CITY OF SANIBEL

ISLAND WIDE BEACH MANAGEMENT PLAN

SANIBEL ISLAND WIDE BEACH MANAGEMENT PLAN

APRIL 1995

EXECUTIVE SUMMARY

The purpose of this Beach Management Plan is to compliment existing codes and regulations of the City of Sanibel in areas which relate to protecting and preserving the beach environment of Sanibel Island. This Plan was prepared in three phases: (1) Coastal Processes; (2) Natural Resources, Coastal Activities and Impacts, and Beach Access and Public Lands; and (3) Beach Management Goals and Objectives, and Management Strategies.

The first two phases provide technical and environmental information and serve as a basis for the formulation of management strategies under phase three. All three phases have been combined into one document. For convenience, sections prepared under phase three contain some restatement of content from sections prepared under earlier phases, with cross references provided for easy access to more detailed information.

Under the first phase the physical features of Sanibel's shoreline are identified, characterized, and evaluated, with respect to the natural processes that formed and continue to transform the beaches. Historic shoreline data, up-to-date information on the dynamics of Sanibel Island's beaches, and the application of numerical models of coastal processes were used in this study. This phase of the Beach Management Plan also quantifies specific erosion problems, evaluates alternative means that are available for dealing with erosion problems, and provides information about impacts that result from alteration of the littoral environment. The coastal processes phase makes up Section I of the Beach Management Plan Document, and provides a basis upon which to make technical decisions on management policies.

Phase two includes Natural Resources, Coastal Activities and Impacts, and Beach Access and Public Lands. This phase of the Plan examines the wildlife, habitat, and natural ecosystems of Sanibel Island, and quantifies impacts on these resources that result from various land uses and human activities that take place in Sanibel's beach environment. The results of phase two of the Management Plan are contained in Sections II, III, and IV of the Beach Management Plan Document, and provide information on the value of environmental preservation as a basis upon which to establish management policies which are compatible with the natural beach zone ecosystems.

Phase three draws upon the results of the two earlier phases in order to define beach management goals and objectives, and to establish management strategies to achieve those goals and objectives. This phase makes comparisons of the relative effectiveness of technical engineering alternatives, weighed against natural processes and environmental considerations, to delineate appropriate management strategies for Sanibel Island. Sections V and VI comprise phase three of the Beach Management Plan.

The 1976 Sanibel Report and the Comprehensive Land Use Plan, also originally adopted in 1976, identify six ecological zones which require separate management strategies. The six zones are; (1) Gulf Beach; (2) Gulf Beach Ridge; (3) Interior Wetland Basin; (4) Mid Island Ridge; (5) Mangroves, and; (6) Bay Beach. This Beach Management Plan was prepared in response to the needs initially defined in the Sanibel Report, with respect to the island's beach areas which include zones (1), (2), and (6) listed above, and to supplement and expand upon the provisions of the Comprehensive Land Use Plan consistent with present management goals and objectives of the City of Sanibel.

This beach management plan identifies problem areas and beach management needs. Current projects, policies, and programs impacting Sanibel's beaches environment are considered, and alternative means to address Sanibel's needs to protect coastal resources are presented. It provides cost comparisons for environmental and engineering alternatives, and discusses regulatory alternatives and funding options. Recommendations for effective long term beach management are included, with consideration for short term emergencies, relative costs, and environmental impacts.

Acknowledgements

This Beach Management Plan has been prepared under the direction of Gary A. Price, Sanibel City Manager. Preparation of the Plan was coordinated by Robert K. Loflin, Ph.D, City of Sanibel Natural Resources Director. This management plan document represents the results of a coordinated effort among City of Sanibel Staff from the Natural Resources Department, Planning Department, Attorney's Office, City Managers Office, and Public Works Department.

Public hearings were held by the City Council to review each phase of the Beach Management Plan, and direction by City Council from each of the hearings has been incorporated in this Beach Management Plan document.

Graphic Illustrations in Section II. Natural Resources, Section III. Coastal Activities and Impacts, and Section IV. Beach Access and Public Lands were prepared by Sandra Larsen. All photographs copyright Robert K. Loflin.

Humiston & Moore Engineers prepared sections of this plan under contract to the City of Sanibel, provided technical support on coastal engineering issues and alternative management strategies, and coordinated with City Staff in assembling the management plan document.

CITY OF SANIBEL

RESOLUTION NO. 95 - 111

A RESOLUTION APPROVING AND ADOPTING THE SANIBEL ISLAND-WIDE BEACH MANAGEMENT PLAN; AND PROVIDING AN EFFECTIVE DATE.

WHEREAS, Sanibel Island is ringed by miles of beautiful beaches providing a tremendous natural resource; and

WHEREAS, the City of Sanibel has sought to protect and conserve this resource by the development of an Island-Wide Beach Management Plan; and

WHEREAS, following two years of extensive research on coastal processes, engineering and environmental issues, the Beach Management Plan was presented to the public for review and comment at two public workshops before the Sanibel City Council; and

WHEREAS, changes and modifications to the Plan have been made as a result of those public hearings;

NOW, THEREFORE, BE IT RESOLVED by the City Council of the City of Sanibel, Lee County, Florida:

Section 1. The Sanibel Island-Wide Beach Management Plan, the original of which shall be kept on file in the office of the City Manager, is hereby approved and adopted.

Section 2. Effective Date.

This resolution shall take effect immediately upon adoption.

DULY PASSED AND ENACTED by the Council of the City of Sanibel, Lee County, Florida, this 16th day of May 1995.

AUTHENTICATION: Wallace M. Kain (signature)
Mayor

(signature)
City Clerk

APPROVED AS TO FORM: Robt D. Pritt (signature)
City Attorney

5/9/95
Date

Vote of Councilmembers:

Davison	aye
Janes	aye
Kain	aye
Miller	aye
Westall	aye

Date filed with City Clerk: MAY 19 1995

COASTAL PROCESSES

SANIBEL ISLAND WIDE BEACH MANAGEMENT PLAN

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I. COASTAL PROCESSES

The beaches of southwest Florida are composed of unconsolidated granular sand which constantly moves around in response to the forces of water waves and currents. The beach is in fact so dynamic that it has been referred to as a "river of sand". There are many factors, both natural and man-made, which influence the manner in which this sand movement occurs. A complete understanding of this is necessary for the proper management of beaches as a natural resource. The purpose of this section of the Island Wide Beach Management Plan is to present a summary of the coastal processes, how those processes have effected the islands beaches, what has been done to counteract erosion, and what alternatives are available for dealing with these littoral processes. This Coastal Processes Section, along with the Natural Resources Section, will provide information to be used to formulate management polices and guidelines under Sections V and VI of this Beach Management Plan.

A. Causes of Erosion.

1. Natural Processes.

1.1 Wave Induced Transport.

The primary means by which sand moves along the coast is by the action of wind generated waves. This occurs when the impact and turbulence generated by each breaking wave puts sand in suspension. Due to the fact that waves usually approach the beach at an angle, a longshore current is generated which transports the suspended sand grains a short distance before the grains have time to settle back to the bottom. The manner in which this occurs is graphically illustrated in Figure I-1. The uprush and backwash of water on the sloping beach face, as well as other currents that may be present due to tides, waves, and wind forces can be strong enough to entrain grains of sand from the beach and nearshore bottom surface and carry them along in slightly different transport process known as saltation.

Figure I-2 illustrates the shape of a typical beach profile, and the distribution of sand transport across the littoral zone. The distribution of transport shown in Figure I-2 is general for descriptive purposes. Experiments by Kraus (1987) have shown the actual shape of the distribution curve to be dependent upon wave characteristics and profile shape. The distribution curve may exhibit two peaks as shown in Figure I-2, it may have only one peak, or it may be nearly flat during times when the distribution of transport is relatively uniform across the surf zone.

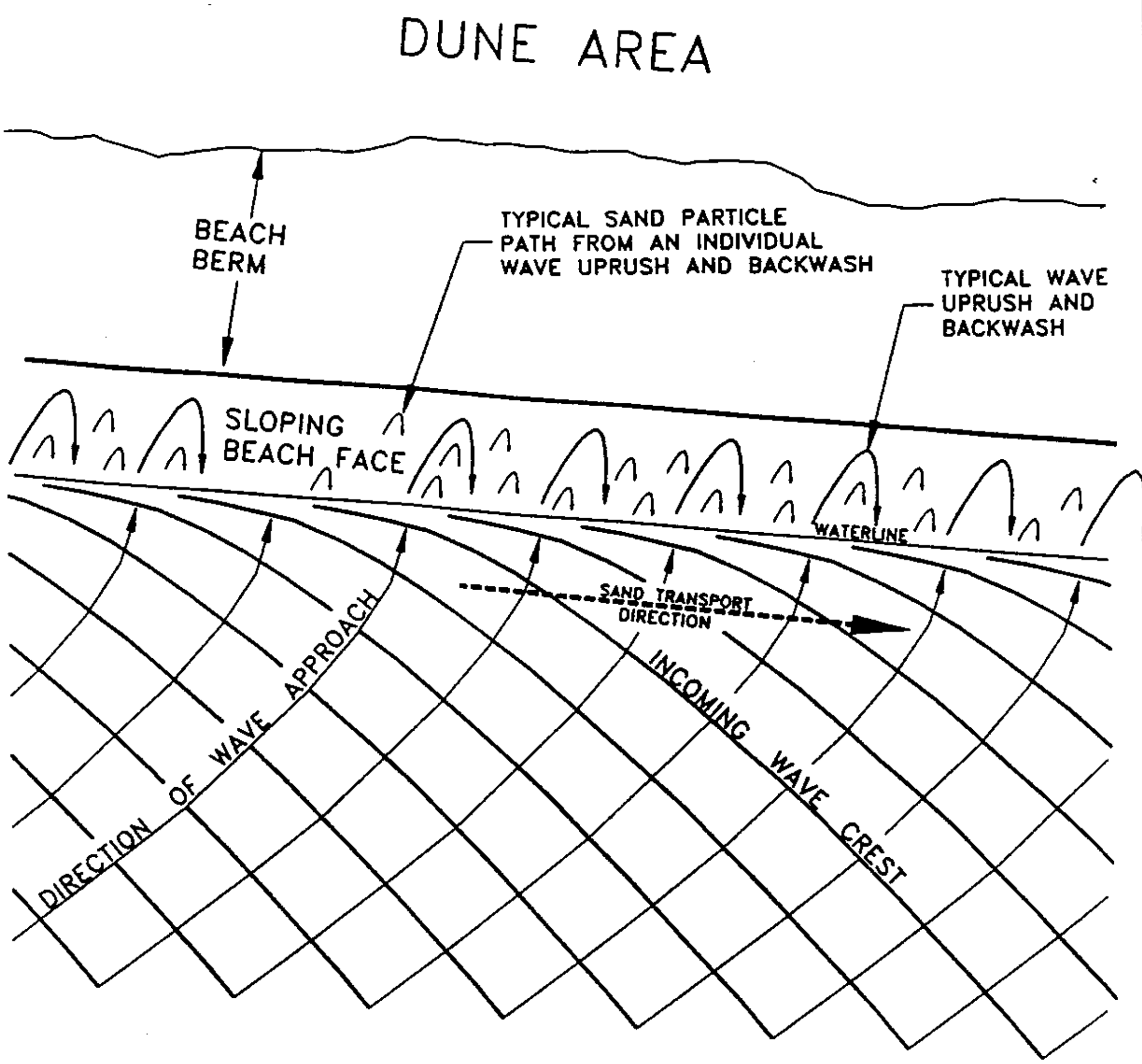


FIGURE I-1

LITTORAL TRANSPORT ILLUSTRATION
FROM PARTIALLY REFRACTED INCOMING WAVES

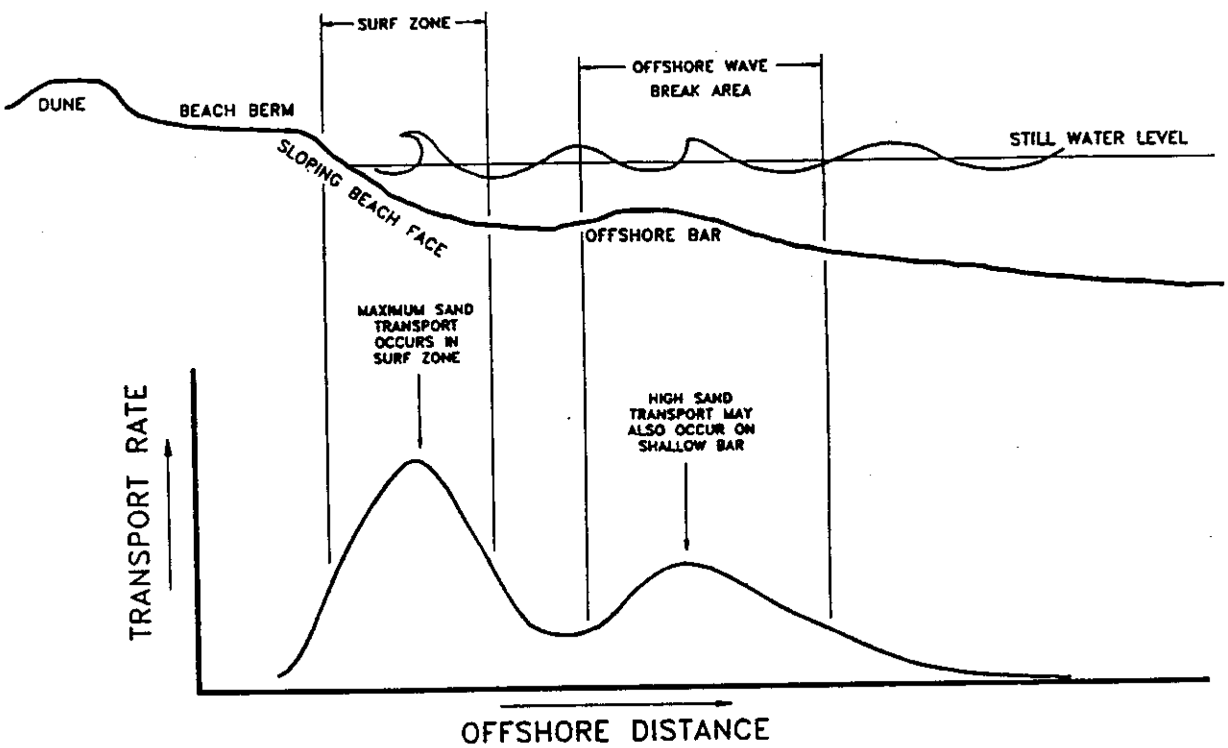


FIGURE I-2

TYPICAL BEACH PROFILE (TOP) AND CORRESPONDING DISTRIBUTION OF SAND TRANSPORT AS A FUNCTION OF OFFSHORE DISTANCE

Wave action is responsible for the shape of the profile shown in Figure I-2, as the result of an onshore-offshore element of sand transport. Steep waves associated with storms and general winter wave climate tend to move sand offshore, which results in a narrower beach and a prominent offshore bar. More gentle waves typical of summer months move sand toward shore.

The cumulative effect of perpetual wave action can result in transport of large quantities of sand. Sand transported in this manner is known as littoral drift. The actual quantity of littoral drift transported in a given period of time may vary considerably due to variations in wave energy and direction.

When these forces distribute littoral drift in a way that results in a net loss of material in a particular area, it is known as erosion. Conversely, when there is a net gain in material, it is known as accretion. Complex interactions between many factors result in erosion and accretion patterns which may range from highly variable and unpredictable, to more predictable patterns which may persist for long periods of time. Some of the factors which influence sand transport are: weather; physical characteristics of the sand grains; geographic features which may refract and diffract wave energy, such as offshore contours, shoals, shoreline orientation, and inlets; and man-made coastal structures.

1.2 Long Term and Short Term Trends.

As described in the Corps of Engineers Beach Erosion Control Study of Lee County (1969), Sanibel and the other Lee County barrier islands are post-Pleistocene deposits related to the present emerging shoreline. According to Missimer (1973), a prograding sand spit grew over a 5,000 year period to become Sanibel Island. Over shorter time intervals within that 5,000 year period the process was irregular, with alternating periods of erosion and accretion, or one area eroding while at the same time another was accreting. Evidence for this irregular process can be seen in the beach ridge patterns in Figure I-3, which was prepared from a 1944 aerial photograph taken before development obscured much of the vegetative definition of relic beach ridge and swale patterns.

Seasonal changes in beach width make determination of long term erosion rates difficult if the available data represents only a short period of time. Seasonal fluctuations in the beach profile are illustrated in Figure I-4. These seasonal changes alter the position of the water line and may obscure the effects of long term erosion to the casual observer, unless there is a landmark, such as a coastal structure or a building, by which to compare changes in shoreline position from one year to the next. The most accurate way to quantify erosion rates is with survey data tied in to common survey control points from one survey to the next. The Florida Department of Environmental Protection (DEP), Coastal Construction

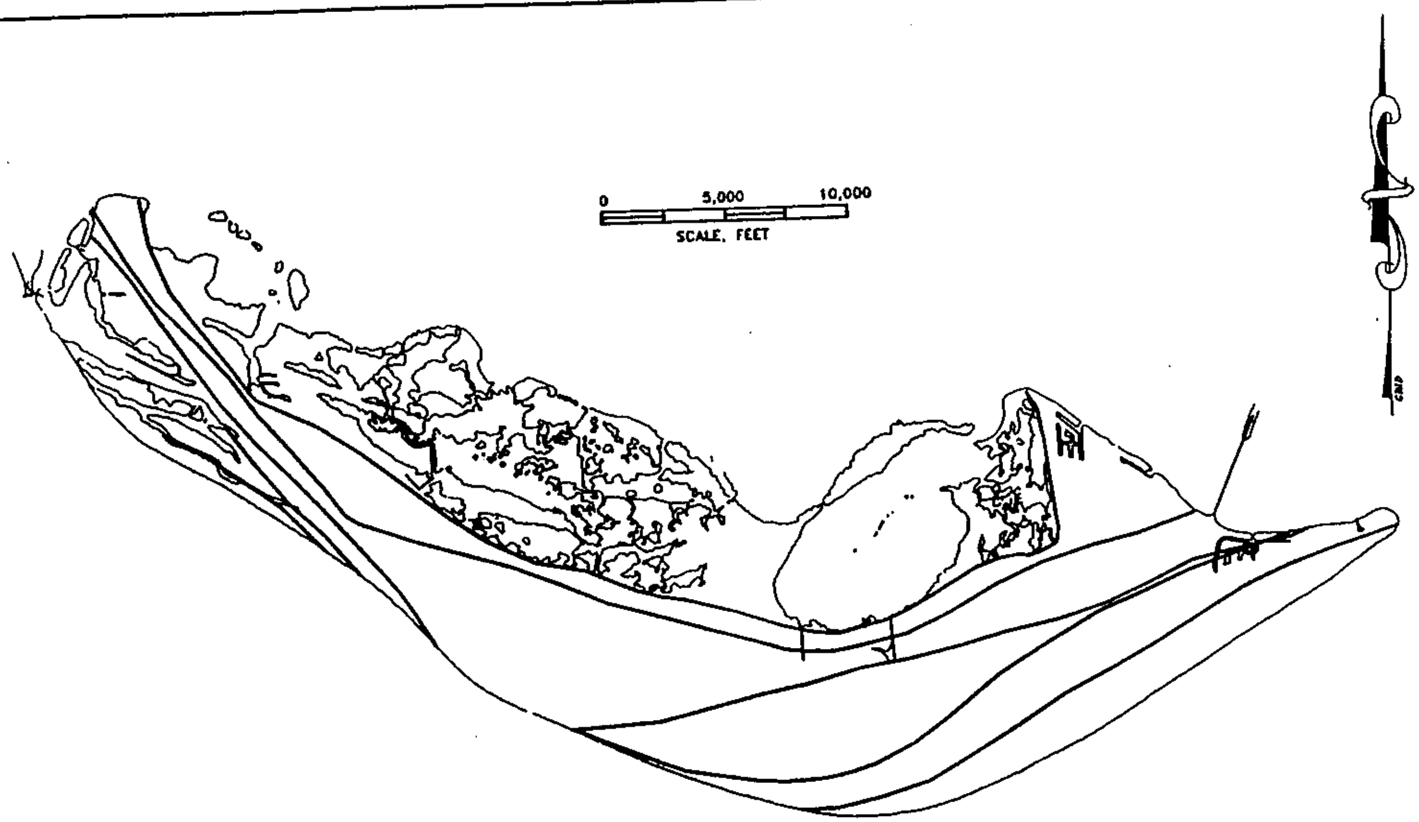


FIGURE I-3

BEACH RIDGE PATTERNS
FROM 1944 AERIAL PHOTOGRAPHY

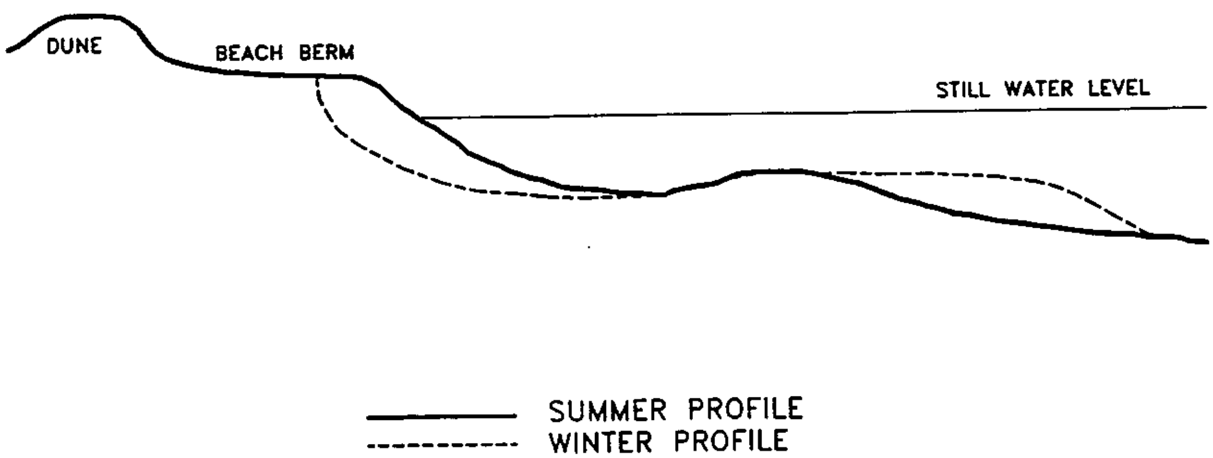


FIGURE I-4

TYPICAL SEASONAL BEACH PROFILE ILLUSTRATING OFFSHORE MOVEMENT OF SAND DURING WINTER MONTHS, RESULTING IN A NARROW BERM, STEEP BEACH FACE SLOPE, AND MORE PROMINENT OFFSHORE BAR.

control Line program has established a system of concrete monuments along the coast of Florida which serves as common control for most coastal monitoring programs today.

Early sources of information are maps and charts prepared by the United States Coast & Geodetic Survey (U.S.C.& G.S.), the United States Geological Survey (U.S.G.S.), and aerial photographs. More recent information is available in surveys performed by the Florida Department of Environmental Protection. There are also surveys of specific areas which have been done by the City of Sanibel and the Captiva Erosion Prevention District (CEPD).

1.3 Seasonal Trends.

Littoral transport is primarily due to the action of waves. Summer months along the southwest coast of Florida are normally characterized by waves out of the southwest which typically contain less energy, and therefore have less sand transport potential, than the steeper winter waves which are predominantly out of the northwest. Consequently, in many areas sand transport during the summer months is predominantly from south to north. During winter months, however, it is from north to south, at a relatively higher rate. The result is a net transport, on an annual basis, from north to south.

These seasonal trends are normally expressed in terms of statistical averages, which include a component for reversals in the direction of transport as the result of storms during any time of year. The relatively higher wave energy which occurs during the winter months is well documented. Seasonal changes in wave climate also cause characteristic changes in the shape of the beach. Winter waves are steeper and higher than gentler summer waves. The stormy winter waves take sand from the beach face and beach berm and move it offshore onto shore parallel sand bars, leaving a steep and narrow beach. This beach shape is called the "winter profile". During the summer months the lower energy waves transport sand from the offshore bars back to the beach. This reduces the size of the offshore bar, increases beach width, and results in the "summer profile". A typical beach profile with seasonal variations is shown in Figure I-4.

2. Tidal Inlets.

2.1 Natural Inlets.

Tidal inlets have significant affects on littoral transport for adjacent beaches. This is due to the way tidal currents entering and exiting an inlet affect the transport distribution of littoral drift.

In the throat of the inlet, tidal currents are very swift and predominate over wave induced longshore transport. Consequently, sand which reaches an inlet through the longshore transport process may be carried offshore by ebb tidal currents, or carried into the inlet by flood tidal currents. In either case, as the tidal current velocities decrease with distance from the throat of the inlet, the sand is deposited in formations which are referred to as flood tidal delta shoals inside the inlet, or ebb tidal delta shoals outside the inlet. In this manner inlets act as sand sinks, in that they trap sand and effectively remove it from the littoral supply to adjacent beaches.

As ebb tidal shoal growth progresses further offshore, beyond the limits of strong tidal currents, sand deposited in shallow areas on those shoals again becomes subject to being transported predominantly due to wave action. When enough sand accumulates in an ebb tidal shoal for this to occur, it represents what is commonly called an "equilibrium condition" in that the offshore movement of sand due to tidal currents is essentially balanced by the onshore and longshore movement of sand due to wave action.

Theoretically, under ideal circumstances, once a condition of equilibrium is achieved, the tidal shoal should not accumulate any additional sand. However, the natural variability of littoral transport results in conditions which are far from ideal. It should therefore be understood that equilibrium in the sense used here does not mean a precise steady state condition. This is because the supply of sand to the inlet through littoral transport is weather dependent and variable from season to season and year to year. Furthermore, tides vary substantially between spring and neap tide on a monthly basis, and also exhibit significant seasonal and annual variations. The complexity of the situation is enhanced by the interrelationship between these various factors:

1. A change in sand transport rates on adjacent beaches will change the sand supply to the inlet.

2. A change in the sand supply to the inlet will result in a change in shoal geometry.

3. Alteration of the shoal geometry will result in alteration of wave refraction and diffraction patterns.

4. The modified refraction and diffraction patterns in turn effect the wave energy incident upon the adjacent beaches.

5. The wave energy incident on adjacent beaches is responsible for sand transport rates, as described in step 1.

This complex and weather dependent interaction is the reason inlet shoals are dynamic. In some situations, a small induced change may alter dynamics and bring about other more dramatic changes. Within certain limits, however, the amount of sand stored in the ebb tidal shoal at "equilibrium" is a function of the size of the inlet. The size of the inlet is determined by the volume of water which flows in or out of the inlet over a tidal cycle during a spring tide. This volume of water is known as the tidal prism.

2.2 "Improved" Inlets.

Many tidal inlets have been altered by man through dredging and jetty construction. These alterations to the natural system are referred to as "inlet improvements" because jetties are primarily constructed to aid in the maintenance of navigation projects by preventing sand from entering and forming shoals in dredged navigation channels. These structures are sometimes constructed for the related purpose of retaining sand on adjacent beaches.

Jetties alter the sand supply to the inlet, they alter wave energy reaching the inlet, and they change the inlet geometry which alters the tidal current velocity distribution. These alterations effect the adjacent beaches in several ways:

1. The flow of sand to the inlet may be reduced, which will reduce the amount of sand available for natural sand bypass of the inlet across tidal shoals. This may result in increased erosion stress on the down drift beach. Along the southwest coast of Florida, in most cases, the downdrift beach is on the south side of the inlet.

2. The equilibrium position of the ebb tidal shoal will generally be moved further offshore because the jetties confine tidal flow which will extend high current velocities further offshore. This will carry sand into deeper water where wave induced sand transport is less effective, and more of the sand will therefore be trapped. This process will continue until the shoal growth results in depths shallow enough that wave induced transport is reestablished at former levels, at which time it may be said that a new equilibrium condition has been established.

   A reduction in sand supply to the inlet will also alter the natural channel geometry. This is because a lower sand supply will result in a lower tidal current bottom shear stress necessary to keep sand scoured out of the inlet (van de Kreeke, 1984). This may result in an enlargement of the inlet, which could contribute to additional shoal growth.

3. The structures and evolving shoal configuration will result in new wave refraction and diffraction patterns which will further modify wave energy incident upon adjacent beaches.

Given the complexity of the littoral system briefly described above, it is easy to see how structural modification of an inlet may bring about unexpected and dramatic changes in what is an inherently dynamic system.

3. Coastal Structures.

Hardened shorelines fall into two categories; shore protection, and erosion control. Additional discussion about structures may be found under Section I.B.3.

3.1 Shore Protection Structures.

Shore protection structures are designed to protect uplands in eroding areas to prevent further loss of land. Seawalls, bulkheads, and revetments are examples of shore protection structures. By hardening the shoreline with these structures, the sand and soil on the upland side is retained in place because it is protected from erosive wave forces.

Shore protection structures are intended to prevent the loss of additional land, usually to protect an upland feature or building from being undermined. These structures do not, however, stop erosion. Littoral transport due to wave energy continues to occur in front of the structure, and wave reflection off of vertical seawalls and bulkheads causes localized scour and may actually increase sand transport rates and exacerbate erosion. Furthermore, sand that is retained by the structure would otherwise have been part of the sand supply to the littoral transport system. A reduction in this natural supply of sand can result in adverse effects to adjacent sections of the shoreline. Moreover, shore protection structures that generate these effects without addressing the cause of the erosion may eventually be destroyed by that erosion.

3.2 Erosion Control Structures.

Erosion control structures are designed to actually reduce erosion by modifying the sand transport processes. Two examples of this are groins and breakwaters.

Breakwaters are located offshore and are designed to absorb a portion of the incoming wave energy. This results in less wave energy available for transporting sand along the beach. Reducing the wave induced transport in the lee of the breakwater, when the rate of transport into the area remains unchanged, will result in sand accumulation and a wider beach.

Groins also absorb some wave energy, but are primarily intended to be a barrier to the longshore movement of sand in the littoral zone. Trapping sand in this manner results in a wider beach on the updrift side of the structure.

The drawback to erosion control structures is that although they may effectively reduce erosion in one area, they do so by trapping sand from the natural littoral system. Sand trapping results in a reduction in sand supply to the downdrift beaches. If not properly designed, a groin field may also alter sand transport as depicted in Figure I-5, which may result in an offshore movement of sand and further contribute to downdrift erosion.

Both shore protection structures and erosion control structures can provide the benefits for which they are designed. However, both also have the potential for transferring the erosion problem to another location. Adverse downdrift impacts of erosion control structures are sometimes compensated for with beach nourishment. A groin, for example, may be filled to design capacity on the updrift side so that no net accumulation of sand from the natural system will occur. The reasoning here is that if there is no net accumulation, and transport rates remain unchanged, there should be no adverse downdrift impacts. This must be considered in the design of each structure, because downdrift impacts may also result from shifting the transport zone to a more offshore location dependent upon the length of the groin, or by reorientation of the updrift shoreline which could alter littoral transport potential.

4. Storm Effects.

Storms generate large waves that may be accompanied by tides that exceed normal tide ranges. Large storm waves also have a relatively short wave length, which means that they are typically steeper than normal. An abnormally high tide associated with a storm is referred to as a storm surge. This combination of large steep waves superimposed on top of a storm surge can dramatically affect sandy shorelines.

Hurricanes, and to a lesser extent other tropical storms and subtropical storms, may generate storm surges of varying magnitude, dependent upon certain conditions. Storm surge is primarily due to the effects of wind over water, which induces water currents that move in the same direction as the wind. If the wind direction is toward land, the wind induced flow of water toward land results in higher than normal tides. This effect is more pronounced where natural gravity flow away from the vicinity of the surge may be restricted by landforms or shallow water depths. Consequently, areas with a shallow nearshore shelf and shallow bay areas are most likely to experience the highest storm surges. The opposite occurs with an offshore wind which may cause unusually low water elevations.

Other factors which contribute to storm surge are: wave induced setup, low barometric pressure, and the size and speed at which the storm is traveling. The latter will influence the amount of time other factors may have during which to make their contribution to building the storm surge.

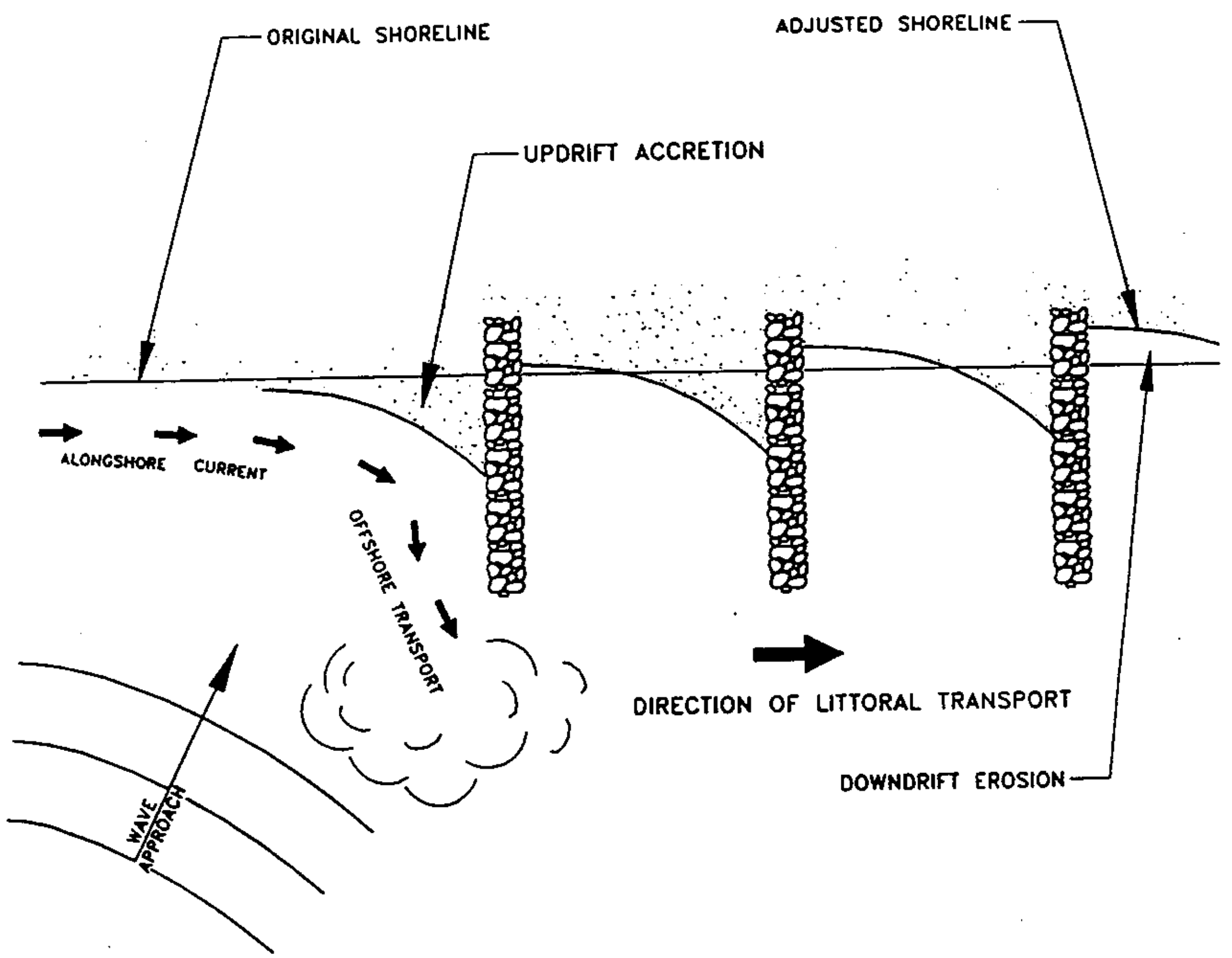


FIGURE I–5

SHORELINE RESPONSE TO A GROIN FIELD

Large and steep storm waves remove sand from the beach and deposit it on offshore bars. This creates a profile which is similar to the profile created by winter seasonal waves, as discussed in the Section on Seasonal Trends. As with the seasonal waves, the result of storms may be a loss of dry beach which is not necessarily indicative of a volumetric loss of sand. The eroded beach usually experiences some degree of recovery when sand which moved offshore during the storm episode eventually returns to the beach in response to normal wave conditions. Low frequency storms such as severe hurricanes may carry sand offshore beyond the seasonal bar, or, depending on the surge elevation relative to the upland beach dune, material may be deposited on or behind the dune area. Under these extreme circumstances, not all material lost from the beach during a storm will work its way back during the subsequent recovery period.

Due to the fact that storms are of short duration and relatively infrequent, compared to the constant effects of normal littoral drift, in many cases large scale changes to the shoreline are due to normal littoral processes rather than storms. This contradicts the often heard argument that beach nourishment is a waste of time because the first storm will take it away. The fact of the matter is that if a beach fill project is constructed with compatible sand, it will respond to storm waves in a manner similar to the natural beach, and most storms are of short enough duration that they normally redistribute the sand locally while only a small portion may be carried away to cause permanent loss.

There are other situations where storms cause permanent changes in the littoral system and affect long term shoreline trends. For example, one such situation occurs predominantly as the result of storm surge in locations where the coast is made up of barrier islands separated from the mainland by bays and estuaries. The elevated tides associated with storms may overtop the barrier islands, and strong currents resulting from water rushing over the island into the bay may scour troughs across the barrier, and those troughs may turn into new inlets. The action of new inlets forming as the result of storm surge also occurs when the surge recedes, with scour caused by strong ebb currents returning to the ocean, or Gulf of Mexico. Low and narrow sections of barrier islands which are vulnerable to breakthrough may become more vulnerable if imprudent coastal construction causes acceleration of erosion during storms.

The manner in which inlets affect adjacent beaches was discussed in the previous section. If a storm causes a new inlet to form, it can result in continuing influence on the local littoral system and much greater effects than the immediate and direct effects of the storm.

4.1 Hurricane History.

Table I-1 shows a history of hurricanes and tropical storms which have passed within 75 miles of Sanibel Island. This table was made from data contained in the National Oceanic and Atmospheric Administration's Historical Climatological Series 6-2, "Tropical Cyclones of the North Atlantic Ocean, 1971-1986" , plus supplemental hurricane charts for the years 1987-1992 published by the National Hurricane Center.

Table I-1 lists storms categorized as either hurricanes or tropical storms. To further categorize storms of hurricane intensity, and to relate hurricane intensity to damage potential, the National Hurricane Center has adopted the Safir/Simpson Hurricane Scale, which is provided below.

Safir/Simpson Hurricane Scale

Scale No. 1- Winds of 74 to 95 miles per hour. Damage primarily to shrubbery, trees, foliage, and unanchored mobile homes. No real damage to other structures. Some damage to poorly constructed signs. And/or: storm surge 4 to 5 feet above normal. Low-lying coastal reads inundated, minor damage, some small craft in exposed anchorage torn from moorings.

Scale No. 2- Winds of 96 to 110 miles per hour. Considerable damage to shrubbery and tree foliage: some trees blown down. Major damage to exposed mobile homes. Extensive damage to poorly constructed signs. Some damage to roofing materials of buildings: some window and door damage. No major damage to buildings. And/or: storm surge 6 to 8 feet above normal. Coastal roads and low lying escape routes inland cut by rising water 2 to 4 hours before arrival of hurricane center Considerable damage to piers. Marinas flooded. Small craft in unprotected anchorages torn from moorings. Evacuation of some shoreline residences and low lying island areas required.

Scale No. 3- Winds of 111 to 130 miles per hour. Foliage torn from trees: large trees blown down. Practically all poorly constructed signs blown down. Some damage to roofing materials of buildings: some window and door damage. Some structural damage to small buildings. Mobile homes destroyed. And/or: storm surge 9 to 12 feet above normal. Serious flooding at coast and many smaller structures near coast destroyed: larger structures near coast damaged by battering waves and floating debris. Low-lying escape routes inland cut by rising water 3 to 5 hours before hurricane center arrives. Flat terrain 5 feet or less above sea level flooded inland 8 miles or more. Evacuation of low lying residences within several blocks of shoreline possibly required.

Scale No. 4- Winds of 131 to 155 miles per hour. Shrubs and trees blown down: all signs down. Extensive damage to roofing materials, windows and doors. Complete failure of roofs on many small residences. Complete destruction of mobile homes. And/or: storm surge 13 to 18 feet above normal. Flat terrain 10 feet or less above sea level flooded inland as far as 6 miles. Major damage to lower floors of structures near shore due to flooding and battering by waves and floating debris. Low lying escape routes inland cut by rising water 3 to 5 hours before hurricane center arrives. Major erosion of beaches. Massive evacuation of all residences within 500 yards of shore possibly required, and of single story residences on low ground within 2 miles of shore.

Scale No. 5- Winds greater than 155 miles per hour. Shrubs and trees blown down: considerable damage to roofs of buildings; all signs down. Very severe and extensive damage to windows and doors. Complete failure of roofs on many residences and industrial buildings. Extensive shattering of glass in windows and doors. Some complete building failures. Small buildings overturned or blown away. Complete destruction of mobile homes. And/or: storm surge greater than 18 feet above normal. Major damage to lower floors of all structures less that 15 feet above sea level within 500 yards of shore. Low-lying escape routes inland cut by rising water 3 to 5 hours before hurricane center arrives. Massive evacuation of residential areas on low ground within 5 to 10 miles of shore possibly required.

4.2 Storm Probability.

Table I-1 shows the dates of hurricanes and other tropical storms that did not reach hurricane strength. There have been 25 hurricanes that passed within 75 miles of Sanibel Island during a 117 year period. This averages out to one hurricane every 4.7 years. There were an additional 28 tropical storms that did not

YEAR	HURRICANES DATE	HURRICANES NAME	TROPICAL STORMS DATE	TROPICAL STORMS NAME
1876	9/19			
1877				
1878	7/2			
1879				
1880				
1881	8/17			
1882				
1883				
1884				
1885	10/10			
1886				
1887			10/29	
1888			9/8	
1889				
1890				
1891	8/24		10/9	
1892			6/10	
1893				
1894	9/25			
1895			10/16	
1896	10/8			
1897			9/20	
1897			10/19	
1898			10/10	
1899				
1900				
1901				
1902				
1903			9/12	
1904				
1905				
1906				
1907				
1908				
1909			9/26	
1910	10/17			
1911	8/9			
1912				
1913				
1914				

YEAR	HURRICANES DATE	HURRICANES NAME	TROPICAL STORMS DATE	TROPICAL STORMS NAME
1915				
1916				
1917				
1918				
1919				
1920				
1921				
1922				
1923				
1924	10/20			
1925	11/30			
1926	9/18			
1927				
1928			8/13	
1929	9/29			
1930				
1931				
1932			8/30	
1933				
1934			5/27	
1935	9/3			
1936			6/14	
1936			7/29	
1937				
1938				
1939				
1940				
1941	10/6			
1942				
1943				
1944	10/18			
1945			9/6	
1946	10/7			
1947	9/17			
1948	9/21			
1949				
1950	9/3	EASY		
1951			10/1	HOW
1952				
1953			8/29	

YEAR	HURRICANES DATE	HURRICANES NAME	TROPICAL STORMS DATE	TROPICAL STORMS NAME
1953			10/9	HAZEL
1954				
1955				
1956				
1957				
1958				
1959			10/18	JUDITH
1960	9/10	DONNA		
1961				
1962				
1963				
1964	10/14	ISABEL		
1965	9/8	BETSEY		
1966	6/8	ALMA		
1967				
1968			6/4	ABBY
1969			10/2	JENNY
1970				
1971				
1972				
1973				
1974				
1975				
1976				
1977				
1978				
1979				
1980				
1981			8/17	DENNIS
1982			6/6	ALBERTO
1983			8/25	BARRY
1984				
1985			7/23	BOB
1986				
1987				
1988			11/22	KEITH
1989				
1990			10/11	MARCO
1991				
1992	8/24	ANDREW		

SEE APPENDIX A FOR STORM TRACK MAPS

TABLE I-1

HISTORY OF HURRICANES PASSING WITHIN 75 MILES OF SANIBEL ISLAND
INCLUDING DATE OF HURRICANE OR TROPICAL STORM
(FROM NOAA HISTORICAL CLIMATOLOGICAL SERIES 6-2 AND SUPPLEMENTAL INFORMATION)

reach hurricane strength, for a total of 48 tropical storms, including the 25 hurricanes. Including the tropical storms that did not reach hurricane strength, there was an average of one storm every 2.3 years.

Table I-1 provides the information from which we can derive storm probability, in terms of an average return interval, as summarized below in Table I-2.

1876 to 1992	Number of Storms	Return Interval
Hurricanes	24	4.8
Other Tropical Storms	28	4.1
Both	52	2.2

TABLE I-2

STORM PROBABILITY

Table I-1 also shows that storm probability is highly variable for shorter time periods within the 115 years of record. For example, during the ten year period from 1941 through 1950 there were 6 hurricanes and one tropical storm for an average of one storm every 1.4 years.

Table I-2 illustrates storm probability by simple averaging. Figures I-6, I-7, and I-8 illustrate that the frequency of storm occurrence has been highly variable during shorter intervals within the period of record. These figures show that storms occur most frequently within a few years of another storm, often in the same or consecutive years. The tall bar on the left in Figure I-6 shows that there were seven times when hurricanes occurred in consecutive years. Figure I-7 illustrates that there were three occasions where more than one tropical storm (of less than hurricane strength) occurred in the same year. Figure I-8 illustrates that when all tropical storms including hurricanes are considered together, there were four occasions when more than one storm occurred in one year, and twenty four occasions when storms occurred in two consecutive years. Figure I-9 is a graphic representation of the information in Table I-1, a history of hurricanes and tropical storms which passed within 75 miles of Sanibel Island.

Prior to Hurricane Andrew in 1992, the last time a hurricane passed within 75 miles of Sanibel Island was in 1966. The preceding

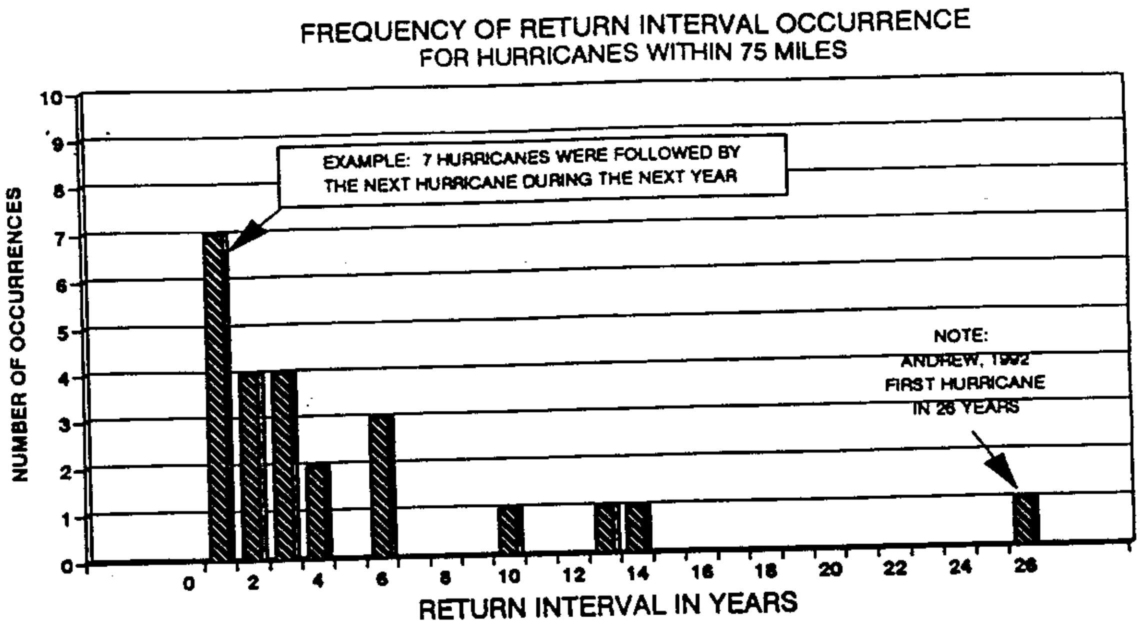


FIGURE I-6

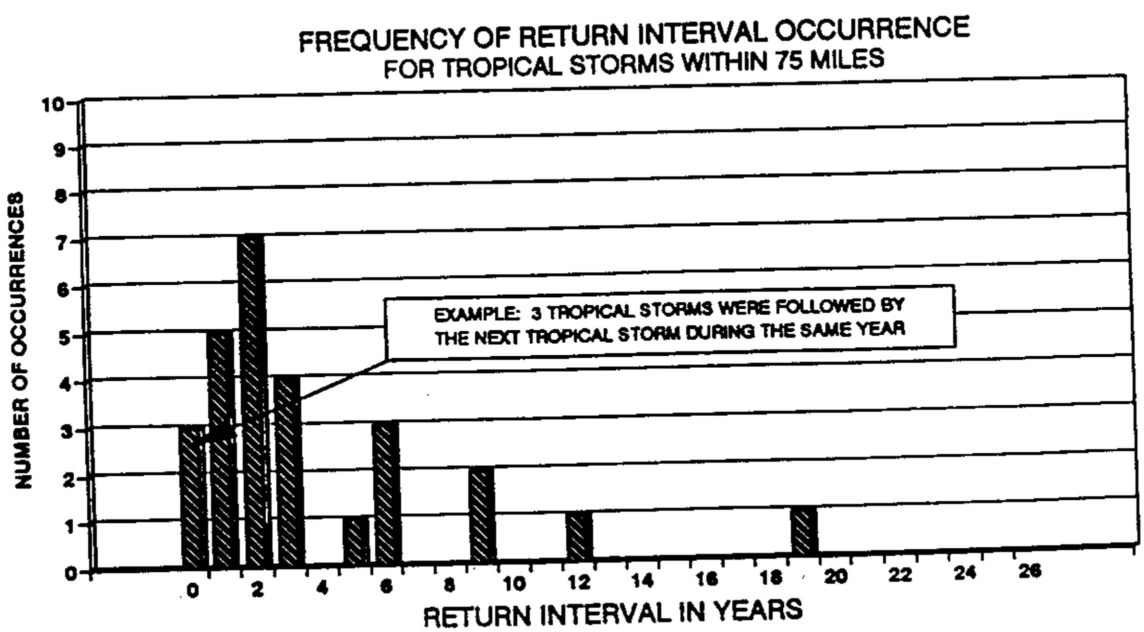


FIGURE I-7

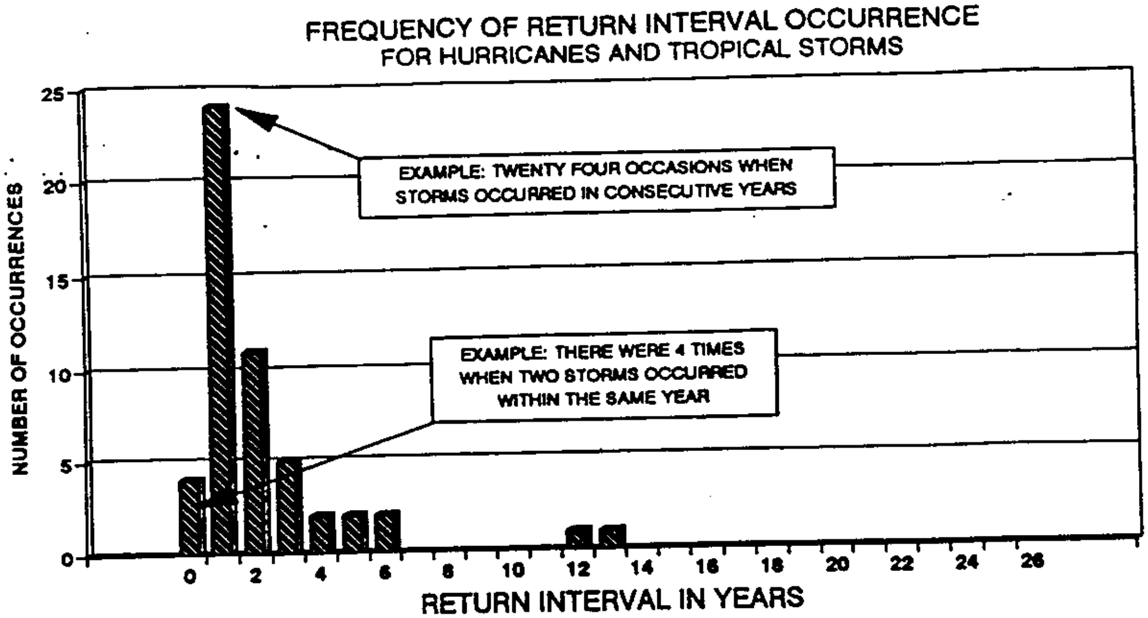


FIGURE I-8

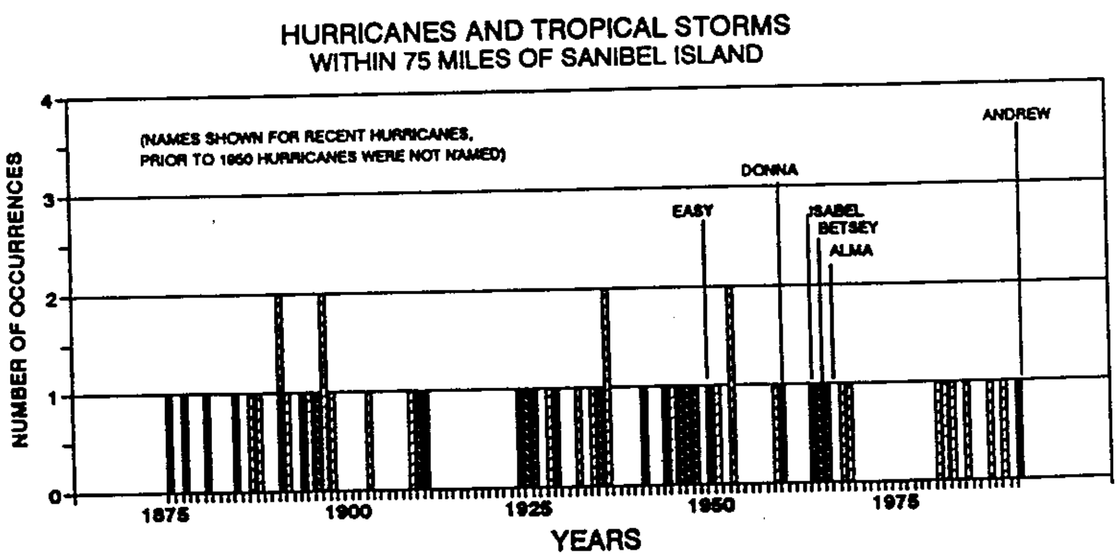


FIGURE I-9

discussion illustrates that this period of 26 years is by far the longest period of time without a hurricane in this 115 year historical record.

4.3 Storm Tides.

Storm tides are discussed in the City of Sanibel Comprehensive Land Use Plan with respect to the safety issues of hurricane evacuation and immediate post storm response. The Comprehensive Plan uses the National Oceanic and Atmospheric Administration (NOAA) SLOSH (Sea, Lake, and Overland Surge from Hurricanes) model to compute the effects of three hypothetical hurricanes. The three cases are representative of realistic scenarios for a direct hit by a severe storm, and they are used for establishing criteria for; hurricane preparedness; evacuation; and post hurricane relief and disaster management.

As demonstrated by the SLOSH model in the City Comprehensive Plan, the direction of approach and forward speed of a hurricane strongly influence the magnitude of the storm surge. From a beach management standpoint, it is more appropriate to look at hurricanes in terms of the return interval for various storm surge elevations, in order to select an appropriate design condition for predicting storm erosion. These predictions may be used in: planning; assessment of development requests; integrity of evacuation routes; and in feasibility and design of erosion control and shore protection projects.

The standard for storm surge elevation probability in Florida is provided by the Florida Department of Environmental Protection, Bureau of Beaches and Coastal Systems, in the form of storm surge model studies for the Florida's coastal counties. The Lee County Storm Surge Model Study, "Combined Total Storm Tide Frequency Analysis for Lee County, Florida", was prepared by the Beaches and Shores Resource Center Institute of Science and Public Affairs, Florida State University, in July 1990. This document contains a storm surge probability curve for five profiles at five locations in Lee County. Figure I-10 shows the location of the five profiles, of which profiles No. 3 and No. 4 provide the storm surge probability for Sanibel Island illustrated in Figure I-11 and Figure I-12.

5. Sea Level Rise.

Recently there has been increased concern over sea level rise with regard to theories about global warming, and how that may increase sea level rise by causing a melting of the polar ice caps.

Sea level rise is made up of a local component and a eustatic component. Local sea level rise is due to land subsidence (conversely, local sea level lowering is due to land emergence). Eustatic sea level rise is the global change that may result from

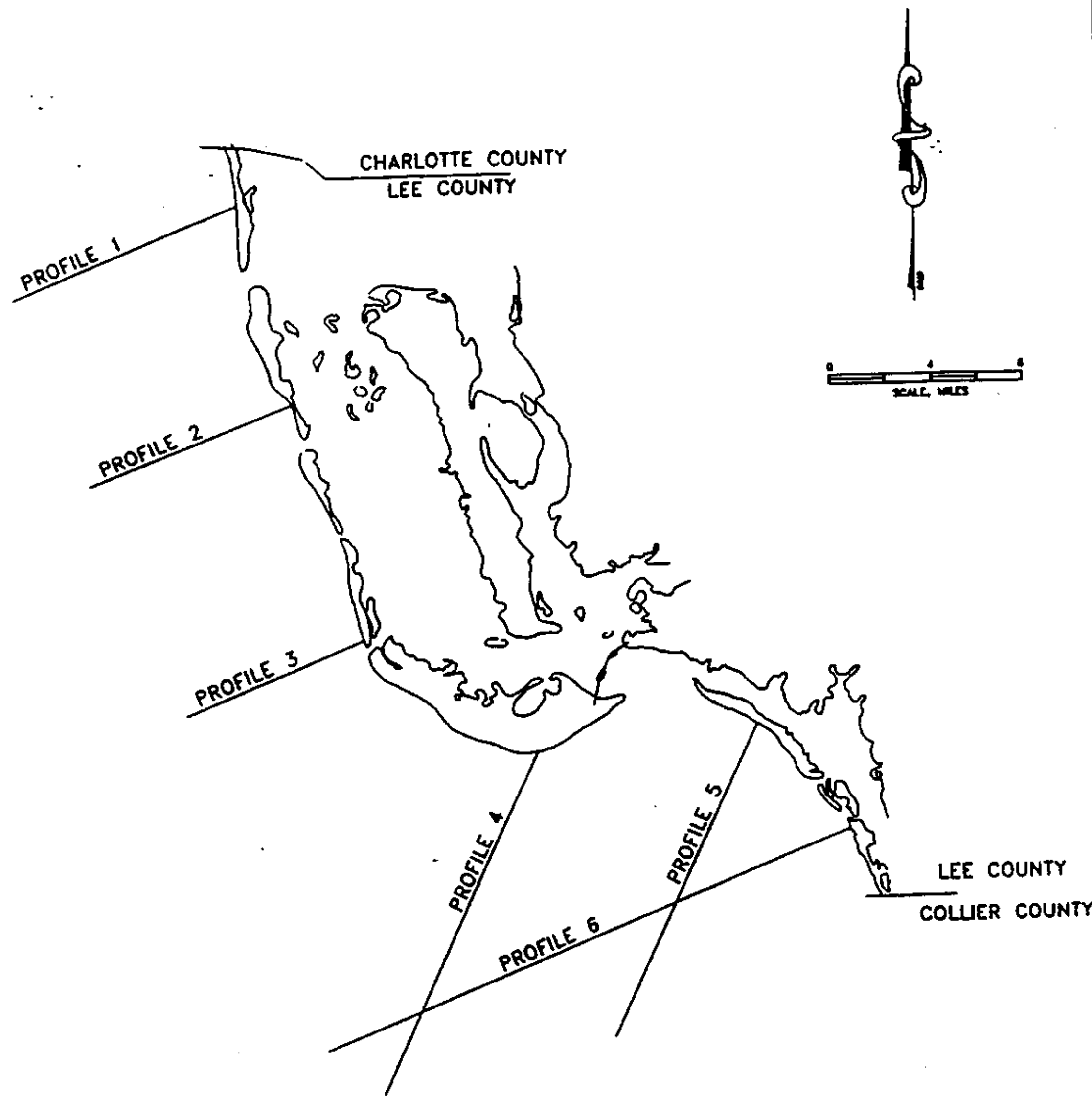


FIGURE I-10

DNR STORM SURGE MODEL PROFILE LOCATIONS

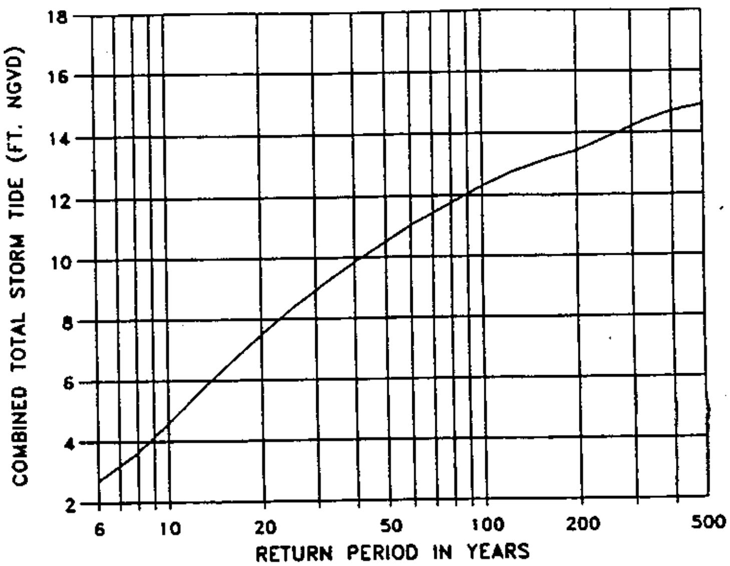


FIGURE I-11

PROFILE NUMBER 3

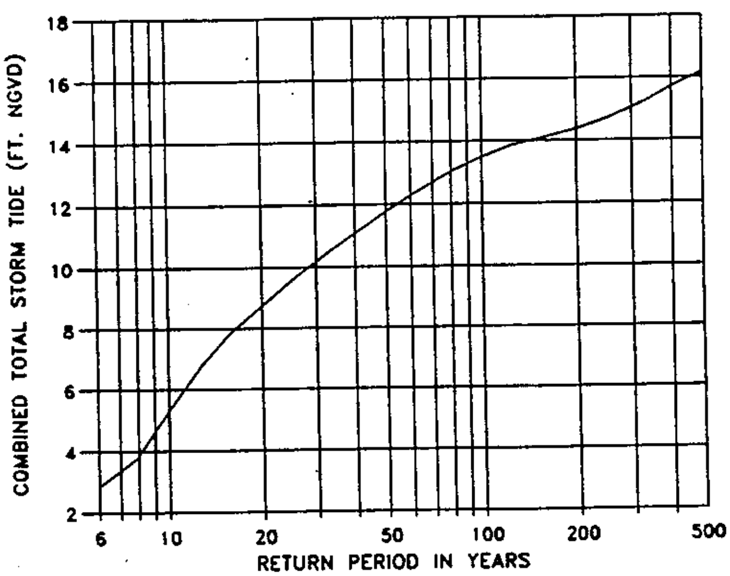


FIGURE I-12

PROFILE NUMBER 4

STORM SURGE ELEVATION AND RETURN PERIOD
FROM DNR STORM SURGE MODEL STUDY

glacial melting, or thermal expansion of seawater from a global increase in ocean temperature.

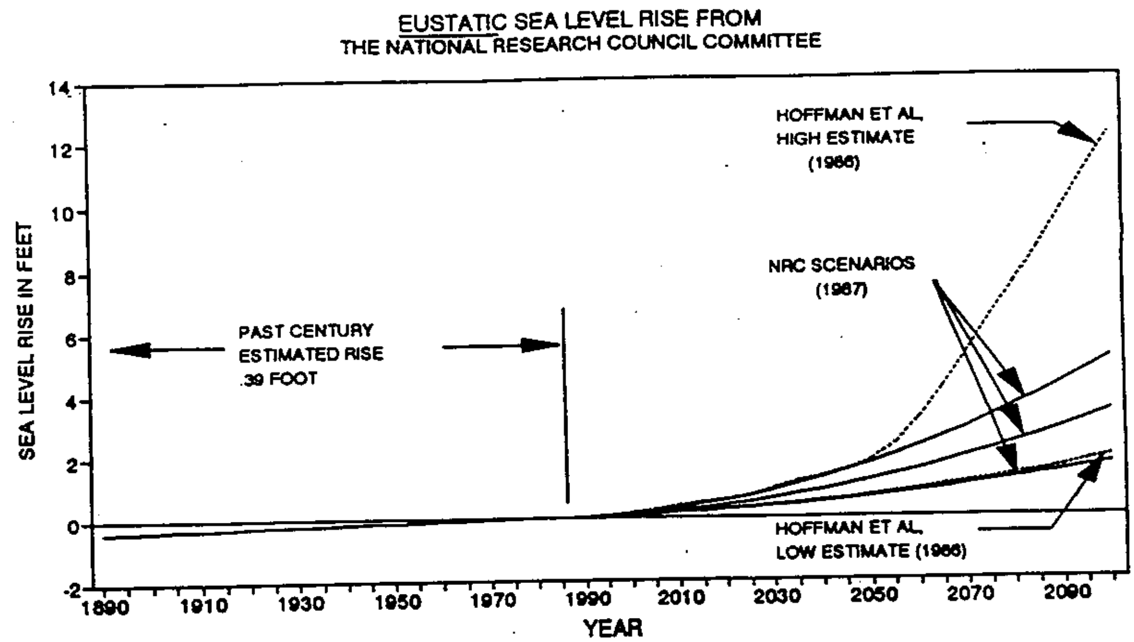
Over the past century, eustatic sea level rose approximately 4.7 inches. The relative sea level rise component varies from one location to another around the world. For example, in Louisiana relative sea level rise is about ten times faster than eustatic sea level rise. This is due to the land subsidence as a result of hydrocarbon and water extraction, the compression of soft substrates, and man-made changes to sediment deposition by the Mississippi River. In higher latitudes glacial rebound may have an opposite effect, that of relative sea level lowering, of a similar magnitude. World wide sea level fluctuations are also related to meteorological phenomena such as shifts in the jet-stream wind patterns and the El Niño-Southern Oscillation mechanisms which lead to atmospheric pressure anomalies and temperature changes that may cause rise or fall of mean sea level by 0.5 to 1.0 foot over a few years.

Along a coast characterized by low elevations and sandy beaches, the effect of sea level rise is dependent upon the slope of the beach and how the beach profile will readjust to a rise in sea level. As a general approximation, sandy beaches along an open coastline may be expected to recede about one hundred times the amount of a given sea level rise (Bruun rule, Committee on Engineering Implications of Changes in Relative Mean Sea Level, National Research Council, 1987).

Along the Gulf coast of Florida, sea level has risen approximately 0.6 foot in the last century. For the sea level rise over the last hundred years this would mean a horizontal change in shoreline position of approximately 60 feet, or 0.6 foot per year, along the open sandy coast. The problem is less severe along protected sections of the coastline which may be stabilized by vegetation and where high wave energy is not present to reshape the profile.

The magnitude of future sea level rise is uncertain, and in many areas where severe erosion is occurring, it is due to man-made situations which are having a much greater effect on the shoreline than that which can be attributed to the eustatic sea level rise of recent history. Examples of this are channel entrances which have been dredged and stabilized with jetties for navigation purposes, and other coastal structures which have been constructed for erosion control purposes, but which have only resulted in shifting, and sometimes aggravating, the erosion problem.

The National Research Council's Committee on Engineering Implications of Changes in Relative Mean Sea Level looked at various scenarios for future sea level rise. The scenarios adopted by the committee in their report is reproduced in Figure I-13.



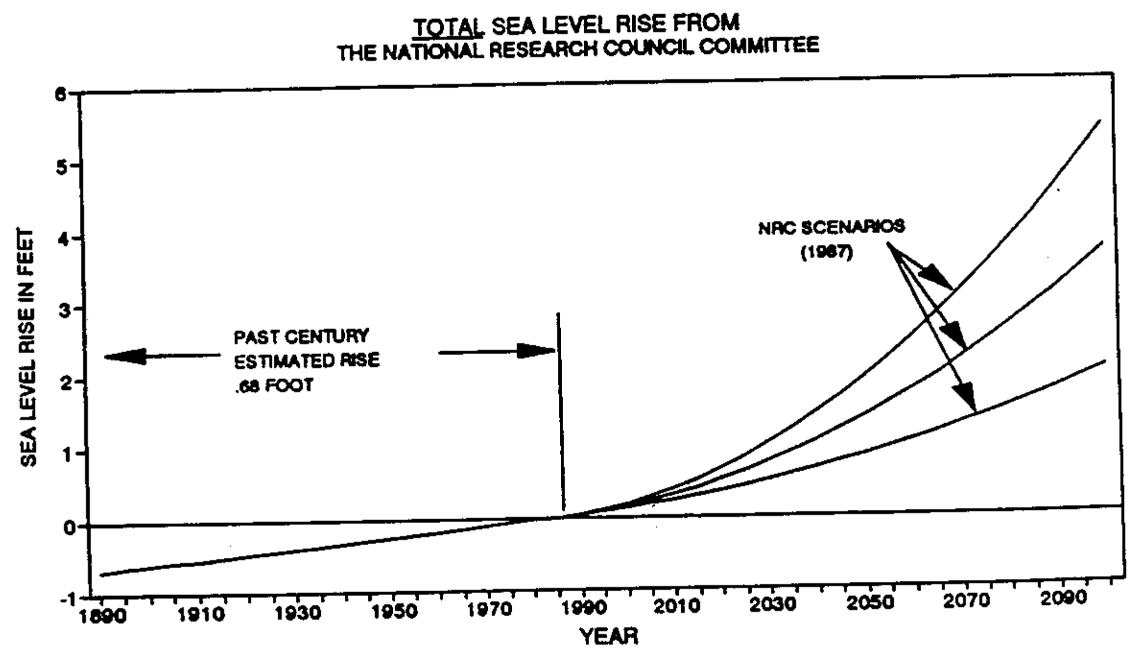


FIGURE I-13

THREE SCENARIOS OF SEA LEVEL CHANGE AS PRESENTED BY THE NATIONAL RESEARCH COUNCIL'S COMMITTEE ON SEA LEVEL RISE

Until more accurate predictions of sea level rise can be made, the National Research Council Committee on Engineering Implications of Change in Relative Mean Sea Level recommends that decisions not be based on a particular sea level rise scenario, but that options be kept open for responding to future changes in the rate of sea level rise. This necessitates long range planning that considers the probability of future increased rates of sea level rise.

There are two general responses to sea level rise:

1. Stabilize the shoreline with armoring or nourishment.
2. Leave the shoreline to change naturally, and retreat from eroding shorelines.

The consequences of sea level rise will vary dependent upon the vulnerability of the coastline and coastal structures. It is important that these consequences be considered in establishing a decision making policy for dealing with sea level rise. Retreat is more feasible for a sparsely developed low lying sandy coastline because the cost of stabilization would probably exceed the cost of moving a few structures. On the other hand, more intensely developed coastal areas with established infrastructure may more appropriately be protected with engineering solutions. The slow rate of rise in sea level provides a practical time frame in which to implement virtually any engineering solution deemed appropriate.

Planners and engineers need to consider sea level rise in coastal projects. Projects with a design life of 50 years or less, such as boat docks for instance, would not be significantly affected. Seawalls and multi-story structures on an open coast are much more vulnerable to increased wave attack and other effects of a small rise in sea level, and should accordingly be designed with an adequate margin of safety. Planning efforts in areas where environmental characteristics of natural shorelines are to be preserved should not contemplate alternatives that would require future protection with a revetment or seawall.

Another problem which sea level rise will aggravate is salinity intrusion into coastal aquifers. The displacement of the salt and freshwater interface is a large multiple of sea level rise.

B. Erosion Control Methods.

Losses due to erosion may be significant due to the loss of land, the threat that land loss poses to upland development and infrastructure, or both. Each situation may have its own unique characteristics, and appropriately there are many alternatives that can be considered in searching for a solution to a specific erosion problem.

There are two primary avenues of approach to dealing with coastal erosion issues; (1) limiting development in coastal areas through regulatory means in order to reduce potential losses from erosion and storms, or (2) controlling nature to reduce land losses and reduce vulnerability of upland structures. Under the regulatory approach there are federal, state, and local programs. There are also many non-regulatory measures such as beach restoration and a variety of structures that are designed to either protect the shoreline, or to reduce erosion by modifying the erosive force. Very often the most appropriate solution to a given problem is a combination of several options.

This section describes the variety of alternatives that are available and those that are currently being applied on Sanibel Island.

1. Regulatory.

Regulatory measures primarily deal with restricting development in vulnerable areas close to the coast. For the most part, regulatory purpose is not erosion control but rather reduction of the impact to structures that results when the structures are undermined by land loss from erosion. However, structures placed in the dynamic coastal zone also may actually contribute to erosion. Restricting placement of such structures may therefore assist the erosion control effort.

Regulatory restrictions vary from building code requirements in some areas to prohibition in areas where erosion or storm damage potential are the most severe. Regulatory measures exist on federal, state and local levels. In some instances regulatory programs influence coastal development or erosion control programs by providing funding for activities that are encouraged, or by not funding activities that are discouraged. An example of this is the federal flood insurance program incentives to communities which restrict development in high hazard areas. The City of Sanibel's participation in this program is described in Section III.B. of this Beach Management Plan.

1.1 Federal.

The federal government regulatory programs are administered primarily through three agencies. These agencies are listed below with a description of the regulatory program for each.

The Corps of Engineers has regulatory jurisdiction over activities in the navigable waters of the United States. This regulatory authority is exercised in conjunction with a joint permitting procedure administered by the State of Florida Department of Environmental Protection (DEP). Any construction, excavation, or other activities which are in, or will impact waters under state or federal jurisdiction, must receive a Water Quality Certificate from DEP. Under the permit application procedure, DEP forwards a copy of the application to the Corps of Engineers. The Corps reviews the activity with respect to navigation issues, but also receives input from the Environmental Protection Agency, the United States Fish and Wildlife Service, and other interested parties.

The Federal Insurance Administration (FIA) administers the National Flood Insurance Program (NFIP). This is comprised of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973, which provide subsidized flood insurance to participating communities that enact regulations which restrict development in flood-prone areas and increase the ability of structures to withstand flooding with minimal damage. This includes special considerations for coastal areas which present a higher hazard due to the potential for storm surge accompanied by waves and high velocity currents that accompany hurricanes and tropical storms. A detailed analysis of this federal program is provided in the Florida Sea Grant report by Hamann and Wade, 1990, and a discussion of the City of Sanibel's participation in the program is provided in Section III.B. of this Beach Management Plan.

The Coastal Barrier Resources Act restricts the use of federal funds, including insurance subsidies, on designated coastal barrier islands. The Act establishes a Coastal Barrier Resources System (CBRS) along the Atlantic and Gulf coasts, and essentially prohibits "future federal expenditures and financial assistance which have the effect of encouraging development of coastal barriers" (16 U.S.C. § 3501(b) (1986). A detailed analysis of this federal program is also provided by Hamann and Wade.

1.2 State of Florida.

The Beach Erosion Control Assistance Program was established by the Florida Legislature in order for the Department of Natural Resources (DNR), now under the new Department of Environmental Protection (DEP), to carry out the proper state responsibility in a comprehensive long range statewide plan for beach erosion control, beach preservation, and hurricane protection. Section 161.091 of the Florida Statutes (F.S) establishes a Beach Management Trust Fund. Under the provisions of Section 161.101, F.S., public works projects and studies relating to beach erosion control, beach preservation, and hurricane protection, are eligible for state funding consideration.

Section 161.161, F.S. directs the Department of Environmental Protection to prepare an inlet management plan for each improved coastal beach inlet as a part of the beach management program. Improved inlets are inlets which have been modified, for navigation or other purposes, with structures such as jetties or terminal groins, or by dredging. This is because beach erosion is often related to inlets and the improvements at inlets.

Applications for funding must be submitted by May 1st in order to be considered for funding in the next fiscal year. This means that a funding application submitted by May 1 of a given year, if approved, would receive funding in the following fiscal year, which begins on July 1 of the year after the year in which the application was made.

<u>The Coastal Construction Control Line Program</u> regulates construction activities along the coastline. The program establishes and periodically updates a regulatory zone that is defined based on erosion and other impacts which would be expected to result from a 100-year storm event. The purpose of this regulatory zone is reduction or elimination of structural damage and erosion within that zone. The landward limit of the zone is the Coastal Construction Control Line (CCCL) which is established at a location defined as the landward limit of " that portion of the beach-dune system which is subject to severe fluctuations based on a 100-year storm surge, storm waves, or other predictable weather conditions."

The CCCL on Sanibel Island was first established on April 17, 1978, then relocated to a more landward position on May 30, 1991. In relocating the CCCL, it was considered that low lying areas which would be completely inundated by the 100-year storm surge would experience less erosion because the beach and dune would be overtopped rather than directly impacted by storm waves. In such areas the line may be established by an alternative criteria of the landward limit of penetration of a 3 foot wave. This is the criteria that was used for relocating the CCCL on most of Sanibel Island in 1991, with the exception of a small segment located seaward of Terrell Ridge Subdivision.

A third criterion may be used by DEP in citing the CCCL. If the dune is located more landward than the location established by either of the above criteria, the line may be established further landward, at the landward toe of the beach dune (F.S. § 161). The purpose of this is to preserve the natural dune.

Any construction or excavation activity seaward of the CCCL must receive a permit from DEP, and must be consistent with special design and citing criteria established in Section 161.053 F.S., and Chapter 16B-33, of the Florida Administrative Code. It is also a requirement of DEP that all projects must be consistent with the local comprehensive plan.

The Thirty-Year Erosion Line is defined as the projected location of the seasonal high water (SHW) 30 years from the date of an application. See Section VI.D.1 for a definition of SHW and how the thirty-year erosion projection is determined. Construction of most major structures, except for a single-family residence meeting specific citing criteria, is not eligible for a permit seaward of this line.

1.3 Lee County.

Lee County Ordinance 91-21, as modified by Ordinance 92-46, is the "Coastal Zone Protection Ordinance". It provides specific standards for coastal construction to protect the health, safety, and welfare of the citizens of Lee County, and to protect the environment and natural resources in the coastal zone from pressures of development. This is necessary before the county will provide a notice of local approval, which is a requirement of the DEP CCCL permit review process. Incorporated Sanibel Island, however, is not subject to this jurisdiction.

Lee County does not have a permitting authority for other activities in the coastal zone which are under the jurisdiction of the State and the Corps of Engineers. Lee County does, however, have the opportunity to review and comment on applications to the State of Florida and the Corps of Engineers, for approval of activities in those coastal areas. Through this process, Lee County can make the State and Federal agencies aware of environmental issues and other issues of local concern.

1.4 City of Sanibel.

The City Land Development Code (LDC) Article I establishes zones and development standards for each zone. As described in Section I.D.2 of the LDC, the primary intended use for zone A - Gulf Beach Zone, and zone B - Bay Beach Zone, is passive recreation and conservation uses. This includes such activities as recreational beach activities, hiking, birding, boating, and diving. Other permitted uses are elevated beach access ways and public facilities. No other development is permitted, except as provided for under Section I.D.2.b.(1) which states that residential development permits may be issued if certain conditions are met. Those conditions provide for the protection of the natural beach and dune system, natural beach processes, native vegetation and wildlife, including lighting restrictions for sea turtle protection and preservation of habitat. Section I.E.14 specifies the standards for outdoor lighting seaward of the CCCL, and Section I.E.17 specifies structural standards and citing requirements.

Permitted activities may not interfere with public use, and seawalls and other hardened shorelines are prohibited (see Sections I.D.2.a.(1).(e)., I.D.2.a.(2).(e), and I.I.3.u.(2)). Section

I.E.44, Emergency Beach Shoreline Erosion Control Development, allows for temporary installation of sandbags if the activity is also approved by the State of Florida DEP, and Section I.I.3.u. which permits erosion control structures as conditional uses on the banks of San Carlos Bay, Dinkins Bayou, Clam Bayou, and Blind Pass, subject to certain conditions. The activity also must not interfere with public use.

2. Beach Nourishment.

2.1 General Considerations.

Beach nourishment with compatible sand is often chosen as the preferred way of dealing with beach erosion. It is usually accomplished by a process known as hydraulic fill. This involves mining sand from underwater deposits, and pumping it as a slurry of sand and water to the beach through a temporary pipeline. Beach nourishment may also be done mechanically by transporting the sand on barges if the source is so distant that a pipeline is impractical, or with trucks if the source is inland.

Trucking sand from an inland source is sometimes practical for small projects that could not justify the heavy mobilization expenses associated with the type of equipment needed for mining sand from offshore locations. Small projects, however, usually have a relatively short design life due to natural lateral dispersion of sand, or "end losses", to adjacent unnourished beaches. These end losses are independent of the size of the project and therefore will represent a larger percentage of a small project than of a larger project. End losses, therefore, deplete a small project more quickly than a large project. As a result, small projects typically require more frequent maintenance.

Beach nourishment has several advantages over other methods; it offsets the effects of erosion, provides storm protection, and at the same time provides a beach habitat for sea turtle and shorebird nesting, as well as for recreation.

The disadvantages associated with beach nourishment are that there may be temporary environmental impacts during construction. One such issue is generation of turbidity near the point of the pipeline discharge. This is generally not a problem if the borrow area contains suitable sand, although the proximity of sensitive environmental resources, such as live corals, may dictate higher turbidity standards than might otherwise be necessary. Other environmental issues are interference with sea turtle or shorebird nesting if sand is being placed on an existing beach during nesting season. Beach nourishment is often restricted to winter months to eliminate the possibility of interference with sea turtle nesting or other seasonally sensitive environmental habitat.

This is unfortunate from an economic standpoint, because winter construction is much more expensive due to rough winter weather which creates difficult and hazardous operating conditions for the necessary floating construction equipment. The cost differential between winter and summer construction is due primarily to the fact that it may take 25% to 50% longer to complete a project in the winter because of lost time during bad weather.

In some instances restriction to a winter construction window is not justified, for example in nourishment of an armored shoreline on which turtles and shore birds cannot nest until after the beach is restored. Putting off creation of nesting habitat until after the nesting season is over will not accomplish anything for environmental preservation. Additionally, turtles and birds sometimes nest in areas which provide little chance of hatching successfully. Examples are areas where predators such raccoons as will dig up the eggs, and rapidly eroding areas which would expose nests before hatching. In some of these areas, conservation groups have routinely relocated nests to protected hatchery areas in order to improve hatching success rate. The economics of summer vs. winter construction are such that if nourishment projects are done during the summer, a turtle protection program including any necessary nest relocation could be paid for with construction cost savings, and both turtle protection and beach nourishment would benefit.

Often there is insufficient information to answer relevant environmental questions and quantify impacts, consequently restrictions may be based on total avoidance of sea turtle nesting season. A question that often comes up with regard to sea turtle preservation is whether or not nest relocation may be detrimental. There are indications that relocation may alter natural incubation temperatures, which may affect the natural hatchling sex ratio. Resolution of these issues is not a simple matter, however, a cooperative effort between environmental and nourishment project concerns could provide additional long term benefits to sea turtle protection by also funding research on nest relocation and other pertinent issues, and helping to quantify the long term benefits afforded through reestablishment and maintenance of nesting habitat.

2.2 Beach Nourishment, South West Florida.

There are a number of beaches in south west Florida that have been nourished with hydraulic beach fill. Most were done as a by-product of inlet channel navigation projects. Consequently, the effort put into surveys to document before and after construction conditions, and post construction monitoring, was focused on the navigation channel and not on the beach fill. Unfortunately, this means that there is limited information available on how successful these projects were in terms of how long the beach fill remained in place.

Two projects in Lee and Collier counties have been completed specifically to restore beaches. These projects are monitored with annual surveys which provide data on project performance.

The first of these projects to be completed is on the north end of Captiva Island at South Seas Plantation, which was completed in 1982. Part of that project was renourished in 1988, and in addition at that time the project was extended southward to Blind Pass, nourishing the remaining approximately three miles of Captiva Island Gulf beach which were not nourished in 1982.

The second beach project in southwest Florida is on Marco Island, which was completed in February 1991. This project consists of the placement of approximately 1.3 million cubic yards of sand, divided among three separate beach fill sections. The nourished sections of beach are separated from each other by several thousand feet of shoreline that were not nourished.

The Marco project is being monitored annually. The information available at this time consists of the post construction survey, the first monitoring survey taken approximately six months later, and two subsequent annual monitoring surveys.

Due to the innate variability in shoreline trends, monitoring information for a short time interval may not be precisely indicative of what will occur over the design life of the project. This is particularly true of the initial post construction monitoring period, since newly constructed beaches tend to have a very steep slope below the water line, and wave action rapidly flattens this slope by taking sand from higher elevations and depositing it at lower elevations immediately offshore. This is a natural adjustment process, which results in a natural beach slope consistent with stability characteristics of the fill material. This post-construction adjustment often gives the appearance of rapid erosion after nourishment because the shoreline may recede rapidly and exhibit a vertical erosion scarp.

Keeping these circumstances in mind, the available data does nonetheless provide us with some useful insight. Figure I-14 illustrates a comparison between the expected post construction shoreline recession (which was estimated to be similar to the historic erosion rate of -3 feet per year), and what was measured during the first six months after construction. The six months of survey data have been annualized for comparison with annual projections.

These results show that the shoreline recession rate within the limits of the north project was about equal to the projected rate, and within the central project the shoreline actually advanced. This indicates excellent stability, for these sections of beach. This is particularly significant considering that the monitoring

MARCO ISLAND BEACH NOURISHMENT PROJECT
PROJECTED VS. ACTUAL EROSION RATES

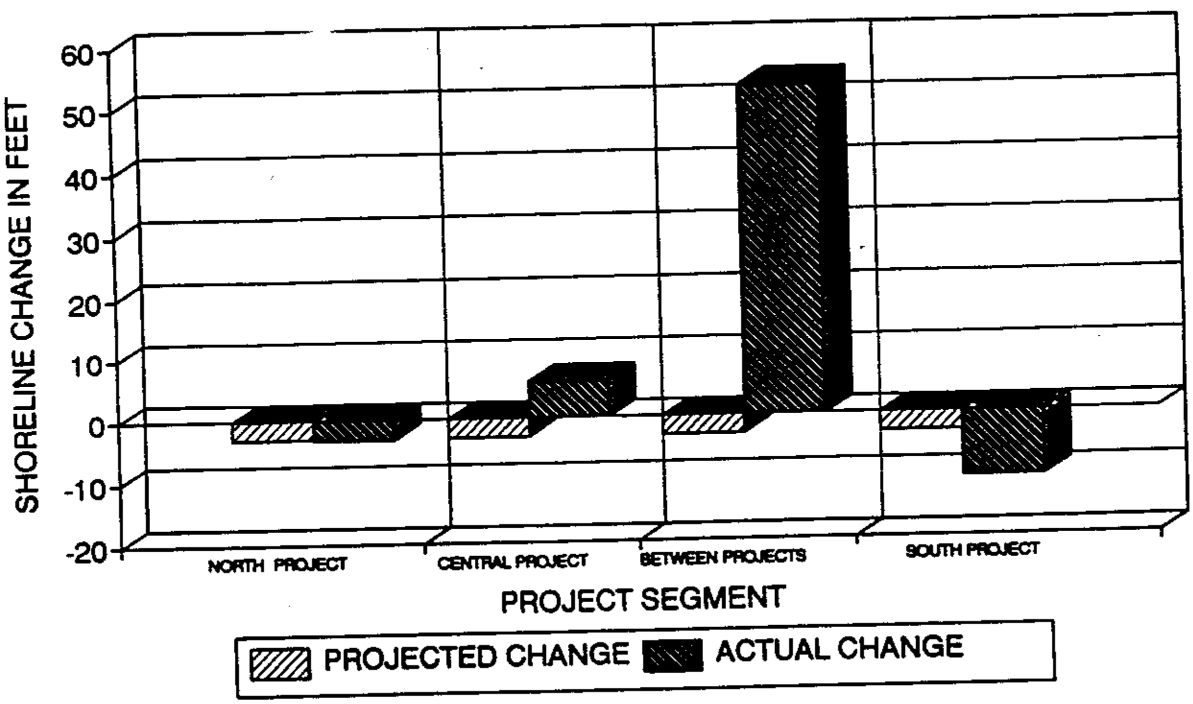


FIGURE I-14

data was collected during a period of time, shortly after construction, when a significant amount of profile readjustment would normally be expected to result in rapid shoreline recession.

The un-nourished section of shoreline between the central and south projects experienced a large advance. This is consistent with what normally happens to beaches adjacent to nourishment projects; the adjacent beaches benefit as natural forces redistribute sand placed on the nourished sections. This illustrates how, in the long run, beach nourishment benefits those areas that are nourished as well as those adjacent areas which are not nourished.

Within the limits of the south project, the shoreline recession rate was greater than the projected rate. There are, however, two circumstances which should be considered in interpreting this high erosion rate. One, discussed previously, is that the beach fill should experience high recession during readjustment immediately after construction. The other is that during the engineering design for this project, a high rate of erosion was anticipated at the south end of the south project, at the southern tip of Marco Island. The high rate of erosion was anticipated because of site specific conditions in this area which had resulted in historically high erosion rates. Consequently, rather than constructing a project with a relatively short project life, the engineers included a segmented offshore breakwater as an erosion control feature in the project design. However, due to regulatory agency concerns over lack of sufficient justification for the breakwater, the erosion control feature was not permitted for construction during the first phase of the project, and has therefore not been built. Consequently, the observed erosion on the south project actually does not exceed the design projections for the project, as built, without the erosion control feature.

To further put this in prospective, Figure I-15 shows the same information as Figure I-14, except that the erosion experienced by the southernmost 500 feet of the south project has been omitted from the comparison. If considered in this manner, the project performance is well within the design expectations which provided financial justification for the project.

The beach nourishment permit was issued with a condition that if the erosion rate exceeded a threshold rate specified in the permit, the breakwater phase would be authorized for construction. This threshold rate has been exceeded, and the breakwater phase is proceeding.

Volumetric change in sand quantities is also a measure of project performance. The design estimate was that volumetric losses would be on the order of 25,000 cubic yards of sand per year. Actual losses were measured to be approximately 15,000 cubic yards per year. The relatively small volumetric sand losses also illustrate the success of this project.

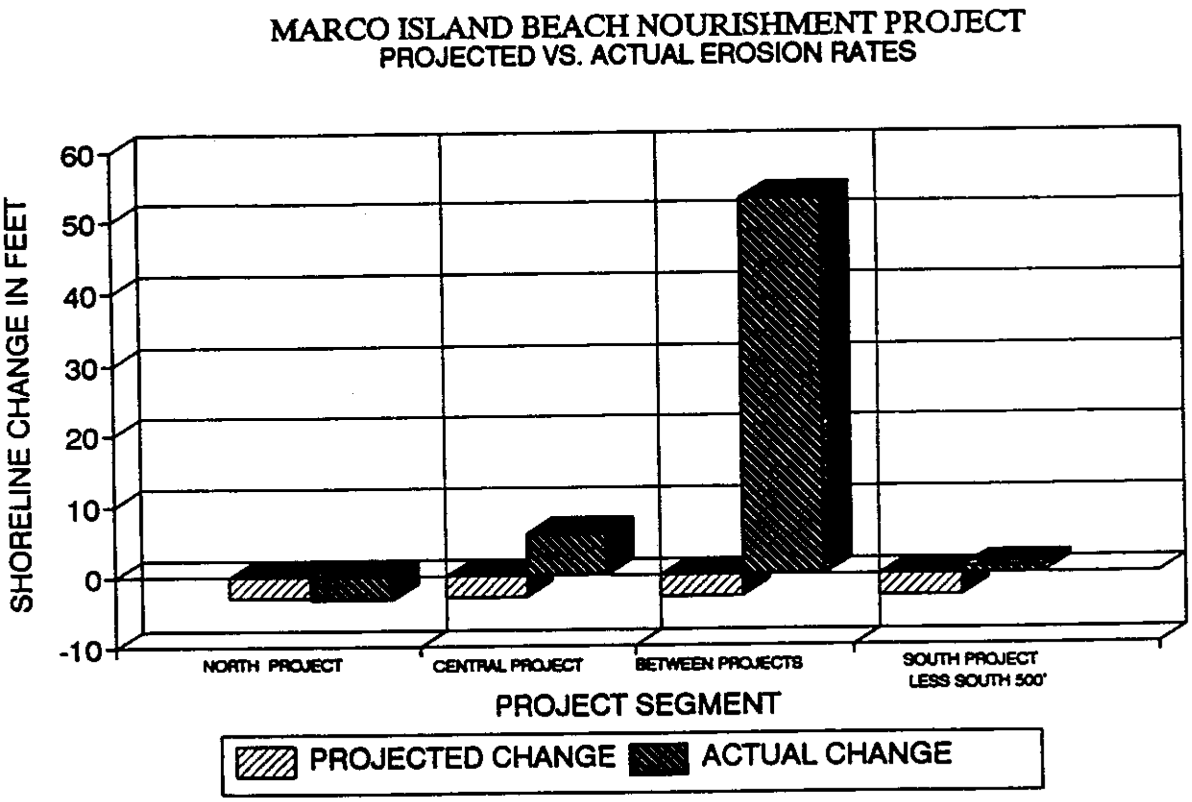

MARCO ISLAND BEACH NOURISHMENT PROJECT
PROJECTED VS. ACTUAL EROSION RATES
SHORELINE CHANGE IN FEET
60
50
40
30
20
10
0
-10
NORTH PROJECT
CENTRAL PROJECT
BETWEEN PROJECTS
SOUTH PROJECT LESS SOUTH 500'
PROJECT SEGMENT
PROJECTED CHANGE
ACTUAL CHANGE

FIGURE I-15

Both of these projects show that beach nourishment on Florida's Gulf coast is a viable alternative for addressing beach erosion.

3. Structures.

There are a variety of structural alternatives that have been or are currently used for erosion control. Some of these were discussed earlier in Section I.A.3, with regard to potential impacts that some of them may produce. Although there are adverse impacts associated with some structural solutions to erosion problems, very often the problem and setting have unique characteristics, and the full range of alternatives should be available for consideration.

3.1 Rock Revetments.

Rock revetments are used to provide upland protection from erosion. Revetments are not considered to be beneficial to the beach system and have the potential for adverse impacts to adjacent property. They are, however, preferred over vertical seawalls because the sloping irregular rock surface of the revetment absorbs or dissipates wave energy, whereas the vertical flat surface of a seawall will reflect and amplify wave energy in front of the wall, which accelerates sand transport.

The Florida Department of Environmental Protection (DEP) considers the application of revetments to be justified under certain circumstances. Justification includes the immediate danger of the upland structure to expected failure from erosion losses due to a five year (or smaller) return interval storm event. The upland structure must be a major habitable structure or found to be in the public interest to protect, such as a highway providing the main hurricane evacuation route for the area. Alternative solutions to the problem must also be considered, such as the possibility of relocation of the threatened structure. Allowances are also given for closing an existing gap in a long line of continuous coastal armoring, provided that the unprotected shoreline in the gap is being adversely effected by the adjacent structures.

Permits issued for revetments normally have strict permit conditions to guard against adjacent shoreline impacts. Recordation of easements to ensure lateral public beach access across the site to be protected is commonly required by DEP. Revetments are usually one of the final alternatives to consider if the upland structure cannot be moved.

3.2. Seawalls.

Seawalls find application in circumstances similar to those of revetments, but revetments are the preferred treatment from an engineering standpoint because of the wave reflection issue.

Seawalls should have rock revetment placed in front of the wall to reduce wave reflection from the vertical surface.

Recently, DEP has considered that vertical walls take up less sea turtle nesting habitat, because a vertical wall is only about 18 inches thick but a revetment has a horizontal dimension typically of 15 to 20 feet. The agencies are therefore now encouraging the use of vertical walls of limited design.

3.3. Groin Field.

Groins are intended to slow erosion by trapping sand moving in the shore parallel (longshore) direction. This results in a wide beach, or fillet, on the updrift side and a recessed shoreline on the downdrift side (see Figure I-5). This shoreline offset must be considered in the groin design. Because of this offset, part of which is the adverse impact of downdrift erosion, groins are usually installed in conjunction with other groins in a groin field to slow the sand transport along an entire segment of shoreline. The length and spacing of groins in a groin field must be carefully designed to suit the specific site.

In recent years, groins have attained a general reputation of not working very well. There are, however, places where groin fields have been proven effective for erosion control. The suitability of sites for groin field emplacement must be evaluated on a case by case basis, and there must be an adequate supply of littoral drift for the groins to work properly. Consequently, groin fields are often applied in conjunction with beach nourishment.

One appropriate application for groins is at the end of a nourishment project and at the end of a littoral system. The end of a littoral system can be at a large inlet which represents a total barrier to sand transport. Groin fields can also be effective in reestablishing a natural shoreline configuration adjacent to such inlets where tidal currents have contributed to erosion. In such situations the location, length, and alignment of the groin must be designed to appropriately interact with the littoral system.

3.4. Offshore Breakwaters.

Offshore breakwaters attenuate wave energy to reduce sand transport along the section of shoreline in the lee of the structure. This will result in accretion along that segment of shoreline as sand from normal littoral transport accumulates in the lee of the structure. Installation of these structures is often in conjunction with nourishment projects. They may be used in combination with groins to achieve a desired effect.

Downdrift impacts from offshore breakwaters must be considered. One appropriate location for such structures is at the end of a littoral system. Some drawbacks to breakwaters is that they are expensive to construct, and may pose a hazard to navigation if not properly marked.

Advantages to breakwaters are that they have low maintenance requirements and their performance is proven and predictable with reasonable certainty. They have no adverse environmental effects, and do provide an environmental benefit of hard surface habitat for benthic organisms.

Breakwaters fall into two general categories, emergent and submerged. Emergent structures have a crest elevation above mean high water and effectively modify wave energy at any tide level. Submerged breakwaters are essentially an artificial reef. Wave overtopping allows for transmission of more wave energy than the emergent structure. The submerged breakwater must therefore have a much broader crest to be as effective as an emergent breakwater, and consequently, the submerged design is less cost effective.

Navigation safety is another issue for structures placed in open water. Both the emergent and submerged breakwaters should be appropriately marked with Coast Guard approved navigation aids, but the emergent breakwater is also visible to the navigator. The submerged breakwater represents a hidden hazard unless the water depth over the crest is deep enough to allow for passage of boats using the area, in which case it would probably be too deep to be effective as a breakwater.

There are in general two types of construction for breakwater; (1) prefabricated systems, and (2) rock mound structures.

a) Prefabricated Systems: There are a number of offshore breakwater products which have yet to be proven in terms of performance and cost effectiveness. One such installation has been permitted by the State of Florida as an experimental project. This experimental project consists of a series of interlocking prefabricated concrete modules.

Preliminary monitoring results for this experimental project have been disappointing in that erosion has occurred in the area protected by the breakwater. This has been attributed to the fact that the structure is submerged and of a solid impermeable concrete construction, and wave overtopping transports enough water across the crest in the landward direction to cause a ponding effect between the breakwater and the beach. Because of this ponding, a return flow parallel to the beach and around the ends of the breakwater occurs, and this return flow may be creating an erosion stress that off-sets the wave attenuation capability of the submerged structure.

Another potential problem with a rigid modular construction is the lack of flexibility for adjustment if settlement or shifting occur during a storm. The alternative conventional rock mound structures are considered flexible because movement of individual rocks during storms does not result in failure of the structure, and in fact usually results in a tighter interlocking of the rocks and greater stability. On the other hand, if a rigid interlocking prefabricated structure incurs storm damage, it may result in structural failure.

At this time, the State DEP still considers prefabricated offshore breakwater modules as experimental. There is no information that indicates there is any better performance level achieved by the prefabricated modular units as opposed to conventional rock mound structures. Because of the experimental status of these structures, the state requires a more extensive monitoring program than for conventional structures, and this monitoring becomes a significant part of the overall project cost.

ALTERNATIVES	SEAWALL	REVETMENT	GROINS	BREAK-WATER	NOURISH-MENT
PERMITTING FEASIBILITY	VERY LOW	LOW	LOW	LOW	HIGH
EFFECTIVE EROSION CONTROL	VERY LOW	LOW	MODERATE	HIGH	HIGH
EFFECTIVE SHORE PROTECTION	HIGH	HIGH	MODERATE	MODERATE	HIGH
ENVIRONMENTAL BENEFITS	LOW	LOW	HIGH	HIGH	HIGH
DOWNDRIFT IMPACTS	MODERATE	MODERATE	HIGH	MODERATE	LOW
INITIAL COSTS	MODERATE	MODERATE	HIGH	HIGH	HIGH
MAINTENANCE COSTS	MODERATE	LOW	HIGH	LOW	HIGH

TABLE I-3

GENERAL CATEGORIZATION OF ALTERNATIVES

Table I-3 provides a general categorization of various alternatives. The categorization is necessarily general because each erosion control project must be evaluated on an individual basis to determine the best solution.

b) Rock Mound Breakwaters: The conventional method of constructing breakwaters is with a rock mound structure. A significant advantage of these type of structures over the prefabricated units is that they are flexible. This means that if any differential settlement or movement due to storm forces occurs, the individual rocks will naturally settle into a new interlocking configuration that is usually more dense and more stable than the rocks can economically be placed during initial construction.

These structures are also easier to modify and adjust if it becomes necessary to modify the wave attenuation characteristics of the design. Rock mound breakwaters may be constructed in a variety of configurations. One continuous structure may be used for a small erosion control project. A larger project may require a series of segments separated by gaps to allow some wave energy to pass through, in order to achieve a desired level of wave energy attenuation. The rubble mound structure is also porous with voids between the rock armor units allowing for a return flow that would prevent the ponding that may be occurring with the solid modular concrete units. A similar effect may be obtained with a submerged breakwater or artificial reef which will transmit a portion of the wave energy across the top of the structure.

4. Alternative Technologies.

Because of the prevalence of coastal erosion problems, the high cost and sometimes uncertainty in conventional solutions, new ideas for erosion control are continuously being generated. Modular breakwater units previously discussed are one such idea, and there are a variety of these. Some other alternatives are discussed below.

Sand Filled Geotextile Bags. Geotextile bags filled with sand are an alternative construction material for coastal structures such as revetments, groins, and breakwaters. The installation of geotextile bags for shore protection is a method which is currently being tested within the State of Florida. Their installation has been approved by the state regulatory agencies primarily as immediate short term protection for upland structures threatened by erosion. Generally, the authorizations are for temporary installation until a more suitable long term solution can be found.

The attractiveness of geotextiles as an alternative construction material is lower cost than other conventional materials, particularly if they are permitted to be filled with native sand at the project site as opposed to having to import sand from a remote location. Additionally, as temporary structures, they are relatively easy to remove. The drawback to their cost effectiveness is that they are not as durable as conventional materials, and consequently may not be cost effective as permanent installations due to high maintenance costs.

Geotextile bags also have some of the same problems as other construction materials. The DEP Division of Marine Resources has concerns over impacts to marine turtle nesting because they can be nearly as much a barrier to a nesting turtle as are seawalls. If they function as effectively as groins and breakwaters, they will have the same potential as conventional rock mound structures for adverse downdrift impacts.

In simple terms, the geotextile bags are sandbags, some with a hard protective exterior surface. They are available in a wide variety of sizes and materials. They may be used as breakwaters, groins, and revetments. The application of these structures as more conventional groins is being considered by the State regulatory agencies very cautiously on a site by site basis, and their installations are still considered to be experimental. Currently, the State Department of Environmental Protection is considering their installation south of the south jetty at Cape Canaveral Inlet to reduce the losses of sand through the jetty within the transport reversal zone immediately south of the inlet. This design consists of one large bag. Another project under consideration for installation is along the southeast coast of Amelia Island. This project consists of a series of short groins constructed of geotextile bags.

The "undercurrent stabilizer", which has been promoted locally is a variation of the application of sandbags as groins. Like many experimental systems, there is no scientific evidence in the literature researched to support this as a viable alternative.

There is presently an experimental installation in Clearwater Beach which consists of sand filled geotextile tubes as groins, extended offshore where they connect with a shore-parallel segment below mean high water. The area defined by this perimeter has been filled with sand. This is essentially a perched beach, because the shore parallel offshore tube acts as a sill to retain the sand fill on the landward side and acts as support for the toe of the beach fill. The project was recently completed and is currently undergoing a ten-year monitoring effort as required by the state regulatory agencies for experimental projects.

The long term stability of these structures as groins is not well known. The installation at Clearwater Beach required a modification to the original design soon after construction because the shore-normal bags began to shift. The modified design provided additional smaller bags on either side of the main shore-normal bags for stability.

Beach Dewatering System. Another method of stabilizing the beach which has been permitted by the State DEP on an experimental basis is a beach dewatering system. The general principle behind the dewatering system is to lower the water table under the beach by pumping water out of the area. The dewatering process draws the water table down, theoretically promoting faster percolation of water down through the beach face during wave uprush. This should promote more rapid settlement of suspended sand. By reducing the amount of time sand particles remain in suspension, the distance those particles will be transported by longshore currents is also reduced. This would potentially result in an accumulation of sand along the dewatered section of beach. Beach dewatering is accomplished by drawing water from beneath the beach through a collection of perforated subgrade pipes. The discharge location is very site dependent. In some cases discharge may be cited to assist in flushing of interior bay waters or marinas.

This process has been tested on Hutchinson Island a short distance north of St. Lucie Inlet. The project has been in operation for a number of years and has recently received an operational permit from the Florida DEP. This means DEP no longer considers the project installation at that location to be experimental and are allowing the system to continue to operate. The operational permit, however, only allows the facility to operate during the time period from November 1st through April 30th to avoid potential impacts to marine turtle nesting.

The beach dewatering system does not introduce new material into the sediment budget, rather works with the existing sediment within the system and attempts to control erosion by increasing the stability of sand on the beach or trapping sand from the littoral system. If it effectively traps enough sand, there could be downdrift impacts.

A concern with respect to the system is its high installation, operation, and maintenance costs, and lack of flexibility. The continued maintenance of the pumps in the marine environment can be costly. Additionally, should there be significant changes in the beach profile geometry, new pipes would need to be added to adjust for the changing system.

Sand Web. This is a system which uses a material similar to a fish net in a configuration where it acts like a permeable groin. The net is strung out perpendicular to the beach into the surf zone and suspended from rods driven into the sand so that the bottom edge of the net lies on the beach face. The net will trap course shell fragments, and the combination of the net and the fillet of shell fragments will then trap finer sand particles.

This alternative is promoted as being effective in bringing offshore sand bar material onshore to nourish the beach, rather than trapping littoral drift moving along the beach. However, the offshore bar is in fact part of the littoral transport system. Monitoring of an experimental installation in Naples, Florida showed that the beach in the net installation area gained some sand, but the amount was not cost effective, and the downdrift area to the south suffered erosion. There may also be environmental impacts due to the nets trapping marine organisms, and state agencies would not permit their use during marine turtle nesting season. There were reports of large numbers of horseshoe crabs being trapped by the nets during the Naples experimental project.

Like many experimental systems, there is no scientific evidence in the literature researched to support this as a viable alternative at this time.

C. Shoreline Description of Sanibel Island

1. Gulf Shoreline.

Shoreline change analysis is based on data from a variety of sources, including; an atlas of shoreline changes in Lee County prepared for the Florida DEP, the DEP data file on historic shoreline positions, recent survey data, and aerial photographs. Recent survey data is more plentiful in some parts of the island than in others. In particular, the two most rapidly eroding areas have been surveyed more frequently than other areas so that erosion in those areas can be carefully monitored, and to develop a data base of information that can be used in the evaluation and possibly design of solutions to those erosion problems. This recent information covers a relatively short time interval in comparison to other historical data, and therefore will be considered under the section on short term trends and in the identification of problem areas.

1.1 Long and Short Term Trends.

Shoreline position maps are included at the end of this section, but to facilitate better understanding of trends, data on shoreline position at each DEP monument has been tabulated and converted to annualized rates of change. Long term trends are shown in a series of bar graphs which illustrate the historic rates of change in shoreline position over a 130-year period of time.

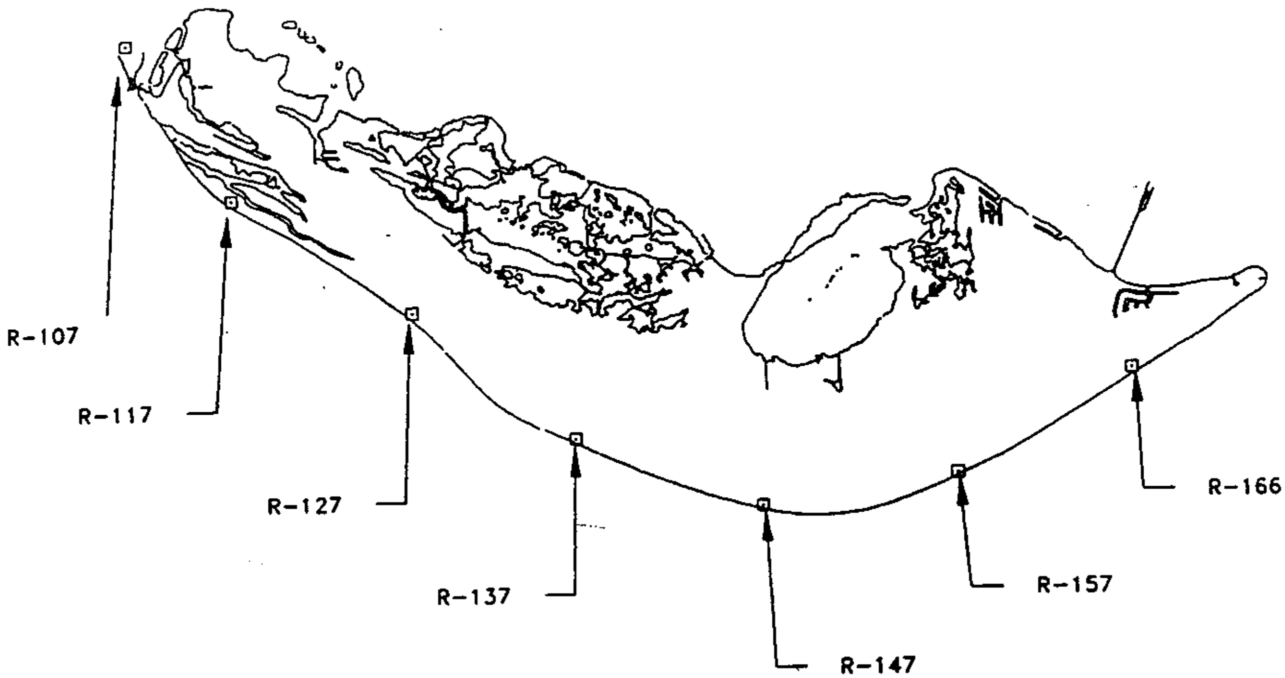
The first of these bar graphs, Figure I-16, shows the rates of shoreline change from the earliest data 1859 (USC&GS), to 1939 (USC&GS). This figure illustrates that, with respect to long term trends, six distinct shoreline zones can be identified. Those zones are identified in this report by DNR reference monument number. DNR R-monuments are approximately 1,000 feet apart along the coast.

1. R-110 to R-115. Erosion at an average of -8.4 feet per year. This covers approximately the first 1.1 miles of beach south of Blind Pass.

2. R-116 to R-125. Rapid shoreline advance at an average rate of +18.4 feet per year. This 2.0 miles of shoreline includes Bowmans Beach.

3. R-126 to R-133. Low level erosion at an average rate of -2.2 feet per year. This 1.6 miles of shoreline includes the Gulf Shores and Gulf Pines subdivisions.

4. R-134 to R-155. Low rates of change, both erosion and accretion, for the most part less than one foot per year. Average change was -0.4 feet per year. This is the longest zone at 4.1 miles.


R-107
R-117
R-127
R-137
R-147
R-157
R-166

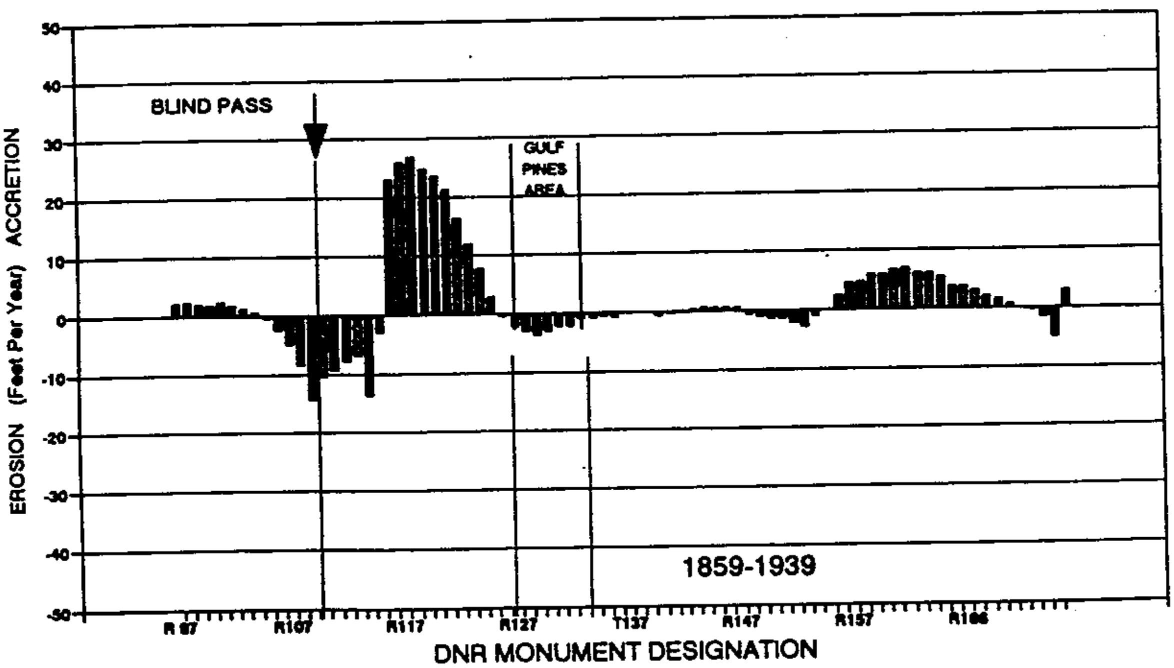
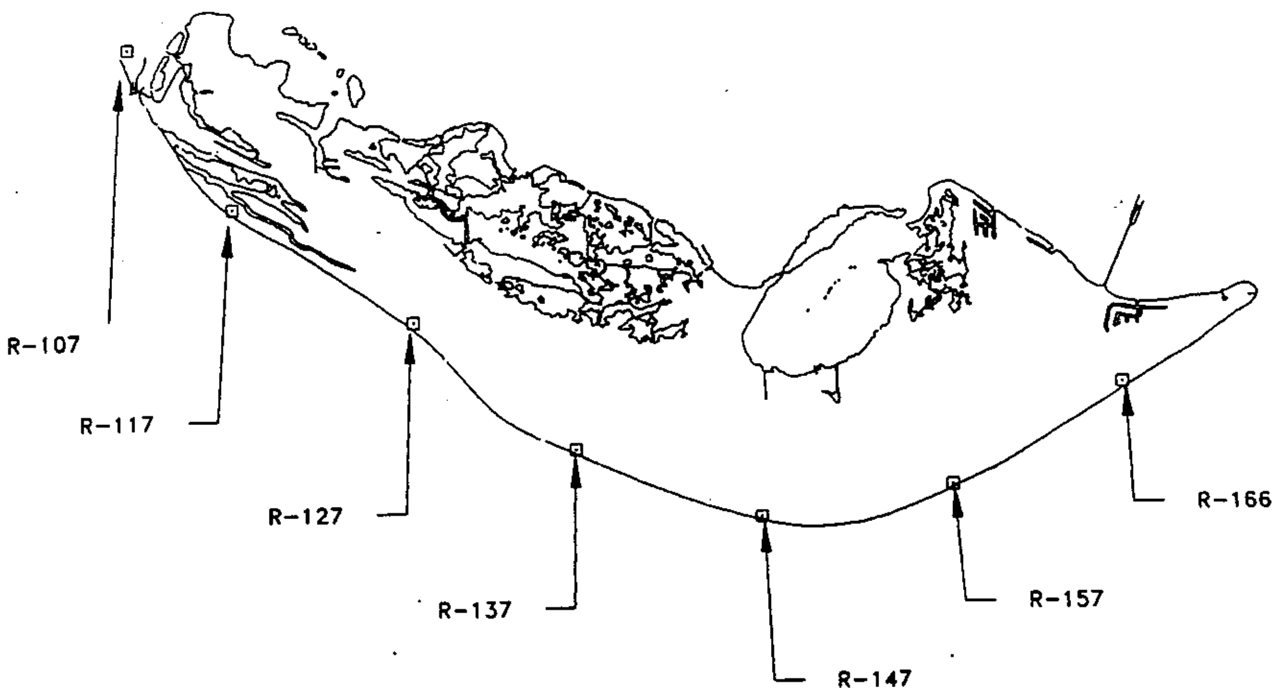

BLIND PASS
GULF
PINES
AREA
EROSION (Feet Per Year) ACCRETION
50
40
30
20
10
0
-10
-20
-30
-40
-50
1859-1939
R 97
R107
R117
R127
T137
R147
R157
R166
DNR MONUMENT DESIGNATION

FIGURE I-16


R-107
R-117
R-127
R-137
R-147
R-157
R-166

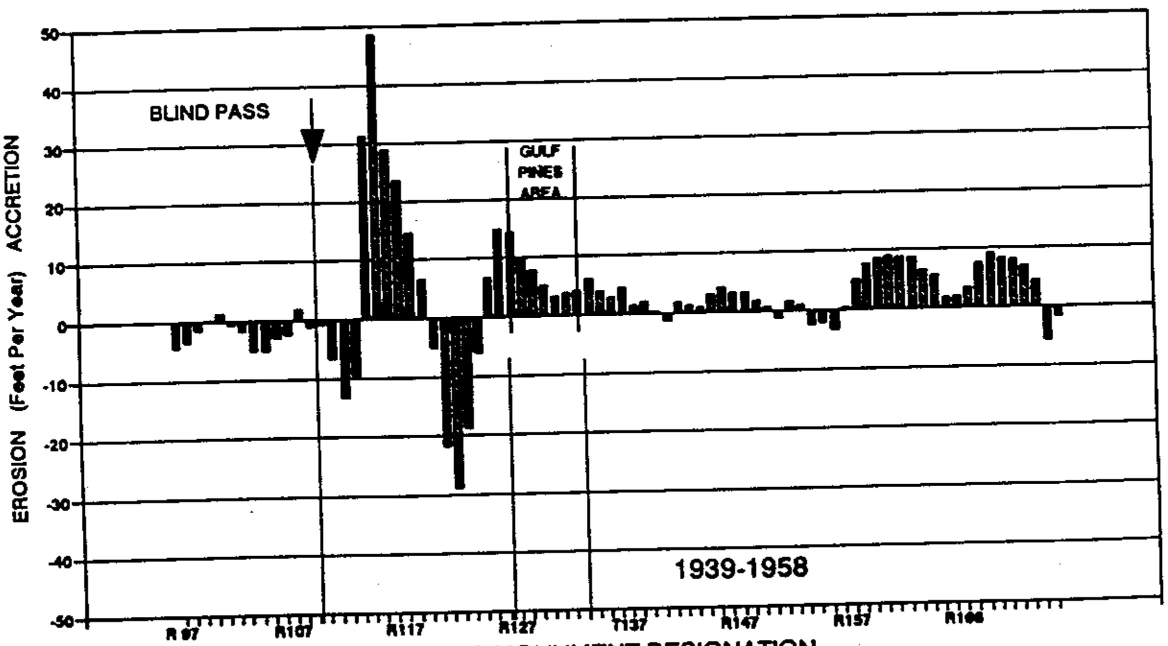
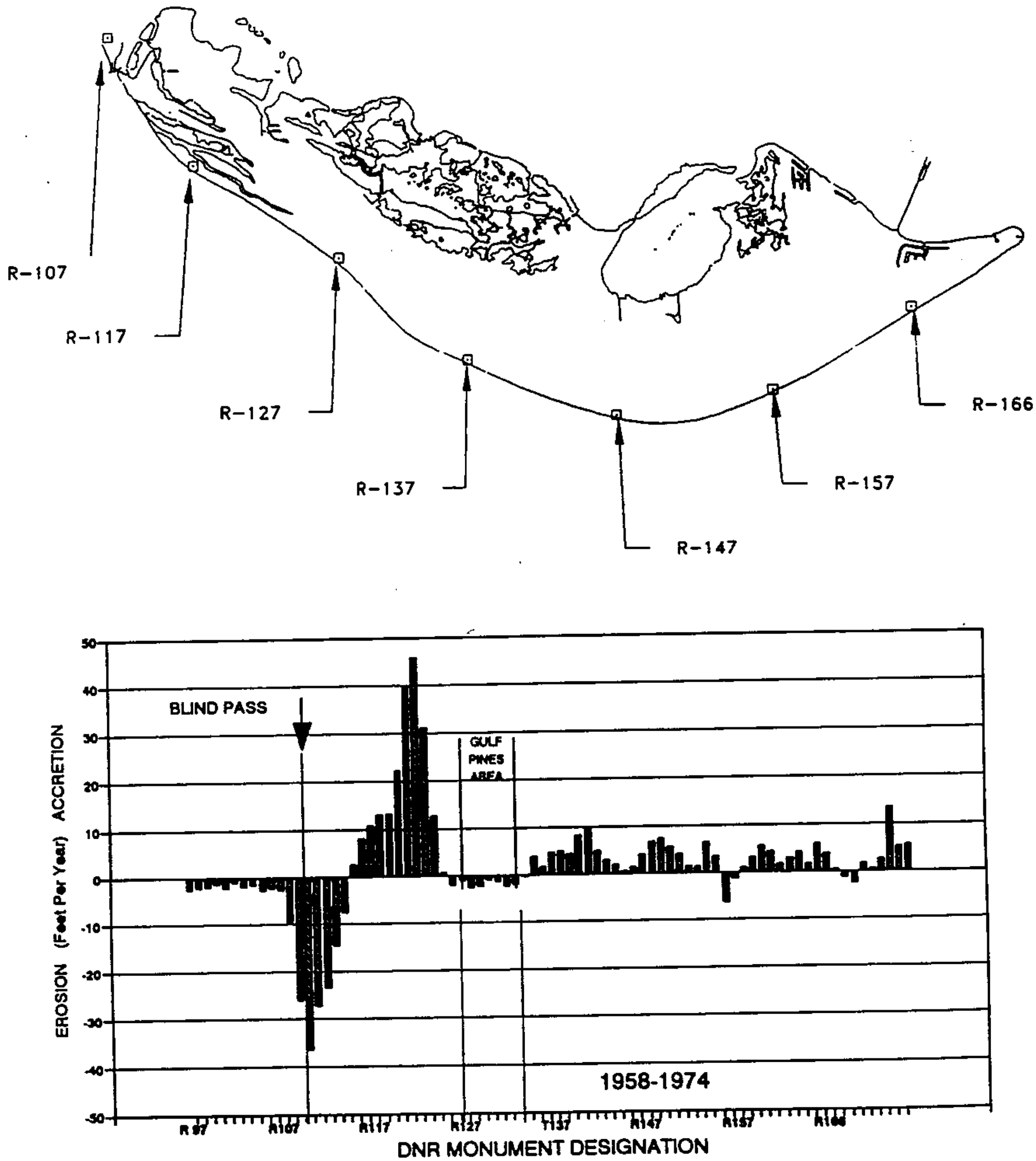

BLIND PASS
GULF
PINES
AREA
EROSION (Feet Per Year) ACCRETION
1939-1958
DNR MONUMENT DESIGNATION

FIGURE I-17



R-107
R-117
R-127
R-137
R-147
R-157
R-166
BLIND PASS
GULF
PINES
AREA
EROSION (Feet Per Year) ACCRETION
50
40
30
20
10
0
-10
-20
-30
-40
-50
1958-1974
DNR MONUMENT DESIGNATION

FIGURE I-18

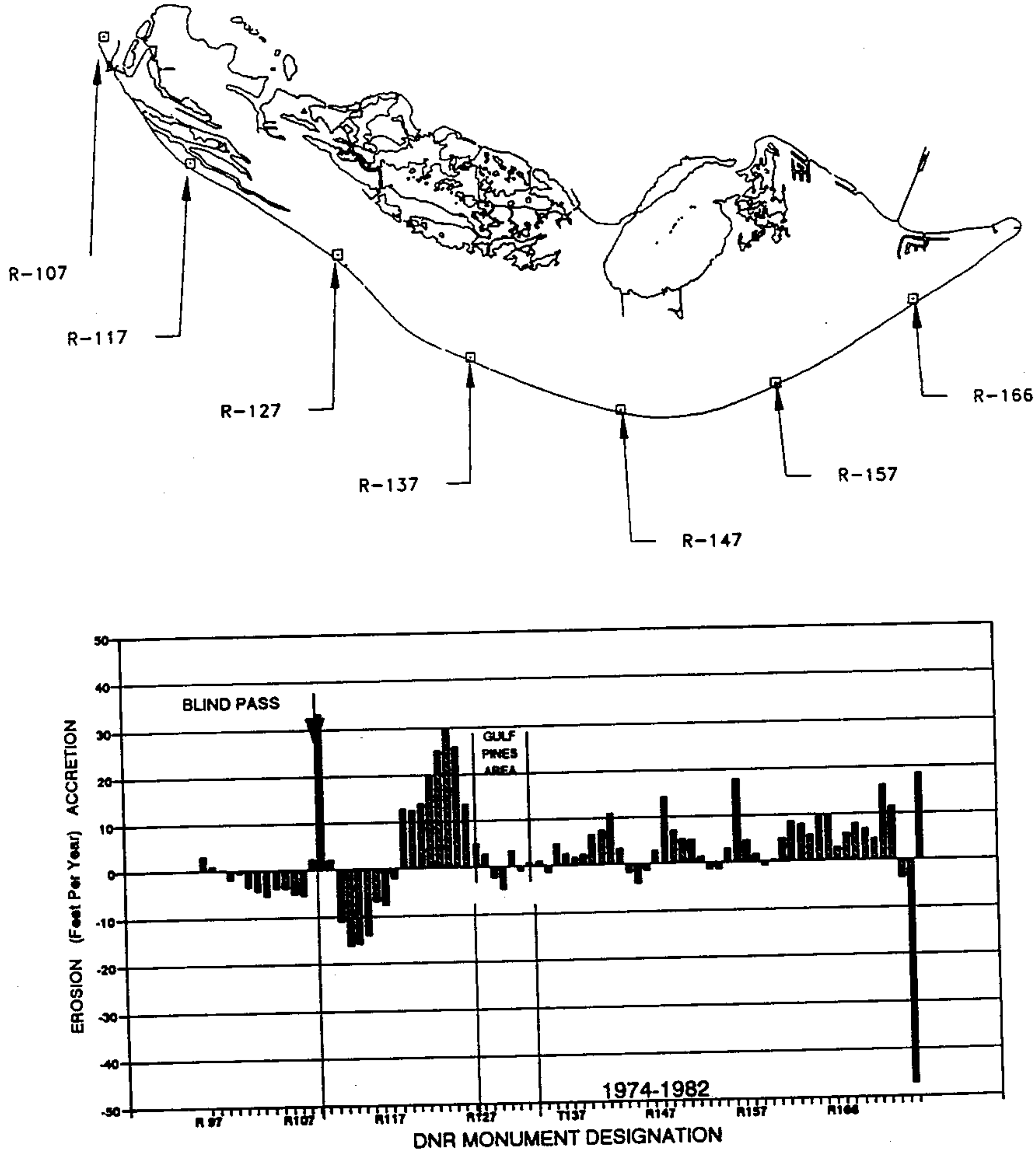
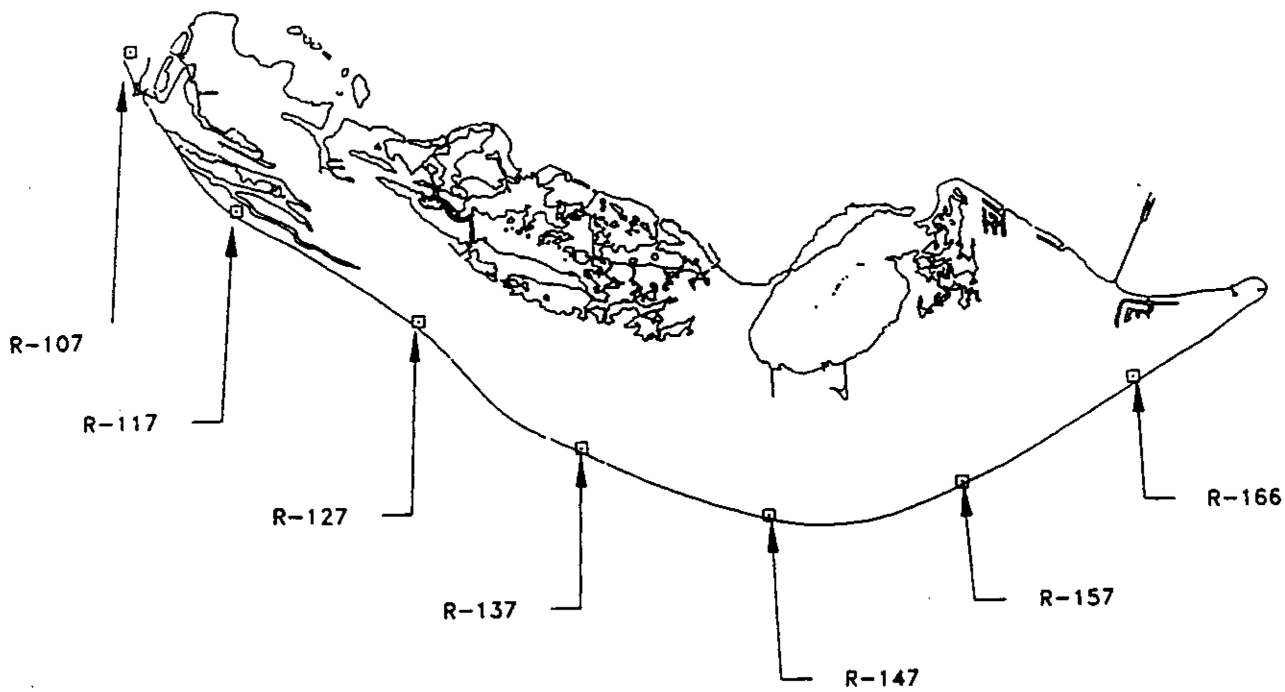

R-107
R-117
R-127
R-137
R-147
R-157
R-166
BLIND PASS
GULF PINES AREA
EROSION (Feet Per Year) ACCRETION
50
40
30
20
10
0
-10
-20
-30
-40
-50
1974-1982
R 97
R107
R117
R127
T137
R147
R157
R166
DNR MONUMENT DESIGNATION

FIGURE I-19


R-107
R-117
R-127
R-137
R-147
R-157
R-166

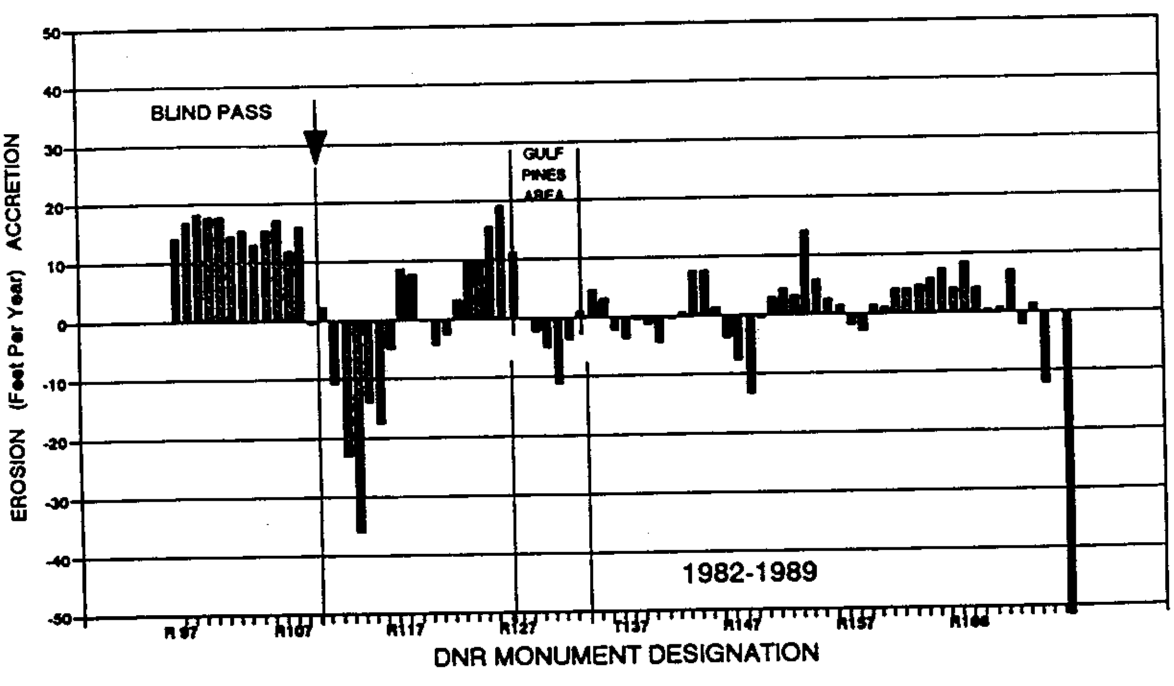

BLIND PASS
GULF
PINES
AREA
1982-1989
EROSION (Feet Per Year) ACCRETION
DNR MONUMENT DESIGNATION

FIGURE I-20

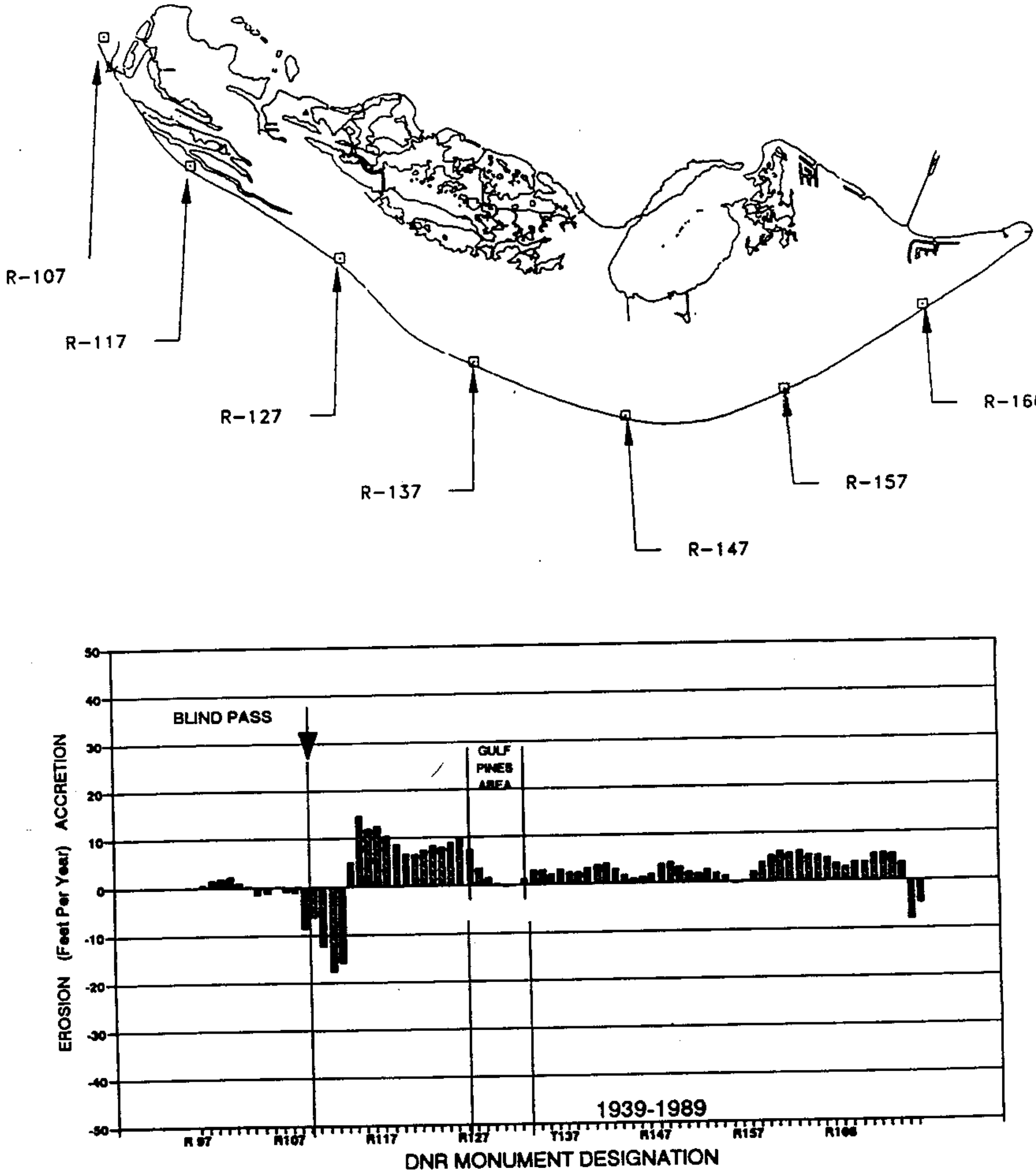

R-107
R-117
R-127
R-137
R-147
R-157
R-166
BLIND PASS
GULF
PINES
AREA
ACCRETION
EROSION (Feet Per Year)
50
40
30
20
10
0
-10
-20
-30
-40
-50
1939-1989
R 97
R107
R117
R127
T137
R147
R157
R166
DNR MONUMENT DESIGNATION

FIGURE I-21

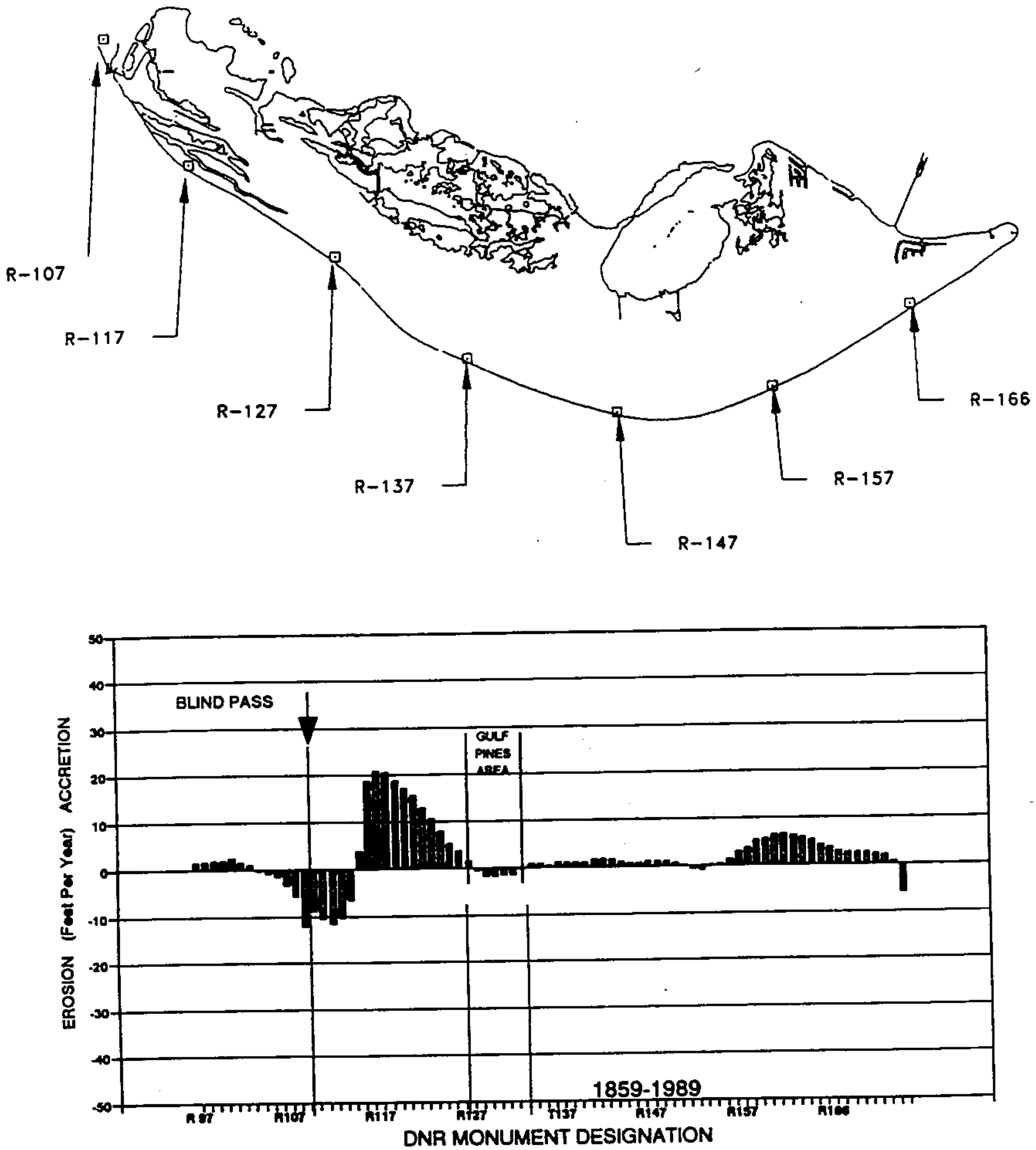

R-107
R-117
R-127
R-137
R-147
R-157
R-166
BLIND PASS
GULF
PINES
AREA
EROSION (Feet Per Year) ACCRETION
50
40
30
20
10
0
-10
-20
-30
-40
-50
1859-1989
R 97
R107
R117
R127
T137
R147
R157
DNR MONUMENT DESIGNATION

FIGURE I-22

5. R-156 to R-172. Accretion with an average of 4.0 feet per year. This represents 3.4 miles of gradually accreting shoreline.

6. R-173 to R-174. Point Ybel at the eastern extremity of the island experienced accretion and erosion, with an average change of -0.9 feet per year, over the last 0.4 mile of shoreline.

A significant characteristic of Figure I-16 is the relatively smooth transition in erosion rates from one zone to the next. This can be attributed to the fact that this figure represents changes which occurred over an 80 year period of time, which tends to smooth out high variability often seen over shorter periods of time.

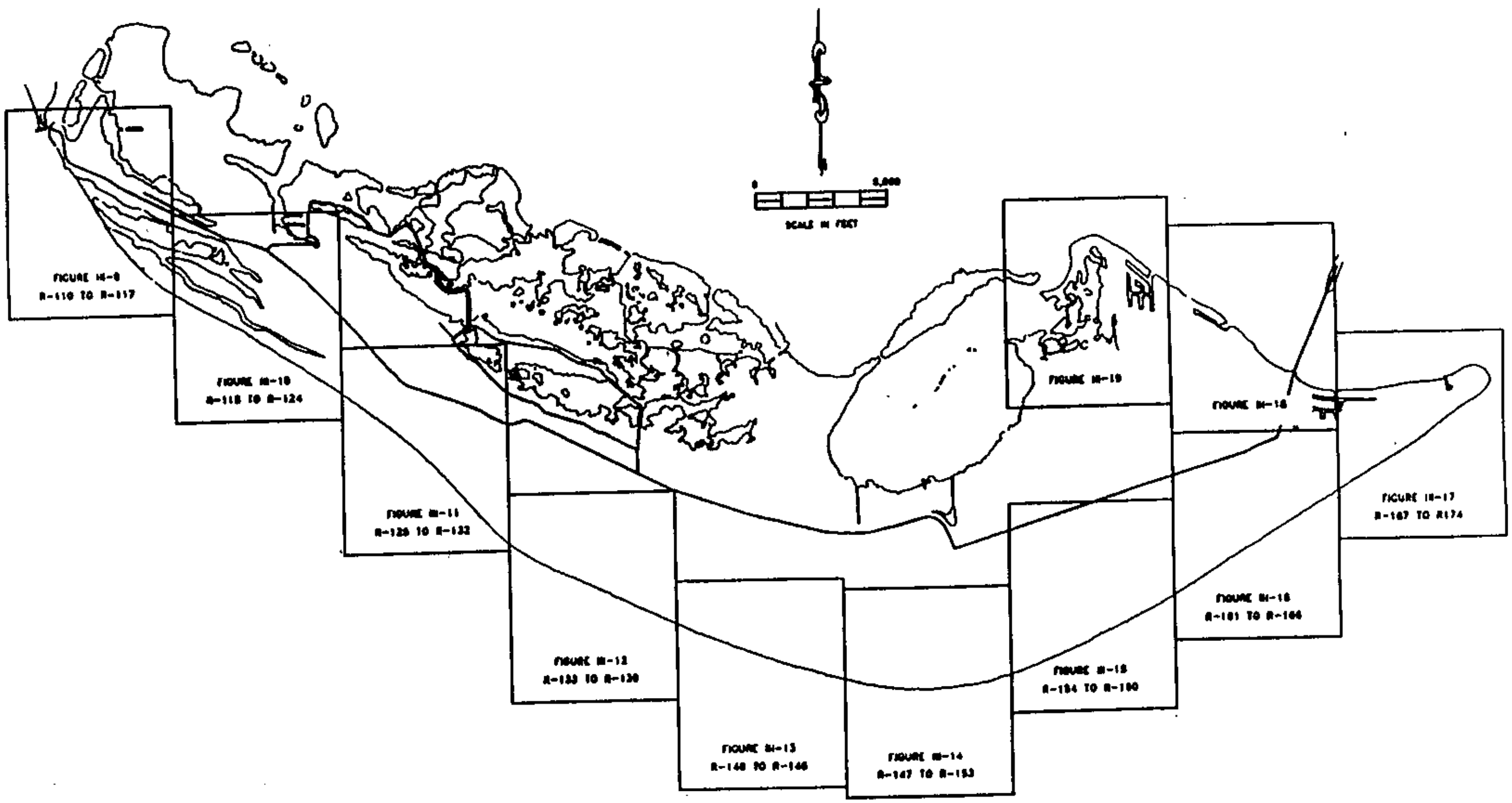
By contrast, Figures I-17, 18, 19, and 20 individually cover shorter periods of time ranging from seven to nineteen years long. These figures also show distinct zones of accretion and erosion, but with somewhat abrupt transitions along the coast and significant variability from one period of time to the next.

Figures I-17 through 20 cover a 50-year period between 1939 and 1989. Figure I-21 illustrates the cumulative result over that entire period, and illustrates again how long term trends show less variability; in this case exhibiting trends that are in many ways similar to the earlier long term rates shown in Figure I-16.

The final figure in this series, Figure I-22, represents long term rates over the entire 130-year period of record. This figure exhibits trends very similar to those seen in Figure I-16, although several shifts in the trends can be seen:

1. The erosion south of Blind Pass is focused a little further south but the band of erosion is slightly narrower.
2. The band of accretion immediately to the south is broader, extending from R-115 to R-127 (previously extended from R-116 to R-125).
3. The erosion in the Gulf Pines area has persisted, although over a slightly narrower area, and at a slightly reduced rate, notwithstanding the high recent short term rate seen in Figure I-20.
4. The relatively stable area from R-134 to R-155 has become slightly more accretional.
5. The rapidly accreting area from R-156 to R-172 has broadened slightly at both the north and south ends, but otherwise has shown little change.
6. Point Ybel has fluctuated between accretion and erosion.

The shoreline changes represented as change rates in Figures I-16 through I-22 are also represented in Figures I-23 through I-34 which are shoreline position change maps. These maps illustrate



SANIBEL ISLAND HISTORIC SHORELINE CHANGE MAP INDEX
BY DNR REFERENCE MONUMENT NUMBER

FIGURE I-23

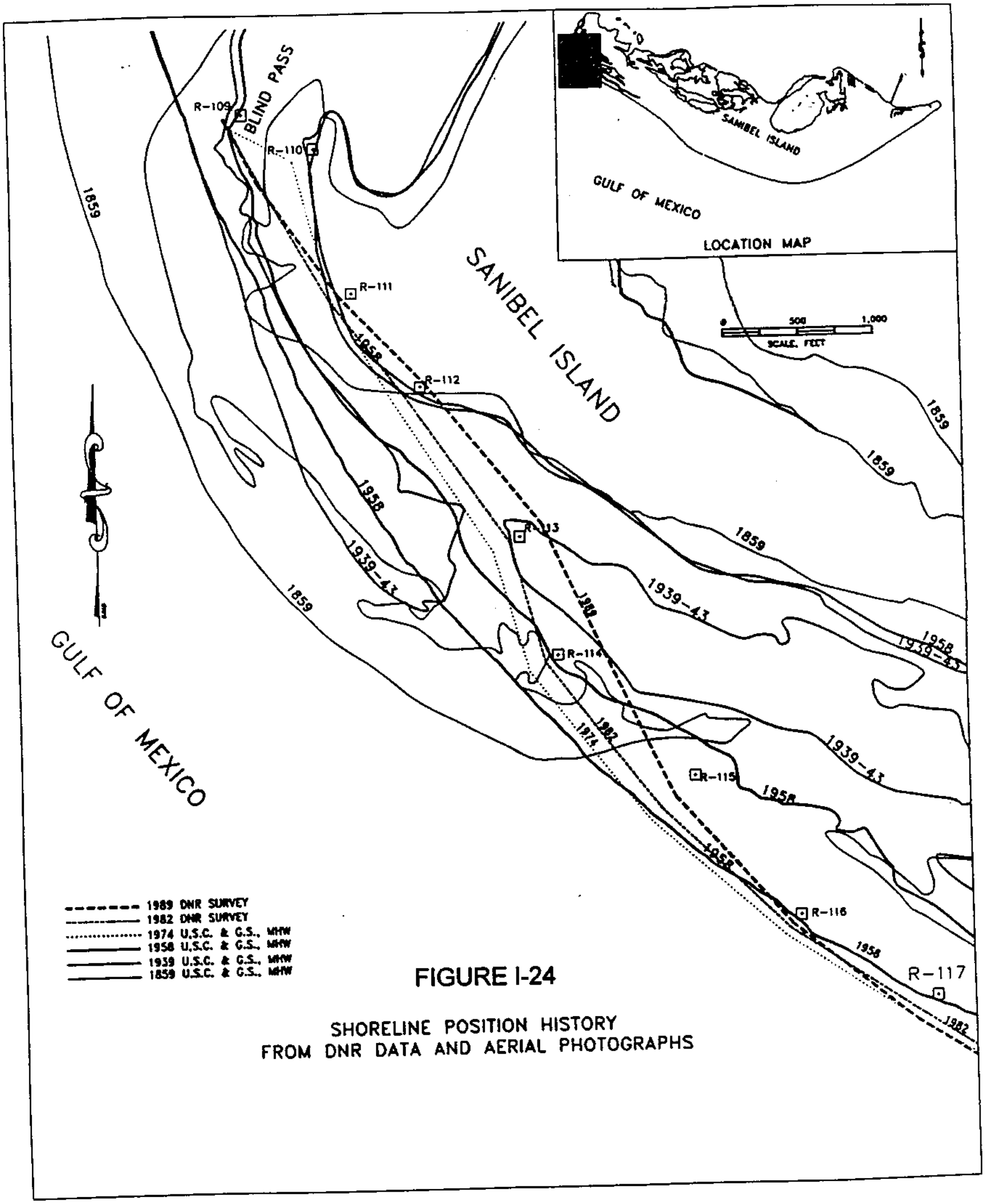


FIGURE I-24

SHORELINE POSITION HISTORY
FROM DNR DATA AND AERIAL PHOTOGRAPHS

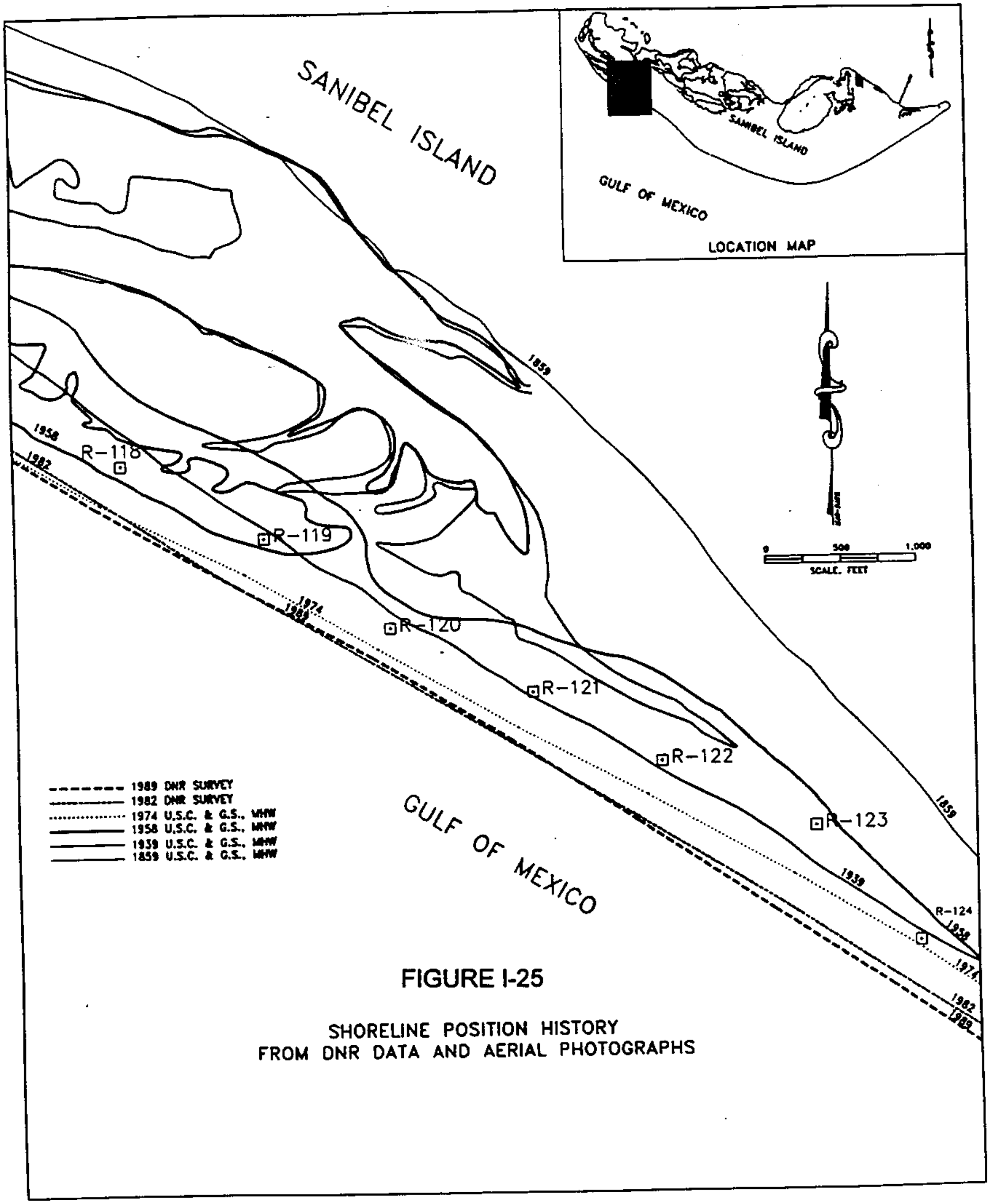


FIGURE I-25

SHORELINE POSITION HISTORY
FROM DNR DATA AND AERIAL PHOTOGRAPHS

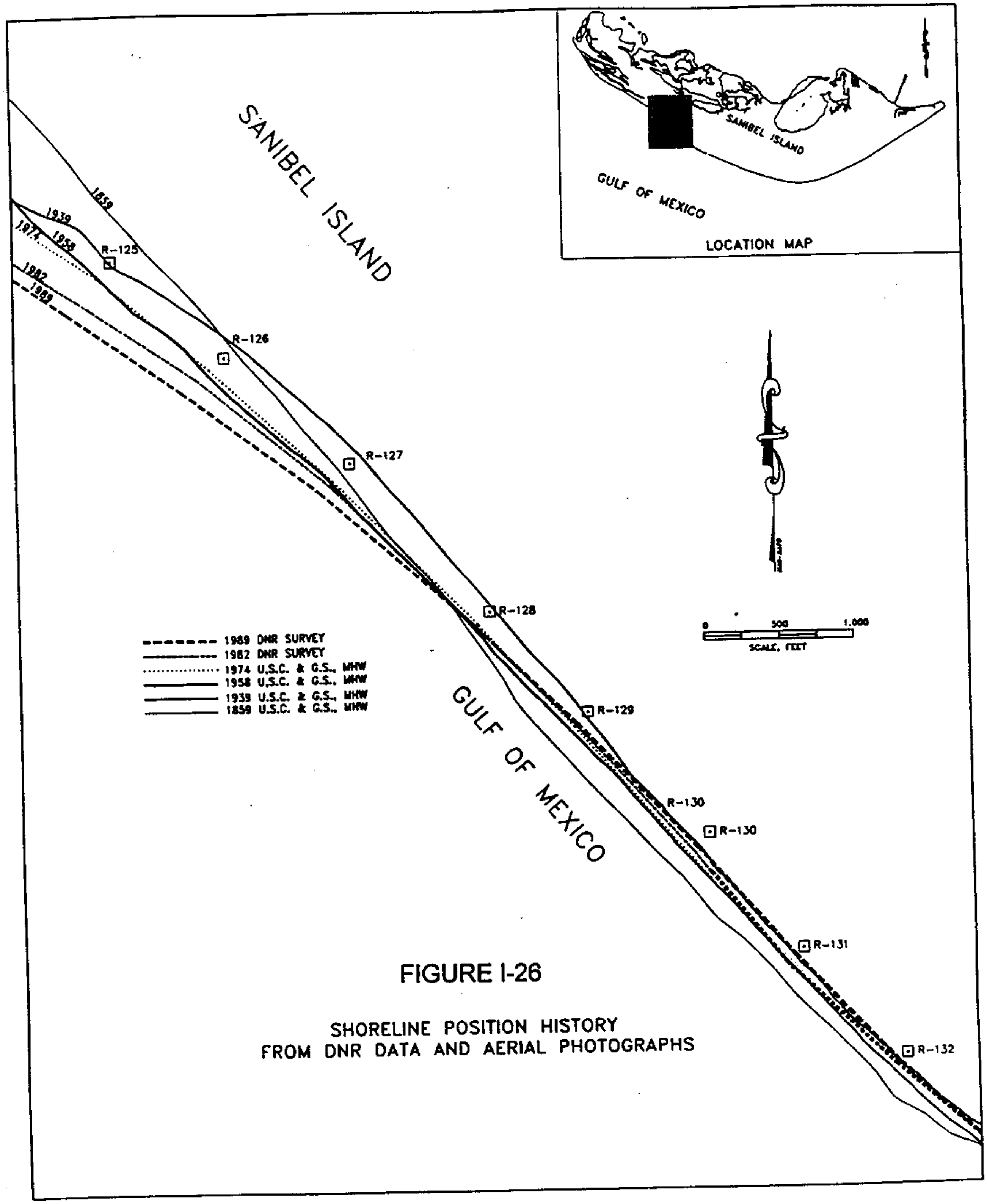


FIGURE I-26

SHORELINE POSITION HISTORY
FROM DNR DATA AND AERIAL PHOTOGRAPHS

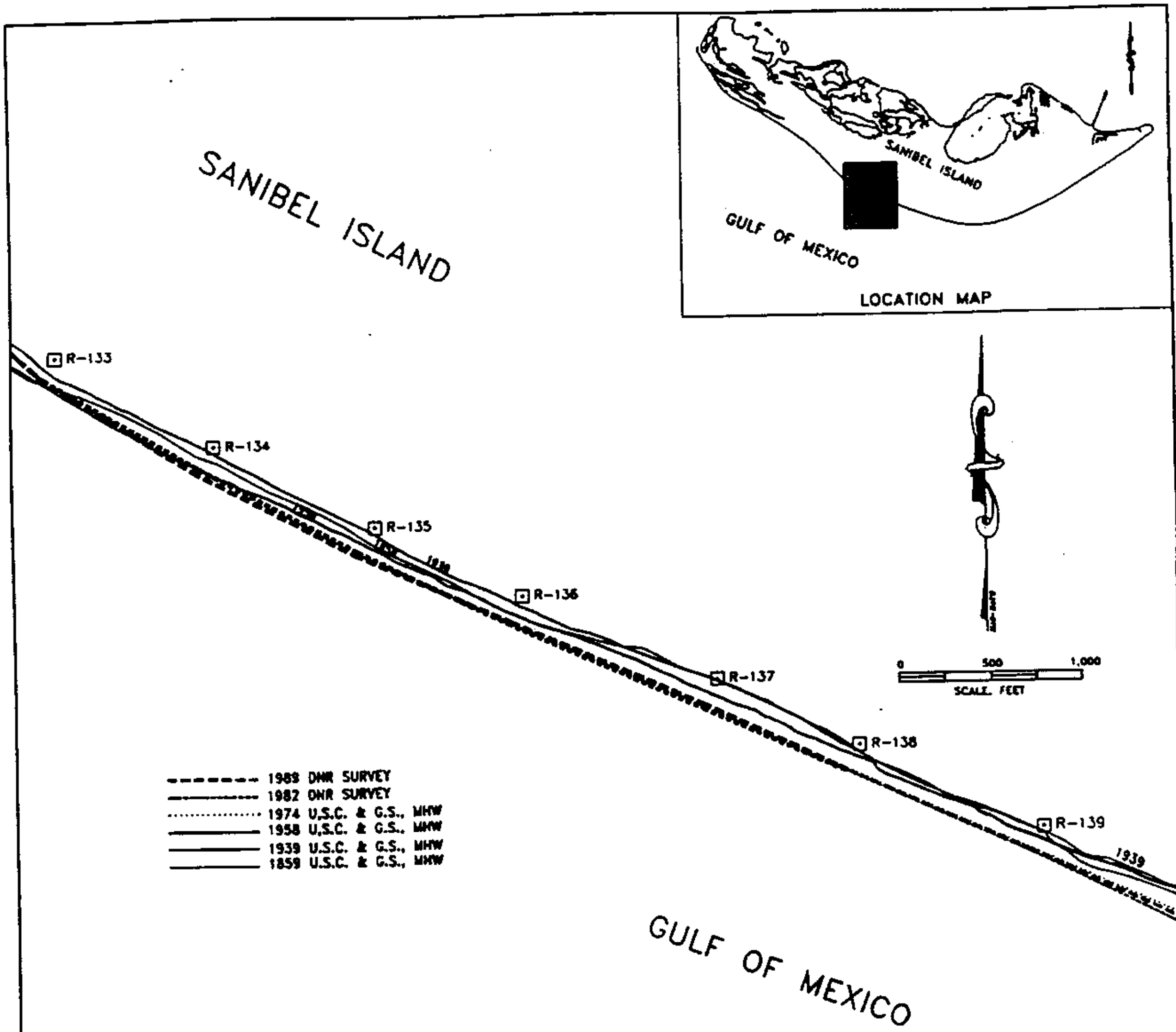


FIGURE I-27

SHORELINE POSITION HISTORY
FROM DNR DATA AND AERIAL PHOTOGRAPHS

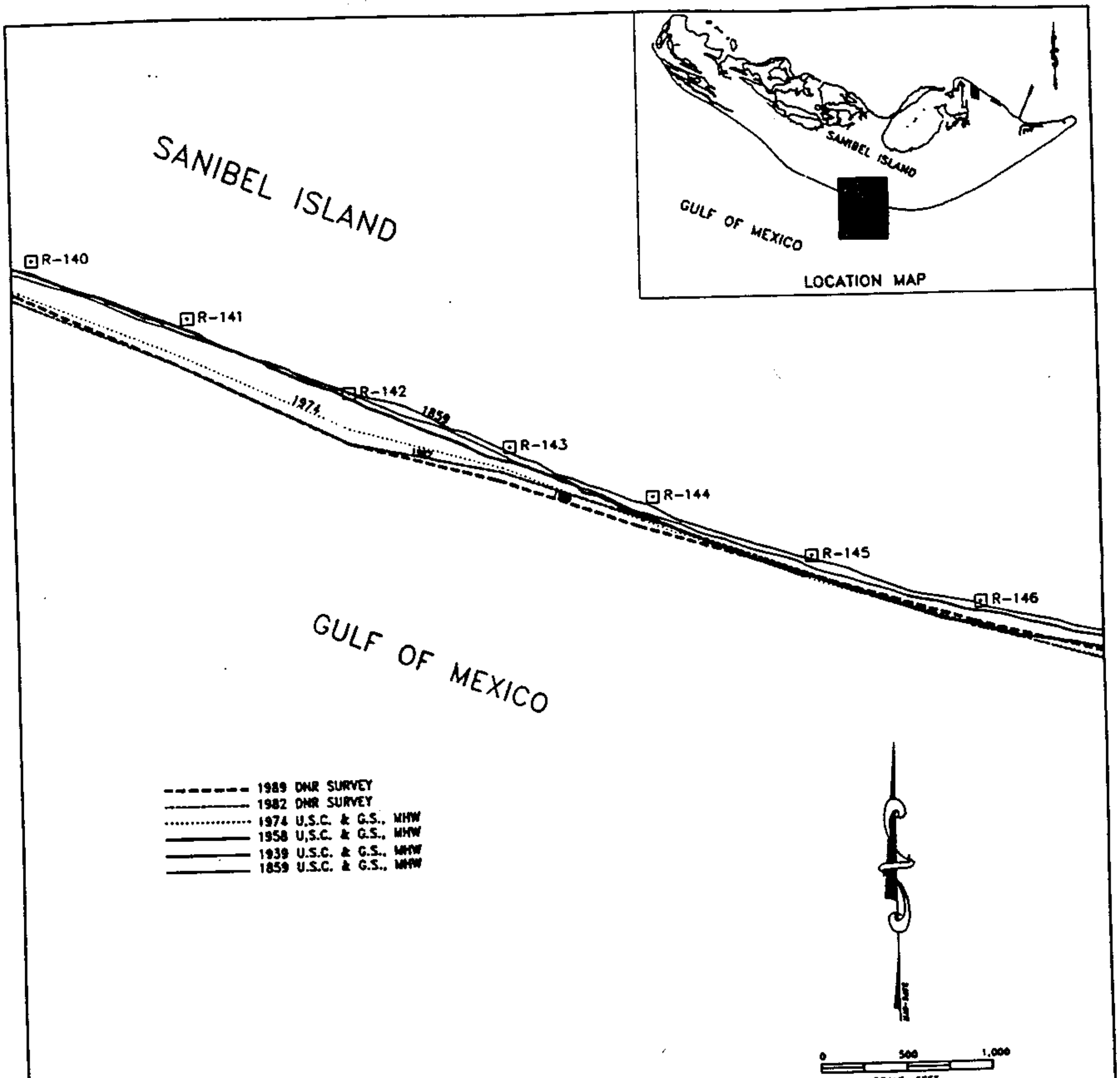


FIGURE I-28

SHORELINE POSITION HISTORY
FROM DNR DATA AND AERIAL PHOTOGRAPHS

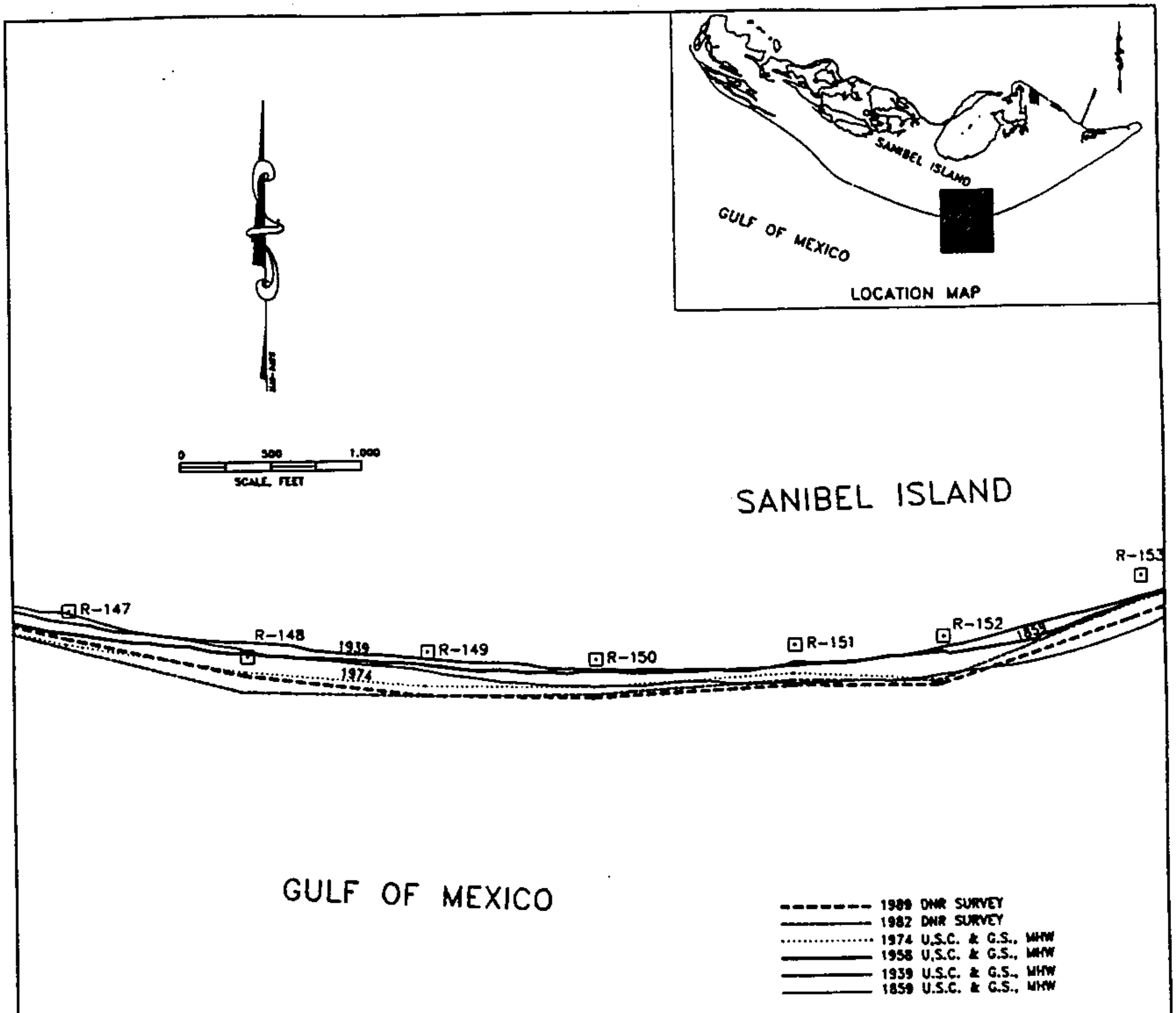


FIGURE I-29

SHORELINE POSITION HISTORY
FROM DNR DATA AND AERIAL PHOTOGRAPHS

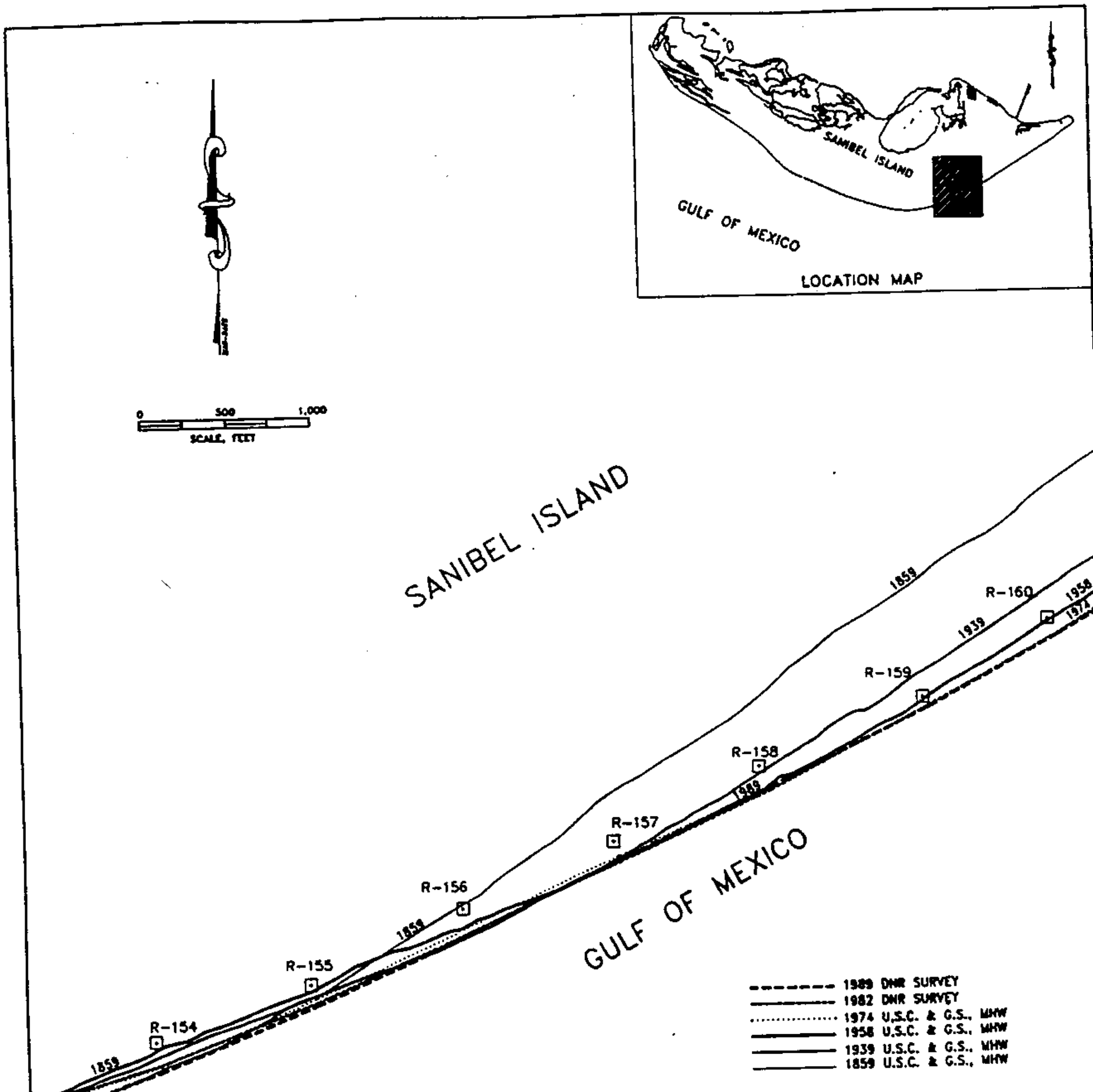


FIGURE I-30

SHORELINE POSITION HISTORY
FROM DNR DATA AND AERIAL PHOTOGRAPHS

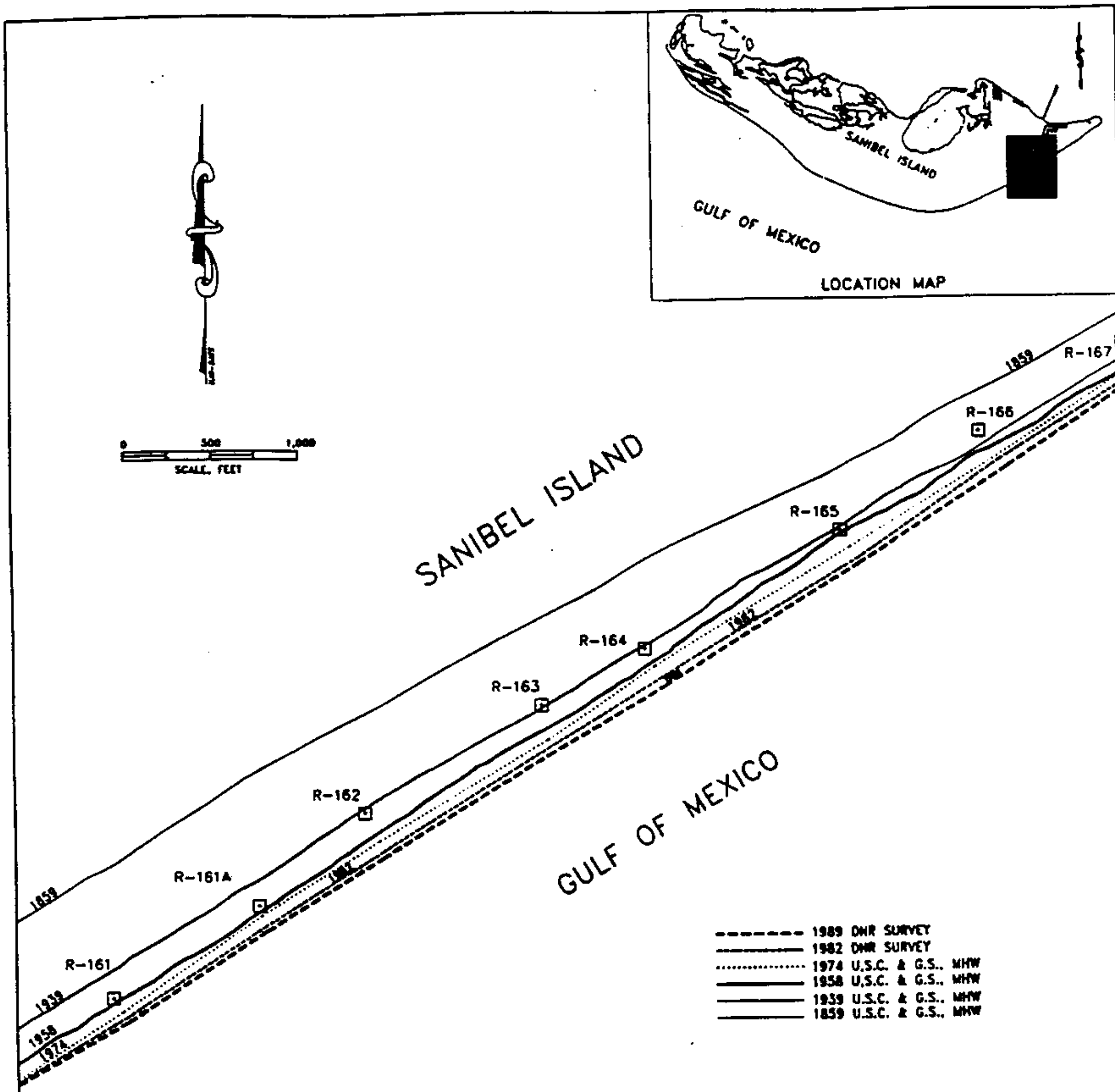


FIGURE I-31

SHORELINE POSITION HISTORY
FROM DNR DATA AND AERIAL PHOTOGRAPHS

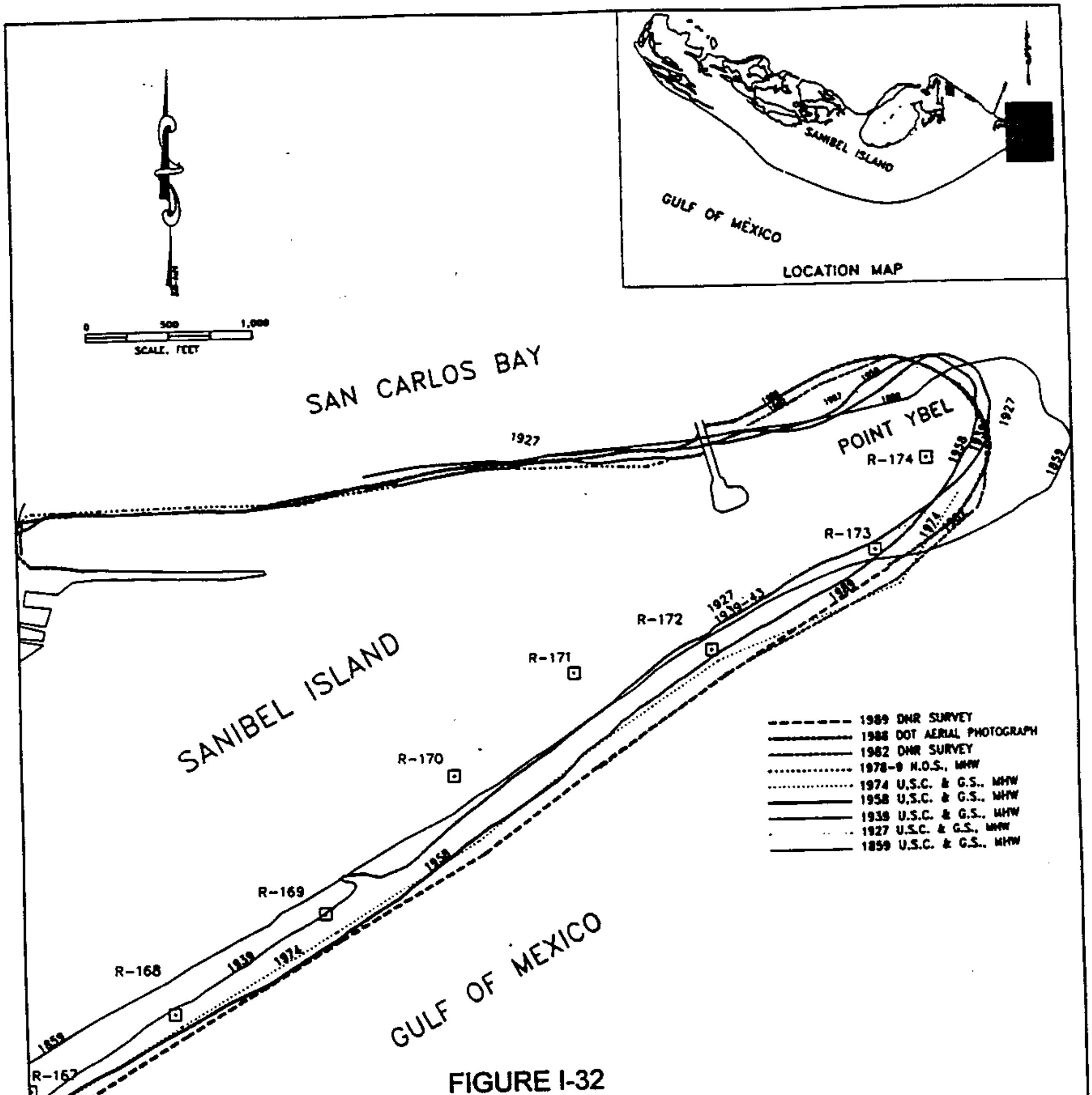


FIGURE I-32

SHORELINE POSITION HISTORY
FROM DNR DATA AND AERIAL PHOTOGRAPHS

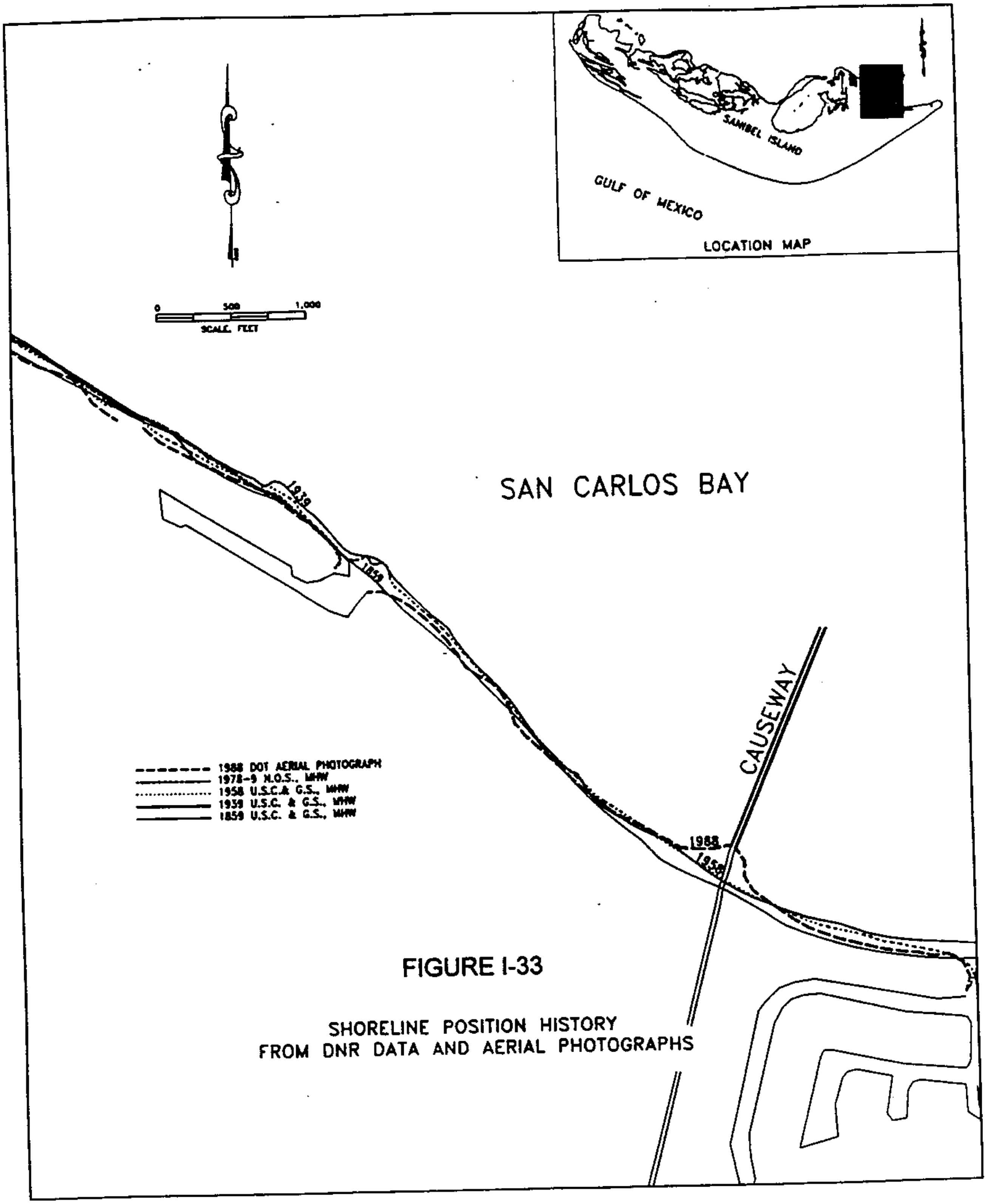


FIGURE I-33

SHORELINE POSITION HISTORY
FROM DNR DATA AND AERIAL PHOTOGRAPHS

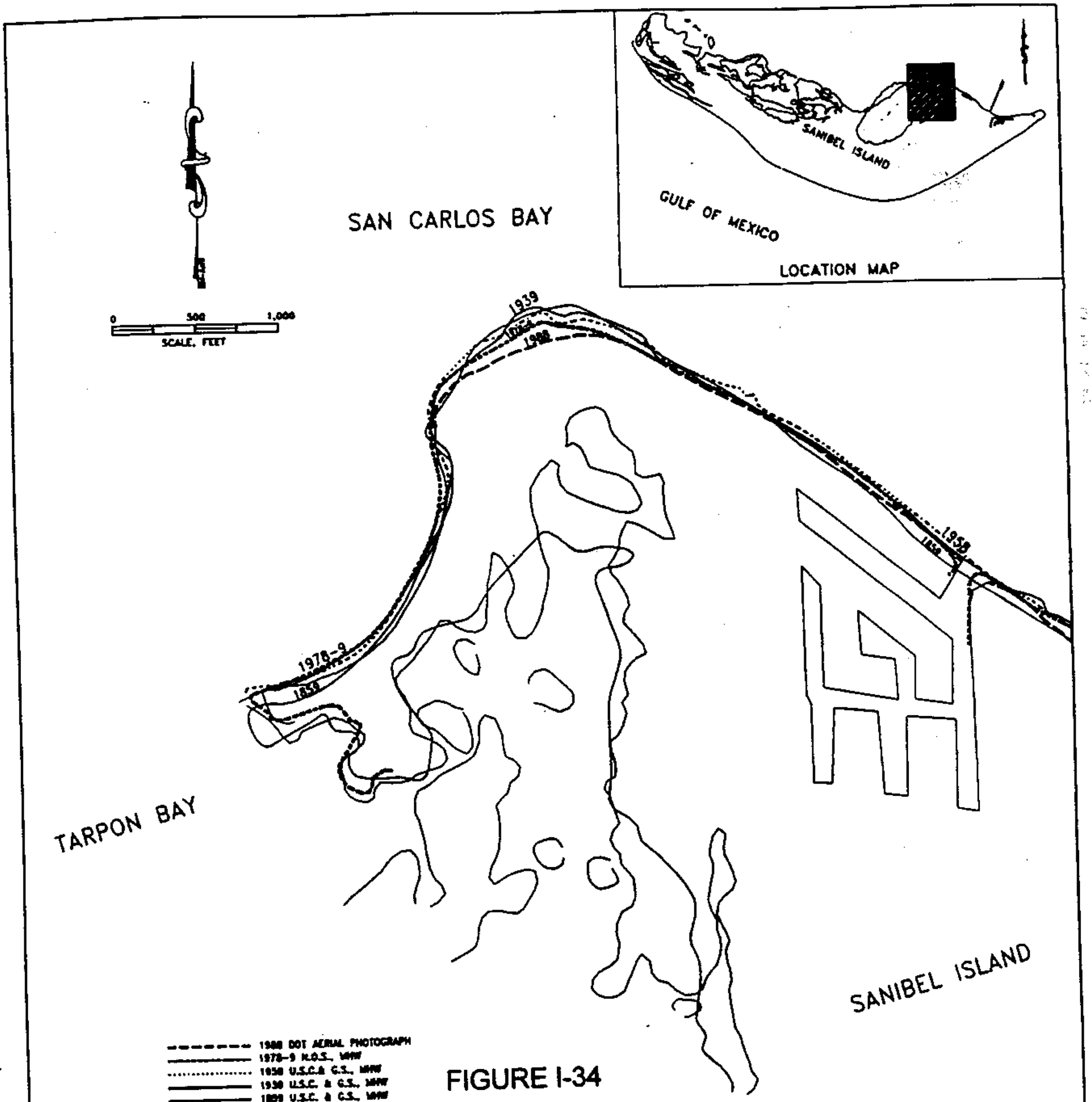


FIGURE I-34

SHORELINE POSITION HISTORY
FROM DNR DATA AND AERIAL PHOTOGRAPHS

how a particular change rate over a period of time translates into a shift in shoreline position.

This information can be used to identify and evaluate problem areas. For example, the Gulf Pines area has experienced persistent long term erosion. Although the rapid accretion immediately north of this area had extended into the Gulf Pines area between 1939 and 1958. Since 1958, the shoreline at R-128 has remained virtually unchanged, but erosion has persisted over several thousand feet of shoreline to the south. This is illustrated in Figure I-26. In conjunction with historic aerial photographs, it appears as if this may be a migrating coastal feature, and over the long term, it should be anticipated that this trend will continue.

1.2 Storm Erosion.

A recent study sponsored by the State of Florida Department of Environmental Protection (DEP, formerly DNR) and completed by the Florida State University Beaches and Shores Research Center was used in estimating the response of Sanibel's coastline to a major storm event. This DEP study was conducted as part of the reestablishment of the Coastal Construction Control Line (CCCL).

During impact of a major storm, erosion of the foredune area may be expected to continue until the storm surge overtops the dune area. Beyond this point the damage potential turns from beach and dune erosion losses, to storm surge and wave impact damage to upland structures. The CCCL location is therefore based on either the landward limits of erosion, or the landward penetration of a three foot wave, during a 100-year return interval storm event.

The average dune heights along Sanibel's coastline range from +6 to +8 feet NGVD in height. The predicted 100-year storm surge ranges from +12.4 to +14.0 feet NGVD. Because Sanibel is a low barrier island with a low dune area relative to the high storm surge, as illustrated in Figure I-35, the DEP study found that the most significant impacts would result from damaging storm surges and waves, while beach and dune erosion would not be extreme. Therefore, for Sanibel Island the CCCL reestablishment was based on the penetration of a three foot wave, except for the area including R-137 and R-138 located immediately south of the Gulf Pines area.

For the purposes of predicting the erosion anticipated during a 100-year return interval storm event, the DEP study employed the use of the Dean/Kriebel Dune Erosion Model. Input for the model includes a shape coefficient representative of the general profile shape and sediment size for a specific area of shoreline to be studied. In consideration of the offshore profile shape and sediment type along Sanibel's coastline, the DEP study divided the island into two sections. Section I extends from the northern limit of Sanibel to R-134 at the approximate southern end of the

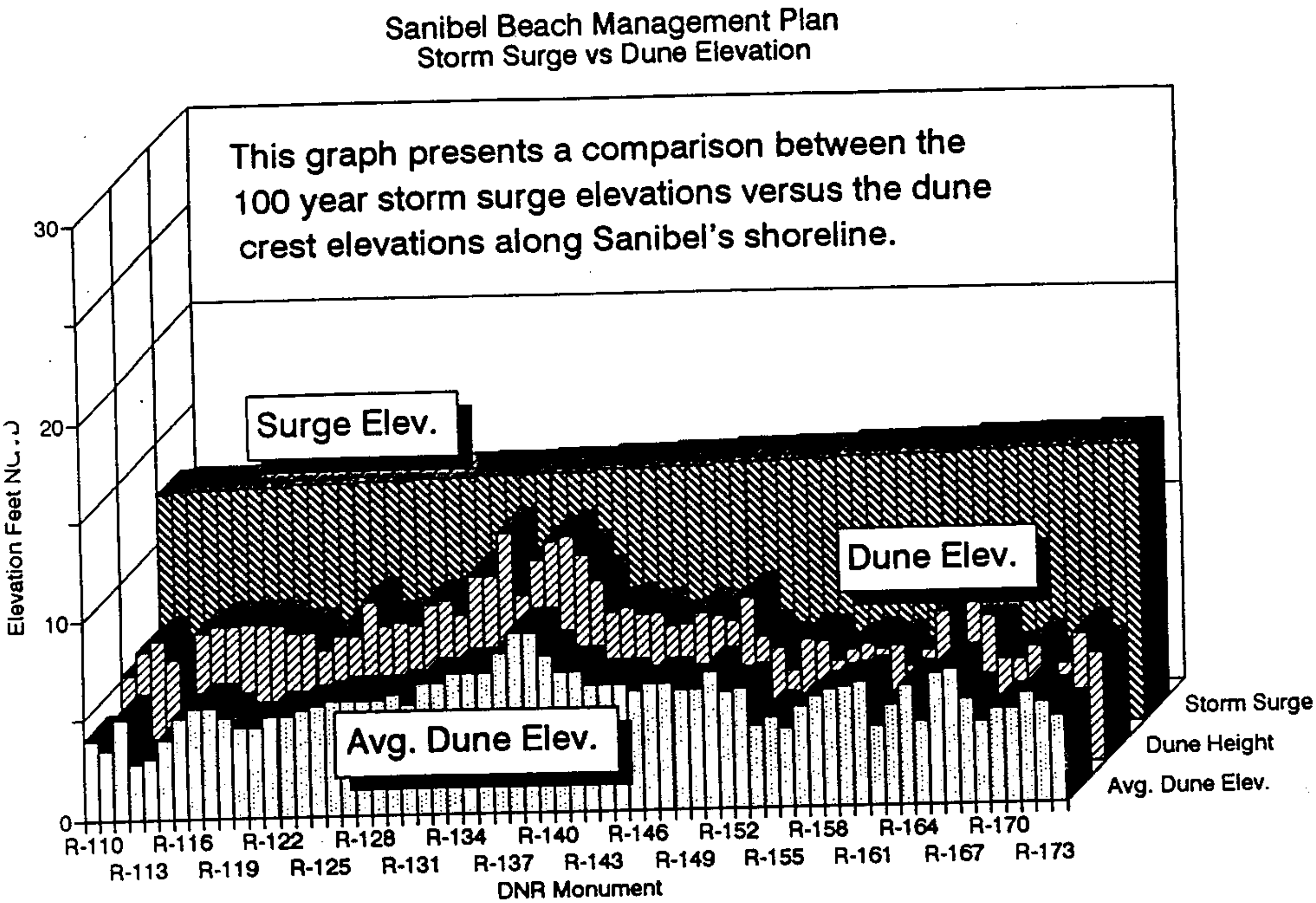

Sanibel Beach Management Plan
Storm Surge vs Dune Elevation
This graph presents a comparison between the 100 year storm surge elevations versus the dune crest elevations along Sanibel's shoreline.
Surge Elev.
Dune Elev.
Avg. Dune Elev.
Elevation Feet NGVD
30
20
10
0
R-110
R-113
R-116
R-119
R-122
R-125
R-128
R-131
R-134
R-137
R-140
R-143
R-146
R-149
R-152
R-155
R-158
R-161
R-164
R-167
R-170
R-173
DNR Monument
Storm Surge
Dune Height
Avg. Dune Elev.

FIGURE I-35

Gulf Pines area, and Section II continues from R-136 to the southern end of the island at DNR reference monument R-174. Input for the model also includes erosion model parameters shown in Figure I-36. A representation of the storm surge water elevation change as the storm passes, known as a storm hydrograph, is also needed to run the model. In applying the dune erosion model to the shoreline of Sanibel, the storm hydrograph was truncated once the dune was overtopped by the storm surge. This was done to simulate the maximum erosion anticipated during storm impact. The results indicate some limited erosion up to and including the dune crest with overtopping inland.

To complete this analysis, four representative profiles were selected and the dune erosion model used in the DEP study was applied to each profile. The results are shown on Figures I-37 through I-40, for the storm hydrographs shown in Figure I-41. The dune erosion predicted by the model for the four cases studied is shown below:

DNR Monument	Erosion (-) or Accretion (+) at Contour Elevation in Feet NGVD		
	+6 feet	**+5 feet**	**0 feet**
SECTION I			
R-116	-49.1	-30.2	+22.6
R-125	-35.3	-16.5	+58.5
SECTION II			
R-148	-52.0	-39.4	+173.3
R-166	-25.0	-36.1	+128.6
Average	-40.4	-30.6	+95.8

TABLE I-4

POST STORM PROFILE

The storm profile predicted by the model is dependent upon the beach profile shape factor used for the two areas. The shoreline north of R-135 from Gulf Pines to Blind Pass is expected to have a steeper post storm profile while the southern area is expected to have a flatter post storm profile. This is illustrated by the significant advancement of the 0 foot contour for the profiles in Section II.

For general planning considerations, the 5 to 6 feet dune elevation is expected to recede on the order of approximately 30 to 40 feet. Structures upland of that area may be expected to be impacted by surge levels as high as 14 feet NGVD and storm waves having crest elevations up to +18 to +19 feet NGVD.

The results of the storm surge analysis indicate minor erosion from a 100-year storm. This is because the low dune system is overtopped by the storm surge. Being totally inundated, the dune is

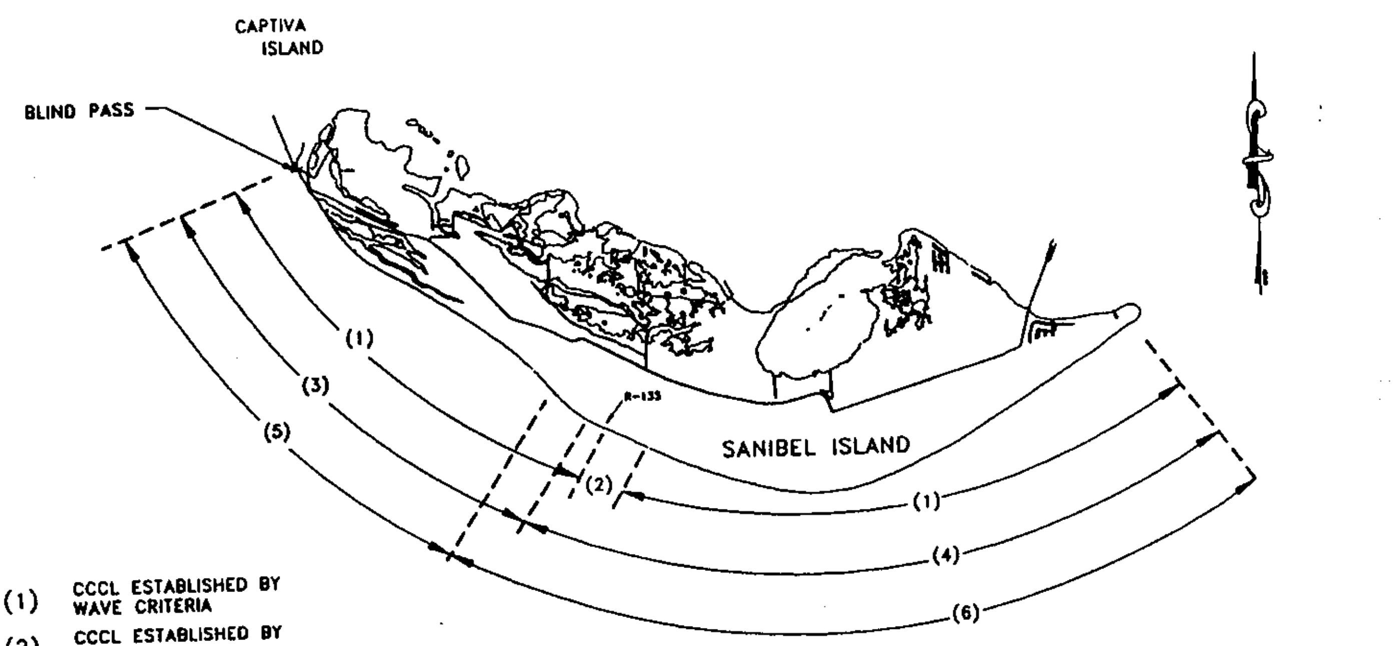


FIGURE I-36

VARIATION IN STORM
EROSION MODELLING PARAMETERS
FOR SANIBEL ISLAND

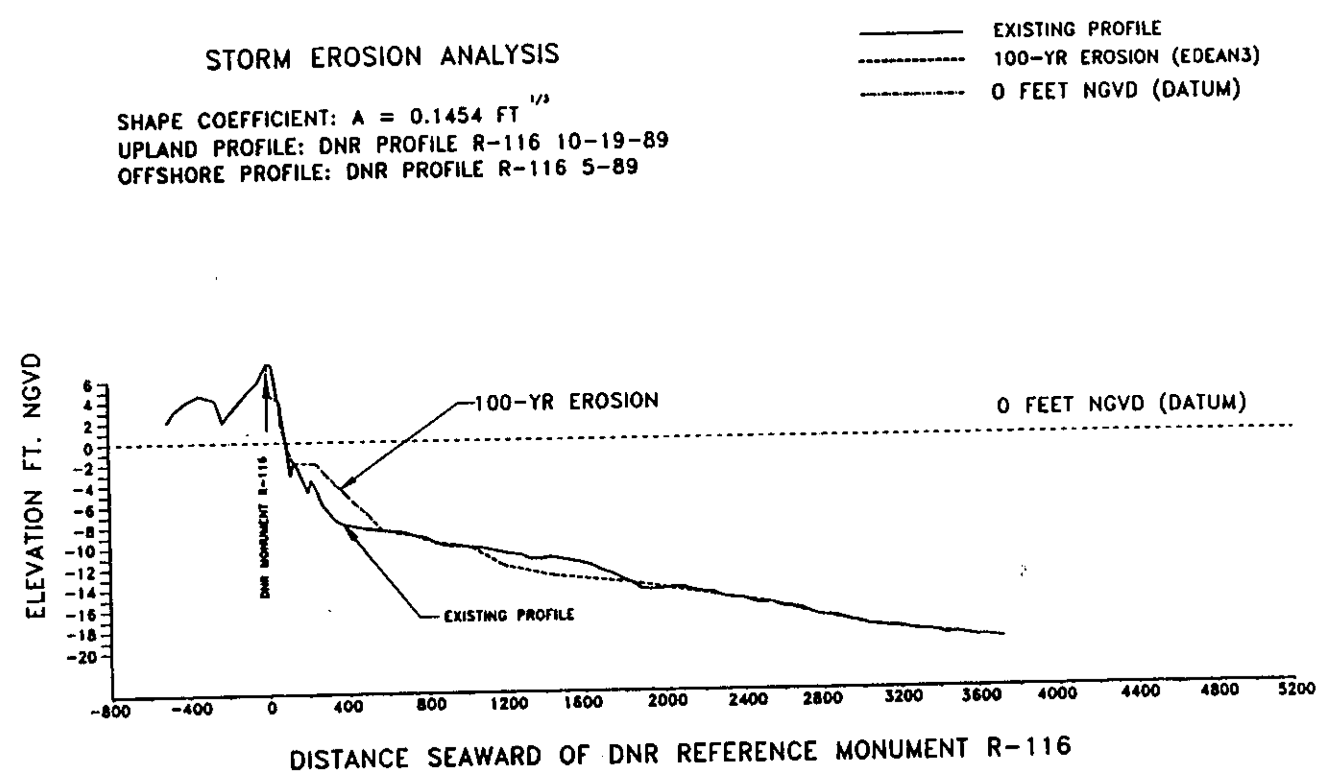


FIGURE I-37

STORM EROSION ANALYSIS

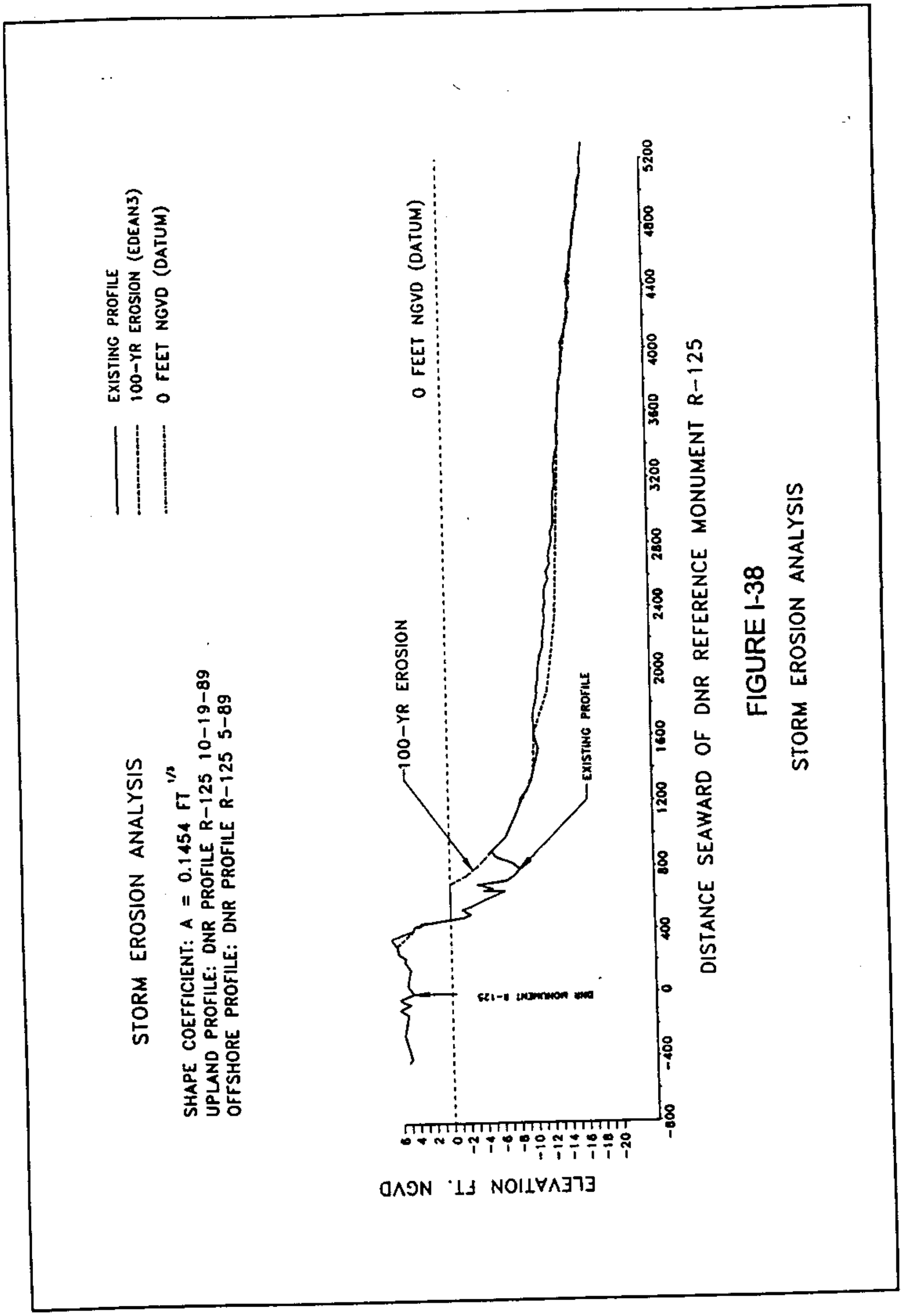


FIGURE I-38

STORM EROSION ANALYSIS

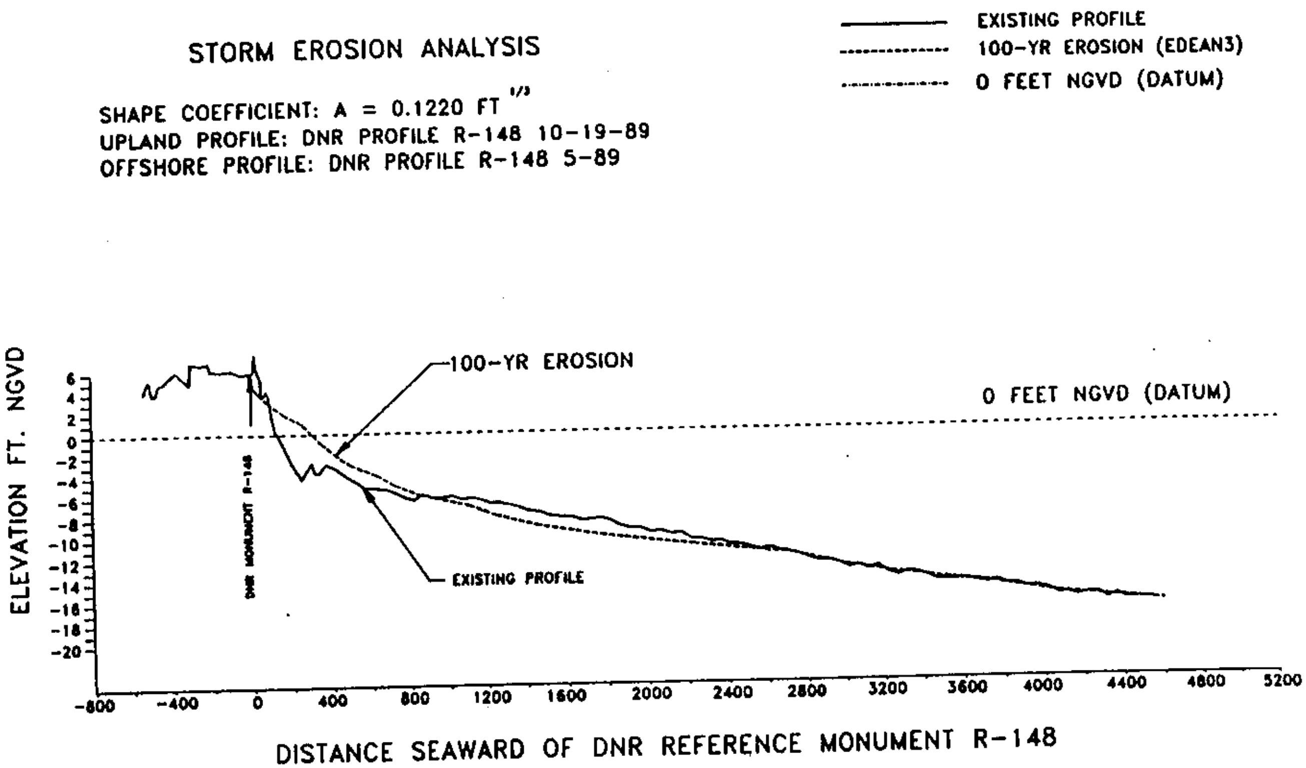


FIGURE I-39

STORM EROSION ANALYSIS

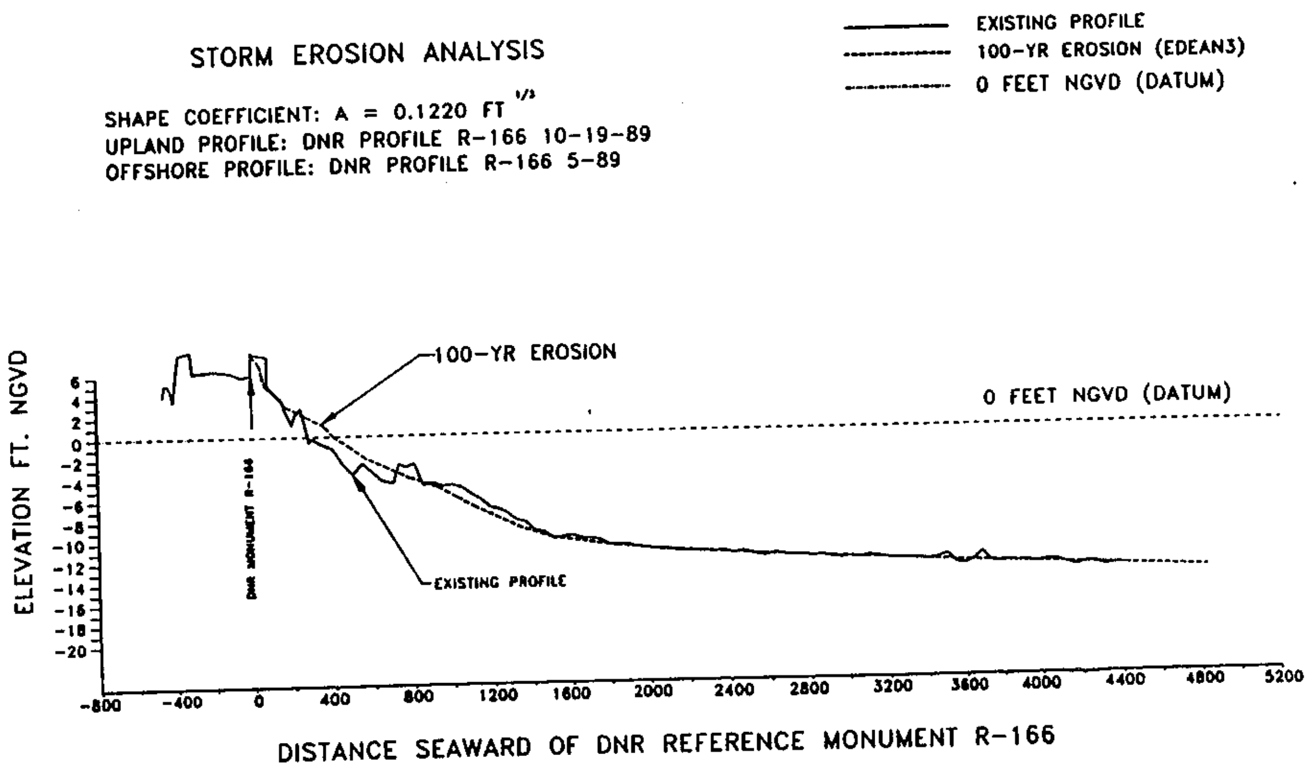


FIGURE I-40

STORM EROSION ANALYSIS

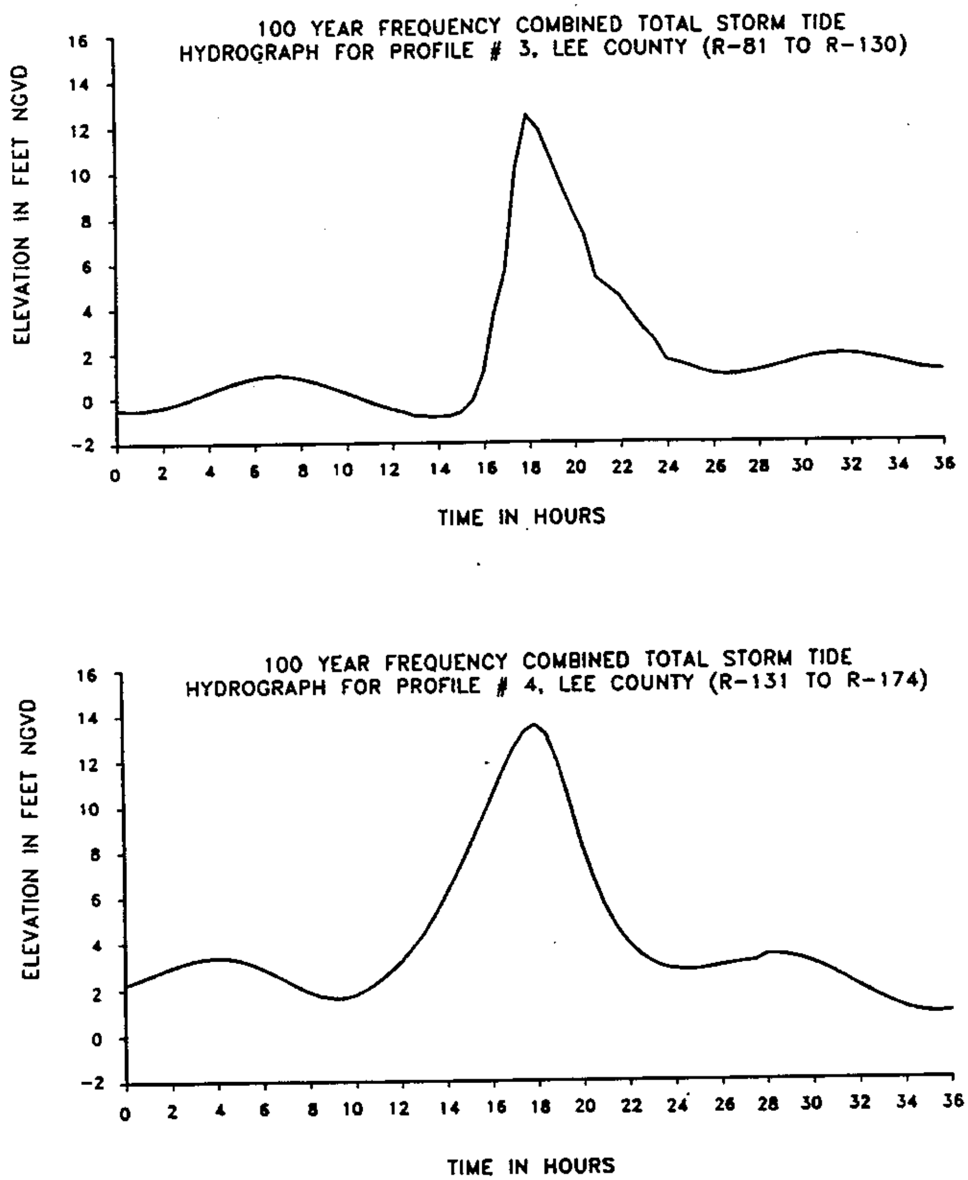


FIGURE I-41

STORM HYDROGRAPHS FOR SANIBEL ISLAND

below the elevation where the most erosive wave action would occur. It should be considered that more severe erosion of this low dune system would result from a higher frequency storm with a storm surge of perhaps only five to eight feet.

1.3 Identification of Problem Areas.

Although the shoreline change information shows that Sanibel Island has historically, and is predominantly accretional, there are three locations along the gulf shoreline which have erosion problems.

Blind Pass. The shoreline south of Blind Pass has recently experienced severe erosion. Because of the fact that this section of shoreline receives littoral drift from the north which is the supply of sand for Sanibel Island's beaches, and other unique aspects of this situation, it is described in detail in Section C.3.

Gulf Pines and Gulf Shores. As can be seen on the shoreline change map, Figure I-26, there is a section of shoreline approximately 6,000 feet long which has consistently experienced erosion. Although the survey data on shoreline position shows a relatively slow erosion rate, the erosion has been persistent, and the cumulative effect is that homes in the area are now being threatened. As described in Section I.D, the sand budget analysis shows that the problem is due to a combination of wave refraction by the offshore bathymetry and the orientation of the shoreline. These features are relatively permanent, and it is therefore anticipated that the erosion stress on this section of the coast will continue.

Point Ybel. As can be seen by the shoreline changes illustrated in Figure I-32, Point Ybel has been very dynamic, loosing over 600 feet of upland to erosion between 1859 to 1958. Since 1958 the beach has recovered some on the southeast, continued to erode on the east and northeast sides, and accreted on the north side. The pattern of erosion and accretion is having the effect of bending the point around to the north.

1.4 Previous Erosion Control Efforts.

Blind Pass Area. Shore protection has been attempted on an individual basis on several properties south of Blind Pass. These efforts have consisted of a wooden seawall, a rock revetment, and a concrete seawall on two properties immediately north of Clam Bayou. The first two have been insufficient to protect the properties from the ongoing erosion in this area; two rental units and one single family home have been destroyed, and a third home still standing on piles is completely surrounded by water. The concrete seawall was built as a subgrade structure by new owners soon after purchasing the property in 1989, and due to the ongoing erosion it is now exposed to direct wave energy from the gulf. As described more thoroughly in Section C.3, there is a permit for the Blind Pass groin extension which contains regulatory conditions requiring mitigation of erosion in this area. Additionally, the City of Sanibel has had several surveys done to evaluate the erosion in this area, and presently an inlet management plan is being prepared by the Captiva Erosion Prevention District. These ongoing efforts which should address this erosion problem are also more thoroughly discussed in Section C.3.

Gulf Shores Area. A Beach Erosion Study of the Gulf Shores area was prepared for the City of Sanibel by Taylor Engineering in 1991. This study evaluated several alternatives and recommended an offshore breakwater as potentially the most effective solution, and beach nourishment as the least risky but potentially most expensive solution. The recommendations of the Taylor report have not been implemented. Attempts have been made to protect the upland in the Gulf Pines area with a sandbag revetment. In spite of this effort, the erosion has continued.

2. Bay Shoreline.

Most of Sanibel Island's bay shoreline is natural undeveloped mangrove fringe, which in some areas has a narrow intertidal strip of sand. These mangrove areas appear to be stable based on comparison between 1944 and 1988 aerial photographs. This area is generally not subject to high wave energy, and any change to occur in this area by natural processes would be gradual and would not be expected to change the character of the shoreline.

Between the entrance to Tarpon Bay and Point Ybel to the east, there is approximately 3.4 miles of shoreline characterized by a narrow sandy beach with a low beach berm, and mostly developed upland. This area is also exposed to lower wave energy than the gulf beaches, but it does receive enough wave energy through the broad entrance to San Carlos Bay to maintain a sandy beach in contrast to the mangrove fringed areas further to the west. This section of the management plan will be limited to discussion of the sandy beach areas along the section of the shoreline that lies on either side of the causeway between the entrance to Tarpon Bay and Point Ybel.

2.1 Long Term Shoreline Trends.

Long term shoreline changes are shown in the shoreline change maps in Figures I-32, I-33, and I-34. This shoreline bordering San Carlos Bay has in general been more stable than the gulf shoreline. Exceptions are the eastern most end at point Ybel, and the western end near the entrance to Tarpon Bay.

A baseline was drawn to establish locations for analysis of shoreline change trends from the shoreline change maps. The baseline is shown in Figure I-42. Figures I-43 through I-54 illustrate shoreline changes and shoreline change rates for the bay shoreline. The earliest period from 1859 to 1939, illustrated in Figures I-43 and I-44, shows the area to be mostly accretional. The next period, from 1939 to 1953, illustrated in Figures I-45 and I-46 shows an eroding shoreline.

Recent shoreline change data on the bay shoreline is not as plentiful as it is for the gulf shoreline. This is primarily because the DEP Coastal Construction Control Line program only monitors the gulf shoreline. Data available for the bay shoreline is derived from maps and aerial photographs, and therefore may not be as complete or as accurate as the more recent monitoring surveys which are available for the gulf coast. Because of the uneven availability of data along the bay shoreline, Figures I-47 through I-52 represent some overlapping time periods in an effort to present as complete a picture of these shoreline trends as possible. Some of the trends that may be seen could be due to effects of the jetties constructed at the basin entrance at Ferry Landing in the 1950's, and construction of the Causeway in the early 1960's, as well as the construction of a variety of revetments and seawalls. Figures I-53 and I-54 illustrate long term changes from 1859 to 1988.

2.2 Short Term Trends.

The most recent period of time for which data is available is 1978 to 1988 as shown in Figures I-51 and I-52. This figure shows that most of the shoreline is experiencing erosion, with the exception of the eastern most 3,000 feet which includes the north side of point Ybel. However, other sources of information, including site inspections, recent photographs, and a 1981 report prepared for Ray Fenton Associates, by Missimer and Associates and David T. Tackney, P.E., indicate that there is a pocket of erosion in this eastern area as well. This erosion is most notable in the area west of the jetties at the canal entrance to the boat basin at the Lighthouse Point Condominium.

2.3 Previous Erosion Control Efforts: Inventory of Structures.

Figure I-55 shows the approximate location and type of armoring prevalent along this section of Sanibel Island's bay shoreline. The information on this drawing was derived from a site inspection and aerial photographs and therefore the location and extent of the shoreline armoring is approximate. It is intended here to illustrate the prevalence and relative distribution of armoring as an indication of the erosion problems along this section of the shoreline.

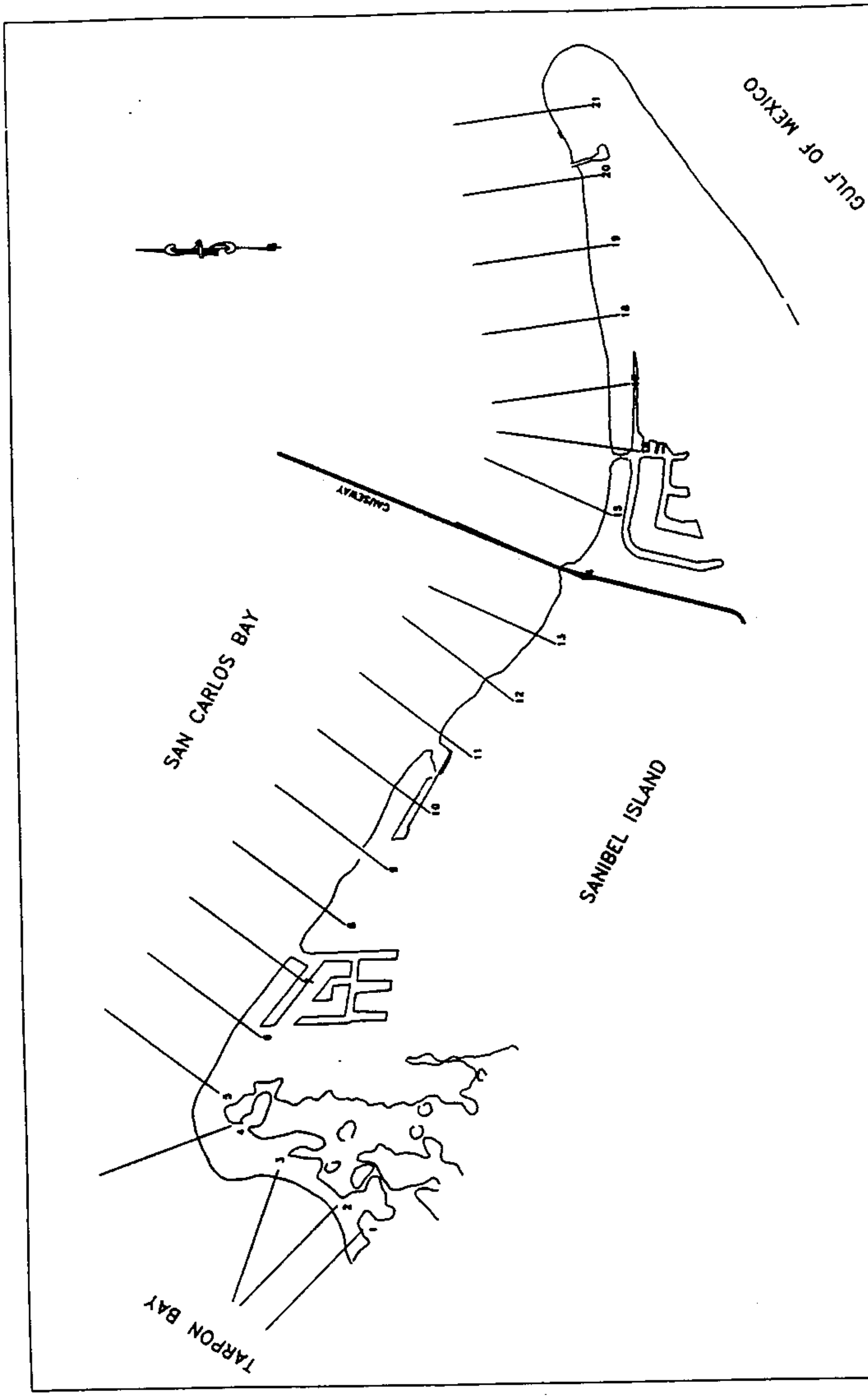


FIGURE I-42

SHORELINE CHANGE BASELINE
FOR CHANGES DIGITIZED FROM DNR SHORELINE
ATLAS AND AERIAL PHOTOGRAPH DATA

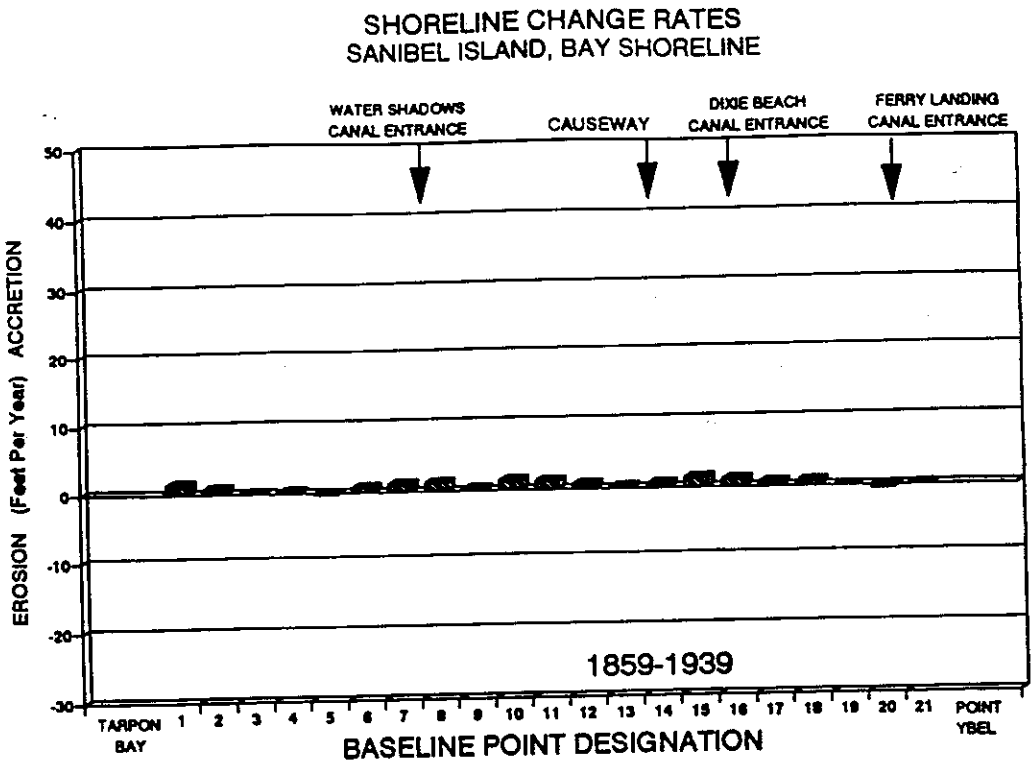


FIGURE I-43

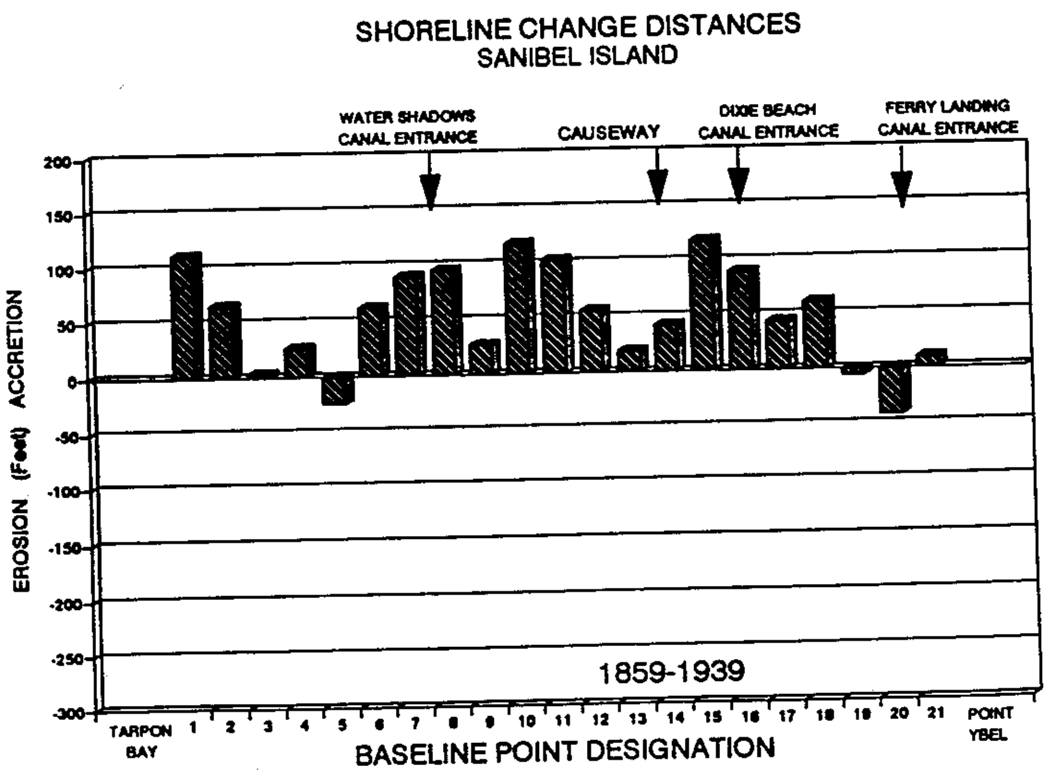


FIGURE I-44

SHORELINE CHANGE RATES
SANIBEL ISLAND, BAY SHORELINE

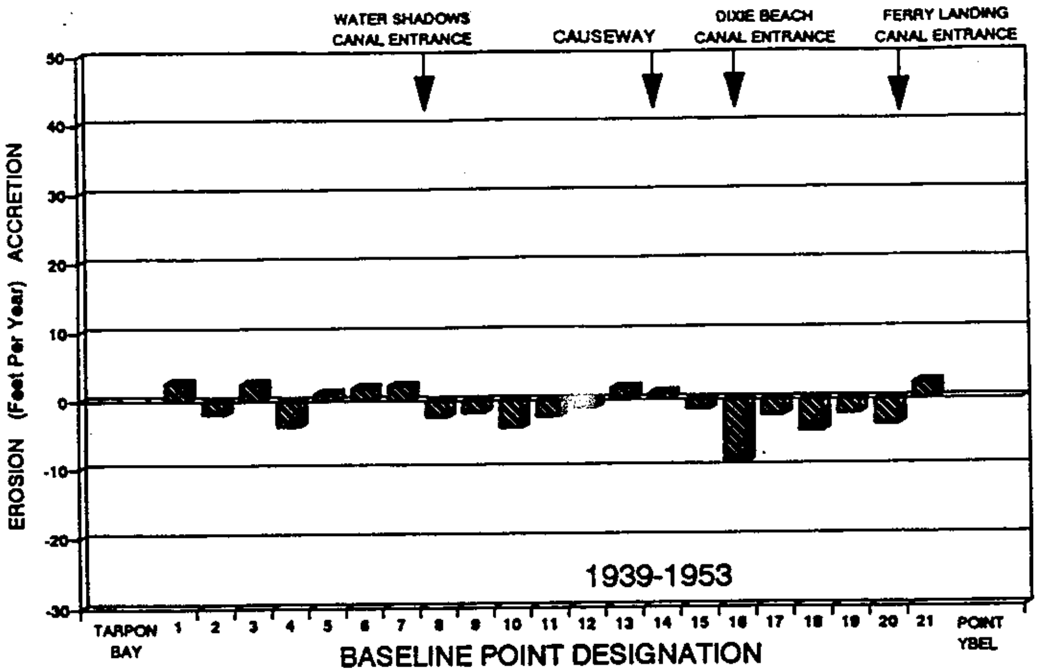


FIGURE I-45

SHORELINE CHANGE DISTANCES
SANIBEL ISLAND

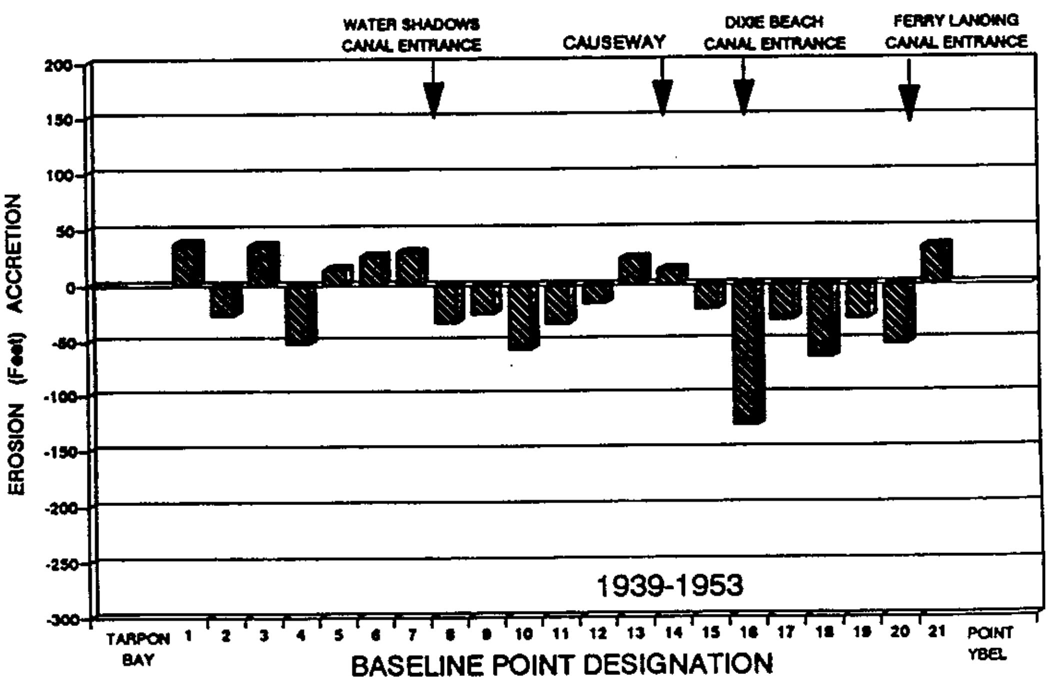


FIGURE I-46

SHORELINE CHANGE RATES
SANIBEL ISLAND, BAY SHORELINE

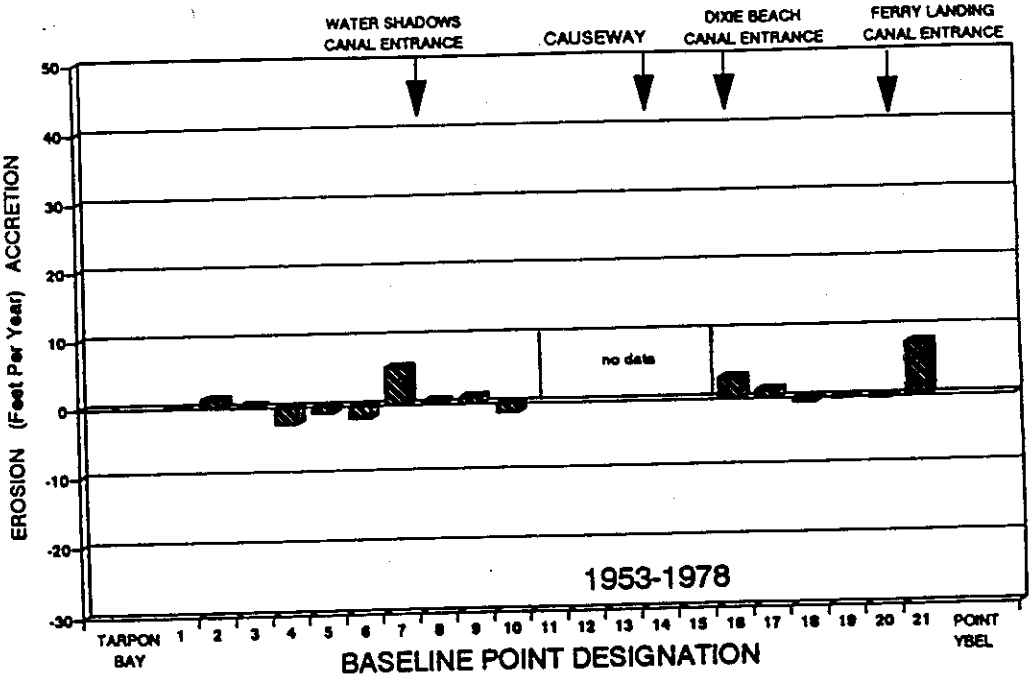


FIGURE I-47

SHORELINE CHANGE DISTANCES
SANIBEL ISLAND

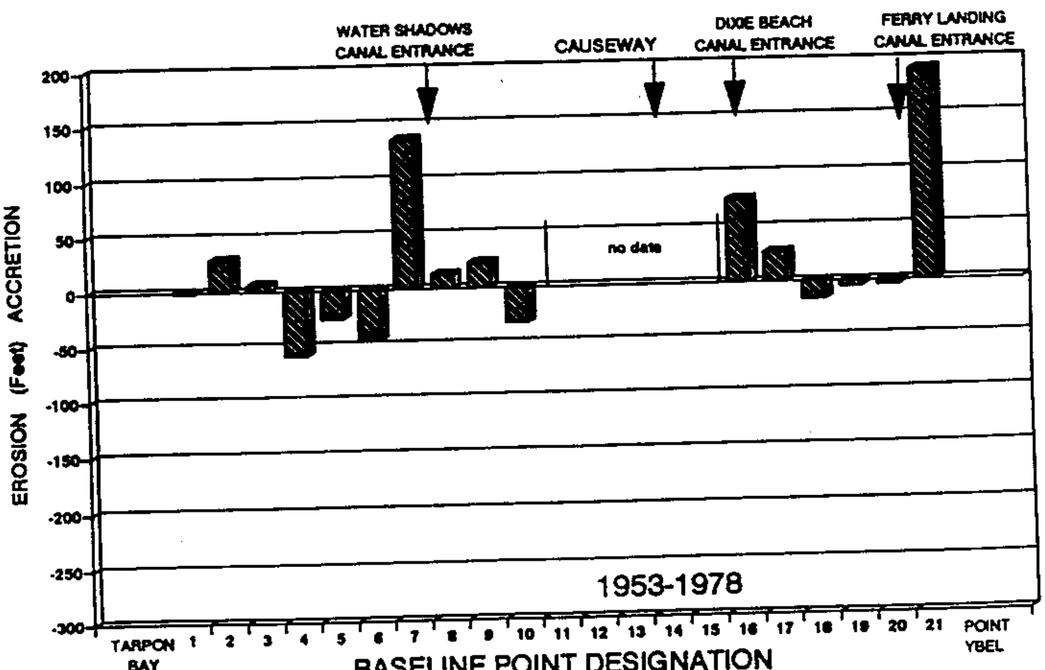


FIGURE I-48

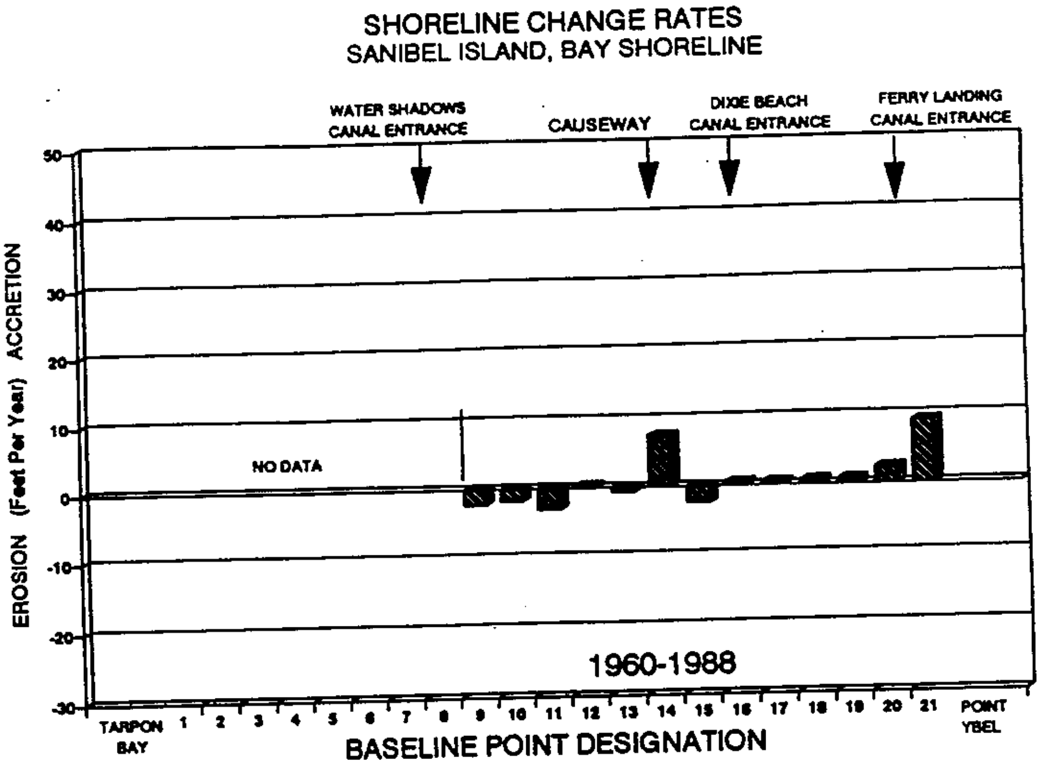


FIGURE I-49

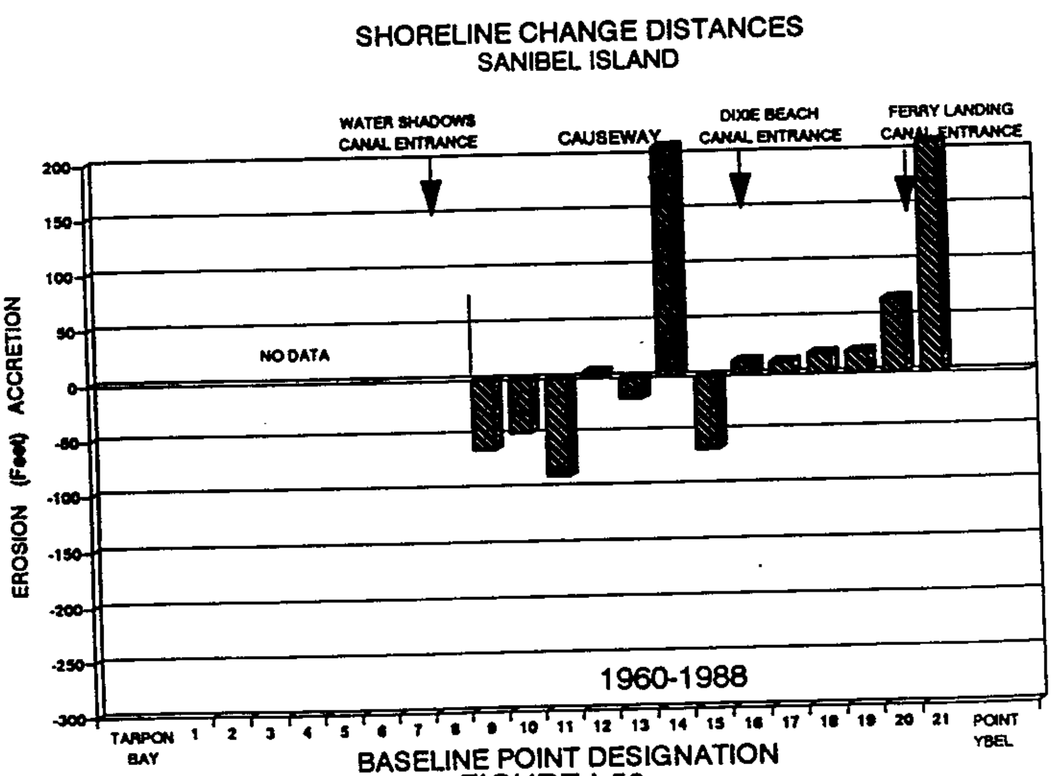


FIGURE I-50

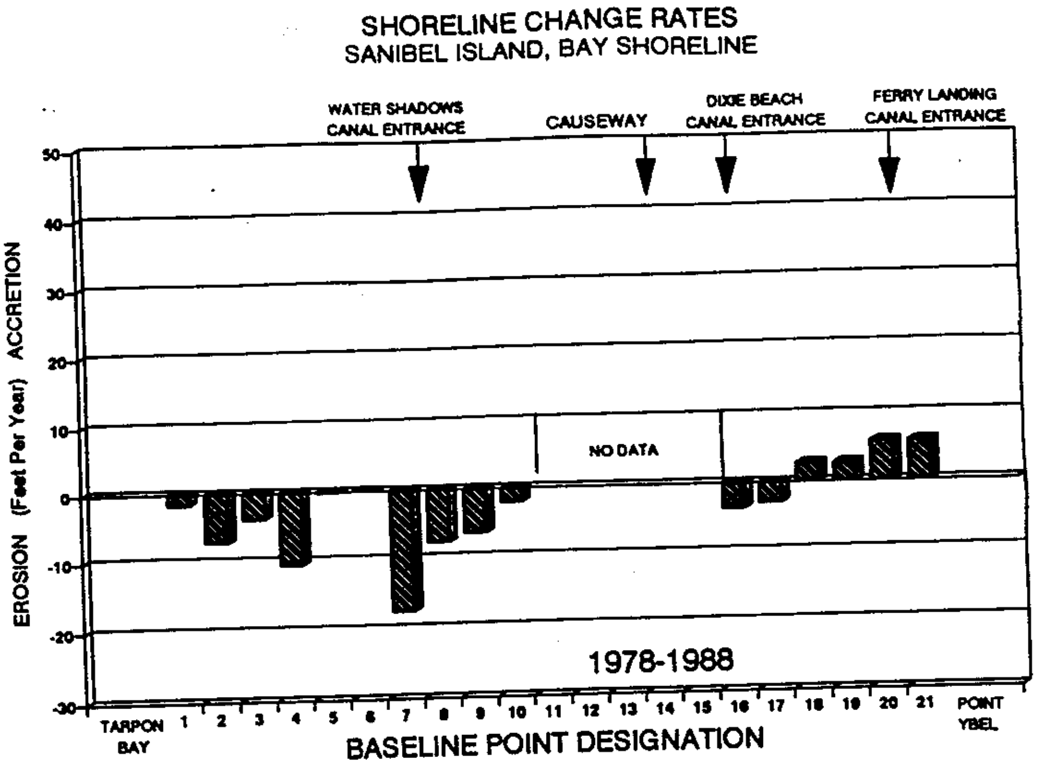


FIGURE I-51

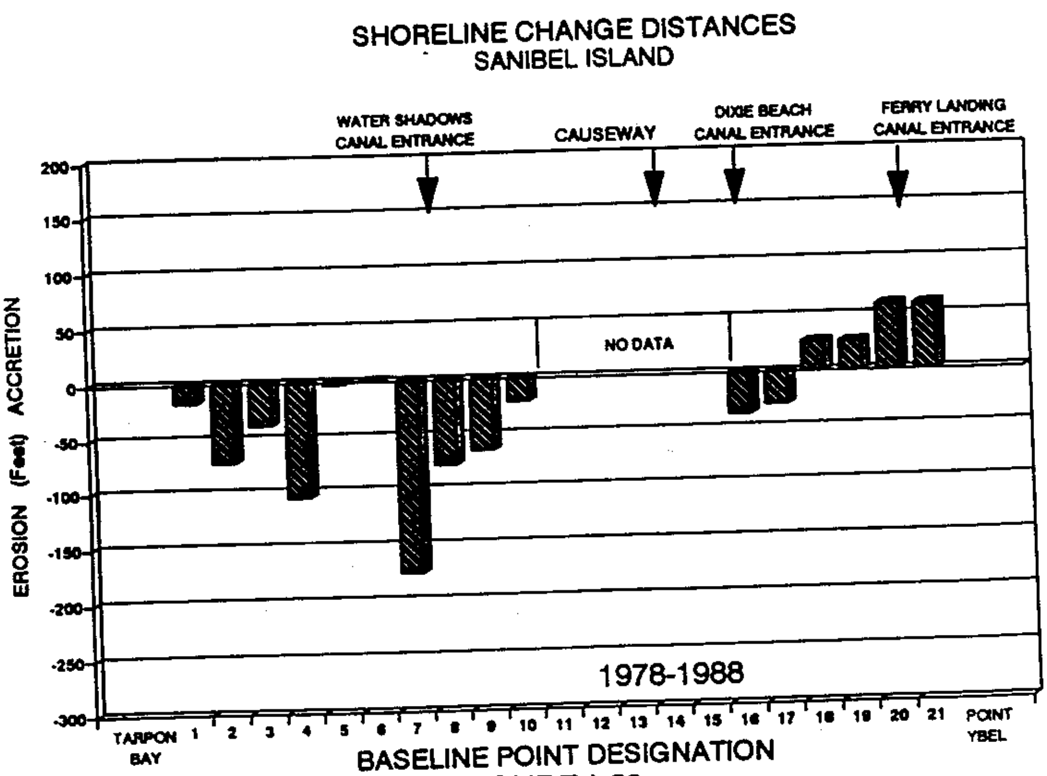


FIGURE I-52

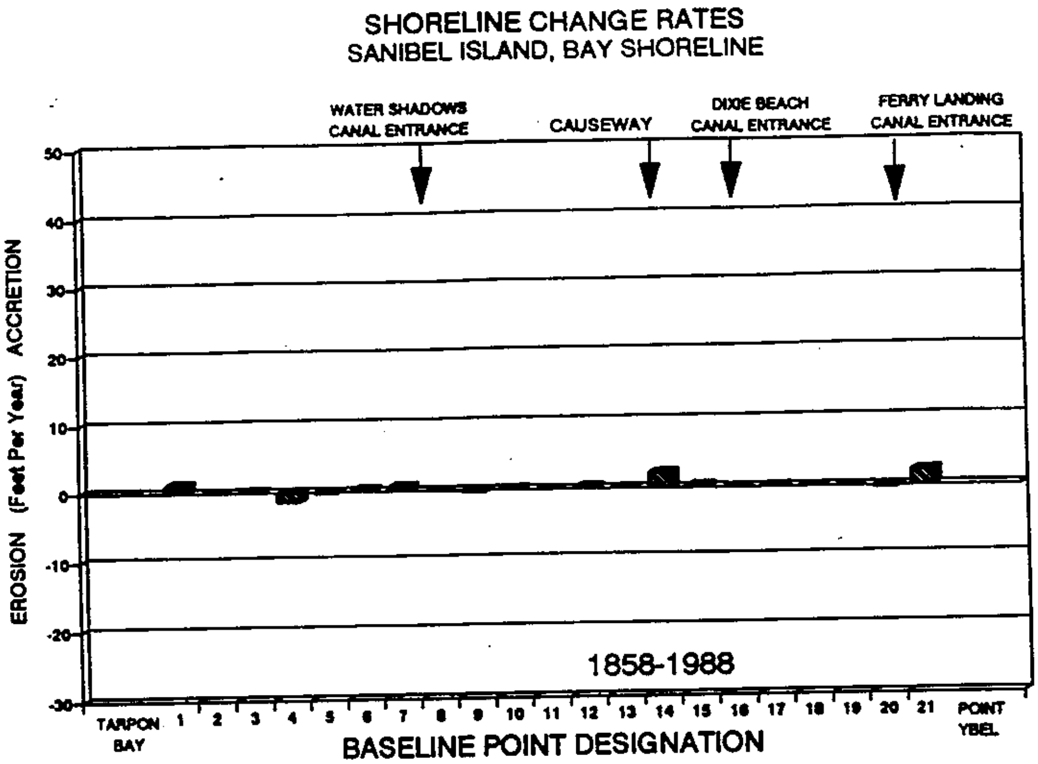


FIGURE I-53

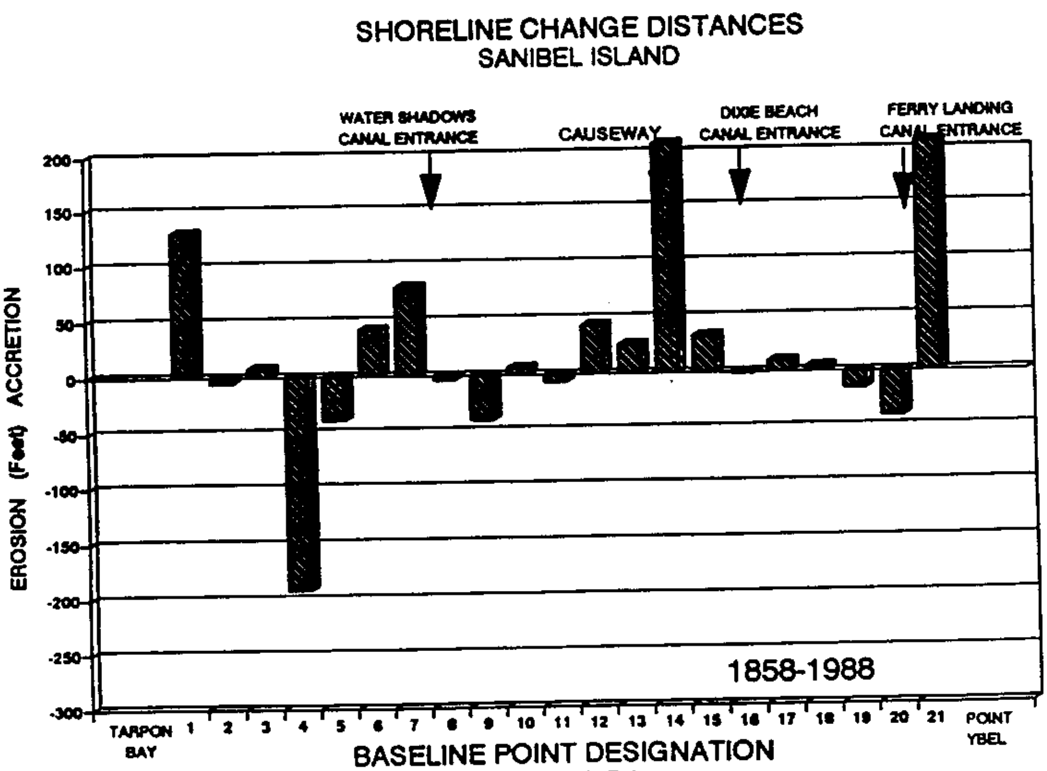


FIGURE I-54

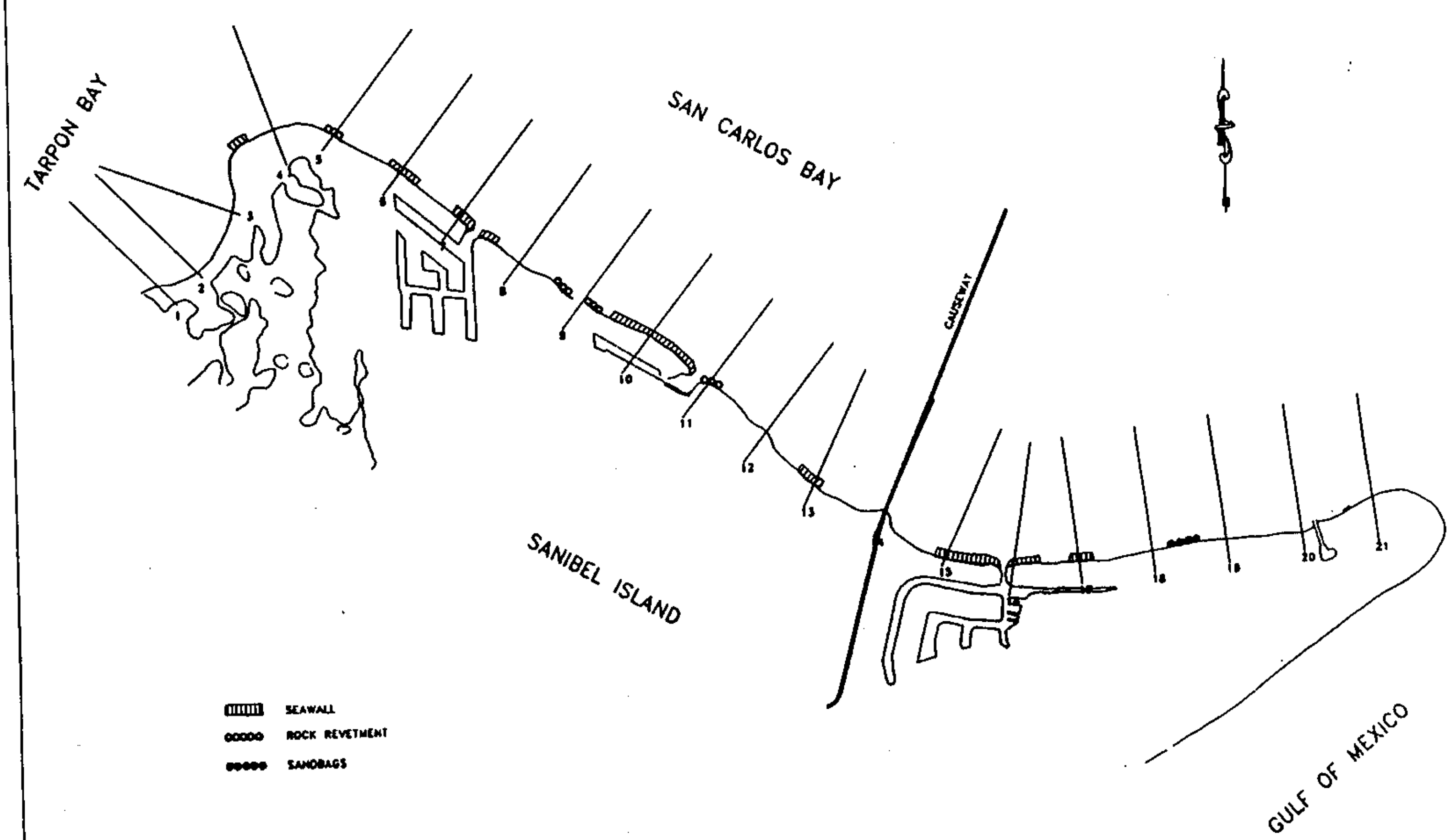


FIGURE I-55

SHORELINE CHANGE BASELINE AND STRUCTURE INVENTORY

2.4 Evaluation of Effectiveness.

When a portion of an eroding shoreline is armored with a seawall or revetment, the upland is protected from further erosion, but erosion of adjacent unprotected areas may accelerate. There are three reasons for this:

(1) Armoring cuts off part of the littoral sand supply by halting erosion of the upland, and the deficit may be compensated by additional losses from adjacent unprotected areas.
(2) Wave interaction with armored shorelines (particularly seawalls) may result in reflected wave energy that can rapidly erode sand from in front of the structure and increase erosive forces on the immediate adjacent areas.
(3) Structures that protrude perpendicularly from the shoreline may function like groins.

These are the kinds of problems that are occurring adjacent to some of the armored sections of bay shoreline.

2.5 Identification of Problem Areas.

Approximately the eastern most 1,500 feet of the bay shoreline, between the Lighthouse Point basin entrance and Point Ybel, has historically been stable or accreting, with the exception of the tip of point Ybel which has been eroding on the eastern and southeastern exposure. The remainder of this section of bay shoreline has at one time or another experienced erosion.

As described in Section 2.3 above, Figure I-55 illustrates the extent to which armoring has been employed to address those erosion problems. There appear to be a number of problem areas adjacent to or between armored sections of shoreline which are being affected as described by (1) and (2) above in Section 2.4, Evaluation of Effectiveness. A good example of this kind of problem can be seen at the west end of the seawall shown in the vicinity of profile line 15 on Figure I-55. An example of the kind of problem described in (3) in the previous section can be seen at the Lighthouse Point Condominium basin entrance canal. This has seawalls on both sides which extend perpendicularly across the beach out into the water, and they are functioning like groins. This is having an adverse effect on the downdrift properties to the west.

Additionally, many of the unprotected areas between armored sections of shoreline are experiencing some level of erosion. In order to quantify this erosion, more data is required, as is discussed later under section I.F, Monitoring.

3. Blind Pass

3.1 Management.

Information contained in Section 1.1 shows that the shoreline in the vicinity of Blind Pass has been very dynamic. See Figure I-24 for a history of the shoreline changes.

Because of the dynamic nature of the shoreline in this area, there is potential for adverse impact to upland property, and there have been efforts to protect the upland on both sides of the pass. Because of this, management of an inlet requires a comprehensive plan that addresses beaches on both sides of the inlet. An inlet management plan, as described under Section I.B.1.2 (state regulatory programs) is being prepared with state funding by the Captiva Erosion Prevention District (CEPD). The purpose of this plan, pursuant to Section 161.161 of the Florida Statutes, is to reduce impacts to adjacent beaches from the inlet and the existing erosion control structure on the north side of the inlet. The formulation of the inlet management plan and various issues related to the plan will be discussed in the following two sections.

3.2 Past Efforts.

Background. Blind Pass is a natural inlet that has a history of southward migration due to the influx of sand from the north. Sand reaching the inlet from the north, from the early 1940's to 1972, resulted in the formation and growth of a sand spit which pushed the inlet entrance southward, until such time as a break in the spit allowed the inlet to relocate in a more northerly position.

The sand in the southern portion of the spit, once cut off in this manner, was transported onshore by wave action and naturally nourished the shores of Sanibel Island. The inlet has at times been closed by the influx of sand from the north, and at such times natural southward transport was continuous along the beach across the inlet entrance. During times when the inlet is open, sand bypass of the inlet occurs on the ebb tidal shoal.

The very substantial spit that formed in the years prior to 1972 extended more than 9,000 feet southward from the end of Captiva Island. A photograph contained in the Coastal Engineering Archives at the University of Florida shows that by June 23, 1972 a revetment and short groin had been constructed near the road approach on the north side of the Blind Pass bridge. This original structure may have been constructed to protect either the road, or a beach recreational area, or both, from gradual erosion, but the inlet was not open at this time.

The June 23, 1972 photograph referred to above was taken shortly after waves from Hurricane Agnes washed over the narrow spit south of the groin on or about June 19, 1972. A landward offset of the beach on the south side of the structure is evident, but the inlet was not yet open. Another University of Florida Archives photograph shows Blind Pass had reopened near its present location by July 15, 1972.

A third University of Florida Archives photograph shows that by November 1972, the short groin had been extended by approximately 100 feet, probably to the dimensions of what is now commonly referred to as the "original structure", which was subsequently sand tightened and extended an additional 100 feet in 1988.

A December 1987 DNR report prepared by R.G. Dean and M.P. O'Brien, " Florida's West Coast Inlets Shoreline Effects and Recommended Action", provides a brief description of the history of Blind Pass. The report states that "Blind Pass was opened by Hurricane Agnes in 1972 and a small terminal structure was constructed on the north side by the Department of Transportation (Lee County) to protect the bridge abutment." Based on historic photographic information, it appears as if the reopening of the pass was due to a combination of effects of Hurricane Agnes and the effects of a preexisting structure.

Landward migration and erosion of the sand spit south of Blind Pass subsequently began to threaten the north end of Sanibel Island, and sections of that shoreline were armored with seawalls and revetments to protect upland properties.

Captiva Island. In addition to the groin on the north side of Blind Pass, sections of shoreline north of the pass on Captiva Island were also armored to protect upland properties from erosion. This armoring of the shoreline reduced the sand supply for natural transport from Captiva Island southward to Blind Pass and Sanibel Island. In October 1988 the groin on the north side of Blind Pass was reconstructed to "sand tighten" it to prevent sand from passing through to the south, and at the same time it was extended an additional 100 feet to further reduce the movement of sand from Captiva to Sanibel. The purpose of this construction was to stabilize the south end of a beach fill project on Captiva Island.

The project was designed with nourishment to widen the beach on the north side of the groin a sufficient amount to result in an increase in the amount of sand passing around the sand tightened and extended structure. The additional sand that would pass around the structure as a result of the nourishment was intended to offset impacts that would result from the sand tightening and extension. The beach nourishment was completed in April 1989.

Because of concern over potential impacts to the shoreline on Sanibel Island, the State of Florida Department of Environmental Protection (DEP, formerly the Department of Natural Resources, or DNR) permit issued for the groin extension contains special permit conditions requiring CEPD to monitor the shoreline on the northern end of Sanibel. The purpose of the monitoring is to identify and quantify impacts to Sanibel's shoreline from interruption of littoral transport by the groin extension.

The permit conditions state that the DEP Bureau of Beaches and Coastal Systems may require mitigation for erosion attributable to the groin extension and, or, modification or removal of the structure at no cost to the State of Florida. The amount of mitigation is to be determined by DEP.

The area south of Blind Pass is the most rapidly eroding section of Sanibel's shoreline, posing a threat to upland property as well as to the road which is the only hurricane evacuation route from locations to the north. Because of the importance of this issue to Sanibel Island, and because it has become a complicated issue for a variety of reasons, this section presents a detailed accounting of those issues.

Background Erosion. Subsequent to issuance of the DEP permit to CEPD for the groin extension and beach nourishment, a background erosion rate to be used by DEP in gauging impacts to Sanibel Island was established and agreed upon by DEP and CEPD. Sanibel was not a party to this agreement. It was further agreed upon, between DEP and CEPD, that if the background erosion rate was exceeded for two consecutive monitoring periods, then mitigation would be required.

The background rate was computed by means of a "rate averaging" procedure. This procedure considers all individual shoreline change rates computed over all combinations of time intervals from data collected within the more inclusive time interval. It then eliminates some of those rates, through application of an error analysis and statistical selection program, and finally computes an average of the remaining rates. The background rate computed by this procedure was an average annual erosion rate of -13.3 feet per year, as an average over the first approximately 6,300 feet of shoreline south of the inlet.

One purpose of the rate averaging procedure is to eliminate erosion rates computed from short time intervals because such rates may be more indicative of seasonal trends rather than genuine erosion or accretion. Another purpose is to be able to compare data with different limits of accuracy, such as information digitized off of maps, which is typically less accurate than survey data.

In a report to the City of Sanibel, R.G. Dean (1991) reached a different conclusion regarding an appropriate background erosion rate for measuring effects of the CEPD structure at Blind Pass. Dean's reason for this was a dissimilarity between the background and monitoring period erosion process. Landward migration of a thin barrier island often occurs partly due to sand washing over the island to the back side, which is a somewhat different process from erosion of a headland. During the background period a larger portion of the north end of Sanibel was a thin barrier subject to over-wash than was the case during the post groin extension monitoring period. On this basis, Dean concluded that the DEP background rate was 13% too high.

The rate averaging procedure described above, as presented by CEPD and DEP, may be appropriate as a standard method for general comparison of large amounts of data with varying levels of accuracy and in different geographic regions. However, as Dean pointed out, for more specific site analysis, and for using historic data to project future trends, there may be disadvantages.

Another potential problem with the rate averaging procedure is that the resulting average may be weighted or biased. This can occur if the data points selected for averaging predominantly represent a shorter period of time from within the inclusive time interval. If the erosion trend during the shorter time interval was substantially different from the all inclusive time interval, the averaged rate will not be representative of the actual change in shoreline position. Additionally, the background rate in this case was computed using only a portion of the 1974 data. The data which was eliminated was from close to the inlet where accretion had occurred between 1974 and 1988. Elimination of this data from the computation resulted in a higher value of the background erosion than had actually occurred.

There are a variety of alternative ways of analyzing erosion rates. The simplest and most commonly used is the "endpoint rate", which is based on the measured difference between the shoreline positions at the beginning and end of a time interval. When this rate is multiplied by the amount of time in the interval, and the resultant distance is subtracted from (or added to) the shoreline position at the start of the interval, a shoreline position the same as the actual measured location at the end of the interval is obtained. With the rate averaging method, as applied by DEP, a different result is obtained.

Figure I-56 illustrates how simple endpoint averaging of points selected as representative of a trend is more appropriate than the previously discussed rate averaging method. This figure is a bar graph which illustrates a series of endpoint averages. Moving from left to right, each rate represents a longer time interval, but they all start with the 1972 shoreline position. The first bar on the left represents the rate for the 2 year period from 1972 to 1974, the last bar on the right represents the average rate for the 16 year period from 1972 to 1988. It is a cumulative rate in the sense that the 1988 shoreline position is the result of variable rates of change over a 16 year period.

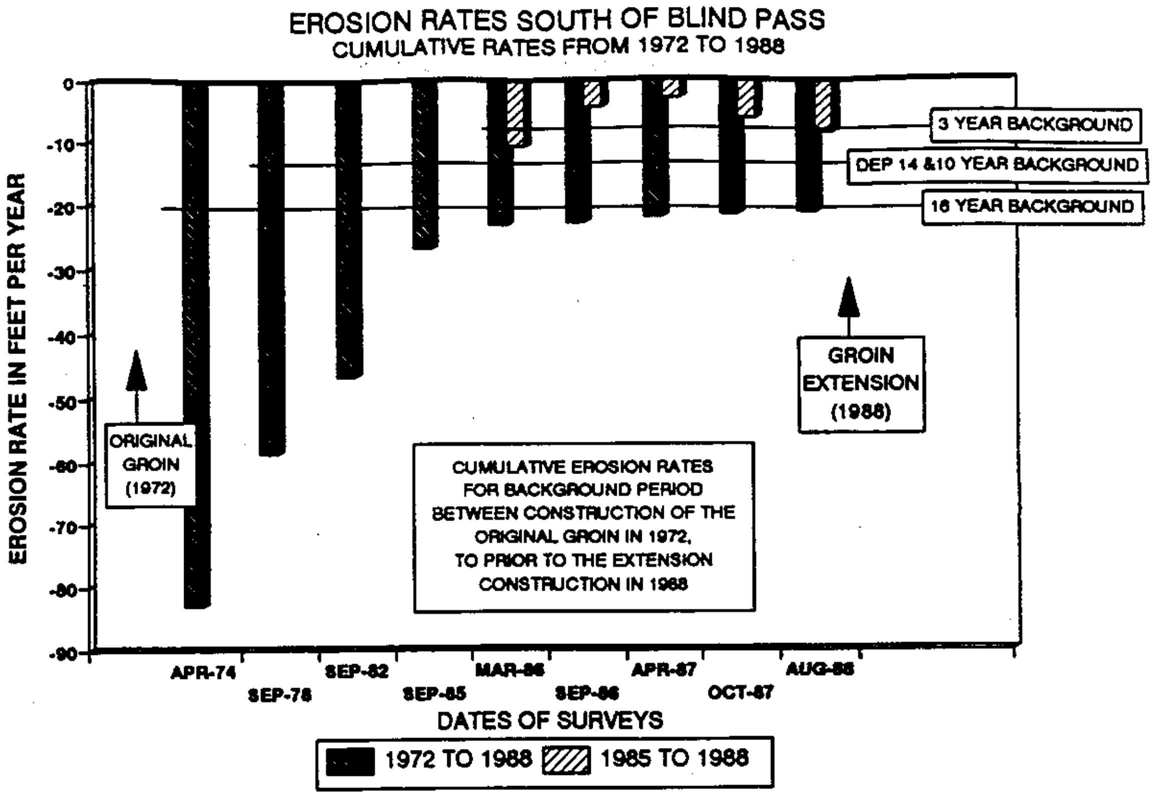


FIGURE I-56

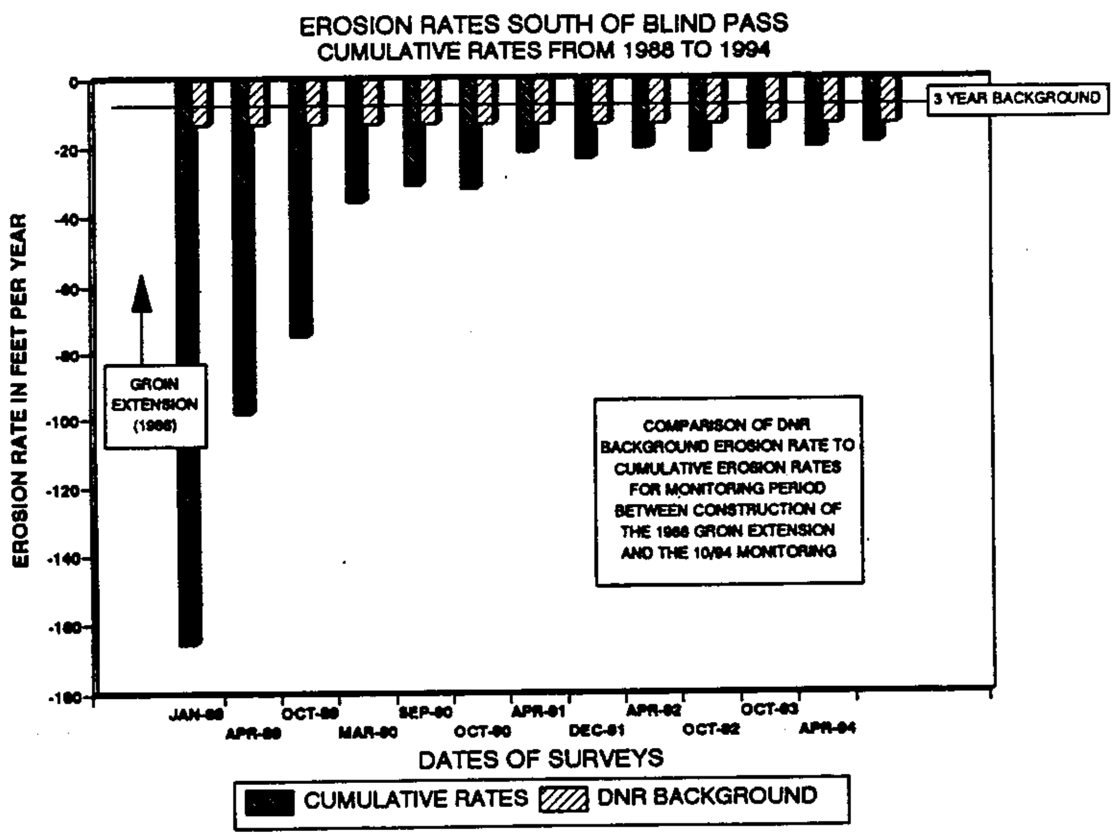


FIGURE I-57

One of the useful aspects of visualizing the data in this manner is that trends can be identified. The DEP permit condition specifically recognizes the importance of trends in stating that "The mitigative sand placement shall not include losses which occur as a result of erosional trends which existed prior to the sand-tightening and extension..." What Figure I-56 illustrates is that the impact of an initial high rate of erosion is diminished when averaged in with subsequent rates over a longer period of time, if the erosion rate decreases. In this case the initial high rate of erosion is attributed to the groin constructed in 1972 on the north side of Blind Pass. It is evident that subsequent to the initial high erosion, the shoreline stabilized to a somewhat lower rate.

A process described in Section A.2 explains the cause of this trend. It is caused by diversion of sand into a tidal delta accumulation due to ebb tidal currents through the reopened inlet. The result is erosion and landward migration of the shoreline thus deprived of its normal sand supply. Eventually, water depths over the ebb tidal delta became shallow enough that wave induced sand transport apparently began to restore the littoral supply of sand to the shoreline south of the inlet, and the cumulative erosion rate leveled off, although at a rate above the earlier background.

If it were desirable to predict an erosion rate beyond August 1988 from this information, it would be appropriate to base that estimate on the period of time on the right of Figure I-56 where the cumulative erosion rate has leveled off to around -20 feet per year. The average erosion rate for the period represented by only the last five bars, three years from September 1985 to August 1988, is -8.2 feet per year. In contrast, the background erosion rate estimated by DEP with the rate averaging method for the period from 1974 to 1987 is more than 60% higher at -13.3 feet per year.

Note that the average for the most recent three years during the background period is less than half of the average for the entire sixteen-year period. The DEP rate was computed over a fourteen-year period for part of the study area and a ten-year period over the remainder of the area. As would be expected, based on the trend shown in Figure I-56, the DEP rate falls between the other two rates.

It is clear that including the earlier data from the 1970's and early 1980's in a background rate for the purpose of measuring the 1988 groin extension impacts is not appropriate.

Monitoring Period: Figure I-57 illustrates a similar analysis of monitoring data collected since the groin extension in 1988. It shows a similar shoreline response to the groin extension as that which resulted from the original groin construction; initial high erosion followed by leveling off at a lower rate. Also shown on Figure I-57 for comparison purposes is a bar which represents the background erosion rate determined by DEP, and the more recent rate representative of what occurred during the three years immediately preceding the groin extension.

It can be seen in Figure I-57 that since construction of the groin extension the rate of erosion has exceeded the background rate established by DEP. The erosion that has occurred during this period of time has resulted in structural damage to several upland properties, as previously described in Section I.C.1.4, Previous Erosion Control Efforts.

Mitigation: Figure I-58 illustrates the quantities of sand represented by the erosion rates shown in Figure I-57. These quantities are based on a conversion factor of 0.36 cubic yards per square foot, meaning that each square foot area of beach lost to erosion represents a loss of .36 cubic yards of sand. The conversion factor was calculated from actual sand losses and shoreline changes documented by the August 1988 pre-construction survey and the December 1991 monitoring survey beach profiles.

Based on this assessment, the mitigation required under the groin permit condition and the DEP background erosion rate is 50,000 cubic yards of sand as of October 1994. Figure I-59 shows the same information as Figure I-58 except the three year background erosion rate of -8.2 feet per year, computed from endpoint averages, is used as the background rate. This shows that the mitigation quantity should be 120,000 cubic yards as of October 1994.

If Dean's consideration of the barrier island migration issue is considered as well, -8.2 feet per year is 13% higher than is appropriate for post groin extension, and a more appropriate rate would be -7.3 feet per year. This results in a mitigation quantity of 135,000 cubic yards as of October 1994.

3.3 Ongoing Efforts.

The DEP permit for the Captiva beach nourishment and groin extension was issued in 1988. The permit condition which requires mitigation for impacts to Sanibel's shoreline from the groin extension stipulates that mitigation is required if the background erosion rate is exceeded over two consecutive monitoring periods.

In April 1991, DEP issued a mitigation order to CEPD requiring placement of 15,387 cubic yards of sand on Sanibel as mitigation. Upon further analysis, this quantity was determined by DEP to be insufficient to mitigate impacts of the groin extension. In the meantime, in August of 1991, CEPD began preparation of a Blind Pass Inlet Management Plan, under contract to DEP, pursuant to the provisions of Florida Statute 161.161 (see Section I.B.1.2). The purpose of the management plan is to determine inlet impacts to adjacent beaches, to provide a means of mitigating those impacts,

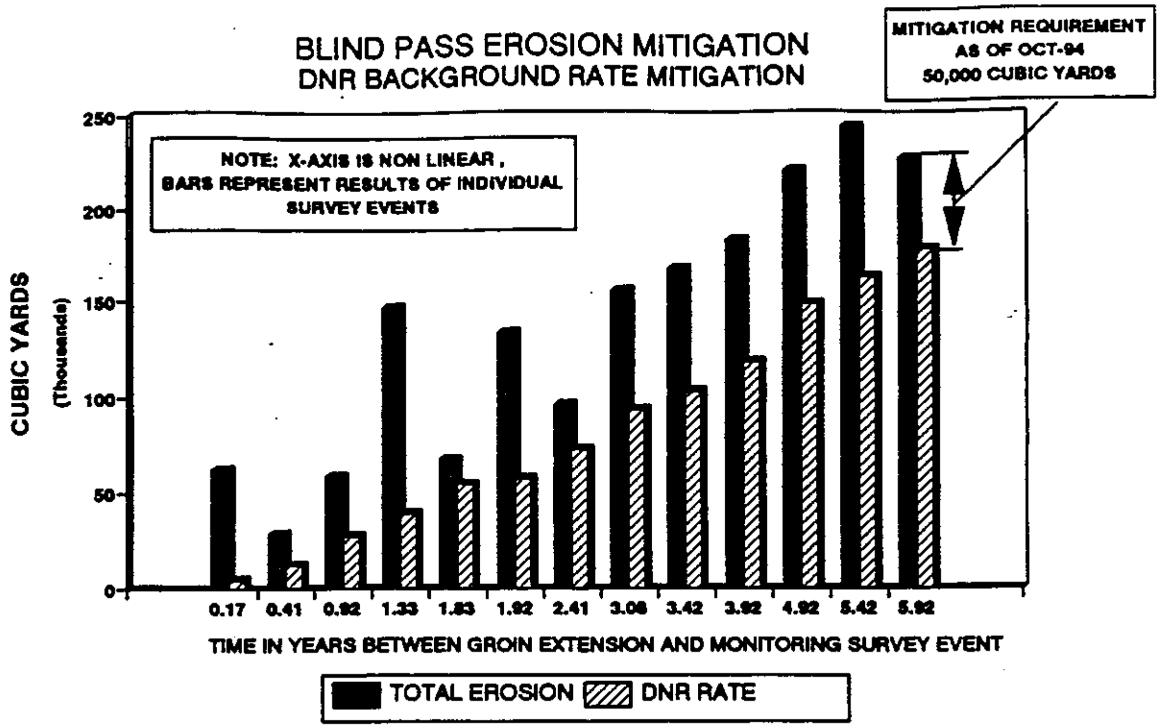
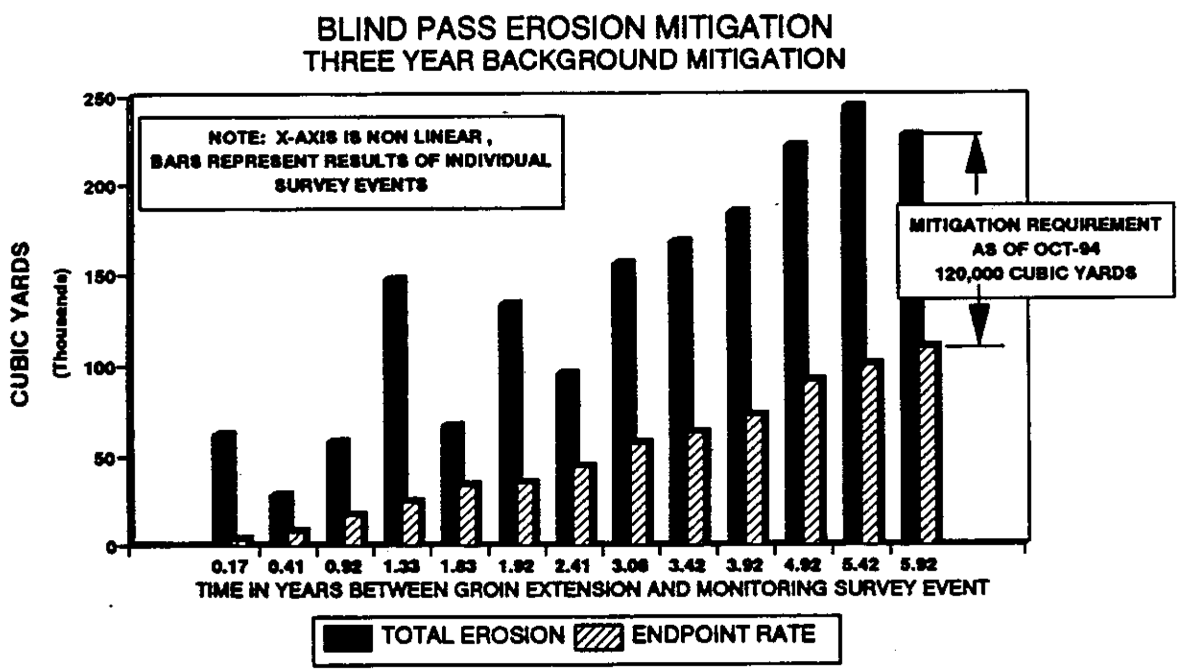


FIGURE I-58



SAND VOLUMES BASED ON 0.36 CUBIC YARDS OF SAND FOR EACH SQUARE FOOT OF BEACH LOST. THE DIFFERENCE BETWEEN THE BACKGROUND RATE AND THE TOTAL EROSION IS REPRESENTATIVE OF THE AMOUNT OF MITIGATION REQUIRED UNDER THE DEP PERMIT FOR THE CAPTIVA GROIN EXTENSION AND BEACH NOURISHMENT PROJECT

FIGURE I-59

and to make recommendations for cost sharing among the beneficiaries of the inlet improvements.

It was anticipated that a comprehensive inlet management plan would resolve the groin extension mitigation issue, and DEP withdrew the original mitigation order in anticipation that the issue would be settled through comprehensive inlet management. At the time of preparation of this Coastal Processes Element of the Sanibel Island Beach Management Plan, the Blind Pass Inlet Management Plan is incomplete. DEP will hold a public workshop prior to final approval of the plan.

3.4 Effects on Sand Budget.

The preceding discussion of shoreline changes shows how the inlet and structure on the north side of the inlet have influenced shoreline changes. This is the result of several things. One is the groin acting as a barrier to littoral transport, trapping southward transport and holding it on Captiva Island's beach. The trapped sand forms a wider beach on the north side of the groin resulting in a slightly different shoreline orientation that would further reduce southward transport. Finally, sand that does get around the 100-foot extension does so in deeper water where wave induced transport is not as effective in transporting it to the southward shore as are tidal currents in transporting it offshore.

It was mentioned earlier that reopening the inlet caused downdrift erosion because the new inlet trapped sand to form an ebb tidal shoal. The construction of a groin, or extension of that groin adjacent to an inlet causes the ebb shoal to form further offshore, in deeper water, which requires additional sand accumulation.

This process has resulted in accumulation of sand in the area shown in Figure I-60. Figures I-61 through I-65 are beach profiles which cross the growing ebb shoal, and show that in some places the water depth over the shoal has decreased as much as from 11 feet to 5 feet.

A graphic history of the growth of the shoal volume and extent over 6 years is shown in Figure I-66. This bar graph shows how the offshore part of the ebb tidal shoal grew and at the same time migrated southward. This shoal growth was accompanied initially by offshore erosion in the area south of the growing shoal formation, and as the shoal grew southward, the area of erosion migrated southward ahead of the shoal. In this manner, these offshore features appear to propagate southward like a slow moving wave form.

The Blind Pass ebb shoal grew persistently over the first five years after the groin was extended, for a net increase in sand volume of over 124,600 cubic yards. There was a decrease in shoal volume over the most recent year of monitoring. This decrease was

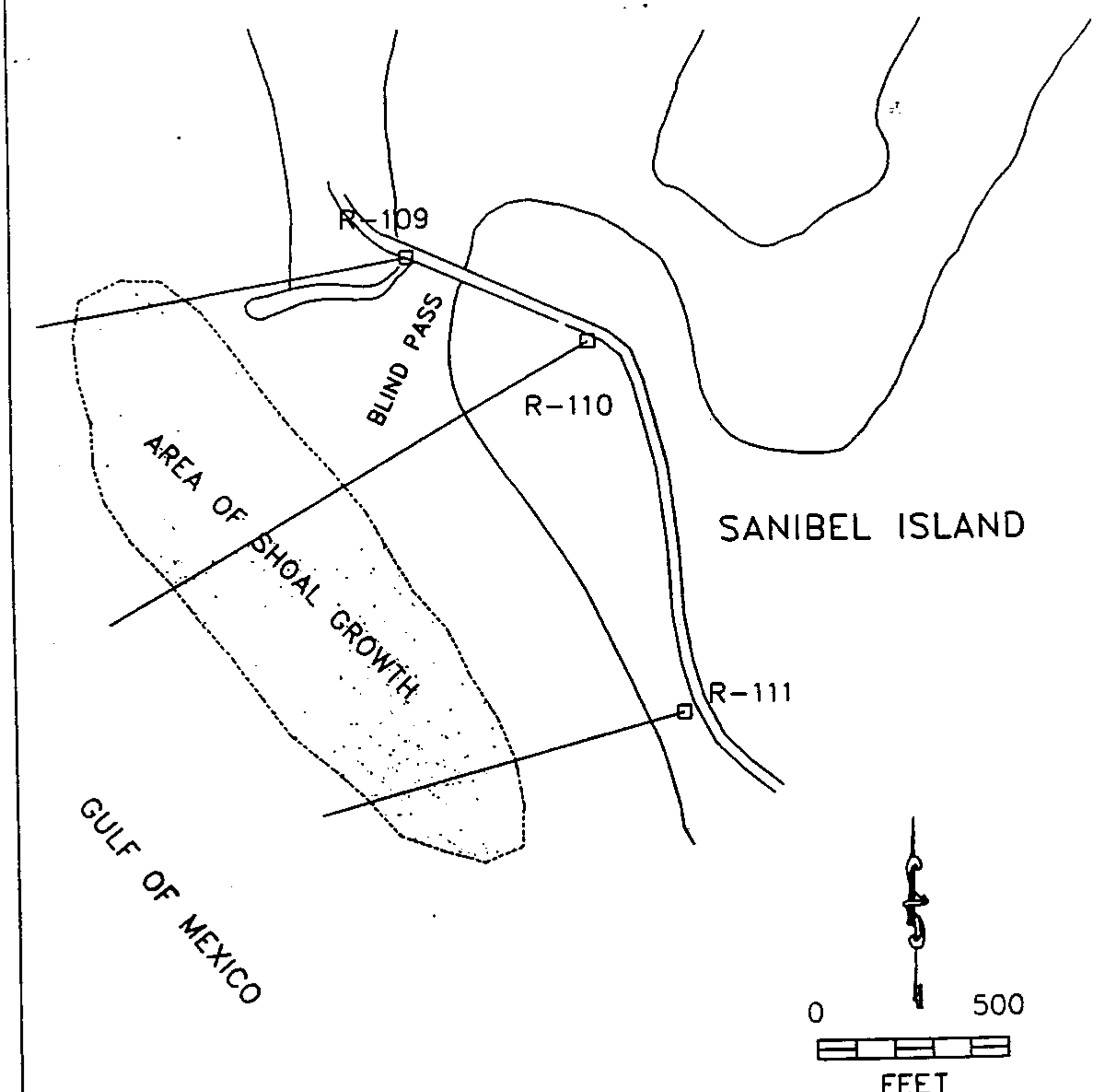
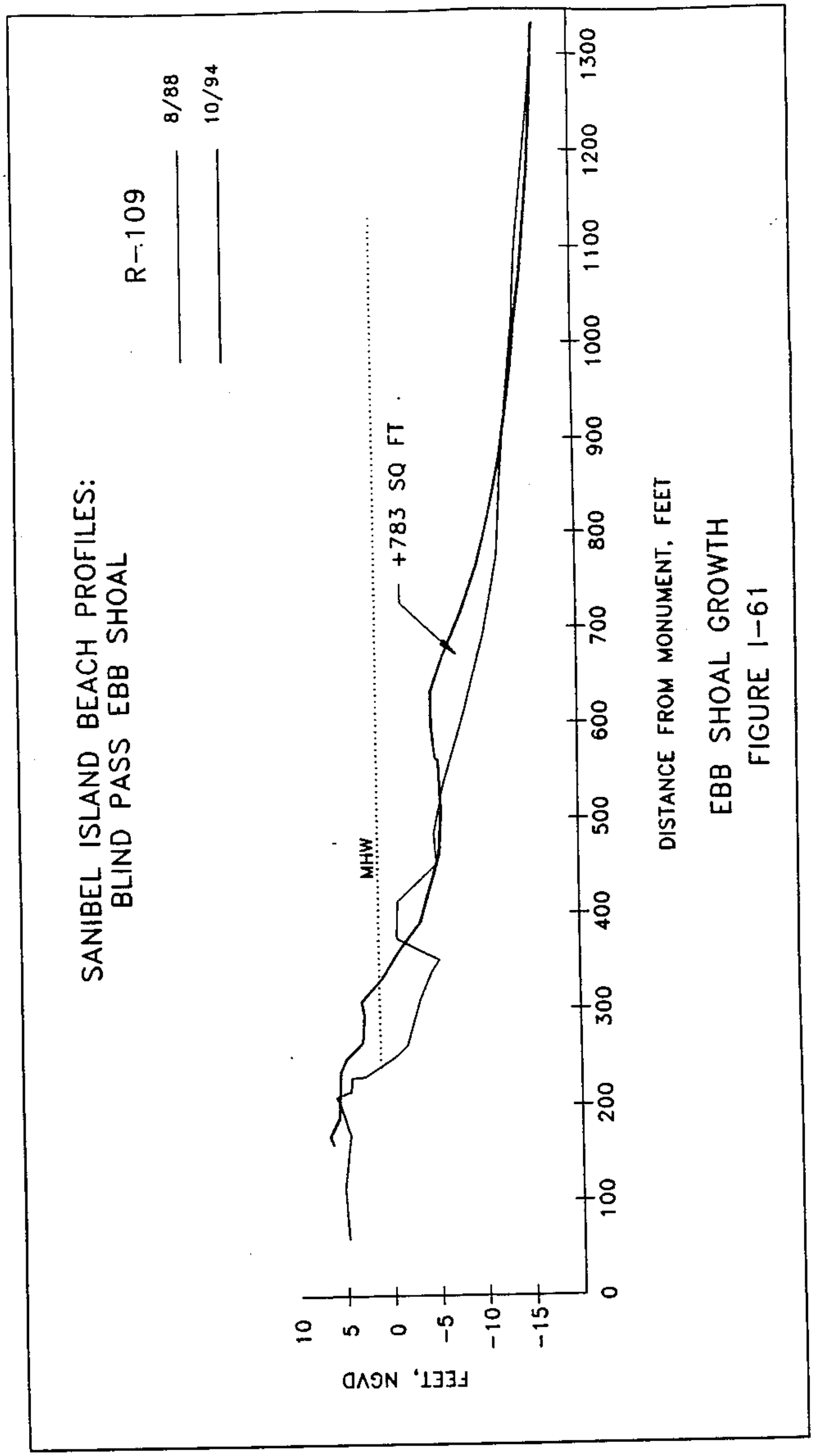
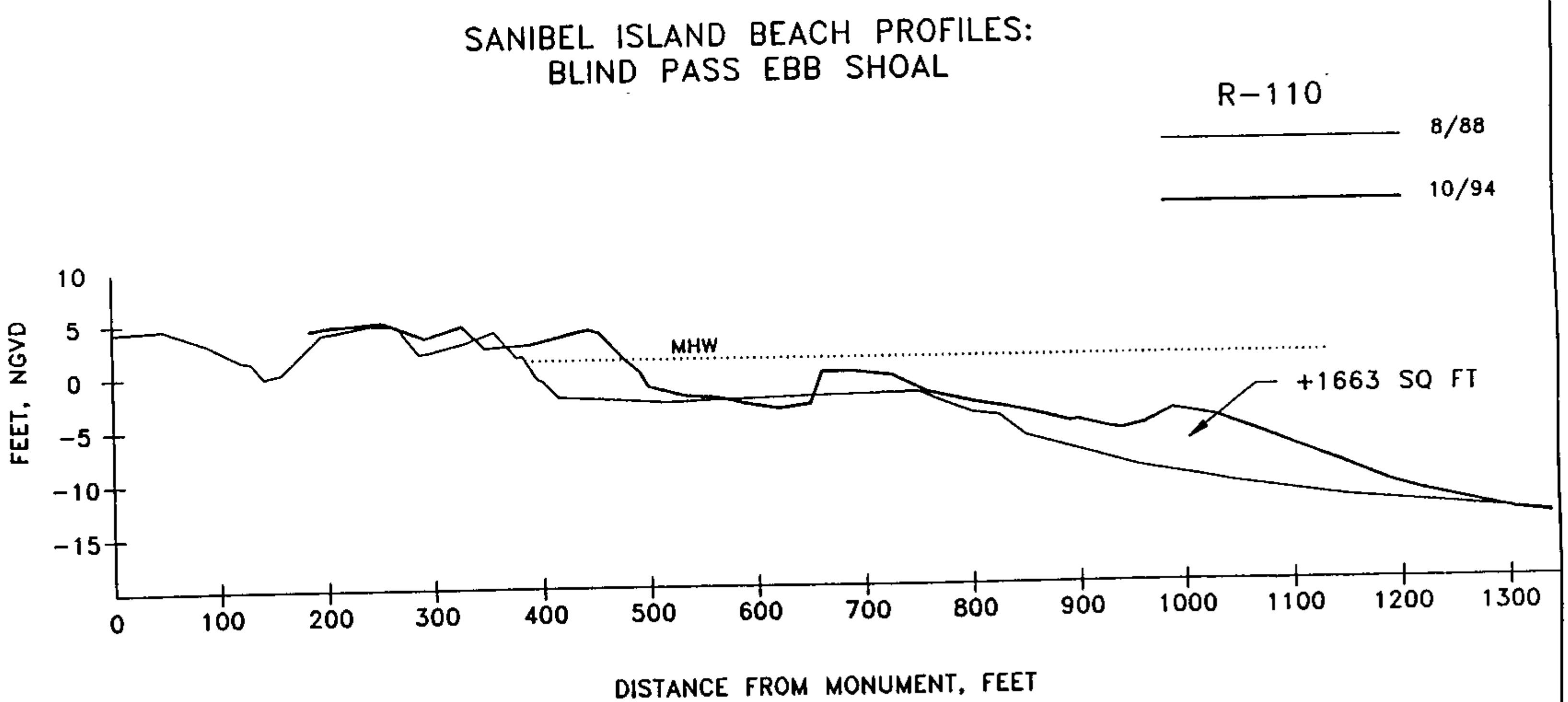


FIGURE I-60

LOCATION OF SAND ACCUMULATION IN BLIND PASS SHOALS FROM AUGUST 1988 TO OCTOBER 1992

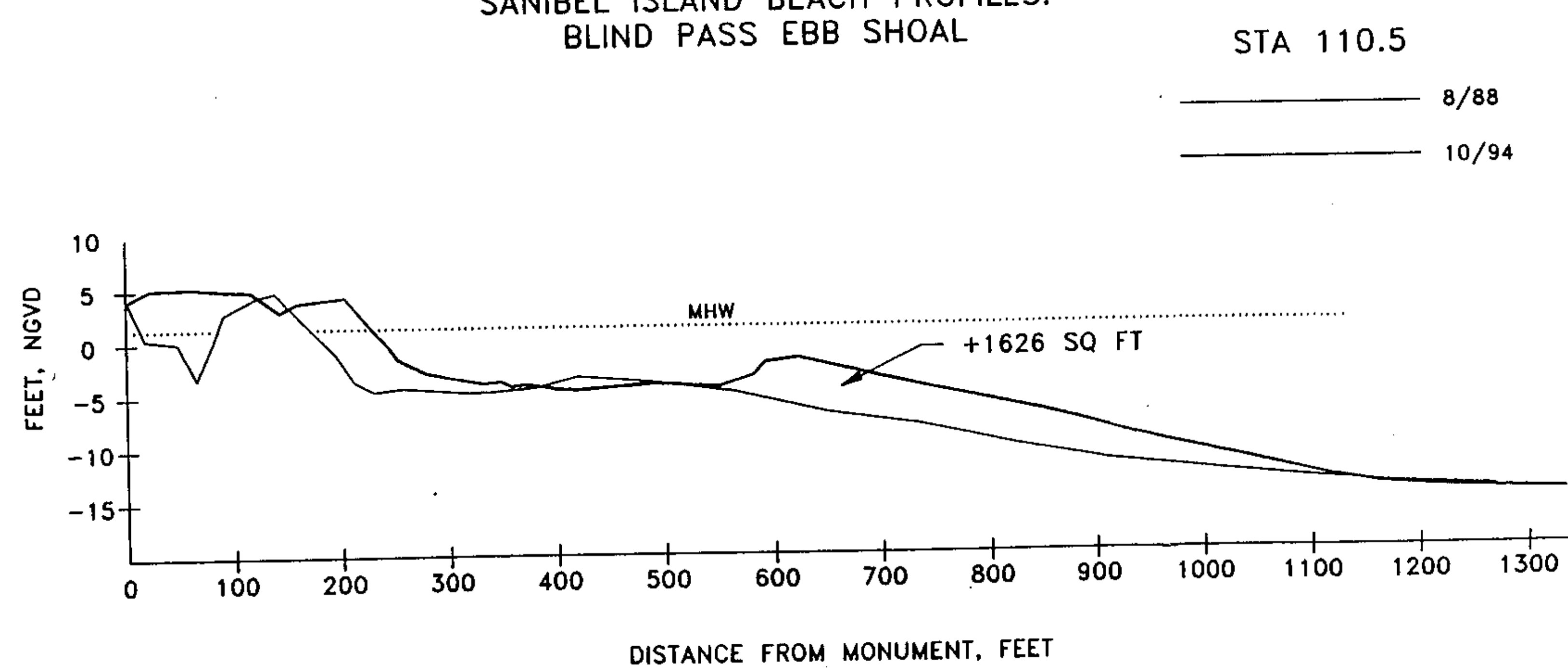


EBB SHOAL GROWTH
FIGURE I-61

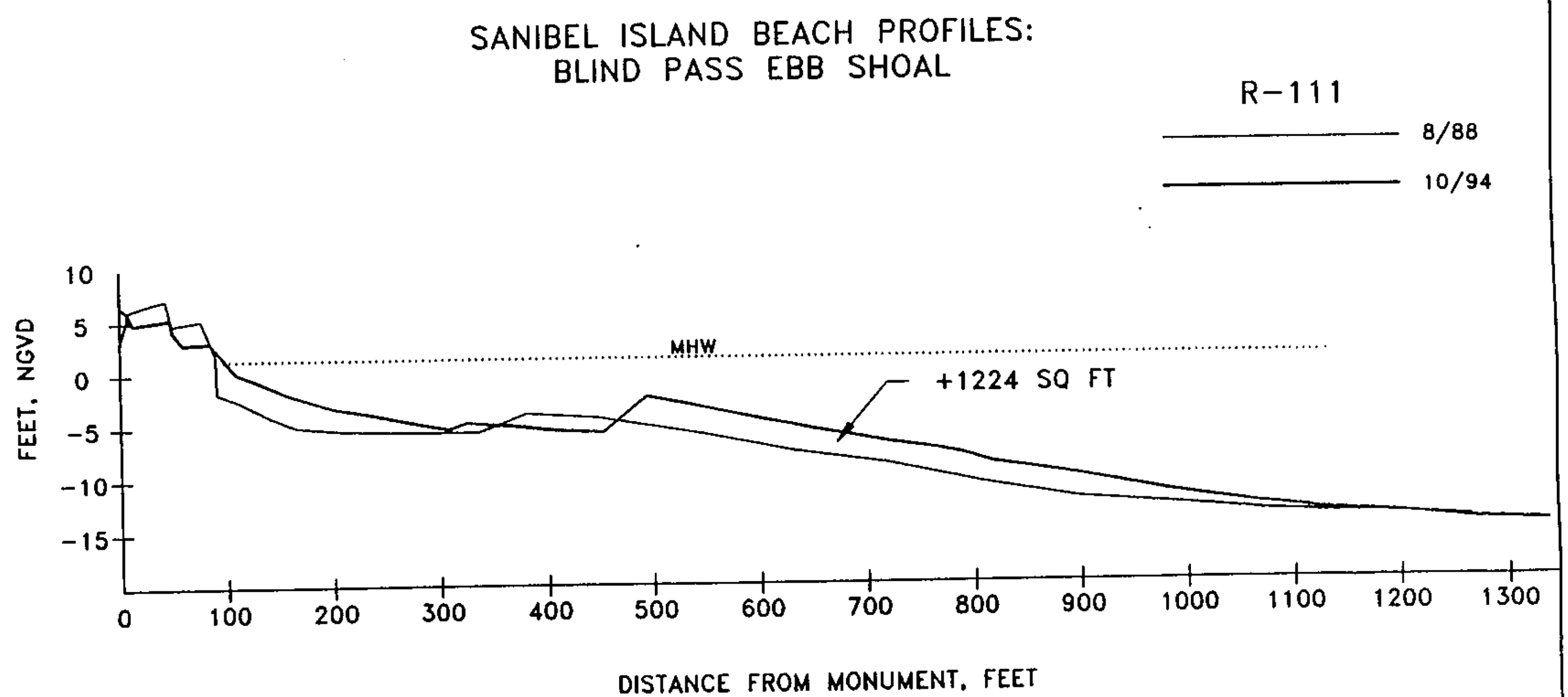


EBB SHOAL GROWTH
FIGURE I-62

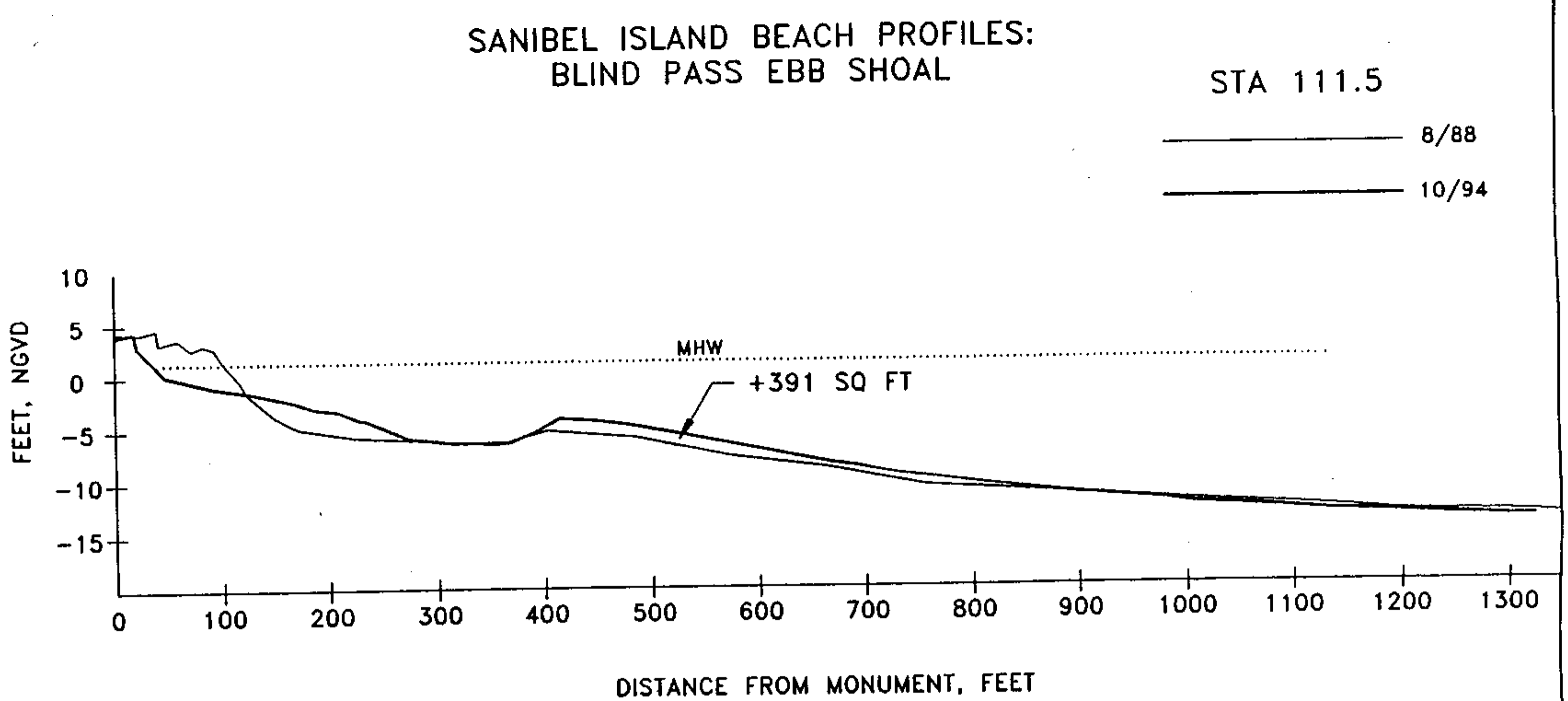
SANIBEL ISLAND BEACH PROFILES:
BLIND PASS EBB SHOAL



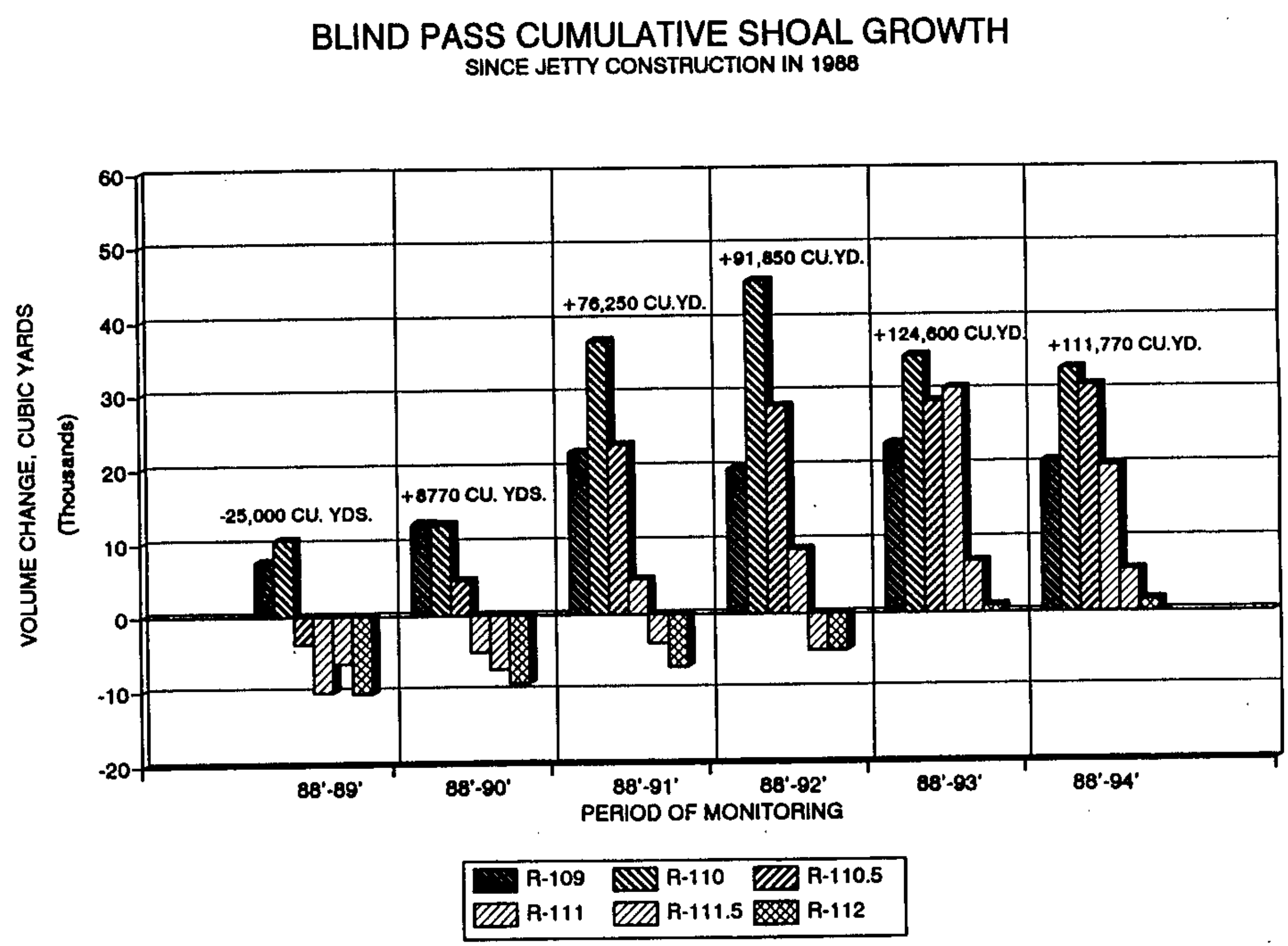
EBB SHOAL GROWTH
FIGURE I-63



EBB SHOAL GROWTH
FIGURE I-64



EBB SHOAL GROWTH
FIGURE I−65



BLIND PASS CUMULATIVE SHOAL GROWTH
SINCE JETTY CONSTRUCTION IN 1988
VOLUME CHANGE, CUBIC YARDS
(Thousands)
60
50
40
30
20
10
0
-10
-20
-25,000 CU. YDS.
+8770 CU. YDS.
+76,250 CU.YD.
+91,850 CU.YD.
+124,600 CU.YD.
+111,770 CU.YD.
88'-89'
88'-90'
88'-91'
88'-92'
88'-93'
88'-94'
PERIOD OF MONITORING
R-109
R-110
R-110.5
R-111
R-111.5
R-112

FIGURE I-66

accompanied by a net gain in beach area over the same time period, as indicated by a decrease in the required mitigation shown in Figure I-57. This apparent reduction in jetty impact therefore appears to be the result of onshore movement of sand from the offshore bar. If this continues, it would represent reestablishment of natural bypass of the inlet, however, it should be noted that this onshore movement occurred during the summer months and may be a seasonal variation such as those which occurred during the 2nd, 5th, and 7th monitoring periods, as is evident in the variability in the computed mitigation quantities on the left half of Figure I-59.

A portion of the eroding area south of Blind Pass is a narrow strip of sand which separates Clam Bayou from the Gulf of Mexico. As discussed previously under Section I.C.3.2, when this strip of sand erodes subject to a storm tide, some of the sand removed from the beach face is washed by wave action over into Clam Bayou.

It has been suggested that this wash-over process has caused increased erosion rates which should not be counted in measuring the effects of the Blind Pass jetty extension. However, any contribution the wash-over process makes to shoreline recession rates was included in the background rate, and if that contribution is any greater during the monitoring period, then it should be considered an impact. It may be that the structure has interrupted the sand budget resulting in this section of shoreline becoming more vulnerable to wash-over. Furthermore, as discussed by Dean (1991), wash-over was more significant during the background period because a longer section of shoreline was subject to wash-over at that time. Appropriately accounting for the wash-over issue would therefore result in increasing the amount of mitigation required for the jetty extension impacts.

D. Sand Budget Analysis.

Introduction. A sand budget analysis was completed to address two specific sections of Sanibel Island's shoreline. The purpose of the analysis is to gain a better understanding of the causes of erosion. This knowledge can be useful in estimating the effects of continued erosion, and in designing ways to combat erosion.

The focus of this study is two sections of shoreline previously identified as problem areas. They are the Blind Pass area at the northern end of Sanibel between the Florida Department of Environmental Protection (DEP, formerly Department of Natural Resources) reference monuments R-109 through R-116, and the Gulf Pines area approximately between R-127 through R-133. Both lie within the study area shown in Figure I-67.

This analysis was done using a computer wave refraction model and sand transport computation procedures prescribed by the Corps of Engineers Shore Protection Manual (SPM). The refraction model was developed by Dr. R.A. Dalrymple and Dr. J.T. Kirby, both with the Center for Applied Coastal Research at the University of Delaware. The model considers the incoming wave direction, and modifies that direction by simulating refraction as the waves move into shallower water. Finally, the model calculates the breaking wave height, location, and angle to the shoreline in the zone where sand transport takes place. The SPM procedures use these breaking wave characteristics to determine the amount of sand transport.

Bathymetry. In order to run the model, detailed water depth information must be stored in the computer. This was done by first generating a digital terrain model of bottom elevations within the study area from recent DEP beach profiles. A rectangular grid was then defined over the terrain model, with grid points spaced 500 feet apart in the longshore direction, and 250 feet apart in the offshore direction. A depth value was then obtained from the terrain model, at the corresponding location of each of 1,800 grid intersection points, for input to the refraction model.

Wave Data. Model wave data input came from the U.S. Army Corps of Engineers Wave Information Study (WIS) 1989 Report 18, entitled, "Gulf of Mexico Hindcast Wave Information." Hindcast wave data consists of wave heights, directions, and periods, which would theoretically have been generated by meteorological conditions covering some previous time period. The WIS report contains twenty years of hindcast wave data based on wind data collected at a series of offshore stations between 1956 and 1975. The information used for this analysis is from WIS Station No. 42, which is located approximately twenty (20) miles offshore from Sanibel. In order to input this twenty years of hindcast wave data to the refraction model, the data were first broken down into two categories: normal waves and storm waves. The wave data were then

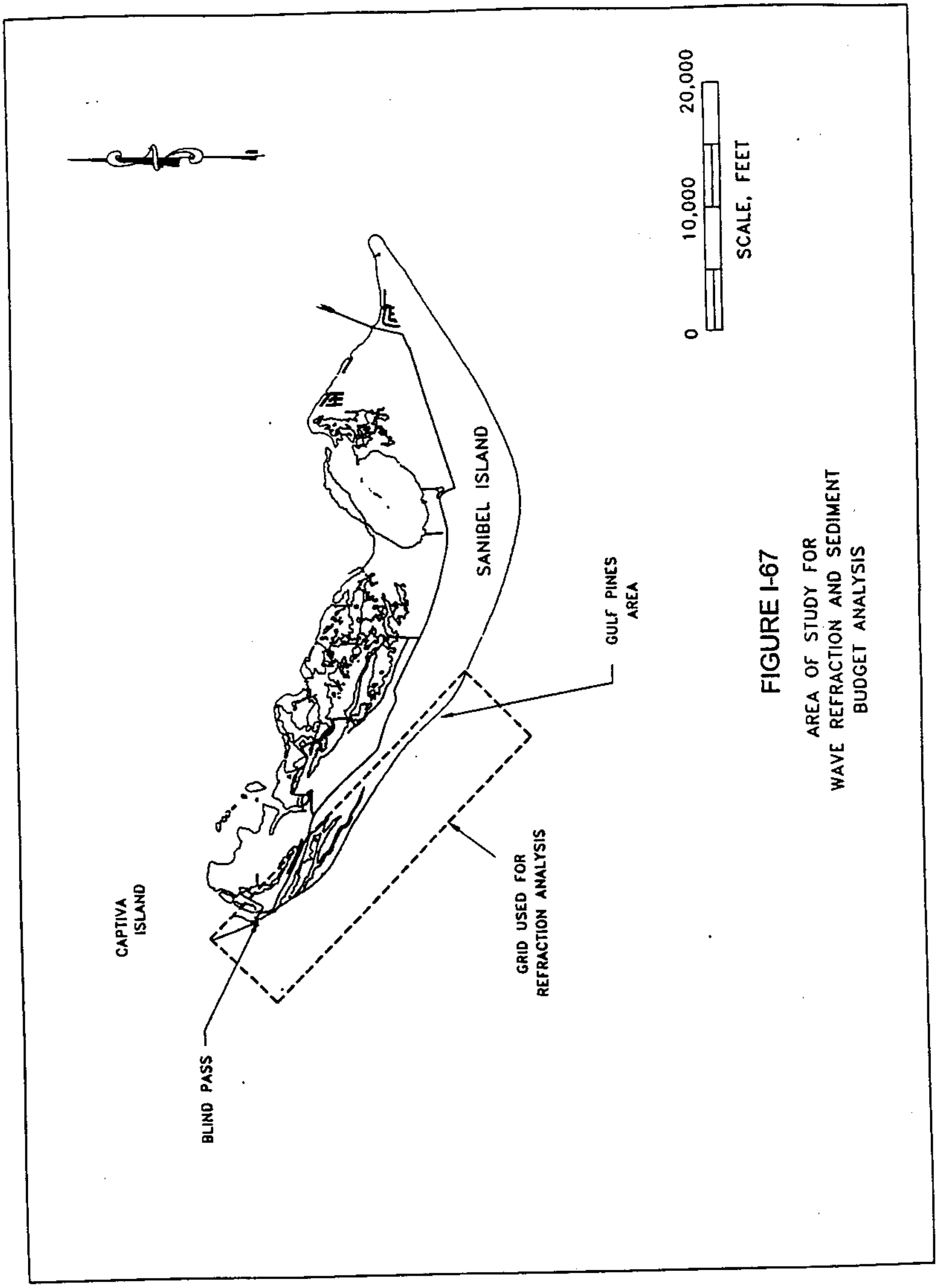


FIGURE I-67
AREA OF STUDY FOR
WAVE REFRACTION AND SEDIMENT
BUDGET ANALYSIS

further divided into groups according to the direction of wave approach, in 22.5 degree intervals approaching the shoreline.

The data presented in Table IV-1 represents annualized averages of deep water wave conditions for Station 42.

Wave Approach Angle (R-107 to R-135)	**Wave Height (ft.)**	**Wave Period**	**Percent Return (sec.) (%)**
North			
45.0 (s)	5.87	7.10	0.1
45.0 (n)	2.72	4.81	3.3
22.5 (s)	5.58	7.04	0.1
22.5 (n)	2.58	4.90	2.7
0.0 (s)	5.15	7.26	0.3
0.0 (n)	2.79	5.02	3.7
-22.5 (s)	5.18	7.44	0.5
-22.5 (n)	2.66	4.95	3.7
-45.0 (s)	4.92	7.45	1.0
-45.0 (n)	2.69	5.01	3.2
-67.5 (s)	2.92	5.06	4.0
-67.5 (n)	4.92	7.48	1.3
South			

(s) = storm conditions
(n) = normal conditions

TABLE I-5

INPUT WAVE DATA

Figure I-68 shows the relationship of the grid to the shoreline orientation, and an example incoming wave direction.

From the directional wave data, the model predicted the change in direction and height of the wave as it approached the shoreline. The model results consist of the breaking wave location, height, and angle, for conditions representative of each wave group at 500 foot intervals along the shoreline. These results provide the information necessary to compute the longshore component of sand transport at each location for that given wave condition.

Sand Transport. The results of the wave refraction model were used with empirical relationships presented in the U.S. Army Corps of Engineers Shore Protection Manual to compute longshore wave energy flux. The energy flux can be used to compute average longshore sand transport rates, which provide estimates of volumetric change rates in the study areas.

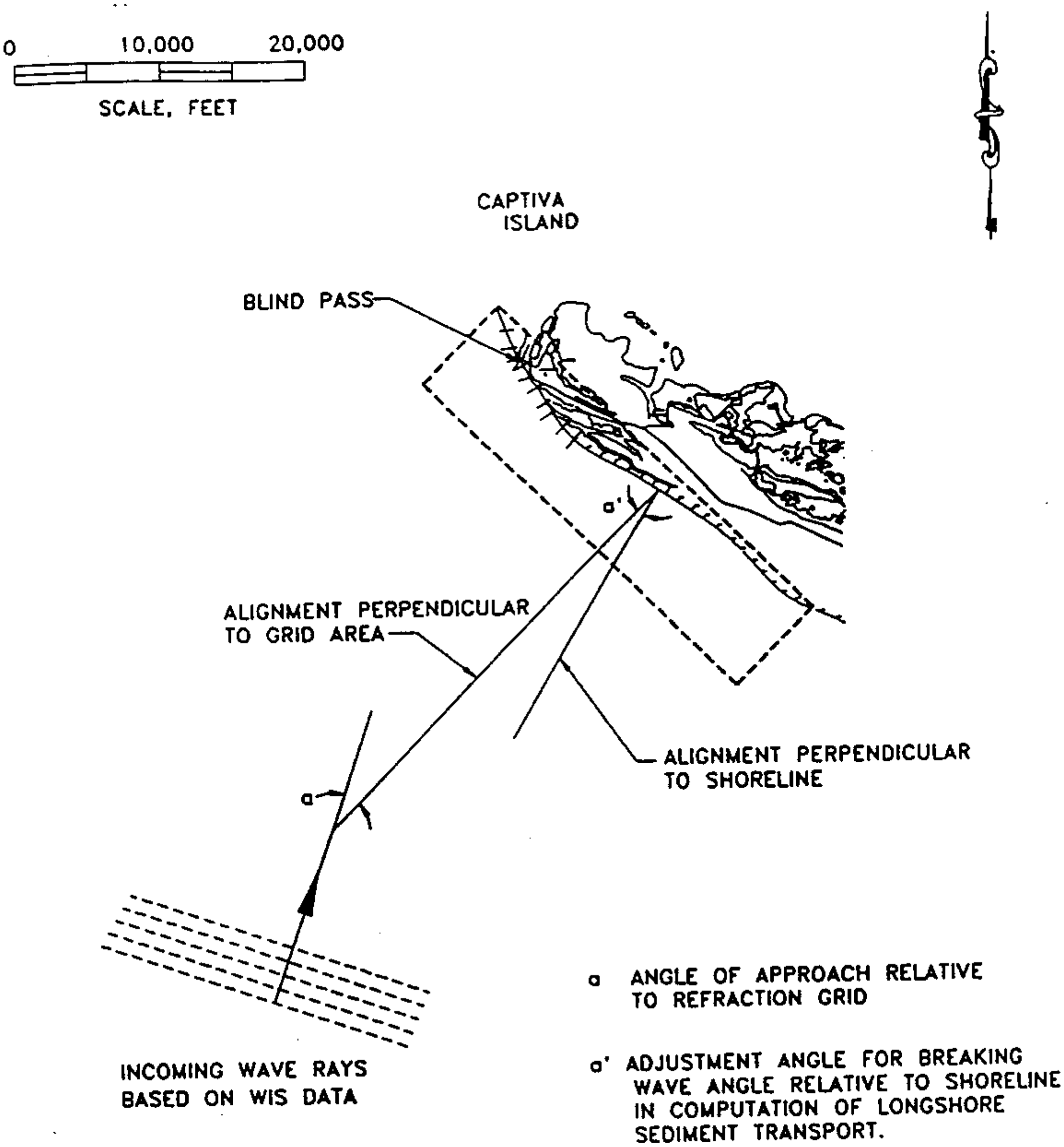


FIGURE I-68
WAVE REFRACTION

The longshore energy flux equation (4.1) and the sediment transport equation (4.2) from the Shore Protection Manual are given below.

$$P_{lb} = \frac{\rho g}{16} H_b^2 C_b \sin(2\alpha) \qquad 4.1$$

$$Q = \frac{K}{\rho_s - \rho} g a' P_{lb} \qquad 4.2$$

Where:

- P_{lb} = longshore energy flux factor
- H_b = breaking wave height
- C_b = breaking wave velocity
- α = breaking wave angle to shoreline
- Q = longshore transport rate
- K = a dimensionless coefficient
- ρ_s = mass density of sand
- ρ = mass density of sea water
- g = acceleration of gravity
- a' = solid to void ratio of sand

The breaking wave angles predicted by the refraction model were based on a rectangular grid and a linear shoreline. However, the actual shoreline is not linear, and the location and relative direction of breaking waves is significantly influenced by local variation in the orientation of the shoreline. Furthermore, waves break before they reach the shoreline, and the orientation of the nearshore contour where the waves break may provide a better indication of the direction of sand transport than does the shoreline orientation. This is particularly true in the vicinity of the ebb tidal shoals near Blind Pass where a significant amount of wave energy is expended before reaching the shore.

In order to refine this element of the analysis, recent aerial photography was used to determine the appropriate shoreline orientation at each grid point where wave breaking was computed by the model. Figure I-69 presents a comparison of the modeled breaking wave angles to both the linear shoreline and to the nearshore contour at the point where waves break. Figure I-70 shows the difference between the two angles (Alternatively, Figure I-70 may be thought of as the difference between the orientation of the refraction grid shoreline, and the orientation of the shoreline or nearshore contour where the wave breaks).

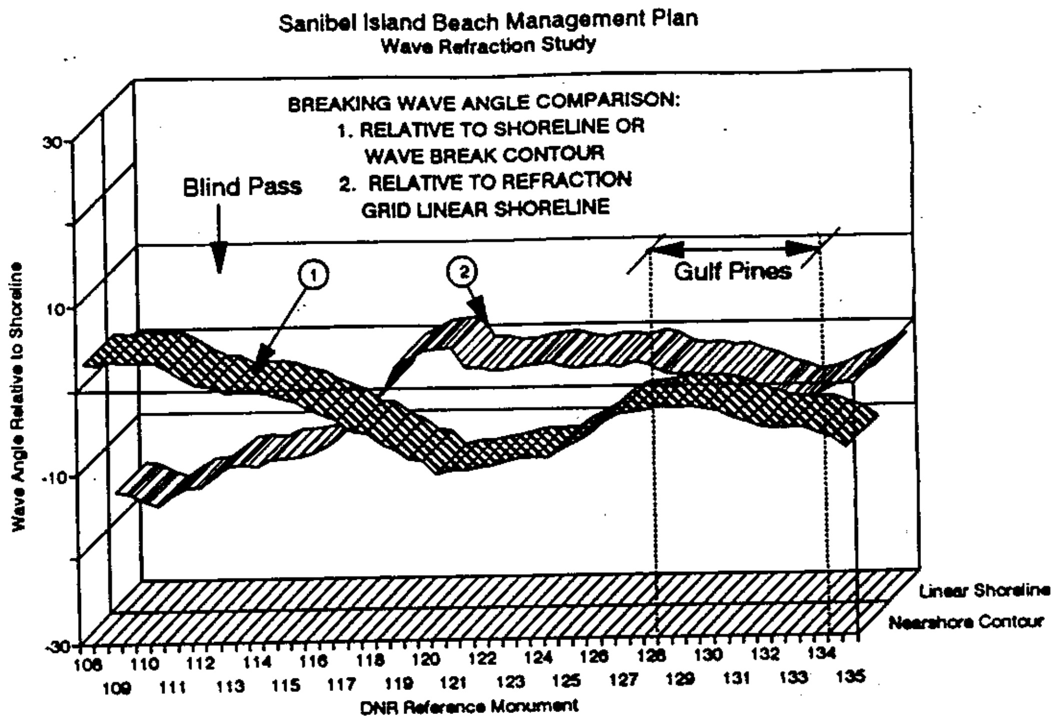


FIGURE I-69

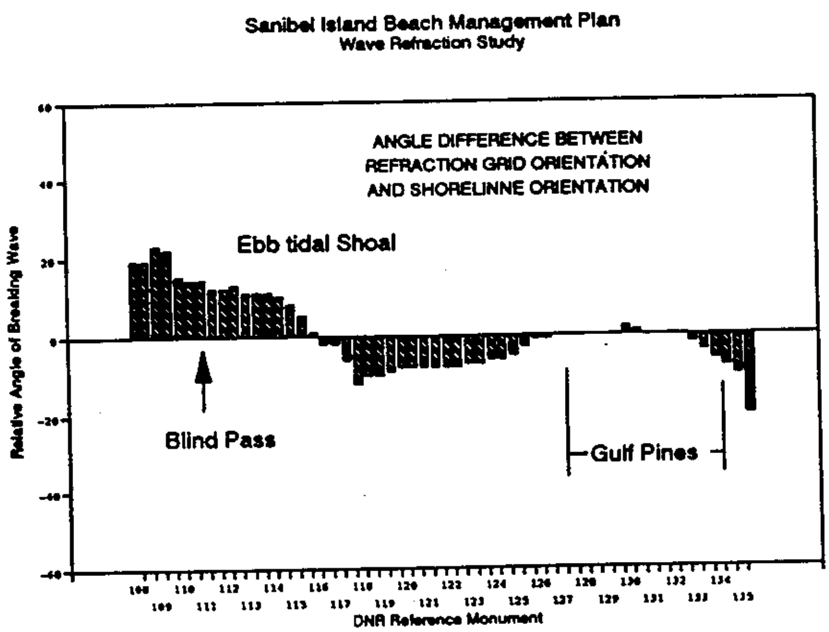


FIGURE I-70

Figure I-69 illustrates that nearshore shoals have a significant impact on littoral transport, and should be considered in sand transport analysis.

Analysis of Results. The wave angles indicate how sand is moving. In cases where refraction causes waves to converge on an area, sand will accumulate in that area. Conversely, waves diverging from an area will cause erosion. Figure I-71 presents the breaking wave angle relative to the wave break contour alignment. It shows two sections of shoreline which might be expected to be erode and two which might be expected to accrete, based on breaking wave angles.

It is recognized that the general alignment of Sanibel's shoreline is northwest to southeast. However, reference to north and south is generally used in discussions of the gulf coast of Florida. With this convention, negative values on Figure I-71 and I-72 represent transport from north to south.

The longshore sand transport rates for the study area were computed, and the results are shown in Figure I-72. This data has been smoothed, ie., each bar is the average of values of two points to either side. This was done because the model only considers a set of 12 specific incoming wave criteria rather than a continuous wave spectrum, and the smoothing procedure imparts the results with a higher degree of continuity.

Figure I-72 shows that either erosion or accretion may occur whether transport is toward the north or toward the south. What matters is the direction and magnitude of transport at either end of a beach section. If the difference between what is coming in and what is going out is positive, the beach section is accreting, if the difference is negative, the beach section is eroding. If a section of shoreline has increasing transport rates in the direction of transport, that section of shoreline will erode.

Similar to the results of the wave breaking patterns, the results of the longshore transport rate analysis show two areas of erosion and two areas of accretion. The two eroding areas are divided further, and the areas are labeled A through F for discussion purposes. The sand budget for the segments is shown in Table I-6.

Segment	**Area**	**Result**
A	R-108 to R-110.5	Accretion
B	R-110.5 to R-113	Erosion
C	R-113 to R-121	Accretion
D	R-121 to R-127	Erosion
E	R-127 to R-132	Accretion
F	R-132 to R-135	Erosion

TABLE I-6

EROSION AND ACCRETION TRENDS

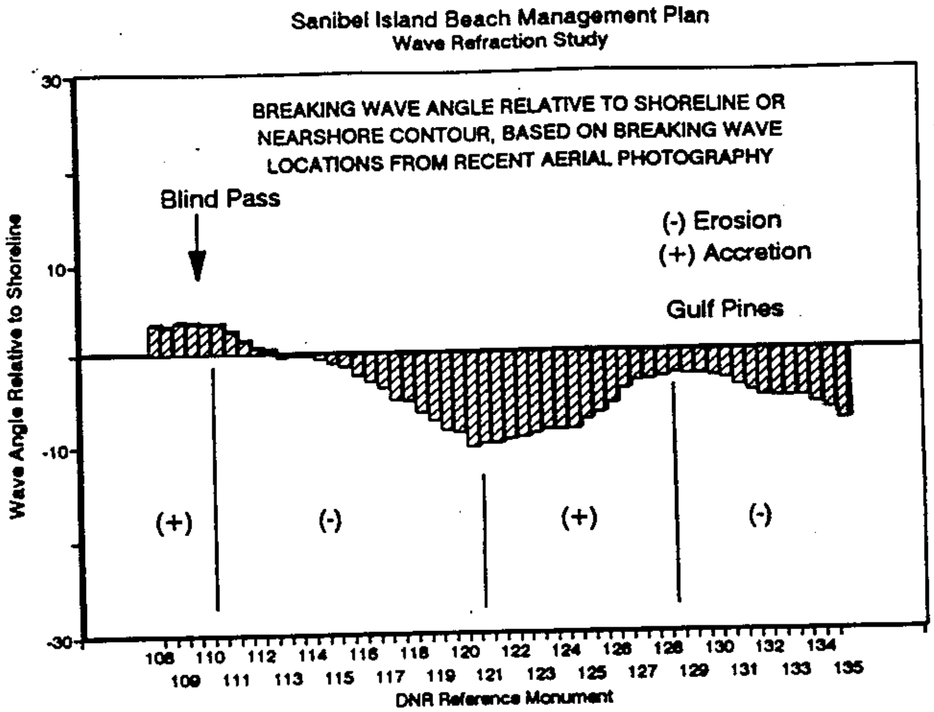


FIGURE I-71

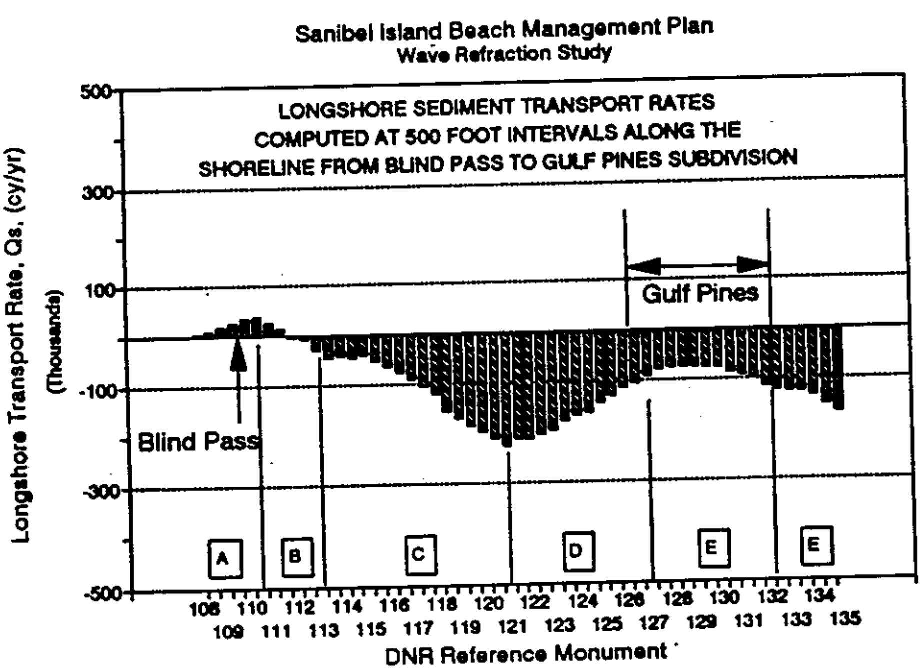


FIGURE I-72

Interpretation of the sand transport computation results is a critical part of the computer model process. It is important to understand that the results are average conditions derived from hindcast data representing a long period of time. They should therefore be considered as being more representative of expected long term rather than short term trends. Furthermore, these results are based on sand transport potential. Actual transport may be effected by other factors. For example, incoming wave direction near inlets is altered when waves encounter tidal currents, and the wave breaking angle will therefore be tide dependent and different from that which was predicted by the model. A barrier such as the jetty at Blind Pass may prevent sand movement in spite of longshore energy potential. Similarly, an armored section of shoreline may limit the amount of sand that is available for transport, resulting in lower transport than predicted by the model.

Areas affected as discussed above may not quantitatively agree well with the model results. However, agreement between the model predictions compared with measured changes in other areas where the coastal processes are less complicated provides assurance that the model is telling us what the natural forces are trying to accomplish. This is valuable information in designing solutions in problem areas.

Following is a brief discussion of sand transport computation results in each area.

Section A. The refraction analysis results predict that the area from R-108 through R-110.5 is an area which should be experiencing a volumetric gain. Comparison with shoreline change rates shown in Figure I-20 shows that this area has experienced considerable accretion in recent years, but those changes include sand placed on the beach in the 1989 beach nourishment, which makes it difficult to verify model results.

An additional factor is that this area is north of the jetty where the beach has undergone a significant readjustment in shoreline orientation. This shoreline reorientation is responsible for the model predicting northward transport. The jetty, which enhances the tendency for sand to accumulate here during periods of southward transport, would reduce the supply of sand into the area during periods of northward transport. Therefore, although the model predicts northward transport in this area, the amount of sand available to be moved in that direction is limited.

Section B. The model predicts erosion in section B between R-110.5 and R-113, in the immediate vicinity of Blind Pass. It also shows sand moving northward at R-111.5 and southward at R-112, indicating a drift reversal. This is consistent with historic shoreline trends shown in Figures I-19 and I-20, which show shoreline advance at R-110 but erosion over the rest of this area.

Section C. The model results show a fairly constant transport rate at the north end of this area from R-113.5 to R-115, indicating stability. However, with a limited sand supply from the north, and an increasing rate of transport southward from R-115, this area would be expected to erode, which is what has occurred as is shown in Figures I-19 and I-20.

Growth of the ebb tidal shoal offshore from area A, described in Section I.C.3.4 and Figure I-66, is of interest in comparison with predicted sand transport. Sand trapped in this shoal is a symptom of limiting the supply of sand to the Sanibel shoreline. The model in fact predicts stability south of the present location of the ebb shoal. This is consistent with continuance of the recent progressive migration of that shoal to the south, as shown in Figure I-66. If the shoal continues to accumulate sand in this manner, erosion of the shoreline south of R-115, along which southward transport is predicted to gradually increase to the south to R-121, should be expected to continue.

Section D. This section of beach from R-121 to R-127 is an area with decreasing transport rates in the direction of transport. This indicates the area should be accreting. Figure I-20 shows that the shoreline has been accreting, and the model agrees well with measured changes.

Section E. Between R-127 and R-132 the model predicts accretion at the north end and mild erosion at the south end. This is consistent with recent shoreline trends. The beach at R-129 has experienced fluctuations between erosion and accretion. R-129, near the north end of Gulf Pines, lies between an area to the north which has historically been accreting, and an area to the south which has historically been eroding. The results in this area quantitatively agree with an earlier analysis of this area done by Taylor (1991).

Section F. The area from R-132 through R-135 is an area in which wave energy is divergent. As one moves north to south in this region, the longshore sand transport rate increases, resulting in erosion.

Summary. As mentioned earlier, the sediment budget analysis is based on wave refraction over nearshore contours, and shoreline orientation. There are several things which influence sand transport that the modeling did not consider, such as wave refraction caused by tidal currents, the jetty as a physical barrier to transport, and hardened shorelines which have no sand to contribute to the littoral system. Wave energy may be expended on a structure if sand is physically restrained from moving. However, the results of the model qualitatively agree with actual shoreline behavior over a significant portion of the study area. Furthermore, differences between survey data and model results may be an indication of the degree to which something is interfering with natural processes.

The specific delineation of problem areas is subject to change with localized changes in the bathymetry. For example, as the ebb tidal shoal at Blind Pass continues to grow to the south, erosion may be expected to shift further to the south, as has been occurring during the six years during which monitoring data has been collected. The model predicts that the most severe erosion will be south of where it has been observed in recent years. The same is true for the Gulf Pines area. Recommendations in Section I.F are made to address information needed to continue monitoring the dynamic situation south of Blind Pass, as well as the progressive erosion in the Gulf Pines area.

Figure I-73 presents a comparison of beach profiles extending out to 3500 feet offshore. The four profiles presented are from DNR reference monuments R-116, R-125, R-137 and R-148. The monument notation increases north to south. Figure I-73, illustrates that the offshore profiles become flatter toward the south. As waves approach the Sanibel coastline from the west, they begin to slow down in the shallower waters due to the friction they encounter from the bottom. This results in a general breaking angle directed to the south. Because of this, the remainder of Sanibel's shoreline, south of the area included in the forgoing refraction modeling, would in general be expected to experience southward transport toward Point Ybel. Of course nearshore variations in the bottom contours have significant effects on the final breaking angle as discussed above.

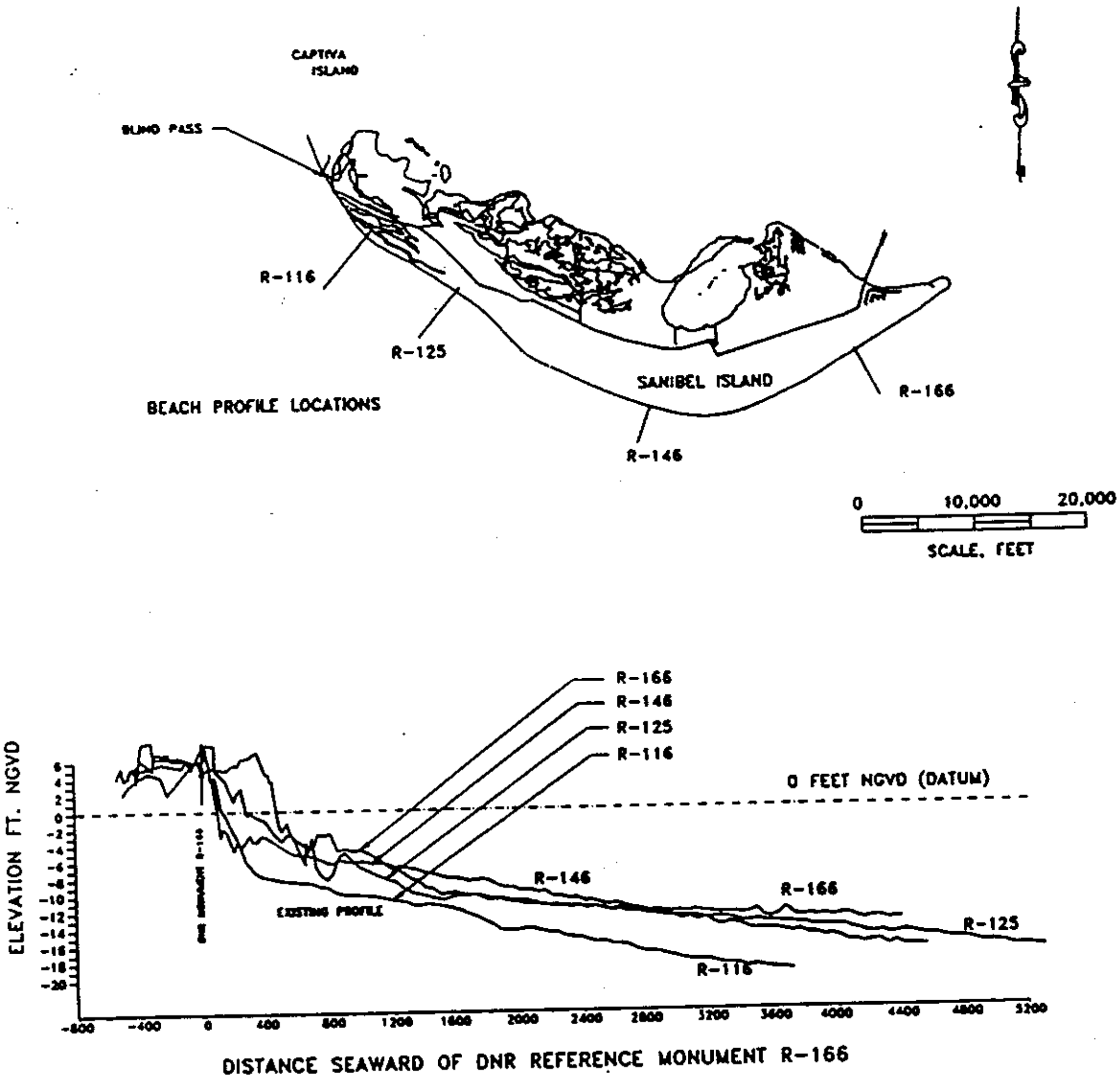


FIGURE I-73

BEACH PROFILE COMPARISON

E. Sand Source Inventory.

The nature of sand sources in the area can be inferred to some degree from the geology of Sanibel Island, as well as from prior sand source investigations conducted for adjacent island beaches.

According to Hine (1987) the northern part of the Florida Platform was once under a body of water known as the Suwannee Straits. The Suwannee Straits eventually filled with quartz sands and muds brought down from the southern Appalachian Mountains. The quartz sands were eventually carried further to the south along the Florida Platform and reworked with in varying proportions with native carbonate deposits to produce materials composing the beaches of Florida today.

The Beach Erosion Control Study of Lee County prepared by the U.S. Army Corps of Engineers, 1969, describes the State of Florida as occupying a portion of the much larger geographic formation known as the Floridian Plateau, which is the partially submerged plateau between the deep water of the Gulf of Mexico and the deep water of the Atlantic Ocean. During geologic time, successive rises and falls in sea level caused the water line to advance and recede across this plateau, and waves and currents working on marine sediments formed and then transformed offshore bars, beaches, and islands. Sanibel and the other Lee County barrier islands are post-Pleistocene deposits related to the present emerging shoreline.

A review of data from core borings taken across Sanibel Island reveals that the Island is composed of a top layer of coarse tan oxidized beach sand and shell which ranges in thickness from 6 to 16 feet (Missimer, 1973). Below the layer of coarse beach sediments is a layer of similar thickness but composed of fine grey sand. This is characteristic of sediments deposited in a submerged offshore environment. Below this layer is a thin layer of marine mud containing un-weathered shell and some sand lying on top of Pleistocene sandy limestone. The marine mud layer is characteristic of intertidal deposits, which indicate a period of either lower sea level or tectonic subsidence within the last 50,000 years, prior to the origination of the present island formation. A representative typical cross section of Sanibel Island is shown in Figure I-74.

The sandy upper layer was most likely formed by a process in which wave action transported littoral drift from north to south along a prograding spit, until it reached the southern extremity of the formation. There it was transported around the southern tip of the spit and deposited where it was protected from further wave induced transport. Missimer also reported that all of the sand deposits have high quartz sand content indicating that geologically there

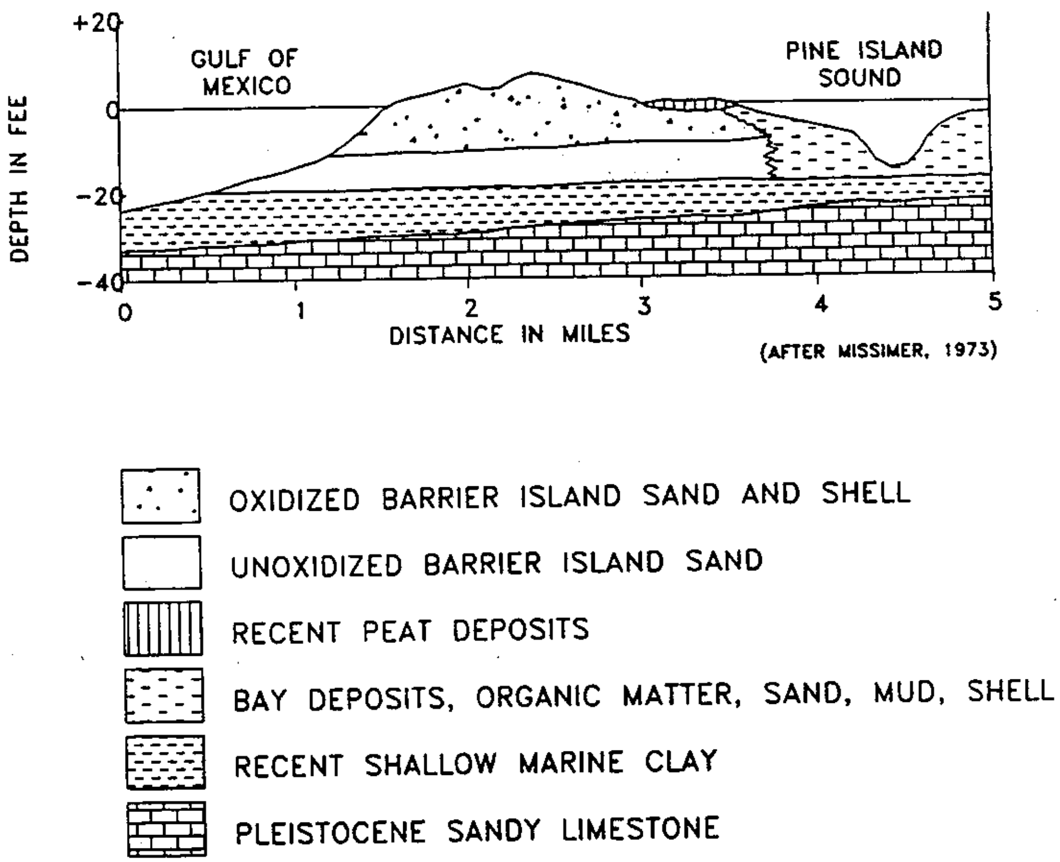


FIGURE I-74

IDEALIZED CROSS SECTION, PERPENDICULAR TO THE AXIS OF SANIBEL ISLAND has been a consistent supply of this sand. The oldest part of the island is the bay side of the northwestern end of the island, which is approximately 5,000 years old according to the results of radiocarbon dating by Missimer. Radiocarbon dating indicates progressively more recent sediments toward the east, with the most recent being less than 1,000 years old near the eastern end of the island at Point Ybel. Figure I-75 shows the radiocarbon dating locations, and also shows interpolated age contours which might be considered as approximate shoreline positions during the evolution of Sanibel Island. This supports the hypothesis that the island formed as the result of a prograding sand spit. Furthermore, the quantity of sand in this upper layer is equivalent to an accumulation of approximately 40,000 cubic yards per year over a 5,000 year period. This is an amount which is similar in magnitude to estimates of the present rate of littoral sand transport along this section of the Gulf Coast of Florida. Figure I-76 reproduced from Missimer's report, illustrates the stratigraphy of Sanibel Island.

Additional more specific information on sand sources in the area is contained in previous studies by the Corps of Engineers (1969), South Seas Plantation (1980), and the Captiva Erosion Prevention District (1989).

5.1 Corps of Engineers.

The Corps of Engineers Beach Erosion Control Study of Lee County (1969) included a limited number of offshore core borings as an initial exploration for locating potential sand sources for beach nourishment. Unfortunately, during the Project Formulation, nourishment was not considered for sections of shoreline which were either stable or accreting, inaccessible, undeveloped, or privately owned with no apparent interest in conversion to public use and hence not eligible for federal participation under present law and policy. Consequently, no nourishment projects were considered, and no borings were taken from areas offshore of Sanibel Island. However, information collected in other areas, particularly offshore of Captiva Island to the north and Estero Island to the east, may provide some insight into the nature of sediments offshore of Sanibel.

The offshore borings on Captiva Island showed the thickness of sand deposits to be from 9 to 14 feet thick over the top of a layer of limestone. The thickest sand layer, at 14 feet, was the closest to Sanibel Island, although it was taken approximately 4,000 feet north of the present location of Blind Pass.

Core borings were also taken offshore of Estero Island to the east of Sanibel, where the sand layer ranged in thickness from 4 to 29

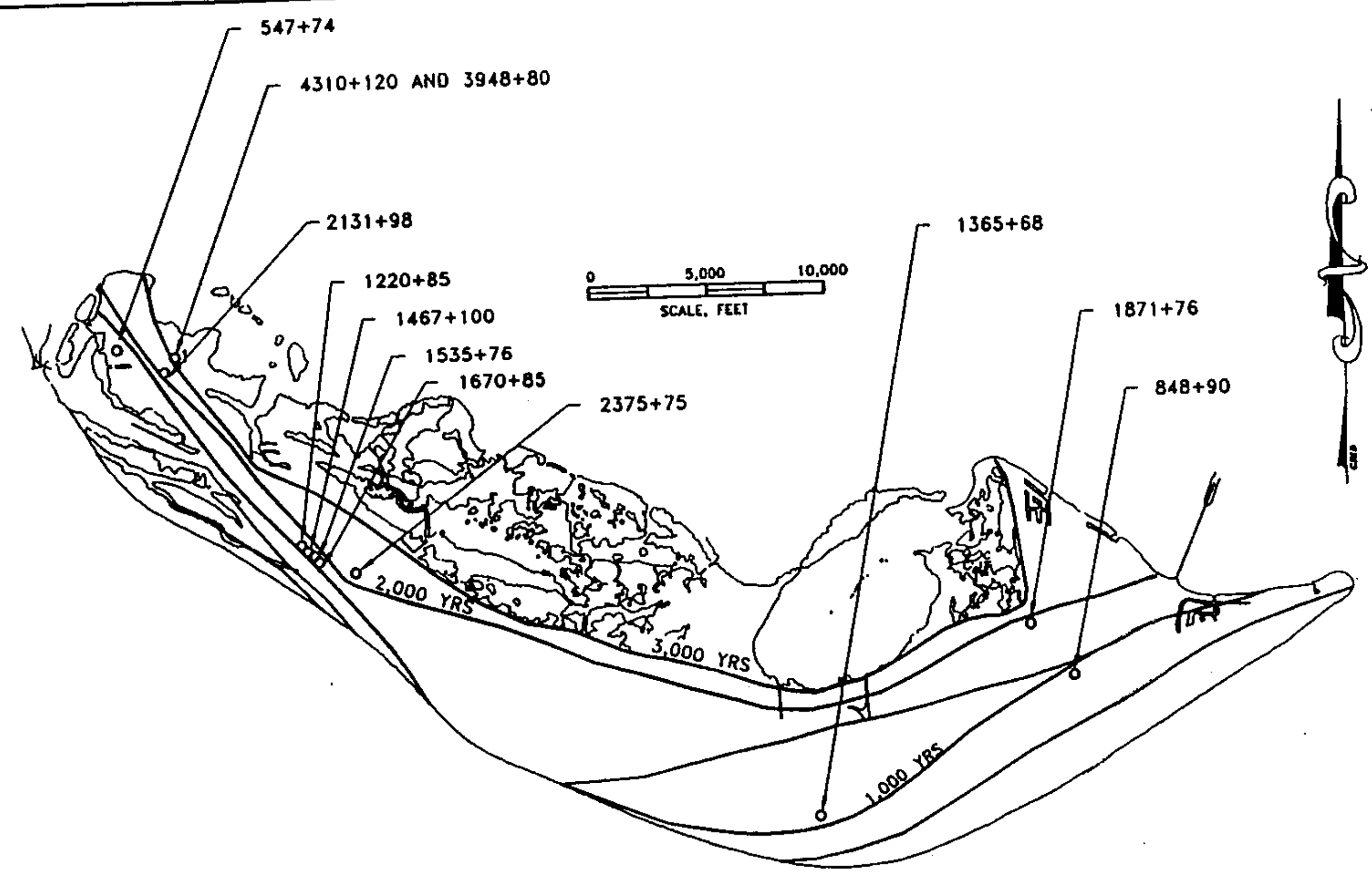


FIGURE I-75

RADIOCARBON SOIL AGE LOCATIONS
FROM MISSIMER, AND APPROXIMATE AGE CONTOURS

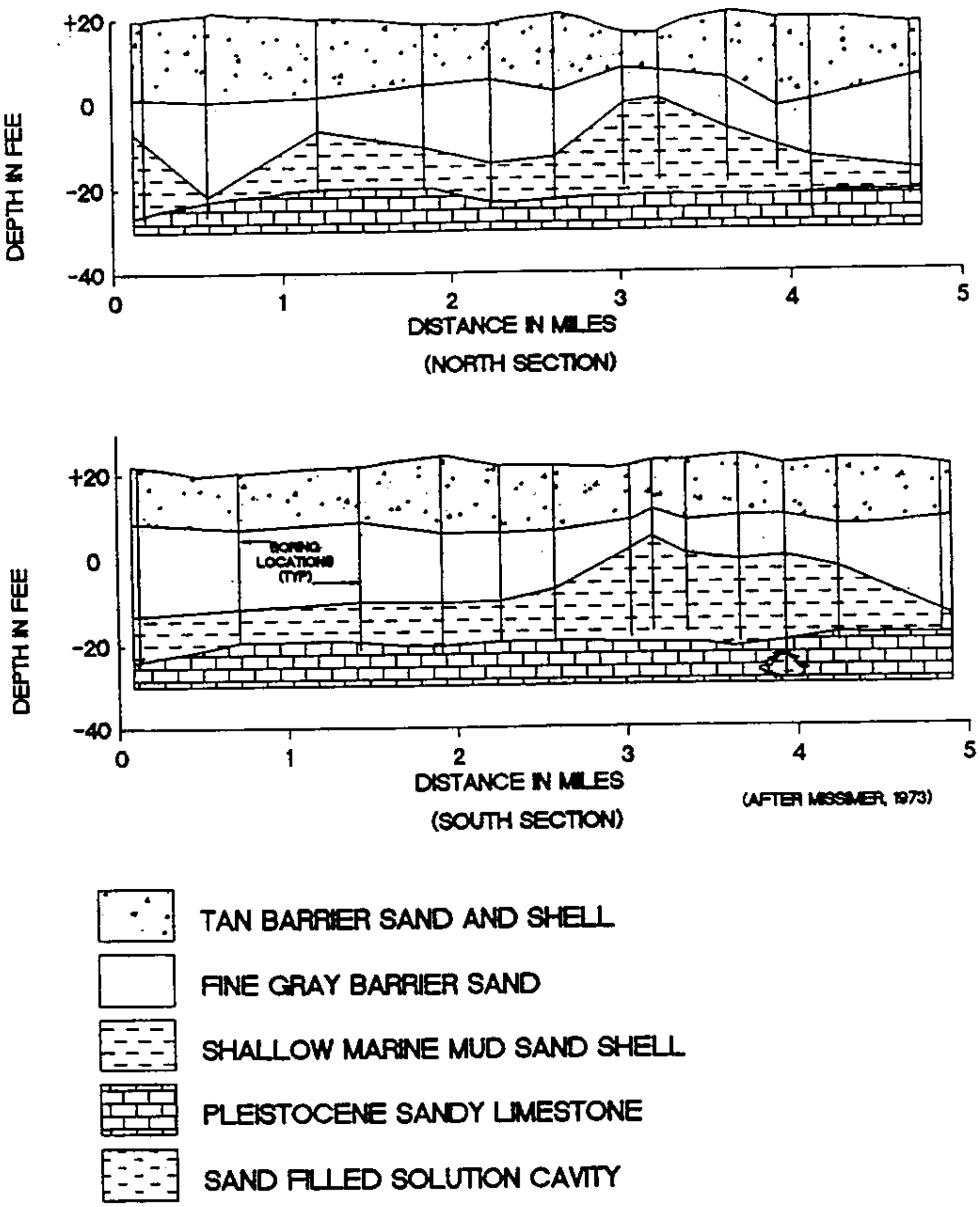


FIGURE I-76

EAST TO WEST SECTIONS
PARALLEL TO THE AXIS OF SANIBEL ISLAND

feet. The thickest deposit, at 29 feet, was at the north end of Estero Island. Although this is also closest to Sanibel, the core location was about 14,000 feet east of point Ybel. The significance of this information to Sanibel, however, is that this core was taken directly across the entrance to San Carlos Bay from extensive shoals that extend for several miles to the south from Point Ybel. The borings from the east side of the entrance to San Carlos Bay may indicate the kind of deposits that lie in shoals to the south of Point Ybel.

5.2 Captiva Erosion Prevention District.

Sand source investigations have been conducted over a broad offshore area for the Captiva Beach Nourishment Project. The most suitable source, with respect to low silt content and compatibility with the native beach material, is the Red Fish Pass ebb tidal shoal. This was the source for the first nourishment of South Seas Plantation in 1981, and for the Captiva beach nourishment project constructed in 1988 and 1989. This and other sources that were considered, and are being considered for future maintenance nourishment, are shown on Figure I-77. Also shown on this figure are the locations of borings taken by the Corps of Engineers, South Seas Plantation, and the Captiva Erosion Prevention District.

5.3 Sand Source Assessment.

Other sources and considerations are:

Upland. Upland sources on Sanibel Island would involve excavation that would create inland lakes in order to obtain the sand. As an example, a project the size of that proposed by Taylor (1991) for the Gulf Pines area would require a borrow pit 10 feet deep and covering approximately 27 acres. This would be considered detrimental to ground water quality, as described in the City of Sanibel Comprehensive Land Use Plan. Upland sources on the mainland would most likely be prohibitive logistically because of difficulties in hauling the required amount of material across the causeway and on local roads in order to truck it to the project.

Back Bay Sources. Although there are potentially adequate quantities of sand in the bay areas, they lie within the Pine Island Sound Aquatic Preserve. Sand mining in these estuarine areas would potentially be harmful to benthic and aquatic biological communities.

The most viable sources of sand for beach nourishment on Sanibel Island are offshore borrow sources. Detailed exploration with subbottom and side scan sonar is necessary to supplement information identified in Figure I-27, and to delineate the limits of suitable sand deposits and specific borrow area boundaries for

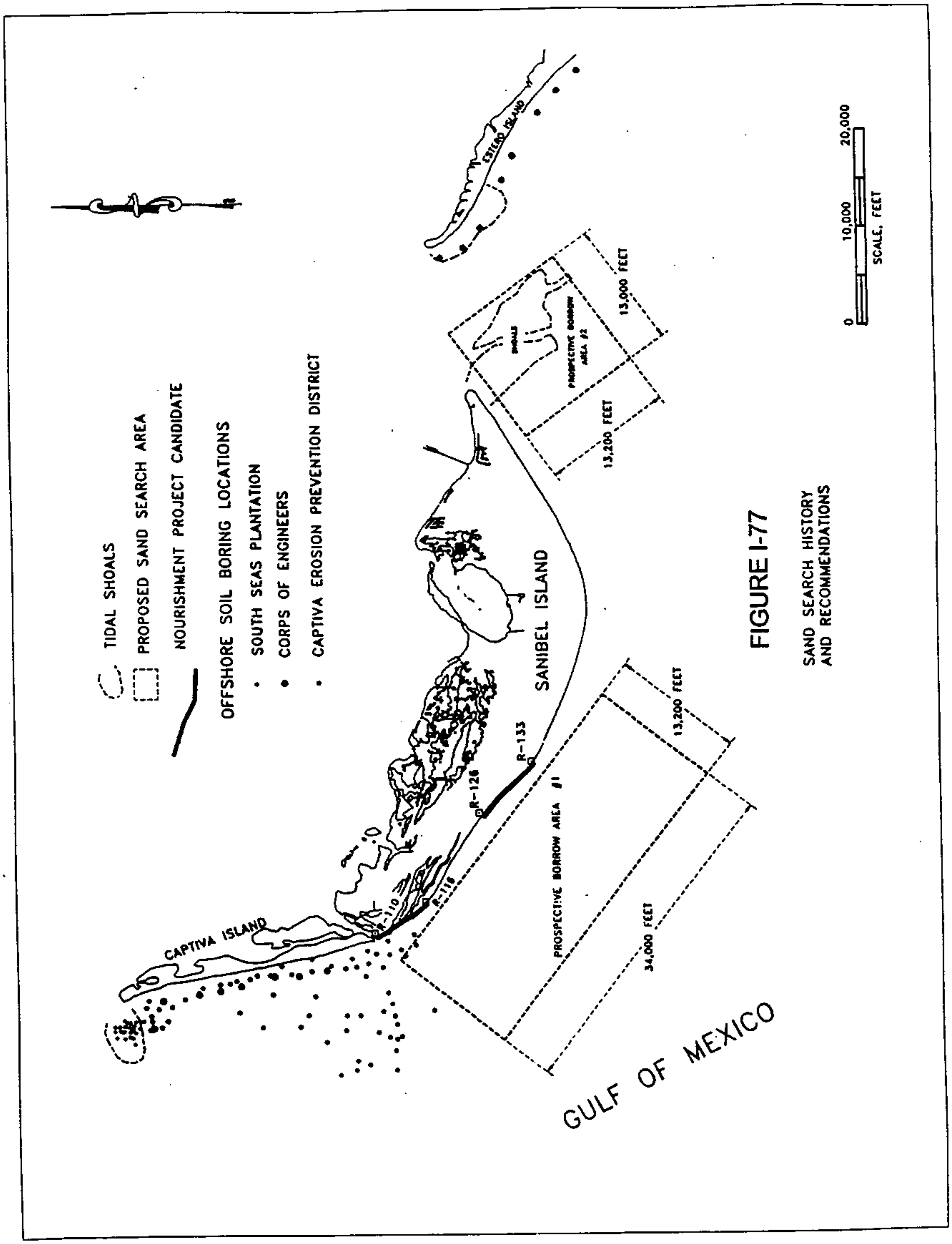


FIGURE I-77

SAND SEARCH HISTORY AND RECOMMENDATIONS

excavation. Shoals off of Point Ybel present the most likely location for suitable sand, but not necessarily the most cost effective source for beach nourishment south of Blind Pass and in the Gulf Pines and Gulf Shores areas because of the relatively large distance between the source and beach nourishment area. The cost would be high because the sand would probably have to be transported by barge or hopper dredge. Furthermore, the geological sections, particularly the south section shown in Figure I-76 indicate that sand deposits near the west end of the island may have greater thickness of sand over the layers of marine mud and limestone. For these reasons, it is recommended that area 1 be given first priority for future sand search efforts.

F. Monitoring.

1. State of Florida.

The State of Florida Coastal Construction Control Line (CCCL) program has established a system of permanent reference monuments along the coast of Florida. These monuments (still referenced as DNR monuments by DEP) are used as a baseline in surveying beach profiles from time to time, in order to measure shoreline changes and to collect data for maintaining and updating the CCCL program.

The DNR monuments are in general spaced at approximate 1,000 foot intervals. There are 66 DNR monuments on Sanibel Island, labeled R-110 through R-174 plus intermediate monuments at R-161A and R-174E. DEP has surveyed beach profiles at the monuments on Sanibel Island in 1974, 1982, and 1989. There have also been several conditional surveys for the purpose of documenting changes after storms, however, the conditional surveys do not include beach profiles at all of the monuments.

2. Local.

Sanibel. The City of Sanibel has commissioned surveys of the Blind Pass area, and the Gulf Shores and Gulf Pines areas, which were done in June 1990, July 1991, and July 1993. These surveys were conducted using the same survey control points for beach profiles as those used by the state DEP so that the data can be accurately compared with the existing database to quantify changes in the beach profile and shoreline position.

Captiva Erosion Prevention District (CEPD). The CEPD has been monitoring the shoreline of Captiva Island and the northernmost approximate 6,000 feet of Sanibel Island since 1985. Since 1988, as required by the CEPD groin extension and beach nourishment permit, the monitoring surveys have been done twice per year. The surveys have included beach profiles at reference monuments R-110 through R-116, plus three additional profile lines located approximately midway between DNR monuments from R-110 through R-113 on the north end of Sanibel Island.

3. Recommendations.

Monitoring data is extremely important both for understanding erosion as well as for designing solutions to erosion problems. This data is also important in the permitting process when regulatory agencies must be provided with justification for the proposed erosion control activities. Fortunately, because of surveys done by DEP, Sanibel, and CEPD, there is some good data for the gulf shoreline, although for most of the gulf shoreline there are only three surveys from 1974 to the present. Furthermore, there is practically no data for the bay shoreline other than USGS maps, NOS maps, and historic aerial photographs. The following recommendations are made for future monitoring.

Gulf Shoreline. The two most significant problem areas on the gulf shoreline lie between DNR monuments R-110 and R-137. A portion of this reach is being covered by the CEPD monitoring, and Sanibel has surveyed the southern portion three times. It is recommended that these ongoing programs be supplemented as necessary to obtain a survey once per year over this entire reach. Additionally, the entire gulf shoreline should be monitored, to maintain an accurate data base by which future changes or storm effects may be measured. Because large sections of the shoreline have historically been very stable, surveys of monuments at one mile interval should be adequate for annual monitoring of these areas. However, for future analysis of shoreline trends, it is recommended that all DNR monuments along the gulf shoreline be surveyed at intervals of five years or less.

This study has determined that the dynamic shoals at Blind Pass play a significant role in the sand budget at the north end of Sanibel Island, which ultimately has been the source of sand for all of Sanibel's beaches. Although the northernmost mile of Sanibel Island and the south end of Captiva Island are being monitored on a regular basis, a higher density of data collection in the vicinity of the Blind Pass shoals would provide a better understanding of the dynamic processes in this critical area.

Bay Shoreline. It is recommended that a monumented baseline be established along the bay shoreline. The monument spacing should be similar to that of the DNR monument network on the gulf coast. Profiles should be surveyed once per year for the first two years to establish an initial data base and document erosion in the most rapidly changing areas. Thereafter the survey timing could appropriately be adjusted, based on needs established by the first two surveys, to correspond to the surveys of the gulf beaches.

Specifications. Because of the dynamic nature of the area around Blind Pass as well as the other issues discussed under Section I.C.3, it is recommended that the area between reference monuments R-108 and R-113 be surveyed on an annual basis, with profile lines spacing of 250 feet. Additionally, Blind Pass should be surveyed with cross sections perpendicular to the axis of the channel. Surveys should be conducted annually at the same time of year limit the effects of seasonal changes.

The accuracy of hydrographic survey data tends be more variable than upland beach profile data. This is because upland data is taken with a level and level rod by surveyors on dry land or at wading depth in the nearshore zone, while hydrographic data collected in a boat has to contend with a number of additional variables. Weather is obviously a factor, and hydrographic surveys should be done during calm sea conditions. There are other variables associated with echo sounding depth measuring instruments which measure depth indirectly by measuring the interval of time required for an emitted sound pulse to reach the bottom and be reflected back to the transducer. Distances measured between the transducer and the bottom must be accurately adjusted for the depth of the transducer, which may vary according to the speed of the survey boat, the number of people in the boat, and the amount of fuel on board. Depths must also be adjusted for the tide. Since the measurement is dependent on determining a distance from the time it takes a sound pulse to traverse that distance, it is essential that the instrument be calibrated to the speed of sound in the survey area.

One of the most common errors in hydrographic survey data is improper instrument calibration. It can also be one of the most difficult to detect, or to correct for once detected. It is therefore recommended that hydrographic surveyors be required to provide their calibration data along with the hydrographic data. The calibration data should be in the form of a bar check, by which a bar or other object be suspended under the boat on a calibrated chain or cable, to provide a depth signal on the fathometer chart over a known range of depths. The range of depths should be consistent with the range of depths to be encountered within the survey area. The bar check should be performed during calibration at the beginning of the survey, and without calibration at the end of the survey in order to document any changes which may have occurred during the data collection. Any additional recalibration or bar checks performed during the survey should also be recorded.

DEP maintains an extensive database of beach profile data around the coast of Florida. That data is made available to coastal communities around the state for their own uses. DEP collects the data in a specific format which contains all the vital information necessary to make proper use of that data in analyzing coastal processes. It is recommended that data collected by the City of Sanibel be provided to DEP, in the standard DEP format, for addition to the State's coastal database.

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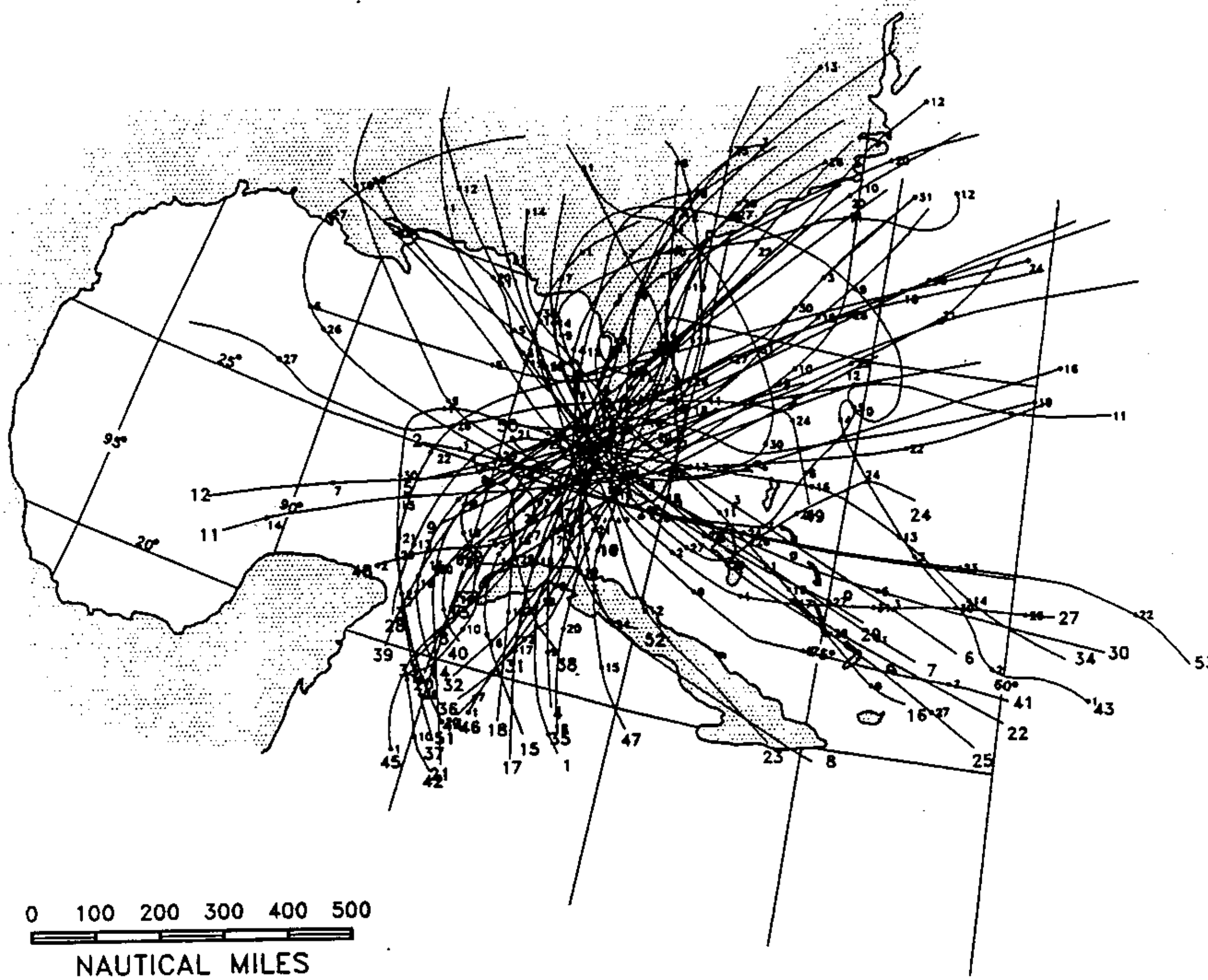
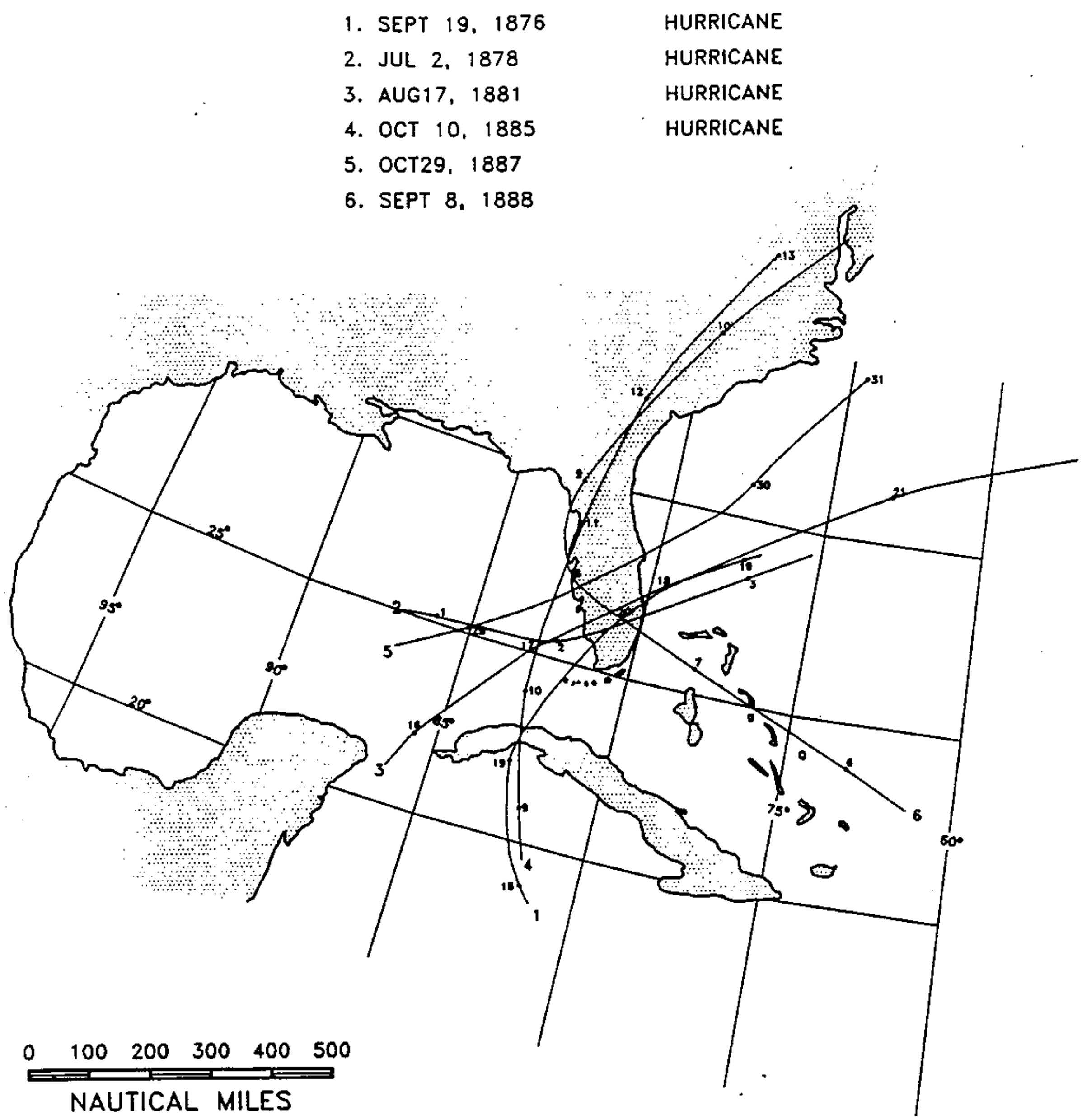
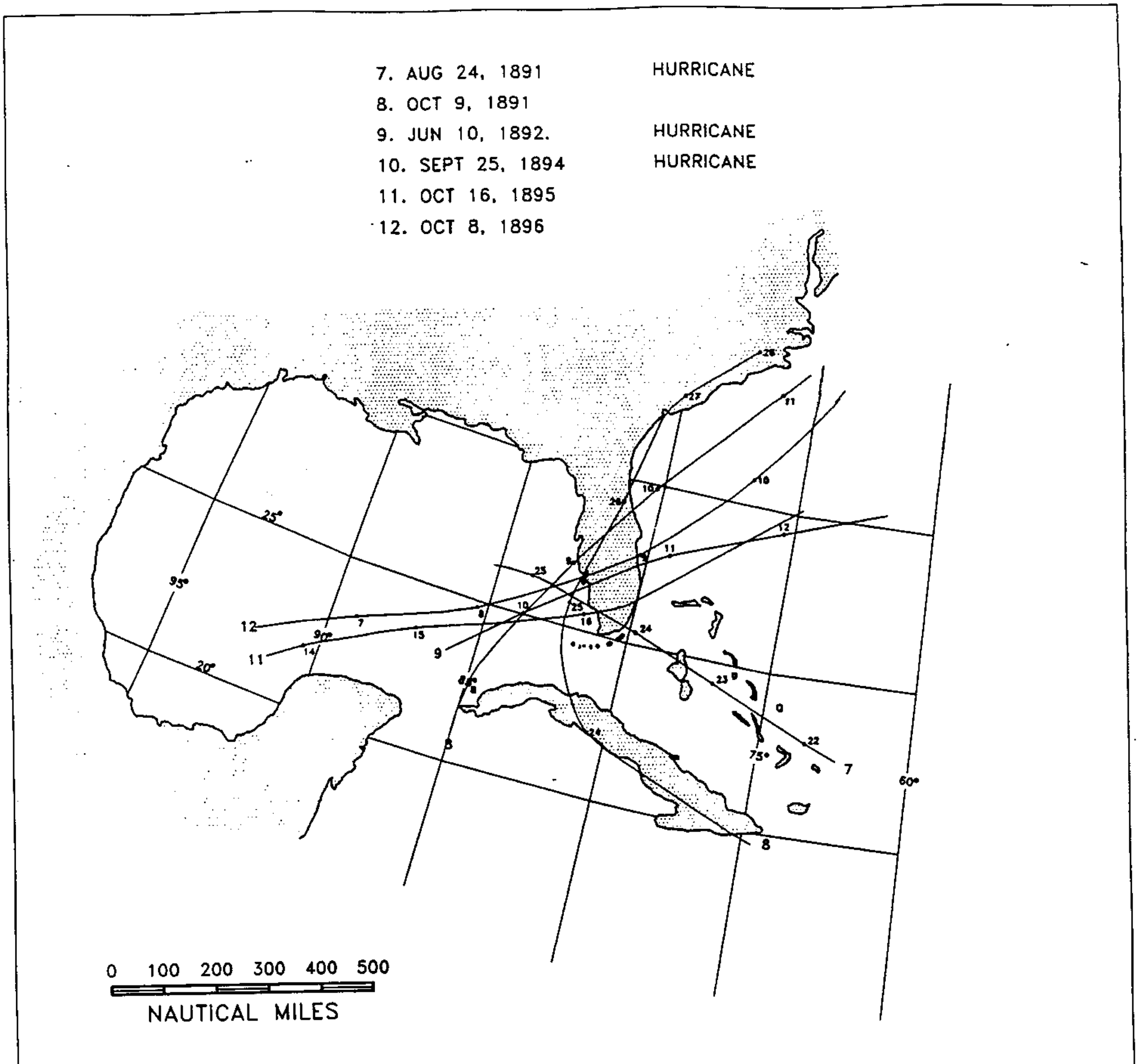


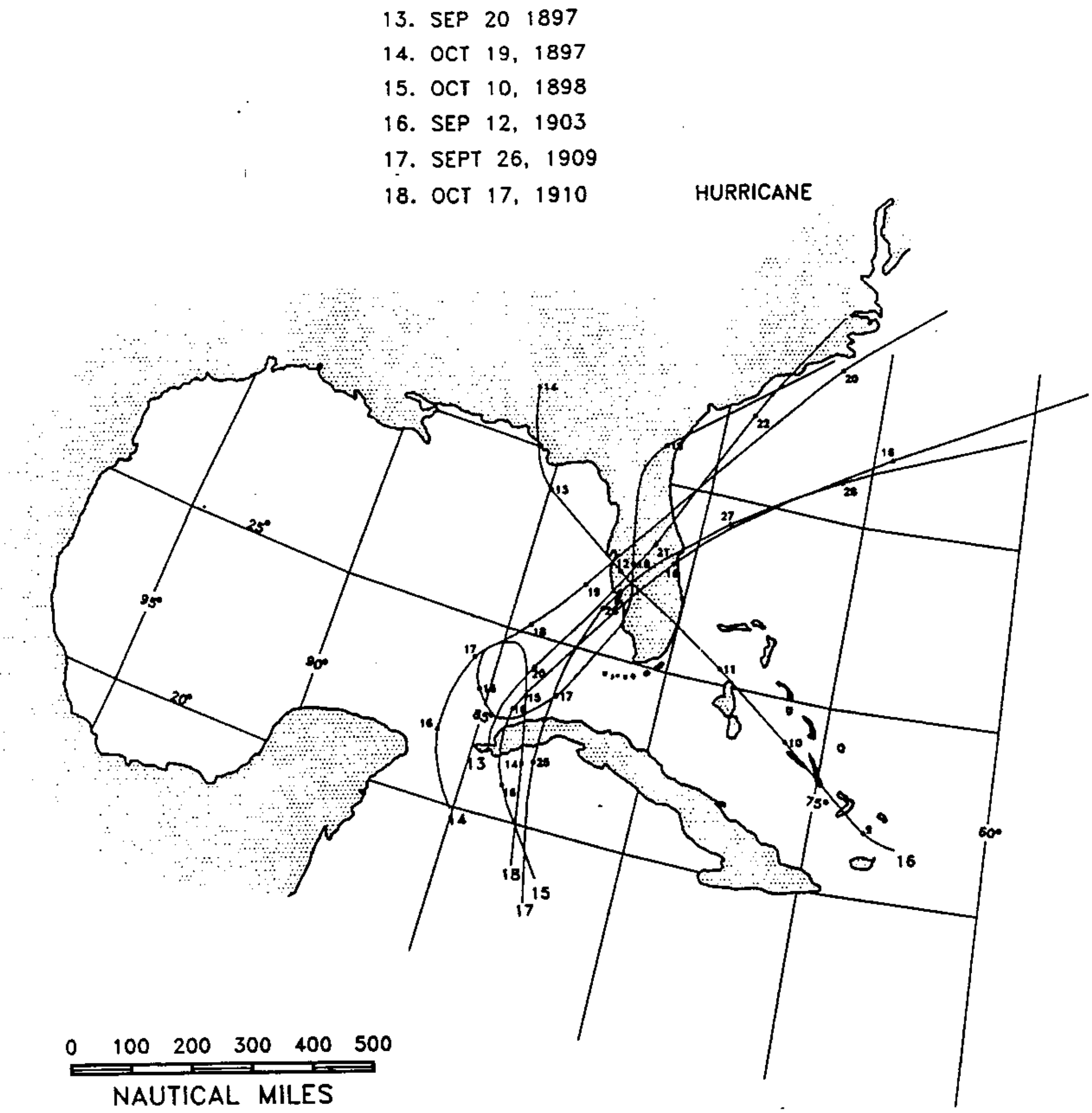
STORM TRACKS FOR ALL HURRRICANES AND TROPICAL STORMS PASSING WITHIN 75 MILES OF SANIBEL FROM 1876 TO 1993



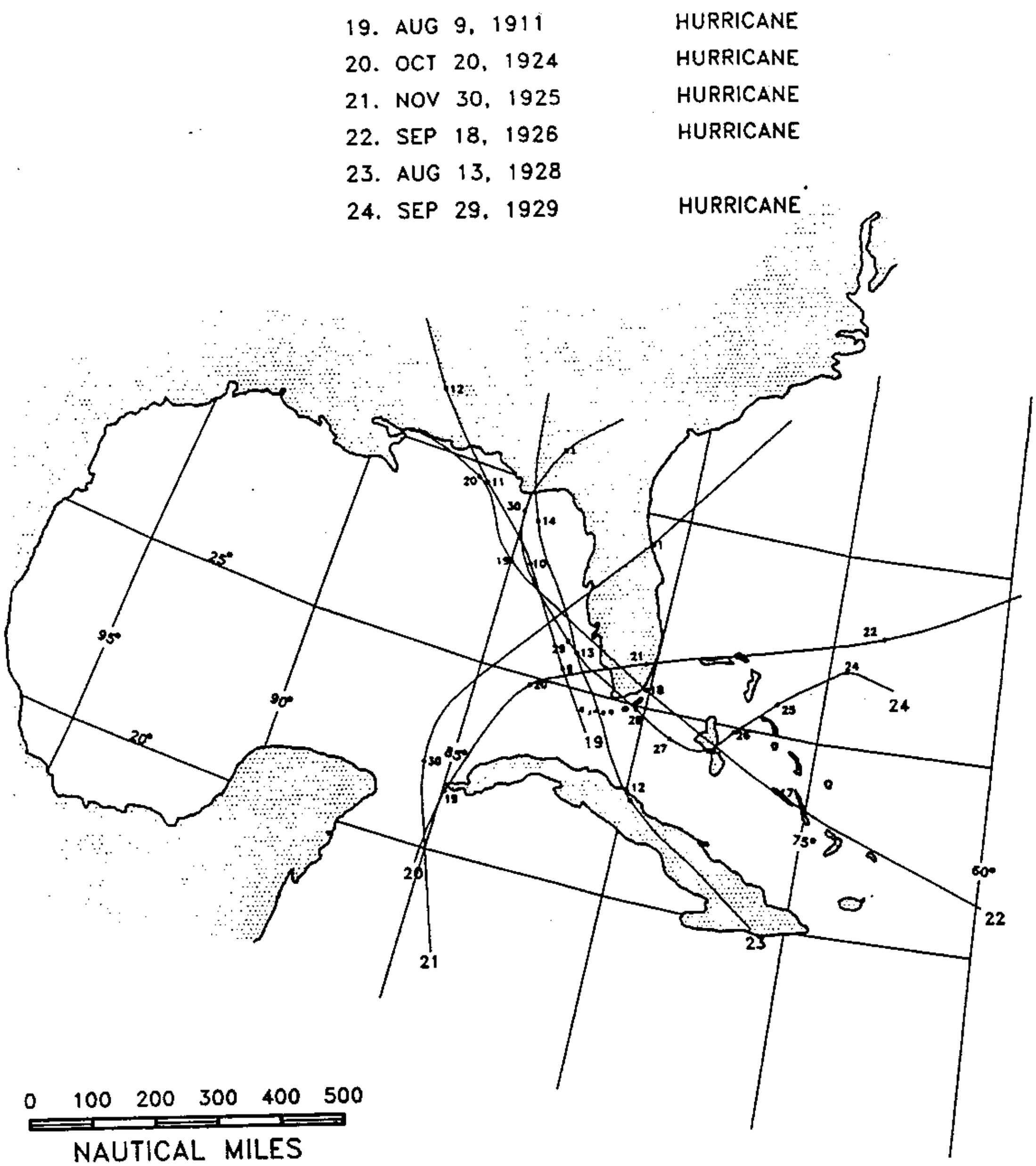
STORM TRACKS FOR ALL HURRRICANES
AND TROPICAL STORMS PASSING WITHIN
75 MILES OF SANIBEL FROM 1876 TO 1890



STORM TRACKS FOR ALL HURRRICANES
AND TROPICAL STORMS PASSING WITHIN
75 MILES OF SANIBEL FROM 1891 TO 1896

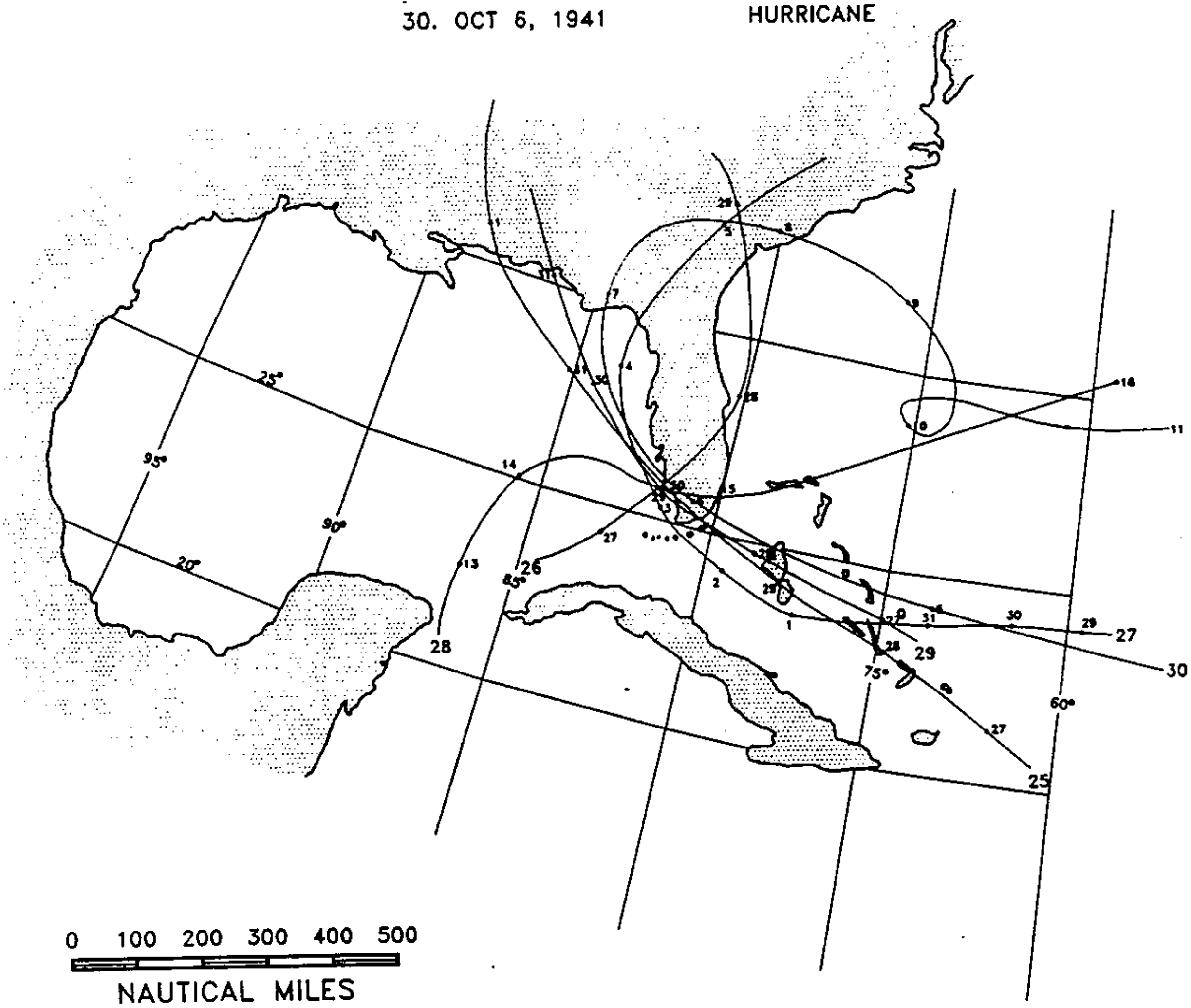


STORM TRACKS FOR ALL HURRRICANES AND TROPICAL STORMS PASSING WITHIN 75 MILES OF SANIBEL FROM 1897 TO 1910



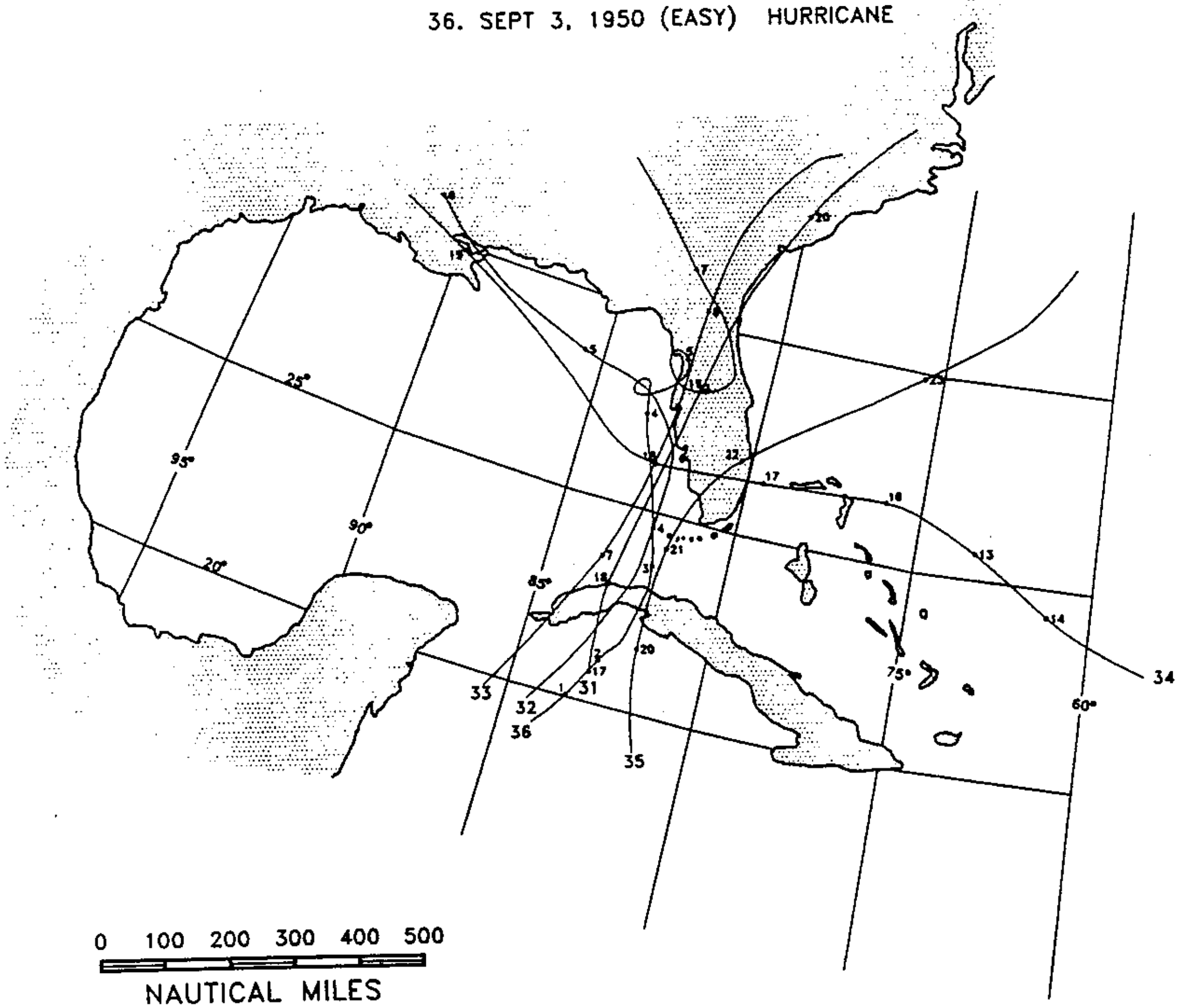
STORM TRACKS FOR ALL HURRRICANES AND TROPICAL STORMS PASSING WITHIN 75 MILES OF SANIBEL FROM 1911 TO 1929

25. AUG 30, 1932
26. MAY 27, 1934
27. SEP 3, 1935 HURRICANE
28. JUN 14, 1936
29. JUL 29, 1936
30. OCT 6, 1941 HURRICANE

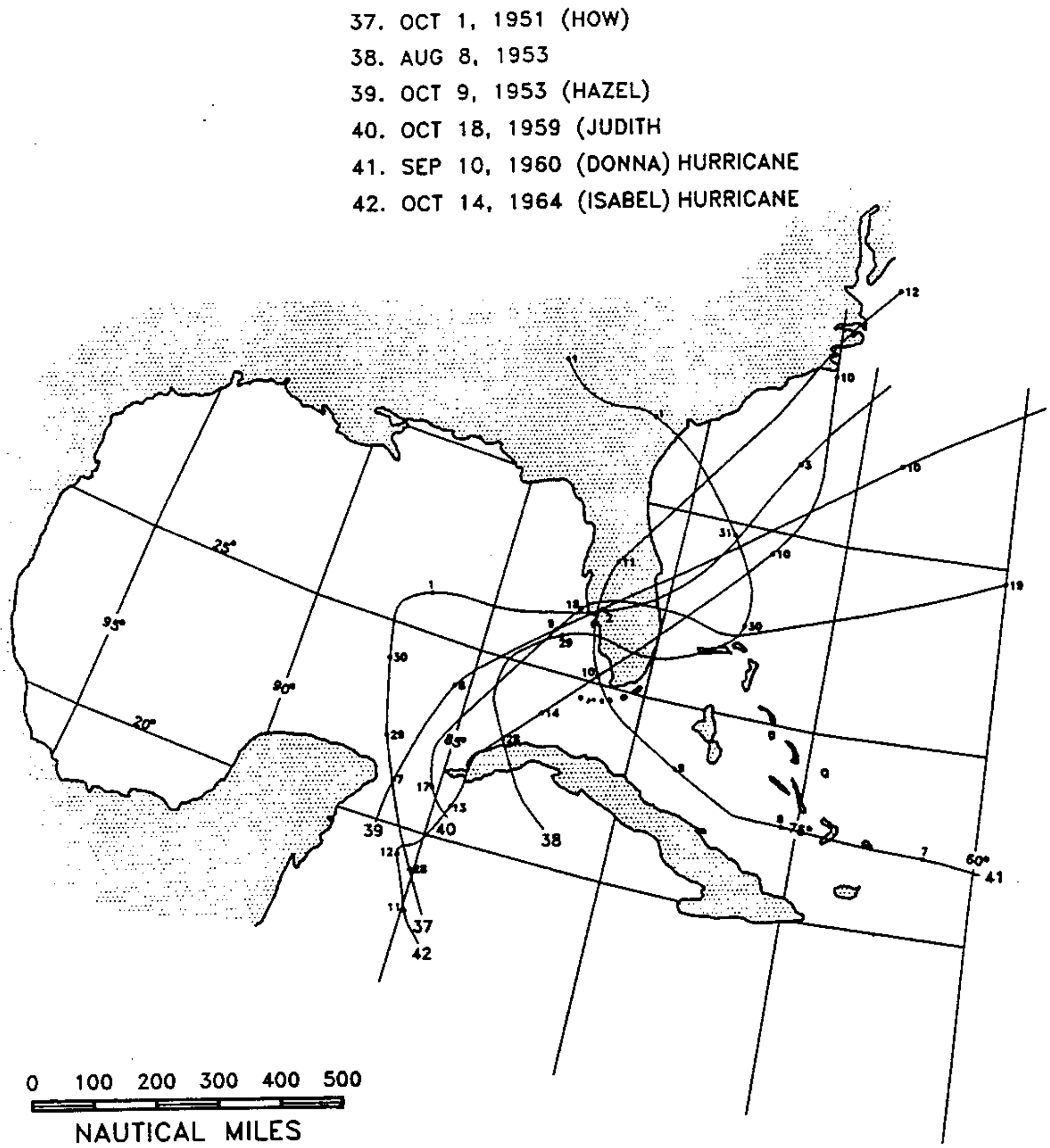


STORM TRACKS FOR ALL HURRRICANES
AND TROPICAL STORMS PASSING WITHIN
75 MILES OF SANIBEL FROM 1930 TO 1941

31. OCT 18, 1944 HURRICANE
32.OOCT 4, 1945
33. OCT 7, 1946 HURRICANE
34. SEP 17, 1947 HURRICANE
35. SEP 21, 1948 HURRICANE
36. SEPT 3, 1950 (EASY) HURRICANE

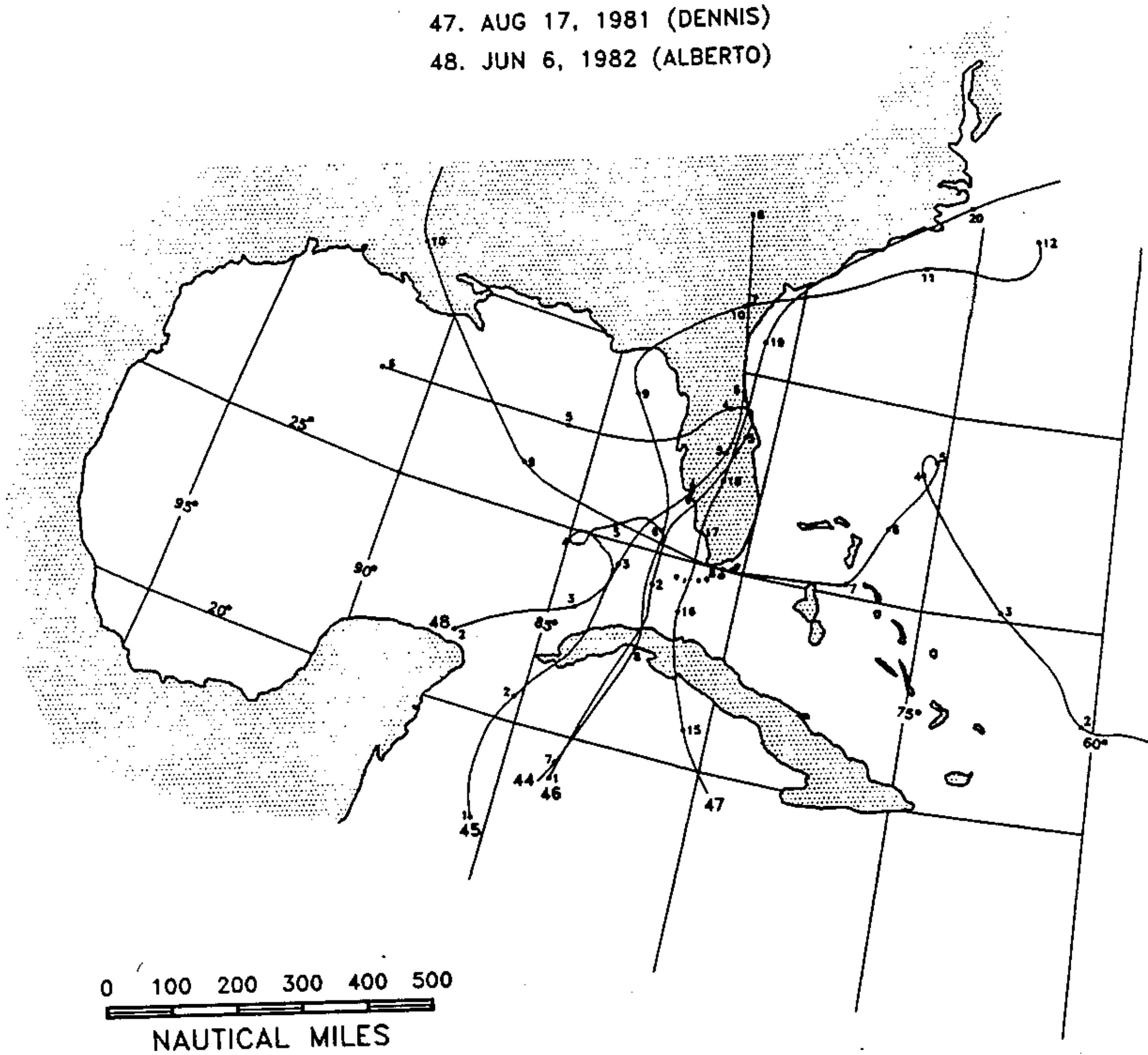


STORM TRACKS FOR ALL HURRRICANES AND TROPICAL STORMS PASSING WITHIN 75 MILES OF SANIBEL FROM 1942 TO 1950

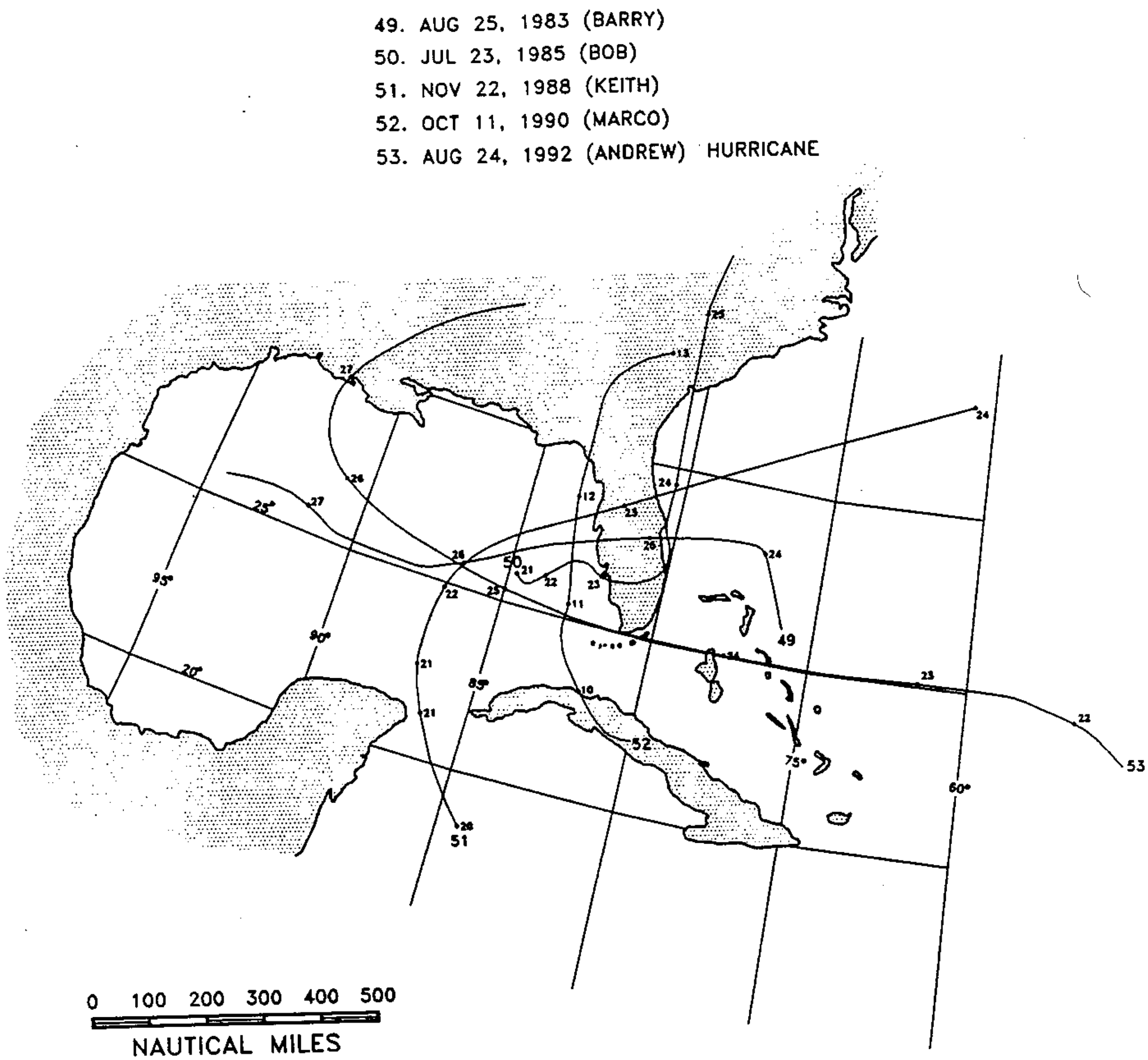


STORM TRACKS FOR ALL HURRRICANES
AND TROPICAL STORMS PASSING WITHIN
75 MILES OF SANIBEL FROM 1951 TO 1964

43. SEP 8, 1965 (BETSY) HURRICANE
44. JUN 8, 1965 (ALMA) HURRICANE
45. JUN 4, 1968 (ABBY)
46. OCT 2, 1969 (JENNY)
47. AUG 17, 1981 (DENNIS)
48. JUN 6, 1982 (ALBERTO)



STORM TRACKS FOR ALL HURRRICANES AND TROPICAL STORMS PASSING WITHIN 75 MILES OF SANIBEL FROM 1965 TO 1982



STORM TRACKS FOR ALL HURRRICANES AND TROPICAL STORMS PASSING WITHIN 75 MILES OF SANIBEL FROM 1983 TO 1992

NATURAL RESOURCES

SANIBEL ISLAND WIDE BEACH MANAGEMENT PLAN, SECTION II

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A. Natural Communities.

1. Gulf Beach Zone.

Florida Gulf Coast beaches are in a state of continual flux where the only constant is change. Life directly on the beach and adjacent storm ridges is a challenge to plants, animals and people alike due to shifting sands and assault by winds, salt and wave action. Even the classic beachgoer's day of light surf, warm sun and cooling breezes belies a brutal desiccating environment of non-nutritive, waterless soils, high salt exposure and relentless heat and ultraviolet radiation. Only vegetation highly adapted to the extreme conditions of a saline desert can prevail.

The ecology of Sanibel's beaches cannot be accurately described by focusing solely on the relatively narrow strip of sand and dune along the shoreline. The beach zone is the interface of a continuum formed by the gulf waters out to the continental shelf and moving inland to the adjacent coastal scrub, sub-tropical hardwood hammocks and interior freshwater wetlands. The makeup of the beach zone is shown in Figure II-1. Consideration of the distinct yet interactive nature of these components is the key to understanding this deceptively complex ecosystem.

2. The Nearshore Biology of the Gulf of Mexico.

Easily the subject of multiple volumes, (and has been, see further information list at end of this section) the web of life in the Gulf is inexorably linked to the productive nursery areas of the mangrove/seagrass/oyster bar estuarine system close inshore. Typically, for most fish and higher invertebrates, reproduction takes place in the tidal passes or offshore, and larval stages take their place initially amongst the myriad organisms of drifting zooplankton. Carried inshore at random locations by the vagaries of wind and tide, juveniles settle out, and those avoiding predation and a multitude of other deadly conditions will grow and develop in the estuaries, returning to the Gulf as adults to complete the cycle. Some of the nearshore fish species found in the vicinity of Sanibel Island are shown in Photograph II-1.

Habitat offshore is dependent on sediment conditions and the location of limerock outcroppings. Of particular importance in determining benthic community composition are silt and deposition patterns. The Caloosahatchee River has over thousands of years delivered copious quantities of silt to the nearshore system especially toward the east end of Sanibel near the mouth of San Carlos Bay. Even moderate wind driven waves pick this silt up and hold it in suspension turning the characteristic jade green Gulf to

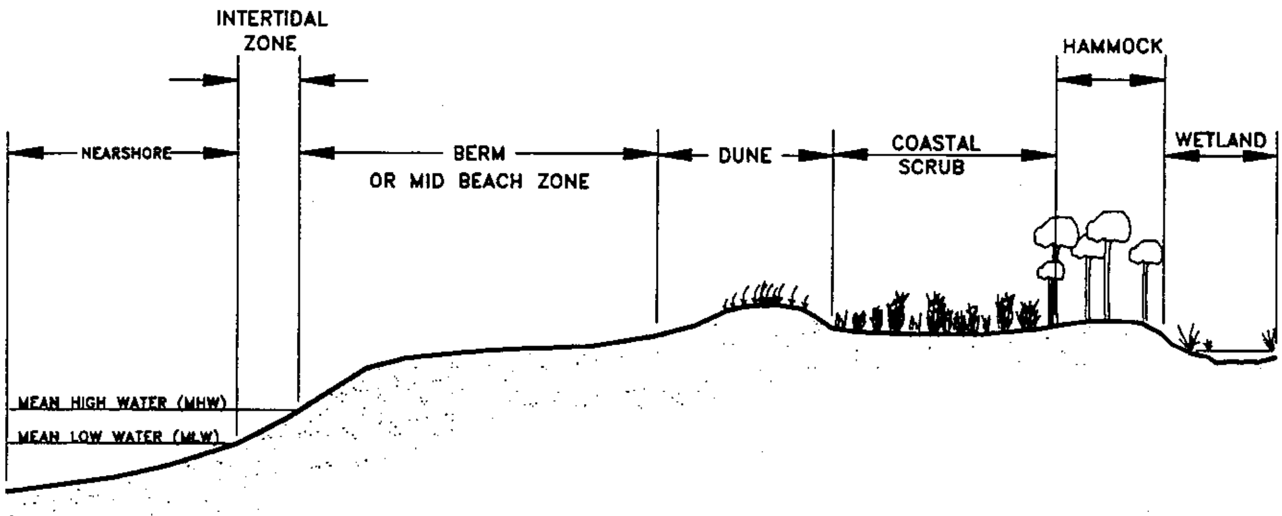
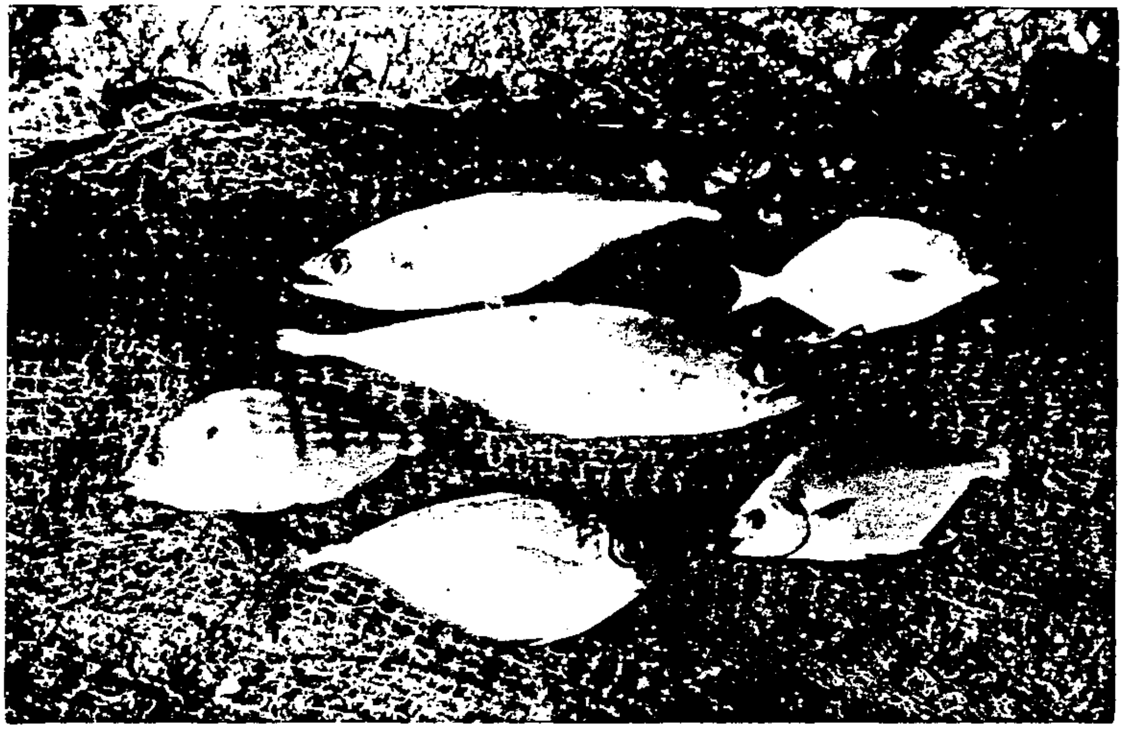


FIGURE II-1

BEACH ZONE DEFINITION DIAGRAM

HUMISTON & MOORE ENGINEERS
SANIBEL BEACH MANAGEMENT PLAN
JANUARY, 1995



Photograph II-1

Some of the nearshore fish species found in the vicinity of Sanibel Island are clockwise from top: leatherjacket, pompano, Atlantic bumper and pinfish.

a milky grey. This heavy silt loading and periodic redeposition greatly affects the fitness of bottom dwelling organisms, especially those that must remain permanently attached to the substrate like sponges, corals, seaweeds, etc. As a result, much of the sea floor within the zone of influence of the Caloosahatchee is relatively barren in terms of sessile (immobile) plant and animal life but still supports an abundance of mobile mollusks, echinoderms, and crustaceans such as horse conch (Fasciolaria gigantea), calico scallops (Pecten gibbus), nine-armed Luidia starfish (Luidia senegalensis), key-hole sand dollar (Mellita quinquiesperforata), stone crab (Menippe mercenaria) and pink shrimp (Penaeus duorarum). Those invertebrates, by virtue of their mobility, can adjust to the suffocating blanket of silt while sessile filter feeders like sponges cannot.

Encrusting organisms do find habitat where exposed limerock ledges protrude from the sediment. Locations of these ledges, often found 10-20 miles from shore, are closely guarded secrets among fishermen, and if these areas are in shallower water they may be temporary in nature as storms alternately cover and re-expose them.

Rock ledges support diverse clustering of algae and filter feeding soft corals and sponges which in turn create habitat for mobile invertebrates and fish such as snapper, grouper, and grunts. While such rock reefs are by no stretch as spectacular as the coral reefs found offshore of the Florida Keys, their bounty nonetheless attracts recreational scuba divers, spearfishing enthusiasts, and both sport and commercial hook and line fishermen.

The nearshore Gulf's relatively empty mud flats are also punctuated by occasional so-called "hard-bottom" communities where consolidated sediments and a relative lack of silt allow for attachment by sponges and algae. These inadequately studied aggregations of sealife attract and support predatory fish but generally not in densities or diversity comparable to rock ledges. Hard-bottom associations are more frequently found in excess of one mile from shore and become more extensive further from the influence of Caloosahatchee silt (i.e., west and north of Sanibel).

3. The Beach Intertidal Zone.

Where the water meets the sand is a realm that is characterized by movement and flux. In the midst of breaking waves are; the transport of littoral drift which is composed of sand, shell particles, and shells; the scurry of sand fleas; the darting and probing of shorebirds and the adjustment by all life forms to the inexorable surge and retreat of waves and tides.

On the liquid side of the interface, strong swimming and/or burrowing ability is found in all successful inhabitants. Mole crabs (also known as sand fleas, (Hippa cubensis and Emerita spp.))

and coquinas, (Donax variabilis) which are tiny colorful clams, are the most abundant visible prey organisms, providing a feast for numerous shorebirds such as sanderlings (Crocethia alba), willets (Catoptrophorus semipalmatus), ruddy turnstones (Arenaria interpres), and aquatic predators such as cow-nose rays (Rhinoptera bonasus), pompano (Trachinotus carolinas), and gulf whiting (Menticirrhus littoralis). Cow-nose rays, stingarees (Dasyatis sabina) and southern sting rays (Dasyatis americana) are commonly observed cruising and foraging at the waters edge to the consternation of beachgoers in the spring and summer months. A shuffling step is recommended for bathers to prevent serious injury which could (and sometimes does) occur when a ray lying on the bottom is stepped on and pinned to the sand. The barb is located on the dorsal surface (back) of the tail, not the tip, and is highly venomous and causes an extremely painful wound. Swimming rays are, however, harmless and non-aggressive and pose no threat to waders or swimmers.

4. The Mid-Beach Zone.

The bounty of the Gulf of Mexico, featuring in various seasons, seaweeds, parchment worm tubes, uncountable seashells, seagrass blades, mangrove propagules, and the remains of departed sea creatures, washes up in abundance along high water and storm tide wrack lines on the beach. These treasures, though sometimes odoriferous, represent a smorgasbord for hungry shorebirds and are especially important during spring and fall migrations to provide fuel for hundreds of thousands of visiting long distance fliers. The piles of colorful and exquisitely shaped seashells also of course attract nearly equal numbers of human visitors, stooping to find trophies for display. The bare sand beach just above the tide line cannot support vegetation due to the extremes of heat, dryness, salt, occasional inundation and wave attack, and trampling by people. Few organisms make this infertile zone their permanent habitat other than ghost crabs (Ocypode quadrata), tiger beetles (Cicindela spp.), and ants. However, it is of critical importance to nesting loggerhead sea turtles (Caretta caretta), May 1 to October 30) and colonial shorebirds especially least terns (Sterna albifrons), black skimmers (Rynchops nigra), Wilson's plovers (Charadrius wilsonia), and snowy plovers (Charadrius alexandrinus) in April to August. A large tern and plover colony exceeding 80 pairs of breeding birds successfully nested just east of Bowman's Beach in 1993 and tern and skimmer nesting areas at Silver Key have occurred historically. Open sandy beach with a minimum of human disturbance is required for shorebird nesting colonies to become established.

Sanibel's beaches are used extensively for recreation by residents and tourists. Typical recreational beach activities include volleyball, paddleball, sunbathing, etc. During the winter season these activities may preclude the use of many parts of the beach by wildlife.

5. The Upper Beach (Dune Area).

Drought tolerant plant species that are adapted to the saline desert-like conditions of the upper beach area are hardy and relatively few in number. Those that become established are a welcome front line in the protection of the beach and beachfront structures from storm conditions. Strong winds accompanying storms and cold fronts blow significant quantities of sand completely off the beach area in locations without dune vegetation. Where there are established plant communities, windblown sand accumulates at the base of vegetation clumps. Even low growing grasses such as sea oats (Uniola paniculata), and salt grass (Distichlis spicata) trap sand during storms where it is still available to the beach system after winds subside. While dune vegetation will not stop the Gulf of Mexico from reclaiming beach during storm-driven erosive events, it can reduce losses by absorbing wave energy and holding sand within the extensive root systems of many dune species much better than an unvegetated beach. Excessive trimming, mowing and trampling of dune vegetation is a common practice at many condominium, hotel and single family residences on Sanibel's beachfront and greatly reduces the dunes' ability to protect the beach and adjacent structures.

Dune vegetation can generally be characterized as low-growing species with extensive root systems that are extremely drought and salt tolerant and able to subsist in very low nutrient sandy soils. These brutal conditions support a relatively low diversity of flora. The upper beach is dominated by sea oats, salt grass, railroad vine (Ipomoea pes-caprae), panic grass (Panicum spp.), sea purslane (Sesuvium portulacastrum) and in places, the dreaded sandspur (Cenchrus spp.). This zone of pioneering plants also frequently includes scattered shrubs such as inkberry (Scaevola plumieri), bay cedar (Suriana Maritima, a threatened species), seagrape (Coccoloba uvifera) and seacoast marsh Elder (Iva imbricata). All of these shrubs are more commonly found in areas further landward of the upper beach where only the strongest storm tides reach. Other common shrubs found in the upper beach area include cocoplum (Chrysobalanus icaco), coin vine (Dalbegia ecastophyllum), bay bean (Canavalia maritina), nickerbean and prickly pear cactuses (Opuntia sp.).

The invasive exotic trees Australian pine (Casuarina spp.) and Brazilian pepper (Schinus terebinthifolius) are common damaging interlopers on the dune and will be considered in detail in a separate section of this report. Dune vegetation harbors numerous insects and a few reptiles such as brown anoles (Anolis sagrei), black racers (Coluber constrictor) and protected gopher tortoises (Gopherus polyphemus). The seeds and fruits produced attract ground doves (Columbigallina passerina), mourning doves (Zenaidura macroura), mockingbirds (Mimus polyglottos), cardinals (Richmondena cardinalis), and rufous-sided towhees (Pipilo erythrphthalmus).

During migration, many wood warblers, sparrows, buntings, vireos and flycatchers utilize this habitat as forage areas.

6. The Coastal Scrub Zone.

This is a rare and threatened habitat type along the southwest coast of Florida which is rapidly being replaced with development. It occurs where coarse sandy soils persist inland of the dune system, usually along higher historic storm ridges. This is an arid zone of scattered shrubs, often dominated by patches of seagrape, wild olive (Forestiera segregata), wild lime (Zanthoxylum fagara), cabbage palm (Sabal palmetto), bay cedar, joewood (Jacquinia Keyensis), buckthorn (Bumelia celastrina) and white indigo berry (Randia aculeata) with open sandy areas supporting sea oats, muhly grass, prickly pear cactus, hairy gramma grass, gopher apple (Licania michauxii) and the threatened golden creeper (Ernodea littoralis). This is the preferred habitat of the gopher tortoise and consists of less than 300 acres in total on Sanibel.

7. The Hardwood Hammock.

The upland forests of Sanibel support numerous tropical West-Indian Hammock tree species, though at a lower diversity than similar habitats in the Florida Keys. These generally freeze-sensitive coastal trees are present in extensive stands in the J.N. "Ding" Darling National Wildlife Refuge and in many areas have gradually colonized and overtaken former coastal scrub habitat and overdrained former freshwater wetlands in the absence of fire and hurricanes. A few of the more common hammock tree species include: gumbo limbo (Bursera simaruba), strangler fig (Ficus aurea), Mastic (Mastichodendron foetidissium), Jamaica dogwood (Piscidia piscipula), cat-claw (Pithecellobium unguis-cati), seagrape and cabbage palm.

8. Interior Freshwater Wetlands.

This dwindling habitat surrounding the Sanibel River has been filled, dredged, ditched, overdrained and heavily infested with the exotic Brazilian pepper. Recent focus on these wetlands provides hope for restoration of much of the remaining acreage by increasing the hydroperiod via water control structures (especially the Tarpon Bay weir which was re-designed and replaced in 1994) and exotic plant control and controlled burning land management techniques. Physical re-contouring to fill in ditches and remove old fill roads on preservation lands will also be required.

Historically, these lowlands were dominated by cordgrass (Spartina bakeri), leather fern (Acrostichum danaeifolium, the largest fern in North America), and sawgrass (Cladium jamaicense) forming a savannah-like habitat with scattered cabbage palms and stands of buttonwood (Conocarpus erecta). Unlike the hardwood hammock, these wetlands share many of the same avian species with the open beach zone, especially the wading birds which move from beach to interior wetlands to estuarine areas depending upon food availability.

9. The Bay Beach Zone.

Primarily on the eastern end of the island, east of Tarpon Bay, is a narrow sand beach zone, in many places no more than a few feet wide. Some stretches of this slender bay beach are gradually retreating, as currents and wind driven waves are causing a slow but steady rate of erosion. Saltmarsh vegetation, buttonwoods and mangroves prevail, but much of this area is developed, and vegetation is relegated to a narrow strip waterward of deposited fill. Due to this sandwiching effect of erosion and development, little real wildlife habitat is present along this shoreline, though fiddler crabs (Uca sp.), mangrove tree crabs (Aratus pisonii), and sea roaches (Ligia exotica) find a tenuous home within the interface, and wading birds ply the shallows for minnows and shrimp.

10. Tidal Passes.

Really an integral part of the estuarine system discussed below, three tidal passes are particularly important for Sanibel: Blind Pass, Clam Bayou/Old Blind Pass, and the unnamed entrance to San Carlos Bay at the east end of the island. These gateways to the estuary are where the saltwater of the Gulf meets the nutrient-laden freshwater of the bays. The surging currents pulled by the gravity of the moon through these narrow openings is the engine driving the tremendous productivity of coastal waters. Their significance in terms of water quality, fisheries, beach dynamics, navigation and recreation should not be underestimated.

Both Blind Pass and the pass that often connects Clam Bayou with the Gulf (alternately referred to as Clam Bayou Pass or Old Blind Pass) are very dynamic and are sometimes even closed entirely (see the history of Blind Pass in Section I, the Coastal Processes Section of this Beach Management Plan). When these passes close there are some serious detrimental effects on the environment. Flushing of Pine Island Sound with the cleaner water of the Gulf is reduced which can impact water quality. Breeding of many species of fish (for example, snook) occurs in Blind Pass when open. The use by fishes and wading birds and of course the quality of fishing and the overall ecological productivity of the area drops drastically with pass closure.

When Clam Bayou is closed off and stagnant, the very fecund estuary within grinds down to that of a saline lake. Salinity fluctuations, changes in water quality and depth affect seagrasses, mangroves, fishes and perhaps most importantly, use of the area by thousands of wading birds for feeding. Extended closures can and have caused the major die-off of fringing mangroves and the concurrent loss of their functional values.

Maintaining an open water connection to Clam Bayou artificially may be something to be considered seriously. This would be a departure somewhat from the "let nature take its course" beach management philosophy but may be justified considering how human impacts, especially the groin at Blind Pass, have already artificially changed the conditions in this area. Photograph II-2 illustrates the area east of Blind Pass where downdrift inlet impacts have destroyed dwellings and left some uninhabitable.

11. The Charlotte Harbor Estuary.

This extraordinarily productive ecosystem, consisting of a reticulated matrix of salt marshes, mangrove forest, oyster bars, seagrass beds, mudflats, tidal creeks, passes and open water, provides a major nursery for most fish and invertebrate species in the Gulf of Mexico. Sanibel is fortunate in having preserved most of its estuarine areas, mainly due to the public ownership of wildlife refuge lands and property surrounding Clam Bayou (Silver Key and Bowman's Beach Park). Without maintenance of the integrity and water quality of other parts of the estuary outside of Sanibel's boundaries, however, the nearshore waters of both bay and beach risk becoming much less productive for fishermen and other predators, and drastic drops in shelling potential for beachgoers are a possibility.

B. Protected and Endangered Species of Sanibel.

There are at least 49 "listed" species of plants and animals found on Sanibel, (meaning they are on either Federal or State listings of threatened or endangered organisms), including at least 12 listed as endangered (see Table II-1). Of particular note pertaining to beaches are the sea turtles, gopher tortoises and nesting and migrating shorebirds. Atlantic loggerhead sea turtles (Caretta caretta) nest May to October on the upper beach. In recent years 150 nests per season on Sanibel is average. Photograph II-3 shows a juvenile loggerhead sea turtle and egg. Rarely, a leatherback turtle (Dermochelys coriacea) will lay eggs or "false crawl" (leaving the sea but returning without completing a nest).

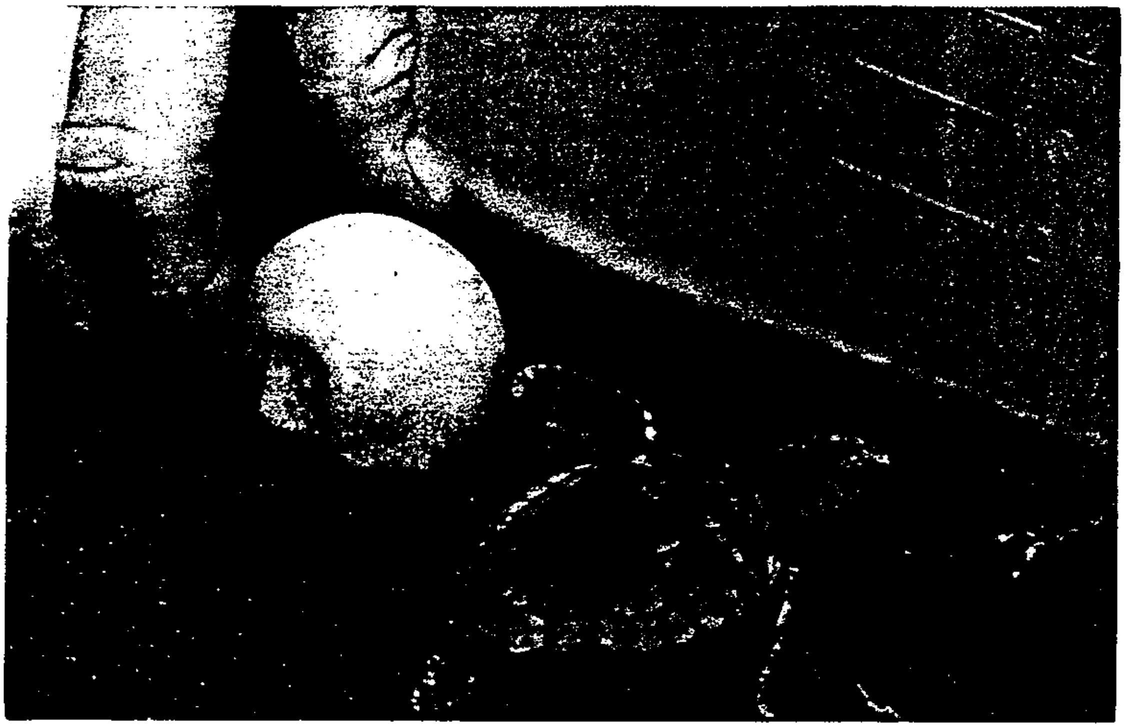
All sea turtles need intact upper beach and dune zones free of beach chairs, boat storage or structures such as chickee huts, and a dark landward horizon. Both nesting females and hatchlings orient toward the brightest horizon when trying to reach the sea. On a natural, undeveloped beach this always sets them going in the right direction, but the bright lights from homes, hotels, etc. can and does disorient the reptiles and often results in the deaths of hundreds of nestlings each season. Further discussion of this issue and sea turtle protection in general is found in Section III.C.

Another species of turtle frequently observed at the beach, though very much terrestrial rather than aquatic, is the gopher tortoise (Gopherus polyphemus). These prehistoric-looking animals are sometimes mistaken by well-meaning beachgoers as lost sea turtles and taken into the surf to "help" them. Fortunately tortoises can swim, but such illegal handling of wildlife by the public should be discouraged to prevent injury being done. Tortoises excavate deep burrows in the upper dune and coastal scrub habitats, as shown in Photograph II-4, and are therefore adversely affected by development too close to the Gulf and loss of dune areas from trampling or intrusion by Australian pines. A ten acre clear-cut in 1992 of Australian pines at Bowman's Beach upset some adjacent residents who objected to the look of the project and the loss of shade, but benefitted gopher tortoises, which moved into the newly opened dune and scrub areas in large numbers.

Migrating shorebirds, including protected least terns (Sterna antillarum), southeastern snowy plovers (Charadrius alexandrinus), piping plovers (Charadrius melodus), black skimmers (Rynchops nigra, see Photograph II-5) and seven species of listed wading birds utilize the beaches by the thousands during the spring and fall migrations. Photograph II-6 shows a very rare white phase reddish egret. Many shorebirds stay the winter along southwest Florida beaches, and all need relatively undisturbed beach and mudflat areas for feeding and resting. Such sanctuaries are tough to find during the winter months as the birds compete for beach space with thousands of recreational beachgoers in resort areas.

Photograph II-2

Severe erosion east of Blind Pass has destroyed dwellings and left some uninhabitable. Note how toppled Australian Pines block beach access.



Photograph II-3

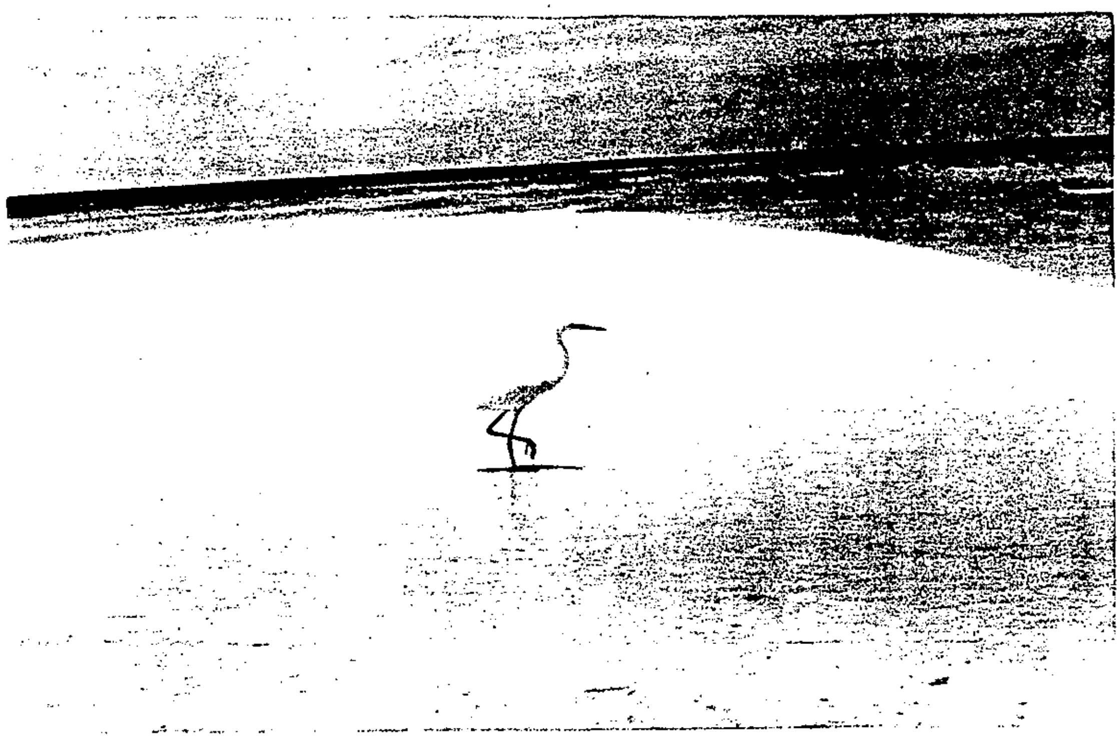
Juvenile loggerhead sea turtles hatch after about 60 to 100 days incubation from eggs resembling ping pong balls buried in the sand after tremendous efforts on land by the huge amphibious females.

Photograph II-4

A dune system inhabitant which has suffered drastic population declines due to development, loss of dune and scrub habitat, disease and automobile is the Gopher Tortoise. Tortoise burrows support numerous other organisms finding shelter in the cool, damp depths.

Photograph II-5

Along the more remote stretches of beach, some shorebirds find enough solitude to nest and raise their young like these black skimmers.



Photograph II-6

Sanibel's beaches provide feeding areas for many threatened species of birds such as this very rare white phase reddish egret.

Being continually disturbed by strollers, bicycles and dogs, and being preempted from feeding areas by heavy tourist use, clearly has negative consequences for these species which must instead use ever dwindling stretches of more remote beaches.

Protected shorebirds that nest directly on Sanibel beaches include least terns, black skimmers, snowy plovers, Wilson's plovers and American oystercatchers. All have declining populations due to the few beach nesting sites that remain suitable along developed barrier islands. In recent years, nesting colonies have been located at the east end of Bowman's Beach Park and at Silver Key. In 1993 approximately 80 pairs of least terns, 4 pairs of Wilson's plovers and 2 pairs of snowy plovers successfully nested at the Bowman's Beach site.

TABLE II-1

Endangered and Potentially Endangered Flora and Fauna of Sanibel

Scientific Name	Common Name	FGFWFC[1] Status	USFWS[2] Status	FDA[3]
Centropomus undecimalis	Common snook	SSC		
Rivulus marmoratus	Rioulus	SSC		
Caretta caretta	Atlantic loggerhead turtle	T	T	
Dermochelys coriacea	Leatherback turtle	E	E	
Gopheris polyphemus	Gopher tortoise	SSC		
Alligator mississippiensis	American alligator	SSC	T	
Charadrius alexandrinus	Southeastern snowy plover	T	C2	
Charadrius melodus	Piping plover	T	T	
Egretta caerulea	Little blue heron	SSC		
Egretta rufescens	Reddish egret	SSC	C2	
Egretta thula	Snowy egret	SSC		
Ajaia ajaja	Roseate spoonbill	SSC		
Rynchops nigra	Black skimmer			
Egretta tricolor	Tricolored heron	SSC		
Haliaeetus leucocephalus	Bald eagle	T	T	
Mycteria americana	Wood stork	E	E	
Rallus longirostris insularum	Mangrove clapper rail		C2	
Sterna antillarum	Least tern	T		
Oekecabys occidentalis	Brown pelican	SSC		
Haematopus palliatus	American oystercatcher	SSC		
Eudocimus albus	White ibis	SSC		
Liguus fasciatus	Florida tree snail	SSC		
Acrostichum aureum	Golden leather fern			E
Acrostichum danaeifolium	Giant leather fern			T
Cereus gracilus	Prickly apple			E
Encyclia tampensis	Butterfly orchid			T
Eragrostistis tracyi	Sanibel love grass			T

Scientific Name	Common Name	FGFWFC[1] Status	USFWS[2] Status	FDA[3] Status
Ernodia littoralis	Beach creeper			T
Gossypium hirsutum	Wild cotton			E
Habeneria sp.	Habenoria orchid			T
Jacquinia keyensis	Joewood			T
Lobelia cardinalis	Cardinal flower			T
Mallotonia gnaphalodes	Sea lavender			E
Opuntia stricta	Prickly pear cactus			T
Poinsettia pinetorum	Everglades poinsettia			E
Suriana maritima	Bay cedar			E
Tillandsia flexuosa	Twisted air plant			T
Vittaria lineata	Shoestring fern			T
Scaevola plumieri	Inkberry			T
Eugenia rhombea	Red stopper			T
Myrcianthes fragrans var simpsonii	Simpson's stopper			T
Spiranthes sp.	Ladies tresses orchid			
Tripsaum floridanum	Florida gamagrass		C2	
Crocodylus acutus	American crocodile	E	E	
Drymarchon corais	Eastern indigo snake	T	T	
Mustela vison lutensis	Florida mink		C2	
Oryzomys palustris sanibeli	Sanibel Island rice rat	SSC	C2	
Sigmodon hispidus insulicola	Sanibel hispid cotton rat		C2	
Chelonia mydas	Atlantic green turtle	E	E	
Trichechus manatus	West Indian manatee	E	E	

Not listed but unusual, uncommon or rare bird species found regularly on Sanibel:

Nycticorax nycticorax	Black-crowned night heron
Nyctanassa violacea	Yellow-crowned night heron
Vireo altiloquus	Black-whiskered vireo
Coccyzus minor	Mangrove cuckoo
Dendroica discolor	Mangrove prairie warlder
Ardea occidentalis	Great white heron

Scientific Name	Common Name	FGFWFC[1] Status	USFWS[2] Status	FDA[3] Status
Protected migratory birds found in winter or during migration on Sanibel:				
Charadrius melodus	Piping plover	T		
Falco peregrinus tundrius	Artic peregrine falcon	E		
Falco sparverius paulus	Southeastern American kestrel	T		

1 Florida Game and Fresh Water Fish Commission (list published in Section 39-27.03-05, Florida Administrative Code).

2 United States Fish and Wildlife Service (list published in List of Endangered and Threatened Wildlife and Plants, SOCFR 17.11.52).

3 Florida Department of Agriculture and Consumer Services (list published in Preservation of Native Flora of Florida Act, Section 581.185-187, Florida Statutes).

E = Endangered

T = Threatened

C2 = A candidate for listing, with some evidence of vulnerability, but for which not enough data exist to support full protection under the Endangered Species Act.

Photograph II-7

The remarkable productivity of South Florida estuaries is represented in the mammoth West Indian Manatee which feed on seagrasses and may reach 3,000 lbs. in weight.

C. Coastal Exotic Plant Identification and Control.

1. Australian Pines.

Two species of introduced trees on Sanibel have significant adverse effects on the beach and dune system. Foremost of these is the Australian pine (Casuarina spp.), a pioneering tree that has become pan-tropical in distribution along coastal areas throughout the world. It is highly adapted to establishing itself in open sandy areas by virtue of its salt tolerance, rapid growth and its ability to fix atmospheric nitrogen in bacteria-filled nodules in its roots. The nitrogen-fixing bacteria enable the tree to access nutrients not available to native trees and shrubs and hence provide a competitive advantage and an extremely fast growth rate on poor soils.

The Australian pine rapidly establishes itself on soils disturbed by coastal processes or land-clearing activities and is abundant in many areas of dune, coastal scrub and hammock on Sanibel. Although not truly a conifer, it regularly drops a profusion of "needles" which are highly modified leaves that blanket the ground and smother native vegetation growing below. The open, park-like mulched forest of pines, illustrated in Photograph II-8, is attractive to many people, especially since these are the tallest trees that grow on Sanibel and provide extensive shade in areas along the beach that otherwise naturally have little shade. However, the virtual monoculture which is formed by clusters of pine trees displaces native plants and on the dune systems can seriously affect the integrity of the dune and its function as wildlife habitat. Unlike native dune species, the pine has a very shallow root system, and the tall spreading canopy makes the tree extremely susceptible to wind-throw, as was the case when hundreds of acres of downed pines in Dade County resulted from Hurricane Andrew in 1992. When the tree falls, the uplifted root mass takes several cubic yards of beach surface with it leaving large craters and, in some cases, contributing to sand loss on eroding shorelines. Where Casuarinas border such a shoreline, the falling trees often cover the open beach zone blocking beach access. Wading birds, ospreys and bald eagles sometimes make their nests in mature pines which should be kept in mind during control efforts.

Complete eradication of Australian pines on Sanibel is neither practical from a logistical standpoint or feasible politically because of the affection so many residents have for these trees. However, they are causing enough damage to dune systems and other natural areas on the island that selective control is necessary and is, in fact, called for in the Comprehensive Land Use Plan. However, all pines should be removed from the dune systems of Sanibel as they are no substitute for these important protective habitats. The big tagged trees along Periwinkle Way should all be

Photograph II-8

Australian Pines are attractive to many people but are exotic intruders on our beaches and dense clusters of these trees preclude the growth of most other plants in their shade and under the prodigious blanket of "needles".

preserved as well as mature pines along parking and picnic areas at public parks for purely aesthetic reasons.

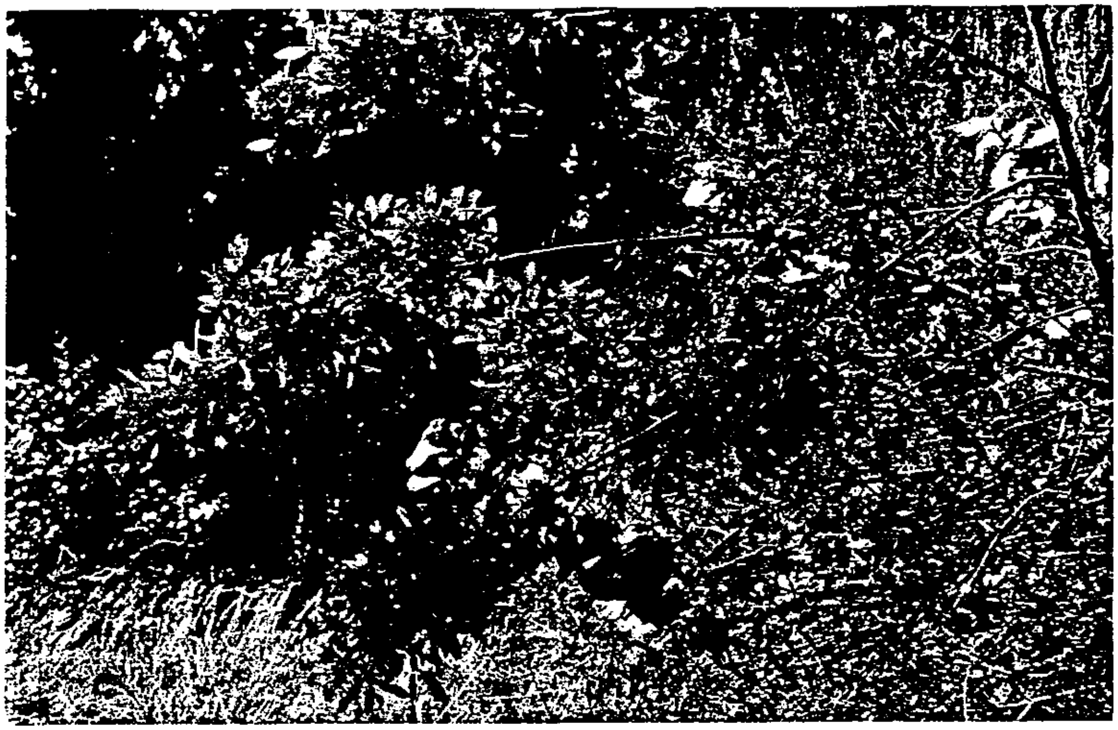
Pines in the dune system on private property should not be overlooked in this process. The dunes protect the coastal berm and to a lesser extent also protect residents well inland of the beach, so private landowners should be encouraged to remove these trees and maintain their dunes pine-free. One potential way in which the City could reward residents for removing their pines along the beach, (which will, of course, also improve their waterviews in many cases), is to offer replacement native plantings. A similar program was successful during Melaleuca eradication efforts. A City ordinance requiring that pines in the dune zone be removed on all properties where development permits are issued should be instituted as well as the limited use of public funds to restore dunes on both public and private lands. Pines in the coastal scrub and hammock areas should be selectively thinned so as to improve wildlife habitat while retaining a few mature trees for shade. Monocultures of pines on preservation lands should be aggressively deterred, and restoration of native vegetative communities in these areas should be continued.

2. Brazilian Pepper.

Island-wide, the most damaging exotic tree on Sanibel is the Brazilian pepper, found in all but the wettest and most saline habitats on the island. Virtually every property has to have an active maintenance program to remove it or there will be pepper growing somewhere on the site. In the interior wetlands, this is unfortunately the dominant plant, with virtual monocultures covering in excess of 1600 acres. Photograph II-9 shows the Brazilian Pepper, which is a massive densely growing tree that overtakes native plants and does not provide suitable native wildlife habitat.

To witness this problem first-hand, one should try taking a stroll through a Brazilian pepper forest. Within several feet you will be on your hands and knees beneath the oppressive crush of dense overhanging branches cutting out all but a dim light from above. Sanibel is blessed with a spectacular variety of indigenous plants and animals including 49 species listed as endangered, threatened or of special concern. Without room to grow and habitat that can provide for their needs, however, Sanibel Island stand to lose many of them to invasive exotic trees.

The City, the United States Fish and Wildlife Service and the Sanibel-Captiva Conservation Foundation all have active programs getting control of pepper on their properties piece by piece. Large portions of the Interior Wetlands Conservation District surrounding the Sanibel River however, are so densely covered that mechanical means of removal by root rake or hydroax may be the only



Photograph II-9

Brazilian pepper is a massive, densely growing tree that overtakes native plants and frequently form monocultures providing virtually nothing in the way of wildlife habitat.

practical methodology. Once under control, pepper can be kept at bay in these wetlands by controlled burns, which also protect adjacent properties from the potential for uncontrolled wildfires and open up excellent wildlife habitat. The rewards of successful removal projects are great as birds and mammals quickly re-colonize former pepper wastelands and migratory songbirds feed extensively in the new growth of native species.

A combination of restoring the historic water levels of the interior wetlands, as with the Tarpon Bay weir improvements under the City's Surface Water Management Plan, and chemical and mechanical control on public properties is expected to make significant impacts on this infestation, though long-term maintenance and management are concerns. The underlying hope among natural resource area managers in South Florida is that some form of biological control will eventually exert its influence as an insect, fungus or bacteria takes advantage of these large monocultures of exotics. Private landowners will also have to cooperate if public efforts are to succeed as seed sources on adjacent lands could make management extremely difficult and costly.

3. Melaleuca.

The spread of melaleuca or punk tree (Melaleuca quinquenervia) has been successfully controlled on Sanibel as a result of a 10 year removal effort and continuing maintenance. This has been an important undertaking because in many areas on the south Florida mainland this tree is the worst exotic plant pest. A single, 30' tall melaleuca growing in the open can release over 20 million seeds following any event that cuts the vascular flow of fluids to the branches such as a fire, chainsaw or lightening strike. When one tree is cut down, the potential for thousands of seedlings becoming established nearby is created. The melaleuca still has the ability to cause extreme disruption to native systems on Sanibel, and residents and public officials alike need to be vigilant. Anyone observing a melaleuca growing on Sanibel can help by reporting the location to the City's Natural Resources Department.

4. Other Invasive Exotic Trees.

A total of 35 plant species found on Sanibel are on the Florida Exotic Pest Plant Council's 1994 list of the most invasive and potentially damaging introduced plants. Of these, the most significant (in order of concern next to the above species) are 1) lead tree (Leucaena leucocephala), 2) earleaf acacia (Acacia auriculiformis), 3) air potato (Dioscorea bulbifera) and 4) java plum (syzgium cumini). These four species are being observed more and more in the wild, and in some places are forming near monocultures. An obvious example of this are the lots totally dominated by lead trees along Palm Ridge Road. In the interest of heading these species off before they become pests of the magnitude of Brazilian pepper, the City should maintain its own properties free of these species and revise the Vegetation Standards to include a requirement for their removal on private property for new construction projects.

Worthy of mentioning due to its spread on Sanibel beaches are the exotic Scaevolas (Scaevola taccada and S. Frutescens). These species, commonly known as inkberry, are sometimes planted by landscape companies as "native", but are in fact more aggressive and fast growing than the true native dune species (S. plumieri).

D. Red Tide.

Many sub-tropical and temperate coastal areas of the world are subject to blooms of single-celled algae which release neurotoxins causing fish kills. This toxin is present in cells of the dinoflagellate (possessing 2 flagella, tiny whip-like propulsion organelles) algae <u>Gynmodinium</u> <u>breve</u>, commonly found at non-lethal levels in the Gulf of Mexico. When conditions are right, (intermediate salinity, temperature and wave conditions, and large volumes of stormwater runoff containing iron-rich compounds), tremendous populations of these microscopic plants build, sometimes as high as 75 million cells per liter of seawater. In the United States this condition is known as red tide as the masses of living and dead algae give a reddish-brown tinge to the Gulf.

When these organisms die, their cell walls rupture, releasing the toxin which interferes with fish's ability to utilize their gills, although few invertebrates seem to be affected. As the bloom reaches the beach, waves send this toxin into the air as an aerosol, which can cause acute respiratory distress, sore throats and coughing spells for beachgoers and beachfront residents. Piles of dead fish, suffocated by the toxin's effects, sometimes wash ashore resulting in offensive odors, and in extreme cases, public health hazards. Many filter feeding organisms, including clams, oysters and mussels, may temporarily accumulate the red tide toxin making it necessary to temporarily close shellfish harvesting areas such as the oyster bars in Pine Island Sound.

Major red tides generally last 2 - 4 months during which time they can generate considerable distress for coastal residents and sometimes a decline in tourism. One devastating outbreak along Florida's west coast in 1946-47 continued for 11 months. It is currently considered impossible to control red tide by any method, although region-wide pre-treatment of stormwater run-off in swales and filter marshes could reduce the severity of blooms.

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COASTAL ACTIVITIES AND IMPACTS

SANIBEL ISLAND BEACH MANAGEMENT PLAN, SECTION III

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III. COASTAL ACTIVITIES AND IMPACTS.

A. Existing Land Uses - as they affect the shoreline and nearshore waters.

1. Overall Coastal Development Philosophy.

In December of 1974, the island of Sanibel became incorporated as a municipality of Lee County, Florida. The desire for self-determination grew from the perceived need for the planned development of Sanibel such that the natural characteristics of the island are preserved. The act establishing the city includes the following language: "...in the planning for the orderly future development of an island community known far and wide for its unique atmosphere and unusual natural environment and to ensure compliance with such planning so that these unique and natural characteristics of the island shall be preserved..." Some communities have allowed their beach to be overdeveloped which puts people and property at risk from storms and excludes wildlife, as illustrated in Photograph III-1. In contrast, perhaps more than any other developed barrier island, Sanibel has the opportunity to provide unsurpassed recreational experiences for beachgoers, as shown in Photograph III-2, while still providing quality wildlife habitat.

The way the Sanibel Comprehensive Land Use Plan is structured is virtually unique with all zoning and land use decisions based on ecological zones. The City's entire beachfront from Woodring Point around Punta Ybel and up to Blind Pass constitutes a Preservation District. On the bay side, the area 50' landward of mean high water out to the City's offshore corporate limits is the Bay Beach Zone, and is designated for passive recreation and conservation uses. On the gulf side, the area seaward of the state's 1978 Coastal Construction Control Line out to the City's offshore corporate limits (1/2 mile from shore) is the Gulf Beach Zone, and is designated for passive recreation and conservation uses.

There are instances of nonconforming uses, primarily residential and frequently multifamily structures, which are located in these preservation districts. The heaviest concentrations of these nonconforming uses are located on the east end of the island. These uses, or permit authorization for these uses, were already in existence at the time of incorporation of Sanibel as a City.

2. Infrastructure.

With the exceptions of the Blind Pass Bridge, which is the highway connection to Captive Island, and the Causeway, which is Sanibel's roadway link to the mainland, there is virtually no infrastructure

Photograph III-1

Some communities have allowed their beach to be heavily developed which puts people and property at risk from storms and excludes wildlife.

Photograph III-2

Perhaps more than any other developed barrier island, Sanibel has the opportunity to provide unsurpassed recreational experiences for beachgoers while still providing quality wildlife habitat.

in these preservation districts. However, roads, water transmission lines, wastewater collection lines and stormwater management features are widely distributed adjacent to these linear coastal preservation zones.

3. Surface Water Patterns.

Along most of the Island's gulf shoreline there is a coastal berm or ridge that has been created by historic storm conditions. This ridge tends to separate the surface water run-off flows. All run-off north of this ridge tends to run north. In most areas of the island this means inland to the Sanibel River or to other interior waterbodies such as the Shell Harbor canal system at the east end of the island or Clam/Dinkins Bayou at the west end. The manmade drainage systems are generally designed to send stormwater to the Sanibel River and behind the main water control structures at Tarpon Bay and Beach Road. This provides the maximum possible stormwater treatment within the interior wetlands prior to release of water to San Carlos Bay and Pine Island Sound.

B. Existing Coastal Regulations and Ordinances.

1. Federal.

The Federal Emergency Management Agency (FEMA) administers several major coastal programs including the National Flood Insurance Program (NFIP), the Community Rating System (CRS), flood disaster relief and flood zone mapping in coordination with the National Coast and Geodetic Service.

To qualify for the National Flood Insurance Program, a community must adopt and enforce a floodplain management ordinance to regulate development in flood hazard areas. The basic objective of such an ordinance is to ensure that development will not aggravate existing flooding conditions and that new buildings will be protected from flood damage via stringent building codes.

The Community Rating System provides incentives for communities to more strictly regulate new construction beyond the minimum national standards. Flood insurance premiums are adjusted to reflect community activities that go above and beyond these standards to minimize flood damage, thereby hopefully reducing future claims. The three objectives of the CRS Program are to reduce flood losses, to facilitate accurate insurance ratings, and to promote the awareness of flood insurance.

The City initially applied to the CRS in December 1990. On October 1, 1991 Sanibel was classified as a 'Class 9' community, and property owners received a 5% discount on their flood insurance premiums. On October 1, 1992, the City's classification was improved to a 'Class 8', and premium discounts were increased to 10%. After additional flood protection and awareness measures were implemented by the City, Sanibel became a 'Class 7' community on October 1, 1994, and residents flood insurance premiums were discounted by 15%.

As the City's greatest flood threat lies in tropical storms and the tidal surges that can accompany such weather systems, the Island's natural beach and dune system is the City's best protection against tidal surge flooding, and the City's beach management policies should strive to preserve and enhance the beach and dune system.

In order to provide protection against flooding, the City should preserve the beach and dune system in a natural state. The policy of no development on the beach should continue, and dune protection and restoration efforts should be encouraged, including the construction of beach paths and walkovers and selective Australian pine removal and native vegetation planting.

The City should actively encourage a 'retreat from the beach' policy by encouraging damaged structure removal, structure relocation, raising of structure elevation, and continued enforcement of the City's substantial improvement regulations. The City should consider relaxing certain land development code standards (i.e. coverage, clearance, setbacks,) in order to accommodate structure relocations further landward of the beach and dune system. The City should also consider public acquisition of damaged structures whenever feasible.

In emergency situations, particularly when public infrastructure is involved, the City should consider renourishment and protection efforts as deemed necessary. The City should also continue its routine erosion monitoring studies to keep on top of changing beach profiles and potential trouble spots.

Following Hurricane Andrew's destructive visit to Dade County in 1992, FEMA was the lead agency in emergency Federal disaster relief. This agency also may have limited funds available in the future for certain flood avoidance measures such as structure relocation.

The U.S. Army Corps of Engineers is the Federal environmental regulatory agency that reviews development applications in coastal wetlands and below the mean high water mark along the Gulf and interior waters.

2. State.

The old term "Coastal Construction Setback Line" has been replaced by the "Coastal Construction Control Line" (CCCL) to delineate the area waterward of the line where permits from the state are required for construction of any structures or alteration of the dune or dune vegetation. The most recent CCCL was set in 1991 while the old line dates back to 1978. Property owners (or local governments for that matter) wishing to alter lands waterward of the line can expect to encounter a strict project review from the Florida Department of Environmental Protection (DEP). The goals of the state regulatory program are to minimize hazards to coastal residents and structures while maintaining the integrity of the beach and dune system.

3. City.

The previously described Gulf Beach Zone is designated for passive recreation and conservation uses only and is delineated by the State's 1978 CCCL. Trimming or removal of native dune vegetation is prohibited without a vegetation permit from the City. Building codes for Sanibel are reflective of the extreme vulnerability of island structures to hurricane winds and storm surge and are therefore much stricter than in non-coastal communities. Numerous other City ordinances and directives pertain directly or indirectly to beach related subjects such as beach furniture, removing Australian pines from the Gulf Beach Zone, fires on the beach, alcohol use, lighting during sea turtle nesting season, slow speeds for boaters, chumming for sharks near beaches, etc.

It should be noted that a thorough review of the Comprehensive Land Use Plan (CLUP) of the City has been made in regard to beaches and the implications of this beach management plan. This plan and its recommendations and directives appear to be consistent with those of the CLUP in general. However, some specific definitions, findings, and recommendations either go beyond the detail found in the CLUP, or essentially replace and improve some specific CLUP sections relating to the beach. To put into effect the findings of this plan, there should be serious consideration of adopting the plan as part of the CLUP and revising or deleting a few differing or redundant sections of the CLUP.

C. Effects of Development and Activities on Natural Resources.

The beach, dune and coastal scrub zones support an outstanding diversity of plants and wildlife, including many listed threatened and endangered species, which are placed in a struggle for existence with competing human activities.

The land values and demand for coastal development and the tendency for resorts and beachfront homeowners to want to turn their shoreline into a playground for people is often in direct conflict with natural habitats and the organisms that have become adapted to living in them for thousands of years. The challenge for Sanibel, as first identified in the 1976 Sanibel Report by John Clark, is how to maintain these natural systems under an ever-increasing onslaught of human use. The current overall condition of these areas on Sanibel is poor along developed properties (most of the Gulf shoreline of the island) and a unified public effort to restore the function of these damaged shorelines is necessary.

1. Definition of the Upper Beach Zone.

For the purposes of regulatory control of such items as beach chairs and other beach-related paraphernalia and for the purposes of the restoration and maintenance of the important vegetated areas of the beach, the following definition should replace all others in the City CLUP, Land Use Code and any related ordinances:

The Upper Beach Zone, commonly referred to as the dune system or Gulf Back Beach, is defined as a strip of land generally parallel to the Gulf of Mexico or tidal passes which is contiguous with the sandy beach and extends landward from the pioneer beach vegetation line, encompasses any area of built up sand accumulated by natural forces of wind and water, and is vegetated primarily with salt tolerant plant species including but not limited to the following list:

Common Native Dune Vegetation of Sanibel

Sea oats (*Uniola paniculata*)
Railroad vine (*Ipomoea pes-caprae*)
Dune sunflower (*Helianthus debilis*)
Inkberry (*Scaevola plumieri*)
Seacoast march elder (*Iva imbricata*)
Golden creeper (*Ernodea littoralis*)
Spanish bayonet (*Yucca aloifolia*)
Bay cedar (*Suriana maritima*)
Sea purslane (*Sesuvium portulacastrum*)
Coin vine (*Dalbergia ecastophyllum*)
Nickerbean (*Caesalpinia crista*)
Bay bean (*Canavalia maritima*)
Bitter panicum grass (*Panicum amurum*)

Crowfoot grass (Dactyloctenium aegyptium)
Saltmeadow cordgrass (Spartina patens)
Seashore dropseed (Sporobololus virginicus)
Seashore paspalum (Paspalum vaginatum)
Seashore saltgrass (Distichlis spicata)
Patridge pea (Cassia spp.)
Cocoplum (Chrysobalanus icaco)
Seagrape (Cocoloba uvifera)
Prickly pear cactus (Opuntia spp.)
Buttonwood (Conocarpus erectus)

In the absence of such a conspicuous vegetated area, the Upper Beach Zone is defined as that strip of land similar in dimensions and location to the Upper Beach Zone on neighboring properties as defined above and in any case an area extending landward from the pioneer vegetation line on the subject or neighboring properties a distance not less than one hundred feet (100').

For the purposes of applying this definition, the Upper Beach Zone shall not be considered to include areas dominated by St. Augustine, Burma, Bermuda or Zoysia grasses growing within fifty feet (50') of existing principal structures.

2. Trimming, Trampling, Removal and Mowing of Coastal Vegetation.

Cutting or mowing of native dune vegetation on Sanibel Island requires a permit from both the State of Florida Department of Environmental Protection's Beaches and Shores Division and the City of Sanibel. However, for a variety of reasons, many beachfront properties routinely mow, trim and remove these important species without the authorization of appropriate permits. Whether this derives from a desire for better views of the water, a golf-course like, neatly-trimmed landscape or to make room for beach chairs, volleyball, sailboats, etc., this illegal practice has destroyed many acres of protective coastal vegetation.

One way to perhaps encourage beachfront property owners to cooperate with the City's permitting program would be to increase the number of years such a trimming permit is valid. Since this is basically a maintenance effort with similar trimming work to be done each year, if permits were good for say 5 years, better compliance could be achieved. This should however, be coupled with stronger enforcement and more effective education programs.

3. Beach Access Paths and Walkovers.

Often, little or no planning goes into the location of paths to the beach, and at many condominiums and resorts multiple intertwined and bifurcating pathways result in significant unnecessary dune loss. Trampling not only kills vegetation, but ruts the sand forming an area of lowered elevation inviting incursion by storm driven waters. If the dune is completely cut through, these paths may allow saltwater to reach inland swales or even wetlands which may result in further habitat loss, or property damage.

This problem has been addressed on beaches throughout the United States by the construction of elevated dune walkovers which minimizes vegetation damage and eliminates path-generated sand loss. Dune walkovers such as the one shown in Photograph III-3 provide safe beach access, without having to walk on sandspurs, while protecting the fragile vegetation of the upper beach zone. Beachfront property owners should be encouraged to construct walkovers wherever practical, and such structures should be required for all new multi-family construction, or permits for substantial improvement, and permits for beach furniture or paraphernalia. Except for extremely high use areas, or narrow lots with individual walkovers on each lot, walkovers should be located no closer than 150' apart so as to allow a substantial undisturbed dune area to remain between them.

If walkovers cannot be utilized, the number of walkways should be minimized at each property. As with walkovers, the selective closing of existing multiple access paths should be accompanied by the installation of a rope and bollard system to direct pedestrians to appropriate walkways. These can consist of pressure-treated 4" x 4" lumber or recycled plastic set 3-4' above the sand surface and connected onto a clearly visible manilla or polypropylene rope Figures III-1 and III-2 illustrate the rope and bollard walkway.

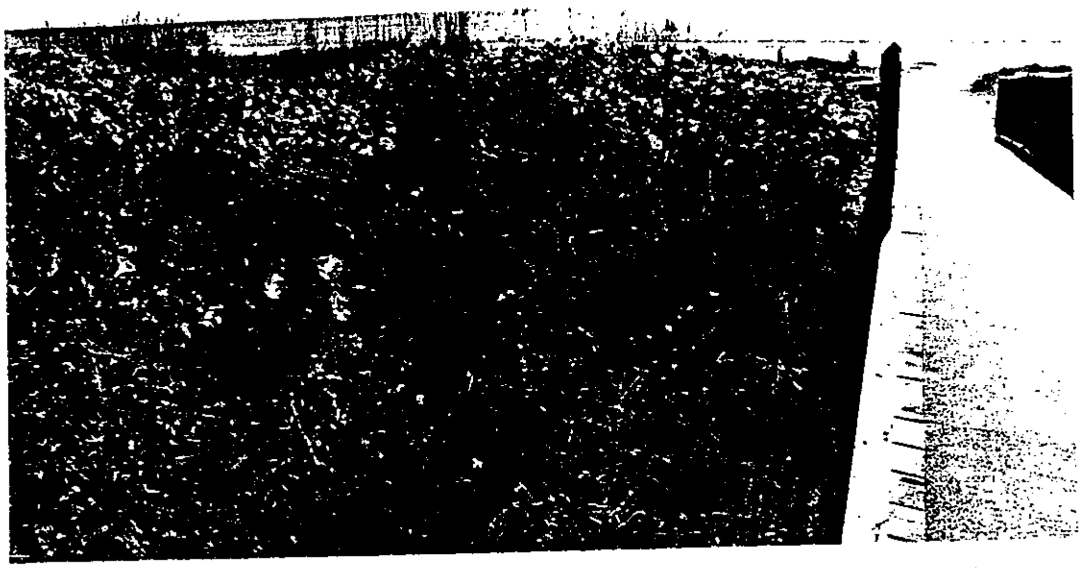
Signs such as "Dune Restoration Program, Please Use Marked Path" can be displayed for public information. The rope and bollard directional aids should be removed once dune vegetation becomes re-established in the old walkways and other trampled areas (usually in about two years).

4. Additional Planting Techniques and Dune Restoration.

On bay front properties, planting of mangroves and other salt tolerant vegetation behind or within minor rock revetments can effectively stabilize a shoreline. This planting technique is illustrated in photograph III-4.

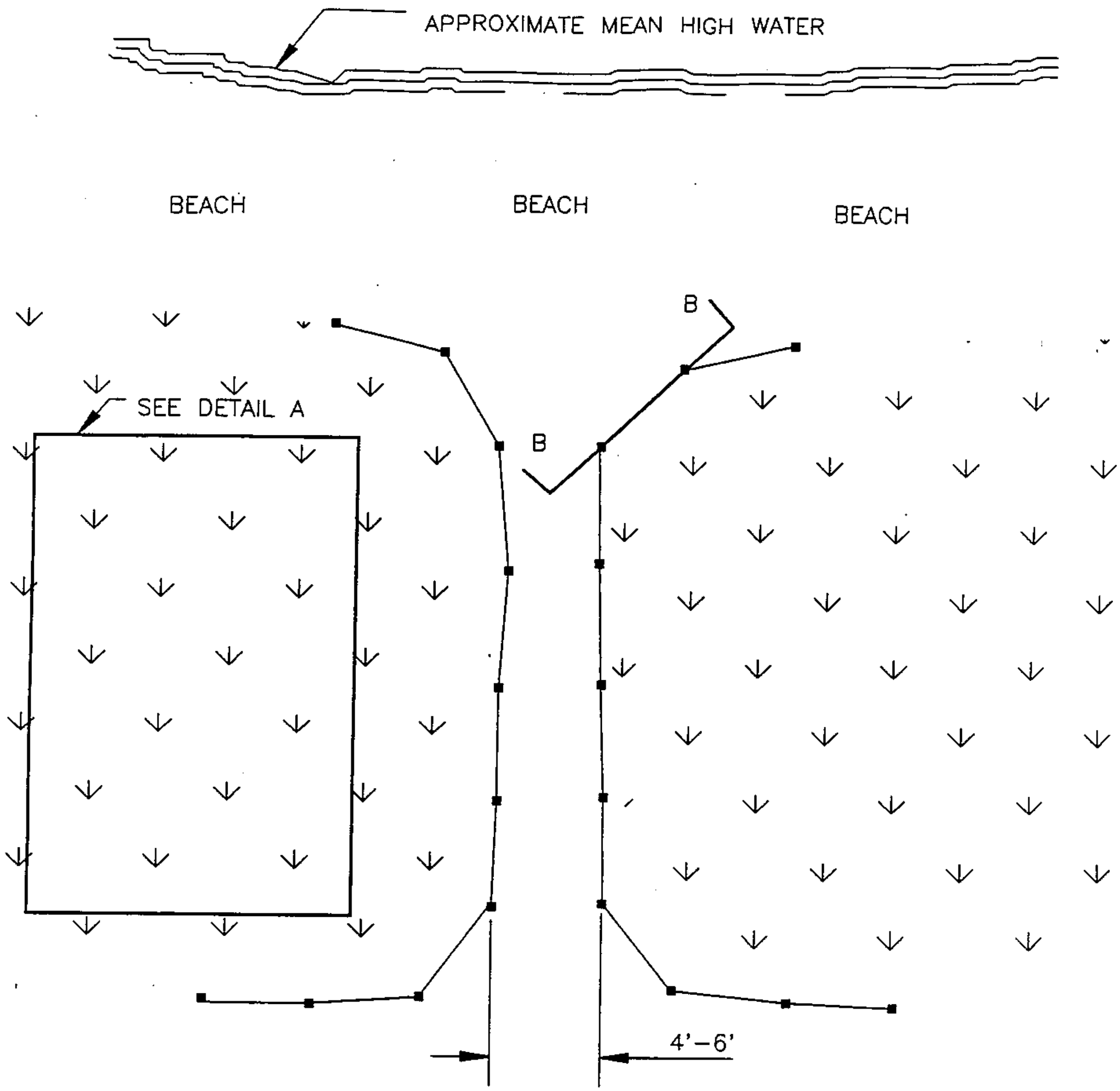
The first step in attempting to restore the integrity of any dune system is an assessment of its overall condition and determining the cause of problems in any areas. It will do little good to replant an area which is subject to heavy trampling, growth of exotic trees, or other continuing sources of disturbance without planning how to reduce or eliminate such damaging elements.

A decision should be made whether to augment the existing dune system with additional beach quality sand trucked to the site. Some heavily used access pathways are so compacted they essentially



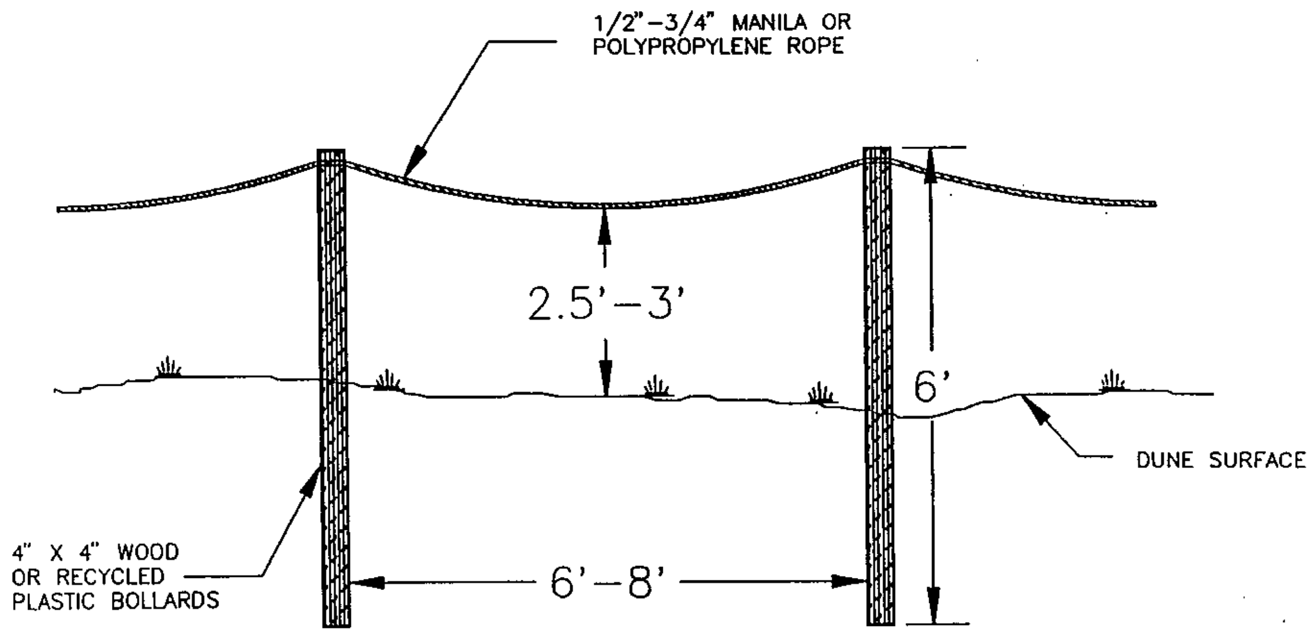
Photograph III-3

Dune walkovers can provide safe beach access while protecting the fragile vegetation of the upper beach zone.



BEACH RESTORATION
PLAN VIEW

PROJECT SITE PLAN		City of Sanibe
DATE: 10/21/94	SCALE: 1"=10'	800 Dunlop Road
PROJECT NO.: 94-101	FIGURE III-1	Sanibel, FL 33957



TEMPORARY ROPE AND BOLLARD SYSTEM

SECTION B-B	
DATE: 10/21/94	SCALE: 1"=2.5'
PROJECT NO.: 94-101	FIGURE III-2

City of Sanibel
800 Dunlop Road
Sanibel, FL 33957

Photograph III-4

On bay front properties, planting of mangroves and other salt tolerant vegetation behind or within minor rock revetments can effectively stabilize a gradually eroding shoreline.

become swales and are subject to erosion both during high tides and in the other direction from upland stormwater run-off. Some particularly trampled-out areas should be considered as sites for considerable sand placement to be planted as small dunes. Few properties on Sanibel are protected by naturally occurring high dunes, but artificially constructed dunes can be an effective erosion control mechanism. This is demonstrated by the man-made dunes constructed at the south end of Gasparilla Island during a renourishment project which are heavily vegetated and traversed by wooden walkovers, illustrated in Photograph III-5.

Once any necessary fill is in place, Australian Pines are removed and trampling and beach access issues are addressed via walkovers or rope and bollard systems, planting should be done as soon as possible to restore barren areas. Table III-1 is a list of plants recommended for dune plantings on Sanibel. The plants are separated into two categories, with the "Pioneering" species capable of becoming established farthest seaward and the "Secondary" species benefitting from a planting location further landward. A typical planting design is shown in Figure III-3.

Diversity of plantings is important and a minimum of 6′ centers is recommended for completely barren locations. For best results, plantings should be done in late June to early September to take advantage of the rainy season. Otherwise, arrangements for regular watering for at least six weeks should be made with installation of a temporary irrigation system. Planting projects are the only type permitted on the dune during sea turtle nesting season. All plantings should be kept well clear of nest location markers set by the Sanibel-Captiva Conservation Foundation's volunteer turtle patrol so as not to interfere with hatchling survival.

The good news is that many of the species that can be planted with success on Sanibel's dune systems are very attractive and are low-growing so as to not block water views. The sight of sea oats rippling in the wind and the bright flowers of railroad vine, dune sunflower, partridge pea and others add great beauty to any beach trip. See Photograph III-6 and Photograph III-7. Other native species will also very rapidly "recruit" into protected planting areas stablishing good vegetative coverage generally following only two rainy seasons after initial planting.

5. Beach Furniture.
The placement of beach chairs, umbrellas, tents, sailboats, etc. on the dunes, and movement back and forth for overnight storage is another human impact that can be lessened with some common sense planning. Improper storage and dragging of beach chairs and the uncontrolled trampling of multiple access paths damage the vegetated upper beach zone along with all the protective and habitat functions this area provides, as illustrated in Photograph III-8. All beach sundries with the possible exception of larger boats should be stored well behind the vegetated dune area, moved

Photograph III-5

The man-made dune on the south end of Gasparilla Island, here shown just after construction and planting, is an outstanding example of how sand placement, walkovers and native plantings can be combined to excellent effect.

TABLE III-1 Appropriate native species for dune plantings on Sanibel

Pioneering Species

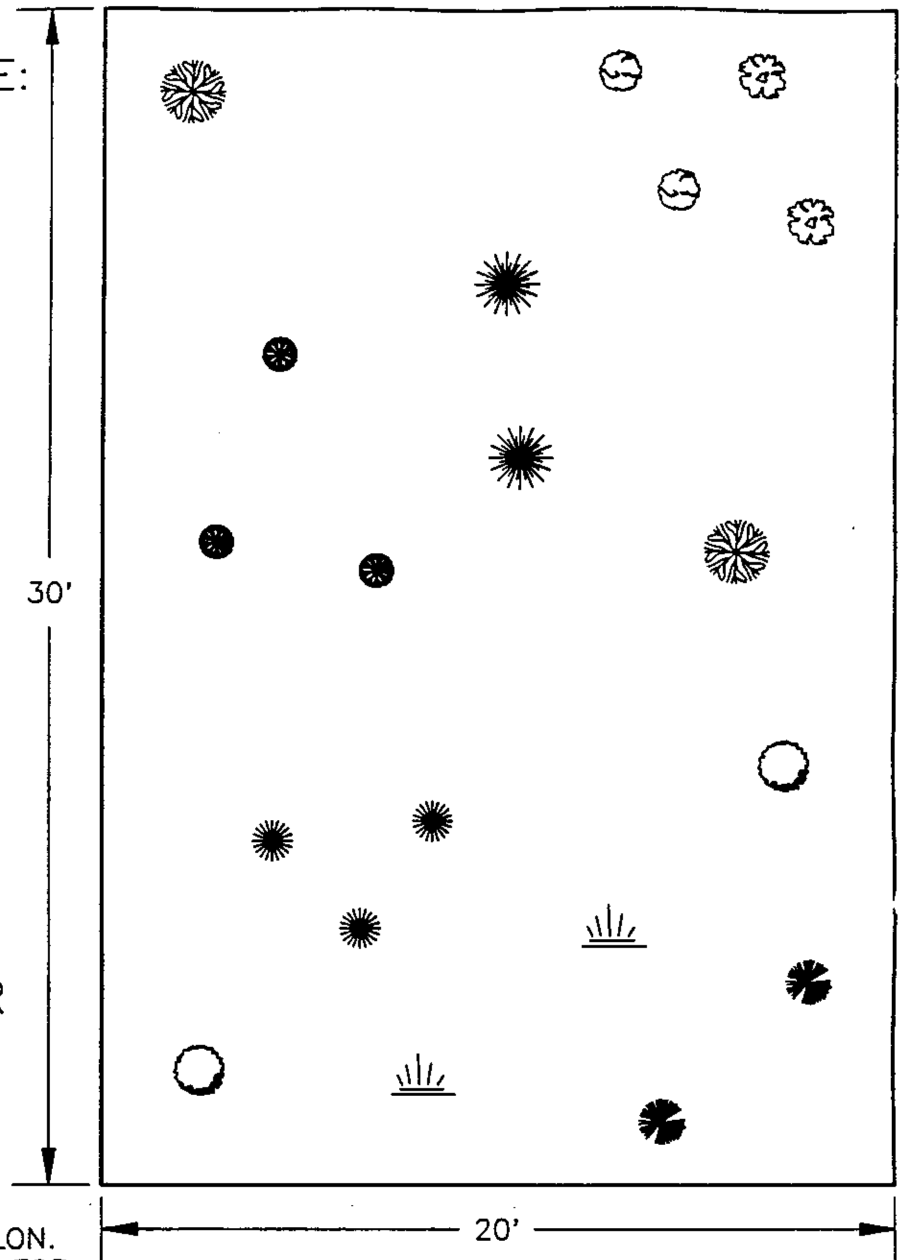
- Sea oats (*Uniola paniculata*)
- Railroad vine (*Ipomoea pes-caprae*)
- Dune sunflower (*Helianthus debilis*)
- Seacoast elder (*Iva imbricata*)
- Sea purslave (*Sesuvium portulacastrum*)
- Bitter panicum grass (*Panicum amurum*)
- Saltmeadow cordgrass (*Spartina patens*)
- Seashore dropseed (*Sporobolus virginicus*)
- Seashore paspalum (*Paspalum vaginatum*)
- Seashore saltgrass (*Distichlis spicata*)
- Inkberry (*Scaevola plumieri*)

Secondary Species . . . .

- Golden creeper (*Ernodea littoralis*)
- Spanish bayonet (*Yucca aloifolia*)
- Bay cedar (*Suriana maritima*)
- Coin vine (*Dalbergia ecastophyllum*)
- Bay bean (*Canavalia maritima*)
- Partridge pea (*Cassia* spp.)
- Cocoplum (*Chrysobalanus icaco*)
- Seagrape (*Cocoloba uvifera*)
- Prickly pear cactus (*Opuntia* spp.)
- Blanket flower (*Gaillardia pulchella*)
- Cabbage palm (*Sabal palmetto*)
- Wax myrtle (*Myrica cerifera*)

NATIVE SPECIES INCLUDE:

- SEA OATS
- INKBERRY
- GOLDEN CREEPER
- BAY CEDAR
- SEAGRAPE
- CABBAGE PALM
- RAILROAD VINE
- SEACOAST MARSH
- DUNE SUN FLOWER

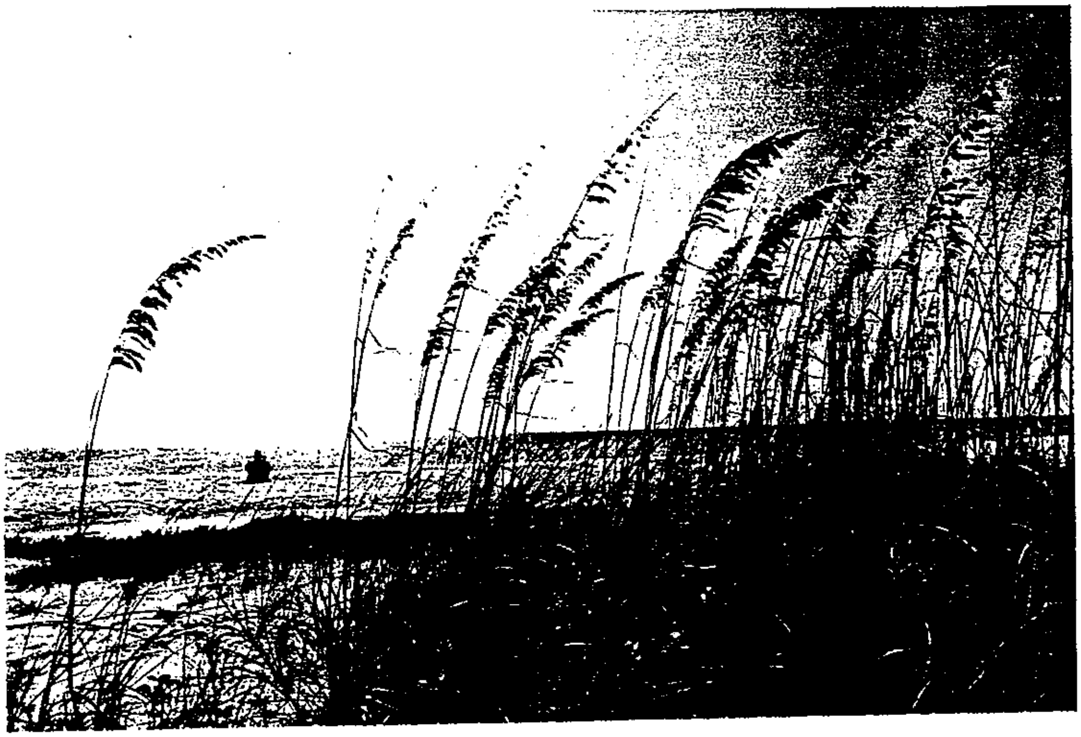


NOTES:

6 FOOT CENTERS ON AVERAGE RANDOMLY SPACED.
TREE SIZES VARIED.
GROUND COVERS AT LEAST 1 GALLON.
PLANTING AREA TO BE MONITORED FOR SURVIVORSHIP AND NATIVE RECRUITMENT.
REPLANTING AND EXOTIC REMOVAL WILL BE COMPLETED AS NECESSARY TO ACHIEVE RESTORATION OF DUNE WITH 100% NATIVE SPECIES.

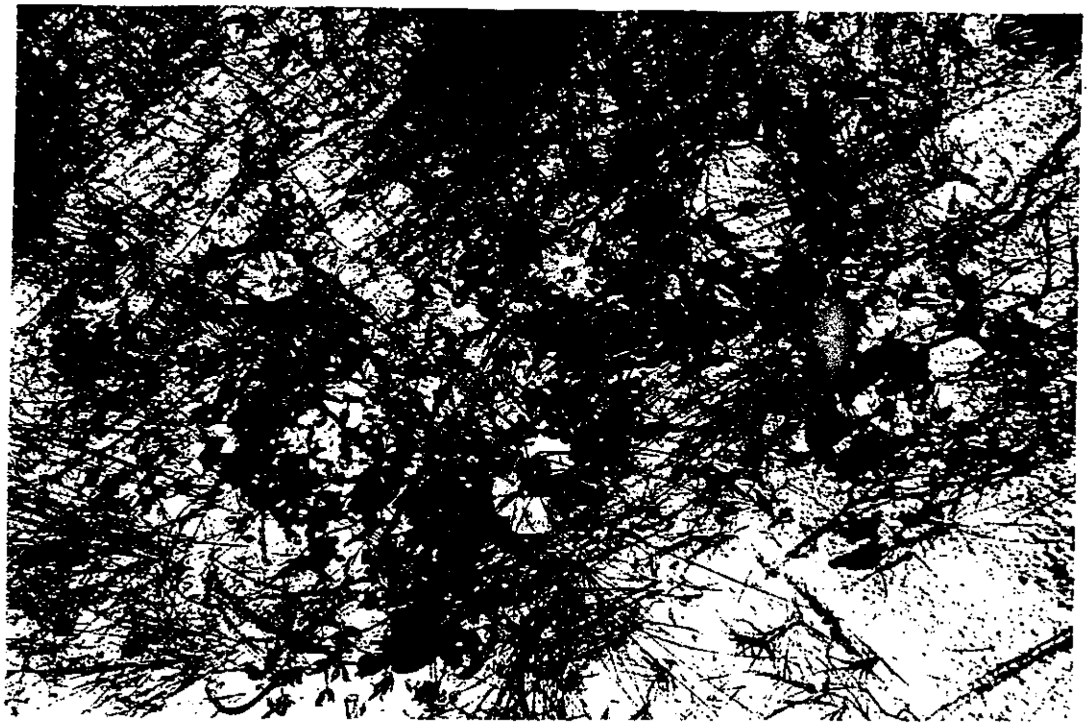
DETAIL A-2
TYPICAL PLANTING AREA

DETAIL A-2		City of Sanibel 800 Dunlop Road Sanibel, FL 33957
DATE: 10/21/94	SCALE: 1" =5'	
PROJECT NO.:	FIGURE III-3	



Photograph III-6

Sea oats are one of the dominant and certainly most attractive of the pioneering dune vegetation species. They are protected by both City and State law and seed collecting is prohibited due to their importance in stabilizing beach sands.



Photograph III-7

Morning glories add a splash of color to a saltgrass patch within a Sanibel dune system.

Photograph III-8

Improper storage and dragging of beach chairs and the uncontrolled trampling of multiple access paths to the beach can destroy the vegetated upper beach zone along with all the protective and habitat functions this area provides.

via walkovers or a minimal number of designated beach access paths, and only utilized on the open, unvegetated beach itself. Many resorts make beach chairs and other equipment available to their guests either under a rental program or as amenities. Currently only the rental of beach furniture requires a permit from the Sanibel Planning Department. This program should be expanded to all multi-family developments that provide beach equipment in order that a review of the condition of the dune system on site can be made and restoration instituted where necessary. Frequently, such operations tend to gradually trample away the dunes as a result of improper storage, dragging of equipment across these areas, and placement of paraphernalia on top of vegetation. Restricting beach furniture types to easily transported and lightweight designs could also reduce impacts caused in part by current use of heavy wooden or metal materials. A complete review of this issue and subsequent preparation of a new beach paraphernalia ordinance better addressing current problems areas seems appropriate.

There is also a very real aesthetic impact that results from over-commercialization of the beach. To many, a much more attractive and natural beach is enjoyed when numerous pieces of furniture do not clutter the view. Controlling the number of beach items in use at one time on short stretches of beach could help address this problem.

6. Alteration of Beaches by Raking, Digging and Burying Natural Beach Debris.

A standard practice in many beach communities, such as Fort Myers Beach, is to periodically or even daily rake up and dispose of the seaweeds, sponges, worm tubes, seagrass blades, mangrove propagules, etc. that wash up at the high water mark. The impetus to rake stems from the imposition of neat and tidy human ideals on the not always immaculate natural beach system. Indeed, sometimes strong smells emanate from such flotsam as it decays in the sun, and there are hidden squishy and slimy objects that can be encountered with an unwary footfall. Some raking programs use mechanical devices towed by a tractor or golf cart which of course also remove treasures such as the dried exoskeleton of sea urchins and sand dollars and a multitude of shells. The wrack that is being treated like garbage is also a bounty from the sea for many shorebirds, particularly during migration when the ability to feed efficiently is important to fuel up for the long flights to come.

Raking or removal of naturally occurring wrack is currently not advocated by the City, but should be specifically prohibited except in the case of red tides or dangerous litter such as the large number of stone crab traps and lines which often wash up after a storm. In these two restrictive cases, the public health factor should become paramount and beachfront owners should have the right to clean the beach.

7. Beach Lighting, Furniture and Sea Turtles.

As described in the Natural Resources Section, artificial lighting that shines onto the beach at night can discourage female sea turtles from nesting and can, and may disorient hatchlings in their crawl toward the water, which often results in their death if they end up in streets or parking areas. Lights out for sea turtles season lasts from May through October and also has aesthetic benefits for evening strollers who can enjoy the beach without glaring lights in their eyes. Building and property security can still be maintained by setting light fixtures down low to the ground, attaching shade covers on the waterward side of fixtures, and by using low pressure sodium vapor lights where needed.

Both lights on the beach and the overnight presence of beach furniture on the beach or dune is prohibited by City law during the turtle nesting season. Furniture can trap and disorient nesting females and result in poorly located nests.

The Sanibel-Captiva Conservation Foundation currently runs a loggerhead sea turtle monitoring program started by Charles LeBuff as Carretta Research, Inc. The Foundation's mostly volunteer sea turtle patrols coordinate with City staff on lighting and beach furniture violations.

8. Disturbance of Nesting, Resting and Feeding Shorebirds.

The presence of large numbers of people on the beach can displace shorebirds at critical times during their migration and interfere with nesting. Public education is really the only tool available to help the situation. Instructing beachgoers not to disturb flocks of birds, walking slowly around nesting or feeding birds, roping-off and posting nesting areas, removing beach furniture when not in use, and keeping loose pets off the beach are all positive approaches.

9. Live Shelling.

The collection of living specimens of non-edible mollusks (bivalves, example: penshell clams and univalves, example: snails, like the fighting conch) and echinoderms (starfish, sand dollars, sea urchins, etc.), is commonly referred to as "live-shelling", although the trophy recovered upon killing and removal of the living organism is actually a non-living exoskeleton. The abundance of empty shells from as many as 400 species that wash up on Sanibel's shores is indisputably a huge economic resource. Sanibel is known as a world-class shelling destination and the expectation of finding these treasures lures many visitors. Photograph III-9 illustrates the "Sanibel Stoop", a familiar sight along the shell laden beaches.

Photograph III-9

The "Sanibel Stoop" is a familiar sight along the shell laden beaches. January 1, 1995 marked the start of a new state law prohibiting the taking of any "live" shells within City waters to 1/2 mile offshore. This includes whelks, conchs, olive shells, etc., as well as starfish and sand dollars.

The City has sought to protect this important biological and economic asset by petitioning the Florida Marine Fisheries Commission (MFC) to restrict live shelling. In 1987, the MFC passed a special Sanibel Shelling Rule (MFC Rule Chapter 46-26) restricting live shell collection to 2 specimens of any one species per person per day. In addition, any non-resident technically needs a State saltwater products fishing license, a little known and often ignored regulation. This rule was in effect for six years and was of value from an educational standpoint. However, enforcement was virtually impossible and collecting in excess of these limits has occurred regularly.

In 1993, the City, following a recommendation by the Wildlife Committee, further petitioned the MFC to establish a complete ban on live-shelling for Sanibel offshore to the city limits (1/2 mile from shore). This more stringent rule is justified considering the extraordinary ecological and economic values of this resource and the expansive consequences should populations collapse due to overharvest. This new rule was approved at a final Public Hearing in October, 1994 and went into effect January 1, 1995.

10. Littering and Flotsam and Jetsam.

Sanibel is very fortunate compared to some resort areas in the lack of a serious litter problem due to beachgoers. Most beach visitors clean up after themselves, and it is not unusual to see strollers and shellers carrying trash they've found on the beach to dispose of properly later. However, like many coastal communities, Sanibel's beaches suffer from a heavy load of trash washed up on shore. Despite considerable marine-targeted education programs and widely publicized fines on cruise lines, there are still significant problems with recreational and commercial vessels dumping all manner of debris into the Gulf and bays.

Annual beach clean-ups sponsored by the Sanibel-Captiva Conservation Foundation have yielded an average of 3700 pounds of trash between 1989 and 1993. Of special environmental concern are monofilament fishing line and plastic six-pack rings which entangle birds and other wildlife, and plastic bags and balloons which are sometimes mistaken by sea turtles as jelly fish and ingested with fatal results.

Continuing boater and fisher person education programs, monofilament recycling and litter law enforcement all must play their part to improve this situation. Unfortunately, it appears there may always be those among us that are too lazy or ignorant to properly dispose of waste.

11. Boats and Related Activities.

Storage of boats on the beach and dune system and power boat operation in shallow waters can have environmental and public safety repercussions. Like any type of beach furniture, boats stored and dragged across dunes can damage vegetation and can interfere with sea turtle nesting. Because of their size and weight, the catamaran-type sailboats, which seem to be the most popular, are difficult to remove from the beach by hand without dragging. It is very desirable to get them off the beach after use so maneuvering them down established beach access paths via some kind of non-motorized wheeled caddie or hand-cart is recommended. To reduce impacts of storage of these boats on the beach, resorts should be limited in the number of catamarans on the beach at any one time.

The Sanibel Vessel and Boating Law established in City Ordinance No. 93-13 designates slow speed, minimum wake zones within 500′ from the beach or shoreline island-wide and within all inshore bays and waterways between Clam Bayou and Woodring Point. In addition, all residential canals are posted idle speed, no wake and jet skis are prohibited from entering all natural bays and waterways except to travel at slow speed to and from docking or launching facilities. Boats exceeding the speed limits close to the beach are a common occurrence, however, and an increased enforcement presence by police, and State and County Marine Patrol officers is needed.

12. Docks and Seagrass Beds.

In the Bay Beach Zone, large docking facilities located over shallow submerged seagrass beds can have significant detrimental effects. A City research study on these impacts found that over 3.5 acres of scarce and highly productive seagrass meadows could be lost if all bayfront residences built such structures. The problem is not with properties which have close access to deep waters, but lies with those where docks built to reach adequate water depths for boat navigation have to extend 75′ to 250′ or more. Sanibel law now prohibits new dock construction between Woodring Road and Lighthouse Park to protect such shallow and extensive seagrass beds. Docks on the Gulf side of the Island have not been recently applied for due to the exposed and often rough conditions and the very likely chance of future storms destroying any structures.

D. Additional Public Use Issues.

There are many ways that the beach is utilized that may have notable public safety, health, aesthetic or moral implications, in addition to any impacts on beach ecology.

1. Vehicles On The Beach.

Bicycles, golf carts, dune buggies, three-wheel ATV's, and four-wheel drive motor vehicles are all used from time to time for beach access, recreation and convenience. All can initiate irritation and disturbance for pedestrian beach goers. While bicycles can be legally driven on the beach, motor vehicles currently require express written permission from the City Manager, which is given rarely. Examples of such permitted uses are the off-road vehicles used by the Sanibel-Captiva Conservation Foundation for sea turtle patrols, ATV use by Lee County staff at Bowman's Beach and special use permits allowed for tree removal or construction projects such as dune walkovers. Sanibel appears to be in no danger of becoming another Daytona Beach, but vehicle use should be minimized and actively managed as demands on beaches grow.

2. Domestic Animals On The Beach.

There is currently no prohibition on dogs, cats, horses, etc. on Sanibel beaches (though Bowman's Beach prohibits pets and all dogs elsewhere must be kept on leashes). There are reported instances of negative interactions between unleashed dogs (and their by-products) and beachgoers, and dogs chasing feeding and resting shorebirds. No change in the status quo is called for except that enforcement of leash and poop scoop laws and monitoring of the extent of pet activity should be continued.

3. Boats and Personal Water Craft.

All manner of motor vessels are permitted to idle directly in to the beach at slow speed, minimum wake starting 500' from the shore. Especially on weekends and in season, the eastern end of the Island is very popular with boaters from all over Lee County who anchor close to shore and swim, picnic, etc. At times, this can be an eyesore and bother for others whose view of the water is occluded by numerous boats and who must listen to the sound of revving motors and whining personal watercraft. Legally, the City is probably in a difficult position as to regulating such temporary marine usage other than via speed zones. Permanent mooring structures such as anchor, chain and buoy systems do require specific review and approval by the City Manager.

4. Swimming Safety.

With no lifeguards posted at resorts or public beaches, swimming in the Bay or Gulf is strictly at the swimmer's own risk. Tidal passes both at Lighthouse Beach Park and Blind Pass/Turner Beach near Captiva, create rapid and powerful tidal flows that can be deadly for even strong and experienced swimmers. Swimmers should always avoid these areas and scan the waters at all locations for high seas or powerful currents before entering. All waders and bathers should also shuffle their feet while walking in shallow waters to reduce the chance of injury from Stingrays.

5. Public Nudity.

Some individuals and groups have attempted to establish portions of Sanibel beaches as nude or clothing-optional beaches, most notably, Bowman's Beach and the newly-acquired Silver Key. The City's position is that any such use has been and is unlawful under state law and that the City has no current interest in setting aside any portion of Sanibel beaches as clothing-optional.

The reasons most often given for having clothing-optional beaches, historical use as such, remoteness of the beach, appeal to foreign tourists, and lack of harm to others, are not accepted by the City. Any history of nude sunbathing is not a history of a lawfully permitted nudity. The beaches are not very remote in fact, but are in proximity to homes. The societal norm in the United States and in Sanibel continues to be to wear clothing. Beachgoers in Sanibel have a legitimate interest in being free from exposure to others' private body parts and to have their families and children free from same.

E. Pollution Sources and Monitoring.

The most important threats to Sanibel's water quality in the Gulf, Bay and surface water systems and aquifers are sewage, stormwater runoff and oil/fuel leakage or spills.

The City is actively pursuing island-wide conversion from septic systems to central sewage treatment in accordance with the City's Wastewater Management Plan which is the single most critical need to protect water quality. The porous sandy soils of barrier islands and the shallow water table and proximity to open seawater make septic systems unreliable at best. Until this transition is complete there remains a remote chance of contamination of surrounding waters and the need to close swimming beaches. The City is currently monitoring six beach and bay locations for coliform bacteria, an indicator species for septic pollutants. So far, no test results have shown levels exceeding State standards, but coliforms are present at all sites sampled. It should be noted that the presence of low levels of coliform bacteria is most likely natural as fecal matter from other vertebrates such as birds and manatees also includes these organisms. They are naturally found in the digestive tracts of many animals and most strains are harmless, probably even helpful components of our internal symbiotic fauna. It is only at high levels in the water that their presence indicates septic contamination.

The potential for disaster from oil spills looms over every beach community and even more so for areas with mangrove forests. Every day, an oil fuel barge travels fully loaded from the Florida Power and Light storage facility at Boca Grande Pass down Pine Island Sound along Sanibel to the power plant up the Caloosahatchee River. The grounding and rupture of this vessel would have the potential for catastrophic damage to mangroves, seagrasses, and fisheries. There are action plans prepared by the Lee County Emergency Management staff for such an eventuality, but the chance of getting sufficient oil collecting booms and skimmer vessels on the site in time for containment in such an event is slim.

Continued vigilance as practiced by the Sanibel City Council to object to any and all offshore oil exploration plans is necessary to minimize the chance for a oil spill in the Gulf to contaminate local beaches.

F. Beach Nourishment Impacts.

Although currently beach nourishment is the erosion control method of choice due to its "soft" characteristics and long term benefits for beachgoers, sea turtles and nesting shorebirds, there are potentially some problems with the process. This is more true on critically eroding shorelines where maintenance renourishment may be required at frequent intervals, of under ten years.

Whether the sand is hydraulically dredged directly onto the beach or into a hopper barge which is transported to the beach and emptied, it is pumped to the beach as a slurry. Temporary turbidity is generated by this process as particles finer than sand, in the particle size range which includes silt and clay, are put into suspension. When the sand is deposited on the beach, the turbid water runs off into the surrounding water creating a plume of turbidity.

High turbidity conditions frequently occur naturally during storms, and many organisms on the Gulf coast are adapted to these conditions. However, excessive quantities of silt from dredging may create a problem if they exceed those natural levels, in concentration or duration. Higher than normal silt concentrations are problematic for filter feeding organisms like clams, sponges, corals, sea anemones and tube worms. For this reason, State permits require careful monitoring of turbidity during dredging operations. Fortunately, turbidity from beach nourishment is localized and temporary, and will primarily be a factor only during the construction process.

The identification and use of sand sources with low silt content can obviously reduce the severity of turbidity problems, and extensive investigations of potential borrow sources is an important element of beach nourishment design. All natural sand deposits contain some silt because it is a natural component of the environment and is deposited along with sand when shoals form. Sand from high energy environments such as inlet ebb tidal shoals tends to be lowest in silt content, with typical concentrations of from 0.0 to 3.0 percent. Clean sand such as this generally will not create environmental problems due to turbidity.

For material with high silt content, effective means of turbidity control have not been developed, mainly due to the difficulty in settling out or filtering large volumes of water that are pumped with the hydraulic dredging process. Temporary berms and dikes help reduce turbidity in waters returning off the beach and into the open Gulf, but a visible turbidity plume in the area of dredge discharge is unavoidable.

Turbidity curtains, often used to contain silt on calm water bodies, are generally not practical due to the high wave energy nearshore. Silt deposited within silt curtains would be quickly redistributed by waves once the curtains were removed.

A more long term affect of the silt content of dredged sand would be the gradual release of turbidity from the sand placed on the beach. This, however, is not normally a problem because the dredging process washes the sand, resulting in silt concentrations of less than 2 percent. Restored beaches may in fact be cleaner than the natural eroding beach, especially if the erosion cuts into underlying layers of relict organic material, which is often the case.

Studies have shown that some small "bait fish" such as sardines and menhaden and the commercially valuable pompano reduce their use of areas around recently nourished beaches. This could have some localized population affects in the case of larger projects.

Overall there is no question that beach renourishment helps sea turtles in the long run, especially compared to hardened structures which can destroy the beach and eliminate it as a nesting location. The hydraulic filling process, however, results in compact sand which some sea turtle experts believe may interfere with female turtle nest excavation attempts, so loosening the sand by tilling the beach after completion of construction has become a standard condition of beach nourishment permits issued by Florida's Department of Environmental Protection.

G. Hurricane Evacuation, Erosion and Flood Issues.

Sanibel, like most barrier islands, is extremely vulnerable to hurricanes, especially considering its average height above sea level is less than four feet. The Comprehensive Land Use Plan contains details on hurricane preparedness, evacuation and post-storm planning. The most complete reference on this subject is the City's Emergency Management Plan. This thick document contains all the plans and procedures that are in place should a hurricane threaten the Island.

The Sanibel Police Department currently employs two full time employees, one half of each's responsibilities is to oversee the Sanibel Emergency Management Program (SEMP). One of the most important aspects of this program is to have access to the most accurate storm forecasting information available. Currently Sanibel is under contract with a company which has an excellent record to date in accurately tracking storms that might affect Southwest Florida.

One of the projects the SEMP team is working on at present is the feasibility of establishing an off-island emergency operation center and recovery facility that would coordinate re-entry, security, post disaster infrastructure repair and other public needs. Access to the Island may be severely affected if the Causeway bridges are destroyed by a storm or the large Australian Pines along major travel routes such as Periwinkle Way fall and block traffic. A long term program to remove pine trees along Gulf Drive between Lindgren and Tarpon Bay Road is strongly recommended to aid in post-storm access since Periwinkle Way will most likely be impassable for many days and at least one open route will be needed.

Another aspect of storm preparedness which needs more attention is the condition and functionality of the dune system. Trapping and holding sand with its root system and emergent biomass, dune vegetation is the first line of defense for the Island. Although tall dunes with large volumes of sand, such as found in North Carolina and parts of the Florida panhandle are not characteristic here, intact, vegetated dunes should be a goal for Sanibel. As discussed in the Coastal Activities and Impacts Section, the dune is currently not in good condition due to trampling, beach paraphernalia, etc., and a dune restoration program should have significant value in erosion and flood minimization as championed by FEMA.

BEACH ACCESS & PUBLIC LANDS

SANIBEL ISLAND BEACH MANAGEMENT PLAN, SECTION IV.

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FIGURES

IV. BEACH ACCESS AND PUBLIC LANDS.

A. Public Lands Inventory.

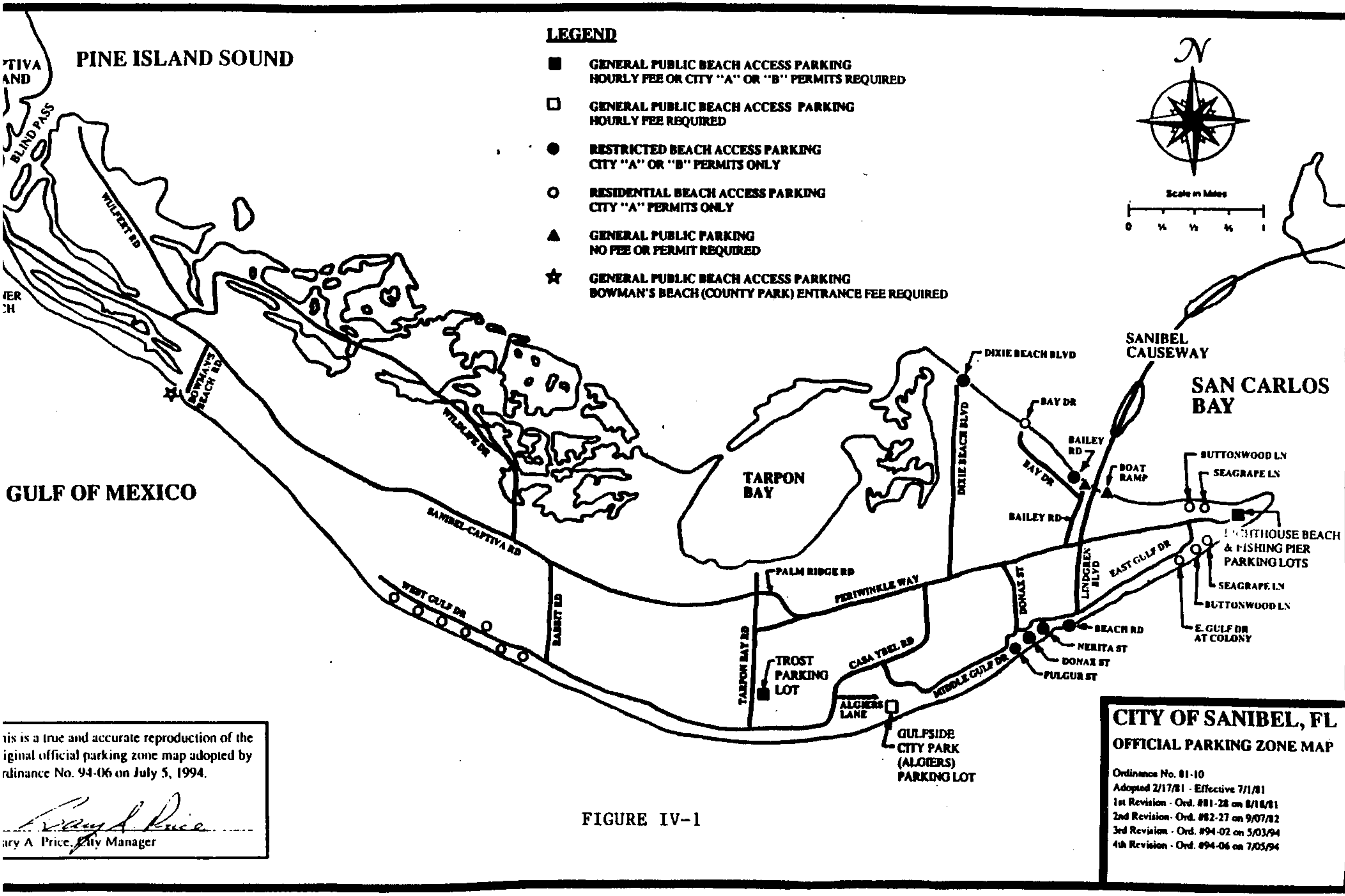
1. Beach Access Sites.

Public beach parking on Sanibel is categorized as "General Public", "Restricted", and "Residential" parking. (See Figure IV-1) There are currently seven "General Public" beach parking lots on the island, six of which are owned and operated by the City, and one by Lee County. Two of the City's general public beach parking lots are free, one requires an hourly fee of $.75, and three require either a $.75 hourly fee or an annual City "Resident" or "Restricted" beach parking decal. The County beach access parking lot requires a $3.00 daily entry fee.

The City also maintains seven "Restricted" beach parking lots which require an annual City "Resident" or "Restricted" beach parking decal. There are an additional 12 City beach parking lots that are classified as "Residential" that require an annual City "Resident" beach parking decal. Annual "Restricted" beach parking decals are available to the general public for a $30.00 fee. Annual "Resident" beach parking decals are available to Sanibel residents only for a $5.00 fee.

The potential for future acquisition of additional beach access sites is minimal. No land purchases that would include additional beach parking are anticipated by the City. This is because the beachfront properties of Sanibel are near buildout and high land costs make acquisition of large parcels unlikely. Publicly owned coastal lands include the 5400+ acre J.N. "Ding" Darling National Wildlife Refuge, Lighthouse City Park and Bowman's Beach County Park. A recent gulf front acquisition is Silver Key at the west end of the Island, purchased under the City's Environmentally Sensitive Lands Acquisition Program and the State of Florida Communities Trust Program.

Future waterfront preservation lands targeted for acquisition include erosion vulnerable lots near Blind Pass and an outparcel at Bowman's Beach.



LEGEND
GENERAL PUBLIC BEACH ACCESS PARKING
HOURLY FEE OR CITY "A" OR "B" PERMITS REQUIRED
GENERAL PUBLIC BEACH ACCESS PARKING
HOURLY FEE REQUIRED
RESTRICTED BEACH ACCESS PARKING
CITY "A" OR "B" PERMITS ONLY
RESIDENTIAL BEACH ACCESS PARKING
CITY "A" PERMITS ONLY
GENERAL PUBLIC PARKING
NO FEE OR PERMIT REQUIRED
GENERAL PUBLIC BEACH ACCESS PARKING
BOWMAN'S BEACH (COUNTY PARK) ENTRANCE FEE REQUIRED
N
Scale in Miles
0 ¼ ½ ¾ 1
PINE ISLAND SOUND
GULF OF MEXICO
BLIND PASS
WULFERT RD
BOWMAN'S BEACH RD
WILDLIFE DR
SANIBEL-CAPTIVA RD
WEST GULF DR
RABBIT RD
TARPON BAY
PALM RIDGE RD
TARPON BAY RD
PERIWINKLE WAY
TROST PARKING LOT
CASA YBEL RD
ALGIERS LANE
GULFSIDE CITY PARK (ALGIERS) PARKING LOT
MIDDLE GULF DR
DIXIE BEACH BLVD
BAY DR
BAILEY RD
DONAX ST
LINDGREN BLVD
BEACH RD
NERITA ST
DONAX ST
FULGUR ST
EAST GULF DR
SANIBEL CAUSEWAY
SAN CARLOS BAY
BOAT RAMP
BUTTONWOOD LN
SEAGRAPE LN
LIGHTHOUSE BEACH & FISHING PIER PARKING LOTS
SEAGRAPE LN
BUTTONWOOD LN
E. GULF DR AT COLONY
CITY OF SANIBEL, FL
OFFICIAL PARKING ZONE MAP
Ordinance No. 81-10
Adopted 2/17/81 - Effective 7/1/81
1st Revision - Ord. #81-28 on 8/18/81
2nd Revision - Ord. #82-27 on 9/07/82
3rd Revision - Ord. #94-02 on 5/03/94
4th Revision - Ord. #94-06 on 7/05/94
his is a true and accurate reproduction of the
iginal official parking zone map adopted by
rdinance No. 94-06 on July 5, 1994.
ary A. Price, City Manager

FIGURE IV-1

BEACH MANAGEMENT GOALS & OBJECTIVES

SANIBEL ISLAND BEACH MANAGEMENT PLAN, SECTION V.

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PHOTOGRAPHS

V. BEACH MANAGEMENT GOALS AND OBJECTIVES.

A. Overall Management Philosophy.

The overall philosophy of managing Sanibel Island's beaches is for people as well as wildlife. This includes a goal of restoring deteriorated stretches of dune to as natural a conditon as possible, active encouragement of retreat from eroding stretches of beach, and an otherwise non-intervention policy by the City of Sanibel including letting nature take it's course regarding beach erosion.

It is stated in the City of Sanibel Comprehensive Land Use Plan (CLUP) that Sanibel Island became incorporated as a municipality of Lee County because of a desire for self-determined orderly development such that the natural characteristics of the island would be preserved. Beaches are a fundamental element of Sanibel Island's natural characteristics that has both aesthetic and environmental value, as well as being the primary attractor of tourists. Management of beaches is therefore an inherent objective of the comprehensive plan.

The CLUP addresses immediate problems of environmental protection and planned growth within the terms of reference of current knowledge of existing conditions and anticipated resources. As parts of the plan are implemented and new problems or resources are known, then the comprehensive plan is to be reviewed and modified to reflect public attitudes to the new circumstances.

Beaches are dynamic, and constantly present new circumstances. Some of these new circumstances are the result of natural changes and some are changes brought about by man's interference in the dynamic littoral system. The technical ability to understand and deal with those changes has improved significantly in recent years, and in itself represents a new circumstance.

This Beach Management Plan defines beach processes, the importance of beaches, beach problem areas, and outlines methods of addressing those problems. It also makes recommendations regarding collection of additional information to establish a strong legal basis and technical justification upon which to respond to management needs.

This Plan is, therefore, a part of the same continuous and ongoing planning process of which the Comprehensive Land Use Plan is a part. Beach management goals, objectives, and strategies, as adopted for the Beach Management Plan, should be consistent with or be incorporated into the Comprehensive Land Use Plan. In this manner, specific issues relating to the beaches of Sanibel Island will be addressed through implementation of this Beach Management Plan, or the Beach Management Plan as modified by City Council, as discussed under Section III-B,3.

1. The Importance of Beaches.

Sanibel Island has approximately 31 miles of shoreline, 14 of which consist of sandy beaches. Beaches are one of the geographical characteristics that distinguish Sanibel Island as a unique place that has inspired residents to preserve existing natural resources and to restore those which have been compromised by man-made influences. This effort is apparent in shoreline preservation; today Sanibel's coastline contains very little coastal armoring, which may disrupt the natural beach environment in a variety of ways, and may also act as a barrier to recreational access along the beach.

The importance of Sanibel Island's beaches can be divided into two areas, environmental and economic. The following two sections discuss the importance of beaches in these two areas.

1.1 Environment.

Beaches are a unique landform for several reasons. They are limited in extent to a relatively narrow zone where water meets land. They are primarily made up of sand, which is unconsolidated and readily moves about under the influence of water waves, currents, and wind, making the beach a dynamic land form which is constantly changing. Beaches are subject to intense direct sunlight and periodic inundation with saline water. The beach supports distinctive flora and fauna which have adapted to an environment which is too dynamic and too harsh for other forms of life. Survival and maintenance of this specialized plant community is important in offering limited stability to the dune system as well as maintaining habitat for a variety of species.

Section II of this Beach Management Plan provides a detailed description of the beach environment. There are four distinct zones which make up this environment, as illustrated in Figure II-1. Moving in the landward direction from the water these zones are: (1) the shallow nearshore area below mean low water, (2) the intertidal zone between mean low water and mean high water, (3) the beach berm above mean high water, and (4) the dune system.

Maintaining these zones in their natural state provides an environment for native species of plants and animals, including dune vegetation which promotes accumulation of sand, so the system can function naturally. As a naturally functioning system the beach is an integral part of the surrounding environment essential to the survival of other species which spend a significant amount of time elsewhere but come to the beach for feeding or nesting.

1.2 Economic.

Beaches make a strong contribution to the economy of Sanibel Island in two principle ways. The first is the volume of business activity generated by recreational beach visitors who purchase goods and services while on Sanibel Island, and the resulting jobs which are created to provide those goods and services. The second economic benefit is through the enhancement of property values. Beaches therefore are a valuable economic resource.

Storm Protection. A healthy beach provides storm protection benefits in a number of ways. One type of benefit relates to the protection afforded by a wide beach to upland structures from moderate storm waves that cause erosion and may threaten upland development. If there is a wide beach, the erosion will take place on the beach where it does no harm to upland structures. If the beach is narrow, the erosion may undermine habitable structures, roads, or other infrastructure.

Another way in which a healthy beach provides storm protection benefits is during tropical storms and hurricanes. Severe storms such as these do not occur very often and are therefore referred to as "low frequency" storms. Low frequency storms are often accompanied by extremely high tides known as storm surges. If the elevated tides are high enough, very little beach erosion will occur because the erosive action of the waves will overtop the beach rather than impact it directly. Under storm tide conditions, however, the water is shallow enough over the beach to cause large storm waves to break and a natural beach is wide enough to cause broken waves to expend energy as they move further inland. Under such storm conditions, waves that traverse a wide beach before impacting upland habitable structures will have less potential to cause damage than waves that do not cross a wide beach before encountering upland structures.

During the winter season, the higher level of storm frequency typically results in material being eroded off of the beach and being stored in a nearshore bar. As the summer season approaches, the milder summer wave activity will tend to move portions of this offshore bar back onshore resulting in a wider summer beach profile. These seasonal changes are cyclical and result in a varied beach width throughout the year. A healthy natural beach provides sufficient width so that seasonal variations along the beach profile will not result in removal of material from the protective vegetated dune area during the winter season. Additionally, dune vegetation may trap windblown sand, naturally nourishing the upper part of the profile. Section I, the Coastal Processes Section of this Beach Management Plan, provides a more detailed description of these seasonal changes.

Public Benefits. Public benefit is inherent in the benefits described above. Environmental enhancement not only aides in the preservation of endangered and threatened species, it also preserves life at the bottom of the food chain which in turn benefits the fishing industry as well as recreational fishing and tourism. Increased property values benefit individual property owners and increase the tax base. Recreational benefits accrue to local residents as well as tourists, and tourism represents a significant part of the local, county, and state economies through increased jobs and payrolls for those whose employment is associated with beach related activities. Finally, storm protection preserves property values and protects emergency storm evacuation routes.

2. Shoreline Armoring Policy Statement.

2.1 Background. Development usually causes permanent alteration of natural geographic features. Redevelopment may improve aesthetic appearances but seldom does much to restore natural biologic and physical processes as integral parts of the surrounding ecosystem.

Beaches have existed as geological features through the ages. Primarily, they are composed of unconsolidated granular sands deposited by littoral and alluvial processes. As described in the Coastal Processes Section of this Beach Management Plan, Sanibel Island is a terminus barrier island made up of material from the islands to the north. It is predominantly made of beach sand which accumulated over the past 4,000 years.

Because of the sandy unconsolidated nature of beaches, the same processes which caused the formation of Sanibel Island may remove beach material as quickly as it was deposited. This may occur if there is a small shift in the balance of gulf wave and current characteristics.

Over short time intervals, relative to the 4,000 year history of Sanibel Island, beaches may exist in a state of near dynamic equilibrium. Dynamic equilibrium means that there is no apparent change in the location of the water line or shape of the beach, even though littoral transport continues to move large quantities of sand along the coast. Under these conditions, sand is being deposited at more or less the same rate as it is being removed, resulting in a steady-state condition with no net change.

This dynamic equilibrium is a fragile state of balance. A small shift in forces may result in a net loss of sand from one section of shoreline which will erode, and net accumulation of sand on an adjacent section of shoreline, which will accrete. Along undeveloped shorelines, this normally does not create a problem and is generally unnoticed because the beach simply shifts either landward or seaward without consequence.

In the natural scheme of things, undeveloped shorelines evolve through both periods of erosion and periods of accretion. However, if the upland is developed, erosion may threaten upland structures. Upland structures vary significantly in design, and over the past twenty years, coastal development standards have greatly enhanced the ability of structures to withstand limited amounts of erosion and storm impact.

Older structures built to earlier standards in many cases were not designed with consideration of long term erosion rates. In hindsight, it may be said that they were built too close to the shoreline. However, it should be noted that some of the current erosion problem areas were originally developed with equivalent or greater setbacks than other sections of the coast which presently do not have erosion problems. This inherent vulnerability of coastal areas is the reason for regulatory programs, such as the State of Florida Coastal Construction Control Line, which is discussed in Section VI-D,3.

Many of these older structures were built at too low an elevation and with insufficient structural foundations, and without consideration for the level of storm surge and wave activity associated with low frequency storm events such as tropical storms and hurricanes. They may therefore be threatened by relatively minor storm events along Sanibel's coastline.

Armoring the shorelines is one method of dealing with threatened structures. Once a section of shoreline is armored, however, it will no longer function as a natural part of the dynamic beach system, and the beach most likely will never recover to act as a buffer against the impact of storm wave activity. Additionally, armoring often disrupts natural beach processes along the shoreline well beyond the limits of the armoring.

Armoring is therefore undesirable in most cases because it permanently alters the natural system, often shifts the erosion problem to another area, and may exacerbate the erosion problem if the structure intrusively interferes with littoral processes. In general, armoring constitutes shore protection but not erosion control, and therefore it may temporarily prevent damage to upland structures but does not address the cause of the erosion problem. In the past, coastal armoring is often sought as the sole solution to an erosion problem without careful consideration of adverse impacts or other alternatives for long term protection of the beach and dune system.

2.2 Goal. It is the intent of this document to set forth policies which are not inconsistent with the State of Florida regulations and criteria in order to preserve the natural beach and dune system in all beach areas, both natural and developed, and to restore and maintain a natural dune in developed areas by rigorously restricting the use of armoring for erosion control purposes.

The State of Florida Department of Environmental Protection (DEP), formerly the Florida Department of Natural Resources, has been developing a coastal armoring policy within the State of Florida over the past twenty years. This policy is being developed because of concern for the adverse effects armoring has on the littoral system. The intent of the policy is, therefore, to minimize the use of armoring. Construction along the Gulf of Mexico coastline of Sanibel Island is regulated by the State DEP Coastal Construction Control Line (CCCL) program pursuant to Section 161.053, Florida Statutes.

Many of the goals of the DEP CCCL program are consistent with the goals and objectives of the Sanibel Island Wide Beach Management Plan. The State's coastal armoring policy recommends that coastal armoring be avoided and that efforts be directed toward addressing the cause of erosion on a regional basis. This comprehensive approach to addressing erosion problems may at times seem to be insensitive toward individual hardship cases, however, in the long run it will tend to provide more effective long term solutions to difficult coastal problems.

It should be the policy of the City of Sanibel to consider coastal armoring only as an alternative of last resort, for the protection of public infrastructure. Additionally, in cases where coastal armoring is considered acceptable it should be accompanied by a beach nourishment project, except in certain site specific situations on the bay shoreline which involve closing a gap in an otherwise continuously armored section of shoreline. Sandbags may be considered as a temporary solution to erosion in emergency situations, and conventional armoring may only be considered for the protection of vital public interests such as hurricane evacuation routes. Under all other circumstances, the use of armoring shall generally be prohibited along the Sanibel Island coastline.

B. Conservation of Biological Natural Resources, Goals and Objectives.

The major goal for the long term ecological health of Sanibel's beaches is to restore the dune system (Upper Beach Zone) to the point where it functions as a contiguous and intact habitat. Such an integrated upper beach will not only provide for the mutually beneficial coexistence of man and natural flora and fauna as fellow coastal residents but will also function in accumulating and stabilizing sand in a continuous protective barrier.

The open beach itself and the intertidal zone needs to be maintained as a natural system and not raked, scraped, blocked with rocks or seawalls or covered with beach chairs, umbrellas, boats, tents and ball courts. Photograph V-1 illustrates how seawalls with revetments protect upland properties at the expense of the beach. Other communities in Florida have allowed their beaches to turn into nothing but playgrounds for humans, precluding virtually all use by wildlife. Sanibel must be vigilant to be spared this unfortunate result of over use.

This watchful awareness should not be myopically limited to Sanibel shores, for outside influences on surrounding waters such as oil drilling, destruction of coastal wetlands, over development and chemical pollutants could ruin Sanibel's coastal resources from afar.

Photograph V-1

Hardened structures, such as this seawall with a rip-rap revetment toe, may protect private property but often does so at the expense of public beach.

C. PRESERVATION OF BEACHES, GOALS AND OBJECTIVES.

1. Storm protection for upland development.

Maintain natural beaches for the protection they afford against erosion from severe but non dune-overtopping storms, to avoid damage to upland structures from erosion caused by those storms. Develop design storm criteria and corresponding adequate beach dimensions to accomplish the desired level of storm protection. The desired natural beach will be maintained through implementation of acceptable alternatives as described in Section VI of this Beach Management Plan.

2. Emergency Evacuation Routes.

Maintain natural beaches for the protection they afford against erosion from severe but non dune-overtopping storms to avoid damage to evacuation routes from erosion caused by those storms. Presently this applies to Sanibel-Captiva Road immediately south of Blind Pass.

3. Recreation Areas.

Maintain natural beaches to accommodate both tourists and residents for recreational purposes, in order to enhance property values and tourism, and to reduce competition for limited beach space between humans and wildlife. Primary public recreation areas are south of Blind Pass, Bowmans Beach, Point Ybel, and street ends which provide parking and access.

4. Limit of Beach Commercialization.

Control and limit commercialization of beaches with such activities which include but are not limited to rental or use by paying guests of motorcraft, beach chairs and umbrellas.

D. POST DISASTER MANAGEMENT STRATEGIES.

The Comprehensive Land Use Plan deals with disaster safety issues. This section addresses beach management issues related to the effects of hurricanes on the beach and dune system. Of primary concern is beach erosion that may be caused by storm waves. The adverse impacts beach erosion may have, along with other problems that may be related to erosion conditions, are:

1. Loss of beach, as natural habitat for wildlife, for recreation, and for storm protection.

2. Sand overwash, landward onto developed areas and roads.

3. Road damage, in particular damage to evacuation routes.

4. Blind Pass or Clam Pass closure.

5. Old Blind Pass reopening.

6. Residential area damage.

    a. Residential structure damage.
    b. Residential structure destruction.
    c. Loss of residential land due to erosion.

7. Dune walkover destruction.

The following list some strategies for dealing with each of these impacts.

1. Sanibel has established a program of periodic monitoring of beach profiles. Following any storm event causing significant erosion, monitoring surveys should be completed to document the effects of the storm. Quantifying the impact of such a storm may be useful in planning future beach management strategies with regard to storm protection. Monitoring surveys would also be useful in the event of subsequent efforts to reclaim land lost due to avulsion, which is the sudden and dramatic loss of land from a storm event. (Land gradually eroded away or permanently inundated by water becomes part of the bed of the water and belongs to the owner of the bed. Land detached from the land of an owner by the sudden process of avulsion belongs to the person from whose land it was detached, and therefore may be reclaimed. See "Boundary Control and Legal Principles, Brown, et. al.)

A procedure that has been used in the past in some areas of Florida, as an intermediate measure in the wake of severe storm erosion, is beach scraping. This involves excavation of sand from the portion of the beach that is exposed during a low tide and using the excavated material to restore the beach dune and berm.

It must be conducted in a very controlled manner to prevent over excavation which might have downdrift impacts. Concern for preservation of natural processes on Sanibel Island could preclude the use of this procedure.

Beach scraping is considered to be most effective after a storm because storm activity often takes sand from the berm and deposits it in the nearshore area, sometimes in a nearshore bar. Some recovery of eroded beaches normally occurs from natural onshore sand movement after a storm, so beach scraping in such a situation is to some extent helping a natural recovery process.

2. Sand overwash deposited in dune areas may be beneficial in building a natural dune. Any native dune vegetation damaged during the process should naturally reestablish itself. Sand overwash deposited in residential areas or on roads that requires removal in the aftermath of a storm should be restored to the beach and dune system.

3. Roads damaged due to beach erosion should be repaired on a higher priority than the beach, as a safety issue, if the roads serve as hurricane evacuation routes. It is recommended that such evacuation routes be repaired and be protected with armoring. Such sections of shoreline armored out of necessity must be restored with beach nourishment, leaving the armoring buried as defense against future storm damage.

4. Waves associated with a severe storm could deposit enough sand in Blind Pass or Clam Pass to close either inlet. If inlet closure causes environmental degradation in the interior waterway, these inlets should be studied to determine if reopening the inlet through either mechanical or hydraulic dredging would be appropriate. The decision on reopening the inlet should be based on water quality issues, fisheries issues, or mangrove and other sensitive wetland issues.

If activities such as sand placement for nourishment of adjacent beaches contribute to the closure, such that the closure can not be considered a natural event, then the inlet should be reopened to restore natural processes. Reopening of the inlet should be accomplished in a manner which will best promote stability of the reopened tidal channel through the scour action of the natural tidal flow. This may involve removing more material than is necessary to merely reestablish tidal exchange. Additional dredging and possibly removal of overwashed material may be necessary in order to achieve optimum tidal flow velocities and volumes to enhance natural scour in the inlet. Inlet maintenance permits should be obtained in advance in case of an emergency.

5. Old Blind Pass reopening would divert some of the Clam Pass tidal prism, resulting in a smaller tidal prism for each inlet. Less tidal flow means lower self-scouring potential and lower stability for both inlets so that the closure of one or the other would probably occur.

Under these circumstances, it might be desirable to determine if it would be preferable to maintain one inlet over the other, and to promote closure of the least preferable inlet. A primary consideration in this situation is that water quality is typically improved by tidal flushing.

The Old Blind Pass location may provide better tidal exchange because of the long narrow geometry of the bay system, and of the two inlets, Old Blind Pass is located nearer to the center of that system. This geometry may tend to provide greater stability to the Old Blind Pass channel from a tidal prism standpoint which would therefore favor natural closure of Clam Pass. However, Clam Pass in its present location is adjacent to a seawall that artificially imparts some stability to a channel in this location due to wave interaction with the seawall. This wave interaction causes scour preventing accumulation of sand in this area.

6. Residential damage can occur in varying degrees.

a. Residential Structure Damage. Structures damaged but repairable should be repaired to conform with DEP and the City of Sanibel structural standards wherever possible. In cases where a higher structural elevation cannot be achieved, windload compliance should still be a goal. Repairs must be made consistent with the Sanibel Land Development Code (LDC), which requires that structures sustaining substantial damage, as defined in Section 1-E-17 of the LDC, be rebuilt according to current standards. Repairs must remain within the confines of the limits of the original foundation.

b. Residential Structure Destruction. Structures which are completely destroyed such that the original foundation is unusable, if rebuilt, should be rebuilt in a more landward position where possible, and must be rebuilt in accordance with DEP and City of Sanibel standards. Unless relocated to a more landward position, rebuilt structures must remain within the confines of the limits of the original foundation. Under circumstances where one or more structures are destroyed and the opportunity exists for a more landward location of redevelopment, the City of Sanibel should consider an interim local coastal construction setback line to promote a more appropriate setback on a regional basis. This would be a more efficient management practice than evaluating each application on an individual basis because it would result in a uniform line of construction and limit all rebuilding to a less vulnerable more landward position, resulting in less impact on the beach and dune system.

c. Loss of Residential Land Due to Erosion. Land lost during a single storm event is said to have been lost due to avulsion rather than erosion which refers to a slow and imperceptible process. Land lost due to avulsion remains the property of the upland owner, and may be reclaimed by filling. Filling to recover land lost on an individual lot along the Gulf of Mexico is of course economically impractical. The City of Sanibel should conduct post construction surveys as described under item (1) of this Subsection above to document storm effects and provide that information to the individual property owners in a cooperative effort to pursue the most environmentally compatible response to the storm damage. Bayside restoration on a lot by lot basis may be more feasible than on the Gulf Side.

7. Any dune walkovers destroyed by storms should be repaired because they protect the natural dune and dune vegetation. The dune vegetation allows the dune to grow through the trapping of windblown sand. The benefits of elevated dune walkovers are presented in Section III.C.3. Based on the nature of the storm damage or erosion of the dune, rebuilt dune walkovers should be located to provide the optimum conditions for promotion of a naturally functioning dune and beach system.

MANAGEMENT STRATEGIES

SANIBEL ISLAND BEACH MANAGEMENT PLAN, SECTION VI.

CONTENTS

FIGURES

TABLES

VI. MANAGEMENT STRATEGIES.

A. Management Issue Categories.

1. Establish Criteria for Categorizing Problems.

Beach problem areas along Sanibel's coastline vary considerably and affect both private and public interests. This section establishes criteria for the purpose of categorizing these erosion or problem areas for the implementation of management strategies. The justification for taking action to implement solutions to those problems relates to the importance of the beaches to Sanibel's economy and ecology, as described in Section V, "Beach Management Goals and Objectives."

Typically, a coastal problem may be categorized as to whether or not it is an emergency and whether it is a public or private concern. Some problems encountered along Sanibel's coastline may fall under more than one categorization. The following categories are established for addressing shoreline problems.

Category I. Emergency Situations Affecting Public Good. This category shall include situations which affect the public good, safety, or welfare which are in imminent danger from erosion or shoreline changes. These situations should be considered for implementation of an appropriate solution by the City of Sanibel. Where the State of Florida or Lee County have an interest, such as with public roads, erosion control measures implemented by the State or County should be consistent with this Beach Management Plan. An example of this category level would include hurricane evacuation routes threatened by erosion.

Category II. Emergency Situations Affecting Private Property Owners. Addressing erosion of private property is typically the responsibility of the private property owner. However, it is recognized that the economy of the community is to a large extent dependent upon the quality of Sanibel's beaches, both public and private, as a natural resource, a recreational resource, and as physical storm protection for the upland property owners. Therefore, it should be the policy of the City of Sanibel to further a cooperative approach in which the City would provide some assistance, other than direct financial support, for emergency situations affecting private property, within the overall policy of the City as identified in Section VI-B, to support or facilitate acceptable solutions to those problems.

Category III. Long Term Situations Affecting Either Public or Private Interests. This category applies to situations which affect the public good, safety, or welfare, but which are not emergency situations. Typically this category would include areas of public recreation, or areas experiencing a persistent ongoing erosion problem which, if left unattended, could develop into a situation that would affect infrastructure. Another example for this category would be dealing with derelict, or damaged coastal and shore-protection structures. Such derelict structures represent a liability, and may contribute to downdrift erosion.

Long range situations affecting private property provide the opportunity for private property owners to exercise foresight and planning to protect individual property interests in a responsible manner. The City of Sanibel has implemented a monitoring program which will be used to evaluate the seriousness of those situations should erosion continue. If those situations progress to the point where structures are threatened, the City's policy will be as described above for Category II.

2. Categorization of Identified Problems.

Listed below are eight areas of concern along Sanibel's coastline. Each area is discussed with regard to the appropriate category. Figure VI-1 is a location map showing the areas of concern.

2.1. Shoreline South of Blind Pass-Category I.

The first mile of shoreline south of Blind Pass has been rapidly eroding in recent years. This erosion has damaged beach front dwellings, three of which have either been destroyed or rendered un-inhabitable, and others are threatened. Under present conditions, ongoing erosion or severe storms are serious threats to Sanibel-Captiva Road which is a vital evacuation route. Closure of this road during evacuation for an approaching hurricane would constitute a potentially life threatening emergency.

2.2. Shoreline South of Blind Pass-Category III.

A number of properties south of Blind Pass have been significantly impacted by erosion and habitable structures have been destroyed. Some of these properties have been purchased by the City of Sanibel, and the destroyed structures have been removed. Such derelict structures interfere with lateral beach access and natural littoral process, however, they do not present an emergency situation and are therefore included under category III.

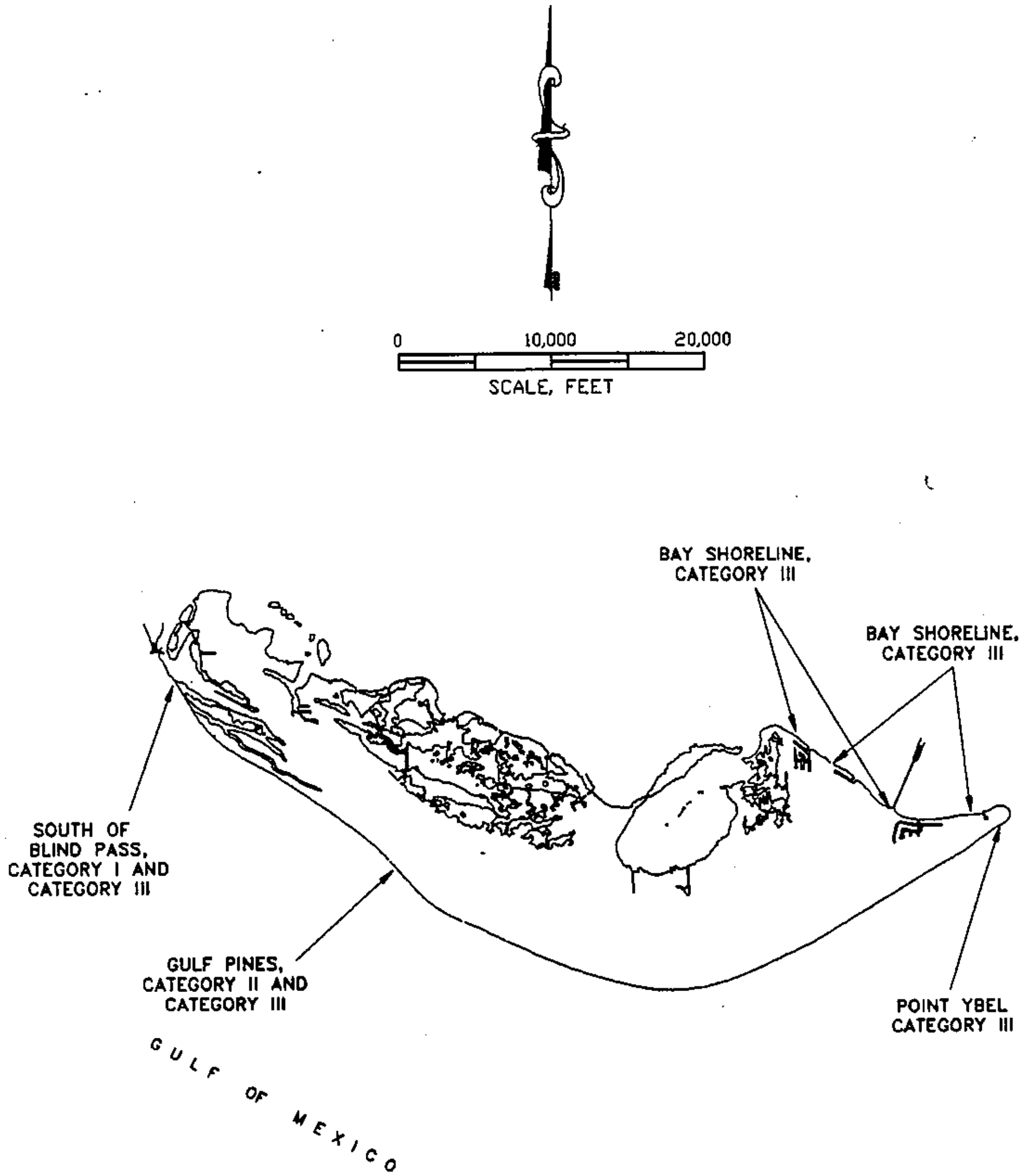


FIGURE VI-1

LOCATION OF IDENTIFIED PROBLEM AREAS

HUMISTON & MOORE ENGINEERS
SANIBEL BEACH MANAGEMENT PLAN
JANUARY, 1995

2.3. Gulf Pines, from R-129 to R-131 - Category II .

This section of shoreline has historically been eroding at a long term rate of between two and three feet per year. This is described in detail in Section III of the Coastal Processes Phase of this Beach Management Plan, and it was the subject of a study by Taylor Engineering, Inc., 1991. This long term erosion rate has been relatively low but persistent, and there have been recent higher short term erosion rates, in some locations in excess of ten feet per year. The overall result is that several homes are in imminent danger of incurring structural damage from ongoing erosion, or a moderate or severe storm, which would constitute an emergency situation for the affected property owners. If some form of mitigation is not taken in the near future, structure failures may occur and additional areas now classified under Category III will become Category II.

2.4. Gulf Pines, West of R-129 and East of R-131 - Category III.

In addition to the Gulf Pines areas where habitable structures are in imminent danger from erosion, there are adjacent properties which are experiencing similar erosion rates, but the erosion has not yet progressed to the point where the upland structures are threatened. These areas are therefore not considered to be in an emergency status. However, if the erosion trend continues, these structures will eventually be threatened, and the existence of this condition adversely affects property values. The need for finding a solution to this problem is not as urgent as it is for the properties between R-129 and R-131, but an opportunity exists for affected property owners to carefully evaluate available alternatives and implement a long term solution.

2.5. Point Ybel - Category III.

Point Ybel at the southeastern end of Sanibel Island has shoreline exposure to the north, east, and south at various times one portion of it has been eroding while at the same time another portion was accreting. The shorelines along the southern and eastern exposure, however, have predominantly been eroding, so that the net change from 1859 to the present has been a substantial loss of land to erosion. This is a loss of public recreational land, and if the trend continues, it may eventually threaten the historic Point Ybel Lighthouse.

2.6. Bay Shoreline, City Property - Category III.

There are three parcels of City owned land on the bay shoreline between Point Ybel to the east and the entrance to Tarpon Bay to the west. Two of these are adjacent to and on either side of the causeway, including the boat ramp park to the east of the causeway. The third is at Dixie Beach Park further to the west. There is very little survey data available to document the extent of the erosion that has occurred in these areas, but comparison of shoreline position from historic aerial photographs indicates that there has been erosion in these areas. Furthermore, Woodring Road leading west from the Dixie Beach Park area has been threatened by erosion, as evidenced by a section of shoreline which has been armored with rip-rap. This road represents the only land access to properties along the eastern shoreline of the entrance to Tarpon Bay.

2.7. Bay Shoreline, Private Property - Category III.

There is intermittent armoring along the privately owned sections of the bay shoreline between Point Ybel and the entrance to Tarpon Bay. Unprotected reaches of shoreline between the armored sections have in many cases receded landward of the line established by the armoring. This is evidence of continuing erosion. In many cases these unprotected areas also exhibit a vertical escarpment near the high water line, which is characteristic of eroding shorelines. This condition will continue to erode private property values, and there will likely be ongoing efforts to armor additional sections of shoreline to protect individual upland properties.

B. ALTERNATIVE ANALYSIS OF INDIVIDUAL PROBLEM AREAS.

1. General Policy on Alternatives.

Implementation of erosion control measures is primarily the responsibility of private property owners on Sanibel Island. The City of Sanibel will provide no direct financial assistance but may help affected property owners who approach the City with a specific proposal and a mechanism for funding. The City may provide professional engineering and environmental review of erosion problems and proposed solutions, assist in permit application preparation and coordination with regulatory agencies, aid in the establishment of taxing authority or application for funding from other sources, and relax setback and vegetation protection regulations for property owners who desire to relocate residential structures to an appropriate landward location.

The City of Sanibel has implemented a beach profile monitoring program to document shoreline changes. This information may be used for evaluating erosion problems when they occur, and in the design of erosion control measures in appropriate situations.

Erosion control measures to be permitted by the City of Sanibel are limited. In general, only the most environmentally compatible and least impactive on natural systems will be allowed. In the case of any erosion control measure that is approved, provisions must be made to insure against any potential adverse impacts.

Alternative erosion control measures are described in Section I-B, the Coastal Processes Section of this Beach Management Plan, with respect to the kinds of situations in which they may be successfully employed, their effectiveness, and potential adverse impacts to the littoral system or the environment. Because of the potential adverse impacts, groins, seawalls, revetments and jetties shall be generally prohibited on the Gulf shoreline. Those erosion control measures which may, under appropriate circumstances, be used on Sanibel Island are listed below.

1. Retreat.
2. Beach nourishment.
3. Sandbag revetments, constructed of sandbags weighing 200 lbs. or less as a temporary emergency measure.
4. Breakwaters.
5. Rock revetments for protection of public infrastructure only, with a beach maintained in front of any such structures.
6. On the bay side only, revetments which include planting of mangroves and buttonwoods among the rip-rap.
7. New technologies proven to be effective, and consistent with the overall philosophy for managing beaches, may be considered.

In the case of emergency structures, permit issuance should be contingent upon procurement of a performance bond of adequate amount to insure removal of the structure. In the case of debris from failed erosion control structures on the beach, City Code Enforcement staff should be directed to assess the problem and initiate enforcement action against responsible property owners. Where no responsibility can be determined, City funds may be used to clean up debris in the intertidal zone where public safety hazards exist. Where debris is the result of unpermitted projects, the responsible parties should be directed to clean up the debris, or City funds may be used for clean up with the responsible party reimbursing the City, or the City may place a lien on the private property.

Following is a discussion of alternatives for dealing with specific identified erosion problems on Sanibel Island.

2. Shoreline South of Blind Pass - Category I.

The Blind Pass Jetty was extended in 1988 as a terminal groin in conjunction with the Captiva Island Beach Nourishment Project. The City of Sanibel as well as engineers on the staff of the State Department of Environmental Protection (DEP, formerly DNR) expressed concern over the potential for the jetty extension to interrupt littoral sand transport and cause erosion on the downdrift beach on the north end of Sanibel Island. Because of these concerns, the permit issued by DEP for construction of the jetty extension included special permit conditions which would require the Captiva Erosion Prevention District (CEPD) to mitigate any adverse downdrift impacts. Pursuant to the permit condition, specific threshold erosion criteria were established by DNR, after the permit was issued, to determine if the jetty extension caused erosion that would require mitigation.

Based upon the criteria adopted by DEP, and monitoring surveys collected through October 1993, the jetty extension has significantly contributed to the erosion on the north end of Sanibel Island. The permit conditions stipulate that the CEPD shall be required, at the direction of Florida's Department of Environmental Protection (DEP), to mitigate that erosion by sand placement in the eroded areas, removal or modification of the jetty extension, or some combination of nourishment and structure modification.

Phase I of this Beach Management Plan, the Coastal Processes Section, contains an erosion analysis based upon the procedures established pursuant to the jetty extension permit condition. That analysis quantifies the impact that the jetty extension has had on the north end of Sanibel Island. Additional details of this analysis are contained in a work document, completed on behalf of the City of Sanibel titled "Blind Pass, Inlet Impacts on Adjacent Shoreline", prepared by Humiston & Moore Engineers, March, 1994, for a workshop with CEPD and DEP representatives. That document further quantifies those impacts as well as the beneficial effect the jetty extension has had on the stability of the shoreline on the south end of Captiva Island immediately north of the jetty.

The threshold erosion rates established pursuant to the DEP permit conditions that require mitigation on Sanibel have been exceeded. Implementation of the jetty extension permit conditions is therefore the most proper alternative for immediately addressing this erosion problem.

The original jetty was constructed in 1972, and has contributed to the erosion on the north end of Sanibel Island. The downdrift impact and updrift benefits of the original structure are also quantified in the 1994 report by Humiston & Moore Engineers. If the extended jetty is to be kept in place, the beneficiaries of the structure should be held responsible for the downdrift erosion.

Management Alternatives:

1. No Action. In this case the erosion has been induced by a man-made structure, and the "No Action" alternative is therefore not the same as allowing nature to take its course. This area has been consistently eroding since construction of the groin on the north side of the pass in 1972, and the erosion stress was intensified by extension of the groin as a jetty in 1988. If nothing is done to rectify this situation, high erosion rates may be expected to continue, threatening the road and the remaining homes south of the inlet.

2. Retreat. This would involve relocating the Sanibel-Captiva Road, as well as several homes, to a more landward location. Additionally, landward relocation of the road would impact additional residences, depending upon the position of the relocated road. The feasibility of relocating the road to several more easterly locations was considered in the "Sanibel-Captiva Roadway Study" by Jenkins & Charland Inc., in 1989, during planning for the Blind Pass bridge replacement. Due to opposition by residents of Sanibel Island and Captiva Island, road relocation was not pursued (personal communication, Paul Carroll, Jenkins & Charland, Inc.).

Under this alternative, erosion of the shoreline would be expected to continue. Maps locating the City Gulf Beach Zone limits should be revised to address changes in the Blind Pass area shoreline, to minimize potential for installation of hardened structures such as seawalls.

3. Implementation of the 1988 Captiva Island Beach Nourishment and Terminal Groin Extension permit condition.

a. Mitigation of past erosion with beach nourishment through placement of sand by the Captiva Erosion Prevention District, with an ongoing maintenance program to address ongoing impacts.

b. Modify the jetty by decreasing the length, in combination with mitigation of past erosion with beach nourishment through placement of sand by the Captiva Erosion Prevention District, with an ongoing maintenance program to address ongoing impacts.

c. Remove the jetty, in combination with mitigation of past erosion with beach nourishment through placement of sand by the Captiva Erosion Prevention District.

4. The CEPD is preparing an Inlet Management Plan for Blind Pass. The Inlet Management Plan is being prepared with funding assistance through the DEP Beaches and Coastal Ecosystems Management Program. If that plan adequately addresses downdrift inlet impacts, those impacts may be addressed through implementation of the Inlet Management Plan. This alternative is actually very similar to alternative (1) above, because the costs of plan implementation should be apportioned among the beneficiaries of the inlet improvements.

5. An additional option has been proposed by the DEP Beaches and Coastal Ecosystems Management section, consisting of an interim nourishment project along the north end of Sanibel Island. It is proposed that this would be funded under the State Beach Management Program. Funding for this interim project has been requested but has not yet been appropriated by the Florida Legislature. It has been proposed that the Captiva Erosion Prevention District would implement this alternative in conjunction with maintenance renourishment of Captiva Island. Shortening the jetty may also be included as part of this alternative in order to achieve greater cost effectiveness in terms of future mitigation requirements on the north end of Sanibel Island.

6. The CEPD is planning for renourishment of Captiva Island's beach. This proposed project includes placement of a "feeder beach" several thousand feet north of Blind Pass to address the erosion on the south side of the pass.

For as long as the groin on the Captiva side of Blind Pass remains in place, no placement of sand on Captiva Island should be permitted without concurrent placement of quantities of sand along the northwestern Gulf shoreline of Sanibel to mitigate the groin impacts.

In some circumstances, the use of a "feeder beach" is an accepted engineering practice to promote natural movement of sand from a nourished area into an adjacent downdrift eroding area, to reduce downdrift erosion. However, a "feeder beach" would be ineffective if placed on the updrift side of an inlet to address downdrift inlet impacts, since inefficient sand bypass of the inlet is causing the erosion. Furthermore this is contrary to the State's inlet management guidelines which require placement of sand on the downdrift side of an inlet to offset inlet impacts.

A "feeder beach" on Captiva Island will benefit the Captiva Island the area north of the Blind Pass Jetty, which is the area feeding sand to the growing ebb shoal. Survey data show that this is what happened to the sand that was placed in the proposed "feeder beach" area during the original Captiva nourishment project in 1989. Without efficient inlet bypassing, sand placement in this ares is unlikely to provide any benefit Sanibel island. Placing sand on Captiva and calling it a "feeder beach" for Sanibel is inappropriate and should in no way relieve the CEPD of it's responsibility to mitigate erosion caused by the Blind Pass Jetty.

Environmental issues related to sand placement along the north end of Sanibel Island include the possibility that beach nourishment could result in the closure of Blind Pass or the entrance to Clam Bayou. Mitigation of erosion caused by the jetty should therefore include a provision that these tidal channels be reopened if they close as a result of mitigative nourishment. <u>It is extremely important that these issues be resolved so that they do not interfere with placement of sand on the eroded beach.</u>

The manner in which these channels are reopened should improve the hydraulic efficiency of the tidal channel by design of a channel of the appropriate length, width, and depth. These dimensions must be designed to be consistent with the tidal prism because improving hydraulic efficiency will reduce the chances that the channels would close again.

Improving inlet efficiency may involve modifying the interior portions of these channels to the extent possible within environmental constraints. Biologically productive bay areas include grass beds such as those found inside Blind Pass, and bird feeding areas such as the shallow sandy areas near the entrance to Clam Bayou. These shallow sandy areas have been created by waves washing sand over the beach berm into Clam Bayou. Unfortunately, these sand deposits may also reduce the efficiency of the inlet and promote inlet closure. Environmental impacts of improving the tidal channels must therefore be carefully weighed against the environmental benefits of maintaining tidal circulation to the biologically productive bay areas, and where those impacts cannot be avoided environmental mitigation should be included as part of the plan so that there will be a net positive environmental result.

3. Shoreline South of Blind Pass - Category III.

Removal of damaged structures is recommended because their removal eliminates a potential liability to the owner, and restores the shoreline to a natural condition from the standpoint of littoral processes and wildlife habitat.

4. Gulf Pines, from R-129 to R-131 - Category II.

Temporary shore protection structures, in particular sandbag revetments, have been used in this area in the past. These temporary installations are the only structural alternative which is permitted under the City of Sanibel's Land Development Code. They are only allowed as a temporary measure, and practically, they only afford a limited amount of protection during relatively mild storm conditions.

Management Alternatives:

1. No Action. This will result in failure of residential structures when they are undermined by erosion, leading to the necessity of removing the derelict structures from the beach zone.

2. Retreat. Relocating the affected habitable structures landward, is the alternative preferred by the State of Florida's Department of Environmental Protection wherever sufficient land exists for such a relocation. This results in no adverse impacts to the littoral beach zone because it leaves the beach free to transform naturally in response to the forces of nature.

3. Beach Nourishment. Restoration of the eroded beach with sandy material similar to the native beach material, is the method of choice where relocation is not feasible. When done properly with beach compatible material, this also provides a natural beach from the standpoint of littoral processes, wildlife habitat and nesting area, and recreation. The feasibility and cost effectiveness of this alternative often depend upon the availability and proximity of a suitable source of beach compatible sand as well as the vulnerability of the upland structures.

Large nourishment projects are more successful than small projects. This is because some sand naturally moves from the ends of nourished area to adjacent unnourished areas, which is known as end losses. End losses may be large in comparison with the amount of sand placed in a small nourishment project. Nourishment of the beach in front of an individual property is therefore usually not feasible without some additional measures to reduce erosion stress. Those additional measures would consist of structural alternatives such as groins or breakwaters, which would not be cost effective for small nourishment projects on individual properties.

4. Sandbag revetments have been used as temporary limited shore protection under emergency conditions as provided for in the Land Development Code. The size of the sandbags is limited to a maximum weight of 200 pounds in order to insure that the installation is temporary.

5. Erosion control with offshore breakwaters is an option directed at addressing the cause of erosion. The breakwater alternative includes a wide range of configurations which are discussed in Section I.B.3. Although there are potential adverse downdrift impacts associated with breakwaters if they have too great an effect on wave induced transport, the problem area in this case is an isolated area of erosion updrift of an area that has historically been accreting. There is an opportunity in this situation to design a breakwater system that could potentially stabilize the eroding problem area without causing downdrift erosion.

In addition to being the only structural alternative that provides an essentially natural and stable beach as wildlife and sea turtle nesting habitat, there are environmental benefits associated with breakwaters. They also create a biologically productive area because they provide "hard bottom" under water and intertidal surfaces to which a variety of marine organisms may attach.

6. Groins are not recommended in this location because they interfere with littoral processes and result in downdrift erosion unless the downdrift effects are continuously mitigated with nourishment.

5. Gulf Pines - Category III.

1. No Action. Since structures in this area are not in imminent danger of being undermined by erosion, there would be no immediate effects from this alternative. However, if recent trends continue, this will eventually result in undermining and failure of residential structures due to erosion, and the necessity of removing the derelict structures from the beach zone.

2. Retreat. As discussed previously, relocating the affected habitable structures landward is the alternative preferred by the

State of Florida's Department of Environmental Protection wherever sufficient land exists for such a relocation. Relocation results in no adverse impacts to the littoral beach.
3. Nourishment. The erosion in these areas is not critical in terms of an immediate threat to upland development, and there is adequate time for planning, design, and implementation of a nourishment project as a long term solution.

4. Erosion Control Structures. Justification for this alternative is the same as the long term solution to problem area #3, and would be implemented either as a part of that project or perhaps as a second phase if monitoring determined that expansion of the project were necessary to provide additional shoreline stability. Shore protection structures are limited to sandbags, and erosion control structures to breakwaters, or other new technologies as developed and proven satisfactory.

6. Point Ybel - Category III.

1. No Action. Since structures in this area are not in imminent danger from erosion, there would be no immediate effects from this alternative. However, if recent trends continue, erosion will eventually result in impact to upland structures.

2. Retreat. Relocating the affected structures landward, is the alternative preferred by the State of Florida's Department of Environmental Protection wherever sufficient land exists for such a relocation. Since the structures are not in imminent danger of collapse, there is sufficient time to plan for and investigate the feasibility of retreat. As noted previously, retreat results in no adverse impacts to the littoral beach zone because it leaves the beach free to transform naturally in response to the forces of nature.

3. Beach Nourishment. Sand transport along the shoreline of Point Ybel and beyond results in accumulation of sand in the shoals in and around the entrance to San Carlos Bay. Surveys and aerial photographs in fact show extensive shoals in this area, containing potentially immense quantities of sand. The proximity of these shoals to Point Ybel are potentially a convenient and cost effective source of sand for beach nourishment.

4. Erosion Control Structures. Point Ybel is the southeastern most extremity of Sanibel Island, and as such is essentially the end of a littoral system. Alternative solutions that have high potential for downdrift impact may be considered technically appropriate under these circumstances, since there is no downdrift shoreline that would be impacted. However, the City of Sanibel does not

permit the use of groins, so the only structural alternative that could be considered here are breakwaters.

Prior to recommendation of the use of any erosion control structures, it would be necessary to determine if the natural processes in this area include transport of sand northward around the point and then westward to the bay beaches. Shoreline change history and the shoreline offset at the Lighthouse Point Condominium sheetpile groins indicate that this may be occurring either intermittently, or to some limited extent.

7. Bay Shoreline, City Property - Category III.

1. No Action. Recent gradual erosion should be expected to continue.

2. Beach nourishment. Available information indicates that erosion rates in these areas are relatively low. One reason for this is because there is less wave energy incident upon the bay shoreline than there is along the gulf shoreline. Areas such as this with low erosion rates are good candidates for beach nourishment because the restored beach has an excellent prognosis for stability and low maintenance costs. Beach nourishment is more successful for large projects than it is for small projects as described under Section VI.B.3.3 above, and design of a nourishment project for this area should therefore be considered an opportunity to look at the possibility of structural removal and nourishment on adjacent areas.

An environmental overview of sea grass beds and a mapping of environmentally sensitive areas would be necessary prior to design of the beach fill. No activities would be allowed that would adversely impact sea grass beds.

3. As noted above, beach nourishment of small projects is less successful than it is for large projects. In areas where extensive armoring exists and that armoring is adversely affecting unarmored shoreline between armored sections, it may be appropriate to "close the gap" in the armored shoreline. If this proves to be the most feasible alternative, in some cases the gap closure should be accomplished with a revetment designed so that mangroves may be planted among the revetment armor units as a form of environmental mitigation for the armoring.

8. Bay Shoreline, Private Property - Category III.

1. No Action. Gradual erosion should be expected to continue, with attempts by property owners to protect their shoreline with armoring.

2. Beach Nourishment. Justification for recommendation of this alternative is substantially the same as for problem area 6 above. Additionally, many sections of this shoreline are armored, and beach restoration along the armored areas not only would restore the beach where none presently exists, it would eliminate the structural interference with natural littoral processes.

Grass beds near potential nourishment sites would have to be evaluated and considered during design to eliminate potential for adverse impacts. If nourishment projects may not be accomplished without impact to grass beds, then the project will not be allowed.

3. Structure Removal. In many cases the eroding areas are adjacent to shore protection structures such as seawalls and revetments. These structures are beneficial to the upland properties they were intended to protect, but often transfer the erosion to adjacent unprotected properties. Furthermore, the protected properties themselves have an armored shoreline where there once was a beach, and the chances of any beach naturally recovering in these areas is remote.

Removal of the shore protection structures would reestablish the beach, but slope readjustment would result in sacrifice of upland area as the beach would be at a more landward position. In areas where this is unacceptable, which is often the case, structural removal may be done in conjunction with beach restoration. However, adequate beach nourishment may render structural removal unnecessary if the structures are adequately covered and the restored beach is maintained.

4. Additional Armoring. In some cases this may be an appropriate solution if it is determined that the erosion is the result of adverse impacts from man made structures on adjacent properties, however, this will only be allowed in closing a gap with riprap revetment in an otherwise continuously armored shoreline.

C. Natural Resources Management Strategies

1. Dune Restoration.

Sanibel Island does not have a prominent coastal barrier dune, and some geologists have stated that Sanibel has no dunes at all. The natural beaches do however have an area upland of the beach berm that is in many areas slightly elevated above the berm, and this area is vegetated with characteristic native dune vegetation. Through a comprehensive restoration program this upper beach zone may become more like a traditional dune system.

Dune enhancement may be accomplished by regulating activities that are detrimental to natural dune vegetation and sand accumulation, such as illegal landscape trimming of natural vegetation, unrestricted pedestrian access, and beach furniture and recreational equipment deployment and storage. These may be accomplished through more thorough enforcement of restrictions on trimming vegetation, improved pedestrian accessways, and better regulation of beach paraphernalia.

Beach access improvements may include elevated dune walkovers, walkways on grade, or designated paths defined with rope and bollards. The elevated dune walkover is the most effective because it protects vegetation and provides the opportunity to protect an elevated beach dune, which provides more storm protection and reduces salt water overwash onto upland areas and potentially into freshwater swale areas. Elevated walkovers are however more expensive, and must comply with building code requirements regarding hand rails.

Non-elevated walkways, or the least expensive alternative of rope and bollard defined paths, provide the same protection for the general dune area as do walkovers by routing human activity through a designated walkway. However, the walkway itself becomes a channel through the dune area which allows saltwater intrusion during elevated storm tides and high wave uprush.

Restoration may also be accomplished through replanting native dune vegetation where it has been destroyed or damaged. Broward County has used a dune replanting procedure that includes the use of compost material to promote rapid establishment of vegetation. This procedure should be evaluated to determine its value in dune enhancement for Sanibel Island.

Trampled out areas of the upper beach zone should be replanted with native salt tolerant vegetation on a minimum of six-foot centers where the cause of the destruction can be redirected or removed.

This upper beach zone restoration program needs to have a clear-cut foundation framed by the concise definition of this conservation zone, in Section III-8. This program should include mapping for identification of this upper beach dune zone, to work with property owners in promoting a better understanding of the limits of this zone, and to identify and prioritize problem areas for restoration. Maps should be updated at five year intervals to maintain an accurate database of current conditions.

The City should adopt an ordinance defining this as a preservation area. The restoration or enhancement of this area should begin at the east end of Sanibel Island in the lighthouse area, and progress toward the west.

2. Open Beach and Intertidal Areas.

New City ordinances are necessary to guide the regulatory control and management of beach paraphernalia and over-commercialization of the open beach. Commercialization includes, but is not limited to such activities as rental or use by paying guests of watercraft, beach chairs, and umbrellas. Raking and scraping of naturally occurring beach wrack, other than litter and the large accumulation of dead fish from such an occurrence as red tide, should be prohibited by ordinance to assist shorebirds and shell-seekers.

The prohibition on live-shelling should be widely advertised accompanied by an education program. Severe violations should be considered serious enough to cite and fine perpetrators.

The use of vehicles on the beach should continue to be regulated with approval only released for beneficial purposes such as turtle patrol and removal of Australian pines.

3. Exotic Species Policy.

As described in Section III-C, a variety of exotic species have invaded the beach dune area crowding out native species that support wildlife and promote dune growth. As a condition of development permits on beach front properties, Brazilian pepper and Melaleuca on these properties must be cleared. This requirement should be extended to Australian pines within the upper beach zone on Gulf front properties.

Australian pines are considered by some to be desirable as a shade tree or for aesthetic reasons. An active effort toward controlling this exotic species might include incentives such as an allowance for alternative shade in the form of providing alternative replacement vegetation such as cabbage palms which also provide shade and aesthetic benefits.

Lead trees, ear-leaf acacia, air potato and java plum should be added to the list in the Vegetation Standards to be required to be removed for the issuance of development permits along with Brazilian pepper, Melaleuca and Australian pines (in the upper beach zone). The current active battle to control Brazilian pepper on all parts of the Island should be continued full throttle.

4. Endangered Species Policy.

Physically maintaining a natural beach system free of exotic species will benefit several endangered species. Sea turtles will have adequate beach for nesting, and the dune area is habitat for the gopher tortoise. Additionally, migrating shorebirds and wading birds utilize the beaches and many spend the winter in this area.

Presently, the State of Florida Department of Environmental Protection conducts a Marine Turtle Impact Assessment during review of permit applications for construction activity seaward of the Coastal Construction Control Line. This assessment results in projects with lighting that conforms to standards which will not interfere with turtle nesting or hatchlings return to the sea, and may restrict project construction timing to be outside of the turtle nesting season if any construction activity would disrupt potential nesting areas. The City of Sanibel also has a Sea Turtle Protection Ordinance which addresses lighting and beach furniture issues. A comprehensive program including both State and local policies such as this would be more effective if adopted and enforced locally.

Several species of endangered shorebirds nest on beach areas, but the nesting pairs are often disturbed by recreational beach users or predatory wildlife, primarily cats and raccoons. Beach areas where nesting pairs are observed should be designated as off limits to recreational beach users, and the need for removal of predatory feral cats and raccoons should be evaluated.

5. Mitigation of Armored Shorelines.

Existing bayfront seawalls should have rip-rap revetments placed in front of them to reduce wave interaction with the flat vertical surface as long as such revetments do not interfere with sea grass beds and the seawall alignment is reasonable. Rip-rap also provides more submerged and intertidal hard surface for attachment by marine organisms. Such rip-rap areas as well as existing rip-rap revetments along the bay shoreline should be designed as "planters" to accommodate planting with mangrove and buttonwood.

6. Pollution Control.

Septic tanks and oil spills are the two highest potential sources of pollution for Sanibel Island. Septic tanks are a somewhat ubiquitous source that may gradually contaminate ground water and runoff into beach areas. The City of Sanibel is actively pursuing island-wide transfer from septic systems to central sewer treatment in order to reduce the potential for contamination of groundwater which may ultimately reach the beach. This conversion should be continued.

An oil spill, if one should occur, is a sudden impact of potentially disastrous proportions. The Lee County Emergency Management staff has plans for such an event. The City of Sanibel has coordinated with Lee County on this plan and provided input on issues of local concern. This plan needs to be evaluated for sufficiency in protecting sensitive mangrove and other wetland areas. The plan should include a provision for rapid deployment of oil booms at strategic locations such as Blind Pass, Clam Pass, and the entrance of Tarpon Bay. The ability to rapidly seal off these strategic locations could help to contain the spill and prevent contamination of large sections of shoreline, and equipment for this should therefore be available locally. Additionally, any perceived changes in potential for oil spills, either from offshore or inland waterway operations, should trigger a review of the Emergency Management Plan by the Lee County and City of Sanibel staff.

7. Tidal Pass Shoals.

Shoals at tidal passes are sometimes designated as sources of sand for beach restoration. There are potential impacts associated with this. Ebb shoals are part of the littoral transport system, and dredging sand from those shoals may interrupt natural sand bypass of the inlet, which would lead to downdrift erosion. Flood shoals may be populated by sea grasses or other biologically productive features. Because of the potential for such adverse impacts, dredging of shoals in the vicinity of Blind Pass and Clam Bayou Pass should be prohibited.

D. Land Use Alternative Solutions.

1. Regulatory Controls.

Zoning districts, including the Blind Pass Zone and the Gulf Beach Zone, as defined in the Comprehensive Land Use Plan should be revised to reflect current conditions that have resulted from recent erosion.

2. Regulatory Controls, Structures.

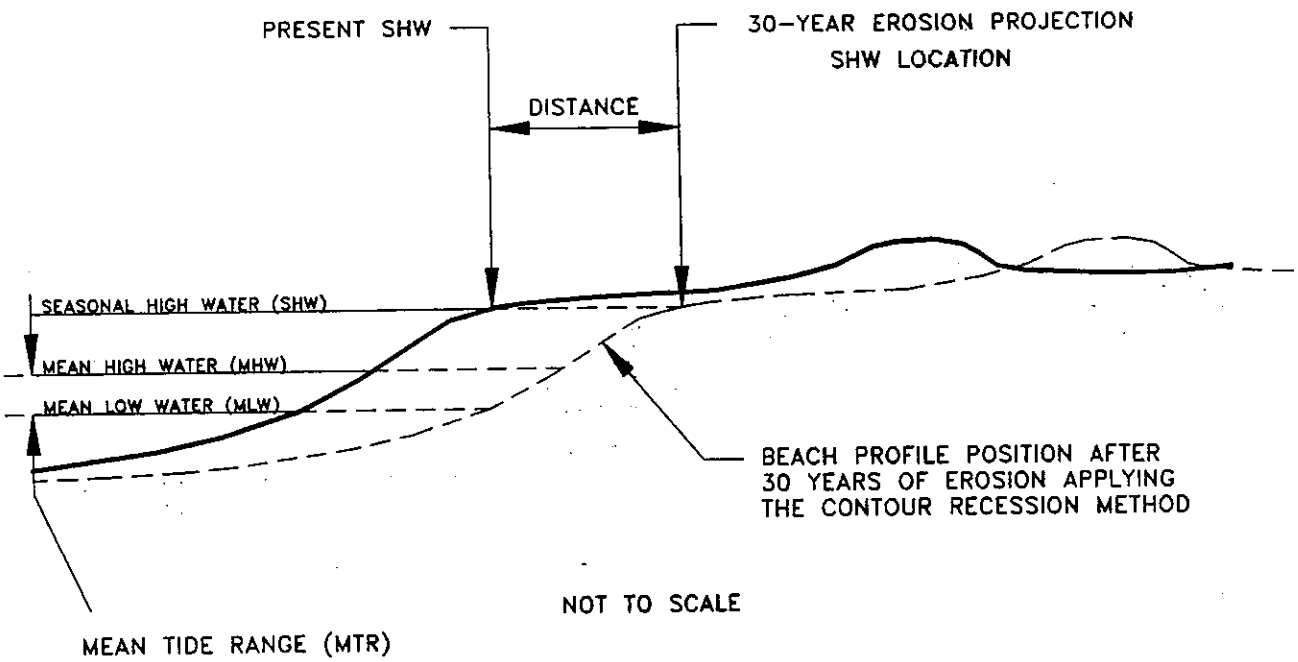
Requests for coastal armoring originate from erosion conditions relative to the siting of upland structures and the design adequacy of those structures. This section will focus on structural design elements with regard to coastal construction. Design considerations for coastal construction involve appropriate siting of structures and design adequacy to withstand the impacts of specific return interval storm events. In all cases, the siting of the coastal construction should consider past, current, and projected erosion trends. This should be applied to both original construction and redevelopment of residential structures, swimming pools, and roads. The alignment of existing adjacent construction may be considered, yet should not be the sole determining factor in where a structure should be sited.

One element of the State DEP's review with regard to siting is to require new structures to be located upland of the thirty-year erosion projection. This mandatory setback is the projected location of the seasonal high water line thirty years from the date of the permit application. Seasonal high water, as defined by Section 161.053, Florida Statutes, is the elevation of mean high water plus 150 percent of the mean tidal range. Seasonal high water and the 30-year erosion projection are illustrated in Figure VI-2. Other siting issues account for line of construction, upland site use, and dune and vegetation impacts.

Dependent upon the siting of a structure, the design should take into account the anticipated storm conditions that may reasonably be encountered during the life of the structure. For coastal development, the State of Florida DEP requires structures to be designed to withstand the impacts associated with a storm event having a return interval of 100 years. A 100-year return interval means that would be a storm event which would have a one percent (1%) chance of occurrence in any given year. Storm hydrographs which provide the water elevation associated with such a storm surge for the Gulf front areas of Sanibel's coastline are included in Section III.1.2 of the Coastal Processes Phase of this Beach Management Plan. These hydrographs may be used as guidelines in structural design and for evaluating permit applications.

SHW=(MHW) + (1.5 X MTR)

DISTANCE = (30 YEARS) X (LONG TERM EROSION RATE)



RANGE OF VALUES FOR SANIBEL ISLAND (MHW AND MLW RE: NGVD DATUM)			
LOCATION	MHW	MLW	MTR
R-109	+1.26	-0.46	1.72
R-174	+1.33	-0.48	1.81

FIGURE VI-2

30-YEAR EROSION PROJECTION

HUMISTON & MOORE ENGINEERS
SANIBEL BEACH MANAGEMENT PLAN
JANUARY, 1995

The DEP structural criteria include a pile supported foundation which would continue to support the structure even if undermining by erosion occurred, and a finished floor elevation above the maximum wave height on top of the storm surge specified by the storm hydrograph. The state DEP considers structures that are built to these standards as not in jeopardy of failure when erosion reaches the foundation, and therefore coastal armoring for the protection of such a structure foundation is not necessary. This avoids the need for emergency measures involving armoring for shore protection and allows for evaluation of other alternatives more suitable for long term erosion control.

3. Littoral Budget Protection.

As described in the Coastal Processes Section of this report, the stability of the coastline is directly related to the littoral sand budget. This is why structures in the littoral zone, including shore protection and erosion control structures, may have an effect upon shoreline stability in adjacent areas.

Littoral transport is a continuous process along the coast, and the sand budget on Sanibel Island is therefore effected by changes that may occur in adjacent areas, including Blind Pass and Captiva Island to the north as well as shoals near the entrance to San Carlos Bay to the southeast. Activities that can effect the littoral budget in either of these areas, or locally within the offshore reaches of Sanibel Island, must be considered and analyzed for their potential shoreline impacts.

Activities which have a high potential for effecting the sand budget include shoreline armoring with seawalls or revetments, groins, the jetty at Blind Pass, breakwaters, and the use of nearshore shoals as a source of sand for beach nourishment. Detailed coastal engineering impact analyses should be performed for any such proposed activity. As described in this Beach Management Plan, these alternatives are prohibited or severely restricted on Sanibel Island.

In the case of structures such as groins or the jetty at Blind Pass, the analysis should include not only the sand budget in terms of total longshore transport, but also the spatial distribution of that transport. This is necessary in evaluating potential impacts because sand which bypasses these structures typically does so further offshore in deeper water where it will accumulate in shoals instead of continuing transport to the downdrift beaches. These shoal changes will further disrupt the littoral transport processes by modifying incoming wave energy through refraction, diffraction, and shoaling, which may alter sand transport potential some distance from the structure.

The same is true for dredging activity within shoal areas. Removal of sand for beach restoration or other uses may potentially effect the littoral budget in two ways. One is that borrowing sand from the shoal area results in an excavation which will in time naturally re-fill with sand from the littoral system. This re-filling process will remove material from the littoral budget and can have localized impacts on the coastline. Second, the change in bathymetry that results from dredging the shoal will affect the wave refraction patterns and the resulting angle of wave approach to the coastline. This, in turn, will affect the littoral transport processes along that section of the shoreline.

The ebb tidal shoals to Blind Pass and the entrance to San Carlos Bay are very important features in the stability of the adjacent coastlines. Blind Pass is a relatively small inlet with a relatively small ebb shoal which should not be considered as a source for beach nourishment. Prior to any removal or alteration of material from the shoals around the entrance to San Carlos Bay, a detailed comprehensive coastal engineering analysis should be performed to ensure that the shoreline would not be effected, and that sand sources are not depleted if there are future anticipated needs for sand from that source.

All such projects require permits from the State of Florida. It should be the policy of the City of Sanibel to provide official input to the State during the permit application review process to insure that the permit includes conditions for adequate monitoring and mitigation. In Cases where the proposed project is found to be unacceptable to the City, and in conflict with the goals and objectives of this Beach Management Plan, the City shall provide the State with justification for denial of such permit application.

The Sanibel Island littoral budget may be enhanced in the future through beach restoration. One of the areas identified in the Coastal Processes Section of this Beach Management Plan as a potential sand source is west of the northwest side of the Island. This area has recently been proposed as the sand source for the renourishment of Captiva Island. Because the cost effectiveness of a beach restoration project is directly related to the accessibility of a suitable sand source, the use of this source by Captiva should be a concern to Sanibel. There are a growing number of conflicts between local governments for offshore sand rights occurring along the southwest coast of Florida, and DEP has become sensitive to this issue. Sanibel should move to protect any rights to this offshore sand source in order to maintain cost effective options for restoration of Sanibel's beaches in the future and minimize the likelihood that any such activities would have an adverse impact on Sanibel Island's littoral system.

4. Lateral Beach Access.

A wide beach will normally provide an opportunity for unobstructed pedestrian traffic to enjoy the recreational use of the beach along the coastline. Once structures are encountered along the beach, the structures may present obstructions and restrictions to normal pedestrian traffic along the coastline. In cases where structures are considered to impede or have the potential to impede pedestrian traffic along the coastline, such structures should be prohibited, or if existing altered or removed, so as to maintain lateral access along the shoreline.

E. FINANCIAL STRATEGIES.

1. Funding Options.

There are various sources of funds available for beach management purposes, depending on the nature of the project, and many projects are accomplished with funds from two or more sources. For example, most federal projects have a local cost sharing requirement, and the State of Florida will often pay a portion of the local share on such federal projects. The following is a listing of some potential sources of funding.

The State of Florida. Chapter 161.091, Florida Statutes, establishes a Beach Management Trust Fund. Under Chapter 161.101, the Florida Department of Environmental Protection is authorized to fund up to 75% of the cost of projects, with the actual level of funding dependent upon the level of public benefit.

The level of funding for beach restoration projects is dependent upon the level of public recreation benefits. Public access areas with public parking will make a beach nourishment project eligible for some level of state funding. The actual level of funding is dependent upon how much of that total project area is accessible by the public.

Chapter 161.161 directs the Department of Environmental Protection to prepare an inlet management plan for each improved coastal beach inlet as part of the State beach management program. This is because beach erosion is often related to inlets and the improvements at inlets. Blind Pass is considered to be an improved inlet because a jetty has been constructed on the north side for the purpose of controlling erosion on the south end of Captiva Island, and the Department is therefore authorized to pay up to 75% of the preparation of an inlet management plan. Such a plan is currently being prepared by the Captiva Erosion Prevention District under contract with the State of Florida, and Lee County is contributing to the local share of the costs.

The availability of funding is subject to legislative appropriation. The contact for this funding is the DEP Beaches and Coastal Ecosystems Management Section. The deadline for submitting applications for funding is May 1 in order to be eligible for funding in the next fiscal year; applications submitted by May 1, 1996 would be eligible for funding in July 1997. There is a pre-application review process which must be completed by submitting a form describing the project to DEP by December 31.

The Department of Community Affairs (DCA) has a Coastal Action Plan under which grant money is available to implement the goals of that plan. Those goals include a variety of issues, including comprehensive plans, economic studies, beach access, and natural resource inventory and preservation. The deadline for grant applications is December 1, and further information may be obtained by calling DCA at 904-922-5438.

Federal Government. To receive federal funding, the project must be authorized as a federal project. The process is initiated by a formal request through a Federal Legislative Representative. The entire process, from the initial request through construction takes eight to ten years.

Lee County. A portion of the Tourist Development Tax money collected by Lee County helps to fund the Lee County Capital Projects Program.

Within this program the County has established a Beach Nourishment Trust Fund which can be used as "seed money" for permitting and design of erosion control projects. The County currently appropriates $100,000 per fiscal year for this purpose. The local sponsor of an erosion control project may apply to the County Commission for this assistance. Money used from the seed fund must eventually be reimbursed from the State or local sponsor.

The Lee County Capital Projects Program also uses Tourist Development Tax money for a variety of other beach issues which are described under Section 125.0104, Florida Statutes. Among those authorized uses are beach improvement, maintenance, renourishment restoration, and erosion control. Table VI-1 lists funds that have been approved for Sanibel projects.

Table VI-1

Lee County Tourist Development Tax
Sanibel Island Beach Funds For FY 95-99
(Thousands of Dollars)

Project	FY95	FY96	FY97	FY98	FY99	TOTAL
Beach Maintenance	122	122	122	122	122	610
Envir. Rest. Equip.	35	0	0	0	0	35
Beach monitoring	25	0	0	0	0	25
Dune Planting	15	0	0	0	0	15
Pier Renovations	51	0	0	0	0	51
Exotic Removal Equip.	10	0	0	0	0	10
Totals	258	122	122	122	122	746

There is an additional $511,000 included in the FY95 budget and $117,000 in the FY96 budget for the Bowman's Beach Master Plan and Development.

At the time of preparation of this plan, Lee County is considering adding a third cent to the Tourist Development Tax for the collection of local funds specifically for beach and erosion control projects. The final decision for appropriation of such funds, if they become available, would rest with the Lee County Tourist Development Council and the Lee County Board of Commissioners.

Local Funding. Local funds may be appropriated from the General Fund, raised with a Special Assessment, or through the formation of a special taxing district. There are two types of special districts: dependent and independent.

A dependent district would be formed by city or county ordinance, and the district board could either be appointed by, or be the same as, the governing body which created the district. If funds are collected through ad valorem taxes, the total millage assessed, including all other taxes, cannot exceed the cap on the county millage rate. This restriction does not apply if funds are collected by special assessment.

An independent district would not be controlled by the city or county government. An independent district must be formed by a State of Florida Legislative act. This alternative is available to form a special district which includes portions of more than one governmental jurisdictional area, or to groups or organizations other than county or municipal governments who may wish to form a special district. This process is initiated through a local State Legislative delegation which would prepare a bill which must pass through various committees and then be approved by the Florida Legislature. Once such a special district is formed, it is governed by an elected board, and may levy special assessments or ad valorem taxes not subject to the county millage rate cap.

2. Alternatives Cost Analysis, Beaches.

The alternatives listed below are conceptual and design details are not available for cost estimation purposes. The estimates provided here are therefore based upon a hypothetical erosion control-shore protection project one mile long, strictly for the purpose of making a general comparison of relative costs between alternatives. It is important to understand that the alternatives listed normally do not serve the same specific purposes as described below, and their evaluation for a specific erosion situation would therefore depend upon design applicability as well as cost.

1. No Action. The hypothetical situation being evaluated here is for the purpose of comparing the cost of implementation of various erosion control alternatives. The 'No Action' alternative is not

an erosion control method, and as such has no implementation costs. However, dependent upon the value of the eroding land, and the value of upland development damaged by the erosion, the cost of the damage caused by erosion may range from very low to many times the cost of erosion control measures. In the case of upland which is developed, this alternative may result in collapsed structures in the beach zone which are undesirable environmentally and may also result in adverse downdrift impacts.

2. Retreat. This alternative is desirable from the standpoint that it allows the natural processes to proceed without interference; it results in a natural beach, and there are no downdrift impacts.

3. Nourishment. Nourishment is the most widely accepted method for erosion control because it restores the beach to a pre-eroded state with respect to wildlife habitat, recreation, and storm protection. However, this alternative depends upon the availability of a suitable source of sand similar to the native beach material, for nourishment as well as future renourishment for maintenance purposes unless the project includes measures to reduce erosion stress.

The cost for this method is based on the assumption that a dry beach 150 feet wide will be created in an area requiring 0.5 cubic yards per square foot of beach. This would require 396,000 cubic yards of sand. Based on prices of beach nourishment projects completed in the last four years, the unit cost could be expected to range from approximately $3.00 to $6.00 per cubic yard. Total project cost would range from $1.2 million to $2.4 million.

4. Breakwaters. Offshore breakwaters stabilize the beach immediately landward of the structure by reducing sand transport across an eroding section of shoreline by reducing incoming wave energy. Because of this, breakwaters may have potential for downdrift erosion and must be designed carefully considering the local sand budget. A properly sited and designed breakwater is cost effective because maintenance costs are low.

Breakwaters are more desirable than other structural solutions because they stabilize the natural beach without obstructing use of the beach as wildlife habitat or for recreation. They also create a biologically productive nearshore "hardbottom" area because the submerged portions provide hard surfaces to which a variety of marine organisms may attach.

There are several variables involved in the design of breakwaters that significantly affect the size, and therefore cost, of the structure. Those having the greatest affect on the cost are the slope of the beach profile and the distance of the breakwaters from shore. Assuming that the project would consist of a segmented breakwater with 14 segments 150 feet long and spaced 150 feet apart, placed in water depths of 6 feet to 8 feet, with a crest elevation of +2.0 feet NGVD, the project would require between 23,000 and 34,000 tons of rock. Further assuming a unit cost of $80.00 per ton (offshore placement is more expensive than the cost of building a revetment from land), the total cost would range from approximately $1.8 million to $2.8 million.

5. Groins. Groins stabilize the beach on the updrift side of the structure by trapping sand but often cause downdrift erosion. There use is more appropriately limited to situations at the downdrift end of a littoral system, or in conjunction with nourishment to reduce downdrift impacts.

This estimate is based a project that would consist of 22 groins each 100 feet long and spaced 250 feet apart, with a crest elevation of +2.0 and a base elevation of -5.0. This would require approximately 19,000 tons of rock. At a unit cost of 60.00 per ton, this project would cost approximately $1.1 million.

6. Revetment. Revetments are normally not the preferred solution to erosion problems on the open coast of the Gulf of Mexico because they may result in downdrift impacts to adjacent beaches, and they do not provide a beach for wildlife habitat or recreation. They may however be the most appropriate solution in a situation such as where an emergency evacuation route is threatened by erosion.

The cost for this assumes conditions requiring the revetment crest at elevation +6 and the toe at elevation -4 with a slope of 1:2. The revetment thickness would be 3 feet with a 1 foot layer of bedding stone, and the revetment toe and crest aprons would each be 10 feet wide. This revetment would require approximately 35,600 tons of armor stone and 11,800 tons of bedding stone, and at a cost of $50.00 per ton and $60.00 per ton respectively, the total cost of this structure including filter material would be approximately $2.6 million.

The estimated costs are summarized below in Table VI-2. It should be noted that this is a general comparison of the relative magnitude of the costs of these alternatives. It is unlikely that all four of these alternatives would be appropriate for any one project, and this comparison is therefore of limited value with respect to any specific situation.

It should also be noted that there are a wide variety of concepts for breakwaters and groins. Breakwaters may be continuous or segmented, submerged or emergent, and there are a number of experimental modular varieties being tested. The cost effectiveness of various alternatives may vary considerably. The function of a groin is highly dependent on its length and they may also be permeable in which case they function more like a shore connected breakwater.

Table VI-2

Alternative General Erosion Control Cost Comparisons

Alternative	Cost in millions	Down-drift Impacts	Environ-mental Benefits	Environ-mental Impacts	Maint-enance Cost
Do Nothing	*	high	none	high	*
Retreat	**	none	high	low	none
Nourishment	1.2 - 2.0	benefit	high	low	moderate
Breakwater	1.8 - 2.8	low	high	low	low
Groin field	1.1	high	low	high	high
Revetment	2.6	high	none	high	high

* Cost of damage to upland properties is highly variable because it is dependent upon the characteristics of the upland development.
** Cost of moving or rebuilding structures in a more landward location is dependent the type of structures.

3. Alternatives Cost Analysis, Natural Resources.

3.1 Land Acquisition

The purchase of Silver Key by the City in 1992 marked probably the last major Gulf front acquisition possible for the City with the exception of perhaps Bowman's Beach (if Lee County someday divests itself of this park). Land use values up to a half million dollars for a quarter acre Gulf front lot (West Gulf Drive) make significant new purchases unrealistic under any foreseeable acquisition funding program. Lots experiencing severe erosion may be closer to the $50 - $100,000 range (Blind Pass) for similar-sized properties which may make it feasible to purchase small at risk areas over time. The privately owned out parcel at Bowman's Beach, while not Gulf front, is environmentally significant and important to the integrity of this beach park and, if feasible, it should be purchased for preservation.

Some State and Federal grant mechanisms do exist for public acquisition (for example, the State of Florida Communities Trust Program was used to fund approximately 40% of the Silver Key purchase), but often the City is at a competitive disadvantage for these funds because of the extraordinary waterfront land values on Sanibel.

3.2 Upper Beach Zone (Dune System) Restoration.

Depending on the condition of the dune area, the amount of public use and the need for specific additions such as walkovers and sand placement, the cost of restoring a diminished dune system varies widely. Many commonly occurring dune plant species can be purchased as "liners" or in "flats" with individual plants costing only $.25 - $1.50 each. Installing these smaller plants on 6' centers and providing adequate irrigation can result in fairly large areas of completely replanted dune costing less than $10,000/acre. Rope and bollard systems utilizing 4" x 4" pressure-treated wood or recycled plastic and polypropylene line can be completed on most sites for under $500. Walkovers are expensive, generally costing between $5,000 - $14,000 each depending upon dimensions and design. In the long term, however, these are certainly more desirable than the rope and bollard method which can still result in worn and compacted paths. Australian pine removal costs vary with tree size and ease of access but can easily end up at $200 - $500/tree. A program to assist homeowners in this cost by providing replacement vegetation should be considered.

3.3 Water Quality Testing.

The City currently has a quarterly water quality testing program which utilizes volunteers to carefully collect samples to be analyzed by the Lee County lab and the State's Lakewatch Program. This is a project heavily subsidized by the State, and due to the use of volunteers trained by Lakewatch, the City is able to continue this project for about $5,000/year. The cost of contracting this entire program out to a commercial lab would increase costs by at least a factor of 5.

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