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 II. TECHNICAL REPORTS AND APPENDICES

FEBRUARY, 1988

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VOLUME II: TECHNICAL REPORTS AND APPENDICES

CONTENTS

THE ECONOMICS OF LEE COUNTY'S COASTAL ZONE:

DATA BY TOWNSHIP, RANGE AND SECTION

SUBMITTED TO THE

BOARD OF COUNTY COMMISSIONERS OF

LEE COUNTY, FLORIDA

BY

JAMES C. NICHOLAS, PhD

DECEMBER 1987

An economic study was prepared as part of the Coastal Study of Lee County. The economic study is incorporated as Part II of the final report. The data utilized in this economic study is quite voluminous and could not be incorporated into the final report. Therefore, the source data are to be set out in this separate report so that there is an accurate record of the data utilized and the methods used to summarize these data. The data contained in the body of this report are summarized in Table A-1. This is the same summary data as found in Table 1 of Part II of the final report.

Following Table A-1 are the data by Township, Range and Section. This data series contains the location of the section in term of whether it is within the Coastal Zone, the V Zone or has Gulf or bay frontage. Furthermore, it sets out the number of dwelling units, the assessed value of those units, and other assessed values. The other data covers commercial, industrial and hotel/motel values.

The data set out herein were derived by summarizing the tax files for Lee County. These data files (tapes) were provided by the Florida Department of Revenue and were developed by the North East Regional Data Center and the University of Florida.

TABLE A-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%

COUNTY TRS	STUDY AREA COASTAL ZONE	STUDY AREA V ZONE	STUDY AREA FRONTAGE	NO. OF DUs	ASSESSED VALUE OF RESIDENTIAL DEVELOPED	RESIDENTIAL VACANT	COMMERCIAL DEVELOPED	COMMERCIAL VACANT	INDUSTRIAL DEVELOPED	INDUSTRIAL VACANT	HOTELS/ MOTELS
4320001	0.0%	0.0%	0.0%	0	0	32900	0	0	0	0	0
4320002	100.0%	100.0%	100.0%	17	4236350	10189600	0	0	0	0	0
4320011	100.0%	100.0%	100.0%	234	31496050	15337320	4368260	23590	89240		1929280
4320014	100 0%	100.0%	100.0%	36	6052230	480980	3067250				2239260
4320023	100.0%	100.0%	100.0%	194	20941030	7438230	208390				
4320026	100.0%	100.0%	100.0%	11	648560	843760	1573300				360370
4321005	100.0%	100.0%	100.0%	0	0	17900					
4321006	100.0%	100.0%	100.0%	0	0	132950					
4321025	100.0%	100.0%	100.0%	91	10333940	1257670	110240				
4321026	100.0%	100.0%	100.0%	0	0	0			766580		
4321035	100.0%	100.0%	100.0%	1	276070	0					
4321036	100.0%	100.0%	100.0%	4	90670	26700					
4322001	100.0%	0.0%	100.0%	348	33151840	1019700	1607340				
4322012	0.0%	0.0%	0.0%	0	0	1001000					
4322013	0.0%	0.0%	0.0%	1	1570	6126060					
4322014	0.0%	0.0%	0.0%	0	0	2700					
4322025	0.0%	0.0%	0.0%	0	0	3711560					
4322029	100.0%	100.0%	100.0%	0	0	28840					
4322030	100.0%	100.0%	100.0%	213	7622230	3191180	811870				
4322031	100.0%	0.0%	0.0%	165	2704160	2189410	207040				23360
4322032	100.0%	0.0%	0.0%	10	391820	1356700					
4322035	0.0%	0.0%	0.0%	0	0	200					
4322036	0.0%	0.0%	0.0%	0	0	2120220					
4323004	0.0%	0.0%	0.0%	0	0	544510					
4323005	0.0%	0.0%	0.0%	0	0	905970					
4323006	100.0%	0.0%	0.0%	30	1886620	722100					
4323007	0.0%	0.0%	0.0%	3	4940	2514570					
4323008	0.0%	0.0%	0.0%	0	0	1165920					
4323010	0.0%	0.0%	0.0%	0	0	385320					
4323014	0.0%	0.0%	0.0%	0	0	192000					
4323016	0.0%	0.0%	0.0%	0	0	720000					
4323017	0.0%	0.0%	0.0%	0	0	755500					
4323018	0.0%	0.0%	0.0%	0	0	2434520					
4323019	0.0%	0 0%	0.0%	5	139320	1077440					
4323022	0.0%	0.0%	0.0%	0	0	605000					
4323023	0.0%	0.0%	0.0%	1	19170	3742660					
4323024	0.0%	0.0%	0.0%	11	825450	929590					
4323025	0.0%	0.0%	0.0%	3	42550	5123350					
4323027	0.0%	0.0%	0.0%	0	0	2049230					
4323028	0.0%	0.0%	0.0%	0	0	2796210					
4323029	0.0%	0.0%	0.0%	0	0	2867930					
4323030	0.0%	0.0%	0.0%	3	273970	1613160					
4323031	0.0%	0.0%	0.0%	0	0	4304830					
4323032	0.0%	0.0%	0.0%	0	0	2461090					
4323033	0.0%	0.0%	0.0%	0	0	3104610					
4323034	0.0%	0 0%	0.0%	0	0	3243250					
4323035	0.0%	0.0%	0.0%	1	24550	3223320					
4323036	0.0%	0.0%	0.0%	2	45720	1760710					
4324002	0.0%	0.0%	0.0%	0	0	62900					

	- - STUDY AREA	-			- - - - - - - - - -		- ASSESSED VALUE OF	- - - -		- - - - -	
COUNTY	COASTAL	"V		NO. OF	RESIDENTIAL		COMMERCIAL		INDUSTRIAL		HOT
TRS	ZONE	ZONE	FRONTAGE	DUs	DEVELOPED	VACANT	DEVELOPED	VACANT	DEVELOPED	VACANT	MC
4324003	0.0%	0.0%	0.0%	2	127660	1380480					
4324004	0.0%	0.0%	0.0%	46	817840	2752380		30000	267820		
4324005	0.0%	0.0%	0.0%	0	0	186000					
4324006	0.0%	0.0%	0.0%	0	0	572000					
4324007	0.0%	0.0%	0.0%	0	0	0					
4324008	0.0%	0.0%	0.0%	1	2013120	0					
4324009	0.0%	0.0%	0.0%	105	1772660	3583470		135640			
4324010	0.0%	0.0%	0.0%	14	280750	1086830					
4324011	0.0%	0.0%	0.0%	0	0	153120					
4324014	0.0%	0.0%	0.0%	0	0	335750					
4324015	0.0%	0.0%	0.0%	11	446400	2792060	389880	25000		20850	9
4324016	0.0%	0.0%	0.0%	356	4326810	1538610	99300		1072860		
4324017	0.0%	0.0%	0.0%	0	0	6197890					
4324018	0.0%	0.0%	0.0%	0	0	3911280		1570			
4324020	0.0%	0.0%	0.0%	0	0	2803490					
4324021	0.0%	0.0%	0.0%	0	0	2111120	26650	63000			
4324022	0.0%	0.0%	0.0%	13	3015800	3750780	1006000		1304480		38
4324023	0.0%	0.0%	0.0%	1146	6972030	3799860	284170		96340		
4324025	0.0%	0.0%	0.0%	0	0	716150	97470				
4324026	0.0%	0.0%	0.0%	585	5151160	1480290	101930				
4324027	0.0%	0.0%	0.0%	596	5780110	4253940	5753510	1442540	1422170	32310	42
4324028	0.0%	0.0%	0.0%	84	2509170	3006110		82740	17340		
4324029	0.0%	0.0%	0.0%	14	243360	4947390					
4324030	0.0%	0.0%	0.0%	0	0	1080000				195650	
4324031	0.0%	0.0%	0.0%	10	171570	3156350					
4324033	0.0%	0.0%	0.0%	21	3905920	575960					
4324034	0.0%	0.0%	0.0%	471	5281170	2408870	1716650	139200	723050		
4324035	0.0%	0.0%	0.0%	171	7707430	6730030	6228540	161220	281580		47
4324036	0.0%	0.0%	0.0%	1783	23307650	3571620	672250	26780	55340		
4325001	0.0%	0.0%	0.0%	19	603920	122200					
4325002	0.0%	0.0%	0.0%	1	37990	467500					
4325003	0.0%	0.0%	0.0%	9	908930	1061580					
4325004	0.0%	0.0%	0.0%	44	882510	1072130					
4325005	0.0%	0.0%	0.0%	17	251080	536410					
4325006	0.0%	0.0%	0.0%	27	497450	927010					
4325007	0.0%	0.0%	0.0%	104	1545650	441880					
4325008	0.0%	0.0%	0.0%	33	877610	815990					
4325009	0.0%	0.0%	0.0%	33	785360	663340					
4325010	0.0%	0.0%	0.0%	76	1383630	865260	1400				
4325011	0.0%	0.0%	0.0%	38	807740	501060					
4325012	0.0%	0.0%	0.0%	43	964440	457220					
4325013	0.0%	0.0%	0.0%	68	1462800	834100	89500		114680		
4325014	0.0%	0.0%	0.0%	86	1108400	977430					
4325015	0.0%	0.0%	0.0%	50	1017610	1015160			19260		
4325016	0.0%	0.0%	0.0%	6	94900	315230					
4325017	0.0%	0.0%	0.0%	26	691810	516820					
4325018	0.0%	0.0%	0.0%	55	1060700	714570	51780		10870		
4325019	0.0%	0.0%	0.0%	49	1162950	702340			96990		
4325020	0.0%	0.0%	0.0%	1	118020	757870		52500	2131280	1025800	
4325021	0.0%	0.0%	0.0%	68	3592010	2302210	82510		184090	45000	

	- - STUDY AREA - -				- - - - - - - - - - - ASSESSED VALUE OF - - - - - - - - - - -						
COUNTY	COASTAL	"V"		NO. OF	RESIDENTIAL		COMMERCIAL		INDUSTRIAL		HOTELS/
TRS	ZONE	ZONE	FRONTAGE	DUs	DEVELOPED	VACANT	DEVELOPED	VACANT	DEVELOPED	VACANT	MOTELS
4325022	0.0%	0.0%	0.0%	95	3201250	1920170	151200	21030			
4325023	0.0%	0.0%	0.0%	117	3576670	1813560	217310				
4325024	0.0%	0.0%	0.0%	34	2255510	2895010	398870				
4325025	0.0%	0.0%	0.0%	4	713370	2722900	70650	15000	328470		
4325026	0.0%	0.0%	0.0%	8	489080	806480					
4325027	0.0%	0.0%	0.0%	8	237680	173730				60720	
4325028	0.0%	0.0%	0.0%	0	0	416430				353580	
4325029	0.0%	0.0%	0.0%	243	10229490	3719750		8360	292900		
4325030	0.0%	0.0%	0.0%	78	3263830	1668290	427800	96300	24640		
4325031	0.0%	0.0%	0.0%	277	8618180	5364450	281520				
4325032	0.0%	0.0%	0.0%	17	1293320	562080					
4325033	0.0%	0.0%	0.0%	25	713150	292750					
4325034	0.0%	0.0%	0.0%	148	4475460	1404800	402870				
4325035	0.0%	0.0%	0.0%	28	2549670	3120650					
4325036	0.0%	0.0%	0.0%	26	2075460	2583160	362290				
4326008	0.0%	0.0%	0.0%	3	40440	176520					
4326013	0.0%	0.0%	0.0%	12	241440	221750					
4326014	0.0%	0.0%	0.0%	7	430560	724900					
4326015	0.0%	0.0%	0.0%	39	1739070	833980					
4326016	0.0%	0.0%	0.0%	8	227670	194100					
4326017	0.0%	0.0%	0.0%	1	42390	385750					
4326018	0.0%	0.0%	0.0%	0	0	0	342240				
4326019	0.0%	0.0%	0.0%	280	6090050	1602800					
4326020	0.0%	0.0%	0.0%	434	13867730	3467400	264710				37590
4326021	0.0%	0.0%	0.0%	436	11621020	2938660	871630	30000	185740		
4326022	0.0%	0.0%	0.0%	84	1331520	1008910					
4326023	0.0%	0.0%	0.0%	18	749740	1016800			78000		
4326024	0.0%	0.0%	0.0%	33	2480640	436350	125170				
4326025	0.0%	0.0%	0.0%	50	2002210	972300					
4326026	0.0%	0.0%	0.0%	10	383640	258380					
4326027	0.0%	0.0%	0.0%	10	348160	220800					
4326028	0.0%	0.0%	0.0%	153	3021730	2694050	2642350	562910			
4326029	0.0%	0.0%	0.0%	269	3847970	1386760	695650	928200	61470		135550
4326030	0.0%	0.0%	0.0%	261	4296360	2154370	880580	5090	45300		
4326031	0.0%	0.0%	0.0%	28	1097030	374960		240000			
4326032	0.0%	0.0%	0.0%	4	171160	168400					
4326033	0.0%	0.0%	0.0%	0	0	94210					
4326035	0.0%	0.0%	0.0%	0	0	210000					
4327001	0.0%	0.0%	0.0%	0	0	20000					
4327002	0.0%	0.0%	0.0%	0	0	20000					
4327003	0.0%	0.0%	0.0%	0	0	80000					
4327009	0.0%	0.0%	0.0%	0	0	40000					
4327010	0.0%	0.0%	0.0%	1	12750	36950					
4327011	0.0%	0.0%	0.0%	0	0	20000					
4327012	0.0%	0.0%	0.0%	0	0	15000					
4327013	0.0%	0.0%	0.0%	16	457630	100840			86150		
4327014	0.0%	0.0%	0.0%	2	39780	111240					
4327015	0.0%	0.0%	0.0%	5	76280	9890					
4327016	0.0%	0.0%	0.0%	1	24720	74500					
4327017	0.0%	0.0%	0.0%	4	169090	224280					

COUNTY TRS	- - STUDY AREA - COASTAL ZONE	V ZONE	FRONTAGE	NO. OF DUs	- - - ASSESSED VALUE OF - - - RESIDENTIAL DEVELOPED	RESIDENTIAL VACANT	COMMERCIAL DEVELOPED	COMMERCIAL VACANT	INDUSTRIAL DEVELOPED	INDUSTRIAL VACANT	HOT MC
4327019	0.0%	0.0%	0.0%	24	1436590	448500					
4327020	0.0%	0.0%	0.0%	15	709360	1141420					
4327021	0.0%	0.0%	0.0%	12	990880	127570					
4327022	0.0%	0.0%	0.0%	141	2473630	1208190	71560				
4327023	0.0%	0.0%	0.0%	6	1550300	521440	11170				
4327024	0.0%	0.0%	0.0%	1	17870	375400					
4327025	0.0%	0.0%	0.0%	88	553790	590400	79320				
4327026	0.0%	0.0%	0.0%	8	321630	384780					
4327027	0.0%	0.0%	0.0%	43	1017620	654330	450940				8
4327028	0.0%	0.0%	0.0%	60	1504710	1490790					
4327029	0.0%	0.0%	0.0%	15	421670	830840	41690				
4327030	0.0%	0.0%	0.0%	9	112770	443530	51700	18690	71260		
4327031	0.0%	0.0%	0.0%	7	272330	145150					
4327032	0.0%	0.0%	0.0%	2	27980	30550		19260			
4327033	0.0%	0.0%	0.0%	1	6740	0					
4327034	0.0%	0.0%	0.0%	21	606740	405350					
4327035	0.0%	0.0%	0.0%	28	790220	1107440					
4327036	0.0%	0.0%	0.0%	5	122010	481280					
4420012	100.0%	100.0%	100.0%	6	54250	1944100					
4420013	100.0%	100.0%	100.0%	3	58040	1284880					
4421010	100.0%	100.0%	100.0%	0	0	41540					
4421011	100.0%	100.0%	100.0%	1	112150	4060					
4421013	100.0%	100.0%	100.0%	0	0	24300					
4421014	100.0%	100.0%	100.0%	0	0	25560					
4421018	100.0%	100.0%	100.0%	4	48870	512960					
4421029	100.0%	100.0%	100.0%	6	164070	357450					
4421032	100.0%	100.0%	100.0%	19	884030	1905490					
4422001	0.0%	0.0%	0.0%	0	0	1663640					
4422003	100.0%	0.0%	100.0%	0	0	440					
4422004	100.0%	0.0%	100.0%	0	0	412870					
4422005	100.0%	0.0%	0.0%	15	287500	2883930					
4422006	100.0%	100.0%	100.0%	63	1976740	4138840	417760				
4422007	100.0%	100.0%	100.0%	31	1131780	724460					
4422008	100.0%	0.0%	0.0%	9	166270	1767450	67820		38880		
4422009	100.0%	0.0%	100.0%	9	146580	1136410			9750		
4422010	100.0%	0.0%	100.0%	1	162500	79500					
4422013	100.0%	100.0%	100.0%	18	956690	419920	153430				
4422016	100.0%	0.0%	100.0%	108	1936850	2340360	87600				
4422017	100.0%	100.0%	100.0%	21	427130	1109020					
4422018	100.0%	100.0%	100.0%	0	0	10000					
4422019	100.0%	100.0%	100.0%	0	0	52000					
4422020	100.0%	100.0%	100.0%	1	33350	448730					
4422021	100.0%	0.0%	100.0%	215	3168650	5370060					
4422024	100.0%	100.0%	100.0%	468	13086390	1766290	794390	59310	281180		
4422027	100.0%	0.0%	100.0%	0	0	45920					
4422028	100.0%	0.0%	0.0%	139	2279490	3511520	1523120	13140	455550		
4422029	100.0%	100.0%	100.0%	0	0	75400					
4422032	100.0%	100.0%	100.0%	1	222440	15580	75250				
4422033	100.0%	100.0%	100.0%	0	0	1536290	1966520	85830			
4422034	100.0%	0.0%	100.0%	0	0	225320					

COUNTY TRS	- - STUDY AREA - - COASTAL ZONE	"V ZONE	FRONTAGE	NO. OF DUs	- - - ASSESSED VALUE OF - - - RESIDENTIAL DEVELOPED	RESIDENTIAL VACANT	COMMERCIAL DEVELOPED	COMMERCIAL VACANT	INDUSTRIAL DEVELOPED	INDUSTRIAL VACANT	HOTELS/ MOTELS
4422036	100.0%	100.0%	100.0%	0	0	40000					
4423001	0.0%	0.0%	0.0%	18	489840	9923090					
4423003	0.0%	0.0%	0.0%	0	0	3449870					
4423004	0.0%	0.0%	0.0%	0	0	2475660					
4423005	0.0%	0.0%	0.0%	0	0	2428600					
4423006	0.0%	0.0%	0.0%	0	0	4407980					
4423007	0.0%	0 0%	0.0%	1	9360	4469490		21030			
4423008	0.0%	0.0%	0.0%	2	59850	3521450					
4423009	0.0%	0.0%	0.0%	1	20110	2884460					
4423010	0.0%	0.0%	0.0%	6	170840	1997120					
4423011	0.0%	0.0%	0.0%	13	450080	5483870	231920	36260	365980		
4423012	0.0%	0.0%	0.0%	194	6786370	10428770	383180	223260	1805770		
4423013	0.0%	0.0%	0.0%	6	178500	0					
4423014	0.0%	0.0%	0.0%	89	3251790	11124040	337790	2740			
4423015	0.0%	0.0%	0.0%	15	860020	4079180					
4423016	0.0%	0.0%	0.0%	7	252640	3402480	90300				
4423017	0.0%	0.0%	0.0%	6	252990	4175920	174080		354010		
4423018	33.3%	0.0%	0.0%	80	3212270	5876580	26110				
4423019	100.0%	100.0%	100.0%	18	577540	386000	94260				
4423020	100.0%	0.0%	0.0%	8	1206620	897030					
4423021	33.3%	0.0%	0.0%	20	591870	6217780					
4423022	0.0%	0.0%	0.0%	102	3513270	13220250	2420140				
4423024	0.0%	0.0%	0.0%	731	25564420	23748700	347680				
4423025	0.0%	0.0%	0.0%	122	3410090	3697210					
4423026	0.0%	0.0%	0.0%	35	1676230	8005200					
4423027	0.0%	0.0%	0.0%	30	1501520	0					
4423028	0.0%	0.0%	0.0%	4	95070	3699670					
4423029	100.0%	0.0%	0.0%	1	135600	0					
4423030	100.0%	100.0%	100.0%	0	0	0					
4423031	100.0%	100.0%	100.0%	0	0	95000					
4423032	0.0%	0.0%	0.0%	0	0	4576500					
4423033	0.0%	0.0%	0.0%	0	0	1351000					
4423034	0.0%	0.0%	0.0%	29	930090	11587140					
4423035	0.0%	0.0%	0.0%	77	2582390	7341910		6280			
4424001	0.0%	0.0%	0.0%	351	11044680	3245970		5100	49560		
4424002	0.0%	0.0%	0.0%	659	13862470	3001370	6030540	90110	1942530	41600	858370
4424003	0.0%	0.0%	0.0%	330	8325780	2731800	2087900	25800	455930		
4424004	0.0%	0.0%	0.0%	227	8955820	2100030	458890		92300		
4424005	0.0%	0.0%	0.0%	172	4101750	4761240	941500	65800	1088590	14800	
4424006	0.0%	0.0%	0.0%	59	1761710	5146420	171270				
4424007	0.0%	0.0%	0.0%	460	11904530	6206330	1395000	62290			
4424008	0.0%	0.0%	0.0%	140	3381080	686410	309320	59200	272670		
4424009	0.0%	0.0%	0.0%	916	18711380	2040630	2422780	631780	517240		
4424010	0.0%	0.0%	0.0%	735	38716890	4668910	3372260		23230		2273840
4424011	0.0%	0.0%	0.0%	243	5839480	2867390	16237950	2836390	749770		2215390
4424013	0.0%	0.0%	0.0%	486	17169610	2983410	39576870	1192560	1183620		1607110
4424015	0.0%	0.0%	0.0%	55	5796890	2454800					
4424016	0.0%	0.0%	0.0%	1343	53756960	5296720	2534810	88910			
4424017	0.0%	0.0%	0.0%	1088	39404090	19859310	2739260	105360			
4424018	0.0%	0.0%	0.0%	353	12797590	7045590	1932830				

	- - STUDY AREA - -				- - - - - - - - - - - ASSESSED VALUE OF - - - - - - - -						
COUNTY	COASTAL	"V		NO. OF	RESIDENTIAL		COMMERCIAL		INDUSTRIAL		HOT
TRS	ZONE	ZONE	FRONTAGE	DUs	DEVELOPED	VACANT	DEVELOPED	VACANT	DEVELOPED	VACANT	MO
4424019	0.0%	0.0%	0.0%	515	17892300	10851270	6588690	150230	12834780	43940	
4424020	0.0%	0.0%	0.0%	88	3162390	431390					
4424021	0.0%	0.0%	0.0%	47	2456060	1023200					
4424023	0.0%	0.0%	0.0%	669	33565750	750460	15944620	831760	47280		256
4424024	0.0%	0.0%	0.0%	888	24539280	1922140	18120160	658660	7621170	182910	106
4424025	0.0%	0.0%	0.0%	1017	23870680	4393870	18727400	128100	5764280	290190	177
4424026	0.0%	0.0%	0.0%	1202	43440360	1768620	6660460		41670		17
4424027	0.0%	0.0%	0.0%	22	3325290	85120					
4424028	0.0%	0.0%	0.0%	93	4256910	7508050	6458070	24000			
4424029	0.0%	0.0%	0.0%	60	1841780	1441080	5462900	11860			
4424030	0.0%	0.0%	0.0%	1535	48099330	16254560	1880020	67890			
4424031	0.0%	0.0%	0.0%	786	41244400	15530330			198540		
4424032	0.0%	0.0%	0.0%	402	15008720	340390					
4424034	0.0%	0.0%	0.0%	534	26571550	1706890	333640	199990			
4424035	0.0%	0.0%	0.0%	1063	27109500	2364010	12998040	1387360	957880		
4424036	0.0%	0.0%	0.0%	511	39147810	3802940	80023840	9203240	1971760	876450	28
4425001	0.0%	0.0%	0.0%	216	2838800	2166260	4437350	231820	104800		
4425002	0.0%	0.0%	0.0%	188	2698440	661270	124830				
4425003	0.0%	0.0%	0.0%	265	5338570	1078170	698200	504960			
4425004	0.0%	0.0%	0.0%	1020	13324670	2008330	4200590		580980		26
4425005	0.0%	0.0%	0.0%	284	6950060	897240	551700				
4425006	0.0%	0.0%	0.0%	0	0	1054000					
4425007	0.0%	0.0%	0.0%	235	6876660	1258120	2769360	114530	781560	363930	
4425008	0.0%	0.0%	0.0%	1033	24466680	2538130	10449400	18800	820830		11
4425009	0.0%	0.0%	0.0%	851	12792480	1672460	765460	108070			
4425010	0.0%	0.0%	0.0%	1	10680	3500600		2539800	2075590		
4425011	0.0%	0.0%	0.0%	94	1142440	479680	17210				
4425012	0.0%	0.0%	0.0%	15	723250	372660					
4425013	0.0%	0.0%	0.0%	18	514730	478440					
4425014	0.0%	0.0%	0.0%	53	906780	1059880					
4425015	0.0%	0.0%	0.0%	54	1049090	874860			686710	416310	
4425016	0.0%	0.0%	0.0%	369	4443240	1355990	570970	12330	256720		
4425017	0.0%	0.0%	0.0%	536	7044680	1908190	664010	66210	1345310		
4425018	0.0%	0.0%	0.0%	818	9876100	1866510	4333680	434580	2652480	476300	39
4425019	0.0%	0.0%	0.0%	987	9741730	2302330	2150880	36330	5729040	184850	
4425020	0.0%	0.0%	0.0%	264	2138540	2245030	2913500	508730	5312260	551450	9
4425021	0.0%	0.0%	0.0%	4	186690	490980	535790		673280	78410	
4425022	0.0%	0.0%	0.0%	8	781470	1114230	574860				
4425023	0.0%	0.0%	0.0%	1	201120	685960					
4425026	0.0%	0.0%	0.0%	0	0	1730					
4425027	0.0%	0.0%	0.0%	0	0	0					
4425028	0.0%	0.0%	0.0%	0	0	167270		1326190			
4425029	0.0%	0.0%	0.0%	2	52900	2541060			755050		
4425030	0.0%	0.0%	0.0%	37	130400	3550180	1699230	255730	19764720	417790	
4425031	0.0%	0.0%	0.0%	0	0	0				11803800	
4425032	0.0%	0.0%	0.0%	0	0	5411600	516970	274120	992320	61920	
4425033	0.0%	0.0%	0.0%	0	0	3251910	410250				
4425035	0.0%	0.0%	0.0%	0	0	400000					
4425036	0.0%	0.0%	0.0%	0	0	1423790			103690		
4426001	0.0%	0.0%	0.0%	0	0	2054800					

	- - STUDY AREA - -				- - - - - - - - - - - ASSESSED VALUE OF - - - - - - - - - - -						
COUNTY	COASTAL	V		NO. OF	RESIDENTIAL		COMMERCIAL		INDUSTRIAL		HOTELS/
TRS	ZONE	ZONE	FRONTAGE	DUs	DEVELOPED	VACANT	DEVELOPED	VACANT	DEVELOPED	VACANT	MOTELS
4426002	0.0%	0.0%	0.0%	0	0	2050400		1100			
4426003	0.0%	0.0%	0.0%	0	0	697300					
4426004	0.0%	0.0%	0.0%	42	1387020	773170					
4426005	0.0%	0.0%	0.0%	75	2352620	871930	160150	71810			
4426006	0.0%	0.0%	0.0%	55	1628400	1669010					
4426007	0.0%	0.0%	0.0%	61	1074880	482630					
4426008	0.0%	0.0%	0.0%	54	2580010	551600	278410				
4426009	0.0%	0.0%	0.0%	27	678360	540270					
4426010	0.0%	0.0%	0.0%	33	882050	334900					
4426011	0.0%	0.0%	0.0%	0	0	1863400					
4426012	0.0%	0.0%	0.0%	0	0	1888710					
4426013	0.0%	0.0%	0.0%	1	6570	709500		8800			
4426014	0.0%	0.0%	0.0%	0	0	344000					
4426015	0.0%	0.0%	0.0%	56	1963040	1949550	7840	5050			
4426016	0.0%	0.0%	0.0%	1	1200	474860		1200			
4426018	0.0%	0.0%	0.0%	57	810690	632900					
4426019	0.0%	0.0%	0.0%	9	123620	1003610					
4426020	0.0%	0.0%	0.0%	0	0	2207820					
4426021	0.0%	0.0%	0.0%	3	18470	1787320		400			
4426022	0.0%	0.0%	0.0%	0	0	676370					
4426023	0.0%	0.0%	0.0%	0	0	334000		4000			
4426024	0.0%	0.0%	0.0%	0	0	716000					
4426025	0.0%	0.0%	0.0%	3	49180	1677130		264900			
4426026	0.0%	0.0%	0.0%	14	314270	1257100	161840	41340	154260		
4426027	0.0%	0.0%	0.0%	49	796820	1920610					
4426028	0.0%	0.0%	0.0%	32	503580	1895150	21960				
4426029	0.0%	0.0%	0.0%	47	433450	3047220		71390			
4426030	0.0%	0.0%	0.0%	0	0	656380	69660	230180	849350	592060	
4426031	0.0%	0.0%	0.0%	0	0	1373350		159570			
4426032	0.0%	0.0%	0.0%	44	330980	2070420		1800			
4426033	0.0%	0.0%	0.0%	16	159010	1364400	46250	176400			
4426034	0.0%	0.0%	0.0%	28	395790	3198600					
4426035	0.0%	0.0%	0.0%	33	294960	3322830		3720			
4426036	0.0%	0.0%	0.0%	18	202230	3517440		1860			
4427001	0.0%	0.0%	0.0%	15	171660	1267200					
4427002	0.0%	0.0%	0.0%	21	209990	1842840		22910			
4427003	0.0%	0.0%	0.0%	13	327230	920130	150350	11040			
4427004	0.0%	0.0%	0.0%	0	0	308250					
4427005	0.0%	0.0%	0.0%	0	0	439820					
4427006	0.0%	0.0%	0.0%	0	0	698970					
4427007	0.0%	0.0%	0.0%	12	245790	941060					
4427008	0.0%	0.0%	0.0%	4	50690	964620					
4427009	0.0%	0.0%	0.0%	12	156950	988000		2930			
4427010	0.0%	0.0%	0.0%	0	0	21260					
4427011	0.0%	0.0%	0.0%	9	113620	1631640					
4427012	0.0%	0.0%	0.0%	11	118320	1438500					
4427013	0.0%	0.0%	0.0%	6	60120	1457820					
4427014	0.0%	0.0%	0.0%	19	382140	1571830					
4427015	0.0%	0.0%	0.0%	42	781450	1560780		2570			
4427016	0.0%	0.0%	0.0%	19	273040	1587550					

	- - STUDY AREA - -				- - - - - - - - - - - - ASSESSED VALUE OF - - - - - - - - - -						
COUNTY	COASTAL	"V		NO. OF	RESIDENTIAL		COMMERCIAL		INDUSTRIAL		HO
TRS	ZONE	ZONE	FRONTAGE	DUs	DEVELOPED	VACANT	DEVELOPED	VACANT	DEVELOPED	VACANT	M(
4427017	0.0%	0.0%	0.0%	9	107820	1594400					
4427018	0.0%	0.0%	0.0%	8	128930	1483500		6200			
4427019	0.0%	0.0%	0.0%	8	75640	1466800					
4427020	0.0%	0.0%	0.0%	13	196440	1495000					
4427021	0.0%	0.0%	0.0%	30	585240	2731900					
4427022	0.0%	0.0%	0.0%	176	3296100	2273020					
4427023	0.0%	0.0%	0.0%	45	844440	2731390		36060			
4427024	0.0%	0.0%	0.0%	13	101670	1494580					
4427025	0.0%	0.0%	0.0%	10	160960	1399200					
4427026	0.0%	0.0%	0.0%	230	5329680	3251380	156450	30310			
4427027	0.0%	0.0%	0.0%	201	4548760	2345780			131130		
4427028	0.0%	0.0%	0.0%	71	1579810	2972070					
4427029	0.0%	0.0%	0.0%	39	679980	2202330		46300			
4427030	0.0%	0.0%	0.0%	473	7128020	12050	1459480	112920	932610		
4427031	0.0%	0.0%	0.0%	686	15233960	986650	6634850	403290			
4427032	0.0%	0.0%	0.0%	1007	12669140	1723880	1192360	120420	32590		
4427033	0.0%	0.0%	0.0%	927	18532490	1572140	15500				
4427034	0.0%	0.0%	0.0%	805	40272690	3137570	3394650				15
4427035	0.0%	0.0%	0.0%	151	3424910	3761660					
4427036	0.0%	0.0%	0.0%	29	449430	2713500					
4521004	100.0%	0.0%	100.0%	1	38880	460270					
4521005	100.0%	100.0%	100.0%	43	2202290	8939570		1000			
4521009	100.0%	100.0%	100.0%	0	0	578350					
4521015	100.0%	100.0%	100.0%	0	0	1256660					
4521016	100.0%	100.0%	100.0%	0	0	74000					
4521022	100.0%	100.0%	100.0%	176	35837190	1246370	2417840				16
4521027	100.0%	100.0%	100.0%	2	74590	14000					
4521035	100.0%	100.0%	100.0%	159	22233940	1200930	3301710				30
4521036	100.0%	0.0%	100.0%	0	0	55830					
4522001	100.0%	100.0%	100.0%	0	0	60000					
4522003	100.0%	0.0%	0.0%	45	929030	1354620			20370		
4522004	100.0%	100.0%	100.0%	10	221570	629560	139040				
4522005	100.0%	100.0%	100.0%	0	0	5280					
4522009	100.0%	100.0%	100.0%	231	1914380	1487560					
4522010	100.0%	0.0%	0.0%	126	1318360	1746780					
4522011	100.0%	0.0%	100.0%	0	0	273090					
4522012	100.0%	0.0%	100.0%	0	0	25660					
4522013	100.0%	0.0%	100.0%	0	0	3000					
4522014	100.0%	0.0%	100.0%	0	0	484700					
4522015	100.0%	0.0%	0.0%	5	281800	1860310					
4522016	100.0%	100.0%	100.0%	0	0	60360					
4522021	100.0%	100.0%	100.0%	0	0	87000					
4522022	100.0%	100.0%	100.0%	8	209880	1498970	31220				
4522023	100.0%	0.0%	100.0%	109	2504670	4437720	1056820	23780			
4522024	100.0%	0.0%	100.0%	0	0	3100					
4522025	100.0%	0.0%	100.0%	0	0	42940					
4522026	100.0%	0.0%	0.0%	4	798820	721680					
4522027	100.0%	100.0%	100.0%	1	44720	408050					
4522028	100.0%	100.0%	100.0%	0	0	22770					
4522034	100.0%	100.0%	100.0%	128	1946640	941490					

	- - STUDY AREA - -				- - - - - - - - - - - ASSESSED VALUE OF - - - - - - - - - - - -						
COUNTY	COASTAL	"V		NO. OF	RESIDENTIAL		COMMERCIAL		INDUSTRIAL		HOTELS/
TRS	ZONE	ZONE	FRONTAGE	DUs	DEVELOPED	VACANT	DEVELOPED	VACANT	DEVELOPED	VACANT	MOTELS
4522035	100.0%	0.0%	0.0%	203	5642790	6096130	1168670		64550		214630
4523001	0.0%	0.0%	0.0%	1869	76118320	0	418820		110630		
4523002	0.0%	0.0%	0.0%	154	4644430	6759380		2740			
4523004	0.0%	0.0%	0.0%	35	1004760	22517120		7060			
4523005	0.0%	0.0%	0.0%	0	0	360000					
4523006	0.0%	0.0%	0.0%	0	0	3000					
4523008	0.0%	0.0%	0.0%	5	199600	4264240		2210			
4523010	0.0%	0.0%	0.0%	97	3969220	9715660					
4523011	0.0%	0.0%	0.0%	251	9598660	9846010					
4523012	0.0%	0.0%	0.0%	1026	36378250	3145770					
4523013	0.0%	0.0%	0.0%	2593	117312810	9513080	6197960	41250	295940		145270
4523014	0.0%	0.0%	0.0%	220	11484180	5776060					
4523015	0.0%	0.0%	0.0%	419	21122740	21447380		22490			
4523016	0.0%	0.0%	0.0%	21	742850	17884730		10190			
4523017	0.0%	0.0%	0.0%	4	205000	0					
4523020	0.0%	0.0%	0.0%	0	0	62000					
4523022	0.0%	0.0%	0.0%	35	2086470	11929110					
4523023	0.0%	0.0%	0.0%	66	3705300	372070					
4523025	100.0%	0.0%	0.0%	26	3768430	1882880					
4523028	100.0%	0.0%	100.0%	0	0	41450					
4523029	0.0%	0.0%	0.0%	0	0	8460					
4523030	0.0%	0.0%	0.0%	0	0	1050					
4523031	100.0%	100.0%	100.0%	0	0	7000					
4523033	100.0%	0.0%	100.0%	0	0	224000					
4523034	100.0%	0.0%	0.0%	92	7677860	4091010					
4523035	100.0%	0.0%	0.0%	59	5024390	2940880	256670	141000	785550		
4523036	100.0%	0.0%	0.0%	522	22972730	9213480	1471730				
4524001	0.0%	0.0%	0.0%	1	51290	3357860	8475900	755220	1553880	805860	1394070
4524002	0.0%	0.0%	0.0%	471	18169900	2450920	21959400	6551630			
4524003	100.0%	0.0%	0.0%	866	35889540	1671700	297630	619220			
4524005	0.0%	0.0%	0.0%	2307	124398140	23207970	10751470	170850	400990		884000
4524006	0.0%	0.0%	0.0%	439	15033030	1870570					
4524007	0.0%	0.0%	0.0%	468	19165550	1724740	3691390	23630	162500		
4524008	0.0%	0.0%	0.0%	97	8225100	812620	640790				
4524009	100.0%	0.0%	0.0%	184	13246950	199950	64930				
4524010	100.0%	0.0%	0.0%	1011	61922370	2355210	647010				
4524011	100.0%	0.0%	0.0%	855	37224020	2281680	7379720	5142940	3337180	15630	
4524012	0.0%	0.0%	0.0%	465	13417000	2258290	7807430	52450	7335300	37660	
4524013	100.0%	0.0%	0.0%	1458	42384030	1815700	12845350	209130	3060770	10880	4076760
4524014	100.0%	0.0%	0.0%	1435	54463470	6856840	18740860	1236140	47940		
4524015	100.0%	0.0%	0.0%	1073	53635900	6774750	8400650	2889340			
4524016	100.0%	0.0%	0.0%	799	49482530	2529020	12901770	37500			
4524017	100.0%	0.0%	0.0%	823	42449460	3550170	9236730	94180	53770		3975350
4524018	0.0%	0.0%	0.0%	600	29386490	1007670	3315700				
4524019	0.0%	0.0%	0.0%	63	3622180	872910					
4524020	100.0%	0.0%	0.0%	757	91706960	4331430		227340	73680		
4524021	100.0%	0.0%	0.0%	1556	73035270	2173290	6475180	1733060			
4524022	100.0%	0.0%	0.0%	1339	46894270	1253410	2389040	152500			
4524023	100.0%	0.0%	0.0%	893	33270790	7617740	1237630				
4524024	100.0%	0.0%	0.0%	210	18845770	6273250	20653100		270630		

	- - STUDY AREA - -				- - - - - - - - - - - ASSESSED VALUE OF - - - - - - - - - -						
COUNTY	COASTAL	"V		NO. OF	RESIDENTIAL		COMMERCIAL		INDUSTRIAL		HOT
TRS	ZONE	ZONE	FRONTAGE	DUs	DEVELOPED	VACANT	DEVELOPED	VACANT	DEVELOPED	VACANT	MO
4524025	100.0%	0.0%	0.0%	16	846720	3643910	4466620		10148940	904500	
4524026	100.0%	0.0%	0.0%	33	2483490	2589690	1941520		310990		
4524027	100.0%	0.0%	0.0%	962	38447160	2731070	1610300				
4524028	100.0%	0.0%	0.0%	305	15100550	173500	346300				
4524029	100.0%	0.0%	0.0%	123	6487590	1920950	1244200		2212410		17
4524030	100.0%	0.0%	0.0%	1	2337750	79800					
4524031	100.0%	0.0%	0.0%	361	15238400	2102130	15999600			2000	
4524032	100.0%	0.0%	0.0%	145	1351380	1423220	360020		1270130	31260	
4524033	100.0%	0.0%	0.0%	17	1563410	883720					
4524034	100.0%	0.0%	0.0%	272	13833000	2362250	245000				
4524035	100.0%	0.0%	0.0%	227	7651500	5017660	387790		11480	60660	
4524036	100.0%	0.0%	0.0%	29	7441720	2207250	1379100		587990	355270	
4525002	0.0%	0.0%	0.0%	0	0	75000					
4525003	0.0%	0.0%	0.0%	0	0	363470					
4525004	0.0%	0.0%	0.0%	0	0	442690					
4525005	0.0%	0.0%	0.0%	20	734110	3198900					
4525006	0.0%	0.0%	0.0%	0	0	3749860	181680		1107540	2132960	
4525007	0.0%	0.0%	0.0%	12	684830	2898200			2087130	724950	
4525008	0.0%	0.0%	0.0%	5	164340	841930					
4525009	0.0%	0.0%	0.0%	0	0	192000					
4525010	0.0%	0.0%	0.0%	1	75670	1174000					
4525014	0.0%	0.0%	0.0%	0	0	1343100					
4525015	0.0%	0.0%	0.0%	8	254720	1383920					
4525016	0.0%	0.0%	0.0%	23	761370	930980					
4525017	0.0%	0.0%	0.0%	10	247930	803810					
4525018	0.0%	0.0%	0.0%	38	1495320	2251400				1267030	
4525019	0.0%	0.0%	0.0%	1	52960	2381620					
4525020	0.0%	0.0%	0.0%	0	0	56650					
4525021	0.0%	0.0%	0.0%	32	1147910	2813930					
4525022	0.0%	0.0%	0.0%	14	740690	2226110	87470				
4525023	0.0%	0.0%	0.0%	3	131070	3658620					
4525024	0.0%	0.0%	0.0%	0	0	708880					
4525026	0.0%	0.0%	0.0%	0	0	240000					
4525027	0.0%	0.0%	0.0%	0	0	636370					
4525029	100.0%	0.0%	0.0%	0	0	3136000					
4525030	0.0%	0.0%	0.0%	0	0	1293060					
4525031	100.0%	0.0%	0.0%	87	3999920	1925670					
4525032	0.0%	0.0%	0.0%	99	10671680	26213700					
4525035	0.0%	0.0%	0.0%	0	0	200000					
4525036	0.0%	0.0%	0.0%	0	0	400000					
4526001	0.0%	0.0%	0.0%	4	14880	2743650					
4526002	0.0%	0.0%	0.0%	15	187790	2695500					
4526003	0.0%	0.0%	0.0%	30	113350	2797560					
4526004	0.0%	0.0%	0.0%	0	0	1152640					
4526009	0.0%	0.0%	0.0%	0	0	54000					
4526010	0.0%	0.0%	0.0%	18	342250	1729280					
4526011	0.0%	0.0%	0.0%	8	27100	2398940					
4526012	0.0%	0.0%	0.0%	15	71860	2740500					
4526013	0.0%	0.0%	0.0%	2	22490	1215220					
4526014	0.0%	0.0%	0.0%	0	0	78020					

	- - STUDY AREA - -				- - - - - - - - - - ASSESSED VALUE OF - - - - - - - - - - - -						
COUNTY	COASTAL	"V		NO. OF	RESIDENTIAL		COMMERCIAL		INDUSTRIAL		HOTELS/
TRS	ZONE	ZONE	FRONTAGE	DUs	DEVELOPED	VACANT	DEVELOPED	VACANT	DEVELOPED	VACANT	MOTELS
4526015	0.0%	0.0%	0.0%	12	198410	663050					
4526017	0.0%	0.0%	0.0%	0	0	5920					
4526022	0.0%	0.0%	0.0%	12	189280	617500					
4526024	0.0%	0.0%	0.0%	7	309730	228000					
4526025	0.0%	0.0%	0.0%	2	139450	641710					
4526026	0.0%	0.0%	0.0%	0	0	8690					
4526033	0.0%	0.0%	0.0%	1	34300	0					
4527001	0.0%	0.0%	0.0%	0	0	2137660					
4527002	0.0%	0.0%	0.0%	7	94480	2287060					
4527003	0.0%	0.0%	0.0%	10	183090	4363150					
4527004	0.0%	0.0%	0.0%	580	15376910	1819590					
4527005	0.0%	0.0%	0.0%	1243	18975710	726890	225140				
4527006	0.0%	0.0%	0.0%	6	302320	1889700					
4527007	0.0%	0.0%	0.0%	0	0	1181600					
4527008	0.0%	0.0%	0.0%	19	680590	569950	168340				
4527009	0.0%	0.0%	0.0%	5	117660	266750	246000		79800		
4527010	0.0%	0.0%	0.0%	7	165130	4305260					
4527011	0.0%	0.0%	0.0%	4	33930	2648080					
4527012	0.0%	0.0%	0.0%	2	31190	2581450					
4527013	0.0%	0.0%	0.0%	3	48520	2446270					
4527014	0.0%	0.0%	0.0%	2	33970	2629820					
4527015	0.0%	0.0%	0.0%	23	909570	4394130	615430				
4527016	0.0%	0.0%	0.0%	0	0	594420	131870				
4527017	0.0%	0.0%	0.0%	0	0	1857230					
4527019	0.0%	0.0%	0.0%	1	149820	5160					
4527020	0.0%	0.0%	0.0%	1	74630	4440					
4527021	0.0%	0.0%	0.0%	0	0	683570					
4527022	0.0%	0.0%	0.0%	7	184680	3899930					
4527023	0.0%	0.0%	0.0%	0	0	635930					
4527024	0.0%	0.0%	0.0%	2	23960	2542900					
4527025	0.0%	0.0%	0.0%	1		2328450					
4527026	0.0%	0.0%	0.0%	0	0	622510					
4527027	0.0%	0.0%	0.0%	0	0	2936000					
4527028	0.0%	0.0%	0.0%	0	0	319480					
4527029	0.0%	0.0%	0.0%	0	0	45400					
4527034	0.0%	0.0%	0.0%	0	0	39560					
4527035	0.0%	0.0%	0.0%	0	0	91270					
4527036	0.0%	0.0%	0.0%	0	0	1580460					
4621001	0.0%	0.0%	0.0%	0	0	480300					
4621002	90.0%	90.0%	90.0%	29	7587990	3414600					
4621011	20.0%	20.0%	20.0%	119	9362700	8405640	751150		98480		294190
4621012	0.0%	0.0%	0.0%	27	1797590	3006890					
4621013	0.0%	0.0%	0.0%	26	1397560	2272670	74210				
4622001	100.0%	100.0%	100.0%	251	7639390	5001650	5380				
4622002	100.0%	100.0%	100.0%	595	14986840	5372010	80870				
4622003	100.0%	100.0%	100.0%	0	0	43000					
4622013	0.0%	0.0%	0.0%	10	938190	516260					
4622018	0.0%	0.0%	0.0%	138	14277540	6429470			30300		
4622019	0.0%	0.0%	0.0%	109	12311090	5925740					
4622020	0.0%	0.0%	0.0%	146	14482030	4078950	242710				

COUNTY	- - STUDY AREA - -			NO. OF	- - - - - - - - - - - ASSESSED VALUE OF - - - - - - - - - - -						
	COASTAL	"V			RESIDENTIAL		COMMERCIAL		INDUSTRIAL		HOT
TRS	ZONE	ZONE	FRONTAGE	DUs	DEVELOPED	VACANT	DEVELOPED	VACANT	DEVELOPED	VACANT	MO
4622021	0.0%	0.0%	0.0%	2	545640	384150					
4622024	0.0%	0.0%	0.0%	100	6189100	2203980					
4622025	0.0%	0.0%	0.0%	259	21199750	9917980	7747440				
4622026	0.0%	0.0%	0.0%	18	2875730	3919100	5337800		75910		
4622027	0.0%	0.0%	0.0%	89	6508020	5447240	1567060				140
4622028	0.0%	0.0%	0.0%	207	23443440	7086160	282300				
4622029	0.0%	0.0%	0.0%	40	8395030	4177990	937050				93
4622034	0.0%	0.0%	0.0%	275	39099960	1538290	4596340				459
4622035	0.0%	0.0%	0.0%	475	73316290	2846400	1450950				122
4622036	0.0%	0.0%	0.0%	213	26654360	424130					
4623001	100.0%	0.0%	0.0%	61	7444400	3600020	872610				
4623002	100.0%	0.0%	0.0%	574	14012010	6393320	530180				
4623003	100.0%	0.0%	100.0%	0	0	1278060					
4623004	100.0%	100.0%	100.0%	0	0	105600					
4623009	100.0%	100.0%	100.0%	123	13446750	2012470	891040				
4623010	100.0%	100.0%	100.0%	11	1020640	3867520	1221900				
4623011	100.0%	100.0%	100.0%	1	74880	2484410					
4623012	100.0%	0.0%	0.0%	687	10432370	1408940	1815740				
4623013	100.0%	100.0%	100.0%	248	17563230	2306760	701370				36
4623014	100.0%	100.0%	100.0%	0	0	32510					
4623018	0.0%	0.0%	0.0%	110	13557970	4182430					
4623019	0.0%	0.0%	0.0%	211	17188930	9106220	4380770				27
4623020	0.0%	0.0%	0.0%	743	73848630	11567220	2746040				182
4623021	0.0%	0.0%	0.0%	270	38723600	1212500	571930				
4623024	100.0%	100.0%	100.0%	543	47715300	2547260	12703390		163830	22130	817
4623029	0.0%	0.0%	0.0%	389	43650450	860860	4811110				481
4623030	0.0%	0.0%	0.0%	1142	144583860	4814480	3721440				266
4624001	100.0%	0.0%	0.0%	246	23080380	9482210	3036040		1633560	141140	
4624002	100.0%	0.0%	0.0%	0	0	800000					
4624003	100.0%	0.0%	0.0%	3	660000	2223000					
4624004	100.0%	0.0%	0.0%	5	337000	1457360					
4624005	100.0%	0.0%	0.0%	9	568140	2271610	873850			250000	
4624006	100.0%	0.0%	0.0%	1485	30959190	7718410	3815610		541470		
4624007	100.0%	0.0%	0.0%	532	15765420	4600780	3892690	1049750	203010		32
4624008	100.0%	0.0%	0.0%	0	0	1233710			1152040		
4624010	100.0%	0.0%	0.0%	1	104630	3028860					
4624012	100.0%	0.0%	0.0%	298	11681750	2687890					
4624013	100.0%	0.0%	0.0%	106	4282110	1459250	30440				
4624014	100.0%	0.0%	0.0%	0	0	56200					
4624015	100.0%	0.0%	0.0%	0	0	1499470					
4624016	100.0%	100.0%	100.0%	0	0	1068420					
4624017	100.0%	100.0%	100.0%	0	0	857420					
4624018	100.0%	0.0%	100.0%	1	659400	126690	141720	69030			
4624019	100.0%	100.0%	100.0%	1426	84766530	9735090	15007690	174280	2537010	483840	486
4624020	100.0%	100.0%	100.0%	81	3543250	715660					
4624021	100.0%	100.0%	100.0%	0	0	14600					
4624022	100.0%	0.0%	0.0%	0	0	63200					
4624023	100.0%	100.0%	100.0%	0	0	44400					
4624024	100.0%	100.0%	100.0%	0	0	27600					
4624025	100.0%	100.0%	100.0%	0	0	6400					

	- - STUDY AREA - -				- - - - - - - - - - - ASSESSED VALUE OF - - - - - - - - - - -						
COUNTY	COASTAL	"V		NO. OF	RESIDENTIAL		COMMERCIAL		INDUSTRIAL		HOTELS/
TRS	ZONE	ZONE	FRONTAGE	DUs	DEVELOPED	VACANT	DEVELOPED	VACANT	DEVELOPED	VACANT	MOTELS
4624026	100.0%	100.0%	100.0%	0	0	9500					
4624027	100.0%	100.0%	100.0%	0	0	30000					
4624028	100.0%	100.0%	100.0%	420	32473920	1908820	1549640				621930
4624029	100.0%	100.0%	100.0%	591	29124560	2714050	1188060				436690
4624033	100.0%	100.0%	100.0%	654	44247550	3150780	9356520				8648300
4624034	100.0%	100.0%	100.0%	502	38642740	3081550	1271590				1085540
4624036	100.0%	100.0%	100.0%	0	0	26720					
4625004	0.0%	0.0%	0.0%	0	0	111470					
4625005	100.0%	0.0%	0.0%	11	279220	1501470			1876170		
4625006	100.0%	0.0%	0.0%	21	968720	1923860	755420		681290	390450	
4625007	100.0%	0.0%	0.0%	435	5150220	4537110		479260			
4625008	100.0%	0.0%	0.0%	354	14204570	5897820	695190	192810	2433390	251160	
4625009	0.0%	0.0%	0.0%	177	3338150	5137630	107590	7220			
4625010	0.0%	0.0%	0.0%	0	0	652000					
4625012	0.0%	0.0%	0.0%	0	0	0			1426160		
4625015	0.0%	0.0%	0.0%	312	7461720	3153740	22360				
4625016	0.0%	0.0%	0.0%	230	3544470	7313850	12450		214580		
4625017	100.0%	0.0%	0.0%	655	15414410	5491210	3507780	955270	232640		958620
4625018	100.0%	0.0%	0.0%	44	3259750	1363920		303180			
4625019	100.0%	0.0%	0.0%	0	0	435000					
4625020	100.0%	0.0%	0.0%	242	3480960	1628930	720500		171620		
4625021	0.0%	0.0%	0.0%	1	1298400	16000					
4625022	0.0%	0.0%	0.0%	249	5040350	1740050					
4625026	0.0%	0.0%	0.0%	0	0	72040					
4625027	0.0%	0.0%	0.0%	20	1621720	173690					
4625028	100.0%	0.0%	0.0%	319	4401730	2412880	523280		233230		
4625029	100.0%	0.0%	0.0%	543	10881400	3849220			63540		
4625030	100.0%	100.0%	100.0%	0	0	1396900					
4625031	100.0%	0.0%	100.0%	14	474480	4902150					
4625032	100.0%	0.0%	0.0%	0	0	654960					
4625033	0.0%	0.0%	0.0%	18	480700	1480160					
4625034	0.0%	0.0%	0.0%	60	1052150	1083780	47280				47280
4625035	0.0%	0.0%	0.0%	482	6934580	382200					
4626009	0.0%	0.0%	0.0%	16	281390	240390					
4626010	0.0%	0.0%	0.0%	6	90160	104260					
4626011	0.0%	0.0%	0.0%	1	27270	0					
4626015	0.0%	0.0%	0.0%	0	0	11330					
4626021	0.0%	0.0%	0.0%	0	0	56270					
4626023	0.0%	0.0%	0.0%	2	36930	353100					
4626025	0.0%	0.0%	0.0%	2	118230	49500					
4627001	0.0%	0.0%	0.0%	11	230130	1166980					
4627002	0.0%	0.0%	0.0%	8	102660	151940					
4627011	0.0%	0.0%	0.0%	3	63800	62590					
4627012	0.0%	0.0%	0.0%	0	0	185740					
4627013	0.0%	0.0%	0.0%	1	38310	562550					
4627019	0.0%	0.0%	0.0%	0	0	131850					
4627021	0.0%	0.0%	0.0%	1	52100	0					
4627023	0.0%	0.0%	0.0%	1	64660	0					
4627026	0.0%	0.0%	0.0%	0	0	10000					
4627027	0.0%	0.0%	0.0%	0	0	204000					

	- - STUDY AREA - -				- - - - - - - - - - - - ASSESSED VALUE OF - - - - - - - - -						
COUNTY	COASTAL	"V"		NO. OF	RESIDENTIAL		COMMERCIAL		INDUSTRIAL		HO
TRS	ZONE	ZONE	FRONTAGE	DUs	DEVELOPED	VACANT	DEVELOPED	VACANT	DEVELOPED	VACANT	M
4627028	0.0%	0.0%	0.0%	12	349360	419020					
4627029	0.0%	0.0%	0.0%	1	33730	24260	19800				
4627031	0.0%	0.0%	0.0%	1	12180	420000					
4627033	0.0%	0.0%	0.0%	1	35800	469610					
4627034	0.0%	0.0%	0.0%	0	0	54240					
4627035	0.0%	0.0%	0.0%	0	0	7280					
4627036	0.0%	0.0%	0.0%	1	33790	0					
4724002	100.0%	100.0%	100.0%	1	1448080	2859500		1272000			
4724003	100.0%	100.0%	100.0%	2241	179679140	7981910	8481850	2487040			33
4724013	100.0%	100.0%	100.0%	0	0	12000					
4724024	100.0%	100.0%	100.0%	0	0	125700					
4724025	100.0%	100.0%	100.0%	1156	115463910	6851110	2141180				3
4725005	100.0%	0.0%	0.0%	4	51970	872570					
4725006	100.0%	100.0%	100.0%	0	0	421200					
4725007	100.0%	100.0%	100.0%	22	263560	42700					
4725008	100.0%	0.0%	0.0%	61	1987760	1441860					
4725009	0.0%	0.0%	0.0%	0	0	1886430	444880				
4725014	0.0%	0.0%	0.0%	118	4136410	8511360	407040	18910			
4725015	0.0%	0.0%	0.0%	0	0	11590			368840		
4725016	0.0%	0.0%	0.0%	459	4765350	3529690	1013260	400330	1166360	132350	
4725017	100.0%	0.0%	100.0%	344	4969220	5398830			338770		
4725018	100.0%	100.0%	100.0%	0	0	296590					
4725019	100.0%	100.0%	100.0%	0	0	90200					
4725020	100.0%	100.0%	100.0%	0	0	2817250					
4725021	100.0%	0.0%	0.0%	0	0	817620					
4725022	100.0%	0.0%	0.0%	0	0	86400	20190				
4725023	0.0%	0.0%	0.0%	238	11120130	3250580	765660				
4725025	100.0%	0.0%	0.0%	218	2083450	3242260	12280				
4725026	100.0%	0.0%	0.0%	335	8898870	2956530	776700				1
4725027	100.0%	0.0%	0.0%	528	4741440	1408660					
4725028	100.0%	0.0%	0.0%	240	2450020	3476600	497790				
4725029	100.0%	100.0%	100.0%	0	0	2671240					
4725030	100.0%	100.0%	100.0%	40	3401500	3204260					
4725031	100.0%	100.0%	100.0%	433	18664810	3290890	71430				
4725032	100.0%	0.0%	0.0%	325	13769660	5587720	559300	154580			
4725033	100.0%	0.0%	0.0%	101	6651370	9410910	1201900	213850			[illegible]
4725034	100.0%	0.0%	0.0%	983	36826340	14819870	6155510	576910			
4725035	100.0%	0.0%	0.0%	567	15319360	4660880	4381780	191150			[illegible]
4725036	100.0%	0.0%	0.0%	510	12024080	5846510		45030	205260		
4726008	0.0%	0.0%	0.0%	0	0	15000					
4726009	0.0%	0.0%	0.0%	0	0	477500					
4726010	0.0%	0.0%	0.0%	0	0	240000					
4726013	0.0%	0.0%	0.0%	0	0	636000					
4726016	0.0%	0.0%	0.0%	0	0	652250					
4726017	0.0%	0.0%	0.0%	0	0	640000					
4726018	0.0%	0.0%	0.0%	20	1400640	1122750					
4726019	0.0%	0.0%	0.0%	1	971230	0					
4726021	0.0%	0.0%	0.0%	0	0	353750					
4726030	0.0%	0.0%	0.0%	32	753340	1580860					
4726031	100.0%	0.0%	0.0%	46	863570	2355480			80460		

	- - STUDY AREA - -				- - - - - - - - - - - - ASSESSED VALUE OF - - - - - - - - - - - -						
COUNTY	COASTAL	"V"		NO. OF	RESIDENTIAL		COMMERCIAL		INDUSTRIAL		HOTELS/
TRS	ZONE	ZONE	FRONTAGE	DUs	DEVELOPED	VACANT	DEVELOPED	VACANT	DEVELOPED	VACANT	MOTELS
4726032	0.0%	0.0%	0.0%	8	251880	1052750					
4726033	0.0%	0.0%	0.0%	5	136420	740980			367450		
4825002	0.0%	0.0%	0.0%	26	1611170	3856470	4726240	428800	2714410	17500	
4825004	100.0%	0.0%	0.0%	100	3257270	4557620	8542380	3353830			
4826006	0.0%	0.0%	0.0%	5	158520	1498520					
TOTALS			TOTAL	104287	4341199440	1577364590	700955000	63193610	148086970	26167850	85711000

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

KEVIN L. ERWIN

APPENDICES

* Indicates an appendix not included in this Volume, but available in the Lee County Division of Planning.

APPENDIX IV-I

Aerial Photographs (1981)

Study Area Mapped Using Florida Land Use Cover and Forms Classification System (FLUCFCS) Level III

(On File in Lee County Planning Department Office)

APPENDIX IV-II

Color Infrared Aerials

Mapping of Estuaries and Associated Islands

(On File in Lee County Planning Department Office)

APPENDIX IV-III

Habitat Acreages Compiled by Section, Township, Range, and Ecosystem Unit

FLUCFCS *	3222	3223	3224	3228	3229	422	437	5412
GASPARILLA ISLAND								
02-43-20			32.31					
11-43-20			7.70					
12-43-20								
13 & 14-43-20								
23-43-20		1.57	24.53	79.21	1.62	0.43	6.60	
26-43-20		11.18	6.76		9.73		0.70	10.37
TOTAL		12.75	71.30	79.21	11.35	0.43	7.30	10.37
HOAGEN KEY								
12-43-20								
THREE SISTERS KEY								
12-43-20	1.03							0.16
GRAND TOTAL	1.03	12.75	71.30	79.21	11.35	0.43	7.30	10.53

FLUCFCS #	612	6121	6122	6123	6124	6125	6423	651
GASPARILLA ISLAND								
02-43-20		63.49	5.64					
11-43-20	1.87	47.55						
12-43-20		7.04						
13 & 14-43-20		13.56						0.52
23-43-20	8.92	26.62		0.79		3.84	0.43	
26-43-20		23.77			1.61			
TOTAL	10.79	182.03	5.64	0.79	1.61	3.84	0.43	0.52
HOAGEN KEY								
12-43-20		14.32						
THREE SISTERS KEY								
12-43-20		9.19			0.64			
GRAND TOTAL	10.79	205.54	5.64	0.79	2.25	3.84	0.43	0.52

FLUCFCS #	3221	3222	3229	4114	4262	4263	4264	4283
CAYO COSTA								
36-43-20		5.01						
01-44-20	19.44	161.11	11.30	18.38				
12-44-20	76.74	80.13	33.23	9.10				
13-44-20	25.49	80.35	21.87					
06-44-21	2.84		13.53		1.71	5.50		
07-44-21				5.71				
18-44-21 (N)	0.98							
18-44-21 (S)	12.45	184.00					4.07	
19-44-21		67.56	20.07	34.30			7.63	
20-44-21		12.78			6.11	1.10	19.09	0.97
29-44-21		5.43	1.14				2.95	
32-44-21		2.35					9.38	
TOTAL	136.96	599.70	101.14	67.49	7.82	6.60	43.12	0.97
POINT PLANCO ISLAND								
07-44-21								
08-44-21								
TOTAL								
BIRD KEYS								
08-44-21								
MONDONGO ISLAND								
08-44-21						5.42		
PRIMO ISLAND								
18-44-21 (N)								
PRIMO ISLAND								
18-44-21 (S)								
NARROWS KEY								
19-44-21								
CABBAGE KEY								
17-44-21						6.94	7.97	
MIDDLE KEY								
17-44-21								
GRAND TOTAL	136.96	599.70	101.14	67.49	7.82	18.96	51.09	0.97

	4284	4373	4374	5412	6121	6122	6123	641	642
CAYO COSTA									
36-43-20	76.07				0.36			0.36	
01-44-20	115.19							2.24	
12-44-20	81.14							1.47	
13-44-20	24.10							0.45	
06-44-21	57.34				40.29				0.36
07-44-21	78.72		1.09		69.21	6.84	0.49	17.90	
18-44-21 (N)	54.41			10.77	89.28				
18-44-21 (S)	107.97				40.45			0.52	
19-44-21					155.00	12.27			
20-44-21		1.82			56.95				
29-44-21					15.29				
32-44-21					38.34	0.17			
TOTAL	594.67	1.82	1.09	10.77	505.17	19.28	0.49	22.94	0.36
POINT PLANCO ISLAND									
07-44-21					105.02				
08-44-21		11.30			13.99				
TOTAL		11.30			119.01				
BIRD KEYS									
08-44-21					10.15				
MONDONGO ISLAND									
08-44-21					19.65				
PRIMO ISLAND									
18-44-21 (N)					0.58				
PRIMO ISLAND									
18-44-21 (S)					7.29				
NARROWS KEY									
19-44-21					5.06				
CABBAGE KEY									
17-44-21					59.87	0.79			
MIDDLE KEY									
17-44-21					11.02	0.39			

FLUCFCS #	746
CAYO COSTA	
36-43-20	
01-44-20	
12-44-20	
13-44-20	
06-44-21	
07-44-21	0.66
18-44-21 (N)	
18-44-21 (S)	
19-44-21	0.82
20-44-21	
29-44-21	0.71
32-44-21	
TOTAL	2.19
POINT PLANCO ISLAND	
07-44-21	
08-44-21	
TOTAL	
BIRD KEYS	
08-44-21	
MONDONGO ISLAND	
08-44-21	7.85
PRIMO ISLAND	
18-44-21 (N)	
PRIMO ISLAND	
18-44-21 (S)	
NARROWS KEY	
19-44-21	
CABBAGE KEY	
17-44-21	2.80
MIDDLE KEY	
17-44-21	
GRAND TOTAL	12.84

FLUCFCS #	3221	3222	3229	4261	4263	4264	4283	4284
NORTH CAPTIVA								
04-45-21		37.25						5.71
05-45-21	17.53	185.09		0.68	5.16	6.59	1.59	61.98
09-45-21						9.61		27.24
15-45-21			19.37					
16-45-21			25.90					
TOTAL	17.53	222.24	45.27	0.68	5.16	16.20	1.59	94.93

FLUCFCS *	6121	6122	641	652	721	746
NORTH CAPTIVA						
04-45-21	17.55		1.22			
05-45-21	37.43			6.55		19.76
09-45-21	78.75	6.31				
15-45-21	4.74	3.58				
16-45-21	16.28	10.40			7.31	
TOTAL	154.75	20.29	1.22	6.55	7.31	19.76

FLUCFCS #	4264	4374	5412	6121
CAPTIVA ISLAND				
15-45-21		1.67		17.15
23-45-21				145.02
26-45-21				4.78
02-46-21		4.17		8.65
TOTAL		5.84		175.60
BUCK KEY				
35-45-21	115.80			122.26
02-46-21	29.16		0.47	94.60
TOTAL	144.96		0.47	216.86
GRAND TOTAL	144.96	5.84	0.47	392.46

FLUCFCS #	3221	3222	3223	3229	4272	4274	437	4372	4373	4374	5412	612	6121	6122	6123	6124
ESTERO ISLAND																
24-46-23									11.13				0.22			
19-46-24					3.29	0.83							45.17			9.62
28-46-24	DEVELOPED//															
29-46-24													8.06			4.80
30-46-24	DEVELOPED//															
33-46-24													16.93			
34-46-24													18.55	1.57		
02-47-24													0.80			
03-47-24	4.26											24.64	12.78			
TOTAL	4.26				3.29	0.83			11.13			24.64	102.51	1.57		14.42
BLACK ISLAND COMPLEX																
02-47-24	NO AREAS THAT ARE RECORDED///															
11-47-24			0.47							0.56			45.37			
12-47-24													3.67			
TOTAL			0.47							0.56			49.04			
DAVIS KEY COMPLEX																
12-47-24													13.85			
TOTAL													13.85			
LITTLE DAVIS KEY																
12-47-24													3.36			
TOTAL													3.36			
LOVERS KEY COMPLEX																
11-47-24		21.65	1.75	29.98									17.12			
13-47-24																
14-47-24		9.69		19.35									22.29			
TOTAL		31.34	1.75	49.33									39.41			
INNER KEY COMPLEX																
11-47-24				20.25									23.65	0.53		
TOTAL				20.25									23.65	0.53		
LONG KEY COMPLEX																
12-47-24											3.87		50.86			
13-47-24													84.51			
14-47-24			0.53										1.80			
TOTAL			0.53								3.87		137.17			
HICKORY ISLAND																
13-47-24													19.01			
TOTAL													19.01			
BIG HICKORY ISLAND																
19-47-24													6.48			
24-47-24				9.13							0.78		307.07	0.71	2.89	
TOTAL				9.13							0.78		313.55	0.71	2.89	
LITTLE HICKORY ISLAND																
24-47-24								0.86				.03	.03			
25-47-24													35.83			
30-47-24											1.05		51.99			
31-47-24							7.86				.17	129.54				
TOTAL							7.86	0.86			1.22	129.57	87.85			
GRAND TOTAL	4.26	31.34	2.75	78.71	3.29	0.83	7.86	0.86	11.13	0.56	5.87	154.21	789.40	2.81	2.89	14.42

FLUCFCS #	6125	6126	6423	651	746
ESTERO ISLAND					
24-46-23					
19-46-24					
///28-46-24					
29-46-24					
///30-46-24	//////////	//////////	//////////	//////////	//////////
33-46-24	3.53	0.36			
34-46-24					2.33
02-47-24					
03-47-24			1.26	13.78	
TOTAL	3.53	0.36	1.26	13.78	2.33
BLACK ISLAND COMPLEX					
///02-47-24	//////////	//////////	//////////	//////////	//////////
11-47-24				15.76	
12-47-24				8.06	
TOTAL				23.82	
DAVIS KEY COMPLEX					
12-47-24					
TOTAL					
LITTLE DAVIS KEY					
12-47-24					
TOTAL					
LOVERS KEY COMPLEX					
11-47-24				1.03	
13-47-24				4.49	
14-47-24					
TOTAL				5.52	
INNER KEY COMPLEX					
11-47-24					
TOTAL					
LONG KEY COMPLEX					
12-47-24				0.78	
13-47-24	0.73			5.51	
14-47-24				2.68	
TOTAL	0.73			8.97	
HICKORY ISLAND					
13-47-24					
TOTAL					
BIG HICKORY ISLAND					
19-47-24				0.09	
24-47-24	1.91			8.41	
TOTAL	1.91			8.50	
LITTLE HICKORY ISLAND					
24-47-24				0.70	
25-47-24				2.01	
30-47-24				2.56	
31-47-24					
TOTAL				5.27	
GRAND TOTAL	6.17	0.36	1.26	65.86	2.33

FLUCFCS #	261	321	411	412	422	424	426	4264	427	4271	428	4286	4285	429
PINE ISLAND														
25-43-21														
26-43-21														
29-43-22			6.64			1.27		5.13						
30-43-22			18.92					4.65						
31-43-22			63.35			47.41				0.48				
32-43-22			31.14		8.57	105.45						5.74		
33-43-22			24.45			8.92								
35-43-21														
36-43-21														
01-44-21														
03-44-22														
04-44-22			38.85											
05-44-22			5.87											
06-44-22	24.52		63.14		11.46	51.07								
07-44-22		1.55	16.17	2.28	10.18				7.85					
08-44-22			2.47											
09-44-22			246.65			34.07						10.49		
10-44-22														
16-44-22			48.26			11.43						4.62	3.65	
17-44-22			41.82	1.50	1.28									
18-44-22			0.93											
19-44-22														
20-44-22			114.78	1.32										
21-44-22			95.67			51.86						1.70		
27-44-22						17.76								
28-44-22			147.55		1.88	42.27								
29-44-22						0.67								
32-44-22														
33-44-22			361.67		36.42	11.51			7.56					1.8
34-44-22			47.10		54.44									
02-45-22														
03-45-22			161.13											
04-45-22			257.53											
09-45-22	38.08				10.57	6.14								
10-45-22	199.87	16.71	117.04		1.92				8.17		7.05			
11-45-22			55.88											
14-45-22			257.63											
15-45-22	20.87		510.49		5.92						1.63			
16-45-22							0.24							
21-45-22														
22-45-22			438.67						1.53					
23-45-22			142.07			9.12					0.46	0.99		
24-45-22														
25-45-22														
26-45-22			293.50			29.46								
27-45-22			125.94			18.60								
28-45-22														
34-45-22					2.40	7.17					1.83			
35-45-22			112.36			68.04								
36-45-22														
01-46-22														
02-46-22														
03-46-22														
10-46-22														
TOTAL	283.34	18.26	3847.67	5.10	145.04	522.22	0.24	9.78	25.11	0.48	10.97	23.54	3.65	1.8

FLUCFCS #	437	4371	4372	4373	4374	5412	612	6122	6123	6124	6125	6127	6128	641	6412
PINE ISLAND															
25-43-21						0.44	73.91								
26-43-21							0.38								
29-43-22	8.32				0.44	3.12	199.66								
30-43-22	1.92					0.99	109.98			1.55					
31-43-22	26.58				1.66	0.26	18.20		2.77						
32-43-22	44.18					2.49	63.51								
33-43-22	2.62						90.57						76.35		
35-43-21						1.88	114.13	2.32							
36-43-21						13.89	493.91	12.80	13.44						
01-44-21	20.64					1.46	334.47	0.51	0.26						
03-44-22						0.42	55.18								
04-44-22	3.48					13.30	241.03								
05-44-22															
06-44-22	36.75						13.57								
07-44-22						3.13	115.39			4.72	7.81				
08-44-22															
09-44-22											1.63	6.30			
10-44-22						4.17	29.90								
16-44-22	49.77						63.30			5.05					
17-44-22		0.82	0.17		3.21	0.17	149.78		0.39						
18-44-22						1.89	81.77								
19-44-22						2.16	48.19								
20-44-22					3.73	2.17	328.98		2.15						
21-44-22	22.49						67.49					9.94			
27-44-22				1.26		0.76	39.17	7.94	52.90						
28-44-22	4.89					1.22	68.33	2.09							
29-44-22						1.91	228.55								
32-44-22						0.41	102.44								
33-44-22						2.04	158.72	2.34						2.87	1.13
34-44-22						2.23	152.08	7.92	4.82						1.36
02-45-22						0.21	21.74								
03-45-22						0.98	200.06	7.8	6.65						
04-45-22							197.62	1.36							0.34
09-45-22	25.83					3.47	237.52	4.74	1.83		12.14				
10-45-22	8.17						19.22	6.05							
11-45-22						2.76	199.39	1.84							
14-45-22						0.68	167.50		6.89						
15-45-22	2.98				11.80		29.38	0.29	15.59					2.52	
16-45-22	0.81					0.32	285.82	1.31							
21-45-22						0.93	167.08	0.33							
22-45-22						6.32	233.29	0.21	17.64					2.07	1.65
23-45-22						5.60	164.68	2.19			16.34	12.34			
24-45-22							3.74								
25-45-22							5.21								
26-45-22	1.50					4.90	210.77	4.57							0.44
27-45-22						2.88	295.42		2.37						
28-45-22							50.63								
34-45-22						9.99	244.98	0.19				7.50			
35-45-22	13.35					4.27	296.72	5.04	5.07						
36-45-22						0.18	90.55								
01-46-22	1.83			1.87		1.54	182.02	0.05							
02-46-22					5.87	0.31	80.98								
03-46-22						3.49	246.65		0.44						
10-46-22							2.93								
TOTAL	276.11	0.82	0.17	3.13	26.71	109.34	7076.49	71.89	133.21	11.32	37.92	36.08	76.35	7.46	4.92

FLUCFCS #	6413	6414	642	6422	6423	6424	6425	746
PINE ISLAND								
25-43-21								
26-43-21								
29-43-22								
30-43-22								
31-43-22								
32-43-22								
33-43-22								
35-43-21								
36-43-21								
01-44-21								
03-44-22								
04-44-22								
05-44-22								
06-44-22			0.50					
07-44-22					0.73			1.55
08-44-22								
09-44-22								
10-44-22								
16-44-22					0.76			
17-44-22					0.99			
18-44-22								
19-44-22					2.61			
20-44-22					8.40			
21-44-22				1.28				
27-44-22					49.33			
28-44-22								
29-44-22								
32-44-22								
33-44-22					2.73			
34-44-22					9.95			
02-45-22								
03-45-22								
04-45-22								
09-45-22							1.69	
10-45-22								
11-45-22								
14-45-22								
15-45-22	1.18	0.84			11.14			
16-45-22					1.42			
21-45-22								
22-45-22					22.86			
23-45-22							2.49	
24-45-22								
25-45-22								
26-45-22								
27-45-22					1.12			
28-45-22								
34-45-22						0.28		
35-45-22								
36-45-22								
01-46-22								0.85
02-46-22		9.06						
03-46-22								
10-46-22								
TOTAL	1.18	9.90	0.50	1.28	112.04	0.28	4.18	2.40

FLUCFCS #	5412	612	6123
E. OF MATLACHA PASS			
12-45-22		4.80	
DEER STOP KEY			
31-44-23		1.40	
06-45-23	0.22	21.14	
07-45-23		11.50	
12-45-22		42.00	
19-45-23		71.41	
30-45-23		11.70	
EGRET ISLAND			
31-44-23		0.71	
LUMPKIN ISLAND			
31-44-23		1.36	
KITE ISLAND			
31-44-23		2.75	
13-45-22		73.53	0.38
GRAND TOTAL	0.22	242.30	0.38

FLUCFCS #	3221	411	4371	612
BURNT STORE				
01-43-22		0.50		10.41
06-43-22		39.32		
TOTAL		39.82		10.41
YUCCA PEN CREEK				
01-43-22	0.98		0.98	46.04
06-43-22	DEVELOPED//////////////////////////////			
TOTAL	0.98		0.98	46.04
GRAND TOTAL	0.98	39.82	0.98	56.45

FLUCFCS #	261	422	424	437	5412	612	6123	641	6422	6423
PONTOON BAY										
13-44-22				2.02	0.47	25.29				
24A-44-22					1.03	115.77				
17-44-23	DEVELOPED//									
18-44-23					0.11	17.02			2.37	
19-44-23	38.29		59.66		8.20	337.54	14.45		67.39	42.78
20-44-23			65.98					14.02		
29-44-23		4.47	18.56			1.94	4.88	3.43		11.86
30-44-23			14.84		2.29	281.83	12.05		45.23	31.84
TOTAL	38.29	4.47	159.04	2.02	12.10	779.39	31.38	17.45	114.99	86.48

FLUCFCS #	261	411	412	4124	422	424	437	612	6128	621	6412	746
WHISKEY CREEK												
03-45-24												
09-45-24												
10-45-24			7.08					14.45				
11-45-24						1.70		0.65		0.65	0.41	
13-45-24												
14-45-24		10.81	10.88			41.21						
15-45-24	29.64	5.36	24.06	20.86	2.01			12.15	2.50			28.97
16-45-24							2.44	0.34				
E 1/2 17-45-24							10.51	2.30				
20-45-24												
21-45-24				10.26		7.25						6.10
22-45-24	47.34		2.53								1.76	2.19
27-45-24												
28-45-24												
TOTAL	76.98	16.17	44.55	31.12	2.01	50.16	12.95	29.89	2.50	0.65	2.17	37.26

FLUCFCS #	261	411	4124	422	424	427	428	4286	4285	4291	437	5412	612	6122
DEEP LAGOON														
20-45-24											3.80		63.80	
21-45-24		38.04	1.06		24.50									
27-45-24	DEVELOPED///													
28-45-24	280.15	14.42	3.79	5.68	30.12									
29-45-24	14.49	4.12	24.52		5.42		30.49	4.57			12.49	0.68	118.89	
32-45-24		82.68	1.32	3.52	18.10		33.67			0.84		3.66	80.98	
33-45-24	170.51	17.81	0.46	25.17	56.78	4.92	8.36	1.31		1.09				
04-46-24	163.23	17.76		15.11			11.89					1.92	9.50	
05-46-24	57.48	41.82	6.91	10.77	32.57	.	6.59	3.33	8.30		18.61	18.71	99.56	
08-46-24				8.76	67.75							4.25	13.46	12.21
TOTAL	685.83	216.65	38.06	69.01	235.24	4.92	91.00	9.21	8.30	1.93	34.90	29.22	386.19	12.21

FLUCFCS #	6125	6127	6128	641	6412	6414	642	6422	6423	6425	643	746
DEEP LAGOON												
20-45-24												
21-45-24												
27-45-24	//////////	//////////	//////////	//////////	//////////	//////////	//////////	//////////	//////////	//////////	//////////	//////////
28-45-24				9.14								
29-45-24		2.45						11.15	8.31	24.00		28.67
32-45-24			4.24	9.88								43.77
33-45-24				3.97	1.75						1.32	
04-46-24	3.66						1.12					
05-46-24			0.91		5.77	2.80	8.56		27.19			18.46
08-46-24				0.79								69.26
TOTAL	3.66	2.45	5.15	23.78	7.52	2.80	9.68	11.15	35.50	24.00	1.32	160.16

FLUCFCS #	261	411	412	4123	422	424	426	427	428	4286	4291	5412	612	6122
BUNCH BEACH														
36-45-23									0.16					
31-45-24	121.28				26.81				6.13		1.30			
01-46-23	20.97					3.90		0.66						
02-46-23			21.68			1.78								
10-46-23							10.11					3.45	153.98	
11-46-23							0.60	5.19		17.39		9.43	412.59	92.19
12-46-23			39.19									3.36	249.15	68.72
13-46-23												1.21	199.61	
14-46-23													25.05	
24-46-23													2.97	
06-46-24		4.23		4.21	17.55									
07-46-24			3.36		4.19			2.95	8.31			5.09	21.33	0.71
TOTAL	142.25	4.23	64.23	4.21	48.55	5.68	10.71	8.80	14.60	17.39	1.30	22.54	1064.68	161.62

FLUCFCS #	6123	6124	6128	642	6423	746
BUNCH BEACH						
36-45-23						
31-45-24						6.23
01-46-23						
02-46-23						
10-46-23	0.73					
11-46-23			0.28			
12-46-23			1.74	80.95	15.24	
13-46-23	2.17	5.73				
14-46-23	0.30					
24-46-23						
06-46-24						12.22
07-46-24						15.46
TOTAL	3.20	5.73	2.02	80.95	15.24	33.91

FLUCFCS #	261	3228	411	412	4124	422	424	426	427	428	4286	4285	437	5412
IONA														
25-45-23						1.29								
33-45-23														0.61
34-45-23			11.25										1.07	
35-45-23	73.30						0.59					4.35	1.15	2.06
36-45-23		6.42		4.74	19.54	3.97								
29-45-24	DEVELOPED//													
30-45-24						13.98		3.66					2.02	
31-45-24										7.93				
01-46-23	28.60					8.35								
02-46-23	19.43			5.27		8.85	33.75		0.89		3.62			0.56
03-46-23			1.20				7.45							9.87
04-46-23													0.93	
09-46-23								10.38					5.13	0.19
10-46-23								1.44						1.50
11-46-23											2.39			
TOTAL	121.33	6.42	12.45	10.01	19.54	36.44	41.79	15.48	0.89	7.93	6.01	4.35	10.30	14.79

FLUCFCS #	612	6122	6123	6125	6127	6412	6414	642	6425	746
IONA										
25-45-23	4.55									
33-45-23	303.73									
34-45-23	217.29							3.00		
35-45-23	42.31		1.13		0.90					10.44
36-45-23	1.92									
/////29-45-24		//////////	//////////	//////////	//////////	//////////	//////////	//////////	//////////	//////////
30-45-24	12.55									
31-45-24										
01-46-23										
02-46-23	28.51	3.79	5.46	3.12	93.40	2.81	2.50			14.45
03-46-23	550.80		2.54		43.10			0.49		
04-46-23	110.51									
09-46-23	130.13	7.47	5.57							
10-46-23	175.20	8.83	1.01							
11-46-23	5.80								7.10	
TOTAL	1583.30	20.09	15.71	3.12	137.40	2.81	2.50	3.49	7.10	24.89

FLUCFCS #	261	321	411	422	424	4262	428	5412	612	6122	6123	6127	64
COW CREEK													
24-46-23	DEVELOPED//												
03-46-24	21.09												
04-46-24	215.73		1.72		3.37		1.54	1.19	12.50				
07-46-24				23.73					1.50				
08-42-24					152.29			11.05	42.04	13.88	2.96		26.6
09-46-24	189.85	0.35			57.18		3.69	30.55	145.84	7.28	17.81		
10-46-24	106.42				82.01								
15-46-24								12.64	68.53		36.40	2.01	
16-46-24		3.82			20.98			29.21	440.96		7.58		
17-46-24					69.38			31.16	344.88		18.13		2.7
18-46-24					34.32			9.91	363.66		1.22		
19-46-24									85.02				
20-46-24								6.29	479.71				
21-46-24								10.14	398.01				
22-46-24								6.98	395.63	0.06	154.15		
23-46-24								2.13	67.52				
26-46-24									4.58				
27-46-24								10.52	254.11				
28-46-24								0.10	117.53				
29-46-24								1.46	90.99				
DOG KEY													
21-46-24						2.71		0.13	19.83				
28-46-24									1.85				
TOTAL	533.09	4.17	1.72	23.73	556.93	2.71	5.23	163.46	3334.69	21.22	238.25	2.01	29.3

FLUCFCS #	6413	6414	642	6422	6423	6425
COW CREEK						
24-46-23		//////////	//////////	//////////	//////////	//////////
03-46-24						
04-46-24			2.18			
07-46-24	5.43					
08-42-24		8.01	10.95		61.59	
09-46-24			3.39	27.97	137.98	0.70
10-46-24						
15-46-24					82.66	
16-46-24				18.82	102.89	20.53
17-46-24				7.30	85.88	44.90
18-46-24					2.71	
19-46-24						
20-46-24						
21-46-24						
22-46-24				2.93	112.68	
23-46-24				3.33		
26-46-24						
27-46-24				18.84		
28-46-24						
29-46-24						
DOG KEY						
21-46-24						
28-46-24						
TOTAL	5.43	8.01	16.52	79.19	586.39	66.13

FLUCFCS #	261	321	411	412	4123	4124	422	424	427	428	4286	4285	4291	
HENDRY CREEK														
22-45-24	DEVELOPED//////////////////////////													
23-45-24			10.14					184.97						
24-45-24			11.62					28.58						
25-45-24		17.80						88.78						
26-45-24			28.52					164.81						1
27-45-24			45.67					14.63		1.82			4.12	
28-45-24	83.04													
33-45-24	197.59						2.08							
34-45-24	94.05		78.65			2.23	8.73	12.50		4.52				1
35-45-24			28.65	14.04			7.42	40.34	4.77	0.69				4
36-45-24	4.18		14.29	24.21	19.80	13.80		12.28	13.67					
01-46-24	DEVELOPED//////////////////////////													
02-46-24			2.39					52.48						
03-46-24			278.10					97.79						1
04-46-24			7.60				18.48	0.83						
10-46-24	64.18	2.76	7.40					278.77			0.93			
11-46-24								20.95			3.61	10.63		
12-46-24		5.68						58.93						
13-46-24								17.05						
14-46-24								2.22						
15-46-24								75.89						
22-46-24														
23-46-24														
24-46-24														
26-46-24														
27-46-24														
TOTAL	443.04	26.24	513.03	38.25	19.80	16.03	36.71	1151.80	18.44	7.03	4.54	10.63	4.12	9

FLUCFCS #	441	5412	612	6122	6123	6214	641	6411	6412	6414	642	6422	6423	746
HENDRY CREEK														
22-45-24	//////////	//////////	//////////	//////////	//////////	//////////	//////////	//////////	//////////	//////////	//////////	//////////	//////////	//////////
23-45-24														
24-45-24														
25-45-24														34.26
26-45-24														
27-45-24		0.77				2.33	0.90		0.80					
28-45-24														
33-45-24														
34-45-24	26.98	0.66					17.91							9.55
35-45-24		1.36	98.41	7.38	57.91		13.42				0.26	21.93		4.48
36-45-24										4.23				3.84
01-46-24	//////////	//////////	//////////	//////////	//////////	//////////	//////////	//////////	//////////	//////////	//////////	//////////	//////////	//////////
02-46-24		0.77	162.72	6.06	2.92				1.77	1.34	3.23	200.04		
03-46-24		1.06	29.69		0.26		11.17	1.70			6.14	0.84		
04-46-24								10.99						
10-46-24		0.10	4.54	1.48	5.12		1.95	0.52		0.17		4.96	53.53	
11-46-24		2.30	249.90	9.14	25.69							206.60	25.43	
12-46-24		0.76	15.12	2.43	5.36					0.53		18.63	5.68	
13-46-24		0.21	60.28	5.57	2.18				5.08				9.53	
14-46-24		14.27	386.34	6.02	4.36							120.29	14.43	
15-46-24		8.83	8.68	4.14	9.99		2.27						155.57	
22-46-24			10.34	9.86	10.98									
23-46-24		1.92	348.99	3.10								38.29		
24-46-24			7.97									1.99		
26-46-24		0.46	101.48											
27-46-24			41.32											
TOTAL	26.98	33.47	1525.78	55.18	124.77	2.33	47.62	13.21	7.65	6.27	9.63	613.57	264.17	52.13

FLUCFCS #	320	321	411	4123	424	427	4286	6175	621	6214	641	6412	6414	
TEN MILE CANAL														
31-45-25					20.20	1.51			5.55	12.56	1.50			
05-46-25				0.28	18.66			3.92						
06-46-25		4.08	1.07	26.18	211.61		0.88	1.61		6.01				91
07-46-25	3.02		12.59		171.91				1.86	7.78		4.09	5.88	17
TOTAL	3.02	4.08	13.66	26.46	422.38	1.51	0.88	5.53	7.41	26.35	1.50	4.09	5.88	108

FLUCFCS #	261	321	411	412	424	428	4291	4374	5412	612	6122	6123	617	6174
MULLOCK CREEK														
12-46-24			34.15		21.21					2.07	4.21			
13-46-24					28.05				0.31	203.25	3.65	0.15		
24-46-24									0.30	55.84				
07-46-25					6.76									
08-46-25			19.60		5.79									
17-46-25		1.26		90.15	18.59		3.76							21.27
18-46-25	73.84	16.35	6.43	24.59	214.70	17.86		0.35		48.90	0.98	8.74	18.87	
19-46-25		55.20			111.21	3.95			0.56	10.13	6.52	8.88		
20-46-25	4.49	27.44	4.92		112.90	4.67	0.96				3.36			16.77
29-46-25		6.47	7.41											
TOTAL	78.33	106.72	72.51	114.74	519.21	26.47	4.72	0.35	1.17	320.19	15.36	17.77	18.87	38.04

FLUCFCS #	621	6214	624	641	6411	642	6422	6423	643
MULLOCK CREEK									
12-46-24		8.07		15.91			6.93		
13-46-24				4.29		4.38	131.62	1.56	1.30
24-46-24						0.36	4.67		
07-46-25									
08-46-25									
17-46-25				0.97					2.98
18-46-25		4.19				1.78	8.67	6.65	1.75
19-46-25						1.07			
20-46-25	0.95	22.75	5.95		0.80				
29-46-25		4.44							
TOTAL	0.95	39.45	5.95	21.17	0.80	7.59	151.89	8.21	6.03

FLUCFCS #	320	321	411	412	4123	424	428	5412	612	6122	6123	621	6214
ESTERO RIVER													
24-46-24								8.34	351.44				
25-46-24									141.03				
36-46-24								0.13	70.40				
19-46-25		16.66	85.60		3.88	78.05		7.50	214.12	17.71	31.67		4.50
28-46-25	20.91			53.90			2.96						
29-46-25		8.67	51.93	5.86		49.32	2.68					4.38	2.52
30-46-25	56.62		74.83			110.77		1.19	183.75	8.99	4.03		
31-46-25			1.34					0.22	83.76		0.20		
32-46-25	1.48	27.70				12.39							
33-46-25	KORESHAN SETTLEMENT//												
TOTAL	79.01	53.03	213.70	59.76	3.88	250.53	5.64	17.38	1044.5	26.70	35.90	4.38	7.02

FLUCFCS #	642	6422	643
ESTERO RIVER			
24-46-24	4.25	22.69	
25-46-24		-	
36-46-24			
19-46-25			
28-46-25			
29-46-25			0.87
30-46-25		64.90	
31-46-25	1.77	5.34	
32-46-25			
33-46-25	//////////	//////////	//////////
TOTAL	6.02	92.93	0.87

FLUCFCS #	261	320	411	424	4373	4374	612	6124	6144	6174	621	641	642
HALFWAY CREEK													
29-46-25			2.89				4.13						
30-46-25			6.10				1.69						
31-46-25		6.17	21.78										
32-46-25		124.39	31.76				22.20	0.32	3.98				14.78
04-47-25			2.63								6.84		
05-47-25	37.28	2.43	75.29	10.13	2.16	5.13				24.77	28.39	2.44	
08-47-25			4.87								22.93	5.39	
09-47-25			1.38								5.69		
TOTAL	37.28	132.99	146.70	10.13	2.16	5.13	28.02	0.32	3.98	24.77	63.85	7.83	14.78

FLUCFCS #	320	321	411	421	424	428	4286	4291	5412	612	6122	6123	641	6·
COCONUT														
05-47-25	59.58	30.38	39.18	2.37	2.75	30.32	0.87	16.87	0.75	1.79				
06-47-25			62.12		3.51	6.54	9.99		11.89	331.77	6.16	7.18		
07-47-25			33.83						0.67	85.11				
08-47-25		3.92	50.85	2.23		27.34		5.49					4.94	
31-46-25	14.75	1.24			37.53		41.52		6.28	261.70	2.19	6.57	1.60	36.
STINGAREE KEY										3.72				
32-46-25	10.59		15.26			2.96								
TOTAL	84.92	35.54	201.24	4.60	43.79	67.16	52.38	22.36	19.59	684.09	8.35	13.75	6.54	36.

FLUCFCS #	261	320	321	411	412	4124	422	424	4272	428	4282	4285	429	4
SPRING CREEK														
07-47-25				18.79				4.25						
08-47-25		10.19	57.19	49.77						37.84				
17-47-25		6.76	18.51	83.97	0.69	0.71	1.39	16.17			0.99			0
18-47-25				2.75			4.22	19.11			1.91			
19-47-25				16.62										
20-47-25		64.85		140.49			0.70					11.76		
21-47-25	71.36	50.63	0.63	126.14						5.50			1.34	
22-47-25	21.29			64.65										
26-47-25				0.38										
27-47-25				40.74										
28-47-25		3.07	7.76	40.03										
29-47-25		40.35		184.71					2.04	21.90				
30-47-25				0.14										
31-47-25														
32-47-25		4.06		159.03				3.18		15.41				
33-47-25		63.66	0.91	32.67						19.03				
TOTAL	92.65	243.57	85.00	960.88	0.69	0.71	6.31	42.71	2.04	99.68	2.90	11.76	1.34	0

FLUCFCS #	5412	611	612	6122	6123	617	641	6411	642	6422	643
SPRING CREEK											
07-47-25	0.93		72.85	3.59	7.46						
08-47-25	0.58		6.69	0.60							
17-47-25	0.21		32.56	0.67	0.59	24.65	4.16		2.51		
18-47-25			125.07	1.80	39.82				0.53		
19-47-25	1.90		86.34	1.12	5.32						
20-47-25		13.49	157.69	1.41	12.72		2.98	0.56	21.18	15.02	
21-47-25			11.97			10.50	5.69		6.03	2.41	8.48
22-47-25						12.76					
26-47-25											
27-47-25						5.84					
28-47-25							13.47				10.70
29-47-25		25.69	74.48				45.69	2.42	24.04		
30-47-25			29.54								
31-47-25			121.14								
32-47-25			58.22				21.03		15.32		
33-47-25		2.83					15.45				0.53
TOTAL	3.62	42.01	776.55	9.19	65.91	53.75	108.47	2.98	69.61	17.43	19.71

FLUCFCS #	261	320	321	411	424	4271	4272	4273	428	4283	4286	429	4291	43
IMPERIAL RIVER														
25-47-25				7.39										
26-47-25			2.45	28.79										
27-47-25	102.58		94.63	43.90	8.74					4.01		11.59		
28-47-25		1.79	3.10	36.85	1.65									
31-47-25														
32-47-25				25.50					14.33					
33-47-25		54.67	11.19	81.02	5.20			1.43	5.25		0.93			1.5
34-47-25				49.99										
35-47-25		15.15		28.59										
36-47-25		8.89		12.99			3.24							
31-47-26			1.74	5.88		2.59	1.65							
01-48-25		2.21		6.83										
TOTAL	102.58	[illegible].71	113.11	327.73	15.59	2.59	4.89	1.43	19.58	4.01	0.93	11.59		1.5
UPPER LITTLE HICKORY BAY														
04-48-25	9.82	2.58	23.77	19.23	13.27								0.82	

FLUCFCS #	612	6121	617	6172	6172/512	6173	6173/512	6174	6243	641	6411	6422	643
IMPERIAL RIVER													
25-47-25					1.50								
26-47-25							0.20						
27-47-25										25.92			9.97
28-47-25										5.47			7.40
31-47-25	43.06												
32-47-25	54.26												
33-47-25	11.95									1.35		25.24	1.16
34-47-25	0.68	5.97		3.39								5.21	1.07
35-47-25					5.69	3.03	2.03					30.45	
36-47-25				1.99		2.99		5.00					
31-47-26					4.29								
01-48-25					4.43			8.11					
TOTAL	109.95	5.97		5.38	14.41	6.02	2.23	13.11		32.74		60.09	19.60
			17.07						0.91	8.58	7.73		10.81

FLUCFCS #	321	411	424	5412	612	6122	6123	6423
LITTLE PINE ISLAND.								
14-44-22				0.22	40.89			
15-44-22					144.81			
16-44-22					51.85			
21-44-22				4.19	36.30			
22-44-22			35.03	24.49	521.79		18.80	74.83
23-44-22			77.62	13.93	378.40		2.74	27.79
24B-44-22				0.81	8.94			
25-44-22				10.87	286.15			
26-44-22	1.31	5.82						
27-44-22		31.06	72.88	31.78	148.14		128.54	76.22
34-44-22			1.84	37.44	295.87			42.91
35-44-22			13.07	10.93	655.81	17.75	4.90	43.76
36-44-22								
01-45-22				0.39	107.48			
02-45-22				29.53	487.40	0.20		
03-45-22				1.01	57.37			
11-45-22				1.79	95.97			
TOTAL	1.31	36.91	589.21	177.20	3668.14	17.95	172.11	348.10

FLUCFCS #	3224	426	4262	4264	4273	4274	437	5412	612	6124	6423
MISCELLANEOUS ISLANDS											
BOKEELIA ISLAND											
25-43-21				10.64	6.49			5.50	124.01		
26-43-21	14.25							1.87	38.43		
30-43-22				3.03			0.63		5.55	5.88	
TOTAL FOR BOKELLIA				13.67			0.63	7.37	167.99	5.88	
LITTLE BOKEELIA ISLAND											
25-43-21									1.17		
26-43-21								1.20	67.23		
35-43-21 & 02-44-21						4.66			30.77		2.43
TOTAL FOR LITTLE BOKEELIA						4.66		1.20	99.17		2.43
BIG SMOKEHOUSE KEY											
33-43-22 & 34-43-22								1.75	40.75		
04-44-22									20.63		
TOTAL FOR BIG SMOKEHOUSE								1.75	61.38		
LITTLE SMOKEHOUSE KEY											
04-44-22									3.71		
PUMPKIN KEY											
09-45-22								0.06	21.09		
RAG ISLAND											
23-45-22									14.00		
24-45-22									33.16		
25-45-22									8.48		
26-45-22									8.10		
TOTAL FOR RAG ISLAND									63.74		
BEAR KEY											
15-44-22				0.40					3.01		
DEER KEY											
15-44-22									6.71		
REGLA ISLAND											
21-45-22									34.37		
28-45-22									2.54		
TOTAL FOR REGLA ISLAND									36.91		

FLUCFCS #	3224	426	4262	4264	4273	4274	437	5412	612	6124	6423
MACKEEVER KEYS											
28-45-22									4.13		
CAT KEY											
19-44-22									8.41		
JOSSLYN ISLAND											
19-44-22				7.73				0.13	45.84		
DEMERE ISLAND											
32-44-22			7.16						5.27		
LUMBER ISLAND											
36-44-22									1.87		
WOODSTORK ISLAND											
36-44-22									26.45		
NON PARIEL ISLAND											
11-44-22									3.08		
BROWN PELICAN ISLAND											
11-44-22									1.82		
BULL ISLAND											
11-44-22									3.22		
13-44-22									14.74		
14-44-22									7.48		
TOTAL FOR BULL ISLAND									25.44		
LANIER ISLAND											
14-44-22									8.74		
IBIS ISLAND											
14-44-22									16.75		
HERON ISLAND											
14-44-22									9.23		
TERN ISLAND											
13-44-22									3.91		
BIG PANTHER KEY											
29-44-22								4.09	30.16		
GALT ISLAND											
27-45-22									2.77	2.93	
33-45-22				5.54					10.80		
34-45-22				9.72					14.09		
TOTAL FOR GALT ISLAND				15.26					27.66	2.93	

FLUCFCS 8	3224	426	4262	4264	4273	4274	437	5412	612	6124	6423
HAVELOCK KEY											
03-46-22									0.42		
YORK ISLAND											
02-46-22									0.35		
03-46-22								0.07	9.97		
10-46-22			9.97						173.41		
TOTAL FOR YORK ISLAND			9.97					0.07	10.32		
MASON ISLAND											
16-45-22		1.07							23.91		
PANTHER KEYS											
30-44-22								0.02	34.87		
									4.11		
HEMP ISLAND											
30-44-22		0.34							4.11		
INDIAN FIELD											
03-44-22									1.92		
10-44-22				0.84				0.20	70.53		
TOTAL FOR INDIAN FIELD				0.84				0.20	72.45		
SISTER KEYS											
01-46-22 & 06-46-22									1.60		
BIG SISTER KEYS											
01-46-22 & 06-46-22									3.72		
UNNAMED ISLAND											
13-44-22									10.94		
GRAND TOTAL	14.25	1.41	17.13	37.90	6.49	4.66	0.63	14.89	1018.22	8.81	2.43

FLUCFCS #	3229	426	4261	4264	5412	612	9111	9112	9113
GRASS BEDS & ISLANDS									
45-227						55.73	2006.66	939.20	
BLACK KEY						13.50			
CHARLIE KEY						4.23			
COUMBS KEY						67.56			
MOUND KEY				56.75		77.75			
TOTAL				56.75		218.77	2006.66	939.20	
307-39							2404.91	3077.72	245.79
CHINO ISLAND		2.05				19.64			
WULFERT KEYS						34.37			
TOTAL		2.05				54.01	2404.91	3077.72	245.79
299-84						19.28	680.54	1656.49	
SANDFLY KEY						16.46			
DEVILFISH KEY					5.84	29.90			
CAYO PELAU					2.00	137.56			
TOTAL					7.84	203.20	680.54	1656.49	
307-37						0.45	540.39	7860.57	1318.86
BIG BIRD ROOKERY						18.42			
BENEDICT KEY						2.38			
CORK KEY						0.65			
CORK ISLAND						3.03			
TOTAL						24.93	540.39	7860.57	1318.86
307-11					0.40	84.05	612.83	2225.78	253.33
JULIE'S ISLAND						74.98			
STARVATION KEY						11.48			
COON KEY						95.24			
TOTAL					0.40	265.75	612.83	2225.78	253.33
39-190	1.73					38.52	1806.92	4210.21	274.86
MACKEEVER KEYS						28.15			
CLAM KEY						0.06			
CHINO ISLAND						9.10			
GIMEY KEY						2.16			
STARVATION KEY						3.80			
BIRD ISLAND						1.30			
MERVIN KEY						50.49			
BIG ISLAND						62.84			
FISHERMAN KEY						59.81			
KITCHEL KEY 1						4.76			
KITCHEL KEY 2						4.33			
MIQUEL KEY						5.63			
TOTAL	1.73					270.95	1806.92	4210.21	274.86

FLUCFCS #	3229	426	4261	4264	5412	612	9111	9112	9113
299-82			12.96			37.79	2040.05	14382.71	3540.04
RAT KEY						13.78			
WOOD KEY						83.89			
LITTLE WOOD KEY						38.60			
COVE KEY					0.81	69.16			
COON KEY						7.09			
PART ISLAND				7.91	14.93	218.88			
BLACK KEY					5.73	97.53			
DARLING KEY						1.50			
BROKEN KEY						12.82			
PATRICIO ISLAND				23.19		103.79			
WHOOPEE ISLAND						4.91			
USEPPA ISLAND				4.64		9.40			
TOTAL			12.96	35.74	21.47	699.14	2040.05	14382.71	3540.04
45-229					0.27	11.04	315.37	1101.11	
39-192							1502.52	2555.72	
MCCARDLE ISLAND			6.93			74.60			
TOTAL			6.93			74.60	1502.52	2555.72	
39-194							533.92	3162.30	3097.62
307-9							169.68	143.76	962.24
299-122							249.21	992.63	
39-196							165.35	808.52	
TOTAL							1118.16	5107.21	4059.86
GRAND TOTAL	1.73	2.05	19.89	92.49	29.98	1822.39	13028.35	43116.72	9692.74

APPENDIX IV-IV

A Compilation of the Typical and Protected Fauna for Each of the Major Vegetation Communities Within the Lee County Coastal Zone

by

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2077 Bayside Parkway
Fort Myers, Florida 33901

January 1988

181 - BEACHES/SWIMMING

	Common Name	Scientific Name
Birds	Laughing Gull	Larus atricilla
	Ring-billed Gull	Larus delawarensis
	Black Skimmer	Rynchops niger
	Royal Tern	Sterna maxima
	Common Tern	Sterna hirundo
	*Least Tern	Sterna antillarum
	*Piping Plover	Charadrius melodus
	Sanderling	Calidris alba
	Dunlin	Calidris alpina
	Willet	Catoptrophorus semipalmatus
	Wilson's Plover	Charadrius wilsonia
	Semi-Palmated Plover	Charadrius semipalmatus
	*Brown Pelican	Pelecanus occidentalis
	Great Egret	Casmerodius albus
	*Snowy Egret	Egretta thula
	Black-bellied Plover	Pluvialis squatarola
	Boat-tailed Grackle	Quiscalus major
	Fish Crow	Corvus ossifragus
	*American Oystercatcher	Haematopus palliatus
	Semipalmated Plover	Charadrius semipalmatus
	Red Knot	Calidris canutus
	*Southeastern Snowy Plover	Characrius alexandrinus tenuirostris
Mammals	Raccoon	Procyon lotor
	Opossum	Didelphis marsupialis
Reptiles	Green Anole	Anolis carolinensis
	Cuban Brown Anole	Anolis sagrei
	*Green Sea Turtle	Chelonia mydas
	*Atlantic Loggerhead Sea Turtle	Caretta caretta caretta
	*Altantic Hawksbill Sea Turtle	Eretmochelys imbricata
	*Atlantic Ridley Sea Turtle	Lepidochelys kempi
	*Leatherback Sea Turtle	Dermochelys coriacea
	*American Loggerhead Turtle	Caretta caretta caretta

320 - SAND SCRUB/OAK - PALMETTO - ROSEMARY

	Common Name	Scientific Name
Birds	*Florida Scrub Jay	Aphelocoma coerulescens
	Blue Jay	Cyanocitta cristata
	Rufous-sided Towhee	Pipilo erythrophthalmus
	Northern Cardinal	Cardinalis cardinalis

	Northern Mockingbird	Mimus polyglottos
	Loggerhead Shrike	Lanius ludovicianus
	Common Ground Dove	Columbina passerina
	Carolina Wren	Thryothorus ludovicianus
	White-eyed Vireo	Vireo griseus
	Northen Bobwhite	Colinus virginianus
	Brown Thrasher	Toxostoma rufum
Mammals	Cotton Mouse	Peromyscus gossypinus
	Eastern Cottontail	Sylvilagus floridanu
	White-tailed Deer	Odocoileus virginianus
	Florida Mouse	Peromyscus floridanus
	Bobcat	Lynx rufus floridanus
Amphibians	Southern Toad	Bufo terrestris
	*Florida Gopher Frog	Rana areolata aesopus
	Eastern Spade foot	Scaphiopus holbrooki holbrooki
Reptiles	*Gopher Tortoise	Gopherus polyphemus
	Green Anole	Anolis carolinensis
	Dusky Pigmy Rattlesnake	Sistrurus miliarius barbouri
	Eastern Diamondback Rattlesnake	Crotalus adamanteus
	Southeastern Five-lined Skink	Eumeces inexpectatus
	Six-lined Racerunner	Cnemidophorus sexlineatus sexlineatus
	*Eastern Indigo Snake	Drymarchon corais couperi
	Southern Black Racer	Coluber constrictor priapus
	*Florida Scrub Lizard	Sceloporus woodii
	Everglades Racer	Coluber constrictor paludicola
	Florida Scarlet Snake	Cemophora coccinea coccinea

321 - PALMETTO PRAIRIE

	Common Name	Scientific Name
Birds	Rufus-sided Towhee	Pipilo erythrophthalmus
	Northern Bobwhite	Colinus virginianus
	Northern Cardinal	Cardinalis cardinalis
	Eastern Kingbird	Tyrannus tyrannus
	Mourning Dove	Zenaida macroura
	Common Ground Dove	Columbina passerina
	Wild Turkey	Meleagris gallopavo
	Loggerhead Shrike	Lanius ludovicianus
	Common Yellowthroat	Geothlypis trichas

Mammals	Nine-banded Armadillo	Dasypus novemcinctus
	Eastern Gray Fox	Urocyon cineroargenteus
	Raccoon	Procyon lotor
	Opossum	Didelphis marsupialis
	Spotted Skunk	Spilogale putoruis
	Eastern Cottontail	Sylvilagus floridanu
	Hispid Cotton Rat	Sigmodon hispidus
	Florida Mouse	Peromyscus floridanus
	Bobcat	Lynx rufus floridanus
Amphibians	Southern Toad	Bufo terrestris
	Oak Toad	Fufo quercicus
Reptiles	Green Anole	Anolis carolinensis
	Dusky Pigmy Rattlesnake	Sistrurus miliarius barbouri
	Eastern Diamondback Rattlesnake	Crotalus adamanteus
	Six-lined Racerunner	Cnemidophorus sexlineatus sexlineatus
	*Eastern Indigo Snake	Drymarchon corais couperi
	Southern Black Racer	Coluber constrictor priapus
	Ground Skink	Scincella lateralis
	Southeastern Five-lined Skink	Eumeces inexpectatus
	Eastern Glass Lizard	Ophosaurus ventralis
	Eastern Garter Snake	Thamnophis sirtalis
	Eastern Hognose Snake	Heterodon platyrhinos
	Yellow Rat Snake	Elaphe obsoleta
	Gulf Coast Box Turtle	Terrapene carolina major
	*Gopher Tortoise	Gopherus polyphemus
	Rough Green Snake	Opheodrys aestivus
	Corn Snake	Elaphe guttata guttata
	Southern Ringneck Snake	Diadophus punctatus punctatus
	Florida Scarlet Snake	Cemophora coccinea coccinea

322-3229 - COASTAL SCRUB

	Common Name	Scientific Name
Birds	Gray Catbird	Dumetella carolinensis
	American Robin	Turdus migratorius
	Rufous-sided Towhee	Pipilo erythrophthalmus
	Northern Flicker	Colaptes auratus
	Gray Kingbird	Tyrannus dominicensis
	Northern Cardinal	Cardinalis cardinalis
	Northern Mockingbird	Mimus polyglottos
	Red-bellied Woodpecker	Melanerpes carolinus
	Piliated Woodpecker	Dryocopus pileatus
	Prairie Warbler	Dendroica discolor

	Palm Warbler	Dendroica palmarum
	Common Yellowthroat	Geothlypis trichas
	Blue-gray Gnatcatcher	Polioptila caeurulea
	Black-whiskered Vireo	Vireo altiloguus
	White-eyed Vireo	Vireo griseus
	Fish Crow	Corvus ossifragus
	Mourning Dove	Zenaida macroura
	Ground Dove	Columbina passerina
Mammals	Eastern Cottontail	Sylvilagus floridanu
	Feral Hog	Sus scrofa
	Eastern Gray Squirrel	Sciurus carolinensis
	House Mouse	Mus musculus
	Hispid Cotton Rat	Sigmodon hispidus
	Black Rat	Rattus rattus
	Raccoon	Procyon lotor
	Bobcat	Lynx rufus floridanus
	Marsh Rabbit	Sylvilagos palustris
	Silver Rice Rat	Oryzomys argentatus
	Opossum	Didelphis marsupialis
	Striped Skunk	Mephitis mephitis
	Spotted Skunk	Spilogale putoruis
	Nine-banded Armadillo	Dasypus novemcinctus
	*Sanibel Island Rice Rat	Oryzomys palustris Sanibeli
Amphibians	Southern Toad	Bufo terrestris
	Green Treefrog	Hyla cinerea
	Squirrel Treefrog	Hyla squirella
Reptiles	Green Anole	Anolis carolinensis
	Cuban Brown Anole	Anolis sagrei
	Southeastern Five-lined Skink	Eumeces inexpectatus
	Six-lined Racerunner	Cnemidophorus sexlineatus sexlineatus
	*Eastern Indigo Snake	Drymarchon corais couperi
	*Gopher Tortoise	Gopherus polyphemus
	Gulf Coast Box Turtle	Terrapene carolina
	Rough Green Snake	Opheodrys aestivus
	Eastern Diamondback Rattlesnake	Crotalus adamanteus
	Dusky Pigmy Rattlesnake	Sistrurus miliarius barbouri
	Southern Black Racer	Coluber constrictor priapus
	Eastern Garter Snake	Thamnophis sirtalis

411 (1-4) PINE FLATWOOD

	Common Name	Scientific Name
Birds	*Bald Eagle	Haliaeetus leucocephalus
	Red-tailed Hawk	Buteo jammaicensis
	Red-shouldered Hawk	Buteo lineatus
	Sharp-shinned Hawk	Accipiter striatus
	American Kestrel	Falco sparverius
	Turkey	Meleagris gallopavo
	Northern Bobwhite	Colinus virginianus
	Mourning Dove	Zenaida macroura
	Ground Dove	Columbina passerina
	Eastern Screech Owl	Ottus asio
	Great Horned Owl	Bubo virginianus
	Barred Owl	Strix varia
	Chuck-will's-widow	Caprimulgus carolinensis
	Red-headed Woodpecker	Melanerpes erythrocephalus
	Red-bellied Woodpecker	Melanerpes carolinus
	Downy Woodpecker	Picoides pubescens
	Hairy Woodpecker	Picoides villosus
	Northern Flicker	Colaptes aurates
	Great Crested Flycatcher	Myiarchus crinitus
	Blue Jay	Cyanocitta cristata
	Northern Mockingbird	Mimus polyglottos
	Palm Warbler	Dendroica palmarum
	Pine Warbler	Dendroica pinus
	Northern Cardinal	Cardinalis cardinalis
	Rufous-sided Towhee	Pipilo erythrophthalmus
	Common Grackle	Quiscalus quiscula
	Brown Thrasher	Toxostoma rufum
	Black Vulture	Coragyps atratus
	Black and White Warbler	Mniotilta varia
	Blue-gray Gnatcatcher	Poliptila caerulea
	Carolina Wren	Thryothorus ludouicianus
	Cooper's Hawk	Accipiter cooperii
	Eastern Bluebird	Sialia sialis
	Eastern Kingbird	Tyrannus tyrannus
	Eastern Meadow lark	Sturnella magna
	Eastern Phoebe	Sayornis phoebe
	Eastern Wood-peewee	Contopus verinus
	Gray Catbird	Dumetella carolinensis
	Loggerhead Shrike	Lanius ludovicianus
	Prairie Warbler	Dendroica discolor
	Robin	Turdus migratorius
	Ruby-throated Humming-bird	Archilochus colubris
	Short-tailed Hawk	Butero brachyurus
	Starling	Sturnus vulgaris
	Tree Swallow	Iridoprocne bicolor
	Turkey Vulture	Cathartes avra
	Whip-poor-will	Caprimulgus vociferus
	Yellow-bellied Sapsucker	Sphyrapicus varius

	Yellow-rumped Warbler	Dendroica coronata
	Yellowthroat	Geothlypis trichas
	Yellow-throated Warbler	Dendroica dominica
	*Red-cockaded Woodpecker	Picoides borealis
	Pileated Woodpecker	Dryocopus pileatus
	*Southeastern Kestral	Falco sparverius paulus
	*Migrant Loggerhead Shrike	Lanius ludovicianus migrans
Mammals	Feral Hog	Sus scrofa
	White-tailed Deer	Odocoileus virginianus
	Eastern Gray Fox	Urocyon cineroargenteus
	Bobcat	Lynx canadensis
	Nine-banded Armadillo	Dasypus novemcinctus
	Evening Bat	Nycticrius humeralis
	Eastern Gray Squirrel	Sciurus carolinensis
	*Mangrove Fox Squirrel	Sciurus niger avicennia
	Hispid Cotton Rat	Sigmodon hispidus
	Black Rat	Rattus rattus
	Raccoon	Procyon lotor
	Opossum	Didelphis marsupialis
	Spotted Skunk	Spilogale putoruis
	Cotton Mouse	Peromyscus gossypinus
	Shorttail Shrew	Blarina brevicauda
	Striped Skunk	Mephitis mephitis
	South Florida Mole	Scalopus aquaticus
	*Florida Weasel	Mustela frenata peninsulae
	Eastern Cottontail	Sylvilagus floridanus floridanus
	Marsh Rabbit	Sylvilagus palustris paludicola
	Big Brown Bat	Eptesicus fuscus
	Eastern Yellow Bat	Lasiurus intermedios
	Seminole Bat	Lasiurus seminolus
	*Floirda Panther	Felis concolor coryi
	*Florida Black Bear	Ursus Ameicanus floridanus
	*Florida Weasel	Mustela frenata peninsulae
Amphibians	Southern Toad	Bufo terrestris
	Eastern Narrow-mouthed Toad	Gastrophryne carolinensis
	*Florida Gopher Frog	Rana areolata aesopus
	Southern Leopard Frog	Rana utricularia
	Oak Toad	Bufo quercicus
	Squirrel Treefrog	Hyla squirella
	Pine Woods Treefrog	Hyla femoralis
	Barking Treefrog	Hyla gratiosa
	Cuban Treefrog	Hyla septentrionalis
	Florida Chorus Frog	Pseudacris brimleyi

Reptiles	Southeastern Five-lined Skink	Eumeces inexpectatus
	Six-lined Racerunner	Cnemidophorus sexlineatus sexlineatus
	Eastern Coachwhip	Masticophis flagellum
	Florida King Snake	Lampropeltis getulis
	Scarlet King Snake	Lampropeltis doliatus
	Coral Snake	Micrurus fulvius
	Green Anole	Anolis carolinensis
	Dusky Pigmy Rattlesnake	Sistrurus miliarius barbouri
	Eastern Diamondback Rattlesnake	Crotalus adamanteus
	*Eastern Indigo Snake	Drymarchon corais couperi
	Southern Black Racer	Coluber constrictor priapus
	Ground Skink	Scincella lateralis
	Eastern Glass Lizard	Ophosaurus ventralis
	Eastern Garter Snake	Thamnophis sirtalis
	Eastern Hognose Snake	Heterodon platyrhinos
	Yellow Rat Snake	Elaphe obsoleta
	Gulf Coast Box Turtle	Terrapene carolina major
	*Gopher Tortoise	Gopherus polyphemus
	Rough Green Snake	Opheodrys aestivus
	Corn Snake	Elaphe guttata guttata
	Southern Ringneck Snake	Diadophus punctatus punctatus
	Florida Scarlet Snake	Cemophora coccinea coccinea

414 - WET PINE FLATWOOD

	Common Name	Scientific Name
Birds	*Bald Eagle	Haliaeetus leucocephalus
	Red-tailed Hawk	Buteo jammaicensis
	Red-shouldered Hawk	Buteo lineatus
	Sharp-shinned Hawk	Accipiter striatus
	American Kestrel	Falco sparverius
	Turkey	Meleagris gallopavo
	Northern Bobwhite	Colinus virginianus
	Mourning Dove	Zenaida macroura
	Ground Dove	Columbina passerina
	Eastern Screech Owl	Ottus asio
	Great Horned Owl	Bubo virginianus
	Barred Owl	Strix varia
	Chuck-will's-widow	Caprimulgus carolinensis
	Red-headed Woodpecker	Melanerpes erythrocephalus
	Red-bellied Woodpecker	Melanerpes carolinus
	Downy Woodpecker	Picoides pubescens
	Hairy Woodpecker	Picoides villosus

	Flicker	Colaptes aurates
	Great Crested Flycatcher	Myiarchus crinitus
	Blue Jay	Cyanocitta cristata
	Northern Mockingbird	Mimus polyglottos
	Palm Warbler	Dendroica palmarum
	Pine Warbler	Dendroica pinus
	Northern Cardinal	Cardinalis cardinalis
	Rufous-sided Towhee	Pipilo erythrophthalmus
	Common Grackle	Quiscalus quiscula
	Brown Thrasher	Toxostoma rufum
	*Southeastern Kestral	Falco sparverius paulus
	*Red-cockaded Woodpecker	Picoides borealis
	*Migrant Loggerhead Shrike	Lanius ludovicianus migrans
Mammals	Feral Hog	Sus scrofa
	White-tailed Deer	Odocoileus virginianus
	Eastern Gray Fox	Urocyon cineroargenteus
	Bobcat	Lynx canadensis
	Nine-banded Armadillo	Dasypus novemcinctus
	Evening Bat	Nycticrius humeralis
	Eastern Gray Squirrel	Sciurus carolinensis
	*Mangrove Fox Squirrel	Sciurus niger avicennia
	Southern Flying Squirrel	Glaucomys volans
	Hispid Cotton Rat	Sigmodon hispidus
	Black Rat	Rattus rattus
	Raccoon	Procyon lotor
	Opossum	Didelphis marsupialis
	Spotted Skunk	Spilogale putoruis
	Cotton Mouse	Peromyscus gossypinus
	Shorttailed Shrew	Blarina brevicauda
	Least Shrew	Cryptotis parva
	Red Bat	Lasiurus borealis
	Striped Skunk	Mephitis mephitis
	South Florida Mole	Scalopus aquaticus
	*Florida Weasel	Mustela frenata peninsulae
	Eastern Cottontail	Sylvilagus floridanus floridanus
	Marsh Rabbit	Sylvilagus palustris paludicola
	Big Brown Bat	Eptesicus fuscus
	Eastern Yellow Bat	Lasiurus intermedios
	Seminole Bat	Lasiurus seminolus
	*Florida Panther	Felis concolor coryi
	*Florida Black Bear	Ursus Americanus floridanus
Amphibians	Southern Toad	Bufo terrestris
	Eastern Narrow-mouthed Toad	Gastrophryne carolinensis
	*Florida Gopher Frog	Rana areolata aesopus
	Southern Leopard Frog	Rana utricularia
	Green Treefrog	Hyla cinerea

	Squirrel Treefrog	Hyla squirella
	Pine Woods Treefrog	Hyla femoralis
	Barking Treefrog	Hyla gratiosa
	Cuban Treefrog	Hyla septentrionalis
	Florida Chorus Frog	Pseudacris brimleyi
	Bull Frog	Rana catesbeiana
	Green Frog	Rana clamitans
	Little Grass Frog	Limnaoedus ocularis
	Pig Frog	Rana grylio
Reptiles	Green Anole	Anolis carolinensis
	Southeastern Five-lined Skink	Eumeces inexpectatus
	Six-lined Racerunner	Cnemidophorus sexlineatus sexlineatus
	*Eastern Indigo Snake	Drymarchon corais couperi
	Eastern Coachwhip	Masticophis flagellum
	Dusky Pigmy Rattlesnake	Sistrurus miliarius barbouri
	Eastern Diamondback Rattlesnake	Crotalus adamanteus
	Southern Black Racer	Coluber constrictor priapus
	Ground Skink	Scincella lateralis
	Eastern Glass Lizard	Ophosaurus ventralis
	Eastern Garter Snake	Thamnophis sirtalis
	Eastern Hognose Snake	Heterodon platyrhinos
	Yellow Rat Snake	Elaphe obsoleta
	Florida Brown Snake	Storeria dekayi
	Southern Ringneck Snake	Diadophis punctatus
	Rough Green Snake	Opheodrys aestivus
	Corn Snake	Elaphe guttata
	Florida Pine Snake	Pituophis melanoleucus mugitus
	Florida King Snake	Lampropeltis getulis
	Scarlet King Snake	Lampropeltis doliatus
	Coral Snake	Micrurus fulvius
	Brown Anole	Anolis sagrei
	Brown Water Snake	Nerodia taxispikota
	Common Garter Snake	Thamnophis sirtalis sirtalis
	Cottonmouth	Agkistrodon piscivorus
	Penninsula Ribbon Snake	Thamnophis savritis sackeni

424 - OAK HAMMOCK

	Common Name	Scientific Name
Birds	Red-eyed Vireo	Vireo olivaceus
	Eastern Screech Owl	Ottus asio
	Barred Owl	Strix varia
	Great Crested Flycatcher	Myiarchus crinitus

	Blue Jay	Cyanocitta cristata
	Northern Mockingbird	Mimus polyglottos
	Carolina Wren	Thryothorus ludovicianus
	Yellow-bellied Cuckoo	Coccyzus americanus
	Red-bellied Woodpecker	Melanerpes carolinus
	Northern Cardinal	Cardinalis cardinalis
	Great Horned Owl	Bubo virginianus
	Turkey	Meleagris gallopavo
	Northern Flicker	Colaptes auratus
	Blue-gray Gnatcatcher	Polioptila caeurulea
	Black and White Warbler	Mniotilta varia
	Red-tailed Hawk	Buteo jammaicensis
	Red-shouldered Hawk	Buteo lineatus
	Pileated Woodpecker	Dryocopus pileatus
	Gray Catbird	Dumetella carolinensis
	Prairie Warbler	Dendroica discolor
Mammals	White-tailed Deer	Odocoileus virginianus
	Bobcat	Lynx canadensis
	Eastern Gray Fox	Urocyon cineroargenteus
	Nine-banded Armadillo	Dasypus novemcinctus
	Raccoon	Procyon lotor
	Opossum	Didelphis marsupialis
	Striped Skunk	Mephitis mephitis
	Eastern Gray Squirrel	Sciurus carolinensis
	Eastern Cottontail	Sylvilagus floridanus floridanus
	South Florida Mole	Scalopus aquaticus
	Shorttail Shrew	Blarina brevicauda
	Eastern Woodrat	Neotoma floridana
Amphibians	Southern Toad	Bufo terrestris
	Oak Toad	Bufo quercicus
Reptiles	Green Anole	Anolis carolinensis
	Cuban Brown Anole	Anolis sagrei
	Eastern Diamondback Rattlesnake	Crotalus adamanteus
	*Gopher Tortoise	Gopherus polyphemus
	Southern Black Racer	Coluber constrictor priapus
	Southern Ringneck Snake	Diadophis punctatus
	Florida Scarlet Snake	Cemophora coccinea coccinea
	Dusky Pigmy Rattlesnake	Sistrurus miliarius barbouri
	*Eastern Indigo Snake	Drymarchon corais couperi

426 - TROPICAL HARDWOOD

	Common Name	Scientific Name
Birds	Gray Kingbird	Tyrannus dominicensis
	Black-whiskered Vireo	Vireo altiloquus
	Red-shouldered Hawk	Buteo lineatus
	Eastern Screech Owl	Ottus asio
	Barred Owl	Strix varia
	Chuck-will's-widow	Caprimulgus carolinensis
	Red-bellied Woodpecker	Melanerpes carolinus
	Great Crested Flycatcher	Myiarchus crinitus
	White-eyed Vireo	Vireo griseus
	Prairie Warbler	Dendroica discolor
	Black-and-white Warbler	Mniotilta varia
	Mangrove Cuckoo	Coccyzus minor
	Gray Catbird	Dumetella carolinensis
	Palm Warbler	Dendroica palmarum
	Northern Parula	Parula americana
	Oven Bird	Seiurus aurocapillus
	Pileated Woodpecker	Dryocopus pileatus
Mammals	Nine-banded Armadillo	Dasypus novemcinctus
	Eastern Gray Squirrel	Sciurus carolinensis
	*Mangrove Fox Squirrel	Sciurus niger avicennia
	Raccoon	Procyon lotor
	Opossum	Didelphis marsupialis
	Spotted Skunk	Spilogale putoruis
	Cotton Mouse	Peromyscus gossypinus
	South Florida Mole	Scalopus aquaticus
	Silver Rice Rat	Oryzomys argentatus
	Bobcat	Lynx canadensis
	Black Rat	Rattus rattus
Amphibians	Green Treefrog	Hyla cinerea
	Squirrel Treefrog	Hyla squirella
	Southern Toad	Bufo terrestris
Reptiles	Green Anole	Anolis carolinensis
	Southeastern Five-lined Skink	Eumeces inexpectatus
	*Eastern Indigo Snake	Drymarchon corais couperi
	Eastern Diamondback Rattlesnake	Crotalus adamanteus
	Southern Black Racer	Coluber constrictor priapus
	Southern Ringneck Snake	Diadophis punctatus
	Rough Green Snake	Opheodrys aestivus
	Coral Snake	Micrurus fulvius
	Cuban Brown Anole	Anolis sagrei
	Eastern Garter Snake	Thamnophis sirtalis
	Common King Snake	Lampropeltis getulus getulus

	Southern Black Racer	Coluber constrictor priapus
	Everglades Racer	Coluber constrictor paludicola
	Everglades Rat Snake	Elaphe obsoleta rossa lleni

428 - CABBAGE PALM

	Common Name	Scientific Name
Birds	Red-eyed Vireo	Vireo olivaceus
	Great Crested Flycatcher	Myiarchus crinitus
	Northern Mockingbird	Mimus polyglottos
	Carolina Wren	Thryothorus ludovicianus
	Yellow-billed Cuckoo	Coccyzua americanus
	Red-bellied Woodpecker	Melanerpes carolinus
	Common Flicker	Colaptes aurates
	Blue-gray Gnatcatcher	Polioptila caeurulea
	Rufous-sided Towhee	Pipilo erythrophthalmus
	Northern Bobwhite	Colinus virginianus
	Red-Shouldered Hawk	Buteo lineatus
	Downy Woodpecker	Picoides pubescens
	Hairy Woodpecker	Picoides villosus
	*Crested Caracara	Polyborus plancus
Mammals	White-tailed Deer	Odocoileus virginianus
	Bob Cat	Lynx canadensis
	Nine-banded Armadillo	Dasypus novemcinctus
	Raccoon	Procyon lotor
	Opossum	Didelphis marsupialis
	Eastern Woodrat	Neotoma floridana
	Striped Skunk	Mephitis mephitis
	Eastern Gray Squirrel	Sciurus carolinensis
	Eastern Cottontail	Sylvilagus floridanu
	Hispid Cotton Rat	Sigmondon hispidus
	Wild Hog	Sus scrofa
Reptiles	Green Anole	Anolis carolinensis
	Southeastern Five-lined Skink	Eumeces inexpectatus
	Six-lined Racerunner	Cnemidophorus sexlineatus sexlineatus
	*Eastern Indigo Snake	Drymarchon corais couperi
	Eastern Coachwhip	Masticophis flagellum
	Dusky Pigmy Rattlesnake	Sistrurus miliarius barbouri
	Eastern Diamondback Rattlesnake	Crotalus adamanteus
	Southern Black Racer	Coluber constrictor priapus
	Yellow Rat Snake	Elaphe obsoleta
	Cuban Brown Anole	Anolis sagrei

Amphibians	Chorus Frog	Pseudacris nigrita
	Cricket Frog	Acris gryllus
	Oak Toad	Bufo quercicus
	Southern Toad	Bufo terrestris
	Green Treefrog	Hyla cinerea
	Pinewoods Treefrog	Hyla femoralis
	Squirrel Treefrog	Hyla squirella

512 - STREAM/FRESHWATER

	Common Name	Scientific Name
Birds	*Bald Eagle	Haliaeetus leucocephalus
	Anhinga	Anhinga anhinga
	Osprey	Pandion haliaetus
	Pied-billed Grebe	Podilymbus podiceps
	Great Blue Heron	Ardea herodias
	Great Egret	Casmerodius albus
	*Snowy Egret	Egretta thula
	Belted Kingfisher	Megaceryle akyon
	Common Moorhen	Gallinula chloropus
	*Limpkin	Aramus guarauna
	Wood Duck	Aix sponsa
	Ring-necked Duck	Aythya collaris
	American Redstart	Setophaga ruticilla
	Green-backed Heron	Butorides striatus
	Black-crowned Night-Heron	Nycticorax nycticorax
	*Wood Stork	Mycteria americana
	*Little Blue Heron	Egretta caerula
	*Tricoloried Heron	Egretta tricolor
Mammals	River Otter	Latra canadensis
	Raccoon	Procyon lotor
	Opossum	Didelphis marsupialis
	*Everglades Mink	Mustela vison evergladensis
Amphibians	Green Treefrog	Hyla cinerea
	Bull Frog	Rana catesbeiana
	Pig Frog	Rana grylio
	Southern Leopard Frog	Rana utircularia
Reptiles	*American Alligator	Alligator mississippiensis
	Snapping Turtle	Chelydra serpentina
	Soft-shelled Turtle	Trionyx ferox
	Red-bellied Turtle	Chrysemys nelsoni
	Eastern Cottonmouth	Agkistrodon piscivorus
	Brown Water Snake	Nerodia taxispilot
	Stinkpot	Sternotherus odoratus
	Banded Water Snake	Natrix spp.

	Ribbon Snake	Thamnophis sauritis sackeni
	Chicken Turtle	Deirochelys reticularia
	Striped Mud Turtle	Kinosternon bauri

542 - ESTUARINE WATERS

	Common Name	Scientific Name
Birds	*Bald Eagle	Haliaeetus leucocephalus
	Anhinga	Anhinga anhinga
	Osprey	Pandion haliaetus
	*Brown Pelican	Pelecanus occidentalis
	Lesser Scaup	Aytha affinis
	Pied-billed Grebe	Podilymbus podiceps
	Red-breasted Merganser	Mergus serrator
	American Coot	Fulica americana
	Great Blue Heron	Ardea herodias
	Great Egret	Casmerodius albus
	*Snowy Egret	Egretta thula
	*Least Tern	Sterna antillarum
	Black Skimmer	Rynchops niger
	Laughing Gull	Lavus atricilla
	Ring-billed Gull	Larus delawarensis
	Fish Crow	Corvus ossifragus
	Boat-tailed Grackle	Quiscalus major
	Spotted Sandpiper	Actitus macularia
	Belted Kingfisher	Megaceryle akyon
	Blue-winged Teal	Anas discors
	Double-crested Cormorant	Phalacrocorax auritus
	Black-crowned Night-Heron	Nycticorax nycticorax
	*Little Blue Heron	Egretta caerulea
	*Tri-colored Heron	Hydranassa tricolor
	*Reddish Egret	Egretta rufescens
	*Roseate Spoonbill	Ajaia ajaja
	White Ibis	Eudocimus albus
	*American Oystercatcher	Haematopus palliatus
	Royal Tern	Sterna maxima
	Common Tern	Sterna hirundo
	Snowy Plover	Charadrius alexadrinus
	*Piping Plover	Charadrius melodus
	Sanderling	Calidris alba
	Dunlin	Calidris alpina
	Willet	Catoptrophorus semipalmatus
	Ruddy Turnstone	Arenaria interpres
	Wilson's Plover	Charadrius wilsonia
	Semi-Palmated Plover	Charadrius semipalmatus
	Black-bellied Plover	Pluvialis squatarola
	Black-necked Stilt	Himantopus mexicanus
	Greater Yellowlegs	Tringa melanoleuca
	Lesser Yellowlegs	Tringa falvipes

	American Avocet	Recurvirostra americana
	Short-billed Dowitcher	Limnodromus griseus
	Solitary Sandpiper	Tringa solitaria
	Western Sandpiper	Calidris mauri
	Least Sandpiper	Calidris minutilla
	Semi-palmated Sandpiper	Calidris pusilla
	American White Pelican	Pelecanus erythrorhynchos
	Common Loon	Gavia immer
	*Wood Stork	Mycleria americana
	*Roseate Tern	Sterna dougalli
Mammals	*West Indian Manatee	Trichechus manatus
	Bottlenosed Dolphin	Tursiops truncatus
	River Otter	Lutra canadensis
	Raccoon	Procyon lotor
	Virginia Opossum	Didelphis virginiana
	*Sperm Whale	Physeter catodon
	*Humpback Whale	Megaptera novaeangliae
Amphibians	Green Treefrog	Hyla cinerea
	Bull Frog	Rana catesbeiana
	Pig Frog	Rana grylio
	Southern Leopard Frog	Rana utircularia
Reptiles	Diamondback Terrapin	Malachemys terrapin
	*American Alligator	Alligator mississippiensis
	Managrove Water Snake	Natrix fasciata
	Eastern Cottonmouth	Agkistrodon piscivorus
	*Atlantic Loggerhead Sea Turtle	Caretta caretta caretta
	*Leatherback Sea Turtle	Dermochelys coriacea
	*Atlantic Hawksbill Sea Turtle	Eretmochelys imbricata
	*Atlantic Ridley Sea Turtle	Lopidochelys kempi

611 - COASTAL BAY HAMMOCK

	Common Name	Scientific Name
Birds	Great Crested Flycatcher	Myiarchus crinitus
	Carolina Wren	Thryothorus ludovicianus
	Yellow-bellied Cuckoo	Coccyzus americanus
	Red-bellied Woodpecker	Melanerpes carolinus
	Common Flicker	Colaptes aurates
	Blue-gray Gnatcatcher	Polioptila caeurulea
	Red-shouldered Hawk	Buteo lineatus
	Red-eyed Vireo	Vireo olivaceus
	Barred Owl	Strix varia
	Chuck-will's-widow	Caprimulgus carolinensis
	Pine Warbler	Dendroica pinus
	Gray Catbird	Dumetella carolinensis

	Northern Cardinal	Cardinalis cardinalis
	Tufted Titmouse	Parus bicolor
	Piliated Woodpecker	Dryocopus pileatus
	American Redstart	Setophaga ruticilla
	Swamp Sparrow	Melospiza georgiana
	American Woodcock	Scolopax minor
	Yellow-throated Warbler	Dendroica dominica
	Red-tailed Hawk	Buteo jammaicensis
	Ruby-throated Hummingbird	Archilochus colubris
	*Limpkin	Aramus guarauna
	*Wood Stork	Mycteria americana
Mammals	Raccoon	Procyon lotor
	Opossum	Didelphis marsupialis
	Shorttailed Shrew	Blarina brevicauda
	Wild Hog	Sus scrofa
	White-tailed Deer	Odocoileus virginianus
	Eastern Gray Squirrel	Sciurus carolinensis
	*Mangrove Fox Squirrel	Sciurus niger avicennia
	Southern Flying Squirrel	Glaucomys volans
	Hispid Cotton Rat	Sigmodon hispidus
	Cotton Mouse	Peromyscus gossypinus
	Least Shrew	Cryptotis parva
	Marsh Rabbit	Sylvilagus palustris
	Rice Rat	Oryzomys palustris
Reptiles	*American Alligator	Alligator mississippiensis
	Snapping Turtle	Chelydra serpentina
	Soft-shelled Turtle	Trionyx ferox
	Red-bellied Turtle	Chrysemys nelsoni
	Eastern Cottonmouth	Agkistrodon piscivorus
	Brown Water Snake	Nerodia taxispilota
	Musk Turtle	Sternotherus odoratus
	Ribbon Snake	Thamnophis sauritis sackeni
	Chicken Turtle	Deirochelys reticularia
	Striped Mud Turtle	Kinosternon bauri
	Florida Mud Turtle	Kinosternon subrubrum
	Florida Cooter	Chrysemys floridana
	Green Anole	Anolis carolinensis
	Southeastern Five-lined Skink	Eumeces inexpectatus
	*Eastern Indigo Snake	Drymarchon corais couperi
	Dusky Pigmy Rattlesnake	Sistrurus miliarius barbouri
	Eastern Diamondback Rattlesnake	Crotalus adamanteus
	Southern Black Racer	Coluber constrictor priapus
	Yellow Rat Snake	Elaphe obsoleta
	Green Water Snake	Nerodia cyclopion
	Florida Water Snake	Nerodia sipedon

	Eastern Garter Snake	Thamnophis sirtalis
	Southern Ringneck Snake	Diadophis punctatus
	Rough Green Snake	Opheodrys aestivus
	Florida Crowned Snake	Cantilla coronata
	Ribbon Snake	Thamnophis sauritis sackeni
	Striped Swamp Snake	Liodytes alleni
	Mud Snake	Farancia abacura
	Green Anole	Anolis carolinensis
Amphibians	Greater Siren	Siren lacertina
	Amphiuma	Amphiuma means
	Eastern Spadefoot Toad	Scaphiopus holbrooki
	Greenhouse Frog	Eleutherodactylus ricordi
	Southern Toad	Bufo terrestris
	Eastern Narrow-mouthed Toad	Gastrophryne carolinensis
	*Florida Gopher Frog	Rana areolata aesopus
	Southern Leopard Frog	Rana utricularia
	Oak Toad	Bufo quercicus
	Green Treefrog	Hyla cinerea
	Squirrel Treefrog	Hyla squirella
	Pine Woods Treefrog	Hyla femoralis
	Barking Treefrog	Hyla gratiosa
	Cuban Treefrog	Hyla septentrionalis
	Florida Chorus Frog	Pseudacris nigrita
	Cricket Frog	Acris gryllus
	Pig Frog	Rana grylio
	Peninsula Newt	Diemictylus viridenscens
	Dwarf Salamander	Manculus quadridigitatus

612 - MANGROVE SWAMP

	Common Name	Scientific Name
Birds	*Wood Stork	Mycteria americana
	Peregrine Falcon	Falco peregrinus
	*Brown Pelican	Pelecanus occidentalis
	Great Egret	Casmerodius albus
	*Snowy Egret	Egretta thula
	Gray Kingbird	Tyrannus dominicensis
	Black-whiskered Vireo	Vireo altiloquus
	Red-shouldered Hawk	Buteo lineatus
	Red-bellied Woodpecker	Melanerpes carolinus
	White-eyed Vireo	Vireo griseus
	Black-and-white Warbler	Mniotilta varia
	Mangrove Cuckoo	Coccyzus minor
	Gray Catbird	Dumetella carolinensis
	Great Blue Heron	Ardea herodias
	*Little Blue Heron	Egretta caerulea
	*Tri-colored Heron	Hydranassa tricolor
	*Reddish Egret	Egretta rufescens
	*Roseate Spoonbill	Ajaia ajaja

	White Ibis	Eudocimus albus
	Red-winged Blackbird	Agelaius phoeniceus
	Palm Warbler	Dendroica palmarum
	Yellow Warbler	Dendroica petechia
	Common Yellowthroat	Geothlypis trichas
	Spotted Sandpiper	Actitus macularia
	Yellow-throated Warbler	Dendroica dominica
	Double-Crested Cormorant	Phalacrocorax auritus
	Anhinga	Anhinga anhinga
	Osprey	Pandion haliaetus
	Belted Kingfisher	Megaceryle akyon
	Green-backed Heron	Butorides striatus
	Black-Crowned Night Heron	Nycticorax nycticorax
	Yellow-Crowned Night Heron	Nyctanassa violacea
	King Rail	Rallus elgans
	Clapper Rail	Rallus longirostris
	*Mangrove Clapper Rail	Rallus longirostris insularum
	*Swallow-tailed Kite	Elanoides forficatus
	Magnificent Frigatebird	Fregata magnificens
	*Bald Eagle	Haliaeetus leucocephalus
	*American Oystercatcher	Haematopus palliatus
	*Least Tern	Sterna antillarum
	*Roseate Tern	Sterna dougalli
Mammals	Raccoon	Procyon lotor
	Opossum	Didelphis marsupialis
	White-tailed Deer	Odocoileus virginianus
	Hispid Cotton Rat	Sigmodon hispidus
	Marsh Rabbit	Sylvilagus palustris
	Bob Cat	Lynx canadensis
	Striped Skunk	Mephitis mephitis
	Black Rat	Rattus rattus
	*West Indian Manatee	Trichechus manatus Latirostris
Reptiles	*American Alligator	Alligator mississippiensis
	Soft-shelled Turtle	Trionyx ferox
	Green Anole	Anolis carolinensis
	Cuban Brown Anole	Anolis sagrei
	Green Water Snake	Nerodia cyclopion
	Florida Mud Turtle	Kinosternon subrubrum
	*Green Sea Turtle	Chelonia mydas
	*Atlantic Hawksbill Sea Turtle	Eretmochelys imbricata
	*Atlantic Loggerhead Sea Turtle	Caretta caretta caretta
	Mangrove Water Snake	Nerodia compressicauda
	*American Crocodile	Crocodylus acutus
	Giant Toad	Bufo marinus
	Diamonadback Terrapin	Maleclemys terrapin

Amphibians	Squirrel Treefrog	Hyla squirella
	Cuban Treefrog	Hyla septentrionalis

614/617 - STREAM SWAMP/MIXED WETLAND HARDWOODS

	Common Name	Scientific Name
Birds	*Wood Stork	Mycteria americana
	Great Egret	Casmerodius albus
	*Snowy Egret	Egretta thula
	Gray Kingbird	Tyrannus dominicensis
	Red-shouldered Hawk	Buteo lineatus
	Red-bellied Woodpecker	Melanerpes carolinus
	White-eyed Vireo	Vireo griseus
	Great Blue Heron	Ardea herodias
	White Ibis	Eudocimus albus
	Yellow-throated Warbler	Dendroica dominica
	Anhinga	Anhinga anhinga
	Belted Kingfisher	Megaceryle akyon
	Green-backed Heron	Butorides striatus
	Black-Crowned Night Heron	Nycticorax nycticorax
	Yellow-Crowned Night Heron	Nyctanassa violacea
	*Swallow-tailed Kite	Elanoides forficatus
	*Limpkin	Aramus guarauna
	Glossy Ibis	Plegadis falcinellus
	Great Crested Flycatcher	Myiarchus crinitus
	Common Flicker	Colaptes aurates
	Blue-gray Gnatcatcher	Polioptila caeurulea
	Red-eyed Vireo	Vireo olivaceus
	Barred Owl	Strix varia
	Chuck-will's-widow	Caprimulgus carolinensis
	Northern Cardinal	Cardinalis cardinalis
	Tufted Titmouse	Parus bicolor
	Piliated Woodpecker	Dryocopus pileatus
	American Redstart	Setophaga ruticilla
	Swamp Sparrow	Melospiza georgiana
	American Woodcock	Scolopax minor
	Red-tailed Hawk	Buteo jammaicensis
	Ruby-throated Hummingbird	Archilochus colubris
	Eastern Screech Owl	Ottus asio
	Yellow-billed Cuckoo	Coccyzus americanus
	American Robin	Turdus migratorius
	Downy Woodpecker	Picoides pubescens
	Hairy Woodpecker	Picoides villosus
	Yellow-rumped Warbler	Dendroica coronata
	Common Night Hawk	Chordeiles minor
	Carolina Wren	Thryothorus ludovicianus
	Tree Swallow	Iridoprocne bicolor
	Common Grackle	Quiscalus quiscula

	Wood Duck	Aix sponsa
	American Bittern	Botaurus lentiginosus
	*Bald Eagle	Haliaeetus leucocephalus
	*Little Blue Heron	Egretta caerulea
	*Tricolored Heron	Egretta tricolor
Mammals	Red Bat	Lasiurus borealis
	Eastern Mole	Scalopus aquaticus
	Raccoon	Procyon lotor
	Opossum	Didelphis marsupialis
	Shorttailed Shrew	Blarina brevicauda
	White-tailed Deer	Odocoileus virginianus
	Eastern Gray Squirrel	Sciurus carolinensis
	*Mangrove Fox Squirrel	Sciurus niger avicennia
	Southern Flying Squirrel	Glaucomys volans
	Hispid Cotton Rat	Sigmodon hispidus
	Cotton Mouse	Peromyscus gossypinus
	Least Shrew	Cryptotis parva
	Marsh Rabbit	Sylvilagus palustris
	Marsh Rice Rat	Claucomys volans
	Eastern Gray Fox	Urocyon cineroargenteus
	Eastern Cottontail	Sylvilagus floridanu
	Black Bear	Ursus americanus
	*Florida Black Bear	Ursus americanus floridanus
	*Florida Panther	Felis concolor coryi
	Striped Skunk	Mephitis mephitis
	Spotted Skunk	Spilogale putoruis
	River Otter	Latra canadensis
	Bob Cat	Lynx canadensis
	*Everglades Mink	Mustela vison evergladensis
	*Florida Weasel	Mustela frenata peninsulae
	Eastern Woodrat	Neotoma floridana
	*Round-tailed Muskrat	Neofiber alleni
Amphibians	Greater Siren	Siren lacertina
	Amphiuma	Amphiuma means
	Eastern Spadefoot Toad	Scaphiopus holbrooki
	Greenhouse Frog	Eleutherodactylus ricordi
	Southern Toad	Bufo terrestris
	Eastern Narrow-mouthed Toad	Gastrophryne carolinensis
	*Florida Gopher Frog	Rana areolata aesopus
	Southern Leopard Frog	Rana utricularia
	Oak Toad	Bufo quercicus
	Green Treefrog	Hyla cinerea
	Squirrel Treefrog	Hyla squirella
	Pine Woods Treefrog	Hyla femoralis
	Barking Treefrog	Hyla gratiosa
	Cuban Treefrog	Hyla septentrionalis
	Florida Chorus Frog	Pseudacris nigrita
	Cricket Frog	Acris gryllus

	Pig Frog	Rana grylio
	Peninsula Newt	Diemictylus viridenscens
	Dwarf Salamander	Manculus quadridigitatus
Reptiles	*American Alligator	Alligator mississippiensis
	Snapping Turtle	Chelydra serpentina
	Soft-shelled Turtle	Trionyx ferox
	Red-bellied Turtle	Chrysemys nelsoni
	Eastern Cottonmouth	Agkistrodon piscivorus
	Brown Water Snake	Nerodia taxispilota
	Musk Turtle	Sternotherus odoratus
	Ribbon Snake	Thamnophis sauritis sackeni
	Chicken Turtle	Deirochelys reticularia
	Striped Mud Turtle	Kinosternon bauri
	Florida Mud Turtle	Kinosternon subrubrum
	Florida Cooter	Chrysemys floridana
	Green Anole	Anolis carolinensis
	Southeastern Five-lined Skink	Eumeces inexpectatus
	*Eastern Indigo Snake	Drymarchon corais couperi
	Dusky Pigmy Rattlesnake	Sistrurus miliarius barbouri
	Eastern Diamondback Rattlesnake	Crotalus adamanteus
	Southern Black Racer	Coluber constrictor priapus
	Yellow Rat Snake	Elaphe obsoleta
	Green Water Snake	Nerodia cyclopion
	Florida Water Snake	Nerodia sipedon
	Eastern Garter Snake	Thamnophis sirtalis
	Southern Ringneck Snake	Diadophis punctatus
	Rough Green Snake	Opheodrys aestivus
	Florida Crowned Snake	Cantilla coronata
	Ribbon Snake	Thamnophis sauritis sackeni
	Striped Swamp Snake	Liodytes alleni
	Mud Snake	Farancia abacura

621 - CYPRESS

	Common Name	Scientific Name
Birds	*Wood Stork	Mycteria americana
	Great Egret	Casmerodius albus
	Red-shouldered Hawk	Buteo lineatus
	Red-bellied Woodpecker	Melanerpes carolinus
	Great Blue Heron	Ardea herodias
	White Ibis	Eudocimus albus
	Green-backed Heron	Butorides striatus
	*Swallow-tailed Kite	Elanoides forficatus
	Blue-gray Gnatcatcher	Polioptila caeurulea

	Barred Owl	Strix varia
	Chuck-will's-widow	Caprimulgus carolinensis
	Northern Cardinal	Cardinalis cardinalis
	Tufted Titmouse	Parus bicolor
	Piliated Woodpecker	Dryocopus pileatus
	Red-tailed Hawk	Buteo jammaicensis
	Yellow-billed Cuckoo	Coccyzus americanus
	Common Night Hawk	Chordeiles minor
	Carolina Wren	Thryothorus ludovicianus
	Tree Swallow	Iridoprocne bicolor
	Common Grackle	Quiscalus quiscula
	Yellow-bellied Sapsucker	Sphyrapicus varius
	Eastern Phoebe	Sayornis phoebe
	American Robin	Turdus migratorius
	*Little Blue Heron	Egretta caerulea
	Great Horned Owl	Bubo virginianus
	Northern Mockingbird	Mimus polyglottos
	Brown Thrasher	Toxostoma rufum
	Prothonotary Warbler	Protonotaria citrea
	Northern Parula	Parula americana
	Pine Warbler	Dendroica pinus
	*Limpkin	Aramus guarauna
	*Bald Eagle	Haliaeetus leucocephalus
	*Snowy Egret	Egretta thula
	*Tricolored Heron	Egretta tricolor
Mammals	Evening Bat	Nycticrius humeralis
	Black Bear	Ursus americanus
	*Florida Black Bear	Ursus americanus floridanus
	Raccoon	Procyon lotor
	White-tailed Deer	Odocoileus virginianus
	Eastern Gray Squirrel	Sciurus carolinensis
	Hispid Cotton Rat	Sigmodon hispidus
	Cotton Mouse	Peromyscus gossypinus
	Marsh Rabbit	Sylvilagus palustris
	Striped Skunk	Mephitis mephitis
	River Otter	Latra canadensis
	Bob Cat	Lynx canadensis
	*Florida Panther	Felis concolor coryi
	Mink	Mustela vison
	*Everglades Mink	Mustela vison lutensis
	Wild Hog	Sus scrofa
	*Florida Weasel	Mustela frenata pennsulae
	*Round-tailed Muskrat	Neofiber alleni
Amphibians	Greater Siren	Siren lacertina
	Amphiuma	Amphiuma means
	Eastern Spadefoot Toad	Scaphiopus holbrooki
	Greenhouse Frog	Eleutherodactylus ricordi
	Southern Toad	Bufo terrestris
	Eastern Narrow-mouthed Toad	Gastrophryne carolinensis
	*Florida Gopher Frog	Rana areolata aesopus

	Southern Leopard Frog	Rana utricularia
	Oak Toad	Bufo quercicus
	Green Treefrog	Hyla cinerea
	Squirrel Treefrog	Hyla squirella
	Pine Woods Treefrog	Hyla femoralis
	Barking Treefrog	Hyla gratiosa
	Cuban Treefrog	Hyla septentrionalis
	Florida Chorus Frog	Pseudacris nigrita
	Cricket Frog	Acris gryllus
	Pig Frog	Rana grylio
	Green Anole	Anolis carolinensis
	Peninsula Newt	Diemictylus viridenscens
	Dwarf Salamander	Manculus quadridigitatus
Reptiles	*American Alligator	Alligator mississippiensis
	Snapping Turtle	Chelydra serpentina
	Soft-shelled Turtle	Trionyx ferox
	Red-bellied Turtle	Chrysemys nelsoni
	Eastern Cottonmouth	Agkistrodon piscivorus
	Brown Water Snake	Nerodia taxispilota
	Musk Turtle	Sternotherus odoratus
	Ribbon Snake	Thamnophis sauritis sackeni
	Chicken Turtle	Deirochelys reticularia
	Striped Mud Turtle	Kinosternon bauri
	Florida Mud Turtle	Kinosternon subrubrum
	Florida Cooter	Chrysemys floridana
	Green Anole	Anolis carolinensis
	Southeastern Five-lined Skink	Eumeces inexpectatus
	*Eastern Indigo Snake	Drymarchon corais couperi
	Dusky Pigmy Rattlesnake	Sistrurus miliarius barbouri
	Eastern Diamondback Rattlesnake	Crotalus adamanteus
	Southern Black Racer	Coluber constrictor priapus
	Yellow Rat Snake	Elaphe obsoleta
	Green Water Snake	Nerodia cyclopion
	Florida Water Snake	Nerodia sipedon
	Eastern Garter Snake	Thamnophis sirtalis
	Southern Ringneck Snake	Diadophis punctatus
	Rough Green Snake	Opheodrys aestivus
	Florida Crowned Snake	Cantilla coronata
	Ribbon Snake	Thamnophis sauritis sackeni
	Striped Swamp Snake	Liodytes alleni
	Mud Snake	Farancia abacura

624 - CYPRESS - PINE - CABBAGE PALM (Cypress dominant overstory)

	Common Name	Scientific Name
Birds	Red-shouldered Hawk	Buteo lineatus
	Red-bellied Woodpecker	Melanerpes carolinus
	Blue-gray Gnatcatcher	Polioptila caeurulea
	Barred Owl	Strix varia
	Chuck-will's-widow	Caprimulgus carolinensis
	Northern Cardinal	Cardinalis cardinalis
	Tufted Titmouse	Parus bicolor
	Piliated Woodpecker	Dryocopus pileatus
	Yellow-billed Cuckoo	Coccyzus americanus
	Common Night Hawk	Chordeiles minor
	Carolina Wren	Thryothorus ludovicianus
	Great Horned Owl	Bubo virginianus
	White-eyed Vireo	Vireo griseus
	Yellow-throated Warbler	Dendroica dominica
	Great Crested Flycatcher	Myiarchus crinitus
	Common Flicker	Colaptes aurates
	Red-eyed Vireo	Vireo olivaceus
	American Redstart	Setophaga ruticilla
	Eastern Screech Owl	Ottus asio
	Downy Woodpecker	Picoides pubescens
	Hairy Woodpecker	Picoides villosus
	*Limpkin	Aramus guarauna
	*Bald Eagle	Haliaeetus leucocephalus
	*Southeastern Kestrel	Falco sparverius paulus
Mammals	Eastern Mole	Scalopus aquaticus
	Raccoon	Procyon lotor
	Virginia Opossum	Didelphis virginiana
	Shorttailed Shrew	Blarina brevicauda
	White-tailed Deer	Odocoileus virginianus
	Eastern Gray Squirrel	Sciurus carolinensis
	*Mangrove Fox Squirrel	Sciurus niger avicennia
	Southern Flying Squirrel	Glaucomys volans
	Hispid Cotton Rat	Sigmodon hispidus
	Least Shrew	Cryptotis parva
	Eastern Gray Fox	Urocyon cineroargenteus
	Black Bear	Ursus americanus
	*Florida Black Bear	Ursus americanus floridanus
	Striped Skunk	Mephitis mephitis
	Spotted Skunk	Spilogale putoruis
	Bob Cat	Lynx canadensis
	*Florida Panther	Felis concolor coryi
	Nine-banded Armadillo	Dasypus novemcinctus
	Wild Hog	Sus scrofa
	Evening Bat	Nycticrius humeralis
	Black Rat	Rattus rattus
	*Florida Weasel	Mustela frenata lutensis

Amphibians	Greater Siren	Siren lacertina
	Amphiuma	Amphiuma means
	Eastern Spadefoot Toad	Scaphiopus holbrooki
	Greenhouse Frog	Eleutherodactylus ricordi
	Southern Toad	Bufo terrestris
	Eastern Narrow-mouthed Toad	Gastrophryne carolinensis
	*Florida Gopher Frog	Rana areolata aesopus
	Southern Leopard Frog	Rana utricularia
	Oak Toad	Bufo quercicus
	Green Treefrog	Hyla cinerea
	Squirrel Treefrog	Hyla squirella
	Pine Woods Treefrog	Hyla femoralis
	Barking Treefrog	Hyla gratiosa
	Cuban Treefrog	Hyla septentrionalis
	Florida Chorus Frog	Pseudacris nigrita
	Cricket Frog	Acris gryllus
	Pig Frog	Rana grylio
	Peninsula Newt	Diemictylus viridenscens
	Dwarf Salamander	Manculus quadridigitatus
Reptiles	*American Alligator	Alligator mississippiensis
	Snapping Turtle	Chelydra serpentina
	Soft-shelled Turtle	Trionyx ferox
	Red-bellied Turtle	Chrysemys nelsoni
	Eastern Cottonmouth	Agkistrodon piscivorus
	Brown Water Snake	Nerodia taxispilota
	Musk Turtle	Sternotherus odoratus
	Ribbon Snake	Thamnophis sauritis sackeni
	Chicken Turtle	Deirochelys reticularia
	Striped Mud Turtle	Kinosternon bauri
	Florida Mud Turtle	Kinosternon subrubrum
	Florida Cooter	Chrysemys floridana
	Green Anole	Anolis carolinensis
	Southeastern Five-lined Skink	Eumeces inexpectatus
	*Eastern Indigo Snake	Drymarchon corais couperi
	Dusky Pigmy Rattlesnake	Sistrurus miliarius barbouri
	Eastern Diamondback Rattlesnake	Crotalus adamanteus
	Southern Black Racer	Coluber constrictor priapus
	Yellow Rat Snake	Elaphe obsoleta
	Green Water Snake	Nerodia cyclopion
	Florida Water Snake	Nerodia sipedon
	Eastern Garter Snake	Thamnophis sirtalis
	Southern Ringneck Snake	Diadophis punctatus
	Rough Green Snake	Opheodrys aestivus
	Florida Crowned Snake	Cantilla coronata
	Ribbon Snake	Thamnophis sauritis sackeni

	Striped Swamp Snake	Liodytes alleni
	Mud Snake	Farancia abacura

641/643 - FRESHWATER MARSH/WET PRAIRIE (Fresh)

	Common Name	Scientific Name
Birds	*Wood Stork	Mycteria americana
	Great Egret	Casmerodius albus
	*Snowy Egret	Egretta thula
	Red-shouldered Hawk	Buteo lineatus
	White-eyed Vireo	Vireo griseus
	Great Blue Heron	Ardea herodias
	*Little Blue Heron	Egretta caerulea
	*Tri-colored Heron	Hydranassa tricolor
	White Ibis	Eudocimus albus
	Glossy Ibis	Plegadis falcinellus
	Red-winged Blackbird	Agelaius phoeniceus
	Common Yellowthroat	Geothlypis trichas
	Clapper Rail	Rallus longirostris
	*Swallow-tailed Kite	Elanoides forficatus
	Pied-billed Grebe	Podilymbus podiceps
	Common Moorhen	Gallinula chloropus
	*Limpkin	Aramus guarauna
	American Bittern	Botaurus lentginosus
	Least Bittern	Ixobrychus exilis
	*Sandhill Crane	Grus canadensis pratensis
	American Coot	Fulica americana
	Common Snipe	Capella gallinago
	Tree Swallow	Iridoprocne bicolor
	Chuck-will's-widow	Caprimulgus carolinensis
	Common Night Hawk	Chordeiles minor
	Carolina Wren	Thryothorus ludovicianus
	Blue-gray Gnatcatcher	Polioptila caeurulea
	Eastern Meadowlark	Sturnella magna
	Marsh Wren	Cistothorus spp.
	Solitary Sandpiper	Tringa solitaria
	Prothonotary Warbler	Protonotaria citrea
	Northern Harrier	Circus cyaneus
	Great Horned Owl	Bubo virginianus
	Barred Owl	Strix varia
	Great Crested Flycatcher	Myiarchus crinitus
	Tree Swallow	Iridoprocne bicolor
	Killdeer	Charadrium vociferus
	Black Vulture	Coragyps atratus
	Turkey Vulture	Cathartes aura
Mammals	Raccoon	Procyon lotor
	Virginia Opossum	Didelphis virginiana
	Hispid Cotton Rat	Sigmodon hispidus
	Wild Hog	Sus scrofa

	River Otter	Latra canadensis
	Marsh Rabbit	Sylvilagus palustris
	*Round-tailed Muskrat	Neofiber alleni
	Least Shrew	Cryptotis parva
	Shorttail Shrew	Blarina brevicauda
	Florida Water Rat	Neofiber alleni
	Rice Rat	Oryzomys palustris
	Opossum	Didelphis marsupialis
	Eastern Gray Fox	Urocyon cineroargenteus
	Striped Skunk	Mephitis mephitis
	Spotted Skunk	Spilogale putoruis
	Evening Bat	Nycticrius humeralis
	Marsh Rice Rat	Claucomys volans
	*Florida Panther	Felis concolor coryi
	*Florida Weasel	Mustela frenata pennsulae
	*Round-tailed Muskrat	Neofiber alleni
	*Everglades Mink	Mustela vison evergladensis
Amphibians	Greater Siren	Siren lacertina
	Amphiuma	Amphiuma means
	Eastern Spadefoot Toad	Scaphiopus holbrooki
	Greenhouse Frog	Eleutherodactylus ricordi
	Southern Toad	Bufo terrestris
	Eastern Narrow-mouthed Toad	Gastrophryne carolinensis
	*Florida Gopher Frog	Rana areolata aesopus
	Southern Leopard Frog	Rana utricularia
	Oak Toad	Bufo quercicus
	Green Treefrog	Hyla cinerea
	Squirrel Treefrog	Hyla squirella
	Pine Woods Treefrog	Hyla femoralis
	Barking Treefrog	Hyla gratiosa
	Cuban Treefrog	Hyla septentrionalis
	Florida Chorus Frog	Pseudacris nigrita
	Florida Cricket Frog	Acris gryllus dorsalis
	Pig Frog	Rana grylio
	Dwarf Salamander	Manculus quadridigitatus
	Cricket Frog	Acris gryllus
	Little Grass Frog	Hyla ocularis
Reptiles	*American Alligator	Alligator mississippiensis
	Snapping Turtle	Chelydra serpentina
	Soft-shelled Turtle	Trionyx ferox
	Red-bellied Turtle	Chrysemys nelsoni
	Eastern Cottonmouth	Agkistrodon piscivorus
	Brown Water Snake	Nerodia taxispilota
	Musk Turtle	Sternotherus odoratus
	Chicken Turtle	Deirochelys reticularia
	Striped Mud Turtle	Kinosternon bauri
	Florida Mud Turtle	Kinosternon subrubrum
	Florida Cooter	Chrysemys floridana
	*Eastern Indigo Snake	Drymarchon corais couperi

Southern Black Racer	Coluber constrictor priapus
Yellow Rat Snake	Elaphe obsoleta
Green Water Snake	Nerodia cyclopion
Florida Water Snake	Nerodia sipedon
Eastern Garter Snake	Thamnophis sirtalis
Southern Ringneck Snake	Diadophis punctatus
Rough Green Snake	Opheodrys aestivus
Striped Swamp Snake	Liodytes alleni
Mud Snake	Farancia abacura
Florida Box Turtle	Terrapene carolina
Florida Brown Snake	Storeria dekayi
Green Anole	Anolis carolinensis
Dusky Pigmy Rattlesnake	Sistrurus miliarius barbouri
South Florida Black Swamp Snake	Seminatrix pygaea
Ribbon Snake	Thamnophis sauritis sackeni
Florida King Snake	Lampropeltis getulis

642 - SALTWATER MARSH

	Common Name	Scientific Name
Birds	Great Blue Heron	Ardea herodias
	*Little Blue Heron	Egretta caerulea
	*Tri-colored Heron	Hydranassa tricolor
	Great Egret	Casmerodius albus
	*Snowy Egret	Egretta thula
	White Ibis	Eudocimus albus
	Boat-tailed Grackle	Quiscalus major
	Black-necked Stilt	Himantopus mexicanus
	American Avocet	Recurvirostra americana
	Northern Harrier	Circus cyaneus
	Sharp-shinned Hawk	Accipiter striatus
	Peregrine Falcon	Falco peregrinus
	Osprey	Pandion haliaetus
	Green-backed Heron	Butorides striatus
	Black-Crowned Night Heron	Nycticorax nycticorax
	Yellow-Crowned Night Heron	Nyctanassa violacea
	Clapper Rail	Rallus longirostris
	Black Rail	Laterallus jamaicensis
	Common Night Hawk	Chordeiles minor
	Marsh Wren	Cistothorus spp.
	Seaside Sparrow	Ammodramus maritimus
	Tree Swallow	Iridoprocne bicolor
	Red-winged Blackbird	Agelaius phoeniceus
	Pied-billed Grebe	Podilymbus podiceps
	American Coot	Fulica americana

		*Brown Pelican	Pelecanus occidentalis
		*Reddish Egret	Egretta rufescens
	**	Lesser Scaup	Arythya affinis
	**	Pintail	Anas acuta
	**	Blue-winged Teal	Anas discors
	**	Green-winged Teal	Anas crecca
	**	American Wigeon	Anas americana
	**	Northern Shoveler	Anas clypeata
	**	Common Loon	Gavia immer
	**	Mottled Duck	Anas fulvigula

** open water in marsh

Mammals		
	Raccoon	Procyon lotor
	Virginia Opossum	Didelphis virginiana
	Hispid Cotton Rat	Sigmodon hispidus
	Marsh Rabbit	Sylvilagus palustris
	Cotton Mouse	Peromyscus gossypinus
	*Sanibel Island Rice Rat	Oryzomys palustris sanibeli
	Insular Cotton Rat	Sigmondon hispidus insulicola
	*West Indian Manatee	Trichechus manatus latirostris
	*Pine Island Rice Rat	Oryzomys palustris planirostris
Reptiles	*American Alligator	Alligator mississippiensis
	Florida Mud Turtle	Kinosternon subrubrum
	Rough Green Snake	Opheodrys aestivus
	Mangrove Water Snake	Nerodia compressicauda
	Diamondback Terrapin	Malachemys terrapin
	Atlantic Saltmarsh Water Snake	Nerodia fasciata inosternon subrubrum

651 - TIDAL FLAT

	Common Name	Scientific Name
Birds	Great Blue Heron	Ardea herodias
	*Little Blue Heron	Egretta caerulea
	*Tri-colored Heron	Hydranassa tricolor
	Great Egret	Casmerodius albus
	*Snowy Egret	Egretta thula
	*Reddish Egret	Egretta rufescens
	*Roseate Spoonbill	Ajaia ajaja
	White Ibis	Eudocimus albus
	*American Oystercatcher	Haematopus palliatus
	Laughing Gull	Larus atricilla
	Ring-billed Gull	Larus delawarensis

	Black Skimmer	Rynchops niger
	Royal Tern	Sterna maxima
	Common Tern	Sterna hirundo
	*Least Tern	Sterna antillarum
	Snowy Plover	Charadrius alexandrinus
	*Piping Plover	Charadrius melodus
	Sanderling	Calidris alba
	Dunlin	Calidris alpina
	Willet	Catoptrophorus semipalmutus
	Ruddy Turnstone	Arenaria interpres
	Wilson's Plover	Charadrius wilsonia
	Semi-palmated Plover	Charadrius semipalmatus
	Black-bellied Plover	Pluvialis squatarola
	Boat-tailed Grackle	Quiscalus major
	Fish Crow	Corvus ossifragus
	Black-necked Stilt	Himantopus mexicanus
	Greater Yellowlegs	Tringa melanoleuca
	Lesser Yellowlegs	Tringa falvipes
	American Avocet	Recurvirostra americana
	Short-billed Dowitcher	Limnodromus griseus
	Spotted Sandpiper	Actitus macularia
	Solitary Sandpiper	Tringa solitaria
	Western Sandpiper	Calidris mauri
	Least Sandpiper	Calidris minutilla
	Semi-palmated Sandpiper	Calidris pusilla
	American White Pelican	Pelecanus erythrorhynchos
	*Brown Pelican	Pelecanus occidentalis
	*Roseate Tern	Sterna dougalli
	*Southeastern Snowy Plover	Charadrius alexandrinus tenuirostris
Mammals	Raccoon	Procyon lotor
	Virginia Opossum	didelphis virginiana

654 - OYSTER BAR

	Common Name	Scientific Name
Birds	Great Blue Heron	Ardea herodias
	*Little Blue Heron	Egretta caerulea
	Great Egret	Casmerodius albus
	*Snowy Egret	Egretta thula
	*American Oystercatcher	Haematopus palliatus
	Willet	Catoptrophorus semipalmatus
	Ruddy Turnstone	Arenaria interpres
	Black-bellied Plover	Pluvialis squatarola
	*Brown Pelican	Pelecanus occidentalis
	*Least Tern	Sterna antillarum
	*Roseate Tern	Sterna dougalli
	*Roseate Spoonbill	Ajaija ajaja
	*Reddish Egret	Egretta rufescens

	*Piping Plover	Charadrius melodius
Mammals	Raccoon	Procyon lotor
Reptiles	Diamondback Terrapin	Malachemys terrapin

911 - SEA GRASS

	Common Name	Scientific Name
Birds	Great Blue Heron	Ardea herodias
	*Little Blue Heron	Egretta caerulea
	*Tri-colored Heron	Hydranassa tricolor
	Great Egret	Casmerodius albus
	*Snowy Egret	Egretta thula
	*Reddish Egret	Egretta rufescens
	*Roseate Spoonbill	Ajaia ajaja
	White Ibis	Eudocimus albus
	*American Oystercatcher	Haematopus palliatus
	Laughing Gull	Larus atricilla
	Ring-billed Gull	Larus delawarensis
	Black Skimmer	Rynchops niger
	Royal Tern	Sterna maxima
	Common Tern	Sterna hirundo
	*Least Tern	Sterna antillarum
	Snowy Plover	Charadrius alexandrinus
	*Piping Plover	Charadrius melodus
	Sanderling	Calidris alba
	Dunlin	Calidris alpina
	Willet	Catoptrophorus semipalmutus
	Ruddy Turnstone	Arenaria interpres
	Wilson's Plover	Charadrius wilsonia
	Semi-palmated Plover	Charadrius semipalmatus
	Black-bellied Plover	Pluvialis squatarola
	Boat-tailed Grackle	Quiscalus major
	Fish Crow	Corvus ossifragus
	Black-necked Stilt	Himantopus mexicanus
	Greater Yellowlegs	Tringa melanoleuca
	Lesser Yellowlegs	Tringa falvipes
	American Avocet	Recurvirostra americana
	Short-billed Dowitcher	Limnodromus griseus
	Spotted Sandpiper	Actitus macularia
	Solitary Sandpiper	Tringa solitaria
	Western Sandpiper	Calidris mauri
	Least Sandpiper	Calidris minutilla
	Semi-palmated Sandpiper	Calidris pusilla
	American White Pelican	Pelecanus erythrorhynchos
	*Brown Pelican	Pelecanus occidentalis
	Red-breasted Merganser	Mergus serrator
	Common Loon	Gavia immer
	Lesser Scaup	Arythya affinis
	Double-crested Cormorant	Phalacrocorax auritus

	Osprey	Pandion haliaetus
	*Bald Eagle	Haliaeetus ieucocephalus
Mammals	*West Indian Manatee	Trichechus manatus
	Bottlenosed Dolphin	Tursiops truncatus
Reptiles	*Atlantic Loggerhead Turtle	Caretta caretta caretta
	*Leatherback Sea Turtle	Dermochelys coriacea
	*Atlantic Hawksbill Sea Turtle	Eretmochelys imbricata
	*Atlantic Ridley Sea Turtle	Lepidochelys kempi

* Indicates those species listed by the State of Florida and the U.S. Fish and Wildlife Service as Endangered, Threatened, or Species of Special Concern

STATUS OF
ENDANGERED, THREATENED AND SPECIES OF SPECIAL CONCERN
LEE COUNTY COASTAL ZONE

BIRDS

Common Name	Scientific Name	FGFWFC	USFWS	FDA
American Oystercatcher	Haematopus palliatus	SSC		
Bald Eagle	Haliaeetus leucocephalus	T	E	
Brown Pelican	Pelecanus occidentalis	SSC		
Crested Caracara	Polyborus plancus	T	UR2	
Florida Scrub Jay	Aphelocoma coerulescens	T	T	
Least Tern	Sterna antillarum	T		
Limpkin	Aramus guarauna	SSC		
Little Blue Heron	Egretta caerula	SSC		
Migrant Loggerhead Shrike	Lanius ludovicianus migrans		UR2	
Piping Plover	Charadrius melodus	T	T	
Red-cockaded Woodpecker	Pecoides borealis	T	E	
Reddish Egret	Egretta rufescens	SSC	UR2	
Roseate Spoonbill	Ajaija ajaja	SSC		
Roseate Tern	Sterna dougalli	T	UR2	
Sandhill Crane	Grus canadensis pratensis	T		
Snowy Egret	Egretta thula	SSC		
Southeastern Kestrel	Falco sparverius paulus	T	UR2	
Southeastern Snowy Plover	Characrius alexandrinus tenuirostris	T	UR2	
Swallow-tailed Kite	Elanoides forficatus		UR2	
Tricolored Heron	Egretta tricolor	SSC		
Wood Stork	Mycteria americana	E	E	

MAMMALS

Common Name	Scientific Name	FGFWFC	USFWS	FDA
Everglades Mink	Mustela vison evergladensis	T	UR2	
Florida Black Bear	Ursus ameicanus floridanus	T	UR2	
Florida Panther	Felis concolor coryi	E	E	
Florida Weasel	Mustela frenate paninsulae	E	E	
Humpback Whale	megaptera novaeangliae	E	E	
Mangrove Fox Squirrel	Sciurus niger avicennia	T	UR2	
Pine Island Rice Rat	Oryzomys palustris planirostris	SSC		
Round-tailed Muskrat	Neofiber alleni		UR2	
Sanibel Island Rice Rat	Oryzomys palustris Sanibeli	SSC	UR2	
Sperm Whale	Physeter catodon	E	E	
West Indian Manatee	Trichechus manatus	E	E	

AMPHIBIANS

Common Name	Scientific name	FGFWFC	USFWS	FDA
Florida Gopher Frog	Rana areolata aesopus	SSC		UR2

FISH

Common Name	Scientific Name	FGFWFC	USFWS	FDA
Common Snook	Centropomus undecimalis	SSC		

REPTILES

Common Name	Scientific Name	FGFWFC	USFWS	FDA
American Alligator	Alligator mississippiensis	SSC	T	
American Crocodile	Crocodulus acutus	E	E	
Atlantic Hawksbill Sea Turtle	Eretmochelys imbricata	E	E	
Atlantic Loggerhead Sea Turtle	Caretta Caretta Caretta	T	T	
Atlantic Ridley Sea Turtle	Lipidochelys kempi	E	E	
Eastern Indigo Snake	Drymarchon corais couperi	T	T	
Florida Scrub Lizard	Sceloporus woodii			UR2
Gopher Tortoise	Gopherus polyphumus	SSC	UR2	
Leatherback Sea Turtle	Dermochelys coriacea	T	T	

FGFWFC - Florida Game and Freshwater Fish Commission
USFWS - U.S. Fish and Wildlife Service
FDA - Florida Department of Agriculture

E - Endangered
T - Threatened
SSC - Species of Special Concern
UR1 - Under Review for the First Time
UR2 - Under Review for the Second Time

APPENDIX IV-V

A Compilation of Major Indicator and Protected Plant Species for Each of the Major Vegetation Communities Within the Lee County Coastal Zone

by

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January 1988

181 - Beaches/Swimming

	Common Name	Scientific Name
Overstory Dominants	*Inkberry	Scaevola plumieri
	*Bay Cedar	Suriana maritima
	Beach Elder	Iva imbricata
	Sea Oats	Uniola paniculata
	Beach Grass	Panicum amarulum
	Sea Grape	Coccoloba uvifera
Understory	*Golden Creeper	Ernodea littoralis
	*Prickly Pear	Opuntia stricta
Other Ground Cover	Seashore Paspalum	Paspalum vaginatum
	Seashore Dropseed	Sporobolus virginicus
	Beach Bean	Canavalia maritima
	Railroad Vine	Ipomoea pes-caprae
	Beach Dune Sunflower	Helianthus debilis
	Sea Purslane	Sesuvium portulacastrum
	Creeping Morning-Glory	Evolvulus alsinoides

320 - Sand Scrub/Oak - Palmetto - Rosemary

	Common Name	Scientific Name
Overstory	Scrub Live Oak	Quercus geminata
	Myrtle Oak	Quercus myrtifolia
	Chapman's Oak	Quercus chapmanii
	Turkey Oak	Quercus laevis
	Bluejack Oak	Quercus incana
	Live Oak	Quercus virginiana
	Dwarf Live Oak	Quercus minima
Midstory	Rosemary	Ceratiola ericoides
	Saw Palmetto	Serenoa repens
	Wireweed/Jointweed	Polygonella polygama
	Huckleberry	Gaylussacia dumosa
	Broomsedge	Andropogon spp.
	Threeawn	Aristida spp.
	Blazing Star	Liatris gracilis
	Runner Oak	Quercus pumila
		Palafoxia feayi
Understory	Gopher Apple	Licania michauxii
	Deer Moss	Cladonia spp.
	*Curtiss Milkweed	Asclepias curtissii
	*Spring Ladies Tresses	Spiranthes vernalis

321 - Palmetto Prairie

	Common Name	Scientific Name
Overstory	Dahoon Holly	Ilex cassine
	Slash Pine	Pinus elliottii
	Scrub Live Oak	Quercus geminata
	Cabbage Palm	Sabal palmetto
	Persimmon	Diospyros virginiana
Midstory	Rusty Lyonia	Lyonia ferruginea
	Fetterbush	Lyonia lucida
	Staggerbush	Lyonia fruiticosa
	Gallberry	Ilex glabra
	Tarflower	Befaria racemosa
	Southern Sumac	Rhus copallina
	American Beautyberry	Callicarpa americana
	Wax Myrtle	Myrica cerifera
	Saw Palmetto	Serenoa repens
	*White Squirrel Banana	Deeringothamnus pulchellus
Understory	Paw Paw	Asimina recticulata
	Runner Oak	Quercus pumila
	Broomsedge	Andropogon spp.
	Pennyroyal	Satureja rigida
	Dwarf Wax Myrtle	Myrica pusilla
	Blueberry	Vaccinium myrsinites
	Panicum Grass	Panicum dichotomum
	Milkwort	Polygala spp.
	*Coontie	Zamia floridana
Vines	Greenbriar	Smilax spp.

322-3229 - Coastal Scrub

	Common Name	Scientific Name
Overstory	Cabbage Palm	Sabal palmetto
	Sea Grape	Coccoloba uvifera
	Buttonwood	Conocarpus erectus
	Strangler Fig	Ficus aurea
	*Wild Olive	Forestiera segregata
Midstory	*Bay Cedar	Suriana maritima
	*Joewood	Jacquinia keyensis
	Cat's Claw	Pithecellobium unguis-cati
	Cocoplum	Chrysobalanus icaco
	*Red Stopper	Eugenia rhombea
	White Stopper	Eugenia axillaris

	Myrsine	Myrsine guianensis
	Marlberry	Ardisia escallonioides
	Spanish Bayonet	Yucca aloifolia
	*Inkberry	Scaevola plumieri
	Beach Elder	Iva imbricata
	Coralbean	Erythrina herbacea
	Necklace Pod	Sophora tomentosa
	Buckthorn	Bumelia reclinata
	*Wild Olive	Forestiera segregata
Understory	Sea Purslane	Sesuvium portulacastrum
	Railroad Vine	Ipomoea pes-caprae
	Paspalum	Paspalum spp.
	Coast Sandspur	Cenchrus incertus
	Muhly Grass	Muhlenbergia capillaris
	Beach Grass	Panicum amarum
	Marsh Hay	Spartina patens
	Sea Oats	Uniola paniculata
	*Prickly Pear	Opuntia spp.
	Ground Cherry	Physalis viscosa

411 - Pine Flatwood

	Common Name	Scientific Name
Overstory	Slash Pine	Pinus elliottii
	Live Oak	Quercus virginiana
	Cabbage Palm	Sabal palmetto
Midstory	Dahoon Holly	Ilex cassine
	Gallberry	Ilex glabra
	Wax Myrtle	Myrica cerifera
	Saw Palmetto	Serenoa repens
	Buckthorn	Bumelia reclinata
	Tarflower	Befaria racemosa
	Southern Sumac	Rhus copallina
	Staggerbush	Lyonia fruiticosa
	Fetterbush	Lyonia lucida
	Rusty Lyonia	Lyonia ferruginea
	*White Squirrel Banana	Deeringothamnus pulchellus
Understory	Broomsedge	Andropogon virginicus
	Muhly Grass	Muhlenbergia capillaris
	Threeawn	Aristida spiciformis
	Panicum Grass	Panicum dichotomum
	Dwarf Wax Myrtle	Myrica pusilla
	Bittermint	Hyptis alata
	Pennyroyal	Satureja rigida
	Dropseed	Paspalum spp.
	Milkwort	Polygala spp.
	*Fakahatchee Burmannia	Burmannia flava

	Common Name	Scientific Name
	*Coontie	Zamia floridana
	*Pineland Panic Grass	Panicum pinetorum
	*Pine Pink	Bletia purpurea
	*Many Flowered Grass Pink	Calopogon multiflorus

414 - Wet Pine Flatwood

	Common Name	Scientific Name
Overstory	Slash Pine	Pinus elliottii
	Bald Cypress	Taxodium distichum
Midstory	Wax Myrtle	Myrica cerifera
	Bald Cypress	Taxodium distichum
Understory	Bog Buttons	Lachnocaulon anceps
	Broomsedge	Andropogon virginicus
	Cyperus Sedge	Cyperus odoratus
	Goldenrod	Solidago spp.
	Hatpin	Eriocaulon compressum
	Panicum Grass	Panicum dichotomum
	Corkwood	Stillingia aquatica
	St. John's-wort	Hypericum galioides
	Swamp Fern	Blechnum serrulatum
	*Fakahatchee Burmannia	Burmannia flava
	*Pineland Panic Grass	Panicum pinetorum
	*Bearded Grass Pink	Calopogon barbatus
	*Pale Grass Pink	Calopogon pallidus
	*Grass Pink	Calopogon tuberosus
	*Slender Ladies Tresses	Spiranthes brevilabris
	*Long Lip Ladies Tresses	Spiranthes longilabris
	*Spring Ladies Tresses	Spiranthes vernalis
	*Michaux's or Long Horned Orchid	Habenaria quinquesta
	*Wild Coco	Eulophea alta

426 - Tropical Hardwood

	Common Name	Scientific Name
Overstory	Gumbo Limbo	Bursera simaruba
	Mastic Tree	Mastichodendron foetidissimum
	Strangler Fig	Ficus aurea
	Wild Tamarind	Lysiloma bahamense
	Jamaican Dogwood	Piscidia piscipula
	Cabbage Palm	Sabal palmetto

	Common Name	Scientific Name
	Laurel Oak	Quercus laurifolia
	Water Oak	Quercus nigra
	Live Oak	Quercus virginiana
Midstory	White Stopper	Eugenia axillaris
	*Red Stopper	Eugenia rhombea
	Marlberry	Ardisia escallonioides
	Myrsine	Myrsine guianensis
	Sea Grape	Coccoloba uvifera
	Wild Lime	Zanthoxylum fagara
	*Satin Leaf	Chrysophyllum oliviforme
	White Indigo Berry	Randia aculeata
	Cat's Claw	Pithecellobium unguis-cati
	*Iguana Hackberry	Celtis iguanaea
	*Spiny Hackberry	Celtis pallida
Understory	Snowberry	Chiococca alba
	Wild Coffee	Psychotria nervosa P. sulzneri
	Panicum Grass	Panicum dichotomum
	Coralbean	Erythrina herbacea
	*Wild Cotton	Gossypium hirsutum
	*Prickly Apple	Cereus gracilis
	*Coontie	Zamia floridana

427 - Oak Hammock

	Common Name	Scientific Name
Overstory	Live Oak	Quercus virginiana
	Laurel Oak	Quercus laurifolia
	Water Oak	Quercus nigra
	Cabbage Palm	Sabal palmetto
	Blue Beech	Carpinus caroliniana
Midstory	Saw Palmetto	Serenoa repens
	Dahoon Holly	Ilex cassine
	Red Bay	Persea borbonia
	Sweet Bay	Magnolia virginiana
	Myrsine	Myrsine guianensis
	Marlberry	Ardisia escallonioides
	American Beautyberry	Callicarpa americana
Understory	Boston Fern	Nephrolepsis exaltata
	Cape Weed	Lippia nodiflora
	Small Cane	Lasiacis divaricata
	Bog Hemp	Boehmeria cylindrica
	Bracken Fern	Pteridium acquilinum var. caudatum
	Chain Fern	Woodwardia virginica
	Wild Coffee	Psychotria nervosa P. sulzneri

	*Golden Polypody Fern	Phlebodium aureum
	*Hand or Adders Tongue Fern	Ophioglossum palmatum
Epiphytes	Resurrection Fern	Polypodium polypodioides
	*Air Plant	Tillandsia fasiculata
	*Air Plant	Tillandsia utriculata
	*Air Plant	Tillandsia valenzuela
	*Air Plant	Tillandsia setacea
	*Air Plant	Tillandsia paucifolia
	*Air Plant	Tillandsia flexuosa
	*Shoestring Fern	Vittaria lineata
	*Butterfly Orchid	Encyclia tampensis
	Bull Moss	Tillandsia recurvata

428 - Cabbage Palm

	Common Name	Scientific Name
Overstory	Cabbage Palm	Sabal palmetto
	Slash Pine	Pinus elliottii
	Live Oak	Quercus virginiana
	Laurel Oak	Quercus laurifolia
Midstory	Saw Palmetto	Serenoa repens
	Wax Myrtle	Myrica cerifera
	American Beautyberry	Callicarpa americana
Understory	Panicum Grass	Panicum dichotomum
	Swamp Fern	Blechnum serrulatum
	*Golden Polypody Fern	Phlebodium aureum
	Bracken Fern	Pteridium aquilinum var. caudatum
	Boston Fern	Nephrolepsis exaltata
	*Hand or Adders Tongue Fern	Ophioglossum palmatum
Vines	Wild Grape	Vitis rotundifolia
	Virginia Creeper	Parthenocissus quinquefolia

511 - River/Tidal

	Common Name	Scientific Name
Dominants	Widgeon Grass	Ruppia maritima
	Shoalweed	Halodule wrightii
	Red Mangrove	Rhizophora mangle
	Black Mangrove	Avicennia germinans
	White Mangrove	Laguncularia racemosa

512 - Stream/Freshwater

	Common Name	Scientific Name
Dominants	Pondweed	Potamegeton spp.
	Najad	Najas quadalupensis
	*Giant Leather Fern	Acrostichum danaeifolium
	Flat Sedge	Cyperus spp.

513 - Tidal Creek

	Common Name	Scientific Name
Dominants	Red Mangrove	Rhizophora mangle
	White Mangrove	Laguncularia racemosa
	Black Mangrove	Avicennia germinans
	Black Rush	Juncus roemeriamus
	*Giant Leather Fern	Acrostichum danaeifolium
	Saltmarsh Cordgrass	Spartina alterniflora
	Widgeon Grass	Ruppia maritima
	Shoalweed	Halodule wrightii
	Seashore Dropseed	Sporobolus virginicus
	Seashore Paspalum	Paspalum vaginatum
	Seashore Saltgrass	Distichlis spicata
	Manatee Grass	Syringodium filiforme
	Turtle Grass	Thalassia testudinum

5411 & 542 - Embayments

	Common Name	Scientific Name
Dominants	Turtle Grass	Thalassia testudinum
	Shoalweed	Halodule wrightii
	Manatee Grass	Syringodium filiforme
	Red Mangrove	Rhizophora mangle
	White Mangrove	Laguncularia racemosa
	Black Mangrove	Avicennia germinans
	Marine Algae	

5412 - Tidal Pond

	Common Name	Scientific Name
Dominants	Widgeon Grass	Ruppia maritima
	Spike Rush	Eleocharis cellulosa
	Black Rush	Juncus roemerianus
	White Mangrove	Laguncularia racemosa

	Red Mangrove	Rhizophora mangle
	Black Mangrove	Avicennia germinans
	Saltwort	Batis maritma

611 - Coastal Bay Hammock

	Common Name	Scientific Name
Overstory	Red Bay	Persea borbonia
	Sweet Bay	Magnolia virginiana
	Laurel Oak	Quercus laurifolia
	Water Oak	Quercus nigra
	Cabbage Palm	Sabal palmetto
	Slash Pine	Pinus elliottii
	Red Maple	Acer rubrum
Midstory	Wax Myrtle	Myrica cerifera
	Dahoon Holly	Ilex cassine
	Primrose Willow	Ludwigia peruviana
	Coastal Plain Willow	Salix caroliniana
Understory	Swamp Fern	Blechnum serrulatum
	Mermaidweed	Proserpinaca palustris
	Spike Rush	Eleocharis cellulosa
	Jack in the Pulpit	Arisaema triphyllum
	*Giant Leather Fern	Acrostichum danaeifolium
	*Royal Fern	Osmunda regalis
	Wild Coffee	Psychotria nervosa P. sulzneri
	*Marsh Fern	Thelypteris palustris
	*Giant Leather Fern	Acrostichum danaeifolium
	*Golden Polypody Fern	Phlebodium aureum

612 - Mangrove Swamp

	Common Name	Scientific Name
Overstory	Red Mangrove	Rhizophora mangle
	White Mangrove	Laguncularia racemosa
	Black Mangrove	Avicennia germinans
	Buttonwood	Conocarpus erectus
Understory	Christmas Berry	Lycium carolinianum
	*Giant Leather Fern	Acrostichum danaeifolium
	Sea Oxeye Daisy	Borrichia frutescens & B. aborescens
	Sea Purslane	Sesuvium portulacastrum
	Saltwort	Batis maritima
	Perennial Glasswort	Salicornia virginica
	*Prickly Apple	Cereus gracilis

614 - Stream Swamp

	Common Name	Scientific Name
Overstory	Laurel Oak	Quercus laurifolia
	Water Oak	Quercus nigra
	Bald Cypress	Taxodium distichum
	Red Maple	Acer rubrum
	Pond Apple	Annona glabra
Midstory	Red Bay	Persea borbonia
	Sweet Bay	Magnolia virginiana
	Buttonbush	Cephalanthus occidentalis
	Coastal Plain Willow	Salix caroliniana
	Wax Myrtle	Myrica cerifera
	Primrose Willow	Ludwigia peruviana
	Elderberry	Sambucus canadensis
	Dahoon Holly	Ilex cassine
Understory	Blue Hyssop	Bacopa caroliniana
	Spike Rush	Eleocharis cellulosa
	Pondweed	Potamegeton spp.
	Mermaidweed	Proserpinaca palustris
	Najad	Najas quadalupensis
	*Marsh Fern	Thelypteris palustris
	Iris	Iris hexagona var. savannarum
	*Giant Leather Fern	Arostichum danaeifolium
	*Royal Fern	Osmunda regalis
	*Air Plant	Tillandsia pruinosa
	*Air Plant	Tillandsia fasiculata
	*Air Plant	Tillandsia utriculata
	*Air Plant	Tillandsia valenzuela
	*Air Plant	Tillandsia setacea
	*Air Plant	Tillandsia paucifolia
	*Air Plant	Tillandsia flexulosa
	*Strap Fern	Campyloneurum phyllitidus
	*Shoestring Fern	Vittaria lineata

617 - Mixed Wetland Hardwoods

	Common Name	Scientific Name
Overstory	Bald Cypress	Taxodium distichum
	Laurel Oak	Quercus laurifolia
	Florida Elm	Ulmus floridana
	Pop Ash	Fraxinus caroliniana
	Pond Apple	Annona glabra
	Water Oak	Quercus nigra

	Cabbage Palm	Sabal palmetto
	Red Maple	Acer rubrum
Midstory	Dahoon Holly	Ilex cassine
	Buttonbush	Cephalanthus occidentalis
	Pop Ash	Fraxinus caroliniana
	Myrsine	Myrsine guianensis
	Primrose Willow	Ludwigia peruviana
	Coastal Plain Willow	Salix caroliniana
	Red Bay	Persea borbonia
	Swamp Bay	Persea palustris
	Wax Myrtle	Myrica cerifera
	Buckthorn	Bumelia reclinata
Understory	Swamp Fern	Blechnum serrulatum
	*Marsh Fern	Thelypteris palustris
	*Royal Fern	Osmunda regalis
	*Strap Fern	Campyloneuron phyllitidis
	Boston Fern	Nephrolepis exaltata
	Sawgrass	Cladium jamaicense
	Pickerelweed	Pontederia lanceolata
	Climbing Hempweed	Mikania scandens
	Arrowhead	Sagittaria spp.
	Mermaidweed	Proserpinaca palustris
	Blue Hyssop	Bacopa caroliniana
	Smooth Hyssop	Bacopa monnieri
	Mistletoe	Phoradendron serotinum
	*Butterfly Orchid	Encyclia tampensis
	Resurrection Fern	Polypodium polypodioides
	*Air Plant	Tillandsia pruinosa
	*Air Plant	Tillandsia fasiculata
	*Air Plant	Tillandsia utriculata
	*Air Plant	Tillandsia valenzuela
	*Air Plant	Tillandsia setacea
	*Air Plant	Tillandsia paucifolia
	*Air Plant	Tillandsia flexulosa
	*Shoestring Fern	Vittaria lineata
	*Giant Leather Fern	Acrostichum dnagefolium
	*Ghost Orchid	
	*Shell Orchid	Encydia cochleata
	*Umbelled Epidendrum	Epidendrum difforme
	*Rigid Epidendrum	Epidendrum rigidum
	*Bog Torch	Habenaria nivea
	*Rein Orchid	Habenaria odontopetala
	*Michaux's/Long-Horned Orchid	Habenaria quinquesta
	*Water Spider/Creeping Orchid	Habenaria repins
	*Shadow Witch	Ponthieva racemosa
	*Lace Lip Ladies Tresses	Spiranthes lociniatta
	*Long Lip Ladies Tresses	Spiranthes longilabris
	*Spring Ladies Tresses	Spiranthes vernalis

*Low Erythrodes	Erythrodes Querceticola
*Tall Liparis Orchid	Liparis elata
*Florida Malaxis (Adders Mouth)	Malaxis spicata
*Dingy-flowered Epidendrum	Epidendrum anceps

621 - Cypress

	Common Name	Scientific Name
Overstory	Bald Cypress	Taxodium distichum
Midstory	Slash Pine	Pinus elliottii
	Dahoon Holly	Ilex cassine
	Wax Myrtle	Myrica cerifera
	Cocoplum	Chrysobalanus icaco
	Coastal Plain Willow	Salix caroliniana
	Primrose Willow	Ludwigia peruviana
	Red Maple	Acer rubrum
	Pop Ash	Fraxinus caroliniana
	Swamp Bay	Persea palustris
	Buttonbush	Cephalanthus occidentalis
	Elm	Ulmus americana
Understory	Yellow-Eyed Grass	Xyris elliottii
	Maidencane	Panicum hemitomon
	Hatpin	Eriocaulon compressum
	Slender Spike Rush	Eleocharis baldwinii
	Cyperus Sedge	Cyperus odoratus
	Marsh Pink	Sabatia grandiflora
	Swamp Fern	Blechnum serrulatum
	Beak Rush	Rhyncospora tracyi
	Blue Hyssop	Bacopa caroliniana
	Smooth Hyssop	Bacopa monnieri
	St. John's-wort	Hypericum fasciculatum
	Sawgrass	Cladium jamaicense
	Iris	Iris hexagona var. savannarum
	Rush	Juncus megacephalus
	Spike Rush	Eleocharis cellulosa
	Corkwood	Stillingia sylvatica
	St. John's-wort	Hypericum galioides
	Mermaidweed	Proserpinaca palustris
	Bladderwort	Utricularia purpurea
	Marsh Feabane	Pluchea rosea
	Bog Hemp	Boehmeria cylindrica
	Boston Fern	Nephrolepsis exaltata
	Chain Fern	Woodwardia virginica
	Coinwort	Centella asiatica
	Lizard's Tail	Saururus cerauus
	Myrsine	Myrsine guianensis

Pennywort	Hydrocotyle umbellata
Red Ludwigia	Ludwigia repens
*Royal Fern	Osmunda regalis
*Air Plant	Tillandsia pruinosa
*Air Plant	Tillandsia fasiculata
*Air Plant	Tillandsia utriculata
*Air Plant	Tillandsia valenzuela
*Air Plant	Tillandsia setacea
*Air Plant	Tillandsia paucifolia
*Air Plant	Tillandsia flexulosa
*Shoestring Fern	Vittaria lineata
*Giant Leather Fern	Acrostichum dnagefolium
*Ghost Orchid	
*Shell Orchid	Encydia cochleata
*Umbelled Epidendrum	Epidendrum difforme
*Rigid Epidendrum	Epidendrum rigidum
*Bog Torch	Habenaria nivea
*Rein Orchid	Habenaria odontopetala
*Michaux's/Long-Horned Orchid	Habenaria quinquesta
*Water Spider/Creeping Orchid	Habenaria repins
*Shadow Witch	Ponthieva racemosa
*Lace Lip Ladies Tresses	Spiranthes lociniatta
*Long Lip Ladies Tresses	Spiranthes longilabris
*Spring Ladies Tresses	Spiranthes vernalis
*Low Erythrodes	Erythrodes Querceticola
*Tall Liparis Orchid	Liparis elata
*Florida Malaxis (Adders Mouth)	Malaxis spicata
*Dingy-flowered Epidendrum	Epidendrum anceps
*Marsh Fern	Thelypteris palustris
*Whisk Fern	Psilotum nudum
*Strap Fern	Campyloneurum phyllitidus
*Hand or Adders Tongue Fern	Ophioglossum palmatum
*Butterfly Orchid	Encyclia tampensis

624 - Cypress - Pine - Cabbage Palm (Cypress dominant overstory)

	Common Name	Scientific Name
Overstory	Bald Cypress	Taxodium distichum
	Cabbage Palm	Sabal palmetto
Midstory	Slash Pine	Pinus elliottii
	Dahoon Holly	Ilex cassine
	Wax Myrtle	Myrica cerifera
	Cocoplum	Chrysobalanus icaco

	Saltbush	Baccharis halimifolia
	Saw Palmetto	Serenoa repens
Understory	Muhly Grass	Muhlenbergia capillaris
	Threeawn	Aristida purpurescens
	Yellow-Eyed Grass	Xyris elliottii
	Sand Cordgrass	Spartina bakeri
	Maidencane	Panicum hemitomon
	Hatpin	Eriocaulon compressum
	Spike Rush	Eleocharis cellulosa
	Umbrella Grass	Fuirena scirpoides
	Umbrella Grass	Fuirena squarosa
	White-top Sedge	Dichromena colorata
	Cyperus Sedge	Cyperus odoratus
	Marsh Pink	Sabatia grandiflora
	Swamp Fern	Blechnum serrulatum
	Beak Rush	Rhyncospora tracyi
	Blue Hyssop	Bacopa caroliniana
	Smooth Hyssop	Bacopa monnieri
	St. John's-wort	Hypericum fasciculatum
	Sawgrass	Cladium jamaicense
	*Royal Fern	Osmunda regalis
	*Air Plant	Tillandsia pruinosa
	*Air Plant	Tillandsia fasiculata
	*Air Plant	Tillandsia utriculata
	*Air Plant	Tillandsia valenzuela
	*Air Plant	Tillandsia setacea
	*Air Plant	Tillandsia paucifolia
	*Air Plant	Tillandsia flexulosa
	*Shoestring Fern	Vittaria lineata
	*Ghost Orchid	
	*Shell Orchid	Encydia cochleata
	*Umbelled Epidendrum	Epidendrum difforme
	*Rigid Epidendrum	Epidendrum rigidum
	*Bog Torch	Habenaria nivea
	*Rein Orchid	Habenaria odontopetala
	*Michaux's/Long-Horned Orchid	Habenaria quinquesta
	*Water Spider/Creeping Orchid	Habenaria repins
	*Shadow Witch	Ponthieva racemosa
	*Lace Lip Ladies Tresses	Spiranthes lociniatta
	*Long Lip Ladies Tresses	Spiranthes longilabris
	*Spring Ladies Tresses	Spiranthes vernalis
	*Low Erythrodes	Erythrodes Querceticola
	*Tall Liparis Orchid	Liparis elata
	*Florida Malaxis (Addei's Mouth)	Malaxis spicata
	*Dingy-flowered Epidendrum	Epidendrum anceps
	*Marsh Fern	Thelypteris palustris
	*Whisk Fern	Psilotum nudum

*Butterfly Orchid	Encyclia tampensis

641 - Freshwater Marsh

	Common Name	Scientific Name
Emergent	Wapato	Sagittaria latifolia
	Arrowhead	Sagittaria graminae, subulata, lancifolia
	Sawgrass	Cladium jamaicense
	Maidencane	Panicum hemitomon
	Cattail	Typha angustifolia, T. domingensis & T. latifolia
	Pickerelweed	Pontederia lanceolata
	Fireflag	Thalia geniculata
	Iris	Iris hexagona var. savannarum
	Slender Spike Rush	Eleocharis baldwinii
	Rush	Juncus megacephalus
	Beak Rush	Rhynchospora tracyi
	Sand Cordgrass	Spartina bakeri
	Carex Sedge	Carex spp.
	Spike Rush	Eleocharis cellulosa
	Chain Fern	Woodwardia virginica
	Lizard's Tail	Saururus cernuus
	Button Bush	Cephalanthus occidentalis
	Coastal Plain Willow	Salix caroliniana
	Coinwort	Centella asiatica
	Primrose Willow	Ludwigia peruviana
	Red Lugwigia	Ludwigia repens
	Corkwood	Styllingia sylvatica
	St. John's-wort	Hypericum galioides
	Mermaidweed	Proserpinaca palustris
	Water Dropwort	Oxypolis filiformis
	Wax Myrtle	Myrica cerifera
	Red Maple	Acer rubrum
	Bald Cypress	Taxodium distichum
Floating/ Submerged	Mermaidweed	Proserpinaca palustris
	Bladderwort	Utricularia purpurea
	Duckweed	Lemna spp.
	Spatterdock	Nuphar luteum
	Water Lily	Nymphaea odorata
	Pennywort	Hydrocotyle umbellata
	Najad	Najas guadalupensis
	Chara	Chara spp.
	Blue Hyssop	Bacopa caroliniana
	Smooth Hyssop	Bacopa monnieri

642 - Saltwater Marsh

Common Name	Scientific Name
Saltmarsh Cordgrass	Spartina alterniflora
Gulf Cordgrass	Spartina spartinae
Marsh Hay	Spartina patens
Sand Cordgrass	Spartina bakeri
Blackrush	Juncus roemerianus
Seashore Saltgrass	Distichlis spicata
Key Grass	Monanthochole littoralis
Seashore Paspalum	Paspalum vaginatum
Saltbush	Baccharis halimifolia
Sea Lavender	Limonium carolinianum
Seashore Dropseed	Sporobolus virginicus
Sea Oxeye Daisy	Borrichia frutescens & B. aborescens
Sea Purslane	Sesuvium portulacastrum
*Giant Leather Fern	Acrostichum danaeifolium
Saltwort	Batis maritima
Saltmarsh Aster	Aster tenuifolius
Marsh Elder	Iva frutescens
Christmas Berry	Lycium carolinianum
Marsh Foxglove	Agalimus maritima
Perennial Glasswort	Salicornia virginica
Red Mangrove	Rhizophora mangle
White Mangrove	Laguncularia racemosa
Black Mangrove	Avicennia germinans

643 - Wet Prairie (Fresh)

Common Name	Scientific Name
Sawgrass	Cladium jamaicense
Muhly Grass	Muhlenbergia filipes
Maidencane	Panicum hemitomon
Panicum grass	Panicum dichotum
Blue Maidencane	Amphicarpum muhlenbergianum
Beak Rush	Rhynchospora tracyi
Spike Rush	Eleocharis baldwinii
Sand Cordgrass	Spartina bakeri
Yellow-Eyed Grass	Xyris elliottii
Whitetop Sedge	Dichromena colorata
St. John's-wort	Hypericum galioides
St. John's-wort	Hypericum fasciculatum
St. John's-wort	Hypericum mutilum
Redroot	Lachnanthes cardiniana
Wax Myrtle	Myrica cerifera
Blue Hyssop	Bacopa caroliniana

Smooth Hyssop	Bacopa monnieri
Mermaidweed	Proserpinaca palustris
Bladderwort	Utricularia purpurea
Saltbush	Baccharis halimifolia
Smartweed	Polygonum hydropiperoides
Capeweed	Lippia nodiflora
Bittermint	Hyptis alata
Bog Button	Lachnocaulon anceps
Cyperus Sedge	Cyperus odoratus
Drum-heads	Polygala cruciata
Glades Lobelia	Lobelia glandulosa
Hatpin	Erinocaulon compressum
Marsh Pink	Sabatia grandiflora
Panicum Grass	Panicum dichotomum
Corkwood	Styllingia sylvatica

651 - Tidal Flat

Common Name	Scientific Name
Shoalweed	Halodule wrightii
Turtlegrass	Thalassia testudinum
Widgeon Grass	Ruppia maritima
Red Mangrove	Rhizophora mangle
Black Mangrove	Avicennia germinans
White Mangrove	Laguncularia racemosa
Seashore Saltgrass	Distichlis spicata
Beach Carpet	Philoxerus vermicularis
Marine Algae	

654 - Oyster Bar

Common Name	Scientific Name
Shoalweed	Halodule wrightii
Widgeon Grass	Ruppia maritima
Marine Algae	

911 - Sea Grass

Common Name	Scientific Name
Turtle Grass	Thalassia testudinum
Shoalweed	Halodule wrightii
Manatee Grass	Syringodium filiforme
Widgeon Grass	Ruppia maritima
Marine Algae	

* Indicates those species listed by the State of Florida and the U.S. Fish and Wildlife Service as Endangered, Threatened, or Species of Special Concern

STATUS OF
ENDANGERED, THREATENED, AND SPECIES OF SPECIAL CONCERN
LEE COUNTY COASTAL ZONE

Common Name	Scientific Name	FGFWFC	USFWS	FDA
Air Plant	Tillandsia pruinosa			E
Air Plant	Tillandsia fasiculata			C
Air Plant	Tillandsia utriculata			C
Air Plant	Tillandsia valenzuela			T
Air Plant	Tillandsia setacea			T
Air Plant	Tillandsia paucifolia			T
Air Plant	Tillandsia flexuosa			F
Bay Cedar	Surieana maritima			E
Bearded Grass Pink	Calopogon barbatus			T
Bog Torch	Habenaria nivea			T
Butterfly Orchid	Encyclia tampensis			T
Coontie	Zamia floridana			C
Curtiss Milkweed	Asclepias curtissii			T
Dingy-flowered Epidendrum	Epidendrum anceps			T
Fakahatchee Burnannia	Burmannia flava			E
Florida Malaxis	Milaxis spicata			T
Ghost Orchid				T
Giant Leather Fern	Acrostichum danaeifolium			T
Golden Creeper	Ernodea littoralis			T
Golden Polypody Fern	Phlebodium aureum			T
Grass Pink	Calopogon tuberosus			T
Hand Adders Tongue Fern	Ophioglossum palmatum	UR5		E
Joewood	Jacquinia keyensis			T
Iguana Hackberry	Celtis iguanaea			E
Inkberry	Scaevola plumieri			T
Lace Lip Ladies Tresses	Spiranthes lociniatta			T
Long Lip Ladies Tresses	Spiranthes longilabris			T
Low Erythrodes	Erythrodes Querceticola			T
Marsh Fern	Thelypteris palustris			T
Michaux's or Long Horned Orchid	Habenaria quinquesta			T
Pale Grass Pink	Calopogon barbatus			T
Pineland Panic Grass	Panicum pinetorum		UR2	
Pine Pink	Bletia purpurea	T		
Prickly Apple	Cereus gradilis		UR2	E
Prickly Pear	Opuntia stricta			T
Many Flowered Grass Pink	Calopogon multiflorus	T		
Red Stopper	Eugenia rhombea			E

Rein Orchid	Habenaria odontopetala			T
Rigid Epidendrum	Epidendrum rigidum			T
Royal Fern	Osmunda regalis			C
Satin Leaf	Chrysophyllum oliviforme			E
Shadow Witch	Ponthieva racemosa			T
Shell Orchid	Encydia cochleata			T
Shoestring Fern	Vittaria lineata			T
Slender Ladies Tresses	Spiranthes brevilabris			T
Spiny Hackberry	Celtis pallida			E
Spring Ladies Tressses	Spiranthes vernalis			T
Strap Fern	Campyloneurum phyllitidus			T
Tall Liparis Orchid	Liparis elata			T
Umbelled Epidendrum	Epidendrum difforme			T
Water Spider/Creeping Orchid	Habenaria repins			T
White Squirrel Banana	Seeringothamnus pulchellus	E	E	
Whisk Fern	Psilotum nudum			T
Wild Coco	Eulophea alta			T
Wild Cotton	Gossypium hirsutum			E
Wild Olive	Forestiera segregata		UR1	

FGFWFC - Florida Game and Fresh Water Fish Commission
USFWS - U.S. Fish and Wildlife Service
FDA - Florida Department of Agriculture

E - Endangered
T - Threatened
SSC - Species of Special Concern
UR1 - Under Review for the First Time
UR2 - Under Review for the Second Time

APPENDIX IV-VI

Commercial Fish Landings

(On File in Lee County Planning Department Office)

APPENDIX IV-VII

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ESTUARINE POLLUTION CONDITIONS OF THE SPECIAL COASTAL STUDY FOR LEE COUNTY, FLORIDA

Richard B. Morgan

July, 1987

LEE COUNTY COASTAL STUDY

Godschalk & Associates, Consultants

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Maps and Tables

INTRODUCTION

The purpose of this section of the Special Coastal Study for Lee County, Florida is to inventory and analyze estuarine pollution conditions and recommend actions needed to maintain the quality of the County's coastal zone. This work is being performed in compliance with requirements of Florida Department of Community Affair's rule, Chapter 9J-5, F.A.C., entitled "Minimum Criteria for Review of Local Government Comprehensive Plans and Determination of Compliance". The data and recommendations resulting from the study are intended to form the basis for revisions to the Lee County Comprehensive Plan.

The Special Coastal Study for Lee County is divided into three phases. Phases I and II, on which this report is based, involved the inventory of existing data sources and evaluation of estuarine conditions. Phase III will address the development of final recommendations for future consideration and possible implementation by the Lee County Commission.

The method of data collection and evaluation for Phase I and II consisted of personal communications with county, state, and federal agency staff; the procurement and review of reports and data from those agencies; review of aerial photography; and both aerial and ground observations.

SUMMARY OF FINDINGS

1) Water quality in the Lee County coastal zone was generally rated good to fair in a 1986 assessment of data by the Department of Environmental Regulation (DER). The assessment is a bi-annual review required by federal law which evaluates statewide water quality according to whether the use of the waterbody is achieved totally, partially, or not at all.

2) The greatest threat to the maintenance of water quality in the Lee County coastal zone is stormwater runoff, also known as nonpoint pollution. On a statewide average, stormwater contributes approximately 50% of the pollutants found in receiving waters and up to 90% of the heavy metals and sediments (Tschinkel, 1987). Point source, or pipe, discharges in Lee County are limited in number and the quality and quantity of effluent is regulated by the Florida Department of Environmental Regulation.

3) To adequately protect resources in the Lee County coastal zone from stormwater runoff, it is necessary to document the presence of pollutants, identify their source,

and eliminate their entry into surface waters. In the absence of specific knowledge of which constituents are being discharged to receiving waters at the source, great reliance must be placed on monitoring programs to provide an "early warning" of water quality degradation.

Phase I and II investigations reveal an overall lack of consistent, long-term water quality data for most areas of the Lee County coastal zone. Few comprehensive studies have been conducted to document baseline conditions of the coastal zone. Numerous, localized water chemistry and biological assessments have been performed in the Charlotte Harbor/Estero Bay region since the early 1970's. As part of the current U.S. Geological Survey (U.S.G.S.) study of Charlotte Harbor, Stoker and Karavitis compiled more than 1,200 literature citations on these subjects in a 1983 report. Most of the studies identified in the report were short-term, localized, and limited in scope. The data on estuarine conditions in Lee County exist in "bits and pieces" as described by a South Florida Water Management District staff member (Chamberlain, 1987).

The on-going, 7 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 made up of a number of interacting components. The results of the Charlotte Harbor study should provide a greater understanding of how the estuary functions, what its health is, and what factors may threaten its future. Unfortunately, the Special Coastal Study for Lee County will be completed before all the U.S.G.S. reports are published some time after the 1989 project termination date. Several reports on Charlotte Harbor already released by the U.S.G.S. are a part of this study.

A three year, comprehensive study of the estuarine impact of freshwater, discharged from the Frankiln lock and dam is being conducted by the SFWMD. The goal of the District's study is to document baseline conditions in San Carlos Bay, Pine Island Sound, and the lower Caloosahatchee River under several wet/dry season cycles. Guidelines for future operation of the Franklin lock, to minimize negative affects of the freshwater discharged to the estuaries, will be developed from data generated by the study. In addition, the information gained from the SFWMD study will supplement the U.S.G.S. work and provide data for a portion of the coastal zone for which little information is currently available.

4) Problems exist with the interpretive use of the single most extensive water quality database as an aid in assessing estuarine pollution conditions. Known as the STORET system, this water quality database is maintained by the U.S. Environmental Protection Agency (EPA).

Data obtained from the sampling program of the DER or its predecessor agency, the Department of Pollution Control (DPC), are entered into the STORET system. With data entries for nine estuarine stations in Lee and Charlotte counties going back to the early 1970's, this source of information on water quality conditions is the most extensive and long-term of all sources investigated.

Unfortunately, interpretation of the data has proven unexpectedly difficult. Upon request, DER provided all available water quality data for the nine subject stations in both raw and summarized form. The summarized data is categorized by parameter, sampling medium, remarks, number of samples, mean values, variance, standard deviation, maximum values, minimum values, sample begining data and sample ending date.

During our review of this information, apparent violations of certain DER water quality standards for pesticdes and heavy metals were noted. However, closer examination of the computer generated printout revealed a coded remark "U", meaning "Indicates material was analyzed for but not detected". This remark is confusing because of the large number of samples having a mean value in excess of DER numerical standards.

The explanation from DER staff (Jackman, Sessions, 1987) is that the STORET system contains entries for samples where the analytical detection limit is higher than the DER standard. In this case, the value at the detection limit was entered as the sample concentration of the parameter being assessed and the sample given a remarks code U.

Jackman was not certain whether the code U samples exceeding specific standards were due to samples analyzed before sophisticated equipment permitted lower detection limits or instances where problems in the laboratory caused the premature termination of the analytical process. Regardless, the end result causes considerable uncertainty as to the validity of the data when compared to DER's water quality standards and renders much of the large database of questionable value.

Judgements of water quality conditions in the study area must be made very carefully when using the STORET data. A computer run of violations of certain selected DER water quality standards was obtained for further assessment. Data including code "U" entries showed violations of certain parameters. When code "U" entries are deleted from the data base, no violations were found in the remaining samples.

5) Recent studies by the DER's Office of Coastal Management (OCM) suggest that sampling the water column for heavy metals, as DER districts have routinely done for years, may

not accurately reflect the extent of metals pollution in the environment. Heavy metals tend to precipitate out of the water column quickly in the presence of fine organic particles, especially where fresh and salt water mix (Ryan, 1987).

As a result, violations of heavy metals standards in samples taken from the water column are rarely found, whereas heavy metal concentrations in the sediments may be quite high. The DER has no standards for heavy metal pollution in sediments and there is little knowledge of toxic affects on plant and animal life, and food chains. (Ryan, 1987).

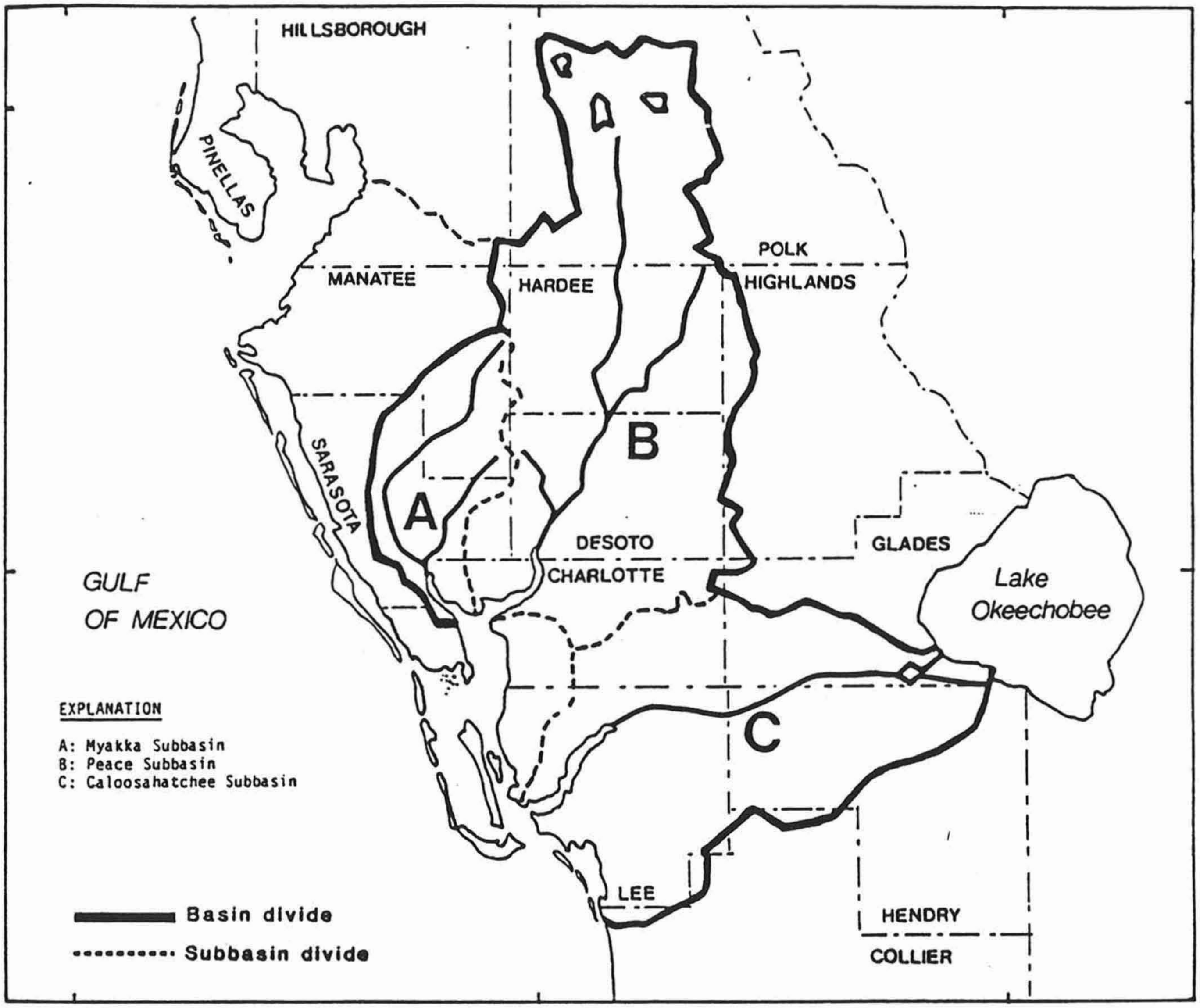
This finding has significant implications for all Florida waters and will require further study and possible administrative action by the DER. It is included in this report to Lee County in order to alèrt County officials to the fact that existing water quality data on heavy metals may not reflect actual conditions in the coastal zone. The Lee County water quality study of Estero Bay performed in 1986 was designed to measure metals in sediments for the first time. Future investigations should also be concentrated on sediments for reasons detailed in the "Review of Existing Water Quality" section of this report.

6) The Lee County coastal zone can be adversely affected by sources in the county landward of the coastal zone as well as sources outside the county. For example, data obtained by the SFWMD documents numerous violations of various DER standards in the Caloosahatchee River upstream of the coastal zone and an OCM study found metals enrichment from the Franklin lock to Redfish Point.

Further, the geographical boundaries of the special coastal study, and financial constraints, did not permit identification of existing or potential sources of pollution landward of the coastal zone boundary. An example is the limitation for the tributary streams around Estero Bay---Hendry Creek, Ten Mile Canal, Mullock Creek, Estero River, Spring Creek, and the Imperial River where County regulatory action may be needed to protect Estero Bay from poorly planned development in the headwaters of watersheds outside the study area.

On a broader scale, it should be recognized that the Lee County coastal zone is the receiving water, in part, for stormwater originating throughout the entire watersheds of the Myakka, Peace, and Caloosahatchee Rivers, and smaller coastal watersheds. The total area of these watersheds is large compared to the area of the waterbodies they discharge to.

Charlotte Harbor, including Matlacha Pass, Pine Island Sound and San Carlos Bay, occupies an area of 236 square miles, Drainage Basins of the Myakka, Peace, and Caloosahatchee Rivers



Adapted from Estevez, 1986

yet watersheds of the Peace, Myakka and Caloosahatchee Rivers cover some 3,900 square miles. The surface water area of Estero Bay is 15 square miles and its drainage basin totals 293 square miles (DNR, 1983).

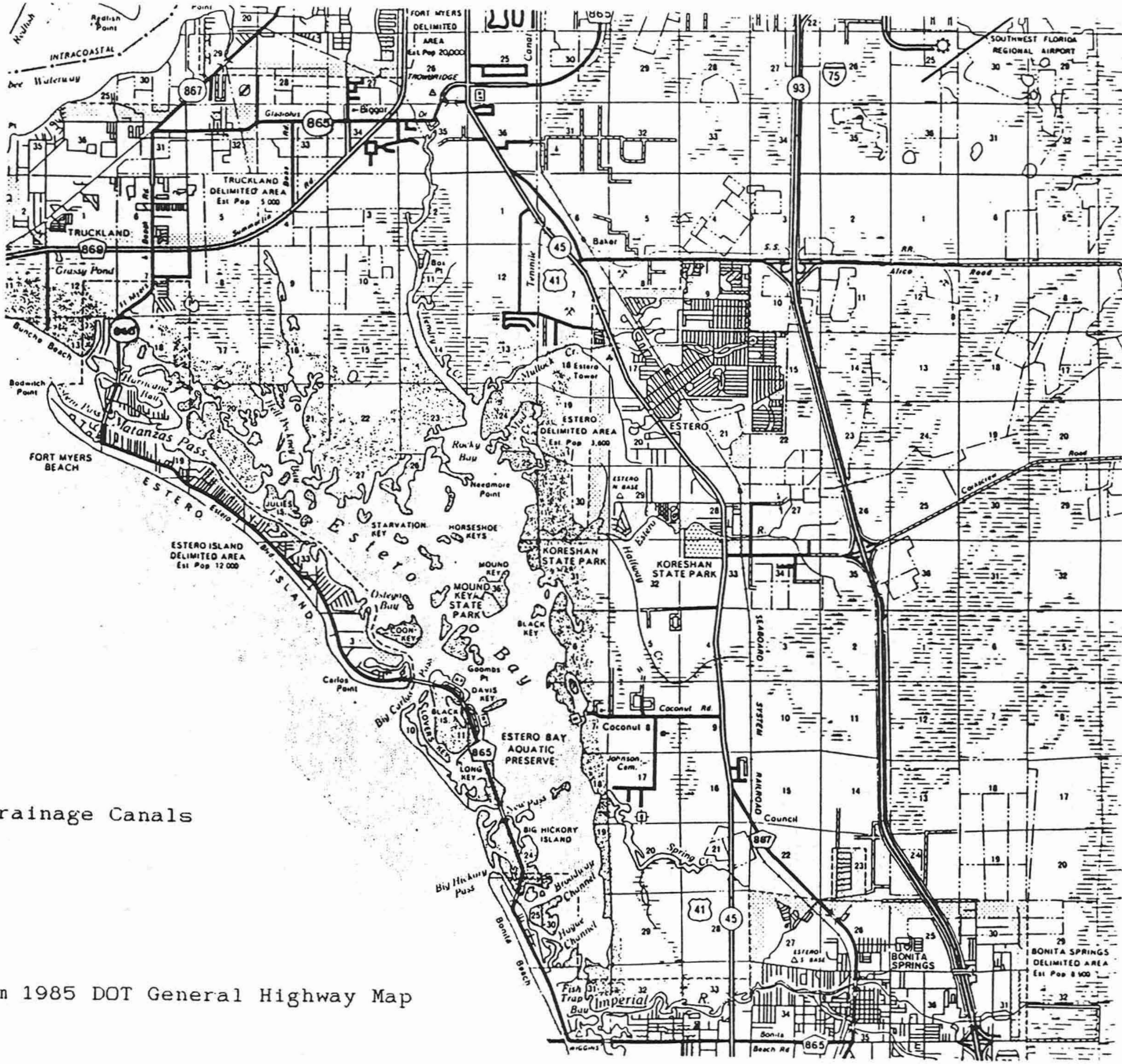
The quality of water from major and minor tributaries, in combination with local pollution loading and the mixing effect of Gulf tidal waters, determines the water quality characteristics in the Lee County Charlotte Harbor estuarine system. Although the County is not responsible for the quality of waters entering from outside its boundaries, it has a vested interest in ensuring the quality is as high as possible. Methods and procedures are discussed in the Assessment Section that may be used to monitor the quality of water and respond when problems are noted.

7) Estero Bay may be very susceptible to water quality degradation because of its shallow nature, poor flushing characteristics, and increased runoff from development around its perimeter (DNR, 1983, Lee County, 1986). Compounding these threats, is the paucity of long-term information on the biological and chemical quality of the Estero Bay estuary. Previous poorly designed and limited scope studies give only "window" views (Clark, 1987) of estuarine conditions in the bay.

8) Of immediate concern is the affect of the inflow of increasing amounts of freshwater into Matlacha Pass. The U.S.G.S. has documented the existence of unusually low salinity levels in Matlacha Pass Aquatic Preserve, due in part to the discharge of large volumes of freshwater from the canal system in western Cape Coral. The discharge may be adversely affecting productivity by displacing marine organisms adapted to brackish water conditions, but the extent of damage to the flora and fauna of Matlacha Pass has not been documented by further study (LaRose, 1987).

These volumes of freshwater alone are a pollutant because historic salinity regimes in Matlacha Pass are being altered. However, their impact on receiving waters in the future will be exacerbated by the increase in pollutant loading resulting from buildout. As more lots in Cape Coral are built out, the amount of freshwater runoff will increase, as will nutrients, pesticdes, herbicides, heavy metals, oils and greases, and other pollutants.

A similar occurrence could be taking place in Estero Bay that has not been identified by past limited research or the one DER sampling station at Big Carlos Pass. Without a long-term baseline study, increases in freshwater, nutrients, heavy metals, sediments, pesticides, or other pollutants cannot be measured and corrective action initiated where necessary.



Key:

___ · · ___ = Drainage Canals

Adapted from 1985 DOT General Highway Map

The 1986 Lee County water quality study of Estero Bay was performed to provide data on a number of parameters in the estuary. Although questions have been raised concerning the data for heavy metals in sediments, discussed in a later section of this report, the County's efforts should be continued through implementation of an ongoing baseline sampling program as recommended by Kervin Erwin.

The urgency in installing a regular baseline sampling program for Estero Bay and Charlotte Harbor is underscored by the fact that the bay is likely to be further stressed by future upland and shoreline development. The longer the delay in documenting baseline conditions and pollution trends, the higher the levels of contamination that will be considered "baseline". Baseline conditions today are significantly different than would have been found in 1950.

BACKGROUND

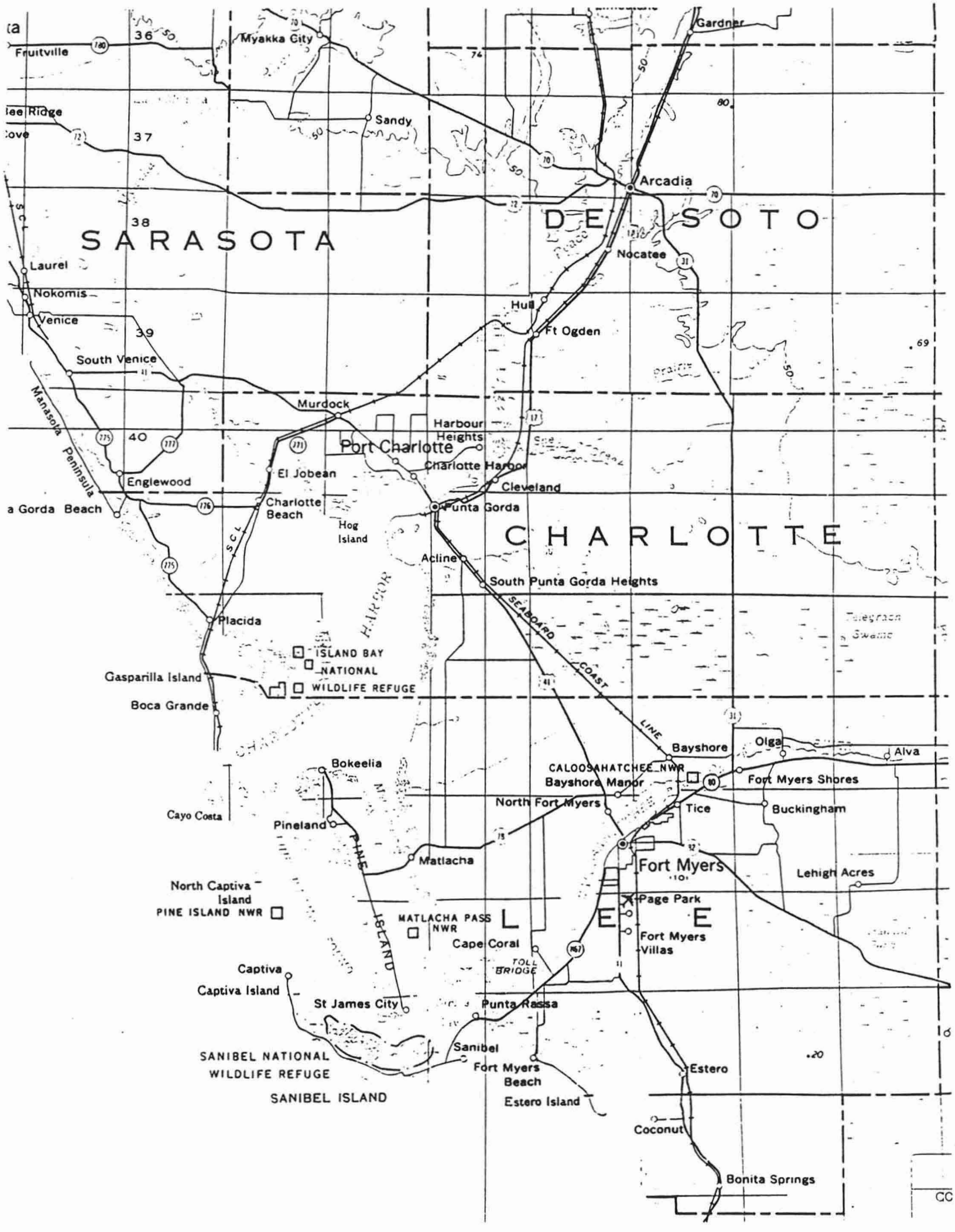
Since the early 1960's, Sarasota, Charlotte, and Lee counties, surrounding Charlotte Harbor, have experienced rates of growth among the highest in the United States. Lee County saw a 95% increase in population between 1970 and 1980; Charlotte and Sarasota counties grew by 112% and 68% respectively (Morris, 1983). The average for the United States during the same period was 11.5%.

Large tracts of agricultural and forest lands, in close proximity to Gulf coastal waters, and the area's mild climate brought developers to the region beginning in the late 1950's when lot sales subdivisions where established at Port Charlotte, Cape Coral, and Lehigh Acres. Smaller subdivisions followed so that by 1980, there were over 855,000 platted lots on 239,000 acres in the three counties (Schnidman, 1983).

In order to create waterfront property offering direct boating access to adjacent waters, finger-fill canals were constructed which also provided the fill necessary to bring residential lots up to minimum grade. In addition, drainage systems at these sites were extended many miles inland in order to facilitate septic tank use and provide some degree of flood protection during the summer rainy season.

Over 370 square miles of platted lands and their drainage systems are now found in Sarasota, Charlotte and Lee counties (Schnidman, 1983). Most of the stormwater from these systems is discharged to the Myakka, Peace, or Caloosahatchee rivers or directly to Charlotte Harbor proper. Cape Coral alone, sited on a peninsula between Charlotte Harbor, Matlacha Pass, and the Caloosahatchee River, has over 400 miles of freshwater and tidal canals and

Regional Map



may someday house between 350,000 and 400,000 people (Cape Coral Comprehensive Plan, 1982). The population of platted subdivisions in Charlotte County, including the 200 square mile Port Charlotte community, is projected to be nearly 1,000,000 (DNR, 1983).

The construction of extensive canal systems in Sarasota, Charlotte, and Lee counties has, in effect, greatly increased the shoreline of the Myakka, Peace, and Caloosahatchee rivers compared to pre-development conditions. The net result is the hundreds of thousands more homes, plus roads and commercial/industrial sites that now have a greater potential to contribute pollutants to area waterbodies than would be the case had interior lake systems been constructed on the uplands. In addition, large volumes of freshwater are quickly routed to surface waters where rainfall historically recharged the groundwater table and sheetflow previously released rainfall runoff to the estuaries over a extended period of time. Regulatory actions by state and federal agencies in the mid-70's curtailed the destruction of wetlands around Charlotte Harbor and Estero Bay and ended the practice of finger-fill canal development.

Although the coastal uplands in the three counties contain large platted subdivisions and their associated drainage systems, the waters of the region and the remaining fringing wetlands generally rank high in quality at this time. The diverse vegetation and habitats, and wide variety of waterbodies, attract to the region over 40% of the species listed as endangered, threatened, or of special concern (DNR, 1983). Approximately 33% of these statewide species have been identified within the various aquatic preserves of the coastal zone.

The value of fish and shellfish landed in Lee County ($17,381,840) was the second highest of all coastal counties in 1983, surpassed only by Monroe ($32,283,888). The weight of fish and shellfish in Lee County landings amounted to 10,249,214 pounds for fish and 4,404,922 pounds of shellfish. By comparison, Charlotte County fish and shellfish landings totaled only 4,671,333 pounds valued at $1,782,798 (1986 Florida Statistical Abstract).

An indication of the quality of water-oriented recreational and commercial activities in Lee County is the fact that the County has the highest number of registered pleasure and commercial boats during fiscal year 1984-1985 than any other coastal county in southwest Florida. Lee County's total of 21,898 pleasure boats and 1,701 commercial vessels outpaced Sarasota's 14,702 and 492, Charlotte's 9,281 and 521, and Collier's 11,612 and 969 respectively (1986 Florida Statistical Abstract).

Future threats to the maintenance of present water quality will come as coastal communities in the region grow toward buildout and pollution loads in stormwater subsequently rise. With Cape Coral and subdivisions in Charlotte County having the potential to house 1.4 million persons, stresses on the estuarine environment are sure to increase.

The 1980 census documented a population in Charlotte County of 58,460. At the same time, the population of the City of Cape Coral totaled 32,103. Thus, the total 1980 population of 90,563 constituted less than 10% of the possible buildoutpopulation of these large subdivisions alone. Furthermore, the City of Ft. Myers, Ft. Myers Beach, Lehigh, San Carlos Park, and numerous other subdivisions in Lee County will no doubt contribute increasing quantities of pollutants as their populations expand.

The present high quality of estuarine ecosystems in Lee and Charlotte counties and the need to protect these systems have been the initiative for legislative and administrative designation of much of the area as aquatic preserves, Outstanding Florida Waters, national wildlife refuges, and Class II waters suitable for shellfish harvesting.

The concept of setting aside sovereignity lands as preserves came in 1967 when statutory authority was granted, pursuant to Chapter 253.03, Florida Statutes, for the Board of Trustees of the Internal Improvement Trust Fund to exercise proprietary control over state-owned lands. In 1968, the Interagency Advisory Committee issued a report recommending the establishment of 26 waterbodies as aquatic preserves. In 1969, the Governor and Cabinet established by resolution, aquatic preserves at 18 of the 26 recommended sites. The designation of other aquatic preserves followed in later years.

State and federal designation of various sections of the Lee/Charlotte coastal zone as aquatic preserves, state parks, Outstanding Florida Waters, Class II waters suitable for shellfish harvesting, and national wildlife refuges provides extra regulatory protection against adverse human-induced impacts. Their habitat for a wide diversity of plant and animal life, aesthetic, recreational and scientific values, and significant fish and shellfish resources are protected and managed through a complex layer of administrative rules which regulate the type of activity allowed and the quality and quantity of effluent discharged.

Additional protection of environmentally sensitive lands has been applied through the outright purchase of property under the 1972 Land Conservation Act and its successor, the 1979 Conservation and Recreation Land Trust Fund. Large tracts of state-managed wetlands, primarily mangrove forests, in Lee and Charlotte counties act as a buffer to encroaching development and as well as providing many important biological functions related to the maintenance of water quality and marine food chains.

Lee County is fortunate to have within its boundaries, all or part of the following aquatic preserves which are also Outstanding Florida Waters: Charlotte Harbor, Cape Haze-Gasparilla Sound, Pine Island Sound, Matlacha Pass, and Estero Bay. These preserves were established in order to maintain their generally pristine nature against the consequences of rapid development on adjacent uplands.

The northern half of Estero Bay, from just above Black Island, north, was the state's first aquatic preserve when it was established in December 1966 (DNR, 1983). The southern half was added in 1983. The remaining Charlotte/Lee aquatic preserves were established subsequent to Estero Bay aquatic preserve. These cover a total of over 200 square miles or approximately 90% of the surface water area in the Charlotte Harbor estuarine complex (DNR, 1983).

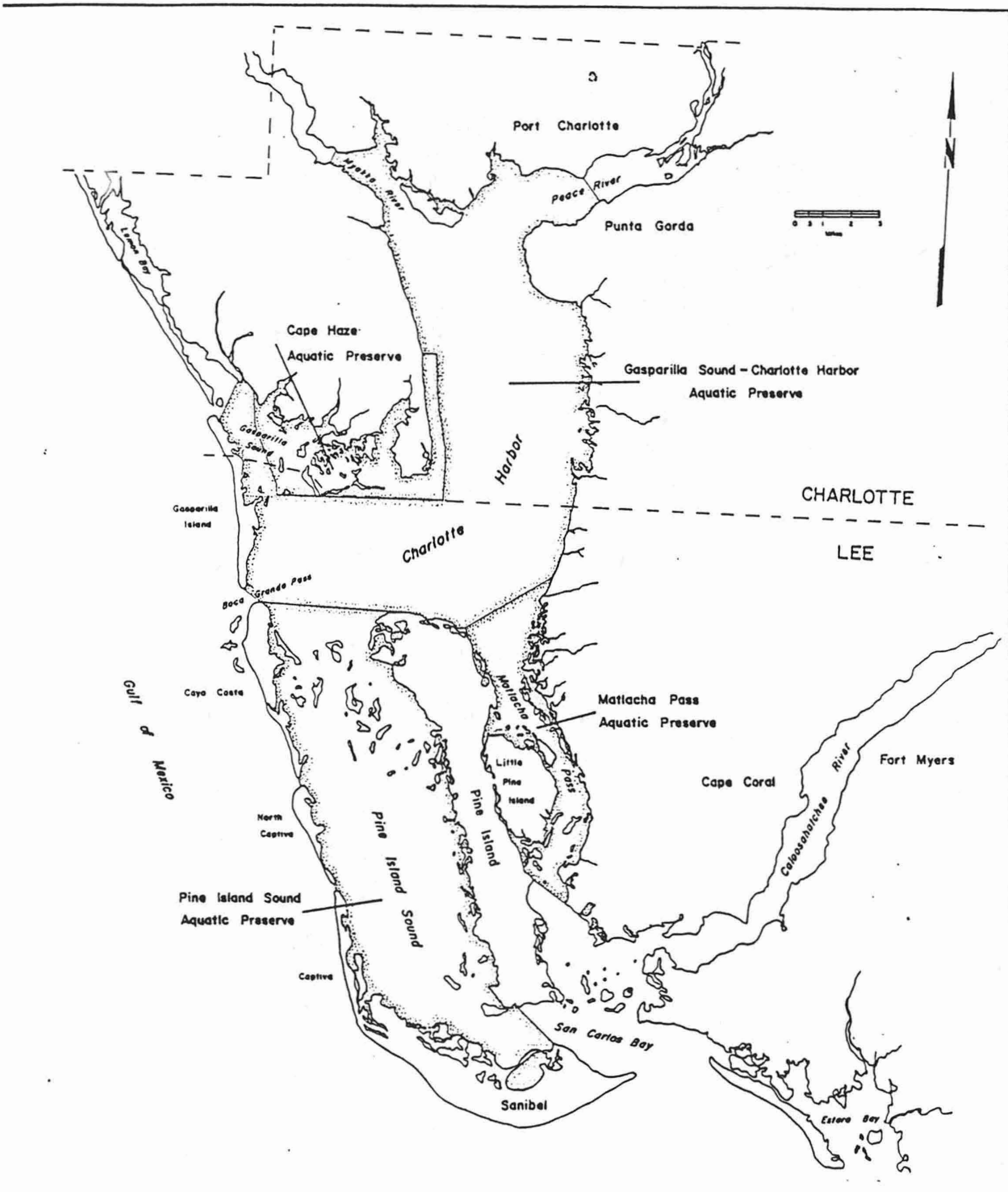
A number of national wildlife refuges are scattered near or within the Lee aquatic preserves, the most notable of which is the J.N. "Ding" Darling National Wildlife Refuge on Sanibel Island. The high recreational value of the Lee County coastal zone is also indicated by state parks on Cayo Costa Island and Lovers Key, in addition to numerous county parks at other coastal sites.

The impact of continued development and population growth was the initiative for the formation of the Charlotte Harbor Resource Planning and Management Committee at the direction of former Governor Bob Graham in 1979. The Committee issued its findings in 1981 which recommended methods local governments could use to better protect the integrity of the Charlotte Harbor estuarine system. These methods were subsequently incorporated into revised local government comprehensive plans. In addition, the Committee recommended that a comprehensive water quality study be undertaken of the Charlotte Harbor estuary, the result of which is the present U.S.G.S. investigation.

Three state agencies are actively involved in monitoring physical, chemical, and biological conditions in various areas of the Lee County coastal zone. They are the DNR, DER, and SFWMD. In addition, activities involving dredge and fill, and the discharge of pollutants within the coastal zone and adjacent uplands are regulated through various permitting programs of these agencies.

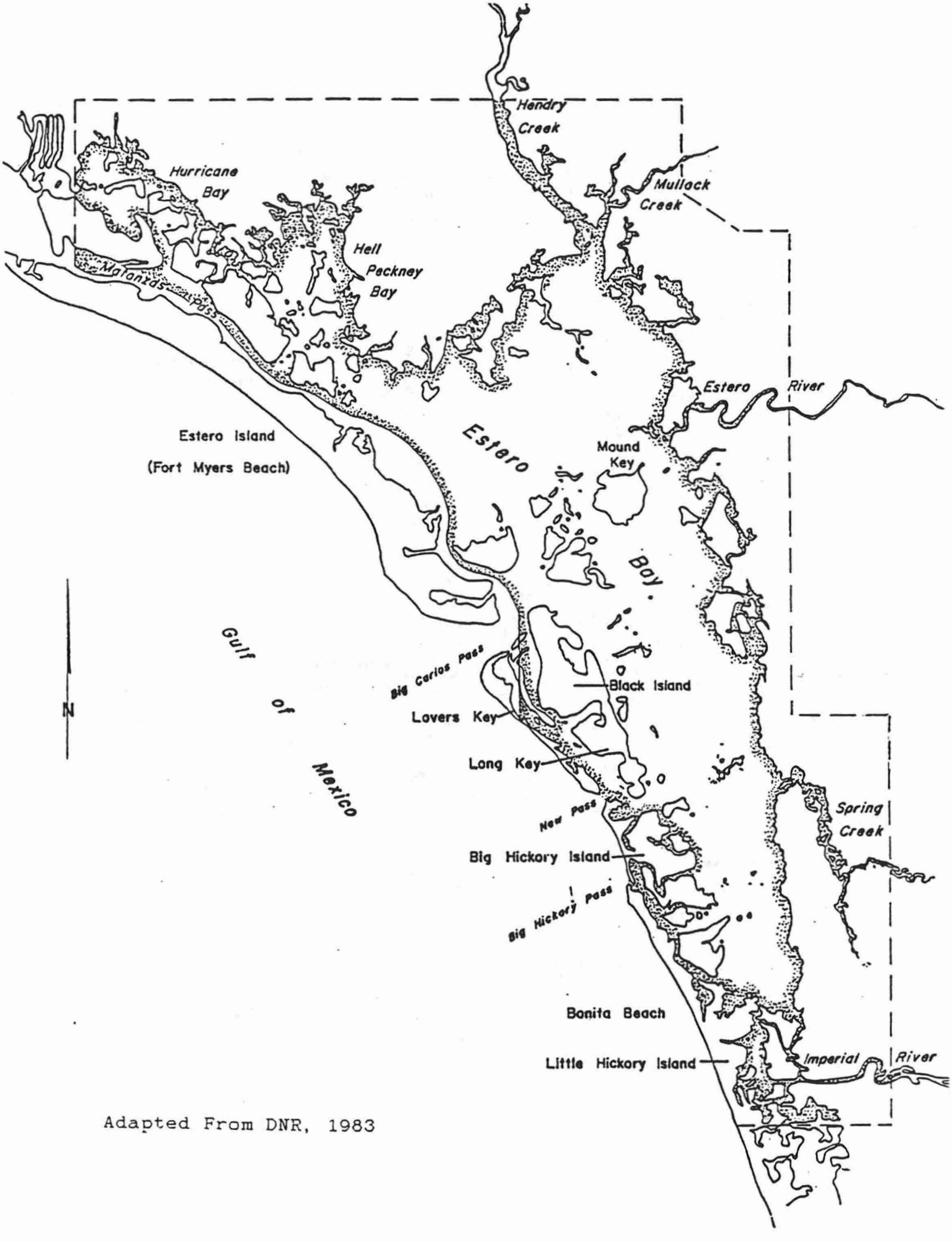
Florida's five water management districts regulate the consumptive use of water and the storage and management of surface waters under that authority granted by Chapter 373, F.S. Other functions are monitoring of water quality and quantity, flood control, and restoration and maintenance of

Aquatic Preserves Map



Adapted From DNR Management Plan, 1983

Estero Bay Aquatic Preserve



Adapted From DNR, 1983

water quality. Lee County and all of the Caloosahatchee River watershed are within the boundaries of the SFWMD which maintains its district offices in West Palm Beach. In order to be more accessible to citizens and expedite permitting on the Gulf coast, the SFWMD maintains staff in the DER offices in Ft. Myers. All of the Myakka and Peace river watersheds fall within the purview of the Southwest Florida Water Management District (SWFWMD) headquartered in Brooksville.

Construction involving the alteration of natural drainage patterns require surface water management permits. The permits contain special performance conditions and criteria for the storage and treatment of stormwater as specified in SFWMD rule, Chapter 40E-4, F.A.C.. This rule does not apply to the treatment of stormwater from antiquated drainage systems built in the 50's, 60's, and early 70's because such systems constructed prior to the effective date of the rule are grandfathered.

The Southwest Florida Regional Planning Council (SWFRPC) in Ft. Myers is a state regional planning agency which assesses developments of regional impact and coordinates the investigation of environmental problems having regional significance. Staff of the Council may perform special studies or contract them to consultants.

For example, the SWFRPC 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 nonpoint pollution were performed in Charlotte Harbor, Estero Bay and the canal system at Cape Coral. Section 208 funds presently available to state governments have been severely reduced due to fiscal contraints.

At the federal level, the U.S. Geological Survey (U.S.G.S.) and the U.S. Army Corps of Engineers (COE) operate investigatory and regulatory programs in Lee County. The U.S.G.S. office in Ft. Myers has conducted numerous studies of the region's geology, and surface and groundwater quality and quantity.

Activities in waters and wetlands in Lee County are regulated by the COE under the authority granted by Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Federal Water Pollution Control Act Amendments of 1977. The Corps maintains a field office in Ft. Myers to facilitate permitting and enforcement programs. Permits are required for construction of structures and dredge and fill projects within the Corps' jurisdiction.

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 Ft. Myers Beach. Maintenance dredging of Boca Grande Pass, the channel to Ft. Myers Beach and parts of the lower Caloosahatchee River have been performed since 1972 with the spoil placed at designated sites offshore, on nearby beaches, or in the river proper.

INVENTORY FINDINGS

This section describes how state and other governmental entities function with specific regard to the Lee County coastal zone. In addition, special studies in progress and ongoing monitoring programs that may provide new information concerning the status of estuarine pollution conditions are discussed along with findings of previous studies and existing water quality data.

A) REVIEW OF AGENCIES AND PROGRAMS

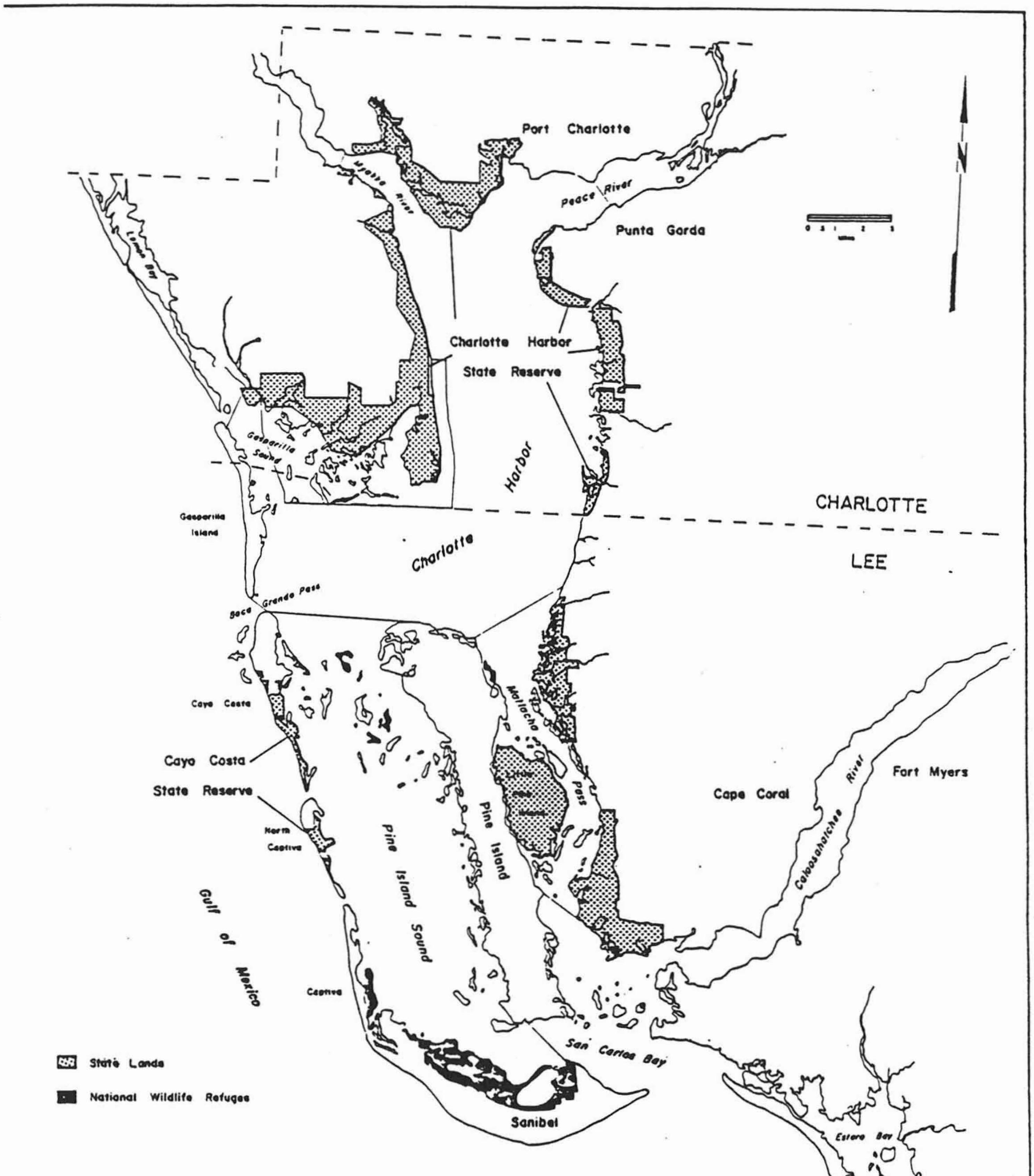
1) DEPARTMENT OF NATURAL RESOURCES

Management of state lands such as parks and aquatic preserves in Lee County is the responsibility of the DNR. DNR-regulated sovereignty lands within aquatic preserves do not include submerged lands previously sold to private interests, and the bottoms of water bodies excavated from uplands such as canals. The majority of submerged lands in Lee County coastal waters are in the public domain, although some privately owned submerged lands are located on the bay side of Gasparilla Island near the Charlotte County line.

DNR regulates activities in the coastal zone through its permitting program authorized by sections of Florida Statute, Chapter 253 and implemented pursuant to the requirements of Chapters 16Q-20, Aquatic Preserves, and 16Q-21, Sovereignty Submerged Lands Management, F.A.C. Chapter 16Q-20 specifies prohibited activities and sets standards and conditions for other activities that are permitted in the aquatic preserves. Rule 16Q-21 requires that any activity on sovereignty lands be approved by the Department through the issuance of a letter of consent, lease, or easement. Leases and easements must be approved by the Governor and Cabinet sitting as the Board of Trustees of the Internal Improvement Trust Fund.

DNR staff have been placed in a field office on Pine Island to monitor and manage activities in the Charlotte and Lee county aquatic preserves under the authority granted in Chapter 258, Florida Statutes and 16Q-20, F.A.C. (DNR, 1983). Specific management plans for these aquatic preserves were

State Lands and National Wildlife Refuges



Adapted From DNR Management Plan, 1983

adopted by the Governor and Cabinet in 1983 and are intended to ensure the natural attributes of the preserves are maintained. Duties of the DNR field staff include monitoring the preserves for unauthorized activities, assessment of applications for consent of use, lease, or easement in the preserve, and providing technical assistance to local governments considering matters related to the preserves.

Management plans for Estero Bay and Charlotte Harbor aquatic preserves were adopted by resolution of the Governor and Cabinet in 1983. The plan for Charlotte Harbor covers the Cape Haze, Gasparilla Sound-Charlotte Harbor, Matlacha Pass, and Pine Island preserves because of the extensive nature of water resources in the dynamic Charlotte Harbor estuarine system (DNR, 1983). These preserves are designated "wilderness preserves" wherein the primary management objective will be the maintenance of the preserves in an essentially natural state (DNR, 1983).

In general, the management plans for the aquatic preserves mentioned above set forth management authority and major program directives; describe resources, resource management techniques, and a management implementation network involving state, federal, regional agencies, and local governments; establish public, private, commercial, and scientific uses; specify methods of environmental education; and, identify further management program needs.

Resource descriptions in the management plans include commentary on geologic features and landforms, community associations, archaeological and historical sites, water resources, and cultural features of the preserves. The water resources section of each plan is extremely pertinent to the Lee County coastal study, particularly the 1980 findings of the Technical Advisory Committee of the Charlotte Harbor Resource Planning Management Committee. In the Charlotte Harbor estuarine system, the Technical Committee found the following after reviewing existing data (DNR, 1983):

1. "Levels of pH are within normal limits.

2. More data are needed on biocides, including heavy metals. Aldrin, dieldrin, and Baytex have been reported in dangerous concentrations in Gasparilla and Pine Island Sounds.

3. Dissolved oxygen depletion is a present and growing problem in canal systems and nearshore habitats.

4. There may be evidence that Charlotte Harbor's nutrient content has increased through time, due to human activities.

5. Oils and grease exist in notably high levels within

parts of the estuarine complex. The presence of more volatile (and toxic) fractions is probable.

6. Salinity and temperature regimes are typical of a substantial estuary but are optimal for the amplification of pollution effects.

7. Turbidity has not been a system-wide problem due to minimal dredging. Short-term effects of causeway and channel construction mediated by turbidity, have been severe and some will remain so over long periods.

8. Based on shellfish data, coliform counts are unacceptably high for large areas within the complex".

The deficiency in water quality data on Charlotte Harbor is being addressed by the current U.S.G.S. study.

The Committee also identified sensitive areas within the Charlotte Harbor estuarine system and perceived threats to water quality (DNR, 1983). They are:

1."Gasparilla Sound, valued for its nurseries, fisheries, and recreation; listed because of pesticide, dredge and fill hazards.

2. All the tidal creeks, valued as habitat, nursery, and nutrient assimilation functions; listed because of use in land drainage and upland development.

3. Myakka River estuary, valued for its productivity, scenic and scientific value; listed because of Peace River influence, effects of upland development and upstream activities, and a relative lack of information.

4. All tidal canal systems, valued for their real estate and navigation uses; listed for being "worst case" water quality areas and hazardous to human health.

5. All "Interceptor" or "Spreader" waterways, valued for the proven utility of retention in nutrient assimilation, but listed for lack of data, loss of valuable resources when retention structures displace native coastal habitat instead of disturbed uplands, consequences as problem areas if they fail, or as regional precedents if they function.

6. Pine Island Sound and Matlacha Pass, valued for their recreational and fisheries value; listed because of their hydrographic position between Charlotte Harbor proper and San Carlos Bay, and vulnerability to upland development and overuse.

7. All major sources of freshwater to each estuary.

8. Mangroves, seagrasses, and marshes".

Estero Bay differs from the Charlotte Harbor estuary by lacking significant freshwater input and having weak tidal exchange due to the restricted size of its inlets (DNR, 1983). Sediments carried into Estero Bay by its small creeks and rivers filled it to its present shallow depths. The result is an estuary with the characteristics of a lagoon. Because this estuary is adapted to weak freshwater inflow, it is extremely sensitive to changes in upland drainage that would affect the quality, quantity, and seasonality of freshwater influx.

The DNR management plan for the Estero Bay aquatic preserve reflects the lack of a long-term, comprehensive, water quality database on estuarine conditions. According to the plan, studies by Tabb et al., 1974 and Environmental Science and Engineering, 1978, indicate the estuary is generally healthy. However, the DNR concludes there is not now available, sufficent water resource data to understand how the system operates or to identify the water quality problems existing now and for the future (DNR, 1983).

The Charlotte Harbor Technical Advisory Committee identified sensitive areas within Estero Bay estuary as they did for Charlotte Harbor. These sensitive areas are as follows:

1. "Estero Bay, valued for recreational, fishery, and scientific uses; listed because of urban development hazards.

2. All tidal creeks, valued as habitat, nursery, and nutrient assimilation functions; listed because of use in land drainage and upland development.

3. All tidal canal systems, valued for their real estate and navigation uses; listed for being "worst case" water quality areas and hazardous to human health.

4. All major sources of fresh water to each estuary.

5. Mangroves, seagrasses, and marshes".

The management plans also require that DNR map preserve features according to their resource value in order to identify "Resource Protection Areas" (RPA). Three levels of classification are used in the RPA mapping program. 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 by declining to class three or building to class one. Examples are patchy or sparse grass beds, mangroves in scrub condition, and saltwater colonizing new lands. Class three features of aquatic preserves lack the characteristics of class one or two resources.

When complete, the RPA maps will be used as a DNR planning tool by the central ofice in Tallahassee and local staff. Resources of the aquatic preserves will thus be considered in assessments of dredge and fill permit applications and other proposed uses.

2) DEPARTMENT OF ENVIRONMENTAL REGULATION

The DER is the lead state agency for overall regulation of activities affecting the environment. The DER maintains its South Florida District office in Ft. Myers and a chemistry/biology laboratory in Punta Gorda. Pursuant to enabling legislation contained in Chapter 403, Florida Statutes, it implements environmental protection programs in a number of areas. Of particular relevance to this study are rules addressing water quality standards (17-3), permits (Chapter 17-4), wastewater facilities (Chapter 17-6), dredge and fill activities (Chapter 17-12), coastal management program grants (Chapter 17-24), regulation of stormwater discharge (Chapter 17-25), and mangrove protection (Chapter 17-27).

DER's Chapter 17-3 specifies limits for dissolved oxygen, bacteriological quality, detergents, oils and greases, certain heavy metals, and pesticides. The standards apply to ground water used for potable purposes and surface waters, both fresh and marine. Surface waters are divided into five classes according to their primary use. The five classes are Class I, or surface waters used for potable purposes; Class II, waters suitable for shellfish harvesting, or having the potential for harvesting; Class III, waters suitable for recreation and the propagation of fish and wildlife; Class IV, waters used for agricultural purposes; and Class V, waters used for industrial purposes (Chapter 17-3, F.A.C.).

Class II waters have a higher use than Class III waters because they may be used for shellfish harvesting in addition to recreation and propagation of fish and wildlife. Class III waters, on the other hand may not be used for shellfish harvesting although shellfish may be found there.

Waters within the Lee County coastal zone are Class II and III. Although the standards for these two classes are nearly identical, actual levels of bacteriological contamination from septic tank leachate, sewage discharges from boats, and stormwater runoff determine where shellfish may be safely harvested for human consumption. As a result, Class II waters open to harvesting are generally found in those estuarine areas not adversely influenced by human activity.

The status of Class II waters is determined by the DNR through observation of activities on adjacent uplands and regular field monitoring to ensure bacteriological standards are met. The agency produces and distributes maps which depict the standing of areas within Class II waters according to four categories.

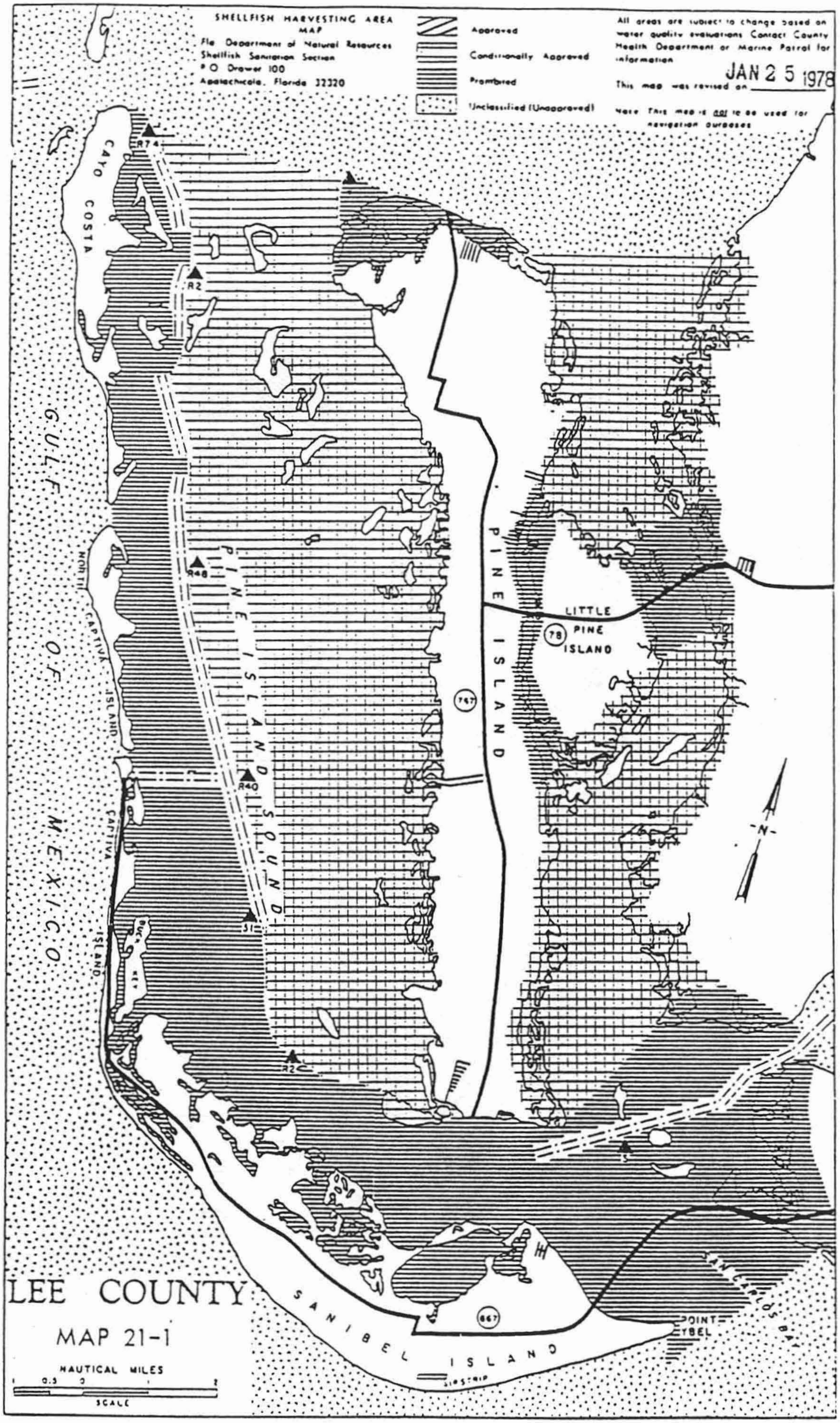
Clean waters are designated approved for shellfish harvesting. Waters subject to water quality changes are conditionally approved, degraded waters are prohibited for the taking of shellfish, and other waters are unclassified. Unclassified Class II waters have the potential for shellfish harvesting but are not approved because water quality trends have not been established through extensive testing. An example of the various Class II categories is shown on the attached maps for Lee County.

The maps for all Class II waters around the state are grouped together by DNR in its Shellfish Harvesting Area Atlas. Maps are revised as field testing and water quality dictate. An undated, current issue of the Atlas was obtained from the DNR central office in July, 1987 after a telephone inquiry to the Division of Marine Resources revealed the Atlas had been upgraded since 1978.

A comparison of the most current map for Pine Island Sound, Matlacha Pass and San Carlos Bay with the 1978 map shows a significant upgrading of large areas of Pine Island Sound and Matlacha Pass from prohibited and conditionally approved to approved. New areas of the prohibited classification are included around St. James City, Useppa Island and Cabbage Key, south of Little Bokeelia Island and from Demere Key to Cork Island. The upgrading of Class II waters is probably due to increased water quality evaluations by DNR staff and not due to dramatic improvements in water quality.

San Carlos Bay and Estero Bay were closed to shellfish harvesting in 1978 and remain so today. That portion of the Cape Haze-Gasparilla Sound Aquatic Preserve in Lee County north of Pine Island Sound remains conditionally approved, as was the case after a 1983 map revision, except for an area behind the town of Boca Grande which is closed.

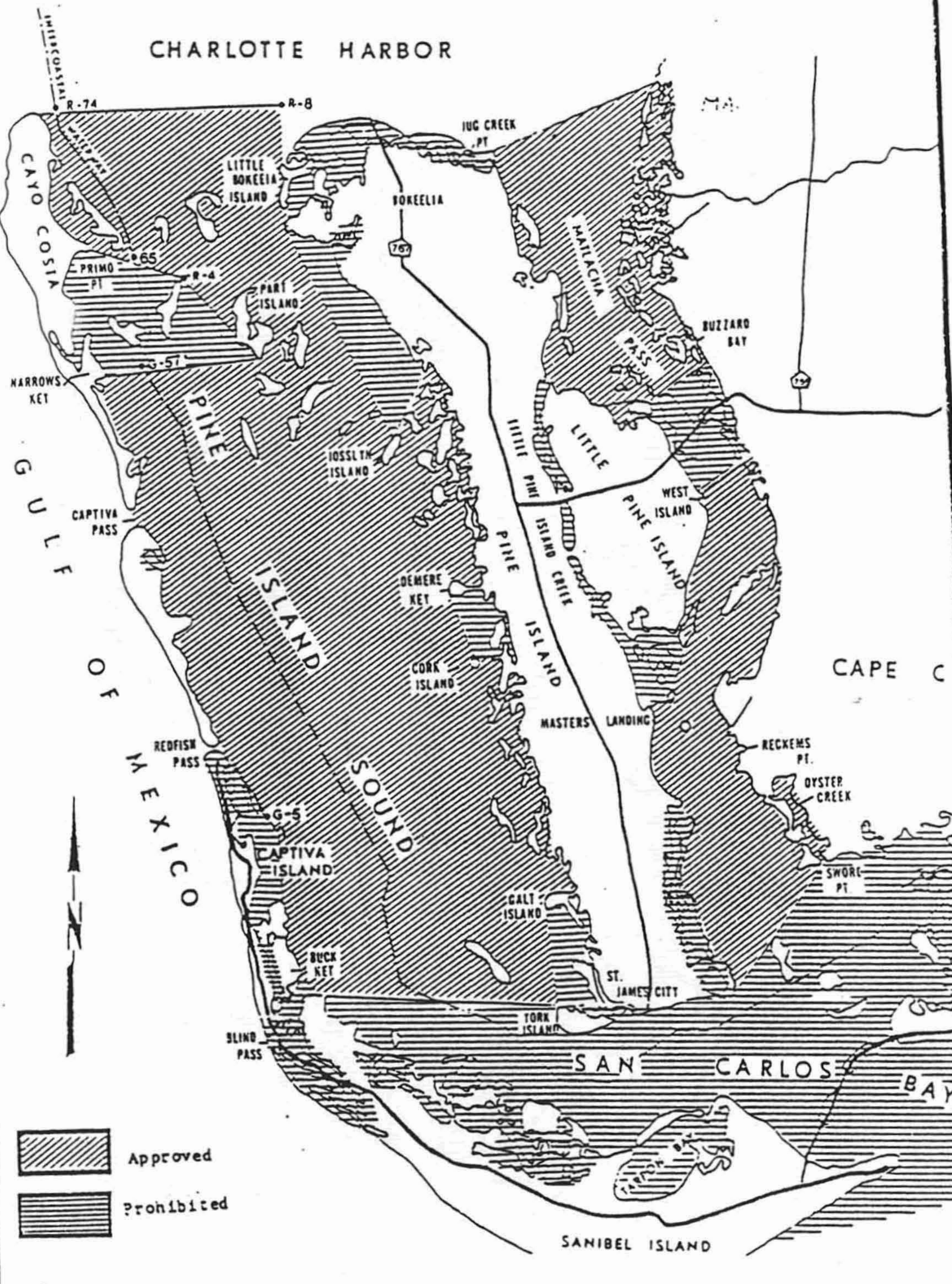
The preservation of Class II waters is clearly related to the degree of upland development and nonpoint source runoff in addition to the presence of polluting point source discharges and natural events such as red tides. Where DNR sampling documents violations of water quality standards, shellfish harvesting is halted, temporarily or permanently, Class II Waters in Lee County (1978)



Adapted From DNR, 1978

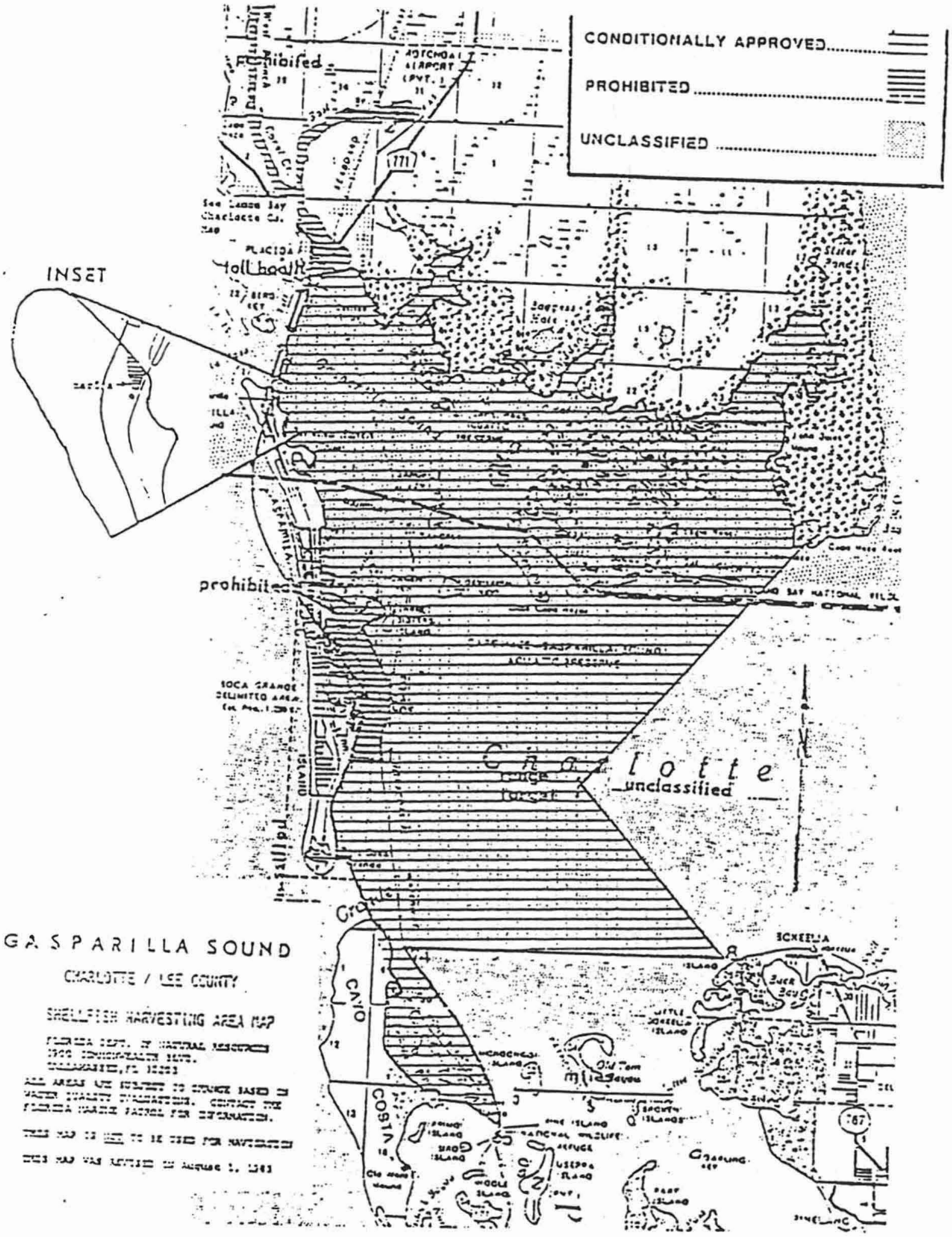
MAP 21-1

Class II Waters in Lee County (1987)



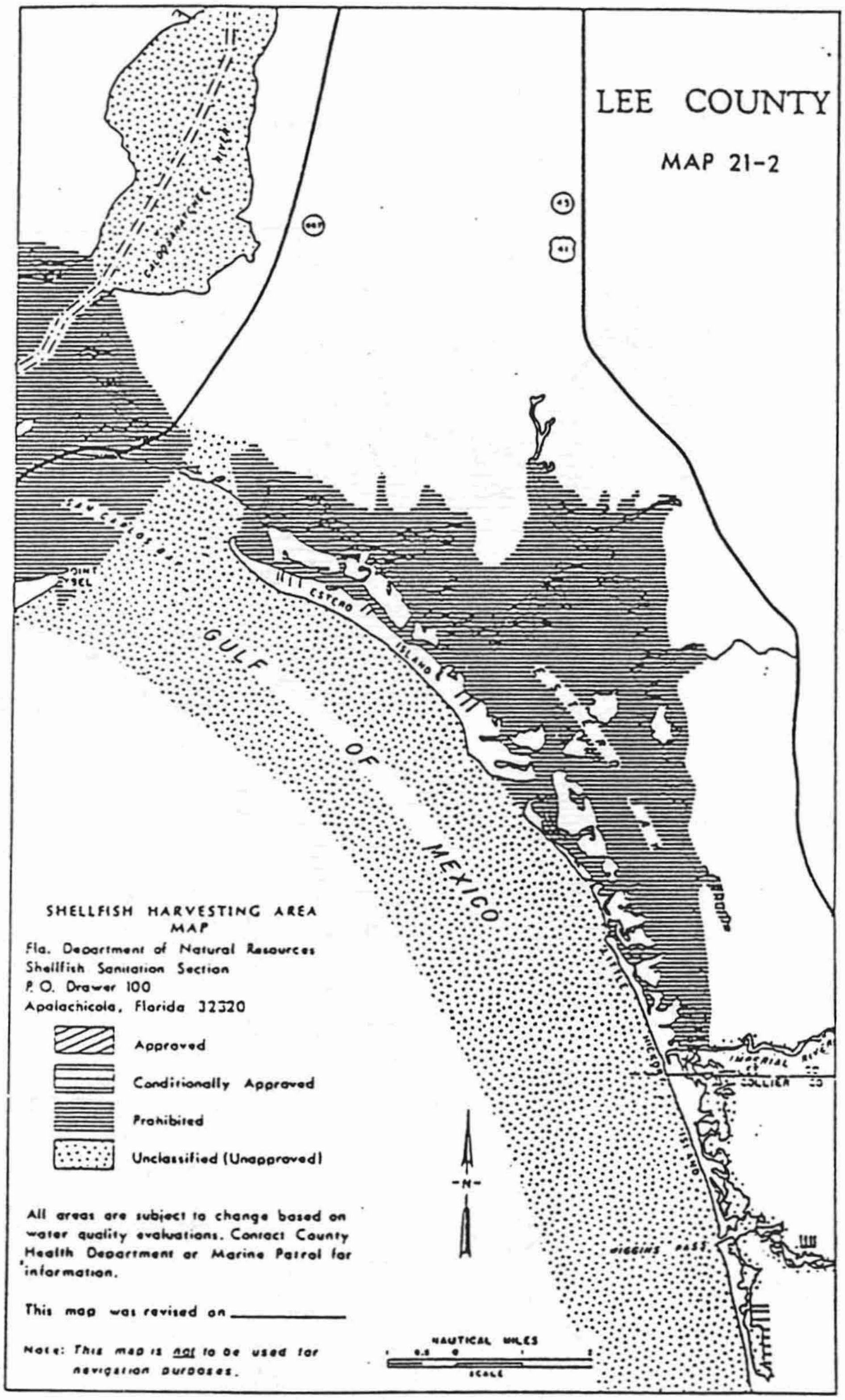
Adapted From DNR, 1987

Class II Waters in Lee County (1983-1987)



Adapted From DNR, 1987

Class II Waters in Lee County (1973-1987)



Adapted From DNR, 1987

depending on the nature of the pollution source and the potential of the waters to meet standards.

DER rule, Chapter 17-4, F.A.C., requires permits for the operation, maintenance, construction, or expansion of stationary installations which are reasonably expected to be sources of pollution. This rule is the basis for the DER regulatory program covering a large number of activities including dredge and fill projects, stormwater, sewage treatment plants, landfills, industrial operations, and hazardous waste generators. A 1984 statutory revision to this rule also extended DER's authority over wetlands by increasing its wetland plant indicator list from approximately 100 species to approximately 300 species (F.S. 403, 1984 Warren S. Henderson Wetlands Protection Act).

Chapter 17-6, F.A.C., sets standards for wastewater treatment and disposal. Point source dischargers in Lee County are subject to the requirements of this rule.

Chapter 17-12, F.A.C., regulates dredge and fill projects. It lists both exempt activities and those requiring permits, prescribes procedures for obtaining a permit, and sets application fees.

Coastal management program grants are administered according to the provisions of Chapter 17-24, F.A.C. Under the rule, procedures for the application, evaluation, and distribution of federal funds supplied to the State of Florida pursuant to Sections 306 and 306A of the Coastal Zone Management Act of 1972. The 1986 Estero Bay water quality study was performed by Lee County with a grant from the DER Office of Coastal Zone Management.

Stormwater from new construction is regulated according to the requirements of DER Chapter 17-25, F.A.C. This rule was delegated to the South Florida and Southwest Florida Water Management Districts in 1982 for implementation with their surface water management rules.

DER Chapter 17-27, F.A.C., prohibits the indiscriminate cutting of mangroves. This rule protects mangroves from an activity not previously regulated through Chapters 17-4 and 17-12, F.A.C.

The Department of Environmental Regulation is the agency which has regularly conducted water quality and biological sampling in the study area since the early 1970's. Yet, due to changing priorities and manpower and budget constraints, the number and location of sampling stations is limited. Stations in some cases are sited at bridge crossings to facilitate sampling without a boat. This permits sampling by a small team, coverage of a wider area in a given time period, and expedites the return of samples to the laboratory.

The DER has six water quality sampling stations on Charlotte Harbor, two stations in Lee County on the Caloosahatchee River, and the one previously mentioned at Big Carlos Pass. The stations in Charlotte Harbor include one at the U.S. Highway 41 Peace River bridge and the remainder scattered down the harbor to a point opposite Bokeelia on Pine Island. The river stations are located at the S.R. 78 highway bridge and Redfish Point in the lower reach of the river.

All of the stations offer a high degree of confidence that the data collected is representative of conditions in the waterbody with the exception of the station at Big Carlos Pass. There, the open waters of the Gulf of Mexico may indicate a higher quality than might be found in the eastern half of the bay. Sampling on incoming tides, and the diluting effect of tidally induced mixing might cause observers to miss increases in concentrations of pollutants and declining salinity levels until the estuary is severely damaged. A more centrally located DER station in Estero Bay is highly recommended considering the rapid development of uplands on the mainland and the poor flushing characteristics of the estuary.

The biological health of the Lee County coastal zone is necessarily related to the quality of its waters and integrity of grass beds, marshes, and mangrove forests. As the agency with primary responsiblity for monitoring water quality, biologists at the DER Punta Gorda laboratory have established three "marine trend" stations in the Lee County coastal zone. The stations are located in Estero Bay (east of Coon Key), Pine Island Sound, and Redfish Point in the Caloosahatchee River. Macroinvertebrate benthic samples are collected through the use of a ponar grab device.

The District Biologist (Rutter, 1987) reports that several years of data on benthic invertebrates are on file in the Punta Gorda office. Long-term, site-specific monitoring is required to determine ambient conditions from which pollution trends may be identified. At this time, however, the marine trend data have not been analyzed and the Department is continuing to establish ambient conditions.

Other pertinent biological sampling by the DER Punta Gorda laboratory includes a special study of grass bed diversity and an ongoing program of benthic sampling at six sations throughout Charlotte Harbor. The grass bed study was a qualitative evaluation to obtain data for use in assessing dredge and fill impacts pursuant to the agency's dredge and fill rule, Chapter 17-12, F.A.C. Benthic samples at the Charlotte Harbor stations have been collected since 1979 and the data are filed in notebook form at the laboratory. As with the data for the marine trend stations in Lee County waters, the Charlotte Harbor benthic data have not yet been analyzed. Analysis of biological data for Charlotte Harbor will be performed when time and manpower permit and the project receives a high priority.

According to the District Chemist (Sessions, 1987) in Punta Gorda, the DER de-emphasized extensive background water monitoring about 4 years ago and began special "basin studies" (Sessions, 1987). As the name implies, basin studies are localized, intensive water quality investigations as opposed to routine monitoring over large geographical areas. Basin studies have been performed by the DER on water bodies of special concern such as the lower Peace River, Highlands County lakes, and the Kissimmee River/Lake Okeechobee system. Reports of findings are then issued upon review of the data. In addition to its basin studies, the DER does ,however, continue to monitor some of its formerly established "permanent network" stations.

Important water quality sampling and research has been performed by the DER's Office of Coastal Management (OCM). This branch of the DER receives federal funding from the Office of Coastal Zone Management, National Atmospheric and Atmospheric Administration.

Sampling by the OCM for heavy metals in sediments initially began as a effort to document heavy metals pollution associated with ports and marinas. When the expected high levels of metals were not found in the water column at test sites, staff looked at the sediments. Interpretation of data obtained from sediment samples proved difficult since heavy metals are found naturally in the earth's crust. As a result, new analytical techniques were developed to take into account background concentrations of heavy metals. The new DER analytical procedure is described in a paper titled "Identifying Metals Pollution in Florida Bays and Estuaries" by Ryan et al., which was presented at the Coastal Zone Conference in Seattle, Washington in May 1987.

Experience has shown that metals can be found naturally in pristine coastal areas not yet affected by human activity. They are transported to the coastal zone from contintental uplands by erosion and weathering processes. When saline waters are encountered, differences in ionic composition of fresh and salt water cause a number of physical reactions such as flocculation and co-precipitation to occur. Further, most metals tend to be associated with fine grain sediment fractions because of their greater surface area and stronger binding affinities between metals and particulates. The result is that most metals in contact with fine-grain suspended silt particles are rapidly removed from the water column to bottom sediments. According to Ryan (1987), geochemical principles predict that heavy metals in saline water will be very low even where large anthropogenic metal inputs occur.

The inadequacy of the present DER water quality standard for metals and the practice of testing for heavy metals in the water column is illustrated by comparing average water column values for copper from the Hudson River and Miami River with the DER standard. The DER standard for copper in the water column is 15 ug/l, or 15 parts per billion. The natural level of copper in Florida coastal waters is 2 ug/l. Copper in the Hudson River averages 7 ug/l and the Miami River averages 3 ug/l. Although the levels of copper in the Hudson and Miami Rivers are well below the DER standard, studies have shown the underlying sediments are so enriched with metals and other pollutants that organisms cannot survive. By the time copper levels reach the regulatory level, trophically important biota that recycle chemicals are destroyed, producing reverberations throughout local food webs (Ryan et al, 1987).

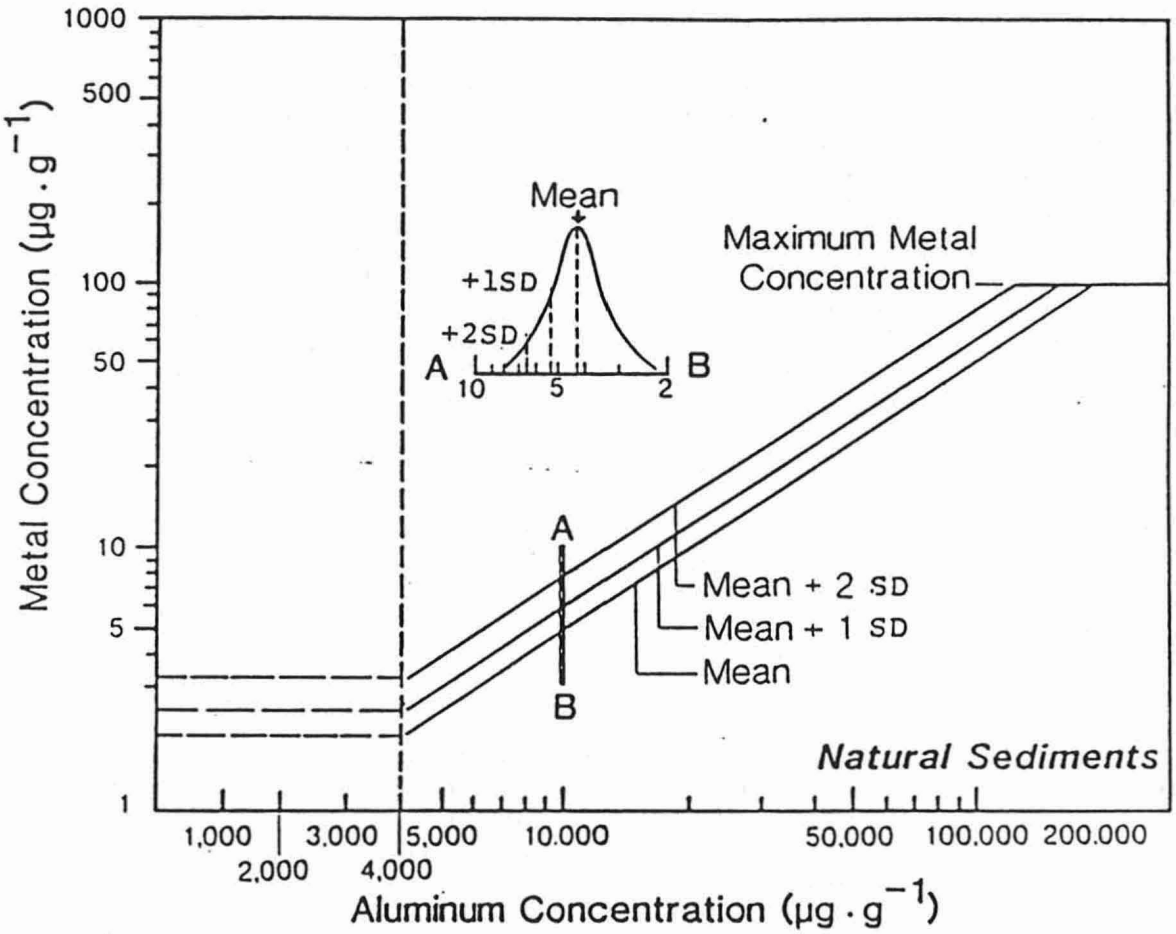
Aluminum, the most abundant element in the earth's crust, is one metal not likely to be discharged to surface waters as a result of human activity and is extremely refractory in sediments. It is used by OCM as a "normalizing" element for variables in sediment grain size, i.e., it is the one metal against which others will be compared because of its above noted attributes. Where sediment grain size is large, the concentration of aluminum will be less than where sediment grain size is small, nevertheless, aluminum will be present in the sample because of its overall dominance in the earth's crust.

Studies have shown a direct correlation between the concentration of aluminum in bottom sediments and the concentration of other metals such as arsenic, cadmium, chromium, copper, mercury, lead, and zinc (Ryan et al, 1987). The data were obtained from samples taken at "clean" stations in a variety of drainage basins and sediment types along Florida's coastline.

After the data were submitted to statistical analysis, a graph was developed which shows the expected, or predicted, concentration of a hypothetical metal based on the concentration of aluminum in the sample. Actual samples indicating metals "enrichment" plot above the mean+2 standard deviation line on the graph.

The results of data on heavy metals in sediments obtained by OCM have far-reaching implications concerning the validity of DER heavy metals data from samples obtained in the water column. The DER's water quality standards apply only to samples taken from the water column. There are no such standards for heavy metals pollution in sediments which might protect organisms from toxic effects and preclude their entry into food chains.

OCM Hypothetical Metal-Aluminum Distribution Graph



Hypothetical metal-aluminum graph showing calculated mean and standard deviations. The graph can be used to interpret absolute concentrations of a hypothetical metal at different aluminum concentrations. The line AB depicts the mean, and plus one and two standard deviations (SD) for the metal at 10,000 ppm aluminum. The horizontal line at the right side of the graph represents the highest metal concentration observed in clean sediments.

Adapted From Ryan et al. 1987

This detailed description of OCM methods for assessing metals pollution in the coastal environment is included to alert Lee County officials to the fact that a major problem now exists within the DER over where, and how to test for heavy metals. No evidence has been seen to indicate these questions will be resolved any time soon.

Serious concern is also raised regarding interpretation of existing DER water quality data for heavy metals obtained from the water column. The lack of known violations of DER standards should not routinely be accepted as meaning there is no metals pollution problem in the coastal zone. On the contrary, the uncertainity over validity of metals data, coupled with the lack of overall historical water quality data, makes more urgent the continued sampling of threatened areas such as Estero Bay. The results of OCM sampling in the Caloosahatchee River and Charlotte Harbor are discussed in the section on assessment of existing data.

3) SOUTH FLORIDA WATER MANAGEMENT DISTRICT

The SFWMD is currently conducting an important water quality study of the lower Caloosahatchee River below S-79, the Franklin lock and dam, and waters of 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 sparse.

At issue is the effect on the estuary of the release of large volumes of freshwater from water control structures on the Caloosahatchee River. The goals of the three year study, which started in 1986, are to document baseline conditions in the river and estuaries over several wet/dry season cycles and the development of management guidelines for operation of the locks (Chamberlain, 1987).

The study area includes 17 stations scattered throughout the river, San Carlos Bay, and Pine Island Sound, where biological and water chemsitry samples are collected monthly. Eight of the stations are located over grass beds.

No results of the study have been published to date and a final report is at least three years away. Upon completion of the baseline study, it is possible that the District will continue its investigation to determine how the estuary responds to a variety of recommended management guidelines for operation of the Franklin lock (Chamberlain, 1987).

A report covering two years of water quality monitoring in the Calooshatchee River, between Lake Okeechobee and the Franklin locks, and its tributaries was obtained and is part of the data inventory for this study. It is recognized that the SFWMD study area is not a part of the coastal zone, but the data may have implications for future estuarine conditions in Lee County.

The District's Division of Water Resources is investigating the hydrodynamics of the Caloosahatchee River in order to develop a model as has been done for the Kissimmee River. The model will enable the District to understand how the entire river and lock systems function under a variety of loading conditions. This project involves one year of work.

4) U.S. GEOLOGICAL SURVEY

As mentioned earlier in this report, the U.S.G.S. is approximately two-thirds of the way through its 7 year study of Charlotte Harbor. This project is one of the most ambitious of its type ever undertaken in southwest Florida.

In addition to its Charlotte Harbor work, the Survey is also involved in two other studies which might ultimately affect the water quality of Lee County coastal waters. One is an investigation to determine where connections might be made to existing dead-end saltwater canals in Cape Coral to improve circulation and prevent build-up of pollutants (Goodwin, 1986). This study is completed and the results are being reviewed internally before publication.

The other U.S.G.S. study is an effort to determine how water from the canals in northern Cape Coral might be diverted to canals in southern Cape Coral to reduce the flow of freshwater into Matlacha Pass. The study will also assess whether excess freshwater from the canals could be used to recharge the depressed mid-Hawthorn aquifer under Cape Coral by gravity flow. This study began in October 1986 and provides for a 2 year period of data collection with another year for analysis (LaRose, 1986).

B) <u>LOCAL GOVERNMENT WATER MONITORING PROGRAMS</u>

Two local governments in Lee County have performed limited water quality sampling, the City of Cape Coral and Lee County. Lee County's program is better developed, having been in operation since the mid-1970's.

The City of Cape Coral hired an aquatic scientist in response to a recommendation of the 1984 Cape Coral 208 Water Quality Study. Using a grant from the DER Pollution Recovery Trust Fund, the City is sampling water quality at 18-20 stations. Priority is being given to sampling saltwater canals and adjacent natural, background stations because the 208 study concentrated primarily on freshwater canals.

Lee County operates a laboratory at which water samples are analyzed. This facility permits the County to perform special water quality investigations on a priority basis. The laboratory also serves government and private sector clients.

In addition to water quality sampling in other surface waters throughout the county, the lab engaged in water quality testing in Estero Bay at Big Hickory Pass. This sampling was initiated as a result of complaints concerning the quality of bay waters when the pass closed naturally. In 1986, Lee County completed a study of Estero Bay water quality and circulation patterns, and a sediment analysis. This project was funded by a grant from the DER Office of Coastal Management. The results of the 1986 report are discussed in the "Review of Existing Data" section.

C) <u>POINT/NONPOINT POLLUTION SOURCES</u>

1) POINT SOURCES

Point source discharges in Lee County are limited, generally, to sewage outfalls, most of which are not in the coastal zone. These sources are closely regulated by the DER through its permitting and enforcement programs.

Major point source discharges into the Caloosahatchee River come from two sewage plants belonging to the City of Fort Myers, a plant in the City of Cape Coral, and Florida Cities Water Company plants at Waterway Estates and Fiesta Village. The cumulative design capacity of these plants is 26 million gallons per day. A small, unauthorized discharge at River Trails Mobile Home Park is under enforcement action.

Waste load allocations to improve treatment and reduce the amount of nutrients entering the Caloosahatchee River are imposed on the plants by the DER. These allocations are based on existing water quality conditions in the river as determined by sampling and are updated periodically. The latest intensive survey of the river was conducted in June 1987. If water quality conditions in the Caloosahatchee River deteriorate, the wasteload allocations will become more restrictive.

2) NONPOINT SOURCES

Nonpoint pollution is a more complex problem in Lee County because of the diverse nature of activities generating uncontrolled runoff and the wide variety of constituents that may be discharged to surface waters. Sources are those where stormwater runoff is allowed to enter the surface waters without treatment.

New development must meet treatment standards for stormwater imposed in Lee County by the SFWMD. Routine maintenance of detention/retention treatment facilities must be performed for them to function as designed. Even though new stormwater treatment systems permitted under current regulations are an improvement over antiquated drainage designs, the cumulative impact of increasing numbers of treated stormwater discharges on sensitive estuaries like Estero Bay, is not known.

In large, older urban/suburban areas, it is difficult and expensive to correct the discharge of inadequately treated stormwater. No state regulations exist that require that they and large agricultural drainage systems be retrofitted with some form of treatment mechanism, although the DER proposed such legislation in 1986. The Surface Water Improvement and Management Act of 1987 addresses the improvement and maintenance of water quality in specific problem areas, none of which are in Lee County. Improvements in the water quality of Lake Okeechobee, one of the threatened waterbodies, would benefit the Lee County coastal zone, however, by enhancing the quality of water discharged to the Caloosahatchee River.

The exact methods for improving the water quality of Lake Okeechobee have not yet been determined. One proposal from the SFWMD was to bypass nutrient-laden water from the Kissimmee River directly into the Caloosahatchee River. If implemented, this action may improve the water quality of Lake Okeechobee but would very likely worsen the water quality of the Caloosahatchee River and ultimately, the Lee County coastal zone. Algae blooms, oxygen depression and fishkills could result. The DER District Office in Ft. Myers did not give the bypass suggestion favorable consideration (Blackburn, 1987).

Review of aerial photographs and ground truthing revealed a number of land uses and activities in the coastal zone with potential to cause water quality degradation. Agricultural lands near Iona, or Truckland as shown on the general highway map for Lee County, are drained by canals and ditches of the Iona Draiange District which connect to Hendry Creek. These lands may contain heavy metals and non-biodegradable pesticides from their use prior to strict environmental regulation. Some of these agricultural lands are still actively planted in tomatoes, gladiolus flowers and other crops. Although banned pesticides should no longer be used, fertilizers, herbicides, and degradable pesticides may enter drainage systems.

Road systems and older industrial/commercial facilities, built prior to regulatory agency treatment requirements, may permit the discharge of oils, greases, sediment, and heavy metals to nearby drainage systems. Ten Mile Canal extends from the coastal zone of Estero Bay north to the City of Ft. Myers picking up stormwater drainage from industrial, commercial, and residential development as well as the Six Mile Cypress Strand and lands formerly used for agricultural purposes. The Ten Mile Canal/Six Mile Cypress watershed covers 57 square miles of various land uses (Lee County, 1986).

Golf courses require intensive management and maintenance of greens and fairways. As a result, pesticides and fertilizers are heavily applied to control pests and promote the lush growth of grasses. Runoff from golf courses may contain high concentrations of these chemicals.

Residential developments may contribute nutrients and pesticides from lawn and shrubbery care, animal wastes, and sediments, heavy metals, oils, and greases from driveways and roads. The discharge of these pollutants is accelerated in the numerous canal systems found on the mainland and barrier islands. There, stormwater enters surface waters directly without the benefit of filtration, precipitation, and nutrient assimilation provided by vegetated ditches, swales or retention ponds.

Septic tank wastes are also a problem near the water when central sewer systems are not available. Central sewer facilities constucted by Lee County at Matlacha and Estero Island where high densities of septic tanks formerly existed have no doubt improved local surface water quality. The number of septic tanks still in use in the coastal zone and their condition, is not known.

The section of Lee County between Estero Bay and Interstate 75 is perhaps the fastest growing in the county. Several new subdivisions are being constructed along Island Park Road where stormwater runoff will enter Estero Bay through Ten Mile Canal or Hendry Creek. Another subdivision is being built around the rock pits south of Ten Mile Canal where a navigable access channel and docks are proposed. Further to the south, the Bonita Bay DRI is planned for the area between Spring Creek and the Imperial River.

The strong, water-oriented life style and abundant marine resources of Lee County have resulted in the presence of large numbers of pleasure and commercial boats. To service these boats, numerous multi-slip docks, full service marinas, and maintenance facilities have been constructed. An inventory of multi-slip docking facilities shows 88 in Lee County alone (DNR, 1987).

Matanzas Pass likely contains the highest concentration of boats in the county. Its confined waters have a high density of pleasure boats and large number of shrimp boats, especially in season. No specific data exist for water quality conditions at Matanzas Pass, a fact recognized in the DNR management plan for the Estero Bay aquatic preserve (DNR, 1983). Typical pollutants found in and around marinas and maintenance yards are oils and greases, heavy metals, sediments, detergents, and possibly, human wastes. These may be discharged directly to surface waters from vessels, or by stormwater from uplands.

The DER does not routinely collect long-term data on the quality of waters at any one marina. Permits for the construction of new facilities or the expansion of existing ones frequently contain the requirement that monitoring of water quality be performed. When submitted, water quality data has not, in the past, been carefully reviewed due to other workload priorities (Tschinkel, 1987). Except in extreme circumstances where severe problems are noted requiring corrective action, the monitoring condition terminates upon expiration of the construction permit itself.

A proposal to require marina owners to obtain operating permits with long-term monitoring responsibility has been given a low priority and the rule making process has not begun (Latch, 1987). Until a marina rule is adopted, the impact of marinas on receiving water quality will not be documented unless a special sampling effort is undertaken by the DER or Lee County laboratories.

Sewage from boats with persons living aboard became such a problem that the Lee County Commission enacted Ordinance No. 85-21. The ordinance restricts the use of live-aboard boats to marinas having public restroom facilities for those boats without holding tanks. Live-aboard boats having sewage holding tanks are permitted only in marinas having pump-out systems. The ordinance became effective on July 17, 1985 and allowed marina owners one year to build facilities with which to comply.

Several commercial operations in the Lee County coastal zone have the potential to cause severe pollution during rare storm events. They are the Belcher Oil transfer facility at the south end of Gasparilla Island and the Balgas petroleum storage complex on Matanzas Pass.

Belcher offloads shipload quantities of fuel oil from seagoing vessels to its upland storage tanks. Daily, oil is loaded onto one to two barges for the trip down the Intercoastal Waterway to the Florida Power and Light Company plant on the Caloosahatchee River at Tice. This transfer and transport operation has been relatively free of polluting accidents to date, however the potential remains daily for widespread damage to sensitive estuaries should a spill occur.

The handling, storage, and transport of petroleum products in a coastal environment is regulated by the DNR and the U.S. Coast Guard. Containment dikes and other protective measures such as spill control plans and equipment are required. Oil storage at these two facilities in the Lee County coastal zone have caused no environmental problems to date. However, during rare storm events such as a major hurricane, storm surges along with strong winds and heavy rainfall will stress the storage structures.

The Belcher facility is located on a section of Gasparilla Island that has experienced severe erosion in the past. As a result, the complex may be susceptible to collapse of the dike structure and tanks by a combination of storm surges washing over the tip of the island and erosion of the shoreline.

D) REVIEW OF EXISTING DATA

As part of the inventory and evaluation phase of the special coastal study for Lee County, a number of published reports and actual DER water quality data were reviewed. As previously mentioned, DER water quality data, filed in the EPA STORET system, is the most extensive and long-term database available, and yet, there are disturbing questions regarding interpretation of the data and its application to this study. In addition, we also previously stated that the majority of studies performed prior to the comprehensive U.S.G.S. investigation on Charlotte Harbor were short-term, highly localized, site-specific projects. They constitute a patchwork approach to assessing water quality in the region with no continuity or consistency in the parameters sampled.

Notable exceptions are the previous 208 studies and current special studies of the SFWMD (lower Caloosahatchee River and estuaries) and U.S.G.S. (Cape Coral freshwater diversion and tidal canal interconnection). Studies like these are better funded and broader in scope and sampling term, thus, the data generated has a higher probability of being an accurate assessment of actual water quality conditions.

1) STORET

We initially requested and received from the DER, all the available water quality data for the nine Charlotte Harbor/Lee County stations in both raw and summarized form. The raw data for the nine stations covers some 167 computer-generated pages. The data in summarized form totals 37 pages. In the latter format, all entries for individual parameters at each station are totaled to give mean, maximum, and minimum values, variance, and standard deviation.

The extensive nature of the STORET database is indicated by a directory of parameters which covers 627 pages. The number of parameters sampled varies from station to station, however, parameters for which data was reported includes 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 limited sampling for metals, pesticides, nitrites, nitrates, and ammonia in the sediments was performed. Some data were also given for metals and pesticide concentrations in shell samples. Since there are no standards for metals and pesticides in sediments and shell samples, the relevance of these data as they pertain to the health of Lee County estuarine systems cannot readily be ascertained.

Initial review of the summarized data indicated violations of DER standards for the pesticides endrin, heptachlor, malathion, mirex, and parathion and the metals copper, iron, lead, and zinc. Typically, the data for each parameter were grouped according to coded remarks. For example, data for total copper in a sample taken from the water column lists 7 uncoded entries, 8 entries coded "K", and 1 entry coded "U" for a total of 16 samples. Code K means "Actual value is known to be less than value given". Code U "Indicates material was analyzed for but not detected". Entries with no remarks code are actual values which required no coded explanation.

The coded remarks U and K in the DER printout are quite prevelant in data for metals and pesticides. Furthermore, code U was especially confusing for some parameters because the values given were in excess of DER standards. In discussions with DER staff, Sessions and Jackman (1987) regarding the apparent discrepancy between the data and the code, we were told that the computer was picking up cases where pollutants were below detection limits, yet, the value at the detection limit was being factored into the database. Jackman suggested that two computer runs be made to detect violations, one to include all data for selected parameters and another that would exclude all entries with remarks code U.

DER rule, Chapter 17-3, F.A.C., includes a set of water quality standards against which STORET data can be compared to determine violations requiring further investigation and corrective action if attributed to human causes. A copy of the standards is included in Appendix A of this report.

The water quality standards contain maximum, threshold, values according to the use, or class category of the waterbody, for heavy metals, pesticides, and coliform bacteria and a minimum value for dissolved oxygen. Class II (shellfish harvesting) and Class III (recreation and fish and wildlife propagation) standards were applied to the DER data for the purpose of identifying problem areas.

Except for dissolved oxygen which is reported in mg/l, STORET data for metals and pesticides, are reported in ug/l. The DER standards for metals are specifed in mg/l, therefore, a conversion of the Storet data is required in order to compare it with DER standards (1,000 ug/l=1 mg/l).

Maximum/minimum values had to be included in our request for computer runs identifying violations in the data base for the nine stations of interest in Lee and Charlotte counties. The STORET system includes data from a number of states having different water quality standards and is not programmed to automatically sort out violations of any one state's standards.

DER standards for ten parameters (copper, iron, endrin, dissolved oxygen, toxaphene, lead, cadmium, mercury, DDT, and malathion) were specified for the purpose of comparing them with data in the Storet system. Maximum values were listed for all parameters except for a minimum value (4.0 mg/l) assigned to dissolved oxygen.

Two computer runs were subsequently requested for ten parameters under the conditions suggested by Jackman as an alternative to personal review of the 167 pages of raw data. Dissolved oxygen, copper, iron, lead, cadmium, mercury, toxaphene, endrin, malathion, and DDT were selected for a random overview of water quality conditions at the nine DER stations. The maximum concentrations for all parameters except dissolved oxygen were taken from the DER water quality standards. In addition, the DER standard for dissolved oxygen, 4.0 mg/l, was included in the request as a minimum value.

A computer run for violations of the above specified parameters, including code "U" samples, was received. Of the 9 stations selected, 4 had data for all or some of the selected parameters. The remaining 5 stations had only data for dissolved oxygen. The data demonstrate the DER does not sample a wide variety of constituents at all its stations.

A total of 1,217 values were checked and 119 violations identified. No violations of the DER dissolved oxygen standard were found at any of the nine stations.

Another computer run for detection of violations for the same stations, parameters, and DER standards without the inclusion of code "U" samples was requested. This time the data did not indicate any violations out of 152 values checked. Code "U" samples in the database for 10 parameters thus accounted for 1,065 samples, or 88% of the total entries.

Our experience working with the STORET data and subsequent conversations with DER staff did not result in our having a high degree of confidence in the data available in the system. Further research to verify the weaknesses in the DER water quality database is recommended. Total local government reliance on the present state system to provide an adequate warning of water quality degradation at specific stations should be avoided.

2) 1986 FLORIDA WATER QUALITY ASSESSMENT 305(b) TECHNICAL REPORT

The DER's Bureau of Water Quality Management, Water Quality Monitoring and Assurance Section issued its "1986 FLORIDA WATER QUALITY ASSESSMENT 305(b) TECHNICAL REPORT" in June, 1986. This report is required every two years in accordance with provisions of Section 305(b) of the 1972 Federal Water Pollution Control Act, Public Law 92-500. 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. Environmental Protection Agency (EPA) to improve these problem areas (Hand et al, 1986). This document is the most significant review of general, overall water quality, found in the inventory phase of the Lee County coastal study, although it does not identify violations of DER's standards.

The assessment involved computer analysis of 97,000 water quality samples collected statewide between 1970-1985. The computer analysis required assigning STORET stations to their respective EPA reaches, a national numbering system similar to zip codes which uniquely identifies portions of streams, lakes, and estuaries. More than 5,000 Florida STORET water quality stations were assigned to 926 EPA reaches. About 70% were stream reaches, 20% ocean or estuarine reaches, and 10% lake reaches.

The water quality of these reaches was classified according to an EPA stream water quality index and a DER lake and estuary trophic state index. The 1970-1985 index information was then plotted for each reach to yield a time trend analysis. Summary statistics were compiled, including the reach's water quality and trends, the DER special studies performed on each reach, the domestic and industrial point sources which discharge to each reach, and the current cleanup activities for each of the problem reaches.

One of the most important questions EPA wants addressed through the 305(b) assessment is whether Florida waterbodies meet their intented use. If a reach exhibits good water quality, it meets its use. If a waterbody rates fair, it only partially meets its use and if it rates poor, it is deemed not to meet its use.

Out of a total 9,320 miles of streams statewide, 68% rated good, 25% rated fair, 7% rated poor, and 29% were not sampled. Estuaries account for 2,728 square miles in the state. Fifty-nine percent rated good, 33% rated fair, 8% rated poor, and 16% were not sampled.

The assessment describes the decline in sampling by the USGS, DER, and EPA from a high in the mid-70's when approximately 700 reaches per year were sampled. The present sampling effort covers only about 1/2 of the 700 reaches sampled in the 70's. In the future, the DER will supplement its sampling information with data collected by county governments and regional water management districts.

Dissolved oxygen was the parameter sampled most often (97,000 samples), followed by pH, turbidity, nutrients, bacteria (34,000 samples), inorganic toxic metals (9,000 samples), and pesticides (400 samples). An overall water quality index was calculated for those samples (41,000) which had at least dissolved oxygen and nutrient measurements. The lake and estuary trophic index was calculated for those lakes and estuaries which had at least phosphorous and nitrogen measurements (8,000 samples).

Two water quality index procedures were utlilized in developing the overall water quality index. They are: 1) a stream water quality index procedure (WQI) based on EPA's National Profiles Index (1983), and a lake trophic state index (TSI) based on an index presented in Florida's Lake Classification Study (1983), and 2), a trophic level index (TSI) developed by Carlson in 1977.

The WQI makes use of 7 water quality paramters (dissolved oxygen, pH, bacteria, nutrients, turbidity, organic toxics, inorganic toxics, plus an overall average). Raw data are converted to index values, averaged by month to adjust for seasonal effects, and the mean of the monthly data is calculated. The index values range from 0 to 100. A WQI of 0-30 indicates good water quality, 30-59 fair, 60-100 poor.

The overall TSI is made up of the average of the chlorophyll TSI, the Secchi depth TSI, and the nutrient TSI. Depending on actual water quality values, lakes, and estuaries are rated "good" (TSI=0-49), "fair" (TSI=50-59), or "poor" (TSI=60-100).

Statewide, 64% of the reaches evaluated exhibited no water quality trend, 23% were improving in quality, and 13% were worsening in quality. Fifty-five percent of the pollution was identified as coming from point sources, 42% from non-point sources, 2% from unknown sources and 1% from natural sources. Of the point source pollution, 33% is from domestic sources and 22% from industrial sources.

The 1986 Florida Water Quality Assessment Report contins a basin by basin evaluation of Florida waters. Basins of specific interest to the Lee County coastal study are the Myakka River, Peace River, Charlotte Harbor, Caloosahatchee River, and Everglades-West Coast (Estero Bay). A general description of each basin is included along with a discussion of specific water quality problems and pollution sources.

An introductory description of basin conditions in southwest Florida is given thusly:

> "The Peace River has several problems, most of which originate in the upper reaches of the system. Tributaries to the upper Peace River originate from lakes which have eutrophic conditions. Sources of discharge to the upper Peace include phosphate mining, fertilizer and other chemical manufacturing, effluents from wastewater treatment facilities, citrus processing, and runoff from agriculture and urban areas. Concentrations of nutrients and chlorophyll are very high for this river system. Tributaries to the middle and lower Peace River have significantly lower nutrient concentrations than the Peace River itself.
>
> The Myakka River has good water quality although it has naturally low DO concentrations from swamp drainage and has nutrient loading from agricultural runoff. Its flow varies greatly during the year, sometimes falling to zero net flow in the dry spring season. 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 STP 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".

Detailed information, including water quality ratings and trends, trophic states, point sources of pollution, and type of special survey are presented for each of the 52 basins studied by the DER. Each basin is broken down into a number of reaches within the drainage system. The water quality status and other information relating to pollution sources and agency actions are given for each reach.

Myakka River Basin:

The headwaters of the Myakka River arise in Hardee County and traverse 54 miles to Charlotte Harbor. The drainage basin is approximately 540 square miles. Rangeland (46%) and agriculture (26%) are the major land uses.

This basin generally has good water quality and supports productive habitats in both freshwater and estuarine areas. In the lower basin, Big Slough (through the City of North Port), shows elevated coliform bacteria and nutrient levels presumably due to pasture and urban development runoff. The estuary, though high in phosphorous, supports a healthy flora and fauna.

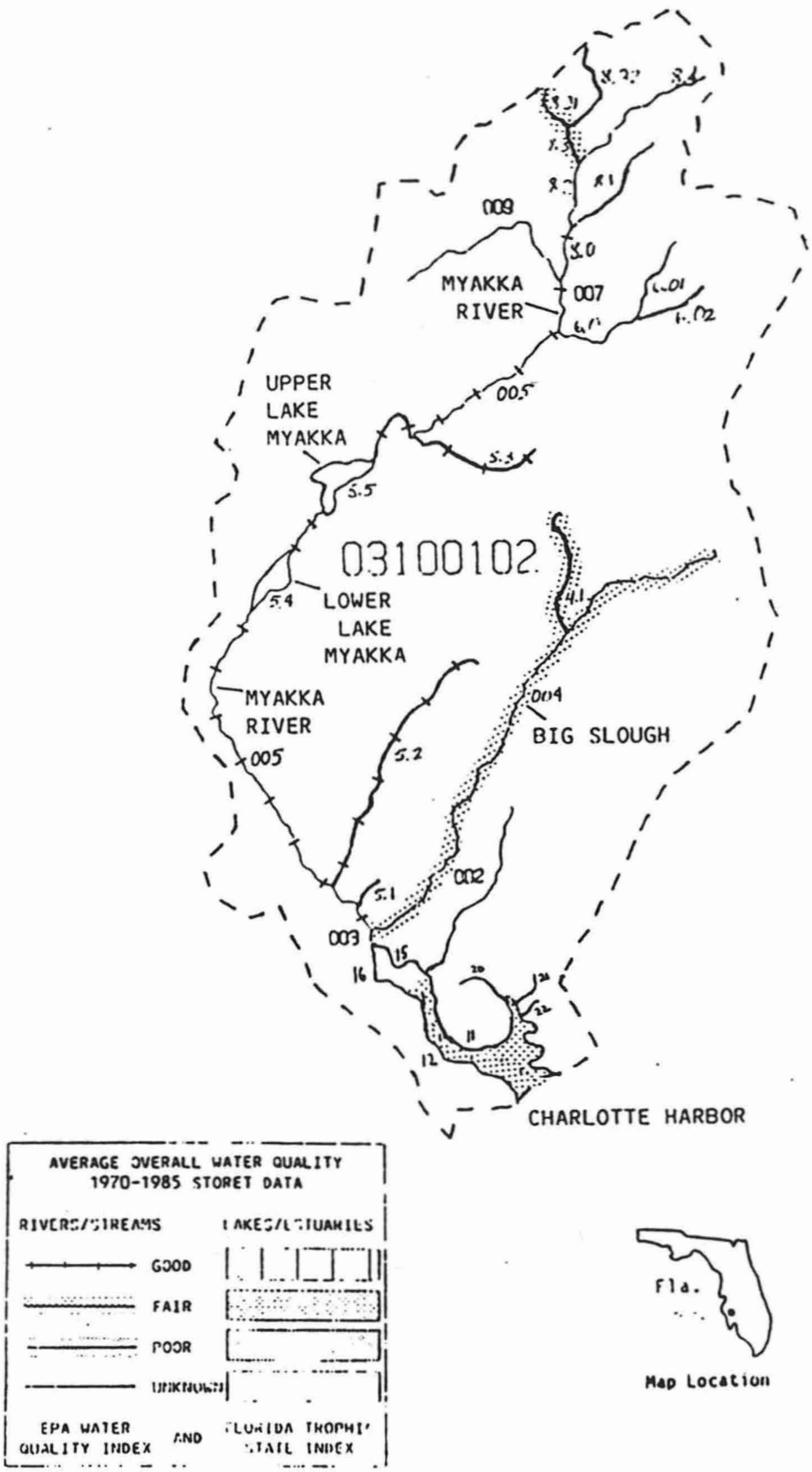
Big Slough rates fair in average overall water quality according to the EPA Water Quality Index (WQI) for streams while the rest of the riverine system rates good except for a small reach in the upper river which also rates fair. The estuarine portion of the Myakka River basin system is rated fair according to the Florida Trophic State Index (TSI).

There are insufficient data to evaluate a water quality trend for the estuarine portion of the basin, however, Big Slough exhibited an improvement in water quality over the last 6 years. Consequently, Big Slough is the only reach in the Myakka Basin for which the water quality trend is predicted as getting better. The only point source in the basin is a phosphate outfall to Wingate Creek and the only special study has been a wasteload allocation on the City of Sarasota's sprayfield site.

Peace River Basin:

The Peace River originates in the Green Swamp of central Polk County and flows some 105 miles to Charlotte Harbor. Its drainage basin covers over 2,300 square miles. Land use in the upper river basin is predominantly agricultural. An additional percentage (25%) is barren phosphate-mined property. In the lower section of the basin, land use consists primarily of agriculture and rangeland. Pollution sources in the Peace River basin include sewage discharges, heavy industrial discharges from phosphate mining activities, chemical and citrus processing plants, and

Average Water Quality in the Myakka River Basin



Adapted from DER, 1986

surface runoff from urban, agricultural, range, and mined lands.

The majority of water quality problems originate in the upper portion of the basin in Lakes Parker, Hancock, and Banana and their tributaries. Pollution there is primarily due to sewage and citrus wastes. The Peace River in the vicinity of Bartow, Fort Meade, and Zolfo Springs is affected by phosphate mining and fertilizer production. South of Zolfo Springs, there are few point sources, and nonpoint runoff changes from phosphate mining to agricultural and rangeland. Water quality of the Peace River entering Charlotte Harbor is fairly good but the estuarine portion of the Peace River basin is being impacted by the development of Port Charlotte and Punta Gorda.

Most of the length of the Peace River is rated fair in water quality according to the EPA WQI. Tributaries to the Peace River generally rate good. Exceptions to the above are several lakes at the northern end of the basin. The southern half of the estuarine section of the Peace River basin, to the mouth of the Myakka River, is rated good by the Florida TSI. The northern half of the estuarine area has not been sampled.

Seven reaches of the Peace River have a poor TSI rating caused by high nutrient levels and shallow Sechhi disc readings. Improvements are predicted in two other reaches and a worsening condition is expected in only one reach near Ft. Meade due to mining/fertilizer operations.

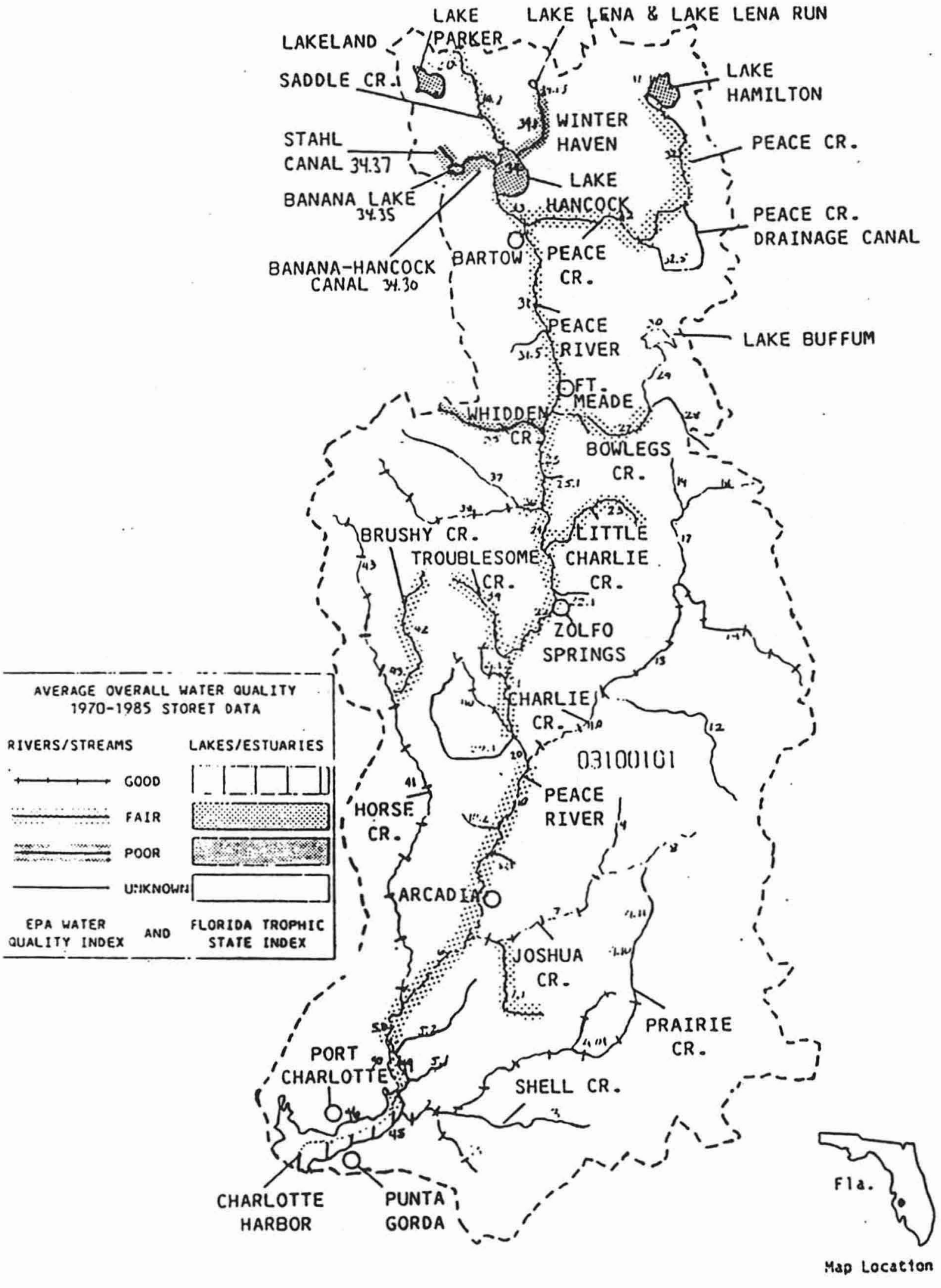
The DER water quality assessment report indentifies numerous point sources along the Peace River. Many of these are outfalls from phosphate operations or sewage plants. These pollution sources have been the subject of many special studies by the EPA/DER such as bioassays, wasteload allocations or the investigation of complaints.

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. The sportfishery and nursery area are impacted by the Myakka, Peace, and Caloosahatchee Rivers. The Charlotte Harbor basin consists of Charlotte Harbor (119 square miles), Pine Island Sound (71 square miles), San Carlos Bay (23 square miles) and Matlacha Pass (23 square miles).

Although the water quality of the Charlotte Harbor basin is generally good, there are 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 Ft. Myers area of the

Average Water Quality in the Peace River Basin



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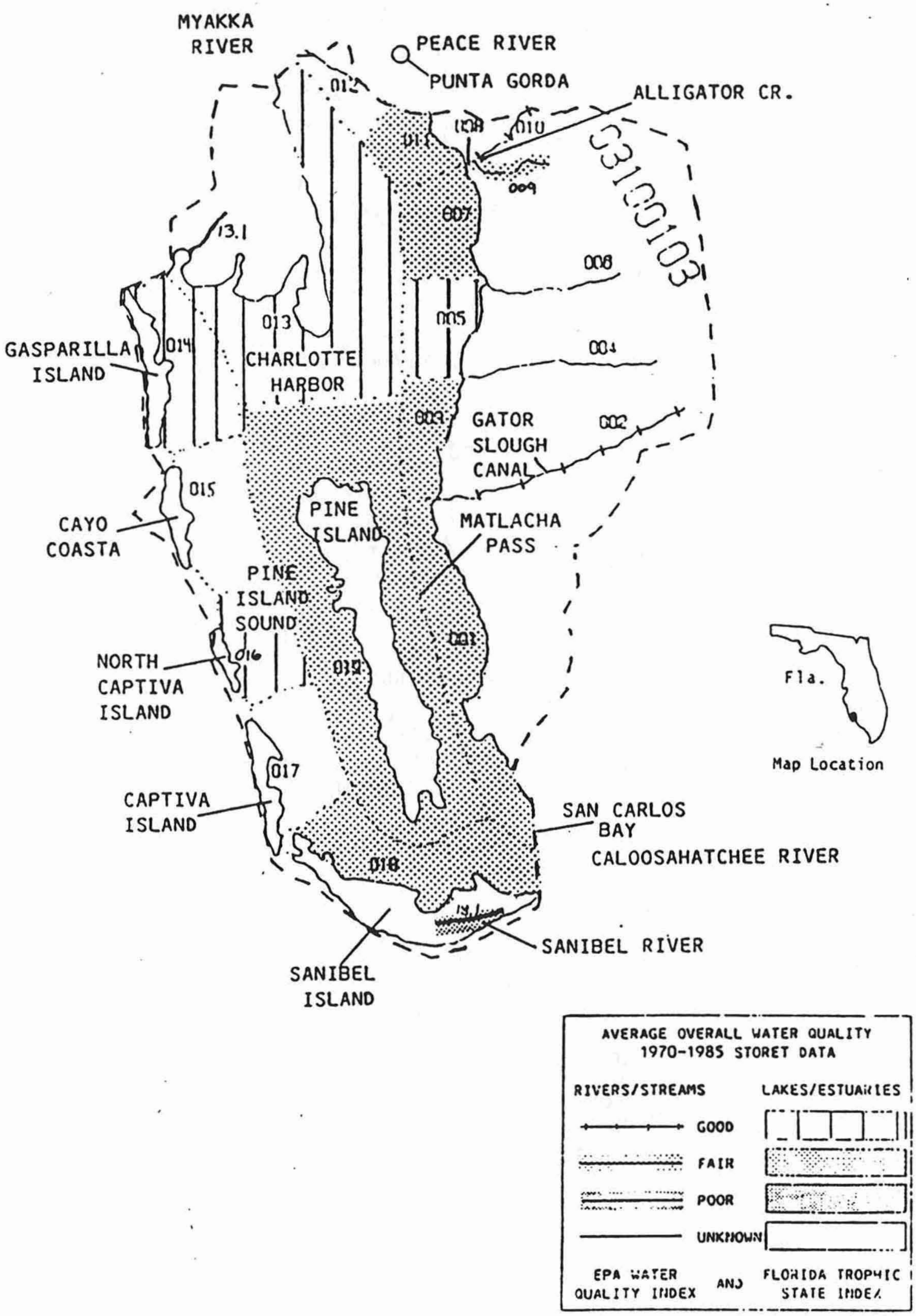
Average Water Quality in the Charlotte Harbor Basin



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lower Caloosahatchee River. Upper Charlotte Harbor is probably impacted to some degree by urbanization at the mouth of the Peace River. A small sewage treatment plant in Punta Gorda may have some affect on Alligator Creek. The only serious pollution problem in the basin occurs in the Sanibel River, on Sanibel Island. It previously received stormwater runoff and effluent from sewage ponds. Leachate from local sewage treatment plants has been controlled, but stormwater runoff continues to enter the river.

The trophic state index for Charlotte Harbor, as shown on the following map, ranges from good to fair for various sections of the basin, except for the Sanibel River as mentioned above. Other sections of the basin have not been sampled enough to permit the development of a ratings designation. Matlacha Pass, San Carlos Bay, the eastern half of Pine Island Sound and a reach adjacent to Alligator Creek in the northeastern quadrant of the basin 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 Captiva 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.

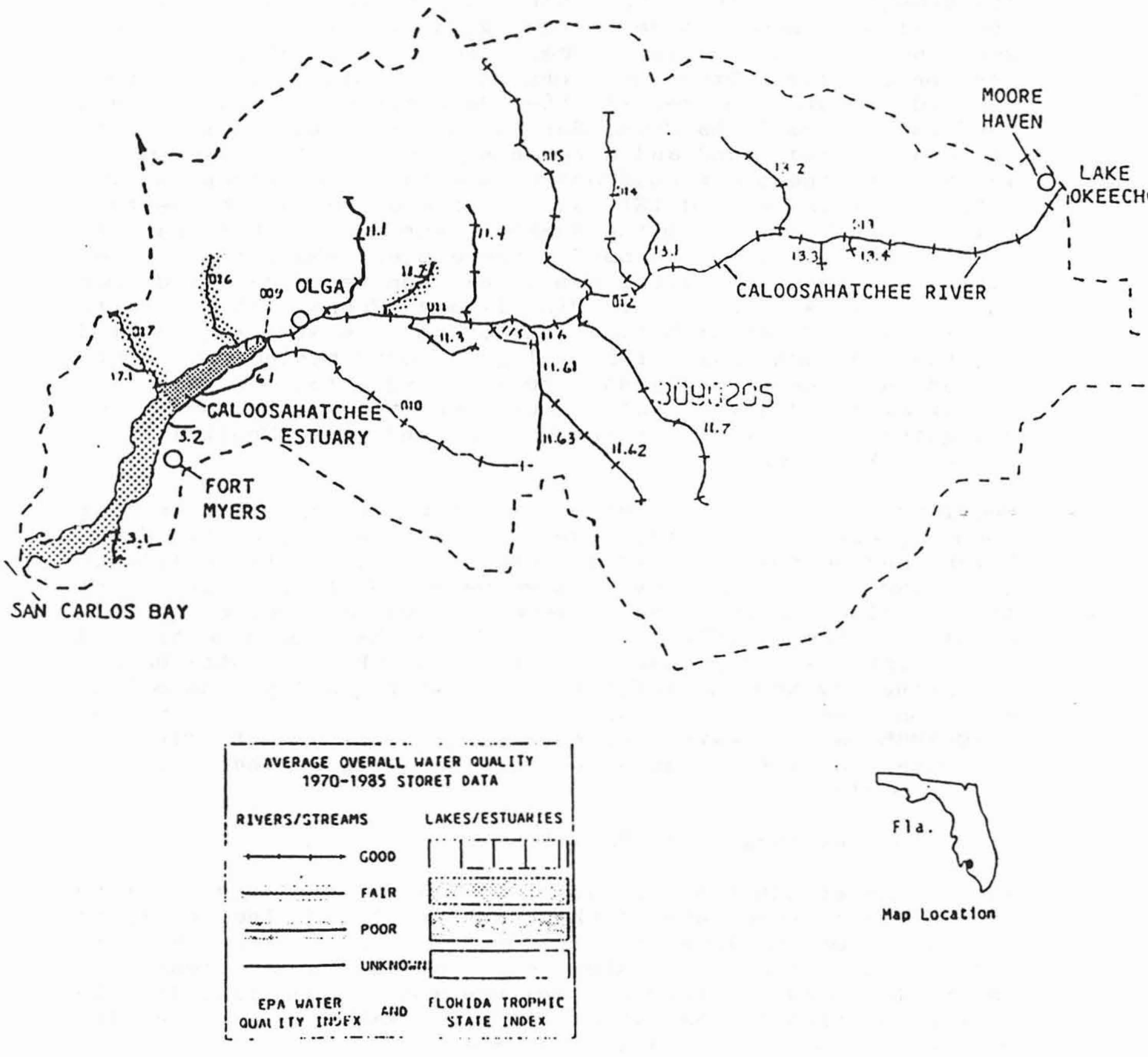
Sections of Charlotte Harbor having a fair TSI rating commonly experienced high levels of nutrients from the Peace River and nearby urban areas, and poor Secchi disc readings. Only two small utility systems were identified as point source dischargers. There were no special water quality studies by the DER/EPA but the U.S.G.S has been contracted to perform a comprehensive study of the Charlotte Harbor estuarine system and influences on water quality. The STORET data on Charlotte Harbor for the period of reference, 1970-1985 was not extensive enough to allow a determination of water quality trends in the 21 reaches of the Charlotte Harbor basin.

The Caloosahatchee River Basin:

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% of the land use category in the basin.

Generally, the water quality in the basin is quite good.

Average Water Quality in the Caloosahatchee River Basin



Adapted From DER, 1986

There are some borderline problems with low DO values in some of the feeder canals to Lake Okeechobee and some of the slower moving tributaries to the river. These problems are believed to be caused by nonpoint agricultural runoff and the warm climate of the area.

The estuarine portion of the Caloosahatchee River and its tributaries have experienced elevated nutrient levels and poor Secchi disc readings. The domestic waste dischargers in the estuary have been eliminated or significantly upgraded and water quality is expected to improve. The area is highly developed and nonpoint source pollution will continue to impact water quality.

According to the 1986 Florida Water Quality Assessment, the Caloosahatchee River and its tributaries above the Franklin locks rate good in the EPA WQI, except for Telegraph Creek which rates fair. The estuarine section of the basin has a WQI rating of fair in the reach from San Carlos Bay to Hancock Creek near the U.S. 41 bridge. From that point east to the Orange River the estuary rate poor on the Florida 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.

Pollution sources in the basin are sewage treatment plants and nonpoint runoff. Streams, or sections of the estuary, which have a fair or poor WQI or TSI rating exhibit a combination of high nutrient levels, low Secchi disc readings and low dissolved oxygen levels.

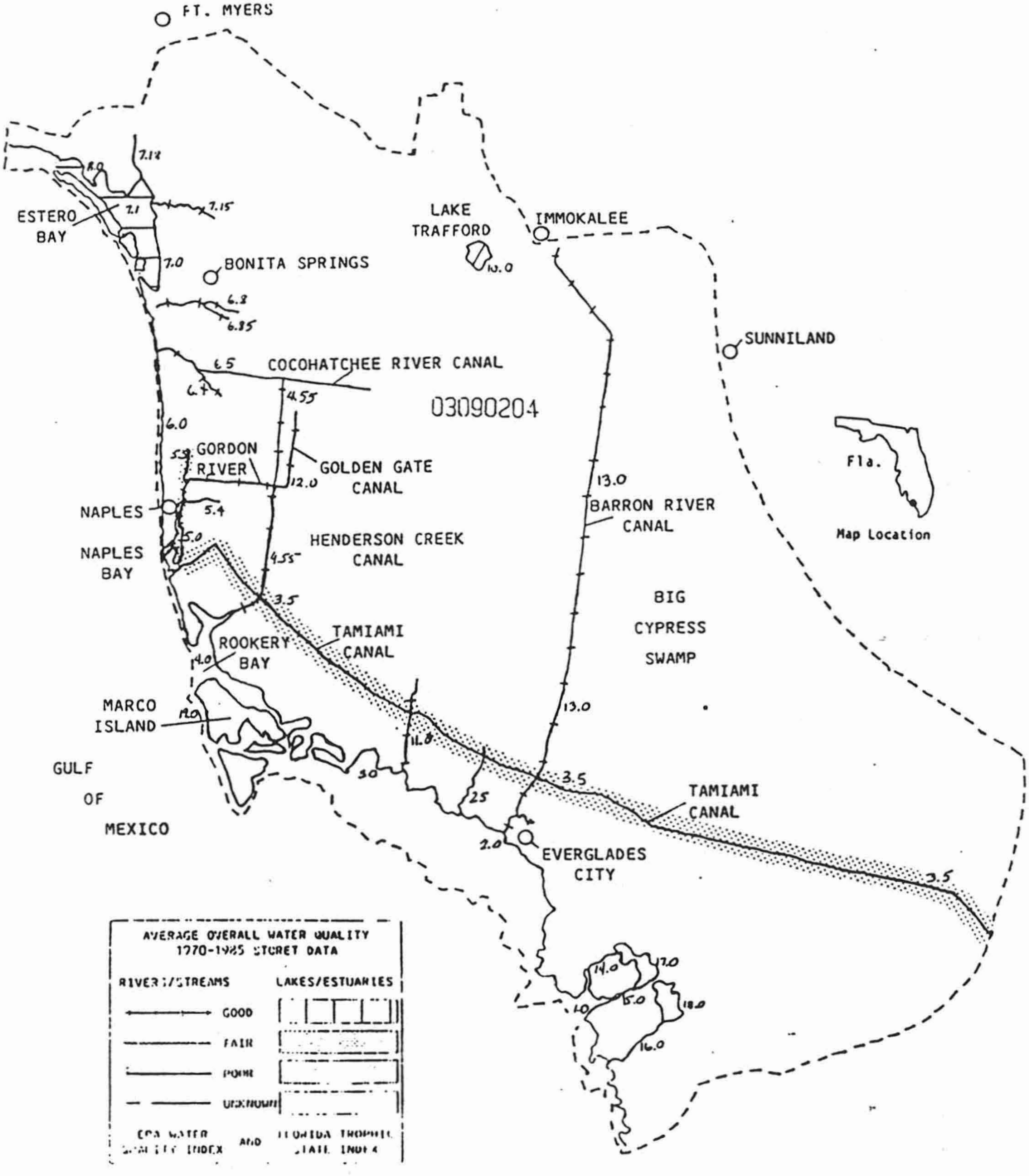
Point source dischargers in the Caloosahatchee River basin include sewage plants, the City of Cape Coral reverse osmosis plant (1.6 mgd brine discharge), the Florida Power and Light Company (563.0 mgd thermal discharge), Citrus Belle in Labelle and the City of Moore Haven. Special DER studies in the basin consist of intensive surveys, wasteload allocations and bioassays. The available data was insufficient to permit a water quality trend analysis.

Everglades-West Coast Basin:

The 1986 Florida Water Quality Assessment places Estero Bay in the Everglades-West Coast Basin. This basin consists of 2,657 square miles extending from south of Ft. Myers and Lake Okeechobee to the Broward County line and southwest to the vicinity of Lostmans River in Everglades National Park.

According to the DER, this basin has very limited STORET water quality data. Only four reaches have been sampled since 1980. They are Estero Bay, Lake Trafford, the Gordon River and the Tamiami Canal. Estero Bay and the Estero River are given a good water quality index rating and Estero Bay

Average Water Quality in the Everglades-West Coast Basin



Adapted From DER, 1986

received a good trophic state index designation. Reaches in Hendry Creek and the Gulf of Mexico were not categorized.

Only one point source was listed for Estero Bay, Bay Beach on Ft. Myers Beach with a discharge of 43.2 mgd. The nature of this large discharge is not specified. Another point source, Imperial Harbor Mobile Home Park, is sited on Spring Creek, a tributary to Estero Bay. No special studies have been performed by the DER in Estero Bay and no assessment of trends in water quality within the bay was made.

Several points should be noted concerning water quality assessments made in the 1986 Florida Water Quality Assessment 305(b) Technical Report. One involves the DER assessment that water quality in the Caloosahatchee River system is generally quite good and the other concerns the good WQI and TSI ranking of water quality in Estero Bay.

The DER assessment of overall good water quality in the Caloosahatchee River basin seems to be at odds with the findings (Technical Publication 82-4) of the SFWMD intensive study of the Caloosahatchee River and its tributaries. That study found violations of dissolved oxygen standards in 22% of surface and bottom samples taken from the river itself, and in 31% of samples taken from tributaries. Certain pesticides and heavy metals also exceeded DER standards.

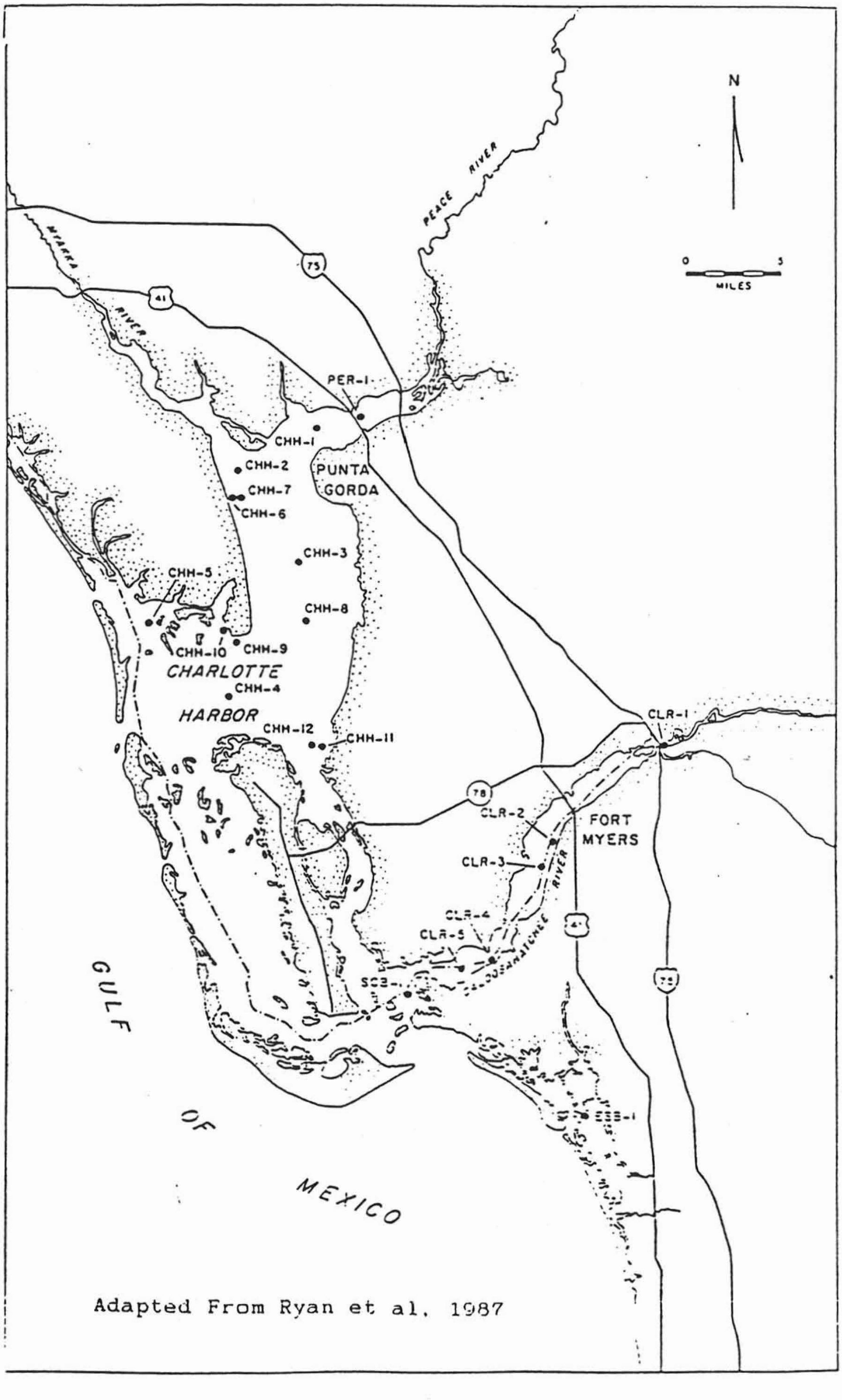
A possible explanation is the possibility that SFWMD data are not a part of the STORET database and DER's routine sampling in the basin was not as intensive as the SFWMD effort. DER staff (Jackman, 1987) indicated the DER is attempting to have data from outside sources entered into the STORET system, a fact mentioned in the 1986 Florida Water Quality Assessment report. The SFWMD study is discussed in detail in a later section of this report.

The DER's WQI and TSI good rating for Estero Bay may be due to an overall lack of data for much of the estuary and the less-than-representative data collected from its one station, at Big Carlos Pass. The data collected at Big Carlos Pass, in close proximity to the open Gulf, may mask water quality degradation that might exist elsewhere in the bay. True conditions in Estero Bay may not be known because of a lack of stations near nonpoint pollution sources on the mainland.

3) OCM CHARLOTTE HARBOR/CALOOSAHATCEE RIVER STUDY

As previously mentioned, the DER's Office of Coastal Management has conducted water quality sampling in the Peace River, Charlotte Harbor, the lower Caloosahatchee River, San Carlos Bay, and Estero Bay under its Estuarine Research Program. The scope of study involved the assessment of metals, nutrients, and organochlorines in the sediments at

1985-1986 OCM Charlotte Harbor/Caloosahatchee River Sample Stations



one station on the Peace River, San Carlos Bay, and Estero Bay, 5 stations on the Caloosahatchee River between the Franklin lock and San Carlos Bay, and 12 stations in Charlotte Harbor. The field work was performed during 1985 and 1986. The data obtained were presented to the Southwest Florida Regional Planning Council in a meeting March 26, 1987. Any follow-up action in the form of further study will have to be initiated by the planning council according to Ryan (1987).

Some of the OCM data for various stations show metals enrichment of sediments. OCM plotted data are included in Appendix B at the end of this report. Metal concentrations considered enriched are those falling above the top line of the graph.

Of particular interest are levels of chromium, lead, mercury and zinc. The majority of stations having enriched metals in sediments are located in the Caloosahatchee River. In fact, Caloosahatchee River station CLR-1 located at the I-75 bridge had the highest value for all metal parameters and arsenic of all stations tested.

The absence of metals enrichment at other stations does not necessarily indicate that sediments are relatively free of metals, according to Ryan (1987). Metals enrichment may occur in areas having high percentages of organic silt in the bottom sediments. In a semi-confined water body like the Caloosahatchee River, single, scattered sample stations may be more representative of bottom conditions that large, open water bodies such as Charlotte having variable bottom sediment characteristics.

The OCM selects its estuarine sampling stations according to its estimates of where riverine silt loads are believed to settle out, leading to "worst-case" metals contamination. A relatively few sampling stations, in a one time survey, may miss areas of bottom sediments having high concentrations of metals. In order to better assess bottom conditions, numerous randomly scattered stations are required. Transects across the waterbody may be used in conjunction with, or as an alternative to, randomly scattered single stations.

According to Ryan (1987), the results of the 1985/1986 study of Charlotte Harbor and the Caloosahatchee River are surprising inasmuch as the highest values were expected at the mouths of the Peace and Caloosahatchee rivers where metal-bound sediments might tend to settle out of the water column as the stream velocity slows. Instead, higher concentrations were found at the most landward Caloosahatchee River station. The data suggest metals in sediments may leach, or migrate, to the water column/sediment interface where concentrations are less, in order to reach equilibrium (Ryan, 1987). Silt and metals accumulation in the Caloosahatchee River may be more pronounced east of Ft. Myers due to the runoff of untreated stormwater from longstanding agricultural practices. Because the inland reaches of the river have experienced metals deposition for longer periods than the recently urbanized lower section, higher concentrations in samples may be due to an extended term of migration.

Three current sources of data on Charlotte Harbor are reports from the U.S.G.S. estuarine study. These do not include the literature search by Stoker and Karavitis mentioned earlier.

4) WATER QUALITY OF THE CHARLOTTE HARBOR ESTUARINE SYSTEM, FLORIDA, NOVEMBER 1982 THROUGH OCTOBER 1984

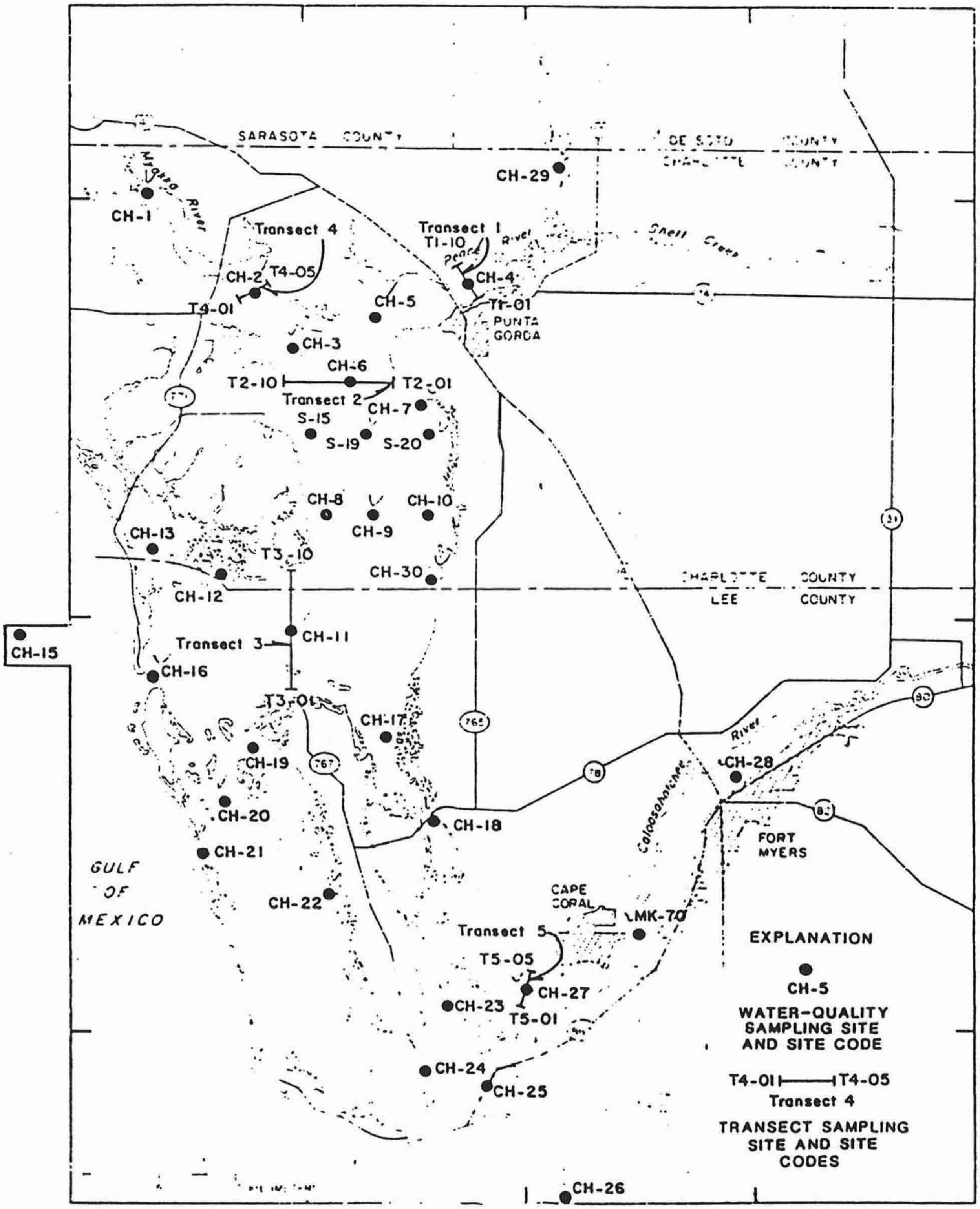
Open- file report 85-563, titled, "WATER QUALITY OF THE CHARLOTTE HARBOR ESTUARINE SYSTEM, FLORIDA, NOVEMBER 1982 THROUGH OCTOBER 1984" is a compilation of two years of water quality data. A total of 33 stations are sited in the Myakka, Peace and Caloosahatchee rivers, San Carlos Bay, Matalacha Pass, Pine Island Sound, Cape Haze, and Gasparilla Sound. Estero Bay was not included in the study because it is considered a separate, distinct, estuary and not a part of the Charlotte Harbor estuarine system. The following map depicts station locations.

Water quality samples were taken from the water column at all stations. Composite sediment samples were collected at each of 5 transect stations. No interpretations of the water quality data were presented in this report. Data for a large variety of constituents are provided in map form as average values for all 33 stations, and tabular form. Statistical summaries for all stations are also included.

A review of the data in open-file report 85-563 was made using DER water quality standards for evaluation of selected parameters. Average values for dissolved oxygen at all stations were above the DER standard of 4.0 mg/l minimum, however, the data show violations of the DER standard at Charlotte Harbor stations CH-4 and CH-29 with minimum values at the surface of 3.8 and 3.1 mg/l respectively. It is not known whether other violations between the listed minimums and the DER standard of 4.0 mg/l occurred, however, mean values for dissolved oxygen at these stations were 6.6 and 5.4 mg/l respectively. Near bottom sampling at station CH-6 showed another violation of standards with a minimum oxygen value of 1.6 mg/l. Mean values at this station were at the minimum 4.0 mg/l.

The DER standard of 15 ug/l for copper was equal to the average concentration at two stations (CH-20 and Ch-27) and exceeded at four other stations (CH-6, 19 ug/l; CH-11, 19 ug/l; CH-24, 34 ug/l; and CH-26, 21 ug/l). The standard for

U.S.G.S. Water Quality Stations on Charlotte Harbor



Adapted From Stoker, 1986

iron, 300 ug/l, was exceeded by average concentrations at six stations (CH-1, 360 ug/l; CH-@, 380 ug/l; CH-4, 328 ug/l; Ch 20, 323 ug/l; CH-26, 335 ug/l; and CH-27, 353 ug/l).

Table 10 of Open-File Report 85-563 lists pesticides sampled December 14-16, 1982 in bottom sediments and the concentrations detected. Chlordane (1.0 ug/kg) was found at transect 1; DDD (0.2 ug/kg) at transect 5; DDE (0.9 ug/kg) at transect 1 and (0.1 ug/kg) at transect 5.

Composite samples of metals in the water column at transects 1 through 5 taken on one sampling day in December 1982 show violations of the DER standard for copper (15 ug/l) at all five transects, iron (300 ug/l) at transects 1,4, and 5; mercury (.1 ug/l) equaled at transects 1, 3, and 4 and exceeded at transect 5; and zinc (100 ug/l) exceeded at transects 2 and 5.

Concentrations of selected metals in bottom sediments collected are presented in Table 8 of Open-File Report 85-563. A comparison of these concentrations with those found by Lee County and the DER in Estero Bay is discussed later.

5) LONG-TERM WATER-QUALITY CHARACTERISTICS OF CHARLOTTE HARBOR, FLORIDA

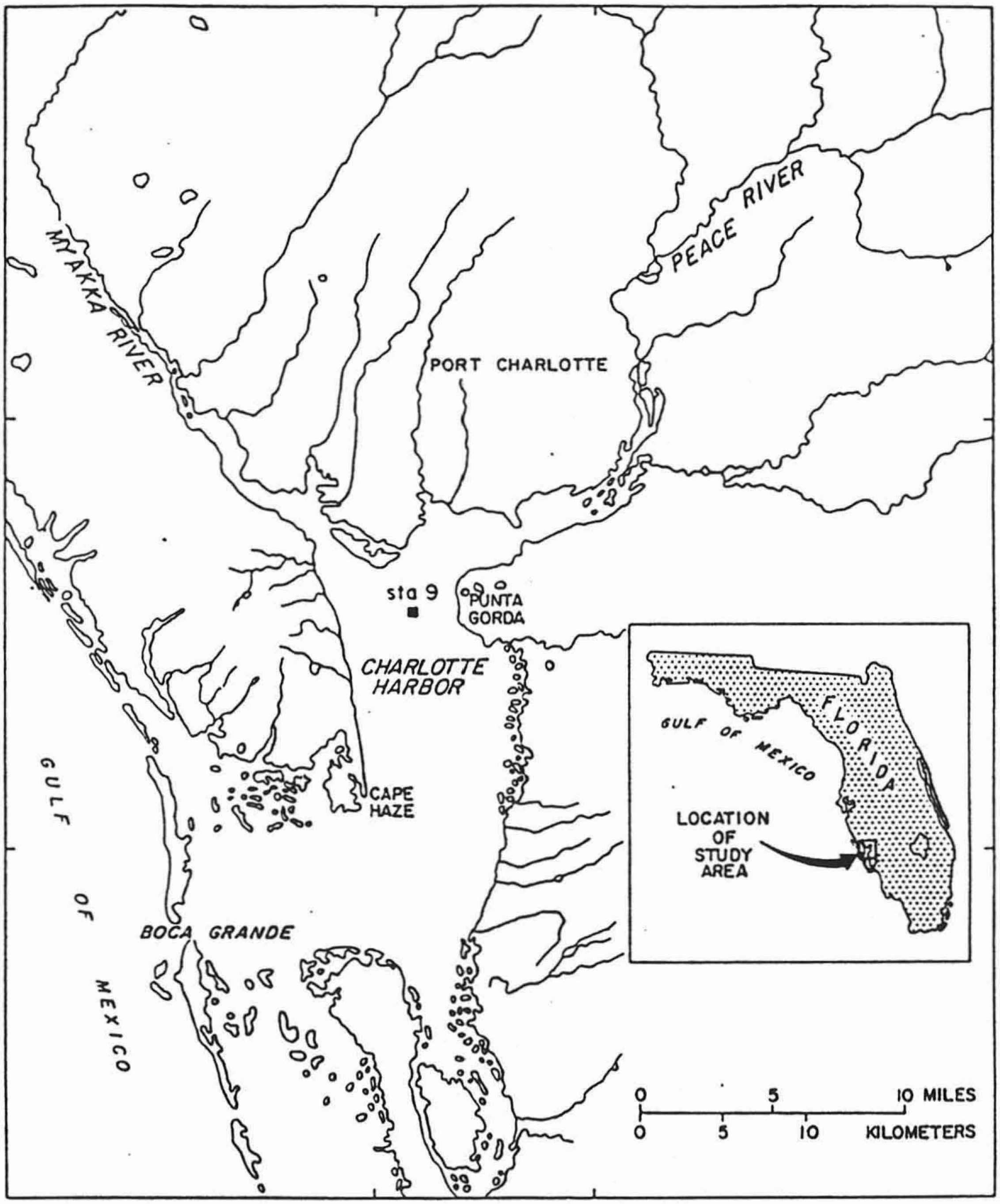
The most recent report associated with the U.S.G.S. study was obtained in May 1987 after delays in publication. Water-Resources investigations report, 86-4180, entitled "LONG-TERM WATER-QUALITY CHARACTERISTICS OF CHARLOTTE HARBOR, FLORIDA", by Fraser, is an assessment of water quality trends at one station in Charlotte Harbor. The study is based on 8 years of data collected by the Environmental Quality Laboratory, Inc. in Port Charlotte, Florida. The sample site, designated Station 9 by the laboratory, is near marker 1 at the confluence of the Myakka and Peace Rivers. The data for this station were subjected to multilinear regression, autoregression, and adjusted seasonal Kendall analyses.

Temperature and orthophosphate showed increasing trends. The cause of the temperature trend seemed to be related to low winter temperatures early in the sample period that resulted from large-scale meterological events. Increasing orthophosphate was the result of changes related to a major source such as the Peace River.

Dissolved oxygen decreased in near-surface waters, but showed no change in near-bottom waters. The cause of the surface decline was not clear, but some indications suggest a relation with primary producers (phytoplankton).

Changes were not found for organic nitrogen, reactive

Environmental Quality Laboratory Sample Station



Adapted From Fraser, 1986

silica, and total phosphate. Furthermore, ammonia and nitrate plus nitrite were in such low supply (many samples below detection limits) analysis for a trend was not possible.

The study found that temperature, salinity, orthophosphate, total phosphate, and reactive silica all had seasonal patterns that were similar near the surface and the bottom.

Dissolved oxygen had a different seasonal pattern near the surface compared with the bottom. This difference was related to biological activity and vertical density stratification.

In the nitrogen series, only near-bottom ammonia values showed a seasonal pattern. The near-bottom ammonia was related to biological activity and vertical stratification.

Fraser (1986) notes the analysis and evaluation of water quality trends at one station in Charlotte Harbor is useful as an initial approach. However, the identification and explanation of trends may be limited because by the single station assessment because some constituents, like dissoved oxygen could be different at other stations.

6) INFAUNAL MACROINVERTEBRATES OF THE CHARLOTTE HARBOR ESTUARINE SYSTEM AND SURROUNDING INSHORE WATERS, FLORIDA

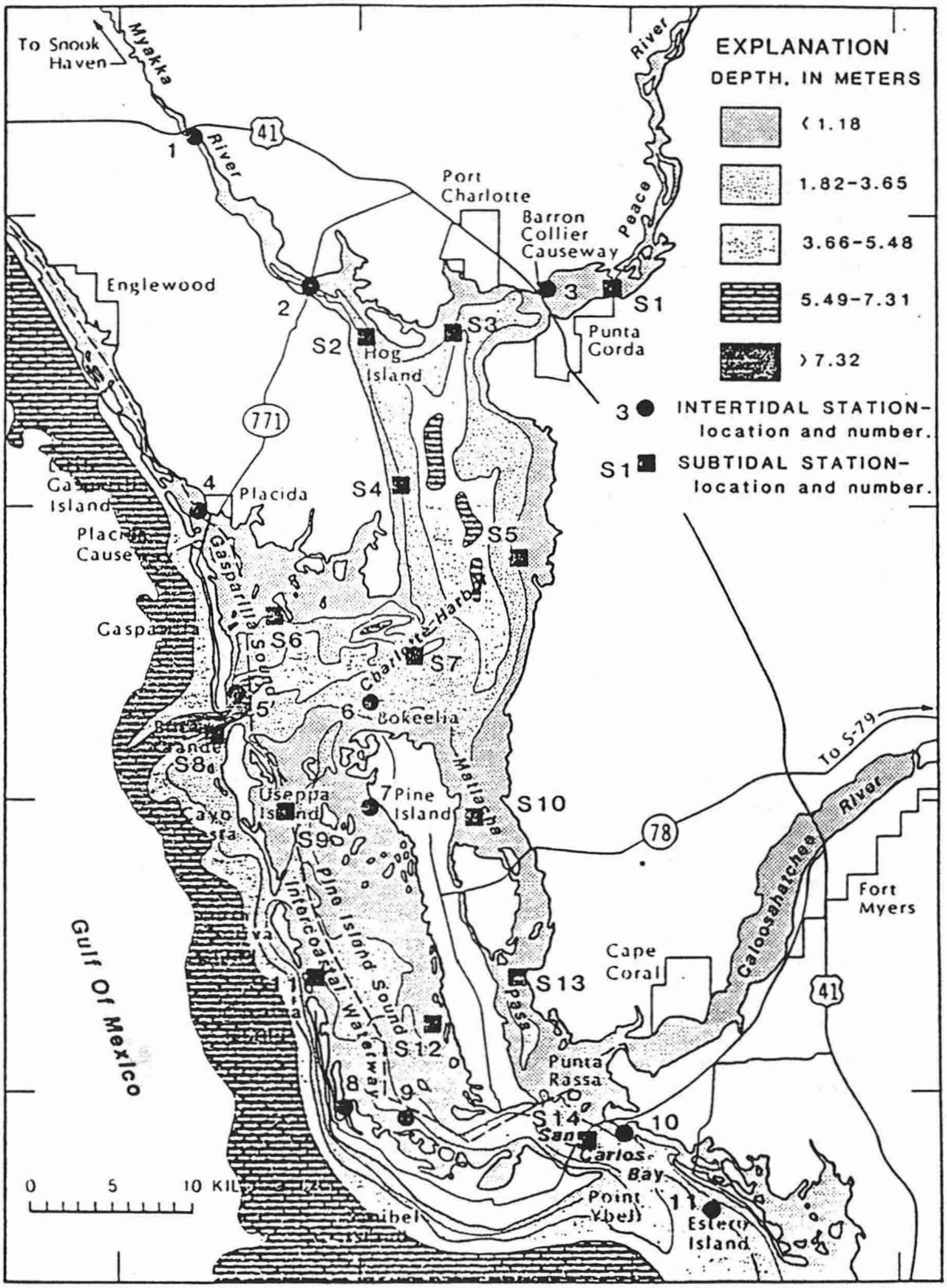
The third U.S.G.S. report from the Charlotte Harbor study is Water Resources Investigations Report 85-4260 by Estevez, entitled, "INFAUNAL MACROINVERTEBRATES OF THE CHARLOTTE HARBOR ESTUARINE SYSTEM AND SURROUNDING INSHORE WATERS, FLORIDA".

This purpose of this study was to evaluate the macroinvertebrate infauna of soft bottom environments of Charlotte Harbor and surrounding inshore waters. Approximately 80-85% of the study area is presumed to be soft-bottomed benthic environment, based on the quantification of bottom types by Harris, et al, in a 1983 study described below. Oyster reefs and grass beds were not sampled.

Unvegetated sandy bottoms are the most common benthic environment of the Charlotte Harbor estuarine system and inshore waters. Sediments of the area are relatively free of contaminants, except near residental canals and marinas.

The average discharge of the Myakka River is 7.2 cubic meters/second, a value that reflects no-flow conditions in some years. Average discharges to Charlotte Harbor from the Peace River (32.7 cubic meters/second) and Caloosahatchee River (40.8 cubic meters/second) are much larger by

Bathymetry and Sampling Stations



Adapted From Esteves, 1986

comparison. Data for the year October 1979 to September 1980, indicate the flow contribution of the Myakka, Peace, and Caloosahatchee Rivers as a percent of the total to Charlotte Harbor. The contribution of the Myakka River ranges from less than 1% in February and March of 1980 to a high of 15% in September, 1980. The Peace River contributed a low of 13% total flow to Charlotte Harbor in February, 1980 and a high of 47% in July 1980. The highest percentage contribution for the Caloosahatchee River was 87% in February 1980 and the lowest came in July 1980. For the referenced year, the most uneven month of freshwater inflow was February, 1980 with the Myakka contributing less than 1%, the Peace 13% and the Caloosahatchee 87%. July, 1980 had the most even distribution between the Peace and Caloosahatchee Rivers of 47% and 48% respectively.

A total of 14 intertidal and 11 tidal stations were sampled during two seasons (May-June and September, 1980). Sampled were benthic infauna, sediment, and hydrographic parameters. All 14 subtidal stations were sampled at the surface and bottom on May 15, 1980. All values for dissolved oxygen were above 4.0 mg/l although one station was close at 4.3 mg/l. Sampling at the same stations on September 16, 1980 found 2 stations in violation of the DER standard at bottom depths. Four stations were close to the standard with values below 5.0 mg/l at the surface while 5 stations had similar values at bottom depths (Estevez, 1986).

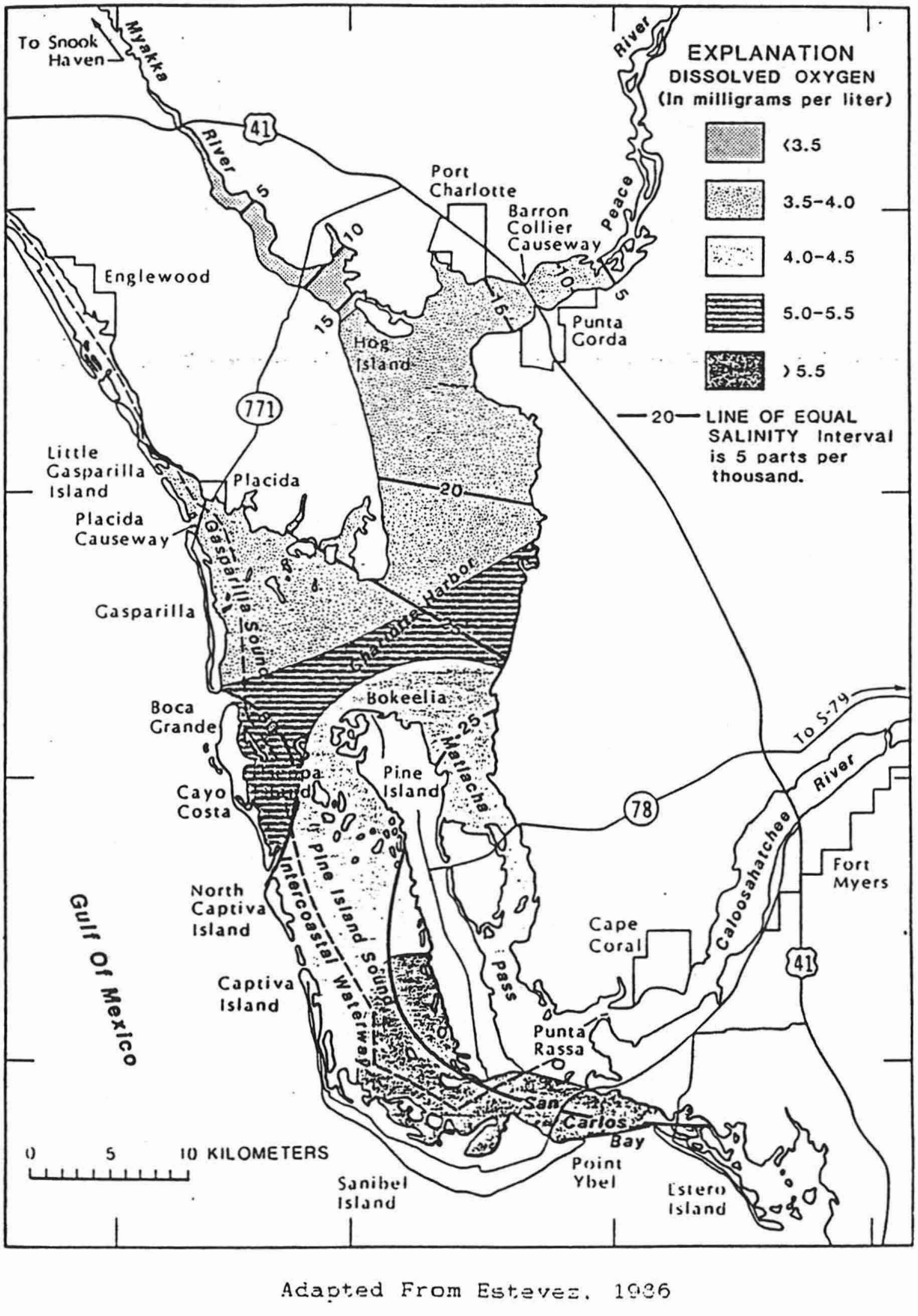
June/September, 1980, values for intertidal salinity and dissolved oxygen were combined to give a composite value for each parameter. Bottom salinity was found to be highest in Boca Grande Pass and San Carlos Bay. Gasparilla Sound and most of Pine Island Sound had bottom salinities of 25 to 30 parts per thousand. Salinities of 5 parts per thousand were found at, or before, stations on the Peace and Myakka Rivers.

Means of dissolved oxygen at the bottom were lowest (below 3.5 mg/l) in the Myakka River and between 3.5 and 4.0 mg/l for lower Peace River, upper Charlotte Harbor, and Gasparilla Sound. The DER standard for dissolved oxygen in marine waters is an average of 5.0 mg/l, with a minimum of 4.0 mg/l. Highest mean values for dissolved oxygen were in San Carlos Bay and lower Pine Island Sound.

Fauna collected during the study totaled 546 species representling 15 phyla. Most common (197 species) were Annelida (polychaete worms) followed by 156 species of Mollusca (gastropods, bivalves and related forms) and Arthropoda (113 species of crustaceans and 5 species of insects). Ninety percent of all species were from these three phyla (Estevez, 1986).

Investigators found that "bottom sediments were similar throughout the study area, except at inlets where they were

Bottom Salinity and Dissolved Oxygen, September, 1980



Adapted From Estevez, 1986

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. Six subsystems had characteristic hydrographic and faunal features that portray the system as an integrated, rather than sharply subdivided, environment. Seasonal trends within and among subsystems were evident, but not extreme, due to relatively dry conditions in 1980" (Estevez, 1986).

Estevez (1986) recommends that new infaunal studies in the area should focus on: the trophic role of key species, the role of infauna in controlling events within overlying waters, and the nature of infauna communities in natural areas (oyster reefs, and seagrass beds) and areas affected by man (residential canals, navigation channels, and petroleum contaminated sediments).

7) ASSESSMENT OF FISHERIES HABITAT: CHARLOTTE HARBOR AND LAKE WORTH, FLORIDA

A study by the DNR (Harris and others, 1983) compared acreages of bottom types found in the Charlotte Harbor/Lake Worth area in 1945 and in 1982. The DNR subcontracted to the Department of Transportation's (DOT) Topographic Bureau to provide the interpretation and mapping of historical and current land use, vegetation, and drainage patterns of the Charlotte Harbor and Lake Worth sites.

For current interpretation of Charlotte Harbor, controlled aerial photographs, (scale, 1"=2,000') were obtained on April, 1982. Positive false color infrared transparencies were produced for standard photointerpretation utilizing stereoscopic equipment. Historical interpretation of the Charlotte Harbor estuary involved the use of black and white aerial photographs taken between 1946 and 1951. Interpretation and subsequent classification of surface features followed the scheme of Kuyper et al (1981). Acreages for various Level I land uses were applied to U.S.G.S. quadrangle sheets. Land use, vegetation, and drainage categories were also digitized into the DOT computer graphics system.

Results of the comparative study and mapping project are described in a 1983 report by Harris et al, titled "ASSESSMENT OF FISHERIES HABITAT: CHARLOTTE HARBOR AND LAKE WORTH, FLORIDA". It was found that salt marsh acreages declined by 51%, unvegetated tide flats declined by 76%, oyster reefs declined by 39%, and seagrass beds by 29%. The same study found an 8% increase in open water and a 10% increase in mangrove coverage.

The increase in open water is believed to be the result of canal construction and the loss of vegetation (seagrasses) in some areas. The increase in mangrove coverage is attributed to colonization of non-vegetated tidal flats (Harris et al, 1983). Conversely, the loss in non-vegetated tidal flats, 11,206 acres to 2,723 acres, is probably due to the increase in mangroves described above.

Oyster reefs are difficult to identify because the reefs are too small for photointrepretation and turbid waters often associated with the reefs make remote sensing difficult. The loss in oyster reefs found in Charlotte Harbor may have involved overharvesting, circulation changes, and particularly, changes in salinity (Harris et al, 1983).

Quad sheets showing the greatest losses in salt marsh were El Jobean, Punta Gorda, Punta Gorda SE, Matlacha, Pine Island Center, and Fort Myers, SW. The decline in salt marsh acreage is attributed to the development of major subdivisions, directly by filling, or indirectly through channelization that diverted the flow of freshwater from uplands.

The 29% reduction in seagrasses in Charlotte Harbor was surprising to the DNR study team because the Harbor is perceived as an area of little detrimental impact. However, virtually every quad sheet showed some loss of sea grasses with the greatest loss, 9745 acres, or 40% of the total decline in acreage, found in the area of the Captiva quadrangle sheet. Adjacent Wulfert, Sanibel, and Pine Island Center quads showed seagrass losses which, combined with the Capitiva loss, make up 57% of the total seagrass decline.

The loss of seagrasses in the Charlotte Harbor estuarine system, particularly, in Pine Island Sound, is believed to be related to several major alterations which occurred in the early 1960's. One was the dredging of the Intercoastal Waterway through Pine Island Sound and the other was the construction of the Sanibel Causeway across San Carlos Bay. Prior to these alterations, Pine Island Sound was under oceanic influence, with sponges, some corals, Thalassia, and other higher salinity species growing within the Sound. Furthermore, the area was a major scallop producer with yields as high as 180,000 lbs/year. By 1964, two years after the causeway was completed, there was no scallop population in lower Pine Island Sound.

The causeway is believed to have caused a change in circulation patterns, forcing freshwater into Pine Island Sound rather than permitting its entry into the Gulf as was the case prior to construction. The resulting decrease in salinity was not conducive to scallop colonization. This effect was predicted by the U.S. Fish and Wildlife Service in an assessment of the causeway's impact before the Corps of Engineer's permit was issued. Even before the causeway was constructed, dams and locks on the Caloosahatchee River disrupted historic patterns of freshwater inflow to Matlacha Pass, San Carlos Bay, and Pine Island Sound.

Seagrass losses in Pine Island Sound may also be attributed to the construction of the Sanibel causeway to some extent. The 13,936 acre seagrass loss in the four mid and lower Pine Island quadrangle areas, occurred primarily in water depths greater than 3 feet. The causeway acted as a dam causing a buildup of freshwater that resulted in net flow up Matlacha Pass and Pine Island Sound. Tannins and suspended particulates associated with freshwater increased turbidity and decreased water clarity. Outright destruction of grassbeds and the reintroduction of fine sediments caused by dredging compounded the adverse impacts of causeway construction (Harris, et al, 1983).

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. The DNR Bureau of Marine Resources is using LANDSAT imagery as part of its Marine Resources Geobased Information System (MRGIS) program. The MRGIS is designed for processing, analyzing, and integrating satellite data and other digital data from a grid system with a variety of environmental and socioeconomic data for resource analyses and applications modeling (Harris, et al, 1983). It will be used primarily as a research tool for coastal zone resource management and for integrating coastal zone data bases. General LANDSAT vegetation cover classifications, Level I/Level II, have been developed for the Charlotte Harbor area as the initial stage of the MRGIS operational development.

8) A SURVEY OF WATER QUALITY CHARACTERISTICS AND CHLOROPHYLL *a* CONCENTRATIONS IN THE CALOOSAHATCHEE RIVER SYSTEM, FLORIDA

The Caloosahatchee River is a major tributary to Matlacha Pass, Pine Island Sound, and San Carlos Bay and the quality of its waters affects the quality of waters in the coastal zone. For this reason, water quality data for sections of the river outside the coastal zone are included in this report.

The SFWMD conducted a two year study of water quality characteristics in the Caloosahatchee River between Lake Okeechobee and the Franklin lock and dam. The river and associated tributaries were sampled from 1978 to 1980. In

1982, a final report, titled, "A SURVEY OF WATER QUALITY CHARACTERISTICS AND CHLOROPHYLL a CONCENTRATIONS IN THE CALOOSAHATCHEE RIVER SYSTEM, FLORIDA", was published.

The study was initiated in 1978 because of the importance of the system to the lower west coast, the general lack of water quality data specific to the Caloosahatchee River and its tributaries, and a recent recurrence of nuisance algal blooms near the Lee County water treatment plant (SFWMD, 1982). Water samples were collected monthly from 17 river stations and 17 tributary stations.

The study found that phosphorus levels decreased from east to west, as did total nitrogen concentrations. 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 study area.

The data were also reviewed by the SFWMD for compliance with DER water quality standards. The section of the river between the Franklin lock and the Lee/Hendry County line is designated by the DER as being Class I waters used for potable purposes. The remainder of the river and its tributaries are designated Class III waters used for recreation and the propagation of fish and wildlife.

In Class III waters of the Caloosahatchee River, 99 violations, or 22% of total samples, of the DER standard of 5.0 mg/l were noted. Violations in Class 1 waters on the river totaled 38 or 22% of all samples collected. In the Class III waters of tributaries, values below the state standard accounted for 182 or 31% of all samples (SFWMD, 1986).

The pesticides aldrin plus dieldrin, chlordane, and DDT were found to exceed water quality standards for Class III waters. In Class I waters, aldrin plus dieldrin and DDT violated standards. Additional sampling in April 1981, conducted subsequent to the initial sampling of October 1979, confirmed that only chlordane in Class III waters remained in violation of water quality standards (SFWMD, 1986).

Total iron concentrations in Class I waters usually exceeded the standard of 0.30 mg/l (SFWMD, 1986). In the eastern half of the study area, all tributaries exhibited iron in excess of standards except for two. In the western half of the study area, iron exceeded standards in only four tributaries, Crawford Canal, Jack's Branch, Ft. Simmons Branch, and the Townsend Canal (SFWMD, 1986). At all stations except for three tributaries, zinc exceeded the DER standard at some time during the study.

9) THE CAPE CORAL 208 WATER QUALITY STUDY

The 400-mile-long canal system in Cape Coral presents a significant, long-term threat to the water quality of the Lee County coastal zone as a major source of stormwater. A special, 208 water quality study was funded by the Southwest Florida Regional Planning Council to document biological and chemical baseline conditions in Cape Coral canals with emphasis on the freshwater section of the system. Due to the extensive nature of the freshwater canal network, 300 miles, and the large quantities of water discharged from it, the study also was to contain recommendations for protecting the freshwater canals from the impacts of continued growth in order that the canals might be used in the future as a source of water for various purposes. The study did not evaluate the spreader canal along the western and southern perimeter of Cape Coral because it was considered to still be in a state of transition after construction.

The 1983 208 water quality study found that the freshwater canals and lakes had generally good to excellent water quality. Aquatic vegetation in the freshwater sections of the canal system at present are buffering the discharge of pollutants into these waterways. Not surprisingly, the water quality of freshwater canals in high denisty areas was worse than the water quality in undeveloped areas.

Most of the urban core of Cape Coral lies in the southeast quadrant of the city which also contains the majority of tidal canals having direct access to the brackish waters of the lower Caloosahatchee River. Tidal canal stations exhibited marginally acceptable dissolved oxygen levels and generally higher levels of most constituents than freshwater canals. In tidal canals, littoral and submerged vegetation is non-existent and stormwater is discharged directly into the canals with very limited treatment on adjacent uplands.

The 208 report cautions that the water quality and ecological health of Cape Coral's freshwater canals and lakes will decline, and most of its potential as a recreational and water supply resource will be severely curtailed, unless proper stormwater and canal management programs are implemented.

10) FINAL REPORT AND TECHNICAL APPENDIX OF THE PRODUCTIVITY STUDY FOR THE ESTERO BAY STUDY AREA

Relatively little is known about hydrology and water quality dynamics in the Estero Bay watershed (Fish and Wildlife Service, 1984). Tabb et al reported on tides, physical/chemical characteristics and nutrients 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 (FWS, 1984).

The productivity of Estero Bay was studied by a private consultant to the Southwest Florida Regional Planning Council. The "FINAL REPORT AND TECHNICAL APPENDIX OF THE PRODUCTIVITY STUDY FOR THE ESTERO BAY STUDY AREA" was submitted by Environmental Science and Engineering, Inc. in February 1978.

This project was carried out by the SWFRPC with Section 208 funds. The focus of the study was to use overall measures of productivity, biomass, and diversity as indicators of estuarine health; the potential incorporation of selected biological measurements into water quality monitoring programs; and the use of simplified ecosystems diagrams for estimating waste load allocations and evaluating impacts of contributing systems on receiving bays.

The study found that total community metabolism in the Estero Bay estuarine system was moderate to high for a semi-tropical estuary and generally indicative of a viable biological system. Phytoplankton diversities were moderate as were zooplankton. Benthic macroinvertebrate diversities were high, in fact, the highest mean diversity of any of the estuaries sampled during the 208 program. None of these diversity values were indicative of stresses acting on component biotic subsystems. Net fish production was also found to be the highest calculated for areas in the 208 program.

At the time of the study, the bay was found to be removing 52% of the organic load the bay receives from internal and external sources. It was found to be a very effiecient nutrient trap for phosphorus, removing almost all that received. It was also estimated that organic loads could be increased 23% before net fish production capability would be lost.

Among its sampled characteristics, Estero Bay had the highest benthic diversities, the highest nutrient removal efficiency, and one of the highest organic scrubbing capabilities of all southwest Florida 208 estuaries sampled by the consultants.

Further biological monitoring suggested by the consultants included quarterly sampling for diurnal productivities, and seasonal monitoring of chlorophyll, total organic carbon, total phosporous, and total nitrogen.

11) WATER QUALITY, CIRCULATION PATTERNS AND SEDIMENT ANALYSIS OF THE ESTERO BAY ESTUARINE SYSTEM, 1986

The 1986 Lee County study of Estero Bay focused on the analysis of bottom sediments for selected parameters, including trace metals, pesticides, and nutrients. Sediment analyses had not been previously performed, therefore the study was to provide information on baseline conditions in the bay. The study also investigated circulation patterns within the bay, nutrients, bacteria levels, and certain other physical/chemical parameters. Lee County staff compared data for selected water column and bottom sediment parameters with data published in the U.S.G.S. report "WATER QUALITY OF THE CHARLOTTE HARBOR ESTUARINE SYSTEM, FLORIDA, NOVEMBER 1982 THROUGH 1984". A follow-up, detailed analysis of the data was being prepared for presentation to the County Commission in June 1987.

The Lee County study of Estero Bay found that values for orthophosphorous, total nitrogen and nitrite-nitrate were similar in Estero Bay to those in Charlotte Harbor in 1982-1984. Values for dissolved oxygen had more of a range than the average values reported in the U.S.G.S. study.

We reviewed the dissolved oxygen data presented in the 1986 Lee County study for comparison with the DER Class II standard (5.0 mg/l mean, 4.0 mg/l minimum) and Class III standard (5.0 mg/l fresh, 4.0 mg/l marine). Sample collection dates were January 16, 1986, June 18, 1986, and August 6/7, 1986.

Violations of the DER Class III standard were noted in Table #3 for mid and bottom depth samples at station #10 located on the Imperial River at the U.S. 41 bridge. Salinity data indicates stratification of the water column with a wedge of salt water on the bottom. Further violations of Class III standards were seen in surface and bottom depth samples at station #11 at the east end of the Imperial River.

Table #7 lists values for surface, mid-depth, and bottom samples collected June 18, 1986 which fall below the Class II (4.0 mg/l minimum) standard at station #16 sited on Mullock Pass. Surface, mid-depth, and bottom samples at station #17 at the mouth of Spring Creek gave values (4.5 mg/l) close to the DER standard.

Table #11 contains data for dissolved oxygen and other parameters taken August 6 and 7th. Top and bottom values for station 23, Dixon Point, were below 5.0 mg/l and near the DER standard of 4.0 mg/l minimum at 4.2 mg/l and 4.6 mg/l respectively.

Circulation studies using dye provided a general interpretation of the effect of tributaries on the circulation patterns within Estero Bay. Water from Hendry and Mullock Creeks, and the Estero River, appeared to flow towards Big Carlos Pass. Water from Spring Creek appeared to flow north and west towards New Pass. Water from the Imperial River appeared to flow through Fish Trap Bay and through Hogue Channel northward.

The concentration of pesticides and polychlorinated biphenyls (PCBs) were all below detection limits. Bottom sediment concentrations from Estero Bay were compared with those found in Charlotte Harbor by the U.S.G.S. It was concluded that ranges for aluminum, lead, cadmimum and mercury were similar. Levels of chromium, copper, and zinc in Estero Bay sediments were higher in 1986 than those in Charlotte Harbor in 1984.

We evaluated the concentration of metals in sediments in Estero Bay with Charlotte Harbor/Caloosahatchee River data obtained from samples collected by the DER Office of Coastal Management and the U.S.G.S. The DER study included a station, ESB-1, on Estero Bay east of Coon key. This station was in close proximity to Lee County station #36 at Mound Key. Because of their closeness, the metals data from each could reasonably be compared.

A station in Charlotte Harbor, CHH-12, at the north end of Matlacha Pass, was chosen as a representative background station. Data from CHH-12 could then be compared with the DER/Lee County data from Estero Bay to give an indication of metals contamination.

The Lee County data were first organized to show highest and lowest values for arsenic, cadmium, chromium, lead, copper, and zinc. Stations where these data were obtained were identified. The Lee County high/low values were then compared with highest/lowest Charlotte Harbor data from the U.S.G.S. after two years of sampling and the data obtained by the DER Office of Coastal Management. Lee County high/low values in excess of U.S.G.S./DER high/low values for the same parameters were denoted. Stations having a large number of values in excess of U.S.G.S./DER data were designated "hot spots" and stations having the largest number of lowest values were designated the "cleanest" areas in Estero Bay evaluated by the sampling program.

Since there were 6 parameters selected for review and 3 sets of data, there were 18 possible chances for Lee County Estero Bay data to exceed DER/U.S.G.S. data. Highest reported values in the Lee County study exceeded values for the Charlotte Harbor background station CHH-12 a total of 17 times. Lowest Estero Bay data exceeded the background values 13 times. Highest Lee County data exceeded U.S.G.S. transect (composite sample) data 4 times and lowest values exceeded lowest U.S.G.S. data 5 times in one set of data 4 times and 1 time respectively in another.

Charlotte Harbor station CHH-12 (background) was lower for all values than DER station ESB-1, and Lee County station #36, in Estero Bay. Although there are no DER standards against which to measure metals concentrations, the

COMPARISON OF OCM AND LEE COUNTY SAMPLE STATIONS IN ESTERO BAY WITH A CHARLOTTE HARBOR BACKGROUND STATION

	PARAMETER						
STATION	As	Cd	Cr	Pb	Hg	Cu	Zn
LEE CO. #36	1.03	0.27	12.6	7.28	0.05	2.43	6.18
CZM ESB-1	4.00	0.02	12.0	2.80	0.02	5.40	5.20
CZM CHH-12 (BACKGROUND)	0.61	0.01	2.20	1.15	-2	0.84	0.90

Note: All values in mg/kg.

comparison of Estero Bay values with those of a relatively pristine Charlotte Harbor station indicates metals are accumulating in the bay.

Metals samples taken from bottom sediments at the DER permanent network sampling station on Big Carlos Pass yielded results substantially lower than stations DER ESB-1 and Lee County #36 except for zinc which was five times the level at station #36. This supports our belief that this station is not representative of conditions in the eastern half of the bay where pollutants may be entering from tributary streams.

The DER Office of Coastal Management reviewed the results of the Lee County Estero Bay study. Ryan (1987) said the metals data indicated there was a real pollution problem with metals in Estero Bay or else there might have problems with the laboratory analysis of the samples.

To reduce the possibility that results may be due to contaminated glassware or other errors in the analytical process, samples should be taken in duplicate, and ideally, in triplicate if possible. One sample is then analyzed, and if questions arise concerning the accuracy of the data, the second and possibly, third, sample are used to confirm one of the first data set.

Samples were not collected in duplicate in the Lee County study for budgetary reasons, therefore it is not possible to confirm the original data through a careful analysis of backup samples. However, when data from DER station ESB-1 and Lee County station #36 are compared, it is noted that DER values for arsenic and copper exceeded Lee County values whereas Lee County values for cadmium, lead, and zinc exceeded DER values for the same metals. Chromium values were nearly identical. The overlapping data pattern would suggest the Lee County data is as valid as the DER data, although further confirmation of data from station #36 and the others in the study area is not possible.

ASSESSMENT

Recommendation:

It is a recommendation of this report that one agency and preferably, one individual, in county government be responsible for obtaining and reviewing water quality reports and data from local, state, and federal agency programs being conducted in the region.

This function may logically be assigned to the Division of Environmental Protection, but for the sake of simplicity, the monitoring entity shall be referred to in this report as the Lee County Monitoring Authority (LCMA). Regular communication and liaison between the LCMA and sampling agenices should be a component of its responsibilities.

The LCMA should establish personal contact with City of Cape Coral representatives engaged in water quality monitoring to exchange data and coordinate water quality sampling priorities where possible.

In addition, the LCMA should follow the progress and recommendations of the two U.S.G.S. studies in Cape Coral concerning the possible diversion of canal waters from northern canals to southern canals and interconnection of canals to facilitate flushing. These proposals, if implemented, are intended to improve water water quality in Matlacha Pass and Cape Coral canals. Flushing and diversion could, in fact, shift problems to other areas if impacts are not carefully analyzed. Other studies of importance to Lee County requiring close monitoring are the U.S.G.S. study on Charlotte Harbor and the SFWMD study of the lower Caloosahatchee River and estuaries.

Where and when actual, or potential, water quality problems affecting Lee County are noted, representatives of the LCMA should contact the appropriate sampling agency and determine what corrective actions are planned and monitor the progress of such plans as they are implemented.

Recommendation:

It is a recommendation of this report that the County study the feasibility of eliminating the filled portions of the Sanibel Causeway and substitute a piling-supported roadway as a method of improving water quality in Matlacha Pass/Pine Island Sound/San Carlos Bay.

The present SFWMD study of the lower river and estuaries is especially important to the causeway issue because it will provide valuable information on current conditions in San Carlos Bay and Pine Island Sound related to discharges from the Caloosahatchee River. This study may document the effect of the Sanibel causeway diverting freshwater into Pine Island Sound and Matlacha Pass suggested by Harris (1983) as the cause for loss of seagrasses and scallops in lower Pine Island Sound.

Regardless of whether the SFWMD study restricts itself to recommendations for modifying the operation of the Franklin lock and dam, the feasibility of bridging the filled portions of the Sanibel causeway should be pursued upon evaluation of the findings of the SFWMD study.

Elimination of the causeway fill, alone or in combination with other possible corrective measures throughout Lee County, would better protect the resources of the Pine Island Sound/Matlacha Pass/San Carlos Bay estuarine area from the future effects of increased stormwater runoff caused by the rapid growth of Cape Coral, Ft. Myers, and other urban areas. Pollutants and excessive amounts of freshwater water would be diluted and dispersed by re-establishing historic circulation patterns.

Recommendation

It is a recommendation of this report that the County perform a master plan evaluation of freshwater inflow into the coastal zone, with special emphasis on Estero Bay. Limited sampling by the U.S.G.S. in western Cape Coral documented unusually low salinity levels in Matlacha Pass caused by excessive freshwater discharged from the Gator Slough drainage system and the Cape Coral spreader canal.

Documentation of this condition raises a disturbing question as to whether the same problem is occurring elsewhere in the coastal zone. Estero Bay, with its shallow depths and poor flushing characteristics, might be very susceptible to damage by increasing amounts of freshwater as drainage in adjacent uplands increases with development. The bay is historically adapted to low freshwater inflows. Tidally induced flows are far greater in volume than the freshwater inflow (FWS, 1984). Therefore, any large-scale increases in freshwater discharged to the bay may adversely alter the diversity of flora and fauna in the estuary. For this reason, an assessment of existing and future freshwater inflows is essential if the biological and chemical integrity of the bay is to be protected.

Recommendation:

It is a recommendation of this report that additional water quality monitoring be performed in Lee County. Kevin Erwin, in discussions with County officials, has suggested a network of 65 to 80 sampling sites where surface and some sediment samples should be collected and analyzed. These stations are proposed to be sited near significant points of discharge for stormwater or sewage, or in pristine areas that will serve as background reference stations. In addition, the upstream reaches of streams, creeks, and rivers would be sampled extending down into the receiving estuary. Upon completion and analysis of the initial monitoring survey, a coastal surface water monitoring network could be established that would be sampled on a quarterly or semi-annual basis. Problem areas identified by sampling would receive additional, intensive investigation.

Current comprehensive U.S.G.S. and SFWMD studies will provide valuable information for the northern and central sections of the Lee County coastal zone. However, a County operated water quality monitoring network will give the County information on areas (upstream reaches of creeks and rivers, etc.) not sampled by other agencies, continuity in sampling term and coverage, better quality control and access to data, and the ability to respond quickly with more intensive sampling of "hot spots".

In view of the question regarding possible metals pollution raised by the 1986 Lee County study, a follow-up investigation is strongly suggested. Conversations with Lee County staff (Clark, 1987) indicate a grant application for further study will be submitted to the DER OCM upon evaluation of the 1986 Estero Bay data and presentation to the County Commission. Depending on the urgency and priority given the task, the DER District office in Ft. Myers may perform a special basin study. Other assistance may come from the SFWMD.

Recommendation:

It is a recommendation of this report that Lee County review disaster preparedness plans for the Balgas and Belcher oil storage facilities at Matanzas Pass and Boca Grande Pass respectively, and any others that may be situated where they have the potential to contaminate the waters of the coastal zone. Coordination through the appropriate regulatory agencies is suggested.

The review should include an assessment of the stability of the shoreline at the Boca Grande site and the engineering specifications of the containment dikes at each site compared to projected 100-year storm surge elevations.

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Appendix A

WATER QUALITY CLASSIFICATIONS AND STANDARDS

Parameter	DER Ground Water Potable Water Standards	DER Surface Water Quality Classifications: Class I Potable	Class II Shellfish	Class III Recreation Fish & Wildlife	Class IV Agricultural	Class V Industrial	EPA Surface Water Quality Index Criteria: Good	Fair	Poor	Typical Range[1]
Alkalinity		20 mg/l min. as $CaCO_3$		20 mg/l min. as $CaCO_3$ (fresh)	800 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 - (.008) - .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				

WATER QUALITY CLASSIFICATIONS AND STANDARDS
(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				
Aldrin-Dieldrin	Pesticides		0.003 µg/l	0.003 µg/l	0.003 µg/l						
Chlordane	Pesticides		0.01 µg/l	0.004 µg/l	0.01 µg/l (fresh) 0.004 µg/l (marine)						
2,4—D	Pesticides	100 µg/l	100 µg/l								
2,4,5—TP	Pesticides	10 µg/l	10 µg/l								
DDT	Pesticides		0.001 µg/l	0.001 µg/l	0.001 µg/l						
Demeton	Pesticides		0.1 µg/l	0.1 µg/l	0.1 µg/l						
Endosulfan	Pesticides		0.003 µg/l	0.001 µg/l	0.003 µg/l (fresh) 0.001 µg/l (marine)						
Endrin	Pesticides	0.2 µg/l	0.004 µg/l	0.004 µg/l	0.004 µg/l						
Guthion	Pesticides		0.01 µg/l	0.01 µg/l	0.01 µg/l						
Heptachlor	Pesticides		0.001 µg/l	0.001 µg/l	0.001 µg/l						
Lindane	Pesticides	4 µg/l	0.01 µg/l	0.004 µg/l	0.01 µg/l (fresh) 0.004 µg/l (marine)						
Malathion	Pesticides		0.1 µg/l	0.1 µg/l	0.1 µg/l						
Methoxy-Chlor	Pesticides	100 µg/l	0.03 µg/l	0.03 µg/l	0.03 µg/l						
Mirex	Pesticides		0.001 µg/l	0.001 µg/l	0.001 µg/l						
Parathion	Pesticides		0.04 µg/l	0.04 µg/l	0.04 µg/l						
Toxaphene	Pesticides	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 - (7.0) - 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)						

WATER QUALITY CLASSIFICATIONS AND STANDARDS

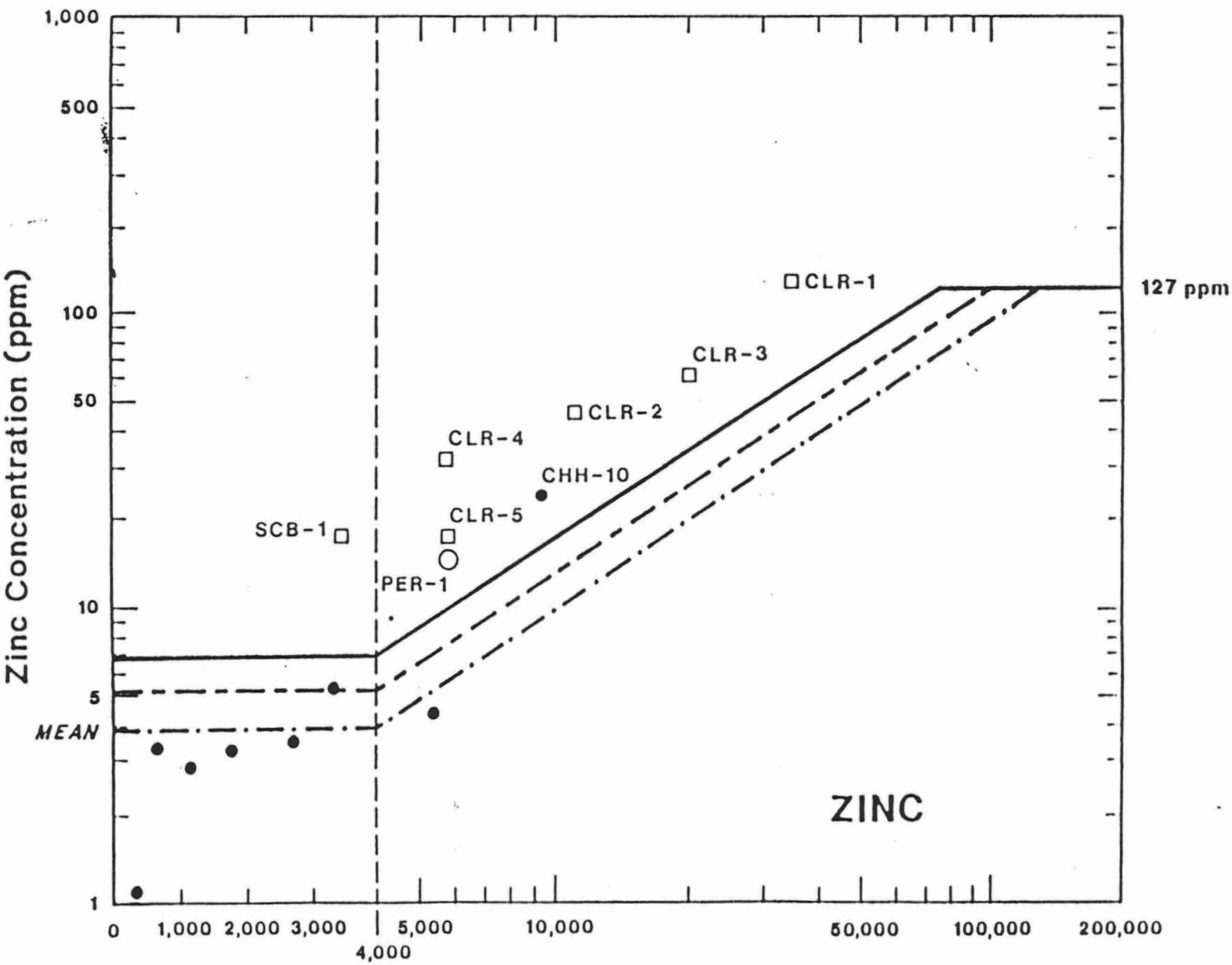
(continued)

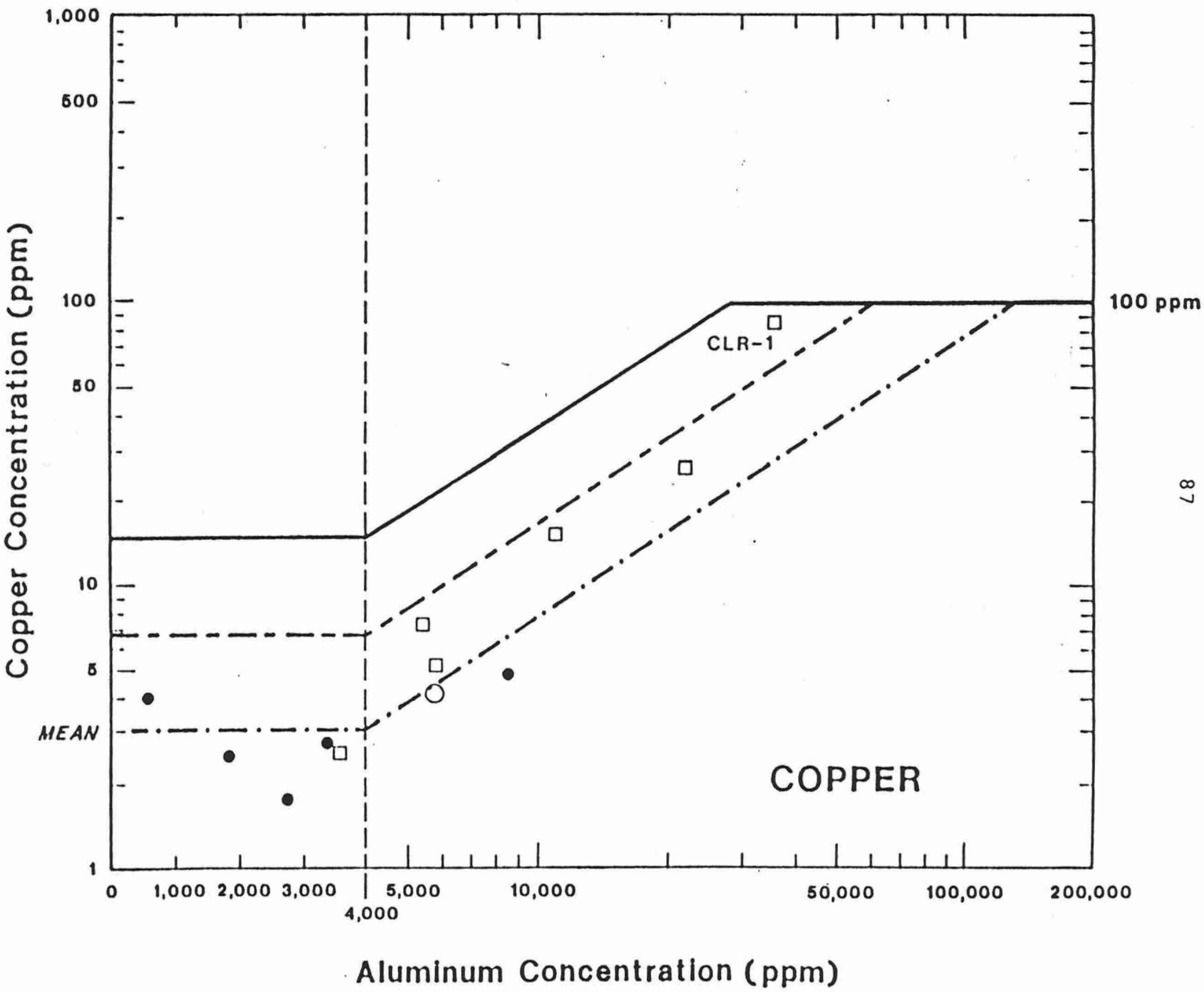
Parameter	DER Ground Water Potable Water Standards	DER Surface Water Quality Classifications					EPA Surface Water Quality Index Criteria			
		Class I Potable	Class II Shellfish	Class III Recreation Fish & Wildlife	Class IV Agricultural	Class V Industrial	Good	Fair	Poor	Typical Range[2]
Phosphorus, Total (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 e: 15 pCi/l[1]	Ra: 5 pCi/l e: 15 pCi/l[1]	Ra: 5 pCi/l e: 15 pCi/l[1]	Ra: 5 pCi/l e: 15 pCi/l[1]	Ra: 5 pCi/l e: 15 pCi/l[1]	Ra: 5 pCi/l e: 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	

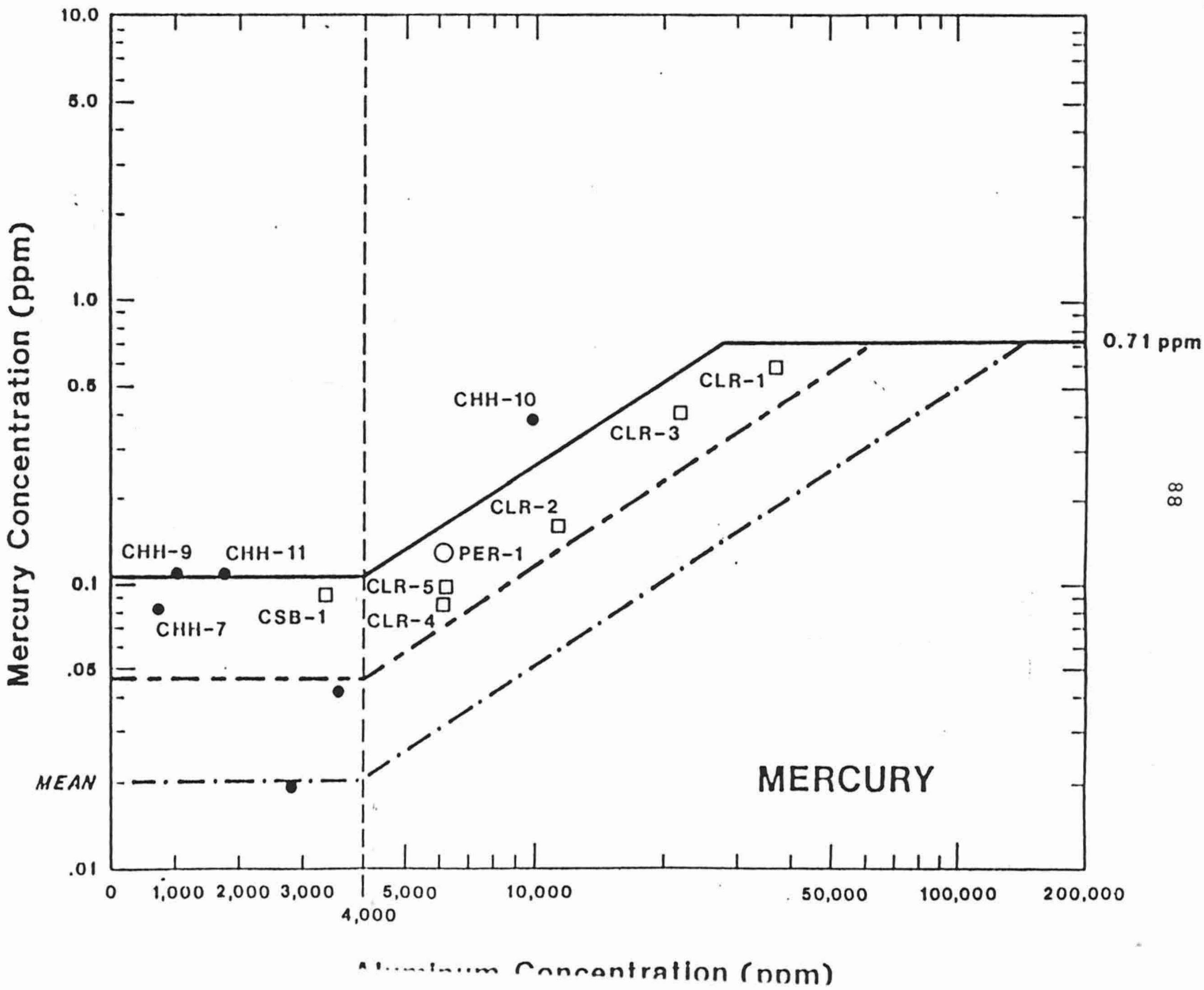
ctual standards are more complex than numbers displayed hart (see Chapter 17-3, FAC).

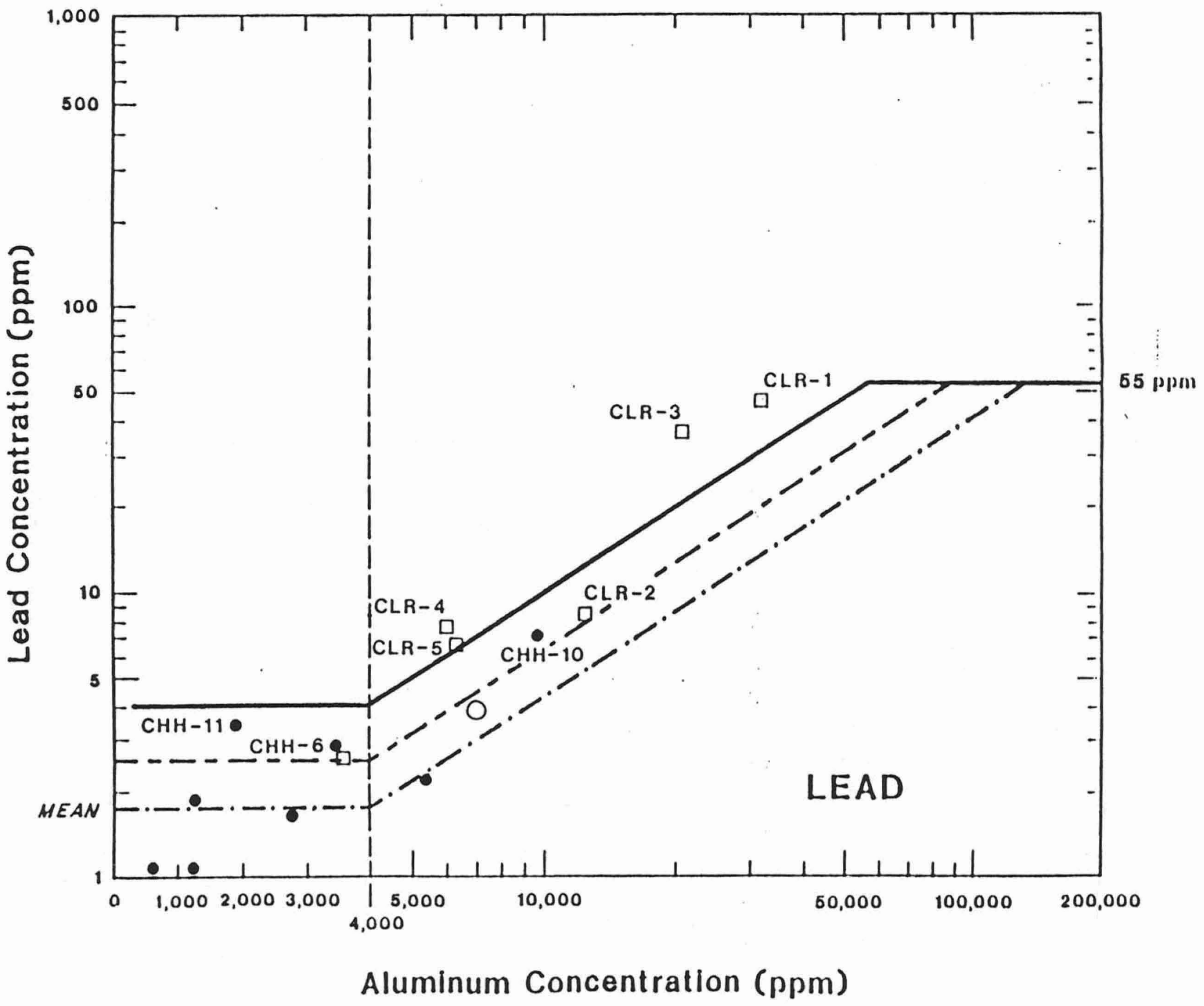
hese values are based on 6,000 samples from 94 lake, stream, estuary sampling stations collected from 1974-1982 by DER. The value is the tenth percentile, the second value is the median, and ast value is the ninetieth percentile.

Appendix B


Zinc Concentration (ppm)
1,000
500
100
50
10
5
MEAN
1
0
1,000
2,000
3,000
4,000
5,000
10,000
50,000
100,000
200,000
127 ppm
CLR-1
CLR-3
CLR-2
CLR-4
CHH-10
CLR-5
SCB-1
PER-1
ZINC


1,000
500
100
50
10
5
1
MEAN
Copper Concentration (ppm)
100 ppm
CLR-1
COPPER
0
1,000
2,000
3,000
4,000
5,000
10,000
50,000
100,000
200,000
Aluminum Concentration (ppm)


MERCURY
Mercury Concentration (ppm)
Aluminum Concentration (ppm)
10.0
5.0
1.0
0.5
0.1
.05
MEAN
.01
0
1,000
2,000
3,000
4,000
5,000
10,000
50,000
100,000
200,000
0.71 ppm
CHH-9
CHH-11
CHH-7
CSB-1
CHH-10
CLR-1
CLR-2
CLR-3
CLR-4
CLR-5
PER-1



Lead Concentration (ppm)
1,000
500
100
50
10
5
MEAN
1
Aluminum Concentration (ppm)
0
1,000
2,000
3,000
4,000
5,000
10,000
50,000
100,000
200,000
55 ppm
CLR-1
CLR-3
CLR-2
CLR-4
CLR-5
CHH-10
CHH-11
CHH-6
LEAD

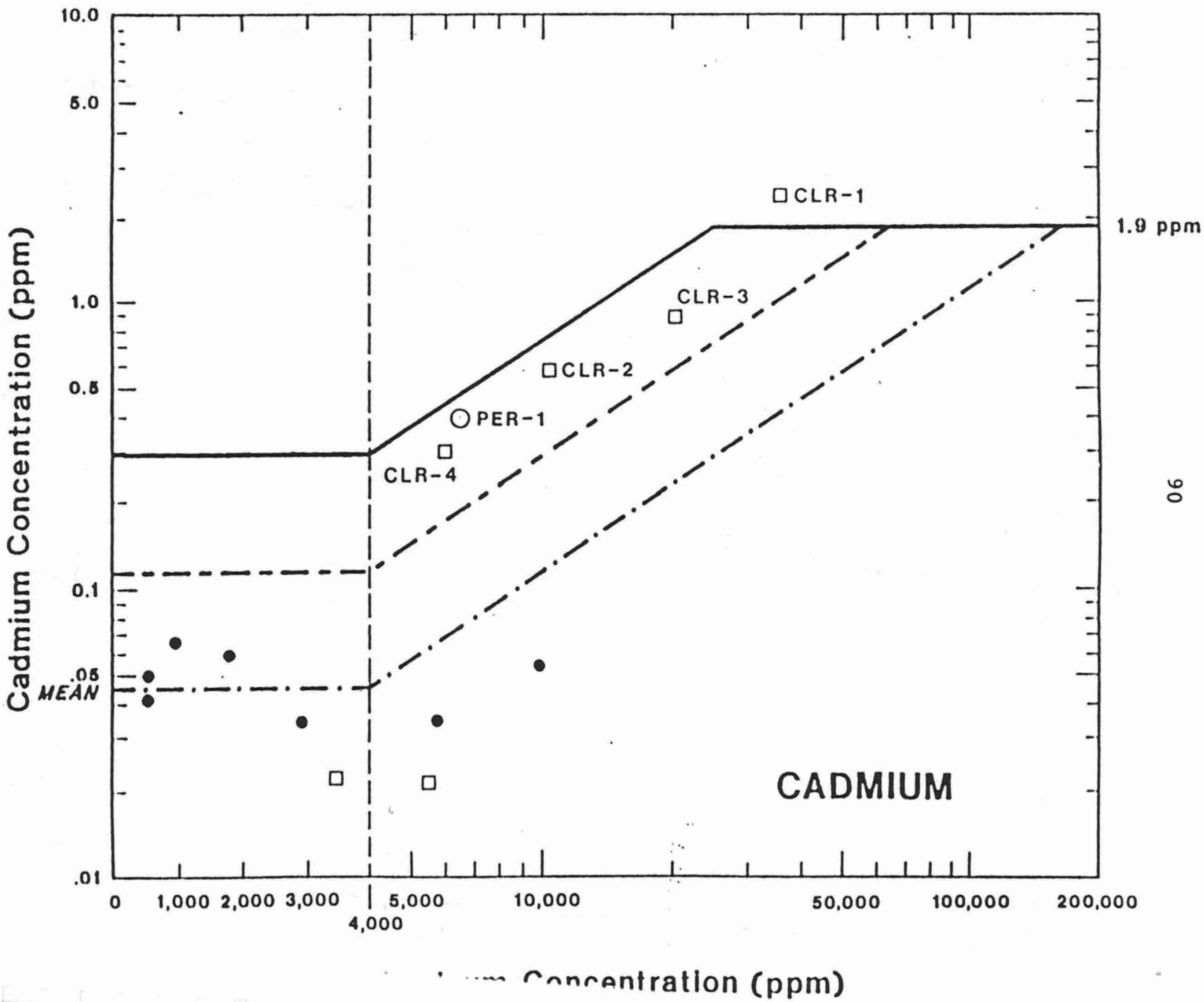

CADMIUM
Cadmium Concentration (ppm)
10.0
5.0
1.0
0.5
0.1
.05
MEAN
.01
1.9 ppm
CLR-1
CLR-2
CLR-3
CLR-4
PER-1
0
1,000
2,000
3,000
4,000
5,000
10,000
50,000
100,000
200,000
Concentration (ppm)

TABLE OF CONTENTS

TABLES

INTRODUCTION

The purpose of this supplement to the report on Estuarine Pollution Conditions is to assess the impact on water quality resulting from projected growth in the coastal zone to the year 2010, and at ultimate buildout. Data for existing and projected population and dwelling units in the coastal zone were provided by the Lee County Planning Division.

The earlier assessment of estuarine water quality found nonpoint discharges of stormwater runoff to be a major source of generally untreated pollutants. Point source discharges resulting from development such as sewage effluent outfalls and reverse osmosis brine discharges are closely regulated and monitored by the Department of Environmental Regulation. For this reason, our consideration of water quality impacts from future growth in the coastal zone centered on the characteristics of stormwater and efficiency of accepted treatment methods.

In order to obtain background information on how this complex task might most efficiently be addressed, telephone or personal consultations were held with staff of the Department of Environmental Regulation's Nonpoint Source Management Section and the South Florida Water Management District's Resource Control Division. In addition, recent literature on the subject was reviewed.

SUMMARY OF FINDINGS

1) It is not possible to predict the impact on estuarine water quality resulting from continued growth in the coastal zone without extensive water quality sampling and modeling whose cost is prohibitively expensive. The estuarine areas of Lee County are not closed systems that receive pollutants from sources only in the coastal zone. As previously described in the report on estuarine pollution conditions, the County's estuaries are hydrologically connected to large watersheds, several of which extend far inland into other counties. Without 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.

2) Nonpoint source pollution from new development in the coastal zone will likely threaten estuarine water quality more than point sources in the coastal zone.

3) Present regulations of the South Florida Water Management District require that new development provide for treatment of stormwater, however relatively little is known about the fate of pollutants once they enter stormwater treatment systems. Preliminary studies indicate the treatment

efficiency of treatment systems is highly variable from one constituent to another. Furthermore, treatment efficiency of retention/detention ponds seems to be related to the age of the pond. The SFWMD is funding a series of studies to evaluate design criteria for stormwater treatment systems and will modify their rules as necessary.

4) Research suggests that regular maintenance of stormwater retention/detention ponds is necessary for the most efficient removal of pollutants such as nutrients and heavy metals.. A lack of maintenance may actually increase concentrations of these pollutants. At present, the SFWMD requires maintenance of permitted treatment facilities, but leaves the schedule to the discretion of the entity responsible for operation of the system. As a result, maintenance may not be undertaken until treatment systems reach their worst state, which may be long after system treatment efficiency has peaked and declined.

5) Negative effects on adjacent water quality from construction in the coastal zone may not necessarily be restricted to the discharge of pollutants from stormwater treatment systems. Development of coastal uplands may alter historic drainage patterns, peak flow characteristics, and the amount of total runoff entering receiving waters.

6) The Department of Environmental Regulation recommends a comprehensive approach to the treatment of stormwater as opposed to the piecemeal pattern traditionally resulting from agency permitting processes. The comprehensive stormwater treatment concept involves the development and implementation of a watershed master plan which identifies the most appropriate control measures and optimum locations to control watershed-wide impacts.

7) Stormwater treatment systems are approved by the SFWMD at random in Lee County as project applications are submitted by developers. The result is a large number small, scattered treatment systems whose cumulative impact on receiving waters is not known.

BACKGROUND

Abatement of pollution entering Florida waters from point sources was initiated by the Department of Pollution Control, predecessor to the Department of Environmental Regulation, in the late 1960's. At that time and continuing through the 1970's, industrial and domestic waste discharges were placed on schedules for improved treatment and/or removal from surface waters.

Increased state and federal attention was given to the regulation and treatment of stormwater as point sources were brought into compliance. Section 208 of the Federal Water

Pollution Control Act required states to control nonpoint sources of pollution generated by agriculture, mining, forestry, urban construction, and other activities. Federal grants were given to the State of Florida to conduct baseline water quality sampling programs and establish methods for control of nonpoint pollution. It was with these funds that the Southwest Florida Regional Planning Council contracted studies of water quality in Charlotte Harbor, Cape Coral canals, and Estero Bay. Unfortunately, the recommended nonpoint source abatement methods derived from each study were recommendations only and their implementation could not be mandated by the planning council.

In 1982, the Department of Environmental Regulation adopted Chapter 17-25, Florida Administrative Code in order to require the treatment of stormwater to consistent standards on a statewide basis. This rule superceded and strengthened a 1979 modification to the permitting rule, Chapter 17-4 F.A.C. Chapter 17-25 requires the treatment of runoff from the first 1" of rainfall for projects over 100 acres in size and treatment of the first 1/2" of runoff from a drainage area of 100 acres or less.

These particular criteria were adopted because studies by Wanielista in 1979 showed that for a variety of land uses, the first 1/2" of runoff, when projected to annual loadings, contained 80-95% of the annual loadings of most pollutants. This phenomenon, commonly referred as the "first flush", occurs when the majority of pollutants on uplands are carried off in the first 1/2" of rainfall runoff. For watersheds larger than 100 acres, Wanielista found that first flush effects generally diminish below 80% removal as the size of the drainage basin increases and the percent impervious area increases. This is due to the unequal distribution of rainfall over the watershed and the additive phasing of inflows from numerous smaller drainages.

The Department of Environmental Regulation conducted a review of data from the 208 water quality studies and found that untreated stormwater discharges were responsible for:

1. 80% to 95% of the heavy metals loading to Florida surface waters

2. virtually all of the sediment deposit to state waters

3. 450 times the suspended solids entering surface waters and 9 times the load of BOD substances compared to discharges from sewage effluent treated to secondary standards

4. nutrient loads comparable to those in secondarily treated sewage effluent (Livingston, 1986)

/

Table 1 is a comparison of the concentrations of urban and rural stormwater constituents with treated and untreated wastewater.

Untreated stormwater may have a number of adverse affects on receiving waters and their biota. Following is a general description of sediments, nutrients, heavy metals, and BOD/COD which are common constituents in stormwater.

Sediments are commonly discharged to surface waters as a result of the removal of vegetation during the land development process. The quantity, characteristics, and causes of sediment transport are due to a number of factors including slope, length of slope, soil characteristics, land use and traffic volume. Large sediment particles tend to accumulate in areas of the receiving waterbody where velocities are slowed, allowing the particles to fall out of the water column. The subsequent shallowing of historic water depths may eliminate valuable habitat used for spawning cover, or feeding; restrict navigation; and cause the degradation of water quality by adversely affecting water circulation. Lighter sediment particles suspended in the water column for long periods of time reduce light penetration and photosynthesis by plants, and smother microscopic plants and animals in aquatic food chains. Fishkills may result from a decline of oxygen as plants die and decompose.

Nutrients in stormwater, such as phosphorus and various forms of nitrogen, originate in fertilizers used for agricultural purposes and residential lawn care, effluent from malfunctioning septic tank drainfields, pet wastes, grass clippings and other sources. When nutrients in the receiving waters exceed typical background levels, algae blooms may occur. Subsequent fishkills in the receiving water follow when the plants die off in large proportions and reduce oxygen levels to lethal limits. Nutrients from dead fish and plants are then released back into the water column for recycling by plants and animals. Additional inputs of nutrients will exacerbate the bloom of algae and the replacement of beneficial fish by "trash" species more tolerant of low oxygen conditions.

Table 2 is a list of parameters and concentrations at which, in natural waters, they might cause water quality related problems. The list was developed by the DER's Water Quality Management Section to screen water quality data for potential problem areas.

Heavy metals such as lead, copper, cadmium, iron, zinc, chromium, manganese, and nickel are common components of stormwater. The most abundant heavy metals in stormwater are

TABLE 1

CHARACTERISTICS OF DIFFERENT POLLUTION SOURCES

(1) PARAMETER	URBAN STORMWATER	RURAL STORMWATER	UNTREATED WASTEWATER	SECONDARY TREATE[D] WASTEWATER
BOD_5	1-400	1-200	100-350	10-30
SS	2-7340	3-726	100-350	10-30
TN	1-49	3.7-15.5	35-100	15-35
TP	.1-16	.5-12.5	10-50	3-10
OP	.1-10.0	.1-10.0	6-35	.5-10
TOC	3-384	1-100	100-300	10-120
COD	5-3100	2-150	250-1000	25-150
LEAD	.1-10	.01-2.0	.05-1.27	.0005-.20
ZINC	.1-4.6	.01-1.5	.03-8.31	.047-.02
CADMIUM	0-.10	0-.05	.004-.14	.0002-.02
OILS/GREASE	0-110	0-50	50-150	5-15
FECAL COLIFORM	$55\text{-}112 \times 10^6$	$55\text{-}112 \times 10^6$	$10^7\text{-}10^9$	200
TOTAL COLIFORM	$200\text{-}146 \times 10^6$	$200\text{-}146 \times 10^6$	$10^9\text{-}10^{11}$	1000

(1) All parameters expressed in Mg/l except coliform which are number of organisms/100m .

Adapted from DER

TABLE 2

WATER QUALITY SCREENING LEVELS

PARAMETER	CONCENTRATION
NH_3	0.2 mg/ℓ
BOD	5.0 mg/ℓ
Chlorides	250 mg/ℓ (fresh)
Chlorophyll A	15 ug/ℓ
NO_3	0.3 mg/ℓ
NO_2	0.2 mg/ℓ
$NO_2 + NO_3$	0.5 mg/ℓ
Organic nitrogen	0.7 mg/ℓ
Suspended solids	1000 mg/ℓ
TKN	0.9 mg/ℓ
TN	1.2 mg/ℓ
TP	0.06 mg/ℓ

***Levels set by WQMS based on average background data for Florida Waters.**

Adapted from DER

lead, zinc, and copper which together account for 90-98% of the total metal concentrations (Harper, 1985). They affect plants and animals in the aquatic environment by entering food chains, interrupting feeding and reproductive behavior, and causing mortality at higher concentrations.

Oxygen-demanding substances, designated as either BOD or COD, are those which take oxygen from receiving waters either biologically or chemically. They are common constituents of sewage and industrial wastes and are treated prior to discharge to receiving waters. Common sources of BOD/COD in stormwater from residential areas are grass clippings, leaf litter, and pet wastes. Septic tank effluent leaching from drain fields situated over a high water table contribute heavy loads of BOD to surface waters.

Various methods have been devised for the abatement of stormwater from an urban environment. They essentially fall into three categories: prevention, treatment, and control. According the Department of Environmental Regulation's reference manual for nonpoint source management, studies by Wanielista et al in 1976 showed that an integrated abatement program for stormwater would include all three elements.

Preventive measures are those employed prior to construction as a result of planning and regulatory requirements. Examples of preventive stormwater concepts are floodplain management and regulation, and on-site detention/retention facilities to manage the quality and quantity of stormwater.

Treatment measures for stormwater include the use of a physical, chemical, or biological process in order to reduce or eliminate residual levels of nonpoint pollution not prevented. Examples of treatment processes are the use of natural drainage systems for stormwater management, the construction of conventional sedimentation ponds, and treatment through secondary or specialized wastewater treatment facilities.

Control measures for stormwater are those used in existing development to reduce pollution sources in order to minimize nonpoint source effects. Street cleaning operations, regulation schedules for stormwater facilities which manage the quality and quantity of discharges, routine inspection and maintenance of treatment facilities and anti-litter ordinances are examples of control measures.

In 1978, the Department of Environmental Regulation published a series of manuals describing reference management practices (RMP) for urban, construction, agricultural, and silvicultural activities. The concept of RMP's was used at the time because best management practices (BMP) referred to in the statutory language of Public Law 92-500 had not been established by adequate testing.

DISCUSSION

The Lee County Division of Planning estimates that the Lee County coastal zone is 163.4 square miles or 19% of the County's total 823.6 square miles. As of 1986, the coastal zone contained 56,856 dwelling units with a population of 115,986 persons. By the year 2010, the coastal zone is projected to contain another 50,244-57,201 dwelling units, an increase of 88%-101% respectively over 1986 levels for a total of 107,100-114,057. The population at that time will be between 218,484 and 232,676 persons.

Ultimate buildout allowed in the coastal zone by the present Lee County Comprehensive Plan is 162,318 dwelling units, a 185% increase over 1986 totals. Projected population at buildout is estimated to be 331,129 persons, or 30% of the County's overall population of 1,106,599.

Given these increases in dwelling units and population in the Lee County coastal zone to the year 2010 and beyond to buildout, a determination of their impact on water quality in adjacent estuarine areas would be useful to planners and officials responsible for making future land use decisions.

The complexity of the task of predicting future water quality impacts from growth in the coastal zone can be appreciated when the size of the drainage basins, whose receiving waters are the estuarine areas of Lee County, are considered. Not only do tributaries extend landward of the coastal zone within Lee County proper, major tributaries drain large portions of Sarasota, Charlotte, and Hendry counties into Lee County estuaries.

We found in our investigation of estuarine pollution conditions that the total area of the Charlotte Harbor estuarine system comprising Charlotte Harbor, Pine Island Sound, Matlacha Pass, and San Carlos Bay is 236 square miles. On the other hand, the drainage basins of the Myakka, Peace, and Caloosahatchee rivers combined, total 3,675 square miles. Estero Bay covers 15 square miles but its watershed area drains 293 square miles. Of the nearly 4,000 square miles of upland watershed discharging to Charlotte Harbor/Estero Bay estuaries, the Lee County coastal zone covers 163 square miles.

Representatives of the DER and SFWMD were consulted concerning the task of predicting impacts in estuarine waters resulting from continued growth in the Lee County coastal zone. They confirmed our opinion that future development would be subject to stormwater treatment requirements. They further advised that an attempt to quantify the impact from an increase in dwelling units from 56,000+ to 162,000+ would be an extremely complex undertaking (Cox, Anderson, 1987) because of the infinite number of variables associated with estuarine water quality. Anderson pointed out that such a project could take a lifetime and still be subject to loss if a hurricane came through and changed the , biological, chemical, and physical characteristics of the estuaries.

Since new development will be subject to the treatment requirements of the DER stormwater rule, Chapter 17-25, F.A.C. which is administered by the South Florida Water Management District we concentrated our investigation on the efficiency of "state-of-the-art" stormwater treatment systems. The efficiency of these systems in treating stormwater is of paramount interest and concern because the quality of runoff leaving developed upland sites may adversely affect adjacent estuarine waters and their biota.

The nature of untreated nonpoint pollution has been documented since the early 1970s by numerous studies by private, state, and federal organizations. Values for certain constituents in stormwater have subsequently been derived from the data which permit an understanding of pollutant loading from different land uses (Tables 3 and 4). Further studies have recently been undertaken in Florida to assess the treatment efficiency of commonly used stormwater treatment systems.

The U.S. Environmental Protection Agency conducted an intensive assessment of stormwater quality in its Nationwide Urban Runoff Program (NURP) in which 1,900 separate storm events were sampled at 72 sites in 23 cities. None of the sample sites were downstream of stormwater treatment systems so the data represent concentrations of constituents in untreated stormwater only. From data acquired in the NURP study, EPA developed event median concentrations (EMC) for various constituents in residential, mixed, commercial, and open/nonurban land uses (Table 5). (Event <u>mean</u> concentrations were determined to be essentially uncorrelated with runoff volume).

In order to characterize the quality of stormwater in Florida, the Department of Environmental Regulation analyzed data from 208 water quality studies performed around the state. Table 6 lists loading rates from nonpoint sources, in pounds per acre per inch of rain, for total nitrogen, total phosphorus, suspended solids, biochemical oxygen demand, and total oganic carbon from several different land uses.

These data would theoretically permit calculation of additional pollutant loading from new development in the Lee County coastal zone if the area, in acres, subject to future development were known. However, the results would reflect the amount of pollution going into stormwater treatment systems and not the quantity entering surface waters after

TABLE 3

COMPARISON OF LOADINGS OF DIFFERENT TYPES OF ROADWAYS FOR COMMON POLLUTION PARAMETERS AND CERTAIN HEAVY METALS

Parameter	lb/curb mile		
	City Street	Rural Road	Highway
BOD_5	18	2.4	15
COD	95	77	299
PO_4^{-3}	1.1	3.0	1.32
NO_3^-	0.043	0.22	0.23
N	2.4	0.79	4.22
Cd	0.0037	0	0.058
Cr	0.231	0.34	1.20
Cu	0.129	0.06	0.26
Fe	24.4	36	136
Mn	0.468	1.35	2.39
Ni	0.040	0.16	0.68
Pb	1.66	0.10	3.17
Sr	0.22	0.078	0.32
Zn	0.409	0.11	1.24

Adapted from DER

TABLE 4

HEAVY METAL LOADING INTENSITIES (lbs/curb mile)

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

Adapted from DER

TABLE 5

MEDIAN EMCs FOR ALL SITES IN DESIGNATED LAND USE CATEGORY

Pollutant		Residential		Mixed		Commercial		Open/Nonurban	
		Median	CV	Median	CV	Median	CV	Median	CV
BOD	mg/ℓ	10.0	0.41	7.8	0.52	9.3	0.31	-	-
COD	mg/ℓ	73	0.55	65	0.58	57	0.39	40	0.78
TSS	mg/ℓ	101	0.96	67	1.14	69	0.85	70	2.92
Total Lead	ug/ℓ	144	0.75	114	1.35	104	0.68	30	1.52
Total Copper	ug/ℓ	33	0.99	27	1.32	29	0.81	-	-
Total Zinc	ug/ℓ	135	0.84	154	0.78	226	1.07	195	0.66
Total Kjeldahl Nitrogen	ug/ℓ	1900	0.73	1288	0.50	1179	0.43	965	1.00
NO_2 -N + NO_3 -N	ug/ℓ	736	0.83	558	0.67	572	0.48	543	0.91
Total P	ug/ℓ	383	0.69	263	0.75	201	0.67	121	1.66
Soluble P	ug/ℓ	143	0.46	56	0.75	80	0.71	26	2.11

Adapted from EPA

TABLE 6

FLORIDA NPS LOADING RATES (LBS/ACRE/INCH RAIN)

Land Use	TN	TP	SS	BOD	TOC
Residential	.1869	.0532	6.971	.8343	.3576
Commercial	.2946	.1297	25.750	1.0586	1.658
Industrial	.28	.07	29.1	1.21	
Open developed	.0759	.0486	4.815	.7590	1.1418

Adapted from DER

treatment in swales, natural wetlands, or retention ponds. Even if assumptions were made regarding the percentage of pollutants passing through treatment systems, it would be impossible to predict estuarine responses without extensive background sampling and modeling.

These and other studies have given the regulatory agencies a limited database from which to base design requirements for stormwater treatment facilities. Since stormwater characteristics are now generally known, the efficiency of treatment systems, critical to the protection of ground and surface waters, has been the subject of further investigations.

A study of the efficiency of a residential stormwater treatment system in southeast Florida was funded by the South Florida Water Management District. This was the first in a series of studies to evaluate the effectiveness of District regulatory criteria for stormwater. The initial purpose of the 1985 study by Wanielista and Yousef was to see how theoretical hydrologic predictions derived from engineering literature compared to actual performance. Water quality considerations were later introduced into the study.

Timbercreek, the study site, is a 122 acre single family residential development in Boca Raton, Florida containing 311 residences for a gross density of 2.5 units/acre. The drainage system in the project consists of grassed swales, catch basins, storm sewers, and 7.9 acres of interconnected lakes. The major soil classification at the site is Immokalee fine sand which was kept relatively dry by drainage canals on the north and east sides of the development.

The Timbercreek development and its system of swales, storm sewers, and lakes for treatment of stormwater is similar in many ways to newer subdivisions in Lee County. Rainfall patterns, water table elevation, and topography are also generally comparable to southwest Florida conditions. The efficiency of the Timbercreek stormwater treatment system, therefore, is probably close to that of such systems serving residential development in Lee County.

Two separate water quality monitoring programs were utilized in the Timbercreek study. Background water quality in the lakes and groundwater was sampled biweekly and the efficiency of the treatment system was measured during storm events. The majority of surface and groundwater samples were collected during periods of low loading. Storm event sampling was conducted over a period of 18 months which provided a cross-section of samples representing the short term, high intensity convective events of summer and long term, low intensity frontal events of winter. During the 18 month storm event sampling period, nine discrete storms were sampled.

Groundwater quality at the site differed markedly from surface water quality. Ortho phosphate and ammonia concentrations were 300% higher than the highest surface water site. Chloride, alkalinity and specific conductance were also higher in the groundwater than surface water, while particulate matter in the form of total suspended solids and turbidity were lower in the groundwater than surface water.

The quality of stormwater runoff at Timbercreek was superior to that reported in the EPA NURP study except for total Kjeldahl nitrogen and ortho phosphate which were both slightly in excess of the lower range found by EPA. The use of highly maintained grassed swales in the development is believed to be the reason for the high quality runoff.

Pollutant concentrations flowing into the detention lakes were compared with concentrations flowing out of the lakes. Variations in treatment efficiency were noted which ranged from a high of 95% for ortho phosphate to a low of -98% for chloride. Table 7 lists the results for all parameters.

Negative values for pollutant removal in the lake system are attributed to the inflow of groundwater. Chloride and specific conductance were higher in the outflow than the inflow. The higher outflow value for turbidity was probably due to pond algae suspended in the water sample.

The pollutant concentrations from groundwater and rainfall contributions to the treatment system were added to the surface discharge to yield removal efficiencies of the entire hydrologic unit. Table 8 lists removal efficiencies for surface water only, and the total system.

The fate of heavy metals entering a stormwater treatment system was not included in the Timbercreek study but was the subject of a study by Yousef et al, of two ponds next to Interstate 4 in Orange County. There, the Florida Department of Transportation and Federal Highway Administration funded research to study the best management practices for highway runoff.

The two study sites were ponds at Maitland and I-4 and at EPCOT Interchange and I-4. The Maitland pond was constructed in 1976 and the EPCOT pond in 1983. Composite water samples of highway runoff were collected at each site as were overland flow samples and samples from several locations in each pond. Stormwater constituents measured in samples were pH, total phosphorus, total nitrogen, and the metals lead, zinc, copper, iron, nickel, cadmium, and chromium.

TABLE 7

AVERAGE DETENTION POND INFLOW AND OUTFLOW AND SHALLOW GROUNDWATER CONCENTRATIONS

	Average Inflow Concn.[2]	Average Outflow Concn.[2]	Percent Difference	Average Groundwater Concen.
TSS	20.6	6.5	68	3.5
Turbidity	2.4	3.3	-38	1.8
Ortho Phosphate	0.084	0.004	95	0.026
Total Phosphate	0.0136	0.035	74	0.039
Total Nitrogen	0.93	0.65	30	0.90
NOX	0.18	0.02	89	0.026
Ammonium	0.13	0.05	62	0.260
TKN	0.75	0.63	16	0.87
Organic Nitrogen	0.62	0.58	6	0.62
Chloride	8.6	17.0	-98	29.9
Alkalinity (meq/L)	0.49	0.48	2	1.02
Sp. Conductance (umhos/cm)	84.	134.	-60	260.

1/ All in mg/L unless noted.
2/ Flow weighted Mean.

Adapted from Wanielista

TABLE 8

MASS LOADING REMOVAL EFFICIENCIES OF TIMBERCREEK DETENTION LAKES FOR SELECTED POLLUTANTS

Parameter	Surface Water Only		Total System	
	Median	Range	Median	Range
TSS	68	(600)-84	64	(79)-84
Ortho Phosphate	93	67-98	82	44-94
Total Phosphate	55	25-89	60	28-82
Total Nitrogen	12	(186)-91	15	(69)-60
TKN	(31)	(335)-91	0	(127)-48
NOX	93	(8)-98	87	64-98
Ammonium	54	(16)-78	12	(225)-87
Chloride	(159)	(602)-73	(75)	(187)-22
Alkalinity	(19)	(115)-71	(10)	(88)-42

( ) Depicts Negative Removal

Adapted from Wanielista

This study found that the Maitland pond, which was the older of the two, was very effective in reducing high nutrient loads. About 99% of the total phosphorus loading and 85-90% of the total nitrogen loading accumulated in the sediments.

Heavy metals seemed to be removed from the water column at a faster rate than nutrients. Particulate metals deposit close to the inflow point while dissolved metals are removed by physical adsorption, biological uptake, or chemical precipitation. Metals deposited in the bottom sediment were concentrated in the top few centimeters. Only iron was released back to solution under anaerobic conditions.

Maintaining an aerobic condition at the water/sediment interface appears to result in high removal of nutrients and heavy metals from highway runoff. It appeared that it may take several years after pond construction for biological and chemical treatment processes to develop to maximum efficiency.

Recommendations from the study are: 1) that an aerobic environment at the sediment/water interface be maintained by the design of ponds less than 2 meters deep; 2) use areal loadings for TP and TN as high as 5 and 30 g/m2/yr; 3) maximize detention time in the pond by adding baffles after the inlet and before the outlet; 4) develop maintenance procedures based on further studies conducted on ponds older than the ones studied, perhaps 15-20 year old ponds.

An additional study of the fate of heavy metals entering the Maitland pond was conducted by Harper beginning in 1982. One objective of this study was to assess the potential for contamination of groundwater by heavy metals entering a stormwater retention system.

Harper found that, in general, concentrations of all heavy metals measured, except copper, were greater in groundwaters beneath the pond than within the pond. As sediment accumulation occurs in retention ponds over time, the corresponding decreases in pH and oxidation-reduction potential (ORP) of the sediments will increase the release of metal ions into the groundwater. When the pH reaches 5.0, 25-30% of the cadmium and almost all of the manganese are released from the sediments while lesser amounts of zinc, iron, aluminum, copper, lead, and chromium are released. This finding demonstrates the need for pond maintenance if the highest treatment efficiency is to be achieved. The effectiveness of swale treatment of stormwater was documented when concentrations of all heavy metals tested, except for copper and nickel, were found to be significantly higher beneath swale areas than beneath the retention pond.

The use of natural systems to treat stormwater was the subject of a study by Harper et al in 1984. This work consisted of literature review and field and laboratory investigations. Studies of the use of wetlands for treatment of stormwater have been extremely limited. The few studies undertaken reveal several general conclusions: 1) a wide disparity exists in the capability of wetlands to remove nonpoint source pollution; 2) the nature of flow and seasonal factors are major influences on pollutant removal capabilities in certain wetlands; and 3) the greatest consistency in pollutant reduction appears to be for BOD, suspended solids, and heavy metals (Harper, 1986).

The study site consisted of a 48.4 hectare hardwood wetland hammock located just south of Sanford, Florida. The wetlands surround Hidden Lake, a 4.4 hectare open water body. The focus of the study was a 1.0 hectare wetland flowpath for stormwater carried by an upland canal from a 22.4 hectare subdivision. Stormwater from the subdivision entered the canal and was discharged into the flowpath from which it eventually entered Hidden Lake.

The details of the study, and all of its summary, conclusions, and recommendations are too voluminous to be included in this report. However, several findings should be noted:

1) The treatment efficiency of the wetland hammock was found to be in excess of 80% for BOD and suspended solids; 70% for cadmium, nickel, and chromium; 40-60% for zinc, copper, aluminum, and lead. Nitrogen and phosphorous apparently were not retained by the system but only total iron was found to exhibit a net export.

2) Some of the anticipated pollutant treatment levels from the Hidden Lake wetland may exceed Department of Environmental Regulation criteria for Class III waters. In particular, cadmium, copper, and lead might exceed Class III limits while pH and oxygen may be depressed below minimum levels.

3) Wet detention (pond) systems may provide better treatment of stormwater runoff than a hardwood wetland system of the type at Hidden Lake.

FINDINGS

Discussions with staff of the DER and SFWMD and review of studies on the management of stormwater have demonstrated the limited, still-evolving, database on the fate of pollutants in stormwater treatment systems. Without question, the use of reference management practices, or "state-of-the-art" treatment systems, is an improvement over the outdated concept of draining stormwater to the nearest receiving water by a direct channel. However, even the newer systems do not afford 100% protection of receiving waters.

Studies have shown that new treatment methods such as swales, use of natural wetlands, and retention ponds are efficient in removing some types of pollutants more than others depending on a wide variety of chemical, physical, and biological factors. At the Timbercreek residential development in Boca Raton, the South Florida Water Management District funded the first in a series of studies to evaluate the effectiveness of design criteria on hydrologic considerations and water quality. The District may modify its stormwater treatment criteria if the data from their studies indicate changes are necessary to meet statutory responsibilities.

The Timbercreek subdivision has a stormwater treatment system similar to what might be used in the Lee County coastal zone now or in the future. That system removed more than 80% of ortho phosphate and NOX, 64% of suspended solids, 60% of total phosphate, and only 15% of total nitrogen. If these results are representative of similar treatment systems in Lee County, receiving waters may be degraded by further growth in the coastal zone through the discharge of additional quantities of nutrients such as those mentioned above.

Studies of the fate of heavy metals discharged to either retention ponds or a natural wetland demonstrated the ability of sediments to hold metals removed from stormwater by coagulation, precipitation, adsorption or other processes, provided the pH does not fall to 5.0 or below. Regular maintenance of ponds is suggested in order to remove accumulated sediments and maintain aerobic conditions at the sediment/water interface, although researchers do not yet know how often, and at what pond age, the maintenance is needed. Further studies of this question have been recommended by researchers.

A number of factors, in addition to those associated with stormwater treatment systems, will affect the impact of continued growth in the Lee County coastal zone. Flushing characteristics of the receiving waters are critical to the ability of estuarine waters to assimilate additional pollutants. Charlotte Harbor, with its strong tidal flow, may be better able to withstand additional pollution loads than Estero Bay which is shallow and poorly flushed. Pine Island Sound, Matlacha Pass, and San Carlos Bay may also be further threatened if the fill portion of the Sanibel Causeway acts as a dam as suggested in the Department of Natural Resources assessment of fisheries habitat in Charlotte Harbor. In that case, increased quantities of pollutants may degrade estuarine waters rather than being dispersed in Gulf waters.

Alteration of historic hydrologic regimes on uplands is considered by Cox of the DER's Nonpoint Source Management Section to be more of a threat to estuarine water quality than the cumulative affect of treated stormwater. Sheetflow of stormwater, which filters naturally across vegetated uplands along a long reach of shoreline, is often replaced by a drainage system which discharges from interior lakes over a dam in a manner similar to a point source. Peak flows, flow velocity, flow duration, and quantity and quality of runoff water may also be altered.

It is recognized that new construction in the coastal zone will have to meet the stormwater treatment requirements of the DER and SFWMD. Studies have shown that the treatment efficiency of these systems is highly variable and dependent upon a large number of physical, chemical, and biological factors, not all of which are understood. Removal rates for some pollutants is consistantly low, particularly total nitrogen, for which reductions over 30% have not been reported in the literature (Wanielista, 1985).

The cumulative affect of these systems on estuarine areas is not known (Anderson, 1987), therefore, the County is cautioned not to presume that estuarine water quality is being fully protected because the treatment systems have been required of developers by the SFWMD. Further development in the coastal zone will result in increased amounts of pollutants entering estuarine waters. The impact on water quality of these pollutants, alone or in combination with pollutants from outside the coastal zone, cannot be predicted at this time.

Nonpoint pollution from existing sources inside and outside the coastal zone having antiquated drainage systems should also be of immediate concern, particularly in the Estero Bay watershed. These sources might be identified through further water quality sampling at points in the tributaries previously suggested by Kevin Erwin.

Further water quality sampling by Lee County in Estero Bay and its watershed may indicate that local government controls are necessary to mitigate impacts from current and future land uses. Attempts to control nonpoint pollution from sources inside and outside the coastal zone around Estero Bay might best be accomplished by developing a comprehensive watershed master plan.

According to the DER, the watershed master plan concept would result in the identification of the most appropriate control measures and optimum locations to control watershed-wide impacts. This approach typically involves strategically locating a single stormwater detention facility to control post-development runoff from several land development projects; providing stream channel improvements where necessary upstream of the stormwater detention facility; and nonstructural measures such as parkland aquisition to supplement structural control measures. Watershed management also allows for the coordination of infrastructure improvements and point source management.

Financing public stormwater treatment facilities was the subject of a study by Priede and Hobel in 1986. Based on the concept of the establishment of a stormwater utility, annual revenues were projected. Proposed user rates of $1.00-$4.00 per month were applied to the total Single Family Unit Equivalent for Tallahassee, Florida to yield funding for a possible stormwater utility.

RECOMMENDATIONS

Lee County should implement as quickly as possible a comprehensive sampling program to determine water quality in tributary streams to Estero Bay. The sampling program should be designed to show the extent of pollutants entering tributary streams upstream of the landward coastal zone boundary as well as the degree to which pollutants are contributed from those sections of tributary streams within the coastal zone. The purpose of this study would be to evaluate the need for special stormwater treatment measures in the watershed landward of the coastal zone boundary where antiquated drainage systems may exist.

The Ten Mile canal, a major County stormwater drainage system discharging to Estero Bay, should be operated according to a plan which provides flood protection and maximizes treatment of stormwater. Water quality sampling should be performed at selected stations throughout the canal system to establish levels of treatment provided and possibly identify methods to enhance treatment. When practical, as much water as possible should be routed to Six Mile Cypress via the Daniels' Road overflow.

The concept of watershed management for the Estero Bay watershed should be evaluated and considered as a method of controlling the impacts of present and future growth on Estero Bay. Although the tributary sampling program may show the need for such action, water sample results alone should not be the basis for a decision. A finding of good water quality in the tributaries would mean the County has an opportunity to minimize development impacts before they become a problem, which is cheaper and more effective than remedial actions after water quality in tributaries and Estero Bay becomes further degraded.

An engineering study is recommended for the Estero Bay watershed to evaluate existing drainage facilities and identify locations where modifications might be made to mitigate adverse water quality impacts. The study would incorporate solutions to problem areas identified by the water quality sampling program. The engineering study and its recommendations may be a component of a watershed master plan.

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EVALUATION OF THE LEE COUNTY BARRIER-ISLAND COASTLINE: DOMINANT PROCESSES, SHORELINE TRENDS, PAST STABILIZATION EFFORTS, AND RECOMMENDATIONS FOR BEACH MANAGEMENT

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INTRODUCTION

The purpose of this report is to present findings concerning: (1) the basic geology, geologic history, 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 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.

An important objective of this report was to find and interpret information that determines past shoreline changes and identifies zones of historical instability and erosion. Coincidentally to this project, two departments of Florida's Division of Beaches and Shores have been analyzing maps, aerial photographs, and topographic profiles. Some of this research was contracted out to and performed by Dr. William Tanner of the Department of Geology, Florida State University. Additionally, an existing analysis of historical shoreline trends was conducted by the U.S. Army Corps of Engineers at the Jacksonville, FL District (Department of the Army, 1969). All three sources of information as well as field observations and verbal information from residents provided the primary data base for this project.

Data from the two Division of Beaches and Shores reports and the older Corps of Engineers study have been included as appendices to this report (Appendices A, F, and G). Although the basic findings and recommendations in this report and those of the Division of Beaches and Shores were arrived at completely independently, there is almost universal agreement concerning the location of erosion problems and the proposed solutions to these problems.

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) Coastal and Oceanographic Engineering Laboratory Archives at the University of Florida in Gainesville, (2) 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 and mapping after an overflight of the County's coastline from a helicopter. Access to the barrier island beach was done by field vehicle or small boat. Engineering structures were mapped on 1"=100" aerial photographs. Key geologic features such as beachrock outcroppings, fore-dune ridge erosional scarps, overwash, eolian dune structures, etc., were identified on these photos as well.

Finally, a data analysis of a coastal sand budget based upon existing information is presented (Fig. 7). The purpose of this analysis was to determine primary sand sources and sinks and the rate of sand transfer from one to the other. This effort helped to identify areas of erosion and accretion and to provide an understanding why these changes have occurred.

SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

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. However, some areas like Captiva Island are relatively well understood. However, there is no one comprehensive analysis of wave climate, sand volume changes, tidal inlet-island interaction, island/beach response to storms, and subsurface geologic structure.

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

3. 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.

4. 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. Protection of sand dunes should be strongly encouraged.

5. Where public facilities and public access exist, tax dollars can be justified in funding beach nourishment. These areas would include the central-south portion of Gasparilla Island, southern end of Captiva Island, and the NW and central-south locations on Estero Island. The best sources of beach-quality sand for beach nourishment are the ebb-tidal deltas associated with the larger tidal inlets (Boca Grande,

Captiva, and Big Carlos Passes). A detailed, careful analysis should be performed before attempting to remove a sizeable (>50%) portion of the ebb-tidal delta at Redfish Pass.

6. 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/revetments the beach is narrow or non-existent. For purposes of helping to stabilize a public beach at the south end of Captiva Island, this report supports extending the terminal groin located along the north side of Blind Pass.

7. 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. The County should have a detailed file of all consulting activity and develop a library that would have copies of all studies (student theses, dissertations, etc.) dealing with the Lee County coast. In addition, the County should have copies of all aerial photographs and maps of the coastline on file. The County should have a coastal geologist and coastal engineer on staff.

8. The County should develop and fund its own coastal research program. A first priority would be to find and accurately determine size and quality of borrow sites for beach renourishment. More detailed models for storm surge penetration along a number of landfall sites should be developed for a variety of storm sizes and approach directions. There should be a rapid response research effort to study the effects and after-effects of hurricanes. There should be a detailed sand budget analysis for the County coastline based upon accurate wave and bathymetric data. Beach profiles should be measured at set time intervals, plotted, and interpreted. Tidal prism measurements of the inlets should be made through time. A directional wave gauge should be set up offshore.

These data would allow County and other scientists to understand shoreline changes and to help predict future changes. Funding for such a data collection and monitoring effort could come from private, municipal, County, neighboring counties, and State sources.

9. The County could do more to educate its citizens about coastal sciences and the limitations/costs of engineering solutions.

BACKGROUND

The State of Florida is the subaerial portion of an enormous carbonate platform (the Florida Platform; Chen, 1965) that during periods of high sea level 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 in that the sediments produced were almost entirely calcium carbonate (Chen, 1965). These carbonate sediments eventually lithified to create the limestone formations that presently underlie the State and are so important to our groundwater system. Dissolution of these limestones by undersaturated, acidic waters has created a dynamic subsurface topography (sinkholes; Beck, 1984) that significantly has affected surficial geologic processes and human activity.

The Florida Platform developed partially as the result of a large, open seaway that extended from the Panama City area to the modern Savannah, Georgia area. Water flowing through this seaway (Suwannee Straits) prevented silici-clastic sands and muds being shed off the southern Appalachian Mountains from inundating and burying the carbonate sedimentation occurring on the Florida Platform (Chen, 1965; McKinney, 1984; Pinet and Popenoe, 1985). However, with time, the Suwannee Straits filled in and the quartz sands that we see today on the beaches began to spill-over to the south onto the Florida Platform. Since there were probably no large south-flowing rivers, 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. Pine Island, for example, is most likely an ancient barrier island of Pleistocene age. The modern barrier islands forming the Lee County coast consist of those well-reworked quartz sands, ultimately derived from the north.

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. The contribution of carbonate sediments in the form of shells and shell fragments, although significant in local areas, is not considered a dominant factor when considering the total volume of sand in the lagoon/barrier island/tidal delta system. Admittedly, this is an area of study that needs quantification.

Although much as been written about the origin of barrier islands, little field work has been done on the Lee County barrier islands concerning their geologic history. Stapor and Matthews (1980) using radiocarbon dating techniques indicate that this barrier island chain began to form and prograde seaward approximately 3,500 years before present. This time corresponds to the late Holocene reduction in the rate of sea-level rise seen in so many sea level curves. Since there are no data from the adjacent continental shelf, we have no way of knowing if earlier barrier islands migrated across this flat expanse via overwash processes or not. However, the beach-ridge dominated morphology of many of the Lee Country barriers, particularly Sanibel Island, suggest that the combination of a reduction of the rate of sea level rise, a local supply of sand, and possibly pre-existing topography played a key role in the location, initial growth, and formation of the present barrier-island chain.

The extensive coastwise, lateral spit growth mode of island formation postulated by Harvey (1979) most likely did not occur. However, local spit development was an important component in the development and evolution of barrier islands 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 east coast (Hine and Belknap, 1986), or other higher wave energy, barrier-island coastlines such as the North Carolina Outer Banks (Nummedal et al., 1977). The limited fetch of the Gulf as compared to the Atlantic Ocean and the dominant winds blowing from the northeast or offshore are other reasons for this low wave energy character. The dominant onshore winds are from the northwest 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. Climate and wave data are present in Tables 1, 2 and Figure 2. The prevailing wind direction and speed in Table 1 does not reflect short-term, higher velocity winds--those associated with thunderstorms or the NW winds associated with passing extratropical cold fronts. These fronts are responsible for generating the NW wave conditions and ultimately the net southerly longshore sand transport.

TABLE 1
AVERAGE MONTHLY WEATHER CONDITIONS (Jones, 1980, p. 7)

Month	Temperature (F°)	Rainfall (in.)	Wind	
			Prevailing Direction	Mean Speed (mph)
Jan.	63.5	1.52	E	8.6
Feb.	65.2	2.21	E	9.2
Mar.	68.2	2.62	SW	9.6
Apr.	72.8	2.64	E	8.9
May	77.4	3.85	E	8.2
June	80.8	8.96	E	7.4
July	82.2	9.08	ESE	6.9
Aug.	82.7	7.38	E	6.9
Sep.	81.3	8.50	E	7.9
Oct.	76.1	4.09	NE	8.5
Nov.	69.2	1.20	NE	8.3
Dec.	65.0	1.29	NE	8.3
Avg/total	73.7	53.34	E	8.2

TABLE 2

WAVE CHARACTERISTICS FROM THE CERC WAVE GAUGES AT NAPLES

(Jones, 1980, p. 17)

Wave Characteristics	Mar. 1964-Apr. 1967 (5837 observations)	Dec. 1969-Dec. 1974 (2579 observations)
Ave. Significant Wave height (ft)	0.83	1.16
Variance (ft^2)	0.32	0.54
Standard Deviation (ft)	0.56	0.74
Ave. Wave Period* (sec)	4.23	4.71
Variance (sec^2)	2.58	4.49
Standard Deviation* (sec)	1.61	2.12

*omitting calms

Tides - The tides are mixed diurnal/semi-diurnal. 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 ranges from 1.7 feet (Boca Grande) to 2.8 feet (San Carlos Bay; NOAA, 1983). Wind-tidal events may significantly affect this astronomically driven signal. Storm tides and surges and their effects will be addressed in another section.

Tidal Currents - Most strong currents are associated with the tidal inlets. To date, few current-meter studies have been found. Coastal charts indicate that velocities up to 3.7 ft/sec may be expected to occur in the inlet throats. Jones (1980) calculated maximum cross-sectional average velocities for New Pass and Big Carlos Pass. Suboceanic Consultants (1978) determined tidal hydraulic parameters for Big Carlos and New Passes.

Hurricanes - 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). Between 1969 and 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 3 is an enumeration of 100 yr. storm surge elevations for two different approach paths (landfalling; i.e., shore normal; and alongshore) for various Lee County sites. Figure 4 illustrates predicted storm surges along the entire Lee County coast.

TABLE 3

Peak Storm Surges, Computed Using the FEMA Model, for Hypothetical 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)

Location	Peak Storm Surge For		Difference
	Landfalling Path (Feet)	Alongshore Path (Feet)	(Feet)
Coastal Locations			
Sanibel Island	11.7	7.8	3.9
Captiva 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

The Ft. Myers area statistically is influenced by hurricane force winds (<74 mph) every 11 years. The probability of the occurrence in any single year over a 50 mile stretch of coast in Lee County of a great hurricane (winds <125 mph) is 2% (NOAA, 1972; Jones, 1980).

Tropical storm statistics and the absence of extensive washover fans both indicate that the west-central Florida coast has not been dominated by hurricanes or large storms. Maps of hurricane tracks indicate that most of these storms, once they have entered the Gulf of

Mexico, pass off to the north and northwest. Tropical storms approaching from the west are relatively rare. A recent study from the Sarasota barrier island coast does suggest that the west-central Florida coast has been struck by extremely large hurricanes in the geologic past (Knowles, 1983; Knowles and Davis, 1983). The geologic data (large, thick, extensive, buried washover fans) suggest that these super-storms may occur every several hundred years. A listing of the effects of past storms along Lee County is provided in the Appendix B.

Sea Level Rise - Finally, much has been written and said concerning the past effects of sea-level rise on the evolution of barrier islands and the effect of present-day sea level rise on erosion rates. In addition, there has been considerable interest in the predicted rates of sea-level rise due to the Greenhouse Effect and how the shoreline will be impacted by this phenomenon (Barth and Titus, 1984). Figure 4 illustrates the rate of sea level rise over the past 5,000 years based upon radiocarbon dates. Figure 5 illustrates the rate of sea level rise in south Florida from tide gauge data over the past 50 years. The tide gauge data indicate that sea level is 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.). In addition, several important studies indicate that sea level will rise from 56 to 345 cm by the year 2100 (Barth and Titus, 1984). Even though this is a wide range of projections, these studies indicate that a projected rise of about 100 cm by 2100 (≈87 cm/100 yrs.) is a consensus value. A conclusion seems inescapable that not only is sea level continuing to rise, the rate of rise is increasing at a rapid rate.

The effect of this global process on the Lee County beaches is difficult to determine. Local beach erosion may be due to local problems in sand supply (temporary storage of excessive amounts of sand in an ebb-tidal delta, for example), or increased wave energy due to more frequent frontal passages and may have little to do with worldwide sea-level rise. However, present level of erosion can only be further exacerbated by an increase in the rate of sea-level rise.

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 represent some of the most complex coastal geomorphology of the 5500 km long barrier-island coast of the U.S. East and Gulf of Mexico shoreline which is the longest barrier island coast in the world (King, 1972).

Commonly, a shoreline having a highly irregular shape (no one straight stretch) and complex geomorphology has beaches that contrast significantly in historical erosion/depositional trends. Therefore, to understand past and present shoreline changes, one must understand the processes controlling sand transfer and resulting coastal geomorphology.

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 4 lists, from north to south, the islands and inlets comprising the Lee County Coast.

TABLE 4

LEE COUNTY BARRIER ISLANDS AND TIDAL INLETS

Islands	Inlets
Gasparilla (southern 3/4)	
	Boca Grande Pass
Cayo Costa	
	Captiva Pass
North Captiva	
	Redfish Pass
Captiva	
	Blind Pass (reopened 1982)
Sanibel	
	San Carlos Bay/Matanzas Pass
Estero	
	Big Carlos Pass
Black Island/Lovers Key	
	New Pass (Little Carlos)
Big Hickory	
	Big Hickory Pass
Little Hickory	
(Bonita Beach)	

Inlet size is most appropriately measured by the average volume of water passing in or out of the inlet throat during a flooding or ebbing tide. This water volume is called tidal prism and the range of the inlet tidal prisms in Lee County is very large. The recently opened (Clark, 1982) Blind Pass separating Sanibel from Captiva Island is a good example of an inlet with a small tidal prism. At the other end of the spectrum, Boca Grande Pass has an enormous tidal prism. The remaining Lee County inlets fall somewhere in between this wide range.

Unfortunately, there are presently few measurements to adequately quantify the prism size of the County's inlets. However, the size of the inlet's minimum cross-section or the volume of sand in the ebb-tidal delta system are ways to rank the inlets by relative size within the same coastal system. This ranking is shown in Table 5.

TABLE 5

LEE COUNTY INLETS RANKED BY SIZE

Inlet	Minimum Cross-Section Area (ft^2)	Tidal Prism (ft^3) (Jones, 1980)	Ebb Tidal Delta (yds^3; Hine et al., 1986)
1. Boca Grande	183,600		159×10^6
2. Captiva	63,000		11.7×10^6
3. Big Carlos	20,810	8.19×10^8	8.04×10^6
4. Red Fish	12,200*	4.29×10^7	2.80×10^6
5. New Pass	7,300	2.71×10^8	$.42 \times 10^6$
6. Matanzas	700		Insignificant
7. Blind	600		Insignificant
8. Big Hickory	Now Closed		
	(7,300 in 1978)	1.20×60^6 (1978)	Insignificant

*COEL (1974)

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 the tidal prism, the larger (wider/deeper) the inlet. An obvious problem arises when one bay is serviced by multiple inlets. Determining how much of the total tidal prism is diverted to each inlet can be difficult to assess without expensive, long-term field measurements. However, by looking at a map or chart, it is obvious that Boca Grande Pass is a large 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 range in sizes of these back-barrier bays is tied to earlier geologic history. Charlotte Harbor is an estuary that flooded a former river valley during the last sea-level rise associated with deglaciation. When sea level was lower, the Peace and Myakka Rivers combined to form one fluvial system that created the topographic low area while flowing to the west (Evans, unpublished data). Tampa Bay to the north is an identical system (Hebert, 1985; Hine, unpublished data). As a result, the inlet at the mouth of Tampa Bay is also very large due to its large interior bay and its enormous tidal prism. In areas not influenced by past drainage systems, the regional slope of the land is an important factor in determining the size of the flooded area (bay or lagoon) behind the island system. So, if the topography of the flooded surface is highly irregular, the sizes of back-barrier lagoons, bays, and estuaries will differ greatly, and the resulting tidal inlets will display a significant range in size.

In addition to having a direct control on the sizes and shapes of the lagoons and estuaries, recent seismic data (Evans and Hine, 1986) have shown that events of the geologic past may have also controlled the location and trend of a major portion of the Lee County barrier island chain. There is a subsurface ridge or topographic high beneath Cayo Costa, North Captiva, and Captiva Islands. This ridge may have played a key role in the late Holocene development of these islands. Additionally, the abrupt end of this barrier-island chain at Sanibel causing a major change in the trend of the Lee County shoreline is controlled by a subsurface structure formed in the geologic past. 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.

North Barrier-Island System

The stability and behavior of tidal inlets are dependent upon a balance between the tidal flushing capability of the inlet and the volume of sand introduced laterally by the longshore transport system (Keulegan, 1967; O'Brien, 1976; Jarrett, 1976; Hubbard, 1979). 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 are wave dominated. 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 (Davis, et al., 1987). 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 (see Table 5). 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 it 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. These inlets do not have the same capability to migrate laterally as do the wave-dominated systems. However, the tide-dominated inlets, 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-water bathymetry of the ebb-tidal deltas causes changes in the incoming wave-refraction pattern and therefore changes in the level and direction of wave energy striking the beach.

The ebb-tidal delta at Redfish Pass has caused a longshore sand transport reversal 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 (Coastal Planning and Engineering, June, 1985; October, 1985; April, 1986). Figure 6 is a wave refraction diagram illustrating how waves approaching from the NW are refracted 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.

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 (Table 5). 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. 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 a much lower waves 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 (Fig. 6). 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. Indeed, the longshore transport curves from Walton (1973) indicate that minor changes in the magnitude/direction of incoming waves energy and/or minor shoreline changes will cause the direction of net sand transport to vary from north to south across a nodal point.

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.

INVENTORY FINDINGS

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. The west-central Florida barrier island coast has been historically ignored by coastal scientists. Some portions of the Lee County coast are perhaps the least studied segment of this chain. Other portions, i.e., Captiva Island, are among the most heavily studied barrier-island beaches anywhere. Well-studied barrier-island coasts elsewhere in the U.S. include Texas, Louisiana, portions of Mississippi and Alabama, Georgia, South and North Carolina, Delaware, Long Island, Rhode Island, and Massachusetts.

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.

Gulf Coast Wide Studies - These are studies that are important in that Lee County as well as the other Florida Gulf coastal counties can be seen as parts of a much larger framework, system, condition, or problem. Key studies at this level include: Tanner, 1960; Bruun et al., 1958; Bretschneider and Gaul, 1956; Marmer, 1954; El-Ashry, 1966; Brooks, 1973; Banks, 1975; Davis et al., 1979; Ceryak, 1980; Tanner, 1983; Clark, 1986; Hine et al., 1986. Note that most of these studies address a wide range of topics.

County Wide Studies - 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. Other coastal studies that have taken a county-wide approach are Miller and Benson (1976), Stapor and Matthews (1980), County Commissioners of Lee County (1970), National Research Council (1983), and Winton et al. (1981).

Island Studies - The next level of research involves those studies that have examined individual islands 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.

The following is a chronological listing of the reports and publications written about Captiva Island: Coastal Engineering Laboratory (1958), Clifford and Associates (1959), COEL (1974), CEPD (1971), Duane Hall and Associates (1971, 1975), Coastal Engineering and

Construction (1977), Olsen (1979, 1980a,b), Silberman (1980), Tetra Tech (1982), Tackney and Associates, Inc. (1983), Tetra Tech (1984a,b,c; 1985), Coastal Planning and Engineering, Inc. (June, 1985a; October, 1985b,c; April, 1986), Coastal Engineering Consultants (undated), and the latest being a comprehensive plan written by Applied Technology and Management, Inc. (1987). Recommendations made in this plan are essentially parallel to those made in this study and the study for the Division of Beaches and Shores (1987).

Although there are a number of studies concerning Sanibel Island (Cooley, 1955; Missemer, 1973a,b; Boggess, 1974; Clark, 1976; Silberman, 1980, for example), they were only used to help understand the larger barrier-island system in that Sanibel Island itself has been excluded from this report. In addition, studies concerning tidal inlets should be placed in this category (COEL, 1974; Suboceanic Consultants, Inc., 1978; Jones, 1980; Hine et al., 1986).

Site Specific Studies - 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.

Sand Budget Considerations

Longshore sand transport curves based upon wave data derived from Summary of Synoptic Meteorological Observations (Walton, 1973) allow one to determine sand transport rates along specific coastlines depending upon their orientation. There are many assumptions and limitations with this technique. However, in the absence of field data and accurate nearshore bathymetric maps, this technique is as good as any. The data are presented in the Appendix C. The results are illustrated in Figure 7.

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 was calculated as well as the rate of entrapment (Hine et al., 1986; see Appendix D). These measurements were made by comparing ebb-tidal delta sizes from initial bathymetric surveys in the late 1800's to recent surveys. These data are shown in the Appendix D,E. Several important conclusions can be drawn from this data base. 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 is particularly impressive as it is the second largest of all the 64 inlets found along the Florida coastline. The ebb-tidal delta associated with the mouth of Tampa Bay is the largest (401,000,000 yds^3 vs. 159,000,000 yds^3; Hine et al., 1986).

Not only is the ebb-tidal delta at Boca Grande Pass very large, it has been trapping sands at an impressive rate. This sand shoal has grown by 47,000,000 yds^3 since 1883 (1883-1985) which averages 456,310 yds^3 yr. Note that this value is much higher than the annual net longshore sand transport (to south) along the Gasparilla Island. So, not only is this ebb-tidal delta trapping all the sand carried to it from the north, it is receiving nearly three times as much from other sources; most likely from the inside of Charlotte Harbor. An alternative explanation is that longshore transport rates along Gasparilla Island were much higher in the past than the value shown in Figure 7. The ebb-tidal delta seaward of Big Carlos Pass has also received an abundance of sand.

Due to the intense interest in Captiva Island, a detailed, localized sand budget has been established. The beach monitoring done by Coastal Planning and Engineering for the Captiva Erosion Prevention District has quantified, using field measurements through time, the gains and losses of the Captiva beach/inlet system (Coastal Planning and Engineering, Inc., June, 1985; October, 1985; April, 1986).

Dune System

Field observations indicate that the fore-dune system associated with the Lee County barrier islands is commonly absent and topographically low (<2.5 m above MSL: <1.5 m in relief) where present. The fore-dunes or fore-dune ridge are the first dunes one encounters on a traverse from the beachface toward the island interior. 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 prograding 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. If plants are to trap sands to build dunes, prevailing winds blowing onshore above a certain critical threshold velocity for sand-grain transport must occur for significant lengths of time during the year. The dry upper beach/berm system is the source of sand for dune growth. If the prevailing winds blow offshore, there is generally no inland source of sand for dune growth due to the presence of inland vegetation stabilizing the substrate. Secondly, as sand is blown off the dry, upper beach, the coarse shell material is left behind forming a shell-lag concentrate on the surface. This deflation pavement prevents underlying sands from becoming transported. These sands are trapped by this upper coarser layer. The sand supply is shut down and the dunes can no longer build. Along the Lee County coast, newly formed dunes reach no higher than .5-1m before a coarse shell concentrate armors the upper beach and begins to shut down sand supply.

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 m 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.

The height of the fore-dune ridge, either active or relict, can be determined by reviewing the 1 inch equals 300 feet aerial photos with topographic lines superimposed (Hamrich Aerial Surveys, Inc., 1981). The contour interval is 1 foot. In addition, these photo/maps have numerous spot locations indicated and measured to .1 foot.

Past Storm Effects

As mentioned earlier, an annotated listing of the physical effects of past tropical storms and hurricanes that have influenced the Lee County coast are listed in Appendix B (Department of the Army, 1969; Clark, 1982). However, a few excerpts and observations are presented in this section for emphasis.

The hurricane of October, 1873 generated a storm surge of 14 feet. The hurricane of October, 1910 generated a storm surge of 10.5 feet in the Everglades. The hurricane of October, 1921 generated a storm surge from 7 to 11 feet. The hurricane of 1926 generated a storm surge of 12 feet. Within a 53 year period, four hurricanes striking the southwest

Florida Gulf coast developed storm surges capable of entirely submerging any barrier island on the Lee County coast.

Other pertinent facts are: (1) the hurricane of October 1921 formed Redfish Pass. As a result of the formation of this new inlet, the barrier-island system within a mile of the inlet both to the north and south eroded back over 1500 feet (Harvey, 1979); (2) wave heights associated with the hurricane of August/September 1935 were estimated to be 16 feet; (3) Hurricane Donna of August/September 1960 destroyed or badly damaged 1,100 buildings and 200 trailers in Lee County alone; (4) Hurricane Betsy of August/September 1965 destroyed 1,300 feet of highway along Captiva Island; (5) Hurricane Agnes reopened Blind Pass in 1972, subsequently closed between 1975 and 1980; (6) the subtropical storm of June 1982 reopened Blind Pass (Clark, 1982).

Shoreline Behavior

Figures 8-11 illustrate shoreline trends, for Gasparilla, southern portion of North Captiva, Captiva, and Estero Islands from the mid to late 1800's until 1967. The data are from The Department of the Army (1969) and have been plotted in graph form. In addition, the more recent shoreline changes (1967-1980) for Captiva Island are illustrated in Figure 12. Note that most of this island has undergone erosion during that time interval. Historical accretion/erosion trends for Captiva Island are shown in Table 6. Those trends for Big Hickory Island and Bonita Beach are shown in Table 7. Finally, county wide shoreline trends from 1974-1982 based upon topographic beach profiles taken by the Division of Beaches and Shores are shown in Figure 13. The location of these profiles is shown in Figure 14.

Human Influence

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.

All dredging activity within the inlets is listed in Table 3 in Appendix D. Most of the inlet maintenance dredging has concentrated in Boca Grande Inlet. Most all sand dredged from this inlet has been placed in the open waters of the Gulf of Mexico. However, on one occasion, in 1981, about 260,000 yds^3 were placed in a 1280 foot long section of the Lee County Park Beach on Gasparilla Island (Hine et al., 1986; Gail Gren, Chief, Construction-Operations Division, Jacksonville District, Corps of Engineers, written communication, 1987). Recent field observations and aerial photographs indicate that most of this sand has been eroded away.

The entrance to San Carlos Bay/Matanzas Pass/Ft. Myers Beach Channel is the other area where dredge material has been placed on the neighboring beach. During five dredging operations over the past 25 years, the U.S. Army Corps of Engineers has placed about 767,000 yds^3 of sand on the NW portion of Estero Island. The latest dredging

TABLE 6

SUMMARY OF ACCRETION/EROSION CALCULATIONS AT CAPTIVA ISLAND
(COEL, 1974, p 81)

Location	Surveys Used in Comparison and Coverage of Surveys	Actual Period Covered Between Surveys	Volume Accreted or Eroded During Period	Volume Accreted or Eroded Annually	Remarks
Blind Pass bay side tidal delta	USCGS[1] 1879-80 and USCGS 1956-60 MHW to -40 MLW	80 years	1,112,000 cu. yds. accreted	14,000 cu. yds. accreted	During much of the intervening period, this pass was closed, therefore a shoaling rate of 14,000 cu.yds. annually is very conservative.
Redfish Pass bay side tidal delta	USCGS 1879-80 and USCGS 1956-60 MHW to -40 MLW	80 years (Redfish Pass opened in 1926)	3,747,000 cu. yds. accreted	110,000 cu. yds. accreted	Volume shoaled annually is based on 34 year period between opening of Redfish Pass and the 1956-60 survey.
Redfish Pass gulf side bar	USCGS 1879-80 and USCGS 1956-60 MHW to -40 MLW	80 years (Redfish Pass opened in 1926)	4,250,000 cu. yds. accreted	125,000 cu. yds. accreted	" " "
Captiva Island gulf side	USCGS 1956-60 and CE 1967 MHW to -18 MLW	6¼ years	781,000 cu. yds. (963,000)[2] eroded	125,000 cu. yds. (154,000) eroded	182,000 cu. yds. placed on beach during period 1962-65.
Captiva Island gulf side	Duane Hall 1960 and Duane Hall 1970 +4 MSL to -6 MSL	10 years	420,000 cu. yds. (602,000)[2] eroded	42,000 cu. yds. (60,200) eroded	" " "
Captiva Island gulf side	CE[2] - Dec. 1964 CE - 1966-67 50 profiles MHW to -12 ft. MLW 8 profiles MHW to -18 ft. MLW	2 years	400,700 cu. yds. (450,000)[2] eroded	200,400 cu. yds. (225,400) eroded	50,000 cu. yds. placed on beach during period Dec. 1964 - Dec. 1966. Profile 17 in both surveys was not used due to 3 ft. discrepancy in depth at outer limit of profile.

[1]United States Coast and Geodetic Survey (presently, National Ocean Survey).
[2]Quantities in parenthesis denote volumes eroded taking into account beach fills during intervening periods.

TABLE 7

Mean-high-water shoreline changes

Position	1858-59 Advance	to	1927 Recession	
		BIG HICKORY ISLAND		
1			400	(1)330
2			200	
3			320	
4			400	
		BONITA BEACH (Little Hickory Island)		
1	90			(1) 98
2			200	
3			120	
4			160	

NOTE: (1) Average change for bracketed reach.

operation occurred during 1985-86 involving about 190,000 yds^3 of sand. Field observations indicate that this last dredging operation excavated below the younger beach quality sands and reached the lower blue-green clays of Hawthorn equivalent formations. Numerous clay balls could be seen on the NW end of Estero Island. Future dredging operations should exercise care in avoiding these poor quality beach sediments.

An enormous amount of consultant-related research has been done on Captiva Island making it the best studied island of the Lee County coast.

The following is a listing of major past events that have or will affect this barrier island:

1958-Captiva Erosion Prevention District (CEPD) formed by the Florida legislature.

1961-134 Budd, "dog-bone", groins installed down the length of the island. Cost was $280,000. Their effect has been marginal (Tetra Tech, 1984).

1962-7,000 yds^3 of sediment from Roosevelt Channel on the bayside placed on the center portion of the island.

1963-50,000 yds^3 of sediment pumped to the area of Post Office Road.

1964-1966-Beginning of extensive rock revetments/seawalls along Captiva installed by private owners. Forty percent of the island now has hardened structures along the open Gulf of Mexico.

1965-CEPD installed two timber groins near center of island. Another 50,000 yds^3 of sediment from channel between Buck Key and Captiva on the bayside was pumped in between these two groins. Fine-grained nature of bayside fill caused rapid erosion.

1964-1967-Lee County trucked in 50,000 to 100,000 yds^3 for same Post Office Road area. Another 17,000 yds^3 brought in to repair the County highway after Hurricane Gladys.

1969-Beach erosion control study completed by U.S. Army Corps of Engineers (Department of the Army, 1969). Study was done at the request of the Lee County Commission. Captiva was recommended to receive 1,800,000 yds^3. This was authorized by Congress in 1970 but never implemented due to local opposition to more public access.

1973-CEPD contracted the Coastal and Oceanographic Engineering Laboratory of the University of Florida to conduct a study (COEL, 1974). This study recommended renourishment of the beach and a terminal groin placed at Redfish Pass.

1973-Rock groin installed by Lee County at Turner's Beach on the north side of Blind Pass.

1975-Another CEPD study by Duane Hall and Associates recommended beach renourishment and a terminal groin at Redfish Pass.

1978-1981-South Seas Plantation initiated a privately funded beach renourishment project along the northern 1.8 miles of Captiva Island.

This project was completed in October, 1981 at a cost of $3.66 million. The sand borrow site was the seaward portion of the Redfish Pass ebb-tidal delta. The borrow site was 1,500' x 2,000' and amounted to 760,000 yds^3 of sand. A terminal groin was installed at Redfish Pass. Sea oats were planted along the upper beach. The performance of this project has been and continues to be monitored. As of April 1986, about 74% of this sand has remained in the renourished are (Coastal Planning and Engineering, Inc., June, 1985; October, 1985; April, 1986).

1984-CEPD proposes two experimental beach projects:

a. perpendicular stabilizing structures-5 large sand bag groins
b. artificial seaweed anchored offshore

1984-CEPD funded study by Tetra Tech (1984a,b,c) recommends renourishing 16,000 linear feet of Captiva up to south boundary of South Seas Plantation. A 125' wide beach consisting of 1,300,000 yds^3 of sand costing $6,000,000 was proposed. The borrow site would be the ebb-tidal delta of Redfish Pass. The terminal groin on the north side of Blind Pass would be extended 190'. Project later modified to $5,600,000 by Tetra Tech (1985).

1985-CEPD funds study by Coastal Planning and Engineering, Inc. to investigate the feasibility of installing offshore breakwaters to stabilize erosion.

1986-CEPD installs experimental perpendicular stabilizing structures in February. CEPD later ordered by State DER to remove them due to permit violation.

1987-CEPD contracts Applied Technology and Management, Inc. of Gainesville, FL to produce a comprehensive beach erosion/management plan. The engineering component is due to CEPD by March 1, 1987.

A listing of permits for all shoreline construction activity along the Lee County open beach and tidal inlets has been furnished by the Corps of Engineers (Paerl Levin, Permitting Section, Jacksonville District, Corps of Engineers).

Finally, maps based upon recent field work illustrating the distribution of hardened structures and key geologic features along Gasparilla, Cayo Costa, North Captiva, Captiva and Estero Islands are in the Appendix A (Figures 15-19).

DATA ASSESSMENT/RECOMMENDATIONS

This section provides a geologic description of each barrier island of Lee County coupled with past engineering activities. Finally, recommendations concerning future activity are presented.

It should be pointed out that the Florida Division of Beaches and Shores has just completed (release date approximately mid October 1987) a beach erosion management plan for Lee County. For convenience, that plan is included as Appendix F in this report. 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

The reader should contact the Florida Division of Beach and Shores (904-487-1262) for more information concerning this plan.

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 becoming more erosional toward the south end, particularly near Boca Grande Pass (Fig. 8). This is reflected in the longshore sand transport calculations which show that sand transport increases toward the south end of the island (Fig. 7). The 124,000 yds^3 yr net southerly transport is the second highest net transport rate calculated for the entire Lee County coast. Most of this sediment is trapped within the enormous ebb-tidal delta system of the Boca Grande Pass. The high net transport rate to the south and the relative, historical stability of this barrier island indicate that sands are largely being bypassed down the length of the island. In addition, large outcroppings of beachrock help to provide an overall stability.

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 1-2m. See the earlier discussion explaining the reasons why this is so. 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 (Figs. 21A,B,C).

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 (Fig. 21C).

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 (Figs. 22A,B,C,D). Along the southern portion of the island starting at 1st St., the 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 1, 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 to be relatively inexpensive as nourishment projects go.

The 1981 nourishment at the Lee County Park Beach consisting of 260,000 yds^3 of sand 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' above mean sea level, one could expect major flooding every 25 years (Fig. 3). A healthy, extensive fore-dune ridge would reduce the adverse effects of such flooding events.

Cayo Costa Island

Geology: This is a wide, beach-ridge dominated barrier island 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 (Fig. 23A). 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 (Fig. 23B). The southern portion of the island has not received the beneficial influence of this large, offshore sand body and is narrower, lower, and punctuated by past inlet migration and overwash activity (Fig. 16).

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. As mentioned before, these fine sands are easily transported by the winds and trapped by beach vegetation to form dunes. With time, coarse shells become concentrated on the beach surface as a result of the fines being blown away. Ultimately, no more fine sands are available and the dunes cease developing until a new source of fine sands is introduced through the overwash process.

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' set behind the seaward vegetation line shown in the 1974 1"=100' aerial photos. It is unclear why the developed barrier islands have the CCCL set so much closer to the beach than the undeveloped barrier islands.

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. This island should be left in a completely natural state. Pedestrian traffic should be controlled 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 (Hayes, 1979) having a bulbous north end and a narrow, erosional south end (Figs. 9 and 17). 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. 7) explains the erosional nature of the southern portion of this island. The very north end of the island near Captiva Pass is presently eroding as seen by the scarped shoreline (Figs. 24A,B,C). 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 (Fig. 24A).

Engineering Efforts: Most of the coastal engineering along North Captiva Island has been local, "homemade" type of construction to protect private dwellings. These revetments are mostly restricted to the north end of the island (Figs. 24A,B). They have been ineffective in retarding erosion as they are easily undermined. Comparison of the 1974 and 1981 1"=100' aerial photos show that a number of dwellings have been constructed seaward of the CCCL along the north end of the island. The CCCL lies between 150-300' 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 north end of the island is already littered enough with concrete blocks, boulders, etc. No beach nourishment is needed as there are no public facilities. The island should be allowed to change naturally. The 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. 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 (65,000 yds^3 yr to the south) 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 there is an enormous amount of data that 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, no doubt, due to the efforts by the Captiva Erosion Prevention District 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 (Appendix F).

Past engineering efforts are illustrated and summarized in Figure 18. 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 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 (Fig. 25).

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 stability for this highly unstable tidal inlet. The proposed 190 ft. of 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 (to north) the beach 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). Studies have shown that updrift benefits resulting from inlet jetties and terminal groins are geographically more limited than the downdrift negative effects (Marino and Mehta, 1986; Hine et al., 1986). 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 data base 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 is located in the southern barrier island system of Lee County. As mentioned earlier, it is sheltered or protected by the northern barrier-island system from the relatively higher energy NW approaching waves. Consequently, the highest net longshore sand transport rates are about 50% less than the highest rates calculated for the northern barrier island system (Fig. 7). The shoreline erosion data (Fig. 12) indicate that most of this island has been receding except for the north-central quarter which has been relatively more stable. The erosion within the south-central quarter is due to the longshore sand transport reversal illustrated in Figure 7. The low energy character of this island also means that it is not as topographically as high as the islands located to the north. The contour map indicates that most of Estero is only 5-7' 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 (Fig. 26A). Local residents reported that these offshore bars (ridge and runnel) were formed during/after Hurricane Donna in 1960. However, normal non-storm waves after the storm were unable to drive these sand bodies shoreward to replace the sands that had been stripped off during the hurricane. The ridges had been built up above the normal spring high tide swash line. Through time, vegetation colonized the upper portions of these stagnated ridges and sand dunes began to build. Essentially, these ridges became small barrier islands located offshore of the parent system. They now offer excellent protection to the beaches and buildings located on the main portion of southern Estero Island.

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

Engineering Efforts: Estero, in spite of the heavy demands placed upon this barrier island, is little studied and has not been the subject of a comprehensive beach management plan similar to Captiva Island. Figure

19 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 (Fig. 26B). Most of these relatively old hardened structures are concentrated along the central-south quarter of the island (points #31-33 in Fig. 12) where the island is most susceptible to erosion.

The very southern end of the island facing Big Carlos Pass has undergone recent and rapid human development (Fig. 26C). 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 (points #31-33, Fig. 12) 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; 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 (Fig. 26D). However, stablilizing beaches at the south end will prove to be very difficult. This is an exposed area subject to chronic erosion (Fig. 26C). This will probably always be a problem area. 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 (Fig. 26D). 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. The net longshore sand transport calculations indicate a small amount (11,000 yds^3/yr) 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 (Fig. 27A). 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'), 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 (Fig. 27A). 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' 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 (Figs. 27B,C). 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 must unstable is the area where, unfortunately, most of the extensive and expensive development is occurring. Since this is not a public 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. The use of offshore breakwaters is still largely experimental. Their use is conditional only upon a good understanding of local sand budget.

There is no nearby source of sand for beach nourishment. The ebb-tidal delta at New Pass is very small (see Table 5). 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.

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APPENDICES

A. FIGURES

B. HISTORY OF STORM EFFECTS

C. LONGSHORE TRANSPORT TABLES

D. INLET SEDIMENT VOLUME TABLE

E. INLET SUMMARIES

F. LEE COUNTY BEACH RESTORATION MANAGEMENT PLAN (Division of Beaches and Shores)

G. HISTORICAL SHORELINE CHANGE DATA (Division of Beaches and Shores)

APPENDIX A

LIST OF ILLUSTRATIONS

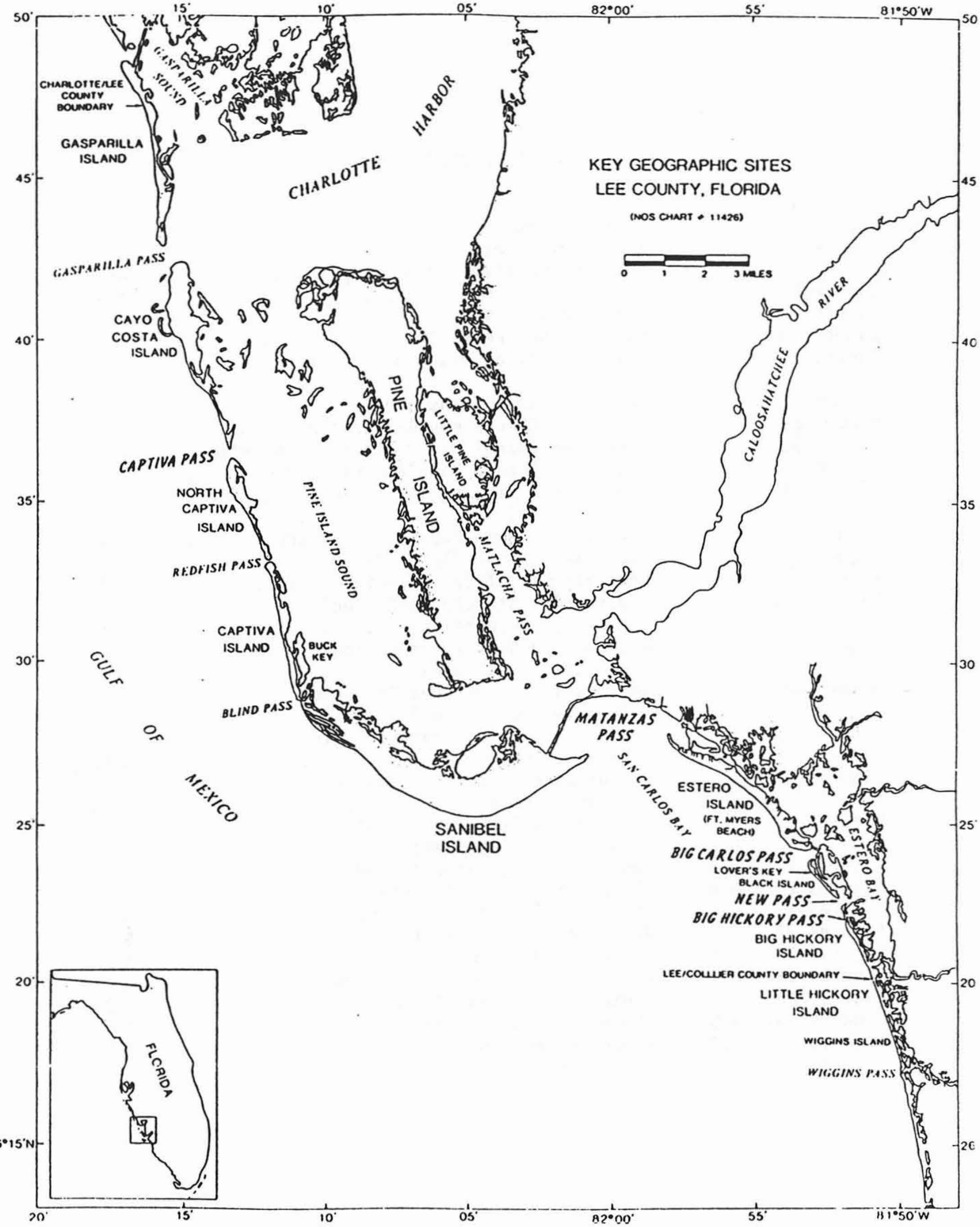


Figure 1. Location map of key geographic features in Lee County.

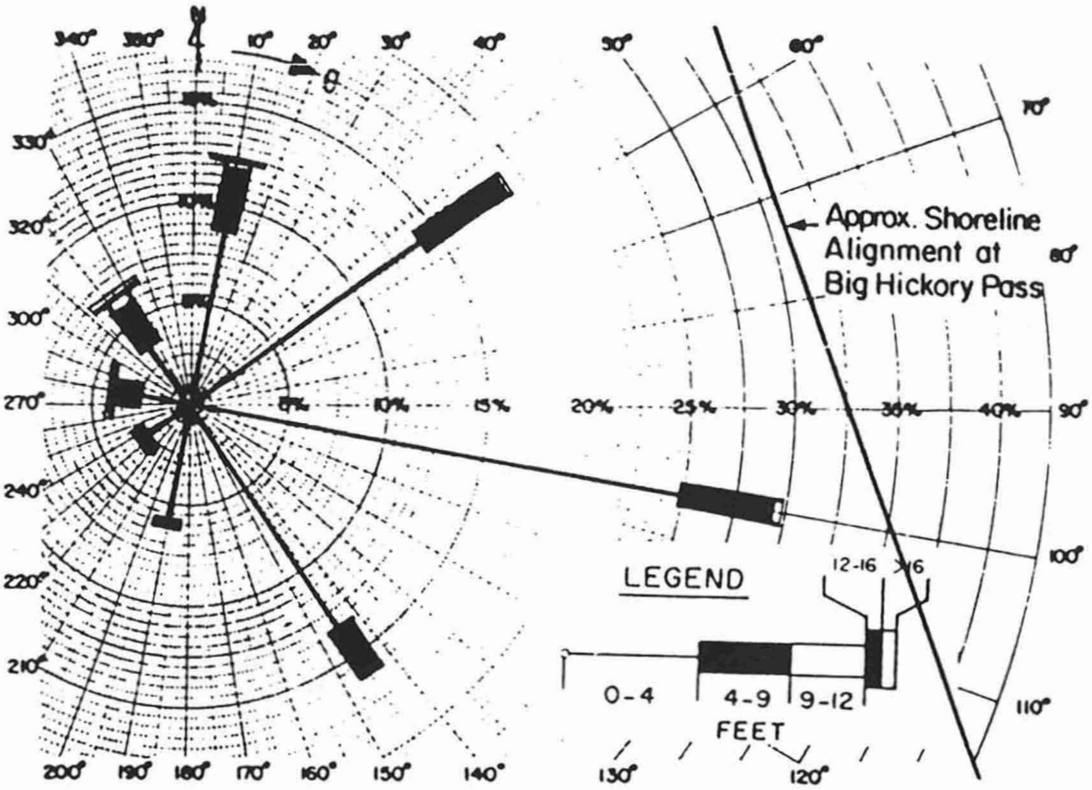


Fig. 6.5 Wave Height Rose for Offshore Wave Climate (Walton, 1973)

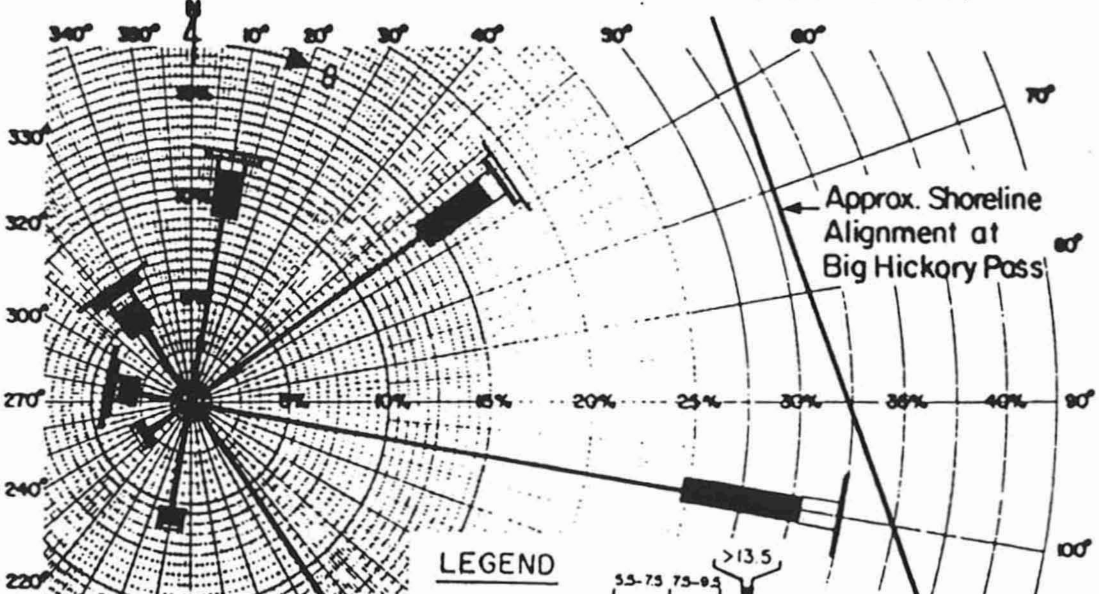


Figure 2. Wave energy diagrams for Lee County. Note that most of the onshore wave energy is from the NW (Walton, 1973).

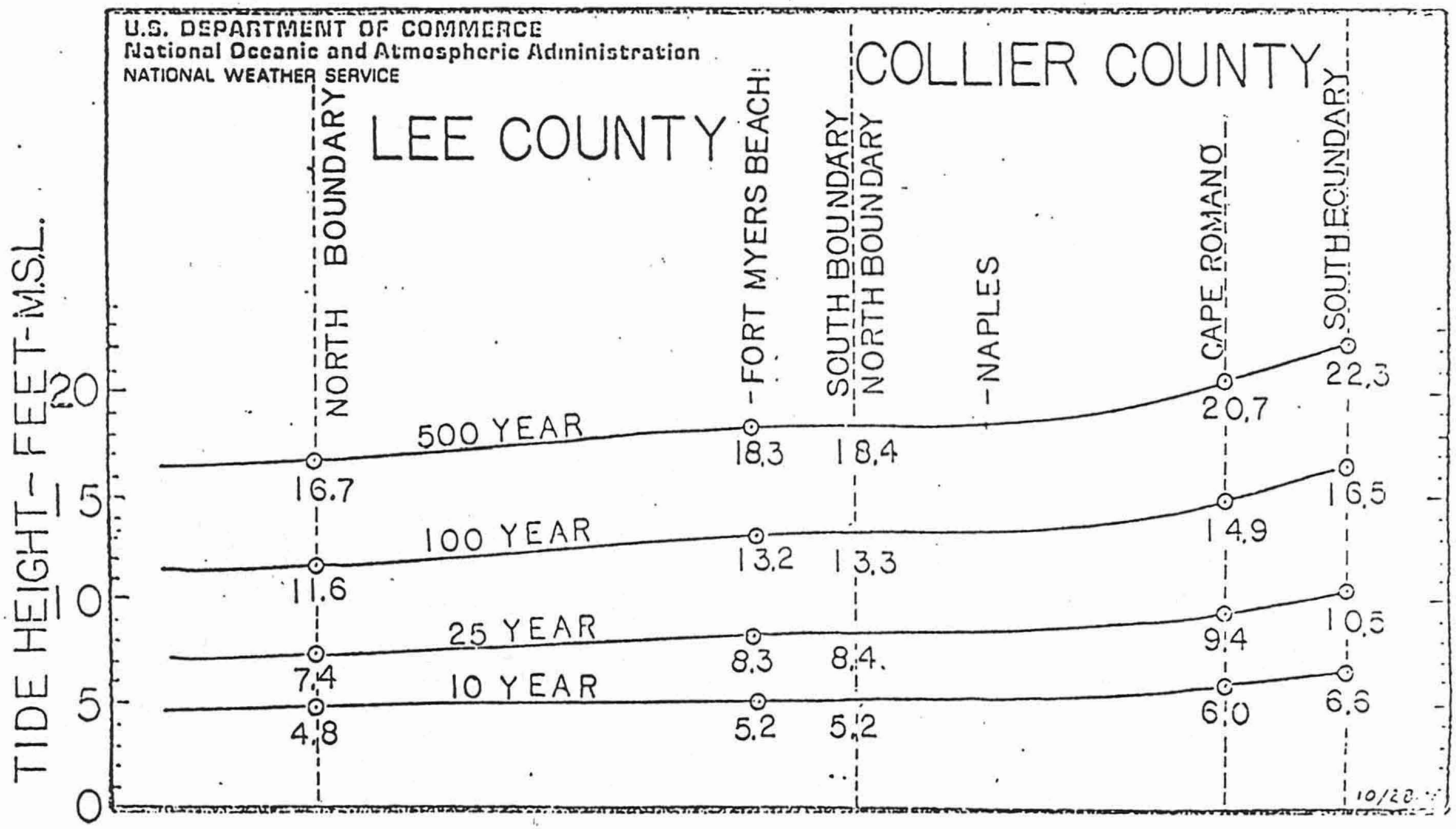


Figure 3. Storm surge elevations along Lee and Collier County.

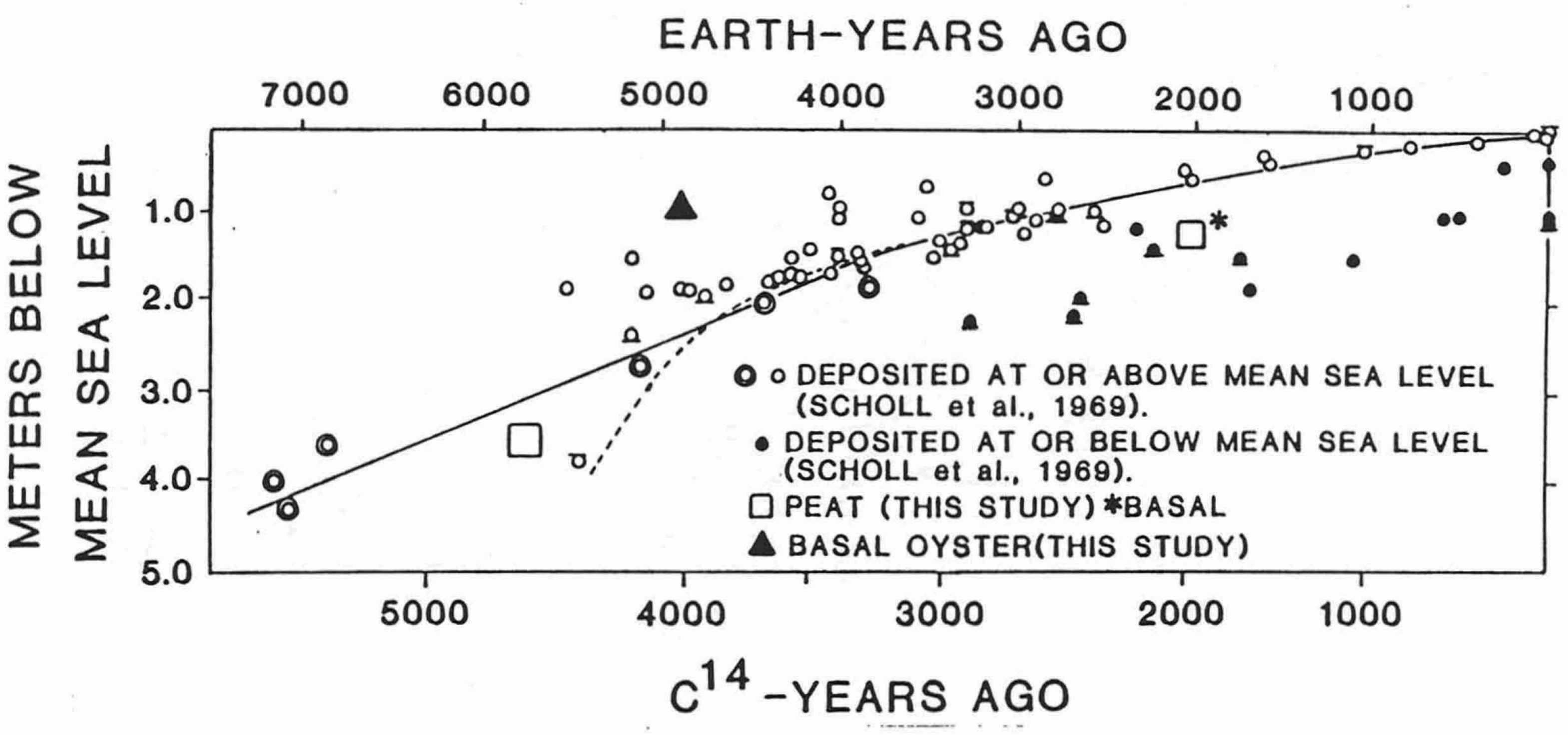


Figure 4. Sea Level curve extending back 7,000 years in time (based upon radiocarbon dating techniques; Hine and Belknap, 1986).

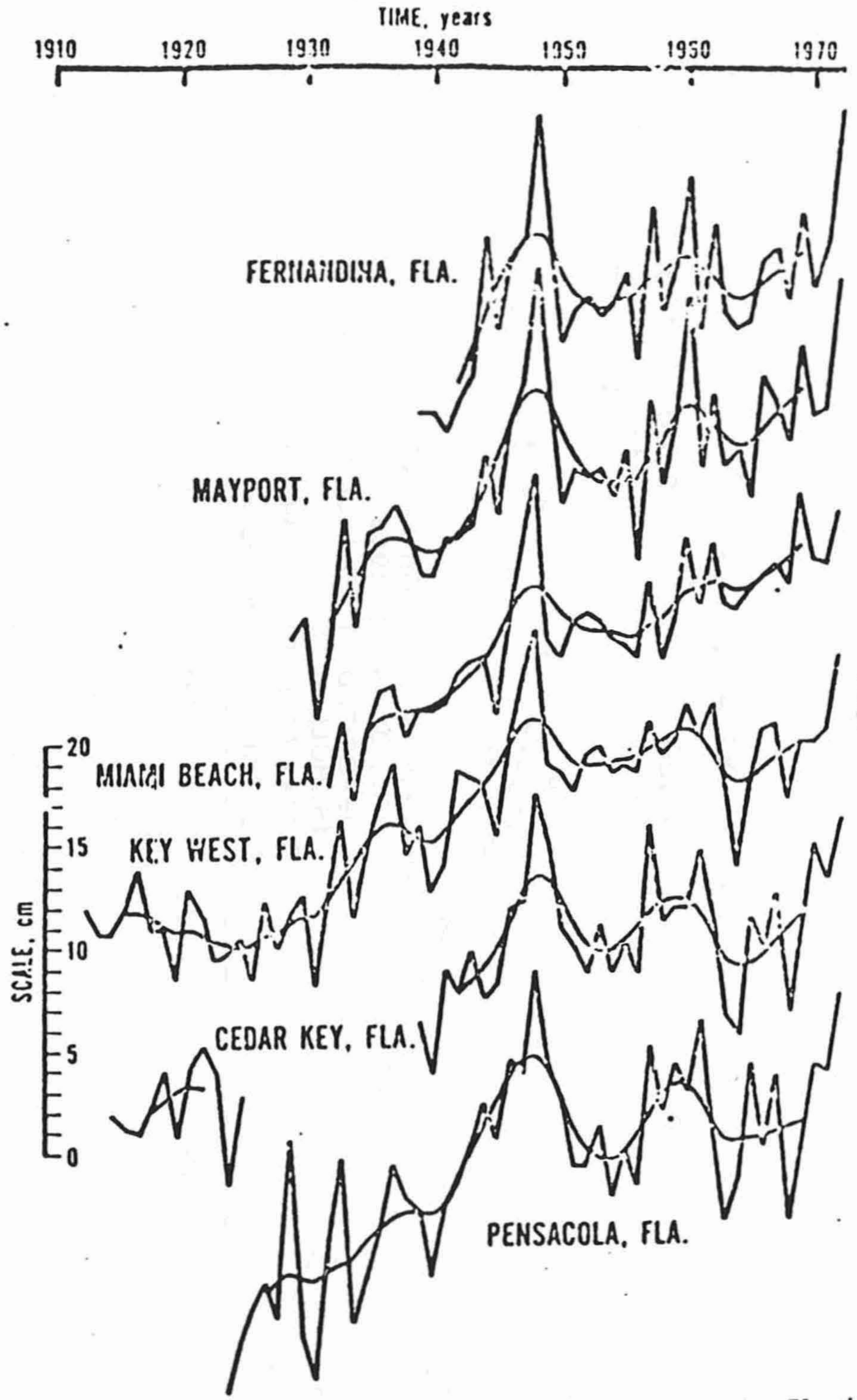


Figure 5A. Tide gauge data for various sites along the Florida coast illustrating sea-level rise over a 50 year time frame.

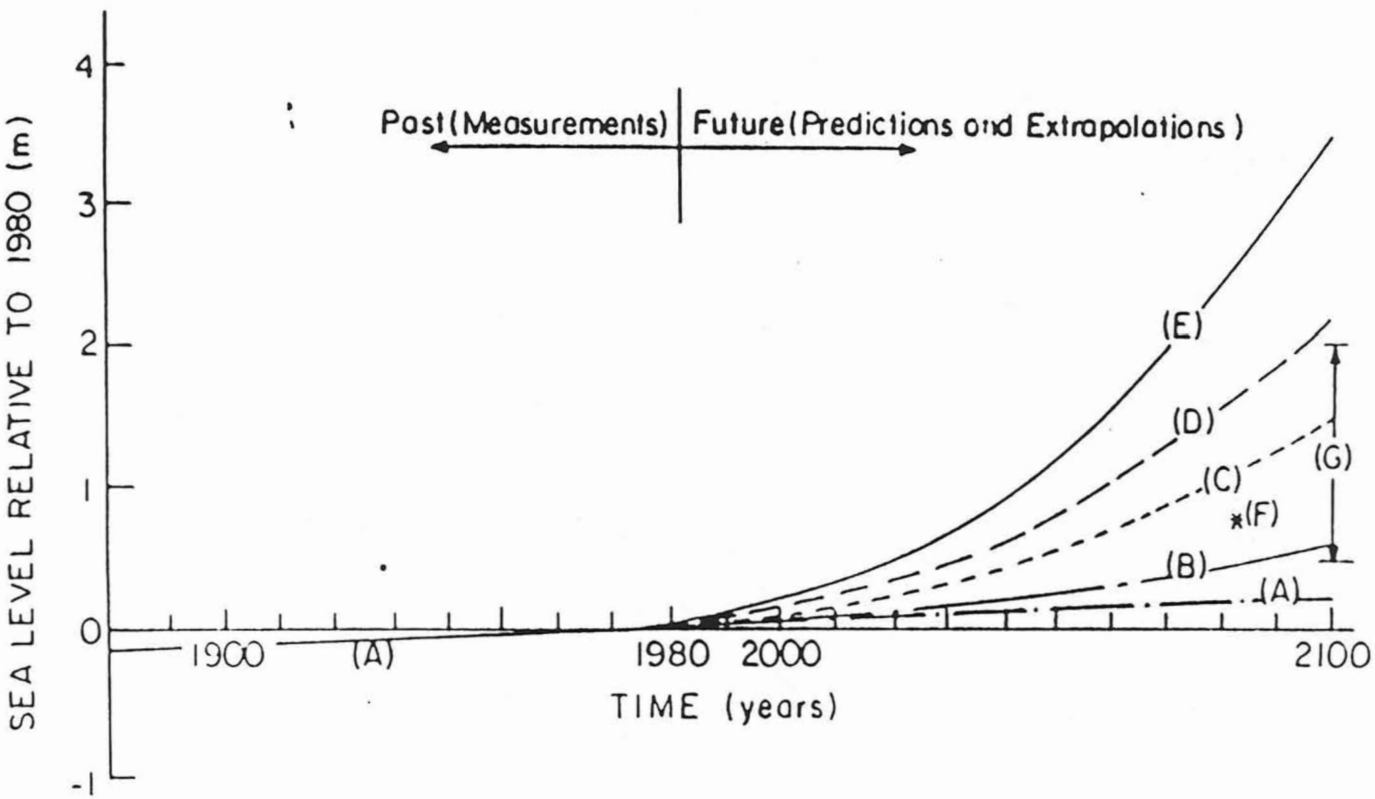


Figure 5B. Eustatic Sea Level Rise. (A) Rate Over La[illegible] century or so and Projected into Future. (B), (C), (D) AND (E): EPA 1984 Estimates for Conservative, Mid-Range Low, Mid-Range High and High, Respectively. (F) Revelle Estimate. (G) Polar Research Board Augmented with Revelle Estimate for Thermal Expansion.

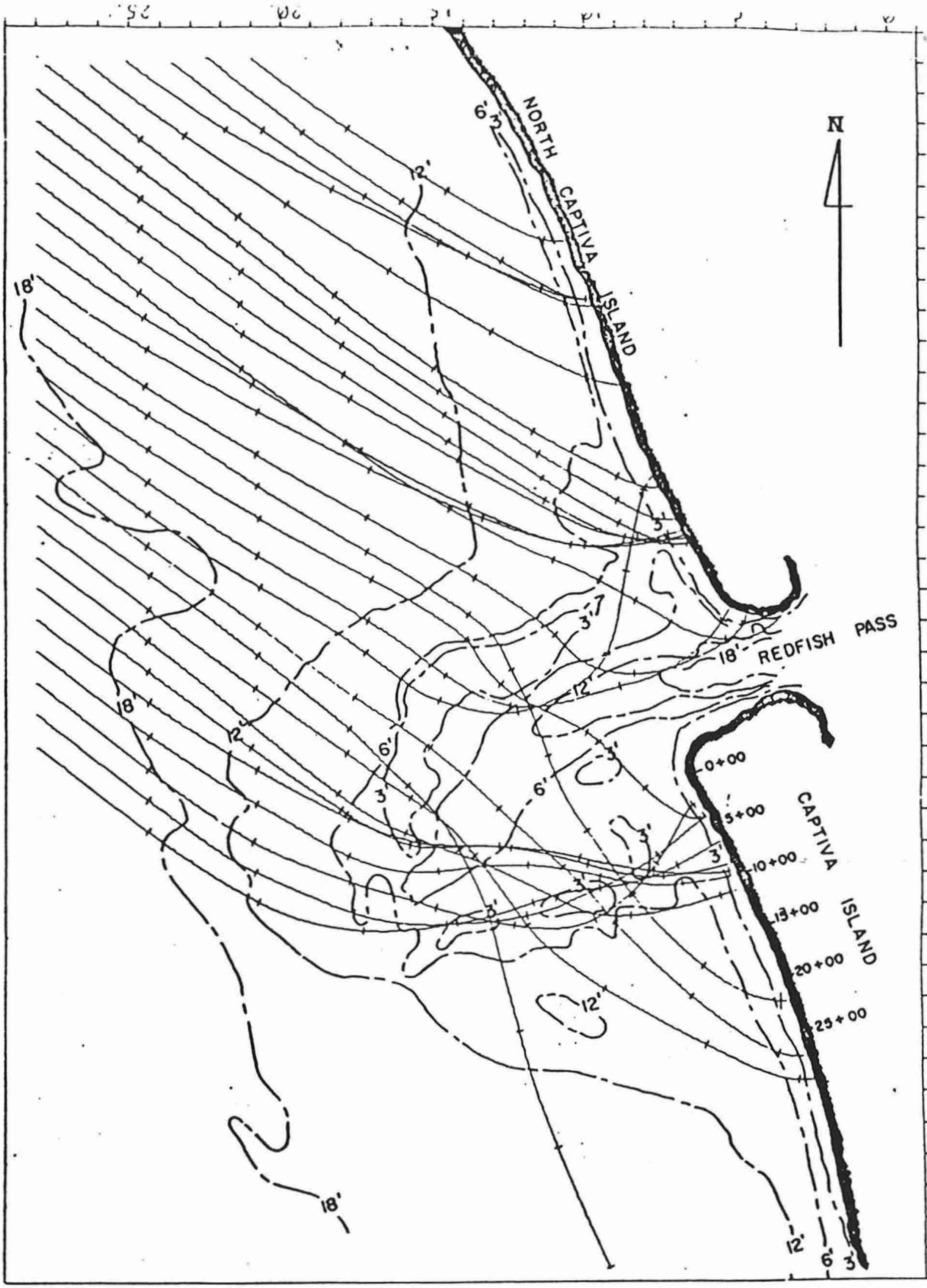


Figure 6. Wave refraction diagram illustrating the wave refracting character of the ebb-tidal delta associated with Redfish Pass.

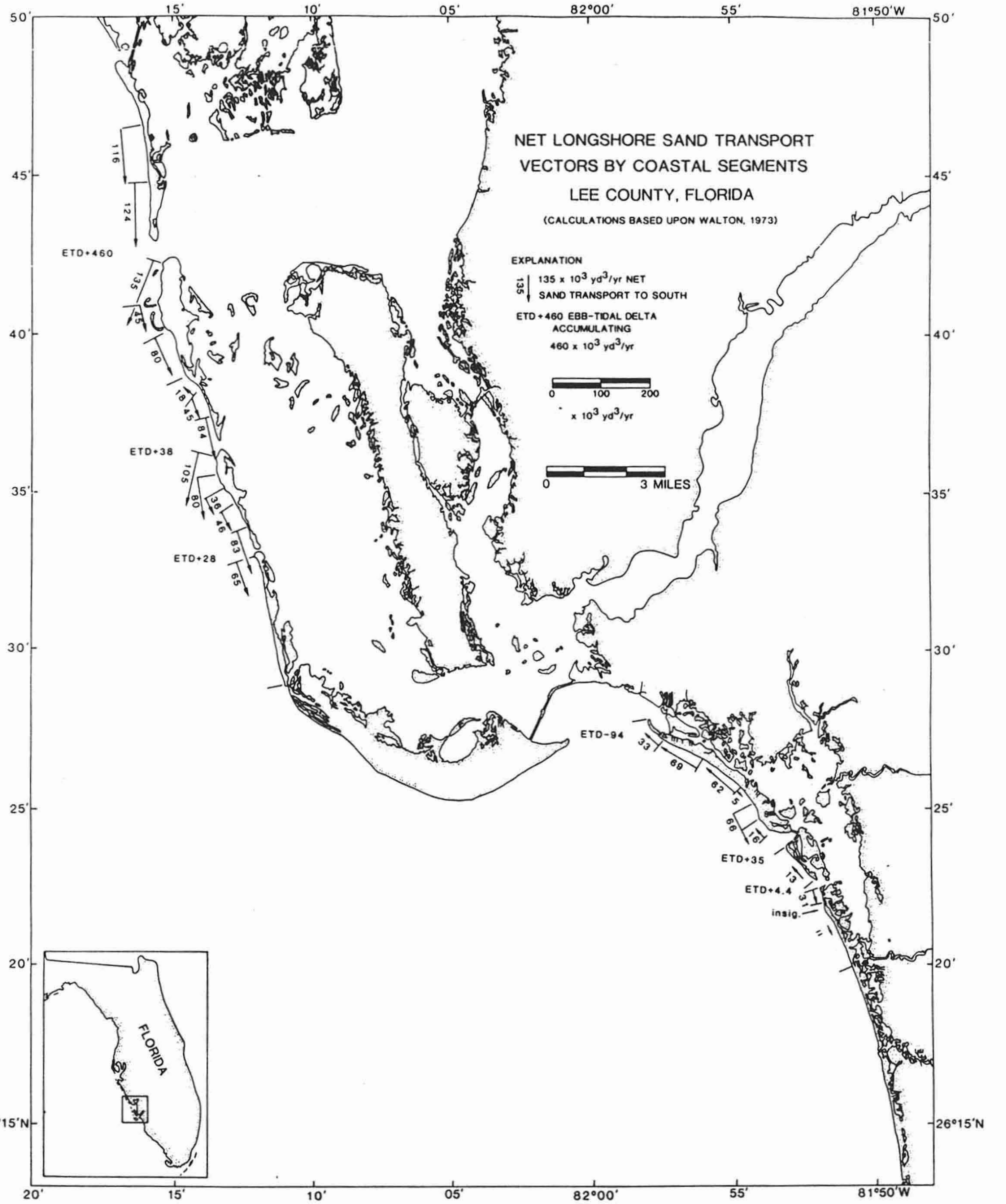


Figure 7. Net longshore sand transport vectors for various coastal sectors of Lee County (based upon Walton, 1973).

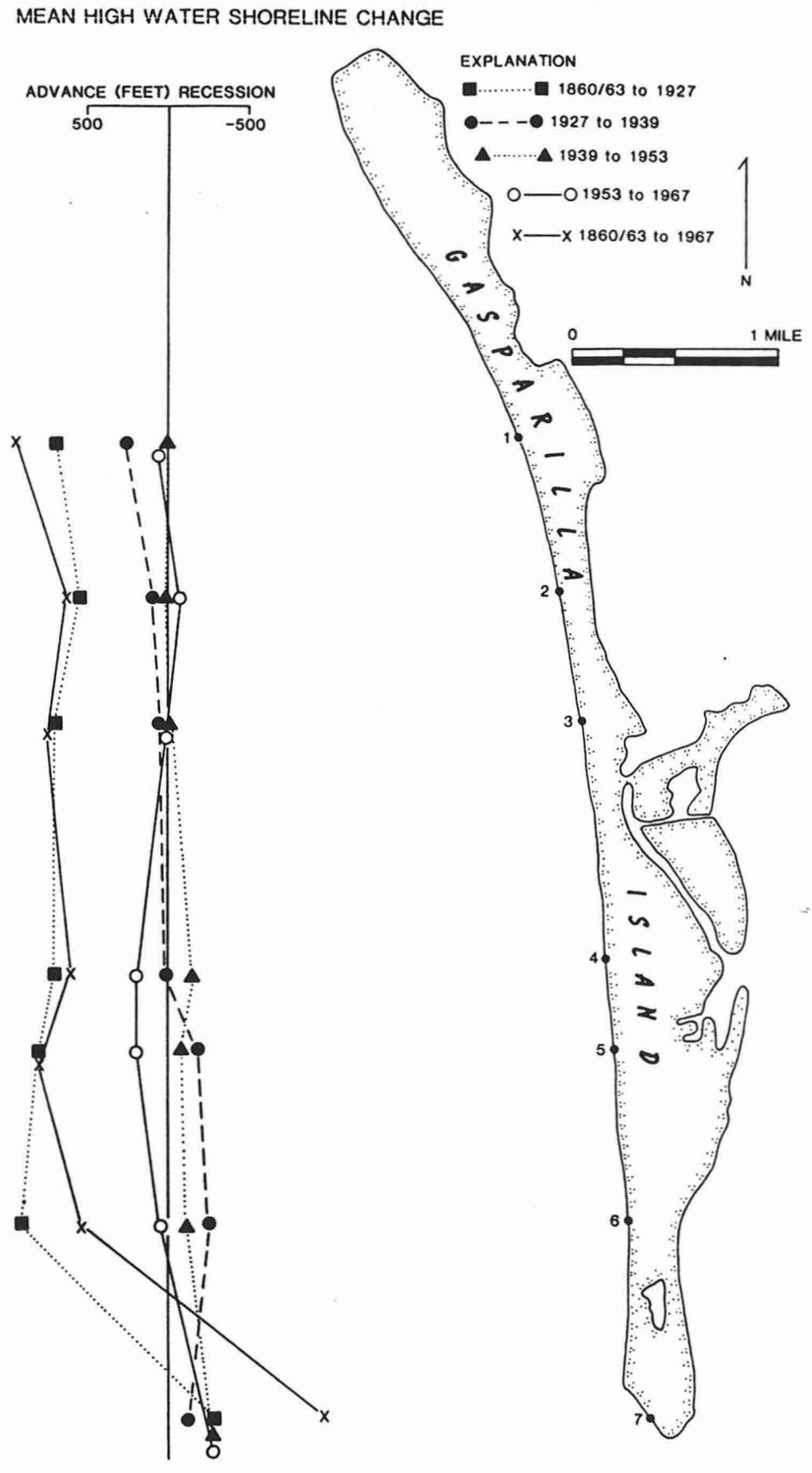


Figure 8. Shoreline change map for Gasparilla Island (Based upon data in Department of the Army, 1969).

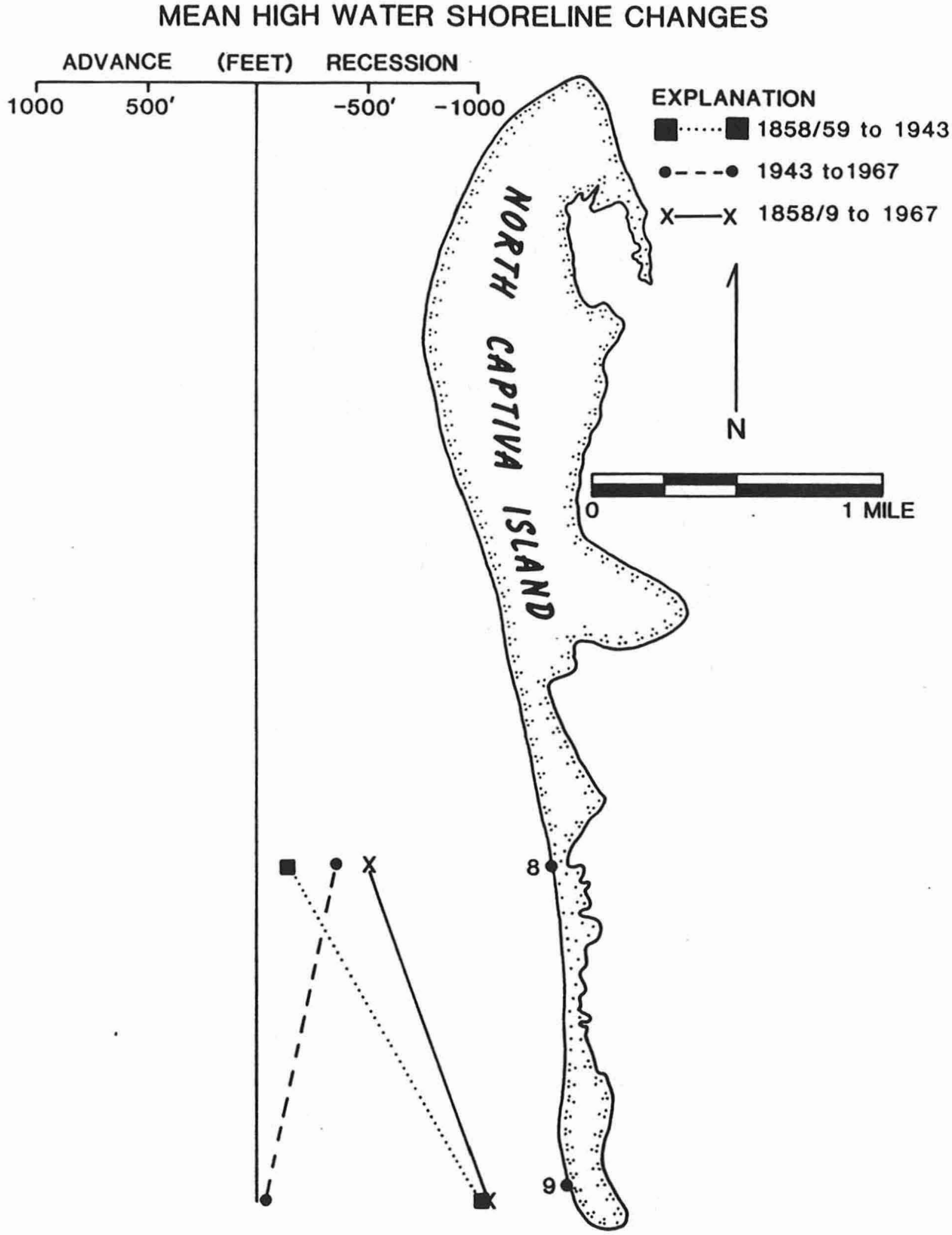


Figure 9. Shoreline change map for southern North Captiva Island (same data base as Figure 8).

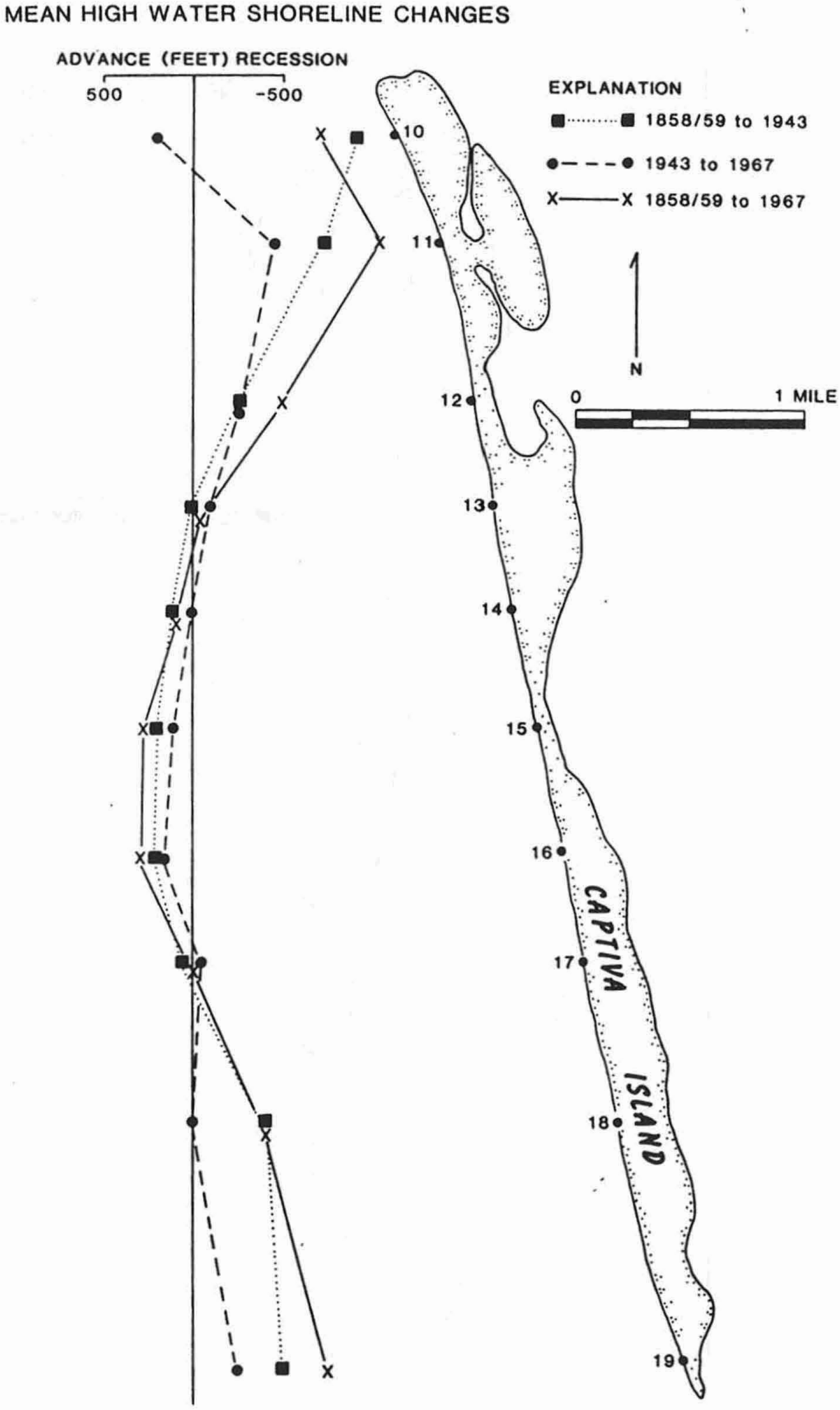


Figure 10. Shoreline change map for Captiva Island (same data base as Figure 8).

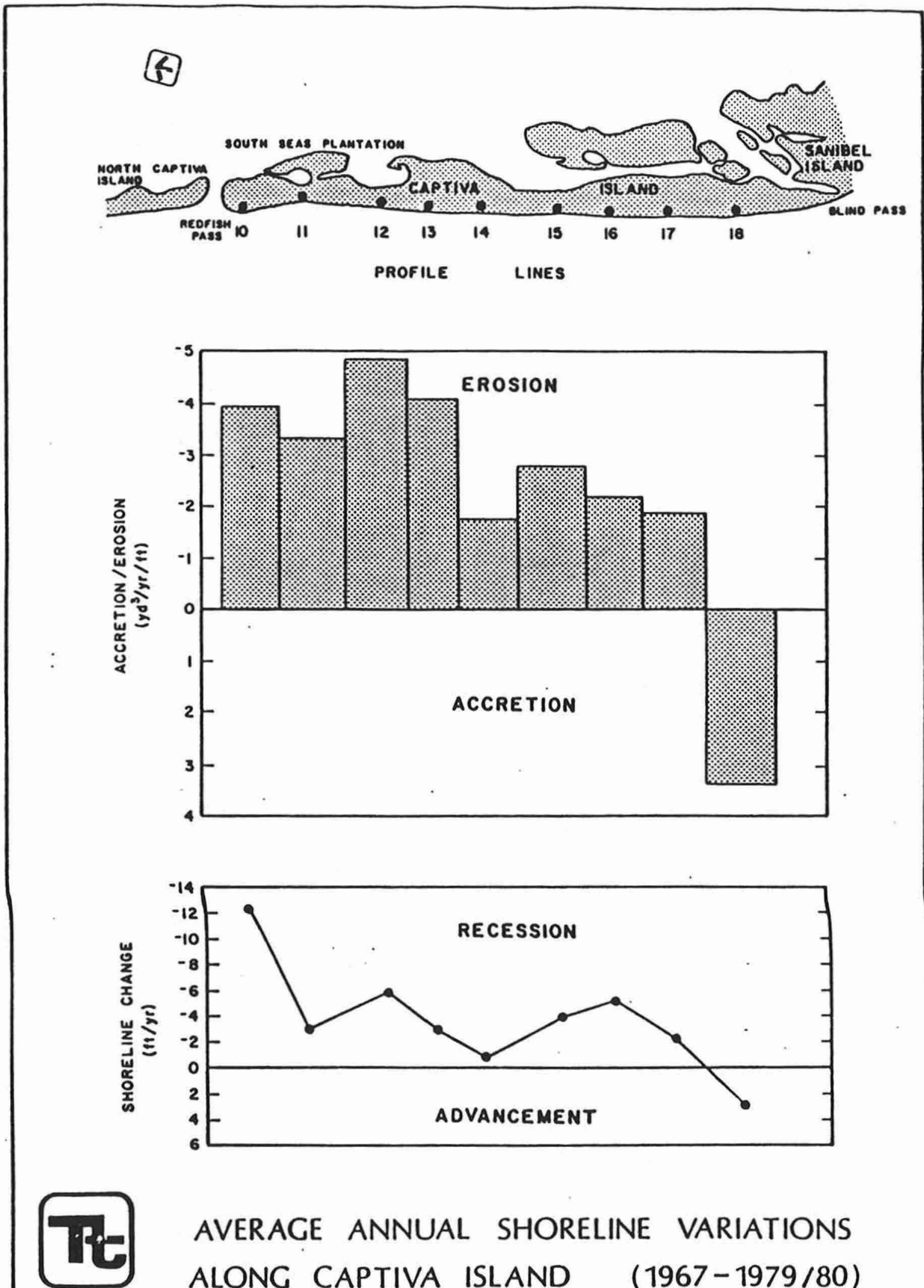


Figure 11. Shoreline change map for Captiva Island based upon more recent data than Figure 10 (Tetra Tech, 1985).

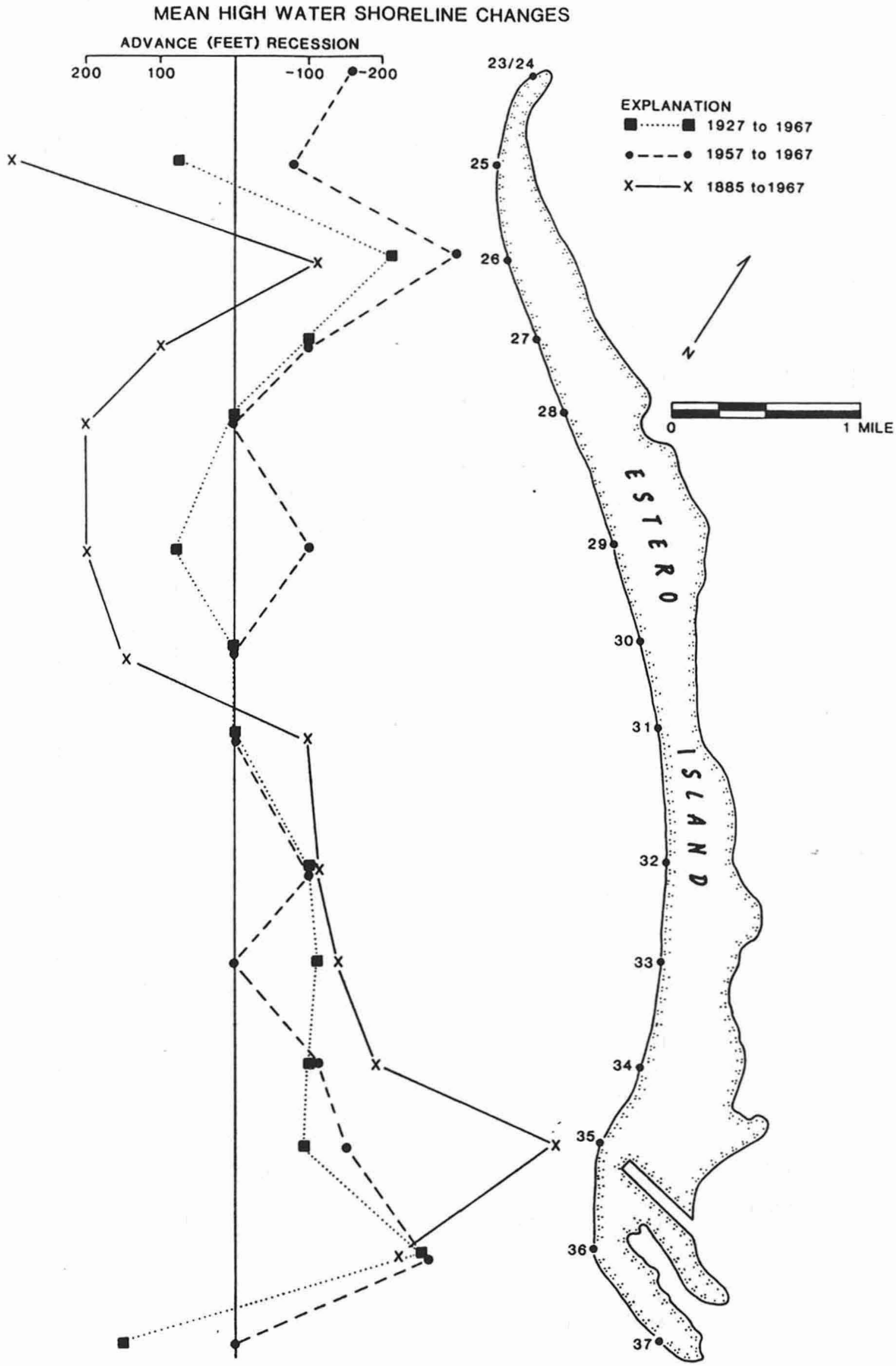


Figure 12. Shoreline change map for Estero Island (same data base as Figure 8).

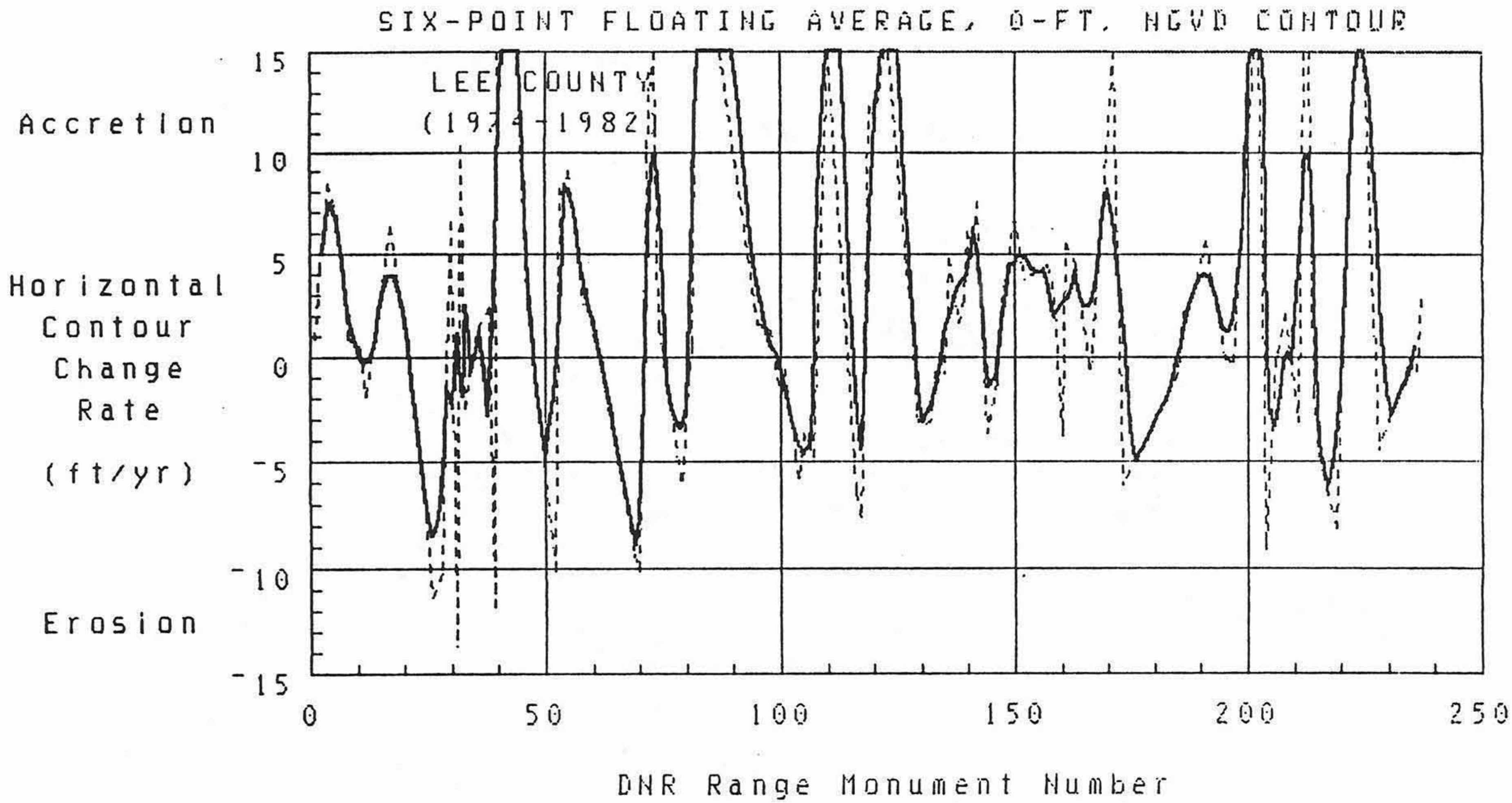


Figure 13. Lateral shoreline movement trend (0' contour) from 1974-1982 based upon beach profile data collected by Florida Division of Beaches and Shores (courtesy of Jim Balsille).

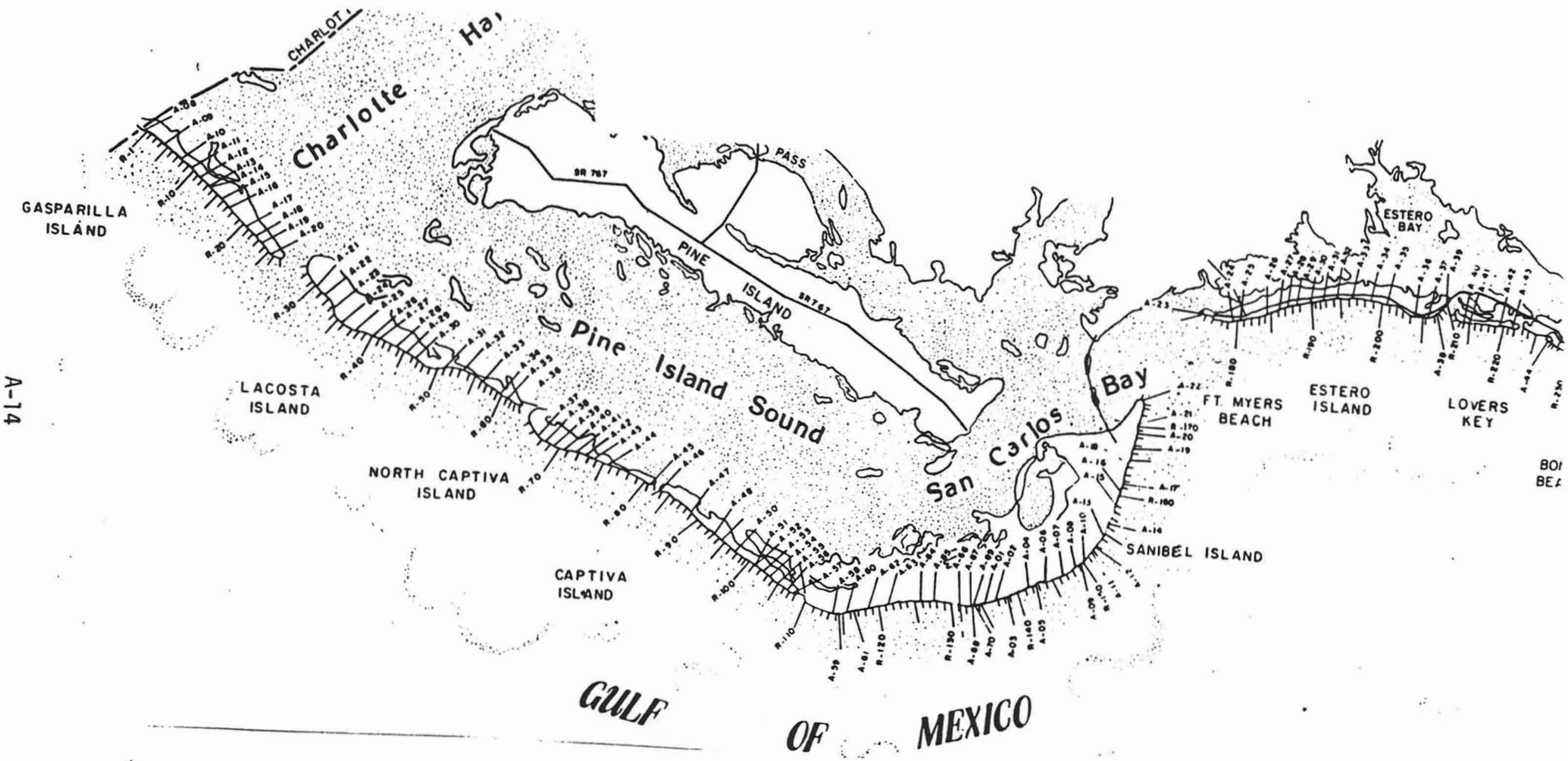


Figure 14. Location of Division of Beaches and Shores beach Profile sites for data shown in Figure 13.

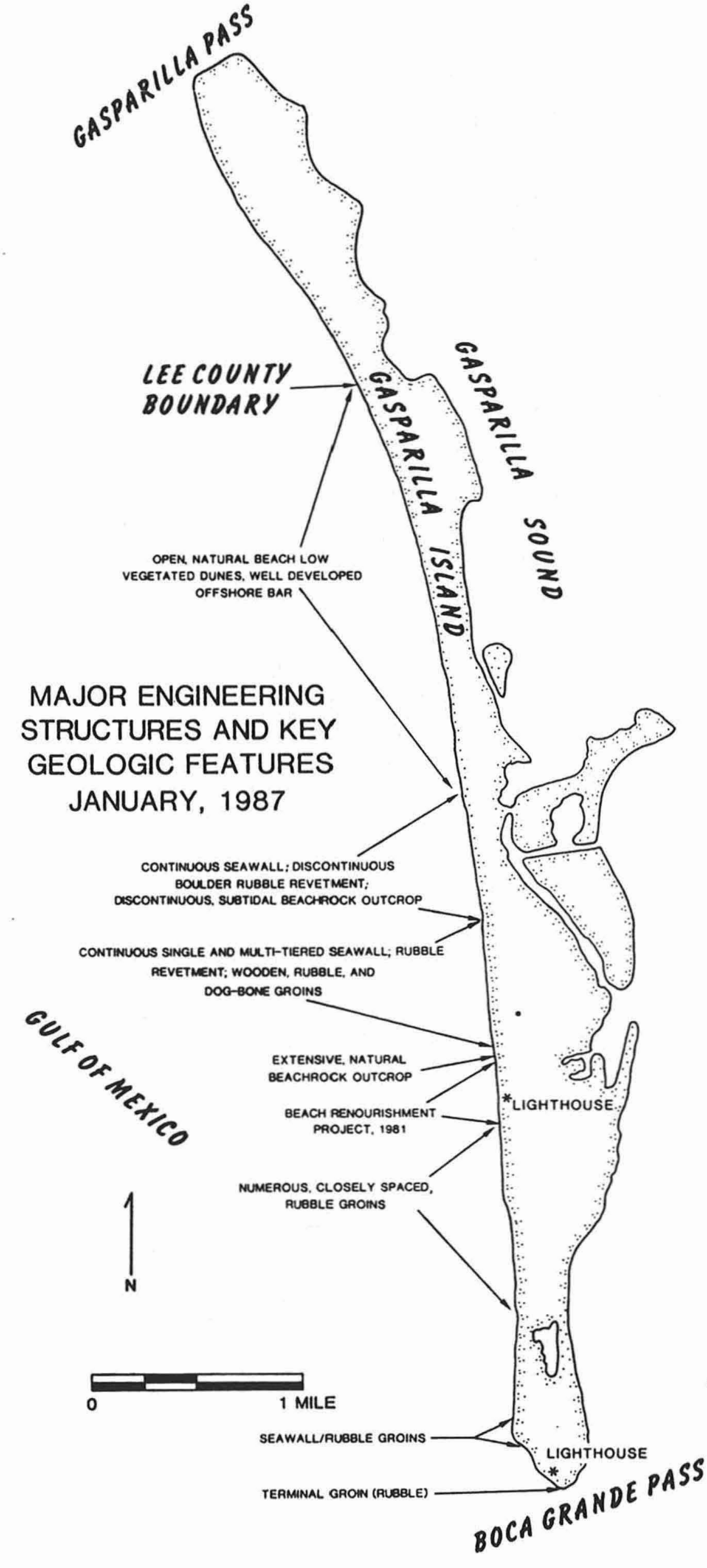


Figure 15. Map of engineering structures and key geologic features of Gasparilla Island (January, 1987).

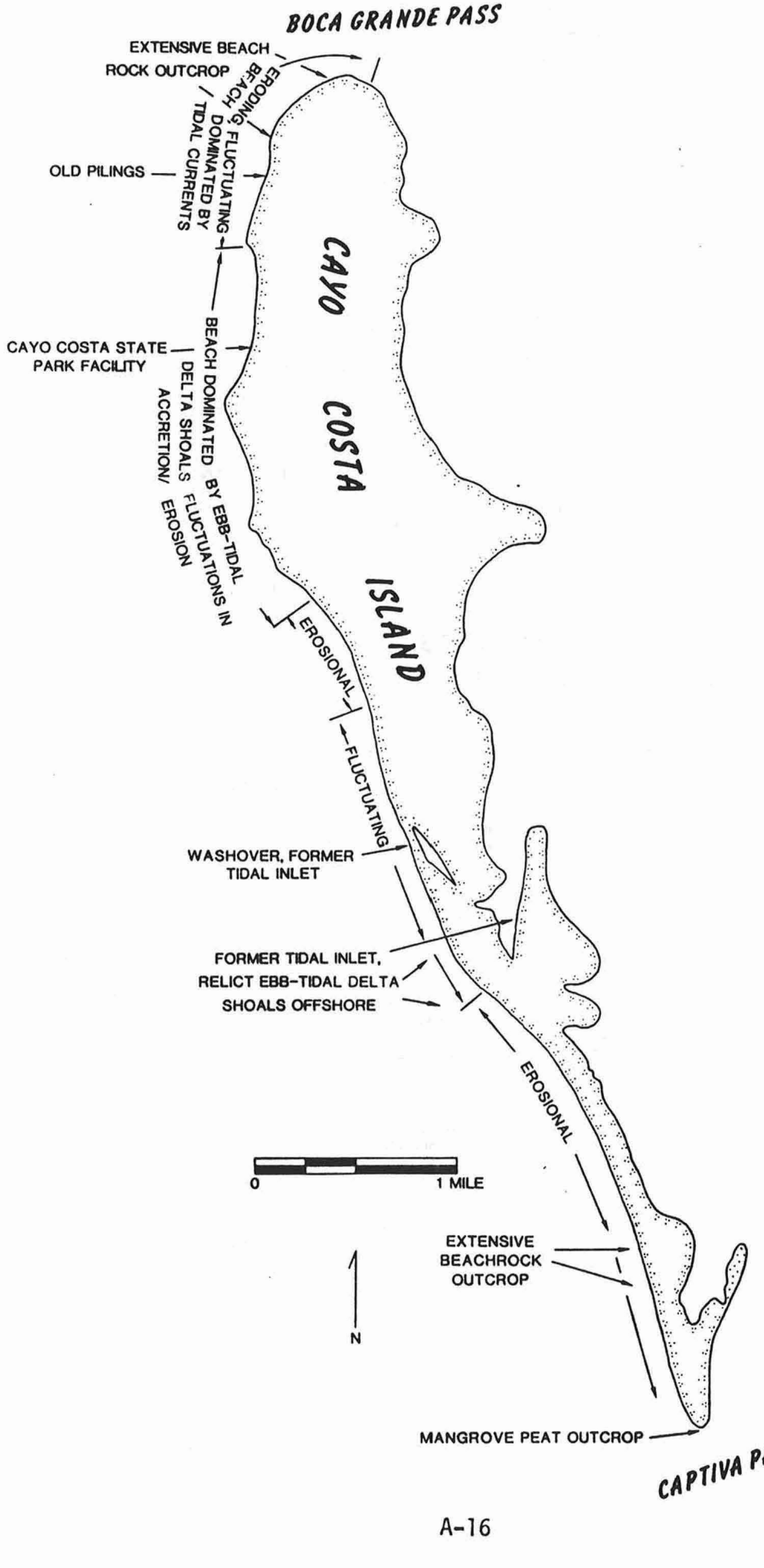


Figure 16. Map of engineering structures and key geologic features of Cayo Costa Island (December, 1986).

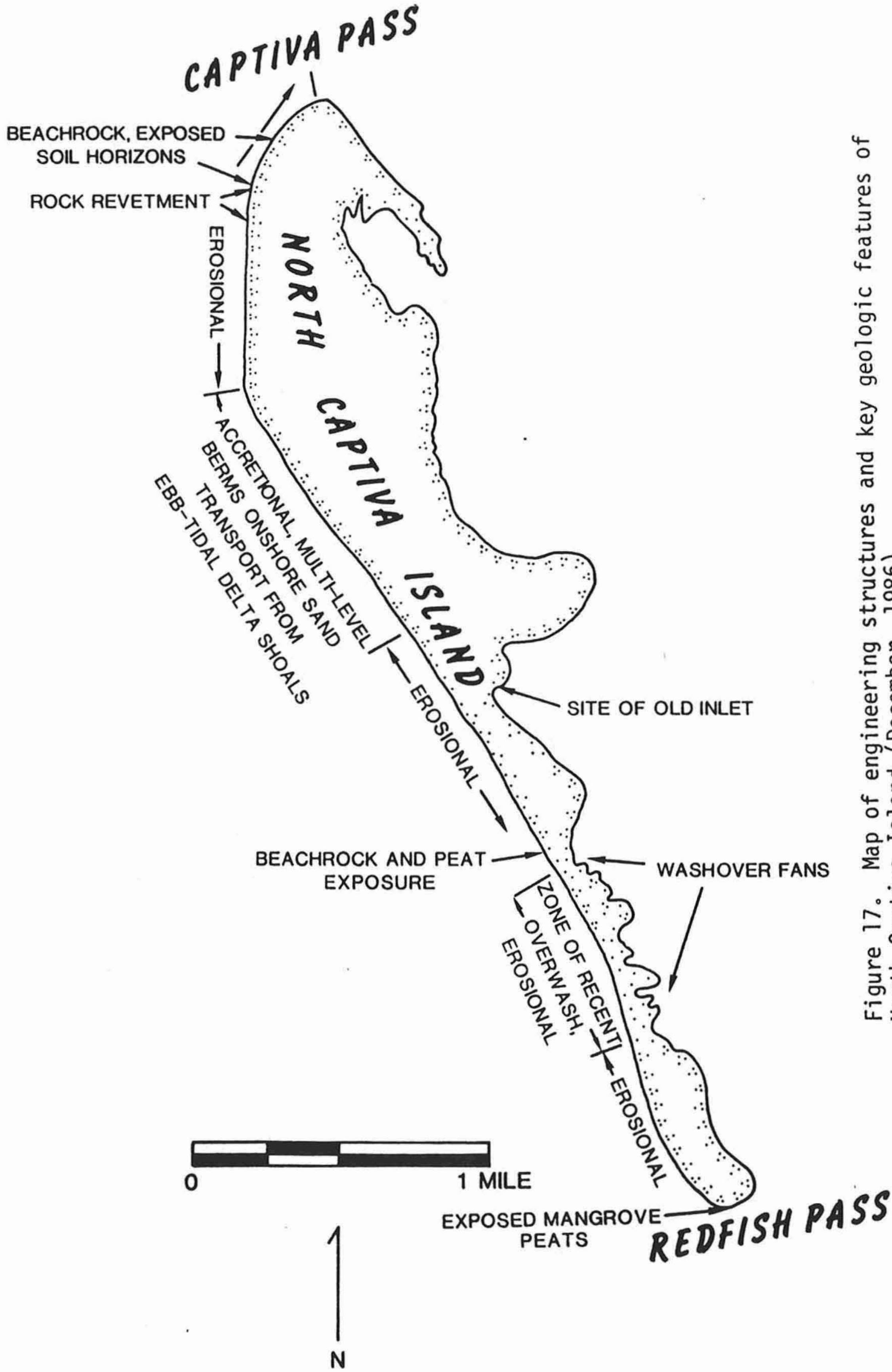


Figure 17. Map of engineering structures and key geologic features of North Captiva Island (December, 1986).

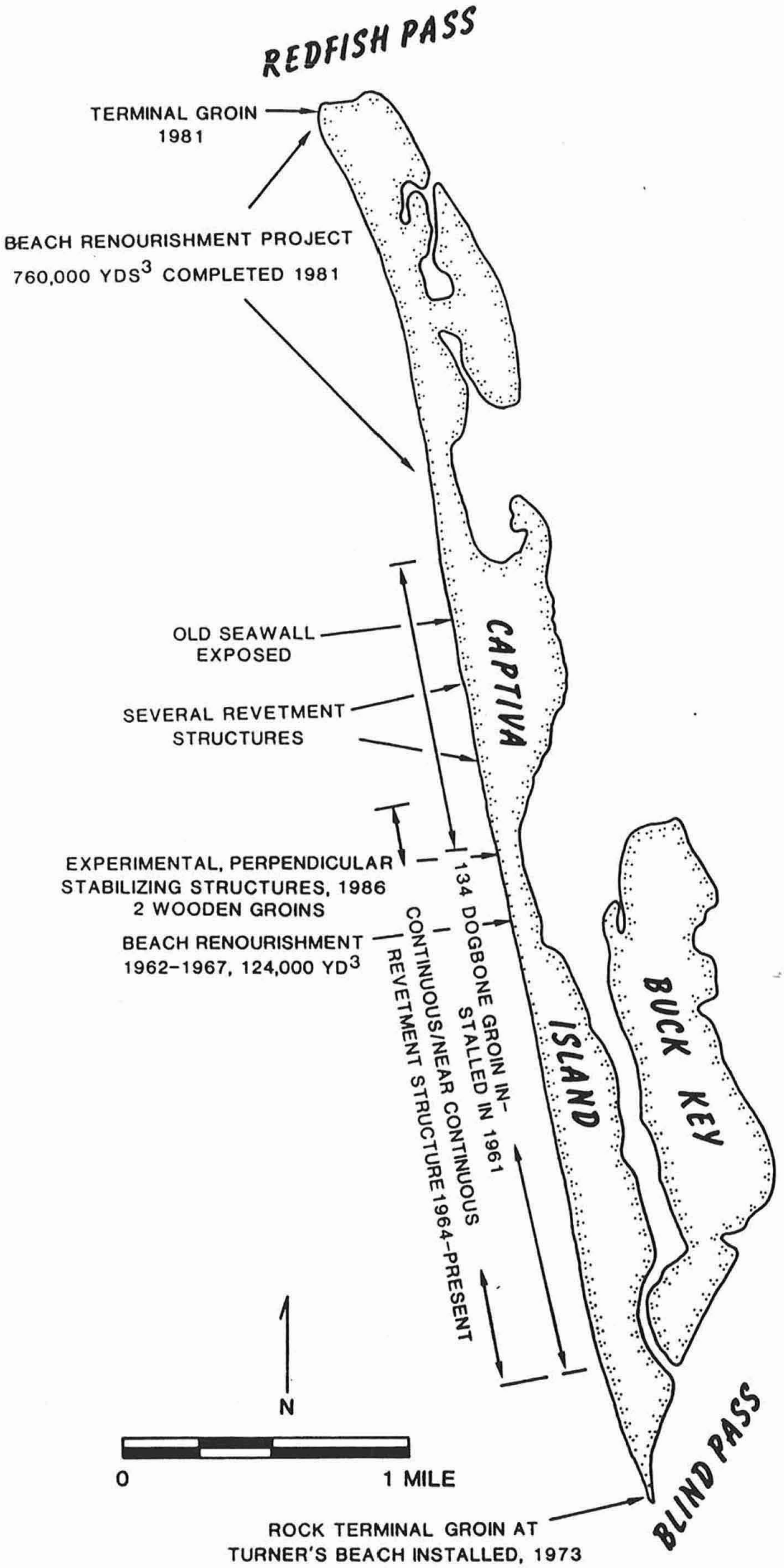


Figure 18. Map of engineering structures and key geologic features of Captiva Island (January, 1987).

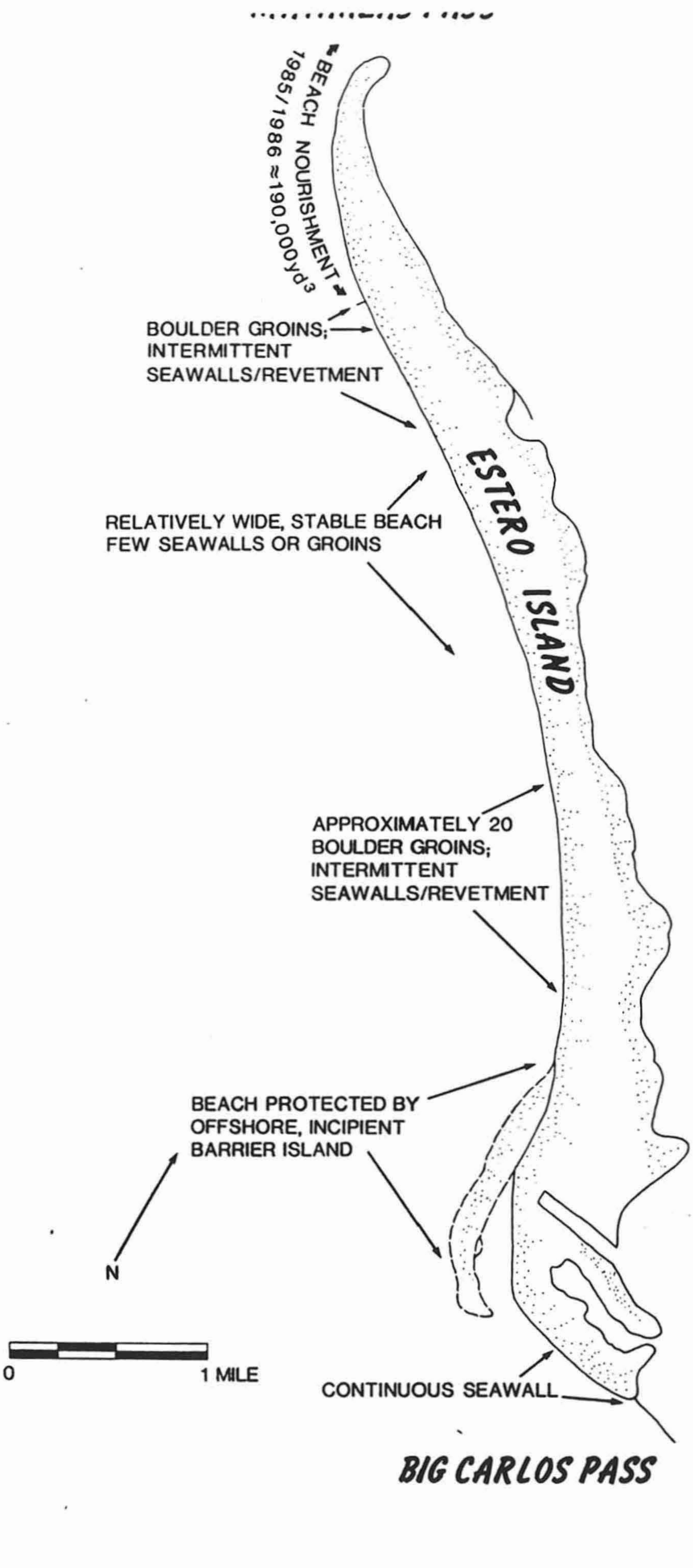


Figure 19. Map of engineering structures and key geologic features of Estero Island.

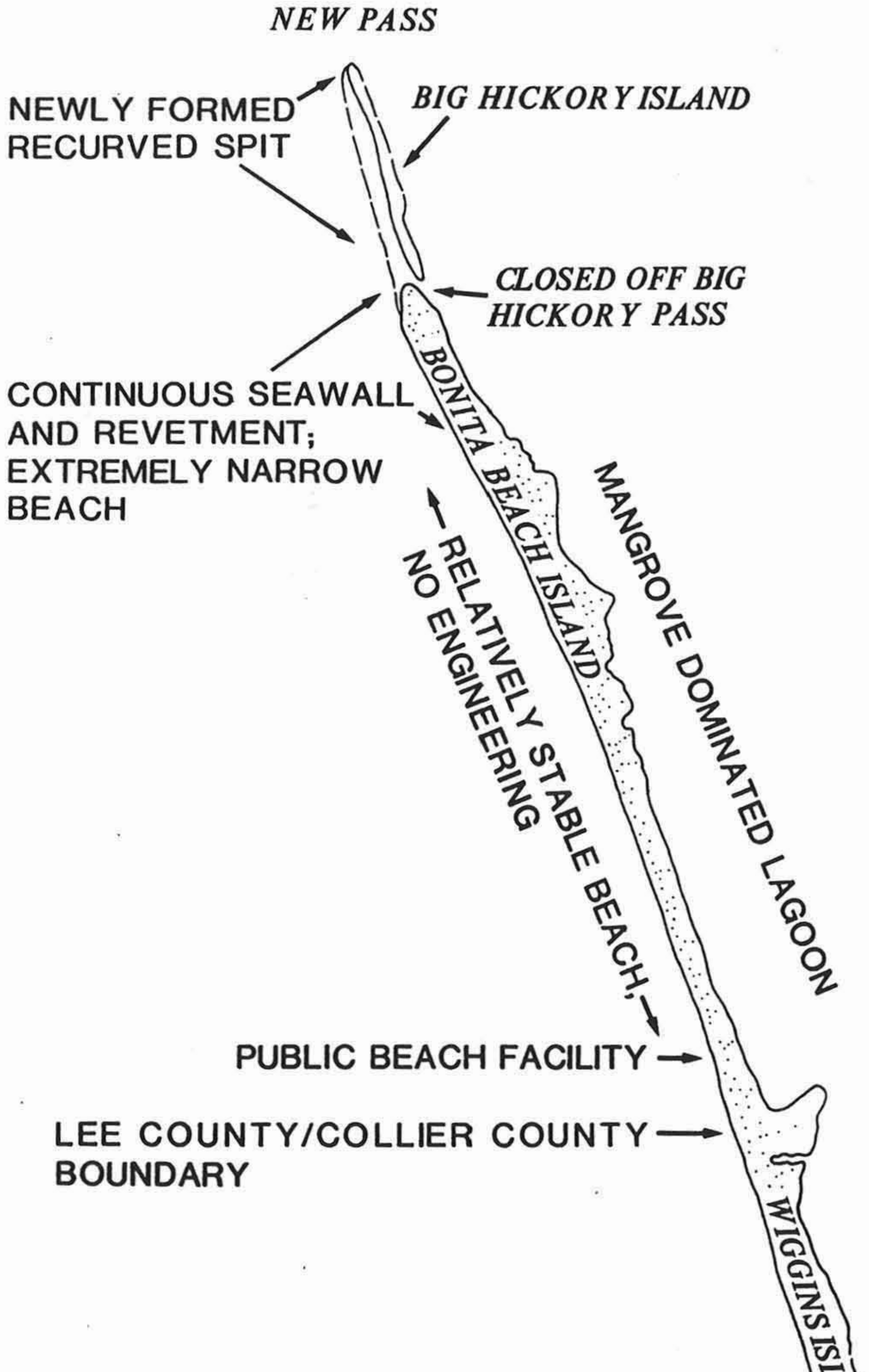


Figure 20. Map of engineering structures and key geologic features of Bonita Beach Island.

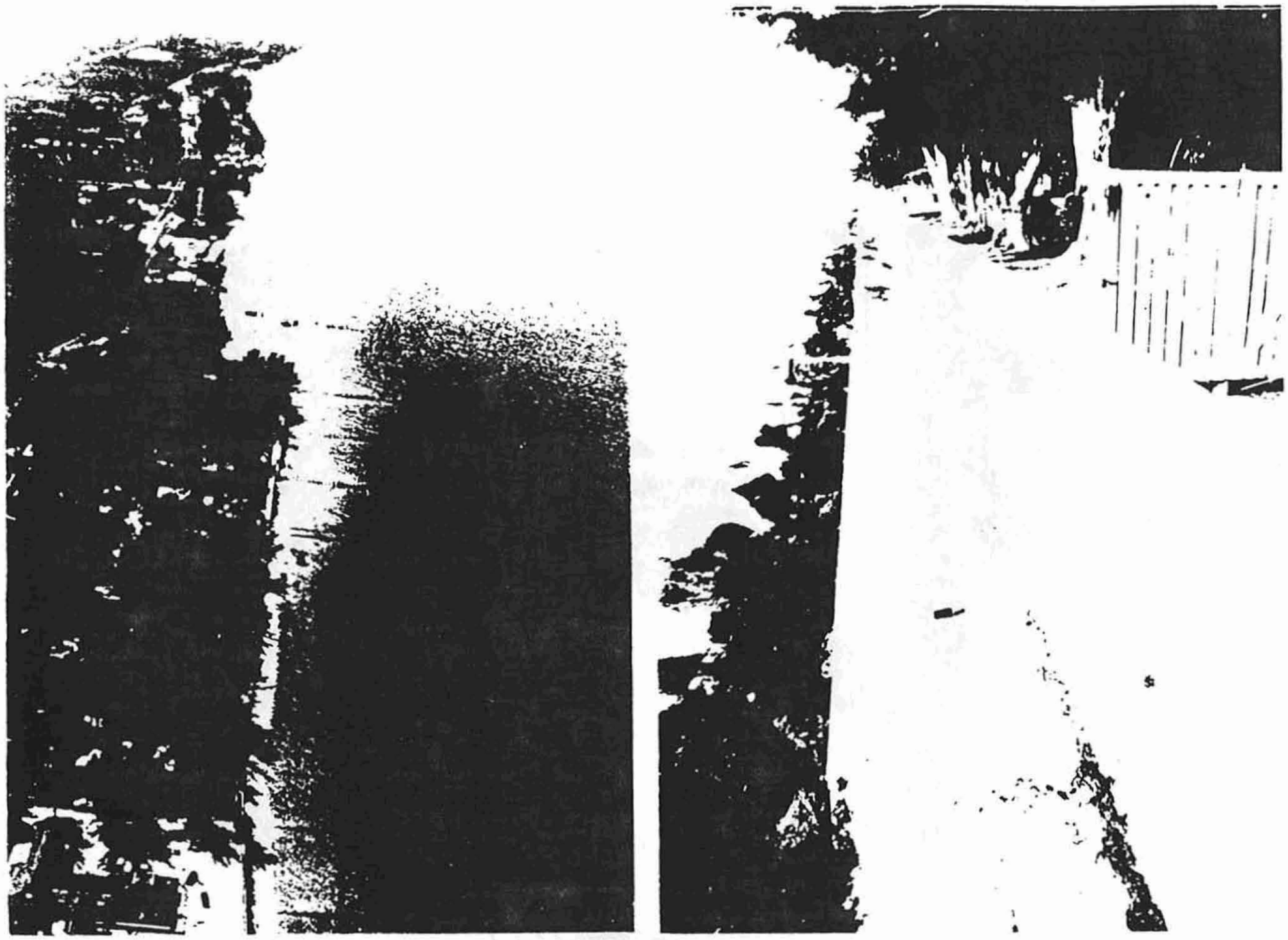


Figure 21A. Aerial photo of southern Gasparilla Island looking south illustrating erosional nature of island. Figs. 21B,C. Continuous seawalls with no beach along central portions of Gasparilla.

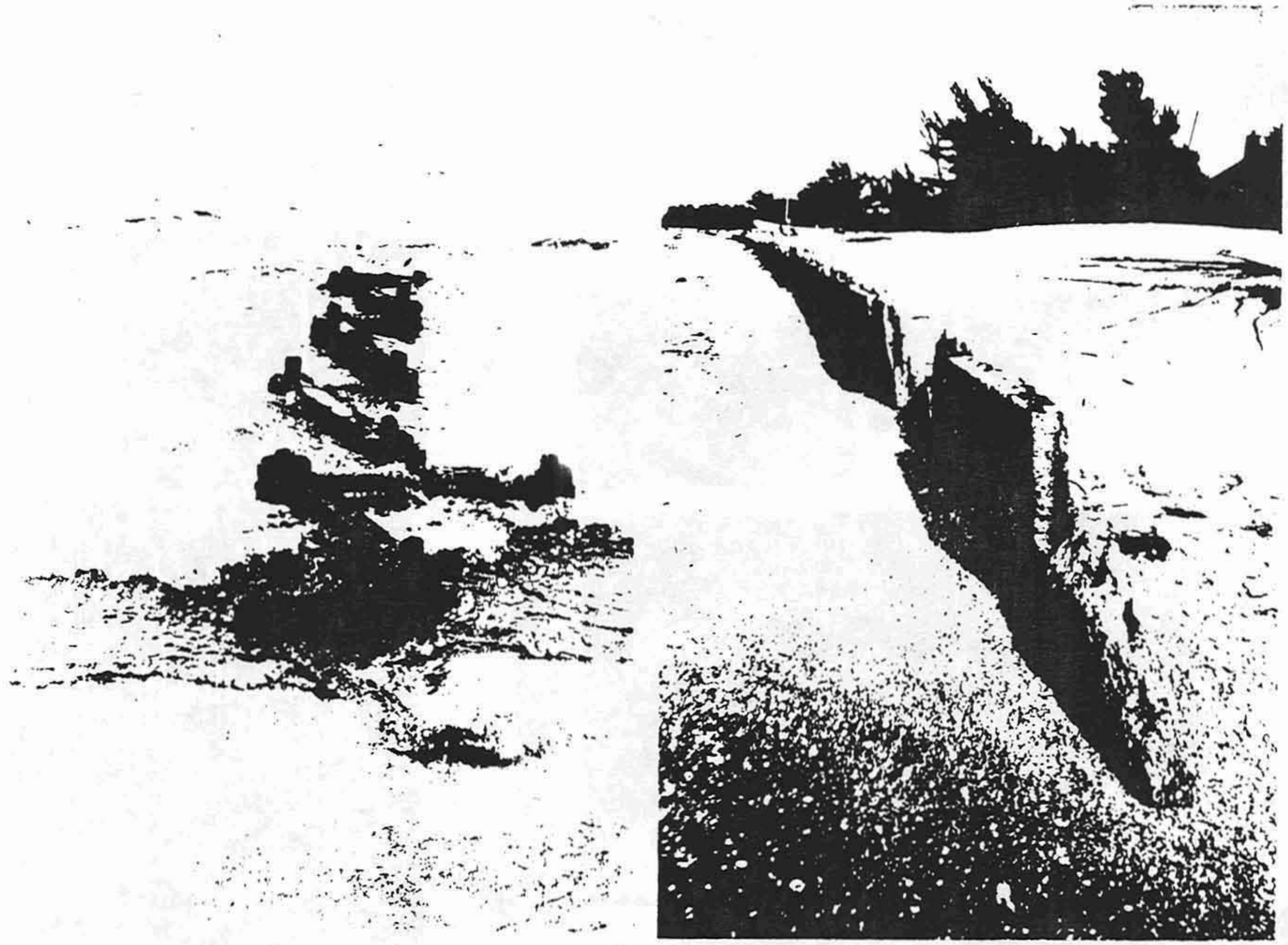


Figure 22A. Dogbone groin on Gasparilla. Fig. 22B. Failed seawall along southern Gasparilla.

Figure 22C. Unmaintained boulder groin along southern Gasparilla. Fig. 22D. Unmaintained wooded groin along central Gasparilla.

Figure 23A. Trees undermined by erosion along north end of Cayo Costa Island. Fig. 23B. Newly forming sand dune along central portion of Cayo Costa.

Figure 24A. Boulder revetment (rip rap) along northern North Captiva Island attempting to stem erosion. Fig. 24B. Homemade coastal engineering along northern North Captiva.

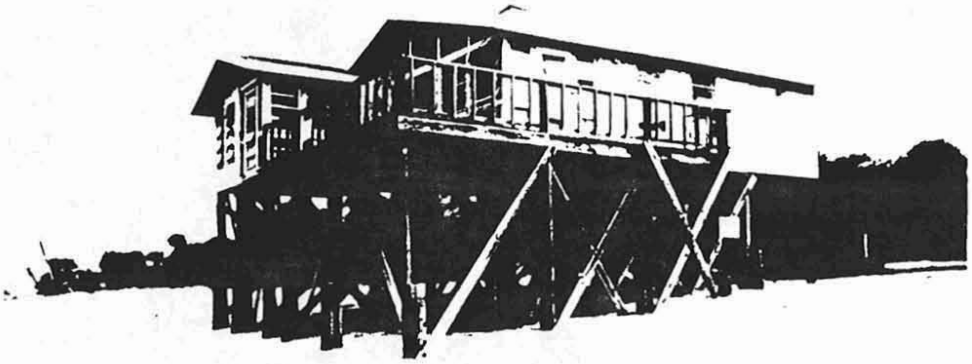


Figure 24C. Abandoned cottage for sale undermined by erosion on beachface of North Captive. Fig. 24D. Overwash fan along south-central North Captiva.

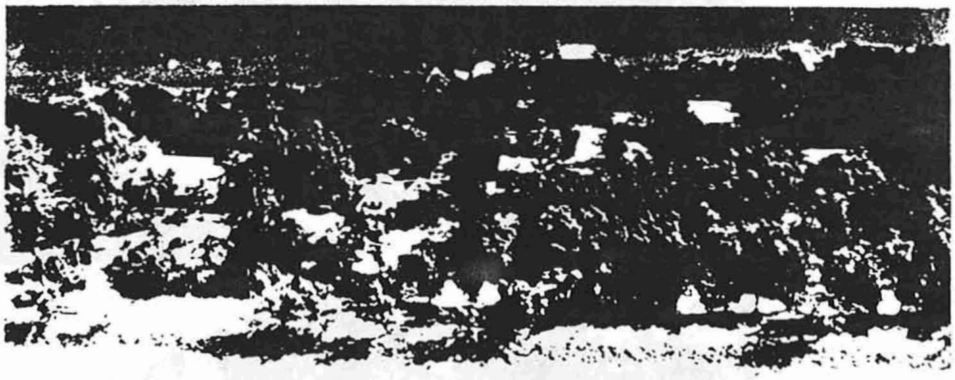


Figure 25. North-central Captiva Island showing past engineering structures. There is little to no beach along this area. Note continuous revetment protecting coastal highway. Also note old groin field that is no longer trapping sand.

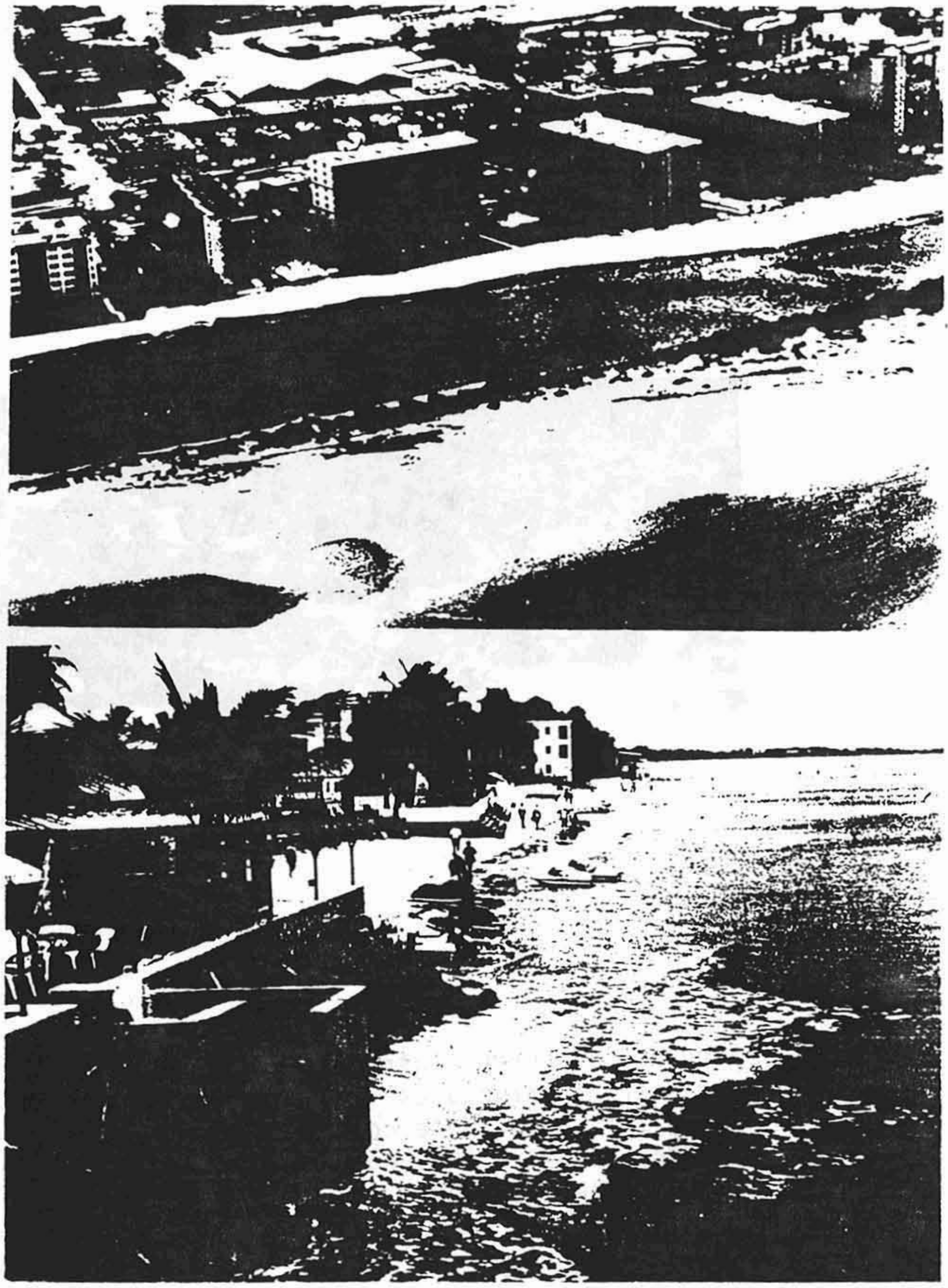
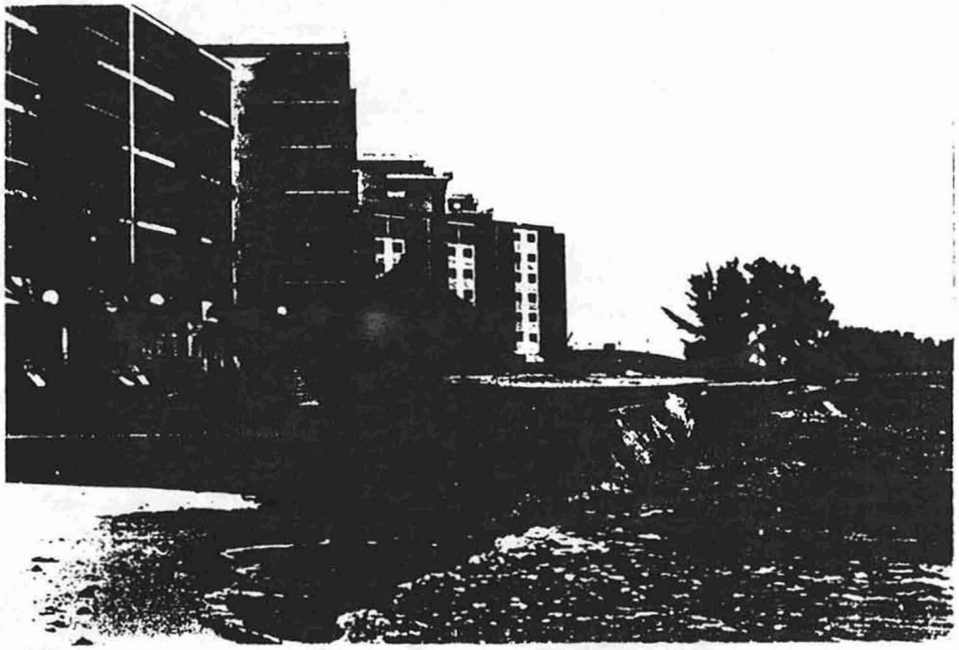


Figure 26A. Incipient barrier-island system located just offshore of southern Estero Island. Fig. 26B. Variety of coastal engineering structures near fishing pier on Estero. Note narrow character of beach.



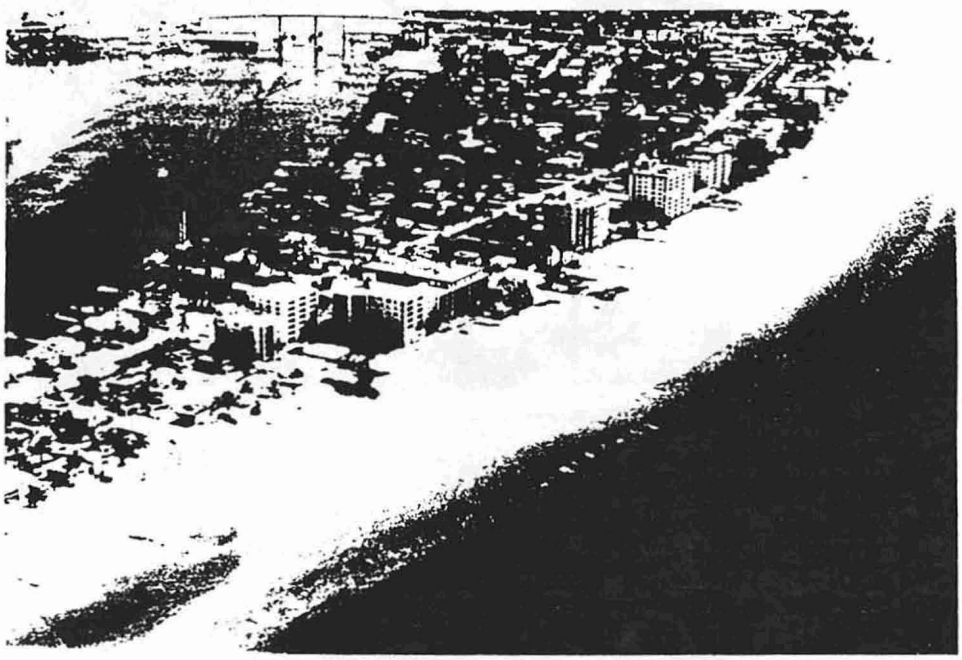


Figure 26C. New development along extreme south end of Estero Island. No beach exists where seawalls have been constructed. Fig. 26D. Partially renourished beach along NW end of Estero.

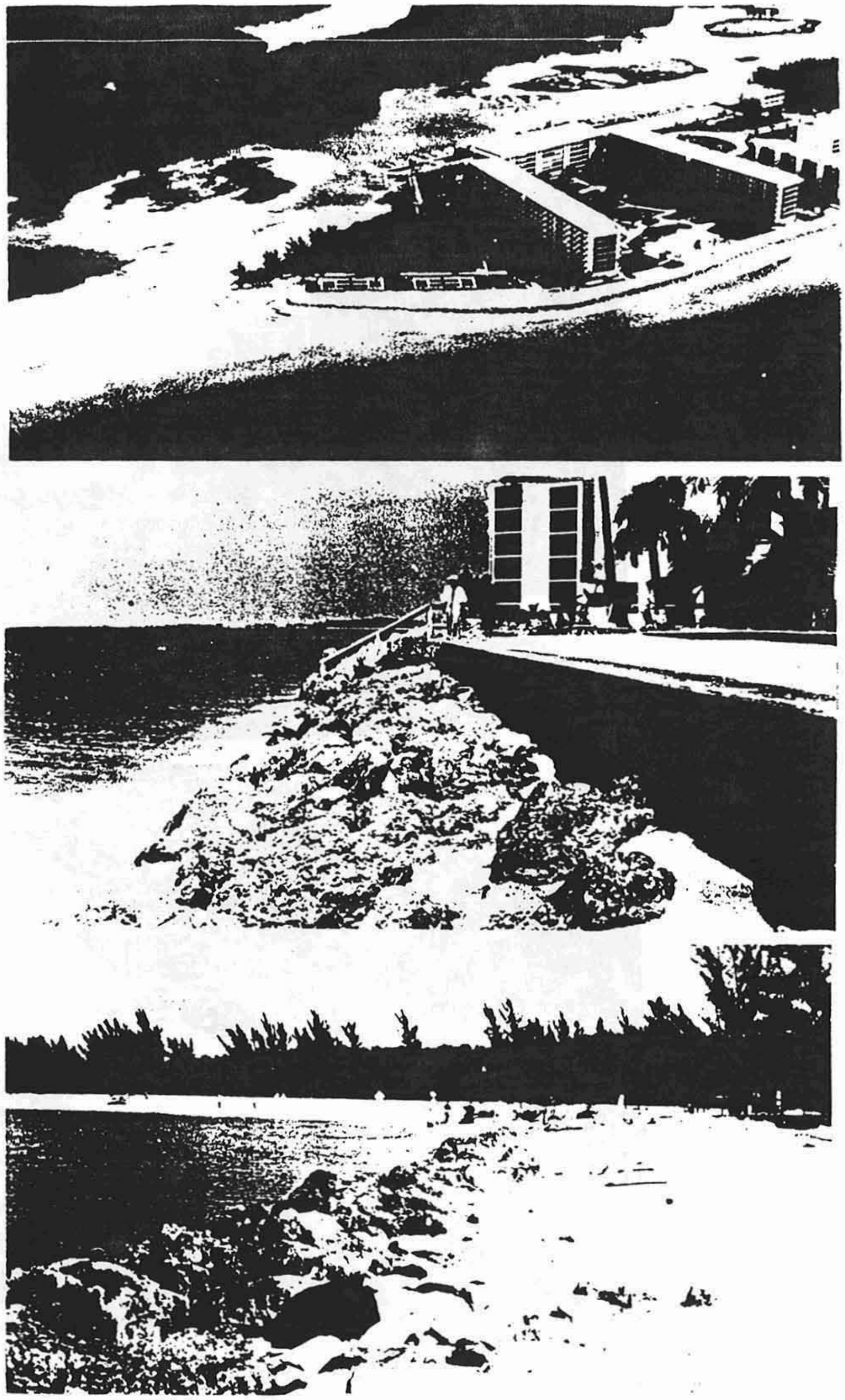


Figure 27A. North end of Bonita Beach showing former inlet site and proximity of new construction. Fig. 27B. Ground photo of area shown in Fig. 27A. Note that there is little to no beach. Fig. 27C. Boulder revetment north of area shown in Fig. 27B. This affords little protection in area of chronic erosion or during storms.

A SUPPLEMENT TO THE REPORT ON ESTUARINE POLLUTION CONDITIONS, LEE COUNTY FLORIDA

Richard B. Morgan

November, 1987

LEE COUNTY COASTAL STUDY

Godschalk & Associates, Consultants

APPENDIX B

PAST STORMS AND THEIR EFFECTS

The following is taken directly from Appendix C, Department of the Army (1969):

1. General.--Records indicate that a total of 46 hurricanes and tropical disturbances passed within 50 miles of Lee County between 1830 and 1968. Of that total, 23 were classified as being of hurricane intensity. Since 1900, 17 hurricanes and 14 tropical disturbances have passed within 50 miles of the area. Specific hurricanes and their effects on the shores of Lee County are discussed in paragraphs 2-16.

2. Hurricane of October 5-7, 1873.--The origin of that hurricane is unknown. It moved northeastward, entered Florida at Punta Rassa, and destroyed the entire settlement. A minimum pressure of 28.40 inches was recorded at Punta Rassa on the 6th. A wind velocity of 90 miles an hour was registered before the anemometer cups were blown away. At the lull, the water was noted at 14 feet above mean tide.

3. Hurricane of August 14-24, 1888.--Originating over the lower Bahamas, that storm moved northwestward. It entered Florida 12 miles south of Miami and passed into the gulf about 35 miles south of Lee County. Damages resulting from the storm are not known.

4. Hurricane of August 18-25, 1891.--Forming in the South Atlantic, that storm crossed the east coast of Florida on the 24th and entered the Gulf of Mexico south of Fort Myers. No damage information is available for Florida.

5. Hurricane of October 11-18, 1910.--Originating in the western Caribbean sea, that hurricane passed over Cube and moved northward in the gulf for 3 days, passing inland about 50 miles north of Fort Myers. Damages in Lee County were estimated at $258,000, a large percentage of which was citrus loss. A high-water mark of 10.5 feet was reported at Everglades, about 65 miles south of Fort Myers, indicating flooding of 4 to 6 feet deep in the area.

6. Hurricane of October 21-31, 1921.--That storm was considered one of the most severe to strike the gulf coast. It originated in the Caribbean Sea, followed a northerly path, and entered Florida about 125 miles north of the study area. Maximum flood elevations in the vicinity of Lee County were reportedly 7 to 11 feet above normal. High tides caused flooding of Sanibel and Estero Islands and the entire point at Punta Rassa was reportedly under water. Houses that were not washed from their foundations were seriously damaged. Flooding to depths of 1 to 3 feet was reported in Fort Myers residential and business areas.

7. Hurricane of September 6-22, 1926.--That storm was one of the four most destructive hurricanes of the present century. It first appeared near the Cape Verde Islands, passed north of Puerto Rico and entered Florida at Miami. After leaving Miami in shambles, with over 100

lives lost and great property damage, the storm passed across Florida and entered the Gulf of Mexico at Fort Myers. High tides flooded the docks and buildings along the Fort Myers waterfront, piling up a large mass of wreckage. Flooding was reported in the city. Giant waves swept over Punta Rassa Point and drowned two women who were attempting to reach Fort Myers in an automobile. Houses at the point were reported swept from their foundations and deposited some 100 feet inland in a badly damaged condition. Tide at the point was between 11 and 12 feet. The bridge to Estero Island (Fort Myers beach area), the casino, and many of the cottages on the island were a mass of wreckage. Tides estimated to be about 12 feet were reported over Sanibel and Captiva Islands. The bridge connecting the two islands was destroyed during the storm. Damages in the Fort Myers area were estimated at $1 million.

8. Hurricane of August 31-September 8, 1935.--That hurricane, first observed east of Turks Island in the Bahamas and traveling toward the Florida Straits, was one of the most severe tropical storms ever recorded. It passed over the Florida Keys taking a heavy toll of human life and property before proceeding up the west coast of Florida. Fort Myers Beach was flooded several feet deep. Wave heights were estimated at 16 feet. Low areas along the riverfront in Fort Myers were flooded.

9. Hurricane of October 13-21, 1944.--Originating in the western Caribbean, that storm entered the west coast of Florida about 40 miles north of Lee County. High winds extended 200 miles to the east and 100 miles to the west. At Sanibel Island, winds of 100 miles an hour and 6-foot tides were reported by the United States Coast Guard. Tides and waves swept over the island, destroying many hours, wharves, and a ferry slip. Estero Island Beach was inundated. A tide of 7 feet overtoppped Gasparilla Island and severely damaged the phosphate-loading facilities there. Beaches on the gulf side of the island were eroded landward as much as 50 to 60 feet in places.

10. Hurricane of October 7-9, 1946.--That hurricane formed in the northwestern Caribbean Sea and moved north-northeastward in the Gulf of Mexico, passed about 40 miles west of Lee County and entered Florida in the Tampa Bay area. Fort Myers reported winds of 80 miles an hour. Much of Sanibel Island and Estero Island were inundated to depths of 1.5 to 3 feet. Waterfront areas in Fort Myers were flooded, as were low beaches on offshore islands. Maximum tides were about 4 to 5 feet on the lower gulf coast.

11. Hurricane of September 11-19, 1947.--That was a severe Cape Verde hurricane that entered the east coast of Florida near Fort Lauderdale, crossed the State, and passed into the Gulf of Mexico just south of Lee County. Wind velocities of 120 miles an hour were reported at Sanibel Island and velocities of 90 miles an hour were reported at Fort Myers. Eleven deaths in Florida were directly caused by the hurricane. Over 8 inches of rain fell in a 24-hour period in the Fort Myers-Punta Gorda area. Damages in the Fort Myers area from hurricane winds and rainfall approached $1 million.

12. Hurricane of August 29-September 13, 1960.--Hurricane Donna ranks as one of the great storms of the century and is probably second in

intensity only to the September 1935 "Labor Day" hurricane. It was termed the most destructive hurricane of all time in terms of damage to the entire State of Florida. The total damages in Florida from various sources were estimated at over $86 million, not including an estimated $60 million loss in citrus. Hurricane Donna formed in the Cape Verde area, traveled west-northwestward and crossed the central keys near Long Key. From there it curved northward, passing over Cape Sable, Naples, Fort Myers, and Punta Gorda. A further recurvature to the northeast carried the hurricane over the Atlantic Ocean at Flagler Beach. Over 50,000 families in Florida were affected by the hurricane. Estero Island (Fort Myers Beach) was swept by tides and wave action. Dune elevations of 5 to 78 feet were lowered several feet, exposing and undermining foundations and toppling homes. Tides of 4 to 5 feet above normal overtopped Captiva Island, cutting through the narrow beaches to the bay in several places. In Lee County over 1,100 buildings and 200 or more trailers were badly damaged or destroyed. Tidal flood damages in Naples and Fort Myers Beach comprised nearly $11 million.

13. Storm of September 29, 1963.--An intense low-pressure area over the Gulf of Mexico produced winds gusting up to 50 miles an hour and caused considerable damage to Lee County beaches. Although that storm was not a hurricane, tides were reported to be 3 to 4 feet above normal. At Sanibel Island and Fort Myers Beach (Estero Island), the streets and some homes were flooded, and the beach was heavily eroded. At Captive Island, the main access road was undermined and collapsed in several places. The northern tip of Captiva Island was inaccessible due to water over the road. A foot or more of water covered most of the roads on that island.

14. Hurricane of August 27-September 10, 1965.--Hurricane Betsy was an unusual storm. It developed from a tropical depression in the southwest Atlantic Ocean. On 8 September the center, 40 miles in diameter, passed over extreme south Florida. The storm center then followed a path west to northwest through the Gulf of Mexico, crossed inland just west of New Orleans, and passed northward through Louisiana and into eastern Arkansas. The greatest damages in Florida occurred in the southern end of the State, where about 15,000 acres of agriculture lands and sections of Miami were inundated by rising tides in Biscayne Bay. The President of the United States declared 10 south Florida counties a disaster area because of the extent of damages resulting from the hurricane. Estimated damages in the State of Florida as a result of the hurricane were about $140 million. This consisted of about $123 million damages to private facilities, $9 million damages to public facilities, and $7.5 million damages to the agricultural industry. Tides were highest along the lower gulf coast. At Everglades, tides in excess of 5 feet were reported. Fort Myers reported a tide 3.5 feet above normal. High tides and rough seas caused considerable erosion of the gulf shores of Lee County. About 1,300 feet of roadway which fronted the beach on Captiva Island were severely damaged and made impassable by the hurricane. Repairs to the roadway, exclusive of labor costs, amounted to $2,362. Total storm damage in Lee County was estimated at $200,000.

15. Hurricane of June 6-11, 1966.--Hurricane Alma was one of the few tropical storms on record to reach full hurricane intensity before

mid-June and seasonally the earliest known hurricane to cross the Florida coastline. It passed west of Key West and skirted the gulf coast of Florida on June 9. The storm crossed the Florida coastline just east of Apalachicola, passed east of Tallahassee, and entered southern Georgia. Nearly all sections of Florida felt some effects of this storm. Four tornadoes were reported in the State during the storm period. The strongest wind reported during the storm was 125 miles an hour at Dry Tortugas, where the lowest pressure of 28.65 inches was also recorded. Sustained winds may have exceeded hurricane force (75 miles an hour) at exposed beach locations from Sanibel Island northward as the storm passed offshore. Tides were 5 feet above normal at Fort Myers. There were six known fatalities in Florida during the storm period. Total storm damages in Florida were estimated not to exceed $10 million.

16. Hurricane of October 16-20, 1968.--Hurricane Gladys was first observed in the western Caribbean on 15 October 1968. It attained minimal hurricane force on 16 October and later moved across the western tip of Cuba into the Gulf of Mexico. It continued northward and entered the west coast of Florida at Homosassa Springs, north of Tampa, during the night of 18-19 October. The hurricane moved northeastward across Florida during the night, leaving the state early on 19 October near St. Augustine, passing seaward of Cape Hatteras, North Carolina, on 20 October, and out to sea. Central pressure was about 29.1 inches and maximum winds were about 100 miles an hour at landfall. Considerable damage to shorefront property was incurred along parts of the middle gulf coast of the state. Several affected counties were declared a disaster area by the President of the United States. Principal damages in Lee County included the failure of a section of a seawall and resulting damage to a shorefront highway near the southerly end of Gasparilla Island. Also, the shorefront highway along the northerly end of Captiva Island was washed out in several places and the fishing pier on Estero Island was reportedly damaged. Tides in the study area during the offshore passage of Hurricane Gladys reportedly varied from about 2 feet above normal at Charlotte Harbor to 3 feet above normal at Bonita Beach Island.

The following is taken from Clark (1982) concerning the effects of the June 18, 1982 subtropical storm on Lee County:

I. General Lee County Coastal Impact

The center of the low pressure associated with the subtropical storm of June 18, 1982 passed to the north of Lee County, thus inflicting a considerable portion of the highest energy wind and wave forces associated with the storm to the Lee County coastline. In general, the major coastal impacts were beach and dune erosion, barrier island breakthroughs and substantial flooding associated with the storm surge and storm wave setup coupled with a high astronomical tide. Moderate to heavy dune erosion was sustained along the chain of barrier islands fronting Charlotte Harbor and Pine Island Sound, including Gasparilla Island, Cayo Costa Island, North Captive Island, Captive Island, and Sanibel Island. Cayo Costa Island experienced new inlet breakthroughs and Blind Pass, previously closed between Captiva Island and Sanibel Island has reopened. Numerous washover fans were developed by the flooding along the southern portion of North Captiva Pass. Substantial flooding and two concrete bulkheads were destroyed on Estero Island. Moderate to heavy dune erosion and four concrete bulkheads were destroyed on Bonita Beach where four multistory condominiums were temporarily condemned following severe undermining of the buildings.

II. Lee County Shoreline Conditions

Area	Erosion Conditions
1. Gasparilla Island	III
2. Cayo Costa Island - Breakthroughs created new inlets	III - IV
3. North Captiva Island	III - IV
4. Captiva Island	III
a. Road damage at R-96 - R-101	
b. Blind Pass reopened	
5. Sanibel Island	III
6. Estero Island	II
7. Lovers Key	II
8. Bonita Beach	III - IV

*(See Appendix - Beach and Dune Erosion Conditions)

III. Lee County Structural Damage

A. Habitable Major Structures

1. Minor damage was sustained due to waves at numerous residences and commercial structures.

2. Four beach front multistory condominimums were condemned at Bonita Beach for several days following failure of concrete bulkheads and substantial scour and undermining of the buildings. The buildings undermined are on piling foundations and only minor damage was sustained to the understructure area of the buildings.

B. Coastal and Shore Protection Structures (Excluding Beaches and Dunes)

1. One hundred and thirty (130) feet of concrete bulkhead destroyed at the Smuggler Cove condominium on Estero Boulevard, Fort Myers Beach near R-195. Requires major reconstruction seaward of control line (permit is required).

2. One hundred (100) feet of concrete bulkhead destroyed at the San Bar Motel at 5480 Estero Boulevard, Fort Myers Beach, near R-195. Requires major reconstruction seaward of the control line (permit is required).

3. Four hundred (400) feet of rock revetment in need of repair at the Bonita Beach Club at Bonita Beach, near R-226 (permit is required).

4. Five hundred (500) feet of concrete bulkhead destroyed at the Seascape III Condominium at Bonita Beach, near R-227. Requires major reconstruction seaward of control line (permit is required).

5. Four hundred (400) feet of concrete bulkhead destroyed at the Seascape I and II Condominium at Bonita Beach, near R-227. Requires major reconstruction seaward of control line (permit is required).

6. Fifty (50) feet of a 235 foot concrete bulkhead destroyed at the Casa Bonita II Condominium at Bonita Beach, near R-228. Requires major reconstruction seaward of control line (permit is required).

7. One hundred (100) feet of a 356 foot concrete bulkhead destroyed at the Casa Bonita Grande Condominium at Bonita Beach, near R-228. Requires major reconstruction seaward of control line (permit is required).

8. Minor damage incurred by the concrete bulkhead at the Casa Bonita I Condominium at Bonita Beach, near R-228, requiring major reconstruction seaward of the control line (permit is required).

9. Numerous bulkheads and rock revetment structures on Gasparilla Island, North Captiva Island, Captiva Island, and Estero Island incurred minor damage. Most of these structures are nonconforming in design and construction with current state construction standards and will require maintenance and repair seaward of the control line which will require permits being issued.

APPENDIX C

LONGSHORE SAND TRANSPORT CALCULATIONS
BASED UPON WALTON (1973)

GASPARILLA ISLAND LONGSHORE SAND TRANSPORT

Section#	Azimuth (Θ_n)	Table# (Walton, 1973)	Pos (right-to north) yd^3/day yd^3/yr	Neg (left-to south) yd^3/day yd^3/yr	Net yd^3/day	Annual Net yd^3/yr (direction)	Range (± 11.25°) yd^3/yr (direction)
1	263°	A43/A44	160 58,400	480 175,200	320	116,800 (to south)	98,550-127,750 (to south)
2	269°	A43/A44	150 54,750	490 178,850	340	124,100 (to south)	131,400-109,500 (to south)

CAYO COSTA LONGSHORE SAND TRANSPORT

Section#	Azimuth (Θ_n)	Table# (Walton, 1973)	Pos (right-to north) yd^3/day yd^3/yr	Neg (left-to south) yd^3/day yd^3/yr	Net yd^3/day (direction)	Annual Net yd^3/yr (direction)	Range (± 11.25°) yd^3/yr (direction)
1	290°	A45/A46	180 65,700	550 200,750	370 (south)	135,050 (south)	129,575-131,400 (south)
2	239°	A45/A46	185 67,525	310 113,150	125 (south)	45,625 (south)	18,250- 78,500 (south)
3	250°	A45/A46	180 65,700	400 146,000	270 (south)	80,300 (south)	25,550-105,850 (south)
4	218°	A45/A46	290 105,850	240 87,600	50 (north)	18,250 (north)	21,900- 73,000 (south) (north)
5	239°	A45/A46	185 67,525	310 113,150	125 (south)	45,625 (south)	18,250- 78,500 (south)
6	252°	A45/A46	180 65,700	410 149,650	230 (south)	83,950 (south)	49,275-109,500 (south)

NORTH CAPTIVA ISLAND LONGHSORE SAND TRANSPORT

Section#	Azimuth (Θ_n)	Table# (Walton, 1973)	Pos (right-to north) yd^3/day yd^3/yr	Neg (left-to south) yd^3/day yd^3/yr	Net yd^3/day (direction)	Annual Net yd^3/yr (direction)	Range (± 11.25°) yd^3/yr (direction)
1	271	A45/A46	140 51,100	430 156,950	790 (south)	105,850 (south)	93,078-109,500 (south)
2	250°	A45/A46	180 65,700	400 146,000	270 (south)	80,300 (south)	25,550-105,850 (south)
3	234°	A45/A46	190 69,350	790 105,850	100 (south)	36,500 (south)	12,775- 63,875 (south)
4	239°	A/45A46	185 67,525	310 113,150	125 (south)	45,625 (south)	18,250- 78,500 (south)
5	252°	A45/A46	180 65,700	410 149,650	230 (south)	83,950 (south)	19,275-109,500 (south)

ESTERO ISLAND LONGSHORE SAND TRANSPORT

Section#	Azimuth (Θ_n)	Table# (Walton, 1973)	Pos (right-to north) yd^3 /day yd^3/yr	Neg (left-to south) yd^3/day yd^3/yr	Net yd^3/day (direction)	Annual Net yd^3/yr (direction)	Range (± 11.25°) yd^3/yr (direction)
1	218°	A47/A48	230 83,950	140 51,100	90 (north)	32,850 (north)	54,750- 7,300 (north)
2	204°	A47/A48	310 113,150	120 43,800	190 (north)	69,350 (north)	43,800- 96,725 (north)
3	206°	A47/A48	290 105,850	120 43,800	170 (north)	62,050 (north)	29,200- 91,250 (north)
4	*229°	A47/A48	185 67,525	170 62,050	15 (south)	5,475 (south)	29,200- 21,900 (south) (north)
5	255°	A47/A48	100 36,500	280 102,200	180 (south)	65,700 (south)	43,800- 80,300 (south)
6	223°	A47/A48	205 74,825	160 58,400	45 (north)	16,425 (north)	18,250- 41,900 (south) (north)

*Nodal point at 230°
(Equal sand transport in either direction)

LITTLE HICKORY ISLAND LONGSHORE SAND TRANSPORT

Section#	Azimuth (θ_n)	Table# (Walton, 1973)	Pos (right-to north) yd^3/day yd^3/yr	Neg (left-to south) yd^3/day yd^3/yr	Net yd^3/day (direction)	Annual Net yd^3/yr (direction)	Range (± 11.25°) yd^3/yr (direction)
1	242°	A47/A48	145 59,925	230 83,950	85 (south)	31,025 (south)	0 - 45,625 (null pt) (south)

LOVERS KEY LONGHSORE SAND TRANSPORT

Section#	Azimuth (θ_n)	Table# (Walton, 1973)	Pos (right-to north) yd^3/day yd^3/yr	Neg (left-to south) yd^3/day yd^3/yr	Net yd^3/day (direction)	Annual Net yd^3/yr (direction)	Range (± 11.25°) yd^3/yr (direction)
1	224°	A47/A48	200 73,000	165 60,225	35 (north)	12,775 (north)	9,175- 36,550 (south) (north)

BIG HICKORY ISLAND LONGSHORE SAND TRANSPORT

Section#	Azimuth (Θ_n)	Table# (Walton, 1973)	Pos (right-to north) yd^3/day yd^3/yr	Neg (left-to south) yd^3/day yd^3/yr	Net yd^3/day (direction)	Annual Net yd^3/yr (direction)	Range (± 11.25°) yd^3/yr (direction)
1	235°	A47/A48	160 58,400	190 69,350	30 (south)	10,900 (south)	34,675- 14,600 (north) (south)

APPENDIX D

Table 1. Inlet Sediment Volumes[a] - West Coast of Florida (* jettied inlet)

Inlet	Ebb Tidal Delta			Flood Tidal Delta[c]		
	Period	Current Volume (10^6 cu yds)	Volume Change (10^6 cu yds)	Period	Current Volume (10^6 cu yds)	Volume Change (10^6 cu yds)
Boca Grande	1883-1985	159.70	+47.10	insignificant	flood	development
Captiva Pass	1883-1982	11.97	+3.77	1958	2.7	no appreciable change[h]
Redfish Pass	1883-1982	2.80	+2.80[A]	1958	2.60	no appreciable change[h]
Blind Pass	insignificant	ebb	development	1979	4.00	no appreciable change[h]
Entrance to San Carlos Bay	1883-1982	26.08	-9.22	insignificant	flood	development[c]
Big Carlos Pass	1889-1982	8.04	+3.36	1979	4.20	[c]
New Pass	1889-1982	0.42	+0.42[A]	1953	0.30	[c]
Big Hickory Pass	insignificant	ebb	development	1953	0.70	[c]

Table 2. Beach Changes[a]

Inlet	West Beach[b] (North Beach)			East Beach[b] (South Beach)		
	Period	Volume Change (10^6 cu yds)	Length of Influence (yards)	Period	Volume Change (10^6 cu yds)	Length of Influence (yards)
Boca Grande Pass	1909-1985	+17.50	5,670	1909-1985	+17.60	7,340
Captiva Pass			2,710			5,170
Redfish Pass			910			1,680
Blind Pass			450			850
San Carlos Bay Entrance			5,680			
Big Carlos			3,800			1,150
New Pass			710			790
Big Hickory Pass			650			890

Table 3. Dredging Activity

Inlet	Period	Total Volume Dredged (10^6 cu yds)	Vol. disposed Open Gulf[c] (10^6 cu yds)	Vol. disposed Nearshore[d] (10^6 cu yds)	Vol. disposed Beach/Upland[e] (10^6 cu yds)	Vol. disposed[f] Bay[f]
Boca Grande	1912-1984	8.80	8.54	0	0.26	0
Captiva Pass						
Redfish Pass	1981	0.76	0	0	0.76	0
Big Hickory Pass	1976	unknown				

a - Incomplete records of disposal practices make it impossible to track the disposal of all material dredged. Only volumes known to be disposed of in a specific site are reported here.

b - Material dredged from the inlet's entrance channel alone; excludes inner bay channels removed from inlet processes, turning basins, harbor channels, etc.

c - Material disposed in water depths great enough (>30 m) to ensure that the spoil is permanently removed from the inlet and nearshore littoral system.

d - Material disposed in shallow water (>10 m) of the nearshore zone so that it may enter the littoral drift system and be transported back to the beaches.

e - Material placed directly on upland areas or beaches for renourishment.

f - Material disposed within the bay.

APPENDIX E

LEE COUNTY INLET SUMMARIES
(From Hine et al., 1986)

BOCA GRANDE PASS

Summary of Works

DREDGING DATES	LOCATION	DISPOSAL AREA	QUANTITY (c.y.)
1912		offshore	
1927		offshore	
1937		offshore	
1950		offshore	
1981		Gasparilla Island	264,062
		TOTAL	8,800,000

Comments

Boca Grande Pass is the major shipping channel to Charlotte Harbor. Prior to dredging, the natural channel had a relatively stable depth of 19 feet below mean low water. The first dredging of Boca Grande took place in 1912 when the pass was deepened to 24 feet. In 1927 the pass was deepened again to 27 feet and again in 1937 to 30 feet. The present depth of 32 feet was attained in 1950. Approximately 8.8 million cubic yards of material have been taken out of the pass between 1912 and 1984. All of the dredged material was placed in offshore disposal sites, except in 1981 when 264,062 cubic yards was placed along a section of beach on Gasparilla Island.

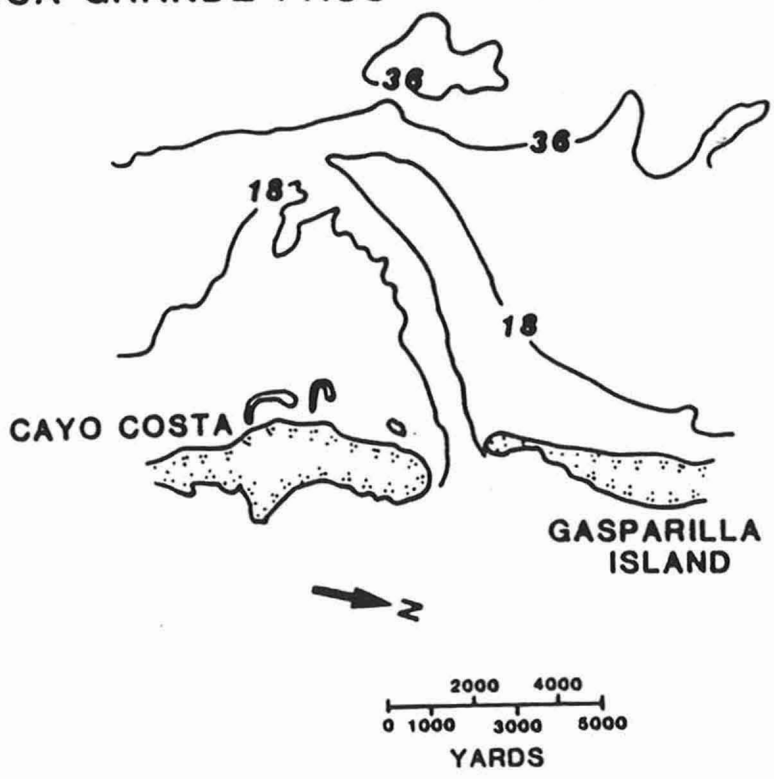
Boca Grande Pass remains a federal project with a depth of 32 feet and a width of about 1,000 yards.

INLET: BOCA GRANDE

SAND VOLUMES

REGION	PERIOD/YR	CURRENT OR TOTAL VOLUME 10^6 yds^3	VOLUME CHANGE 10^6 yd^3	REMARKS
Ebb-Tidal Delta	1883-1985	159.70	47.10	
Flood-Tidal Delta				Insignificant
Updrift Beach (north)	1909-1985		17.50	Length of influence 5670 yds
Downdrift Beach (south)	1909-1985		17.60	Length of influence 7340 yds
Total Dredged Material	1912-1984	8.80		
Material Dumped Offshore		8.54		
Material Dumped Nearshore				
Material Dumped Beach or Upland		.26		

BOCA GRANDE PASS



CAPTIVA PASS

Summary of Works

Comments

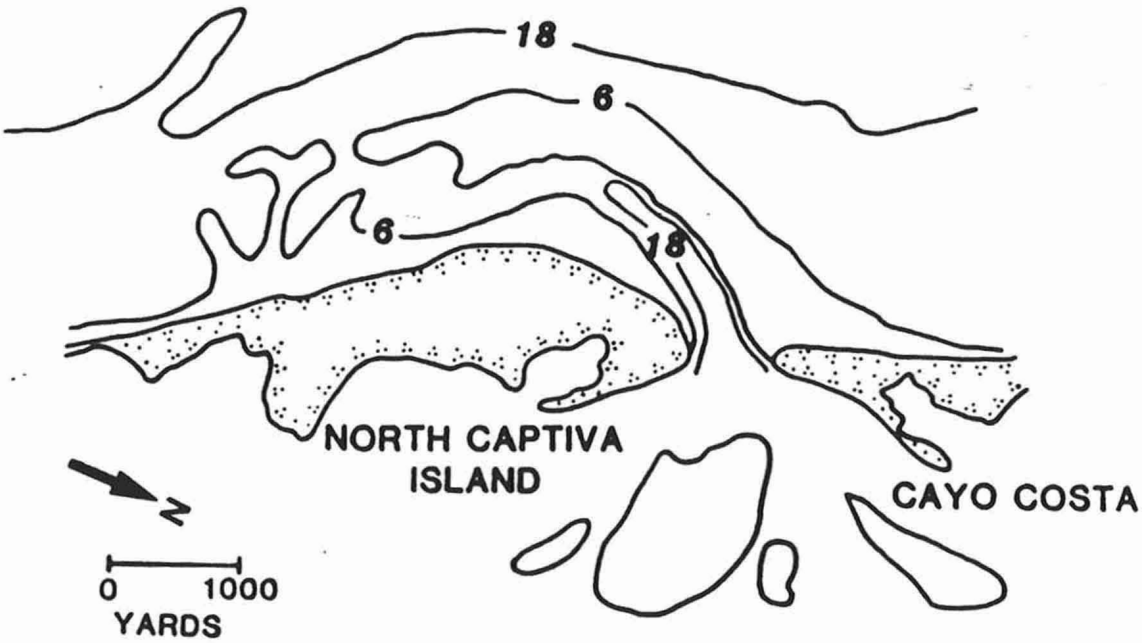
Captiva Pass is not federally or locally maintained at this time. The pass has never been dredged or jettied. The pass is about 600 yards wide and has an average depth of about 15 feet.

INLET: CAPTIVA PASS

SAND VOLUMES

REGION	PERIOD/YR	CURRENT OR TOTAL VOLUME 10^6 yds^3	VOLUME CHANGE 10^6 yd^3	REMARKS
Ebb-Tidal Delta	1883-1982	11.97	3.77	
Flood-Tidal Delta	1958	2.7		No appreciable change
Updrift Beach (north)				Length of influence 2,710 yds
Downdrift Beach (south)				Length of influence 5,170 yds
Total Dredged Material				
Material Dumped Offshore				
Material Dumped Nearshore				
Material Dumped Beach or Upland				

CAPTIVA PASS



REDFISH PASS

Summary of Works

DREDGING DATES	LOCATION	DISPOSAL AREA	QUANTITY (c.y.)
1981	ebb-tidal delta	Captiva Island	765,000
		TOTAL	765,000

Comments

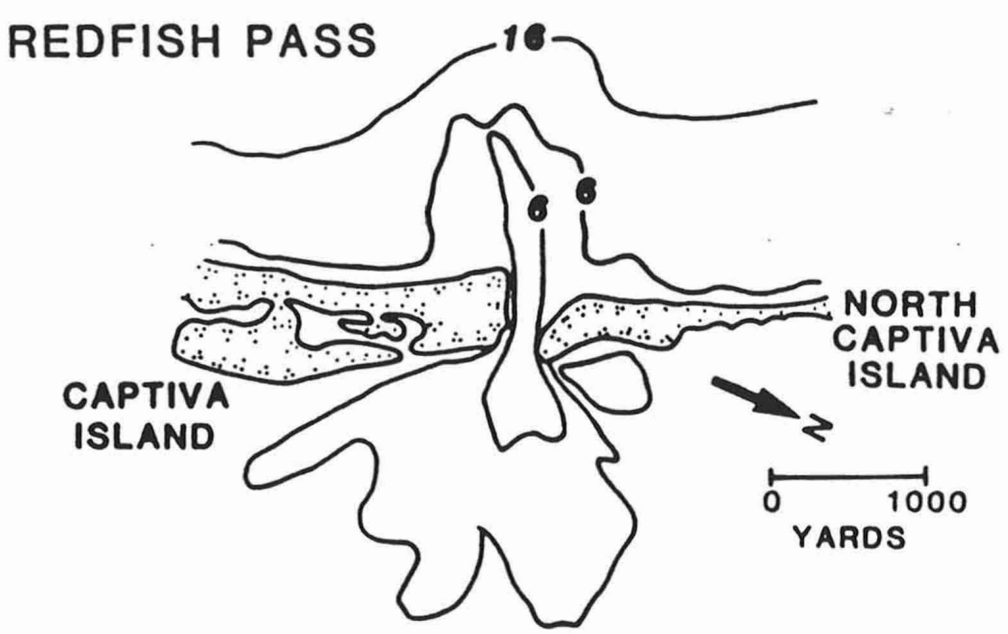
Redfish Pass was formed in 1921 when a severe hurricane breached Captiva Island, separating North Captiva from Captiva Island. The pass has not been dredged or altered. Some limestone rip rap has been placed on the north end of Captiva Island. In 1981 765,000 cubic yards of material were dredged from a borrow source located about 2,000 feet offshore of the pass, in the pass' ebb tidal delta. The dredged material was placed along the beaches on Captiva Island.

Redfish Pass is not federally or locally maintained at this time. The Pass is about 200 yards wide with an average depth of about 15 feet.

INLET: REDFISH PASS

SAND VOLUMES

REGION	PERIOD/YR	CURRENT OR TOTAL VOLUME 10^6 yds^3	VOLUME CHANGE 10^6 yd^3	REMARKS
Ebb-Tidal Delta	1883-1982	2.8	2.8	
Flood-Tidal Delta	1958	2.6		No appreciable change
Updrift Beach (north)				Length of influence 910 yds
Downdrift Beach (south)				Length of influence 1,680 yds
Total Dredged Material	1981	.76		
Material Dumped Offshore				
Material Dumped Nearshore				
Material Dumped Beach or Upland		.76		



BLIND PASS (LEE CO.)

Summary of Works

1974 - Short rip-rap jetty on north side constructed by Lee County

Comments

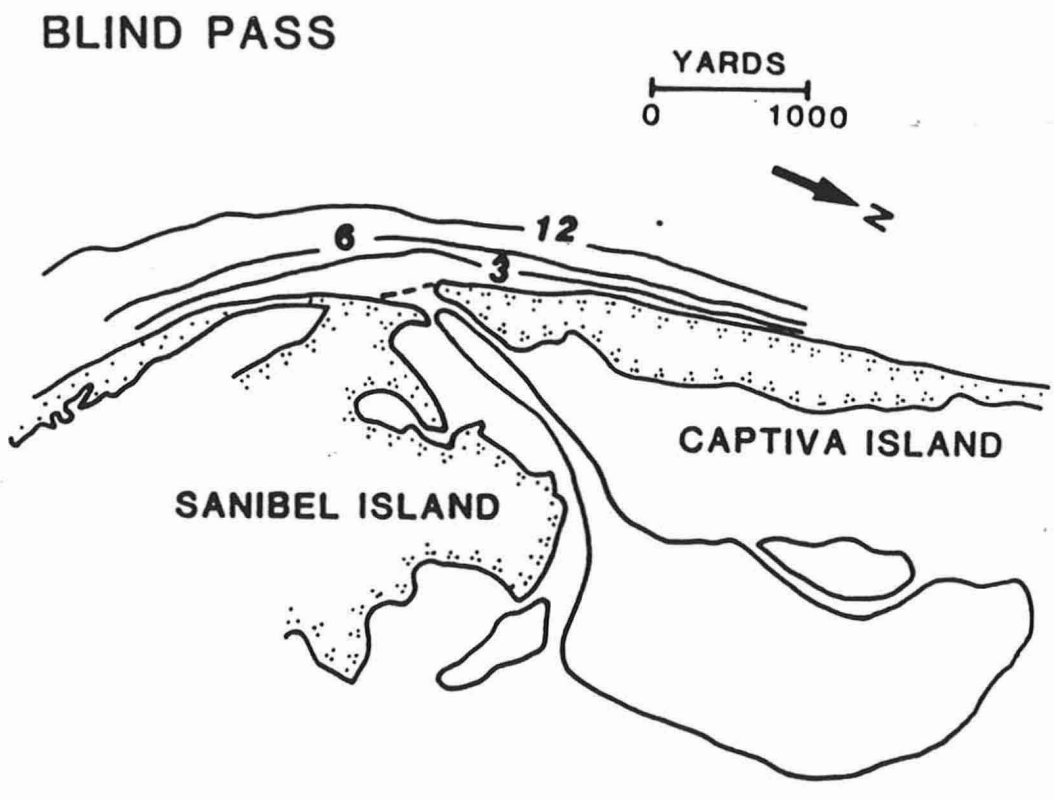
Blind Pass separates Captiva from Sanibel Island in southern Lee County. It has had the most dramatic history of migration of any of the passes in Lee County. Between 1859 and 1961 a prograding spit from the south end of Captiva Island overlapped and became attached to Sanibel Island at least three times. The entire inlet feature would migrate to the south during this process. Eventually, a new channel was opened by storm breaching near the original position. The isolated sand extension then gradually became attached to the north end of Sanibel Island and the cycle began again. Between 1859 and 1944 over 2,000 feet of progradation were added to the north end of Sanibel Island in this manner.

Blind Pass is not federally or locally maintained and has not be dredged or jettied.

INLET: BLIND PASS (LEE CO.)

SAND VOLUMES

REGION	PERIOD/YR	CURRENT OR TOTAL VOLUME 10^6 yds^3	VOLUME CHANGE 10^6 yd^3	REMARKS
Ebb-Tidal Delta				Insignificant
Flood-Tidal Delta	1979		4.0	No appreciable change
Updrift Beach (north)				Length of influence 450 yds
Downdrift Beach (south)				Length of influence 850 yds
Total Dredged Material				
Material Dumped Offshore				
Material Dumped Nearshore				
Material Dumped Beach or Upland				



ENTRANCE TO SAN CARLOS BAY

Summary of Works

Comments

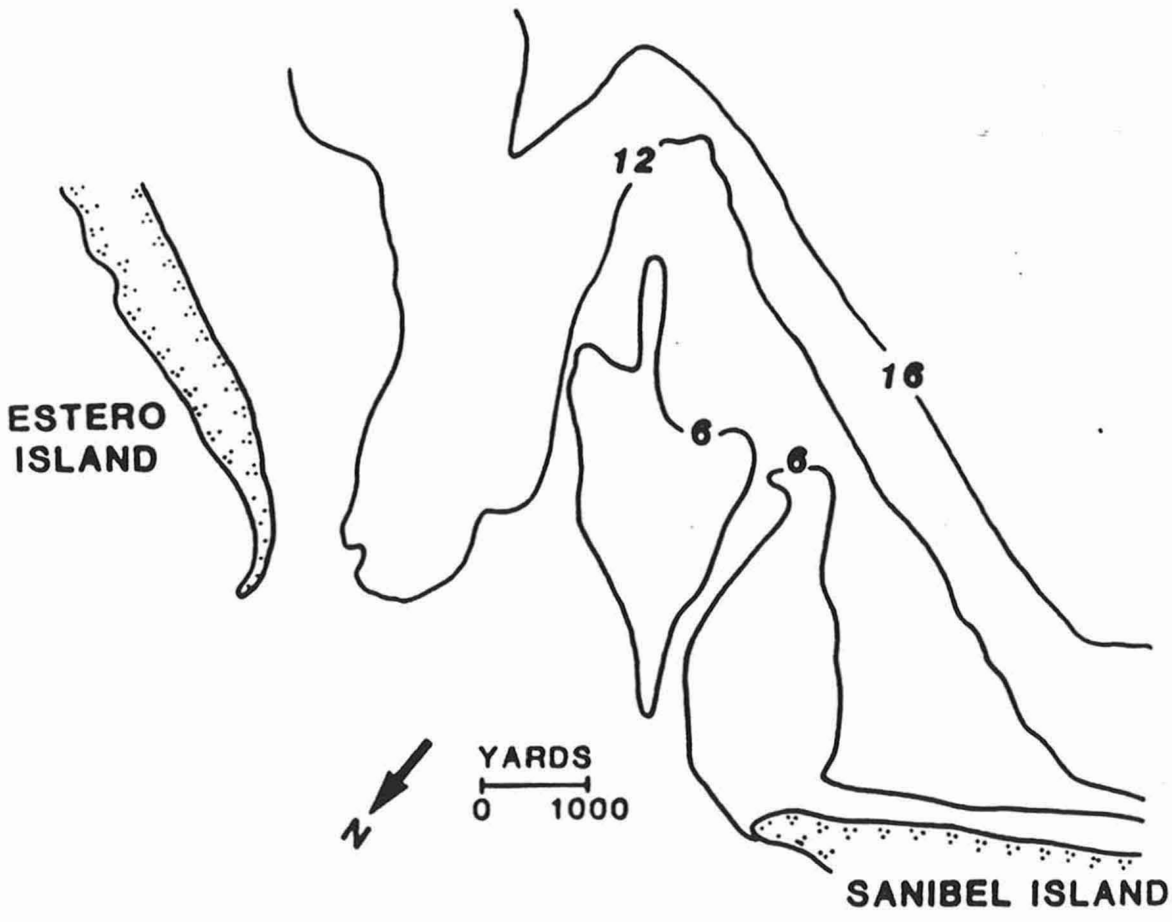
The entrance to San Carlos Bay is located in southern Lee County between the southern end of Sanibel Island and the northern end of Ft. Myers Beach. The entrance channel is not federally or locally maintained at this time and no dredging has been reported. The entrance is about 5,500 yards wide and most of it is between 12-18 feet deep.

INLET: ENTRANCE TO SAN CARLOS BAY

SAND VOLUMES

REGION	PERIOD/YR	CURRENT OR TOTAL VOLUME 10^6 yds^3	VOLUME CHANGE 10^6 yd^3	REMARKS
Ebb-Tidal Delta	1883-1982	26.08	-9.22	
Flood-Tidal Delta				Insignificant
Updrift Beach (north)				Length of influence 5,680 yds
Downdrift Beach (south)				
Total Dredged Material				
Material Dumped Offshore				
Material Dumped Nearshore				
Material Dumped Beach or Upland				

ENTRANCE TO SAN CARLOS BAY



BIG CARLOS AND NEW PASS (LEE CO.)

Summary of Works

1963-65 - causeway construction

Comments

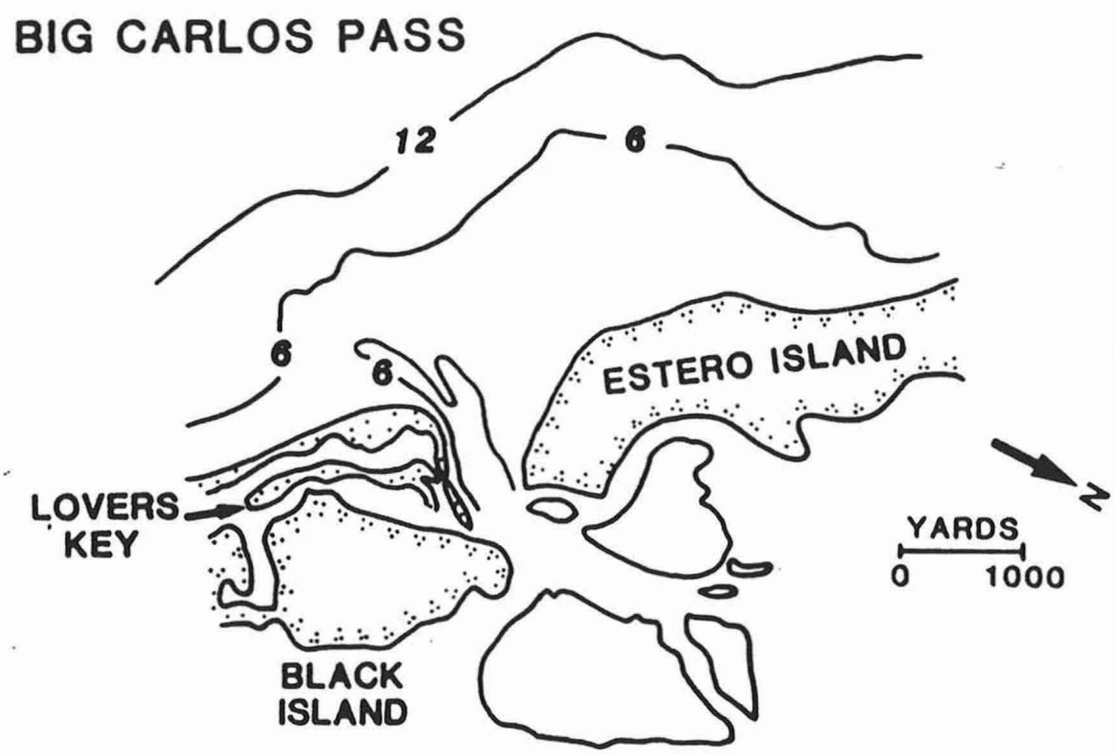
Big Carlos and New Pass are located in southern Lee County. The construction of a causeway between Fort Myers Beach and Bonita Beach between 1963 and 1965 caused the closure of several smaller tidal channels between Big Carlos and New Pass. This in turn caused more flow to be channeled through Big Carlos and New Pass resulting in a widening of the two passes. Neither pass has been dredged or had any other man-made alterations done to them.

Neither Big Carlos or New Pass is federally or locally maintained at this time. Big Carlos Pass is 500 yards wide and about 11 feet deep, while New Pass is 450 yards wide and only 7 feet deep.

INLET: BIG CARLOS PASS

SAND VOLUMES

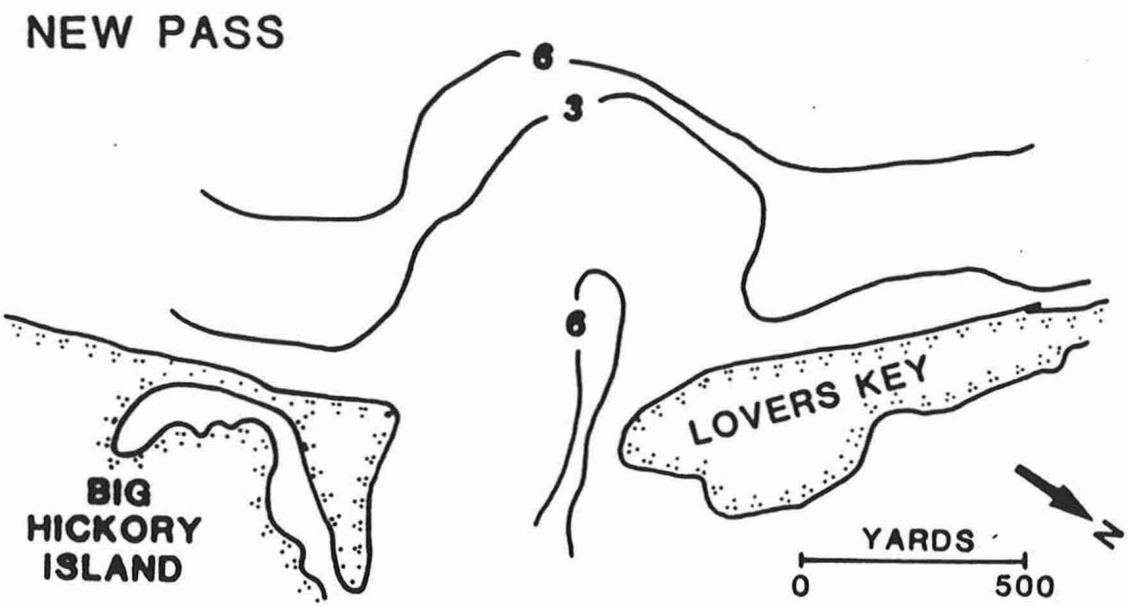
REGION	PERIOD/YR	CURRENT OR TOTAL VOLUME 10^6 yds^3	VOLUME CHANGE 10^6 yd^3	REMARKS
Ebb-Tidal Delta	1889-1982	8.04	. 3.36	
Flood-Tidal Delta	1979	4.20		No significant change
Updrift Beach (?) (north)				Length of influence 3,800 yds
Downdrift Beach (?) (south)				Length of influence 1,150 yds
Total Dredged Material				
Material Dumped Offshore				
Material Dumped Nearshore				
Material Dumped Beach or Upland				



INLET: NEW PASS (LEE CO.)

SAND VOLUMES

REGION	PERIOD/YR	CURRENT OR TOTAL VOLUME 10^6 yds^3	VOLUME CHANGE 10^6 yd^3	REMARKS
Ebb-Tidal Delta	1889-1982	.42	.42	
Flood-Tidal Delta	1953	.30		
Updrift Beach (north)				Length of influence 710 yds
Downdrift Beach (south)				Length of influence 790 yds
Total Dredged Material				
Material Dumped Offshore				
Material Dumped Nearshore				
Material Dumped Beach or Upland				



BIG HICKORY PASS

Summary of Works

1976 - pass reopened by dragline

Comments

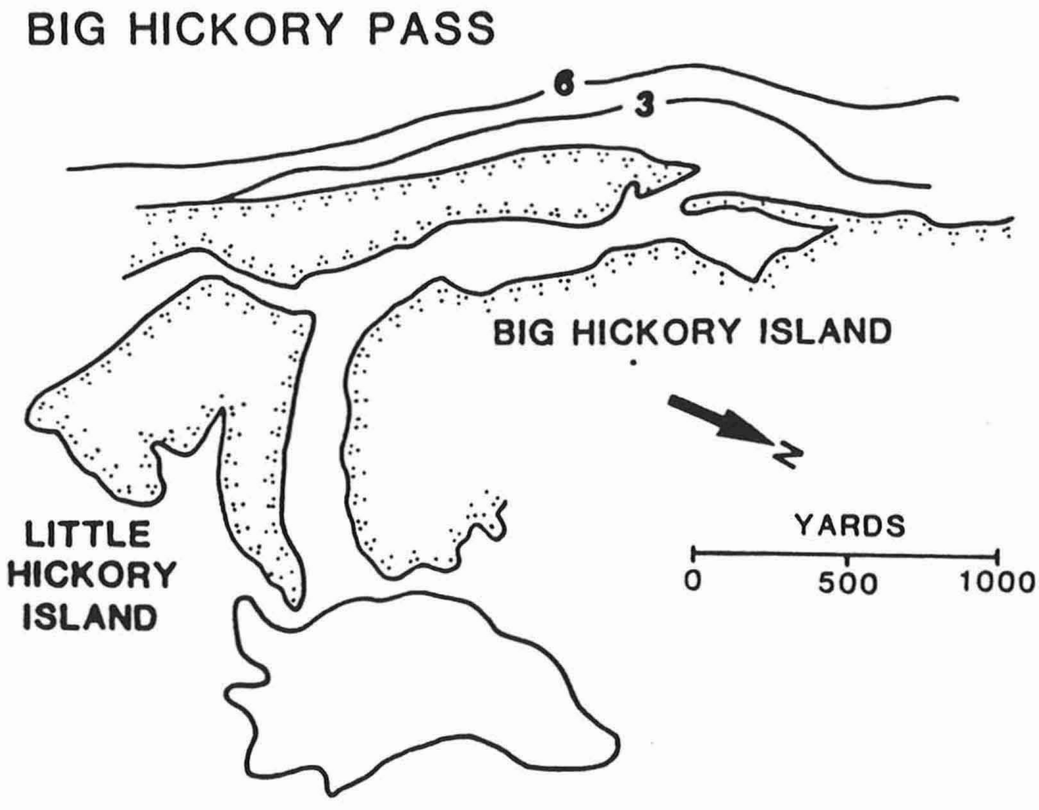
Big Hickory Pass is located in southern Lee County. The pass has closed several times in the past. It closed in 1976 when a spit which had been restricting the pass for several years completely closed off the pass. The pass was reopened by Lee County using a dragline. An unknown amount of dredged material was placed on the beach directly south of the pass on Little Hickory Island. The pass closed again in 1979 about 1000 feet north of the point where it closed in 1976.

Big Hickory Pass is not federally or locally maintained at this time. The pass remains closed at the present time.

INLET: BIG HICKORY PASS

SAND VOLUMES

REGION	PERIOD/YR	CURRENT OR TOTAL VOLUME 10^6 yds^3	VOLUME CHANGE 10^6 yd^3	REMARKS
Ebb-Tidal Delta				Insignificant
Flood-Tidal Delta	1953	.70		No significant change
Updrift Beach (north)				Length of influence 650 yds
Downdrift Beach (south)				Length of influence 890 yds
Total Dredged Material	1976	unknown		
Material Dumped Offshore				
Material Dumped Nearshore				
Material Dumped Beach or Upland				



APPENDIX F

LEE COUNTY BEACH RESTORATION MANAGEMENT PLAN

(Florida Division of Beaches and Shores)

LEE COUNTY
BEACH RESTORATION MANAGEMENT PLAN

DESCRIPTION OF COUNTY

The study area addressed by this report is comprised of the Gulf of Mexico shoreline and the nine coastal barrier islands of Lee County. Together, the islands have a cumulative gulf-front length of approximately 47 miles. From north to south, the islands included are the southern three quarters of Gasparilla Island, Cayo Costa, North Captiva Island, Captiva Island, Sanibel Island, Estero Island, Lovers Key, Big Hickory Island and the northernmost quarter of Little Hickory Island. The Lee County shoreline borders Charlotte County on the north and Collier County on the south. Widths of the barrier islands vary from approximately 200 to 13,000 feet. Elevations of the upland generally average less than 10 feet NGVD. Island lengths range from a high of 12.1 miles at Sanibel to a low of 1.5 miles at Lovers Key.

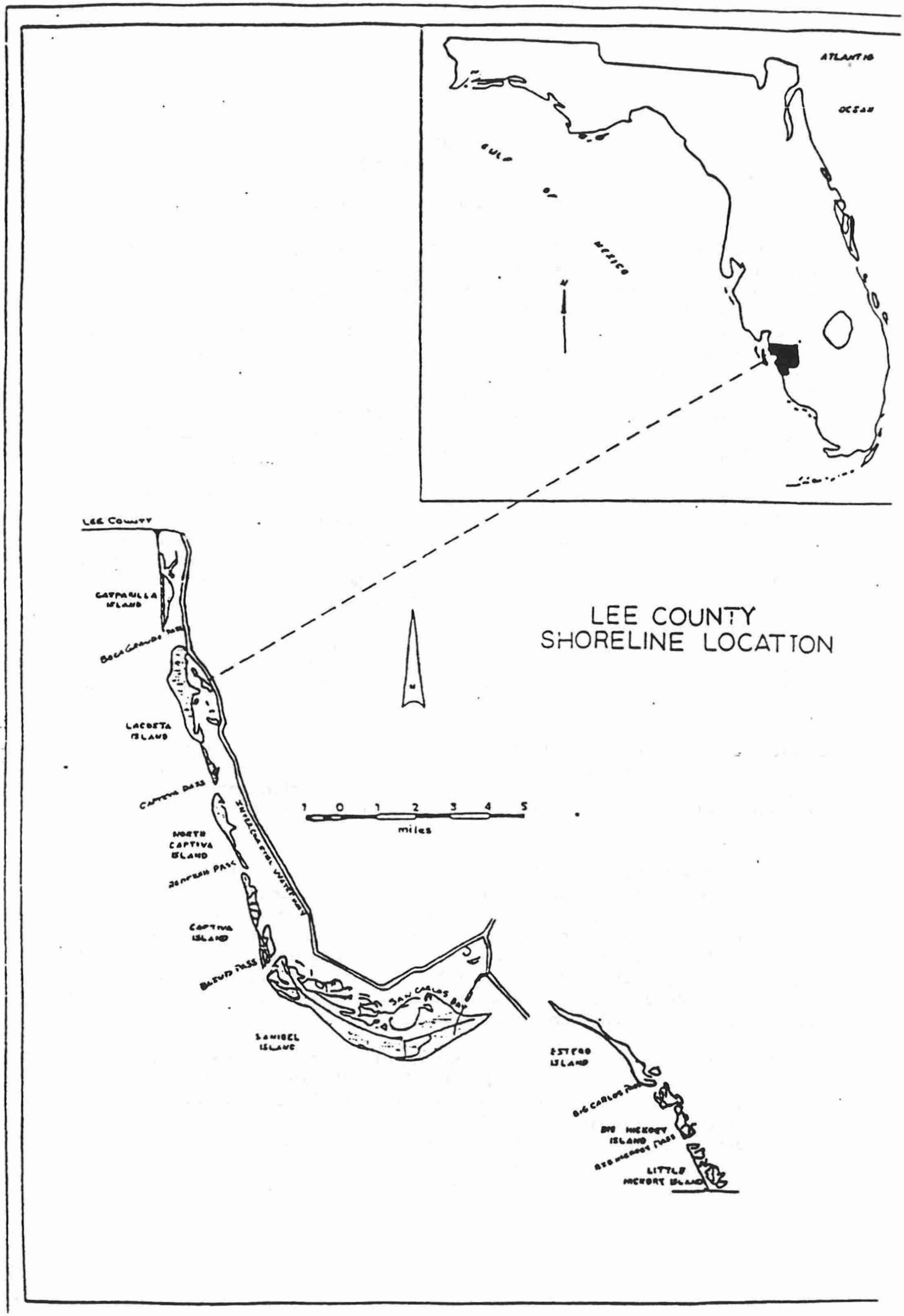
At present, the nine coastal barrier islands are divided by eight tidal inlets, or passes. Beginning at the southern end of Gasparilla Island, the inlets in order are: Boca Grande Pass, Captiva Pass, Redfish Pass, Blind Pass, Matanzas Pass, New Pass, ~~Little Carlos~~ Pass and Big Hickory Pass. Both Big Hickory Pass and Blind Pass can be considered "unstable" and are therefore subject to relatively infrequent closures only to be opened again during storms.

None of the Passes can be considered to be structurally stabilized. Federal navigation projects, which are maintained by dredging, presently exist at Boca Grande and Matanzas Pass. The latter project is also referred to as the Fort Myers Beach Channel.

Although the general shoreline configuration of the study area can be expected to remain relatively "stable", the entire area continues to be prone to major changes due to storm effects as well as continued fluctuations of the unstabilized inlets and their associated ebb tidal shoals.

The rapid growth of Florida's lower gulf coast can be attributed to the many natural characteristics of the general area, including a semi-tropical climate with warm humid summers and mild dry winters, many miles of clear coastal water along the gulf front of the county, the excellent quality of sand in the "available" gulf beach areas, natural harbors and waterways, scenic and productive estuaries, and varied fish and shellfish resources. Continued growth of both incorporated and unincorporated communities continues to be related to these unique geographic characteristics.

Rapid and intense oceanfront development of the coastal zone has occurred along most of the east coast of Florida as well as the majority of the habitable southwest Florida shoreline. This is particularly true of five of the nine coastal barrier islands in Lee County where ready access has been provided by either bridge or causeway. During the last few decades Lee County has made the transition from an agriculturally based economy and low key "wintering spot" to a relatively full-fledged tourist based economy and large scale retirement community.



ATLANTIC
OCEAN
GULF
OF
MEXICO
LEE COUNTY
LEE COUNTY
SHORELINE LOCATION
CAPTIVA PASS
NORTH
CAPTIVA
ISLAND
CAPTIVA
ISLAND
BLIND PASS
SAN CARLOS BAY
SANIBEL
ISLAND
ESTERO
ISLAND
BIG CARLOS PASS
BIG HICKORY
ISLAND
LITTLE
HICKORY ISLAND
1 0 1 2 3 4 5
miles

Lee County is a housing oriented community rather than an industrially oriented community. The leading sources of personal income are service and trade (19% and 18%, respectively), construction (13%), and state and local government (12%). In 1978, residents 55 years of age and older represented over 38% of the county population, almost twice the percentage for the United States as a whole and 1.34 times that of Florida as a whole (Bureau of Economic Analysis, 1979).

The Lee County population is highly seasonal. In 1985-86, the number of visitors to Lee County who stayed two months or less varied from about 40,000 in October to over 210,000 in March. Resident population of the county is estimated as 294,000 (a six-percent increase from one year ago).

COASTAL DEVELOPMENT

The portion of Gasparilla Island within Lee County is characterized by low to moderately dense development. Single-family residences comprise approximately 39% of the shorefront development, while multi-family dwellings comprise about 12%. The relatively modest community of Boca Grande is located towards the southern end of the island. The southernmost tip of the island is a Florida Power and Light oil unloading and storage facility, representing the only large scale "industrial" type usage of gulf-front property within Lee County.

Cayo Costa and North Captiva Island, located south of Gasparilla Island, are accessible only by boat. Cayo Costa State Park comprises all of Cayo Costa and the southern two-thirds of North Captiva Island. With the exception of a few cottages and small dwellings (mostly along the north end of North Captiva Island), both barrier islands are almost completely undeveloped.

Coastal development along the northern third of Captiva Island's shoreline includes South Seas Plantation, a full amenity resort consisting of single-family and low-density, multi-family dwellings extending some 3,000 feet south of Redfish pass. The northernmost 2,000 feet of shoreline is fronted by the Plantation golf course. Outside of South Seas Plantation, coastal development along Captiva Island consists primarily of single-family residences, low-density multi-family residences, and a few small motels. The Island is essentially fully developed along the entirety of its shoreline.

Sanibel Island exhibits a wide variety of coastal development characteristics. The island's westernmost two miles of shoreline include county-owned Turner Beach and Bowmans Beach which serve as public beach facilities. East of these, development consists almost exclusively of single-family and low-density duplex and triplex type dwellings for approximately the next four miles. Further east, coastal development becomes increasingly higher-density, and is dominated by mid-rise, resort and commercial structures with older single-family residences interspersed. This trend continues along the remainder of the island gulf-front shoreline with the exception of Gulfside City Park and the easternmost mile of the island where structure density lessens. The eastern tip of the island is a federally maintained facility know as Lighthouse Point and is designated for public access.

The northern shoreline of Estero Island, more popularly know as Ft. Myers Beach, is undeveloped for the first 1,500 feet south of Matanzas Pass. Commencing south of this point, the highly developed, densely populated community of Ft. Myers Beach extends over the entire length of the island. Exceptions to this trend are the county-owned Lynn Hall Memorial Park public access facility, which is located approximately one mile south of the pass at the Ft. Myers Beach fishing pier. Development along the shoreline consists of a spatially-dense mix of older cottages, single-family dwellings, mid-rise motels, and high-rise condominiums. Lovers Key, separated from the south end of Estero island by Big Carlos Pass, is a relatively "new" barrier island. It is owned by the State of Florida and may be accessed either by boat or via a tram system which transports visitors to the island from SR 865 on Black Island. South of Lovers Key, Big

Hickory Island is undeveloped and is accessible by boat (or by foot depending upon the state of Big Hickory Pass).

The northern portion of Little Hickory Island is popularly referred to as Bonita Beach and is intensely developed along the shoreline commencing with the Bonita Beach Club, an exclusive multi-family development located immediately south of Big Hickory Pass.

EXISTING EROSION PROBLEMS

Examination of the shoreline change data for Lee County indicates that the northern end of Gasparilla Island has undergone northerly shoreline advancement while the southern tip has experienced considerable eastward recession. This trend is most likely due to the orientation of the island shoreline relative to the predominant south-southwesterly wave direction which in combination with the ebb tidal shoals of Gasparilla Pass has resulted in a net northerly drift along the northern end of the island.

Large scale shoreline changes along Cayo Costa Island have been essentially negligible. Analysis of several aerial photographs would indicate that since the 1940's, shoreline changes at this island have been in more of a longshore direction than in a shore-normal direction. On adjacent North Captiva Island shoreline recession is discernible, particularly along the northern end of the island. Numerous overwash areas have developed along the southern third of the island which could result in a fairly permanent breach of the island during a severe storm event.

Captiva Island has historically suffered chronic erosion along its entirety. The majority of this erosion may be considered to be due to the interruption in longshore transport by the formation of Redfish Pass in 1926. Numerous efforts to address shoreline recession by means of structural erosion control devices (i.e. groins) as well as beach fills within the last thirty years have attenuated this erosion in some areas and aggravated it in others. At present the southern half of the island is severely starved of sand to the point that the actual "potential" for erosion may be greater than what is presently being predicted based upon shoreline monitoring. Historically, the areas of most severe erosion are along the northern and southern portions of the Island in the vicinity of Redfish and Blind Pass, respectively.

Historically, Sanibel Island has been one of the few barrier islands in southwest Florida that has been consistently stable to accretional. Eventually, however, shoreline erosion may be expected to pose an increasing threat to upland development in certain areas. This is considered probable due to sand starvation along the updrift shoreline of Captiva Island, as well as the large-scale migration of the spits formerly associated with Blind Pass. Areas presently exhibiting the most volatile shoreline migration tendencies are those near Blind Pass and Port Ybel, the western and eastern extremities of the island, respectively.

Historical shoreline changes along Estero Island have consisted of minor landward recession along virtually its entire length. Longshore net sediment transport rates are estimated, and northerly, at the north end of the island. This is most likely due to the sheltering effects of Sanibel Island and San Carlos Bay from northerly waves. Near the middle of the island, transport can be expected to resume a potential net southerly direction thereby creating a nodal point from which sediment transport diverges to the north and south, resulting in net sand starvation at that location. Along the south end of the island a very prominent spit feature exists immediately offshore of the main strand and extends for almost 1.5 miles parallel to the shoreline. Erosion at the very southern end of the island has accelerated since the construction resulted in a potential increase in the tidal prism at Big Carlos Pass and corresponding changes in the adjacent shoreline as the Pass adjusted to a new equilibrium cross section.

Available studies (UF/COEL, 1971) report that Lovers Key is presently accreting at its northern and southern extremities while undergoing erosion along its middle section. Prior to construction of the Ft. Myers-Bonita Beach Causeway in 1963-65, several small tidal channels truncated the land from which formed Lovers Key. This shoreline should continue to be considered as very dynamic.

Over time, the stability of Little Hickory Island (generally know as Bonita Beach) has been directly related to the migration of the two inlets located to the north and the construction of several causeways across these inlets. Recent profile data (i.e. 1974-82) for the Bonita Beach shoreline indicates an annual recession rate of almost 4 ft/yr between R226 and R230. Immediately south of R230 the shoreline is presently stable to mildly accretional.

With few exceptions, virtually the entire Lee County shoreline has experienced long-term erosion of magnitude. This erosion is due in part to rising sea-level, interruption of longshore sediment transport, inlet effects (natural and man made), and structural shoreline modifications. Of particular interest are the high erosion rates along the south end of Gasparilla Island, the north end of Captiva island, and along the entire shoreline of Estero Island.

EFFECTS OF ENTRANCES

As previously mentioned, Boca Grande Pass is a federal navigation project and has required maintenance dredging since 1912. Prior to 1981, dredged material totaling approximately 8.55 million cubic yards was disposed of offshore, thereby removing it entirely from the littoral system. The contribution of such disposal practices to the erosion problems along adjacent beaches can be expected to be detrimental. Boca Grande Pass acts as a virtual sediment sink by storing sand over the entirety of its relatively deeper ebb tidal shoal system. It has been estimated that the volume of this shoal (extending to the 36 foot contour) is 160 million cubic yards (Hine et al., 1987). Again the natural effect of this sediment sink in contributing to the erosion problems along adjacent shorelines is readily apparent. It is also estimated that a net loss of 35.0 million cubic yards of material has been realized from the shoreline extending approximately 3.6 miles north and 4.2 miles south of the Pass over the period 1909-1985.

Captiva Pass

This pass has remained in its natural state and appears to have remained open since the turn of the century. Estimates indicate ebb-tidal and flood tidal shoal volumes of 11.97 and 2.7 million cubic yards, respectively, and that Captiva Pass has an immediate influence on shoreline erosion/accretion rates 1.5 miles north and 2.9 miles south of the Pass, (Hine, et al., 1987).

Redfish Pass

Prior to 1981, this Pass had not been improved or modified. At that time, approximately 765,000 cubic yards of sand was dredged from the ebb tidal shoals and placed on the adjacent 10,000 feet of shoreline to the south. These shoals, as well as the flood tidal shoals, continue to act as a sink thereby entraining significant quantities of sediment. Although the effects on the North Captiva shoreline to the north appear relatively minimal, chronic erosion to the south along developed Captiva Island continues at an appreciable rate. Available estimates indicate that the combined flood and ebb tidal shoals at Redfish Pass contain more than 5.4 million cubic yards of sand which has been driven from longshore sediment transport since the opening of the Pass in 1926 by a hurricane.

Blind Pass

Since 1958, this Pass has undergone a very dramatic cyclical history of large scale migration, closure and re-opening. Most important is the fact that its tidal prism was greatly reduced as a result of the opening of Redfish Pass in 1926. These changes have historically been associated with a prograding spit which originated at the south end of Captiva Island and extended southward to various lengths. The combination of a rock terminal groin structure along the north bank of the Pass, and the significant change in shoreline orientation along adjacent Sanibel Island, appears to result in southerly sediment transport which passes offshore of the Pass. Virtually no significant ebb tidal shoal formation is observed in the vicinity of Blind Pass.

San Carlos Bay

The entrance to the Pass has maintained a relatively stable configuration in the past 100 years and has not been dredged or otherwise "improved", except for the Ft. Myers Beach Channel. This is believed to be attributable to the sheer size of the entrance (well over three miles in width) and the fact that it is the main tidal outlet for the Caloosahatchee River as well as the south ends of both Pine Island South and the Charlotte Harbor estuary system. Nevertheless, historical shoreline trends and the predominate direction of longshore transport indicate that the majority of sand eroded from the eastern end of Sanibel Island was deposited in the vicinity of this entrance. Ebb tidal shoal volume estimates of 26.1 million cubic yards would indicate that much of this sand has remained in this area.

Estero Pass and Ft. Myers Beach Channel

This Pass, or the Channel, appear to be intercepting much of the northerly sediment transport along Estero Island as evidenced by the ongoing maintenance dredging projects necessary to maintain a navigable channel in the Pass. The combination of the Pass trapping northerly drift from Estero Island and the apparent lack of southerly bar-bypassing across the San Carlos Bay from Sanibel Island has greatly contributed to the erosion problems along the northern Estero Island shoreline.

Big Carlos Pass

This pass has remained unaltered by direct structural means but underwent noticeable widening and deepening subsequent to the construction of a causeway between Ft. Myers and Bonita Beach in 1965. The widening and deepening of the Pass resulted from a probable increase in its tidal prism attributable to the causeway. This in turn has resulted in the enlargement of the flood and ebb tidal shoal systems which store sediment derived from the adjacent beaches. It is estimated (Hine et al., 1987) that these flood and ebb tidal shoals contain approximately 4.2 and 8.0 million cubic yards of sand, respectively.

New Pass

The Pass has experienced the same apparent phenomenon associated with an increase in its tidal prism subsequent to the construction of the Ft. Myers-Bonita Beach causeway. New Pass, however, has maintained relatively smaller dimensions than Big Carlos Pass due to its comparatively smaller tidal prism. Erosion of adjacent shorelines has been less severe, however, and the flood and ebb tidal shoals contain smaller volumes of sand; i.e., 0.30 and 0.42 million cubic yards, respectively.

Big Hickory Pass

This is a relatively small pass bordering the northern extent of Bonita Beach. The Pass has a history of intermittent closure and re-opening due to spit migration across the mouth and eventual breaching. The migrating spit phenomena and current closed condition of the inlet indicates a very small tidal prism relative to longshore transport volumes. Accordingly the Pass would be expected to have negligible shoal volumes and an equally negligible effect on adjacent shorelines. These assumptions are corroborated by Hine, et al. (1987). However, it appears that northerly drift along north Bonita Beach is deposited in a spit which has grown north across the Pass.

IMPACT OF EXTREME STORM EVENTS

Although little specific recorded storm damage data are available for Lee County, damage resulting from such storms could be expected to cause both structural demolition and severe beach erosion. In addition, the majority of the county shoreline should be considered to be extremely susceptible to overtopping and overwash resulting from the super elevation of water levels associated with such occurrences. Available data indicate that a hurricane or tropical disturbance passes within 50 miles of Lee County approximately once in every three years.

Coastal energy conditions are moderate along the Lee County coast. Mean tide levels and mean tide ranges are +1.0 foot and 1.0 foot respectively. Because c low primary dune elevations and narrow beaches most of the county falls within the MODERATE to HIGH range of storm wave susceptibility.

HISTORY OF EFFORTS TO RESOLVE EXISTING EROSION PROBLEMS

Structures designed to prevent shoreline recession have been implemented, with varying degrees of success, along virtually the entire developed shoreline in Lee County. The more notable successes have typically been terminal groins constructed at the ends of several coastal barriers near tidal inlets. It should be noted that no such structures have been implemented along the shorelines of Cayo Costa, Gasparilla Island, Lovers Key or Big Hickory Island.

No mechanical sand by-passing operations are in existence at any of the Lee County passes, nor are any anticipated in the near future. As previously mentioned, however, several of the passes have been dredged by either federal c local interests (Boca Grande-1981; Ft. Myers Beach Channel-1966 through 1986). These dredging operations are primarily for the purpose of navigation improvement and not until the last decade or so, when a secondary benefit of beach nourishment was realized, was the material returned to adjacent beaches. With the rate of erosion presently existing along the countywide beaches of Lee County, it is obviously desirable that all future maintenance dredging of beach quality sediment be returned to the adjacent shorelines.

In a 1969 Beach Erosion Control Study for Lee County, the U.S. Army Corps of Engineers presented a recommended plan of beach nourishment along portions of Gasparilla, Captiva, and Estero Islands. Except for the above referenced placement of suitable dredged material along Gasparilla and Estero Islands, the federal plan of improvement has not been constructed.

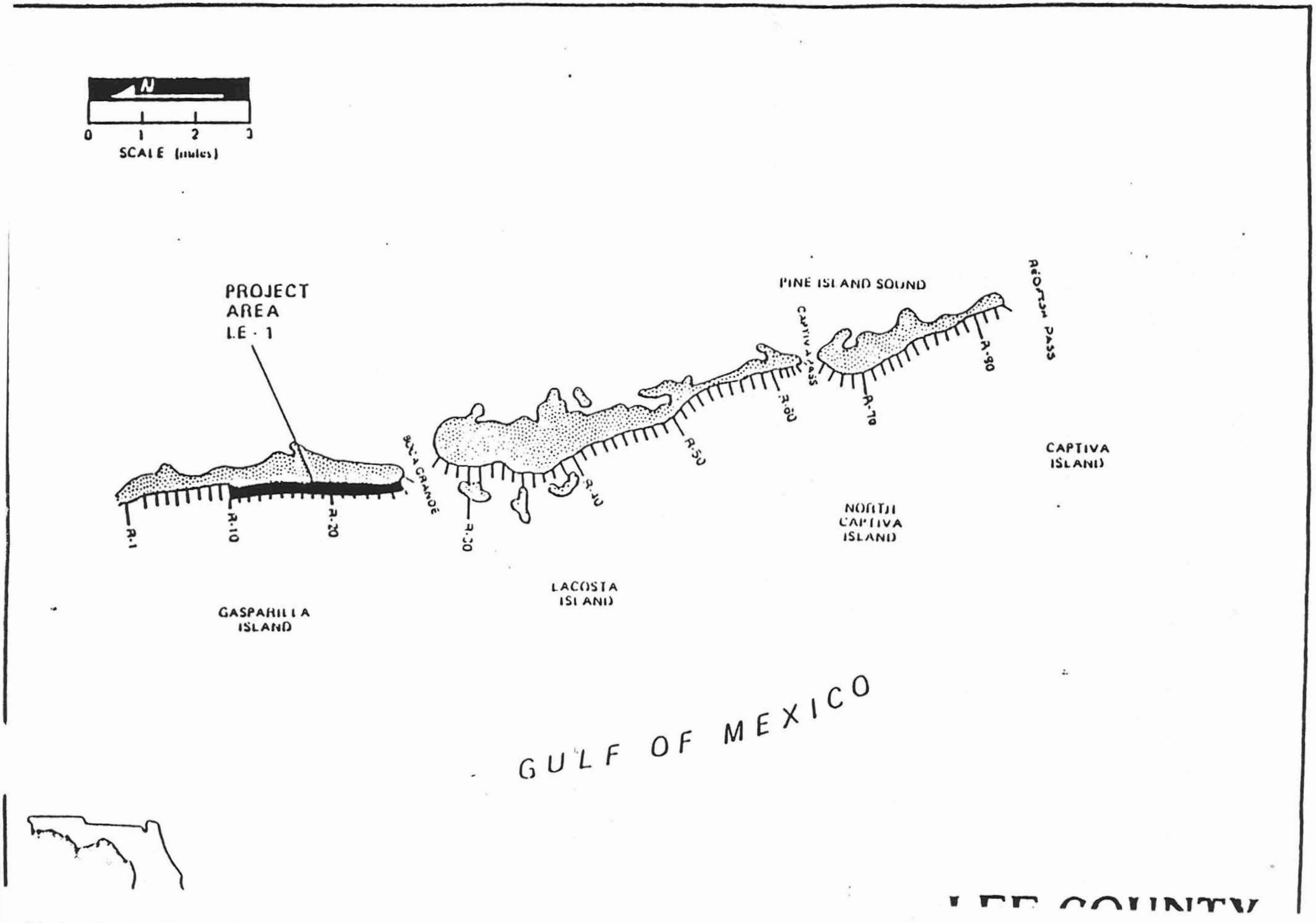
In 1981, private interests placed approximately 765,000 cubic yards of sand excavated from Redfish Pass along the northernmost 10,000 ft. of Captiva Island Subsequent restoration of the island by the Captiva Erosion Prevention District has been designed and permitted but not implemented. No other plans for local or federal beach nourishment efforts presently exist for Lee County.

ADDRESSING IDENTIFIED EROSION PROBLEMS

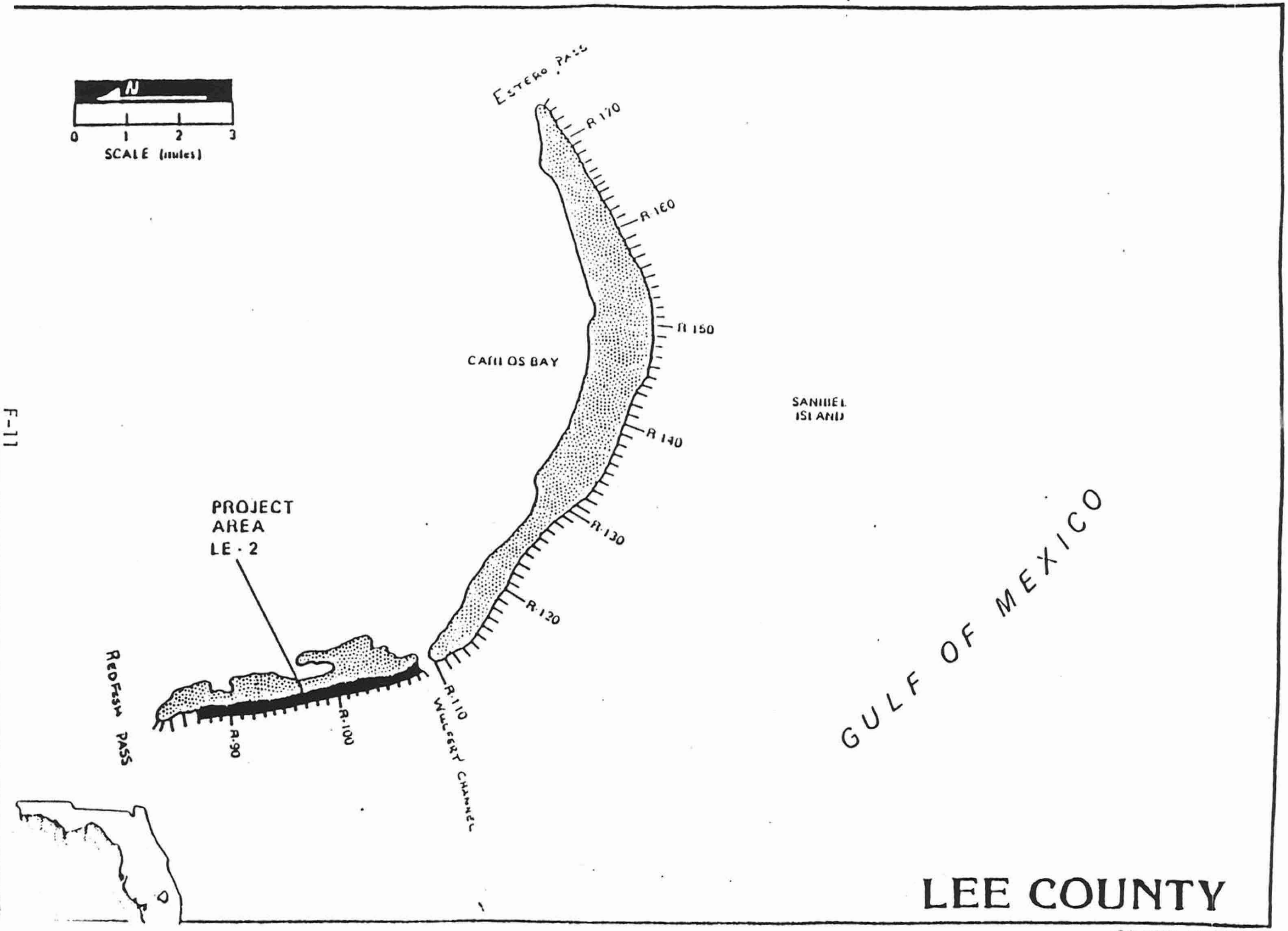
Of the total 47 miles of gulf-front beach in Lee County some 11.27 miles or 24 percent are considered to be eroding. Four projects were identified making up the 11.3 miles of eroding beach shoreline. A summary of the four projects identified are:

Summary of
Identified Beach Restoration Projects
in Lee County

Project Number	Project Name	Proposed Project Length (Miles)	Estimated Project Cost
LE -1	Gasparilla South R10-R26A	3.42	$ 5,823,000
LE -2	Captiva Island R87-R109	4.30	7,954,000
LE -3	Estero Island R180-R210	2.64	400,000
LE -4	Bonita Beach R225-R230	.90	Not Recommended
TOTAL		11.26	$ 14,177,000



N
0
1
2
3
SCALE (miles)
PROJECT AREA LE-1
PINE ISLAND SOUND
CAPTIVA PASS
R-1
R-10
R-20
R-30
R-50
R-60
R-70
R-90
CAPTIVA ISLAND
NORTH CAPTIVA ISLAND
LACOSTA ISLAND
GASPARILLA ISLAND
GULF OF MEXICO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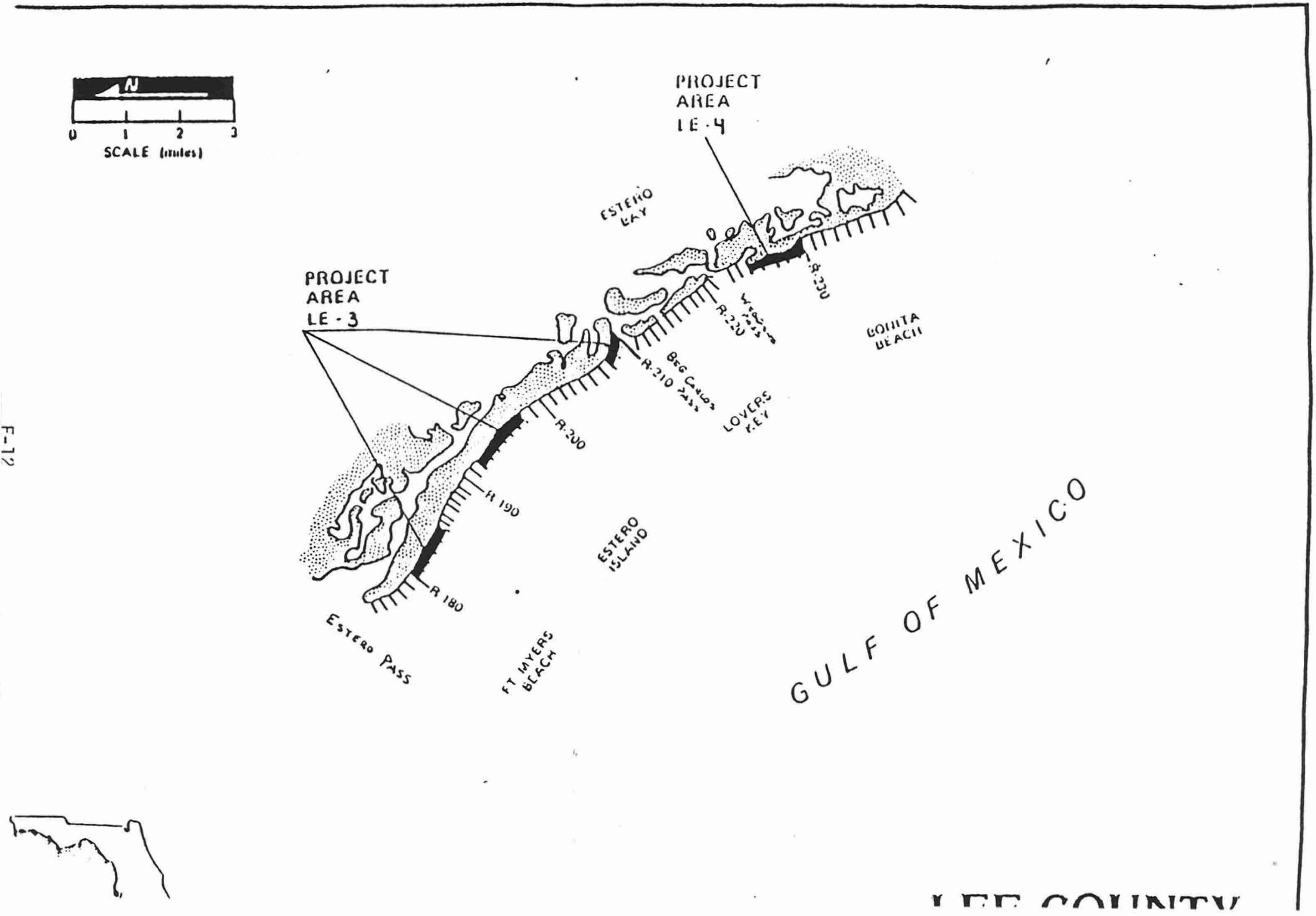
ESTERO PASS
R-170
R-160
R-150
R-140
R-130
R-120
R-110
WULFERT CHANNEL
R-100
R-90
REDFISH PASS
CARLOS BAY
SANIBEL ISLAND
GULF OF MEXICO
PROJECT AREA LE-2
LEE COUNTY

CONTINUED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PROJECT
AREA
LE-4
PROJECT
AREA
LE-3
ESTERO
BAY
R-230
R-220
R-210
R-200
R 190
R 180
BONITA
BEACH
LOVERS
KEY
ESTERO
ISLAND
ESTERO PASS
FT MYERS
BEACH
GULF OF MEXICO
LEE COUNTY

(SOUTH) GASPARILLA ISLAND BEACH RESTORATION PROJECT - PROJECT NO. LE-1

A nourishment project was considered for 18,050 feet of shoreline along the southernmost portion of Gasparilla Island. The project is located between DNR monuments R-10 and R-26A and includes the community of Boca Grande, the Gasparilla State Recreation Area, and the Boca Grande lighthouse. The project was divided into three segments in order to address varying nourishment requirements along the shoreline. (The diversity of requirements is in part due to a previous nourishment project implemented over part of the area in 1981) Segment I includes the northern 7,380 feet of the project, beginning at R-10 and ending at approximately R-16.5. This segment includes the major part of the Boca Grande community and is characterized by medium- to high-density and single- and multi-family dwellings. Segment 2 extends 7,055 feet south of the first segment to a point about 1,500 feet north of the oil terminal at the south end of the island (i.e., from R-16.5 to R23.5). This segment is characterized by about 8 multi-family dwelling developments located along the gulf side of the access road (S.R. 771), while the upland side of the road is only moderately developed. Segment 3 includes the southern tip of the island (i.e., R-23.5 to R-26A), and most notably includes the oil terminal complex and the Boca Grande lighthouse. This segment includes about 3,615 feet of gulf-front shoreline. This relatively short segment represents a mix of state-owned and commercial properties. North of the oil terminal bulkhead, about 30 feet of recreational beach width exists. The bulkhead extends notably seaward and is fronted by the gulf. Structures associated with the bulkhead and oil terminal are between 10 and 70 feet landward of MHW. The estimated fill volume for the project is 1,228,075 cubic yards. The estimated project cost is $5,823,000. Potential sources of the nourishment material include maintenance dredging of Boca Grande Pass (also called the Charlotte Harbor entrance channel) and the shoals associated with the Pass. The previous beach nourishment along the project site in 1981 included 264,062 cubic yards of material resulting from maintenance dredging of the entrance channel. From 1978 through 1985, the entrance channel was dredged for maintenance purposes five times for a cumulative removal of approximately 1.6 million cubic yards. This represents an average annual rate of 228,500 cubic yards of material per year, or 1.7 times the estimated project renourishment requirements. Accordingly, the Boca Grande Pass channel is the most likely source of the project renourishment material and at least a portion of the initial nourishment. Additional material, as required, could be derived from the ebb-tidal shoals of the Pass, estimated to contain 159 million cubic yards of sediment (Hine et al., 1987). Data indicating the quality of the shoal material is not available.

The preferred source of material would be centered about the Pass rather than along sites offshore of the island. It is not anticipated that excavating material from the Pass to the northern shoreline will adversely affect the southern shoreline. Briefly stated, this is based upon the assumption that Boca Grande Pass does not normally, nor naturally, bypass significant net amounts of sediment to the south.

Anticipated Environmental Impact

As the Charlotte Harbor entrance channel has been used several times, with Department of Environmental Regulation water quality certifications obtained, it is assumed this source of sand can continue to be used and at the same time provide for maintenance dredging of the channel. Because of this it can be reasonably assumed and anticipated that the project would not have any long-term significant adverse impact on natural resources in the area.

Public Use of Project Area

Within the proposed south Gasparilla Island beach restoration there exists 20 beach access sites. Most of the 20 sites have no parking facilities available. Four of the beach access sites are considered good with three considered excellent. The largest access site in the project reach is the Gasparilla State Recreation Area with some 2,810 feet of beachfront. Collectively the 20 beach access sites within the project area have approximately 3,937 feet of beachfront with approximately 701 public parking spaces.

The demand supply ratio as calculated by the Department of Natural Resources, Division of Recreation and Parks is 0.87, indicating that supply exceeds estimated demand in Lee County for beach activities.

The project area is very heavily used by area residents and Lee County tourists. An additional 6,076 user occasions can be accommodated by the proposed increased beach width.

Property Threatened by Erosion

Combined land and structure value within the project area total $70,651,180. Of significance, however, is the value of land area estimated at $20,169,000 which includes the several publicly owned beach access sites. The land use in the northern project area is primarily multi-family development and recreation lands. The center segment of the project, encompassing about 7,055 feet of shoreline, and is characterized by multi-family development and recreational lands. The more southern portion of the project represents a mix of state-owned and commercial properties and includes an oil terminal complex and the Boca Grande lighthouse. The storm wave susceptibility category for this project is moderate high to high.

Extent of Public Support

The sand source for this project is also a continuing maintenance dredging area by the U.S. Army Corps of Engineers in maintaining the Boca Grande channel. Cost sharing for this project is available from this source. More information is needed regarding extent of public support.

Recommended Project Disposition

The Department recommends state authorization for this project and that coordination be made with the U.S. Army Corps of Engineers in an effort to place fill from the maintenance dredging of Boca Grande channel on this project shoreline under an inlet maintenance dredging program schedule each time the channel is dredged.

CAPTIVA ISLAND BEACH RESTORATION PROJECT - PROJECT NO. LE-2

A beach nourishment project was considered for the entirety of Captiva Island; i.e., approximately 22,750 feet (4.3 miles) of shoreline extending from Redfish pass (R-87) to Blind Pass (R109). The project was considered as three contiguous segments in order to address varying nourishment needs. Segment 1 corresponds to South Seas Plantation (R-87 to R-93.4) and includes 6,370 feet of shoreline. South Seas Plantation (SSP) is a privately-owned development consisting of mixed single- and multi-family dwellings, a golf course, marina, and other recreational facilities. Approximately 765,000 cubic yards of material was placed along the SSP shoreline in 1981. About 70% of this material remains in the project area to date (Coastal Planning & Engineering, 1986).

Segment 2 includes the northern half of the remainder of the island, that is, the northern half of the Captiva Erosion Prevention district (CEPD). This segment is 8,480 feet long and extends from the southern boundary of South Seas Plantation (R-93.4) to the southern end of the long revetment which protects the access road (R-101.4). The area is, characterized by medium-density residential dwellings.

Segment 3 includes the southern half of CEPD. This segment is 7,900 feet long and extends from segment 2 to Blind Pass; i.e., R-101.4 to R-109.3. The area is characterized by low-density residential dwellings and estates.

Two sites have been identified as potential sources for beach nourishment material for projects along Captiva Island (Olsen, 1980). The preferred site is located 2,000 feet westward of Redfish Pass and corresponds to the Redfish Pass ebb tidal shoal. This area is characterized by clean sand and shell and was used for the SSP nourishment project in 1981. It is estimated that about 2.8 million cubic yards of material exists in the Redfish Pass ebb tidal shoal (Hine et al., 1987). The entire shoal system may contain as much as 8 million cubic yards, half of which may be seaward of the Pass (UF/COEL, 1974). Over 2 million yards of the seaward shoal sediments may have been derived from net erosion of the adjacent shoreline, and the entire shoal system may be continuing to accrete at a rate of 100,000 to 200,000 cubic yards per year (Olsen, 1980; UF/COEL, 1974). Accordingly, the existing shoal volume is probably sufficient (by a factor of 2) to supply the project's initial nourishment needs. The total project reach of 22,750 feet is proposed to be filled with 1,465,100 cubic yards which will add an additional 67 feet (average) of beach width. The cost of the proposed project is estimated at $7,954,000 if pipeline dredge is used. The renourishment interval is expected to be 5 years.

Public Use of the Project Area

As described earlier, the project area is characterized on the north by South Seas Plantation, a privately-owned resort development, and to the south by medium density residential dwellings. Public access areas existing within the project area includes a small beach access site located immediately south of South Seas Plantation which has the capacity for about 20 vehicles. An additional 30 spaces is expected to be added to this site. The only other access site available is Turner Beach, an 800 foot beach park with about 70 public parking spaces available. Together, the two beach access sites, which are considered good sites, offer some 90 public parking spaces for the 4.3 mile project reach with an additional 30 spaces in the planning stage.

Anticipated Environmental Impact

Considerable literature regarding the environmental resources around the Captiv Island area is available as a result of the recent restoration project undertaken at South Seas Plantation. Available literature suggests that use of the borrow site recommended (Redfish Pass) will destroy the existing biota; however, it is believed that this is short term and that the area will rapidly recover much as did the same borrow area after dredging for the South Seas Plantation project. Vertical biota zones in the fill area will be affected. Sufficient evidence exists to anticipate no long-term adverse environmental impact will occur as a result of the project. Increase beach width will provid additional beach area for turtle nesting.

Property Threatened by Erosion

Structure value of the project area is $93,423,000 with land value estimated at $76,495,000 for a total property value of $169,918,000 which represents a $7,46 value per linear foot for the project. The storm wave susceptibility for the project area is moderate high to high.

Extent of Public Support

The Captiva Erosion Prevention District supports the project as well as Lee County government. There is a good possibility of federal funding being made available.

Recommended Disposition of Project

The Department feels that beach restoration is the preferred method for coping with the erosion problem of the area and protecting considerable upland private property value. Two public access sites are available and 90 public parking spaces with 30 more spaces planned. The Department has had a strong indication that the expansion of parking spaces will be seriously considered. If such is the case, state involvement in at least three-fourths of a mile of the project area could be realized.

Department staff recommends state authorization for this project.

ESTERO ISLAND BEACH RESTORATION PROJECT - PROJECT NO. LE-3

Beach nourishment projects were considered for three non-contiguous areas along Estero Island at a total cost of $5,180,000. The three projects were considered together because of the likelihood that each could be initiated and/or renourished as a common project; that is, by one dredging contractor with a single mobilization.

The first area, or segment 1, includes 5,182 feet of shoreline beginning one mile from the northern tip of the island. The area extends from 700 feet north of the Ft. Myers Beach fishing pier to 4,480 feet south of the pier; that is, from the northern boundary of Lynn Hall Memorial Park (R-180) to Mango Street (R-185). From a public viewpoint, this area is the primary "commercial" region of Ft. Myers Beach. Development and traffic here are congested, as the only northern access to the lower barrier islands of Lee County (Rt.867) is situated towards the northern end of the area. North of the pier, beneficial effects of previous beach nourishment in 1986 are still somewhat recognizable. However, south of the pier, the existing beach conditions give the impression of severe local erosion. This is primarily due to the poor local set-back of structures; specifically, the orientation of the structure line at this point is west-northwest while the barrier island coastline curves to the north.

The second area, segment 2, includes 6,204 feet of shoreline between Strandview Avenue (R-192) and Lanark Avenue (R-198), and is located 8,170 feet (1.55 miles) south of segment 1. Inspection of this area in January, 1987, indicated severe beach erosion. The area is densely developed with single- and multi-family dwellings. Sporadically-placed groins and low-elevation bulkheads are present along the area.

Near the middle of the island and in the project area vicinity, there exists a nodal point from which sediment transport diverges to the north and south resulting in net sand starvation at that location.

The third area, segment 3, is referred to as Carlos Point, and includes 2,556 feet of shoreline at the southern end of Estero Island, just north of the bridge over Big Carlos Pass. The area is located "below" the major spit field which is developing along southern Estero island. Although these major spit and shoal features may eventually migrate onto the southern portion of the island, it appears at present that southerly-drifting sediment is stored along the spits and shoals and does not reach Carlos Point. Currently, the Point is receding, most probably because of sediment starvation and the influence of flow through and around Big Carlos Pass. Development along this area is slightly less dense than the rest of the island, but includes several substantial homes and recently constructed high-rise condominium buildings.

A number of potential borrow sites were considered for the project. These include: 1) the Ft. Myers Beach channel, 2) a site offshore of Ft. Myers Beach, 3) the outer spit/shoal features along the southern portion of the island, and 4) the ebb-tidal shoals of Big Carlos Pass.

The entrance to San Carlos Bay, referred to as the Ft. Myers Beach Channel, is a relatively shallow (12 ft) navigation project. The U.S. Army Corps of Engineers has removed a cumulative total of approximately 767,000 cubic yards of material from the channel during five maintenance operations conducted over the past 25 years. (USAGE Jacksonville District, personal communication). All of the material has been placed along Ft. Myers Beach in the vicinity of segment 1 of the project described herein. From limited core-boring data, it appears that the gulfward-most portion of the channel includes a 9-ft thick lense of medium to fine quartz sand with no overburden at an existing bottom depth of about -12 ft MLW. (USAGE, 1985) It appears that the silt and clay content of the channel increases markedly north of and leeward of the island.

Core borings taken along the northern quarter of the island (USAGE, 1969) indicate that beach quality sand may exist in a lens of 5 to 20 ft thickness about 1,800 feet offshore along the northernmost mile of the island. Existing seabed depths in this area are between -7 and -10 ft MLW. Further south, lense thickness and sand quality decreases markedly.

The shoals of Big Carlos Pass at the south end of the island represent a basically unexpired potential source of borrow material. Hine et al. (1987) estimates that the ebb-tidal shoals of the Pass include over 8 million cubic yards of sediment; however, no data are available which describe the quality of the material. The outer edge of the shoals and spit features along the southern shoreline of the island may also represent a potential source of material. The degree to which the subaqueous portions of these features are vegetated is not known at this time. Certainly, the borrowing of material from these areas must be limited so as not to destroy the integrity of the shoals nor remove the protective role which these features play for much of southern Estero Island.

Most likely, one or both of the northern borrow sites would be appropriate for segment 1 of the project. A single, typical maintenance dredging of the Ft. Myers beach channel may provide sufficient material for the estimated periodically required renourishment of segment 1. However, initial placement may require borrowing from the site offshore of Ft. Myers Beach, as well as routine maintenance dredging of the channel. Clearly, if both segments 1 and 2 were to share a common general borrow site, the site most probably must include both maintenance dredging of the channel as well as borrowing from the area offshore of the island's northern shoreline. However, initial and renourishment requirements of segments 1 and 2 could theoretically deplete the offshore supply of beach quality material within 30 years.

The Big Carlos Pass shoals may provide the most likely source of material for segment 3. Operations here would require short transit distances (less than 6,000 feet, total). The relatively small requirements of the initial project and renourishment (192,000 cubic yards and the equivalent of 15,700 cy/yr, respectively) could probably be met with little difficulty.

Although some grain size data exists along the Ft. Myers Beach Channel (USAGE, 1985), detailed data from the native shoreline, potential offshore borrow site, spits and shoals, and Big Carlos Pass are not available.

It is anticipated that beach fill material placed along segment 1 may drift predominately northwards (while also providing some "feeder" material to the south). Based on recent aerial inspection, this appears to be the case for the last nourishment of this area (1986). If this is true, then renourishing the project from maintenance dredging of the channel may be viewed as fill back-passing. It is anticipated that material placed along segment 2 may drift both north and south. This would provide feeder beach benefits to the north, but would be of diminished benefit to the south, as the material would likely be "lost" to the nearshore spits and shoals which are located just south of segment 2. This may argue for the judicious borrowing of material from the gulfward edge of the spits and shoals to renourish segment 2. Finally, it is anticipated that fill performance along segment 3 will be affected by the currents of Big Carlos Pass and fill material will drift along the bayside of the island and/or be "lost" to the nearshore shoals; hence, no "feeder beach" benefits are anticipated from segment 3 of the project.

Public Use of Project Area

Within the first segment of the project area there exists fifteen beach access sites of which thirteen are considered poor, one site is considered excellent, with one good site. Eleven of the poor sites have no public parking available. Considering the existence of one excellent site and one good beach access site with a total of 223 public parking spaces available this segment of the project area qualifies for state participation at least for this qualification factor.

The additional user occasions that could be served by increased beach area, if restoration is provided for this segment, is 1,703. The demand supply ratio computed by the DNR Division of Recreation and Parks is .87 indicating that supply slightly exceeds demand for beach activities in Lee County. However, localized demand in the highly congested Ft. Myers Beach area would certainly indicate a need for increased beach area.

The second segment of the project area, (R192 to R198), located approximately mid-Estero Island, has ten public beach access sites varying in length from 15 feet to 50 feet. All of the sites are considered poor and collectively have 39 public parking spaces available.

The third segment of the project, (R207 to R210), is a .49 mile stretch at the southern end of Estero Island. No public beach access exists within this segment of the project. Considering public use benefit of the three segments of this project only the first segment (Ft. Myers Beach) qualifies for state involvement.

Anticipated Environmental Impact

Material from the Ft. Myers Beach channel has been placed on Ft. Myers Beach several times in the past with water quality certifications provided.

Considering this, it can be assumed that environmental concerns for this segment of the project have been satisfied, if only use of the channel is considered. Insufficient data exists to anticipate environmental impact for the restoration of segments 2 and 3 of the project.

Property Threatened Due to Erosion

There exists extensive commercial development and a large excellent beach access site within segment 1 of the proposed project. The structure value of the reach is estimated at $33,869,000 with land values set at $20,408,000 for a total property value of $54,277,000. The average estimated property value for this segment is $10,474 per foot.

Segment 2 has a total property value of $41,305,000 with land value estimates set at $11,105,000 and structure value set at at $30,200,000.

In segment 3, there exists an estimated $27,646,000 in structure value and $6,633,000 in land value.

Recommended Disposition of Project

Based on information collected for this project, as previously summarized, it is recommended that segment 1 of the project area (5,180 feet) be under a continuing nourishment program with coordination between the U.S. Army Corps of Engineers and the Department. Material for the renourishment would come from the Ft. Myers Beach Channel under the periodic maintenance dredging of that federally authorized project.

Because of the lack of beach access and public parking, segment 2 of the project area does not qualify for state involvement.

Segment 3 of the project area has no beach access, thus any benefits derived from restoration would largely accrue to the upland owners and not to the general public. There are no detailed data regarding quality of sand source for the project. If Big Carlos Pass were to be used as a sand source, the performance along the segment 3 area will be affected by the currents of Big Carlos Pass and fill material will drift along the bayside of the island and/or be lost to the nearshore shoals. Environmental concerns are evident if the fill material enters the bayside of the island .

Department staff recommends state authorization for Segment 1 of this project only.

BONITA BEACH RESTORATION - PROJECT NO. LE-4

A beach restoration project was considered for the northern-most 4,750 feet of Little Hickory Island (Bonita Beach) at an estimated cost of $1,911,000. Specifically, the area extends from just north of the Bonita Beach Club below Big Hickory Pass southward to about 1,000 feet south of the Black Island/Bonita Beach bridge. This corresponds to DNR monuments R-225.5 through R-230. The gulf shoreline along this area is developed almost exclusively with high-rise condominiums. The effects of erosion along the northern half of the area are readily apparent; virtually no sandy beach is exposed at mean high water. Bulkheads line the shorefront along this northern half and are reinforced by a rock revetment along the Bonita Beach Club at the far north end. The average existing set-back of the structure line along this northern half is approximately 26 feet form MHW. From aerial or ground inspection, it is immediately evident that the structure line of the large condominiums along the northern half of the proposed fill area is projected far too seaward and is not oriented with the existing shoreline. Presumably, this is due to natural realignment (straightening) of the shoreline associated with recent changes at Big Hickory pass. Potential sources of beach fill material include the shoals of New Pass and remnant shoals of Big Hickory Pass. The ebb-tidal shoal volume at New Pass is estimated at between 420,000 cubic yards (Hine et al., 1987) and 540,000 cubic yards (Walton and Dean, 1976). In light of this information, the initial nourishment project may deplete the borrow source. A possible alternative for the renourishment would be to back-pass the fill from the spit and shoal area of Big Hickory Pass, since it is anticipated that much of the fill may drift northwards along the spit towards Big Hickory Pass. If this is the case, it is also apparent that there may be little "feeder beach" benefits of the project to the remainder of Bonita Beach.

No detailed geotechnical data exists around the proposed borrow area. If the nourishment material were developed by dredging the spit at the north end of Bonita Beach so as to re-open Big Hickory Pass, some beneficial flushing of the shallow bays around Little Hickory Island might be achieved. However, it is not likely that the pass would remain open for very long. If each periodic renourishment subsequently re-opened Big Hickory Pass in a similar way, the water quality of the bays would fluctuate cyclically with each renourishment (not considering other changes to the area due to natural and man-made conditions). The environmental consequences of such action must be carefully addressed before this type of borrow scenario could be implemented.

Public Use of Project Area

There are no good public beach access sites within the project area. In particular, entrance to the Bonita Beach Club at the far north end of the island is restricted by a private guard, and the remainder of the shorefront condominiums clearly post the owners' objections to trespassers. This poses a classic difficulty to members of the public who wish to walk along the northern, undeveloped portions of the island/spit, because access to these areas is generally only possible by walking along the condominium bulkheads or concrete "boardwalks". Accordingly, some public recreational benefit could theoretically be realized from the project, but it is presently superseded by the problem of limited public parking and restricted initial beach access.

Recommended Disposition of Project

One public access site is available within the project area but has no public parking spaces. As such, the project does not qualify for state involvement.

Department staff does not recommend this project for state authorization.