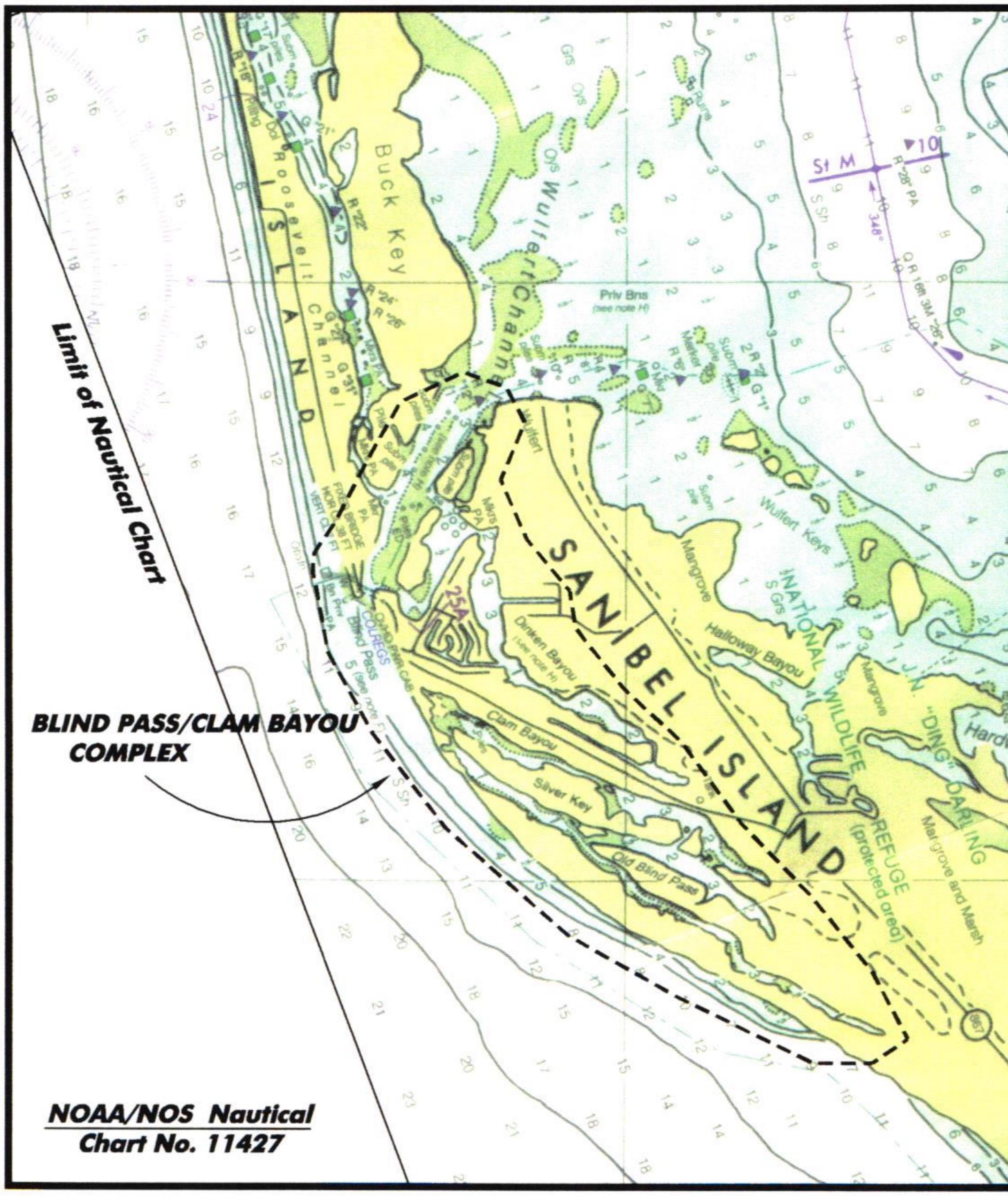
BLIND PASS ECO-ZONE

Feasibility Study

June 2003



Prepared for: Lee County, City of Sanibel and Captiva Erosion Prevention District

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Blind Pass Eco-zone Project Description

Introduction - The Blind Pass Eco-zone is an area comprised of Wulfert Channel, Roosevelt Channel, Dinkins Bayou, Sunset Bay (adjacent to Albright Key), and Clam Bayou. With the closure of Blind Pass and tidal channel to Clam Bayou, significant environmental damage has occurred in Clam Bayou, and water quality conditions in Dinkins Bayou are degraded.

The Blind Pass Eco-zone Feasibility Study, completed in June 2003 by Hans Wilson & Assoc.. Inc., evaluated existing conditions and developed alternatives to improve Clam Bayou, Dinkins Bayou, and Blind Pass. Sponsored by the City of Sanibel, the Captiva Erosion Prevention District, and Lee County, the study recommended making a tidal connection between Clam Bayou and Dinkins Bayou, and discussed alternatives to improve tidal connections to the Gulf of Mexico. Based on the hazard mitigation and stakeholder discussions in the report, and by direction via formal motion by the Sanibel City Council, the proposed project would include re-opening Blind Pass to maximize the flushing benefit to both Clam Bayou via the flushing channel, and Dinkins Bayou.

Subsequent modeling runs completed by Erickson Consulting Engineers fine tuned the proposed design to address constrictions in the tidal channel connecting Blind Pass with Dinkins Bayou. In addition, the model runs also looked at the tidal prism through Blind Pass, and the flow necessary to keep the pass open and stable. The final result of the modeling (Alternative 8) is a recommendation to improve the tidal channel through Wulfert Channel to Pine Island Sound, including side channel to Roosevelt Channel and the south side of Albright Key.

Work Scope - The proposed project is broken down into three areas. Work within Blind Pass, work connecting Dinkins Bayou and Clam Bayou, and work within Clam Bayou.

Blind Pass - As discussed in the second generation of modeling runs, the principal criteria is to improve the tidal prism into Dinkins Bayou and assure the stable opening of Blind Pass though enhance tidal prism. Alternative 8, as discussed in Appendix A to the feasability study, provides the best solution to meeting these goals.

The proposed construction consists of dredging the following tidal channels (all depths reference N.G.V.D.)

Blind Pass - Entrance from the Gulf of Mexico to the Bridge: -8'; 250' wide to 200' wide.
- Bridge to 200' interior: -8'; narrowing from 200' to 150' wide.
- East of Dinkins Bayou entrance, narrow from 150' wide to 100' wide. shallow from -8' to -6'.

Roosevelt Channel - Wulfert Channel north; 6' deep by 50' wide.
Albright Key Channel - South of Blind Pass; 6' deep by 50' wide.
Dinkins Bayou entrance - South of Wulfert channel; 6' deep by 50' wide.

The extremes of the flushing channels in Dinkins Bayou, Roosevelt Channel, and the Albright Key channel will taper up from the -6' design depth to ambient grade within a 100' reach.

Disposal of beach compatible materials will be on the north side of the jetty extending from Turner Beach. This is to assist in the creation of the ebb tidal shoal for sand bypassing to the down drift beaches. Material that is not beach compatible will be trucked or barged off site to a suitable disposal location.

Clam Bayou/Dinkins Bayou Flushing Channel - The design for the flushing channel remains essentially the same as proposed in the feasibility study. The channel extends southeast of the artificially excavated basin at the headwaters of Dinkins Bayou. The channel is 3.5' deep by 30' wide by 250' long before it makes a right angle turn into the land. The outside perimeter of the channel will be lined with riprap to address scouring from storm events. The channel continues across the mainland, underneath Sanibel Captiva Road, retaining the -3.5' NGVD controlling depth, and 30' clear width. A 30' wide box culvert or bridge is proposed to cross the flushing culvert. The width of the flushing channel flares out on both sides for a 25' width. The purpose for the flair is to accommodate storm surge events where the increase in the discharge velocity through the channel is mitigated by the widening the channel. Mangroves are proposed for this area for stabilization of the substrate. The total length of the channel across the upland is 520'. The depth at each end matches the natural grade in both waterbodies.

Clam Bayou Interior Connection Channel - Results of the modeling study indicated that a "short cut" through Clam Bayou would substantially improve flushing into the dead end portion of Clam Bayou. This is essential in meeting the state's preference, as outlined in Chapter 40E of the Florida Administrative Code - Basis of Review parameters, for water bodies to flush in a 3 to 4 day cycle. This channel significantly shortens the travel time for a particle of water to get from the Bowmans Beach/East Clam Bayou area to the Flushing Channel.

The interior channel consists of excavating a channel that is 50' wide by 5' deep, short circuiting the travel time to the east end of Clam Bayou. This channel would be 500' long, removing material from within 400' of a submerged section of the Bayou that averages about -2' in depth. The remaining 100' would require removal of a shell berm that forms the upland, at an elevation of approximately 3.5'. The location of the Connection Channel is depicted on the Clam Bayou East plan, revised, in Appendix A.

Appendix A
Additional Model Simulations to Evaluate Improvements at Blind Pass and Clam Bayou

Alternative 6 – Blind Pass Open with Wulfert Channel Dredging and Dinkins/Clam Flushing Channel

Similar to Alternative 1, Alternative 6 would include a flushing channel between Dinkins Bayou and Clam Bayou. It would also re-open the tidal channel at Blind Pass to -8 ft (NGVD) between the Gulf of Mexico and Wulfert Channel to improve circulation, flushing, and to convey elevated freshwater flows out of both Dinkins and Clam Bayous. It also includes deepening of Wulfert Channel to 6 ft (NGVD). **Figure IX-26** provides a graphic representation of the model grid layout for this alternative.

As seen in **Figures IX-23 to IX-25**, model simulations show a 15 percent increase in velocity in a comparison of Alternative 7 to Alternative 5 for locations within Dinkins and Clam Bayous. The most marked increase in velocity is seen at Locations 1 and 3 in Dinkins Bayou and Location 4 in Clam Bayou. The greatest increase in maximum velocities in Dinkins Bayou and Clam Bayou, in a comparison of Alternative 7 to 5, is seen where the velocities increased from 2.5 to 2.8 ft/sec at Location 3 and from 0.2 to 0.3 ft/sec at Location 4. Location 4 is within the center water body of Clam Bayou therefore, velocity and flushing values indicate average conditions within Clam Bayou.

As presented in **Figures IX-21 and IX-22**, Alternative 7 flushing conditions were run for the case of a 100% mass concentration in Clam Bayou (Alternative 7) and compared to the flushing conditions for Alternatives 1b and 5(b). Flushing associated with this alternative indicates that, over a 5 day period, the mass concentration decreases to 60% indicating that 40% of the water within Clam Bayou will be moved out of the Bayou and into Dinkins Bayou. Extrapolating these flushing conditions will result in a total water exchange of 10 to 12 days (i.e. Bayou to reach a 10 percent of original water). Further, these results indicate that additional improvements to the flushing channel dimensions (culvert) and, interior connections within Clam Bayou, will further increase flow rates and improve flushing times. For this reason, the changes between Alternative 5 and 7 (although modest), indicate that the constrictions and time of travel necessitate adjustments in the culvert cross-sectional area and interior connections within Clam Bayou to achieve significant reductions in flushing times..

Alternative 7 – Blind Pass Open with Wulfert Channel Dredging and Clam/Dinkins Bayou Flushing Channel Widened.

A widened flushing channel (60 ft as compared to 30 ft) between Dinkins Bayou and Clam Bayou distinguishes Alternative 7 from the previously discussed Alternative 6 design configuration. As in Alternative 6, the inlet channel at Blind Pass would be reopened to a depth of 8 ft (NGVD) between the Gulf of Mexico and Wulfert Channel.

As discussed previously, the purpose of the re-opened inlet is to provide improvements to circulation and flushing, and to convey elevated freshwater flows out of both Dinkins and Clam Bayous. It also includes deepening of Wulfert Channel to 6 ft (NGVD) to provide an increase in the tidal prism through the inlet, thus enhancing inlet stability.

As seen in **Figure IX-30 to IX-32**, model simulations show a 7 to 18 percent increase in velocity in a comparison of Alternative 7 to Alternative 6 for locations 3 and 4 within Dinkins and Clam Bayous. The most marked increase in velocity is seen at Location 3 in Dinkins Bayou where the maximum velocities in Dinkins Bayou and Clam Bayou, increased from 3.0 to 3.5 ft/sec at Location 3 and from 0.27 to 0.29 ft/sec at Location 4. Location 4 is within the center water body of Clam Bayou.

As presented in **Figures IX-27 and IX-29**, Alternative 7 flushing conditions were run for the case of a 100% mass concentration in Clam Bayou (Alternative 7) and compared to the flushing conditions for Alternatives 6 and 1b. Flushing associated with this alternative indicates that, over a 5 day period, the mass concentration decreases to 61%, indicating that 39% of the water within Clam Bayou Location 4 will be moved out of the water body/finger of the Bayou. Similarly, the mass concentration decreases to 84%, indicating that 16% of the water within Clam Bayou Location 5 will be moved out of the backwaters of the Bayou. Extrapolating these flushing conditions indicates a total water exchange of 10 to 12 days (i.e. Bayou to reach a 10 percent of original water). Further, these results indicate that additional improvements to the interior connections within Clam Bayou should be evaluated to determine if flow rates and flushing times can be improved (i.e. proposed Alternative 8). For this reason, the changes between Alternative 6 and 7 (although modest), indicate that the constrictions and time of travel requires adjustments in the interior connections within Clam Bayou to achieve a greater (i.e. more significant) reduction in flushing time.

Alternative 8 – Blind Pass Open with Wulfert Channel Dredging, Dinkins/Clam Bayou Flushing Channel, with a Clam Bayou Interior Channel.

Alternative 8 would add an interior flushing channel within the backwaters of Clam Bayou. An interior channel connection within Clam Bayou (width of 50 ft) would be constructed by excavating the end of an existing natural embayment within the Bayou that is situated near Location 5. This connection is the only design change that distinguishes Alternative 8 from the previously discussed Alternative 6 (Dinkins/Clam Flushing Channel @ 30'). As in Alternative 6, the inlet channel at Blind Pass would be reopened to a depth of 8 ft (NGVD) between the Gulf of Mexico and Wulfert Channel.

As discussed previously, the purpose of the reopened inlet is to provide improvements to circulation and flushing and to convey elevated freshwater flows out of both Dinkins and Clam Bayous. It also includes deepening of Wulfert Channel to 6 ft (NGVD) to provide an increase in the tidal prism through the inlet thus enhancing inlet stability.

Model simulations show only minimal increases in velocity in a comparison of Alternatives 8 to Alternative 6 and 7 for location 5 within Clam Bayou (refer to **Figures IX-31 to IX-32**). Flushing associated with this alternative indicates that, over a 5 day period, the mass concentration decreases to 61% indicating that 39% of the water within Clam Bayou Location 4 will be moved out of the water body/finger of the Bayou (**Figures IX-27 and IX-29**). More marked changes are shown to occur at Location 5, where the mass concentration decreases to 71% over a 5 day period, indicating that 29% of the water within the backwaters of Clam Bayou will be flushed. This alternative provides a 15% improvement in flushing when compared to Alternative 7 for the water bodies that comprise Clam Bayou. Extrapolating these flushing conditions will result in a total water exchange of 8 to 10 days (i.e. Bayou to reach a 10 percent of original water). These results indicate significant improvements in flushing for the proposed interior connection within Clam Bayou would result from the construction of Alternative 8.

Alternative 9 – Blind Pass Open with Wulfert Channel Dredging, Dinkins/Clam Bayou Flushing Channel Widened, with an Interior Connection Channel in Clam Bayou

Alternative 9 includes the design features of Alternatives 7 and 8, by both constructing a widened (60 ft) flushing channel between Dinkins Bayou and Clam Bayou, and an interior channel connection within the backwaters of Clam Bayou. It also reopens the tidal channel at Blind Pass to -8 ft (NGVD) between the Gulf of Mexico and Wulfert Channel to improve water exchange, circulation, and flushing to interior water bodies surrounding the Blind Pass and Clam Bayou Eco Zone. **Figure IX-33** provides a graphic representation of the model grid layout for this alternative.

As seen in **Figures IX-31 to IX-32**, model simulations show the greatest maximum velocities at Locations 3, 4 and 5, with Alternative 7 and 9 showing the comparable values. The most marked increase in velocity is seen at Locations 1 and 3 in Dinkins Bayou and Location 4 in Clam Bayou. The greatest increase in maximum velocities in Dinkins Bayou and Clam Bayou, in a comparison of Alternative 9 to 8, is seen where velocities increased from 2.5 to 3.2 ft/sec at Location 3 and from 0.27 to 0.35 ft/sec at Location 4.

Alternative 9 flushing conditions (**Figures IX-27 and IX-29**) were run for the case of a 100% mass concentration in Clam Bayou (Alternative 9) and compared to the flushing conditions for Alternatives 1b and 6, 7 and 8. Flushing associated with this alternative indicates that, over a 5 day period, the mass concentration decreases to 56% indicating that 44% of the water near Location 4 is exchanged. Similarly, over a 5 day period, the mass concentration decreases to 68% indicating that 32% of the water near Location 5 is exchanged/flushed. Extrapolating these flushing conditions will result in a total water exchange of 8 to 9 days (i.e. Bayou to reach a 10 percent of original water). Alternative 9 (although modest), indicates a nominal improvement in flushing when compared to Alternative 8 as a result of increases in the culvert cross-sectional area and interior connections within Clam Bayou.

Table IX-1a. Description of Additional Hydrodynamic and Flushing Simulation Alternatives (6, 7, 8 and 9) for Blind Pass Eco Zone

Alternative	Description	Flushing Analysis (Mass Concentration)	Plan Design Elements
Alternative 1 **Alternative 1a** **Alternative 1b**	Flushing Channel Connecting Dinkins and Clam Bayou	Clam Bayou (100%) Dinkins Bayou (100%) **Alternative 1a** Dinkins Bayou (100%) Clam Bayou (0%) **Alternative 1b** Dinkins Bayou (0%) Clam Bayou (100%)	• Blind Pass Inlet Channel 8 ft • Clam to Dinkins Bayou Flushing Channel 30 ft • Wulfert Channel 6 ft
Alternative 6	Flushing Channel from Dinkins to Clam Bayou and Blind Pass Open	Clam Bayou (100%) Dinkins Bayou (0%)	• Blind Pass Inlet Channel 8 ft • Clam to Dinkins Bayou Flushing Channel 30 ft • Wulfert Channel 6 ft
Alternative 7	Flushing Channel from Dinkins Bayou to Clam Bayou and Blind Pass Open	Clam Bayou (100%) Dinkins Bayou (0%)	• Blind Pass Inlet Channel 8 ft • Clam to Dinkins Bayou Flushing Channel 60 ft • Wulfert Channel 6 ft
Alternative 8	Flushing Channel from Dinkins Bayou to Clam Bayou and Blind Pass Open with Interior Clam Bayou Connector Channel	Clam Bayou (100%) Dinkins Bayou (0%)	• Blind Pass Inlet Channel 8 ft • Clam to Dinkins Bayou Flushing Channel 30 ft • Clam Bayou Interior Connection Channel 5 ft • Wulfert Channel 6 ft
Alternative 9	Blind Pass Open and a Flushing Channel from Dinkins to Clam Bayou with Interior Clam Bayou Connector	Clam Bayou (100%) Dinkins Bayou (0%)	• Blind Pass Inlet Channel 8 ft • Clam to Dinkins Bayou Flushing Channel 60 ft • Clam Bayou Interior Connection Channel 5 ft • Wulfert Channel 6 ft

Alternative	Description	Flushing Analysis (Mass Concentration)	Plan Design Elements
Alternative 8	Flushing Channel from Dinkins Bayou to Clam Bayou and Blind Pass Open with Interior Clam Bayou Connector	Clam Bayou (100%)	• Entrance Channel (8 ft) • Interior-Connector Channel (6 ft)
Alternative 10	Flushing Channel from Dinkins Bayou to Clam Bayou and Blind Pass Open with Interior Clam Bayou Connector	Clam Bayou (100%)	• Reduced channel width of 25 percent through Inlet Channel • 30 percent channel reduction through Interior – Connector Channel
Alternative 11	Same as Alternative 10	Clam Bayou (100%)	• Increased channel depth of 2 ft for the inlet channel (10 ft) • Increased channel depth of 2 ft for the interior-connector channel (8 ft)
Alternative 12	Same as Alternative 10	Clam Bayou (100%)	•Increased channel depths of 4 ft for the inlet channel (12 ft) • 4 ft for the interior-connector channel (10 ft)
Alternative 13	Same as Alternative 12 with a sand trap (300 ft by 750 ft) located near the entrance to Dinkins Bayou	Clam Bayou (100%)	Same as the above

Averaged discharge

Tidal Prism at Blind Pass

Simulation	Flood (10^6 ft^3)	Ebb (10^6 ft^3)	Ebb/Flood
8	85.0	103	1.21
10	89.5	105	1.17
11	100	116	1.16
12	108	125	1.15
13	109	131	1.21

Discharge into Dinkins Bayou

Simulation	Flood		Ebb		Ratio of Ebb/Flood
	Discharge (10^6 ft^3)	%	Discharge (10^6 ft^3)	%	
8	5.8	6.8	6.3	6.1	1.08
10	5.7	6.4	6.2	5.9	1.09
11	5.0	5.0	5.3	4.6	1.07
12	4.4	4.1	4.7	3.7	1.05
13	4.3	4.0	4.5	3.4	1.04

Discharge into Roosevelt Channel

Simulation	Flood		Ebb		Ratio of Ebb/Flood
	Discharge (10^6 ft^3)	%	Discharge (10^6 ft^3)	%	
8	27.5	32.3	26.3	25.6	0.96
10	26.3	29.4	24.6	23.5	0.94
11	24.5	24.5	23.9	20.7	0.97
12	22.5	20.8	22.6	18.1	1.01
13	23.2	21.4	24.8	18.9	1.07

Discharge into Wulfert Channel

Simulation	Flood		Ebb		Ratio of Ebb/Flood
	Discharge (10^6 ft^3)	%	Discharge (10^6 ft^3)	%	
8	51.7	60.8	70.2	68.3	1.36
10	57.5	64.2	74.0	70.6	1.29
11	70.8	70.8	86.5	74.7	1.22
12	81.3	75.1	97.6	78.1	1.20
13	80.0	74.7	102	77.7	1.26

Note: Assumed that flood/ebb at Blind Pass is 100% for each simulation.
Flood – flow coming from Gulf
Ebb – flow going to Gulf

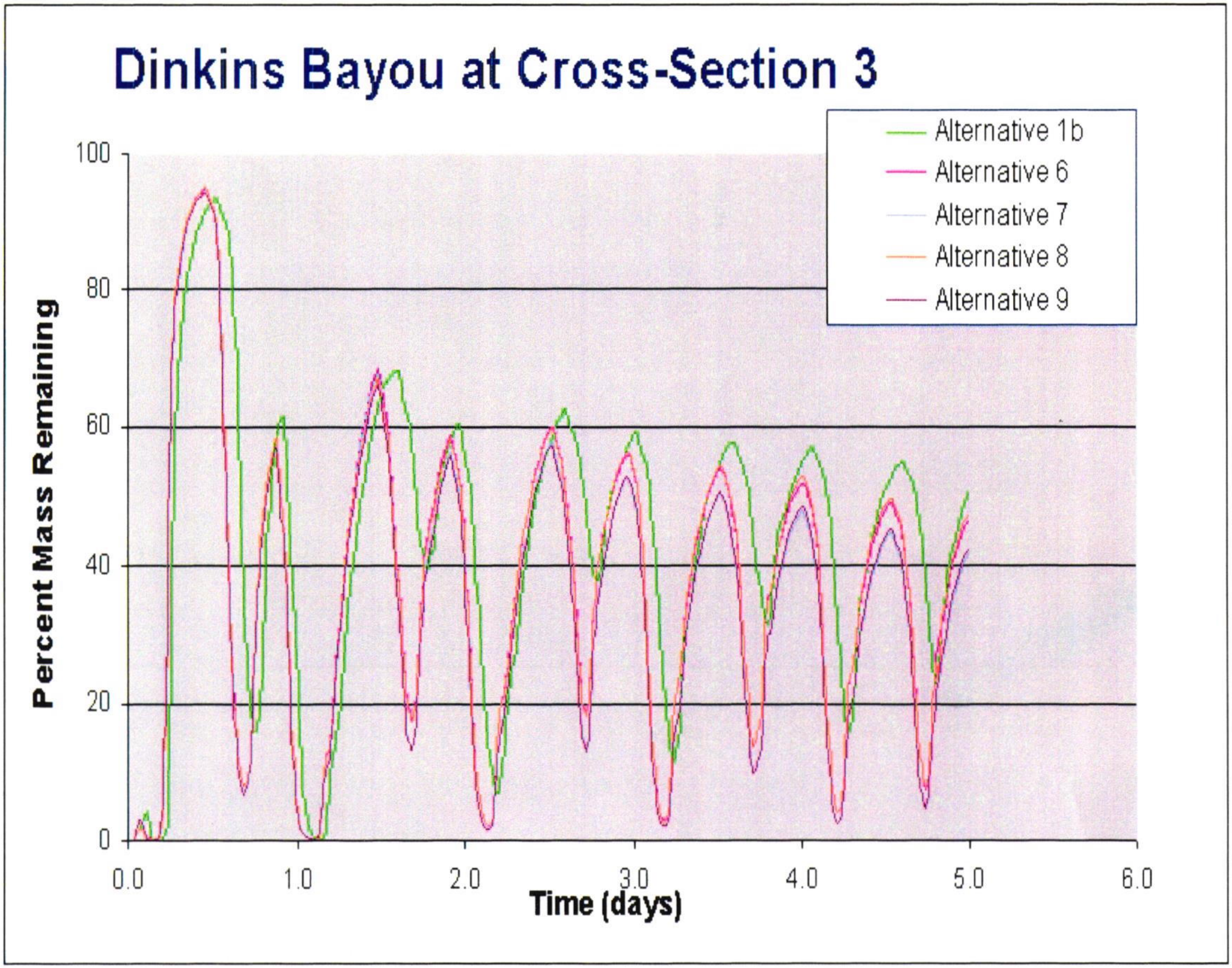

Figure IX-27
Comparison of Flushing over Time at Location 3 for the Proposed Alternatives

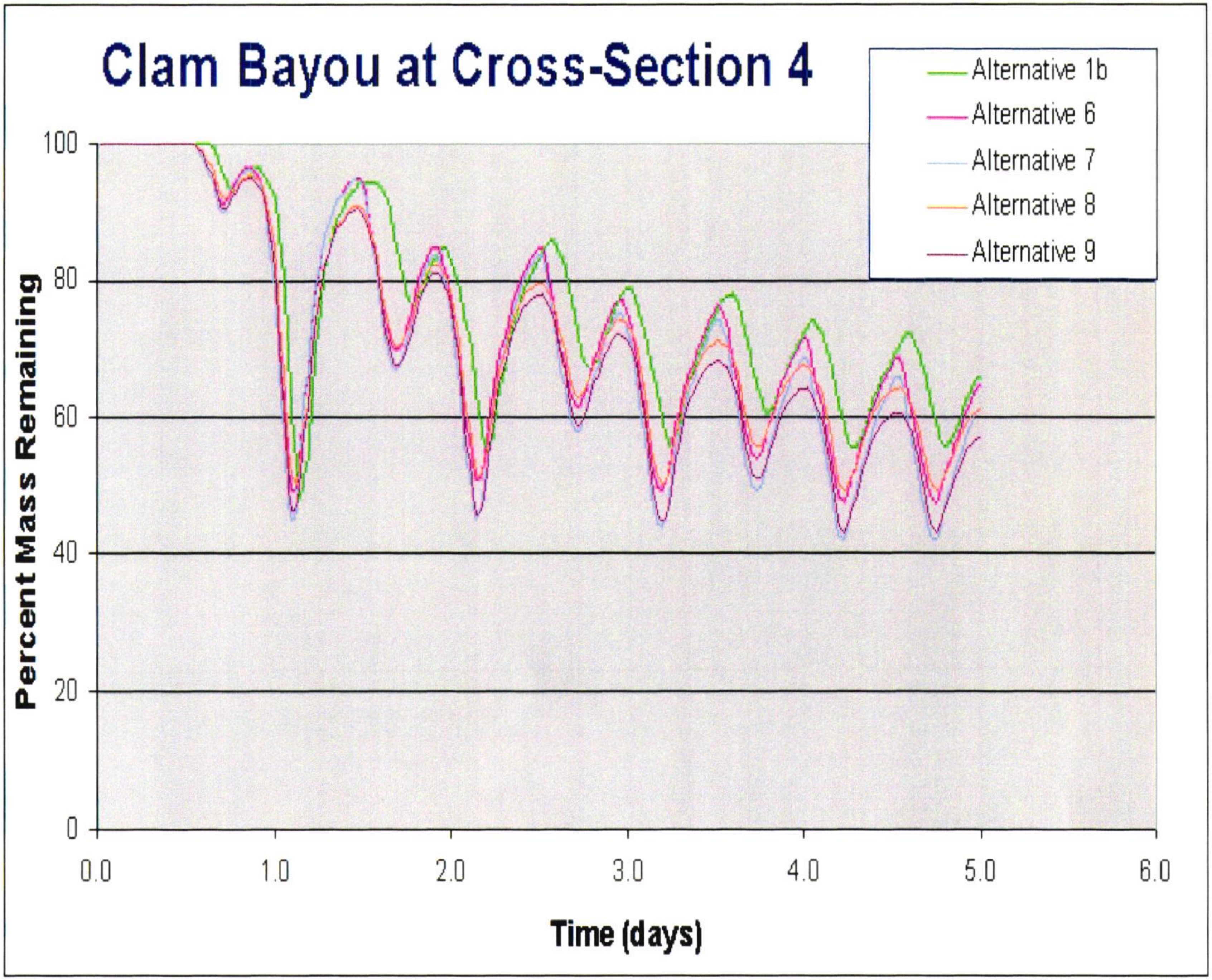

Figure IX-28
Comparison of Flushing over Time at Location 4 for the Proposed Alternatives

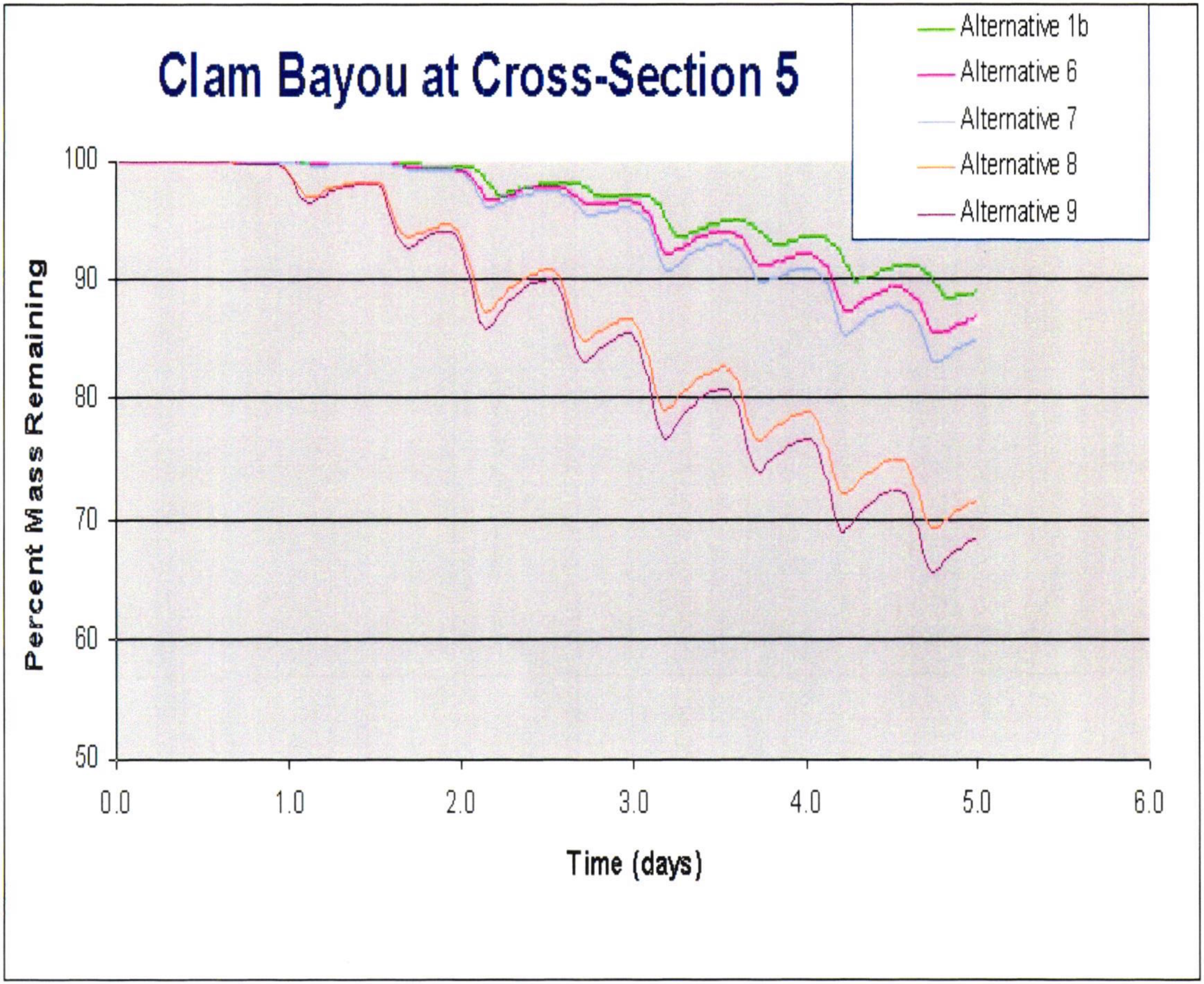

Figure IX-29
Comparison of Flushing over Time at Location 5 for the Proposed Alternatives

Erickson Consulting Engineers

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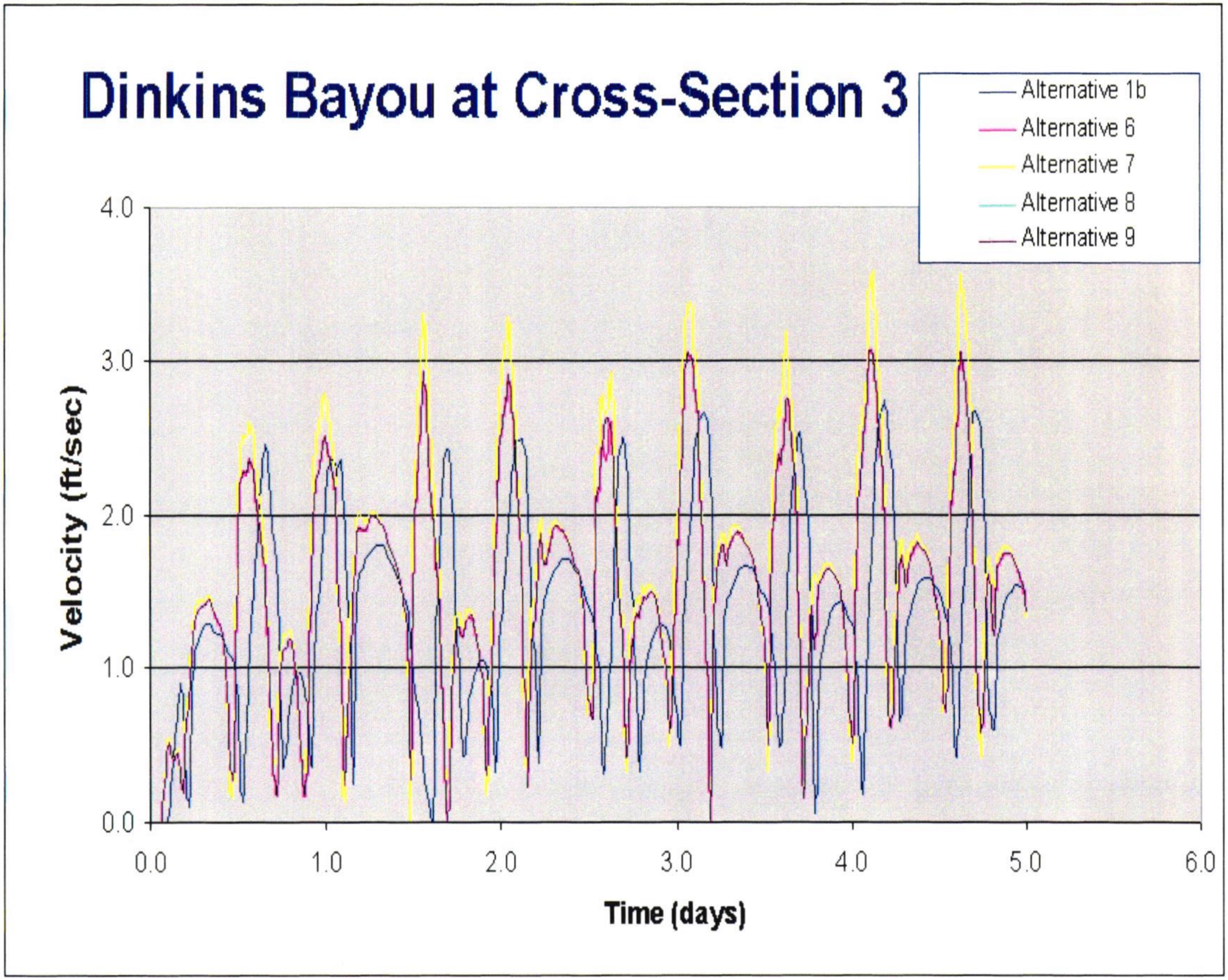

Figure IX-30
Comparison of Tidally-Induced Velocities at Location 3 for the Proposed Alternatives

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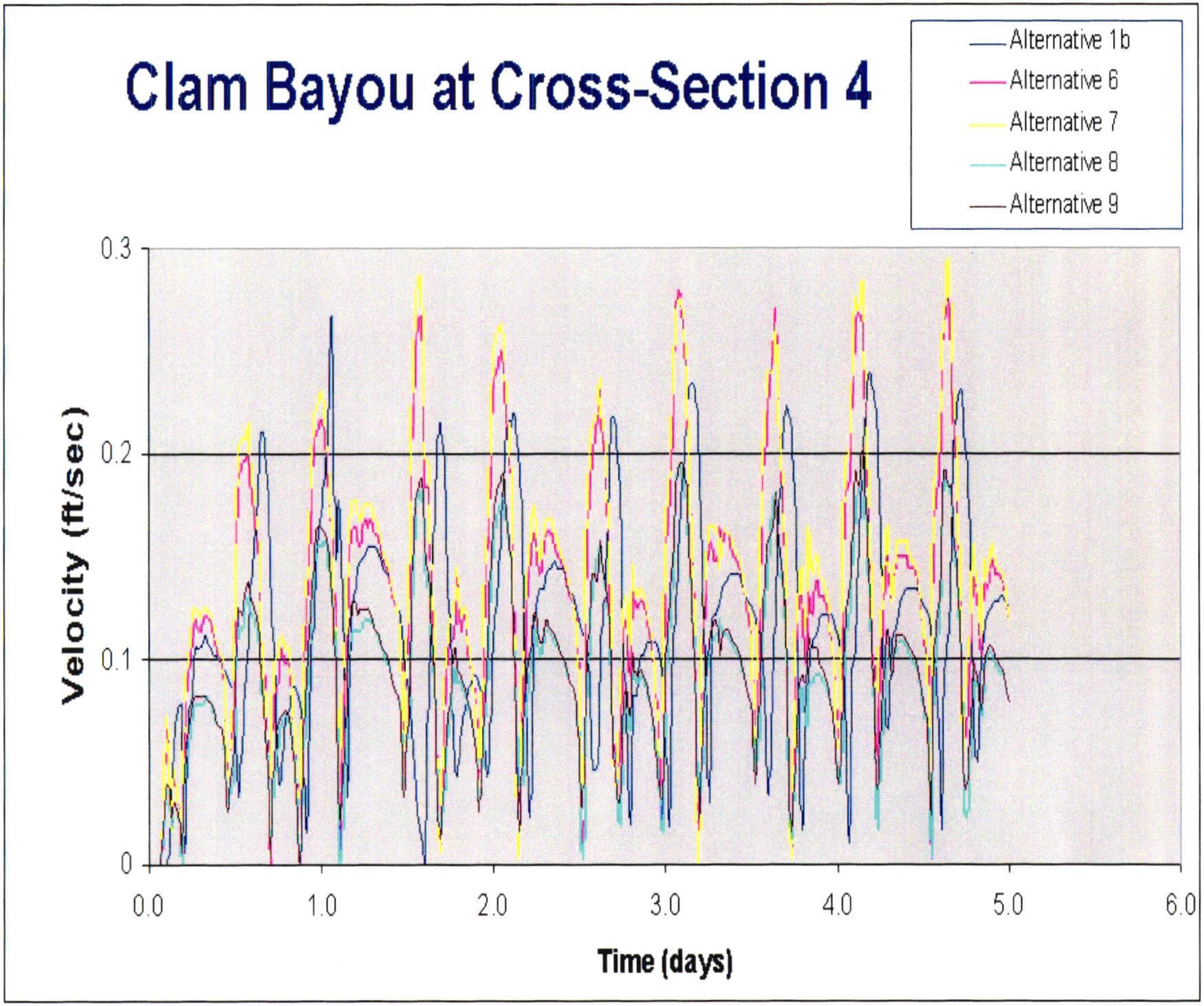


Figure IX-31
Comparison of Tidally-Induced Velocities at Location 4 for the Proposed Alternatives

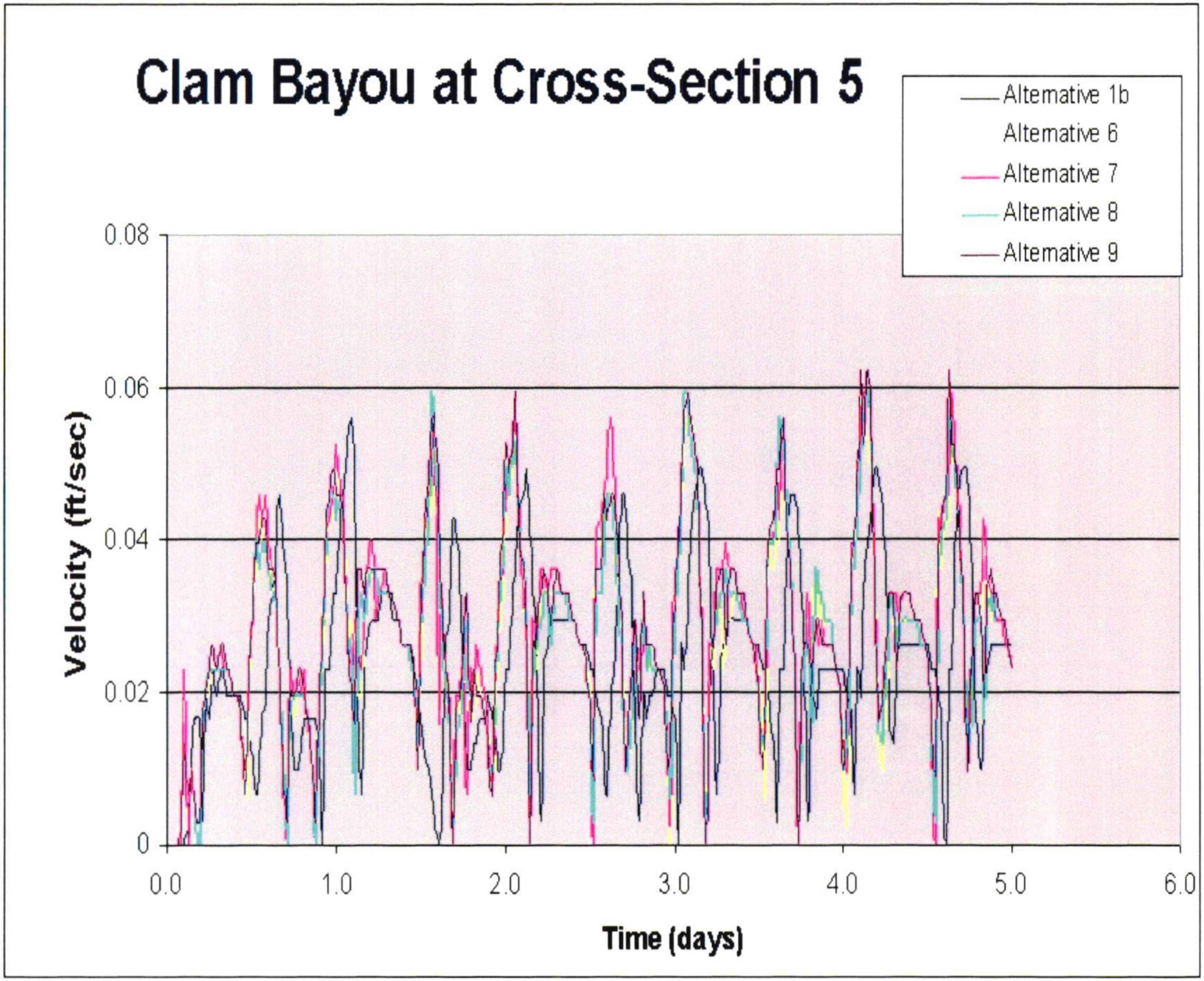


Figure IX-32
Comparison of Tidally-Induced Velocities at Location 5 for the Proposed Alternatives

Table of Contents

I. INTRODUCTION

Study Purpose – The purpose for this study is to form a knowledgeable opinion for selecting restoration alternatives for Clam Bayou, from the perspective of the Blind Pass Eco-zone or system. Clam Bayou's relationship to Dinkins Bayou, Wulfert Channel, Blind Pass, and the Gulf of Mexico suggests a strong inter-relationship that transcends the property lines that separate the various water bodies. There is a consensus among the responsible governments and the affected stakeholders that a comprehensive approach to assessing the needs of Clam Bayou should include evaluating the relationship to the surrounding waterbodies.

This report reviews the relationship between Blind Pass/Dinkins Bayou/Clam Bayou, referred to as the Blind Pass Eco-zone. This report creates a template from which the stakeholders can select alternatives and prepares the selected project for regulatory permitting at the local, state, and federal level. Bathymetric, ecological, and tidal analyses were completed to develop an understanding of the Blind Pass Eco-zone with principal focus on how best to improve the estuarine health of Clam Bayou and realize the maximum benefit for the various stakeholders affected by the project. A number of design alternatives are described, cost to benefit ratios considered, impacts from coastal hydraulics evaluated, and ecological issues addressed as part of the recommendations.

Clam Bayou is a shallow, mangrove estuary approximately 200+ acres in size. The configuration of Clam Bayou is the product of hundreds of years of coastal erosion and deposition, creating offshore bar systems that have migrated on shore, creating the long spits that define the various waterbodies in the bayou. The south portion of Clam Bayou, also known as Old Blind Pass, has been connected to the Gulf of Mexico for many years. Blind Pass has been one of the main tidal connections between Pine Island Sound and the Gulf of Mexico.

Current Conditions - Clam Bayou is now a closed, distressed, estuary with over 100 acres of mangroves imminently threatened and 48.8 acres critically impacted or lost, as a result of sustained water elevations above normal mean high water datum. Clam Bayou is subject to storm surge and rainfall inundation with no release mechanisms to equilibrate water levels to normal tidal elevations. The result is a distressed mangrove habitat, fluctuations in habitat productivity, and overall degradation of significant fisheries and wildlife communities. Secondary impacts include deteriorating quality of life for surrounding residents, lack of sufficient drainage to address flooding emergencies, and loss of tourism related to degraded environmental habitat.

Clam Bayou consists of a number of shallow, elongated bays, fringed with extensive mangrove habitat. These mangroves habitats are no longer tidally inundated, having lost all tidal connections for a number of reasons. They include long term erosion trends along the coast, changes in littoral transport dynamics, the closure of Blind Pass, the earlier opening of Redfish Pass, and the recession of the mean high water line. Clam Bayou has a history of being tidally connected to either the Gulf of Mexico or Pine Island Sound via Blind Pass. Clam Bayou is currently isolated from tidal flushing, and water quality, flora, and fauna have been negatively impacted as a result of extreme variations in water elevations, salinity, and dissolved oxygen levels.

This 200± acre estuary undergoes significant fluctuations in water quality. Brackish conditions are created by the impoundment of rainfall and stormwater runoff. Super salty, or hypersaline status results from storm surges overtopping the narrow section of beach separating the bayou from the Gulf of Mexico. This is further compounded by the dry season evaporation of the freshwater component of the bayou. The system is constantly adapting to changing conditions, with periods of growth and regeneration, followed by periods of habitat loss. Impacts from these fluctuations include the following;

a. Super-elevation of both stormwater runoff and tropical storm surges has resulted in the continual loss of acres of mangrove habitat through "drowning" of the plants.

b. Lack of tidal flushing, nutrient transport, and variable water clarity has an impact on submerged seagrasses in Clam Bayou. Seagrass losses eliminate a vital nursery and feeding ground for many marine species and wading birds. Variations in salinity cause die offs of seagrasses.

c. Loss of mangroves has significantly reduced bird nesting and roosting habitat. Dramatic changes in water quality have reduced dissolved oxygen levels in the past, resulting in fish kills, which also eliminated food sources for many wading birds utilizing Clam Bayou.

d. Bowmans Beach, a county park, borders the coastal regions of Clam Bayou. Continued loss of mangroves reduces opportunities for viewing wildlife, reduces water clarity, and eliminates recreational fishing opportunities during die offs.

e. The mangroves that exist in Clam Bayou provide a significant storm buffer between the Gulf of Mexico and residential development along the eastern and northern perimeter, including Sanibel Captiva Road. Continued loss of these mangroves increases vulnerability of the road to storm surge and associated wave energy, potentially severing the only emergency access for north Sanibel and Captiva Island.

f. Dead trees, lack of wildlife, and odiferous waters along the waterfront diminish re-sale and taxable value of residential properties. Super-elevated water, aside from drowning mangroves, impacts landscaping at residences, and increases mosquito breeding potential.

The two nearest waterbodies that create a potential for restoring flushing to Clam Bayou are the Gulf of Mexico and Dinkins Bayou. The Gulf is separated by a narrow strip of beach, subject to continued erosion and overtopping from storms. Dinkins Bayou is a natural embayment, with manmade canals extending off of the bayou. Dinkins Bayou connects to Wulfert channel at its northern extreme and thence to waters of Pine Island Sound.

It is at this point that a significant variation in average annual tidal range occurs. Based on published tidal station information, Pine Island Sound (annual range of 1.35') has a smaller range than the Gulf of Mexico (annual range at 1.69'). With Pine Island Sound now functioning as the exchange waterbody instead of the Gulf of Mexico, flushing of Dinkins Bayou is reduced, and ecological health of the estuary suffers from reduced tidal flushing.

Blind Pass is a narrow tidal inlet, or pass, located between the islands of Sanibel and Captiva. It is subject to opening and closing based on variations in coastal sediment transfer. The pass is not subject to any significant sources of freshwater outflow and depends on tidal regime to remain open. Passes are dependent on tidal prism to maintain stability (cross-sectional and locational). In recent history, Blind Pass has been unstable, having a history of opening and closing since Redfish Pass was opened. It has remained closed since 1998, when the last attempts were made to reopen the pass. A tidal connection to the Gulf of Mexico via Blind Pass would increase the tidal prism available for flushing Dinkins Bayou, as well as improve water quality along the western side of Pine Island Sound. Both Clam Bayou and Dinkins Bayou have been directly connected to the Gulf of Mexico in the past, and have been significant contributors to the regional ecology through mangrove seedling export, seagrass productivity, and as a fishery.

II. PROJECT LOCATION and LOCAL GOVERNMENTS

Project Boundaries - The study area is the northern portion of Sanibel Island and southern limit of Captiva Island, located in Sections 1,2,3,11,12, 13, and 14, Township 46 South, and Range 21 East of Lee County. Refer to the **Location Map** and **Vicinity Map** at the end of this section for details. The center of the Eco-zone is at Latitude 26° 29' and Longitude 81° 11'. Blind Pass functions as both the physical demarcation between the barrier islands of Sanibel and Captiva as well as the jurisdictional line between the City of Sanibel and Lee County. The two islands are connected by bridge across Blind Pass. Sanibel is reached via causeway from the mainland and is approximately 13 miles long and varies up to 3 miles wide. The island is crescent shaped, oriented east to west in contrast to the predominantly north to south orientation of most barrier islands along the southwest Florida coast, including Captiva Island. Captiva is smaller, both in length and width, at approximately 5.5 miles long and little over a half mile wide.

The project study area incorporates a mix of artificially created waterways, natural embayments, resource protection areas, undeveloped land, and residential/commercial development. Waterbodies included in the Blind Pass Eco-zone are Dinkins Bayou, Clam Bayou, Blind Pass, and Wulfert Channel. The Wulfert Channel area is bounded to the east by the marked entrance from Pine Island Sound, to the west by Blind Pass Bridge, to the north by the entrance to Roosevelt Channel and to the south by the entrance to Dinkins Bayou. Refer to the **Aerial Photograph – SFWMD 2000** graphic and subsequent detail graphics for each area within the Blind Pass Eco-zone at the end of this section.

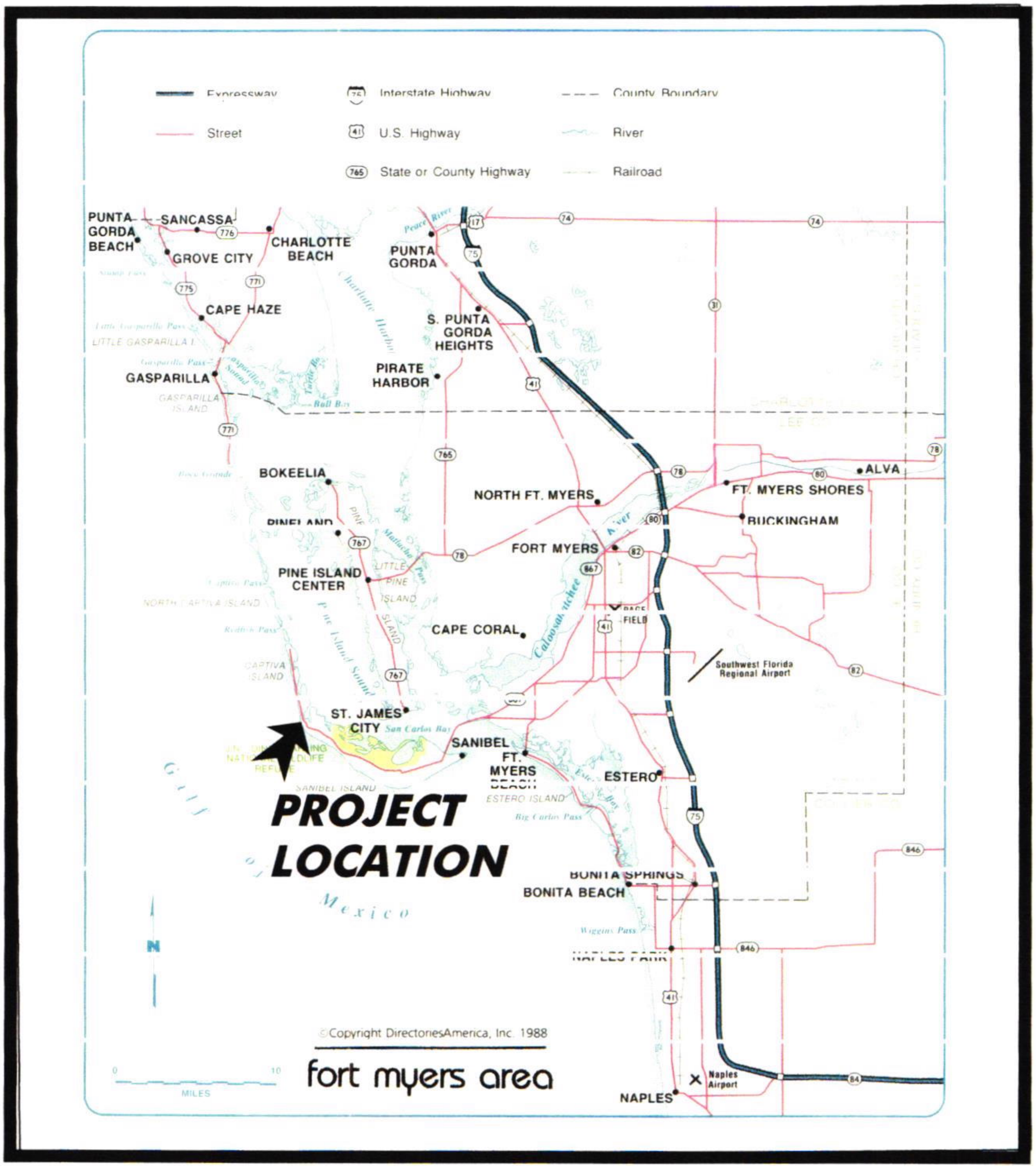
Stakeholder Governments - In 1963 the completion of the Sanibel causeway made development of Sanibel and Captiva more attractive, and profitable, as a barrier island. Originally under the jurisdiction of Lee County, Sanibel incorporated in 1974 to control the destiny of the island and manage long term development. Residents developed a growing environmental awareness and appreciation for the uniqueness of the island, which became the catalyst for forming its comprehensive plan. In 1995 the City completed an Island Wide Beach Management Plan which addressed the goals and policies of the City regarding its coastal resources, including the Blind Pass Eco-zone area.

The Captiva Erosion Prevention District (CEPD) was established in 1959 to manage erosion of the Gulf beaches on Captiva. The districts jurisdiction encompasses the entirety of Captiva Island, but has focused predominantly on the coastal areas and was limited by its founding legislation to erosion issues. Early projects included installation of Budd Wall groins along the majority of island beaches, various experimental projects such as submerged breakwaters, undercurrent stabilizers, and more conventional riprap revetments. Beginning in the early 80's the CEPD pursued beach restoration and renourishment as a preferred alternative to shoreline hardening, beginning with restoration of the northern 1.5 miles of Captiva. An island wide restoration project was completed in 1988 and again in 1995.

Lee County developed and adopted a Beach Management Plan in September 1995. The County Beach Management Plan sets up the Coastal Advisory Council to oversee the management goals and objectives of the plan, focusing activities in areas seaward of the states Coastal Construction Control Line, and funded by the Tourist Development Council. Lee County continues to regulate activities in unincorporated Lee County, which includes Captiva Island.

These three governments now have in place management goals and objectives that directly influence proposed restoration alternatives within the Blind Pass Eco-zone, including Clam Bayou. In Clam Bayou, 12 of 14 miles of shoreline is government owned. Under separate contracts with each government, Hans Wilson & Assoc. Inc. has incorporated a team approach to the project. In joint venture with Erickson Consulting Engineers, Inc. and Gooderham & Associates, Inc. various tasks have been carried out by coastal engineers, permit specialists, public relations experts, and biologists, working in conjunction with agency staff and local residents to assemble the required data. This work included discussions with past consultants with experience in this area, and anticipates continuing a team approach to implementing the selected alternatives.

SECTION: 11
TOWNSHIP: 46 South
RANGE: 21 East



Location Map

SCALE: 1" = 10 Miles

June 14, 2003 5:45:49 p.m.
Drawing: CLAM-1_MAPS.DWG (HW)

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Blind Pass Eco-zone Feasibility Study

SHEET

SECTION: 11
TOWNSHIP: 46 South
RANGE: 21 East

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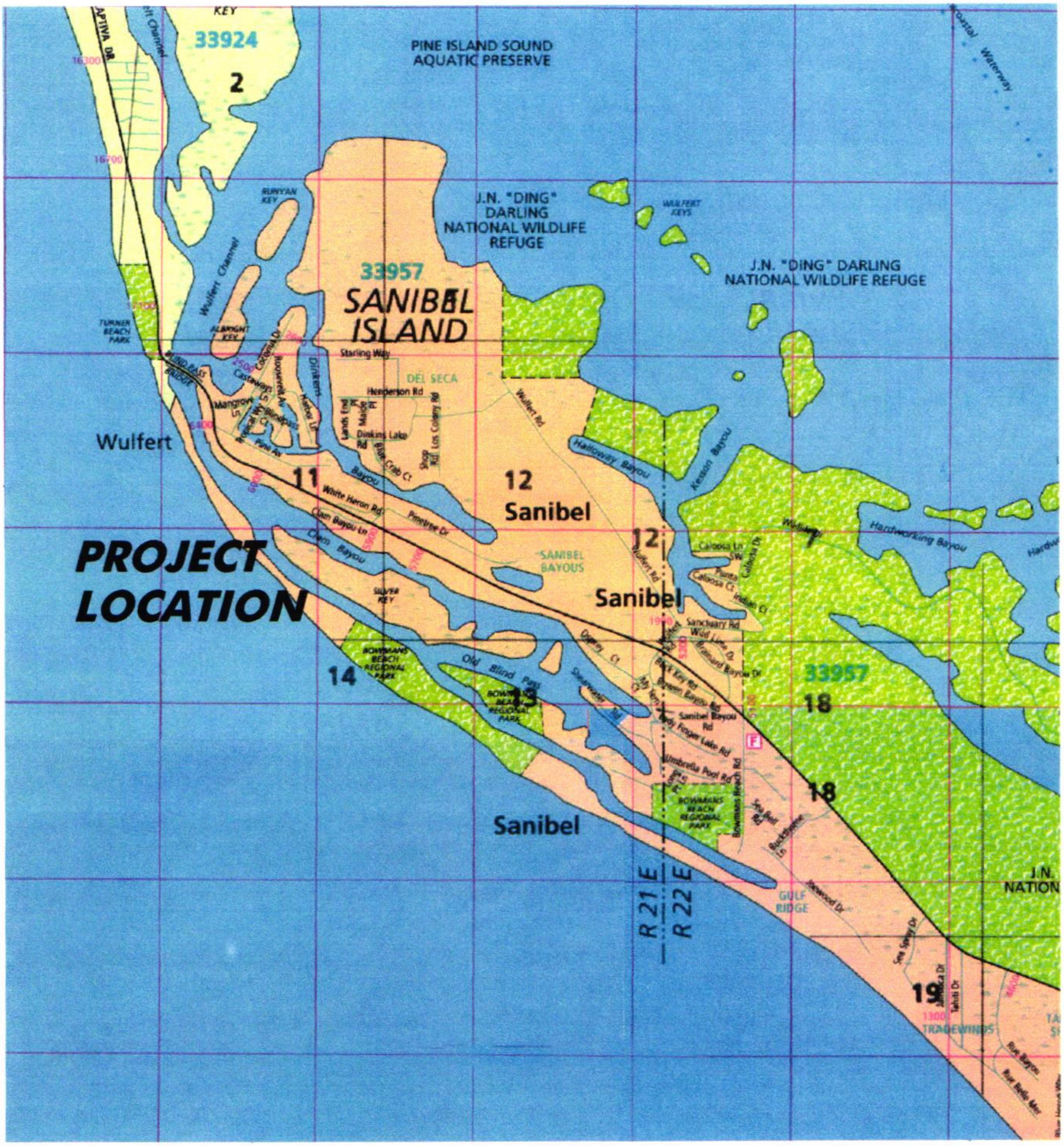
SCALE MILES



Vicinity Map

SCALE 1" = 1/2 MILE

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Aerial Photograph - SFWMD 2000

SCALE: 1" = 2000'

June 14, 2003 5:37:13 p.m.
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0 5 10
SCALE FEET

Wulfert Channel Entrance

SCALE: 1" = 600'

June 14, 2003 5:37:13 p.m.
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Blind Pass Bayside

SCALE: 1" = 600'

June 14, 2003 5:37:13 p.m.
Drawing: CLAM-1_PLAN.DWG (HW)

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Blind Pass Gulfside

SCALE: 1" = 600'

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Dinkins Bayou

SCALE: 1" = 600'

June 14, 2003 5:37:13 p.m.
Drawing: CLAM-1_PLAN.DWG (HW)

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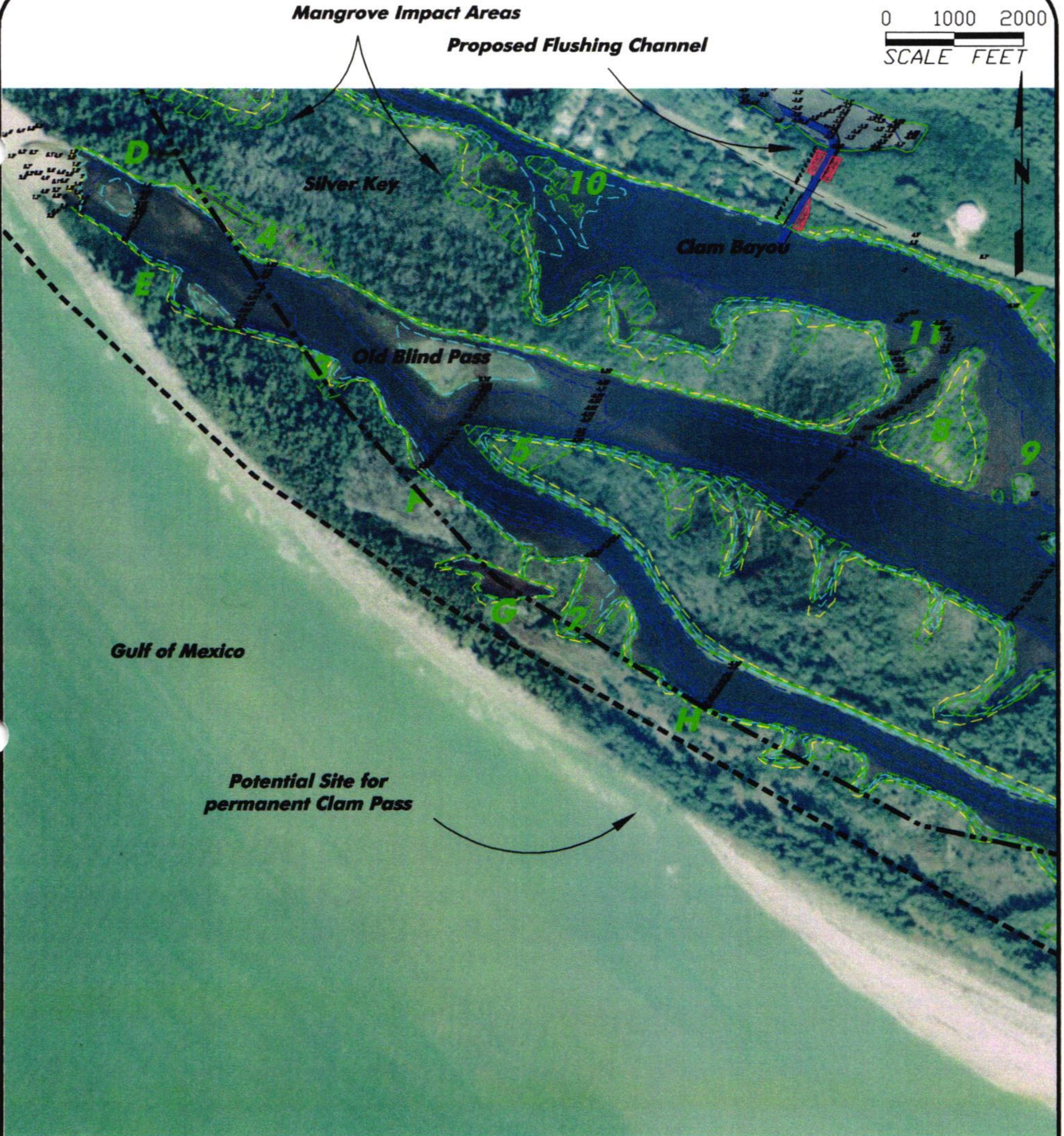

Clam Bayou West

SCALE: 1" = 600'

June 14, 2003 5:37:13 p.m.
Drawing: CLAM-1_PLAN.DWG (HW)

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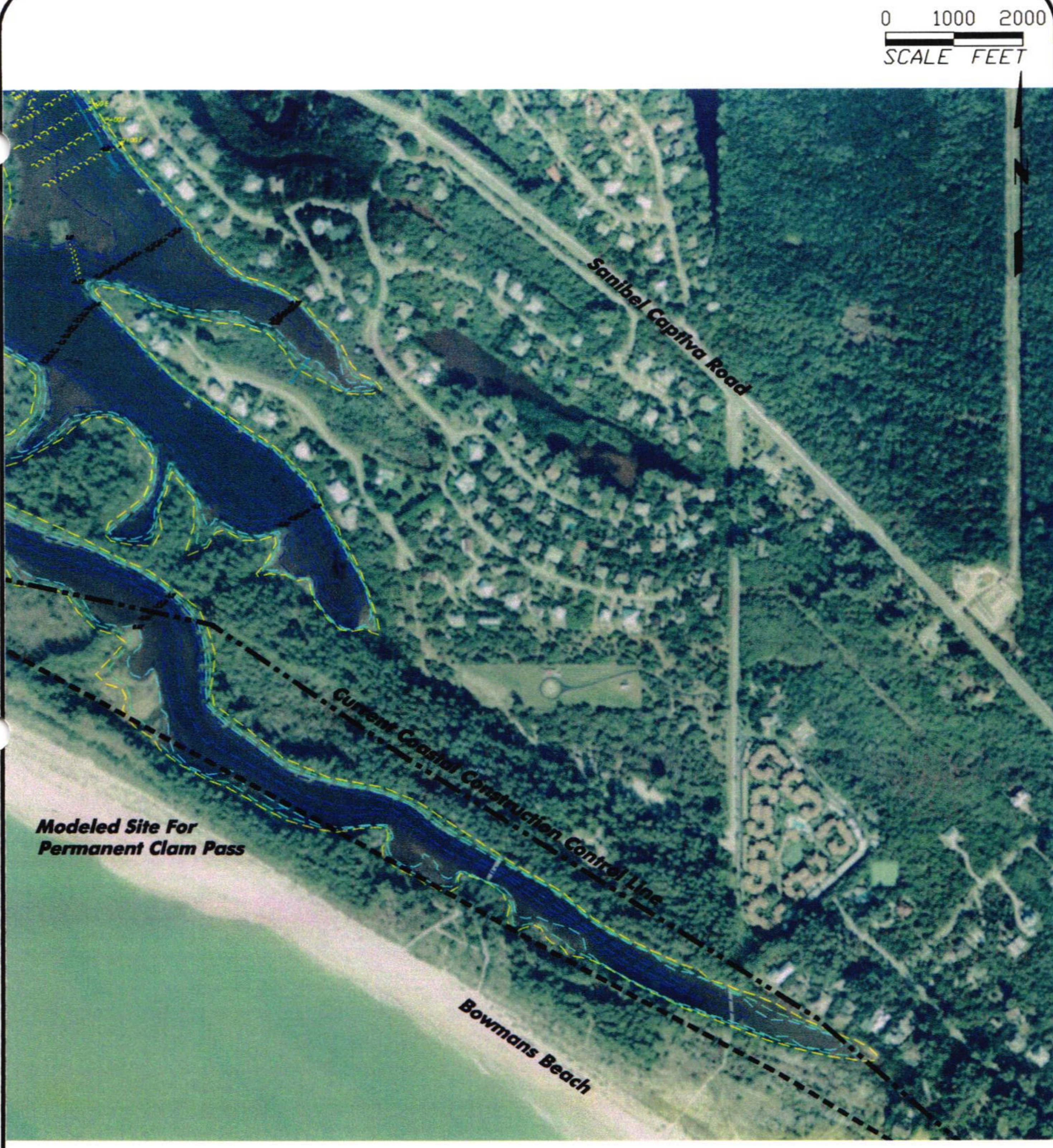

Clam Bayou East

SCALE: 1" = 600'

June 14, 2003 5:37:13 p.m.
Drawing: CLAM-1_PLAN.DWG (HW)

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III. RESTORATION ALTERNATIVES

There are a number of alternatives available to the community to restore Clam Bayou. Baseline modeling data was collected to establish water quality conditions as they exist today. As discussed in Section IX – Hydrodynamic Modeling a number of alternatives were investigated to determine what changes in the water mass and tidal velocities would occur. We have approached our discussion of these alternatives from a regional perspective, beginning with just Clam Bayou and expanding our approach to include Blind Pass and Wulfert Channel.

To complete the analysis, we assessed how the various alternatives affect the various waterbodies. Similar to physically placing a marking dye in the entire water body, and watching how long it takes for the dye to dilute or reduce its concentration in the water over time, we simulate a water mass in the computer model. The more appropriate scientific definition would be assigning a Mass Concentration at 100% and evaluating how long it would take to reduce the concentration to 10% of the initial value. From a layman's perspective, this begins to answer the question is how long it will take to flush the waterway under the various alternatives.

A. Baseline Alternative: Do Nothing - The **Baseline Alternative** is essentially the Do Nothing Alternative and evaluates Dinkins Bayou as it exists today. Since no action is proposed in Clam Bayou, it was important to establish the baseline condition as exists in Dinkins Bayou. This is the least costly alternative, in the short term. It requires no further evaluation as to feasibility; no design or permitting battles; no construction or long term maintenance costs. Short term benefits result by not altering Clam Bayou, which at present is in fairly good health. **Alternative 4** is a variation on the **Baseline Alternative**, and evaluated the conditions in Dinkins Bayou with Blind Pass being opened, essentially documenting past conditions in Dinkins Bayou. This alternative did not explore any physical changes to the waterway in Dinkins Bayou, only changes in Blind Pass to make the tidal connection to the Gulf of Mexico instead of Pine Island Sound. This was done to give us an idea of how Dinkins Bayou baseline conditions would be affected if Clam Bayou were connected via a flushing channel. The **Baseline Alternative** also has an impact on Dinkins Bayou residents. Information about their existing conditions will affect their decision process regarding future activities that affect their waterbody.

Salinity - The litmus test regarding this alternative is looking at the long-term costs and benefits. It is expected that the Clam Bayou environment will continue to adapt to changes in water elevation, salinity, dissolved oxygen, and productivity. Because of the close proximity to the Gulf of Mexico, this system is expected to fluctuate between fresh and salt water conditions. The stress on floral and faunal habitats is significant, as evidenced by past fish kills and dead mangroves observed at the site.

Water Elevation - As Clam Bayou resides in its current state, plant and animal species that are quick to adapt, or transitory, will likely dominate the system. Species that can adjust to extremes in salinity will survive in the system. The adaptation process for these plant communities must include an ability to adjust to varying water levels. As observed in the field evaluations and depicted in the photographs at the end of Section VII, there is still sufficient seed stock within Clam Bayou for mangroves to re-establish in areas previously damaged by the higher water elevations. However, seasonal storm inundations that elevate the water in the bayou continue to drown out even the most prolific plant species if they cannot adjust to the seasonal water elevation change. The result will be a continuing adaptation process that will eventually result in a unique ecosystem that will be less productive than the highly desirable mangroves estuaries. In most cases, plant species that thrive in these extreme fluctuations, because of their limited diversity, tend to create a monoculture.

Economic Impacts - Because of the unpredictable nature of seasonal rainfall amounts and storm surge events, it is expected that die offs of both plant and animal species, as evidenced before, will continue into the future. This has a direct, unsavory impact on local land values, recreation, and tourism. The inability to control water elevations will have a long term impact on surrounding residential properties, both in flooding and landscaping losses. Property values would be expected to decrease when potential buyers observe dead and/or dying plants, and animals at these properties.

Storm Protection - It is clear that storm protection benefits are derived from extensive mangrove fringes along developed properties. These benefits will decrease as those fringes die off. Water levels in Clam Bayou will continue to adjust to the lowest available discharge elevation, which has historically been the land spit separating the bayou from the Gulf of Mexico. With the City of Sanibel's goals of stabilizing coastal beaches through "soft" approaches like beach restoration and dune implementation, it could be expected that the elevation of these beach areas will continue to increase as vegetation establishes and wind driven sand is captured in the vegetation. This will eventually raise the static or discharge water elevation of Clam Bayou, further expanding the damage limits to protective vegetation buffers as the water elevation increases. If the beach berm reaches an elevation that resists all but the most aggressive storm events, Clam Bayou could eventually become a brackish, if not a fresh water system. The impact of varying salinities would diminish, potentially stabilizing with the bio-diversity of a freshwater system.

Stewardship - The greatest long term cost could conceivably be reputation. Given the strong environmental background from which the City of Sanibel was conceived, it would be contrary for the citizenship not to take action to preserve and protect this productive mangrove estuary. With the technology that is available, and suitable evidence of other successful restoration projects with similar conditions, there appears to be no limitation on the technical feasibility of accomplishing this task. The only apparent limitations would be economics and public will. It can be demonstrated that from an economic perspective, the productive evaluation of a mangrove estuary is measurable. Depending on the valuation process, the end result is only a time issue. Considering the communities approach to protecting resources for future generations, it is expected that the cost of this project will eventually pay for itself.

B. Flushing Connection direct to Gulf of Mexico - A number of alternatives were evaluated for this approach. **Alternative 2 and 3** represent variations on this plan. **Alternative 3** entails making a direct connection to the Gulf of Mexico as has occurred at various times in the past. This alternative provides the greatest amount of improved flushing direct to Clam Bayou, based on the least travel distance to the far ends of the Bayou and the tidal prism that exists in the gulf. The design of the pass entrance should be furthest from Blind Pass ebb tidal shoal system and at a location that maximizes tidal flushing into Clam Bayou. **Alternative 2** incorporate a flushing channel to Dinkins Bayou in combination with the direct connection to the Gulf of Mexico.

There are a number of issues that relate to the feasibility of a direct connection to the Gulf. First and foremost is the stability of the opening. On an average annual basis, will a direct connection to the Gulf remain open, and can the interior of Clam Bayou provide enough tidal exchange to keep the pass sediment free? Second, given the impact of seasonal storm events and littoral transport of sediments along the coast, will the system still remain connected to the Gulf on a permanent basis? Third, will the political climate of Sanibel allow any manmade structures to be implemented as part of the stabilization of the pass? Finally, can the cost of the project be borne by the benefiting stakeholders?

<u>Stability</u> - In order for Clam Pass to remain open on a permanent basis the velocity of water that flows into Clam Bayou, and subsequently out again on the ebb tide, has to be sufficient to prevent sand from accumulating in the mouth of the pass. In most cases, a stable pass opening has enough internal flow velocity to push the sand offshore into an ebb tidal shoal. The transfer of sand along the coast migrates onto the shoal and eventually arrives at the down drift beach. In cases where a continuous freshwater source like a river makes the pass an ebb dominant system, the opening is stable. In passes that are not ebb dominant, and rely solely on tidal hydraulics, an extensive interior basin that can transport tidal flows efficiently is required. Even in cases like Stump Pass in Charlotte County, where there is significant flood tidal channels and open bay waters, restoring a winding, narrow channel in the pass can result in hydraulic inefficiencies that doom the stability of the pass opening. This was evidenced in the dredging project prior to the current restoration project.

Longevity - Tidal passes open to the Gulf of Mexico are subject to significant storm events, which include frontal systems that occur in the winter months, tropical storms and hurricanes. These events deposit large amounts of sediments in tidal openings, and in some cases, completely sever the connection to the Gulf of Mexico. In those cases, restoration dredging is the only alternative available to restore the tidal dynamics to the estuary. Design of a tidal pass to resist the impacts of storm generated wind and wave energy can be cost prohibitive.

City of Sanibel Policies - In the Island Wide Beach Management Plan prepared by Humiston & Moore, the City of Sanibel adopted a number of policies directed towards maintaining and preserving the island beaches in a natural state. The area seaward of the 1978 State Coastal Construction Control Line seaward to the seaward limits of the incorporated limits of the city is designated for passive recreation and conservation uses. Any shore hardening structure or coastal armoring is considered an alternative of the last resort and is generally prohibited except for special cases. Even though shoreline armoring provides resistance against wave energy parallel to the shoreline, any pass or inlet improvements may require limited armoring of the shoreline. The management plan does provide for unique cases of armoring, and in almost all respects emphasizes beach renourishment as a requisite companion to an armoring project. The management plan also recognizes the value of passes as a tidal connection critical to the health of interior waterways such as Clam Bayou and Blind Pass. Under Post Disaster Management Strategies, there is a discussion regarding closure of these types of passes, encouraging reopening of the pass to restore natural processes.

Stakeholders - Is the total cost of the project benefiting a cross section of stakeholders at a ratio that is equitable and politically acceptable for cost assessing purposes? In other words, with a Clam Pass solution, the principal beneficiaries are limited to the immediate adjacent property owners, including the city and county, and secondary beneficiaries which would be expected to contribute through ad valorem taxes, special assessments, or referendum. Distributing this cost over a limited range of beneficiaries may be difficult.

C. Connecting Clam Bayou to Dinkins Bayou via a flushing channel - By making this connection, a number of opportunities are presented to improving the long term results and overall flushing effect on Clam Bayou. We also expand our sphere of influence, going beyond Clam Bayou and impacting Dinkins Bayou (additional Sanibel residents) and Blind Pass (Captiva residents). These alternatives determine how viable this plan is, and to what degree the various combinations improve the success of this option. These alternatives include:

Alternative 1 - flushing channel only.
Alternative 2 - flushing channel and Gulf connection.
Alternative 5 - flushing channel and Blind Pass opening.
Alternative 6 – flushing channel, Blind Pass open, channel to Dinkins

Factors that directly affect a flushing connection at this site include land ownership, water quality conditions in both water bodies, regulatory jurisdictions, and benefiting stakeholders.

Alternative 1 - Performance based on no additional improvements – This plan is simply to connect Clam Bayou to Dinkins Bayou. This is accomplished by creating an open flushing channel, connecting to the same depth contours that exist in both bayous, and providing Sanibel-Captiva Road with unencumbered access via box culvert or bridge. The performance of this alternative is based on the tidal prism that exists at the headwaters of Dinkins Bayou. With Blind Pass closed, and Wulfert Channel significantly restricted in depth, the flow of water through Dinkins Bayou to the flushing channel is limited. The average annual tidal range, based on the Pine Island Sound tide station, is 1.35 ft. With constrictions in width and depth in Wulfert Channel and Dinkins Bayou, tidal range diminishes, lessening the total volume that can enter Clam Bayou during a normal tide cycle.

Ownership - To create a flushing channel acquisition of land or perpetual easements will be necessary to provide access. Currently, the land on the Dinkins Bayou side of Sanibel Captiva Road is privately owned. Under the proposed design, the minimum width of the flushing channel is 30', which expands to include mangrove wetland planting areas increasing the impact area to as much as 100' wide. This is a land mass typical of single family home sites along this area. Cooperation with the existing property owner, through either land purchase or easement agreement, is absolutely critical to accomplishing this alternative.

Water Quality - Connecting Clam Bayou to Dinkins Bayou accomplishes some basic goals. It acts as an outlet for stormwater, flowing into Dinkins Bayou, and subsequently Pine Island Sound or the Gulf of Mexico. This connection also restores the tidal fluctuation necessary to restore the health of the mangrove estuary. By connecting this 200± acre estuary, it is assumed that a significant volume of water will flow through the Dinkins Bayou waterbody to reach Clam Bayou. This should improve water quality conditions in Dinkins, and restore flushing in Clam Bayou. General water quality testing shows that water quality is generally better in Clam Bayou than Dinkins Bayou. Dinkins Bayou's complex of narrow, deep, artificially created canals reduce water quality whereas Clam Bayou is a natural, shallow, open water body that generally exhibits good, wind driven, mixing characteristics. Clam Bayou will tend to act as a filter for water quality entering from Dinkins Bayou, resulting in an improved condition when the ebb tide returns the water back to Dinkins Bayou. Wind mixing will be a significant contributor to this improved condition.

Jurisdictions - Connecting to Dinkins Bayou presents a more rigorous standard for permitting because of the Outstanding Florida Water designation associated with the Pine Island Sound Aquatic Preserve. Unless research into the ownership proves that the submerged lands in the area of the proposed flushing channel are privately owned, this work will take place on sovereign submerged lands. As a result the project have to meet or exceed ambient water quality standards in Dinkins Bayou, which can be demonstrated in the sampling data, but the project also has to be clearly in the public interest. These criteria can be met, but the process of convincing agencies like the Dept. of Environmental Protection Aquatic Preserve staff and politicians like the Governor and Cabinet can be arduous.

Stakeholders - With the tidal connection between Clam Bayou and Dinkins Bayou, the range of benefiting stakeholders expands significantly. Aside from the primary stakeholders benefiting from the Clam Bayou improvements, a similar set of property owners along the length of Dinkins Bayou also benefit. Secondary stakeholders also expand, with improvements in water quality and habitat productivity, through improved fishing opportunities, recreational boating, improved navigation resulting from improved water clarity, and expanded manatee habitat resulting from deeper channels and increased seagrass productivity. Vertical clearance for navigational access to Clam Bayou via the flushing channel is not proposed, however access to Clam Bayou for manatees, alligators, otters, and other water based wildlife is created.

Alternative 2. Performance based on flushing channel combined with tidal connection to the Gulf of Mexico. This alternative combines the benefits of a direct connection to the Gulf of Mexico with a flushing channel connecting to Dinkins and Clam Bayou. This utilizes the greater tidal prism of the Gulf and still provides the long term benefit of connecting to Dinkins Bayou. However, there are long term implications that are discussed in Section X - Hazard Mitigation that apply to this alternative. The distribution of stakeholders remains essentially the same as discussed before.

Alternative 5. Performance based on flushing channel combined with Blind Pass opening - This alternative results in the opening of Blind Pass to the Gulf of Mexico. The project would include dredging a significant volume of material from the entrance and flood shoal system necessary to maintain a stable hydraulic opening. It would require an assessment of the CEPD beach management plan regarding ebb shoal volumes and long term maintenance of the tidal opening. The scope of the improvements would initially benefit Dinkins Bayou and Clam Bayou the greatest, but extends beyond these areas to benefits in the interior of Pine Island Sound and Roosevelt Channel. The primary result would be increased tidal prism, which would increase the subsequent tidal exchange volumes entering Dinkins Bayou and Clam Bayou. This work might require the dredging of the Dinkins Bayou interior waterway to facilitate this improved flow.

Stakeholders - This alternative expands the beneficiary base, and adds another government stakeholder, the CEPD. Although not a real property owner, the CEPD acts as the voice of the Captiva population regarding beach management. By improving water quality and flushing conditions within Dinkins Bayou, which will also occur with **Alternative 1**, it can be expected that properties on both sides of Dinkins Bayou will directly benefit to a greater degree with **Alternative 5.** These property owners, which might otherwise be considered a primary beneficiary, may be relegated to a secondary level, relying on government taxation versus individual parcel assessments to defray the cost. The primary stakeholders that benefit are numerous, however, the secondary beneficiaries expand almost exponentially to all of Lee County, or at least to those individuals that benefit from habitat improvements in Pine Island Sound. This benefit extends to commercial fishing, recreational boaters, manatees, area wildlife, etc. An increase in stakeholder benefits occurs with this alternative, including an expansion of primary stakeholder benefits, restored navigational access to existing residential properties, increased secondary stakeholder benefits, and habitat improvements.

Opening Stability - The critical component of success to this alternative will be the design of Blind Pass so that it remains open in perpetuity. Many of the issues discussed regarding the creation of Clam Pass also apply. **Alternative 5 and 5a** are essentially the culmination of all of the previously listed alternatives, both in benefits and issues. **Alternative 6,** includes deepening and extending the channel to improve tidal connections to Roosevelt and Wulfert Channel, and Dinkins Bayou, and is simply a variation on **Alternative 5.** This alternative is also going to be the costliest, however, the array of benefiting stakeholders may in fact make this the cheapest per capita solution. In **Alternative 5**, Blind Pass is to be excavated to a 240' width and 6' NGVD, depth beginning in the Gulf of Mexico and tapering to 100' wide and 4' deep landward of the bridge. **Alternative 6** begins at -8 ft (NGVD) in the Gulf of Mexico shallows to –6' in Wulfert Channel, including improving the connection to Dinkins Bayou with a channel 100' wide by 5' deep.

Dinkins Bayou Navigation - In **Alternative** 6, we consider improving the channels connecting Wulfert Channel to Dinkins Bayou, which also has a positive benefit to navigation for the waterfront properties along this waterway. Variations in the design can include making direct connections to Roosevelt Channel, improving flushing and export to the emergent habitats around the base of the Blind Pass Bridge, and expanding the navigation benefits. Improvements in tidal prism result in a greater volume of water entering Clam Bayou, and subsequent increased mixing and tidal exchange. To increase tidal prism, additional dredging beyond the entrance, may be necessary in Dinkins

Bayou to reduce or eliminate restrictions in flow and enhance benefits to navigation.

Dredging - The majority of the dredging would occur within the historic alignment of Blind Pass. Additional dredging may be appropriate at the south end of Albright Key, to improve the flushing in this area. Any dredging proposed would be that necessary to maintain a stable opening and maximize flushing into the interior waterways.

Permitting - A number of issues will arise in response to agency concerns about construction in the Aquatic Preserve. These issues will include concerns regarding water quality, impacts to benthic habitat from dredging, concerns over navigation improvements, the likelihood of increased boating activity, seagrass impacts, etc. The regulatory agencies will be conservative in their assessment of the need for this alternative. In previous applications, the DEP has requested baseline water quality data, which is available to a limited degree. Testing will likely require an expanded scope to set some baseline values in other areas of Dinkins Bayou. Similar assessment of benthic communities within the alignment of the dredging will be requested. The regulatory agencies are typically concerned about setting precedents for similar activities that might occur elsewhere in the State, even if the precedent is a favorable or positive one. An assessment of boating activities in the waterways is also likely to be requested to determine the impact of the navigation improvements. A final analysis and recommended alternative is listed in Section XV. - Summary and Recommendations.

IV. LITERATURE SEARCH and BACKGROUND

To develop a general assessment of the Blind Pass Eco-zone, and how it has evolved through time, a general overview of past written materials on the Blind Pass area was conducted. Project engineers for both the CEPD and the City have authored several reports that document activities in the coastal environment around Blind Pass. The Blind Pass Inlet Management Plan developed by Coastal Planning and Engineering, Inc. in 1993 contains an excellent history of the Blind Pass and Clam Bayou area, and should be considered a companion document to this report. The Island Wide Beach Management Plan developed by Humiston and Moore for Sanibel has provided a good deal of background materials for this report as well. Recent history is depicted in the **1944, 1953, and 1958 NRCS Aerials** at the end of this Section.

Research has also been carried out on tidal culverts and flap gate connections as well as mangrove restoration work, both through personal communications and web based research. This has included a review of work carried out at Squaw Creek on Estero Bay by Lee County, restoration activities by the Pelican Bay Services Division at Clam Bay in Collier County, and the restoration of Johnson Bay proposed in Isle of Capri, also in Collier County. This is by no means an exhaustive review of all potential wetland restoration scenarios, but includes the most recent proposals similar to the conditions exhibited in Clam Bayou.

Tidal Passes - Passes, known as inlets on the east coast of Florida, can be natural or man made connections from inland waters to the Gulf of Mexico. They typically exhibit strong tidal currents depositing sediments, both seaward as the ebb tidal shoal and in the flood tidal shoal found on the bay side of a pass. The interaction of tides and waves affect the dynamics of the pass, including the littoral transport along the gulf coast. A slight change in tidal prism can shift pass dynamics from a stable opening to one that is unstable. This can occur through continuous build up of the flood tidal shoal, engineering projects that can overwhelm the sediment carrying capacity of the ebb tidal shoal, or other structural and natural features which can all affect the amount of sand migrating along the shore as littoral drift.

Passes act as sediment storage bins and some basic premises that can be applied include the following;

- They are self adjusting, to fit the hydraulic pressures at any one time.
- Those located near rivers are larger and more stable.
- Those that are predominantly tidal are more ephemeral.
- Passes act as natural safety valves preventing barrier islands from acting as dams and causing flooding.
- Passes will occur in roughly the same location as needed over time.

The nearest passes that receive river waters on top of their normal tidal prism flows are Boca Grande, acting as the primary outlet for the Myakka and Peace Rivers and San Carlos Bay, as the outlet for the Caloosahatchee River. Captiva, Redfish, and Blind Pass open opposite Pine Island and do not receive a major freshwater outfall. Blind Pass is the farthest from any freshwater source, relying heavily on sufficient cross section and tidal prism to retain its flushing potential. The dominant littoral flow direction along the shoreline in the Blind Pass area is in the north to south direction, typical for most of the coastline of southwest Florida. Despite some localized deposition, the overall trend, as noted in the 1976 Sanibel Report is towards erosion and loss of sand to the offshore area.

Spits occur when sediment moving along the shore is coupled with a small tidal prism which eventually results in the migration of the spit southward and often, closure of the inlet. This has typically been the past experience at Blind Pass, readily observed by comparing the 1944, 1953, and 1958 aerials. There is a known history of opening and closing of Blind Pass over the last 150 years. As sand migrates down the coast, it forms this spit or peninsula. This causes the tidal channel to lengthen, reducing the hydraulic stability. When storms breach the tidal spits, they frequently move the sand onshore, and form a new opening that recaptures the original hydraulic efficiency. This has been the history of the development of the long and narrow land masses that comprise Clam Bayou.

In some cases, if flood tidal shoals reduce the pass opening, the combined effect of the migrating ebb shoal and expanding flood shoal will constrict the pass and cause it to close, as exists today. In some cases, a reduction in the tidal prism can cause closure of the pass, such as occurred at Blind Pass when a hurricane in 1921 formed Redfish Pass, effectively reducing the tidal prism that existed between San Carlos Bay and Captiva Pass. Between this loss of tidal prism, and subsequent coastal projects on Captiva which supply a sediment source for constant spit creation on the northern shore, the pass has periodically opened and closed.

Blind Pass does exist as a natural safety valve for the high-energy environment of the Gulf of Mexico and storm surge impacts occurring in Pine Island Sound. When storm surge elevations in the bay are coupled by a low tide in the Gulf, the subsequent stress in the system will yield in the low barrier separating the two water bodies. Blind Pass functions as this safety valve, allowing storm surge flow to occur minimizing flooding impacts to adjacent developed property. The sensitivity of this region is well understood. It was suggested in 1976 that Blind Pass and the surrounding area should be declared a natural hazard area. It was recognized that the dynamic geologic processes should be allowed to continue without interference , i.e. that no further development be allowed in the vicinity, and that the bridge between Sanibel and Captiva be relocated from the active mouth of the pass further landward.

Blind Pass Bridge/History - The feasibility of relocating the Blind Pass bridge was reviewed in the late 1980's, and public comment narrowed the recommended options to rebuilding within the existing alignment. The new bridge was constructed in late 1990, replacing the first concrete bridge constructed in 1954. The original bridge was constructed in 1918. The current bridge design incorporates safety factors to resist hurricane impacts, including high density stone utilized at the base of both bridge abutments.

The history of Blind Pass included reports of navigating a channel between Captiva and Sanibel connecting Pine Island Sound with the Gulf of Mexico. In 1880, Blind Pass, also known as Boca Ciega, consisted of a channel 400' wide, and was used by fishing schooners in fair weather. Blind Pass was the only connection to the Gulf of Mexico between the tip of Sanibel and Captiva Pass, almost equidistant between the two tidal openings. Pine Island Sound was an important shipping corridor, with merchant vessels navigating around the shoals that extended off the south end of Pine Island in the Blind Pass vicinity. Subsequent creation of the Intracoastal Waterway in the 1960's further altered the flow regime into Wulfert channel and Blind Pass, but significantly improved navigation in this area.

0 1000 2000
SCALE FEET

1944 NRCS Aerial

SCALE: 1" = 2000'

HANS J.M. WILSON
REGISTERED PROFESSIONAL ENGINEER
FLORIDA REGISTRATION NO. 39680
DATE: June 14, 2003 5:37:13 p.m.
Drawing: CLAM-1_PLAN.DWG (HW)

HANS WILSON & ASSOC., INC.
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1953 NRCS Aerial

SCALE: 1" = 2000'

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1958 NRCS Aerial

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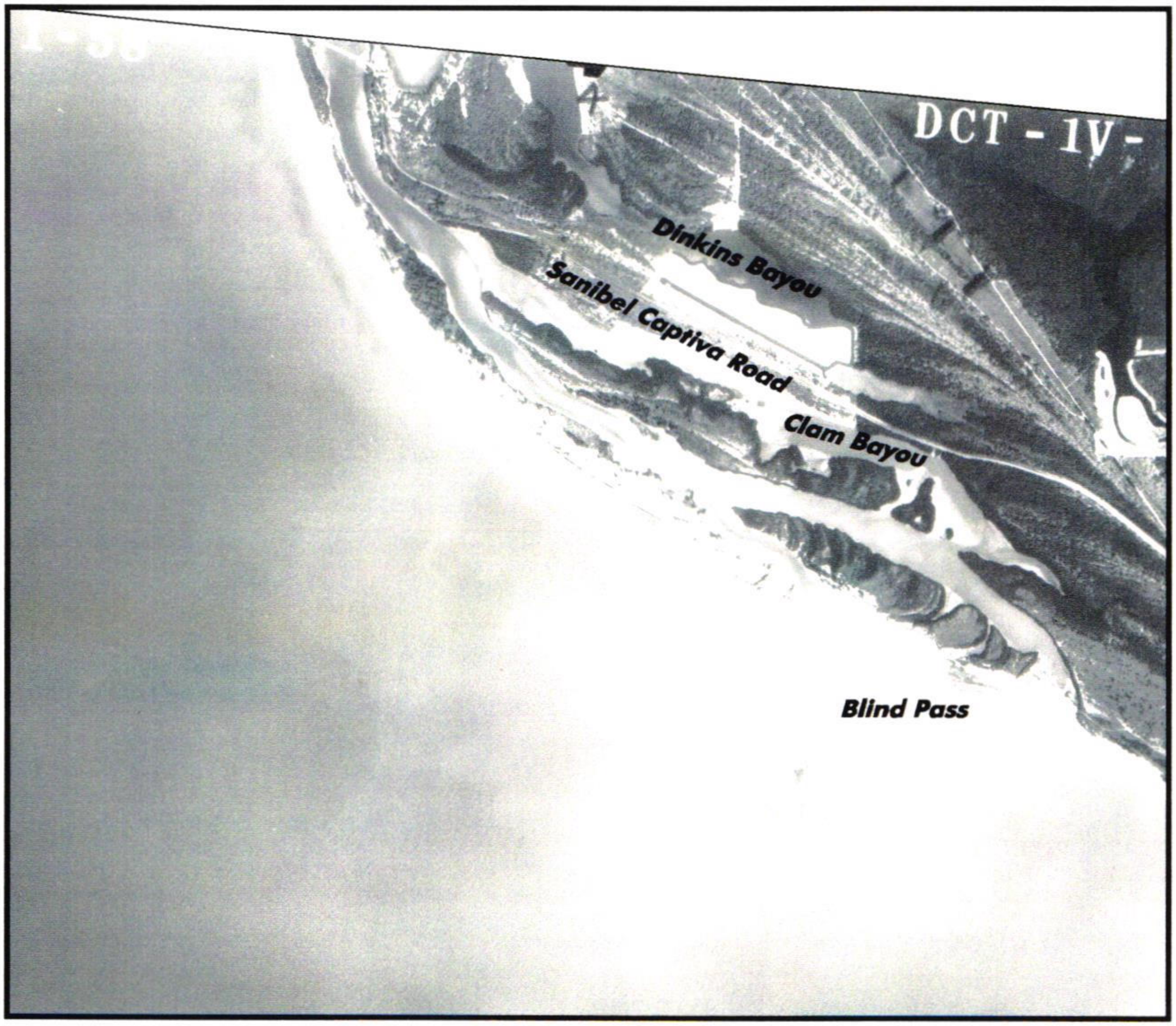

June 14, 2003 5:37:13 p.m.
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V. BATHYMETRIC SURVEY

Survey Area - Bathymetric (depth) surveys were completed as necessary to generally evaluate the tidal dynamics of the project area of Blind Pass, Wulfert Channel, Clam Bayou and Dinkins Bayou. Elevations and depths were measured using a combination of methods, including survey boats using electronic measuring devices, tape and rod measurements, and survey grade GPS data collection system. All elevations were corrected for tide to NGVD.

Prior to field surveys, transects were selected, through review of aerial photographs, to best evaluate depth conditions. Limited by funding scope, base transects would be completed in the field, and correlations established between actual depths related to aerial photos, using photo interpretation, to extend this depth information to acquire total volume estimates for the Blind Pass Eco-zone.

Specific to the proposed connection area to Dinkins Bayou, a very tight grid of depth information was collected, as directed by City staff. Depths were collected on both 50' stations within 300' of the connection area and 100' stations within 1000' of the proposed connection area. Data was collected in the field using the various survey instruments, corrected for datum, and transferred to the master data set.

Where prior information, such as past surveys and navigational charts were available, known depths were matched with aerial photographs to extrapolate bathymetry throughout the system. Site specific depth information was collected within the Blind Pass Eco-zone including select locations in the Wulfert Channel, Clam Bayou, and Dinkins Bayou.

In addition to bathymetry, topographic surveys were carried out seaward of the Blind Pass bridge and at the previous, now closed, tidal entrances to Clam Bayou to estimate potential dredging volumes relative to options for opening these passes. Elevations were cross referenced with, and augmented by, data from DEP beach profiles collected at the Coastal Construction Control Line monuments and past data obtained for Blind Pass inlet management.

Overall Depths - Generally Clam Bayou is a shallow tidal estuary, with depths seldom exceeding -4' NGVD. It has a combination of naturally occurring, deep water, channels and areas where the shoreline has been dredged for fill on the uplands. Similarly, Dinkins Bayou is also a shallow tidal estuary, with navigable access to the developed shorelines acquired by dredging to fill the upland areas. In many locations depths are less than -3' NGVD. At the confluence with Dinkins Bayou, Wulfert Channel and the bay fronting Castaways marina, the depths are very shallow, with a marked channel yielding close to -4' NGVD. Progressing down Wulfert Channel, depths gradually increase in the naturally cut waterway to -5' and -6' NGVD, shallowing slightly before exiting in Pine Island Sound at marker #1.

Elevations at the three tidal passes, Blind Pass and the two recent tidal cuts into Clam Bayou, were somewhat similar. The most recent tidal connection to Clam Bayou at the southern cut is lower in overall elevation, still succumbing to tidal overwash during storm events. The connection was naturally opened on Sept. 15, 2001 when Tropical Storm Gabrielle imported a storm surge creating the opening. This was also the site where the city made an emergency cut through in 2002 to release some of the super-elevated water from Clam Bayou, attempting to prevent further drowning of the mangrove fringe.

VI. TIDAL SURVEY

Tidal Conditions - Tides in the region are mixed, a combination of diurnal and semi-diurnal tides through the month, with a range of between 1 to 3 feet, depending on season. Two tide stations exist in the project area, one at the southern limit of Captiva documenting the Gulf of Mexico (Station 872-5383) and the second at mid island on Captiva providing data for Pine Island Sound (Station 872-5417). Refer to the individual tide station data background sheets attached. There is a notable difference in tidal range between the two tide stations. Additional tide control stations from the surrounding area were used to calibrate the inlet model.

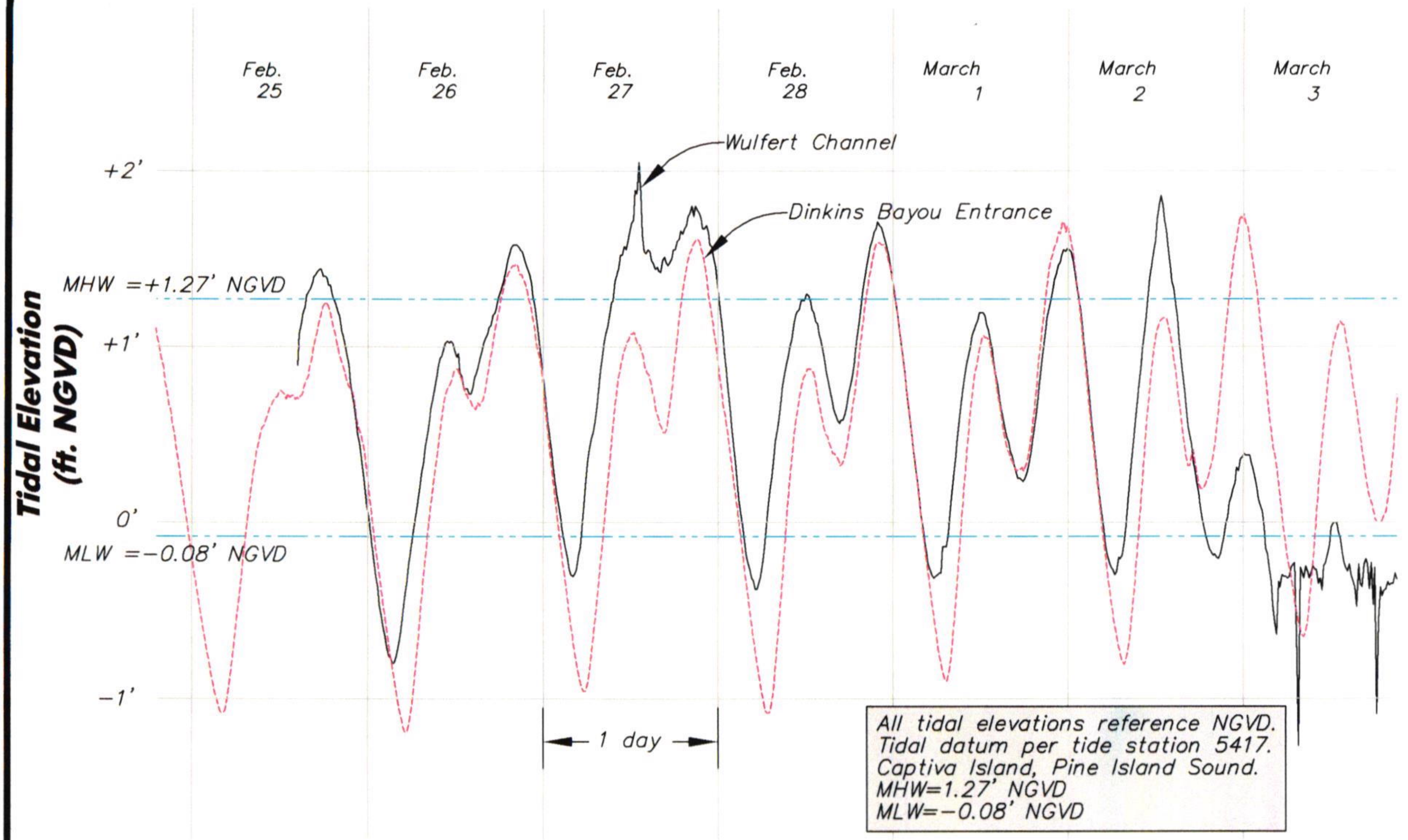
There were a number of reasons for collecting tidal information in this area. Principal was to determine the range or tidal prism that would have a direct impact on a tidal connection to Clam Bayou, whether through Dinkins Bayou or the Gulf of Mexico. Second, to determine if friction factors created through turns in the waterway, shallow water, boat docks, and other obstructions reduced the tidal prism between the various water bodies. This would determine if dredging is necessary to maximize the tidal flow to the restoration area.

Real time tidal information was collected over a two month period, using four tide gages manufactured by Infinities USA, Inc. Data Logger Series. A gage was set at the entrance to Wulfert Channel at Pine Island Sound adjacent to entrance channel marker #1; at the entrance to Dinkins Bayou at 2727 Coconut Dr.; and at the headwater of Dinkins Bayou, at 5650 Sanibel-Captiva Road, within the proximity of the proposed flushing connection. A fourth tide gauge was set at the southern limit of Clam Bayou along the coastal spit to determine if there was any tidal fluctuation attributed to subterranean flow between the bayou and the Gulf of Mexico. Each gauge was set up to record on 15 minute intervals, leveled into NGVD datum, with a recording resolution of 0.01 inches. A map is attached depicting the tide station locations. In addition, the tidal information for the four tide gages is included in various comparative forms.

Results - The tide gauge located within Clam Bayou recorded the changes in elevation attributed to rainfall but did not show any sinusoidal tidal pattern anticipated with subsurface flow through the soil substrate separating Clam Bayou and the Gulf of Mexico. This confirms that Clam Bayou does not tidally fluctuate.

Refer to the 11" x 17" foldout in the back of this section, labeled **Dinkins Bayou Tides**. There was no significant tidal phase lag between the entrance and headwater of Dinkins Bayou, indicating a fairly unrestricted, or limited friction factor, existing between the two entrances. The tide range observed at the headwaters was essentially the same as the range recorded at the Dinkins entrance, 2.0'.

The data collected and contrasted in **Wulfert Channel and Dinkins Bayou entrance tides** graphics at the end of this section refer to the tide differences between the entrance to Wulfert Channel and Dinkins Bayou. The graphs show significant variations, both in phase lag and tidal amplitude. In most cases the two tide gages reflect normal tide ranges and periodicity. The Wulfert Channel tide gauge, which is probably the most indicative of tidal conditions represented by the Pine Island Sound tide station 872-5417, was typically higher in overall elevation. However, there were variations when the elevations were lower than the Dinkins Bayou gages. The tidal range observed at the Wulfert Channel tide gauge was also less than the range recorded within Dinkins Bayou, at 1.8'. This is anomalous to what would be expected with Dinkins Bayou further "upstream". The result is some insight as to the influence of Roosevelt Channel on Dinkins Bayou, as well as the impact of wind driven currents in the shallow waters of Wulfert Channel. It is suggested from the discontinuity between the two tide gages that Roosevelt Channel has a significant influence on tide conditions in Dinkins Bayou.



Wulfert Channel and Dinkins Bayou entrance tides

Week 1

June 16, 2003 11:08:42 a.m.
Drawing: CLAM1 COMBINED TIDES.DWG (CY)

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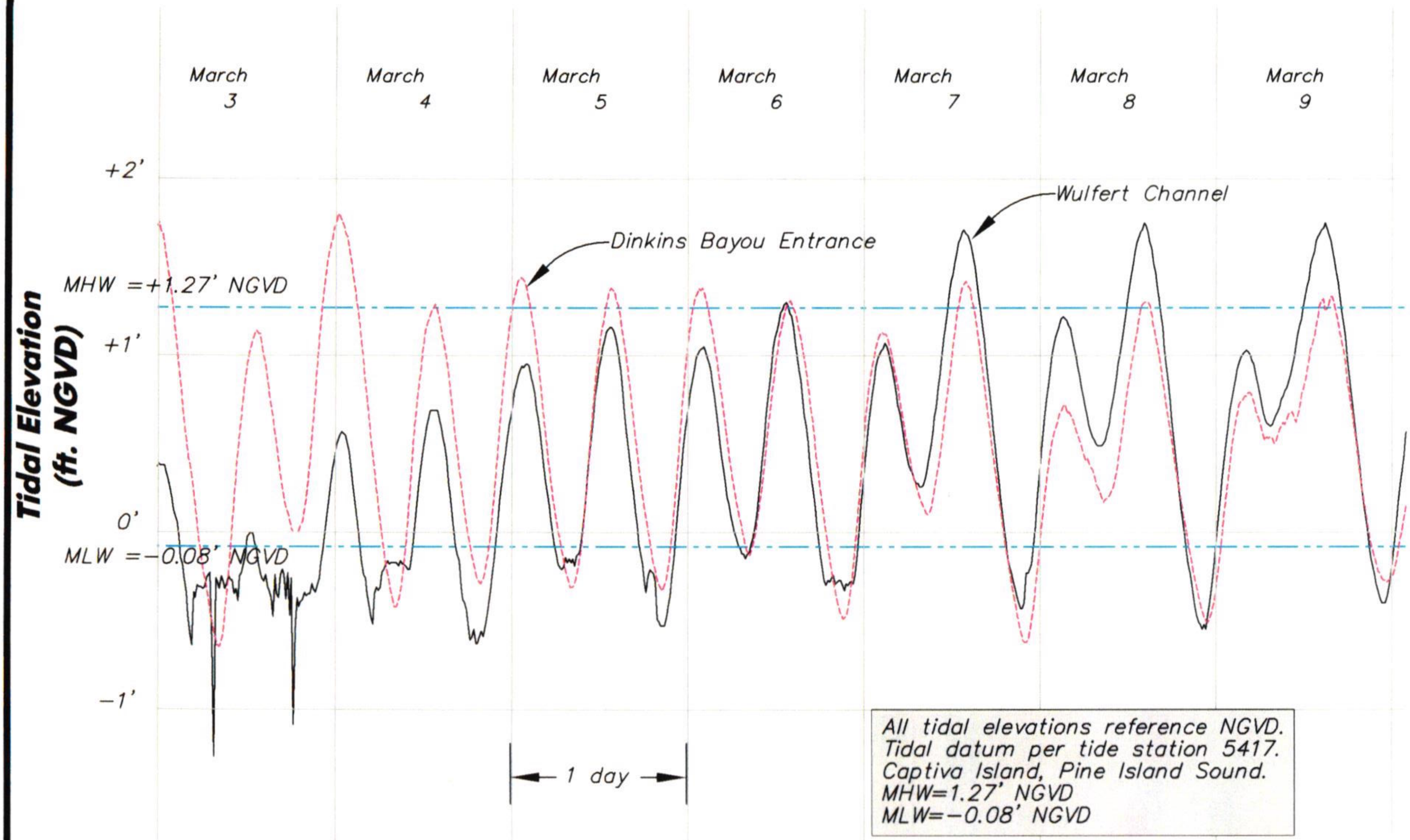

Wulfert Channel and Dinkins Bayou entrance tides

Week 2

June 16, 2003 11:08:42 a.m.
Drawing: CLAM1 COMBINED TIDES.DWG (CY)

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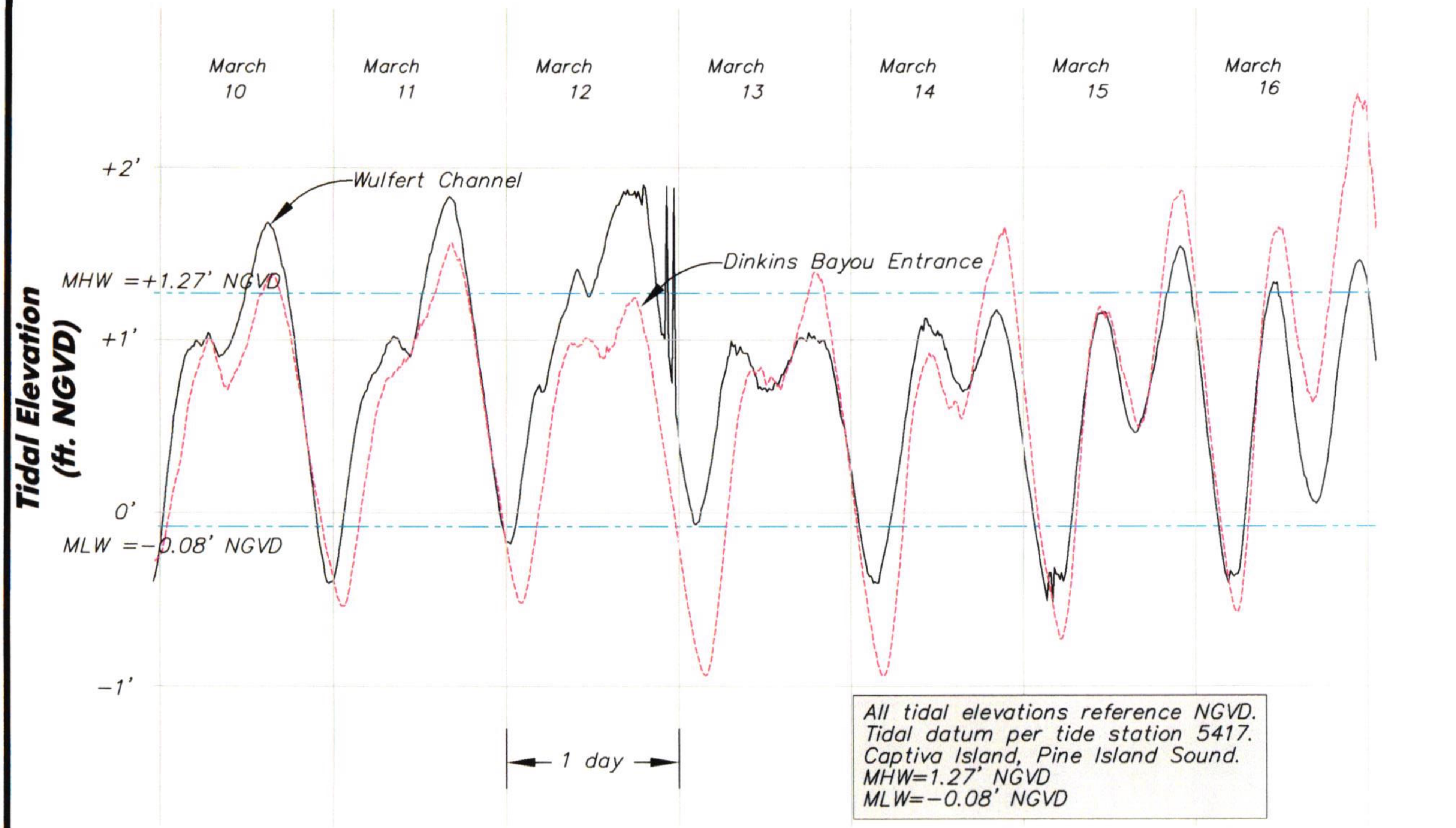

Wulfert Channel and Dinkins Bayou entrance tides

Week 3

June 16, 2003 11:08:42 a.m.
Drawing: CLAM1 COMBINED TIDES.DWG (CY)

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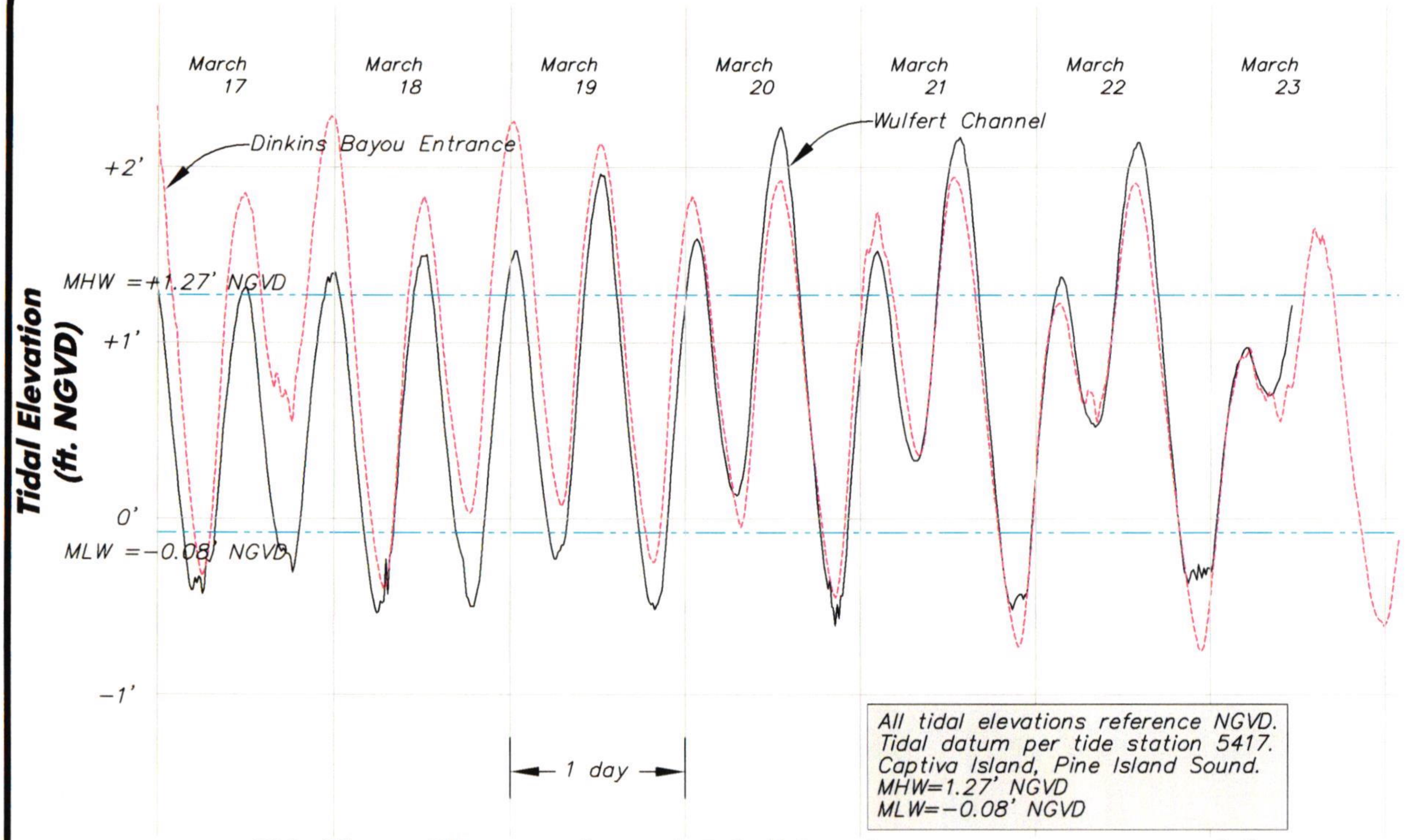

Wulfert Channel and Dinkins Bayou entrance tides

Week 4

June 16, 2003 11:08:42 a.m.
Drawing: CLAM1 COMBINED TIDES.DWG (CY)

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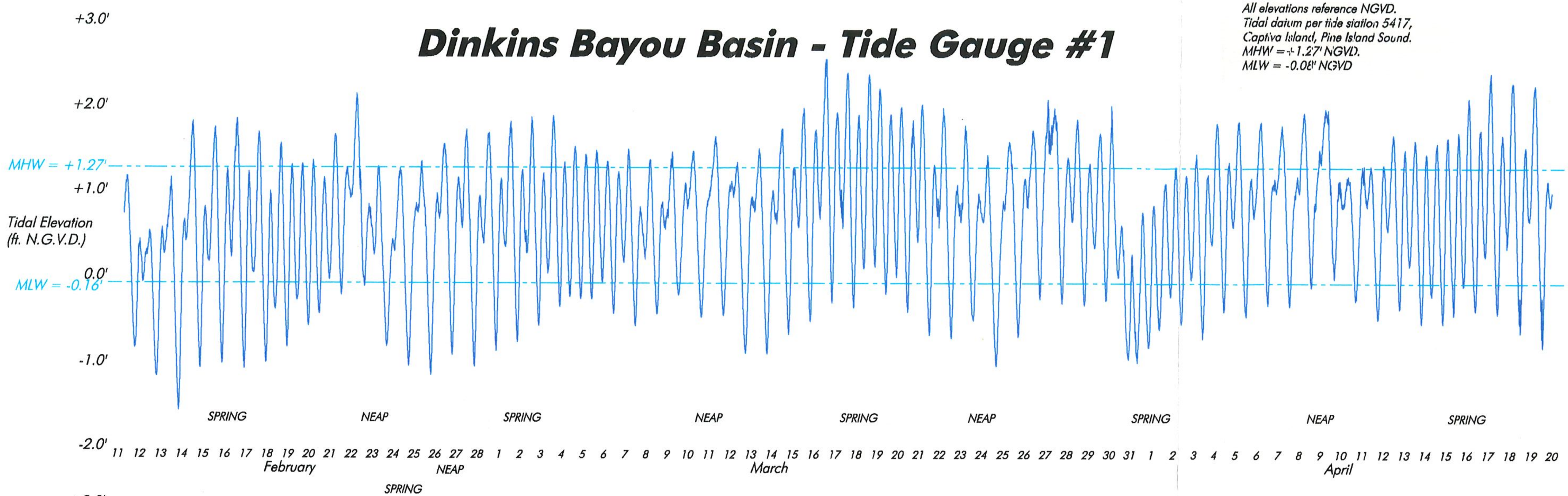
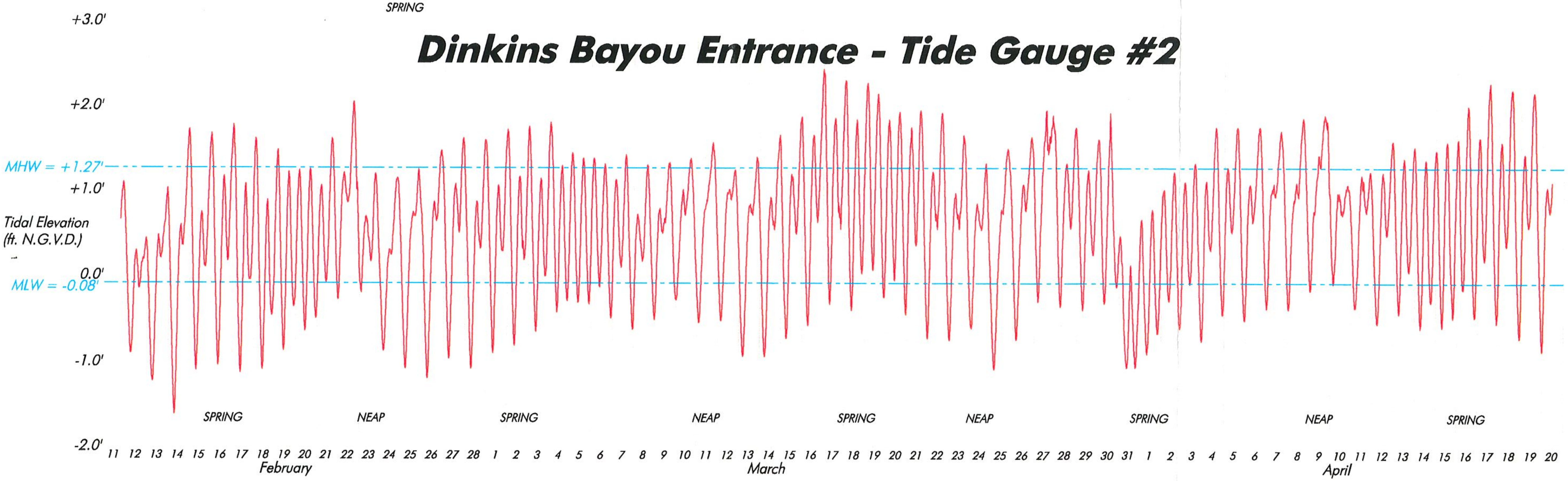
Notes:
All elevations reference NGVD.
Tidal datum per tide station 5417, Captiva Island, Pine Island Sound.
MHW = +1.27' NGVD.
MLW = -0.08' NGVD





HANS WILSON & ASSOC., INC. 1938 Hill Ave. Ft. Myers, Florida 33901 Tel: 239-334-6870 Fax: 239-334-7810 MARINE and ENVIRONMENTAL CONSULTANTS	5/25/03	**Dinkins Bayou Tides**	**Blind Pass Eco-zone Feasibility Study**	SHEET

VII. ECOLOGICAL SURVEY

General - An assessment of the current ecological health of both Dinkins and Clam Bayou was completed, focusing predominantly on mangrove losses in Clam Bayou. This survey included a recent aerial overview of Clam Bayou. Refer to **Photos #1 - #4** , at the end of this section. Even with hazy conditions, the impact of mangroves lost in Clam Bayou is visible in the photos. General, and measured, observations of mangrove impacts, at various transects at locations around the site, were also completed. These transects were extended from the waterward edge of the dead vegetation, to the landward limit of the edge of water. The limits of viable vegetation fringes were also noted. Transects were based on a random selection of sites around Clam Bayou, used to calibrate aerial mapping of the impacted region. **Photo #7** is an example of the type transect completed around the area. Referring to the **Blind Pass Gulfside** graphic at the end of Section II, the result of the survey transects was to establish the limit of the Mangrove Impact Areas, resulting in the estimate of 48.8 acres of dead or dying mangroves as shown in the photo.

General observations of habitat conditions were also noted, included seagrass meadows (**Photo #6**), wading and loafing areas for birds (**Photo #11**), and plant diversity (**Photo #12**). The alignment of the proposed flushing channel was developed based on a ground survey, noting vegetation type and density (**Photos 16 – 19**), with a focus on the optimum location to minimize wetland impacts. Additional work was done wading the Dinkins Bayou areas for an assessment of any seagrasses and other benthic habitats potentially impacted by construction.

Clam Bayou - The most consistent reason for the extensive damage to the mangrove systems in Clam Bayou is based on a relatively uniform, flat substrate on which they have established. Similar to the emergent flood tidal shoals in Blind Pass, these shallow, broad deltas are relatively uniform in depth. Dependent on tidal fluctuations, mangroves can thrive in this environment. When the water stays elevated for extended periods of time, the mangroves essentially drown, unable to transport oxygen to the deeper root systems. This was further confirmed when investigating mangroves that are established along shorelines with steeper banks. Examples of this exist along the developed residential shorelines and in the most southern bayou along Bowman's beach. Because these mangrove trees have established their root systems with a quickly varying elevation, it is surmised that they can survive the extended increase in water elevation. In other words, within their own root systems, they can still survive by maximizing oxygen exchange through the root systems located on higher ground. Mangroves that have established in the broad, shallow deltas are essentially submerged and cannot adapt as quickly. **Photo #9** is a good example of this condition. Note the mangrove in the foreground is dead, with its entire root system inundated, while in the background the mangroves located on higher ground survive. If elevations in Clam Bayou are increased, eventually these mangroves will succumb to the flooding of their root systems.

Within the 100+ acres of mangrove wetlands that are threatened by uncontrolled water elevations, it is estimated that 48.8 acres have been critically damaged or dead. These mature mangroves have been lost from shallow tidal deltas and perimeter shoreline fringes. With the lowering of Clam Bayou in October 2002, there is evidence of re-establishment of mangroves in these shallow deltas, encouraging the possibility of long-term recovery if tidal elevations can be controlled (refer to **Photo #10**). In the interim, without benefit of controlled water elevations, it is expected that these mangroves will also succumb to flooding conditions associated with the summer rains.

General observations regarding submerged habitat include noting extensive Widgeon Grass (*Ruppia martima*) throughout the northwestern sections of Clam Bayou. This seagrass appeared in thick mats at elevations shallower than -3'. We also observed numerous fry species, Mullet (*Mugil cephalus*), and Jack Crevalle (*Caranx hippos)* in the bayou. Nesting birds appeared to be almost exclusively Ospreys (*Pandion haliaetus*). An assortment of birds were observed in the bayou, including Brown pelicans (*Pelecanus occidentalus*); Great blue heron (*Ardea herodias);* Roseate spoonbill (*Ajaia ajaja);* Great egret *(Casmerodius albus);* Black-necked Stilt (*Himantopus mexicanus);* Willet (*Catoptrophorus semipalmatus);* and Sandpiper spp. It was noted that the numbers and variety of birds appeared to have declined based on past observations.

Mangroves - Within the various ecological zones found on Sanibel Island, mangroves are recognized as the most important in terms of the number of jobs done for man at no cost. Benefits created by healthy mangrove systems include: acting as protective nursery and feeding grounds for many species of fish and invertebrates; providing a substrate for attachment for colonizing sessile invertebrates that form both the basis of food chains and filter feeding; improve water quality, being highly efficient primary producers and uptaking nutrients, typically associated with water quality degradation; attenuating the erosion of low energy coastlines; and providing necessary habitat for birds for roosting, loafing, and nesting.

Sanibel Island is approximately 11,000 acres, of which there were approximately 2,800 acres of mangroves noted in 1976. Approximately 2,300 acres of mangroves are located within the Ding Darling Wildlife refuge and other important areas surrounding the Blind Pass Eco-zone. Work carried out as part of The Sanibel Report (1975) showed that the mangroves in areas around Blind Pass were mostly red mangroves forming fringing forests up to 100 feet in width. They were vigorously flushed near the mouths of the respective bayous, but less so inland, although daily inundation and detritus export was observed and few white and black mangroves found.

Red mangrove communities are dependant to a large extent on their relationship to tidal range and freshwater inflow, with associated nutrients. Mangroves are salt tolerant trees with biological adaptations to enable them to exist in waterlogged soils including stabilizing root systems and mechanisms to alleviate oxygen depletion. Specific adaptations allow them to survive in saline soils although they do not require salt. In freshwater environments they are out-competed by other plant species and more highly adapted to survive in the salt environment with much less competition. Without tidal exchange salt can build up in mangrove soils which thus become hypersaline and toxified by the by products of respiration, leading to stress and deterioration of the trees. Mangroves have developed prop roots, drop roots, and cable roots (with associated pneumataphores) that are critical to oxygen uptake by the plant.

In Red Mangroves, the above ground portion of the roots contain small pores called lenticels that assist with diffusion of oxygen into the plant down to the underground roots, via the air space tissues in the cortex called aerenchyma. When these pores are covered, oxygen transport is cut off and the plant is stressed, and eventually dies. In addition, the export by tidal flow of the primary production (detritus) of these mangrove systems, some of the highest in the world, is lost. Leaves that would otherwise fall and decay in place, with the associated nutrients, are not taken up into the bodies of other organisms. In other words, without adequate tidal exchange a mangrove forest loses much of its productive value.

Flushing Connections - To address the loss of tidal exchange with the extensive mangrove system that resides in Clam Bayou, a preliminary evaluation of potential short cuts to tidal waters yield two alternatives considered economically viable. The first alternative is a direct connection to the Gulf of Mexico. The location that creates the least likely impact is the south overwash area, however this may not be the most effective to restore flushing to the entire Clam Bayou system. This area was previously excavated to lower flood levels in Clam Bayou, and has already been impacted. Within this proposed alignment there is minimal impacts to mangroves or seagrasses. This area is very transitional in nature and construction in this location would create a minimal long term impact. The feasibility of making this connection is also dependent on keeping the pass open through tidal flushing. An evaluation of a tidal connection in this area is discussed in Section IX – Hydrodynamic Modeling.

The second alternative that appears most practical is making a tidal connection under Sanibel Captiva Road to Dinkins Bayou. An investigation of a proposed flushing channel through this area was conducted to evaluate the level of impact associated with the construction. The survey extended from the waterward edge of Clam Bayou to the submerged areas within Dinkins Bayou. Refer to **Culvert Cross Section** for a representative cross section of this area, located in Section VIII – Flushing Conditions and Water Quality. This site is adjacent, and west of, the Island Water Association storage tank, and east of the platted residential subdivision along Sanibel Captiva Road. The road, at crest elevations around 6.0' NGVD, appears to follow a natural ridge that drops off fairly quickly on both sides. There is evidence of earth modifications in the form of berms on each side of the road. It is unknown if the road bed was raised artificially, or based on the height of the existing berm. The road has been elevated during improvements to drainage in the late 1980's. Elevations level off on the Clam Bayou side around 3.0' NGVD, with a gradual slope down to the edge of the water. On the Dinkins Bayou side, there is a fairly rapid drop from the berm height of 6.4' NGVD down to the 2' contour where is gradually tapers down to the waters edge.

Vegetation on the Dinkins Bayou side is a mixed hardwood hammock transitioning to tidal wetlands (refer to **Photo #19**). The entire area on this side is dominated by Brazilian pepper (*Schinus terebinthifolius*), with Buttonwood (*Conocarpus erectus*) and Cabbage Palm (*Sabal palmetto)* as the main canopy. Scattered Sea oxeye (*Borrichia frutescens)* and Stoppers (*Eugenia spp.)* dominate the understory. Vegetation identified along the tidal shoreline consists of Red mangrove *(Rhizophora mangle),* Black mangrove (*Avicennia germinans)* and White mangrove (*Laguncularia racemosa).* The width of the tidal wetland was fairly uniform, around 30' from the root line to the mean high water line. Red mangroves are the dominant plant species along the shoreline. A survey transect along the shoreline was discovered, and later confirmed by Bean, Whittaker, Lutz and Kareh surveyors as an approximate mean high water line survey, verifying our measurements.

On the south side of Sanibel Captiva Road the property was cleared and was higher in elevation than the Dinkins Bayou side. A concrete monument was observed on the southwest corner of the survey alignment. Vegetation observed in this area was similar to the north side, and included Seagrape (*Coccoloba uvifera*), Gray Nickerbean *(Caesalpinia bonduc),* Australian Pine (*Casuarina equisetifolia),* Brazilian Pepper (*Schinus terebinthifolius),* Buttonwood (*Conocarpus erectus*) and Cabbage Palm (*Sabal palmetto).* The density of pepper on site was less, and it appeared that the property had been cleared of most of the exotics.

It appears that the location of a flushing channel, located equally on both side of Sanibel-Captiva Rd., will impact less wetlands by locating it further to the west of the Island Water Association storage tank than originally estimated. This also provides room for equipment operation and traffic management. There is also greater opportunity to remove extensive exotic vegetation in this area and restore native habitats, both wetland and upland, on both sides of the flushing channel. This further enhances water quality and assists with storm flooding impacts.

Dinkins Bayou headwaters - For a flushing channel to perform adequately, it needs to connect to suitable adjacent depths. The area where a flushing channel could optimally be constructed and connected to the controlling channel depth of -3' NGVD, was checked for seagrasses on May 26, 2003, within the U.S. Fish and Wildlife Service official seagrass growing season (May 1 through September 30). None were observed within the alignment, which covered an area approximately 60' wide by the length necessary to match the -3' contour in Dinkins Bayou. Drift algae, Spiny Seaweed (*Acanthophora spidifera*), dominated the bottom through out the site. The bottom composition was silty grey sands, relatively unconsolidated, and easily penetrated to a 2' to 3' depth. Probes to locate bivalves were fruitless, and there were only a few gastropods such as Crown conch (*Melongena corona)* and Lightening whelk (*Busycon sinistrum)* observed in the channel area. Water clarity was fair to poor (less than 2') and sediments within bayou easily suspended. The majority of the sampling occurred by hand sweeping the area and probing for bivalves.

Further to the north, in the broader reaches of Dinkins Bayou, similar conditions existed. Where past personal observations of seagrasses existed in the bayou, only similar meadows of the drift algae were observed. Water clarity was slightly better (less than 3'). The survey occurred at the peak of a strong incoming tide, and water clarity in Pine Island Sound at the entrance to Wulfert Channel was excellent (5'+).

Habitat Valuation - Part of the assessment of the habitat and restoration options includes a valuation of the habitat. There are a number of information sources and project scenarios that can be used to assess the value of the Clam Bayou estuary. Charlotte Harbor National Estuary Program is the closest, and most comparable program evaluating estuarine resources. The Charlotte Harbor estuary covers 4,468 square miles in eight counties in southwest Florida (Polk, Manatee, Hardee, Desoto, Charlotte, Sarasota, Lee and Highlands) (Hazen and Sawyer, 1998). This estuary provides $1.8 billion per year in net value to recreation and Florida households and produces about $3.2 billion per year in net income (Hazen and Sawyer, 1998). For a very gross estimation, $3.2 billion net income divided over 4,468 square miles yields a base income value of $1,103 per acre. If applied to Clam Bayou with an approximate estuary expanse of 200 acres, that results in an annual value of $220,690. Critical facts that include the value of Clam Bayou are listed as follows (Jones, 2003).

- 85% of sport and commercially harvested species in Florida depend on estuaries and in 1996 Florida's commercial fishing industry had a value of$718,210,000- Over 75 percent of the United States' commercial fish catch depends on estuaries.

- The economic value of commercial fisheries supported by estuaries is at least $19 billion annually.

- Approximately 45 percent of the nation's endangered and threatened species inhabit coastal areas and about 80 percent of all fish and shellfish worldwide use estuaries as primary habitat, or as spawning or nursery grounds.

Approximately 48.8 acres of mature mangroves in Clam Bayou have been lost, or are critically impacted and will be permanently lost, if restoration does not take place. With increased elevations in Clam Bayou, additional mangroves are damaged. Estimates of the value of healthy mangrove systems vary widely. From Bacalar Chico marine reserve in Belize values range from $9,000 - $25,000 per acre (Eltringham, 2003). In Malaysia the value of intact mangroves swamps just for storm protection and flood control was given at $300,000 per kilometer ($91/linear foot of shoreline) (Ramsar Bureau, 2003). Other authors have given an average value (based on values in the US economy) of the physical, commercial and ecological services provided by mangroves or other tidal swampland of around $10,000/ha ($4,047/acre) (Mangrove Conservation and Development). In state land purchases and agreements for use of private easements, the fee simple value of mangroves and other submerged lands average between $1,000 and $1,500 per acre. (Bowen, 2002). Approximately 200 acres constitutes the submerged and mangrove portions of Clam Bayou. On a fee simple basis this would equate to $300,000 of land value.

It is clear that a value can be placed on the Clam Bayou estuary from both an economic productivity perspective ($220,690 annually) and fee simple land valuation ($300,000). Using the lowest end of the economic spectrum, in any given year Clam Bayou constitutes at least a half a million dollars of value. This value is probably significantly higher given proximity to the Pine Island Sound Aquatic Preserve and Ding Darling Wildlife Refuge. This value also does not consider the impact on recreation, tourism, storm protection, and land values with the loss of this habitat.

Photo #1
View of Blind Pass looking north on March 10, 2003. Note pass is closed and an emergent flood shoal continues to develop vegetation.

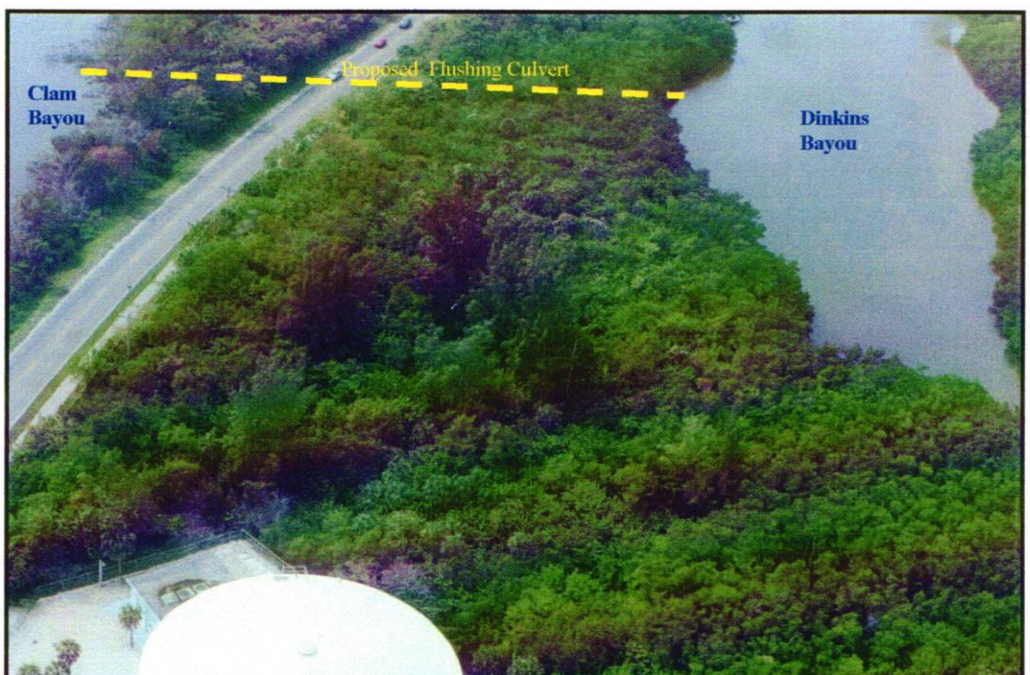


Photo #2
Proposed area for flushing channel/culvert to connect Clam and Dinkins Bayou.

Photo #3
Mangrove losses in Clam Bayou, looking west. Note emergency cut through at Clam pass in background.

Photo #4
Mangrove losses in Clam Bayou

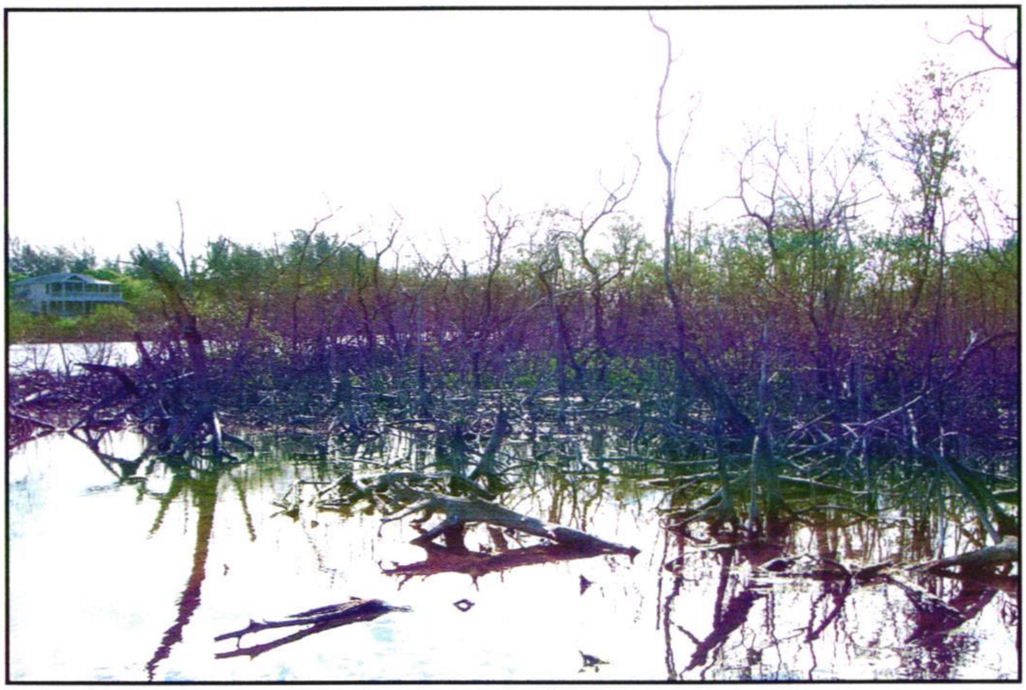


Photo #5
Typical mangrove losses in Clam Bayou

Photo #6
Extensive grass beds (*Ruppia maritima)* in Clam Bayou.

Photo #7
Typical width of mangrove fringe losses. Person in background represents approximate limit of impacted mangroves.

Photo #8
Note mangrove losses on both sides of tidal cut to internal bayou.

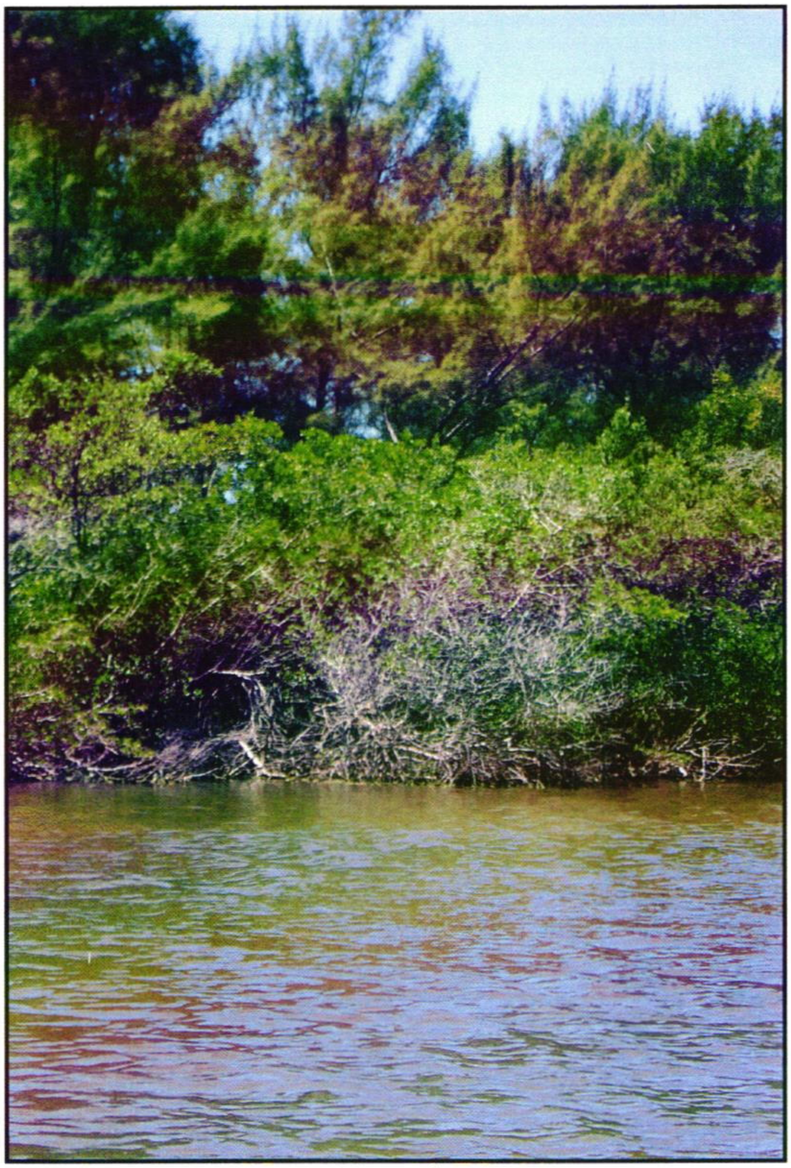


Photo #9
Note mangroves established in areas of rapid elevation change (higher up on the banks) have survived better than those established at lower elevations.

Photo #10
Recent emergency water release has stabilized water elevation and allowed for natural mangrove recruitment in areas where mangroves were dying.

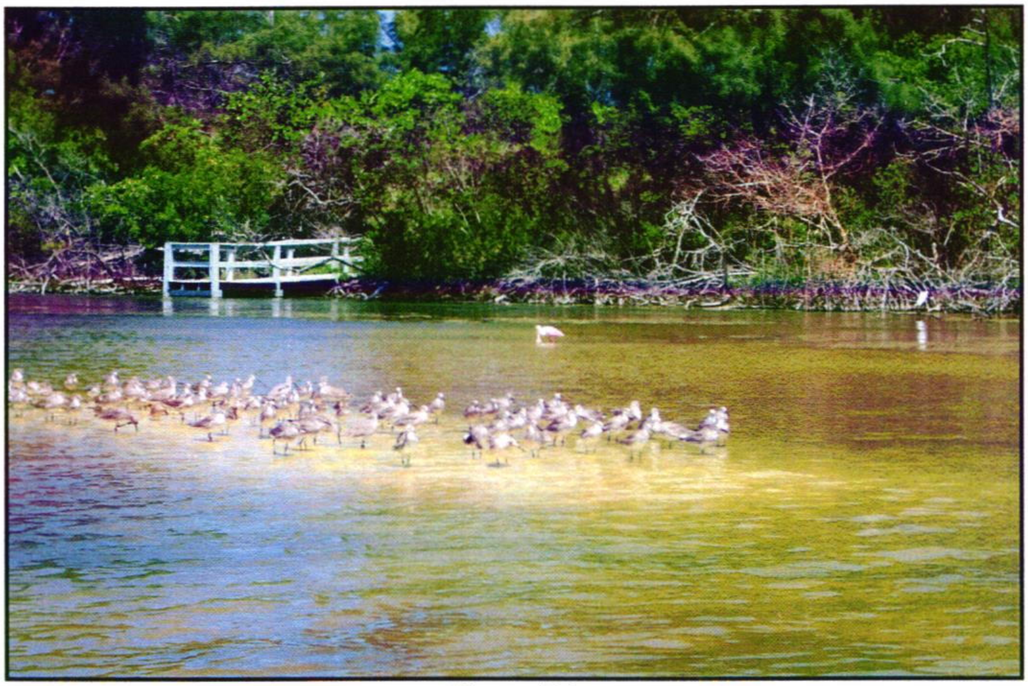


Photo #11
Wading bird habitat near location of emergency water release cut.

Photo #12
Plant species found in Clam Bayou. Species from left to right: Sea Blight (*Sueda linearis*), Saltwort (*Batis maritima*), and Sea Purslane (*Sesuvium spp.*), and on bottom is Sea Lettuce (*Ulva spp.*).

Photo #13
Typical sessile organisms colonizing in a limited vertical distribution.

Photo #14
Close up of diversity of mussels and other organisms colonizing in limited vertical distribution.

Photo #15
Tourism is an important reason for habitat restoration.

Photo #16
View of flushing channel alignment at edge of jurisdictional wetland limit. Note the predominance of brazillian pepper (*Schinus terebinthifolius*) vegetation.

Photo #17
Shoestring fern growing on Cabbage Palm.

Photo #18
Note berm separating road and bike path from upland area, near proposed flushing channel.

Photo #19
View of proposed flushing channel alignment with Sanibel-Captiva Road in the background.

VIII. FLUSHING CONDITIONS and WATER QUALITY

Water Quality and Biological Parameters - Marine waters around the island are classified as Class II Outstanding Florida Waters within Pine Island Sound. Turbidity around Sanibel was noted in 1975 to be worst around the Dinkins and Clam Bayou area. Also noted was a thick 12-18 inch deep lagoonal mud within Clam Bayou, an area which historically was said to have a white sandy bottom. Within Dinkins Bayou, an soft, gray-white, marly sediment overlies sand (Tanner, 1978).

Blind Pass is the youngest, and least stable, part of the island, where the sinuous nature of the bays, blockage by Australian Pines, Mangroves and sand bars, reduces tidal flushing such that pollutants entering from human activities can quickly build up in the Bay system, with limited or absent dispersive ability provided by the Gulf of Mexico. Communities surrounding these waterbodies are on septic treatment systems and in many cases are lushly landscaped and maintained with the use of herbicides and pesticides that contribute to water quality degradation.

In the Sanibel Report (1975) both turtle and shoal grass existed in Dinkins Bayou, and in Clam Bayou shoal grass was observed. It was also reported that Clam Bayou historically supported large numbers of the Marsh clam (*Polymesoda floridana*) and was the only place on Sanibel that supported the pointed Venus clam, (*Anomalicardia cuneimenis*). The report concluded that the waters around Blind Pass are considered intermediate between the Gulf of Mexico and Pine Island Sound tidal areas, and as such warrant special preservation status, including minimizing further development.

Water quality data for Clam Bayou is available from 1996 through April of 2002. A graphical representation of this data **Dissolved Oxygen/Salinity for Clam Bayou and Dinkins Bayou**) is included at the end of this Section. The raw data collected by Lee County Environmental Laboratory and put in table format for this report, shows variations in salinity from 19 ppt to 43 ppt. Standard seawater salinity is 35 ppt. Data collected for dissolved oxygen ranges from 1.8 mg/l to 8.1 mg/l. Additional water quality data was also gathered by the City of Sanibel for both Clam Bayou and Dinkins Bayou for 2002, and added to the graphics. Salinity values in Dinkins are fairly uniform, ranging from 28.5 ppt to 37.5 ppt. Dissolved oxygen was consistently lower than the state standard of 5.0 mg/l, ranging from 1.0 mg/l to 5.2 mg/l. In the same time frame, salinity in Clam Bayou ranged from 18.8 ppt to 50.4 ppt, while dissolved oxygen was generally better, ranging from 1.0 mg/l to 8.3 mg/l. A number of other parameters, both physical and chemical, were sampled in this time frame, but not included in this report. Salinity and dissolved oxygen were chosen for discussion, since they relate well to the overall condition of the waterbody and the availability of oxygen for biological production. The graphic labeled **Clam Bayou Water Level and**

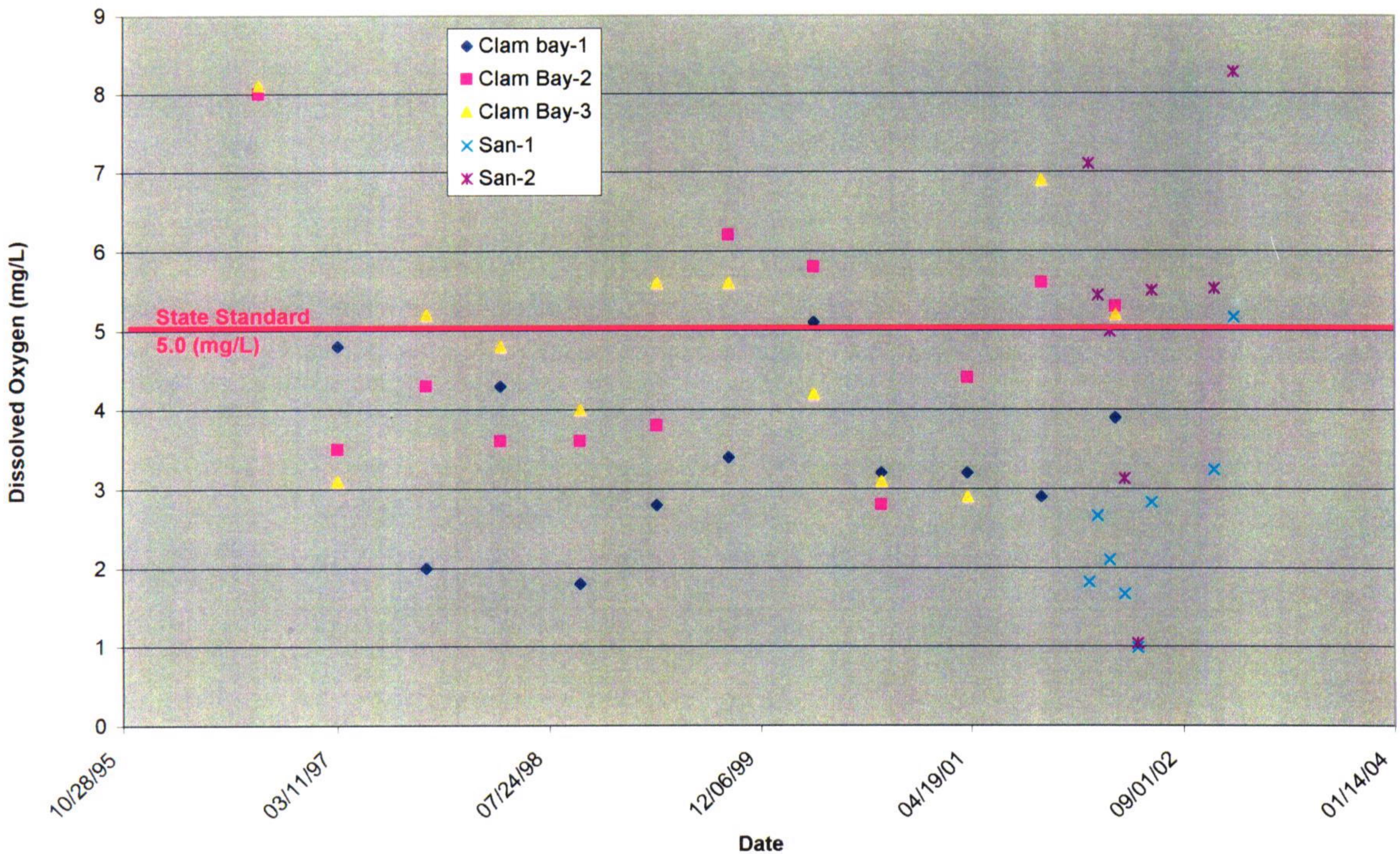
Rainfall shows the relationship between water elevation in Clam Bayou relative to rainfall amounts and frequency.

Flushing Channel Design Parameters - Cross sectional depth information was collected at various constrictions within Dinkins Bayou. Cross sectional area was used to assess the final channel size, based on tidal prism both from the Gulf of Mexico and Pine Island Sound. Application of tidal prism theory to flow velocity and volume through the narrowest portion of Dinkins Bayou results in an estimation of the flow volume expected to reach Clam Bayou on an average annual tide basis, limited by velocities that create scour. The narrowest opening affecting a flushing channel to Clam Bayou occurs at the headwaters of Dinkins Bayou, at the terminus of Pine Tree Avenue. Three cross section profiles were collected at the shallowest locations along the centerline. Of the three profiles, the mid length location was the most confining. Cross sectional area at low tide was 78 sf. and at high tide was 150 sf.

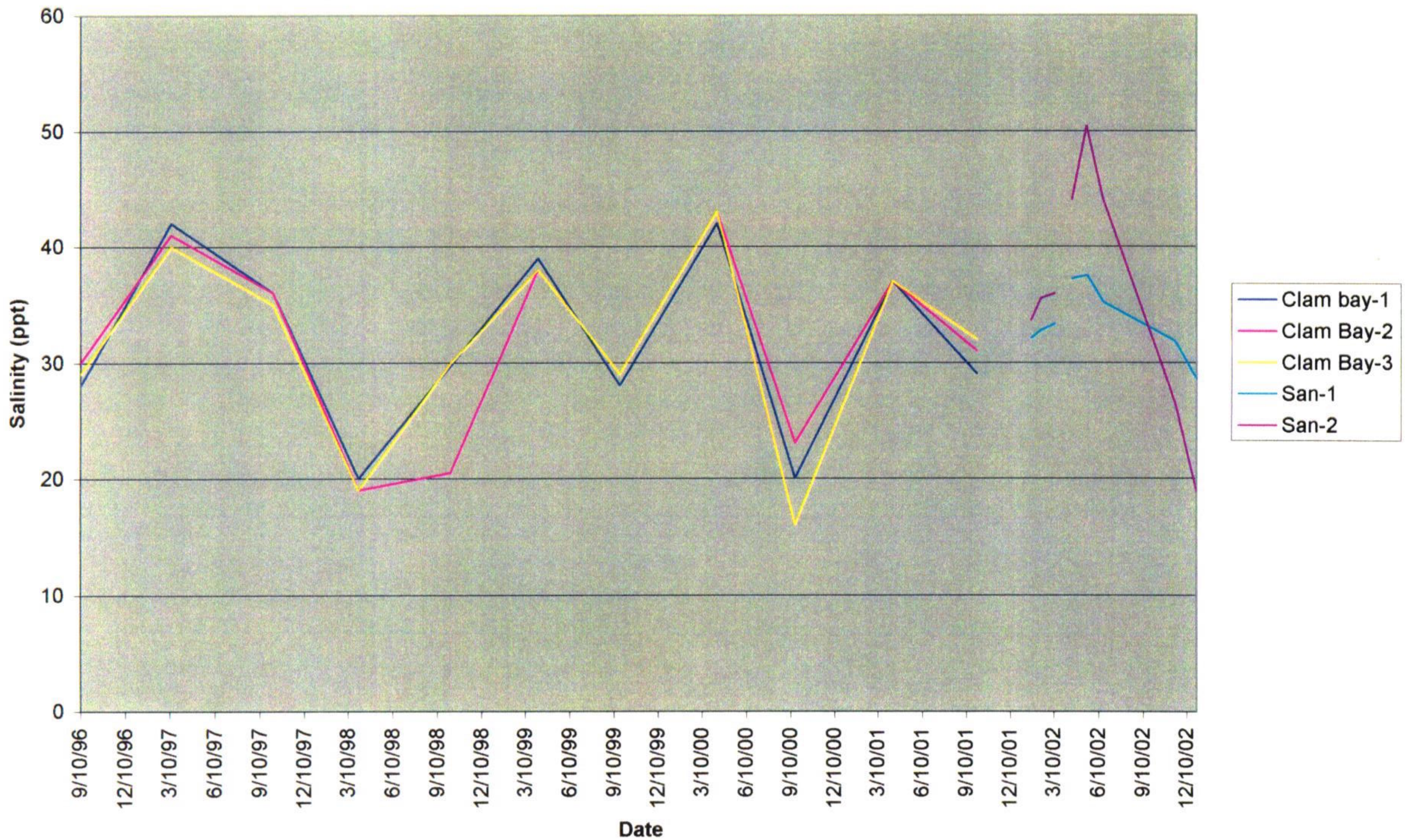
Using this cross section as a template, we selected a channel opening and box culvert or bridge crossing that would provide a minimum of 90 sf. of area at low tide (refer to **Flushing Channel Cross Section** and **Culver Cross Section** at the end of this section). This set the invert elevation to a minimum of -3' NGVD, requiring a width of 30'. We added an additional 0.5' of depth to get us closer to the 150 sf. of cross sectional area at high tide. With a vertical dimension of 5.27' at high tide and a 30' width, the total cross sectional area is 158 sf. This is more than the 150 sf. at the controlling width, but will be reduced by the supporting vertical structures in a box culvert or bridge crossing and growth in the intertidal zone of the fixed structure. Sedimentation in the invert is unlikely based on the tidal flow velocities expected at this site.

The proposed connecting channel to the box culvert/bridge is lined with riprap for habitat and prevention of scour under storm conditions. A mangrove tidal shelf is proposed on both sides of the flushing channel for habitat and to decrease tidal velocities, as the tide elevation increases.

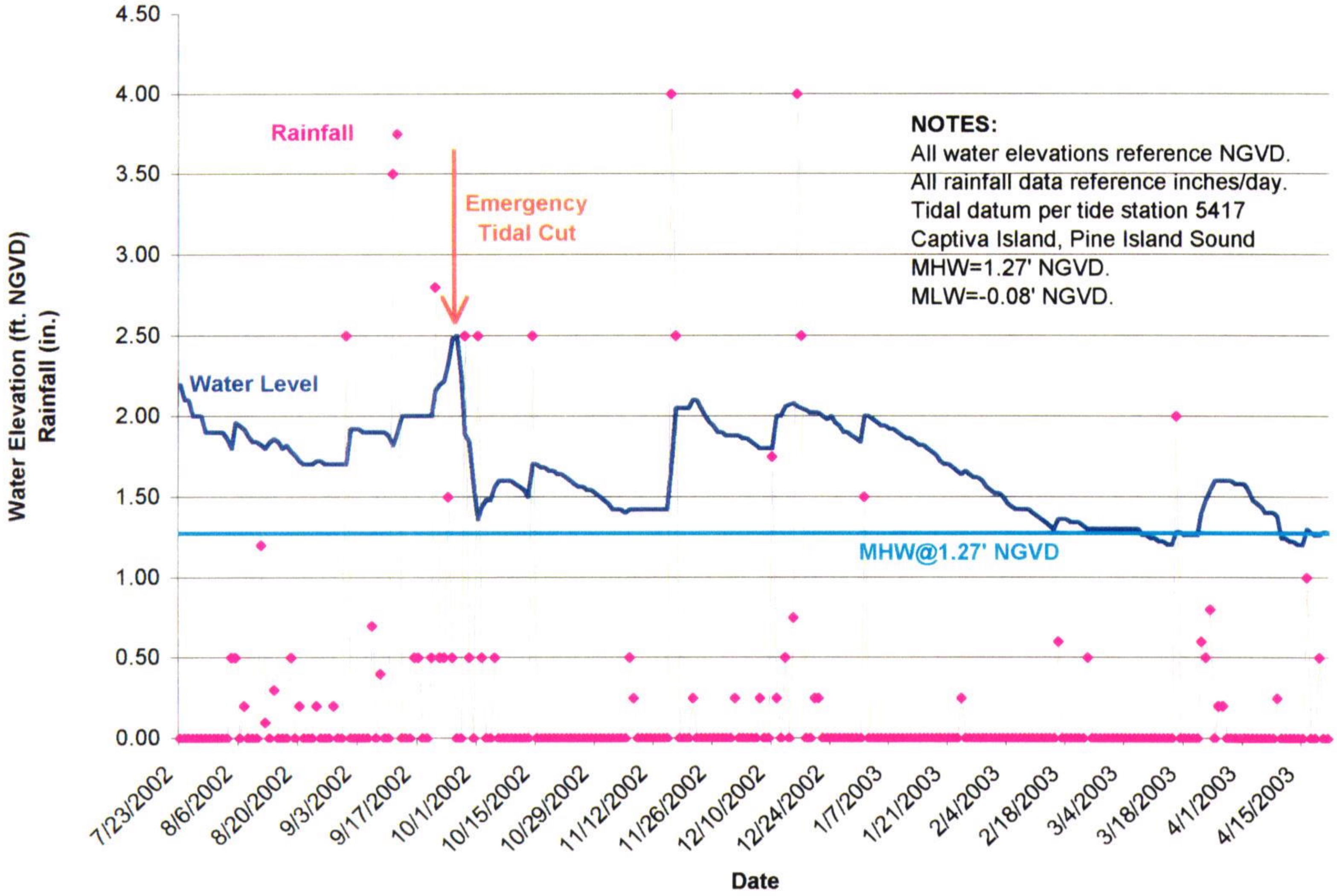
Dissolved Oxygen for Clam Bayou and Dinkins Bayou

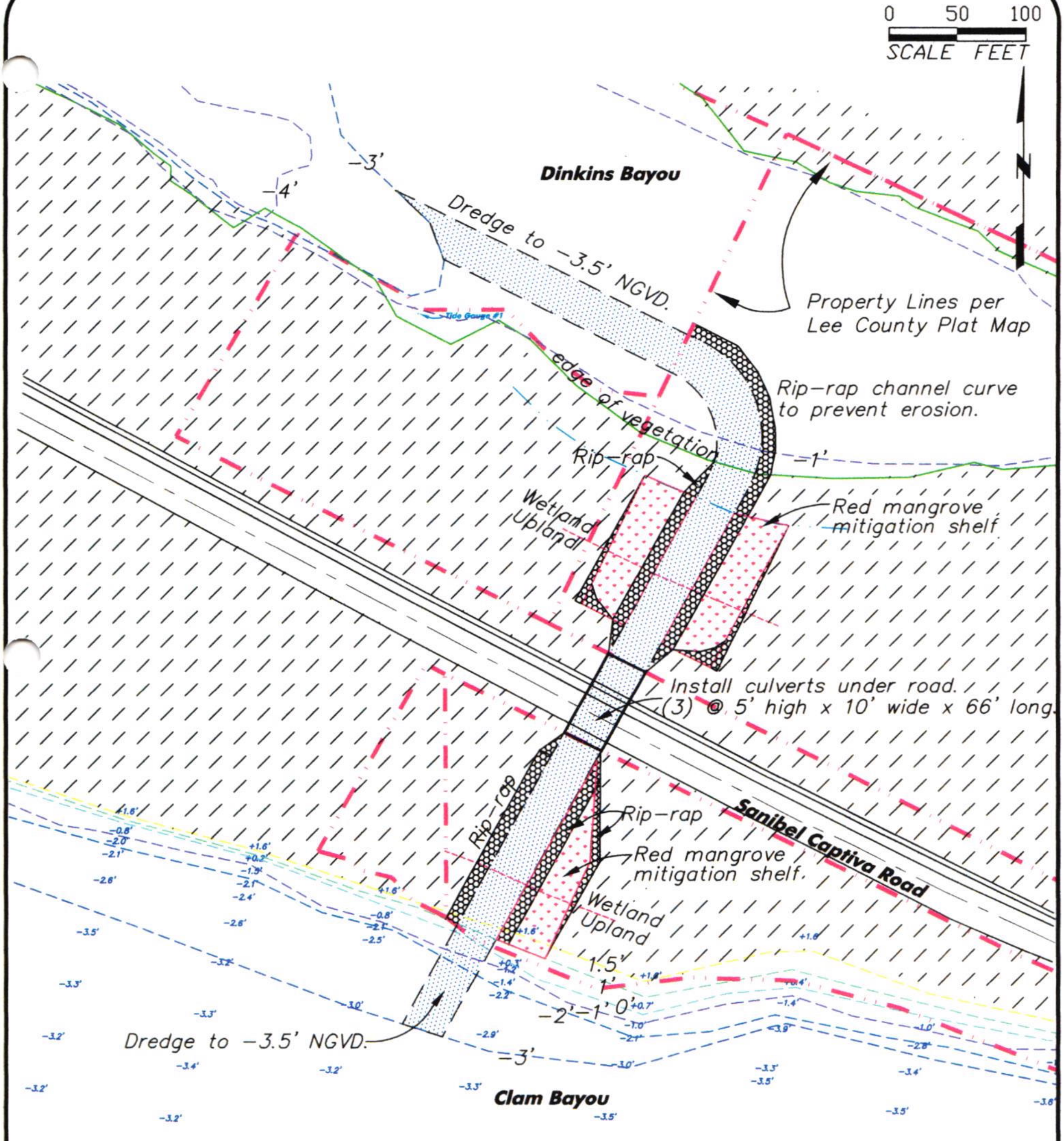


Salinity for Clam Bayou and Dinkins Bayou



Clam Bayou Water Level and Rainfall





Proposed Culvert Connection

SCALE: 1" = 100'

June 14, 2003 5:37:13 p.m.
Drawing: CLAM-1_PLAN.DWG (HW)

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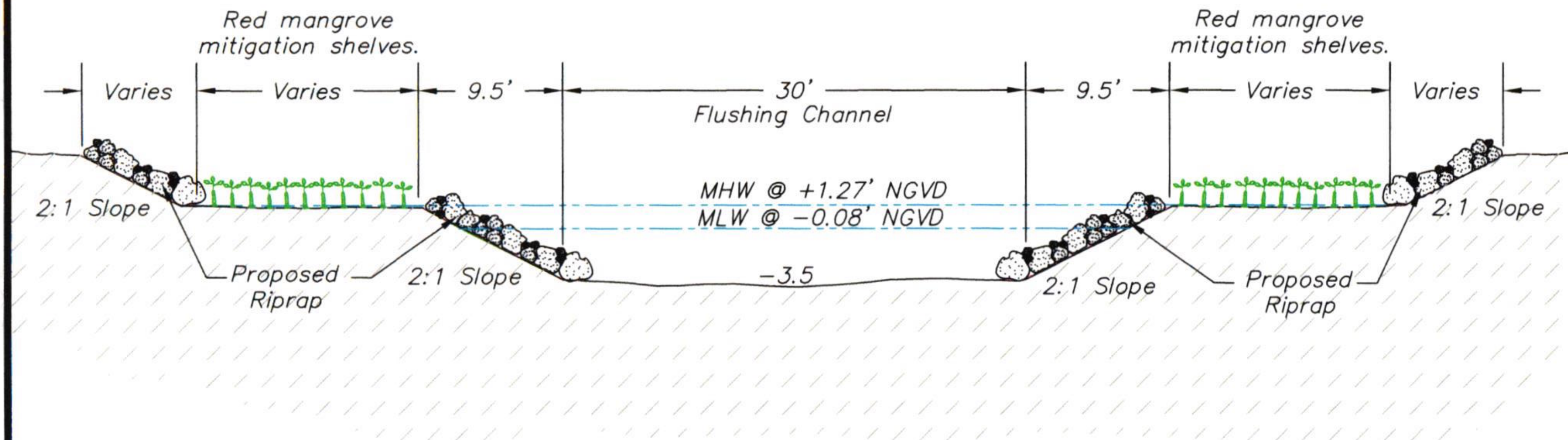
MARINE and ENVIRONMENTAL CONSULTANTS

Blind Pass Eco-zone Feasibility Study

SHEET

SECTION: 11
TOWNSHIP: 46 South
RANGE: 21 East

0 5 10
SCALE FEET



MHW @ +1.27' NGVD
MLW @ -0.08' NGVD
Tide Station 5417 Captiva Island, Pine Island Sound
Depth information reference NGVD
Survey Completed by Hans Wilson & Associates 04-04-03

Flushing Channel Cross Section

HORIZONTAL SCALE: 1" = 10'

HANS J.M. WILSON
REGISTERED PROFESSIONAL ENGINEER
FLORIDA REGISTRATION NO. 39680
DATE: May 31, 2003 5:14:48 p.m.
Drawing: CLAM-1_XS.DWG (HW)

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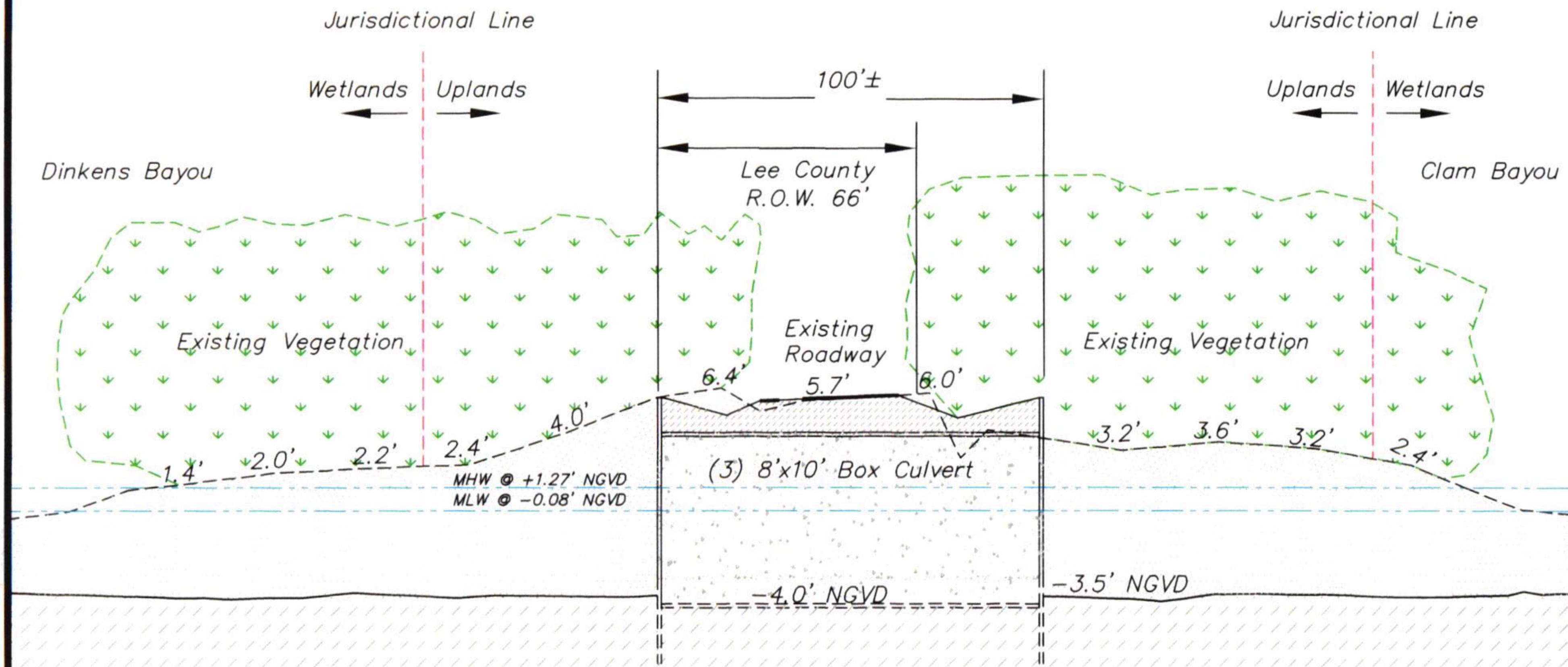
5/13/03

Blind Pass Eco-zone Feasibility Study

SHEET

SECTION: 11
TOWNSHIP: 46 South
RANGE: 21 East

0 20 40
SCALE FEET



MHW @ +1.27' NGVD
MLW @ -0.08' NGVD
Tide Station 5417 Captiva Island, Pine Island Sound
Depth information reference NGVD
Survey Completed by Hans Wilson
& Associates 04-04-03

Culvert Cross Section

HORIZONTAL SCALE: 1" = 40'
VERTICAL SCALE: 1" = 4'

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Blind Pass Eco-zone Feasibility Study

SHEET

IX. HYDRODYNAMIC MODELING OF BLIND PASS ECO-ZONE

ADCIRC Model Study Description and Objectives - Erickson Consulting Engineers, Inc. (ECE) performed a computer model study to evaluate the project alternatives relative to improved circulation and restored flushing in Clam Bayou and the Blind Pass Eco-zone. These studies were designed to simulate the complex circulation patterns and flushing, resulting from three significant actions (and variations on these actions) regarding Clam Bayou. A connection to the Gulf of Mexico and a connection to Dinkins Bayou have been proposed to improve transport within this estuarine system. The study included the application of the model ADCIRC to the study area, the verification of the model using measured field data (i.e. water level measurements), and the use of the model as a predictive tool to evaluate several project design alternatives.

The ADCIRC model is an appropriate model to apply to the Gulf of Mexico and Pine Island Sound Estuary. This model has been applied successfully in many projects around the U.S. and has been the subject of numerous technical papers and journal articles. It is a well-accepted model by engineering professionals and scientists within the hydrodynamic modeling community.

Model Description - The ADCIRC model is a highly developed computer program for solving the equations of motion for a moving fluid on a rotating earth. These equations have been formulated using the traditional hydrostatic pressure and Boussinesq approximations, and have been discretely defined in space using the finite element (FE) method, and in time, using the finite difference (FD) method. ADCIRC was run as a two-dimensional depth integrated (2DDI) model that allows the user to adjust the model grid resolution as desired. Water surface elevations are obtained from the solution of the depth-integrated continuity equation in Generalized Wave-Continuity Equation (GWCE) form. Velocity is obtained from the solution of the 2DDI momentum equations. All nonlinear and advective terms have been retained in these equations. A technical description of the ADCIRC hydrodynamic and transport model used for these studies is provided below.

The model study used the ADCIRC hydrodynamic model for the purposes of predicting the immediate post-project tidally induced flows, current velocities and flushing characteristics for various design alternatives. The two-dimensional model (ADCIRC) is a vertically integrated hydrodynamic model, which is appropriate to simulate shallow, well-mixed, tidally dominated barotropic type systems. Three-dimensional analysis is not necessary to simulate flows for the (relatively shallow) Blind Pass Eco-zone - Pine Island Sound Estuary system.

Continuity equation

$$\frac{\partial \zeta}{\partial t}+\frac{\partial UH}{\partial x}+\frac{\partial VH}{\partial y}=0 \qquad (1)$$

Longitudinal Momentum:

$$\frac{\partial U}{\partial t}+U\frac{\partial U}{\partial x}+V\frac{\partial U}{\partial y}-fV=-\frac{\partial}{\partial x}\left[\frac{p_s}{\rho_0}+g\zeta-g(\eta+\Upsilon)\right]+\frac{\tau_{sx}}{\rho_0 H}-\frac{\tau_{bx}}{\rho_0 H}+D_x \qquad (2)$$

Lateral Momentum:

$$\frac{\partial V}{\partial t}+U\frac{\partial V}{\partial x}+V\frac{\partial V}{\partial y}+fU=-\frac{\partial}{\partial y}\left[\frac{p_s}{\rho_0}+g\zeta-g(\eta+\Upsilon)\right]+\frac{\tau_{sy}}{\rho_0 H}-\frac{\tau_{by}}{\rho_0 H}+D_y \qquad (3)$$

where $(\eta+\Upsilon)$ represent the Newtonian tidal potential, earth tide, self attraction and load tide, τ_{bx}, τ_{by} represent the bottom stresses, *U* and *V* are depth averaged velocities, *H* is the depth, ζ is the water surface elevation and Dx and Dy are turbulent diffusion parameters.

Solutions to the equations of motion are made in a spherical coordinate system after the governing primitive equations are transformed, using the well known Generalized Wave Continuity Equation (GWCE). The GWCE is formed by taking the derivative of the primitive continuity equation, with respect to time, and adding the primitive continuity equation, multiplied by a spatially variable numerical weighting parameter. This parameter is related to the bottom roughness, and is typically a constant, except in unusual problems.
The *SALINITY* transport model is represented in the flow field by the convection/diffusion equation:

$$\frac{\partial S}{\partial t}+U\frac{\partial S}{\partial x}+V\frac{\partial S}{\partial y}=\frac{\partial}{\partial x}\left(D_x\frac{\partial S}{\partial x}\right)+\frac{\partial}{\partial y}\left(D_y\frac{\partial S}{\partial y}\right)+\text{Sources and Sinks} \qquad (4)$$

where *S* = salinity or conservative concentration and *Dx, Dv* = horizontal diffusion coefficients (m2 s-1). The transport equation is solved after the equations of motion. Since the equations of motion do not depend upon the salinity, as this is a barotropic model, the transport equation is solved independently.

Grid Generation - The grid was generated using the bathymetric measurements described in <u>Section V - Bathymetric Survey</u> and supplemented using the most recent NOS bathymetric data for the surrounding water bodies. The grid was created by locating grid points along the coastlines and bathymetric features, such as channels and depth contours, which are expected to become flooded. Each nodal point has an assigned grid index that is related to the adjoining grid points to track how each point relates to the adjoining grid points.

Wetting and Drying - The hydrodynamic portion of the modeling system incorporates the ability to simulate the inflow and outflow of water and mass to marsh areas that flood and dry over the tidal cycle. This is important because the extensive low-lying coverage of marsh (mangroves) in Clam Bayou and Blind

Pass plays a key role in the hydrodynamics of this system. Dinkins Bayou is a representative example of the creek (bayou) geomorphology typically found within the backwaters of Sanibel Island and Captiva Island, where circulation is inhibited by the long distance to the headwater of the creek boundary. The manipulation of the friction factor was used to adjust the flow rates and resultant surface elevations.

Model Set-Up (Geometry and Bathymetry) - The bathymetry data used for the model included two sources: National Ocean Service (NOS) bathymetry and shoreline data provided by NOAA, referenced to mean tide level (MTL) vertical elevation; and HWA hydrographic survey data obtained in March through May 2003 within the Blind Pass Eco-zone. These data were merged and overlain, using the HWA survey data to complete the baseline bathymetry in the areas of primary interest. The location of the shoreline was also modified to match the recent 2002 aerial photographs of the area.

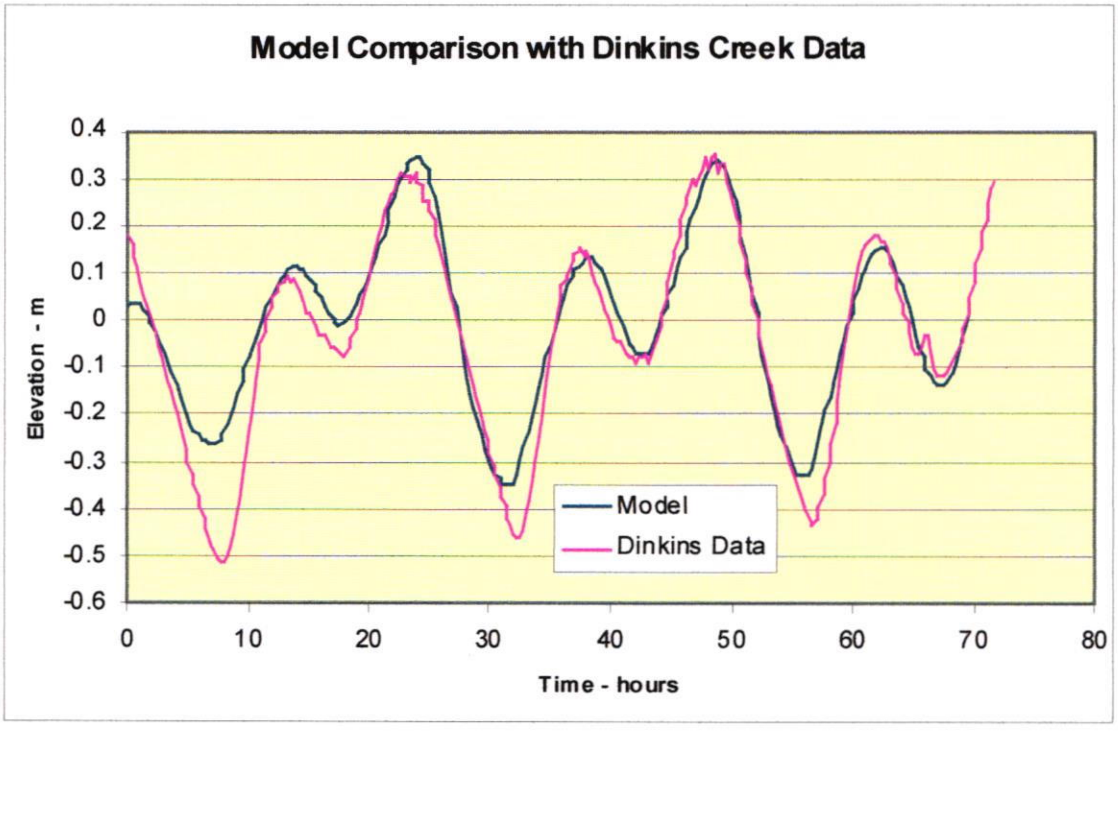
Each of the simulations, subsequent to the verification of the baseline conditions, used a modified grid including the channel connection between Dinkins Bayou and Clam Bayou to evaluate **Alternative 1 and 1a**. For the case of **Alternative 2 and 2a,** a shallow relatively narrow tidal swash channel (30' wide by 4' deep) connecting Clam Bayou with the Gulf of Mexico was added to the model grid created for **Alternative 1**. **Alternative 3** used the modified grid representing a tidal swash channel between the Gulf of Mexico and Clam Bayou, but without a connection to Dinkins Bayou. A new inlet channel was added to the grids at Blind Pass to connect the Gulf of Mexico directly with Wulfert Channel (ranging from a 6 ft depth nearshore to a 4 ft depth along the interior tidal channel to simulate **Alternative 4 and 5**.

The development of the grid required approximately 17,000 elements and 9,500 nodes. The time step for the model was determined by gradually decreasing the time step until the model stabilized. After this point, the solution does not change with decreasing time step. The model was run with a time step of 1.0 or 2.0 seconds. **Figures IX-1 through IX-4, and Figure IX-26** are graphic representations of the model grid overlaying the Blind Pass Eco-zone and areas of interest. The grid is shown, where in certain cases, no tidally induced flows exist due to the attributes associated with each node (i.e. the elevation of the grid is above the tidal range).

Tidal Forcing - The only forcing necessary for the model application at Blind Pass and Pine Island Sound Estuary is the offshore tidal forcing. To accommodate tidal forcing in the model, the ocean boundary in the Gulf of Mexico was selected well away from the entrances to the Pine Island Sound Estuary, which is important to establish the flow within the local water bodies of interest. Accordingly, the ocean boundary was located approximately 50 miles from the entrance to Blind Pass.

The tidal forcing in ADCIRC is normally imposed via time and spatially varying water levels along the open "ocean" boundary of the model. ADCIRC also includes terms representing the Newtonian tidal potential and corrections due to the effect of the Earth tides, ocean tide loading and self-attraction. The tidal forcings are applied throughout the domain. For this model the major tidal constituents of K1, O1, M2, N2 and S2 were used. The amplitude and phase for each were developed based upon the comparison for the start date of 00:00:00 on 28 February 2003.

Data/Model Comparisons - Water elevation data were recorded at the entrance to Wulfert Channel, the entrance to Dinkins Bayou, at the headwaters of Dinkins Bayou, and Clam Bayou. These continuous tidal records were used for comparison with the "model" simulated water levels. An example of the comparison between the model output and the Dinkins Bayou data (referred to as Dinkins Creek in the graphic) are shown in the following figure. It should be noted that the first 24 hours of time represents a "spin-up" of the hydrodynamic forcing and thus does not represent fully developed flow conditions. To obtain these results, no modification of the spatially variable weighting parameter or the bottom friction was required. It appears that the model provides adequate comparison with recorded water surface elevations for this system.



Description of Project Alternatives - A summary of the alternatives evaluated to improve flushing and circulation within Clam Bayou and the Blind Pass Eco-zone, including Dinkins Bayou, Blind Pass and Wulfert Channel is shown in Table IX-1 below. The model was used to simulate the existing conditions (**Baseline Alternative**), and six alternative project hydrodynamic conditions, to establish the impacts on the circulation patterns and flushing characteristics in the Blind Pass Eco-zone. Variations on these alternatives were based on changes in the mass concentrations within Clam Bayou and Dinkins Bayou. This was necessary to assess the flushing potential of each alternative as it affects these long, and physically distinct, tidal bayous.

The simulations were run for five days, which represented a spring tidal cycle. This yields model results that are representative of typical tidal variations and conditions within the system on an annual basis. Each of the varying model alternatives were evaluated by two criteria: average current velocity at five locations and flushing characteristics for a mass concentration in Dinkins Bayou, or Clam Bayou, at five locations. Flushing and flow data were saved for comparison with the results for the model's baseline conditions.

Station 1 is located at the entrance to Dinkins Bayou, at 2727 Coconut Drive.
Station 2 is located in the middle of the southern expanse of Dinkins Bayou.
Station 3 is located at the narrow inlet at the end of Pine Tree Drive.
Station 4 is located in the center of the middle water body in Clam Bayou.
Station 5 is located on the inside of Bowmans Beach, at the proposed pass opening.

Note that in **Figures IX-1, 2, and 3** this location is also visible with the increased density in the grid points at the interface with the Gulf of Mexico. A site location map showing the five data results locations is provided in **Figure IX-5** at the end of this Section.

Table IX-1. Description of Flushing Alternatives for the Blind Pass Eco-zone

Alternatives	Description	Principal Flushing Analysis (Mass Concentration)	Mass Concentration Variation (a) and (b)
Baseline	Existing Conditions	Dinkins Bayou (100%) Clam Bayou (0%)	
Alternative 1 **Alternative 1a** **Alternative 1b**	Flushing Channel Connecting Dinkins and Clam Bayou	Clam Bayou (100%) Dinkins Bayou (100%)	**Alternative 1a** Dinkins Bayou (100%) Clam Bayou (0%) **Alternative 1b** Dinkins Bayou (0%) Clam Bayou (100%)
Alternative 2 **Alternative 2a**	Flushing Channel from Dinkins to Clam Bayou, with Gulf opening to Clam Bayou	Clam Bayou (100%) Dinkins Bayou (0%)	Dinkins Bayou (100%) Clam Bayou (0%)
Alternative 3	Pass opening between Gulf and Clam Bayou	Clam Bayou (100%)	
Alternative 4	Blind Pass Open	Dinkins Bayou (100%)	
Alternative 5 (Combined Alternative 1 and 4)	Blind Pass Open, Flushing Channel from Dinkins to Clam Bayou	Clam Bayou (100%) Dinkins Bayou (100%)	**Alternative 5a** Dinkins Bayou (36 ppt) Clam Bayou (20 ppt) **Alternative 5b** Dinkins Bayou (0%) Clam Bayou (100%)
Alternative 6	Blind Pass Open, Wulfert Channel Dredged to Dinkins Bayou, flushing channel	Clam Bayou (100%) Dinkins Bayou (0%)	

Analysis of Project Alternatives - The flushing impacts were evaluated for each of the six alternatives described above for the two primary water bodies of concern, Clam Bayou and Dinkins Bayou. Output files were saved for all hydrodynamic simulations, thus allowing flushing information to be developed should it be deemed important in the selection of an alternative for further development in the design development phase of the project.

The flushing impacts of each alternative were compared to the **Baseline Alternative** as shown in **Figure IX-6 through IX-12** and **IX-21 through IX-22**. Similarly, the velocities of each alternative were compared for each of five locations within Dinkins Bayou and Clam Bayou, as shown in **Figures IX-11 through IX-17** and **IX-23 through IX-25**.

Alternative 1: Flushing Channel Connection - As described above, this alternative would construct a flushing channel between Dinkins Bayou and Clam Bayou to improve tidal circulation and to convey elevated freshwater flows associated with significant rainfalls between the water bodies. The model simulations show a significant increase in velocity at Locations 1, 2, and 3 within Dinkins Bayou. The maximum velocities increased from the baseline condition of 0.5 ft/sec to 0.7 ft/sec at Location 1 (Dinkins Bayou) and from 0 to 0.2 ft/sec at Location 4 (Clam Bayou). The greatest increase in velocity is seen at Location 3 in Dinkins Bayou adjacent to the proposed flushing channel. Maximum velocities increased from 0.1 to 2.5 ft/sec.

Flushing associated with this alternative improved at Locations 3 and 4. As shown in **Figures IX-6 through 10**, the initial baseline condition was run for the case of a 100% mass concentration only in Dinkins Bayou. There was no connection to Clam Bayou so that a mass concentration (of a theoretical conservative pollutant) would always remain at 100% for the baseline condition at Locations 4 and 5 within Clam Bayou.

Alternative 1 represents a 100% mass concentration in both Clam Bayou and Dinkins Bayou. To separately evaluate and compare the effects of the flushing channel on the separate water bodies, simulations were run for **Alternative 1a** representing a 100% mass concentration in Dinkins Bayou and 0% in Clam Bayou (refer to **Figures IX-6 and IX-7).** As seen in Clam Bayou, the mass concentration was reduced from 100% to 65% over a 5 day period at Location 4. The mass concentration at Location 5 was reduced by only 3% over a 5 day period due to the long distance to the backwaters of Clam Bayou and the small tidal range affecting dilution.

Alternative 1b represents conditions for a 100% mass concentration in Clam Bayou and 0% in Dinkins Bayou. (refer to **Figure IX-21 and IX-22**). A discussion on the impact of this alternative is better addressed in **Alternative 5.**

Alternative 2: Flushing Channel and Clam Pass Connection - As described above, this alternative would include a flushing channel between Dinkins Bayou and Clam Bayou and construct a tidal swash channel between the Gulf of Mexico and Clam Bayou. The goal would be to improve circulation, flushing, and to convey elevated freshwater flows out of the Bayou. The model simulations show a modest increase in velocity at locations within Dinkins Bayou and a significant increase at both locations in Clam Bayou. The maximum velocities increased significantly from the baseline condition of 0.25 to 1.2 ft/sec at

Location 3 (Dinkins Bayou), from zero to 0.7 ft/sec at Location 4, and 0.8 ft/sec at Location 5 (Clam Bayou). The greatest increase in velocity is seen at Location 5 where maximum velocities increased to 0.9 ft/sec.

Flushing associated with this alternative markedly improved at Locations 1 through 5. As presented in **Figures IX-6 through 10**, **Alternative 2** conditions were run for the case of a 100% mass concentration in Clam Bayou and 0% in Dinkins Bayou. **Alternative 2a** was for a 100% mass concentration in Dinkins Bayou and 0% in Clam Bayou. As seen for Dinkins Bayou and Clam Bayou, the mass concentrations were reduced from 100% to 10% in a 1 to 1.5 day period at all locations. The mass concentration at Location 5 was reduced in less than a day due to the shortest distance to the tidal swash channel.

<u>**Alternative 3: Clam Pass Connection to the Gulf of Mexico**</u> – The **Alternative 3** project proposed would construct a tidal swash channel between the Gulf of Mexico and Clam Bayou to improve circulation, flushing, and to convey elevated freshwater flows out of the Bayou. Refer to the **Clam Connection to Gulf of Mexico** graphic depicting the configuration of the channel, located at the end of this section. The model simulations show no increase in velocities at locations within Dinkins Bayou (no connection from Clam Bayou) and a significant increase in velocity at both Locations 4 and 5 in Clam Bayou. The maximum velocities increased significantly from the baseline condition of zero to 0.5 ft/sec at Location 4 and 1.5 ft/sec at Location 5 (Clam Bayou). The greatest increase in velocity is seen at Location 5 where maximum velocities increased to 1.5 ft/sec.

Flushing associated with this alternative markedly improved at Locations 4 and 5. As presented in **Figures IX-6 through 10**, **Alternative 3** hydrodynamic conditions were run for the case of a 100% mass concentration in Clam Bayou. There was no connection to Dinkins Bayou reflecting the **Baseline Alternative** in this waterbody.

As seen for Dinkins Bayou and Clam Bayou, the mass concentrations were reduced from 100% to 10% in a 2 to 4 day period for both Locations 4 and 5. The mass concentration at Location 5 was reduced most rapidly due to the shortest distance to the tidal swash channel.

<u>**Alternative 4: Blind Pass Open without Flushing Channel**</u> **-** Alternative 4 would include constructing a new tidal channel between the Gulf of Mexico and Blind Pass, expecting to improve circulation and flushing in Dinkins Bayou, Wulfert Channel, and the associated small tidal channels contiguous to the Pass. The model simulations show a no significant increase in velocities at Locations 1, 2 or 3 in comparison to the **Baseline Alternative** and **Alternative 1** (flushing channel). With no tidal connection to Clam Bayou, no velocity or flushing improvement would occur in that waterbody. The greatest increase in

velocity is seen at Locations 1 and 3 (in Dinkins Bayou and adjacent to the tidal channel entrance) where maximum velocities increased to 0.2 to 0.5 ft/sec.

Flushing associated with this alternative showed some improvement at Location 1 with minimum effects at Location 3. As presented in **Figures IX-6 through 10**, **Alternative 4** hydrodynamic conditions were run for the case of a 100% mass concentration in Dinkins Bayou.

<u>Alternative 5: Blind Pass open with Flushing Channel</u> - This alternative would construct a flushing channel between Dinkins Bayou and Clam Bayou, and include a re-opening of Blind Pass. As discovered in **Alternative 4**, there was minimal improvement in flushing to Dinkins Bayou with Blind Pass re-opened. Refer to the graphic labeled **Channel Through Blind Pass** at the end of this Section for dimension and depth details. The model simulations show a modest increase in velocity at locations within Dinkins Bayou with the most marked increase at Location 1 in Dinkins Bayou and Location 4 in Clam Bayou. The greatest increase in velocity was in Dinkins Bayou and adjacent to the channel entrance where maximum velocities increased to 0.6 ft/sec.

Flushing associated with this alternative was similar to **Alternative 1** where Clam Bayou is shown to exchange some 35% of the water within the area of Location 4 over a 5 day period (i.e. a mass concentration is reduced to 65%). As presented in **Figures IX-11 and IX-18, Alternative 5** flushing conditions were run for the case of a 100% mass concentration in both Clam Bayou and Dinkins Bayou. The results indicate that further modifications to the flushing channel dimensions and water depths within the bayous are needed to increase flow rates. The model was also run to simulate a 100% mass concentration in the Clam Bayou water body only (**Alternative 5b**). As shown in **Figures IX-21 and IX-22**, the mass concentration decreases to approximately 65 percent over a five day period at Location 4 within Clam Bayou. This alternative would likely result is further flushing benefits to Clam Bayou if the project included channel improvements between Wulfert Channel and Dinkins Bayou, and increased channel size in the connection between Clam Bayou and Dinkins Bayou. The model was not run with these changes in place, knowing that they would result in improved flushing based on the results of **Alternative 1**.

Figure IX-20 shows the response of the various sites relative to a 12" rainfall event (50 to 100 yr storm) superimposed over the normal tidal cycles. This is applied to the **Alternative 5** configuration, creating **Alternative 5a**. The smaller rainfall events produced a relatively insignificant change in salinity in the system. Using a lower frequency return event, we assumed 36 parts per thousand (ppt) salinity in Dinkins Bayou and 20 ppt in Clam Bayou. Location 1 responds with slight decreases in salinity as the freshwater outflow from Clam Bayou and Dinkins Bayou pass through the location. Location 2 and 3 show a greater response to the freshwater in flow from this type of rainfall event, with an initial dip approximating 22 ppt, slowly rising back to normal salinity values. Moving into the Clam Bayou area, Location 4 is initiated at 20 ppt.

As expected, closer proximity to the flushing channel results in a decrease of the freshwater component and a response to tidal fluctuations, with salinity returning to normal. In Location 5, essentially the headwater of Clam Bayou in relation to the flushing channel, tidal response or flushing of the freshwater component is a very gradual process, exceeding the five day run for the model. This would be expected with large scale rainfall events. As shown with this model run, for a continuous rainfall event, or heavier than normal rainfall quantity and duration, the flushing channel allows for the eventual restoration of normal salinity to Clam Bayou over time. With the enhancement offered in **Alternatives 3** (Clam Pass opening) the time for recovery to a saltwater estuary condition is accelerated.

Alternative 6 - Blind Pass Open, flushing channel connecting Clam Bayou and Dinkins Bayou, and improved flow way between Wulfert Channel and Dinkins Bayou entrance - This alternative includes the flushing channel as discussed in Alternative 1, coupled with Blind Pass re-opened (Alternative 4), and added a revised channel layout connecting the Blind Pass channel with Wulfert Channel, Roosevelt Channel, and the Dinkins Bayou entrance. Refer to Figure IX-26 for a layout of the model grid and general configuration of the improvements. The tidal channel in Blind Pass would begin at -8 ft (NGVD) between the Gulf of Mexico and Wulfert Channel to improve circulation, flushing, and to convey elevated freshwater flows out of both Dinkins and Clam Bayous. It also included deepening of Wulfert Channel to -6 ft (NGVD), and improving the connection to Dinkins Bayou with a channel 100' wide by 5' deep.

As seen in **Figures IX-23 to IX-25**, model simulations show a 15 percent increase in velocity in a comparison of **Alternative 6** to **Alternative 5** for locations within Dinkins and Clam Bayous. The most marked increase in velocity is seen at Locations 1 and 3 in Dinkins Bayou and Location 4 in Clam Bayou. The greatest increase in maximum velocities in Dinkins Bayou and Clam Bayou, in a comparison of **Alternative 6** to **Alternative 5**, is seen where the velocities increased from 2.5 to 2.8 ft/sec at Location 3 and from 0.2 to 0.3 ft/sec at Location 4. Location 4 is within the center water body of Clam Bayou and represents average conditions in Clam Bayou for velocity and flushing values.

As presented in **Figures IX-21 and IX-22**, **Alternative 6** flushing conditions were run for the case of a 100% mass concentration in Clam Bayou and compared to the flushing conditions for **Alternatives 1(b)** and **5(b).** Flushing associated with this alternative indicates that, over a 5 day period, the mass concentration decreases to 60% indicating that 40% of the water within Clam Bayou will be moved out of the Bayou. Extrapolating these flushing conditions will result in a total water exchange of 10 to 12 days (i.e. Clam Bayou to reach 10 percent of original water concentrations).

With the improve flushing connection into Dinkins Bayou, we have determined that the limiting factor regarding the flushing of Clam Bayou is the configuration of the channel at the end of Pine Tree Drive and the size of the flushing channel. Improving the interior connections within Clam Bayou will further increase flow rates and improve flushing times. For this reason, the differences between **Alternative 5** and **Alternative 6**, although modest, indicate that the channel constrictions and time of travel necessitate adjustments in the culvert cross-sectional area and interior connections within Clam Bayou. This will be necessary to achieve reductions in flushing times that approximate the state criteria outlined in the Basis of Review in Chapter 40E of the Florida Administrative Code.

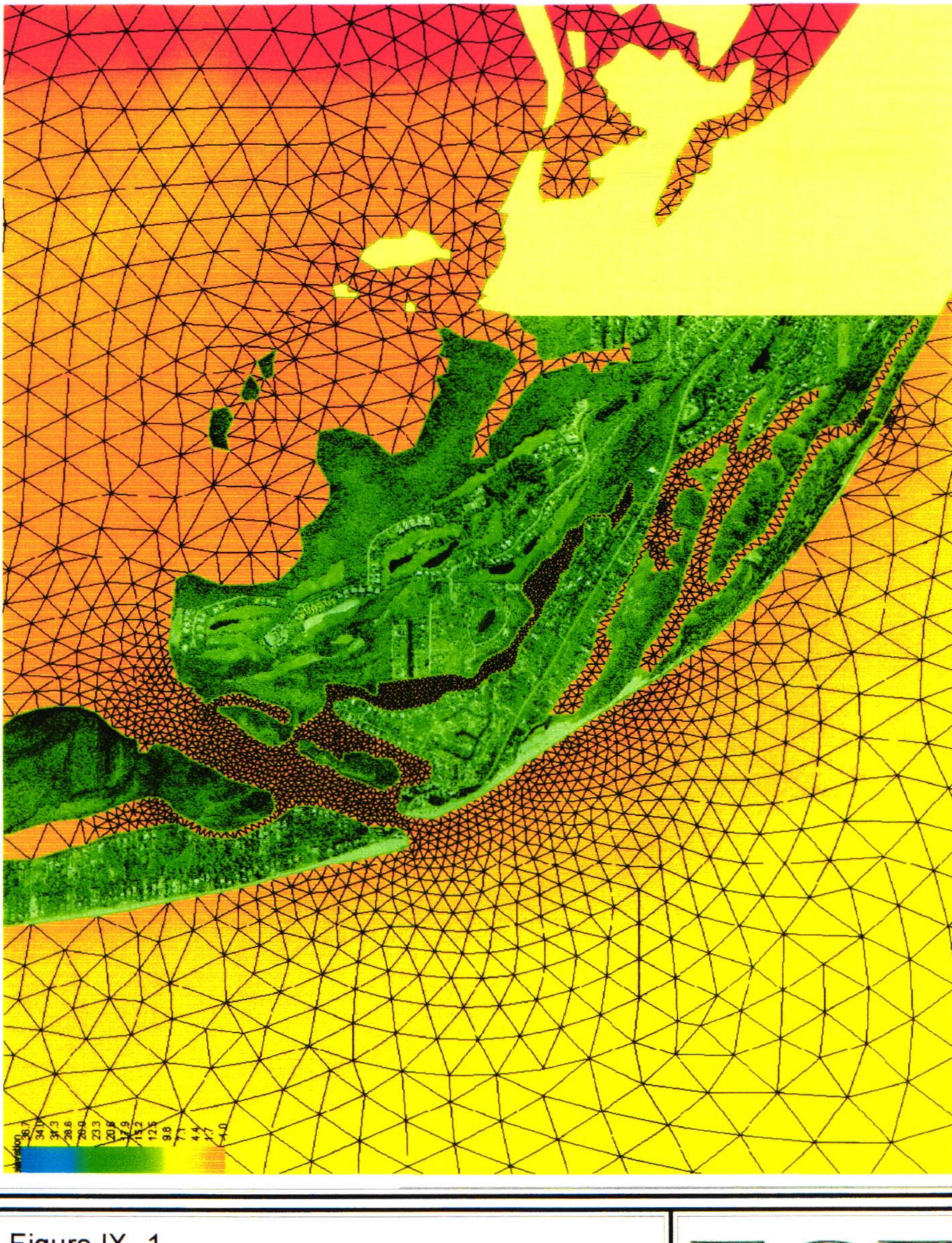


Figure IX -1

Grid Layout for Baseline Conditions at Clam Bayou and Blind Pass

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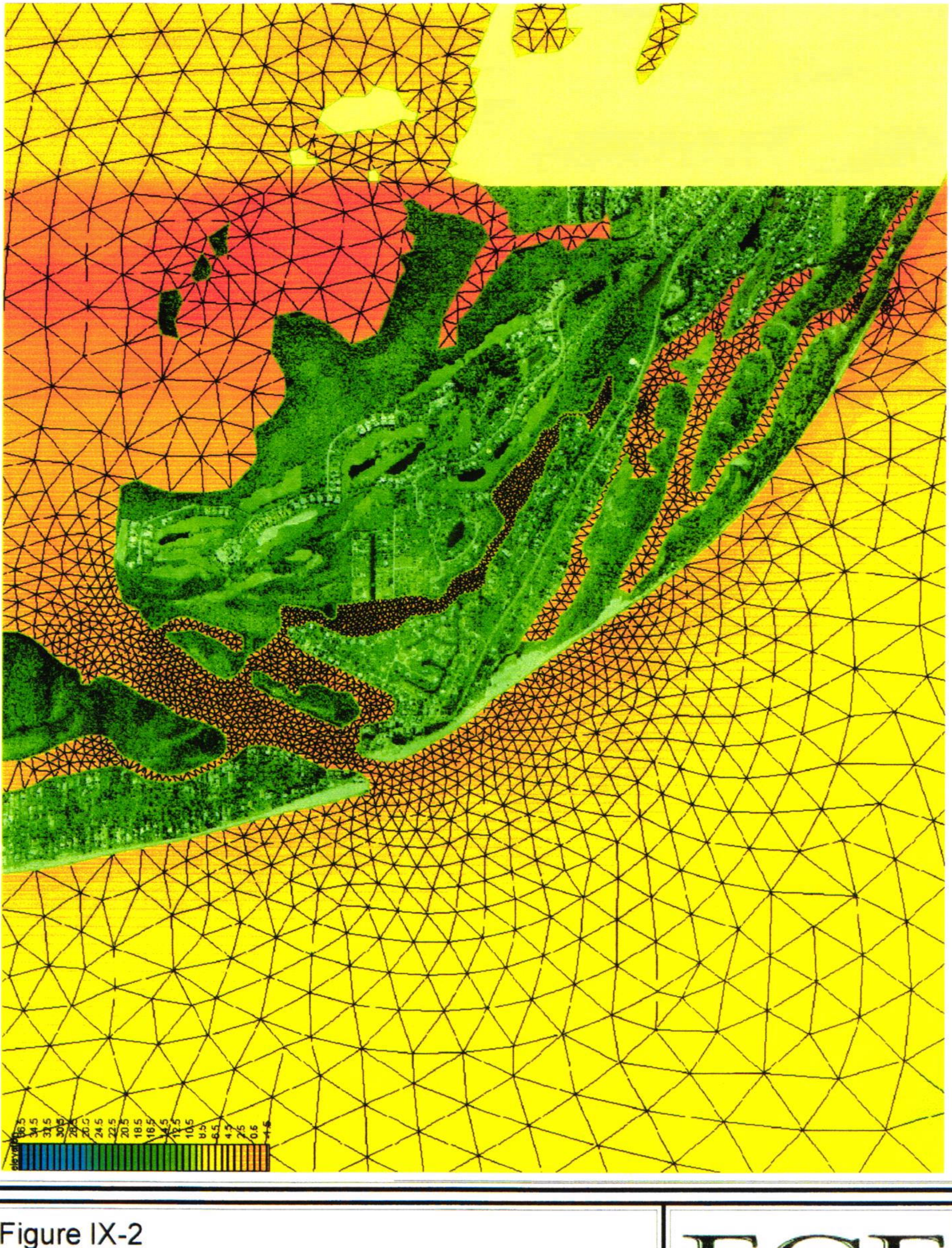

03-110FIG9-2 6/11/03

Figure IX-2

Grid Layout for Alternative 1 Conditions at Clam Bayou and Blind Pass

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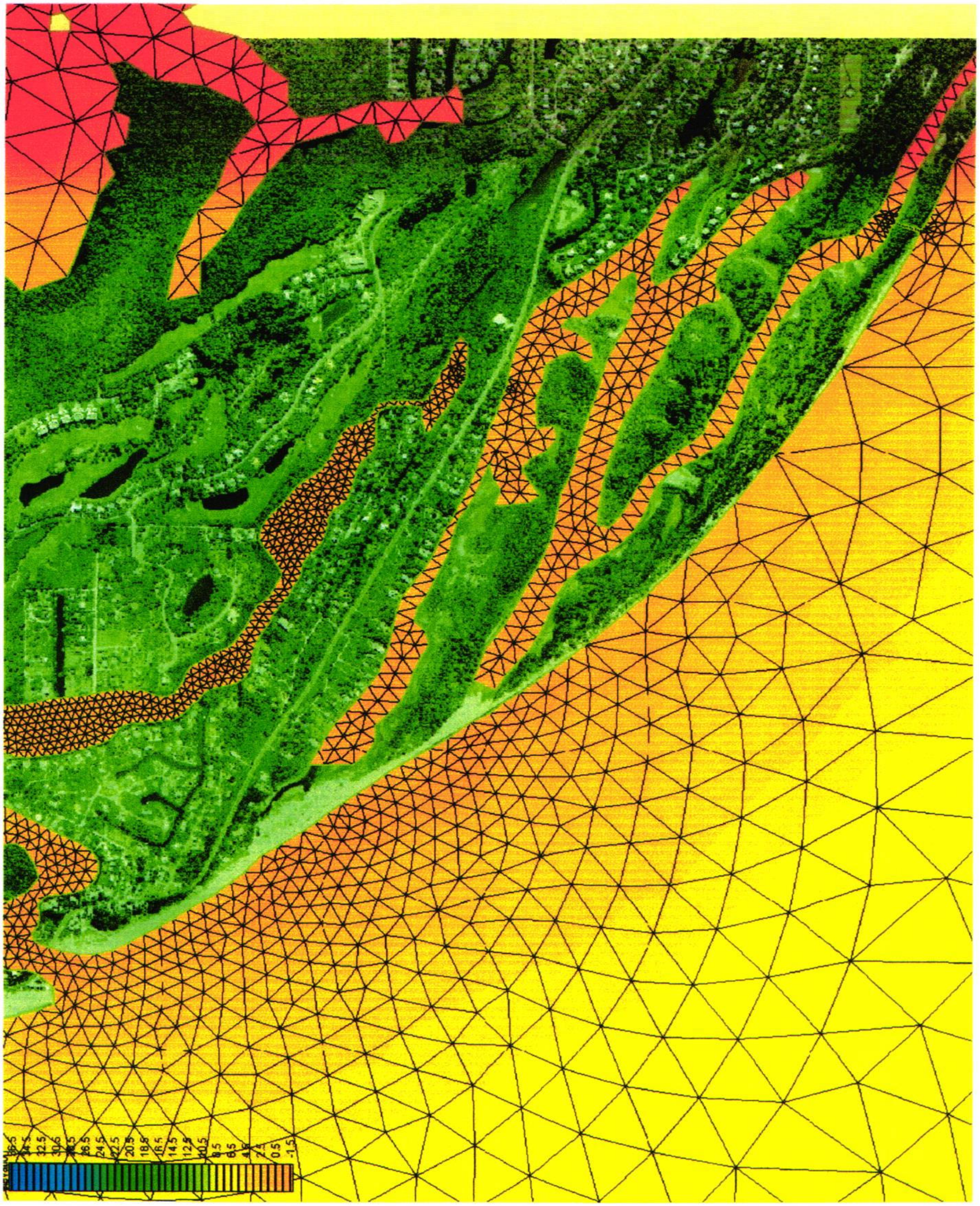

03-110FIG2-2 6/11/03

Figure IX-3

Grid Layout for Alternative 3 Conditions at Clam Bayou and Blind Pass

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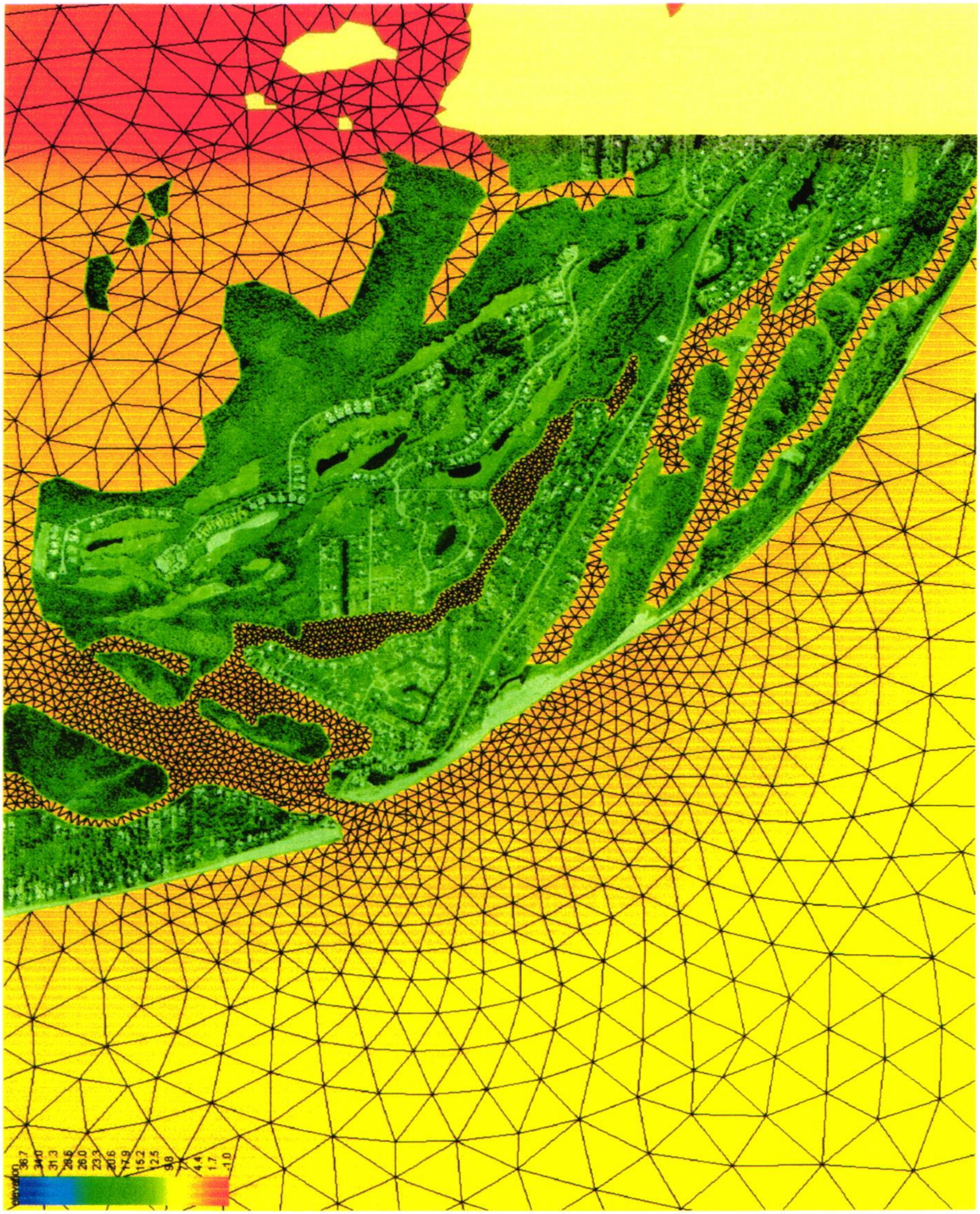

03-110FIG9-5 6/11/03

Figure IX-4

Grid Layout for Alternative 4 Conditions at Clam Bayou and Blind Pass

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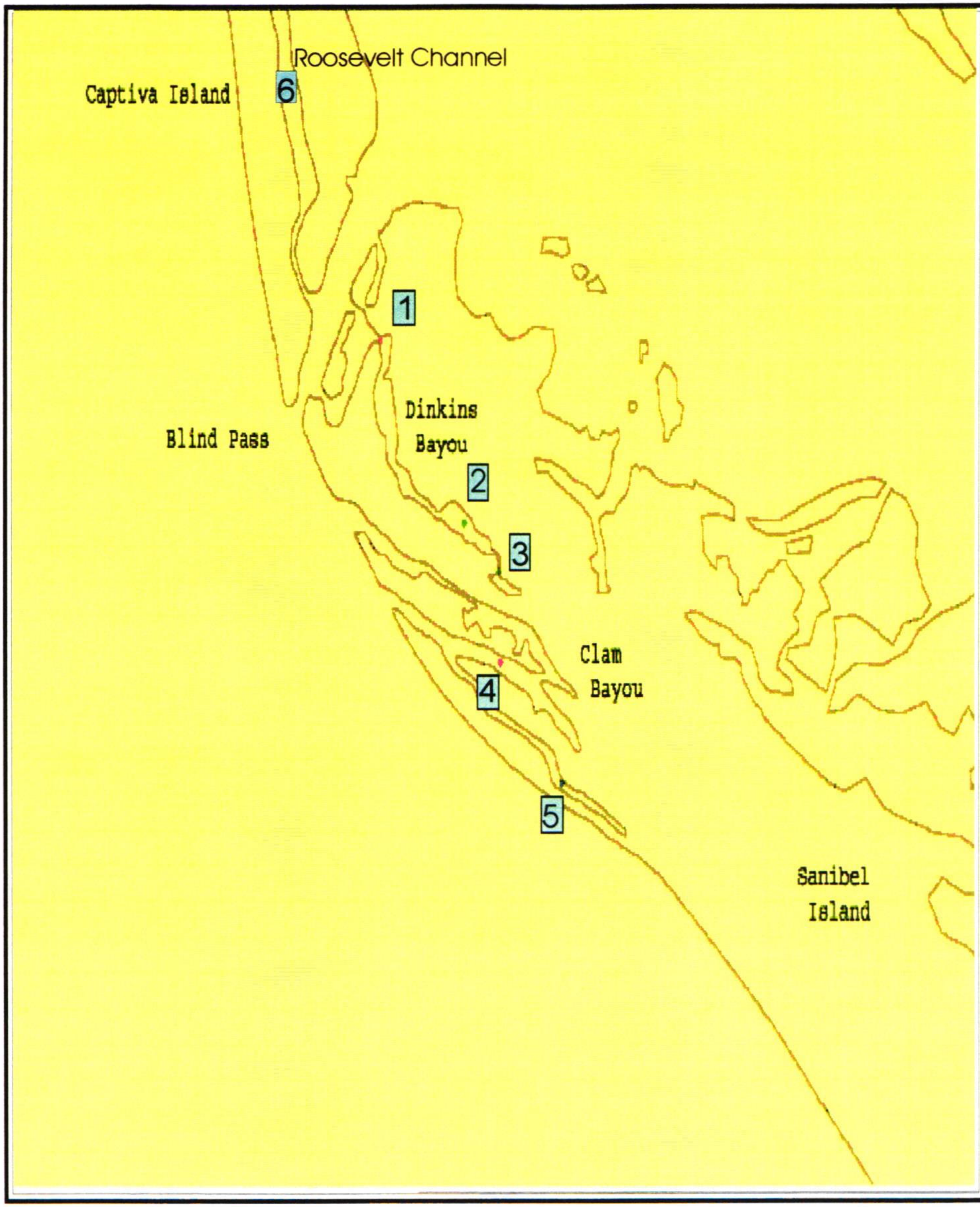

02-102FIG2-2 7/15/02

Figure IX-5
Location Cross-Sections for Sites 1 through 6
(Mass Concentration Flushing and Velocities)

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03-110FIG9-5

03-110FIG9-6 6/11/03

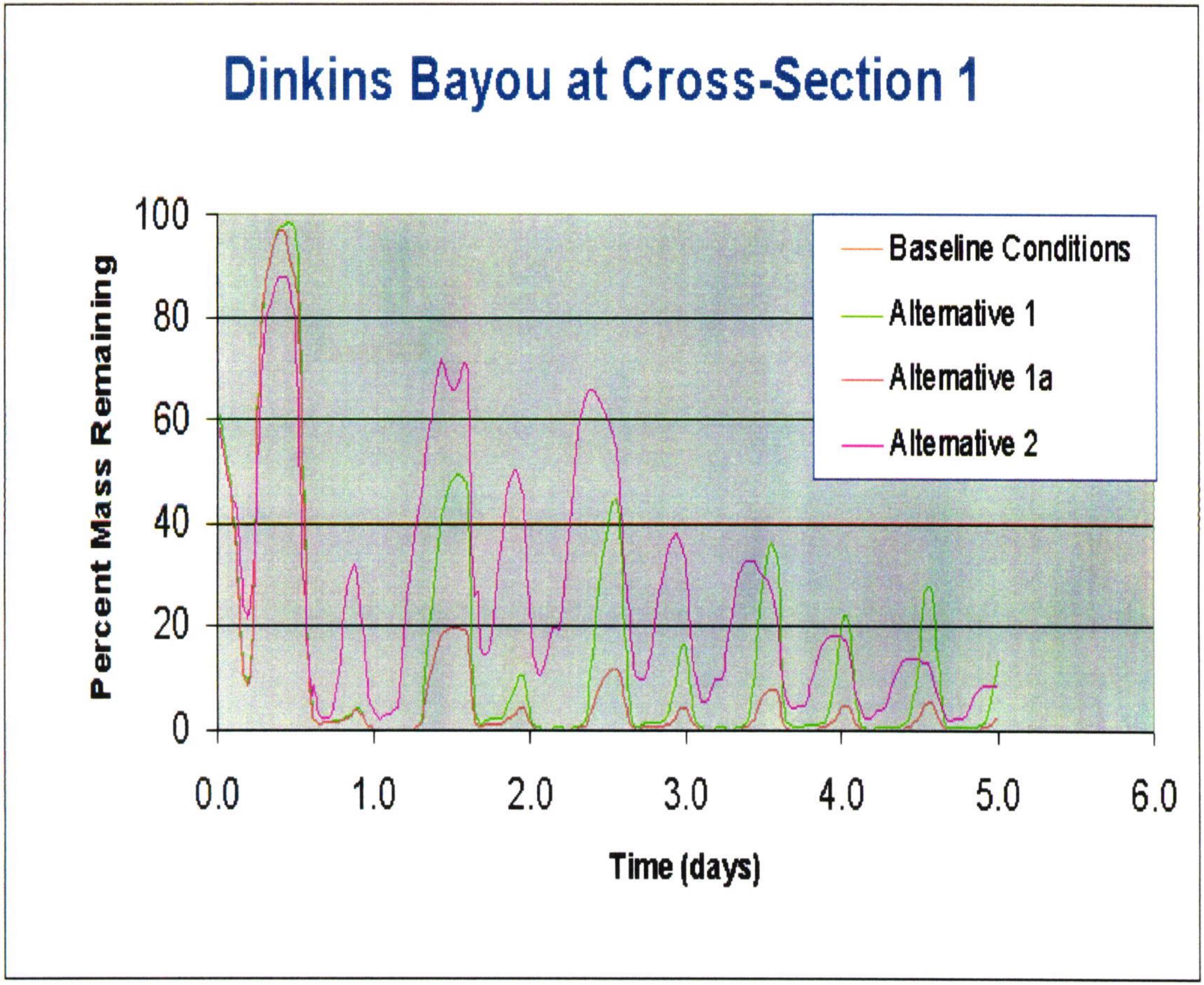

Figure IX-6
Comparison of Flushing over Time at Location 1 for the Proposed Alternatives

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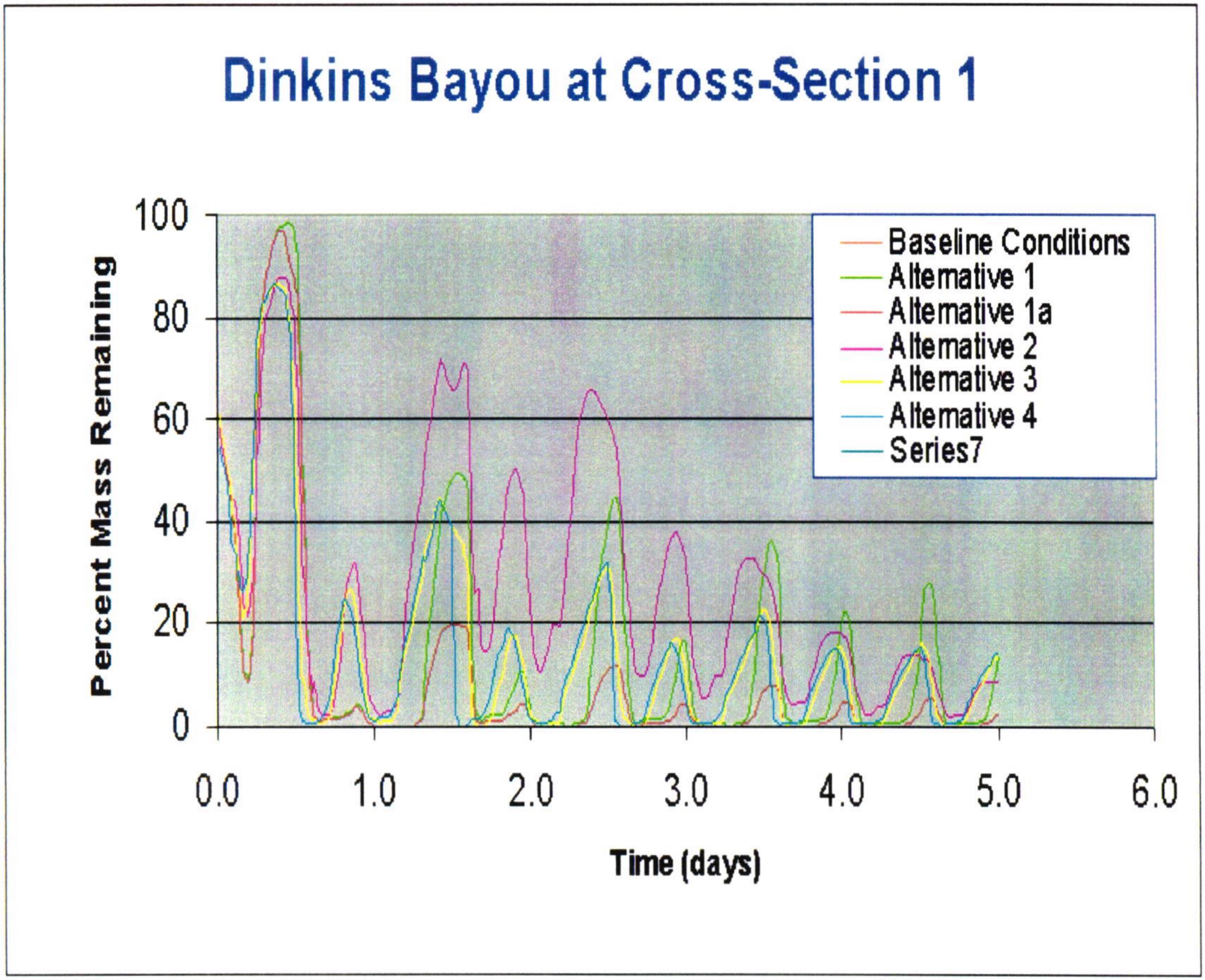
Erickson Consulting Engineers

03-110FIG9-7 6/11/03

Figure IX-7
Comparison of Flushing over Time at Location 1 for the Proposed Alternatives



03-110FIG9-8 6/11/03

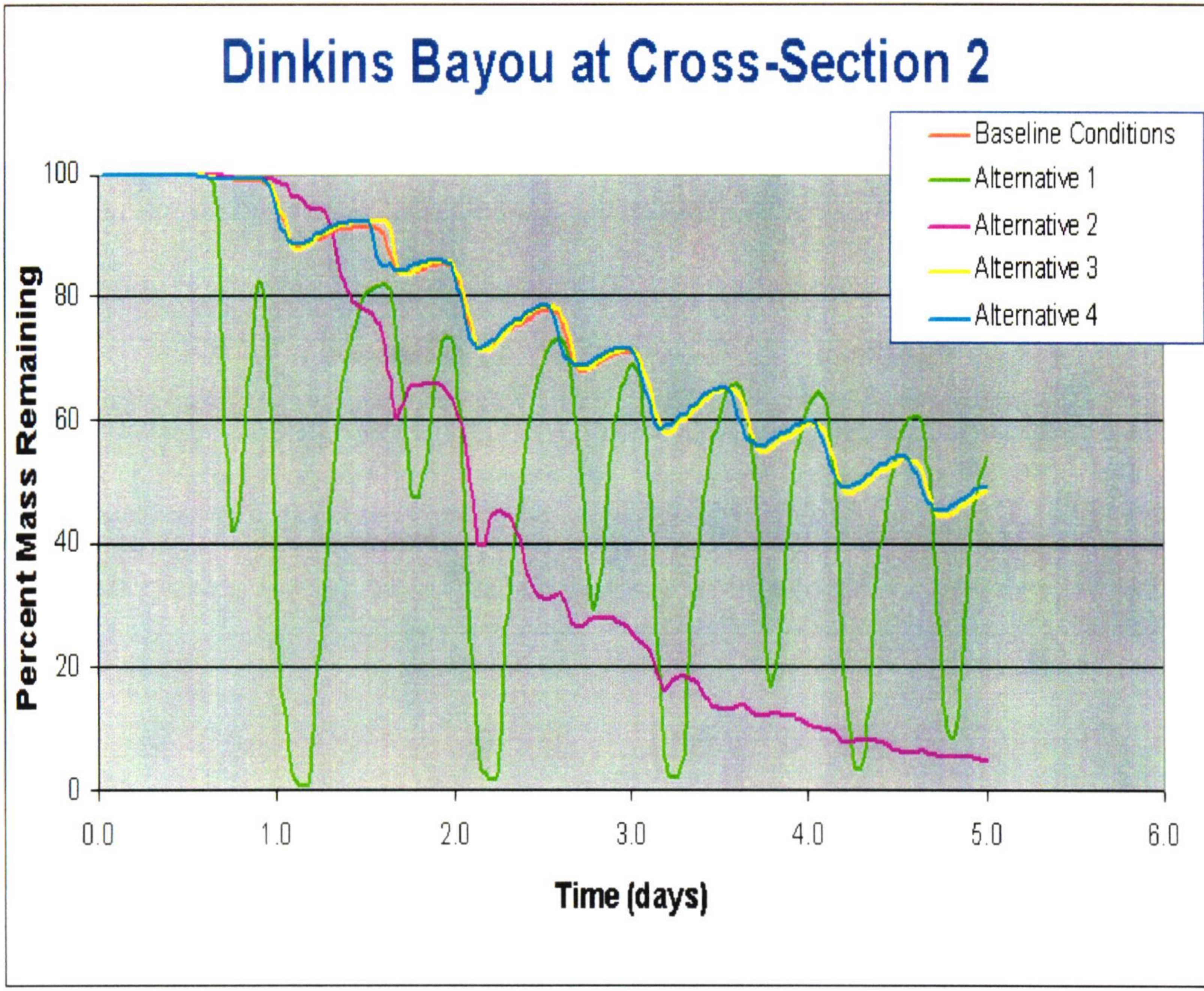


Figure IX-8
Comparison of Flushing over Time at Location 2 for the Proposed Alternatives

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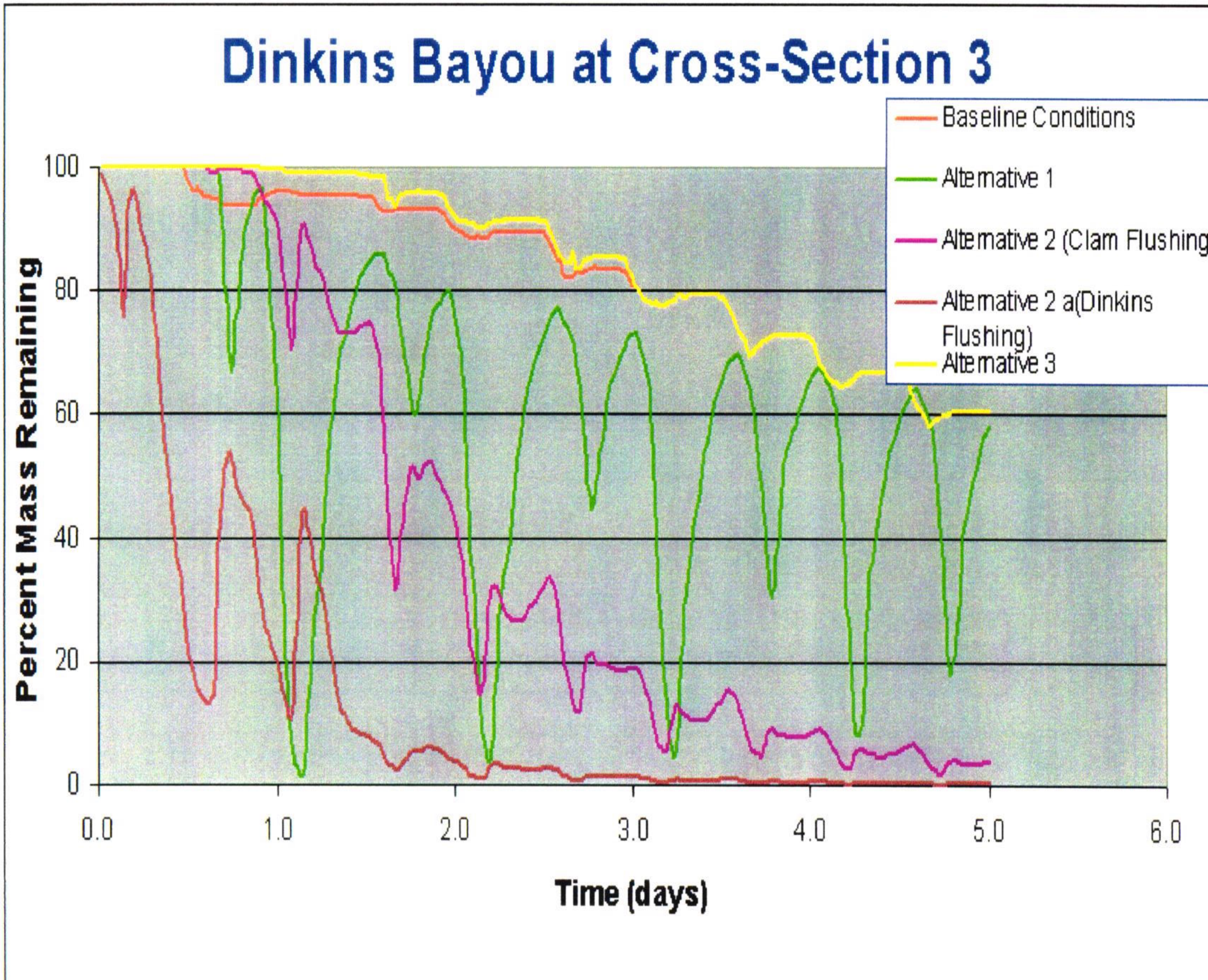
03-110FIG9-9 6/11/03

Figure IX-9
Comparison of Flushing over Time at Location 3 for the Proposed Alternatives



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03-110FIG9-10 6/11/03

Figure IX-10
Comparison of Flushing over Time at Location 3 for the Proposed Alternatives

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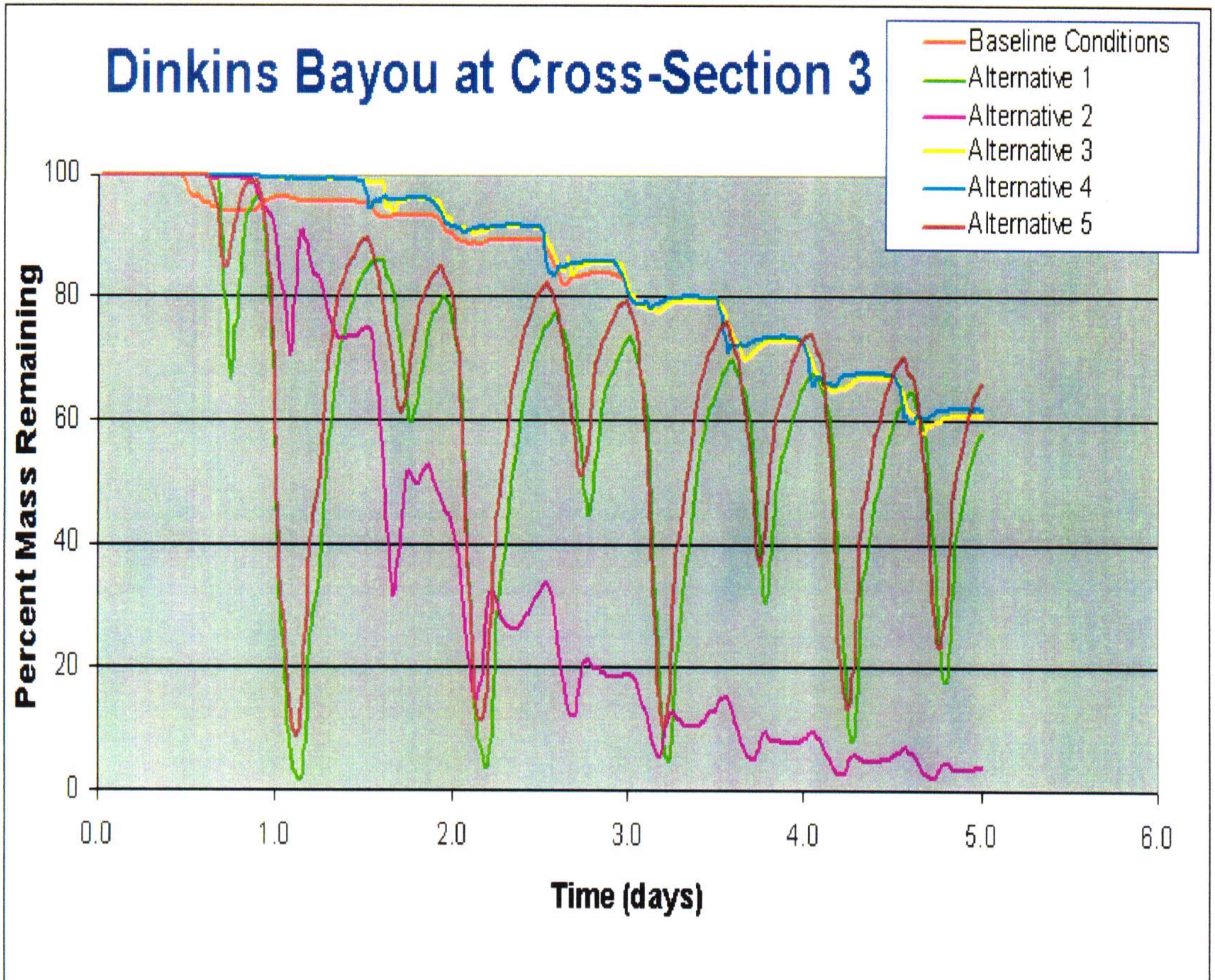

03-110FIG9-11 6/11/03

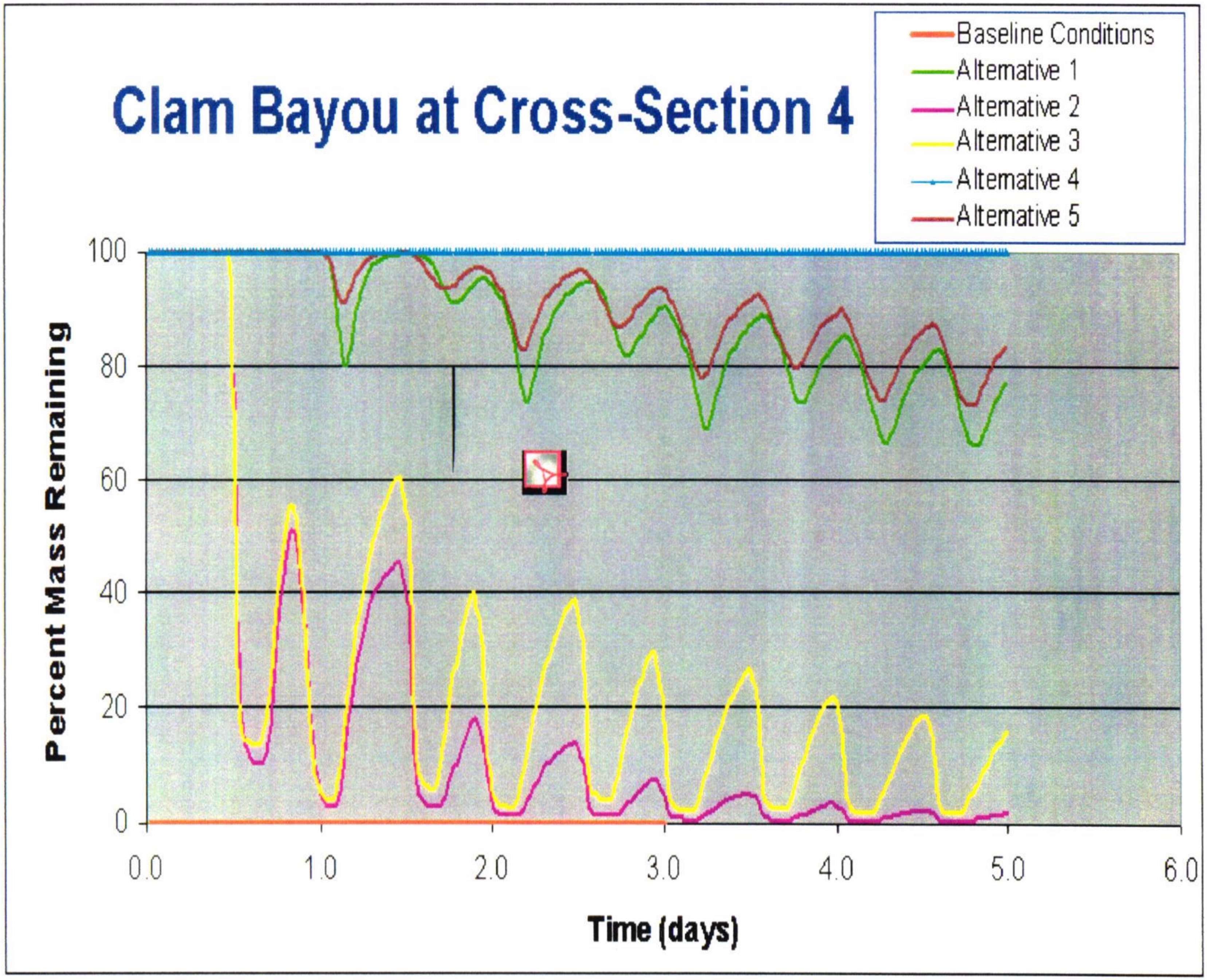

Figure IX-11
Comparison of Flushing over Time at Location 4 for the Proposed Alternatives

03-110FIG9-12 6/11/03

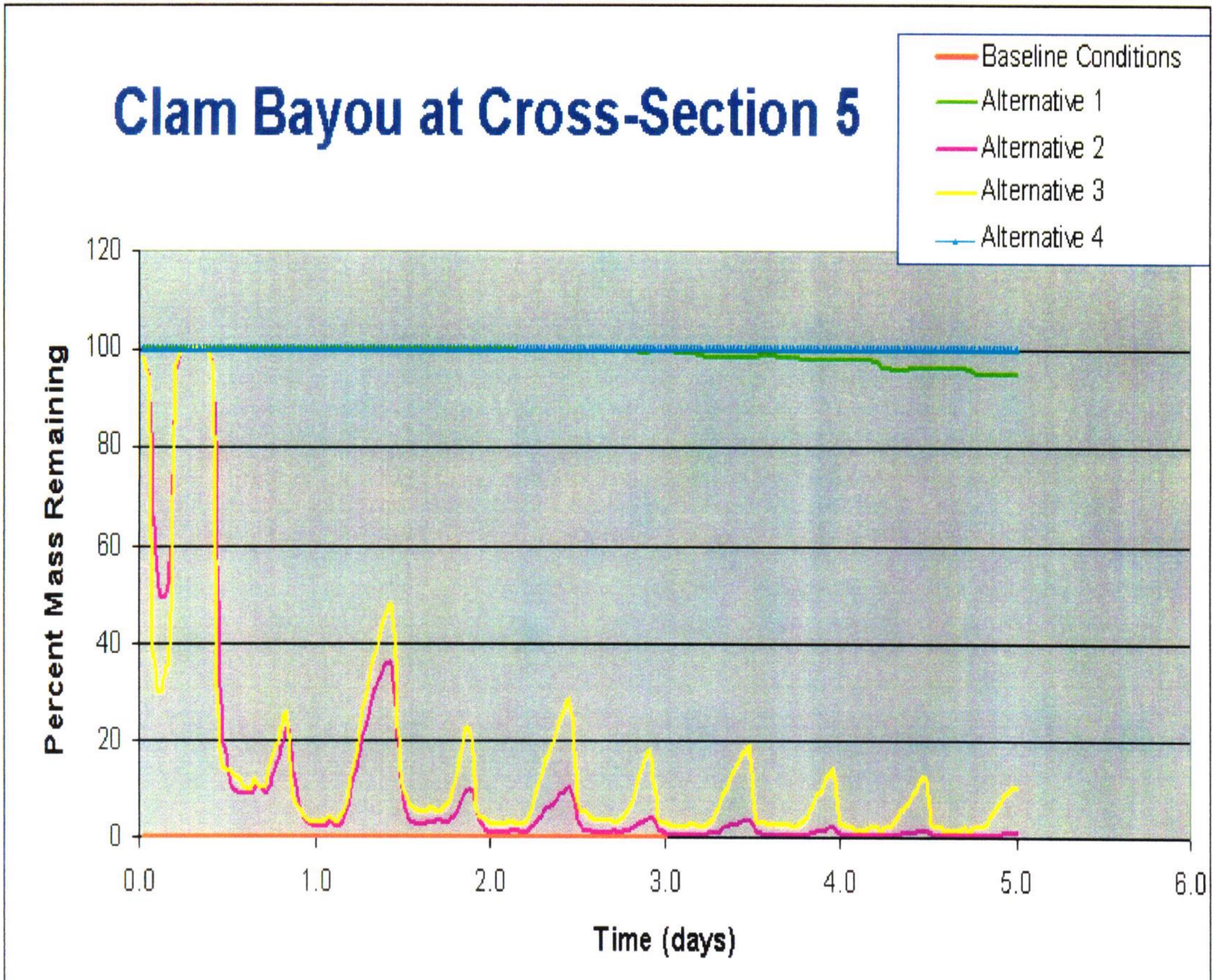

Figure IX-12
Comparison of Flushing over Time at Location 5 for the Proposed Alternatives

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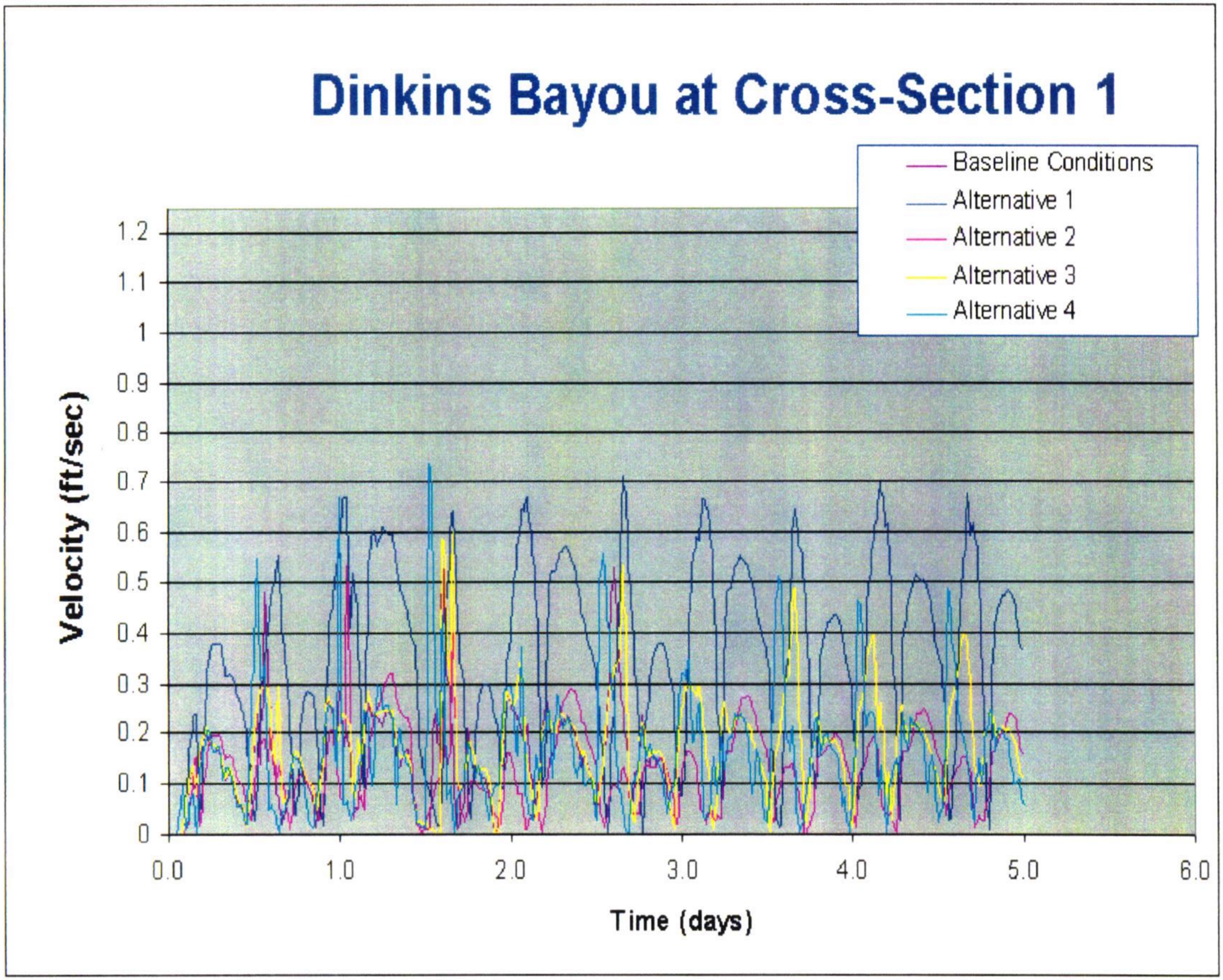

Figure IX-13
Comparison of Tidally-Induced Velocities at Location 1 for the Proposed Alternatives

03-110FIG9-14 6/11/03

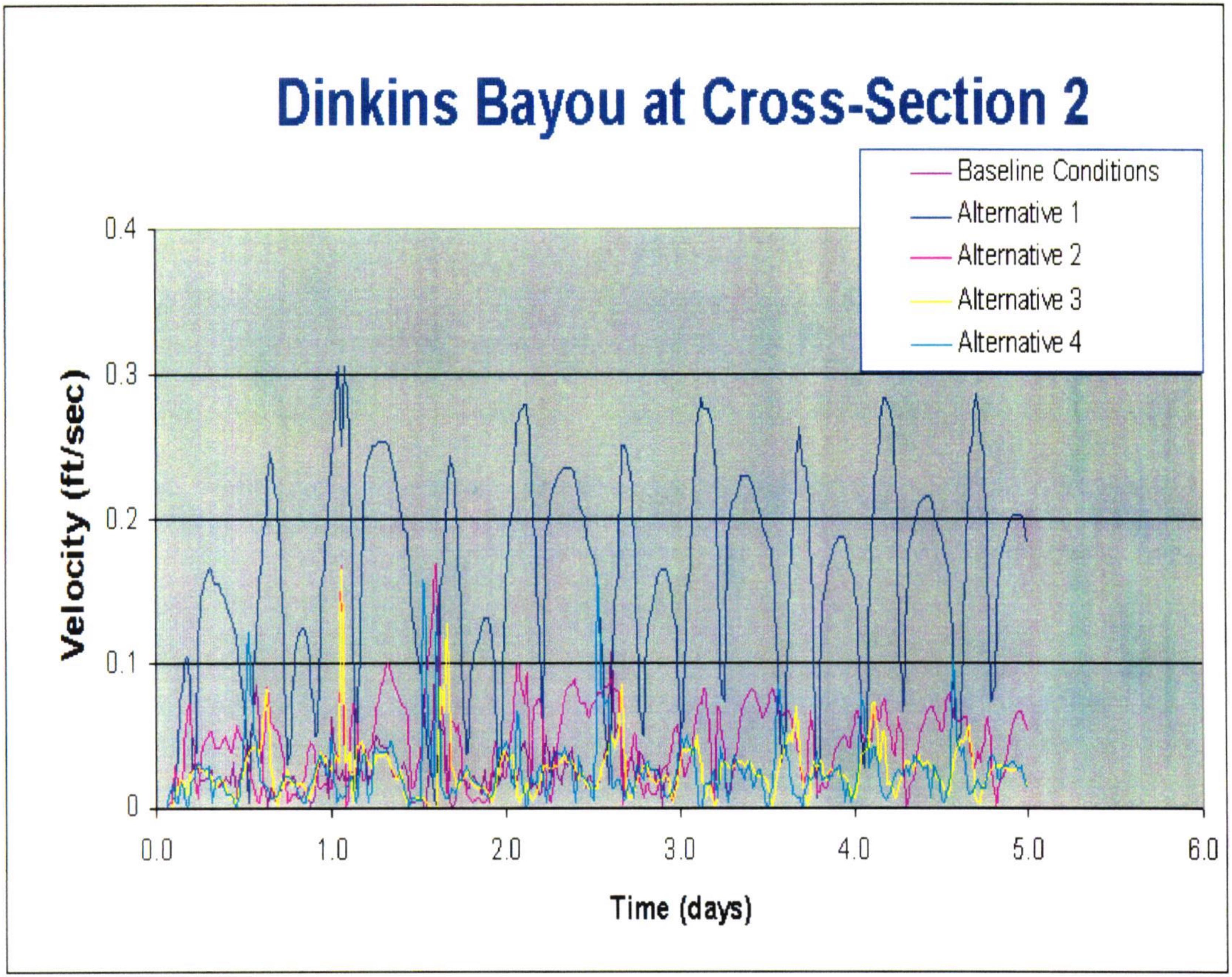

Figure IX-14
Comparison of Tidally-Induced Velocities at Location 2 for the Proposed Alternatives

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03-110FIG9-15 6/11/03

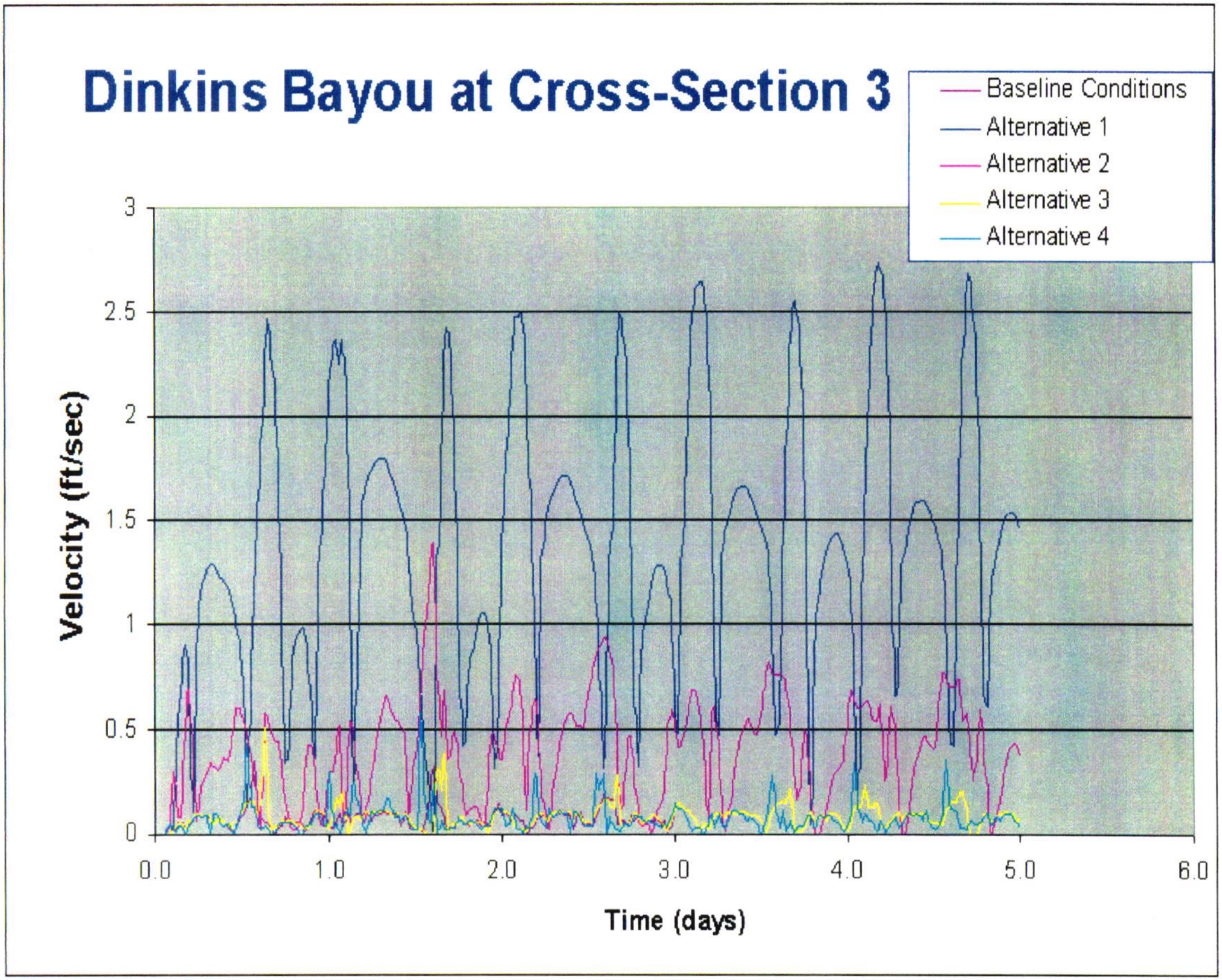

Figure IX-15
Comparison of Tidally-Induced Velocities at Location 3 for the Proposed Alternatives

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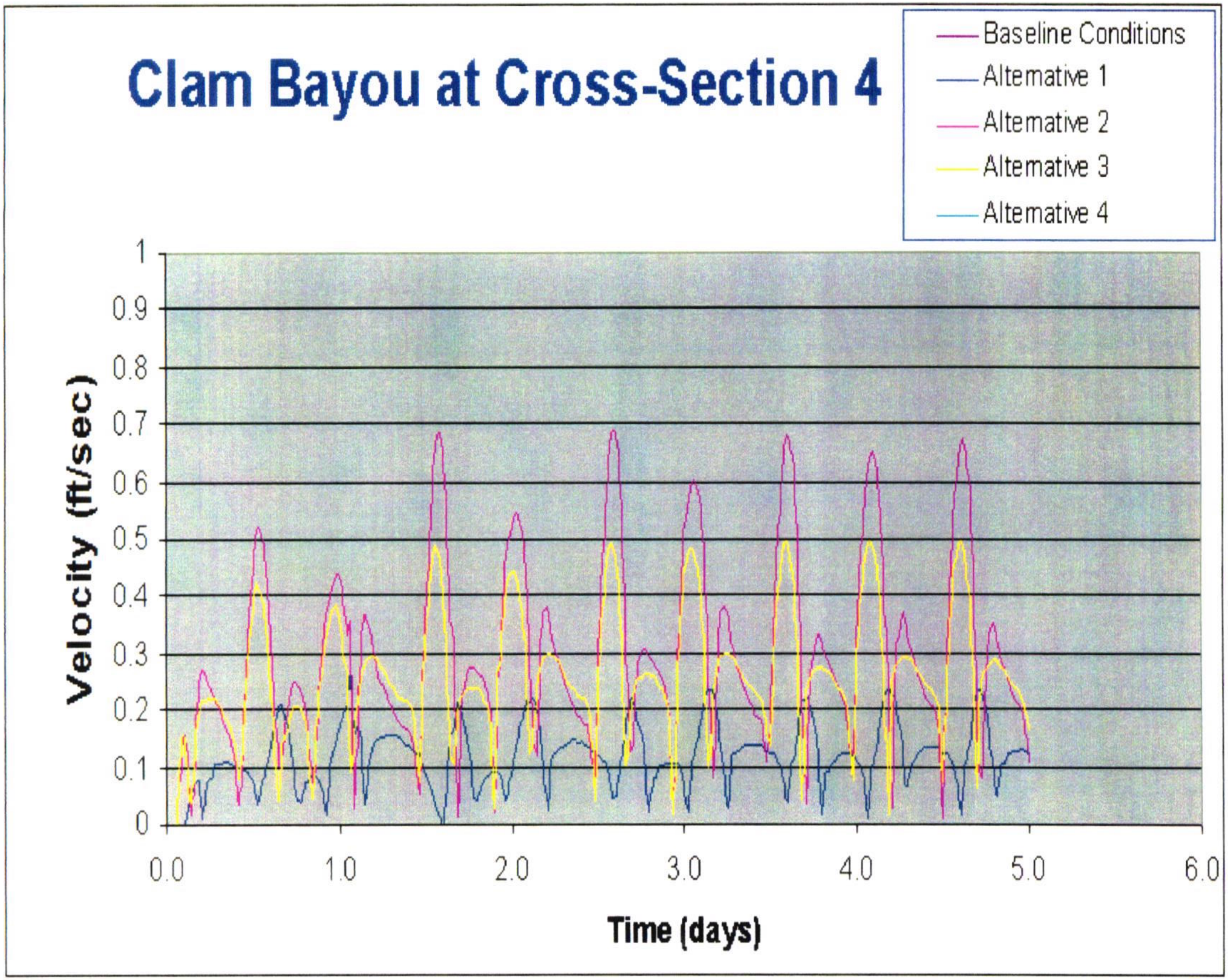
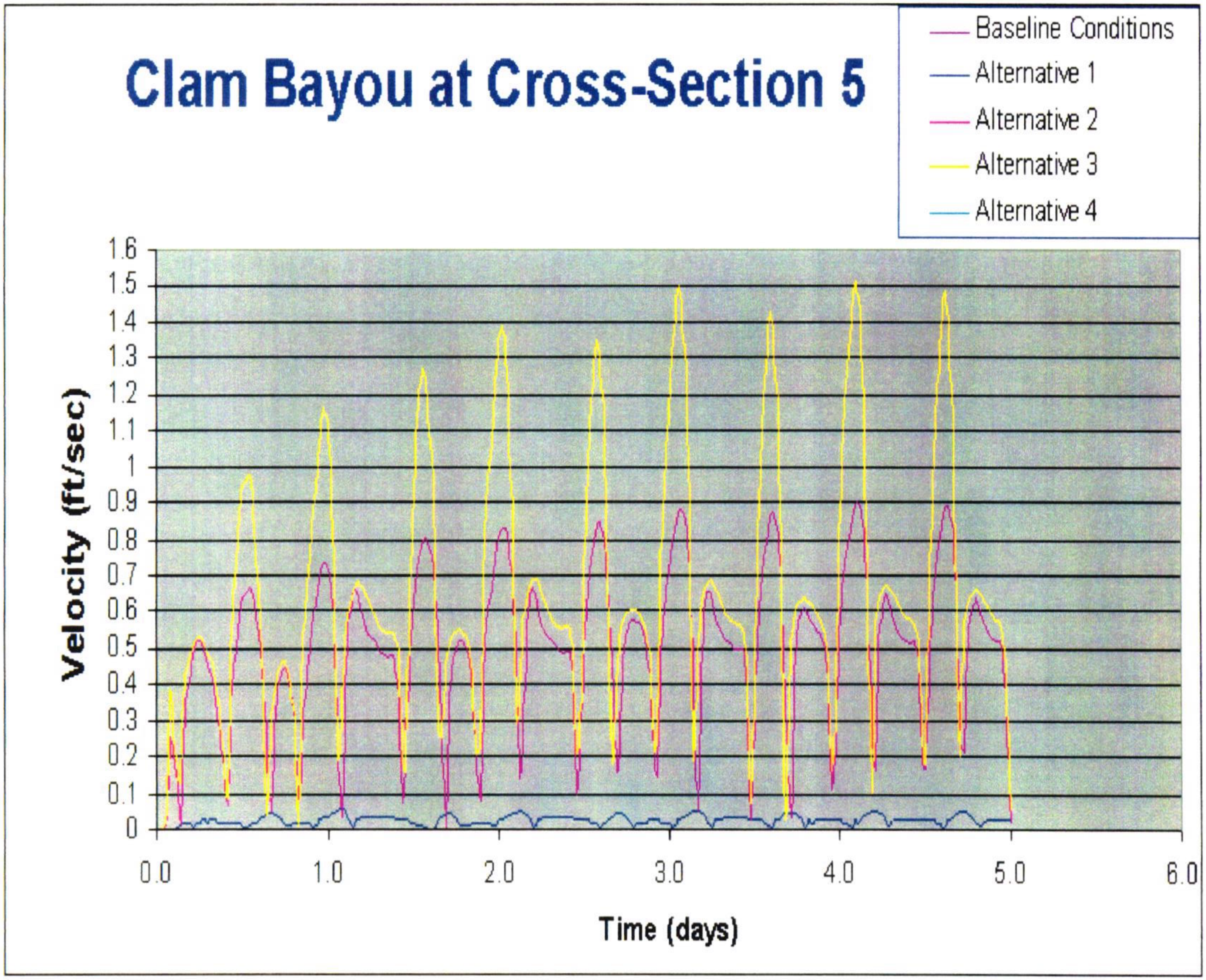
03-110FIG9-16 6/11/03

Figure IX-16
Comparison of Tidally-Induced Velocities at Location 4 for the Proposed Alternatives



03-110FIG9-17 6/11/03

Figure IX-17
Comparison of Tidally-Induced Velocities at Location 5 for the Proposed Alternatives



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03-110FIG9-18 6/12/03

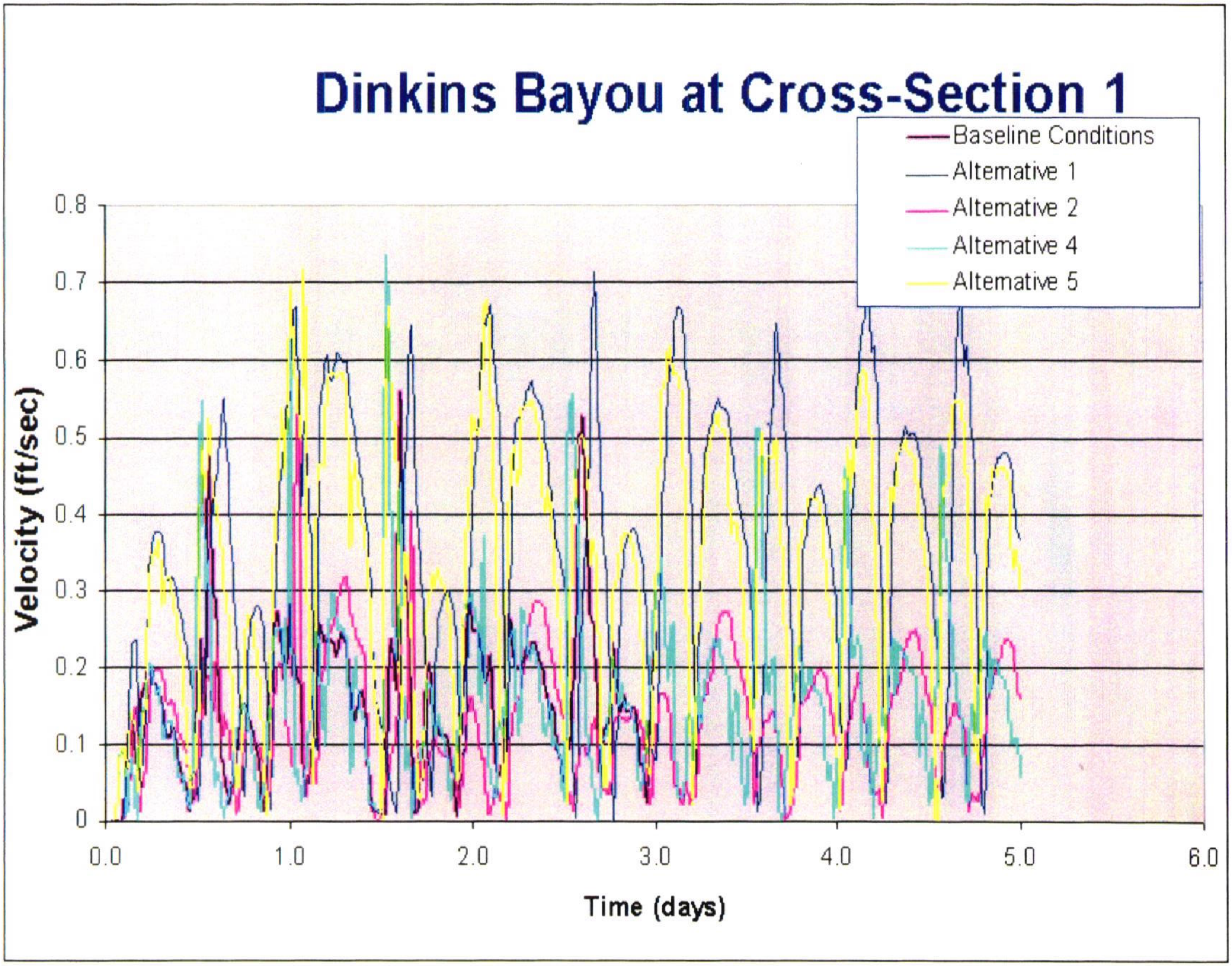


Figure IX-18
Comparison of Tidally-Induced Velocities at Location 1 for the Proposed Alternatives

02-102FIG2-2 7/15/02

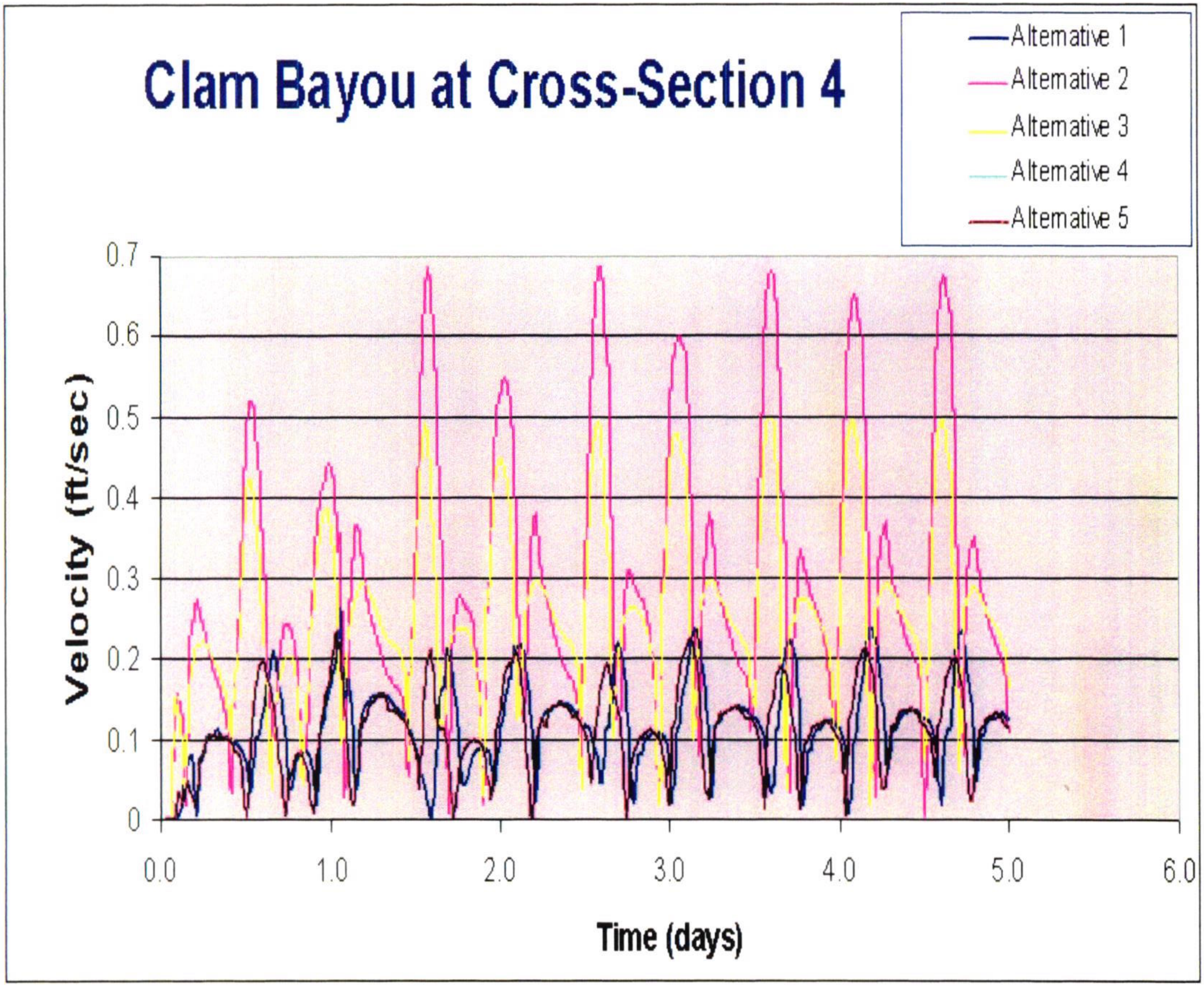


Figure IX-19
Comparison of Tidally-Induced Velocities at Location 4 for the Proposed Alternatives

Figure IX-20
Comparison of Flushing at Locations in Dinkins and Clam Bayous for Alternative 5a

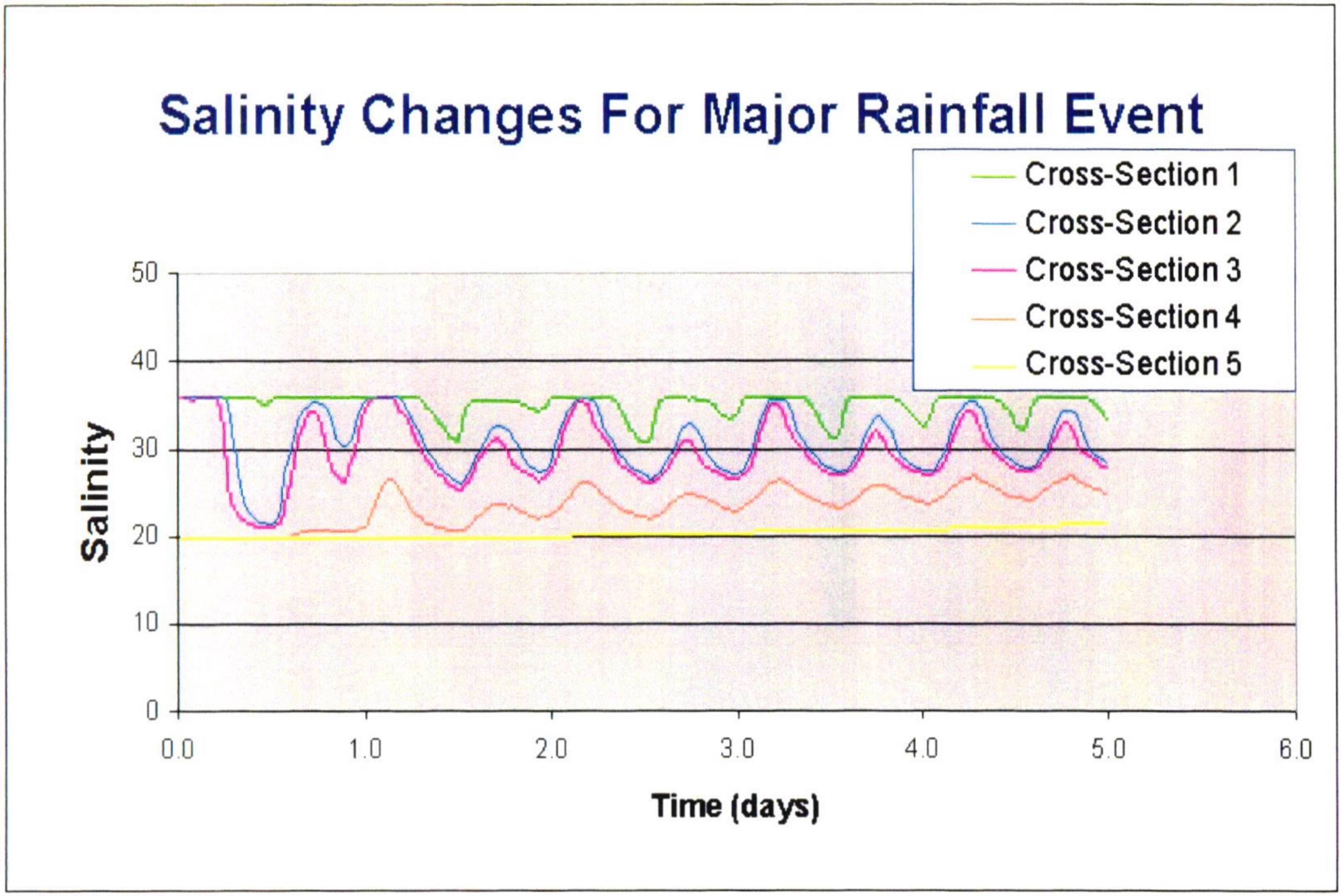


Figure IX-21
Comparison of Flushing at Location 4
in Clam Bayou for Alternatives 1, 5 and 6

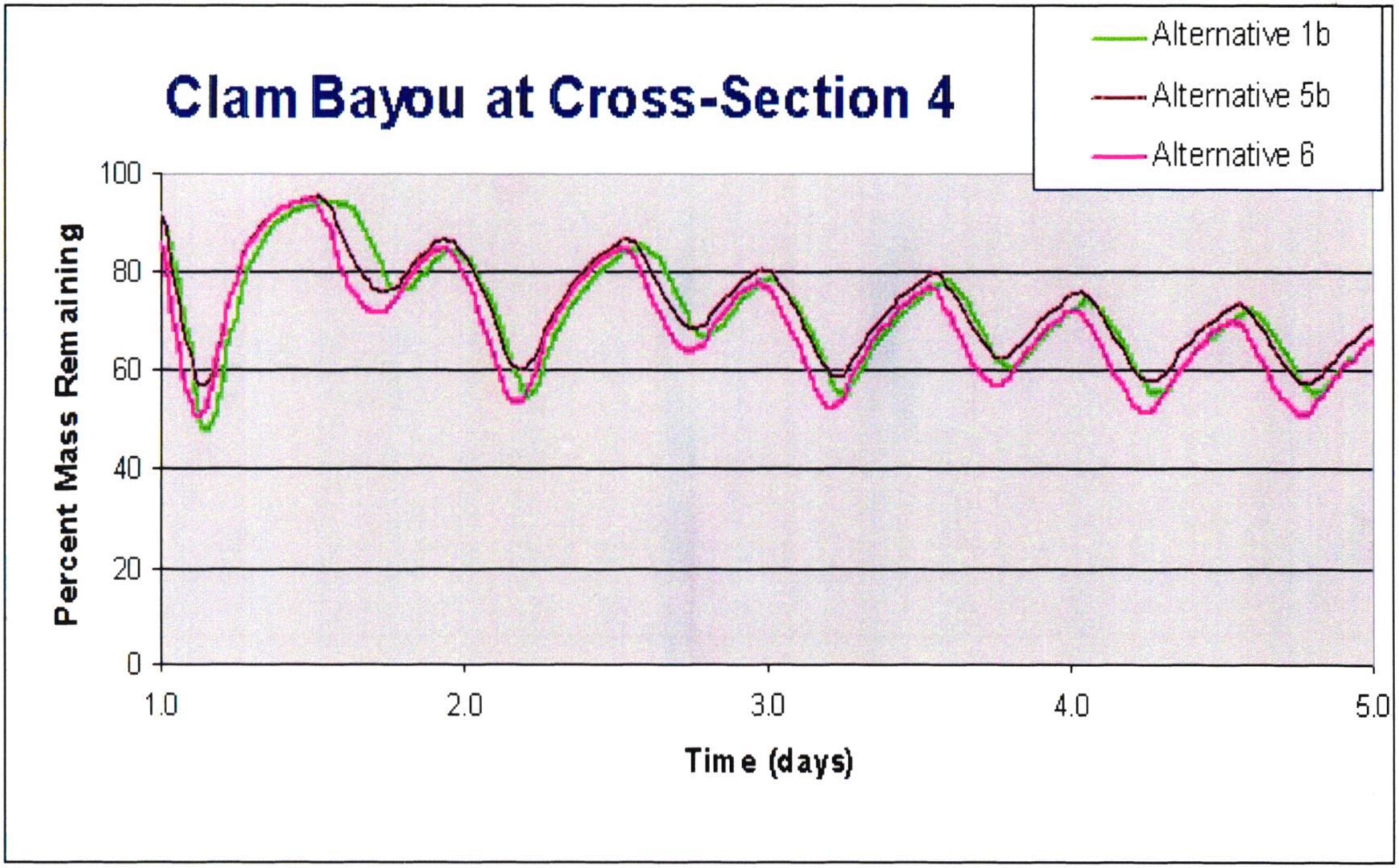
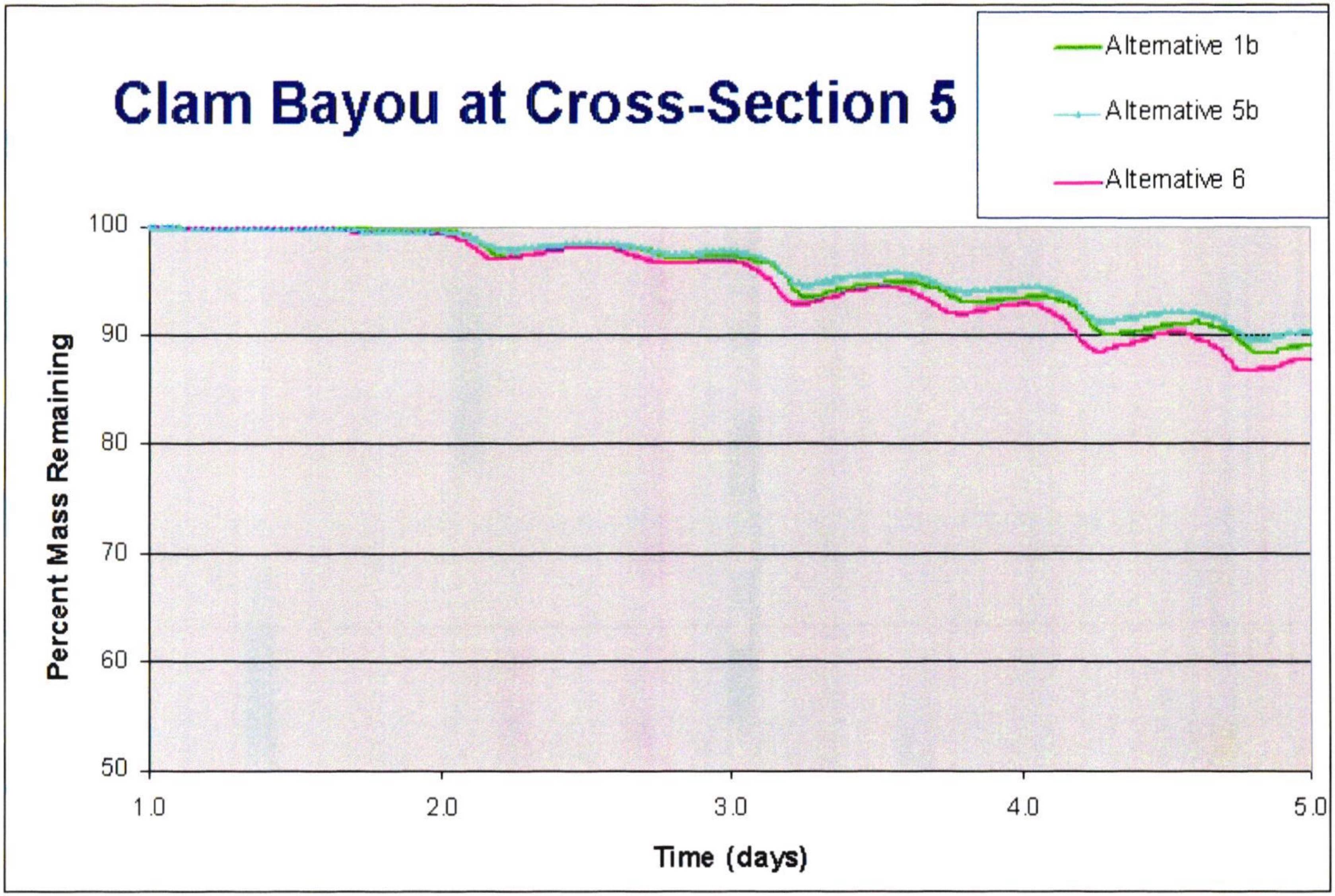


Figure IX-22
Comparison of Flushing at Location 5 in Clam Bayou for Alternatives 1, 5 and 6



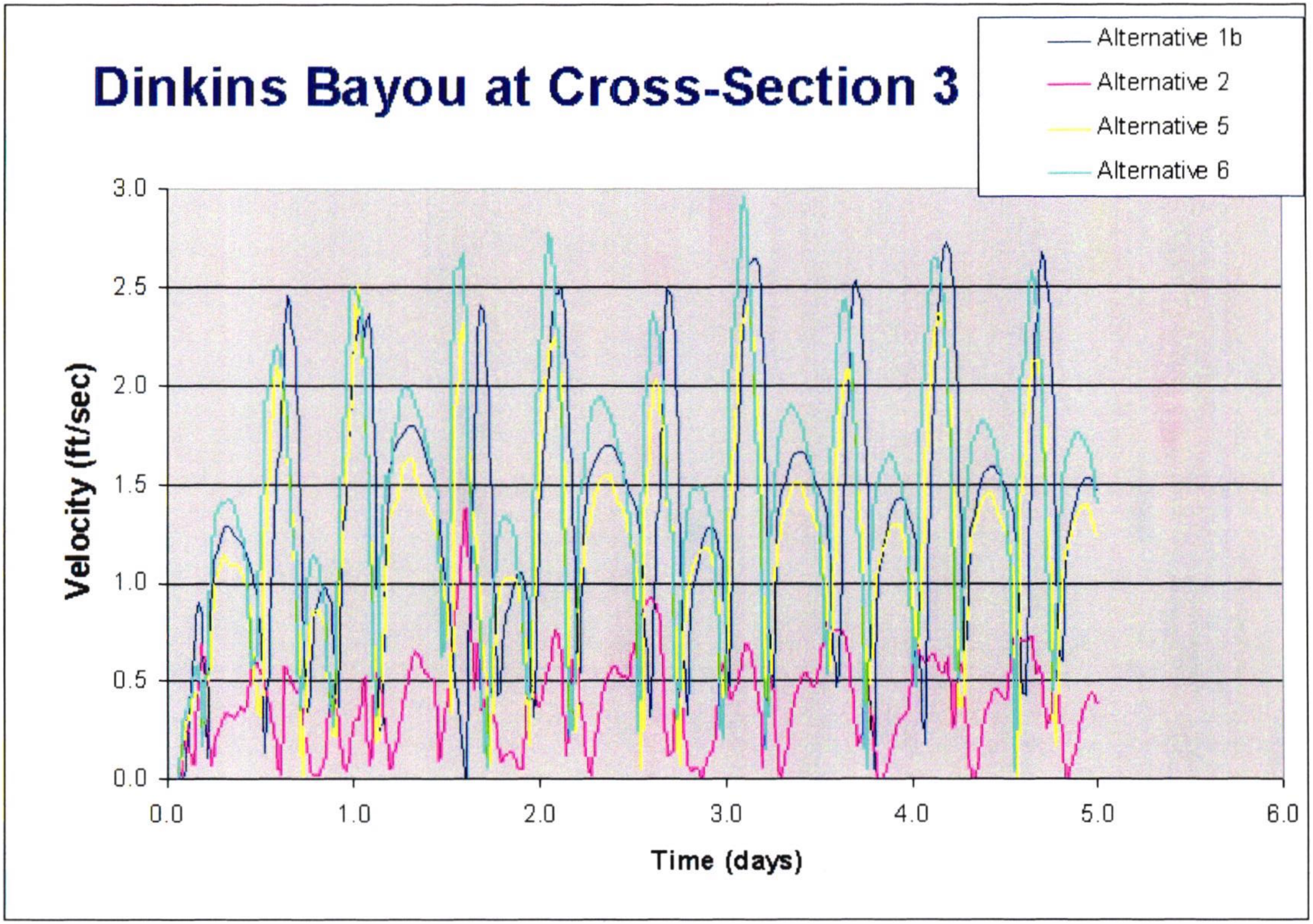


Figure IX-23
Comparison of Tidally-Induced Velocities at Location 3 for the Proposed Alternatives

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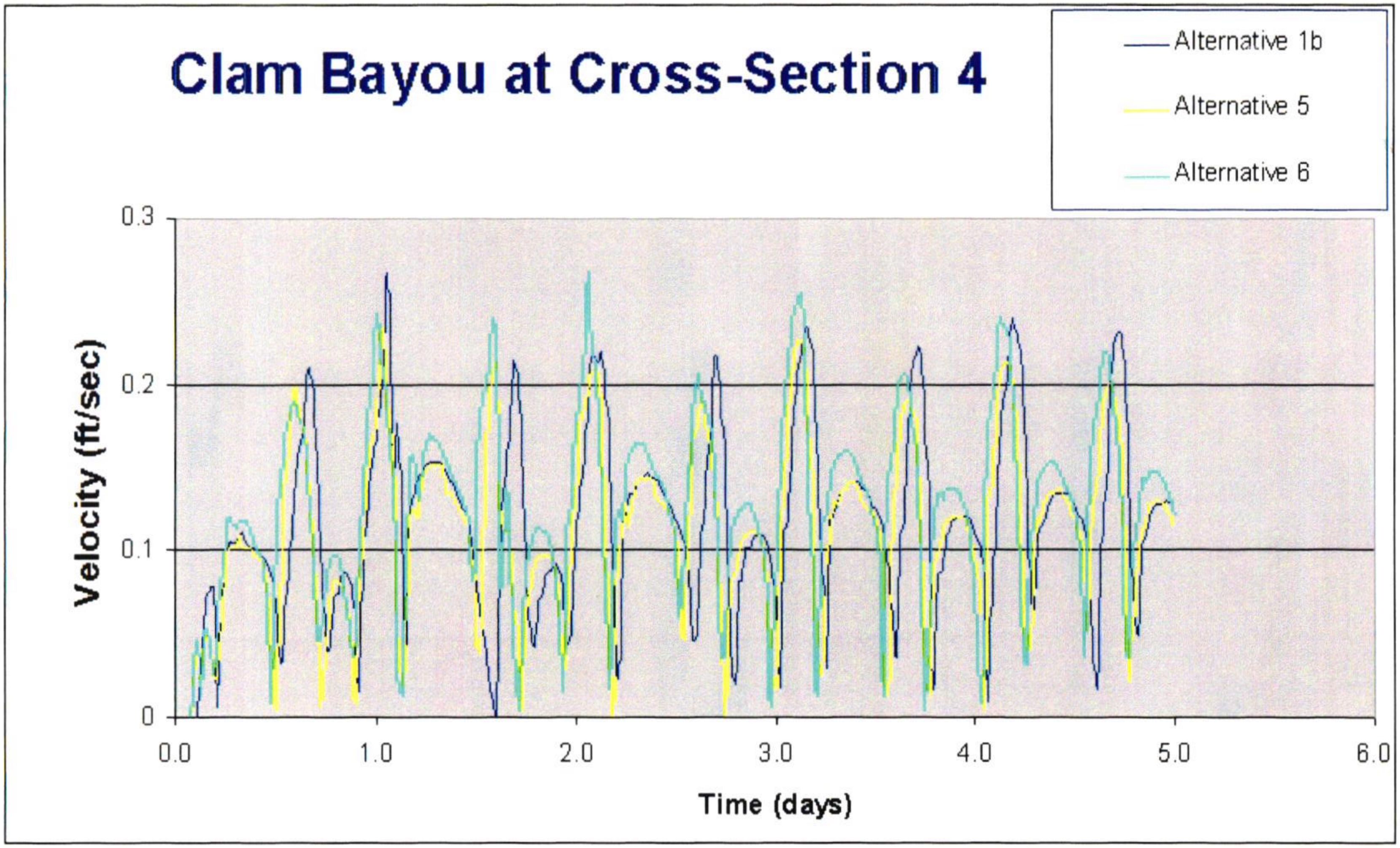

Figure IX-24
Comparison of Tidally-Induced Velocities at Location 4 for the Proposed Alternatives

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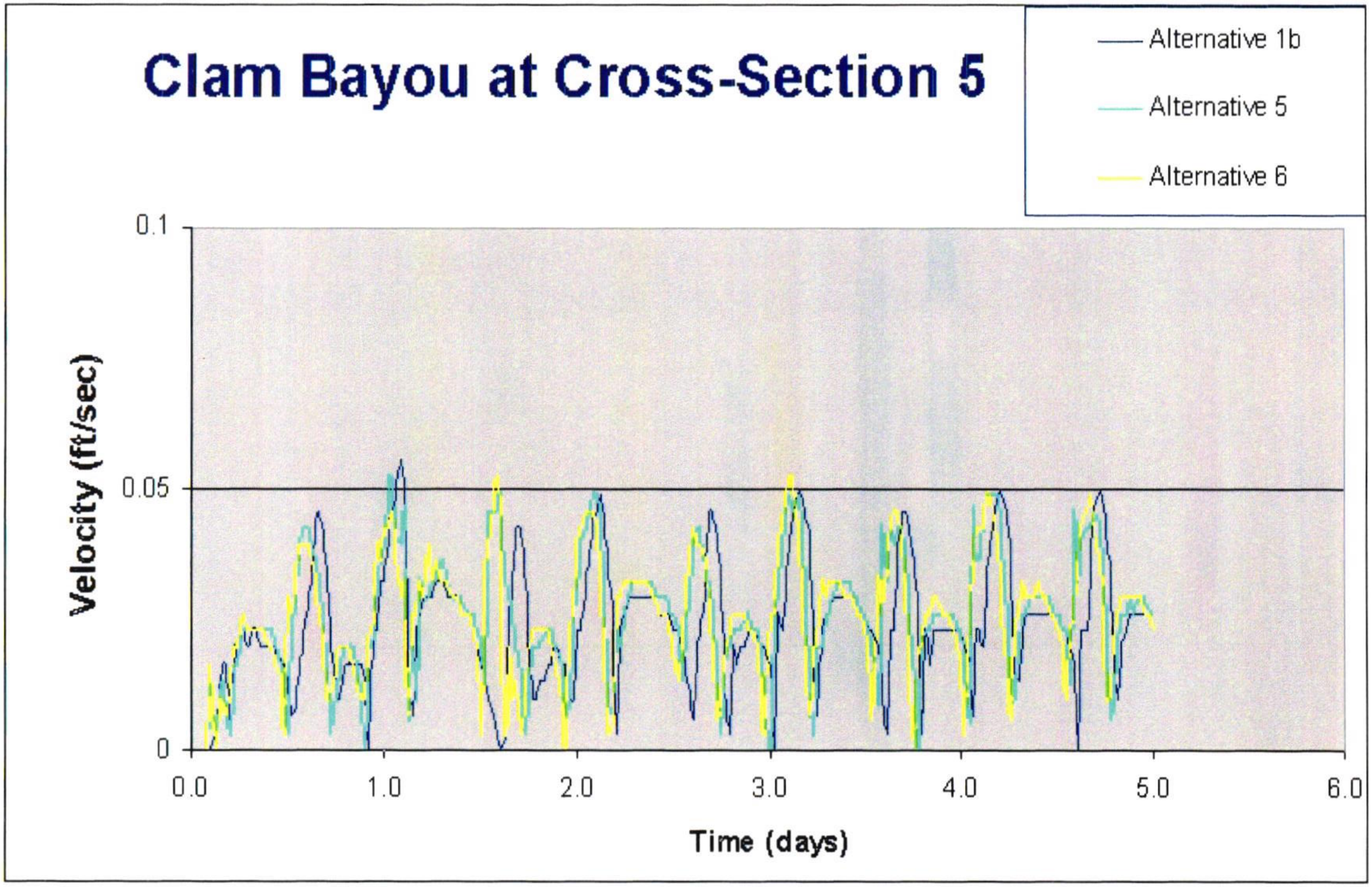
Figure IX-25
Comparison of Tidally-Induced Velocities at Location 5 for the Proposed Alternatives



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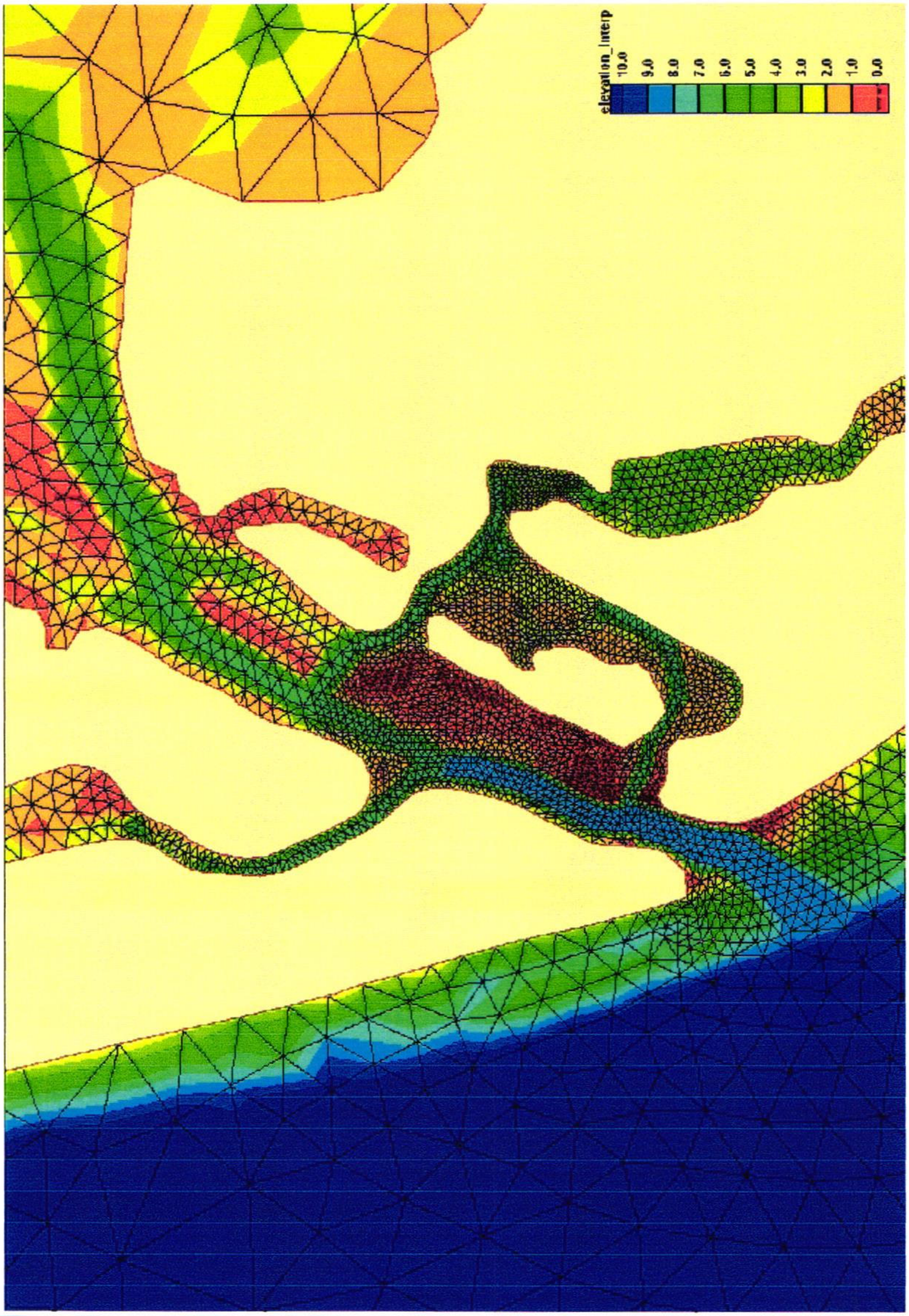

Figure IX-26

Grid Layout for Alternative 6 Conditions at Blind Pass, Dinkins Bayou and Clam Bayou

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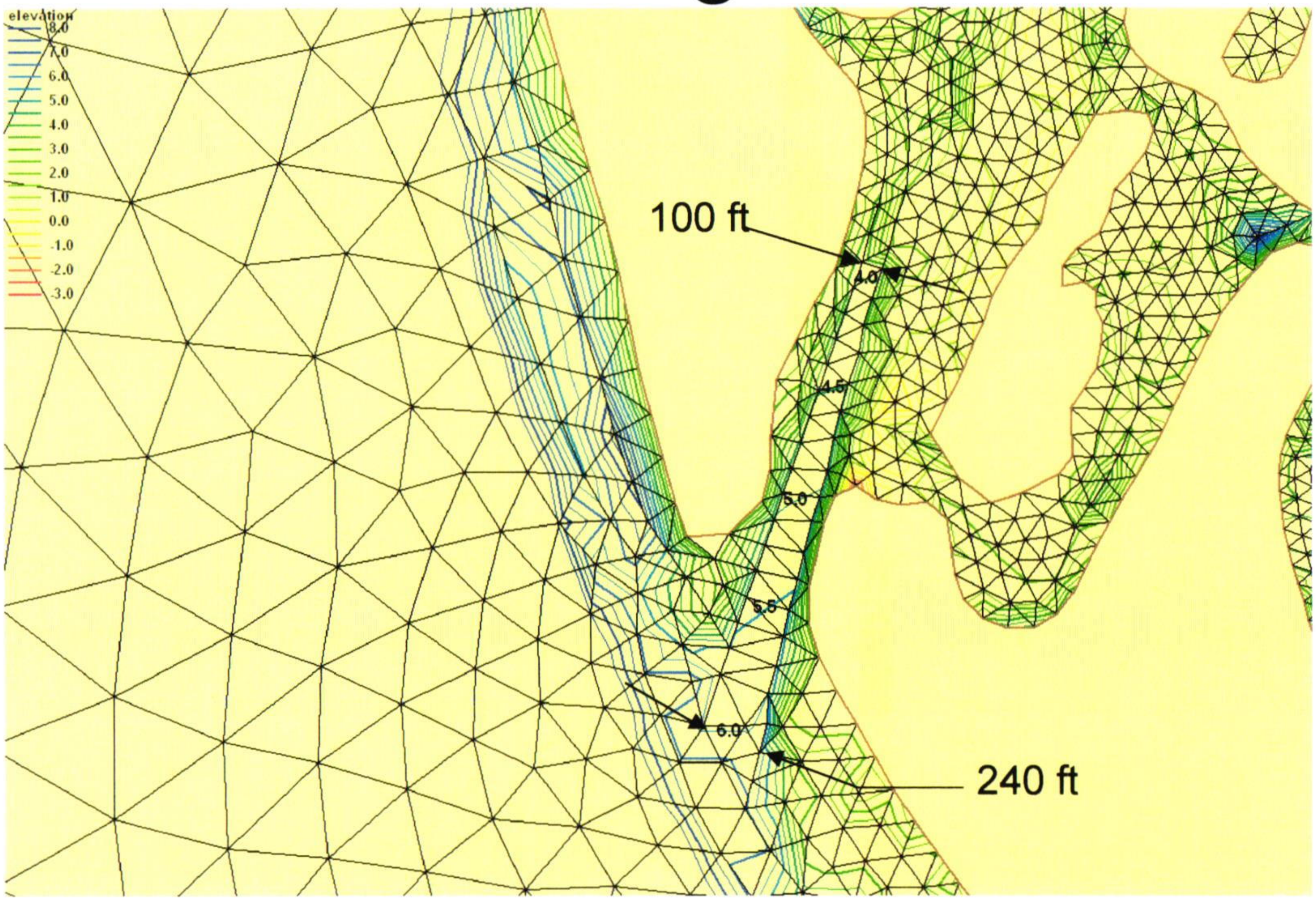
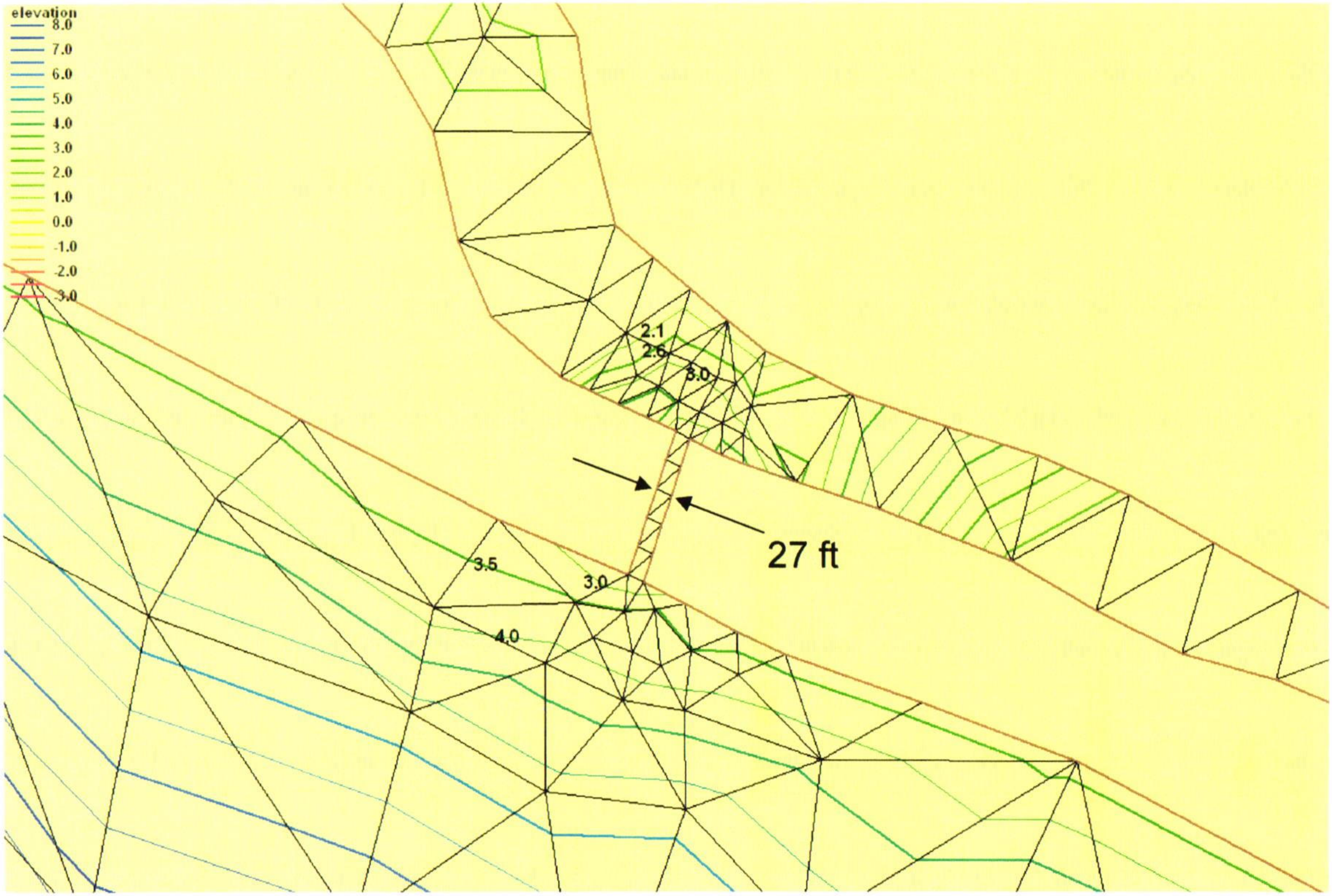
Channel Through Blind Pass



Clam Connection to Gulf of Mexico



X. HAZARD MITIGATION DISCUSSION

General - According to the third law of Sir Isaac Newton "For every action there is an opposite and equal reaction". Such might be the concern of those less daring and more comfortable with the **Baseline Alternative**, which is essentially Doing Nothing. We might also keep in mind the phrase "No risk, no reward". The regulatory agencies will fully evaluate any proposed action that may have long term impacts, even if those impacts are positive. In an effort to review each alternative with as objective an eye as possible, recognizing every possible scenario, and assessing the outcome, it is expected that something may be overlooked. However, this discussion is necessary in order to weigh the risks of each alternative relative to the benefits.

A. Baseline Alternative (Do Nothing) - The outcome of this alternative is well discussed in the Section III - A, considering that there was no action associated with this plan.

B. Flushing Connection direct to Gulf of Mexico – Alternative 3 proposes to make a direct connection from Clam Bayou to the Gulf by creating a new tidal channel (Clam Pass). During average annual tidal conditions, this alternative is an ideal solution, as the Pass would exchange the greatest volume of clean water to the bayou. Based on the tidal prism provided by a direct connection with the Gulf from Clam Bayou, this alternative is the most obvious corrective measure. However, this option directly exposes Clam Bayou to the Gulf of Mexico. The result of creating an opening to the Gulf at this location is an increased exposure to storm surges and, in particular, high frequency events such as winter nor'easters and tropical storms.

Currently, the Gulf of Mexico is barred from Clam Bayou until a storm surge reaches an elevation that overtops the narrow spit of land that separates the two water bodies. The result is that sand is moved from the upland beach landward into the bayou, and the tidal surge creates a superelevation of the water body, with potential road flooding. As the storm tidal elevations increase there is a time lag prior to time when surge and wave overtopping occurs and flooding begins. With a direct opening to the Gulf, any storm surge will impact Clam Bayou and surrounding properties immediately. Only when that storm surge exceeds the current height of the sand spit separating the two water bodies does the difference between the alternatives disappear.

Incoming waves will cause the movement of sand into the bayou. The damage associated with waves breaking will be low to moderate during high frequency storms (i.e. 10 to 15 year storm recurrence intervals) as waves will shoal and break at the entrance due to shallow depths. However, there will be more wave action in Clam Bayou than with the other alternatives, and increased erosion of the shorelines may occur.

The stability, and thus longevity, of the pass is probably the greatest concern. Storms and hurricanes move tremendous amounts of water and sand in the nearshore coastal environment. This increases the potential for sedimentation with the Bayou and infilling of Clam Pass, to the extent that restoration of the pass, and associated annual maintenance costs, will be required to maintain adequate flows and flushing within the bayou. For these reasons, a new pass opening will need to be stabilized by some type of structure to control infilling by wave and tidally induced sand movement. This changes the cost of the project, reducing maintenance of the pass opening, but adding cost for maintaining the structures that keep the pass open. Sedimentation may not necessarily close the pass, but structural stabilization of the pass opening may result in downdrift impacts that would reduce the beach width. This could have an impact on recreational users at both Bowmans Beach and the south end of Turner Beach.

C. Connecting Clam Bayou to Dinkins Bayou via a flushing channel – Alternative 1 proposes the "safest" connection between Clam Bayou and tidal waters. It solves the first problem of alleviating flooding associated with impounded stormwater and tidal surges. The first concern is the potential weakening of the roadway by installing a channel underneath the road. In extraordinary conditions, it is possible that storm surges on either side of the road would seek to equilibrate the water elevation through the channel. With unusual storm surge events, discharge from Clam Bayou will be limited by the opening of the box culvert or bridge, then eventually the 6.0' elevation of the roadway. This creates a potential scouring condition within the channel that could erode the embankment. This is addressed through the installation of riprap or other protective means. A certain level of scour is required to prevent siltation within the flushing channel.

Tidal surges, overtopping the coastal barrier into Clam Bayou, and exceeding the carrying capacity of the culvert, may eventually exceed the crest elevation of the roadway and sheet flow into Dinkins Bayou. The intensity of flow may fill in the dredged sections of the waterway, but this could happen regardless of the tidal opening into Clam Bayou. The best way to address concerns over excessive tidal elevation differentials between Clam and Dinkins Bayou is to install controlling gates at the flushing channel. This can be as simple as building steel guides in the box culvert or bridge crossing in which wooden timbers can be placed manually. Controlling discharges can also be as complex as an electronically controlled gates that activate when differentials between both sides exceed a predetermine elevation. A number of alternatives are available on the market and have been successfully implemented.

The second concern is water quality. It is clear in conversations with Dinkins Bayou residents that they do not want to become the receiving waters for Clam Bayou runoff without assurances that overall water quality in Dinkins Bayou will be improved. This perception of poor water quality in Clam Bayou is further exemplified with fish kills in the past, and the associated smell. Even though water quality in Clam Bayou is generally better than in Dinkins Bayou, if the proposed project does not flush both systems adequately, there is the potential for decreasing water quality in both systems.

Adding the Gulf of Mexico connection, along with the flushing channel (**Alternative 2**), eliminates the barrier that separates Clam Bayou from the Gulf. A direct connection will convey these flows into Clam Bayou, and subsequently Dinkins Bayou, immediately as the storm tidal elevations increase. Without flood controls at the flushing channel, storm surges may have a greater impact on Dinkins Bayou. This could happen regardless of the tidal opening into Clam Bayou depending on the elevation of the storm surge and overtopping Sanibel Captive Road.

Alternative 4,5, and 6 create a number of potential hazards with the opening of Blind Pass. A permanent Blind Pass opening exposes the bridge to coastal elements that would be significantly less if the pass remains closed. In discussions with the structural engineers who designed the current bridge, special armor stone has been placed around the abutments, and the piling lengths are consistent for a bridge designed to cross a tidal pass connected with the Gulf of Mexico. However, depending on the depth of water that would exist under the bridge, significant storm surge and wave height could affect the integrity of the bridge. It could also be argued that a designed pass opening would include some manner of an ebb shoal to bypass sand transport down drift. This shoal would function as a speed bump or wave break, tripping incoming waves further away from the bridge, and potentially affording it greater protection than the current beach location.

Depending on the final design of a Blind Pass channel, properties along the south beach could potentially be more vulnerable to storm events with an open pass. However, considering the scale of an event that would be necessary to damage these properties, we would likely experience significant losses on both sides of the bridge, including Turner Beach, and likely infilling of the pass.

The last potential hazard concern associated with a reopened pass is exposure of waterfront properties along the south shore of Captiva. A significant number of these properties have revetted their shoreline to address scour created by Blind Pass when it was open in the 1980's. These revetments have dealt with scour velocities effectively. With a pass opening, a significant storm event could increase flooding and longshore sand transport increasing beach erosion along this area of the island. Since most of these properties are in the "lee" of the island, exposure of these properties to flooding would remain the same as currently exists

XI. REGULATORY PERMITS

General - Any construction activities in waters of the state must be authorized through the various local, state and federal regulators. The City of Sanibel regulates upland development, with limited interest by the State, except for stormwater management, which is dependent on the acreage of the project. Issues of concern with the U.S. Army Corps of Engineers (COE), and the Department of Environmental Protection (DEP), related to a flushing channel and dredging improvements will include water quality impacts, existing and proposed uses, habitat impacts, secondary and cumulative impacts, construction in the Pine Island Sound Aquatic Preserve, and coordinated review with state and federal agencies regarding protected and endangered species impacts. Part of the permitting review will include a comprehensive assessment of existing water quality conditions and flushing characteristics at the site, depending on the proposed work. Since the majority of the bottom lands associated with the project include work on sovereign state lands, submerged easements for dredging of channels and pass openings will be required. The following is a general description of the various regulators and their jurisdictions.

City of Sanibel - It is likely that the City of Sanibel will be an applicant if the flushing channel alternative is pursued. Depending on the total scope of work, it may fall to Lee County as the applicant if it includes activities outside of the jurisdiction of the City. In either case, the City has a Land Development Code (LDC) that must be considered when contemplating a local approval for the project. Securing a Development Permit for the construction may require a Conditional Use authorization if the proposed activity is not consistent with current zoning or provisions of the LDC. If the project can be demonstrated to comply with the intent of the Comprehensive Land Use Plan and is consistent with the LDC, City approvals should be available. Based on the unique nature of the restoration alternatives, it is likely that the project will be considered by both the Planning Commission and City Council and authorized via resolution.

Florida Department of Environmental Protection (DEP) - The Bureau of Beaches and Wetland Resources regulates activities that affect water quality, the use of sovereign submerged lands, and activities seaward of the Coastal Construction Control Line. DEP functions as a regulator of the environment, empowered under Chapter 161,403, 373, and 258 of the Florida Statutes. The administrative codes (rules) developed under these specific authorities directly affecting development in state waters and along the coastal zone include: Capter 62B-49 Joint Coastal Permits; Chapter 62-302/Surface Water Quality; Chapter 120/ Administrative Procedures Act; Chapter 18-21/Sovereign State Lands; Chapter 18-20/Aquatic Preserves. The DEP will also administrate water quality impacts through Chapter 40E of the Florida Administrative Code, rules drafted by the South Florida Water Management District in the southwest Florida region.

Relative to water quality and compliance with the Clean Water Act, water quality testing and assessments of the flushing characteristics of the site are typically issues associated with permitting any construction in waters of the state. Issues relative to water quality usually include heavy metal (eg. copper, lead, zinc, chromium) contamination in the water column, biological oxygen demand, and dissolved oxygen levels. Existing water quality data for both Dinkins Bayou and Clam Bayou will be valuable as part of any pre-application conferences.

Regarding use of sovereign state lands, the Governor and the Cabinet sit as the Trustees of the Internal Improvement Trust Fund (Trustees) who govern use of sovereign submerged lands. Delegation to the local DEP staff relative to rules and management of sovereign state lands has been streamlined into the environmental resource permit (ERP) process. Given the complexity of the potential alternatives it is expected that the Trustees will review the project.

Florida Fish and Wildlife Conservation Commission (FWCC) - This commission includes the Office of Protected Species. This group is charged with assessing impacts to protected wildlife species from projects requiring DEP permits. Wildlife potentially impacted from any activities in Clam Bayou, will include manatees, eagles, piping plovers, and sea turtles.

The Fish and Wildlife Conservation Commission established the Florida Manatee Sanctuary Act in December 1992, and amended it in November of 1999. The Florida Manatee Sanctuary Act was adopted to protect the West Indian manatee in the waters of the State of Florida from disturbance, harassment, injury or harm. The FWCC established manatee protection zones in areas where manatee sightings were frequent or assumed that they inhabit these areas on a regular, periodic or continuous basis. Any dredging improvements to enhance flushing, and resulting in navigational improvements will be reviewed relative to manatee, and manatee habitat, impacts. At a minimum, enough clearance for manatees to enter Clam Bayou must be provided for average annual tidal conditions. If a box culvert is selected, this must include enough clearance between the water surface and the top of the culvert for manatees to breath if traversing the 100' length of the culvert.

U.S. Army Corps of Engineers (USACE) - The COE is the federal agency charged with review and assessment of dredge/fill projects affecting navigation, and impacts to wetlands. Under Section 404 of the Clean Water Act, any dredging or filling in jurisdictional wetlands must undergo review by the COE. As part of the assessment process, they notify other federal agencies of pending projects, and solicit comments within a specified time frame. The most prevalent commenting agencies are the Environmental Protection Agency (EPA), the U.S. Fish and Wildlife Service (FWS), and the National Marine Fisheries Service (NMFS).

The EPA reviews the project for compliance with the Clean Water Act, and considers permits issued by the state DEP or regional WMD as water quality certification. This is why the issuance of the DEP/WMD permit is required before a COE permit is issued. The NMFS is usually concerned about impact to fishery habitat and is involved in the mitigation aspects of wetland impacts. The U.S. Fish and Wildlife Service is focused on impacts to threatened and endangered species, and is essentially the sister agency of the Florida Fish and Wildlife Conservation Commission. If an endangered species is adversely affected by a development, FWS will enact consultation under Section 7 of the Endangered Species Act. For activities in navigable waters, impacts to the West Indian Manatee are usually assessed, and mitigated for, through review by FWS and adoption of conditions within the COE permit. In most cases the deployment of manatee information and awareness signs and establishment of slow speed zones will mitigate the impacts created by navigational improvements. For box culverts and flushing pipes, structural modifications will have to be considered to prevent entrapment of manatees.

In February 2000, the Save the Manatee Club (SMC) and 18 other manatee advocate organizations filed a federal lawsuit against the COE and FWS, contending that those federal agencies were not doing enough to protect manatees. The outcome of this lawsuit has been to establish additional manatee sanctuaries, refuges, and speed zones, including portions of Lee County. Although it is unlikely that the proposed flushing channel will be considered a threat to manatees, improving channels for flow also can improve navigation for boaters. Any activities that directly affect boating will likely be reviewed by the SMC for manatee impacts. Considering past experience with SMC, any proposed activity in this area will likely require coordination with their organization. This project should not pose any significant concern for SMC, and they should encourage the project as an opportunity for manatees to use Clam Bayou as additional forage area.

Florida Department of Community Affairs (DCA) - The local representative of the DCA is the Southwest Florida Regional Planning Council (SWFRPC). This group consists of a compilation of regulators, typically county commissioners, city council representatives, and various other public agencies, charged with reviewing various developments of a regional nature. Shopping malls, large housing developments, port expansions, and similar construction that has a regional impact on infrastructure and transportation services must submit an Application for Development Approval (ADA) for a Development of Regional Impact (DRI).

Under Chapter 380 of the Florida Statutes, and Rule 9J of the Florida Administrative Code, certain thresholds have been developed to determine whether a project is a DRI or exempt from the process. Although this project will likely be considered of regional significance, it is not expected that this project will be considered a DRI. However, the DCA functions as a clearinghouse at the state level, much like the COE at the federal level, and outside regulatory agencies, environmental groups, and citizens rely on DCA comments to determine if a project requires additional scrutiny within their own organizations.

XII. FUNDING SOURCES

With the exception of special assessments and ad valorem taxes, all these funding sources require a match. Care must be taken to work within limited windows of opportunity and to be sure to observe the match restrictions. This list is by no means exhaustive.

Federal Government

Beach Restoration: Federal funding may be available to authorized projects (e.g. Captiva) for beach restoration. Congress must authorize funds. Obtaining authorizations for new projects is very difficult, expensive and time-consuming.

National Estuary Program: The Charlotte Harbor National Estuary Program provides grants of up to $20,000 per participating partner for improving hydrologic alterations, water quality degradation/nutrient enrichment, and fish and wildlife habitat loss. A Technical Advisory Committee makes recommendations for funding.

Community-based Habitat Restoration Projects: This program helps communities with on-the-ground restoration to ensure the healthy and sustainable fisheries resources. Several times each year proposals are requested for individual projects. Projects are selected based on technical merit, level of community involvement, ecological benefits to marine and anadromous fish habitat, and partnership opportunities. Only 20% of the grant request can be to fund planning and design.

Gulf of Mexico Foundation Partnership: The awards are made on a competitive basis to help Gulf of Mexico communities restore important fishery habitats.

Five Star Program: This program brings together citizen groups, corporations, students, landowners, youth conservation corps, and local, state and federal agencies to restore stream banks and wetlands. Primary funding is provided by the Wetlands Division in the U.S. Environmental Protection Agency's Office of Wetlands, Oceans, and Watersheds and the National Marine Fisheries Service's Community-Based Restoration Program. The average grant is $10,000.

National Fish and Wildlife Foundation: This program is a challenge grant program concerned with conservation education, fisheries conservation, neotropical migratory birds, wetlands and private land, and wildlife habitat. Grants range from $10,000 to $150,000 and are dispersed with two decision cycles.

National Marine Fisheries Service: This program provides grants for restoration for coastal marine resources and anadromous fish. Proposals may request up to $300,000 per year for a maximum of two years.

State

Beach Erosion Control Program: The Erosion Control Trust Fund provides grants for inlet management and beach restoration, including projects that utilize experimental technology. Current rule changes have modified cost share arrangements for activities that include levels of beach access and parking. The CCCL is located over 150 feet bayward of the Blind Pass Bridge.

Regional

WCIND: The West Coast Inland Navigation District is authorized to aid and coordinate with governments in planning and carrying out public navigation, environmental education and inlet management directly related to the waterways. They match local funds and activities must take place within three years of approval. Restoration projects are eligible for grants if sand is removed from the channel. Sand transfer or channel maintenance dredging may also be eligible

Local

CEPD: The Captiva Erosion Prevention District may fund erosion control projects on Captiva Island as the beach and shore preservation authority for Captiva. They may levy and assess an ad valorem tax not to exceed 10 mils. They may also levy a special assessment. Any bond issues require approval by the voters.

Sanibel Ad Valorem: The City of Sanibel can levy ad valorem taxes for any public purpose. Sanibel is a significant property owner in the Clam Bayou area.

Sanibel Special Assessment District: Municipalities have the right to set up special assessment districts in a geographic area and assess the property owners.

Lee County Ad Valorem: Lee County can levy ad valorem taxes for any public purpose. Lee County is a significant property owner in the Blind Pass and Clam Bayou areas.

Lee County Boating Improvement Trust Fund: Lee County's Waterway Advisory Committee determines who is funded from taxes collected from boat registrations. Generally this committee funds boat ramps and other public access facilities.

Lee County TDC Funds: Lee County collects a one percent tax on all short-term rentals that is used for beach and shoreline projects. The Lee County Coastal Advisory Council (CAC) makes recommendations to the Tourist Development

Council (TDC) concerning beach projects. The TDC determines the projects funded.

Lee County MSBTU: Counties have the right to set up Municipal Services Taxing (or Benefit) Units in geographic areas and assess the property owners in unincorporated areas. Captiva is unincorporated.

Sanibel Causeway Funds (county or city portion): If a project serves as road protection, Sanibel Causeway funds could be utilized. This would apply to the portion of Sanibel Captiva Road fronted by Clam Bayou, because the mangroves serve as road protection. This is also true for the portion of the road on both sides of Blind Pass which is protected by beach restoration. Unfortunately, because the Sanibel Causeway is facing high maintenance costs, it is unlikely those funds will be available.

Foundations - There are numerous private and public foundations that include environmental restoration as part of their programs. Local organizations like the Sanibel Captiva Conservation Foundation will provide funding for restoration activities, habitat enhancement, and conservation land purchases. Other national level organizations like The Pew Charitable Trusts, Arthur M. Blank Family Foundation
David and Lucile Packard Foundation, and John D. and Catherine T. MacArthur Foundation have grant programs that also include environmental issues within their grant programs.

Private - The heightened environmental awareness and benefits of restoring Clam Bayou present an attractive opportunity for individuals willing to donate proceeds towards the project. Individuals might well be interested in donating funds for restoration of Clam Bayou in exchange for naming rights to the bridge/culvert crossing the flushing channel.

XIII. PROJECT BENEFITS

Who participates in the decision making process is as important as the alternatives to be considered. There is a vast array of stakeholders impacted by any of the proposed actions, including the do nothing alternative. Below is a general breakdown of affected stakeholders and benefits resulting from the various alternatives.

Sanibel Island
(Clam Bayou): Residents along Clam Bayou, also referred to as Sunset Bay, will benefit from improved water quality, restored habitat, improved wildlife, flood control, and stabilized property values. If Clam Pass is restored, navigation improvements will also occur.

(Dinkins Bayou): Residents along Dinkins Bayou will benefit from significant improvements in water quality, restored flushing, improved water clarity, recreation of seagrass beds, improved fishing, and related navigation improvements.

Captiva Island
(Blind Pass): Residents along Blind Pass will benefit if water quality, wildlife habitat, fishing, and navigation are improved.

(Roosevelt Channel north to Tween Waters): Residents along Roosevelt Channel will benefit if water quality, tidal flushing, and navigation are improved.

(Gulf of Mexico): Residents along the south end of Captiva along the Gulf of Mexico will benefit if sand removed from Blind Pass to facilitate improved flushing to Clam Bayou is placed on the beach for shore protection and recreation.

Lee County
(Bowman's Beach): Lee County owns Bowman's Beach Park and will benefit if sand from any pass dredging is placed on the beach for recreation. Similarly restoration of mangrove habitat and overall estuary quality improves wildlife habitat and subsequent recreational and fishing benefits.

(Sanibel-Captiva Road): Lee County owns Sanibel-Captiva Road and will benefit if sand from either Blind Pass or Clam pass is placed at Turner Beach for recreation. Similarly the county will also benefit from mangroves being restored along the Clam Bayou shoreline, protecting the road from storms.

(Turner Beach): Lee County owns Turner Beach Park, and associated improvements, and will benefit if sand from any pass dredging is placed on Turner Beach for recreation.

City of Sanibel
(Silver Key): The City of Sanibel owns most of Silver Key and upland and wetland habitat will benefit from this mix, suffering no further degradation. The result is increased habitat for birds and fish, complementary to the longstanding tradition of environmental protection and awareness constituting City of Sanibel philosophy.

West Coast Inland Navigation District - Creating a permanent, maintained Blind Pass channel will provide an emergency access for smaller boats exiting the Gulf of Mexico seeking shelter from storm events. Blind Pass also provides for an secondary access route to the Gulf of Mexico for smaller vessels, reducing some of the traffic impact in other areas such as Redfish Pass.

Tourist Development Council - Improvements to water quality via creation of a permanent opening at Blind Pass also results in a more varied use of the beaches and bridge. This creates additional recreation dollars from use of Turner Beach Park and Blind Pass bridge for fishing, boating, shelling, swimming, and other waterfront activities.

General Public
Wildlife: There will be benefits from restored habitat, enhanced habitat productivity, increased wildlife populations within a relatively undisturbed, protected area under government ownership.

Boating: Benefits accrue from improved navigation, significantly enhanced habitat, open sandy beach areas for recreation, alternative routes for sightseeing, and emergency shelter from storms.

Fishing: Benefits result from improved habitat via a restored tidal connection to a 200+ acre fishery.

Eco-tourism: Benefits are derived from improved wetland habitat, restored bird rookery, improved wildlife photography and observation opportunities.

XIV. PUBLIC PARTICIPATION

Stakeholders - One of the goals of the overall study is to provide sufficient information so that residents of Sanibel and Captiva are able to choose an acceptable alternative (or combination of alternatives). The Captiva Erosion Prevention District, the City of Sanibel, and Lee County are the governments for these communities and represent the interests of the community as well as being material owners or stewards of the lands associated with the project.

A "stakeholder" is a person, or group of people, materially impacted or affected by an issue. We have excluded the "outside" governments, including the state and federal regulatory agencies, from the stakeholder discussion because they do not have a material interest in the project and their concerns will be addressed during the design, permitting, and funding process.

For all of the alternatives, the details will be critical. The goals for communication will be to:

- Identify all of the stakeholders and assess the magnitude of individual impact.
- Provide accurate information to the stakeholders concerning the advantages and disadvantages of the various alternatives.
- Centralize communications input and address the concerns of the various stakeholders.
- Encourage their participation in the decision making process.

Regardless of which alternative is chosen, community initiative translates into political and permitting support, and is vital to project success. To be able to reach a consensus, clear information has to be delivered in a timely manner to the stakeholders, and subsequent feedback received. Education through information is essential to the success of the project.

Action Alternatives - The action alternatives have previously discussed in detail in <u>Section III - Restoration Alternatives</u>. Based on the various alternatives, the following is an assessment of the affected Stakeholders based on each alternative. Regarding the **Baseline Alternative: Do Nothing,** no public participation plan is needed if the "Do Nothing" alternative is chosen. Only the action alternatives are addressed below. These alternatives may be implemented individually, or in combination, depending on the final recommendations.

B. Flushing Connection direct to Gulf of Mexico: Restore Clam Bayou via direct connection to the Gulf of Mexico. In this alternative, and subsequent variations, the entrance to Clam Bayou would be permanently opened to the Gulf of Mexico, requiring some manner of stabilized pass design or mechanism to mitigate the coastal dynamics.

Stakeholders
City of Sanibel (representative government)
City of Sanibel and Lee County (property owners)
Clam Bayou Residents (property owners)
Sanibel-Captiva Environmental Community (environmental stewards, recreation)
Sanibel and Captiva Residents (storm protection, recreation, tourism)
Fishing Community (recreation)
Boating Community (recreation, navigation)
Beachgoers (recreation, shelling, swimming)

C. Connecting Clam Bayou to Dinkins Bayou via a flushing channel:
Restore Clam Bayou via a flushing connection between Clam Bayou and Dinkins Bayou. This plan is broken down into four alternatives. They include:
Alternative 1 - a flushing channel as a stand alone alternative.
Alternative 2 - flushing channel combined with an opening to the Gulf.
Alternative 5 - flushing channel with Blind Pass re-opened.
Alternative 6 - flushing channel with Blind Pass re-opened, and improvements to Dinkins Bayou entrance channel for flushing.

Stakeholders (**Alternative 1**)
City of Sanibel (representative government)
City of Sanibel and Lee County (property owners)
Clam Bayou and Dinkins Bayou residents (property owners)
Ding Darling Wildlife Refuge (environmental stewards)
Sanibel-Captiva environmental community (environmental stewards, recreation)
Residents of Sanibel and Captiva (storm protection, recreation, tourism)

Stakeholders (**Alternative 2**)
City of Sanibel (representative government)
City of Sanibel and Lee County (property owners)
Clam Bayou and Dinkins Bayou residents (property owners)
Ding Darling Wildlife Refuge (environmental stewards)
Sanibel-Captiva environmental community (environmental stewards, recreation)
Sanibel and Captiva Residents (storm protection, recreation, tourism)
Fishing Community (recreation)
Boating Community (recreation, navigation)
Beachgoers (recreation, shelling, swimming)

Stakeholders (**Alternative 5/6**)
CEPD, Lee County, City of Sanibel (representative government)
Lee County, City of Sanibel (property owners)
Wulfert Channel, Blind Pass, and Roosevelt Channel residents (property owners)
Clam Bayou and Dinkins Bayou residents (property owners)
Sanibel-Captiva Gulf front residents (property owners, storm protection)
Ding Darling Wildlife Refuge (environmental stewards)
Sanibel-Captiva Environmental Community (environmental stewards, recreation)

Residents of Sanibel and Captiva (storm protection, recreation, tourism)
Commercial Enterprise (property owners, recreation, tourism, navigation)
Lee County Environmental Community (habitat improvement, recreation)
Fishing Community (recreation)
Boating Community (recreation, navigation)
Beachgoers (recreation, shelling, swimming)
Enforcement (navigation, resource protection, safety)

Strategic Plan for Communications - The following are existing channels of communication that can be used to communicate the issues, educate the stakeholders, and receive feedback.

Media: Island Reporter/Captiva Current, Island Sun, Fort Myers News-Press - The purpose of the island media is to provide a general source of information to all the Stakeholders. They can also be a source of information for Stakeholders when they are not on the islands. The News-Press provides information important to county support.
The following are tasks associated with this objective.
- Initial briefings provided individually.
- Updates at significant milestones.
- Prepare timelines.
- Prepare media advisories.
- Manage media contacts.
- Prepare fact sheets (specific information on the project).
- Focus on photography, since we have a highly visual project.

Web site: The purpose of a Web site is to provide consistent, accurate information for the Stakeholders that are communications proactive, regardless of location. It can also be a resource for the news media to secure updates and new information. The following are tasks associated with this objective.

- Establish a Web site for the project.
- Place all information generally distributed on the Web site including press releases, fact sheets, timelines, and photography.
- Provide opportunities for feedback.

Individual meetings: The purpose of individual meetings is to begin the communication process with each of the Stakeholders via a key contact person for the group. The following are tasks associated with this objective.

- Establish a key contact for each of the Stakeholders (including e-mail addresses).
- Meet with key contacts and determine strategy for that particular stakeholder group.
- Meet with government officials individually.

- Provide key contacts with an information packet including timelines and fact sheets.

Small group meetings: The purpose of small group meetings is to provide a comfortable, informal setting for two-way communication and development of support for the project. Concerns can be addressed in such a way to avoid polarization and misinformation.

- Determine how the group is comprised and notify members.
- Provide information packets.
- Stage and conduct meetings.
- Begin to develop e-mail list for various groups.
- Provide opportunities for feedback.

Community meetings: The purpose of community meetings is to encourage community participation beyond the principal Stakeholders.

- Arrange locations.
- Stage and conduct meetings.
- Provide PowerPoint presentation.
- Prepare media advisories and press releases.
- Provide opportunities for feedback.

PowerPoint presentation: The purpose of a PowerPoint Presentation is to provide the community with a visual information resource that is consistent and understandable to the lay person.

E-mail Communications: The purpose of developing an e-mail group list is to be able to quickly communicate with the various Stakeholders on matters of particular concern.

XV. SUMMARY AND RECOMMENDATIONS

The results of the hydrodynamic modeling were useful in defining alternatives that provide the most relief to Clam Bayou and improve flushing in the Blind Pass Eco-zone.

Alternative 1, the flushing channel as a stand alone option, results in the most immediate improvement to reduced flooding from stormwater events but does not provide significant relief to flushing conditions within Clam Bayou. Even after a five day time frame, 80% of the mass concentration remains in the center of Clam Bayou, and Location 5 near the Bowmans Beach boardwalk shows very little change. When looking at its performance at Location 3, the headwaters of Dinkins Bayou, the mass concentration does not meet the state criteria. This indicates that an additional feature associated with the flushing channel is necessary to improve conditions in Clam Bayou.

When looking at the flushing channel in combination with re-opening Blind Pass (**Alternative 5b**), the mass transport from Clam Bayou is not significantly improved compared to simply installing the flushing channel (**Alternative 1b**). This is counterintuitive to reports from residents in the Dinkins Bayou area from when Blind Pass was open. Only with the improvements to the entrance to Dinkins Bayou from Wulfert Channel (**Alternative 6**) do we begin to see improvement to flushing in Clam Bayou. It appears that the constrictions at the entrance to Dinkins Bayou limit are a limiting factor regarding flushing and water quality in both Dinkins Bayou and Clam Bayou, with the flushing channel connection. In addition, based on the results of **Alternative 6**, additional model runs are necessary to assess the final flushing channel width, which may get the project closer to meeting the states preferred 3 to 4 day flushing period.

Alternative 2, the flushing channel connecting Dinkins Bayou and Clam Bayou, in combination with a connection to the Gulf of Mexico (Clam Pass) gives the best results, achieving a 10% mass concentration within 3 to 4 days at the headwaters of Dinkins Bayou, and performing even better within Clam Bayou. This is consistent with Chapter 40E F.A.C. - Basis of Review.

The residents of Sanibel will also need to consider the cost, vulnerability, and maintenance associated with coastal structure necessary to stabilize the pass. Hazard mitigation issues will also weigh heavily on whether this alternative should be pursued. This alternative is entirely within the jurisdiction of Sanibel, which limits the number benefiting stakeholders who might share the cost. It may be more beneficial to pursue collaboration with the CEPD and Lee County regarding a cost share to further evaluate and implement **Alternative 6,** which has a broader benefit and cost share base.

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