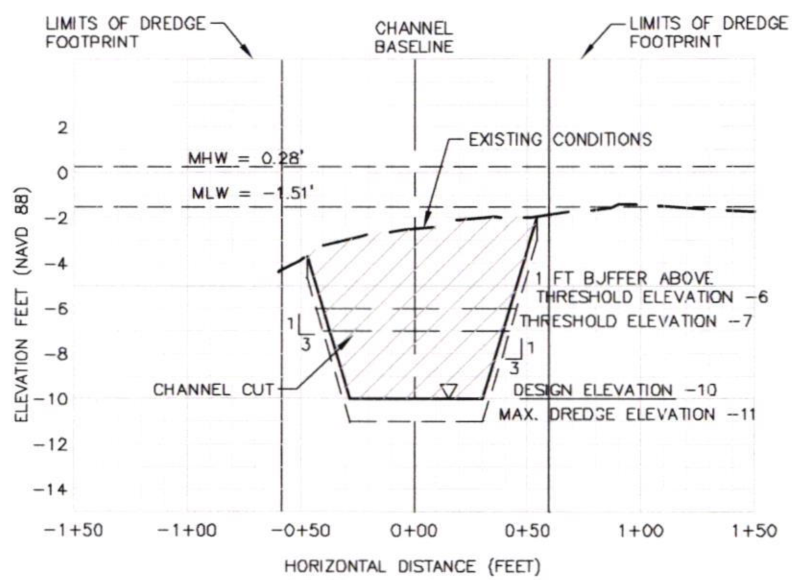

STATION 20+00 AREA 3

SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET

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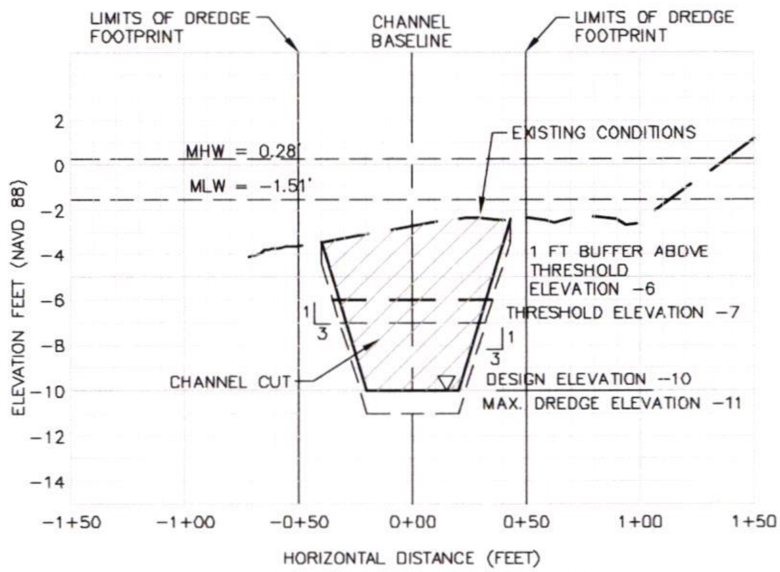

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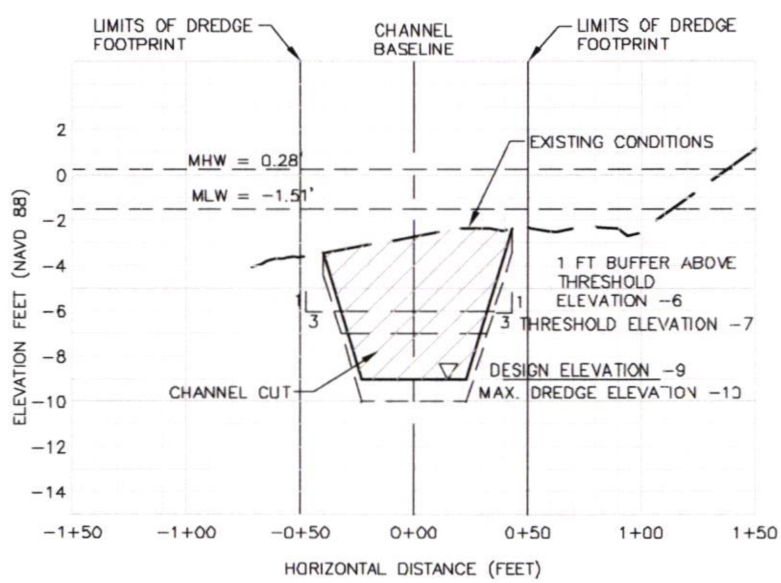

STATION 21+48 AREA 4 (NORTH)
SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET

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CHANNEL CROSS SECTIONS
STATION 21+48

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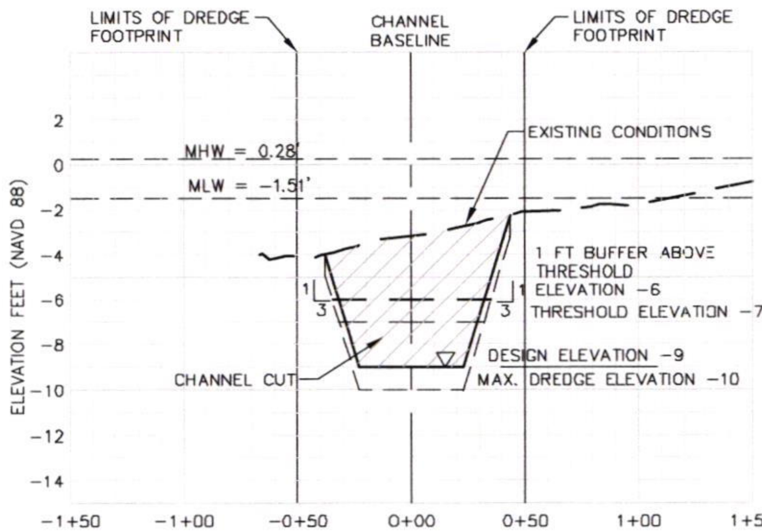

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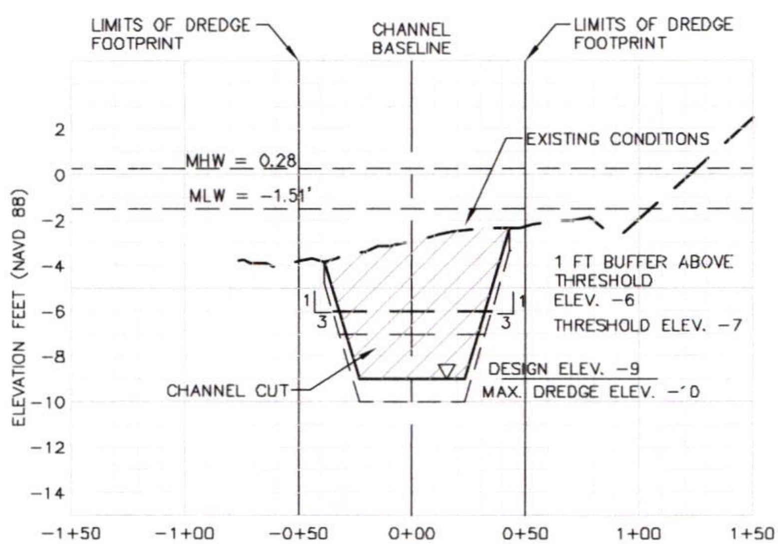

STATION 25+00 AREA 4 (SOUTH)

SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET

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STATIONS 23+00 AND 25+00

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LEE COUNTY, FLORIDA

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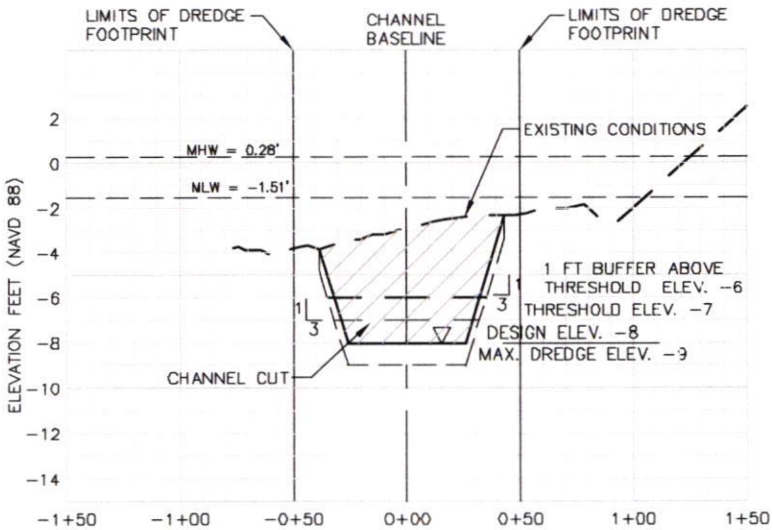

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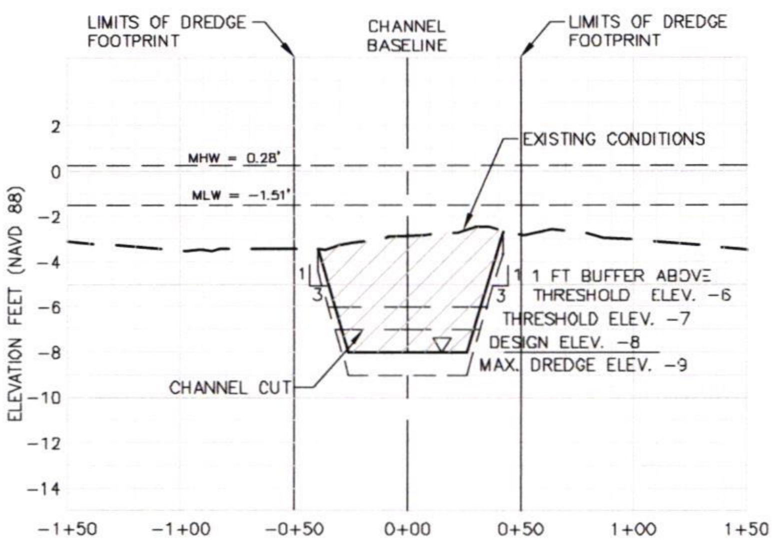

STA 26+85 AREA 5 (SOUTH)

SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET

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CHANNEL CROSS SECTIONS
STATIONS 25+00 AND 26+85

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LEE COUNTY, FLORIDA

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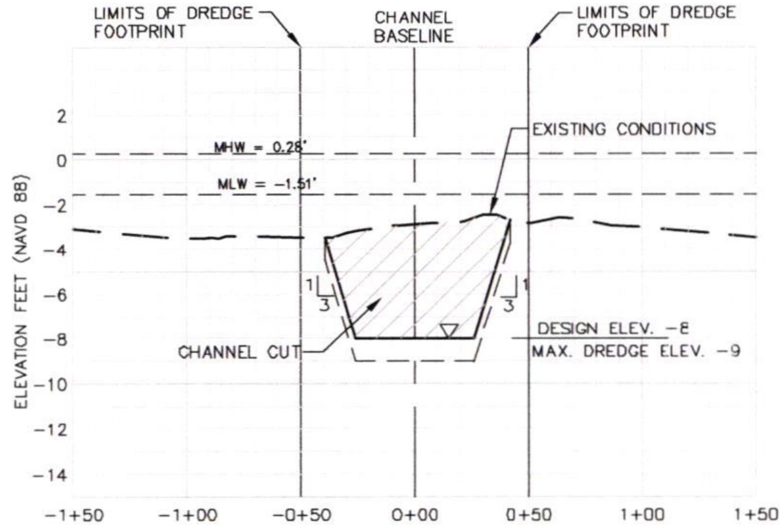

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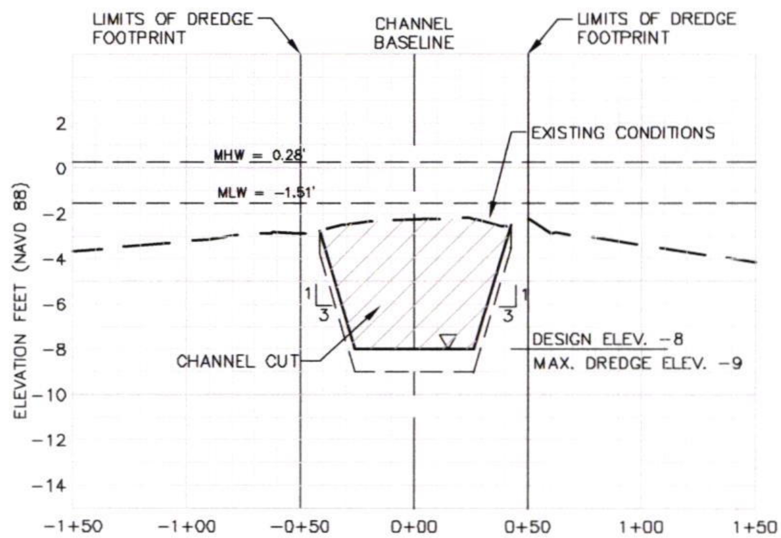

STA 28+63 AREA 6
SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET

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Professional Engineer #41897
NOT FOR CONSTRUCTION

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CHANNEL
CROSS SECTIONS 26+85 and 28+63

BLIND PASS RESTORATION
LEE COUNTY, FLORIDA

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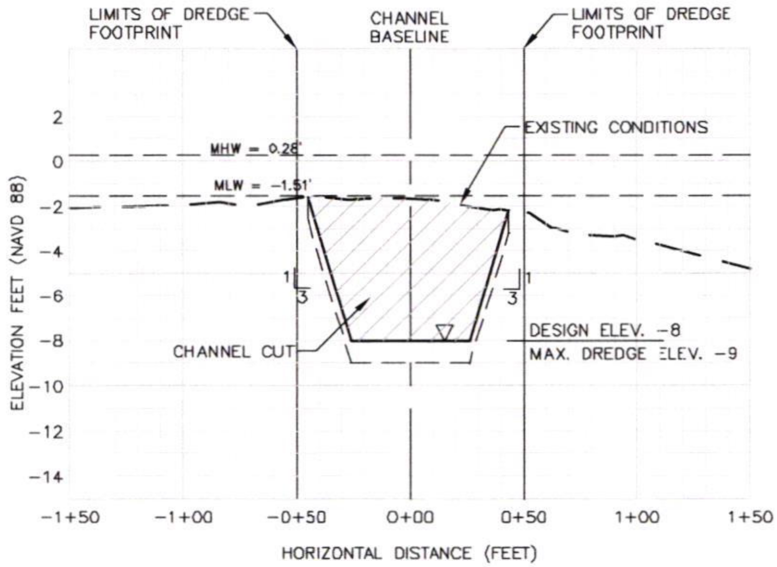

STA 30+80 AREA 6
SCALE: HORIZ. 1"=80 FEET
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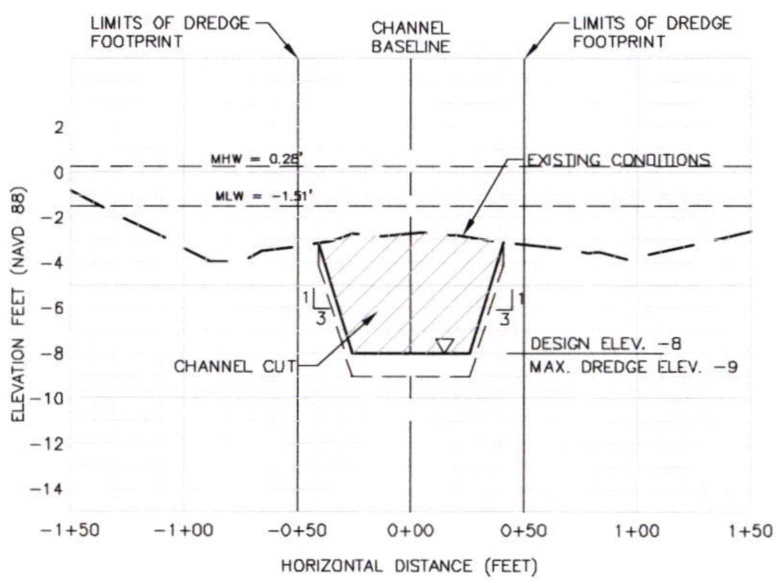

STA 33+00 AREA 6 (SOUTH)
SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET

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Professional Engineer #41897
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CHANNEL
CROSS SECTIONS 30+80 AND 33+00

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LEE COUNTY, FLORIDA

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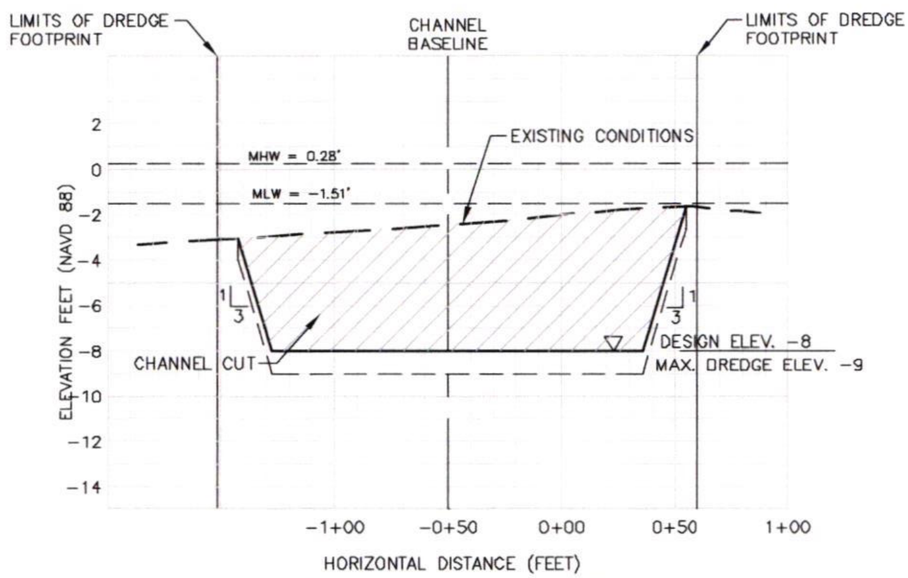

ROOSEVELT CHANNEL STA 0+73 AREA 6

SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET

Karyn M. Erickson, P.E. Date
Professional Engineer #41897
NOT FOR CONSTRUCTION

ECE 7201 Delainey Court Sarasota, FL 34240 (941) 373-6460	ROSEVELT CHANNEL CROSS SECTIONS STATION 0+73 BLIND PASS RESTORATION LEE COUNTY, FLORIDA	REVISIONS DEC 2007	PROJECT 05-129 DATE 11/05/07 SCALE AS SHOWN	CHECKED BY KE DRAWN BY JE SHEET: 20 of 36

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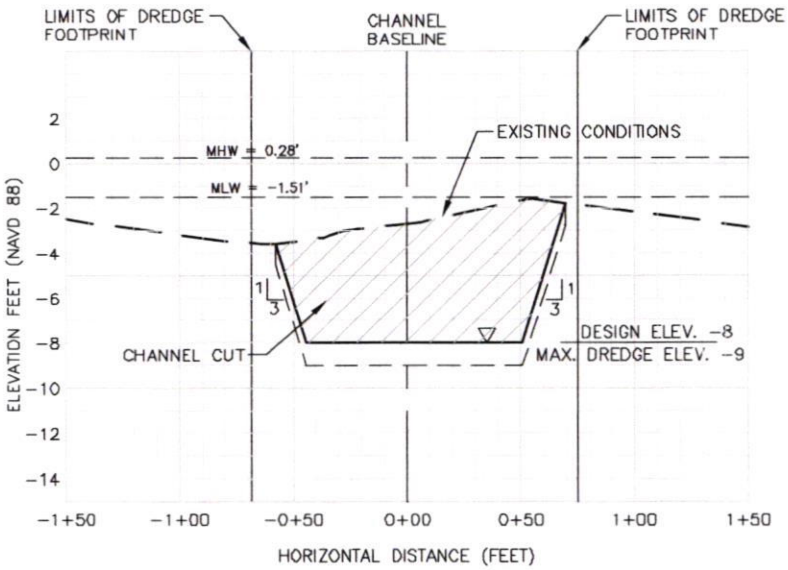
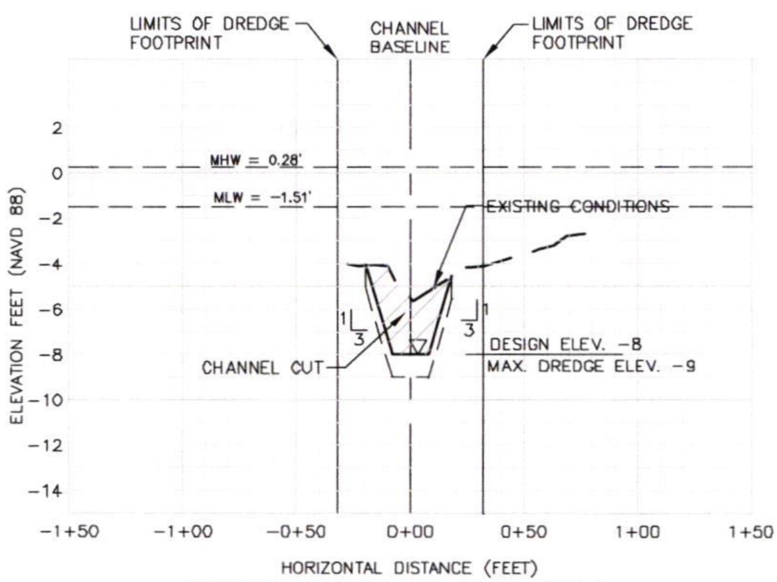


ROSEVELT CHANNEL STA 2+76 AREA 6

SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET



ROSEVELT CHANNEL STA 5+27 AREA 6

SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET

Karyn M. Erickson, P.E. Date
Professional Engineer #41897
NOT FOR CONSTRUCTION

ECE
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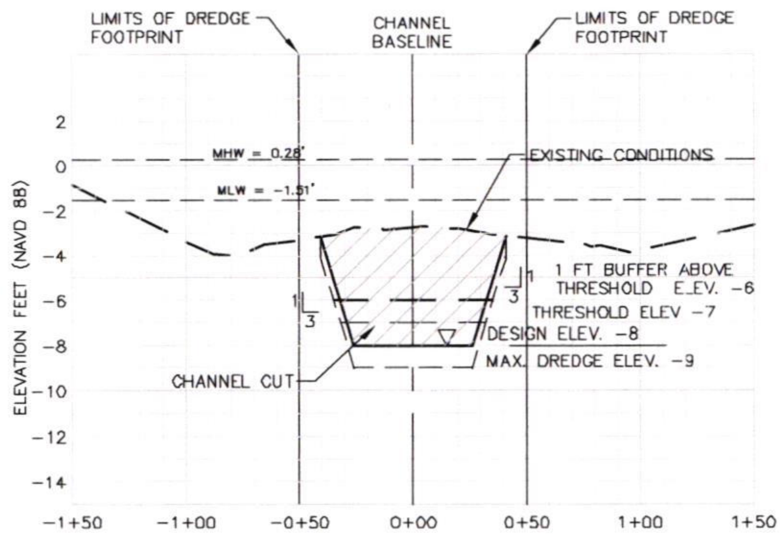
Sarasota, FL 34240
(941) 373-6460

ROSEVELT CHANNEL CROSS SECTIONS
STATION 2+76 AND 5+22

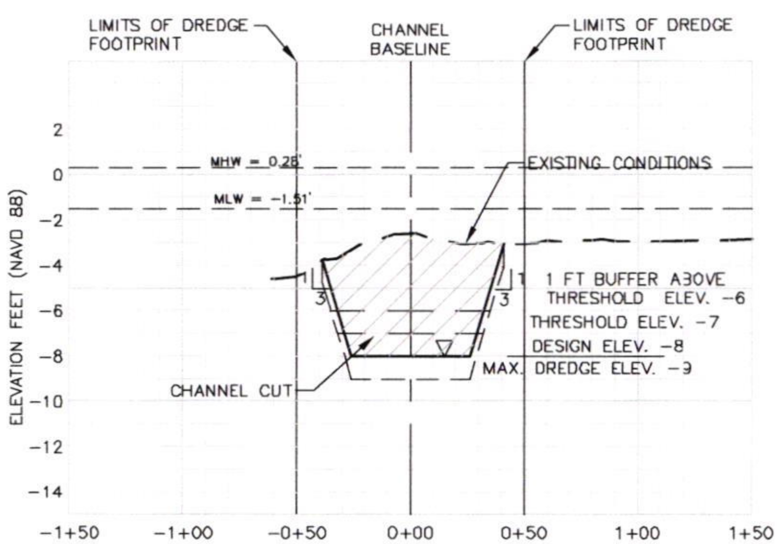
BLIND PASS RESTORATION
LEE COUNTY, FLORIDA

REVISIONS
DEC 2007

PROJECT 05-129	CHECKED BY KE
DATE 11/05/07	DRAWN BY JE
SCALE AS SHOWN	SHEET: 21 of 36



STA 33+00 AREA 7 (NORTH)
SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET



STA 35+16 AREA 7
SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET

Karyn M. Erickson, P.E. Date
Professional Engineer #41897
NOT FOR CONSTRUCTION

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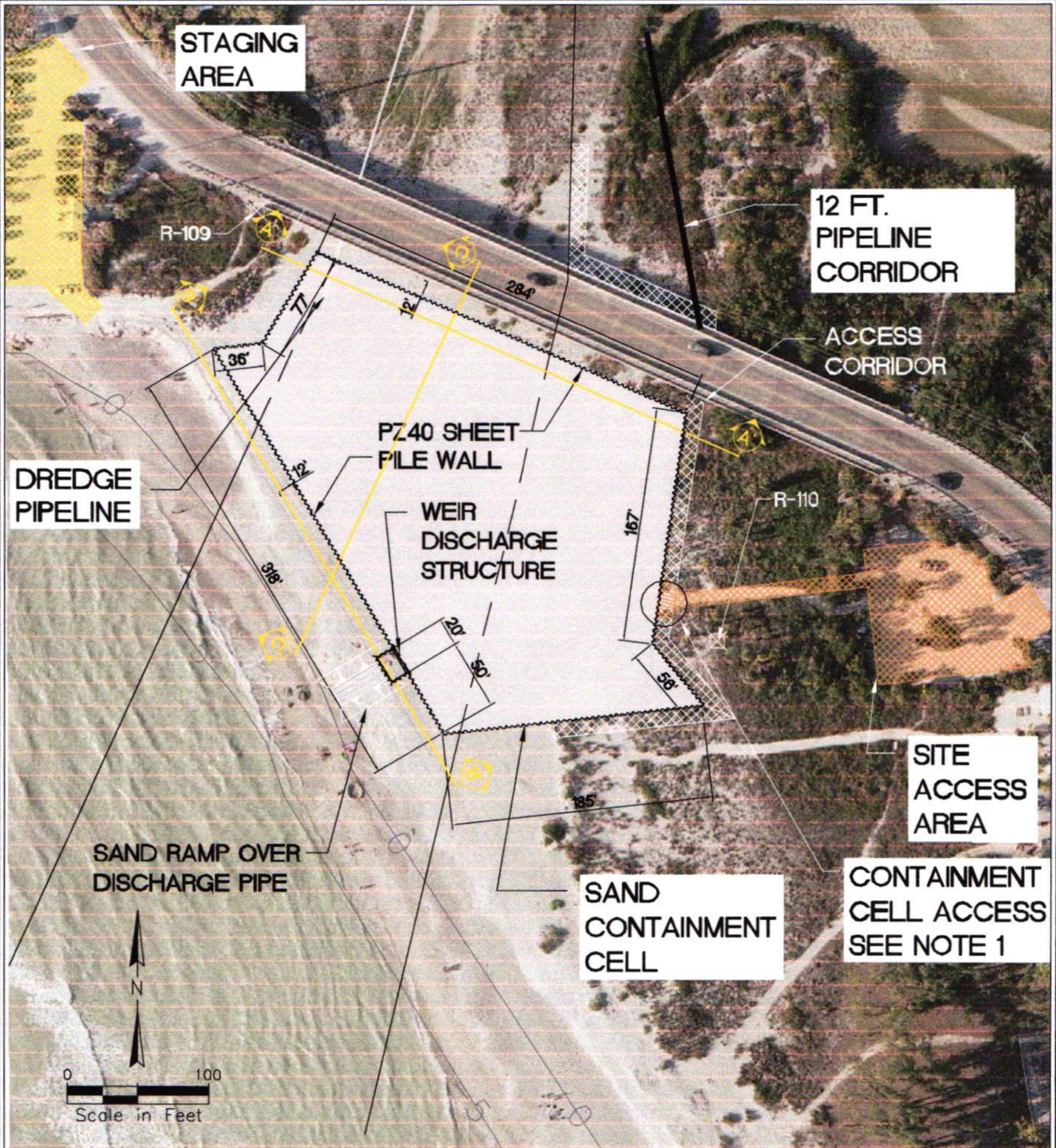
CHANNEL CROSS SECTIONS
STATIONS 33+00 AND 35+16

BLIND PASS RESTORATION
LEE COUNTY, FLORIDA

REVISIONS
DEC 2007

PROJECT 05-129	CHECKED BY KE
DATE 11/05/07	DRAWN BY JE
SCALE AS SHOWN	SHEET: 22 of 36

Appendix C – Permit Sketches of Containment Cell



NOTES:
1. BERM TO PROVIDE CONTRACTOR ACCESS TO CONTAINMENT CELL. SHEETPILE MAY BE DELETED AND TWENTY (20) FOOT SAND BERM MAY BE CONSTRUCTED TO REPLACE SHEETPILE. ELEVATION MAY VARY +8' TO +10'.
2. FINAL PLAN AREA FOR CONTAINMENT MAY BE LESS THAN THAN SHOWN IN THE DRAWINGS.

Karyn M. Erickson, P.E. Date
Professional Engineer #41897
NOT FOR CONSTRUCTION

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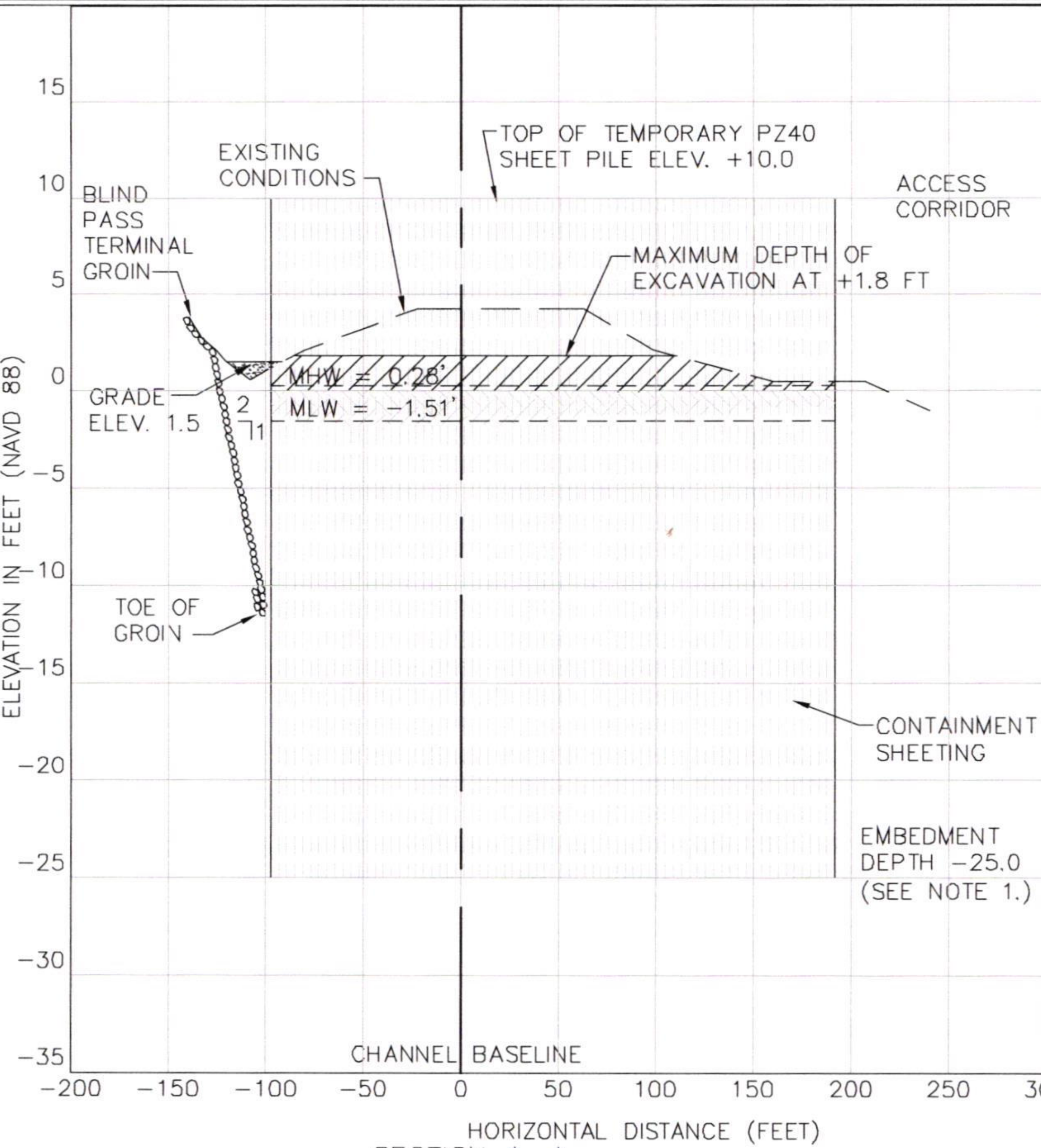
SAND CONTAINMENT SITE PLAN VIEW	REVISIONS	PROJECT 05-129	CHECKED BY KE
BLIND PASS RESTORATION LEE COUNTY, FLORIDA	DEC 2007	DATE 11/05/07	DRAWN BY JE
		SCALE 1"=100'	SHEET: 28 of 36



SECTION A–A
SAND CONTAINMENT CELL
SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET

NOTES
1. EMBEDMENT AND CREST SHEETPILE ELEVATIONS SHALL BE FIELD DETERMINED BY CONTRACTOR AND SUBJECT TO COUNTY APPROVAL. THE EMBEDMENT SHALL BE A MINIMUM OF 22 FEET FOR A 35 FOOT LONG SHEET. THE CONTRACTOR SHALL ALSO MAINTAIN A MINIMUM FREEBOARD OF 2 FEET IN THE CONTAINMENT CELL DURING CONSTRUCTION OPERATIONS.
2. THE CONTAINMENT CELL MAY BE SMOOTH GRADED PRIOR TO THE PRE–FILL SURVEY. MATERIAL STOCKPILING OUTSIDE THE CONTAINMENT CELL SHALL NOT BE ALLOWED.
3. BLIND PASS TERMINAL GROIN ELEVATIONS OF STONE AND LOCATION BELOW MSL WILL BE FIELD VERIFIED BY CONTRACTOR USING JET PROBES.

Brian Stirling, P.E. Date
Professional Engineer #34927
NOT FOR CONSTRUCTION

Karyn M. Erickson, P.E. Date
Professional Engineer #41897
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Sarasota, FL 34240
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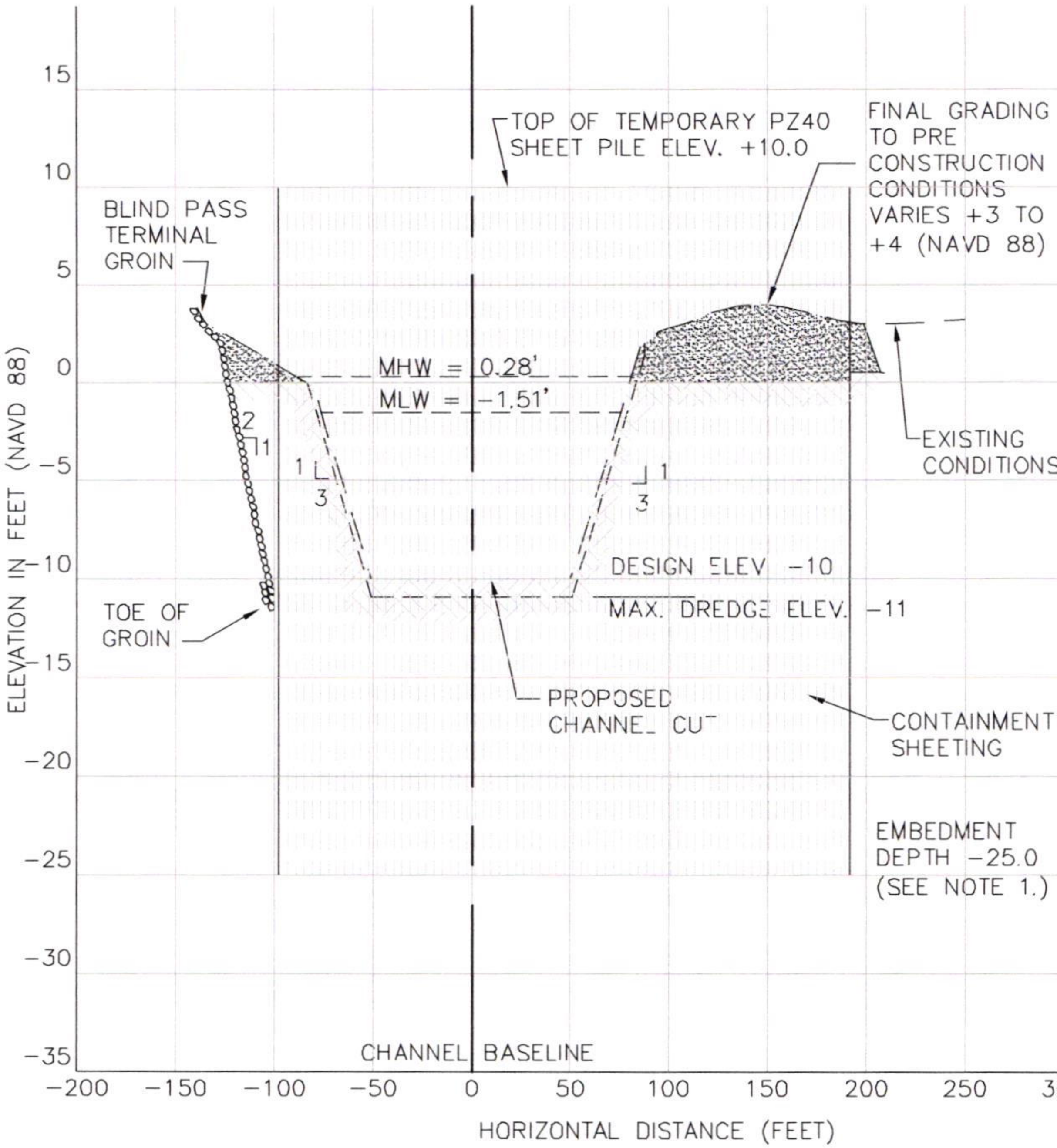
SAND CONTAINMENT CELL
SECTION A–A

BLIND PASS RESTORATION
LEE COUNTY, FLORIDA

REVISIONS

PROJECT 05–129	CHECKED BY KE
DATE 11/05/07	DRAWN BY JE
SCALE As Shown	SHEET: 29 of 36



SECTION A-A PRIOR TO PASS OPENING
SAND CONTAINMENT CELL
SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET

NOTES
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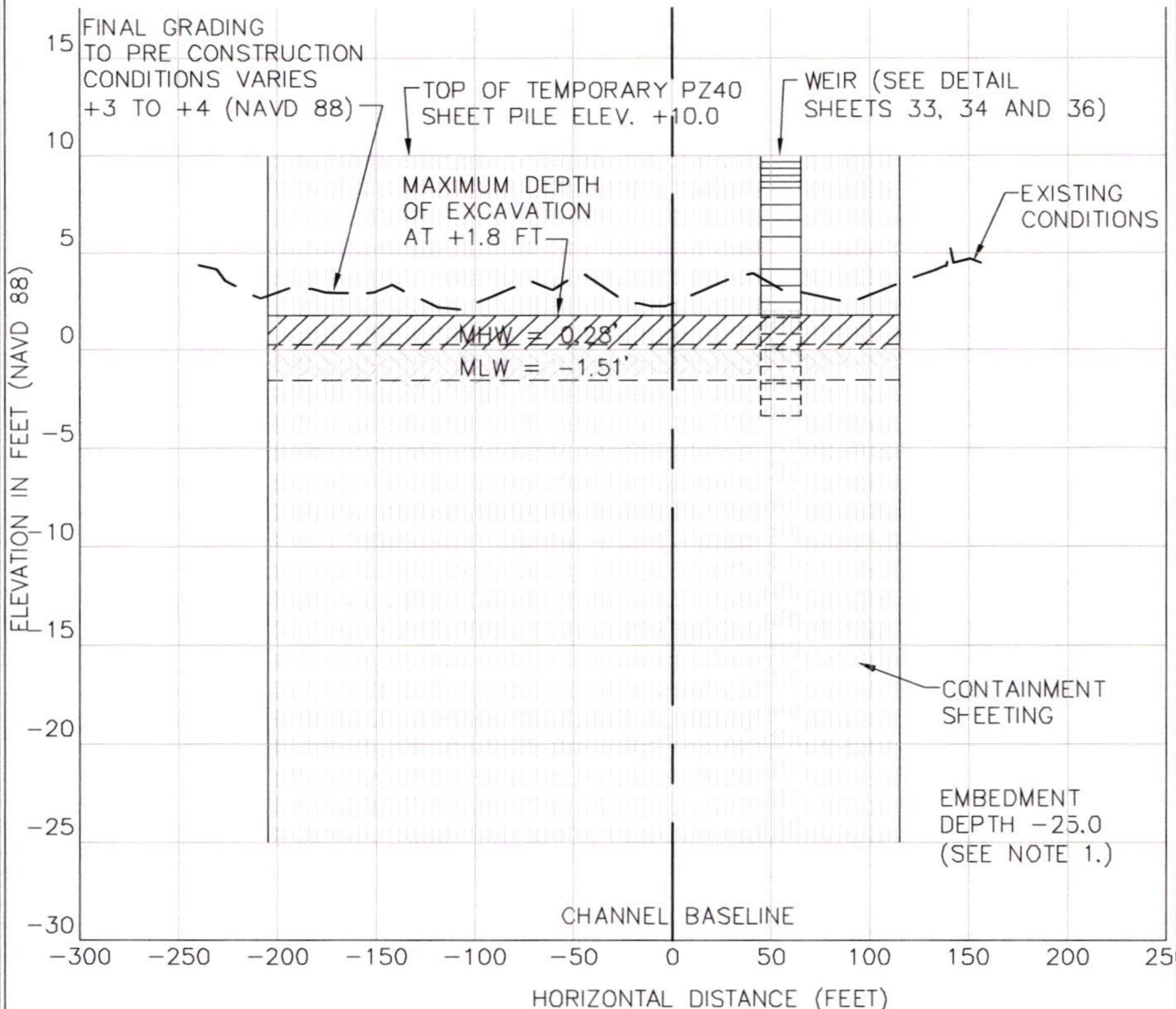
SAND CONTAINMENT CELL
SECTION A-A PRIOR TO PASS OPENING

BLIND PASS RESTORATION
LEE COUNTY, FLORIDA

REVISIONS		
	PROJECT 05-129	CHECKED BY KE
	DATE 11/05/07	DRAWN BY JE
	SCALE As Shown	SHEET: 30 of 36



SECTON B-B
SAND CONTAINMENT CELL
SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET

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Sarasota, FL 34240
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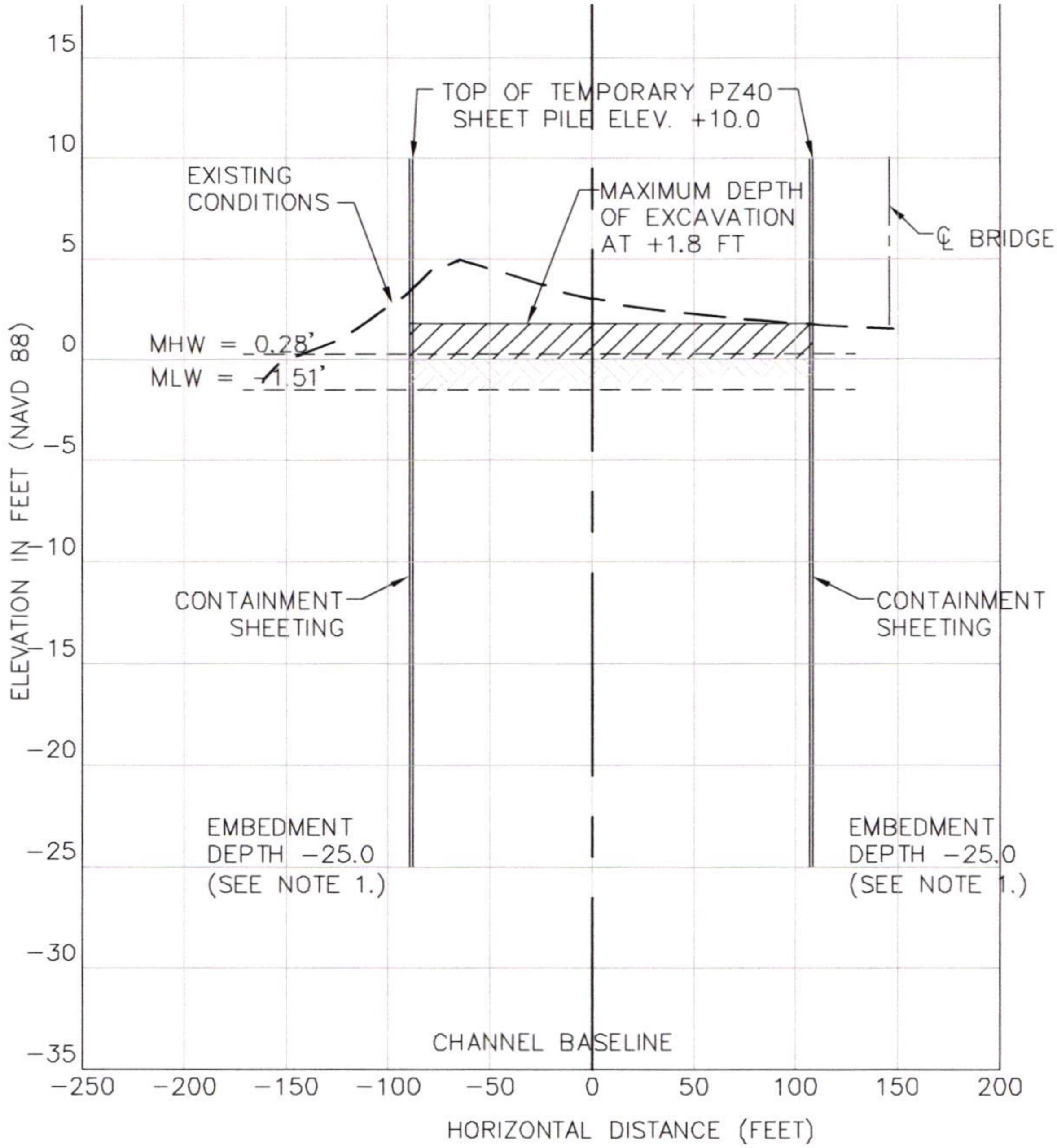
SAND CONTAINMENT CELL
SECTION B-B

BLIND PASS RESTORATION
LEE COUNTY, FLORIDA

REVISIONS		
	PROJECT 05-129	CHECKED BY KE
	DATE 11/05/07	DRAWN BY JE
	SCALE As Shown	SHEET: 31 of 36



SECTION C-C
SAND CONTAINMENT CELL
SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET

NOTES
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NOT FOR CONSTRUCTION

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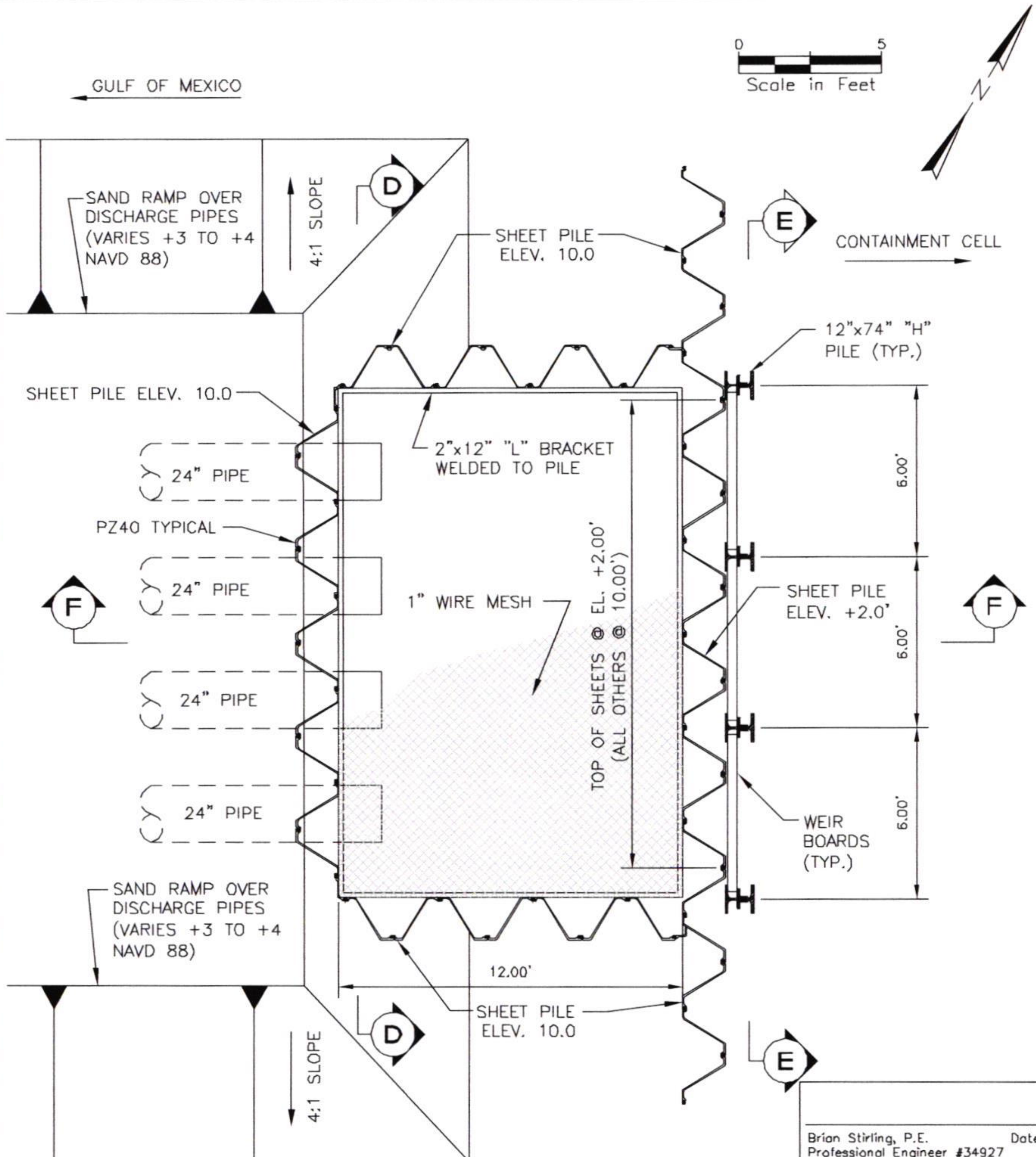
SAND CONTAINMENT CELL
SECTION C-C

BLIND PASS RESTORATION
LEE COUNTY, FLORIDA

REVISIONS

PROJECT 05-129	CHECKED BY KE
DATE 11/05/07	DRAWN BY JE
SCALE As Shown	SHEET: 32 of 36



Brian Stirling, P.E. Date
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2. LENGTH OF DISCHARGE PIPE VARIES. SEAWARD END OF PIPE TO BE PLACED ABOVE MEAN HIGH WATER.

Karyn M. Erickson, P.E. Date
Professional Engineer #41897
NOT FOR CONSTRUCTION

ECE 7201 Delainey Court Sarasota, FL 34240 (941) 373-6460	SAND CONTAINMENT WEIR DETAIL PLAN VIEW BLIND PASS RESTORATION LEE COUNTY, FLORIDA	REVISIONS DEC 2007	PROJECT 05-129 DATE 11/05/07 SCALE As Shown	CHECKED BY KE DRAWN BY JE SHEET: 33 of 36

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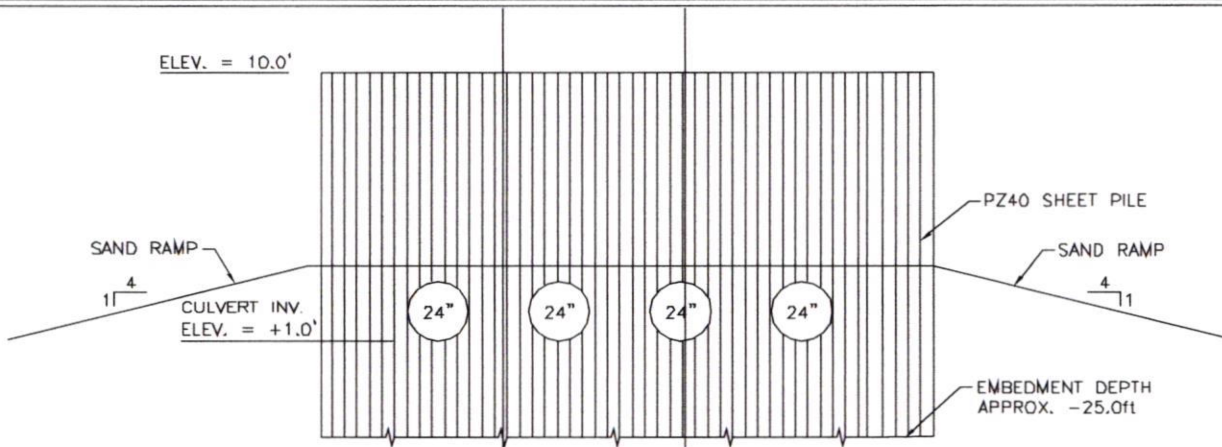
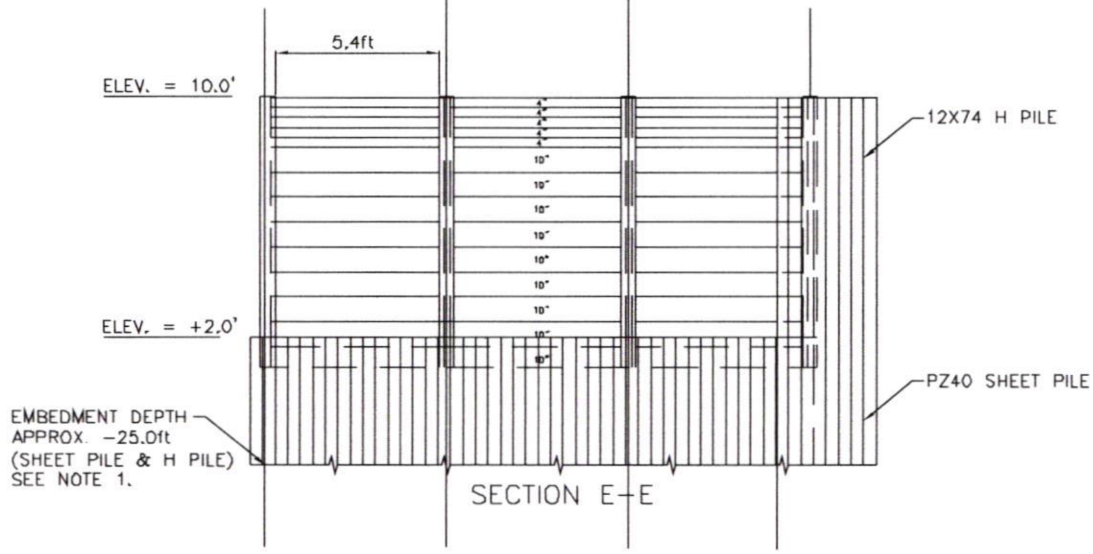
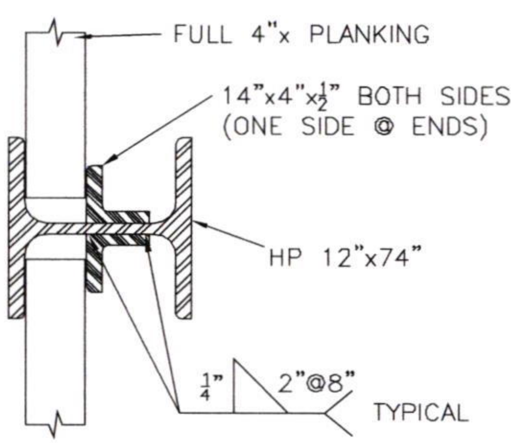


SECTION D-D



SECTION E-E



12"x74 "H" PILE DETAIL

SCALE: 1" = 1'-0"

NOTES

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Brian Stirling, P.E. Date
Professional Engineer #34927
NOT FOR CONSTRUCTION

Karyn M. Erickson, P.E. Date
Professional Engineer #41897
NOT FOR CONSTRUCTION

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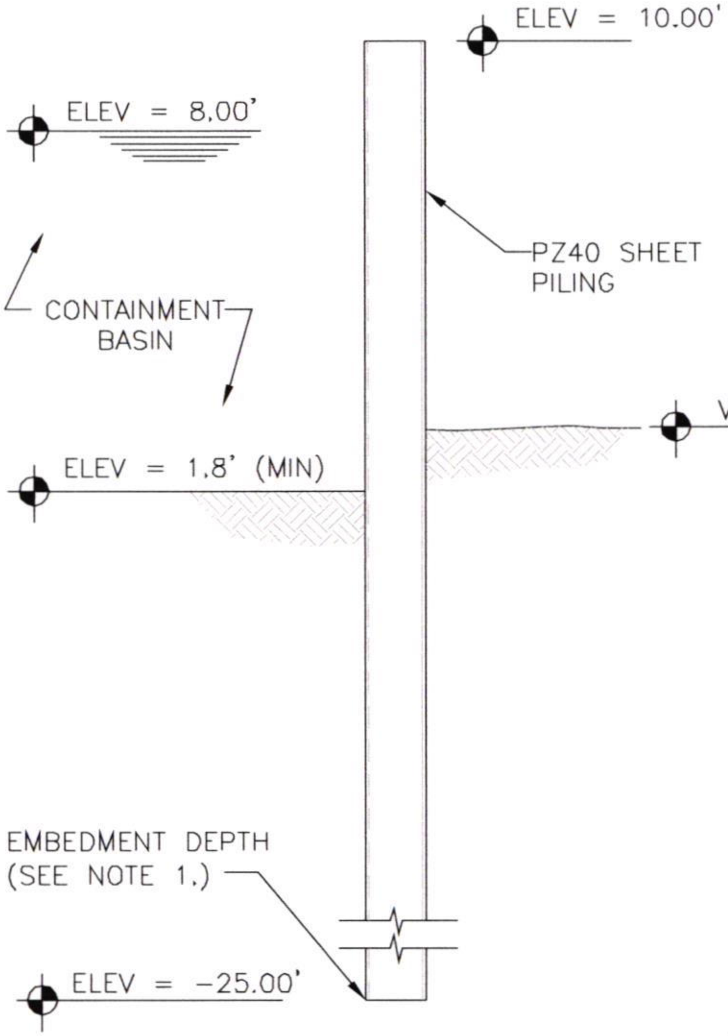
SAND CONTAINMENT WEIR DETAIL
SECTION VIEWS

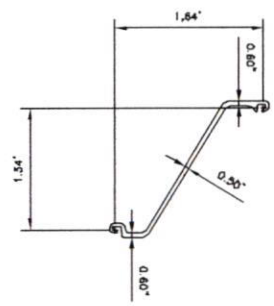
BLIND PASS RESTORATION
LEE COUNTY, FLORIDA

REVISIONS		
DEC 2007	PROJECT 05-129	CHECKED BY KE
	DATE 11/05/07	DRAWN BY JE
	SCALE As Shown	SHEET: 34 of 36



TYPICAL SECTION

SCALE: 1-1/4" = 1'-0"



PZ40 DETAIL

SCALE: 1/2" = 1'-0"

NOTES
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3. LENGTH OF DISCHARGE PIPE VARIES. SEAWARD END OF PIPE TO BE PLACED ABOVE MEAN HIGH WATER.

Brian Stirling, P.E. Date
Professional Engineer #34927
NOT FOR CONSTRUCTION

Karyn M. Erickson, P.E. Date
Professional Engineer #41897
NOT FOR CONSTRUCTION

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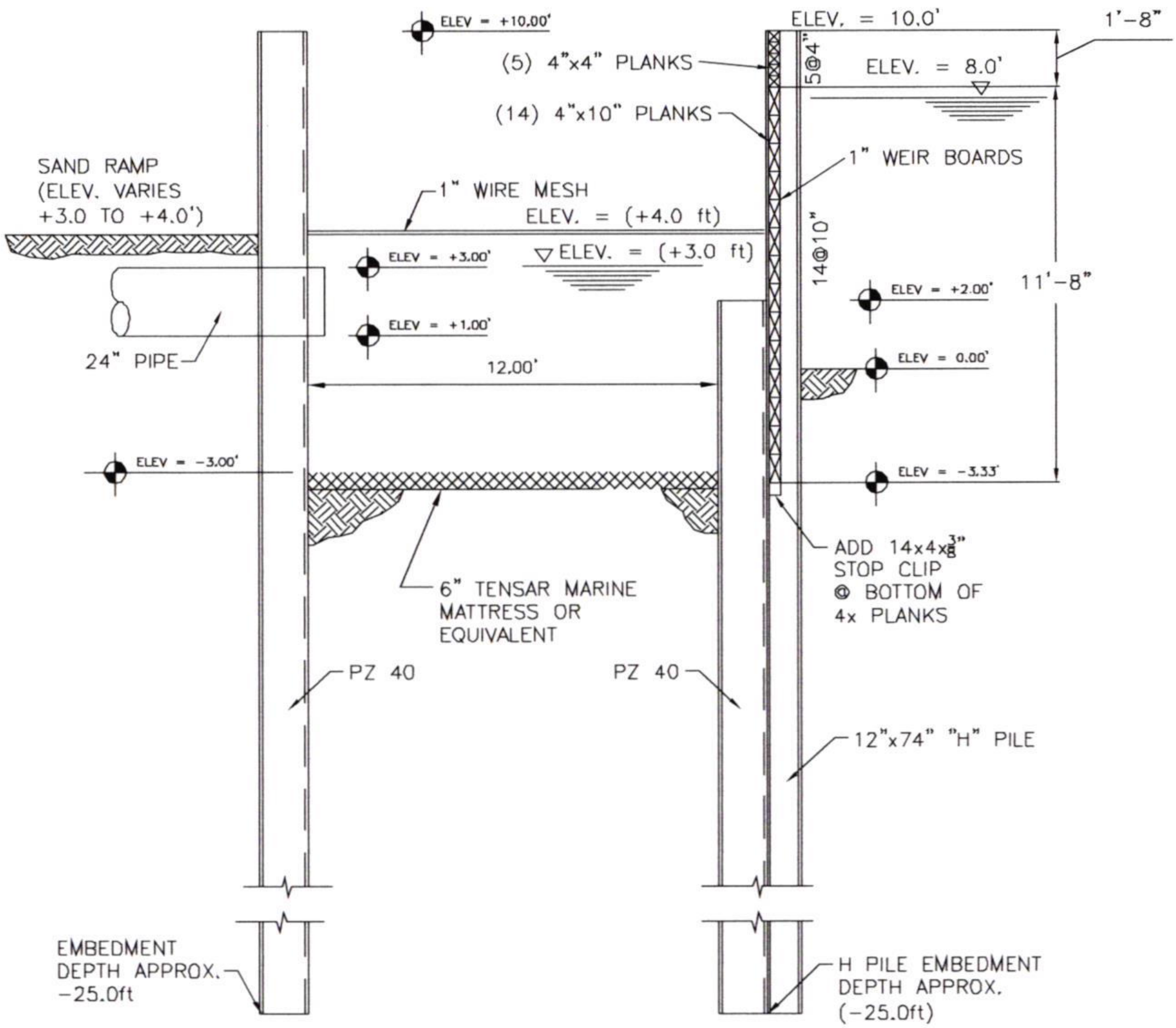
SAND CONTAINMENT SHEETPILE
TYPICAL SECTION AND DETAIL

BLIND PASS RESTORATION
LEE COUNTY, FLORIDA

REVISIONS

PROJECT 05-129	CHECKED BY KE
DATE 11/05/07	DRAWN BY JE
SCALE As Shown	SHEET: 35 of 36



SECTION F-F

SCALE: 1"=5'

NOTES

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Brian Stirling, P.E. Date
Professional Engineer #34927
NOT FOR CONSTRUCTION

Karyn M. Erickson, P.E. Date
Professional Engineer #41897
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SAND CONTAINMENT WEIR
STRUCTURAL DETAILS

BLIND PASS RESTORATION
LEE COUNTY, FLORIDA

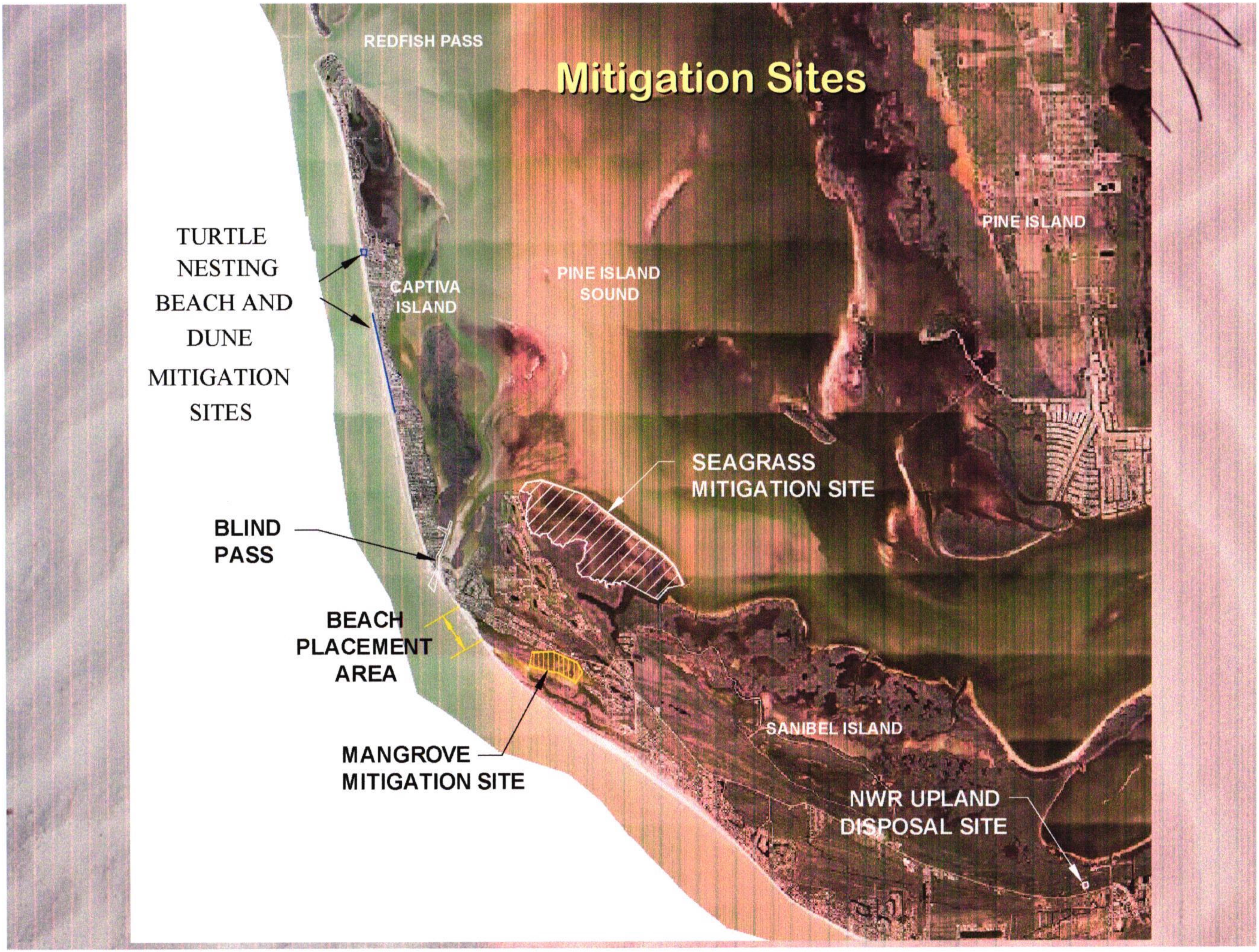
REVISIONS

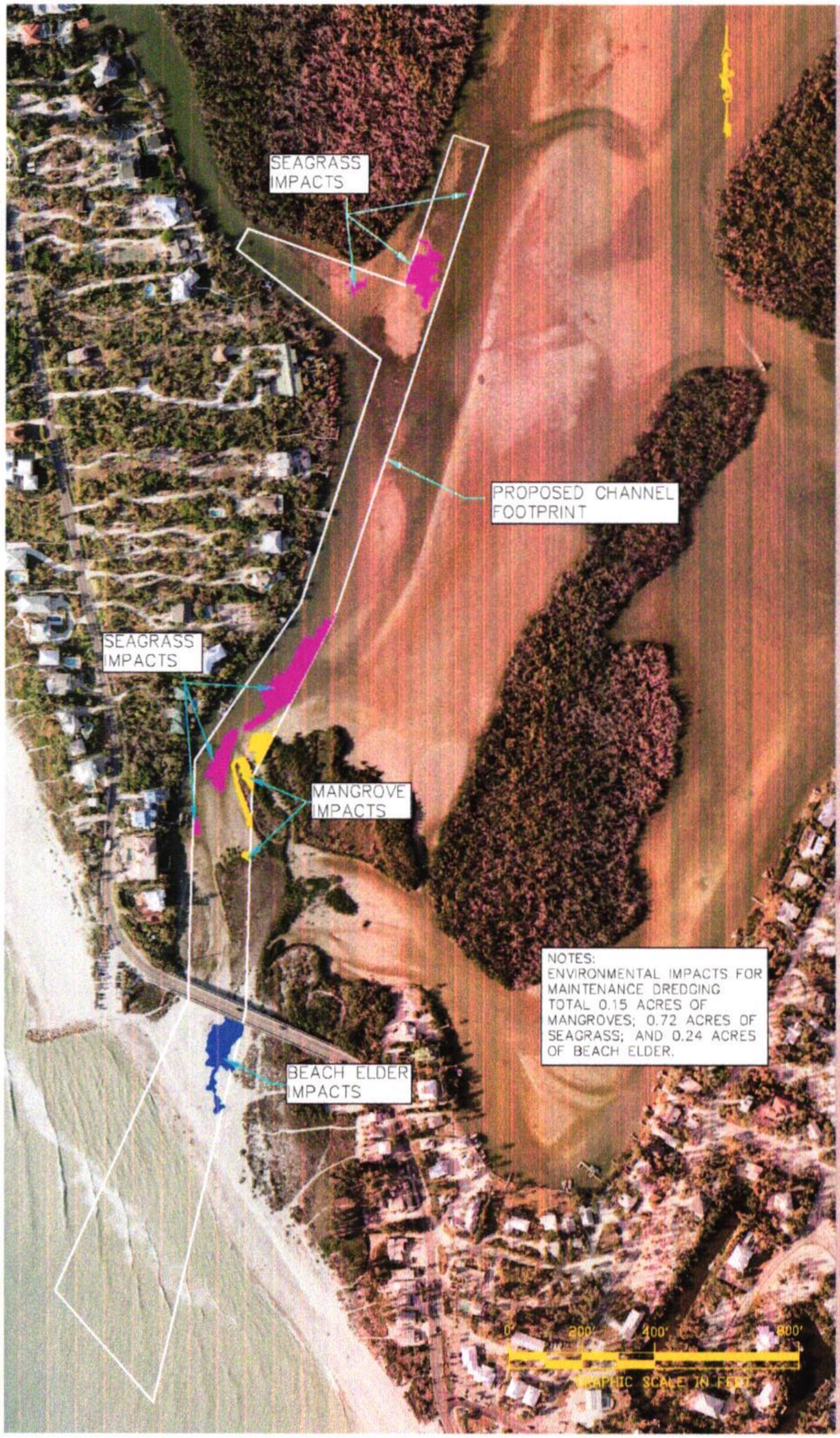
PROJECT 05-129	CHECKED BY KE
DATE 11/05/07	DRAWN BY JE
SCALE As Shown	SHEET: 36 of 36

Blind Pass Maintenance Dredging Project Update

June 2008

City of Sanibel


Mitigation Sites
REDFISH PASS
TURTLE NESTING BEACH AND DUNE MITIGATION SITES
CAPTIVA ISLAND
PINE ISLAND SOUND
PINE ISLAND
SEAGRASS MITIGATION SITE
BLIND PASS
BEACH PLACEMENT AREA
MANGROVE MITIGATION SITE
SANIBEL ISLAND
NWR UPLAND DISPOSAL SITE

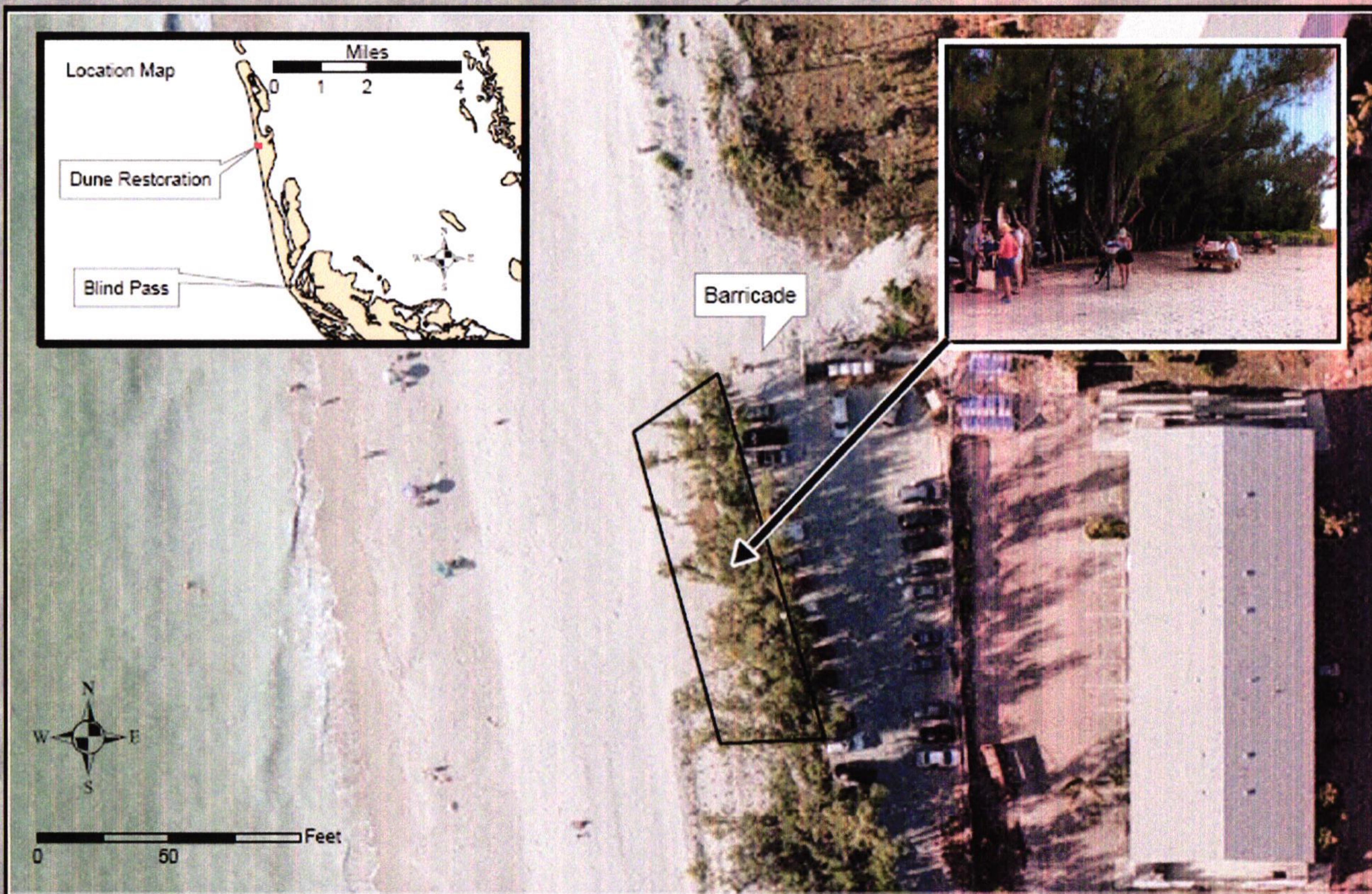


Resource Impact Areas

- Seagrass impacts total 0.72 acres
- Mangrove impacts total 0.15 acres.
- Beach elder impacts total 0.24 acres
- Turtle nesting habitat total 1.3 acres.

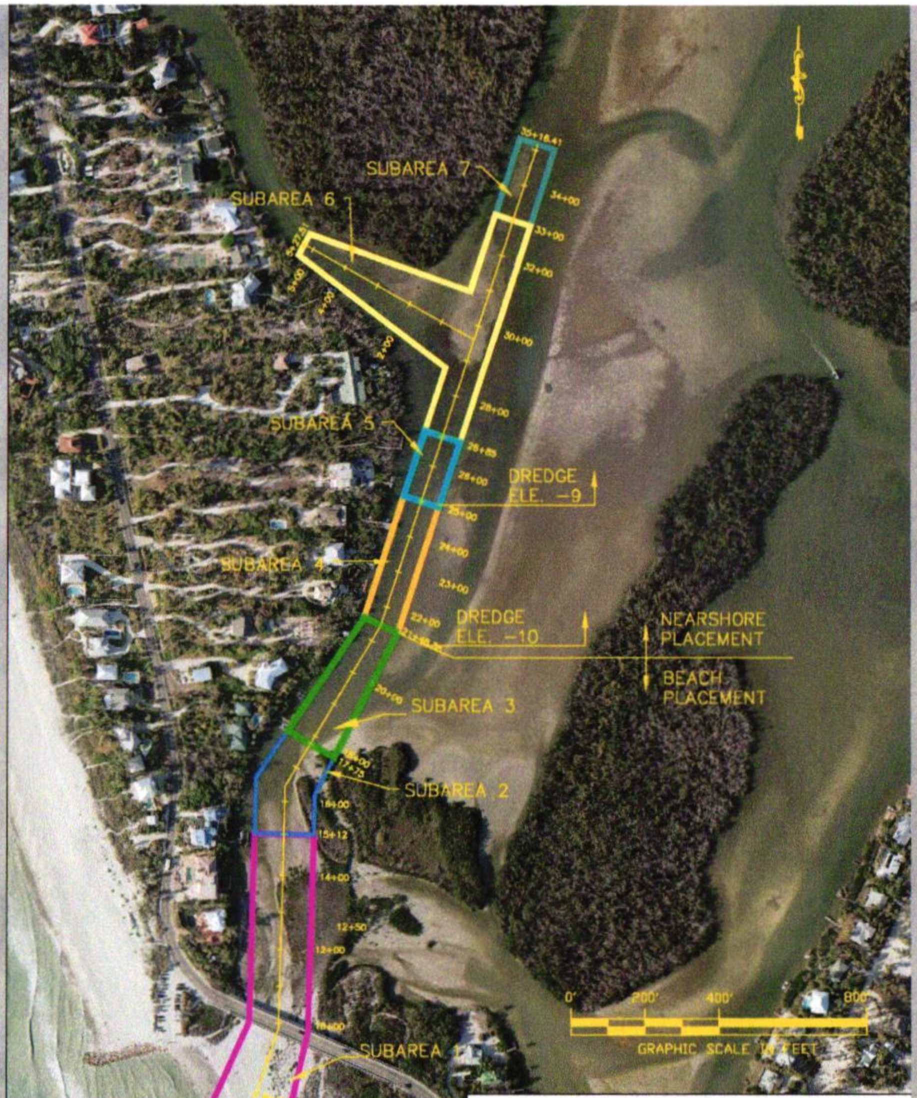
Sea Turtle Mitigation

Sea Turtle Mitigation



Mangrove Planting

Additional Mangrove Planting

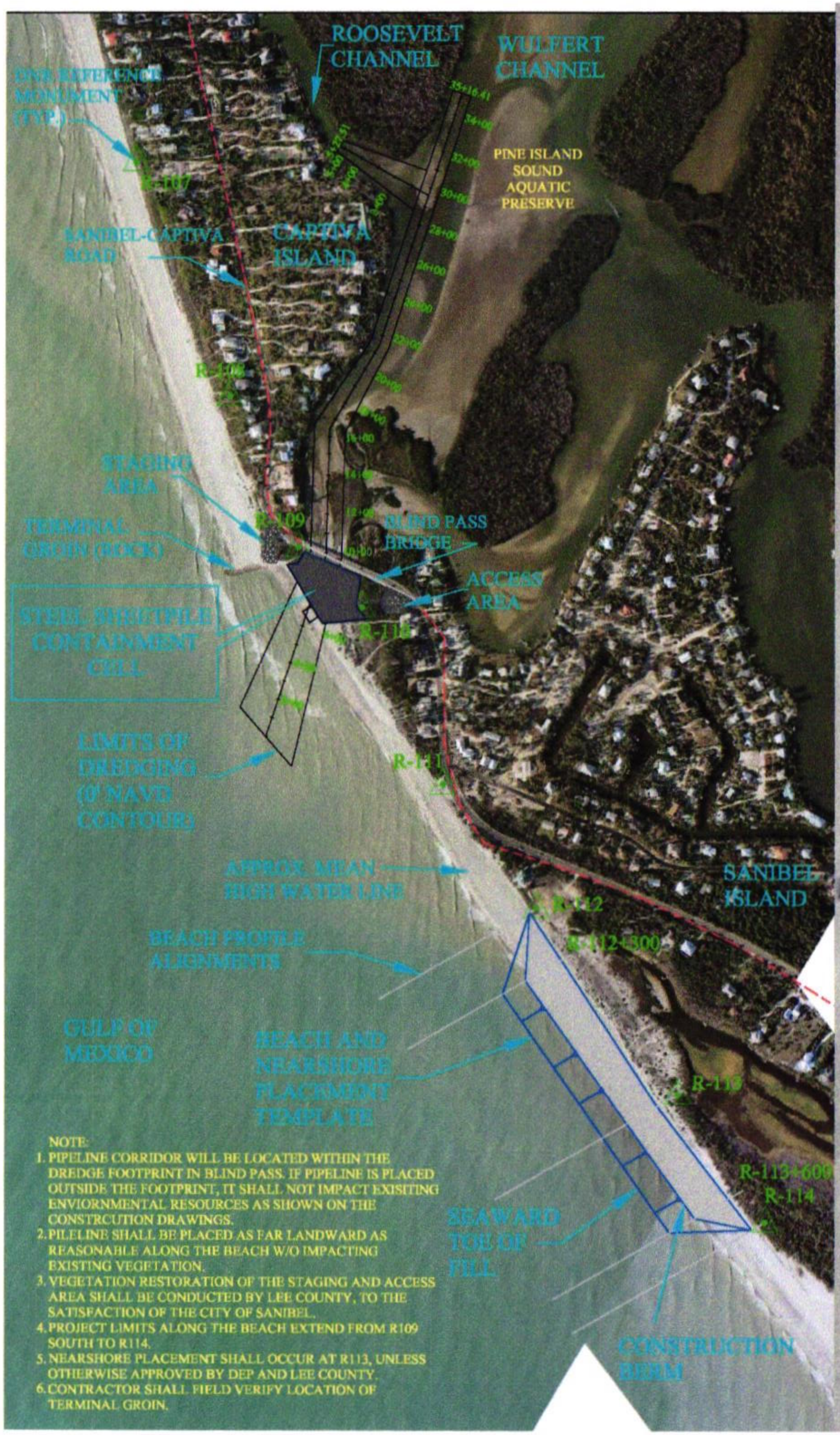


SUB AREA	STATION LIMITS	DREDGE ELEVATION	THRESHOLD ELEVATION
1	0+00 - 15+12	-11	N/A
2	15+12 - 17+75	-11	-9
3	17+75 - 21+48	-11	-7
4	21+48 - 25+00	-10	-7
5	25+00 - 26+85	-9	-7
6	26+85 - 33+00	-9	N/A
7	33+00 - 35+16.41	-9	-7

NOTES:
1. ELEVATIONS REFERENCE NAVD88.
2. ALL MATERIAL BELOW THRESHOLD ELEVATIONS SHALL BE DISPOSED IN AN APPROVED UPLAND FACILITY.
3. MATERIAL ABOVE THE THRESHOLD ELEVATION IN SUBAREAS 1-3 SHALL BE PLACED ON THE BEACH.
4. MATERIAL ABOVE THE THRESHOLD ELEVATION IN SUBAREAS 4-7 SHALL BE PLACED IN THE NEARSHORE.
5. CORE STRATUMS ARE IN FEET AND REFERENCE NAVD88 ELEVATIONS.
6. DREDGE ELEVATIONS ARE THE MINIMUM (DEEPEST) DREDGE ELEVATIONS ALLOWABLE BY PERMIT.

Project Footprint

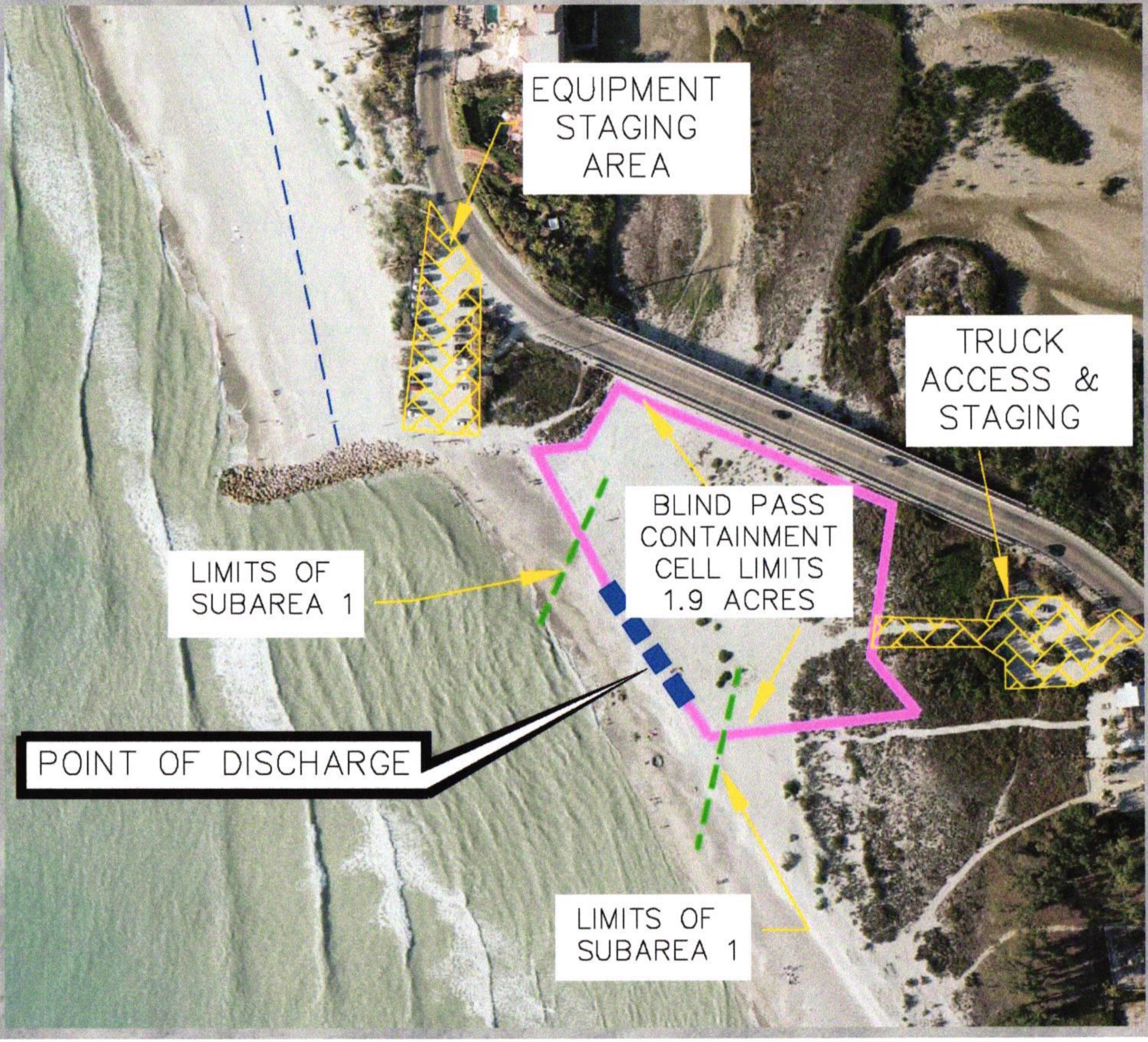
- Seven sub areas identified due to sediment concerns.
- 127,000 total cubic yards to be removed.
  - 10,275 to be disposed upland.
  - 32,359 to be placed in the nearshore zone.
  - 80,039 to be placed directly on the beach.



Beach Fill Area

- Beach and Nearshore Placement will occur between R112 and R114.
- Average Shoreline Extension 100 ft.
- Approx. 500ft of beach will be closed to public at any one time.

Special Sediment Handling



Project Goals

- Provide a stable pass opening with a 5 Year maintenance schedule
- Increase water circulation in Clam & Dinkins Bayou (4 Day Flushing Cycle in Clam Bayou)
- Improve habitat for Mangroves, Seagrasses, Shorebirds, Benthic Invertebrates, and Fisheries.
- Enhance recreational opportunities in the Pass and along the adjacent beach on Sanibel Island.
- Supplement storm protection along Sanibel Island and Bowmans Beach.
- Continue a long term management program to maintain Blind Pass and the surrounding ecosystem.

Remaining Tasks

- Permitting
- Establishment of the Wulfert Flats No Motor Zone
- Contractor Selection

Current Status (Permitting)

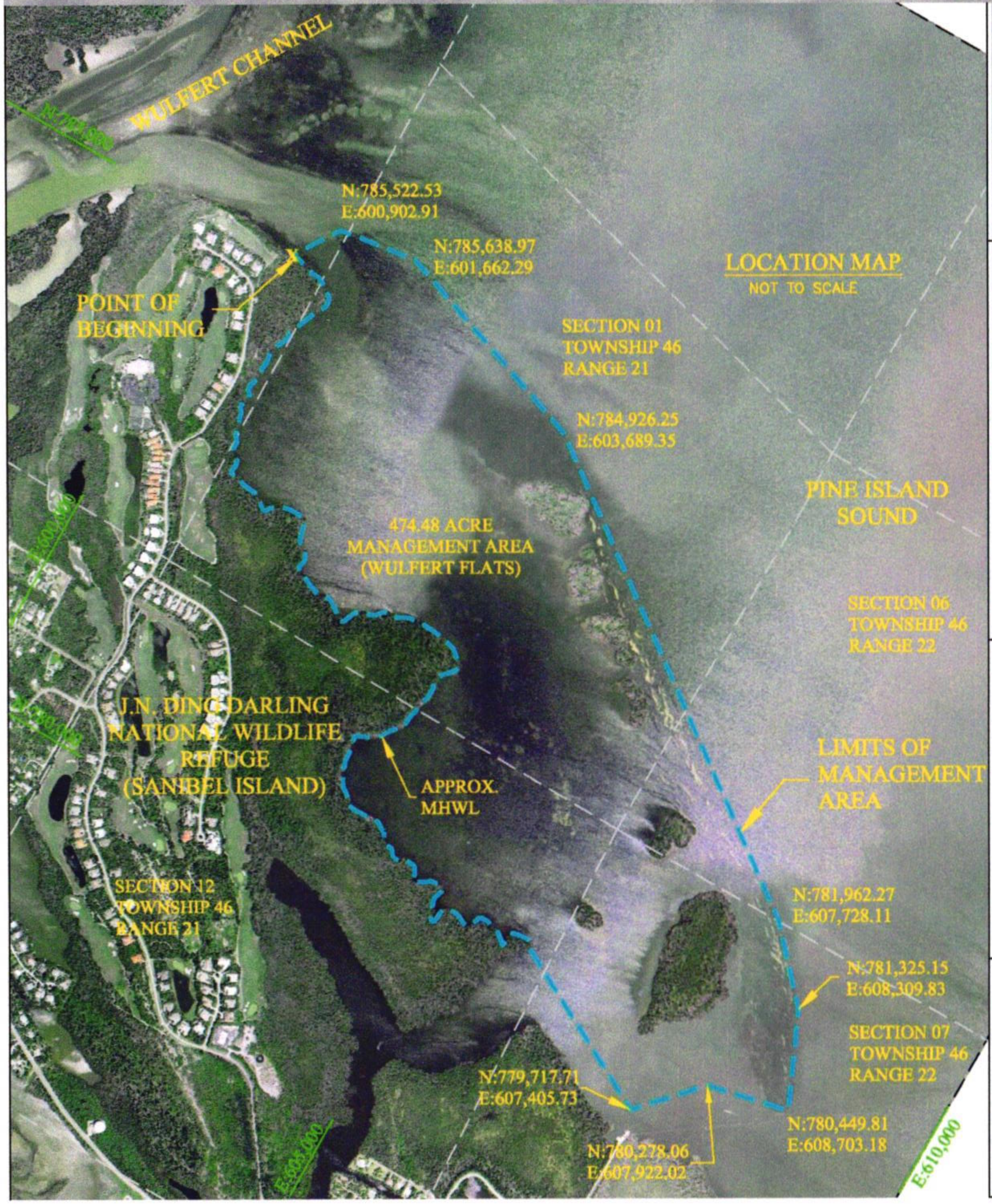
- FWS Biological Opinion (BO) Issued on March 21, 2008.
- DEP Permit issued on June 6, 2008.
- Lee County requested a modification to the construction techniques on May 8th. State (DEP) approval provided on May 22nd . Federal approval and permit anticipated in July.

Current Status
(No Motor Zone)

Lee County, Ding Darling NWR, and DEP continue work to establish the NMZ in Wulfert Flats. Resolution expected in August. Current Activities are as follows:

- Legal Notices of DEP's intent to grant a lease to Lee County for the NMZ sent on May 23rd. (Property Owners w/n 500 ft)
- Completion of NWR Management Plan expected in June.
- DEP issuance of lease expected in July.
- Management Agreement between Lee County and NWR expected in August.

No Motor Zone



- 474 Acre Zone
- Trolling motors will be allowed
- Zone established for Seagrass Restoration

Current Status (Contractor Selection)

Construction is anticipated to begin in September 08. Scheduled activities are as follows:

- Construction documents scheduled for completion by June 30th.
- Request for bids anticipated on June 26th.
- Bid Opening anticipated on July 30th.
- Construction anticipated to begin in September 08.

What to Expect During Construction

- A 6 month construction window
- Closure of both parking lots at Blind Pass (Sanibel and Captiva)
- Closure of the beach in the work area at Blind Pass and the fill area.
- 2 – 5 weeks of trucks moving material from Blind Pass to Ding Darling (December/January)
- Heavy equipment noise on the beach during night-time hours.
- Hydrogen Sulfide odors (rotten eggs)


Questions?
Please contact Robert Neal @ 239.533.8566
or email: rneal@leegov.com

Whats New
Blind Pass
- Blind Pass

Quick Links
Blind Pass Restoration
- Project Description
- Construction Information
- Current Status

Bonita Beach Nourishment
- Project Description
- Construction Information
- Current Status

Estero Island Restoration
- Project Description
- Easements FAQ
- Construction Information
- Current Status

Gasparilla Island
- Project Description
- Construction Information
- Current Status

Lovers Key Restoration
- Project Description
- Construction Information
- Current Status

Mantanzas Pass Maintenance Dredging
- Project Description
- Construction Information
- Current Status

Back to Beaches Homepage

Blind Pass Ecozone Restoration & Sand Bypassing

Photo Provided by: Hans Wilson and Associates

Last Updated 6/18/08

Project Description

The restoration consist of maintenance dredging Blind Pass, Wulfert Channel and portions of Roosevelt Channel. Approximately 127,000 cubic yards (cyds) of material will be removed from the pass and interior waters.

Approximately 127,000 cubic yards (cy) of material from Blind Pass and interior waters, to restore a flushing connection to the Gulf of Mexico). The goals and objectives of the project are as follows:

- Provide a stable pass opening with a 5 Year maintenance schedule
- Increase water circulation in Clam & Dinkins Bayou (4 Day Flushing Cycle in Clam Bayou)
- Improve habitat for Mangroves, Seagrasses, Shorebirds, Benthic Invertebrates, and Fisheries.
- Enhance recreational opportunities in the Pass and along the adjacent beach on Sanibel Island.
- Supplement storm protection along Sanibel Island and Bowmans Beach.
- Continue a long term management program to maintain Blind Pass and the surrounding ecosystem.

The channel alignment will extend from the -10 NAVD contour in the Gulf of Mexico at a maximum width of 330 feet and narrow to 160 feet as it enters into the interior waters. The dimensions reduce further as the alignment traverses into Wulfert Channel. The dimensions of the channel on the interior of the pass maintain an approximate 100 foot width and 8 foot depth.

As an integral part of the restoration, the City of Sanibel intends to install a connection between Dinkins Bayou and Clam Bayou under San-Cap Road. This connection will alleviate inundated mangrove habitats within Clam Bayou.

For Questions or Comments, please contact Robert Neal at Rneal@leegov.com

Whats New
Blind Pass
- Blind Pass

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- Project Description
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Gasparilla Island
- Project Description
- Construction Information
- Current Status

Lovers Key Restoration
- Project Description
- Construction Information
- Current Status

Mantanzas Pass Maintenance Dredging
- Project Description
- Construction Information
- Current Status

Back to Beaches Homepage

General Information

Consultant: Coastal Engineering Consultants, Inc.

Initial Restoration & Sand Bypassing

Date: 10/23/2008

Estimated Start Date:	November 2008
Estimated Completion Date:	May 2009
Contractor:	Energy Resources Inc.
Volume of Sand Placed:	0 cyds
Volume of Sand Remaining:	127,000 cyds

Cost:

Construction Cost	$3.2 Million
State Share	1,000,000
TDC Share (County)	$1,100,000
CEPD Share	$1,100,000

(1)

County Government Information: (239) 332-2737
www.lee-county.com

For Questions or Comments, please contact Robert Neal at Rneal@leegov.com

Joint Coastal Permit to restore Blind
Pass issued by State of Florida on 6/6/08
Federal Permit issued in August 08.

Blind Pass Restoration
Project Update
July 11, 2008

<u>Acronyms:</u>

Agencies of the Florida Department of Environmental Protection (DEP)
BBCS – Bureau of Beaches and Coastal Systems (State);
CHAP –Charlotte Harbor Aquatic Preserve;
FWC – Florida Fish and Wildlife Conservation Commission

Federal Agencies:
USACE – United States Army Corps of Engineers
FWS – U.S. Fish and Wildlife Service
NMFS – National Marine Fisheries (also part of NOAA)

Local Agencies:
CEPD – Captiva Erosion Prevention District
NWR – J. N. Ding Darling National Wildlife Refuge

Other:
RAI – Request for Additional Information
BO – Biological Opinion (issued by FWS through USACE)
JCP – Joint Coastal Permit (State and Federal portions.)
NTP – Notice To Proceed

<u>Items Previously Completed</u>:

- **DEP Permit**

The State permit was issued on June 6, 2008.

- **Biological Opinion**

FWS issued the BO on March 21st

Lee County requested a modification to the BO on June 13. The modification would revise the turtle monitoring conditions of the BO to mirror the conditions of the State permit. The modification was conceptually agreed by FWS staff and is expected to be granted by mid July.

<u>Progress This Month:</u>

- **Contractor Selection**

Lee County began work on the contract documents with the plans and specifications. Coastal Engineering Consultants, Inc. is the design professionals assisting with this task. (The plans were completed on July 7th, and the specifications are expected by July 15th.) The specifications detail the work to be completed by the contractor.

- **No Motor Zone**

The NWR and BBCS continue to work to complete a management plan and lease agreement, respectively, for the "No Motor Zone" in Wulfert Flats. Both must be completed prior to the BBCS issued NTP. The NTP is the BBCS's final approval to begin construction and must come after a contractor is selected. Both agencies are on schedule to accomplish this in adequate time for construction.

<u>Outstanding Items:</u>

- **Federal Permit**

The federal portion of the Joint Coastal Permit is expected by first of August, or 3 weeks after the modification to the BO is finalized.

- **No Motor Zone**

Lee County must document the current condition of the seagrass resources in Blind Pass and Wulfert Flats to establish a "No Motor Zone". This work began the week of July 4th, with aerial photography scheduled for July 18th. Analysis of the data will take 1 month. The "No Motor Zone" must be completed prior to the beginning of construction.

Lee County, BBCS and NWR must collectively finalize a lease agreement and management plan to establish the No Motor Zone over Wulfert Flats. This is on schedule to be completed by mid-September. Construction can not begin prior to the establishment of this item.

- **Contractor Selection**

Bids solicitations are expected to be advertised on July 25th in order to facilitate construction beginning in October. (This item has been delayed to resolve some construction specifics dealing with the upland disposal of the clay material.)

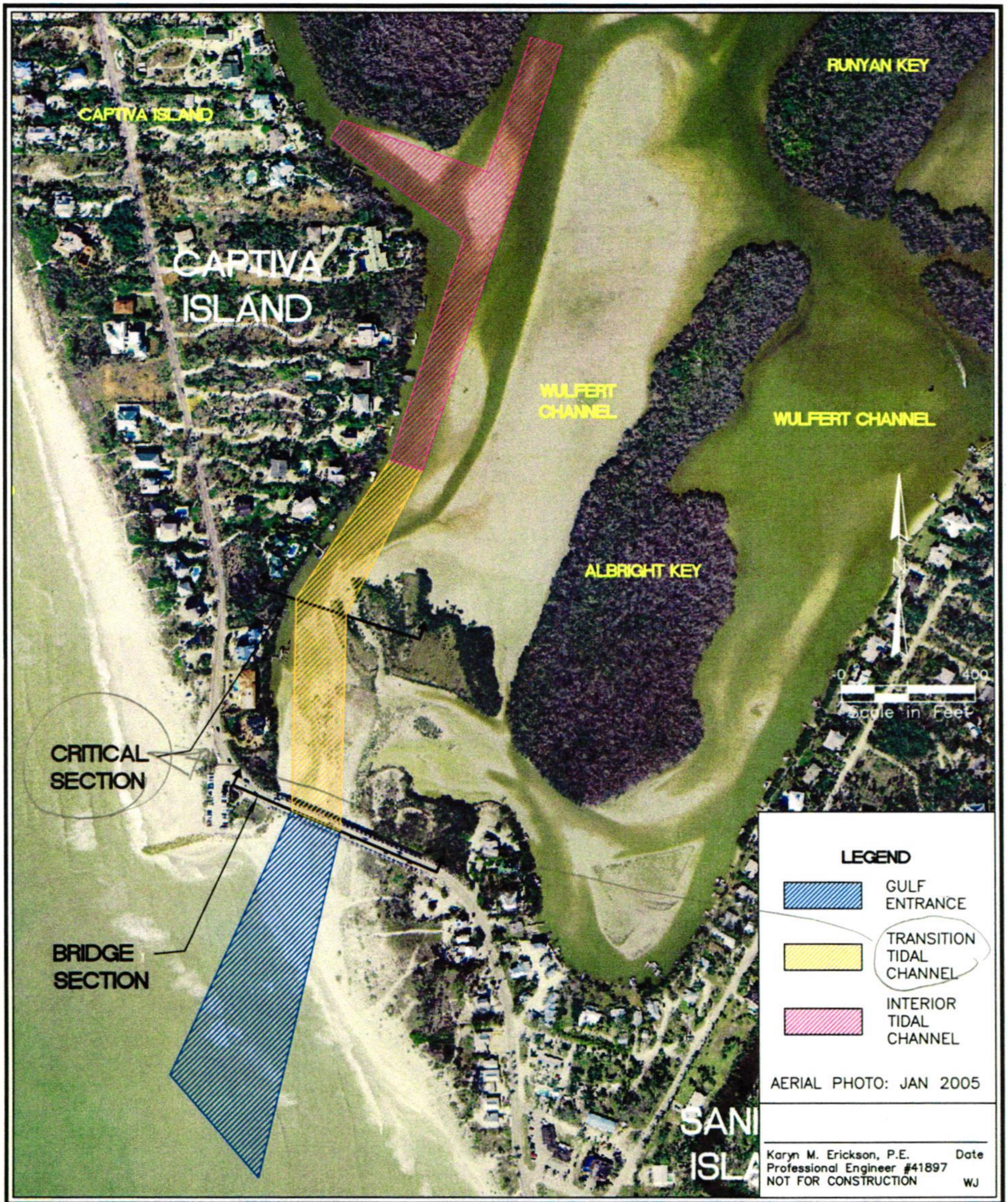
- **Funding**

State funding for the project is expected to be secured in July. Anticipated costs have increased due to the sediments special handling requirements and rise in fuel costs.

- **Schedule**

The schedule continues to progress but has slipped approximately 1 month. The delays have been necessary for review and implementation of recommended alternatives for construction.

:ADD_Graphics\Blind Pass Restoration\Planning & Permitting\Preferred Design\C Plan View Preferred Design.dwg 4/28/2006 2:53:52 PM EDT



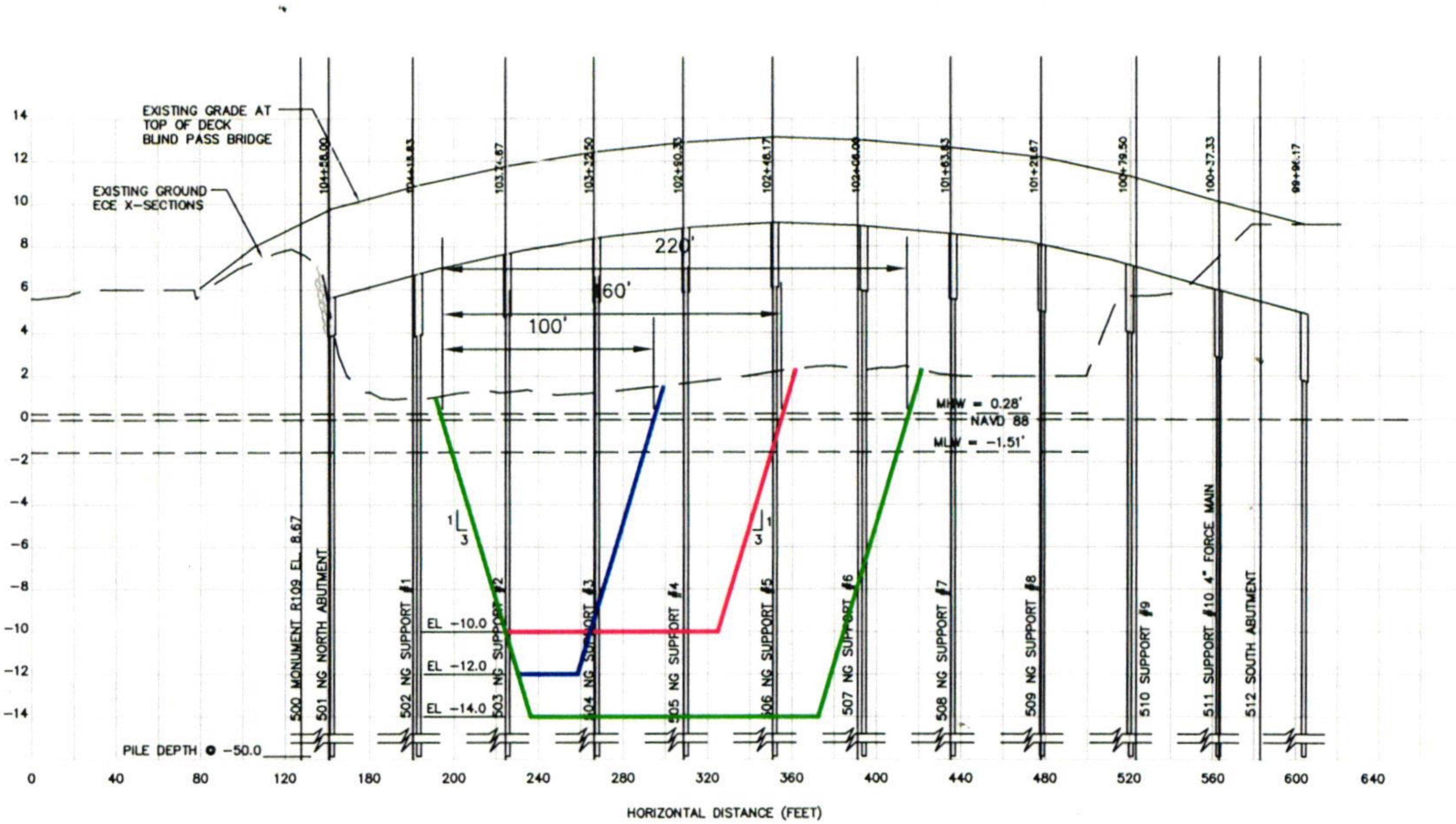
ECE
Erickson Consulting Engineers
1819 Main St., Suite 402
Sarasota, FL 34236
(941) 952-0487

FIGURE 3-1 GENERAL PLAN VIEW OF CHANNEL ALTERNATIVES

Blind Pass Restoration
Lee County, Florida

REVISIONS

PROJECT 05129	CHECKED BY
DATE 04/28/06	DRAWN BY JE
SCALE Scale	SHEET: 1 of 1



CHANNEL SECTION AT EXISTING BRIDGE

SCALE: HORIZ. 1"=80 FEET
VERT. 1"= 8 FEET

NOTES:

1. CHANNEL CROSS SECTIONS BASED ON SURVEY BY MCKIM AND CREED, MAY 2005. ELEVATIONS IN FEET, NAVD 88.

2. BRIDGE PROFILE TAKEN FROM RECORD DRAWINGS B-2, B-6 & B-7, BLIND PASS BRIDGE REPLACEMENT, DATED FEB. 26, 1991 BY JENKINS & CHARLAND, INC.

LEGEND:

ALTERNATIVE A

ALTERNATIVE F

ALTERNATIVE H

ECE Erickson Consulting Engineers
1819 Main St., Suite 402
Sarasota, FL 34236
(941) 952-0487

FIGURE 3-2 CROSS SECTIONS AT BRIDGE LOCATION

Blind Pass Restoration
Lee County, Florida

REVISIONS

PROJECT 05-129 CHECKED BY JG

DATE 04/28/06 DRAWN BY JE

SCALE As Shown SHEET: 1 of 1

Karyn M. Erickson, P.E. Date
Professional Engineer #41897
NOT FOR CONSTRUCTION