4946K

LEE COUNTY COASTAL STUDY
****

A REPORT TO THE
LEE COUNTY, FLORIDA
DEPARTMENT OF COMMUNITY DEVELOPMENT

FROM

GODSCHALK AND ASSOCIATES, CONSULTANTS:
DAVID R. GODSCHALK, CHAPEL HILL, NC
KEVIN L. ERWIN, FORT MYERS, FL
ALBERT C. HINE, ST. PETERSBURG, FL
RICHARD B. MORGAN, TALLAHASSEE, FL
JAMES C. NICHOLAS, GAINESVILLE, FL

VOLUME I. FINDINGS AND RECOMMENDATIONS

FEBRUARY, 1988

LEE COUNTY COASTAL STUDY
****

A REPORT TO THE
LEE COUNTY, FLORIDA
DEPARTMENT OF COMMUNITY DEVELOPMENT

FROM

GODSCHALK AND ASSOCIATES, CONSULTANTS:
DAVID R. GODSCHALK, CHAPEL HILL, NC
KEVIN L. ERWIN, FORT MYERS, FL
ALBERT C. HINE, ST. PETERSBURG, FL
RICHARD B. MORGAN, TALLAHASSEE, FL
JAMES C. NICHOLAS, GAINESVILLE, FL

VOLUME I. FINDINGS AND RECOMMENDATIONS

FEBRUARY, 1988

LEE COUNTY COASTAL STUDY
****

VOLUME I: FINDINGS AND RECOMMENDATIONS

CONTENTS

LIST OF FIGURES

I. INTRODUCTION

Purpose

The purpose of this Coastal Study is to provide information and assistance to Lee County for amending the Coastal Management Element of their Comprehensive Plan. The study is designed to meet the requirements of the 1985 Local Government Comprehensive Planning and Land Development Regulation Act and the 1986 Department of Community Affairs Minimum Criteria for Review of Local Government Comprehensive Plans and Determination of Compliance (Rule 9J-5.012 Coastal Management).

Methodology

This study was conducted by a consultant team in collaboration with the Lee County planning staff. It involved both collection of new data and compilation of existing data.

Primary consultants and their responsibilities were:

-David R. Godschalk, study design and management, preparation of overall summary report and of sections on land use, hurricane evacuation and hazard mitigation, and intergovernmental relations.

-Kevin L. Erwin, study design, preparation of natural resource inventory and analysis.

-Albert C. Hine, preparation of beach and dune system analysis.

-Richard B. Morgan, preparation of estuarine pollution analysis.

-James C. Nicholas, preparation of economic base analysis.

In addition, William Drummond had responsibility for the design and implementation of the computerized land use inventory, and James Holway assisted in the preparation of this summary report.

Among the Lee County staff who worked on the study were:

Planning Division:

-Rob Magee

-Bill Spikowski

-Juddson Dewar

-Ray Judah

-Louetta DeGroot

-Deborah Brooker-Marzella

Emergency Management Division:

-John D. Wilson.

COASTAL STUDY AREA

Definition:

The Coastal Study Area is defined as all sections of unincorporated Lee County containing any portion of the A Zone (the 100 year floodplain as mapped by FEMA), lying westward (toward the Gulf) of the municipal boundaries of Fort Myers and Cape Coral. Municipalities (Fort Myers, Cape Coral, and Sanibel) are not included in the Coastal Study Area. The Coastal Study area is shown in Figure I-1. It includes 273 sections, as listed in Table I-1.

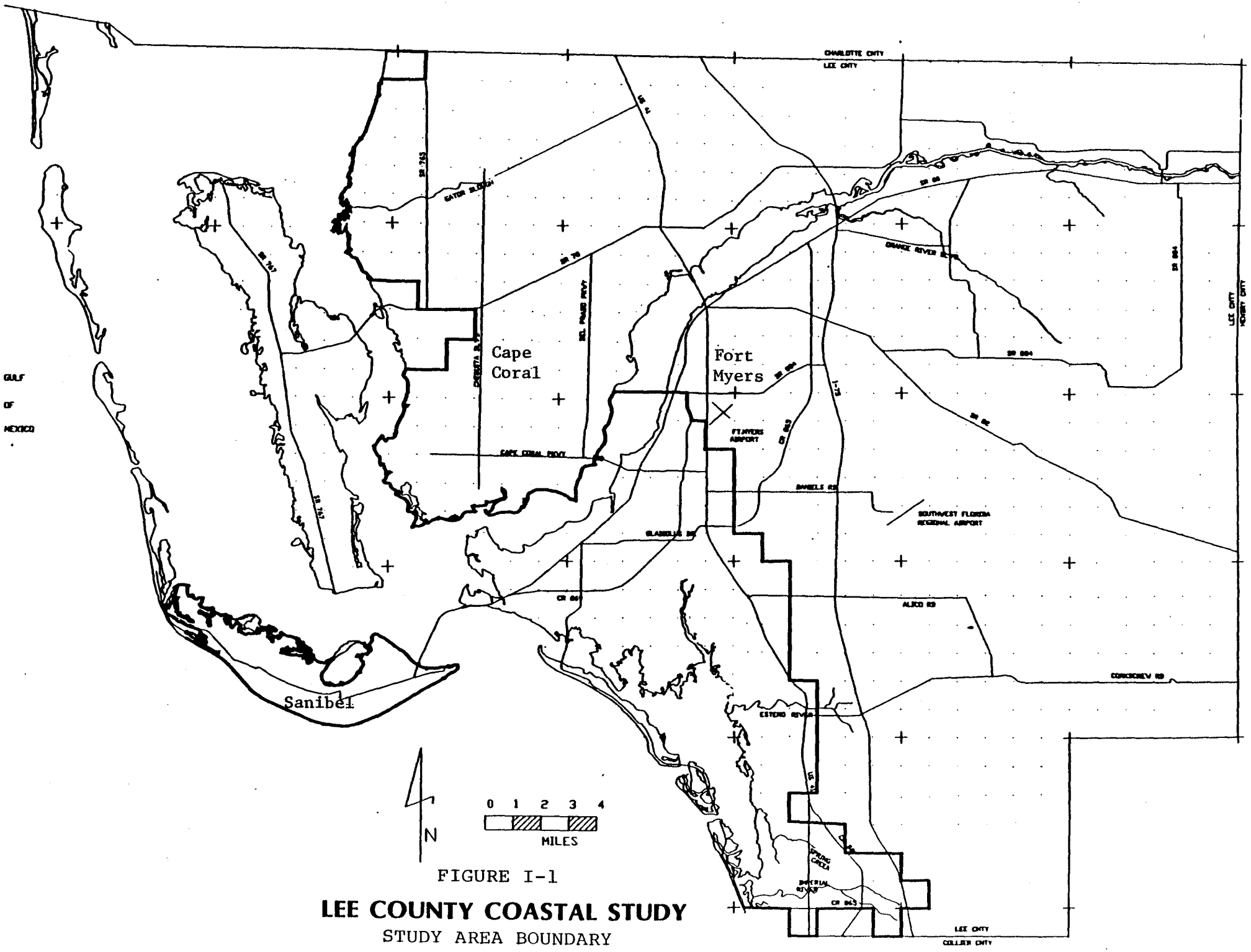


FIGURE I-1

LEE COUNTY COASTAL STUDY

STUDY AREA BOUNDARY

The Coastal Study Area includes all of the following Lee County Planning Districts:

10. Fort Myers & Bonita Beach
11. Iona McGregor
12. Pine Island
14. Captiva
15. Boca Grande.

It includes small parts of the western sections of the following Planning Districts:

1. Fort Myers
2. South Fort Myers
3. Cape Coral
7. East Fort Myers
8. Bonita Springs
9. San Carlos Park.

The Planning Districts are shown on Figure I-2.

Size:

Based on planimetering by the Lee Planning Division, the Coastal Study Area contains approximately 104,593 acres or 163 square miles of land. This is about 20% of the total land area of Lee County (including municipalities), which is approximately 527,116 acres or 824 square miles.

PROJECTED COASTAL AREA GROWTH

Two growth measures are relevant for the coastal study:

- Dwelling Units--number of individual housing units located within the Study Area.
- Population--number of people, permanent residents and seasonal visitors, residing within the Study Area.

These measures are calculated for the present and for two future time periods:

- Buildout--the theoretical future time when the development capacity of the Lee Plan has been completely used up by new growth.
- 2010--the Census year ending the present 20 year planning cycle, which is the horizon year for the revised plan.

Dwelling Unit Growth:

Based on Lee Planning Division land use inventories in 1981 and 1986 and on analysis of the units allowed by the Lee Plan on vacant or undeveloped land, the Coastal Study Area has a potential buildout under the present Lee Plan of 161,109 dwelling units, which is 30% of the total unincorporated County potential buildout. This would be a Coastal Area increase of 99,384 dwelling units (161%) over the 1986 inventory total of 61,410 dwelling units.

BUILDOUT DWELLING UNITS

	Coastal Area		Unincorporated County	
1981 existing	45,068	(53%)	85,118	(100%)
Potential	116,041	(25%)	457,333	(100%)
Buildout	161,109	(30%)	542,451	(100%)

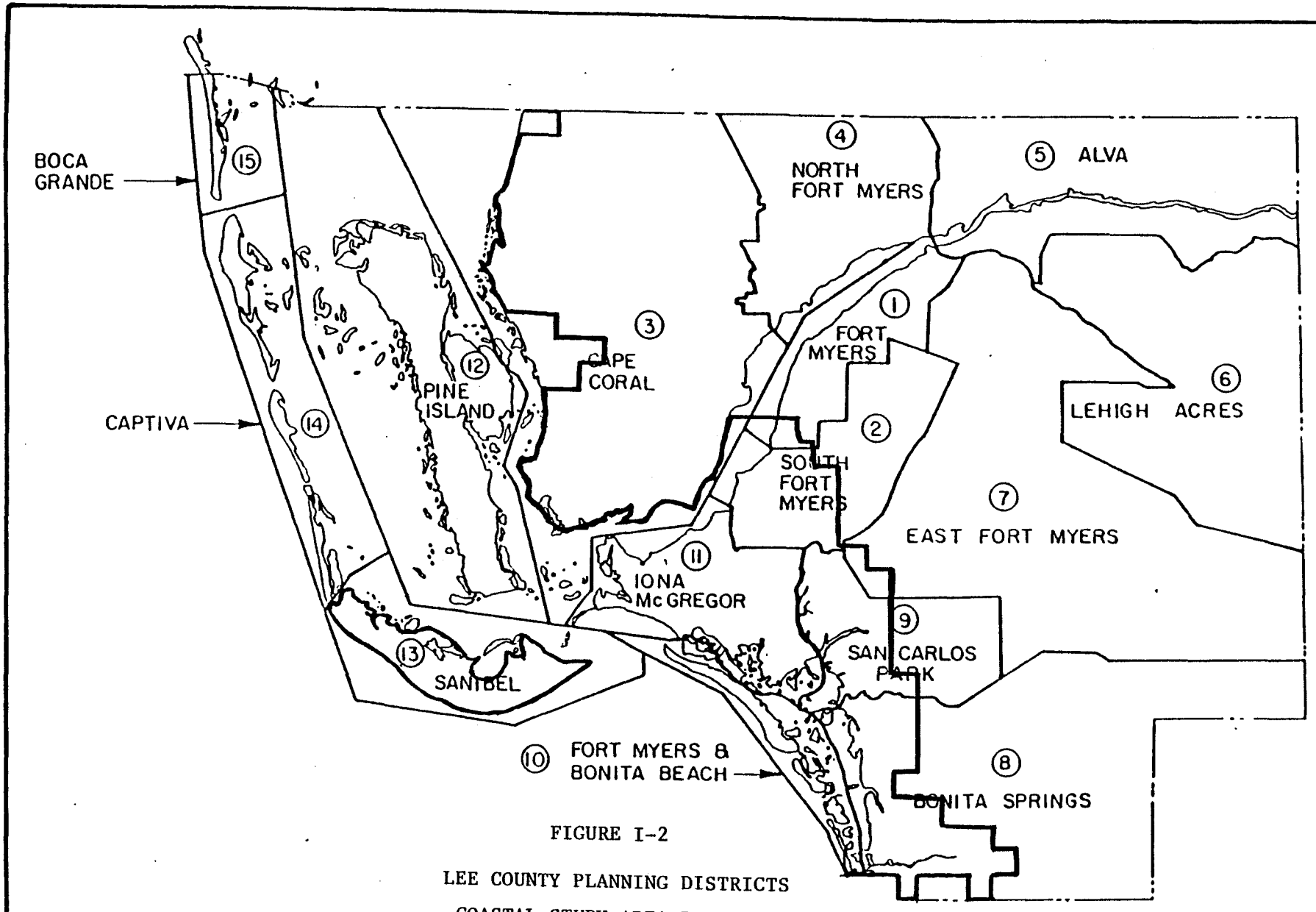


FIGURE I-2

LEE COUNTY PLANNING DISTRICTS

COASTAL STUDY AREA BOUNDARY

Dwelling unit projections for the year 2010 were derived from applying estimated growth rates to existing dwelling units in each planning district. Two estimates were made by the staff, one based on applying the 1981-1986 growth rate and one based on an adjusted growth rate that accounts for expected changes in certain planning districts (Iona-McGregor, Pine Island, and South Fort Myers). The resulting range is 118,342 to 126,404, an increase over 1986 of between 56,932 and 64,994 dwellings (93% to 106%). Taking an average of the two growth rates gives an estimated 2010 Coastal Study Area dwelling unit total of 122,373, which is an increase of 60,963 over 1986.

2010 COASTAL AREA DWELLING UNITS

Total	122,373	
Increase over 1986	60,963	(99%)

For a breakdown of existing and projected coastal study area dwelling units by planning district, see Table I-2.

Population Growth:

At buildout, the Coastal Study Area could contain an average permanent population of 328,662, equal to 30% of the unincorporated County population of 1,106,599. (This estimate is based on planning staff analysis of dwelling units and a countywide ratio of 2.04 persons per dwelling unit.) When seasonal population (based on hotel and motel occupancy) is added, the peak population for the Coastal Study Area at buildout is estimated at 357,831. (See Chapter II for discussion of population projections.)

COASTAL AREA BUILDOUT POPULATION

Permanent	Peak
328,662	357,831

For the year 2010 population estimate, the average 2.04 persons per dwelling was applied to the average of the constant and adjusted rate 2010 dwelling unit projections. This results in an estimated Coastal Study Area population of 249,641 in the year 2010. Adding the seasonal population results in a peak 2010 population of 271,298 persons.

COASTAL AREA 2010 POPULATION

Permanent	Peak
249,641	271,298

SUMMARY OF PROJECTED COASTAL AREA GROWTH

Dwellings	1981	1986	2010	Buildout
	45,068	61,410	122,373	161,109

Population	2010		Buildout	
	Permanent	Peak	Permanent	Peak
	249,641	271,298	328,662	357,831

REPORT ORGANIZATION AND COVERAGE

This report (Volume I) is a summary of Findings and Recommendations from a number of other, more detailed studies. Each section of this report describes existing conditions and problems, impacts of projected future growth, and recommended goals, objectives, and policies.

Following this Introduction, this report covers the following aspects of the coastal study area:

- -Economics
- -Land Use and Growth Management
- -Ecological Inventory and Analysis
- -Estuarine Water Quality
- -Beach and Dune Systems
- -Hurricane Evacuation and Hazard Mitigation
- -Intergovernmental Relations

Certain aspects of the required Coastal Management element for the 1988 Lee Plan Amendments are covered under other related Plan elements. These include:

-Water-dependent and water-related uses are covered in the Port element.

-Impacts of development and redevelopment on historic resources and sites, along with policies and techniques for protection of historic resources in the coastal area, are covered in the Historic Preservation element.

-Public access facilities and needs are covered in the Recreation and Open Space element, except for marinas and maps of water-dependent uses which are covered in the Port element.

-Sanitary sewer, potable water, and drainage facilities are covered in the Infrastructure element.

-Criteria, policies, and management techniques for prioritizing and siting shoreline uses are covered in the Port element.

Volume II of this coastal study includes the following Technical Reports and Appendices for those who wish to consult them for further details:

-Nicholas, James C. (1987) "The Economics of Lee County's Coastal Zone: Data by Township, Range and Section ."

-Erwin, Kevin L. (1988) "Ecological Inventory and Analysis of the Lee County Coastal Zone and Recommendations for Future Resource Management: Appendices IV-I through IV-VII."

-Morgan, Richard B. (1987) "Estuarine Pollution Conditions of the Special Coastal Study for Lee County, Florida", and "A Supplement to the Report on Estuarine Pollution Conditions, Lee County, Florida."

-Hine, Albert C. (1987) "Evaluation of the Lee County Coastline: Dominant Processes, Shoreline Change, Stabilization Efforts, and Recommendations for Beach Management (including Appendices A-G)."

TABLE I-1. SECTIONS IN COASTAL AREA LAND USE INVENTORY

43-20

01, 02, 11-14, 23, 24, 26, 35, 36

43-21

5, 6, 25, 26, 31, 33-36

43-22

01, 28-34

43-23

06

44-20

01, 12, 13

44-21

01-04, 06-15, 17-20, 23-25, 29, 32

44-22

03-10, 13-36

44-23

18-21, 29, 30

45-21

04, 05, 08, 09, 15, 16, 22, 23, 26, 27, 35, 36

45-22

01-05, 08-12, 14-16, 21-28, 32-36

45-23

25, 27, 28, 31-36

45-24

03, 04, 09-11, 13-17, 20-36

45-25

31

46-21

02, 03, 11

46-22

01-05, 10

46-23

01-06, 09-14, 24

46-24

01-30, 33-36

46-25

05-08, 17-20, 28-33

47-24

01-03, 11-14, 23-25

47-25

04-09, 17-22, 25-36

47-26

31

48-25

01, 04

TABLE I-2. COASTAL STUDY AREA DWELLING UNITS: 1986, 2010, & BUILDOUT

Lee Planning District	1986 Dwelling Units	2010 Dwelling Units	Buildout Dwelling Units
1 (P)	1,363	1,487	1,487
2 (P)	15,886	32,294	36,458
3 (P)	1,510	3,344	5,194
4	0	0	0
5	0	0	0
6	0	0	0
7 (P)	180	473	683
8 (P)	7,913	19,476	36,867
9 (P)	6,106	14,013	14,013
10	9,956	10,581	10,581
11	11,880	28,904	35,879
12	4,682	8,691	16,704
13	0	0	0
14	1,195	1,790	1,923
15	739	1,320	1,320
Total	61,410	122,373	161,109

Note: (P) indicates Planning Districts where the Coastal Study Area includes only a portion of the complete Planning District, and thus the dwelling unit totals in this table are smaller than the complete Planning District dwelling unit totals. For those Planning Districts that do not include any of the Coastal Study area, zero dwelling units are indicated in this table.

II. THE ECONOMICS OF LEE COUNTY'S COASTAL ZONE

The economy of Lee County is clearly and significantly influenced by the location of the county. The mild winters together with access to the Gulf of Mexico and several bays make Lee County a very desirable location for tourists and retirees. These same facets are also important to Lee County's agricultural sector and its marine industries. However, the precise determination of the economic role and scope of these locational and climatic influences are not reported in available statistics. The objective of this section is to set out a reasonable basis to estimate the present role of these influences and then to make projections with respect to future roles.

Because economic data are not collected on a sub-county basis, the economic role of the coastal areas of the county must be estimated. This estimation is undertaken by means of an evaluation of the Lee County tax records. For this analysis, tax records were obtained from the Florida Department of Revenue for 1985. The relevant data were summed by section (as in Township, Range and Section) and then the sections were grouped into 3 sub-groupings. The sub-groupings utilized are (1) those sections within unincorporated Lee County within the identified Coastal Zone, (2) those sections within unincorporated Lee County containing properties within the V (for velocity) Zone and (3) those sections within unincorporated Lee County containing Gulf or Bay frontage. This method allows analysis of several definitions of coastal Lee County. The detailed classification and values of the individual sections are set out in a separate report entitled "The Economics of the Lee County Coastal Zone".

EXISTING CONDITIONS

The method of analyzing existing conditions proceeded first by identifying all sections within Lee County which contained any of the following; residential dwellings units, vacant land identified as being residential, developed commercial areas, vacant land identified as being commercial, developed industrial areas, vacant land identified as being industrial or hotel/motel units. The total number of dwelling units together with the taxable value of all commercial, industrial and hotel/motel properties were summed by section. Any section containing land within the Coastal Zone, the V Zone or with Gulf or Bay Frontage was grouped accordingly. Sections totally within incorporated areas were omitted and those partially within incorporated areas were allocated based upon analysis of aerial photography.

Dwelling Units and Property Value

Table 1 summarizes the analysis of the 1985 tax records. The magnitudes themselves may not be very instructive. However, the percentage distribution of dwelling units and values are highly instructive. Within Lee County 39.1% of all existing dwelling units are within the Coastal Zone. Additionally, 11.1% of existing dwellings units are within the V Zone and 12.2% have Gulf or Bay frontage. Note might be taken of the fact that there are areas with bay frontage which are not within the V Zone thus the number of dwellings with frontage exceeds the number within the V Zone. Looking at value rather than number, the proportion of all residential value is 45.9% in the Coastal Zone, 19.2% within the V Zone and 20.3% in frontage sections. This would be expected because generally those dwellings with a coastal orientation would have a higher market value. Map 1 shows the assessed values of all residential properties within Lee County by location. These data are for 1985.

There are still substantial quantities of undeveloped residential properties within these zones. 28.7% of the value of vacant residential property is to be found within the Coastal Zone, 10.0% within the V Zone and 11.8% with Gulf or bay frontage. It is clear that the proportion of residential property to be developed within these study zones is substantially less than that already developed. Again, this would be expected because coastal areas tend to be preferred. Additionally, Lee County has a vast reserve of vacant residential property, especially within Cape Coral and Lehigh Acres.

The Coastal Zone contains 36.3% of developed commercial property and 38.3% of undeveloped commercial property. The V and frontage areas have approximately 11% of developed commercial and 7% of undeveloped commercial. The Coastal Zone contains what might be a surprising portion of total county industrial property at 24.6% while the V and frontage areas contain very little. This is due, in part, to many marine activities being classified as industrial.

As would be expected, the Coastal Zone contains the majority of hotel and motel properties within the county, 56.5%. Additionally, these data show that the vast majority of the hotel and motel properties are within the V Zone (76.9%) and the Frontage area (with all of the V Zone hotels and motels having Gulf or bay frontage).

Collectively the Coastal Zone accounts for 40.5% of all value within Lee County. This proportion takes on additional significance when it is recognized that the Coastal Zone amounts for only 19.8% of the total land area of Lee County. The proportions for the V and Frontage Zones are less than the Coastal Zone but again it is necessary to recall that the V Zone amounts to only a portion of the Coastal Zone while constituting

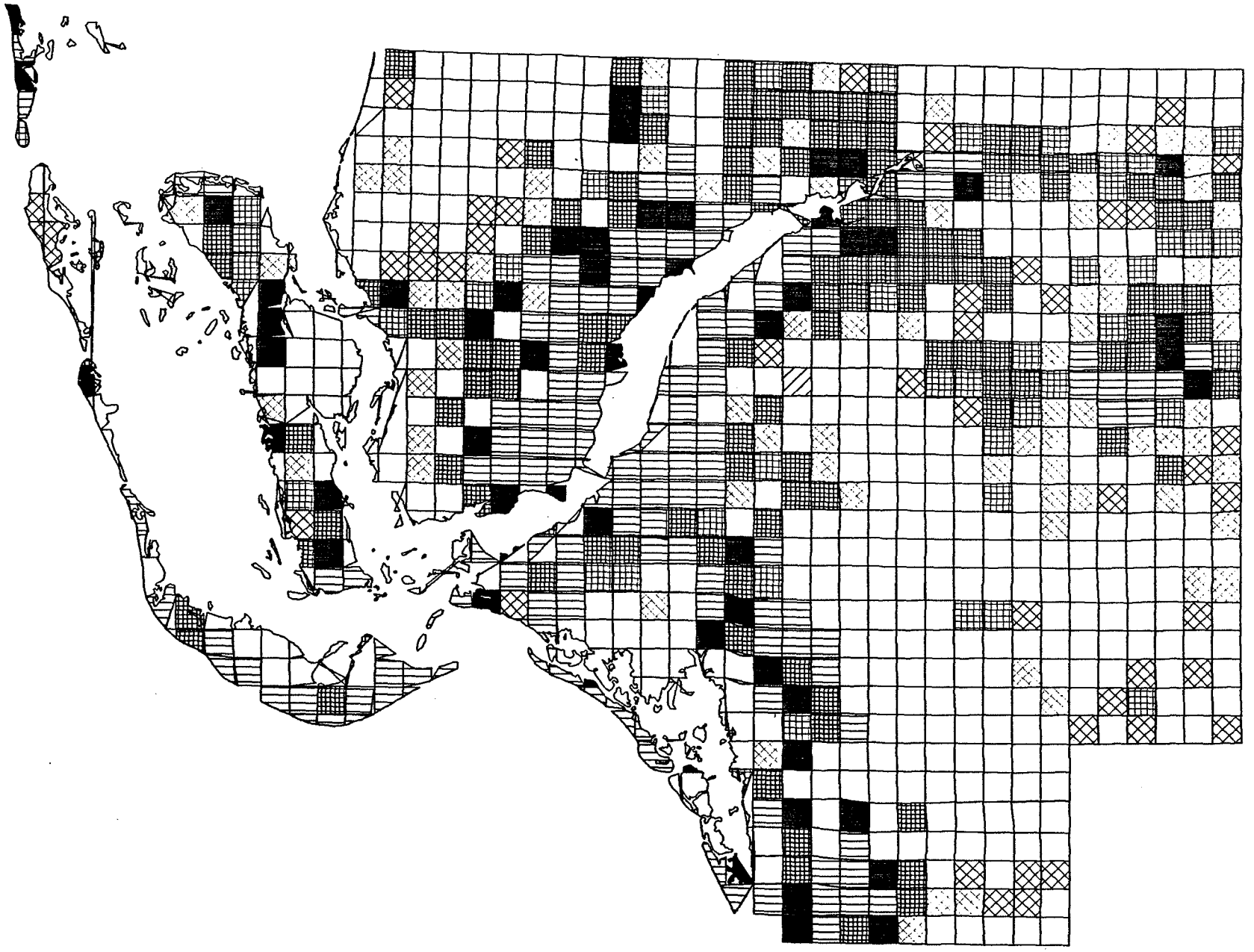


FIGURE II-1

ASSESSED VALUE OF RESIDENTIAL PARCELS
LEE COUNTY FLORIDA 1985, IN 1000S

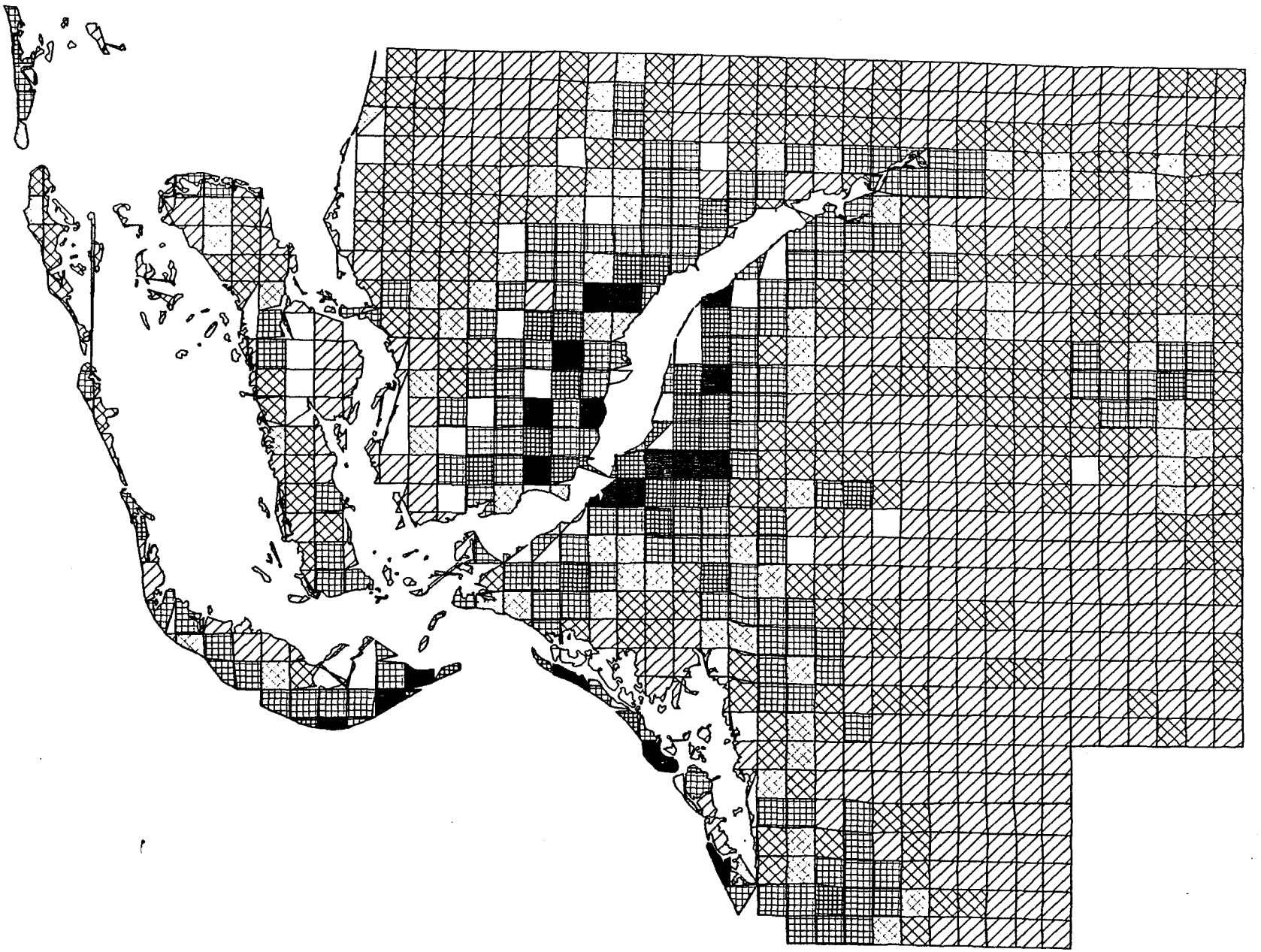


FIGURE II-2

ASSESSED VALUE OF ALL PARCELS
LEE COUNTY FLORIDA 1985. IN 10000S

TABLE 1

LEE COUNTY DWELLING UNITS AND TAXABLE VALUES
LEE COUNTY AND SUB-AREAS
1985

	TOTAL COUNTY	COASTAL ZONE	"V" ZONE	GULF OR BAY FRONTAGE
NO. OF DWELLINGS	144,821	56,569	16,120	17,717
TAXABLE VALUES ($)				
RESIDENTIAL				
DEVELOPED	$4,341,199,440	$1,992,463,710	$833,841,061	$881,054,131
VACANT	$1,577,364,590	$451,979,299	$158,360,836	$186,748,908
COMMERCIAL				
DEVELOPED	$700,955,000	$254,417,305	$74,352,870	$77,246,350
VACANT	$63,193,610	$24,206,970	$4,103,050	$4,195,860
INDUSTRIAL				
DEVELOPED	$148,086,970	$36,464,546	$3,857,536	$4,206,056
VACANT	$26,167,850	$2,918,920	$505,970	$505,970
HOTEL/MOTEL	$85,711,000	$48,401,328	$37,224,538	$37,224,538
SUMMARY	$6,942,678,460	$2,810,852,078	$1,112,245,861	$1,191,181,813
PER CENT OF DWELLINGS	100.0%	39.1%	11.1%	12.2%
TAXABLE VALUES (%)				
RESIDENTIAL				
DEVELOPED	100.0%	45.9%	19.2%	20.3%
VACANT	100.0%	28.7%	10.0%	11.8%
COMMERCIAL				
DEVELOPED	100.0%	36.3%	10.6%	11.0%
VACANT	100.0%	38.3%	6.5%	6.6%
INDUSTRIAL				
DEVELOPED	100.0%	24.6%	2.6%	2.8%
VACANT	100.0%	11.2%	1.9%	1.9%
HOTEL/MOTEL	100.0%	56.5%	43.4%	43.4%
SUMMARY	100.0%	40.5%	16.0%	17.2%

SOURCES: 1. Florida Department of Revenue, unpublished data.
2. Florida Statistical Abstract, 1986, pp.47-50.

NOTE: The number of dwelling units is estimated from the 1985 number of households and then adjusted to estimate dwelling units by the ratio of dwelling units to households established by the 1980 census.

16.0% of all property value. Map 2 shows the total assessed value of all all properties within Lee County as of 1985. The dominance of the Coastal Zone may be clearly seen in this map.

Population

Lee County had a 1985 population of 264,367. Based upon the distribution of dwelling units (Table 1), it follows that the residential population within the Coastal Zone is 107,562. The estimated peak population of the Coastal Zone is 121,633. While only 28.5% of the Coastal Zone residential population is within the V Zone, 76.9% of the tourist population will be there for a total of 41,472 persons. This is equal to 13.8% of the total county population.

As with the discussion of value, the significance of these data may be seen by contrasting the land area with the concentration of the population. The Coastal Zone constitutes 19.8% of the land area and 40.5% of the population. The V Zone contains 13.8% of the total county population.

TABLE 2

LEE COUNTY RESIDENTIAL AND PEAK POPULATION
1985

	COUNTY	COASTAL ZONE	V ZONE	GULF & BAY FRONTAGE
RESIDENTIAL	275,367	107,562	30,651	33,687
	100.0%	39.1%	11.1%	12.2%
HOTEL/MOTEL UNITS	15,429	8,713	6,701	6,701
PEAK OCCUPANCY	1.7	1.7	1.7	1.7
TOURIST POPULATION	24,918	14,071	10,822	10,822
PEAK POPULATION	300,285	121,633	41,472	44,509
PER CENT	100.0%	40.5%	13.8%	14.8%

SOURCE: Florida Statistical Abstract - 1986
Pages 32 and 61.

Employment

Direct Impact: The coastal areas of Lee County constitute a primary economic base. This primacy is exerted in two ways. The first is the economic activities which are carried on within coastal areas and the second is the economic activities which exist outside of the coastal zone but are dependent upon this zone or area for their vitality. Table 3 sets out the distribution of employment within Lee County. The dominance of services, retail trade and construction is apparent.

TABLE 3

LEE COUNTY EMPLOYMENT
1985

AG. SERVICE, FOREST & FISHING	3,213
MINING	180
CONSTRUCTION	10,974
MANUFACTURING	4,666
T.C.U.	4,988
WHOLESALE TRADE	3,633
RETAIL TRADE	25,086
F.I.R.E.	6,754
SERVICES	29,966
GOVERNMENT	5,003
OTHER NON-AGRICULTURAL	63
AGRICULTURAL AND OTHER	14,314
TOTAL	108,840

SOURCE: Florida Statistical Abstract - 1986
Page 160 and 177

NOTES: T.C.U. - Transportation, Communications and Public Utilities
F.I.R.E. - Finance, Insurance and Real Estate.

Table 4 re-groups the employment data in Table 3 into aggregates. These aggregates are designed to be consistent with the property classifications summarized in Table 1. In this manner, attribution of employment is possible. The data shown in Table 4 attribute the employment to the sub-areas on the basis of the property distribution from Table 1. Based upon the distribution of commercial and industrial properties within the County (as shown in Table 1), it follows that the Coastal Zone of Lee County directly employs 23.9% of Lee County employees. Additionally, the V Zone provides employment for 9,689 which is 8.9% of total employment.

TABLE 4

EMPLOYMENT BY ACTIVITY
LEE COUNTY
1985

	COUNTY	COASTAL ZONE	V ZONE	GULF & BAY FRONTAGE
COMMERCIAL	34,394	12,484	3,648	3,790
INDUSTRIAL	26,958	6,638	702	766
TOURIST	12,293	6,942	5,339	5,339
OTHER	35,195	NA	NA	NA
TOTAL	108,840	26,063	9,689	9,895
	100.0%	23.9%	8.9%	9.1%

SOURCE: Florida Statistical Abstract - 1986, Pages 470, 472 & 474.

NOTES: Commercial employment is defined as; 100% of Retail Trade, 50% of Wholesale Trade and 25% of Services. Industrial is defined as 100% of Manufacturing, 50% of Transportation, Communications and Public Utilities, 50% of Wholesale Trade, 50% of Services, 25% of Agricultural Services (Fishing) and 20% of Construction.

Table 5 distributes personal income on the basis of where earned, in the case of earned income (wages and salaries) and where received in the case of all other sources of income. The distribution of employment, as set out in Table 4, is the basis for attributing earned income and the distribution of residential population, as set out in Table 2, is the basis for attributing all other sources of personal income. The Coastal Zone directly accounts for 31.8% of all income received by Lee County residents, a total of $1.039 billion annually. The V Zone contributes $328.8 million annually to Lee County personal income.

TABLE 5

PERSONAL INCOME BY SUB-AREA
LEE COUNTY
1984

	COUNTY	COASTAL ZONE	V ZONE	GULF & BAY FRONTAGE
EARNED	$1,579,000,000	$378,116,263	$140,569,362	$143,549,492
ALL OTHER	$1,691,100,000	$660,567,948	$188,233,325	$206,881,527
TOTAL	$3,270,100,000	$1,038,684,212	$328,802,687	$350,431,019
	100.0%	31.8%	10.1%	10.7%

SOURCE: Florida Statistical Abstract - 1985
Pages 113 and 123.

Indirect Impact: Any direct economic impact will result in an indirect, secondary, or induced impact. This is commonly known as the "ripple effect". While there can be little doubt that such secondary impacts exist, their measurement is another matter. The objective of this study is not to conduct a detailed structural analysis of the Lee County economy. Rather, the objective is to identify the economic role and scope of the several coastal areas within Lee County. Studies undertaken elsewhere, but specifically in Dade and Broward Counties, have concluded that each direct job and each direct dollar of personal income results in an additional job and dollar of personal income. Based upon this generalized datum, the indirect and total economic role of the coastal areas may be estimated. Table 6 sets out these estimates.

TABLE 6

TOTAL ECONOMIC IMPACT
LEE COUNTY COASTAL AREAS
1985

	COUNTY	COASTAL ZONE	V ZONE	GULF & BAY FRONTAGE
EMPLOYMENT:				
DIRECT	108,840	26,063	9,689	9,895
INDIRECT		26,063	9,689	9,895
TOTAL		52,127	19,379	19,790
PER CENT		47.9%	17.8%	18.2%
PERSONAL INCOME:				
DIRECT	$3,270,100,000	$1,038,684,212	$328,802,687	$350,431,019
INDIRECT		$1,038,684,212	$328,802,687	$350,431,019
TOTAL		$2,077,368,423	$657,605,375	$700,862,038
PER CENT		63.5%	20.1%	21.4%

These estimates indicate that the Coastal Zone accounts for 47.9% of all employment and 63.5% of all personal income within Lee County. This latter percentage is deserving of note. The V Zone accounts for 17.8% of employment and 20.1% of personal income. These data present a very basic fact which should come as no surprise. The Lee County economy has been and is now economically tied to the coast. The level of growth which has occurred and the economic prosperity prosperity currently enjoyed have been due, more than anything else, to the location of Lee County within a semi-tropical environment adjacent to the Gulf of Mexico.

FUTURE CONDITIONS: BUILDOUT

This sections deals with a buildout condition. This condition is based upon the total development which would be permissible under the Lee Plan. No time for buildout to be attained has been established.

Dwelling Units and Population

At build-out, Lee County would have a projected total of 768,235 dwelling units. These dwelling units would contain an estimated 1,567,199 residents. Residential population within the Coastal Zone would be 328,662. The estimated peak population of the Coastal Zone is 357,831. While only 8.3% of the Coastal Zone residential population is within the V Zone, 76.9% of the tourist population will be there for a total of 49,597 persons. This is equal to 3.1% of the total county population. The percentage increases in peak population from 1985 to build-out are; 439.1% for total population, 194.2% for the population in the Coastal Zone, 119.6% for the V Zone and 20.1% for Gulf and Bay frontage.

These data suggest several points. First, the non-coastal areas of Lee County will be growing more rapidly than the coastal. Second, that population growth in the Coastal and V Zones will be substantial and, third, that population living with Gulf or Bay frontage will decline. This latter change is attributable to changing demographics (smaller household size) rather than to land use changes.

TABLE 7

LEE COUNTY DWELLING UNITS, RESIDENTIAL AND PEAK POPULATION BUILDOUT

	COUNTY	COASTAL ZONE	V ZONE	GULF & BAY FRONTAGE
DWELLING UNITS	768,235	161,109	13,316	15,204
	100.0%	21.0%	1.7%	2.0%
POPULATION	1,567,199	328,662	27,165	31,016
HOTEL/MOTEL UNITS	31,983	18,061	13,890	13,890
PEAK OCCUPANCY	1.7	1.7	1.7	1.7
TOURIST POPULATION	51,653	29,168	22,433	22,433
PEAK POPULATION	1,618,852	357,831	49,597	53,449
	100.0%	22.1%	3.1%	3.3%

SOURCE: Lee County, Dept. of Community Development

Employment

Direct Impact: The coastal areas of Lee County will remain a significant primary component of the economic base. Table 8 sets out the projected employment and the distribution of that employment within Lee County, by industry. The continuing dominance of services, retail trade and construction should be apparent.

TABLE 8

LEE COUNTY EMPLOYMENT
BUILDOUT

AG. SERVICE, FOREST & FISHING	18,748
MINING	1,050
CONSTRUCTION	60,977
MANUFACTURING	20,722
T.C.U.	25,630
WHOLESALE TRADE	22,089
RETAIL TRADE	193,646
F.I.R.E.	39,411
SERVICES	178,530
GOVERNMENT	29,194
OTHER NON-AGRICULTURAL	367
AGRICULTURAL AND OTHER	83,527
TOTAL	673,896

SOURCE: Florida Statistical Abstract - 1986
Page 160 and 177

Table 9 re-groups the employment data in Table 8 into aggregates. These aggregates are designed to be consistent with the property classifications summarized in Table 1. The Coastal Zone of Lee County is projected to directly employ 11.2% of Lee County employees. Additionally, the V Zone is expected to provide employment for 13,978 which is 2.1% of total employment.

TABLE 9

EMPLOYMENT BY ACTIVITY
LEE COUNTY
BUILDOUT

	COUNTY	COASTAL ZONE	V ZONE	GULF & BAY FRONTAGE
COMMERCIAL	249,323	49,269	3,068	3,346
INDUSTRIAL	61,464	12,544	609	694
TOURIST	23,718	13,393	10,301	10,301
OTHER	339,391	NA	NA	NA
TOTAL	673,896	75,206	13,978	14,341
	100.0%	11.2%	2.1%	2.1%

SOURCE: Thomas H. Roberts & Assoc.

NOTE: Employment are defined in Table 4.

Table 10 distributes personal income on the basis of where it is expected to be received, in the case of earned income (wages and salaries) and where received in the case of all other sources of income. The distribution of employment, as set out in Table 9, is the basis for attributing earned income and the distribution of residential population, as set out in Table 7, is the basis for attributing all other sources of personal income. The Coastal Zone is projected to directly account for 15.7% of all income received by Lee County residents, a total of $2.842 billion annually. The V Zone contributes $347.5 million annually.

TABLE 10

PERSONAL INCOME BY SUB-AREA
LEE COUNTY
BUILDOUT

	COUNTY	COASTAL ZONE	V ZONE	GULF & BAY FRONTAGE
EARNED	$9,776,562,891	$1,091,059,858	$202,787,136	$208,050,186
ALL OTHER	$8,347,131,429	$1,750,503,870	$144,682,852	$165,196,611
TOTAL	$18,123,694,320	$2,841,563,728	$347,469,987	$373,246,797
	100.0%	15.7%	1.9%	2.1%

SOURCE: Florida Statistical Abstract - 1986
Pages 113 and 123.

Indirect Impact: The indirect economic impact at buildout is estimated in the same manner as above. The total economic role of the coastal zones at build-out is shown in Table 11. At the present, the coastal area is of vital economic importance to Lee

County. In the future this importance is expected to continue but at a lower level than the present. This expectation is based upon a policy of industrial development and diversification. Such developments resulting from this policy are expected to be located, predominately, outside of the coastal areas. These policies will have the advantage of providing a degree of protection to the Lee County economy in the event of a major coastal disaster. Moreover, the limited coastal area remaining for development together with the limitations to such development makes such policies even more necessary. While the coast has been Lee County's major economic asset, Lee County must develop other bases for economic prosperity.

TABLE 11

TOTAL ECONOMIC IMPACT
LEE COUNTY COASTAL AREAS
BUILDOUT

	COUNTY	COASTAL ZONE	V ZONE	GULF & BAY FRONTAGE
EMPLOYMENT:				
DIRECT	673,896	75,206	13,978	14,341
INDIRECT		75,206	13,978	14,341
TOTAL		150,413	27,956	28,682
PER CENT		22.3%	4.1%	4.3%
PERSONAL INCOME:				
DIRECT	$18,123,694,320	$2,841,563,728	$347,469,987	$373,246,797
INDIRECT		$2,841,563,728	$347,469,987	$373,246,797
TOTAL		$5,683,127,456	$694,939,975	$746,493,594
PER CENT		31.4%	3.8%	4.1%

These estimates indicate that the Coastal Zone accounts for 22.3% of all employment and 31.4% of all personal income within Lee County. The V Zone accounts for 4.1% of employment and 3.8% of personal income. These data present a very basic fact which should come as no surprise. The Lee County economy is inexorably tied to the coast. The level of growth and the prosperity that is expect to occur are due, more than anything else, to the location of Lee County adjacent to the Gulf. The importance of the coast to the Lee County economy cannot be over emphasized.

FUTURE CONDITIONS: 2010

This sections deals with projections for the year 2010. This condition is also based upon the development which would be permissible under the Lee Plan together with specific available projections for the year 2010.

Dwelling Units and Population

In 2010, Lee County is expected have a projected total of 244,853 dwelling units with a projected residential population of 499,500. Residential population within the Coast Zone would be 249,641. The estimated peak population of the Coastal Zone is 271,298. While only 19.7% of the Coastal Zone residential population is within the V Zone, 76.9% of the tourist population will be there for a total of 65,839 persons. This is equal to 12.2% of the total county population. The percentage increases in population from 1985 to 2010 are; 79.1% for peak population, 81.4% for the residential population, 105.2% for the(peak) population in the Coastal Zone, 58.8% for the V Zone and 47.9% for Gulf and Bay frontage.

It is clear that the coastal areas of Lee County are expected to be primary recipients of the growth projected to occur by 2010. By 2010 over 75% of all development which could occur within the coastal zone is projected to have taken place. This would mean that the majority of future development (i.e., post 2010) within Lee County must take place in non-coastal locations. This is reflected in the data set out in Table 6 above and Table 18 below. It is anticipated that the decline in the residential population in areas with Gulf or Bay frontage should occur by 2010.

TABLE 12

LEE COUNTY DWELLING UNITS, RESIDENTIAL AND PEAK POPULATION
2010

	COUNTY	COASTAL ZONE	V ZONE	GULF & BAY FRONTAGE
DWELLING UNITS	244,853	122,373	24,109	16,209
	100.0%	50.0%	9.8%	6.6%
POPULATION	499,500	249,641	49,183	33,067
HOTEL/MOTEL UNITS	23,747	13,410	10,313	10,313
PEAK OCCUPANCY	1.7	1.7	1.7	1.7
TOURIST POPULATION	38,351	21,657	16,656	16,656
PEAK POPULATION	537,851	271,298	65,839	49,722
	100.0%	50.4%	12.2%	9.2%

SOURCE: Lee County, Dept. of Community Development

Employment

Direct Impact: The coastal areas of Lee County are expected to retain their importance to the County's economic base. Table 13 sets out the distribution of employment within Lee County. The continuing dominance of services, retail trade and construction to the Lee economy is apparent.

TABLE 13

LEE COUNTY EMPLOYMENT
2010

AG. SERVICE, FOREST & FISHING	10,895
MINING	610
CONSTRUCTION	38,241
MANUFACTURING	16,809
T.C.U.	17,842
WHOLESALE TRADE	13,856
RETAIL TRADE	85,871
F.I.R.E.	22,903
SERVICES	107,870
GOVERNMENT	16,965
OTHER NON-AGRICULTURAL	213
AGRICULTURAL AND OTHER	48,540
TOTAL	380,616

SOURCE: Florida Statistical Abstract - 1986
Page 160 and 177

Table 14 re-groups the employment data in Table 13 into aggregates. These aggregates are designed to be consistent with the property classifications summarized in Table 1. The Coastal Zone of Lee County is projected to directly employ 14.5% of Lee County employees in 2010. Additionally, the V Zone is projected to provide employment for 18,839 which is 4.9% of total employment.

TABLE 14

EMPLOYMENT BY ACTIVITY
LEE COUNTY
2010

	COUNTY	COASTAL ZONE	V ZONE	GULF & BAY FRONTAGE
COMMERCIAL	110,560	25,520	3,443	3,633
INDUSTRIAL	49,856	10,557	640	718
TOURIST	33,975	19,186	14,756	14,756
OTHER	186,224	NA	NA	NA
TOTAL	380,616	55,263	18,839	19,107
	100.0%	14.5%	4.9%	5.0%

SOURCE: Thomas H. Roberts & Assoc.

NOTE: Employment categories are defined in Table 4.

Table 15 distributes personal income on the basis of where it is expected to be received, in the case of earned income (wages and salaries) and where received in the case of all other sources of income. The distribution of employment, as set out in Table 14, is the basis for attributing earned income and the distribution of residential population, as set out in Table 12, is the basis for attributing all other sources of personal income. The Coastal Zone directly accounts for 21.6% of all income received by Lee County residents, a total of $1.496 billion annually. The V Zone contributes $410.1 million annually. Gulf and Bay frontage areas are expected to account for $248.5 million in annual personal income.

TABLE 15

PERSONAL INCOME BY SUB-AREA
LEE COUNTY
2010

	COUNTY	COASTAL ZONE	V ZONE	GULF & BAY FRONTAGE
EARNED	$5,521,793,824	$801,726,032	$273,305,259	$156,557,824
ALL OTHER	$1,388,913,186	$694,153,284	$136,758,897	$91,945,110
TOTAL	$6,910,707,010	$1,495,879,316	$410,064,156	$248,502,934
	100.0%	21.6%	5.9%	3.6%

SOURCE: Florida Statistical Abstract - 1985
Pages 113 and 123.

Indirect Impact: The indirect economic impact at 2010 is estimated in the same manner as above. The total economic role of the coastal zones at 2010 is shown in Table 16. At the

present the coastal area is of vital economic importance to Lee County. Between the present and 2010, the economic role of the coast will decline. This decline is due, in part, to space and development limitations in the coastal areas and, in part, to industrial development and diversification policies currently being developed. Such policies will become increasingly important to Lee County and would be especially important in the event of a major coastal disaster.

TABLE 16

TOTAL ECONOMIC IMPACT
LEE COUNTY COASTAL AREAS
2010

	COUNTY	COASTAL ZONE	V ZONE	GULF & BAY FRONTAGE
EMPLOYMENT:				
DIRECT	380,616	55,263	18,839	19,107
INDIRECT		55,263	18,839	19,107
TOTAL		110,525	37,678	38,214
PER CENT		29.0%	9.9%	10.0%
PERSONAL INCOME:				
DIRECT	$6,910,707,010	$1,495,879,316	$410,064,156	$248,502,934
INDIRECT		$1,495,879,316	$410,064,156	$248,502,934
TOTAL		$2,991,758,632	$820,128,311	$497,005,868
PER CENT		43.3%	11.9%	7.2%

The data in Table 16 show that the Coastal Zone is projected to be responsible for 29.0% of all employment and 43.3% of all personal income within Lee County. The V Zone accounts for 9.9% of employment and 11.9% of personal income. These data reiterate the basic fact that the Lee County economy is inexorably tied to the coast. This fact will remain true even with industrial development and diversification.

CONCLUSIONS

The coastal areas of Lee County have been the most important determinant in the evolution of the county. The Gulf of Mexico and its various bays have been critical to the development of tourism and the attraction of retirees. Needless to say, the coast is essential to the marine industries. It has played a significant role both as a basis for development and as a location for development. The coast will continue to play a significant role in the future development of Lee County. However, this role will be more as a basis for growth and development than as a location of new development.

Table 18 summarizes the data set out above. These summary data show that growth is expected to continue within the Coastal Zone, but at rates below that of the county. This trend is even more pronounced after 2010 when the coast is expected to be largely developed. Perhaps the most significant indicator of the economic role of the Coastal Zone is the personal income to be received by Lee County residents. The Coastal Zone is expected to contribute annual personal income of $5,683.1 million out of a total of $18,123.7 million at buildout. While the percentage contribution to total personal income is expected to decline, it is unlikely that the non-coastal areas of Lee County will be in a position to enjoy the $12,440.6 million annually expected if there had been no coastal zone in the first place or if the coastal zone ceased to exist.

TABLE 18

COMPARISON OF 1985 TO 2010 AND BUILD-OUT
LEE COUNTY

	1985	2010	BUILDOUT
POPULATION:			
RESIDENTIAL;			
COUNTY TOTAL	275,367	499,500	1,567,199
% CHANGE FROM ±85		81.4%	469.1%
COASTAL ZONE	107,562	249,641	328,662
% CHANGE FROM ±85		132.1%	205.6%
TOURIST;			
COUNTY TOTAL	24,918	38,351	51,653
% CHANGE FROM ±85		53.9%	107.3%
COASTAL ZONE	14,071	21,657	29,168
% CHANGE FROM ±85		53.9%	107.3%
PEAK POPULATION;			
COUNTY TOTAL	300,285	537,851	1,618,852
% CHANGE FROM ±85		79.1%	439.1%
COASTAL ZONE	121,633	271,298	357,831
% CHANGE FROM ±85		123.0%	194.2%

TABLE 18 Continued

	1985	2010	BUILDOUT
EMPLOYMENT:			
DIRECT;			
COUNTY TOTAL	108,840	380,616	673,896
% CHANGE FROM ±85		249.7%	519.2%
COASTAL ZONE	26,063	55,263	75,206
% CHANGE FROM ±85		112.0%	188.6%
TOTAL;			
COUNTY TOTAL	108,840	380,616	673,896
% CHANGE FROM ±85		249.7%	519.2%
COASTAL ZONE	52,127	110,525	150,413
% CHANGE FROM ±85		112.0%	188.6%
PERSONAL INCOME (in millions):			
DIRECT;			
COUNTY TOTAL	$3,270.1	$6,910.7	$18,123.7
% CHANGE FROM ±85		111.3%	454.2%
COASTAL ZONE	$1,038.7	$1,495.9	$2,841.6
% CHANGE FROM ±85		44.0%	173.6%
TOTAL;			
COUNTY TOTAL	$3,270.1	$6,910.7	$18,123.7
% CHANGE FROM ±85		111.3%	454.2%
COASTAL ZONE	$2,077.4	$2,991.8	$5,683.1
% CHANGE FROM ±85		44.0%	173.6%

METHODOLOGICAL NOTES

The analysis contained in this section requires the projection of certain parameters. The projections made are conditions and magnitudes at buildout, which will occur at no specified date, and at the year 2010.

The build-out projections were generally made by an analysis of The Lee Plan in terms of what type and magnitude of development is permitted. This analysis was prepared by the Lee County Department of Community Development. The departmental analysis did not contain any projections of hotel/motel units so projections of these magnitudes were undertaken herein.

The number of transient (hotel, motel, rooming house, and rental apartments) units in Lee County was obtained from the Florida Statistical Abstract for the period 1975 through 1985. A time series analysis of these data was undertaken. The first step in this analysis was the calculation of a Zero Year. A Zero Year is that date when, statistically, the time trend passed through zero. This date was 1944. The form of the time series equation was specified as being both logarithmic and increasing at a decreasing rate. This form was specified based upon the premise that the rate of increase would decline as both Lee County and transient areas approached build-out. The following equation was used:

$$\log(\text{UNITS}) = 154.59578 - 19.747 * \log(\text{YEAR}) + .672477 * \log(\text{YEAR} - 1944)^2$$

The coefficient of determination, R^2, was equal to 94.96%, thus indicating statistical significance. This equation indicated that the peak number of transient units would be 31,983 and that this peak would occur in the year 2086. Thus, the peak figure was utilized in the build-out analysis and the projection for 2010, based upon this equation, was utilized for 2010.

Employment projections were made by establishing ratios of employees to total population. This implied that employment changes in Lee County are driven, primarily, by changes in the population. Thus, total population at both build-out and 2010 were the determining aggregate for employment. Total employment was then distributed among industries based upon the past experience of Lee County and the stated objective of increasing the industrial sector of the economic base. Earned income was projected by multiplying annual earnings by employment groupings. Non-earned income was projected by estimating the number of persons receiving non-earned income and then multiplying this total by the average non-earned income for 1985.

III. COASTAL AREA LAND USE AND GROWTH MANAGEMENT

Purpose

The purpose of this chapter is to inventory existing land uses and to analyze the effects of future land uses within the Coastal Study Area, and to recommend goals, objectives, and policies needed to achieve sound coastal land use patterns under the comprehensive plan. According to Florida law, these land use patterns must account for protection of coastal resources from development, and for protection of human life and limitation of public expenditures in areas subject to destruction by natural disasters. The chapter reviews existing land use for each planning district within the Coastal Study Area and discusses projected future land use in each district at two periods: 1) the year 2010 and, 2) buildout--the future time when the area has been fully developed. It recommends goals, objectives, and policies to balance land development, resource protection, disaster protection, and public expenditures.

Methodology

A land use inventory was conducted by the county planning staff in 1981, as part of the process of preparing the 1984 Lee Plan. To update this inventory, land use information for this coastal study was obtained from two primary sources; a 1986 land use inventory by County planning staff and 1987 aerial photography-based land classification mapping by the South Florida Water Management District and the Southwest Florida Regional Planning Council.

First, an inventory of 1986 Coastal Study Area land use was conducted by the planning staff. This inventory utilized 1986 parcel data from the Lee County tax appraiser's computer tapes, supplemented by review of aerial photographs and field checks, to create a computerized database. Land uses were classified according to the Florida Land Use, Cover and Forms Classification System (FLUCFS; Florida DOT, 1985), with some additions to account for Lee County conditions. (See Appendix for the FLUCFS classification system used.)

Within the database, parcels may be located by the STRAP (section, township, range, and parcel) number, and also by various geographic sub-area categories, including: Planning District, Census Tract, and Traffic Analysis Zone. This database, developed by Willliam Drummond for dBase III software running on IBM Personal Computers, allows information on the land use, geographic sub-areas, and number of dwelling units for any coastal area parcel to be rapidly retrieved and displayed. It also allows the generation of reports on land use (FLUCFS) codes by section, Census Tract, Planning District, and Traffic Analysis Zone.

Because the appraiser's tapes only included land area (acreage) on fewer than one-quarter of the parcels and manual planimetering of the remaining parcels was too time consuming to be completed within the planning period, complete data on land use acreage was not available. Ultimately, the complete land use inventory, including acreage information, will be available on the county's Intergraph geographic information system; however, the digitizing of parcels

under the Intergraph program was not completed for the coastal area during this planning period.

The second source of existing land use information was a series of computer-generated maps prepared by the South Florida Water Management District (SFWMD), using land classification data derived by the Southwest Florida Regional Planning Council from aerial photographs. These maps, received late in the planning period, identify land uses according to the SFWMD Land Use and Land Cover Classification Codes.

Three problems were encountered with using these maps for this study: 1) the SFWMD classification system was different from the FLUCFS codes used in the county land use inventory and from the land use classes required under Rule 9J-5, 2) the numerous small polygons (areas of individual land use on the maps) identified under the SFWMD system of 100 codes were impossible for the eye to organize into a coherent set of overall land use patterns, and 3) the large scale of the maps printed on numerous sheets made it impossible to assemble them into a single map of existing land use for the Coastal Study Area. (The last two problems will be resolved when SFWMD processes the maps as planned, but this has not occured in time for use in this study.)

In order to overcome the problems of converting into the 9J-5 land use categories, organizing the data into coherent patterns and assembling the multiple sheets, we grouped the 100 SFWMD codes into ten classes (residential, commercial, industrial, agricultural, recreational, conservation, public, vacant/undeveloped, beaches/shores, and rivers/bays/harbors) and hand-colored a set of maps, which were taped together into two large collages of individual sheets. These maps are not included in this report, but may be viewed at the Lee County Division of Planning.

A third source of information, developed for this coastal study, is the land cover (vegetation) inventory conducted as part of the coastal natural resources analysis. This inventory is described in Chapter IV of this report.

EXISTING AND FUTURE LAND USE

Coastal Study Area Geography

The Lee County Coastal Study Area is characterized by a complex geography. The county is split into northern and southern portions by the Caloosahatchee River. The western edge consists of a string of coastal barrier islands. Inside this string on the north lies another group of coastal islands. These islands, as well as the western edge of the mainland, are fringed with extensive, protected saltwater wetlands vegetated with mangroves. A system of sounds, bays, and estuaries is located between the islands and the mainland.

The two major incorporated urban areas of the county, Fort Myers and Cape Coral, are located on the eastern edge of the Coastal Study Area. A third incorporated urban area, Sanibel, occupies the largest coastal barrier island, connected to the mainland by a causeway. Most of the developable Gulf beachfront land with automobile access, including Gasparilla Island, Captiva, Sanibel, Estero Island (Fort Myers Beach), and Little Hickory Island (Bonita Beach), has been developed.

Defined by the A Zone, or 100 year flood zone, the Coastal Study Area is low

lying and subject to coastal flooding. South of Fort Myers, the eastern edge of the Coastal Study Area generally parallels the ridge on which U.S. Highway 41 is built. In its southern section, a number of waterways penetrate the area and fresh water wetlands lie along its eastern edge.

This chapter first considers the land use of the northern part of the coastal area, including the northern barrier islands, the coastal sound islands, and the northern edge of the mainland adjacent to Cape Coral. It then discusses the land use of the southern part, including the southern barrier islands and the unincorporated coastal areas of the southern mainland. The discussion refers to the land use categories from the Table of Residential Densities from the Lee Plan (reproduced as Table III-1).

Northern Barrier Islands

The northern barrier islands are located in Planning Districts 14 and 15. (See Chapter I for a map of Planning Districts.) The northernmost, Planning District 15--Boca Grande, is developed primarily with residential land use, containing 739 dwelling units on the Lee County portion of Gasparilla Island as of 1986. Auto access is by bridge from Charlotte County. By the year 2010, this district is expected to reach full development (buildout) at 1,320 dwelling units. Land use allowed under the Lee Plan on Gasparilla Island is primarily Urban Community, with a maximum permitted density of three dwelling units per acre (three islands have such special density limitations: Gasparilla, Captiva, and Pine Island). Hurricane evacuation and resource protection are important limits to growth.

Planning District 14--Captiva contains two largely undeveloped coastal barriers: Cayo Costa and North Captiva, accessible only by boat. It also contains the more developed Captiva Island, connected by bridge to Sanibel. Each island contains designated "undeveloped" units of the Coastal Barrier Resources System, under the federal Coastal Barrier Resources Act. (See Chapter VI for maps showing the locations of these units and a description of the limits on federal expenditures related to them.) Where development occurs, the predominant urban land use is single family residential, with some multi-family areas on Captiva. The district includes 1,195 dwelling units, as well as several marinas and restaurants. Under the Lee Plan, moderate growth is projected, reaching 1,790 dwelling units by the year 2010 and 1,923 units at buildout. Planned land use on Cayo Costa and North Captiva is predominantly Resource Protection, with a few small Rural areas with an allowable density of one dwelling unit per acre. Planned land use on Captiva is predominantly Urban Community, with a maximum permitted residential density of three dwelling units per acre on this island. Hurricane evacuation and resource protection are important planning considerations.

Coastal Sound Islands

Planning District 12--Pine Island contains Pine Island, Little Pine Island, and a number of small fringing islands and keys surrounded by the waters of Pine Island Sound, Charlotte Harbor, Matlacha Pass, and San Carlos Bay. Pine Island, the major developed area, has automobile access to the mainland via bridge and causeway crossing Little Pine Island. Saltwater wetlands ring Pine Island and cover most of Little Pine Island. Existing land use on Pine Island is primarily single family residential and mobile home, interspersed with some multi-family residential, public, and service and marine commercial, and is located in several clusters along the central road traversing the island. A

number of tracts are currently under development. Open areas include a golf course, agricultural acreage, and pine flat woods. Dwelling units in 1986 numbered 4,682. Substantial growth is projected, with 8,691 dwelling units by 2010 and 16,704 units at buildout under the current Lee Plan. Planned urban land use is a mixture of Rural (one unit per acre) and Urban Community (six units per acre). A 1986 amendment to the Lee Plan limited rezoning on Pine Island to a maximum density of three units per gross acre outside the existing Urban Service areas of Matlacha, Bokeelia, and St. James City. Hurricane evacuation and resource protection are important planning considerations; the present capacity of the route to the mainland is inadequate for the projected future growth.

Northern Mainland

Planning District 3--Cape Coral contains small sections of the Coastal Study Area adjacent to the Pine Island causeway and just south of the Charlotte County line. These unincorporated areas lie along the shore to the west of the Cape Coral municipal limits, including the island of Matlacha. Existing land use on Matlacha is primarily single family residential, with some mobile home and service commercial. These same uses are found along the Pine Island access road on the mainland toward Cape Coral, but the predominant land use there is saltwater wetlands. South of Charlotte County, the primary land use is multi-family residential, with a small marine commercial area. Within the coastal portion of this district (a very small part of the entire district) there were 1,510 dwelling units in 1986. Projected future growth goes to 3,344 units in 2010 and 5,194 at buildout. The Lee Plan classifies Matlacha and mainland areas along the Pine Island access road as Urban Community, with wetlands on the mainland classified as Resource Portection and mainland areas adjacent to Cape Coral classified as Rural and Central Urban. The multi-family area just south of Charlotte County is classified primarily as Fringe (maximum standard density of six dwelling units per acre). Resource protection will continue to be an important planning concern.

Southern Barrier Islands

Planning District 10--Fort Myers Beach and Bonita Beach contains the southern islands on the Gulf side of Estero Bay, including San Carlos Island, Estero Island (Fort Myers Beach), Black Island, Lovers Key, Big Hickory Island, Little Hickory Island (Bonita Beach), and several small keys. This island chain is connected to the mainland by a high bridge between San Carlos Island and the north end of Estero Island; a road runs south the length of the chain, bridging the islands between Estero and Bonita Beach. A small undeveloped CBRS unit is located at Bodwitch Point on the north end of Estero Island. (The County is acquiring Bodwitch Point as public open space.) Existing urban land use on San Carlos Island is primarily residential (single family, mobile home, and receational vehicle), with marine (commercial fishing) and service commercial along the shore and some industrial uses. Existing land use on Estero Island is composed of mostly single family residential on the Bay side, with mostly multi-family residential and commercial uses along the Gulf beach side. Lovers Key and Black Island are a state park, with automobile parking on Black Island and a tram running to Lovers Key. An undeveloped CBRS unit is located on Lovers Key and Black Island. Black Island is undeveloped except for a small multi-family residential area on its north tip. Big Hickory Island, a saltwater wetland, is designated as an undeveloped CBRS unit. Bonita Beach land uses are primarily single family and multi-family residential facing the Gulf, with small commercial areas interspersed and

saltwater wetlands on the Bay side. In 1986, this district contained 9,956 dwelling units. Only moderate growth to complete development (buildout) of 10,581 units is projected by 2010. Primary planned land uses are Urban Community and Industrial on San Carlos Island, Urban Community on Estero Island, Resource Protection on Lovers Key, Resource Protection and a small area of Urban Community on Black Island, Resource Protection on Big Hickory, and Urban Community and Resource Protection on Bonita Beach. Major concerns are resource protection, hurricane evacuation, and storm hazard mitigation.

Southern Mainland

Within the Coastal Study Area, the unincorporated portion of the mainland south of the Caloosahatchee River contains the bulk of the projected future growth. This area includes all of Planning District 11, and parts of Planning Districts 1, 2, 7, 8, and 9.

Planning District 11--Iona McGregor adjoins the Caloosahatchee River, San Carlos Bay, and Estero Bay. Its western side is mostly saltwater wetlands. Inland uses include single and multi-family residential, mobile homes, commercial areas along major roads, a County sewage treatment plant, agricultural acreage, and fill dirt pits. Dwelling units in 1986 totaled 11,880 with major growth projected to 28,904 units in 2010 and ultimately to 35,879 units at buildout. Future land use under the Lee Plan designates the wetlands as Resource Protection, with much of the remaining area designated as Urban Community and Suburban. Two Industrial areas are designated, along with a small Central Urban area and a very small Rural area. The primary hurricane evacuation routes for Sanibel, Captiva, and Fort Myers Beach run through this district. As the second largest coastal district at present and the third largest at buildout, its major planning concerns are resource protection, hurricane evacuation, storm hazard mitigation, and provision of adequate infrastructure.

Planning District 9--San Carlos Park lies inland to the east of Iona McGregor, with a small frontage on Estero Bay. Only its western portion lies within the Coastal Study Area. This contains a varied mix of land uses, including residential (single and multi-family, mobile home, and recreational vehicle), agricultural, industrial, commercial, and conservation (wetlands), as well as some areas that are vacant and some under development. U.S. 41 passes through it running north-south. Its 1986 dwelling units totaled 6,106. This portion of the planning district is projected to complete its development by 2010 with 14,013 units, its buildout capacity. Planned land uses include Urban Community (around San Carlos Park), Suburban, Rural, Industrial, and Resource Protection. Planning concerns are resource protection and hazard mitigation.

Planning District 8--Bonita Springs is south of the Estero River, fronting on Estero Bay. Only its western portion lies within the Coastal Study Area. This contains a mix of older residential areas (single and multi-family, mobile home), as well as commercial, agriculture, wetlands, and small industrial and public areas. It contained 7,913 dwelling units in 1986. It is projected for major growth to 19,476 units by 2010 and to 36,867 units at buildout, to become the largest of the Coastal Study Area Planning Districts. Planned land uses are Urban Community, Rural, Fringe, Transition, Resource Protection, Industrial, and General Interchange (at I-75 in the southern part of the district). Planning concerns are resource protection, hazard mitigation, and provision of adequate infrastructure.

Planning District 1--Fort Myers has a small part of its southwestern tip within the Coastal Study Area. Existing land uses in this portion of the planning district are primarily single family residential, with small multi-family, commercial, and public areas. Its 1986 dwelling unit count was 1,363. This is projected to increase slightly to its buildout capacity of 1,487 by 2010. The major Lee Plan land use category is Central Urban, with some Intensive Development. The planning concern is centered on hazard mitigation.

Planning District 2--South Fort Myers has its southwestern portion within the Coastal Study Area. Existing land uses include single family and multi-family residential, commercial (especially along U.S. 41), public, recreational (golf courses), and industrial. In 1986, dwelling units totaled 15,886. By 2010, this is projected to more than double to 32,294. By buildout, the expected total is 36,458 units. Planned land uses are Central Urban, Intensive Development, Urban Community, Industrial, and Resource Protection. Planning should account for hazard mitigation and the provision of adequate infrastructure.

Planning District 7--East Fort Myers has a very small part of its southwestern tip within the Coastal Study Area. Existing land uses include single family residential, industrial, and freshwater wetlands. Only 180 dwelling units were located in this portion of the planning district in 1986. Minimal growth to 473 units is projected in 2010 and to 683 units at buildout. Planned land uses are Rural and Industrial. Hazard mitigation is a planning concern.

LAND USE AND INFRASTRUCTURE ISSUES

Lee County has a very extensive, highly developed, and complex coastal area. The Coastal Study Area includes some 163 square miles of land, or about a fifth of the land area of the County. Because so much of the County lies within the 100 year flood zone, coastal management issues have a dominant role in overall land use planning and growth management. Despite extensive areas of protected wetlands, the Coastal Study Area includes some 40% of the 1985 tax base of the County; 16% of this tax base is located in the V (Velocity) Zone, the shoreline area most vulnerable to storm hazards. Because such a high proportion of the existing development is subject to coastal flooding, disaster management issues play a large role in land use planning and growth management. Finally, the complex geography of the Coastal Study Area with its barrier and sound coastal islands, its multiple rivers and bays, and its salt and freshwater wetlands, requires a sophisticated planning process that blends land use and environmental management with progressive public policymaking.

Because Lee County is subject to coastal storms and hurricanes, its land use and growth management policies must account for these potential natural disasters. While not a frequent target of hurricanes, the Lee shore has been struck in the past and prudence requires that the possibility of future strikes be considered in land use and coastal management policy. Because of uncertainty about the exact location and force of future hurricances, plans for mitigating or reducing the negative impacts of such strikes are usually based on two time frames: 1) before the storm, when general mitigation measures may be taken, and 2) after the storm, when the worst is known about specific destruction and plans can be adjusted on the basis of actual damage assessments.

Pre-Storm Hazard Mitigation and Development Management

In the face of certain future coastal storms and likely future sea level rise, the dynamic barrier islands and beaches will be unstable platforms for urban development. Different policies are needed for the undeveloped barriers, which should be conserved in their natural state, exempted from public infrastructure investments, and allowed to retreat before wave forces; and for the developed barriers, which require a balance of conservation, beach replenishment, and development management to ensure protection of coastal resources, property, and human life. Similarly, the developed coastal sound islands, while not exposed to the same wave action as the barriers, also require a balance of conservation and development management to avoid overloading the carrying capacity of both ecological and manmade systems (such as evacuation route)s. (See Chapters IV, V, and VI for detailed analyses of coastal natural resource systems.)

Mainland areas subject to coastal flooding constitute a large proportion of existing and future development within the County. The shoreline of most of this area is now protected under the Lee Plan through designation of the coastal wetlands as very low density Resource Protection (environmentally critical) Areas. These wetlands must be strictly protected from urban development in the future, and conservation practices extended inland through drainage basin plans that recognize the interconnected nature of coastal natural resource systems. Future land development in all areas subject to coastal flooding must be regulated to ensure that public expenditures are not unduly exposed to storm hazards, that measures are taken to protect people and property, and that natural systems are conserved and enhanced.

Post-Storm Hazard Mitigation and Development Management

Following the next major hurricane that strikes Lee County, it will be necessary to take another hard look at planned land use in the coastal area. Many of the current assumptions about appropriate development locations and practices could well be wiped out in a direct hit by a Category Three or Four hurricane. Chapter VII (Hurricane Evacuation and Hazard Mitigation) proposes a procedure for reassessing development and redevelopment options following a disaster. This chapter discusses land use implications of rebuilding after a major hurricane.

Redevelopment of some parts of the developed barrier islands, such as Captiva, could be rendered untenable under a scenario in which existing buildings and roads are destroyed, shorelines eroded hundreds of feet, new inlets cut through, and large areas overwashed by a massive storm surge. Under such an extreme circumstance, it could be necessary to consider returning vulnerable areas to undeveloped status through public acquisition and prohibition of rebuilding on the beach. Current policy which permits the rebuilding to original size of structures damaged beyond 50% of replacement cost by natural forces, providing they comply with federal, state, and local regulations, would be difficult to apply if original property lines were permanently under water due to shoreline erosion during a major hurricane.

Because most of the developed mainland sections in the coastal area are not in the V Zone, their hurricane damage would tend to be caused by still water flooding and high winds. Reconstruction in this case would not be as problematic as in areas overtopped by storm surge. Even here, however,

redevelopment should be guided by concern for future hazard mitigation. All rebuilt structures should be elevated and floodproofed to meet federal flood insurance requirements. Roads and utility systems should be relocated outside vulnerable areas, where possible. Evacuation routes should be expanded to meet future demands.

GOALS, OBJECTIVES, AND POLICIES

Three major goals are proposed for managing land use in the Coastal Study Area. They are aimed at Resource Protection, Protection of Life and Property, and Limitation of Public Expenditures in Hazard Areas.

GOAL 1: RESOURCE PROTECTION. To protect the natural resources of the coastal area from damage caused by development.

OBJECTIVE 1.1: ENVIRONMENTALLY CRITICAL AREAS. By 1990, land within and adjacent to coastal area environmentally critical areas, including present Resource Protection Areas and other critical areas identified by the Coastal Study, shall be regulated and managed so as to conserve and enhance the natural functions of these critical areas.

POLICY 1.1.1: Undeveloped coastal barriers shall be maintained in their natural state, no development shall be permitted in critical environmental areas, and no public expenditures for infrastructure shall be allowed on them.

POLICY 1.1.2: Critical environmental areas on developed coastal barriers, coastal sound islands, and mainland shoreline areas shall be expanded to include natural resource systems necessary to the healthy functioning of estuarine areas, and development shall be limited in these areas as well as in current Resource Protection Areas.

GOAL 2: PROTECTION OF LIFE AND PROPERTY. To protect human life and developed property from natural disasters.

OBJECTIVE 2.1: DEVELOPMENT IN HAZARD AREAS. By 1990, development within the V Zones shall not be allowed seaward of the Coastal Construction Control Line, new development on barrier islands shall be limited to densities that meet required evacuation standards, no new development requiring sea walls for protection from coastal erosion will be permitted, and densities within vulnerable A Zone areas will be reduced where possible.

POLICY 2.1.1: Pending revisions to coastal construction setback lines by the state, all development shall adhere to coastal setback criteria previously established by the County.

POLICY 2.1.2: New development on barrier and coastal islands shall not be permitted if capacity of critical evacuation routes would be exceeded.

POLICY 2.1.3: Shoreline development in V Zones shall be protected from coastal erosion, wave action, and storms by setbacks and/or beach replenishment, rather than hardened coastal structures such as sea walls which tend to hasten beach erosion.

POLICY 2.1.4: Land use designations of undeveloped areas within the A Zone shall be considered for reduced density categories or assignment of

minimum allowable densities where density ranges are permitted, in order to limit the future population exposed to coastal flooding and hurricane damage.

GOAL 3: LIMITATION OF PUBLIC EXPENDITURES IN HAZARD AREAS. To restrict public expenditures in areas subject to destruction by natural disasters, except to maintain required service levels, to protect existing residents, and to provide for recreation and open space uses.

OBJECTIVE 3.1: HAZARD AREA EXPENDITURES. By 1990, public expenditures in areas subject to destruction by natural disasters shall be limited to necessary repairs, public safety needs, and recreation and open space uses.

POLICY 3.1.1: All further public expenditures made for new facilities on undeveloped coastal barriers, within V zones, or within other areas subject to destruction by natural disasters, shall require a finding by the County Commission that such expenditures are vital to maintain required service levels, to protect existing residents, or to provide for recreation and open space needs.

POLICY 3.1.2: No new bridges or causeways shall be constructed to undeveloped barrier islands.

TABLE III-1. LEE PLAN RESIDENTIAL DENSITIES.

	Standard Density Range	Maximum Bonus Density
Intensive Development Area	8-14 du/acre	22 du/acre[1]
Central Urban Area	5-10 du/acre	15 du/acre[1]
Urban Community[2]	0.5-6 du/acre	10 du/acre[1]
Suburban	0.5-6 du/acre	No Bonus
Rural Areas	1 du/1 acre	No Bonus
Open Lands	1 du/1-5 acre	No Bonus
Fringe Area	0.5-6 du/acre	10 du/acre[1]
Transition Zones	1 du/20 acre	No Bonus
Resource Protection Areas	1 du/40 acre	No Bonus
Planned Devel. Dist. Option	0.5-6 du/acre	No Bonus
New Community	6 du/acre Maximum	

1 As a planned development and if development rights are transferred from Resource Protection Areas or Transition Zones or critical upland habitat for flora and fauna indicated as endangered, threatened, or species of special concern in the "Official Lists of Endangered Fauna and Flora in Florida," Florida Game and Freshwater Fish Commission, as periodically updated, or is at least ten percent (10%) of the residential units are permanently for low and moderate income families as defined by the most recent definition from the U.S. Department of Housing and Urban Development Section 8.
(Adopted by Ordinance 86-35)

2 In no case shall the maximum permitted density exceed 3 du/acre on Captiva Island and Gasparilla Island.

3 No land shall be rezoned on Pine Island, excluding the Matlacha, Bokeelia, and St. James City areas which currently are classified as Urban Service, to a Zoning

District which permits a density higher than three (3) dwelling units per gross acre. Land currently zoned in a Zoning District which permits a residential density in excess of three (3) dwelling units per gross acre shall be allowed a density higher than 3 du/acre provided, however, that all applicable regulations are met and provided further, that no density shall be allowed above that which is permitted for the Land Use category in which the property is located, or which is permitted by the zoning which was in effect for said property as of November 25, 1986, whichever is lower.
(Adopted by Ordinance 86-35)

4 Adherance to minimum densities should not be construed as mandatory but are recommended and desirable in order to promote the Urban Service Theory.
(Adopted by Ordinance 86-35)

Lee County Coastal Study
Land Use and Land Cover Classification

Code	Description
0---	Precede any 3 digit code with 0 to signify abandoned use
1000	Urban and built up
1001	Mixed land use
1100	Residential, low density (less than two dwelling units per acre)
1101	Vacant residential lot, low density
1110	Fixed single family units
1120	Mobile home units
1124	Low density travel trailers, not transient
1125	Low density mixed travel trailers, mobile homes
1130	Mixed units (fixed and mobile home units)
1139	Low density condominiums on divided land
1190	Low density under construction
1200	Residential medium density (2 to 5 DU per acre)
1201	Vacant residential lot, medium density
1210	Fixed single family units
1220	Mobile home units
1224	Medium density travel trailers, not transient
1225	Medium density mixed travel trailers, mobile homes
1230	Mixed units (fixed and mobile home units)
1239	Medium density condominiums on divided land
1290	Medium density under construction
1300	Residential high density
1301	Vacant residential lot, high density
1310	Fixed single family units (6 or more DU per acre)
1320	Mobile home units (6 or more DU per acre)
1324	High density travel trailers, not transient
1325	High density mixed travel trailers, mobile homes
1330	Multiple dwelling units, low rise (2 stories or less)
1331	Duplex
1334	Apartment units
1339	Condominiums on divided land (separate lots)
1340	Multiple dwelling units, high rise (3 stories or more)
1350	Mixed units (fixed and mobile home units)
1390	High density under construction
1400	Commercial and services
1401	Vacant commercial
1409	Accessory parking on separate parcel related to commercial use
1410	Retail sales and services
1411	Shopping center (see 9400)
1412	Service stations
1413	Banking facilities
1414	Convenience stores (without gas pumps)
1415	Restaurants

Code	Description
1416	Builders' supply
1417	Petroleum (fuels)
1418	Mixed sales and services
1419	Convenience stores with gas pumps
1420	Wholesale sales and services
1421	Warehouses
1422	Mini-warehouses
1423	Junkyard
1424	Farmers' markets
1425	Other, includes bulk storage other than boats
1430	Professional services - includes realtors
1440	Cultural and entertainment
1441	Theaters
1442	Museums
1443	Open air theaters
1444	Amphitheaters
1445	Amusement parks
1446	Art galleries
1447	Libraries
1448	Other
1450	Tourist services
1451	Hotels
1452	Motels
1453	Travel trailer parks
1454	Campgrounds
1455	Other
1460	Oil and gas storage (except industrial and manufacturing)
1470	Mixed commercial and services
1480	Cemeteries
1490	Commercial and services under construction
1500	Industrial
1501	Vacant industrial
1502	Mixed industrial
1503	Building and contracting
1510	Food processing
1513	Seafood
1520	Timber processing
1530	Mineral processing
1540	Oil and gas processing
1550	Other light industrial
1551	Boat building and repair
1552	Electronics industry
1553	Furniture manufacturers
1554	Aircraft building and repair
1555	Container manufacturers (cans, bottles, etc.)
1556	Mobile home manufacturers
1560	Other heavy industrial
1561	Ship building and repair
1562	Pre-stressed concrete plants

Code	Description
1563	Metal fabrication plants
1564	Cement plants
1570	Industrial marinas
1590	Industrial under construction
1600	Extractive
0160	Abandoned extractive
1610	Strip mines
1620	Sand and gravel pits
1630	Rock quarries
1640	Oil and gas fields
1650	Reclaimed land
1660	Holding ponds
1700	Institutional
1701	Vacant institutional
1710	Educational facilities
1711	Universities or colleges
1712	Vocational schools
1713	High schools
1714	Middle schools
1715	Elementary schools
1720	Religious
1721	Parochial schools
1722	Churches, synagogues
1730	Military
1740	Medical and health care
1741	Hospitals
1742	Nursing homes or convalescent centers
1743	Clinics
1750	Governmental
1751	City halls
1752	Court houses
1753	Police stations
1754	Fire stations
1755	Office buildings
1756	Maintenance yards
1757	Post offices
1758	Other - includes light houses
1760	Correctional
1770	Other institutional
1771	Non-profit social service
1772	Group homes
1773	Fraternal and service
1780	Commercial child care
1790	Institutional under construction
1800	Recreation
1801	Private recreational facilities
1810	Swimming beach
1820	Golf courses

Code	Description
1830	Race tracks
1831	Automobile tracks
1832	Horse tracks
1833	Dog tracks
1840	Marinas and fish camps
1841	Marinas (basins)
1842	Fish camps
1850	Parks and zoos
1851	City parks, including any government owned parks
1852	Zoos
1860	Community recreational facilities
1861	Baseball
1862	Basketball
1863	Football/soccer
1864	Tennis
1870	Stadiums (not educational)
1880	Historical sites
1881	Prehistoric
1882	Historic
1890	Other recreational
1891	Riding stables
1892	Go-cart tracks
1893	Skeet ranges
1894	Rifle and/or pistol ranges
1895	Golf driving ranges
1896	Other
1900	Open land
1910	Undeveloped land within urban areas
1920	Inactive land with street patterns but no structures
1930	Urban land in transition/no clear indicators of intended activity
1940	Other open land
1945	Wildlife preserve, nature or environmental; private or non-profit
2000	Agriculture
2100	Cropland and pasture land
2110	Improved pastures
2120	Unimproved pastures
2130	Woodland pastures
2140	Row crops
2150	Field crops
2156	Sugar cane
2157	Rice
2160	Fallow cropland
2200	Tree crops
2210	Citrus groves
2220	Fruit orchards
2230	Other groves

Code	Description
2300	Feeding operations
2310	Cattle feeding operations
2320	Poultry feeding operations
2330	Swine feeding operations
2400	Nurseries and vineyards
2410	Tree nurseries
2420	Sod farms
2430	Ornamentals
2440	Vineyards
2450	Floriculture
2460	Timber nurseries
2500	Specialty farms
2510	Horse farms
2520	Dairies
2530	Kennels
2540	Aquaculture
2590	Other specialty farms
2600	Other open land (rural)
2610	Fallow cropland
3000	Rangeland
3100	Herbaceous
3200	Sand scrub/oak, palmetto-rosemary
3210	Palmetto prairies
3220	Coastal scrub
3222	Coastal scrub
3223	Coastal scrub
3228	Coastal scrub/invaded by Brazilian pepper
3229	Coastal scrub/invaded by Australian pine
3290	Other shrubs and brush
3300	Mixed rangeland
4000	Upland forests
4100	Upland coniferous forests
4110	Pine flatwoods
4120	Slash pine/midstory oak
4123	Slash pine/midstory oak/invaded by melaleuca
4124	Slash pine/midstory oak/invaded by Brazilian pepper
4130	Sand pine
4140	Pine - cypress
4150	Pine and melaleuca
4190	Other pines

Code	Description
4200	Upland hardwood forests
4210	Sand scrub/oak, palmetto-rosemary
4220	Brazilian pepper
4230	Oak - pine - hickory
4240	Melaleuca invaded by pine flatwood
4250	Temperate hardwoods
4260	Tropical hardwoods
4263	Tropical hardwoods
4264	Tropical hardwoods
4270	Live oak hammock
4272	Live oak
4274	Live oak
4280	Cabbage palm hammock
4283	Cabbage palm
4284	Cabbage palm
4285	Cabbage palm/invaded by Brazilian pepper
4284	Cabbage palm/invaded by melaleuca
4290	Wax myrtle/schinus
4291	Willow
4300	Upland hardwood forests continued
4310	Beech - magnolia
4320	Sand live oak
4330	Western everglades hardwoods
4340	Hardwood - conifer mixed
4350	Dead trees
4370	Australian pine
4371	Australian pine
4372	Australian pine
4373	Australian pine
4374	Australian pine
4380	Mixed hardwoods
4390	Other hardwoods
4391	Cabbage palms and melaleuca
4392	Cabbage palms and oaks
4393	Cabbage palms and pines
4400	Tree plantations
4410	Pine plantations
4420	Hardwood plantations
4430	Forest regeneration areas
4440	Experimental tree plots
4450	Seed plantations
5000	Water
5100	Streams and waterways
5110	River
5120	Stream/freshwater
5130	Tidal creek

Code	Description
5140	Canal/fresh
5150	Canal/tidal
5200	Lakes
5210	Lakes larger than 500 acres
5220	Lakes larger than 100 acres but less than 500 acres
5230	Lakes larger than 10 acres but less than 100 acres
5240	Lakes less than 10 acres
5241	Cypress pond (open water)
5300	Reservoirs
5310	Reservoirs larger than 500 acres
5320	Reservoirs larger than 100 acres but less than 500 acres
5330	Reservoirs larger than 10 acres but less than 100 acres
5340	Reservoirs less than 10 acres which are dominant features
5400	Bays and estuaries
5410	Embayments opening directly into the Gulf or Atlantic
5412	Tidal pond
5420	Embayments not opening directly into the Gulf or Atlantic
5500	Major springs
5600	Slough waters
6000	Wetlands
6100	Wetland hardwood forests
6110	Coastal bay hammock
6120	Mangrove
6121	Mangrove
6122	Mangrove-Buttonwood/vegetated saltern > 50% cover
6123	Mangrove-Buttonwood/vegetated saltern < 50% cover
6124	Mangrove/invaded by Australian pine
6125	Mangrove/cleared, undeveloped
6126	Mangrove/rookery area
6127	Mangrove/invaded by melaleuca
6128	Mangrove/invaded by Brazilian pepper
6130	Gum swamps
6140	Stream swamps
6141	Stream swamps
6142	Stream swamps
6143	Stream swamps
6144	Stream swamps
6150	Stream and lake swamps (bottom land)
6160	Inland ponds and sloughs
6170	Mixed wetland hardwoods
6171	Mixed wetland hardwoods
6172	Mixed wetland hardwoods
6173	Mixed wetland hardwoods
6174	Mixed wetland hardwoods

Code	Description
6175	Mixed wetland hardwoods/invaded by melaleuca
6180	Wetland willow
6190	Wetland melaleuca
6200	Wetland coniferous forests
6210	Cypress
6211	Cypress domes and wet prairies
6214	Cypress/invaded by melaleuca
6220	Pond pine
6230	Atlantic white cedar
6240	Pine - cypress
6250	Cypress and melaleuca
6300	Wetland forested mixed
6400	Vegetated non-forested wetlands
6410	Fresh water marshes, < 66% dominant
6411	Sawgrass
6412	Cattail marsh
6413	Spartina bakeri marsh
6414	Freshwater marsh/invaded by melaleuca
6417	Bullrush
6418	Wire cordgrass
6420	Saltwater marsh
6422	Blackrush marsh
6423	Saltmarsh/predominantly saltwort/saltgrasses
6424	Saltmarsh/predominantly leather fern
6425	Saltmarsh/invaded by melaleuca
6430	Wet prairie (fresh)
6440	Emergent aquatic vegetation
6450	Submergent aquatic vegetation
6500	Non-vegetated
6510	Tidal flats
6520	Shorelines/not vegetated
6530	Intermittent ponds
6540	Oyster bars
7000	Barren land
7100	Beaches other than swimming beaches
7110	Dunes
7200	Sand other than beaches
7210	Overwash sand
7300	Exposed rock
7310	Exposed rock with marsh grasses
7400	Disturbed land
7410	Rural land in transition without indicators of intended activity

Code	Description
7420	Excavation areas
7430	Spoil areas
7440	Fill areas (highways - railways)
7450	Burned areas
7460	Cleared upland areas/not returned to native species composition
8000	Transportation, communication, and utilities
8100	Transportation
8101	Vacant transportation
8110	Airports
8111	Airports, large
8112	Airports, small grass
8120	Railroads
8130	Bus and truck terminals
8140	Roads and highways
8150	Port facilities
8160	Canals and locks
8170	Oil, water or gas long distance transmission lines
8180	Auto parking facilities (not related to other land use)
8190	Transportation facilities under construction
8200	Communications
8201	Vacant communication
8210	Transmission towers
8220	Communication facilities
8221	Telephone
8222	Radio
8223	Television
8290	Communication facilities under construction
8300	Utilities
8301	Vacant utilities
8310	Electrical power facilities
8320	Electrical power transmission lines
8330	Water supply plants
8331	Treatment plants
8332	Settling plants
8333	Water tanks
8334	Well fields
8335	Pumping stations
8340	Sewage treatment
8341	Treatment plants
8342	Lift stations
8343	Aeration fields
8344	Percolation ponds
8350	Solid waste disposal
8390	Utilities under construction
9000	Special classifications

Code	Description
9111	Sea grass/sparse-medium
9112	Sea grass/dense
9113	Sea grass/patchy
9400	Shopping centers (detailed)
9410	Neighborhood shopping centers
9420	Community shopping centers
9430	Regional shopping centers
9440	Specialty malls

IV. ECOLOGICAL INVENTORY AND ANALYSIS OF THE LEE COUNTY COASTAL ZONE AND RECOMMENDATIONS FOR FUTURE RESOURCE MANAGEMENT

by
Kevin L. Erwin

Purpose

This study is designed to meet the requirements of the 1985 Local Government Comprehensive Planning and Land Development Regulation Act (particularly Section 163.3178, Florida Statutes), and the 1986 Department of Community Affairs minimum criteria for review of local government comprehensive plans and determination of compliance (Chapter 9J-5, Florida Administrative Code, particularly Rule 9J-5.012). This study's inventory and analysis will be used by Lee County to prepare amendments to the comprehensive plan to incorporate the required coastal management goals, objectives, and policies. The purpose of this study is to provide an inventory and evaluation of the natural resources within Lee County's coastal zone which is based upon a scientific database. Findings are presented concerning 1) the limits of the study area, 2) the location of watershed basins within the study area, 3) vegetative cover, 4) wetlands and submerged estuarine habitats, 5) rare and unique habitats, 6) wildlife including listed species, 7) flora including listed species, 8) fisheries, and 9) a detailed literature synthesis. From this data Lee County's coastal natural resources have been identified and future management practices recommended to assure protection and conservation of critical resources.

Methodology

The study area boundary for purposes of the natural resources evaluation was established to include all areas of Lee County seaward of the upper limits of the A zone or 100 year floodplain, excluding those incorporated areas such as the City of Sanibel, the City of Cape Coral, and the City of Fort Myers.

Geographical features such as barrier islands, estuaries and coastal islands, and mainland watersheds were selected as discrete ecosystem units for database management and evaluation of the natural resource inventories conducted throughout the study area. Watershed boundaries were established by utilizing the vegetative cover maps prepared for this study, aerial topographic maps furnished by Lee County, and limited groundtruthing. The barrier island and mainland watershed evaluations do not include inventories of any offshore or adjacent waterbody features. Pine Island and Little Pine Island are evaluated as discrete geographical units although they are not considered barrier islands.

The entire study area, including the estuaries and associated islands, was mapped using the Florida Land Use Cover and Forms Classification System (FLUCFCS) Level III (FDOT, 1985). This detailed mapping was accomplished by using 1" = 300' aerial photographs (1981) upon which the final Level III classification

lines are drawn (Appendix IV-I), 1" = 300' aerial photographs with topographic (1984), 1" = 300' aerial photographs (1986), 1" = 1,320' color infrared photographs (NHAP), and groundtruthing. The final mapping was completed on the Lee County 1981 aerial photograph mylars since this set of photographs has the highest resolution. All mapping was cross referenced with the 1986 series of aerial photographs so that corrections could be made with regard to newly developed areas which have occurred since the 1981 aerial photographs were made. Only natural areas were mapped and no attempt was made to map small (<2 acres) vegetated areas located wholly within developments such as residential subdivisions. The mapping of the estuaries and associated islands was done on the color infrared aerials obtained from National Aeronautics and Space Administration's High Altitude Photograph Section (Appendix IV-II).

All mapped habitats were planimetered with habitat acreages compiled according to Section, Township, and Range and then for each ecosystem unit (Appendix IV-III).

Inventories of flora and fauna were compiled via literature synthesis. Lists are given for each Level III habitat classification of typical species of fauna (Appendix IV-IV) and indicator species of flora (Appendix IV-V) that are expected to be found within these habitats. Special emphasis is given to species that are listed by the State of Florida or the U.S. Fish and Wildlife Service as endangered or threatened species. The current status of Endangered, Threatened, and Species of Special Concern within the Lee County coastal area is presented in Appendix IV-IV and IV-V. Commercial fish landings data (pounds and dollars) was collected from the Florida Department of Natural Resources and the National Marine Fisheries Service and presented in Appendix IV-VI.

A literature synthesis was conducted to prepare a "Reference Bibliography" of reports, studies, books, and scientific articles that were undertaken within the Lee County coastal zone study area or whose findings would be applicable to the study area (Appendix IV-VII). The bibliography was compiled by conducting interviews and checking a number of private and institutional libraries. There is currently no centrally located source of information concerning natural resource studies that have been completed within the Lee County coastal zone.

Although the coastal area of Lee County has been discussed in a variety of studies it has not been systematically evaluated as an ecosystem, but rather, as an area within a larger region (ie. southwest Florida, Eastern Gulf or Mexico, etc.). In addition, previous studies which included some work in the Lee County coastal zone area usually consisted of nonspecific general information, and partial or estimated inventories. The objective of this study is to provide specific data on the coastal ecosystem so that the biological resources can be identified, a report given on their location, acreage and

relative abundance, suitability for conservation and conditions and policies required for their future protection.

EXISTING CONDITIONS

Ecosystem Units; A Description

The Lee County coastal study area occupies 220,148.27 acres of which 104,593.0 acres or 47.5% is land (including wetland) and 115,555.27 acres or 52.5% is water area (estuary). Developed lands, including farmland and cleared land, occupy 50,643.95 acres or 48.4% of the land area with undeveloped lands occupying 53,942.19 acres or 51.6% of the land area (Table IV-1). The habitat acreage totals for each ecosystem unit and the study area are provided in Table IV-2. Table IV-2 also provides the total undeveloped native land acreages for each unit. Table IV-3 provides acreages of the major native upland, wetland and estuarine areas within the study area. This study found significant acreages of native habitats infested by problematic exotic plants (6,171 acres or 31% of uplands and 524 acres of wetlands). Long recognized as a problem, Melaleuca, Schinus and Casuarina will continue to alter habitat structure function and diversity at an increasing rate without the implementation of effective corrective action.

Vegetative Cover

The vegetative cover mapping was completed on the 1" = 300' aerial photographs (1981) contained within Appendix IV-I. Overlays of the 1" = 1320' color infrared aerials are contained in Appendix IV-II. Sixty five (65) vegetative habitats were identified and mapped within this study area (Figure IV-1). Disturbed lands such as spoil and excavation areas, when located within vegetated areas, were also mapped. Most of the mapping was at Level III (three digit category number), however, some Level IV classifications were developed and used in order to describe some habitats with greater specificity, particularly with regard to infestation by problematic exotics such as Melaleuca, Schinus, and Casuarina. Appendix IV-V lists the plant indicator species for 26 major vegetation communities identified within the study area.

BARRIER ISLANDS

A description and geomorphological analysis of Lee County's barrier islands and inlets is given by Hine 1988. The Lee County barrier-island chain can be considered as two different systems; a north and south barrier system separated from each other by the mouth of San Carlos Bay (Hine 1988). The north barrier system consists of the southern three-fourths of Gasparilla Island, Cayo Costa, North Captiva, Captiva and Sanibel Islands. The south barrier system consists of Estero, Black Island/Lovers Key, Big Hickory, and Little Hickory (Bonita Beach) islands. These islands together total 4,317 acres of undeveloped terrestrial and wetland habitat. Three morphological categories of islands are found within this barrier system; 1) the undeveloped islands with

TABLE 1. Lee County Coastal Zone Acreages of Estuary Development and Undeveloped Land

	Total Acreage	% Study Area	% of Land Area
Study Area (Lands and Water)	220,148.27		
Study Area - Land (Including Wetland)	104,593.00	47.50	
Study Area - Water (Estuary)	115,555.27	52.50	
Undeveloped Land	53,942.19	24.50	51.60
Developed Land (Including 261 and 746)	50,643.95	23.00	48.40

TABLE 2. LEE COUNTY COASTAL STUDY HABITAT TOTALS BY ECOSYSTEM UNIT
Approximately 220,148.27 acres in study area

	261	320/421	321	322	3228
Gasparilla Island				85.08	79.21
Cayo Costa				735.68	
North Captiva				239.87	
Captiva					
Estero				38.35	
Pine Island	283.34	3.00	18.26		
Area East of Matlacha					
Burnt Store					
Yucca Pen Creek				.98	
Pontoon Bay	38.29				
Whiskey Creek	76.98				
Deep Lagoon	685.83				
Bunche Beach	142.25				
Iona	121.33				6.42
Cow Creek	533.09		4.17		
Hendry Creek	443.04		26.24		
Ten Mile Canal		3.02	4.08		
Mullock Creek	78.33		106.72		
Estero River		79.01	53.03		
Halfway Creek	37.28	132.99			
Coconut		89.52	35.54		
Spring Creek	92.65	243.57	85.00		
Imperial River	102.58	82.72	113.11		
Upper Little Hickory	9.82	2.58	23.77		
Little Pine Island			1.31		
Pine Isl. Misc. Isl.				14.25	
Estuaries					
Total	2644.81	636.41	471.23	1114.21	85.63

TABLE 2. LEE COUNTY COASTAL STUDY HABITAT TOTALS BY ECOSYSTEM UNIT
Approximately 220,148.27 acres in study area

	3229	411	412	4123	4124
Gasparilla Island	11.35				
Cayo Costa	101.14	67.49			
North Captiva	45.27				
Captiva					
Estero	78.71				
Pine Island		3847.67	5.10		
Area East of Matlacha					
Burnt Store		39.82			
Yucca Pen Creek					
Pontoon Bay					
Whiskey Creek		16.17	44.55		31.12
Deep Lagoon		216.65			38.06
Bunche Beach		4.23	64.23	4.21	
Iona		12.45	10.01		19.54
Cow Creek		1.72			
Hendry Creek		513.03	38.25	19.80	16.03
Ten Mile Canal		13.66		26.46	
Mullock Creek		72.51	114.74		
Estero River		213.70	59.76	3.88	
Halfway Creek		146.70			
Coconut		201.24			
Spring Creek		960.88	.69		.71
Imperial River		327.73			
Upper Little Hickory Bay		19.23			
Little Pine Island		36.91			
Pine Isl. Misc. Isl.					
Estuaries	1.73				
Total	238.20	6711.79	337.33	54.35	105.46

TABLE 2. LEE COUNTY COASTAL STUDY HABITAT TOTALS BY ECOSYSTEM UNIT
Approximately 220,148.27 acres in study area

	414/624	422	424	426	427
Gasparilla Island		.43			
Cayo Costa				77.87	
North Captiva				22.04	
Captiva				144.96	
Estero					4.12
Pine Island		145.04	522.22	7.02	25.59
Area East of Matlacha					
Burnt Store					
Yucca Pen Creek					
Pontoon Bay		4.47	159.04		
Whiskey Creek		2.01	50.16		
Deep Lagoon		69.01	235.24		4.92
Bunche Beach		48.55	5.68	10.71	8.80
Iona		36.44	41.79	15.48	.89
Cow Creek		23.73	556.93	2.71	
Hendry Creek	26.98	36.71	1151.80		18.44
Ten Mile Canal	5.95		422.38		1.51
Mullock Creek			519.21		
Estero River			250.53		
Halfway Creek			10.13		
Coconut			43.79		
Spring Creek		6.31	42.71		2.04
Imperial River			15.59		8.91
Upper Little Hickory	.91		13.27		
Little Pine Island			589.21		
Pine Isl. Misc. Isl.				56.44	11.15
Estuaries				114.43	
Total	33.84	372.70	4629.68	451.66	86.37

TABLE 2. LEE COUNTY COASTAL STUDY HABITAT TOTALS BY ECOSYSTEM UNIT
Approximately 220,148.27 acres in study area

	428	4285	4286	429	4291
Gasparilla Island					
Cayo Costa	541.50				
North Captiva	96.52				
Captiva					
Estero					
Pine Island	10.97	3.65	23.54		1.86
Area East of Matlacha					
Burnt Store					
Yucca Pen Creek					
Pontoon Bay					
Whiskey Creek					
Deep Lagoon	91.00	8.30	9.21		1.93
Bunche Beach	14.60		17.39		1.30
Iona	7.93	4.35	6.01		
Cow Creek	5.23				
Hendry Creek	7.03	10.63	4.54		4.12
Ten Mile Canal			.88		
Mullock Creek	26.47				4.72
Estero River	5.64				
Halfway Creek					
Coconut	67.16		52.38		22.36
Spring Creek	102.58	11.76		1.34	.86
Imperial River	23.59		.93	11.59	
Upper Little Hickory Bay					.82
Little Pine Island					
Pine Isl. Misc. Isl.					
Estuaries					
Total	1000.22	38.69	114.88	12.93	37.97

TABLE 2. LEE COUNTY COASTAL STUDY HABITAT TOTALS BY ECOSYSTEM UNIT
Approximately 220,148.27 acres in study area

	437	441	5412	611	612
Gasparilla Island	7.30		10.53		216.33
Cayo Costa	14.21				648.44
North Captiva					154.75
Captiva	5.84		.47		392.46
Estero	20.41		5.87		943.97
Pine Island	306.94		109.34		7076.49
Area East of Matlacha			.22		242.30
Burnt Store					10.41
Yucca Pen Creek	.98				46.04
Pontoon Bay	2.02		12.10		779.39
Whiskey Creek	12.95				29.89
Deep Lagoon	34.90		29.22		386.19
Bunche Beach			22.54		1064.68
Iona	10.30		14.79		1583.30
Cow Creek			163.46		3334.69
Hendry Creek	92.85	26.98	33.47		1525.78
Ten Mile Canal					
Mullock Creek	.35		1.17		320.19
Estero River			17.38		1044.50
Halfway Creek	7.29				28.02
Coconut			19.59		684.09
Spring Creek			3.62	42.01	776.55
Imperial River	1.56				115.92
Upper Little Hickory Bay					
Little Pine Island			177.20		3668.14
Pine Isl. Misc. Isl.	.63		14.89		1018.22
Estuaries			29.98		1822.39
Total	518.53	26.98	665.84	42.01	27913.13

TABLE 2. LEE COUNTY COASTAL STUDY HABITAT TOTALS BY ECOSYSTEM UNIT
Approximately 220,148.27 acres in study area

	6122	6123	6124	6125	6127
Gasparilla Island	5.64	.79	2.25	3.84	
Cayo Costa	20.46	.49			
North Captiva	20.29				
Captiva					
Estero	2.81	2.89	14.42	6.17	
Pine Island	71.89	133.21	11.32	37.92	36.08
Area East of Matlacha		.38			
Burnt Store					
Yucca Pen Creek					
Pontoon Bay		31.38			
Whiskey Creek					
Deep Lagoon	12.21			3.66	2.45
Bunche Beach	161.62	3.20	5.73		
Iona	20.09	15.71		3.12	137.40
Cow Creek	21.22	238.25			2.01
Hendry Creek	55.18	124.77			
Ten Mile Canal					
Mullock Creek	15.36	17.77			
Estero River	26.70	35.90			
Halfway Creek			.32		
Coconut	8.35	13.75			
Spring Creek	9.19	65.91			
Imperial River					
Upper Little Hickory Bay					
Little Pine Island	17.95	172.11			
Pine Isl. Misc. Isl.			8.81		
Estuaries					
Total	468.96	856.51	42.85	54.71	177.94

TABLE 2. LEE COUNTY COASTAL STUDY HABITAT TOTALS BY ECOSYSTEM UNIT
Approximately 220,148.27 acres in study area

	6128	614	617	6175	621
Gasparilla Island					
Cayo Costa					
North Captiva					
Captiva					
Estero					
Pine Island	76.35				
Area East of Matlacha					
Burnt Store					
Yucca Pen Creek					
Pontoon Bay					
Whiskey Creek	2.50				.65
Deep Lagoon	5.15				
Bunche Beach	2.02				
Iona					
Cow Creek					
Hendry Creek					
Ten Mile Canal				5.53	7.41
Mullock Creek			56.91		.95
Estero River					4.38
Halfway Creek		3.98	24.77		63.85
Coconut					
Spring Creek			53.75		
Imperial River			41.15		
Upper Little Hickory Bay			17.01		
Little Pine Island					
Pine Isl. Misc. Isl.					
Estuaries					
Total	86.02	3.98	193.59	5.53	77.24

TABLE 2. LEE COUNTY COASTAL STUDY HABITAT TOTALS BY ECOSYSTEM UNIT
Approximately 220,148.27 acres in study area

	6214	641	6411	6412	6413
Gasparilla Island					
Cayo Costa		22.94			
North Captiva		1.22			
Captiva					
Estero					
Pine Island		7.46		4.92	1.18
Area East of Matlacha					
Burnt Store					
Yucca Pen Creek					
Pontoon Bay		17.45			
Whiskey Creek				2.17	
Deep Lagoon		23.78		7.52	
Bunche Beach					
Iona				2.81	
Cow Creek		29.35			5.43
Hendry Creek	2.33	47.62	13.21	7.65	
Ten Mile Canal	26.35	1.50		4.09	
Mullock Creek	39.45	21.17	.80		
Estero River	7.02				
Halfway Creek		7.83			
Coconut		6.54			
Spring Creek		108.47	2.98		
Imperial River		32.74			
Upper Little Hickory Bay		8.58	7.73		
Little Pine Island					
Pine Isl. Misc. Isl.					
Estuaries					
Total	75.15	336.65	24.72	29.16	6.61

TABLE 2. LEE COUNTY COASTAL STUDY HABITAT TOTALS BY ECOSYSTEM UNIT
Approximately 220,148.27 acres in study area

	6414	642	6422	6423	6424
Gasparilla Island				.43	
Cayo Costa		.36			
North Captiva					
Captiva					
Estero				1.26	
Pine Island	9.90	.50	1.28	112.04	.28
Area East of Matlacha					
Burnt Store					
Yucca Pen Creek					
Pontoon Bay			114.99	86.48	
Whiskey Creek					
Deep Lagoon	2.80	9.80	11.15	35.50	
Bunche Beach		80.95		15.24	
Iona	2.50	3.49			
Cow Creek	8.01	16.52	79.19	586.39	
Hendry Creek	6.27	9.63	613.57	264.17	
Ten Mile Canal	5.88				
Mullock Creek		7.59	151.89	8.21	
Estero River		6.02	92.93		
Halfway Creek		14.78			
Coconut		36.52			
Spring Creek		69.61	17.43		
Imperial River			60.09		
Upper Little Hickory Bay					
Little Pine Island				348.10	
Pine Isl. Misc. Isl.				2.43	
Estuaries					
Total	35.36	255.77	1142.52	1460.25	.28

TABLE 2. LEE COUNTY COASTAL STUDY HABITAT TOTALS BY ECOSYSTEM UNIT
Approximately 220,148.27 acres in study area

	6425	643	651	652	721
Gasparilla Island			.52		
Cayo Costa					
North Captiva				6.55	7.31
Captiva					
Estero			65.86		
Pine Island	4.18				
Area East of Matlacha					
Burnt Store					
Yucca Pen Creek					
Pontoon Bay					
Whiskey Creek					
Deep Lagoon	24.00	1.32			
Bunche Beach					
Iona	7.10				
Cow Creek	66.13				
Hendry Creek					
Ten Mile Canal					
Mullock Creek		6.03			
Estero River		.87			
Halfway Creek					
Coconut					
Spring Creek		19.71			
Imperial River		19.60			
Upper Little Hickory Bay		10.81			
Little Pine Island					
Pine Isl. Misc. Isl.					
Estuaries					
Total	101.41	58.34	66.38	6.55	7.31

TABLE 2. LEE COUNTY COASTAL STUDY HABITAT TOTALS BY ECOSY
Approximately 220,148.27 acres in study area

	746	9111	9112	9113
Gasparilla Island				
Cayo Costa	12.84			
North Captiva	19.76			
Captiva				
Estero	2.33			
Pine Island	2.40			
Area East of Matlacha				
Burnt Store				
Yucca Pen Creek				
Pontoon Bay				
Whiskey Creek	37.26			
Deep Lagoon	160.16			
Bunche Beach	33.91			
Iona	24.89			
Cow Creek				
Hendry Creek	52.13			
Ten Mile Canal	108.94			
Mullock Creek				
Estero River				
Halfway Creek				
Coconut				
Spring Creek				
Imperial River				
Upper Little Hickory Bay				
Little Pine Island				
Pine Isl. Misc. Isl.				
Estuaries		13028.35	43116.72	9692.74
Total	454.62	13028.35	43116.72	9692.74

TABLE 2. LEE COUNTY COASTAL STUDY HABITAT TOT
Approximately 220,148.27 acres in st

	Mapped Acreage Totals	(undevel-oped)
Gasparilla Island	423.70	(423.70)
Cayo Costa	2243.42	(2230.58)
North Captiva	613.58	(543.73)
Captiva	543.73	(543.82)
Estero	1187.17	(1184.84)
Pine Island	12900.94	(12615.20)
Area East of Matlacha	242.90	(242.90)
Burnt Store	50.23	(50.23)
Yucca Pen Creek	48.00	(48.00)
Pontoon Bay	1245.61	(1207.32)
Whiskey Creek	306.41	(192.17)
Deep Lagoon	2109.96	(1263.97)
Bunche Beach	1711.84	(1535.68)
Iona	2108.14	(1961.92)
Cow Creek	5678.23	(5145.14)
Hendry Creek	5192.25	(4697.08)
Ten Mile Canal	637.64	(528.70)
Mullock Creek	1570.54	(1492.21)
Estero River	1901.25	(1901.25)
Halfway Creek	477.94	(440.66)
Coconut	1280.83	(1280.83)
Spring Creek	2720.33	(2627.68)
Imperial River	957.81	(855.23)
Upper Little Hickory	114.53	(104.71)
Little Pine Island	5010.93	(5010.93)
Pine Isl. Misc. Isl.	1126.82	(1126.20)
Estuaries	67806.34	(67806.34)
Total	120211.07	(117061.02)

TABLE 3. Summary of Habitat Acreages

Part 1.	Total Acreage	% Study Land Area	% Undeveloped Land (incl. wet.)	% of Upland
Undeveloped Upland	19,665.91	18.80	36.50	
Undeveloped Upland without exotics	13,494.86	12.90	25.00	68.60
Undeveloped Upland with exotics	6,171.05	5.90	11.40	31.40

Part 2.	Total Acreage	% Study Land Area	% Undeveloped Land Area	Freshwater Wetland Acreage	Tidal Wetland Acreage	% of Wetland Area
Wetland without exotics	33,752.03	32.30	62.60	844.18	32,907.85	
Wetland with exotics	524.26	0.50	1.00	116.04	408.22	
Wetland Freshwater and Tidal	34276.28	32.80	63.50			
Tidal Wetlands (Marsh and Swamps)	33,316.07	31.90	61.80			97.20
				% of Tidal Wetland		
Tidal Marsh/Pond	3,625.95	3.50	6.70	10.90		10.60
Tidal Swamp/Mangrove	29,690.12	28.40	55.00	89.10		86.60
Freshwater Wetland (Marsh and Swamp)	960.22	0.90	1.80			2.80
				% of Freshwater Wetland		
Freshwater Marsh	490.84	0.50	0.90	50.80		1.40
Freshwater Swamp	469.38	0.50	0.90	49.20		1.40
Estuarine Study Area	115,555.27					
Estuary vegetated with seagrasses	65,904.19					
Estuary not vegetated with seagrasses	49,651.08					

FIGURE 1. LEVEL III CLASSIFICATION LIST: LEE COUNTY COASTAL ZONE

Category	Habitat Type	Acreage
181	BEACHES/SWIMMING	N/A
261 Dev.	FALLOW CROP LAND	2,644.81
320/421	SAND SCRUB/OAK-PALMETTO-ROSEMARY	633.40
321	PALMETTO PRAIRIE	471.23
322 (1-4)	COASTAL SCRUB	1,114.21
3228	COASTAL SCRUB/INVADED BY BRAZILIAN PEPPER	85.63
3229	COASTAL SCRUB/INVADED BY AUSTRALIAN PINE	238.20
411 (1-4)	PINE FLATWOOD	6,711.79
412	SLASH PINE/MIDSTORY OAK	337.39
4123	SLASH PINE/MIDSTORY OAK/INVADED BY MELALEUCA	54.35
4124	SLASH PINE/INVADED BY BRAZILAIN PEPPER	105.46
414/624	PINE-CYPRESS	33.84
422	BRAZILIAN PEPPER	372.70
424	MELALEUCA INVADED PINE FLATWOOD	4,629.68
426	TROPICAL HARDWOOD	454.66
427	LIVE OAK HAMMOCK	86.37
428	CABBAGE PALM HAMMOCK	1,000.22
4285	CABBAGE PALM/INVADED BY BRAZILIAN PEPPER	38.69
4286	CABBAGE PALM/INVADED BY MELALEUCA	114.88
429	WAX MYRTLE/SCHINUS	12.93
4291	WILLOW	37.98
437 (1-4)	AUSTRALIAN PINE	518.53
441	PINE PLANTATION (INCL. W/ 411 FOR COMPUTATIONS) OLD GROWTH	26.98
511	RIVER	N/A
512	STREAM/FRESHWATER	N/A
513	TIDAL CREEK	N/A
514	CANAL/FRESH	N/A
515	CANAL/TIDAL	N/A
524	LAKE/<10 AC	N/A
5241	CYPRESS POND (OPEN WATER)	N/A
5412	TIDAL POND	665.84
611	COASTAL BAY HAMMOCK	42.01
612	MANGROVE	27,913.13
6122	MANGROVE-BUTTONWOOD/VEGETATED SALTERN > 50% COVER	468.96
6123	SALTERN/ < 50% VEGETATION COVER	946.51

FIGURE 1. CONTINUED

6124	MANGROVE/INVADED BY AUSTRALIAN PINE	42.85
6125	MANGROVE/CLEARED, UNDEVELOPED	54.71
6127	MANGROVE/INVADED BY MELALEUCA	177.94
6128	MANGROVE/INVADED BY BRAZILIAN PEPPER	86.02
614 (1-4)	STREAM SWAMP	3.98
617 (1-4)	MIXED WETLAND HARDWOODS	193.65
6175	MIXED WETLAND HARDWOODS/INVADED BY MELALEUCA	5.53
621	CYPRESS	77.24
6214	CYPRESS/INVADED BY MELALEUCA	75.15
641	FRESHWATER MARSH/ <66% DOMINANT	336.65
6411	SAWGRASS	24.72
6412	CATTAIL MARSH	29.16
6413	SPARTINA BAKERI MARSH	6.61
6414	FRESHWATER MARSH/INVADED BY MELALEUCA	35.36
642	SALTWATER MARSH	255.65
6422	BLACKRUSH MARSH	1,142.52
6423	SALTMARSH/PREDOMINANTLY SALTWORT/SALTGRASSES	1,460.25
6424	SALTMARSH/PREDOMINANTLY LEATHER FERN	.28
6425	SALTWATER MARSH/INVADED BY MELALEUCA	101.41
643	WET PRAIRIE (FRESH)	58.34
651	TIDAL FLATS	66.38
652	SHORELINES/NON-VEGETATED	6.55
654	OYSTER BARS	N/A
710	BEACHES/OTHER THAN SWIMMING BEACHES	N/A
721	OVERWASH SAND	7.31
742	EXCAVATION AREA	N/A
743	SPOIL AREAS	N/A
746 Dev.	CLEARED UPLAND AREAS/NOT RETURNED TO NATIVE SPECIES COMPOSITION (EXOTICS ONLY)	454.62
911	SEAGRASS/SPARSE-MEDIUM	N/A
9112	SEAGRASS/DENSE	N/A
9113	SEAGRASS/PATCHY	N/A
TOTAL MAPPED AREA		54,463.20

large areas of relatively pristine upland and wetland habitats, 2) the undeveloped islands dominated by a low elevation profile (little or no uplands) and mangrove habitat, and 3) islands dominated by extensive development with little remaining native habitat.

Seven major barrier island complexes form the seaward boundary of the coastal zone from Gasparilla Island south to the Bonita Beach/Big Hickory Island Complex. Pine Island Sound, Matlacha Pass, Charlotte Harbor, San Carlos and Estero Bays and the tidal Caloosahatchee River comprise the major elements of one of the most pristine estuarine systems within an urbanized area of the state. The estuaries are bordered by extensive mangrove and salt marsh wetlands which form a buffer between the open water and the flat poorly drained upland habitats.

There are 19 native habitat types found on Lee County's barrier-islands. (Only undeveloped lands were evaluated and mapped.) The major vegetation associations found on the barrier islands (Figure IV-2) are mangrove (1,932.83 acres or 44.8%), coastal scrub (1,413.83 acres or 32.7%), cabbage palm hammock (637.05 acres or 14.8%), tropical hardwoods (79.58 acres or 1.8%), and pine flatwood (67.49 acres or 1.1%). As detailed in Figure IV-3, the amount of remaining native (undeveloped) land varies greatly from one barrier island to the next. The total mapped area in Figure IV-3 shows the remaining acreages of undeveloped native habitat on each barrier island. Cayo Costa has the highest amount of existing undeveloped habitats at 1,973.38 acres or 45.71% of all mapped habitats on the barrier islands (Figure IV-3). North Captiva follows with 613.48 acres of undeveloped habitat. Cayo Costa and North Captiva have been impacted to a lesser extent than any of the other barrier islands which is reflected in the relatively high amount of undeveloped habitat and relatively even distribution of habitat types. Significant portions of Cayo Costa (1,536 acres) and North Captiva (125 acres) are owned by the state and managed as parks. Captiva and North Captiva are the only barrier-islands not connected to the mainland by a highway. Gasparilla Island, Estero Island, and Captiva Island have been heavily impacted by development which is reflected in the habitat acreages given in Figure IV-3. The barrier-island which has been developed and impacted to the greatest extent is Estero Island where 183.91 acres of native habitat remains from a total of 1,820.55 acres, of which only 42.47 acres is upland not altered by exotics.

ESTUARIES

An estuary is a semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted with freshwater derived from land drainage. Lee County's estuaries can be considered as three different systems; the Charlotte Harbor estuary, the Caloosahatchee River estuary, and the Estero-Hickory Bay estuary. The Charlotte Harbor estuary consists of Charlotte Harbor, Pine Island Sound,

FIGURE 2. VEGETATION ASSOCIATIONS AND ACREAGES OF LEE COUNTY'S BARRIER-ISLANDS

	Habitat Type (Level III)				
Barrier Island	322*	411	426	612**	428
Gasparilla Island	174.61			204.70	
Captiva				175.60	
Cayo Costa	836.82	67.49	57.54	443.45	540.53
Estero Island	4.26			147.03	
Lovers Key	82.72			39.41	
Inner key	20.25			24.18	
Black Island	0.47			49.04	
Big Hickory Island	9.13			319.06	
Little Hickory Island				217.42	
Long Key	0.53			137.90	
North Captiva	285.04		22.04	175.04	96.52
Total (Acres)	1,413.83	67.49	79.58	1,932.83	637.05
	(32.7%)	(1.6%)	(1.8%)	(44.8%)	(14.8%)

**612 Mangrove type habitats
*322 Coastal scrub type habitats

FIGURE 3. REMAINING NATIVE HABITAT ACREAGE TOTALS OF LEE COUNTY'S BARRIER-ISLANDS

Barrier Island	Total Mapped Area	% of Total Area	Total Area (Developed and Undeveloped Lands)
Gasparilla Island	397.93	(9.21)	1,516.92
Captiva	181.44	(4.20)	1,195.94
Cayo Costa	1,973.38	(45.71)	2,520.51
Estero Island	183.91	(4.26)	1,820.55
Lovers Key	127.65	(2.96)	146.62
Inner Key	44.43	(1.03)	44.43
Black Island	73.89	(1.71)	263.00
Big Hickory Island	337.47	(7.82)	352.70
Little Hickory Island*	232.63	(5.39)	479.47
Long Key	151.27	(3.50)	175.55
North Captiva	613.48	(14.21)	747.27
Total Acreage of Undeveloped Native Habitat on Barrier Islands	4,317.48	(100.00)	Total. 9,262.96

* Includes Little Hickory Island (392.72), Hickory Island (19.01), Davis Key (14.85), and No name Island (52.89).

Matlacha Pass, and San Carlos Bay. The Estero-Hickory Bay estuary consists of Matanzas Pass, Estero Bay, and Hickory Bay. The three systems are separated by the Sanibel Causeway and lower San Carlos Bay and are different in several respects.

Charlotte Harbor Estuary: The Charlotte Harbor estuary is a large 109,593.86 acre system with all components tide dominated. This well flushed system is connected to the Gulf of Mexico via several large tidally dominated inlets and San Carlos Bay as detailed in Hine 1988. The Charlotte Harbor estuarine system may be subdivided into smaller embayments including Charlotte Harbor, Gasparilla Sound, Matlacha Pass, Pine Island Sound and San Carlos Bay. The Charlotte Harbor estuary is bordered on the west by the barrier island system. The Caloosahatchee, Myakka, and Peace Rivers and the Cape Coral canal system are the major freshwater tributaries of the estuary with a combined watershed of approximately 3,900 square miles. The northern portion of Charlotte harbor and the entire watersheds of the Peace and Myakka rivers lie outside of Lee County. Within the estuary are Pine Island, Little Pine Island and hundreds of smaller islands, many with no upland areas and dominated by mangroves. The Gasparilla Sound-Charlotte Harbor, Pine Island Sound and Matlacha Pass Aquatic Preserves are located within the estuary. The Board of Trustees of the Internal Improvement Trust Fund approved a management plan for these Aquatic Preserves and designated them as "wilderness preserves" in 1983 (DNRa, 1983). The location of these Aquatic Preserves is shown in Figure V-3.

Caloosahatchee River Estuary: This estuary consists of the tidally influenced portion of the Caloosahatchee River located between the river's mouth at Punta Rassa and Franklin Locks near the town of Olga. The portion of the Caloosahatchee River within the study area is located downstream of the City of Fort Myers and occupies approximately 7,565.45 acres. Much of the Caloosahatchee River upstream of the study area has been channelized for flood control and navigation and extends east to Lake Okeechobee. The Caloosahatchee River watershed includes agricultural and residential areas including La Belle, Fort Myers, and much of Cape Coral. This long, narrow and shallow estuary discharges into San Carlos Bay which forms the lower end of the Charlotte Harbor estuarine system. The location of the Caloosahatchee River estuary is shown in Figure V-3. A reasonable geophysical description of the Caloosahatchee River estuary is given in Drew and Schomer 1984.

Estero-Hickory Bay Estuary: The Estero-Hickory Bay estuarine system is bordered on the west by the south barrier island system. Unlike the Charlotte Harbor and Caloosahatchee River estuaries, the Estero-Hickory Bay estuary does not receive freshwater by any major tributary, but instead is fed by several small rivers and creeks including the Imperial and Estero Rivers and Spring, Mullock and Hendry Creeks. Ten Mile Canal and various finger and drainage canals also discharge significant quantities of freshwater into this estuary. The Estero-Hickory

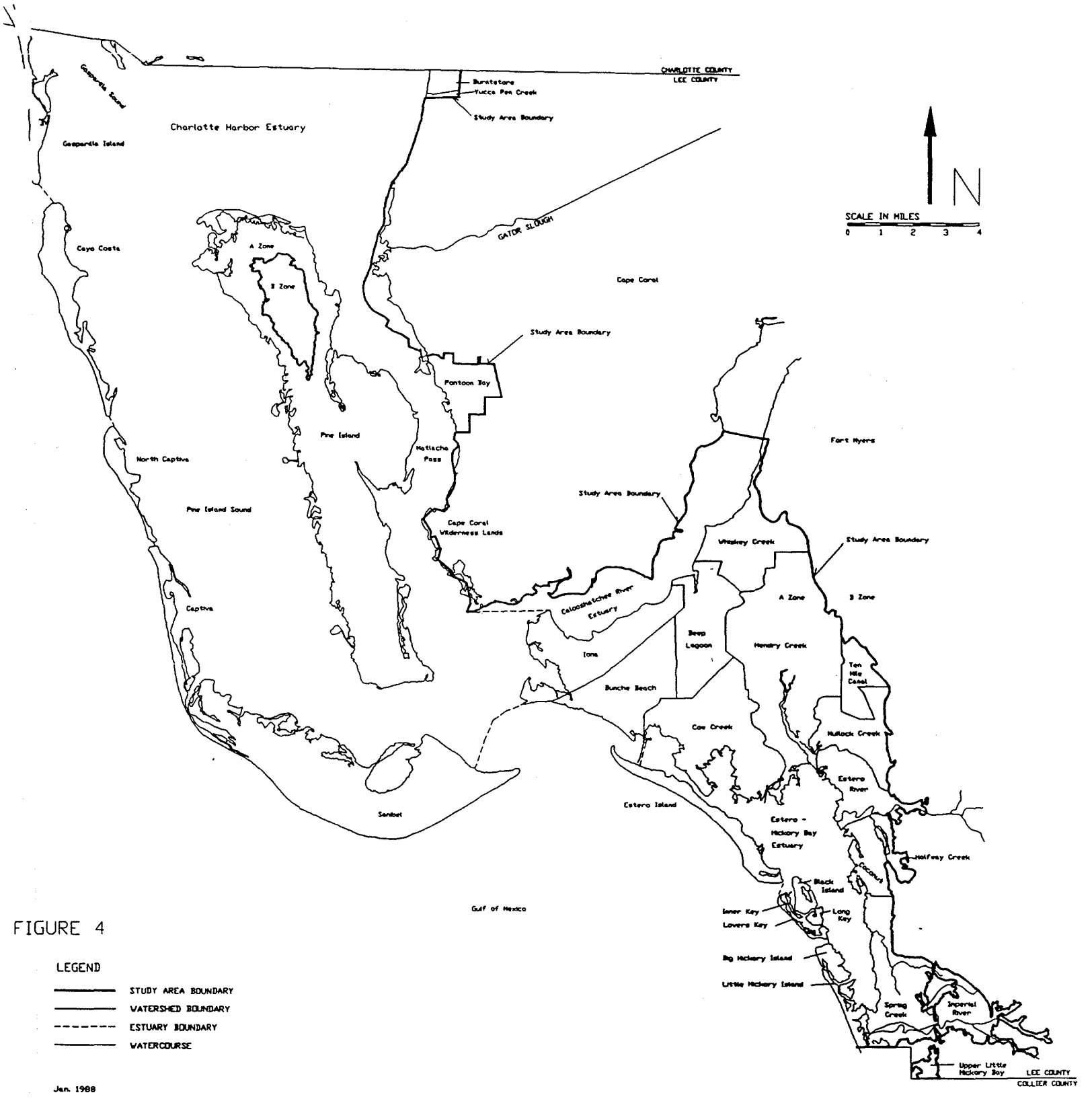


FIGURE 4

MASTER WATERSHED AND LOCATION MAP FOR THE LEE COUNTY COASTAL AREA

Bay watershed occupies approximately 293 square miles. The estuary is very shallow and poorly flushed via tides. Although the estuary is hydrographically separated from the Caloosahatche River and Charlotte Harbor estuaries, it does receive some water from the Caloosahatchee River indirectly through San Carlos Bay. The majority of the estuary has been designated as the Estero Bay Aquatic Preserve (Figure V-3). The Board of Trustees of the Internal Improvement Trust Fund approved a management plan for the Aquatic Preserve and designated it a "wilderness preserve" in 1983 (DNRb, 1983).

A breakdown of submerged habitat acreages for all estuaries as a total is given in Table IV-3. The predominant submerged habitats within the estuarine complex are; areas apparently not vegetated by seagrasses/algae occupying 49,651 acres, patchy to bare seagrasses/algae (1-10% cover) occupying 9,693 acres, sparse to medium seagrasses/algae (11-50% cover) occupying 13,028 acres, and dense seagrasses/algae (51-100% cover) occupying 43,117 acres (Table IV-3). The estuarine complex occupies 115,555 acres of which 65,904 acres (or 57%) are vegetated by seagrasses/algae. The estuarine complex contains 29,690 acres of mangrove swamp, the majority of which is located along the shorelines.

WATERSHEDS

The mainland portion of the study area from the coastal wetland interface with the estuary landward to the 100 year flood zone, consists of seventeen discrete watersheds or surface water drainage basins from the Hickory Bay watershed, at the Lee-Collier County line north, to the Burnt Store watershed at the Lee-Charlotte County line. The location of each watershed is given in the Master Watershed Location Map (Figure IV-4). The mapped acreage totals for each watershed (and barrier island) are given in Table IV-2. This table also gives the acreages of specific habitats within each watershed (and barrier island) and for the entire coastal zone study area. The quantity of remaining native habitats in the coastal zone can be placed in proper perspective by the examination of Table IV-2. The acreage of each watershed (within the coastal area) is also given in Table IV-2. The acreages given in Table IV-2 do not reflect the total acreage for those watersheds, except Deep Lagoon, Iona, Bunche Beach, and Cow Creek, because the landward boundaries of the other watersheds extend beyond the study area boundary (100 year flood line).

The watershed must be considered as the basic ecosystem unit for evaluating the combination of natural and cultural attributes. Watershed energy flow is affected by biological and physical influences. The physical forces such as tidal fluctuations, rainfall, heat energy, winds, and sunlight form the basic energy sources that generally determine the composition of the biological community as well as soil and water characteristics. Energy is stored and transformed by biological forces. In

addition, biological organisms transport energy and materials as they travel from one watershed to the next.

The hydrologic boundaries between watersheds serve as complex biophysical membranes. They naturally divide the landscape into a mosaic of distinct units or watersheds, each possessing a physical/chemical integrity defined by topography and drainage. At the same time these membranes are also permeable. Each watershed, upon closer examination, is itself partitioned into a mosaic of natural habitats and cultural land uses which often transcend hydrological boundaries. Through biological transport, cultural activities, and atmospheric processes, energy and matter are constantly exchanged across watershed boundaries. Within each watershed there is also a systematic partitioning of physical/chemical resources by competing animals and plants. The variety of land uses found within the watersheds actively tap into and modify available resources to produce a wide range of fish and wildlife as well as industrial and agricultural goods.

Watershed Summaries

Burnt Store: The Burnt Store watershed located at the northern boundary of the study area occupies approximately 102 acres of which 51 acres or 51% and has been developed and 50 acres or 49% remains undeveloped. Cropland (211) and cleared upland (746), although mapped and measured, are considered to be developed areas. The predominant native habitats are (411) pine flatwoods - 40 acres and a 10 acre mangrove fringe along the Charlotte Harbor estuary.

Yucca Pen Creek: The Yucca Pen Creek watershed is located south of and adjacent to the Burnt Store watershed occupying approximately 441 acres of which 48 acres or 10.9% remains undeveloped. The predominant native habitats are 56 acres of mangrove fringe along Charlotte Harbor and Yucca Pen Creek and 42 acres of uplands of which 40 acres are pine flatwoods.

Pontoon Bay: The Pontoon Bay watershed is an enclave surrounded by Cape Coral east of Matlacha occupying approximately 2,312 acres of which 1,207 acres or 52.2% remains developed. The predominant native habitats are a 811 acre mangrove fringe. The problematic exotics Melaleuca, Casuarina and Shinus have altered 166 acres of undeveloped uplands. No native upland habitat remains within this watershed.

Whiskey Creek: The Whiskey Creek watershed is within a highly urbanized area along the south shore of the Caloosahatchee River, south of and adjacent to the City of Fort Myers. Whiskey Creek is the major drainage feature of the watershed and a tributary of the Caloosahatchee. The Whiskey Creek watershed occupies approximately 3,484 acres of which 192 acres or 5.5% remains undeveloped. Native upland habitat remaining in this watershed is limited to 16 acres of pine flatwoods and 43 acres of rare and unique slash pine/midstory oak. Wetlands remaining include

30 acres of mangrove, 1 acre of cypress and 2 acres of freshwater marsh. The majority of the remaining undeveloped upland habitat (96 acres) has been altered by exotic infestation.

Deep Lagoon: The Deep Lagoon watershed is in an urbanized area on the south shore of the Caloosahatchee River located between the Whiskey Creek watershed to the north and Iona watershed to the south. The watershed occupies 3,665 acres of which 1,264 acres or 34% remains undeveloped. The remaining predominant native upland habitats include 217 acres of pine flatwoods, 91 acres of cabbage palm hammock and 5 acres of rare and unique live oak hammock. Predominant freshwater wetlands include 2 acres of willow swamp and 33 acres of marsh. Tidal wetlands consist of 29 acres of tidal ponds, 398 acres of mangrove and 56 acres of saltmarsh. Problematic exotics have altered 395 acres of uplands and 34 acres of wetlands.

Little Pine Island: Little Pine Island is a 5,000± acre island located in the Matlacha Pass estuary and Aquatic Preserve. The island is separated from Pine Island to the west by Pine Island Creek. Approximately 4,993 acres or 53% of the total park acreage (9,397 acres) in the Lee County coastal area is located on Little Pine Island within the Little Pine Island State Wilderness Area. Approximately 5,011 acres or 99.8% of Little Pine Island's total remains undeveloped. Native upland habitats on Little Pine Island include 1 acre of palmetto prairie, and 37 acres of pine flatwoods. The vast majority of the remaining undeveloped upland habitat, 589 acres, has been altered by Melaleuca infestation. Tidal wetlands dominate the island with 177 acres of tidal ponds, 3,858 acres of mangrove and 348 acres of saltmarsh.

Pine Island: Pine Island is the largest (24,246 acres) island in Lee County, located between Matlacha Pass and Little Pine island to the east and Pine Island Sound to the west. While the mangrove fringe bordering Pine Island remains essentially intact, large areas of the interior once dominated by extensive pine flatwoods have been connected for agricultural residential and commercial use. Approximately 1,2615 acres or 52 % of Pine Island remains undeveloped. The predominant upland habitats remaining include 18 acres of palmetto prairie, 3,848 acres of pine flatwoods, and 11 acres of cabbage palm hammock. Rare and unique upland habitats include approximately 3 acres of sand scrub, 5 acres of slash pine/midstory oak, 7 acres of tropical hardwoods and 26 acres of live oak hammock. Tidal wetlands are dominated by 109 acres of tidal ponds, 7,282 acres of mangrove and 114 acres of saltmarsh. Freshwater wetlands remaining are limited to 14 acres of marsh. Problematic exotics have altered 1,001 acres of undeveloped upland habitats, 124 acres of mangrove, 4 acres of saltmarsh and 10 acres of freshwater marsh.

Bunche Beach: The Bunche Beach watershed drains south into San Carlos Bay and occupies approximately 3,896 acres of which 1,536

acres or 39.4% remains undeveloped. The predominant native habitats are 64 acres of pine/midstory oak, 15 acres of cabbage palm hammock, 1,230 acres of mangrove swamp and 96 acres of salt marsh. Rare habitats include 11 acres of tropical hardwoods and 9 acres of oak hammock. The infestation of exotics has altered 76 acres of undeveloped uplands and 8 acres of wetlands.

Iona: The Iona watershed is located on the south shore of the Caloosahatchee River bordered by the Deep Lagoon (northeast), Punta Rassa (southwest), and Bunche Beach (south) watersheds. The Iona watershed occupies approximately 4,332 acres of which 1,962 acres or 45.3% is undeveloped. The predominant native upland habitats are 12.5 acres of pine flatwoods, 10 acres of slash pine midstory oak, and 8 acres of cabbage palm hammock. Rare upland habitats include 15 acres of tropical hardwoods and 1 acre of live oak hammock. The predominant wetland habitat is mangrove which covers 1,619 acres. The infestation of exotics has altered 125 acres of undeveloped uplands and 147 acres of wetlands.

Cow Creek: The Cow Creek watershed is located south of the Deep Lagoon watershed. Cow Creek is a mangrove fringed tidal creek tributary of Hill Peckish Bay and the Estero Bay Aquatic Preserve. The Cow Creek watershed occupies approximately 6,124 acres of which 5,145 acres or 84% remains undeveloped. This watershed is dominated by mangrove (3,594 acres), tidal ponds (163 acres) and saltmarsh (682 acres). Native upland habitat is restricted to 4 acres of palmetto prairie, 2 acres of slash pine 3 acres of tropical hardwoods and 5 acres of cabbage palm hammock, for a total of 13 native upland acres. Problematic exotics have altered 581 acres of undeveloped upland habitats and 76 acres of wetlands.

Hendry Creek: The Hendry Creek watershed is located south and east of the Whiskey Creek and Cow Creek watersheds, respectively. Hendry Creek is a major tributary of the Estero Bay aquatic preserve. This watershed occupies approximately 9,965 acres of which 4,697 acres or 47.1% remains undeveloped. The predominant native upland habitats are 26 acres of palmetto prairie and 513 acres of pine flatwoods. Rare uplands include 38 acres of slash pine/midstory oak and 18 acres of live oak hammock. Tidal wetlands are the most abundant native habitats with 1,706 acres of mangroves and 887 acres of salt marsh. Approximately, 100 acres of freshwater wetlands (all marsh) remain in this watershed. Problematic exotics have altered 1,332 acres of undeveloped upland habitats and 9 acres of wetlands.

Ten Mile Canal: The Ten Mile Canal watershed is located east of and adjacent to the Hendry Creek watershed. The majority of this 55 mile square watershed extends north of and outside the coastal area boundary to the City of Fort Myers. Ten Mile Canal was excavated around 1920 to drain the surrounding lands for agricultural development. This canal is a major tributary of the Estero Bay Aquatic Preserve discharging into the Mullock Creek

(tidal) system. This Ten Mile Canal watershed occupies approximately 1,368 acres of which 529 acres or 39% remains undeveloped. The remaining native upland habitats include 4 acres of palmetto prairie, 14 acres of pine flatwoods and 3 acres of rare and unique sand scrub. Approximately 6 acres of pine-cypress, 7 acres of cypress and 6 acres of freshwater marsh remain. Problematic exotics have altered 450 acres of undeveloped upland habitats and 38 acres of freshwater wetlands.

Mullock Creek: The Mullock Creek Watershed is located east and south of the Hendry Creek and Ten Mile Canal watersheds, respectively. Mullock Creek is a tributary of the Estero Bay Aquatic Preserve with a significant portion of the watershed extending east and outside the coastal area boundary. The Mullock Creek watershed occupies approximately 2,608 acres of which 1,492 acres or 57.2% remains undeveloped. The remaining predominant native upland habitats include 107 acres of palmetto prairie, 73 acres of pine flatwoods, and 26 acres of cabbage palm hammock. Rare and unique uplands include 115 acres of slash pine/midstory oak. Tidal wetlands include 353 acres of mangrove and 168 acres of salt marsh. Approximately 91 acres of freshwater wetlands remain of which 57 acres are rare and unique mixed wetland hardwoods. Problematic exotics have altered 520 acres of undeveloped upland habitats and 39 acres of wetlands.

Estero River: The Estero River watershed is located on the northeast shoreline of Estero Bay south of and adjacent to the Mullock Creek watershed. The majority of this watershed extends to the east and outside of the coastal area boundary. The Estero River is a tributary of the Estero Bay Aquatic Preserve. This watershed occupies approximately 2,370 acres of which 1,901 acres or 80.2% remains undeveloped. The remaining predominant native upland habitats include 53 acres of palmetto prairie and 214 acres of pine flatwoods. Rare and unique uplands include 79 acres of sand scrub and 60 acres of slash pine/midstory oak. Tidal wetlands are the most abundant native habitat with 1,107 acres of mangrove and 99 acres of saltmarsh. Freshwater wetlands remaining include 4 acres of cypress and 1 acre of wet prairie. Problematic exotics have altered 254 acres of undeveloped upland habitats and 7 acres of wetlands.

Halfway Creek: The Halfway Creek watershed is located south and east of the Estero River and Coconut watersheds, respectively. Halfway Creek is a tributary of the Estero River. The majority of this watershed lies within the coastal area, occupying 519 acres of which 441 acres or 84.9% remains undeveloped. The remaining predominant upland habitats include 147 acres of pine flatwoods and 133 acres of rare and unique sand scrub. Predominant freshwater wetlands remaining include 4 acres of stream swamp, 64 acres of cypress, 8 acres of marsh and 25 acres of rare and unique mixed hardwoods. Tidal wetlands include 28 acres of mangrove and 15 acres of saltmarsh. Problematic exotics have altered 17 acres of undeveloped upland habitats and 1 acre of wetlands.

Coconut: The Coconut Watershed is located north of Coconut Road south and west of the Estero River and Halfway Creek watersheds, respectively. This watershed lies within the coastal area with its surface waters discharging into the Estero Bay Aquatic Preserve. The Coconut watershed occupies approximately 1,436 acres of which 1,281 acres or 89.2% remains undeveloped. The remaining predominant native upland habitats include 36 acres of palmetto prairie, 201 acres of pine flatwoods, 67 acres of cabbage palm hammock and 90 acres of rare and unique sand scrub. Tidal wetlands are dominated by 706 acres of mangrove and 37 acres of saltmarsh. Freshwater wetlands include 22 acres of willow swamp, and 7 acres of freshwater marsh. Problematic exotics have altered 96 acres of undeveloped upland habitats.

Spring Creek: The Spring Creek Watershed is located south of the Coconut watershed and north of the Imperial River watershed. Spring Creek is a tributary of the Estero Bay Aquatic Preserve and the watershed extends east and outside of the coastal area. This watershed occupies 3,452 acres of which 2,628 acres or 76.1% remains undeveloped. The remaining predominant native upland habitats include 85 acres of palmetto prairie and 961 acres of pine flatwoods. Rare and unique upland habitats include 243.57 acres of sand scrub, 1 acre of slash pine/midstory oak, and 2 acres of oak hammock, and 103 acres of cabbage palm hammock. Predominant freshwater wetlands include 42 acres of cypress, 131 acres of marsh, and 42 acres of rare and unique coastal bay hammock. Tidal wetlands are dominated by 852 acres of mangrove and 87 acres of saltmarsh. Problematic exotics have altered 63 acres of undeveloped upland habitats.

Imperial River: The Imperial River Watershed is located south of the Spring Creek watershed and extends east and outside the coastal area. The Imperial River discharges into Fish Trap Bay and is a major tributary of the Estero Bay Aquatic Preserve. The Imperial River watershed occupies approximately 2,519 acres of which 855 acres or 34% remains undeveloped. The remaining predominant native upland habitats include 113 acres of palmetto prairie 328 acres of pine flatwoods and 24 acres of cabbage palm hammock. Rare and unique upland habitats include 83 acres of sand scrub and 9 acres of oak hammock. Predominant freshwater wetlands include 41 acres of rare and unique mixed wetland hardwoods and 52 acres of marsh. Tidal wetlands are dominated by 116 acres of mangrove and 60 acres of saltmarsh. Problematic exotics have altered 30 acres of undeveloped upland habitats.

Upper Little Hickory Bay: The Upper Little Hickory Bay watershed is the southernmost watershed in the coastal area. This watershed drains into Upper Little Hickory Bay, which is connected to Fish Trap Bay and the Estero Bay Aquatic Preserve. The watershed extends south (into Collier County) and east outside the coastal area. This watershed occupies 262 acres of which 105 acres or 40% remains undeveloped. The remaining predominant native upland habitats include 24 acres of palmetto

prairie, 19 acres of pine flatwoods and 3 acres of rare and unique sand scrub. Freshwater wetlands are limited to 1 acre of willow swamp, 1 acre of pine-cypress, 27 acres of marsh, and 17 acres of rare and unique mixed wetland hardwoods. Problematic exotics have altered 13 acres of undeveloped upland habitats.

As one evaluates each of the individually mapped habitats, they should not be considered for future management as individual entities. Each of the habitats represented within the complex mosaics of natural systems within each ecosystem unit are interdependent, and therefore, future management plans should consider the linkage of these systems. Plans must conserve the variety of interconnected habitats, not permitting their individual isolation and envelopment by urbanization or agriculture.

The movement of organisms and materials between different types of habitats (i.e. seagrasses and mangrove) means that terrestrial and marine communities sometimes cannot be defined simply by their physical boundaries. The effectiveness of efforts to protect one community type may be diminished by failing to protect neighboring communities or habitats as well as adjacent watersheds. It is now apparently clear that the once abundant upland resources of the coastal zone have been significantly diminished by development. In addition, remaining uplands infested by exotics such as Melaleuca lose their biological diversity and become virtually useless as wildlife habitat. The continued loss of native habitats will cause a direct proportional loss of wildlife utilization.

The coastal wetlands, dominated by over 19,000 acres of mangroves remain generally intact, however, the interface connecting remaining native uplands with these shoreline areas has all but disappeared throughout most of the coastal zone. Upland habitats, such as xeric scrub, may not have a high number of animal species present, but they may have a high proportion of species not found elsewhere (i.e. high endemism). Such areas are considered valuable for maintaining biological diversity because they contribute substantially to diversity on a regional or global scale. Without immediate institution of a balanced resource management plan, the future Lee County coastal zone will consist of completely urbanized lands with a fringe of mangroves. Gone will be the functioning native lands, their floral and faunal constituents, and the contribution attributable to the natural systems.

The coastal wetlands are currently afforded protection status as Resource Protection Areas (RPA) and Transition Zones (TZ) under the current Conservation and Coastal Zone Element of the Lee County Comprehensive Plan. These protective measures are adequate to a limited extent since there is currently a limited effort to incorporate protected wetlands within connected native upland corridors. This concept (Erwin, 1987) must be pursued to ensure the future values of both wetlands and uplands are not

significantly diminished. Since the majority of native uplands have been developed/disturbed some enhancement or reclamation of uplands may be required.

A number of native upland habitats currently exist in the coastal zone on a very limited basis because of overdevelopment, geographic limitations or a combination of both. The original predevelopment acreages of these habitats is unknown.

Sand or xeric scrub occupies approximately 636 acres or 3.2% of the coastal area's undeveloped uplands. These relic beach dune areas are characterized by their open, well drained sandy substrate, high groundwater recharge potential, and flora (found in many cases in this habitat only) such as dwarf live oak (Quercus minima) rosemary (Ceratiola ericoides), the threatened Curtiss Milkweed (Asclepias curtissii), and spring ladies tresses (Spiranthes vernalis). Listed (protected) fauna endemic to the sand scrub include the scrub jay (Aphelocoma coerulescens - T), gopher tortoise (Gopherus polyphemus - SSC), eastern indigo snake (Drymarchon corais couperi - T), and gopher frog (Rana areolata - SSC). The vast majority of remaining scrub habitat is found on the upland ridge bordering Estero Bay from the Estero River south to the Imperial River.

Coastal scrub occupies approximately 1,114 acres or 5.7% of the coastal areas undeveloped uplands. This habitat is characterized by vegetation such as cabbage palm (Sabal palmetto), sea grape (Coccoloba uvifera), buttonwood (Buttonwood erectus), myrsine (Myrsine guianensis), buckthorn (Bumelia reclinata), and prickly pear cactus (Opuntia stricta). Found almost exclusively on the sand and shell ridges of the barrier islands, this habitat is richly diverse in flora and fauna. Listed fauna found in the coastal scrub includes the gopher tortoise (SSC), eastern indigo snake (T) and Sanibel Island rice rat (SSC). Listed flora includes joewood (Jacquinia keyinsis - T), bay cedar (Suriana maritima - E), red stopper (Eugenia rhombea - E), inkberry (Scaevola plumieri - T), and prickly pear (Opuntia stricta - T).

Mature pine forest occupies perhaps less than 1,000 acres of the remaining 6,712 acres of undeveloped pine flatwood. If so, this would constitute less than 5% of the coastal areas remaining undeveloped lands. Once very abundant in the coastal zone, this habitat was extensively logged and is now highly valuable to development interests. It has been impacted by agriculture, drainage, and exotic infestations. The few areas of mature pine forest that have avoided these impacts are easily identified by large pines, well developed palmetto understory, and open midstory. This habitat shelters a number of listed species including the bald eagle (Haliaeetus leucocephalus -E), red-cockaded woodpecker (Pecoides borealis - E), southeastern kestral (Falco sparverius paulus - T), eastern indigo snake (Drymarchon corais couperi - T), mangrove fox squirrel (Sciurus niger avicennia - T), Florida weasel (Mustela frenate paninsulae - E), and the Florida black bear (Ursus ameicanus floridanus -T).

Listed plants include Fakahatchee burmannia (Burmannia flava - E), white squirrel banana (Deeringothamnus pulchellus - E), pine pink (Bletia purpurea -T), bearded grass pink (Calopogon barbatus - T), pale grass pink (Calopogon pallidus - T), slender ladies tresses (Spiranthes brevilabris - T), long lip ladies tress (Spiranthes longilabris -T), spring ladies tresses (Spiranthes vernalis - T), Michaux's or long horned orchid (Habenaria quinquesta - T), and wild coco (Eulophea alta - T). The majority of the mature pine forested areas are found on pine island and the uplands between Hendry Creek and the Imperial River.

Slash pine/midstory oak is found on only 337 acres or 1.7% of the study areas lands. Unlike the pine flatwoods described above, this pine habitat reflects a dominant oak midstory. Little is known of this community, the majority of which in found between the Whiskey Creek and Estero river watersheds. Many of the wildlife species found in the sand scrub, pine flatwood, and oak habitats may be found in this habitat. This habitat should be inventoried for listed species of flora and fauna.

Tropical hardwoods occupy 452 acres or 2.3% of the study area's lands. Tropical hardwoods occupy the high well drained soils in frost free areas of the coast. Often found on indian shell middens, the vegetation is a mixture of tropical species from the West Indies area mixed with endemic varieties. The typical species found in this richly diverse habitat include gumbo limbo (Bursera simaruba), mastic (Mastichodendron foetidissimum, wild tamarind (Lysiloma bahamense), jamaican dogwood (Piscidia piscipula), stoppers (Eugenia spp.), wild lime (Zanthoxylum fagara), satin leaf (Chrysophyllum oliviforme), hackberry (Celtis spp.), and coontie (Zamia floridana). Listed fauna found in this habitat include the mangrove fox squirrel (Sciurus niger avicennia T) and eastern indigo snake. Listed flora includes red stopper (Eugenia rhombea - E), satin leaf (Chrysophyllum oviviforme - E), iguana hackberry (Celtis iguanaea - E), spiny hackberry (Celtis pallida - E), wild cotton (Gossypium hirsutum - E), and prickly apple (Cereus gracilis -E). Tropical hardwoods are most abundant on Gasparilla Island, Cayo Costa, North Captiva and the islands of Charlotte Harbor.

Oak hammocks occupy 86 acres or 0.4% of the study area's lands. Oak hammocks are usually small in size and were once scattered throughout the study area. Usually located on a topographic rise, they are often associated with archeological features as are tropical hardwoods. This community is usually dominated by large live oak (Quercus virginiana), laurel oak (Quercus laurifolia), water oak (Quercus nigra), cabbage palm (Sabal palmetto), blue beech (Carpinus caroliniana), dahoon (Ilex cassine), myrsine (Myrsine quianensis), marlberry (Ardisia escallonioides), wild coffee (Psychotria nervosa P. sulzneri), and a number of ferns and epiphytes. Listed species found in these areas include the gopher tortoise (Gopherus polyphemus - SSC) and the eastern indigo snake (Drymarchon corais couperi - T). Listed flora found in oak hammocks include golden polypody

fern (Phlebodium aureum - T), hand or adder's tongue fern (Ophioglossum palmatum - E), Tillandsia valenzuela (T), T. setacea (T), T. paucifolia (T), T. flexuosa (T), shoestring fern (Vittaria lineata - T), and butterfly orchid (Encyclia tampensis - T).

Cabbage palm hammocks occupy 1,000 acres or 5.1 % of the study area's lands. This upland to mesic habitat is often difficult to distinguish from the oak hammock where oaks are the dominant canopy. Cabbage palms, oaks (Quercus spp.) and slash pine are usually equally dominant in the well developed canopy of the cabbage palm hammock. The hammock floor may be wet or dry but always open and vegetated by ferns and grasses. Listed fauna of this habitat include the eastern indigo snake (Drymarchon corais couperi - T). Listed flora include golden polypody fern (Phlebodium aureum - T) and hand or adder's fern (Ophioglossum palmatum - E). This habitat is found most extensively on Cayo Costa and North Captive Island, the Deep Lagoon watershed and the area between the Coconut and Imperial River watersheds.

Most of these upland habitats, except for the pine flatwoods, were never very abundant, however, recent development activities have caused their acreages to dwindle. Without conservation these habitats will probably disappear from private lands in the next decade.

IMPLICATION OF ECOLOGICAL EVALUATION AND RESOURCE INVENTORY

Summary of Findings

1. The Lee County coastal area is a complex dynamic natural system comprised of barrier islands, estuaries and mainland watersheds. Prior to this study the absence of any areawide ecological evaluation has resulted in a poor understanding of the area's natural system and how future growth and development should be managed to best protect the functions of these ecosystems.

2. All undeveloped land and water areas within the 220,148 acre coastal study area has been evaluated by individual ecosystem unit. Sixty five vegetative habitats were identified, mapped and statistically evaluated.

3. The coastal area's tidal wetlands and estuaries have benefited by protection from recent development. However, future functions of these systems will be adversely impacted by growth, drainage alterations and pollution, without appropriate management practices within the adjacent watersheds.

4. Native upland habitat has been severely reduced in area and diversity due to development and exotic infestation. Conservation of remaining high quality native uplands should be a high priority. Based upon this study, sand scrub,

coastal scrub, mature pine flatwood, slash pine/midstory oak, tropical hardwood, live oak hammock, and cabbage palm hammock should be designated as Rare and Unique habitats worthy of conservation. Only 13,495 acres (12.9% of Study Area Land) of native uplands remain in the coastal area and a significant percentage of those habitats are being altered by exotic infestations.

5. Within the coastal area species currently listed by the U.S. Fish and Wildlife Service. Florida Department of Agriculture, or the Game and Fish Commission as; endangered species total 11 animals and 11 plants; threatened species total 17 animals and 38 plants; and species of special concern total 14 animals. These animal species are strongly dependent on the area's wetlands and remaining native uplands for nesting, feeding, roosting and cover. Presently, there are approximately 204 species of animals listed as endangered or threatened in the United States, 65 of those species are listed in Florida and 26 in the Lee County coastal area.

6. An indicator of the impact of development on the coastal natural resource system is a 26.5 % decline in commercial fish landings from 9,961,379 lbs. in 1979 to 7,324,750 lbs. in 1985.

7. There is no central source of information concerning studies that have been completed in Lee County.

8. There is no effort in Lee County to adequately manage natural resources and data acquisition. Current activities are focused on regulation and long range planning, but with a very limited supportive database.

9. The natural resource information produced in this study is, for the most part, lacking for the remainder of Lee County.

GOALS, OBJECTIVES AND POLICIES

GOAL 1: To manage the coastal wetland and upland ecosystems so as to maintain and enhance native habitats, floral and faunal species diversity, water quality, and natural surface water characteristics.

OBJECTIVE 1.1: By 1990 the County will adopt a resource management plan that will ensure the long term protection and enhancement of the natural upland and wetland habitats through the retention of interconnected, functioning, and maintainable hydroecological systems where the remaining wetlands and uplands function as a productive unit resembling the original landscape.

POLICY 1.1.1: The County shall designate a division of resource management as the natural resource management agency, with responsibilities including:

1. Identifying upland and wetland habitats/systems most suitable for protection, enhancement, reclamation and conservation.

2. Preparing standards for development and conservation that will protect and integrate wetlands (Resource Protection Areas and transitional zones) , and significant areas of rare and unique upland habitats (RE) including but not limited to; sand scrub (320), coastal scrub (322), mature pine flatwood (411), slash pine/midstory oak (412), tropical hardwood (426), live oak hammock (427), and cabbage palm hammock (428).

3. Preparing standards for wetland and rare and unique upland mitigation.

4. Preparing a <u>prioritized</u> listing of wetlands, rare and unique uplands, and critical endangered and threatened species habitat properties for possible acquisition.

5. Recommending a plan for eradicating and controlling problematic exotics <u>Melaleuca</u>, <u>Schinus</u> and <u>Casuarina</u> with the highest priority placed on preventing new or accelerated infestations in wetlands and rare and unique upland habitats.

6. Maintaining a central clearing house for all environmental studies and recommendations by both public and private organizations.

7. Completing the mapping of the hydrological boundaries and habitats of each coastal watershed that extend landward of the coastal area study boundary and;
   a. Preparing recommendations for maintaining or restoring the desired seasonal base flows and water quality into the coastal zone.

8. Coordinating the preparation of plans with the City of Cape Coral, City of Fort Myers, South Florida Water Management District, and Southwest Florida Water Management District to better control flows of freshwater and reduce pollutant discharges into the Lee County coastal waters.

9. Regularly updating the Level III maps and database of this report to reflect the existing conditions following each aerial photography overflight of the County and;
   a. Providing an annual report to the County on the status of wetlands, native uplands, and rare and unique habitats. The report should focus on the adequacy of the land use regulations and management plan to protect and enhance these natural systems. Adjustments should be made in the regulatory process to address whatever deficiencies are noted.

REFERENCES

Clark, J. R. 1977. Coastal Ecosystems. Conservation Foundation, Washington, D.C. 921 pp.

Day, J. W., and R. Yanez-Arancibia. 1982. Coastal lagoons and estuaries, ecosystem approach. Aincia Interamericana OAS Washington, D.C. 22:11-26.

Department of Natural Resources (a). 1983. Charlotte Harbor Aquatic Preserves Management Plan.

Department of Natural Resources (b). 1983. Estero Bay Aquatic Preserve Management Plan.

Drew, Richard D. and N. Scott Schomer, FDER. 1984. An Ecological Characterization of the Caloosahatchee River/Big Cypress Watershed, FWS/OBS.

Erwin, Kevin L. 1987. The Implications of Hydrology and Landscape Ecology on the Maintenance of Freshwater Wetland Ecosystems in Florida. National Wetlands Newsletter. Nov. - Dec. 1987.

Estevez, E.D., J.M. Miller, and J. Morris. 1981. A review of scientific information: Charlotte Harbor Estuarine Complex. Final Report to Southwest Florida Regional Planning Council. Mote Laboratory, Review Series No. 3, Fort Myers. FL.

Florida Department of Transportation. 1985. Florida Land Use, Cover and Forms Classification System. State Topographic Bureau, Thematic Mapping Section. 79 pp.

Hine, Albert. 1988. Evaluation of the Lee County Barrier-Island Coastline: Dominant Processes, Shoreline Trends Past Stabilization Efforts, and Recommendations for Beach Management. Lee County Coastal Study.

Lindall, W.N. Jr., and C.H. Saloman. 1977. Alteration and destruction of estuaries affecting fishery resources of the Gulf of Mexico. Mar. Fish. Rev. 39(9): 1-7.

Nakamura, E.L., J.R. Taylor and I. K. Workman. 1980. The Occurrence of life stages of some recreational marine fishes in estuaries of the Gulf of Mexico. NDAA Tech. Memo NMFS-SEFC-45:53pp.

Odum, W.E. 1971. Pathways of energy flow in a South Florida estuary. Miami Sea Grant Tech. Bull. No. 7.162 pp.

Taylor, J.L. 1974. The Charlotte Harbor Estuarine System, Fla. Sci. 37(4): 205-216.

V. ESTUARINE WATER QUALITY

Purpose

The purpose of this chapter is to inventory and analyze estuarine pollution conditions in Lee County and to recommended actions needed to maintain the quality of estuarine waters in the county's coastal zone. First, Lee County's estuary areas and drainage basins within the county which contribute freshwater to them are defined. Then, concepts of estuary ecosystems and the pollution threats are described. Next, existing estuary management programs and the results of water quality studies performed by government agencies are discussed. We conclude with an identification of the actions needed to remedy pollution problems.

Methodology

This section summarizes findings from a 1987 report by Richard Morgan, "Estuarine Pollution Conditions of the Special Coastal Study for Lee County, Florida". This report, and a supplement by Morgan, were prepared from a review of the water quality reports and data of county, regional, state, and federal agencies; a review of aerial photography; and aerial and ground observations. Personal interviews were also held with water quality agency personnel.

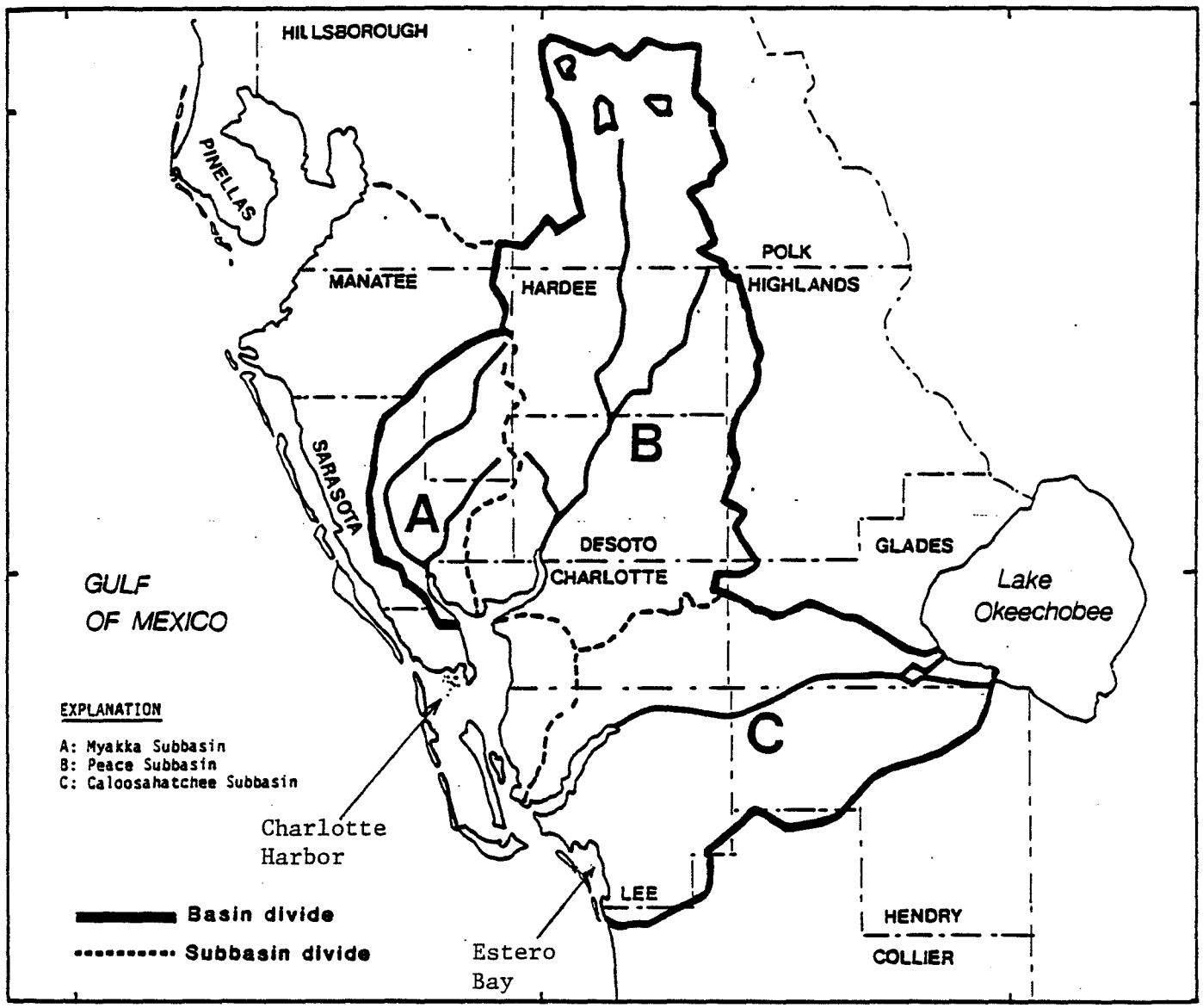
LEE COUNTY ESTUARINE SYSTEMS

The Lee County estuarine system includes Estero Bay and the southern portion of Charlotte Harbor. Charlotte Harbor, including Matlacha Pass (23 square miles), Pine Island Sound (71 square miles), and San Carlos Bay (23 square miles), occupies a total area of 236 square miles. The drainage basin for Charlotte Harbor covers 3,900 square miles, however, and includes the watersheds of the Peace, Myakka, and Caloosahatchee (including Lake Okeechobee) rivers (see Fig. V-1). The Caloosahatchee River is the largest tributary, with an average discharge of 40.8 cubic meters/second, the Peace and Myakka rivers contribute 32.7 and 7.2 cubic meters/second respectively.

The northern portion of Charlotte Harbor and the entire watersheds of the Peace and Myakka rivers lie outside of Lee County. The Caloosahatchee River flows through the middle of Lee County, but much of its watershed lies to the east. The Caloosahatchee River flows 45 miles from the western side of Lake Okeechobee to the Franklin locks. The remaining 30 miles from the locks to the Gulf of Mexico is a tidally influenced estuarine system. Land use in the Caloosahatchee basin is predominately agriculture (80%), especially in the eastern portion of the basin; wetlands make up another 15 percent of the basin.

Estero Bay occupies 15 square miles. Its drainage basin covers 293 square miles and includes Hendry Creek, Ten Mile Canal, Mullock Creek, Estero River, Spring Creek, and the Imperial River. Estero Bay differs from the Charlotte Harbor estuary in that the Bay has no significant rivers flowing into it and has only weak tidal exchanges because of restricted inlets. Sediments carried into Estero Bay by its small creeks and rivers have filled it to its present

Drainage Basins of the Myakka, Peace, and Caloosahatchee Rivers



Adapted from Estevez, 1986

shallow depths, resulting in an estuary with the characteristics of a lagoon[1]. Because of its adaptation to a weak freshwater inflow, Estero Bay is particularly sensitive to changes in upland drainage.

Both Charlotte Harbor and Estero Bay are bar-bounded estuaries. They have resulted from the development of off-shore barriers which restricted circulation and created a mixing of freshwater and saltwater. These estuaries are important for a number of reasons. As biological habitats they tend to be enormously productive, in both the variety and the volume of organic material (Schweithzer 1977). The quality of these estuaries is also important to the local economy. Lee County had the second highest value of fish and shellfish landed of all coastal counties in 1983 and the highest number of registered pleasure and commercial boats of any coastal county in southwest Florida in 1984-85 (Shoemyen 1986).

Although this study is restricted to the coastal zone and the identification of existing and potential sources of pollution within that zone, county officials should be aware of the impact of developments outside this coastal area (such as in the headwaters of the Estero Bay tributaries), and outside the boundaries of the county (such as along the Caloosahatchee River and Lake Okeechobee[2]).

Estuarine Ecosystems

The complex mix of fresh and saline water environments which makes estuaries productive also makes these ecosystems fragile. Estuarine ecosystems are very sensitive to stresses caused by changes in the quantity or quality of water flowing into them. Estuaries with restricted circulation, such as Estero Bay, are particularly sensitive. The governing ecological principle for management of estuary ecosystems is that "the natural volume, rate, seasonal pattern (and quality) of freshwater inflow provides for optimum ecosystem function" (Clark 1977: 24). The factors which have been identified as most important in ecosystem function are; circulation patterns, chemical constituents, dissolved gasses, and penetration of sunlight.[3]

Water circulation patterns within estuaries are determined by tide, wind, waves, physical structure, and land runoff. Actions of humans which affect the structure of an estuary (such as the building of a causeway) or the

---

[1]Currently, relatively little is known about the hydrology and water quality dynamics in the Estero Bay watershed (Drew and Schomer 1984). Tabb et al reported on tides and physical, chemical and nutrient characteristics in the northern bay in 1974. Water quality was investigated by Duane Hall and Associates in 1974. Jones (1980) issued reports on salinity and temperature, and Estevez (1981) summarized data on tides, current, and runoff, (these studies are each cited in the U.S. Fish and Wildlife Service report: Drew and Schomer, 1984).

[2]South Florida Water Management District efforts to improve the water quality of Lake Okeechobee could have a major impact on the quality of the Caloosahatchee River. One action being considered by the SFWMD is to bypass the nutrient laden water from the Kissimmee River directly into the Caloosahatchee River, thereby increasing the nutrient load to Charlotte Harbor.

[3]This discussion is abstracted from Clark (1977, Chapter 1)

pattern of land runoff will alter natural circulation patterns. The second factor, chemical constituents of the estuary, falls into three classes: 1) nutrients, 2) trace elements and 3) contaminants. Nutrients, necessary for the production of plant life, come from recycling within the estuarine system, and input (primarily with freshwater inflow). The major plant nutrients, nitrogen and phosphorus, are taken up by plant life and for a natural ecosystem are generally scarce in dissolved form. Available nitrogen (as nitrate) is usually the factor limiting plant growth in estuarine systems. Several trace elements are also necessary for plant life, including inorganic elements such as iron, sodium, and potassium. Many of the trace elements as well as other contaminants such as oils, heavy metals and pesticides become toxic when present in sufficient concentrations. Even nutrients, when available in excessive quantities, will impair the ecosystem by speeding eutrophication, the process by which a lake of estuary evolves into a marsh or wetland.

The salinity of coastal waters is a major factor in determining what species of plant and animal life can live in the estuary. Typically salinity varies from 35 parts per thousand (ppt) in the open ocean to less than 0.5 ppt in upland rivers. Examples of sensitivity to salinity levels are salt marsh grasses which require salinity greater than 15 ppt, and shrimp which require specific salinity ranges that are different for larvae, juvenile and adult stages.

Dissolved oxygen and carbon dioxide are also important for marine life. Most animal species can not survive if dissolved oxygen drops below a certain level, 6 parts per million (ppm) is a recommended minimum. Photosynthetic plants produce oxygen, during daylight, which is then used by aerobic bacteria and higher animals. A large input of organic material (such as sewage effluent), also known as biological oxygen demand, will result in a rapid increase in the population of bacteria which decomposes the organic matter. As the bacteria use oxygen, the dissolved oxygen level may drop below the level that other species require, resulting in a loss of habitat.

The final factor, sunlight, is necessary for the growth of plant life. The depth to which sunlight can penetrate the water surface is determined by the water color and turbidity (a function of suspended sediment and density of plant life). This factor is generally measured by Secchi Depth, the maximum depth at which a black and white disk can be seen under water.

Trophic state, a frequently used indicator of water quality in lakes and estuaries, illustrates the relationship between several of these factors. Trophic state is a measure of the health and biological age of a water body. Oligrotrophic water bodies are clear, clean, and contain very few nutrients. Highly euthrophic bodies have high nutrient levels, are subject to blooms of algae (including red tide), have low levels of dissolved oxygen, and generally contain low quality water. Eutrophication is a natural process which occurs over a long time, however, this process can be greatly speeded up by the land use activities of man. One commonly used index measure of trophic state (TSI) combines information on phosphorus concentration (nutrients), chlorophyl a level (a measure of phytoplankton biomass, e.g. photosynthetic algae), and Secchi disk depth (sunlight penetration and turbidity).

The factors -- circulation, chemical constituents, dissolved gasses, and sunlight penetration -- which control the health and productivity of an

estuary are greatly affected by the freshwater entering the estuary. Estuaries have adapted to the natural variation of freshwater and saltwater inflows, however, estuaries may be seriously impaired by the large changes in quality and patterns of freshwater inflow caused by man. Precipitation moves towards the sea by flowing through channels (canals and rivers), across the surface (in sheet flow), and through the ground (in aquifers). Flow over land, and through the ground slows water movement, and allows sediment and contaminants to be filtered out by soil and vegetation. Removal of land cover, draining of wetlands, and construction of drainage canals alters the preexisting flows of water. Water quality is reduced when human produced contaminants are carried off with the water, the volume of water discharged is increased in the vicinity of channel outlets (reducing salinity), and the variability of water flow is increased. Channels, built to remove water, result in large flows following storms, and little or no flow during dry periods. This results in large fluctuations in circulation patterns, salinity levels, nutrient content, and water quality. Many species may be unable to survive under such conditions.

Ecologically vital habitats are greatly affected by these conditions. An evaluation of the health of estuary habitats, along with measurement of the factors necessary for maintenance of the habitat, provides an excellent indicator of the health of the estuary, and the stresses to which the estuary is being subjected.

Bottom (benthic) life in estuaries is often abundant. Benthic species include worms, lobsters, clams, oysters, shrimp, and fish. Changes in these species and their habitat is one indicator of water quality and estuary health. Oyster beds, for example, are concentrated in certain areas and are therefore easy to identify. These beds provide a habitat for many species, and oysters constitute a major food source for many species, and filter a significant portion of the water each day (thereby concentrating any pollutants in their bodies).

Submerged grass beds supply food to many animals, store nutrients, add oxygen, stabilize the estuary bottom, and provide a habitat utilized by many other species. These beds are sensitive to salinity levels. Coastal wetlands also provide essential habitat, stabilize shore areas, cleanse inflowing waters removing toxic materials and excess nutrients, and stabilize water flows providing flood protection to shore environments and a regular flow to the estuary. Wetlands, particularly upper ones and freshwater ones have often been destroyed by draining and filling for land development. Tideflats, or mudflats, store nutrients in their sediments. They prevent excess nutrients from entering the estuary and serve as feeding areas during high tides.

Measures exist for many of the water quality factors discussed above. The Department of Environmental Regulation has established water quality standards for acceptable levels of dissolved oxygen, bacteriological quality, detergents, oils and greases, certain heavy metals, and pesticides. These standards (see Table V-1), can be used to assess the quality of both the freshwater inputs and the receiving waters of the estuary.

WATER QUALITY CLASSIFICATIONS AND STANDARDS

Parameter	DER Ground Water Potable Water Standards	DER Surface Water Quality Classifications					EPA Surface Water Quality Index Criteria			
		Class I Potable	Class II Shellfish	Class III Recreation Fish & Wildlife	Class IV Agricultural	Class V Industrial	Good	Fair	Poor	Typical Range[2]
Alkalinity		20 mg/l min. as $CaCO_3$		20 mg/l min. as $CaCO_3$ (fresh)	600 mg/l max. as $CaCO_3$					
Aluminum			1.5 mg/l	1.5 mg/l (marine)						
Ammonia, un-ionized		0.02 mg/l		0.02 mg/l (fresh)			< 0.02 mg/l	0.02-0.20 mg/l	> 0.20 mg/l	
Antimony			0.2 mg/l	0.2 mg/l (marine)						
Arsenic	0.05 mg/l	0.05 mg/l	0.05 mg/l	0.05 mg/l	0.05 mg/l	0.05 mg/l				
Bacteriological Quality	Total coliform 4/100 ml	1,000/100 ml mean;[1] 200/100 ml mean fecal	70/100 ml median;[1] 14/100 ml median fecal	1,000/100 ml mean;[1] 200/100 ml mean fecal			< 200 MPN/100 ml fecal	200-2,000 MPN/100 ml fecal	> 2,000 MPN/100 ml fecal	2 - (33) - 490 MPN/100 ml
Barium	1 mg/l	1 mg/l								
Beryllium		0.011 mg/l soft 1.10 mg/l hard		0.011 mg/l soft,[1] 1.10 mg/l hard (fresh)	0.1 mg/l soft 0.5 mg/l hard					
Biological Integrity		min. 75% of Diversity Index	min. 75% of Diversity Index	min. 75% of Diversity Index						
Boron					0.75 mg/l					
Bromine & Bromates			0.1 mg/l free bromine 100 mg/l bromates	0.1 mg/l free bromine, 100 mg/l bromate (marine)						
Cadmium	0.010 mg/l	0.0008 mg/l soft 0.0012 mg/l hard	0.005 mg/l	0.0008 mg/l soft (fresh) 0.0012 mg/l hard (fresh) 0.005 mg/l (marine)			< 0.004 mg/l	0.004-0.020 mg/l	> 0.020 mg/l	
Chlorides	250 mg/l	250 mg/l	10% above background[1]	10% above background (marine)[1]		10% above background (marine)[1]				
Chlorine, Residual		0.01 mg/l	0.01 mg/l	0.01 mg/l						
Chlorophyll							< .015 mg/l (lakes)	.015-.050 mg/l (lakes)	> .050 mg/l (lakes)	.001 - (.005) - .048 (lakes)
Chromium	0.05 mg/l	0.05 mg/l total[1]	0.05 mg/l total[1]	0.05 mg/l total[1]	0.05 mg/l total[1]	0.05 mg/l total[1]	< 0.1 mg/l	0.1-0.3 mg/l	> 0.3 mg/l	
Color	15 color units	no nuisance conditions	no nuisance conditions	no nuisance conditions[1]	suitable for use[1]	no nuisance conditions				
Copper	1 mg/l	0.03 mg/l	0.015 mg/l	0.03 mg/l (fresh) 0.015 mg/l (marine)	0.5 mg/l	0.5 mg/l	< 0.025 mg/l	0.025-0.125 mg/l	> 0.125 mg/l	
Corrosivity	Noncorrosive									
Cyanide		0.005 mg/l	0.005 mg/l	0.005 mg/l	0.005 mg/l	0.005 mg/l	< 0.005 mg/l	0.005-0.042 mg/l	> 0.042 mg/l	
Detergents		0.5 mg/l	0.5 mg/l	0.5 mg/l	0.5 mg/l	0.5 mg/l				
Dissolved Oxygen		5.0 mg/l min.[1]	5.0 mg/l mean 4.0 mg/l min.[1]	5 mg/l min. (fresh)[1] 4 mg/l min. (marine)	4.0 mg/l mean 3.0 mg/l min.[1]	2.0 mg/l min.[1]	> 5 mg/l	3-5 mg/l	< 3 mg/l	9.3 - (6.8) - 3.5 mg/l
Dissolved Solids	500 mg/l (total)	500 mg/l monthly av. 1,000 mg/l max.					< 500 mg/l (fresh)	500-2,000 mg/l (fresh)	> 2,000 mg/l (fresh)	
Fluorides	1.4-2.4 mg/l	1.5 mg/l	1.5 mg/l	5.0 mg/l (marine) 10.0 mg/l as fluoride ion	10.0 mg/l as Fluoride ion	10.0 mg/l as fluoride ion				

(continued)

Foaming	0.5 mg/l									
Iron	0.3 mg/l	0.3 mg/l	0.3 mg/l	1.0 mg/l (fresh) 0.3 mg/l (marine)	1.0 mg/l					
Lead	0.05 mg/l	0.03 mg/l	0.05 mg/l	0.03 mg/l (fresh)	0.05 mg/l	0.05 mg/l	< 0.10 mg/l	0.10-0.30 mg/l	> 0.30 mg/l	
Manganese	0.05 mg/l		0.1 mg/l							
Mercury	0.002 mg/l	0.0002 mg/l	0.0001 mg/l	0.0002 mg/l (fresh) 0.0001 mg/l (marine)	0.0002 mg/l	0.0002 mg/l	< 0.00005 mg/l	0.00005-0.0025 mg/l	> 0.0025 mg/l	
Nickel		0.1 mg/l	0.1 mg/l	0.1 mg/l	0.1 mg/l					
Nitrate (as N)	10 mg/l[1]	10 mg/l								
Nitrogen, Total (as N)		←		See 17-3.011(11)		→	< 0.7 mg/l (inorganic N in streams)	0.7-3.5 mg/l (inorganic N in streams)	> 3.5 mg/l (inorganic N in streams)	0.4 – (1.2) – 2.7 mg/l
Nutrients		varies[1]	varies[1]	varies[1]	discharge limited[1]	discharge limited[1]				
Odor	threshold odor number of 3	no nuisance conditions	threshold odor number of 24[1]	no nuisance conditions	suitable for use[1]	suitable for use[1]				
Oils & Greases		5.0 mg/l; no taste or odor	5.0 mg/l; no taste or odor	5.0 mg/l; no taste or odor	5.0 mg/l; no taste or odor	5.0 mg/l; no taste or odor				
Pesticides: Aldrin-Dieldrin		0.003 µg/l	0.003 µg/l	0.003 µg/l						
Pesticides: Chlordane		0.01 µg/l	0.004 µg/l	0.01 µg/l (fresh) 0.004 µg/l (marine)						
Pesticides: 2,4—D	100 µg/l	100 µg/l								
Pesticides: 2,4,5—TP	10 µg/l	10 µg/l								
Pesticides: DDT		0.001 µg/l	0.001 µg/l	0.001 µg/l						
Pesticides: Demeton		0.1 µg/l	0.1 µg/l	0.1 µg/l						
Pesticides: Endosulfan		0.003 µg/l	0.001 µg/l	0.003 µg/l (fresh) 0.001 µg/l (marine)						
Pesticides: Endrin	0.2 µg/l	0.004 µg/l	0.004 µg/l	0.004 µg/l						
Pesticides: Guthion		0.01 µg/l	0.01 µg/l	0.01 µg/l						
Pesticides: Heptachlor		0.001 µg/l	0.001 µg/l	0.001 µg/l						
Pesticides: Lindane	4 µg/l	0.01 µg/l	0.004 µg/l	0.01 µg/l (fresh) 0.004 µg/l (marine)						
Pesticides: Malathion		0.1 µg/l	0.1 µg/l	0.1 µg/l						
Pesticides: Methoxy-Chlor	100 µg/l	0.03 µg/l	0.03 µg/l	0.03 µg/l						
Pesticides: Mirex		0.001 µg/l	0.001 µg/l	0.001 µg/l						
Pesticides: Parathion		0.04 µg/l	0.04 µg/l	0.04 µg/l						
Pesticides: Toxaphene	5 µg/l	0.005 µg/l	0.005 µg/l	0.005 µg/l						
pH	6.5 minimum	1.0 unit variation[1] 6.0-8.5	1 unit variation 6.5-8.5[1]	1 unit variation 6.0-8.5 (fresh)[1] 6.5-8.5 (marine)	1 unit variation 6.0-8.5[1]	5.0-9.5[1]	5.5-8.5	4.5-5.5 or 8.5-9.5	< 4.5 or > 9.5	6.6 – (7.6) – 8.4
Phenolic Compounds		0.001 mg/l[1]	0.001 mg/l[1]	0.001 mg/l[1]	0.001 mg/l[1]	0.001 mg/l				
Phosphorus, Elemental			0.0001 mg/l	0.0001 mg/l (marine)						

TABLE V-I

WATER QUALITY CLASSIFICATIONS AND STANDARDS
(continued)

Parameter	DER Ground Water Potable Water Standards	DER Surface Water Quality Classifications					EPA Surface Water Quality Index Criteria			
		Class I Potable	Class II Shellfish	Class III Recreation Fish & Wildlife	Class IV Agricultural	Class V Industrial	Good	Fair	Poor	Typical Range[2]
Phosphorus, Total (as P)		←		See 17-3.011(11)		→	< 0.1 mg/l (streams)	0.1-0.5 mg/l (streams)	> 0.5 mg/l (streams)	0.02 – (0.10) – 1.2 mg/l
Phthalate Esters		0.003 mg/l		0.003 mg/l (fresh)						
PCBs		0.001 µg/l	0.001 µg/l	0.001 µg/l						
Radioactive Substances	Ra: 5 pCi/l α: 15 pCi/l[1]	Ra: 5 pCi/l α: 15 pCi/l[1]	Ra: 5 pCi/l α: 15 pCi/l[1]	Ra: 5 pCi/l α: 15 pCi/l[1]	Ra: 5 pCi/l α: 15 pCi/l[1]	Ra: 5 pCi/l α: 15 pCi/l[1]				
Selenium	0.01 mg/l	0.01 mg/l	0.025 mg/l	0.025 mg/l						
Silver	0.05 mg/l	0.00007 mg/l	0.00005 mg/l	0.00007 mg/l (fresh) 0.00005 mg/l (marine)						
Sodium	160 mg/l									
Specific Conductance		varies[1]	varies[1]	varies[1]	varies[1]	varies[1]	< 750 micromhos (fresh)	750-3,000 micromhos (fresh)	> 3,000 micromhos (fresh)	125 – (600) – 41,000 micromhos
Sulfates	250 mg/l									
Suspended Solids							< 80 mg/l	80-250 mg/l	> 250 mg/l	1 – (8) – 43 mg/l
Temperature		no nuisance conditions[1]	no nuisance conditions[1]	no nuisance conditions[1]	no nuisance conditions[1]	no nuisance conditions[1]	< 28°C	28-34°C	> 34°C	15 – (24) – 29°C
Total Dissolved Gases		110% of saturation value	110% of saturation value	110% of saturation value						
Transparency		min. 90% of background	min. 90% of background	min. 90% of background						
Trihalomethanes	0.10 mg/l[1]									
Turbidity	1 TU month av. 5 TU 2-day av.[1]	29 NTU above background	29 NTU above background	29 NTU above background	29 NTU above background	29 NTU above background	< 25 JTU	25-100 JTU	> 100 JTU	1 – (4) – 31 JTU
Zinc	5 mg/l	0.03 mg/l	1.0 mg/l	0.03 mg/l (fresh)	1.0 mg/l	1.0 mg/l	< 0.25 mg/l	0.25-0.90 mg/l	> 0.90 mg/l	

[1]Actual standards are more complex than numbers displayed in chart (see Chapter 17-3, FAC).

[2]These values are based on 6,000 samples from 94 lake, stream, and estuary sampling stations collected from 1974-1982 by DER. The first value is the tenth percentile, the second value is the median, and the last value is the ninetieth percentile.

Protected Areas: Class II Waters, Aquatic Preserves and Wildlife Areas
Designation of various sections of the Lee and Charlotte county coastal zone as aquatic preserves, state parks[4], Outstanding Florida Waters, Class II waters suitable for shellfish harvesting, and national wildlife refuges provides extra regulatory protection against human-induced impacts.

The occurrence of Class II waters, those suitable for shellfish harvesting or having the potential for harvesting, provides one indication of water quality in the Lee County coastal area. The Department of Natural Resources (DNR) determines the status of Class II waters and divides them further into four sub-categories through observation of activities on adjacent uplands and through regular testing to ensure bacteriological standards are met. Clean waters are approved for shellfish harvesting. Waters subject to water quality changes are conditionally approved, degraded waters are prohibited for the taking of shellfish. Other waters are unclassified because water quality trends have not been established. The classification of Class II waters for Lee County is shown on the following map (see Fig. V-2).

Areas upgraded from prohibited to conditionally approved and approved, since 1978, include large areas of Pine Island Sound and Matlacha Pass[5]. Areas prohibited for harvesting shellfish since 1978 include the vicinity of St. James City, Useppa Island, and Cabbage Key south of Little Bokeelia Island and from Demere Key to Cork Island. San Carlos Bay and Estero Bay have been closed to shellfishing since 1978.

Lee county is fortunate to have within its boundaries, all or part of the following aquatic preserves: Gasparilla Sound-Charlotte Harbor, Cape Haze, Pine Island Sound, Matlacha Pass, and Estero Bay (see Fig. V-3). These aquatic preserves cover approximately 90% of the surface water in the Charlotte Harbor estuarine complex (DNR 1983). State owned lands and national wildlife refuges are also scattered near or within the Lee County aquatic preserves, most notably the J.N. Ding Darling National Wildlife Refuge on Sanibel Island (Fig. V-4).

Water Pollution Sources
Point Sources: Sources of water pollution are generally classified as point sources and nonpoint sources. Point sources of pollution are those that are discharged from specific pipes or discharge canals, notably sewage treatment plant and industrial waste outlets. Major point source discharges into the Caloosahatchee River in Lee County come from five sewage treatment plants with a cumulative design capacity of 26 million gallons per day[6]. These sources

---

[4]State purchase of large tracts of wetlands (primarily mangrove forests) under the 1972 Land Conservation Act and the 1979 Conservation and Recreation Land Trust Fund provides a buffer to encroaching development.

[5]This upgrading of Class II waters is probably due to increased water quality evaluations by DNR staff and not because of dramatic improvements in water quality.

[6]Two plants operated by the City of Fort Myers, a City of Cape Coral plant and two Florida Cities Water Company plants located at Waterway Estates and Fiesta Village. A small unauthorized discharge at River Trails Mobile Home Park is currently under enforcement action.

FIGURE V-2

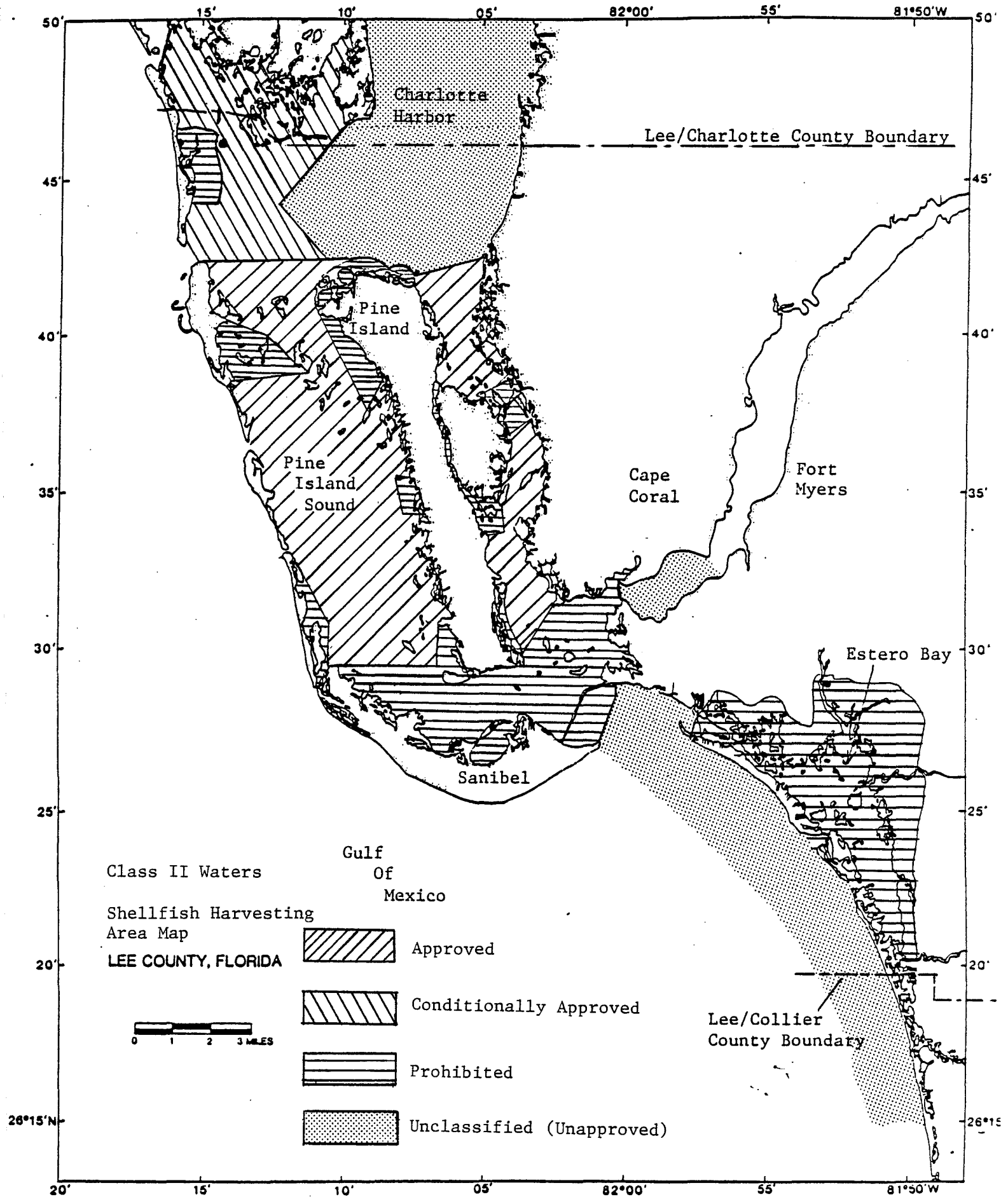

Charlotte Harbor
Lee/Charlotte County Boundary
Pine Island
Pine Island Sound
Cape Coral
Fort Myers
Estero Bay
Sanibel
Gulf Of Mexico
Lee/Collier County Boundary
Class II Waters
Shellfish Harvesting Area Map
LEE COUNTY, FLORIDA
0 1 2 3 MILES
Approved
Conditionally Approved
Prohibited
Unclassified (Unapproved)
50'
45'
40'
35'
30'
25'
20'
26°15'N
15'
10'
05'
82°00'
55'
81°50'W

FIGURE V-3

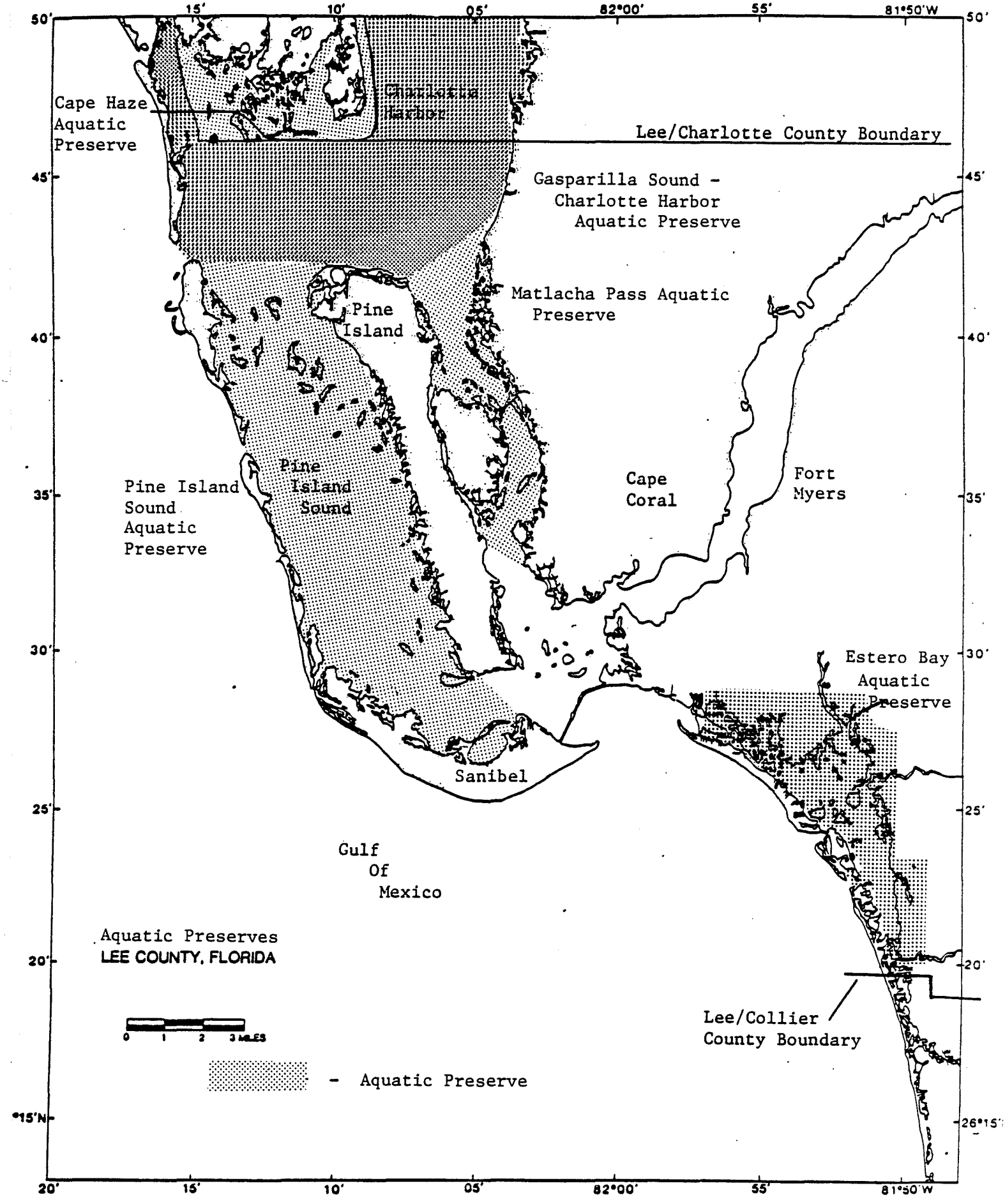
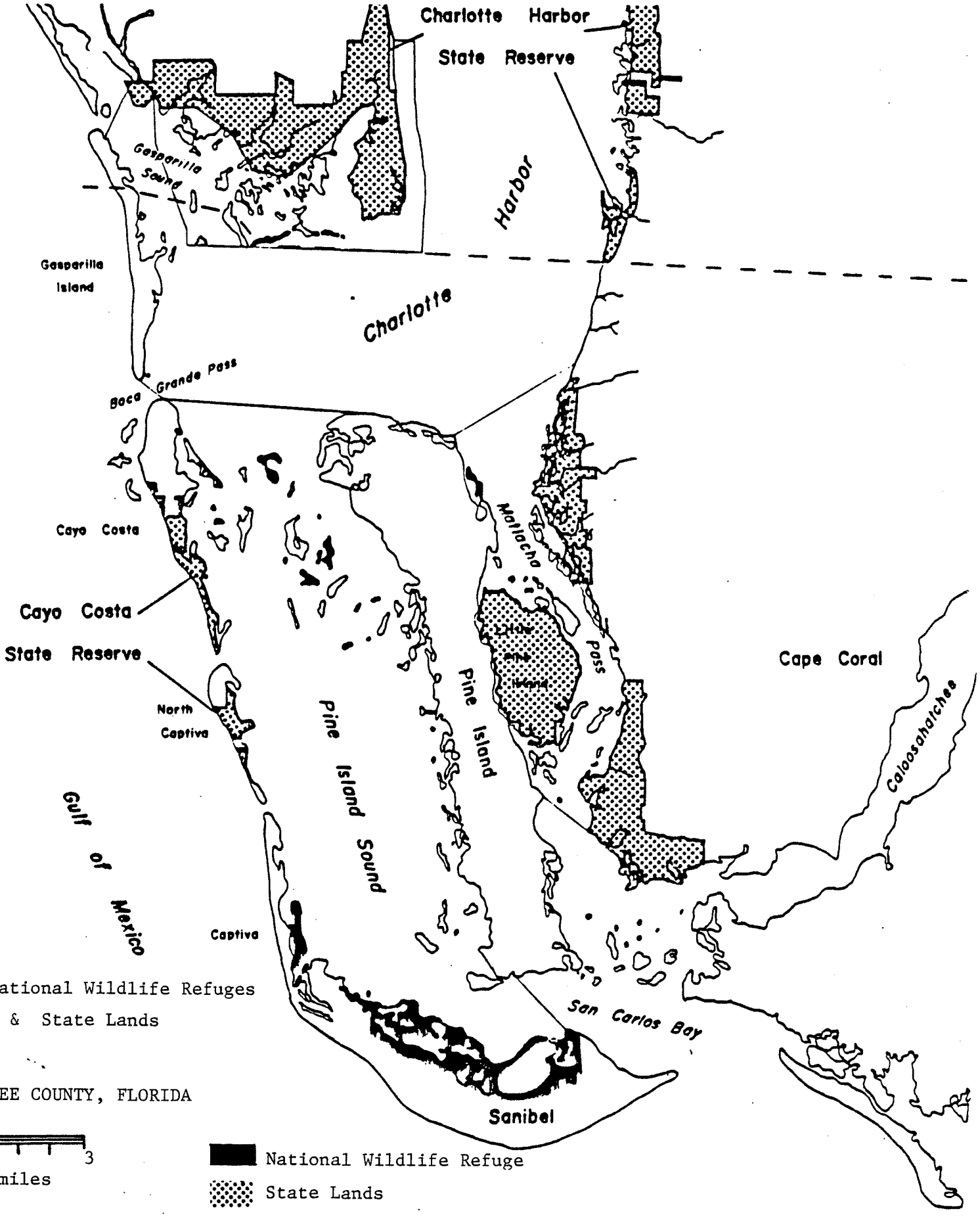

Cape Haze Aquatic Preserve
Charlotte Harbor
Lee/Charlotte County Boundary
Gasparilla Sound - Charlotte Harbor Aquatic Preserve
Matlacha Pass Aquatic Preserve
Pine Island
Pine Island Sound
Pine Island Sound Aquatic Preserve
Cape Coral
Fort Myers
Estero Bay Aquatic Preserve
Sanibel
Gulf Of Mexico
Aquatic Preserves
LEE COUNTY, FLORIDA
0 1 2 3 MILES
- Aquatic Preserve
Lee/Collier County Boundary
50'
45'
40'
35'
30'
25'
20'
15'
10'
05'
82°00'
55'
81°50'W
26°15'N

FIGURE V-4


Charlotte Harbor
State Reserve
Gasparilla Sound
Harbor
Gasparilla Island
Charlotte
Boca Grande Pass
Boca
Cayo Costa
Cayo Costa
State Reserve
Mallacha
Pass
Cape Coral
North Captiva
Pine Island Sound
Pine Island
Caloosahatchee
Gulf of Mexico
Captiva
San Carlos Bay
Sanibel
National Wildlife Refuges
& State Lands
LEE COUNTY, FLORIDA
0
3
miles
National Wildlife Refuge
State Lands

are closely regulated by the DER through its permitting and enforcement programs. If water quality conditions in the Caloosahatchee River deteriorate, the DER could tighten its standards and require these plants to reduce the level of nutrients they discharge.

Nonpoint Pollution Sources: Nonpoint pollution arises from various activities, such as urban development and agriculture, that degrade the quality and alter the quantity of freshwater which is carried into water bodies. Runoff of stormwater from land surfaces contaminated by industrial, agricultural, residential and commercial activities can greatly impair the water quality in freshwater streams and lakes, and coastal estuaries. On a statewide average, stormwater contributes approximately 50 percent of the pollutants found in receiving rivers, lakes, and estuaries. For heavy metals and sediments, stormwater runoff contributes up to 90 percent. A Department of Environmental Regulation review of past water quality studies found that untreated stormwater discharges were responsible for:

1) 80 to 95 percent of the heavy metals loading to Florida surface waters.
2) Virtually all of the sediment deposited in state waters.
3) 450 times the suspended solids and 9 times the BOD load to surface waters that exists in sewage effluent treated to secondary standards.
4) Nutrient loads comparable to those in sewage effluent treated to secondary standards. (Livingston, 1986)

Residential developments contribute nutrients, pesticides and sediment from lawns and animal wastes to streams. Heavy metals, oils, and greases are contained in runoff from driveways and roads. The discharge of these contaminants is accelerated in the numerous canal systems[7] which allow stormwater to enter the waterbodies directly without the benefit of filtration, precipitation, and nutrient assimilation that would occur in vegetated ditches, swales, retention ponds, upland lakes, and wetlands. In addition, large volumes of freshwater are quickly routed through canals to surface waters, reducing recharge to wetlands and groundwater.

An example of this problem was documented by a U.S.G.S. study which showed that discharges of large volumes of freshwater from the canal system in western Cape Coral have been at least partially responsible for the existence of unusually low salinity levels in the Matlacha Pass Aquatic Preserve. The volumes of freshwater alone are a pollutant because historic salinity regimes are being altered. This change may be adversely affecting productivity by displacing marine organisms, but the extent of damage has not been documented. As more lots in Cape Coral are built out, the amount of freshwater runoff will increase, as will nutrients, pesticides, herbicides, heavy metals, oils and greases, and other pollutants. A similar problem could be taking place in Estero Bay, but its extent remains unknown due to limited monitoring.

Regulatory actions by state and federal agencies in the mid-1970's curtailed the destruction of wetlands around Charlotte Harbor and Estero Bay and ended

---

[7]Drainage canals are built to drain wetlands and create buildable lots, facilitate septic tank use, and provide flood protection. Additionally, finger fill canals formerly were built to allow residential development with boating access.

the practice of finger-fill canals. However, in the older subdivisions built prior to these changes it is difficult and expensive to correct the discharge of inadequately treated stormwater. No state regulations exist that require either these areas or the agricultural drainage systems to be retrofitted with treatment mechanisms. Also in areas where sewage systems are not provided, septic tanks are still used and may be contributing nutrients and bacteria. The number and condition of septic tanks in use in the coastal zone is unknown

New developments must meet treatment standards for stormwater imposed in Lee County by the South Florida Water Management District[8]. However, even though these regulations have improved the management of stormwater runoff, the cumulative impact of increasing numbers of treated stormwater discharges on sensitive estuaries, such as Estero Bay, is not known.

Non-residential uses also contribute nonpoint pollution to the estuary system. Stormwater runoff from golf courses, with their intensively managed turf, may contain high concentrations of pesticides and fertilizers. Industrial and commercial facilities, particularly those built prior to current regulations, may allow the discharge of oils, greases, sediment, and heavy metals to nearby drainage systems. The Ten Mile Creek and Six Mile Cypress watershed, running from the City of Fort Myers to Estero Bay, may contain particularly high concentrations of contaminants from the mixed land uses in its 57 square mile drainage basin.

The nature of untreated stormwater runoff has been examined in several studies. Table V-2 lists pollutant loadings for stormwater runoff from urban land uses. In another effort, the DER analyzed Florida data to determine typical loading rates of pollutants from area watersheds (Table V-3). These data allow the calculation of additional pollutant loading from untreated stormwater. In order to determine the pollutant concentrations in treated stormwater, further investigations have examined the efficiency of stormwater management facilities in reducing runoff quantity and contaminant levels.

Various methods have been devised for the reduction of stormwater. They essentially fall into three categories: prevention, treatment, and control. Preventive measures, those employed prior to construction of a development, include floodplain management and regulation and on-site detention/retention facilities. Treatment measures involve the use of physical, chemical, or biological processes such as the use of natural drainage systems, sedimentation ponds, and specialized wastewater treatment in order to reduce nonpoint pollution. Control measures, such as street cleaning, anti-litter ordinances, and schedules for maintaining and inspecting stormwater facilities are used in existing developments.

The South Florida Water Management District funded the examination of stormwater treatment in a Boca Raton subdivision (Timbercreek). This system, similar to those that might be used in Lee County, removed more than 80 percent of ortho phosphate and NOX, 64 percent of suspended solids, 60 percent of total phosphate and 15 percent of total nitrogen. A separate investigation (Yousef et al 1985, Harper 1985) studied the fate of heavy metals entering

---

[8]These regulations, Chapter 17-25, were adopted by the Department of Environmental Regulation in 1982.

TABLE V-2

Heavy Metal Loading Intensities
(lbs/curb mile of roads)

Land Use	Chromium	Nickel	Lead	Copper	Zinc	Mercury
Residential	2.0	0.5	15.7	4.8	16.8	4.8
Commercial	1.0	0.3	3.5	1.8	3.0	1.5
Industrial	4.7	2.2	14.8	7.7	29.2	0.8

Adapted from DER (1979)

TABLE V-3

Florida Nonpoint Source Loading Rates
(lbs/acre of land use/inch of rain)

Land Use	Total Nitrogen	Total Phosphorus	Suspended Solids	Biological Oxygen Demand	Total Organic Carbon
Residential	0.1869	0.0532	6.971	0.8343	0.3576
Commercial	0.2946	0.1297	25.750	1.0586	1.658
Industrial	0.28	0.07	29.1	1.21	-
Open Developed	0.0759	0.0486	4.815	0.7590	1.1418

Adapted from DER (1979)

stormwater treatment systems near Interstate 4 in Orange County, Florida. This study indicated that sediments will hold metals removed from stormwater by physical and chemical processes, provided the Ph does not fall to 5.0 or below (which would release the heavy metals into the groundwater). Regular maintenance of ponds is suggested in order to remove accumulated sediments and maintain aerobic conditions. A third study (Harper et al 1985) examined the fate of stormwater in a hardwood wetland. Treatment efficiency in the wetland was in excess of 80 percent for BOD and suspended solids; 70 percent for cadmium, nickel, and chromium; and 40 - 60 percent for zinc, copper, aluminum, and lead. Nitrogen and phosphorus apparently were not removed by the wetland system[9].

These studies of stormwater treatment efficiencies and contaminant levels in untreated stormwater runoff indicate that Lee County estuarine waters may be

[9]More information on these studies is available in the supplemental report by Morgan.

degraded by the discharge of additional quantities of freshwater and contaminants which further growth will cause.

Marine activities also threaten water quality. The large number of pleasure and commercial boats operating in the Lee County coastal area, and the associated marinas are likely to contribute oils and greases, heavy metals, sediments, detergents and possibly human wastes to the estuary. Matanzas Pass with its high concentration of boats and confined waters would be an area particularly susceptible to such pollution.

Two Lee County commercial facilities pose potentially severe contamination risks during a severe storm. The Belcher Oil transfer facility at the south end of Gasparilla Island and the Balgas petroleum storage complex on Matanzas Pass could be damaged by erosion and storm surges.

Summary of Current Water Quality Conditions

An overview of water quality for the region is provided in the introductory description of basin conditions contained in a 1986 water quality assessment:

> "The Caloosahatchee River has no major pollution problems. It has somewhat elevated nutrient levels and depressed oxygen levels from agricultural runoff but supports a healthy biological community. The estuarine portion receives urban runoff and some sewage treatment plant discharge and exhibits water quality problems. Recent upgrading of several of the area's sewage treatment facilities should help to improve water quality.
>
> Charlotte Harbor and associated estuaries have generally good water quality. Phosphorous loading is high as a result of the contribution from the Peace River which is impacted by phosphate mining, and from the Myakka and Caloosahatchee Rivers' nonpoint nutrient loading. The harbor is also affected by urbanization, but supports a healthy estuarine habitat." (Hand et al 1986)

The water of the region and the remaining fringe wetlands generally rank high in quality at this time. However, future threats to the maintenance of present water quality will come as coastal communities in the region grow toward their ultimate buildout, and pollution loads and quantities of stormwater subsequently rise. With Cape Coral and subdivisions in Lee Charlotte counties having the potential to house 1.4 million persons, stresses on the estuarine environment are sure to increase.

As part of our evaluation of estuarine pollution conditions, we considered the effects of the projected coastal zone population growth. We concluded that it was not possible to model the effect of this population growth on estuarine water quality. The coastal zone makes up only a small portion of the total estuary drainage basin and the pollutant loading which comes from the coastal area, relative to the whole basin, is unknown. Staff of both the South Florida Water Management District and the Department of Environmental Regulation indicated that such an effort would be extremely complex, and if a hurricane changed the biological, chemical, and physical characteristics of the estuaries any model would no longer be valid. For these reasons, instead of attempting to model future water quality conditions we have provided information on stormwater runoff, the major threat posed by new development.

We also have provided information about current water quality conditions in the Lee County coastal zone.

Summaries of eleven recent water quality studies, contained in the next section of this report, provide more information on estuarine pollution conditions in the Lee County coastal area.

ENVIRONMENTAL AGENCIES: PROGRAMS & WATER QUALITY STUDIES

Three state agencies monitor environmental conditions in the Lee County coastal zone, the Department of Natural Resources (DNR), the Department of Environmental Regulation (DER), and the South Florida Water Management District (SFWMD). In addition the Southwest Florida Regional Planning Council and local governments are involved in studying water quality conditions and reviewing local developments. Two federal agencies, the United States Geological Survey and the Army Corps of Engineers are also involved in the regulation or study of the Lee County coastal area. The activities of each of these agencies, and the results of their recent water quality studies are summarized below.

Most of these previous water quality studies were short-term, site-specific projects. They constitute a patchwork approach to assessing water quality in the region, with no continuity or consistency in the parameters sampled. Fortunately, several notable exceptions do exist. Previous 208 studies, and current special studies by the South Florida Water Management District and the U.S. Geological Survey are better funded, broader in scope, and more likely to provide an accurate assessment of water quality conditions.

DEPARTMENT OF NATURAL RESOURCES (DNR)

The DNR is responsible for the management of state lands such as parks and aquatic preserves, which includes the majority of submerged lands in Lee County's coastal zone. DNR currently operates a field office on Pine Island for the purpose of monitoring and managing the aquatic preserves in Lee and Charlotte counties.

DNR regulates all activities on sovereign lands through its permitting program, authorized by Florida statute. Pursuant to these requirements management plans were adopted for both Estero Bay and Charlotte Harbor aquatic preserves in 1983.

Aquatic Preserve Management Plans:
These plans set forth management authority and major program directives; describe resources (geologic features and landforms, community associations, archaeological and historical sites, water resources, and cultural features), and resource management techniques; establish current uses of the estuaries; specify methods of environmental education; describe the current network of management agencies; and identify further management needs. The water resources section of these plans is particularly pertinent to the Lee County Coastal Study.

The management plans also rank the quality of resource areas in one of three classes. Class one resources include grass beds, mangrove swamps, saltwater marsh, oyster bars, endangered species habitat, colonial waterbird nesting

sites, and archaeological and historical sites. Class two resources are those in transition, such as patchy or sparse grass beds, and mangroves in scrub condition. Class three resource areas lack the characteristics of the areas above. Based on these classifications, "Resources Protection Areas" maps are being prepared. When completed, these maps will be used by DNR in assessments of development permits.

Results of DNR water quality studies

Charlotte Harbor and Estero Bay Aquatic Preserve Management Plans:
The water resources section of the aquatic preserve management plans provides evidence on water quality in the Lee County coastal zone. For the Charlotte Harbor estuarine system several water resources findings were made by the Charlotte Harbor Technical Advisory Committee based on a review of existing data in 1980, (DNR, 1983):

1. pH levels are within normal limits.
2. More data are needed on biocides.
3. Dissolved oxygen depletion is a present and growing problem in the canal system and nearshore habitats.
4. Human activity may be increasing the nutrient content in the estuary.
5. Oils and grease exist in notably high levels.
6. Salinity and temperature regimes, although normal, are optimal for the amplification of pollution effects.
7. Turbidity, although not a system-wide problem, has caused problems near causeway and channel construction.
8. Coliform counts are unacceptably high for large areas of the estuary.

The Technical Advisory Committee also identified eight sensitive areas within the Charlotte Harbor estuarine system. These areas were considered significant because they are important to the estuarine system and they are threatened by upland development.

1. Gasparilla Sound
2. Myakka River Estuary
3. Interceptor or spreader waterways
4. Pine Island Sound and Matlacha Pass
5. Tidal creeks
6. Tidal canals
7. All major freshwater sources
8. Mangroves, seagrasses, and marshes

Areas five through eight were also identified as sensitive areas in the Estero Bay estuary. In the Estero Bay aquatic preserve management plan the DNR concludes that there is not sufficient water resource data to understand how the system operates or to identify the water quality problems existing now and for the future (Clark, 1983). However, two previous studies indicated that the estuary was generally healthy (Tabb, 1974; Environmental Science and Engineering, 1978).

Assessment of Fisheries Habitat: Charlotte Harbor and Lake Worth, Florida

This study (Harris et al, 1983) compared acreages of bottom types found in the Charlotte Harbor and Lake Worth area in 1945 and in 1982. It was found that salt marsh acreages declined by 51 percent, unvegetated tidal flats declined by 76 percent, oyster reefs declined by 39 percent, and seagrass beds by 29 percent. Open water increased by 8 percent and mangrove coverage increased 10 percent. The decline in non-vegetated tidal flats, from 11,206 acres to 2,723 acres is probably due to the increase in mangrove coverage. The increase in open water is believed to be the result of canal construction and the loss of vegetation. Oyster reefs were likely lost due primarily to changes in salinity. Other causes may be changing circulation patterns and overharvesting. The decline in salt marsh is attributed to filling of wetlands and increased freshwater runoff (reducing salinity) caused by development of major subdivisions. Dredging of the intercoastal waterway and the construction of the Sanibel Causeway in the early 1960's are believed to be a major cause of the decline in seagrasses (particularly in Pine Island Sound) and the complete loss of the scallop population. The causeway is believed to have caused a change in circulation patterns which reduced salinity by forcing freshwater into Pine Island Sound rather than permitting its entry into the Gulf. It is not known at this time whether seagrasses are continuing to be lost in the Charlotte Harbor estuarine system. Such information will only come after further measurements over time.

DEPARTMENT OF ENVIRONMENTAL REGULATION (DER)

The DER is the lead state agency for regulation of activities affecting the environment. The DER maintains a district office in Fort Myers and a laboratory in Punta Gorda. Pursuant to enabling legislation, Chapter 403 Florida Statutes, the department implements environmental protection programs in several areas which are relevant to the Lee County Coastal Study.

Regulatory Activities

DER's Water Quality Standards (Chapter 17-3) specify limits for dissolved oxygen, bacteriological activity, detergents, oils and greases, certain heavy metals, and pesticides. These standards apply to potable ground water, and fresh and marine surface waters that are separated into five classes based on their quality and primary use. These five classes are:

Class I, surface waters used for potable purposes
Class II, waters suitable for shellfish harvesting
Class III, waters suitable for recreation and the propagation of fish and wildlife
Class IV, waters used for agricultural purposes
Class V, waters used for industrial purposes.

All waters within the Lee County coastal zone are Class II and III. The standards for these two classes are nearly identical. The status of Class II waters is determined by the DNR through observation of activities on adjacent uplands and regular field monitoring. The agency produces maps which depict the standing of areas within Class II waters according to four sub-categories (clean, subject to change, degraded, unclassified).[10]

---

[10]These maps and a description of current conditions were discussed above, see Figure V-2. The classifications of clean, subject to change, and degraded are also referred to respectively as approved, conditionally approved and prohibited for shellfish harvesting.

DER issues permits (Chapter 17-4) for many activities which could be sources of pollution including; dredge and fill, stormwater, sewage treatment, landfills, industrial operations, and hazardous waste generation.

Standards for wastewater treatment and disposal and other point source discharges are subject to Chapter 17-6. Chapter 17-12 regulates dredge and fill projects. Stormwater from new construction is regulated according to Chapter 17-25 which requires treatment of the first 1" of runoff for projects over 100 acres in size and treatment of the first 1/2" for projects less than 100 acres[11]. The Southwest Florida Water Management District was delegated responsibility for implementation of these stormwater regulations. Indiscriminate cutting of mangroves is prohibited by Chapter 17-27. Finally, the DER administers federal coastal management program grants under Chapter 17-24. These funds were used for Lee County's 1986 Estero Bay water quality study.

Water Quality Monitoring and Sampling

The Department of Environmental Regulation has regularly conducted water quality and biological sampling since the early 1970's. The DER has six water quality sampling stations on Charlotte Harbor, two stations in Lee County on the Caloosahatchee River, and one at Big Carlos Pass[12]. Due to manpower and budget constraints the number and location of sampling stations is limited. Stations tend to be sited at bridge crossings to facilitate sampling without a boat. DER has also discontinued extensive background water monitoring and is utilizing localized, intensive water quality "basin studies" on water bodies of special concern.

Three marine trend stations have been established to collect macroinvertebrate benthic samples in the Lee County coastal zone, in Estero Bay (east of Coon Key), in Pine Island Sound, and at Redfish Point in the Caloosahatchee River. DER (at the Punta Gorda laboratory) also has collected benthic samples at six stations in Charlotte Harbor since 1979, and has conducted a special study of grass bed diversity. The benthic data has not been analyzed for either the Lee County coastal waters or the Charlotte Harbor. Such long-term monitoring of biological health is required to determine ambient conditions from which pollution trends may be identified. These trends are important because the quality of coastal waters, grass beds, marshes, and mangrove forests is necessarily related to the biological health of the coastal zone.

Water quality sampling and research on heavy metals pollution have been conducted by DER's Office of Coastal Management (OCM). This study has pointed out the inadequacy of both the present DER standards for metals and the current practice of testing for these metals in the water column. The results

---

[11]These standards were adopted based on studies showing that the first 1/2" of runoff contained 80 - 95 percent of the annual loadings of most pollutants.

[12]The water quality data from Big Carlos Pass may not be indicative of the water quality in Estero Bay. Incoming tides and the effect of tidally induced mixing could result in observations that will miss pollutant concentrations and declining salinity levels until the estuary is severely damaged. A sampling station should be more centrally located in Estero Bay.

of this study are discussed in more detail below.

Results of DER water quality studies

1) STORET:
All water quality data collected by the DER is stored by the U.S. Environmental Protection Agency in the STORET system, a long-term, national, water quality database. Parameters for which data are reported include depth, BOD, pH, transparency, conductivity, turbidity, dissolved oxygen, temperature, salinity, all forms of nitrogen, total phosphorus, heavy metals, and pesticides. The vast majority of samples were obtained from the water column, although some sampling from sediments is included.

For this evaluation data were requested from the nine area sampling stations in raw and summarized form. In order to check for violations of DER water quality standards, a computer check of ten parameters (copper, iron, endrin, dissolved oxygen, toxaphene, lead, cadmium, mercury, DDT, and malathion) was requested. Five of the nine stations had data only for dissolved oxygen. None of the nine stations showed violations of dissolved oxygen standards. A total of 1,217 values were recorded in the STORET system for the ten parameters from the nine stations. Eighty-eight percent (1065 values) of these values had a coding remark of 'U', indicating that the material was analyzed for but not detected. In these cases the detection limit for the method of measurement (in some cases the detection limit is higher than the DER water quality standard) was entered for the parameter. For the 152 values where actual levels of the material are recorded, no violation of water quality standards exists.

Based on analysis of the STORET data and conversations with DER staff further research is recommended to verify the weaknesses in the STORET database. Meanwhile, total local government reliance on the present state system to provide an adequate warning of water quality degradation at specific stations should be avoided[13].

2) 1986 Florida Water Quality Assessment 305(b) Technical Report:
This report, legally required every two years, was last issued in June 1986. It describes the quality and trends of Florida's surface waters, the causes of water quality problems, and the present cleanup activities conducted by DER and the U.S. EPA (Hand et al, 1986). This is the most complete report of overall water quality available, but it does not identify violations of DER's water quality standards.

The 305(b) studies are intended to determine whether water quality is sufficient to meet the intended uses for specific waterbody segments, and whether this quality is changing over time. The current statewide sampling effort included only about one-half of the 700 reaches that were sampled in the 1970's. Statewide, 23 percent of the reaches were improving in quality, 13 percent worsening and 64 percent showed no trend. Fifty-five percent of the pollutants were identified as coming from point sources (33% domestic and 22% industrial), 42 percent from non-point sources, 2 percent from unknown and 1 percent from natural sources.

---

[13]The full consultant report on Estuarine Pollution Conditions contains more information on the evaluation of the STORET system.

The remaining discussion of the 305(b) report summarizes the information presented for basins which include parts of Lee County.

The Caloosahatchee River Basin: Generally, the water quality in the basin is quite good. There are some borderline problems with low dissolved oxygen values in some of the feeder canals from Lake Okeechobee and some of the slower moving tributaries of the river. These problems are believed to be caused by nonpoint agricultural runoff and the warm climate of the area.

According to the 1986 Florida Water Quality Assessment, the estuarine section of the basin has a Water Quality Index (WQI) rating of fair in the reach from San Carlos Bay to Hancock Creek near the U.S. 41 bridge (see Fig. V-5). From that point east to the Orange River the estuary rates poor on the Florida Trophic State Index (TSI), except for a small area near Daughtrey Creek which rates good. Yellow Fever Creek and Daughtrey Creek rate fair and the Orange River rates good as tributaries to the estuary.

The domestic waste dischargers in the river have been eliminated or significantly upgraded and water quality is expected to improve. However, the area is highly developed and nonpoint source pollution will continue to impact water quality. Point source dischargers in the Caloosahatchee River basin include sewage plants, the City of Cape Coral reverse osmosis plant (1.6mgd brine discharge), the Florida Power and Light Company (563 mgd thermal discharge), Citrus Belle in Labelle and the City of Moore Haven.

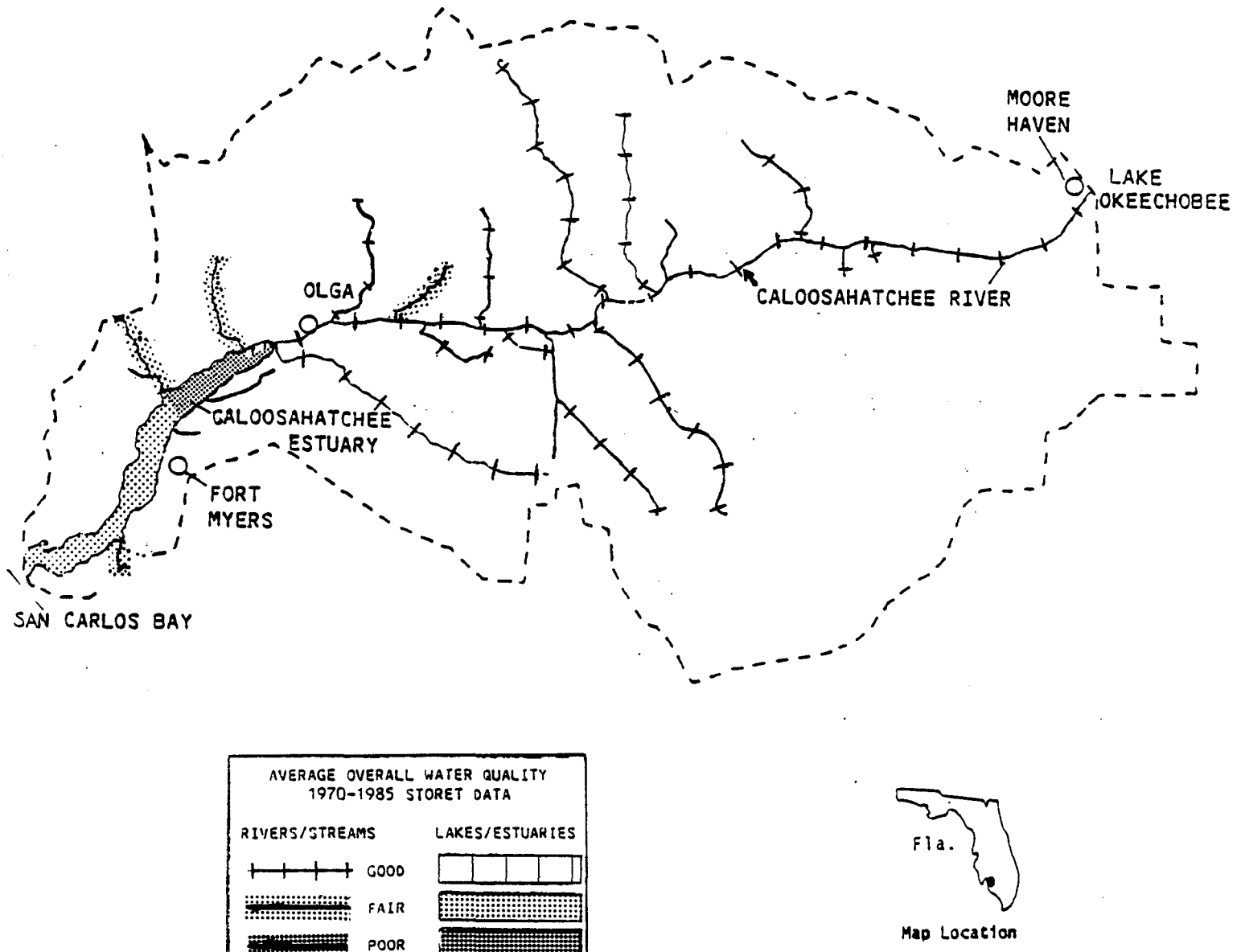
Charlotte Harbor Basin: The water quality of the Charlotte Harbor basin is generally good, but the potential for severe damage to this productive estuary is high. There are several areas where nutrient levels, especially phosphorous, are elevated and Secchi readings are somewhat low. Nutrient loading in San Carlos Bay may be resulting from urban runoff in the Fort Myers area of the lower Caloosahatchee River. The only serious pollution problem in the basin occurs in the Sanibel River, on Sanibel Island. Leachate from local sewage treatment plants has been controlled, but stormwater runoff continues to enter the Sanibel River.

The trophic state index (TSI) for Charlotte Harbor (Fig V-6), ranges from good to fair for various sections of the basin, except for the Sanibel River as mentioned above. Matlacha Pass, San Carlos Bay, the eastern half of Pine Island Sound and a reach adjacent to Alligator Creek are given a TSI rating of fair. A good TSI rating extends down the western half of the harbor from the Myakka River around Cape Haze to Gasparilla Sound and across to the eastern shoreline between Winegard Creek and Yucca Pen Creek. Another area rated good is the western half of Pine Island Sound behind North Captiva Island. Areas having an unknown status are located in the western half of Pine Island Sound behind Cayo Costa Island and Captive Island. Areas having a fair or good TSI rating also had a good WQI except for the south prong of Alligator Creek which ranked fair and the Sanibel River which ranked poor.

Water quality trends in the 21 reaches of the Charlotte Harbor basin could not be determined due to insufficient data.

FIGURE V-5

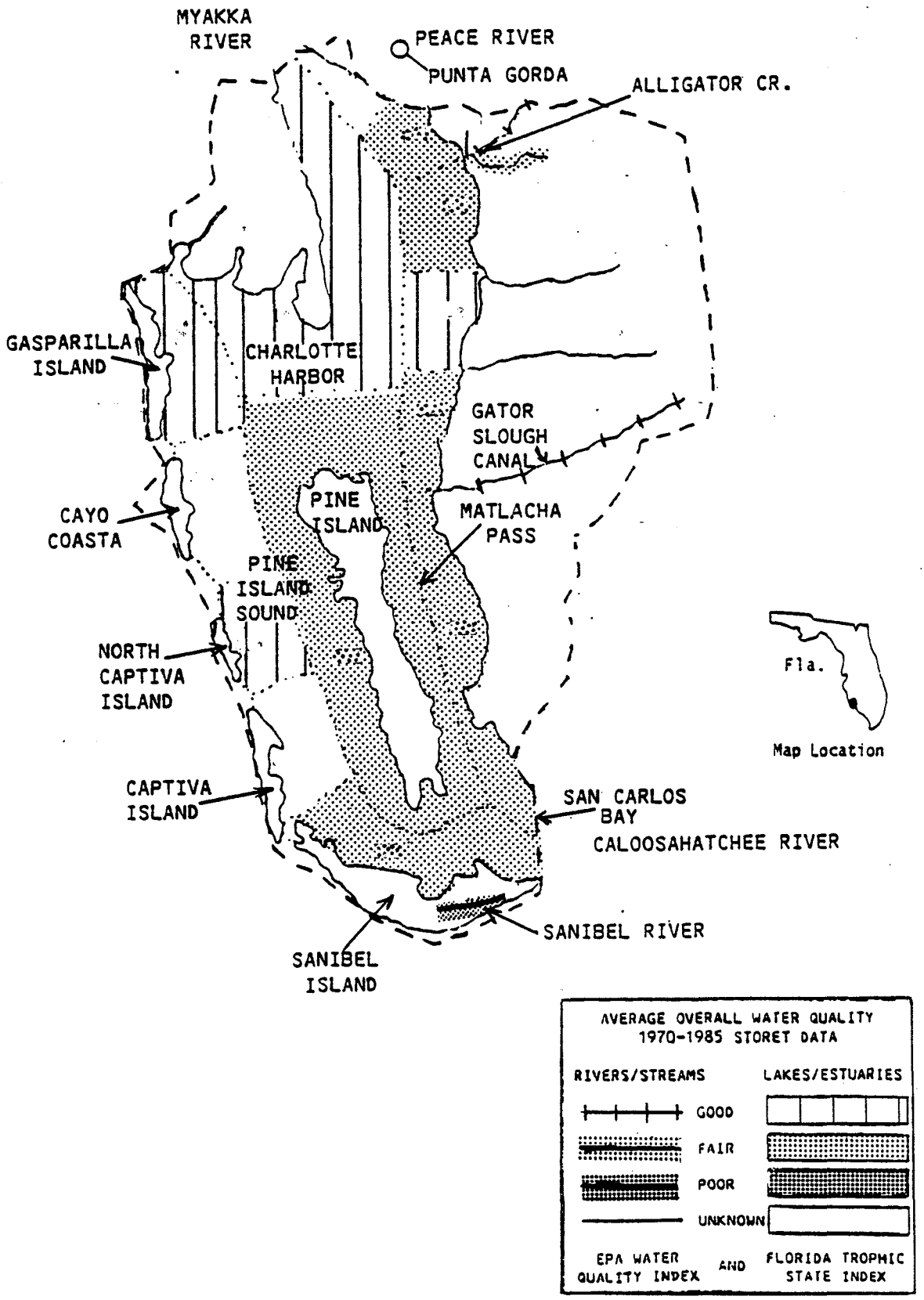
Average Water Quality in the Caloosahatchee River Basin



Adapted from DER 1986

FIGURE V-6

Average Water Quality in the Charlotte Harbor Basin



Adapted from DER 1986

Estero Bay: Everglades - West Coast Basin: Estero Bay and the Estero River are given a good water quality index rating and Estero Bay received a good trophic state index designation, (see Fig. V-7). Reaches in Hendry Creek and the Gulf of Mexico were not categorized.

Bay Beach, on Fort Myers Beach was the only point source listed for Estero Bay (43.2 mgd), the nature of this large discharge is not specified. Another point source, Imperial Harbor Mobile Home Park, is located on Spring Creek, a tributary to Estero Bay.

3) OCM Charlotte Harbor and Caloosahatchee River Study:
The DER's Office of Coastal Management has conducted water quality sampling at twenty stations under its Estuarine Research Program. This study, performed during 1985 and 1986, involved the assessment of metals, nutrients, and organochlorines in the sediments.

The majority of stations showing enriched metals in the sediments are located in the Caloosahatchee River, with the station at the I-75 bridge having the highest value for all metal parameters and arsenic of the twenty stations. Of particular concern are the levels of chromium, lead, mercury, and zinc[14]. This accumulation in the Caloosahatchee River may be due to the longstanding runoff from agricultural areas. The lower concentrations downstream suggest that metals in the sediment may leach, or migrate, to the water column where water column concentrations of metals are lower.

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Florida's five water management districts regulate the consumptive use of water and the storage and management of surface waters (Florida Statutes Chapter 373). The South Florida Water Management District (SFWMD) also regulates any construction which alters natural drainage patterns, and enforces performance criteria for the storage and treatment of stormwater (SFWMD rule, Chapter 40E-4, F.A.C.). The SFWMD's jurisdiction includes Lee County and all of the Caloosahatchee River Watershed[15]. SFWMD maintains its office in West Palm Beach and a field staff at DER's Fort Myers office.

Ongoing SFWMD studies and sampling
The District's Division of Water Resources is investigating the hydrodynamics of the Caloosahatchee River in order to develop a model that will enable the District to understand how the river and lock systems function under a variety of conditions. The SFWMD is also conducting a study of water quality in the lower Caloosahatchee River, the Franklin lock and dam, San Carlos Bay, and Pine Island Sound. This study will provide valuable data on sections of the Lee County coastal zone for which data is currently sparse.

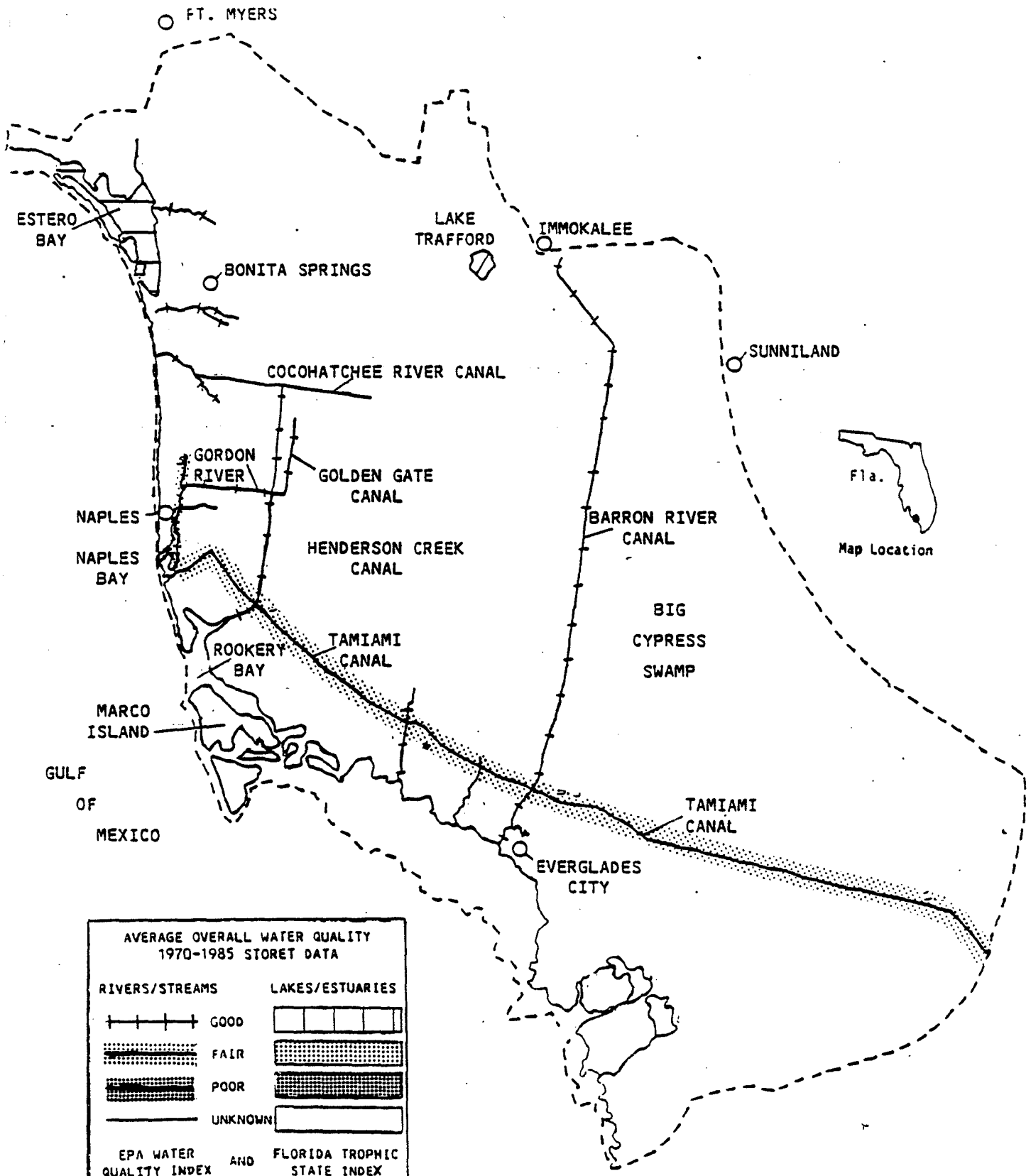
---

[14]The absence of metals enrichment at other stations may be due to sampling location. Sampling must occur in the areas where metal enriched sediments settle out. To better assess bottom conditions numerous randomly scattered stations are required.

[15]All of the Myakka and Peace river watersheds are within the Southwest Florida Water Management District's jurisdiction.

FIGURE V-7

Average Water Quality in the Everglades-West Coast Basin



Adapted from DER 1986

Results of SFWMD water quality studies

A Survey of Water Quality Characteristics and Chlorophyll a Concentrations in the Caloosahatchee River System, Florida. (Miller et al, 1982)
For this two year study (1978 - 1980) of water quality characteristics in the Caloosahatchee River between Lake Okeechobee and the Franklin lock and dam the SFWMD analyzed monthly samples from 17 river and 17 tributary stations[16].

The study found that Lake Okeechobee contributed the most water (55%), nitrogen (62%) and chloride (42%) to the river. The most phosphorus (43%) came from tributaries in the eastern half of the river. Nutrient levels in the river decreased from east to west. The DER dissolved oxygen standard was violated in 22 percent of the samples taken from the river and 31 percent of the samples from the tributaries. The pesticides aldrin, dieldrin, DDT, and chlordane were found in excess of DER water quality standards. Iron and zinc also exceeded standards at various times during the study.

SOUTHWEST FLORIDA REGIONAL PLANNING COUNCIL (SWFRPC)

The Southwest Florida Regional Planning Council, headquartered in Fort Myers, assesses developments of regional impact and coordinates the investigation of environmental problems having regional significance. The SWFRPC has funded several section 208 nonpoint pollution studies in Lee and Charlotte counties using federal grants. These one-time assessments of water quality and sources of non-point pollution were performed in Charlotte Harbor, Estero Bay, and the canal system at Cape Coral[17].

Results of SWFRPC water quality studies

1) The Cape Coral 208 Water Quality Study:
This study was conducted to establish biological and chemical baseline conditions in the 400 miles of Cape Coral canals. The emphasis was on the freshwater canal system (300 miles). This canal system, as a major source of stormwater runoff, presents a significant, long-term threat to the water quality of the Lee County coastal zone.

The 1983 study found that the freshwater canals and lakes had generally good to excellent water quality. However, the water quality in high density areas was lower than in undeveloped areas of Cape Coral. Tidal canals, in the southeast of the city (the most densely populated area), exhibited marginally acceptable dissolved oxygen levels and higher levels of most constituents than the freshwater canals. Littoral and submerged vegetation was non-existent in the tidal canals. The report cautions that unless proper stormwater and canal management programs are implemented the quality of the freshwater canals and lakes will decline.

---

[16]Although this reach of the river is outside of the coastal zone we discuss the study here because the Caloosahatchee River is a major tributary to Charlotte Harbor.

[17]Section 208 funds available to state governments have been drastically reduced by the federal government.

2) Final Report and Technical Appendix of the Productivity Study for the Estero Bay Study Area: (Environmental Sciences and Engineering Inc., 1978) This section 208 funded study, completed in 1978, found that Estero Bay had high benthic diversities, nutrient removing efficiency and organic scrubbing capabilities. The bay was found to be removing 52 percent of the organic load received from internal and external sources, and it was estimated that the organic loads received by Estero Bay could be increased 23 percent before net fish production capability would be lost.

LOCAL GOVERNMENT PROGRAMS

Local governments have a major role in maintaining water quality. The sensitive areas identified earlier are threatened primarily by the effects of land use, particularly new land development in upland areas. Control of land use and the location and process of land development is one of the primary functions of local governments.

The City of Cape Coral and Lee County have both performed limited water quality sampling. Cape Coral used a DER grant to hire an aquatic scientist in 1984. The city is sampling water quality at 18 - 20 stations, primarily in and around saltwater canals. Lee County has been conducting a sampling program since the mid-1970's and operates a water quality analysis laboratory which serves both government and private sector clients. The county has been engaged in water quality testing at Big Hickory Pass in Estero Bay, and at other surface water stations around the county.

Results of Lee County water quality studies

Water Quality, Circulation Patterns and Sediment Analysis of the Estero Bay Estuarine System, 1986: (Clark, 1986)
This study focused on the analysis of bottom sediments to provide information on baseline conditions in Estero Bay. Circulation patterns, nutrient and bacteria levels were also examined. Circulation studies using dye indicated that water from Hendry and Mullock creeks and the Estero River flowed towards Big Carlos Pass. Water from Spring Creek appeared to flow towards New Pass and water from the Imperial River appeared to flow through Fish Trap Bay and through Hogue Channel northward.

Pesticides and PCB's were not detected. Comparison with the U.S.G.S. study of Charlotte Harbor indicated that the ranges for aluminum, lead, cadmium, and mercury in the bottom sediments were similar. Levels of chromium, copper, and zinc were higher in Estero Bay sediments. This comparison indicates that metals are accumulating in Estero Bay relative to Charlotte Harbor.

Estero Bay levels of orthophosphorous, total nitrogen, and nitrite-nitrate were similar to those found in the 1982-1984 U.S.G.S. Charlotte Harbor study. Values for dissolved oxygen had more of a range in Estero Bay and these standards were violated at several stations; bottom depth samples at the U.S. 41 bridge over Imperial River, surface and bottom depth samples at the east end of the Imperial River, and surface, mid-depth and bottom samples at Mullock Pass all violated minimum dissolved oxygen standards.

UNITED STATES GEOLOGICAL SURVEY (USGS)

The USGS office in Fort Myers has conducted numerous studies of the region's geology, and surface and groundwater quality and quantity. Currently the USGS is involved in three studies which involve the Lee County coastal area. The Geological Survey is investigating the possibility of connecting the existing dead-end saltwater canals in Cape Coral thereby improving circulation and preventing the build-up of pollutants. A second study, to be completed in 1989, is examining the diversion of water from canals in northern Cape Coral to canals in the south to reduce the flow of freshwater into Matlacha Pass. The possibility of using excess freshwater from the canals to recharge the mid-Hawthorn aquifer under Cape Coral is also being examined. The USGS is conducting a major seven year study of Charlotte Harbor which is two-thirds complete. This study is discussed below.

Results of USGS water quality studies

The ongoing seven year U.S.G.S. study of the Charlotte Harbor estuarine system, begun in 1982, is the first such study in the region to evaluate the estuary as a complex, dynamic unit. The results of this study should provide a greater understanding of how the estuary functions, its current health, and the factors threatening its future. Although the U.S.G.S. study will not be completed and released until after the completion date of the Special Coastal Study for Lee County, three individual reports have been released and are reviewed below.

1) "Water Quality of the Charlotte Harbor Estuarine System, Florida, November 1982 through October 1984" - Open file report 85-563. (Stoker, 1986)
This report is a compilation of two years of water quality data from thirty-three sampling stations. Water quality samples were taken from the water column at all stations, and from bottom sediments at five transect stations. Data are presented as average values, and with statistical summaries for each of the stations.

Data were reviewed to detect violations of DER water quality standards. For a transect at the outlet of the Caloosahatchee River into San Carlos Bay, standards were exceeded for copper, iron, zinc, and mercury in the water column. The pesticides DDD and DDE were also detected in bottom sediments at that transect. A transect in the Lee County portion of Charlotte Harbor, above Pine Island, showed high levels of mercury, and violated copper standards, but violated no other DER standards. Sampling stations at several locations in San Carlos Bay, Pine Island Sound and the Lee County portion of Charlotte Harbor showed high levels of both copper and iron. Dissolved oxygen standards were violated by minimum levels in the vicinity of the Peace River, but were at acceptable levels in the Lee County portions of the estuary.

2) Long-Term Water-Quality Characteristics of Charlotte Harbor, Florida.
Water Resources Report 86-4180. (Fraser, 1986)
This study is based on eight years of data collected at one sampling station, near the confluence of the Myakka and Peace Rivers. Orthophosphate levels showed an increasing trend, probably the result of changes in a major source upriver. Changes were not found for organic nitrogen, reactive silica, and total phosphate. Furthermore, amonia, nitrate, and nitrite levels were often below detection limits. Dissolved oxygen decreased in near-surface waters, possibly due to phytoplankton. Dissolved oxygen did not change in near-bottom

levels. Seasonal patterns of variation for each of these factors were also examined in this study.

3) Infaunal Macroinvertebrates of the Charlotte Harbor Estuarine System and Surrounding Inshore Waters, Florida. Water Resources Report 85-4260. (Estevez, 1986)
The purpose of this study was to evaluate the macroinvertebrate infauna of soft bottom environments of Charlotte Harbor and surrounding inshore waters (approximately 80 -85 percent of the study area is comprised of such a bottom environment). Fourteen intertidal stations (sampled at both surface and bottom depths) and 11 tidal stations (sampled at bottom depths only) were sampled during two seasons (May through June, and September, 1980) for benthic infauna, sediment, dissolved oxygen and hydrographic parameters.

Investigators found that "...bottom sediments were similar throughout the study area, except at inlets where they were coarser and the upper river stations where they were more organic. Bottom salinity and dissolved oxygen increased along a gradient toward the south and west, especially in September. Species number increased along the same gradient, but densities were highest at river mouths and Pine Island Sound (May-June) or in coastal Charlotte Harbor (September). The middle harbor is a transitional area along the gradient. It is affected by stratification and near-anoxic bottom conditions" (Estevez, 1986).

UNITED STATES ARMY CORPS OF ENGINEERS (COE)

The Corps manages and regulates activities in the waters and wetlands of the United States, however, they are not involved in water quality sampling (Section 10, Rivers and Harbors Act of 1899; Section 404, Federal Water Pollution Control Act Amendments of 1977). The COE maintains a field office in Fort Myers for issuance of dredge and fill and construction permits. The COE is also responsible for maintaining the Caloosahatchee River waterway and its lock system as well as intercoastal waterway channels through Pine Island Sound and Gasparilla Sound, and access channels to Boca Grande Pass and Fort Myers Beach.

IMPLICATIONS OF WATER QUALITY STUDIES

Summary of Findings
Based on the discussion of the Lee County coastal system and the eleven water quality studies reviewed, there are twelve points which we feel require special emphasis.

1 Water quality in the Lee County coastal zone was generally rated good to fair in a 1986 assessment by the Department of Environmental Regulation.

2 Stormwater runoff represents the greatest threat to the county's coastal water quality. Nonpoint source pollution originating in runoff from new development will likely continue as a greater threat to estuarine water quality than point sources in the coastal zone.

3 The Lee County coastal zone receives stormwater from a very large system of watersheds covering several counties, which are therefore outside the control of the Lee County government.

4 The South Florida Water Management District (SFWMD) requires that new developments provide for treatment of stormwater, however, permits are granted to a large number of small systems without knowledge of what the cumulative impact will be on the receiving waters. In addition, little is known about the fate of pollutants once they enter stormwater treatment systems.

5 Research indicates that the efficiency of stormwater retention/detention ponds is highly variable for different constituents, and that the efficiency is related to the age and the maintenance of the pond. The SFWMD requires maintenance of ponds, but does not specify a maintenance schedule

6 Development of coastal uplands may alter historic drainage patterns, peak flow characteristics, and total flow of runoff to receiving waters. These changes in drainage may be a greater threat to estuarine water quality than the cumulative effect of treated stormwater runoff.

7 Increasing freshwater flow into Matlacha Pass is an immediate concern. The discharge from drainage canals is reducing salinity and introducing pollutants.

8 Estero Bay water quality is particularly vulnerable due to the bay's shallow depth, poor flushing, and increasing runoff from surrounding development. Establishment of base line conditions for this bay is urgently needed. Additional sampling is needed; the County will need to supplement state sampling programs.

9 The presence of pollutants and their source must be documented by water quality investigations and ongoing monitoring programs. The studies reviewed in this chapter have not been sufficient to establish baseline conditions. The seven year U.S.G.S. and three year SFWMD studies, which are comprehensive, will not be completed prior to the completion of the Lee County Comprehensive Plan Update.

10 Interpretation of the STORET database is clouded by a coding system that may misrepresent potential violations of water quality standards.

11 Heavy metals pollution may be underestimated due to sampling of the water column instead of the bottom sediments.

12 The impact on estuarine water quality resulting from population growth in the coastal zone can not be predicted at a reasonable cost. Without extensive sampling to determine how much of the estuarine pollution load originates in the coastal zone, it is not possible to predict, through modeling, the impact on water quality of further growth in the coastal zone.

GOAL 1: To manage estuarine ecosystems so as to maintain good water quality and high wildlife diversity, and to reduce future pollution and system imbalances in order to conserve estuarine productivity and permit best use of estuarine areas.

OBJECTIVE 1.1: By 1990, establish baseline conditions and an ongoing monitoring system for estuarine water quality, including pollutant and freshwater loadings, and maintain communication with other local, state, and federal estuarine water quality studies to ensure that the latest data and recommendations are available.

POLICY 1.1.1: The County shall designate the Division of Environmental Services as the estuarine water quality monitoring agency, with responsibility for:

1. setting up and operating a network of water quality sampling sites to fill in gaps in the state sampling program, especially in Estero Bay.
2. maintaining liaison with other local, state, and federal agencies engaged in water quality monitoring and reviewing their data, conclusions, and recommendations.
3. developing a system for reporting on water quality conditions and trends on a regular basis.
4. recommending actions to ensure that estuarine water quality meets the Department of Environmental Resources "good" standard and is approved for shellfish harvesting.

OBJECTIVE 1.2: By 1990, establish procedures for reviewing all new upland development in the coastal area in terms of its impacts on estuarine systems and prepare estuarine watershed management plans which maximize stormwater retention and treatment, with priority to the Estero Bay watershed.

POLICY 1.2.1: The County shall designate the Division of Planning as the estuarine watershed management agency, with responsibility for:

1. preparing management plans for estuarine watersheds, with priority to the watershed of Estero Bay, a critical estuary undergoing development impacts.
2. recommending modifications to the Sanibel causeway in order to improve estuarine water quality.
3. reviewing the feasibility of changing canal patterns and retrofitting existing stormwater collection systems in order to reduce the impact of freshwater on estuaries.
4. assessing the adequacy of disaster preparedness plans for coastal oil storage facilities.

REFERENCES

Clark, John R., 1977. Coastal Ecosystem Management: A Technical Manual for the Conservation of Coastal Zone Resources. The Conservation Foundation. NY: John Wiley & Sons, Inc.

Clark, R., 1986. Water Quality, Circulation Patterns and Sediment Analysis of the Estero Bay Estuarine System. Department of Community Development, Lee County, Florida.

Clark, R., 1983. Estero Bay Aquatic Preserve Management Plan. Department of Natural Resources, Tallahassee, Florida.

Department of Environmental Regulation, 1979. State Water Quality Management Plan: Nonpoint Source Assessment, Nonpoint Source Control Needs for Urban and Construction Activities. Tallahassee, Florida.

Department of Natural Resources, 1983. Charlotte Harbor Aquatic Preserves Management Plan. Department of Natural Resources, Tallahassee, Florida.

Drew, Richard D. and Schomer, Scott N., 1984. An Ecological Characterization of the Caloosahatchee River/Big Cypress Watershed. U.S. Fish and Wildlife Service, Slidell, Louisiana. FWS/OBS-82/58.2.

Environmental Science and Engineering Inc. 1978. Final Report and Technical Appendix of the Productivity Study for the Estero Bay Study Area. Gainsville, Florida: prepared for the Southwest Florida Regional Planning Council.

Estevez, Ernest D., 1986. Infaunal Macroinvertebrates of the Charlotte Harbor Estuarine System and Surrounding Inshore Waters, Florida. U.S. Geological Survey of Tallahassee, Florida. Water Resources Investigations 85-4260.

Fraser, Thomas H., 1986 Long-Term Water-Quality Characteristics of Charlotte Harbor, Florida. U.S. Geological Survey of Tallahassee, Florida. Water Resources Investigations Report 86-4180.

Hand, J., Tauxe, V. and Watts, J., 1986. 1986 Florida Water Quality Assessment 305(b) Technical Report. Water Quality Monitoring and Quality Assurance Section, Bureau of Water Quality Management, Department of Environmental Regulation, Tallahassee, Florida.

Harper, H.H. 1985. Fate of Heavy Metals From Highway Runoff in Stormwater Management Systems. Phd Dissertation, University of Central Florida, Department of Civil Engineering and Environmental Sciences, Orlando, Florida.

Harper, H.H., Wanielista, W.P., Fries, B.M., and Baker, D.M., 1986 "Stormwater Treatment by Natural Systems". Final Report for STAR Project #84-026, Department of Environmental Regulation, Tallahassee, Florida.

Harris, Barbara A., Haddad, Kenneth D., and others, 1983. Final Report-Assessment of Fisheries Habitat: Charlotte harbor and Lake Worth,

Florida. Department of Natural Resources, Bureau of Marine Research, Marine Research Laboratories, St. Petersburg, Florida.

Livingston, E.H., 1986. "Comprehensive Watershed Approaches to the Control of Point/Nonpoint Source Pollution in Florida". North American Lake Management Society Symposium, Portland, Oregon. November

Miller, T.H. IV, Fererico, A.C. and Millerson, J.F., 1982. Final Report - A Survey of Water Quality Characteristics and Chlorophyll A Concentrations in the Caloosahatchee River System, Florida. South Florida Water Management District, West Palm Beach, Florida. Technical Publication 82-4.

Schweithzer, James P. 1977. "Estuarine Circulation ". in John Clark 1977.

Shoemyen, Ann H., 1986. 1986 Florida Statistical Abstract, Twentieth Edition. Bureau of Economic and Business Research, College of Business Administration, University of Florida, Gainsville, Florida.

Southwest Florida Regional Planning Council and Alverez, Lehman and Associates, Inc., 1984. The Cape Coral 208 Water Quality Study. Fort Myers, Florida.

Stoker, Yvonne E. 1986. Water Quality of the Charlotte Harbor Estuarine System, Florida, November 1982 through October 1984. U.S. Geological Survey of Tallahassee, Florida. Open File Report 85-563.

Yousef, Y.A., Wanielista, M.P., and Harper, H.H., 1985. "Fate of Pollutants in Retention/Detention Ponds". Stormwater Management Workshop, Orlando, Florida. July 15-17, 1985.

VI. BEACH AND DUNE SYSTEMS

Purpose

The purpose of this chapter is to present findings concerning: (1) the basic geology, and key coastal processes that have and are now shaping the Lee County barrier-island coast; (2) the size and structure of the coastal dune system, (3) the coastal response to past storm activity, and (4) past and present coastal engineering and stabilization activity. Key geographic sites are illustrated in Figure VI-1. From these findings, areas of critical concern have been identified and recommendations for beach management (i.e., nourishment, stabilization, sand dune construction, etc.) are presented.

Methodology

Data collection has proceeded along two paths: (1) analysis of past written work done by various agencies and individuals, and (2) actual field work. Four organizations have provided most of the written work: (1) the Coastal and Oceanographic Engineering Laboratory Archives at the University of Florida in Gainesville, (2) the Division of Beaches and Shores, Department of Natural Resources in Tallahassee, (3) the U.S. Army Corps of Engineers District Office in Jacksonville, and (4) the Captiva Erosion Prevention District (CEPD) on Captiva Island. The field work consisted of detailed ground observation, an overflight from a helicopter, mapping, and interviews with residents.

Finally, a coastal sand budget was developed, based upon existing information, in order to identify areas of erosion and accretion. Further detail may be found in the 1987 report, "Evaluation of the Lee County Coastline: Dominant Processes, Shoreline Change, Stabilization Efforts, and Recommendations for Beach Management", by Albert C. Hine.

LEE COUNTY BARRIER ISLAND COASTLINE SYSTEM

The State of Florida once formed a shallow tropical sea 500 miles long and 400 miles wide. This warm, clear water environment was very similar to the modern Bahama Banks. With time, this area filled in with the sands and muds being eroded from the southern Appalachian Mountains and the quartz sands that we see today on the beaches began to spill-over to the south onto the Florida Platform. Most of these sands were carried south onto peninsular Florida in the longshore transport system; that is, the sand was moved along the beach by breaking waves.

This southerly transport coupled with numerous sea level fluctuations over millions of years were responsible for the present distribution of quartz sand deposits on the underlying limestones and the many former shoreline features that now form much of the State's surface topography.

A key point to remember is that no new quartz sands are being introduced into the present coastal system. It is a closed sand budget. Sand accumulating at one site is doing so at the expense of some other site.

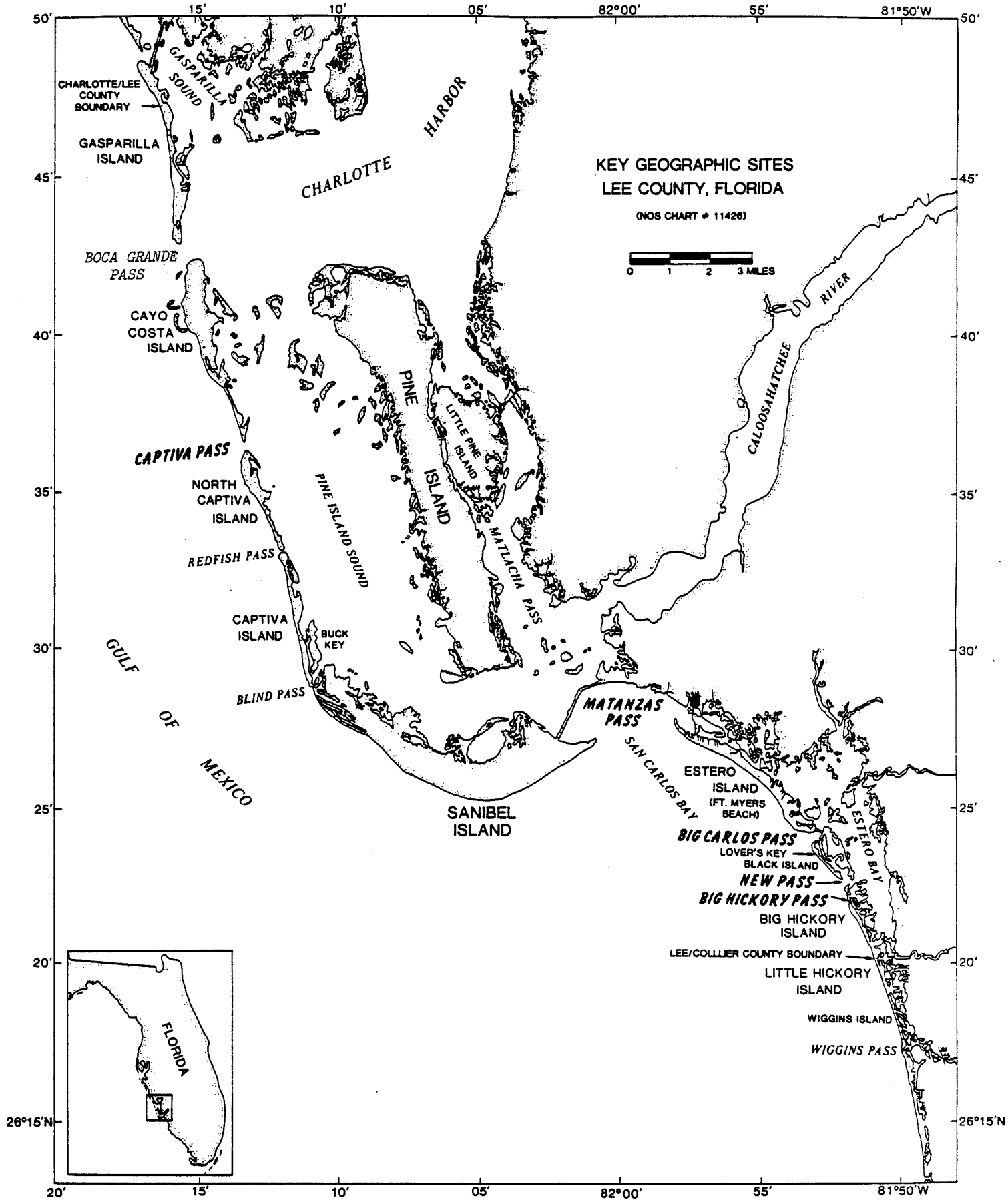


Figure VI-1 Location map of key geographic features in Lee County.

General Processes

Wind and Waves: The inherited topography of the flat, broad ancient Florida Platform has formed a present-day, wide, shallow continental shelf seaward of the west-central Florida Gulf coast. This low gradient feature is one of the reasons that the Florida Gulf coast is such a low wave energy coastline compared to Florida's east coast (Hine and Belknap, 1986). The limited distance over which wind and waves can build up in the Gulf -- as compared to the Atlantic Ocean -- and the dominant winds blowing offshore (from the northeast) are other reasons for this low wave energy character. The dominant onshore winds are from the northwest and are associated with winter frontal passages. This is the reason why the regional, net longshore sand transport is to the south. There are, however, important local exceptions which will be addressed later.

Tides and Tidal Currents: The tides are mixed diurnal/semi-diurnal. There is a lower and a higher high tide and a lower and a higher low tide each day. The mean tidal range extends from 1 foot at the north end of the County to 2 feet at the south end. The diurnal tide (higher high and lower low tide) ranges from 1.7 feet at Boca Grande to 2.8 feet at San Carlos Bay (NOAA, 1983). Wind-tidal interactions and storm surges may significantly affect these normal tides.

Most strong currents which occur in the coastal zone are associated with the tidal inlets. Velocities up to 3.7 feet/second may be present in the inlet throats.

Sand Budget: Longshore sand transport curves based upon wave data (Walton, 1973) allow one to determine sand transport rates along specific coastlines (see Figure VI-2).

There are a number of important observations that can be made from these data. The rate of longshore sand transport in the north barrier island system is much higher than in the south barrier system. Sand transport is to the south in the north system. It is highly variable in the south system, with the transport direction decidedly to the north along the north end of Estero Island. Where rates of longshore transport decrease from one sector to another in the downdrift direction, one should expect an abundance of sand, and therefore accreting beaches. The north ends of Cayo Costa and North Captiva Islands as well as the south end of Estero Island are good examples. Where rates of longshore sand transport increase in the downdrift direction, one should expect a deficit of sand, and therefore eroding beaches. The middle section of Estero Island illustrates this trend.

In addition to the longshore transport rates, the volume of sand trapped by the ebb-tidal deltas of the inlets is important. The ebb-tidal delta shoals form important storage areas of sand which could be dredged for beach replenishment purposes. The ebb-tidal delta at Boca Grande Pass, the second largest of all the 64 inlets found along the Florida coastline, is particularly large and it has been trapping sands at an impressive rate. This ebb-tidal delta is trapping all the sand carried to it from the north, and is receiving nearly three times as much from other sources; most likely from the inside of Charlotte Harbor.

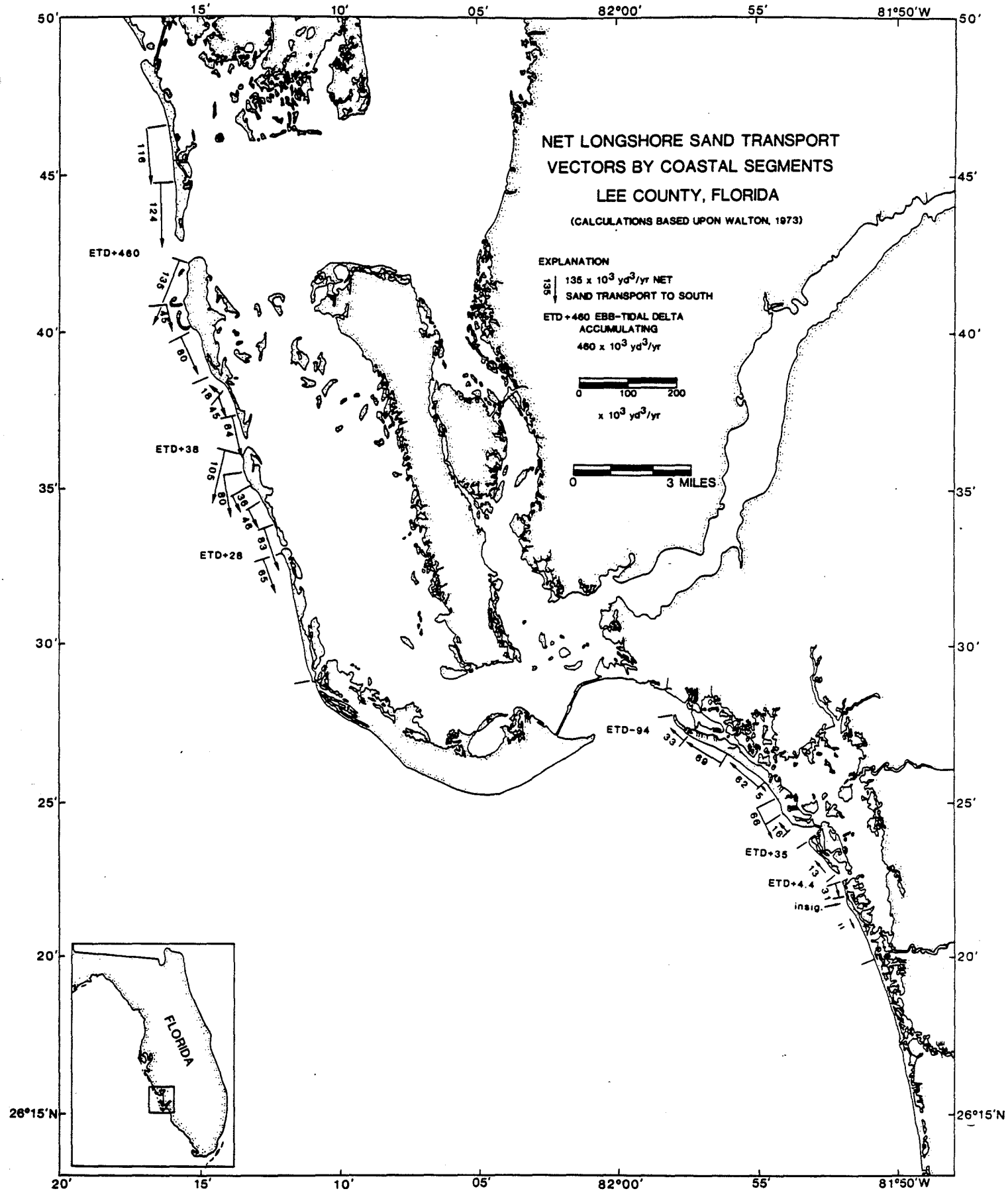


Figure VI-2 Net longshore sand transport vectors for various coastal sectors of Lee County (based upon Walton, 1973).

Dune System: Field observations indicate that a fore-dune system, the dunes closest to the beach, is commonly absent or topographically low (less than 2.5 meters above mean sea level: less than 1.5 meters in relief) on the Lee County barrier islands. Along the Lee County coast, there are only a few restricted areas where new dunes are being formed. These areas are of two types: (1) where the beach/berm is actively being widened as a result of net onshore sand transport, and (2) on top of relatively recent washover fans. The north ends of Cayo Costa and North Captiva are the best examples of the first type. The washover fans on Cayo Costa, North Captiva, and Lovers Key form the second type. Both washover fans and seaward propagating berms form a flat terrace on top of which pioneer plants can begin to grow. These plants block and trap sands carried by the winds, resulting in incipient dune formation. This is a self-regenerative process in that the more sand that is trapped, the larger the dune, the more plant life it can sustain as a result of the protection and increased availability of a highly localized, elevated, fresh-water table source. Eventually, a succession of different plant species evolves.

Unfortunately, no studies have been found to date which addressed mechanisms and rates of dune growth along the west-central Florida Gulf coast. The dunes never attain significant heights in Lee County or in other counties along this portion of the Florida Gulf coast because of two reasons: (1) the dominance of offshore, not onshore, breezes, and (2) the relatively high concentrations of coarse shell material which forms a layer (deflation lag) over the sands, preventing the sands from being blown onto the dunes.

Outside of areas dominated by human structures, erosional scarps and well-vegetated beach ridges with soil horizons at the fore-dune ridge location indicate chronic erosion (also, trees falling into the surf zone). These vegetated beach ridges were once active dunes that became vegetated by more inland plants (coastal strand, savannah, cabbage palm forest, etc.; Herwitz. 1977) as the barrier island widened. With erosion, these inland beach ridges became re-exposed at the open beach. Very commonly, 1 meter high scarps separate the active beach face from these vegetated, relict dunes. Due to the unstable nature of these shorelines, the relict dunes do not become reactivated, i.e. start to build vertically again; instead, they supply the longshore transport system with sand.

No active dunes are found where the shoreline is dominated by seawalls and buildings.

Hurricanes: Storms can have a major effect on the Lee County coastal zone. Between 1830 and 1969, a total of 46 hurricanes and tropical storms have passed within 50 miles of the Lee County coast (Department of the Army, 1969) and four hurricanes striking the southwest Florida Gulf coast between 1873 and 1926 have generated surges elsewhere that would have been capable of entirely submerging any barrier island on the Lee County coast. Between 1969 and the present, there have been at least 6 additional hurricanes and tropical storms in the eastern Gulf whose winds and waves reached the Lee County coast (NOAA, 1973). Table VI-1 lists 100 year storm surge elevations for two different approach paths (landfalling and alongshore) for various Lee County sites. These storms have altered the coastal geology.

However, the west-central Florida coast has not been dominated by hurricanes or large storms. Maps of hurricane tracks indicate that most of

TABLE VI-1

PEAK STORM SURGES

Location	Peak Storm Surge For Landfall Path (feet)	Peak Storm Surge For Alongshore Path (feet)	Difference (feet)
Coastal Locations			
Sanibel Island	11.7	7.8	3.9
Captive Island	11.4	6.4	5.0
Inland Waters			
Estero Island	13.2	10.4	2.8
Estero Bay	13.6	10.8	2.9
Matlacha Pass	11.6	4.2	7.5
Pine Island West	12.3	6.8	5.6
Pine Island East	11.2	5.1	6.2
Punta Rassa	12.3	7.7	4.6
Caloosahatchee River Entrance	11.2	7.0	4.2
Cape Coral Bridge	11.1	6.7	4.4
Fort Myers	12.7	7.0	5.7

Peak Storm Surges, computed using the FEMA Model, for hypothetically Landfalling and Alongshore Hurricanes characterized by P = 2.07 inches of mercury (70.2 millibars), R - 30 nautical miles, V_F = 14 knots (National Research Council, 1983)

these storms, once they have entered the Gulf of Mexico, pass off to the north and northwest. But large hurricanes do occur here; a recent study from the Sarasota barrier island coast does suggest that the west-central Florida coast has been struck by extremely large hurricanes every several hundred years (Knowles and Davis, 1983).

Sea Level Rise: Four major studies funded by various agencies of the U.S. Government indicate that the level of the world's oceans will rise between approximately 2 and 11 feet by the year 2100. The processes responsible for this global response are complex and not well understood. Briefly, as certain industrially and agriculturally produced "greenhouse" gases continue to build up in the atmosphere, the earth's ability to radiate the sun's energy back into space is slightly reduced. As a result, the atmosphere becomes warmer. This additional heat is transferred to the upper layers of the global ocean which undergo thermal expansion (the density of water decreases and the volume increases with increasing temperature), thus causing sea level to rise. An additional, delayed, sea-level rise is caused by the melting of glacial ice. Tide gauge data for south Florida indicate that the sea-level is already rising at a much faster rate now (16 cm/100 yrs.) than the rate averaged over the past 3,000 years (4 cm/100 yrs.).

Although 2 to 11 feet represents a wide variation, the results of these studies indicate that a rise of 3.5 feet by 2100 is an approximate consensus figure. In addition, all the projections indicate that the rate of sea-level rise will increase exponentially (i.e. most of the projected increase will occur in the second half of the next century). By the year 2040, the adverse effects of this rise may start to become serious. Most likely, no sudden increases in flooding or erosion will occur within the next 30 years as a result of this phenomenon. Over this 30 year period, large hurricanes will remain the most important threat to human habitation of coastal areas.

Global sea-level rise will not become important in the immediate future, but planners need to understand the long term effects. Significant changes in the location of the land/sea boundary and coastal morphology will begin to occur in the next 60 years. There are two basic results of rising sea-level: 1) erosion of the barrier-island shoreface, overwash, and wholesale landward movement of the barrier islands, and 2) flooding or inundation of back barrier lowlands.

The magnitude of the first effect, given a certain rise in sea-level, is difficult to quantify due to the number of factors governing sand supply. At one extreme, if enough sand could be supplied to a barrier island, it is possible that such an island could even widen or grow seaward during sea-level rise. At the other extreme, if sand is efficiently carried away from a barrier island during sea-level rise, then the island could submerge and disappear. Since no new sand is being introduced into the Lee County barrier island system, a 3.5 foot rise in sea-level could cause some of the islands to migrate landward several island widths. A wide island, like Sanibel, being at the receiving end of the longshore sand transport system would erode, perhaps severely, but probably would not revert to an overwash mode of translation. There is no way to accurately quantify, at this point in time, how barrier islands will respond to a given rate and magnitude of sea-level rise.

Flooding or inundation of low-lying areas adjacent to lagoons and estuaries is somewhat easier to predict. Areas that are 3.5 feet above mean sea-level today will be at sea-level by 2100 if the 3.5 foot rise prediction turns out to be accurate. With much of Lee County being very flat, large dry areas could become wetlands. The likelihood of wetland formation at any given site behind the barrier island system could be determined by consulting a topographic map.

As a final word, in spite of our relatively poor understanding of how the "greenhouse effect" works, there is near-universal consensus in the scientific community that the atmosphere will warm and that sea-level will rise. Additionally, there is universal consensus in the scientific community that any sea-level rise will further aggravate present-day erosion problems. Given our penchant for wanting to live as close to the water as possible, natural threats to human structures will only increase.

Coastal Geomorphology

The Lee County open marine coastline consists entirely of barrier islands which are separated from the mainland by open lagoons. These barrier islands are some of the most complex coastal geomorphology in the world (King, 1972).

A primary reason for this complex coastal geomorphology is the presence of the numerous tidal inlets segmenting the barrier island chain. The tidal inlets provide water exchange between the back-barrier lagoons and the Gulf of Mexico. Table VI-2 lists, from north to south, the islands and inlets comprising the Lee County coast. The range in size of the tidal inlets is ultimately due to the size of the bay or lagoon behind the barriers that is influenced by the inlet; the larger the bay, the larger(wider/deeper) the inlet. Boca Grande Pass is the largest tidal inlet because it is backed by most of Charlotte Harbor. On the other hand, Blind Pass is a small tidal inlet because it services only a small, restricted part of Pine Island Sound.

The barrier islands to the east and south of Sanibel Island, starting with Estero Island and extending down into Collier County are very different in process and response than those barrier islands north of Sanibel Island. It is important to note that the Lee County barrier-island chain can be considered as two different systems; a north and south barrier system separated from each other by the mouth of San Carlos Bay. These differences are the result of earlier geologic history.

North Barrier Island System

The stability and behavior of tidal inlets is dependent upon a balance between the tidal flushing capability of the inlet and the volume of sand introduced laterally by the longshore transport system. If the net longshore transport (net volume of sand moving along the beach due to breaking waves) is relatively large compared to the inlet's ability to flush it out, the inlet channel will migrate in the direction of the net longshore transport. These are called wave-dominated inlets in that the wave energy and its ability to carry sand into the inlet throat is more important than the tidal currents going in and out of the inlet. Inlets with very small tidal prisms (the average volume of water passing in or out of the inlet throat during a flooding or ebbing tide), are wave dominated. The minimum cross section can also be used to rank the inlets by relative size. A typical behavior is for such an inlet to migrate laterally (up to many 1000's of feet) before closing off due to the increasingly inefficient channel. These inlets form long narrow channels that are aligned parallel to the beach trend. These small inlets frequently reopen during large storms, and the cycle of migration and closure begins all over again. Blind Pass at Sanibel/Captiva is a good example. Such inlets store very little sand within their ebb-tidal deltas. The sand in the longshore transport system is relatively easily and rapidly carried across the inlet and passed onto the beaches on the downdrift side (bar bypassing).

At the other extreme, there are inlets which have large tidal prisms capable of easily flushing out any sands carried to them by the longshore transport system. Most of these large inlets are ebb-dominated and the sands are carried seaward to form large offshore shoals called ebb-tidal deltas. These large offshore shoals are excellent sand storage areas and form the best locations to find beach renourishment material (Walton and Dean, 1976). These inlets are called tide-dominated inlets. There is a much longer residence time for sand stored in these ebb-tidal deltas compared to the wave-dominated inlets.

Because the longshore sand transport cannot cause these inlets to migrate laterally, they remain relatively stable. However, the tide-dominated inlets.

TABLE VI-2

LEE COUNTY BARRIER ISLANDS AND TIDAL INLETS

Islands	Inlets	Inlet Size (minimum cross-section in square ft)
Gasparilla (southern 3/4)	Boca Grande Pass	183,460
Cayo Costa	Captiva Pass	63,000
North Captiva	Redfish Pass	12,200[a]
Captiva	Blind Pass	600
Sanibel	San Carlos Bay/Mantanzas	700
Estero	Big Carlos Pass	20,810
Black Island/Lovers Key	New Pass (Little Carlos)	7,300
Big Hickory	Big Hickory Pass	Now Closed
Little Hickory (Bonita Beach)		

a COEL (1974)

through their ebb-tidal deltas, can affect beach erosion/deposition trends to a far greater degree than the wave-dominated inlets. Tide-dominated inlets can directly affect beach sedimentation long distances (3 miles away from the inlet throat). The ever changing, shallow depth of the ebb-tidal deltas causes changes in the level and direction of wave energy striking the beach.

The wave energy that ultimately strikes the beach drives the longshore transport system and controls beach erosion and deposition. So, changes in the ebb-tidal delta long distances offshore can directly cause beach changes onshore well beyond the immediate vicinity of the pass between the barrier islands.

Because of the large size of Charlotte Harbor and Pine Island Sound, Boca Grande Pass is an excellent example of a tide-dominated inlet. Captiva and Redfish Passes are also tide-dominated. All three inlets have large ebb-tidal deltas located seaward of the inlet throat. Both Boca Grande and Captiva have large, shallow shoals built up on these ebb-tidal deltas (Johnson Shoals off Cayo Costa, for example). These shoals are being driven ashore by shoaling and breaking waves. Ultimately, the sand in these shoals will be re-incorporated into the island's longshore transport system and will be carried downdrift to the next inlet (tidal flow transfer). The highly irregular trend of the beaches at the north ends of both Cayo Costa and North Captiva Islands

has resulted from these shallow sand bars by: (1) locally controlling wave energy while they lie just offshore on the ebb-tidal delta and, (2) welding onto the beach thus providing a new pulse of sand to locally widen the berm.

Because the net longshore sand transport is to the south along the northern Lee County coast, the ebb-tidal deltas are asymmetrically shaped in that most of the sand lies to the south (downdrift) of the main ebb channel (deep-water channel used for navigation seaward of the inlet throat). As a result, the north ends of the islands are partially sheltered from large storm waves and are the areas that initially receive sand returning to the beach from the ebb-tidal deltas. Consequently, the north ends of the islands are wider, have more beach ridges, and have better dune systems than the south portions of the islands which are narrower and more prone to washover processes. Cayo Costa and North Captiva well illustrate these trends. To a lesser degree, so does Captiva Island.

The ebb-tidal delta of the tide dominated inlets can also cause a longshore sand transport reversal. Redfish Pass has caused such a situation along the northern end of Captiva Island. A nodal point has formed whereby to the north of this point, sand is carried to the north, to the south of this point, sand is transported to the south. Waves approaching from the NW are bent around the ebb-tidal shoals at Redfish pass and set up a northerly sand transport at the north end of the island. The ebb-tidal delta also partially shelters the north end of Captiva from NW approaching waves, thus allowing for a net northerly sand transport driven by SW approaching waves. Along other northern portions of Cayo Costa and North Captiva islands there is probably a nodal point and longshore transport reversal as shown earlier for northern Captiva Island.

South Barrier Island System

The Lee County barrier coast south of Sanibel Island contrasts sharply to the Lee County north barrier coast for two reasons: (1) it is sheltered from the dominant northwest-approaching waves and, (2) the bays behind these barrier islands are much smaller and hence the tidal inlets are smaller. The sheltering effect by the westward-offset, north barrier island chain results in much lower wave energy striking the beaches. The lack of waves from the northwest results in a slight dominance by waves approaching from the southwest. Both facts mean that net longshore sand transport is much reduced. In addition, along portions of the south barrier coast, the net longshore sand transport is directed to the north--an important exception to the regional southerly longshore sand transport that dominates the west-central barrier island section of the Florida Gulf coast.

The relatively small tidal inlets (except for Big Carlos Pass) mean that the ebb-tidal deltas are relatively small and that they have little effect on the adjacent beaches. This south barrier system is both a low wave and low tidal energy system when compared to the north barrier island coast of Lee County. As a result, these islands comprising the south barrier system are narrower (few to no beach ridges) and are topographically lower than the north barrier counterparts.

BARRIER ISLAND ASSESSMENT AND RECOMMENDATIONS

This section provides a geologic description of each barrier island of the Lee County coastal zone, coupled with a discussion of past engineering activities. The extent of human activity along the Lee County coastline in the form of shore protection devices, dredging, beach renourishment, etc., when compared to other counties such as Pinellas or Dade, has not been extensive. However, portions of Gasparilla, Captiva, and Estero Islands have been significantly modified by structures and sand pumping. Finally, recommendations concerning future activity are presented.

Certain portions of Lee County's barrier islands are designated as "undeveloped" under the federal Coastal Barrier Resources Act of 1982 (CBRA). The purposes of this Act are to minimize loss of life, wasteful expenditure of federal resources, and damage to natural resources by restricting federal expenditures that encourage development in hazardous undeveloped coastal barrier areas. Within these undeveloped coastal barriers, no federal flood insurance may be issued and no federal funds may be used for bridges and roads, utilities, new access channels, erosion control, storm protection, community development, and post-storm redevelopment and disaster relief, except to alleviate emergencies.

The undeveloped coastal barriers designated under CBRA within Lee County include the following:

- P17 - Lovers Key, includes portions of Lovers Key (not shown) and Big Hickory Island (see Fig. VI-8)
- P17A - Bodwitch Point, the northern tip of Estero Island (see Fig. VI-7)
- P18 - Sanibel Island, includes portions of Sanibel Island (not shown) and the southern tips of both Captiva Island and Buck Key (Fig. VI-6)
- P19 - North Captiva Island (see Fig. VI-5)
- P20 - Cayo Costa Island (see Fig. VI-4).

Summary of Past Studies

There have been no geologic studies of the Lee County coastline that could in any way be considered complete or exhaustive. In general, the west-central Florida barrier island coast has been historically ignored by coastal scientists and portions of the Lee County coast are perhaps the least studied. However, certain portions, such as Captiva Island, are among the most heavily studied barrier-island beaches anywhere.

Past studies can be grouped by their geographic scope. There are studies that: (1) address issues and problems that concern the whole Florida Gulf coast, (2) address the entire Lee County coast as an integrated system, (3) address single barrier islands as complete systems, and (4) address problems at a specific site.

The beach erosion control study done in 1969 by the U.S. Army Corps of Engineers, Jacksonville District (Department of the Army, 1969) is perhaps the most complete analysis of the entire County's barrier island coast, even though it is now 18 years old. This report identifies current zones of erosion and illustrates past shoreline and nearshore bathymetric changes.

Several studies have examined individual islands in the Lee County coastal zone as one system. The New College Environmental Studies Program (Herwitz,

1977; Morris et al., 1978; Harvey, 1979; Morrill and Harvey, 1980) and the Captiva Erosion Prevention District have taken more or less "whole island" views of Cayo Costa, North Captiva, and Captiva Islands. The University of Florida Coastal and Oceanographic Engineering Laboratory (COEL, 1971) examined Black Island and Lovers Key.

With the outstanding exception of the northern portion of Captiva Island, there are surprisingly few studies available that address restricted stretches of coastline. Most likely, beach problems that involve a single or a few property owners are rarely written up in a report format. If they are, few seem to be available to the general public.

It should be pointed out that the Florida Division of Beaches and Shores has just completed (release data approximately mid-October 1987) a beach erosion management plan for Lee County. The reader is encouraged to review the State's report as it provides more detailed information concerning specific volumes of sand to be transported for recommended nourishment areas and the costs involved in such efforts. Essentially, the Division of Beaches and Shores report recommends the following beach restoration:

1. 3.42 miles along south Gasparilla; cost $5,823,000
2. 4.30 miles along Captiva; cost $7,954,000
3. 2.64 miles along Estero; cost $400,000

Gasparilla Island

Geology: This is a long and narrow barrier island whose shoreline has been relatively stable along the northern portions of the island but becomes more erosional toward the south end, particularly near Boca Grande Pass (Fig. VI-3). This is reflected in the longshore sand transport calculations which show that sand transport, the second highest for the Lee County coast, increases toward the south end of the island (Fig. VI-2). Large outcroppings of beachrock help to provide an overall stability to the island.

Where natural beach profiles exist (i.e. no development), a small vegetated dune system can be found. As is the case along the entire Lee County shoreline, natural sand dunes along the active beach almost never build to heights beyond 1-2 meters. Along Gasparilla, there are natural dune systems along the northern end of the island as well as few selected sites on the southern end. Artificial dunes are being constructed near the Boca Grande Lighthouse. The central portion of the island is dominated by seawalls--hence there are no dunes in this area.

Engineering Efforts: In the northern portion of the island there are no shoreline engineering structures. There is much new development, but most of these buildings seem set back behind the natural dune system. The central portion of the island has a much narrower beach due to a near continuous line of seawalls/revetments that have prevented the beach from migrating landward over the past 50 years. In some areas there is no longer an intertidal beach exposed at low water.

In addition to the complex array of different types of seawalls, there are groins of various designs as well: dogbone, wooden piling, metal sheets, and boulder. Along the southern portion of the island starting at 1st St., the

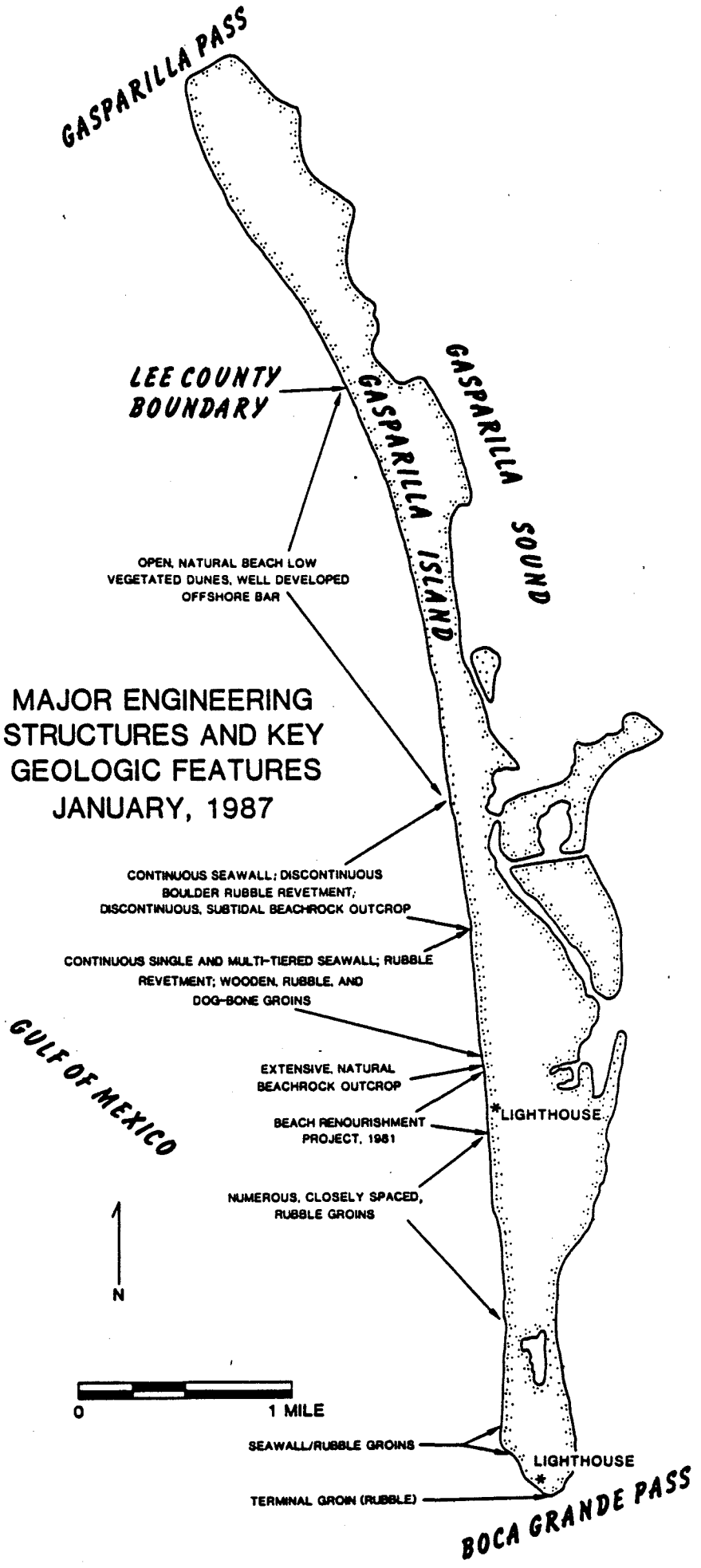


Figure VI-3 Map of engineering structures and key geologic features of Gasparilla Island (January, 1987).

continuous line of seawalls ends. The natural shoreline at the Lee County Park Beach by the lighthouse has retreated back, illustrating the recent erosional nature of this part of the island. This also well illustrates the trade-off between protecting property with seawalls but losing the beach or allowing erosion to occur but maintaining a beach. South of this public beach are remnants of older, failed seawalls, and boulder groins. Finally, at the south end of Gasparilla, the seaward-protruding seawall-pier complex has caused extensive erosion immediately downdrift. The road on top of this feature appears to require constant upkeep. The terminal groin has provided protection to the Boca Grande Lighthouse.

Recommendations: The Coastal Control Construction Line (Zone I. Area 1a) is set approximately 50-75' behind the natural vegetation line or seawall, whichever is present. Certainly, no new construction should be allowed seaward of this line. In view of the poor performance of groins and seawalls to protect the beach, no hardened engineering solutions should be implemented. With one of the largest volumes of beach-quality sand along the entire Florida west coast trapped within the Boca Grande pass ebb-tidal delta, beach nourishment should be considered as the best alternative to restoring/widening the narrow beaches. The proximity and volume of this sand should make nourishment along Gasparilla Island relatively inexpensive as nourishment projects go.

The 1981 nourishment at the Lee County Park Beach has been mostly eroded away some 5 years later. A 5 year renourishment cycle is consistent with renourishment plans that the U.S. Army Corps of Engineers has proposed for other beaches. A larger renourishment plan extending further up the beach (north of 1st St. up to 12th St.) would last longer and provide more stability to the public beaches. Certainly, if there is to be periodic maintenance dredging of Boca Grande Pass, the beach-quality sands should be placed back updrift on Gasparilla Island.

Natural dunes and vegetation associated with their development should be rigorously protected. Wooden walkways should be built over the dunes to provide access to the beach. Artificial dune construction by planting appropriate vegetation should be encouraged by the County. The dunes provide added natural scenery to the beach, but more importantly provide a measure of protection during storms. With an average elevation of 6-8 feet above mean sea level, one could expect major flooding every 25 year. A healthy, extensive foredune ridge would reduce the adverse effects of such flooding events.

Cayo Costa Island

Geology: This is a wide, beach-ridge dominated barrier island (Fig. VI-4) whose geologic history has been closely tied to the presence of the large ebb-tidal delta of Boca Grande Pass. The north end of the island has grown as a result of onshore sand transport. However, this onshore transport has not been constant through time and periods of erosion are evident. Much of the shoreline along the northern portion of the island is now erosional as evidenced by Australian Pines and cabbage palms littering the beachface. In addition to the offshore shoals (Johnson Shoals) controlling beach dynamics, extensively submerged beachrock outcroppings have played a role in this activity as well. Where sand is being transported onshore, multiple level berms with incipient dunes are found. The southern portion of the island has

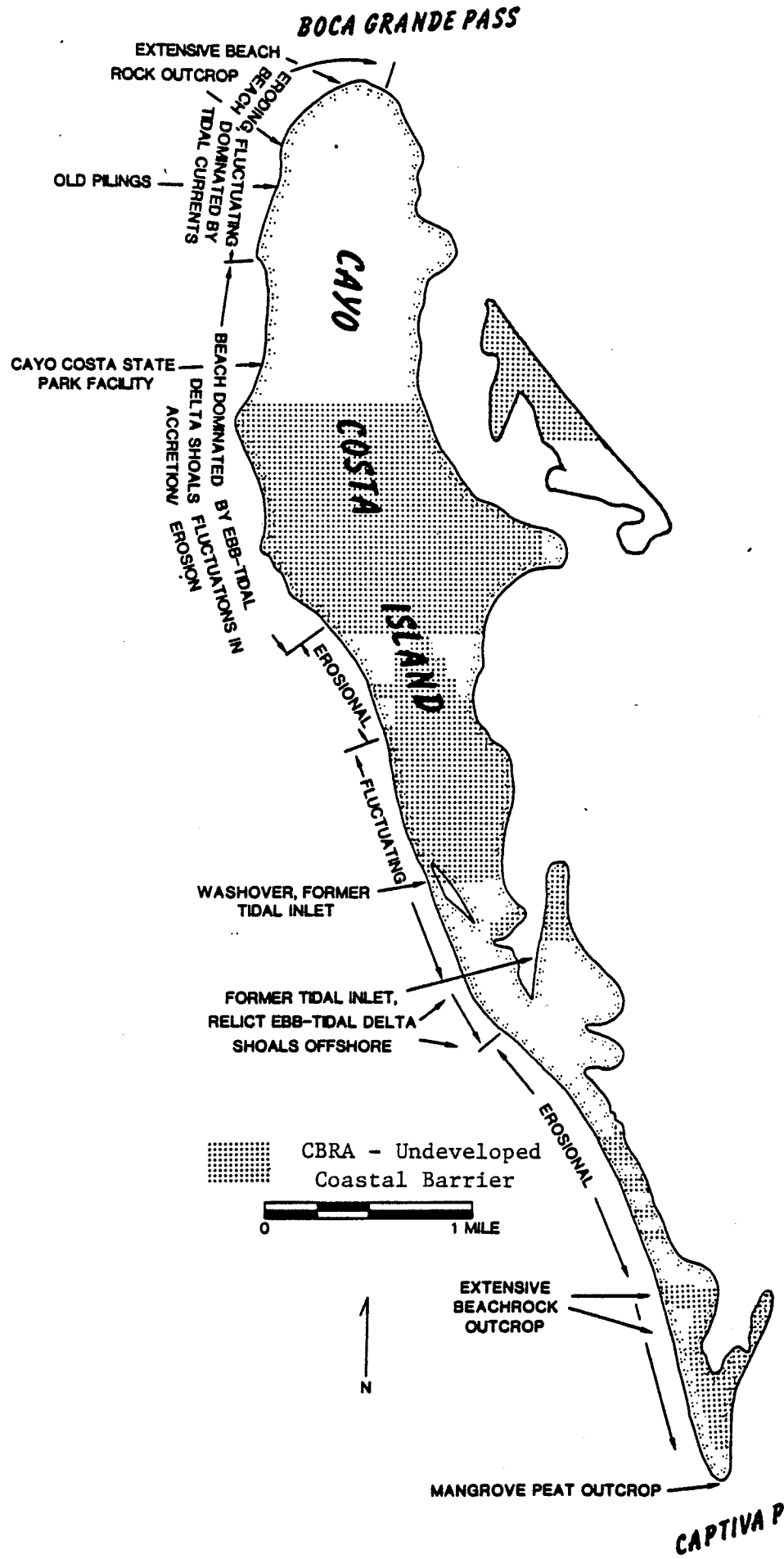


Figure VI-4 Map of engineering structures and key geologic features of Cayo Costa Island (December, 1986).

not received the beneficial influence of this large, offshore sand body and is narrower, lower, and punctuated by past inlet migration and overwash activity

The natural dune construction on the island, particularly where there is overwash, illustrates an interesting paradox. The overwash process is one that generally is considered to inhibit dune growth. However, if the overwash is not overwhelming in nature, this process can augment dune growth by bringing in a new supply of fine quartz sand grains--the building material of all dunes.

Engineering Efforts: There have been no major attempts to stabilize the beaches along Cayo Costa Island. The island is and has been, mostly uninhabited. The CCCL is from 150-450 feet set back behind the seaward vegetation line.

Recommendations: This barrier island should remain in its undeveloped condition. The large State Park facility will help to preserve a large portion of this island. There is no reason to suggest, promote, or encourage any type of coastal engineering. Pedestrian traffic should be restricted to certain pathways. Areas of new dune growth should be left undisturbed. If large volumes of sand are to be removed from the ebb-tidal delta at Boca Grande Pass for beach nourishment purposes, studies should be made to determine the effects, if any, on the adjacent beach system.

North Captiva Island

Geology: North Captiva Island is a classic "drum-stick" shaped barrier island having a bulbous north end and a narrow, erosional south end (Fig VI-5). The wide north end is the result of onshore transport from the ebb-tidal delta associated with Captiva Pass. The increasing net longshore sand transport to the south (Fig. VI-2) explains the erosional nature of the southern portion of this island. The very north end of the island near Captiva Pass is presently eroding. This shoreline is dominated by strong tidal flows passing into and out of the inlet. These tidal currents and the flood channel just offshore prevent onshore sand transport. Peat outcrops and beachrock formations also indicate the erosional nature of the very north end and the southern section of this island as well. The north-central quarter of the island receives the onshore sand transport off the adjacent ebb-tidal delta. Consequently, multiple-level berms and incipient dunes are developing here. The overwash dominated portion of this island (south-central quarter) provides an excellent field site to study overwash processes as well as dune development.

Engineering Efforts: Most of the coastal engineering along North Captiva Island has been local, "homemade" type of construction to protect private dwellings. These revetments, mostly restricted to the north end of the island, are easily undermined and have been ineffective in retarding erosion. A number of dwellings have been constructed seaward of the CCCL along the north end of the island. The CCCL lies between 150-300 feet landward of the vegetation line.

Recommendations: No more construction seaward of the CCCL should be allowed. There should be no development along the southern portion of the island due to its unstable nature (prominent overwash). There should be no more "homemade" coastal engineering. The island should be allowed to change naturally. The

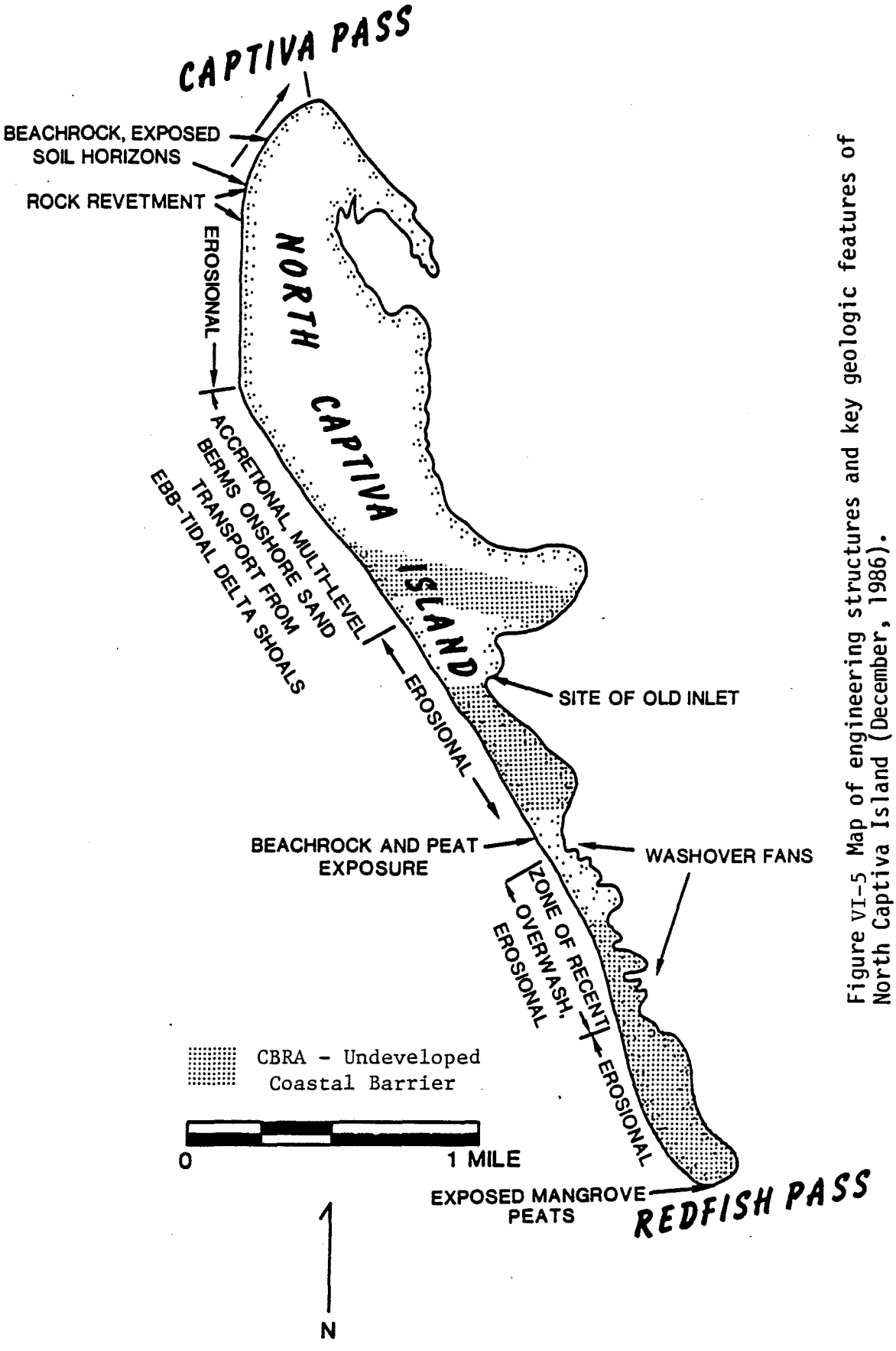


Figure VI-5 Map of engineering structures and key geologic features of North Captiva Island (December, 1986).

ebb-tidal delta of Captiva Pass makes an attractive site to obtain sand for beach nourishment projects on Captiva Island. This is a large offshore shoal that would provide beach-quality sand in great volume. If this shoal is to be mined for sand, a study analyzing the effects on North Captiva Island should be completed. Finally, incipient dunes should be protected as well as the newly forming vegetation on the multiple berms.

Captiva Island

Geology: Captiva is a long, slender barrier island which has not had the benefit of a large ebb-tidal delta positioned at its north end like North Captiva and Cayo Costa Islands (Fig. VI-6). Redfish Pass is much smaller than Captiva Pass or Boca Grande Pass. As a result, there has not been significant onshore sand transport capable of building a wide, bulbous northern section of the island. Captiva has shared a similar past with Cayo Costa and North Captiva in that the mid and southern sections of the island have been influenced by past tidal inlet activity thus creating narrow zones that might be prone to storm surge overwash. The net longshore sand transport rate is not as high as the rate for Gasparilla Island or other portions of Cayo Costa and North Captiva. However, the coastal geomorphology indicates that sand is not being retained along this island and is bypassed on down to Sanibel Island. As a result of the extensive human development along this barrier island, there are few natural sand dunes. Where the beach has been nourished to the north, incipient dunes are forming.

Although large amounts of data have been and continue to be collected concerning beach changes and sand volume transfer, relatively little is known about the past geological history of the island. This is, of course, true for all the Lee County barrier islands.

Engineering Efforts: The modern beach system of Captiva, on the other hand, is the most heavily studied on the Lee County coastline. This is due to the efforts of the Captiva Erosion Prevention District (CEPD) and some commercial land developers to understand the dynamics of the beach and to provide solutions to beach erosion problems. The number of funded consulting reports is impressive and represents high quality work. It is beyond the scope of this report to summarize all the technical data that have been generated. The CEPD library on Captiva Island should be consulted if one is interested in reviewing the consulting reports. A recent report funded by the CEPD (Applied Technology and Management, Inc., 1987) is the most comprehensive plan to date concerning a long-term approach to providing beaches to Captiva Island. This restorative beach fill project recommends: (1) placing 1,260,000 yds^3 of beach-quality sand along 26,000 feet of Captiva Island, (2) building a terminal groin extension at Blind Pass, and (3) developing a project maintenance program with a four year cycle.

The plan proposed by the Division of Beaches and Shores calls for 1,465,100 yds^3 of sand placed over 22,750 feet of beach. The cost is estimated at $7,954,000 and will widen the beach by an average of 67 feet. There is no mention of a terminal groin in the State's report.

Since there continues to be an erosion problem along much of this barrier island, one can generally conclude that the hardened structures installed in the past have failed to retain the beach. Many of the private homeowners

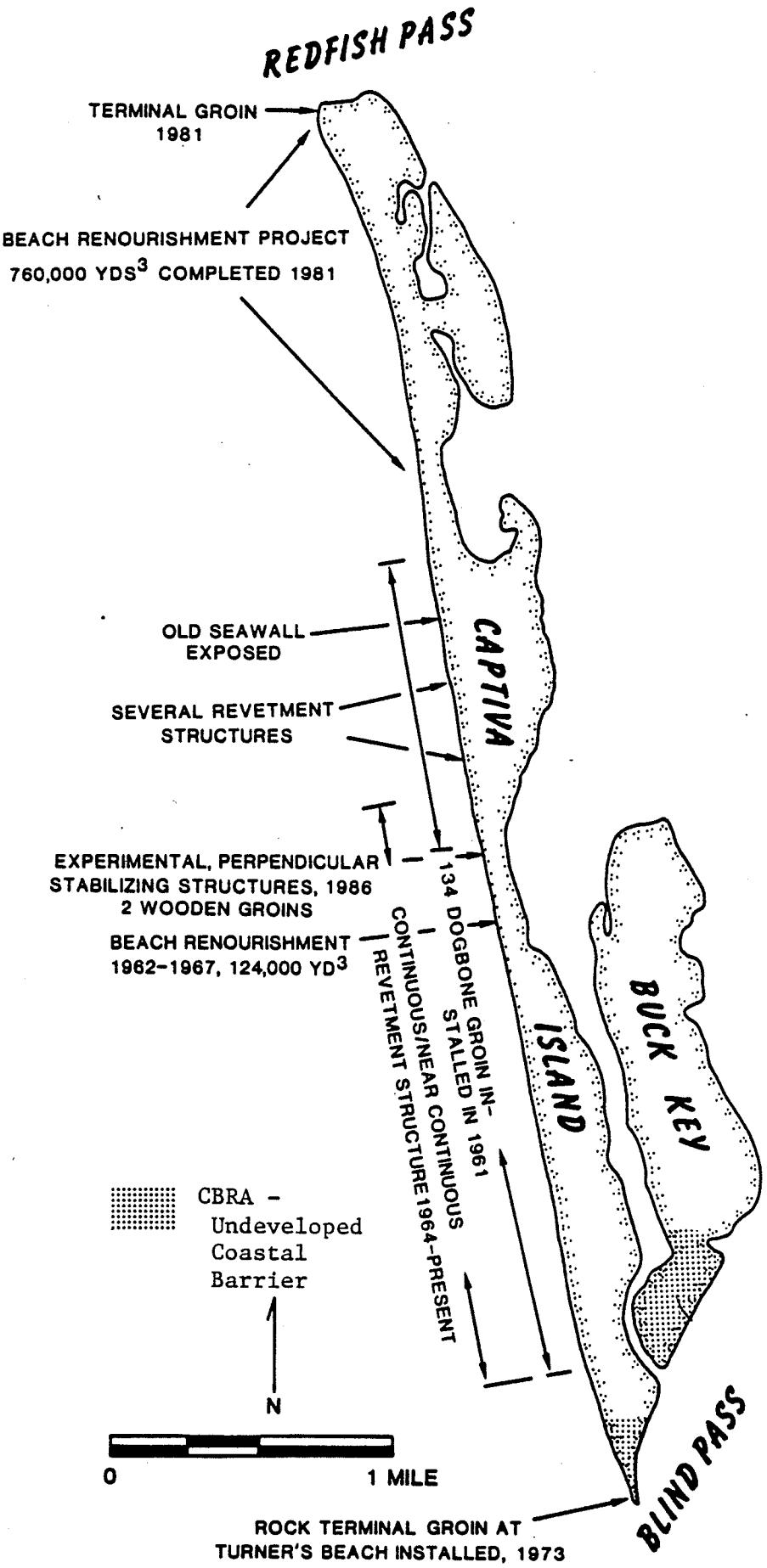


Figure VI-6 Map of engineering structures and key geologic features of Captiva Island (January, 1987).

residing along the central and south-central portions of the island have relied upon seawalls of various design to protect their property. These structures have succeeded in that capacity. However, the shoreline has retreated up to many of the structures, thus sacrificing the beach.

Recommendations: No new hardened structures should be placed along the beaches at Captiva. The terminal groin at the south end along Blind Pass provides a localized, wider beach for the public that would not normally be there. In addition, this structure provides a measure of stability for this highly unstable tidal inlet. The proposed 190 ft. extension of the existing terminal groin will prevent sand from entering this inlet system. However, one should not expect that the beaches will widen very far up the beach (to the north) as a result of the terminal groin. The trapping effect is only local. It is likely that the sand trapped by the groin will cause some additional erosion immediately downdrift (to south). Since the south tip of Captiva Island is so popular with the public and there are so few public sections of beach on this island, the County should take an interest in maintaining the terminal groin and the local beach.

Beach nourishment coupled with planting dune-building vegetation is the best general policy to widen the beaches along this barrier island. This has already been done along the north end of the island with success. However, continued use of the ebb-tidal delta as a sand source at Redfish Pass should be done with caution. The complete removal of this sand body may have deleterious effects on the shoreline of both barrier islands adjacent to this inlet. The Captiva Pass ebb-tidal delta should be considered as a major source of sand for extensive nourishment of Captiva Island. In addition, some geophysical studies examining the offshore of Captiva Island indicate a possible source of sand on the inner continental shelf. However, the quality of these sediments should be carefully examined prior to final consideration. The existing database is not sufficient to adequately determine the availability of offshore, beach-quality sand deposits other than the ebb-tidal deltas.

Estero Island

Geology: Estero Island, located in the southern barrier island system of Lee County (Fig VI-7), is protected from high energy waves by the northern barrier island system. Consequently, the highest net longshore sand transport rates are about 50 percent less than the highest rates calculated for the northern barrier island system (Fig. VI-2). However, the shoreline erosion data indicates that most of this island has been receding. The low energy character of this island also means that it is not topographically as high as the islands located to the north. The contour map indicates that most of Estero is only 5-7 feet above sea level making it one of the more easily flooded barrier islands in Lee County.

The southern portion of the island not immediately adjacent to Big Carlos Pass is protected by a series of offshore bars that have built vertically and now support some of the best sand dunes in all of Lee County. Local residents reported that these offshore bars (ridge and runnel) were formed during/after Hurricane Donna in 1960. Through time, vegetation colonized the upper portions of these stagnated ridges and sand dunes began to build. They now offer excellent protection to the beaches and buildings located on the main portion of southern Estero Island.

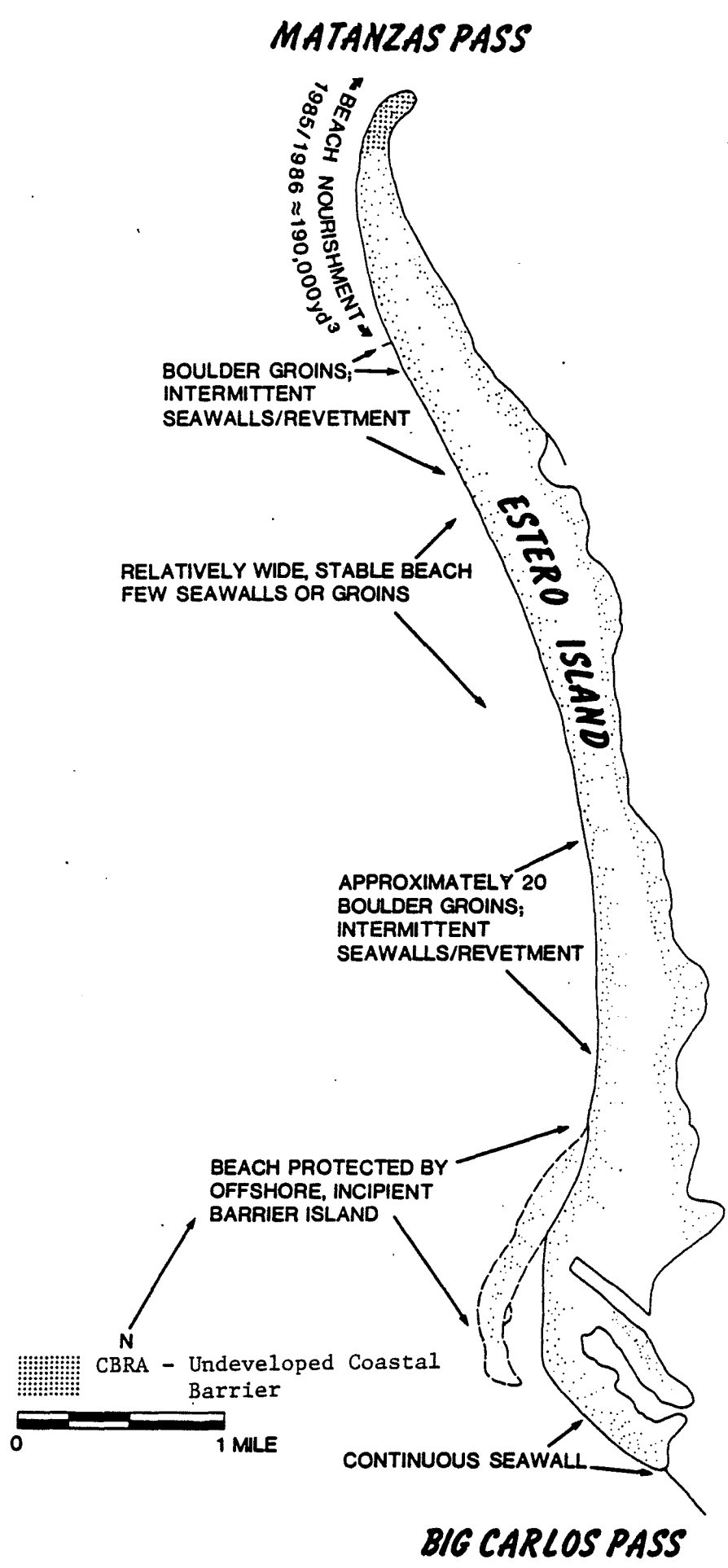


Figure VI-7 Map of engineering structures and key geologic features of Estero Island.

Like most other barrier islands, the ends of Estero are unstable due to the presence of the inlets.

Engineering Efforts: Estero Island, in spite of the heavy demands placed upon it, is little studied and has not been the subject of a comprehensive beach management plan similar to Captiva Island. Figure VI-7 illustrates the locations of the one beach nourishment project and the location of the major coastal engineering structures. Generally, there has been a mosaic of seawalls, groins, and revetments placed along the island. Most of these relatively old hardened structures are concentrated along the central-south quarter of the island where the island is most susceptible to erosion. The very southern end of the island facing Big Carlos Pass has undergone recent and rapid development. Nearly all of these developments have seawalls to protect the property behind. In some areas, these seawalls have failed and collapsed into the inlet. The shoreline facing Big Carlos Pass has very little to no beach at all.

Recommendations: By pumping a large volume of sand from the ebb-tidal delta associated with Big Carlos Pass to the area of longshore sand transport reversal on Estero Island, one could provide a long-term widened beach for much of the island. The sand would be transported in both directions toward the ends of the island (feeder beach concept). Most of the sand would be transported to the northwest where it is needed the most. Some would go to the southeast providing sand to the small-detached barrier island system. These new sands might help to continue to build the dune system there, thus providing more protection landward, but also augmenting a natural coastal system. The County should begin to manage this new coastal system at the south end of Estero, particularly in protecting the dunes and dune vegetation. If the ebb-tidal delta at Big Carlos is to be used as a sand source, care should be taken to assure that the incipient barrier islands at the south end of Estero Island are not negatively impacted.

If and when Matanzas and Big Carlos Passes are dredged and if the material dredged is of beach quality, it should be placed back on the beach. This was done in 1985/86 at the north end. However, the beaches at the south end will prove to be very difficult to stabilize. This is an exposed area subject to chronic erosion. In addition, the U.S. Army Corps of Engineers might object to placing sand along the extreme south end of Estero Island as those sediments could be transported back into the inlet very quickly thus negating the effects of the dredging operation.

The same problem (renourished beach sands passing back into an inlet system) exists to some degree along the NW end of the island. However, the beach area to be renourished is much longer here than at the south end and the public benefits would be much greater. In addition, much of this beach is not as significantly impacted by the main ebb channel of Matanzas Pass. Finally, there may be other offshore sand sources off the north end of Estero Island if channel dredging does not provide the quantity or quality of material needed to nourish the NW end of the island. More geotechnical data will be needed to make this determination.

Lovers Key

This undeveloped barrier island is a State owned park (Carle Johnson Center) that can be reached only by boat or by shuttle cars. The island should be

left in its natural environment. The large overwash fans in the north-central part of the island would provide an excellent study area to cage off sections of incipient dunes to measure their growth through time and the influence of new overwash whenever it might occur.

Bonita Beach/Big Hickory Island

Geology: This is a long, narrow, low barrier island backed by a small lagoon (Fig VI-8). The net longshore sand transport calculations indicate a small amount of sand moves to the south. However, the northward migrating spit that closed off Big Hickory Pass indicates that net northerly sand transport can be expected to occur from year to year. Climate cycles controlling winds and waves will cause temporal net sand transport cycles. Like the weather, these cycles are impossible to predict over the long term.

The north end of the island has been dominated by a rapidly moving recurved spit. This newly created land is topographically low (2.5-3.9 feet), but incipient dunes are forming that may increase the overall elevation. A small inlet or breach was open in 1972. It was sealed off in 1975, but reopened in 1981. Presently, there is no inlet. However, this recent activity well illustrates the unstable nature of this portion of the island. There is no CCCL for this portion of the island.

Further south, beyond the dense development at the end of Hickory Blvd., the beach is relatively wide. However, few dunes have formed as a result of the high, coarse shell concentration. The dunes that exist are well vegetated and are 1-2 feet in height. The sand along this portion of Bonita Beach is significantly different than the sand on Estero Island or Lover's Key. The seemingly random high concentrations of the shelly (carbonate) fraction of beach sediment along the Lee County coastline is a subject for study. In addition to the shelly material, there are cobble/gravel sized limestone and coral fragments indicating that rock outcroppings occur offshore. This further indicates that there probably is no source of sand offshore to be used for beach nourishment.

Engineering Efforts: All engineering efforts on this barrier island have been concentrated along a short section of beach where the former Big Hickory Pass was located. The new condominiums at the north end were built too close to the beach and too close to an inlet. Small inlets along the west coast of Florida are wave-dominated and are generally not stable. Extensive seawalls with a boulder revetment have been placed seaward of these relatively new buildings to protect them. Here, as in other areas, there is virtually no beach seaward of the seawalls. A small boulder revetment has been placed along the tennis courts just to the north of the buildings. This type of coastal engineering offers little protection as these rocks will be easily undermined as chronic erosion continues.

Recommendations: Most of Big Hickory Island/Bonita Beach is in no need of nourishment or hardened structures. This is a low energy barrier island that has a low longshore sand transport rate. Most of the island is stable. Of course, due to its topographically low character, it will be flooded during the 100 year storm event.

The area that is most unstable is the area where, unfortunately, most of the extensive and expensive development is occurring. Since this is not a public

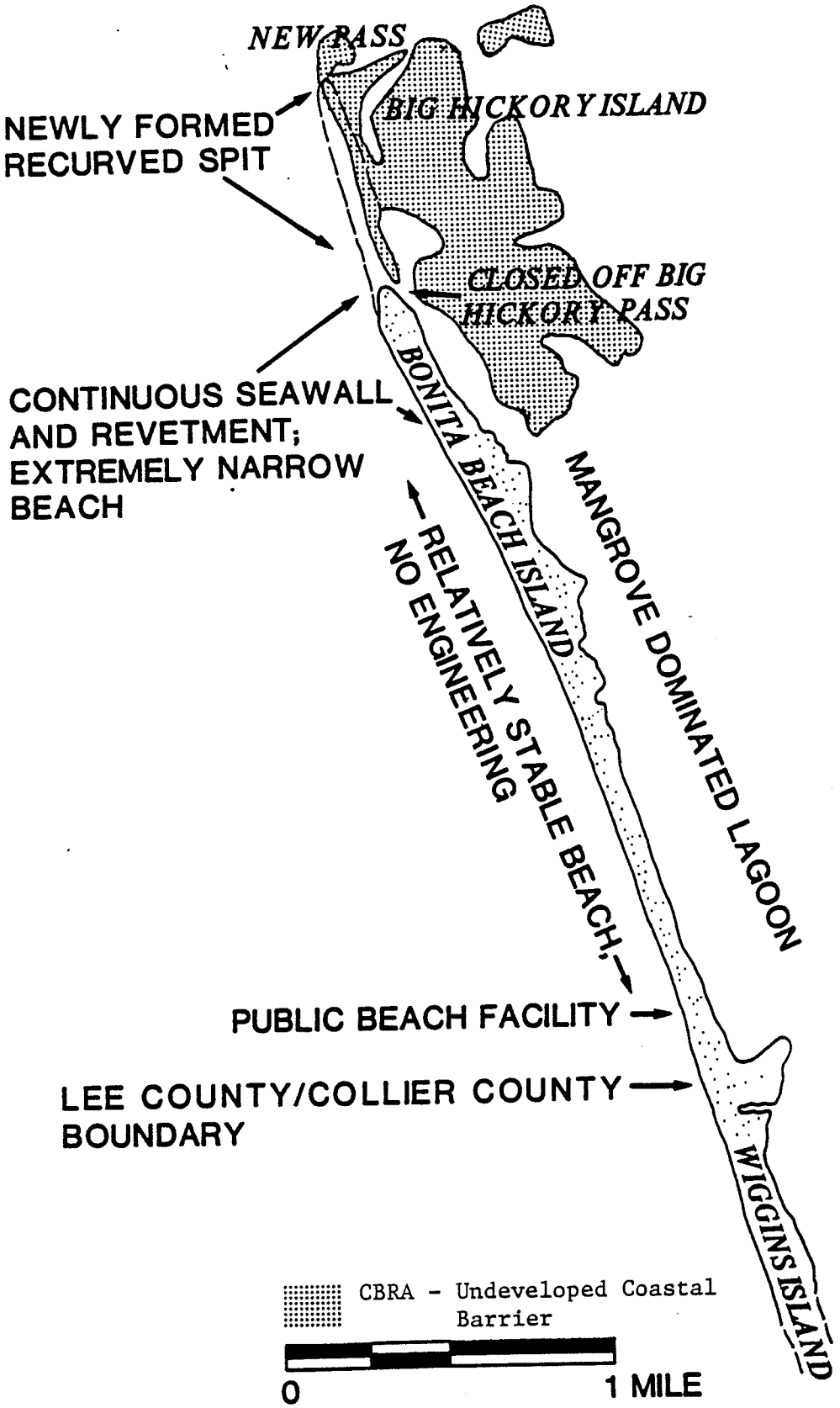


Figure VI-8 Map of engineering structures and key geologic features of Bonita Beach Island.

beach area, the cost of beach widening must be carried by the private landowners. A new beach in this area can only be made by bringing in new sands. Trapping sands by hardened structures will not work and the use of offshore breakwaters is still largely experimental. There is no nearby source of sand for beach nourishment. The ebb-tidal delta at New Pass is very small. The closest material available would be in the Big Carlos Pass ebb-tidal delta located approximately 2 miles to the northwest. With the absence of a public access and the relative unavailability of an easily accessible sand supply to nourish the beach at the north end of the island, the probability of a tax-funded beach restoration initiative here is low. The private sector will have to go it alone.

IMPLICATIONS OF BEACH AND DUNE STUDIES

Summary of Findings

1. The Lee County coastline is perhaps the most complex barrier-island system in Florida because of the large number of tidal inlets. In addition, the wide range in size of these inlets and the fundamental geologic/geographic division of this island chain into northern and southern segments accounts for this complexity. The lack of physical studies of this island system has led to an existing poor understanding concerning the details of sand budget changes in time and space, morphological changes, geologic history and evolution of the County's islands, storm response, and available sand resources.

2. There is no central source of information concerning studies that have been completed in Lee County. There appears to be no mechanism for the County to observe and track coastal consulting activity.

3 The low wave energy, low frequency of major storms, low elevation, and low tidal range make the Lee County coast highly susceptible to excessive damage resulting from the relatively rare, very large storms.

4. Based upon existing data and field work, identification of critical erosion areas affecting human development can be made. Those areas are:

   a. South-central and southern portion of Gasparilla Island
   b. Northern North Captiva Island
   c. All of Captiva Island
   d. Three segments of Estero Island (NW end, central-south, and extreme SE tip).
   e. North end of Bonita Beach Island.

   Erosion is also occurring along relatively uninhabited islands such as Cayo Costa and Lovers Key as well as the south-central portion of North Captiva Island.

5. Sand dunes, particularly those forming the initial dune line adjacent to the beach (fore-dune ridge) are discontinuous and low in relief. Few dunes exist along developed coastal sectors and none exist where seawalls have been installed.

6. Studies indicate that the rate of sea-level rise is increasing and that the sea level in southwest Florida may rise 3.5 feet by 2100. Most of this increase will occur in the second half of the next century

7. Hardened coastal engineering structures installed along the Lee County coast have failed to protect or preserve the beach. Groin fields have proved useless. Terminal groins have been temporarily effective. Seawalls and rock revetments have afforded protection to the buildings and property behind them, but have done little to protect the beach. In many areas where there are seawalls or revetments the beach is narrow or non-existent.

8. The Coastal Control Construction Line (CCCL) is set much closer to the beach on developed barrier islands than on undeveloped barrier islands. According to the State Division of Beaches and Shores the CCCL for developed barrier islands runs along the top of the seawall, rather than further inland, to avoid having to process requests for variances for construction seaward of the CCCL.

GOALS, OBJECTIVES, AND POLICIES

GOAL 1: To conserve, maintain, and enhance coastal beach and dune systems so as to retain their contributions to storm protection, recreation, natural resources, and economic development.

OBJECTIVE 1.1: Establish a beach and dune management program to include beach renourishment, sand budget analysis, storm surge modeling, and tide and wave measurement.

OBJECTIVE 1.2: Prepare standards for beach and dune protection, including restrictions on hardened coastal engineering structures, such as groin fields and seawalls.

OBJECTIVE 1.3: Designate critical erosion areas affecting development and enact policies to reduce future erosion.

OBJECTIVE 1.4: Maintain a central clearinghouse for all beach and dune studies and recommendations by both public and private organizations.

POLICY 1.1.1: The county shall designate the Division of Planning as the beach and dune conservation agency, with responsibility for:

1. preparing beach and dune management plans, with priority to the critical erosion areas:
   a. south-central and southern portion of Gasparilla Island.
   b. northern North Captiva Island.
   c. all of Captiva Island.
   d. three segments of Estero Island (NW end, central-south, and extreme SW tip).
   e. north end of Bonita Beach.

2. collecting information on available sources of beach-quality sand for renourishment, and preparing renourishment plans for eroding areas where public facilities and access exist, including central-south Gasparilla Island, south end of Captiva Island, and NW and central-south Estero Island.
3. recommending regulations and policies to restrict hardened coastal engineering structures, protect eroding coastal areas and sand dunes, and discourage development of undeveloped coastal barriers.
4. maintaining a central clearinghouse for information on beach and dune studies and recommendations by both public and private organizations.
5. educating citizens and developers about the costs and benefits of alternative beach and dune conservation approaches.

REFERENCES

Applied Technology and Management, Inc., 1987, Comprehensive beach and shore preservation plan. Captiva Erosion Prevention District, Captiva, FL, 40 p.

Barth, M.C., and Titus, J.G., 1984, Greenhouse effect and sea level rise. New York, Van Nostrand Reinhold Co., 658 p.

Coastal and Oceanographic Engineering Laboratory, 1971. Black Island-Lovers Key shoreline stability and coast development. UF-COEL 71/007, Gainesville, University of Florida. ...

Coastal and Oceanographic Engineering Laboratory, 1974. Coastal engineering study of Captiva Island. Florida Engineering and Industrial Experiment Station, University of Florida, Gainesville, 131 p.

Department of the Army, 1969. Beach Erosion Coastal Study on Lee County, Florida. Corps of Engineers, Jacksonville District, Serial Number 120.

Harvey, J., 1979. Beach Processes and Inlet Dynamics in a Barrier-Island Chain, Southwest Florida. New College Environmental Studies Program Publication No. 22, Sarasota, FL.

Herwitz, S.R., 1977. "Elements of the Cayo Costa Island Ecosystem, Lee County Florida". New College, University of South Florida, 4th Annual Conference on Restoration of Coastal Vegetation in Florida, p 152-165.

Hine, A.C., and D.F. Belknap, 1986. Recent Geological History and Modern Sedimentary Processes of the Pasco, Hernando, and Citrus County Coastline: West- Central Florida. Florida Sea Grant College, Report No. 79, University of Florida, Gainsville.

King, C.A.M., 1972. Beaches and Coasts. 2nd Edition. New York, St. Martin's Press.

Knowles, S.C. and R.A. Davis Jr., 1983. "Hurricane Influence on Holocene Sediment Accumulation in Sarasota Bay, FL". American Association of Petroleum Geologists Bulletin, V.67, p.496.

Morrill, S., and J. Harvey, 1980. An Environmental Assessment of North Captive Island. New College Environmental Studies Program Publication #14.

Morris, J., J. Miller, W.K. Byle, and J.B. Morrill, 1979. Survey of the Natural Systems of Gasparilla Island, Florida: With Special Reference to Conservation, Protection, Restoration, and Public Use. Unpublished contract report, Conservation Foundation, Washington, D.C.

National Research Council, 1983. Evaluation of the FEMA model for Estimating Potential Coastline Flooding from Hurricanes and its Application to Lee County, FL. National Academy Press, Washington, D.C.

NOAA, 1973. Flood Insurance Study - Lee and Collier Counties, FL. Silver Springs, MD, U.S. Department of Commerce.

Walton, T.L., 1973. Littoral Drift Computations Along the Coast of Florida by means of Ship Wave Observations. Coastal and Oceanographic Engineering Laboratory Technical Report #15, University of Florida.

Walton, T.L., and R.G. Dean, 1976. "Use of Outer Bars of Inlets as Sources of Beach Nourishment Material", Shore and Beach Magazine, V.44,2:11.

VII. HURRICANE EVACUATION AND HAZARD MITIGATION

Purpose

The purpose of this section is to consider plans for hurricane evacuation and hazard mitigation for the Coastal Study Area. It analyzes the projected impact of the population density allowed in the land use element of the Lee Plan on the hurricane evacuation plan, and reviews measures to maintain or reduce hurricane evacuation times. It analyzes land use and development in coastal "high-hazard" areas, and reviews post disaster redevelopment measures which could be used to reduce exposure to storm hazards.

Rule 9J-5.012 (2) (e) of the Florida Department of Community Affairs states:

The following natural disaster planning concerns shall be inventoried or analyzed:

1. Hurricane evacuation planning based on the hurricane evacuation plan contained in the local peacetime emergency plan shall be analyzed and shall consider the hurricane vulnerability zone, the number of persons requiring evacuation, the number of persons requiring public hurricane shelter, the number of hurricane shelter spaces available, evacuation routes, transportation and hazard constraints on the evacuation routes, and evacuation times. The projected impact of the anticipated population density proposed in the future land use element and any special needs of the elderly, handicapped, hospitalized, or other special needs of the existing and anticipated populations on the above items shall be estimated. The analysis shall also consider measures that the local government could adopt to maintain or reduce hurricane evacuation times.

2. Post-disaster redevelopment including: existing and proposed land use in coastal high-hazard areas; structures with a history of repeated damage in coastal storms; coastal or shore protection structures; infrastructure in coastal high-hazard areas; and beach and dune conditions. Measures which could be used to reduce exposure to hazards shall be analyzed, including relocation, structural modification, and public acquisition.

3. Coastal high-hazard areas shall be identified and the infrastructure within the coastal high-hazard areas shall be inventoried. The potential for relocating threatened infrastructure shall be analyzed.

Methodology

This section was prepared from materials provided by the Lee County Division of Emergency Management and the Southwest Florida Regional Planning Council. These agencies are responsible for preparing hurricane evacuation and emergency management plans for the County. Reports used are listed in the Reference section.

STORM DAMAGE HISTORY

Four major coastal storms have caused damage to Lee County during the second half of this century:

- -Hurricane Donna, 1960
- -No-Name Storm, 1982
- -Tropical Storm Bob, 1985
- -Hurricane Elena, 1985.

Damage from Hurricane Donna, a major Category 4 storm striking in September 1960, was described by the Corps of Engineers report (1961) as follows:

"North of Naples, the areas hardest hit appeared to be Vanderbilt and Bonita Beaches. Nearly all beachfront homes were badly damaged or destroyed. Those further inland sustained tidal flooding but only minor structural damage, mainly from first-phase winds. Trailer camps on the keys and gulf coastal areas were badly damaged from wind, tide, and wave action. Strong second-phase winds of short duration forced Estero and Imperial Rivers out of their banks, thus flooding some urban developments below the 10-foot contour bordering the rivers. In Little Hickory Bay and at Everglades, 8-foot maximum tide-level gages installed by this office were completely overtopped by tide, as indicated by high-water marks near the gages. Estero Island (Fort Myers Beach) was swept by tides and wave action on the afternoon of 10 September. Dune elevations of 5 to 7 feet were lowered several feet, exposing and undermining foundations and toppling homes. First-phase winds lowered levels in Caloosahatchee River, and second-phase tides did not reach flood heights in Fort Myers except in extremely low areas bordering the river. A similar lowering of water levels occurred at Punta Gorda and at Charlotte Harbor as first-phase winds over Charlotte Harbor caused tidal flooding at Bokeelia on Pine Island and in the Matlacha Pass area. In the South Banks area of Captiva Island, tides of 4 to 5 feet above normal overtopped the island, cutting through the narrow beaches to the bay in several places. A new entrance was cut to Blind Pass about one-fourth mile south of Blind Pass bridge."

Physical damage from Donna in Lee County was 1100 buildings and 210 mobile trailers destroyed or suffering major damages. The Corps report estimated total damages of some $16.5 million in Lee County:

Hurricane Donna Damage Estimates
(In thousands of dollars)

Urban	Roads	Utilities	Total
15,565	254	630	16,449

Damages from the No-Name storm of June 17-18, 1982 were estimated by the Lee County staff at over $4 million:

No-Name Storm Damage Estimates
(In thousands of dollars)

Public Property	Private Property	Miscellaneous	Total
491	3,000	600	4,091

Areas damaged by the No-Name storm included Captiva Road, residences on the southern tip of Boca Grands, flooded streets in downtown Fort Myers, and areas affected by erosion on Boca Grande, Lovers Key, and Cayo Costa.

Tropical Storm Bob resulted in the following damages:

Tropical Storm Bob Damage Estimates
(In thousands of dollars)

Public Property	Private Property	Total
65	706	771

Areas damaged by Bob included condominiums and restaurants on Fort Myers Beach and Sanibel, a Fort Myers Beach RV park, the Sanibel Causeway, and eroded coastal beaches and flooded County streets.

Hurricane Elena caused some $385,340 in damage during August 30-September 1, 1985.

Hurricane Elena Damage Estimates
(In thousands of dollars)

Public Property	Private Property	Total
35	350	385

Elena damage occurred at Boca Grande, Captiva, Blind Pass, and Fort Myers Beach. Two Fort Myers sewage lift stations were flooded out and the Fort Myers city docks were damaged.

COASTAL HIGH HAZARD AREAS

Coastal high hazard areas are to include areas where public facilities have been damaged or undermined by coastal storms, Federal Emergency Management Agency (FEMA) designated V (Velocity) zones, areas seaward of the coastal construction control line, and inlets which are not structurally controlled. Figure VII-1 shows the Lee County Flood Hazard Zones, as designated by the Federal Emergency Management Agency.

In unincorporated Lee County, the coastal high hazard areas include:

1. Previously storm-damaged public facilities:
   a) Sanibel causeway
   b) Captiva Road
   c) County piers at Cayo Costa
   d) Boca Grande Lighthouse
   e) Gasparilla Road on Boca Grande.
2. V zones, areas ranging from a few hundred to 3000 feet deep along the western and southwestern shores of:
   a) Boca Grande
   b) Cayo Costa
   c) North Captiva
   d) Captiva
   e) Pine Island
   f) Mainland north and west of Cape Coral
   g) Punta Rassa to San Carlos Island
   h) Estero Island, Lovers Key, Black Island, and south to Collier County line
   i) Mainland facing Estero Bay.
3. Areas seaward of the coastal construction control line.
4. Inlets between the coastal islands and entrances to the bays.

HURRICANE VULNERABILITY ZONE

The hurricane vulnerability zone is the area requiring evacuation in the event of a 100-year storm or Category 3 storm event (hurricane).

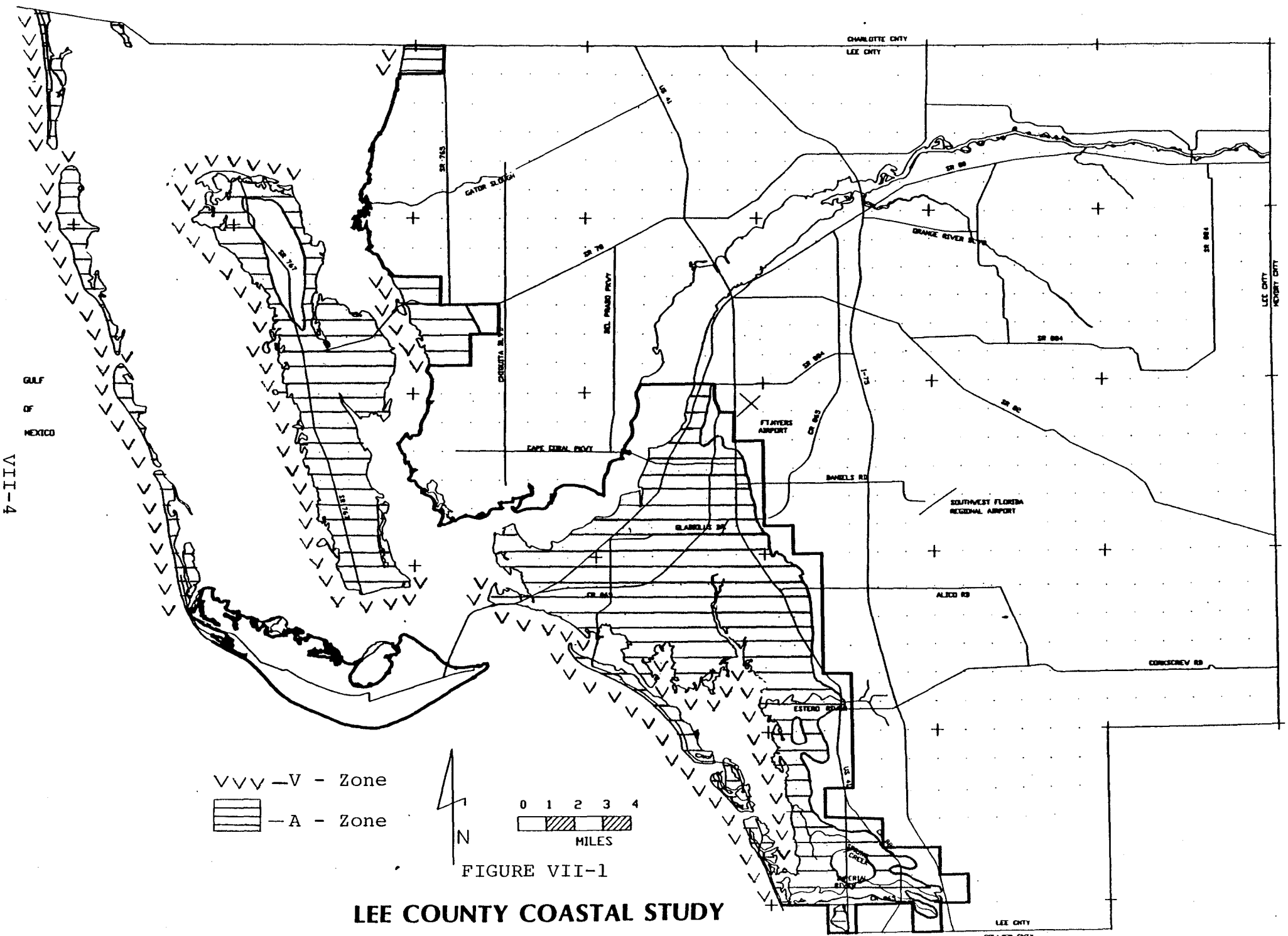


FIGURE VII-1

LEE COUNTY COASTAL STUDY

FLOOD HAZARD ZONE

For unincorporated Lee County, the Coastal Study area includes all sections of land containing portions of the A-Zone (100-year storm flood hazard zone, as defined by the Federal Emergency Management Agency) seaward of the municipalities of Fort Myers and Cape Coral, and excluding the municipality of Sanibel. This includes the unincorporated Gulf islands and generally extends inland (eastward) from the Gulf to include Bonita Springs and the mainland areas seaward of the ridge along which U.S. Highway 41 runs.

The Category 3 storm surge area, defined by SLOSH modeling, extends further inland than the A-Zone, generally reaching eastward from the Gulf to the I-75 highway corridor. Figure VII-2 shows the maximum areas subject to flooding by each storm category. Because this map is a composite of all possible storm tracks, this entire area is unlikely to be flooded from any single storm.

VULNERABILITY ANALYSIS

According to data compiled by the Lee County Division of Emergency Management in 1987, there is a serious gap between the potential demand for and supply of shelter and evacuation capacity. (Note that this anaylsis is based on total County vulnerability, not just the unincorporated portion of the County.)

VULNERABILITY ANALYSIS: CATEGORY 3 STORM

POPULATION AT RISK*	259,706
SEEKING PUBLIC SHELTER:	
24%	62,329
45%	116,868
PUBLIC SHELTER CAPACITY:**	23,580
DEFICIT AT 24%	-38,747
DEFICIT AT 45%	-93,288
CLEARANCE TIME (HOURS)	10.3
PRE-LANDFALL HAZARDS TIME	12.5
TOTAL EVACUATION TIME	23
PREPARATION TIME	3--9
DECISION TIME FRAME	26--32
FORECAST PERIOD	36--24

* Population figures last updated in 1985.
** Shelter capacity updated in 1987.

The population at risk includes all those within the Category 3 surge area at risk from flood and wind hazards. Those seeking public shelter are based on two assumptions, depending on whether 24% or 45% of those evacuating seek public shelter, with the remainder leaving the County, going to friends' houses, motels, etc. The percentages were derived from a behavioral survey in which 24% of the respondents stated that they would seek public shelter, and an additional 21% responded "don't know" when asked about their destination during hurricane evacuation. Thus, the 45% figure is a combination of the 24% who responded they would seek public shelter and the 21% who responded don't know.

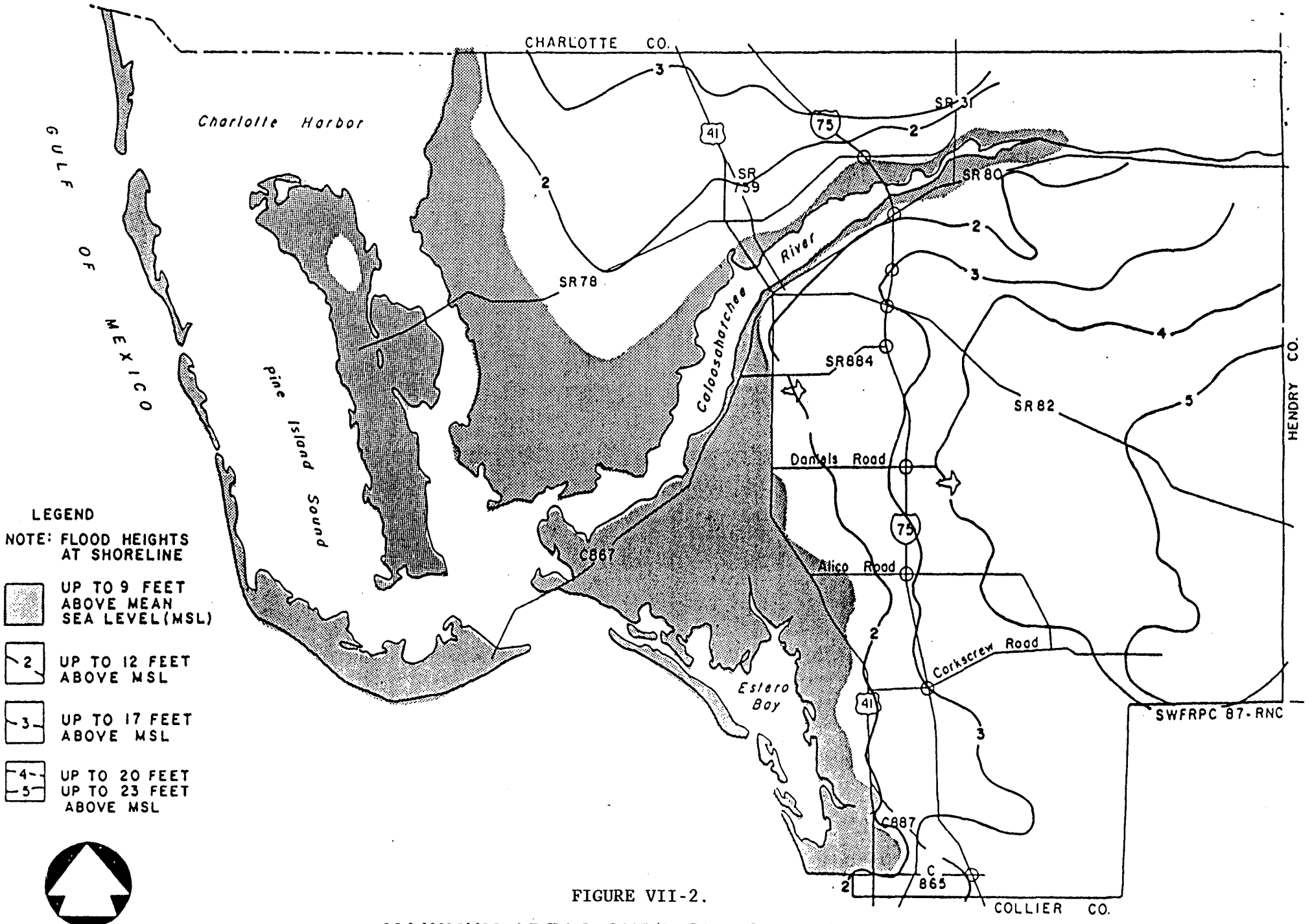


FIGURE VII-2.

MAXIMUM AREAS SUBJECT TO FLOODING BY STORM CATEGORY

SOURCE: SWFRPC (1987)

In 1980, 22.3% (45,871 of 205,266) of Lee County's population was aged 65 or over. By 1986, that percentage had increased to 24.4%, according to the 1987 Florida Statistical Abstract. As the percentage of elderly and retired population living on fixed incomes in the County increases, the need for public shelters should also increase since this group is liable to have fewer storm shelter options. Also, the adjacent inland counties do not have excess shelter capacity to assist Lee County. It is important to set an objective to increase the in-county shelter capacity, to at least accommodate the 24% stated demand.

Total evacuation time also presents a problem. Pre-landfall hazards time is that period immediately before hurricane eye landfall during which evacuation should not be carried out due to the effects of the arrival of gale force winds. For a Category 3 storm, gale force (45mph) winds are anticipated to arrive 12.5 hours before the eye of the hurricane, making further evacuation difficult. In order to safely evacuate the population at risk, evacuation would have to be ordered some 23 hours prior to the arrival of the eye of the storm (10.3 hours clearance time to move the evacuating population to safety plus 12.5 hours pre-landfall hazards time). Yet the National Hurricane Center typically can not provide more than 12 hours of "high confidence" warning time prior to the storm impact.

Emergency management decision-makers must order an evacuation based on the probability of a storm strike well before those probabilities are very high, if a safe evacuation is to result. Yet, they must also weigh the consequences of calling an evacuation when the storm does not actually strike their jurisdiction--the "Cry wolf" scenario which can affect the credibility of future evacuation orders. To increase evacuation capacity requires construction of more east-west highways allowing the vulnerable coastal population to move inland expeditiously. To prevent further overtaxing of evacuation capacity requires the limiting of future development and density increases in the hurricane vulnerability zone without equivalent increases in evacuation capacity.

One other possible method of increasing evacuation capacity is to designate "vertical evacuation areas" in inland locations within Category 3,4, and 5 surge areas. In the vertical evacuation areas, buildings engineered to withstand storm stresses and elevated above flood surge levels would be designated as vertical refuges. They would supplement the use of horizontal evacuation routes and existing public shelters. The concept of vertical evacuation is still in its formative stages, and remains somewhat controversial. Among the unanswered questions are whether there are enough hurricane-resistant buildings to serve as vertical refuges, whether the buildings are actually safe during major hurricanes, whether the buildings would be available for public use when needed, and what the legal liability of the government and the building owners would be in the event of injuries to those taking shelter there. Certainly, vertical evacuation should not be seen as a substitute for horizontal evacuation nor as a reason for permitting unsafe levels of development in vulnerable coastal areas.

Emergency Shelters

Emergency shelters and their capacities have been inventoried. Figure VII-3 shows emergency shelter locations and Table 1 lists shelter capacities.

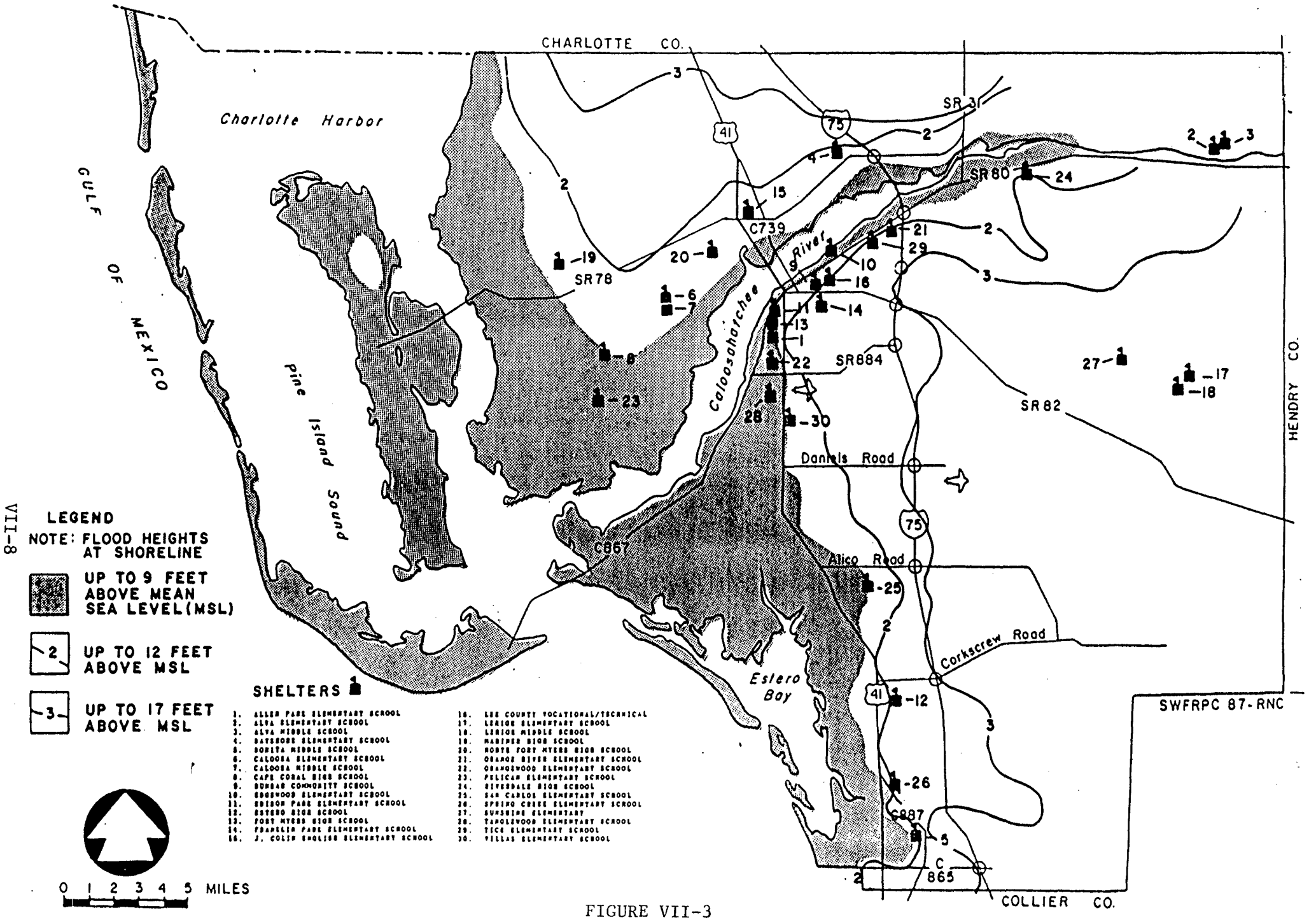


FIGURE VII-3

RED CROSS MANAGED PUBLIC SHELTER LOCATIONS

SOURCE: SWFRPC (1987)

TABLE VII-1. HURRICANE EVACUATION PRIMARY SHELTER CAPACITY/AVAILABILITY.

Emergency Shelter	Capacity*	Shelter Availability Category of Storm 1	2	3	4	5
Allen Park Elem.	530	X	X			
Alva Elem.	1,040	X	X	X	X	X
Alva Middle	1,460	X	X	X	X	X
Bayshore Elem.	1,570	X	X			
Bonita Middle	3,110	X	X	X		
Buckingham School**	650	X	X	X		
Caloosa Elem.	2,610	X	X			
Caloosa Middle	2,770	X	X			
Cape Coral High	6,390	X				
Dunbar Community	720	X	X			
Edgewood Elem.	360	X				
Edison Park Elem.	190	X	X	X		
Estero High	3,260	X	X	X		
Ft. Myers High	2,920	X	X			
Franklin Park Elem.	1,350	X				
J. Colin English	670	X	X			
Lee Voc. Tech School	1,640	X	X	X		
Lehigh Elem.	690	X	X	X	X	X
Lehigh Middle	3,020	X	X	X	X	X
Mariner High	3,260	X	X			
N. Ft. Myers High	1,040	X				
Orange River Elem.	180	X	X			
Orangewood Elem.	490	X	X			
Pelican Elem.	2,720	X				
Riverdale High	6,070	X	X			
San Carlos Elem.	2,940	X	X	X		
Spring Creek Elem.	2,580	X	X	X		
Sunshine Elem.	2,510	X	X	X	X	X
Tanglewood Elem.	1,310	X				
Tice Elem.	1,140	X	X	X		
Villas	1,130	X				

Shelter Availability Storm Category	Shelters	Capacity*
1	30	59,670
2	23	45,370
3	12	23,580
4	5	8,720
5	5	8,720

*20 sq. ft. per person
**Volunteer Worker Family Shelter. Capacity figure not included in totals.

Source: Lee County Division of Emergency Management, 2/20/87
Lee County Natural Hazard Shelter Survey, Florida Division of Emergency Management

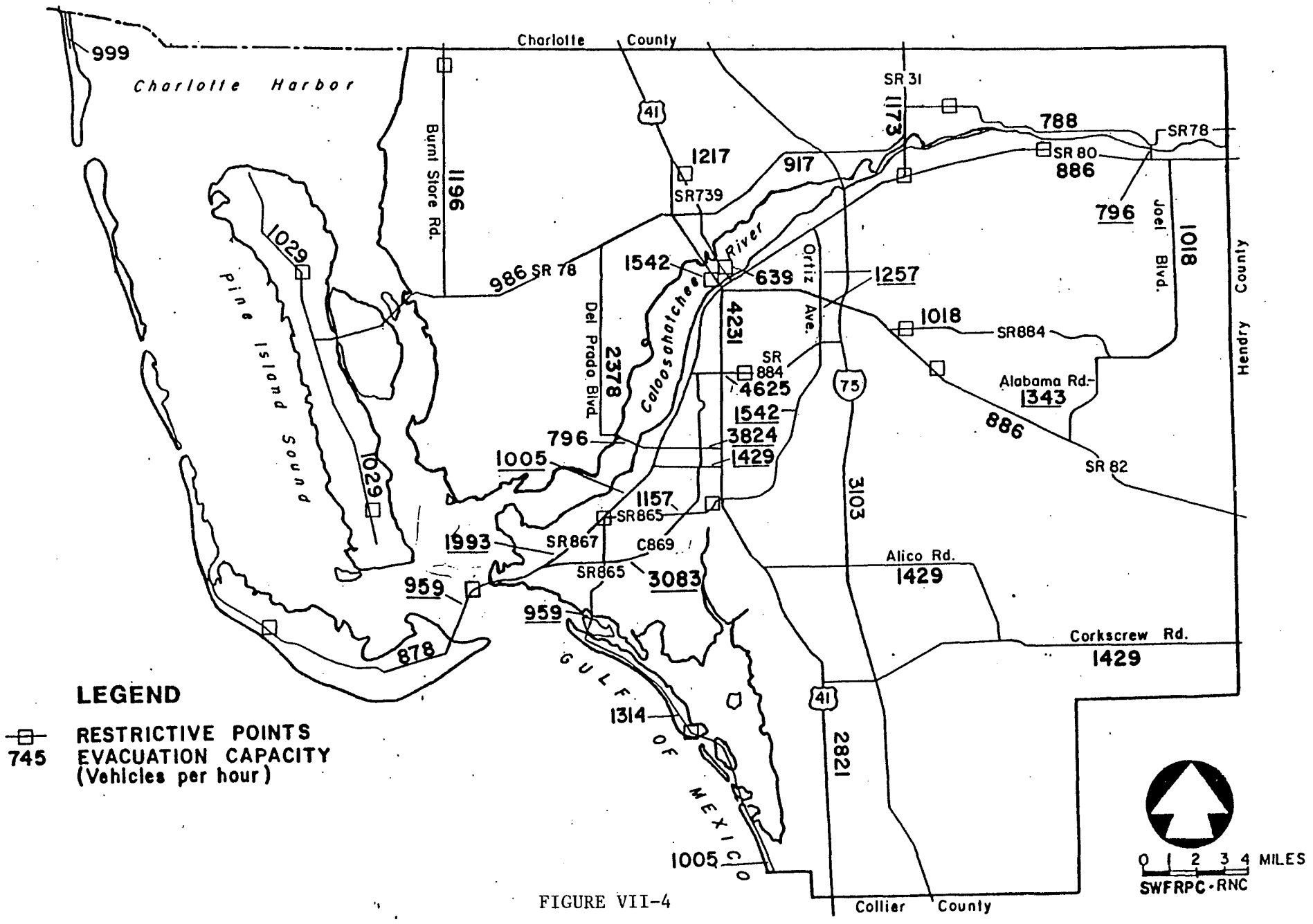


FIGURE VII-4

EVACUATION ROUTES, CAPACITIES, AND RESTRICTIVE POINTS LEE COUNTY

SOURCE: SWFRPC (1983, p. E-11)

Evacuation Routes

Figure VII-4 shows evacuation routes, capacities, and restrictive points. Major capacity is oriented north-south, rather then east-west. Restrictive points occur at bridges and major intersections. Evacuation zones are shown in Figure VII-6. Routes subject to flooding by rainfall prior to arrival of storm winds or rising waters are shown in Figure VII-7.

Vulnerable Infrastructure

In addition to roads and bridges, major infrastructure within the County includes a number of other public facilities. Table VII-2 lists the number of public facilities in the County and Table VII-3 shows the estimated amount of public assistance required for a Category 3 storm.

Table VII-2. Lee County Public Facilities

Water	Waste-water	Public Util.	Trans-port	Health Care	School
38	189	30	6	18	63

Source: SWFRPC Hurricane Loss Study. 1984.

Table VII-3. Category 3 Storm Public Assistance ($000)

Water	566
Wastewater	617
Public Utilities	2,845
Transportation	93
Health Care	13,759
Schools	11,888
Total	29,768

Source: SWFRPC Hurricane Loss Study. 1984.

Water and wastewater treatment facilities within the Coastal Study Area are shown In Figure VII-5 and listed in Tables VII-4 and VII-5.

Road and transportation facilities within the high hazard area include:

- Gasparilla Road
- Captiva Road
- Blind Pass Bridge
- Sanibel Causeway
- Pine Island Road Bridge.

POST-DISASTER REDEVELOPMENT

Because almost 20% of Lee County lies within the 100 year flood zone, an unusually large proportion of the developed land uses are exposed to coastal storm flooding. Some $2.8 billion (40%) of the 1985 tax base of the unincorporated county was located in a section containing the A Zone, and about $1.1 billion (16%) was in a section containing the V Zone, the most hazardous part of the flood zone due to exposure to waves atop rising flood waters. Over 39% of the dwelling units, housing about 108,000 people, were in

A Zone sections, with 11% and about 31,000 people in V Zone sections. During the peak season, these exposed populations increase to about 122,000 in A Zone sections and about 41,000 in V Zone sections. (See Chapter II.)

A key feature of redevelopment is the public policy defining conditions under which storm-damaged buildings in vulnerable locations may be rebuilt. This is important because of the possibility for repeated damage to the structures, repeated exposure of population to future hazards, repeated disaster relief demands, and repeated necessity for expenditures to rebuild associated public facilities.

The present County policy toward redevelopment is expressed in its adopted reconstruction policy, which states:

Structures which have been damaged by fire or other natural forces to the extent that the cost of their reconstruction or repair exceeds 50% of the replacement cost of the structure may be reconstructed at, but not to exceed the legally documented actual use, density, and intensity existing at the time of destruction, thereby allowing such structures to be rebuilt or replaced to the size, style and type of their original construction, including their original square footage; provided, however, that the affected structure, as rebuilt or replaced, complies with all applicable federal, state and other local regulations.

This reconstruction policy will be an important part of the post disaster ordinance recommended in the goals and policies. It should be clearly stated with respect to its application in hazard areas. In its current form, it appears to state that:

1) Structures damaged less than 50% of their replacement cost at the time of damage can be rebuilt to their original condition, with no further regulatory requirements.

2) Structures damaged more than 50% of their replacement cost at the time of damage can be rebuilt to their original size and density, provided that they comply with:

a) federal requirements for elevation above the 100 year flood level,

b) building code requirements for floodproofing,

c) any required conditions or variances thereof for open space, parking, setbacks, Coastal Construction Control Line, or other development regulations.

3) No provision is made to redevelop property containing damaged structures for a higher intensity use or at a density higher than the original density.

Comprehensive post-disaster redevelopment policies need to be prepared and disseminated so that property owners are aware of potential limitations on redevelopment following a natural disaster. A process for this is proposed in the goals and policies section of this chapter.

FUTURE GROWTH IMPACTS

By the year 2010, the Coastal Study Area could contain a population of about 249,641. This is an increase of 102,257 or 69% over the estimated 1986 population of 147,384 in this area. (1986 dwelling units of 61,410 times 2.4 persons per unit from Hurricane Evacuation Plan Update 1983, p.11, equals 147,384.) For purposes of estimating growth impacts on hurricane shelter demand, we can assume that increase in demand will be generally proportional to increase in coastal study area population.

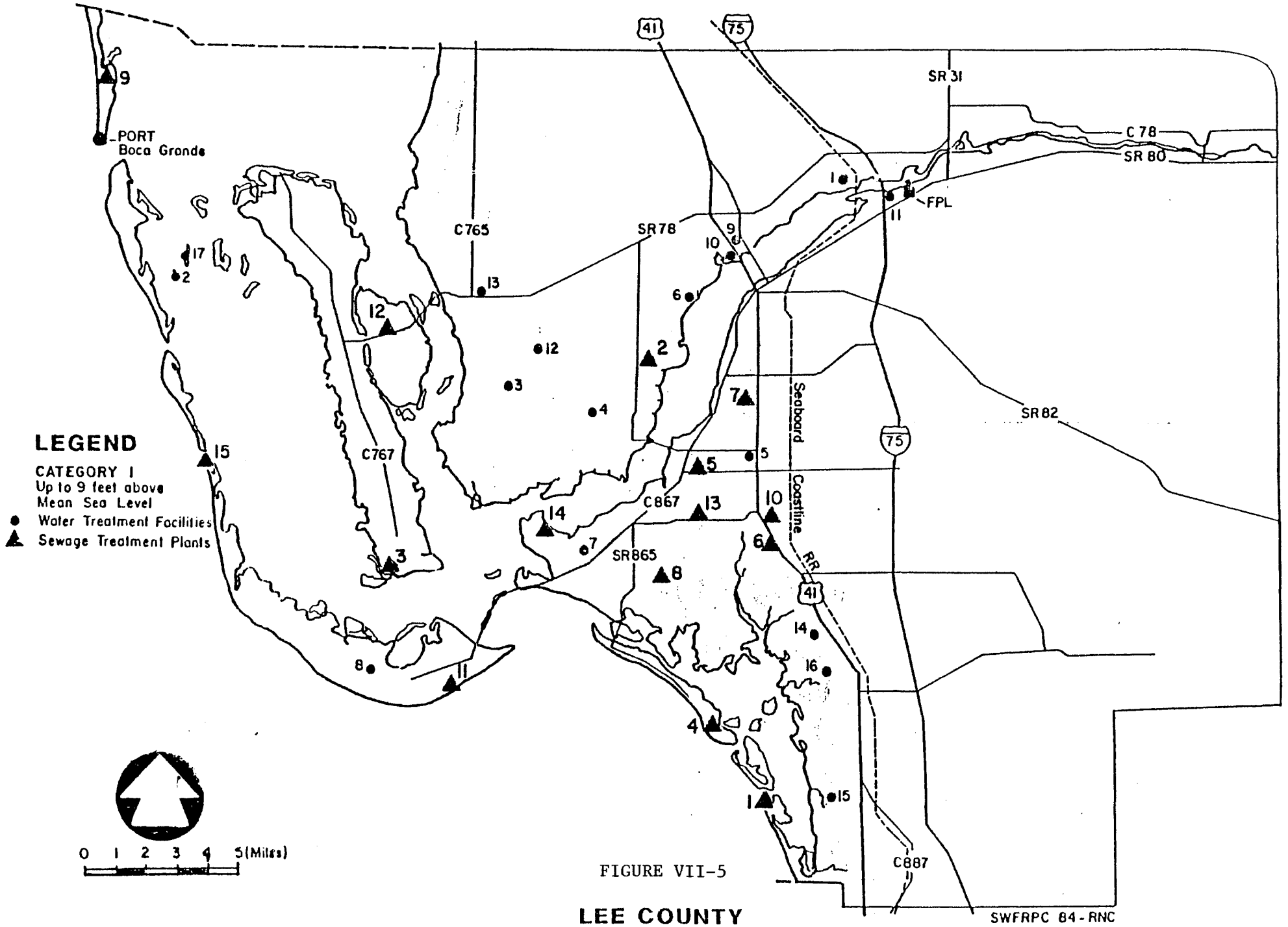


FIGURE VII-5

LEE COUNTY
WATER AND WASTEWATER TREATMENT FACILITIES
CATEGORY 1 FLOOD ZONE

SOURCE: SWFRPC (1984, p. 65)

TABLE VII-4. WATER FACILITIES AND SOURCES: CATEGORY 1 FLOOD ZONE.

Facility	Source*
Bayshore Utilities	S
Cabbage Key	G
Cape Coral R.O.	G
Cape Coral Lime	G
Florida Cities Water (Cypress Lake)	G
Florida Cities Water (Waterway Estates)	G
Iona Trailer Ranch	G
Island Water Association	G
Logans Trailer Park	S
Mariner's Cove	G
Orange Harbor	S
Palmetto Pines	G
Pine Island Water Association	G
Shady Acres	G
Spring Creek Village	G
Tahiti MHP	G
Useppa Island Club	G

SOURCE: SWFRPC

* G = Groundwater
S = Surface water

SOURCE: SWFRPC (1984, p. 62)

TABLE VII-5. WASTEWATER TREATMENT PLANTS: CATEGORY 1 FLOOD ZONE.

FACILITY	CAPACITY (MGD)*	TYPE TREATMENT**
Bonita Bay	.100	S.D.
City of Cape Coral	4.00	S.
Cherry Estates, Inc.	.100	S.D.
Estero 7000	.200	S.S.I.
Fiesta Village	2.00	S.S.I.
The Forest	.500	S.P.
City of Fort Myers, Bowling Green	6.00	S.
Fort Myers BeachSewer District	2.71	S.
Gasparilla Island Water Assoc.	.275	S.S.I.
Jamaica Bay	.200	S.P.P.
Jamestown Beachview	1.00	S.S.I.
Matlacha Sewer District	.150	S.P.
Paddle Creek STP	.100	S.D.
Shell Point Village, Palm Acres	.200	S.P.
South Seas Plantation	.160	S.S.I.

* Capacity greater than or equal to .01 mgd

** KEY: TYPE TREATMENT

S.	Secondary Treatment
S.D.	Secondary Treatment, Drainfield
S.P.	Secondary Treatment, Percolation
S.R.	Secondary Treatment, Retention
S.P.P.	Secondary Treatment, Polishing Pond
S.S.I.	Secondary Treatment, Spray Irrigation
A.D.	Secondary Treatment, Aerobic Disc
O.D.	Secondary Treatment, Overland Distribution

SOURCE: SWFRPC (1984, p. 68)

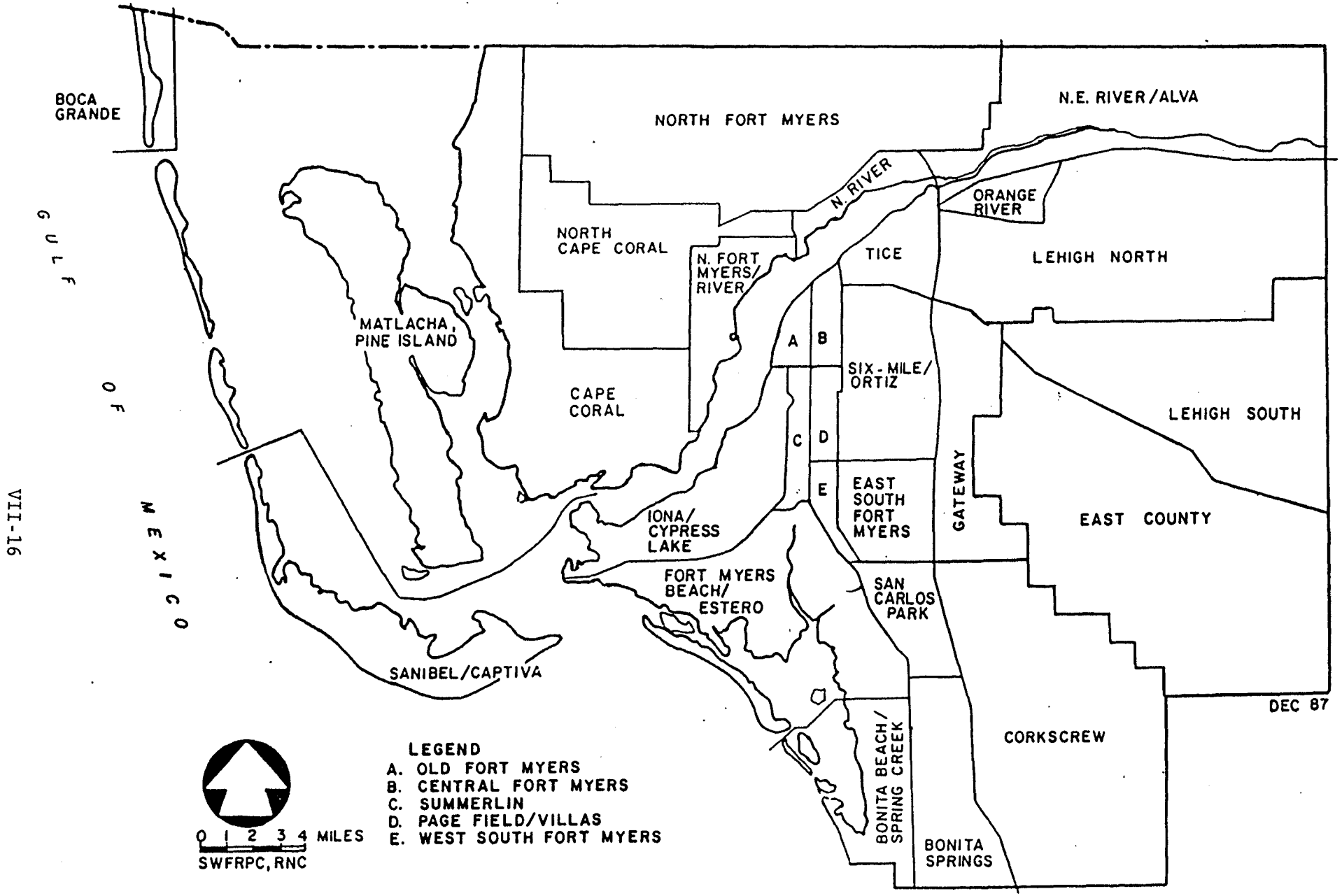


FIGURE VII-6.

EVACUATION ZONES

SOURCE: SWFRPC (1987)

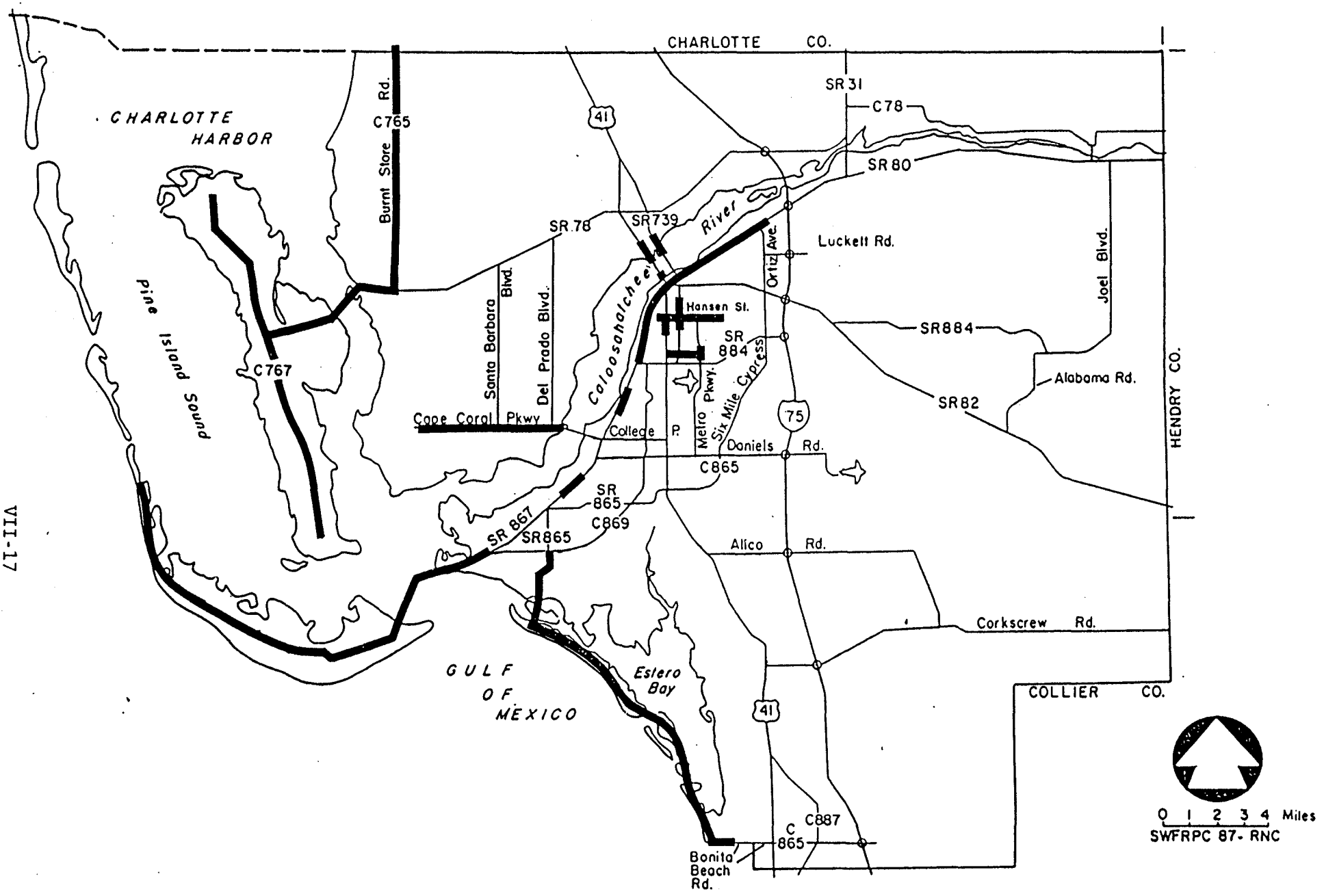


FIGURE VII-7.

ROUTES SUBJECT TO RAINFALL FLOODING

SOURCE: SWFRPC (1987)

If the current shelter demand figures are applied to this population increase, then some 21,474 to 46,016 additional shelter spaces will be needed in 2010, depending on whether a 21% or a 45% utilization rate is assumed.

2010 SHELTER DEMAND RANGE

2010 Coastal Area Population		
Number	249,641	
Increase over 1986	102,257	
2010 Shelter demand increase		
Utilization Rate	21%	45%
Increase over 1986	21,473	46,016

Because additional roads and bridges will be built to accommodate the regular transportation needs of the new population, it is not possible to estimate the exact impacts of the new growth on the evacuation system and its performance. However, it is important to establish the principle that this new growth should not be permitted to expand evacuation demand without concurrently expanding evacuation capacity, so that the already overextended system is not taxed further. It is also important to plan for additional evacuation capacity to meet the regional goal of maximum evacuation times of 18 hours by the year 2010.

GOALS, OBJECTIVES, AND POLICIES

Lee County goals, and objectives, and policies must be consistent with state and regional goals and policies.

State and Regional Goals and Policies

Florida has adopted a Public Safety goal which includes "protecting lives and property from natural and manmade disasters."

The Southwest Florida Regional Planning Council has identified regional issues related to natural disasters and adopted a set of regional goals and policies in 1987. Regional issues include:

1. Evacuation time and route protection.
2. Adequate storm evacuation shelters.

Regional goals are:

1. By 1995, evacuation times will be restored to 1985 levels, and by 2010, evacuation times will not exceed 18 hours in any part of the region.
2. By 2010, there will be adequate shelter space for citizens who do not wish to evacuate from the region.

The description of these regional issues and the adopted regional policies to implement them are shown in the Appendix to this section.

County Goals, Objectives, and Policies

Three major goals related to hurricane evacuation and hazard mitigation are proposed. They are aimed at Evacuation and Shelter, Hazard Mitigation, and Post-Disaster Redevelopment. Accompanying each goal are objectives specified in terms of timed targets for accomplishment, and policies defining

administrative, regulatory, and fiscal actions to achieve these objectives.

GOAL 1: EVACUATION AND SHELTER. To provide evacuation and shelter capabilities adequate to safeguard the public against the effects of hurricanes and tropical storms.

OBJECTIVE 1.1: EVACUATION. By 1995, evacuation times will be restored to 1987 levels using the 1987 Southwest Florida Regional Hurricane Plan Update as guidance; and by 2010, the clearance time portion of evacuation time will not exceed 12 hours.

POLICY 1.2.1: The County shall assess the impact of all new residential development upon the projected hurricane evacuation network and upon projected hurricane evacuation times, and shall require mitigation either through structural (on-site, off-site shelter) provisions or through non-structural methods or techniques.

POLICY 1.1.2: By the 1990 hurricane season, the annual update of the hurricane evacuation portion of the Comprehensive Emergency Management Plan shall be carried out with a computer transportation model able to identify critical roadway links.

POLICY 1.1.3: Critical roadway links causing congestion on evacuation routes for Category 1 through 3 hurricanes shall receive high priority for capital improvement expenditures.

POLICY 1.1.4: New or replacement bridges on evacuation routes spanning major or marked navigable waterways shall not be draw bridges.

OBJECTIVE 1.2: SHELTER. By 2010, adequate shelter space will be available for the population in the Hurricane Vulnerability Zone at risk under a Category 3 storm.

POLICY 1.2.1: By 1989, the percentage rate of the evacuation population to be used as the standard for in-county and on-site shelter demand shall be determined by the Division of Emergency Management using the best available behavioral response information, and this rate shall be used to set the target shelter capacity for 2010.

POLICY 1.2.2: By 1990, <u>on-site</u> shelter facilities shall be required for all new residential development of more than 100 units and all new mobile home and recreational vehicle developments of more than 50 units outside Category 1 areas of the Hurricane Vulnerability Zone, unless an in-lieu payment (amount to be determined) is made to the County for off-site shelter provision.

POLICY 1.2.3: By 1990, all new residential development of more than 100 units and all new mobile home and recreational vehicle developments of more than 50 units inside Category 1 areas of the Hurricane Vulnerability Zone shall be required to make an in-lieu payment to the County for <u>off-site</u> shelter provision.

POLICY 1.2.4: On-site shelters shall be required to meet standards established by the Division of Emergency Management, including provision of twenty square feet of space per person, elevation above Category 3 hurricane

flooding levels, windproofing for 140 mph winds, glass protection, emergency power and water supplies, and other basic needs.

POLICY 1.2.5: On-site shelters shall not be built on barrier or coastal islands.

POLICY 1.2.6: By 1990, the county shall determine the feasibility of evacuating residents from the Category 1 and 2 areas to vertical shelters within residential, commercial, and industrial sites in the Category 3, 4, and 5 areas of the Hurricane Vulnerability Zone.

GOAL 2: HAZARD MITIGATION. To provide through County plans, programs, and regulations means to minimize future property losses from tropical storms and hurricanes.

OBJECTIVE 2.1: DEVELOPMENT REGULATIONS. By 1990, all development regulations shall be reviewed and revised to require that the vulnerability of future development in the A-Zone (as defined by the Federal Emergency Management Agency) be reduced.

POLICY 2.1.1: Regulations and incentives will be examined for additional setbacks in critical erosion areas, conservation and enhancement of dunes and vegetation, floodproofing of utilities, and appropriate requirements for structural wind resistance and floodplain management.

POLICY 2.1.2: The County shall not permit new or expanded mobile home or recreational vehicle development on barrier islands or in Coastal High Hazard Areas (which include V-Zones as defined by the Federal Emergency Management Agency).

POLICY 2.1.3: By 1990, all new residential development of more than 50 units shall be required to provide continuing information to residents concerning hurricane evacuation and shelters, through the establishment of a homeowners' or residents' association.

POLICY 2.1.4: By 1990, all new residential development of more than 100 units shall be required to formulate an emergency hurricane preparedness plan; this plan is subject to the approval of the County's Division of Emergency Management.

OBJECTIVE 2.2: PUBLIC FUNDS. By 1990, the County shall establish a funding source to provide funds for hazard mitigation and disaster recovery needs.

POLICY 2.2.1: The County shall establish a Hazard Mitigation MSBU to cover the public costs of hazard mitigation, floodproofing, evacuation, search and rescue, acquisition of hazard-prone property, reconstruction of public facilities, construction of (or improvements to existing or proposed) shelters, and similar needs.

GOAL 3: POST-DISASTER REDEVELOPMENT. To provide for planning and decision-making to guide redevelopment during the response and recovery period following major emergencies, such as tropical storms and hurricanes.

OBJECTIVE 3.1: POST-DISASTER STRATEGIC PLAN. By 1990, the County shall

formally establish post-disaster institutions and procedures to guide County actions following a natural or technological disaster.

POLICY 3.1.1: The plan shall establish a Recovery Task Force to work with state and federal emergency officials, assess damage, review emergency actions, prepare a redevelopment plan, and recommend needed changes to the Strategic Plan and to the Comprehensive Plan.

POLICY 3.1.2: The plan shall establish guidelines for determining priorities for the acquisition of storm-damaged property in hazard-prone areas.

POLICY 3.1.3: The plan shall establish principles for repairing, replacing, modifying, or relocating public facilities in hazard-prone areas.

POLICY 3.1.4: The applicable portions of the Comprehensive Emergency Management Plan shall be modified to comply with these policies, and shall contain step-by-step details for post-disaster recovery operations.

OBJECTIVE 3.2: POST-DISASTER ORDINANCE. By 1990, the County shall adopt an ordinance to implement (where necessary) the Post-Disaster Strategic Plan, and to provide regulations that may be needed following a natural or technological disaster.

POLICY 3.2.1: The ordinance shall provide for enactment of a temporary moratorium on rebuilding not immediately needed for the public health, safety, and welfare (e.g., to allow repairs to water, power, fire, police, and medical facilities; debris removal; stabilization or removal of structures in danger of collapsing; and minimal repairs to make dwellings habitable).

POLICY 3.2.2: The ordinance may incorporate a redevelopment plan for hazard-prone areas where such a plan would minimize repeated exposures to life-threatening situations.

POLICY 3.2.3: The ordinance shall implement the County reconstruction policy:

Structures which have been damaged by fire or other natural forces to the extent that the cost of their reconstruction or repair exceeds 50% of the replacement cost of the structure may be reconstructed at, but not to exceed the legally documented actual use, density, and intensity existing at the time of destruction, thereby allowing such structures to be rebuilt or replaced to the size, style and type of their original construction, including their original square footage; provided, however, that the affected structure, as rebuilt or replaced, complies with all applicable federal, state and other local regulations.

In accordance with this policy, the ordinance shall provide that:

1) Structures damaged less than 50% of their replacement cost at the time of damage can be rebuilt to their original condition, with no further regulatory requirements.

2) Structures damaged more than 50% of their replacement cost at the time of damage can be rebuilt to their original size and density, provided that they comply with:

a) federal requirements for elevation above the 100 year flood level,

b) building code requirements for floodproofing,

c) any required conditions or variances thereof for open space, parking, setbacks, Coastal Construction Control Line, or other development regulations.

3) No provision is made to redevelop property containing damaged structures for a higher intensity use or at a density higher than the original density.

REFERENCES

Southwest Florida Regional Planning Council (SWFRPC). 1984. Hurricane Loss Study, Mitigation and Assistance.

SWFRPC. 1987. Hurricane Evacuation Study Update.

SWFRPC. 1987-a. Southwest Florida Regional Goals, Issues, and Policies.

SWFRPC. 1983. Hurricane Evacuation Plan Update.

SWFRPC. 1982. Southwest Florida Hurricane Loss Study.

Lee County Division of Emergency Management. 1985. Hurricane Evacuation Plan Update.

Lee County Division of Emergency Management. 1987. Vulnerability Analysis.

APPENDIX

SOUTHWEST FLORIDA REGIONAL PLANNING COUNCIL EVACUATION AND SHELTER GOALS AND POLICIES (1987).

REGIONAL GOAL: By 1995, Evacuation Times Will Be Restored To 1985 Levels, And By 2010, Evacuation Times Will Not Exceed 18 Hours In Any Part Of The Region.

STANDARD/MEASURE: Evacuation times.

POLICIES:

1. Programs to ensure safe evacuation should:

   a. identify flood hazard areas and require development within these areas to occur in a manner which will not cause increases in evacuation times;

   b. include detailed plans and procedures for the evacuation of all new and existing development within flood hazard areas in the event of hurricane-type high wind and high water conditions;

   c. require mitigation of the impact of new development on emergency evacuation routes;

   d. increase coordination among local governments in Disaster Preparedness Plans;

   e. increase coordination between the needs of local Disaster Preparedness Plans and other relevant government planning efforts;

   f. increase the dissemination of public information on how to evacuate, who needs to evacuate, and what services are available for the population in the event of a disaster;

   g. require new service facilities to be elevated above the level subject to flooding as identified by either the statistical 100-year storm or the Federal Flood Insurance Program, if applicable to the site;

   h. prevent the development of public facilities in the most hurricane-vulnerable areas (category 1) except when necessary for the public health, safety and welfare and to provide service for existing residents;

   i. include provisions for the acquisition of hurricane-vulnerable land, including channels, low-lying areas, and shoreline by both state and local governments;

   j. require that deeds in the most hurricane-vulnerable areas (Category 1) be accompanied by a disclosure statement describing the potential hurricane hazards for that property; and

k. increase public acquisition of property that has been destroyed or damaged as the result of a hurricane or similar event.

2. Evacuation routes with evacuation capacity restrictions, particularly intercommunity evacuation routes, should receive high priority in FDOT or local capital improvement programs.

3. State, regional, and local governments should have hurricane evacuation plans and hurricane protection development requirements which include:

   a. participation in the Federal Flood Insurance Program where applicable,

   b. pertinent requirements for structural wind resistance as stated in South Florida building codes and subsections 161.051(1) and 161.053(1), Florida Statutes,

   c. additional disaster preparedness requirements for new developments whose future residents, including the elderly, might have limited mobility or demand specialized attention,

   d. identification of appropriate evacuation routes,

   e. identification of appropriate shelters with adequate emergency provisions, and

   f. identification of potential disaster field offices and disaster assistance centers.

4. Local governments should develop post-disaster reconstruction and redevelopment to aid in evacuation route protection plans which:

   a. discourage post-hurricane reconstruction and redevelopment that utilize pre-hurricane building practices in vulnerable areas,

   b. encourage post-hurricane reconstruction and redevelopment outside those areas most vulnerable to hurricane impacts,

   c. discourage post-hurricane reconstruction and redevelopment of facilities which encourage growth in hazardous areas, except for necessary services for existing developments and residents, and

   d. limit redevelopment in areas scoured by storm waters, to water dependent or related uses, or open space.

5. Residential development should be discouraged from locating in areas most vulnerable to hurricanes.

REGIONAL GOAL: By 2010, There Will Be Adequate Shelter Space For Citizens Who Do Not Wish To Evacuate From The Region.

STANDARD/MEASURE: The number and capacity of public evacuation shelters.

POLICIES:

1. Structures meeting requirements for storm shelter designation should be identified and designated.

2. Programs to provide adequate storm evacuation shelters should:

   a. require all habitable areas of new residential construction in identified flood-prone areas to be elevated above the level subject to flooding as identified for the statistical 100-year storm or Federal Flood Insurance Program;

   b. require all structures identified as potential storm evacuation shelters to be elevated above the level subject to flooding as identified for the statistical 100-year storm or Federal Flood Insurance Program;

   c. require mobile home developments located in category three storm zones to have storm evacuation centers on-site with sufficient structural characteristics, warning systems, and evacuation procedures for the resident population in the event of wind conditions;

   d. consider the additional disaster preparedness requirements by new developments whose future residents might have limited mobility and/or demand specialized attention for relocation;

   e. require all new development of more than 100 dwelling units located outside category one and two storm zones to provide on-site shelter facilities where it is determined that the necessary evacuation road facility or shelter capacity is unavailable or inadequate;

   f. require all development located outside category one and two flood zones to provide refuge space at a ratio of 20 square feet per person in common areas or other shelter areas; all development in category 1 and 2 zones should identify unused shelter space in inland areas;

   g. require deeds, covenants, and other documents which contain provisions to permit temporary shelters during minor storms in the upper interior hallways of multi-story structures or similarly protected areas containing no openings directly to the exterior which are located outside of category one and two storm zones;

h. require any shelter to be designed and constructed to withstand winds of at least 140 miles per hour;

i. require any shelter to be equipped with emergency power and potable water supplies;

j. require any shelter to be constructed with as little glass as possible, while providing adequate protection by shutters or boards for any glass used;

k. require any shelter to have adequate ventilation, sanitary facilities, and first-aid equipment;

l. establish Homeowner's Associations to provide information to their residents concerning hurricanes, evacuation shelters, and related matters;

m. include the requirement of an Emergency Operating Center in Disaster Preparedness Plans;

n. encourage the location of temporary housing, disaster field offices, and disaster assistance centers outside the most vulnerable (category 1) areas;

o. discourage the placement of storm shelters on barrier islands; and

p. require all new residential development within category 1, 2, and 3 storm zones and/or with evacuating population, to mitigate impact on inland shelter space.

3. Public buildings which are identified and designated as public shelters should be required to meet building standards for shelters and have on-site facilities which are adequate for maximum capacity short-term occupation.

4. To reduce public shelter demand, shelter needs should be reduced through stronger building codes for residential areas.

5. The concept of refuge space should only be considered as an option of last resort.

6. Hotels/motels in category 1 and 2 storm zones should be advised to close during a hurricane watch and should not be utilized as storm shelters.

7. Innovative programs should be instituted to increase shelter space, including retrofitting.

8. Innovative programs for financing shelter space should be examined, including municipal service benefit districts.

VIII. COASTAL INTERGOVERNMENTAL RELATIONS

Purpose

The purpose of this chapter is to describe the needs for intergovernmental coordination in management of the Lee County coastal area. It discusses the way in which Lee County natural resource systems overlap political jurisdiction boundaries, resulting in need for coordinated management of development, stormwater, and wastewater, as well as estuarine resources, beaches and dunes, and other natural resources. It identifies existing resource protection plans affecting Lee County coastal resources. Finally, it proposes goals, objectives, and policies to coordinate intergovernmental activities with impacts on the coastal area.

Methodology

This chapter draws upon information presented in previous chapters of this report, as well as information from the Southwest Florida Regional Planning Council.

INTERJURISDICTIONAL NATURAL RESOURCE SYSTEMS

Lee County estuaries receive stormwater runoff from a large system of watersheds covering several counties. (See Chapter V.) The most critical areas, however, are within the County itself, where the municipalities directly adjacent to coastal waters send stormwater into the estuaries. Thus, the most important need is to coordinate stormwater management and development policies among Fort Myers, Cape Coral, and Lee County.

A second need is to coordinate control of wastewater discharges into estuarine waters. Again, the governments most directly involved are Fort Myers, Cape Coral, and Lee County.

RESOURCE PROTECTION PLANS

Lee County waters are covered by a number of resource protection plans, as described in Chapter V. These include:

- Charlotte Harbor Aquatic Preserves Management Plan, covering the Lee County aquatic preserves of Gasparilla Sound - Charlotte Harbor, Pine Island Sound, and Matlacha Pass.
- Estero Bay Aquatic Preserve Management Plan.
- Charlotte Harbor Resource Planning and Management Plan.

The County has adopted policies to comply with these resource protection plans. Recommendations in this report are aimed at strenthening this compliance.

GOALS, OBJECTIVES, AND POLICIES

GOAL 1. INTERGOVERNMENTAL COORDINATION. To protect natural resource systems that cross governmental boundaries through intergovernmental coordination.

OBJECTIVE 1.1: By 1990, the County will establish a permanent Lee County intergovernmental organization to coordinate protective policies for natural resource systems.

POLICY 1.1: The County shall convene an intergovernmental task force consisting of representatives from Fort Myers, Cape Coral, Sanibel, and Lee County to develop a permanent intergovernmental resource protection organization to deal with stormwater runoff, wastewater discharge, and development management policies aimed at protecting estuarine water quality.

OBJECTIVE 1.2: The County shall continue to participate with other governments to implement the Charlotte Harbor Plan, the Charlotte Harbor Aquatic Preserves Management Plan, and the Estero Bay Aquatic Preserve Management Plan.

POLICY 1.2.1: The Department of Community Development shall review the status of implementation of the Charlotte Harbor Plan, the Charlotte Harbor Aquatic Preserves Management Plan, and the Estero Bay Aquatic Preserve Management Plan in light of current and forthcoming water quality studies to ensure that Lee Plan policies continue to be effective in protecting these natural areas.