

SITE CERTIFICATION APPLICATION
BIG BEND STATION UNIT 4
TAMPA ELECTRIC COMPANY

VOL. 1



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PERTINENT APPLICANT INFORMATION

PERTINENT APPLICANT INFORMATION

In this application the following information should be supplied:

Applicant's Official Name Tampa Electric Company

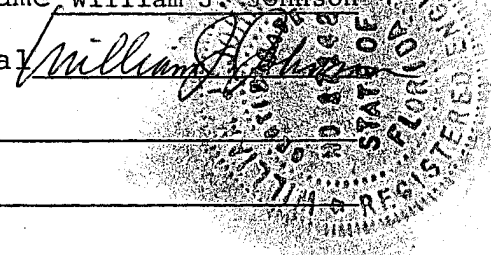
Address Post Office Box 111 Tampa, Florida 33601

Address of Official Headquarters 111 North Dale Mabry Highway, Tampa,
Florida

Business entity (corporation, partnership, co-operative, name(s),
owner(s), etc., Corporation

Name and Title of Chief Executive officer(s) H. L. Culbreath,
President and Chief Executive Officer

Name, title, address and phone number of official representative
responsible for obtaining certification William J. Johnson, PhD, P.E.,
Manager Environmental Planning P.O. Box 111, Tampa, Florida 33601

Professional Engineer Submitting Application Name William J. Johnson
Florida Registration No. 17142 Seal 

Site Location: County Hillsborough

Nearest Incorporated City Tampa

Latitude and Longitude 27° 47' 42" / 82° 24' 16"

UTMs Northerly 3075000

Easterly 361900

Name plate Generating Capacity; Currently Existing on site 1512 MWe

Capacity of Proposed Additions and Ultimate Site Capacity (where
applicable) Proposed Addition of 425 MWe.

**1. PURPOSE OF PROPOSED FACILITY AND
ASSOCIATED TRANSMISSION**

CHAPTER 1

PURPOSE OF PROPOSED FACILITY AND ASSOCIATED TRANSMISSION

1.1 SYSTEM DEMAND AND RELIABILITY

Incorporated December 2, 1899, reincorporated 1949, Tampa Electric Company (TECO) is a public utility operating wholly within Florida, principally engaged in the generation and sale of electric energy.

The service area of nearly 1900 square miles on Florida's central west coast includes all of Hillsborough County and parts of Pasco, Pinellas, and Polk Counties, which includes a population of over 700,000. TECO serves approximately 296,000 customers, has 2,390 employees, and 14,000 common shareholders. Figure 1-1 illustrates TECO's service area.

TECO produces electricity in three wholly owned power plants located on or near the eastern shores of Tampa Bay. The units in these plants have a generation capability mix of approximately 65 percent coal, 29 percent No. 6 low sulfur oil, and 6 percent No. 2 low sulfur oil. The energy produced from these plants has a generation mix of approximately 80 percent coal, 19 percent No. 6 fuel oil, and 1 percent No. 2 low sulfur oil.

Hookers Point station is the oldest of TECO's three power plants. It is located just southeast of the Tampa business district on Hookers Point, fronting the Seddon Ship Channel. Hookers Point boilers burn No. 6 low sulfur fuel oil.

Gannon station, 6 miles south of Tampa, was added to the TECO system beginning in the 1950s when Florida's growth was extremely rapid. Six units went into service between 1957 and 1967, all originally burning coal. In 1975 and 1976, in order to comply with environmental requirements the first four were converted to low sulfur No. 6 oil. Unit Nos. 5 and 6 burn low sulfur coal. One 14-MW gas turbine which burns No. 2 low sulfur oil is also located at Gannon station.

Big Bend, 10 miles south of Tampa, is TECO's newest power plant and was designed to be efficient and in harmony with the environment. Three units are burning coal. One 14-MW and two 65-MW gas turbines which burn No. 2 low sulfur oil are located just north of Big Bend station.

Presently, TECO's three power plants have a total generating capability of 2,529 net megawatts. Table 1-1 (DSP Form 1A) is a summary of existing generating facilities. Figures 1-2 and 1-3 show the historical and projected load vs capacity for the TECO system.

TECO, a member of the Florida Electric Power Coordinating Group, actively participates in the coordination, planning, and operation of the Peninsular Florida electric system.

1.1.1 Load Characteristics

Figures 1-4 through 1-15 illustrate Tampa Electric Company's hourly load shapes for the peak day in each month of the year. The summer months (April to October) have a distinct afternoon peak from 2 pm to 9 pm as a result of air conditioning. During the winter months (December to February), there are usually two peaks (one in the morning and one in the afternoon) resulting from electric space heating. The transition months (March and November) can resemble the summer or winter characteristics, depending on the type of weather.

Figure 1-16 is a graph of the Tampa Electric Load Duration Curves in 1977 and 1986. The load factor is expected to decline during this period and is reflected by the change in the curves. This decrease is attributed to a lower percentage of sales to the high load factor phosphate industry over the next decade and a larger percentage of sales to the residential and commercial sectors.

Table 1-2 details the historical and projected relationships of summer and winter peak loads. This table reflects TECO as a winter peaking utility (the summer peak loads are less than the following winter loads) over the next decade. The TECO estimates are compared with SERC (winter peaking) and the U.S. utilities (summer peaking). Additional information describing TECO's load characteristics can be found in Table 1-3.

1.1.1.1 Load Analysis

Appendix 1A details the historical and projected demand and energy data, as well as additional information on load factors, phosphate sales, customers, price, and appliances. The data in Appendix 1A is the result of using several different forecasting methods which are explained in Appendix 1B. Tables 1-3, 1-4, and 1-5 depict the history and forecast of the energy use by customer class and the history and forecast of summer and winter peak demands.

Projected data listed in this report include the period from 1979 to 1988 while Table 1-6, however, does present estimates of demand and energy growth rates from 1988 to 1998, as well as 1968 to 1988 data. This table illustrates that the demand and energy growth after 1988 is expected to be slightly lower than the 1978 to 1988 period. The reduction in demand after 1988 is the result of one or both of the following:

(1) Decline in new customer increases

(2) Decline in major appliance increases, due to saturation.

Appendix 1E outlines projected data of other utilities in the state (1979 Ten Year Site Plan for State of Florida). This data is included for comparison purposes although many of the forecasts may have been revised since the study was completed.

1.1.1.2 Demand Projections

Tampa Electric Company historical and projected data and assumptions are listed in Appendix 1A. Tables 1-7 and 1-8 summarize key assumptions that have been made in preparing this forecast. Table 1-7 details information in the following areas:

Population

Price of Electricity

System Load Factor

Appliance Saturation

Average Use per Residential Customer

Table 1-8 details information for Hillsborough County on income and employment.

Appendices 1B and 1C describe the technique that has been used to prepare this forecast. Three different methods are combined to produce the demand and energy projections. Each of the methods is unique and relies, in varying degrees, on statistical analysis and judgment.

1.1.1.3 Capacity Exchanges

A future unit power contract from TECO's Big Bend Unit No. 4 to another utility is in negotiations with a term beginning approximately May 1985 and continuing through December 1987. The capacity to the other utility will be in accordance with the schedule of need as determined by the utility but not to exceed an amount set by TECO which will allow TECO to assure reliable service to its customers.

TECO is pursuing joint ownership for future generation expansion. To meet future base load requirements, coal and nuclear will continue to be reviewed to determine the most economical and feasible generation expansion. By using economy of scale, two or more utilities may benefit from joint ownership.

TECO has three full interchange agreements with Florida Power & Light Company, Florida Power Corporation, and the city of Lakeland.

In addition, TECO has economy interchange agreements with Fort Pierce Utilities Authority, city of Homestead, Lake Worth Utilities Authority, Orlando Utilities Commission, and Vero Beach Municipal Utilities. TECO will participate in economy interchange transactions whenever possible.

1.1.2 System Capacity

TECO is an active participant in the Florida Electric Power Coordinating Group (FCG) as well as in the committee in FCG responsible for reviewing the Peninsular Florida's reliability, the System Planning Committee. The System Planning Committee prepares the Peninsular Florida Generation Reliability Study annually. A copy of the August 23, 1978 report is included as Appendix 1F. The results of the study as shown in Table 13 of the report indicate that, for the period of 1978-1987 and with the currently planned additions, the Peninsular Florida exposure to loss-of-load averages 0.18 days per year as compared with the accepted desired value of 0.1 days per year. As shown in Appendix 1E, the 1978 Ten Year Site Plan for the State of Florida, the 1978/79 total system winter peak for TECO is 10.5 percent of the Peninsular Florida's total system peak, which demonstrates that TECO plays an important role in the Peninsular Florida reliability.

Capacity requirements and system reliability are determined by the Loss of Load Probability (LOLP) method in conjunction with General Electric Company's Optimized Generation Planning (OGP) Program. The LOLP method combines a probabilistic capacity model with a model of daily peak hour loads to determine the number of days per year that can be expected to incur some degree of capacity shortage. The LOLP is defined as the expected number of days per year when generation will be insufficient to meet firm load. Firm load is defined as the total system load less interruptible load. Only those customers who are receiving an interruptible rate and whose service can be directly interrupted are included as interruptible load.

The single area calculation of LOLP considers all loads and generators of a system to be on the same electrical bus. The transmission system effects are not modeled in this calculation. The LOLP method does not give any weight to the amount or duration of the capacity shortage, but only to the fact that there is a certain probability of having some capacity shortage during the peak hours of the day.

1.1.3 Reserve Margin

TECO has an obligation to contribute its fair share of the generation additions to maintain the Peninsular Florida reliability. TECO evaluates its reliance upon the

Peninsular Florida generating system and its interconnections periodically with the use of probability studies. TECO's objective is to maximize the effective benefit of both the interconnections and diversity of generation outages associated with a large electric supply system, while at the same time contributing TECO's fair share to assure system reliability. TECO's fair share is evaluated through a measure of reliance upon the Peninsular Florida generation and interconnecting system.

From the projected load growth as shown in DSP Form 4 in Appendix 1D, TECO needs additional generating capacity of approximately 100 MW per year beginning in 1983. In addition, the economics of generation mix and the desire for flexibility in case of changes in load growth indicate that the required capacity is best provided with peaking capacity in 1983 and 1984 followed by Big Bend No. 4 in 1985. The reserve margin resulting from this expansion after the impact of maintenance is considered is shown on DSP Forms 7A and 7B in Appendix 1D.

Planned maintenance is manually forecasted for the first two years of the ten-year study. Starting with the third year, the maintenance schedule is estimated using a computer program that levelizes risk.

A summary of the interties that TECO has with other utilities is listed in Table 1-11.

TECO is negotiating a firm power unit contract associated with Big Bend Unit No. 4, as discussed in Section 1.1.1.3.

1.2 OTHER OBJECTIVES

The proposed facility is not planned to be used for other objectives at this time, such as the production of steam for resale.

1.3 CONSEQUENCES OF DELAY

Big Bend No. 4 plays an important role in the reliability of Peninsular Florida. As shown in Table 16 of the Peninsular Florida Generation Reliability Study, the effect of delaying the proposed units in Peninsular Florida for one year that are presently scheduled for a 1985 in-service-date would have the effect of decreasing the reliability from 0.19 to 1.5 days per year loss of load probability. Further, the effect on the TECO system reserve by delaying Big Bend Unit No. 4 is demonstrated in Table 1-12 of the Appendix 1E. As shown, the total system load and firm load winter reserves will drop to 9 percent and 20 percent, respectively, in 1985 without the addition of Big Bend Unit No. 4. With the addition of Big Bend Unit No. 4, the same reserve values are 26 percent and 38 percent.

While baseload generation is the foundation of TECO's present and future system, flexibility is built into the future expansion plans by having an in-service-date of 1985 for Big Bend No. 4 and 100 MW of gas turbines in each year 1983 and 1984. Due to the short lead time in the construction of gas turbines, should a delay in the load forecast or other factors occur that would reduce the need for generating capacity, some or all of the gas turbines could be deleted. Conversely, if the load forecast or other factors occur that will require additional generating capacity, additional gas turbines could be added without detriment to the optimal generation mix. However, should Big Bend No. 4 be delayed, a significant amount of gas turbines would be needed, requiring a much greater use of #2 fuel oil. A significant increase in the use of #2 oil would be undesirable due both to the uncertainty in availability and rapidly escalating costs.

While the social and economic impact of power shortages are recognized, the specific impact due to the delay of Big Bend Unit No. 4 has not been quantified. However, the social and economic benefits of the unit are addressed in Chapter 7.

Should TECO experience a capacity deficiency, a plan is maintained which when implemented would reduce the load through priority assignments to assure system stability. This is a short term plan, however, and should not be relied upon in lieu of good system reliability planning.

The plan, beginning with curtailment of the interruptible load is frequently implemented in varying degrees. The latter phases of the plan involving curtailment of firm load have been required only on very rare occasions such as January 18, 1977 when it was snowing in Tampa.

TABLE 1-1
EXISTING GENERATING FACILITIES

TAMPA ELECTRIC COMPANY

(DSP FORM 1A)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Plant Name	Unit No.	Location	Type	Fuel		Com'l In-Service Mo/Yr	Exptd. Retirmt Mo/Yr	Gen Max Nameplate kW (x1000)	Net Capability	
				Pri	Alt				Summer MW	Winter MW
Francis J. Gannon		Hillsborough Co. 4/30S/19E								
	1		F	HO	No	8/57	Unknown	1288.38	1106	1106
	2		F	HO	No	10/58	Unknown	125	98	98
	3		F	HO	No	8/60	Unknown	179.52	108	108
	4		F	HO	No	7/63	Unknown	125	150	150
	5		F	C	No	9/65	Unknown	187.5	169	169
	6		F	C	No	9/67	Unknown	239.36	229	229
1		CT	LO	No	1/69	Unknown	414	338	338	
							18	14	14	
Hookers Point		Hillsborough Co. 19/29S/19E								
	1		F	HO	No	7/48	12/90	232.6	193	193
	2		F	HO	No	6/50	12/90	33	28	28
	3		F	HO	No	8/50	12/90	34.5	29	29
	4		F	HO	No	10/53	12/90	34.5	28	28
	5		F	HO	No	5/55	12/90	49	42	42
								81.6	66	66
Big Bend		Hillsborough Co. 9/31S/19E								
	1		F	C	No	10/70	Unknown	1512	1206	1206
	2		F	C	No	4/73	Unknown	445.5	362	362
	3		F	C	No	5/76	Unknown	445.5	362	362
	1		CT	LO	No	1/69	Unknown	445.5	362	362
	253		CT	LO	No	11/74	Unknown	18	14	14
								157.5	130	130
TOTAL								2529	2529	2529

Note: All information as of July 1, 1979.

TABLE 1-2

SUMMER PEAK LOADS EXPRESSED AS PERCENTAGE OF PEAK LOAD
FOR THE FOLLOWING WINTER

ACTUAL									FORECAST								
70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87
TECO 99	108	100	105	105	92	88	91	91	91	93	92	91	90	90	89	88	88
SERC 111	109	108	106	109	100	93	99	97	98	97	97	97	96	97	96	97	96
TOTAL ELECTRIC UTILITY INDUSTRY OF THE CONTIGUOUS UNITED STATES																	
111	112	110	117	115	108	106	110	108	108	108	107	107	107	107	107	106	106

Note: All information as of July 1, 1979.

TABLE 1-3
HISTORY AND FORECAST OF ENERGY USE

TAMPA ELECTRIC COMPANY

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Year	GWh	Rural & Residential		Commercial		Industrial	
		Average* No. of Customers	Average kWh Consumption Per Customer	GWh	Average* No. of Customers	GWh	Average* No. of Customers
1969	1774	177,472	9,996	933	18,876	2525	670
1970	2019	186,153	10,849	1041	19,496	2772	661
1971	2200	195,702	11,242	1166	20,362	2718	645
1972	2416	207,213	11,657	1335	21,440	2784	639
1973	2843	221,251	12,852	1525	22,861	3004	624
1974	2828	233,356	12,118	1640	25,076	3102	614
1975	2906	239,215	12,150	1767	26,539	3297	598
1976	2911	243,548	11,952	1804	27,221	3564	599
1977	3139	249,362	12,590	1904	28,119	4008	579
1978	3313	258,971	12,792	2030	29,226	4080	576
1979	3405	270,560	12,585	2090	30,547	4016	577
1980	3524	280,030	12,584	2175	31,631	4139	580
1981	3613	287,030	12,588	2242	32,433	4170	583
1982	3702	294,206	12,583	2311	33,254	4202	586
1983	3795	301,561	12,585	2384	34,096	4235	589
1984	3908	310,608	12,582	2468	35,132	4289	592
1985	4027	319,926	12,587	2557	36,200	4329	595
1986	4147	329,524	12,585	2648	37,300	4372	598
1987	4272	339,409	12,587	2743	38,433	4416	601
1988	4400	349,592	12,586	2842	39,600	4461	604

TABLE 1-3 (Cont)

(9)	(10)	(11)	(12)	(13)	(14)	(15)
Year	Street & Highway Lighting GWH	Other Sales to Ultimate Consumers GWH	Total Sales to Ultimate Consumers GWH	Sales For Resale** GWH	Utility Use & Losses GWH	Net Energy For Load GWH
1969	28	275	5,535	0	350	5,885
1970	29	313	6,174	0	368	6,542
1971	30	367	6,481	0	365	6,846
1972	32	402	6,969	0	460	7,429
1973	35	436	7,843	0	448	8,291
1974	33	429	8,032	0	453	8,485
1975	32	462	8,469	0	546	9,015
1976	35	487	8,801	0	492	9,293
1977	35	516	9,602	0	526	10,128
1978	36	576	10,035	0	461	10,496
1979	36	588	10,135	0	564	10,699
1980	37	612	10,487	0	584	11,071
1981	37	631	10,693	0	596	11,289
1982	38	651	10,904	0	607	11,511
1983	38	671	11,123	0	619	11,742
1984	39	695	11,399	0	635	12,034
1985	39	720	11,672	0	650	12,322
1986	40	746	11,953	0	665	12,618
1987	41	772	12,244	0	682	12,926
1988	41	800	12,544	0	698	13,242

Note: All information as of July 1, 1979.

*Average of end-of-month customers for the calendar year.

**To Class III and Class V Systems.

TABLE 1-4

(DSP FORM 4)

HISTORY AND FORECAST OF SEASONAL PEAK DEMAND AND ANNUAL ENERGY REQUIREMENTS

TAMPA ELECTRIC COMPANY

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Summer Peak Demand			Load		Winter Peak Demand	
	Net MW		Net Energy	Factor*		Net MW	
Year	Interruptible	Total	For Load - GWh	%	Year	Interruptible	Total
1969	146	1022	5,885	65.7	1969-70	181	1114
1970	165	1098	6,542	68.0	1970-71	150	1105
1971	178	1194	6,846	65.5	1971-72	142	1110
1972	145	1302	7,429	65.0	1972-73	171	1300
1973	139	1441	8,291	65.7	1973-74	152	1366
1974	146	1527	8,485	63.4	1974-75	155	1458
1975	147	1565	9,015	65.8	1975-76	155	1693
1976	134	1568	9,293	67.5	1976-77	178	1784
1977	193	1720	10,128	67.2	1977-78	206	1891
1978	169	1780	10,496	67.3	1978-79	211	1960
1979	211	1861	10,699	65.6	1979-80	221	2055
1980	221	1954	11,071	64.7	1980-81	217	2104
1981	217	1984	11,289	65.0	1981-82	221	2159
1982	221	2029	11,511	64.8	1982-83	219	2235
1983	219	2087	11,742	64.2	1983-84	227	2323
1984	227	2154	12,034	63.8	1984-85	225	2411
1985	225	2216	12,322	63.5	1985-86	225	2501
1986	225	2286	12,618	63.0	1986-87	222	2588
1987	222	2352	12,926	62.7	1987-88	222	2678
1988	222	2424	13,242	62.4	1988-89	195	2751

Note: All information as of July 1, 1979.

*Load Factor Based on Summer Peak.

TABLE 1-5

(DSP FORM 5)

TWO-YEAR FORECAST OF PEAK DEMAND AND ENERGY REQUIREMENTS BY MONTH

TAMPA ELECTRIC COMPANY

(1)	(2)	(3)	(4)	(5)
<u>Year</u>	<u>Month</u>	<u>Peak Demand - Net MW</u>		<u>Net Energy For Load - GWH</u>
		<u>Interruptible</u>	<u>Total</u>	
1979	Jan	211	1960	917
	Feb	211	1880	837
	Mar	211	1642	824
	Apr	211	1593	804
	May	211	1667	907
	Jun	211	1772	952
	Jul	211	1816	976
	Aug	211	1831	983
	Sep	211	1861	953
	Oct	211	1742	851
	Nov	211	1777	807
	Dec	211	1877	889
TOTAL				10700
1980	Jan	221	2055	949
	Feb	221	1971	866
	Mar	221	1720	852
	Apr	221	1671	832
	May	221	1749	939
	Jun	221	1860	985
	Jul	221	1907	1010
	Aug	221	1923	1018
	Sep	221	1954	987
	Oct	221	1828	880
	Nov	221	1833	834
	Dec	221	1937	919
TOTAL				11071

Note: All information as of July 1, 1979.

TABLE 1-6

TAMPA ELECTRIC COMPANY
GROWTH RATE COMPARISON
DEMAND & ENERGY,
1968-1998

	<u>1968-1978</u>	<u>1978-1988</u>	<u>1988-1998</u>
Total Summer Peak Demand	6.5%	3.1%	2.6%
Total Winter Peak Demand	8.0%	3.4%	2.9%
Total Energy Sales	6.5%	2.3%	2.1%

Note: Growth rates are computed as compound annual percentage change. All information is as of July 1, 1979.

TABLE 1-7

TJIPA ELECTRIC COMPANY

SUMMARY OF SELECTED FORECAST ASSUMPTIONS

	Hillsborough County Population	Average Residential Customers	Price of Electricity 1970 \$/kWh			Total System Load Factor*	Appliance Saturation (%)			Average Use (kWh) Per Residential Customer
			Res.	Com.	Ind.		Central A/C	Central Heat	Water Heater	
1968		170,839				.67				8,962
1969		177,472				.66				9,996
1970	490,265	186,153	2.0	1.9	1.08	.67	21	25	89	10,849
1971		195,702	1.9	1.9	1.08	.65				11,242
1972		207,213	2.12	2.01	1.24	.65				11,657
1973		221,251	2.01	1.94	1.23	.65				12,052
1974		233,356	2.16	2.12	1.48	.63				12,118
1975		239,215	2.59	2.52	1.88	.66	42	40	90	12,150
1976		243,548	2.77	2.73	2.16	.63				11,952
1977		249,362				.65				12,590
1978		258,944				.64				12,792
1979		270,560				.62				12,585
1980	647,800	280,030	2.77	2.73	2.16	.62	56	50	91	12,584
1981		287,030				.61				12,588
1982		294,206				.61				12,583
1983		301,561				.60				12,585
1984		310,608				.59				12,582
1985		319,926	2.77	2.73	2.16	.58	66	58	92	12,587
1986		329,524				.58				12,585
1987		339,504				.57				12,587
1988		349,592	2.77	2.73	2.16	.56				12,586
1990	790,600						74	64	93	

*Based on Annual Peak Load

TABLE 1-8

TAMPA ELECTRIC COMPANY

SUMMARY OF SELECTED FORECAST ASSUMPTIONS

	Hillsborough County Per Capita Income (1970 \$)	Hillsborough County Employment		
		<u>Commercial</u>	<u>Industrial</u>	<u>Phosphate Chemicals</u>
1968				
1969				
1970	3,357	159,300	27,628	3,304
1971	3,461	167,823	27,014	3,359
1972	3,773	183,850	29,070	3,156
1973	3,988	204,808	30,202	3,360
1974	3,894	213,308	31,282	3,258
1975	3,781	208,402	27,787	3,467
1976	3,919	209,027	28,740	3,564
1977	4,062	219,478	29,732	3,664
1978	4,211	224,900	30,765	3,766
1979	4,365	235,492	31,841	3,872
1980	4,525	246,584	32,961	3,980
1981	4,630	256,489	33,042	3,964
1982	4,737	264,184	33,130	3,948
1983	4,847	272,110	33,224	3,917
1984	4,960	280,273	33,326	3,901
1985	5,075	288,025	33,434	3,878
1986	5,199	296,666	33,363	3,855
1987	5,325	303,489	33,298	3,831
1988	5,455	310,470	33,236	

Note: All information as of July 1, 1979.

TABLE 1-9

(DSP FORM 7A)

FORECAST OF CAPACITY, DEMAND, AND SCHEDULED MAINTENANCE
AT TIME OF SUMMER PEAK

TAMPA ELECTRIC COMPANY

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Year	Total Installed Capacity MW	Firm Capacity Import MW	Total Available Capacity MW	Peak Demand MW	Margin Before Maint.		Sched. Maint. MW	Margin During Maint.	
					MW	% of PK.		MW	% of PK.
1979	2529	0	2529	1861	668	35.9	300*	368	16.1
1980	2529	0	2529	1954	575	29.4	338	237	12.1
1981	2529	0	2529	1984	545	27.5	362	183	9.2
1982	2529	0	2529	2029	500	24.7	362	138	6.8
1983	2629	0	2629	2087	542	26.0	362	180	8.6
1984	2729	0	2729	2154	575	26.7	362	213	9.9
1985	3146	0	3146	2216	930	42.0	417	513	23.1
1986	3146	0	3146	2286	860	37.6	417	443	19.4
1987	3146	0	3146	2352	794	33.8	417	377	16.0
1988	3146	0	3146	2424	722	29.8	417	305	12.6

*Based on 1979 Maintenance Schedule (revised 12/15/78).

Note: Capacity additions and changes must be made by May 31 to be considered in effect at the time of the summer peak. All values are summer net MW. All information is as of July 1, 1979.

TABLE 1-10
FORECAST OF CAPACITY, DEMAND, AND SCHEDULED MAINTENANCE
AT TIME OF WINTER PEAK

TAMPA ELECTRIC COMPANY

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Year	Total Installed Capacity MW	Firm Capacity Import MW	Total Available Capacity MW	Peak Demand MW	Margin Before Maint.		Sched. Maint. MW	Margin During Maint.	
					MW	% of PK.		MW	% of PK.
1979-80	2529	0	2529	2055	474	23.1	229	245	11.9
1980-81	2529	0	2529	2104	425	20.2	229	196	9.3
1981-82	2529	0	2529	2159	370	17.1	229	141	6.5
1982-83	2629	0	2529	2235	294	12.7	229	65	2.9
1983-84	2629	0	2629	2323	306	13.2	229	77	3.7
1984-85	2729	0	2729	2411	318	13.2	229	89	3.7
1985-86	3146	0	3146	2501	645	25.8	229	416	16.6
1986-87	3146	0	3146	2588	558	21.6	229	329	12.7
1987-88	3146	0	3146	2678	468	17.5	229	239	8.9
1988-89	3146	0	3146	2751	395	14.4	229	166	6.0

Note: Capacity additions and changes must be made by November 30 to be considered in effect at the time of the winter peak. All values are winter net MW.
All information is as of July 1, 1979.

TABLE 1-11

TAMPA ELECTRIC COMPANY INTERTIES

FLORIDA POWER CORPORATION

<u>TECO Substation</u>	<u>FPC Substation</u>	<u>kV Rating</u>
1. Dade City	Zephyrhills	69
2. Dade City	Brooksville	69
3. Orchid Springs	Lake Wales	69
4. Pebble Dale	Fort Meade	69
5. Sheldon Road	Denham	69
6. Double Branch	Higgins	115
7. South Eloise	West Lake Wales	230
8. Pebble Dale	Fort Meade	230
9. Sheldon Road	Lake Tarpon	230
10. Sheldon Road	Lake Tarpon	230
11. Pebble Dale*	Barcola	230

FLORIDA POWER & LIGHT COMPANY

<u>TECO Substation</u>	<u>FP&L Substation</u>	<u>kV Rating</u>
1. Big Bend	Ringling	230
2. Big Bend	Manatee	230

CITY OF LAKELAND

<u>TECO Substation</u>	<u>Lakeland Substation</u>	<u>kV Rating</u>
1. Ariana	Larsen Plant	69
2. Sandhill	Highland City	69

*Replace No. 8 in 1982

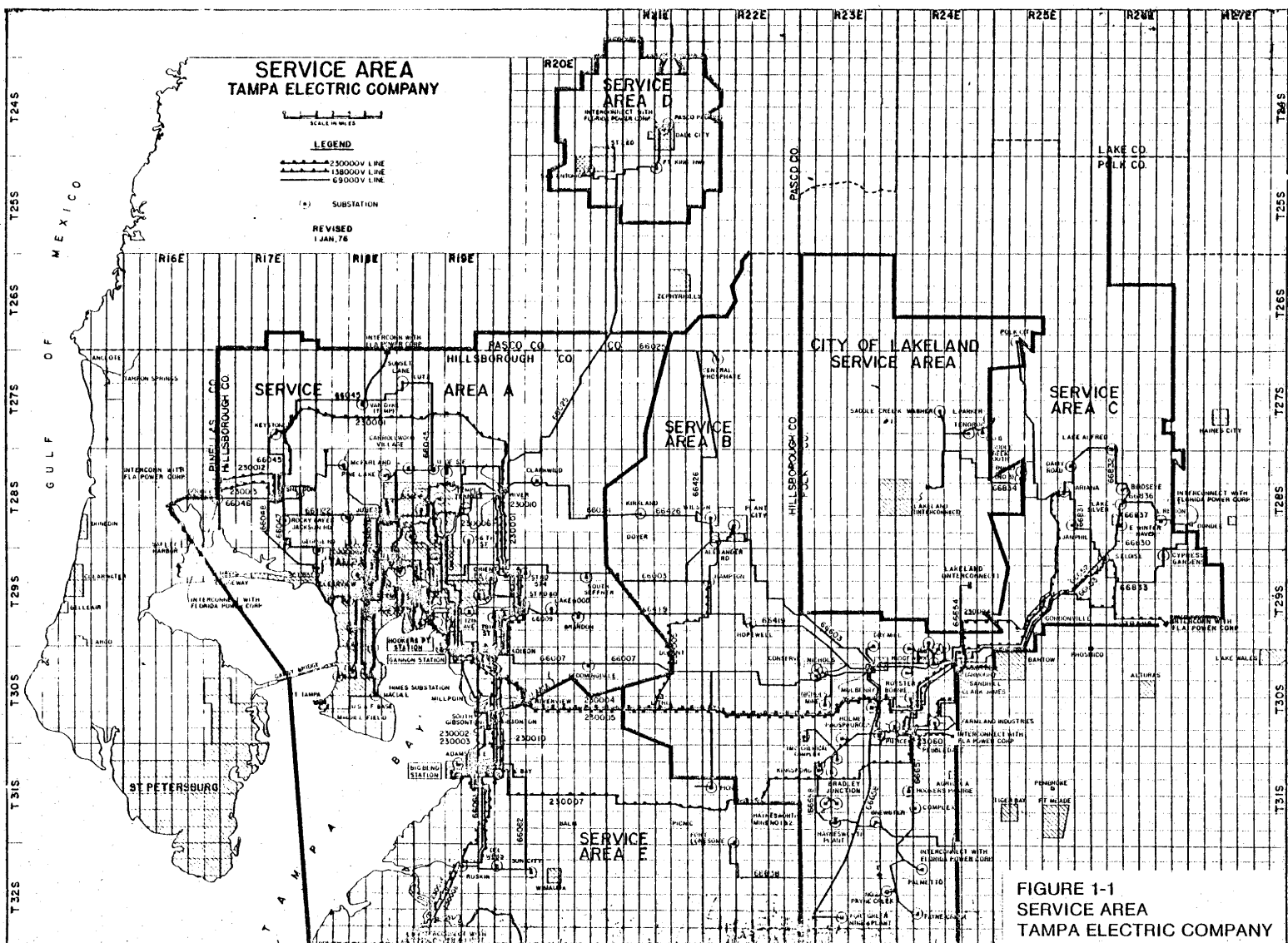
TABLE 1-12

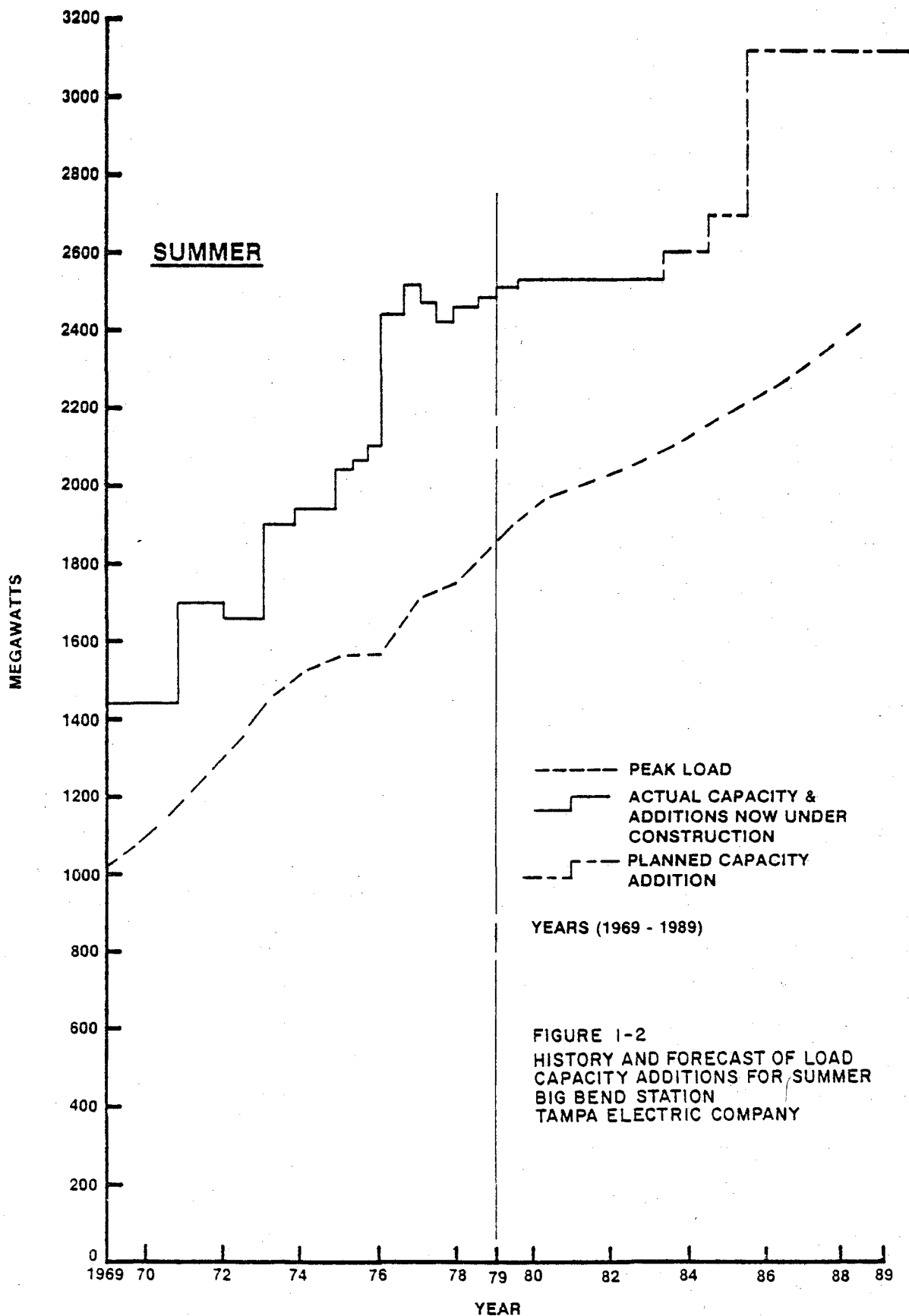
RESERVES WITH/WITHOUT BIG BEND UNIT NO. 4

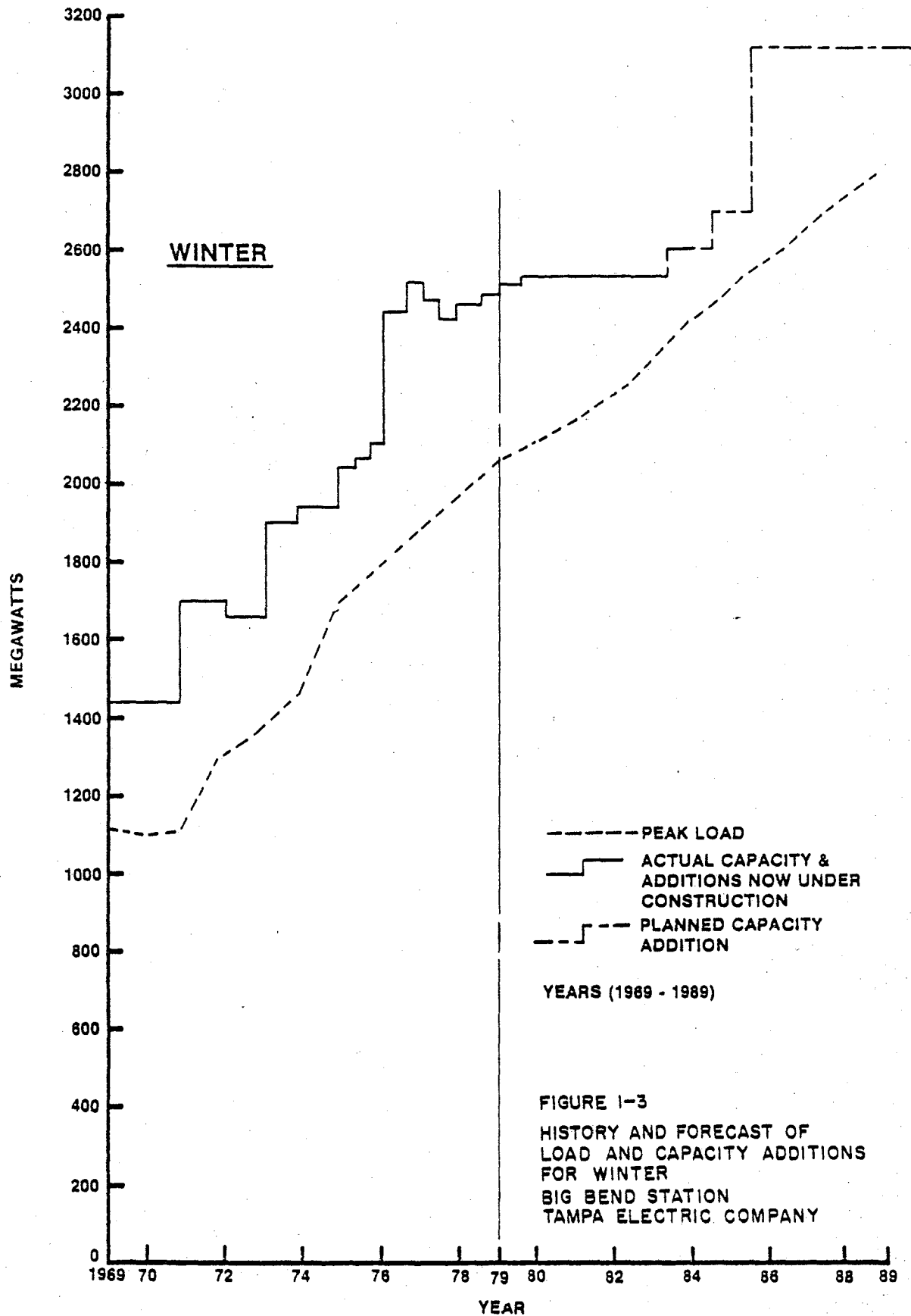
Year	System Capability*		Peak Demands				With Big Bend No. 4				Without Big Bend No. 4			
			Total		Firm		TSL Reserves		Firm Reserves		TSL Reserves		Firm Reserves	
			Sum.	Win.	Sum.	Win.	Sum.	%	Sum.	%	Sum.	%	Sum.	%
1979	2529	2529	1861	2055	1650	1834	36	23	53	38	36	23	53	38
1980	2529	2529	1954	2104	1733	1887	29	20	46	34	29	30	46	34
1981	2529	2529	1984	2159	1767	1938	27	17	43	30	27	17	43	30
1982	2529	2529	2029	2235	1808	2016	25	13	40	25	25	13	40	25
1983	2629	2629	2087	2323	1868	2096	26	13	41	25	26	13	41	25
1984	2729	2729	2154	2411	1927	2186	27	13	42	25	27	13	42	25
1985	3146*	2729** 3149*	2216	2501	1991	2276	42	26	58	38	23	9	37	20
1986	3146*	2729** 3146*	2286	2588	2061	2366	38	22	53	33	19	5	32	15
1987	3146*	2729** 3146*	2352	2678	2130	2456	34	18	48	28	16	2	28	11
1988	3146	2729** 3146	2424	2751	2202	2556	30	14	43	23	13	(1)	24	7

*Values include Big Bend No. 4 export contract.

**Capacity without Big Bend No. 4.







January 16, 1978

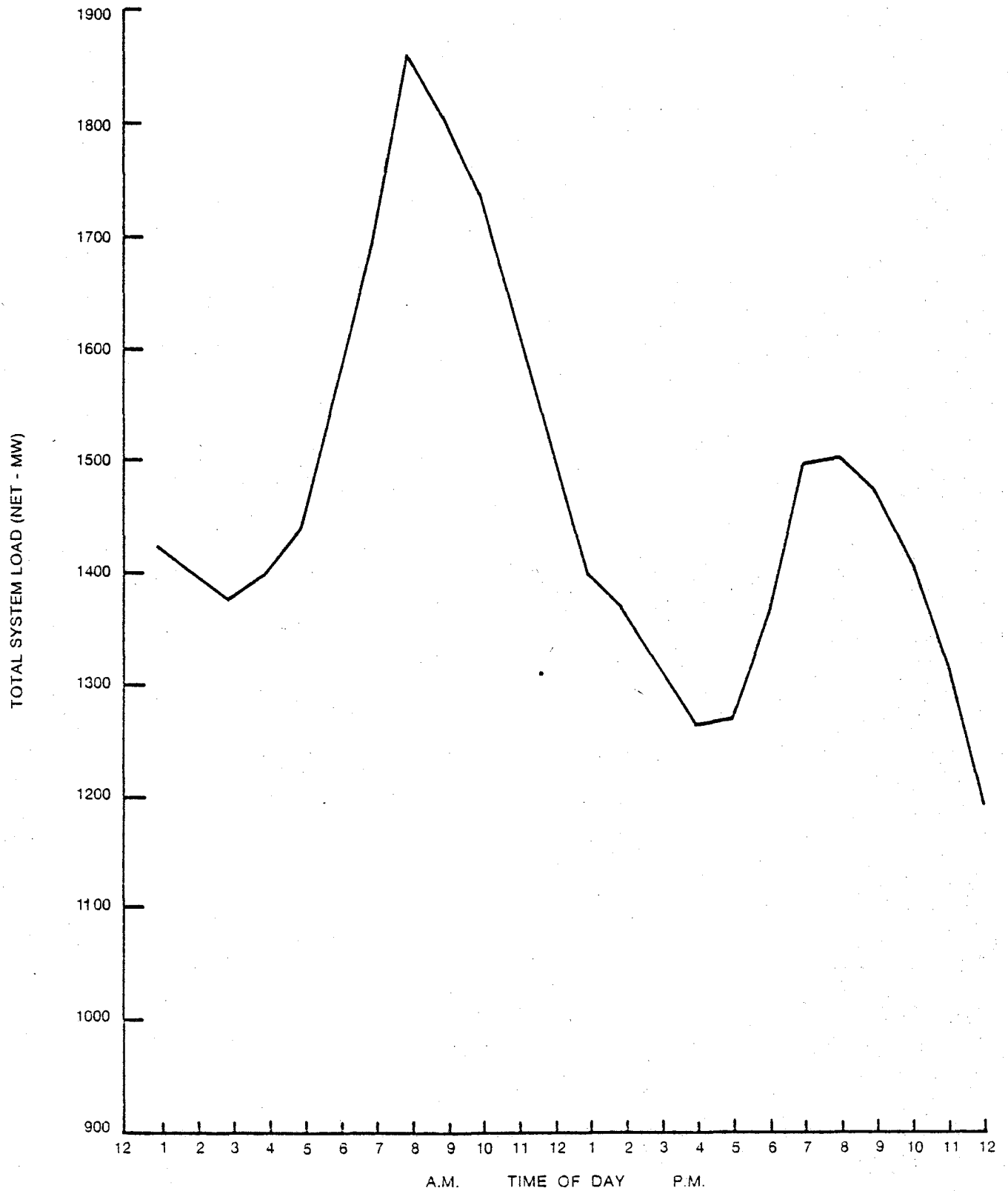


FIGURE I-4
HOURLY LOAD ANALYSIS
PEAK DAY-JANUARY 1978
BIG BEND STATION
TAMPA ELECTRIC COMPANY

February 7, 1978

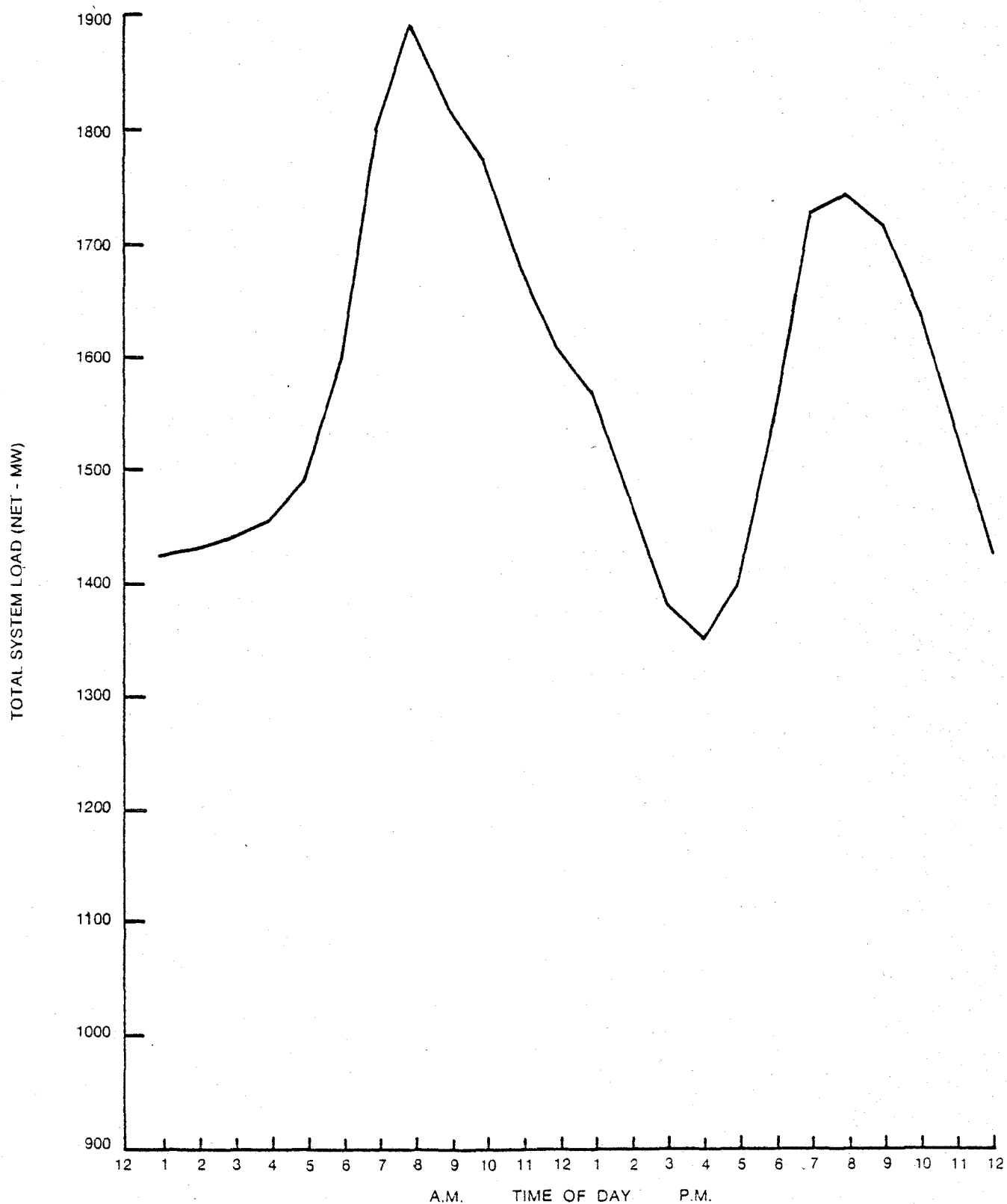


FIGURE I-5
HOURLY LOAD ANALYSIS
PEAK DAY-FEBRUARY 1978
BIG BEND STATION
TAMPA ELECTRIC COMPANY

March 6, 1978

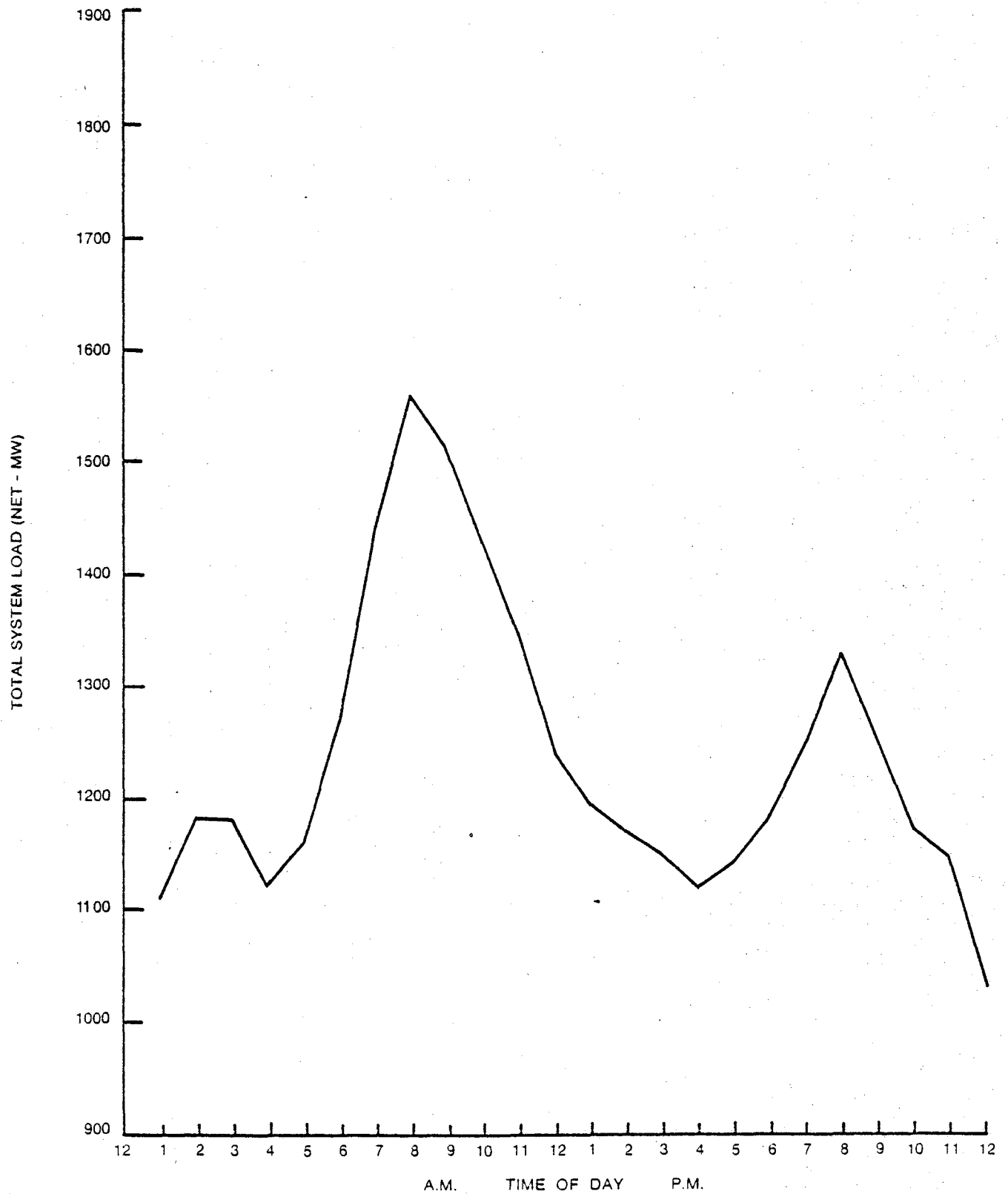


FIGURE I-6
HOURLY LOAD ANALYSIS
PEAK DAY - MARCH 1978
BIG BEND STATION
TAMPA ELECTRIC COMPANY

April 12, 1978

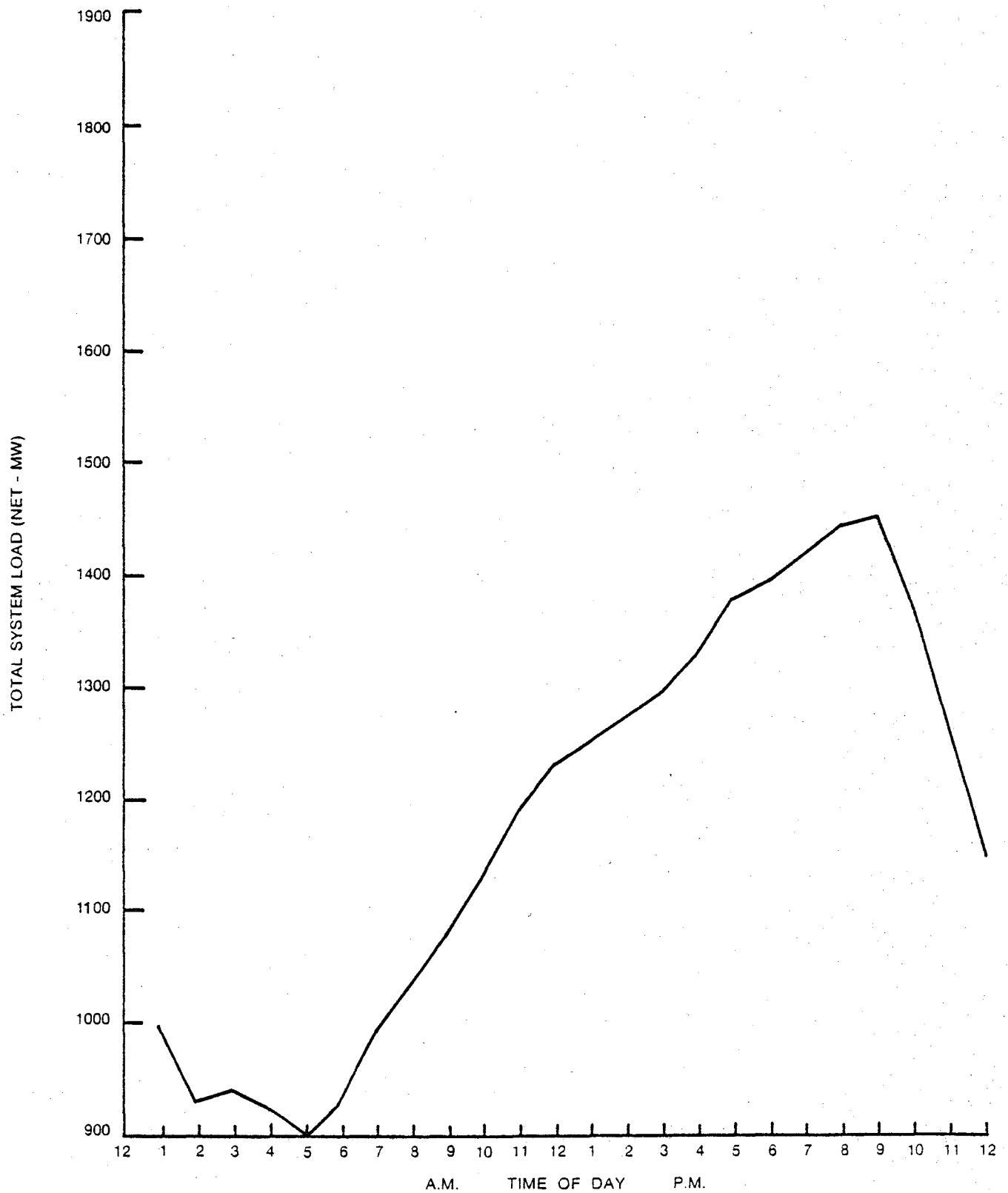


FIGURE I-7
HOURLY LOAD ANALYSIS
PEAK DAY - APRIL 1978
BIG BEND STATION
TAMPA ELECTRIC COMPANY

May 31, 1978

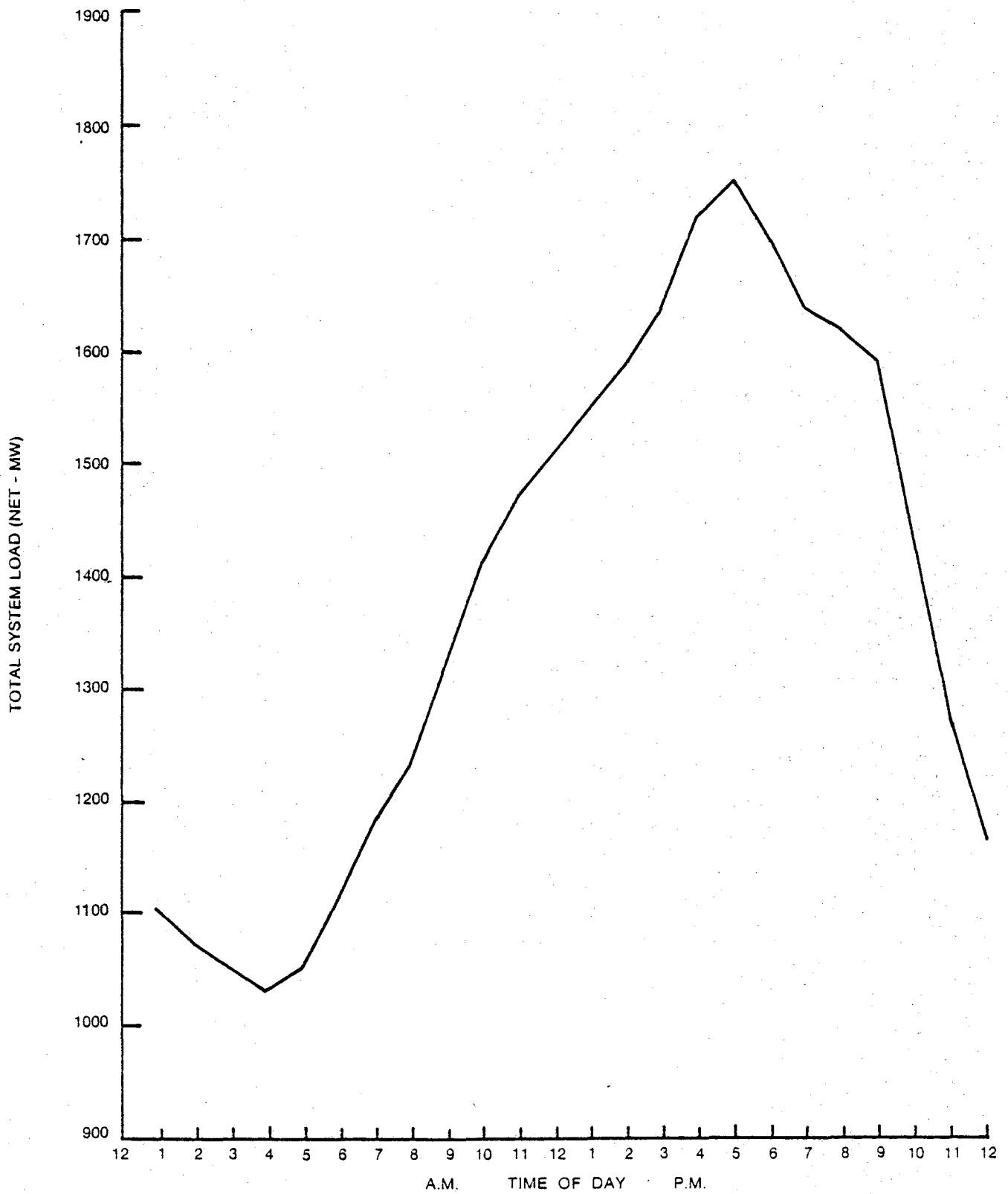


FIGURE I-8
HOURLY LOAD ANALYSIS
PEAK DAY - MAY 1978
BIG BEND STATION
TAMPA ELECTRIC COMPANY

June 26, 1978

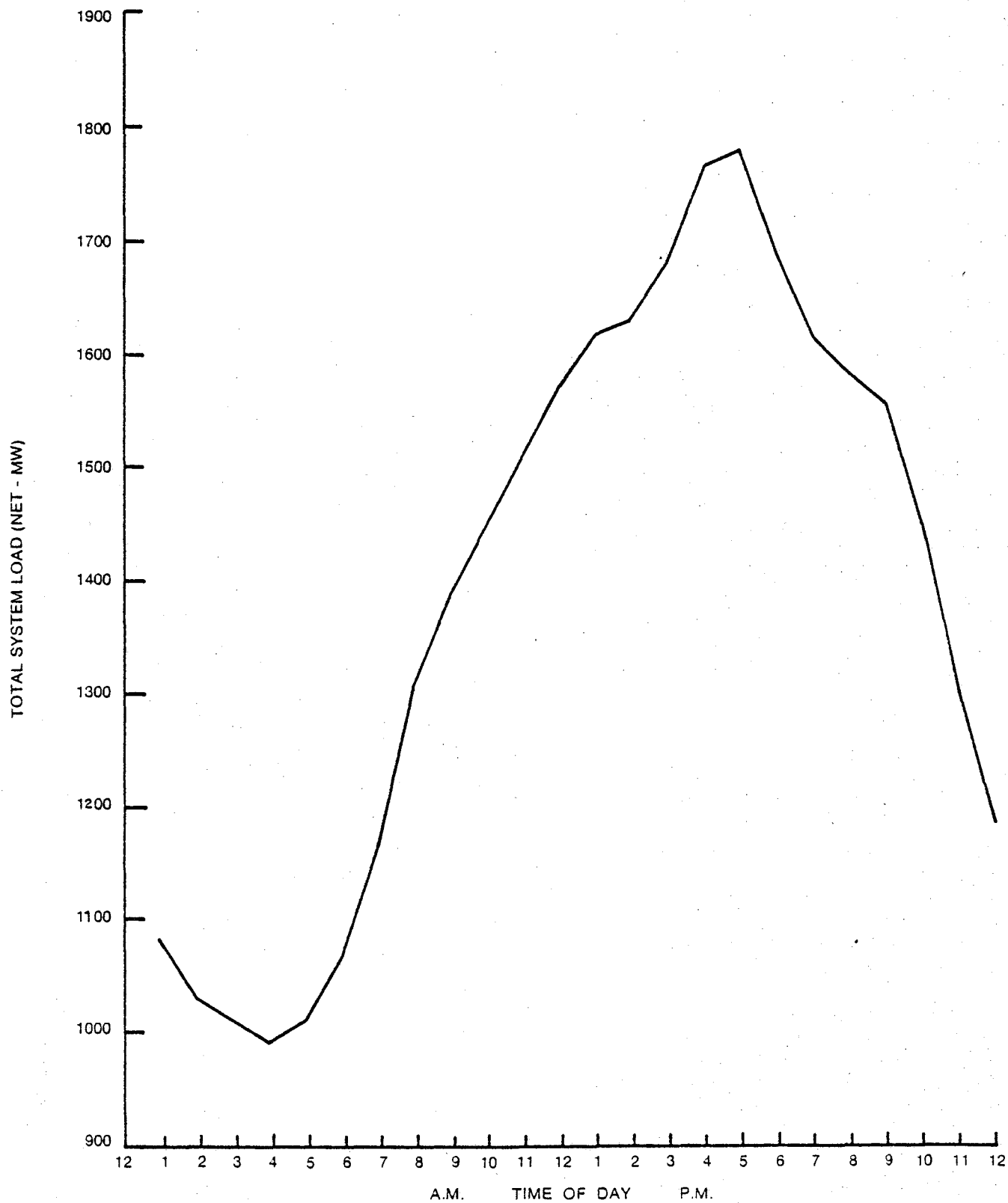


FIGURE I-9
HOURLY LOAD ANALYSIS
PEAK DAY-JULY 1978
BIG BEND STATION
TAMPA ELECTRIC COMPANY

July 24, 1978

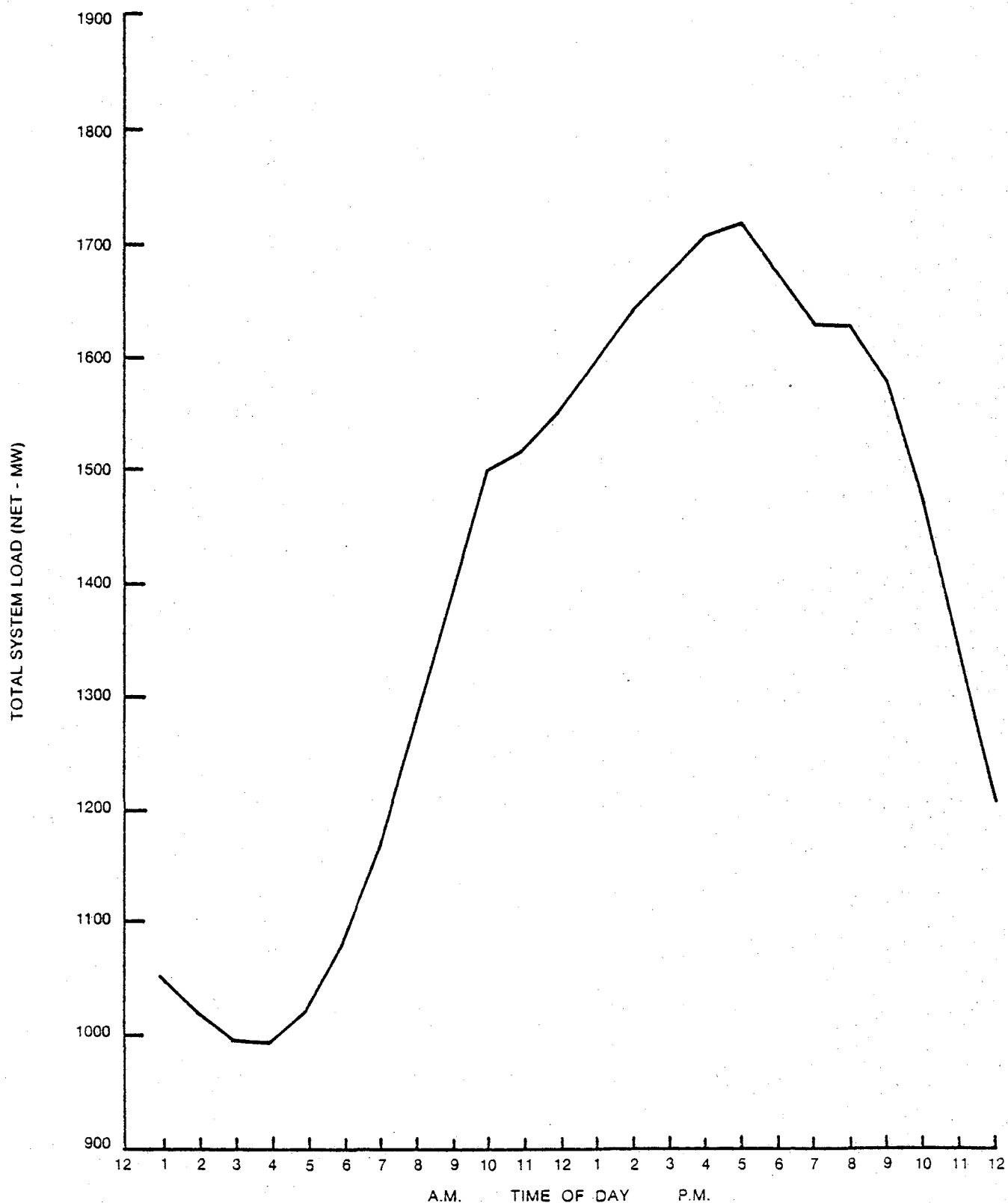


FIGURE I-10
HOURLY LOAD ANALYSIS
PEAK DAY-JULY 1978
BIG BEND STATION
TAMPA ELECTRIC COMPANY

August 24, 1978

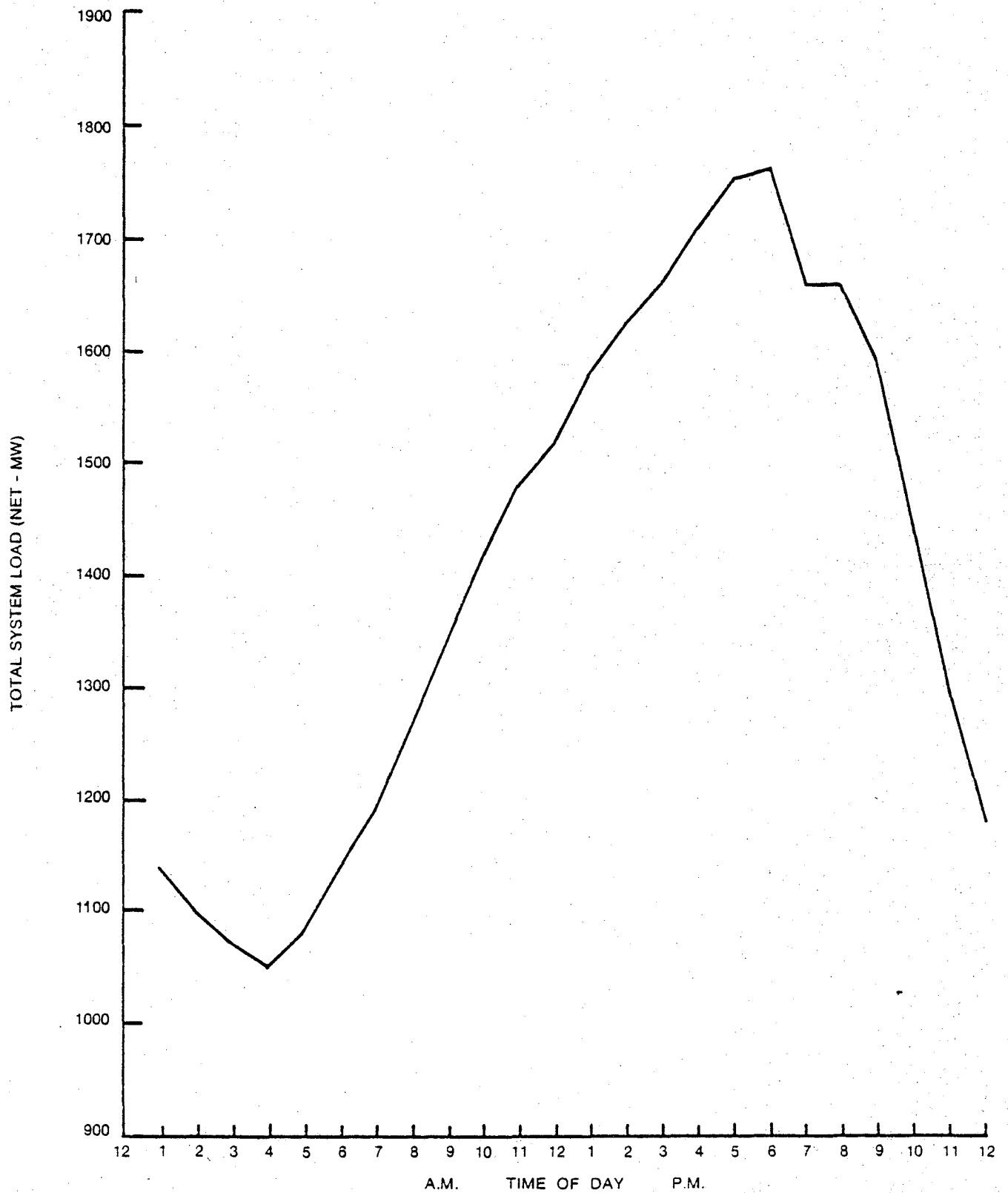


FIGURE I-11
HOURLY LOAD ANALYSIS
PEAK DAY - AUGUST 1978
BIG BEND STATION
TAMPA ELECTRIC COMPANY

September 14, 1978

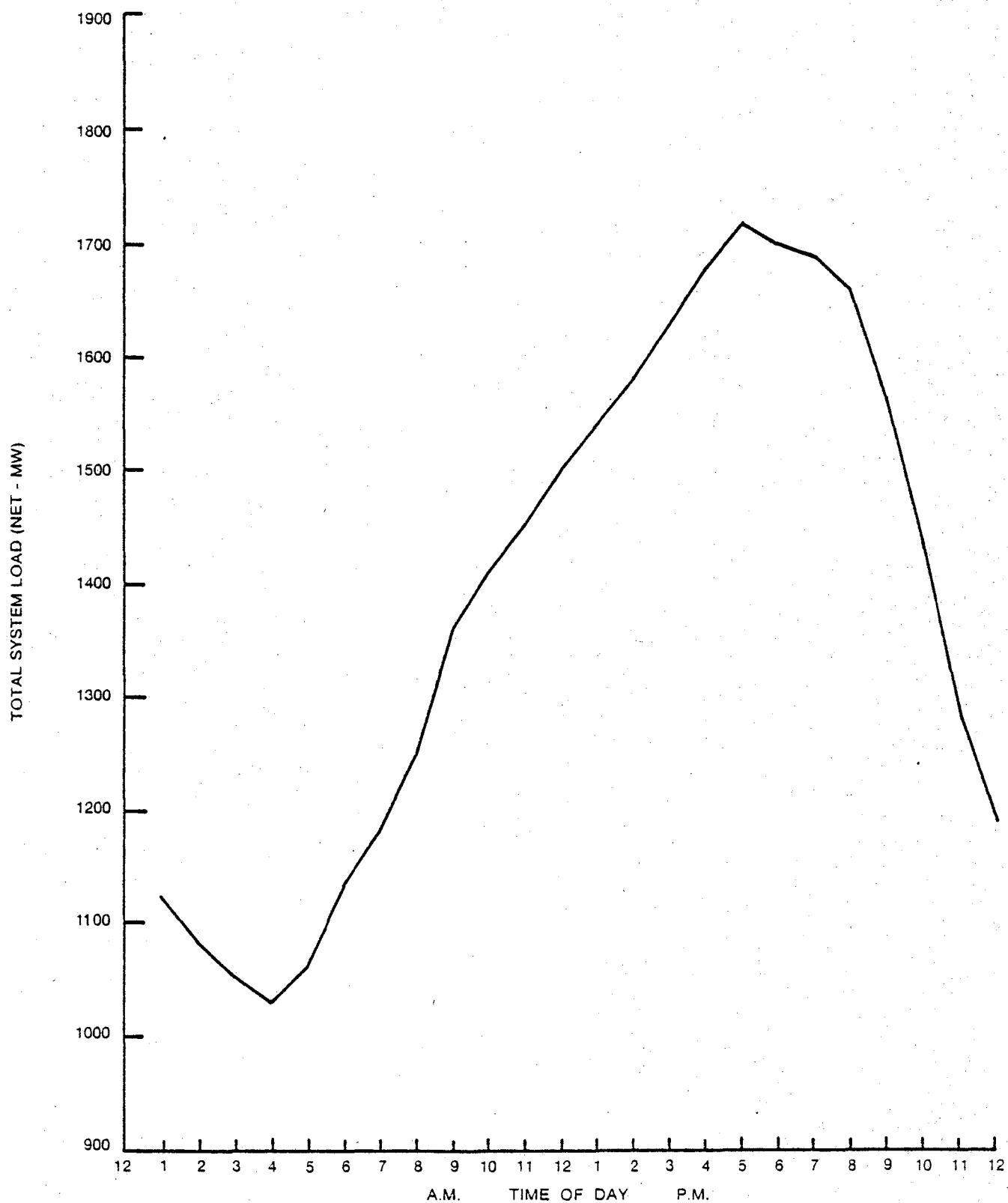


FIGURE I-12
HOURLY LOAD ANALYSIS
PEAK DAY-SEPTEMBER 1978
BIG BEND STATION
TAMPA ELECTRIC COMPANY

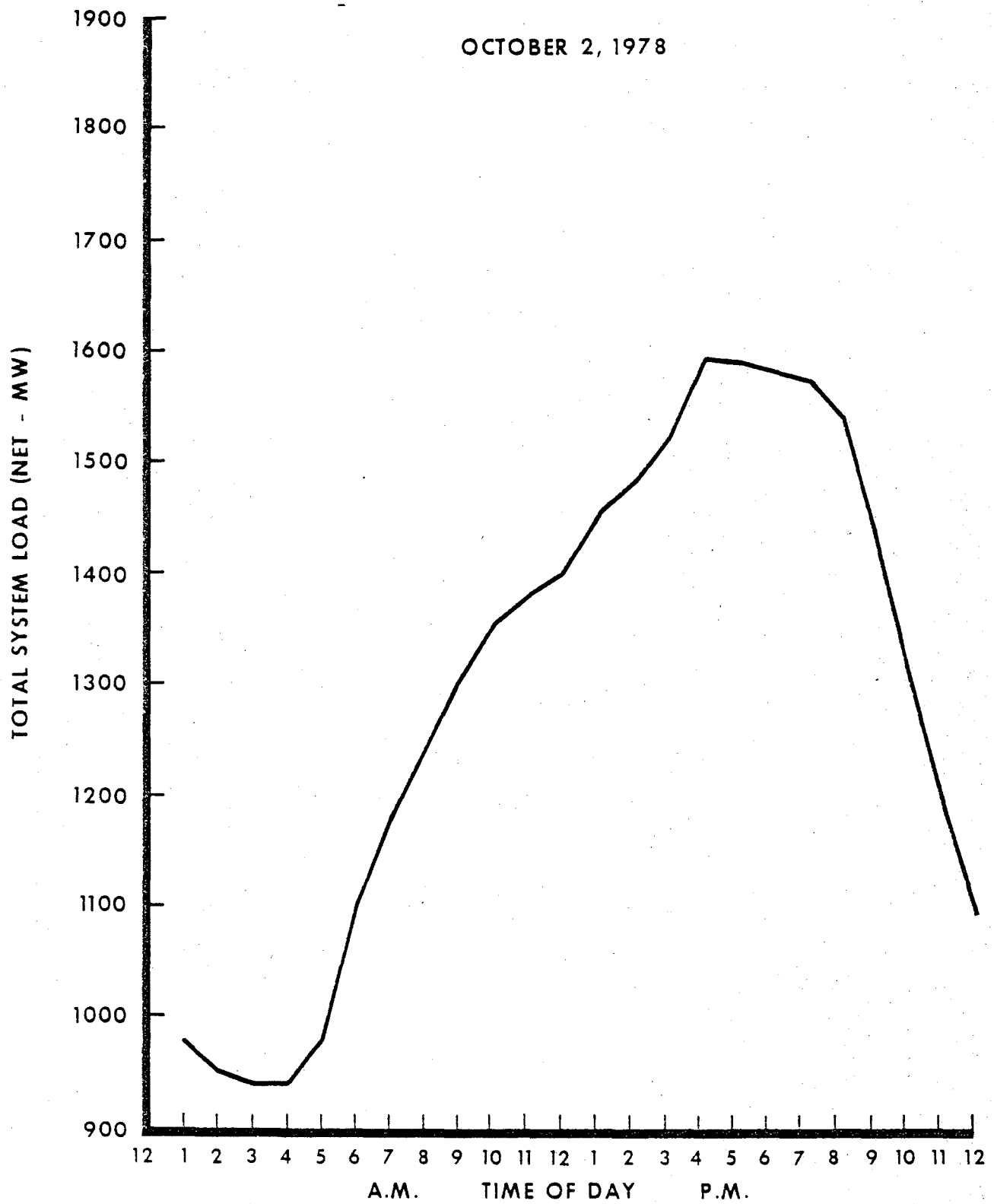


FIGURE 1-13
HOURLY LOAD ANALYSIS
PEAK DAY - OCTOBER, 1978
BIG BEND STATION
TAMPA ELECTRIC COMPANY

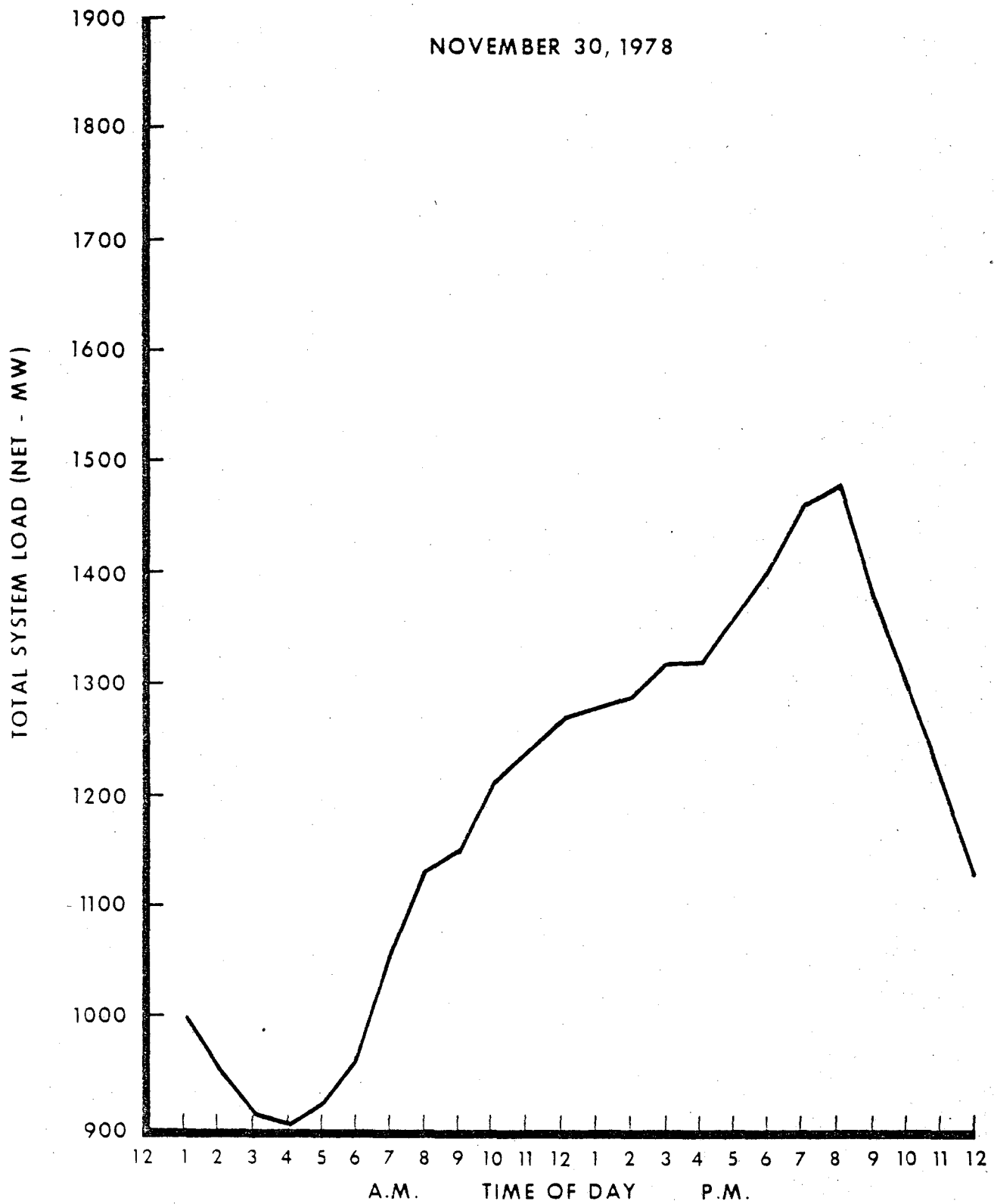


FIGURE I-14
HOURLY LOAD ANALYSIS
PEAK DAY - NOVEMBER, 1978
BIG BEND STATION
TAMPA ELECTRIC COMPANY

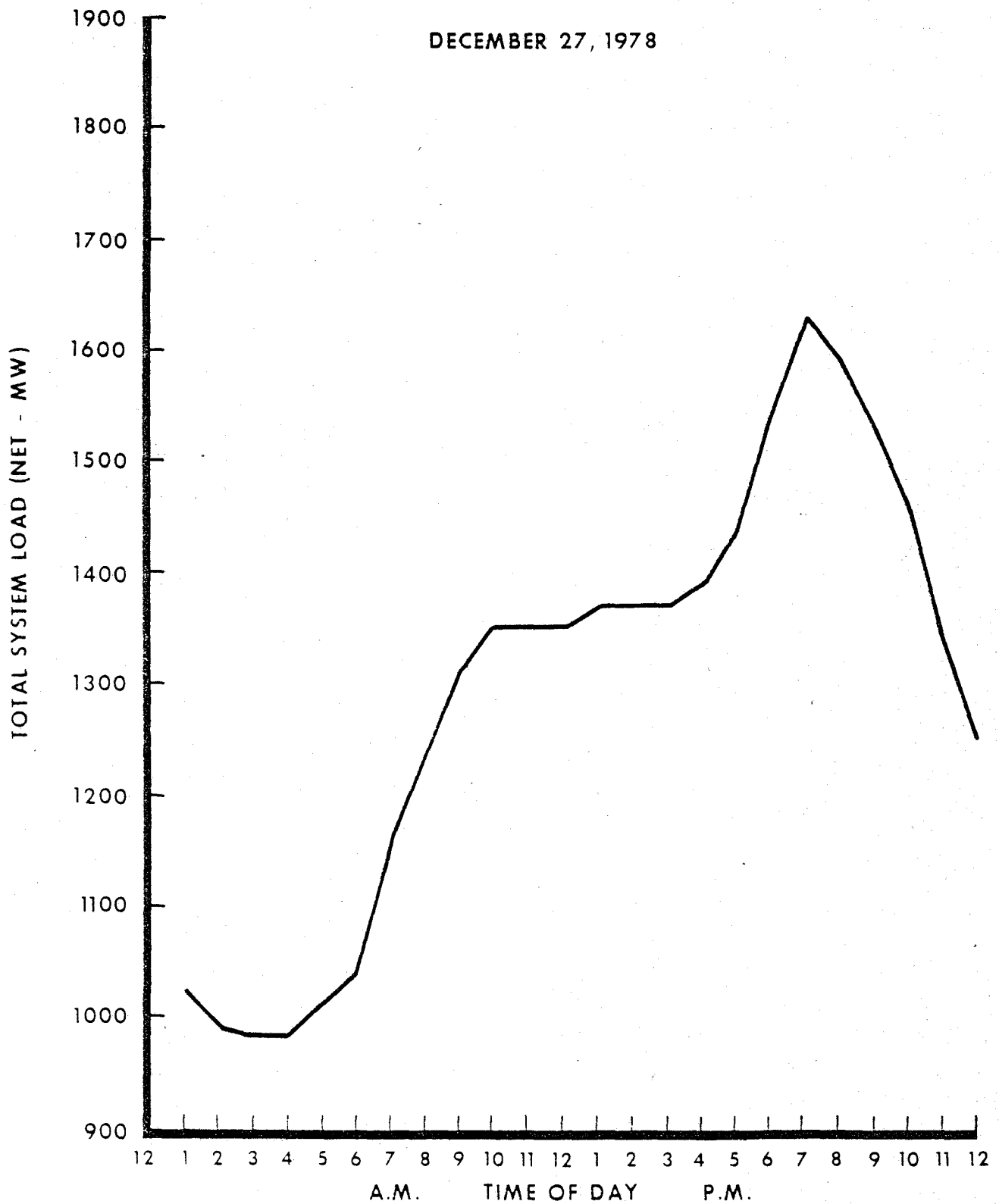


FIGURE I-15
HOURLY LOAD ANALYSIS
PEAK DAY - DECEMBER, 1978
BIG BEND STATION
TAMPA ELECTRIC COMPANY

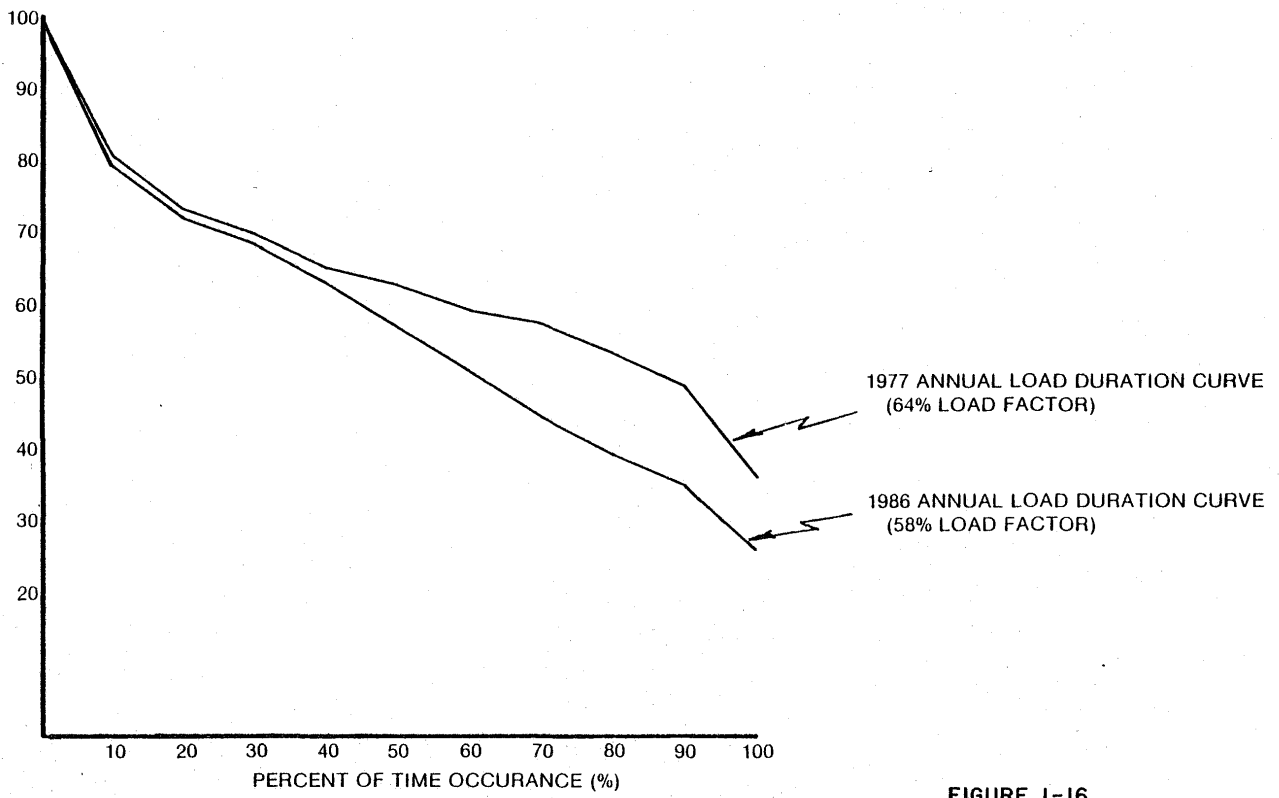


FIGURE I-16
LOAD DURATION CURVE
ANALYSIS 1977 AND 1986
BIG BEND STATION
TAMPA ELECTRIC COMPANY

APPENDIX 1A

DATA - HISTORICAL AND PROJECTED

1A.1 ENERGY

This section illustrates official energy data both historical and projected for the various classes of service for the 1978-1988 forecast: output to line energy, residential energy sales, small and large light and power energy sales, and estimated energy output to line requirements.

1A.2 DEMAND

This section illustrates official peak demand data both historical and projected of total system load and load other than phosphate for the 1978-1988 forecast.

1A.3 PHOSPHATE

This section illustrates official energy and peak demand data both historical and projected of total phosphate energy sales and total phosphate demand related to the 1978-1988 forecast.

1A.4 LOAD FACTORS

Included in this section are figures that illustrate historical and projected load factors which are based on annual peak KW demand. Future annual peak demand is expected to occur in winter. The load factor decrease between 1978 and 1988 is a result of steady increases in the winter growth which is not affected by future appliance efficiency standards. Strip heat, for example, cannot be made more efficient, and is relatively insensitive to price elasticity.

One other item that tends to decrease the load factor is a lack of growth in the phosphate area. Currently, this high load factor industry accounts for 31 percent of sales, but, by 1988, it will be about 25 percent. As this industry becomes a smaller percentage of the total and TECO's load becomes more residential and commercial, the system load factor will decline.

1A.5 POPULATION AND CUSTOMERS

Population projections for TECO's service area were taken from the medium forecast of the Florida Bureau of Economic Business Research (FBEER) (Bulletin 44 - July 1978) after adjusting for 1978 customers (see population graph this section). Based on the FBEER Data, a 2.0 percent annual average growth rate (1978-1988) is forecasted for Hillsborough County population. This growth rate assumes that future migration into the service area is expected to be a smaller percentage of overall migration into the state. This assumption, as illustrated in the following table, is based on a steady decline over the last decade of Hillsborough County population relative to the rest of Florida.

POPULATION DISTRIBUTION

	<u>1960</u>	<u>1970</u>	<u>1977</u>	<u>1980</u>	<u>1990</u>
Florida	4,951,560	6,789,443	8,717,334	9,492,300	11,772,300
Hillsborough County	397,788	490,265	602,667	647,800	790,600
Hillsborough County as percent of Florida	8.0	7.2	6.9	6.8	6.7

Source: 1960 and 1970 data - U.S. Department of Commerce Census;
1977-1990 data - Florida Bureau of Economic Business
Research, Bulletin 44.

Estimation of the Number of Households - The exogenous population forecast for Hillsborough County is the starting point for projecting the number of households. The total population is partitioned into distinct age groupings because different age groups have different rates of forming households. Age-specific population projections are derived by applying changes in the national age distribution to the 1970 Hillsborough County distribution. This estimation procedure is used both because age-specific population estimates by county are generally not available, and the county and national age distribution for 1970 are similar.

The age-specific population estimates are converted to households through heads of household to population ratios (headship ratios).

Nationally, the formation of households is increasing in most age groups as a result of postponed marriages,

increased divorces, and extended life expectancy. To reflect accurately this change, a national household formation trend is applied to the 1970 headship ratios. This trend was computed from national data by first dividing projected age-specific heads of household by the corresponding projected age-specific population. The resulting ratios are then scaled so that the values for 1970 are unity.

The above three factors: age-specific population estimates, headship ratios, and household formation trends are combined to project the numbers of households as follows:

$$HH_{i,t} = POP_{i,t} * HFT_{i,t} * HFR_{i,t}$$

where

$HH_{i,t}$ = Number of households in year t with head of household in age group i

$POP_{i,t}$ = Population in year t and age group i

$HFT_{i,t}$ = 1970 Hillsborough County headship ratio for age group i

$HFR_{i,t}$ = Household formation trend for year t and age group i

Total households in year t are obtained by summing the households by age of head over all age categories.

This procedure for calculating the number of households yields estimates only for Hillsborough County. To convert the estimates to residential customers in the TECO service area a constant multiplier of 1.173 is used.

1A.6 PRICE

This forecast assumes that future electricity prices will rise at the same rate as the Consumer Price Index. (Table 1A-16)

The following table summarizes the price elasticity assumptions used in this forecast:

PRICE ELASTICITY

	<u>Short-term</u>	<u>Long-term</u>
Residential Sector	- 0.2	- 0.5
Industrial Sector		
Paper (SIC 26)	- 0.3	- 0.6
Chemicals (SIC 28)	- 0.3	- 0.6
Primary Metals (SIC 33)	- 0.5	- 0.9
All Others	- 0.2	- 0.3
Commercial Sector	- 0.3	- 1.0

The term elasticity is used to express the relationship between a given percentage change in one variable to the resulting percentage change in another variable. The price elasticity of demand for electricity is, therefore, the relationship between a percentage change in the price of electricity to the resulting percentage change in energy consumption. Mathematically this is expressed by:

$$\begin{aligned}\text{Price elasticity} &= \frac{\text{Percentage change in consumption}}{\text{Percentage change in price}} \quad (1) \\ &= \frac{\frac{\Delta Q}{Q}}{\frac{\Delta P}{P}} \\ &= \frac{\Delta P}{P}\end{aligned}$$

where

P	=	Price of electricity
Q	=	Electricity consumption
ΔP	=	Change in Price
ΔQ	=	Resulting change in consumption

In addition to price elasticity, there are numerous other elasticities. For example, if the demand for a certain product is given as a function of income, population, and industrial output, one may refer to population, income and output elasticities. In each case the elasticity is defined as the ratio of a percentage change in demand over the percentage change in the corresponding independent variable, all other factors held constant.

This definition of elasticity is appropriate only for very small changes in the dependent and independent variables. When larger changes are involved, the definition can lead to serious difficulty. For example, if the price elasticity for a certain product is estimated to equal -1.0, doubling of the price would decrease the demand by 100 percent under our current definition. This of course, is a rather unlikely result. A more precise definition of elasticity is given by:

$$\text{price elasticity} = \frac{\frac{dQ}{Q}}{\frac{dP}{P}} \quad (2)$$

where dQ and dP are the differential of Q and P , respectively.

It should be noted that the above definition is equivalent to the limit of the ratio $\frac{\Delta Q}{Q} / \frac{\Delta P}{P}$ (our previous simple definition) as ΔP goes to zero. In the case where the elasticity is a constant (i.e., a single number), the defining differential equation (2) may be easily solved for Q . Hence:

$$\frac{dQ}{Q} = e \frac{dP}{P} \quad (3)$$

$$\text{and} \quad Q = KP^e$$

Thus, if the demand is given as a product of exponential terms, the exponents are the corresponding elasticities. For example, if Q is given by the following expression:

$$Q = aI^b \times O^c \times P^d$$

$$\begin{array}{ll} \text{where} & I = \text{Income} \\ & O = \text{industrial output} \\ & P = \text{price} \end{array} \quad (4)$$

then b is the income elasticity, c the industrial output elasticity, and d the price elasticity.

The form of equation (4) lends itself very easily to statistical parameter estimation. Thus, after taking logarithms on both sides of the equation, linear least squares techniques may be used to estimate the coefficients a , b , c , and d .

In order to estimate the elasticity coefficients statistically, it is essential to have data which reflects changes in the independent variables. One may be able to detect movements in the independent variables by observing them at one point in time but in various parts of the country, or by observing them in one region but over time. These two techniques are commonly called cross-sectional and time series analysis, respectively. A third technique is to pool cross-sectional and time series observations.

For example, to estimate demand elasticities for a certain product A, one must first hypothesize a mathematical model which takes into account the factors influencing the demand for A. Suppose these factors are population, personal income, the price of A and the price of product B which is a

substitute for A. One then constructs data series across regions and/or time for the independent and the dependent variables. Regression analysis may then be used to estimate the corresponding elasticities.

From the above general discussion, two important observations may be made. First, statistically derived elasticity estimates measure past responses in demand to past changes in the independent or explanatory variables. Thus, if conditions in the future are significantly different from those in the past, the estimates may be inappropriate. A second observation relates to the estimation itself. By definition, elasticity measures the change in demand resulting from a change in the independent variables, all other factors held constant. Since in most cases there are factors other than the ones explicitly stated in the equation which influence demand, adjustments in the dependent or the independent variables often must be made. For instance, adjustments may be required to reflect business conditions, military demand, weather, etc.

In conclusion, although there is some uncertainty and debate as to the "correct" value of the coefficients, it is generally agreed upon that electricity prices do influence the level of consumption. Also, previous work has indicated that the elasticity values cited do perform in a satisfactory manner.

1A.7 APPLIANCES

The general procedure for calculating the number of appliances is shown in Figure 1A-1. A population estimate is combined with household formation ratios to produce the number of households. Distributions of dwelling type and income are then applied to total households to produce the number of households by income classes and dwelling type. The number of households in these categories is then multiplied by corresponding appliance saturation levels yielding the number of appliances in these categories. Using this procedure, historical and projected appliance saturation levels are illustrated on a graph in this section.

The second factor in the residential sector is the average annual appliance consumption. Annual kWh consumption for the temperature insensitive appliances are based upon TECO and Edison Electric Institute estimates.

For temperature sensitive appliances, i.e., room and central air conditioners and electric space heaters, the energy consumption is estimated as a function of temperature.

A number of adjustments are made to the annual appliance consumption to reflect the influence of such factors as price of electricity, impact of other appliances and appliance efficiency. Tables of projected appliance efficiency standards and average appliance consumption are found in this section (Table 1A-17 through 1A-19).

TABLE 1A-1

TAMPA ELECTRIC COMPANY
OUTPUT TO LINE ENERGY - GWH

<u>Year</u>	<u>Output to Line (GWH)</u>	<u>% Change</u>
1968	5880	
1969	5973	1.6
1970	6672	11.7
1971	7537	13.0
1972	8112	7.6
1973	9263	14.2
1974	8750	-5.5
1975	9015	3.0
1976	9294	3.1
1977	10131	9.0
1978	10526 (Preliminary)	3.9
1979	10700	1.7
1980	11071	3.5
1981	11289	2.0
1982	11511	2.0
1983	11742	2.0
1984	12034	2.5
1985	12322	2.4
1986	12618	2.4
1987	12926	2.4
1988	13242	2.4

TABLE 1A-2

TAMPA ELECTRIC COMPANY

RESIDENTIAL ENERGY SALES - GWH (RATE 1)

<u>Year</u>	<u>Rate 1 Residential Energy - GWH</u>	<u>% Change</u>
1968	1520	
1969	1763	16.0
1970	2009	14.0
1971	2189	9.0
1972	2404	9.8
1973	2831	17.8
1974	2836	0.2
1975	2930	3.3
1976	2934	0.1
1977	3163	7.8
1978	3345 (Preliminary)	5.8
1979	3431	2.6
1980	3551	3.5
1981	3640	2.5
1982	3730	2.5
1983	3824	2.5
1984	3938	3.0
1985	4057	3.0
1986	4178	3.0
1987	4304	3.0
1988	4433	3.0

TABLE 1A-3

TAMPA ELECTRIC COMPANY

SMALL & LARGE LIGHT & POWER ENERGY SALES (GWH)

(RATES 25, 36)

<u>Year</u>	<u>Small & Large L&P Sales - GWH</u>	<u>% Change</u>
1968	1684	
1969	1877	11.5
1970	2080	10.8
1971	2290	10.1
1972	2531	10.6
1973	2845	12.4
1974	2926	2.8
1975	3001	2.6
1976	3051	1.7
1977	3251	6.6
1978	3457 (Preliminary)	6.3
1979	3566	3.2
1980	3712	4.1
1981	3827	3.1
1982	3946	3.1
1983	4069	3.1
1984	4215	3.6
1985	4366	3.6
1986	4524	3.6
1987	4686	3.6
1988	4855	3.6

TABLE 1A-4

ESTIMATED ENERGY OUTPUT TO LHL REQUIREMENTS
NET GIGAWATT HOURS
(TOTAL SYSTEM LOAD)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1978	924	857	808	791	899	944	944	973	933	833	785*	852*
1979	917	837	824	804	907	952	976	983	953	851	807	889
1980	949	866	852	832	939	985	1010	1018	987	880	834	919
1981	968	883	869	848	958	1005	1030	1038	1007	897	850	936
1982	987	899	885	863	977	1025	1051	1059	1027	915	866	957
1983	1007	917	902	880	996	1046	1073	1082	1048	933	883	975
1984	1032	939	924	901	1021	1072	1100	1110	1075	956	904	999
1985	1057	961	945	922	1045	1099	1128	1137	1101	978	925	1023
1986	1083	984	967	943	1071	1126	1155	1165	1128	1001	946	1048
1987	1110	1007	990	965	1097	1154	1184	1195	1156	1025	969	1073
1988	1137	1031	1014	988	1124	1183	1214	1225	1185	1050	991	1099

*Estimated

TABLE 1A-5

TAMPA ELECTRIC COMPANY
TOTAL SYSTEM LOAD - NET MW
(SUMMER PEAK)

<u>Year</u>	<u>Summer Total System Load - MW</u>	<u>% Change</u>
1968	951	
1969	1022	7.5
1970	1098	7.4
1971	1194	8.7
1972	1302	9.0
1973	1441	10.7
1974	1527	6.0
1975	1565	2.5
1976	1568	0.2
1977	1720	9.7
1978	1780	3.5
1979	1861	4.6
1980	1954	5.0
1981	1984	1.5
1982	2029	2.3
1983	2087	2.9
1984	2154	3.2
1985	2216	2.9
1986	2286	3.2
1987	2352	2.9
1988	2424	3.1

TABLE 1A-6

TAMPA ELECTRIC COMPANY
TOTAL SYSTEM LOAD - NET MW
WINTER PEAKS

<u>Year</u>	<u>Winter Total System Load - Net MW</u>	<u>% Change</u>
1968	927	
1969	1114	20.2
1970	1105	-0.8
1971	1129	2.2
1972	1300	15.1
1973	1366	5.1
1974	1458	6.7
1975	1693	16.1
1976	1784	5.4
1977	1891	6.0
1978	1960	3.6
1979	2055	4.8
1980	2104	2.4
1981	2159	2.6
1982	2235	3.5
1983	2323	3.9
1984	2411	3.8
1985	2501	3.7
1986	2588	3.5
1987	2678	3.5
1988	2751	2.7

TABLE 1A-7

TAMPA ELECTRIC COMPANY

LOAD OTHER THAN PHOSPHATE - NET MW
SUMMER PEAK

<u>Year</u>	<u>Other Load - Net MW</u>	<u>% Change</u>
1968	695	
1969	805	15.8
1970	854	6.1
1971	944	10.5
1972	1057	12.0
1973	1185	12.1
1974	1271	7.3
1975	1281	0.8
1976	1280	-0.1
1977	1359	6.2
1978	1421	4.6
1979	1491	4.9
1980	1574	5.6
1981	1610	2.3
1982	1650	2.5
1983	1702	3.2
1984	1761	3.5
1985	1825	3.6
1986	1895	3.8
1987	1964	3.6
1988	2036	3.7

TABLE 1A-8

TAMPA ELECTRIC COMPANY

LOAD OTHER THAN PHOSPHATE - NET MW
WINTER PEAKS

<u>Year</u>	<u>Winter Other Load - Net MW</u>	<u>% Change</u>
1968	678	
1969	862	27.1
1970	885	2.7
1971	901	1.8
1972	1045	16.0
1973	1196	14.4
1974	1189	0.6
1975	1398	17.6
1976	1478	5.7
1977	1545	4.5
1978	1590	2.9
1979	1675	5.3
1980	1730	3.3
1981	1780	2.9
1982	1850	3.9
1983	1930	4.3
1984	2020	4.7
1985	2110	4.5
1986	2200	4.3
1987	2290	4.1
1988	2390	4.4

TABLE 1A-9

MONTHLY LOAD FORECAST (NET DATA)

PREPARED 10/78

APR - OCT = SUMMER
NOV - MAR = WINTER

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1978												
INTERRUPTIBLE												
Furnace	33	34	19	22	28	44	34*	34*	34*	34*	15	15
Mining	151	151	136	173	195	176	181*	181*	181*	181*	180	180
Subtotal	184	185	155	195	223	220	215*	215*	215*	215*	195	195
FIRM												
Phosphate	155	160	178	164	151	151	149*	126*	129*	140*	175	175
Other*	1522	1546	1237	1090	1362	1409	1357*	1422*	1375*	1235*	1336	1431
Subtotal	1677	1706	1415	1254	1513	1560	1506*	1548*	1504*	1375*	1511	1606
TOTAL SYSTEM	1861	1891	1570	1449	1736	1780	1721	1763	1719	1590	1706	1801
1979												
INTERRUPTIBLE												
Furnace	15	15	15	15	15	15	15	15	15	15	15	15
Mining	180	180	180	180	180	180	180	180	180	180	180	180
Subtotal	195	195	195	195	195	195	195	195	195	195	195	195
FIRM												
Phosphate	175	175	175	175	175	175	175	175	175	175	175	175
Other*	1590	1510	1272	1223	1297	1402	1446	1461	1491	1372	1407	1507
Subtotal	1765	1685	1447	1398	1472	1577	1621	1636	1666	1547	1582	1682
TOTAL SYSTEM	1960	1880	1641	1593	1667	1772	1816	1831	1861	1742	1777	1877
1980												
INTERRUPTIBLE												
Furnace	15	15	15	15	15	15	15	15	15	15	15	15
Mining	190	190	190	190	196	190	190	190	190	190	190	190
Subtotal	205	205	205	205	205	205	205	205	205	205	205	205
FIRM												
Phosphate	175	175	175	175	175	175	175	175	175	175	175	175
Other*	1675	1591	1340	1291	1369	1480	1527	1543	1574	1448	1453	1557
Subtotal	1850	1766	1515	1466	1544	1655	1702	1718	1749	1623	1628	1732
TOTAL SYSTEM	2055	1971	1720	1671	1749	1860	1907	1923	1954	1828	1833	1937

* Estimated Breakdown

** Other Load Includes 16MW Industrial Interruptible.

TABLE 1A-9 (Cont)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1981												
INTERRUPTIBLE												
Furnace	15	15	15	15	15	15	15	15	15	15	15	15
Mining	186	186	186	186	186	186	186	186	186	186	186	186
Subtotal	201	201	201	201	201	201	201	201	201	201	201	201
FIRM												
Phosphate	173	173	173	173	173	173	173	173	173	173	174	174
Other*	1730	1643	1384	1320	1401	1513	1562	1578	1610	1481	1495	1602
Subtotal	1903	1816	1557	1493	1574	1686	1735	1751	1783	1654	1669	1776
TOTAL SYSTEM	2104	2017	1758	1694	1775	1887	1936	1952	1984	1855	1874	1981
1982												
INTERRUPTIBLE												
Furnace	15	15	15	15	15	15	15	15	15	15	15	15
Mining	190	190	190	190	190	190	190	190	190	190	188	188
Subtotal	205	205	205	205	205	205	205	205	205	205	203	203
FIRM												
Phosphate	174	174	174	174	174	174	174	174	174	174	182	182
Other*	1780	1691	1424	1353	1435	1551	1600	1617	1650	1518	1554	1665
Subtotal	1954	1865	1598	1527	1609	1725	1774	1791	1824	1692	1736	1847
TOTAL SYSTEM	2159	2070	1803	1732	1814	1930	1979	1996	2029	1897	1939	2050
1983												
INTERRUPTIBLE												
Furnace	15	15	15	15	15	15	15	15	15	15	15	15
Mining	188	188	188	188	188	188	188	188	188	188	188	188
Subtotal	203	203	203	203	203	203	203	203	203	203	203	203
FIRM												
Phosphate	182	182	182	182	182	182	182	182	182	182	182	182
Other*	1850	1757	1480	1396	1481	1600	1651	1668	1702	1566	1621	1737
Subtotal	2032	1939	1662	1578	1663	1782	1833	1850	1884	1748	1803	1919
TOTAL SYSTEM	2235	2142	1865	1781	1866	1985	2036	2053	2087	1951	2014	2130

* Other Load Includes 16 MW Industrial Interruptible.

TABLE 1A-9 (Cont)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1984												
INTERRUPTIBLE												
Furnace	15	15	15	15	15	15	15	15	15	15	15	15
Mining	196	196	196	196	196	196	196	196	196	196	194	194
Subtotal	211	211	211	211	211	211	211	211	211	211	209	209
FIRM												
Phosphate	182	182	182	182	182	182	182	182	182	182	182	182
Other*	1930	1833	1544	1444	1532	1655	1708	1726	1761	1620	1697	1818
Subtotal	2112	2015	1726	1626	1714	1837	1890	1908	1943	1802	1879	2000
TOTAL SYSTEM	2323	2226	1937	1837	1925	2048	2101	2119	2154	2013	2088	2209
1985												
INTERRUPTIBLE												
Furnace	15	15	15	15	15	15	15	15	15	15	15	15
Mining	194	194	194	194	194	194	194	194	194	194	194	194
Subtotal	209	209	209	209	209	209	209	209	209	209	209	209
FIRM												
Phosphate	182	182	182	182	182	182	182	182	182	182	182	182
Other*	2020	1919	1616	1496	1588	1715	1770	1788	1825	1679	1772	1899
Subtotal	2202	2101	1798	1678	1770	1897	1952	1970	2007	1861	1954	2081
TOTAL SYSTEM	2411	2310	2007	1887	1579	2106	2161	2179	2216	2070	2163	2290
1986												
INTERRUPTIBLE												
Furnace	15	15	15	15	15	15	15	15	15	15	15	15
Mining	194	194	194	194	194	194	194	194	194	194	191	191
Subtotal	209	209	209	209	209	209	209	209	209	209	206	206
FIRM												
Phosphate	182	182	182	182	182	182	182	182	182	182	182	182
Other*	2110	2004	1688	1554	1649	1781	1838	1857	1895	1743	1848	1960
Subtotal	2292	2126	1870	1736	1831	1963	2020	2039	2077	1925	2030	2162
TOTAL SYSTEM	2501	2395	2079	1945	2040	2172	2229	2248	2286	2134	2236	2368

* Other load includes 16 MW Industrial Interruptible.

TABLE 1A-9 (Cont)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1987												
INTERRUPTIBLE												
Furnace	15	15	15	15	15	15	15	15	15	15	15	15
Mining	191	191	191	191	191	191	191	191	191	191	191	191
Subtotal	206	206	206	206	206	206	206	206	206	206	206	206
FIRM												
Phosphate	182	182	182	182	182	182	182	182	182	182	182	182
Other*	2200	2090	1760	1610	1709	1846	1905	1925	1964	1807	1924	2061
Subtotal	2382	2272	1942	1792	1891	2028	2087	2107	2146	1989	2106	2243
TOTAL SYSTEM	2588	2478	2148	1998	2097	2234	2293	2313	2352	2195	2312	2449
1986												
INTERRUPTIBLE												
Furnace	15	15	15	15	15	15	15	15	15	15	15	15
Mining	191	191	191	191	191	191	191	191	191	191	164	164
Subtotal	206	206	206	206	206	206	206	206	206	206	179	175
FIRM												
Phosphate	182	182	182	182	182	182	182	182	182	182	182	182
Other*	2290	2175	1832	1670	1771	1914	1975	1995	2036	1873	2008	2151
Subtotal	2472	2357	2014	1852	1953	2096	2157	2177	2218	2055	2190	2333
TOTAL SYSTEM	2678	2563	2220	2058	2159	2302	2363	2383	2424	2261	2369	2512

* Other Load Includes 16 MW Industrial Interruptible.

TABLE 1A-10

TAMPA ELECTRIC COMPANY

TOTAL PHOSPHATE ENERGY SALES - GWH
(RATES 36, 37, 39)

<u>Year</u>	<u>Total Phosphate Sales (GWH)</u>	<u>% Change</u>
1968	2026	
1969	1823	-10.0
1970	2006	10.0
1971	1915	-4.5
1972	1938	1.2
1973	2065	6.6
1974	2180	5.6
1975	2460	12.8
1976	2734	11.1
1977	3106	13.6
1978	3104*	0.1
1979	3050	-1.7
1980	3134	2.8
1981	3134	0.0
1982	3134	0.0
1983	3134	0.0
1984	3148	0.4
1985	3148	0.0
1986	3148	0.0
1987	3148	0.0
1988	3148	0.0

*Preliminary

TABLE 1A-11

TAMPA ELECTRIC COMPANY

TOTAL PHOSPHATE DEMAND - NET MW
(COINCIDENT WITH SUMMER PEAK)
(RATES 36, 37, 39)

<u>Year</u>	<u>Total Phosphate Demand - MW</u>	<u>% Change</u>
1968	278	
1969	217	-22.0
1970	244	12.0
1971	255	4.5
1972	245	-3.9
1973	256	4.5
1974	256	0.0
1975	284	10.9
1976	288	1.4
1977	361	25.3
1978	359	-0.6
1979	370	3.1
1980	380	2.7
1981	374	-1.6
1982	379	1.3
1983	385	1.6
1984	393	2.1
1985	391	-0.5
1986	391	0.0
1987	388	-0.8
1988	388	-0.0

TABLE 1A-12

TAMPA ELECTRIC COMPANY

TOTAL SYSTEM DEMAND LOAD FACTOR (BASED ON ANNUAL PEAK)

<u>Year</u>	<u>Total System Load Factor</u>
1968	0.67
1969	0.66
1970	0.67
1971	0.65
1972	0.65
1973	0.65
1974	0.63
1975	0.66
1976	0.63
1977	0.65
1978	0.64*
1979	0.62
1980	0.62
1981	0.61
1982	0.61
1983	0.60
1984	0.59
1985	0.58
1986	0.58
1987	0.57
1988	0.56

$$\text{Load Factor} = \frac{\text{Annual Energy (Output to Line)}}{(\text{Hours in Year}) (\text{Peak Total System Demand})}$$

*Preliminary

TABLE 1A-13

TAMPA ELECTRIC COMPANY

LOAD OTHER THAN PHOSPHATE LOAD FACTOR (BASED ON ANNUAL PEAK)

<u>Year</u>	<u>Other Load Factor</u>
1968	0.54
1969	0.53
1970	0.55
1971	0.55
1972	0.54
1973	0.56
1974	0.53
1975	0.55
1976	0.50
1977	0.50
1978	0.51*
1979	0.51
1980	0.50
1981	0.50
1982	0.50
1983	0.49
1984	0.49
1985	0.48
1986	0.48
1987	0.47
1988	0.47

Load Factor = $\frac{\text{Annual Energy (Other than Phosphate)}}{(\text{Hours in Year}) (\text{Peak Other Load Demand})}$

*Preliminary

TABLE 1A-14

TAMPA ELECTRIC COMPANY
AVERAGE RESIDENTIAL CUSTOMERS

<u>Year</u>	<u>Average Rate 1 Residential Customers</u>	<u>% Change</u>	<u>Average Residential Customers</u>	<u>% Change</u>
1968	170676	-	170839	-
1969	177449	4.0	177472	3.9
1970	186168	4.9	186153	4.9
1971	195821	5.2	195702	5.1
1972	207365	5.9	207213	5.9
1973	221419	6.8	221251	6.8
1974	234307	5.8	233356	5.5
1975	240765	2.8	239215	2.5
1976	245134	1.8	243548	1.8
1977	250956	2.4	249362	2.4
1978	260586*	3.8	258944*	3.8
1979	272275	4.5	270560	4.5
1980	281805	3.5	280030	3.5
1981	288850	2.5	287030	2.5
1982	296071	2.5	294206	2.5
1983	303473	2.5	301561	2.5
1984	312577	3.0	310608	3.0
1985	321954	3.0	319926	3.0
1986	331613	3.0	329524	3.0
1987	341561	3.0	339504	3.0
1988	351800	3.0	349592	3.0

*Preliminary

TABLE 1A-15

TAMPA ELECTRIC COMPANY

AVERAGE USAGE PER RESIDENTIAL CUSTOMER - KWH

<u>Year</u>	<u>Average Usage/Customer-kWh*</u>	<u>% Change</u>
1968	8907	-
1969	9937	11.6
1970	10789	8.6
1971	11177	3.6
1972	11595	3.7
1973	12788	10.3
1974	12103	5.4
1975	12168	0.5
1976	11969	-1.6
1977	12605	5.3
1978	12837**	1.8
1979	12600	-1.8
1980	12600	0.0
1981	12600	0.0
1982	12600	0.0
1983	12600	0.0
1984	12600	0.0
1985	12600	0.0
1986	12600	0.0
1987	12600	0.0
1988	12600	0.0

*Average Use = $\frac{\text{Rate 1 Residential Energy}}{\text{Rate 1 Residential Customers}}$

**Preliminary

TABLE 1A-16

TECO ELECTRICITY PRICES, 1970 CENTS/KWH, 1970 TO 1976

	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>	<u>1975</u>	<u>1976</u>
Residential	2.00	1.90	2.12	2.01	2.16	2.59	2.77
	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>	<u>1975</u>	<u>1976</u>
Commercial	1.90	1.90	2.01	1.94	2.12	2.52	2.73
	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>	<u>1975</u>	<u>1976</u>
Industrial	1.08	1.08	1.24	1.23	1.48	1.88	2.16

TABLE 1A-17
PERCENT APPLIANCE SATURATION

1970 to 1990

	<u>%</u> <u>1970</u>	<u>%</u> <u>1975</u>	<u>%</u> <u>1980</u>	<u>%</u> <u>1985</u>	<u>%</u> <u>1990</u>
Water Heater	89	90	91	92	93
Air Conditioning - Room	55	46	40	34	29
Air Conditioning - Central	21	42	56	66	74
Heating	25	40	50	58	64

TABLE 1A-18

APPLIANCE EFFICIENCY TREND FACTORS, 1970 TO 1995

	<u>1978</u>	<u>1980</u>	<u>1995</u>
Range	1.00	1.00	0.97
Refrigerator	1.00	1.00	0.68
Freezer	1.00	1.00	0.77
Dishwasher	1.00	1.00	0.80
Washer	1.00	1.00	0.68
Dryer	1.00	1.00	0.93
Water Heater	1.00	1.00	0.85
TV, Color	1.00	1.00	0.65
Room A/C	1.00	1.00	0.77
Central A/C	1.00	1.00	0.83
Heating	1.00	1.00	1.00

Source: Federal Register, July 15, 1977, p 36648-36670

TABLE 1A-19

ANNUAL APPLIANCE CONSUMPTION (KWH/YR) 1970 TO 1990

	<u>1970</u>	<u>1975</u>	<u>1980</u>	<u>1985</u>	<u>1990</u>
Range	850	800	750	690	660
Refrigerator, FF	2500	2630	2750	2610	2470
Freezer, FF	1750	1900	2040	2050	2050
Dishwasher	360	330	300	270	260
Washer	100	100	90	80	70
Dryer	990	910	850	790	800
Water Heater	3720	3670	3550	3260	3130
TV, Color	550	550	550	490	420
Room A/C	2260	1990	1790	1510	1380
Central A/C	4570	4020	3620	3120	2930
Heating	1870	1650	1490	1360	1350

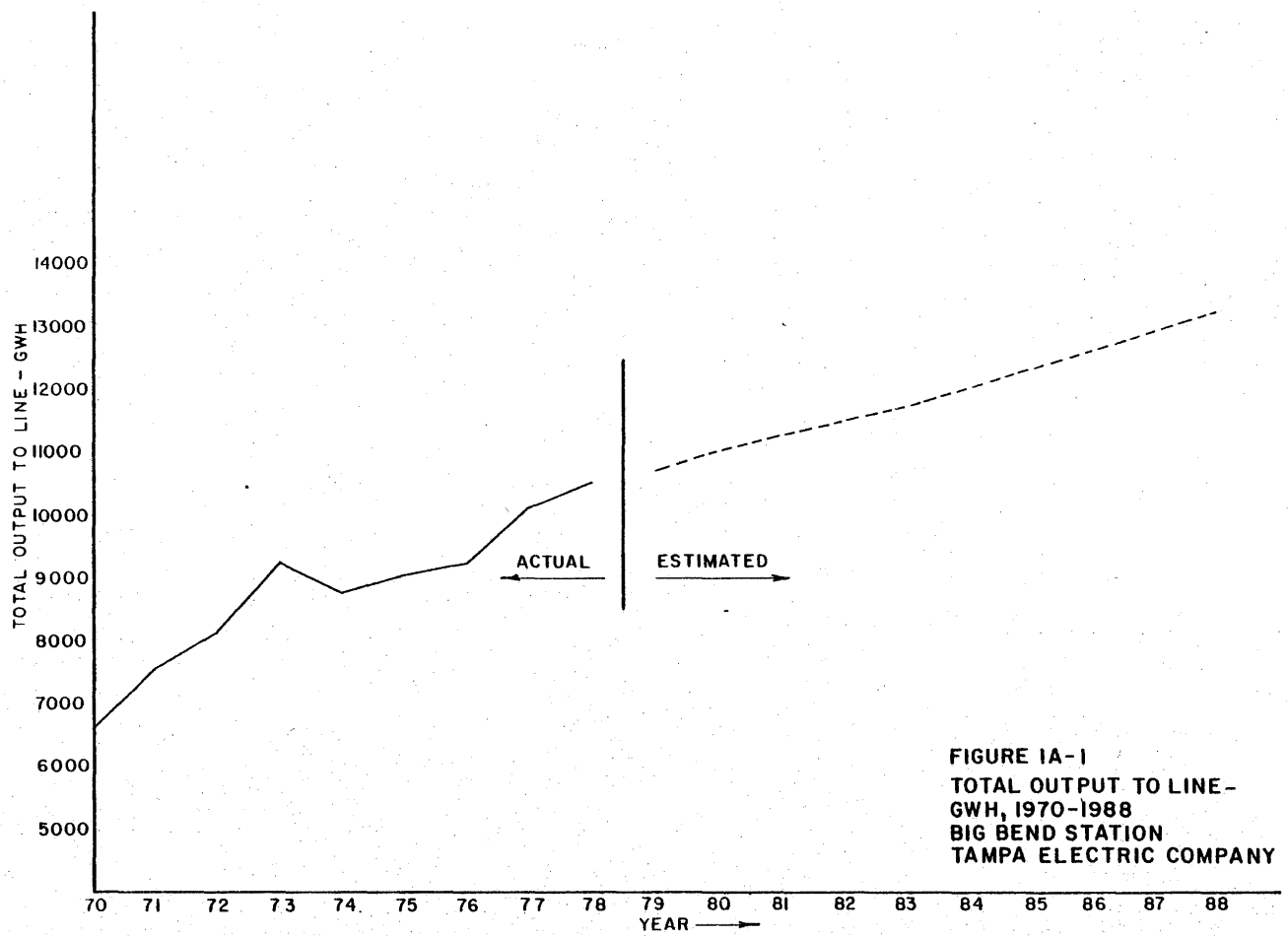


FIGURE 1A-1
TOTAL OUTPUT TO LINE -
GWH, 1970-1988
BIG BEND STATION
TAMPA ELECTRIC COMPANY

TAMPA ELECTRIC COMPANY ENERGY PROFILE

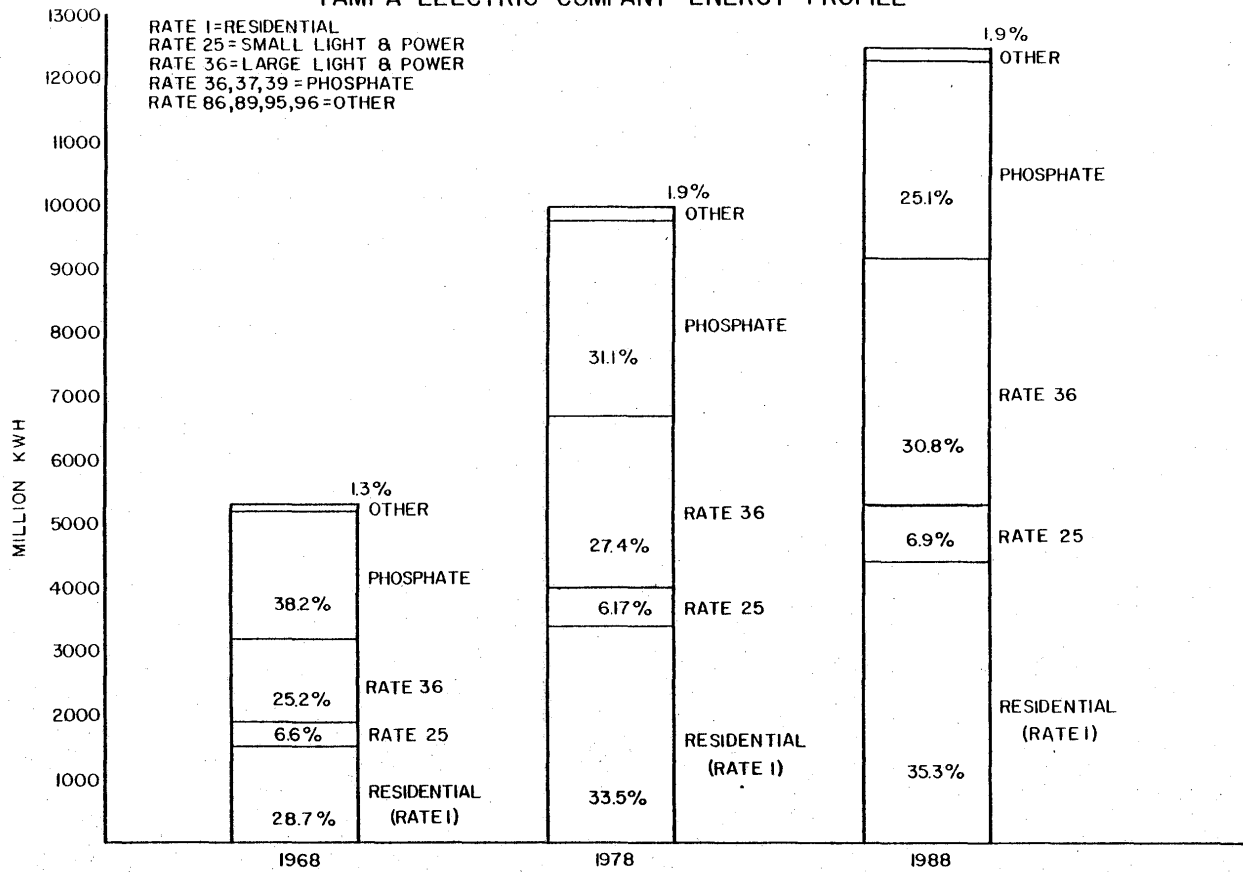


FIGURE 1A-2
 TAMPA ELECTRIC
 ENERGY PROFILE
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY

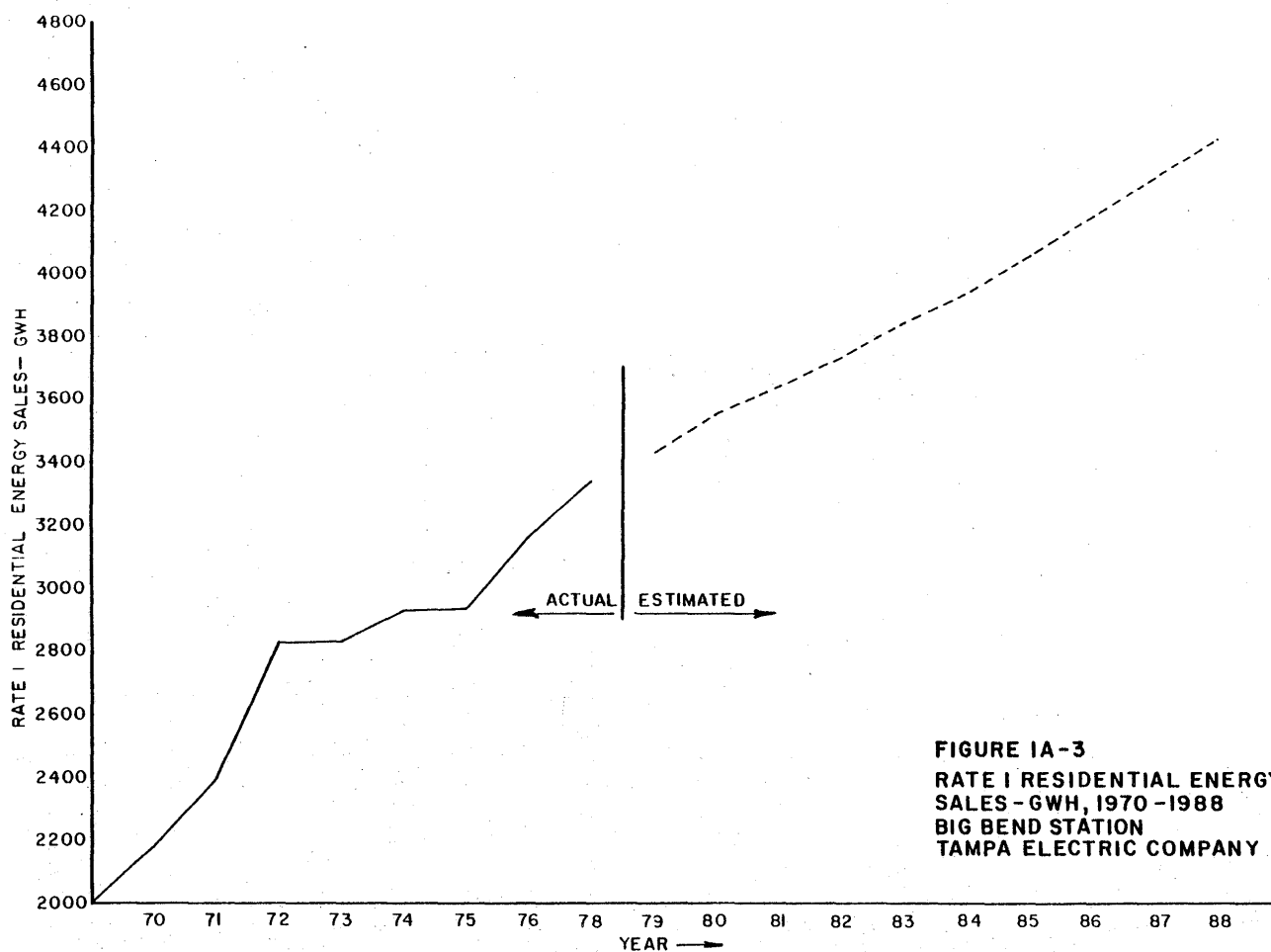


FIGURE 1A-3
RATE I RESIDENTIAL ENERGY
SALES - GWH, 1970 - 1988
BIG BEND STATION
TAMPA ELECTRIC COMPANY

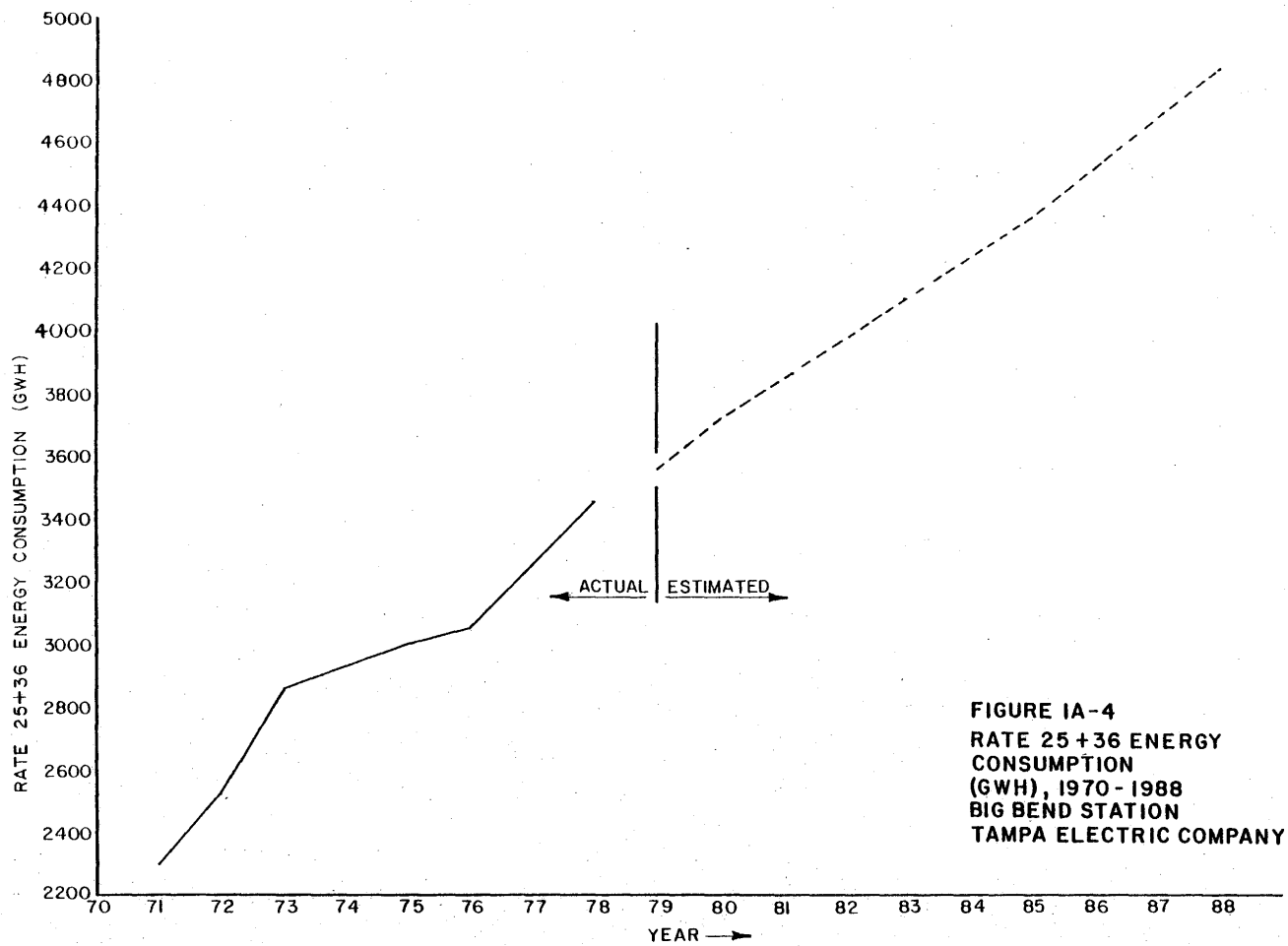


FIGURE IA-4
RATE 25 + 36 ENERGY
CONSUMPTION
(GWH), 1970 - 1988
BIG BEND STATION
TAMPA ELECTRIC COMPANY

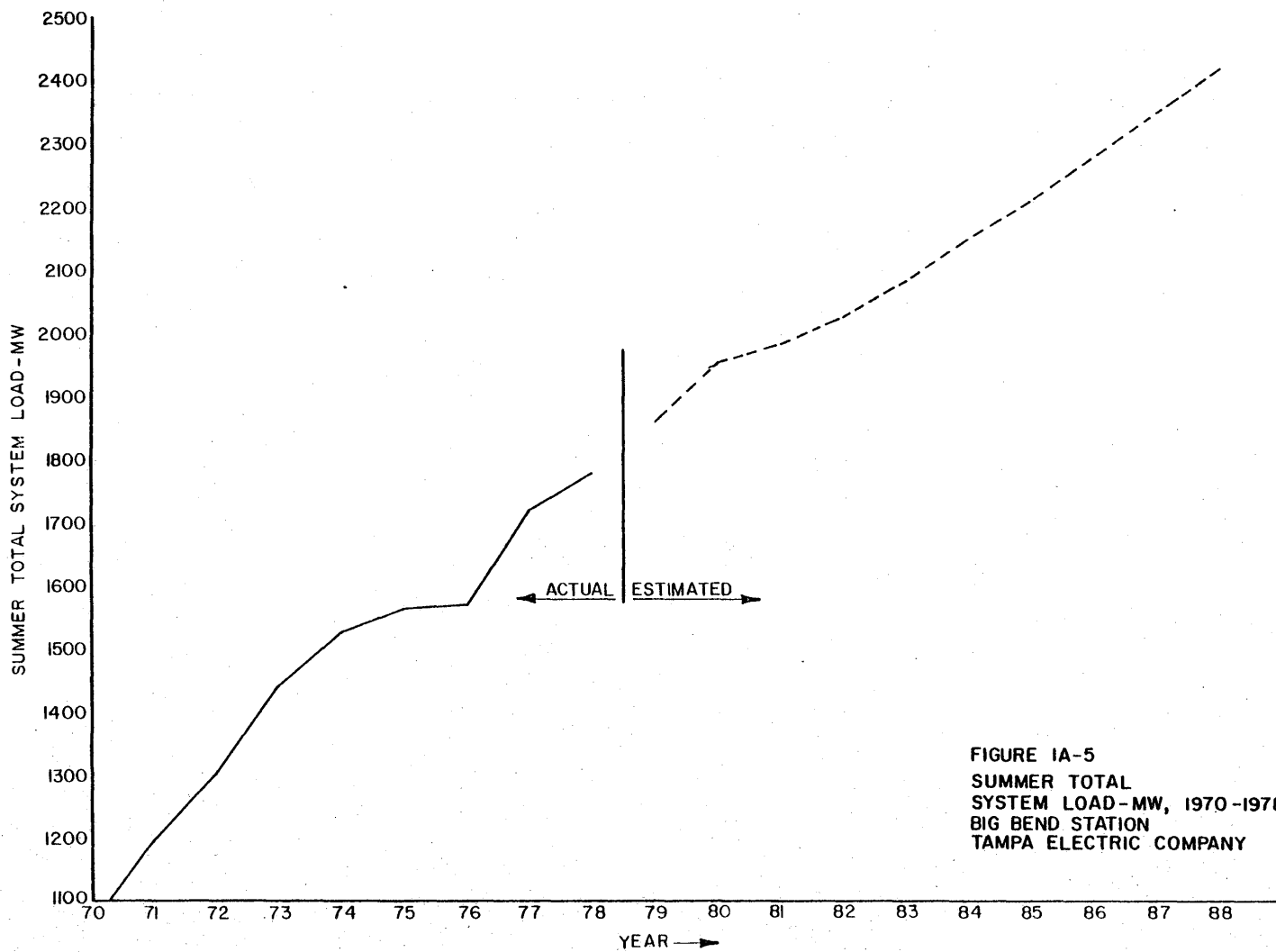


FIGURE 1A-5
SUMMER TOTAL
SYSTEM LOAD-MW, 1970-1978
BIG BEND STATION
TAMPA ELECTRIC COMPANY

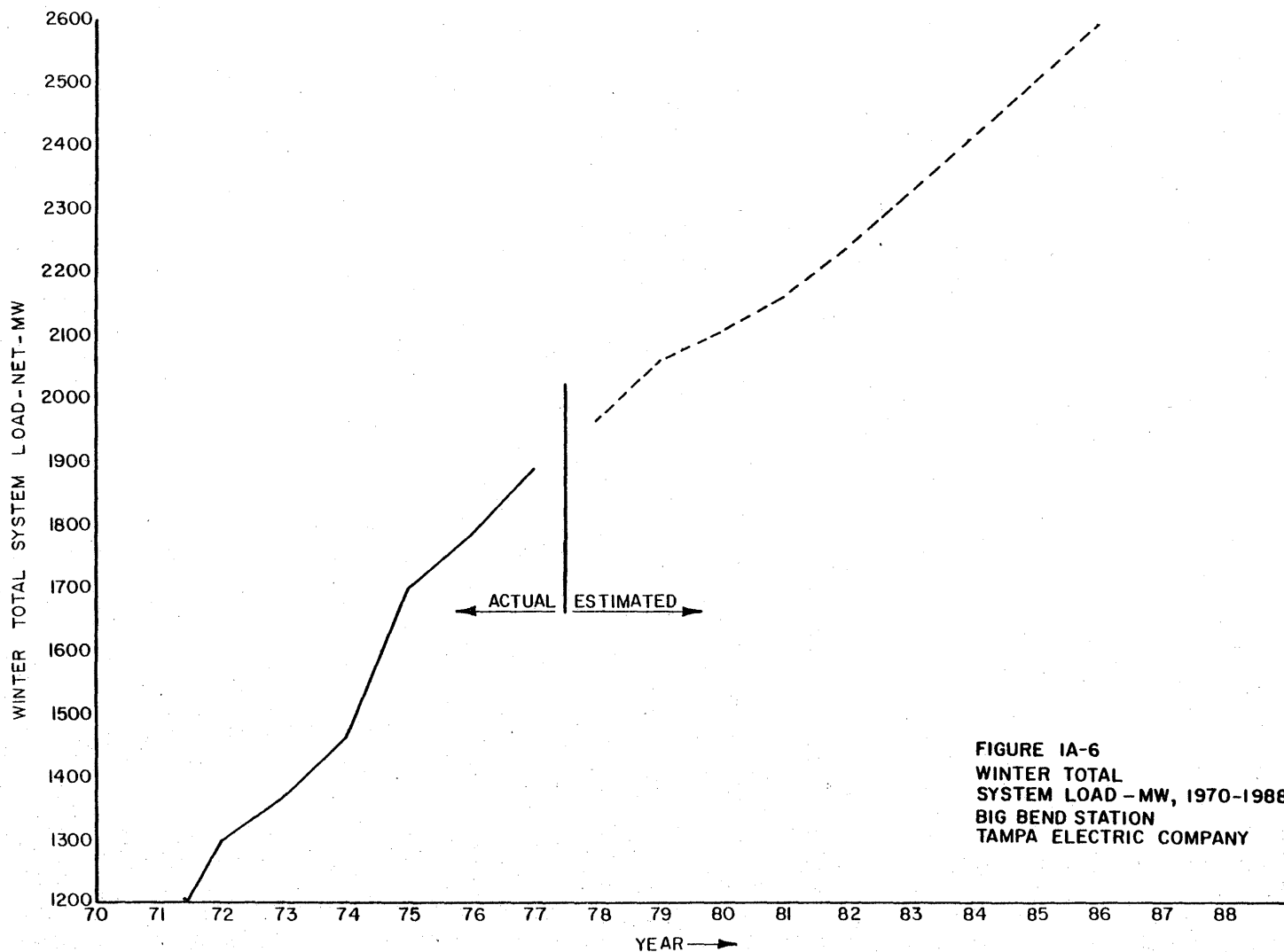


FIGURE 1A-6
WINTER TOTAL
SYSTEM LOAD - MW, 1970-1988
BIG BEND STATION
TAMPA ELECTRIC COMPANY

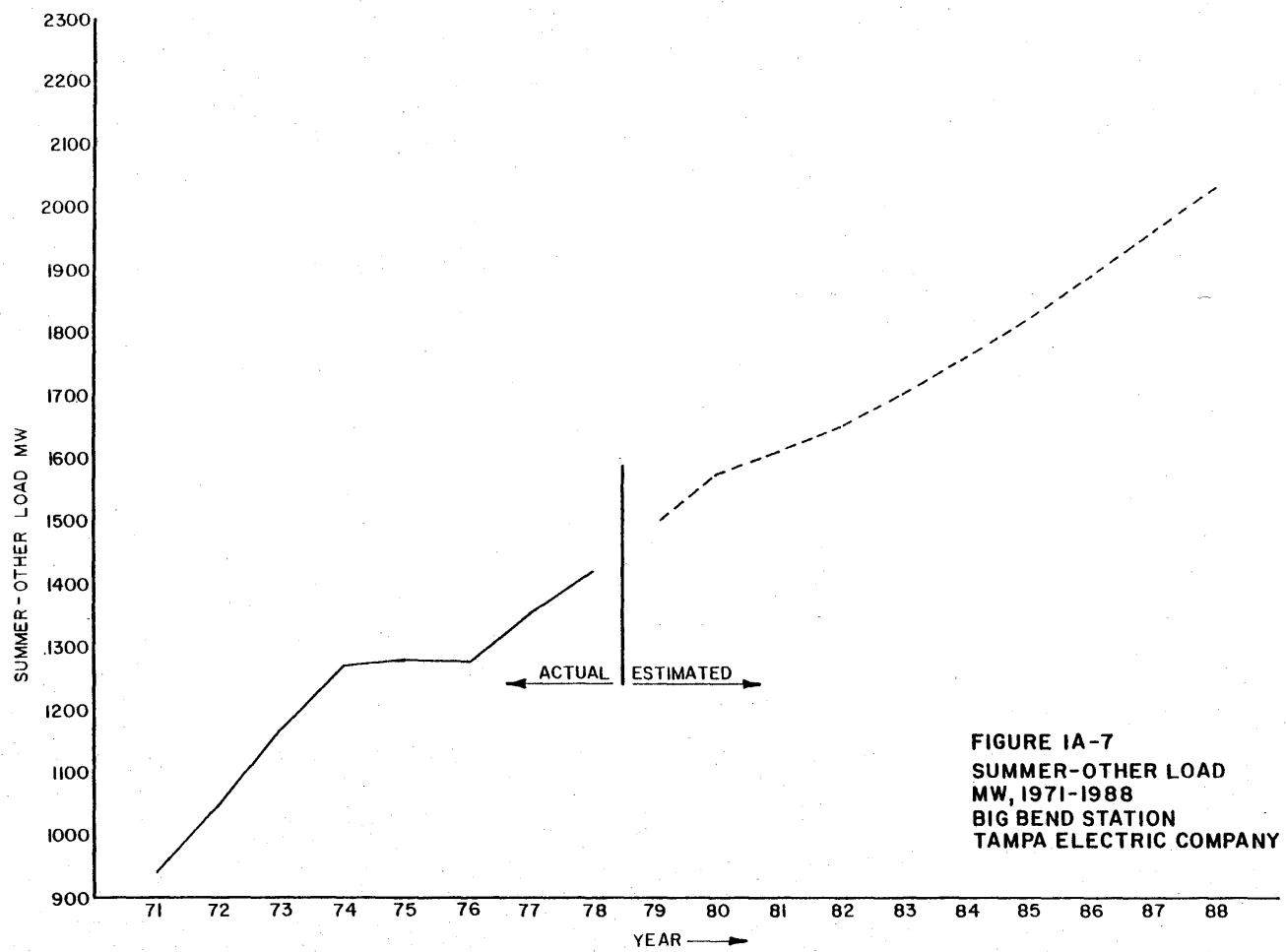


FIGURE 1A-7
SUMMER-OTHER LOAD
MW, 1971-1988
BIG BEND STATION
TAMPA ELECTRIC COMPANY

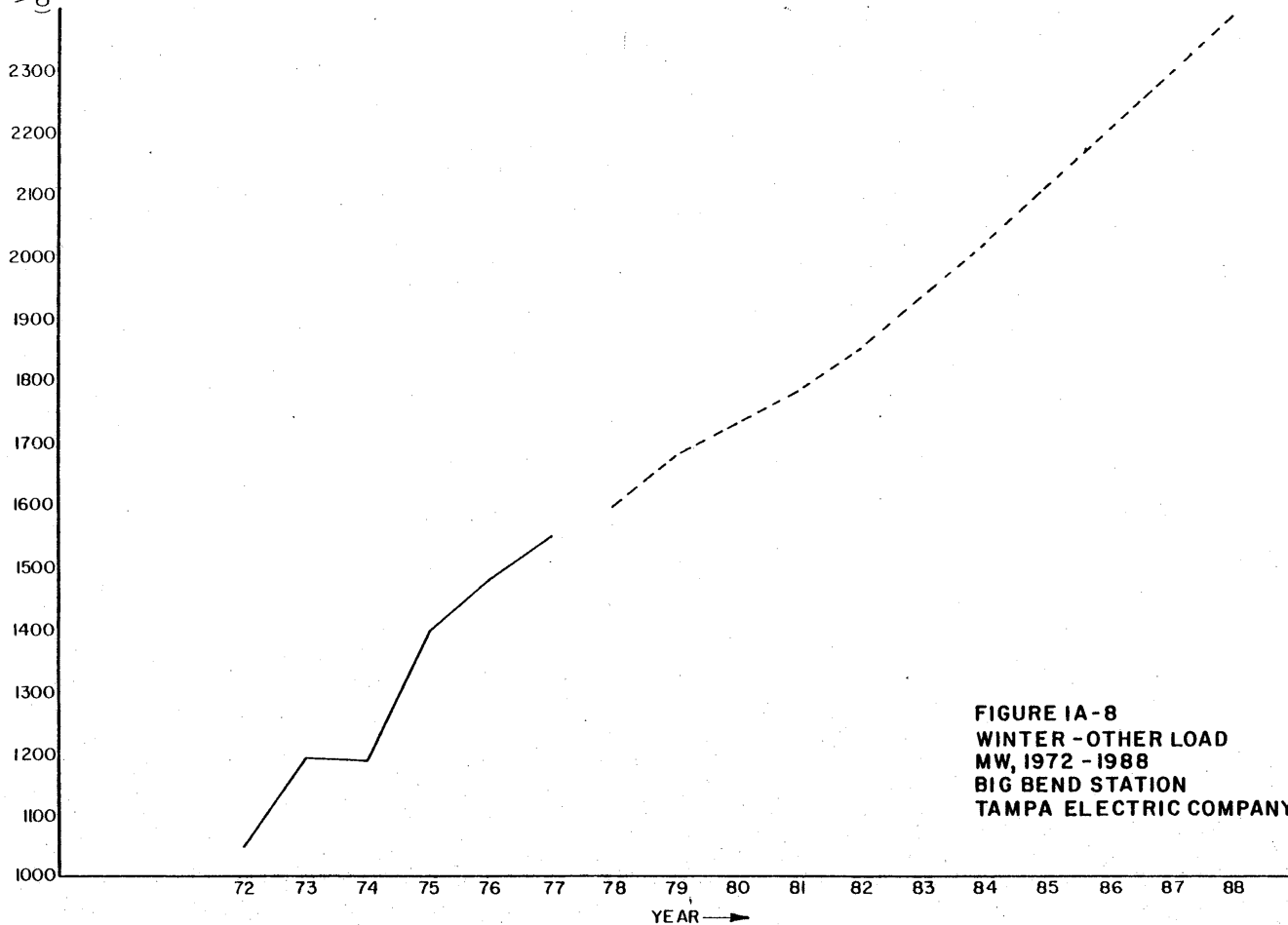
WINTER
(OTHER LOAD)
MW

2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000

72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88

YEAR →

FIGURE 1A-8
WINTER - OTHER LOAD
MW, 1972 - 1988
BIG BEND STATION
TAMPA ELECTRIC COMPANY



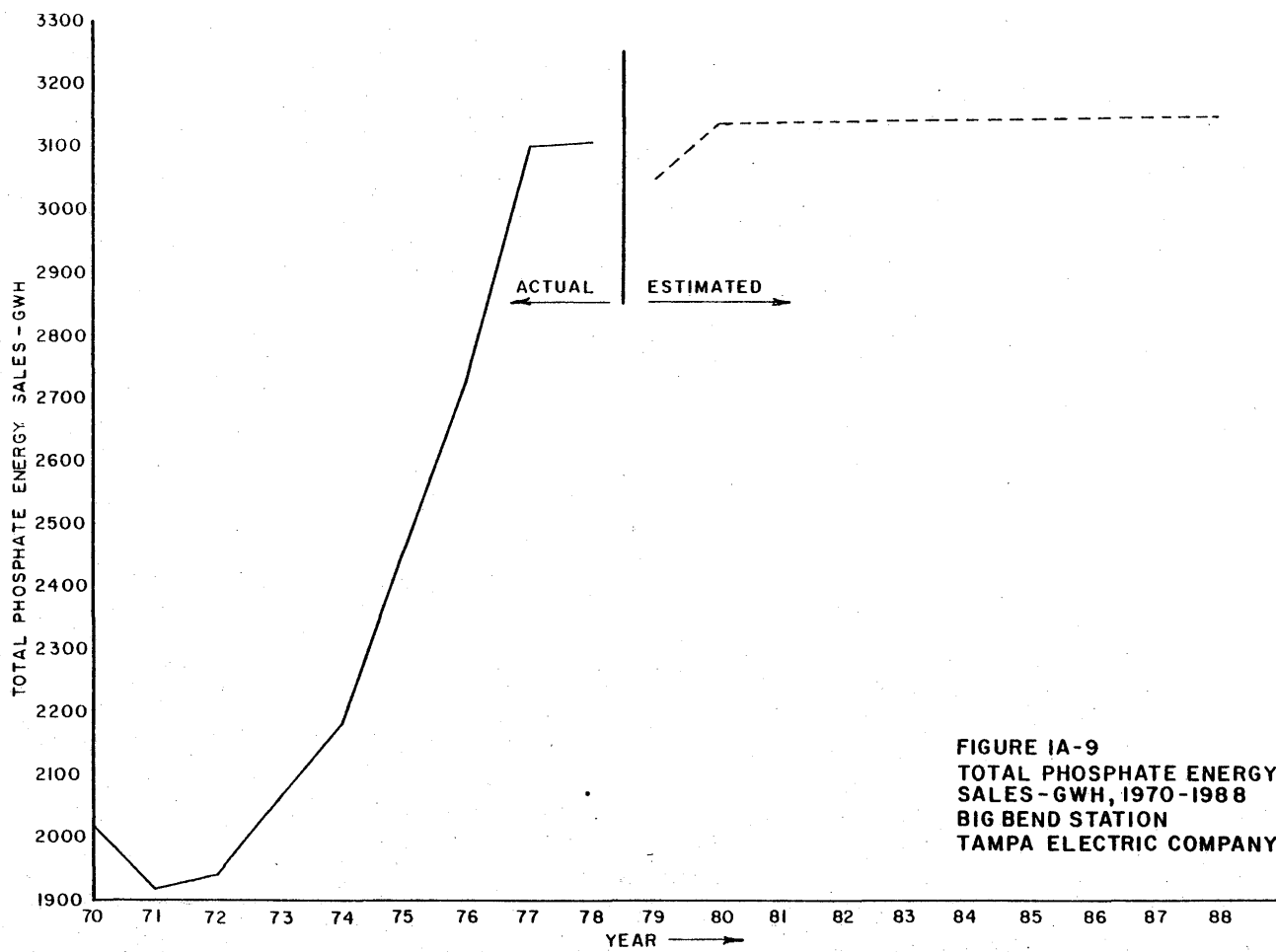


FIGURE 1A-9
TOTAL PHOSPHATE ENERGY
SALES-GWH, 1970-1988
BIG BEND STATION
TAMPA ELECTRIC COMPANY

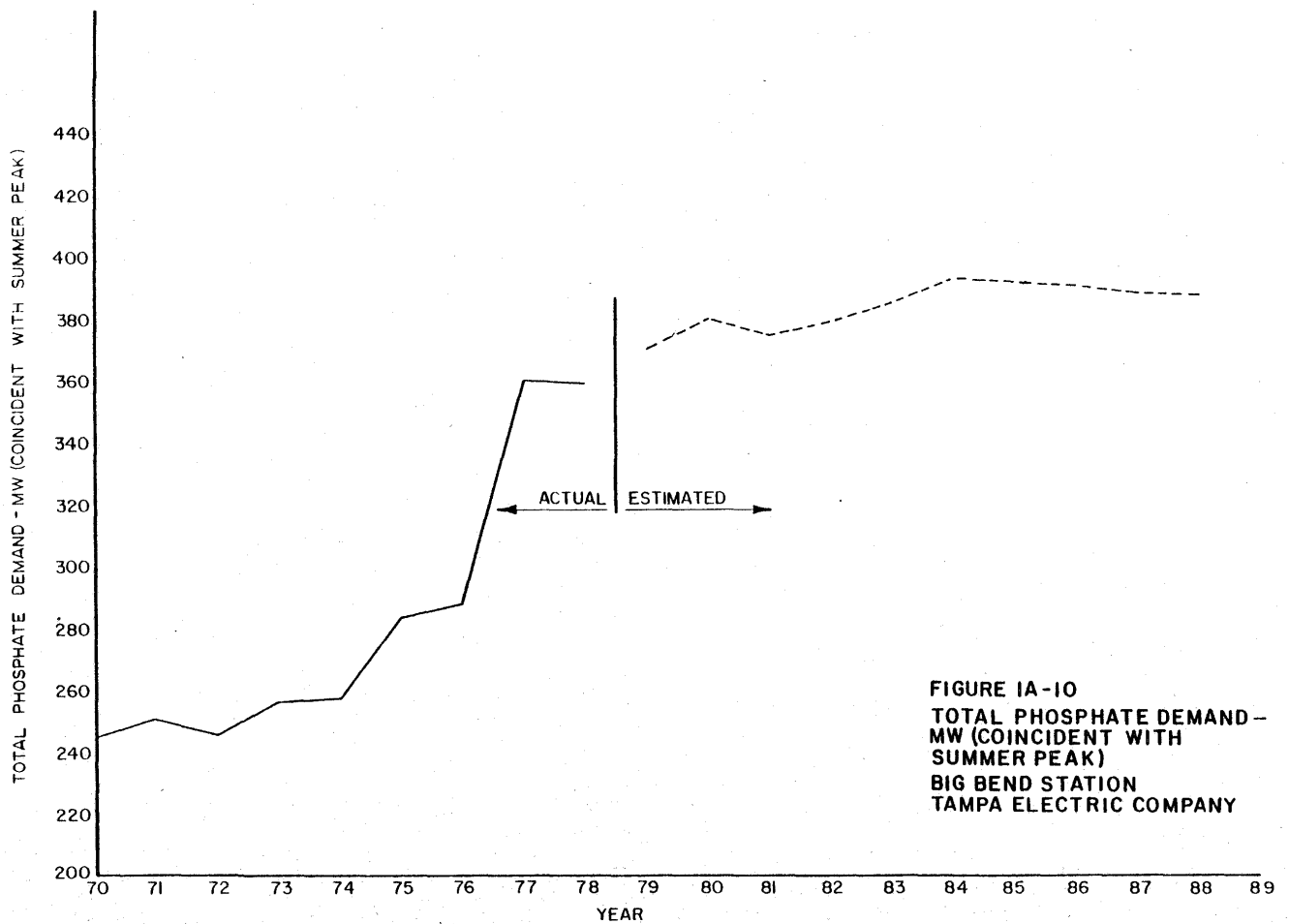


FIGURE 1A-10
TOTAL PHOSPHATE DEMAND -
MW (COINCIDENT WITH
SUMMER PEAK)
BIG BEND STATION
TAMPA ELECTRIC COMPANY

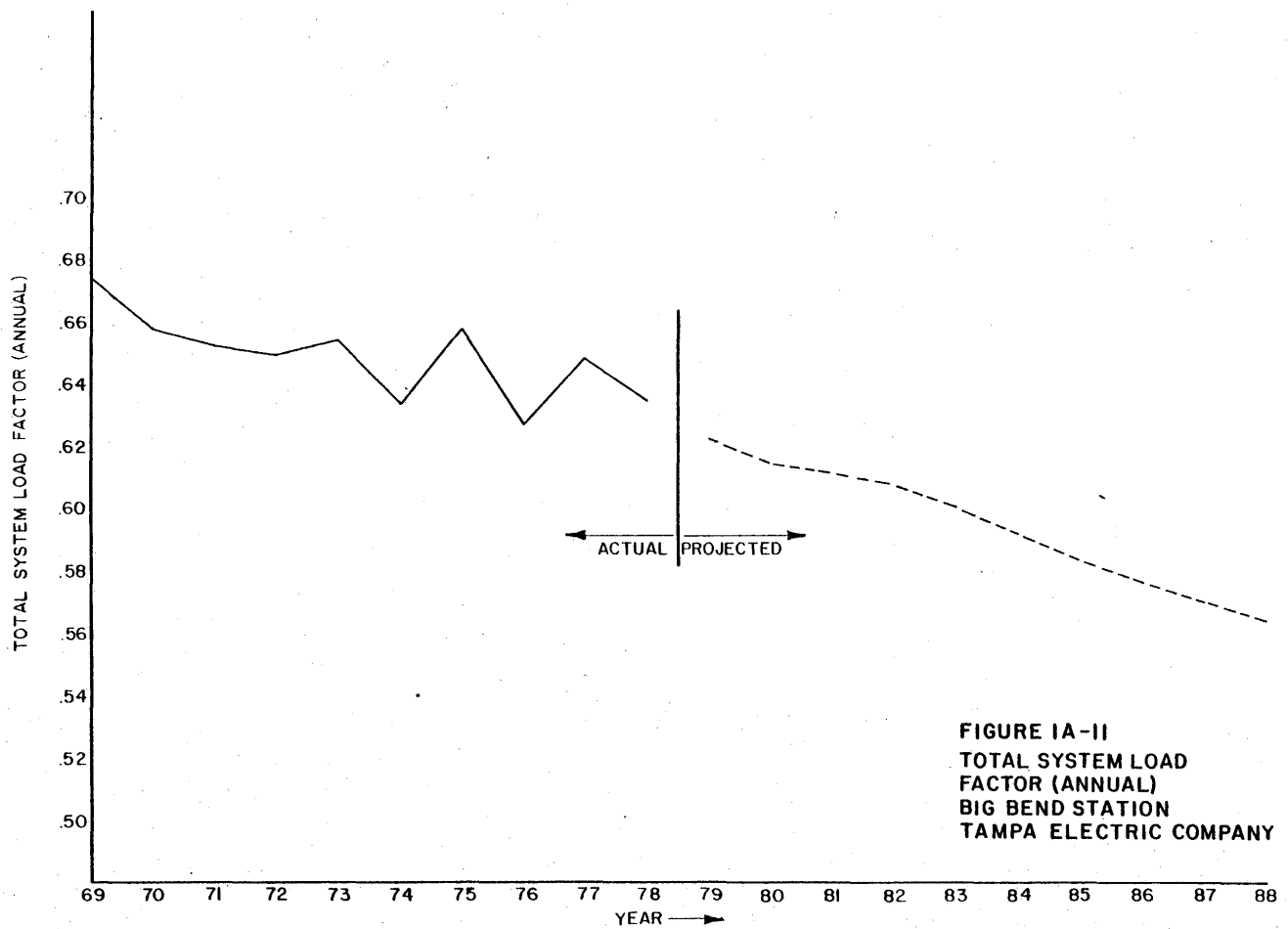


FIGURE 1A-II
TOTAL SYSTEM LOAD
FACTOR (ANNUAL)
BIG BEND STATION
TAMPA ELECTRIC COMPANY

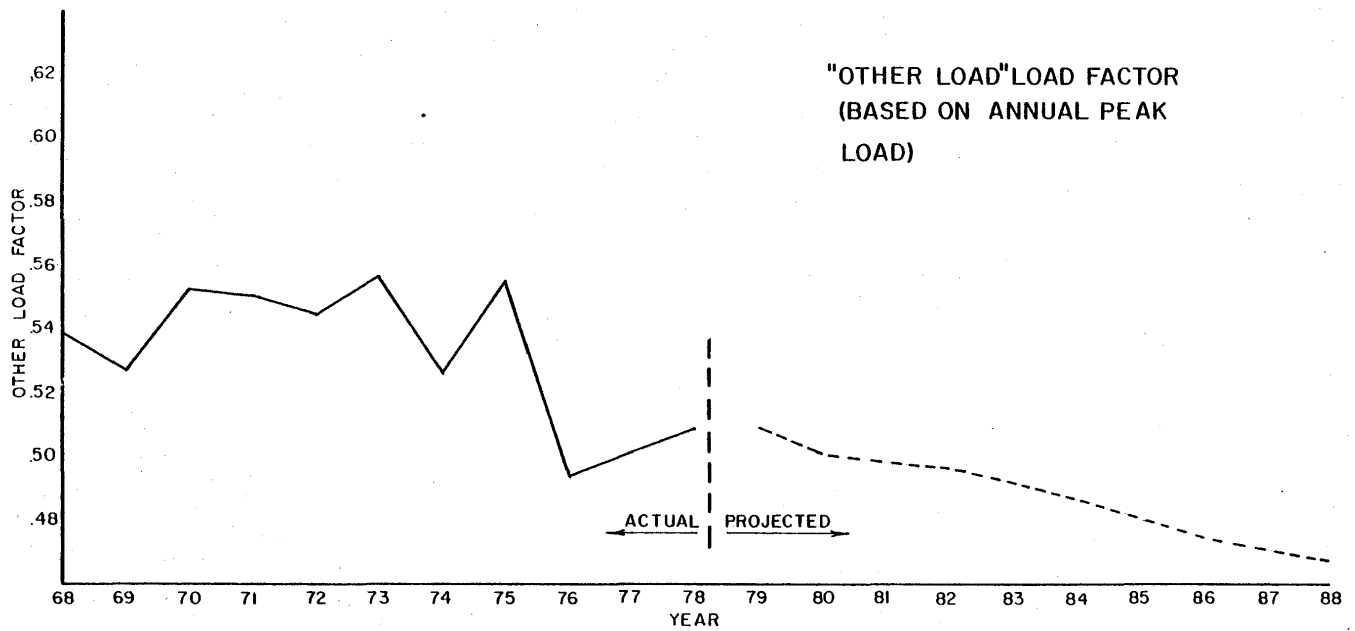
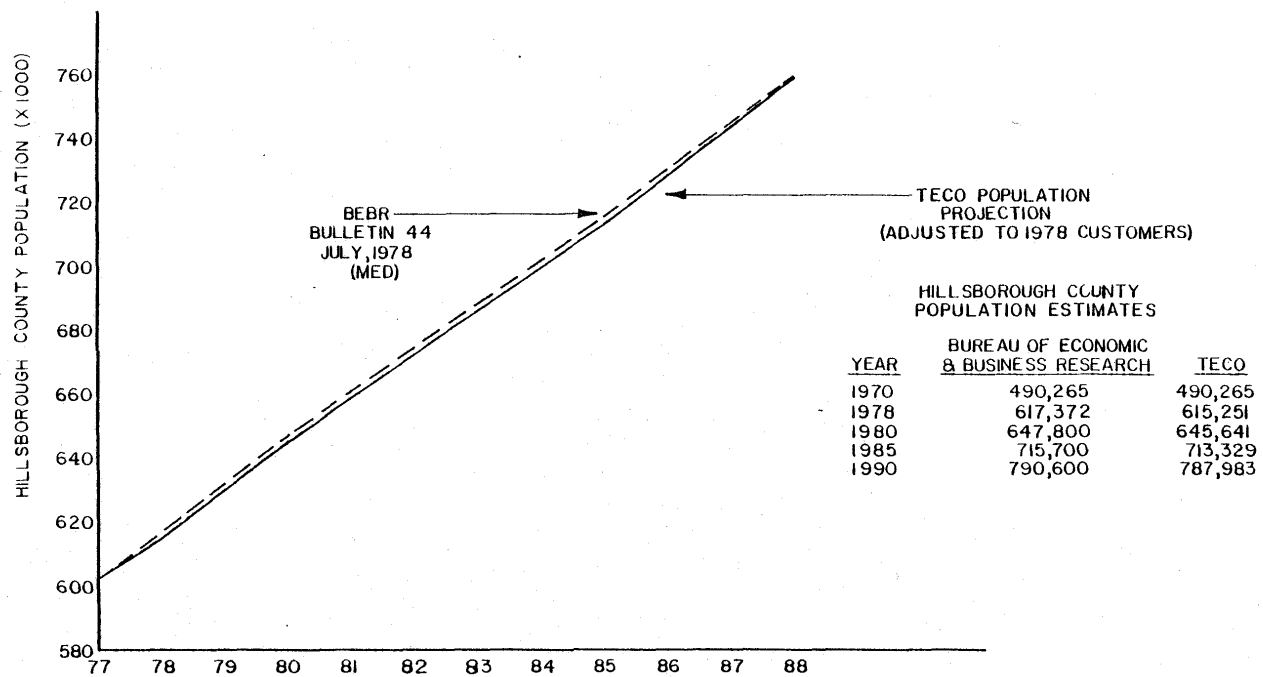


FIGURE 1A-12
"OTHER LOAD" ANNUAL
LOAD FACTOR
BIG BEND STATION
TAMPA ELECTRIC COMPANY



**FIGURE 1A-13
HILLSBOROUGH COUNTY
POPULATION ESTIMATES
BIG BEND STATION
TAMPA ELECTRIC COMPANY**

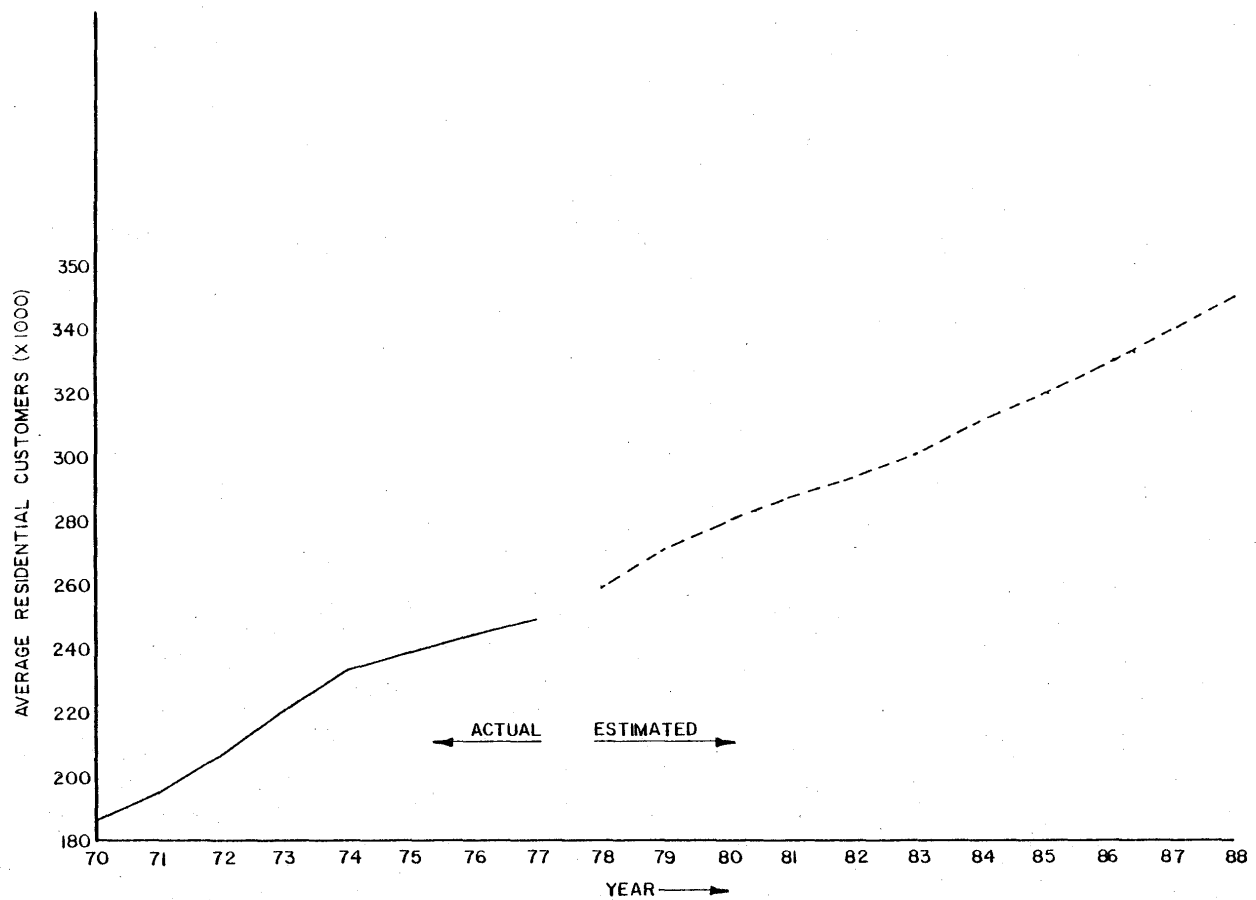


FIGURE 1A-14
AVERAGE RESIDENTIAL
CUSTOMERS, 1970-1988
BIG BEND STATION
TAMPA ELECTRIC COMPANY

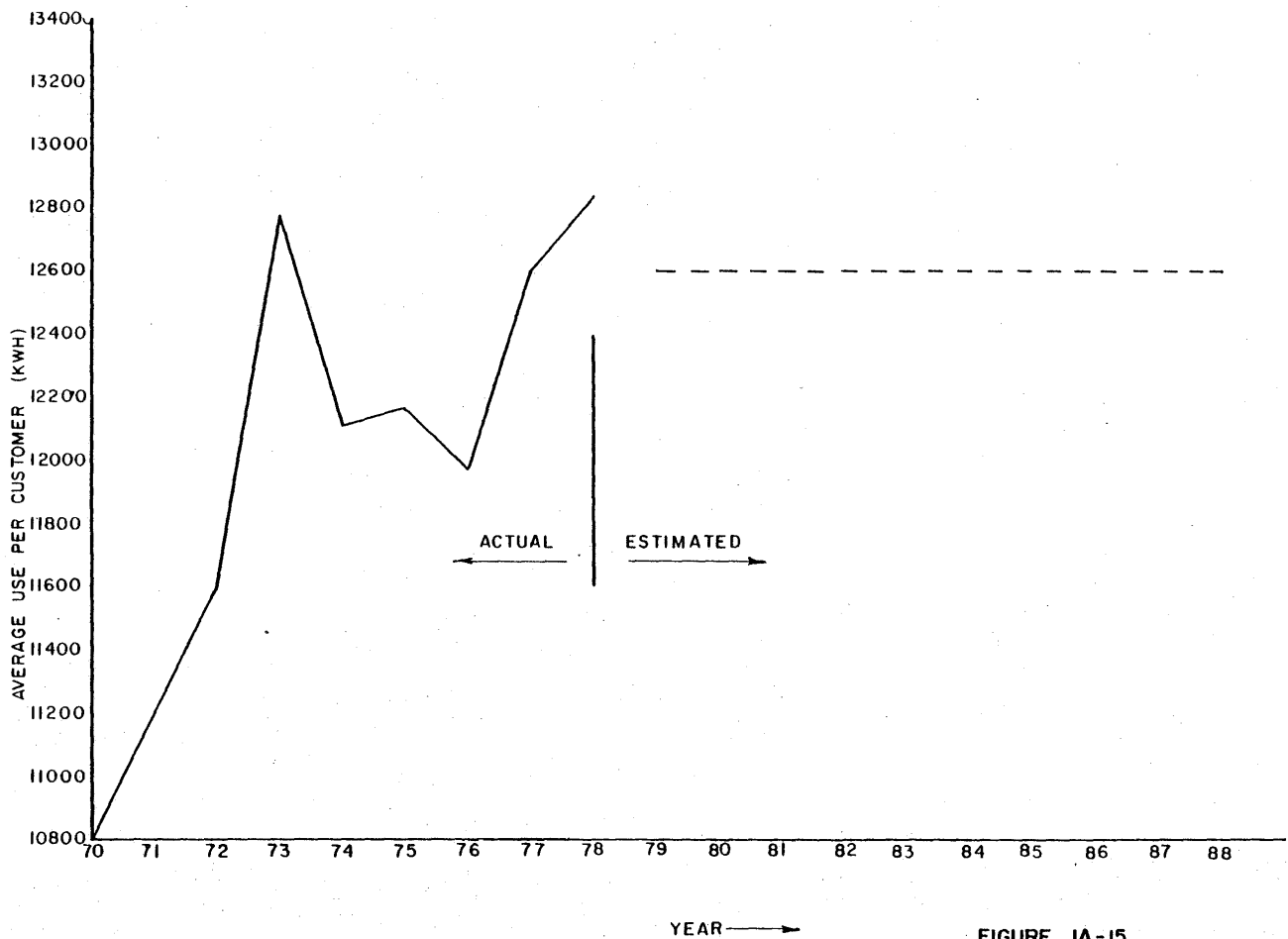


FIGURE 1A-15
AVERAGE USE PER
CUSTOMER (kWh)
BIG BEND STATION
TAMPA ELECTRIC COMPANY

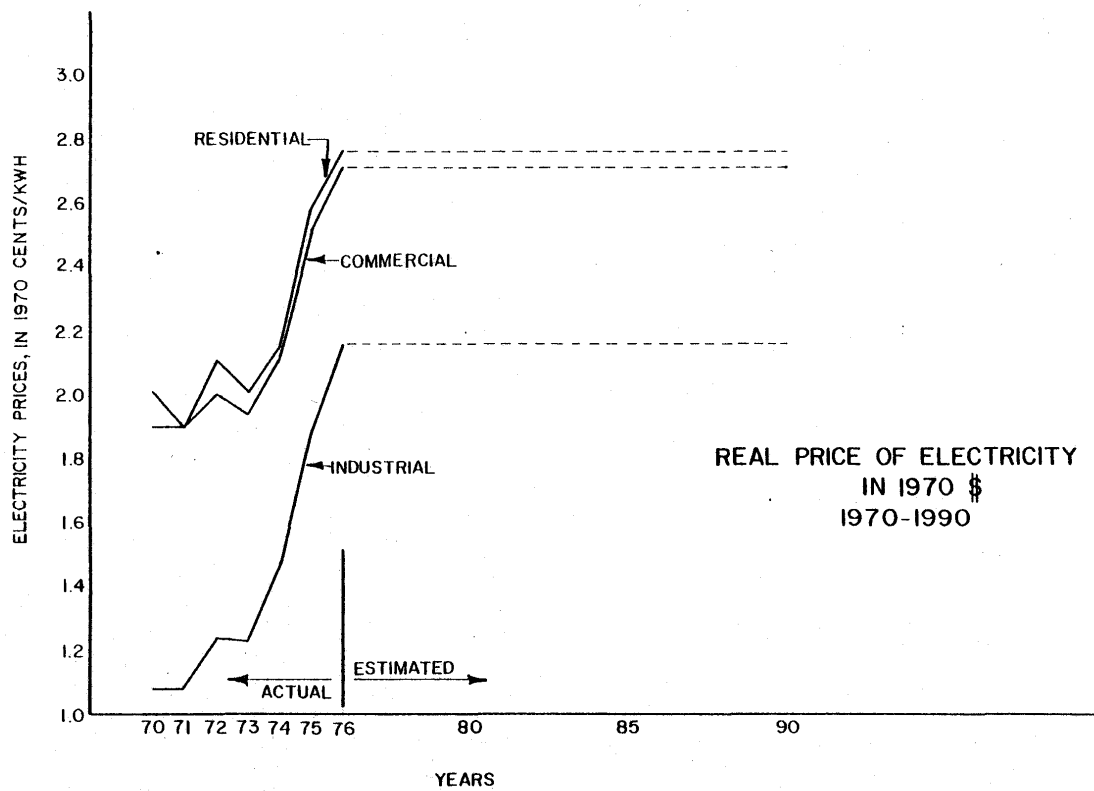


FIGURE 1A-16
REAL PRICE OF ELECTRICITY
IN 1970 DOLLARS, 1970-1990
BIG BEND STATION
TAMPA ELECTRIC COMPANY

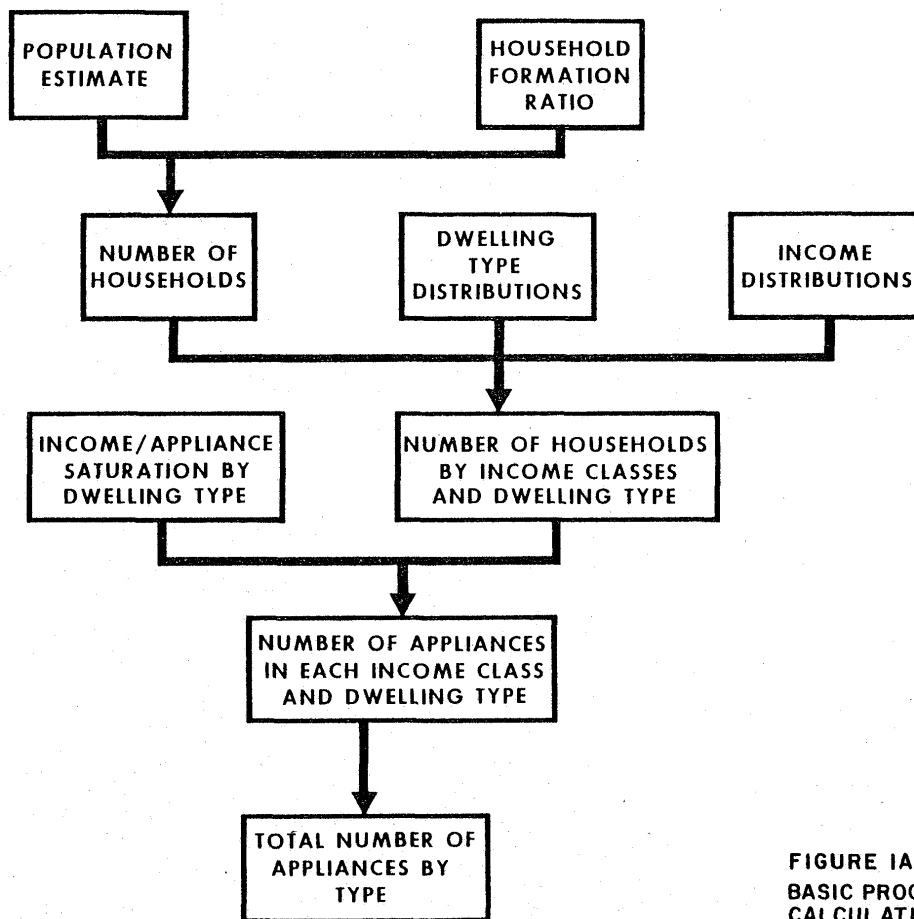


FIGURE 1A-17
BASIC PROCEDURE FOR
CALCULATING THE NUMBER
OF APPLIANCES
BIG BEND STATION
TAMPA ELECTRIC COMPANY

APPLIANCE SATURATION 1970 to 1990

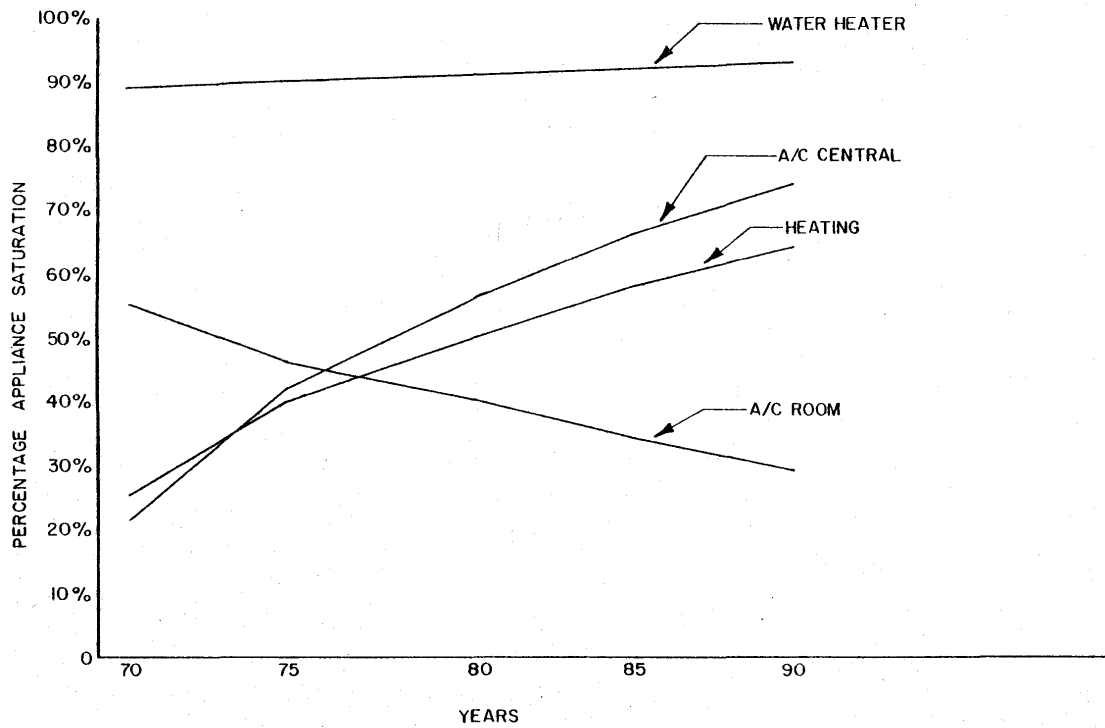


FIGURE 1A-18
APPLIANCE SATURATION
1970-1990
BIG BEND STATION
TAMPA ELECTRIC COMPANY

APPENDIX 1B

FORECAST METHODS

1B.1 TAMPA ELECTRIC COMPANY MULTIVARIATE DEMAND MODEL

The Tampa Electric Company Multivariate Demand Model consists of three regression equations for load other than phosphate. One equation is for the baseload which, by definition, is that load on the system that is independent of temperature. The remaining two equations describe the seasonal peak loads that are sensitive to temperature. One equation describes the summer temperature demand, and the other describes the winter temperature demand. From regression analysis, the following relationships have been determined:

Baseload = $388 + 5.7 (\# \text{ Residential Customers}) - 5611 (\text{Price of EL/CPI})$
The $\bar{R}^2$ for this equation is 0.97.

Temp. Sensitive
Demand (Summer) = $(^{\circ}\text{F} - 65)[16.6 + .16(\# \text{ A/C}) - 895 (\text{Price of EL/CPI})]$
The $\bar{R}^2$ for this equation is 0.88.

Temp. Sensitive
Demand (Winter) = $(65 - ^{\circ}\text{F})[-1.4 + .205 (\# \text{ Electric Heaters})]$
The $\bar{R}^2$ for this equation is 0.86.

Baseload - That component of demand (MW) that is insensitive to changes in temperature.

Temperature Sensitive Demand - That load component (MW) which is sensitive to temperature due to heating or air conditioning on the system.

Residential Customers - The average number of residential customers (in thousands).

CPI - Consumer Price Index.

$^{\circ}\text{F}$ - Average 24-hour temperature prevailing at the time of the system peak load.

A/C - Number of residential electric air conditioners (in thousands).

Electric Heaters - Number of residential electric heaters (in thousands).

$\bar{R}^2$ - Coefficient of determination.

A comparison of the regression equations against the actual data showed that they provide a very close approximation to the actual system loads, including the time period after the oil embargo. This closeness is because the equations are sensitive to price and are able to react to the events that occurred after the embargo. Tables 1B-1 and 1B-2 illustrate the actual and estimated graphs and the degree of "fit" of the multivariate model to historical data.

In order to develop the above equations, many different variables were examined. Some were as follows:

1. Average Use per Customer
2. Population
3. Unemployment
4. kWh Sales
5. GNP
6. Income
7. Assorted Lagged and Dummy Variables.

Once the historical relationships of the demand to certain variables have been quantified through regression analysis, the next step is to make some forecast assumptions of the future movement of independent variables such as customer and appliance saturation. With the multivariate model, the following items have been analyzed in order to make a forecast:

1. Customers (Residential)
2. Weather (Average 24-Hour Temperature)
3. Appliance Saturation (A/C and Heating)
4. Price of Electricity Relative to Price of Other Goods and Services.

The customer forecast has been made by using population projections from the University of Florida Bureau of Economic and Business Research (Bulletin 44). Population forecasts, modified by household formations, can be used to give a customer forecast.

The weather data that are used in the forecast process should be the temperatures (summer and winter) that are most likely to occur in the future at the time of the peak. No attempt is being made to forecast the weather itself, but rather, to make a statistical estimation of the type of weather most likely to occur at the time of a system peak.

The appliance saturation of electric heaters and air conditioners is determined from a knowledge of past trends and the number and type of new customer additions.

Finally, the relationship of the price of electricity to the price of other goods and services must be estimated. This variable can be assumed to remain constant in the sense that rises in cost of electricity will be matched with comparable increases in the price of other consumer commodities. This ratio can, of course, be assumed to increase or decrease to illustrate the effects of price on load forecasts.

Other sections of this demand and energy report illustrate, in detail, the assumptions that have been used to derive the multivariate demand model.

1B.2 TREND ANALYSIS

This forecast technique had been used extensively in the past and, until the oil embargo of 1973, worked quite satisfactorily. After 1973, there had been some difficulty applying the trend analysis or curve-fitting technique due to an inconsistent trend line.

Traditionally, trend analysis develops a simple correlation between a dependent variable and an independent variable. In the electric utility industry, this can be total energy sales correlated against the years the sales were made. With time as the independent variable, a forecast can be made simply by substituting a future year into the resulting curve-fitted equation. The trend technique can be modified by examining different time intervals (staggered or overlapped) to produce different equations (1968-1973 and 1970-1975). The results of the trend technique, when compared and augmented with subjective reasoning and a knowledge of historical growth patterns, can produce a forecast which may not necessarily follow a specific curve fit.

Judgment and the analysis of growth patterns are being added to the forecast technique because of the unpredictable nature of energy use over the last few years. Some of the forecast parameters that have been projected using the trend method are as follows:

1. Residential Customers
2. Street and Highway Lighting Energy Sales
3. Energy Sales to Public Authorities
4. Small Light and Power Energy Sales
5. Large Light and Power Energy Sales

6. Average Use per Customer

The residential energy sales are derived by multiplying the residential customers and average kWh use per customer projections. Both the small and the large light and power energy estimates are made by identifying and extrapolating certain historical relationships between the two energy classes. Miscellaneous sales are based on a simple trend line of historical data. The combination of these items is the major ingredient of the total energy sales projection. A peak kW demand forecast is made by combining total sales with an estimate of the system load factor, which is expected to decline slightly.

The energy forecast was prepared by a team that has nearly a half century of utility experience. This team has spent years studying and analyzing the behavior of the TECO system during growth and no-growth periods. The experience, knowledge, and judgment of this team has played a key role in preparing this forecast, and it has been used to temper the trend line equations. Although the overall method is subjective, it represents the best possible way to adapt trend analysis to growth patterns that are not clearly defined, especially the 1970-1978 time period.

1B.3 PHOSPHATE FORECAST

Preparation of the phosphate demand and energy sales forecast requires detailed knowledge of the phosphate industry. The forecast is prepared by the Phosphate Sales Department, which maintains close contact with each customer and is familiar with their expansion and closeout plans. Some of the primary ingredients in preparing the forecast are as follows:

1. Knowledge of expansion/closeout plans on the mining, furnaces, and chemical plants.
2. Familiarity with historical and projected industry trends.
3. Close working relationships with key phosphate personnel.
4. Awareness of past and future government legislation that may affect the industry.
5. Familiarity with the worldwide demand for phosphate products.
6. Knowledge of geological limitations of the industry in the TECO service area.
7. Correlation of electric energy consumption with the historical activity of the industry.

1B.4 DETAILED END-USE MODEL

The general structure of the TECO detailed end-use load forecasting model is based upon a load forecasting methodology recently developed by Battelle Memorial Institute and implemented for a number of electric utilities. The basic concept underlying this methodology involves breaking out numerous, end-use categories for electricity and then treating each of these in approximately the same way. In its simplest form, the basic forecasting equation is:

$$\begin{array}{lll} \text{Electricity use in} & \text{Number of Users} & \text{Average Consumption} \\ \text{any Category} & = \text{in the Category} & \times \text{by Each Category} \end{array}$$

The TECO model is partitioned into the conventional utility customer categories: residential, commercial, industrial, and miscellaneous. In the residential sector, the factor "number of users" refers to the basic household appliances. In the commercial and industrial sector, this factor refers to proxies of economic activity, such as number of employees.

In the current model structure, the factor "number of users" is derived from exogenous inputs. In the residential sector, these inputs are population and per capita income projections. In the industrial and commercial sector, they are primarily employment forecasts.

1B.4.1 Residential Power Submodel

The residential power submodel utilizes a detailed end-use approach to project annual energy consumption in the residential sector. Although the basic equations in the residential sector focus on the major household appliances, it should be noted that the primary consumption units are households. Estimates of households or customers are derived from exogenously supplied population forecasts (University of Florida Bureau of Economic and Business Research, Bulletin 44).

The energy consuming units in the residential sector are the major household appliances. For each of the appliances, annual energy consumption is calculated as follows:

$$E_i = N_i * C_i$$

where

E_i = Annual energy consumption by appliance i

N_i = Number of appliances of type i

C_i = Annual energy consumption for appliance of type i

Total residential energy consumption is the summation of all appliance consumption estimates plus the estimate for miscellaneous appliances, i.e., those electric appliances not explicitly recognized. It should be noted that the above

equations are strictly definitional, and thus, invariant over time.

From the above equation, it is quite clear that annual energy consumption depends upon two basic factors:

1. the number of appliances of a specific type
2. the annual energy consumption by appliance.

1B.4.2 Commerical Power Submodel

The commerical power submodel is designed to project electric energy consumption of those customers primarily in the service sector of the economy. Energy consumption in the commercial sector is, to a large extent, determined by the level of economic activity in the service area. In the model, economic activity is measured directly in terms of employment in the service sector. An exogenous projection of employment growth in the service sector, i.e., employment in government and private nonfarm and nonmanufacturing, is required to forecast commercial energy consumption.

Aside from employment, there are other measures of economic activity such as numbers of customers or commercial establishments, sales, and floor space. The number of customers or commercial establishments is inappropriate because electricity use varies significantly with establishment size and volume of activity. Sales were rejected because projections of sales volume by region are generally not available. Floor space was rejected for the same reason, as well as the absence of good historical building inventory data. Due to the lack of detailed consumption data, a disaggregation of the commercial category could not be performed.

The basic forecasting equation of commercial energy consumption is as follows:

$$EC_t = EMP_t * CPE_t$$

where

EC_t = Annual energy consumption in the commercial sector
in year t

EMP_t = Service sector employment in year t

CPE_t = Annual energy consumption per employee in year t

Because employment is an input parameter, the following discussion focuses on energy consumption per employee. In the discussion, this factor will be referred to as energy intensiveness. Energy intensiveness or kWh/employee in the commerical sector was derived by examining annual energy consumption and employment in the commercial sector for 1967 to 1975. Employment data for Hillsborough County in the nonfarm and nonmanufacturing sectors, obtained from the Bureau of Economic

Analysis (U.S. Department of Commerce, Regional Economics Information Systems, Table 25, Hillsborough County, Florida) was used in conjunction with TECO commercial energy consumption. For 1974 and 1975, the observed consumption per employee was adjusted so as to take out the price response for these two years. The resulting energy intensiveness is thus computed on a constant price of electricity basis. Regressing the MWH/employee values against time yielded the following expression:

$$\text{CPE}(t) = 6.58 = 0.420 * t$$

where

$\text{CPE}(t)$ = Annual energy consumption per employee in year t , expressed in MWH

t = Time in years ($t=0$ in 1970)

The R^2 for the equation is 0.95.

The above energy intensiveness and its growth over time compare very favorably with results of other electric utilities. This seems to indicate that, although the commercial sector is characterized by a diversity of establishments and activities, taken as a whole, it does act rather uniformly.

1B.4.3 Industrial Power Submodel

The purpose of the industrial power submodel is to project purchased electrical energy requirements, primarily in the manufacturing industries and phosphate mining. Electrical energy consumption in the industrial sector is tied to the level of economic activity. The major driving forces affecting energy consumption are the level of economic activity in the service area and the technologies of the industries involved. Since energy requirements for a given measure of economic activity vary from one industry to another, it is necessary to treat the mix of the industrial activity.

To capture the effect of industrial mix, the industrial sector is disaggregated into the subcategories shown in Table 1B-1. The subcategories have been defined on the basis of similar energy consumption per unit of economic activity.

As in the commercial sector, there are numerous ways of measuring industrial activity. Due to the ready availability of historical employment data on the two-digit SIC level, as well as employment projections, employment was used as the measure of activity in all subcategories except phosphate mining. Thus, the basic forecasting equations of the industrial sector are as follows:

$$EI_{i,t} = EMP_{i,t} * AC_{i,t}$$

where

$EI_{i,t}$ = Annual energy consumption in industrial subcategory i in year t

$EMP_{i,t}$ = Employment in subcategory i in year t

$AC_{i,t}$ = Annual energy consumption per employee in subcategory i in year t

Energy intensiveness in the nonphosphate subcategories is defined as the annual purchased electricity consumption per employee. Annual energy consumption by two-digit SIC was available from TECO data files. (Monthly industrial energy sales at the two-digit level are reported by TECO to the Federal Reserve and the Edison Electric Institute.) Comparing the annual energy sales for all SICs to sales reported in TECO's Financial and Operating Statistics, 1966-1976 showed differences between the two data sources. Since it was impossible to isolate the discrepancies, uniform adjustments were made to the SIC-specific data to make it agree with the data in the Financial and Operating Statistics. These data were combined with employment data by two-digit SICs for Hillsborough County to derive estimates of energy intensiveness (U.S. Department of Commerce, Bureau of the Census, County Business Patterns, Florida, Table 2, various years). Based upon preliminary analyses of these data, SICs were grouped into the four subcategories shown in Table 1B-1. As mentioned above, the primary criterion for grouping was similarity in the energy intensiveness. In deriving the estimates of energy intensiveness, the historical values were adjusted to remove changes in consumption due to price changes. The extrapolations, therefore, are on the basis of 1970 electricity prices.

1B.4.4 Miscellaneous Power Submodel

The miscellaneous power submodel includes those electric energy consumption categories not included in the residential, commercial, or industrial power submodels. Specifically, the following categories are included: street lighting, sales to public authorities, and others. In the following sections, the forecasting mechanisms for these subcategories are described.

1B.4.5 Street Lighting

Annual street lighting energy consumption is forecast as a function of households or residential customers in the service area. Specifically, the following general equation is used:

$$ASL_t = HH_t * ESL_t$$

where

ASL_t = Annual street lighting energy consumption in year t

HH_t = Number of residential customers in year t

ESL_t = Street lighting energy consumption per residential customer in year t

To obtain values of the parameter ESL, street lighting energy consumption and customer data for 1967 to 1977 were analyzed. The analysis showed that prior to 1974, the street lighting energy per customer remained at a constant level of 156 kWh. For 1976 to 1977, this value decreased to 140 kWh. For forecasting purposes, the energy consumption per customer is held constant at the 140-kWh level.

1B.4.6 Sales to Public Authorities

The annual energy consumption in the sales to public authorities subcategory is projected as a function of residential customers or households and time. The forecasting equation has the following form:

$$\text{SPA}_t = \text{HH}_t * \text{EP}_t$$

where

SPA_t = Annual sales to public authorities in year t
 HH_t = Number of residential customers in year t
 EP_t = MWH sales to public authorities per residential customer in year t

Analyzing TECO consumption and customer data for 1967 to 1977, the following expression for EP was obtained:

$$\text{EP}_t = 1.682 + 0.1105 * t$$

where

EP_t = MWH sales to public authorities per residential customer in year t
 t = Time in years = 0 in 1970

The above equation has an R^2 of 0.97 and was derived under the assumption of constant electricity prices. The same price adjustment mechanism as described in the commercial submodel is used to account for changes in consumption resulting from price changes. The short-term and long-term price elasticities of -0.3 and -1.0 for the commercial sector are assumed to apply.

1B.4.7 Peak Demand Submodel

The peak demand submodel is designed to compute summer and winter peak demand for the total system with the exception of the phosphate load. Sufficient information exists within TECO to forecast the phosphate peak demand independently. The peak demand projections are calculated from temperature sensitive and insensitive energy projections by applying a set of load factors. The computations, as well as the derivations of the load factors, are discussed below.

1B4.8 Temperature Insensitive Demand

The temperature insensitive demand for the nonphosphate sectors is computed by:

$$DB_t = E_t / (8760 * LF)$$

where

DB_t = Temperature insensitive demand for the nonphosphate sectors in year t

E_t = Annual energy requirements in all but the phosphate sector

LF = Load factor for temperature insensitive load.

The values of LF were estimated by examining daily peaks for loads other than phosphate for the month of April. Thus, for the years 1970 to 1977, the daily peaks for those weekdays with the maximum temperature less than 85°F were averaged. Based upon this average demand, a load factor for the temperature insensitive energy (as computed by the model) was calculated for each year of the 1970 to 1977 period. The values of the resulting load factors are given in Table 1B-2. Since these load factors do not exhibit any trend, their average was used as the numerical value for LF .

1B4.9 Temperature Sensitive Demand

The temperature sensitive demand for the nonphosphate sectors is computed by:

$$TSD_{t,T} = E_{t,T} / (24 * LF)$$

where

$TSD_{t,T}$ = Temperature sensitive demand in year t on peak day with average temperature T

$E_{t,T}$ = Temperature sensitive daily energy requirements in year t for average temperature T

LF = Load factor for temperature sensitive load on peak day.

The value of $E_{t,T}$ is computed according to the heating and cooling energy equations discussed in the residential and the commercial submodels. No elasticity adjustment is applied to the energy computation for residential heating and cooling on the peak day.

Estimates of the factor LF were derived for heating and cooling from demand data for the years 1970 to 1977. Comparison of summer and winter peak demand with the temperature insensitive demands derived from the April demand data resulted in the temperature sensitive demands. The average temperature sensitive demand was then divided by the corresponding peak demand to yield cooling and heating load factors for the peak day.

The average temperature sensitive demand was calculated using the energy equations for heating and cooling in the commercial and residential sector. The actual average temperature of the peak and the preceding day were used in the energy calculations. The resulting load factors showed no trend over time and, thus, the

averages for the 8 historical years were used. The daily load factors are 0.38 and 0.55 for heating and cooling, respectively.

1B.5 CALIBRATION RESULTS

To establish credibility in the Detailed End Use (DEU) model structure and the underlying data base, the model was used to simulate key outputs for the years 1970 to 1976. In this simulation, historical population, income, employment, and electricity prices were inputs to the DEU model. Also, the actual temperature conditions for the peak and the previous day were used to simulate the peak demand.

Comparisons of the annual energy consumption and peak demand by major sectors are shown in Tables 1B-3 and 1B-4. An examination of the comparisons shows that the DEU model tracks the general pattern of annual energy consumption quite well. The significance of this tracking ability depends upon the amount of structure and the influence of direct historical data on the results. For example, no direct historical data was used in the residential sector, and so the DEU model's ability to track historical consumption is entirely dependent on the structure of the forecasting mechanism and the associated indirect data.

While the above calibration results do not "prove" the validity of the DEU model, they do, however, increase one's confidence in its structure. This is particularly true since the period simulated is characterized by economic upturn and downturn as well as unprecedented increases in energy prices.

TABLE 1B-1
INDUSTRIAL SUBSECTORS

Food Products	SIC 20
Tobacco, Printing, etc	SIC 21, 23-24, 27, 37, 39
Fabricated Metals, etc	SIC 26, 29, 34, 38
Basic Industries	SIC 30, 32, 33, 35, 36

TABLE 1B-2

TEMPERATURE INSENSITIVE LOAD FACTORS

Year	Load Factor
1970	0.67
1971	0.68
1972	0.65
1973	0.69
1974	0.67
1975	0.63
1976	0.64
1977	0.70
Average	0.67

TABLE 1B-3
COMPARISON OF MODEL RESULTS WITH ACTUAL ENERGY CONSUMPTION (10⁶ kWh)
(Energy Less Phosphate)

	1970	1971	1972	1973	1974	1975	1976
RESIDENTIAL							
Actual	2019	2200	2416	2844	2828	2906	2911
Model	2057	2240	2395	2713	2844	2859	2979
Percent Difference	1.89	1.80	-0.88	-4.60	0.55	-1.62	2.24
COMMERCIAL							
Actual	1041	1165	1335	1525	1640	1767	1804
Model	1044	1171	1336	1588	1697	1650	1687
Percent Difference	0.23	0.47	0.07	4.15	3.46	-6.61	-6.50
INDUSTRIAL							
Actual	766	802	846	938	922	837	830
Model	800	803	850	898	936	815	837
Percent Difference	4.42	0.12	0.46	-4.21	1.48	-2.58	0.86
MISCELLANEOUS							
Actual	342	398	434	471	462	499	522
Model	342	378	409	460	486	499	521
Percent Difference	0.08	-4.91	-5.70	-2.27	5.30	0.0	-0.27
TOTAL							
Actual	4168	4565	5011	5778	5852	6009	6067
Model	4243	4591	4990	5660	5963	5824	6024
Percent Difference	1.8	0.57	-0.42	-2.04	1.9	-3.08	-0.71

TABLE 1B-4

COMPARISON OF MODEL PEAK LOADS WITH ACTUAL
(Load other than Phosphate)

		Winter (MW)	Summer (MW)
1970	Model	880	860
	Actual	862 J *	854
	Percent Difference	2.1	0.7
1971	Model	835	931
	Actual	885 J *	944
	Percent Difference	-5.6	-1.4
1972	Model	843	1024
	Actual	897 F *	1056
	Percent Difference	-6.0	-3.0
1973	Model	1059	1161
	Actual	1107 D *	1185
	Percent Difference	-4.3	-2.0
1974	Model	1210	1264
	Actual	1196 F *	1271
	Percent Difference	1.1	-0.6
1975	Model	1228	1263
	Actual	1252 D *	1281
	Percent Difference	-2.0	-1.4
1976	Model	1339	1229
	Actual	1398 J *	1280
	Percent Difference	-4.2	-4.0
1977	Model	1517	1408
	Actual	1477 J *	1359
	Percent Difference	2.7	3.6

* Denotes Month of winter peak.

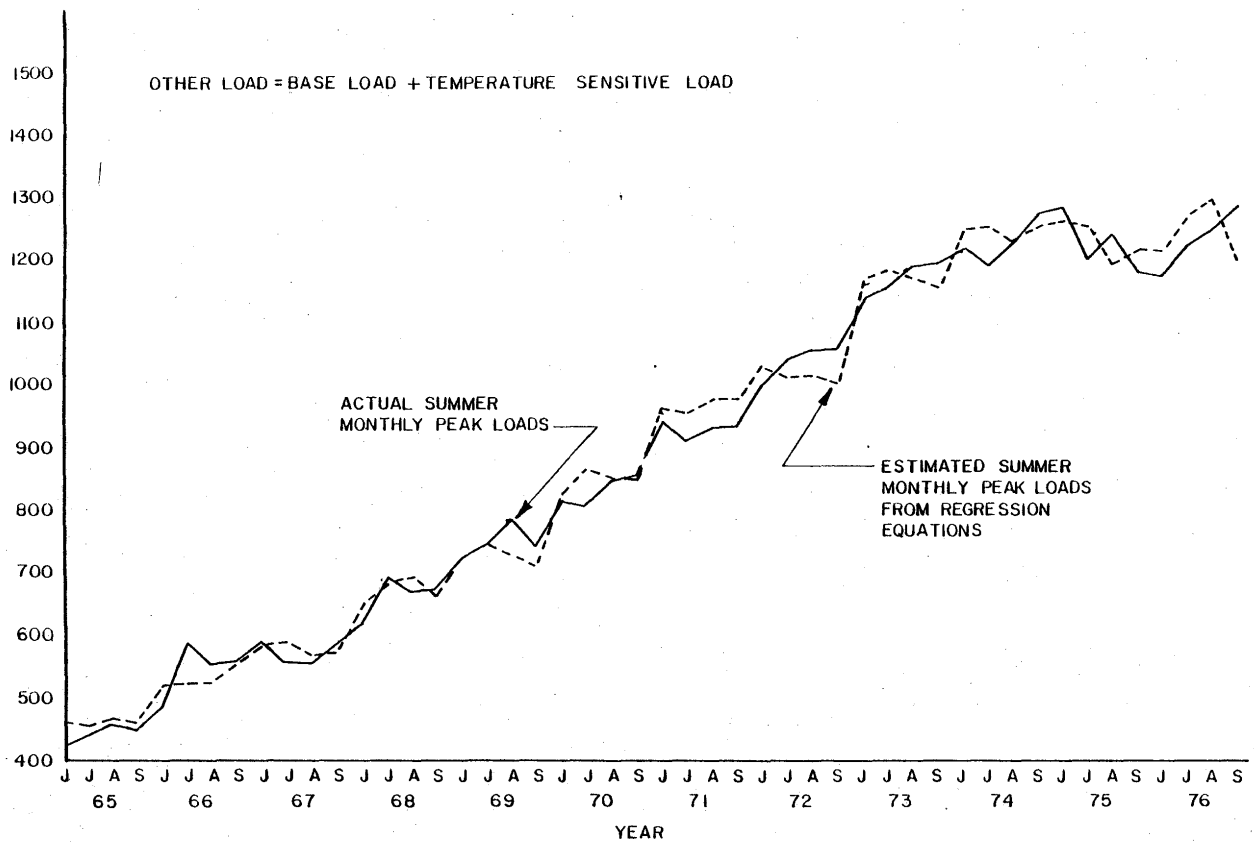


FIGURE IB-1
HISTORICAL ANALYSIS-SUMMERS,
1965-1976 (JUNE-SEPTEMBER)
BIG BEND STATION
TAMPA ELECTRIC COMPANY

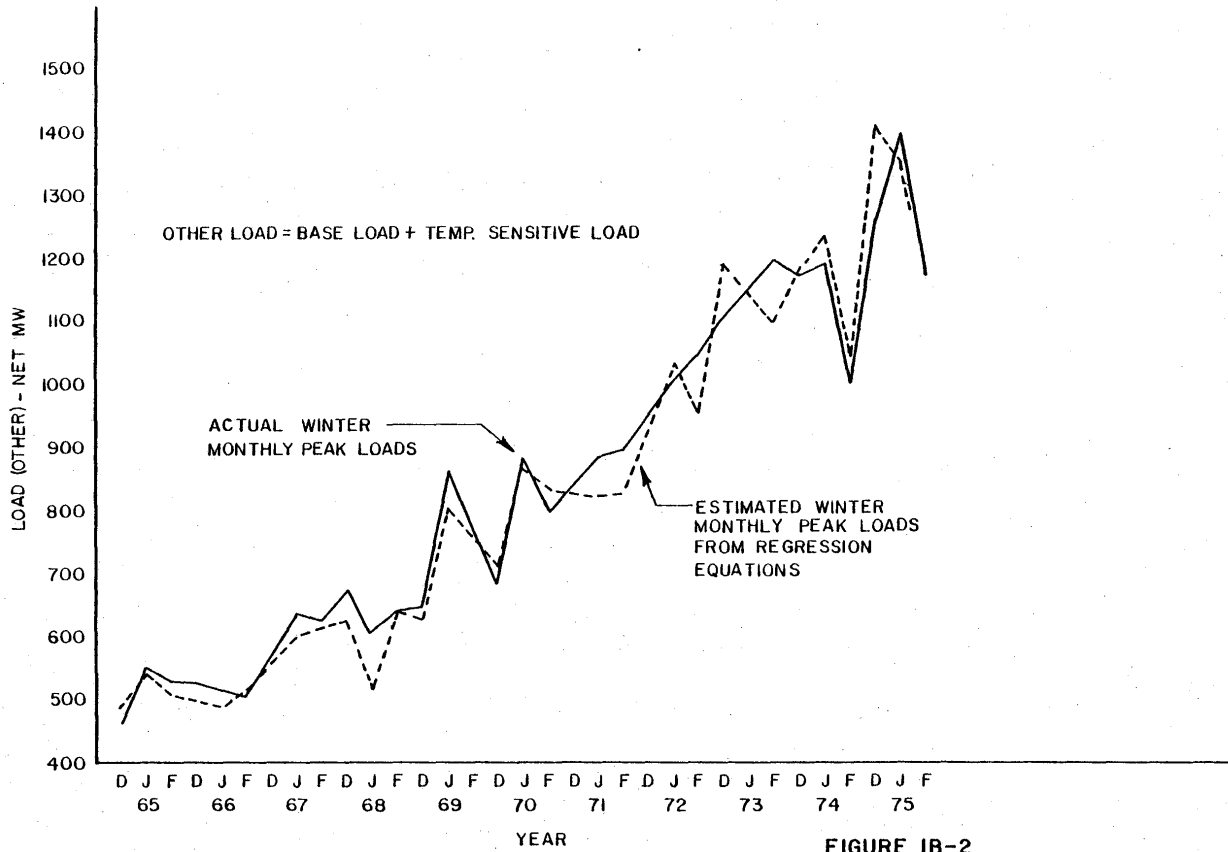


FIGURE IB-2
HISTORICAL ANALYSIS-WINTERS,
1965-1976 (DECEMBER-FEBRUARY)
BIG BEND STATION
TAMPA ELECTRIC COMPANY

APPENDIX 1C

INTEGRATION OF FORECAST METHODS

1C.1 COMPARISON OF METHODS

Independent forecasts were prepared by using each of the three methods outlined earlier for both demand and energy and the results were compared. Figure 1C-1 illustrates a comparison of total energy sales projections using the Detailed End Use (DEU) model and trend analysis. Both forecasts are very similar over the 1978-1988 period. TECO selected the energy forecast from the trend analysis model for the 1978-1988 period. The trend analysis was chosen because the Detailed End Use method is new to TECO, while the trending method applied to energy sales has been used for many years. The Detailed End Use method served as a guidepost to help confirm the results of the trending methods.

Figure 1C-2 compares the summer peak demand projections of the DEU model and the multivariate model. Both methods gave nearly the same results in 1988, but the DEU model shows a decrease in growth after 1980. The decrease in growth is shown because the DEU model is sensitive to appliance efficiency standards that should be in effect after 1980. The multivariate model does not take this appliance efficiency into consideration. In addition, the DEU model offers a more complete representation of appliance penetrations of major cooling equipment over the next 10 years than does the multivariate model. For these reasons, the DEU model forecast of summer peak demand output was selected.

It should be noted that both the DEU and the multivariate models are new to TECO and, consequently, there was no reason to favor any one particular technique. Trend analysis was used to compare the peak demand forecasts, and it gave similar results to corroborate the other, more descriptive models.

The winter peak demand forecast comparisons of the multivariate and detailed end use methods are illustrated on Figure 1C-3. For reasons similar to the summer demand forecast, the detailed end use forecast of winter peak demand was selected. Comparison of Figure 1C-2 and Figure 1C-3 shows that the winter peak demand is less sensitive to appliance efficiency standards than the summer peak demand. The majority of the new heating equipment is resistive, and efficiency improvements are unlikely. As a result of these factors, there has been predicted a steady winter growth increase beyond 1980. On the other hand, the summer growth is expected to drop somewhat after 1980

because appliance efficiency standards are expected to be in force after 1980.

1C.2 CONCLUSIONS

The total TECO energy sales forecast is based on a trend analysis projection that was verified by a new DEU model. The summer and winter peak demand forecasts are based on a DEU model projection. The many assumptions and judgments applied to the demand and energy models are considered to be reasonable and proper, based on the information that is available today. In addition, all of the forecast methods described in this report have been carefully studied and the final results have been tempered by judgment and experience. Figure 1C-4 is a flow chart that illustrates the general procedure that has been used to combine the various forecasting techniques.

1C.3 NEW TECHNOLOGIES

For the 1978-1988 demand and energy forecast, several different new technologies have been studied to determine their impact on future projections. Some of these new technologies are as follows:

- o Electric Cars
- o Solar Heating and Cooling Equipment
- o Load Management

1C.3.1 Electric Cars

It is difficult to predict the introduction of major appliances in the residential sector, but there is no doubt that electric vehicles will be introduced some time in the future. The timing of this new "appliance" will be dependent on political factors as well as advancements in battery technology. Recent information from General Motors predicts the following data for the electric car:

PROJECTED ELECTRIC CAR DATA

1. Expected range of electric car - 100 miles.
2. Average miles driven per year - 8,000 miles.
(This compares with 11,000 miles for conventional auto.)
3. Average trip per day - 30 miles.
4. Top speed - 40 to 50 mph.
5. Energy consumption 25 kWh for 100-mile range;

- 7.5 kWh for average 30-mile trip.
6. Power consumption during charging (assumes 5-6 hour charge cycle)
4 kW from dead battery;
1.5 kW for average 30-mile trip.
 7. Special 230-volt outlet will be required for the charging current.
 8. For driver with an average of twenty 30-mile trips per month, energy use will be 150-kWh/month.
 9. The electric car will primarily be used in town for short distances. It should help families in mid-1980s to save ration coupons so they can use conventional car for longer weekend trips (hypothetical scenario).
 10. U.S. Market Penetration 1982 - 1,000 vehicles;
1985 - 200,000 vehicles; 1990 - 1,500,000 vehicles.
 11. Oil shortages or rationing in near future could increase market penetration and the introduction of an electric car that does not have an ideal 100-mile range or 50 mph top speed.

Based on the above data, there will be approximately 75,000 electric vehicles in operation in Florida by 1990. (Five percent of U.S. car registrations are in Florida.) Hillsborough County (which has about 7 percent of the Florida vehicle registrations) will have about 5,200 electric cars in 1990, each consuming about 1,800 kWh per year and 1.5 kW when charging. This use of electric cars would increase energy sales by less than 0.1 percent, and increase peak demand by less than 0.3 percent (assuming no charging diversity between vehicles). Electric cars should have no significant impact on the TECO 10-year forecast.

1C.3.2 Solar Heating and Cooling

Solar appliances have been examined to determine the impact on the 10-year demand and energy forecast. Some of the major assumptions that were used in the study are presented in the schema below:

Solar Appliances in Existing Buildings

Assumption 1: that 25 percent of all buildings could be retrofitted with solar systems

Assumption 2: that the ultimate market penetration levels which will be achieved in various solar energy applications

over the next decade are as follows:

10 percent for solar hot water heating

2 percent for solar space heating

0.5 percent for solar space cooling in residential buildings

2 percent for solar space cooling in commercial buildings.

Solar Appliances in New Buildings

Assumption 1: that 50 percent of all new buildings will be suitable candidates for installation of solar systems

Assumption 2: that market capture rates, i.e., percent of annual starts, based on economic factors alone are as follows:

30 percent for hot water heating

4 percent for space heating

1 percent for space cooling in residential buildings

5 percent for space cooling in commercial buildings.

Because these rates are assumed to be representative of the situation over the next decade they are applied uniformly over each of the ten years.

Source: Solar Energy Utilization in Florida, Florida Energy Committee, June 1975.

The DEU model applied to the above assumptions resulted in 150 GWh of electrical energy that could be delivered by solar devices for heating/cooling and water heating by 1988. This 150 GWh represents about 1 percent of TECO's total energy sales, and, thus, is not considered to be a major reduction in the overall forecast. Solar devices are not expected to affect peak kW demand because this analysis assumes that future solar equipment will have standby electrical power which may be in use at the time of the system peak (e.g., cold, cloudy, or winter days).

1C.3.3 Load Management

Load management is a broad topic that encompasses the following areas:

- o Time-of-day rates
- o Utility control of appliances
- o Energy efficiency programs.

Time-of-day rates and utility control of appliances will have little impact on energy consumption, because they are designed to shift on-peak energy to an off-peak period. The on-peak demand may be reduced, as it, too, is shifted to an off-peak time period. The overall effect will be to shave on-peak demand while keeping the total energy consumption essentially unchanged.

Due to uncertain political and social considerations, it is difficult to determine the influence of time-of-day rates or direct load control. There are also a host of unresolved economic and technical questions that must be answered before the feasibility of load management is demonstrated. For these reasons, no adjustment has been made either to the demand or to the energy forecast as a result of time-of-day rates or direct load control. At the present time, TECO is participating in a joint TECO/Florida Power Corporation commercial load management test project. The results of this project will help answer some of the economic and technical questions in the commercial arena. In addition, other load management projects throughout the country are being closely watched. To help stay abreast of these projects, TECO is represented on an IEEE load management task force.

Energy efficiency programs have been indirectly factored into this forecast through price elasticity, which results in decreased consumption as customers install better insulation and more efficient appliances.

Currently, TECO has two energy efficiency programs in progress. The first is an Energy Efficiency Award program for builders who meet certain criteria for new housing construction. The Energy Audit program analyzes existing dwellings for energy efficiency and the results are given to the homeowner for possible improvement. Both programs are designed to help the homeowner react to higher price by reducing overall energy consumption (price elasticity).

1C.4 FORECAST SCENARIOS

Three forecast scenarios (Figures 1C-5 through 1C-9) have been prepared and are listed in this section: low, medium, and high. The medium forecast is the official, published projection. It is the estimate most likely to occur over the next ten years. The high and low forecast scenarios were derived from the University of Florida Bureau of Economic and Business Research low and high population projections. This information was then used to calculate customer estimates and the associated demand and energy scenarios. Although these low and high limits represent extremes of population variations, it is possible that future population statistics may not be as high or as low as the University of Florida has estimated. For purposes of this report, the high and low scenarios represent variations from the medium population project combined with factors such as decreasing or increasing electricity prices and appliance efficiency standards.

The high and low projections take into account the amount and the likelihood of deviation of these variables from the medium forecast. The high forecast, for example, is based on a population projection somewhat higher than the medium case, with some decrease in the real price of electricity and no real significant change in proposed appliance efficiency standards. These assumptions are based on the fact that there is a low probability that the independent variables will simultaneously be at the worst extreme. For example, it seems unlikely that high population growth (and customers) would be coupled with sharply decreasing real price of electricity because a rapidly expanding utility system requires large amounts of capital and the price of electricity would tend to increase rather than decrease under these conditions. The medium forecast and the high and low scenarios presented within this report represent a "range of reasonableness" of future assumptions rather than the worst case.

TABLE 1C-1

POPULATION

<u>YEAR</u>	<u>LOW SCENARIO</u>	<u>MEDIUM SCENARIO</u>	<u>HIGH SCENARIO</u>
1978	615,251	615,251*	615,251
1980	630,105	645,641	653,810
1982	648,344	672,716	688,062
1984	667,111	699,791	724,108
1986	686,537	728,260	761,821
1988	706,646	758,121	801,263

*Preliminary

TABLE 1C-2

AVERAGE RESIDENTIAL CUSTOMERS

<u>YEAR</u>	<u>LOW SCENARIO</u>	<u>MEDIUM SCENARIO</u>	<u>HIGH SCENARIO</u>
1968		170,839	
1969		177,472	
1970		186,153	
1971		195,702	
1972		207,213	
1973		221,251	
1974		233,356	
1975		239,215	
1976		243,548	
1977		249,362	
1978		258,944*	
1979	264,909	270,560	270,580
1980	271,070	280,030	281,268
1981	277,325	287,030	291,017
1982	283,713	294,206	301,093
1983	290,237	301,561	311,506
1984	296,899	310,608	322,266
1985	303,704	319,926	333,386
1986	310,382	329,524	344,417
1987	317,185	339,504	355,790
1988	324,116	349,592	367,514

*Preliminary

TABLE 1C-3

TOTAL ENERGY OUTPUT TO LINE - GWH

<u>YEAR</u>	<u>LOW SCENARIO</u>	<u>MEDIUM SCENARIO</u>	<u>HIGH SCENARIO</u>
1968		5,880	
1969		5,973	
1970		6,672	
1971		7,537	
1972		8,112	
1973		9,263	
1974		8,750	
1975		9,015	
1976		9,294	
1977		10,131	
1978		10,526*	
1979	10,614	10,700	10,744
1980	10,897	11,071	11,162
1981	11,069	11,289	11,424
1982	11,247	11,511	11,692
1983	11,428	11,742	11,972
1984	11,668	12,034	12,318
1985	11,900	12,322	12,663
1986	12,139	12,618	13,018
1987	12,383	12,926	13,387
1988	12,636	13,242	13,772

*Preliminary

TABLE 1C-4

TOTAL SYSTEM PEAK DEMAND - MW (SUMMER)

<u>YEAR</u>	<u>LOW SCENARIO</u>	<u>MEDIUM SCENARIO</u>	<u>HIGH SCENARIO</u>
1968		951	
1969		1,022	
1970		1,098	
1971		1,194	
1972		1,302	
1973		1,441	
1974		1,527	
1975		1,565	
1976		1,568	
1977		1,720	
1978		1,780	
1979	1,843	1,861	1,870
1980	1,917	1,954	1,974
1981	1,837	1,984	2,012
1982	1,972	2,029	2,067
1983	2,018	2,087	2,135
1984	2,075	2,154	2,214
1985	2,125	2,216	2,289
1986	2,181	2,286	2,370
1987	2,234	2,352	2,450
1988	2,293	2,424	2,536

TABLE 1C-5

TOTAL SYSTEM PEAK DEMAND - MW (WINTER)

<u>YEAR</u>	<u>LOW SCENARIO</u>	<u>MEDIUM SCENARIO</u>	<u>HIGH SCENARIO</u>
1968		927	
1969		1,114	
1970		1,105	
1971		1,129	
1972		1,300	
1973		1,366	
1974		1,458	
1975		1,693	
1976		1,784	
1977		1,891	
1978	1,936*	1,960*	1,972*
1979	2,004	2,055	2,080
1980	2,044	2,104	2,142
1981	2,097	2,159	2,223
1982	2,162	2,235	2,315
1983	2,237	2,323	2,420
1984	2,307	2,411	2,521
1985	2,382	2,501	2,628
1986	2,453	2,588	2,735
1987	2,529	2,678	2,847
1988	2,581	2,751	2,938

*Preliminary - peak expected to occur January 1979.

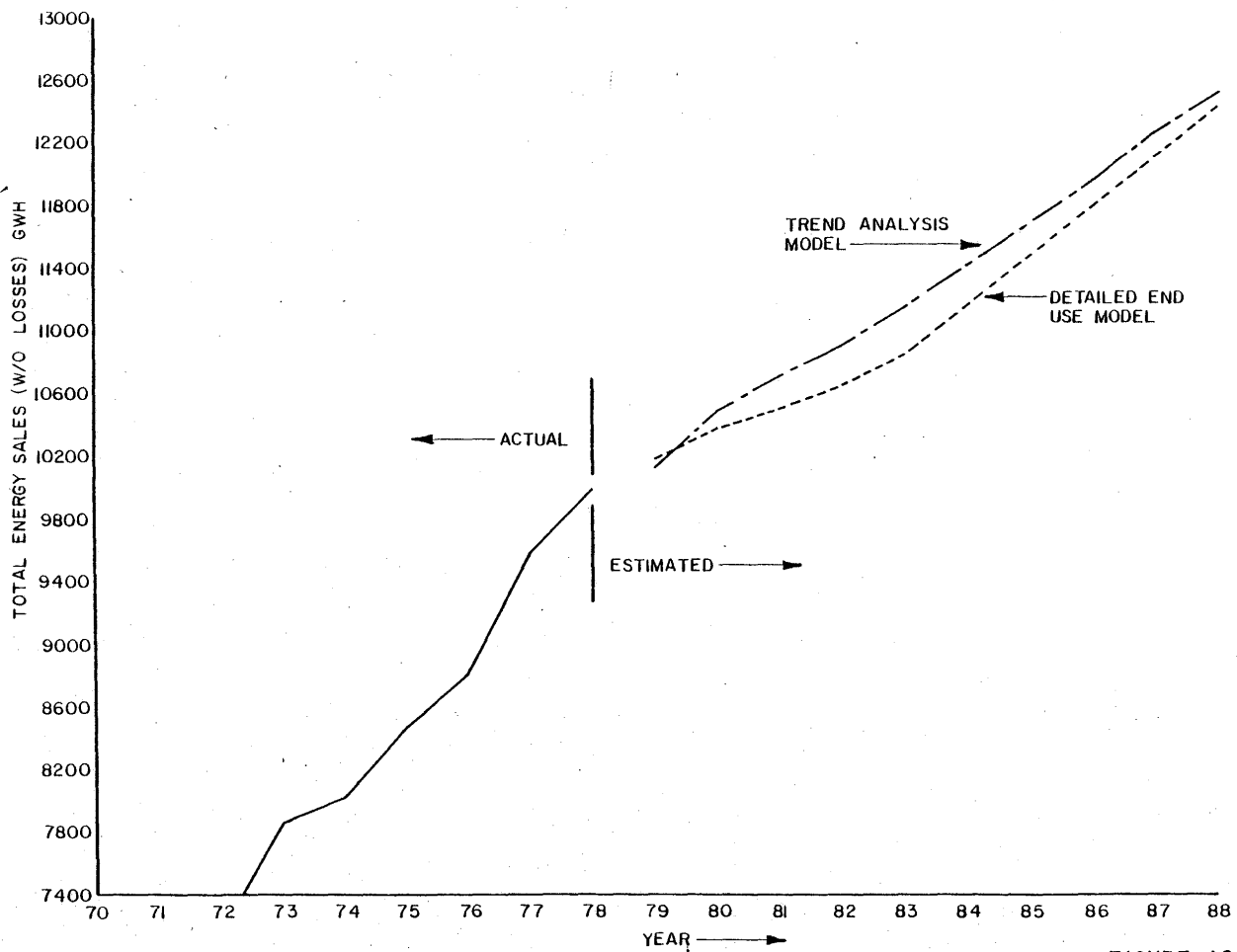


FIGURE 1C-1
TOTAL ENERGY SALES
1970-1988
BIG BEND STATION
TAMPA ELECTRIC COMPANY

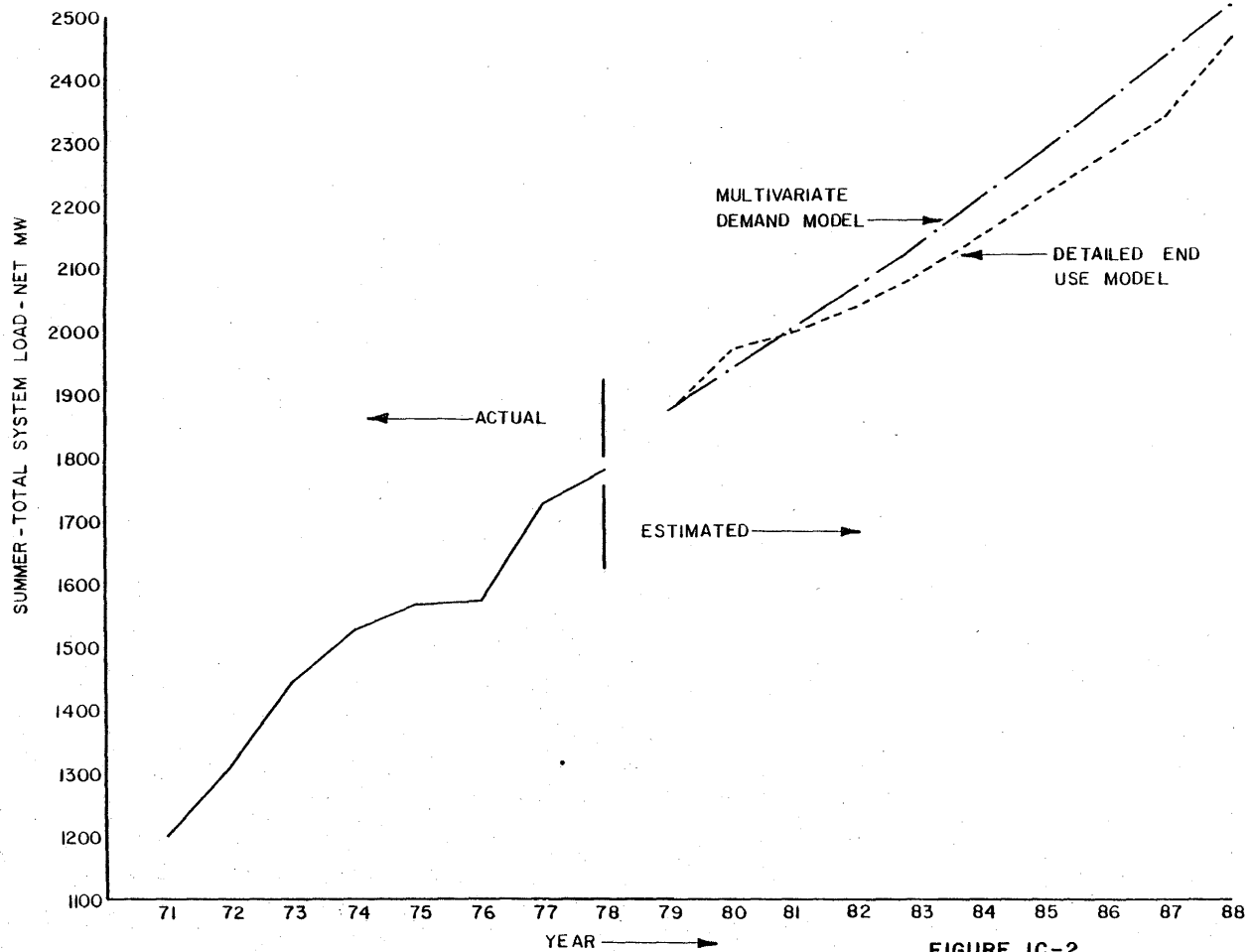


FIGURE IC-2
TOTAL SYSTEM LOAD-
SUMMER 1971-1988
BIG BEND STATION
TAMPA ELECTRIC COMPANY

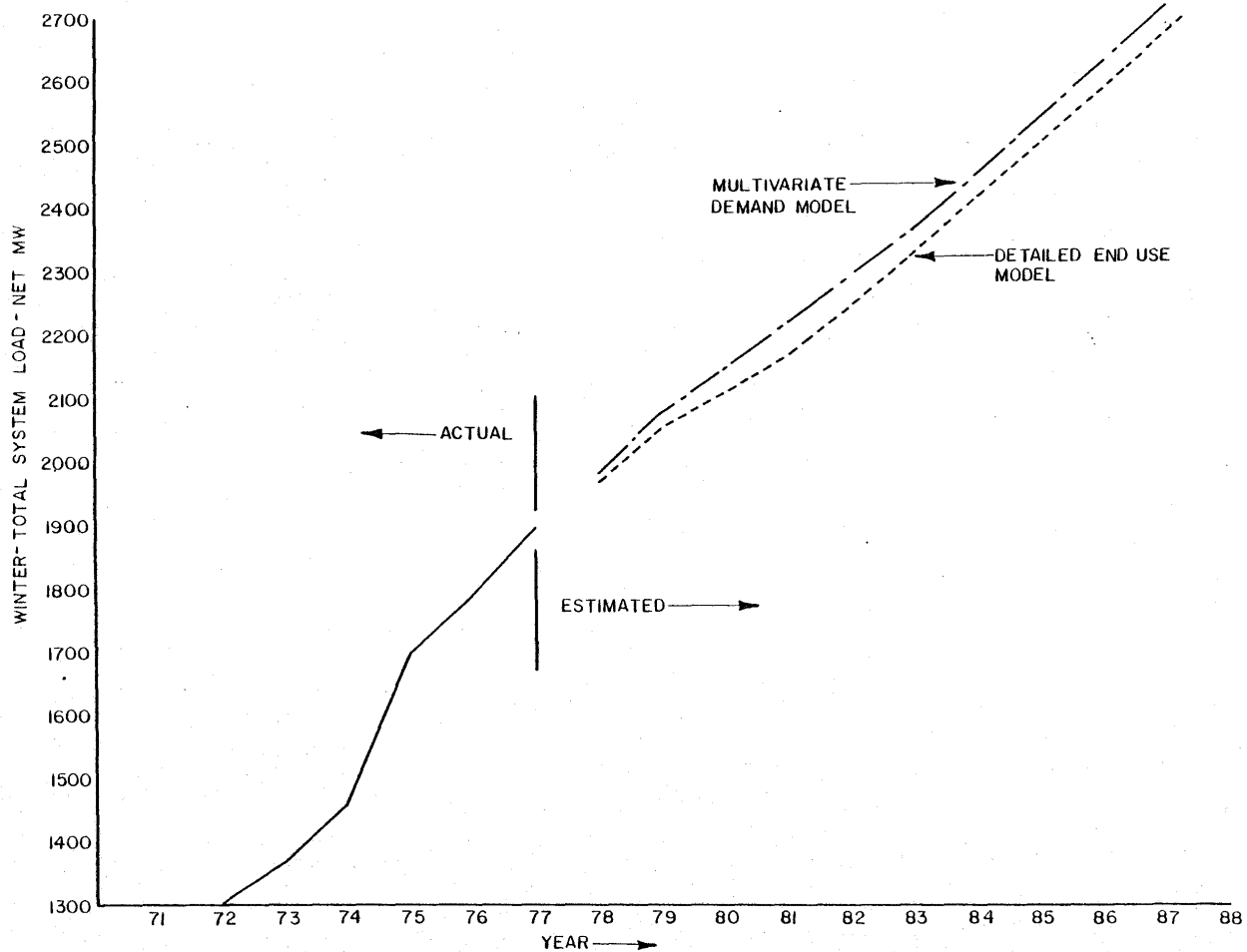


FIGURE IC - 3
TOTAL SYSTEM LOAD
NET MW, 1971-1988
BIG BEND STATION
TAMPA ELECTRIC COMPANY

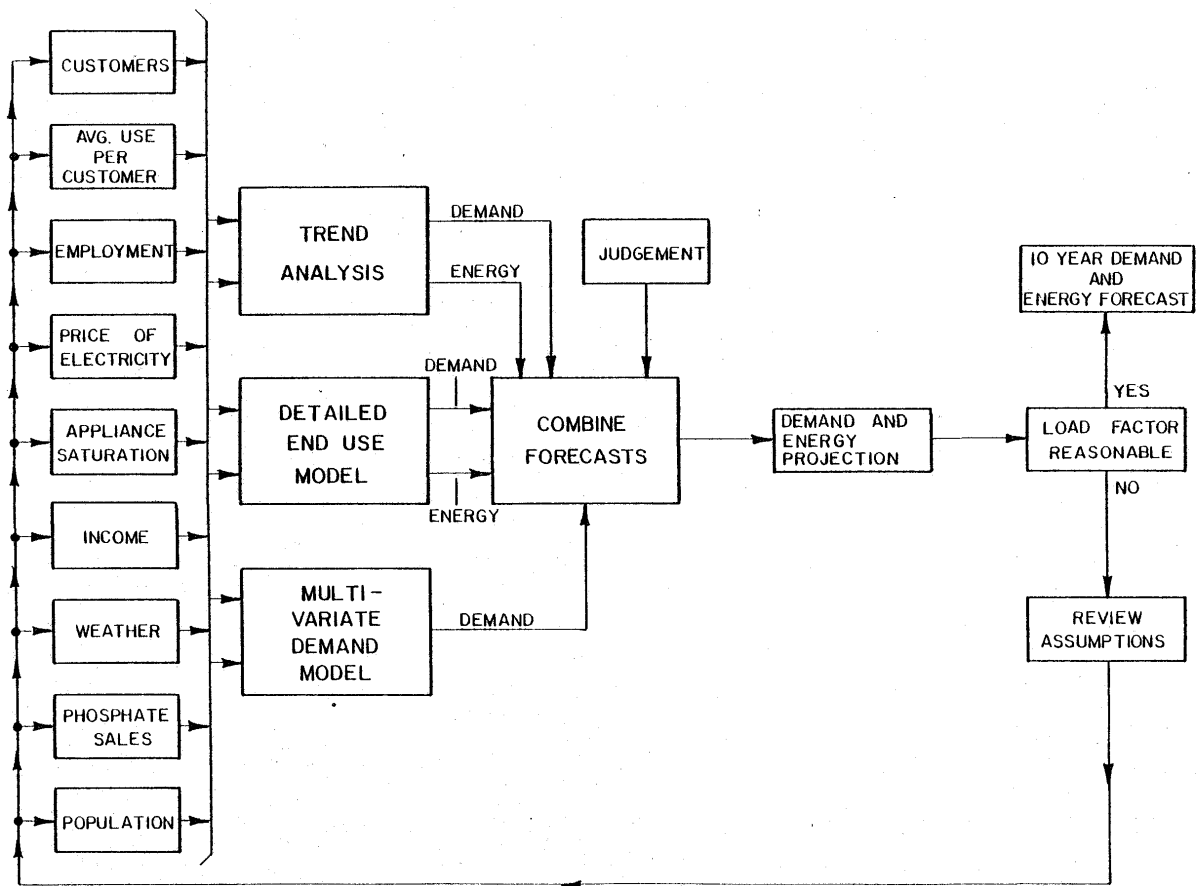


FIGURE IC-4
EXISTING FORECAST
TECHNIQUE
BIG BEND STATION
TAMPA ELECTRIC COMPANY

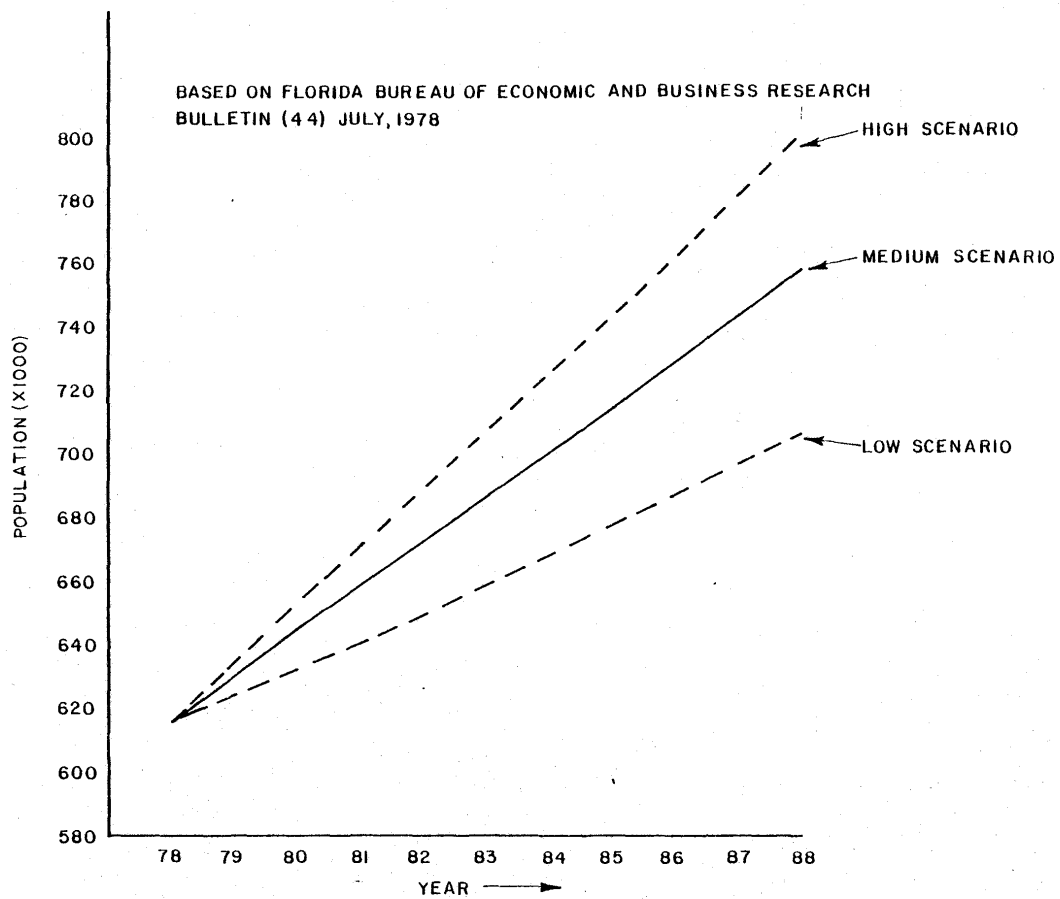


FIGURE IC-5
HILLSBOROUGH COUNTY
POPULATION SCENARIOS
BIG BEND STATION
TAMPA ELECTRIC COMPANY

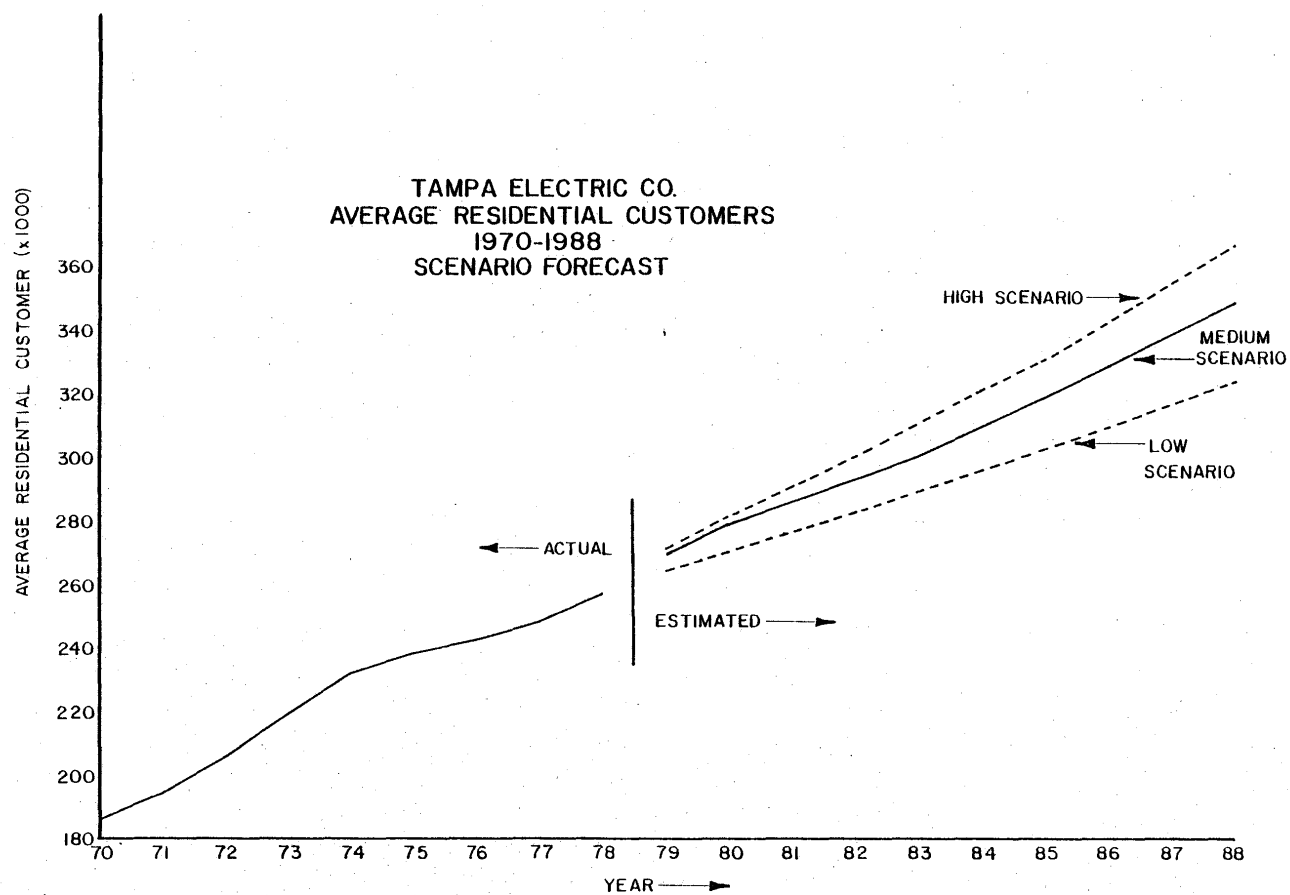


FIGURE IC-6
AVERAGE RESIDENTIAL
CUSTOMERS 1970-1988
BIG BEND STATION
TAMPA ELECTRIC COMPANY

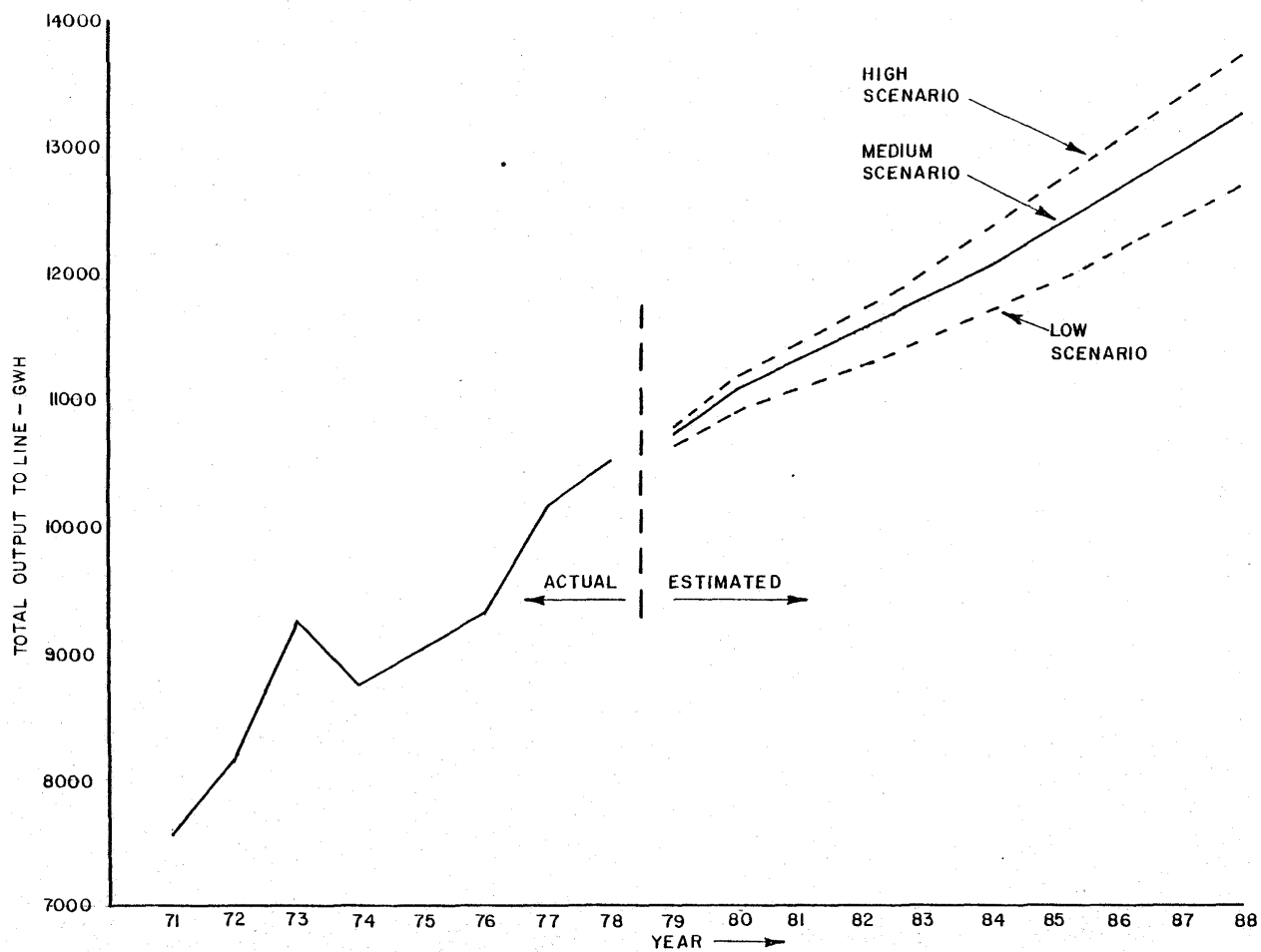


FIGURE IC-7
 ENERGY OUTPUT TO LINE
 1971-1988 SCENARIO
 FORECAST
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY

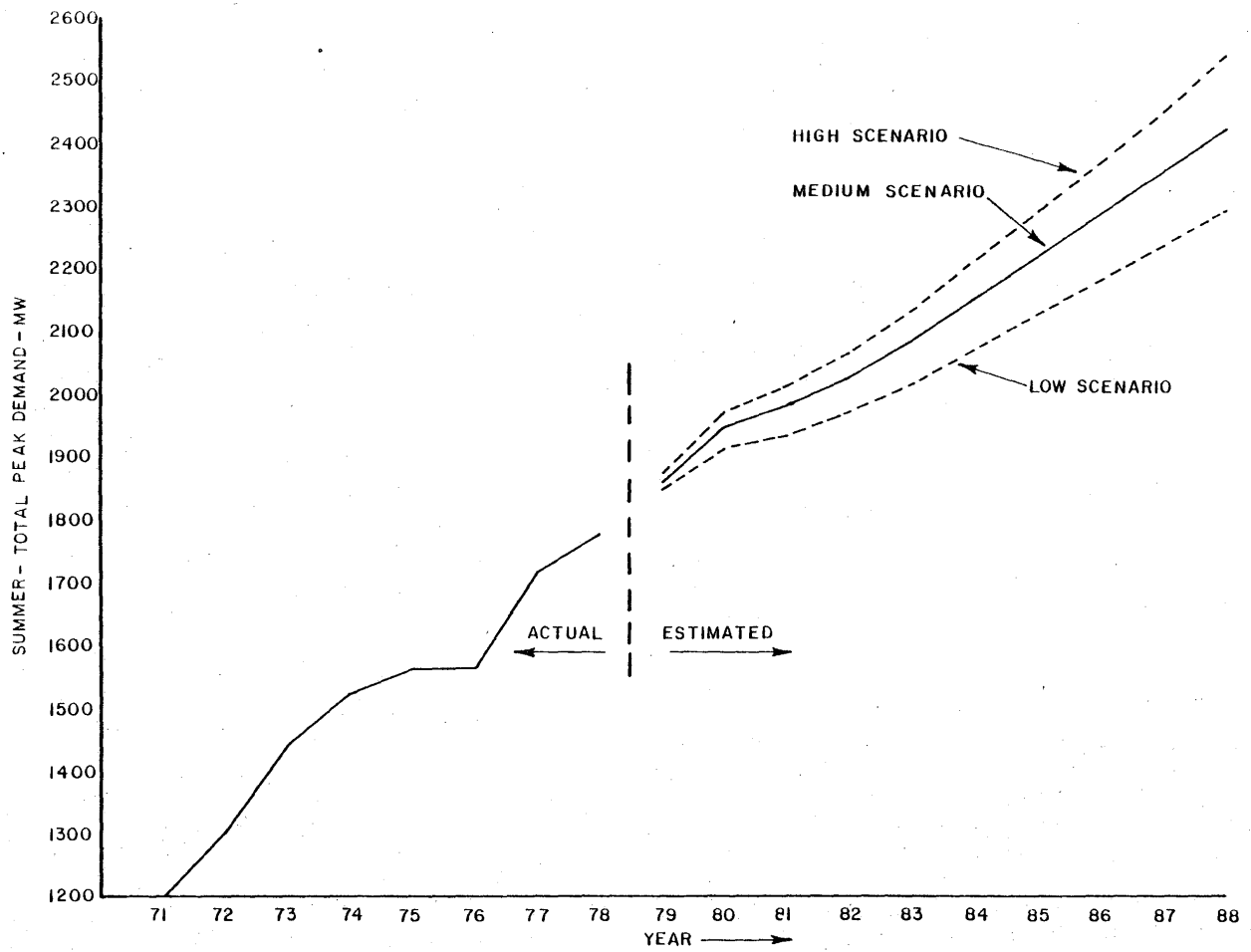


FIGURE IC-8
TOTAL SYSTEM DEMAND-SUMMER
1971-1988 SCENARIO FORECAST
BIG BEND STATION
TAMPA ELECTRIC COMPANY

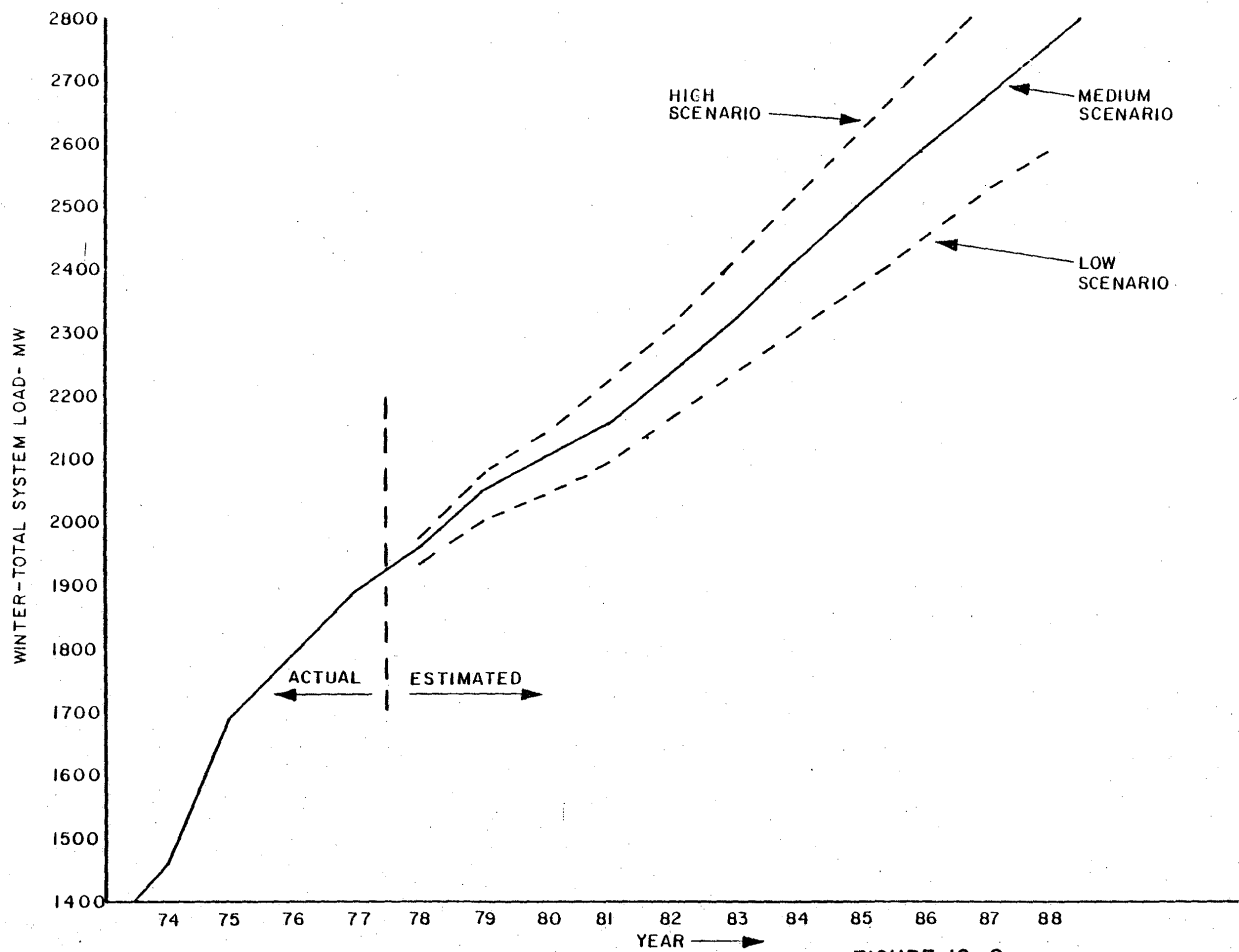


FIGURE IC-9
TOTAL SYSTEM DEMAND-WINTER,
1974-1988 SCENARIO FORECAST
BIG BEND STATION
TAMPA ELECTRIC COMPANY

APPENDIX 1D
TEN YEAR SITE PLAN FORMS
DIVISION OF STATE PLANNING

EXISTING GENERATING FACILITIES

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Plant Name	Unit No.	Location	Type	Fuel		Com'l In-Service Mo/Yr	Exptd. Retrmnt Mo/Yr	Gen Max Nameplate KW	Net Capability	
				Pri	Alt				Summer MW	Winter MW
Francis J. Gannon		Hillsborough Co. 4/30S/19E								
	1		F	HO	No	8/57	Unknown	1,288,380	1,106	1,106
	2		F	HO	No	10/58	Unknown	125,000	98	98
	3		F	HO	No	8/60	Unknown	125,000	108	108
	4		F	HO	No	7/63	Unknown	179,520	150	150
	5		F	C	No	9/65	Unknown	187,500	169	169
	6		F	C	No	9/67	Unknown	239,360	229	229
	1		CT	LO	No	1/69	Unknown	414,000	338	338
								18,000	14	14
Hookers Point		Hillsborough Co. 19/29S/19E								
	1		F	HO	No	7/48	12/90	232,600	193	193
	2		F	HO	No	6/50	12/90	33,000	28	28
	3		F	HO	No	8/50	12/90	34,500	29	29
	4		F	HO	No	10/53	12/90	34,500	28	28
	5		F	HO	No	5/55	12/90	49,000	42	42
								81,600	66	66
Big Bend		Hillsborough Co. 9/31S/19E								
	1		F	C	No	10/70	Unknown	1,512,000	1,206	1,206
	2		F	C	No	4/73	Unknown	445,500	362	362
	3		F	C	No	5/76	Unknown	445,500	362	362
	1		CT	LO	No	1/69	Unknown	445,500	362	362
	2&3		CT	LO	No	11/74	Unknown	18,000	14	14
								157,500	130	130
								TOTAL	2,529	2,529

EXISTING GENERATING FACILITIES
LAND USE AND INVESTMENT

(1)	(2)	(3)	(4)	(5)	(6)	(7)
<u>Plant Name</u>	<u>Land Area</u>		<u>Land</u>	<u>Plant Capital Investment (in \$1,000)</u>		
	<u>Total Acres</u>	<u>In Use Acres</u>		<u>Site & Structures Improvements</u>	<u>Equipment</u>	<u>Total</u>
Hookers Point	26	26	\$ 437	\$ 7,557	\$ 32,059	\$ 40,053
Big Bend	1,187	1,187	5,192	53,282	231,239	289,713
Francis J. Gannon	103	103	350	27,937	156,015	184,302
Gas Turbine Gannon				76	1,744	1,820
Gas Turbine Big Bend	73	73	834	1,203	17,630	19,667
Miscellaneous * Production	5	5	<u>28</u>	<u>769</u>	<u>1,285</u>	<u>7,082</u>
			<u>\$6,841</u>	<u>\$90,824</u>	<u>\$439,972</u>	<u>\$537,637</u>

*Production Office, Production Warehouse, Traveling Maintenance Crew,
Power Plant Construction, and Central Testing Lab

EXISTING GENERATING FACILITIES
ENVIRONMENTAL CONSIDERATIONS FOR STEAM GENERATING UNITS

(1)	(2)	(3)	(4)	(5)	(6)
<u>Plant Name</u>	<u>Unit</u>	<u>Flue Gas Cleaning</u>			<u>Cooling Type</u>
		<u>Particulate</u>	<u>SOx</u>	<u>NOx</u>	
Francis J. Gannon	1	NO	LS	NO	OTS
	2	NO	LS	NO	OTS
	3	NO	LS	NO	OTS
	4	NO	LS	NO	OTS
	5	EP	LS	NO	OTS
	6	EP	LS	NO	OTS
	GT 1	NO	LS	NO	---
Hooker's Point	1	NO	LS	NO	OTS
	2	NO	LS	NO	OTS
	3	NO	LS	NO	OTS
	4	NO	LS	NO	OTS
	5	NO	LS	NO	OTS
Big Bend	1	EP	NO	NO	OTS*
	2	EP	NO	NO	OTS*
	3	EP	NO	NO	OTS*
	GT 1	NO	LS	NO	---
	GT 2-3	NO	LS	NO	---

*With Dilution

GT - Gas Turbine

HISTORY AND FORECAST OF ENERGY USE

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<u>Year</u>	<u>GWH</u>	<u>Rural & Residential</u>		<u>GWH</u>	<u>Commercial</u>		<u>Industrial</u>
		<u>Average*</u> <u>No. of</u> <u>Customers</u>	<u>Average KWH</u> <u>Consumption</u> <u>Per Customer</u>		<u>Average*</u> <u>No. of</u> <u>Customers</u>	<u>GWH</u>	<u>Average*</u> <u>No. of</u> <u>Customers</u>
1969	1,774	177,472	9,996	933	18,876	2,525	670
1970	2,019	186,153	10,849	1,041	19,496	2,772	661
1971	2,200	195,702	11,242	1,166	20,362	2,718	645
1972	2,416	207,213	11,657	1,335	21,440	2,784	639
1973	2,843	221,251	12,852	1,525	22,861	3,004	624
1974	2,828	233,356	12,118	1,640	25,076	3,102	614
1975	2,906	239,215	12,150	1,767	26,539	3,297	598
1976	2,911	243,548	11,952	1,804	27,221	3,564	599
1977	3,139	249,362	12,590	1,904	28,119	4,008	579
1978	3,313	258,971	12,792	2,030	29,226	4,080	576
1979	3,405	270,560	12,585	2,090	30,547	4,016	577
1980	3,524	280,030	12,584	2,175	31,631	4,139	580
1981	3,613	287,030	12,588	2,242	32,433	4,170	583
1982	3,702	294,206	12,583	2,311	33,254	4,202	586
1983	3,795	301,561	12,585	2,384	34,096	4,235	589
1984	3,908	310,608	12,582	2,468	35,132	4,289	592
1985	4,027	319,926	12,587	2,557	36,200	4,329	595
1986	4,147	329,524	12,585	2,648	37,300	4,372	598
1987	4,272	339,409	12,587	2,743	38,433	4,416	601
1988	4,400	349,592	12,586	2,842	39,600	4,461	604

*Use average of end-of-month customers for the calendar year.

HISTORY AND FORECAST OF ENERGY USE

(9)	(10)	(11)	(12)	(13)	(14)	(15)
Year	Street & Highway Lighting GWH	Other Sales to Ultimate Consumers GWH	Total Sales to Ultimate Consumers GWH	Sales For Resale* GWH	Utility Use & Losses GWH	Net Energy For Load GWH
1969	28	275	5,535	0	350	5,885
1970	29	313	6,174	0	368	6,542
1971	30	367	6,481	0	365	6,846
1972	32	402	6,969	0	460	7,429
1973	35	436	7,843	0	448	8,291
1974	33	429	8,032	0	453	8,485
1975	32	467	8,469	0	546	9,015
1976	35	487	8,801	0	492	9,293
1977	35	516	9,602	0	526	10,128
1978	36	576	10,035	0	461	10,496
1979	36	588	10,135	0	564	10,699
1980	37	612	10,487	0	584	11,071
1981	37	631	10,693	0	596	11,289
1982	38	651	10,904	0	607	11,511
1983	38	671	11,123	0	619	11,742
1984	39	695	11,399	0	635	12,034
1985	39	720	11,672	0	650	12,322
1986	40	746	11,953	0	665	12,618
1987	41	772	12,244	0	682	12,926
1988	41	800	12,544	0	698	13,242

*To Class III and Class V Systems.

ENERGY SOURCES AND FUEL REQUIREMENTS

ENERGY SOURCES			Actual 1977	Actual 1978	1979	1980	1981	1982
(1)	PURCH. & INTERCHANGE	GWH	(210)	(245)	(1)	0	0	0
(2)	NUCLEAR	GWH	0	0	0	0	0	0
(3)	COAL	GWH	8,101	8,105	8,658	9,190	9,146	9,232
(4)	RESIDUAL-TOTAL-	GWH	2,192	2,591	1,977	1,842	2,086	2,209
(5)	Steam	GWH	2,192	2,591	1,977	1,842	2,086	2,209
(6)	CC	GWH	0	0	0	0	0	0
(7)	CT	GWH	0	0	0	0	0	0
(8)	DISTILLATE-TOTAL-	GWH	45	45	65	39	57	70
(9)	CT	GWH	45	45	65	39	57	70
(10)	Diesel	GWH	0	0	0	0	0	0
(11)	NATURAL GAS-TOTAL-	GWH	0	0	0	0	0	0
(12)	Steam	GWH	0	0	0	0	0	0
(13)	CC	GWH	0	0	0	0	0	0
(14)	CT	GWH	0	0	0	0	0	0
(15)	Diesel	GWH	0	0	0	0	0	0
(16)	OTHER	GWH	0	0	0	0	0	0
(17)	NET ENERGY FOR LOAD	GWH	10,128	10,496	10,699	11,071	11,289	11,511
FUEL REQUIREMENTS								
(18)	NUCLEAR	BTUx10 ¹²	0	0	0	0	0	0
(19)	COAL	1000 Ton	3,531	3,575	3,744	3,969	3,951	3,986
(20)	RESIDUAL-TOTAL-	1000 BBL	4,045	4,712	3,659	3,400	3,843	4,067
(21)	Steam	1000 BBL	4,045	4,712	3,659	3,400	3,843	4,067
(22)	CC	1000 BBL	0	0	0	0	0	0
(23)	CT	1000 BBL	0	0	0	0	0	0
(24)	DISTILLATE-TOTAL-	1000 BBL	118	118	163	98	142	175
(25)	CT	1000 BBL	118	118	163	98	142	175
(26)	Diesel	1000 BBL	0	0	0	0	0	0
(27)	NATURAL GAS-TOTAL-	1000 MCF	0	0	0	0	0	0
(28)	Steam	1000 MCF	0	0	0	0	0	0
(29)	CC	1000 MCF	0	0	0	0	0	0
(30)	CT	1000 MCF	0	0	0	0	0	0
(31)	Diesel	1000 MCF	0	0	0	0	0	0
(32)	OTHER	BTUx10 ⁶	0	0	0	0	0	0
(33)	ANNUAL AVG. FOSSIL NET H.R.	BTU/KWH	10,376	10,533	10,455	10,416	10,436	10,443

ENERGY SOURCES AND FUEL REQUIREMENTS

ENERGY SOURCES			1983	1984	1985	1986	1987	1988
(1)	PURCH. & INTERCHANGE	GWH	0	0	0	0	0	0
(2)	NUCLEAR	GWH	0	0	0	0	0	0
(3)	COAL	GWH	9,343	9,388	10,496	10,713	11,043	11,204
(4)	RESIDUAL-TOTAL-	GWH	2,293	2,509	1,752	1,821	1,803	1,940
(5)	Steam	GWH	2,293	2,509	1,752	1,821	1,803	1,940
(6)	CC	GWH	0	0	0	0	0	0
(7)	CT	GWH	0	0	0	0	0	0
(8)	DISTILLATE-TOTAL-	GWH	106	137	74	84	80	98
(9)	CT	GWH	106	137	74	84	80	98
(10)	Diesel	GWH	0	0	0	0	0	0
(11)	NATURAL GAS-TOTAL-	GWH	0	0	0	0	0	0
(12)	Steam	GWH	0	0	0	0	0	0
(13)	CC	GWH	0	0	0	0	0	0
(14)	CT	GWH	0	0	0	0	0	0
(15)	Diesel	GWH	0	0	0	0	0	0
(16)	OTHER	GWH	0	0	0	0	0	0
(17)	NET ENERGY FOR LOAD	GWH	11,742	12,034	12,322	12,618	12,926	13,242
FUEL REQUIREMENTS								
(18)	NUCLEAR	BTUx10 ¹²	0	0	0	0	0	0
(19)	COAL	1000 Ton	4,034	4,051	4,552	4,648	4,793	4,861
(20)	RESIDUAL-TOTAL-	1000 BBL	4,220	4,623	3,230	3,358	3,319	3,575
(21)	Steam	1000 BBL	4,220	4,623	3,230	3,358	3,319	3,575
(22)	CC	1000 BBL	0	0	0	0	0	0
(23)	CT	1000 BBL	0	0	0	0	0	0
(24)	DISTILLATE-TOTAL-	1000 BBL	262	338	183	207	198	242
(25)	CT	1000 BBL	262	338	183	207	198	242
(26)	Diesel	1000 BBL	0	0	0	0	0	0
(27)	NATURAL GAS-TOTAL-	1000 MCF	0	0	0	0	0	0
(28)	Steam	1000 MCF	0	0	0	0	0	0
(29)	CC	1000 MCF	0	0	0	0	0	0
(30)	CT	1000 MCF	0	0	0	0	0	0
(31)	Diesel	1000 MCF	0	0	0	0	0	0
(32)	OTHER	BTUx10 ⁶	0	0	0	0	0	0
(33)	ANNUAL AVG. FOSSIL							
	NET H.R. (estimated)	BTU/KWH	10,500	10,500	10,500	10,500	10,500	10,500

HISTORY AND FORECAST OF SEASONAL PEAK DEMAND AND ANNUAL ENERGY REQUIREMENTS

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Year	Summer Peak Demand Net MW		Net Energy For Load - GWH	Load* Factor %	Year	Winter Peak Demand Net MW	
	Interruptible	Total				Interruptible	Total
1969	146	1,022	5,885	65.7	1969-70	181	1,114
1970	165	1,098	6,542	68.0	1970-71	150	1,105
1971	178	1,194	6,846	65.5	1971-72	142	1,110
1972	145	1,302	7,429	65.0	1972-73	171	1,300
1973	139	1,441	8,291	65.7	1973-74	152	1,366
1974	146	1,527	8,485	63.4	1974-75	155	1,458
1975	147	1,565	9,015	65.8	1975-76	155	1,693
1976	134	1,568	9,293	67.5	1976-77	178	1,784
1977	193	1,720	10,128	67.2	1977-78	206	1,891
1978	169	1,780	10,496	67.3	1978-79	211	1,960
1979	211	1,861	10,699	65.6	1979-80	221	2,055
1980	221	1,954	11,071	64.7	1980-81	217	2,104
1981	217	1,984	11,289	65.0	1981-82	221	2,159
1982	221	2,029	11,511	64.8	1982-83	219	2,235
1983	219	2,087	11,742	64.2	1983-84	227	2,323
1984	227	2,154	12,034	63.8	1984-85	225	2,411
1985	225	2,216	12,322	63.5	1985-86	225	2,501
1986	225	2,286	12,618	63.0	1986-87	222	2,588
1987	222	2,352	12,926	62.7	1987-88	222	2,678
1988	222	2,424	13,242	62.4	1988-89	195	2,751

*Load Factor Based on Summer Peak

TWO-YEAR FORECAST OF PEAK DEMAND AND ENERGY REQUIREMENTS BY MONTH

(1) Year	(2) Month	(3) Peak Demand - Net MW		(5) Net Energy For Load - GWH
		Interruptible	Total	
1979	Jan	211	1,960	917
	Feb	211	1,880	837
	Mar	211	1,642	824
	Apr	211	1,593	804
	May	211	1,667	907
	Jun	211	1,772	952
	Jul	211	1,816	976
	Aug	211	1,831	982
	Sep	211	1,861	953
	Oct	211	1,742	851
	Nov	211	1,777	807
	Dec	211	1,877	889
TOTAL				10,699
1980	Jan	221	2,055	949
	Feb	221	1,971	866
	Mar	221	1,720	852
	Apr	221	1,671	832
	May	221	1,749	939
	Jun	221	1,860	985
	Jul	221	1,907	1,010
	Aug	221	1,923	1,018
	Sep	221	1,954	987
	Oct	221	1,828	880
	Nov	221	1,833	834
	Dec	221	1,937	919
TOTAL				11,071

PLANNED AND PROSPECTIVE GENERATING FACILITY ADDITIONS AND CHANGES

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
<u>Plant Name</u>	<u>Unit No.</u>	<u>Location</u>	<u>Type</u>	<u>Fuel</u>		<u>Const. Start Mo/Yr.</u>	<u>Com'l In-Service Mo/Yr.*</u>	<u>Gen Max Nameplate KW</u>	<u>Net Capability</u>	
				<u>Pri</u>	<u>Alt</u>				<u>Summer MW</u>	<u>Winter MW</u>
Big Bend*		Hillsborough Co. 4/30S/19E								
<u>Existing Unit Upgrades</u>										
	2C		F	C	No	3/79	5/79	445,500	24	24
<u>New Unit Additions</u>										
	CT-4		CT	LO	No	9/81	3/83	67,400	50	50
	CT-5		CT	LO	No	9/81	3/83	67,400	50	50
	CT-6		CT	LO	No	9/82	3/84	67,400	50	50
	CT-7		CT	LO	No	9/82	3/84	67,400	50	50
	4		F	C	No	11/81	3/85	486,000	417	417
TOTAL ADDITIONS AND CHANGES									641	641

NOTE: There is a prospective joint generating facility (nuclear or coal) in the early 1990's under study. This facility has the potential of being at the W. C. MacInnes site or at another utility's site.

* This column is to be used also for dates of retirements and changes.

FORECAST OF CAPACITY, DEMAND, AND SCHEDULED MAINTENANCE
AT TIME OF SUMMER PEAK a/

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Year	Total Installed Capacity MW	Firm Capacity Import MW	Total Available Capacity MW	Peak Demand MW	Margin Before Maint.		Sched. Maint. MW	Margin After Maint.	
					MW	% of PK.		MW	% of PK.
1979	2,529	0	2,529	1,861	668	35.9	300*	368	16.1
1980	2,529	0	2,529	1,954	575	29.4	338	237	12.1
1981	2,529	0	2,529	1,984	545	27.5	362	183	9.2
1982	2,529	0	2,529	2,029	500	24.7	362	138	6.8
1983	2,629	0	2,629	2,087	542	26.0	362	180	8.6
1984	2,729	0	2,729	2,154	575	26.7	362	213	9.9
1985	3,146	0	3,146	2,216	930	42.0	417	513	23.1
1986	3,146	0	3,146	2,286	860	37.6	417	443	19.4
1987	3,146	0	3,146	2,352	794	33.8	417	377	16.0
1988	3,146	0	3,146	2,424	722	29.8	417	305	12.6

a/ Capacity additions and changes must be made by May 31 to be considered in effect at the time of the Summer peak. All values are Summer Net MW.

* Based on 1979 Maintenance Schedule (revised 12/15/78).

FORECAST OF CAPACITY, DEMAND, AND SCHEDULED MAINTENANCE
AT TIME OF WINTER PEAK a/

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Year	Total Installed Capacity MW	Firm Capacity Import MW	Total Available Capacity MW	Peak Demand MW	Margin Before Maint.		Sched. Maint. MW	Margin After Maint.	
					MW	% of PK.		MW	% of PK.
1979-80	2,529	0	2,529	2,055	474	23.1	229	245	11.9
1980-81	2,529	0	2,529	2,104	425	20.2	229	196	9.3
1981-82	2,529	0	2,529	2,159	370	17.1	229	141	6.5
1982-83	2,529	0	2,529	2,235	294	12.7	229	65	2.9
1983-84	2,629	0	2,629	2,323	306	13.2	229	77	3.3
1984-85	2,729	0	2,729	2,411	318	13.2	229	89	3.7
1985-86	3,146	0	3,146	2,501	645	25.8	229	416	16.6
1986-87	3,146	0	3,146	2,588	558	21.6	229	329	12.7
1987-88	3,146	0	3,146	2,678	468	17.5	229	239	8.9
1988-89	3,146	0	3,146	2,751	395	14.4	229	166	6.0

a/ Capacity additions and changes must be made by November 30 to be considered in effect at the time of the Winter peak. All values are Winter Net MW.

1979 TEN-YEAR PLAN STATE OF FLORIDA

**ELECTRICAL GENERATING FACILITIES
AND ASSOCIATED TRANSMISSION LINES**

**AUGUST 1, 1979
FLORIDA ELECTRIC POWER COORDINATING GROUP**



1979 TEN-YEAR PLAN
STATE OF FLORIDA

ELECTRIC GENERATING FACILITIES
AND ASSOCIATED TRANSMISSION LINES

PRESENTED TO:

FLORIDA DEPARTMENT OF COMMUNITY AFFAIRS

PREPARED BY:

FLORIDA ELECTRIC POWER COORDINATING GROUP (FCG)
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INTRODUCTION

Introduction

This report has been compiled and prepared by the Florida Electric Power Coordinating Group (FCG) for submission to the State of Florida, Department of Community Affairs, in partial compliance with "Rules for Preparing and Submitting Ten-Year Site Plans for Electrical Generating Facilities and Associated Transmission Lines, September 28, 1973."

The Rules state in part that, "On a voluntary basis, the utilities in Florida will seek to cooperate in compiling a comprehensive statewide plan embracing individual plans and will endeavor to submit this plan to the Division by May 1 of each year." This statewide plan contains, for the most part, tentative information and is subject to change at any time at the discretion of the individual utilities.

Many of the forms required for the plan were designed to obtain information on individual utilities and would not be useful as a composite. The FCG staff has therefore given careful consideration to the legislative intent in requesting a comprehensive statewide plan and used its best judgement in the preparation of this report.

This report specifically contains the following categories of information:

- I. A Description of Existing Facilities - as of January 1, 1979
- II. A History and Forecast of Electric Power Peak Demand, Energy Use, and Fuel Requirements
- III. A Forecast of Facilities Requirements

and follows a format similar to the individual utility Site Plans.

Other Submittals

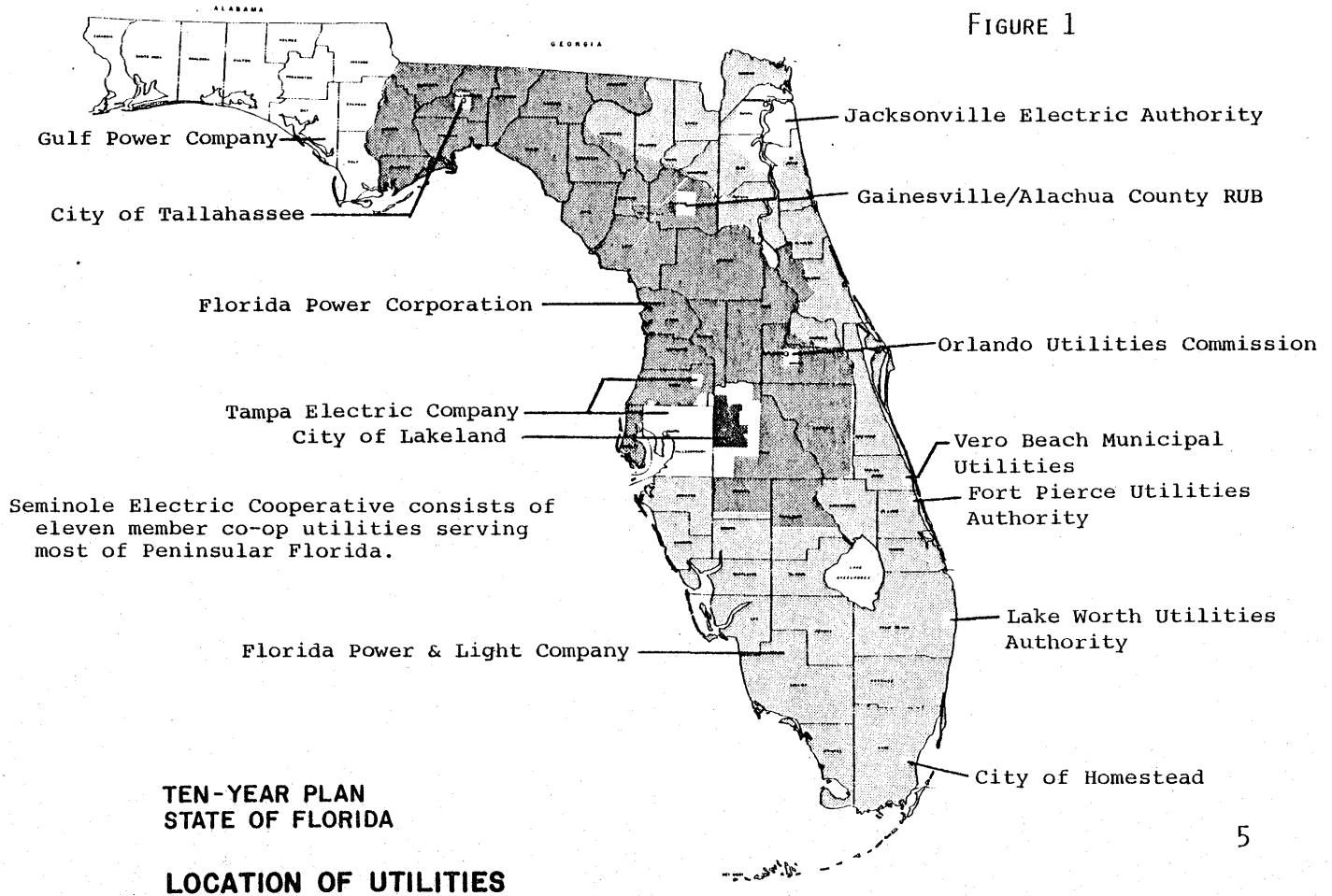
The information contained in this report is consistent with similar reports filed by the FCG under obligations arising from Federal Power Commission (now Department of Energy) Order 383-4 and submittals to the National Electric Reliability Council (NERC). Changes that have occurred since these filings have been incorporated.

UTILITIES PARTICIPATING IN THIS REPORT

Florida Power Corporation
Florida Power & Light Company
Fort Pierce Utilities Authority
Gainesville/Alachua County Regional Utilities Board
Gulf Power Company
City of Homestead
Jacksonville Electric Authority
Lake Worth Utilities Authority
City of Lakeland
Orlando Utilities Commission
Seminole Electric Cooperative
Southeastern Power Administration
City of Tallahassee
Tampa Electric Company
Vero Beach Municipal Utilities

Figure 1 identifies the location of these systems. Data for Fort Pierce Utilities Authority, Vero Beach Municipal Utilities, City of Homestead, Seminole Electric Cooperative, and Southeastern Power Administration have been included even though these utilities were not required to submit site plans during 1979. Information concerning these systems was extracted from data used in the March, 1979, FPC Order 383-4 submittal.

FIGURE 1



ABBREVIATIONS

Utilities

FPC - Florida Power Corporation
FPL - Florida Power & Light Company
FTP - Fort Pierce Utilities Authority
GVL - Gainesville/Alachua County
Regional Utilities Board
GPC - Gulf Power Company
HST - City of Homestead
JEA - Jacksonville Electric Authority
LWU - Lake Worth Utilities Authority
LAK - City of Lakeland
OUC - Orlando Utilities Commission
SEC - Seminole Electric Cooperative
SPA - Southeastern Power Administration
TAL - City of Tallahassee
TEC - Tampa Electric Company
VER - Vero Beach Municipal Utilities

Power and Energy

MW - Megawatt
MWH - Megawatthour
GWH - Gigawatthour (1,000 MWH)

Types of Generating Units

CC - Combined Cycle
CT - Combustion Turbine
D - Diesel
FS - Fossil Steam
N - Nuclear
HY - Hydro
UN - Unknown

Types of Fuels

C - Coal
HO - Heavy Oil (#4, #5, #6, Bunker C)
LO - Light Oil (#1, #2, Middle Distillate)
N - Nuclear
NG - Natural Gas
SW - Solid Waste
HY - Hydro
UN - Unknown

DEFINITIONS

- Net Capability or Net Capacity means the continuous gross capacity, less the power required by all auxiliaries associated with the unit, or the capacity as specified by "SERC" Guideline Number 2 for Uniform Generator Ratings for Reporting.
- Net Energy for Load means net system generation plus energy received from Class I and Class II systems* minus energy delivered to Class I and Class II systems.
- Net Energy for System means net energy for load plus energy received from Class III and Class V systems* minus energy delivered to Class III and Class V systems.
- Peak Demand or Peak Load means the net 60-minute integrated demand, actual or adjusted. Forecasts should be for normal weather conditions.
- Interruptible Load means that peak demand which may be disconnected at the supplier's discretion.
- Average Demand is obtained by dividing the energy in GWH used over a period of time by the number of hours in that period.
- Sales for Resale means energy sales to Class III and Class V systems*.
- Summer means June 1 through September 30.
- Winter means December 1 through March 31.
- Year means the calendar year, January 1 through December 31. Unless otherwise indicated, this is the year used for historical and forecast data.

*See next page.

*System Classification

The following groupings have been established by the Federal Energy Regulatory Commission (formerly Federal Power Commission) for the purposes of reporting power system operations:

<u>Class</u>	<u>Basis</u>
I	System which generates all or part of system requirements and whose net energy for system (NES) for the year reported was greater than 100 GWH.
II	Same as I, but whose NES was between 20 and 100 GWH.
III	Same as I, but whose NES was less than 20 GWH.
IV	System engaged primarily in sales for resale and/or sales to industrials; all other sales being negligible.
V	System which obtains its entire energy requirements from other systems.

I. A DESCRIPTION OF EXISTING FACILITIES

I. A DESCRIPTION OF EXISTING FACILITIES

At the beginning of the calendar year 1979, the fifteen utilities which comprise this report had a combined summer net available capability of 22,804 MW and a winter net capability of 23,896 MW (Table 1). This is a decrease of 329 megawatts (summer) when compared to January, 1978, due to the rerating of several units, the outage of a unit to convert from oil to coal, and the unavailability of several units on extended forced outage. (Unless otherwise stated, all MW ratings in the text are summer net.)

Six types of generation are utilized by electric utilities in Florida: fossil and nuclear steam turbines, combustion turbines, combined-cycle units, diesel engines, and hydro. The small amount of hydro power--36 MW of capacity owned by Southeastern Power Administration at Woodruff Dam and 0.2 MW by Florida Public Utilities--is accounted for, but not discussed in detail. Table 2 lists all units, by utility, existing as of January 1, 1979, and Figure 2 (fold-out map) shows the location of these existing facilities.

A. Fossil Steam

As of January 1, 1979, fossil steam generators comprised 67% (15,350 MW) of the total installed capacity in the state. Modern units of this type, under ideal conditions, often achieve efficiencies as high as 38% and along with their nuclear counterparts are

considered as the base-load capacity. This type of capacity is operated for long periods of time at near maximum continuous capability. Older fossil steam units are economically committed and dispatched for mid-range and, occasionally, peaking operation.

Fossil-fueled boilers in Florida are fired by residual oil, coal, and natural gas, with many having the capability of burning combinations of these fuels. Additionally, some boilers which are normally fired with residual oil or coal may use distillate oil or natural gas for startup purposes or flame stabilization. Presently, the largest fossil steam generators in the state are the 764 MW Manatee 1 and Manatee 2 Units owned by Florida Power & Light Company.

B. Nuclear Steam

First placed on line during the fall of 1972, nuclear generation at the beginning of 1979 comprised 13% (2,876 MW) of the state's generating capacity and, during 1978, supplied 17% of the state's electric utility generated energy. Though the capital cost of a nuclear unit exceeds that of a comparably sized fossil-fueled unit, its operating costs are much lower due to the lower price of nuclear fuel compared to fossil fuel. During 1978, the fuel costs for electric energy produced by nuclear generators were approximately two to three times less than the fuel costs for electricity produced by natural gas and ten times less than residual oil. Presently, there are four nuclear units

in the state, three owned by Florida Power & Light Company and one owned principally by Florida Power Corporation. The latter unit, Crystal River 3, is jointly owned (10%) with several municipal and cooperative utilities and was placed in service early in 1977.

C. Combustion Turbine

Combustion turbines comprise 17% (3,950 MW) of the total existing capacity. These units have the ability of being placed on line and operated at full load within minutes after startup. They are used primarily as peaking units, for "black start" operation, or for sustained periods when base- or intermediate-load generating capacity becomes suddenly insufficient due to a forced outage or an unexpected higher demand than was forecasted is experienced. The combustion turbine's capital cost is lower than a comparably sized fossil steam unit and the lead time for construction is much shorter. However, its operating costs are higher due to its comparative inefficiency and use of expensive distillate fuels. At present, the 81 MW (winter rating) units at Florida Power Corporation's Turner facility are the largest in the state. Some of the most recently installed "regenerative" combustion turbine units employ intake air preheaters, burn treated residual oil, and achieve operating costs as low as modern fossil steam generators.

D. Diesel

Comprising less than 1% (116 MW) of the state's generating capacity, diesel-powered generators are used primarily as peaking and "black start" units by larger utilities and

for backup power at nuclear stations. A number of smaller utilities in the state also use these units as their primary power supply due to the diesel's low capital cost, short lead time for installation, and favorable operating efficiency. Diesel generators use distillate fuel oil or natural gas. Like the combustion turbine, the diesel may be started and fully loaded in only minutes. Its small size (usually 10 MW or less) and expensive fuel prohibit extensive use by most large utilities.

E. Combined-Cycle

The first combined-cycle unit in Florida was placed in service during 1977 at Florida Power & Light Company's Putnam Plant. Since that time, two additional units have become commercially available: a second unit at Putnam and one at Lake Worth Utilities Authority. The combined-cycle system has a design net heat rate of less than 9,000 BTU/kWH, making it the most efficient of any electric generator. A typical combined-cycle system consists of three components: two combustion turbines, each with its own generator, and one steam boiler and associated steam turbine generator. The normally wasted combustion turbine exhaust heat is fed into the steam generator's boiler which may also be supplementally fired. This more efficient use of heat is responsible for the increased system efficiency (lower heat rate) over either the regenerative combustion turbine or fossil-fueled steam generator.

1979 TEN-YEAR PLAN - STATE OF FLORIDA

TABLE 1

SUMMARY OF EXISTING CAPACITY AS OF JANUARY 1, 1979

<u>Utility</u>	<u>Net Capability - MW</u>	
	<u>Summer</u>	<u>Winter</u>
Florida Power Corporation	3647	4040
Florida Power & Light Company	10957	11516
Fort Pierce Utilities Authority	116	116
Gainesville/Alachua County Regional Utilities Board	257	272
Gulf Power Company	1453	1457
City of Homestead	52	52
Jacksonville Electric Authority	1884	1939
Lake Worth Utilities Authority	141	154
City of Lakeland	372	384
Orlando Utilities Commission	742	760
Seminole Electric Cooperative	14	14
Southeastern Power Administration	36	36
City of Tallahassee	495	518
Tampa Electric Company	2505	2505
Vero Beach Municipal Utilities	133	133
Total	22804	23896
Total Hydro	36	36
Total Nuclear	2876	2968
Total Fossil Steam	15350	15565
Total Diesel	116	117
Total Combustion Turbine	3950	4657
Total Combined-Cycle	476	553
Total	22804	23896

1979 TEN-YEAR PLAN - STATE OF FLORIDA

TABLE 2

EXISTING GENERATING FACILITIES
As of January 1, 1979

PAGE 1 OF 9

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Utility	Plant	Unit No.	Location	Unit Type	Fuel	In Service	Net Capability - MW Summer	Winter
FPC	Anclote	1	Tarpon Springs	FS	HO	11/74	466	506
FPC	Anclote 1/	2	Tarpon Springs	FS	HO	11/78	466	506
FPC	Avon Park	2	Avon Park	FS	HO	11/52	42	44
FPC	Avon Park	1	Avon Park	CT	LO	12/68	26	35
FPC	Avon Park	2	Avon Park	CT	LO	3/69	26	35
FPC	Bartow	1	St. Petersburg	FS	HO	9/58	114	114
FPC	Bartow	2	St. Petersburg	FS	HO	8/61	116	116
FPC	Bartow	3	St. Petersburg	FS	HO	7/63	210	215
FPC	Bartow	1- 4	St. Petersburg	CT	LO	7/72	168	204
FPC	Bayboro	1- 4	St. Petersburg	CT	LO	4/73	160	208
FPC	Crystal River 2/	1	Red Level	FS	HO	10/66	383	383
FPC	Cyrstal River	2	Red Level	FS	C	11/69	383	413
FPC	Crystal River (797p)	3	Red Level	N	N	3/77	717	731
FPC	DeBary	1	Volusia County	CT	HO	2/76	42	52
FPC	DeBary	2	Volusia County	CT	HO	3/76	42	52
FPC	DeBary	3	Volusia County	CT	HO	12/75	42	52
FPC	DeBary	4	Volusia County	CT	HO	4/76	42	52
FPC	DeBary	5	Volusia County	CT	HO	12/75	42	52
FPC	DeBary	6	Volusia County	CT	HO	4/76	42	52
FPC	Higgins	1	Oldsmar	FS	HO	6/51	39	40
FPC	Higgins	2	Oldsmar	FS	HO	6/53	39	41
FPC	Higgins	3	Oldsmar	FS	HO	1/54	41	42
FPC	Higgins	1	Oldsmar	CT	LO	3/69	27	30
FPC	Higgins	2	Oldsmar	CT	LO	4/69	27	30
FPC	Higgins	3	Oldsmar	CT	LO	12/70	30	35
FPC	Higgins	4	Oldsmar	CT	LO	1/71	30	35

1979 TEN-YEAR PLAN - STATE OF FLORIDA

EXISTING GENERATING FACILITIES
As of January 1, 1979

TABLE 2

PAGE 2 OF 9

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Utility	Plant	Unit No.	Location	Unit Type	Fuel	In Service	Net Capability - MW Summer	Winter
FPC	Intercession	1- 6	Intercession	CT	LO	5/74	264	330
FPC	Port St. Joe	1	Port St. Joe	CT	LO	12/70	14	17
FPC	Rio Pinar	1	Union Park	CT	LO	11/70	14	17
FPC	Suwannee River	1	Ellaville	FS	HO	11/53	34	34
FPC	Suwannee River	2	Ellaville	FS	HO	11/54	33	33
FPC	Suwannee River	3	Ellaville	FS	HO	10/56	80	80
FPC	Turner	3	Enterprise	FS	HO	11/55	71	72
FPC	Turner	4	Enterprise	FS	HO	5/59	72	75
FPC	Turner	1- 2	Enterprise	CT	LO	10/70	28	34
FPC	Turner	3- 4	Enterprise	CT	LO	8/74	124	162
TOTAL							3647	4040
FPL	Cape Canaveral	1	Brevard County	FS	HO	4/65	367	370
FPL	Cape Canaveral	2	Brevard County	FS	HO	5/69	362	366
FPL	Cutler 3/	4	Dade County	FS	HO	11/52	67	70
FPL	Cutler 3/	5	Dade County	FS	HO	11/54	67	70
FPL	Cutler 3/	6	Dade County	FS	HO	7/55	130	132
FPL	Ft. Myers	1	Lee County	FS	HO	12/58	137	139
FPL	Ft. Myers	2	Lee County	FS	HO	7/69	367	370
FPL	Ft. Myers	1-12	Lee County	CT	LO	6/74	672	828
FPL	Lauderdale	4	Broward County	FS	HO	9/57	137	139
FPL	Lauderdale	5	Broward County	FS	HO	4/58	137	139
FPL	Lauderdale	1-12	Broward County	CT	LO	8/70	426	486
FPL	Lauderdale	13-24	Broward County	CT	LO	8/72	426	486

1979 TEN-YEAR PLAN - STATE OF FLORIDA

TABLE 2

EXISTING GENERATING FACILITIES
As of January 1, 1979

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(1) Utility	(2) Plant	(3) Unit No.	(4) Location	(5) Unit Type	(6) Fuel	(7) In Service	(8) Net Capability - MW		(9) MW
							Summer	Winter	
FPL	Manatee	1	Manatee County	FS	HO	10/76	764		775
FPL	Manatee	2	Manatee County	FS	HO	12/77	764		775
FPL	Palatka 3/	1	Putnam County	FS	HO	8/51	32		34
FPL	Palatka 3/	2	Putnam County	FS	HO	8/56	75		77
FPL	Port Everglades	1	Hollywood	FS	HO	6/60	204		206
FPL	Port Everglades	2	Hollywood	FS	HO	4/61	204		206
FPL	Port Everglades	3	Hollywood	FS	HO	7/64	367		370
FPL	Port Everglades	4	Hollywood	FS	HO	4/65	367		370
FPL	Port Everglades	1- 5	Hollywood	D	LO	4/68	14		14
FPL	Port Everglades	1-12	Hollywood	CT	LO	8/71	426		486
FPL	Putnam	1	Putnam County	CC	HO	4/78	223		259
FPL	Putnam	2	Putnam County	CC	HO	8/77	223		259
FPL	Riviera	1	Riviera	FS	HO	11/46	40		41
FPL	Riviera	2	Riviera	FS	HO	11/53	69		71
FPL	Riviera	3	Riviera	FS	HO	6/62	272		275
FPL	Riviera	4	Riviera	FS	HO	3/63	272		275
FPL	Sanford	3	Volusia County	FS	HO	5/59	137		139
FPL	Sanford	4	Volusia County	FS	HO	7/72	362		366
FPL	Sanford	5	Volusia County	FS	HO	6/73	362		366
FPL	St. Lucie	1	St. Lucie County	N	N	12/76	777		795
FPL	Turkey Point	1	Dade County	FS	HO	4/67	367		370
FPL	Turkey Point	2	Dade County	FS	HO	4/68	367		370
FPL	Turkey Point	3	Dade County	N	N	12/72	666		696
FPL	Turkey Point	4	Dade County	N	N	9/73	666		696
FPL	Turkey Point	1- 5	Dade County	D	LO	4/68	13		13
TOTAL							10957		11516

1979 TEN-YEAR PLAN - STATE OF FLORIDA

EXISTING GENERATING FACILITIES
As of January 1, 1979

TABLE 2

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(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Utility	Plant	Unit No.	Location	Unit Type	Fuel	In Service	Net Capability - MW Summer	Winter
FTP	King	5	Ft. Pierce	FS	HO	1/53	7	7
FTP	King	6	Ft. Pierce	FS	HO	1/58	18	18
FTP	King	7	Ft. Pierce	FS	HO	1/64	35	35
FTP	King	8	Ft. Pierce	FS	HO	5/76	51	51
FTP	King	1	Ft. Pierce	D	LO	4/70	2	2
FTP	King	2	Ft. Pierce	D	LO	4/70	3	3
TOTAL							116	116
GVL	Crystal River (797p)	3	Red Level	N	N	3/77	12	12
GVL	Deerhaven	1	Alachua County	FS	HO	8/72	82	84
GVL	Deerhaven	1	Alachua County	CT	LO	8/76	20	26
GVL	Deerhaven	2	Alachua County	CT	LO	8/76	20	26
GVL	J. R. Kelly	6	Gainesville	FS	HO	3/58	14	14
GVL	J. R. Kelly	7	Gainesville	FS	HO	8/61	22	22
GVL	J. R. Kelly	8	Gainesville	FS	HO	4/65	44	45
GVL	J. R. Kelly	1	Gainesville	D	LO	9/49	1	1
GVL	J. R. Kelly	1	Gainesville	CT	LO	5/68	14	14
GVL	J. R. Kelly	2	Gainesville	CT	LO	9/68	14	14
GVL	J. R. Kelly	3	Gainesville	CT	LO	2/69	14	14
TOTAL							257	272

1979 TEN-YEAR PLAN - STATE OF FLORIDA

TABLE 2

EXISTING GENERATING FACILITIES
As of January 1, 1979

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(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Utility	Plant	Unit No.	Location	Unit Type	Fuel	In Service	Net Capability - MW Summer	Winter
GPC	Crist	1	Pensacola	FS	NG	1/45	22	22
GPC	Crist	2	Pensacola	FS	NG	6/49	19	19
GPC	Crist	3	Pensacola	FS	NG	9/52	31	31
GPC	Crist	4	Pensacola	FS	C	7/59	78	78
GPC	Crist	5	Pensacola	FS	C	6/61	80	80
GPC	Crist	6	Pensacola	FS	C	5/70	319	319
GPC	Crist	7	Pensacola	FS	C	8/73	434	434
GPC	Scholz	1	Sneads	FS	C	3/53	48	48
GPC	Scholz	2	Sneads	FS	C	10/53	48	48
GPC	Smith	1	Panama City	FS	C	6/65	160	160
GPC	Smith	2	Panama City	FS	C	6/67	183	183
GPC	Smith	1	Panama City	CT	LO	5/71	31	35
TOTAL							1453	1457
HST	G. W. Ivey	7- 9	Dade County	D	LO	1/54	7	7
HST	G. W. Ivey	10	Dade County	D	LO	1/58	3	3
HST	G. W. Ivey	11-12	Dade County	D	LO	1/65	8	8
HST	G. W. Ivey	2- 3	Dade County	D	LO	3/70	4	4
HST	G. W. Ivey	1	Dade County	D	LO	10/71	2	2
HST	G. W. Ivey	13-17	Dade County	D	LO	11/72	10	10
HST	G. W. Ivey	18	Dade County	D	LO	4/75	9	9
HST	G. W. Ivey	19	Dade County	D	LO	2/75	9	9
TOTAL							52	52

1979 TEN-YEAR PLAN - STATE OF FLORIDA

EXISTING GENERATING FACILITIES
As of January 1, 1979

TABLE 2

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(1) Utility	(2) Plant	(3) Unit No.	(4) Location	(5) Unit Type	(6) Fuel	(7) In Service	(8) Net Capability - MW Summer	(9) Net Capability - MW Winter
JEA	Kennedy	8	Duval County	FS	HO	7/55	43	45
JEA	Kennedy	9	Duval County	FS	HO	1/58	43	45
JEA	Kennedy	10	Duval County	FS	HO	12/61	130	134
JEA	Kennedy 4/	1- 2	Duval County	CT	LO	2/69	25	26
JEA	Kennedy	3- 5	Duval County	CT	LO	7/73	162	162
JEA	Kennedy 4/	6	Duval County	CT	LO	7/73	54	54
JEA	Northside	1	Duval County	FS	HO	11/66	262	262
JEA	Northside	2	Duval County	FS	HO	3/72	262	262
JEA	Northside	3	Duval County	FS	HO	7/77	460	460
JEA	Northside 4/	1- 2	Duval County	CT	LO	10/68	23	28
JEA	Northside	3- 6	Duval County	CT	LO	1/75	206	244
JEA	Southside	1	Duval County	FS	HO	11/50	27	27
JEA	Southside	2	Duval County	FS	HO	1/51	29	32
JEA	Southside	3	Duval County	FS	HO	1/55	46	48
JEA	Southside	4	Duval County	FS	HO	11/58	70	72
JEA	Southside	5	Duval County	FS	HO	9/64	144	146
JEA	Southside 4/	1- 2	Duval County	CT	LO	2/69	25	30
TOTAL							1884	1939
LWU	Tom G. Smith	1	Lake Worth	FS	NG	1/61	7	8
LWU	Tom G. Smith	2	Lake Worth	FS	NG	3/63	7	8
LWU	Tom G. Smith	3	Lake Worth	FS	NG	11/67	25	26
LWU	Tom G. Smith	4	Lake Worth	FS	NG	8/71	33	35
LWU	Tom G. Smith	5	Lake Worth	CC	NG	3/78	30	35
LWU	Tom G. Smith	1- 5	Lake Worth	D	LO	12/65	10	10
LWU	Tom G. Smith	1	Lake Worth	CT	LO	12/76	29	32
TOTAL							141	154

1979 TEN-YEAR PLAN - STATE OF FLORIDA

TABLE 2

EXISTING GENERATING FACILITIES
As of January 1, 1979

PAGE 7 OF 9

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Utility	Plant	Unit No.	Location	Unit Type	Fuel	In Service	Net Capability - MW Summer	Winter
LAK	Larsen	4	Polk County	FS	HO	1/50	19	19
LAK	Larsen	5	Polk County	FS	HO	1/56	25	25
LAK	Larsen	6	Polk County	FS	HO	1/59	25	25
LAK	Larsen	7	Polk County	FS	HO	1/66	49	52
LAK	Larsen	1- 3	Polk County	CT	LO	1/62	33	39
LAK	McIntosh	1	Polk County	FS	HO	1/70	92	93
LAK	McIntosh	2	Polk County	FS	HO	4/76	104	102
LAK	McIntosh	1- 2	Polk County	D	LO	1/73	5	6
LAK	McIntosh	1	Polk County	CT	LO	1/73	20	23
TOTAL							372	384
OUC	Crystal River (797p)	3	Red Level	N	N	3/77	13	13
OUC	Indian River	1	Titusville	FS	HO	2/60	90	92
OUC	Indian River	2	Titusville	FS	HO	12/64	204	208
OUC	Indian River	3	Titusville	FS	HO	2/74	318	321
OUC	Lake Highland	1	Orlando	FS	HO	9/49	30	31
OUC	Lake Highland	2	Orlando	FS	HO	9/54	30	31
OUC	Lake Highland	3	Orlando	FS	HO	6/56	30	31
OUC	Lake Highland	1	Orlando	D	LO	1/70	1	1
OUC	Lake Highland	1- 2	Orlando	CT	LO	12/58	26	32
TOTAL							742	760
SEC	Crystal River (797p)	3	Red Level	N	N	3/77	14	14
TOTAL							14	14

1979 TEN-YEAR PLAN - STATE OF FLORIDA

EXISTING GENERATING FACILITIES
As of January 1, 1979

TABLE 2

PAGE 8 OF 9

(1) <u>Utility</u>	(2) <u>Plant</u>	(3) <u>Unit No.</u>	(4) <u>Location</u>	(5) <u>Unit Type</u>	(6) <u>Fuel</u>	(7) <u>In Service</u>	(8) <u>Net Capability - MW Summer</u>	(9) <u>Winter</u>
SPA	Woodruff Dam	1- 3	Gadsden County	HY	HY	1/57	36	36
TOTAL							36	36
TAL	Crystal River (797p)	3	Red Level	N	N	3/77	11	11
TAL	Hopkins	1	Leon County	FS	HO	5/71	78	80
TAL	Hopkins	2	Leon County	FS	HO	10/77	225	238
TAL	Hopkins	1	Leon County	CT	LO	2/70	14	16
TAL	Hopkins	2	Leon County	CT	LO	9/72	27	30
TAL	Purdum	1- 3	Wakulla County	FS	HO	1/52	21	24
TAL	Purdum	4	Wakulla County	FS	HO	4/54	7	8
TAL	Purdum	5	Wakulla County	FS	HO	4/58	22	22
TAL	Purdum	6	Wakulla County	FS	HO	1/61	22	22
TAL	Purdum	7	Wakulla County	FS	HO	6/66	46	45
TAL	Purdum	1	Wakulla County	CT	LO	12/63	11	11
TAL	Purdum	2	Wakulla County	CT	LO	5/64	11	11
TOTAL							495	518
TEC	Big Bend	1	Hillsborough County	FS	C	10/70	362	362
TEC	Big Bend	2	Hillsborough County	FS	C	4/73	338	338
TEC	Big Bend	3	Hillsborough County	FS	C	5/76	362	362
TEC	Big Bend	1	Hillsborough County	CT	LO	1/69	14	14
TEC	Big Bend	2- 3	Hillsborough County	CT	LO	11/74	130	130
TEC	Gannon	1	Hillsborough County	FS	HO	8/57	98	98
TEC	Gannon	2	Hillsborough County	FS	HO	10/58	108	108
TEC	Gannon	3	Hillsborough County	FS	HO	8/60	150	150

EXISTING GENERATING FACILITIES
As of January 1, 1979

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Utility	Plant	Unit No.	Location	Unit Type	Fuel	In Service	Net Capability - MW	
							Summer	Winter
TEC	Gannon	4	Hillsborough County	FS	HO	7/63	169	169
TEC	Gannon	5	Hillsborough County	FS	C	9/65	229	229
TEC	Gannon	6	Hillsborough County	FS	C	9/67	338	338
TEC	Gannon	1	Hillsborough County	CT	LO	1/69	14	14
TEC	Hookers Point	1	Hillsborough County	FS	HO	7/48	28	28
TEC	Hookers Point	2	Hillsborough County	FS	HO	6/50	29	29
TEC	Hookers Point	3	Hillsborough County	FS	HO	8/50	28	28
TEC	Hookers Point	4	Hillsborough County	FS	HO	10/53	42	42
TEC	Hookers Point	5	Hillsborough County	FS	HO	5/55	66	66
TOTAL							2505	2505
VER	Municipal Plant	1	Vero Beach	FS	HO	11/61	12	12
VER	Municipal Plant	2	Vero Beach	FS	HO	8/64	17	17
VER	Municipal Plant	3	Vero Beach	FS	HO	9/71	33	33
VER	Municipal Plant	4	Vero Beach	FS	HO	5/76	56	56
VER	Municipal Plant	1	Vero Beach	D	LO	1/47	1	1
VER	Municipal Plant	2	Vero Beach	D	LO	1/37	1	1
VER	Municipal Plant	4	Vero Beach	D	LO	1/52	4	4
VER	Municipal Plant	5	Vero Beach	D	LO	1/53	4	4
VER	Municipal Plant	6	Vero Beach	D	LO	1/57	5	5
TOTAL							133	133

NOTES

1/ Off-line due to EPA thermal restrictions; operation allowed 5/79.

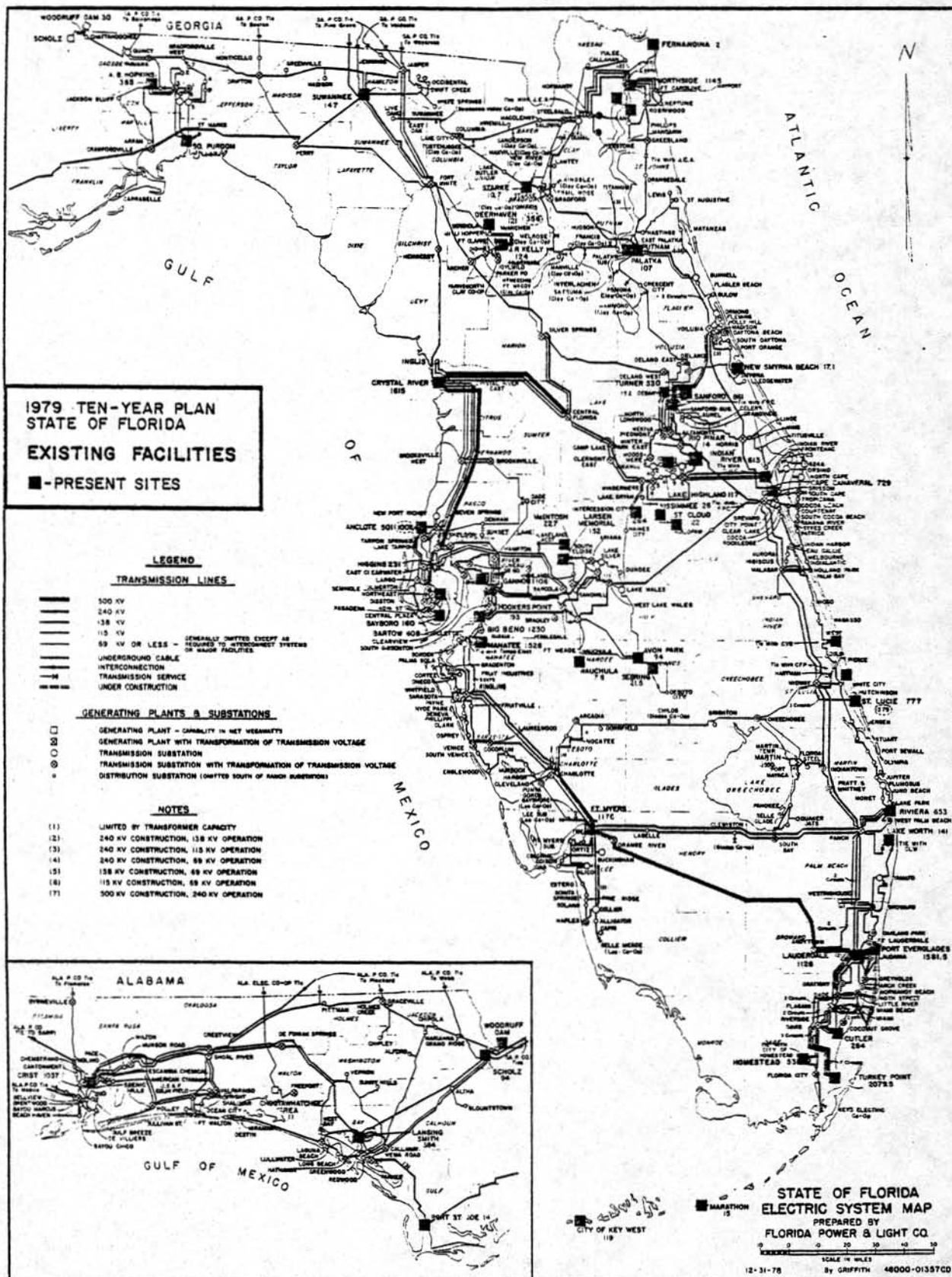
2/ Off-line to convert to coal.

3/ These units have been placed on extended cold standby. Reactivation would require several months. The total capacity of these five units is not included in the total existing capability for Florida Power & Light Company.

4/ Extended outage

(Np) Joint Participation Unit where N is total summer net MW rating.

FIGURE 2



**II. A HISTORY AND FORECAST OF ELECTRIC POWER
PEAK DEMAND, ENERGY USE AND FUEL
REQUIREMENTS**

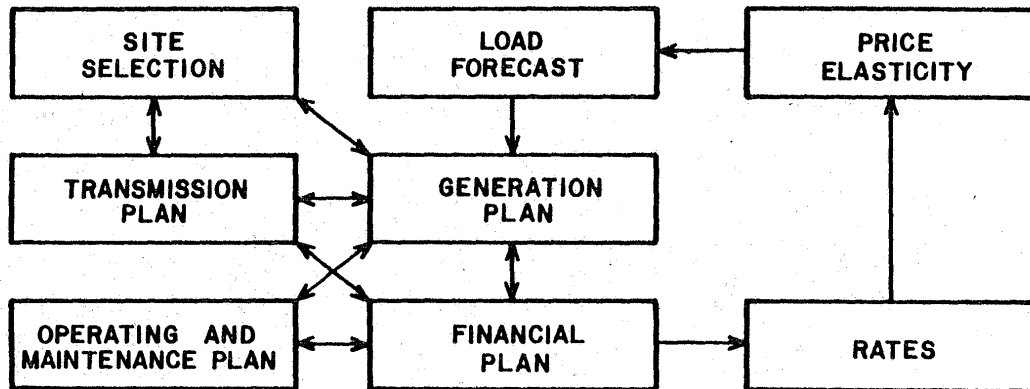
II. A HISTORY AND FOREFAST OF ELECTRIC POWER PEAK DEMAND, ENERGY USE AND FUEL REQUIREMENTS

To determine the need for future facilities and fuel requirements, electric utilities employ various comprehensive generation planning techniques. Figure 3 is a flowchart that shows the typical planning process. Individual utilities use variations of this process depending upon their structure, size, and resources. These individual plans collectively become the joint plan which serves as the basis for the FCG's planning studies.

Projections of electrical demands for at least ten years are necessary to accommodate the multi-year lead times required for siting, permitting, and constructing generating units. In addition to demand forecasts, the associated energy use must also be estimated to assist in the determination of the optimal type of unit to be utilized and to establish fuel requirements and contracts.

Estimates that fall short of actual future peak power demands could lead to power shortages while estimates that exceed actual demands could possibly result in economic inefficiencies due to a one- or two-year excess of generating capacity. In recent years, this possibility has diminished with the extraordinary increase in the viability of economy interchange transactions. Additionally, unforeseen delays, unscheduled maintenance, and environmental regulatory action have reduced the excess capacity margins that were anticipated to be caused by the apparent reduced growth rate of the demand for electricity.

FIGURE 3



1979 TEN-YEAR PLAN
STATE OF FLORIDA

TYPICAL PLANNING PROCESS

FCG
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Methods of Load Forecasting

There are probably as many methods of load forecasting in the state as there are utilities because each utility serves a unique load area with differing load characteristics. In the past, load forecasting was heavily dependent upon historical trends for determining future demands and associated energy use. Electric energy use, averaged among all Florida utilities, was doubling approximately every seven years (a growth rate of 10%)--a fairly consistent trend until 1974 when the price of oil quadrupled and electric bills increased dramatically for many customers. As a partial result, 1974 was a "no growth" year for the electric utility industry in the state and a new growth trend appeared to have been established. During the last four years, 1975 through 1978, electrical energy use has experienced increases of 5.2%, 3.5%, 7.4%, and 6.0% respectively. Allegedly, large portions of the 1977 and 1978 energy use increases can be attributed to the extremely cold winter months of January and February during those years.

Present day load forecasting techniques may utilize econometric models, appliance saturation data, plus weather models and historical trends to establish the forecast of power requirements.

Generally, there are three projection ranges included in the total forecast:

1. Short range - 1 to 5 years
2. Intermediate range - 6 to 10 years
3. Long range - 11 or more years

A brief discussion of each forecasting range follows:

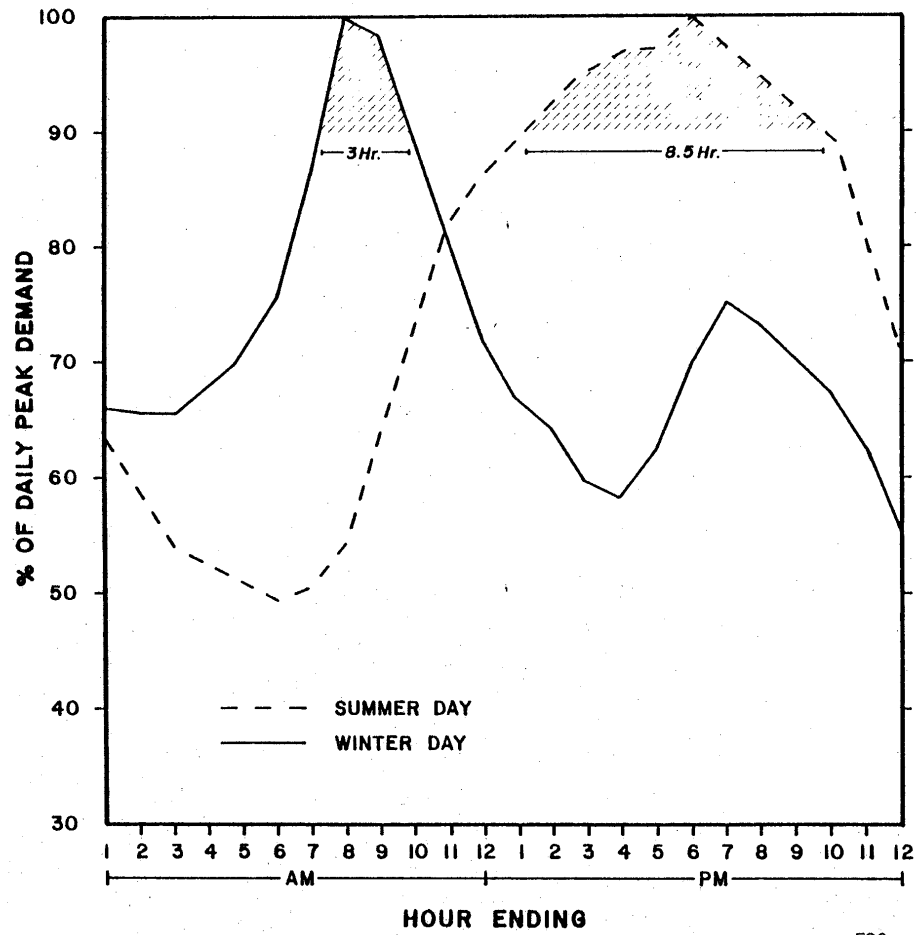
1. The Short Range Estimate: 1979-1980

The short range forecast encompasses that period during which maintenance schedules are formulated and coordinated, interchange agreements for firm power are negotiated to cover shortfalls, and distribution facilities are planned and budgeted. On a yearly basis, Florida is expected to experience a peak demand in both the winter and summer seasons. Due to the heavy use of air conditioning in June, July, August, and September, the daily load cycle during these summer months often consists of as many as eight hours of peak demand during the afternoon and early evening. In contrast, the normal winter daily load cycle consists of sharp peaks during the morning and early evening when heating, cooking, and lighting comprise the majority of the demand. Figure 4 is a graph of the hourly demand of a typical summer day compared to a winter day. Abnormally low winter temperatures, however, have a tendency to levelize the demand near the peak value for the entire day.

Table 3 and Figure 5 show the state of Florida's actual 1978 and estimated monthly net peak demand and net energy for load, shown here as average demand, for the years 1979 and 1980. Each monthly peak is comprised of the forecasted non-coincident 60-minute integrated net demands assuming normal weather conditions.

1979 TEN-YEAR PLAN
STATE OF FLORIDA
DAILY LOAD SHAPES

FIGURE 4



FCG
5-3-78

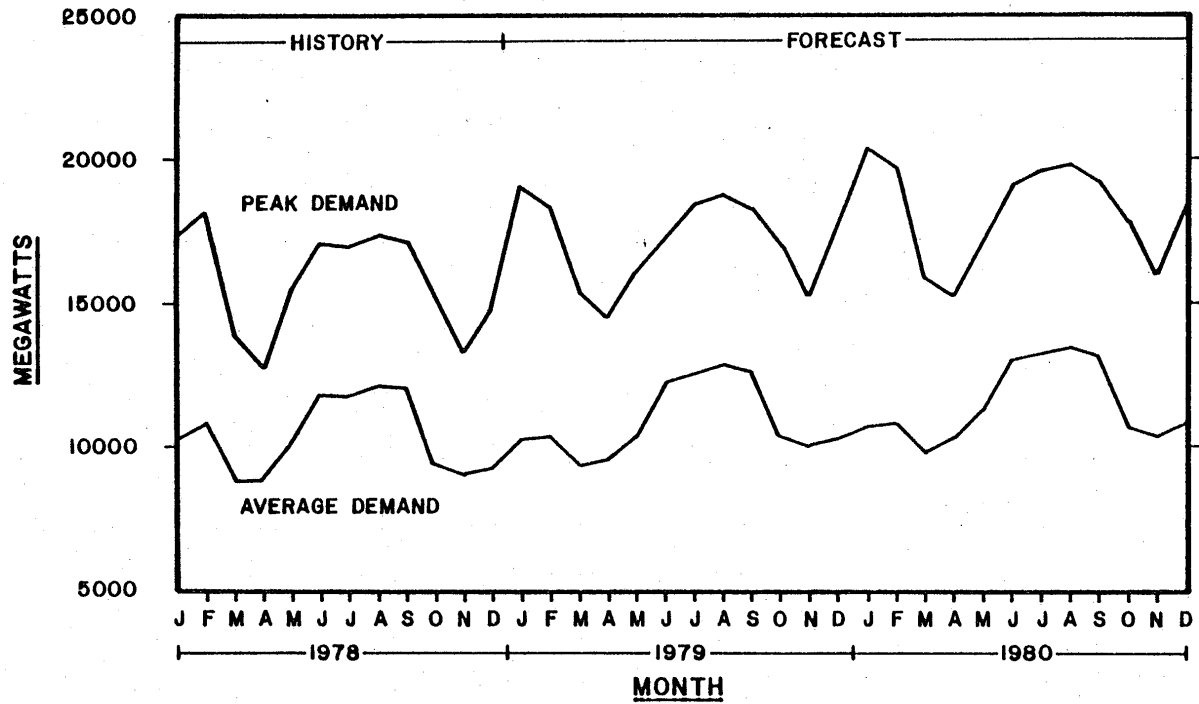
PREVIOUS YEAR ACTUAL AND TWO-YEAR FORECAST OF PEAK DEMAND
AND NET ENERGY FOR LOAD BY MONTH

MONTH	ACTUAL		FORECAST			
	1978		1979		1980	
	PEAK DEMAND MW	NEL GWH	PEAK DEMAND MW	NEL GWH	PEAK DEMAND MW	NEL GWH
JAN	17381	7647	19050	7535	20375	8003
FEB	18143	7269	18334	6970	19609	7298
MAR	13932	6599	15200	6916	15898	7393
APR	12672	6415	14538	6871	15256	7377
MAY	15537	7494	16085	7796	17054	8349
JUN	17022	8508	17725	8839	18933	9301
JUL	16986	8728	18458	9338	19555	9880
AUG	17326	9005	18610	9571	19785	10011
SEP	17100	8676	18256	9077	19380	9459
OCT	15021	7048	16938	7742	17746	8140
NOV	13234	6618	15242	7198	15937	7509
DEC	14743	6882	17675	7700	18395	8010
		90889		95553		100730

1979 TEN-YEAR PLAN
STATE OF FLORIDA

FIGURE 5

PREVIOUS YEAR HISTORY AND TWO-YEAR FORECAST
OF MONTHLY PEAK AND AVERAGE DEMAND



2. The Intermediate Range Estimate: 1979-1988

Ten-year projections serve as the basis for generation and transmission line planning. Decisions utilizing this forecast may determine whether generating facilities are to be built and possibly where they will be located.

Table 4 lists the ten-year history and forecast of the summer and winter non-coincident peak demand, annual net energy for load, and annual load factors. Individual system peak demand and energy data can be found in the appendix of this report. Figure 6 shows how the ten-year forecasted growth rates of the annual summer peak demand have been reduced over the years since the oil embargo of 1973. In recent years, the projections seemed to have leveled out near the 5% level.

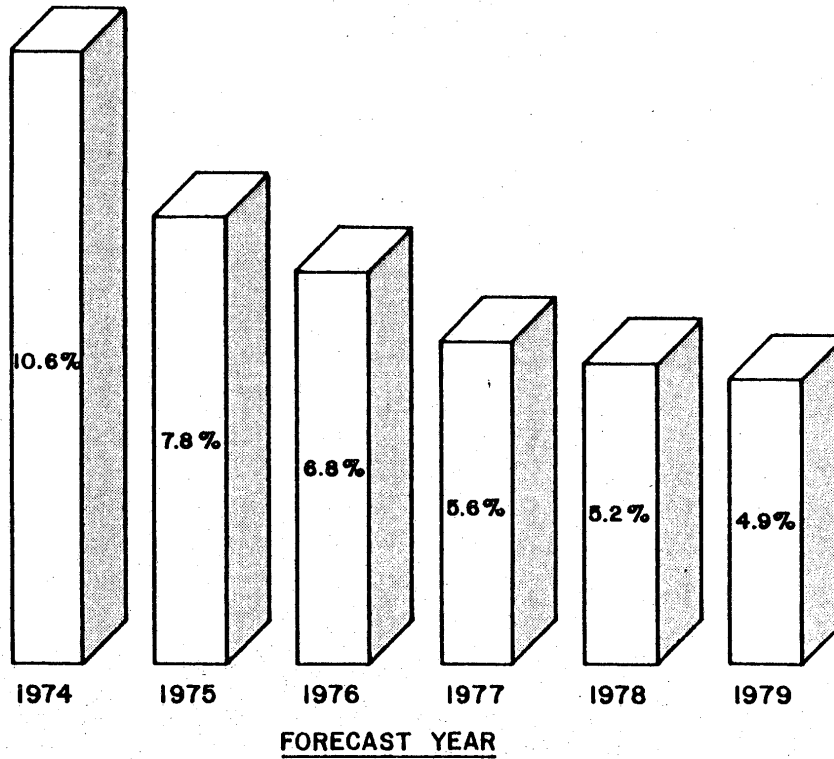
In contrast to historical trends, the winter peaks of 1976/77, 1977/78, and 1978/79 were higher than those of the previous summers. The 1977/78 winter peak was also in excess of the following summer peak. Thus, Florida has gone from winter peaking in the 1950's, to summer peaking in the 1960's, to seasonal peaking in the 1970's, and back to winter peaking in the late 1970's and 1980's.

Figures 5 and 7 show the relationship between the peak demand and average demand. Average demand is a convenient representation of energy obtained by dividing the Net Energy for Load by the number of hours in the year. The result of then dividing the average demand by the peak is the load factor (Table 4, Column (5)).

1979 TEN-YEAR PLAN
STATE OF FLORIDA

FIGURE 6

FORECAST OF TEN-YEAR
AVERAGE ANNUAL GROWTH RATE
OF SUMMER PEAK DEMAND



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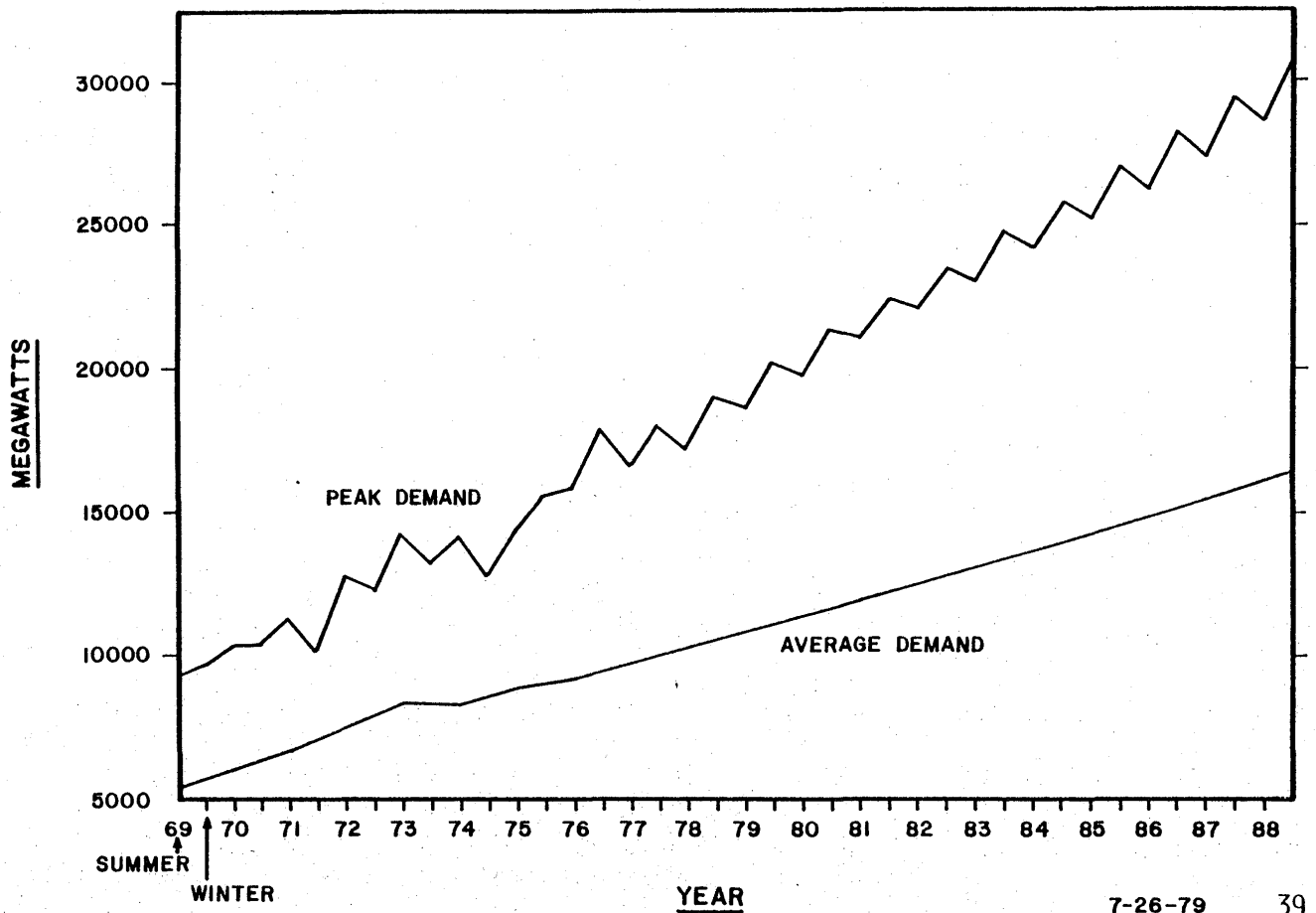
HISTORY AND FORECAST OF SEASONAL PEAK DEMAND AND ANNUAL NET ENERGY FOR LOAD

(1)	(2) Summer Peak Demand Net MW		(4)	(5)	(6)	(7) Winter Peak Demand Net MW		(8)
YEAR	Interruptible	Total	Net Energy For Load - GWH	Load Factor %	YEAR	Interruptible	Total	
1969	316	9248	47163	58.2	1969-70	351	9736	
1970	365	10485	53074	57.8	1970-71	320	10402	
1971	466	11311	58232	58.8	1971-72	312	10216	
1972	320	12845	65606	58.1	1972-73	346	12383	
1973	319	14413	73743	58.4	1973-74	332	13213	
1974	326	14855	73359	56.4	1974-75	335	12978	
1975	337	14957	77208	58.9	1975-76	345	15614	
1976	334	15907	79883	57.2	1976-77	555	17966	
1977	443	16648	85766	58.8	1977-78	445	18139	
1978	439	17326	90889	59.1	1978-79	501	19050*	
AAGR**		7.2%	7.6%					7.7%
1979	501	18610	95553	58.6	1979-80	561	20375	
1980	561	19785	100730	58.0	1980-81	567	21399	
1981	567	21098	105329	57.0	1981-82	601	22472	
1982	601	22086	109896	56.8	1982-83	629	23578	
1983	629	23095	114977	56.8	1983-84	662	24708	
1984	662	24150	120139	56.6	1984-85	685	25842	
1985	685	25226	125370	56.7	1985-86	715	27039	
1986	715	26327	130730	56.7	1986-87	742	28246	
1987	742	27476	135770	56.4	1987-88	767	29481	
1988	767	28641	141428	56.2	1988-89	760	30730	
AAGR**		4.9%	4.5%					4.7%

*Forecast

**Average Annual Growth Rate

**HISTORY AND FORECAST OF SEASONAL
PEAK AND AVERAGE DEMAND**



When arriving at conclusions based on load factors, there are two points which should be considered: First, when comparing the load factor of one utility against another, consideration should be given to the types and percent composition of loads --residential, commercial, and industrial--served by each system. Second, when analyzing the actual magnitude of the load factor, the time period over which the load factor is calculated should also be considered, and whether the summer or winter peak demand is used.

Figure 5 and Figure 8 show the history and forecast of energy use by type of consumer. As with the peak demand, energy use is expected to increase more slowly in the future than in the past. Projections show energy use doubling every 16 years as compared to energy use historically doubling every 7.6 years prior to 1974.

Fuel Requirements: 1979-1988

Table 6 and associated Figures 9 and 10 depict the forecast of the fuel needed to generate the forecasted energy requirement.

Nuclear energy has been utilized in Florida since 1972 and its use is expected to increase through 1988. However, the percent contribution of nuclear energy to the state's total net system generation is expected to decrease from 20.2% in 1977 to 17.6% in 1988.

Three utilities, Florida Power Corporation, Tampa Electric Company, and Gulf Power Company, presently use coal. Energy from coal will increase considerably from 17.6% in

1977 to 42.5% of the total net system generation in 1988. In addition to the expansion plans which include coal-fired units, oil-to-coal conversions at existing facilities has also taken place. Florida Power Corporation's Crystal River 2 (383 MW) was converted during 1976 and Unit 1 (383 MW) conversion was completed during 1979. In addition, Florida Power & Light Company, Seminole Electric Cooperative, City of Lakeland, Orlando Utilities Commission, Jacksonville Electric Authority, and Gainesville/Alachua County Regional Utilities Board have coal-fired generation scheduled during the next ten years.

Residual oil remains the primary source of energy throughout the next ten years, supplying from a high of 52.7% in 1980 to a low of 37.2% in 1988 of the total generation. It is significant to note that even though Florida's reliance on oil declines in percent, it is estimated that the number of actual barrels of oil burned will increase by 17% in 1988, over 1978. Moreover, the use of residual oil may increase further if delays are experienced in placing nuclear and coal burning facilities on line or if the supply of natural gas is curtailed beyond that anticipated. Distillate fuel oil use is expected to increase little in magnitude and its contribution to the total net system generation will decrease from 1.6% to 1.2% during the next ten years.

Probably the most convenient to use and least polluting fossil fuel is natural gas, but reserves are dwindling and the regulatory climate controlling its use and price is

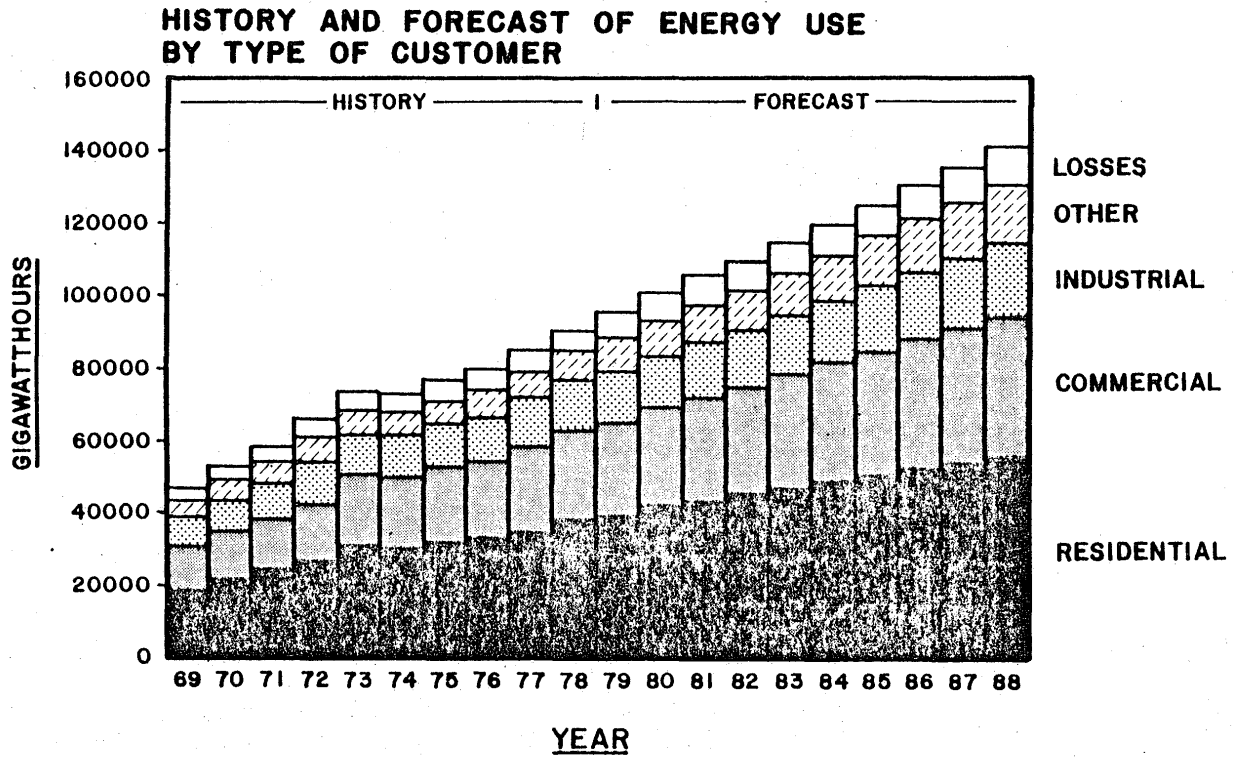
HISTORY AND FORECAST OF ENERGY USE BY TYPE OF CONSUMER-GWH

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
YEAR	Rural and Residential	Commercial	Industrial	Street & Highway Lighting	Other Sales to Ultimate Consumer	Total Sales to Ultimate Consumer	Sales for Resale	Utility Use and Losses	Net Energy for Load
1969	19375	10895	8495	350	2387	41502	2242	3419	47163
1970	22194	12229	9183	369	2418	46393	2636	4045	53074
1971	24413	13804	9694	419	2617	50947	3025	4260	58232
1972	27316	15647	10465	440	2828	56696	3648	5262	65606
1973	31746	18470	11350	482	1925	63973	4310	5460	73743
1974	30940	19498	11329	509	1252	63528	4550	5281	73359
1975	31933	20893	11614	543	1328	66311	4956	5941	77208
1976	32946	21485	12353	579	1357	68720	5381	5782	79883
1977	35739	22843	13247	606	1415	73850	5838	6078	85766
1978	38353	24345	13824	625	1514	78661	6349	5879	90889
AAGR*	7.9%	9.3%	5.6%	6.7%	-4.9%	7.4%	12.3%	6.2%	7.6%
1979	39643	25196	14644	704	1569	81756	6802	6995	95553
1980	41884	26860	15024	758	1629	86155	7062	7513	100730
1981	43728	28331	15497	812	1678	90046	7425	7858	105329
1982	45563	29692	15977	874	1726	93832	7884	8180	109896
1983	47203	31498	16575	939	1774	97989	8622	8366	114977
1984	48824	33119	17209	1012	1827	101991	9390	8758	120139
1985	50625	34657	17862	1090	1885	106119	10260	8991	125370
1986	52465	36128	18529	1179	1940	110241	11148	9341	130730
1987	54089	37457	19185	1274	1998	114003	12092	9675	135770
1988	55954	39016	19934	1377	2059	118340	13041	10047	141428
AAGR*	3.9%	5.0%	3.5%	7.7%	3.1%	3.1%	7.5%	4.1%	4.5%

*Average Annual Growth Rate

1979 TEN-YEAR PLAN
STATE OF FLORIDA

FIGURE 8



ENERGY SOURCES			Actual 1977	Actual 1978	1979	1980	1981	1982
(1)	PURCH. & INTERCHANGE	GWH	(359)	(323)	389	471	(622)	(544)
(2)	NUCLEAR	GWH	17421	15763	16141	19480	19437	20378
(3)	COAL	GWH	15187	15747	18429	19584	22656	25033
(4)	RESIDUAL-TOTAL	GWH	39426	41350	49369	52866	55564	56695
(5)	Steam	GWH	38771	40498	48544	51761	53927	53689
(6)	CC	GWH	367	570	587	906	1445	2857
(7)	CT	GWH	288	282	238	199	182	149
(8)	DISTILLATE-TOTAL	GWH	1623	1483	1355	913	898	1016
(9)	CC	GWH	0	136	31	37	42	42
(10)	CT	GWH	1554	1269	1169	692	657	747
(11)	Diesel	GWH	69	78	155	184	199	227
(12)	NATURAL GAS-TOTAL	GWH	12229	16645	9667	7213	6958	6870
(13)	Steam	GWH	11803	16039	9172	6876	6694	6634
(14)	CC	GWH	0	109	146	168	168	168
(15)	CT	GWH	362	433	304	139	81	68
(16)	Diesel	GWH	64	64	45	30	15	0
(17)	HYDRO	GWH	239	224	203	203	203	203
(18)	OTHER	GWH	0	0	0	0	245	245
(19)	NET ENERGY FOR LOAD	GWH	85766	90889	95553	100730	105329	109896
FUEL REQUIREMENTS								
(20)	COAL	1000 TON	6767	7193	8163	8689	10047	11154
(21)	RESIDUAL-TOTAL	1000 BBL	64327	72776	80151	85297	89424	91453
(22)	Steam	1000 BBL	63241	71243	78829	83591	86974	87028
(23)	CC	1000 BBL	643	1032	834	1291	2068	4118
(24)	CT	1000 BBL	443	501	488	415	382	307
(25)	DISTILLATE-TOTAL	1000 BBL	4008	3353	3123	2058	2009	2418
(26)	CC	1000 BBL	0	3	53	63	71	71
(27)	CT	1000 BBL	3878	3191	2753	1620	1530	1883
(28)	Diesel	1000 BBL	130	159	317	375	408	464
(29)	NATURAL GAS-TOTAL	1000 MCF	134724	153597	99240	75229	71971	70807
(30)	Steam	1000 MCF	127971	142639	92218	70828	68736	67960
(31)	CC	1000 MCF	0	1241	1500	1731	1731	1731
(32)	CT	1000 MCF	6022	8986	5004	2325	1331	1116
(33)	Diesel	1000 MCF	731	731	518	345	173	0

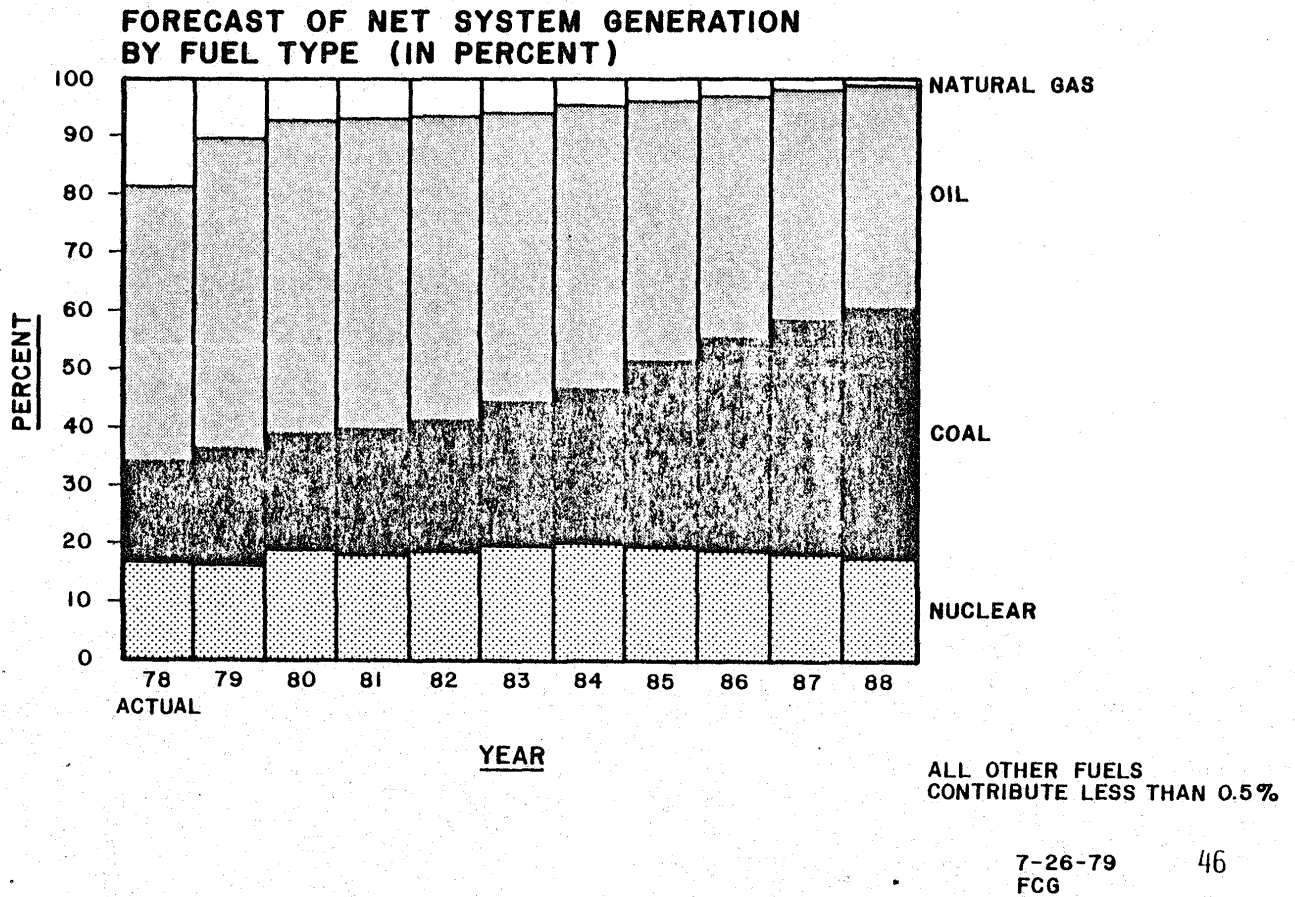
1979 TEN-YEAR PLAN - STATE OF FLORIDA
ENERGY SOURCES AND FUEL REQUIREMENTS

TABLE 6
PAGE 2 OF 2

ENERGY SOURCES			1983	1984	1985	1986	1987	1988
(1)	PURCH. & INTERCHANGE	GWH	(477)	435	5	339	(11)	325
(2)	NUCLEAR	GWH	22798	24018	24619	24719	24472	24847
(3)	COAL	GWH	28611	31988	39516	47046	54332	59941
(4)	RESIDUAL-TOTAL	GWH	56085	56153	54568	52442	52012	52518
(5)	Steam	GWH	53253	53669	52299	50044	49739	50341
(6)	CC	GWH	2721	2406	2199	2354	2209	2122
(7)	CT	GWH	111	78	70	44	64	55
(8)	DISTILLATE-TOTAL	GWH	1037	1403	1374	1806	1644	1764
(9)	CC	GWH	42	42	42	42	42	42
(10)	CT	GWH	757	1111	1068	1486	1310	1416
(11)	Diesel	GWH	238	250	264	278	292	306
(12)	NATURAL GAS-TOTAL	GWH	6475	5694	4840	3930	2873	1585
(13)	Steam	GWH	6238	5384	4564	3630	2597	1313
(14)	CC	GWH	168	168	168	168	168	168
(15)	CT	GWH	69	142	108	132	108	104
(16)	Diesel	GWH	0	0	0	0	0	0
(17)	HYDRO	GWH	203	203	203	203	203	203
(18)	OTHER	GWH	245	245	245	245	245	245
(19)	NET ENERGY FOR LOAD	GWH	114977	120139	125370	130730	135770	141428
FUEL REQUIREMENTS								
(20)	COAL	1000 TON	12891	14462	17778	21080	24245	27830
(21)	RESIDUAL-TOTAL	1000 BBL	90475	90483	88038	84724	84376	85031
(22)	Steam	1000 BBL	86331	86870	84737	81248	81065	81851
(23)	CC	1000 BBL	3910	3452	3153	3383	3181	3062
(24)	CT	1000 BBL	234	161	148	93	130	118
(25)	DISTILLATE-TOTAL	1000 BBL	2460	2986	3140	4152	3753	4100
(26)	CC	1000 BBL	71	71	71	71	71	71
(27)	CT	1000 BBL	1901	2660	2528	3512	3085	4302
(28)	Diesel	1000 BBL	488	255	541	569	597	627
(29)	NATURAL GAS-TOTAL	1000 MCF	66792	59340	50427	41302	30353	17251
(30)	Steam	1000 MCF	63929	55291	46948	37422	26878	13833
(31)	CC	1000 MCF	1731	1731	1731	1731	1731	1731
(32)	CT	1000 MCF	1132	2318	1748	2149	1744	1687
(33)	Diesel	1000 MCF	0	0	0	0	0	0

1979 TEN-YEAR PLAN
STATE OF FLORIDA

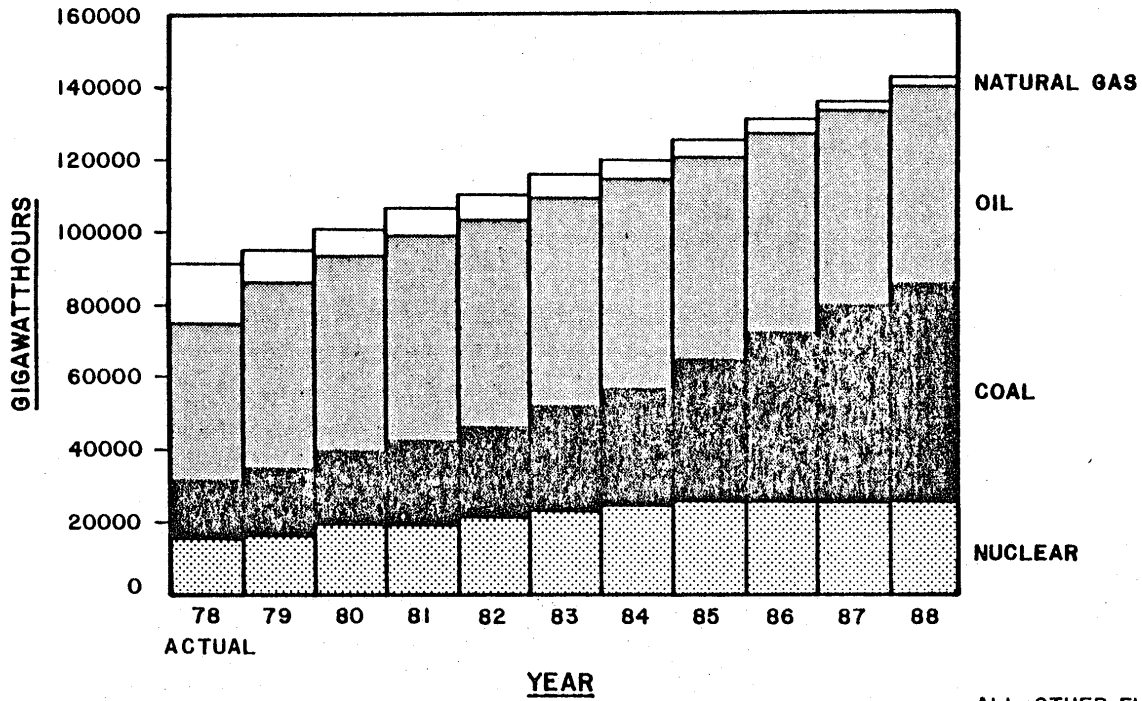
FIGURE 9



1979 TEN-YEAR PLAN
STATE OF FLORIDA

FIGURE 10

FORECAST OF NET SYSTEM GENERATION
BY FUEL TYPE (IN GWH)



ALL OTHER FUELS
CONTRIBUTE LESS THAN
500 GWH

7-26-79
FCG

uncertain at this time. Additionally, the Federal Energy Regulatory Commission has relegated the long-term use of natural gas to fire a steam boiler as an inferior use of this fuel. Natural gas, which produced 18.2% of the generated energy in 1978, will, by 1988, be reduced to 1.1% of the generated energy.

3. The Long Range Estimate: 1979-1998

Long range estimates are used for planning corporate strategy and conceptual generation and major bulk power transmission line planning. The Florida utilities, aware of the general trends of load growth over the next two decades, have already projected a 500 kV transmission system that will assure their customers the most reliable service possible.

Overlying any forecast of generation and fuel requirements are problems never before faced by any industry. Planning and operating efforts are shrouded by the threat of oil embargos, major strikes by organized labor, the continually increasing intervention of governmental and special interest groups into the planning, operating, and rate-making process, and the unknown effect that financing future facilities will have on our economic system. Also, it continues to remain unknown at this time what the effects of the recently passed National Energy Act will be.

III. A FORECAST OF FACILITIES REQUIREMENTS

III. A FORECAST OF FACILITIES REQUIREMENTS

To assure an adequate and reliable supply of electric energy, the Florida utilities have developed coordinated generation expansion plans which strive to achieve acceptable reserve margins utilizing the most economical mix of generation types for base-, intermediate-, and peak-load operation. Some plans include firm capacity interchanges, such as the agreements between Florida Power Corporation and the Cities of Tallahassee, Gainesville, and Lakeland. These types of agreements allow utilities to enjoy the economies of scale associated with units larger than would normally be installed if such interchange were not considered. The expansion plans also anticipate joint ownership among investor-owned, municipal, and cooperative systems. Examples of this are the sale of 10% of the Crystal River 3 nuclear unit to several municipal and cooperative utilities, the jointly owned Lakeland/Orlando McIntosh 3 unit, the proposed Florida Power & Light Company/Jacksonville Electric Authority coal units, and the planned Gulf, Georgia, and Mississippi Power Company joint projects.

The Expansion Plan: 1979-1988

The state's generation expansion plans include the addition of fossil steam, nuclear, combined-cycle, and combustion turbines to the existing installed capacity. Some diesel generators will be retired during this period and new ones may be added by at least

one of the fifteen utilities comprising this report. A total of 12,459 MW of additional installed capacity is planned by the summer peak of 1988.

Table 7 lists the planned capacity additions, retirements, and changes in chronological order of their expected in-service (or retirement) dates. Figure 12 is a map that shows the approximate location of the present and new sites at which generation additions will be placed. Summaries of capacity additions, retirements, and changes are provided by Table 8, which is graphically represented by Figure 11.

Total Available Capacity and Reserve Margins

Tables 9A (summer) and 9B (winter) show the capacity margins remaining before any consideration is given to maintenance, forced outages, and delays. Since maintenance schedules are very dynamic, even for one year in the future, estimated maintenance has been omitted from the report.

Note that Column (3) indicates firm capacity interchange with systems outside of the state which is principally a result of Gulf Power Company's agreements with the remaining systems of Southern Company and exchanges with utilities not yet included in this plan. Peninsular Florida is interconnected directly with Gulf Power Company and Georgia Power Company and though no firm interchange is scheduled, emergency capacity has been and will continue to be available via these interconnections.

A careful look at the margin, Column (7) on Tables 9A and 9B, reveals a wide variation in anticipated reserves during the 1979-1988 time span. During the ten-year period, the summer reserves range from a high of 27.6% in 1979 to a low of 21.9% in 1982. Wintertime reserves vary from 19.0% in 1982/83 to 25.9% in 1985/86. Operating experience during the previous two years has shown that actual reserves dwindle quickly after scheduled and forced outages or if abnormal temperatures are encountered.

Utility	Plant	Unit No.	Location	Unit Type	Fuel	In (Out) Service	Net Capability - MW	
							Summer	Winter
FPC	Anclote	2	Pasco County	FS	HO	5/79	466	506
FPC	Crystal River	1	Citrus County	FS	C	5/79	383	383
JEA	Northside	3C	Duval County	FS	HO	5/79	58	58
TEC	Big Bend	2C	Hillsborough County	FS	C	5/79	24	24
FPC	Crystal River	3C	Citrus County	N	N	6/79	27	27
TOTAL							958	998
VER	Municipal Plant	1- 6R	Vero Beach	D	LO	(1/80)	-15	-15
HST	G. W. Ivey	20-21	Dade County	D	LO	4/80	14	14
FPC	Crystal River	2C	Citrus County	FS	C	5/80	50	50
FPL	Martin	1	Martin County	FS	HO	/80	775	787
JEA	Kennedy	6	Duval County	CT	LO	5/80	54	54
FPC	Suwannee River	1- 3	Ellaville	CT	LO	10/80	153	195
FPL	Solid Waste	1- 2	Unknown	FS	SW	/80	40	40
TOTAL							1071	1125
GVL	Deerhaven	2	Alachua County	FS	C	1/81	235	235
GVL	J. R. Kelly	6R	Alachua County	FS	HO	(1/81)	-14	-14
FPL	Martin	2	Martin County	FS	HO	/81	775	787
GPC	Daniel (1006p)	1- 2	Mississippi	FS	C	5/81	503	503
FPC	Simple Cycle	1- 3	Unknown	CT	LO	10/81	150	150
FPC	Suwannee River	4	Ellaville	CT	LO	10/81	51	65
LAK	McIntosh (334p)	3	Polk County	FS	C	10/81	200	200
OUC	McIntosh (334p)	3	Polk County	FS	C	10/81	134	134
TOTAL							2034	2060
JEA	Kennedy 1/	1- 2	Duval County	CT	LO	1/82	25	26
JEA	Southside 1/	1- 2	Duval County	CT	LO	1/82	25	30
FPC	Crystal River	4	Citrus County	FS	C	12/82	640	640
OUC	Lake Highland	1- 3R	Orlando	FS	HO	(12/82)	-90	-93
TOTAL							600	603

Utility	Plant	Unit No.	Location	Unit Type	Fuel	In (Out) Service	Net Capability - MW	
							Summer	Winter
LAK	Larsen	4R	Polk County	FS	HO	(3/83)	-19	-19
TEC	Big Bend	4- 5	Hillsborough County	CT	LO	3/83	100	100
FPL	St. Lucie (802p)	2	St. Lucie County	N	N	/83	747	764
SEC	St. Lucie (802p)	2	St. Lucie County	N	N	/83	48	48
SEC	Seminole	1	Palatka	FS	C	5/83	600	600
JEA	Unknown	1- 3	Unknown	CT	LO	5/83	150	180
FPC	Simple Cycle	1	Unknown	CT	LO	10/83	100	100
FPC	Simple Cycle	1- 2	Unknown	CT	LO	10/83	100	100
FTP	H. D. King	5R	Fort Pierce	FS	HO	(12/83)	-7	-7
TOTAL							1819	1866
TEC	Big Bend	6- 7	Hillsborough County	CT	LO	3/84	100	100
FPC	Crystal River	5	Citrus County	FS	C	4/84	640	640
TAL	Purdom	1- 4R	Wakulla County	FS	HO	(5/84)	-28	-32
TOTAL							712	708
GPC	Scherer	3	Georgia	FS	C	2/85	216	216
TEC	Big Bend	4	Hillsborough County	FS	C	3/85	417	417
FPL	Martin Coal	3	Martin County	FS	C	/85	700	720
JEA	Unknown	4- 6	Unknown	CT	LO	5/85	150	180
SEC	Seminole	2	Palatka	FS	C	5/85	600	600
TAL	Hopkins	3	Leon County	CT	LO	5/85	50	50
FPC	Avon Park	2R	Highlands County	FS	HO	(6/85)	-42	-44
FPC	Fossil Coal	1	Unknown	FS	C	10/85	660	660
TOTAL							2751	2799

Utility	Plant	Unit No.	Location	Unit Type	Fuel	In (Out) Service	Net Capability - MW	
							Summer	Winter
GPC	Crist	1R	Pensacola	FS	NG	(1/86)	-22	-22
LWU	Smith	1R	Lake Worth	FS	NG	(1/86)	-7	-8
FPC	Suwannee River	1- 2R	Ellaville	FS	HO	(6/86)	-67	-67
OUC	Lake Highland	A- BR	Orlando	CT	LO	(12/86)	-26	-32
TOTAL							-122	-129
GPC	Scherer	4	Georgia	FS	C	2/87	216	216
TAL	Unknown (p)	1	Unknown	UN	UN	4/87	200	200
FPL	Martin Coal	4	Martin County	FS	C	/87	700	720
FPL	Coal (600p)	1	Unknown	FS	C	/87	300	300
JEA	Coal (600p)	1	Unknown	FS	C	/87	300	300
LAK	Unknown (p)		Unknown	FS	UN	5/87	150	150
OUC	Unknown (p)		Unknown	FS	C	5/87	150	150
FPC	Fossil/Coal	2	Unknown	FS	C	10/87	660	660
TOTAL							2676	2696
LAK	Larsen	1- 3R	Polk County	CT	LO	(3/88)	-33	-39
LWU	Smith	2R	Lake Worth	FS	NG	(3/88)	-7	-8
FTP	H. D. King	6R	Fort Pierce	FS	HO	(12/88)	-18	-18
TOTAL							-58	-65

1/ Reactivation

1979 TEN-YEAR PLAN - STATE OF FLORIDA

TABLE 8

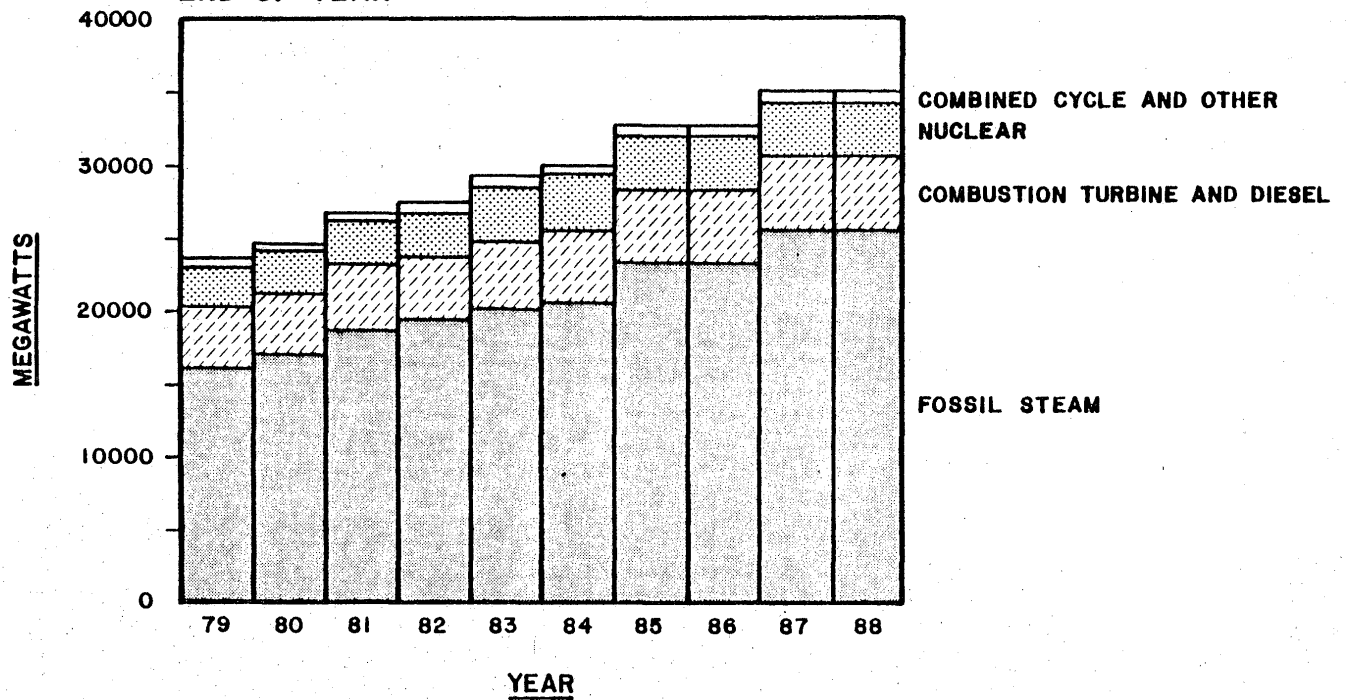
SUMMARY OF PLANNED INSTALLED CAPACITY AT END OF YEAR
(NET MW - SUMMER RATINGS)

YEAR	CAPACITY ADDED SINCE END OF PREVIOUS YEAR								TOTAL CAPACITY AT END OF YEAR								
	FS	CT	CC	D	N	SW	UN	TOTAL	FS	CT	CC	D	N	HY	SW	UN	TOTAL
1979	931	-	-	-	27	-	-	958	16281	3950	476	116	2903	36	0	0	23762
1980	825	207	-	(1)	-	40	-	1071	17106	4157	476	115	2903	36	40	0	24833
1981	1833	201	-	-	-	-	-	2034	18939	4358	476	115	2903	36	40	0	26867
1982	550	50	-	-	-	-	-	600	19489	4408	476	115	2903	36	40	0	27467
1983	574	450	-	-	795	-	-	1819	20063	4858	476	115	3698	36	40	0	29286
1984	612	100	-	-	-	-	-	712	20675	4958	476	115	3698	36	40	0	29998
1985	2551	200	-	-	-	-	-	2751	23226	5158	476	115	3698	36	40	0	32749
1986	(96)	(26)	-	-	-	-	-	(122)	23130	5132	476	115	3698	36	40	0	32627
1987	2476	-	-	-	-	-	200	2676	25606	5132	476	115	3698	36	40	200	35303
1988	(25)	(33)	-	-	-	-	-	(58)	25581	5099	476	115	3698	36	40	200	35245
TOTAL	10231	1149	0	(1)	822	40	200	12441									

1979 TEN-YEAR PLAN
STATE OF FLORIDA

FIGURE 11

FORECAST OF INSTALLED CAPACITY AT
END OF YEAR



FORECAST OF CAPACITY, DEMAND, AND MARGIN AT TIME OF SUMMER PEAK ^{a/}

(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Total Installed Capacity MW	Firm Capacity Import MW ^{c/}	Total Available Capacity MW	Peak Demand MW	Margin ^{b/}	
<u>YEAR</u>					<u>MW</u>	<u>% of Pk.</u>
1979	23735	12	23747	18610	5137	27.6
1980	24640	(4)	24636	19785	4851	24.5
1981	26332	2	26334	21098	5236	24.8
1982	26917	2	26919	22086	4833	21.9
1983	29093	37	29130	23095	6035	26.1
1984	29998	37	30035	24150	5885	24.4
1985	32089	37	32126	25226	6900	27.4
1986	32653	37	32690	26327	6363	24.2
1987	34643	37	34680	27476	7204	26.2
1988	35263	37	35300	28641	6659	23.2

^{a/} Capacity additions and changes must be made by May 31 and retirements by September 30 to be considered in effect at the time of the Summer peak. All values are Summer Net MW.

^{b/} Scheduled maintenance, forced outages, forecast errors, and unit delays are not considered.

^{c/} Includes Gulf Power Company - Southern Company pool exchanges and exchanges with utilities not included in this report (Kissimmee, Sebring).

FORECAST OF CAPACITY, DEMAND, AND MARGIN AT TIME OF WINTER PEAK ^{a/}

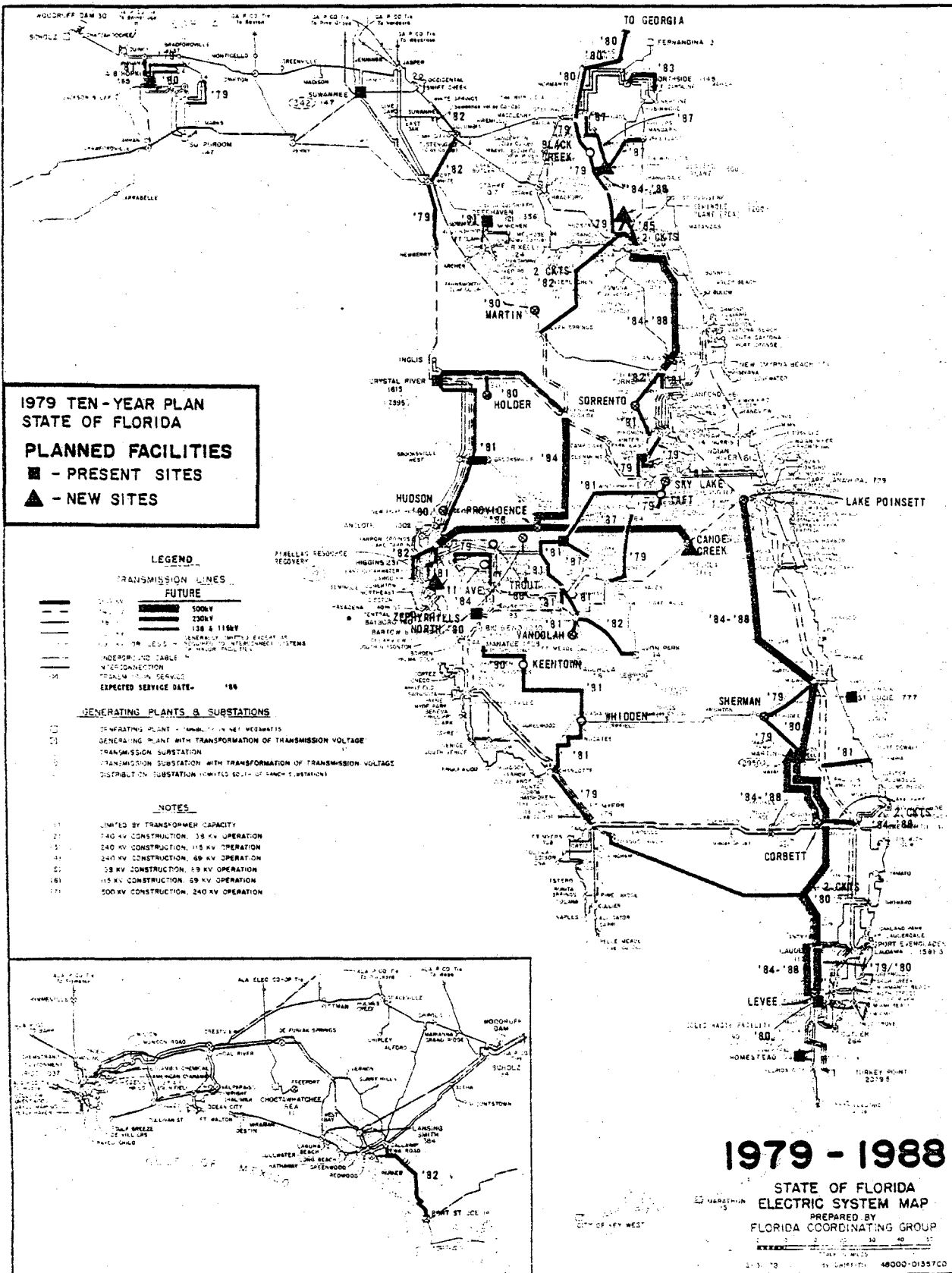
(1)	(2)	(3)	(4)	(5)	(6)	(7)
YEAR	Total Installed Capacity MW	Firm Capacity Import MW ^{c/}	Total Available Capacity MW	Peak Demand MW	Margin ^{b/}	
					MW	% of Pk.
1979-80	24894	(65)	24829	20375	4454	21.9
1980-81	26005	(16)	25989	21399	4590	21.4
1981-82	28079	(16)	28063	22472	5591	24.9
1982-83	28042	19	28061	23578	4483	19.0
1983-84	30548	19	30567	24708	5859	23.7
1984-85	31256	19	31275	25842	5433	21.0
1985-86	34025	19	34044	27039	7005	25.9
1986-87	33926	19	33945	28246	5699	20.2
1987-88	36622	19	36641	29481	7160	24.3
1988-89	36532	19	36551	30730	5821	18.9

^{a/} Capacity additions and changes must be made by November 20 and retirements by February 28 to be considered in effect at the time of the Winter peak. All values are Winter Net MW.

^{b/} Scheduled maintenance, forced outages, forecast errors, and unit delays are not considered.

^{c/} Includes Gulf Power Company - Southern Company pool exchanges and exchanges with utilities not included in this report (Kissimmee, Sebring).

FIGURE 12



APPENDIX

1979 TEN-YEAR PLAN - STATE OF FLORIDA

APPENDIX A

HISTORY AND FORECAST OF SUMMER PEAK DEMAND BY UTILITY - NET MW

YEAR	FPC	FPL	FTP	GVL	GPC	HST	JEA	LWU	LAK	OUC	SEC**	TAL	TEC	VER	TOTAL
1969	1710	4329	36	80	711	16	763	32	112	271	268	127	1022	39	9248
1970	1988	5001	40	91	774	16	834	36	130	288	320	149	1098	40	10485
1971	2143	5378	43	99	842	20	898	41	144	310	365	160	1194	39	11311
1972	2564	6011	52	117	956	22	1013	44	171	352	466	195	1302	46	12845
1973	2862	6894	59	134	1014	30	1090	51	181	400	556	202	1441	55	14413
1974	2835	7235	60	142	1081	26	1067	52	190	379	602	203	1527	58	14855
1975	2975	7076	60	148	1078	28	1116	51	198	385	628	216	1565	61	14957
1976	3223	7598	62	160	1140	26	1181	54	202	406	702	227	1568	60	15907
1977	3407	7841	62	163	1180	26	1243	51	222	435	767	234	1720	64	16648
1978	3521	8345	65	182	1257	38	1303	55	237	433	835	256	1780	73	17545
AAGR*	8.4%	7.6%	6.8%	9.6%	6.5%	10.1%	6.1%	6.2%	8.7%	5.3%	13.5%	8.1%	6.4%	7.2%	7.4%
1979	3440	8546	68	183	1362	38	1393	62	240	486	982	278	1861	74	19013
1980	3640	9069	71	194	1441	40	1481	65	252	509	1093	295	1954	78	20182
1981	3850	9423	75	206	1468	42	1582	68	264	533	1206	316	1984	81	21098
1982	4080	9770	79	218	1521	44	1687	72	277	558	1330	336	2029	85	22086
1983	4270	10123	83	230	1595	46	1797	75	290	583	1468	358	2087	90	23095
1984	4470	10473	87	244	1675	49	1911	79	305	609	1620	380	2154	94	24150
1985	4660	10818	91	258	1757	51	2044	83	320	635	1788	406	2216	99	25226
1986	4840	11163	96	272	1842	53	2182	87	335	663	1973	432	2286	103	26327
1987	5030	11510	101	287	1932	56	2327	92	352	691	2177	460	2352	109	27476
1988	5210	11843	106	304	2027	59	2477	96	369	721	2402	489	2424	114	28641
AAGR*	4.7%	3.7%	5.1%	5.8%	4.5%	5.0%	6.6%	5.0%	4.9%	4.5%	10.4%	6.4%	3.0%	4.9%	4.7%

*Average Annual Growth Rate in Percent

**Historical Data (1969-1978) also included in suppliers' data and not added to total.

HISTORY AND FORECAST OF WINTER PEAK DEMAND BY UTILITY - NET MW

YEAR	FPC	FPL	FTP	GVL	GPC	HST	JE A	LWU	LAK	OUC	SEC**	TAL	TEC	VER	TOTAL
1969-70	1979	4716	45	71	558	17	662	46	124	276	305	90	1114	38	9736
1970-71	2152	5059	46	75	600	18	733	46	139	276	351	115	1105	38	10402
1971-72	2179	4676	43	79	675	18	811	42	145	270	371	126	1110	42	10216
1972-73	2671	5853	56	97	735	26	891	53	165	342	519	140	1300	54	12383
1973-74	2989	6258	55	103	790	21	829	50	183	363	589	152	1366	54	13213
1974-75	3010	5807	58	113	864	23	825	52	196	345	650	168	1458	59	12978
1975-76	3530	7287	66	133	976	24	948	56	227	410	802	196	1693	68	15614
1976-77	3899	8606	79	156	1121	34	1160	69	274	468	952	229	1784	87	17966
1977-78	4135	8617	70	160	1045	36	1123	70	264	430	1007	222	1891	76	18139
1978-79	4224	8791	73	169	1122	36	1180	64	296	454	1069	239	1960	84	18692
AAGR*	8.8%	7.2%	5.5%	10.1%	8.1%	8.7%	6.6%	3.7%	10.2%	5.7%	15.0%	11.5%	6.5%	9.2%	7.5%
1979-80	4200	9069	77	174	1200	38	1172	68	314	468	1228	247	2055	78	20388
1980-81	4460	9423	81	185	1244	40	1246	71	339	496	1366	262	2104	82	21399
1981-82	4730	9770	85	198	1314	44	1331	75	367	525	1507	281	2159	86	22472
1982-83	4980	10123	89	209	1402	46	1420	79	389	554	1663	299	2235	90	23578
1983-84	5240	10473	94	223	1468	48	1512	83	412	585	1835	318	2323	94	24708
1984-85	5480	10818	99	236	1538	50	1608	87	437	616	2025	338	2411	99	25842
1985-86	5730	11163	104	253	1611	53	1720	91	463	650	2235	361	2501	104	27039
1986-87	5960	11510	109	269	1688	56	1836	96	491	684	2466	384	2588	109	28246
1987-88	6190	11843	115	287	1769	59	1958	101	516	721	2721	409	2678	114	29481
1988-89	6410	12176	121	307	1854	62	2084	106	542	758	3004	435	2751	120	30730
AAGR*	4.8%	3.3%	5.2%	6.5%	5.0%	5.6%	6.6%	5.1%	6.3%	5.5%	10.5%	6.5%	3.3%	4.9%	4.7%

*Average Annual Growth Rate in Percent

**Historical Data (1969-1978) also included in suppliers' data and not added to total.

HISTORY AND FORECAST OF NET ENERGY FOR LOAD-GWH (MILLIONS OF KWHR)

YEAR	FPC	FPL	FTP	GVL	GPC	HST	JEA	LWU	LAK	OUC	SEC	TAL	TEC	VER	TOTAL
1969	8713	22218	172	359	3346	87	3709	150	567	1250	-	559	5885	148	47163
1970	9855	25113	195	406	3764	99	4098	172	635	1375	-	656	6542	164	53074
1971	10961	27884	210	449	4072	113	4454	186	687	1480	-	708	6846	182	58232
1972	12678	31498	245	504	4604	129	4831	205	793	1677	-	802	7429	211	65606
1973	14817	35185	271	593	4978	148	5281	231	901	1893	-	910	8291	244	73743
1974	14402	35465	269	604	4983	152	4968	226	890	1787	-	885	8485	243	73359
1975	15237	37151	283	652	5148	161	5318	236	935	1866	-	947	9015	259	77208
1976	16032	38025	296	672	5475	163	5575	235	965	1917	-	971	9294	263	79883
1977	17134	40712	320	736	5823	176	5952	247	1048	2053	73	1076	10128	288	85766
1978	18133	43706	344	797	6044	188	6156	265	1107	2148	44	1145	10496	316	90889
AAGR*	8.5%	7.8%	8.0%	9.3%	6.8%	8.9%	5.8%	6.5%	7.7%	6.2%	-	8.3%	6.6%	8.8%	7.6%
1979	17499	43320	360	806	6412	192	6723	278	1181	2299	4216	1218	10699	350	95553
1980	18675	45364	382	857	6723	201	7165	289	1260	2410	4669	1297	11071	367	100730
1981	19610	47314	405	908	6849	211	7637	300	1345	2523	5171	1382	11289	385	105329
1982	20733	48836	429	961	7093	222	8142	314	1435	2638	5707	1471	11511	404	109896
1983	21837	50676	455	1015	7428	233	8682	329	1531	2760	6298	1567	11742	424	114977
1984	23117	52224	482	1072	7781	245	9260	344	1634	2882	6950	1669	12034	445	120139
1985	24207	53883	511	1133	8157	257	9878	360	1743	3006	7670	1777	12322	466	125370
1986	25333	55463	542	1196	8550	270	10540	374	1860	3138	8464	1893	12618	489	130730
1987	26335	56655	574	1265	8965	284	11250	391	1984	3271	9341	2016	12926	513	135770
1988	27326	58285	608	1334	9399	298	12010	406	2117	3409	10308	2148	13242	538	141428
AAGR*	5.1%	3.4%	6.0%	2.5%	4.3%	5.0%	6.7%	4.3%	6.7%	4.5%	10.4%	6.5%	2.4%	4.9%	4.5%

*Average Annual Growth Rate in Percent

SEMINOLE ELECTRIC COOPERATIVE SUPPLIERS' DATA
(as submitted on individual plans which included Seminole's load)

YEAR	SUMMER PEAK DEMAND - MW			WINTER PEAK DEMAND - MW			NET ENERGY FOR LOAD - GWH		
	FPC	FPL	GVL	FPC	FPL	GVL	FPC	FPL	GVL
1979	3950	8975	188	4750	9540	179	19465	49495	832
1980	4190	9540	200	5050	9930	190	20832	47720	886
1981	4440	9930	212	5360	10320	204	22035	49860	940
1982	4710	10320	225	5660	10715	216	23340	51585	997
1983	4750	10715	238	5760	11105	231	23507	53640	1055
1984	4950	11105	253	6050	11495	245	24180	55375	1118
1985	5030	11495	268	6140	11885	263	24727	57255	1184
1986	5160	11885	283	6310	12275	280	25333	59050	1253
1987	5380	12275	300	6580	12670	300	26335	60420	1329
1988	5500	12670	318	6730	13060	321	27326	62355	1406
AAGR*	3.7%	3.9%	6.0%	3.9%	3.6%	6.7%	3.8%	2.6%	6.0%

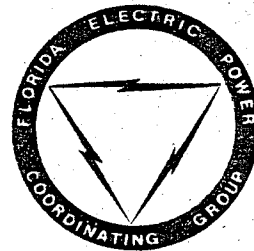
*Average Annual Growth Rate in Percent

FLORIDA ELECTRIC POWER COORDINATING GROUP INC.

PENINSULAR FLORIDA GENERATION RELIABILITY STUDY 1978 - 1987



AUGUST 23, 1978



August 23, 1978

Mr. R. T. Dyer, Acting Chairman
System Planning Committee
Jacksonville Electric Authority
P.O. Box 53015
Jacksonville FL 32201

Dear Bob:

Subject: Generation Reliability Study for 1978

The 1978 Adequacy & Reliability Task Force was assigned to "conduct studies as required to appraise the level of adequacy and reliability of the planned generation system in Peninsular Florida." This report includes the results of the first phase of the project - an analysis of generation reliability for Peninsular Florida. Phase II will extend the analysis to assess reliability on an "area basis."

The Adequacy & Reliability Task Force wishes to express its appreciation to Delia Perez-Alonso (FPL), Sam Nixon (FPC), and Ross Baldwin (TEC) for their efforts in completing this study.

Respectfully submitted,

Rick Sergel

1978 Adequacy & Reliability
Task Force

R. P. Sergel, Chairman (FPL)
D. K. Smith (LAK)
G. D. Jennings (TEC)
M. B. Foley, Jr. (FPC)
T. E. Washburn (OUC)

RPS/pp

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I. EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

The 1978 Adequacy & Reliability Task Force representing the System Planning Committee of the Florida Electric Power Coordinating Group (FCG) was assigned to "conduct studies as required to appraise the level of adequacy and reliability of the planned generation system in Peninsular Florida." The first phase of this project - an analysis of generation reliability for Peninsular Florida - began on April 11, 1978, and was based on the following approach:

- Independent load forecasts and generation plans for each utility were submitted through the year 1987.
- Using the independent load forecasts, a composite load forecast for Peninsular Florida was developed taking into account load diversity and weather uncertainty.
- Using this composite data, the Loss of Load Probability for Peninsular Florida was calculated using the General Electric Optimized Generation Planning Program (OGP).

Those utilities represented in the study were:

Florida Power Corporation (FPC)
Florida Power & Light Company (FPL)
Fort Pierce Utilities Authority (FTP)
Gainesville/Alachua County Regional
Utilities Board (GVL)
Jacksonville Electric Authority (JEA)
Lakeland Department of Electric and
Water Utilities (LAK)

Lake Worth Utilities Authority, City of
Lake Worth (LWU)

Orlando Utilities Commission (OUC)

Seminole Electric Cooperative (SEC)

City of Tallahassee (TAL)

Tampa Electric Company (TEC)

Vero Beach Municipal Utilities (VER)

Neither the load nor the generation for Gulf Power Company or the City of Homestead was included.

The generation reliability index chosen for this study was Loss of Load Probability (LOLP)¹. "THE LOLP IS THE EXPECTED NUMBER OF DAYS PER YEAR WHEN GENERATION WILL BE INSUFFICIENT TO MEET FIRM LOAD." Firm Load was defined as the total system load less interruptible load. Only those utilities whose customers receive service under an interruptible rate schedule and whose service could be directly interrupted by the utility were considered to have interruptible load.

Planned maintenance was optimized by levelizing risk through the use of the OGP computer program. In actuality, a less than optimal maintenance schedule would evolve with respect to generation risk, due to the many other factors which must be considered when planning a maintenance schedule. This study used "optimized" maintenance conditions and, hence, resulted in "optimized" reliability.

¹See Appendix A for a description of the calculation of LOLP.

The modeling techniques used in this study considered Peninsular Florida as a whole. The study did not model limitations within Peninsular Florida which might exist due to transmission or distribution conditions. Therefore, this study was a generation reliability study and did not evaluate potential customer outages caused by transmission, distribution or stability problems.

Table 1 summarizes the results:

TABLE 1

RESERVE ANALYSIS AND LOLP
1978 - 1987

<u>Year</u>	<u>Capability At Time of Annual Peak (MW)</u>	<u>Annual Peak (MW)</u>	<u>Reserves (%)</u>	<u>LOLP (Days Per Year)</u>
1978	21,578	15,861	36.0	0.02
1979	21,967	16,772	31.0	0.04
1980	22,400	17,801	25.8	0.06
1981	23,546	18,847	24.9	0.08
1982	24,955	19,929	25.2	0.18
1983	25,490	20,991	21.4	0.20
1984	27,028	22,045	22.6	0.25
1985	27,733	23,082	20.1	0.19
1986	30,649	24,172	26.8	0.24
1987	30,559	25,271	20.9	0.56

There is not an exact relationship between LOLP and percent reserves from year to year. Notice that for the years 1982 - 1987 the LOLP ranges from 0.18 to 0.56 days per year and percent reserves range from 20.1% to 26.8%. The years 1983 and 1987 have almost the same percent reserves but very different LOLP's (see Table 2).

TABLE 2

RESERVES AND LOLP

<u>Year</u>	<u>Reserves (%)</u>	<u>LOLP (Days Per Year)</u>
1983	21.4	0.20
1987	20.9	0.56

These two years illustrate how dependent the LOLP is on the actual system characteristics for a given year. This means that LOLP and percent reserves can only be related in a particular year for the same given system conditions. These conditions include the size and timing of unit additions, mature and immature forced outage rates, maintenance schedules, load forecast, etc.

The LOLP in 1987 increased to about five days in ten years (0.5 days per year) from an average of about two days in ten years (0.2 days per year) between 1982 and 1986. The fact that no generation was added in 1986 and generation in 1987 was added after the winter peak contributes to the increase

in LOLP in 1987. This clearly illustrates how the size and timing of unit additions impacts the LOLP.

No study of this kind would be complete without examination of the impact that potential changes in system characteristics would have on the overall reliability in Peninsular Florida. Two cases of particular interest were load forecast sensitivity and scheduled unit addition uncertainty.

In the case of the load forecast sensitivity analysis, a small change in the load forecast proved to have a very significant impact on the generation reliability results. A 1% deviation from the forecasted 5% average annual growth rate resulted in the following changes in the LOLP:

TABLE 3
1987 SCENARIO ANALYSIS

<u>Compound Average Annual Growth Rate (%)</u>	<u>LOLP (Days Per Year)</u>
4% Load Growth	0.03
5% Load Growth (Base)	0.56
6% Load Growth	16.50

These results clearly accentuate the necessity to reevaluate the generation expansion plan on an annual basis.

A second case evaluated was, "What if the unit additions scheduled for a given year were delayed by one year?" The results are presented in Table 4.

TABLE 4
EFFECT OF DELAYING PLANNED ADDITIONS

<u>Year</u>	<u>LOLP (Days Per Year)</u>	<u>LOLP if Generation Additions Were Delayed One Year (Days Per Year)</u>
1983	0.20	1.2
1984	0.25	1.2
1985	0.19	1.5
1986	0.24	1.0
1987	0.56	1.3

This analysis clearly shows the impact on the risk index of delays in the generation expansion schedule.

II. METHODS AND PROCEDURES

METHODS AND PROCEDURES

There are several different methods of measuring generation reliability. Those most commonly used are:

1. Reserve Margin Analysis
2. Loss of Load Probability (LOLP)
3. Loss of Energy Probability (LOEP)

Reserve Margin Analysis is a simple percentage calculation of the installed capacity with respect to the expected peak load. The Loss of Load Probability (LOLP) is a generation risk index which measures the expected number of days per year that generation will be insufficient to meet firm load. The third index, Loss of Energy Probability, measures the magnitude of energy not served due to a generation deficiency.

Given the purpose and objectives of this study LOLP was chosen as the risk index to be used. (For a detailed description, see Appendix A). The LOLP index provides a consistent and sensitive measure of generation system reliability although the name, loss of load probability is misleading in two respects. First, this index is not a probability, but it is an expected value of the number of days per year of capacity deficiency. Second, it is not a loss of load, but rather a deficiency of installed available capacity. Despite the misnomers, the LOLP approach is the most widely accepted approach in the utility industry today.¹

¹General Electric, Phase I Report - Factors considered in planning generation, September 1, 1977.

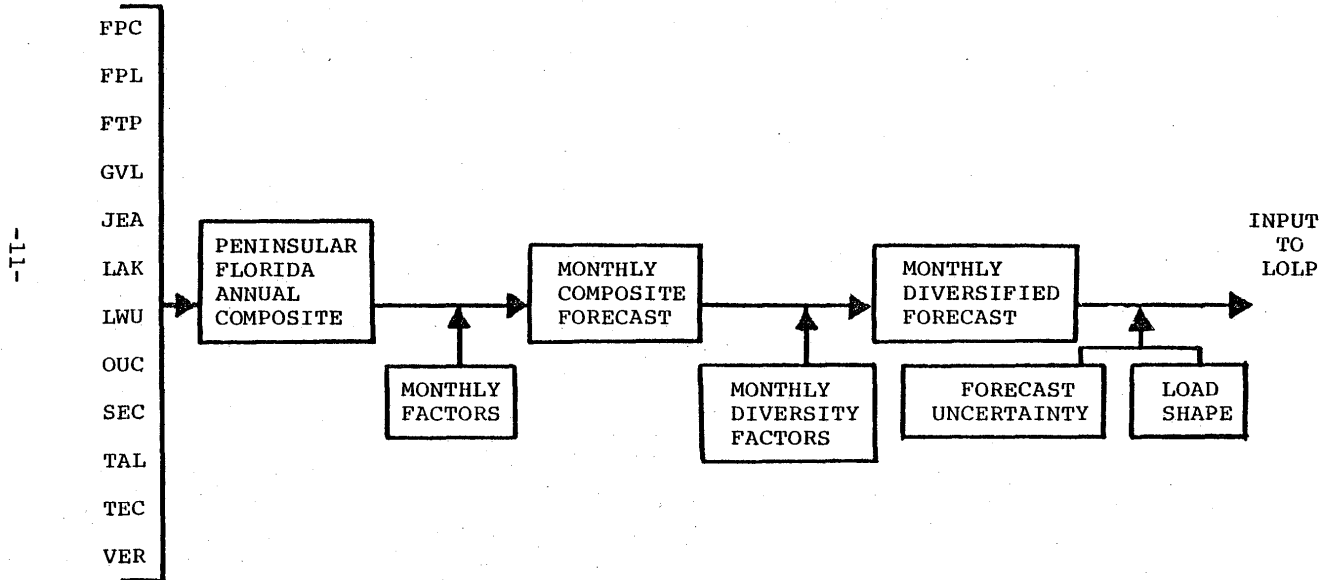
The Optimized Generation Planning Program (OGP) developed by General Electric was selected as the analytical tool used in the Peninsular Florida Generation Reliability Study. The data requirements for the reliability section of this program determined the necessary information to be requested from each utility included in the study. Since this study was conducted subsequent to the April 1, 1978 submission of the 1978 Ten Year Power Plant Site Plans, it contains data which is reflective of those planning estimates. However, in selected cases, the data herein contained may be different from that submitted in the Ten Year Power Plant Site Plans. The input requirements can be separated into a load and a generation section. Following is a discussion of the load data requirements.

A. LOAD MODEL

Exhibit 1 is a flow chart of the procedure followed in the development of a composite peak load forecast for Peninsular Florida. Individual utilities participating in the study were requested to submit their annual load forecast from 1978 through 1987. In order to arrive at a composite monthly forecast, these utilities also supplied one set of monthly multipliers (twelve), which were applicable for the years 1978 through 1987. For those utilities whose monthly multipliers were projected to vary from year to year, their official forecast of

EXHIBIT 1

FORECAST DEVELOPMENT



monthly loads was slightly different, for the off-peak months, from those monthly loads represented in the study. The combined effect of these differences did not affect the results of the study. The resulting monthly forecasts submitted by each utility are included in Appendix B. The composite forecast for 1987 obtained from the summation of the individual forecasts is shown in Table 5.

TABLE 5

NON-DIVERSIFIED
COMPOSITE PEAK LOAD FORECAST

<u>SUMMER</u>		<u>WINTER</u>	
<u>Year</u>	<u>(MW)</u>	<u>Year</u>	<u>(MW)</u>
1977	15,442	1977/78	16,794
1987	25,611	1986/87	26,215
Average Annual Growth Rate	5.2%		5.1%

The next step was to apply a diversity factor that would account for the fact that peak loads do not occur simultaneously throughout the State. The monthly diversity factors (shown in Table 6) were developed by the Load and Energy Task Force and previously used in the Peninsular Florida Generation Expansion Planning Study (PFGEPS).

TABLE 6
MONTHLY DIVERSITY FACTORS

<u>Month</u>	<u>Diversity Factor</u>	<u>Month</u>	<u>Diversity Factor</u>
January	0.964	July	0.988
February	0.970	August	0.980
March	0.965	September	0.988
April	0.980	October	0.985
May	0.971	November	0.981
June	0.980	December	0.976

The monthly diversified forecast can be found in Appendix B. Table 7 shows the 1987 diversified forecast for the winter and summer peaks.

TABLE 7
COMPOSITE PEAK LOAD FORECAST

	<u>WINTER 1986/1987</u>	<u>SUMMER 1987</u>
Composite Forecast (MW)	26,215	25,611
- Diversity (MW)	944	469
Diversified Composite Forecast (MW)	25,271	25,142

Monthly load shapes are an essential input requirement to the OGP program. These load shapes convert the monthly peak load data into the necessary daily peaks.

The load shapes were originally developed for use in the PFGEPS study.

LOLP is evaluated with respect to firm load. Firm load is defined as total load less interruptible load. Only those utilities whose customers receive service under an interruptible rate schedule and whose service could be directly interrupted by the utility were considered to have interruptible load. Individual utilities were asked to separately submit the amount of load that would be considered interruptible under the above definition. The total interruptible load for 1978 - 1987 is found in Table 8.

TABLE 8

INTERRUPTIBLE LOAD

<u>Year</u>	<u>MW</u>	<u>Year</u>	<u>MW</u>
1978	477	1983	563
1979	521	1984	565
1980	543	1985	557
1981	548	1986	560
1982	553	1987	553

Load Forecast uncertainty provides the option of analyzing the peak load forecast in terms of a distribution which is associated with the expected probability of achieving

an actual peak higher or lower than expected. Table 9 lists the probability associated with different percentages of the anticipated peak load.

TABLE 9

LOAD FORECAST PROBABILITY DISTRIBUTION

<u>Probability</u>	<u>Percent of Peak Load</u>
0.05	93.0
0.20	95.6
0.50	100.0
0.20	105.0
0.05	107.0

B. GENERATION MODEL

The following parameters were supplied by each utility for all of their existing and planned units:

1. Unit Name
2. In-Service and Retirement Dates
3. Winter and Summer Continuous Ratings
(in MW)
4. Forced Outage Rates (in percent of time)
5. Planned Outage Rates (in percent of time)

The OGP program allows for the use of only one capability for each unit during a year. The summer continuous ratings were used in the base analysis to define the

capability of each unit. There were two reasons for using the summer ratings as opposed to the winter ratings. The first was that once the winter and summer peaks were diversified, the winter peak was only 129 MW higher than the summer peak in 1987. The second reason was the fact that the summer exposure is approximately 4 months while the winter is only 2 months. Hence, the summer rating is more representative of a unit's performance throughout the year. The forced outage rates were based on each utility's operating experience. The immature forced outage rate was determined to be twice the mature rate for a period of three years.

The planned outage rates submitted by each utility reflected the percent of time routinely allocated for annual maintenance. Due to the interpretation of this data by the program, the planned maintenance schedule was optimized by levelizing risk throughout the study. In actuality, a less than optimal maintenance schedule would evolve, with respect to generation risk, due to a maintenance schedule. Appendix C lists the generation data for each utility.

The existing 1977 generating system consisted of the generation mix shown in Table 10.

TABLE 10

1977 GENERATION MIX

	<u>MW</u>	<u>%</u>
Nuclear	2,862	13.3
Coal	2,086	9.7
Oil	12,529	58.0
Combustion Turbines	<u>4,101</u>	<u>19.0</u>
TOTALS	21,578	100.0

The expected generating mix by the end of the year 1987 is found in Table 11.

TABLE 11

1987 GENERATION MIX

	<u>MW</u>	<u>%</u>
Nuclear	3,664	11.3
Coal	9,873	30.4
Oil	14,482	44.5
Combustion Turbines	<u>4,481</u>	<u>13.8</u>
TOTALS	32,500*	100.0

*Year End 1987

The planned unit additions, conversions and retirements for the period 1978 - 1987 are listed in Table 12.

TABLE 12
PLANNED ADDITIONS, CONVERSION AND RETIREMENTS
1978 - 1987

<u>YEAR</u>	<u>UTILITY</u>	<u>UNIT DESIGNATION</u>	<u>SIZE (MW)</u>	<u>UNIT* TYPE</u>	<u>REMARKS</u>
1978	FPL	PUTNAM 1	242	C.C.	ADDITION
	FPC	ANCLOTE 2	501	OIL	ADDITION
	FPC	CRYSTAL RIVER 1	-383	OIL	CONVERSION
	LWU	SMITH 5	30	C.C.	CONVERSION/ ADDITION
1979	FPC	CRYSTAL RIVER 1	383	COAL	CONVERSION
	FPC	CRYSTAL RIVER 2	50	COAL	INCREASED RATING
1980	FPL	MARTIN 1	775	OIL	ADDITION
	FPC	SUWANNEE P1	50	C.T.	ADDITION
	FPC	SUWANNEE P2	50	C.T.	ADDITION
	FPC	SUWANNEE P3	50	C.T.	ADDITION
1981	FPL	MARTIN 2	775	OIL	ADDITION
	FPC	HIGGINS COMBINED CYCLE	300	C.C.	CONVERSION/ ADDITION
	GVL	DEERHAVEN 2	235	COAL	ADDITION
	LAK/ouc	McINTOSH 3	334	COAL	ADDITION
	GVL	J. R. KELLY	-14	OIL	RETIREMENT
1982	FPC	CRYSTAL RIVER 4	640	COAL	ADDITION
	ouc	LAKE HIGHLAND 1-3	-86	OIL	RETIREMENT

*Notes:

C.C. - Combined Cycle
C.T. - Combustion Turbine
NUC - Nuclear

TABLE 12
PLANNED ADDITIONS, CONVERSIONS AND RETIREMENTS
1978 - 1987

<u>YEAR</u>	<u>UTILITY</u>	<u>UNIT DESIGNATION</u>	<u>SIZE (MW)</u>	<u>UNIT* TYPE</u>	<u>REMARKS</u>
1983	FPL	ST. LUCIE 2	802	NUC	ADDITION
	SEC	SEMINOLE 1	600	COAL	ADDITION
	FPC	FPC P1	100	C.T.	ADDITION
	TEC	BIG BEND GT4	65	C.T.	ADDITION
	LAK	LARSEN 4	-19	OIL	RETIREMENT
1984	FPC	CRYSTAL RIVER 5	640	COAL	ADDITION
	TEC	BIG BEND GT5	65	C.T.	ADDITION
	TAL	PURDOM 1-4	-29	OIL	RETIREMENT
1985	FPL	FPL COAL 1	700	COAL	ADDITION
	FPC	FPC COAL 1	640	COAL	ADDITION
	TEC	BIG BEND 4	425	COAL	ADDITION
	JEA/FPL	JEA/FPL COAL 1	600	COAL	ADDITION
	SEC	SEMINOLE 2	600	COAL	ADDITION
	FPC	AVON PARK 2	-42	OIL	RETIREMENT
1986	LWU	SMITH 1	-7	OIL	RETIREMENT
	FPC	SUWANNEE 1-2	-67	OIL	RETIREMENT
1987	JEA/FPL	JEA/FPL COAL 2	600	COAL	ADDITION
	FPL	FPL COAL 2	700	COAL	ADDITION
	FPC	FPC COAL 2	640	COAL	ADDITION
	GVL	J. R. KELLY 7	-23	OIL	RETIREMENT

*Notes:

C.C. - Combined Cycle
C.T. - Combustion Turbine
NUC - Nuclear

III. RESULTS AND OBSERVATIONS

RESULTS AND OBSERVATIONS

Having gathered the appropriate load and generation data, the base case LOLP was determined for the period 1978 - 1987. After completing the base case, a sensitivity analysis was conducted on the input variables. This analysis included testing assumptions regarding unit ratings, forced outage rates, load growth and timing of unit additions. The results of the base case are presented first.

A. BASE CASE RESULTS

In analyzing the base case results it is important to understand that this study did not attempt to define what an appropriate LOLP for Peninsular Florida should be. A reliability level of one day in ten years (0.1 days per year) has been used by many large electric power systems across the country for evaluating generation reliability. However, it was beyond the scope of this study to evaluate this reliability index.

The base case LOLP was calculated for each of the years 1978 - 1987 using summer continuous ratings and all of the load and generation data submitted by each utility. The results of this analysis are listed in Table 13.

TABLE 13

BASE RESULTS

<u>Year</u>	<u>Loss of Load Probability (Days Per Year)</u>
1978	0.02
1979	0.04
1980	0.06
1981	0.08
1982	0.18
1983	0.20
1984	0.25
1985	0.19
1986	0.24
1987	0.56

First notice that the LOLP rises slowly to about 0.2 days per year in 1982 and remains there through 1986. The LOLP then increases to 0.56 days per year in 1987. An examination of the timing of unit additions explains this change.

TABLE 14

MONTHLY ADDITIONS AND RETIREMENTS
1985 - 1987

<u>Year</u>	<u>Month</u>	<u>Unit Addition/Retirement (MW)</u>
1985	April	425
	June	700
	June	600
	June	600
	June	- 42
	October	640
1986	January	- 7
	June	- 33
	June	- 34
1987	January	- 23
	June	600
	June	700
	October	640

As seen in Table 14, there are no planned additions between October of 1985 and June of 1987. This contributes to the deviation in 1987 from the LOLP of 0.2 in previous years, and illustrates the critical role that the timing of unit additions has on LOLP.

Exhibit 2 is a plot of system LOLP vs. percent reserves. The dashed lines define the reserve margin (20.9%) and the LOLP (0.56 days per year) for this particular year of study. (1987, at time of annual peak). The curve was developed from the M-slope information provided by the computer program (OGP). The M-slope is a system parameter valid only for the exact system studied. It relates the effects of changes in the reserve margin to LOLP.

$$M = \frac{b - a}{\ln (Aa / Ab)}$$

Where Aa = the annual risk for a reserve of a MW
 Ab = the annual risk for a reserve of b MW
 ln = the natural logarithmic function
 M = M-slope

The shape of the curve in Exhibit 2 is extremely important. Notice that as reserves increase from say 25% to 30% the impact on LOLP is marginal, changing from 0.1 to 0.01 days per year. However, for a 5% decrease in reserves from 20% to 15% the LOLP increases from 0.8 to 5.8 days per year.

It is important to remember that the relationship of LOLP versus percent reserve (Exhibit 2) is only an approximation and is valid for only a particular year. To highlight this, Exhibit 3 illustrates the LOLP versus percent reserve relationship for 1983 and 1987. Again, the dashed lines represent the actual LOLP and reserves.

EXHIBIT 2

PENINSULAR FLORIDA
L.O.L.P. VS. RESERVES

(1987)

L.O.L.P.

(DAYS
PER
YEAR)

1.0

0.8

0.6

0.4

0.2

18

20

22

24

26

28

30

RESERVES (%)

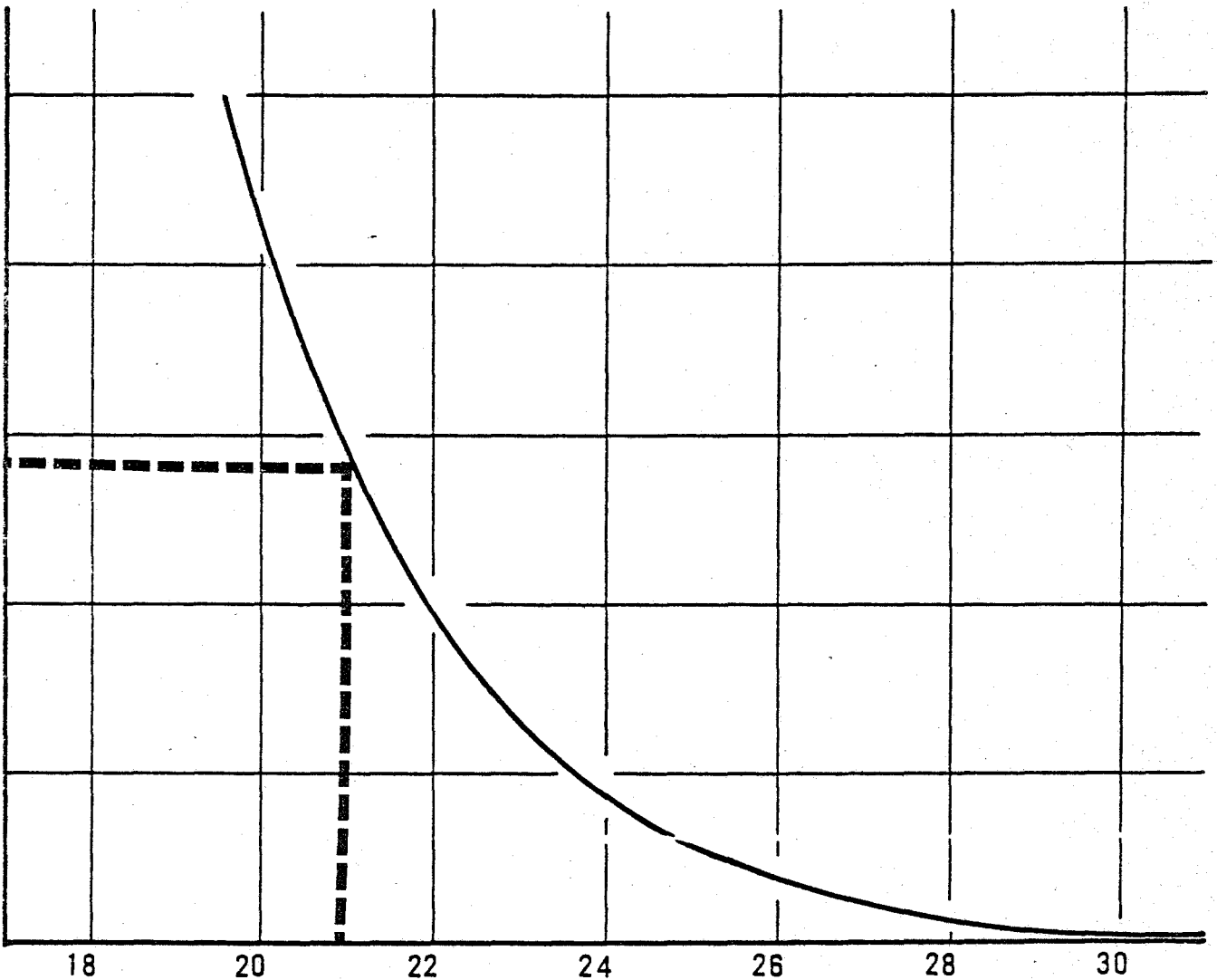
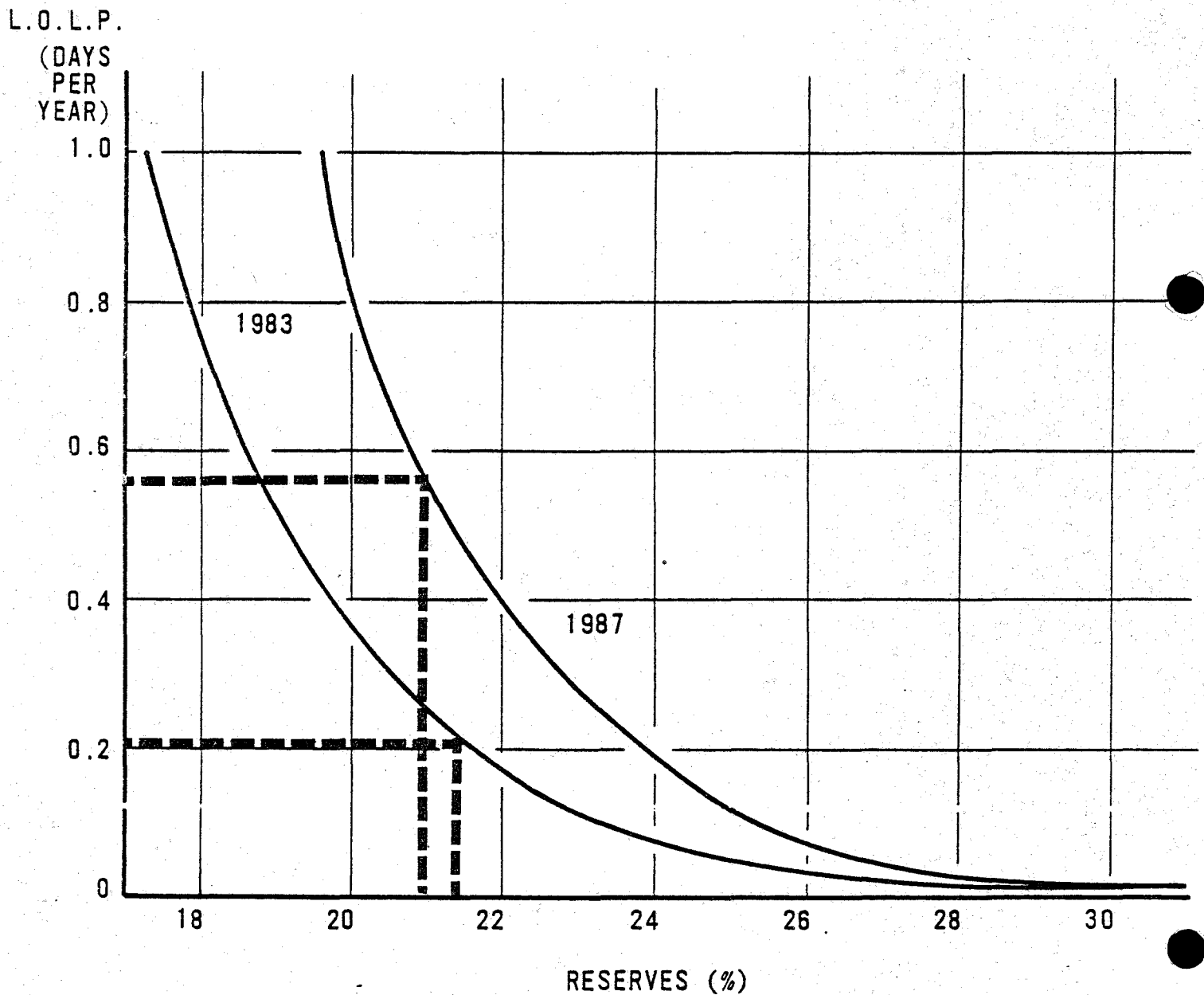


EXHIBIT 3

PENINSULAR FLORIDA
L.O.L.P. VS. RESERVES

(1983 & 1987)



Notice in Table 15 that the percent reserves are almost equal, yet the LOLP's are very different. CLEARLY, THERE IS NOT AN EXACT RELATIONSHIP BETWEEN PERCENT RESERVE AND LOLP.

TABLE 15

RESERVES AND LOLP

<u>Year</u>	<u>Reserves (%)</u>	<u>LOLP (Days Per Year)</u>
1983	21.4	0.20
1987	20.9	0.56

System characteristics such as forced outage rates, timing of unit additions, and the daily peak load distribution are critical in calculating LOLP, but are not even considered when calculating reserve margin. This explains why the relationship between LOLP and reserve is tenuous at best.

B. SENSITIVITY ANALYSIS

Sensitivity studies were conducted to evaluate changes in the unit ratings, load forecast, forced outage rates, and timing of unit additions. These scenarios provide important information required to adequately understand the base case results.

1. Unit Ratings Sensitivity Analysis

Summer continuous ratings were used to define the capabilities of each unit. There were two reasons for using the summer ratings. The first reason was that once the winter and summer peaks were diversified, the winter peak was only 129 MW higher than the summer peak in 1987. The second reason was that the summer exposure is approximately 4 months while the winter is only 2 months. Therefore, the summer rating is more representative of a unit's performance throughout the year. Exhibit 4 shows that when the winter ratings were used, the 1987 LOLP decreased from 0.56 days per year to 0.1 days per year. As previously explained, it is more representative to use summer continuous ratings, and the expected LOLP will be closer to 0.56 days per year.

2. Load Forecast Sensitivity Analysis

In the base case, a composite 5% average annual growth rate was used. The sensitivity analysis consisted of a deviation in the load forecast by 1% per year compounded annually. As shown in Exhibit 5, a 1% increase in the load forecast caused the 1987 LOLP to increase from 0.56 days per year to 16.5 days per year while a 1% reduction caused

EXHIBIT 4

PENINSULAR FLORIDA
L.O.L.P. VS. RESERVES
1987 SENSITIVITY ANALYSIS

L.O.L.P.

(DAYS
PER
YEAR)

1.0

0.8

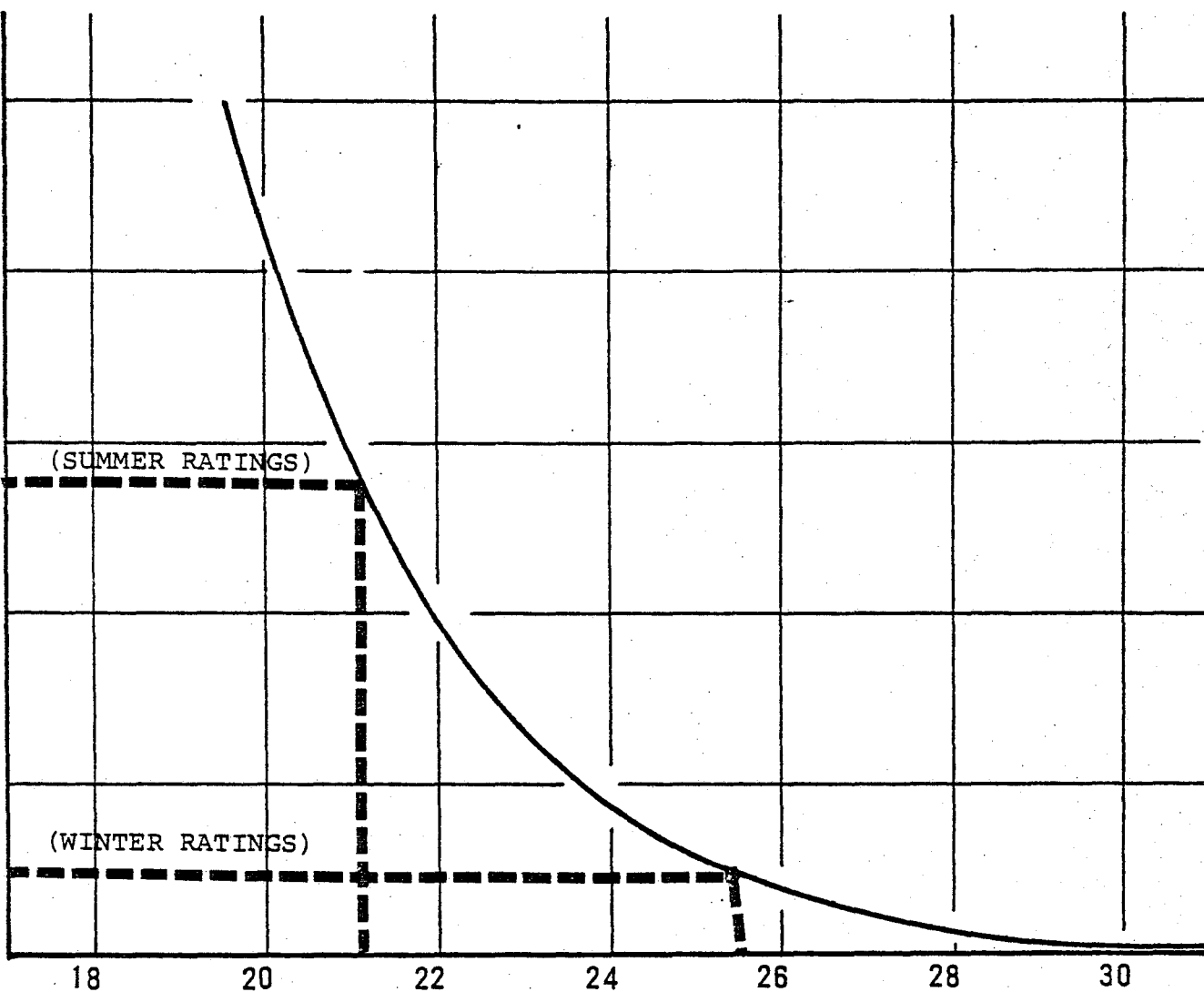
0.6

0.4

0.2

(SUMMER RATINGS)

(WINTER RATINGS)



RESERVES (%)

EXHIBIT 5

PENINSULAR FLORIDA
L.O.L.P. VS. RESERVES
1987 SENSITIVITY ANALYSIS

L.O.L.P.
(DAYS
PER
YEAR)

16.0

14.0

12.0

10.0

8.0

6.0

4.0

2.0

10

14

18

22

26

30

34

RESERVES (%)

6% COMPOUNDED AVERAGE ANNUAL GROWTH RATE

5% COMPOUNDED AVERAGE ANNUAL GROWTH RATE

4% COMPOUNDED AVERAGE ANNUAL
GROWTH RATE

the 1987 LOLP to decrease to 0.03 days per year. These results clearly accentuate the necessity to reevaluate the generation plan on an annual basis.

3. Forced Outage Rate Sensitivity Analysis

A sensitivity analysis was performed on unit forced outage rates. All forced outage rates (F.O.R.) were changed by 10%. This means, for example, that a unit with a 10% F.O.R. in the base case would be increased to an 11% F.O.R. As shown in Exhibit 6, in 1987 the LOLP increased from 0.56 days per year to 0.9 days per year with a 10% increase in F.O.R. A reduction in F.O.R. of 10% decreased the LOLP to 0.28.

4. Timing of Capacity Additions Sensitivity Analysis

Exhibit 7 shows the effect of delaying the planned capacity additions during the years 1983 to 1987. The results are presented in Table 16.

EXHIBIT 6
PENINSULAR FLORIDA
L.O.L.P. VS. RESERVES
SENSITIVITY ANALYSIS
1987

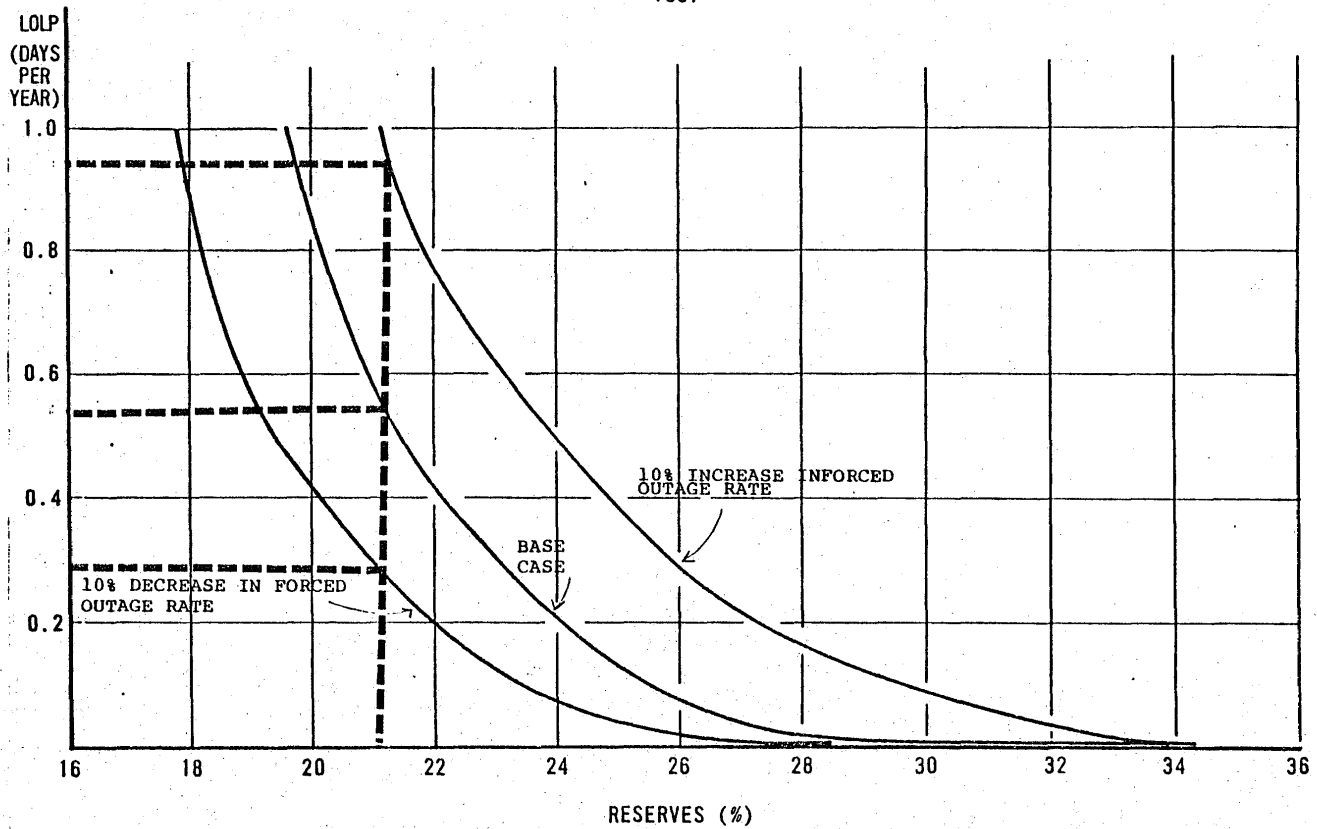


EXHIBIT 7

PENINSULAR FLORIDA
L.O.L.P. VS. PEAK LOAD
1982 - 1987

L.O.L.P..
(DAYS
PER
YEAR)

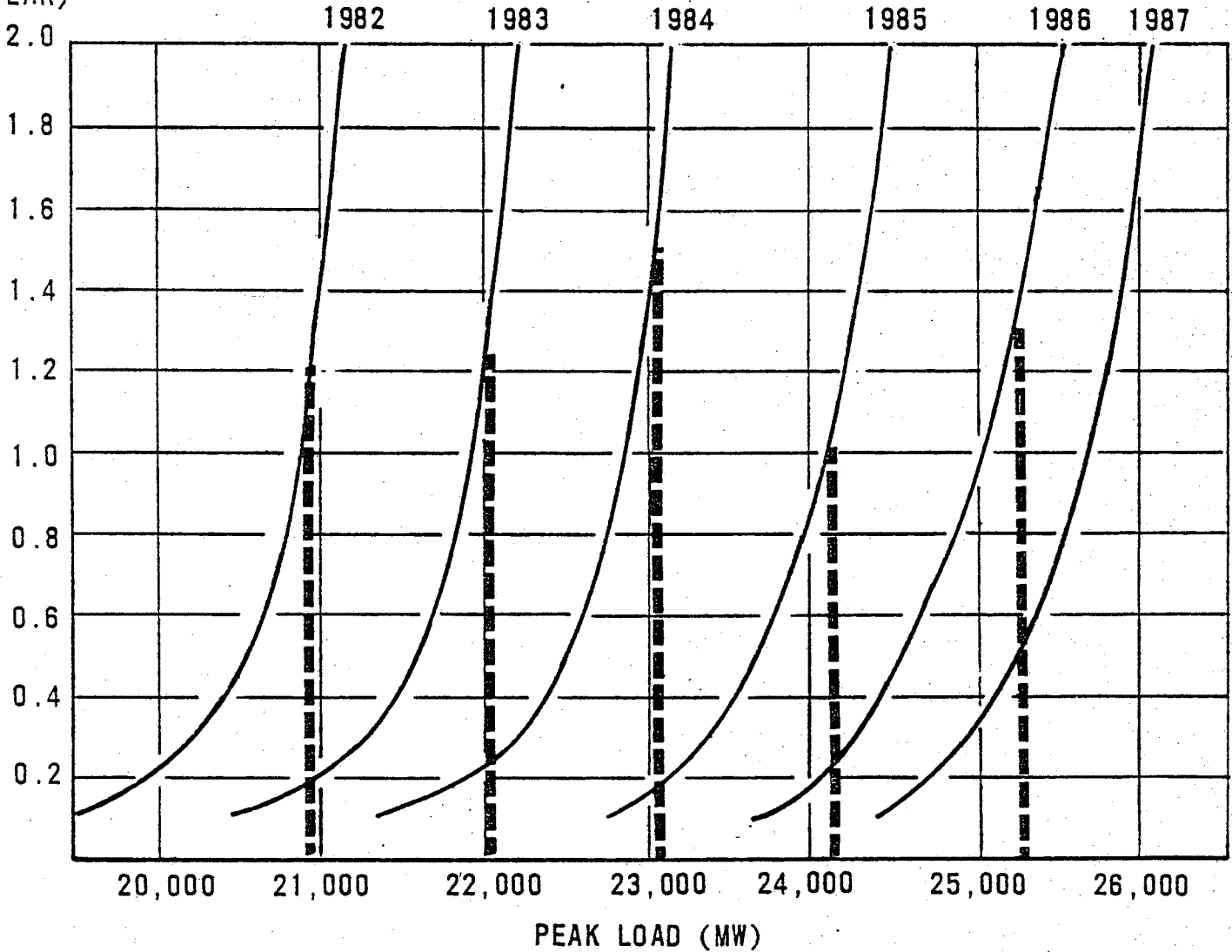


TABLE 16

EFFECT OF DELAYING PLANNED ADDITIONS

<u>Year</u>	<u>LOLP (Days Per Year)</u>	<u>LOLP Generation Additions Are Delayed One Year (Days Per Year)</u>
1983	0.20	1.2
1984	0.25	1.2
1985	0.19	1.5
1986	0.24	1.0
1987	0.56	1.3

This analysis clearly shows the impact on the risk index of delays in the generation expansion schedule.

IV. APPENDICES

APPENDICES

<u>Appendix</u>	<u>Description</u>
A	Calculation Procedure for LOLP
B	Load Data ● Monthly Forecast ● Diversified Forecast Monthly
C	Generation Data

APPENDIX A

CALCULATION PROCEDURE FOR LOSS-OF-LOAD PROBABILITY*L. L. Garver and R. W. Moisan
September, 1972

In 1947, Calabrese and others began proposing a system reliability measure which would be more sensitive to system conditions than per cent reserve and the other measures then in use. Using probability mathematics they were able to represent the system reliability by a number which was termed the loss-of-load probability (LOLP). Since load may be lost due to many causes and only a shortage of generating capacity is considered in the LOLP method, the result will be interpreted as the average need for more capacity. It is measured in expected days of capacity shortage per year and is often referred to as a system's risk index.

The risk index (LOLP) is affected by the installed capability and peak annual load just as is the per cent reserve index. However, the LOLP is also sensitive to the various sizes and outage rates of the installed generators, the annual load shape, maintenance scheduling and load forecast deviations. The following example will serve to illustrate the method of calculating the annual loss-of-load probability.

Assume for simplicity that an electric power system has but three generating units whose maximum capabilities and outage rates are:

TABLE I
UNITS IN GENERATING SYSTEM

UNIT	CAPABILITY MW	FORCED OUTAGE RATE	INAGE RATE
A	100	.01	.99
B	150	.02	.98
C	200	.03	.97

The definition of forced outage rate is taken from "Report on Equipment Availability for the Eleven Year Period 1960-1970", EEI Publication No. 71-26, Issued Sept. 1971.

$$\text{Forced Outage Rate} = \frac{\text{Forced Unavailable Hours}}{\text{Service Hours} + \text{Forced Unavailable Hours}}$$

In practice, unit forced outage rates are taken from EEI publication just mentioned, or perhaps from historical operating records on the unit in question.

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The generating system will be represented by a capacity outage table. To do so requires enumerating all the possible combinations of the units in or out of service and the associated probability of occurrence for each combination.

TABLE II
EXACT OUTAGE PROBABILITY TABLE

On Outage	In Service	Probability
None (0)	A,B,C	$.99 \times .98 \times .97 = .941094$
A (100)	B,C	$.01 \times .98 \times .97 = .009506$
B (150)	A,C	$.99 \times .02 \times .97 = .019206$
C (200)	A,B	$.99 \times .98 \times .03 = .029106$
A,B (250)	C	$.01 \times .02 \times .97 = .000194$
A,C (300)	B	$.01 \times .98 \times .03 = .000294$
B,C (350)	A	$.99 \times .02 \times .03 = .000594$
A,B,C (450)	None	$.01 \times .02 \times .03 = .000006$

Since the question to be answered is "What is the probability of losing load," a more convenient table to build is a cumulative capacity outage table where entries indicate "the probability of losing X MW or more." Using our example, the cumulative outage table would appear as in Table III.

TABLE III
CUMULATIVE OUTAGE PROBABILITY TABLE

X MW	Probability of X or Greater on Outage
0	1.000000
100	.058906
150	.049400
200	.030194
250	.001088
300	.000894
350	.000600
450	.000006

To illustrate the use of this cumulative probability table in calculating the loss of load probability for a series of daily peak loads let us assume the load shape for ten days, shown in Figure 1.

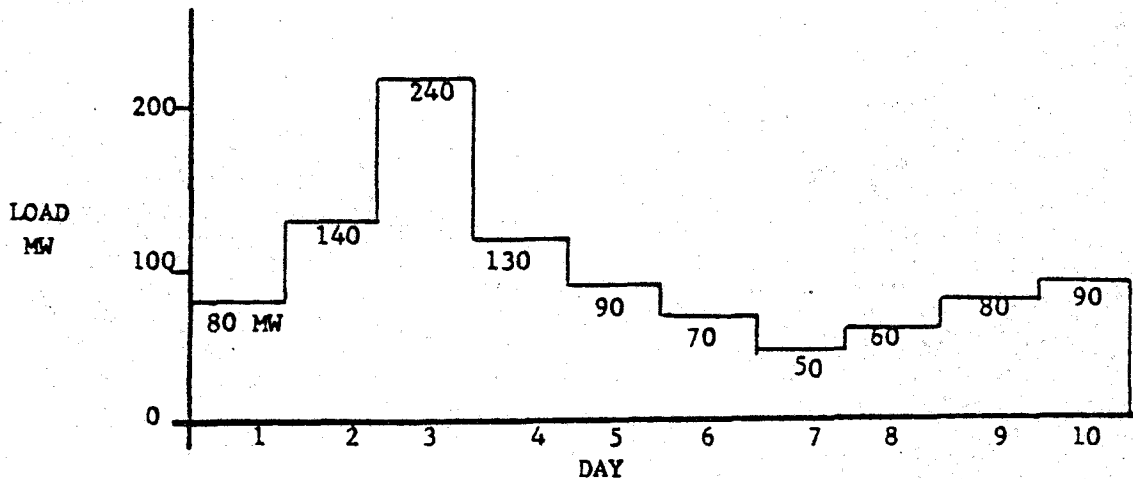


Figure 1. Daily Peak Loads for Example

To find the LOLP for the first day, we determine what outage or greater will cause the available capacity to be less than the load. For the load of 80 MW, an outage of more than $450 - 80 = 370$ MW in capacity will cause a loss of load. Checking the capacity outage table, we see that 370 falls between the 350 MW and 450 MW entry. The 450 outage must be counted but a 350 outage should not count as a loss of load. Thus, the LOLP for the first day is .000006 days/day.

Similarly, the 140 MW load in the second day would require an outage of $450 - 140 = 310$ MW. From the table, a 350 outage or greater has the probability of .000600 days/day.

Continuing in the same manner, the daily LOLP's are shown in Table IV.

TABLE IV
CALCULATION OF INTERVAL LOSS-OF-LOAD INDEX

Day	Expected Shortages, days/day
1	.000006
2	.000600
3	.001088
4	.000600
5	.000006
6	.000006
7	.000006
8	.000006
9	.000006
10	.000006

Interval LOLP = .002330 days/10-day interval

The interval LOLP is .002330 days/interval. If the yearly load pattern contained 26 periods of identical shape, the annual LOLP would be:

$$26 \times .00233 = 0.06058 \text{ days/year.}$$

This system may expect 0.06 days with capacity shortages per year as a long-term average.

In review, the loss-of-load probability method consists of these steps:

- (1) Enumerate the possible capacity outages and compute the probability of each outage or greater (Table III).
- (2) Tabulate the daily peak loads for the interval or year (Figure 1).
- (3) Look up and list the probability of outage greater than reserve for each daily peak (Table IV).
- (4) Add the daily probabilities to obtain the days/interval LOLP index and the interval indices to get an annual days/year index.

For a further description of the loss-of-load probability method and a list of references, see "Application of Probability Methods to Generating Capacity Problems," AIEE Transactions pt. III, Vol. 79, 1960, pp. 1165-1182, or "Bibliography on the Application of Probability Methods in Power System Reliability Evaluation," Roy Billinton, IEEE PAS-91, March/April, 1972, pp. 649-660.

A P P E N D I X B

Note: These loads reflect the data as submitted by each utility. For those utilities whose monthly multipliers are projected to vary from year to year, their official monthly loads are slightly different, for the off-peak months, from the monthly loads represented in the study.

Image Quality

As you review the next group of images, Please note that the original documents were of poor quality.

*** FLORIDA POWER CORPORATION ***

YEAR 1976

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
3690	3332	2638	2724	2498	3004	3236	3081	3114	2457	2411	3513	16420	ENERGY-GWH
												3690	PEAK DEMAND-MW
												0.5080	LOAD FACTOR

YEAR 1977

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
3940	3558	2817	2485	2667	3207	3455	3290	3325	2837	3109	3751	17498	ENERGY-GWH
												3940	PEAK DEMAND-MW
												0.5070	LOAD FACTOR

YEAR 1980

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
4200	3793	3003	2650	2843	3419	3483	3507	3545	3024	3314	3998	18616	ENERGY-GWH
												4200	PEAK DEMAND-MW
												0.5060	LOAD FACTOR

YEAR 1981

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
4460	4027	3189	2614	3019	3630	3911	3724	3764	3211	3519	4246	19759	ENERGY-GWH
												4460	PEAK DEMAND-MW
												0.5060	LOAD FACTOR

YEAR 1982

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
4730	4271	3382	2985	3202	3850	4148	3950	3992	3405	3732	4503	20924	ENERGY-GWH
												4730	PEAK DEMAND-MW
												0.5050	LOAD FACTOR

YEAR 1983

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
4980	4497	3541	3142	3371	4054	4367	4158	4203	3546	3929	4741	21986	ENERGY-GWH
												4980	PEAK DEMAND-MW
												0.5040	LOAD FACTOR

YEAR 1984

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
5240	4732	3747	3306	3547	4265	4595	4375	4423	3773	4134	4988	23043	ENERGY-GWH
												5240	PEAK DEMAND-MW
												0.5020	LOAD FACTOR

YEAR 1985

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
5480	4948	3914	3458	3710	4461	4806	4576	4625	3946	4324	5217	24050	ENERGY-GWH
												5480	PEAK DEMAND-MW
												0.5010	LOAD FACTOR

YEAR 1986

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
5730	5174	4047	3616	3879	4644	5025	4785	4836	4126	4521	5455	25097	ENERGY-GWH
												5730	PEAK DEMAND-MW
												0.5000	LOAD FACTOR

YEAR 1987

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
5960	5302	4241	3761	4035	4851	5227	4977	5030	4201	4702	5674	26052	ENERGY-GWH
												5960	PEAK DEMAND-MW
												0.4990	LOAD FACTOR

*** FLORIDA POWER & LIGHT CO. ***

YEAR 1978

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
7474	7431	5972	6290	6578	7215	7650	7766	7766	7067	6446	6834

YEARLY	ENERGY-GWH	PEAK DEMAND-MW	LOAD FACTOR
40001	7766	0.5880	

YEAR 1979

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
8031	8031	6283	6618	6920	7590	8047	8170	8170	7435	6781	7190

YEARLY	ENERGY-GWH	PEAK DEMAND-MW	LOAD FACTOR
41438	8170	0.5790	

YEAR 1980

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
8470	8470	6624	6979	7296	8004	8487	8615	8615	7941	7151	7582

YEARLY	ENERGY-GWH	PEAK DEMAND-MW	LOAD FACTOR
43398	8615	0.5750	

YEAR 1981

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
8921	8921	6979	7351	7687	8431	8939	9075	9075	8258	7532	7986

YEARLY	ENERGY-GWH	PEAK DEMAND-MW	LOAD FACTOR
45790	9075	0.5760	

YEAR 1982

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
9390	9390	7345	7737	8091	8874	9409	9552	9552	8692	7928	8406

YEARLY	ENERGY-GWH	PEAK DEMAND-MW	LOAD FACTOR
48280	9552	0.5770	

YEAR 1983

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
9843	9843	7700	8111	8481	9302	9863	10013	10013	9112	8311	8811

YEARLY	ENERGY-GWH	PEAK DEMAND-MW	LOAD FACTOR
50523	10013	0.5760	

YEAR 1984

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
10246	10246	8015	8443	8828	9683	10267	10423	10423	9485	8651	9172

YEARLY	ENERGY-GWH	PEAK DEMAND-MW	LOAD FACTOR
52409	10423	0.5740	

YEAR 1985

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
10642	10642	8325	8769	9170	10057	10664	10325	10426	9852	8986	9527

YEARLY	ENERGY-GWH	PEAK DEMAND-MW	LOAD FACTOR
54530	10826	0.5750	

YEAR 1986

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
11042	11042	8433	9059	9514	10435	11065	11233	11233	10222	9323	9885

YEARLY	ENERGY-GWH	PEAK DEMAND-MW	LOAD FACTOR
56383	11233	0.5730	

YEAR 1987

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
11450	11450	8957	9435	9856	10821	11473	11648	11648	10600	9668	10250

YEARLY	ENERGY-GWH	PEAK DEMAND-MW	LOAD FACTOR
58466	11648	0.5730	

APPENDIX B
Page 3 of 13

*** FT. PIERCE UTILITIES AUTHORITY ***

YEAR 1978

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
71	64	54	53	54	63	65	66	64	57	51	69	342	ENERGY-GWH
												71	PEAK DEMAND-MW
												0.5500	LOAD FACTOR

YEAR 1979

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
74	67	56	56	54	64	68	69	67	59	53	71	363	ENERGY-GWH
												74	PEAK DEMAND-MW
												0.5600	LOAD FACTOR

YEAR 1980

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
77	69	59	54	61	69	71	72	69	62	55	74	377	ENERGY-GWH
												77	PEAK DEMAND-MW
												0.5600	LOAD FACTOR

YEAR 1981

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
81	73	62	61	64	72	75	75	73	65	58	78	404	ENERGY-GWH
												81	PEAK DEMAND-MW
												0.5700	LOAD FACTOR

YEAR 1982

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
85	75	65	64	67	76	78	79	76	68	61	82	431	ENERGY-GWH
												85	PEAK DEMAND-MW
												0.5800	LOAD FACTOR

YEAR 1983

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
89	80	68	67	70	79	82	83	80	71	64	85	452	ENERGY-GWH
												89	PEAK DEMAND-MW
												0.5800	LOAD FACTOR

YEAR 1984

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
94	85	71	71	74	84	86	87	85	75	68	90	477	ENERGY-GWH
												94	PEAK DEMAND-MW
												0.5800	LOAD FACTOR

YEAR 1985

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
99	89	75	74	78	88	91	92	89	79	71	95	511	ENERGY-GWH
												99	PEAK DEMAND-MW
												0.5900	LOAD FACTOR

YEAR 1986

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
104	94	79	71	82	93	96	97	94	83	75	100	537	ENERGY-GWH
												104	PEAK DEMAND-MW
												0.5900	LOAD FACTOR

YEAR 1987

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
109	94	83	82	86	97	100	101	94	87	78	105	572	ENERGY-GWH
												109	PEAK DEMAND-MW
												0.6000	LOAD FACTOR

*** GAINSVILLE REGIONAL UTILITIES ***

YEAR 1978

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
156	140	109	113	127	152	171	161	161	147	127	130

YEARLY	734	ENERGY-GWH
	171	PEAK DEMAND-MW
	0.4900	LOAD FACTOR

YEAR 1979

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
165	149	116	119	134	161	181	170	170	156	134	138

YEARLY	776	ENERGY-GWH
	181	PEAK DEMAND-MW
	0.4900	LOAD FACTOR

YEAR 1980

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
173	156	122	125	141	169	190	179	179	163	141	144

YEARLY	815	ENERGY-GWH
	190	PEAK DEMAND-MW
	0.4900	LOAD FACTOR

YEAR 1981

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
184	166	129	133	149	180	202	190	190	174	149	154

YEARLY	867	ENERGY-GWH
	202	PEAK DEMAND-MW
	0.4900	LOAD FACTOR

YEAR 1982

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
196	176	133	142	159	191	215	202	202	185	159	163

YEARLY	922	ENERGY-GWH
	215	PEAK DEMAND-MW
	0.4900	LOAD FACTOR

YEAR 1983

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
207	186	145	150	168	202	227	213	213	195	168	173

YEARLY	974	ENERGY-GWH
	227	PEAK DEMAND-MW
	0.4900	LOAD FACTOR

YEAR 1984

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
220	199	155	160	179	215	242	227	227	208	179	184

YEARLY	1038	ENERGY-GWH
	242	PEAK DEMAND-MW
	0.4900	LOAD FACTOR

YEAR 1985

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
232	209	163	168	189	227	255	240	240	219	189	194

YEARLY	1094	ENERGY-GWH
	255	PEAK DEMAND-MW
	0.4900	LOAD FACTOR

YEAR 1986

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
248	223	174	180	201	242	272	256	256	234	201	207

YEARLY	1157	ENERGY-GWH
	272	PEAK DEMAND-MW
	0.4900	LOAD FACTOR

YEAR 1987

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
262	236	184	190	211	256	288	271	271	248	213	219

YEARLY	1234	ENERGY-GWH
	288	PEAK DEMAND-MW
	0.4900	LOAD FACTOR

•• JACKSONVILLE ELECTRIC AUTH. •••

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YEAR 1978

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	ENERGY-GWH
954	833	924	1078	1124	1211	1229	1309	1257	1042	978	1101	6306	1309
												0.5500	PEAK DEMAND-MW
													LOAD FACTOR

YEAR 1979

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	ENERGY-GWH
1016	827	924	1094	1197	1299	1309	1394	1338	1163	1041	1172	6728	1394
												0.5510	PEAK DEMAND-MW
													LOAD FACTOR

YEAR 1980

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	ENERGY-GWH
1080	943	1046	1143	1273	1371	1392	1482	1423	1236	1107	1246	7140	1482
												0.5500	PEAK DEMAND-MW
													LOAD FACTOR

YEAR 1981

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	ENERGY-GWH
1158	1011	1122	1247	1345	1470	1492	1599	1525	1325	1187	1336	7641	1589
												0.5490	PEAK DEMAND-MW
													LOAD FACTOR

YEAR 1982

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	ENERGY-GWH
1235	1077	1196	1330	1455	1567	1591	1694	1626	1413	1265	1425	8144	1694
												0.5490	PEAK DEMAND-MW
													LOAD FACTOR

YEAR 1983

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	ENERGY-GWH
1315	1147	1274	1416	1550	1669	1694	1804	1732	1505	1348	1517	8675	1804
												0.5490	PEAK DEMAND-MW
													LOAD FACTOR

YEAR 1984

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	ENERGY-GWH
1418	1237	1373	1527	1671	1799	1824	1945	1867	1622	1453	1636	9234	1945
												0.5420	PEAK DEMAND-MW
													LOAD FACTOR

YEAR 1985

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	ENERGY-GWH
1515	1322	1447	1631	1785	1922	1951	2078	1995	1733	1552	1748	9884	2078
												0.5430	PEAK DEMAND-MW
													LOAD FACTOR

YEAR 1986

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	ENERGY-GWH
1615	1407	1544	1740	1904	2050	2081	2216	2127	1948	1755	1864	10540	2216
												0.5430	PEAK DEMAND-MW
													LOAD FACTOR

YEAR 1987

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	ENERGY-GWH
1721	1502	1667	1853	2029	2184	2217	2361	2267	1969	1744	1986	11251	2361
												0.5440	PEAK DEMAND-MW
													LOAD FACTOR

¹As reported in this study; different from the FCG Load and Generation report.

*** CITY OF LAKELAND ***

YEAR 1978

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
245	228	200	209	226	238	241	238	243	215	204	248	1044	ENERGY-GWH
												265	PEAK DEMAND-MW
												0.4500	LOAD FACTOR

YEAR 1979

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
282	242	213	222	241	254	256	253	259	278	217	264	1111	ENERGY-GWH
												282	PEAK DEMAND-MW
												0.4500	LOAD FACTOR

YEAR 1980

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
301	259	228	237	257	271	274	270	276	244	232	282	1186	ENERGY-GWH
												301	PEAK DEMAND-MW
												0.4500	LOAD FACTOR

YEAR 1981

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
321	276	243	253	274	289	292	288	295	260	247	301	1265	ENERGY-GWH
												321	PEAK DEMAND-MW
												0.4500	LOAD FACTOR

YEAR 1982

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
343	295	259	270	293	308	312	308	315	278	264	321	1352	ENERGY-GWH
												343	PEAK DEMAND-MW
												0.4500	LOAD FACTOR

YEAR 1983

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
366	314	277	288	312	329	333	329	336	296	282	343	1442	ENERGY-GWH
												366	PEAK DEMAND-MW
												0.4500	LOAD FACTOR

YEAR 1984

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
390	345	295	307	333	351	355	350	358	316	300	365	1537	ENERGY-GWH
												390	PEAK DEMAND-MW
												0.4500	LOAD FACTOR

YEAR 1985

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
417	358	315	328	356	375	378	374	383	338	321	391	1643	ENERGY-GWH
												417	PEAK DEMAND-MW
												0.4500	LOAD FACTOR

YEAR 1986

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
445	372	336	347	367	405	405	400	408	360	343	417	1754	ENERGY-GWH
												445	PEAK DEMAND-MW
												0.4500	LOAD FACTOR

YEAR 1987

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
474	407	355	375	404	426	431	426	435	384	365	444	1848	ENERGY-GWH
												474	PEAK DEMAND-MW
												0.4500	LOAD FACTOR

APPENDIX B
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*** LAKE WORTH UTILITIES ***

YEAR 1978

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
51	62	47	45	49	55	55	57	59	57	51	60	280	ENERGY-GWH
												62	PEAK DEMAND-MW
												0.5160	LOAD FACTOR

YEAR 1979

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
54	65	50	47	51	58	58	60	42	60	53	63	291	ENERGY-GWH
												65	PEAK DEMAND-MW
												0.5120	LOAD FACTOR

YEAR 1980

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
56	68	52	50	54	60	60	63	45	42	56	66	301	ENERGY-GWH
												64	PEAK DEMAND-MW
												0.5060	LOAD FACTOR

YEAR 1981

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
59	71	55	52	56	63	63	66	58	66	58	69	312	ENERGY-GWH
												71	PEAK DEMAND-MW
												0.5020	LOAD FACTOR

YEAR 1982

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
62	75	58	55	59	67	67	70	72	69	61	73	328	ENERGY-GWH
												75	PEAK DEMAND-MW
												0.5000	LOAD FACTOR

YEAR 1983

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
65	79	61	57	62	70	70	73	76	72	65	76	344	ENERGY-GWH
												79	PEAK DEMAND-MW
												0.4980	LOAD FACTOR

YEAR 1984

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
69	83	64	60	65	74	74	77	79	76	68	80	360	ENERGY-GWH
												83	PEAK DEMAND-MW
												0.4960	LOAD FACTOR

YEAR 1985

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
72	87	67	63	68	77	77	81	83	80	71	94	377	ENERGY-GWH
												87	PEAK DEMAND-MW
												0.4950	LOAD FACTOR

YEAR 1986

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
76	91	70	67	72	81	81	85	87	94	75	88	390	ENERGY-GWH
												91	PEAK DEMAND-MW
												0.4900	LOAD FACTOR

YEAR 1987

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
79	96	74	70	76	85	85	89	92	98	78	93	410	ENERGY-GWH
												96	PEAK DEMAND-MW
												0.4880	LOAD FACTOR

APPENDIX B
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*** ORLANDO UTILITIES COMMISSION ***

YEAR 1978

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
436	345	341	371	408	436	445	459	446	398	391	396	2183	ENERGY-GWH
												459	PEAK DEMAND-MW
												0.5430	LOAD FACTOR

YEAR 1979

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
462	407	361	393	432	462	471	486	472	421	414	419	2316	ENERGY-GWH
												486	PEAK DEMAND-MW
												0.5440	LOAD FACTOR

YEAR 1980

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
487	430	391	415	454	487	477	513	499	445	437	442	2449	ENERGY-GWH
												513	PEAK DEMAND-MW
												0.5450	LOAD FACTOR

YEAR 1981

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
515	454	403	438	482	515	525	542	527	470	462	467	2597	ENERGY-GWH
												542	PEAK DEMAND-MW
												0.5470	LOAD FACTOR

YEAR 1982

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
543	479	425	462	509	543	554	572	556	496	447	493	2740	ENERGY-GWH
												572	PEAK DEMAND-MW
												0.5470	LOAD FACTOR

YEAR 1983

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
572	504	447	480	535	572	583	602	585	522	513	519	2889	ENERGY-GWH
												602	PEAK DEMAND-MW
												0.5480	LOAD FACTOR

YEAR 1984

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
600	530	470	511	562	600	612	632	614	548	538	545	3033	ENERGY-GWH
												632	PEAK DEMAND-MW
												0.5480	LOAD FACTOR

YEAR 1985

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
629	555	492	535	586	629	641	662	643	574	564	571	3195	ENERGY-GWH
												662	PEAK DEMAND-MW
												0.5510	LOAD FACTOR

YEAR 1986

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
659	582	516	561	617	659	672	694	675	602	591	598	3355	ENERGY-GWH
												694	PEAK DEMAND-MW
												0.5520	LOAD FACTOR

YEAR 1987

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
690	608	539	587	645	690	703	726	706	629	619	626	3510	ENERGY-GWH
												726	PEAK DEMAND-MW
												0.5520	LOAD FACTOR

APPENDIX B
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*** SEMINOLE ELECTRIC CORP. ***

YEAR 1978

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
1007	941	744	657	450	733	857	846	845	797	830	966	3810	ENERGY-GWH
												1007	PEAK DEMAND-MW
												0.4320	LOAD FACTOR

YEAR 1979

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
1104	1031	827	720	712	804	940	943	924	873	910	1059	4216	ENERGY-GWH
												1104	PEAK DEMAND-MW
												0.4360	LOAD FACTOR

YEAR 1980

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
1228	1147	912	801	792	894	1045	1093	1030	971	1012	1179	4668	ENERGY-GWH
												1228	PEAK DEMAND-MW
												0.4340	LOAD FACTOR

YEAR 1981

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
1344	1276	1015	891	881	994	1142	1216	1146	1091	1126	1310	5157	ENERGY-GWH
												1366	PEAK DEMAND-MW
												0.4310	LOAD FACTOR

YEAR 1982

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
1507	1408	1120	983	972	1097	1282	1341	1264	1172	1242	1445	5702	ENERGY-GWH
												1507	PEAK DEMAND-MW
												0.4320	LOAD FACTOR

YEAR 1983

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
1663	1553	1236	1084	1073	1211	1415	1440	1395	1315	1370	1595	6293	ENERGY-GWH
												1663	PEAK DEMAND-MW
												0.4320	LOAD FACTOR

YEAR 1984

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
1835	1714	1363	1196	1184	1336	1542	1633	1540	1451	1512	1760	6944	ENERGY-GWH
												1835	PEAK DEMAND-MW
												0.4320	LOAD FACTOR

YEAR 1985

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
2025	1891	1505	1320	1306	1474	1723	1802	1699	1602	1669	1942	7663	ENERGY-GWH
												2025	PEAK DEMAND-MW
												0.4320	LOAD FACTOR

YEAR 1986

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
2235	2087	1661	1457	1442	1627	1902	1949	1875	1768	1842	2143	8457	ENERGY-GWH
												2235	PEAK DEMAND-MW
												0.4320	LOAD FACTOR

YEAR 1987

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
2466	2303	1872	1608	1591	1735	2044	2195	2069	1951	2032	2365	9332	ENERGY-GWH
												2466	PEAK DEMAND-MW
												0.4320	LOAD FACTOR

*** CITY OF TALLAHASSEE ***

YEAR 1978

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
227	193	172	175	222	248	261	253	243	198	184	204

YEARLY
1143
261
0.5000
ENERGY-GWH
PEAK DEMAND-MW
LOAD FACTOR

YEAR 1979

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
236	206	183	185	234	244	278	270	259	211	200	217

YEARLY
1217
278
0.5000
ENERGY-GWH
PEAK DEMAND-MW
LOAD FACTOR

YEAR 1980

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
251	218	195	198	251	280	295	286	274	224	212	230

YEARLY
1292
295
0.5000
ENERGY-GWH
PEAK DEMAND-MW
LOAD FACTOR

YEAR 1981

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
269	234	209	212	264	300	316	307	294	240	228	246

YEARLY
1384
316
0.5000
ENERGY-GWH
PEAK DEMAND-MW
LOAD FACTOR

YEAR 1982

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
286	249	222	225	286	319	336	326	312	255	242	262

YEARLY
1471
336
0.5000
ENERGY-GWH
PEAK DEMAND-MW
LOAD FACTOR

YEAR 1983

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
304	265	236	240	304	340	358	347	333	272	258	279

YEARLY
1568
358
0.5000
ENERGY-GWH
PEAK DEMAND-MW
LOAD FACTOR

YEAR 1984

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
323	281	251	255	323	361	380	369	353	289	274	296

YEARLY
1664
380
0.5000
ENERGY-GWH
PEAK DEMAND-MW
LOAD FACTOR

YEAR 1985

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
345	300	246	272	345	386	406	394	372	309	292	317

YEARLY
1778
406
0.5000
ENERGY-GWH
PEAK DEMAND-MW
LOAD FACTOR

YEAR 1986

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
367	320	285	289	367	410	432	419	402	328	311	337

YEARLY
1892
432
0.5000
ENERGY-GWH
PEAK DEMAND-MW
LOAD FACTOR

YEAR 1987

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
391	340	304	308	391	437	460	446	428	350	331	359

YEARLY
2014
460
0.5000
ENERGY-GWH
PEAK DEMAND-MW
LOAD FACTOR

*** TAMPA ELECTRIC CO. ***

YEAR 1974

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
1873	1795	1563	1475	1547	1645	1687	1701	1729	1617	1673	1770	10254	ENERGY-GWH
												1873	PEAK DEMAND-MW
												0.6250	LOAD FACTOR

YEAR 1979

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
1953	1872	1630	1539	1413	1715	1759	1774	1963	1686	1745	1845	10497	ENERGY-GWH
												1953	PEAK DEMAND-MW
												0.6136	LOAD FACTOR

YEAR 1980

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
2054	1971	1716	1621	1498	1806	1852	1867	1898	1775	1837	1943	10799	ENERGY-GWH
												2056	PEAK DEMAND-MW
												0.5996	LOAD FACTOR

YEAR 1981

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
2125	2037	1773	1675	1755	1866	1914	1930	1962	1835	1898	2008	11280	ENERGY-GWH
												2125	PEAK DEMAND-MW
												0.6060	LOAD FACTOR

YEAR 1982

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
2195	2104	1932	1730	1813	1928	1977	1994	2027	1895	1961	2074	11592	ENERGY-GWH
												2195	PEAK DEMAND-MW
												0.6029	LOAD FACTOR

YEAR 1983

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
2262	2168	1937	1743	1864	1937	2038	2055	2039	1953	2021	2137	11940	ENERGY-GWH
												2262	PEAK DEMAND-MW
												0.6026	LOAD FACTOR

YEAR 1984

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
2318	2222	1934	1827	1914	2036	2088	2105	2140	2001	2071	2190	12232	ENERGY-GWH
												2318	PEAK DEMAND-MW
												0.6024	LOAD FACTOR

YEAR 1985

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
2365	2267	1973	1864	1953	2077	2130	2148	2184	2042	2113	2234	12478	ENERGY-GWH
												2365	PEAK DEMAND-MW
												0.6023	LOAD FACTOR

YEAR 1986

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
2423	2323	2022	1910	2001	2128	2183	2201	2237	2092	2164	2289	12815	ENERGY-GWH
												2423	PEAK DEMAND-MW
												0.6038	LOAD FACTOR

YEAR 1987

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
2473	2371	2063	1949	2042	2172	2228	2248	2283	2135	2209	2336	13167	ENERGY-GWH
												2473	PEAK DEMAND-MW
												0.6078	LOAD FACTOR

*** VERO BCH MUNICIPAL POWER PLANT *** 1

YEAR 1978

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
76	83	50	49	54	67	67	68	64	56	49	72	370	ENERGY-GWH
												83	PEAK DEMAND-MW
												0.5100	LOAD FACTOR

YEAR 1979

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
82	89	54	53	60	72	72	73	69	60	53	77	397	ENERGY-GWH
												89	PEAK DEMAND-MW
												0.5100	LOAD FACTOR

YEAR 1980

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
87	95	57	56	64	77	77	78	73	64	56	82	424	ENERGY-GWH
												95	PEAK DEMAND-MW
												0.5100	LOAD FACTOR

YEAR 1981

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
93	102	61	60	69	82	82	84	79	69	60	88	455	ENERGY-GWH
												102	PEAK DEMAND-MW
												0.5100	LOAD FACTOR

YEAR 1982

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
100	109	66	64	74	88	88	89	84	74	64	95	486	ENERGY-GWH
												109	PEAK DEMAND-MW
												0.5100	LOAD FACTOR

YEAR 1983

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
107	117	70	69	79	94	94	96	90	79	69	101	522	ENERGY-GWH
												117	PEAK DEMAND-MW
												0.5100	LOAD FACTOR

YEAR 1984

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
115	125	75	74	84	101	101	102	96	84	74	108	558	ENERGY-GWH
												125	PEAK DEMAND-MW
												0.5100	LOAD FACTOR

YEAR 1985

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
123	134	81	79	90	108	108	110	103	90	79	116	598	ENERGY-GWH
												134	PEAK DEMAND-MW
												0.5100	LOAD FACTOR

YEAR 1986

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
131	143	86	84	97	115	115	117	110	97	84	124	638	ENERGY-GWH
												143	PEAK DEMAND-MW
												0.5100	LOAD FACTOR

YEAR 1987

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY	
140	153	92	90	103	123	123	125	118	103	90	133	683	ENERGY-GWH
												153	PEAK DEMAND-MW
												0.5100	LOAD FACTOR

¹As reported in this study; different from the FCG Load and Generation report.

*** FLA ELECTRIC POWER COORD. GROUP ***

YFAR 1979

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
15861	15230	12363	12555	13164	14733	15791	15754	15419	14161	13650	15012

YEARLY	ENERGY-GWH
82990	
15861	PEAK DEMAND-MW
0.5973	LOAD FACTOR

YFAR 1979

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
16772	16105	13092	13263	13904	15625	16691	16654	16716	14962	14430	15876

YEARLY	ENERGY-GWH
36548	PEAK DEMAND-MW
16772	LOAD FACTOR
0.5911	

YEAR 1990

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
17801	17690	13893	14067	14742	16570	17707	17646	17732	15868	15314	16851

YEARLY	ENERGY-GWH
91465	PEAK DEMAND-MW
17801	LOAD FACTOR
0.5866	

YEAR 1961

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
18847	18099	14706	14284	15602	17534	18745	18705	18769	16797	16210	17850

YEARLY	ENERGY-GWH
96921	PEAK DEMAND-MW
18847	LOAD FACTOR
0.5870	

YEAR, 1952

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
19929	19120	15545	15726	16487	18530	19815	19773	19436	17754	17134	18877

YEARLY	
102374	ENERGY-GWH
19929	PEAK DEMAND-MW
0.5864	LOAD FACTOR

YEAR 1983

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
20991	20131	16369	16555	17354	19511	20972	20828	20891	18693	19049	19890

YEARLY	ENERGY-GWH
107608	PEAK DEMAND-MW
20991	LOAD FACTOR
0.5852	

YEAR 1984

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
22045	21135	17196	17383	18221	20487	21922	21878	21440	19630	18956	20900

YEARLY	ENERGY-GWH
112529	PEAK DEMAND-MW
22045	LOAD FACTOR
0.5827	

YEAR 1985

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
23082	22117	17497	18191	19069	21443	22951	22914	22469	20551	19846	21896

YEARLY	
117801	ENERGY-GWH
23082	PEAK DEMAND-MW
0.5826	LOAD FACTOR

YEAR 1986

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
24172	23154	19245	17042	19360	27445	24038	24002	24049	21517	20783	22944

YEARLY	ENERGY-GWH
123025	PEAK DEMAND-MW
24172	LOAD FACTOR
0.5810	

YEAR 1987

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
25271	24199	19700	19400	20858	23458	25129	25098	25142	22493	21728	23999

YEARLY	ENERGY-GWH
128561	PEAK DEMAND-MW
25271	LOAD FACTOR
0.5807	

APPENDIX C

Abbreviations

Plant

(P) - Joint Participation Unit

Unit Type

C - Coal

CC - Combined Cycle

CT - Combustion Turbine

D - Diesel

FS - Fossil Steam Oil

N - Nuclear

PENINSULAR FLORIDA GENERATION

RELIABILITY STUDY

Utility	Plant	Unit No.	Unit Type	In- Service	Retirements Through 1987	Net Capability-MW		Mature Outage Rate - %	
						Summer	Winter	Forced	Planned
FPC	Anclote	1	FS	11/74	---	501	513	2.0	8.0
FPC	Anclote	2	FS	10/78	---	501	513	2.0	8.0
FPC	Avon Park	2	FS	11/52	6/85	42	44	0.5	6.0
FPC	Avon Park	1	CT	12/68	---	26	35	10.0	6.0
FPC	Avon Park	2	CT	3/69	---	26	35	10.0	6.0
FPC	Bartow	1	FS	9/58	---	114	114	2.2	6.0
FPC	Bartow	2	FS	8/61	---	116	119	0.7	6.0
FPC	Bartow	3	FS	7/63	---	210	215	3.6	8.0
FPC	Bartow	1-4	CT	6/72	---	168	204	10.0	6.0
FPC	Bayboro	1-4	CT	4/73	---	160	208	10.0	6.0
FPC	Crystal River	1	FS	10/66	9/78	383	383	8.4	8.0
FPC	Crystal River	11	C	2/79	---	383	383	8.4	8.0
FPC	Crystal River	2	C	11/69	3/77	433	433	8.0	8.0
FPC	Crystal River	22	C	4/79	---	483	483	8.0	8.0
FPC	Crystal River (797p)	3	N	3/77	---	717	731	12.0	13.0
FPC	Crystal River	4	C	10/82	---	640	640	8.0	8.0
FPC	Crystal River	5	C	4/84	---	640	640	8.0	8.0
FPC	DeBary	1	CT	2/76	---	42	52	10.0	6.0
FPC	DeBary	2	CT	3/76	---	42	52	10.0	6.0
FPC	DeBary	3	CT	12/75	---	42	52	10.0	6.0
FPC	DeBary	4	CT	4/76	---	42	52	10.0	6.0
FPC	DeBary	5	CT	12/75	---	42	52	10.0	6.0
FPC	DeBary	6	CT	4/76	---	42	52	10.0	6.0
FPC	Higgins	1	FS	6/51	10/81	39	40	5.8	6.0
FPC	Higgins	2	FS	6/53	10/81	41	41	1.8	6.0
FPC	Higgins	3	FS	1/54	10/81	41	42	4.7	6.0
FPC	Higgins	1	CT	3/69	---	25	30	10.0	6.0
FPC	Higgins	2	CT	4/69	---	25	30	10.0	6.0
FPC	Higgins	3	CT	12/70	---	30	35	10.0	6.0
FPC	Higgins	4	CT	1/71	---	30	35	10.0	6.0
FPC	Higgins Combined Cycle	1	CC	10/81	---	421	421	10.0	6.0

PENINSULAR FLORIDA GENERATION

RELIABILITY STUDY

<u>Utility</u>	<u>Plant</u>	<u>Unit No.</u>	<u>Unit Type</u>	<u>In- Service</u>	<u>Retirements Through 1987</u>	<u>Net Capability-MW</u>		<u>Mature Outage Rate - %</u>	
						<u>Summer</u>	<u>Winter</u>	<u>Forced</u>	<u>Planned</u>
FPC	Intercession	1-6	CT	5/74	---	264	330	10.0	6.0
FPC	Port St. Joe	1	CT	12/70	---	14	17	10.0	6.0
FPC	Rio Pinar	1	CT	11/70	---	14	17	10.0	6.0
FPC	Suwannee River	1	FS	11/53	6/86	34	34	2.6	6.0
FPC	Suwannee River	2	FS	11/54	6/86	33	33	3.0	6.0
FPC	Suwannee River	3	FS	10/56	---	80	80	3.7	6.0
FPC	Suwannee River	1	CT	10/80	---	50	50	10.0	6.0
FPC	Suwannee River	2	CT	10/80	---	50	50	10.0	6.0
FPC	Suwannee River	3	CT	10/80	---	50	50	10.0	6.0
FPC	Turner	3	FS	11/55	---	70	72	4.0	6.0
FPC	Turner	4	FS	5/59	---	74	77	8.0	6.0
FPC	Turner	1-2	CT	10/70	---	28	34	10.0	6.0
FPC	Turner	3-4	CT	8/74	---	130	159	10.0	6.0
FPC	FPC P.	1	CT	10/83	---	100	100	10.0	6.0
FPC	FPC Coal	1	C	10/85	---	640	640	8.0	8.0
FPC	FPC Coal	2	C	10/87	---	640	640	8.0	8.0

PENINSULAR FLORIDA GENERATION

RELIABILITY STUDY

Utility	Plant	Unit No.	Unit Type	In-Service	Retirements Through 1987	Net Capability-MW		Mature Outage Rate - %	
						Summer	Winter	Forced	Planned
FPL	Cape Canaveral	1	FS	4/65	---	367	370	7.6	10.5
FPL	Cape Canaveral	2	FS	5/69	---	362	366	7.6	10.5
FPL	Ft. Myers	1	FS	11/58	---	137	139	15.3	7.0
FPL	Ft. Myers	2	FS	7/69	---	367	370	7.6	10.5
FPL	Ft. Myers	1-12	CT	5/74	---	672	828	3.0	10.0
FPL	Lauderdale	4	FS	9/57	---	137	139	15.3	7.0
FPL	Lauderdale	5	FS	4/58	---	137	139	15.3	7.0
FPL	Lauderdale	1-12	CT	8/70	---	426	486	3.0	10.0
FPL	Lauderdale	13-24	CT	8/72	---	426	486	3.0	10.0
FPL	Manatee	1	FS	11/76	---	764	775	9.1	10.5
FPL	Manatee	2	FS	12/77	---	764	775	9.1	10.5
FPL	Martin	1	FS	6/80	---	775	775	9.1	10.5
FPL	Martin	2	FS	6/81	---	775	775	9.1	10.5
FPL	Port Everglades	1	FS	6/60	---	204	206	15.3	7.0
FPL	Port Everglades	2	FS	5/61	---	204	206	15.3	7.0
FPL	Port Everglades	3	FS	6/64	---	367	370	7.6	10.5
FPL	Port Everglades	4	FS	4/65	---	367	370	7.6	10.5
FPL	Port Everglades	1-5	D	1/69	---	14	14	10.0	5.0
FPL	Port Everglades	1-12	CT	8/71	---	426	486	3.0	10.0
FPL	Putnam	2	CC	9/77	---	242	290	15.0	8.5
FPL	Putnam	1	CC	2/78	---	242	290	15.0	8.5
FPL	Riviera	3	FS	6/62	---	272	275	7.6	10.5
FPL	Riviera	4	FS	3/63	---	272	275	7.6	10.5
FPL	Sanford	3	FS	5/59	---	137	139	15.3	7.0
FPL	Sanford	4	FS	8/72	---	362	366	7.6	10.5
FPL	Sanford	5	FS	6/73	---	362	366	7.6	10.5
FPL	St. Lucie	1	N	1/77	---	777	795	12.5	15.4
FPL	St. Lucie	2	N	6/83	---	802	802	12.5	15.4

PENINSULAR FLORIDA GENERATION
RELIABILITY STUDY

<u>Utility</u>	<u>Plant</u>	<u>Unit No.</u>	<u>Unit Type</u>	<u>In-Service</u>	<u>Retirements Through 1987</u>	<u>Net Capability-MW</u>		<u>Mature Outage Rate - %</u>	
						<u>Summer</u>	<u>Winter</u>	<u>Forced</u>	<u>Planned</u>
FPL	Turkey Point	1	FS	4/67	---	367	370	7.6	10.5
FPL	Turkey Point	2	FS	4/68	---	367	370	7.6	10.5
FPL	Turkey Point	3	N	12/72	---	666	696	12.5	15.4
FPL	Turkey Point	4	N	9/73	---	666	696	12.5	15.4
FPL	Turkey Point	1-5	D	1/69	---	13.5	13.5	10.0	5.0
FPL	JEA/FPL Coal (600p)	1	C	6/85	---	300	300	15.2	10.3
FPL	JEA/FPL Coal (600p)	2	C	6/87	---	300	300	16.0	11.5
FPL	FPL Coal	1	C	6/85	---	700	700	16.0	11.5
FPL	FPL Coal	2	C	6/87	---	700	700	16.0	11.5

PENINSULAR FLORIDA GENERATION

RELIABILITY STUDY

<u>Utility</u>	<u>Plant</u>	<u>Unit No.</u>	<u>Unit Type</u>	<u>In- Service</u>	<u>Retirements Through 1987</u>	<u>Net Capability-MW</u>		<u>Mature Outage Rate - %</u>	
						<u>Summer</u>	<u>Winter</u>	<u>Forced</u>	<u>Planned</u>
FTP	King	5	FS	1/53	---	7	7	2.0	4.0
FTP	King	6	FS	1/58	---	18	18	5.0	0.1
FTP	King	7	FS	1/64	---	35	35	5.0	0.1
FTP	King	8	FS	5/76	---	51	51	0.1	4.0
FTP	King	1	D	4/70	---	3	3	10.0	0.1
FTP	King	2	D	4/70	---	3	3	10.0	0.1

PENINSULAR FLORIDA GENERATION

RELIABILITY STUDY

<u>Utility</u>	<u>Plant</u>	<u>Unit No.</u>	<u>Unit Type</u>	<u>In- Service</u>	<u>Retirements Through 1987</u>	<u>Net Capability-MW</u>		<u>Mature Outage Rate - %</u>	
						<u>Summer</u>	<u>Winter</u>	<u>Forced</u>	<u>Planned</u>
TAL	Crystal River (797p)	3	N	3/77	---	11	11	12.0	13.0
TAL	Hopkins	1	FS	5/71	---	78	80	8.0	4.0
TAL	Hopkins	2	FS	10/77	---	220	225	8.0	4.0
TAL	Hopkins	1	CT	2/70	---	14	15.5	10.0	5.0
TAL	Hopkins	2	CT	9/72	---	26.5	30	10.0	5.0
TAL	Purdum	1-3	FS	1/52	1984	22.2	22.8	3.0	5.0
TAL	Purdum	4	FS	4/54	1984	7.4	7.6	3.0	5.0
TAL	Purdum	5	FS	4/58	---	22	22	8.0	4.0
TAL	Purdum	6	FS	1/61	---	22	22	8.0	4.0
TAL	Purdum	7	FS	6/66	---	45.5	45.5	8.0	5.0
TAL	Purdum	1	CT	12/63	---	11	11.5	10.0	5.0
TAL	Purdum	2	CT	5/64	---	11	11.5	10.0	4.0

PENINSULAR FLORIDA GENERATION

RELIABILITY STUDY

<u>Utility</u>	<u>Plant</u>	<u>Unit No.</u>	<u>Unit Type</u>	<u>In- Service</u>	<u>Retirements Through 1987</u>	<u>Net Capability-MW</u>		<u>Mature Outage Rate - %</u>	
						<u>Summer</u>	<u>Winter</u>	<u>Forced</u>	<u>Planned</u>
GVL	Crystal River (797p)	3	N	3/77	---	12	12	12.0	13.0
GVL	Deerhaven	1	FS	8/72	---	81	83	0.2	3.4
GVL	Deerhaven	1	CT	7/76	---	20	26	28.0	5.0
GVL	Deerhaven	2	CT	7/76	---	20	26	28.0	5.0
GVL	J. R. Kelly	6	FS	3/58	1981	14	14	0.2	2.3
GVL	J. R. Kelly	7	FS	8/61	1987	23	23	3.3	2.3
GVL	J. R. Kelly	8	FS	4/65	---	44	45	1.8	4.9
GVL	J. R. Kelly	1	CT	5/68	---	14	15	28.0	5.0
GVL	J. R. Kelly	2	CT	9/68	---	14	15	28.0	5.0
GVL	J. R. Kelly	3	CT	2/69	---	14	15	20.2	5.0
GVL	Deerhaven	2	C	1/81	---	235	235	8.5	6.9

PENINSULAR FLORIDA GENERATION

RELIABILITY STUDY

<u>Utility</u>	<u>Plant</u>	<u>Unit No.</u>	<u>Unit Type</u>	<u>In- Service</u>	<u>Retirements Through 1987</u>	<u>Net Capability-MW</u>		<u>Mature Outage Rate - %</u>	
						<u>Summer</u>	<u>Winter</u>	<u>Forced</u>	<u>Planned</u>
JEA	Kennedy	8	FS	7/55	---	43	45	2.16	6.53
JEA	Kennedy	9	FS	1/58	---	43	45	0.70	7.46
JEA	Kennedy	10	FS	12/61	---	130	134	4.60	37.07
JEA	Kennedy	1	CT	2/69	---	12.5	13	11.57	4.98
JEA	Kennedy	2	CT	2/69	---	12.5	13	11.91	5.12
JEA	Kennedy	3	CT	7/73	---	53.5	53.5	31.25	13.44
JEA	Kennedy	4	CT	7/73	---	54.5	54.5	26.20	11.27
JEA	Kennedy	5	CT	7/73	---	53.5	53.5	29.98	12.89
JEA	Kennedy	6	CT	7/73	---	54.5	54.5	24.12	10.37
JEA	Northside	1	FS	11/66	---	262	262	6.49	26.65
JEA	Northside	2	FS	3/72	---	262	262	7.44	9.75
JEA	Northside	3	FS	7/77	---	518	518	7.44	9.75
JEA	Northside	1	CT	10/68	---	11.5	14	9.86	4.24
JEA	Northside	2	CT	10/68	---	11.5	14	15.59	6.70
JEA	Northside	3	CT	12/74	---	51.25	61.25	13.97	6.00
JEA	Northside	4	CT	12/74	---	51.25	61.25	12.70	5.46
JEA	Northside	5	CT	12/74	---	51.25	61.25	13.20	5.68
JEA	Northside	6	CT	12/74	---	51.25	61.25	14.50	6.24
JEA	Southside	1	FS	11/50	---	27	27	1.08	7.34
JEA	Southside	2	FS	1/51	---	29	32	3.52	10.29
JEA	Southside	3	FS	1/55	---	46	48	3.72	12.77
JEA	Southside	4	FS	11/58	---	70	72	3.74	8.91
JEA	Southside	5	FS	9/64	---	144	146	0.45	10.22
JEA	Southside	1	CT	2/69	---	12.5	15	7.87	3.38
JEA	Southside	2	CT	2/69	---	12.5	15	6.88	2.96
JEA	JEA/FPL Coal (600p)	1	C	6/85	---	300	300	15.20	10.30
JEA	JEA/FPL Coal (600p)	2	C	6/87	---	300	300	16.00	11.50

PENINSULAR FLORIDA GENERATION

RELIABILITY STUDY

<u>Utility</u>	<u>Plant</u>	<u>Unit No.</u>	<u>Unit Type</u>	<u>In- Service</u>	<u>Retirements Through 1987</u>	<u>Net Capability-MW</u>		<u>Mature Outage Rate - %</u>	
						<u>Summer</u>	<u>Winter</u>	<u>Forced</u>	<u>Planned</u>
LAK	Larsen	4	FS	8/50	1983	19	19	6.8	9.6
LAK	Larsen	5	FS	4/56	---	25	25	2.2	9.6
LAK	Larsen	6	FS	12/59	---	25	25	5.1	9.6
LAK	Larsen	7	FS	2/66	---	49	52	5.0	9.6
LAK	Larsen	1 - 3	CT	3/62	---	33	39	10.0	5.8
LAK	McIntosh	1	FS	2/71	---	92	93	1.9	9.6
LAK	McIntosh	2	FS	5/76	---	110	110	1.9	9.6
LAK	McIntosh	1 - 2	D	3/70	---	5	6	1.0	3.8
LAK	McIntosh	1	CT	2/73	---	20	23	10.0	3.8
LAK	McIntosh (334p)	5	C	10/81	---	200	200	5.0	10.0

PENINSULAR FLORIDA GENERATION

RELIABILITY STUDY

<u>Utility</u>	<u>Plant</u>	<u>Unit No.</u>	<u>Unit Type</u>	<u>In- Service</u>	<u>Retirements Through 1987</u>	<u>Net Capability-MW</u>		<u>Mature Outage Rate - %</u>	
						<u>Summer</u>	<u>Winter</u>	<u>Forced</u>	<u>Planned</u>
LWU	Tom G. Smith	1	FS	1/61	1/86	7	8	3.0	4.0
LWU	Tom G. Smith	2	FS	3/63	---	7	8	3.0	4.0
LWU	Tom G. Smith	3	FS	11/67	---	25	26	2.0	4.0
LWU	Tom G. Smith	4	FS	8/71	---	33	35	2.0	4.0
LWU	Tom G. Smith	1 - 5	D	12/65	---	10	10	10.0	3.0
LWU	Tom G. Smith	1	CT	12/76	---	29	32	1.0	8.0
LWU	Tom G. Smith	5	CC	6/78	---	30	35	5.0	6.0

PENINSULAR FLORIDA GENERATION

RELIABILITY STUDY

<u>Utility</u>	<u>Plant</u>	<u>Unit No.</u>	<u>Unit Type</u>	<u>In- Service</u>	<u>Retirements Through 1987</u>	<u>Net Capability-MW</u>		<u>Mature Outage Rate - %</u>	
						<u>Summer</u>	<u>Winter</u>	<u>Forced</u>	<u>Planned</u>
OUC	Crystal River (797p)	3	N	3/77	---	13	13	12.0	13.0
OUC	Indian River	1	FS	2/60	---	90	92	0.1	9.6
OUC	Indian River	2	FS	12/64	---	205	208	2.2	9.6
OUC	Indian River	3	FS	2/74	---	318	321	2.3	9.6
OUC	Lake Highland	1	FS	9/49	12/82	28	30	0.1	9.6
OUC	Lake Highland	2	FS	9/54	12/82	29	30	0.1	9.6
OUC	Lake Highland	3	FS	9/56	12/82	29	30	0.1	9.6
OUC	Lake Highland	1 - 2	CT	12/58	---	26	32	10.0	9.6
OUC	McIntosh (334p)	5	C	10/81	---	134	134	5.0	10.0

PENINSULAR FLORIDA GENERATION

RELIABILITY STUDY

<u>Utility</u>	<u>Plant</u>	<u>Unit No.</u>	<u>Unit Type</u>	<u>In- Service</u>	<u>Retirements Through 1987</u>	<u>Net Capability-MW</u>		<u>Mature Outage Rate - %</u>	
						<u>Summer</u>	<u>Winter</u>	<u>Forced</u>	<u>Planned</u>
SEC	Seminole	1	C	6/83	---	600	600	7.3	7.7
SEC	Seminole	2	C	6/85	---	600	600	7.3	7.7

PENINSULAR FLORIDA GENERATION

RELIABILITY STUDY

<u>Utility</u>	<u>Plant</u>	<u>Unit No.</u>	<u>Unit Type</u>	<u>In - Service</u>	<u>Retirements Through 1987</u>	<u>Net Capability-MW</u>		<u>Mature Outage Rate - %</u>	
						<u>Summer</u>	<u>Winter</u>	<u>Forced</u>	<u>Planned</u>
TEC	Big Bend	1	C	11/70	---	362	362	8.0	15.38
TEC	Big Bend	2	C	4/73	---	362	362	8.0	15.38
TEC	Big Bend	3	C	5/76	---	362	362	8.0	15.38
TEC	Big Bend	1	CT	1/69	---	14	14	1.0	5.77
TEC	Big Bend	2-3	CT	12/74	---	130	130	8.0	11.54
TEC	Gannon	1	FS	9/57	---	98	98	5.0	9.60
TEC	Gannon	2	FS	11/58	---	108	108	5.0	9.60
TEC	Gannon	3	FS	10/60	---	150	150	5.0	9.60
TEC	Gannon	4	FS	11/63	---	169	169	5.0	9.60
TEC	Gannon	5	C	11/65	---	229	229	12.0	15.38
TEC	Gannon	6	C	11/67	---	338	338	20.0	15.38
TEC	Gannon	1	CT	1/69	---	14	14	1.0	5.77
TEC	Hookers Point	1	FS	7/48	---	27	27	5.0	7.69
TEC	Hookers Point	2	FS	6/50	---	28	28	5.0	7.69
TEC	Hookers Point	3	FS	8/50	---	28	28	5.0	7.69
TEC	Hookers Point	4	FS	10/53	---	44	44	5.0	7.69
TEC	Hookers Point	5	FS	6/55	---	66	66	10.0	7.69
TEC	Big Bend	4	CT	3/83	---	65	65	8.0	11.54
TEC	Big Bend	5	CT	3/84	---	65	65	8.0	11.54
TEC	Big Bend	4	C	4/85	---	425	425	14.0	15.38

PENINSULAR FLORIDA GENERATION

RELIABILITY STUDY

<u>Utility</u>	<u>Plant</u>	<u>Unit No.</u>	<u>Unit Type</u>	<u>In- Service</u>	<u>Retirements Through 1987</u>	<u>Net Capability-MW</u>		<u>Mature Outage Rate - %</u>	
						<u>Summer</u>	<u>Winter</u>	<u>Forced</u>	<u>Planned</u>
VER	Municipal Plant	1	FS	1/61	---	13	13	3.0	11.5
VER	Municipal Plant	2	FS	8/64	---	17	20	3.0	7.6
VER	Municipal Plant	3	FS	9/71	---	33	33	3.0	15.4
VER	Municipal Plant	4	FS	5/76	---	56	56	3.0	3.8

2. THE SITE

CHAPTER 2

THE SITE

2.1 SITE LOCATION AND LAYOUT

Big Bend Station is 5 miles north of Ruskin, Hillsborough County, Florida, on the eastern shore of Hillsborough Bay. Hillsborough Bay is a northeasterly extension of Tampa Bay about 26 miles from Egmont Key, which is at the entrance to Tampa Bay from the Gulf of Mexico. The site is about 10 miles south of the city of Tampa and about 14 miles east of St. Petersburg, across Tampa Bay. Located just north of Big Bend Road, the site is approximately 1 mile west of U.S. Highway 41. Figure 2.1-1 shows the general site location on an area map, and Figure 2.1-2 shows the site location and its contiguous areas. Figure 2.1-3 shows the plant perimeter and adjacent property owners. Figure 2.1-4 shows the local zoning around the plant.

The site comprises 1,187 acres of which 521 acres are level fill area and 558 acres are upland, entirely owned by Tampa Electric Company. Of the total, 800 acres are in use. Present yard grade is 8.5 feet mean low water (MLW) datum, with ground floor of the existing facilities at elevation 9.0 feet. Foundations for all structures and equipment are pile supported.

Access to the site for personnel and material is provided both by U.S. Highway 41 on the eastern property boundary line and by railroad spurs from the Seaboard Coast Line Railroad. An extension of the Tampa Bay Channel System permits access to the site by water. Barge deliveries of both fuel and large equipment approach through a dredged, ship-access channel.

Three coal-fired, steam-electric generating units presently exist on site. Although the units have a total nameplate rating of 1336.5 megawatts (MW), they have a present net capacity of 1086 MW. These units utilize a once-through cooling system discharging to Hillsborough Bay via a common thermal discharge channel. Unit Nos. 1 and 2 discharge stack gases through a 490-ft common flue stack. Unit No. 3 discharges stack gases through a second 490-ft stack which will also accommodate Unit No. 4.

A plot plan of the site, locating existing facilities, is presented in Section 3.1 as Figure 3.1-1. (The Big Bend Station site boundaries and topography are shown on Figure 3.1-4.)

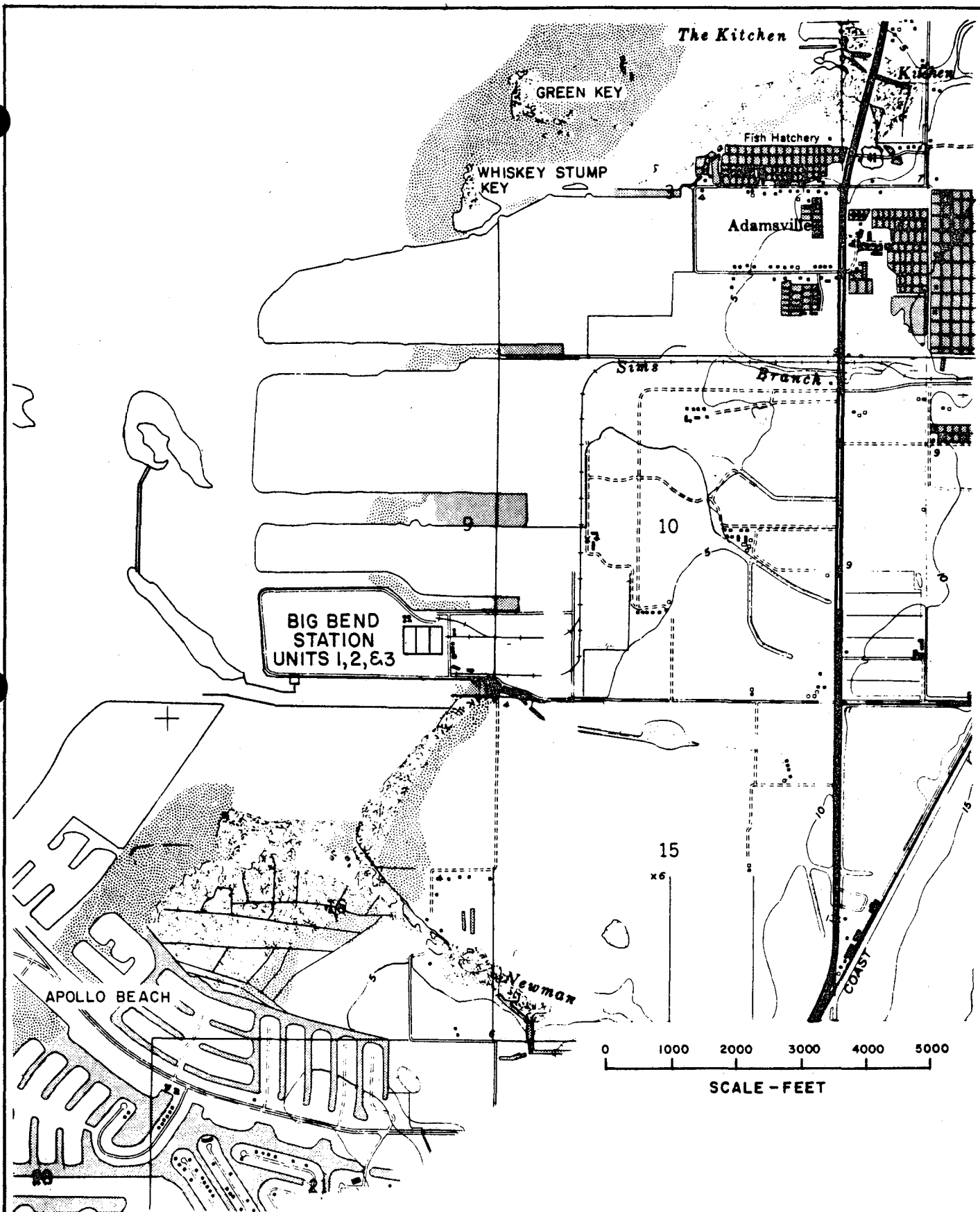
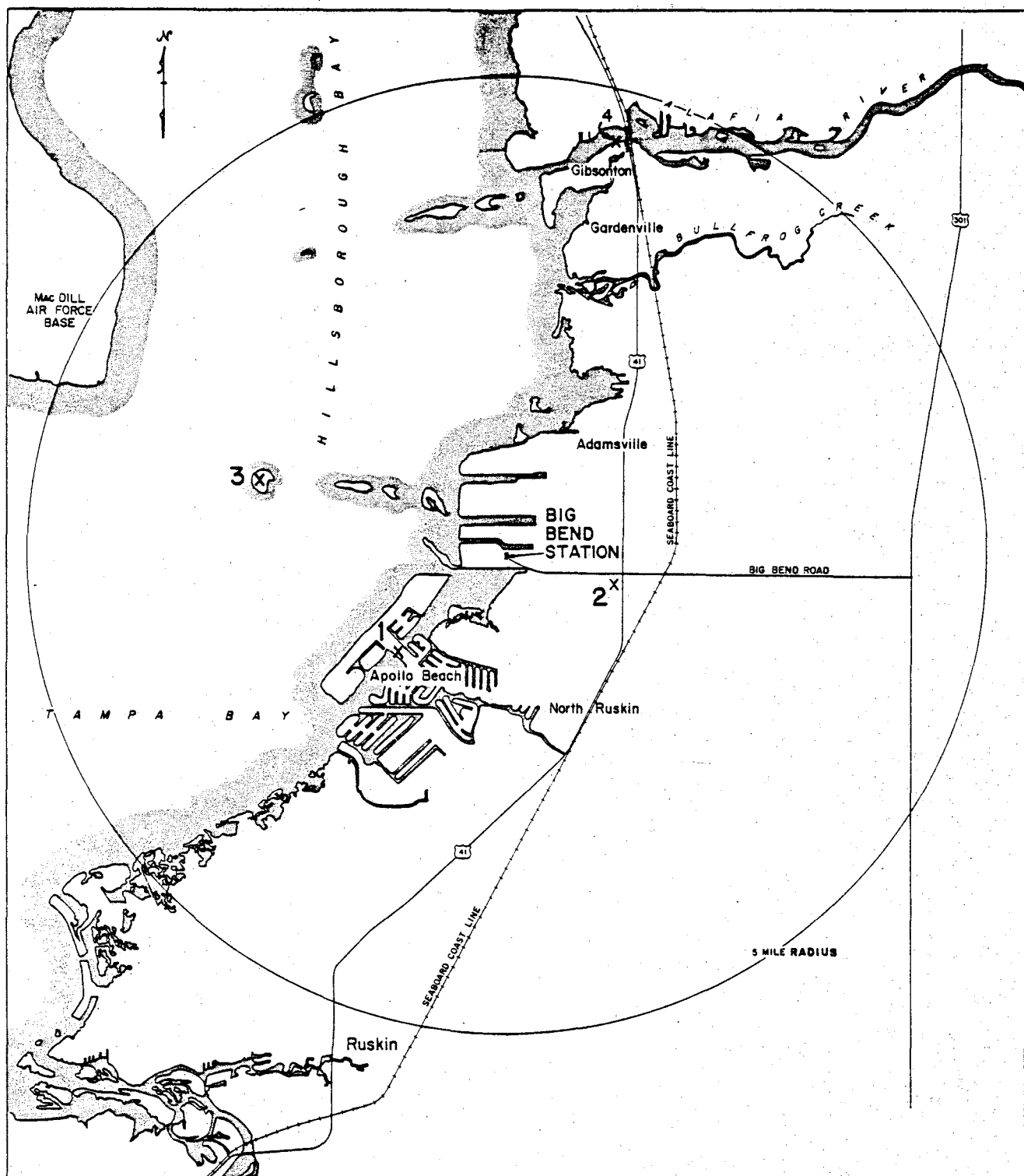


FIGURE 2.1-1
GENERAL SITE LOCATION
BIG BEND STATION
TAMPA ELECTRIC COMPANY

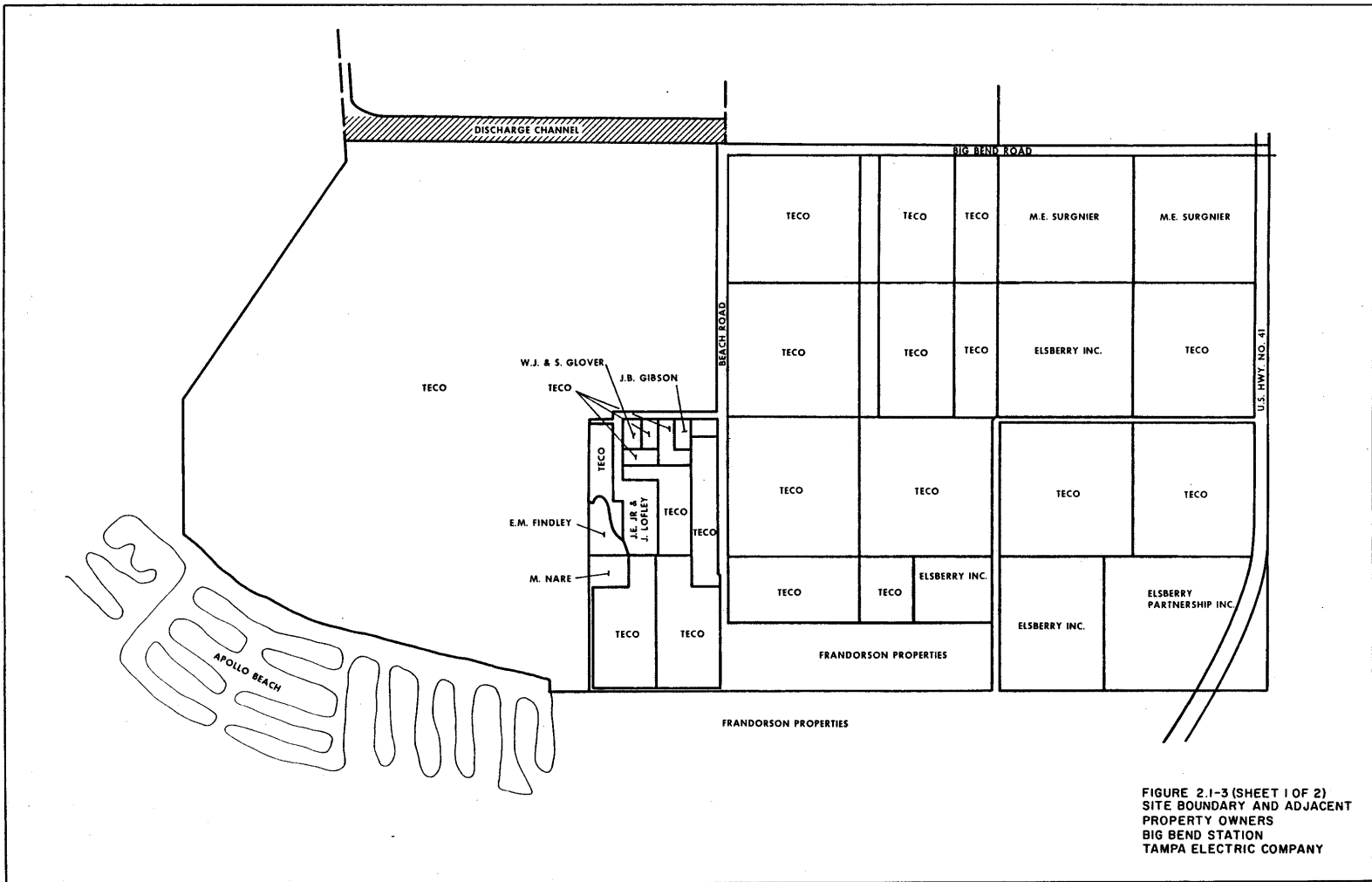


DESCRIPTION:

1. APOLLO BEACH
2. BIG BEND ROAD AND U.S. 41
3. PINE KEY-TAMPA BAY
4. ALAFIA RIVER AND U.S. 41

FIGURE 2.1-2

**SITE AND CONTIGUOUS AREA
BIG BEND STATION
TAMPA ELECTRIC COMPANY**



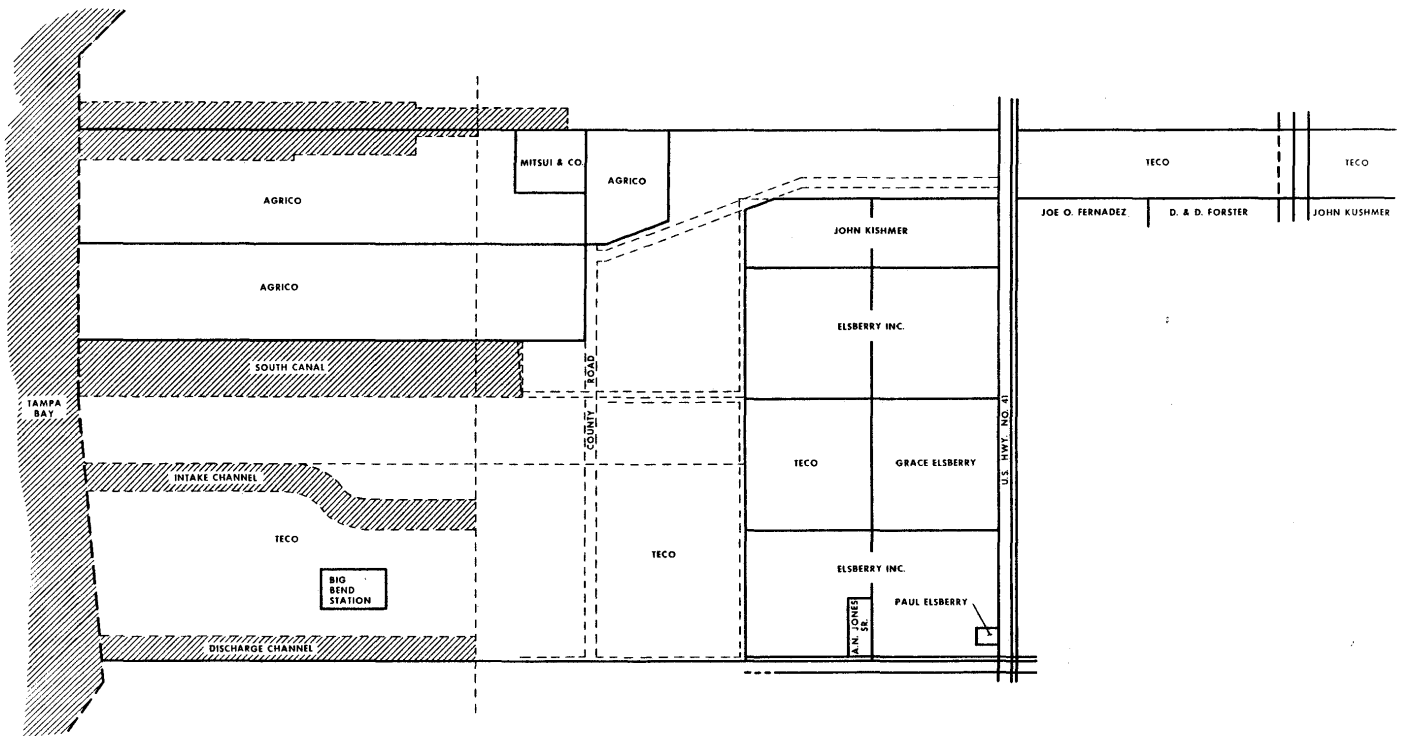
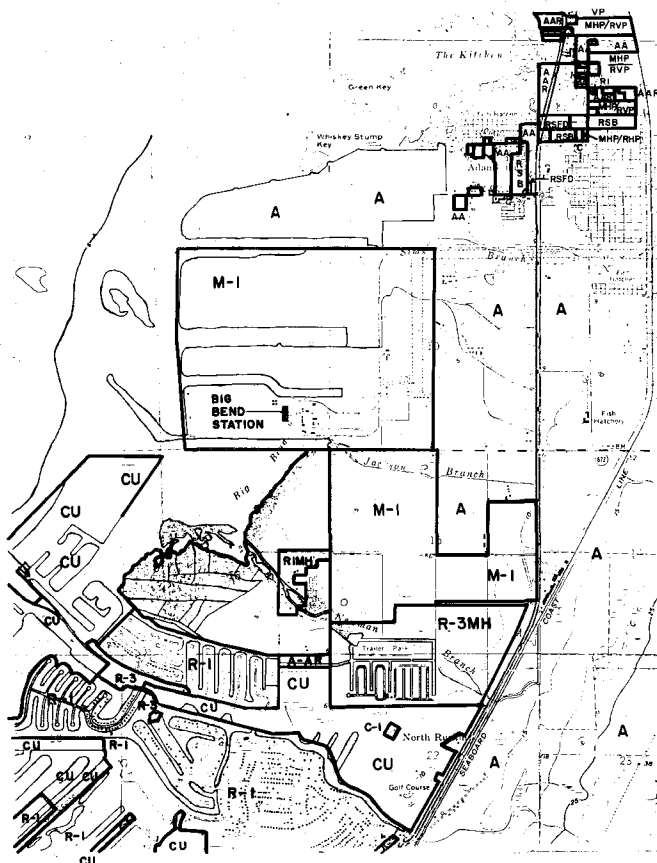


FIGURE 2.1-3 (SHEET 2 OF 2)
 SITE BOUNDARY AND ADJACENT
 PROPERTY OWNERS
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY



LEGEND

"A"	AGRICULTURAL DISTRICT
"AA"	AGRICULTURAL DISTRICT
"A-AR"	AGRICULTURAL RESIDENTIAL DISTRICT
"A-R"	AGRICULTURAL RESIDENTIAL DISTRICT
"R-1"	SINGLE FAMILY RESIDENTIAL DISTRICT
"R-2"	ONE AND TWO FAMILY RESIDENTIAL DISTRICT
"R-3"	MULTIPLE FAMILY RESIDENTIAL DISTRICT
"R-4"	RESIDENTIAL ESTATE DISTRICT
"R-5"	(DELETED APRIL 11, 1977)
"R-6"	SINGLE FAMILY RESIDENTIAL AND MOBILE HOME
"R-7"	ONE AND TWO FAMILY RESIDENTIAL & MOBILE HOME
"R-8"	MULTIPLE FAMILY RESIDENTIAL & MOBILE HOME
"R-9"	MULTIPLE FAMILY RESIDENTIAL MOBILE HOME PARK AND TRAVEL PARK DISTRICT
"R-10"	MULTIPLE FAMILY RESIDENTIAL AND DUPLEX MOBILE HOME PARK DISTRICT
"C-U"	COMMUNITY UNIT DISTRICT
"C-C"	UNIVERSITY COMMUNITY DISTRICT
"C-CU"	COMMUNITY COLLEGE UNIT DISTRICT
"I-P"	INSTITUTIONAL PROFESSIONAL DISTRICT
"H-C"	HIGHWAY COMMERCIAL DISTRICT
"C-P"	PLANNED COMMERCIAL DISTRICT
"C-C"	COMMUNITY COMMERCIAL DISTRICT
"C-1"	NEIGHBORHOOD COMMERCIAL DISTRICT
"C-2"	GENERAL COMMERCIAL DISTRICT
"C-3A"	LIMITED LIGHT INDUSTRIAL DISTRICT
"C-3"	COMMERCIAL LIGHT INDUSTRIAL DISTRICT
"M-1A"	RESTRICTED INDUSTRY DISTRICT
"M-1"	INDUSTRIAL DISTRICT
"M-AP"	AIRPORT DISTRICT
"F-C"	FAIR COMMUNITY UNIT DISTRICT
"R-SB"	SHOW BUSINESS RESIDENTIAL DISTRICT (ADOPTED 3/31/78)
"RSFD"	SINGLE FAMILY SUBURBAN FIXED DWELLING DISTRICT

FIGURE 2.1-4
LOCAL ZONING MAP
BIG BEND STATION
TAMPA ELECTRIC COMPANY

2.2 REGIONAL DEMOGRAPHY, LAND AND WATER USE

2.2.1 Regional Demography

The area within a 5-mile radius of the Big Bend Station site contains all or part of two Census Designated Places (CDP) that have populations specified in the 1970 census. According to the Department of Commerce, Bureau of the Census, a CDP (previously called an "unincorporated place") is defined as a community that has no legally-defined limits and can be identified locally by place name.⁽¹⁾ Apollo Beach is 1.2 miles south of the site and is a planned community that offers the amenities of a waterfront development. The other CDP is Ruskin, also located south of the site on the periphery of the 5-mile radius. January 1, 1977 population estimates indicate Tract 141 inclusive of Apollo Beach and North Ruskin to have a population of 10,870. The 1970 census for Tract 141 indicates a population of 5,050.⁽²⁾ Figure 2.2-1 shows the locations of these towns with respect to the site.

In 1970, Hillsborough County's population was 490,265, a 23.2 percent increase over its 1960 population of 397,788. In January 1977, population estimates for Hillsborough County were 655,600, a 33.7 percent increase over its 1970 population and a 64.8 percent increase over the 1960 population.⁽³⁾

Within a 5-mile radius of Big Bend Station are two county divisions, Gibsonton and Ruskin, with populations of 7,748 and 18,428, respectively. These populations represent an increase of 74.1 percent over the 1960 Gibsonton population and 116.5 percent over the 1960 Ruskin population.⁽¹⁾ Although such increases are substantial, they cannot be considered anomalous compared with other areas of the county. The county's overall growth of 23 percent is heavily influenced by the city of Tampa, an already highly urbanized area, which contains over half the county's population and which grew by only 1 percent between 1960 and 1970 (from 274,970 to 277,767). According to Horizon 2000, prepared by the Hillsborough County Planning Commission, Tampa's January 1977 population is estimated to be 296,390, which is a 6.7 percent increase from 1970 to 1977. Excluding the city of Tampa, Hillsborough County's population grew by approximately 73 percent between 1960 and 1970 (two county divisions, Bloomingdale and Tampa West, actually grew by 196.0 and 220.8 percent over this same period). In 1977 Hillsborough County's population estimate excluding Tampa was 359,210, a 69 percent increase from the 1970 population of 212,512 persons.^(2,3)

Several new residential subdivisions within 5 miles of the site have been developed since 1960. As shown in Figure 2.2-2, most of this development has occurred near the

community of Gibsonton, north of the site, and along U.S. Highway 301 to the east. Figure 2.2-3 shows net population growth in Hillsborough County and in the site area between 1960 and 1970. Most population growth within 5 miles of the site has occurred near Gibsonton, while more limited growth has occurred in Apollo Beach and along U.S. Highways 41 and 301. Population growth and residential expansion in the site area can be expected to continue in and around these communities.

2.2.2 Land Use

The Big Bend Station site is on the eastern shore of Tampa Bay in a rural area. The land within 5 miles of the site is mainly either agricultural or undeveloped. Principal crops are commercial vegetables, tomatoes, and strawberries, the latter two grown extensively in the Ruskin area south of the site. Soil characteristics in the area are not favorable for field crops such as corn and other grains, but do favor fruits and vegetables with proper management such as irrigation and fertilization. Another agricultural activity conducted in the Big Bend site area is livestock raising and dairy farming. A large proportion of the agricultural land in this area is used for pasture. Citrus growing, extensive in Hillsborough County, is not prevalent within 5 miles of the Big Bend site.⁽⁴⁾

Industrial and commercial areas within 5 miles of the site are situated along U.S. Highway 41. The only industrial site is a phosphate plant, 5 miles north. Present land use within a 5-mile radius of the Big Bend site is shown in Figure 2.2-4.⁽⁵⁾

Development immediately adjacent to the site is constrained (Figure 2.2-5) by the presence of swamps, flood-prone areas, and ecologically sensitive coastal waters. High potential areas for future residential growth land expansion, shown in Figure 2.2-6, are anticipated along the shoreline, along major highways, and around the communities of Gibsonton and Ruskin. The Horizon 2000 plan for the area is shown in Figure 2.2-7. The construction of Big Bend Unit 4 at this location is compatible with the Hillsborough County Horizon 2000 Comprehensive land use plan.

The area proposed for the construction of Unit 4, its directly associated transmission lines, and its associated facilities is zoned for industrial use. The FGD byproduct disposal area is to be developed in stages, as the need

arises. Since the FGD byproduct will be marketable, there may never be a need for the entire area.

The site area is served by water, rail, and highway transportation systems as shown in Figure 2.2-8. The Port of Tampa now ranks as the eighth largest in the nation, and phosphate and coal are the chief products passing through these port facilities.⁽⁶⁾

All railways within Hillsborough County are owned by the Seaboard Coast Line and carry mainly freight. Part of the Seaboard Coast Line passes approximately 1 1/2 miles east of the Big Bend site, and spurs from this line serve the site.

Highways are the most extensive mode of travel throughout the county. U.S. Highways 41 and 301 pass in a north-south direction approximately 1 1/2 and 4 miles east of the site, respectively.

Within or bordering the 5-mile site area are six parks and three recreation areas. Island Park is being developed, and three of the existing parks are being expanded. Table 2.2-1 lists the parks and recreational areas and their major attractions. Locations of these areas are shown in Figure 2.2-9. All of the county parks have also been established for the protection of animal and plant life.

Also in this 5-mile area is Apollo Beach which has been developed for the use of the residents of the community of Apollo Beach. The location of this beach is also shown in Figure 2.2-9.

Within 5 miles of the Big Bend site are three public schools: East Bay High School, with a 1977 enrollment of 2,695; Eisenhower Junior High School, 769; and Gibsonton Elementary School, 856. Locations of these schools are shown in Figure 2.2-4.

2.2.3 Water Use

2.2.3.1 Surface Water

The major water bodies within 5 miles of the Big Bend site are Manatee and Alafia Rivers, Hillsborough and Tampa Bays, and Bullfrog Creek. The rivers and creek provide sport fishing opportunities but have not been extensively developed for recreation. The bays offer the best opportunities for water-based recreation and are used extensively for fishing and boating. Hillsborough and Tampa Bays are also used extensively for shipping. The Port of Tampa's total annual volume, based on the most recent records, was about 41,390,000 tons, with phosphate, a major export, accounting for 44 percent of this tonnage.^(6,7)

2.2.3.2 Groundwater

Communities within a 5-mile radius of the Big Bend site rely on deep wells as a potable water source. Two well fields serving water users in the area are found within the 5-mile radius. The Riverview Water Plant and Well Field, located 4.75 miles northeast of the site, is operated by Hillsborough County and serves the communities of Riverview, Gibsonton, and Gardenville, as well as the Big Bend Power Station. The Apollo Beach well field, two miles south-southeast, serves the Apollo Beach development. The locations of these well fields are shown in Figure 2.2-10. Water for irrigation in the site area is drawn from individual wells.(5)

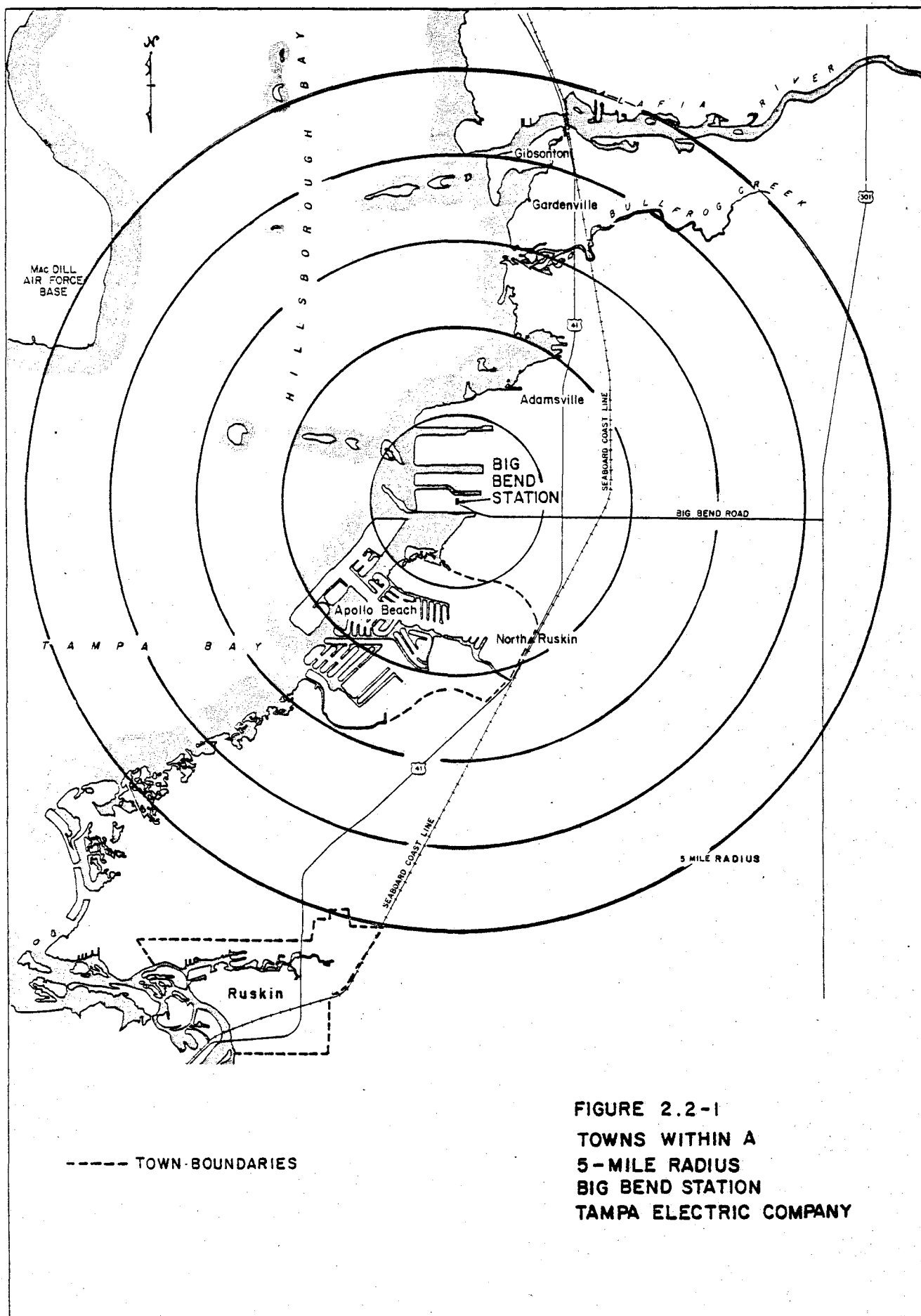
REFERENCES for 2.2

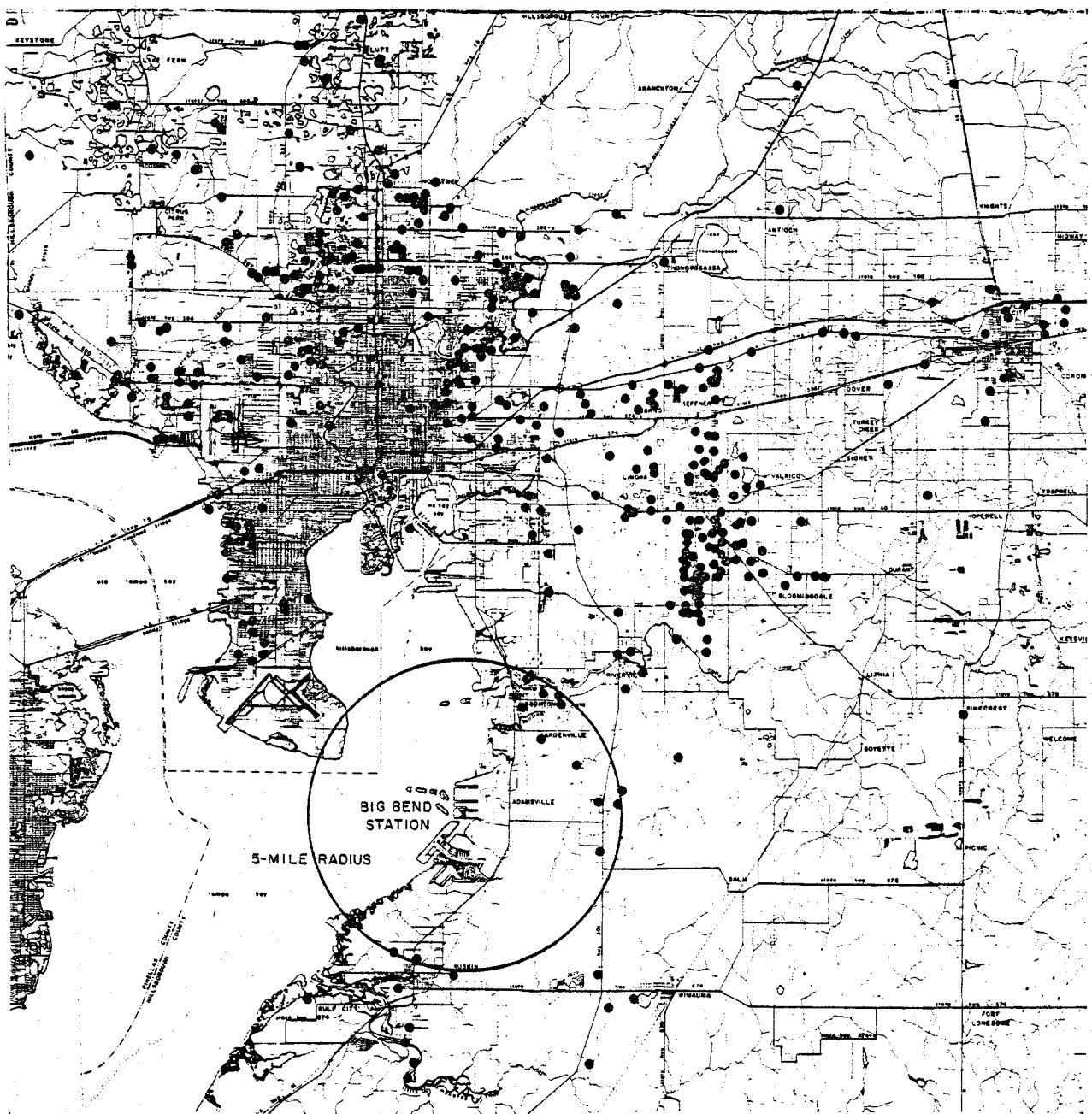
1. Department of Commerce, Bureau of Census. 1980 Census Update. Supplement to Data User News, Issue No. 3, July 1977.
2. Hillsborough County Planning Commission. Population and Housing Estimates, April 1, 1970-January 1, 1977. April 1977.
3. Hillsborough County Planning Commission. Horizon 2000 Plan, Land Use Element, Hillsborough County. 1975.
4. Hillsborough County Planning Commission. Horizon 2000 Plan, Coastal Zone Protection Element, Hillsborough County.
5. Tampa Bay Regional Planning Council. Technical Report: Land Use, Support Services, Land Ownership, Population, Economics. Report No. TBR-76-2-LU. June 30, 1976.
6. Tampa Port Authority. Master Plan of Development for the Port of Tampa. 1975.
7. Hillsborough County Planning Commission. Horizon 2000 Plan, Hillsborough County, Tampa, Florida. November 30, 1977.

TABLE 2.2-1

PARKS AND RECREATION AREAS

<u>Area</u>	<u>Activities & Facilities</u>
<u>Parks</u>	
Bullfrog Creek Park	athletic fields, fishing, nature trails, picnicking, and playground
Island Park	picnicking
Williams Park	boat ramp, fishing, picnicking
E.G. Simmons Park	boat ramp, camping, fishing, nature trails, picnicking, playground, swimming, bathhouse
Gibson Jr.	athletic field, playground, civic building, picnicking
Cities Service Alafia	fishing, picnicking, tennis courts
<u>Recreation Areas</u>	
Gardenville	athletic fields, community center, playground, shuffleboard, volleyball, basketball
<u>Sources:</u>	Hillsborough County Department of Parks and Recreation. Your Guide to the Parks and Recreation Areas of Hillsborough County.
	Hillsborough County Park and Recreation Board, et al. Park Plan - Hillsborough County, Florida, 1975-1990.



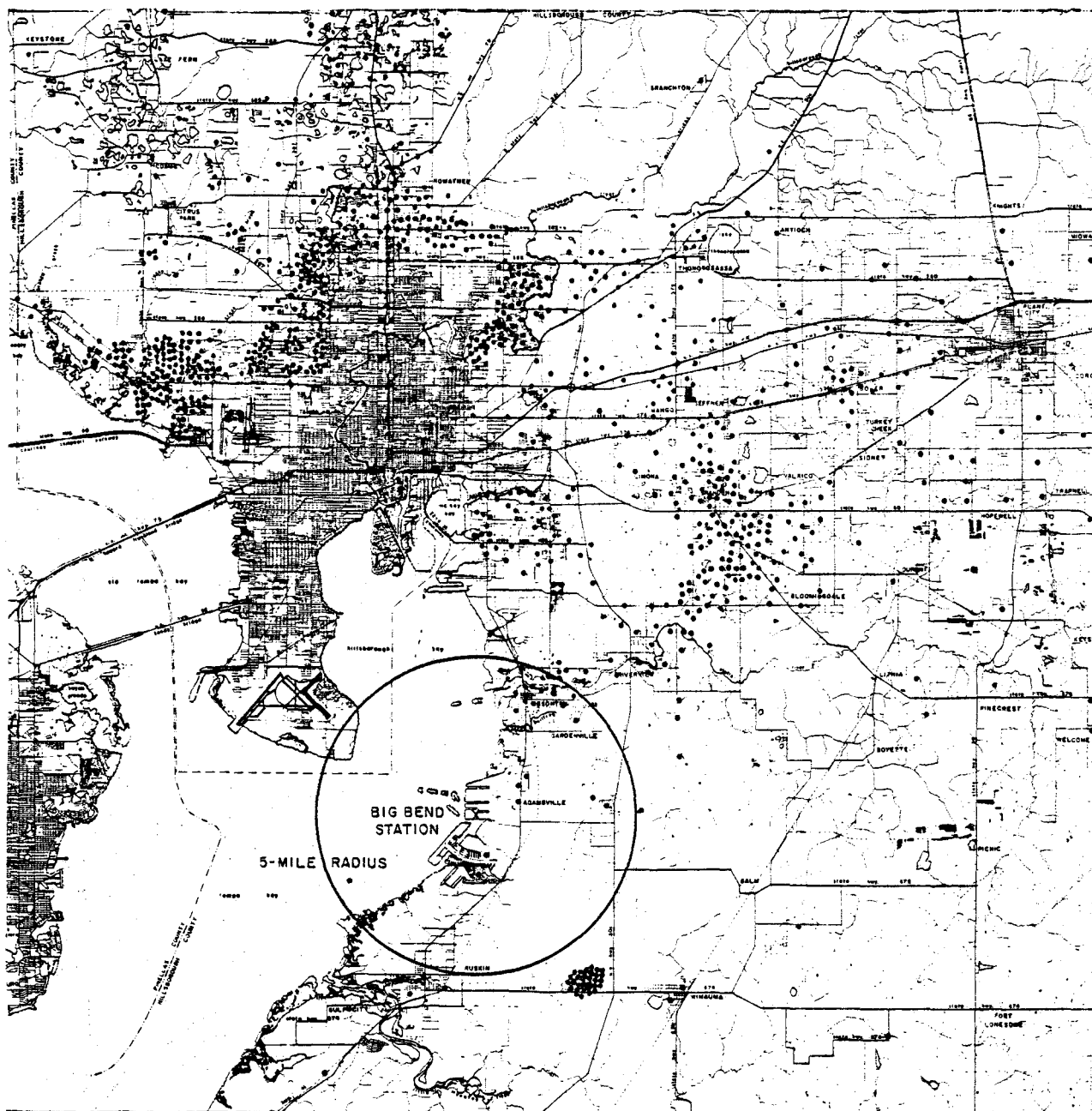


LEGEND

- EACH DOT DENOTES THE LOCATION OF ONE NEW SUBDIVISION RECORDED BETWEEN 1960 AND 1970.

HILLSBOROUGH COUNTY PLANNING COMMISSION

FIGURE 2.2-2
NEW SUBDIVISIONS, 1960-1970
BIG BEND STATION
TAMPA ELECTRIC COMPANY



LEGEND

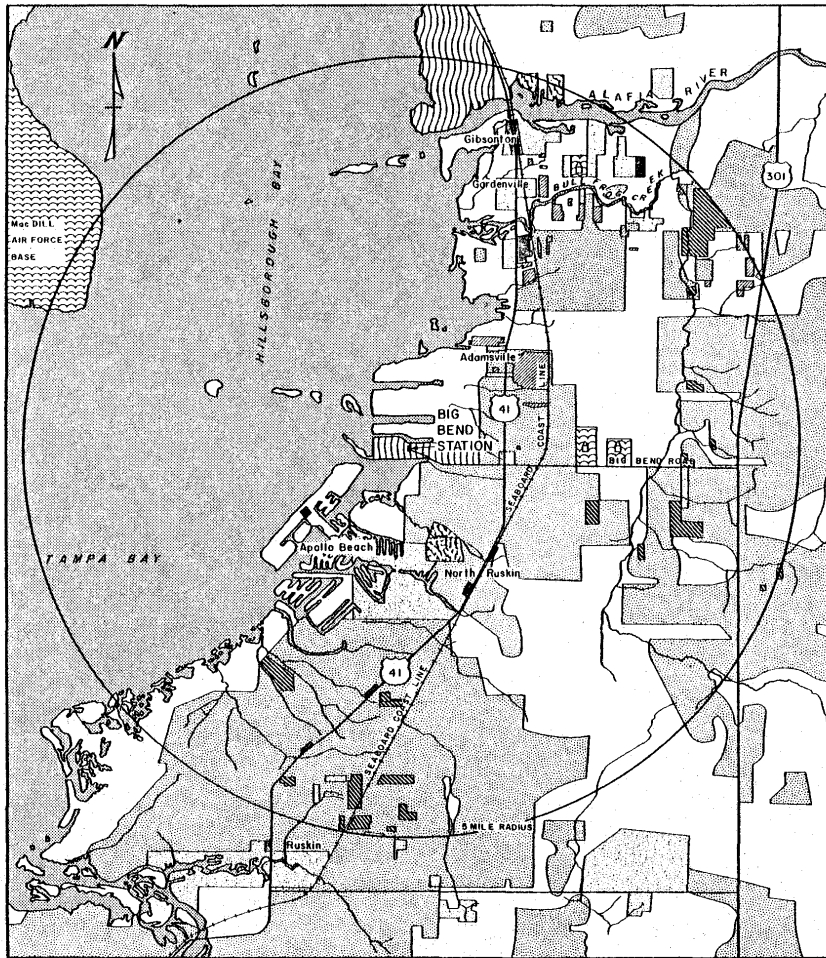
● EACH DOT DENOTES A NET INCREASE OF 100 PERSONS BETWEEN 1960 AND 1970. *

* THE LOCATIONS OF THE DOTS ARE APPROXIMATION BASED ON LAND DEVELOPMENT PATTERN

HILLSBOROUGH COUNTY PLANNING COMMISSION

NOTE:
POPULATION GROWTH PATTERN EXCLUDES
THE CITIES OF TAMPA AND PLANT CITY
AND MACDILL AFB.

FIGURE 2.2-3
NET POPULATION GROWTH
PATTERN, 1960-1970
BIG BEND STATION
TAMPA ELECTRIC COMPANY

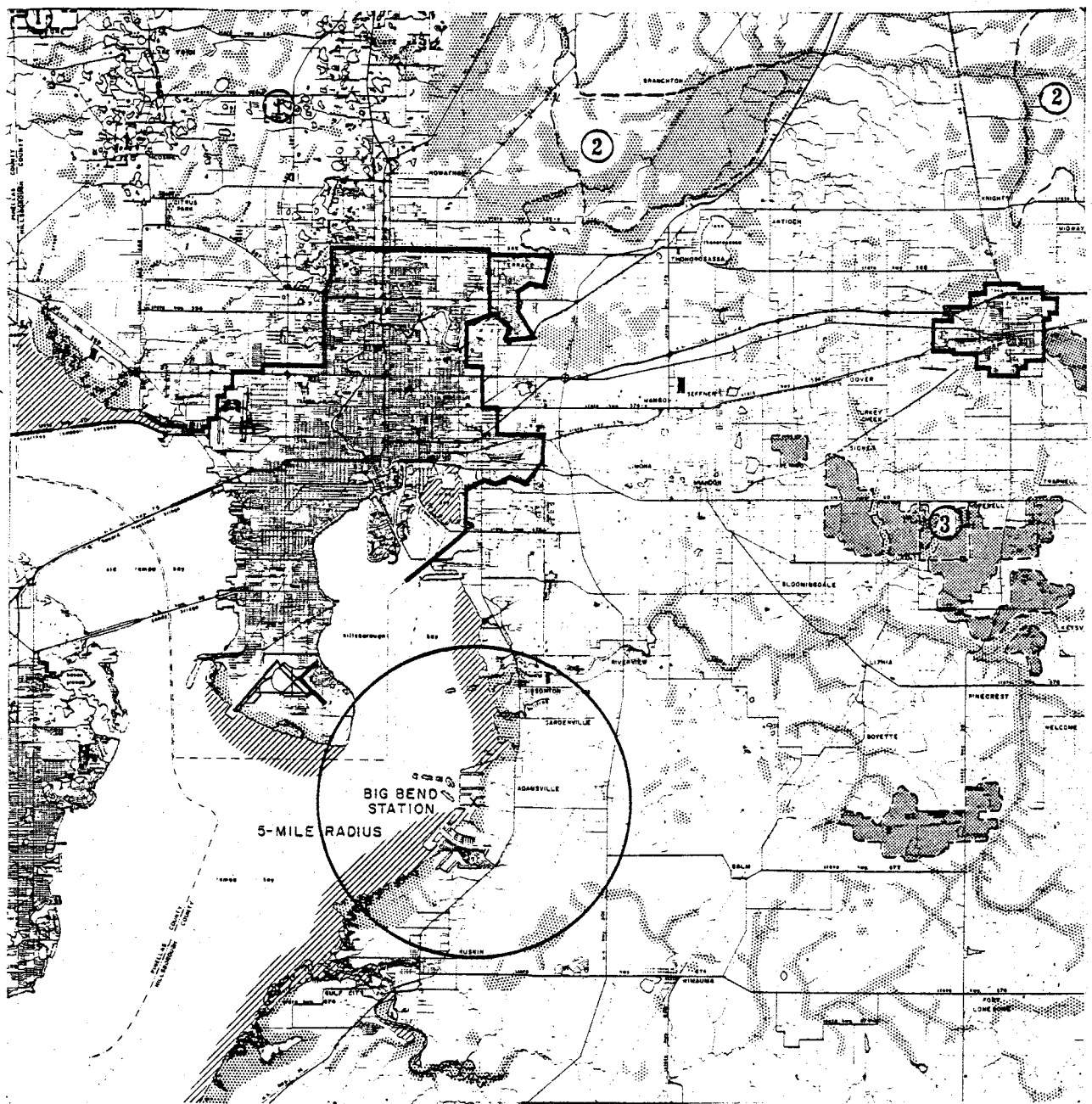


LEGEND

- AGRICULTURE
- ORCHARDS
- FISH HATCHERIES
- RESIDENTIAL
- MOBILE HOMES
- COMMERCIAL
- INDUSTRIAL
- PUBLIC AND SEMI-PUBLIC
- RECREATION AND OPEN SPACE
- UNZONED
- SCHOOLS

0 1 2
SCALE - MILES

FIGURE 2.2-4
EXISTING LAND USE
BIG BEND STATION
TAMPA ELECTRIC COMPANY

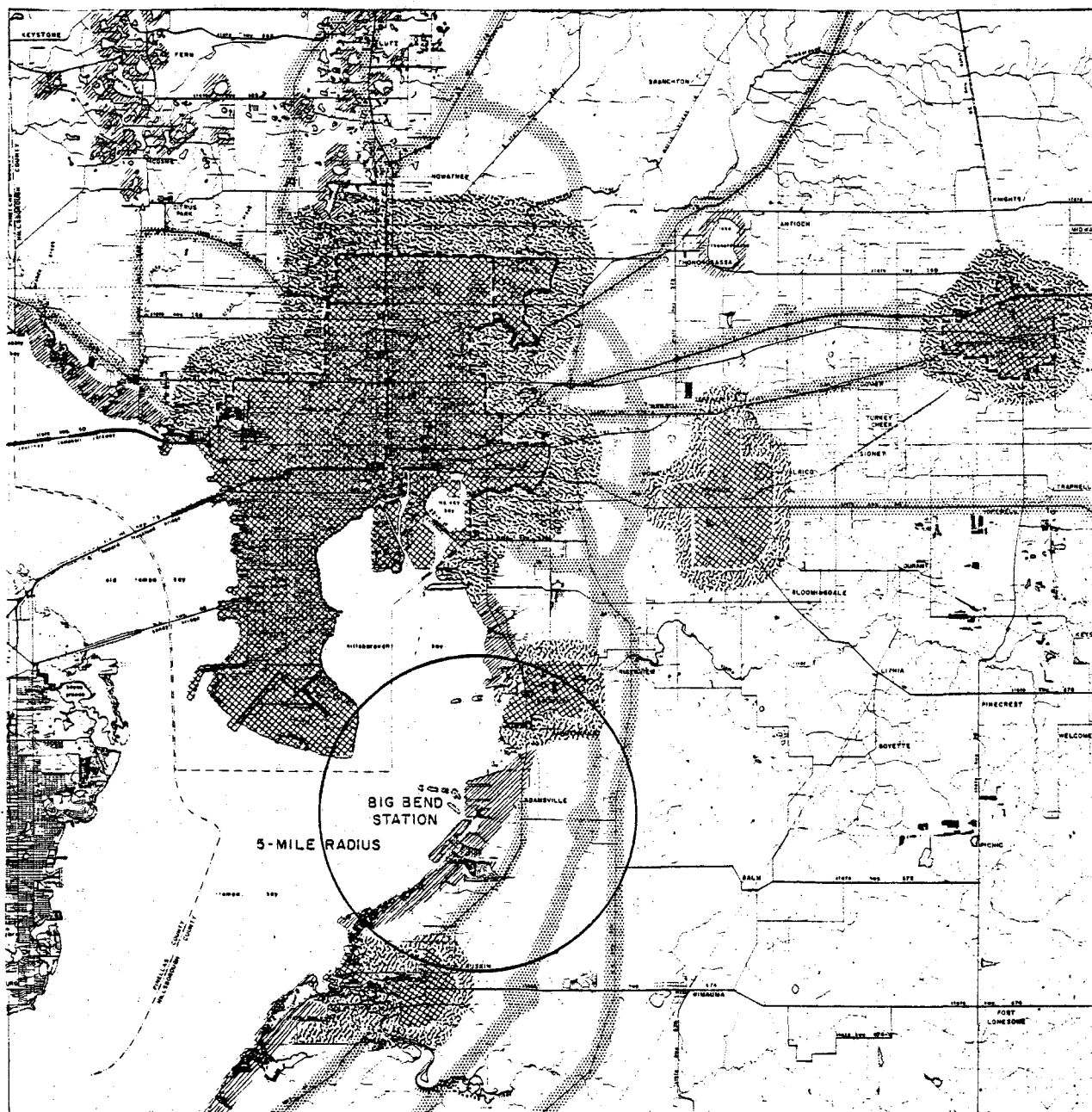


LEGEND

- MUNICIPAL BOUNDARIES
- PHOSPHATE MINING AREA
- /// ECOLOGICALLY SENSITIVE COASTAL WATERS
- ▨ SWAMP AND FLOOD PRONE AREA
- - - WATER RESOURCE AREA
- 1 EXISTING WELL FIELDS
- 2 PROPOSED RETENTION AREA
- 3 EXISTING RETENTION AREA

HILLSBOROUGH COUNTY PLANNING COMMISSION

**FIGURE 2.2-5
CONSTRAINTS TO
DEVELOPMENT
BIG BEND STATION
TAMPA ELECTRIC COMPANY**



LEGEND

-  EXISTING URBANIZED AREA
-  MUNICIPAL BOUNDARIES
-  AROUND EXISTING URBANIZED AREA
-  ALONG MAJOR HIGHWAYS
-  ALONG SHORELINES

FIGURE 2.2-6
HIGH PRESSURE AREAS
FOR DEVELOPMENT
BIG BEND STATION
TAMPA ELECTRIC COMPANY

(LAND USE ELEMENT)
HILLSBOROUGH COUNTY
GENERALIZED LAND USE MAP
YEAR 2000

PROPOSED LAND USE DESIGNATIONS

URBAN DEVELOPMENT AREA (OCCUPANCY RATIO ESTIMATED 95%)
 1 RESIDENTIAL - Density 26-75 dwelling units per gross acre
 2 COMMERCIAL - As per commercial designation in the text
 3 INDUSTRIAL - As per industrial designation in the text

URBAN HIGH DENSITY NODES
 1 RESIDENTIAL - Density 76-200 dwelling units per gross acre
 (Other uses same as Urban)

URBAN TRANSITION DEVELOPMENT AREA (O.R. ESTIMATED 65%)
 1 RESIDENTIAL - Density 16-75 dwelling units per gross acre
 2 COMMERCIAL - As per commercial designation in the text
 3 INDUSTRIAL - As per industrial designation in the text

SUBURBAN DEVELOPMENT AREA (O.R. ESTIMATED 40%)
 1 RESIDENTIAL - Density 16-25 dwelling units per gross acre
 2 COMMERCIAL - As per commercial designation in the text
 3 INDUSTRIAL - As per industrial designation in the text
 4 AGRICULTURE - As per agriculture designations in the text

SUBURBAN ACTIVITY CENTER
 (All uses same as Suburban)

RURAL DEVELOPMENT AREA (O.R. ESTIMATED 15%)
 1 RESIDENTIAL - Density Below 10 dwelling units per gross acre
 2 COMMERCIAL - As per commercial designations in the text
 3 INDUSTRIAL - As per industrial designations in the text
 4 AGRICULTURE - As per agriculture designations in the text

RURAL ACTIVITY CENTER
 1 RESIDENTIAL - Density 0.25-20 dwelling units per gross acre (1/2 mile radius)
 (All uses same as Rural)

LIGHT INDUSTRIAL

HEAVY INDUSTRIAL

MAJOR PUBLIC

MAJOR PUBLIC OPEN SPACE

PRESERVATION - INLAND

PRESERVATION - WATER

★ PROPOSED ELECTRIC POWER PLANT SITE

WATER

COUNTY HIGHWAY CIRCULATION IMPROVEMENTS

— 8 LANE DIVIDED

— 6 LANE DIVIDED

— 4 LANE DIVIDED

— 4 LANE

— 2 LANE

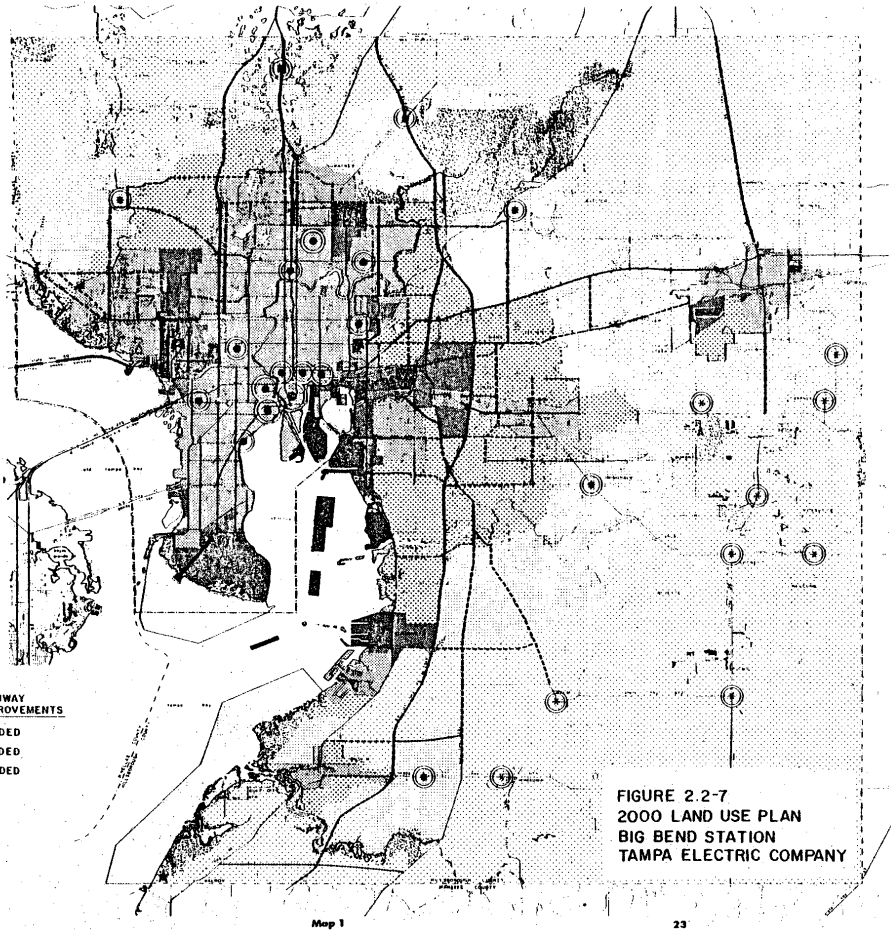
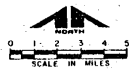


FIGURE 2.2-7
2000 LAND USE PLAN
BIG BEND STATION
TAMPA ELECTRIC COMPANY

Map 1

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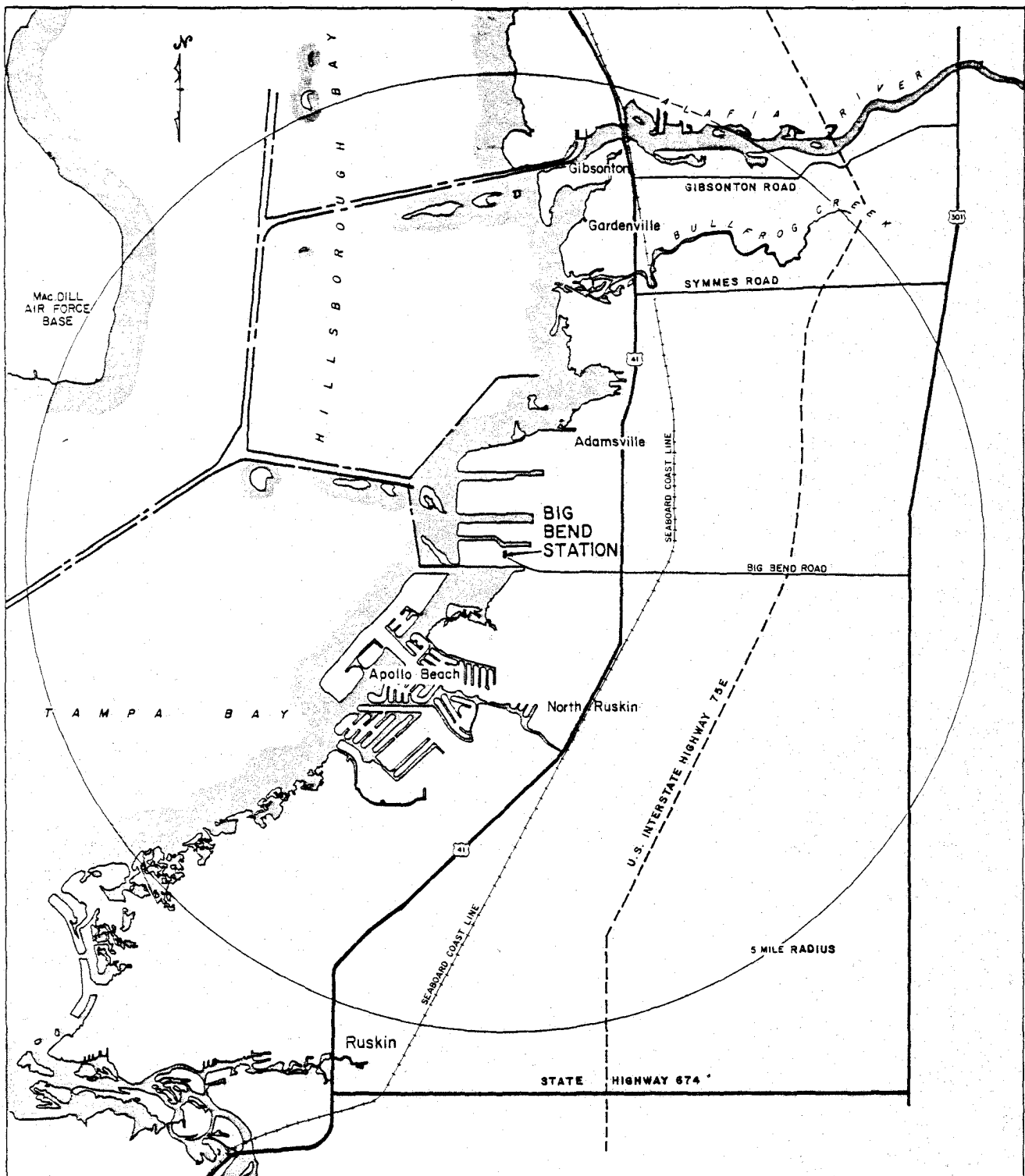


FIGURE 2.2-8
TRANSPORTATION
PRESENT AND PROPOSED
BIG BEND STATION
TAMPA ELECTRIC COMPANY

- PRIMARY ARTERIALS (EXISTING)
- SECONDARY ARTERIALS (EXISTING)
- - - EXPRESSWAY (PLANNED)
- + + + + + RAILROAD
- - - SHIPPING CHANNEL

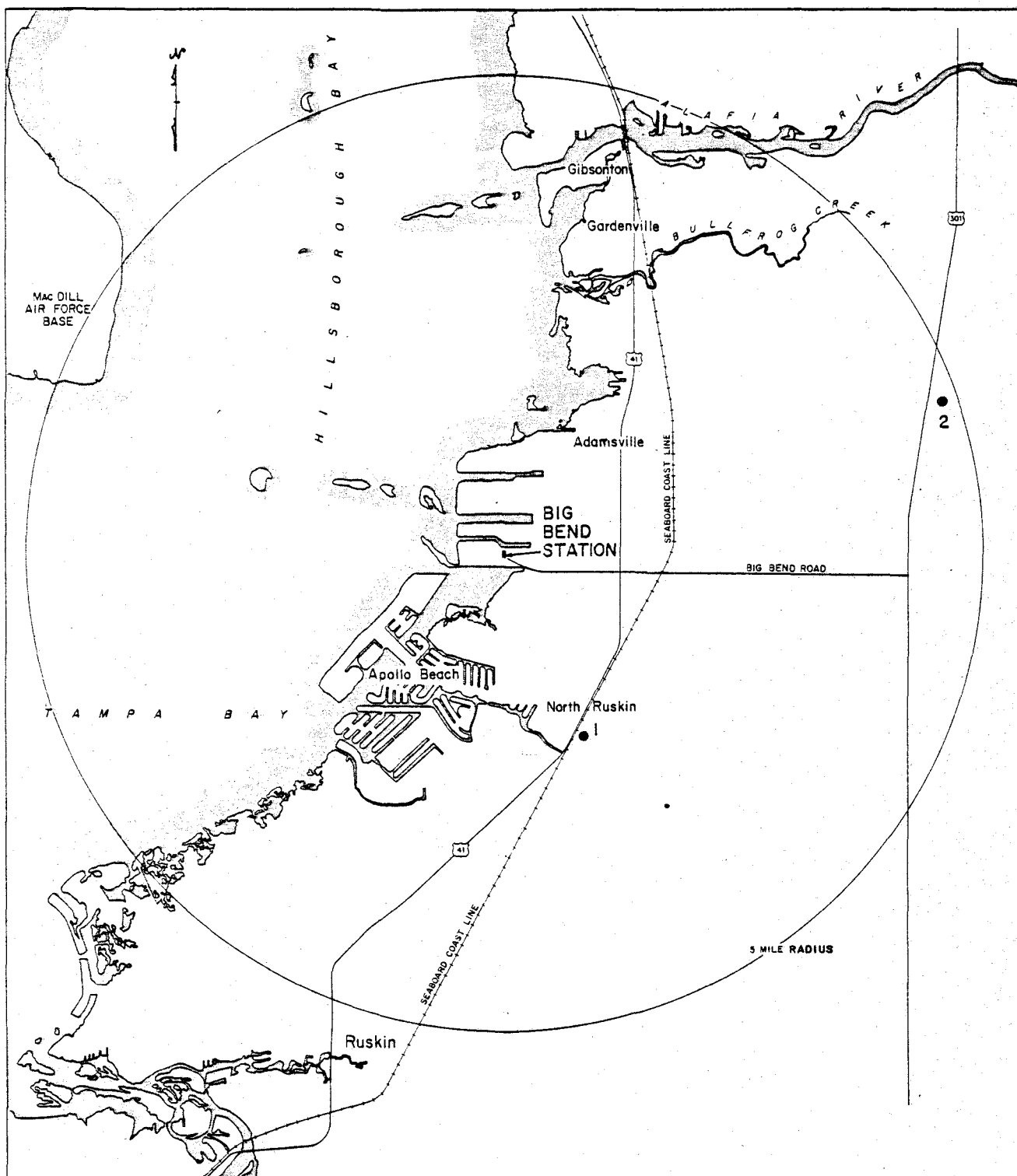


FIGURE 2.2-10
WELL FIELDS
BIG BEND STATION
TAMPA ELECTRIC COMPANY

1. APOLLO BEACH WELL FIELD AND PLANT
2. RIVERVIEW WELL FIELD AND WATER PLANT

2.3 REGIONAL HISTORIC, SCENIC, CULTURAL, AND NATURAL LANDMARKS

The National Register of Historic Places and the National Registry of Natural Landmarks were examined to determine if there are any nationally significant historic, scenic, cultural, or natural landmarks within a 5-mile radius of the Big Bend site. There were no such landmarks registered for this area. Since none of these sites exist within, or are in proximity to, the lands proposed for development of Big Bend Unit 4 and its associated facilities, the Applicant concludes that none will be affected by the proposed construction and operation.

The Florida Department of State, Division of Archives, History, and Records Management, was contacted to determine if there are any locations of archaeological significance on the state level within a 5-mile radius of the site. This contact revealed that there are 28 recorded archaeological sites in this area, and these are shown in Figure 2.3-1. None of the 28 sites are within the tracts of the proposed project and, therefore, none should be affected.

In 1979, Tampa Electric Company requested the Division to perform a cultural resource assessment of the area proposed for Big Bend Unit 4 and its associated facilities. The Division's review of the Florida Master Site File indicated that no archaeological or historic sites and properties are located within the tracts under investigation. In addition, the Division concluded that the proposed development within the indicated tracts is unlikely to affect any sites listed, or eligible for listing on the National Register of Historic Places and may therefore proceed without their agency's further involvement. The Division's findings confirm the Applicant's conclusions that no significant historic, scenic, or cultural landmarks with either national or state significance will be affected by the construction and operation of Big Bend Unit 4.

REFERENCES for 2.3

1. Personal Communication, letter from L. Ross Morrell, Florida State Archaeologist and Chief, Bureau of Historic Sites and Properties, to Stone & Webster Engineering Corporation, March 4, 1974.
2. Personal Communication, letter from L. Ross Morrell, Deputy State Historic Preservation Officer, to J.B. Ramil, Tampa Electric Company, July 13, 1979.

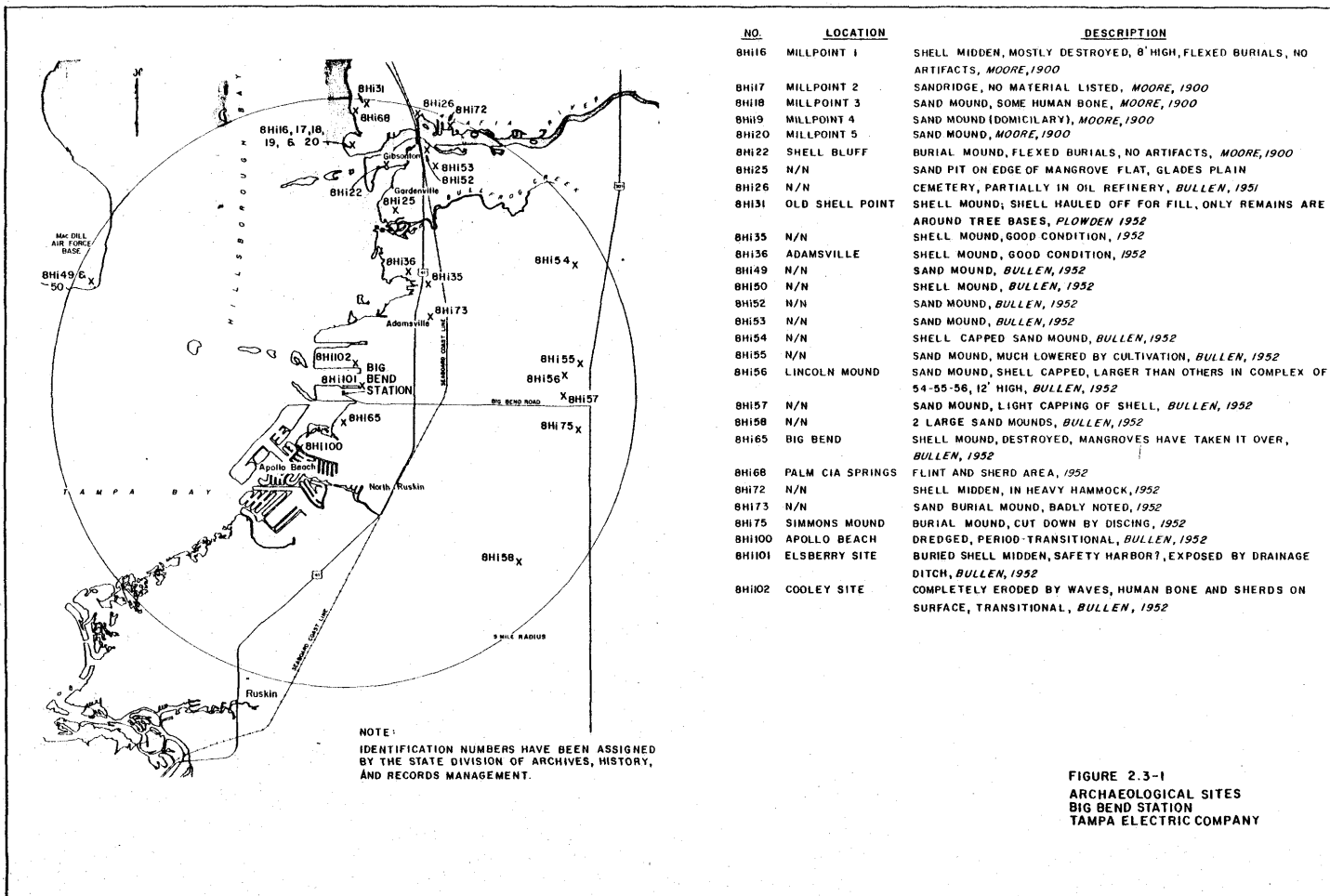


FIGURE 2.3-1
ARCHAEOLOGICAL SITES
BIG BEND STATION
TAMPA ELECTRIC COMPANY

2.4 GEOLOGY AND TOPOGRAPHY

This section includes descriptions of the topographic and geologic setting of the site, including both local and regional geology and geomorphology. Also included is a discussion of the earthquake history and susceptibility of the site and the surrounding region.

2.4.1 Topography

The Big Bend Station site is located in terraced coastal lowlands, a subdivision of the Gulf Coastal Plain province (Figure 2.4-1). The topography consists principally of marine terraces and associated features which were developed during Pleistocene time, several million years ago, and modified by recent erosion.

The actual plant site is located on artificial fill dredged from the bottom soils of Tampa Bay. The plant site and surrounding fill is graded to an essentially flat land surface. Natural land surfaces of the Pamlico terrace adjoining the site are nearly flat, broken only by shallow stream channels, swampy areas, and occasional localized depressed areas.

The present land surface was developed beneath the waters of a shallow sea, the so-called Pamlico Sea, of late Pleistocene time. The former shoreline of the Pamlico Sea is presently at an elevation of about 25 feet above sea level.

Several former shorelines, all formed during Pleistocene time, are present on the Florida peninsula, and the Pamlico shoreline is the lowest and youngest of these. During relatively stationary periods, shoreline features and marine plains, such as those now present as land surface surrounding the site, were developed and laid one on top of the other in layer-like fashion.

2.4.2 Regional Geology

The Hillsborough County area is underlain by 8,000 to 13,000 feet of sediments. These sediments have been deposited on crystalline basement rocks and include sandstone, anhydrite, and dolomite of Mesozoic age overlain by limestone, dolomite, clay, and sand of Cenozoic age. Figure 2.4-2 is a regional geological map of Florida. The stratigraphy of the upper 1,000 feet of rock units underlying the site area is exhibited in Figure 2.4-3. These figures illustrate the following:

1. Eocene Series (60-40 million years old)

Avon Park Limestone - crystalline, lignitic, porous dolomite in the lower part; chalky, granular, foraminiferal limestone in the upper part.

Ocala Group - granular, chalky, fossiliferous coquina limestone.

2. Oligocene Series (40-25 million years old)

Suwannee Limestone - granular, porous, fossiliferous limestone; crystalline and dolomitic in part.

3. Miocene Series (25-11 million years old)

Tampa Formation - sandy, porous to dense limestone; silicified in part.

Hawthorn Formation - clay and marl interbedded with sandy limestone, sand, silt, and shell beds.

4. Late Miocene and Pliocene Series (11-1 million years old)

Sand and gravel with phosphate, shells, clay, and lignite.

5. Pleistocene Series (less than 1 million years old)

Older terrace deposits - sand, silt, and some clay.
Pamlico Sand - sand with shells, calcareous clays, and occasional limestone.

The rocks of the Cenozoic age in this area were deposited in horizontal strata; however, during deposition, the land subsided toward the southwest, resulting in a thickening of sediments in that direction.

The formation of the Florida Plateau (peninsula) is attributed to the development of a long, gentle arch with its axis oriented nearly parallel to the peninsula. Near the end of the Oligocene, the Ocala uplift was developed. The cause of this structure is not known; however, it has been suggested that it was produced by compressive crustal stresses. The uplift resulted in a broad, elongate dome that trends southeast. The Oligocene and Miocene formations were developed on the flanks of this growing dome, resulting in the thickening mentioned above.

Longitudinal tension fractures, oriented parallel to the peninsula axis, are common in the Cenozoic rocks. These fractures developed as stress-relief features in response to the forces which produced the Ocala uplift. Typically,

these fractures are minor structures; however, occasional displacements of up to 200 feet have been noted.

The remnants of four shorelines and five marine terraces of Pleistocene age have been identified in the area surrounding the site. The rise and fall of the sea which produced these terraces is attributed to the advance and retreat of the continental glaciers (with sea level rising during interglacial periods and falling during glacial periods). These shoreline features and marine plains developed during periods of relative stability. The shorelines are now marked by topographic escarpments. The five terraces and the altitude of their shorelines are listed below.

1. Sunderland - 170 feet
2. Wicomico - 100 feet
3. Penholoway - 70 feet
4. Talbot - 42 feet
5. Pamlico - 25 feet

The contacts and internal stratification of these Pleistocene terraces are essentially horizontal and undisturbed.

2.4.3 Site Surficial Geology

The topsoils surrounding the site are either highly organic with matted roots for about 1-foot thickness (in the swampy areas) or fine to medium sands (in the sand flats).

The soil immediately below the topsoil is generally a mixture of silty sand and shells for a depth of 20 to 30 feet. Hard, partially cemented clay occasionally occurs within 15 feet of the ground surface. Surface exposures of weakly cemented coquina are present.

The sands, shells, and clays of the Pamlico terrace cover the surface of most of the site to an average depth of 20 feet. In general, these materials are uncemented, except for the shell beds which may be very weakly cemented. The Pamlico terrace, deposited in late Pleistocene time, has been partially eroded by the action of surface waters. There is considerable variation in density in this stratum. Investigations indicate that a minimum of 10 feet of loose sandy soils may occur within 30 feet of the ground surface. Generally, dense to very dense sandy soils are typical of the Pamlico terrace.

These recently deposited sandy soils range from poorly draining, claylike, silty sands to relatively free-draining sand/shell mixtures.

The unconsolidated materials deposited in the Pleistocene seas overlies layered sedimentary rocks of Miocene age, the Hawthorn Formation and the Tampa Limestone. These Tertiary formations are composed principally of carbonate rocks, although the Hawthorn Formation contains a number of uncemented sediments.

2.4.4 Site Bedrock Geology

The Hawthorn Formation of Tertiary (Miocene) age lies beneath the Pleistocene deposits and conformably overlies the Tampa Limestone. It consists of grayish, sandy, calcareous and phosphoritic clays with interbedded thin layers of light-colored limestone and partially cemented shell layers. Occasionally, the limestone and shell layers provide local and restricted sources of groundwater. The Hawthorn Formation is exposed near the site in places where the Pamlico terrace has been removed by erosion. The unit is about 65 feet thick at the site.

The Tampa Formation of Tertiary (Miocene) age is present beneath the site at about 65 feet below sea level and is believed to be about 400 feet thick in this area. The Tampa Formation consists of a light-colored, sandy, coquina limestone, partly silicified, and is notable as a source of artesian water. The Tampa Formation is underlain by thousands of feet of carbonate and phosphate rocks which form the Florida peninsula and the surrounding continental shelf.

Communication with the Florida State Board of Conservation indicates that the area of the Big Bend site has been defined as a low probability area for sinkholes within 100 feet of the ground surface.

Topographic maps and aerial photographs of the site and adjacent areas show numerous small depressions. Studies indicate such depressions may be the result of solution and collapse features which could be presently active. These features are attributed to the continuing solution removal of localized and discontinuous shell beds in the Pamlico terrace and Hawthorn Formation. These shell beds are usually concentrated along the positions of former shorelines and are rather small and discontinuous features.

2.4.5 Subsurface Soil and Rock Conditions

2.4.5.1 Ash Disposal Area

Thorough soils investigations in the vicinity of the proposed power station and the ash disposal area have been made.⁽¹⁾ These investigations have determined that the ash disposal area is underlain by the following sequence of soils, as illustrated in Figure 2.4-4:

1. Silty fine sand
2. Shells and shell fragments in a silty fine sand matrix
3. Silty sand and clayey sand
4. Marl
5. Interbedded limestones and clays

A description of the engineering properties of these materials is provided in the following paragraphs.

1. Silty Fine Sand

The surface soil zone consists of a layer of dark gray to black fine sand of very uniform grain size. About 3 to 15 percent by weight of the soil is fine enough to pass a No. 200 mesh sieve (U.S. Standard). Approximately 2 percent by weight of the soil is organic material. This surface layer varies in thickness from approximately 4 to 10 inches with an average of about 7 inches. The upper portion of this zone contains many fine roots and weeds. This soil has served as the topsoil for tomato fields.

The topsoil is underlain by a layer of very light gray to white fine sand of very uniform grain size. Approximately 3 percent by weight of the soil passes the No. 200 mesh sieve. This stratum varies in thickness from 0 to 20 inches with an average of about 8 inches.

Underlying the light gray sand is a layer of brown fine sand of very uniform grain size; 3 to 14 percent by weight of the soil is fine enough to pass the No. 200 mesh sieve. This stratum varies in thickness from 0 to 9 inches with an average of about 3 inches.

2. Shell Bed

Underlying the surface layer of fine sand is a shell bed consisting of shells and shell fragments in a matrix of fine sand. Due to the varying shell fragment sizes, the material

is widely graded. The shell content varies from 20 to 50 percent by weight; approximately 7 to 25 percent by weight of the material passes the No. 200 mesh sieve. The material is loose to compact and at times very highly cemented. The average permeability of this zone is estimated to be less than 5×10^{-3} cm/sec. However, the permeability is extremely high in cemented zones or zones containing a high percentage of shell fragments. This layer varies in thickness from approximately 3 to 10 feet.

3. Silty Sand

Underlying the upper sand and shells is a zone of silty or clayey fine sand with approximately 2 to 20 percent by weight composed of fines passing through a No. 200 mesh sieve. An estimate of permeability for this zone is 10^{-5} cm/sec. The silty sand zone ranges in thickness from 5 to 15 feet.

4. Marl

Underlying the sand sequence is a layer of marl consisting of calcareous silty clays, clayey silts, and sandy clays varying in color from very light yellowish gray to greenish gray. The material is highly plastic with approximately 2 to 5 percent medium to fine sand, sometimes cemented into nodules, approximately 0.1 to 0.2 inches in diameter. This stratum is very stiff with blow counts usually in excess of 50 blows per foot.

5. Bedrock

Underlying the recent soil deposits are the interbedded limestones and clays of the Hawthorn Formation. The top of rock is located at approximately elevation -40 msl at the western boundary of the ash pond site and slopes gently upward towards the east to approximately elevation -25 msl near U.S. Highway 41.

The limestone is highly weathered and fractured. There is evidence of solution activity along fractured zones although no extensive open cavities have been encountered.

The clays of this formation are very stiff and usually sandy with gravel-size pieces of phosphate, limestone, and hard nodules of pure clay. In places, the residual character of the soil is evidenced by clear indications of the former rock structure. Investigations by Stone & Webster Engineering Corp. in this area indicate that the Hawthorn

Formation averages about 65 feet in thickness at the Big Bend site.

2.4.5.2 Power Plant Site

The investigations have determined that the power plant site is underlain by the sequence of soils given below. Location of numerous borings onsite drilled as a part of these investigations are shown on Figures 2.4-5a and b.

1. Tampa Bay dredgings
2. Sandy silt
3. Silty sand and clayey sand
4. Marl
5. Interbedded limestones and clays

A description of the engineering properties of these materials is provided in the following paragraphs.

1. Tampa Bay Dredgings

The surface deposits consist of dredgings from Tampa Bay used to raise the grade of the plant to above the water line. The dredgings are predominantly a light gray, very fine sand of uniform grain size. Between 10 and 25 percent by weight of the soil is fine enough to pass through a No. 200 mesh sieve. Less than 5 percent by weight of the soil is gravel particles ranging in size from 1/4 to 1/2 inch. Five to ten percent by volume of marine life shells were also indicated by visual inspection. The thickness of the dredgings ranges from 10 to 15 feet in the plant area.

Since the dredgings were placed by slurry methods, localized pockets of predominantly (up to 90 percent by weight) silt materials occur randomly throughout the fill. Such pockets are a result of depressions in the surface of the fill being filled with slurry-water draining from the sands and depositing the fine-grained materials. These pockets are up to 2 feet in thickness.

2. Sandy Silt

Underlying the hydraulic fill are the original bay bottom deposits, consisting of a dark gray to green silt. Generally a very fine sand of uniform grain size can account for up to 30 to 40 percent by weight of the soil. The silt is nonplastic and very loose. Shell fragments and organic matter are present in this soil. The thickness of this deposit is generally only several feet (3 to 4) and varies over the site.

3. Silty Sand

Underlying the upper sand and shells is a zone of silty or clayey fine sand with approximately 2 to 20 percent by weight composed of fines passing through a No. 200 mesh sieve. An estimate of permeability for this zone is 10^{-5} cm/sec. The silty sand zone ranges in thickness from 15 to 20 feet.

4. Marl

Underlying the sand sequence is a layer of marl consisting of calcareous silty clays, clayey silts, and sandy clays varying in color from very light yellowish gray to greenish gray. The material is highly plastic with approximately 2 to 5 percent medium to fine sand, sometimes cemented into nodules, approximately 0.1 to 0.2 inches in diameter. This stratum is very stiff with blow counts usually in excess of 50 blows per foot.

5. Bedrock

Underlying the recent soil deposits are the interbedded limestones and clays of the Hawthorn Formation. The top of rock is located at approximately elevation -40 msl at the western boundary of the ash pond site and slopes gently upward towards the east to approximately elevation -25 msl near U.S. Highway 41.

The limestone is highly weathered and fractured. There is evidence of solution activity along fractured zones, although no extensive open cavities have been encountered.

The clays of this formation are very stiff and usually sandy with gravel-size pieces of phosphate, limestone, and hard nodules of pure clay. In places, the residual character of the soil is evidenced by clear indications of the former rock structure. Investigations by Stone & Webster Engineering Corp. in this area indicate that the Hawthorn

Formation averages about 65 feet in thickness at the Big Bend site.

2.4.6 Seismicity

Few earthquakes have occurred in or near Florida since the earliest recorded history in 1663. The U.S. Coast and Geodetic Survey designated Florida as a Zone 0 area, a zone of little or no probability of earthquake damage. There are fairly well documented records of 14 different earthquakes within the past 300 years with epicenters in or near the state of Florida. These areas are shown in Figure 2.4-6. Two of these had estimated epicentral intensities of VI (Modified Mercalli Scale). Eleven others had epicentral intensities between IV and V. One or two of the older reports have not been positively identified as earthquakes.

Only two earthquakes are known to have occurred within 100 miles of the site, and one of these occurrences is only tentatively attributed to a seismic source. The other occurred in 1930 and had an estimated epicentral intensity of V.

There have been six other shocks which were probably felt in central Florida and with epicenters more remote from the site. These include the Charleston, South Carolina earthquake of 1886, earthquakes near Savannah, Georgia, and some of the earthquakes occurring in the Caribbean. The strongest of these was the Charleston earthquake, with an estimated epicentral intensity of X.

The nearest region of intensive earthquake activity is the Caribbean area; however, there is no correlation between the Caribbean epicenters or activity and the southeastern United States. An earthquake in 1880, with an epicenter in Cuba, was felt in southern Florida; this is the only Caribbean earthquake whose effects have been definitely established as having been noticed anywhere in Florida.

To summarize, Florida is an area of very little earthquake activity and the probability of a moderate or severe earthquake occurring at or near the site is very low.

REFERENCES for 2.4

1. Stone & Webster Engineering Corporation, Big Bend Site: Geotechnical Field Investigations for Spray Cooling Canal. Tampa Electric Company, August 8, 1973.

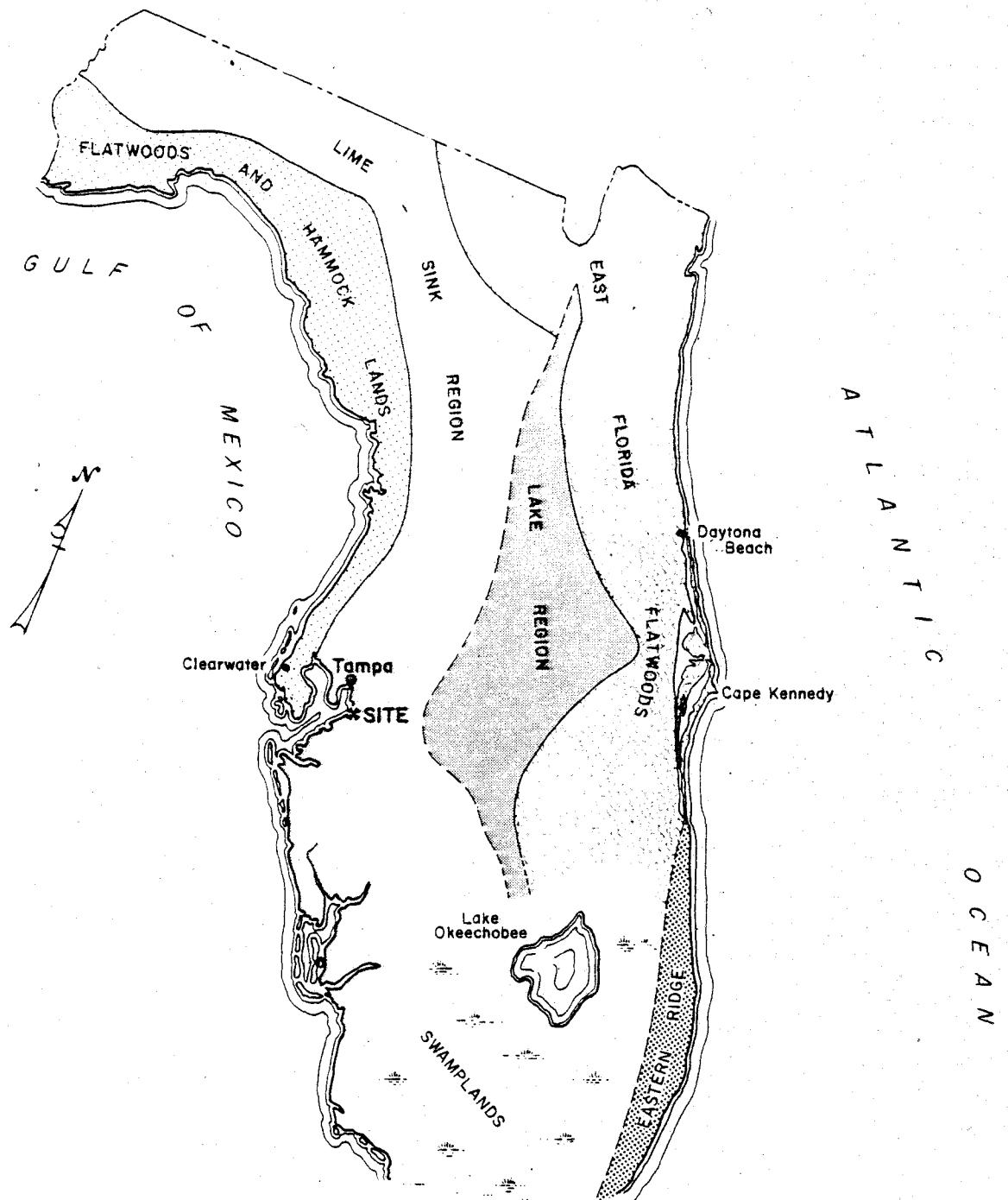
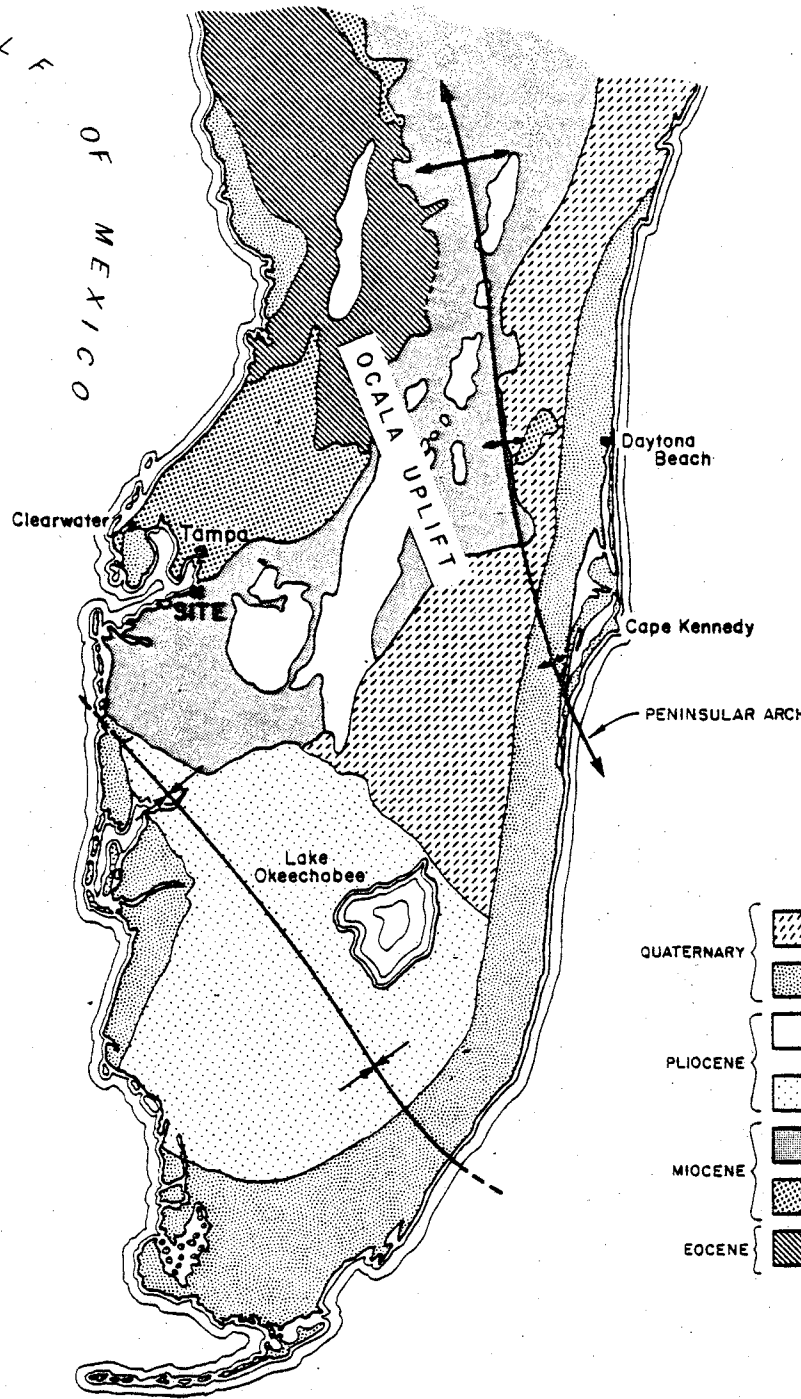


FIGURE 2.4-1
REGIONAL PHYSIOGRAPHIC MAP
BIG BEND STATION
TAMPA ELECTRIC COMPANY

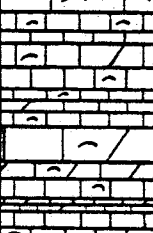
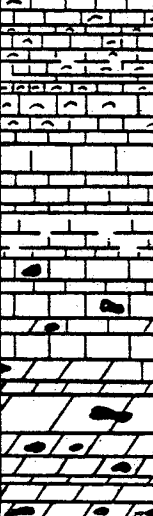
GULF
OF MEXICO

ATLANTIC
OCEAN



EXPLANATION	
QUATERNARY	COASTAL AND ESTUARINE SAND AND GRAVEL - Q_s
	MARINE LIMESTONE - Q_l
PLIOCENE	CONTINENTAL DEPOSITS RIVER AND ESTUARY TERRACE DEPOSITS - P_c
	MARINE SHELL MARL - P_m
MIOCENE	ALUM BLUFF GROUP AND YOUNGER BEDS - M_{ab}
	TAMPA LIMESTONE - M_t
EOCENE	JACKSON GROUP (OCALA LIMESTONE) - E_j

FIGURE 2.4-2
REGIONAL GEOLOGICAL MAP
BIG BEND STATION
TAMPA ELECTRIC COMPANY

Age	Thickness	Graphic Log
Pleistocene	0-60	
Late Miocene and Pliocene	0-20	
	0-25	
Miocene	10-150	
	50-200	
Oligocene	200-225	
Eocene	250 ±	
	600-700	

PAMLICO SAND - SAND, SHELLS, LIMESTONE, CALCAREOUS CLAY.

OLDER TERRACE DEPOSITS - SAND, SILT, SOME CLAY.

UNDIFFERENTIATED DEPOSITS - SAND, QUARTZ AND PHOSPHATE GRAVEL, upper - BONE FRAGMENTS, lower - LIGNITE.

HAWTHORN FORMATION - GREEN/GREY, BLUE/GREY, SANDY, PHOSPHATIC CLAY AND MARL, SANDY LIMESTONE, SAND, SILT, AND SHELL INTERBEDS.

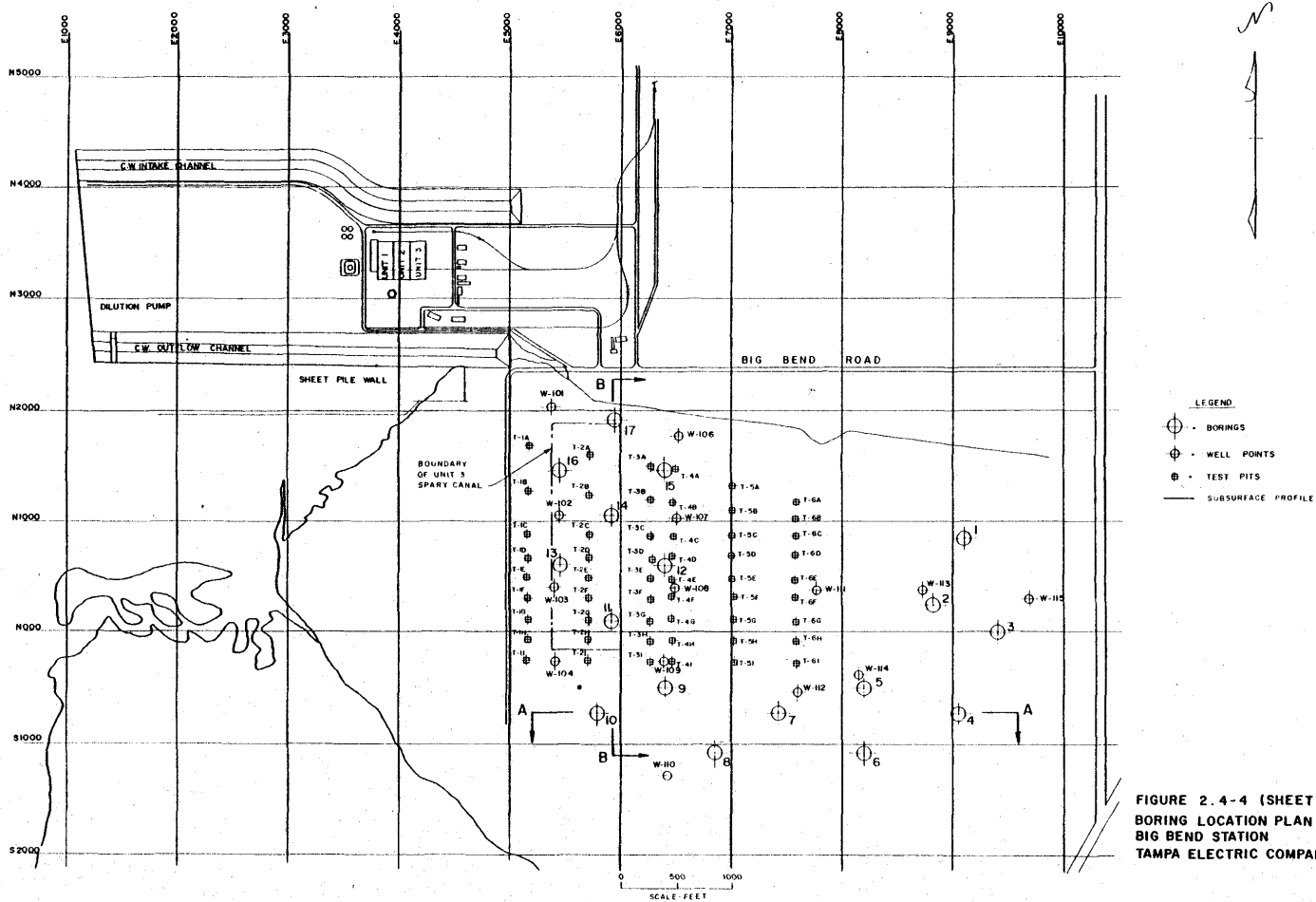
TAMPA FORMATION - WHITE TO GREY AND TAN, FAIRLY HARD, POROUS TO DENSE, SANDY, FOSSILIFEROUS LIMESTONE, OCCASIONALLY SILICIFIED.

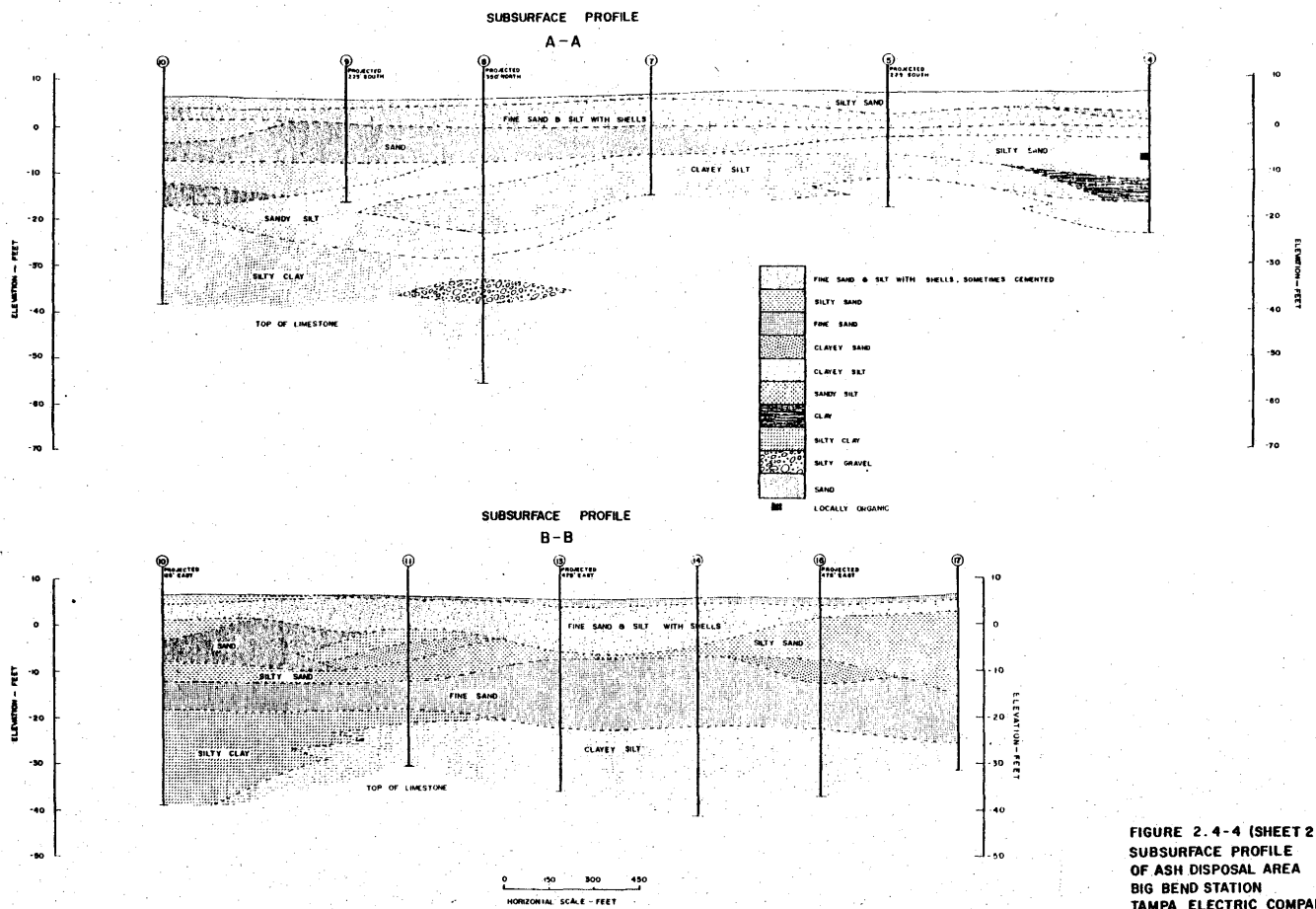
SUWANNEE LIMESTONE - WHITE TO TAN, MODERATELY SOFT, GRANULAR, POROUS, FOSSILIFEROUS, LIMESTONE, OCCASIONALLY DOLOMITIC AND CRYSTALLINE.

OCALA GROUP - WHITE, CREAM, AND TAN, SOFT, GRANULAR, CHALKY, FOSSILIFEROUS LIMESTONE, OCCASIONALLY COQUINOID.

AVON PARK LIMESTONE - upper - WHITE TO TAN, SOFT, SLIGHTLY CHALKY, GRANULAR, FORAMINIFERAL LIMESTONE, lower - TAN TO DARK BROWN, HARD, VERY POROUS, CRYSTALLINE DOLOMITE, OCCASIONALLY LIGNITIC.

FIGURE 2.4-3
GENERALIZED STRATIGRAPHIC
SECTION
BIG BEND STATION
TAMPA ELECTRIC COMPANY





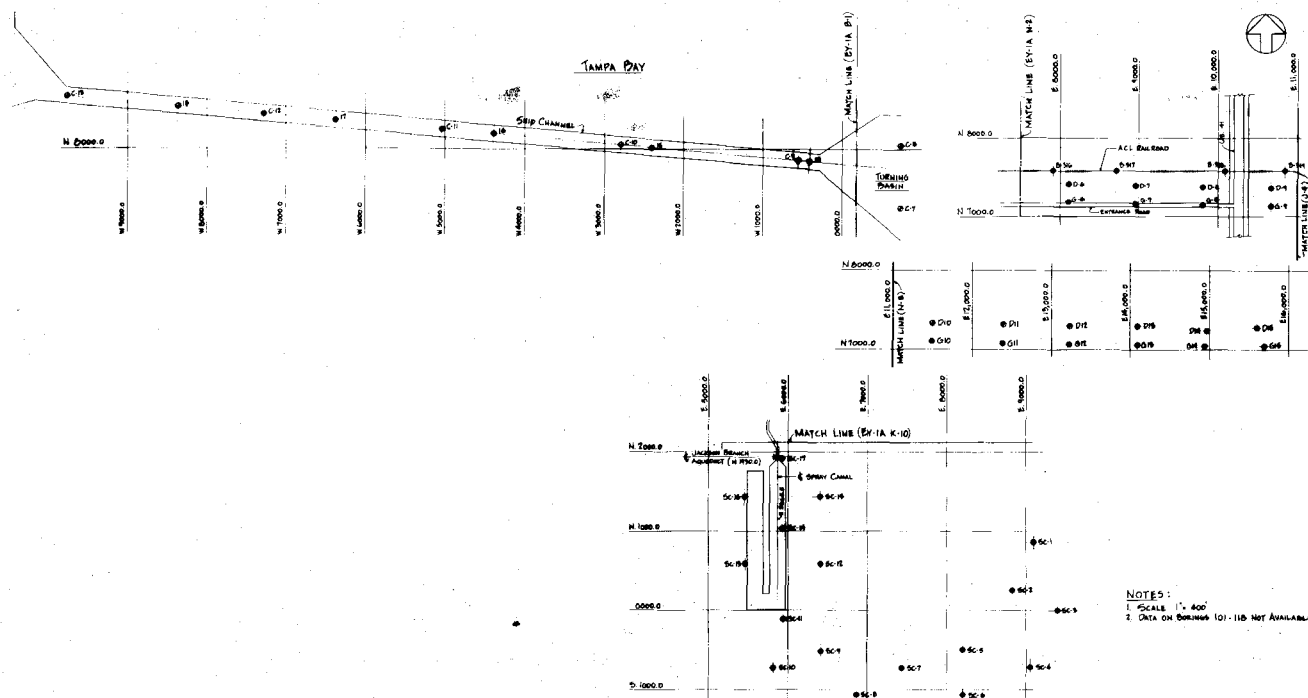


FIGURE 2.4-5B
BORING LOCATION PLAN
BIG BEND STATION
TAMPA ELECTRIC COMPANY

2.5 HYDROLOGY

2.5.1 Affected Waters

The Tampa Bay system is centrally located on the west coast of Florida, as shown on Figure 2.5-1. The main components of this estuary are Tampa Bay, Old Tampa Bay, Hillsborough Bay, McKay Bay, Boca Ciega Bay, and Terra Ceia Bay which together make up a surface area of about 350 square miles and a total shoreline length of about 210 miles.^(1,2) The Tampa Bay system extends about 35 miles north to south and has a maximum width of about 21 miles east to west. The mean water depth is 11 feet, and 90 percent of the estuary is less than 22 feet deep.⁽³⁾

The drainage area of the Tampa Bay system is estimated to be 2,162 square miles. The freshwater addition to this system originates mainly from the Hillsborough, Alafia, Palm, Little Manatee, and Manatee Rivers. The mean annual discharge rate from these rivers and lesser sources is about 1,550 cubic feet per second (cfs).⁽⁴⁾

Hillsborough Bay comprises the northeast sector of the Tampa Bay system, and is approximately 8 miles long and 4 miles wide with a surface area of about 35 square miles.⁽⁵⁾ The average water depth is 10 feet. Shipping channels are maintained in the bay at 34-foot depths but are presently being deepened to 40-feet. Shoreline slopes are gentle. The 6-foot water depth contour is located about 1,200 feet off the west shore and 3,600 feet off the east shore.⁽³⁾ The Hillsborough, Palm, and Alafia Rivers drain into this bay, and the total mean annual discharge rate is about 1,120 cfs.⁽⁴⁾

The water quality of Hillsborough Bay is summarized in Table 2.5-1.

Currents and Tides

There is considerable variation both of magnitude and of direction in the Tampa Bay system currents. Currents are predominantly tidal, except for occasional wind-induced surface currents. Current velocity at the mouth of the bay sometimes exceeds 6.0 feet per second (fps) during maximum tidal ebb conditions. Current velocity during maximum tidal flood conditions rarely exceeds 3.5 fps at the mouth of the bay. This relationship of maximum ebb and flood currents is generally observed throughout the bay system.⁽⁴⁾

The pattern of water movement in the Tampa Bay system is predominantly counterclockwise. Flood flow entering the estuary is normally directed along the deeper eastern shore due to the incidence angle between Tampa Bay and the Gulf of

Mexico. The presence of Old Tampa Bay in the northwest sector tends to direct ebb flow emanating from this area along the western shore, thus completing the counterclockwise current rotation.⁽⁴⁾

The tidal currents of Hillsborough Bay are generally weak and variable with the velocity seldom more than 1 fps.⁽⁵⁾ There are several spoil banks in the bay which have been created from dredged material. These appear to cause locally erratic current direction and circular currents. A mathematical model of water movement in the bay indicated that several circular currents might exist due to the presence of spoil piles in the bay.⁽⁶⁾ A circular movement was predicted to be located just west of the Big Bend Station and south of the spoil islands shown on Figure 2.5-1. The net movement of water in this area was predicted to be in a counterclockwise direction. Data from a float study just offshore from the Big Bend Station indicated that a counterclockwise current movement was predominant south of the line of spoil islands, while a clockwise current movement existed to the north of these islands.⁽⁷⁾

A model study performed by the United States Geological Survey indicated that a predominantly counterclockwise current circulation occurs in Hillsborough Bay. The net water transport model predicted minimal water exchange between Tampa and Hillsborough Bays. In apparent contradiction with previous studies, the model predicted a counterclockwise circulation pattern immediately north of the spoil islands, and a clockwise circulation pattern south of the islands.⁽⁸⁾

Tides in the Tampa Bay system are predominantly diurnal with a strong semi-diurnal component, i.e., two high tides and two low tides per day. The semi-diurnal characteristic increases from the mouth to the head of the estuary.⁽⁴⁾ The Tampa Bay system experiences a diurnal tide range from 2.0 to 2.8 feet, and Hillsborough Bay experiences a diurnal tide range of about 2.8 feet.⁽⁶⁾ The average water level in Tampa Bay is 0.5 feet above mean sea level.⁽⁴⁾ The average water level in Hillsborough Bay is 1.4 feet above mean sea level.⁽³⁾ Generally, high tides at the estuary mouth precede those in the upper bay by about 3 hours. Low tides at the estuary mouth generally occur about 4 hours earlier than those in the upper bay. However, the wind effect from climatic frontal activity can produce water level fluctuations equal to or greater in magnitude than tidal effects.⁽⁴⁾

Salinity

Horizontal salinity gradients exist within the Tampa Bay system. At the mouth of the estuary, salinity values seldom drop below 33 to 34 parts per thousand (ppt) because of the influence of the Gulf of Mexico. In Hillsborough Bay, salinity values normally range between 20 and 28 ppt. This salinity level reduction is due to freshwater inflow sources and from the effluent of the Tampa Sewage Treatment Plant. The salinity gradient changes slightly in character throughout the year due to the variability in seasonal runoff patterns.⁽⁴⁾

Salinity data was acquired during an intensive monitoring program which was conducted between January 1976 and March 1977 in Hillsborough Bay.⁽³⁾ Salinity values for the study period were found to range from 6.8 ppt at the mouth of the Hillsborough River to 34.9 ppt in the Egmont Channel just north of Egmont Key. The southern part of Hillsborough Bay showed average salinity values of 22.0 to 26.0 ppt. Salinity values were lowest during months of greater rainfall and highest during the drier months. Salinity is typically well-mixed, and was found to increase slightly from surface to bottom.

Water Classification

Tampa Bay water adjacent to the Big Bend Station has been classified by the State of Florida Department of Environmental Regulation as Class III, suitable for recreation and propagation - management of fish and wildlife. Nearby ship access channels and dock areas are designated Class III.

Approximately 80 percent of Old Tampa Bay is classified as Class II water, suitable for shellfish harvesting; the remainder is Class III. About 55 percent of Upper and Lower Tampa Bay is classified as Class III water with the remainder designated Class II. McKay Bay is Class III water. Most of Hillsborough and Boca Ciega Bays are Class III water. Egmont Key and Mullet Key areas are Class II water.⁽⁴⁾

The appropriate Class III water standards applicable to Hillsborough Bay are included in the presentation of water quality characteristics shown in Table 2.5-1.

Sedimentation

Sand and shelly sand are the predominant sediment types throughout the estuary. Localized deposits of silt and clay are found in the poorly drained natural and man-made

depressions throughout the bay system. These deposits are principally the result of disposal of dredge material and poorly treated sewage. Sediments in upper reaches of the estuary have a smaller mean grain size than those sediments nearer the Gulf. This is mainly due to a progressively greater proportion of shell fragments in sediments near the Gulf.

Silt and clay fractions increase inland from the mouth of the estuary. Frequent passage of deep-draft ships keeps these particles in suspension in the area of ship channels. Greater deposits of silt and clay are generally found in the less turbulent waters adjacent to a ship channel than at the channel bottom. Sediments outside the channel areas of Upper Tampa and Hillsborough Bays contain 20 to 50 percent fine-grained material. Sources of sediment in Hillsborough Bay are the Hillsborough, Palm, and Alafia Rivers, as well as from municipal sewage treatment plants and several industries. Relatively low current velocity and poor flushing characteristics in this bay allow fine material to settle to the bottom and remain in the system.⁽⁴⁾

Chemical Description

Hillsborough Bay water is moderately buffered with little seasonal fluctuation in pH. The concentrations of the six major dissolved ionic constituents (calcium, chloride, magnesium, potassium, sodium, and sulfate) closely parallel average concentrations in seawater, as shown in Table 2.5-1. Chloride concentrations are lower in the northern segment of the bay, reflecting the influence of freshwater input from the Alafia and Hillsborough Rivers on Hillsborough Bay water quality.⁽³⁾

Fluoride concentrations in this bay are generally higher than average seawater, particularly at the mouth of the Alafia River. Fluoride is a byproduct of phosphate mining operations, and several of these installations are located on the Alafia River. Average fluoride concentrations for 1975 ranged from a high of 10.4 mg/l near the mouth of the Alafia River to a low of 0.9 mg/l near Egmont Key. The eastern portion of Hillsborough Bay averaged greater than 2.5 mg/l fluoride with the remainder of Hillsborough Bay averaging between 2.0 and 2.5 mg/l.⁽³⁾

In a study performed in 1975, turbidity decreased and light penetration increased in a general north to south pattern in Hillsborough Bay, reflecting the impact of wastes discharged into the northern portion of the bay. Near Big Bend Station, water clarity is similar to that of Tampa Bay.⁽³⁾

Turbidity measurements made in 1975 in Tampa Bay ranged from 7.0 Jackson Turbidity Units (JTU) near Big Bend Station to

2.3 JTU near Mullett Key.⁽³⁾ Mean values of turbidity in the estuary are 13.7 JTU in Hillsborough Bay, 7.4 JTU in Old Tampa Bay, 7.9 JTU in Upper Tampa Bay, and 10.6 JTU in Lower Tampa Bay.⁽⁴⁾

Average values of light penetration measured in 1975 were 31 inches in McKay Bay, less than 50 inches in Hillsborough Bay, and 189 inches near Egmont Key.⁽³⁾

Corps of Engineers data show that throughout the estuary the water column is saturated or supersaturated with oxygen at most times. The yearly mean dissolved oxygen (DO) concentration in the estuary is about 6 mg/l. Mean values of DO in the estuary are 6.4 mg/l in Hillsborough Bay, 6.3 mg/l in Old Tampa Bay, 5.8 mg/l in Upper Tampa Bay, and 5.7 mg/l in Lower Tampa Bay.⁽⁴⁾

Measurements made in 1975 indicated that the majority of Tampa Bay showed surface DO of 7.0 mg/l or higher with values of 5.0 to 7.0 mg/l in Hillsborough Bay and southward along the eastern shore. Bottom DO of 5.0 to 7.0 mg/l extended over most of Tampa Bay with areas of 7.0 mg/l or more confined to the western shore of Tampa Bay southward to the Gulf. Nearly all of the bottom of Hillsborough Bay yielded DO values less than 5.0 mg/l.⁽⁴⁾

Water Temperature

Considerable variations of water temperature occur throughout the Tampa Bay system. Summer, fall, winter, and spring average temperatures for this estuary are 30°C, 23°C, 16°C, and 27°C, respectively.⁽⁴⁾ Annual mean and ranges of water temperature in the estuary are listed below:

<u>Area</u>	<u>Annual Mean Temperature (°C)</u>	<u>Annual Range (°C)</u>
Old Tampa Bay	22.6	10.8 to 32.6
Hillsborough Bay	23.2	11.2 to 35.1
Upper Tampa Bay	22.6	11.8 to 32.0
Lower Tampa Bay	21.5	8.8 to 32.0
Boca Ciega Bay	22.5	11.2 to 31.6
Terra Ceia Bay	21.8	12.5 to 29.6

Recent extensive biological studies which included water temperature measurements in Hillsborough Bay have been performed.^(3,9,10,11) Studies indicated that there is a significant amount of solar water heating in the bay. Natural water temperatures in Hillsborough Bay were monitored to determine daily minimum, maximum, and mean temperatures. The collected data demonstrate a close

correlation with data collected at St. Petersburg. The daily water temperature at St. Petersburg, based on 20 years of data, is shown on Figure 2.5-2.

Water temperature near the site increased after the October 1970 startup of the first unit at Big Bend.⁽⁹⁾ A thermal dilution system and Big Bend Unit 2 went into operation in early 1973, which had an additional effect on local water temperatures. Data collected from site monitoring programs indicated that annual means and ranges of water temperature near the site were several degrees higher than the published averages for Tampa Bay.

Figure 2.5-3 illustrates the location of data sampling stations in the plant vicinity and the original configuration at the intake-discharge system. Data indicated high water temperatures northeast of Newman Branch (Station 1-8) which were often higher than those temperatures recorded in the discharge plume (Station 1-1). This was probably due to the impoundment of warm discharge water and to the additional warming effects of sunlight in the shallow waters. In the mid-southern portion of the embayment (Station 1-4), water temperatures were equal to or slightly less than those at the discharge outlet into Hillsborough Bay (Station 1-3). Changes in bottom temperatures were generally found to be less than changes in surface temperatures. Bottom waters were cooler than surface waters throughout the embayment.⁽¹⁰⁾

Additional studies were performed to provide data for an impact analysis of Unit 3 prior to modification of the intake-discharge configuration.⁽³⁾ Data revealed a significant decay in temperature from the discharge plume to the point of discharge to Hillsborough Bay. Average water temperatures at this latter point were 2.5-3.0°C above ambient.⁽³⁾ Heated water remained within about 6 feet of the water surface, supporting earlier indications that water temperatures in the plant vicinity are not fully mixed throughout the water column and some temperature stratification does take place. Surface water temperatures greater than 2°C above ambient water temperature were occasionally observed offshore from the plant, but were generally limited to the discharge canal and embayment area.

Figure 2.5-4 shows the modified intake-discharge configuration which is currently in use. The discharge channel now exits directly to Hillsborough Bay rather than to the Apollo Beach embayment. A qualitative discussion of the thermal dispersion characteristics at the present intake-discharge configuration is presented in Section 2.5.4.

2.5.2 Water Withdrawals

The proposed Big Bend Station Unit 4 is scheduled for commercial operation in March 1985. Unit 4 will be constructed adjacent to Unit 3, which began operation in 1976.

Big Bend Station Units 1, 2, and 3 use an average of 1.1 million gallons per day of fresh water from the Hillsborough County Riverview-Gibsonton Water System. Big Bend Unit 4 will require an additional 1.4 million gallons of fresh water per day for operation. Approximately 1 million gallons per day of this requirement are needed for operation of the flue gas desulphurization equipment. Figure 3.3-1 in Section 3.3 is a plant water balance, which details the Unit 4 water needs.

In comparison with other industrial fresh water users in the South Hillsborough County area, Big Bend 4 will not be a large consumer. The nearby industries and their South West Florida Water Management District (SWFWMD) permitted water withdrawals are as follows:

Gardinier, Inc.	56,260,000 gpd
W. R. Grace & Co.	10,810,000 gpd
Brewster Phosphate	7,272,000 gpd
Borden Chemical	6,369,000 gpd
Gardinier, Inc.	5,840,700 gpd
Gardinier, Inc.	2,176,000 gpd
Agrico, Inc.	1,728,000 gpd
Gardinier- Big River, Inc.	1,627,000 gpd

In addition, there are 13 agricultural users with permitted withdrawals ranging from 1,000,000 gpd to 3,611,000 gpd. Hillsborough County utilities in the south county area is permitted to withdraw 13,075,000 gpd, while Big Bend utilities is allowed to withdraw 1,850,000 gpd.

Currently, there are no known plans for future large industrial users. However, the phosphate industry in central Florida is expected to peak in the 1990s, then begin a decline. Agricultural use is expected to remain constant or decrease. The Hillsborough County Horizon 2000 Plan has projected that the municipal water use will increase.

Big Bend Units 1, 2, and 3 operate with a once-through condenser cooling system. The discharge of Units 1, 2, and 3 is about 1,611 cfs. The temperature rise of the combined discharge at maximum plant load conditions is 16.8°F.

Unit 4 will have a once-through cooling system. The intake flow will be about 537 cfs.

There are several major projects and operations within the Tampa Bay system. These include the Hillsborough Bypass Canal of the Four River Basins project, the Tampa Bay harbor deepening project, the Mullet Key Beach restoration and erosion control project, continuing development of Port Manatee, and a proposed offshore fixed platform berthing facility with a pipeline to a fuel facility at Port Manatee. (*) These projects are not expected to have any significant adverse interaction with the Big Bend 4 project.

Other major water users in the Tampa Bay system include sewage treatment plants, industrial water sources, and marinas and ports.

Sewage Treatment Plants

There are about 56 wastewater discharges to Tampa Bay. These sources and their design discharge rates are listed in Table 2.5-2 and shown on Figure 2.5-5.

With the exception of the advanced wastewater treatment facility for the city of Tampa, all sewage plants are secondary treatment. The largest source is the effluent from the city of Tampa with a design flow of 60 mgd. The treated sewage is discharged into Hillsborough Bay from the Hookers Point Treatment Plant, approximately 6 miles north of Big Bend Station. The city of Tampa has recently installed this facility, replacing a 39-mgd primary treatment system.

Industrial Waste Sources

There are approximately 1,617 industries within the Tampa Bay system. Approximately 91 treat their own wastes and discharge to Tampa Bay, while 1,526 industries discharge their wastes to municipal or county sewage treatment systems.(4)

Marinas and Ports

There are more than 100 marinas in the Tampa Bay system. Boats with sanitary facilities are required to retain their wastes in holding tanks and remove them at dockside facilities. Many boats are not equipped for waste retention and most marinas in the area are not equipped with waste disposal facilities.(4) Therefore, marinas are not significant wastewater sources, although some pollution may exist in these areas.

There is no anticipated adverse interaction with any of these water users due to the construction and operation of Big Bend Unit 4.

2.5.3 Affected Tributaries

Surface Flow

The main surface drainage basins in Hillsborough County are the Hillsborough, Alafia, and Little Manatee River systems. These three rivers have an average combined flow of about 790 cfs and drain about 70 percent of the county. The remainder of the surface flow is drained from land adjacent to the bay by numerous small streams, canals, ditches, and sewers.

The total drainage area of the Hillsborough River is estimated to be 646 square miles and the mean annual discharge is about 671 cfs.(6) During 1940-58, the average discharge of the river was about 270 cfs at a point where the river drains about 220 square miles. The lowest flow recorded during this period was 48 cfs. About 90 percent of the time the flow was greater than 70 cfs, and 10 percent of the time it was greater than 600 cfs. Usually the monthly flow was highest in late summer or early fall and lowest in the late fall or spring seasons.(12)

The total drainage area of the Alafia River is about 418 square miles and the mean annual discharge is estimated to be 384 cfs.(6) During 1934-58, the minimum flow measured about 14 miles upstream from the mouth was about 7 cfs. Ninety percent of the time the flow exceeded 40 cfs, and a

flow of 800 cfs or more occurred 10 percent of the time. Usually, the average monthly flow is highest in September and lowest in May.(12)

The Little Manatee River has a total drainage area of about 205 square miles and an estimated mean annual discharge of 186 cfs.(6) During 1940-58, the minimum flow measured about 15 miles upstream from the mouth was about 1 cfs. Ninety percent of the time the flow was 12 cfs or more, and 10 percent of the time it was 480 cfs or more.(12)

Two additional streams have a significant drainage area and discharge directly to Hillsborough Bay. These are Bullfrog Creek and the Palm River.

Bullfrog Creek drains 40 square miles of land in southern Hillsborough County. The average flow is about 28 cfs at a point where the drainage area is 29 square miles. More than 20 percent of the time the flow is less than 1 cfs. The estimated average flow at the mouth of Bullfrog Creek is about 46 cfs.(12)

The Palm River empties into McKay Bay at Tampa and has a total drainage area of about 45 square miles with an estimated mean annual discharge of about 62 cfs.(6)

Underground Flow

Groundwater in Hillsborough County occurs under artesian as well as nonartesian conditions. A general direction of underground flow towards Tampa Bay is indicated by the slope of the piezometric surfaces of various aquifers.

The surficial lithology of the area is essentially represented by sands and clays. Sands contain groundwater under water-table conditions, although artesian conditions may occur locally due to the presence of clay beds. Occurring approximately 10 ft below ground surface, this aquifer generally yields about 5 gallons per minute (gpm) in wells driven to 20-foot depths.

A major source of this water-table aquifer is local rainfall, with an estimated 700 cfs of precipitation infiltrating into the aquifer. Additionally, 155 cfs of unconfined groundwater flows into Hillsborough County, and an equal amount due to leakage from deeper artesian aquifers. A portion of this underground flow is pumped out

for various uses, approximately 80 cfs emerges in adjoining bays, and the remaining water flows into streams which discharge at the bays.

The water table drops during periods of severe drought. During this time, the flow of groundwater may reverse with Tampa Bay saltwater intruding into the nearshore portion of the groundwater system.

Below the water-table aquifer is a series of shallow, secondary aquifers underlain by the Floridian artesian aquifer. An estimated combined total of 100 cfs of groundwater was pumped in Hillsborough County from the various aquifers for industrial, farm, public, and private water supplies in 1961.⁽¹²⁾ This value increased to about 140 cfs in 1976⁽¹³⁾.

2.5.4 Surface Water

Hydrologic Budget

A hydrologic budget for Hillsborough County was computed by Menke and others (1961). They estimated the average evapotranspiration rate to be 30 in/yr, or 60 percent of total annual rainfall which averages 50.24 inches in the area. They estimated average total runoff to be 15.6 in/yr in the county, or about 31 percent of total annual rainfall. Part of this amount is contributed by groundwater runoff and, therefore, approximately 6.5 in/yr, 13 percent, infiltrates into the groundwater system in Hillsborough County.

Extreme Tides

Since 1830, 46 hurricanes and other tropical disturbances have passed over or near the Tampa Bay area. Observed extreme tide heights at Tampa are given in Table 2.5-3. The historical tide level range between extreme high and low tide conditions is about 21.5 feet.⁽⁴⁾

Temperature Circulation Patterns

An aerial infrared imagery survey of the discharge plume from Units 1, 2, and 3 was conducted in 1976 which documented the thermal effects of the discharge dilution system.⁽³⁾ The following qualitative interpretations from this study were made: (1) a radial dispersion of the

thermal plume was observed during slack water current conditions; (2) recirculation of the thermal effluent to the cooling water intake system was prevented by the breakwater embankment extending offshore from the plant site; (3) a warm surface layer in the embayment south of the plant indicated that warm discharge water was recirculated back to the embayment by a flood tide; and (4) surface water temperature in the embayment rapidly reduced after diminution of the flood tide, suggesting the presence of thermally stratified conditions and a shallow, warm surface layer in the embayment during flood tide thermal recirculation.

2.5.5 Natural Variation of Surface Waters

Flushing Characteristics

Tidal exchange creates the principal circulation of Tampa Bay water. The average volume of water in the bay is estimated to be 2,110,000 acre-feet. At extreme low water level, about 3.5 feet below mean tidal level, the volume of water is approximately 1,570,000 acre-feet.⁽³⁾ The average tidal flow at the mouth of Tampa Bay is estimated to be about 900,000 cfs.⁽⁵⁾ About 25 percent of the tidal ebb flow is permanently removed from Tampa Bay and mixed with Gulf of Mexico water. Approximately 180 days are required to produce a 90 percent reduction in concentration of a substance in Old Tampa Bay.⁽⁶⁾

The high tide and low tide volumes in Hillsborough Bay are 350,000 acre-feet and 269,000 acre-feet, respectively.⁽³⁾ The average tidal flow is about 90,000 cfs at the mouth of Hillsborough Bay. The circulation in Tampa Bay results in minimal flushing of Hillsborough Bay.⁽⁵⁾ Generally, tidal currents of the bay are weak and variable with maximum tidal currents less than 1 fps.

With the addition of Big Bend Unit 4, the total plant cooling water flow will be approximately 4,000 cfs or about 4 percent of the tidal flow at the mouth of Hillsborough Bay.

2.5.6 Groundwater

Groundwater in Hillsborough County is found in a series of unconfined, semiconfined, and confined aquifers. The primary aquifers among these, are the water table or the

surficial aquifer, the shallow artesian aquifer and the artesian Floridan Aquifer.

The surficial aquifer, which underlies the entire site area except the man-made peninsula areas, is composed of a 10 to 40 foot thick sequences of deposit consisting of an upper layer of fine sand and a lower layer of sandy clay. The water table of the aquifer is generally found within a few feet of the ground surface. Contour maps showing the piezometric surface and the bottom are presented in Figures 2.5-6 and 2.5-7 respectively.

The thickness of the surficial aquifer varies across the site and is generally found to increase from the southeast to the northwest.

Pumping test performed in Northwest Hillsborough County shows that the hydraulic conductivity of the upper sand layer is approximately 100 gpd/sq ft⁽¹⁴⁾ (0.01 ft/min). Hydraulic conductivity of the surficial sands calculated from grain size analyses at the site, ranged from 65 to 220 gpd/sq ft (0.015 ft/min).

Recharge of the surficial aquifer is principally by local rainfall. Wells in this aquifer generally produce water of limited quantities and undesirable quality⁽¹²⁾. A discussion of water quality of the surficial aquifer is presented later in Section 5.2.

Directly underlying the surficial aquifer is the Hawthorn formation which is characterized by 30 to 50 ft of interbedded layers of sandy, calcareous, phosphoratic clay and thin layers of sandy, phosphoratic limestone. These thin layers of sand and limestone comprise the shallow artesian aquifer. The clay layers of the Hawthorn formation are much less permeable than the layers of sand and limestone and, hence, dominate the hydraulic conductivity of the unit. The Hawthorn formation therefore, serves as a confining bed for the Floridan aquifer⁽¹⁵⁾.

Wells developed in the shallow artesian aquifer yield up to 500 gpm of water of relatively poor quality. Recharge to this aquifer is upward from the Floridan aquifer⁽¹²⁾.

The artesian Floridan aquifer is composed of a thick sequence of carbonate rocks from the Avon Park formation to the Tampa formation. The upper portion of the Ocala group

overlying the Avon Park is a recognized aquitard zone which, however, does not prevent full hydraulic connection throughout the aquifer. The Tampa and Suwannee limestones act as a hydrologic unit above the Ocala separate from the carbonate formations underlying the Ocala. Hydraulically connected by solution openings, the Tampa and Suwannee limestones above the Ocala and the Avon Park underlying the Ocala, behave as one aquifer except when either system is stressed by large volumes of withdrawal. Relatively thin beds of the top confining zone cover the Floridan aquifer in a discontinuous manner, creating intricate hydraulic conditions. These confining beds are absent from a broad area on the Ocala uplift and from some scattered places locally. The Ocala uplift represents the principal recharge area due to wide exposures of the aquifer rocks. In other land exposures, the aquifer is either locally discharged through springs or recharged depending on the relative position of the potentiometric surface.

The potentiometric surface of the Floridan, as shown in Figure 2.5-8, generally slopes from the Ocala uplift toward the sea, but is marked by local mounds and depressions. Thus, wells in lowland areas yield freshwater under artesian conditions, whereas along the coast, where piezometric head is sharply reduced by pumping, seawater intrusion occurs.

The following are representative values of selected hydrologic parameters for the Floridan aquifer⁽¹⁶⁾:

- o Artesian pressure varies depending on a particular location. In the immediate vicinity of the Big Bend Station, the potentiometric surface varies between 0 elevation and +5 msl. At certain inland locations in the county, however, the potentiometric surface reaches a high of elevation +100.
- o Freshwater usually contains less than 500 ppm total dissolved solids; mineral concentration of brackish water (TDS) exceeds 1000 ppm
- o Aquifer coefficients are:
Transmissivity (T) = to 1,000,000 gpd/ft
Storage (S) = 0.0006 to 0.002

Leakance (L) = 0.005 to 0.009 gpd/ft²/ft.

The Floridan aquifer is the principal source of freshwater supply in the state. Groundwater is usually withdrawn from the upper reaches of this aquifer. Waterwells seldom reach the Avon Park formation, however, industrial users have frequently tapped this formation. Intensive pumping for agricultural and industrial uses during the last 30 years has resulted in substantial lowering of the potentiometric surface in the densely populated coastal areas, thereby permitting local contamination by seawater.

The potentiometric surface of the Floridan aquifer, as measured from several on site wells is higher than that of the surficial aquifer. The potentiometric surface in a few of these wells is even higher than ground elevation. This eliminates the possibility of any downward recharge of the Floridan aquifer from the surficial aquifer.

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TABLE 2.5-1

WATER QUALITY OF HILLSBOROUGH BAY ⁽³⁾				
	Annual Average Ambient Concentration ^(1,4) 1972	Annual Average Ambient Concentration ^(2,5) 1978	Florida Class III Water Standards ⁽⁶⁾	Average Composition of Sea Water ⁽⁷⁾
Alkalinity, total	100.9			
Biochemical Oxygen Demand	3.1			
Calcium	342			413
Chloride	15,030			19,353
Chromium (total)	<0.01		≤1.0	
Color (Pt Co units)	9.2	13.3		
Conductivity (micromho/cm)	36,692	39,535		
Copper	<0.01		≤0.015	<0.002
Effective light penetration (inches)	54.1	32.5		
Fluoride	22.8	2.4	≤5.0	1
Hardness	4,449			
Iron, total	0.03		≤0.3	<0.001
Lead, dissolved	<0.01		≤0.05	
Magnesium	951			1,294
N, total Kjeldahl	0.47	0.13		0.02
N, total nitrate	0.08	0.02		
N, Ammonia	0.01	0.03		
Oxygen, dissolved	6.36	7.2	≥4.0	
pH (standard units)	7.99		6-8.5	8.1
Phosphorous, dissolved orthophosphate	2.03	1.22		0.073
Potassium, dissolved	265.8			387
Salinity (parts per thousand)	27.8	24.9		
Sodium, dissolved	8,197			10,760
Solids, suspended	21.2	42.6		
Sulfate (as SO ₄ ⁻)	2,055			2,712
Sulfide	0.10			
Turbidity (Jackson Units)	5.6	5.9	50	
Water temperature (°C)	24.2	22.4		
Zinc	<0.01		≤0.01	<0.05

⁽¹⁾Hillsborough County Environmental Protection Commission. 1972 Water Quality, Hillsborough County, Florida. Tampa, Florida.

⁽²⁾Hillsborough County Environmental Protection Commission. 1978 Water Quality, Hillsborough County, Florida. Tampa, Florida.

⁽³⁾mg/l unless otherwise stated.

⁽⁴⁾Average value from seven sampling stations in Hillsborough Bay adjacent to Big Bend Station.

⁽⁵⁾Average value from four sampling stations (Nos. 9, 73, 80, 81) in Hillsborough Bay adjacent to Big Bend Stations.

⁽⁶⁾Applicable to most of Hillsborough Bay.

⁽⁷⁾Martin, Dean F. 1970. Marine Chemistry. Dekker, Inc.

TABLE 2.5-2

MAJOR WASTEWATER SOURCES
AFFECTING TAMPA AND HILLSBOROUGH BAYS

St. Petersburg Area

<u>Source Number*</u>	<u>Discharge Source; Affected Area</u>	<u>Design Discharge (mgd)</u>
1a	Fort DeSoto Park; East Beach	0.012
1b	Fort DeSoto Park; Fort Area	0.012
1c	Fort DeSoto Park; North Beach	0.003
2	Madelaine Key; Boca Ciega Bay	0.08
3	Terra Verde Subdivision Boca Ciega Bay	0.05
4	St. Petersburg (city-southwest plant); Tampa Bay	6.0
5	St. Petersburg (city-Albert Whitted plant); Tampa Bay	11.7
6	St. Petersburg (city-northeast plant); Tampa Bay	5.33

Old Tampa Bay Area

7	Largo Plant; Old Tampa Bay	3.0
8	Clearwater (city-east plant); Old Tampa Bay	3.2
9	Safety Harbor (city); Old Tampa Bay	0.192
10	Oldsmar (city); Old Tampa Bay	0.12
11	Double Branch Ranch Trailer Park; Old Tampa Bay	0.004
12	Tampa Shores (Tampa Shores Utility Corp.); Old Tampa Bay	0.4
13	Colonial Coach Estates Mobile Home Park; Old Tampa Bay	0.055
14	River Oaks (Hillsborough County); Old Tampa Bay	0.525

TABLE 2.5-2 (Cont)

<u>Source Number*</u>	<u>Discharge Source; Affected Area</u>	<u>Design Discharge (mgd)</u>
52	Bahia Beach; Tampa Bay	0.035
53	Coffee Cup Restaurant; Tampa Bay	0.003
54	Ruskin Laundry; Tampa Bay	0.02

* See Figure 2.5-5 for location.

Source:

Hillsborough County Environmental Protection Commission, 1972.

TABLE 2.5-3

EXTREME TIDES AND HIGH WATER MARKS AT TAMPA, FLORIDA

High Tides

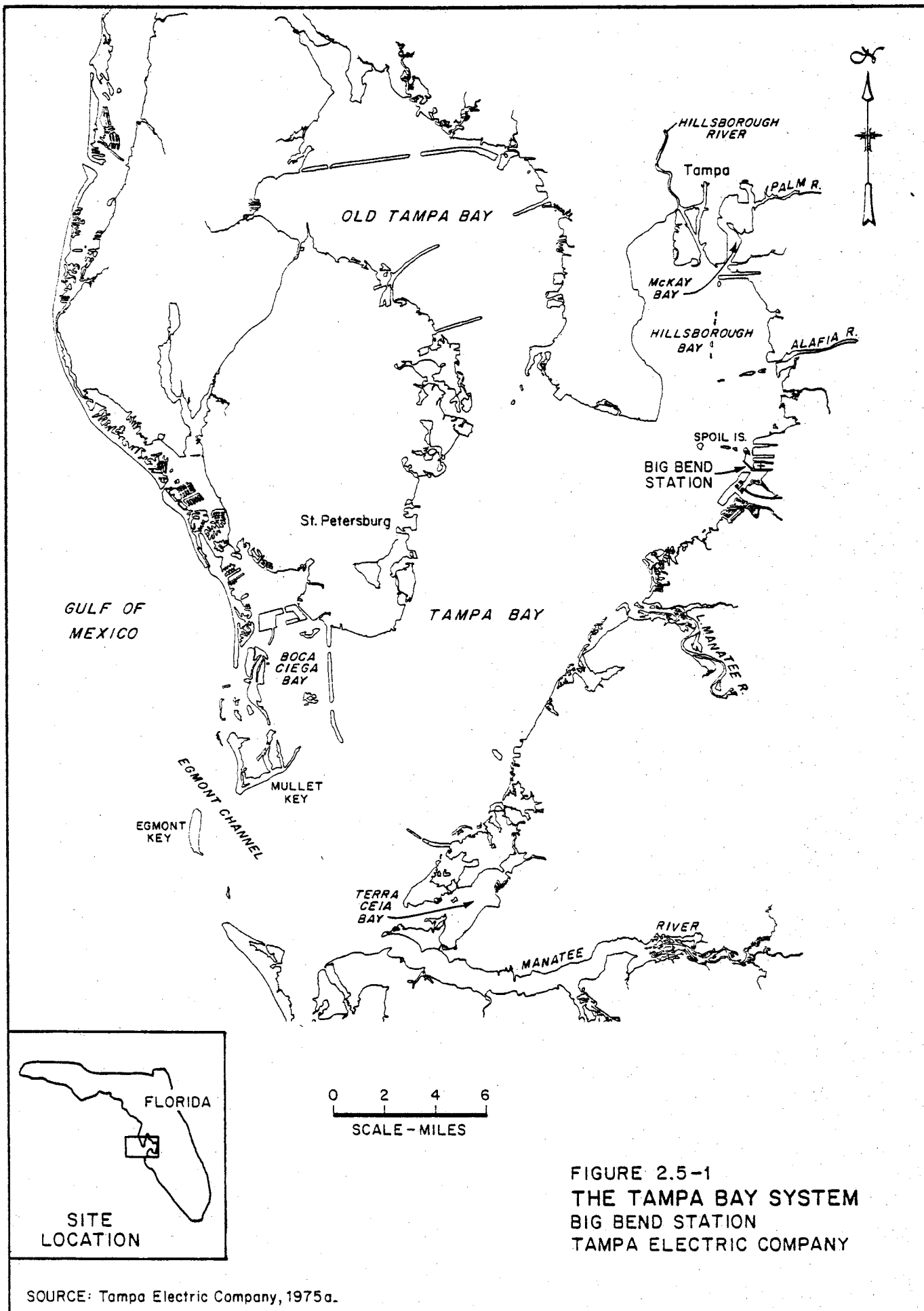
<u>Event</u>	<u>Tide Height (ft msl)</u>
September 1848	14
October 1848	9
September 1919	5+
October 1921	9.6
September 1926	3.6
September 1929	3.1
September 1935	4.4
November 1935	4 to 5
October 1946	3.3
August 1949	3.9
September 1950	5.6
October 1950	2.5
September 1960	2.8
August 1964	1 to 3
June 1966	3 to 5
October 1968	4 to 6
June 1972	3 to 5

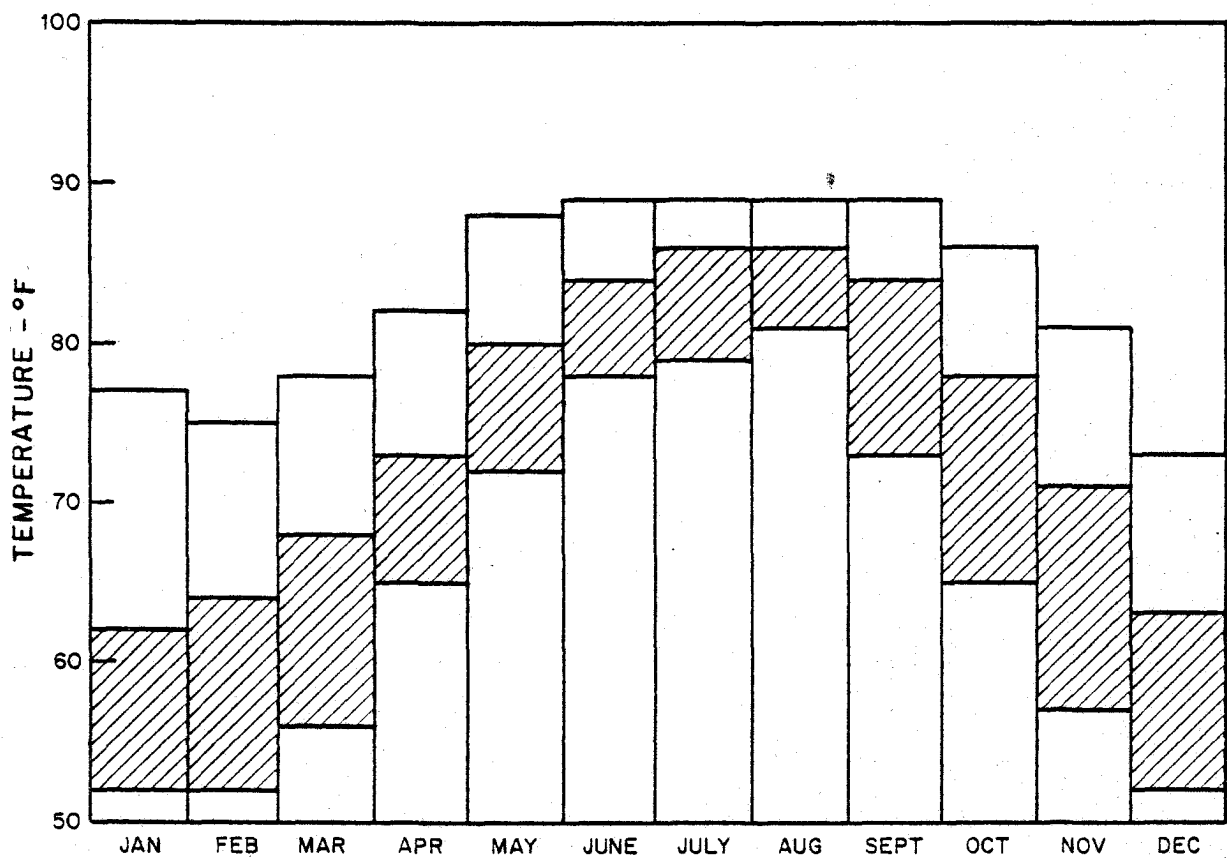
Low Tides

October 1910	-7.5
September 1926	-6.9
September 1935	-5.7
September 1947	-5.8

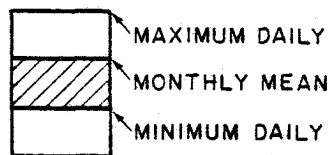
Source:

Corps of Engineers, 1974.



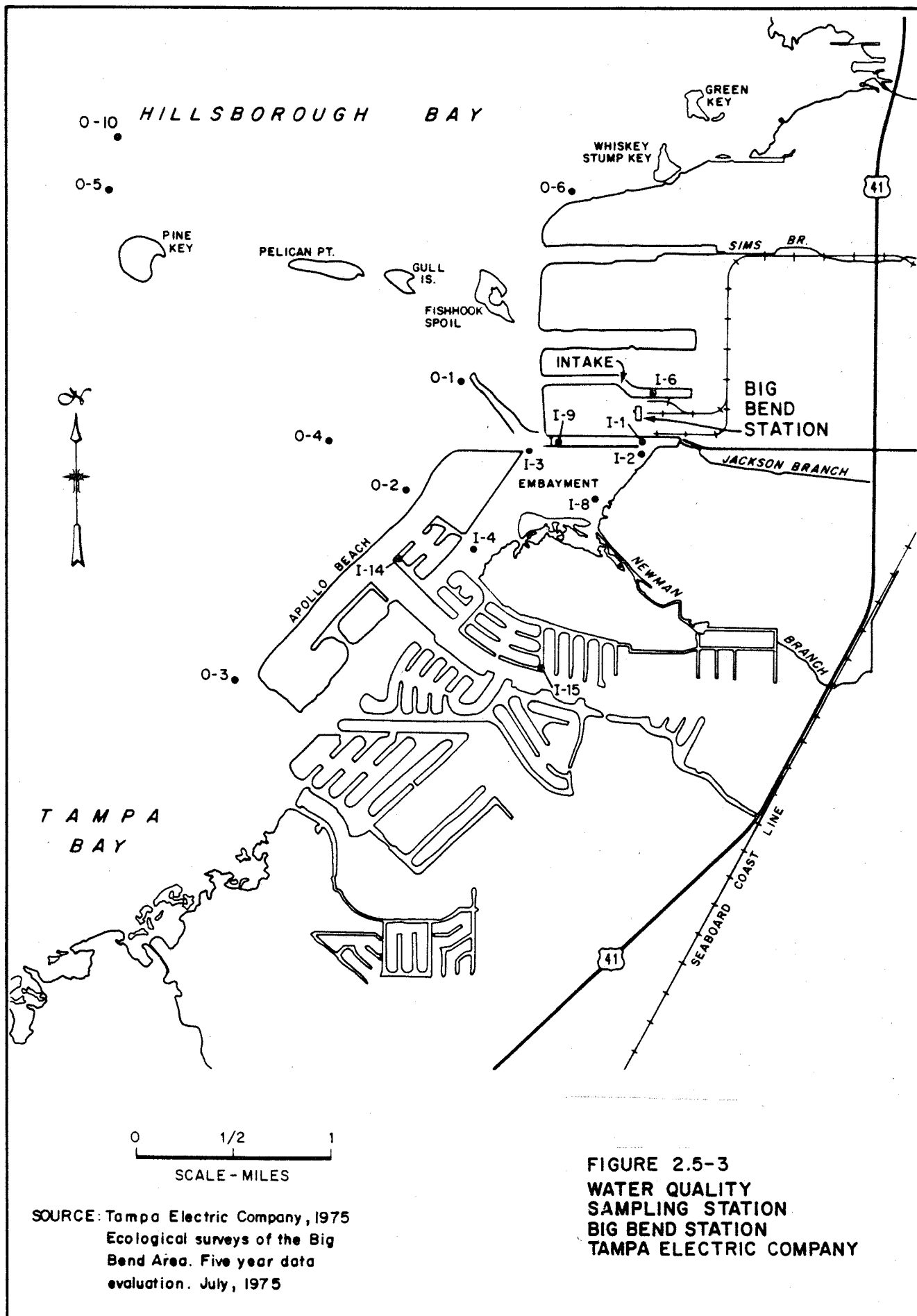


LEGEND



SOURCE: Water temperature data at
St. Petersburg, Florida, 1947-66.
U.S. Dept. of Commerce, Environmental
Science Services Administration, Coast
and Geodetic Survey.

FIGURE 2.5-2
TAMPA BAY
WATER TEMPERATURE
BIG BEND STATION
TAMPA ELECTRIC COMPANY



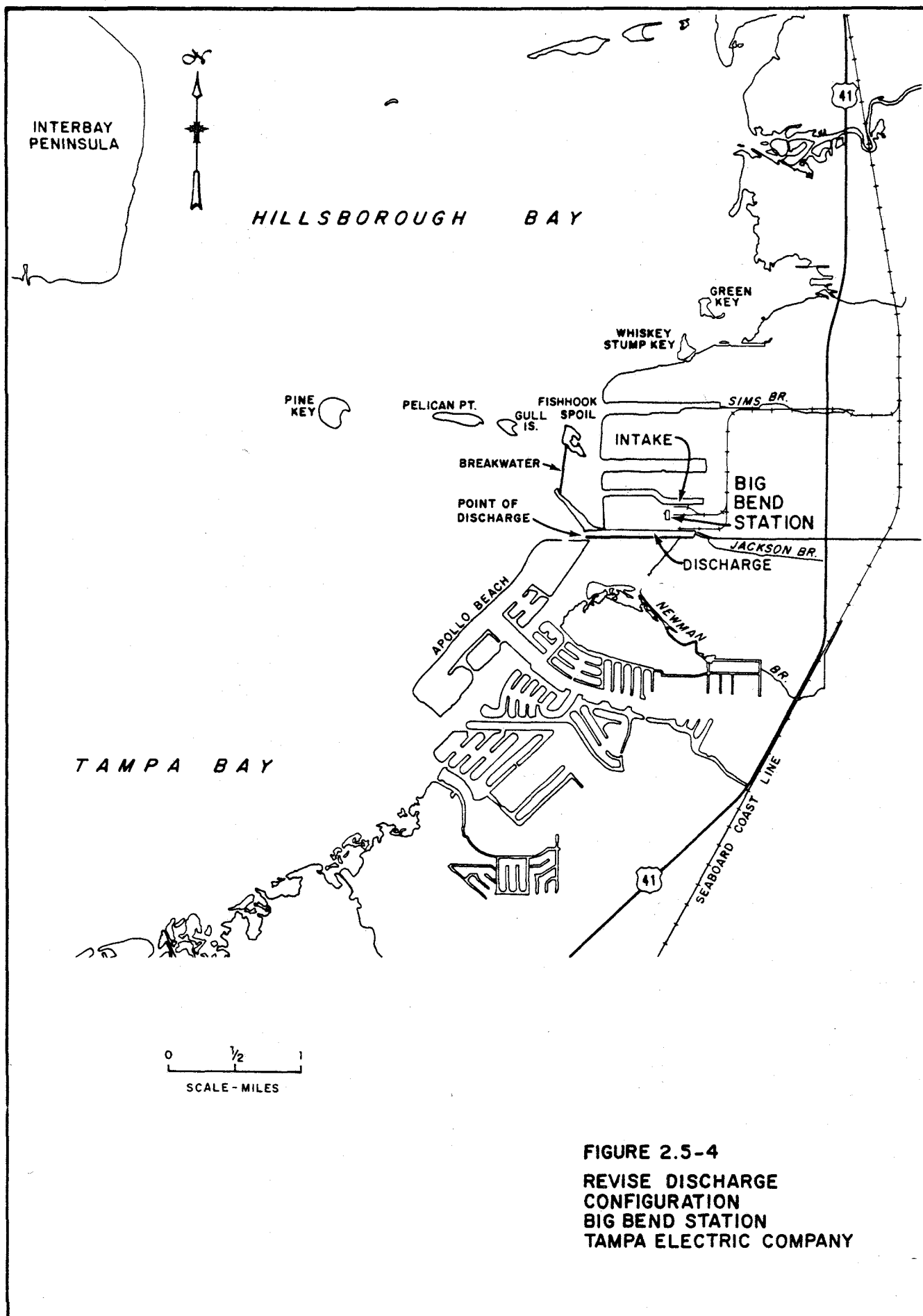
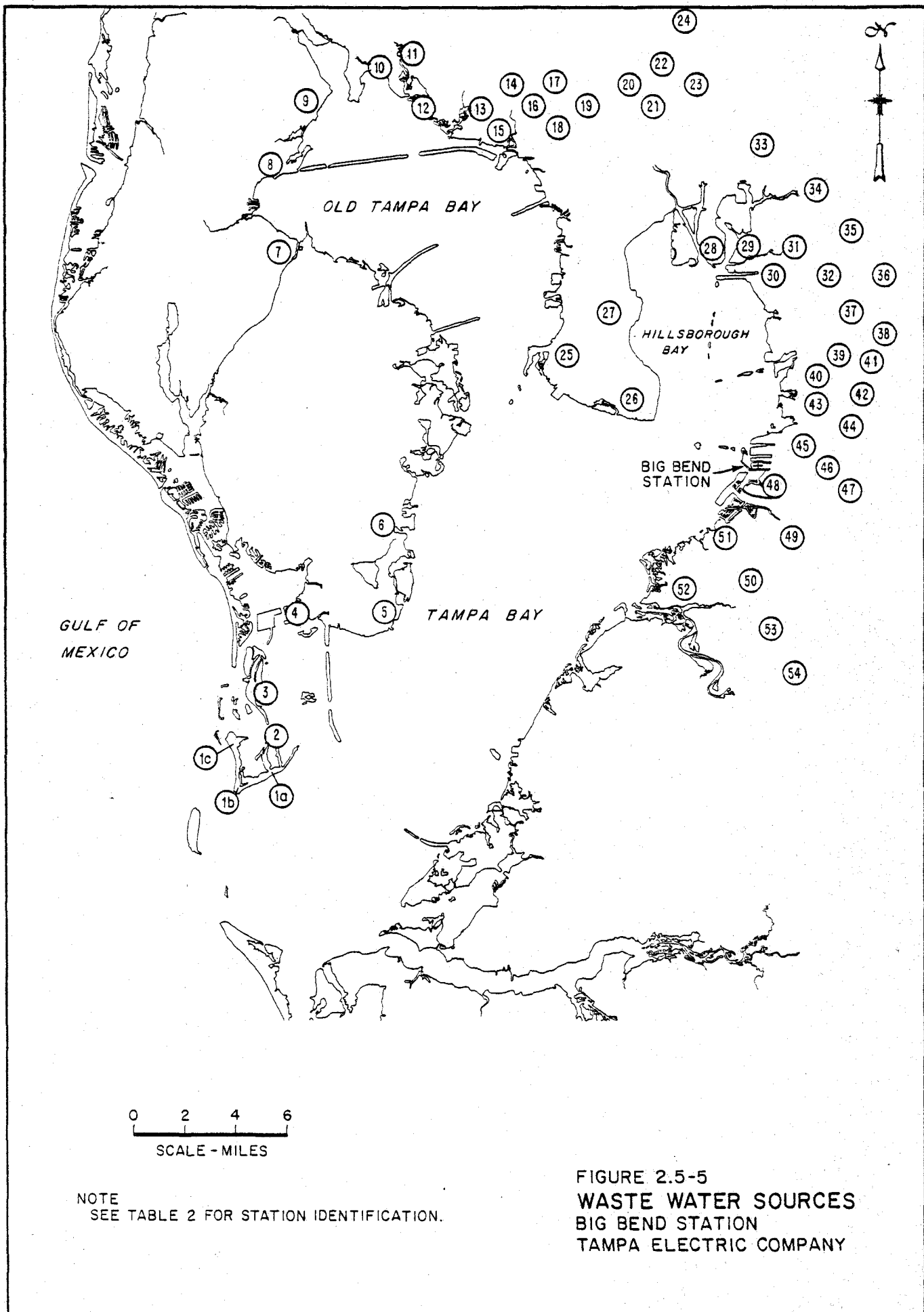
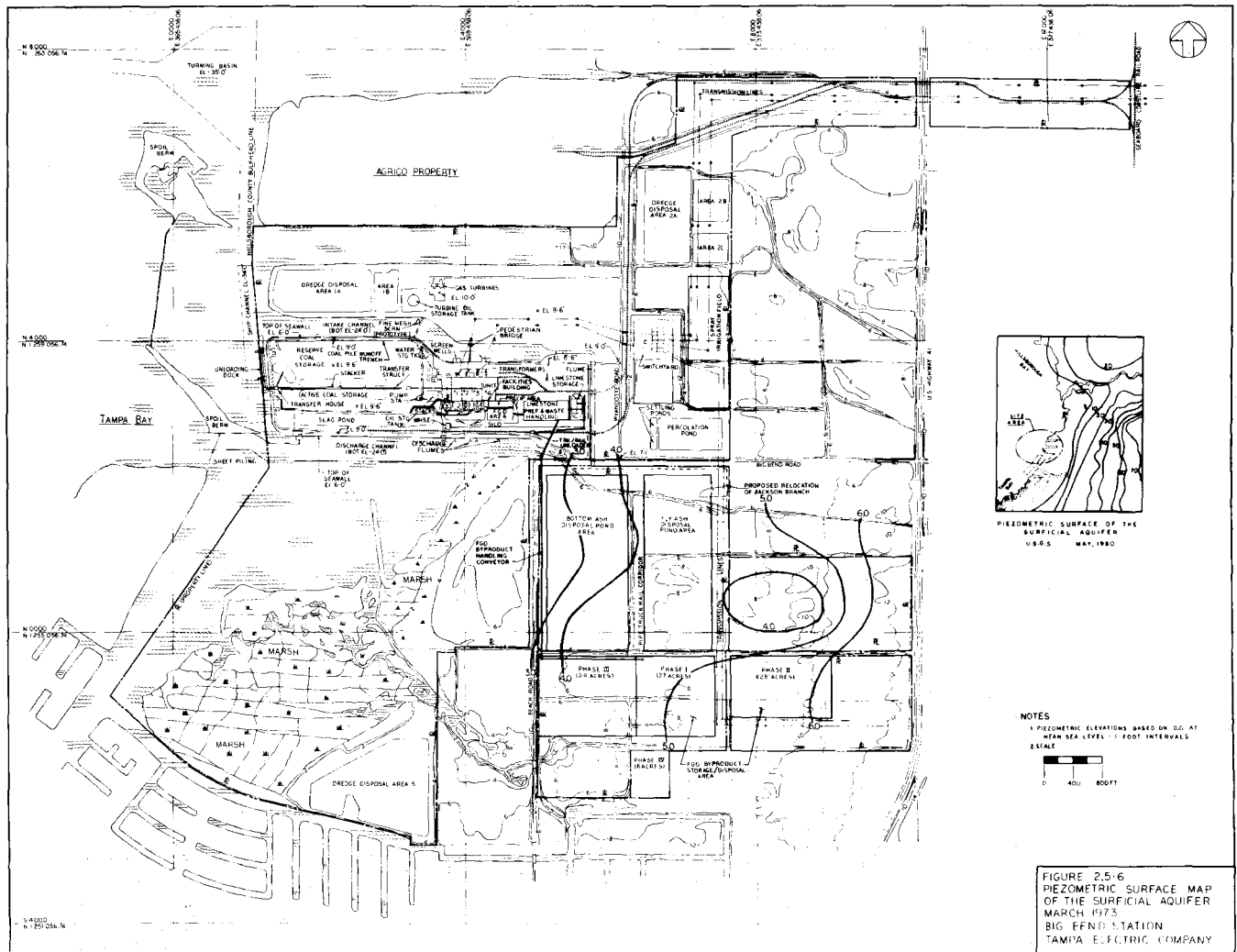
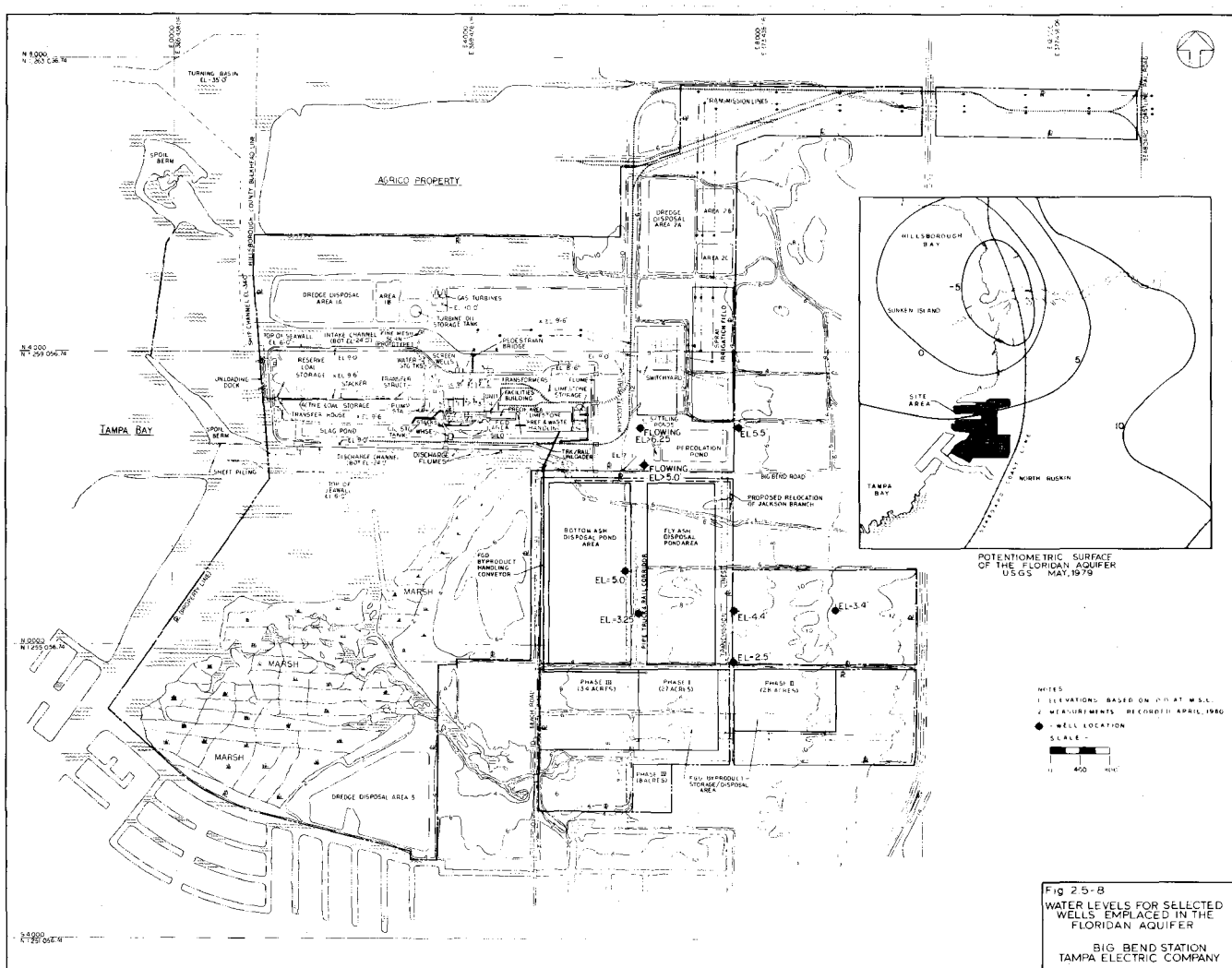


FIGURE 2.5-4
REVISE DISCHARGE
CONFIGURATION
BIG BEND STATION
TAMPA ELECTRIC COMPANY







2.6 CLIMATOLOGY AND DISPERSION METEOROLOGY

2.6.1 Climatology

The Tampa Bay area has two excellent sources of meteorological data: the National Weather Service (NWS) office at Tampa International Airport and the MacDill Air Force Base weather station. There is little difference in weather variables recorded simultaneously at each location. The NWS office, however, has recorded surface and upper air data continuously since 1946 and is, therefore, one of the state's most complete weather sources. Data included in the section are from the NWS office.

The Tampa Bay region has a modified subtropical climate throughout the year because of its proximity to the waters of the Gulf of Mexico and Tampa Bay. The average daily temperature ranges from 27.9°C (82°F) in August to 15.8°C (60°F) in January, with a mean annual temperature of 22.3°C (72.2°F). Table 2.6-1 shows the temperature means and extremes from Tampa's International Airport.

Respective mid-day and nighttime relative humidities remain reasonably constant throughout the year, with a daytime reading close to 57 percent and a nighttime reading near 84 percent as the annual averages. The driest month of the year is November with a normal 45 millimeters (1.79 inches) of precipitation. During the year, there is an average of 1,255 millimeters (49.4 inches) of precipitation, of which nearly 65 percent occurs during the four warmest months in the form of heavy, convective-type thundershowers. Humidity and precipitation data are included in Table 2.6-2.

Since Hillsborough County lies entirely within the trade wind belt (i.e., below approximately 30°N latitude), annually averaged winds predominate from the east. However, because of the marine environment, moderate to strong late afternoon sea breezes occur on days that have strong land heating. Winds, therefore, are locally onshore (southwest to west) at these times. Five-year seasonal and annual averaged wind roses for Tampa International Airport, containing hourly observations from 1971-75, are presented in Figure 2.6-1. The yearly averaged wind speed is 3.9 meters per second (8.8 miles per hour). The highest speeds occur in spring, and lowest occur in summer. The fastest observed wind speed in the 25-year period ending 1977 was 30 meters per second (67 miles per hour). Winds of hurricane strength, 33 meters per second (73 miles per hour), have not occurred recently in this area.

In the 50-mile coastal strip from above Pinellas County to just below Tampa Bay, there is less than 10 percent chance that a storm of at least tropical storm strength will invade

the Bay area during any given year.⁽¹⁾ For storms of hurricane strength (i.e., wind speeds exceeding 33 mps), chances reduce to 1 in 16, with only a one percent chance of winds greater than 55 mps (124 mph), the speed required of a great hurricane. Of greater frequency are thunderstorms which are usually locally very intense. Gusts within these storms may cause extensive damage, along with flash flooding and lightning bolts. The Bay area averages 85 to 90 thunderstorms per year with 65 percent occurring in the summer season. Tornadoes that reach the surface are a rare occurrence in this part of the state, and very destructive storms are almost nonexistent. More frequently, but still rare, are tornado occurrences offshore (i.e., waterspouts), which are sometimes caused by distant tropical cyclones or prefrontal squall line activity. Tornadoes are most likely to occur during seasonal changes when cool, dry air and warm, moist air clash. However, summertime tornadoes can be initiated by mere convection and occasionally reach the surface. Winds within a mature tornado can reach up to 180 meters per second (400 mph).

2.6.2 Dispersion Meteorology

The buildup and decline of effluents within an urban region are related to the positions of nearby synoptic scale systems such as fronts and high pressure regions, but are frequently enhanced by local effects within that region. These local effects - land and sea breezes, shape and type of terrain, and the extent of solar heating - essentially determine the atmospheric stability (stratification), wind speed, and maximum mixing height within a region. When these variables combine in an undesirable fashion, dispersion may be restricted from a few hours to several days.

The three-dimensional dispersion potential of an area is generally associated with its frequency of inversions or occurrences of air stagnation (i.e., episodes). Several types of inversions are experienced in central Florida. The most frequent inversions are nocturnal or radiation inversions which are formed by the radiative cooling of the surface on clear and calm nights. Since air is a poor conductor, heat radiated from the surface will be emitted directly into space. The coldest air forms at the surface first and the inversion then extends to higher levels. In this way, the most stable layers begin as only a few meters thick. If effluents are released above this shallow layer, high concentrations from the plume will be unable to return to ground level until the inversion breaks up. If the stable layer rises above the effluent release point, the plume will fan out horizontally within it. Central Florida has many nocturnal inversions, with the most severe ones (greatest negative lapse rate) occurring during the

autumn.⁽²⁾ Without this inversion, the plume would loft, loop, or cone from the source (see Figure 2.6-2), depending upon the existing temperature stratification of the atmosphere.

The percent frequency of low-level inversion conditions in the Tampa area was determined on a twice-a-day basis for each season. Those findings (see Table 2.6-3) indicate that inversion conditions are observed in 76 percent of the fall mornings but in only 7 percent of spring evenings. Fall has the greatest inversion probability; winter, a close second.

Because of Tampa's proximity to the Gulf of Mexico, mixing depths are affected by onshore and offshore breezes. In the morning, generally high relative humidities and frequent low cloudiness inhibit the formation of intense radiation inversions, so that the layer of air closest to the ground can mix to several hundred meters. Table 2.6-4 represents the 5-year averaged mixing heights for each month and annually.

Heavy fogs occur about 24 mornings each year in Tampa's urban section with considerably more fogs over the rural sections of the county. Such fogs will usually evaporate by 11:00 a.m.

Holzworth discusses the relationship between episode potential and stationary high pressure areas (anticyclones).⁽³⁾ These systems are usually stable with air slowly descending in layers through the center at high levels. Increased stabilization will occur in those layers which "shrink" vertically more than others. When this occurs, a subsidence inversion is formed in the upper air. This type of inversion can appreciably affect air quality since the air below the inversion is not as stable, and only downward mixing will occur. Consequently, since the inversion is formed at high altitudes, it will act as a thermodynamic lid on upward mixing of effluents, and concentrations will increase from below. Unlike nocturnal inversions which are broken up by sunshine, subsidence inversions (resulting from anticyclones) may persist for days and cause increasing deterioration of the air quality within a region. Figure 2.6-3 represents the meteorological potential for air pollution in a five-year period. The scarcity of subsidence inversions (or stagnation anticyclones) in Florida, as compared with other regions, is reflected through the emergence of a "zero" isopleth across the northern peninsula area.

Other inversions are observed in Florida, either to a lesser degree or for brief periods of time. A frontal surface is, by nature, a vertically sloping inversion. A frontal inversion can cause a buildup of effluent concentrations for

a few hours during its passage over an area. These inversions in Florida, however, are generally not very steep or deep and do not cause air quality problems. Their frequency of occurrence is limited to the cooler months when frontal systems enter the state.

To summarize, there are inversions which form at ground level and in the lower to middle atmosphere. Because of a paucity of nighttime cloud cover coupled with low wind speeds, the former type occurs often in the state. Elevated-based "lid" type inversions, which can prevail for days with restricted mixing below, are a rare occurrence in Florida.

Low-level stability has already been discussed with respect to inversion frequencies.⁽²⁾ The annual frequencies of all stability classes, as determined by the Pasquill-Turner method,⁽⁴⁾ are presented in Table 2.6-5 with wind speed class frequencies.

The stability classes are defined as follows:

Daytime:	"A" - Extremely unstable conditions with strong super adiabatic lapse rate, greatest turbulence, mixing
	"B" - Unstable, moderate mixing
	"C" - Slightly unstable, usually moderate wind speeds, minimal turbulence
Neutral:	"D" - Neutral, approximately dry adiabatic lapse rate
Nighttime:	"E" - Slightly stable to very stable (inversion).

The sum of the E frequency (inversion) is 40.3 percent, which is near the 30-40 percent range estimated by the Hosler study.⁽²⁾ Very unstable conditions with maximum mixing (Class A) occur 0.4 percent of the year.

TABLE 2.6-1

DIURNAL AND MONTHLY TEMPERATURE MEANS AND EXTREMES
TAMPA INTERNATIONAL AIRPORT, TAMPA, FLORIDA

Monthly	Daily Maximum* (°F)	Daily Minimum* (°F)	Monthly Average* (°F)	Recorded High** (°F)	Recorded Low** (°F)
January	70.6	50.1	60.4	84	23
February	71.9	51.7	61.8	88	24
March	76.1	55.9	66.0	91	34
April	82.4	61.6	72.0	93	40
May	87.5	66.9	77.2	98	49
June	89.9	72.0	81.0	98	61
July	90.1	73.7	81.9	97	63
August	90.4	74.0	82.2	98	67
September	89.0	72.6	80.8	96	59
October	83.9	65.5	74.7	94	40
November	77.1	56.4	66.8	90	23
December	72.0	51.2	61.6	86	18
Annual	81.7	62.6	72.2	98	18

* 30-year averaged data, 1941-1970.

**33 years of data, June 1946-May 1979.

Source: National Weather Service, Tampa, Florida, 1979.

TABLE 2.6-2

DIURNAL RELATIVE HUMIDITY AND PRECIPITATION MEANS AND EXTREMES
TAMPA INTERNATIONAL AIRPORT, TAMPA, FLORIDA

Month	Relative Humidity* (%)		Precipitation (inches)		
	Daytime	Nighttime	Normal**	Maximum***	Minimum***
January	50	84	2.33	8.02	T
February	54	81	2.86	7.95	0.21
March	54	81	3.89	12.64	0.06
April	49	80	2.10	6.59	T
May	51	83	2.41	8.13	0.17
June	59	84	6.49	13.75	1.86
July	62	84	8.43	20.59	2.31
August	63	86	8.00	18.59	2.35
September	61	85	6.35	13.04	1.28
October	56	84	2.54	7.36	0.23
November	55	84	1.79	6.12	T
December	57	83	2.19	6.66	0.21
Annual	57	83	49.38	76.57	28.89

*14-year averaged data, 1964-1977

**30-year averaged data, 1941-1970

T = trace

***33-year averaged data, June 1949-May 1979

Source: National Weather Service, Tampa, Florida, 1979.

TABLE 2.6-3

PERCENT FREQUENCY OF LOW-LEVEL TEMPERATURE INVERSIONS
1957-1959, TAMPA, FLORIDA

Season	7:00 a.m.	7:00 p.m.	Percent of Total Time
Winter	60	28	37
Spring	52	7	30
Summer	57	14	28
Fall	76	25	38

Source: Hosler, C.R. Low-Level Inversion Frequency in the
Contiguous United States. Monthly Weather Review,
Vol. 89, No. 9, 1961, p. 319-339.

TABLE 2.6-4
FIVE-YEAR AVERAGED MIXING DEPTHS FOR TAMPA, FLORIDA
1960-1964

Month	Mixing Depth (Meters)	
	Morning	Afternoon
January	391	1010
February	477	1106
March	498	1330
April	514	1533
May	497	1701
June	617	1528
July	703	1424
August	649	1423
September	590	1473
October	375	1510
November	307	1239
December	326	1048
Annual	495	1360

NOTE: Morning and afternoon times refer to 7:00 a.m. and the time of highest surface temperature, respectively.

Source: Holzworth, G. Mixing Heights, Wind Speed, and Potential for Urban Air Pollution throughout the Contiguous United States, AP101. U.S. Environmental Protection Agency, Research Triangle Park, N. C. 1972.

TABLE 2.6-5

PERCENT FREQUENCY OF OCCURRENCE OF WIND SPEED
 BY STABILITY CLASS
 TAMPA INTERNATIONAL AIRPORT, 1971-1975 (24 obs/day)

Wind Speed Class (Knots)	Stability Class					All Stability Classes
	A	B	C	D	E	
0-3	0.07	0.66	0.32	0.69	8.29	10.03
4-6	0.32	2.41	2.99	4.46	23.64	34.01
7-10	0.00	2.92	10.02	16.51	8.32	37.77
11-16	0.00	0.00	2.20	14.99	0.00	17.19
17-21	0.00	0.00	0.05	0.81	0.00	0.86
Over 21	0.00	0.00	0.01	0.12	0.00	0.13
All Wind Classes	0.39	6.00	15.60	37.76	40.25	--

Source: National Weather Service, Tampa, Florida, 1976.

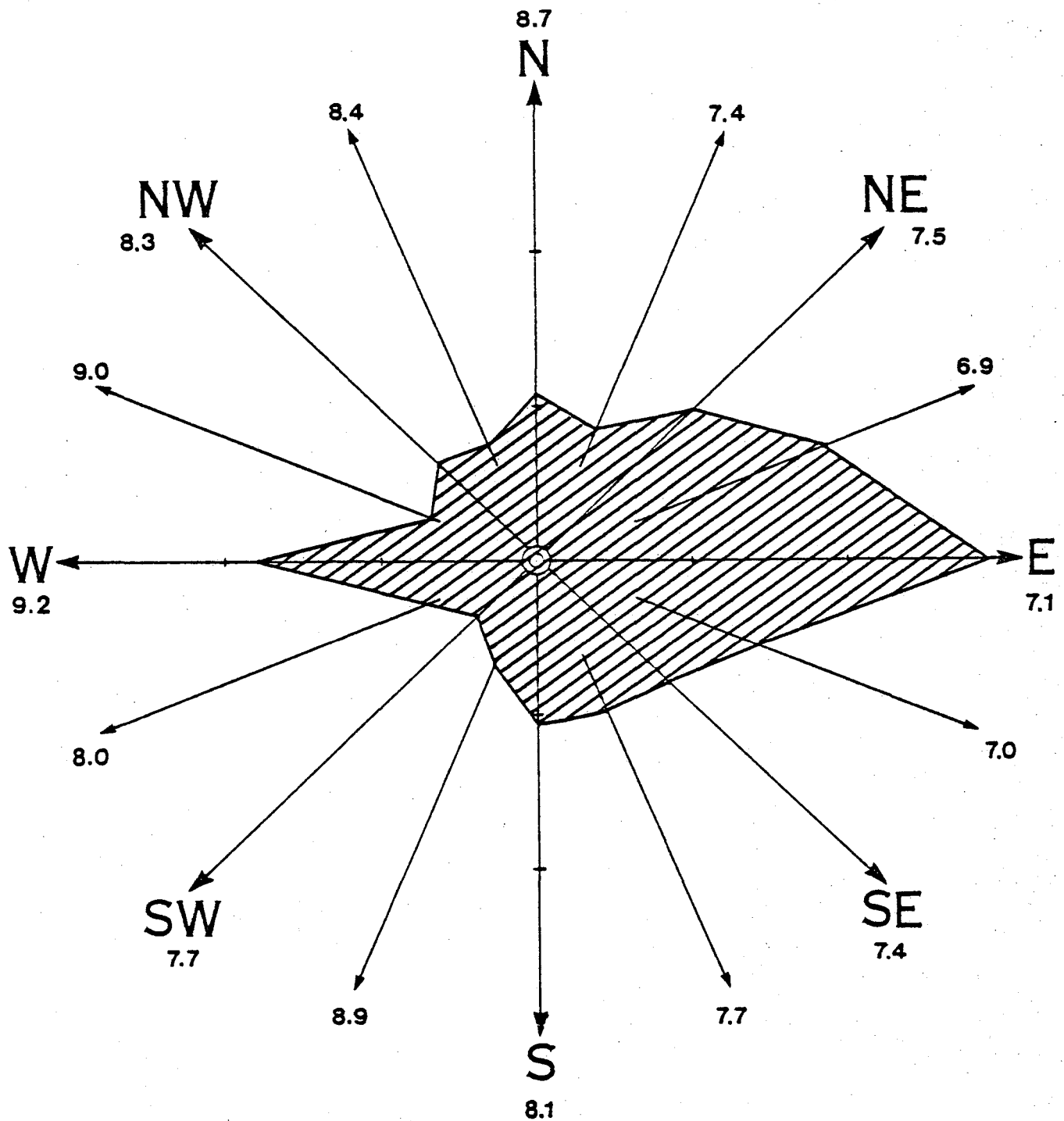
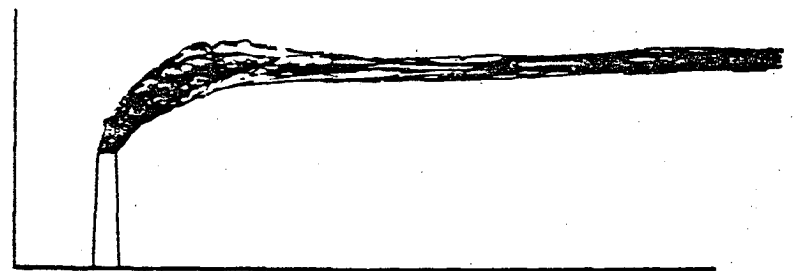
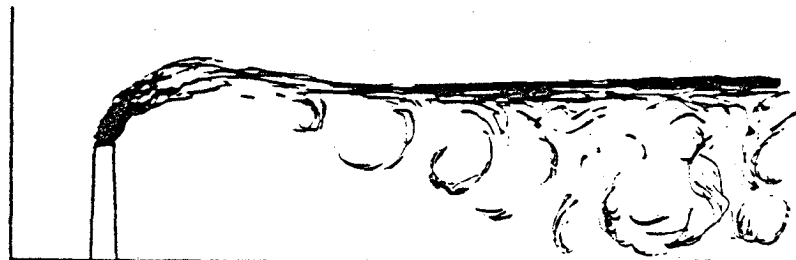


FIGURE 2.6-1 Five-Year Averaged Wind Rose for Tampa International Airport 1971-1975. Scale: 1" = 5%, Calm = 4.4%. Average Speeds Given in Knots.

BIG BEND STATION
TAMPA ELECTRIC COMPANY



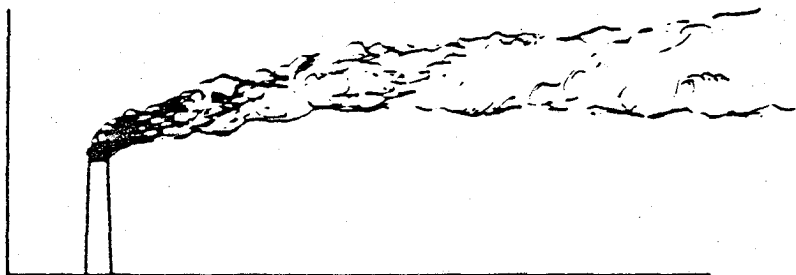
STABLE (FANNING)



NEUTRAL BELOW, STABLE ABOVE (FUMIGATION)



UNSTABLE (LOOPING)



NEUTRAL (CONING)

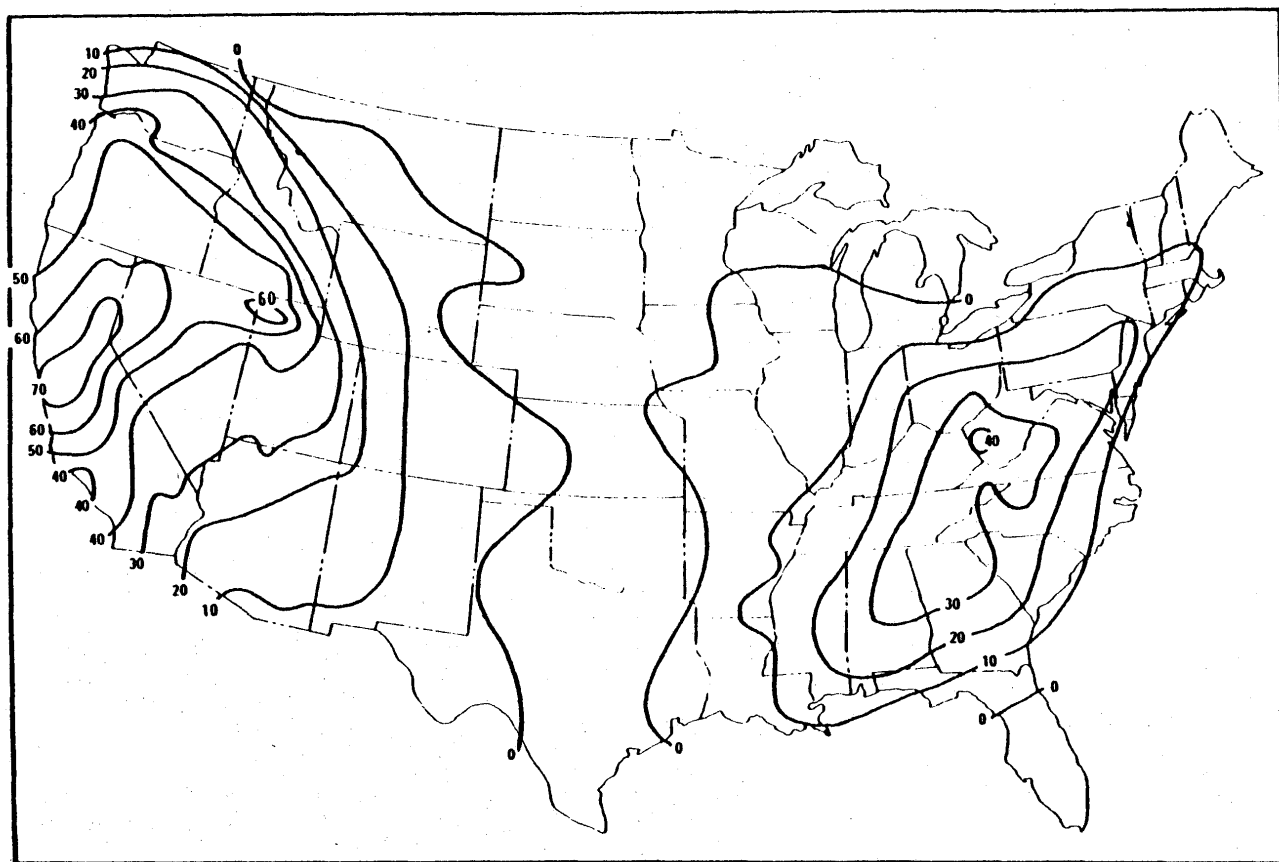


STABLE BELOW, NEUTRAL ALOFT (LOFTING)

SOURCE: U.S. ATOMIC ENERGY COMMISSION, 1968.

FIGURE 2.6-2 TYPES OF PLUMES WHICH WILL BE OBSERVED UNDER DIFFERENT ATMOSPHERIC STABILITIES

**BIG BEND STATION
TAMPA ELECTRIC COMPANY**



SOURCE: HOLZWORTH, 1972.

FIGURE 2.6-3 ISOPLETHS OF THE TOTAL NUMBER OF FORECAST-DAYS OF HIGH METEOROLOGICAL POTENTIAL FOR AIR POLLUTION IN A FIVE-YEAR PERIOD.
BIG BEND STATION
TAMPA ELECTRIC COMPANY

2.7 ECOLOGY

2.7.1 Terrestrial Ecology

From March 1974 through May 1975, members of the faculty and graduate students of the University of South Florida (USF) conducted ecological investigations in the vicinity of Tampa Electric Company's Big Bend Power Station (Big Bend) in Hillsborough County, Florida. A later evaluation was conducted by USF personnel during August, September, and October of 1977. Results of these studies were used to describe the existing ecological conditions near Big Bend and to serve as the basis for an assessment of potential ecological impacts of construction and operation of a fourth fossil-fueled unit at Big Bend.

The following sections (2.7.1.1 through 2.7.1.8) describe the important floral and faunal species in the vicinity of Big Bend, their habitats, distribution, and interrelationships as determined during the 1974-75 and 1977 studies. Important species are herein defined as:

- o Commercially or recreationally valuable.
- o Designated as rare, endangered, threatened, or protected by the state of Florida or the U.S. Department of the Interior.
- o Affecting the well-being of species conforming to Items 1 or 2 above.
- o Critical to the structure or function of the ecological system.

A bibliography of sources pertinent to the description of existing ecological conditions in the area of Big Bend is provided in Section 2.7.1.9.

2.7.1.1 Vegetation Types or Associations

Sampling stations were established in 12 vegetation types or associations in the vicinity of the Big Bend Station during the 1974-75 studies (Figure 2.7-1). These types were selected for further study and designated for future reference on the basis of the predominant use of the area (e.g., ash pond area, power line right-of-way) or the species exerting a strong influence on the particular habitat (e.g., mangroves, Myrica - Baccharis association). Changes in vegetation type usage, species composition, or seral development having occurred since the 1974-75 study were noted during the 1977 study and are presented for the following 12 vegetation types (Tables 2.7-2 through 2.7-33).

The following subheadings are followed by numbers in parentheses. These numbers are shown on Figure 2.7-1.

Power Station (1)

This vegetation type surrounded the Big Bend station and had undergone disruption from construction activities. The recent disruption was reflected in the large number of early successional species (34) and the low number of woody species. Species with the highest importance values throughout the study period included Sesbania exaltata, Chloris petraea, Vigna luteola, Eupatorium compositifolium, Sporobolus dominicensis, Digitaria adscendens, Solidago sempervirens var. mexicana, Melilotus alba, Baccharis halimifolia, and Rhynchelytrum roseum.

This area will continue to proceed through the various stages of secondary succession if it remains unmanaged and free of future disruption.

Power Line Right-of-Way (2)

This vegetation type was similar to the power station type since it was predominantly ruderal and contained 28 species, most of which were herbaceous. Cynodon dactylon, Bidens pilosa, and Ambrosia artemisiifolia had high importance values and are all weedy species commonly found in areas undergoing early secondary succession.

Between the 1974-75 and the 1977 ecological field studies, a wastewater holding pond was constructed within this vegetation type; otherwise, little change was noted in species composition between the 1974-75 and the 1977 studies. Because this area is likely to be cut over to reduce the potential of fire hazards on the right-of-way, secondary succession will be arrested and maintained in an early seral stage.

Ash Pond (3 and 3A)

The original sampling station in this area (3) contained 34 floral species and, although a ruderal community, it was successional more advanced than the previous two vegetation types. Solidago sempervirens var. mexicana, S. microcephala, and Cyperus rotundus had the highest importance values. During the 1974-75 study, this sampling station (3) was eliminated due to construction activities and was replaced by another sampling station (3A) also containing 34 predominantly ruderal species.

Jackson Branch Freshwater Marsh (4)

Sixty-one species were identified in the sampling station at the Jackson Branch freshwater marsh. This was the highest number of species recorded for the 12 vegetation types at the Big Bend site. Dominant species in the upper stratum were Sambucus simpsonii, Schinus terebinthefolius, Myrica cerifera, Baccharis halimifolia, and Salix caroliniana. Verbesina laciniata, Bidens pilosa, Panicum purpureum, and Ambrosia artemisiifolia were the dominant species in the lower stratum.

Construction activity near the marsh (before the 1977 study) had resulted in elimination of most of the aquatic life in the pond.

Palmetto - Juncus Association (5)

This vegetation association contained 32 species and was one of the lesser disturbed areas studied. The upper stratum contained Serenoa repens, Baccharis halimifolia, Quercus virginiana, Schinus terebinthefolius, and Sabal palmetto with the highest importance values. Dominant species in the lower stratum were Solidago sempervirens var. mexicana, S. microcephala, Juncus roemerianus, and Scoparia dulcis. The species composition of this association suggests that this is an ecotone between the salt prairie and the palmetto-pine association.

Mangroves (6)

This vegetation type was a mangrove-dominated community and contained essentially three species: Avicennia germinans, Rhizophora mangle, and Laguncularia racemosa. It showed little or no similarity with any of the other areas studied. There was no detectable change in this vegetation type when observed during the 1977 study, and the mangrove type appears to be the most stable community in the Big Bend study area.

Salt Prairie (7)

This community contained 18 species, three of which showed high importance values during the 1974-75 study: Borrchia frutescens, Monanthocloe littoralis, and Distichilis spicata. This area appears to be undergoing very little change in species composition through time and thereby resembles the mangroves and the palmetto-pine association in terms of temporal stability.

Palmetto-Pine Association (8)

This area contained 50 species and was one of the most successional stable of the communities studied. Solidago microcephala, S. sempervirens var. mexicana, Spartina bakeri, Galactia elliotii, and Scoparia dulcis had high importance values during the study period in the lower stratum. In the upper stratum, Sabal palmetto, Serenoa repens, Myrica cerifera, and Baccharis halimifolia had high importance values. The vegetation studies indicate that this area is in a late seral stage of pineland succession.

Pasture (9)

During the 1974-75 study, the pasture type contained 30 primarily ruderal species in the lower and upper strata. In the lower stratum, Hydrocotyle umbellata, Digitaria adscendens, Desmodium canum, Centella asiatica, Cyperus tenuifolius, and Paspalum notatum had high importance values, and the upper stratum had Myrica cerifera, Baccharis halimifolia, Schinus terebinthefolius, and Lantana camara with high importance values. The pasture was being actively grazed by cattle and was therefore undergoing considerable disturbance. However, at the time of the 1977 study, cattle were no longer grazing in this area and there was a substantial increase in the number of herbaceous ground cover species. If this area continues to be ungrazed, it will proceed through old field succession and ultimately to a pineland community.

Pasture Pond (10)

The pasture pond was not sampled quantitatively during the 1974-75 study period because of the presence of cattle in the area. The pond was somewhat circular, approximately 225 - 250 ft in diameter, and its depth varied from 1 ft at the margin to 3 ft near the center. The most abundant vegetation included Sagittaria graminea, Hydrocotyle umbellata, Polygonum punctatum, Bacopa cyclophylla, Typha latifolia, and Juncus roemerianus. The pond was surrounded by a low, marshy area which, when combined with the pond, included an area over 400 ft in diameter. The peripheral area was wet with some areas having nearly one foot of standing water during the wet season. The wet area was predominantly Spartina bakeri. The remaining plants included Ludwigia octovalvis, Cyperus polystachyos, Cyperus surinamensis, Bacopa cyclophylla, Hydrocotyle umbellata, Lippia nodiflora, Dichromena colorata, Pluchea purpurascens, and Hymenocallis palmeri.

At the time of the 1977 study, nearly all of the pond had disappeared due to the encroachment of herbaceous species into the pond (i.e., hydric succession). The pond and

surrounding area will continue to proceed through secondary succession if left undisturbed in the future.

Myrica - Baccharis Association (11)

During the earlier study, this vegetation association was in an advanced stage of old field succession. It contained 23 species, and Myrica cerifera and Baccharis halimifolia were the predominant upper stratum species. The predominant species in the lower stratum were Solidago microcephala and Rubus trivialis.

Between the 1974-75 and 1977 studies, a holding pond was constructed in this vegetation type, and the entire area was eliminated and therefore not sampled during 1977.

Old Field (12)

The old field type contained 43 species. Species which had high importance values were Eupatorium compositifolium, Ambrosia artemisiifolia, Conyza canadensis, Bidens pilosa, Digitaria sanguinalis, Indigofera hirsuta, Lippia nodiflora, and Baccharis halimifolia. These were all ruderal species, commonly occurring in early old field successional seres.

At some time before the 1977 study, the entire old field type was converted into an active agricultural area and was in cultivated tomatoes during the 1977 study.

Life History Information for Important Species (1,2,3,4)

Ambrosia artemisiifolia (ragweed) - an annual weedy species commonly found in waste places, disturbed habitats, and sea beaches; grows 3-10 m high; flowering July to October.

Avicennia germinans (black mangrove) - tropical tree or shrub growing between high water mark of spring tides and near mean sea level; sheltered shoreline areas and along river banks as far as tide penetrates. Silt, sand, peat, and coral reefs are substrate habitats; flowering April to October.

Baccharis halimifolia (groundsel tree) - a shrub of open woods, thickets, and borders of coastal marshes; flowering August to September.

Borrchia frutescens (sea daisy) - a shrub growing up to 1 m high along the seacoast, especially in salt marshes; flowering March to October.

Distichlis spicata (salt grass) - grows in dense colonies in salt marshes along the coast from Nova Scotia and Prince Edward Island southward to tropical America.

Laguncularia racemosa (white mangrove) - habitat similar to Avicennia germinans; growing in nearly fresh water to 45.8 ppt. salinity.

Myrica cerifera (wax myrtle) - a southern evergreen tree or shrub up to 40 ft high growing in Coastal Plain swamps and wet woodlands on sandy and gravelly soils; leathery leaves; flowering April to June; fruit - small wax-coated nut, August to October.

Pinus elliotii (slash pine) - evergreen; leaves in clusters of twos and threes, 8-12 in long; pollen-producing cones appear in late January and February; seed-bearing cones 3-6 in long.

Quercus virginiana (live oak) - a spreading, southern evergreen tree with leathery leaves; commonly found on Coastal Plain soils.

Rhizophora mangle (red mangrove) - habitat similar to Avicennia germinans; pioneer species on Florida seacoast; growing in salinities ranging from freshwater to 34.9 ppt.

Sabal palmetto (cabbage palm) - height to 80 ft; prefers relatively dry land, but grows in sandy soils near saltwater or freshwater; found from North Carolina to Florida and the Bahamas. (Threatened - state of Florida)

Serenoa repens (saw palmetto) - shrub or tree with recurved spines along edge of petiole; dry pine barrens and sandy soil; Georgia, Florida, Alabama, Mississippi, South Carolina.

Solidago sempervirens var. mexicana (goldenrod) - a southern weedy variety found in saline coastal areas; one to few smooth stems, 0.2 to 2.5 m high; thick, fleshy leaves; rarely extends as far north as Massachusetts; flowering September to November.

2.7.1.2 Mammals

During the 1974-75 study, 13 mammal species were recorded in the 12 vegetation types surveyed. Although only one additional species, the eastern mole (Scalopus aquaticus), was observed during the 1977 study, six previously recorded species were not found during the 1977 study. These differences are attributed to any one or a combination of the following reasons: (1) extensive clearing or modification of several vegetation types, i.e., power line

right-of-way(2), Jackson Branch marsh(4), Myrica-Baccharis association(11), and old field(12); (2) the sampling effort was over a shorter period of time during 1977; or (3) the organisms were not, in fact, present at the time of sampling in 1977.

The most commonly occurring small mammal species was the hispid cotton rat (Sigmodon hispidus) (Table 2.7-34). Although individuals were present in all areas sampled, the preferred habitats for this herbivore include grassy areas, croplands, and fields similar to many of the vegetation types surveyed near Big Bend, (e.g., palmetto-pine association(8), power line right-of-way(2), and old field(12). The house mouse (Mus musculus) and rice rat (Oryzomys palustris) were also recorded in several vegetation types near the site. The house mouse, an omnivore, occurred primarily in old field-type habitats, e.g., power line right-of-way(2) and old field(12), while most of the rice rats were trapped in or near wetter habitats, e.g., Jackson Branch marsh(4), mangrove(6), salt prairie(7), and pasture pond(10).

A comparison of 1974-75 and 1977 data showed that highly significant differences ($P < 0.01$) in numbers of small mammals trapped per number of trap nights were obtained for three vegetation types (Table 2.7-35). The curtailment of cattle grazing in the pasture(9) and pasture pond(10) types coincided with a significant increase in relative density of the hispid cotton rat. This is attributed to a substantial increase in herbaceous ground cover at both locations, and therefore a greater forage base for the species to use. Also, at the pasture pond(10), a significant decrease in rice rat relative density coincided with the increase in cotton rat relative density. This is attributed to the near disappearance of the pond and wetland vegetation (preferred habitat of the rice rat) by 1977 and its replacement by vegetation characteristic of drier areas.

The cause for the significantly higher hispid cotton rat relative density in the palmetto-Juncus association(5) may have been the burning this area sustained between the 1974-75 and the 1977 studies. The burning could have resulted in an increase in food sources for the cotton rat by the time of the 1977 study.

Large mammals observed at the Big Bend site during the 1974-75 period included the eastern cottontail, marsh rabbit, raccoon, opossum, nine-banded armadillo, domestic cat, and gray fox (Table 2.7-36). Of these, the domestic cat and the gray fox were observed only during two sampling periods and in only one and two locations, respectively. Dens of the gray fox were observed in the power line right-of-way(2) and the ecologically similar old field(12). Its preferred food

sources, small mammals (e.g., cotton rat and house mouse) and rabbits (Sylvilagus spp.) were also commonly found in these two habitat types.

Signs of the gray fox were not found during the 1977 study, because both dens were previously destroyed. No other change in large mammal populations was detected during the 1977 study.

Life History Information for Important Species^(5,6,7)

Didelphis marsupialis (opossum) - the only marsupial in North America; head and body 10-12 in; tail 9-20 in; 9-13 lb; prefers agricultural areas, but also is found in woodlands and along streams; usually nocturnal; omnivorous, but plants usually form a small portion of diet; home range 15-40 acres; up to 14 young per litter; one to two litters per year; gestation period 13 days.

Mus musculus (house mouse) - head and body 3.2-3.4 in; tail 2.8-3.8 in; 0.4-0.8 oz; prefers buildings, either abandoned or occupied, but occasionally found in fields; omnivorous; 3-11 per litter; breeds year round; gestation period 18-21 days.

Procyon lotor (raccoon) - head and body 18-28 in; tail 8-12 in; 12-35 lb; found along streams and lake borders near wooded areas or rock cliffs; chiefly a nocturnal omnivore; home range up to 2 mi across, but generally less than 1 mi; average 4 per litter; 1 litter per year; gestation period 63 days.

Sigmodon hispidus (hispid cotton rat) - head and body 5-8 in; tail 3.2-6 in; 4-7 oz; makes surface runways through grassy clearings, croplands, or fields with broomsedge; feeds chiefly on green vegetation and will eat bird eggs; home range 100-200 ft across; usually 5-6 per litter; breeds year round; gestation period 27 days.

Sylvilagus floridanus (eastern cottontail) - head and body 14-17 in; 2-4 lb; prefers heavy brush, forested areas with cleared areas nearby, edges of swamps, and previously disrupted lands; chiefly nocturnal or crepuscular; feeds on vegetation, bark, and twigs; home range 3-20 acres; 4-7 per litter, 3-4 litters per year; gestation period 26 1/2-30 days.

Sylvilagus palustris (Marsh Rabbit) - head and body 14-16 in; 2.5-3.5 lb; prefers wet bottomlands, swamps, hammocks; chiefly nocturnal; feeds on marsh vegetation including rhizomes and bulbs; 2-4 per litter; breeding season February to September.

2.7.1.3 Avifauna

Eighty-four species of birds were recorded at the Big Bend site during the 1974-75 and 1977 field observations (Table 2.7-37). Their use of the area was influenced by habitat preferences (i.e., wading and shore birds present along pond and coastal areas, and birds of prey feeding in old field areas) and seasonal breeding and migratory patterns. Four resident-status categories (winter, permanent, or summer resident, and transient) were identified and applied to each species (Table 2.7-37).

The palmetto-pine association (8) and pasture (9) habitats provided good feeding areas for birds of prey including hawks and the great horned owl. Hispid cotton rats, short-tailed shrews, marsh rabbits, and cottontails were present, especially in the palmetto-pine association, and are among preferred prey sources for these predatory bird species.

Although eight permanent resident species previously occurring at the Big Bend site were not observed during the 1977 study, seven new permanent resident species were added during the 1977 period. (See Section 2.7.1.8 for discussion of endangered, threatened, and protected species observed at the Big Bend site.)

Life History Information for Important Species(*,*)

American oystercatcher - length 21 in; occurring in very small flocks on coastal mudflats and sandy beaches; feeds on shellfish including oysters, clams, and mussels; nests in slight depressions on sandy beaches; 2-3 eggs; range - breeds and winters along coast from Virginia to Texas.

Brown pelican - length 4.5 ft; wingspan 6.5 ft; large, coastal fish-eating bird; nests in rookeries on shores or marshy islands; nests, usually on ground, made of sticks, grasses, and weed stalks; 2-3 eggs; range - Atlantic and Gulf coasts from North Carolina to Texas; winters in Florida and along Gulf Coast.

Caspian tern - length 20-23 in; feeds on a variety of aquatic life; a colonial breeder which nests in hollow areas in dry sand; 2-3 eggs; range - winters on South Atlantic and Gulf coasts.

Florida sandhill crane - length approximately 4 ft; feeds on small rodents, frogs, insects, and vegetation in fields, open pinelands, and marshes; nests on ground in depressions lined with dry grass and weed stems; 2 eggs; range - Florida and southern Georgia.

Great blue heron - length 42-50 in; found in marshlands, swamps, and other wet areas; feeds on fish, amphibians, crayfish, small snakes, grasshoppers, and meadow mice; nests in trees along riverbanks; nests of limbs, twigs, and dry grass; 3-6 eggs; range - saltwater or freshwater throughout most of U.S., more commonly occurring in Southeastern U.S.

Least tern - length 9 in; found on sandy beaches; feeds on small fish and insects; nests in pebbly depressions on dry beach sand; 1-4 eggs; range - Atlantic and Gulf coastal areas; less commonly found inland in Mississippi River basin.

Little blue heron - found in shallow ponds and lakesides and coastal areas of Southern U.S.; feeds on fish, aquatic insects, and frogs; nests in trees or shrubs over or near swamps; 2-4 eggs; range - Atlantic and Gulf coastal regions.

Louisiana heron - length 27 in; saltwater shores; nests are platforms of sticks in mangrove or willow swamps; 3-5 eggs; range - Atlantic and Gulf coastal areas.

Osprey - length 2 ft; wingspan 4.5-5.5 ft; commonly occurring near seacoasts, rivers, and lakes; fish-eater; nests in trees or on ground; nests of coarse sticks, seaweed, etc.; 2-4 eggs; range - more common in southern Florida, but occurring throughout U.S.

Reddish egret - occurring on saltwater flats; fish-eater; range - coastal areas of southern Florida and Texas.

Wood stork - length 4 ft; swamp, marsh, and pond inhabitant; feeds on fish, reptiles, and amphibians; nests of platforms of sticks found in trees; 2-3 eggs; range - Southern U.S., chiefly near coast from South Carolina to Texas.

2.7.1.4 Amphibians and Reptiles

Observations at the Big Bend site during 1974-75 and 1977 indicated the presence of six species of amphibians and 12 species of reptiles (Table 2.7-38). Although all species observed during the 1974-75 study were recorded again in 1977, nine species were observed in 1977 in habitats in which they had not been recorded previously.

Three habitat types had undergone considerable change between the time of the two ecological studies. A holding pond had been constructed in the Myrica-Baccharis association(11). This eliminated habitat of species previously observed in this area, including the six-lined racerunner (Cnemidophorus sexlineatus), indigo snake (Drymarchon corais), southern five-lined skink (Eumeces inexpectatus), striped mud turtle (Kinosternon lauri),

narrow-mouth toad (Gastrophryne carolinensis), green tree frog (Hyla cinerea), and bullfrog (Rana catesbeiana). However, the southern five-lined skink, narrow-mouth toad, and green tree frog were observed in other habitats at the site during the 1977 study. The old field(12) types had been converted into an active agricultural area before the 1977 study and therefore was not sampled for amphibians and reptiles. No amphibians or reptiles were observed in the pond at Jackson Branch freshwater marsh(4), which had previously been disturbed by construction activity. However, three species of reptiles and one amphibian species were observed in nearby areas within the vegetation type. (See Section 2.7.1.8 for description of endangered, threatened, or protected species at the Big Bend site).

Life History Information for Important Species(10)

Eastern indigo snake (Drymarchon corais couperi) - 60-84 in; record 103.5 in; occurs mostly in unsettled areas where its food consists primarily of small mammals, birds, frogs, and snakes; range - southeastern Georgia, peninsular Florida, and lower Keys; disjunct colonies in western Florida and southern Alabama. The state of Florida and the U.S. Department of the Interior lists the eastern indigo snake as threatened.

2.7.1.5 Invertebrates

Two qualitative surveys (Period 1 - May 1 to September 1, 1974; Period 2 - September 1 to December 1, 1974) were conducted at the Big Bend site to characterize conspicuous taxa and to identify unusual infestations of invertebrates. For the two surveys, 36 families of insects in nine orders were recorded; two orders of Arachnida and two orders of Crustacea were also recorded (Table 2.7-39). The largest number of insect families(14) was recorded in the palmetto-pine association and the old field type. Only three insect families were recorded in the mangrove type.

During Period 1, dragonflies (Linellulidae) were abundant in all vegetation types, and six species were identified. At the power station(1) type, an infestation of snout beetle (Curculionidae) was present on sesban (Sesbiana exaltata). In the salt prairie(7) type, unusually large numbers of the gastropod Cerithium sp. were present on the ground and on sea purselane (Sesuvium portulacastrum). Fiddler crabs (Uca sp.) were also abundant in the salt prairie type. Butterflies of the family Pieridae were the most commonly observed group in most of the vegetation types sampled.

During Period 2, the number of lepidopterans and dragonflies had sharply dropped. This was attributed to the cooler and

windier weather occurring during this sampling period. A pulmonate land snail was abundant at the power station(1) vegetation type.

No catastrophic infestations of invertebrates were noted during either sampling period, nor during casual observations of the site during the 1977 study.

2.7.1.6 Environmental Stress

Vegetation

Five sources of stress to vegetation were identified during the 1974-75 and 1977 studies at the Big Bend site: fire, construction activities, agricultural activities, cattle grazing, and insects (Table 2.7-40). These stresses resulted in elimination of some habitats from the study site, e.g., holding pond in Myrica-Baccharis association(11) and agriculture in the old field type(12), or modification of formerly existing habitats, e.g., drying of Jackson Branch freshwater marsh(4) and burning of palmetto-juncus association(5), salt prairie(7), and palmetto-pine association(8). In some cases, stress was temporary and areas subsequently returned to an early seral stage, e.g., construction activities in power station(1) and grazing pressure in Pasture(9). The single incidence of insect infestation [snoutbeetle (Sec. 2.7.1.5) power station(1)] was neither catastrophic nor recurring.

No stresses were observed in the mangroves(6), nor were other sources of stress to vegetation observed during either study period.

Wildlife

There were no indications of stresses on wildlife species observed during either the 1974-75 or the 1977 studies (personal communication, University of South Florida staff).

2.7.1.7 Species - Environment Relationships

The area encompassing the Tampa Bay region is included in Kuchler's southern mixed forest.⁽¹¹⁾ This forest community is defined as the potential natural vegetation for this area and represents its hypothetical climax stage. The dominant species of the southern mixed forest include sweetgum (Liquidambar styraciflua), southern magnolia (Magnolia grandiflora), slash pine (Pinus elliotii), loblolly pine (P. taeda), white oak (Quercus alba), and laurel oak (Q. laurifolia). Other components of this forest include wax myrtle (Myrica cerifera), live oak (Q. virginiana), cabbage palm (Sabal palmetto), and saw palmetto (Serenoa repens). Although several of these species occur within the less

disturbed (i.e., more mature) habitat types at the Big Bend site (see Table 2.7-1), the surrounding area has been modified considerably and thus bears little resemblance to the southern mixed forest.

Most of the site exists in the early seral stages (seres) of secondary succession. These seres have resulted from construction and maintenance activities associated with Big Bend Units 1-3 and nearby agricultural activities associated with crop cultivation and cattle grazing. Fires have also burned over several habitats near the Big Bend site (refer to Section 2.7.1.6, Environmental Stress).

The 1974-75 and 1977 field studies document the presence of flora and fauna typical of early secondary succession. During these studies, a large number of ruderal species and typically associated fauna (e.g., hispid cotton rat, rice rat, and generalists such as the opossum, house mouse, and certain reptiles) were recorded. The composition and functioning of these early seres is also apparent in the relatively simple food webs (Figure 2.7-2) and low biomass compared to that which would be expected in more mature ecosystems. (12)

The two least disturbed habitats at the Big Bend site are the salt prairie (7) and mangrove (6) types. The species and food webs are closely linked with the marine environment of adjacent Tampa Bay. The dominant fauna are shorebirds, which feed primarily on terrestrial and marine vertebrates and invertebrates occurring in these two distinct habitats. These habitats were not, however, extensively used for nesting or breeding by these avian species. Other terrestrial vertebrates occurring in the salt prairie and mangroves included the hispid cotton rat, raccoon, rice rat, and marsh rabbit. The latter two species prefer the wetter, marsh-like habitats to drier, more upland habitats.

In summary, most of the habitat types at the Big Bend site have a history of quite recent disturbance. They are primarily early seres, and are therefore more readily returned to their existing condition following disruption than later seres.

2.7.1.8 Endangered, Threatened, and Protected Species

Table 2.7-41 summarizes the status of the eight species occurring at the Big Bend site which have been listed as endangered or threatened by the state of Florida and/or the U.S. Department of the Interior (DOI).

Life history information for each of these species is presented in Sections 2.7.1.1 through 2.7.1.5. Of the eight species, one, the wood stork, has been listed as endangered

(state of Florida) and two, the eastern indigo snake and the eastern brown pelican, have been listed as threatened by both the state and the DOI. The cabbage palm is the only plant species occurring at the Big Bend site listed as threatened by the State. Three of the eight species, the wood stork, Florida sandhill crane, and eastern indigo snake, were not recorded at the site during the 1977 studies.

Although the six avian species are either year round or winter residents (Table 2.7-37) of the area including the Big Bend site, none were observed nesting at the site. Therefore, during the 1974-75 and 1977 studies, it is likely that the habitats at the Big Bend site were primarily used for resting or feeding by these bird species.

The eastern indigo snake was observed in the Myrica-Baccharis association (11) during the 1974-75 studies. This area was subsequently disrupted by construction of a holding pond, and this species was not recorded at the site during the 1977 study. It is possible, however, that this species may be present in other areas in the vicinity of the site, but probably in low numbers due to the construction and operation activities occurring at the Big Bend site.

Although the cabbage palm occurs at the site, it is not unique to this area since the site is within its geographic range (North Carolina to Florida and the Bahamas). Furthermore, it is not present in high densities at the Big Bend site.

2.7.1.9 Bibliography

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2.7.2 Aquatic Ecology

During preparation of the 316 Demonstration, aquatic ecology information was collected and reported in the 1979 Aquatic Ecology Studies. The reader is referred to the appended 316 Demonstration for additional discussion of the aquatic ecology at the site and a detailed life history of Representative Important Species.

2.7.2.1 Description of the Aquatic Environment in the Area

Big Bend Station is located on the eastern shore of Tampa Bay near the mouth of Hillsborough Bay. The study area encompasses portions of both Hillsborough Bay and Tampa Bay. Water depths range from 1 to 25 feet and average about 11 feet. Figure 2.7-3 illustrates the Big Bend area and adjacent waters. Cooling water for the station is withdrawn from an area northwest of the plant through an artificial embayment created by a spoil island and a breakwater. The 2,500-foot breakwater west of the site reduces wave action on the intake canal and barge dock and serves to minimize recirculation of the station's thermal plume. Cooling water is discharged south of the site into a canal formed by a 3,750-foot breakwater running west through the north embayment of Apollo Beach. The discharge canal is approximately 350 feet wide.

Hillsborough Bay is considered an unusually stressed natural water body due to the urban and industrial development concentrated in the area.^(1,2) The present state of the bay is attributable to several human activities and is not a recent development. A large number of sewage treatment plant and industrial effluents are discharged into the bay, as noted in Section 2.5. Further, substantial dredging associated with commercial materials businesses, landfill, and ship channel maintenance has occurred in the bay on a continuous basis for approximately 100 years.⁽²⁾

The following description of marine ecology near Big Bend Station is based on the results of ecological investigations carried out from April 1970 through September 1978 in conjunction with the operation of Units 1-3. Methods for gathering the data are presented only briefly to provide a basis for understanding the observations presented here; complete technical descriptions are given in Section 6.2.4.2. The most intensive sampling was conducted from January 1976 to March 1977 as part of field studies for the 316 Demonstration for Units 1, 2, and 3. Unless otherwise noted, information provided in the following sections is derived from this source of data⁽³⁾. Information from published literature has also been incorporated. Detailed descriptions of the life histories and local information known for ten species of aquatic organisms that inhabit the Big Bend area are also provided

below. The species were selected for detailed description according to several criteria, including their importance to man and ecosystem, susceptibility to power plant effects, and representation of major segments of the Tampa Bay ecosystem.

A new field study, the 1979 Aquatic Ecology Program, was designed to provide specific ecological data for a list of important species found in the area and potentially susceptible to Big Bend's impact. The program is in progress and will be conducted for a period of one year. Its results will be reported as an amendment to the site certification at a later date.

2.7.2.2 Phytoplankton

Big Bend Observations

All information in this section is derived from Chapter 3, Volume I of the Appendix to Big Bend 316 Demonstration, September 1977, unless otherwise noted. Data were gathered from seven stations (shown in Figure 2.7-4) for fourteen months beginning in January 1976. Twenty liter dip samples were taken approximately once every two weeks. The samples were concentrated to one liter and passed through a 35um net.

Between January 1976 and March 1977, 83 species of diatoms, 42 of dinoflagellates, and eight species from other groups were identified for a total of 133 species. Table 2.7-42 lists the 20 most abundant taxa of phytoplankton found in the Big Bend area. Ten species accounted for over 90 percent of the total phytoplankton. The most abundant was the diatom Skeletonema costatum, followed by Oscillatoria sp. and Hemiaulus sinensis. Skeletonema costatum was present throughout the study reaching maximum abundance in the late winter and early spring. The maximum abundance of Oscillatoria sp., a blue green algae, was recorded in August and September 1976. Hemiaulus sinensis, a diatom, was the third most abundant species collected. Its maximum abundance was recorded during the winter. The most common dinoflagellate, Ceratium hircus, reached its maximum abundance during the summer.

In general, diatoms were the most common phytoplankton collected, and greatest densities were recorded during fall and winter. Figures 2.7-5 and 2.7-6 illustrate the seasonal variation in abundance of diatoms at different sampling locations. Table 2.7-43 lists the most common diatoms in order of abundance with a short description of seasonality and annual percent composition for each species.

Dinoflagellates were collected at all times during the study and demonstrated a succession of blooms during the summer. Two major blooms occurred: the first was noted initially on March 30, 1976 and the dominant species was Gonyaulax polygramma; the second was noted on July 8, 1976 and was attributed to Ceratium hircus. An illustration of dinoflagellate seasonal variation at the sampling locations is shown in Figures 2.7-7 and 2.7-8. A list of the most common dinoflagellates accompanied by a description of the seasonality and percent composition of each species is given in Table 2.7-44.

Occasionally, blooms (rapid growth and reproduction) of algae occur when appropriate environmental conditions coincide. "Red tides" are examples of this phenomenon and are caused by blooms of the dinoflagellates Gonyaulax or Gymnodinium. No red tide outbreaks were observed during the 1976-1977 studies, but a few instances were noted during earlier surveys at Big Bend. In January 1971, isolated blooms of the dinoflagellate Gymnodinium solens occurred and continued through February of that year, at times turning the water rust-red.⁽⁵⁾ In late July and early August 1971, G. breve appeared in the water samples, coinciding with a red tide caused by that organism in Tampa Bay. The bloom in Tampa Bay caused massive fish kills but prevailing winds kept the heaviest concentrations of the organism and the resultant dead fish away from Big Bend Station.⁽⁶⁾ On October 18, 1971, the intake canal water was colored dark brown. Microscopic examination of a dipped sample confirmed the presence of a heavy bloom of the estuarine dinoflagellate, Gonyaulax balechii.⁽⁶⁾ There was no evidence of damage to other flora or fauna caused by this sporadic bloom. Two days later, G. balechii was present in only very limited numbers in the intake and discharge canals as well as at nearshore stations in Tampa Bay.

Eight species of phytoplankton other than diatoms or dinoflagellates were collected and the blue-green alga Oscillatoria sp. was most abundant of these. Its concentration was highest between August 3 and October 4, 1976. Figure 2.7-9 shows the seasonal variation of Oscillatoria sp. at three stations.

Blue-green algae are known to prefer high ambient temperatures (>30°C).⁽⁷⁾ The study reflected this: Oscillatoria sp. was the dominant phytoplankton during the warmest part of the year and was generally most abundant at stations directly influenced by the Big Bend thermal plume. However, Oscillatoria sp. was also noted in extremely high numbers at stations outside the influence of the plume. The dilution pump intake station (0-8) had the highest number

(cells/l) of all stations on three consecutive dates, August 3, August 23, and September 14, 1976. On October 4, 1976, Oscillatoria sp. was the dominant phytoplankton species and had the highest relative abundance at the "open bay" station E-5; the station is a control.

Oscillatoria sp. has also been noted in past Big Bend studies. It occurred briefly in 1972, and in August 1975 it occurred at abundance levels similar to the magnitude noted in the 1976-1977 study.⁽⁴⁾

Total biomass of all phytoplankton was determined by season during the study and values increased through spring to a maximum in the summer. Lowest values corresponded to the presence of diatoms and highest to dinoflagellates. A station (I-3) located at the point of discharge (POD) had the lowest average biomass for the study period, 3.6 mg/l. The highest average was calculated for an open bay station (E-5), 5.6 mg/l; this was attributed to disproportionately high values recorded during summer months.

Community structure was analyzed in terms of three ecological parameters: species richness, diversity, and equitability. Consistent spatial patterns in these parameters were not evident. Temporally, the coincident extreme dominance (by abundance) of certain species influenced the seasonal variation in the parameters. The seasonal variation in abundance of Skeletonema costatum strongly influenced the seasonal trend of the parameters for diatoms. To a lesser extent, seasonal variation in Ceratium hircus influenced the seasonal trends in these parameters for the dinoflagellates. In general, richness and diversity tended to be highest during the late summer and fall for both diatoms and dinoflagellates.

Background

Primarily due to occasional blooms of the red tide dinoflagellate Gymnodinium breve, many studies on phytoplankton and primary productivity have been conducted in Tampa Bay. Gross annual phytoplankton productivity amounts to 314 to 427 gm carbon/m², as high or higher than any other similar area in the world.^(8,9,10) Phytoplankton productivity peaks in the late spring, late summer, and early fall. Hillsborough Bay always has the highest productivity in the Bay System (Table 2.7-45).⁽¹¹⁾ Primary production contributes 61,000 lbs (31,450 kg) of organic carbon per day to Hillsborough Bay.⁽¹²⁾

Turner and Hopkins conducted a study of phytoplankton in Tampa Bay from the fall of 1969 to early summer 1971.⁽¹³⁾ Their study noted 42 diatom and 23 dinoflagellate species. The most abundant diatom was Skeletonema costatum, as it was for the Big Bend study. The most abundant dinoflagellates in their study were Gonyaulax balechii and Ceratium hircus; C. hircus was most abundant in the Big Bend study. Oscillatoria sp. was not noted by Turner and Hopkins.

Red Tide Research

The first reported fish kill accompanied by discolored water off Florida's west coast occurred in 1844. Since then about 30 red tides have been reported,⁽¹⁴⁾ but it was not until the 1946-1947 red tide that the cause was determined.⁽¹⁵⁾ Major Florida red tides are caused by blooms of the unarmored, photosynthetic dinoflagellate, Gymnodinium breve. It produces a toxin which can kill fish and other marine animals; filter-feeding shellfish accumulate the toxin and cause respiratory paralysis and death when eaten by humans.

G. breve can survive and multiply only within a narrow range of chemical and physical parameters. Apparently, specific levels of temperature, light, stability of surrounding media, organic nutritional substances, and metals must coincide for blooms to develop.

G. breve is a coastal species and under normal conditions is restricted by low salinities from entering estuaries where shellfish are harvested. If an offshore bloom is supported by sufficient environmental conditions, it may be concentrated by wind and currents and transported inshore. During droughts when bays and estuaries are more saline, a bloom that has been driven inshore has a greater chance of survival.^(9,16,17) However, red tide outbreaks are also associated with lower salinity waters when rainfall and runoff are high.⁽¹⁸⁾

Wall and Dale⁽¹⁹⁾ confirmed that many marine dinoflagellates have benthic resting cysts which Von Stosch⁽²⁰⁾ indicated may be benthic zygotes. The Florida Department of Natural Resources is attempting to document the existence of these stages for G. breve,⁽²¹⁾ and map their distribution. Pyle and Wallace are examining the possibility of a relationship between underground springs and initial G. breve blooms.⁽²²⁾ The goals of these and other present studies are to determine why G. breve blooms occur, to predict their path and duration, and to lessen the impact on affected aquatic communities.

2.7.2.3 Aquatic Macrophytes

Big Bend Observations

Surveys of marine macrophytes conducted for Tampa Electric Company occurred during three time periods: 1970 to 1973, 1975, and 1977 to 1978. The first two studies were conducted prior to modifications to the discharge canal performed in mid 1976. During this time partially cooled water was discharged directly into the embayment south of Big Bend. Presently, as was the case during the 1977 to 1978 studies, the partially cooled water is discharged into Hillsborough Bay (see Figures 2.7-10 and 2.7-11).

Surveys from 1970 to 1973 sampled stations in the embayment and in Tampa Bay. Results showed the Big Bend area was characterized by a paucity of marine grasses and limited algal diversity⁽⁴⁾ a condition also noted prior to operation of Big Bend Unit 1 in October 1970.⁽⁵⁾ The perennial Ruppia maritima (widgeon grass) was the most commonly reported seagrass while Gracilaria spp. and Ulva lactuca (sea lettuce) were the common algal macrophytes. A report on water quality in Hillsborough Bay⁽¹²⁾ listed only three principal genera of algae in the area: Gracilaria spp., Ulva lactuca, and Chaetomorpha linum. Results of the Big Bend surveys are consistent with the FWPCA report since both indicate limited algal diversity is characteristic of the Big Bend area. Table 2.7-46 lists all algae encountered during the studies.

During the summer of 1975 a synoptic survey of marine angiosperms within the Big Bend embayment was undertaken. As in previous studies, limited floral diversity was found, possibly due to lack of suitable substrate, past dredge and fill activities, and the polluted nature of Hillsborough Bay.^(2,23,24,25) Limited patches of Halodule wrightii (shoal grass) were noted in all areas surveyed. However, dense patches of Ulva and Hypnea were present in all areas surveyed except the shoreline south and west of the former discharge location (area I). Table 2.7-47 lists the species found in the three study areas shown in Figure 2.7-10.

Observations on aquatic macrophytes made after discharge canal modifications are based on a study designed to assess natural revegetation of areas disturbed by the construction and operation of Big Bend.^(26,27,28) Sampling transects were established as shown in Figure 2.7-11. Thus, macrophytes described here are only those found in the vicinity of transects.

The submerged transects A-1, A-2, A-3, B-1 and control transect contained a total of four species of seagrasses: Syringodium filiforme (manatee grass), shoal grass, Thalassia testudinum (turtle grass), and Ruppia maritima (widgeon grass). Only the widgeon grass was found at the embayment transects (A-1, A-2, A-3) where it showed wider variation in coverage and density than at the control transect.⁽²⁷⁾ Figure 2.7-12 shows generalized locations of seagrass beds in the transect areas.

The control transect exhibited two disjunct areas of coverage.⁽²⁷⁾ The inshore area was dominated by widgeon grass in March, June, and September of 1978 and by shoal grass in December 1978. A small area of turtle grass was also found in December. The offshore area at the control contained only manatee grass with density and coverage remaining fairly constant throughout the sampling period. Table 2.7-48 lists all species encountered during March, June, September, and December 1978 samplings.

In addition to the submerged transects, intertidal transects (C, D, and E) were also studied. The twenty-seven species found in the intertidal and associated upland areas are included in Table 2.7-48.⁽²⁷⁾ During the 1977 March and June sampling, Paspalum vaginatum (seaside paspalum) predominated in transect E-3 and appeared to be gradually colonizing the intertidal zone.⁽²⁶⁾ Avicennia germinans (black mangrove) and Laguncularia racemosa (white mangrove) were the only plants present at transect E-2. Primary species present at E-1 were seaside paspalum, Spartina patens (saltmeadow cordgrass), and Casuarina equisetifolia (Australian pine). Similar species were present at transect C-1, C-2, and C-3. Dominant upland species during March and June 1978 were seaside paspalum, Heterotheca subaxillaris (golden aster), and Baccharis halimifolia (groundsel tree). Colonization of the intertidal zone appeared to be slow with a few mangroves visible near transect E-3.

In summary, algal diversity appears limited in the Big Bend vicinity according to observations made before and after operation of Big Bend Unit 1 was initiated in October, 1970.⁽⁵⁾ The abundant algal species noted by TECO consultants were Gracilaria spp., Ulva lactuca and Hypnea spp. An independent study⁽¹²⁾ also found Gracilaria spp. and Ulva lactuca in the vicinity of Big Bend, in addition to Chaetomorpha linum. These observations, which are specific to Big Bend, show some agreement with Phillips' study of macrophytes in Hillsborough Bay⁽²⁹⁾ in which Hypnea, Gracilaria, and Enteromorpha spp. were most abundant.

Seagrasses were scarce during the entire duration of studies at Big Bend, including a period prior to initiation of Big Bend Unit 1 operation.⁽⁵⁾ Widgeon grass was most common and shoal grass was noted sporadically in isolated patches in the embayment before the discharge canal was closed in 1976. After the canal was closed, preventing thermal discharge into the embayment, widgeon grass alone was found at sampling transects in the embayment.

The observed patterns of widgeon and shoal grasses may be the result of competition for dominance between the two species as elucidated by Phillips.⁽²⁹⁾ He found widgeon grass dominated during the cooler portions of the year and was replaced by shoal grass as temperatures warmed. Furthermore, he found shoal grass dominant in southern portions of Hillsborough Bay while widgeon grass dominated in northern portions; both species were present near Big Bend.⁽²³⁾ Thus, incidence of the grasses may be determined by temperature and location in the bay.

Background

According to the literature, submerged vegetation in the Tampa Bay estuary system is composed of four important species of seagrass⁽²⁹⁾ and 216 species of algae exclusive of the Cyanophyta.^(30,31,32,33) Approximately 10 percent of the estuary is vegetated by seagrasses and conspicuous benthic algae.⁽³⁴⁾ The seagrass beds serve as nursery and feeding grounds for young fish and shrimp, and provide habitat for large numbers of small marine animals, fishes, worms, small crustaceans, and bacteria. Nutrients released by decay of seagrass leaves help support a large plankton population. Leaves and roots prevent erosion and build substrate by slowing currents and trapping sediments. The seagrasses also provide substrate for epiphytic growth.⁽²⁹⁾

In his study of the marine algae and their environment in Tampa Bay, Boca Ciega Bay, and Tarpon Springs, Phillips⁽³⁰⁾ reported 86 taxa of algae from three sampling locations in Tampa Bay (including Old Tampa Bay). Large masses of unattached red algae were found at most stations and attached green algae were often found in abundance. In the bays, Hypnea musciformis, Gracilaria verrucosa, and Spyridia filamentosa were plentiful. Enteromorpha intestinalis formed massive growths in winter and spring.

Observed mean salinity decreased from 24.7 ppt at St. Petersburg (Beach Dr. SE) to 21.3 ppt at the northern end of Old Tampa Bay (Mobbly Bay). Phillips suggested that this gradient apparently had an effect on algal growth since the

number of algal taxa decreased from St. Petersburg northward to Old Tampa Bay.

In all areas, the greatest number of algal species were found during autumn, winter, spring, or some portion thereof. In general, Phillips⁽³⁰⁾ concluded the presence of a particular algal species is not rigidly controlled by the seasons. Of the 86 taxa found in Tampa Bay, 2 were found in summer only; 66 were limited to some portion of autumn, winter, or spring; 14 (including Gracilaria verrucosa and Ulva lactuca) were found throughout the year; and others were found in one season only. Thus, the number of species present is apparently lowest during the hot summer months.

Due to eutrophic conditions some algal species such as Gracilaria occur in troublesome quantities in Hillsborough Bay. Upon decay, Gracilaria produces extremely obnoxious odors of rotting vegetation or of hydrogen sulfide.⁽¹²⁾ Other algae that grow abundantly under eutrophic conditions include several species of Enteromorpha, Hypnea musciformis, and several blue-greens.^(12, 35)

Phillips^(23, 29) also conducted studies of seagrasses in the Tampa Bay area. He identified four important species: manatee grass, shoal grass, turtle grass, and widgeon grass. He concluded that optimal salinity was less than 25 ppt for widgeon grass, 25-38.5 ppt for turtle grass, and greater than 20-25 ppt for manatee grass.⁽²⁹⁾ No optimal salinity was determined for shoal grass, though it appears tolerant of a wide range. Optimal temperatures for all four species are between 20-30°C.

Reproduction is primarily vegetative and continuous throughout the year, except during the coldest months, for all species except widgeon grass.⁽²⁹⁾ In widgeon grass both sexual and vegetative reproduction account for new growth. At two sampling stations in Tampa Bay, copious flowering and fruiting occurred from May (water temperature 23.5-27.5°C) through June 1958, tapering off in July (water temperature 29.4-32.5°C), and disappearing in August. Fruits may have remained dormant into the winter and germinated when water temperature began to rise in the late winter and spring.⁽²⁹⁾ No relationship between salinity and flowering was apparent. Setchell⁽³⁶⁾ concluded that a temperature range of 15-20°C was necessary for germination and seedling development, and a range of 20-25°C was necessary for vegetative growth and reproduction.

In describing the distribution of species in Tampa Bay, Phillips⁽²³⁾ generally found shoal grass dominant in the southerly portions of the bay, while widgeon grass dominated

the northerly portion. In the Big Bend area, shoal grass was common and widgeon grass abundant. Offshore, within the one fathom curve manatee grass was plentiful and widgeon grass sparse. Phillips also noted that all attached seagrasses found in Tampa Bay grew on muddy sand bottom and that growth was limited to bottom areas shoreward of the one fathom curve, apparently due to the high turbidity of Tampa Bay. Turtle grass was encountered in the Big Bend area only rarely, probably because of sub-optimal salinity.

2.7.2.4 Invertebrates

2.7.2.4.1 Invertebrate Plankton

Big Bend Observations

Invertebrate plankton have been studied at Big Bend primarily in two studies. The first, conducted from 1970 to 1975, was principally a field investigation to determine what kinds of plankton existed in the power plant's vicinity; the methodology was directed towards characterization of phytoplankton populations. The second investigation was conducted from 1976 to early 1977 and focused on meroplankton of the decapod crustaceans.

From January 1976 through March 1977, samples of meroplankton were taken at approximately two week intervals by towing a 363um mesh net at eleven stations (see Figure 2.7-13 for sampling station locations); additional oblique (January-March 1975) and vertical (April 1976-February 1977) tows were taken using a 30 cm or 50 cm mouth diameter No. 20 mesh (75um) net. Specimens from the 363um net were identified and subjected to comprehensive study if they were either fish or decapod crustacean. In addition, indication of the relative abundance of non-decapod invertebrate plankton was obtained by enumerating those organisms collected from the 363um and 75um nets. Results of the decapod crustacean investigation are reported in detail in the Appendix to 316 Demonstration, Volume III.(37)

The density of all meroplankton species from the 363um mesh net showed peaks of abundance in April and October (see Figure 2.7-14). Larval decapod crustaceans accounted for 94 percent of the larval forms taken. In the coldest months when decapod larvae were rare, molluscan larvae dominated the catch. A total of 105 taxonomic groups belonging to 7 phyla were identified from the samples (see Table 2.7-49).

Most samples from the No. 20 mesh nets were not examined; however, results were reported for one sampling date, January 6, 1976. The abundance of such forms as barnacle

nauplii, gastropod veligers, and bivalve veligers in the No. 20 mesh net was 2 to 4 orders of magnitude greater than their abundance noted in the 363um net. Additionally, gastropod veligers and barnacle nauplii accounted for 3.0 percent and 1.7 percent, respectively, of the meroplankton collected in the larger mesh net. Based on this evidence, abundance of non-decapod larvae is underestimated by the 363um mesh net. Numerically, these forms would probably be the most dominant meroplankton.

On a species basis, a brachyuran crab, Pinnixa sayana, was the most abundant larval decapod in the 363um mesh net samples. Major spawning peaks were apparent in April and October, with a smaller peak in July.

Larvae of the anomuran crab Polyonyx gibbesi were next in abundance. Large swarms of first and predominantly second stage zoea were noted throughout the area during the warm months. More larvae were found during the daytime than nighttime in samples in which they were abundant (with the exception of September 22 when both zoeal stages were more abundant at night). Abundance was quite variable between stations. Sandifer⁽³⁸⁾ found P. gibbesi larvae predominantly in bottom tows, but the 1976-1977 study found many swarms of these zoea near the surface. Also, 10 percent of Sandifer's larvae were megalopae, nearly all from bottom samples, while 2 percent of the larvae from this study were megalopae.

Third in larval abundance was the macruran shrimp Upogebia affinis. There is some indication in the August 18 samples that breeding may have recommenced outside the study area somewhat more rapidly than within the area after the mid-summer depression, as evidenced by the second and third stage zoea in these samples. Sandifer⁽³⁸⁾ reported most specimens as occurring above 23°C with peak abundance at 25-27°C. This correlates well with findings of the meroplankton study though Sandifer found his largest numbers from June to October; highest numbers in this study were found in spring and early summer samples.

Neopanope texana and Hexapanopeus angustifrons were the most abundant xanthid species overall, and the fourth and fifth most abundant decapod species. Both species exhibit late summer/fall breeding which seems to be bimodal. Rouse⁽³⁹⁾ found Neopanope texana to be ovigerous in the winter, while Lyons et al.⁽⁴⁰⁾ found the species bred from February to October.

Both species had unusually high relative abundance of late stage larvae in some mid-summer samples. Late stage zoea

were more abundant than Stage I zoea in the July 20 samples, indicating a recent, rather abrupt end to the production of larvae in the area. In August 18 samples, Stage I zoea were still rather rare, while numbers of later zoea increased well over the previous samples' level. These later stage zoea were probably produced outside the study area and were carried into the area by currents, as the low numbers of Stage I zoea indicated that hatching within the area was still at a low level.

Although not one of the most abundant xanthids, the stone crab Menippe mercenaria, an important commercial species, was regularly collected. Larvae were found from April through October but never in great abundance. Of the larvae taken, 78 percent were first stage zoea. Abundance of the species is illustrated in Figures 2.7-15 and 2.7-16. Densities at inshore stations are slightly greater than at offshore stations and there are strong peaks in abundance in spring and fall. The strongest pattern evident in the graphs, however, is the difference in density between day and night sampling. Stone crab larvae were less abundant at night, suggesting the organisms are more evenly distributed in the water column during the day.

The blue crab, Callinectes sapidus, is commercially important in Tampa Bay. Larvae of this portunid crab were rarely collected, though a few zoea were found between April and September.

The commercially important pink shrimp, Penaeus duorarum, was found in the meroplankton only in late postlarval stages. Numbers collected were quite low, only 24 during the entire study, 11 of which were taken in sampling at station BC-8 during July and August. All but one larva were collected at night. The low numbers were attributed to the offshore spawning behavior of this species.

Generally, seasonal fluctuation in numbers of decapod crustacean larvae is the strongest pattern evident in the collected data. As illustrated in Figure 2.7-17, density of most species peaked in spring and fall. Spatial patterns, as reflected by the stone crab, were weak or absent. This suggests the sampled area is well mixed by tidal action, or no unique spawning habitat exists within the study area.

An earlier sampling study of plankton was conducted in the Big Bend area from 1970 through 1975. Sampling methodologies varied as the studies evolved but, generally, monthly collections were taken by both 135um mesh plankton net and whole water samples. The methodology was sufficient to provide only a qualitative description of local plankton

populations, including species composition and relative abundance; inferences on spatial or temporal patterns could not be made. Results of these studies are found in a series of quarterly reports titled "Ecological Surveys of the Big Bend Area"(*1) and are summarized in "Ecological Surveys of the Big Bend Area, Five Year Data Summary."(*2)

Typically, the zooplankton community was dominated by copepods, of which cyclopoids were generally more abundant than calanoids. Crustacean nauplii, early bivalve/gastropod veligers and polychaete larvae, were usually present in great abundance. These organisms were found every month in at least one of the sampling areas as were spionid larvae, barnacle cypris, nematodes, Trichocerca sp., Oikopleura sp., turbellarians, Favella sp., Salpingella sp., and Tintinnioptes sp. Copepod nauplii reached peak abundance in fall and spring when water temperatures approached 25°C. Adult cyclopoid copepods showed no such temperature response. Early bivalve veligers became prevalent when water temperature approached 18°C. Table 2.7-50 lists species found during the plankton studies.

Background

Kelly and Dragovich(*3) studied the occurrence of macrozooplankton in the Tampa Bay area between September 1961 and August 1962. Although results of this study are not entirely comparable with those obtained at Big Bend, it is probably the most comprehensive study of zooplankton in the area. Surface plankton tows were taken monthly with a 1.024 mm mesh plankton net. The greatest numbers of macrozooplankton were taken in Tampa Bay, central Tampa Bay, lower Hillsborough Bay, central Old Tampa Bay, and 6.5 km offshore in the Gulf of Mexico.

Of all zooplankton taken, 53.5 percent were holoplanktonic, 46.2 percent were meroplanktonic, and 0.3 percent were hypoplanktonic. Lucifer faxoni comprised 45.6 percent of the zooplankton. This species was the most abundant organism in fall, winter, and summer, and was dominant in Tampa Bay. Porcellanid larvae, comprising 27.4 percent of the zooplankton, were the dominant zooplankter in the spring and were most numerous in upper Tampa Bay and lower Hillsborough Bay.

Larval brachyurans were third in abundance comprising 10.5 percent of the zooplankton. These zoea and megalops were most abundant in upper Tampa Bay and lower Hillsborough Bay. Copepods were the fourth most abundant zooplankter, though due to the large net mesh only larger specimens were retained. The greatest numbers of copepods occurred in

spring; in winter they were the third most abundant of all taxa.

2.7.2.4.2 Macroinvertebrates Collected by Benthic Sampling Gear

Big Bend Observations

Ecological investigations of benthos in the Big Bend area have been conducted since 1970, including a particularly comprehensive survey from February 1976 to February 1977. Information collected from the latter investigation is treated in detail in Chapter 5, Volume II of the Appendix to Big Bend Station 316 Demonstration, September 1977. (**) The description provided in this section is from the Demonstration unless otherwise noted. Location of the sampling stations and frequency of sampling is shown in Figure 2.7-18. Six ponar grab samples were taken per station on a given sampling trip. The ponar gear covered a bottom area of 0.022 m².

A total of 352 species were identified from the 400, 740 organisms collected. Nine species accounted for about 70 percent of the fauna (by abundance) collected during the study period and a brief discussion of the abundance and distribution of these species is presented below. Figures 2.7-19 to 2.7-21 illustrate the density of the most abundant of these species at each sampling station.

Mysella planulata, a small bivalve, was the most abundant species collected at the sampling stations. Its distribution appears to be influenced by sediment type: M. planulata was more abundant at medium sand stations. Generally, communities dominated by Mysella planulata were the most frequently encountered type of association. Stations within the influence of Big Bend Station's thermal plume showed a higher proportion of M. planulata than stations outside the plume's influence. Sampling revealed frequent fluctuations in abundance throughout the duration of the study; correspondingly, no seasonal trends in abundance were evident.

Three amphipods were among the most abundant benthos. Ampelisca abdita (incorrectly identified in the 316 Demonstration as A. vadorum) was the second most abundant species collected. Its distribution does not appear to be related to sediment. Its occurrence was sporadic; no temporal or spatial patterns were evident from the data. A. verrilli was the seventh most abundant species, primarily because it was collected in high numbers at the intake station, I-18. The species was sparsely

present at other stations. No temporal pattern was evident in the data. Another amphipod, Rudilemboides naglei, was the ninth most abundant species. It was most abundant at Station SP-1, a control, and was collected at SP-2 and I-18 which are adjacent to SP-1. The species was notably sparse at other stations. Spring and late fall abundance peaks were noted at SP-1.

The third most abundant benthic organism was Parasterope pollex, an ostracod. It was most abundant in spring and fall and greater numbers were found at stations under the influence of the thermal plume. Another ostracod, Haplocytherida setipunctata, was the fifth most abundant benthic species. It was most abundant at stations having medium grain sand containing a low fraction of silt and clay. Otherwise, no spatial or temporal variations were evident.

A bivalve species, presently referred to as the Mulinia-Mactra complex, was the fourth most abundant benthic organism. The sediment of stations at which organisms of this species were most abundant was usually medium grain sand. In addition, these stations were either affected by Big Bend's discharge or were subject to relatively greater solar heating. In general, the species showed a small increase in abundance during the spring of 1976.

Several polychaete species were collected in the study and the most abundant was identified as Pseudopolydora sp. It was the sixth most abundant benthic organism collected. The species was most abundant at three stations, along the "BC" transect (see Figure 2.7-19), and appears to prefer fine sand sediments. In general, an abundance peak occurred in late 1976.

A cumacean species, Cyclaspis varians, was the eighth most abundant benthic organism collected. It was the dominant (by number) at the discharge sampling station from May to July 1976. It was also found at most open bay stations, but was characterized by sporadic peaks of abundance. The studies suggest C. varians is an opportunistic species, briefly colonizing a habitat when conditions allow.

In general, most stations were dominated by a few species and Mysella planulata was most frequently the dominant species. Its occurrence was temporally erratic, however. Abundances of Cyclaspis varians, Ampelisca abdita, and A. verrilli were sporadically high at most stations. Ostracods tended to demonstrate two abundance peaks, in May and November. Bivalves did not demonstrate a consistent pattern of abundance in time but appeared to prefer medium sand

sediment. For all dominants, extreme fluctuations in abundance were common at Big Bend.

Benthic species which have been suggested as indicators of pollution (both thermal and otherwise) were collected at Big Bend. Nereis succinea, a polychaete, was abundant and persistent at the discharge stations (I-1 and I-16) and a station near the POD (BC-8). Highest abundance was found during summer months. In August 1976, N. succinea accounted for 78 percent of the faunal abundance at the outfall station (I-1). However, it accounted for only 8 percent of the BC-8 collection at the same time, its maximum value for the entire study period at BC-8. Most other stations averaged less than 1 percent relative abundance of N. succinea.

Capitella capitata, another polychaete species and suggested pollution indicator, was found at several inshore stations (I-1, I-16, I-2, I-17, I-15 and F-3). Its highest relative abundance was encountered at the outfall station I-1 in April 1976 when C. capitata represented 41 percent of the benthos collected at the station. Its highest average (for the study period) relative abundance was 20 percent at the finger-fill canal station F-3. This station is outside the influence of the thermal plume, but is considered polluted by development activity in Apollo Beach.(**) Relative abundance of C. capitata averaged less than 1 percent at most of the remaining sampling locations.

A number of parameters were calculated to characterize the benthic assemblages in the Big Bend area. These include density and biomass, diversity, richness, equitability and similarity, and are discussed at length in the 316 Demonstration. Faunal density calculated for several of the stations is shown in Figure 2.7-22. Density values were notably low at discharge canal stations, but other stations considered to be controls ("E" transect) had similar values. Only stations under the influence of Big Bend's discharge appeared to demonstrate temporal patterns: densities at discharge stations peaked in May and thermal transect stations showed more variability in density early and late in 1976. Biomass values did not exhibit temporal patterns but spatial patterns were found. Stations along the "C" transect exhibited relatively higher biomass than corresponding "E" transect stations. Average biomass values at "I" stations were slightly less than those of all other stations.

Most communities were dominated by a few species, so equitability (a measure of the distribution of individuals among species) was low. Species richness (basically the

number of species) was low at stations in the discharge canal, the northern embayment of Apollo Beach, and SP-2. Species diversity (a measure of community heterogeneity; diversity is a function of both richness and equitability) generally increased with distance from shore in the bay transects. Diversity values at discharge canal stations were higher than those from "BC" stations, but were similar to "E" station values. In general, diversity was higher during two periods of the study, May-July and November-December; lower values occurred in August and September. Similarity of faunal composition at different stations fluctuated during the study due to shifts in dominance (i.e., the most abundant species at a station was replaced by another as the study progressed). Results of the similarity analysis showed the benthos distributed according to sediment type. However, some dissimilarity occurred between communities at stations along the "BC" and "E" transects that could not be attributed to differences in sediment.

Background

Benthic surveys have shown Tampa Bay supports an abundant and diverse community of benthic invertebrates.^(1, 45-54). In Hillsborough Bay, however, soft highly organic sediments have replaced native sands, and high BOD makes the bay uninhabitable for most benthic organisms.⁽⁵⁵⁾ As a result of dredging activities, sewage, and runoff, Hillsborough Bay and Tampa Bay are typified by altered benthic habitats.

Taylor et al.⁽⁵⁶⁾ conducted an extensive survey of the benthic mollusks of Hillsborough Bay in 1963. They sampled with a bucket dredge and a rigid frame net and collected 64 species, of which only 36 were represented by living specimens. Samples at all stations where live individuals were taken always included one or more of the following species: the dwarf surf clam, Mulinia lateralis; the paper mussel, Amygdalum papyria; the common eastern nassa, Nassarius vibex; and the stout tagelus, Tagelus plebius. Other numerous mollusks were the crown conch, Melongena corona, and the luna dove-shell, Mitrella lunata.

On the basis of the distribution and occurrence of certain mollusks found in this survey, the researchers classified the bay bottom environment into three zones: healthy, marginal, and unhealthy. These classifications were correlated with the degree of man-made alteration that had occurred. Using this system, 42 percent of the bay bottom was considered unhealthy, 36 percent marginal, and 22 percent healthy. Those areas termed unhealthy were marked by accumulations of sediment unsuitable for colonization by

benthic infauna. These sediments were either highly organic anaerobic fine-grained silts, coarse-grained spoil from channel dredging, or gypsum spoil from the processing of phosphate. There were no living mollusks found in this zone. The marginal areas represented transitional zones between the unhealthy and healthy areas. Marginal zones contained a limited number and diversity of mollusks. The healthy area supported numerous and diverse assemblages of species. The sediments were primarily fine sand. Most of the healthy stations were at the mouth of Hillsborough Bay in the offshore areas.

Since the Big Bend Station is located adjacent to extensive dredge-and-fill operations, it is likely that it would be considered either marginal or unhealthy, according to the classifications defined above.

A massive outbreak of red tide in 1971 eradicated the polychaete fauna of a sandy, intertidal area of old Tampa Bay. This provided an excellent opportunity to study the recovery of a benthic community. Analysis of the 22 most common infaunal invertebrates showed a decrease of 97 percent in the total number of individuals and a 77 percent decrease in the number of species between April 1970 and August 1971.^(57,58) The rates of species immigration and extinction were studied over the next two years, and the resulting recolonization curve showed that repopulation conformed to the species equilibrium model of MacArthur and Wilson.^(59,60) Immigration of polychaete species to the area was rapid for the first few months, rose slowly after that, then leveled off eleven months later when there were 28 species in the area. A total of 54 polychaete species were collected during the study.⁽⁶¹⁾ Although the average species number and density of individuals were not significantly different at specific tide levels, the species composition was highly variable over time.⁽⁶²⁾ The species that were dominant during the first year, Eteone heteropoda, Gyptis vittata, Nereis succinea, and Paraprionospio pinnata, were opportunistic and expanded their distributions. Second year dominants, Capitita ambiseta, Minuspio cirrifera, and Travisia sp. were collected later, took longer to increase their densities, and did not show habitat expansion.⁽⁶³⁾ Adult dispersal was important when the populations were becoming established, and larval settlement maintained the population.⁽⁶⁴⁾

Much of the scientific literature concerning Tampa Bay benthos has concentrated on the environmental effects of a variety of dredging activities. These include channel deepening, maintenance dredging, shell dredging, and dredging for landfill.

Channel Deepening

In a study done for the U.S. Army Corps of Engineers, (55) the benthos of the Tampa Ship Channel were surveyed from outside Tampa Bay to Hillsborough Bay in 1963. (64) More than 300 species representing 17 major taxa were collected. Faunal analysis by taxonomic group showed that annelid worms (polychaetes, oligochaetes, and a few marine leeches) made up most of the benthos collected, and dominated the bottom assemblage at each transect. Arthropods (isopods, amphipods, and cumaceans) were the next most common group, followed by mollusks, other minor phyla (predominantly nematodes), chordates (mostly lancelets) and echinoderms (almost entirely ophiuroids). Annelids, arthropods, and mollusks were more numerous at two transects north of Big Bend in Hillsborough Bay than elsewhere in Tampa Bay. One transect, south of the spoil islands, produced the greatest number of organisms in the study area.

Sediment type alone had little bearing on abundance or variety of benthic organisms in the Ship Channel. The most noticeable difference between soft and firm bottom sediments was that those having a weight percentage of more than 20 percent silt and clay almost always contained very large numbers of specific mollusks and polychaetes. Corbula, Tellina, Mulinia, and Macoma were the most common mollusks, and polychaetes from the Family Spionidae were dominant. Although a few species were dominant at soft bottom stations, the diversity indices still indicated fair to good environmental conditions.

The presence of the Ship Channel may have greater influence on infaunal abundance and variety than sediment type alone. Taylor (64) divided the bay bottom into five sediment types: deep ship channel, soft spoil, firm spoil, soft undredged bottoms, and firm undredged bottoms. Firm bottoms (combination of sand and shell) supported the greatest number of species and individuals, while channel areas supported the least. The sampling method and number of stations in each bottom type may have influenced these results.

The polychaete benthos of the Tampa Ship Channel and vicinity were sampled again in 1973. (64) Lists of polychaetes found at stations or areas nearly identical to the 1963 study showed very few similarities. There were many more species in 1963 than 1973, and there was 40 to 73 percent correspondence between years in the species lists of each transect. Different sampling techniques or possibly seasonal differences accounted for the changes in polychaete abundance and species composition. The changes may also

have been a result of deterioration of the estuary by sewage pollution.

Maintenance Dredging

Once the ship channels are deepened, dredging must continue to remove natural sedimentation, sewage and sedimentation that gradually fill in the channels. Instead of open water disposal of this spoil, which was prohibited in 1973, spoil from the Tampa Harbor Deepening Project is deposited in diked areas within Hillsborough Bay.⁽⁶⁵⁾ These spoil areas will total 50 million ft² in Hillsborough Bay alone,⁽²⁾ and they are planned to hold 30 yrs of maintenance spoil. Whether anticipated improvement in water quality will offset the loss of benthic habitat is impossible to determine at this time.⁽²⁾

Shell Dredging

Nearly 18 million tons of oyster shells have been removed from Tampa Bay for commercial purposes since 1946.⁽⁶⁶⁾ Shells and sediment are removed by hydraulic cutterhead dredge and sorted over screens; the sediment and water are returned to the bay. Simon, Doyle, and Connors⁽⁶⁷⁾ conducted a study of the modification of biological communities in dredged areas. They found the area disturbed by shell dredging resumed its initial species assemblage, number of species, density patterns, and the same or slightly lower biomass within one year of dredging activity when compared to undisturbed bay bottom. However, they caution that small, tightly controlled, target specific shell dredging operations cannot be directly compared to the massive changes resulting from large channel deepening projects.⁽²⁾

Dredging for Landfill

Hillsborough Bay has been greatly modified by dredging intended for landfill. One hundred years ago, there were 2,378 ha of marine wetlands in Hillsborough Bay. In 1976, however, only 400 ha of wetlands remained, representing a loss of 83 percent.⁽²⁾ Twelve years ago, filled areas in Tampa Bay estuary totaled 4,266 ha.⁽⁶⁸⁾ Nearly all of this was created through dredging submerged or intertidal bay bottom and pumping the spoil into emergent landsites. The magnitude of this loss can be seen by comparison with studies in Boca Ciega Bay. Taylor and Saloman⁽⁶⁹⁾ estimate that filling in of 1,400 ha of bay bottom resulted in a minimum loss of 25,841 metric tons/year of infauna.

2.7.2.4.3 Macroinvertebrates Collected by Seines and Trawls

Big Bend Observations

Between 1971 and 1975, invertebrate data were collected from trawls and seines at selected stations in the Big Bend area; the stations are shown in Figure 2.7-23. Tables 2.7-51 through 2.7-55 list the twenty-five most abundant species of all organisms found during the last two years of the study (when taxonomic identifications were most certain) for selected stations. The lists included fishes as well as invertebrates. Results of the sampling are discussed in more detail in the series of quarterly reports titled Ecological Surveys of the Big Bend Area.

Further trawl and seine studies were conducted from January 1976 through March 1977. Stations and frequency of sampling were modified from those of the 1971-1975 studies. Figure 2.7-24 shows stations sampled; seine stations were sampled monthly and trawls four times a year. Results of these studies are also reported in Ecological Surveys of the Big Bend area and in the Appendix to 316 Demonstration.(37)

The most abundant macroinvertebrate collected by seine during the later study was the crown conch Melongena corona, primarily taken on the mud flats of embayment station SB-10. Young of this species were captured in May and June 1976. Peak abundance of all organisms occurred in September 1976 through February 1977. The blue crab, Callinectes sapidus, was also abundant in seine hauls, generally being among the three numerically dominant invertebrate species in any given haul. Almost half of those collected were caught at station SB-10 in the embayment north of Apollo Beach.

Macroinvertebrates were most abundant at station SB-10 and least abundant at SB-14. Seasonal peak abundances, noted at most stations, generally occurred in spring and fall; lowest abundance was during winter.

Only four trawls were conducted between January 1976 and March 1977 (none were taken during the first quarter of 1976). Table 2.7-56 lists total numbers of macroinvertebrates caught by station. The large numbers taken at station TB-13 reflect a disproportionate number of Molgula sp. captured in February 1977. Table 2.7-57 lists macroinvertebrate catches excluding Molgula sp. During the February 1977 trawl, sampling was conducted both day and night. Table 2.7-58 lists numbers of macroinvertebrates caught by station in day and night samples for February 1977 only. Greater numbers of organisms were caught at night. Otherwise, the low number of organisms collected during the

program (approximately 400) does not provide sufficient data to elucidate spatial or temporal patterns.

Important Species Life Histories

Presented below is a discussion of life history and local ecological information for four important invertebrate species found in Tampa Bay: pink shrimp, blue crab, stone crab, and American oyster. Though incidence of these species is infrequent when compared to other invertebrates (as reported in previous sections which have described Big Bend ecological studies), their commercial importance necessitates special consideration for Big Bend's potential impact on their populations. In particular, impingement surveys suggest pink shrimp and blue crab are the most abundantly impinged invertebrates. Stone crab and American oyster, due to their benthic adult existence and larval dispersal stages, are more likely susceptible to entrainment impact.

Pink Shrimp (*Penaeus duorarum*)

The pink shrimp is a valuable commercial species in the Tampa Bay area as well as the eastern Gulf of Mexico. Penaeid shrimp are omnivorous animals and ingest a variety of animal and plant material. In the Tampa Bay area, examinations of shrimp stomach contents revealed particles of Thalassia leaves; small sections of Halodule (Diplanthera) leaves and rhizomes; the red algal epiphyte Centrocercla clavulatum; filamentous red algae Erythrotricha carnea; filamentous blue-green algae Oscillatoria nigroviridis; and many species of diatoms. Also, dinoflagellates Ceratium and Gonyaulax were observed at times. Animals ingested included polychaetes, nematodes, caridean shrimp, mysids, copepods, isopods, amphipods, ostracods, mollusks, and foraminiferans. Penaeus duorarum is nocturnal and a bottom feeder, especially in shallow areas where the seagrasses Thalassia and Halodule and the algae Gracilaria occur. (70)

Spawning of pink shrimp occurs offshore and juvenile progeny migrate to estuarine habitats to complete their development. (70, 71, 72) Eldred et al. (70) concluded that the minimum temperature necessary for spawning in North Carolina was 23.9°C, though higher temperatures may be required for peak spawning and development of eggs and larvae. Rising temperatures may initiate spawning and maximal temperatures may terminate it. In warmer, fairly shallow areas, the spawning season may exhibit two peaks of activity, one in spring and one in fall. Sampling done by Eldred et al. (70)

in Tampa Bay during 1957 and 1958 indicated that peak spawning months were April or May through September.

The minimum survival temperature for the pink shrimp is uncertain, though Eldred et al.(70) feel it to be near 12°C. A maximum temperature is also uncertain; Copeland and Bechtel(73) indicated that this species prefers a temperature range of 20-35°C. During extreme cold spells, and perhaps during warm also, this shrimp burrows into the sand for protection.

Thorhaug et al.(74) found that the lethal thermal temperature (LT₁₀₀) of first and second postlarval stage pink shrimp was about 38°C (died within 2.5 hours). There was some mortality at 34.9°C with longer experimental exposures (25 hours) in the first stage. Second stage postlarvae were not tested past 2.5 hours.

Blue Crab (Callinectes sapidus)

Blue crab is an important commercial species in the Tampa Bay area. Mating occurs in water of reduced salinity found in the upper reaches of estuaries.(71) Afterward, females migrate downstream to areas of salinity over 20 ppt to mouths of estuaries.(71,75) The males remain in the low salinity areas.(71) Spawning season in Chesapeake Bay extends from late April to early September with the peak occurring in June, while in Texas the season extends from December to October with the peak occurring in June and early July.(71) As soon as the young reach the first crab stage, they begin migrating to the mating grounds. Maturity is reached in 12-14 months.(71,75) No correlation was found between relative abundance of females and their progeny;(76) cold weather and heavy runoff may be factors affecting survival of the young.

The blue crab is generally regarded as a scavenger; in fact, it is an omnivore and prefers fresh to putrid flesh.(77,78) Its diet may include oysters, clams, and tunicates.(71)

Blue crabs can apparently tolerate wide ranges of temperature and salinity. Copeland and Bechtel(73) found that optimum catches occurred in water between 10° and 35°C, and at a salinity between 0 and 27 ppt. Tagatz(79) studied 48-hour LT₅₀ at various acclimation temperatures and salinities. Adult blue crab acclimated to 100 percent salinity have a 48 hr upper and lower thermal tolerance limits between 33.1 to 38.7 and 0.0 to 4.6°C, respectively. The upper and lower TL₅₀ for juveniles acclimated under the same conditions is between 33.0 to 39.0 and 0.0 to 4.9°C, respectively. Almost all 48 hr LT₅₀ of crabs in 20 percent

seawater were 0.2 to 2.0°C less than those of crabs in 100 percent seawater. Churchill(77) found that eggs hatch in about 15 days at 26.1°C. Larvae never went beyond the first zoeal stage when reared at 20°C and did not progress beyond the third zoeal stage when reared at 30°C.

Stone Crab (Menippe mercenaria)

The stone crab, a xanthid, is another important commercial species. The young reside in channels of the more saline regions of estuaries, and live under shell fragments.(71) When they are approximately 1/2 inch, they apparently move to shallower water where they are found among oyster shells, on rocks, pilings, and jetties. In northwest Florida, they apparently prefer turtle grass flats. Upon attaining full size, they may move to a shoal where they burrow just below low-tide mark.(71) They are active predators on oysters.

Ovigerous females have been taken from May to July in North Carolina. Females may produce more than one egg mass in a season; production of as many as six in 69 days has been documented.(71) Porter(80) concluded that warm water of high salinity was needed for optimum survival of the larvae.

American Oyster (Crassostrea virginica)

American oysters are found from the Gulf of St. Lawrence to the Gulf of Mexico in shallow brackish water on firm bottoms. They are commonly found near the mouths of rivers or in bays and estuaries. The American oyster has probably been studied more thoroughly than any other marine organism. The oyster's life history is described briefly below; Galtsoff(81) provides a more detailed account.

Spawning begins when water temperatures exceed 20°C in the Gulf of Mexico, from approximately April to November.(82) Females produce about 9 million eggs which are 0.002 in. diameter. The fertilized eggs hatch in 5 hours as free-swimming forms. At 32 hours shells appear; in 6 days shells enclose soft parts; and in 3 weeks the spat settles on a solid object and become sessile. After settling, C. virginica may be 1/4 inch across in 10 days and two inches in 82 days.(83) They are sexually mature in two years, and both sexes may be present in one individual. Up to four years are required for wild oysters to become marketable size.(82)

The optimum temperature for growth of larval oysters is between 30 and 32.2°C at salinities above 10 parts per thousand.(84) The optimum temperature for external embryonic development is 27.5°C at salinities above 16 ppt. Although

oysters live in water reaching 36°C in Florida, little is known about prolonged exposures above 32 to 34°C.⁽⁸¹⁾ Experimental evidence indicates that oysters exposed to temperatures of 35°C in western Florida undergo various physiological stresses which may cause mortality.⁽⁸⁵⁾

Both larvae and sessile oysters are filter feeders, consuming plankton and suspended organic matter.

2.7.2.5 Fish

2.7.2.5.1 Ichthyoplankton

Description of the distribution and abundance of early life stage fish was an objective of the sampling program conducted at Big Bend Station from 1976 to early 1977. The study's results are reported in Big Bend Station 316 Demonstration, September 1977⁽³⁾ and are summarized here to provide a brief account of the ichthyoplankton community found near the station.

In brief, the study was conducted as follows: Single samples were collected at eleven stations, day and night, once every two weeks, for a period of fifteen months. Station locations are shown in Figure 2.7-25. The gear was a one meter mouth diameter conical plankton net which employed 363 um mesh net.

The eggs of twelve families of fishes were collected during the study, but two families accounted for more than 99 percent of the specimens. Engraulid and sciaenid eggs represented 73.1 percent and 26.2 percent, respectively, of all eggs collected. Table 2.7-59 provides the taxonomic composition of the collected eggs by family. Anchoa mitchilli (Valenciennes) eggs were the most frequently encountered engraulid although A. hepsetus (Linnaeus) was also found and A. cubana (Poey) was tentatively identified. Sciaenid eggs are difficult to identify, but three genera, Bairdiella, Cynoscion, and Menticirrhus were identified among sciaenid eggs.

Larvae of 22 families representing 41 species were collected during the study; relative composition by family is provided in Table 2.7-59. As was true for fish eggs, the most abundant larval family was Engraulidae, constituting 87.4 percent of all larvae collected. Two or possibly three species of Engraulidae were represented in the collections, although Anchoa mitchilli larvae were most numerous by a wide margin. Larval sciaenids were second in abundance, followed closely by Gobiidae and Pomadasysidae. Seven sciaenid species of five genera were identified in the

larval collections. Of the 22 larval families, six families accounted for 98.3 percent of all larvae collected.

Figures 2.7-26 to 2.7-49 illustrate the densities of Anchoa mitchilli, Harengula jaquana, and sciaenid family plankton collected at each station during the study. Strongest patterns in the data are temporal, demonstrating the seasonal fluctuations expected in early life stage abundances of these species. The temporal patterns are discussed more extensively below for these and other species. Weaker patterns are evident in the distribution of ichthyoplankton among the study's stations. Bay anchovy eggs were more abundant at offshore stations than inshore, though density of the species' larvae did not reflect this pattern. For scaled sardine, the reverse was true; no differential distribution of eggs is evident, but larvae were more abundant offshore than inshore. Sciaenid eggs were more abundant at inshore stations than offshore; no spatial pattern is found for larvae. These data suggest some ideas concerning the ecology of the species. Due to the differential distribution of their eggs, bay anchovies appear to spawn in the open bay, but larvae of the species exhibit no spatial preference. Eggs of the scaled sardine were uniformly distributed (though the adult is typically an ocean spawner), but larvae appear to prefer open bay conditions to near-shore habitat. The predominant abundance of sciaenid eggs in near-shore areas gives some indication of the species which may be spawning in the area: only a few sciaenids, such as silver perch and spotted seatrout, are believed to be estuarine spawners.

Seasonal incidence of ichthyoplankton was broad and variable, reflecting the subtropical climate of this area. Figure 2.7-50 illustrates the seasonal occurrence of fish eggs and larvae as noted from the Big Bend sampling study. In general the spawning season extended from mid-spring to the end of summer, although several species demonstrated longer and more sporadic spawning behavior. For example, Anchoa mitchilli ichthyoplankton were collected in all months except December and January, and Blenniidae and Gobiidae larvae were collected nearly continuously. A more detailed description of the incidence of ichthyoplankton of selected fish taxa is provided below.

Engraulid eggs and larvae were more abundant in Big Bend ichthyoplankton samples than those of any other family, accounting for 73.1 percent of all eggs and 84.4 percent of all larvae taken during the 15 months of sampling. Eggs and larvae of both the striped anchovy, Anchoa hepsetus, and the bay anchovy, A. mitchilli, were common in spring and summer samples. A. mitchilli eggs and larvae were the most

commonly collected engraulid, and frequently, were more numerous than the eggs and larvae of any other species.

A. mitchilli eggs were first taken in early March 1976 and were collected regularly through late October 1976. Peak densities occurred from April through July, reaching 50,000 per 100 m³. The lower numbers taken after July may represent a second spawning by the same individuals or may reflect initial spawning by a smaller number of late maturing females. Larvae were collected from late March through early November. Peak densities of approximately 10,000 per 100 m³ occurred from April through October. Unexpectedly low numbers of larvae in samples from June 22 and August 3, 1976 probably reflect sampling variability since the number of eggs taken on these dates remained high.

Sciaenid eggs and larvae, as a family, were the second most abundant of all families collected during 1976. Only anchovies comprised a larger portion of the total number of eggs and larvae collected. Sciaenid eggs and larvae accounted for 26.2 percent and 3.9 percent, respectively, of all eggs and larvae taken and were present in relatively large numbers between early March and early November 1976. Egg densities reached a peak of approximately 50,000/100 m³ in early April and larval concentration peaked at 500/100 m³ in April, May, and July. Eggs were always more numerous than larvae, indicating that a large amount of spawning was occurring within the study area. Neither eggs nor larvae were collected from late November 1976 through January 1977. Low numbers of eggs and larvae were taken during February, and numbers increased steadily through the final sampling date in March 1977.

Eggs and small larvae of sciaenids are generally indistinguishable to genus and species. However, of those ichthyoplankton which could be identified, sciaenids were represented by a larger number of species (seven) than any other family. The seven species collected were: Bairdiella chrysura (Lacepede), silver perch; Cynoscion arenarius Ginsburg, seatrout; C. nebulosus (Cuvier), spotted seatrout; Leiostomus xanthurus Lacepede, spot; Menticirrhus americanus (Linnaeus), southern kingfish; M. saxatilis (Bloch and Schneider), northern kingfish; and Pogonias cromis (Linnaeus), black drum.

At least two species of clupeids were collected including menhaden larvae identified as Brevoortia sp. and eggs and larvae of the scaled sardine, Harengula jaguana Poey. Eggs and larvae of the scaled sardine were present within the study area from late April through August 1976. This species has slight commercial value as a baitfish, but

stocks in the Big Bend area are not fully exploited for this purpose. Maximum mean numbers per 100 m³ for eggs and larvae were approximately 200 and 100, respectively. Peak egg density occurred in May, preceding peak larval density which occurred in July. Eggs were always more numerous than larvae except on July 20, 1976, but densities of both were always unexpectedly low, indicating the waters in the vicinity of the plant may not be a major nursery area for the species. The later spring and summer spawning season observed in Tampa bay coincides with the spawning season noted for the species in other parts of its range. (**, 27)

Carangid eggs were taken on all sampling dates between April and early September. Three species of carangid eggs were tentatively identified. Only one of these was positively identified to species, Oligoplites saurus (Bloch and Schneider), leather-jacket. Three species of carangid larvae were also present in samples collected between April and October, including O. saurus, Chloroscombrus chrysura (Linnaeus), and an unidentified member of the family. Eggs were most numerous in May (approximately 900/100 m³), with what appears to be a second, smaller peak during July. Inexplicably low numbers of both eggs and larvae occurred on June 22 and August 3, 1976. It is unknown whether these low numbers indicate a cessation of spawning on these dates or whether they reflect sampling variability.

2.7.2.5.2 Adult Fish

Trawl and seine studies were conducted at Big Bend Station for approximately 7 years from 1970 to early 1977. During this period, the general objectives of the field studies were to establish the natural composition of the fish community found in the station's vicinity, incorporating spatial and seasonal variability, and to determine if plant operation was causing a distinguishable effect on the community.

Sampling design was changed periodically to reflect emerging regulatory concerns. From 1970 to 1975, seines and trawls were used to sample the area on a quarterly basis; sampling station locations varied extensively during the period. In 1976, a new program designed with the aid of several regulatory agencies was initiated. The study, conducted from January 1976 to March 1977, was planned to provide specific ecological information pertinent to the requirements of Section 316 of the Federal Water Pollution Control Act. Seines were deployed monthly at six stations and trawls were conducted quarterly at seven stations; locations are shown in Figure 2.7-51. Replicate samples and physical measurements, including temperature, were taken for

both gears. The description provided below relies mostly on the later study, using the data collected from 1970 to 1975 for corroboration.

Approximately 60,000 fish were collected by seines, representing 56 species of 32 families. The tidewater silverside (Menidia beryllina) was the most abundant species, followed by bay anchovy (Anchoa mitchilli) and longnose killifish (Fundulus similis). The number collected, size range, water temperature range, period of occurrence, and location at which largest numbers were collected are provided in Table 2.7-60 for tidewater silverside, bay anchovy, longnose killifish, and several other abundant species. All but the sheepshead minnow, spot, and northern kingfish were common in seine collections made from 1973 to 1975. The table shows most fish were collected from stations which sampled shallow inshore areas - one station, SB-10, located in the northern embayment formed by Apollo Beach, accounted for 37.5 percent of the collected specimens. Moreover, fish collected at SB-10 were predominantly juveniles, including those of the striped mullet, spot, pinfish, sheepshead minnow, spotfin mojarra, and longnose killifish. Often, juveniles of many different species were collected at the same time. To a lesser extent, the same observations were made at stations SB-13 and SB-11. Thus, these three shallow, protected stations are probably nursery areas with the northern embayment being by far the most important.

Patterns of seasonal abundance were generally similar among the seine stations. With the exception of station SB-12, highest abundances were noted in the spring and fall months, and lowest abundances occurred during the winter. Conversely, highest abundance at SB-12 occurred during the winter. Of all seine stations, SB-12 is closest to Big Bend's discharge, and the fish community found there may reflect some sort of attraction caused by the plant's discharge. Information from other analyses tend to support this conclusion (although the analyses included an inconsequential number of invertebrate specimens - 646 invertebrates versus 61,273 fishes). Correlation between diversity (Shannon-Weaver index) and temperature was highest at this station and more species were collected at the station than any other.⁽³⁷⁾ However, when abundance levels at this station are compared against those found at SB-5 (a station of similar physical habitat but outside the thermal plume), a statistical test revealed no significant difference in number of organisms between stations despite a significant difference in temperatures. This suggests that at least abundance at SB-12 is being determined by physical habitat, as opposed to relative proximity to the discharge.

Table 2.7-60 also reveals the transient nature of the fish community in the Big Bend area. In general, most seine catches were numerically dominated by only a few species (two to six), but the dominants changed with time. Seasonal influxes of certain species shifted community structure as the year progressed. The phenomenon was particularly pronounced at the "nursery" stations. For example, young striped mullet, spot, pinfish, and sheepshead minnow dominated the seine catches at SB-10 between December and June, and were replaced by juvenile spotfin mojarra and longnose killifish during the remainder of the year.

Because trawls were conducted only four times during the study period and collection of organisms occurred during daylight hours, the descriptive utility of trawl data collected from 1976 to 1977 is restricted. For example, only 2,109 fish were collected from the quarterly sampling conducted at seven stations, as opposed to approximately 60,000 collected from seines during the same period. Moreover, an experimental set of trawls conducted at night during February 1977 yielded 4,349 fish in 14 tows, approximately twice the number collected in daytime tows, but with a quarter of the effort. For these reasons, it is difficult to elucidate abundance and distribution patterns from these data.

Nonetheless, certain gross phenomena were apparent. Bay anchovies dominated trawl catches in three quarters, and pinfish were numerically dominant in the remaining sampling period in February 1977. Both were among the most abundant species collected in trawls from 1973 to 1975.⁽³⁾ Patterns of relative abundance among stations showed that three stations accounted for 72 percent of the fish collected, TB-12, TB-7, and TB-13. Two stations, TB-1 and TB-6, accounted for less than 100 adults apiece. However, night trawling data tend to suggest these results are misleading, because more specimens were collected during one night at TB-1 and TB-6 than in all the daytime programs at those stations. Consequently, in absence of more frequent trawl data and data collected at night, no conclusions can be made on the spatial distribution of fish in trawled areas.

2.7.2.5.3 Life Histories

Bay Anchovy (Anchoa mitchilli)

The bay anchovy is a ubiquitous fish, found along the western shore of the Atlantic Ocean from Maine to Brazil.⁽²²⁾ This engraulid species is believed to spawn both in the ocean and in estuaries. On the average, it lives about one year, long enough to spawn a single time.

Springer and Woodburn⁽⁸⁹⁾ found almost ripe individuals in Tampa Bay during July, September, and December. Gunter⁽⁸⁶⁾ found ripe individuals from March to August. Spawning occurs when water temperatures are around 9-31°C with a peak above 20°C.⁽⁹⁰⁾ The eggs are buoyant for several hours after fertilization, then sink and hatch in about 24 hr at 27°C when the larvae are 1.8-2.0 mm (Kuntz, 1914).⁽⁹¹⁾

Springer and Woodburn⁽⁸⁹⁾ found lowest abundance during the winter and greatest in the summer and fall in Tampa Bay. Bay anchovies were collected at temperatures ranging from 10.8-32.4°C and salinities from 5.0-35.0 ppt.

Bay anchovies feed on zoea and copepods.⁽⁸⁸⁾ Darnell⁽⁹²⁾ found rotifers, calanoid, and cyclopoid copepods in the stomachs of young bay anchovies. Larger fish eat a variety of organisms, especially small shrimp and fish. Several investigators have suggested A. mitchilli is an important link in the food chain because it constitutes a major portion of the diet of species at higher trophic levels.⁽⁹³⁾

Scaled Sardine (Harengula jaguana)

The scaled sardine is a clupeid and is of some importance in the Tampa Bay area as a baitfish. H. jaguana is an inhabitant of the open bay in the Big Bend area. Adults spawn offshore or in deep bays at night. The spawning season extends from February to August with a peak in April and May.^(87,89) The eggs and larvae of this species are found in the Big Bend area between late April and July.⁽³⁷⁾ 1977d). Fecundity ranged from 5,563 eggs for a 85 mm SL female to 52,753 eggs for one 143 mm SL.⁽⁸⁷⁾ The spherical pelagic eggs are 1.55-1.78 mm dia and larva 2.4 mm long hatch in 24 hr at 28°C.⁽⁹⁴⁾ Like the bay anchovy, scaled sardines are short lived, averaging one year. Growth is rapid and individuals may grow up to 95 mm the first year (Springer and Woodburn, 1960).⁽⁸⁹⁾

There are conflicting reports concerning the temperature and salinity preferences of this species. Gunter⁽⁸⁶⁾ noted the disappearance of H. jaguana when water temperatures fell below 24°C. However, Reid⁽⁹⁵⁾ captured individuals of this species in March, when surface water temperature was 20.8°C and Mountain⁽⁹⁶⁾ captured specimens at a temperature of 17.1°C. One specimen was captured at Big Bend in November when the water temperature was 20°C and two specimens the following February when the water temperature was 14°C.⁽³⁾ The coldest water temperature at which Springer and Woodburn⁽⁸⁹⁾ captured live specimens was 16.8°C. They found two cold-killed specimens after a severe cold wave in which the water temperature had dropped to 13°C. Those captured

near Big Bend at 14°C showed no ill-effects as a result of low water temperature, even though this temperature was apparently close to their lethal minimum temperature.⁽³⁾ Scaled sardines were collected at temperatures as great as 35.1°C by Springer and Woodburn⁽⁸⁹⁾ and 37.9°C by Springer and McErlean.⁽⁹⁷⁾ Gunter⁽⁸⁶⁾ caught few scaled sardines when salinity concentrations dropped below 25 ppt, although greatest abundance at one Big Bend station occurred when salinity values were 22 to 23 ppt.⁽³⁷⁾

Springer and Woodburn⁽⁸⁹⁾ found mysids, amphipods, copepods, ostracods, and small mollusks in gut content analyses of scaled sardines.

Tidewater Silverside (Menidia beryllina)

This species is an atherinid and is common along the Atlantic and Gulf coasts of the United States. It is an inshore species common in open water but prefers some form of shelter such as islands, piers, or oyster bars.⁽⁹⁵⁾ Spawning preferences appear to be specific: ripe adult females and their eggs have been found in the brackish portions of estuaries in heavy vegetation and tree roots. Developing individuals do not appear to migrate far from these habitats, and adults are found in shallow estuarine areas.

Tidewater silversides have an extended spawning season or probably two breeding seasons.^(89,98,99) Ripe adults are taken most of the year^(89,100) when temperatures range from 19–32.7°C.^(86,95,101) Fecundity is about 300 eggs.⁽¹⁰²⁾

Tidewater silverside eggs are demersal and adhesive. Larvae hatch in 8–10 days at 25–28°C, and are 3.5 mm SL.⁽⁹⁸⁾ Growth is rapid. Springer and Woodburn⁽⁸⁹⁾ noted that a length of 75–85 mm SL was attained by the end of the first year. They are mature within a year, but few live beyond the second summer.^(89,103)

Tidewater silverside are found over a wide salinity range (0–75 ppt) on the Gulf Coast.⁽¹⁰⁰⁾ They are found at temperatures ranging from 8.0 to 34.0°C^(104,105) have been found in a 39°C thermal discharge.⁽⁹⁹⁾

Plankton, especially small crustaceans, are the staple of their diet. Darnell⁽⁹²⁾ and Carr and Adams⁽¹⁰⁶⁾ found copepods, mysids, veliger larvae, and crab megalops predominate foods for small fish, while isopods, amphipods, insects, and other benthic organisms were food items for larger fish. Other researchers have found small mollusks,

insects, worms, algae, and detritus in silverside stomachs. (89, 95, 98, 107)

Silver Perch (Bairdiella chrysoura)

The silver perch is a member of the sciaenid or drum family. Adult silver perch are found in deeper bay waters and offshore waters in the winter, migrating to estuaries in the spring to spawn. (86, 108, 109) Spawning occurs year round in the Everglades with a peak probably in late January or early February (110) and May to September in northern Florida. (86) Silver perch eggs were found in the Big Bend area in February and March, indicating a later winter-spring spawning season. (37) Ripe individuals or eggs were taken at salinities of 14.3 - 26 ppt (86, 111) and temperatures of 19.4-28°C. (91, 112) A total of 52,000 eggs were counted in the ovary of a ripe female (140 mm). The pelagic eggs measure 0.66 to 0.88 mm (113) and hatch in 18 hr at about 27°C (91) and 40 to 50 hr at 19-21°C. (114) Most silver perch mature in the third year (111, 114, 115). Reports of size at maturity range from 130-140 mm (91, 115) to 150-210 mm. (114) The species is carnivorous, appearing to prefer a variety of benthic invertebrates and small fish.

Silver perch are euryhaline (91, 108) and are taken at salinities of 0-48 ppt, but most were captured in Tampa Bay at salinities over 20 ppt. (89) They were taken at temperatures from 10-34.5°C. (89, 116)

Black Drum (Pogonias cromis)

Also a drum species, black drum provide a favored sport fishery in the Big Bend area. Spawning occurs offshore of bays and lagoons, (117, 118, 119) but preferred conditions for development of black drum young are found in protected bodies of water. Therefore, eggs and larvae must be transported by tidal currents to such habitats. (113) Apparently, the best nursery conditions are found in muddy, nutrient-rich marsh situations. (120) Spawning occurs in February and March with a prolonged or split season evident from spawning activity in May or June. (121, 122) Spent adults were found in March in Tampa Bay. (89) There may be a second spawning season from late July through November. (117, 121, 122) The mean temperature during spawning is 17.5°C in the Chesapeake Bay area. (120) A 1110 mm female had about 6 million eggs. (117) The pelagic eggs hatch in 24 hr at 20°C (113) when they are 1.9-2.4 mm long. Growth is rapid; age I lengths were reported to be 225-250 mm (121) and 140-180 mm. (122) Black drum live around 35 years. (120)

Black drum prefer low salinities and are commonly found in brackish and fresh water. They may tolerate salinities of 10-88 ppt on the Gulf Coast, but the usual range is 25-50 ppt, (122) and they have been reported as abundant at 10-15 ppt. (84) They are found at temperatures from 3-35°C, (122) but are vulnerable to sudden cold snaps.

Black drum are bottom feeders. Young juveniles feed upon polychaetes, small fishes and crustaceans, adults feed on mollusks and shrimp. (121, 122).

Spotted Seatrout (Cynoscion nebulosus)

Another sciaenid, the spotted seatrout, is an important game fish in Florida. It is an estuarine breeder, preferring grassy areas or channels. (89, 110, 117, 123, 124)

Spawning occurs in late March or early April in Tampa Bay and the Gulf of Mexico. (89, 117, 123) Peak spawning in Florida waters occurs during the dry spring months when salinity has risen to about 30-35 ppt. (125) Water temperature does not appear to affect peak spawning periods as spawning generally occurs around 24-30°C. (110, 126) Tabb (127) reported egg fecundities of 15,000-1,100,000 eggs per females of length 325-625 mm SL. The eggs are initially buoyant but sink after 12 hours. (128) The eggs hatch in 40 hours at 25°C, and the larvae are about 1.7 mm. (129)

Larvae and juveniles migrate to shallow grassy areas. They rarely move over 32-48 km from the release point in tagging studies.

Most males mature during their second or third year and females mature during their third or fourth year of life. (127) After the first year, length has been reported as 120 mm TL to 200 mm SL. (114, 117, 123)

Springer and Woodburn (89) found this species at 7.2-35.1 ppt salinities and at 14.33°C. In Georgia they leave shallow water when temperatures drop below 16°C or rise above 25°C. (130) Exposure to 7°C for 24 hr is lethal. (131)

Both young and adult spotted seatrout are voracious feeders; they eat mainly marine fish and crustaceans. The young feed on copepods, mysids, carid shrimp, and small marine fish, while adults feed primarily on larger marine fish and penaeid shrimp. (123, 127)

2.7.2.6 Rare and Endangered Species

Manatee (*Trichechus manatus*)

The Florida manatee is protected by federal, state, and international law. The manatee is listed as an endangered species by the U.S. Fish and Wildlife Service and protected by the Marine Mammal Protection Act of 1972. It is also protected by Chapter 370.12 (2) of the Florida Statutes and by Appendix 1 of the 1973 Convention on International Trade in Endangered Species of Wild Fauna and Flora.

Manatees are found in slow moving rivers, estuaries, and salt water bays. Four factors influence the choice of habitat: (1) availability of vascular aquatic vegetation, (2) proximity of channels at least 1.5 m deep for migration, (3) winter warm water refuges, and (4) a source of fresh water.⁽¹³²⁾

The number of Florida manatees is not certain, but aerial surveys conducted during 1976, 1977 and 1978 have estimated the basic population at 740-1,000, and recorded the areas of greatest abundance.^(133, 134) More data on summer habitat is needed, but manatees are difficult to locate because they disperse in the summer.

Sexually mature manatees range in size from 2.8 to over 4.5 m (9.2 to 14.8 ft) and weigh from 200 to 600 kg (440 to 1,325 lb) or more. The largest manatee recorded in recent years measured 3.8 m (12.5 ft) and weighed 881 kg (1,950 lb).^(135, 136)

Manatees apparently breed year-round because calves are found in all seasons.^(135, 137, 138) Moore⁽¹³⁹⁾ suggested a breeding season from December to August, but no recent data confirm this. However, calving peaks may occur in spring and early summer,^(133, 140) or fall.⁽¹⁴¹⁾ The gestation period may be as long as 13 months,⁽¹³⁶⁾ and a female will have one or two calves every two to five years.^(132, 140, 142, 143, 144) The calf remains with its mother for 1 to 2 years.⁽¹³²⁾ Female manatees are sexually mature when they are seven or eight years old, and males mature when nine to ten years old. Manatees can live over 25 years in captivity.⁽¹³⁵⁾

Manatees feed for six to eight hours a day and eat a wide variety of plants;⁽¹³²⁾ captives can eat 30 to 50 kg (66 to 110 lb) of vegetation a day.⁽¹⁴⁵⁾ Calves begin to eat vegetation long before they are weaned. Manatees prefer submerged, emergent, and floating vegetation.⁽¹³²⁾ They are also known to eat green algae.⁽¹⁴⁶⁾ They will eat a wide

variety of foods, including fish, when preferred foods are unavailable.^(147, 148) Manatees have passed by rafts of water hyacinth (Eichhornia crassipes) to feed in shallow water on eel grass (Vallisneria americana). Although they are at home in fresh and saltwater, they need a source of fresh water.⁽¹⁴⁶⁾

Manatees congregate in warm water refuges from November to March. There are twenty-five such areas in Florida, six natural and 19 man-made.⁽¹³⁵⁾ Movements between winter congregation areas have been suggested,^(132, 134, 146) but not verified. Although cold water sensitivity of manatees has been reported many times,^(132, 146, 149-153) it is not completely understood. The activity of captive manatees decreases at water temperatures below 21°C. Feeding patterns become irregular at 18-19°C, and feeding may stop completely at temperatures below 16°C.⁽¹⁵²⁾ Exceptionally cold winter temperatures can result in manatee deaths, but the lethal level is not known.

Manatee congregations at power plant outflows during cold weather are well documented^(132-134, 138, 146, 150, 152, 154). Table 2.7-61 lists the incidence of manatees at Big Bend reported from 1971-1976.

An annotated bibliography on the Sirenia published by the Florida Department of Natural Resources⁽¹⁵⁵⁾ contains the more important literature on the manatee published as of 1971.

Other Species

In addition to manatees, the Marine Mammal Protection Act of 1972 also protects porpoises. One species, Delphinus delphis, was sighted on a number of occasions near Big Bend (Table 2.7-62).

Sea turtles have been washed ashore near Big Bend (Table 2.7-63), but species determinations were not provided. However, the Atlantic green turtle (Chelonia mydas), Atlantic hawksbill turtle (Eretmochelys imbricata), Atlantic loggerhead turtle (Carretta carreta), Atlantic Ridley turtle (Lepidochelys kempii), and Atlantic leatherback turtle (Dermochelys coriacea) appear on the Federal List of Endangered and Threatened Wildlife and Plants and on the Florida List of Rare and Endangered Species.

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TABLE 2.7-1

SUMMARY OF FLORAL SPECIES ACCORDING TO HABITAT AT BIG BEND

Scientific Name (Common Name)	Study Site(s)	
	1974-1975	1977
<u>Acalypha gracilens</u> (Three-seeded Mercury)	3	3A, 4, 8, 9
<u>Aeschynomene americana</u> (Sensitive Joint-weed)	2, 4	3A, 4
<u>Agalinis maritima</u> (False Purple Foxglove)	7	7
<u>Albizia julibissin</u> (Mimosa)		4
<u>Alysicarpus vaginalis</u> (False Moneywort)		4
<u>Amaranthus hybridus</u> (Pigweed)	3A, 4	4
<u>Ambrosia artemisiifolia</u> (Ragweed)	1, 2, 3, 4, 8, 11, 12	1, 2, 3A, 4, 8, 9, 10
<u>Amorpha herbacea</u> (Lead Plant)	8	5, 8
<u>Ampelopsis arborea</u> (Pepper Vine)	4	2, 4
<u>Andropogon glomeratus</u> (Beard Grass)	1, 2, 3, 3A, 4, 5, 8, 9, 12	1, 2, 3A, 4, 5, 8, 9, 10
<u>Andropogon longiberbis</u> (Beard Grass)	5, 8	
<u>Andropogon virginicus</u> (Broom Sedge)	8	1, 4, 5, 8, 9
<u>Aristida</u> sp. (Wire Grass)	5	
<u>Aster subulatus</u> (Aster)	1, 7, 9, 12	
<u>Aster tenuifolius</u> (Aster)	7	

TABLE 2.7-1 (Cont)

Scientific Name (Common Name)	Study Site(s)	
	1974-1975	1977
<u>Avicennia germinans</u> (Black Mangrove)	6, 7	6, 7
<u>Baccharis angustifolia</u> (False Willow)	5, 8	5, 7, 8
<u>Baccharis halimifolia</u> (Groundsel Tree)	1, 2, 3, 3A, 4, 5, 9, 12	1, 2, 3A, 4, 5, 8, 9, 10
<u>Bacopa cyclophylla</u>	9, 10	
<u>Bacopa monnieri</u> (Water Hyssop)		2, 10
<u>Batis maritima</u> (Salt Wort)	7	7
<u>Bidens pilosa</u> (Tickseed)	1, 2, 3, 3A, 4, 11, 12	1, 2, 3A, 4, 8
<u>Boltonia diffusa</u> (Doll's Daisy)		3A, 9, 10
<u>Borrichia frutescens</u> (Sea Daisies)	7	7
<u>Buchnera floridana</u> (Bluehearts)		8
<u>Bulbostylis barbata</u> (Water Grass)		8
<u>Bulbostylis stenophyllus</u>		8
<u>Caesalpinia bonduc</u> (Yellow Nicker)		5
<u>Callicarpa americana</u> (Beauty Berry)	11	
<u>Cassia nictitans</u> (Senna)	2	2, 4, 8
<u>Cassia chamaecrista</u> (Partridge Pea)	4, 8, 12	4, 8
<u>Cassia obtusifolia</u>		1, 2, 3A

TABLE 2.7-1 (Cont)

<u>Scientific Name</u> <u>(Common Name)</u>	<u>Study Site(s)</u>	
	<u>1974-1975</u>	<u>1977</u>
<u>Cenchrus echinata</u> (Sandspur)	1, 3A, 4	1, 2, 3A, 4, 8
<u>Cenchrus incertus</u> (Sandspur)		1
<u>Centella asiatica</u> (Coinwort)	9	9, 10
<u>Chamaesyce blodgettii</u> (Spurge)		1
<u>Chamaesyce hirta</u> (Hairy Spurge)		8
<u>Chamaesyce hyssopifolia</u> (Hyssop-leaved Spurge)	3, 3A, 12	1, 3A, 4, 8
<u>Chenopodium ambrosioides</u> (Goosefoot)	1, 2, 4, 11	2, 4
<u>Chloris glauca</u> (Fingergrass)		2
<u>Chloris petraea</u> (Fingergrass)	1, 2, 3A, 4, 5, 7, 12	1, 2, 3A, 4, 5, 7, 8
<u>Cirsium nuttallii</u> (Thistle)		9
<u>Citrus sp.</u> (Orange)		4
<u>Cladium jamaicense</u> (Sawgrass)	5	5
<u>Commelina diffusa</u> (Common Dayflower)	2	2, 4
<u>Conocarpus erecta</u> (Buttonwood)	5	5
<u>Conyza canadensis</u> (Dwarf Horsetail)	1, 2, 3, 3A, 4, 12	1, 2, 3A, 4, 7, 8, 9
<u>Coreopsis laevenworthii</u> (Dye Flower)		8

TABLE 2.7-1 (Cont)

<u>Scientific Name</u> <u>(Common Name)</u>	<u>Study Site(s)</u>	
	<u>1974-1975</u>	<u>1977</u>
<u>Crinum americanum</u> (Swamp Lily)		2
<u>Crotalaria mucronata</u> (Rabbit Bells)	11	
<u>Crotalaria spectabilis</u> (Rattle Box)	2, 4, 11, 12	2, 4
<u>Croton glandulosus</u>		8
<u>Cynanchum palustre</u> (Spiney Pod)		7
<u>Cynodon dactylon</u> (Bermuda Grass)	2, 3A	1, 2, 3A, 4
<u>Cyperus compressus</u> (Nut Grass)		1, 3A, 8
<u>Cyperus esculentus</u> (Chufa)		5, 9
<u>Cyperus globulosus</u> (Nut Grass)		3A, 9, 10
<u>Cyperus ligularis</u> (Nut Grass)	1, 3A, 4	
<u>Cyperus odoratus</u> (Nut Grass)		5
<u>Cyperus pollardi</u> (Nut Grass)		2, 3A, 4, 7, 8
<u>Cyperus polystachyos</u> (Nut Grass)	1, 2, 3, 9, 10, 12	1, 2, 3A, 4, 5, 8, 9, 10
<u>Cyperus pumilus</u> (Nut Grass)		3A, 5
<u>Cyperus retrorsus</u> (Nut Grass)		2, 3A, 4, 7, 8, 9, 10
<u>Cyperus rotundus</u> (Nut Grass)	3, 3A	4

TABLE 2.7-1 (Cont)

Scientific Name (Common Name)	Study Site(s)	
	1974-1975	1977
<u>Cyperus surinamensis</u> (Nut Grass)	1, 2, 4, 9, 10, 12	1, 2, 3A, 4, 8, 10
<u>Cyperus tenuifolius</u> (Nut Grass)	2, 9	2
<u>Dactyloctenium aegyptium</u> (Crowfoot Grass)		1, 2
<u>Desmanthus virgatus</u>		1
<u>Desmodium canum</u> (Begger's Lice)	2, 4, 9, 12	2, 3A, 9, 10
<u>Desmodium tortuosum</u> (Begger's Lice)	4	2, 4
<u>Desmodium triflorum</u> (Begger's Lice)	4	4, 8, 9
<u>Dichromena colorata</u> (White-tops)	9, 10	5, 8, 9
<u>Digitaria ciliaris</u> (Crabgrass)	1, 9	1, 9
<u>Digitaria sanguinalis</u> (Crabgrass)	3A, 4, 12	1, 2, 3A, 4
<u>Diodia virginiana</u> (Buttonweed)		9
<u>Diospyros virginiana</u> (Persimmon)	9	9, 10
<u>Distichlis spicata</u> (Salt Grass)	3, 5, 7	5, 7, 8
<u>Echinochloa walteri</u> (Barnyard Grass)	1	1, 4, 10
<u>Eclipta alba</u>	1, 12	4
<u>Elephantopus elatus</u> (Elephant's foot)		9

TABLE 2.7-1 (Cont)

<u>Scientific Name</u> <u>(Common Name)</u>	<u>Study Site(s)</u>	
	<u>1974-1975</u>	<u>1977</u>
<u>Elcusine indica</u> (Goose Grass)	1, 3, 4, 9, 12	1, 2, 4
<u>Erechtites hieracifolia</u> (Fireweed)	8	4, 8, 10
<u>Erianthus giganteus</u> (Plumegrass)	8	5
<u>Eryngium baldwinii</u> (Button Snakeroot)	<u>8</u>	<u>8</u>
<u>Erythrina herbacea</u> (Eastern Coral Bean)		5
<u>Eupatorium capillifolium</u> (Dog Fennel)		1, 2, 3A, 4, 5, 8, 9, 10
<u>Eupatorium compositifolium</u> (Dog Fennel)	1, 2, 3, 3A, 4, 9, 11, 12	2, 4, 8
<u>Fimbristylis autumnalis</u>		5
<u>Fimbristylis castanea</u> (Fringe Rush)	7, 8, 9	5, 7, 8, 9
<u>Galactia elliotii</u> (Milk Pea)	3A, 4, 5, 8	5, 7, 8
<u>Gaura angustifolia</u> (Southern Gaura)	4, 8	1, 4
<u>Geranium carolinianum</u> (Cranesbill)	4	
<u>Gnaphalium purpureum</u> (Cudweed)	8	8
<u>Hedyotis corymbosus</u>		8
<u>Hedyotis procumbens</u> (Innocence)	8	
<u>Helenium amarum</u> (Bitter Sneezeweed)	3, 3A, 11	4

TABLE 2.7-1 (Cont)

<u>Scientific Name</u> <u>(Common Name)</u>	<u>Study Site(s)</u>	
	<u>1974-1975</u>	<u>1977</u>
<u>Heterotheca subaxillaris</u> (Camphor Weed)	1, 3A, 12	1, 3A, 8, 9
<u>Hydrocotyle umbellata</u> (Pennywort)	9, 10	4
<u>Hymenocallis palmeri</u> (Swamp Lily)	5, 10	
<u>Hypericum cistifolium</u> (St. John's Wort)	5, 8	5, 8
<u>Indigofera hirsuta</u> (Hairy Indigo)	2, 3, 3A, 4, 12	1, 2, 3A, 4, 8
<u>Ipomoea sacittata</u> (Glades Morning Glory)		10
<u>Ipomoea trichocarpa</u> (Morning Glory)	2	2, 3A
<u>Iva frutescens</u> (Marsh Elder)	3, 3A, 5	5, 7
<u>Juncus megacephalus</u> (Rush)		5
<u>Juncus roemerianus</u> (Black Rush)	5, 7, 8, 10	5, 7, 9, 10
<u>Kosteletzkya virginica</u> (Salt Marsh Mallow)		5
<u>Lachnocaulon anceps</u> (Bog Buttons)	8	
<u>Laguncularia racemosa</u> (White Mangrove)	6	6, 7
<u>Lantana camara</u> (Shrub Verbena)	9, 11	5, 8
<u>Lepidium virginicum</u> (Pepper Grass)	2, 4, 12	1, 4, 7
<u>Leptochloa uninervia</u> (Spangletop)	1	

TABLE 2.7-1 (Cont)

Scientific Name (Common Name)	Study Site(s)	
	1974-1975	1977
<u>Linaria canadensis</u> (Toadflax)	3A, 4, 12	
<u>Lindernia crustacea</u> (False Pimpernel)		5
<u>Lippia nodiflora</u> (Frog Bit)	1, 2, 3, 4, 9, 10, 11, 12	1, 2, 3A, 4, 8, 9, 10
<u>Lobelia feavana</u> (Bay Lobelia)	8	
<u>Ludwigia octovalvis</u> (Water Purselane)	2, 3, 5, 8, 10, 12	2, 3A, 5, 8
<u>Ludwigia peruviana</u> (Water Willow)	3A, 4, 12	3A, 4
<u>Lycium carolinianum</u> (Christmas Berry)		5, 7
<u>Lythrum alatum</u> (Loosestrife)	1, 2, 3, 12	2, 4, 10
<u>Mecardonia acuminata</u>		8
<u>Medicago lupulina</u> (Black Medic)	4	
<u>Melia azedarach</u> (Chinaberry)		4
<u>Melilotus alba</u> (Sweet Clover)	1, 3A	1
<u>Melochia corchorifolia</u> (Chocolate Weed)		5
<u>Melothria pendula</u> (Creeping Cucumber)	3, 4, 11	4, 5, 8, 10
<u>Mikania scandens</u> (Climbing Hempweed)	8	5, 8, 10
<u>Monanthochloe littoralis</u> (Salt Grass)	7	7

TABLE 2.7-1 (Cont)

<u>Scientific Name</u> <u>(Common Name)</u>	<u>Study Site(s)</u>	
	<u>1974-1975</u>	<u>1977</u>
<u>Murdannia nudiflora</u>		8
<u>Musa sapientum</u> (Banana)	4	
<u>Myrica cerifera</u> (Wax Myrtle)	4, 8, 9, 12	4, 8, 9
<u>Myrica pusilla</u> (Dwarf Wax Myrtle)	8	5, 8
<u>Oenothera laciniata</u> (Evening Primrose)	3A, 12	2, 3A
<u>Oxalis dillenii</u> (Yellow Sorrel)	8	8
<u>Panicum albomarginatum</u> (Panic Grass)		8
<u>Panicum breve</u> (Panic Grass)	8	
<u>Panicum purpurascens</u> (Panic Grass)	3, 3A, 4	10
<u>Panicum virgatum</u> (Switch Grass)	8	1, 5, 8
<u>Parthenocissus quinquefolia</u> (Virginia Creeper)	3, 4, 11	2, 4, 8, 9
<u>Paspalum notatum</u> (Bahia Grass)	2, 4, 9	2, 4, 8, 9
<u>Paspalum urvillei</u> (Vasey Grass)	1, 2, 3, 3A, 4, 9, 12	1, 2, 3A, 4, 8, 9, 10
<u>Paspalum vaginatum</u>	3	1, 2, 3A, 4, 7, 9, 10
<u>Passiflora suberosa</u> (Passion Vine)	4	4
<u>Phloxerus vermicularis</u> (Saltweed)	7	5, 7

TABLE 2.7-1 (Cont)

Scientific Name (Common Name)	Study Site(s)	
	1974-1975	1977
<u>Physalis angustifolia</u> (Ground Cherry)	5, 11	2, 4
<u>Phytolacca americana</u> (Pokeweed)	1, 3, 4, 9, 11	2, 4, 9, 10
<u>Pinus elliotii</u> (Slash Pine)	8	8, 9
<u>Pluchea odorata</u> (Marsh Fleabane)	1, 3, 4, 10, 12	10
<u>Pluchea rosea</u> (Marsh Fleabane)	3A, 5, 8, 9	5, 8, 9
<u>Polygala grandiflora</u> (Candyroot)	4	4, 8
<u>Polygonum punctatum</u> (Smartweed)	10	10
<u>Polypremum procumbens</u>	12	3A, 8
<u>Portulaca oleracea</u> (Purselane)	3, 12	
<u>Portulaca pilosa</u> (Rose Purselane)	1, 11, 12	1, 5
<u>Psidium guajava</u> (Guava)	4	
<u>Pterocaulon virgatum</u> (Blackroot)		9
<u>Quercus pumila</u> (Running Oak)	8	8
<u>Quercus virginiana</u> (Live Oak)	5	5
<u>Rhizophora mangle</u> (Red Mangrove)	6	6
<u>Rhus copallina</u> (Winger Sumac)	8	5, 8

TABLE 2.7-1 (Cont)

<u>Scientific Name</u> <u>(Common Name)</u>	<u>Study Site(s)</u>	
	<u>1974-1975</u>	<u>1977</u>
<u>Rhynchelytrum repens</u> (Natal Grass)	1, 3A, 4	1, 4, 5
<u>Rhynchospora divergens</u> (Beak Rush)	8	
<u>Rhynchospora odorata</u> (Beak Rush)		10
<u>Richardia brasiliensis</u>		8, 9
<u>Rotala ramosior</u> (Tooth Cup)		3A
<u>Rubus trivialis</u> (Dewberry)	3A, 4, 5, 8, 9, 11	4, 5, 8, 9
<u>Sabal palmetto</u> (Cabbage Palm)	5, 8	2, 3A, 4, 8, 9
<u>Sagittaria lancifolia</u> (Arrowhead)	10	10
<u>Salicornia virginica</u> (Glasswort)	7	7
<u>Salix caroliniana</u> (Southern Willow)	4	2, 4
<u>Sambucus canadensis</u> (Elderberry)	2, 3A, 4	2, 4
<u>Samolus ebracteatus</u> (Pimpernel)	5, 8	9
<u>Samolus parviflorus</u> (Pineland Pimpernel)	8	5, 8, 9
<u>Schinus terebinthifolius</u> (Brazilian Pepper)	3, 3A, 4, 5, 8, 9, 12	2, 3A, 4, 5, 7, 8, 9
<u>Schrankia microphylla</u> (Sensitive Briar)	12	7, 8
<u>Scirpus validus</u> (Bullrush)	5, 8, 12	10

TABLE 2.7-1 (Cont)

Scientific Name (Common Name)	Study Site(s)	
	1974-1975	1977
<u>Scoparia dulcis</u> (Sweet Broom)	5, 8, 12	3A, 5, 8
<u>Scutellaria integrifolia</u> (Skullcap)	8	8
<u>Serenoa repens</u> (Saw Palmetto)	5, 8	5, 8
<u>Sesbania exaltata</u> (Sesban)	1, 3	1, 2, 3A, 4
<u>Sesuvium portulacastrum</u> (Sea Purselane)	7	7
<u>Setaria geniculata</u> (Bristly Foxtail)	1, 3, 4, 9, 12	1, 2, 3A, 4, 5, 8, 9, 10
<u>Sida acuta</u> (Indian Hemp)	3A, 4, 9	2, 3A, 4
<u>Smilax auriculata</u> (Cat Briar)	8	8
<u>Smilax bona-nox</u> (Green Briar)	8	4, 8
<u>Smilax laurifolia</u> (Cat Briar)	5, 8	
<u>Solanum americanum</u> (Nightshade)	11, 12	4, 10
<u>Solidago chapmannii</u> (Goldenrod)	8	5, 8, 9
<u>Solidago microcephala</u> (Goldenrod)	1, 3, 3A, 4, 5, 8, 9, 11, 12	4, 5, 7, 8, 9
<u>Solidago sempervirens</u> (Goldenrod)	1, 2, 3, 3A, 5, 7, 8, 9, 11, 12	1, 2, 3A, 4, 5, 7, 8, 9, 10
<u>Sonchus asper</u> (Sow Thistle)	2, 3A, 12	4

TABLE 2.7-1 (Cont)

Scientific Name (Common Name)	Study Site(s)	
	1974-1975	1977
<u>Spartina bakeri</u> (Cordgrass)	5, 7, 8, 10	5, 7, 8, 10
<u>Spartina patens</u> (Cordgrass)		7
<u>Spartina spartinae</u> (Cordgrass)	7	7
<u>Sporobolus domingensis</u> (Dropseed)	1, 3A, 4, 12	1, 4
<u>Sporobolus poiretii</u> (Smutgrass)		1, 4, 8, 9
<u>Sporobolus virginicus</u> (Dropseed)		7, 8
<u>Stenotaphrum secundatum</u> (St. Augustine Grass)	4, 12	4, 8
<u>Stillingia sylvatica</u> (Queen's Delight)		8
<u>Teucrium canadense</u> (Wood Sage)	4	4
<u>Tillandsia recurvata</u> (Ball Moss)	11	
<u>Tillandsia usneoides</u> (Spanish Moss)	11	
<u>Toxicodendron radicans</u> (Poison Ivy)	4, 5, 8	2, 4, 8
<u>Trifolium repens</u> (Clover)		2
<u>Tripsacum dactyloides</u> (Gama Grass)	4, 5	4, 5
<u>Typha domingensis</u> (Cat-tail)	1, 2, 3A, 4, 10	4, 10
<u>Typha latifolia</u> (Cat-tail)	1, 2, 3A, 4, 10	10

TABLE 2.7-1 (Cont)

Scientific Name (Common Name)	Study Site(s)	
	1974-1975	1977
<u>Urena lobata</u> (Caesar Weed)	2	8
<u>Vaccinium myrsinites</u> (Blueberry)	8	8
<u>Verbesina virginica</u> (Crownbeard)	4, 5, 8	4, 8
<u>Vigna luteola</u> (Cow Pea)	1, 3, 4, 7, 12	1, 4, 7, 8, 9
<u>Vitis aestivalis</u> (Southern Grape)	4	4
<u>Vitis rotundifolia</u> (Muscadine Grape)	4, 8, 9, 11	4, 8
<u>Yucca aloifolia</u> (Spanish Bayonet)		8

TABLE 2.7-2

ANALYSIS OF VEGETATION IN THE POWER STATION
 VEGETATION TYPE - MAY - SEPTEMBER 1974
 BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Sporobolus</u> <u>domingensis</u> Dropseed	.59	1.41	3.5	11.5	6.89	4.06	22.45
<u>Sesbania</u> <u>exaltata</u> Sesban	.32	1.59	19.5	6.24	7.77	22.62	36.63
<u>Chloris</u> <u>petraea</u> Finger grass	.54	2.32	4.5	10.53	11.34	5.22	27.09
<u>Vigna</u> <u>luteola</u> Cow pea	.73	2.6	25.5	14.23	12.71	29.58	56.52
<u>Digitaria</u> <u>adscendens</u> Crabgrass	.09	.09	4.0	1.75	.44	4.64	6.83
<u>Rhynchelytrum</u> <u>roseum</u> Red top	.32	.73	3.5	5.24	3.57	4.06	13.87
<u>Thypha</u> sp. Cattail	.04	.41	.5	.78	2.0	.58	3.36
<u>Solidago</u> <u>semivirens</u> var. <u>mexicana</u> Goldenrod	.36	1.68	7.5	7.08	8.21	8.7	23.99
<u>Cyperus</u> <u>ligularis</u> Rut grass	.09	.09	.5	1.75	.44	.48	2.77
<u>Andropogon</u> <u>glomeratus</u> Beard grass	.23	.64	1.0	4.48	8.13	1.16	8.77
<u>Paspalum</u> <u>urvillei</u> Vasy grass	.22	.86	.5	4.29	4.20	.58	9.07

TABLE 2.7-2 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Leptochloa</u> <u>uninervis</u> Spangletop	.04	.27	3.0	.78	1.32	3.48	5.58
<u>Setaria geniculata</u> Bristly foxtail	.04	.23	.5	.78	1.24	.58	2.6
<u>Eupatorium</u> sp. Dog fennel	.41	3.54	2.7	7.99	17.3	3.13	28.42
<u>Heterotheca</u> <u>subaxillaris</u> Camphor weed	.14	.36	3.0	2.73	1.76	3.48	7.97
<u>Echinochloa</u> <u>walterii</u> Barnyard grass	.04	.04	trace	.78	.19	-	.97
<u>Lythrum alatum</u> var. <u>laciolatum</u> Loosestrife	.09	.14	trace	1.75	.68	-	2.43
<u>Pluchea</u> <u>purpurascens</u> Marsh fleabane	.04	.14	trace	.78	.68	-	1.46
<u>Cyperus poly-</u> <u>stachyos</u> Nut grass	.09	.14	trace	1.75	.68	-	2.43
<u>Cyperus surinam-</u> <u>ensis</u> Nut grass	.04	.04	trace	.78	.19	-	.97
<u>Cenchrus echinata</u> Sandspur	.09	.09	1.0	1.75	.44	1.16	3.35
<u>Eaccharis halimifolia</u> Groundsel tree	23.0	2.5	3.0	4.48	12.22	3.48	20.18
<u>Portulaca pilosa</u> Rose purselane	.04	.14	1.0	.78	.68	1.16	2.62
<u>Bidens pilosa</u> Tickseed	.09	.14	trace	1.75	.68	-	2.43

TABLE 2.7-2 (Cont)

<u>Scientific Name</u> <u>Common Name</u>	<u>Frequency</u>	<u>Density</u> <u>#/m²</u>	<u>Cover</u> <u>%</u>	<u>Relative</u> <u>Frequency</u>	<u>Relative</u> <u>Density</u>	<u>Relative</u> <u>Dominance</u>	<u>Importance</u> <u>Value</u>
<u>Ambrosia artemi-</u> <u>siifolia</u> Ragweed	.04	.04	.5	.78	.19	-	.97
<u>Phytolacca</u> <u>americana</u> Pokeweed	.04	.04	.5	.78	.19	.58	1.55
<u>Eleusine indica</u> Goose grass	.14	.18	1.0	2.73	.88	1.16	4.77

TABLE 2.7-3

ANALYSIS OF VEGETATION IN THE POWER STATION
 VEGETATION TYPE - SEPTEMBER 1974 - DECEMBER 1974
 BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Sesbania</u> <u>exaltata</u> Sesban	.38	.92	2.2	4.56	3.67	5.02	13.25
<u>Sporobolus</u> <u>domingensis</u> Dropseed	.77	2.00	3.7	9.23	7.98	8.45	25.66
<u>Chloris</u> <u>petraea</u> Fingergrass	.69	1.69	4.9	8.27	6.74	11.19	26.20
<u>Vigna</u> <u>luteola</u> Cow pea	.38	.46	1.8	4.56	1.83	4.11	10.50
<u>Digitaria</u> <u>adscendens</u> Crabgrass	.15	2.38	6.0	1.80	9.50	13.70	25.00
<u>Rhynchosyris</u> <u>roseum</u> Red top	.54	1.00	3.7	6.47	3.99	8.45	18.91
<u>Typha</u> sp. Cattail	.15	.85	.7	1.80	3.39	1.60	6.79
<u>Solidago</u> <u>semivirens</u> var. <u>mexicana</u> Goldenrod	.69	3.69	8.1	8.27	14.72	18.49	41.48
<u>Cyperus</u> <u>ligularis</u> Nut grass	.15	.15	.5	1.80	.60	1.14	3.54
<u>Andropogon</u> <u>glomeratus</u> Beard grass	.46	1.23	1.2	5.51	4.90	2.74	13.15
<u>Paspalum</u> <u>urvillei</u> Vasey grass	.38	1.23	.5	4.56	4.90	1.14	10.60

TABLE 2.7-3 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Leptochloa</u> <u>uninervia</u> Spanjletop	.15	.15	trace	1.80	.60	-	2.40
<u>Setaria geniculata</u> Bristly foxtail	.23	.23	trace	2.76	.92	-	3.68
<u>Eupatorium</u> <u>compositifolium</u> Dog fennel	.69	3.46	3.2	8.27	13.81	7.31	29.39
<u>Heterotheca</u> <u>subaxillaris</u> Camphor weed	.15	.15	trace	1.80	.60	-	2.40
<u>Echinochloa walteri</u> Barnyard grass	.08	.08	trace	.96	.32	-	1.28
<u>Lythrum alatum</u> var. <u>lanceolatum</u> Loosestrife	.08	.08	trace	.96	.32	-	1.28
<u>Pluchea</u> <u>purpurascens</u> Marsh fleabane	.15	.23	trace	1.80	.92	-	2.72
<u>Cyperus</u> <u>surinamensis</u> Nut grass	.08	.08	trace	.96	.32	-	1.28
<u>Cyperus</u> <u>polystachyos</u> Nut grass	.08	.08	trace	.96	.32	-	1.28
<u>Cenchrus echinata</u> Sandspur	.08	.08	trace	.96	.32	-	1.28
<u>Baccharis</u> <u>halimifolia</u> Groundsel tree	.38	2.07	4.6	4.56	8.26	10.50	23.32
<u>Portulaca pilosa</u> Rose purselane	.08	.08	trace	.96	.32	-	1.28
<u>Bidens pilosa</u> Tickseed	.15	.23	trace	1.80	.92	-	2.72

TABLE 2.7-3 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Aster subulatus</u> var. <u>ligulatus</u>	.38	1.31	1.1	4.56	5.23	2.51	12.30
<u>Ambrosia</u> <u>artemisiifolia</u> Ragweed	.15	.23	trace	1.80	.92	-	2.72
<u>Eleusine indica</u> Goose grass	.23	.31	1.1	2.76	1.24	2.51	6.51
<u>Melilotus alba</u> Sweet clover	.15	.23	trace	1.80	.92	-	2.72
<u>Lippia nodiflora</u> Frog bit	.23	.23	.5	2.76	.92	1.14	4.82
<u>Eclipta alba</u>	.08	.15	trace	.96	.60	-	1.56

TABLE 2.7-4

ANALYSIS OF VEGETATION IN THE POWER STATION
 VEGETATION TYPE - DECEMBER 1974 - MARCH 1975
 BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Melilotus alba</u> Sweet clover	.7	7.7	13.5	12.1	43.5	35.9	91.5
<u>Chloris petraea</u> Finger grass	.7	2.0	6.2	12.1	11.3	16.5	39.9
<u>Rhynchelytrum</u> <u>repens</u> Natal grass	.5	.9	3.4	8.6	5.1	9.0	22.7
<u>Vigna luteola</u> Cow pea	.8	.8	2.9	13.8	4.5	7.7	26.0
<u>Heterotheca</u> <u>subaxillaris</u> Camphor weed	.3	.3	trace	5.2	1.7	-	6.9
<u>Solidago</u> <u>sempervirens</u> Goldenrod	.3	.7	2.1	5.2	3.9	5.6	14.7
<u>Sporobolus</u> <u>domingensis</u> Dropseed	.6	1.4	3.5	10.3	7.9	9.3	27.5
<u>Baccharis</u> <u>hamillifolia</u> Groundsel tree	.4	1.5	4.2	6.9	8.5	11.2	26.6
<u>Eupatorium</u> <u>compositifolium</u> Dog fennel	.3	.5	.5	5.2	2.8	1.3	9.3
<u>Andropogon</u> <u>glomeratus</u> Beard grass	.4	.9	.5	6.9	5.1	1.3	13.3
<u>Lippia nodiflora</u> Frog bit	.3	.4	trace	5.2	2.2	-	7.4
<u>Bidens pilosa</u> Tickseed	.3	.3	trace	5.2	1.7	-	6.9

TABLE 2.7-4 (Cont)

<u>Scientific Name</u> <u>Common Name</u>	<u>Frequency</u>	<u>Density</u> <u>#/m²</u>	<u>Cover</u> <u>%</u>	<u>Relative</u> <u>Frequency</u>	<u>Relative</u> <u>Density</u>	<u>Relative</u> <u>Dominance</u>	<u>Importance</u> <u>Value</u>
<u>Eleusine indica</u> Goose grass	.2	.3	.8	3.4	1.7	2.1	7.2

TABLE 2.7-5

ANALYSIS OF VEGETATION IN THE POWER STATION
VEGETATION TYPE - MARCH - MAY 1975
BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Chloris</u> <u>petraea</u> Finger Grass	.72	1.63	7.0	11.6	8.67	21.1	41.3
<u>Melilotus</u> <u>alba</u> Sweet clover	.63	5.72	12.7	10.2	30.4	38.25	48.0
<u>Chamaesyce</u> sp. Spurge	.18	.27	trace	2.9	1.43	-	4.3
<u>Rhynchelytrum</u> <u>repens</u> Natal Grass	.63	1.54	4.1	10.2	8.2	12.3	30.7
<u>Vigna</u> <u>luteola</u> Cow pea	.54	.72	2.5	8.7	3.8	7.5	20.0
<u>Heterotheca</u> <u>subaxillaris</u> Camphor weed	.36	.19	.5	5.8	10.1	1.5	17.4
<u>Cenchrus</u> sp. Sandspar	.27	.27	trace	4.4	1.4	-	5.8
<u>Eupatorium</u> <u>composititolum</u> Dog fennel	.54	1.72	1.5	8.7	9.1	4.5	22.3
<u>Solidago</u> <u>sempervirens</u> Goldenrod	.27	1.09	1.0	4.4	5.8	3.0	13.2
<u>Conyza</u> <u>canadensis</u> Dwarf hoisetail	.36	1.0	.5	5.8	5.3	1.5	12.6
<u>Chenopodium</u> <u>ambrosioides</u> Goosefoot	.27	.36	.7	4.4	1.9	2.1	8.4

TABLE 2.7-5 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Eleusine indica</u> Goose grass	.27	.36	1.7	4.4	1.9	5.1	11.4
<u>Bidens pilosa</u> Tickseed	.36	.54	.5	5.8	2.9	1.5	10.2
<u>Lippia nodiflora</u> Frog bit	.18	.18	.5	2.9	1.0	1.5	5.3
<u>Solidago microcephala</u> Goldenrod	.27	.81	trace	4.4	4.3	-	8.7
<u>Portulaca pilosa</u> Rose purslane	.18	.27	trace	2.9	1.43	-	4.3
<u>Ambrosia artemisiifolia</u> Ragweed	.18	.45	trace	2.9	2.4	-	5.3

TABLE 2.7-6

ANALYSIS OF VEGETATION IN THE POWER LINE
RIGHT-OF-WAY VEGETATION TYPE - MAY - SEPTEMBER 1974
BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Ludwigia</u> <u>octovalvis</u> Water purslane	.31	1.21	5.0	4.49	1.67	3.06	9.22
<u>Andropogon</u> <u>glomeratus</u> Beard grass	.21	.26	.5	3.04	36	.30	3.7
<u>Lepidium</u> <u>virginicum</u> Pepper grass	.21	.47	trace	3.04	65	-	3.69
<u>Baccharis</u> <u>halimifolia</u> Groundsel tree	.37	.96	1.0	5.36	1.32	.61	7.29
<u>Commelina diffusa</u> Common day- flower	.42	2.89	5.0	6.09	3.98	3.06	13.13
<u>Cynodon</u> <u>dactylon</u> Bernarda grass	.89	39.58	87.0	12.90	54.52	53.21	120.63
<u>Urena</u> <u>lobata</u> Caesar weed	.05	.05	.5	.72	.07	.3	1.09
<u>Bidens pilosa</u> Tickseed	.63	7.68	12.0	9.13	10.58	7.33	27.04
<u>Cassia aspera</u> Senna	.53	3.05	13.0	7.68	4.20	7.95	19.83
<u>Indigofera hirsuta</u> Hairy indigo	.53	2.00	4.0	7.68	2.75	2.45	12.88
<u>Eupatorium</u> sp. Dog fennel	.66	5.68	9.5	9.85	7.82	5.81	23.48
<u>Crotalaria</u> <u>spectabilis</u> Rattle box	.05	.05	trace	.72	.07	-	.79

TABLE 2.7-6 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Paspalum urvillei</u> Vasey grass	.1	.10	1.0	1.45	.14	.61	2.2
<u>Cyperus poly- stachyos</u> Nut grass	.3	1.21	1.0	4.35	.43	.61	5.37
<u>Ambrosia artemisi- ifolia</u> Ragweed	.37	2.58	15.5	5.36	3.71	9.48	18.39
<u>Ipomea</u> sp. Morning glory	.42	.53	5.5	6.09	.76	3.36	10.18
<u>Conyza canadensis</u> Dwarf horsetail	.21	.42	trace	3.04	.60	-	3.62
<u>Cyperus surinamensis</u> Nut grass	.21	.37	trace	3.04	.53	-	3.55
<u>Chenopodium ambrosioides</u> Goosefoot	.05	.05	trace	.72	.07	-	.79
<u>Cyperus tenuifolius</u> Nut grass	.21	2.37	1.0	3.04	3.41	.61	6.91
<u>Sambucus simpsonii</u> Elderberry	.05	.89	1.0	.72	1.28	.61	2.55
<u>Lippia nodiflora</u> Frog bit	.05	.10	1.0	.72	.14	.61	1.47
<u>Solidago sempervirens</u> var. <u>mexicana</u> Goldenrod	.05	.10	trace	.72	.14	-	.86

TABLE 2.7-7

ANALYSIS OF VEGETATION IN THE POWER LINE RIGHT-OF-WAY
VEGETATION TYPE - MARCH - MAY 1975
BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Lippia</u> <u>nodiflora</u> Frog bit	.33	.44	2.5	4.7	.51	1.7	6.8
<u>Ipomea</u> <u>trichocarpa</u> Morning glory	.55	4.8	3.2	7.9	5.6	2.2	15.7
<u>Bidens pilosa</u> Tickseed	.66	13.5	25.5	9.4	15.8	17.7	42.9
<u>Paspalum notatum</u>	.33	1.1	.5	4.7	1.3	.35	6.2
<u>Eupatorium</u> <u>compositifolium</u> Dog fennel	.55	3.7	7.8	7.9	4.4	5.4	17.6
<u>Cynodon</u> <u>dactylon</u> Bermuda grass	.77	28.1	72.5	11.0	33.0	50.3	94.3
<u>Ambrosia</u> <u>artemisiifolia</u> Ragweed	.55	20.3	27.2	7.9	23.8	18.9	50.6
<u>Aeschynomene</u> <u>americana</u> Sensitive joint- weed	.33	.77	1.0	.47	.9	.7	6.3
<u>Sonchus asper</u> Sow thistle	.22	.22	trace	3.1	.25	-	3.4
<u>Sambucus</u> <u>simpsonii</u> Elderberry	.22	.33	.5	3.1	.39	.35	3.8
<u>Chenopodium</u> <u>ambrosioides</u> Goosefoot	.44	3.0	1.0	6.3	3.5	.7	10.5
<u>Lythrum</u> sp. Loosestrife	.11	.22	trace	1.6	.25	-	1.85

TABLE 2.7-7 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Lepidium virginicum</u> Pepper grass	.55	1.0	.5	7.9	1.2	.35	9.4
<u>Cyperus</u> <u>surinamensis</u> Nut grass	.22	1.0	.5	3.1	1.2	.35	4.7
<u>Desmodium canum</u> Beggar's lice	.22	1.2	trace	3.1	1.4	-	4.5
<u>Conyza</u> <u>canadensis</u> Dwarf horsetail	.44	.39	.8	6.3	4.6	.55	11.4
<u>Ludwigia</u> <u>octovalvis</u> Water purslane	.33	1.0	.5	4.7	1.2	.35	6.2
<u>Urena lobata</u> Caesar weed	.22	.44	.5	3.1	.51	.35	3.9

TABLE 2.7-8

ANALYSIS OF VEGETATION IN THE ASH POND
 VEGETATION TYPE - MAY - SEPTEMBER 1974
 BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Ludwigia octovalvis</u> Water purslane	.04	.04	.5	.73	.07	.70	1.5
<u>Baccharis</u> <u>halimifolia</u> Groundsel tree	.33	.96	3.0	6.05	1.77	4.19	12.01
<u>Solidago sempervirens</u> var. <u>mexicana</u> Goldenrod	.79	13.75	12.0	14.49	25.33	16.78	56.60
<u>Melothria pendula</u> var. <u>pendula</u> Climbing cucumber	.21	.33	1.0	3.85	.61	1.40	5.86
<u>Distichlis spicata</u> Salt grass	.17	2.46	1.0	3.12	4.53	1.40	9.05
<u>Eupatorium</u> sp. Dog fennel	.12	.29	2.0	2.80	.53	2.30	5.63
<u>Panicum</u> sp. Panic grass	.08	.08	.5	1.47	.15	.70	2.32
<u>Pastalum vaginatum</u>	.37	4.5	2.5	6.79	8.29	3.50	18.58
<u>Iva frutescens</u> Marsh elder	.17	1.4	4.0	3.12	2.58	5.59	11.29
<u>Setaria geniculata</u> Bristly foxtail	.21	.54	5.5	3.85	.99	7.69	12.53
<u>Pluchea</u> <u>purpurascens</u> Marsh fleabane	.08	.08	trace	1.47	.15	-	1.62
<u>Chamaesyce</u> <u>hystrofolia</u> Hyssop-leaved spurge	.12	.12	trace	2.20	.22	-	2.42
<u>Chloris petraea</u> Finger grass	.33	.58	4.5	6.05	1.07	6.29	13.41

TABLE 2.7-8 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Cyperus polystachyos</u> Nut grass	.17	.71	1.5	3.12	1.30	2.10	6.52
<u>Helenium amarum</u> Bitter sneezeweed	.12	.12	1.0	2.20	.22	1.40	3.82
<u>Cyperus rotundus</u> Nut grass	.38	16.92	5.0	6.97	31.18	6.99	45.14
<u>Parthenocissus</u> <u>quinquefolia</u> Virginia creeper	.04	.04	trace	.73	.07	-	.80
<u>Acalypha gracilens</u> Three-seeded mercury	.04	.04	.5	.73	.07	.70	1.5
<u>Schinus terebinthe-</u> <u>folius</u> Brazilian pepper	.29	.46	1.5	5.32	.85	2.10	8.27
<u>Phytolacca americana</u> Pokeweed	.04	.04	2.0	.73	.07	2.80	3.60
<u>Indigofera hirsuta</u> Hairy indigo	.17	.5	1.0	3.12	.92	1.40	5.44
<u>Paspalum urvillei</u> Vasey grass	.04	.04	trace	.73	.07	-	.80
<u>Ambrosia artemisiifolia</u> Ragweed	.12	.25	2.0	2.20	.46	2.80	5.46
<u>Andropogon</u> sp. Beard grass	.08	.08	trace	1.47	.15	-	1.62
<u>Vigna luteola</u> Cow pea	.25	.29	1.5	4.59	.53	2.10	7.22
<u>Typha</u> sp. Cattail	.04	.04	.5	.73	.07	.70	1.5
<u>Sesbania exaltata</u> Sesban	.12	.12	4.5	2.20	.22	6.29	8.71
<u>Bidens pilosa</u> Tickseed	.08	.21	trace	1.47	.39	-	1.86

TABLE 2.7-8 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Lythrum alatum</u> var. <u>lanceolatum</u> Loosestrife	.04	.04	1.5	.73	.07	2.10	2.90
<u>Portulaca oleracea</u> Purslane	.04	.04	trace	.73	.07	-	.80
<u>Solidago micro-</u> <u>cephala</u> Goldenrod	.21	8.92	12.5	3.85	16.43	17.48	37.76
<u>Eluesine indica</u> Goose grass	.04	.04	trace	.73	.07	-	.80
<u>Lippia nodiflora</u> Frog bit	.04	.17	trace	.73	.31	-	1.04
<u>Chamaesyce</u> sp. Spurge	.04	.04	trace	.73	.07	-	.80
<u>Conyza canadensis</u> Dwarf horsetail	.04	.04	trace	.73	.07	-	.80

TABLE 2.7-9

ANALYSIS OF VEGETATION IN THE JACKSON BRANCH
FRESHWATER MARSH VEGETATION TYPE - MAY - SEPTEMBER 1974
BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Upper Stratum</u>							
<u>Sambucus sim-</u> <u>psonii</u> Elderberry	.55	.42	14.0	15.49	34.43	31.85	81.77
<u>Schinus tere-</u> <u>binthefolius</u> Brazilian pepper	.78	.19	12.5	21.97	15.57	28.44	65.98
<u>Myrica cerifera</u> Wax myrtle	.89	.25	5.0	25.07	20.49	11.38	56.94
<u>Baccharis</u> <u>halimifolia</u> Groundsel tree	.67	.22	5.5	18.87	18.03	12.51	49.41
<u>Salix carol-</u> <u>iniana</u> Southern willow	.55	.13	5.45	15.49	10.66	12.40	38.55
<u>Musa sapientum</u>	.11	.01	1.5	3.10	.82	3.41	7.33
<u>Lower Stratum</u>							
<u>Parthenocissus</u> <u>quinquefolia</u> Virginia creeper	.55	.17	2.5	3.55	1.90	2.91	8.36
<u>Ampelopsis arborea</u> Pepper vine	1.00	.44	7.5	6.46	4.91	8.74	20.11
<u>Verbesina laciniata</u> Crownbeard	.78	.71	8.0	5.04	7.92	9.32	22.28
<u>Rhynchelytrum</u> <u>roseum</u> Red top	.33	.06	1.0	2.13	.67	1.16	3.96
<u>Bidens pilosa</u> Tickseed	1.00	.67	6.0	6.46	7.48	6.99	20.93

TABLE 2.7-9 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Ambrosia artemisiifolia</u> Ragweed	1.00	.97	11.5	6.46	10.82	13.39	30.67
<u>Desmodium canum</u> Beggar's lice	.33	.06	trace	2.13	.67	-	2.8
<u>Desmodium triflorum</u> Beggar's lice	.44	.11	1.5	2.84	1.23	1.75	5.82
<u>Psidium guajava</u> Guava	.22	.03	1.0	1.42	.33	1.16	2.91
<u>Teucrium canadense</u> Wood sage	.33	.16	.75	2.13	1.78	.87	4.78
<u>Paspalum</u> sp.	.55	.75	3.05	3.55	8.37	3.55	15.47
<u>Galactia elliotii</u> Milk pea	.67	.24	2.5	4.33	2.68	2.91	9.92
<u>Vitis rotundifolia</u> Muscadine grape	.33	.08	1.0	2.13	.89	1.16	4.18
<u>Rubus trivialis</u> Lewberry	1.00	.32	5.5	6.46	3.57	6.41	16.44
<u>Setaria geniculata</u> Bristly foxtail	.55	.14	.5	3.55	1.56	.58	5.69
<u>Gaura angustifolia</u> Southern Guara	.67	.19	2.0	4.33	2.12	2.33	8.78
<u>Toxicodendron radicans</u> ssp. <u>radicans</u> Poison ivy	.11	.03	trace	.71	.44	-	1.04
<u>Chenopodium ambrosioides</u> Goosefoot	.33	.22	3.0	2.13	2.45	3.49	8.07

TABLE 2.7-9 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Paspalum</u> <u>urvillei</u> Vasey grass	.55	.46	5.0	3.55	5.13	5.82	14.50
<u>Sida rhombifolia</u>	.22	.13	1.5	1.42	1.45	1.75	4.62
<u>Sporobolus domin-</u> <u>gensis</u> Dropseed	.44	.46	1.5	2.84	5.13	1.75	9.72
<u>Conyza canadensis</u> Dwarf horsetail	.44	.17	2.0	2.84	1.90	2.33	7.07
<u>Vitis aestivalis</u> Southern grape	.22	.06	1.0	1.42	.67	1.16	3.25
<u>Melothria pendula</u> var. <u>pendula</u> Climbing cucumber	.44	.11	1.5	2.84	1.23	1.75	5.82
<u>Cyperus ligularis</u> Rut grass	.11	.02	trace	.71	.33	-	.93
<u>Lippia nodiflora</u> Frog bit	.44	.11	2.0	2.84	1.23	2.44	6.40
<u>Digitaria</u> <u>sanguinalis</u> Coralgrass	.22	.92	2.5	1.42	0.27	2.91	14.6
<u>Cenchrus echinata</u> Sandspur	.11	.14	.5	.71	1.56	.58	1.85
<u>Indigofera</u> <u>hirsuta</u> Hairy indigo	.22	.05	trace	1.42	.56	-	1.98
<u>Solidago micro-</u> <u>cephala</u> Goldenrod	.22	.13	.5	1.42	1.45	.58	3.45
<u>Passiflora suberosa</u> Passion vine	.22	.05	1.05	1.42	.56	1.22	3.20
<u>Phytolacca</u> <u>americana</u> Pokeweed	.22	.13	3.0	1.42	1.45	3.49	6.36

TABLE 2.7-9 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Chloris petraea</u> Finger grass	.33	.16	1.0	2.13	1.78	1.16	5.07
<u>Lepidium virginicum</u> Pepper grass	.33	.09	2.0	2.13	1.00	2.33	5.46
<u>Typha</u> sp. Cattail	.22	.28	3.0	1.42	3.12	3.49	8.03
<u>Cassia fasciculata</u> Senna	.33	.14	.5	2.13	1.56	.58	4.27

TABLE 2.7-10

ANALYSIS OF VEGETATION IN THE JACKSON BRANCH FRESHWATER MARSH
VEGETATION TYPE - SEPTEMBER - DECEMBER 1974
BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Lower Stratum</u>							
<u>Parthenocissus</u> <u>quinquefolia</u> Virginia creeper	.44	.78	1.8	4.54	2.55	4.13	11.22
<u>Ampelopsis arborea</u> Pepper vine	.22	.33	1.2	2.27	1.08	2.75	6.10
<u>Verbesina laciniata</u> Crownbeard	.44	1.67	9.2	4.54	5.47	21.12	31.13
<u>Rhynchosyris</u> <u>roseum</u> Red top	.55	1.33	.5	5.68	4.36	1.15	11.19
<u>Bidens pilosa</u> Tickseed	.33	1.22	.5	3.41	3.99	1.15	8.55
<u>Ambrosia</u> <u>artemisiifolia</u> Ragweed	.33	.67	trace	3.41	2.19	-	5.60
<u>Desmodium canum</u> Beggar's lice	.33	.67	trace	3.41	2.19	-	5.60
<u>Desmodium triflorum</u> Beggar's lice	.22	.22	trace	2.27	.72	-	2.99
<u>Paspalum</u> sp.	.44	1.44	.5	4.54	4.72	1.15	10.41
<u>Vitis rotundifolia</u> Muscadine grape	.33	.44	.8	3.41	1.44	1.84	6.69
<u>Rubus trivialis</u> Dewberry	.44	.88	1.3	4.54	2.88	2.98	10.40
<u>Setaria</u> <u>geniculata</u> Bristly foxtail	.22	.22	trace	2.27	.72	-	2.99
<u>Gaura angustifolia</u> Southern gaura	.22	.33	trace	2.27	1.08	-	3.35

TABLE 2.7-10 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Toxicodendron</u> <u>radicans</u> ssp. <u>radicans</u> Poison ivy	.11	.11	trace	1.14	.36	-	1.50
<u>Paspalum</u> <u>urvillei</u> Vasey grass	.33	.55	3.4	3.41	1.80	7.81	13.02
<u>Sida</u> <u>rhombifolia</u>	.44	.77	.8	4.54	2.52	1.84	8.90
<u>Sporobolus</u> <u>domingensis</u> Drop seed	.33	.44	trace	3.41	1.44	-	4.85
<u>Vitis</u> <u>aestivalis</u> Southern grape	.22	.33	.5	2.27	1.08	1.15	4.50
<u>Cyperus</u> <u>ligularis</u> Nut grass	.11	.11	trace	1.14	.36	-	1.5
<u>Lippia</u> <u>nodiflora</u> Frog bit	.33	.55	1.1	3.41	1.80	2.52	7.73
<u>Digitaria</u> <u>sanguinalis</u> Crabgrass	.55	5.78	2.5	5.68	18.94	5.74	30.36
<u>Solidago</u> <u>microcephala</u> Goldenrod	.33	1.22	1.2	3.41	3.99	2.75	10.15
<u>Passiflora</u> <u>suberosa</u> Passion vine	.33	.44	2.2	3.41	1.44	5.05	9.90
<u>Chloris</u> <u>petraea</u> Finger grass	.33	1.44	trace	3.41	4.72	-	8.13
<u>Andropogon</u> <u>glomeratus</u> Beard grass	.33	1.33	1.2	3.41	4.36	2.75	10.52
<u>Typha</u> sp. Cattail	.11	2.00	3.05	1.14	6.55	7.00	14.69
<u>Tripsacum</u> <u>dactyloides</u> Gama grass	.22	.55	1.5	2.27	1.80	3.44	7.51

TABLE 2.7-10 (Cont)

<u>Scientific Name</u> <u>Common Name</u>	<u>Frequency</u>	<u>Density</u> <u>#/m²</u>	<u>Cover</u> <u>%</u>	<u>Relative</u> <u>Frequency</u>	<u>Relative</u> <u>Density</u>	<u>Relative</u> <u>Dominance</u>	<u>Importance</u> <u>Value</u>
<u>Crotolaria</u> <u>spectabilis</u> Rattle box	.22	.33	trace	2.27	1.08	-	3.35
<u>Eleusine indica</u> Goose grass	.33	.77	.5	3.41	2.52	1.15	7.08
<u>Eupatorium</u> <u>compositifolium</u> Dog fennel	.33	1.69	2.3	3.41	5.54	5.28	14.23

TABLE 2.7-11

ANALYSIS OF VEGETATION IN THE JACKSON BRANCH
FRESHWATER MARSH VEGETATION TYPE - DECEMBER 1974 - MARCH 1975
BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Bidens pilosa</u> Tickseed	.7	3.7	3.2	9.3	14.2	5.5	29.0
<u>Vitis</u> <u>aestivalis</u> Southern grape	.3	.4	1.6	4.0	1.5	2.7	8.2
<u>Ampelopsis</u> <u>arborea</u> Pepper vine	.4	.6	1.7	5.3	2.3	2.9	10.5
<u>Panicum</u> <u>purpureum</u> Panic grass	.3	2.5	6.9	4.0	9.6	11.0	25.4
<u>Verbesina</u> <u>lacinata</u> Crownbeard	.6	2.1	12.3	8.0	8.0	21.1	37.1
<u>Vitis</u> <u>rotundifolia</u> Muscadine grape	.4	.5	3.4	5.3	1.9	5.8	13.0
<u>Tripsacum</u> <u>dactyloides</u> Gama grass	.3	.5	1.0	4.0	1.9	1.7	7.6
<u>Sida acuta</u>	.4	.7	3.5	5.3	2.7	6.0	14.0
<u>Vigna luteola</u> Cow pea	.3	.3	4.7	4.0	1.1	8.1	13.2
<u>Sporobolus</u> <u>domingensis</u> Dropseed	.2	.3	trace	2.7	1.1	-	3.8
<u>Parthenocissus</u> <u>quinquefolia</u> Virginia creeper	.3	.4	1.2	4.0	1.5	2.1	7.6
<u>Ambrosia</u> <u>artemisiifolia</u> Ragweed	.4	5.8	7.0	5.3	22.2	12.0	39.5

TABLE 2.7-11 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Passiflora</u> <u>suberosa</u> Passion vine	.3	.5	2.8	4.0	1.9	4.8	10.7
<u>Desmodium</u> <u>canum</u> Beggar's lice	.3	.6	trace	4.0	2.3	-	6.3
<u>Rubus</u> <u>trivialis</u> Dewberry	.4	.8	2.1	5.3	3.1	3.6	12.0
<u>Chenopodium</u> <u>ambrosioides</u> Goosefoot	.3	.4	.9	4.0	1.5	1.5	7.0
<u>Linaria</u> <u>canadensis</u> Toadflax	.2	1.3	trace	2.7	4.9	-	7.6
<u>Geranium</u> <u>carolinianum</u> Cranesbill	.3	1.1	trace	4.0	4.2	-	8.2
<u>Ludwigia</u> <u>peruviana</u> Water willow	.2	.3	1.0	2.7	1.1	1.7	5.5
<u>Medicago</u> <u>lupulina</u> Black medic	.1	.2	trace	1.3	.8	-	2.1
<u>Andropogon</u> <u>glomeratus</u> Beard grass	.3	.7	.5	4.0	2.7	.8	7.5
<u>Gaura</u> <u>angustifolia</u> Southern gaura	.2	.5	trace	2.7	1.9	-	4.6
<u>Eleusine</u> <u>indica</u> Goose grass	.2	.3	trace	2.7	1.1	-	3.8
<u>Typha</u> <u>latifolia</u> Cattail	.1	1.6	4.5	1.3	6.1	7.7	15.1

TABLE 2.7-12

ANALYSIS OF VEGETATION IN THE JACKSON BRANCH
FRESHWATER MARSH VEGETATION TYPE - MARCH - MAY 1975
BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Amaranthus hybridus</u> Pigweed	.40	1.80	2.8	4.9	5.3	4.9	15.1
<u>Ambrosia artemisi-</u> <u>ifolia</u> Ragweed	.40	4.40	6.2	4.9	13.0	10.8	28.7
<u>Stenotaphrum secun-</u> <u>datum</u> St. Augustine grass	.20	1.0	.5	2.5	2.9	.9	6.3
<u>Paspalum urvillei</u> Vasey grass	.20	.20	trace	2.5	.6	-	3.1
<u>Lippia nodiflora</u> Frog bit	.30	.60	.5	3.7	1.7	.9	6.3
<u>Guava angustifolia</u> Southern guava	.30	.60	trace	3.7	1.8	-	5.5
<u>Bidens pilosa</u> Tickseed	.70	10.10	17.1	8.6	29.9	29.8	68.3
<u>Sida acuta</u> Sida	.40	1.20	4.0	4.9	3.5	6.9	15.3
<u>Lesmodium canum</u> Beggar's lice	.30	.50	trace	3.7	1.5	-	5.2
<u>Verbesina laciniata</u> Crownbeard	.40	1.60	10.2	4.9	4.7	17.8	27.4
<u>Polygala grand-</u> <u>iflora</u> Candyroot	.20	.30	trace	2.5	.9	-	3.4
<u>Paspalum notatum</u>	.40	1.10	.5	4.9	3.2	.9	9.0
<u>Cechirus</u> sp. Sandspar	.10	.10	trace	1.2	.3	-	1.5
<u>Ampelopsis arborea</u> Pepper vine	.30	.40	2.0	3.7	1.2	3.5	8.4

TABLE 2.7-12 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Panicum pur-</u> <u>pureum</u> Panic grass	.20	2.20	5.2	2.5	6.5	9.1	18.1
<u>Vitis rotundi-</u> <u>folia</u> Muscadine grape	.30	.50	.7	3.7	1.5	1.2	6.4
<u>Passiflora</u> <u>suberosa</u> Passion vine	.30	.50	2.5	3.7	1.5	4.4	9.6
<u>Desmodium</u> <u>tortuosum</u> beggar's lice	.20	.30	trace	2.5	.9	-	3.4
<u>Tripsacum</u> <u>dactyloides</u> Gama grass	.10	.80	1.2	1.2	2.4	2.1	5.7
<u>Parthenocissus</u> <u>quinquefolia</u> Virginia creeper	.30	.40	1.0	3.7	1.2	1.7	6.6
<u>Lepidium virgin-</u> <u>icum</u> Pepper grass	.30	1.00	.5	3.7	2.9	.9	7.5
<u>Vitis aestivalis</u> Southern grape	.30	.40	1.4	3.7	1.2	2.4	7.3
<u>Rhynchelytrum</u> <u>repens</u> Natal grass	.20	.70	trace	2.5	2.1	-	4.6
<u>Sporobolus</u> <u>domingensis</u> Dropseed	.20	.40	.5	2.5	1.2	-	3.7
<u>Crotalaria</u> <u>spectabilis</u> Rattle box	.20	.50	.6	2.5	1.5	1.3	5.3
<u>Chenopodium</u> <u>ambrosioides</u> Goosefoot	.30	.70	1.0	3.7	2.1	1.7	7.3

TABLE 2.7-12 (Cont)

<u>Scientific Name</u> <u>Common Name</u>	<u>Frequency</u>	<u>Density</u> <u>#/m²</u>	<u>Cover</u> <u>%</u>	<u>Relative</u> <u>Frequency</u>	<u>Relative</u> <u>Density</u>	<u>Relative</u> <u>Dominance</u>	<u>Importance</u> <u>Value</u>
<u>Conyza cana-</u> <u>densis</u> Dwarf horsetail	.10	.10	trace	1.2	.3	-	1.4
<u>Aeschynomene</u> <u>americana</u> Sensitive joint- weed	.30	.80	trace	3.7	2.4	-	6.0
<u>Cyperus surina-</u> <u>mensis</u> Nut grass	.20	.60	trace	2.5	1.8	-	4.3

TABLE 2.7-13

ANALYSIS OF VEGETATION IN THE PALMETTO-JUNCUS
ASSOCIATION - MAY - SEPTEMBER 1974
BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Herbaceous Species</u>							
<u>Solidago semper-</u> <u>virens</u> var. <u>mexicana</u> Goldenrod	.9	23.12	18.0	26.16	61.02	29.51	116.69
<u>Solidago</u> <u>microcephala</u> Goldenrod	.9	8.53	12.0	26.16	22.53	19.67	68.36
<u>Juncus</u> <u>roemerianus</u> Black rush	.53	3.1	16.5	16.41	8.10	27.05	50.65
<u>Galactia</u> <u>elliottii</u> Milk pea	.53	1.83	1.5	16.41	5.83	2.46	22.70
<u>Aristida</u> sp. Wire grass	.13	.16	3.5	3.80	.42	5.74	9.96
<u>Cladium</u> <u>jamaicense</u> Sawgrass	.1	.3	2.5	2.91	.79	5.74	9.44
<u>Pluchea</u> <u>rosea</u> Marsh fleabane	.06	.13	0.5	1.74	.34	.82	2.9
<u>Scoparia</u> <u>dulcis</u> Sweet broom	.06	.16	trace	1.74	.42	-	2.16
<u>Spartina</u> <u>bakeri</u> Cordgrass	.23	.53	5.5	6.69	1.40	9.02	17.11

TABLE 2.7-13 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Woody Species</u>							
<u>Serenoa</u> <u>repens</u> Saw palmetto	1.0	.4	17	18.80	47.61	36.17	102.58
<u>Baccharis</u> <u>halimifolia</u> Groundsel tree	1.0	.21	14	18.80	24.00	29.79	73.59
<u>Quercus</u> <u>virginiana</u> Live oak	1.0	.10	1	18.80	11.90	2.13	32.83
<u>Schinus terebin-</u> <u>thefolius</u> Brazilian pepper	1.0	.10	3	18.80	11.90	6.38	37.08
<u>Sabal palmetto</u> Cabbage palm	.66	.02	7	12.41	2.38	14.89	29.68
<u>Baccharis</u> <u>angustifolia</u> False willow	.33	.01	4	6.20	1.19	8.51	15.90
<u>Iva frutescens</u> Marsh elder	.33	.003	1	6.20	.36	2.13	8.69

TABLE 2.7-14

ANALYSIS OF VEGETATION IN THE PALMETTO-JUNCUS
ASSOCIATION - SEPTEMBER - DECEMBER 1974
BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Herbaceous Species</u>							
<u>Solidago</u> <u>sempervirens</u> var. <u>mexicana</u> Goldenrod	1.00	20.67	17.0	12.88	37.12	19.03	69.03
<u>Solidago microcephala</u> Goldenrod	1.00	14.33	23.0	12.88	25.74	25.75	64.37
<u>Juncus roemerianus</u> Black Rush	.58	3.75	15.2	7.47	6.73	17.02	31.22
<u>Spartina bakeri</u> Cord grass	.67	1.42	5.2	8.63	2.55	5.82	17.00
<u>Galactia elliotii</u> Milk pea	.42	.92	.5	5.41	1.65	.56	7.62
<u>Pluchea rosea</u> Marsh fleabane	.58	1.42	1.2	7.47	2.55	1.34	11.36
<u>Scoraria dulcis</u> Sweet broom	.67	3.92	5.5	8.63	7.04	6.16	21.83
<u>Rubus trivialis</u> Dewberry	.42	.83	.5	5.41	1.49	.56	7.46
<u>Hypericum cistifolium</u> St. John's wort	.42	.67	.5	5.41	1.20	.56	7.17
<u>Andropogon glomeratus</u> Beard grass	.42	1.25	1.5	5.41	2.24	1.68	9.33
<u>Andropogon longiberbis</u> Beard grass	.42	.83	1.0	5.41	1.49	1.12	8.02
<u>Tripsacum dactyloides</u> Gamma grass	.25	1.67	7.5	3.22	2.99	8.40	14.61
<u>Cladium jamaicense</u> Sawgrass	.33	2.92	9.5	4.25	5.24	10.64	20.13

TABLE 2.7-14 (Cont)

Scientific Name <u>Common Name</u>	<u>Frequency</u>	<u>Density</u> <u>#/m²</u>	<u>Cover</u> <u>%</u>	<u>Relative</u> <u>Frequency</u>	<u>Relative</u> <u>Density</u>	<u>Relative</u> <u>Dominance</u>	<u>Importance</u> <u>Value</u>
<u>Verbesina laciniata</u> Crownbeard	.33	.67	1.2	4.25	1.20	1.34	6.79
<u>Ludwigia octovalvis</u> False willow	.25	.41	trace	3.22	.74	-	3.96

TABLE 2.7-15

ANALYSIS OF VEGETATION IN THE PALMETTO - JUNCUS ASSOCIATION
 DECEMBER 1974 - MARCH 1975
 BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Solidago</u> <u>microcephala</u> Goldenrod	.8	8.7	21.5	12.5	22.5	27.6	62.6
<u>Scoparia</u> <u>gulcis</u> Sweet broom	.6	2.5	8.0	9.4	6.5	10.2	26.1
<u>Rubus</u> <u>trivialis</u> Dewberry	.5	.8	2.2	7.8	2.1	2.8	12.7
<u>Solidago</u> <u>sempervirens</u> Goldenrod	.7	13.3	12.2	10.9	34.4	15.6	60.9
<u>Cladium</u> <u>jamaicense</u> Sawgrass	.4	2.8	8.1	6.2	7.2	10.4	23.8
<u>Andropogon</u> <u>glomeratus</u> Beard grass	.3	.6	trace	4.7	1.5	-	6.2
<u>Galactia</u> <u>elliottii</u> Milk pea	.5	1.1	.9	7.8	2.8	1.2	11.8
<u>Juncus</u> <u>roemerianus</u> Black rush	.6	5.4	14.5	9.4	13.9	18.6	41.9
<u>Chloris</u> <u>petraea</u> Finger grass	.2	.2	trace	3.1	.5	-	3.6
<u>Smilax</u> <u>laurifolia</u> Cat briar	.2	.2	trace	3.1	.5	-	3.6
<u>Physalis</u> <u>angustifolia</u> Ground cherry	.3	.5	.5	4.7	1.3	.6	6.6

TABLE 2.7-15 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Spartina</u> <u>bakeri</u> Cord grass	.4	.6	4.3	6.2	1.5	5.5	13.2
<u>Tripsacum</u> <u>dactyloides</u> Gaura grass	.2	.8	4.2	3.1	2.1	5.4	10.6
<u>Pluchea</u> <u>purpurascens</u>	.3	.4	trace	4.7	1.0	-	5.7
<u>Verbesina</u> <u>laciniata</u> Crownbeard	.4	.7	1.5	6.2	1.8	1.9	9.9

TABLE 2.7-16

ANALYSIS OF VEGETATION IN THE SALT PRAIRIE
 VEGETATION TYPE - SEPTEMBER - DECEMBER 1974
 BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Portulaca</u> <u>frutescens</u> Sea daisy	.25	61.83	7.5	6.51	12.47	6.22	25.20
<u>Sesuvium</u> <u>portulacastrum</u> Sea purslane	.67	4.92	5.5	17.45	.99	4.56	23.00
<u>Monanthocloe</u> <u>littoralis</u> Salt grass	.75	107.58	26.2	19.53	21.70	21.74	62.97
<u>Distichlis</u> <u>spicata</u> Salt grass	.67	288.50	33.7	17.45	58.21	27.97	103.63
<u>Patis</u> <u>maritima</u> Salt wort	.33	1.75	6.0	8.59	.35	4.98	13.92
<u>Salicornia</u> <u>virginica</u> Glasswort	.33	23.33	5.5	8.59	4.71	4.56	17.86
<u>Juncus</u> <u>roemerianus</u> Black rush	.25	5.17	6.1	6.51	1.04	5.06	12.61
<u>Aster</u> <u>subulatus</u> var. <u>ligulatus</u> Aster	.17	.25	trace	4.43	.05	-	4.48
<u>Solidago</u> <u>sempervirens</u> var. <u>mexicana</u> Goldenrod	.25	2.08	16.0	6.51	.42	13.28	20.21
<u>Spartina</u> <u>bakeri</u> Cord grass	.17	.25	14.0	4.43	.05	11.62	16.10

TABLE 2.7-17

ANALYSIS OF VEGETATION IN THE SALT PRAIRIE
 VEGETATION TYPE - DECEMBER 1974 - MARCH 1975
 BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Herbaceous Species</u>							
<u>Borrchia</u> <u>frutescens</u> Sea Daisy	.3	65.4	6.3	9.1	16.3	7.4	32.8
<u>Monanthochloe</u> <u>littoralis</u> Salt grass	.6	125.6	24.5	18.2	31.3	28.7	78.2
<u>Batis maritima</u> Saltwort	.3	1.1	6.8	9.1	.3	7.9	17.3
<u>Sesuvium</u> <u>portulacastrum</u> Sea purslane	.5	2.7	5.1	15.1	.7	5.9	21.7
<u>Distichlis</u> <u>spicata</u> Salt grass	.5	192.4	30.5	15.1	47.9	35.8	98.8
<u>Spartina</u> <u>spartinae</u> Cord grass	.1	.2	trace	3.0	.05	-	3.05
<u>Juncus</u> <u>roemerianus</u> Black rush	.2	4.1	5.5	6.1	1.0	6.4	13.5
<u>Aster</u> <u>tenuifolius</u> Aster	.2	.2	trace	6.1	.05	-	6.15
<u>Aralinis</u> <u>maritima</u> False purple foxglove	.2	.2	trace	6.1	.05	-	6.15
<u>Salicornia</u> <u>virginica</u> Glasswort	.2	8.5	4.6	6.1	2.1	5.4	13.6

TABLE 2.7-17 (Cont)

<u>Scientific Name</u> <u>Common Name</u>	<u>Frequency</u>	<u>Density</u> <u>#/m²</u>	<u>Cover</u> <u>%</u>	<u>Relative</u> <u>Frequency</u>	<u>Relative</u> <u>Density</u>	<u>Relative</u> <u>Dominance</u>	<u>Importance</u> <u>Value</u>
<u>Spartina</u> <u>bakeri</u> Cord grass	.2	.8	2.0	6.1	.2	2.3	8.6

TABLE 2.7-18

ANALYSIS OF VEGETATION IN THE SALT PRAIRIE
VEGETATION TYPE - MARCH - MAY 1975
BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Chloris petraea</u> Finger grass	.22	.67	trace	5.1	.2	-	5.3
<u>Monanthochloe</u> <u>littoralis</u> Salt grass	.55	152.22	22.8	12.8	43.5	29.2	85.5
<u>Distichilus</u> <u>spicata</u> Salt grass	.55	176.78	27.5	12.8	50.5	35.2	98.5
<u>Sesuvium port-</u> <u>ulacastrum</u> Sea purslane	.55	3.11	4.6	12.8	.9	5.9	19.6
<u>Errichia</u> <u>frutescens</u> Sea daisy	.22	15.5	5.5	5.1	.1	7.0	12.2
<u>Agalinus</u> <u>maritima</u> False-purple foxglove	.22	.44	trace	5.1	.1	-	5.2
<u>Spartina spar-</u> <u>тинае</u> Cord grass	.22	.33	.5	5.1	.1	.6	5.8
<u>Philoxerus ver-</u> <u>micularis</u> Saltweed	.33	.33	.8	7.7	.1	1.0	8.8
<u>Spartina bakeri</u> Cord grass	.22	.55	4.2	5.1	.2	5.4	10.7
<u>Salicornia vir-</u> <u>ginica</u> Glasswort	.33	8.89	5.1	7.7	2.5	6.5	16.7
<u>Eatis maritima</u> Salt wort	.33	1.11	5.0	7.7	.3	6.4	14.4

TABLE 2.7-18 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Juncus roe-</u> <u>marianus</u> Black rush	.22	4.44	1.5	5.1	1.3	1.9	8.3
<u>Vigna luteola</u> Cow pea	.11	.11	trace	2.6	.03	-	2.63
<u>Fimbristylis</u> <u>castanea</u> Fringe rush	.22	.55	.5	5.1	.2	.6	5.9

TABLE 2.7-19

ANALYSIS OF VEGETATION IN THE PINE-PALMETTO
ASSOCIATION - MAY - SEPTEMBER 1974
BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Herbaceous Species</u>							
<u>Solidago</u> <u>microcephala</u> Goldenrod	.84	4.25	2.0	23.33	32.79	10.31	66.43
<u>Solidago</u> <u>sempervirens</u> var. <u>mexicana</u> Goldenrod	.31	2.16	3.8	8.61	16.67	19.60	44.88
<u>Spartina</u> <u>bakeri</u> Cord grass	.16	.16	6.19	4.44	1.23	31.92	37.59
<u>Rhynchospora</u> <u>divergens</u> Beak rush	.06	.06	.2	1.67	.46	1.03	3.16
<u>Pluchea</u> <u>rosea</u> Marsh fleabane	.03	.03	trace	.83	.23	-	1.06
<u>Lachnocaulon</u> <u>anceps</u> Bog button	.13	.22	trace	3.61	1.70	-	5.31
<u>Hedyotis</u> <u>procumbens</u> Innocence	.28	.44	.2	7.78	3.39	1.03	12.2
<u>Panicum</u> <u>virgatum</u> Switchgrass	.16	.5	.5	4.44	3.86	2.58	10.88
<u>Mikania</u> <u>scandens</u> Climbing hempweed	.03	.03	trace	.83	.23	-	1.06
<u>Erianthus</u> <u>giganteus</u> Plumegrass	.03	.03	.3	.83	.23	1.55	2.61
<u>Galactia</u> <u>elliottii</u> Milk pea	.53	2.69	2.5	15.72	20.76	12.89	48.37

TABLE 2.7-19 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Erechtites</u> <u>hieracifolia</u> Fireweed	.03	.03	trace	.83	.23	-	1.06
<u>Panicum breve</u> Panic grass	.13	.81	.2	3.61	6.25	1.03	10.89
<u>Gnaphalium</u> <u>purpureum</u> Cudweed	.03	.06	trace	.83	.46	-	1.29
<u>Ambrosia arte-</u> <u>missifolia</u> Ragweed	.03	.06	trace	.83	.46	-	1.29
<u>Cassia</u> <u>fasciculata</u> Senna	.18	.22	.5	5.0	1.70	2.58	9.28
<u>Samolus</u> <u>parviflorus</u> Pineland pimpernel	.06	.09	trace	1.67	.69	-	2.36
<u>Juncus</u> <u>roemerianus</u> black rush	.09	.18	.7	2.5	1.39	3.61	7.5
<u>Fimbristylis</u> <u>castanea</u> Fringe rush	.09	.28	.8	2.5	2.16	4.12	8.78
<u>Scoraria dulcis</u> Sweet broom	.09	.13	.5	2.5	1.0	2.58	6.08
<u>Andropogon</u> sp. beard grass	.28	.5	1.0	7.78	3.86	5.16	16.8
<u>Oxalis dillenii</u> Yellow sorrel	.03	.03	trace	.23	.23	-	1.06

TABLE 2.7-20

ANALYSIS OF VEGETATION IN THE PINE-PAISETTO
ASSOCIATION - SEPTEMBER - DECEMBER 1974
BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Herbaceous Species</u>							
<u>Solidago</u> <u>microcephala</u> Goldenrod	1.00	17.00	4.1	8.55	33.36	16.60	58.51
<u>Solidago</u> <u>sempe-</u> <u>virens</u> var. <u>mexicana</u> Goldenrod	.87	4.25	3.2	7.43	8.34	12.95	28.72
<u>Spartina</u> <u>bakeri</u> Cord grass	.37	.75	5.1	3.16	1.47	20.65	25.28
<u>Rhynchospora</u> <u>divergens</u> Beak rush	.50	1.12	.2	4.27	2.20	.81	7.28
<u>Pluchea</u> <u>rosea</u> Marsh fleabane	.50	1.25	.3	4.27	2.45	1.21	7.88
<u>Lachnocaulon</u> <u>anceps</u> Bog button	.50	1.00	trace	4.27	1.96	-	6.23
<u>Hebeotis</u> <u>procumbens</u> Innocence	.50	2.00	.1	4.27	3.92	.40	8.59
<u>Panicum</u> <u>virgatum</u> Switch grass	.37	1.12	.5	3.16	2.20	2.02	7.38
<u>Erianthus</u> <u>giganteus</u> Plumegrass	.37	.62	1.5	3.16	1.22	6.07	10.45
<u>Galactia</u> <u>elliottii</u> Milk Pea	.50	2.00	1.2	4.27	3.92	4.86	13.05
<u>Panicum</u> <u>breve</u> Panic grass	.50	4.50	.2	4.27	8.83	.81	13.91
<u>Samolus</u> <u>parviflorus</u> Pineland pimpernel	.37	.75	.2	3.16	1.47	.81	5.44

TABLE 2.7-20 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Juncus roemerianus</u> Black Rush	.25	2.25	1.1	2.14	4.41	4.45	11.00
<u>Fimbristylis castanea</u> Fringe rush	.37	.75	.5	3.16	1.47	2.02	6.65
<u>Oxalis dillenii</u> Yellow sorrel	.37	.50	trace	3.16	.98	-	4.14
<u>Scoraria dulcis</u> Sweet Broom	.75	3.25	2.0	6.41	6.38	8.10	20.89
<u>Andropogon virginicus</u> Broom sedge	.50	1.00	.5	4.27	1.95	2.02	8.25
<u>Andropogon longiberbis</u> Beard grass	.25	.37	trace	2.13	.73	-	2.86
<u>Hypericum cisti- folium</u> St. John's wort	.50	1.50	.5	4.27	2.94	2.02	9.23
<u>Vitis rotundifolia</u> Muscadine grape	.25	.25	.5	2.14	.49	2.02	4.65
<u>Ludwigia octovalvis</u> Water purselane	.37	.87	.2	3.16	1.71	.81	5.68
<u>Amorpha herbacea</u> Lead plant	.50	.87	.6	4.27	1.71	2.43	8.41
<u>Gaura angustifolia</u> Southern gaura	.25	.50	trace	2.14	.98	-	3.12
<u>Verbesina laciniata</u> Crown beard	.37	1.12	1.0	3.16	2.20	4.05	9.41
<u>Andropogon golmer- atus</u> Beard grass	.37	1.00	1.2	3.16	1.96	4.86	9.98
<u>Lobelia feayana</u> Bay lobelia	.25	.37	trace	2.14	.73	-	2.87

TABLE 2.7-21

ANALYSIS OF VEGETATION IN THE PINE-PALMETTO
ASSOCIATION - DECEMBER 1974 - MARCH 1975
BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Solidago</u> <u>microcephala</u> Goldenrod	.9	13.7	3.6	10.3	35.3	13.1	58.7
<u>Spartina bakeri</u> Cord grass	.3	.6	4.4	3.4	1.5	16.0	20.9
<u>Solidago</u> <u>sempervirens</u> Goldenrod	.7	2.0	2.1	8.0	5.1	7.7	20.8
<u>Pluchea rosea</u> Marsh fleabane	.3	.7	trace	3.4	1.8	-	5.2
<u>Panicum virgatum</u> Panic grass	.2	.3	trace	2.3	.8	-	3.1
<u>Samolus parviflora</u> Pineland pimpernel	.2	.4	trace	2.3	1.0	-	3.3
<u>Lobelia feyana</u> Bay lobelia	.4	3.7	.5	4.6	9.5	1.8	15.9
<u>Galactia elliotii</u> Milk pea	.7	3.0	2.5	8.0	7.7	9.1	24.8
<u>Hypericum</u> <u>cistifolium</u> St. John's wort	.3	.7	.5	3.4	1.8	1.8	7.0
<u>Cladium</u> <u>divergens</u> Beak rush	.3	.9	trace	3.4	2.3	-	5.7
<u>Juncus</u> <u>roemerianus</u> Black rush	.3	2.5	1.5	3.4	6.4	5.5	15.3
<u>Andropogon</u> <u>virginianus</u> Broom sedge	.4	1.2	trace	4.6	3.1	-	7.7

TABLE 2.7-21 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Ludwigia</u> <u>octovalvis</u> Water purslane	.1	.1	trace	1.1	.3	-	1.4
<u>Verbesina</u> <u>laciniata</u> Crown beard	.6	1.9	2.2	6.8	5.0	8.0	19.8
<u>Hedyotis</u> <u>procumbens</u> Innocence	.2	.4	trace	2.3	1.0	-	3.3
<u>Andropogon</u> <u>glomeratus</u> Beard grass	.2	.5	trace	2.3	1.3	-	3.6
<u>Scoraria</u> <u>dulcis</u> Sweet broom	.7	2.7	5.2	8.0	6.9	19.0	33.9
<u>Fimbristylis</u> <u>castanea</u> Fringe rush	.2	.4	.5	2.3	1.0	1.8	5.1
<u>Vitis</u> <u>rotundifolia</u> Muscadine grape	.3	.5	1.0	3.4	1.3	3.6	8.3
<u>Amorpha</u> <u>herbacea</u> Lead plant	.6	1.3	1.5	6.8	3.3	5.5	15.6
<u>Gaura</u> <u>angustifolia</u> Southern gaura	.2	.3	trace	2.3	.8	-	3.1
<u>Smilax</u> <u>laurifolia</u> Cat briar	.2	.2	.5	2.3	.5	1.8	4.6
<u>Rubus</u> <u>trivialis</u> Dewberry	.4	.8	1.4	4.6	2.1	5.1	11.8

TABLE 2.7-22

ANALYSIS OF VEGETATION IN THE PINE-PALMETTO
ASSOCIATION VEGETATION TYPE - MARCH - MAY 1975
BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Solidago sem-</u> <u>pervirens</u> Goldenrod	.63	3.8	2.5	6.33	7.2	9.0	22.5
<u>Solidago micro-</u> <u>cephala</u> Goldenrod	.63	18.9	4.8	6.3	36.0	17.3	59.6
<u>Pluchea rosea</u> Marsh fleabane	.38	1.1	.5	3.8	2.0	1.8	7.6
<u>Hypericum cisti-</u> <u>folium</u> St. John's wort	.25	.25	trace	2.5	.5	-	3.0
<u>Galactia elliotii</u> Milk pea	.63	3.0	2.0	6.3	5.7	7.2	19.2
<u>Erianthus giganteus</u> Plumegrass	.25	.25	.5	2.5	.5	1.8	4.8
<u>Gnaphalium</u> <u>purpureum</u> Cudweed	.38	.87	trace	3.8	1.6	-	5.4
<u>Lobelia feayana</u> Bay lobelia	.50	1.3	.5	5.0	2.5	1.8	9.3
<u>Panicum virgatum</u> Switch grass	.25	.75	trace	2.5	1.4	-	3.9
<u>Rhynchospora</u> <u>divergens</u> Beak rush	.38	1.3	trace	3.8	2.5	-	6.3
<u>Spartina bakeri</u> Cordgrass	.38	1.1	4.7	3.8	2.0	1.7	22.8
<u>Scutellaria</u> <u>integrifolia</u> Skull cap	.5	4.0	.5	5.0	7.6	1.8	14.4

TABLE 2.7-22 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Oxalis dillenii</u> Oxalis	.25	.5	trace	2.5	.9	-	3.4
<u>Verbesina lacin-</u> <u>iata</u> Crowbeard	.38	.87	.5	3.8	1.6	1.8	7.2
<u>Samolus florib-</u> <u>florus</u> Pineland pimpernel	.25	.63	trace	2.5	1.2	-	3.7
<u>Samolus ebract-</u> <u>eatus</u> Pimpernel	.13	.13	trace	1.3	.24	-	1.5
<u>Solidago chap-</u> <u-manni< u=""> Goldenrod</u-manni<>	.38	3.10	1.5	3.8	5.9	5.4	15.1
<u>Scoparia dulcis</u> Sweet broom	.75	3.50	4.8	7.5	6.6	17.3	31.4
<u>Hedyotis procumbens</u> Innocence	.63	2.50	trace	6.3	4.7	-	11.0
<u>Vitis rotundifolia</u> Muscadine grape	.25	.38	1.2	2.5	.7	4.3	7.5
<u>Guava anqustifolia</u> Southern guava	.25	.38	trace	2.5	.7	-	3.2
<u>Amorpha herbacea</u> Lead plant	.63	2.1	2.2	6.3	4.0	7.9	18.2
<u>Rubus trivialis</u> Dewberry	.13	.25	.5	1.3	.5	1.8	3.6
<u>Lachnocaulon anceps</u> Dog buttons	.25	.63	trace	2.51	1.2	-	3.7
<u>Smilax auriculata</u> Cat briar	.25	.25	.5	2.5	.5	1.8	4.8
<u>Fimbristylis</u> <u>castanea</u> Fringe rush	.25	.63	.5	2.5	1.2	1.8	5.5

TABLE 2.7-23

ANALYSIS OF VEGETATION IN THE PASTURE
VEGETATION TYPE - MAY - SEPTEMBER 1974
BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Lower Stratum</u>							
<u>Hydrocotyle</u> <u>umbellata</u> Water pennywort	.78	1.13	8.0	8.2	10.39	7.18	25.77
<u>Digitaria</u> <u>adscendens</u> Crabgrass	.89	3.37	33.0	9.3	31.0	29.63	69.99
<u>Desmodium canum</u> Beggar's lice	.89	.88	14.0	9.3	8.09	12.57	30.02
<u>Andropogon</u> <u>glomeratus</u> Beard grass	.55	.49	6.59	5.78	4.51	5.83	16.12
<u>Dichromena</u> <u>colorata</u> White tops	.33	.33	1.32	3.47	3.03	1.18	7.68
<u>Centella</u> <u>asiatica</u> Coinwort	1.0	.8	13.0	10.51	7.36	11.67	29.54
<u>Cyperus</u> <u>polystachyos</u> Nut grass	.55	.6	3.70	5.78	5.52	3.32	14.62
<u>Bacopa</u> <u>cyclophylla</u>	.33	.2	2.50	3.47	1.84	2.24	7.55
<u>Setaria</u> <u>geniculata</u> Bristly foxtail	.55	.27	1.50	5.78	2.40	1.35	9.61
<u>Lippia nodiflora</u> Frog bit	.55	.27	4.0	5.78	2.48	3.59	11.85
<u>Solidago</u> <u>sempervirens</u> var. mexicana Goldenrod	.22	.07	.45	2.31	.64	.45	3.4

TABLE 2.7-23 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Fimbristylis</u> <u>castanea</u> Fringe rush	.44	.18	3.5	4.63	1.65	3.14	9.42
<u>Cyperus</u> <u>surinamensis</u> Nut grass	.22	.07	.5	2.31	.64	.45	3.4
<u>Cyperus</u> <u>tenuifolius</u> Nut grass	.55	1.42	7.5	5.78	13.06	6.74	25.58
<u>Eupatorium</u> sp. Dog fennel	.67	.33	3.0	7.04	3.03	2.69	12.78
<u>Vitis rotundi-</u> <u>folia</u> Muscadine grape	.11	.02	.5	1.16	.18	.45	1.79
<u>Rubus trivialis</u> Dewberry	.22	.09	3.5	2.31	.83	3.14	6.28
<u>Phytolacca</u> <u>americana</u> Pokeweed	.11	.02	1.0	1.16	.18	.90	2.24
<u>Sida acuta</u>	.11	.02	.5	1.16	.18	.45	1.79
<u>Diospyros</u> <u>virginiana</u> Persimmon	.22	.09	2.0	2.31	.83	1.79	4.93
<u>Solidago</u> <u>microcephala</u> Goldenrod	.11	.18	.84	1.16	1.65	.75	3.56
<u>Paspalum</u> <u>urvillei</u> Vasey grass	.11	.04	.34	1.16	.37	.31	1.84
<u>Upper Stratum</u>							
<u>Pinus elliotii</u> var. <u>elliotii</u> Slash pine	.22	.04	6.4	100	100	100	300

TABLE 2.7-24

ANALYSIS OF VEGETATION IN THE PASTURE VEGETATION TYPE
 SEPTEMBER - DECEMBER 1974
 BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Lower Stratum</u>							
<u>Hydrocotyle</u> <u>umbellata</u> Water pennywort	.80	1.73	9.6	9.29	9.07	9.84	28.20
<u>Digitaria</u> <u>adscendens</u> Crabgrass	.80	2.73	29.2	9.29	12.31	29.92	53.52
<u>Desmodium</u> <u>cantun</u> Beggar's lice	.67	1.20	10.1	7.78	6.29	10.35	24.42
<u>Dichromena</u> <u>colorata</u> White tops	.47	1.60	2.3	5.46	8.38	2.36	16.20
<u>Bacopa</u> <u>cyclophylla</u>	.40	.67	2.3	4.64	3.51	2.36	10.51
<u>Setaria</u> <u>geniculata</u> Bristly foxtail	.33	.40	1.0	3.83	2.10	1.02	6.95
<u>Lippia</u> <u>nodiflora</u> Frog bit	.40	.67	4.3	4.64	3.51	4.40	12.55
<u>Andropogon</u> <u>glomeratus</u> Heard grass	.47	.87	7.3	5.46	4.56	7.48	17.50
<u>Centella</u> <u>asiatica</u> Coinwort	.87	1.27	11.9	10.10	6.66	12.19	28.95
<u>Solidago</u> <u>sempervirens</u> var. <u>mexicana</u> Goldenrod	.40	.53	.5	4.64	2.78	.51	7.93

TABLE 2.7-24 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Fimbristylis</u> <u>castanea</u> Fringe Rush	.40	.47	3.2	4.64	2.46	3.28	10.38
<u>Cyperus</u> <u>surinamensis</u> Nut grass	.47	1.27	1.05	5.46	6.66	1.07	13.19
<u>Eupatorium</u> <u>compositifolium</u> Dog fennel	.53	1.60	7.2	6.15	8.38	7.38	21.91
<u>Rubus</u> <u>trivialis</u> Lewberry	.27	.33	2.3	3.13	1.73	2.36	7.22
<u>Sida acuta</u>	.20	.27	trace	2.32	1.40	-	3.46
<u>Solidago</u> <u>microcephala</u> Goldenrod	.27	.80	1.35	3.13	4.19	1.38	8.70
<u>Paspalum</u> <u>urvillei</u> Vasey grass	.20	.27	1.3	2.32	1.42	1.33	5.07
<u>Aster</u> <u>subulatus</u> var. <u>ligulatus</u> Aster	.33	1.47	2.2	3.83	7.70	2.25	13.78
<u>Pluchea rosea</u> Marsh Fleabane	.20	.33	trace	2.32	1.73	-	4.05
<u>Eleusine indica</u> Goose grass	.13	.60	.5	1.51	3.14	.51	5.16

TABLE 2.7-25
ANALYSIS OF VEGETATION IN THE PASTURE
VEGETATION TYPE - MARCH - MAY 1975
BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Setaria geniculata</u> Bristly foxtail	.6	1.1	2.1	7.5	5.8	2.2	15.5
<u>Dichromena colorata</u> White tops	.6	1.2	1.8	7.5	6.3	1.9	15.7
<u>Digitaria</u> <u>ascendens</u> Crab grass	.9	3.6	34.5	11.2	19.0	36.2	66.4
<u>Fimbristylis</u> <u>castanea</u> Fringe rush	.6	.8	2.7	7.5	4.2	2.8	14.5
<u>Lippia nodiflora</u> Frog bit	.6	.7	3.8	7.5	3.7	3.9	15.1
<u>Desmodium canum</u> Beggar's lice	.8	1.4	8.5	10.0	7.4	8.9	26.3
<u>Hydrocotyle</u> <u>umbellata</u> Pennywort	.4	1.2	6.7	5.0	6.3	7.0	18.3
<u>Paspalum notatum</u>	.8	3.8	26.0	10.0	20.1	27.4	57.4
<u>Rubus trivialis</u> Dewberry	.3	.5	2.5	3.7	2.6	2.6	8.9
<u>Phytolacca americana</u> Pokeweed	.2	.2	1.4	2.5	1.0	1.5	5.0
<u>Cyperus surinamensis</u> Nut grass	.5	.8	.7	6.2	4.2	.7	11.1
<u>Eleusine indica</u> Goose grass	.5	1.0	1.5	6.2	5.3	1.6	13.1
<u>Pluchea rosea</u> Marsh fleabane	.3	.5	.5	3.7	2.6	.5	6.8

TABLE 2.7-25 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Solidago micro-</u> <u>cephala</u> Goldenrod	.5	1.2	2.0	6.2	6.3	2.1	14.6
<u>Solidago semper-</u> <u>virens</u> Goldenrod	.2	.3	trace	2.5	1.6	-	4.1
<u>Eupatorium compsi-</u> <u>folium</u> Dog fennel	.2	.6	.5	2.5	3.2	.5	6.2

TABLE 2.7-26

ANALYSIS OF VEGETATION IN THE MYRICA-BACCHARIS
ASSOCIATION - MAY - SEPTEMBER 1974
BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Lower Stratum</u>							
<u>Solidago micro-</u> <u>cephala</u> Goldenrod	.8	7.98	23.5	11.76	78.54	33.00	123.3
<u>Crotalaria</u> <u>spectabilis</u> Rattle box	.4	.13	1.0	5.88	1.28	1.4	8.56
<u>Parthenocissus</u> <u>quinquefolia</u> Virginia creeper	.2	.01	1.0	2.94	.10	1.4	4.44
<u>Solidago semper-</u> <u>virens</u> var. <u>mexicana</u> Goldenrod	.4	.08	1.0	5.88	.79	1.4	8.07
<u>Lippia nodi-</u> <u>flora</u> Frog bit	.4	.15	1.2	5.88	1.48	1.68	9.04
<u>Rubus trivialis</u> Dewberry	1.0	1.0	37.0	14.7	9.84	51.97	76.51
<u>Helenium</u> <u>amarum</u> Bitter sneezeweed	.2	.02	trace	2.94	.20	-	3.54
<u>Lupatorium</u> sp. Dog fennel	.4	.09	1.0	5.88	.88	1.4	8.16
<u>Melothria pendula</u> var. <u>pendula</u> Climbing cucumber	.6	.08	1.0	8.82	.79	1.4	11.01
<u>Ambrosia artemisii</u> <u>folia</u> Ragweed	.4	.38	1.5	5.88	3.74	2.11	11.73

TABLE 2.7-26 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Chenopodium</u> <u>ambrosioides</u> Goose foot	.2	.02	trace	2.94	.20	-	3.14
<u>Phytolacca</u> <u>americana</u> Pokeweed	.4	.03	.5	5.88	.29	.7	6.87
<u>Vitis rotundifolia</u> Muscadine grape	.2	.02	.5	2.94	.2	.7	3.84
<u>Callicarpa</u> <u>americana</u> Beauty berry	.2	.01	1.5	2.94	.1	2.11	5.0
<u>Physalis angusti-</u> <u>folia</u> Ground cherry	.2	.1	.5	2.94	.98	.7	4.62
<u>Tillandsia usneoides</u> Spanish moss	.4	.02	trace	5.88	.2	-	6.08
<u>Tillandsia</u> <u>recurvata</u> Ball moss	.4	.04	trace	5.88	.39	-	6.27
<u>Upper Stratum</u>							
<u>Myrica cerifera</u> Wax myrtle	.4	.03	22.5	16.67	23.08	33.09	72.84
<u>Eragrostis halimifolia</u> Groundsel tree	1.0	.07	40	41.67	53.85	58.82	154.34
<u>Schinus terebinthifolius</u> Brazilian pepper	.6	.02	3.5	25.00	15.38	5.15	45.53
<u>Lantana camara</u> Shrub verbena	.4	.01	2.0	16.67	7.70	2.94	27.31

TABLE 2.7-27

ANALYSIS OF VEGETATION IN THE MYRICA-BACCHARIS
ASSOCIATION - SEPTEMBER - DECEMBER 1974
BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Solidago micro-</u> <u>cephala</u> Goldenrod	.80	7.30	57.2	17.78	58.40	69.46	145.64
<u>Crotolaria</u> <u>spectabilis</u> Rattle box	.40	.50	1.3	8.89	4.00	1.58	14.47
<u>Crotolaria</u> <u>mucronata</u> Rabbit bells	.20	.30	.75	4.44	2.40	.91	7.75
<u>Parthenocissus</u> <u>quinquefolia</u> Virginia creeper	.10	.10	1.0	2.22	.80	1.21	4.23
<u>Solidago</u> <u>sempervirens</u> var. <u>mexicana</u> Goldenrod	.30	.50	.5	6.67	4.00	.61	11.28
<u>Lippia nodiflora</u> Fog bit	.30	.40	.6	6.67	3.20	.73	10.60
<u>Rubus</u> <u>trivialis</u> Dewberry	.60	.70	17.0	13.33	5.60	20.64	39.57
<u>Eupatorium</u> <u>compositifolium</u> Dog fennel	.50	.90	1.5	11.11	7.20	1.82	20.13
<u>Melothria pendula</u> var. <u>pendula</u> Creeping cucumber	.10	.10	trace	2.22	.80	-	3.02
<u>Ambrosia</u> <u>artemisiifolia</u> Ragweed	.20	.30	trace	4.44	2.40	-	6.84
<u>Chenopodium</u> <u>ambrosioides</u> Goose foot	.20	.20	trace	4.44	1.60	-	6.04

TABLE 2.7-27 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Phytolacca americana</u> Pokeweed	.20	.20	.5	4.44	1.60	.61	6.65
<u>Callicarpa americana</u> Beauty berry	.10	.20	1.0	2.22	1.60	1.21	5.03
<u>Portulaca pilosa</u> Rose purslane	10	.10	trace	2.22	.80	-	3.02
<u>Physalis angusti- folia</u> Ground cherry	.20	.30	.5	4.44	2.40	.61	7.45
<u>Tillandsia recurvata</u> Ball moss	.10	.20	trace	2.22	1.60	-	3.82
<u>Vitis rotundi- folia</u> Muscadine grape	.10	.20	.5	2.22	1.60	.61	4.43

TABLE 2.7-28

ANALYSIS OF VEGETATION IN THE MYRICA-BACCHARIS
ASSOCIATION - DECEMBER 1974 - MARCH 1975
BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Rubus</u> <u>trivialis</u> Dewberry	.7	1.6	26.5	14.6	10.8	33.8	59.2
<u>Solidago</u> <u>micro-</u> <u>cephala</u> Goldenrod	.7	6.5	48.2	14.6	43.9	61.5	120.0
<u>Lippia</u> <u>nodiflora</u> Frog bit	.4	.5	1.0	8.3	3.4	1.3	13.0
<u>Eupatorium</u> <u>composi-</u> <u>tifolium</u> Dog fennel	.4	1.6	1.0	8.3	10.8	1.3	20.4
<u>Ambrosia</u> <u>artemisi-</u> <u>olia</u> Ragweed	.4	.9	trace	8.3	6.1	-	14.4
<u>Phytolacca</u> <u>americana</u> Poke weed	.3	.4	15	6.2	2.7	.6	9.5
<u>Crotalaria</u> <u>spec-</u> <u>tabilis</u> Rattle box	.3	.3	trace	6.2	2.0	-	8.2
<u>Solidago</u> <u>seper-</u> <u>virens</u> Goldenrod	.4	.7	trace	8.3	4.7	-	13.0
<u>Chenopodium</u> <u>ambrosi-</u> <u>oides</u> Goosefoot	.3	.4	trace	6.2	2.7	-	8.9
<u>Physalis</u> <u>angust-</u> <u>ifolia</u> Ground cherry	.4	1.0	.6	8.3	6.7	.8	15.8
<u>Vitis</u> <u>rotundi-</u> <u>folia</u> Muscadine grape	.1	.3	.5	2.1	2.0	.6	4.7

TABLE 2.7-28 (Cont)

<u>Scientific Name</u> <u>Common Name</u>	<u>Frequency</u>	<u>Density</u> <u>#/m²</u>	<u>Cover</u> <u>%</u>	<u>Relative</u> <u>Frequency</u>	<u>Relative</u> <u>Density</u>	<u>Relative</u> <u>Dominance</u>	<u>Importance</u> <u>Value</u>
<u>Callicarpa americana</u> Beauty berry	.1	.1	trace	2.1	.7	-	2.8
<u>Tillandsia recurvata</u> Ball moss	.3	.5	trace	6.2	3.4	-	9.6

TABLE 2.7-29

ANALYSIS OF VEGETATION IN THE MYRICA-BACCHARIS
ASSOCIATION - MARCH - MAY 1975
BIG BEND STATION

Scientific Name Common Name:	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Rubus</u> <u>trivialis</u> Dewberry	.75	2.5	32.5	13.7	10.7	37.7	62.1
<u>Solidago</u> <u>sempervirens</u> Goldenrod	.50	1.25	1.5	9.1	5.3	1.7	16.1
<u>Solidago</u> <u>microcephala</u> Goldenrod	.75	13.0	46.0	13.7	55.7	53.4	122.8
<u>Lantana</u> <u>canaria</u> Shrub verbena	.25	.25	2.5	4.6	1.1	2.9	8.6
<u>Physalis</u> <u>angustifolia</u> Ground cherry	.25	.37	.5	4.6	1.6	.6	6.8
<u>Lippia nodiflora</u> Frog bit	.37	.62	1.2	6.7	2.6	1.4	10.7
<u>Portulacca</u> <u>pilosa</u> Rose purslane	.25	.25	trace	4.6	1.1	-	5.7
<u>Vitis</u> <u>rotundifolia</u> Muscadine grape	.12	.12	trace	2.2	.5	-	2.7
<u>Ambrosia</u> <u>artemisiifolia</u> Ragweed	.50	1.0	.5	9.1	4.3	.6	14.0
<u>Solanum</u> <u>americanum</u> Night shade	.25	.25	trace	4.6	1.1	-	5.7
<u>Bidens pilosa</u> Tickseed	.25	.62	trace	4.6	2.6	-	7.2

TABLE 2.7-29 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Tillandsia</u> <u>recurvata</u> Air plant	.25	.87	trace	4.6	3.7	-	8.3
<u>Phytolacca</u> <u>americana</u> Pokeweed	.25	.37	1.0	4.6	1.6	1.2	7.4
<u>Rhynchelytum</u> <u>repens</u> Red top	.37	.87	trace	6.7	3.7	-	10.4
<u>Chenopodium</u> <u>ambrosioides</u> Goosefoot	.25	.87	.5	4.6	3.7	.6	8.9
<u>Crotalaria</u> <u>spectabilis</u> Rattle box	.12	.12	trace	2.2	.5	-	2.7

TABLE 2.7-30

ANALYSIS OF VEGETATION IN THE OLD FIELD VEGETATION TYPE
MAY - SEPTEMBER 1974
BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Eupatorium</u> sp. Dog fennel	.86	18.14	21	17.37	38.53	23.84	79.74
<u>Lippia podiflora</u> Frog bit	.09	.48	3	1.82	1.02	3.40	6.24
<u>Ambrosia</u> <u>artemisiifolia</u> Ragweed	.71	9.66	12	14.34	20.52	13.62	48.48
<u>Oenothera</u> <u>laciniata</u> Evening primrose	.38	2.09	1.5	7.68	4.44	1.70	13.82
<u>Coryza canadensis</u> Dwarf horsetail	.52	2.86	8	10.50	6.07	9.08	25.65
<u>Ludwigia</u> <u>octovalvis</u> Water purslane	.05	.05	1	1.01	.11	1.13	2.25
<u>Ludwigia peruviana</u> Water willow	.05	.05	.5	1.01	.11	.57	1.69
<u>Cyperus polystachyos</u> Nut grass	.10	.33	1	2.02	.70	1.13	3.85
<u>Bidens pilosa</u> Tickseed	.33	7.86	11.5	6.66	16.69	13.05	36.40
<u>Baccharis halimifolia</u> Groundsel tree	.48	1.62	4.6	9.70	3.44	5.22	18.36
<u>Lepidium virginicum</u> Pepper grass	.05	.05	trace	1.01	.11	-	1.12
<u>Solidago micro-</u> <u>cephala</u> Goldenrod	.1	.19	1.0	2.02	.40	1.13	3.55
<u>Portulaca oleracea</u> Purslane	.05	.09	trace	1.01	.19	-	1.2

TABLE 2.7-30 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Paspalum</u> <u>urvillei</u> Vasey grass	.1	.14	5.0	2.02	.30	5.67	7.99
<u>Setaria geniculata</u> Bristly foxtail	.05	.05	.5	1.01	.11	.57	1.69
<u>Crotalaria spec-</u> <u>tabilis</u> Rattle box	.05	.05	trace	1.01	.11	-	1.12
<u>Stenotaphrum</u> <u>secundatum</u> St. Augustine grass	.1	.09	4.0	2.02	.19	4.54	6.75
<u>Pluchea</u> <u>purpurascens</u> Marsh fleabane	.05	.14	trace	1.01	.30	-	1.31
<u>Polypremum pro-</u> <u>cumbens</u>	.05	.14	trace	1.01	.30	-	1.31
<u>Solidago semper-</u> <u>virens</u> var. <u>mexicana</u> Goldenrod	.05	.09	2.0	1.01	.19	2.27	3.47
<u>Portulaca pilosa</u> Rose purslane	.05	.05	trace	1.01	.11	-	1.12
<u>Scoraria dulcis</u> Sweet broom	.24	2.05	5.0	4.85	4.35	5.67	14.87
<u>Schrankia micro-</u> <u>phylla</u> Sensitive briar	.05	.05	trace	1.01	.11	-	1.12
<u>Lythrum alatum</u> var. <u>lanceolatum</u> Loosestrife	.1	.29	1.0	2.02	.66	1.13	3.81
<u>Digitaria san-</u> <u>guinalis</u> Crabgrass	.1	.14	5.0	2.02	.30	5.67	7.99
<u>Myrica cerifera</u> Wax myrtle	.05	.05	.5	1.01	.11	.57	1.69

TABLE 2.7-30 (Cont)

Scientific Name <u>Common Name</u>	<u>Frequency</u>	<u>Density</u> <u>#/m²</u>	<u>Cover</u> <u>%</u>	<u>Relative</u> <u>Frequency</u>	<u>Relative</u> <u>Density</u>	<u>Relative</u> <u>Dominance</u>	<u>Importance</u> <u>Value</u>
<u>Cyperus surina-</u> <u>ensis</u> Nut grass	.14	.33	trace	2.83	.70	-	3.53

TABLE 2.7-31

ANALYSIS OF VEGETATION IN THE OLD FIELD VEGETATION
TYPE - SEPTEMBER - DECEMBER 1974
BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Eupatorium</u> <u>compositifolium</u> Dog fennel	.96	12.10	21.48	12.03	31.97	27.84	71.84
<u>Lippia nodiflora</u> Frog bit	.30	.61	7.5	3.76	1.61	9.72	15.09
<u>Ambrosia</u> <u>artemisiifolia</u> Rayweed	.48	1.96	2.45	6.02	5.18	3.17	14.37
<u>Conyza canadensis</u> Dwarf horsetail	.48	1.35	1.77	6.02	3.57	2.29	11.88
<u>Ludwigia octovalvis</u> Water purslane	.22	.30	.60	2.76	.79	.78	4.33
<u>Cyperus</u> <u>surinamensis</u> Nut grass	.87	1.87	1.32	10.90	4.94	1.71	17.55
<u>Bidens pilosa</u> Tickseed	.48	2.00	1.60	6.02	5.28	2.07	13.37
<u>Eaccharis halimifolia</u> Groundsel tree	.48	.83	7.73	6.02	2.19	10.02	18.23
<u>Setaria geniculata</u> Bristly foxtail	.04	.04	3.67	.50	.10	4.76	5.36
<u>Crotolaria</u> <u>spectabilis</u> Rattle box	.04	.04	trace	.50	.10	-	.6
<u>Pluchea</u> <u>purpurascens</u> Marsh fleabane	.04	.04	.65	.50	.10	.84	1.44
<u>Solidago</u> <u>sempervirens</u> var. <u>mexicana</u> Goldenrod	.43	1.00	1.1	5.39	2.64	1.42	9.45

TABLE 2.7-31 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Scoparia dulcis</u> Sweet broom	.26	.35	trace	3.26	.92	-	4.18
<u>Digitaria</u> <u>sanguinalis</u> Crabgrass	.52	4.35	6.01	6.52	11.49	7.79	25.80
<u>Indigofera hirsuta</u> Hairy indigo	.78	7.87	15.68	9.77	20.79	20.32	50.88
<u>Eleusine indica</u> Goose grass	.22	.35	trace	2.76	.92	-	3.68
<u>Eclipta alba</u>	.17	.26	trace	2.13	.69	-	2.82
<u>Aster subulatus</u> var. <u>ligulatus</u>	.30	.35	1.20	3.76	.92	1.55	6.23
<u>Chamaesyce</u> <u>hyssopifolia</u> Hyssop-leaved spurge	.56	1.83	2.75	7.02	4.8	3.56	15.38
<u>Andropogon</u> <u>glomeratus</u> Beard grass	.17	.17	trace	2.13	.45	-	2.58
<u>Heterotheca</u> <u>subaxillaris</u> Camphor weed	.09	.09	1.0	1.13	.24	1.30	2.67
<u>Schinus terebinthe-</u> <u>folius</u> Brazilian pepper	.09	.09	.65	1.13	.24	.84	2.21

TABLE 2.7-32

ANALYSIS OF VEGETATION IN THE OLD FIELD
 VEGETATION TYPE - DECEMBER 1974 - MARCH 1975
 BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Lippia nodiflora</u> Frog bit	.6	.9	10.2	7.2	2.9	24.6	34.7
<u>Eupatorium</u> <u>compositifolium</u> Dog fennel	.9	6.5	12.4	10.8	21.0	29.9	61.7
<u>Conyza canadensis</u> Dwarf horsetail	.7	4.4	2.5	8.4	14.2	6.0	28.6
<u>Ambrosia</u> <u>artemisiifolia</u> Ragweed	.7	7.0	4.8	8.4	22.6	11.6	42.6
<u>Oenothera laciniata</u> Evening primrose	.6	1.0	1.5	7.2	3.2	3.6	14.0
<u>Lepidium virginicum</u> Pepper grass	.6	1.9	1.0	7.2	6.1	2.4	15.7
<u>Cyperus surinamensis</u> Nut grass	.4	.5	trace	4.8	1.6	-	6.4
<u>Baccharis halimifolia</u> Groundsel tree	.5	.9	7.5	6.0	2.9	18.1	27.0
<u>Sonchus asper</u> Sow thistle	.4	.4	trace	4.8	1.3	-	6.1
<u>Stenotaphrum</u> <u>secundatum</u> St. Augustine grass	.4	2.4	.5	4.8	7.8	1.2	13.8
<u>Solidago sempervirens</u> Goldenrod	.4	1.0	trace	4.8	3.2	-	8.0
<u>Paspalum urvillei</u> Vasey grass	.3	.3	.5	3.6	1.0	1.2	5.8
<u>Linaria canadensis</u> Toadflax	.5	2.0	trace	6.0	6.5	-	12.5

TABLE 2.7-32 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Andropogon glomeratus</u> Beard grass	.3	.4	trace	3.6	1.3	-	4.9
<u>Heterotheca</u> <u>subaxillaris</u> Camphor weed	.3	.3	trace	3.6	1.0	-	4.6
<u>Scoparia dulcis</u> Sweet broom	.4	.7	.5	4.8	2.3	1.2	8.3
<u>Eleusine indica</u> Goose grass	.3	.3	trace	3.6	1.0	-	4.6

TABLE 2.7-33

ANALYSIS OF VEGETATION IN THE OLD FIELD
 VEGETATION TYPE - MARCH - MAY 1975 -
 BIG BEND STATION

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Ambrosia</u> <u>artemisiifolia</u> Ragweed	.77	10.67	13.5	9.8	20.9	24.3	55.0
<u>Ludwigia</u> <u>octovalvis</u> Water purslane	.33	.66	.5	4.2	1.3	.9	6.4
<u>Lippia</u> <u>nodiflora</u> Frog bit	.55	1.55	10.9	7.0	3.0	19.6	29.6
<u>Eupatorium</u> <u>compositifolium</u> Dog fennel	.88	21.33	19.2	11.2	41.8	34.5	87.5
<u>Conyza</u> <u>canadensis</u> Dwarf horsetail	.67	6.40	4.7	8.5	12.5	8.4	29.4
<u>Oenothera</u> <u>laciniata</u> Evening primrose	.67	1.11	1.5	8.5	2.2	2.7	13.4
<u>Vigna</u> <u>luteola</u> Cow pea	.22	.22	trace	2.8	.4	-	3.2
<u>Desmodium</u> <u>canum</u> Beggar's lice	.22	.44	trace	2.8	.9	-	3.7
<u>Bidens</u> <u>pilosa</u> Tickseed	.55	2.44	2.5	7.0	4.8	4.5	16.3
<u>Pluchea</u> <u>purpurascens</u> Marsh fleabane	.22	.33	.5	2.8	.6	.9	4.3
<u>Solidago</u> <u>microcephala</u> Goldenrod	.44	1.22	.6	5.6	.24	1.0	9.9
<u>Indigofera</u> <u>hirsutum</u> Hairy indigo	.22	.77	.5	2.8	1.5	.9	5.2

TABLE 2.7-33 (Cont)

Scientific Name Common Name	Frequency	Density #/m ²	Cover %	Relative Frequency	Relative Density	Relative Dominance	Importance Value
<u>Cassia fasciculata</u> Senna	.11	.22	trace	1.4	.4	-	1.8
<u>Solidago</u> <u>sempervirens</u> Goldenrod	.22	.22	trace	2.8	.4	-	3.2
<u>Scoraria</u> <u>dulcis</u> Sweet broom	.44	1.44	.8	5.6	2.8	1.4	9.8
<u>Eleusine indica</u> Goose grass	.11	.11	trace	1.4	.2	-	1.6
<u>Solanum</u> <u>americanum</u> Night shade	.22	.33	trace	2.8	.6	-	3.4
<u>Chloris petraea</u> Finger grass	.11	.11	trace	1.4	.2	-	1.6
<u>Lepidium</u> <u>virginicum</u> Pepper grass	.33	.55	trace	4.2	1.1	-	5.3
<u>Sporobolus</u> <u>domingensis</u> Dropseed	.33	.55	trace	4.2	1.1	-	5.3
<u>Setaria</u> <u>geniculata</u> Bristly foxtail	.22	.33	.5	2.8	.6	.9	4.3

TABLE 2.7-34

SUMMARY OF SMALL MAMMAL SURVEYS - 1974-1975

<u>Vegetation</u> <u>Type</u>	<u>Sigmodon</u> <u>hispidus</u>	<u>Mus</u> <u>musculus</u>	<u>Oryzomys</u> <u>palustris</u>	<u>Blarina</u> <u>brevicauda</u>	<u>Rattus</u> <u>norvegicus</u>	<u>Rattus</u> <u>rattus</u>
Power Station (1)						
Power Line	3 (7-24/8-7-74) (2)	1 (9-23/12-1-74) (2)	1 (9-23/12-1-74) (2)			
Right-of- Way (2)	8 (9-23/12-1-74) (2) 2 (3-11/4-24-75) (2)	6 (1-10/3-5-75) (2) 4 (3-11/4-24-75) (2)				
Ash Pond (3)	3 (1-10/3-5-75) (2) 6 (3-12/5-1-75) (2)	4 (1-10/3-5-75) (2)				
Jackson Branch Marsh (4)	2 (7-24/8-7-75) (2) 1 (1-10/3-5-75) (2) 3 (3-18/5-1-75) (2)	2 (7-24/8-7-74) (2) 2 (1-10/3-5-75) (2) 1 (3-18/5-1-75) (2)	3 (7-24/8-7-74) (2)		1 (7-24/8-7-74) (2)	
Palmetto- Juncus (5)	1 (8-29-84) (1) 9 (9-23/12-1-74) (2) 9 (1-10/3-5-75) (2) 5 (3-18/5-7-75) (2)	1 (3-18/5-7-75) (2)				
Mangrove (6)	2 (1-10/3-5-75) (1) 1 (4-24-75) (1)		5 (9-23/12-1-74) (2) 6 (1-10/3-5-75) (1) 1 (4-24-75) (1)			
Salt Prairie (7)	13 (4-4/6-6-74) (3) 15 (9-23/12-1-74) (2) 9 (1-10/3-5-75) (1) 1 (4-4-75) (1)		9 (9-23/12-1-74) (2) 4 (1-10/3-5-75) (1)			
Palmetto- Pine (8)	41 (4-1/6-6-74) (4) 23 (9-23/12-1-74) (3) 8 (1-10/3-5-75) (2) 7 (4-4/5-7-75) (2)			2 (9-23/12-1-74) (3) 2 (1-9/3-5-75) (2)		
Pasture (9)	1 (7-19-74) (1)	1 (4-17/5-13-75) (2)				
Pasture Pond (10)	2 (8-29-74) (1) 5 (9-23/12-1-74) (1) 4 (1-10/3-5-75) (1) 3 (4-17/5-13-75) (2)		5 (8-29-74) (1) 3 (9-23/12-1-74) (1) 2 (1-10/3-5-75) (1) 1 (4-17/5-13-75) (2)			2 (1-10/3-5-75) (1)

TABLE 2.7-34 (Cont)

Vegetation Type	<u>Sigmodon</u> <u>hispidus</u>	<u>Mus</u> <u>musculus</u>	<u>Oryzomys</u> <u>palustris</u>	<u>Blarina</u> <u>brevicauda</u>	<u>Rattus</u> <u>norvegicus</u>	<u>Rattus</u> <u>rattus</u>
<u>Myrica-Bac-</u> <u>charis</u> (11)	12 (8-22/8-28-74) (2) 1 (9-23/12-1-74) (1) 5 (1-10/3-5-75) (1) 3 (4-10/5-19-75) (2)		1 (1-10/3-5-75) (1)	1 (8-22/8-28-74) (2) 1 (9-23/12-1-74) (1)		
Old Field (12)	33 (7-3/7-9-74) (2) 7 (9-23/12-1-74) (1) 9 (1-10/3-5-75) (1) 3 (4-10/5-19-75) (2)	12 (7-3/7-9-74) (2) 2 (9-23/12-1-74) (1) 2 (1-10/3-5-75) (1) 2 (4-10/5-19-75) (2)		2 (7-3/7-9-74) (2) 2 (9-23/12-1-74) (1)		
Species Total	260 (61)	40 (24)	41 (17)	10 (11)	1 (2)	2 (1)

LEGEND: 23 (8-22/12-1-74) (2)
No. Individuals Study Period Yr Nights Trapped

TABLE 2.7-35

COMPARISON OF THE NUMBER OF SMALL MAMMALS/NUMBER TRAP NIGHTS
AT 11 SITES AT BIG BEND

The 1974 summary includes both summer and fall trap data and was compared to early fall 1977 data using the difference among proportions test which takes into account sample size.⁽¹⁾ Sampling methods and stations were identical between years.

<u>Site</u>	<u>Species</u>	<u>1974</u>	<u>1977</u>	<u>X²</u>
2	<u>Sigmodon hispidus</u>	$\frac{3}{100}$	$\frac{2}{50}$	n.s.
3	<u>Sigmodon hispidus</u>	$\frac{1}{25}$	$\frac{3}{50}$	n.s.
4	<u>Sigmodon hispidus</u>	$\frac{2}{130}$	$\frac{0}{50}$	n.s.
	<u>Mus musculus</u>	$\frac{3}{130}$	$\frac{0}{50}$	n.s.
	<u>Oryzomys palustris</u>	$\frac{3}{130}$	$\frac{0}{50}$	n.s.
	<u>Rattus norvegicus</u>	$\frac{1}{130}$	$\frac{0}{50}$	n.s.
	Total	$\frac{9}{130}$	$\frac{1}{50}$	n.s.
5	<u>Sigmodon hispidus</u>	$\frac{3}{85}$	$\frac{14}{60}$	13.32(2)
	<u>Oryzomys palustris</u>	$\frac{0}{85}$	$\frac{1}{60}$	n.s.
	Total	$\frac{3}{85}$	$\frac{15}{60}$	14.91(2)
6	<u>Sigmodon hispidus</u>	$\frac{0}{40}$	$\frac{1}{50}$	n.s.
	<u>Rattus rattus</u>	$\frac{0}{40}$	$\frac{3}{50}$	n.s.
	Total	$\frac{0}{40}$	$\frac{4}{50}$	

TABLE 2.7-35 (Cont)

<u>Site</u>	<u>Species</u>	<u>1974</u>	<u>1977</u>	<u>X²</u>
7	<u>Sigmodon hispidus</u>	<u>23</u>	<u>9</u>	n.s.
		200	75	
	<u>Oryzomys palustris</u>	<u>4</u>	<u>0</u>	n.s.
		200	75	
	<u>Rattus rattus</u>	<u>1</u>	<u>1</u>	n.s.
		200	75	
	Total	<u>28</u>	<u>10</u>	n.s.
		200	75	
8	<u>Sigmodon hispidus</u>	<u>50</u>	<u>6</u>	n.s.
		260	60	
	<u>Oryzomys palustris</u>	<u>1</u>	<u>0</u>	n.s.
		260	60	
	Total	<u>51</u>	<u>6</u>	n.s.
		260	60	
9	<u>Sigmodon hispidus</u>	<u>1</u>	<u>11</u>	9.46(2)
		50	50	
10	<u>Sigmodon hispidus</u>	<u>5</u>	<u>12</u>	6.82(2)
		70	50	
	<u>Oryzomys palustris</u>	<u>11</u>	<u>1</u>	6.10(2)
		70	50	
	Total	<u>16</u>	<u>13</u>	n.s.
		70	50	
11	<u>Sigmodon hispidus</u>	<u>12</u>	Site destroyed	
		90		
	<u>Blarina brevicauda</u>	<u>1</u>		
		90		
	Total	<u>13</u>		
		90		
12	<u>Sigmodon hispidus</u>	<u>33</u>	Site destroyed	
		192		
	<u>Blarina brevicauda</u>	<u>2</u>		
		192		
	<u>Mus musculus</u>	<u>12</u>		
		192		
	Total	<u>47</u>		
		192		

(1) Freund, J.E. Mathematical Statistics. Prentice Hall, 1971.

(2) Significant difference.

n.s.=No significant difference.

TABLE 2.7-36

SUMMARY OF LARGE MAMMALS TRAPPED AND/OR OBSERVED DURING 1974-1975 SURVEYS

Vegetation Type Trapping Period(1)	<u>Sylvilagus spp.</u> (2)					<u>Procyon lotor</u>				<u>Didelphis marsupialis</u>				<u>Dasypus novemcinctus</u>				<u>Felis domesticus</u>				<u>Urocyon cinereoargenteus</u>			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
Power Station (1)																									
Power Line Right-of-Way (2)	X	X			X	X			X	X	X	X											X	X	
Ash Pond (3)	X					X	X			X	X			X		X		X		X					
Jackson Branch Marsh (4)	X				X				X		X	X													
Palmetto-Juncus (5)	X									X	X	X		X	X	X									
Mangrove (6)					X	X	X																		
Salt Prairie (7)	X	X	X		X																				
Palmetto-Pine (8)	X	X			X								X	X											
Pasture (9)		X																							
Pasture Pond (10)	X				X																				
<u>Myrica-Baccharis</u> (11)	X		X		X	X	X		X	X		X	X												
Old Field (12)	X	X	X	X							X	X												X	

(1) Trapping/Observation Period 1 - 5-1 to 9-1-74

Observations included sightings, scats, dens, diggings, and roadkills

Trapping/Observation Period 2 - 10-1 to 12-1-74

Trapping/Observation Period 3 - 12-1-74 to 3-7-75

Trapping/Observation Period 4 - 3-6 to 5-31-75

(2) Includes S. floridanus and S. palustris

TABLE 2.7-37

SUMMARY OF AVIFAUNA ACCORDING TO HABITATS AT BIG BEND

<u>Common Name</u>	<u>Status</u>	<u>Study Site(s)</u>	
		<u>1974-1975</u>	<u>1977</u>
American Goldfinch	W	9	
American Oystercatcher	W	Beach	Beach
American Robin	W	9	
Belted Kingfisher	R	Beach, 6	Beach, 9
Black-bellied Plover	R	Beach	Beach
Black-necked Stilt	R		11
Black Skimmer	R	6	11
Blue Jay	R	6, 8	4, 5, 8, 12
Blue-winged Teal	W	10	
Great Tailed Grackle	R	8, 9, 10	9, 10
Bobwhite	R	9, 12	4, 8, 9
Brown Pelican	R	Beach, 6	Beach
Cardinal	R	8	4, 8, 12
Carolina Wren	R	8	8
Caspian Tern	W	Beach	
Cattle Egret	R	9	4, Beach, 8, 12
Chuck Will's Widow	S	8	
Clapper Rail	R	6	6
Common Grackle	R	9	
Common Nighthawk	S	7	8
Common Snipe	W	10	
Common Yellowthroat	R	8, 10, 12	8
Double-crested Cormorant	R	6	

TABLE 2.7-37 (Cont)

<u>Common Name</u>	<u>Status</u>	<u>Study Site(s)</u>	
		<u>1974-1975</u>	<u>1977</u>
Dunlin	W	6	
Eastern Meadowlark	R	7, 9	7, 9
Ereunetes	W		Beach
Fish Crow	R	8, 9	4, 9
Forster's Tern	W	Beach	Beach
Glossy Ibis	R	10	
Great Blue Heron	R	6, 9, 10	5, 6, Beach
Great Egret	R	6	6, Beach
Great Horned Owl	R	9	
Greater Yellowlegs	W	Beach, 10	6, 11
Green Heron	R	6	6, Beach, 9, 11
Ground Dove	R	8, 9, 12	2, 4, 6, Beach, 12
Herring Gull	W	Beach	
House Wren	W	12	
Killdeer	R	9, 10	Beach, 12
Knot	T	6	
Laughing Gull	R	Beach, 6	Beach
Least Bittern	R	6	
Least Sandpiper	W	6, 10	
Least Tern	R	Beach, 6	Beach
Lesser Scaup	W	6	
Lesser Yellowlegs	W	6, 10	Beach
Little Blue Heron	R	10	Beach, 11

TABLE 2.7-37 (Cont)

<u>Common Name</u>	<u>Status</u>	<u>Study Site(s)</u>	
		<u>1974-1975</u>	<u>1977</u>
Loggerhead Shrike	R	8, 9	4, 6, Beach, 9, 10, 12
Long-billed Marsh Wren	W	10	
Louisiana Heron	W	Beach, 6	6, Beach, 11
Marsh Hawk	W	9, 10	
Mockingbird	R	8, 8, 9, 12	2, 3, 4, 5, 8, 9, 12
Mottled Duck	R	8	11
Mourning Dove	R	8, 9	6, Beach, 9
Osprey	R	Beach	Beach, 9, 11
Palm Warbler	W	6, 8, 12	
Pileated Woodpecker	R		2, 5, 8
Prairie Warbler	R	6, 8	
Reddish Egret	R	Beach, 6	6, Beach, 11
Red-bellied Woodpecker	R	9	
Red-breasted Merganser	W	6	
Red-tailed Hawk	R	8, 9	8, 9
Red-shouldered Hawk	R		5
Red-winged Blackbird	R	6, 7, 9, 10, 12	4, 5, 6, 7, Beach
Ring-billed Gull	W	Beach, 6	Beach
Rough-winged Swallow	T	9	9
Roseate Spoonbill	R		7, Beach
Ruddy Turnstone	W	Beach, 6	Beach
Rufous-sided Towhee	R	8, 12	8

TABLE 2.7-37 (Cont)

<u>Common Name</u>	<u>Status</u>	<u>Study Site(s)</u>	
		<u>1974-1975</u>	<u>1977</u>
Florida Sandhill Crane	R	9	
Semi-palmated Plover	W	6	Beach
Sharp-shinned Hawk	W	8	
Short-billed Dowitcher	W	Beach, 6	Beach, 11
Short-billed Marsh Wren	W	10	
Snowy Egret	R	6	11
Starling	R	9	9
Swamp Sparrow	W	10, 12	
Tree Swallow	W	9	
White-eyed Vireo	R	8	
White Ibis	R	6	7, Beach
Willet	R	Beach, 6	6, 7, Beach, 11
Wilson's Plover	R	Beach, 6	Beach, 11
Wood Stork	R	6	
Yellow-rumped Warbler	W	8, 9	
Yellow-crowned Night Heron	R		7, Beach

NOTE:

W = Winter Resident
 R = Permanent Resident
 S = Summer Resident
 T = Transient

TABLE 2.7-38

SUMMARY OF REPTILES AND AMPHIBIANS
ACCORDING TO HABITAT AT BIG BEND

Scientific Name (Common Name)	Study Site(s)	
	<u>1974-1975</u>	<u>1977</u>
<u>Anolis carolinensis</u> (Green Anole)	8	
<u>Chrysemys floridana</u> (Painted Turtle)	4*, 7	
<u>Cnemidophorus sexlineatus</u> (Six-lined Racerunner)	11*	
<u>Coluber constrictor priapus</u> (Southern Black Racer)	2, 8	4
<u>Crotalus adamateus</u> (Eastern Diamondback Rattlesnake)	8	7
<u>Drymarchon corais</u> (Indigo Snake)	11*	
<u>Elaphe obsoleta</u> (Rate Snake)	4	2
<u>Eumeces inexpectatus</u> (Southern Five-lined Skink)	2, 11*, 12*	4
<u>Kinosternon bauri</u> (Striped Mud Turtle)	11*	
<u>Natrix faciata</u> (Water Snake)	2, 4*	
<u>Scincella laterale</u>	4	
<u>Terrepene carolina</u> (Box Turtle)	7	4, 7
<u>Bufo terrestris</u> (Southern Toad)	4	2

*Significant change has occurred in population status.

TABLE 2.7-38 (Cont)

Scientific Name <u>(Common Name)</u>	Study Site(s)	
	<u>1974-1975</u>	<u>1977</u>
<u>Gastrophryne caroliniensis</u> (Narrow-mouth Toad)	4, 11*	2
<u>Hyla cinerea</u> (Green Tree Frog)	4, 8, 11*	2, 4
<u>Hyla squirrela</u> (Squirrel Tree Frog)	8	
<u>Rana catesbeiana</u> (Bullfrog)	11*	
<u>Rana pipiens</u> (Leopard Frog)	2, 4	2

*Significant change has occurred in population status.

TABLE 2.7-39

SUMMARY OF INVERTEBRATE TAXA OBSERVED
IN 12 HABITATS AT BIG BEND DURING 1974-75
FIELD STUDIES

- | | |
|--|--|
| 1 = Power Station | 7 = Salt Prairie |
| 2 = Power Line Right-of-way | 8 = Pine-Palmetto Association |
| 3 = Ash Pond | 9 = Pasture |
| 4 = Jackson Branch Freshwater Marsh | 10 = Pasture Pond |
| 5 = <u>Palmetto-Juncus</u> Association | 11 = <u>Myrica-Baccharis</u> Association |
| 6 = Mangroves | 12 = Old Field |

TAXONHABITAT

CLASS INSECTA

ORDER ORTHOPTERA

- | | |
|---|------------------------|
| Family Acrididae
(Short-horned grasshoppers) | 1, 5, 7, 8, 10, 11, 12 |
|---|------------------------|

ORDER NEUROPTERA

- | | |
|-------------------------------------|---|
| Family Chrysopidae
(Lacewings) | 8 |
| Family Mantispidae
(Mantidflies) | 7 |

ORDER ODONATA

- | | |
|--|---------------------------|
| Family Coenagrionidae
(Damselflies) | 1, 2, 7, 11, 12 |
| Family Libellulidae
(Dragonflies) | 1, 2, 5, 7, 8, 10, 11, 12 |

ORDER HEMIPTERA

- | | |
|--------------------------------------|--------------------------|
| Family Coreidae
(Squash bugs) | 1, 2, 4, 7, 8, 9, 11, 12 |
| Family Pentatomidae
(Stink bugs) | 1, 2, 7, 8, 10, 11, 12 |
| Family Reduviidae
(Assassin bugs) | 3, 10 |

ORDER HOMOPTERA

TABLE 2.7-39 (Cont)

<u>TAXON</u>	<u>HABITAT</u>
Family Cicadellidae (Leafhoppers)	3, 10, 11
Family Dictyophalaridae (Plant hoppers)	8
ORDER COLEOPTERA	
Family Chrysomelidae (Leaf beetles)	7, 12
Family Coccinellidae (Ladybird beetles)	1, 10, 12
Family Curculionidae (Snout beetles)	1
ORDER LEPIDOPTERA	
Family Arctiidae (Tiger moths)	4, 5, 8, 11
Family Danaidae (Queen butterflies)	7, 11, 12
Family Heliconiidae (Heliconid butterflies)	2, 3, 4, 5, 8, 11, 12
Family Hesperidae (Skippers)	1, 2, 3, 5, 7, 8, 9, 10, 11, 12
Family Lycaenidae (Gossamer-wings)	1, 12
Family Nymphalidae (4-footed butterflies)	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12
Family Satyridae (Satyrs)	6
Family Pieridae (Sulphur butterflies)	1, 2, 3, 4, 5, 6, 7, 8, 11, 12

TABLE 2.7-39 (Cont)

<u>TAXON</u>	<u>HABITAT</u>
ORDER DIPTERA	
Family Asilidae (Robber flies)	5
Family Bibionidae (March flies)	7
Family Bombyliidae (Bee flies)	12
Family Micopezidae (Stilt-legged flies)	5
Family Muscidae (Houseflies)	10
Family Syrphidae (Flower flies)	7
Family Tabonidae (Deer flies)	4
Family Tachinidae (Tachinid flies)	4
ORDER HYMENOPTERA	
Family Apidae (Honey bees)	1,5,8,10
Family Chalcididae (Chalcids)	10
Family Formicidae (Ants)	5,9,10
Family Halictidae (Sweat bees)	11
Family Ichneumonidae (Ichneumons)	8,12
Family Megachelidae (Leaf-cutters)	5
Family Vespidae (Wasps)	1,8

TABLE 2.7-39 (Cont)

<u>TAXON</u>	<u>HABITAT</u>
CLASS ARACHNIDA	
ORDER ARANEIDA (Spiders)	2,4,5,8,10,11,12
ORDER ACARINA (Ticks)	11
CLASS CRUSTACEA	
ORDER MALACOSTA (Isopods)	5
ORDER DECAPODA (Crabs)	7

TABLE 2.7-40

SUMMARY OF ENVIRONMENTAL STRESSES
OBSERVED DURING 1974-75 and 1977 FIELD STUDIES

<u>Vegetation Type</u>	<u>Date Occurred</u>	<u>Description of Environmental Stress*</u>
Power Station (1)	1974-75	Disruption due to construction activities and mowing; vegetation in early secondary successional stage
		Infestation of snout beetle on <u>Sesbiana exaltata</u>
Power Line Right-of-Way (2)	between 1974-75 and 1977	Wastewater holding pond constructed within vegetation type; also area mowed
	future	Will probably be cut over periodically to reduce fire hazard
Ash Pond (3 and 3A)	1974-75	Sampling location (3) eliminated due to construction activities
Jackson Branch Freshwater Marsh (4)	between 1974-75 and 1977	Construction activities near marsh eliminated most of aquatic life in pond within vegetation type
Palmetto-Juncus Association (5)	between 1974-75 and 1977	Area burned
Salt Prairie (7)	1974-75	Half of area burned
Palmetto-Pine Association (8)	1974-75	Area burned
Pasture (9)	1974-75	Active cattle grazing; no grazing in 1977
Pasture Pond (10)	1974-75	Active cattle grazing, no grazing in 1977

TABLE 2.7-40 (Cont)

<u>Vegetation Type</u>	<u>Date Occurred</u>	<u>Description of Environmental Stress</u>
<u>Myrica-Baccharis Association(11)</u>	between 1974-75 and 1977	Holding pond constructed which eliminated this area
Old Field(12)	between 1974-75 and 1977	Active agricultural area

* No stresses observed in Mangrove(6)

TABLE 2.7-41

ENDANGERED AND THREATENED SPECIES
OCCURRING AT THE BIG BEND SITE - 1974-75, 1977

<u>Status</u>	<u>Designating Body</u>	
	<u>State of FL</u>	<u>U.S.</u>
Endangered		
Wood Stork (<u>Mycteria americana</u>)	X	
Threatened		
Eastern Indigo Snake (<u>Drymarchon corais couperi</u>)	X	X
Eastern Brown Pelican (<u>Pelecanus occidentalis carolinensis</u>)	X	X
Osprey (<u>Pandion haliaetus</u>)	X	
American Oystercatcher (<u>Haematopus palliatus</u>)	X	
Least Tern (<u>Sterna albifrons</u>)	X	
Florida Sandhill Crane (<u>Grus canadensis pratensis</u>)	X	
Cabbage Palm (<u>Sabal palmetto</u>)	X	

TABLE 2.7-42

DOMINANT PHYTOPLANKTON SPECIES
IN ORDER OF ABUNDANCE(3)

1. Skeletonema costatum (Greville) Cleve (diatom)
2. Oscillatoria sp. (blue-green algae)
3. Hemiaulus sinensis Greville (diatom)
4. Rhizosolenia delicatula Cleve (diatom)
5. Ceratium hircus Schroder (dinoflagellate)
6. Asterionella japonica Cleve & Moller ex Gran (diatom)
7. Gonyaulax polygramma Stein (dinoflagellate)
8. Rhizosolenia setigera Brightwell (diatom)
9. Chaetoceros spp. (diatom)
10. Nitzschia delicatissima Cleve (diatom)
11. Nitzschia pungens v. atlanticum Cleve (diatom)
12. Certaulina pelagica (Cleve) Hendey (diatom)
13. Leptocylindrus danicus Cleve (diatom)
14. Peridinium pellucidum (Bergh) Schutt (dinoflagellate)
15. Nitzschia closterium (Ehrenberg) Wm. Smith (diatom)
16. Thalassionema nitzschioides Hurstedt (diatom)
17. Licmorpha sp. Agardh (diatom)
18. Prorocentrum minimum Schiller (dinoflagellate)
19. Gonyaulax digitalis (Pouchet) Kofoid (dinoflagellate)
20. Dinophysis caudata F. acutiformis Saville-Kent (dinoflagellate)

TABLE 2.7-43

SEASONAL OCCURRENCE OF THE MOST ABUNDANT DIATOM SPECIES AND
THEIR RELATIVE CONTRIBUTION TO TOTAL NUMBER(*)

<u>Diatom</u>	<u>Seasonal Occurrence</u>	<u>Percent Total Diatoms</u>	<u>Comments</u>
<u>Skeletonema costatum</u>	Fall and Winter Peak	39.5	Common throughout the year; highest concentration 1/21/77
<u>Hemiaulus sinensis</u>	Winter	24.4	Highest concentration 2/18/77
<u>Rhizosolenia delicatula</u>	Late Summer Through Winter	18.6	Sporadic throughout year; bloomed 8/23/76 and 12/16/76
<u>Asterionella japonica</u>	Fall and Winter	6.8	Highest concentration 1/21/77
<u>Rhizosolenia setigera</u>	Late Summer and Early Fall	2.6	Sporadic throughout the year; bloomed 8/23/76
<u>Chaetoceros</u>	Late Summer and Early Fall	1.7	Present through most of the year
<u>Nitzschia delicatissima</u>	Late Summer and Fall	1.3	Highest concentration 9/14/76
<u>Nitzschia pungens</u> <u>v. atlanticum</u>	Late Summer and Fall	0.8	Highest concentration 10/4/76

TABLE 2.7-44

SEASONAL OCCURRENCE OF THE MOST ABUNDANT DINOFLAGELLATE
SPECIES AND THEIR RELATIVE CONTRIBUTION
TO TOTAL NUMBER(%)

<u>Dinoflag- ellate</u>	<u>Seasonal Occurrence</u>	<u>Percent Total Dinoflag- ellate</u>	<u>Comments</u>
<u>Ceratium hircus</u>	Summer	55.9	common throughout the year; bloomed July 8
<u>Gonyaulax polygramma</u>	April	15.2	over 99% of the total number occurred during April
<u>Peridinium pellucidum</u>	Winter	3.6	recorded in highest con- centration on 1/21/77
<u>Procentrum minimum</u>	Winter	1.2	recorded in highest concentration 11/24/76
<u>Gonyaulax digitalis</u>	Late summer	1.0	recorded in highest concentration 8/23/76

TABLE 2.7-45

CARBON VALUES IN THE TAMPA BAY SYSTEM - 1966(11)

<u>Subarea</u>	<u>Annual Average lb/acre/day</u>
Hillsborough Bay	15.6
Old Tampa Bay	10.4
Tampa Bay (intermediate)	10.1
Egmont Key	5.5

TABLE 2.7-46

SPECIES LIST OF MARINE ALGAE OF THE
BIG BEND AREA, 1970-1973 SURVEY(156)

Cyanophyta (Blue-green algae)

Hormothamnion sp.

Oscillatoria sp.

Spirulina sp.

Chlorophyta (Green algae)

Caulerpa prolifera

Chaetomorpha sp.

Cladophora gracilis (?)

Enteromorpha intestinalis

Rhizoclonium sp.

Ulva lactuca

Rhodophyta (Red algae)

Acanthophora specifera

Agardhiella tenera

Centroceras clavulatum

Ceramium fastigiatum

Ceramium sp.

Champia parvula

Chondria sp.

Chondria sedifolia

Gracilaria sp.

Gracilaria blodgettii

Gracilaria compressa

Gracilaria debilis (?)

Gracilaria verrucosa

Gelidium sp. (?)

Hypnea cervicornis

Hypnea cornuta

Hypnea musciformis

Hypnea spinella

Rhodophyta

Lomentaria bailyana

Polysiphonia denudata

Spyridia filamentosa

Phaeophyta (Brown algae)

Ectocarpus sp.

TABLE 2.7-47

MAJOR ALGAL AND ANGIOSPERM FLORA OF THE
BIG BEED EMBAYMENT, 1975 SURVEY(157)

<u>Species</u>	<u>Area I</u>	<u>Area II</u>	<u>Area III</u>
Algae			
<u>Chaetomorpha</u> sp.	L		
<u>Cladophora</u> sp.	L	L, SBL	SBL
<u>Cladophoropsis</u> sp.	L	L	L, SBL
<u>Enteromorpha</u> sp.	L, SBL	SBL	SBL
<u>Hypnea</u> sp.		SBL	SBL
<u>Laurencia</u> sp.		SBL	SBL
<u>Ulva lactuca</u>	L	L	SBL, L
Angiosperms			
<u>Avicennia germinans</u>	SPL, L	SPL, L	SPL, L
<u>Coccoloba</u> sp.	SPL	SPL	SPL
<u>Halodule wrightii</u>	SBL	SBL	SBL
<u>Laguncularia racemosa</u>	SPL	SPL, L	SPL, L
<u>Rhizophora mangle</u>	L	SPL, L	SPL, L
<u>Spartina alterniflora</u>	L		

NOTES:

SBL = Sublittoral

L = Littoral

SPL = Supralittoral

TABLE 2.7-48

SPECIES LIST OF FLORA COLLECTED IN THE 1978 SURVEY (27)

<u>Species</u>	<u>Common Name</u>
<u>Andropogon virginicus</u>	Broom sedge
<u>Avicennia germinans</u>	Black mangrove
<u>Baccharis halimifolia</u>	Groundsel tree
<u>Canavalia maritima</u>	June bean
<u>Casuarina equisetifolia</u>	Australian pine
<u>Cenchrus pauciflorus</u>	Sandspur
<u>Cenchrus tribuloides</u>	Sandspur
<u>Chloris glauca</u>	Finger grass
<u>Eupatorium capillifolium</u>	Dog fennel
<u>Halodule wrightii</u>	Shoal grass
<u>Heterotheca subaxillaris</u>	Golden aster
<u>Ipomoea pes-caprae</u>	Railroad vine
<u>Iva frutescens</u>	Marsh elder
<u>Laguncularia racemosa</u>	White mangrove
<u>Lepidium virginicum</u>	Pepper grass
<u>Medicago lupulina</u>	Black medick
<u>Oenothera humifusa</u>	Seaside evening primrose
<u>Paspalum vaginatum</u>	Seaside paspalum
<u>Philoxerus vermicularis</u>	Saltweed
<u>Rhizophora mangle</u>	Red mangrove
<u>Ruppia maritima</u>	Widgeon grass
<u>Sesuvium portulacastrum</u>	Sea purslane
<u>Solidago sempervirens</u>	Goldenrod
<u>Spartina patens</u>	Saltmeadow cordgrass
<u>Sporobolus poiretii</u>	Smutgrass
<u>Stenotaphrum secundatum</u>	St. Augustine grass
<u>Suaeda linearis</u>	Seablite
<u>Syringodium filiforme</u>	Manatee grass
<u>Thalassia testudinum</u>	Turtle grass
<u>Uniola paniculata</u>	Sea oats
<u>Vigna luteola</u>	Cow pea

TABLE 2.7-49

SPECIES LIST, DENSITY AND RELATIVE ABUNDANCE
FOR ALL MEROPLANKTON COLLECTED IN THE BIG BEND AREA
FROM JANUARY 6, 1976 TO MARCH 11, 1977(37)

<u>Species</u>	<u>Mean No./m³</u>	<u>% Total</u>
<u>Pinnixa sayana</u>	148.41	34.70
<u>Polyonyx gibbesi</u>	120.95	28.28
<u>Upogebia affinis</u>	46.05	10.77
<u>Neopanope texana</u>	18.94	4.43
*Gastropoda	12.69	2.97
<u>Hexapanopeus angustifrons</u>	10.78	2.52
<u>Pinnixa chaetopterana</u>	8.78	2.05
*Balanus sp.	7.26	1.70
<u>Ambidexter symmetricus</u>	5.21	1.22
Xanthidae (damaged)	5.06	1.18
Alpheidae sp. A	4.65	1.09
<u>Periclimenes</u> spp.	4.23	<1.0
<u>Eurypanopeus depressus</u>	3.66	
*Grapsizoea spp.	3.15	
<u>Uca</u> spp.	2.83	
<u>Menippe mercenaria</u>	2.31	
<u>Pinnotheres maculatus</u>	2.26	
<u>Persephona punctata</u>	1.94	
*Brachiopoda	1.69	
*Spionidae	1.49	
<u>Ogyrides limicola</u>	1.32	
Echinodermata	1.09	
Pelecypoda	0.93	
<u>Latreutes parvulus</u>	0.925	
<u>Panopeus herbstii</u>	0.838	
<u>Petrolisthes</u> spp.	0.830	
Porcellanidae (damaged)	0.732	
Caridea (damaged)	0.678	
<u>Hippolyte</u> spp.	0.615	
<u>Pagurus longicarpus</u>	0.575	
*Nereidae	0.474	
<u>Sesarma cinereum</u>	0.460	
Decapoda (damaged)	0.450	
Paguridae sp. A	0.381	<0.1
Alpheidae sp. C	0.368	
<u>Sesarma reticulatum</u>	0.362	
Alpheidae (damaged)	0.348	
<u>Processa</u> spp.	0.338	
*Polychaeta	0.305	
<u>Rithropanopeus harrisii</u>	0.262	
<u>Palaemonetes intermedius</u>	0.253	
Pinnotheridae (damaged)	0.247	
Palaemonidae (damaged)	0.228	

TABLE 2.7-49 (Cont)

<u>Species</u>	<u>Mean No./m³</u>	<u>% Total</u>
<u>Libinia dubia</u>	0.200	
<u>Squilla</u> sp.	0.195	
<u>Palaemonetes</u> spp.	0.151	
<u>Urochordata</u>	0.140	
<u>Brachyura</u> (unidentified)	0.123	
<u>Hippolytidae</u> (damaged)	0.122	
<u>Neopanope packardii</u>	0.103	
<u>Leptochela</u> sp.	0.101	
<u>Alpheidae</u> sp. B	0.098	
<u>Megalops</u> (unidentified)	0.094	
<u>Periclimenes americanus</u> (postlarvae)	0.075	
<u>Palaemonetes pugio/vulgaris</u>	0.059	
<u>Palaemonidae</u> sp. C	0.058	
<u>Portunidae</u> sp. A	0.053	
<u>Alpheidae</u> sp. D	0.048	
<u>Palaemon floridanus</u>	0.047	
<u>Callianassa</u> sp. A	0.046	
<u>Tozeuma carolinense</u>	0.046	
* <u>Polynoidae</u>	0.043	
<u>Pinnixa</u> sp. A	0.043	
<u>Pagurus annulipes</u>	0.039	<0.01
<u>Pinnotheres</u> sp. A	0.038	
<u>Brachyura</u> sp. A	0.031	
<u>Processidae</u> (damaged)	0.029	
<u>Callinectes</u> sp. A	0.029	
<u>Hippolytidae</u> sp. D	0.029	
<u>Callianassa</u> sp. D	0.025	
<u>Paguridae</u> (damaged)	0.023	
<u>Penaeus duorarum</u>	0.022	
<u>Euceramus praelongus</u>	0.020	
<u>Aegathoa</u>	0.020	
* <u>Phoronida</u>	0.019	
<u>Zoea</u> (unidentified)	0.015	
<u>Callianassa</u> sp. C	0.014	
<u>Paguridae</u> sp. C	0.012	
* <u>Flabelligeridae</u>	0.012	
<u>Pinnotheres</u> sp. B	0.012	
<u>Postlarvae</u> (unidentified)	0.010	
* <u>Syllidae</u>	0.010	
<u>Brachyura</u> sp. B	0.008	
<u>Callianassa</u> sp. B	0.007	
<u>Leptochela serritorbita</u>	0.007	
<u>Leucosiidae</u> (damaged)	0.007	
<u>Hippolytidae</u> sp. B	0.006	
* <u>Branchiostoma caribaeum</u>	0.006	
<u>Majidae</u> (damaged)	0.006	

TABLE 2.7-50 (Cont)

Unident. Rotifera

Phylum Gastrotricha

Heterolipidoderma sp.

Unident. Gastrotricha

Phylum Nematoda

Unident. Nematoda

Phylum Annelida

Unident. Polychaeta larvae

Unident. Polychaeta trochophores

Unident. Neridae larvae

Unident. Nephtidae

Unident. Spionidae

Chaetopterus sp.

Unident. Capitellidae

Unident. Hirudinea

Phylum Mollusca

Unident. Gastropoda veligers

Unident. Bivalvia veligers

Phylum Arthropoda

Halacardiae

Unident. Ostracoda

Evadne spp.

Podon sp.

pneilia avirostus

Unident. Calanoida

Unident. Pontellidae nauplii

Unident. Harpacticoida

Unident. Cyclopoida

Saphirella spp.

Unident. Copepoda nauplii

Unident. Cirripedia nauplii

Unident. Cypris

Unident. Cypris larvae

Unident. Mysida

Unident. Cumacea

Unident. Isopoda

Unident. Caprellidea

Unident. Amphipoda

Unident. Penaeidea larvae

Unident. Caridea larvae

Lucifer shrimp

Procellenidae zoea

Pinnixa sp.

Unident. Euphausiacea

Unident. Decapoda

TABLE 2.7-50 (Cont)

Crab zoea

Phylum Phoronida
Actinotroch larvae

Phylum Bryozoa
Bryzoan fragments
Ectoproct fragments
Cyphonautes larvae

Phylum Brachiopoda
Brachiopoda larvae

Phylum Echinodermata
Echinodermata larvae
Auricularia larvae
Unident. Holothuroidea

Phylum Hemichordata
Tornaria larvae

Phylum Chordata
Ascidiacea larvae
Oikopleura sp.
Branchiostoma floridae

Phylum Chaetognatha
Chaetognatha
Chaetognatha eggs
Chaetognatha larvae

TABLE 2.7-49 (Cont)

<u>Species</u>	<u>Mean No./m³</u>	<u>% Total</u>
Palaemonidae sp. B	0.005	
<u>Periclimenes longicaudatus</u> (postlarvae)	0.005	
*Grapsizoea sp. A	0.005	
* <u>Limulus polyphemus</u>	0.005	
Portunidae (damaged)	0.004	<0.001
<u>Thor floridanus</u>	0.003	
Grapsidae (damaged)	0.003	
<u>Pinnixa</u> sp. B	0.003	
Hippolytidae sp. A	0.002	
<u>Hippolyte zostericola</u> (postlarvae)	0.002	
*Orbiniidae	0.002	
Alpheidae sp. E	0.002	
<u>Paqurus pollicaris</u>	0.002	
<u>Alpheus</u> sp. (postlarvae)	0.002	
<u>Alpheus heterochaelis</u> (postlarvae)	0.001	
<u>Porcellana sayana</u>	0.001	
<u>Leander</u> sp.	0.001	
<u>Naushonia</u> sp.	0.001	
Penaeidae (damaged)	0.001	
Callianassidae (damaged)	0.001	
*Cirratulidae	0.001	
<u>Callinectes sapidus</u> (postlarvae)	0.001	
TOTAL	427.706	

NOTES:

* Qualitatively sampled

* Unidentified organisms believed to include Uca spp. or Sesarma sp.

TABLE 2.7-50

ZOOPLANKTON TAXA COLLECTED IN 1970-1975(42)

Phylum Protozoa

Dictyocha fibula
Coccolithophora sp.
Unident. Cryptomonadida
Ebria sp.
Euglena mutabilis
Trachelocera sp.
Unident. Euglenida
Amoeba sp.
Unident. Foraminiferida
Unident. Radiolaria
Unident. Heliozoia
Lacrymaria oloa
Carchesium sp.
Vorticella spp.
Stentor sp.
Condonella sp.
Coxtella sp.
Eutintinnus sp.
Farella sp.
Helicostomella sp.
Salpingella sp.
Stentosemella sp.
Tintinniopsis spp.
Unident. Hypotrichida

Cnidaria (Ceolenterata)

Unident. Hydrozoa fragments
Unident. Anthomedusae
Obelia sp.
Unident. Leptomedusa
Unident. Actinulida larvae
Unident. Actinaria
Ephyra larvae
Pleurobrachia sp.
Mnemiopsis sp.
Beroe sp.

Platyhelminthes

Muller's larvae
Unident. Turbellaria

Rhynchocoela (Nemertinea)

Philidium larvae

Phylum Rotifera

Synchaeta sp.
Trichocera sp.

TABLE 2.7-51

RELATIVE ABUNDANCE OF THE TWENTY-FIVE MOST ABUNDANT
ORGANISMS COLLECTED AT TRAWL STATION TB-2 (DISCHARGE CANAL)
1973-1975 (*2)

<u>Species</u> <u>(Phylum)</u>	<u>Percent</u> <u>of Total</u>
<u>Melongena corona</u> (Mollusca)	25.19
<u>Crepidula plana</u> (Mollusca)	18.15
<u>Molgula</u> sp. (Chordata)	14.93
<u>Amphipoda</u> (Arthropoda)	9.88
<u>Hexapanopeus augustifrons</u> (Arthropoda)	2.68
<u>Callinectes sapidus</u> (Arthropoda)	2.60
<u>Pagurus longicarpus</u> (Arthropoda)	2.45
<u>Pagurus pollicaris</u> (Arthropoda)	1.91
<u>Neopanope texana</u> (Arthropoda)	1.84
<u>Penaeus duorarum</u> (Arthropoda)	1.76
<u>Lolliquncula brevis</u> (Mollusca)	1.53
<u>Chaetodipterus faber</u> (Chordata)	1.23
<u>Eurypanopeus depressus</u> (Arthropoda)	1.23
<u>Cynoscion arenarius</u> (Chordata)	1.00
<u>Pogonias chromis</u> (Chordata)	1.00
<u>Mitrella lunata</u> (Mollusca)	0.84
<u>Diapterus plumieri</u> (Chordata)	0.84
<u>Micropogon undulatus</u> (Chordata)	0.84
Unidentified xanthid crabs (Arthropoda)	0.69
<u>Palaemon floridanus</u> (Arthropoda)	0.54
<u>Styela plicata</u> (Chordata)	0.54
<u>Anchoa mitchilli</u> (Chordata)	0.54
<u>Archosargus probatocephalus</u> (Chordata)	0.46
<u>Mugil</u> sp. (Chordata)	0.46
<u>Limulus polyphemus</u> (Arthropoda)	0.38
TOTAL	93.51

TABLE 2.7-52

RELATIVE ABUNDANCE OF THE TWENTY-FIVE MOST ABUNDANT
ORGANISMS COLLECTED AT TRAWL STATION TB-3
1973-1975 (42)

Species (Phylum)	Percent of Total
Brittle stars, unidentified (Echinodermata)	87.03
Anemone, unidentified (Coelenterata)	5.50
<u>Luidia clathrata</u> (Echinodermata)	1.69
<u>Bairdiella chrysur</u> (Chordata)	0.70
<u>Orthoprists chrysopterus</u> (Chordata)	0.60
<u>Chaetodipterus faber</u> (Chordata)	0.57
<u>Chloroscombrus chrysur</u> (Chordata)	0.48
<u>Anchoa mitchilli</u> (Chordata)	0.36
<u>Menticirrhus americanus</u> (Chordata)	0.34
<u>Penaeus duorarum</u> (Arthropoda)	0.23
<u>Portunus gibbesii</u> (Arthropoda)	0.21
<u>Polyonyx gibbesii</u> (Arthropoda)	0.19
<u>Prionotus scitulus</u> (Chordata)	0.17
<u>Molgula</u> sp. (Chordata)	0.14
<u>Leiostomus xanthurus</u> (Chordata)	0.11
<u>Lolliquncula brevis</u> (Mollusca)	0.11
<u>Arius felis</u> (Chordata)	0.10
<u>Symphurus plaguisa</u> (Chordata)	0.10
<u>Lagodon rhomboides</u> (Chordata)	0.10
<u>Chaetopterus variopedatus</u> (Annelida)	0.08
<u>Cynoscion arenarius</u> (Chordata)	0.08
<u>Glottidia pyramidata</u> (Brachiopoda)	0.06
<u>Anchoa hepsetus</u> (Chordata)	0.05
<u>Crepidula plana</u> (Mollusca)	0.05
<u>Libinia dubia</u> (Arthropoda)	0.05
TOTAL	99.10

TABLE 2.7-53

RELATIVE ABUNDANCE OF THE TWENTY-FIVE MOST ABUNDANT
ORGANISMS COLLECTED AT TRAWL STATION TB-4 (INTAKE CANAL)
1973-1975 (•2)

<u>Species</u> <u>(Phylum)</u>	<u>Percent</u> <u>of Total</u>
<u>Neopanope texana</u> (Arthropoda)	15.84
<u>Mulinia lateralis</u> (Mollusca)	14.81
<u>Cynoscion arenarius</u> (Chordata)	13.54
<u>Anchoa mitchilli</u> (Chordata)	11.88
<u>Penaeus duorarum</u> (Arthropoda)	7.79
<u>Lollicuncula brevis</u> (Mollusca)	5.11
<u>Hexapanopeus angustifrons</u> (Arthropoda)	3.70
<u>Squilla empusa</u> (Arthropoda)	2.68
<u>Bairdiella chrysura</u> (Chordata)	2.68
<u>Callinectes sapidus</u> (Arthropoda)	2.17
<u>Portunus gibbesii</u> (Arthropoda)	2.17
<u>Menticirrhus americanus</u> (Chordata)	1.53
<u>Platynereis dumerilii</u> (Annelida)	1.40
<u>Microgogon undulatus</u> (Chordata)	1.28
<u>Trinectes maculatus</u> (Chordata)	1.28
<u>Palaemonetes vulgaris</u> (Arthropoda)	1.15
<u>Alpheus heterochaelis</u> (Arthropoda)	1.02
<u>Luidia clathrata</u> (Echinodermata)	1.02
<u>Styela plicata</u> (Chordata)	0.89
<u>Anadara transversa</u> (Mollusca)	0.77
<u>Macoma tenta</u> (Mollusca)	0.64
<u>Corbula</u> sp. (Mollusca)	0.51
<u>Glottidia pyramidata</u> (Brachiopoda)	0.51
<u>Prunum apicunum</u> (Mollusca)	0.38
<u>Pagurus longicarpus</u> (Arthropoda)	0.38
TOTAL	95.13

TABLE 2.7-54

RELATIVE ABUNDANCE OF THE TWENTY-FIVE MOST ABUNDANT
ORGANISMS COLLECTED AT SEINE STATION SB-1
1973-1975 (42)

<u>Species</u> <u>(Phylum)</u>	<u>Percent</u> <u>of Total</u>
<u>Anchoa mitchilli</u> (Chordata)	37.39
<u>Eucinostomus argenteus</u> (Chordata)	13.07
<u>Eucinostomus gula</u> (Chordata)	10.07
<u>Melongena corona</u> (Mollusca)	5.90
<u>Trachinotus falcatus</u> (Chordata)	5.35
<u>Oligoplites saurus</u> (Chordata)	5.08
<u>Membras martinica</u> (Chordata)	4.08
<u>Fundulus similis</u> (Chordata)	3.18
<u>Sciaenops ocellata</u> (Chordata)	1.72
<u>Hyporhamphus unifasciatus</u> (Chordata)	1.54
<u>Callinectes sapidus</u> (Arthropoda)	1.45
<u>Pagurus longicarpus</u> (Arthropoda)	1.45
<u>Menidia beryllina</u> (Chordata)	1.09
<u>Elops saurus</u> (Chordata)	0.73
<u>Mugil trichodon</u> (Chordata)	0.64
<u>Strongylura timucu</u> (Chordata)	0.54
<u>Strongylura notata</u> (Chordata)	0.54
<u>Archosargus probatocephalus</u> (Chordata)	0.54
<u>Polinices duplicatus</u> (Mollusca)	0.45
<u>Crepidula plana</u> (Mollusca)	0.45
<u>Lagodon rhomboides</u> (Chordata)	0.45
Unidentified gerrid (Chordata)	0.45
<u>Penaeus duorarum</u> (Arthropoda)	0.27
<u>Microgobius gulosus</u> (Chordata)	0.27
Unidentified nereid (Annelida)	0.18
TOTAL	96.88

TABLE 2.7-55

RELATIVE ABUNDANCE OF THE TWENTY-FIVE MOST ABUNDANT
ORGANISMS COLLECTED AT SEINE STATION SB-3
1973-1975 (42)

Species (Phylum)	Percent of Total
<u>Menidia beryllina</u> (Chordata)	21.13
<u>Earenqula jaguana</u> (Chordata)	19.18
<u>Eucinostomus argenteus</u> (Chordata)	18.29
Unidentified gerrid (Chordata)	13.69
<u>Eucinostomus gula</u> (Chordata)	5.77
<u>Anchoa mitchilli</u> (Chordata)	4.10
<u>Melongena corona</u> (Mollusca)	2.72
<u>Portunus gibbesii</u> (Arthropoda)	2.02
<u>Neopanope texana</u> (Arthropoda)	1.20
<u>Laqodon rhomboides</u> (Chordata)	1.13
<u>Strongylura timucu</u> (Chordata)	1.06
<u>Brevoortia</u> sp. (Chordata)	0.88
<u>Callinectes sapidus</u> (Arthropoda)	0.78
<u>Fundulus similis</u> (Chordata)	0.78
<u>Pagurus longicarpus</u> (Arthropoda)	0.71
<u>Penaeus duorarum</u> (Arthropoda)	0.67
<u>Palaemonetes pugio</u> (Arthropoda)	0.50
<u>Menticirrhus focaliger</u> (Chordata)	0.50
<u>Trachinotus falcatus</u> (Chordata)	0.50
<u>Menticirrhus americanus</u> (Chordata)	0.46
<u>Oligoplites saurus</u> (Chordata)	0.46
<u>Muqil cephalus</u> (Chordata)	0.42
<u>Oliva sayana</u> (Mollusca)	0.35
<u>Amygdalum papyrium</u> (Mollusca)	0.25
<u>Hyporhamphus unifasciatus</u> (Chordata)	0.21
TOTAL	97.76

TABLE 2.7-56

MACROINVERTEBRATES CAPTURED (DAY SAMPLES ONLY)
BETWEEN JUNE, 1976 AND FEBRUARY, 1977

<u>Transect</u>	<u>Total Number of Macroinvertebrates</u>	<u>Percent of Total Catch</u>
TB-1	15	3.9
TB-12	25	6.5
TB-5	53	13.8
TB-7	34	8.9
TB-6	19	5.0
TB-13	198	51.7
TB-4	<u>39</u>	<u>10.2</u>
Totals	383	100.0

TABLE 2.7-57

MACROINVERTEBRATES CAPTURED BETWEEN
JUNE, 1976 AND FEBRUARY, 1977 EXCLUDING MOLGULA SP.(37)

<u>Transect</u>	<u>Total Number of Macroinvertebrates excluding Molgula sp.</u>	<u>Percent of Total Catch</u>
TB-1	15	7.0
TB-12	22	10.3
TB-5	53	24.9
TB-7	34	16.0
TB-6	19	8.9
TB-13	31	14.6
TB-4	<u>39</u>	<u>18.3</u>
Totals	213	100.0

TABLE 2.7-58

TOTAL NUMBER OF MACROINVERTEBRATES CAPTURED
IN FEBRUARY 1977 TRAWLS - DAY VS. NIGHT SAMPLING(37)

<u>Transect</u>	<u>Total Number of Macroinvertebrates</u>	
	<u>Day</u>	<u>Night</u>
TB-1	2	3
TB-12	10	85
TB-5	4	9
TB-7	0	5
TB-6	3	34 (33) *
TB-13	188 (21)	80 (28) *
TB-4	23	31

NOTE:

* Number of macroinvertebrates that were captured excluding
Molgula sp.

TABLE 2.7-59

PERCENT OF TOTAL EGGS AND LARVAE TAKEN DURING ICHTHYOPLANKTON
SAMPLING AT BIG BEND, BY FAMILY(3)

Eggs		Larvae	
Family	Percent of Total	Family	Percent of Total
Engraulidae	73.1	Engraulidae	87.4
Sciaenidae	26.2	Sciaenidae	3.9
Carangidae	0.4	Gobiidae	2.7
Clupeidae	0.2	Pomadasyidae	2.1
		Carangidae	1.1
Soleidae		Sparidae	1.1
Triglidae		Clupeidae	0.5
Pomadasyidae		Blenniidae	0.4
Ephippidae	0.1%	Soleidae	0.2
Belonidae	(total)	Triglidae	0.2
Atherinidae		Atherinidae	0.1
Gobiidae			
		Gobiesocidae	
		Syngnathidae	
		Cynoglossidae	
		Ephippidae	
		Ophichthidae	
		Tetraodontidae	0.3%
		Mugilidae	(total)
		Belonidae	
		Bothidae	
		Cyprinodontidae	
		Gerreidae	

TABLE 2.7-60

SUMMARY OF SEINE STUDY, RESULTS FOR ABUNDANT FISH SPECIES,
BIG BEND VICINITY, JANUARY 1976 TO MARCH 1977^(1,2,3)

Common Name/ Species	Number Collected	Size Range (mm)	Temperature Range (°C)	Approximate Period of Occurrence	Location of Highest Abundance
Tidewater Silverside <u>Menidia beryllina</u>	20,256	14-96	12-34.5	Year-round	Ubiquitous
Bay Anchovy <u>Anchoa mitchilli</u>	9,171	18-65	16-32	Fall	Inshore Shallows
Longnose Killifish <u>Fundulus similis</u>	7,704	9-117	12-34.5	Year-round	Inshore Shallows ^(1,3)
Spotfin Mojarra <u>Eucinostomus argenteus</u>	5,541	11-105	14-34.5	Late Summer, Early Winter	Inshore Shallows
Striped Mullet <u>Mugil cephalus</u>	3,005	15-360	12-34	Year-round	Inshore Shallows ⁽²⁾
Sheepshead Minnow <u>Cyprinodon variegatus</u>	2,961	14-58	14-34.5	Late Spring, Summer	North Apollo Embayment
Silver Jenny <u>Eucinostomus gula</u>	2,451	31-100	15-34.5	Fall	Inshore Shallows ⁽³⁾
Scaled Sardine <u>Harengula jaquana</u>	1,721	62-138	12-34	Summer, Fall	Open Bay
Pinfish <u>Lagodon rhomboides</u>	1,465	16-136	18-34.5	Spring, Summer	Shallow, Sandy Areas
Spot <u>Leiostomus xanthurus</u>	1,035	16-104	14-27.5	Late Winter, Spring	Inshore Shallows ⁽⁴⁾
Northern Kingfish <u>Menticirrhus saxatilis</u>	243	15-137	16-31.5	Summer	Open Bay
Permit <u>Trachinotus falcatus</u>	114	15-410	18-33	Summer, Fall	Open Bay ^(1,3)

NOTES:

1. TECO, 1976, p 626 (28th Quarterly Report)
2. TECO, 1977, p 411 (27th Quarterly Report)
3. TECO, 1977, p 644 (29th Quarterly Report)
4. TECO, 1977, p 333 (30th Quarterly Report)

TABLE 2.7-61

MANATEE SIGHTINGS IN THE VICINITY OF BIG BEND 1971-1976

<u>Date</u>	<u>Number Observed</u>	<u>Location</u>	<u>Discharged Water Temperature °C</u>
May 1971	3	Discharge Channel	31
Dec. 31, 1972	5	Discharge Channel	-
Jan. 24, 1973	3	Near #1 Flume	25
Feb. 2, 1973	2	Near #1 Flume	24
Feb. 3, 1973	1	Near boat at mouth of #1 Flume	-
Feb. 6, 1973	1	Discharge Channel	22
Feb. 15, 1973	1	Discharge Channel	21
Feb. 20, 1973	1	Discharge Channel	22
July 25, 1973	5	North of Port Manatee Ship Channel, approximately one mile offshore	-
July 1976	3	-	-
Aug. 1976	2	-	-
Nov. 25, 1976	2	-	-

TABLE 2.7-62

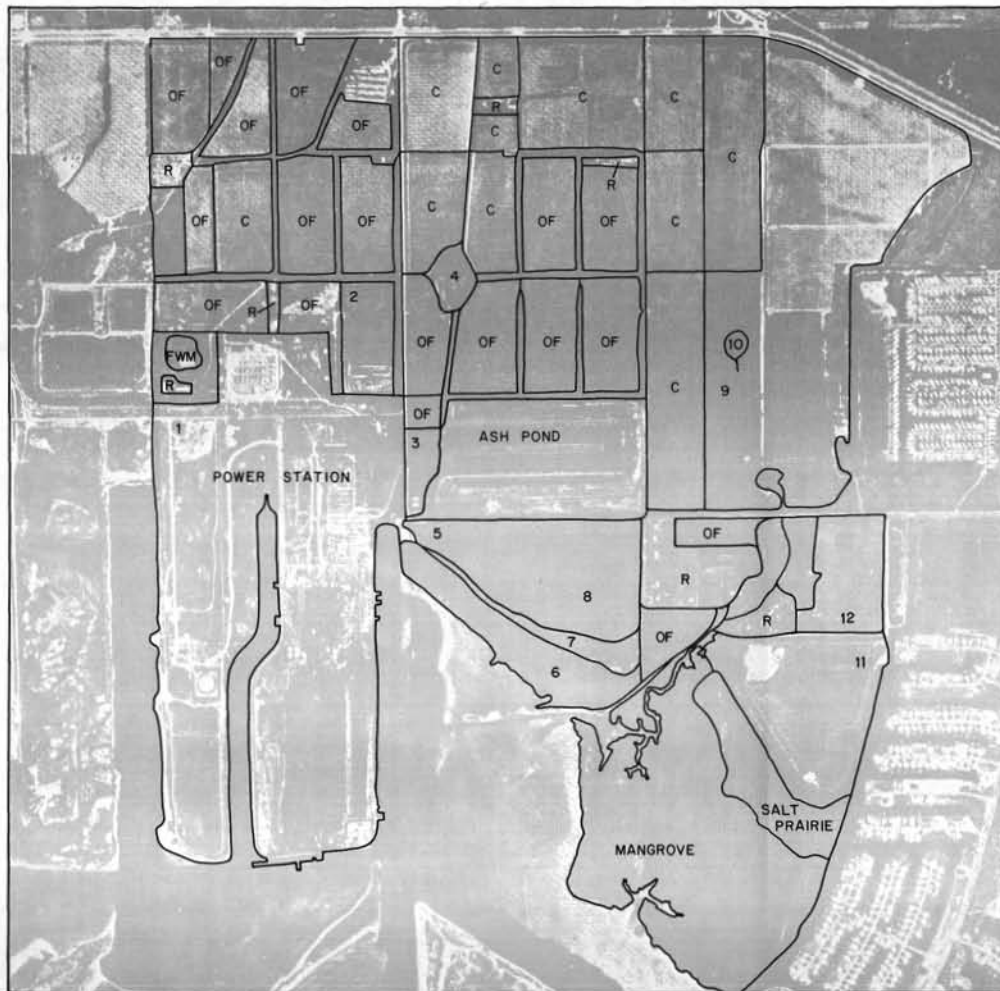
PORPOISE SIGHTINGS IN THE VICINITY OF BIG BEND 1970-1976

<u>Date</u>	<u>Number Observed</u>	<u>Location</u>	<u>Water Temperature °C</u>
November 23, 1970	-	Found dead on beach near Station 0-6	-
June 7, 1971	2	Near discharge flume	30
June 9, 1971	2	Feeding near well screens	29
June 25, 1971	1	Found dead on Fish- hook Spoil during redtide	-
September 14, 1971	-	Sightings near Station I-3	-
September 15, 1971	1	Near Station 0-3	28
April 5, 1972	-	In channel near Station I-4	-
April 11, 1972	-	Near south tip of Apollo Beach	-
April 20, 1972	-	Near Pine Key, west of Big Bend	-
May 16, 1972	-	Between Station 0-5 and Big Bend	-
August 1, 1972	-	In discharge channel	35
September 7, 1972	-	At Apollo Beach	-
September 9, 1972	-	Near Station 0-6	-
October 18, 1972	-	Near breakwater	-
May 10, 1973	-	Near discharge Station I-3	-

TABLE 2.7-63

SEA TURTLE SIGHTINGS IN THE VICINITY OF BIG BEND 1970-1976

<u>Date</u>	<u>Location</u>
June 26, 1971	Large sea turtle with a 3 ft long carapace found dead on beach near Ruskin, Florida
August 10, 1971	Sea turtle with 1-1/2 ft carapace found dead on beach near 0-6
May 2, 1972	Sea turtle with a 3 ft carapace found dead on Fishhook Spoil



SAMPLE STA. No.	DESCRIPTION
1	POWER STATION
2	POWER LINE RIGHT-OF-WAY
3	ASH POND
4	JACKSON BRANCH FRESHWATER MARSH
5	PALMETTO - <i>JUNCUS</i> ASSOCIATION
6	MANGROVES
7	SALT PRAIRIE
8	PINE - PALMETTO ASSOCIATION
9	PASTURE
10	PASTURE POND
11	<i>MYRICA</i> - <i>BACCHARIS</i> ASSOCIATION
12	OLD FIELD

LEGEND
 R - RESIDENTIAL
 C - CULTIVATED LAND
 OF - OLD FIELD
 FWM - FRESHWATER MARSH

0 1000 2000
 SCALE - FEET

FIGURE 2.7-1
 VEGETATION TYPES SAMPLED
 AT THE BIG BEND SITE
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY

TERTIARY
CONSUMER

SECONDARY
CONSUMER

OMNIVORE

PRIMARY
CONSUMER

PRODUCER

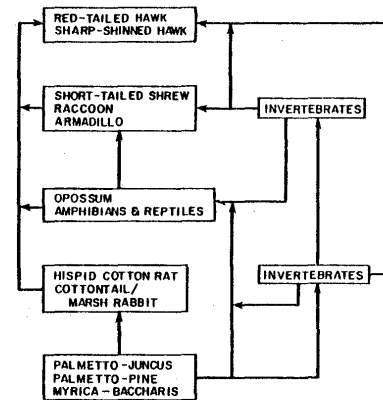
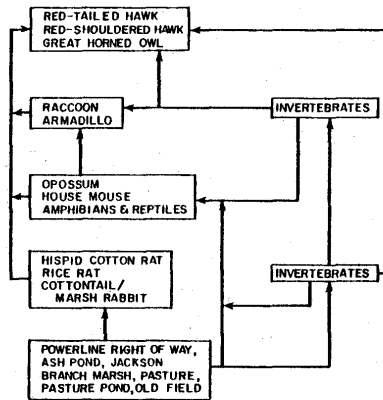
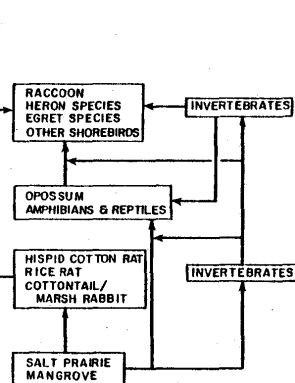
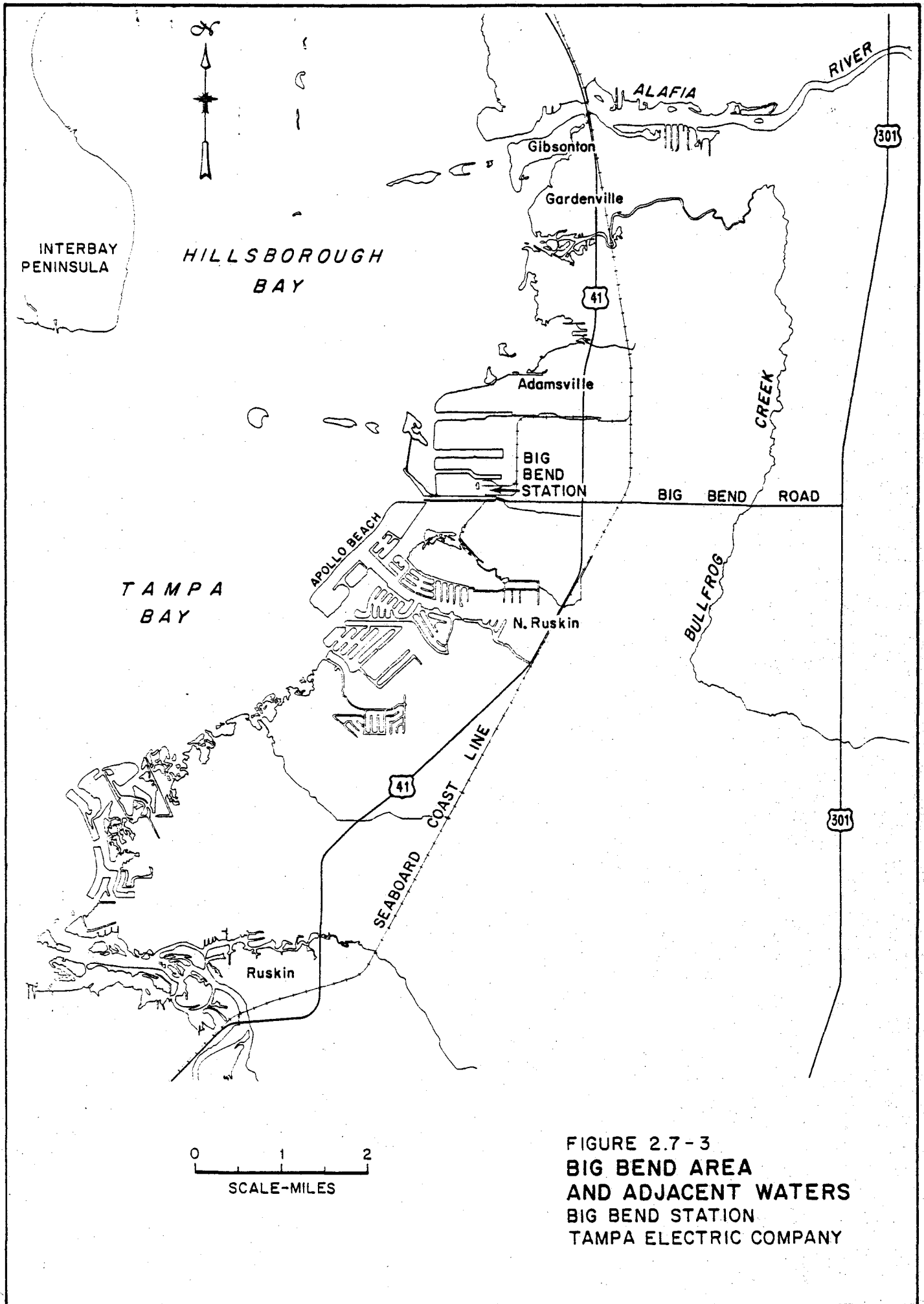


FIGURE 2.7-2
POTENTIAL FOOD WEBS OF
SIMILAR VEGETATION TYPES
AT THE BIG BEND SITE
BIG BEND STATION
TAMPA ELECTRIC COMPANY



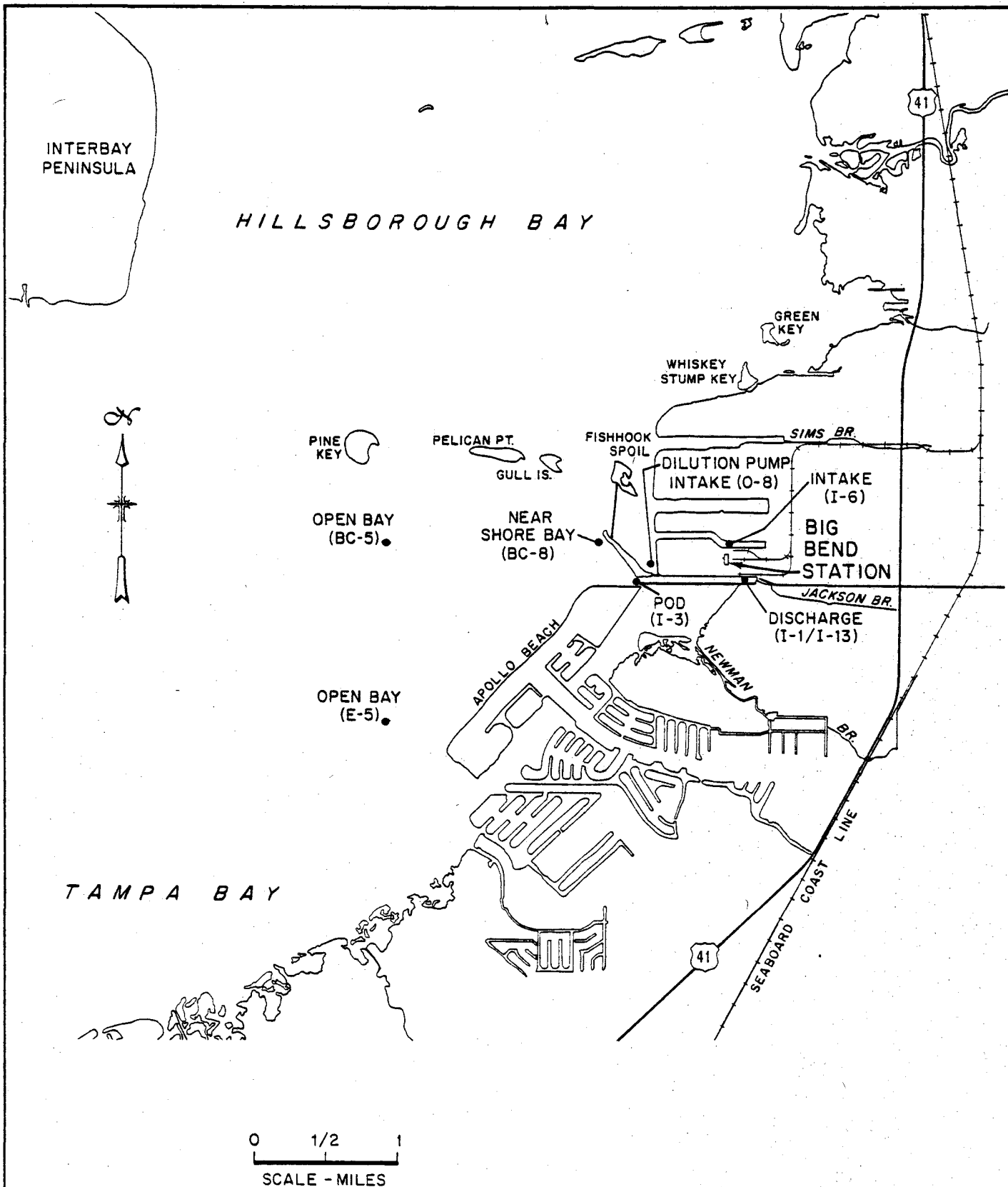
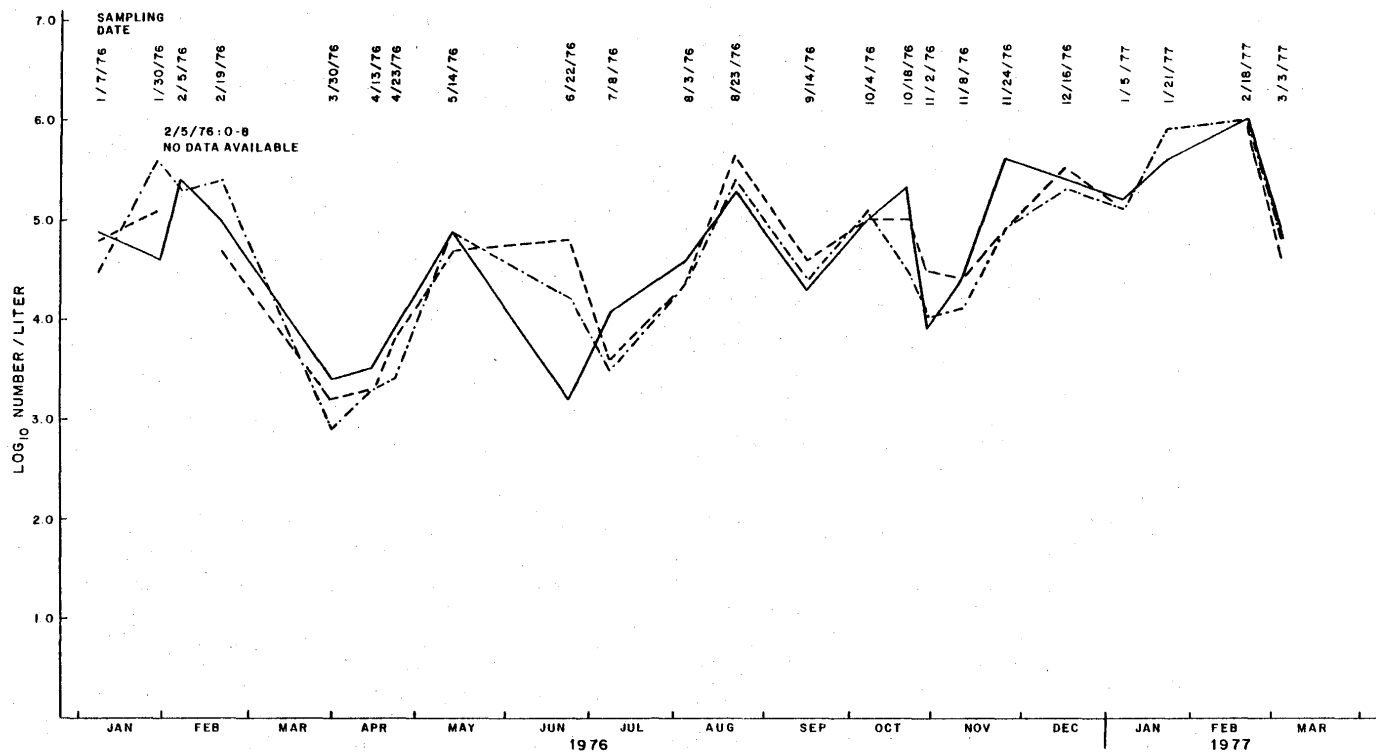


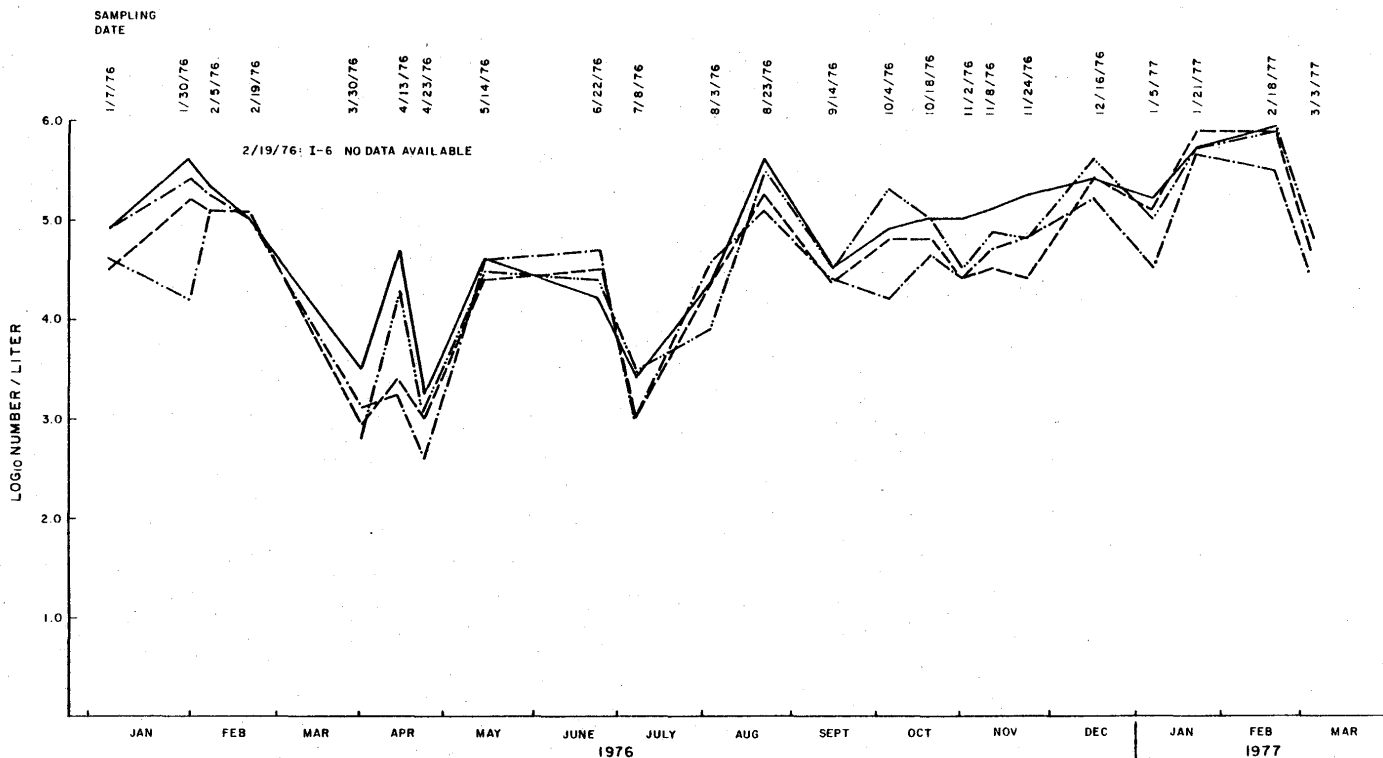
FIGURE 2.7 - 4
 PHYTOPLANKTON STATIONS
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY

SOURCE: Adapted from Appendix to
 316 Demonstration, Volume I, page 3-13.



LEGEND
STATION
E-5 ———
O-8 - - -
BC-8 . . .

FIGURE 2.7-5
TEMPORAL VARIATION OF DIATOMS
(CELLS/LITER)
BIG BEND STATION
TAMPA ELECTRIC COMPANY



LEGEND

STATION

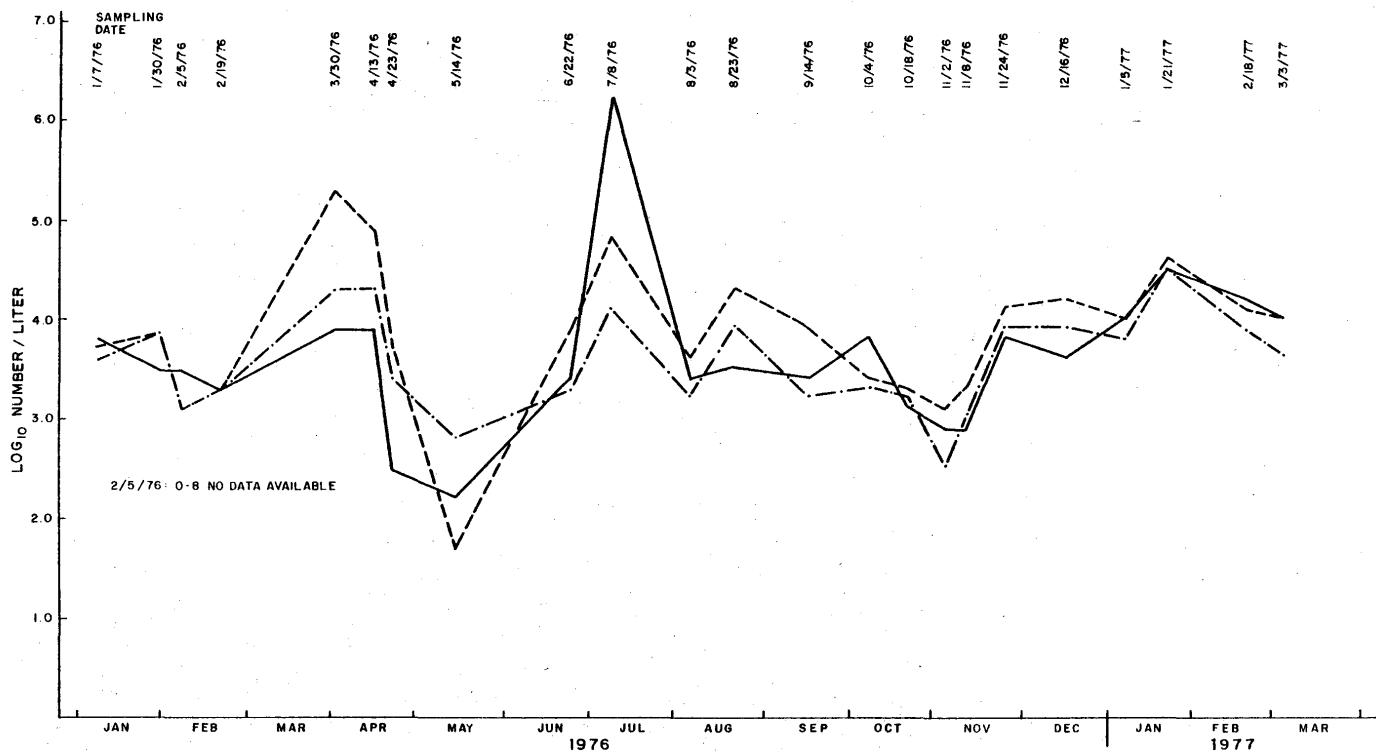
BC-5 —————

I-3 - - - - -

I-1/I-13

I-6 - . - . -

FIGURE 2.7-6
TEMPORAL VARIATION OF DIATOMS
(CELLS/LITER)
BIG BEND STATION
TAMPA ELECTRIC COMPANY



LEGEND
STATION
 E-5 —————
 O-8 - - - - -
 BC-8 - . - . -

FIGURE 2.7-7
TEMPORAL VARIATION OF
DINOFLAGELLATES (CELLS/LITER)
BIG BEND STATION
TAMPA ELECTRIC COMPANY

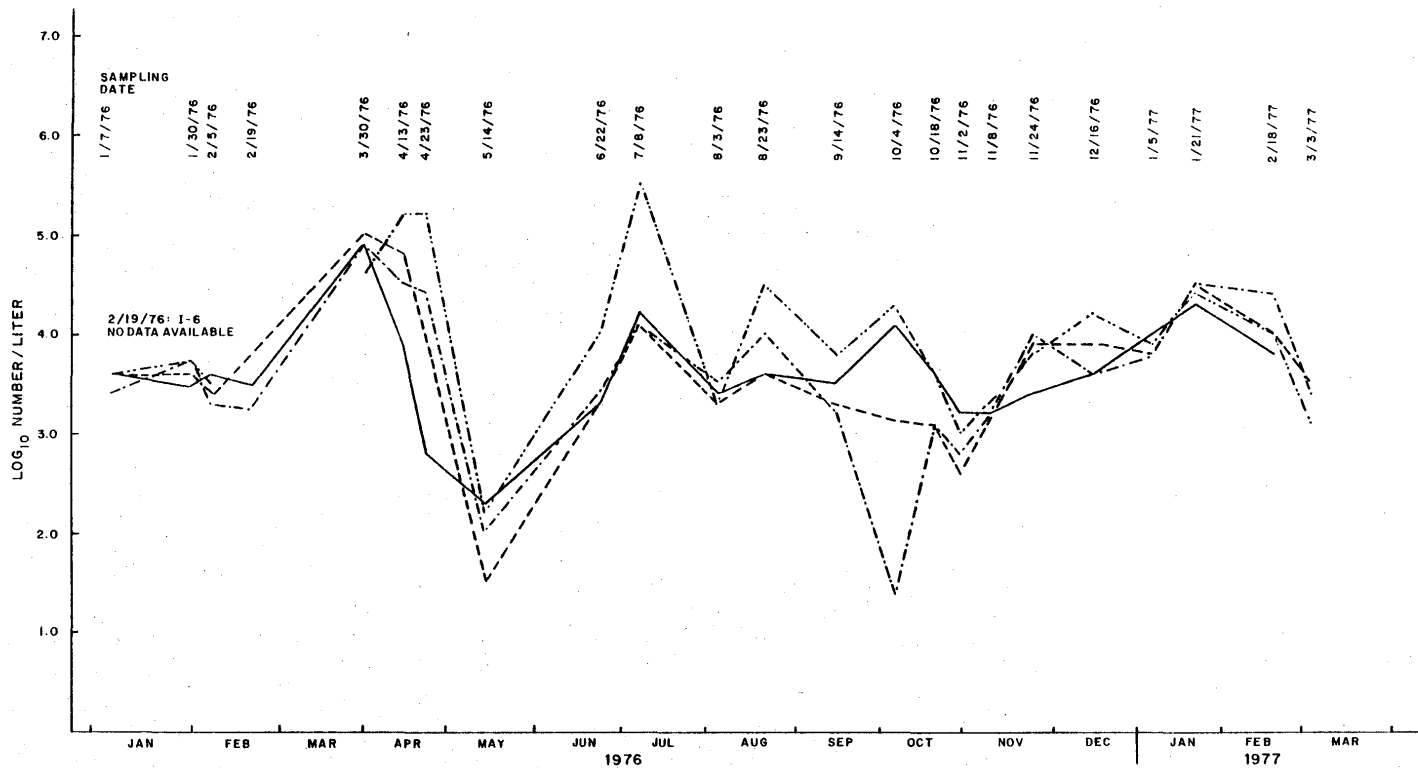
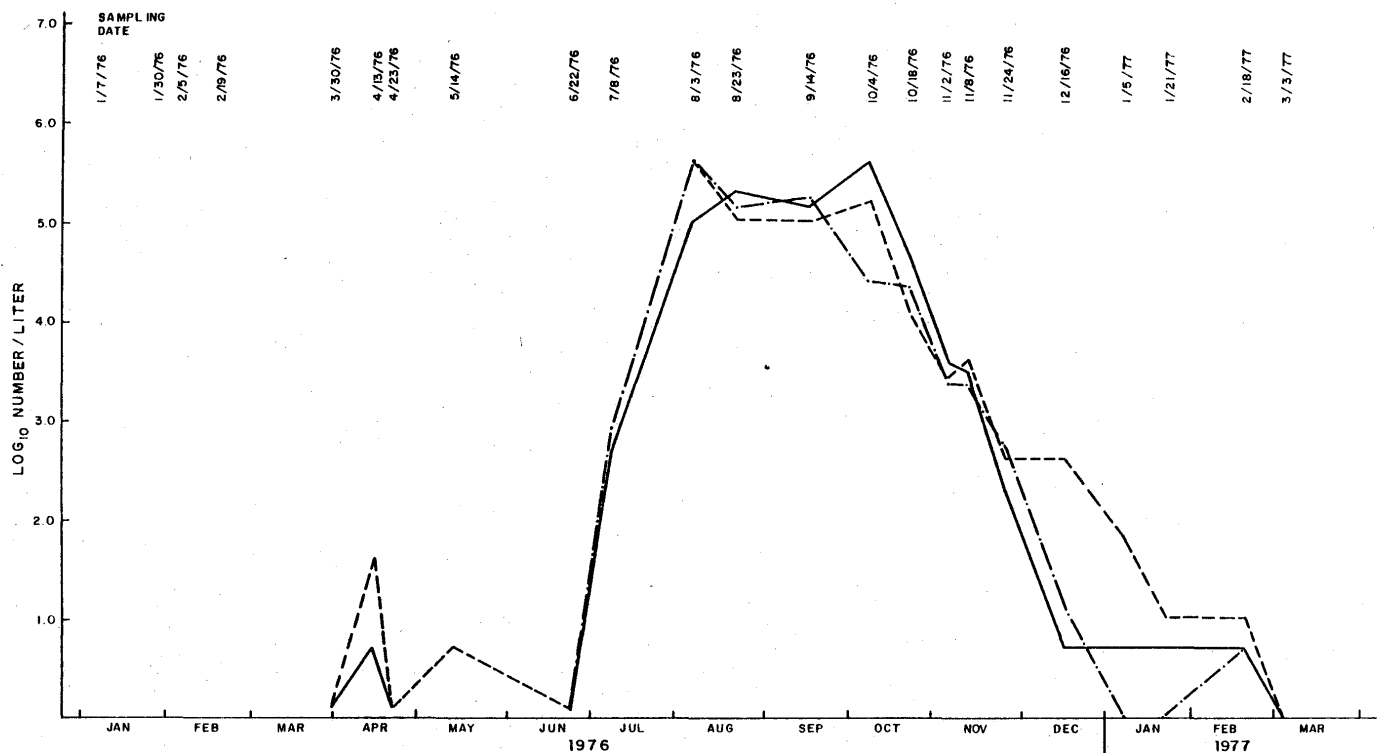
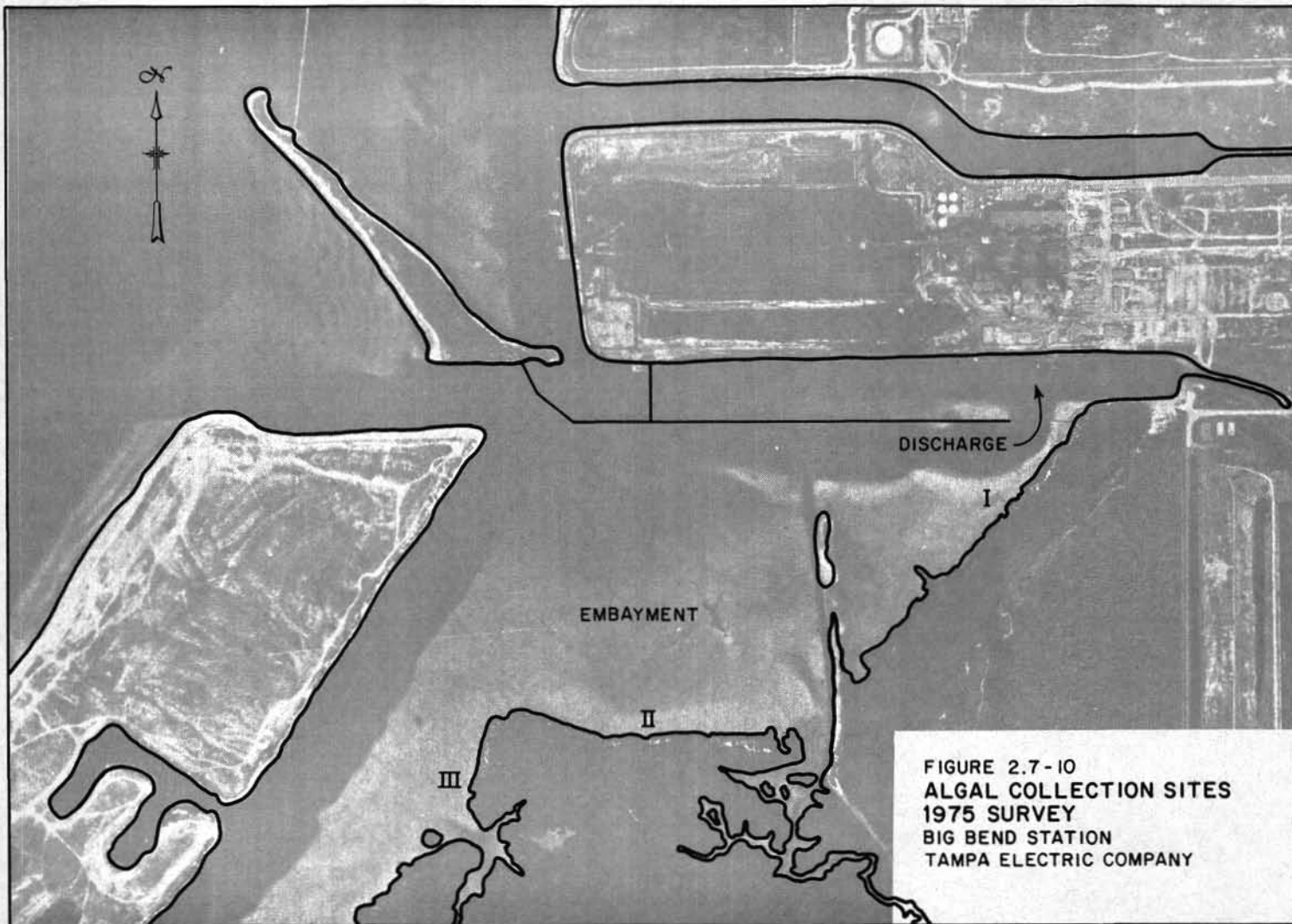


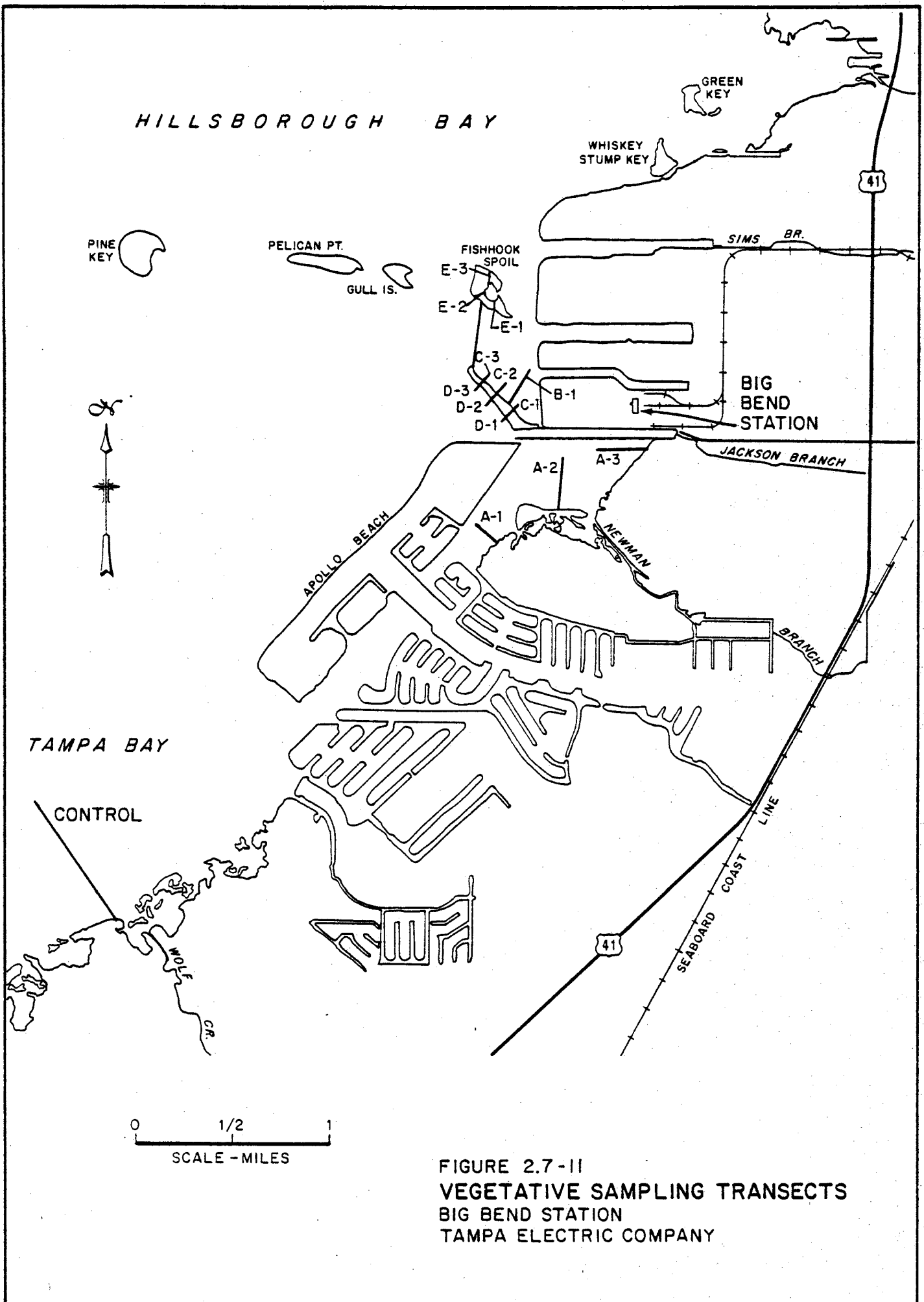
FIGURE 2.7-8
TEMPORAL VARIATION OF
DINOFLAGELLATES (CELLS/LITER)
BIG BEND STATION
TAMPA ELECTRIC COMPANY



LEGEND
STATION
 I-6 —————
 I-1/I-13 - - - - -
 I-3

FIGURE 2.7-9
 OCCURRENCE OF *OSCILLATORIA* SP.
 AT THE PLANT INTAKE (I-6)
 THE PLANT DISCHARGE (I-1/I-13)
 AND THE POINT OF DISCHARGE (I-3)
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY





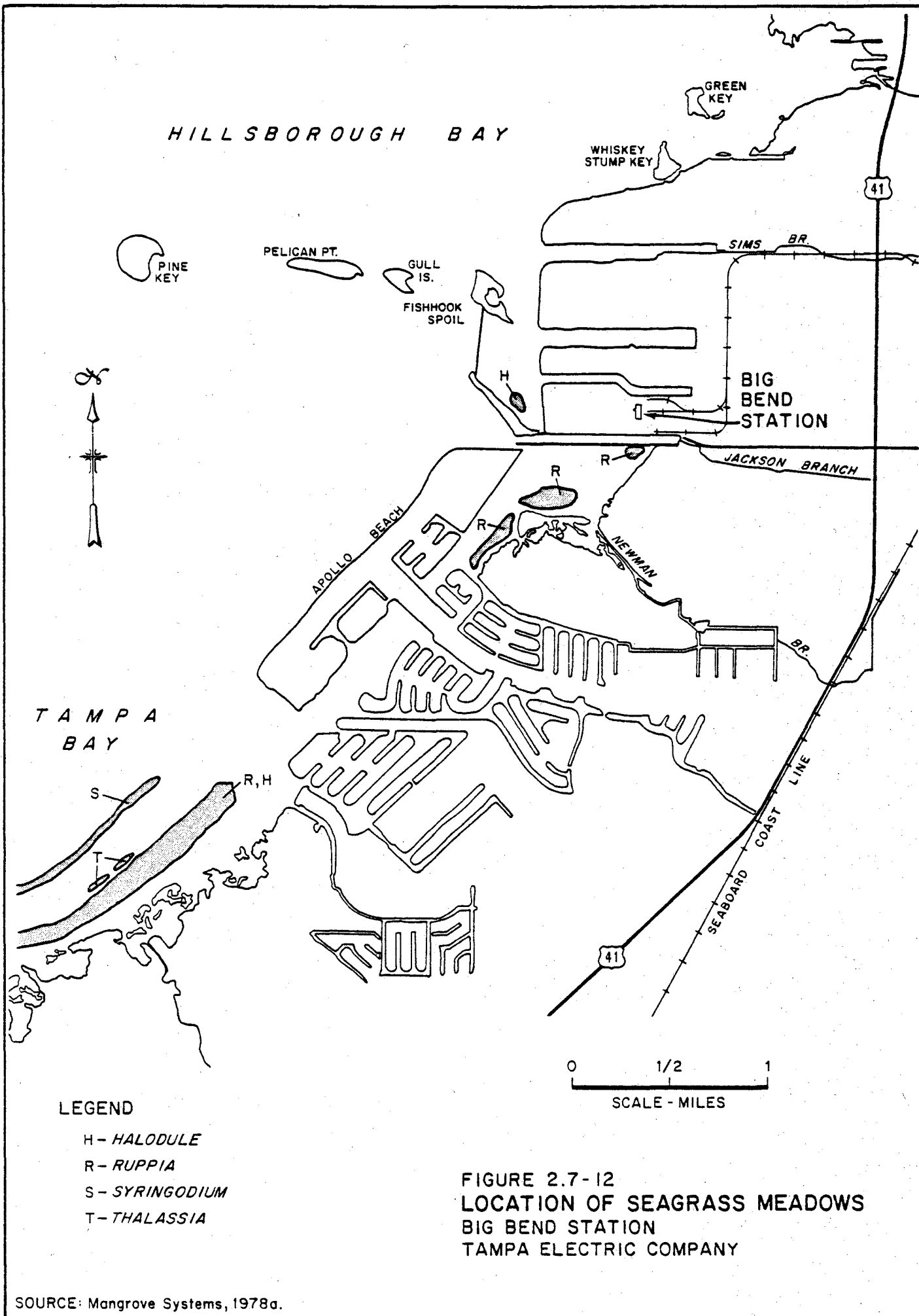


FIGURE 2.7-12
LOCATION OF SEAGRASS MEADOWS
BIG BEND STATION
TAMPA ELECTRIC COMPANY

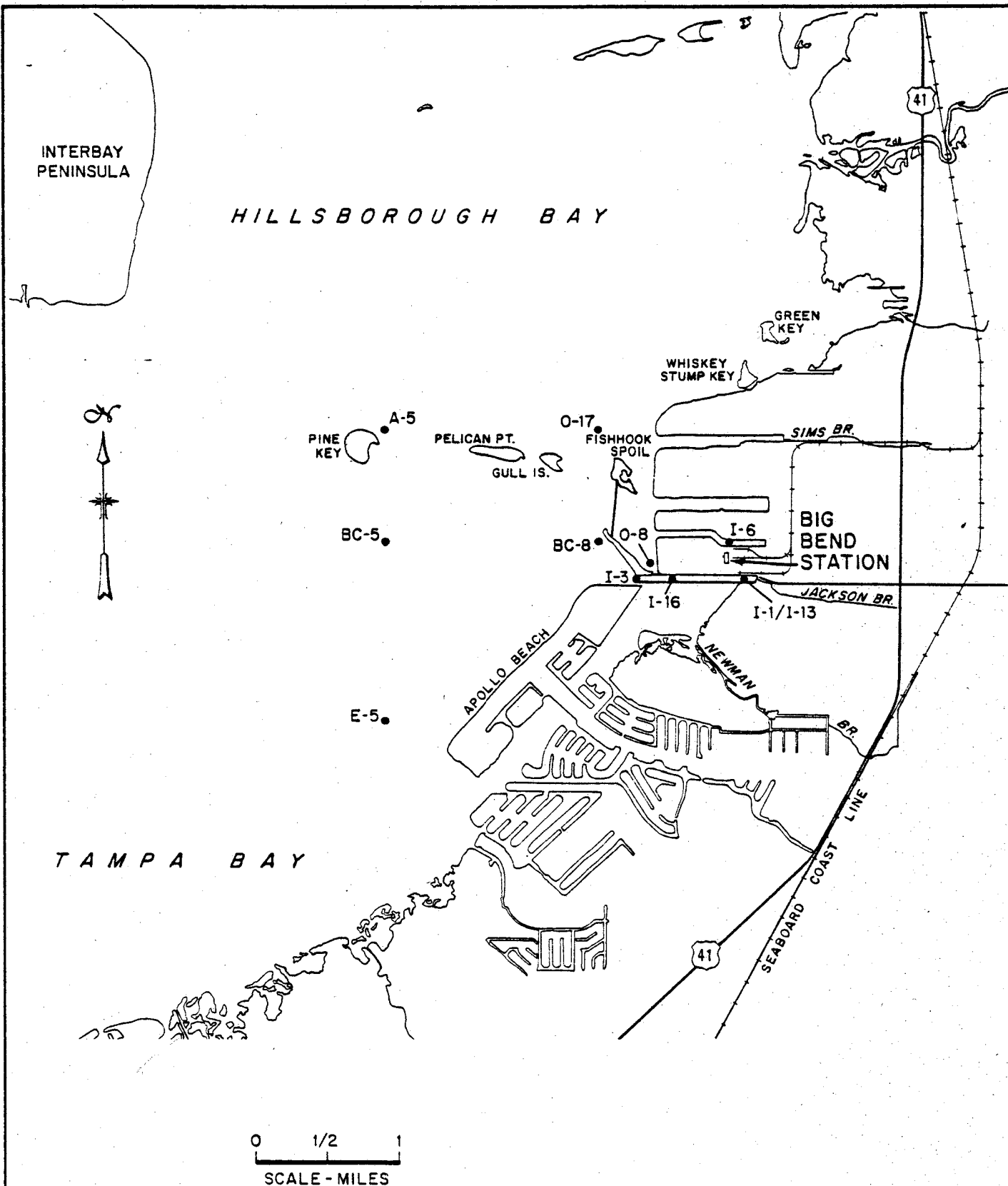


FIGURE 2.7-13
 MEROPLANKTON
 SAMPLING STATIONS
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY

SOURCE: Adapted from Appendix to
 316 Demonstration, Volume III, TECO, 1977d, page 5-12.

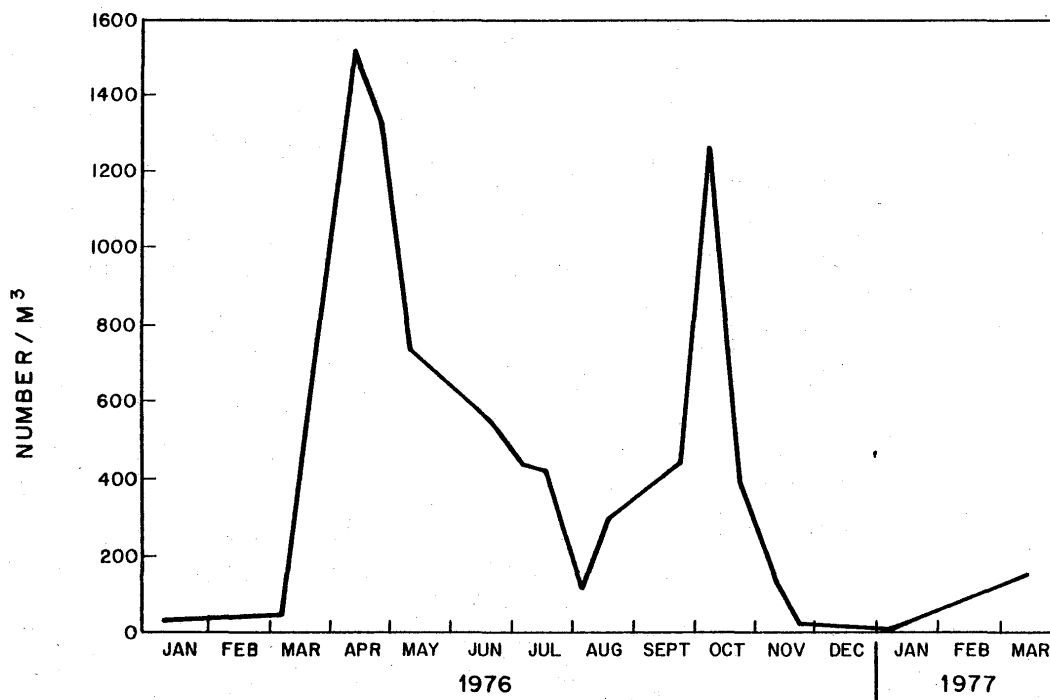
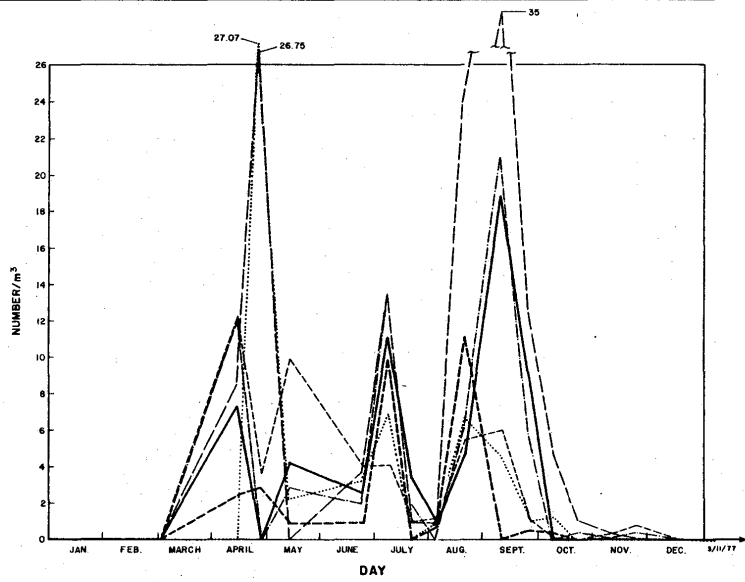


FIGURE 2.7 - 14
 TOTAL MEROPLANKTON
 ABUNDANCE AVERAGE OF ALL
 BIG BEND STATIONS
 (DAY AND NIGHT)
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY

SOURCE: Appendix to 316 Demonstration
 Volume III Page 6-10.



LEGEND

— 0-8	— I-16
--- I-6	 I-5
- - - I-1/I-13	— BC-8

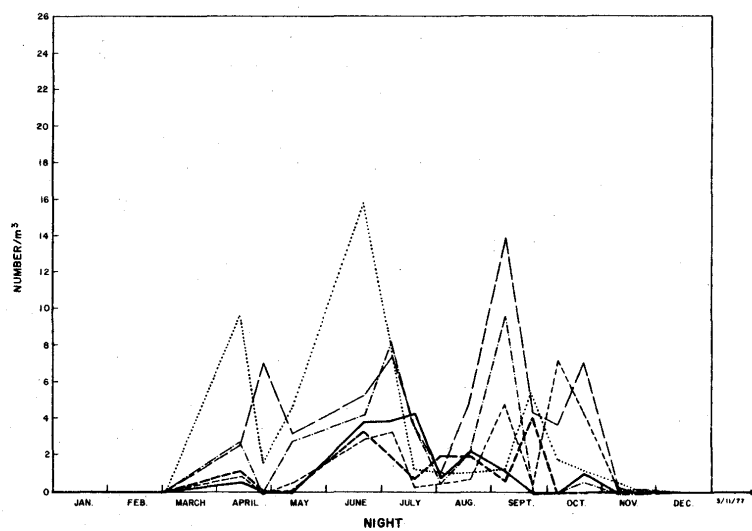
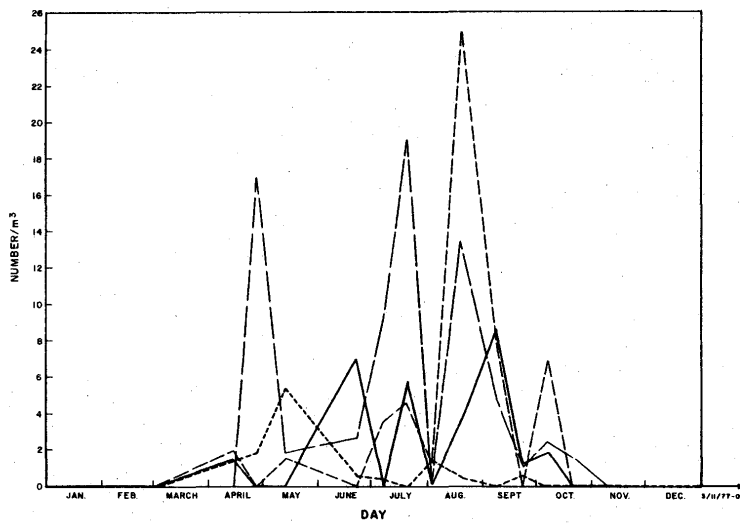


FIGURE 2.7-15
DENSITY OF *MENIPPE MERCENARIA*
LARVAE AT INSHORE STATIONS
BIG BEND STATION
TAMPA ELECTRIC COMPANY



LEGEND

— O-17
 - - - A-5
 . . . BC-5
 - . - E-5

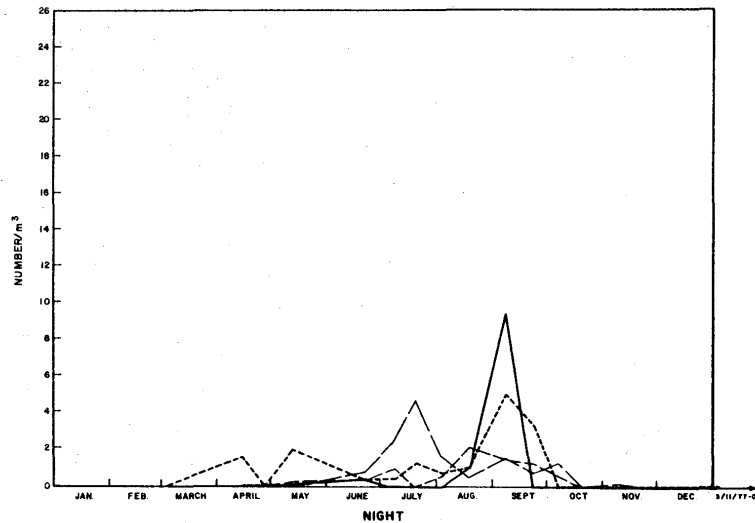
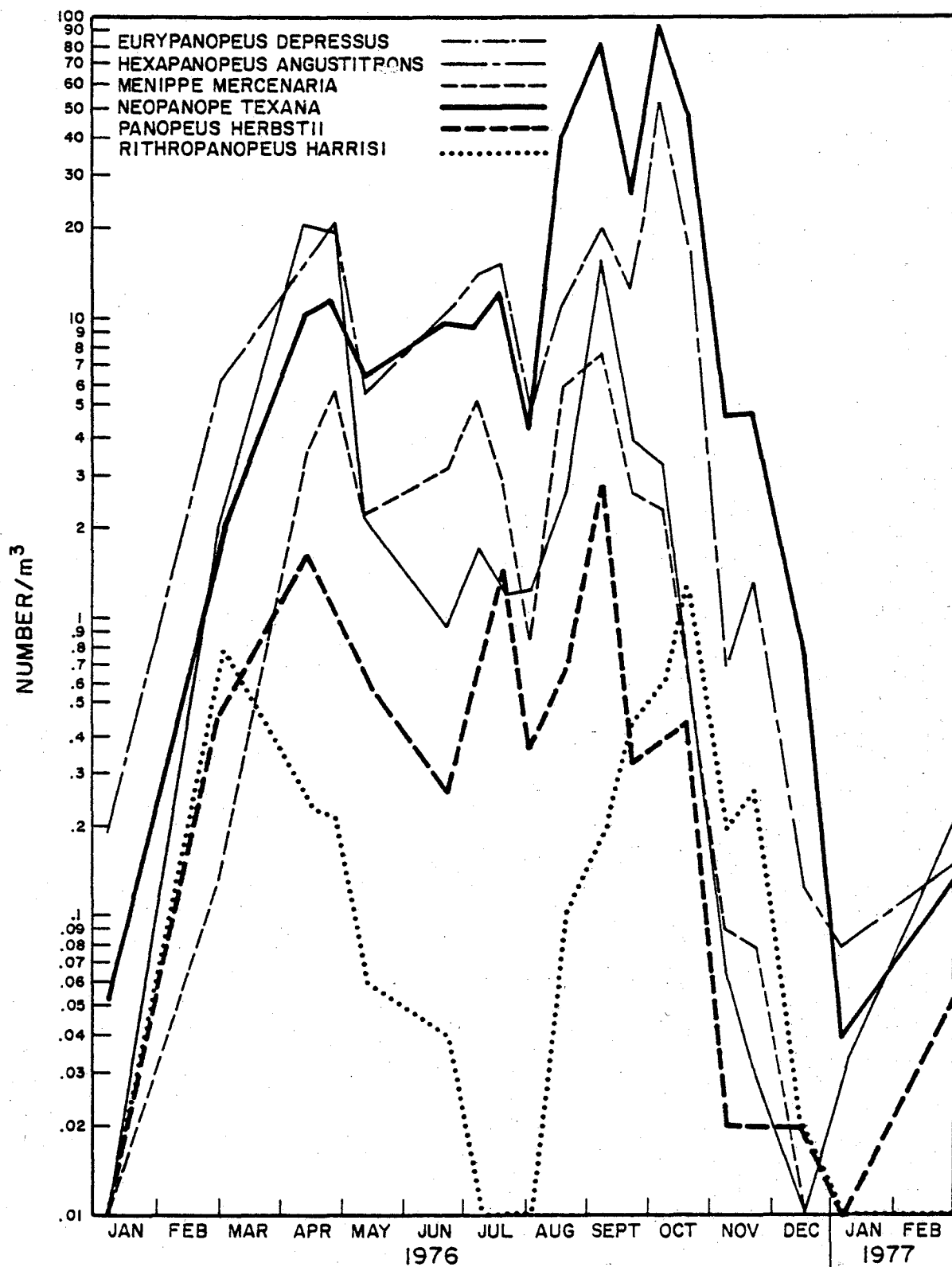


FIGURE 2.7-16
 DENSITY OF *MENIPPE MERCENARIA*
 LARVAE AT OFFSHORE STATIONS
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY



NOTE:

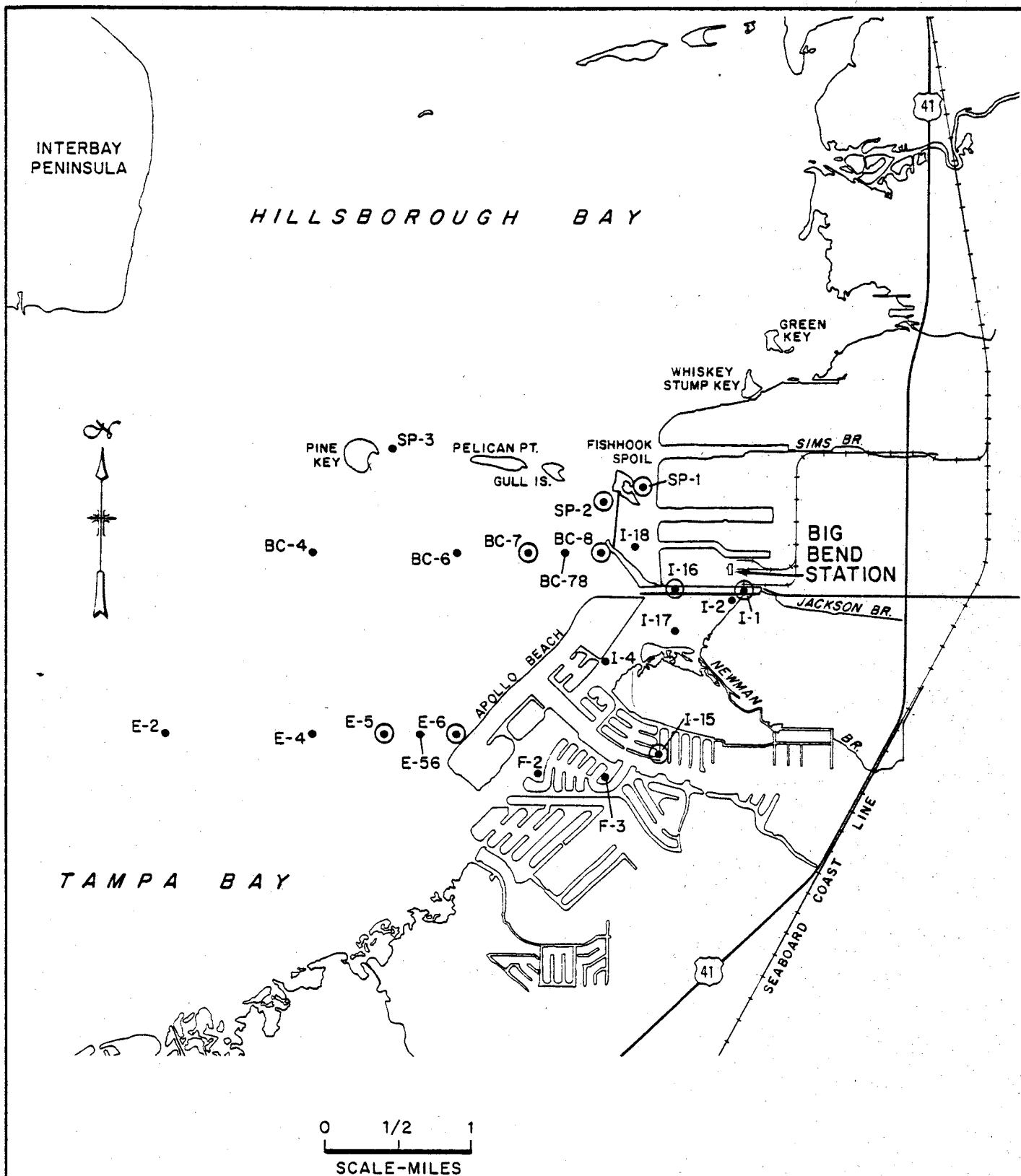
AN OPEN CIRCLE INDICATES
 < 0.01 PER m³ AVERAGE.

FIGURE 2.7 - 17

ABUNDANCE OF SIX MOST COMMON
 TYPES OF XANTHID CRAB LARVA

BIG BEND STATION

TAMPA ELECTRIC COMPANY

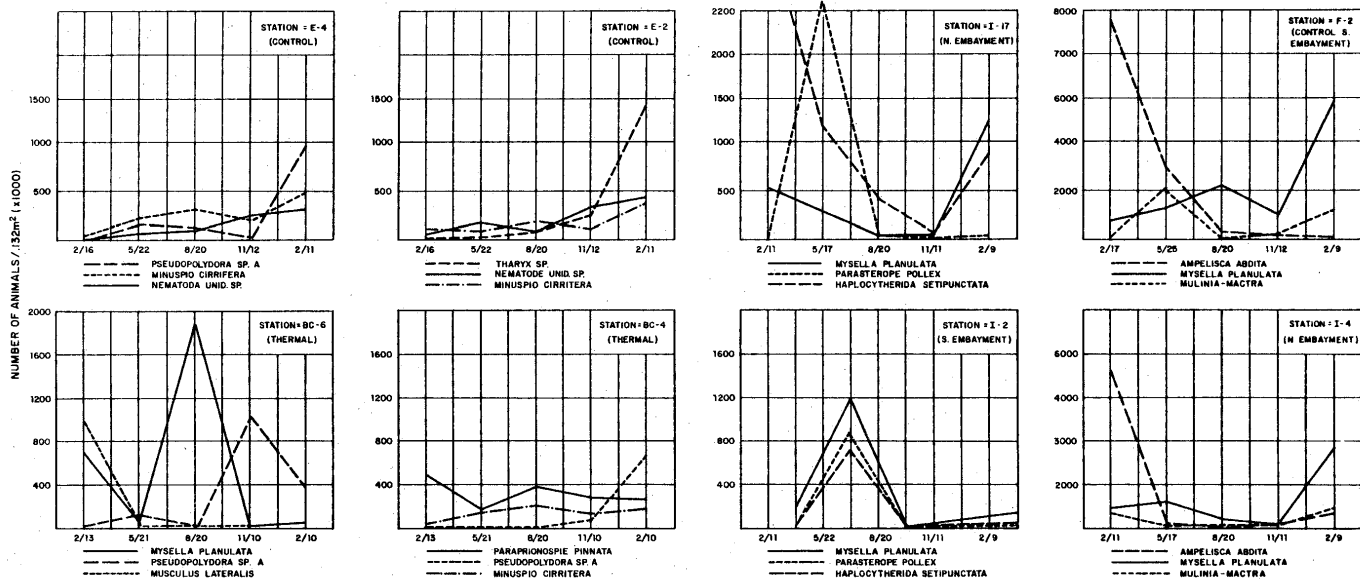


LEGEND

- STATIONS SAMPLED
ONCE A QUARTER
- ⊙ STATIONS SAMPLED
ONCE EVERY SIX WEEKS

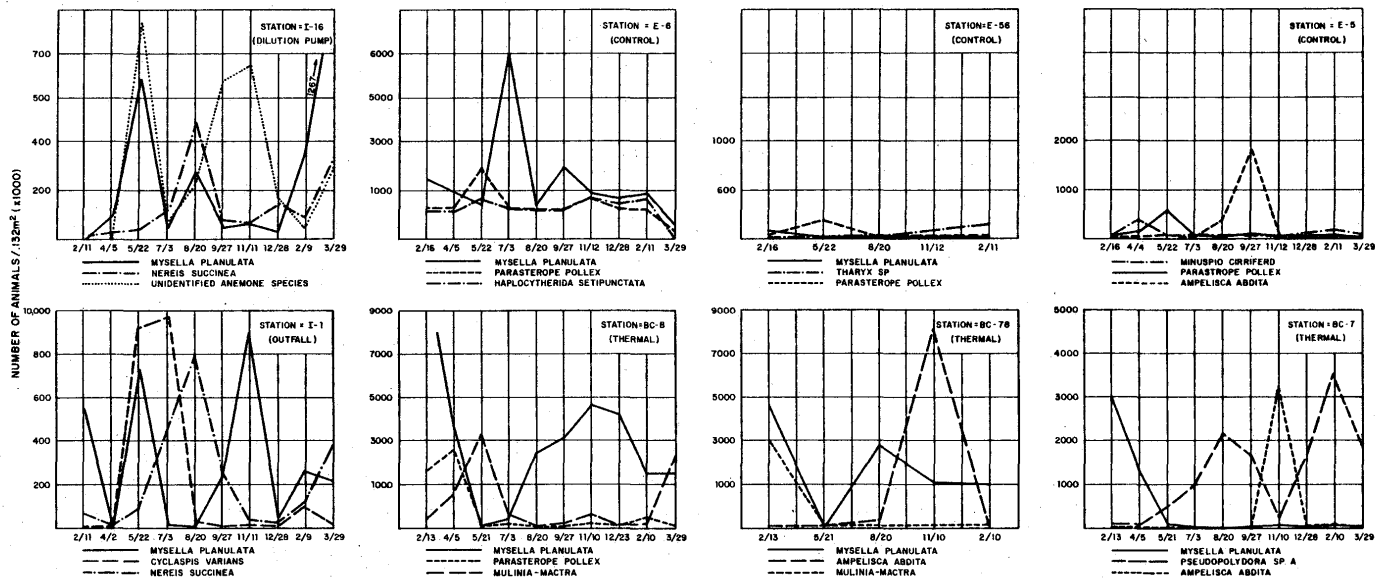
FIGURE 2.7-18
BENTHOS SAMPLING STATIONS
BIG BEND STATION
TAMPA ELECTRIC COMPANY

SOURCE: Adapted from Appendix to
316 Demonstration, Volume III, page 4-10.



SOURCE: TECO, 1977c pp. 4-71, 4-72, 4-77, 4-79

FIGURE 2.7-19
DENSITY OF BENTHIC ORGANISMS
COLLECTED AT SELECTED
STATIONS, 1976 - 1977
BIG BEND STATION
TAMPA ELECTRIC COMPANY



SOURCE: TECO, 1977c pp. 4-66, 4-68, 4-69, 4-70
Mahadevan, S. and J. Cutler. 1978 pp. 54-63

FIGURE 2.7 - 20
DENSITY OF BENTHIC ORGANISMS
COLLECTED AT SELECTED
STATIONS, 1976 - 1977
BIG BEND STATION
TAMPA ELECTRIC COMPANY

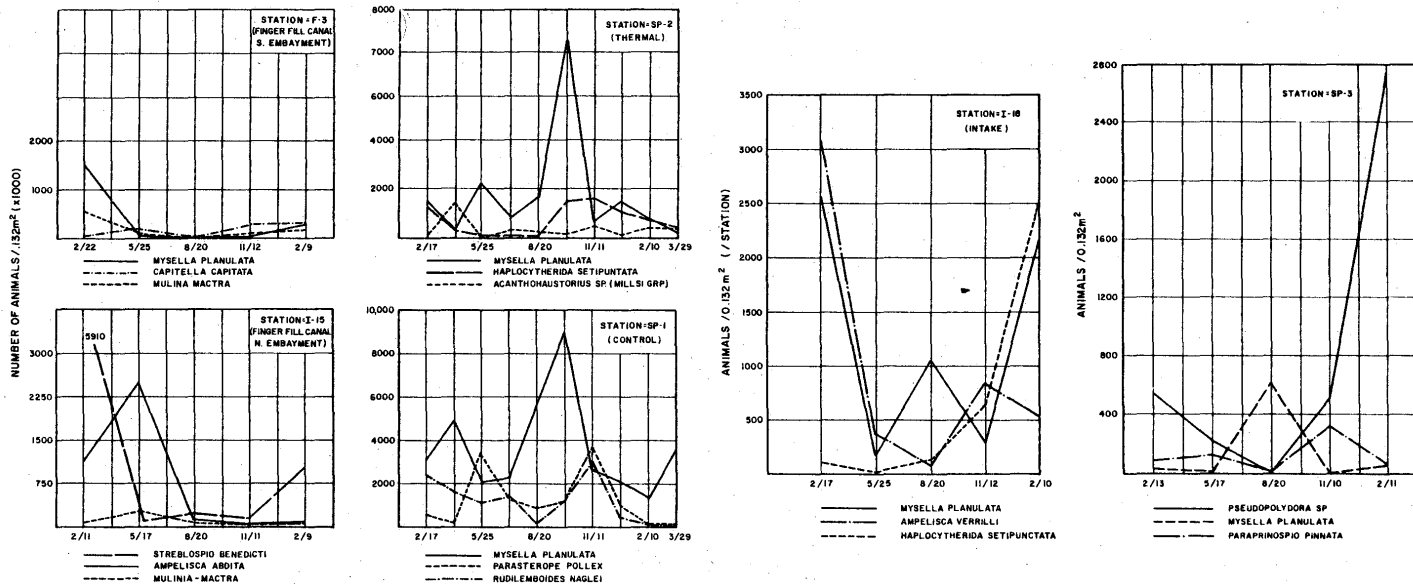
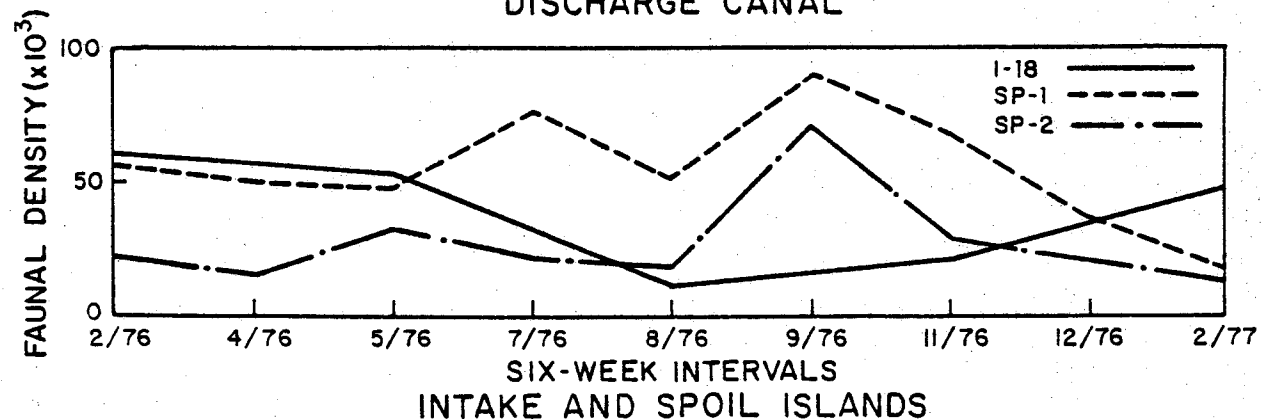
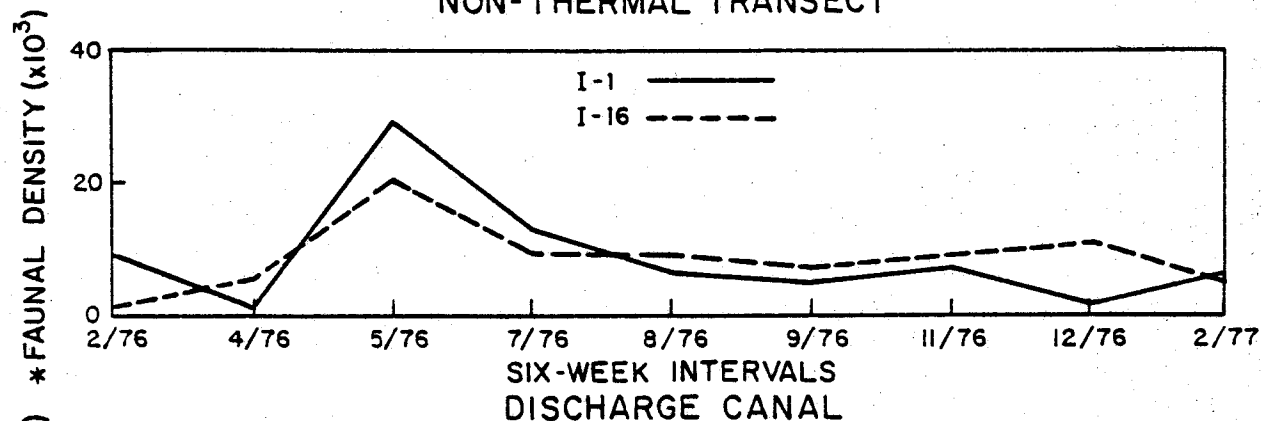
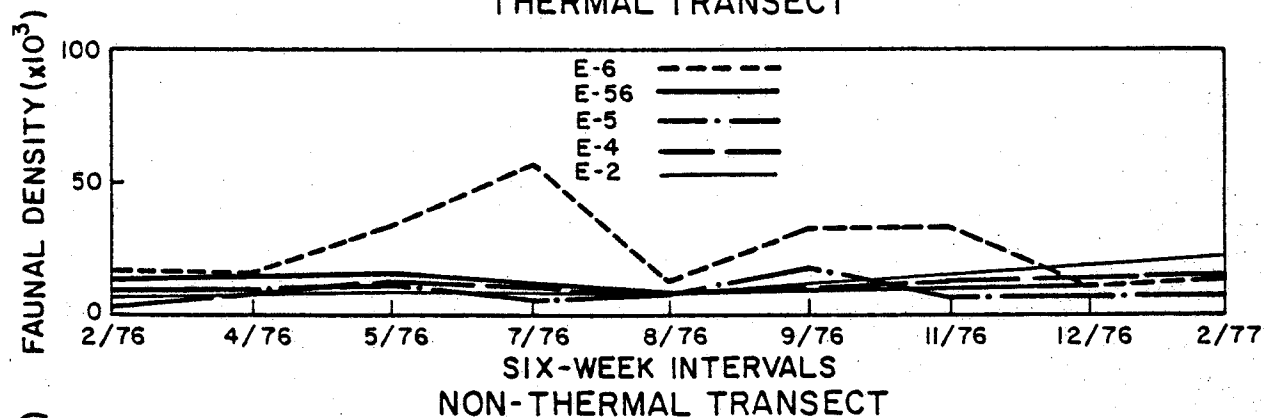
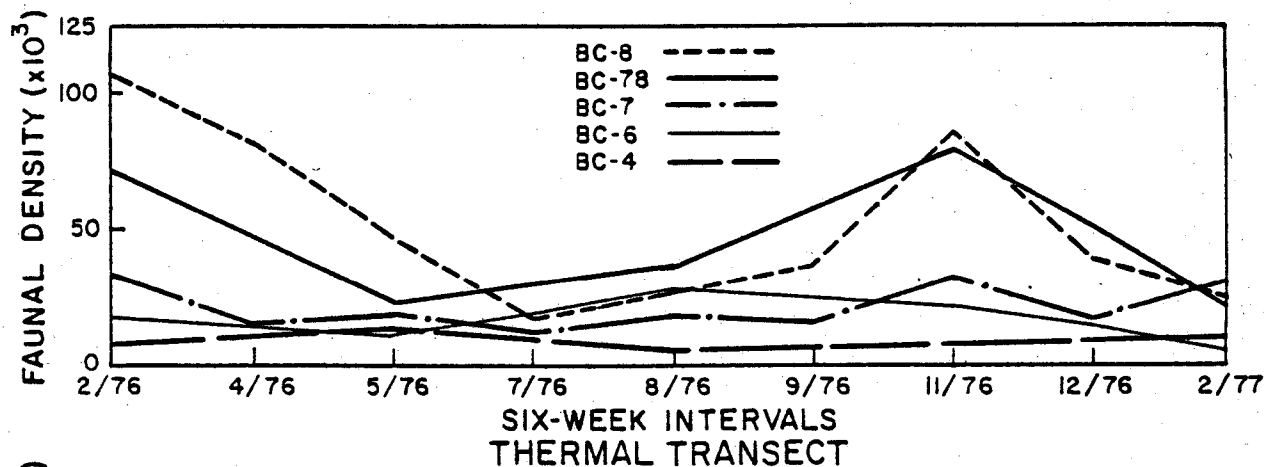


FIGURE 2.7-21
DENSITY OF BENTHIC ORGANISMS
COLLECTED AT SELECTED
STATIONS, 1976-1977
BIG BEND STATION
TAMPA ELECTRIC COMPANY

SOURCE: TECO, 1977c pp. 4-80, 4-82, 4-84, 4-321
Mahadevan, S. and J. Culter, 1978 pp. 64-66



NOTE

* SCALE DIFFERENT FOR
PURPOSE OF CLARITY

FIGURE 2.7-22
TEMPORAL PATTERNS IN FAUNAL DENSITY
AT SELECTED STATIONS
BIG BEND STATION
TAMPA ELECTRIC COMPANY

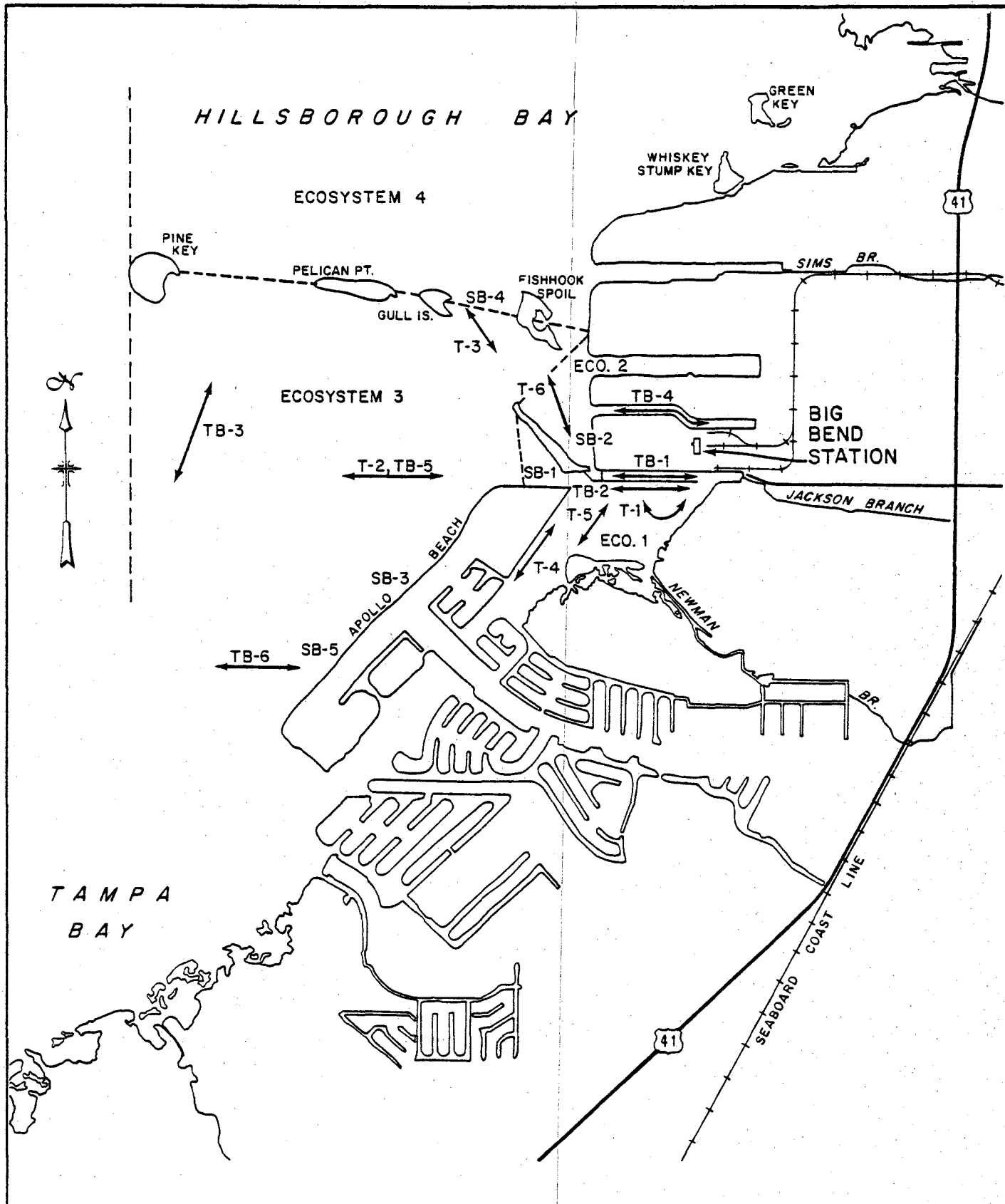
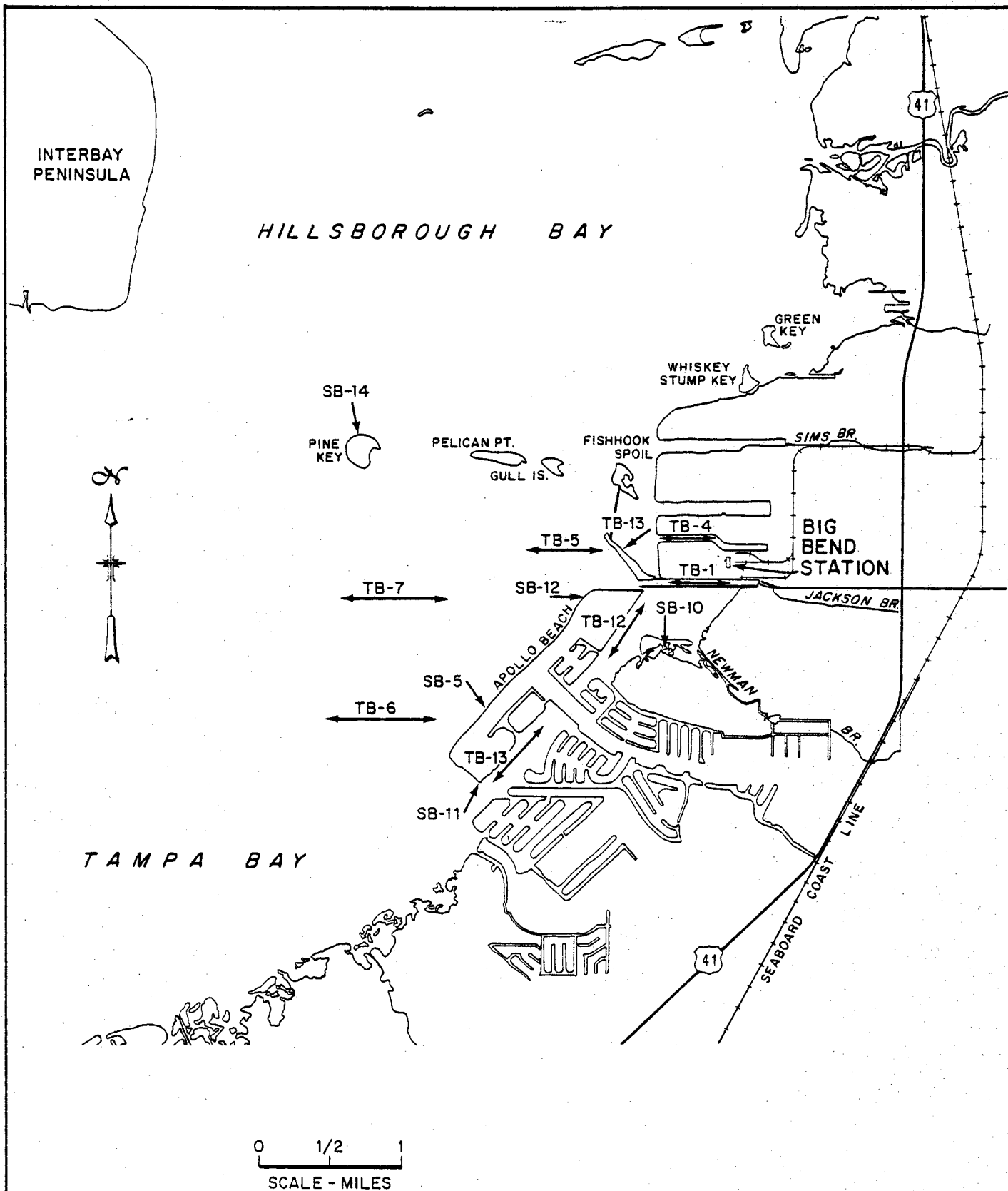


FIGURE 2.7 - 23
 TRAWL AND SEINE STATIONS
 1970-1975
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY

SOURCE: Ecological Surveys of the Big Bend Area;
 Five Year Data Summary TECO, 1975 page 312.



LEGEND

TB - TRAWL STATION
SB - SEINE STATION

FIGURE 2.7-24
TRAWL AND SEINE STATIONS
1976-1977
BIG BEND STATION
TAMPA ELECTRIC COMPANY

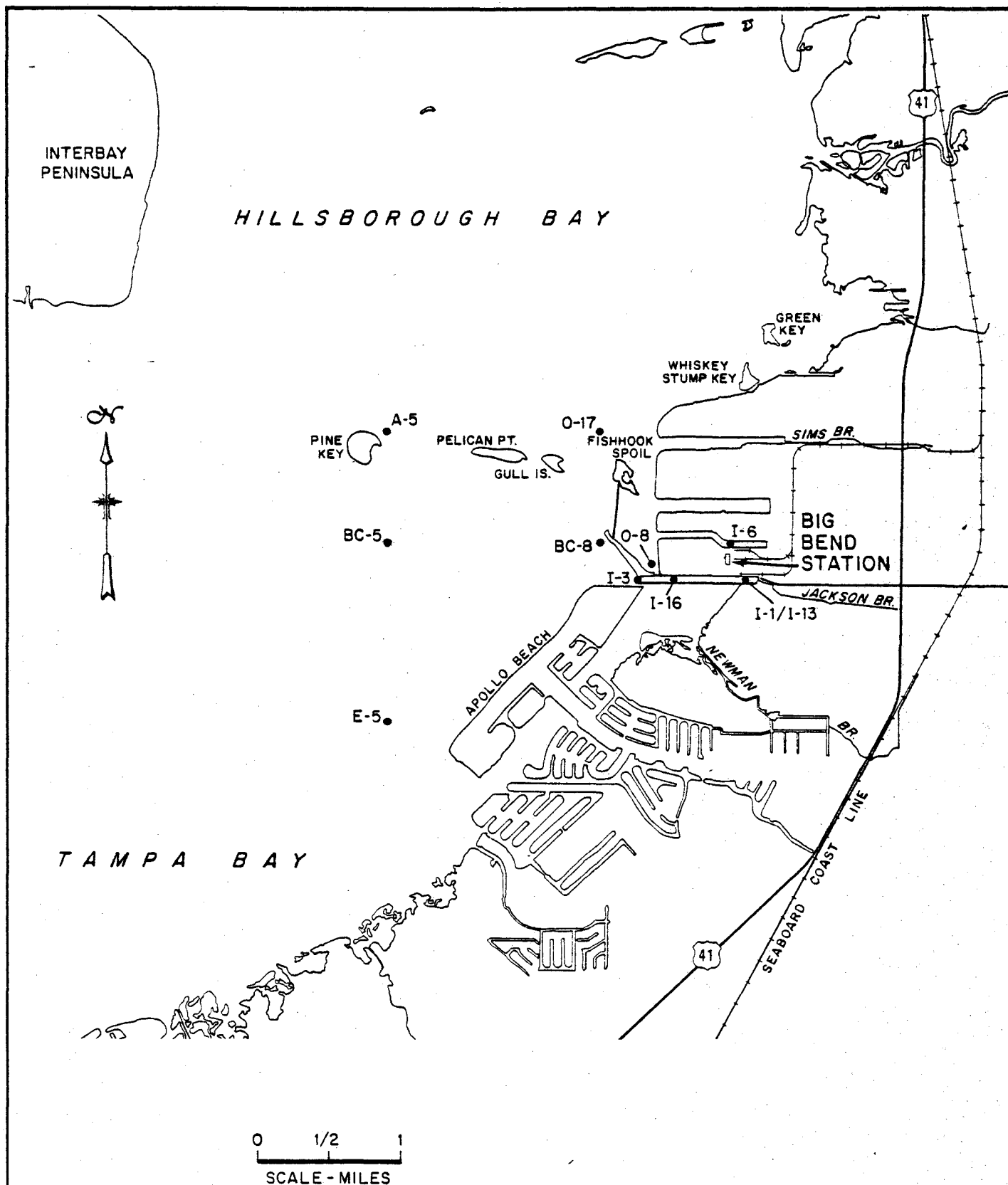


FIGURE 2.7-25
 ICHTHYOPLANKTON
 SAMPLING STATIONS
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY

SOURCE: Adapted from Appendix to
 316 Demonstration, Volume III, TECO, 1977d, page 5-12.

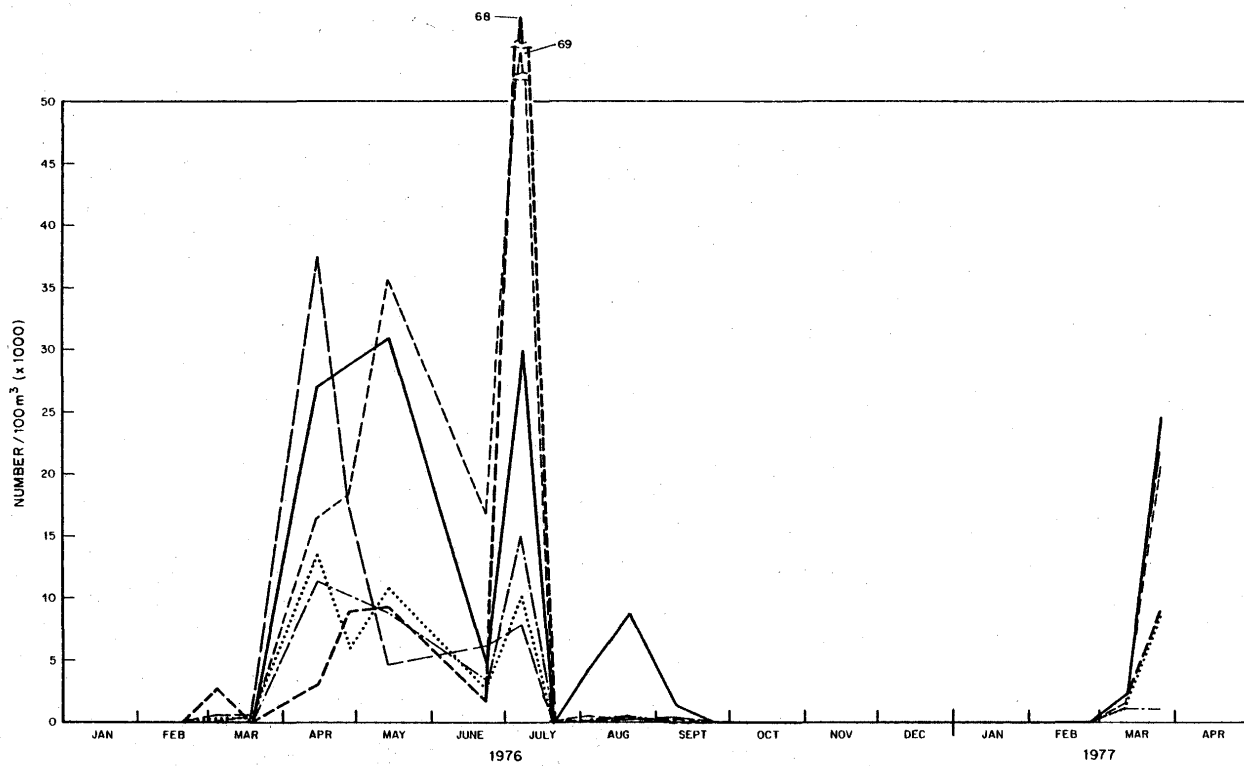
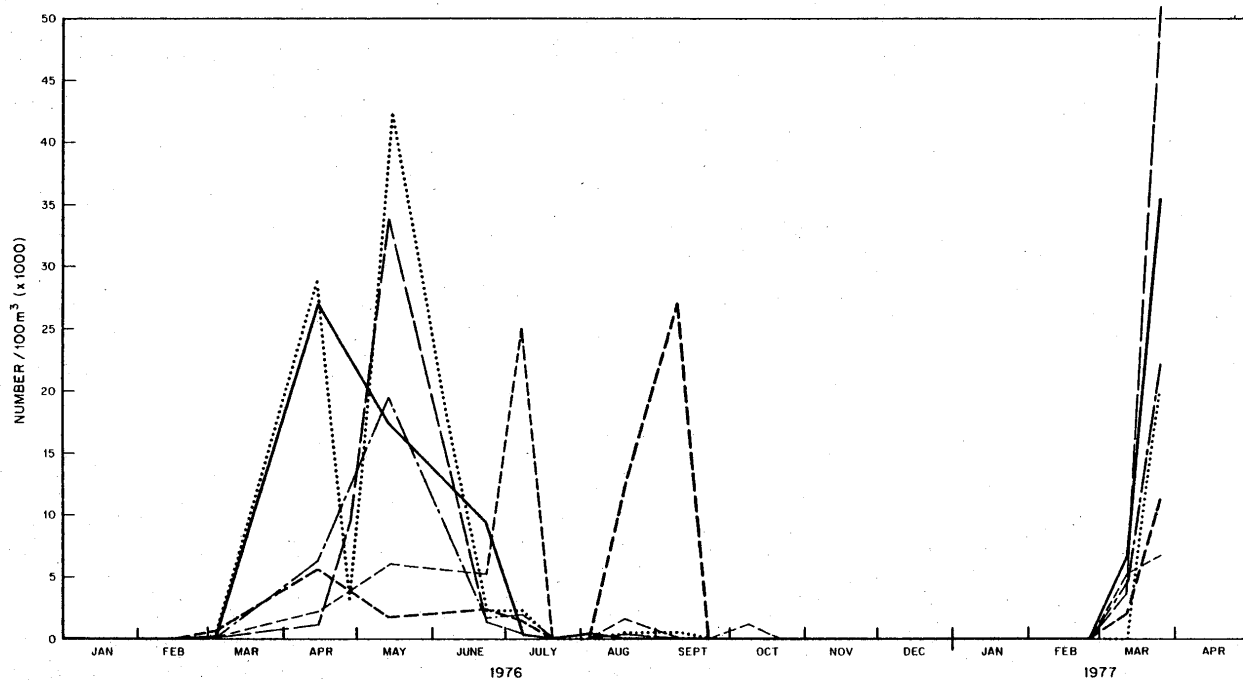


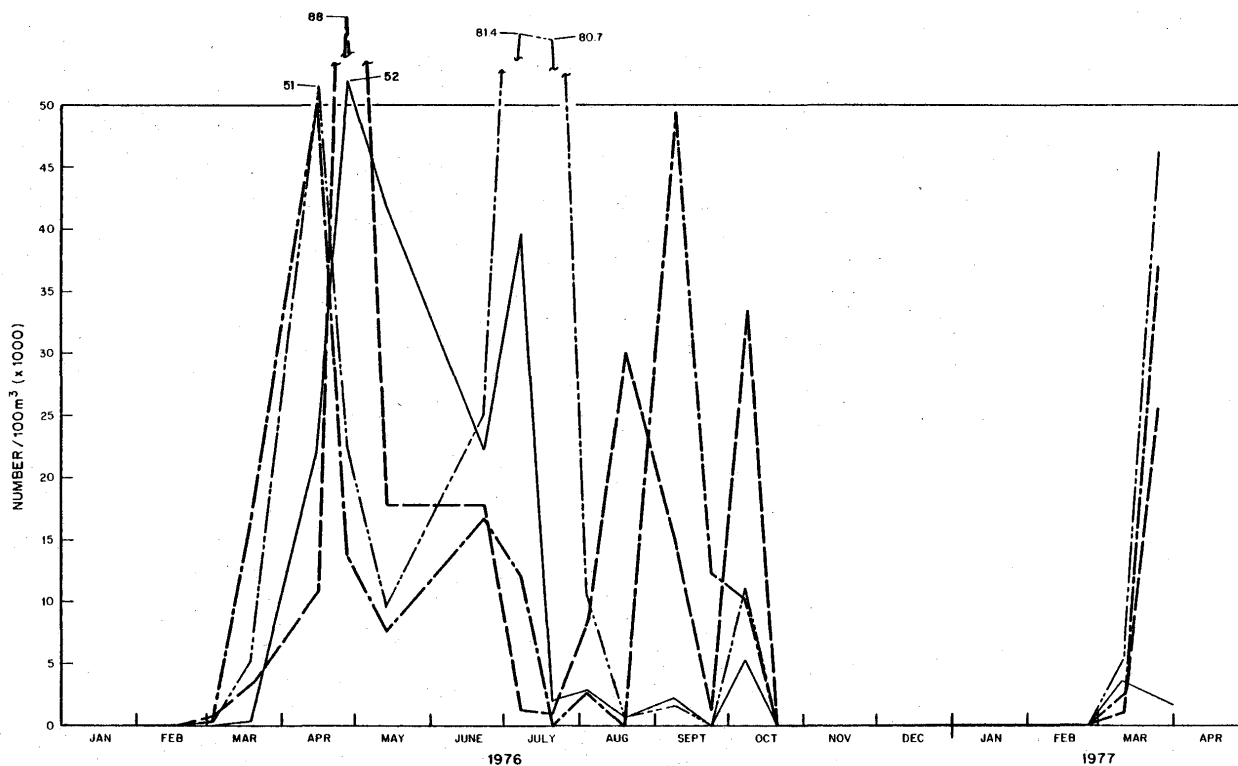
FIGURE 2.7-26
DENSITY OF *ANCHOA MITCHILLI* EGGS
INSHORE STATIONS - DAY
BIG BEND STATION
TAMPA ELECTRIC COMPANY



LEGEND

—— 0-8	—— 1-16
---- 1-6	 1-3
—— 1-1/1-13	-.-.-.- BC-8

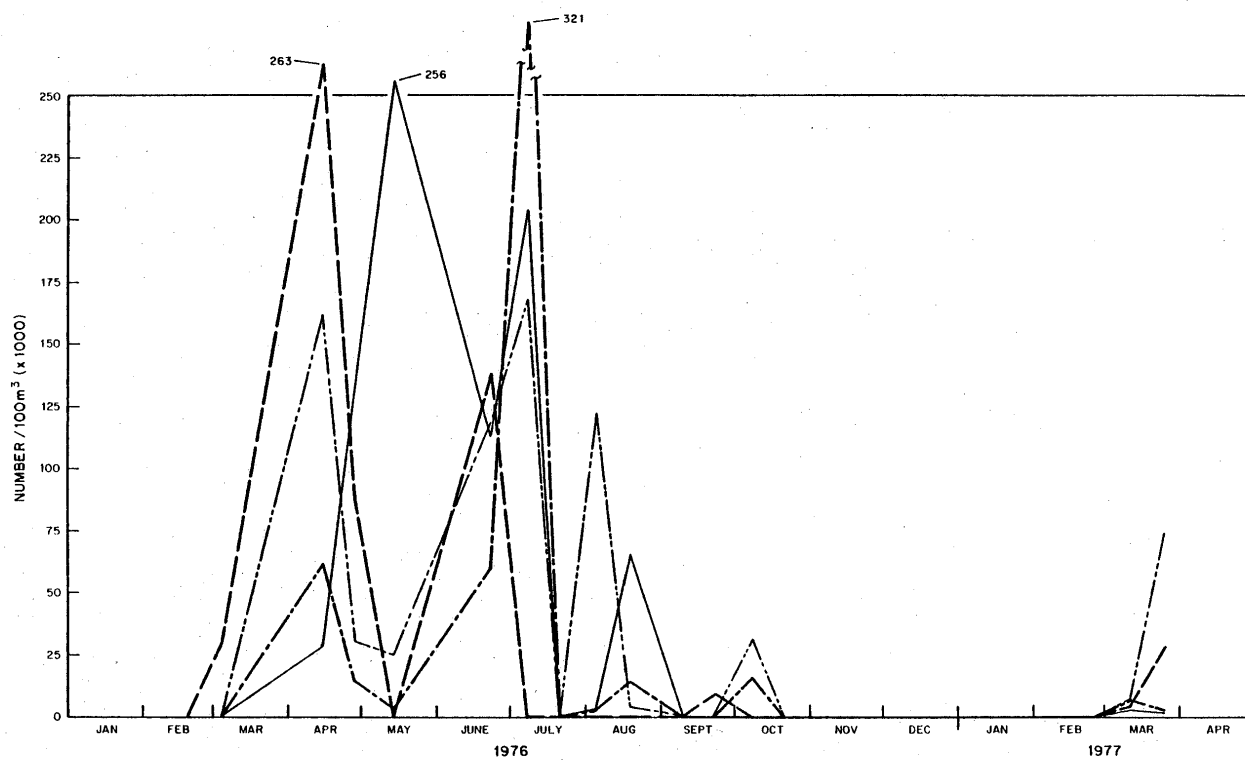
FIGURE 2.7-27
DENSITY OF *ANCHOA MICHILLI* EGGS
INSHORE STATIONS-NIGHT
BIG BEND STATION
TAMPA ELECTRIC COMPANY



LEGEND

- O-17
- - - A-5
- BC-5
- E-5

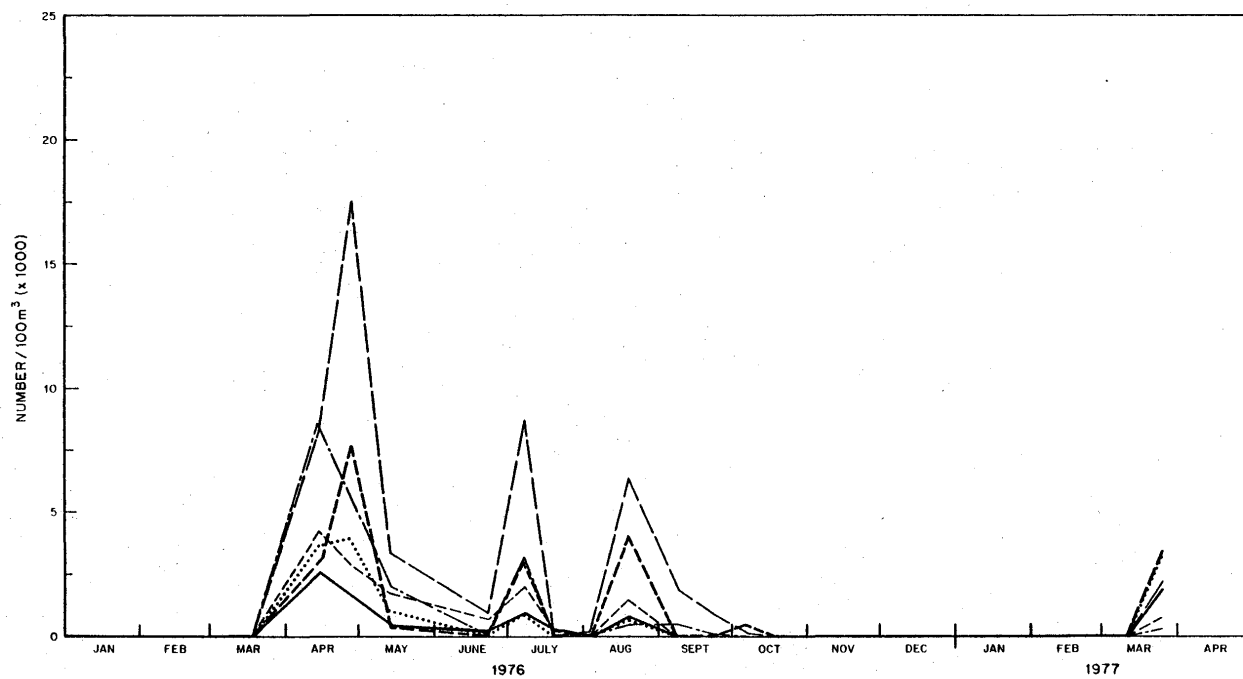
FIGURE 2.7-28
DENSITY OF *ANCHOA MICHILLI* EGGS
OFFSHORE STATIONS-DAY
BIG BEND STATION
TAMPA ELECTRIC COMPANY



LEGEND

- O-17
- - - A-5
- BC-5
- E-5

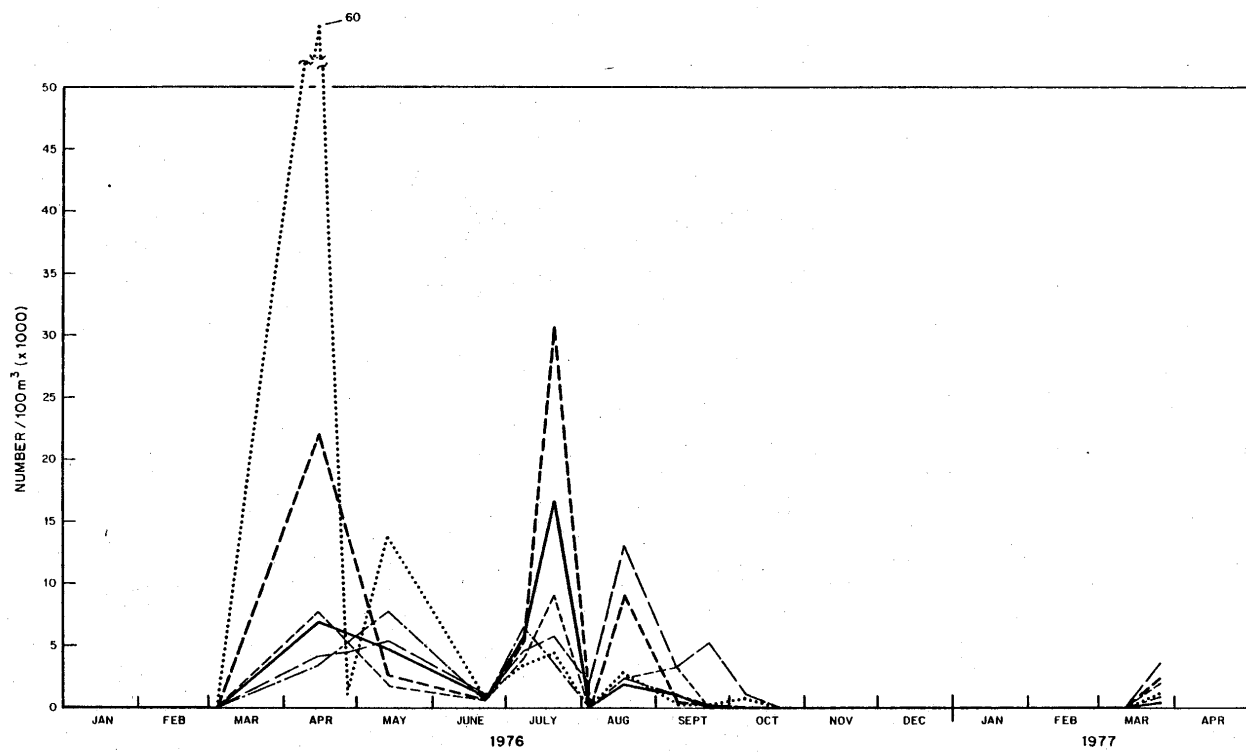
FIGURE 2.7-29
DENSITY OF *ANCHOA MICHILLI* EGGS
OFFSHORE STATIONS - NIGHT
BIG BEND STATION
TAMPA ELECTRIC COMPANY



LEGEND

— O-8	— I-16
- - - I-6	 I-3
— I-1/1-13	- . - . - BC-8

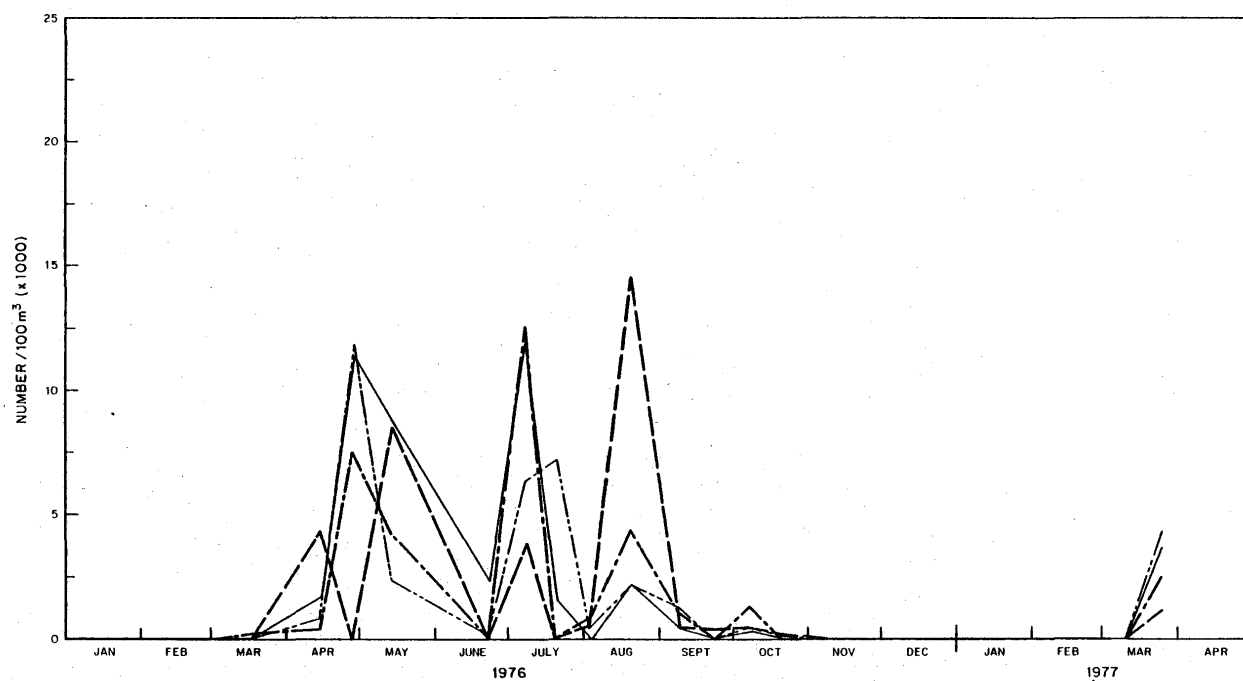
FIGURE 2.7-30
DENSITY OF *ANCHOA MICHILLI* LARVAE
INSHORE STATIONS-DAY
BIG BEND STATION
TAMPA ELECTRIC COMPANY



LEGEND

— 0-8	— 1-16
- - - 1-6	 1-3
- · - 1-1/1-13	- - - BC-8

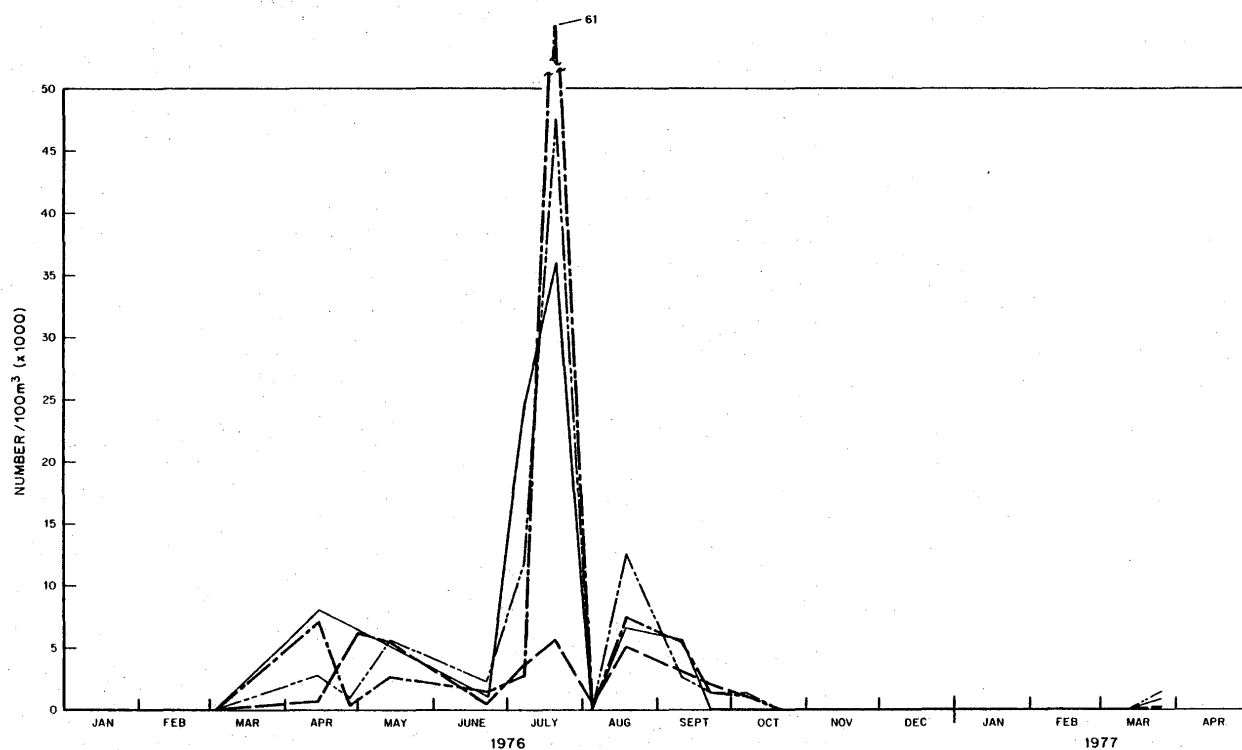
FIGURE 2.7-31
DENSITY OF *ANCHOA MICHILLI* LARVAE
INSHORE STATIONS-NIGHT
BIG BEND STATION
TAMPA ELECTRIC COMPANY



LEGEND

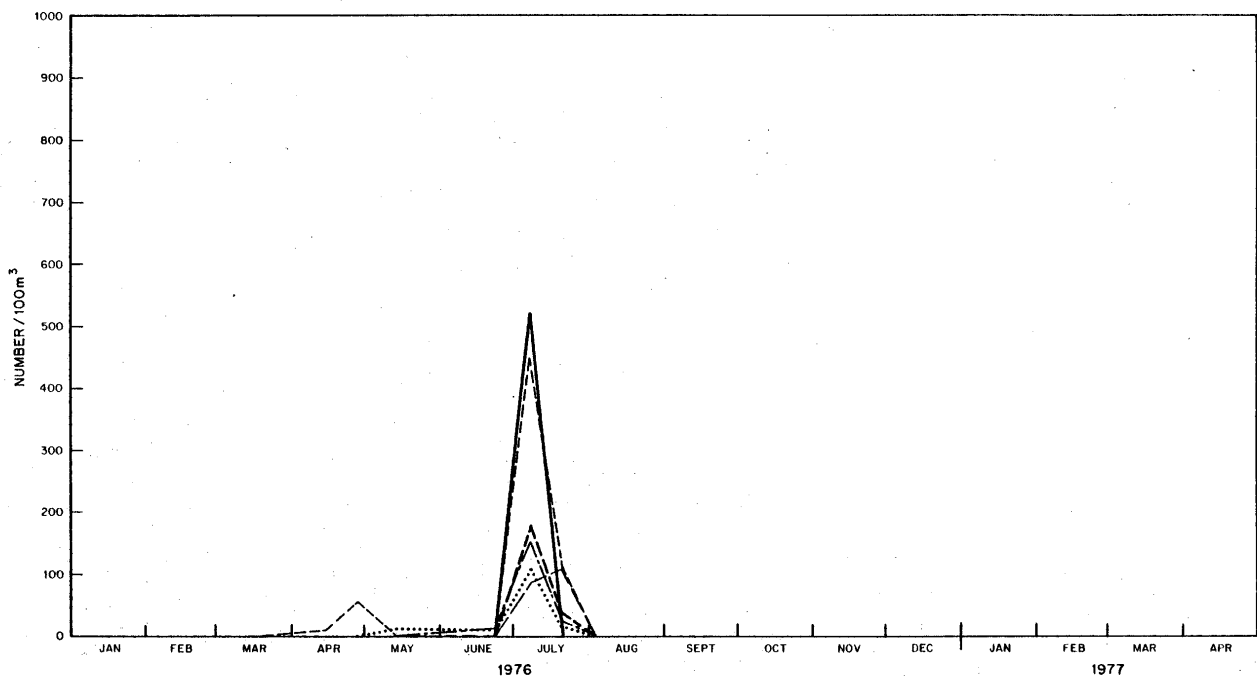
— O-17
 - - A-5
 - · - BC-5
 - - E-5

FIGURE 2.7-32
 DENSITY OF *ANCHOA MICHILLI* LARVAE
 OFFSHORE STATIONS-DAY
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY



LEGEND
 O-17
 A-5
 BC-5
 E-5

FIGURE 2.7-33
 DENSITY OF *ANCHOA MICHILLI* LARVAE
 OFFSHORE STATIONS - NIGHT
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY



LEGEND

— 0-8	— I-16
- - - I-6	 I-3
— I-1/1-13	- - - BC-8

FIGURE 2.7-34
DENSITY OF
HARENGULA JAGUANA EGGS
INSHORE STATIONS-DAY
BIG BEND STATION
TAMPA ELECTRIC COMPANY

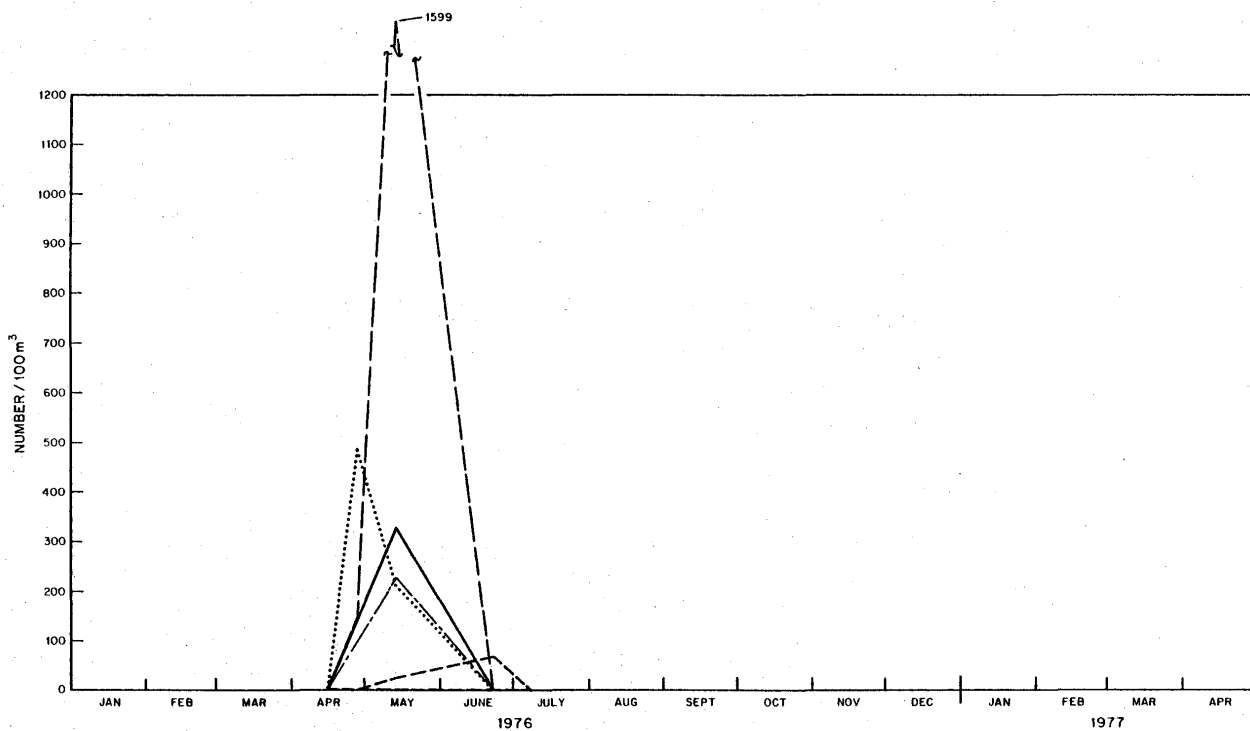
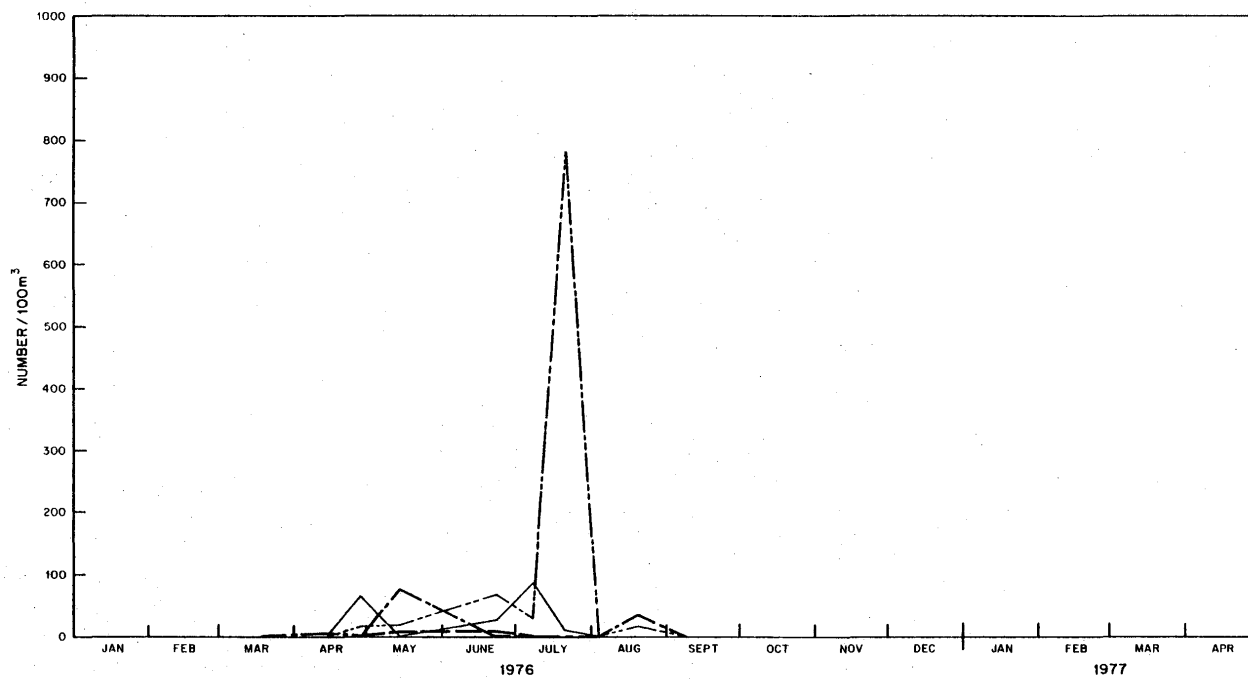
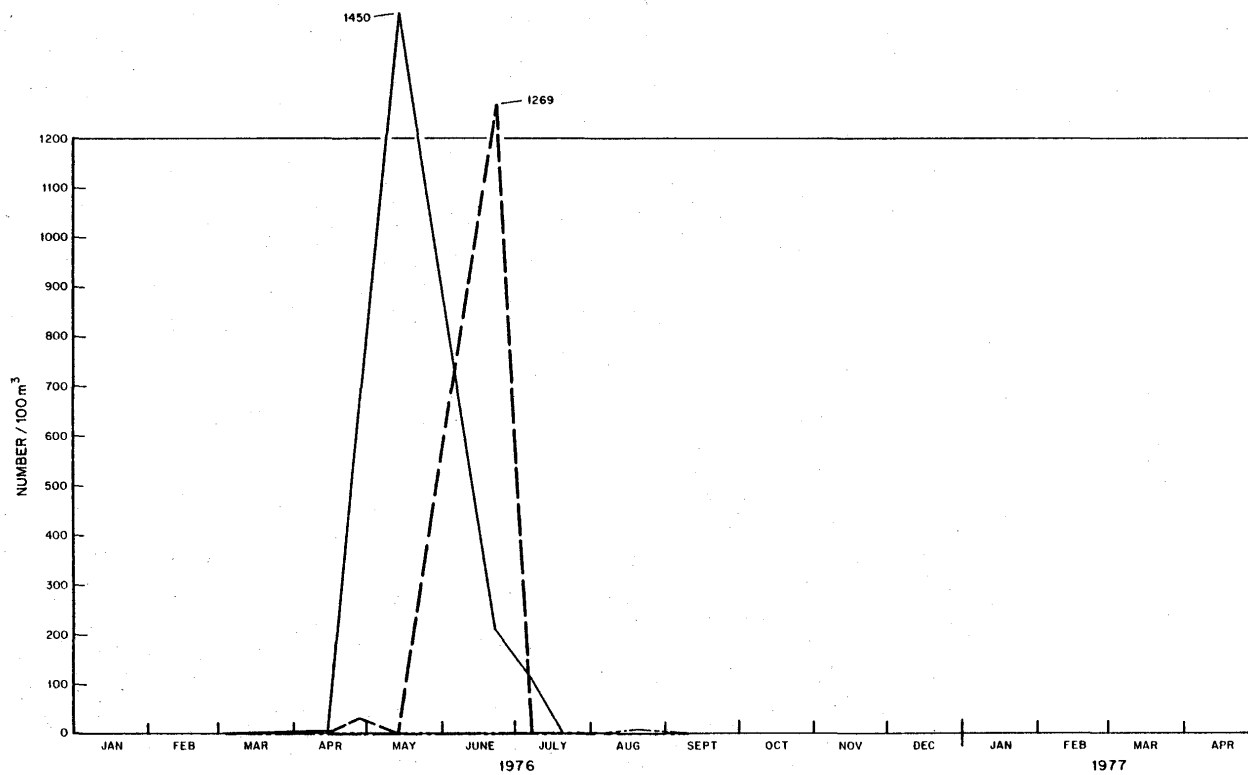


FIGURE 2.7-35
DENSITY OF
HARENGULA JAGUANA EGGS
INSHORE STATIONS-NIGHT
BIG BEND STATION
TAMPA ELECTRIC COMPANY



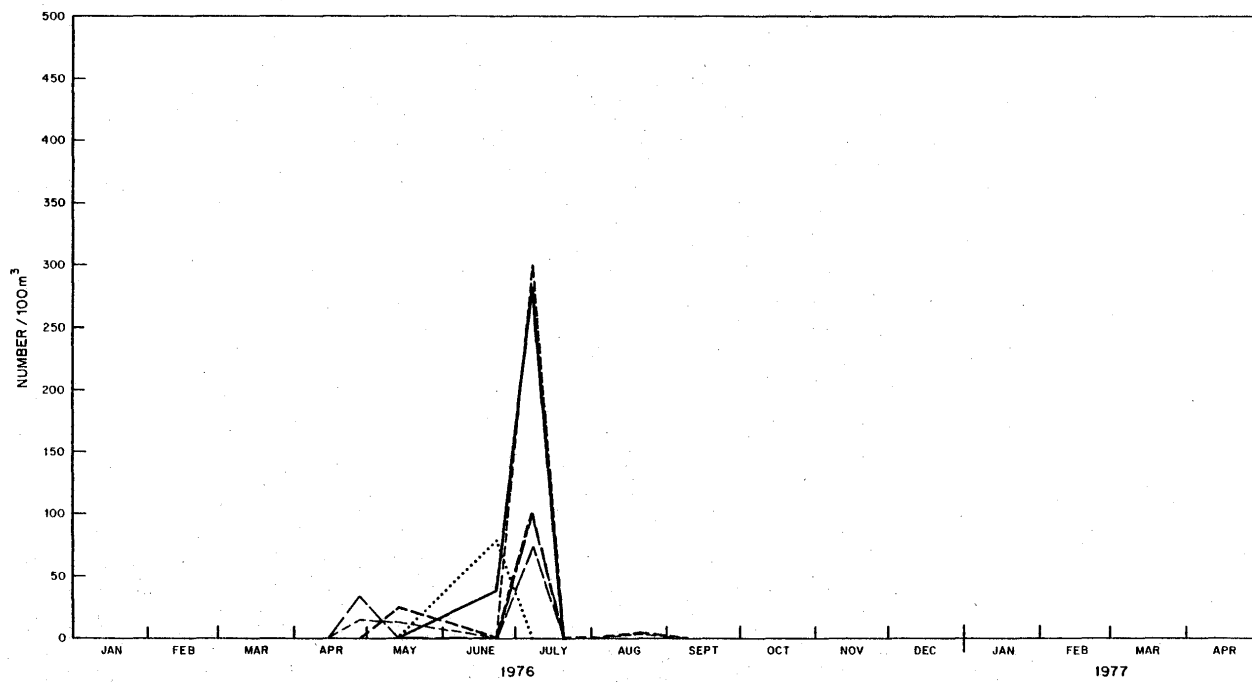
LEGEND
 — O-17
 - - - A-5
 — BC-5
 — E-5

FIGURE 2.7-36
 DENSITY OF
HARENGULA JAGUANA EGGS
 OFFSHORE STATIONS-DAY
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY



LEGEND
 — O-17
 - - - A-5
 - - - BC-5
 - . - E-5

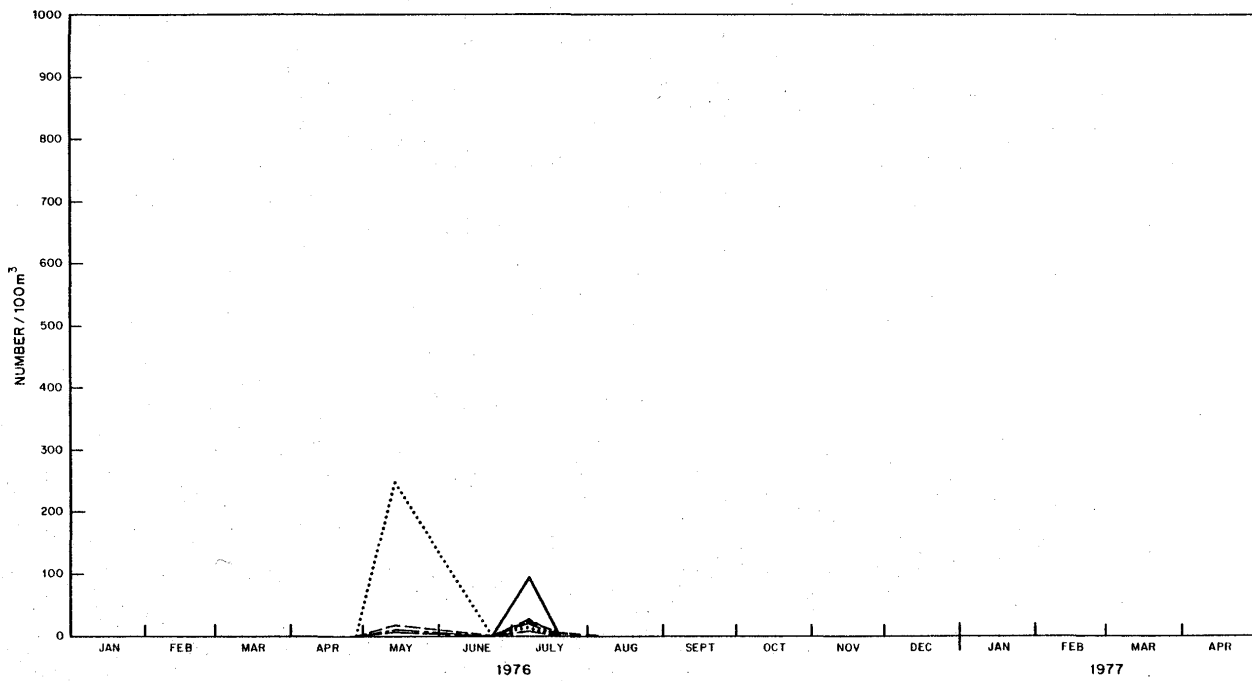
FIGURE 2.7-37
 DENSITY OF
HARENGULA JAGUANA EGGS
 OFFSHORE STATIONS-NIGHT
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY



LEGEND

— 0-8
 - - 1-6
 — 1-1/1-13
 — 1-16
 1-3
 - - - - - BC-8

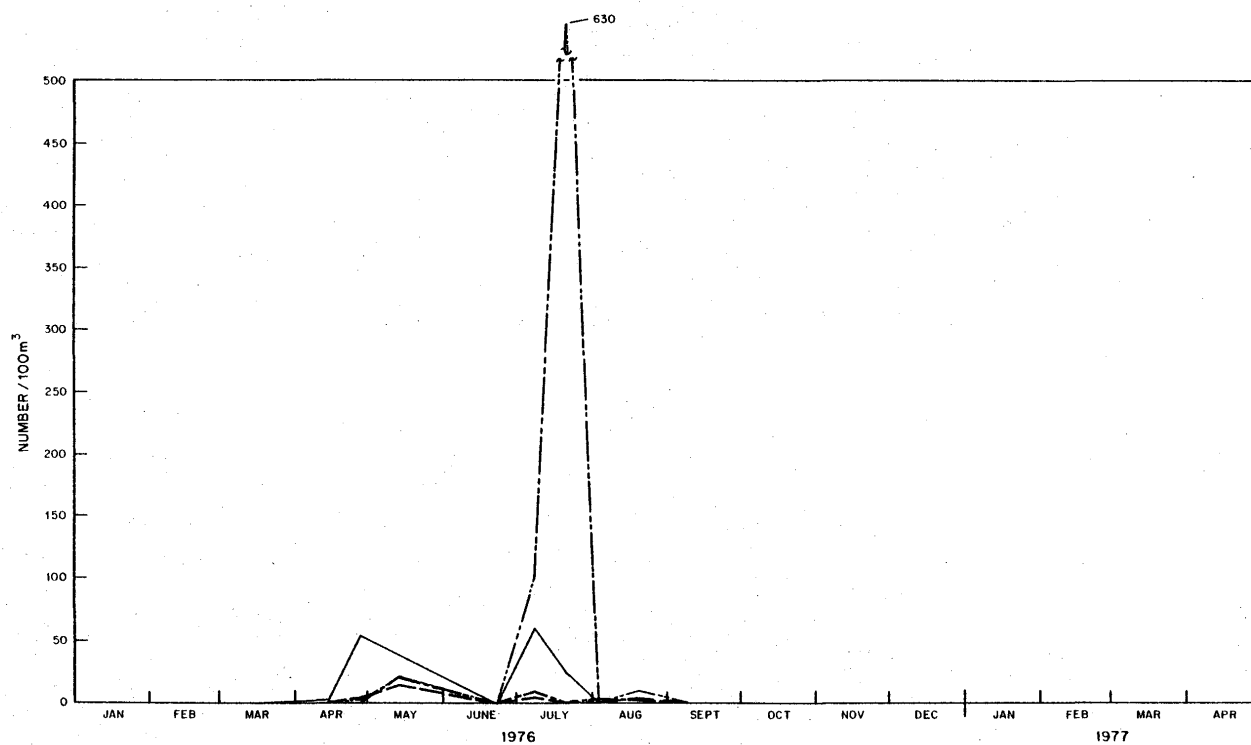
FIGURE 2.7-38
 DENSITY OF
HARENGULA JAGUANA LARVAE
 INSHORE STATIONS-DAY
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY



LEGEND

——— 0-8	——— 1-16
----- 1-6	 I-3
----- 1-1/1-13	----- BC-8

FIGURE 2.7-39
DENSITY OF
HARENGULA JAGUANA LARVAE
INSHORE STATIONS-NIGHT
BIG BEND STATION
TAMPA ELECTRIC COMPANY



LEGEND

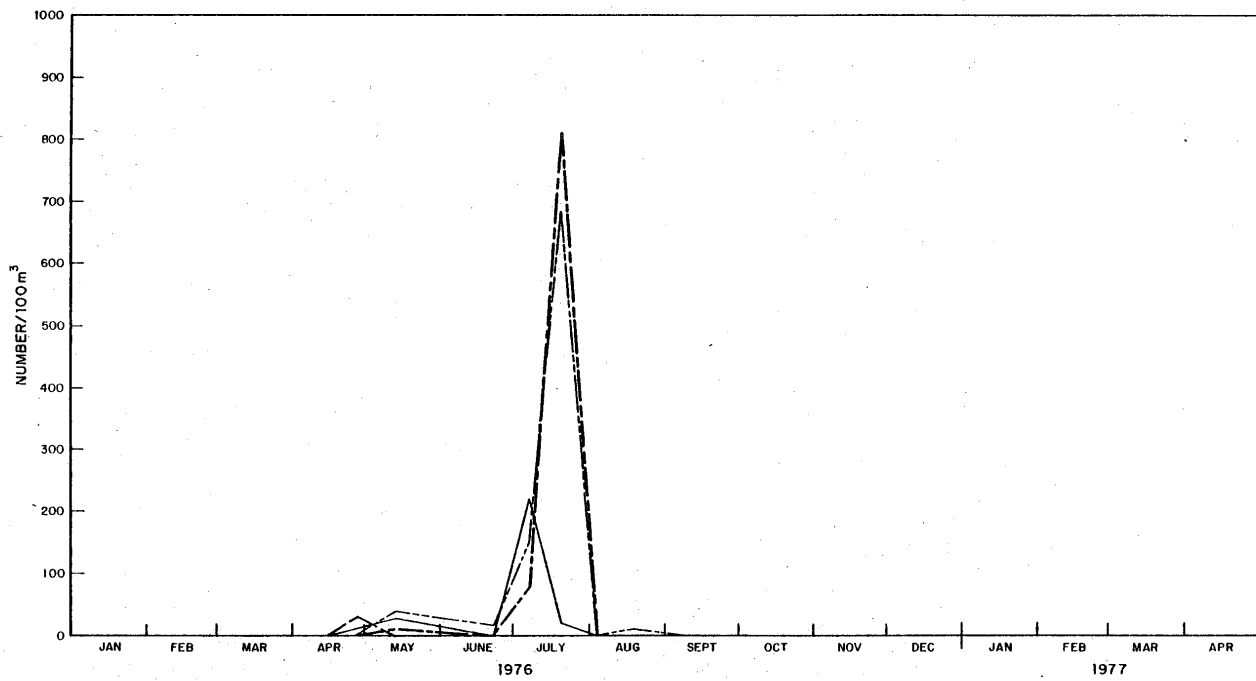
— O-17

— A-5

— BC-5

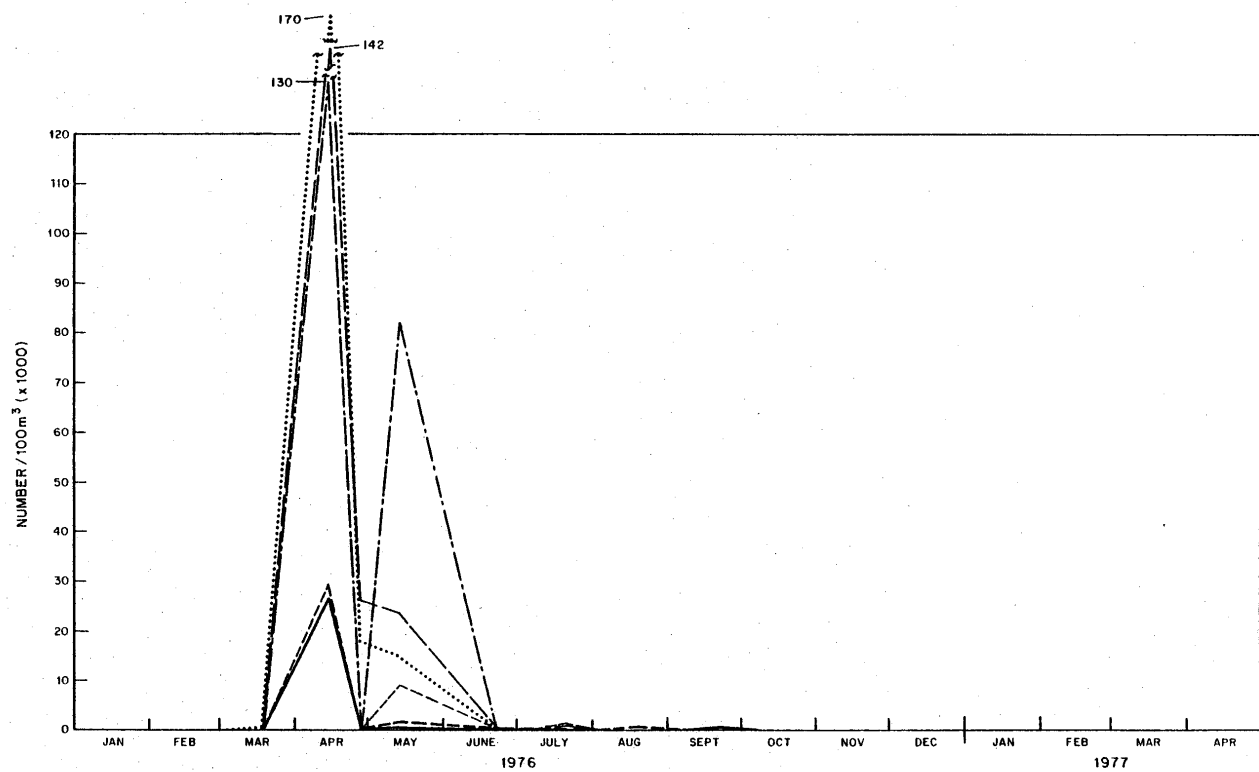
— E-5

FIGURE 2.7-40
DENSITY OF
HARENGULA JAGUANA LARVAE
OFFSHORE STATIONS-DAY
BIG BEND STATION
TAMPA ELECTRIC COMPANY



LEGEND
 O-17
 A-5
 BC-5
 E-5

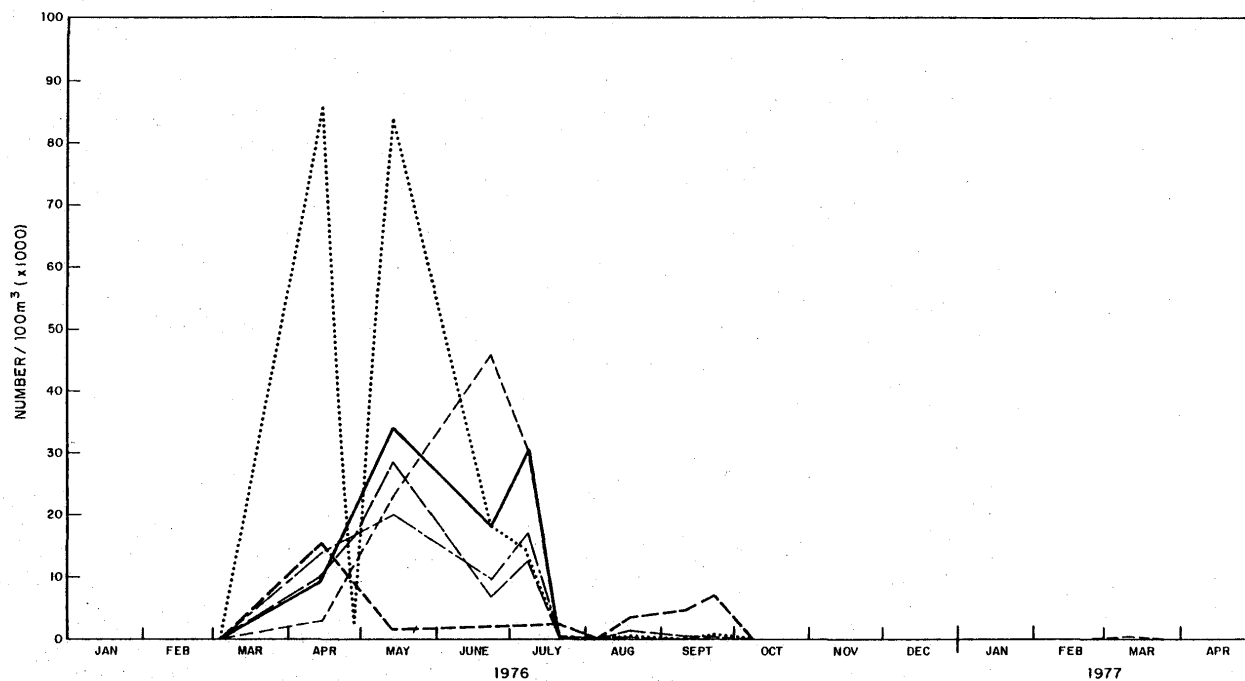
FIGURE 2.7-41
 DENSITY OF
HARENGULA JAGUANA LARVAE
 OFFSHORE STATIONS-NIGHT
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY



LEGEND

— 0-8	— 1-16
- - - 1-6	... 1-3
- - - 1-1/1-13	- . - 8C-8

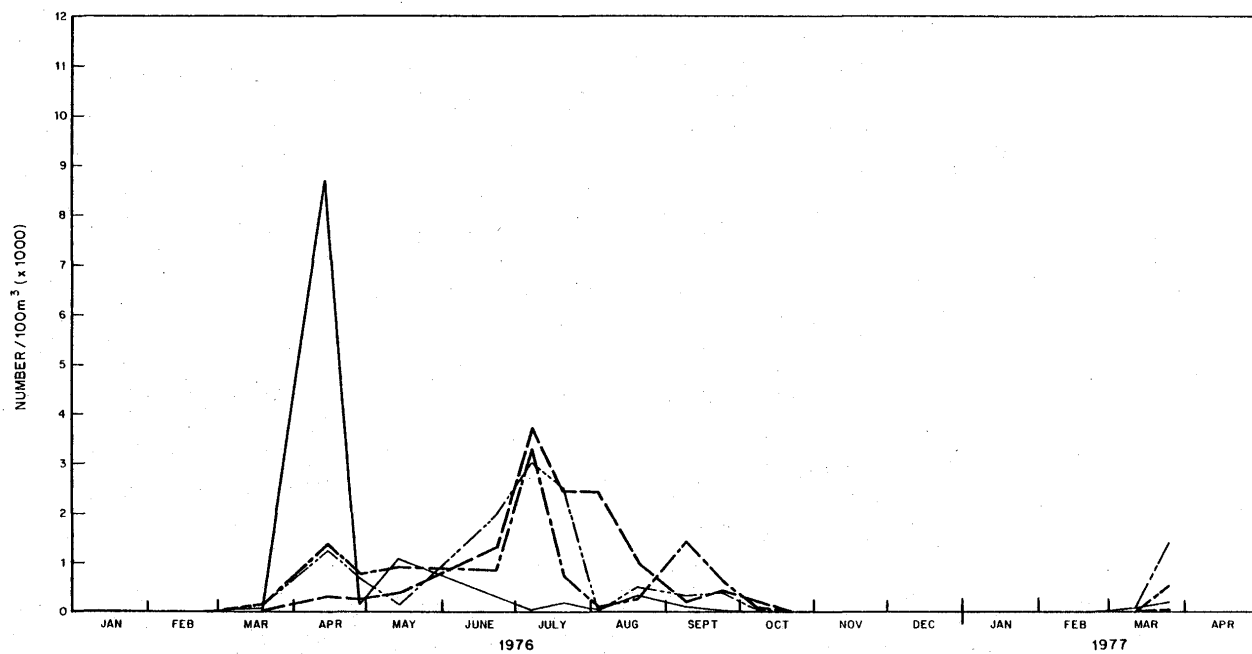
FIGURE 2.7-42
DENSITY OF *SCIAENID* SPP. EGGS
INSHORE STATIONS-DAY
BIG BEND STATION
TAMPA ELECTRIC COMPANY



LEGEND

— 0-8	- · - I-16
- - - I-6	····· I-3
- - - I-1/I-13	- - - BC-8

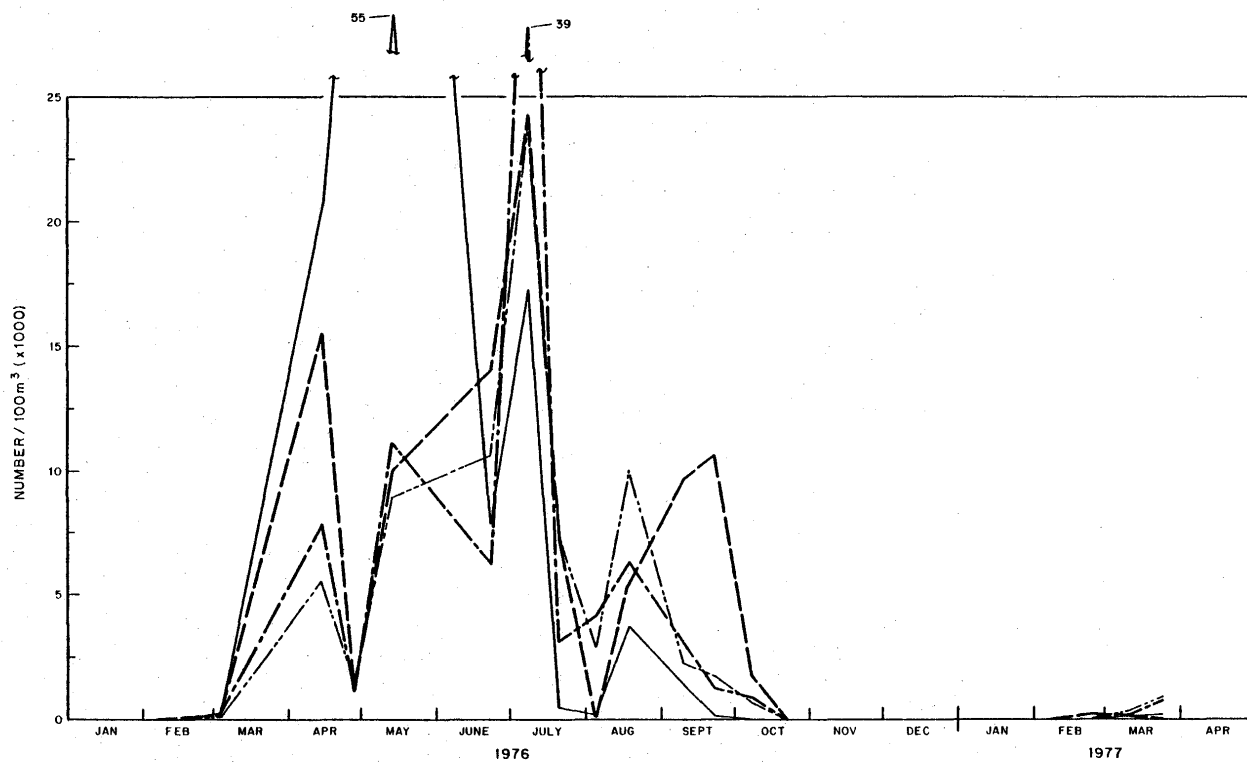
FIGURE 2.7-43
DENSITY OF *SCIAENID* SPP. EGGS
INSHORE STATIONS - NIGHT
BIG BEND STATION
TAMPA ELECTRIC COMPANY



LEGEND

— O-17
 - - - A-5
 - · - BC-5
 — E-5

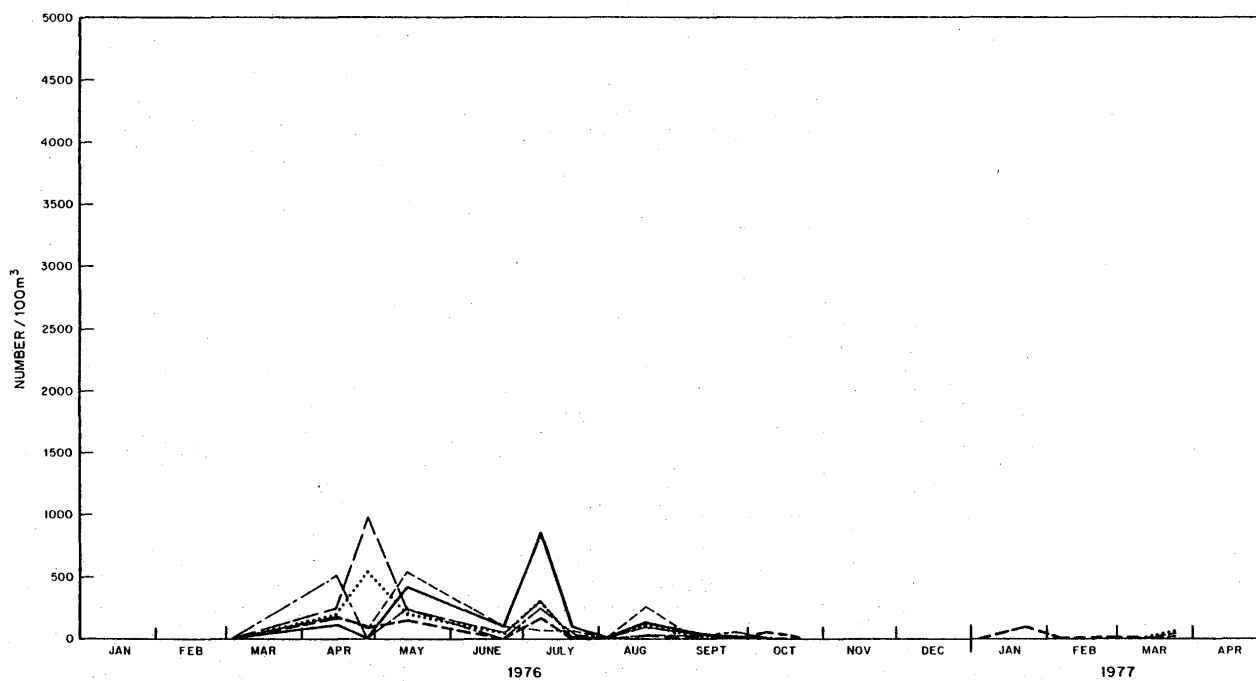
FIGURE 2.7-44
 DENSITY OF *SCIAENID* SPP. EGGS
 OFFSHORE STATIONS-DAY
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY



LEGEND

— O-17
 - - - A-5
 — BC-5
 — E-5

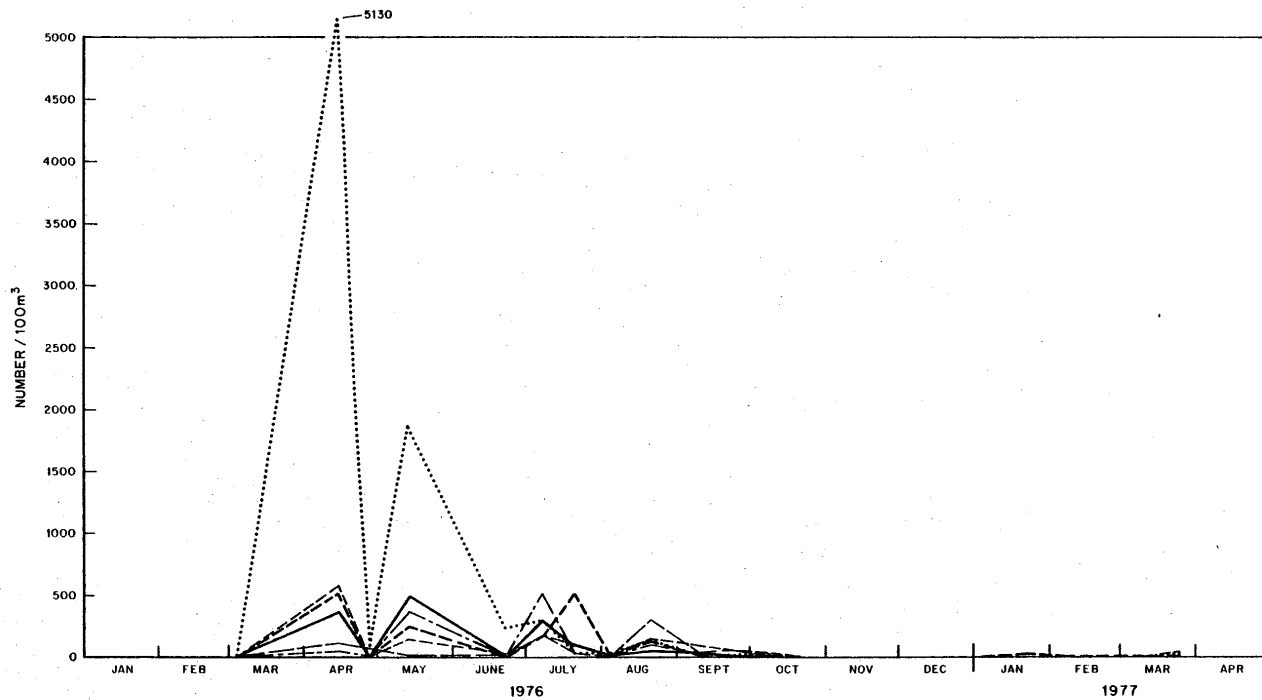
FIGURE 2.7-45
 DENSITY OF *SCIAENID* SPP. EGGS
 OFFSHORE STATIONS-NIGHT
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY



LEGEND

O-8
 I-6
 I-1/I-13
 I-16
 I-3
 BC-8

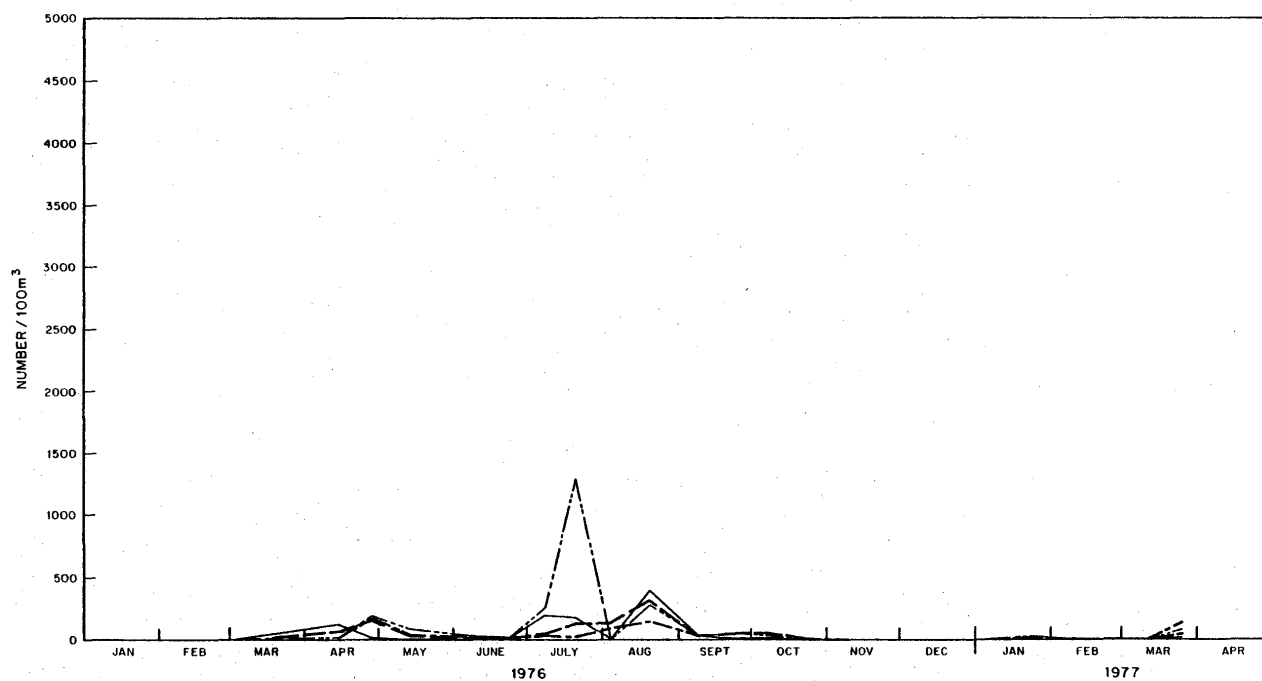
FIGURE 2.7-46
 DENSITY OF *SCIAENID* SPP. LARVAE
 INSHORE STATIONS-DAY
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY



LEGEND

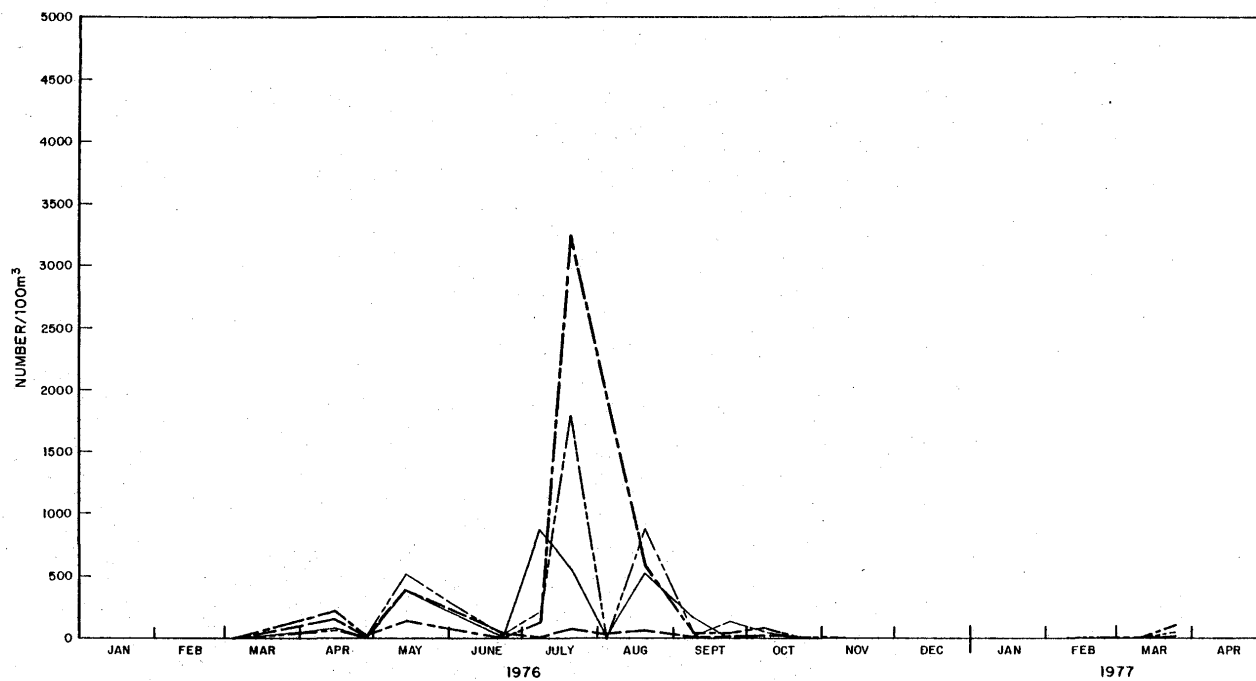
— 0-8
 - - - I-6
 — I-1/I-13
 — I-16
 I-3
 - - - BC-8

FIGURE 2.7-47
 DENSITY OF *SCIAENID* SPP. LARVAE
 INSHORE STATIONS - NIGHT
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY



LEGEND
 O-17
 A-5
 BC-5
 E-5

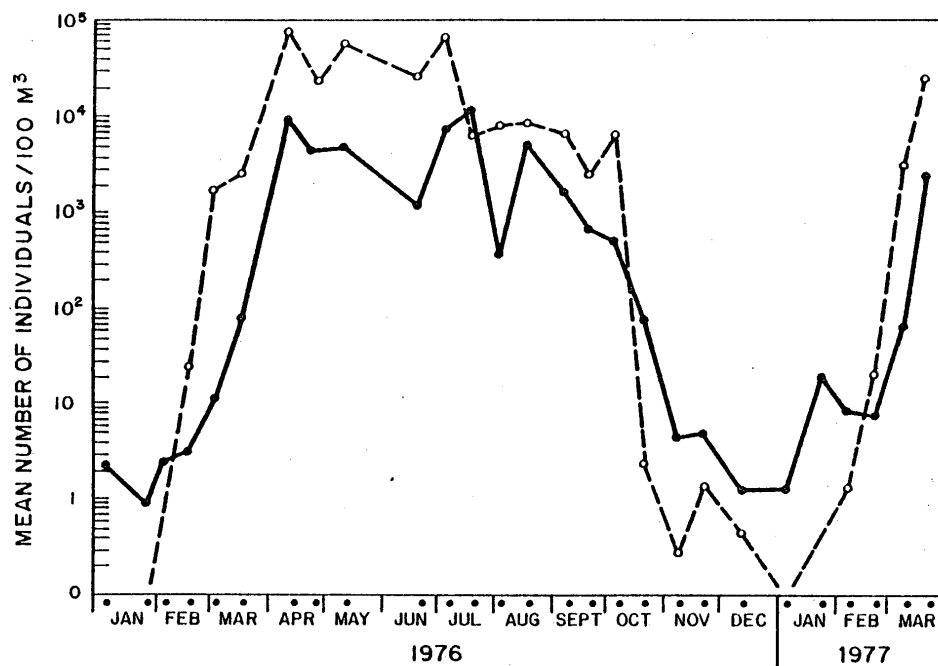
FIGURE 2.7-48
 DENSITY OF *SCIAENID* SPP. LARVAE
 OFFSHORE STATIONS - DAY
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY



LEGEND

— O-17
 - - A-5
 — BC-5
 — E-5

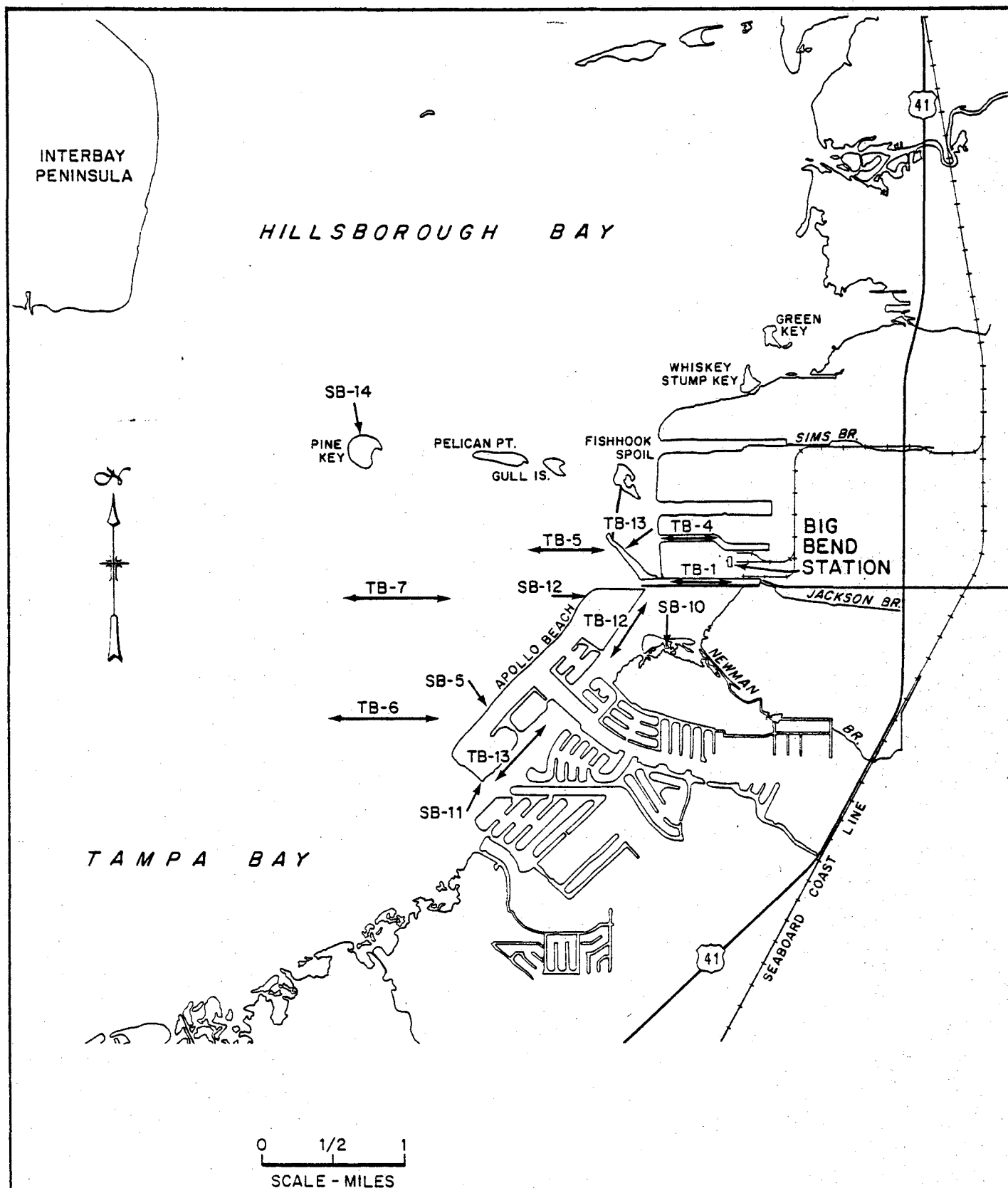
FIGURE 2.7-49
 DENSITY OF *SCIAENID* SPP. LARVAE
 OFFSHORE STATIONS-NIGHT
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY



LEGEND

- — — — ○ EGGS
- — — — ● LARVAE

FIGURE 2.7-50
SEASONAL ABUNDANCE OF
ICTHYOPLANKTON
JANUARY, 1976 - MARCH, 1977
BIG BEND STATION
TAMPA ELECTRIC COMPANY



LEGEND

TB - TRAWL STATION
SB - SEINE STATION

FIGURE 2.7-51
TRAWL AND SEINE STATIONS
1976-1977
BIG BEND STATION
TAMPA ELECTRIC COMPANY

2.8 AMBIENT AIR

2.8.1 General

Prior to construction of Big Bend Unit 4, federal and state approvals must be obtained. These include air pollution source construction permits in which the source applicant is required to demonstrate compliance with applicable air quality regulations prior to permit issuance. These air quality regulations include both Prevention of Significant Deterioration (PSD) for the state of Florida and the U.S. Environmental Protection Agency (EPA) and any applicable regulations dealing with nonattainment areas. Ambient Air Quality Standards (AAQS), control technology review, including Best Available Control Technology (BACT) demonstration, PSD allowable increments, ambient air monitoring, and additional impacts analysis are also required.

Because Big Bend is located near two designated nonattainment areas: one for sulfur dioxide, one for particulate matter (see Figure 2.8-1), it must be demonstrated that emissions from the proposed source will not exceed certain "significance of impact levels" within those nonattainment areas. If such levels were exceeded, the source would be subject to very stringent permitting conditions, including application of Lowest Achievable Emission Rates (LAER) and greater than one-for-one emissions offsets for applicable pollutants.

A summary of air quality regulations applicable to the proposed Big Bend Unit 4 is presented in Table 2.8-1. Table 2.8-2 lists AAQS applicable to the Big Bend site, and Table 2.8-3 lists allowable PSD increments. Hillsborough and surrounding counties are designated Class II for PSD purposes. "Significance of impact levels" for nonattainment areas for sulfur dioxide and particulate matter, as promulgated by the U.S. EPA and state of Florida are shown in Table 2.8-4.

2.8.2 Baseline Data for PSD Review

2.8.2.1 Ambient Air Quality Analysis

2.8.2.1.1 General

Federal regulations for the prevention of significant deterioration (PSD) require an analysis of ambient air monitoring data as part of PSD review. This analysis must be conducted for all PSD pollutants, which, for a coal-fired steam electric generating unit, are sulfur dioxide, particulate matter, nitrogen oxides, and carbon monoxide. Ambient monitoring historically has not been required for

carbon monoxide because power plants do not contribute significantly to ground-level concentrations of this pollutant, and background levels presently do not approach the Ambient Air Quality Standard (AAQS) for carbon monoxide.

This section presents an analysis of available ambient air monitoring data in the vicinity of Big Bend for sulfur dioxide, total suspended particulate matter (TSP), and nitrogen dioxide. The data span a 3-year period in which both continuous and noncontinuous data were obtained. A review of quality assurance procedures and ambient monitoring methodologies for TECO-operated monitors and the validity of collected data is presented in Section 6.2.4.

2.3.2.1.2 Sulfur Dioxide

Noncontinuous Data

Locations of 24-hour sulfur dioxide bubbler air monitoring stations in the vicinity of the Big Bend power plant are shown in Figure 2.8-2. A summary of the available sulfur dioxide data is presented in Table 2.8-5. Sulfur dioxide data are available for the 1976 to 1978 period from both the Hillsborough County Environmental Protection Commission (HCEPC) and Tampa Electric Company's air monitoring network. Beginning in the month of July 1976, the samples collected by both TECO and HCEPC were temperature-controlled during sampling and storage.

A total of eight monitoring stations are located within about a 5-mile radius of Big Bend. The maximum 24-hour sulfur dioxide concentration recorded at any station was 293 $\mu\text{g}/\text{m}^3$, occurring during 1977 at HCEPC Station 54. The second-highest values at Station 54 were well below the AAQS level of 260 $\mu\text{g}/\text{m}^3$, therefore no violations of AAQS were recorded. Station 54 was not in operation in 1978. However, HCEPC Station 54 was co-located with TECO Station 5, and Station 5 operated in 1978.

Other sulfur dioxide monitoring stations did not exceed the 24-hour or annual AAQS. Maximum 24-hour concentrations at these stations were less than 50 percent of the state of Florida standard of 260 $\mu\text{g}/\text{m}^3$. Annual arithmetic mean concentrations at any station were less than 40 percent of the state of Florida AAQS.

Continuous Data

Continuous ambient sulfur dioxide monitoring was conducted by TECO in the vicinity of Big Bend beginning in early 1977. The monitoring was undertaken by TECO as part of a special sulfur dioxide study. Figure 2.8-3 shows the locations of the five monitoring stations utilized in the special study.

Results of the monitoring program are summarized in Table 2.8-6. It shows the number of 3-hour and 24-hour values obtained at each station during the monitoring period, the arithmetic mean concentration, and the highest 3-hour and 24-hour measured concentrations. Two values are shown for the short-term averaging times: a non-overlapping (NOL) or consecutive period maximum average and a running (RUN) maximum average.

As shown in Table 2.8-6, maximum and arithmetic mean sulfur dioxide concentrations did not approach any applicable air quality standard, except at Station T4, Bullfrog Creek. The maximum values at T4, representing about 90 percent of the respective 3-hour and 24-hour standards, occurred on May 7, 1977. The maximum 1-hour concentration during this period was 0.650 ppm, or 1690 $\mu\text{g}/\text{m}^3$. It is noted that the applicable short-term averaging time standards can be exceeded once per year. The second highest recorded concentrations at T4 were well below the air quality standards (see Table 2.8-7).

Maximum measured concentrations at stations other than T4 did not exceed about 80 percent of the air quality standards. Arithmetic mean concentrations did not exceed 30 percent of the applicable standard.

Presented in Tables 2.8-7 and 2.8-8 are frequency distributions of 3-hour averages and 24-hour averages (non-running), respectively, obtained from the continuous monitoring data. Upper limits of each frequency interval are shown in both ppm and $\mu\text{g}/\text{m}^3$. Two distributions are presented for each station, denoted by columns marked "I" and "II". Column I gives the frequency of occurrence of concentrations within each interval, and Column II gives the cumulative frequency of occurrence up to and including the specified interval.

The frequency distribution data display a marked skewness towards the lower concentrations, both for the 3-hour and 24-hour averaging times. Greater than 80 percent of all average observations fall below 0.01 ppm (26 $\mu\text{g}/\text{m}^3$) at each monitoring station. One 3-hour and one 24-hour observation fell within the interval containing the state of Florida AAQS of 1300 $\mu\text{g}/\text{m}^3$ and 260 $\mu\text{g}/\text{m}^3$, respectively. These observations reflect the only time that these standards were approached during the monitoring period.

2.8.2.1.3 Total Suspended Particulate Matter Data

Total suspended particulate matter data obtained in the vicinity of TECO Big Bend are presented in Table 2.8-9. The Federal Reference method of high volume sampling for TSP was utilized to obtain these values on a once-every-sixth day sampling schedule. Locations of the ambient monitors, both HCEPC and TECO, are shown in Figure 2.8-4.

TSP data are available from seven stations for the 1976-1978 period. Two of these stations, TECO Station 5 and HCEPC Station 54, were co-located during this period. The maximum 24-hour TSP concentrations recorded at any station during the sampling period were 143 ug/m^3 at TECO Station 5 in 1976. This value represents 95 percent of the Florida 24-hour AAQS of 150 ug/m^3 . The second-highest 24-hour concentration at TECO Station 5 was 71 ug/m^3 , which is less than half of the standard.

During 1977 and 1978, the maximum measured 24-hour TSP concentration at any station was 115 ug/m^3 , and occurred at TECO Station 6. This value is about 75 percent of the AAQS. The data show all TSP stations within 5 miles of Big Bend to be in compliance with short-term TSP AAQS.

The annual geometric mean AAQS for the state of Florida is 60 ug/m^3 . The highest geometric mean calculated for data collected in the study area was 41 ug/m^3 , which is 68 percent of the standard and occurred at TECO Station 5 in 1976. Since that time, annual geometric means have not exceeded 40 ug/m^3 at any sampling station and are representative of rural background TSP levels.

Background TSP Estimation - Only stationary point sources of particulate matter are accounted for in the emissions inventories used in the atmospheric dispersion models. However, many fugitive particulate matter sources exist in the Tampa and Big Bend area, as well as a natural background TSP level. To account for these fugitive emissions and natural dust levels a background TSP concentration is added to the modeling results for both the long-term and short-term averaging time.

For the annual averaging time, a background TSP level was obtained by averaging the geometric mean TSP concentrations presented in Table 2.8-9. This results in an average concentration of 35.9 ug/m^3 . For convenience, and since this average level reflects point source contributions from particulate matter emitters in the area (i.e., TECO Big Bend), an annual background TSP level of 35 ug/m^3 was used in this study. This value was added to all annual average model results to obtain total air quality level predictions.

A statistical approach was utilized to determine an appropriate short-term (24-hour) background TSP level. It is not justified to utilize the highest or second-highest measured values at the monitoring stations, since it is highly unlikely that worst-case meteorological conditions for point source emissions will occur in conjunction with a worst-case background level. A statistically more valid level, used in previous modeling studies in Florida, is a level that is exceeded 16 percent of the time, or the 84th percentile concentration. The probability of occurrence of this background level and worst-case point source model predictions is less than one day in five years, justifying the utilization of this technique.

Analysis of many years of ambient TSP data has shown that such data tend to be lognormally distributed. If the lognormal distribution is assumed, the method of Larsen (1971) can be utilized to estimate the 84th percentile concentration from the annual average concentration. The equation for the conversion is:

$$C = M S_g^{2-0.5 \ln S_g}$$

Where C = 84th percentile concentration
 S_g = Geometric standard deviation
 $z = 1.0$, number of standard deviations from mean for 84th percentile
 M = arithmetic mean.

The range of S_g values for the sampling data presented (excluding data not representative of an entire year) is from 1.35 to 1.96. Substituting the highest of these values into the above equation yields:

$$C = M \times 1.56$$

Thus, the 84th percentile concentration is equivalent to 1.56 times the arithmetic mean. Applying this factor to the 35.9 ug/m³ annual average background yields a 24-hour TSP background concentration of approximately 55 ug/m³. This is extremely conservative since the average S_g value is 1.48.

2.8.2.1.4 Nitrogen Dioxide

Nitrogen dioxide data from the Big Bend area are available from seven TECO stations for the 1976 to 1978 period (Figure 2.8-4). All samples were generally collected on a once-every-third day schedule utilizing 24-hour bubblers and the sodium arsenite Federal Reference method for nitrogen dioxide. Maximum 24-hour concentrations at any station did not exceed 221 ug/m³ (Table 2.8-10). Only an annual arithmetic mean AAQS exists for nitrogen dioxide, and is 100 ug/m³. The maximum annual arithmetic mean concentration recorded for any station was 38 ug/m³ at TECO Station 17

during 1978. This value represents 38 percent of the annual standard.

2.8.2.2 Baseline - Federal

EPA defines "baseline concentration" as:

that ambient concentration level reflecting actual air quality as of August 7, 1977, minus any contribution from major stationary sources and major modifications on which construction commenced on or after January 6, 1975. The baseline concentration shall include contributions from:...(ii). The allowable emissions of major stationary sources and major modifications which commenced construction before January 6, 1975, but were not in operation by August 7, 1977. (Federal Register, Vol. 43, No. 118, June 19, 1978).

In applying the baseline emissions concept, EPA does not require the establishment of a formal baseline concentration. Essentially, only those sources which have changed emission rates and/or stack parameters or new sources which have commenced construction (and including general growth) since the baseline date need to be evaluated. In essence, these sources would either expand or consume PSD increments. Sources remaining unchanged would not affect PSD increment consumption. "This policy is consistent with the intent of the Act (Clean Air Act) to base increment consumption on all emission increases from new and modified sources, but to allow consumption of the increment to occur from only certain non-modification activities. . .of existing sources" (Federal Register, Vol. 43, No. 118, pg. 26400, June 19, 1978).

In considering factors such as hours of operation, capacity utilization, and types of materials combusted, processed, and/or stored, "1977 values will generally be used"; however, the baseline emissions "also include ...any future increases in hours of operation or capacity utilization as they occur if such are allowed to the source as of August 7, 1977, and if the source could have been reasonably expected to make these increases on this date" (Federal Register, Vol. 43, No. 118 pg. 26400, June 19, 1978).

The baseline sulfur dioxide emission rates utilized in the PSD evaluation were the allowable emission rates of 32 tons per hour, maximum 24-hour emission cap, and 35 tons per hour, maximum 3-hour emission cap, the total emissions from Big Bend Units 1 through 3. This emission limitation was in effect at Big Bend until October 1, 1977, and therefore reflects emissions as of August 7, 1977. Short-term 24-hour

and 3-hour particulate matter emission rates were based upon the allowable emission limit of 0.1 lb/10⁶ Btu heat input.

The annual baseline emissions for Big Bend reflect actual capacity utilization which occurred at the plant in 1977:

Big Bend 1 - 67 percent
Big Bend 2 - 64 percent
Big Bend 3 - 61 percent

The short-term baseline levels were developed by considering Big Bend Units 1 through 3 operating at 100 percent, 75 percent, and 50 percent load, and Units 1 and 3 only operating at 100 percent load.

The baseline concentrations were then determined by identifying the maximum highest, second-highest sulfur dioxide concentration at each receptor point for all operation conditions evaluated.

A number of sources located in Hillsborough, Pinellas, Pasco, and Manatee Counties were identified as being modified after the January 6, 1975 date. These sources consume or expand PSD increments, depending upon the particular modification conditions. To establish the EPA annual baseline levels, these modified sources were modeled at these pre-modification emissions and stack parameters, based upon actual emission rates. These estimated air quality levels will be subtracted from predicted levels (for corresponding receptor points) based on all new sources and modified sources operating at maximum allowable emission rates. The modified source data reflected post-modification conditions. This methodology determined annual EPA increment consumption.

Figures 2.8-6 and 2.8-7 show the results of the EPA baseline annual modeling for sulfur dioxide and TSP, respectively.

The results of the 24-hour and 3-hour sulfur dioxide baseline estimations are shown in Figures 2.8-8 and 2.8-9, respectively. Similarly, Figure 2.8-10 shows the 24-hour TSP baseline concentrations. These baseline concentrations, as described previously, represent maximum highest, second-highest concentrations for a number of representative operating conditions. They are reflective of emissions from Big Bend only.

2.8.2.3 Baseline - State of Florida

The state of Florida has defined baseline concentration for PSD purposes to mean:

For sulfur dioxide and particulate matter, the applicable ambient concentration levels existing during 1974 plus any additional concentrations for the area of impact estimated to result from sources permitted for construction but not operating prior to January 1, 1975 (Chapter 17-2.02(6), Florida Administrative Code).

In October 1978, the FDER Bureau of Air Quality Management published "Guidelines on Prevention of Significant Deterioration (PSD) - PSD Review." The document states: "Baseline emissions data consist of the January 1, 1975 allowable emission rates and January 1, 1975 stack configurations for all sources holding either an operating or construction permit during any part of 1974."

To comply with these requirements, a 1974 allowable emissions inventory reflecting January 1, 1975 conditions was developed for sulfur dioxide and particulate matter, based on available FDER information. For TECO Big Bend, allowable emissions for 1974 were 32 tons per hour sulfur dioxide total from all three units (24-hour average), and 0.1 lb/10⁶ Btu for particulate matter. These allowable emissions include allowable emissions from Big Bend Unit 3, which was permitted for construction but not operating as of January 1, 1975.

For the annual averaging time, all sources located in Pasco, Pinellas, Hillsborough, and Manatee counties were included in the inventory. Shown in Figure 2.8-11 are FDER annual average baseline sulfur dioxide concentrations in the vicinity of Big Bend. Similarly, shown in Figure 2.8-12 are FDER annual average baseline TSP concentrations. Background TSP levels have not been included in the baseline estimates, since background does not affect increment consumption.

The short-term baseline sulfur dioxide and particulate matter concentrations reflect emissions due to Big Bend only. Because other sources are not located within 5 km of Big Bend, such sources would only contribute slightly to baseline concentrations and only for certain wind directions. Big Bend has major impact on short-term levels within this distance. Big Bend baseline emissions are based upon the allowable sulfur dioxide emissions from all 3 units of 32 tons per hour and 35 tons per hour for the 24- and 3-hour averaging times, respectively. Short-term particulate matter emissions were based upon 0.1 lb/10⁶ Btu heat input.

To establish short-term baseline levels, several representative operating conditions were evaluated, including 100 percent load, 75 percent load and 50 percent

load (all 3 units), and Units 1 and 3 only at 100 percent load. Since Units 1 and 2 utilize the same stack, operation of only one of these units significantly decreased the stack gas exit velocity.

The short-term baseline concentrations (see Figures 2.8-8 through 2.8-10) were developed for EPA and are also applicable to the FDER analysis. These concentrations represent the highest, second-highest concentrations for each receptor predicted by the CRSTER model, for any of the operation conditions evaluated. A discussion of the dispersion models methodology is included in Section 6.2.4.2.

TABLE 2.8-1

PREVENTION OF SIGNIFICANT DETERIORATION (PSD)
REGULATIONS APPLICABLE TO THE PROPOSED TECO BIG BEND UNIT 4

Requirement	Federal Regulation	State of Florida Regulation
General Source Applicability	40 CFR* 52.21(i)	FAC** 17-2.04(1)
Control Technology Review	40 CFR 52.21(j)	
New Source Performance Standards	40 CFR 52.21(j) (1)	FAC 17-2.04 (6) (c)
Best Available Control Technology	40 CFR 52.21(j) (2)	FAC 17-2.04 (6) (c)
Air Quality Review	40 CFR 52.21(1)	
Ambient Air Quality Standards	40 CFR 52.21(1) (1)	FAC 17-2.04 (6) (a)
Allowable Increments	40 CFR 52.21(1) (2)	FAC 17-2.04 (6) (a)
Monitoring	40 CFR 52.21(n)	
Source Information	40 CFR 52.21(o)	FAC 17-2.04 (6) (a)
Stack Heights	40 CFR 52.21(h)	
Additional Impact Analyses	40 CFR 52.21(p)	
Public Participation	40 CFR 52.21(r)	FAC 17-2.04 (9)
Referenced Requirements		
New Source Performance Standards	40 CFR 60, Da	FAC 17-2.05 (6)
Best Available Control Technology	40 CFR 52.21(b) (10)	FAC 17-2.03
Ambient Air Quality Standards	40 CFR 50	FAC 17-2.06 (1)
Allowable Increments	40 CFR 52.21(c)	FAC 17-2.04 (1)

* CFR = Code of Federal Regulations

**FAC = Florida Administrative Code

TABLE 2.8-2

NATIONAL AND STATE OF FLORIDA AMBIENT AIR QUALITY STANDARDS (AAQS) APPLICABLE TO THE PROPOSED SITE, HILLSBOROUGH COUNTY, FLORIDA

Pollutant	Averaging Time	National		Florida
		Primary Standard	Secondary Standard	
Suspended Particulate Matter	Annual Geometric Mean 24-Hour Maximum	75 ug/m ³ 260 ug/m ³ *	60 ug/m ³ 150 ug/m ³ *	60 ug/m ³ 150 ug/m ³ *
Sulfur Dioxide	Annual Arithmetic Mean 24-Hour Maximum 3-Hour Maximum	80 ug/m ³ 365 ug/m ³ * N/A	N/A N/A 1,300 ug/m ³ *	60 ug/m ³ 260 ug/m ³ * 1,300 ug/m ³ *
Carbon Monoxide	8-Hour Maximum 1-Hour Maximum	9 ppm* 35 ppm*	9 ppm* 35 ppm*	9 ppm* 35 ppm*
Hydrocarbons	3-Hour Maximum (6 to 9 A.M.)	.24 ppm*	.24 ppm*	.24 ppm*
Nitrogen Dioxide	Annual Arithmetic Mean	100 ug/m ³	100 ug/m ³	100 ug/m ³
Ozone	1-Hour Maximum	120 ppb*	120 ppb*	80 ppb*

*Maximum concentration not to be exceeded more than once per year.

Source: Florida Administrative Code, Chapter 17-2.
Code of Federal Regulations, Title 40, Part 50.

TABLE 2.8-3

FEDERAL AND STATE OF FLORIDA PREVENTION OF SIGNIFICANT
DETERIORATION (PSD) ALLOWABLE INCREMENTS (ug/m³)

Pollutant/Averaging Time	Class		
	I	II	III
Particulate Matter			
Annual Geometric Mean	5	19	37
24-Hour Maximum*	10	37	75
Sulfur Dioxide			
Annual Arithmetic Mean	2	20	40
24-Hour Maximum*	5	91	182
3-Hour Maximum*	25	512	700

*Increment can be exceeded once per year.

Source: Federal Register, Vol. 43, No. 118, June 19, 1978.
Florida Administrative Code, Chapter 17-2.

TABLE 2.8-4

FEDERAL AND STATE OF FLORIDA SIGNIFICANCE OF
IMPACT LEVELS FOR SULFUR DIOXIDE AND PARTICULATE
MATTER ($\mu\text{g}/\text{m}^3$)

Pollutant	Averaging Time		
	Annual	24-Hour	3-Hour
Particulate Matter	1	5	--
Sulfur Dioxide	1	5	25

Source: Federal Register, Volume 43, No. 118, June 19, 1978.
Florida Administrative Code, Chapter 17-2.

TABLE 2.8-5

SUMMARY OF AMBIENT 24-HOUR SULFUR DIOXIDE BUBBLER DATA
IN THE VICINITY OF TECO BIG BEND, 1976-1978

Station Number	Sponsor	Time Period	Number of Observations	Arithmetic Mean (ug/m ³)	Maximum 24-Hour (ug/m ³)	Second-High 24-Hour (ug/m ³)
5	TECO	1/76 - 12/76	133	9	59	54
		1/77 - 12/77	79	22	52	44
		1/78 - 12/78	92	5	31	24
6	TECO	1/76 - 12/76	134	10	86	65
		1/77 - 12/77	92	11	79	76
		1/78 - 12/78	31	9	33	33
11	TECO	1/76 - 12/76	23*	8	24	24
		1/77 - 12/77	103	5	62	22
		1/78 - 12/78	60	5	21	16
13	TECO	1/76 - 12/76	15*	10	32	--
		1/77 - 12/77	104	6	42	35
		1/78 - 12/78	57	8	74	50
15	TECO	1/76 - 12/76	8*	5	13	4
		1/77 - 12/77	70	6	103	20
		1/78 - 12/78	61	5	45	19
17	TECO	1/77 - 12/77	35	7	34	32
		1/78 - 12/78	73	7	50	44

TABLE 2.8-5 (Cont)

Station Number	Sponsor	Time Period	Number of Observations	Arithmetic Mean (ug/m ³)	Maximum 24-Hour (ug/m ³)	Second-High 24-Hour (ug/m ³)
54	HECPC	1/76 - 12/76	129	10	55	54
		1/77 - 12/77	98	11	293	40
9	HECPC	1/76 - 12/76	59	11	149	94
		1/77 - 12/77	64	8	60	34
		1/78 - 12/78	61	8	76	47

* Sampling not conducted for the entire year.

NOTE: Federal Primary Standards--365 ug/m³, 24-hour average (not to be exceeded more than once per year)
80 ug/m³, annual arithmetic mean

State of Florida Standards--260 ug/m³, 24-hour average (not to be exceeded more than once per year)
60 ug/m³, annual arithmetic mean

Sources: Environmental Science and Engineering, Inc., 1979.
Hillsborough County Environmental Protection Agency, 1977, 1978, and 1979.
Tampa Electric Company, 1977, 1978, and 1979.

TABLE 2.8-6

SUMMARY OF CONTINUOUS SULFUR DIOXIDE MONITORING DATA OBTAINED
IN THE VICINITY OF TECO BIG BEND POWER PLANT

Station	Location	Time Period	No. of Observations		Arithmetic Mean	Concentrations (ug/m ³)			
			24-Hr.	3-Hr.		Highest 24-Hr (NOL)	(RUN)	Highest 3-Hr (NOL)	(RUN)
T1	East Bay Substation	2/77-4/79	708	5687	12	156	172	965	967
T4	Bullfrog Creek	5/77-4/79	639	5103	10	237	237	1149	1206
T5	North Ruskin	2/77-4/79	722	5784	14	135	174	767	967
T7	Apollo Beach	2/77-4/79	450	3670	16	135	211	473	520
T8	Gibsonton	2/77-3/78	397	3191	15	99	104	588	650
State of Florida Standards					60	260		1300	
EPA Secondary Standard					--	---		1300	
EPA Primary Standards					80	365		----	

NOTE: NOL = Non-Overlapping Averages
RUN = Running Averages

TABLE 2.8-7

FREQUENCY DISTRIBUTION OF 3-HOUR AVERAGE SULFUR DIOXIDE CONCENTRATIONS,
MEASURED IN THE VICINITY OF TECO BIG BEND POWER PLANT

Station Location	T1 East Bay Substation 2/77 - 4/79 5687		T4 Bullfrog Creek 5/77 - 4/79 5103		T5 North Ruskin 2/77 - 4/79 5784		T7 Apollo Beach 2/77 - 5/77 684		T7 Apollo Beach 9/77 - 4/79 2986		T8 Gibsonston 2/77 - 3/78 3191	
Sampling Period No. of Observations												
Upper Limit of Interval ppm ug/m ³	I	II	I	II	I	II	I	II	I	II	I	II
F 0.01 26	90.297	90.276	92.749	92.749	90.180	90.180	92.251	92.251	84.628	84.628	86.775	86.775
R 0.02 52	5.732	96.008	4.311	97.061	5.411	95.591	2.924	95.175	9.344	93.972	9.025	95.801
E 0.03 78	1.934	97.943	1.137	98.197	1.539	97.130	2.047	97.222	2.512	96.484	2.131	97.932
Q 0.04 104	0.739	98.681	0.607	98.805	0.743	97.873	0.877	98.099	1.139	97.622	1.065	98.997
U 0.05 130	0.440	99.121	0.314	99.118	0.432	98.306	0.292	98.392	0.804	98.426	0.407	99.405
E 0.06 156	0.334	99.455	0.176	99.294	0.328	98.634	0.439	98.830	0.402	98.828	0.157	99.561
N 0.07 182	0.211	99.666	0.118	99.412	0.173	98.807	9.439	99.269	0.301	99.129	0.125	99.687
C 0.08 208	0.053	99.719	0.118	99.530	0.242	99.049	0.292	99.561	0.301	99.431	0.094	99.781
Y 0.09 234	0.035	99.754	0.039	99.569	0.156	99.205	0.146	99.708	0.201	99.632	0.063	99.843
0 0.10 260	0.018	99.771	0.059	99.628	0.156	99.360	0.000	99.708	0.134	99.765	0.031	99.875
D 0.15 390	0.141	99.912	0.235	99.863	0.294	99.654	0.292	100.000	0.167	99.933	0.094	99.969
I 0.20 520	0.035	99.947	0.020	99.882	0.207	99.862	0.000	100.000	0.067	100.000	0.000	99.969
S 0.30 780	0.035	99.982	0.098	99.980	0.138	100.000	0.000	100.000	0.000	100.000	0.031	100.000
T 0.40 1040	0.018	100.000	0.000	99.980	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000
R 0.50 1300	0.000	100.000	0.020	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000
I 0.60 1560	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000
B 0.70 1820	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000
U 0.80 2080	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000
T 0.90 2340	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000
I 1.00 2600	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000
O >1.00 >2600	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000
N												

I = Percent occurrence with interval.
II = Cumulative percent occurrence.

TABLE 2.8-8

FREQUENCY DISTRIBUTIONS OF 24-HOUR AVERAGE SULFUR DIOXIDE CONCENTRATIONS,
MEASURED IN THE VICINITY OF TECO BIG BEND POWER PLANT

Station Location		T1 East Bay Substation 2/77 - 4/79 708		T4 Bullfrog Creek 5/77 - 4/79 639		T5 North Ruskin 2/77 - 4/79 722		T7 Apollo Beach 2/77 - 5/77 85		T7 Apollo Beach 9/77 - 4/79 365		T8 Gibsonston 2/77 - 3/78 397	
Sampling Period No. of Observations													
Upper Limit of Interval ppm ug/m ³		I	II	I	II	I	II	I	II	I	II	I	II
F 0.01	26	90.537	90.537	92.645	92.645	86.427	86.427	88.235	88.235	80.548	80.548	87.406	87.406
R 0.02	52	8.051	98.588	5.477	98.122	8.449	94.875	7.059	95.294	13.973	94.521	11.083	98.489
E 0.03	78	0.565	99.153	0.626	98.748	3.186	98.061	3.529	98.824	3.562	98.082	1.259	99.748
Q 0.04	104	0.424	99.576	0.939	99.687	0.831	98.892	1.176	100.000	1.370	99.452	0.252	100.000
U 0.05	130	0.141	99.717	0.156	99.843	0.831	99.723	0.000	100.000	0.274	99.726	0.000	100.000
E 0.06	156	0.141	99.859	0.000	99.843	0.277	100.000	0.000	100.000	0.274	100.000	0.000	100.000
N 0.07	182	0.141	100.000	0.000	99.843	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000
C 0.08	208	0.000	100.000	0.000	99.843	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000
Y 0.09	234	0.000	100.000	0.000	99.843	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000
0.10	260	0.000	100.000	0.156	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000
D 0.15	390	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000
I 0.20	520	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000
S 0.30	780	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000
T 0.40	1040	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000
R 0.50	1300	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000
I 0.60	1560	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000
B 0.70	1820	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000
U 0.80	2080	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000
T 0.90	2340	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000
I 1.00	2600	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000
O >1.00	>2600	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000	0.000	100.000
N													

I = Percent occurrence with interval.
II = Cumulative percent occurrence.

TABLE 2.8-9

SUMMARY OF AMBIENT 24-HOUR PARTICULATE MATTER DATA
IN THE VICINITY OF TECO BIG BEND POWER PLANT, 1976-1978

Station Number	Sponsor	Time Period	Number of Observations	Geometric Mean (ug/m ³)	Maximum 24-Hour (ug/m ³)	Second-High 24-Hour (ug/m ³)
5	TECO	1/76 - 12/76	49	41	143	71
		1/77 - 12/77	30	38	103	87
6	TECO	1/76 - 12/76	47	36	70	69
		1/77 - 12/77	40	37	115	81
		1/78 - 12/78	15	39	64	61
12	TECO	1/76 - 12/76	6*	28	65	49
		1/77 - 12/77	45	37	111	71
		1/78 - 12/78	49	39	86	78
17	TECO	1/78 - 12/78	31	33	79	55
9	HCEPC	1/76 - 12/76	57	38	85	76
		1/77 - 12/77	54	31	74	55
		1/78 - 12/78	61	36	97	70
50	HCEPC	1/76 - 12/76	54	31	61	57
		1/77 - 12/77	52	32	79	69
		1/78 - 12/78	61	38	109	96
54	HECPC	1/76 - 12/76	61	38	66	64
		1/77 - 12/77	58	38	110	103

* Sampling not conducted for the entire year.

NOTE: Federal Primary Standards--365 ug/m³, 24-hour average (not to be exceeded more than once per year)
80 ug/m³, annual arithmetic mean

State of Florida Standards--260 ug/m³, 24-hour average (not to be exceeded more than once per year)
60 ug/m³, annual arithmetic mean

Sources: Environmental Science and Engineering, Inc., 1979.
Hillsborough County Environmental Protection Agency, 1977, 1978, and 1979.
Tampa Electric Company, 1977, 1978, and 1979.

TABLE 2.8-10

SUMMARY OF AMBIENT 24-HOUR NITROGEN DIOXIDE BUBBLER DATA
IN THE VICINITY OF TECO BIG BEND POWER PLANT, 1976-1978

Station Number	Sponsor	Time Period	Number of Observations	Arithmetic Mean (ug/m ³)	Maximum 24-Hour (ug/m ³)
5	TECO	1/76 - 12/76	133	13	42
		1/77 - 12/77	79	22	52
		1/78 - 12/78	87	37	221
6	TECO	1/76 - 12/76	135	12	43
		1/77 - 12/77	91	17	39
		1/78 - 12/78	26	20	47
11	TECO	1/76 - 12/76	20*	17	37
		1/77 - 12/77	95	17	43
		1/78 - 12/78	57	29	101
13	TECO	1/76 - 12/76	16*	15	30
		1/77 - 12/77	94	11	33
		1/78 - 12/78	56	28	129
15	TECO	1/76 - 12/76	8*	15	24
		1/77 - 12/77	71	13	27
		1/78 - 12/78	59	26	121
17	TECO	1/76 - 12/76	3*	18	22
		1/78 - 12/78	75	38	165
18	TECO	1/76 - 12/76	1*	5	5
		1/77 - 12/77	96	18	37
		1/78 - 12/78	27	23	111

* Samples not collected for the entire year.

NOTE: Federal Primary and State of Florida Standard: 100 ug/m³, annual arithmetic mean.

Sources: Environmental Science and Engineering, Inc., 1977, 1978, and 1979.
Tampa Electric Company, 1977, 1978, and 1979.

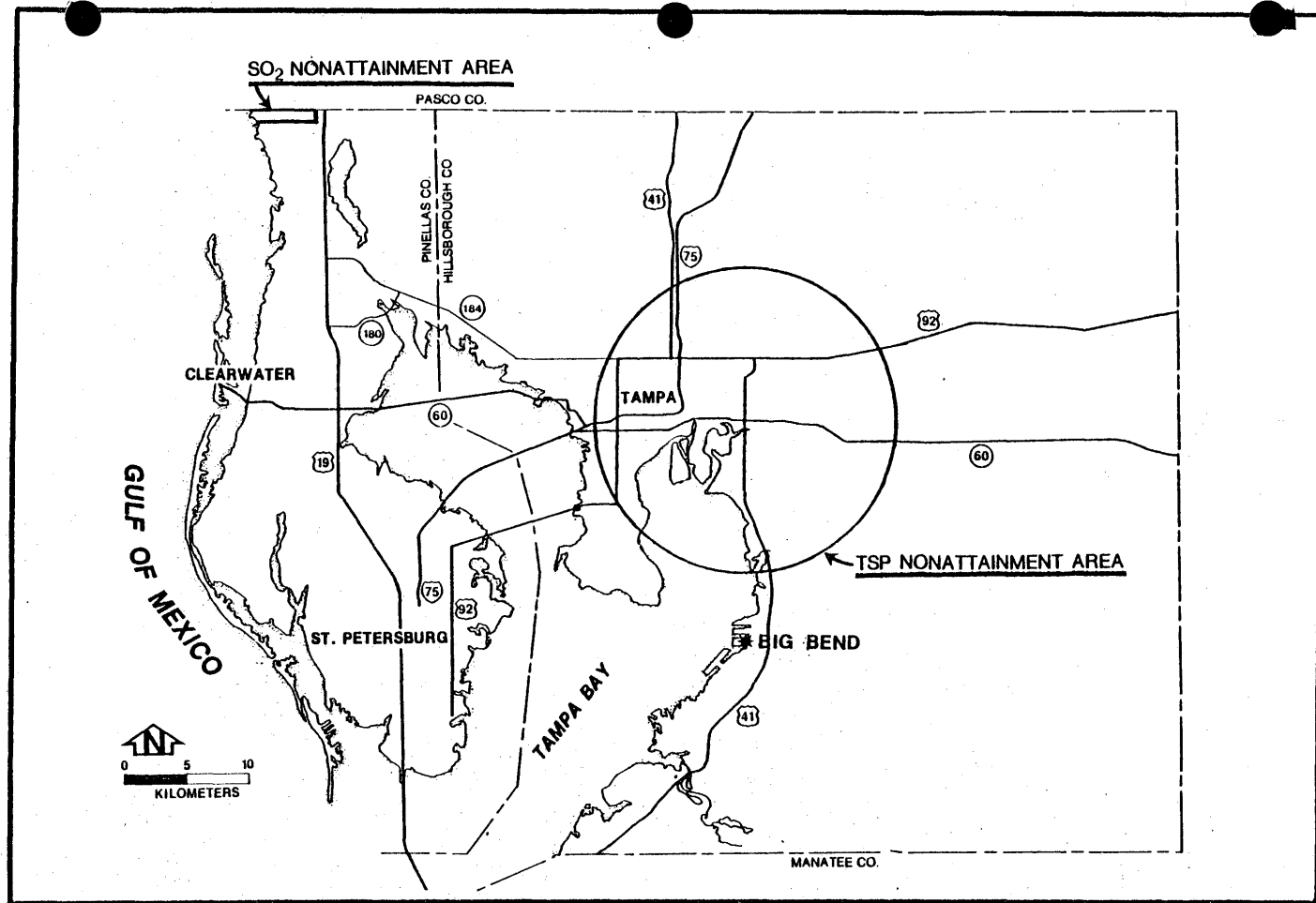


FIGURE 2.8-1
Locations of SO₂ and TSP Nonattainment Areas in Relation to Tampa Electric Company
Big Bend Power Plant
BIG BEND STATION
TAMPA ELECTRIC COMPANY

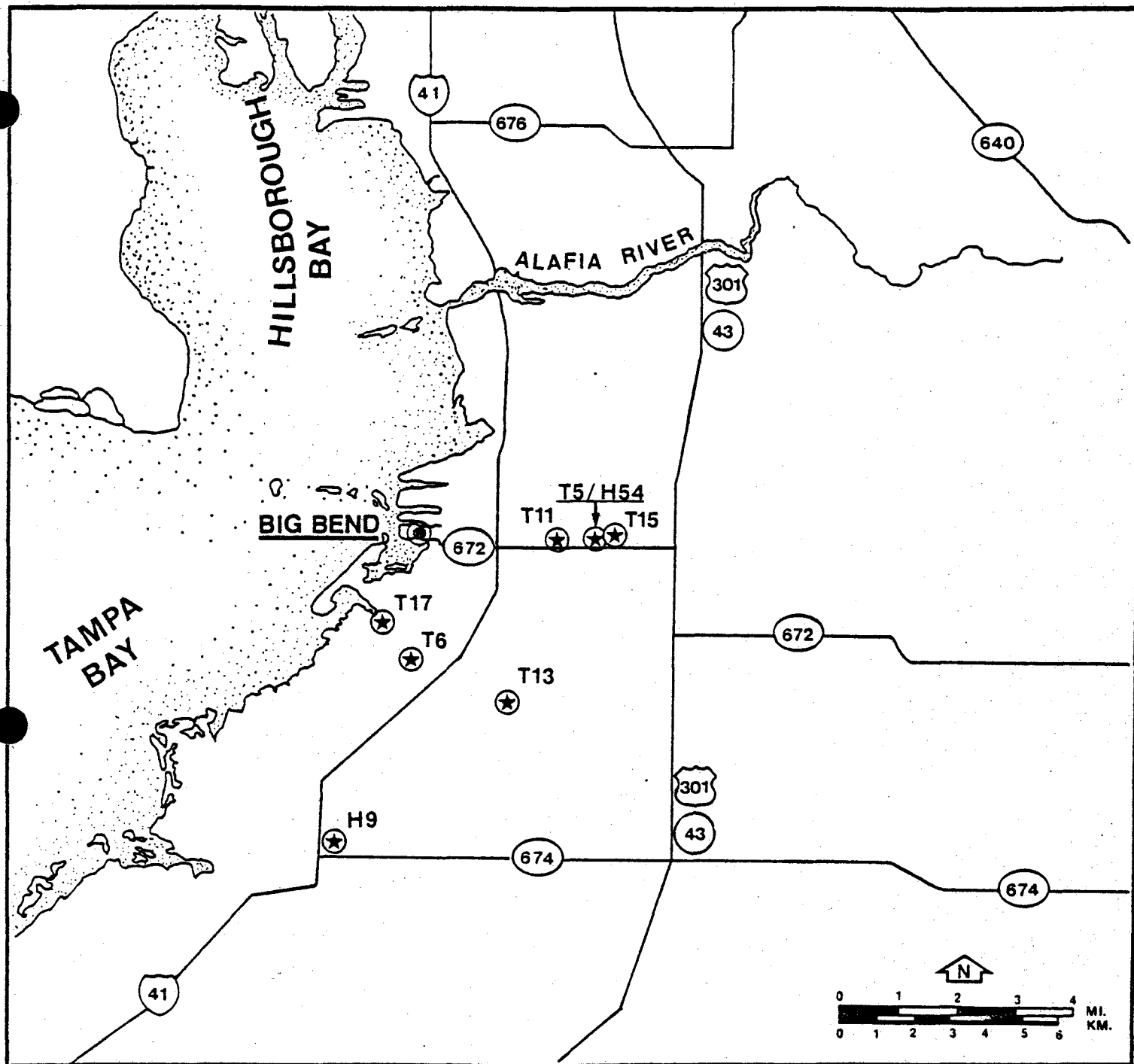


FIGURE 2.8-2

Locations of TECO and HCEPC 24-Hour Ambient Sulfur Dioxide Bubbler Monitoring Stations Within a 5-Mile Radius of Big Bend

BIG BEND STATION
TAMPA ELECTRIC COMPANY

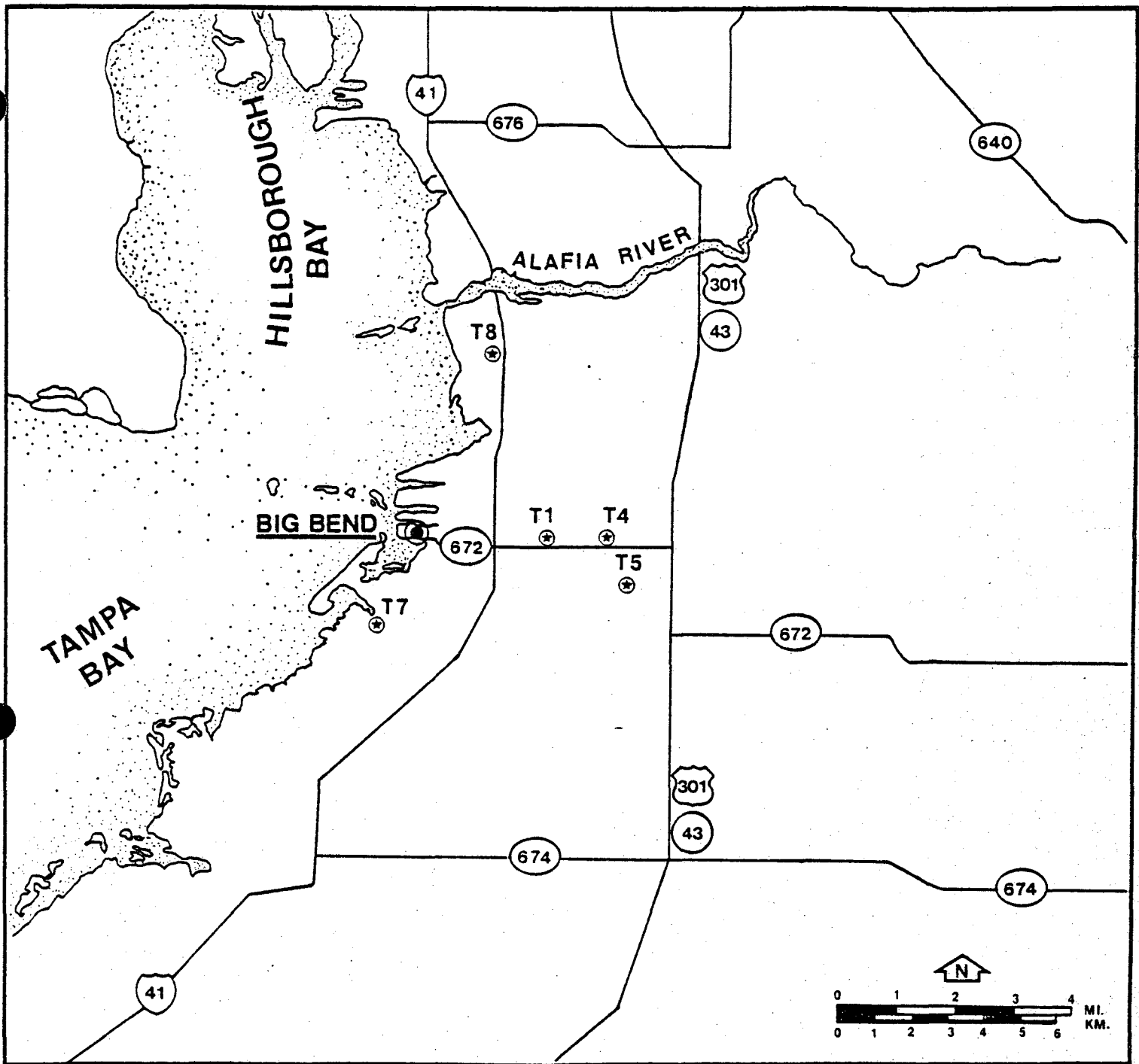


FIGURE 2.8-3

Locations of TECO Continuous Ambient Sulfur Dioxide Monitoring Stations
Within a 5-Mile Radius of Big Bend

BIG BEND STATION
TAMPA ELECTRIC COMPANY

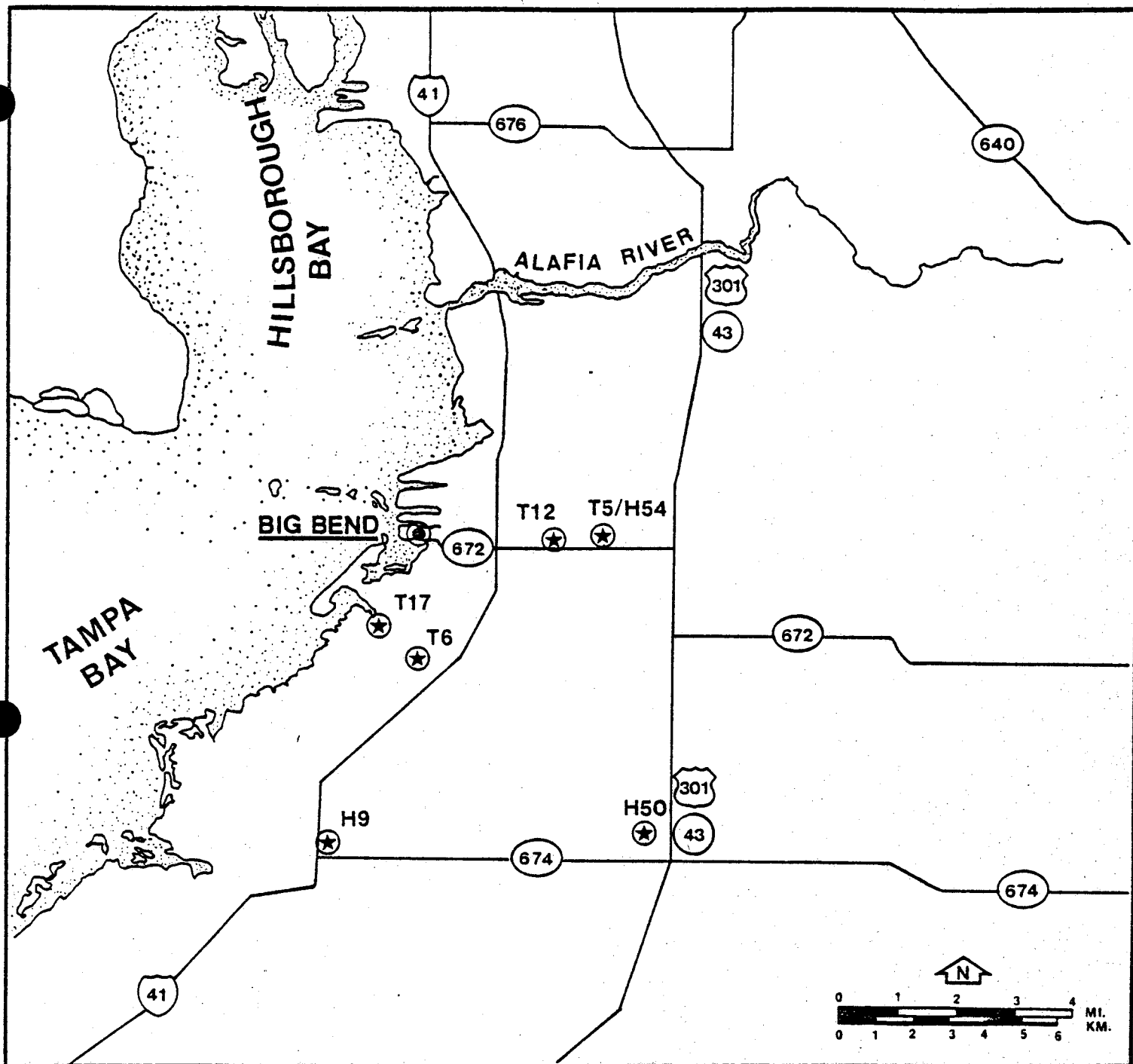


FIGURE 2.8-4

Locations of TECO and HCEPC 24-Hour Ambient Total Suspended Particulate Matter Monitoring Stations Within a 5-Mile Radius of Big Bend

BIG BEND STATION
TAMPA ELECTRIC COMPANY

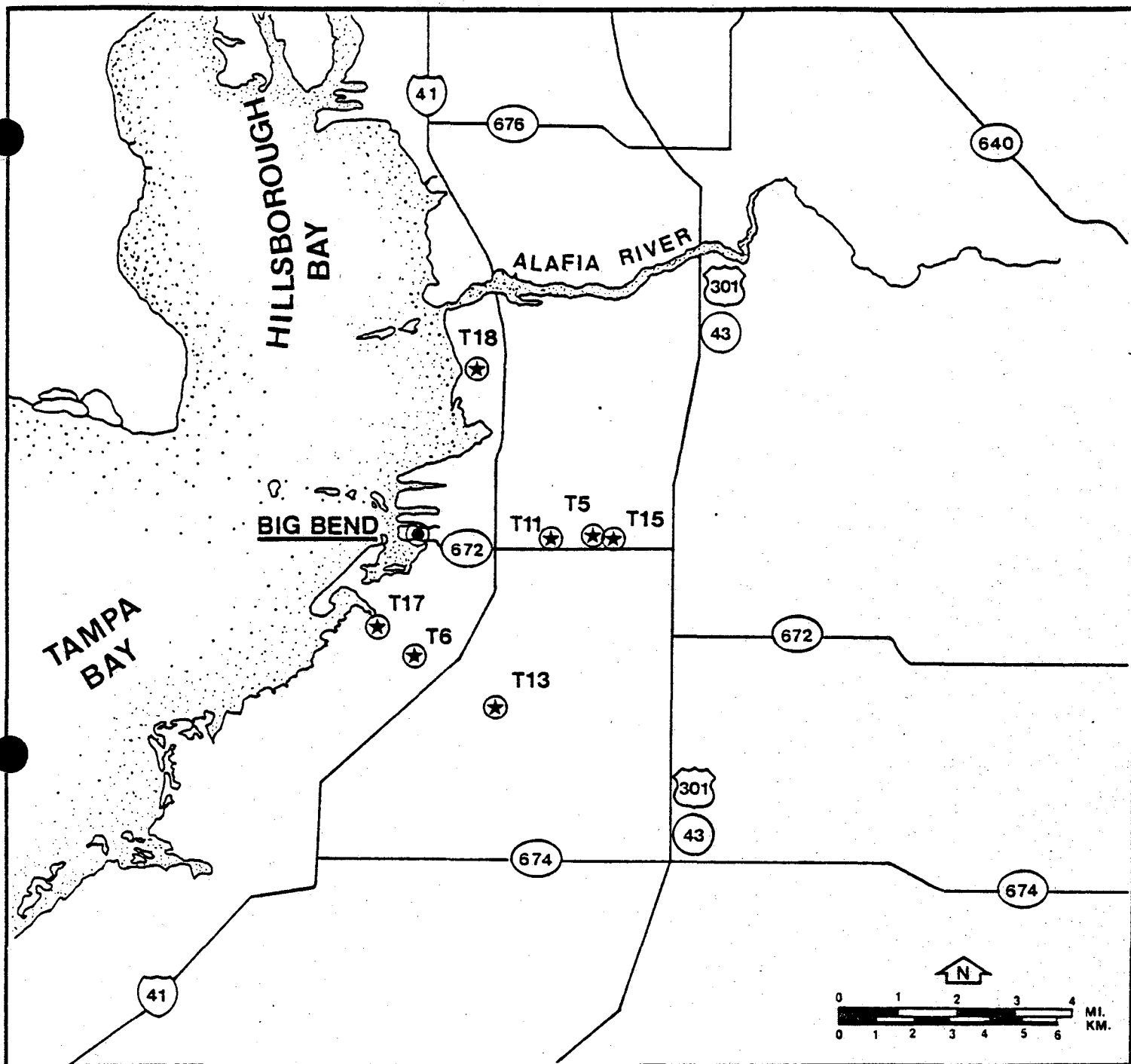


FIGURE 2.8-5
Locations of TECO 24-Hour Ambient Nitrogen Dioxide Bubbler Monitoring Stations
Within a 5-Mile Radius of Big Bend
BIG BEND STATION
TAMPA ELECTRIC COMPANY

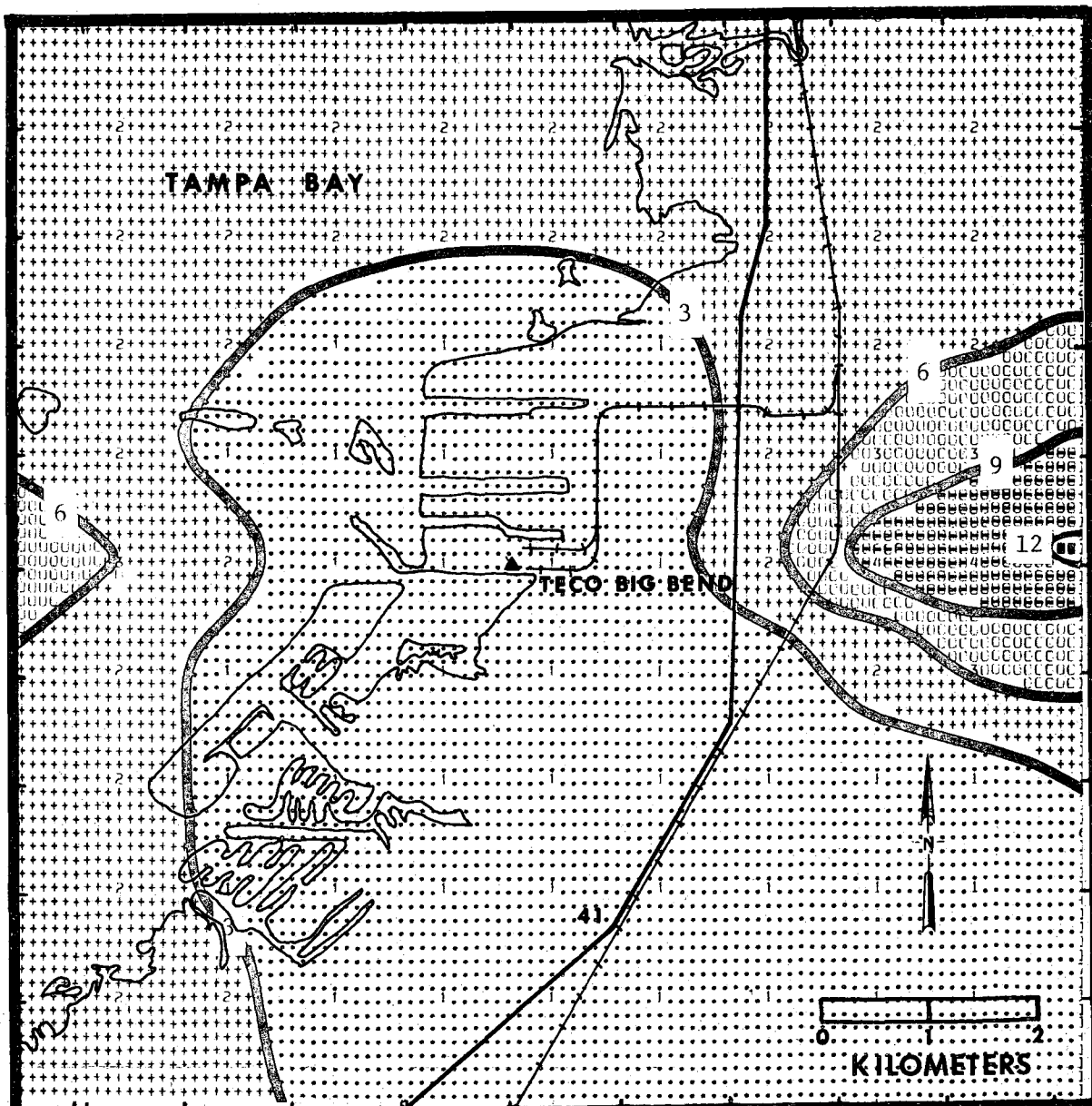


FIGURE: 2.8-6

1
TECO BIG BEND # PSP

ANNUAL AVERAGED CONCENTRATIONS (CG/CO. M)

EPA BASELINE OF SUP INCREMENT CONSUMING SOURCES--BIG BEND SITE

DATA VALUE EXTREMES ARE 1.00 12.10

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(MAXIMUM INCLUDED IN HIGHEST LEVEL ONLY)

	0.0	3.00	6.00	9.00	12.00
MINIMUM	0.0	3.00	6.00	9.00	12.00
MAXIMUM	3.00	6.00	9.00	12.00	15.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

	20.00	20.00	20.00	20.00	20.00
	20.00	20.00	20.00	20.00	20.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5
SYMBOLS	+++++	+++++	+++++	+++++	+++++
FREQ.	52	58	7	3	1

0.000225 MINUTES FOR HISTOGRAM

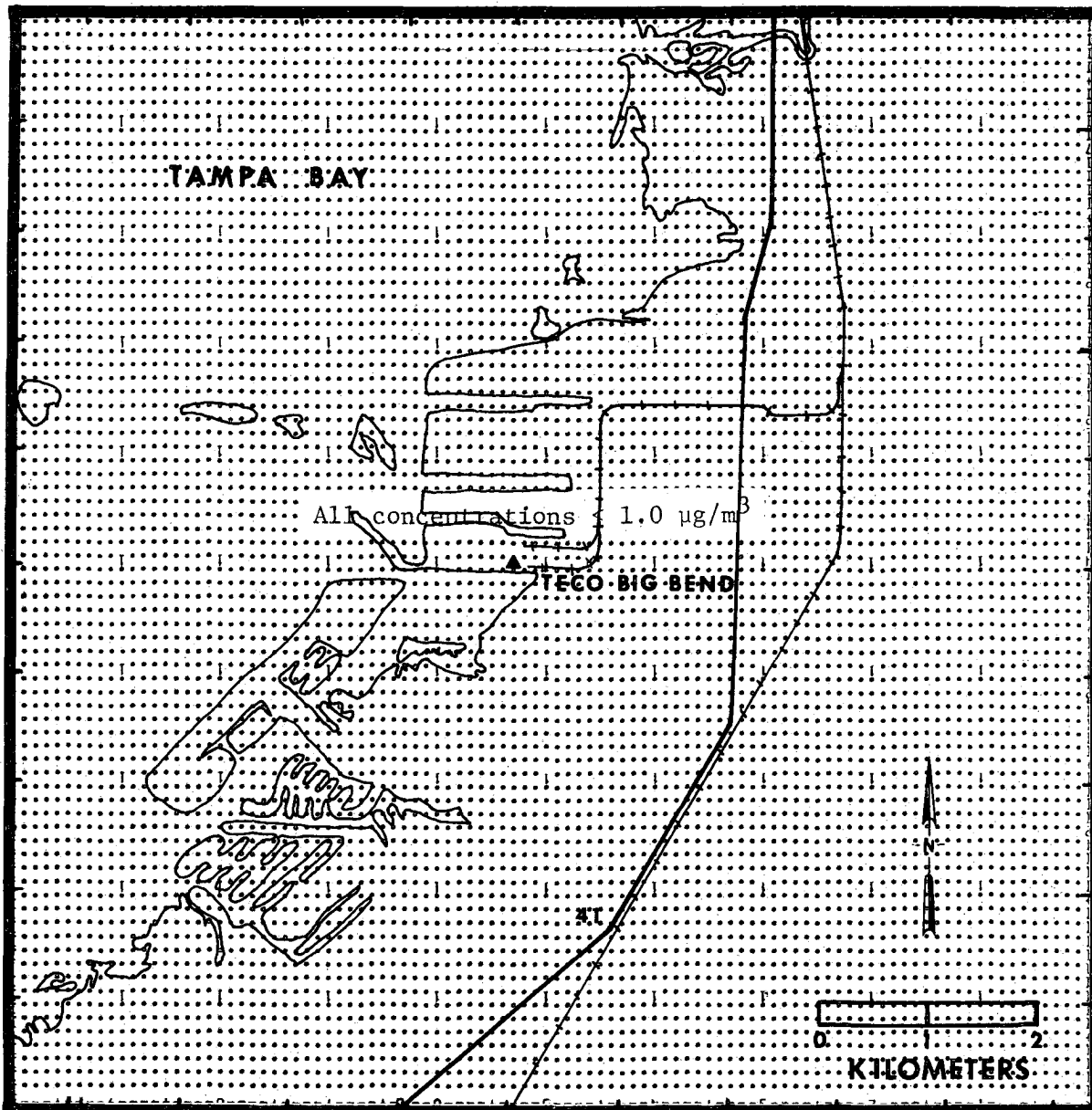


FIGURE: 2.8-7

TECO BIG BEND 4 PSP

ANNUAL AVERAGED CONCENTRATIONS (CG/CG, M)

EPA BASELINE OF TSP INCREMENT CONSUMING SOURCES--BIG BEND SITE

DATA VALUE EXTREMES ARE 0.10 0.40

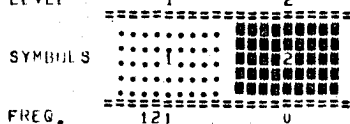
ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(MAXIMUM INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.50
MAXIMUM	0.50	1.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

50.00 50.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL



0.001883 MINUTES FOR HISTOGRAM

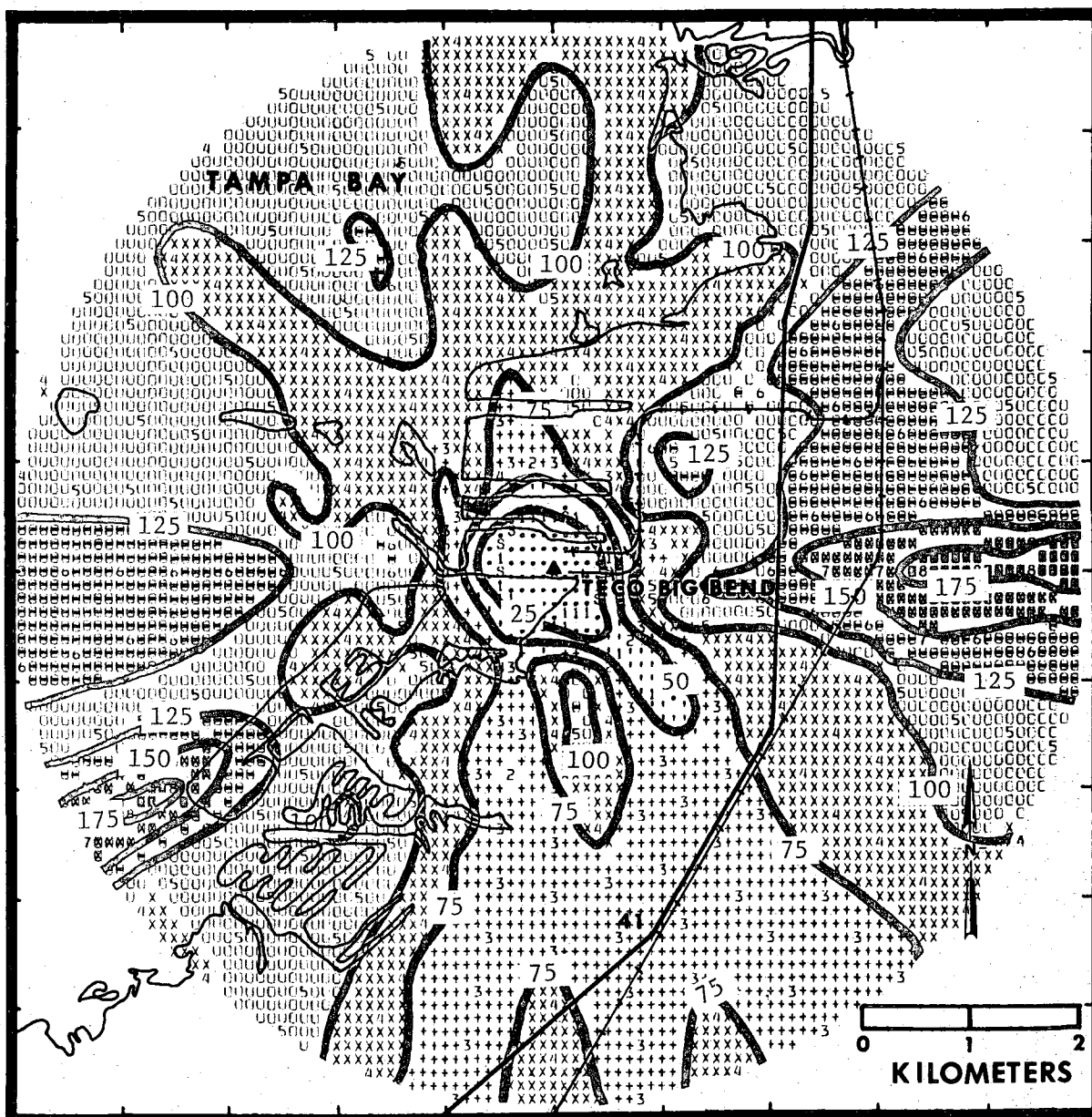


FIGURE: 2.8-8

TECU BIG BEND ONLY

HIGHEST, SECOND-HIGHEST 24-HOUR CONCENTRATIONS, $\mu\text{G}/\text{CU. M}$

SO₂ 24-HOUR COMPOSITE BASELINE CONCENTRATIONS--ALL CASES

DATA VALUE EXTREMES ARE 0.0 187.60

TOTAL SUPERIMPOSED DATA POINTS IS 14. THESE OCCUR IN 7 LOCATIONS.

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(MAXIMUM INCLUDED IN HIGHEST LEVEL ONLY)

	0.0	25.00	50.00	75.00	100.00	125.00	150.00	175.00
MINIMUM	0.0	25.00	50.00	75.00	100.00	125.00	150.00	175.00
MAXIMUM	25.00	50.00	75.00	100.00	125.00	150.00	175.00	200.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50
12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8
SYMBOLS	.....	.....	.....	.....	.....	.....	.....	.....
FREQ.	38	6	51	109	102	43	5	6

0.002896 MINUTES FOR HISTOGRAM

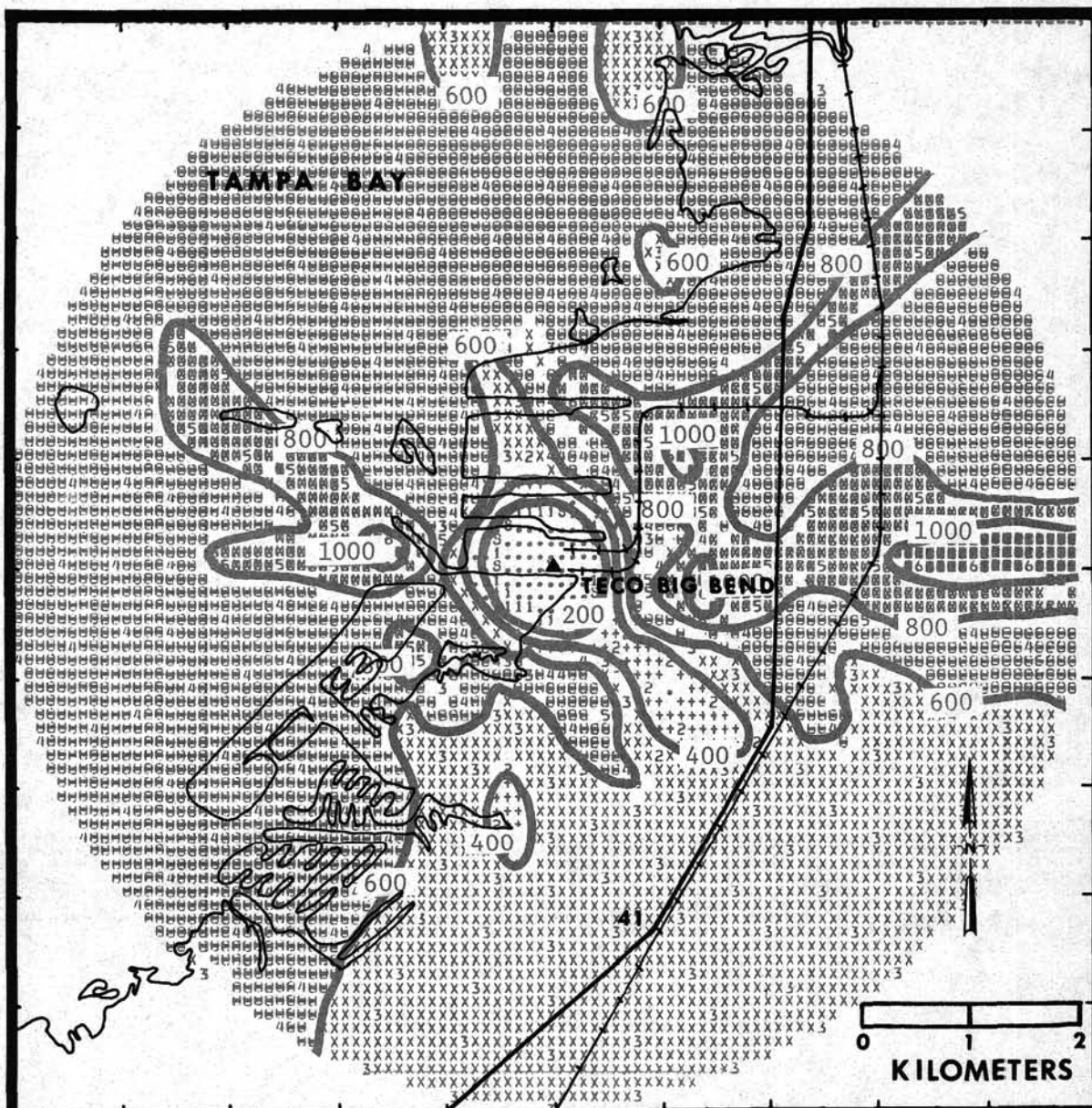


FIGURE: 2.8-9

TECU BIG BEND ONLY

HIGHEST, SECOND-HIGHEST 3-HOUR CONCENTRATIONS, UG/CU. M
SO2 3-HOUR COMPOSITE BASELINE CONCENTRATIONS--ALL CASES

DATA VALUE EXTREMES ARE 0.10 1125.00

TOTAL SUPERIMPOSED DATA POINTS IS 14. THESE OCCUR IN 7 LOCATIONS.

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(MAXIMUM INCLUDED IN HIGHEST LEVEL ONLY)

	0.0	200.00	400.00	600.00	800.00	1000.00	1200.00
MINIMUM	0.0	200.00	400.00	600.00	800.00	1000.00	1200.00
MAXIMUM	200.00	400.00	600.00	800.00	1000.00	1200.00	

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

	16.67	16.67	16.67	16.67	16.67	16.67
	16.67	16.67	16.67	16.67	16.67	16.67

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6
SYMBOLS	+++++	XXXXXXX	HHHHHHH	NNNNNNN	SSSSSSS	TTTTTTT
FREQ.	36	11	85	177	39	12

0.002387 MINUTES FOR HISTOGRAM

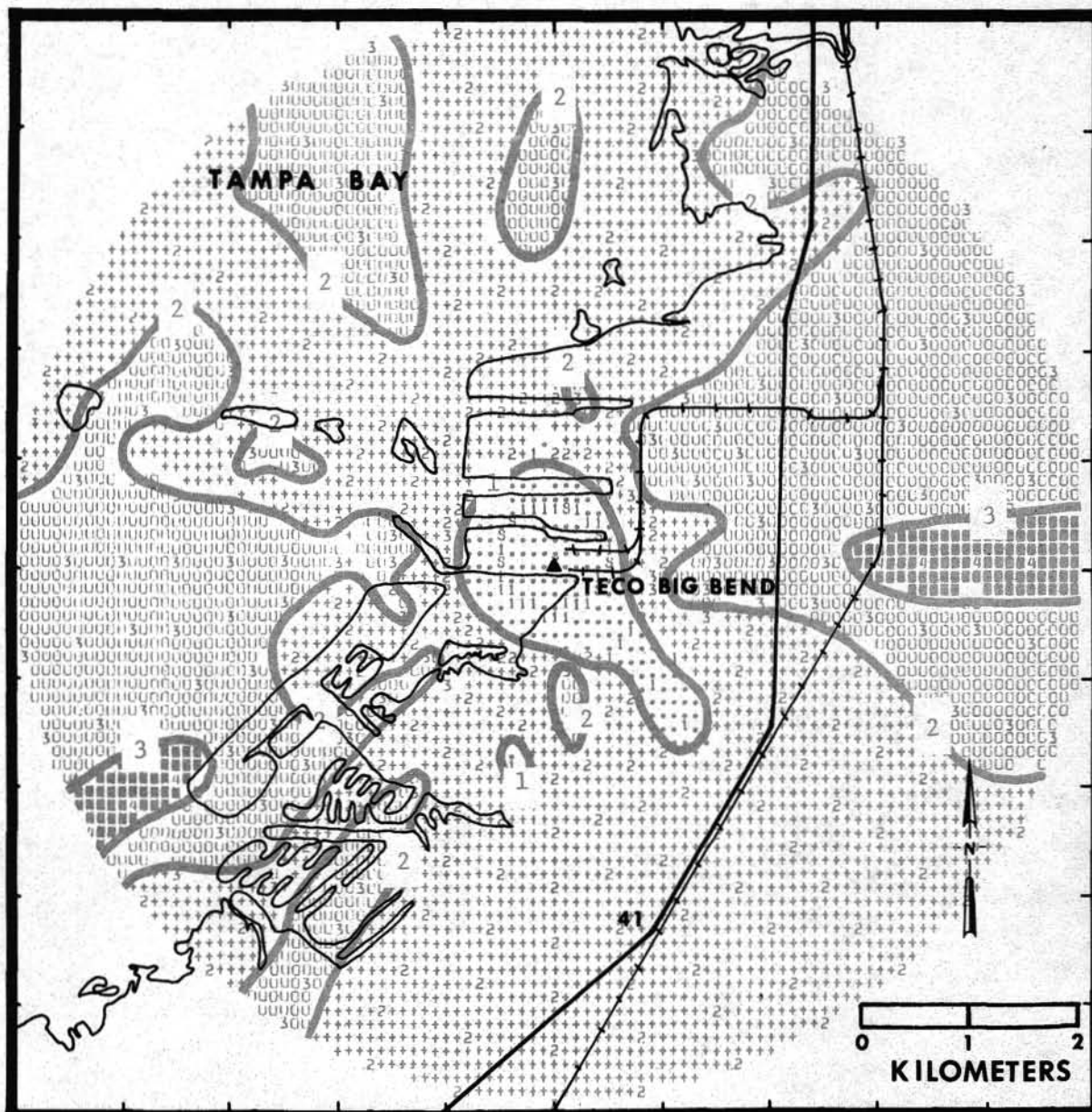


FIGURE: 2.8-10

TECO BIG BEND ONLY

HIGHEST, SECOND-HIGHEST 24-HOUR CONCENTRATIONS, $\mu\text{G}/\text{CU. M}$

TSP 24-HOUR COMPOSITE BASELINE CONCENTRATIONS--ALL CASES

DATA VALUE EXTREMES ARE 0.0 3.60

TOTAL SUPERIMPOSED DATA POINTS IS 14. THESE OCCUR IN 7 LOCATIONS.

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(MAXIMUM INCLUDED IN HIGHEST LEVEL ONLY)

	0.0	1.00	2.00	3.00
MINIMUM	0.00	1.00	2.00	3.00
MAXIMUM	1.00	2.00	3.00	4.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

	25.00	25.00	25.00	25.00
	25.00	25.00	25.00	25.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

	1	2	3	4
SYMBOLS	+++++	+++++	+++++	+++++
FREQ.	44	177	131	8

0.002085 MINUTES FOR HISTOGRAM

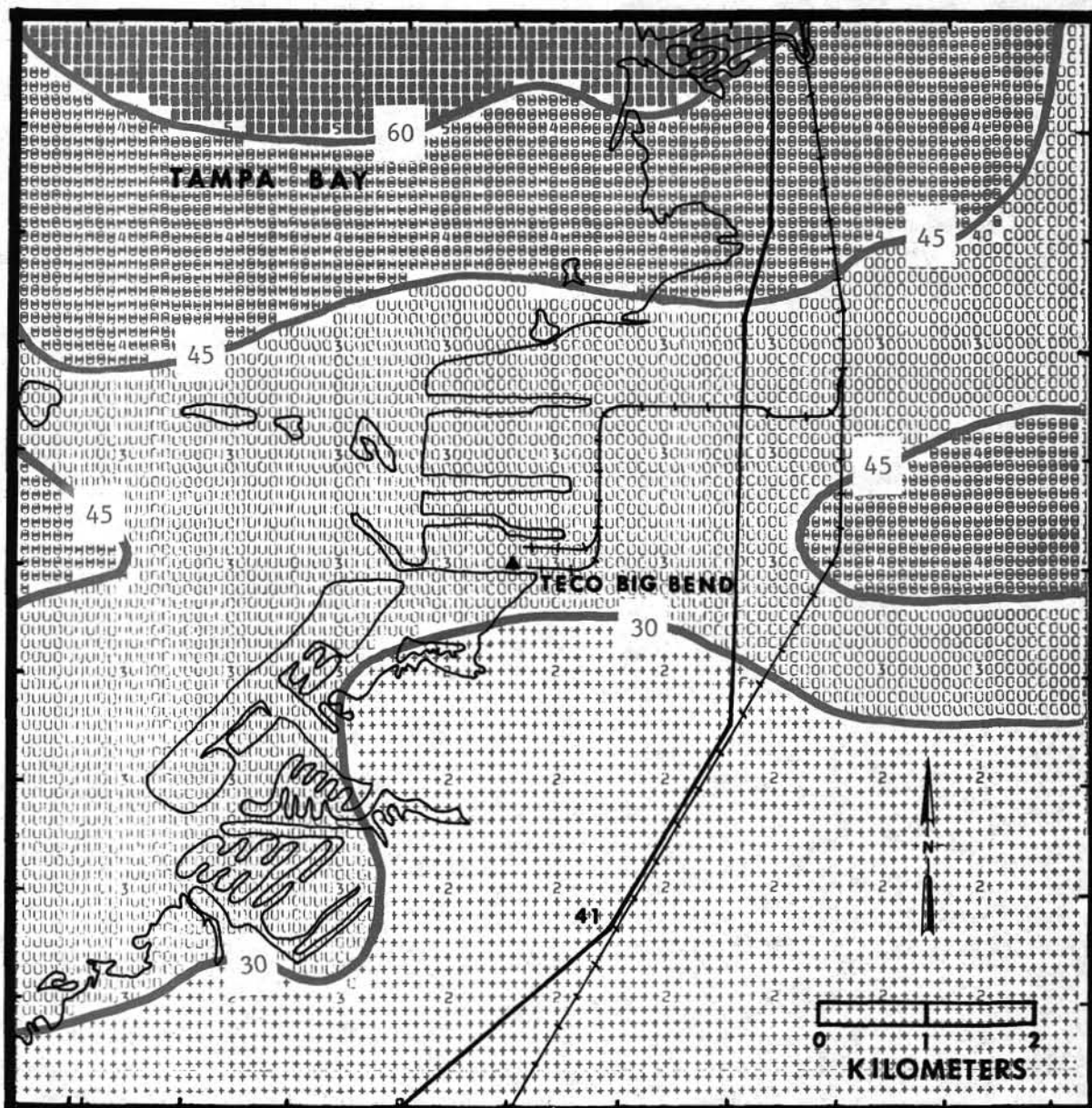


FIGURE: 2.8-11

TECO BIG BEND 4 PSD

ANNUAL AVERAGED CONCENTRATIONS (UG/CU. M)

PER BASELINE---SO2---BIG BEND SITE

DATA VALUE EXTREMES ARE 21.40 73.90

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(MAXIMUM INCLUDED IN HIGHEST LEVEL ONLY)

	0.0	15.00	30.00	45.00	60.00
MINIMUM	0.0	15.00	30.00	45.00	60.00
MAXIMUM	15.00	30.00	45.00	60.00	75.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

20.00	20.00	20.00	20.00	20.00
-------	-------	-------	-------	-------

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5
SYMBOLS		++++++	00000000	00000000	00000000
		++++++	00000000	00000000	00000000
		++++++	00000000	00000000	00000000
		++++++	00000000	00000000	00000000
		++++++	00000000	00000000	00000000
FREQ.	0	30	45	29	11

0.002719 MINUTES PER HISTOGRAM

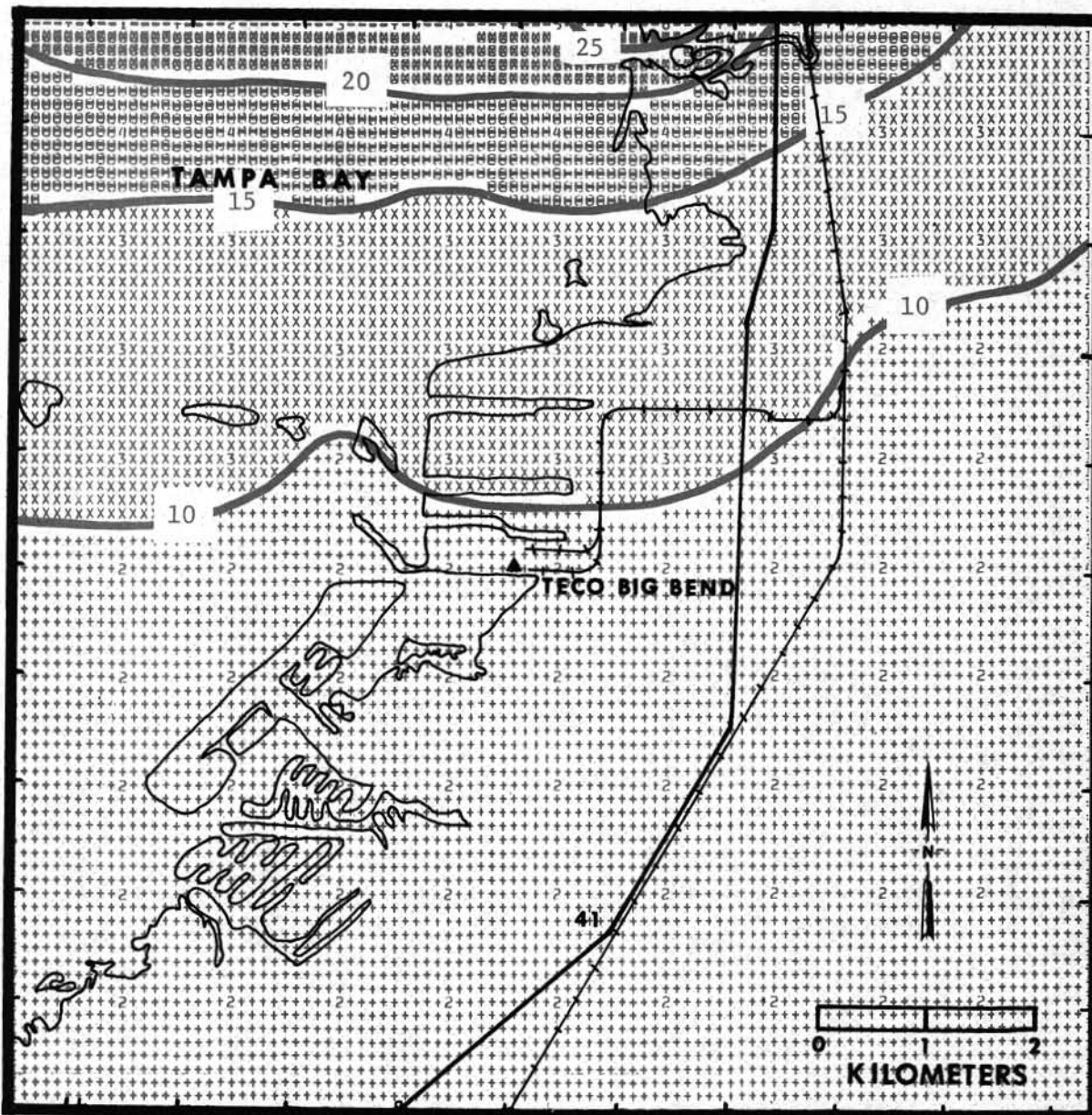


FIGURE: 2.8-12

TECO BIG BEND # PSD

ANNUAL AVERAGED CONCENTRATIONS (UG/CU. M)

DER BASELINE--TSP--BIG BEND SITE

DATA VALUE EXTREMES ARE 5.40 27.20

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(MAXIMUM INCLUDED IN HIGHEST LEVEL ONLY)

	0.0	5.00	10.00	15.00	20.00	25.00
MINIMUM	0.0	5.00	10.00	15.00	20.00	25.00
MAXIMUM	5.00	10.00	15.00	20.00	25.00	30.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

1	2	3	4	5	6
16.67	16.67	16.67	16.67	16.67	16.67

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6
SYMBOLS		++++++	XXXXXXXX	00000000	00000000	00000000
		++++++	XXXXXXXX	00000000	00000000	00000000
		++++++	XXXXXXXX	00000000	00000000	00000000
		++++++	XXXXXXXX	00000000	00000000	00000000
		++++++	XXXXXXXX	00000000	00000000	00000000
FREQ.	0	73	31	9	5	3

0.004469 MINUTES FOR HISTOGRAM

2.9 OTHER ENVIRONMENTAL FEATURES

2.9.1 Ambient Sound Levels

Ambient sound levels are a measure of the total sound at a location and are usually composed of sounds from many sources, both local and distant. The minimum ambient sound levels are an indication of the residual noise level during lulls in the transient noises.

The Big Bend Station is surrounded by open farmland or grassland with a few areas having shrubs or trees. The nearest residential areas are located south of the station. Sound level measurements were made at eight locations at distances of up to 1.5 miles from the station. The sound levels measured during the day and night at each of the measurement locations for each survey are given in Table 2.9-1.

Ambient noise survey methodology is discussed in Section 6.2.9. Measurement locations are shown on Figure 2.9-1. The onsite measurements at locations 1, 2, and 3 are considered typical of the average noise of Units 1 and 2 (1974 data) or Units 1, 2, and 3 (1978 data). The average of all 1974 data at positions 1, 2, and 3 is 58 dBA. The average of the corresponding 1978 data is 61 dBA, indicating an average 3 dBA increase due to the operation of Unit 3.

At the more distant measurement locations, the plant was sometimes audible, depending on the weather conditions as well as other masking noise sources. The degree of plant audibility during each measurement is also noted in Table 2.9-1. In addition to the Big Bend Station, numerous other sources contributed to the ambient sound levels, including the Mineral Aggregates, Inc. plant located east of the station, traffic on Route 41, local traffic, commercial and military aircraft, distant railroad traffic, as well as natural sounds from insects, rustling leaves, birds, and surf. The actual sound levels at locations 4 through 8, therefore, do not always include a significant plant contribution. At locations 4, 5, 6, and, sometimes, locations 7 and 8, local traffic and traffic on nearby U.S. Highway 41 were often the dominant audible noise source. Sound level measurements were made during lulls in traffic. However, distant traffic noise is relatively constant and is part of the ambient noise.

A discussion of operational sound levels will be presented in Chapter 5.

Table 2.9-2 shows that the averages of the 1978 nighttime sound levels at each measurement position were within 3 dBA

of the corresponding 1974 averages, except at location 5, where an 8 dBA increase occurred because the sound levels were dominated by noise from the Mineral Aggregates, Inc. facility. Therefore, it can be concluded that the current nighttime ambient levels are very similar to the 1974 levels. However, the 1978 daytime averages range from 2 dBA to 12 dBA above the 1974 values. Although a small part of the increase may be due to the operation of Unit 3, most of the increase is due to higher level of daytime activities and local traffic because of increased residential development.

The existing ambient sound levels in the vicinity of the plant with Units 1, 2, and 3 operating may be summarized as follows. The highest sound level measured at the offsite locations was 56 dBA at location 5, when sound from the Big Bend Station was not audible. The lowest sound level measured was 31 dBA at location 7, with only distant traffic audible. Although the station contributes to ambient sound levels, there are several other significant community noise sources that dominate the residential sound levels.

TABLE 2.9-1
SUMMARY OF AMBIENT SOUND LEVELS
dBA re 0.0002 Microbars

Location - Description	Daytime - Date and Wind Direction						Nighttime - Date and Wind Direction					
	2/12/74	2/13/74	2/14/74	1/16/78	1/17/78	1/18/78	2/12/74	2/13/74	2/14/74	1/16/78 ²	1/17/78	1/18/78
	W	NW	SW	SE	SW ³	NNW	Calm	Calm	E	SE	SSW ⁴	NNE
1. 1,000 Ft SW (from station)	55 A ¹	56 A	54 A	60 A	59 A	63 A	54 A	58 A	57 A	59 A	56 A	60 A
2. 1,000 Ft ENE	56 A	60 A	59 A	61 A	63 A	59 A	60 A	61 A	59 A	61 A	62 A	61 A
3. 1,000 Ft ESE	58 A	60 A	59 A	63 A	64 A	63 A	60 A	59 A	61 A	61 A	64 A	61 A
4. 7,500 Ft NE at Adamsville	32 J	33 I	37 I	47 I	47 A	44 I	39 I	39 J	41 I	47 A	40 A	41 I
5. 3,800 Ft ESE at Big Bend Road	55 I	47 J	43 I	52 I	56 I	50 A	41 A	47 J	44 A	45 A	54 A	56 I
6. 4,000 Ft S at Newman Branch Road	33 J	39 J	36 I	43 I	40 J	47 A	46 A	48 J	47 A	40 I	47 A	45 I
7. 8,000 Ft SSW at Apollo Beach Road	33 I	34 I	37 I	44 I	41 J	45 J	35 A	41 J	42 A	31 I	38 J	42 I
8. 8,000 Ft SW at Apollo Beach Motel	40 I	43 I	45 I	45 A	44 I	46 A	36 I	44 J	50 J	41 A	41 I	45 A

NOTES: Measurements at locations 1-3 are average values; at locations 4-8 are minimum values.

¹Plant Audibility

A = Very Audible J = Just Audible I = Inaudible

²Unit 2 not operating.

³Except at positions 1, 2, and 3 where wind was S.

⁴Except at positions 6, 7, and 8 where wind was NW.

TABLE 2.9-2

MEASURED AND CALCULATED SOUND LEVELS
BIG BEND UNITS 1, 2, 3, & 4
dBA re 0.0002 Microbars

Location - Description	Average Measured Ambient Levels				Calculated*		Calculated* Units 1-4
	Daytime		Nighttime				
	Units 1 & 2	Units 1, 2, 3	Units 1 & 2	Units 1, 2, 3	Units 1 & 2	Units 1, 2, 3	
1. 1,000 Ft SW (from Station)	55	61	56	58	-	-	Later
2. 1,000 Ft ENE	58	61	60	61	-	-	Later
3. 1,000 Ft ESE	59	63	60	63	-	-	Later
4. 7,500 Ft NE at Adamsville	34	46	40	43	34	37	Later
5. 3,800 Ft ESE at Big Bend Road	48	53	44	52	42	45	Later
6. 4,000 Ft S at Newman Branch Road	36	43	47	44	42	45	Later
7. 8,000 Ft SSW at Apollo Beach Road	35	43	39	37	34	37	Later
8. 8,000 Ft SW at Apollo Beach Motel	43	45	43	42	34	37	Later

NOTES: Individual measurements at locations 1-3 are average values; at locations 4-8 are minimum values.

*Typical maximum values

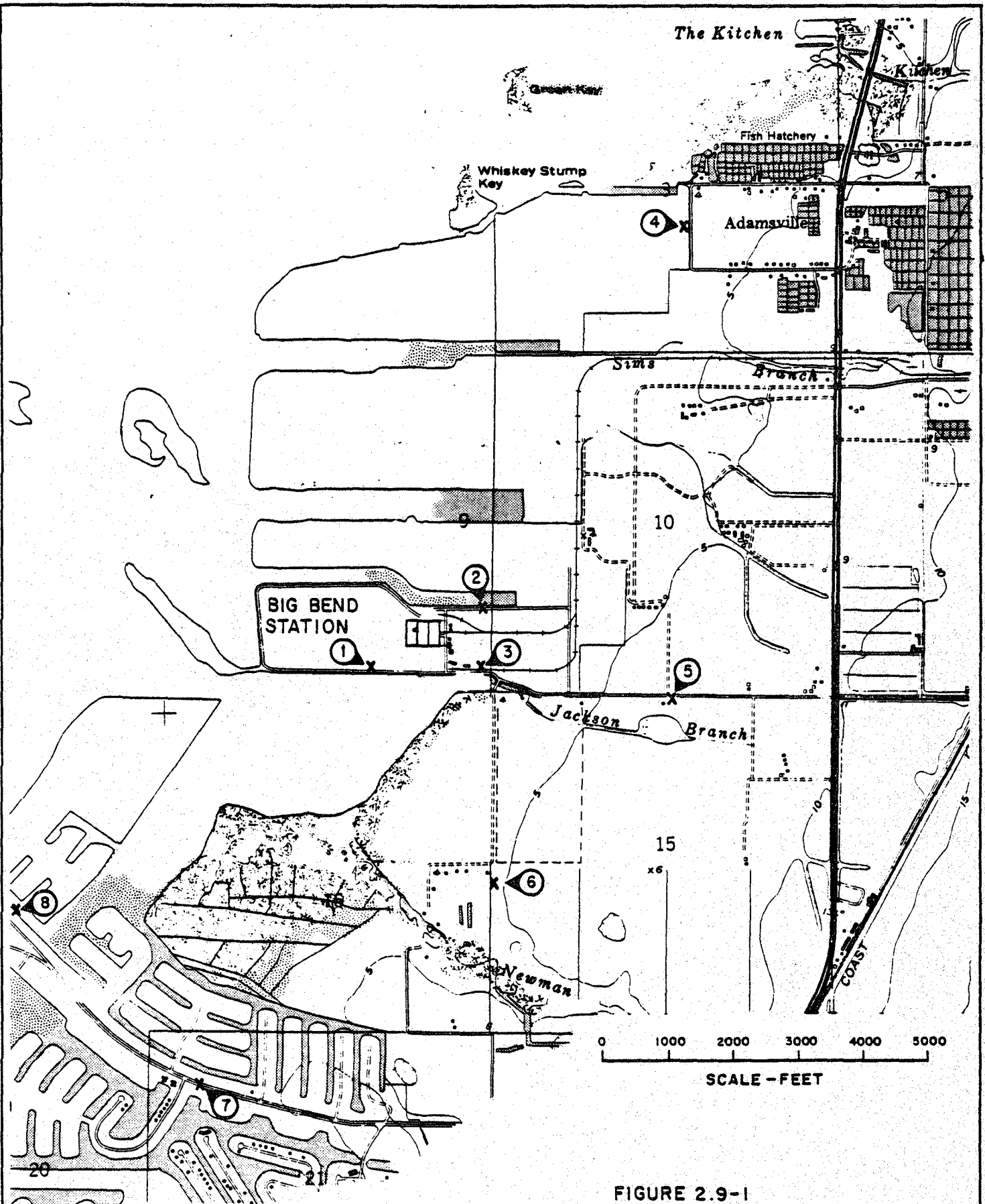


FIGURE 2.9-1
 LOCATION OF AMBIENT
 SOUND LEVEL
 MONITORING STATIONS
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY

CONDUCTED ON FEB. 12-15, 1974

SITE CERTIFICATION APPLICATION
BIG BEND STATION UNIT 4
TAMPA ELECTRIC COMPANY

VOL. 2



SITE CERTIFICATION APPLICATION
BIG BEND STATION UNIT 4
TAMPA ELECTRIC COMPANY



3. THE PLANT

1. The plant is a small, bushy, perennial herb, growing to a height of 1-2 meters. It has a woody base and a dense, rounded, branched habit. The leaves are small, opposite, and elliptical, with a serrated margin. The flowers are small, white, and arranged in a terminal cyme. The fruit is a small, round, capsule.

2. The plant is a small, bushy, perennial herb, growing to a height of 1-2 meters. It has a woody base and a dense, rounded, branched habit. The leaves are small, opposite, and elliptical, with a serrated margin. The flowers are small, white, and arranged in a terminal cyme. The fruit is a small, round, capsule.

3. The plant is a small, bushy, perennial herb, growing to a height of 1-2 meters. It has a woody base and a dense, rounded, branched habit. The leaves are small, opposite, and elliptical, with a serrated margin. The flowers are small, white, and arranged in a terminal cyme. The fruit is a small, round, capsule.

4. The plant is a small, bushy, perennial herb, growing to a height of 1-2 meters. It has a woody base and a dense, rounded, branched habit. The leaves are small, opposite, and elliptical, with a serrated margin. The flowers are small, white, and arranged in a terminal cyme. The fruit is a small, round, capsule.

5. The plant is a small, bushy, perennial herb, growing to a height of 1-2 meters. It has a woody base and a dense, rounded, branched habit. The leaves are small, opposite, and elliptical, with a serrated margin. The flowers are small, white, and arranged in a terminal cyme. The fruit is a small, round, capsule.

6. The plant is a small, bushy, perennial herb, growing to a height of 1-2 meters. It has a woody base and a dense, rounded, branched habit. The leaves are small, opposite, and elliptical, with a serrated margin. The flowers are small, white, and arranged in a terminal cyme. The fruit is a small, round, capsule.



CHAPTER 3

THE PLANT

3.1 EXTERNAL APPEARANCE

The proposed Big Bend Station Unit 4 is scheduled for commercial operation in March 1985. This new, coal-fired steam electric generating unit will have a net capacity of 417 MW, resulting in a total expected plant generating capacity of 1,503 MW.

Unit 4 will be constructed adjacent to Unit 3, which began commercial operation on May 1, 1976. Figure 3.1-1 presents a plot plan of Big Bend Station, including Unit 4. Figure 3.1-2 presents an artist's view, and Figure 3.1-3 presents a plant profile of Big Bend Station including Unit 4. The Big Bend Station site boundaries and topography are shown on Figure 3.1-4; the construction site layout is shown on Figure 3.1-5.

The turbine room and boiler complex will be an extension of the existing station structures. Stack gases will be exhausted via the stack constructed with Unit 3 which was designed to accommodate Units 3 and 4. Figure 3.1-6 shows the location of all liquid and gaseous emissions from Big Bend Station, including Unit 4.

Design of Unit 4 expresses functional architecture. The turbine hall is enclosed in a steel frame sheathed with structural siding, and is an easterly extension of the existing hall. The service facilities are extensions of this dominant mass. The boiler, rising above it, is exposed and offers a complex of forms contrasting with the simple, rectangular turbine building.

Architecturally, the structure is designed to be an interesting balance of shape and mass. Refinement is sought in penetration and detail. The corners of the turbine building are sharply defined in a reentrant motif. Natural light is admitted to the interior through a continuous treatment of translucent plastic panels which form a cornice band at the top of the structure.

Appearance of the plant is enhanced by color, interior as well as exterior. The siding color selected for Unit 4 balances the oyster white of the siding used on Units 1 through 3, and describes the buildings which are defined by a cranberry red trim. The exposed steel framing supporting

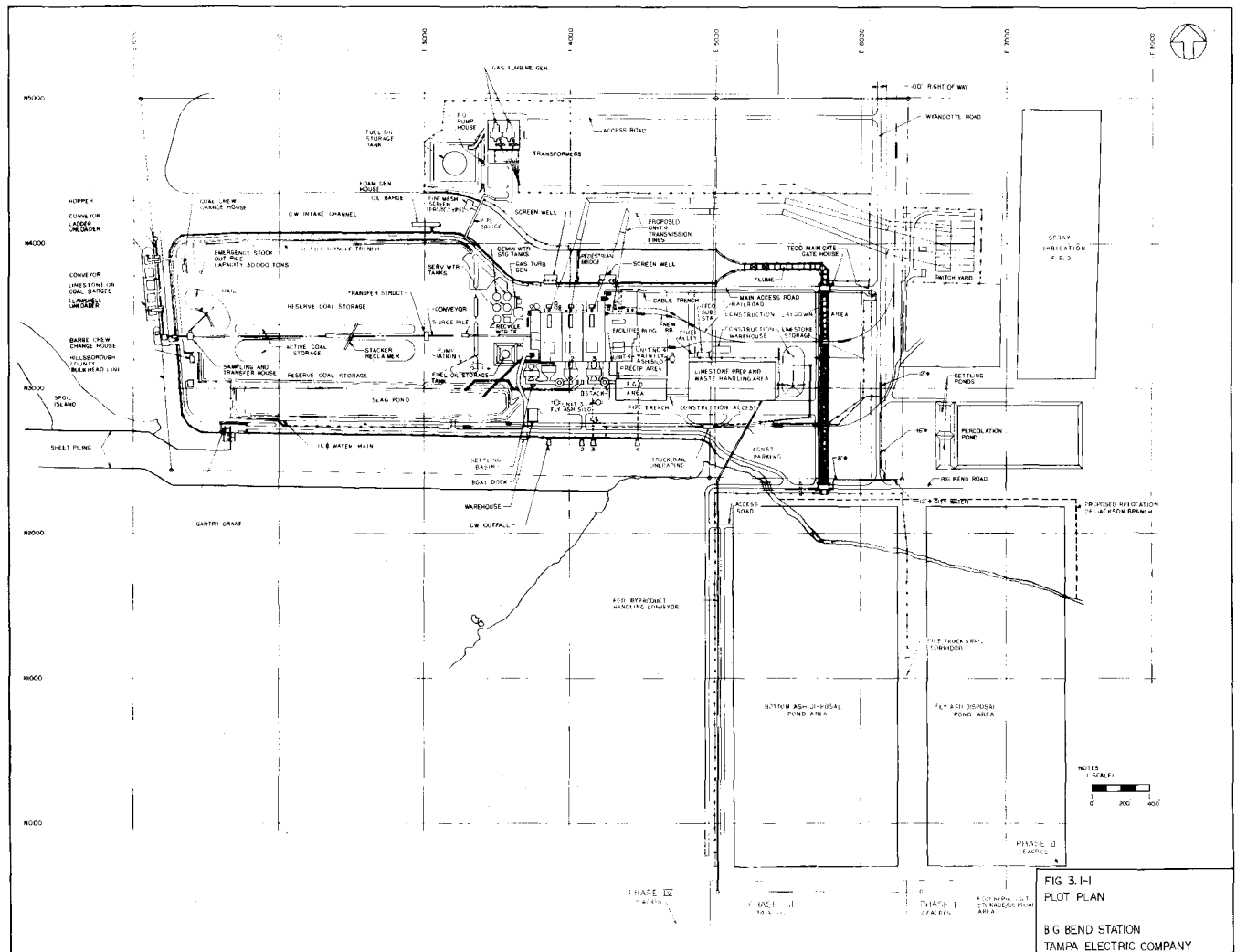
the Unit 3 boiler is painted a bright yellow contrasted by cerulean blue applied to the coal bunkers and exposed steel supporting the precipitator. The cranberry color is repeated, accenting the exposed columns supporting the enclosed conveyor house. This color scheme is repeated for the adjacent Unit 4 boiler, bunkers, and precipitator structures. This scheme, blue accenting the yellow of the mechanical forms, and cranberry red accenting the pale gray of the solid masses, is consistently recalled throughout the plant complex.

This color treatment is effective for the coal unloader and stacker, a unique facility located on the sea wall. The strong colors dramatize the moving parts of this enormous and complex mechanism.

The Big Bend Station, as seen from the bay, composes a pleasing structure of interesting profile with a clean color combination. The areas immediately around the main approaches and personnel entrances are appropriately landscaped.

Image Quality

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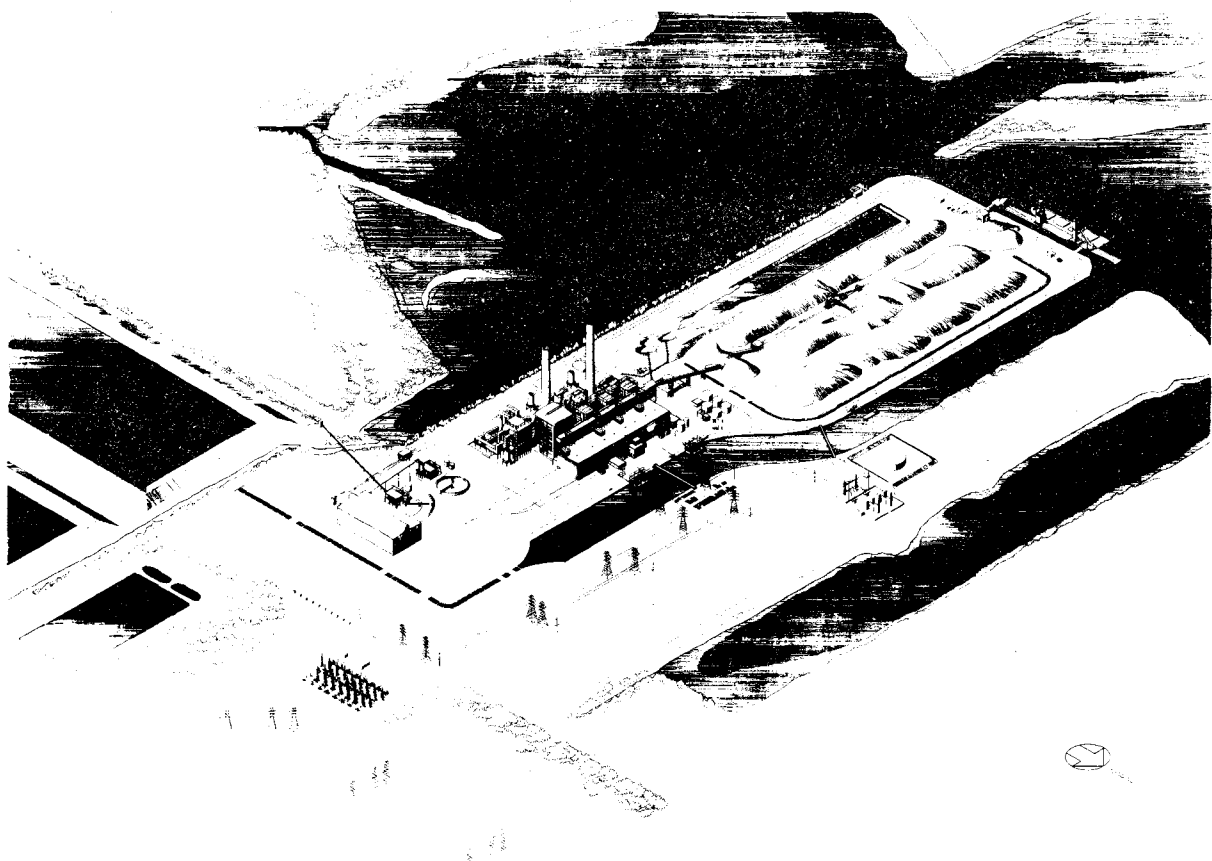


FIGURE 31-2
ARTIST'S VIEW
BIG BEND STATION
TAMPA ELECTRIC COMPANY

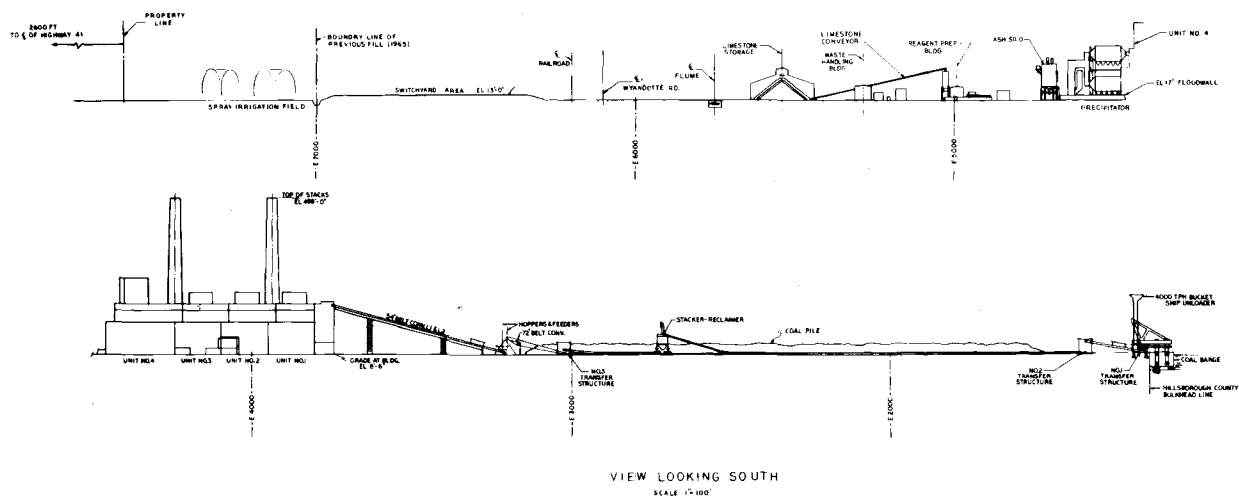
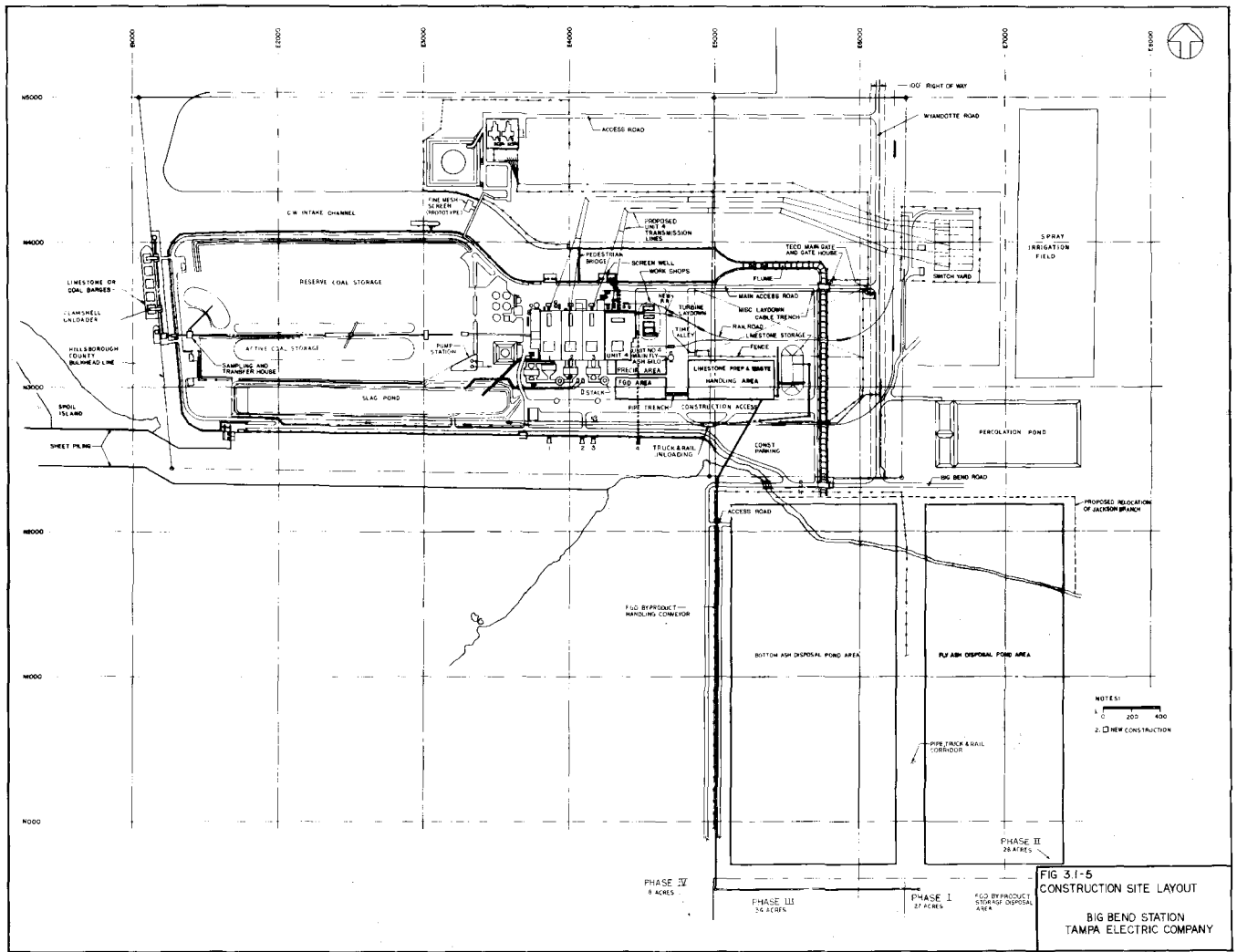
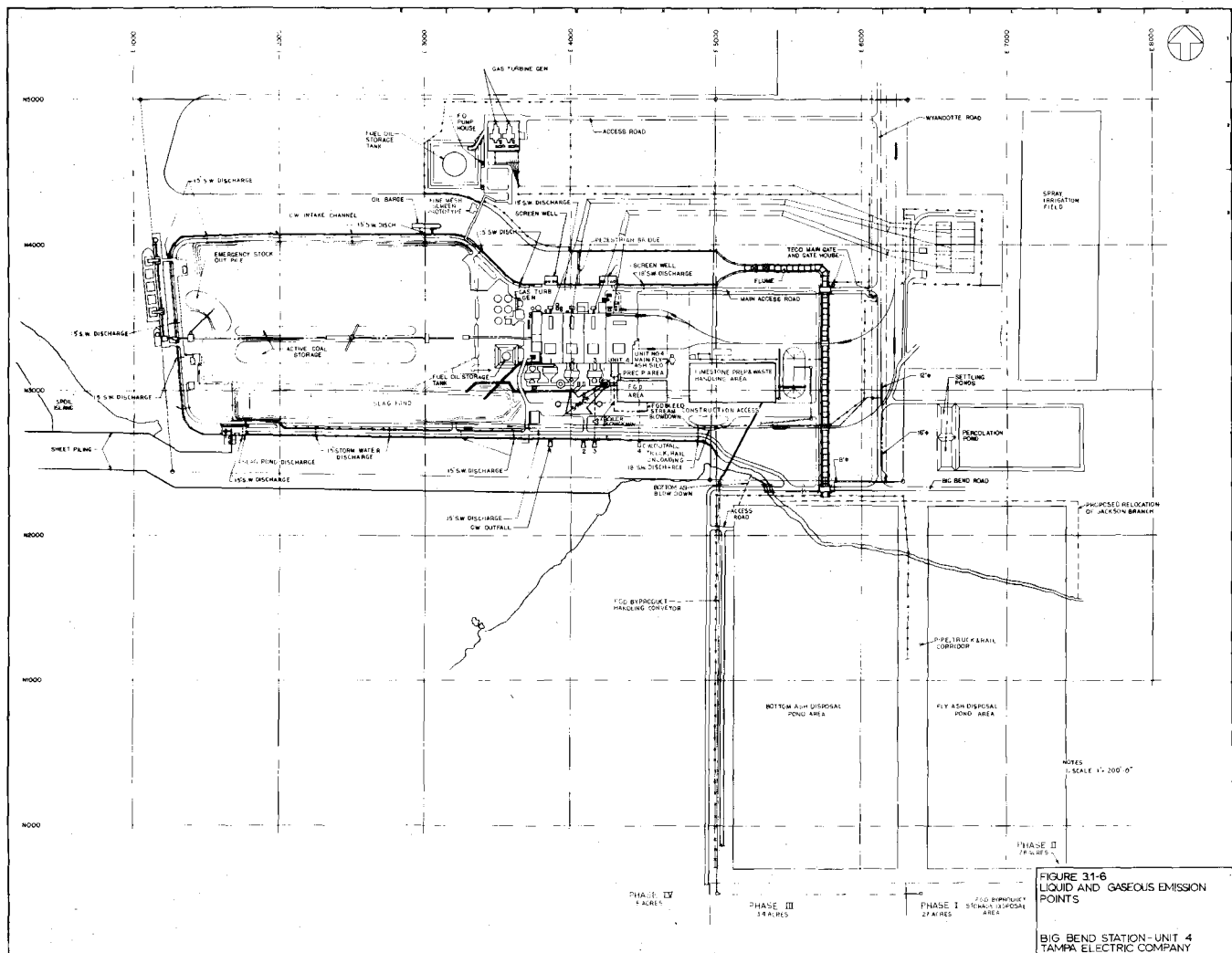


FIG. 3.1-3
PLANT PROFILE

BIG BEND STATION
TAMPA ELECTRIC COMPANY





3.2 FUEL

3.2.1 Fuel Type

The fuel for Big Bend Station, including Unit 4, is planned to be bituminous coal. Fuel specifications for Unit 4 covering the types of coal that may be burned in that unit are listed in Table 3.2-1.

3.2.2 Fuel Handling and Storage

Unit 4 will burn approximately 950,000 tons of coal per year. Coal is delivered to Big Bend Station in covered barges by the Gulf Coast Transit Company. It is unloaded from the barges by a dock-mounted, 4,000 tons per hour ladder unloader. The coal is then transported south along the dock via a 72-inch conveyor belt to transfer tower 1 and then east to transfer tower 2. At transfer tower 2 the coal may either be piled as emergency storage or continue east on the 72-inch belt to a stacker-reclaimer. At the stacker-reclaimer, the coal may either continue on the conveyor belt to transfer tower 3 or may be stacked onto the storage piles. Tower 3 receives coal from the stacker-reclaimer and transfers it to two 54-inch covered conveyors leading to the fuel bunkers within the plant. All transfer points are enclosed.

The coal storage pile north of the stacker-reclaimer is 1,800 feet by 250 feet and is capable of storing 435,000 tons. The coal storage pile south of the stacker-reclaimer is 1,800 feet by 200 feet and can store 238,000 tons (Figure 3.1-1).

The existing facilities presently serve Units 1, 2 and 3 and will continue to be utilized during four-unit operation. The coal field will be modified to allow additional coal to be stored for Unit 4.

It is possible that in the future the economics of transporting other types of coal from regions not accessible to waterborne transportation may dictate the need for fuel delivery by rail. The details of such a system, however, will not be formulated until a need arises. Preliminary thinking suggests that if rail delivery was indeed required, the facilities would provide for unloading coal onto the existing conveyor system.

TABLE 3.2-1
COAL ANALYSIS OF POSSIBLE FUELS
BIG BEND STATION - UNIT NO. 4

	Coal Type No. 1	Coal Type No. 2	Coal Type No. 3	Coal Type No. 4	Coal Type No. 5
	washed	raw	washed	raw	washed
<u>Parameters</u>					
Heating value as received, (Btu/lb)	11,110	11,137	11,630	9,053	11,550
Ash fusion temp--reducing					
Initial	2,090	2,020	2,050	2,100	2,000
Softening (H=W/2)	2,280	2,135	2,150	2,210	2,275
Fluid	2,310	2,275	2,240	2,340	2,450
Ash fusion temp--oxidizing					
Initial	2,190	2,310	2,400		2,224
Softening (H=W/2)	2,295	2,430	2,540		2,363
Fluid	2,370	2,545	2,600		2,546
Grindability--Hardgrove No.	56	64.1	48.8	62.3	55.1
Ultimate Analysis--percent by weight					
Moisture	12.50	10.78	10.04	7.55	9.50
Ash	10.10	18.40	9.63	28.54	11.20
Sulfur	3.20	4.06	3.26	3.92	2.71
Carbon	72.48	54.94	64.47	49.68	63.50
Hydrogen	5.24	3.86	4.37	3.54	4.40
Oxygen	11.17	6.71	6.97	5.40	7.11
Nitrogen	1.22	1.13	1.23	0.95	1.50
Chlorine	0.09	0.12	0.03	0.02	0.08
Proximate Analysis--percent by weight					
Moisture	12.50	10.78	10.04	7.55	9.50
Ash	10.10	18.40	9.63	28.54	11.20
Volatile Matter	34.20	33.06	35.29	27.95	32.18
Fixed Carbon	42.75	37.76	45.04	35.96	47.12
Sulfur	3.20	4.06	3.26	3.92	2.71

TABLE 3.2-1 (Cont)

COAL ANALYSIS OF POSSIBLE FUELS
BIG BEND STATION - UNIT NO. 4

	Coal Type No. 1	Coal Type No. 2	Coal Type No. 3	Coal Type No. 4	Coal Type No. 5
	washed	raw	washed	raw	washed
Ash Analysis--percent by weight					
Ferric Oxide--Fe ₂ O ₃	16.78	19.88	29.41	15.03	19.73
Lime--CaO	7.55	5.55	3.32	4.37	4.00
Magnesia--MgO	0.57	1.21	0.51	1.24	0.85
Sodium Oxide--Na ₂ O	0.59	0.93	0.10	0.27	0.33
Potassium Oxide--K ₂ O ₃	1.51	2.22	1.68	3.31	2.20
Silica--SiO ₂	48.45	46.67	43.62	54.11	48.42
Alumina--Al ₂ O ₃	18.31	17.81	18.51	17.39	19.56
Titania--TiO ₂	0.74	0.77	0.90	0.79	0.90
Phos. Pentoxide--P ₂ O ₅	0.48	0.22	0.22	0.36	0.16
Sulfur Trioxide--SO ₃	0.09	1.73	1.61	2.26	3.53

3.3 STATION WATER USE

As described in Section 2.2.3.2, the plant is served by the Hillsborough County-Riverview-Gibsonston water system for most of its freshwater needs. County water use by Big Bend Unit Nos. 1 through 3 has been 1.1 million gallons per day (average). Estimates show the need for an additional 1.4 million gallons per day (mgd) for Unit No. 4 with the FGD system using the majority of that water.

Hillsborough Bay, the source of once-through cooling water for Big Bend Unit Nos. 1 through 3, is the source for the proposed Unit 4 once-through cooling water. The combined discharge of Units 1, 2, and 3 totals 1611 cfs. The combined discharge of Units 1, 2, 3, and 4 will total 2148 cfs.

Figure 3.3-1 is a plant water balance for Unit 4.

3.3.1 Makeup Demineralizer System

Well water taken from the Riverview-Gibsonston system supplies water to the demineralizer equipment presently used to provide high quality makeup water for the plant.

Typical analysis for this water supply is as follows:

	<u>ppm</u>
Calcium (as Ca ⁺⁺)	74
Magnesium (as Mg ⁺⁺)	30
Sodium (as Na ⁺)	13
Bicarbonate (as HCO ₃ ⁻)	198
Chloride (as Cl ⁻)	27
Sulfate (as SO ₄ ⁻)	129
Fluoride (as F ⁻)	0.5
Silica (as SiO ₄ ⁻)	32
Total Dissolved Solids	510
Free CO ₂ (as CO ₂)	5
Total Hardness (as CaCO ₃)	306
Total Alkalinity (as CaCO ₃)	162
pH	7.5-7.9
Temperature	60°-80°F
Settleable Substances	30

No additional demineralizer equipment is proposed for Unit 4 since existing Unit 3 facilities have the capability to furnish the required makeup.

The existing demineralizer facility consists of two trains of units, each train consisting of an activated carbon unit, cation exchange unit, forced draft decarbonator, anion exchange unit, and mixed-bed exchange unit operating in series. Demineralized water discharges are stored in two 500,000-gallon storage tanks.

Each train can supply up to 600 gpm of demineralized water which will provide system reliability under maximum power operation.

Expected consumption values of water for the makeup demineralizer system are listed in Table 3.3-1.

Water usage and wastes related to the reconditioning and regeneration cycles are summarized in Section 3.5.

3.3.2 Condensate Polishing Demineralizer System

A condensate polishing demineralizer system is required for Unit 4 to maintain the following condensate water quality:

Sodium (as Na)	3 ppb
Chlorides (as Cl)	4.5 ppb
Specific Conductivity at 25°F	0.10 umho/cc max
Total Solids (dissolved and suspended)	27 ppb max
Total Silica (as SiO ₂)	10 ppb max
Metallic Impurities (as the metal)	10 ppb of which copper shall not exceed 2 ppb; iron 5 ppb
Total Hardness (as CaCO ₃)	0
pH (before NH ₃ break)	6.5 to 7.5
pH (after NH ₃ break)	8.8 to 9.6

There will be a total of three condensate polishing demineralizer units (two operating and one spare). The design flow rate for two operating units is 6,000 gpm. The design temperature and pressure are 135°F and 500 psi, respectively.

3.3.3 Cooling Water System

Units 1, 2, and 3 each draw 537 cfs of circulating water. An intake channel of 25-ft depth draws water from a ship access channel of 34-ft depth. Each unit is provided with a screenwell structure equipped with two circulating water pumps of 268.5 cfs capacity. Water is drawn through

traveling water screens and is pumped through two, 72-inch diameter pipes to a condenser for each unit. The water velocity measured immediately in front of the screenwells at the traveling water screens is 1.45 fps. The combined circulating water flow rate for Units 1, 2, and 3 totals 1611 cfs.

Upon leaving the condenser, the warm circulating water from each unit flows to the discharge channel via circulating water discharge structures (Figure 3.4-4). The retention time of the circulating water subsequent to increase in temperature (i.e., from the condenser intake to the circulating water discharge) is approximately 1.5 minutes for each unit.

Flows in the intake and discharge channels and their respective velocities are presented in the following table:

	<u>Unit 1</u>	<u>Unit 2</u>	<u>Unit 3</u>	<u>Unit 4</u>
Intake Channel				
Flow rate, cfs	537	537	537	537
Cumulative flow	537	1074	1611	2148
Velocity, fps	0.14	0.28	0.42	0.56
Discharge Channel				
Unit flow, cfs	537	537	537	537
Cumulative flow	537	1074	1611	2148

3.3.4 Flue Gas Desulfurization (FGD) System

A flue gas desulfurization system is required for Unit 4 to meet state and federal emission and air quality standards. The proposed system, which utilizes the limestone process, is discussed in Section 3.7.2.

A limestone system requires a makeup water source for the sulfur dioxide removal process. An estimated 1.0 mgd is required as makeup for the proposed system.

Current plans are to utilize water from the Hillsborough County South/Central System. In order to minimize the plant's demand on this municipal system, the applicant has evaluated the use of water from other sources. The most promising source would be sewage effluent from Sun City Center since its quality is compatible with the requirements of the FGD system. TECO has been included in the Hillsborough County South 201 Facility Plan for reuse of the

sewage effluent. The plan provides for 1.3 mgd available for Big Bend in 1986.

3.3.5 Bottom Ash Sluice System

The Unit 4 boiler will be of the dry bottom type and will be provided with a recirculating freshwater sluice system to transport ash to a disposal pond. Makeup water requirement to the ash sluice system will be approximately 505,000 gpd. The system requires a blowdown of 115,000 gpd to the discharge channel. The characteristics and effluent limitations for this stream are described in Section 5.2.1.3

3.3.6 Fly Ash, Pyrites and Economizer Sluice System

Unit 4 will be provided with a closed loop freshwater fly ash sluice system for handling fly ash, economizer ash and pyrites. The system will transport these materials to an onsite disposal pond. Makeup water requirements for this system will be approximately 54,600 gpd.

3.3.7 Other Water Uses

There will be many minor water uses associated with Unit 4. These include service cooling water, fire protection water, pump and equipment seal water, and domestic water. In addition, plant recycle water will be used for many purposes such as air preheater, precipitator and boiler washing. These anticipated water quantities are included in Figure 3.5-1.

TABLE 3.3-1

EXPECTED INFLUENTS AND EFFLUENTS - DEMINERALIZER SYSTEM
UNITS 3 AND 4

	<u>Activated Carbon Filter</u>	<u>Combined Anion - Cation</u>	<u>Mixed Bed</u>
Quantity Between Regenerations			
Influent, Gal.	3,300,000	556,600	4,600,000
Effluent, Gal.	3,300,000	444,000	4,568,500
Design Frequency of Regenerations	Approx. Once Every 7 Days	Approx. Once Every 45 Hrs.	Approx. Once Every 20 Days
Quantity of Regeneration Waste, Gal.	4,045	112,000	31,500

NOTE: All information in this table is for one demineralizer train, and is identical for the other train.

PLANT WATER BALANCE (10 ³ GPD)											
LINE IDENTIFICATION	AVERAGE	MAXIMUM	NATURE	DURATION	FREQUENCY	LINE IDENTIFICATION	AVERAGE	MAXIMUM	NATURE	DURATION	FREQUENCY
A. ACTIVATED CARBON BED INFLUENT	145.2	145.2	C	-	-	AA. FGD EVAPORATION LOSSES	989.3	989.3	C	-	-
B. ACTIVATED CARBON BED EFFLUENT	144.9	144.9	C	-	-	BB. HYDROCLONE EFFLUENT TO FILTER	316.8	316.8	C	-	-
C. ACTIVATED CARBON BED BACKWASH	0.3	0.3	I	-	1/WK	CC. VACUUM FILTER SLUDGE (20% WATER)	74.9	74.9	C	-	-
D. ANION/CATION BED EFFLUENT	115.0	115.0	C	-	-	DD. VACUUM FILTER RECYCLE	241.9	241.9	C	-	-
E. ANION/CATION BED BACKWASH	29.8	29.9	I	-	1/30 HRS.	EE. HYDROCLONE RECYCLE	1,424.4	1,424.4	C	-	-
F. MIXED RESIN BED EFFLUENT Δ (BOILER MAKE-UP)	114.2	114.2	C	-	-	FF. RECYCLE TO FGD SYSTEM	1,607.1	1,607.1	C	-	-
G. MIXED BED BACKWASH	0.8	0.8	I	-	1/27 DAYS	GG. LIMESTONE STORAGE RUNOFF Δ	-	-	I	-	-
H. NEUTRALIZATION/EQUALIZATION TANK EFFLUENT	38.7	38.7	C	-	-	HH. SERVICE WATER EFFLUENT Δ	21.2	21.2	I	-	-
I. CONDENSATE POLISHER EFFLUENT BACKWASH	-	-	-	-	-	II. WASTE WATER TREATMENT SYSTEM RECYCLE Δ	21.2	21.2	I	-	-
J. CONDENSATE POLISHER BACKWASH	8.0	8.0	I	-	1/4 DAYS	JJ. AIR PREHEATER WASH Δ	9.4	9.4	I	8 HRS.	1.3 MOS.
K. BOILER BLOWDOWN	43.2	43.2	C	-	1/4 DAYS	KK. PRECIPITATOR WASH Δ	5.3	5.3	I	80 HRS.	3 YR.
L. BOILER CHEMICAL CLEANING WASTE Δ	0.9	0.9	I	2HRS. STAGE	1/2 YRS.	LL. ECONOMIZER WASH Δ	0.3	0.3	I	4 HRS.	3 YR.
M. VENT LOSSES	15.0	15.0	C	-	-	MM. SPARGING SYSTEM Δ	4.6	4.6	I	24 HRS.	3 YR.
N. SOOT BLOWING LOSSES	47.1	47.1	I	-	-	NN. EXTERNAL BOILER WASH Δ	1.6	1.6	I	24 HRS.	2 YR.
O. SERVICE COOLING TOWER MAKEUP	210.0	210.0	C	-	-	OO. FLYASH POND BLOWDOWN	72.0	72.0	I	-	-
P. SERVICE COOLING TOWER EVAP. LOSSES	138.0	138.0	C	-	-	PP. WASTE WATER TREATMENT SYSTEM PERCOLATION LOSSES Δ	30.0	30.0	C	-	-
Q. SERVICE COOLING TOWER BLOWDOWN	72.0	72.0	C	-	-	QQ. SPRAY IRRIGATION SYSTEM Δ	169.5	183.4	I	-	-
R. HIGH & LOW PRESSURE FIRE PROTECTION SYSTEM Δ	NIL	NIL	I	-	-	RR. ROOF/YARD STORM DRAINS Δ	19.4	38.9	I	-	-
S. DOMESTIC SERVICE WATER PHASE II	1.3	1.3	I	-	-	SS. CONDENSER COOLING WATER	347,072.0	347,072.0	C	-	-
T. SEWAGE TREATMENT PLANT EFFLUENT Δ	1.3	1.3	I	-	-	UU. BOTTOM ASH POND MAKEUP	505.0	505.0	C	-	-
U. HOSE CONNECTIONS Δ	0.1	2.9	I	4 HRS	1/4 WEEKS	VV. CONDENSER COOLING EFF	347,072.0	347,072.0	C	-	-
V. PUMP SEALS	10.8	10.8	C	-	-	XX. BOTTOM ASH RECYCLE	1,825.0	1,825.0	C	-	-
W. CLINKER GRINDER SEALS	1.3	5.4	I	2 HRS	3/DAY	YY. FLYASH SLUICE WATER MAKEUP	72.0	72.0	I	-	-
X. COAL EQUIPMENT WASH Δ	2.1	2.1	I	16 HRS	4/YR.	ZZ. FGD DISPOSAL SITE RUNOFF Δ	18.6	37.1	I	-	-
Y. FGD SYSTEM MAKEUP	1,123.2	1,123.2	C	-	-						
Z. FGD SLURRY (85% WATER)	1,741.0	1,741.0	C	-	-						

Δ DENOTES FLOWS WHICH MAY OCCUR DURING UNIT 4 SHUT DOWN.

FIGURE 3.3-1 (SHEET 2 OF 3)
PLANT WATER BALANCE
BIG BEND STATION
TAMPA ELECTRIC COMPANY

PLANT WATER BALANCE (10 ³ GPD)											
LINE IDENTIFICATION	AVERAGE	MAXIMUM	NATURE	DURATION	FREQUENCY	LINE IDENTIFICATION	AVERAGE	MAXIMUM	NATURE	DURATION	FREQUENCY
AAA. BOTTOM ASH SLUICE	2,300.0	2,300.0	I	-	-						
BBB. BOTTOM ASH SYSTEM EVAPORATION LOSSES	30.0	30.0	C	-	-						
CCC. FLYASH SLUICE	1,440.0	1,440.0	I	-	-						
DDD. FLYASH RECYCLE	1,368.0	1,368.0	I	-	-						
EEE. BOTTOM ASH POND PERCOLATION LOSSES Δ	360.0	360.0	C	-	-						
FFF. BOTTOM ASH POND BLOWDOWN	115.0	115.0	-	-	-						
GGG. CONSTRUCTION WATER USES Δ	NOT AVAILABLE	NOT AVAILABLE	I	-	-						
HHH. DOMESTIC WATER USES	NOT AVAILABLE	NOT AVAILABLE									
III. CONDENSER COOLING WATER MAKEUP	15,859.2	15,859.2	C								
JJJ. CONDENSER COOLING TOWER EVAPORATION LOSSES	5,184.0	5,184.0	C								
KKK. CONDENSER COOLING TOWER BLOWDOWN	10,224.0	10,224.0	C								
LLL. FGD SYSTEM BLOWDOWN	59.0	59.0	C								
NNN. COAL STORAGE RUNOFF	-	-	I								

FIGURE 3.3-1 (SHEET 3 OF 3)
PLANT WATER BALANCE
BIG BEND STATION
TAMPA ELECTRIC COMPANY

Δ DENOTES FLOWS WHICH MAY OCCUR DURING UNIT 4 SHUT DOWN.

Δ DENOTES FLOWS WHICH MAY OCCUR DURING UNIT 4 SHUT DOWN.

FIGURE 3.3-1 (SHEET 3 OF 3)
PLANT WATER BALANCE
BIG BEND STATION
TAMPA ELECTRIC COMPANY

PLANT WATER BALANCE (10³GPD)

LINE IDENTIFICATION	AVERAGE	MAXIMUM	NATURE	DURATION	FREQUENCY	LINE IDENTIFICATION	AVERAGE	MAXIMUM	NATURE	DURATION	FREQUENCY
A. ACTIVATED CARBON BED INFLUENT	145.2	145.2	C	-	-	DD. VACUUM FILTER RECYCLE	355.7	355.7	C	-	-
B. ACTIVATED CARBON BED EFFLUENT	144.9	144.9	C	-	-	EE. THICKENER RECYCLE	842.4	842.4	C	-	-
C. ACTIVATED CARBON BED BACKWASH	0.3	0.3	I	-	1/WK	FF. RECYCLE TO FGD SYSTEM	1198.1	1198.1	C	-	-
D. ANION/CATION BED EFFLUENT	115.0	115.0	C	-	-	GG. LIMESTONE & COAL STORAGE RUNOFF ▲	6.9	13.9	I	-	-
E. ANION/CATION BED BACKWASH	29.9	29.9	I	-	1/30 HRS.	HH. SERVICE WATER EFFLUENT ▲	18.9	18.9	I	-	-
F. MIXED RESIN BED EFFLUENT ▲ (BOILER MAKE-UP)	114.2	114.2	C	-	-	II. WASTE WATER TREATMENT SYSTEM RECYCLE ▲	18.9	18.9	I	-	-
G. MIXED BED BACKWASH	0.8	0.8	I	-	1/27 DAYS	JJ. AIR PREHEATER WASH ▲	7.1	7.1	I	5 HRS.	1/3 MOS.
H. NEUTRALIZATION/EQUALIZATION TANK EFFLUENT	38.7	38.7	C	-	-	KK. PRECIPITATOR WASH ▲	5.3	5.3	I	80 HRS.	3/YR.
I. CONDENSATE POLISHER EFFLUENT	956.0	956.0	I	-	1/4 DAYS	LL. ECONOMIZER WASH ▲	0.3	0.3	I	4 HRS.	3/YR.
J. CONDENSATE POLISHER BACKWASH	0.0	0.0	I	-	1/4 DAYS	MM. SPARGING SYSTEM ▲	4.6	4.6	I	24 HRS.	3/YR.
K. BOILER BLOWDOWN	43.2	43.2	C	-	-	NN. EXTERNAL BOILER WASH ▲	1.6	1.6	I	24 HRS.	2/YR.
L. BOILER CHEMICAL CLEANING WASTE ▲	0.9	0.9	I	2HRS/STAGE	1/2 YRS.	OO. WASTE WATER TREATMENT SYSTEM EVAPORATION LOSSES ▲	26.5	26.5	C	-	-
M. VENT LOSSES	15.0	15.0	C	-	-	PP. WASTE WATER TREATMENT SYSTEM PERCOLATION LOSSES ▲	26.3	47.5	C	-	-
N. SOOT BLOWING LOSSES	47.1	47.1	I	-	-	QQ. SPRAY IRRIGATION SYSTEM ▲	81.6	127.2	I	-	-
O. SERVICE COOLING TOWER MAKEUP	210.0	210.0	C	-	-	RR. ROOF/YARD STORM DRAINS ▲	18.4	38.9	I	-	-
P. SERVICE COOLING TOWER EVAP. LOSSES	138.0	138.0	C	-	-	SS. CONDENSER COOLING WATER	346,902	346,902	C	-	-
Q. SERVICE COOLING TOWER BLOWDOWN	72.0	72.0	C	-	-	TT. THERMAL DILUTION WATER	287,470.0	287,470.0	C	-	-
R. HIGH & LOW PRESSURE FIRE PROTECTION SYSTEM ▲	NIL	NIL	I	-	-	UU. BOTTOM ASH POND MAKEUP	451.2	451.2	C	-	-
S. DOMESTIC SERVICE WATER	1.3	1.3	I	-	-	VV. CONDENSER COOLING EFF TO DILUTION SYSTEM	346,450	346,450	C	-	-
T. DOMESTIC SERVICE WATER EFFLUENT ▲	1.3	1.3	I	-	-	WW. COOLING EFFLUENT WATER TO BAY	633,920.0	633,920.0	C	-	-
U. HOSE CONNECTIONS ▲	0.1	2.9	I	4 HRS	1/4 WEEKS	XX. BOTTOM ASH RECYCLE	908.6	908.6	I	2 HRS.	6/DAY
V. PUMP SEALS	10.9	10.9	C	-	-	YY. STACK WASH ▲	0.6	0.6	I	-	-
W. CLINKER GRINDER SEALS	1.3	5.4	I	2 HRS.	3/DAY	ZZ. FGD DISPOSAL SITE RUNOFF ▲	18.6	37.1	I	-	-
X. COAL EQUIPMENT WASH ▲	2.1	2.1	I	16 HRS	4/YR.	AAA. BOTTOM ASH SLUICE	828.8	828.8	I	-	-
Y. FGD SYSTEM MAKEUP	992.0	992.0	C	-	-	BBB. BOTTOM ASH SYSTEM EVAPORATION LOSSES	72.0	72.0	I	-	-
Z. FGD SLURRY (85% WATER)	1284.4	1284.4	C	-	-	CCC. ASH POND EVAPORATION LOSSES ▲	141.2	141.2	C	-	-
AA. FGD EVAPORATION LOSSES	895.7	895.7	C	-	-	DDD. ASH POND SOLIDS REMOVAL	54.8	54.8	I	-	-
BB. THICKENER EFFLUENT TO FILTER	452.0	452.0	C	-	-	EEE. ASH POND PERCOLATION LOSSES ▲	201.8	201.8	C	-	-
CC. VACUUM FILTER SLUDGE (20% WATER)	96.3	96.3	C	-	-	FFF. TURBINE & CONDENSATE SYSTEM	864.0	864.0	-	-	-
						GGG. BOTTOM ASH POND OVERFLOW TO BAY ▲	NOT AVAILABLE (1)	NOT AVAILABLE (1)	I	-	-

NOTES:
1. ONLY WHEN PRECIPITATION EXCEEDS LOSSES DUE TO PERCOLATION AND EVAPORATION.
2. ▲ DENOTES FLOWS WHICH MAY OCCUR DURING UNIT 4 SHUT DOWN.

FIGURE 3.3-1 (SHEET 2 OF 2)
PLANT WATER BALANCE
BIG BEND STATION
TAMPA ELECTRIC COMPANY

A | B | C | D | E | F | G | H | J | K

3.4 HEAT DISSIPATION SYSTEMS

3.4.1 Intake and Outfall

Figure 3.4-2 shows the flow path for the circulating water system. Figures 3.4-3 and 3.4-4 show the general arrangements for the intake structure and outfall structure. A feasibility study is presently underway to evaluate the use of fine mesh screening for the intake structure. This study is being performed in conjunction with the "316 Demonstration" and is discussed in Section 9.2.1.

3.4.2 Source of Cooling Water

Hillsborough Bay is the source of cooling water for the Big Bend Unit 4 once-through cooling system. A description of the existing water quality in Hillsborough Bay is provided in Section 2.5.

3.4.3 System Design

Big Bend Units 1, 2, and 3 operate with once-through condenser cooling systems in combination with a thermal dilution system. It is proposed that Unit 4 have a once-through cooling system with an additional dilution pump. A "316 Demonstration" study has been implemented which will fulfill U.S. EPA and FDER requirements concerning the impact of the proposed system on biological integrity of the receiving waters (Section 5.1).

The original heat dissipation system for Units 1 and 2 is shown in Figure 3.4-1. With the addition of Unit 3 the system was modified to remove the mixed discharge from the embayment south of the plant site. This new arrangement, shown in Figure 3.4-2, does reduce the ultimate dilution capacity available as a portion of the space dedicated to future pumps has been eliminated.

The thermal dilution system is designed to reduce the effects of the thermal discharges from Units 1, 2, and 3 on Hillsborough Bay. A dilution pump supplies 890 cfs of ambient temperature bay water to the dilution channel. The pump structure, detailed in Figure 3.4-5, is provided with trash racks to remove any large floating debris. The low-speed and large-clearance design of the pump permits fish to pass safely.

The dilution flow intersects the circulating water flow at a point just southeast of the dilution pumps. As the flows mix, the temperature of the effluent is reduced. The combined discharge of Units 1, 2, and 3 and the thermal dilution system totals 2501 cfs. The thermal dilution system effectively reduces the temperature rise of the combined

3.4 HEAT DISSIPATION SYSTEMS

3.4.1 Intake and Outfall

Figure 3.4-2 shows the flow path for the circulating water system. Figures 3.4-3 and 3.4-4 show the general arrangements for the intake structure and outfall structure. The spring feasibility study to evaluate the use of fine mesh screening for the intake structure has been completed. This study was performed in conjunction with the 316 Demonstration and is discussed in Section 9.2.1 and Appendix 4 of the 316 Demonstration.

3.4.2 Source of Cooling Water

Hillsborough Bay is the source of cooling water for the Big Bend Unit 4 once-through cooling system. A description of the existing water quality in Hillsborough Bay is provided in Section 2.5.

3.4.3 System Design

Big Bend Units 1, 2, and 3 operate with once-through condenser cooling systems. It is proposed that Unit 4 have a once-through cooling system. A 316 Demonstration study has been prepared to fulfill U.S. EPA and FDER requirements concerning the impact of the proposed system on biological integrity of the receiving waters. This report is discussed in Section 5.1 and is appended to this application.

The original heat dissipation system for Units 1 and 2 is shown in Figure 3.4-1. With the addition of Unit 3 the system was modified to remove the mixed discharge from the embayment south of the plant site. This new arrangement, also showing Unit 4 is shown in Figure 3.4-2.

Unit 4 will have a heat rejection rate similar to that of Units 1, 2, and 3 of about 2×10^9 Btu/hr during full load condition. Like the existing units, Unit 4 will draw cooling water from the intake channel and discharge it to the discharge channel. Once discharged, the Unit 4 flow cannot be distinguished from the discharge of existing units. Depending upon the load carried by other units, the flow from a partially loaded unit may reduce the temperature of fully loaded units. The expanded system is shown in Figure 3.4-2.

The discharge water flows and their temperature contributions are presented in the following table. It is as-

sumed that all four units are simultaneously at full load. Average load temperature rises are also given:

	<u>Unit 1</u>	<u>Unit 2</u>	<u>Unit 3</u>	<u>Unit 4</u>
Unit flow, cfs	537	537	537	537
Cumulative flow, cfs	537	1074	1611	2148
Max. temp. rise °F	16.8	16.8	16.8	16.8
Avg. temp. rise °F	11.0	11.0	11.0	11.0

Thus, the four once-through cooling systems produce a maximum temperature rise of 16.8°F.

To appreciate actual temperature effects on the bay, it is necessary to understand the variation in generation rate by the plant. Figure 3.4-6 shows the expected variation in station generation level, and indicates that the plant will be operating at 80 percent or less of full load 93 percent of the time. Since plant temperature rise is directly proportional to plant load, it is evident that the maximum temperature rises listed above will occur infrequently.

3.4.4 Trash Disposal

Trash and debris collected from the intake structure will be disposed of offsite in an approved landfill.

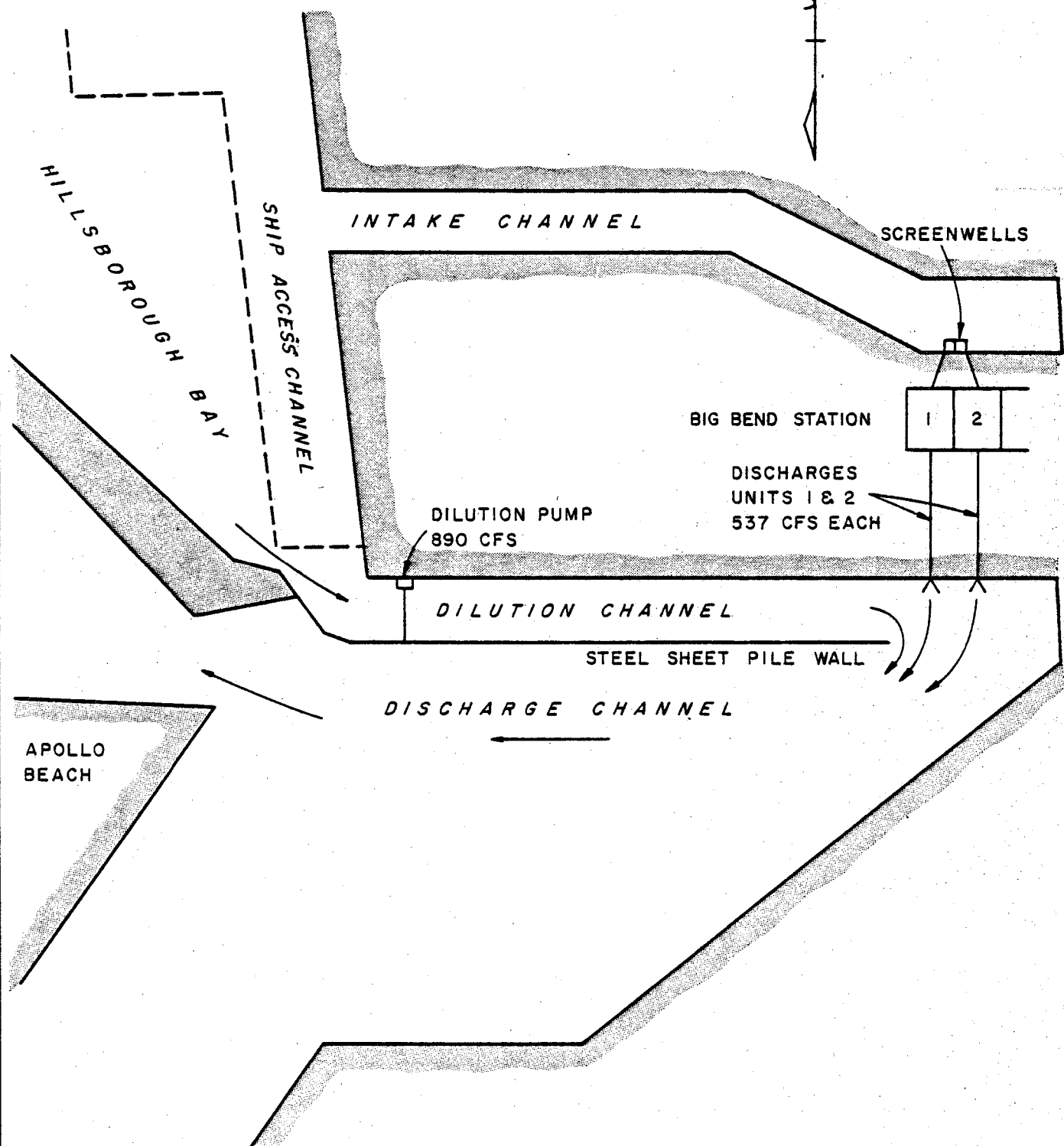


FIGURE 3.4-1
ONCE-THROUGH WITH DILUTION
COOLING SYSTEMS UNITS 1-2
BIG BEND STATION
TAMPA ELECTRIC COMPANY

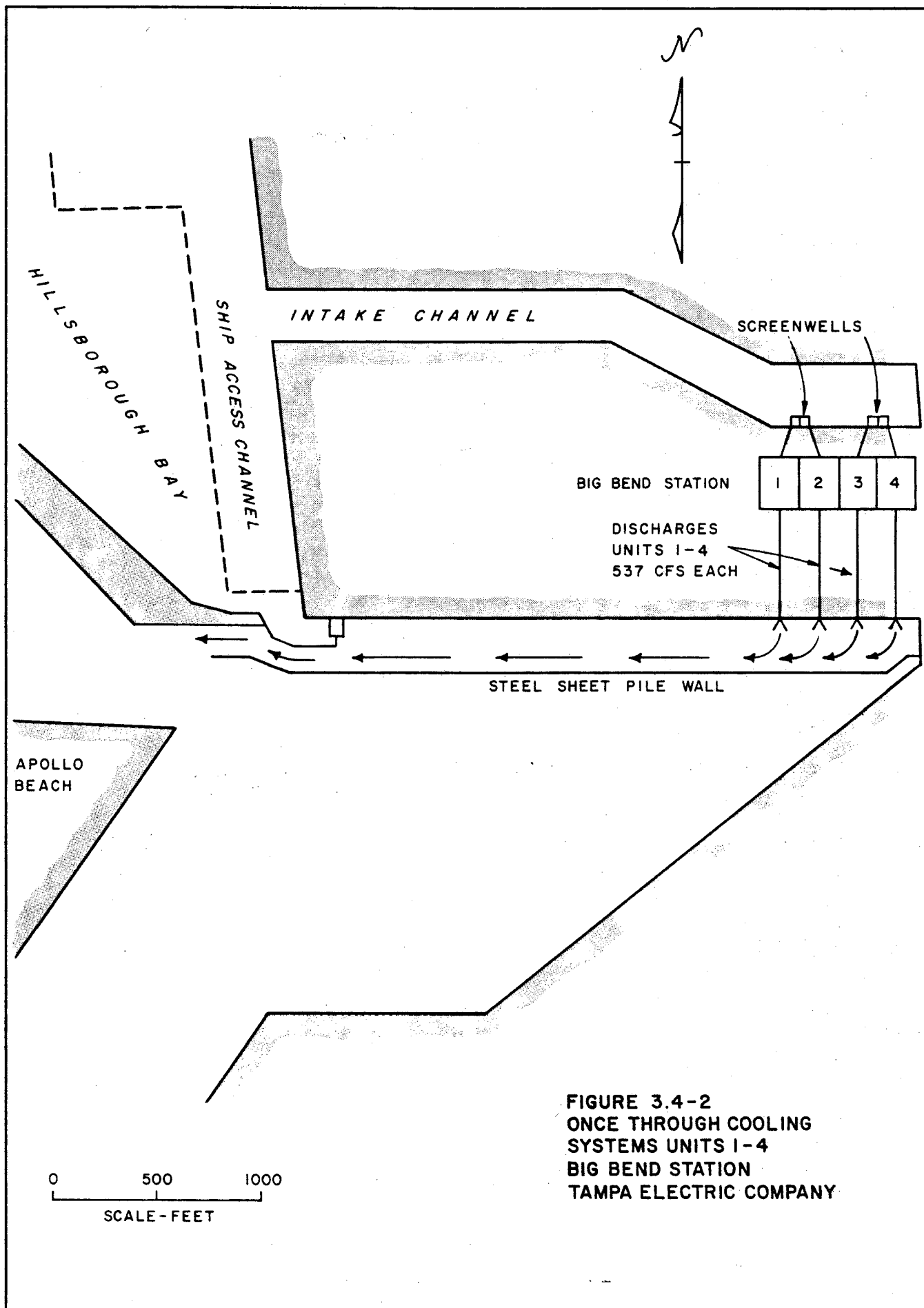


FIGURE 3.4-2
ONCE THROUGH COOLING
SYSTEMS UNITS 1-4
BIG BEND STATION
TAMPA ELECTRIC COMPANY

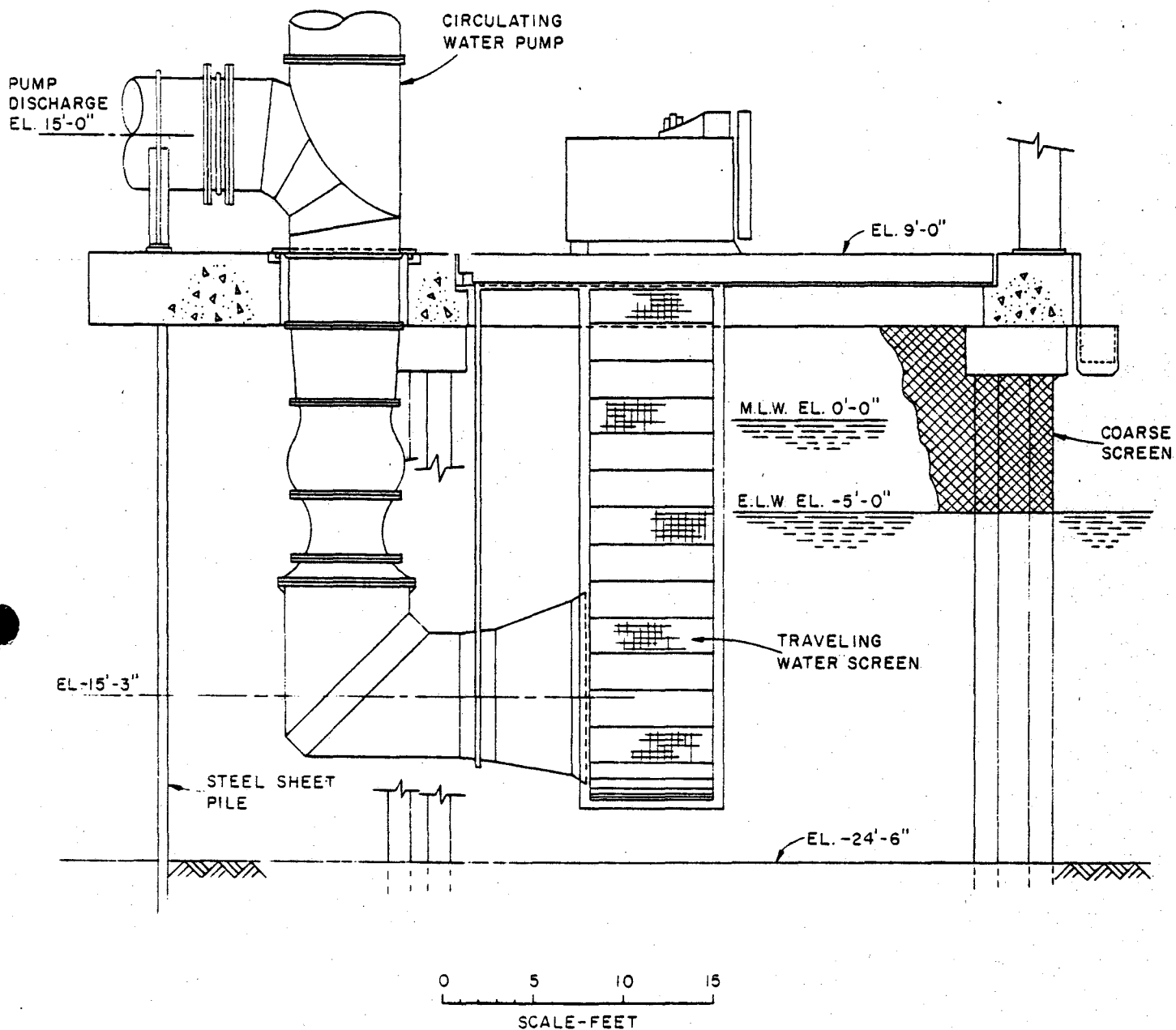


FIGURE 3.4-3
CIRCULATING WATER
INTAKE SYSTEM
BIG BEND STATION
TAMPA ELECTRIC COMPANY

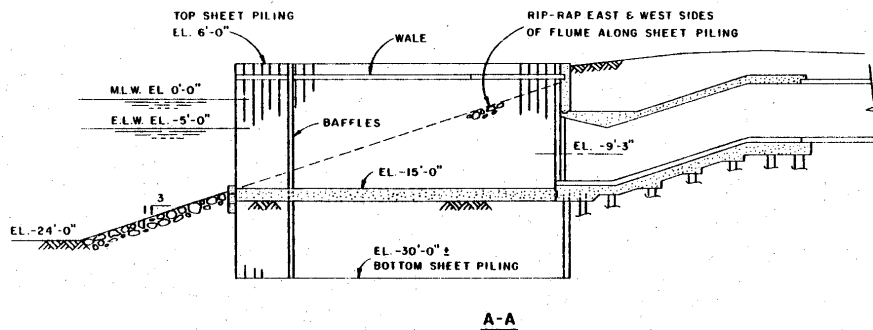
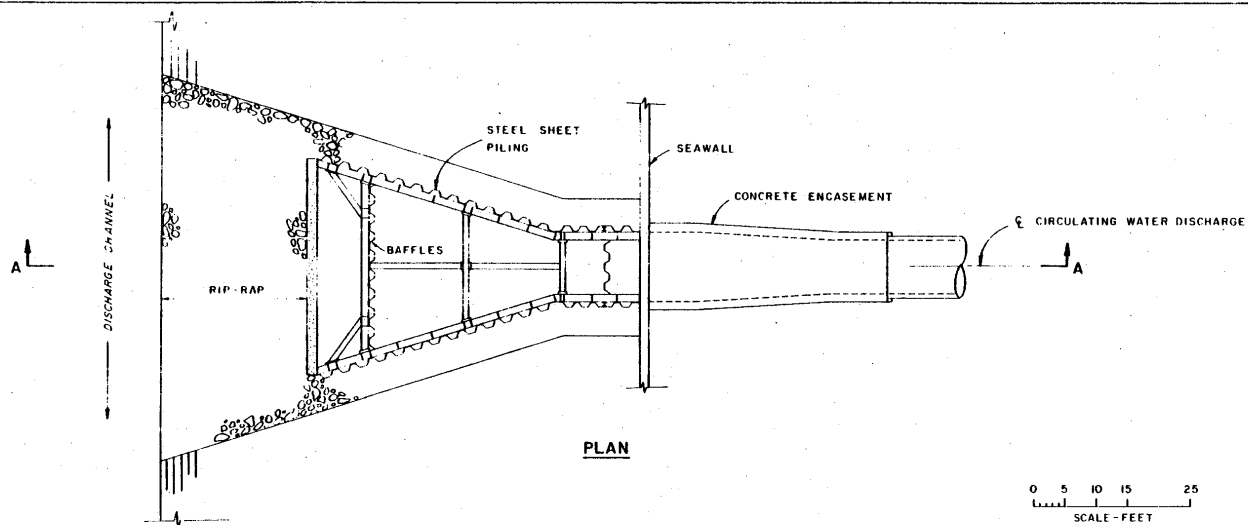


FIGURE 3.4-4
DISCHARGE STRUCTURE
BIG BEND STATION
TAMPA ELECTRIC COMPANY

Amendment 3
August 1980,

Figure 3.4-5

Dilution Pumping Station

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from this document.

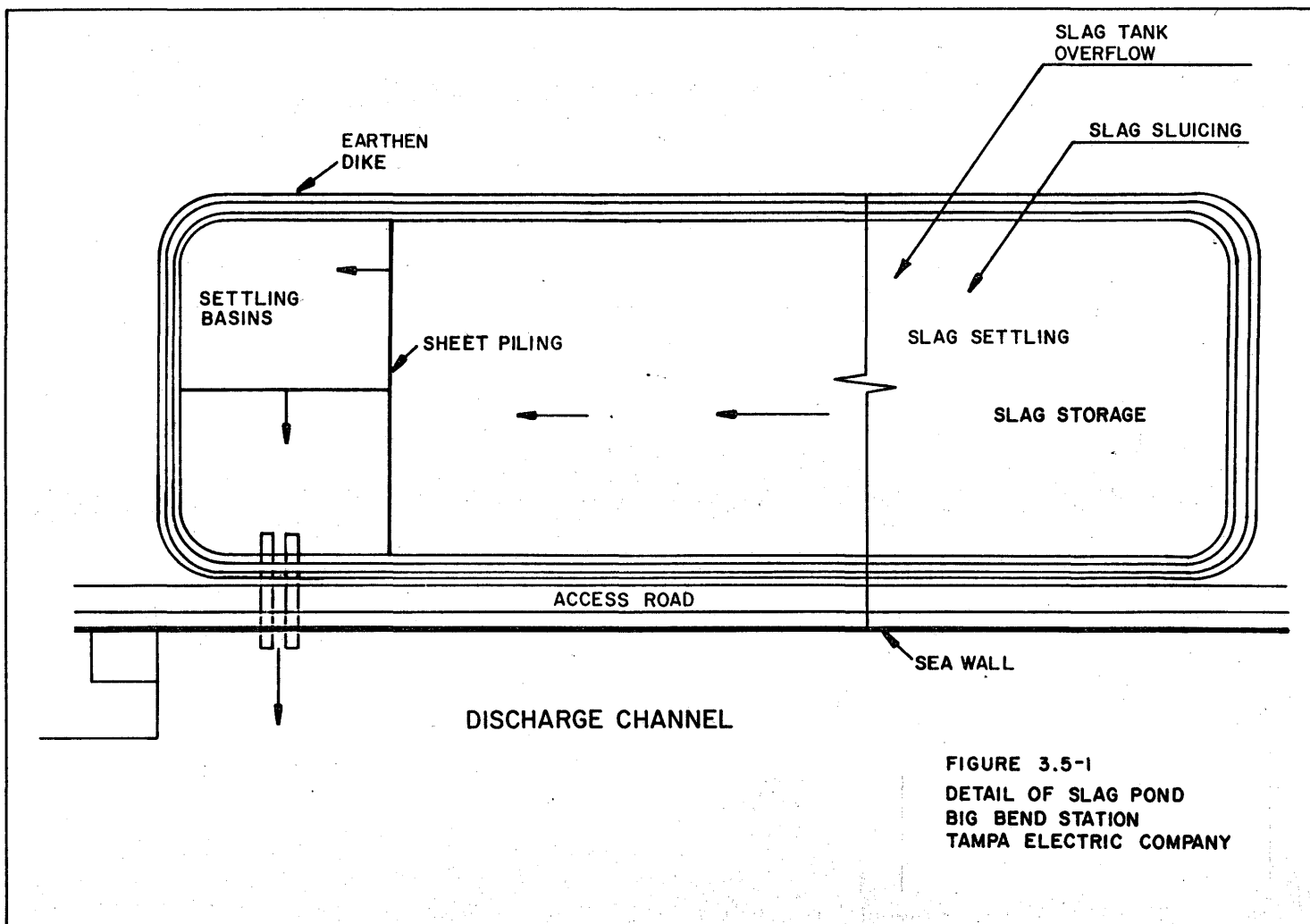
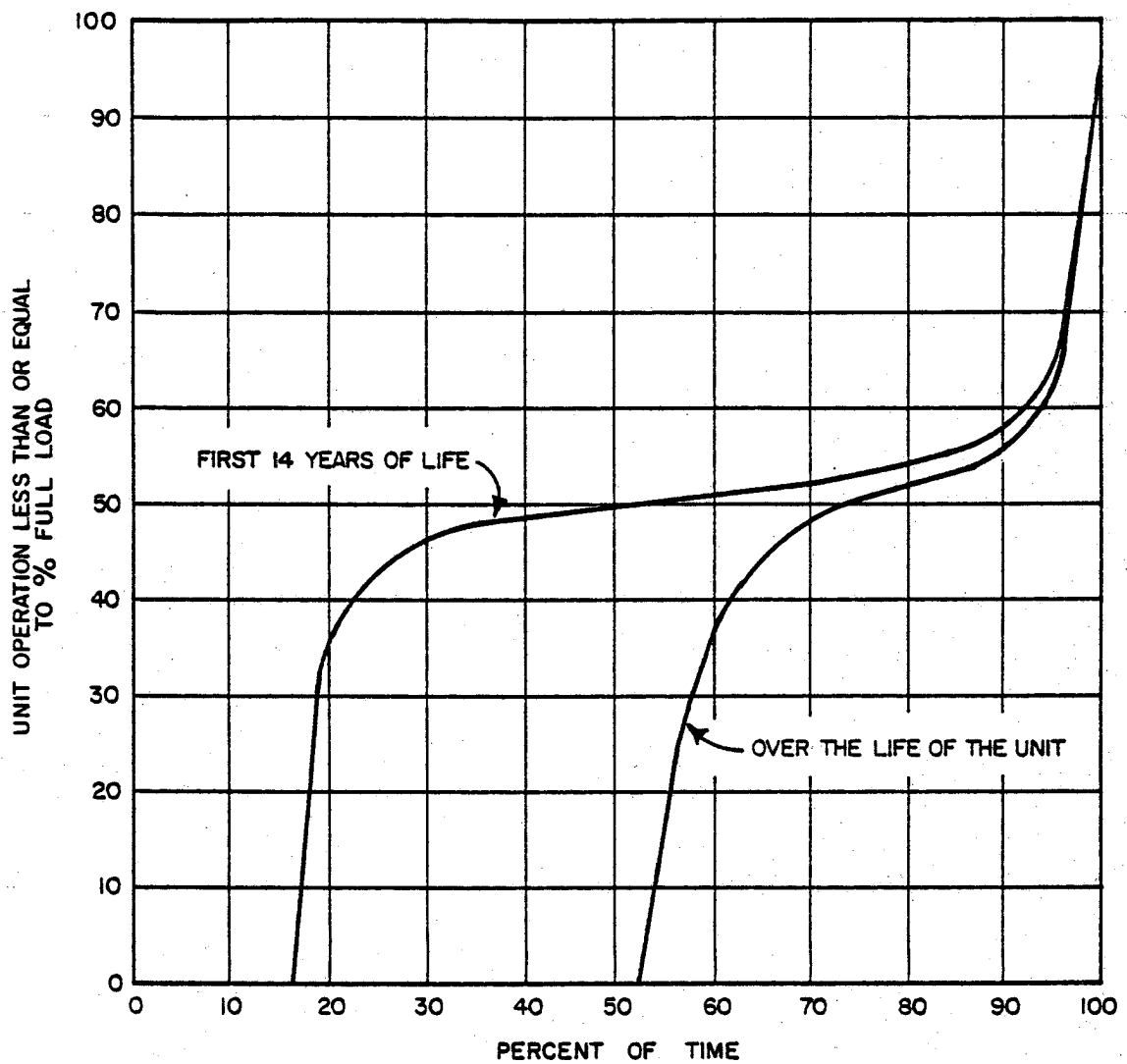


FIGURE 3.5-1
DETAIL OF SLAG POND
BIG BEND STATION
TAMPA ELECTRIC COMPANY



98% OF THE TIME THE
UNIT IS OPERATING AT
80% OR LESS OF FULL LOAD

FIGURE 3.4-6
DURATION OF STATION GENERATION LEVELS
BIG BEND STATION
TAMPA ELECTRIC COMPANY

3.5 CHEMICAL AND BIOCIDAL WASTES

The wastewater system consists of an inplant collection and transportation system, a wastewater treatment pond system, a spray irrigation system, and a recycle system. The wastewater treatment ponds and spray irrigation systems were fully operational on July 1, 1977. The recycle system commenced operation on September 1, 1978. Chemical and biocidal wastewater and the sanitary system effluent will be treated in the wastewater ponds.

Liquid wastes associated with the operation of Big Bend Station Unit 4 will include:

1. Water treatment and condensate polisher wastes.*
2. Equipment washing and boiler chemical cleaning wastes.*
3. Floor and equipment drainage.*
4. Boiler blowdown.
5. Blowdown from the service water cooling tower system.*
6. Bottom ash sluice system blowdown.
7. Ash sluicing wastes.
8. FGD chloride bleed stream.

*These wastes associated with Units 1, 2, and 3 are presently being transported to the wastewater ponds for treatment and disposal. Unit No. 4 waste will also be conveyed to the wastewater treatment ponds.

Each of these wastes is described in Section 3.5.1.

3.5.1 Chemical Wastes

3.5.1.1 Water Treatment Wastes

The makeup water treatment system consists of activated carbon filters; cation, anion, and mixed-bed demineralizers; and a forced-draft decarbonator. In addition, a condensate polisher will be used for further treatment of the condenser water.

The activated carbon filter is automatically backwashed when the pressure drop across the bed reaches a predetermined value. Backwashing removes small quantities of suspended matter and reclassifies the activated carbon bed. Effluent from backwashing will be conveyed to the Unit 1 washwater sump for transport to the station wastewater treatment system.

The ion exchange demineralizers will be regenerated using sulfuric acid for the cation resins and caustic soda for the anion resins. Wastes from the regeneration of the cation and anion demineralizers, the mixed-bed demineralizers, and the condensate polishers will be pumped to the 230,000 gallon waste neutralization tank for equalization and partial neutralization of spent acid and caustic.

The cation and anion exchangers will be regenerated every 45 hours during normal plant operation and every 24 hours under maximum load, resulting in approximately 112,000 gallons of waste. The mixed-bed demineralizers will be regenerated approximately every 20 days resulting in approximately 30,000 gallons of waste, and the condensate polishers will be regenerated approximately once per month resulting in approximately 60,000 gallons of waste.

The regeneration waste from the condensate polisher demineralizer will contain suspended and dissolved solids such as sodium chloride, sodium sulfate, and either ammonium sulfate or calcium sulfate. Quantities and concentrations of these wastes depend on the manufacturer and/or system purchased. The equalized regeneration wastes flow to the Unit 1 washwater sump and are then pumped to the wastewater treatment ponds.

3.5.1.2 Equipment Washing and Boiler Chemical Cleaning

Accumulation of deposits on equipment surfaces will necessitate washing of the air preheaters, economizers, and precipitators every 12 to 26 weeks with the recycle wash system water. The air preheater will be washed at a maximum flow rate of 2,140 gpm and the economizer and precipitator will be washed at a flow rate of between 50 and 400 gpm. The spent washwater will contain soluble metals (principally iron) and will have a pH between 1.4 and 4.0.

Chemical cleaning of the boiler and preboiler system prior to startup is necessary to provide clean, properly conditioned, heat transfer surfaces to ensure reliable unit operation.

The preoperational chemical cleaning of the boiler and preboiler involves the following steps:

1. Freshwater flush
2. Emulsifier washout (200 gallons in water)
3. Alkaline flush (0.5 percent trisodium phosphate and 0.5 percent disodium phosphate)
4. Freshwater flush
5. Acid flush (3 percent citric acid and 1,000 gallons concentrated ammonium hydroxide or 5 percent inhibited hydrochloric acid)
6. Freshwater flush
7. Neutralization (1 percent sodium carbonate)
8. Passivation (0.25 percent mono and disodium phosphate plus 0.5 percent sodium nitrate).

Post-operational chemical cleaning of the boiler will occur approximately every 2 years, and will include the following stages:

1. Acid introduction (5 percent inhibited hydrochloric acid)
2. Freshwater rinse
3. Neutralization (1.0 percent sodium carbonate)

Equipment washwaters are pumped from the washwater sump and disposed of in the wastewater treatment ponds.

3.5.1.3 Floor and Equipment Drainage

Floor and equipment drainage will be collected and conveyed to the wastewater treatment ponds.

Drainage from the fuel oil storage diked areas and fuel oil pumphouse will be conveyed to an oil separator. Oil-free water from the separator will be discharged to the intake channel. Collected oil will be drummed for reuse.

3.5.1.4 Boiler Blowdown

During normal station operation, approximately 30 gpm of water will be blown down continuously from the steam drum and replaced with demineralized water. Blowdown is required to maintain total dissolved solids and silica levels below 50 ppm and 10 ppb, respectively, to ensure reliable boiler operation. Small quantities of aqua ammonia and hydrazine are used to control system pH and to remove trace quantities of dissolved oxygen, respectively, within the boiler and preboiler systems. Boiler blowdown will flow to the discharge channel.

3.5.1.5 Service Water Cooling Tower Blowdown

Well water from Hillsborough County will be used as makeup to a wet evaporative mechanical-draft cooling tower serving heat exchangers such as turbine lube oil coolers and bearing water coolers. Small quantities of sulfuric acid will be added to the recirculating water to control calcium carbonate scaling by reducing the bicarbonate alkalinity. Blowdown from the cooling tower will be required to maintain dissolved solids levels consistent with reliable operation. Approximately 50 gpm of water will be continuously blown down from the tower and discharged to the washwater sump prior to being pumped to the wastewater treatment ponds.

3.5.1.6 Slag/Ash Handling System

The boilers for Units 1, 2, and 3 are equipped with wetbottom slag handling systems. The molten slag falls by gravity from the bottom of the boiler fireside into one of two slag tanks located directly under each boiler. Cooling water is pumped through the slag tanks to cool the slag which solidifies and shatters into approximately 1/4-in diameter pieces. The clear overflow from this system is conveyed to the slag pond prior to discharge.

The slag sluicing system uses saltwater as the sluicing medium to eject the slag from the bottom of the slag tank. A 25-percent slag slurry is pumped from the tanks by hydroejectors to the slag pond. Since the slurry contains only suspended solids, the only treatment provided is sedimentation. Clear overflow from the slag pond is discharged by gravity to the discharge channel. A schematic layout of this system is shown in Figure 3.5-1.

The boiler for Unit 4 will be of the dry-bottom type and will be provided with a freshwater eductor system to transport ash to the bottom ash pond.

In order to maintain the correct system water chemistry, a blowdown will be required. The blowdown flow rate will be equal to 5 percent of the system flow rate, and will be subjected to neutralization and sedimentation prior to discharge.

The characteristics of this effluent stream are discussed in Section 5.2.1.3.

3.5.1.7 Fly Ash, Economizer Ash, and Pyrites Sluicing Wastes

In order to control scaling within the sluice system, 5 percent of the sluice flow will be blown down to the existing plant wastewater pond.

3.5.1.8 FGD System Chloride Bleed Stream

During operation of the FGD system, the liquid in the quencher prescrubber loop and throughout the waste handling system will become concentrated in chlorides. To prevent material corrosion of this loop and to allow production of a commercial grade of gypsum, it is necessary to provide a blowdown, either intermittent or continuous. This blowdown, referred to as the FGD System Chloride Bleed stream, will be clarified and neutralized prior to being discharged to the discharge channel. This effluent stream is categorized as a low volume waste by the USEPA. The stream is discussed in Section 5.2.1.2.

3.5.2 Wastewater Treatment System

A wastewater treatment system was installed during 1976 and 1977 which would enable compliance with provisions of the National Pollution Discharge Elimination System (NPDES) permit issued by the U.S. Environmental Protection Agency on March 31, 1976. The system provides for:

- o Saltwater waste
- o Freshwater waste
- o Material storage runoff

o Sanitary and other wastes.

The system now serves Unit Nos. 1, 2, and 3 and has been sized to receive the wastes from the proposed Unit No. 4.

3.5.2.1 Saltwater Wastes

Unlike Units 1, 2, and 3, there are no saltwater waste streams associated with Unit 4.

3.5.2.2 Freshwater Wastes

Freshwater wastes produced by the proposed Unit No. 4 will be similarly managed as wastes from the existing units. All freshwater inplant waste streams, both continuous and intermittent, are captured by the inplant collection system. This system consists of a series of sumps and piping throughout the plant area which receives wastewater from washing operations, equipment drains, etc, and conveys them to the main transfer sump. In turn, the mixture of wastewaters is conveyed to the wastewater treatment ponds.

The approximate chemical composition of the waste streams presently entering the system is shown on Table 3.5-1.

Consideration is being given to a future refinement of the system, specifically the isolation of intermittent waste streams, such as the equipment washing and the boiler chemical cleaning wastes. This would be done in the interest of preserving water quality in the holding pond. As discussed later, these waters will ultimately be recycled for equipment washing purposes or disposed of through spray irrigation.

3.5.2.3 Wastewater Treatment Ponds

The wastewater is pumped from the main transfer sump located at the plant through two parallel 8-inch and 10-inch fiberglass reinforced pipe (FRP) wastewater pipelines. Three 1,250-gpm pumps located within the transfer sump discharge into these lines through a manifold arrangement and deliver water to the ponds about 2,000 feet to the east. Figure 3.5-2 shows a second manifold arrangement located at the settling basins, which combines the flow from the two pipelines and allows the selection of discharge into either or both of the settling basins. The wastewater enters the settling basins through a 12-inch diameter FRP multiport flow distribution manifold. A major portion of the suspended solids settles out forming a sludge layer within

the basin which must be removed periodically. The clarified wastewater is transferred from each settling basin to the retention pond by submerged transfer pipes leading to the settling basin effluent structures. Each of the effluent structures consists of a concrete sump, inlet and outlet piping, and a 90-degree V-notch weir.

At this time treatment of the wastewater is limited to the removal of settleable solids within the settling basins and self-neutralization within the system of ponds. Each settling pond is approximately 200 feet long and 50 feet wide. The retention pond is approximately 900 feet long and 450 feet wide, has a volume of approximately 25 million gallons at a pond elevation of 11 feet, and detention times on the order of 20 to 40 days. This large volume provides for neutralization of the individual acidic and basic waste streams. Each settling basin has a design volume of approximately 456,300 gallons, resulting in a retention time of approximately 19 hours at the design average daily flow of 400 gpm per basin. Operations records indicate flows on the order of 500 to 700 gpm with peaks as high as 2,800 gpm.

The retention pond is equipped with two 8-inch drain pipes each located within the north pond embankment and discharging into a drainage ditch located north of and adjacent to the retention pond. One is set at invert elevation of 7.5 feet, the other at invert elevation 4.0 feet. Each is valved closed and opened only in an emergency for pond dewatering. A 12-inch emergency overflow pipe exists in the pond embankment at an invert elevation of 11.5 feet allowing a gravity discharge to the drainage ditch should the pond level exceed this level. The drainage ditches are a part of the storm drainage system which eventually discharges to the bay.

3.5.2.4 Spray Irrigation System

The spray irrigation system consists of pumps, piping, valving, controls, and other appurtenances for the purpose of providing land application and disposal of that portion of the wastewater within the retention pond in excess of the demand for recycled wastewater at the plant. The spray irrigation site consists of approximately 29 acres of land lying within the transmission right-of-way located directly north of and adjacent to the retention pond as shown in Figures 3.5-2 and 3.5-3. Approximately 21.1 acres are actually to be irrigated, the remainder of which are to comprise the nonirrigated buffer zone. The site consists of four separate irrigation plots of approximately 5.25 acres

each. Wastewater from the retention pond will be applied as required to one irrigation plot per day on a rotation basis. Irrigation is by means of a fixed system of four impact sprinklers per plot. Plot rotation is accomplished manually through actuation of the 6-inch butterfly valves located on each of the laterals leading to the four irrigation plots.

As a practical matter, the application rate is governed by pond level, seasonal conditions, and groundwater level. The overriding criteria for the system's operation is avoidance of runoff from the sprayed area. When runoff is not a limiting condition, application rates of from 2 to 4 inches per week are considered. At 2 inches per week each of the four plots may be sprayed 2 hours per day; and, at 4 inches per week, each plot may be sprayed 4 hours per day. This provides ultimate water disposal ranging from 254,400 gallons per day (gpd) to 508,800 gpd. An 8-inch propeller flow meter is located in the pump discharge manifold to measure the total quantity of wastewater disposed of by spray irrigation.

Wastewater is transferred from the retention pond to the pumping station via two pump suction lines installed through the pond embankment. An 8-inch FRP suction line serves two spray irrigation pumps. A 10-inch FRP suction line serves two recycle pumps. This system is discussed further in a later section.

A stilling well is attached to the pond drain line, and houses the water level probes which serve to control both the spray irrigation and recycle pump operation and to actuate the pond high and low water level alarms.

The spray irrigation pumps are end suction centrifugal pumps. Pumps are rated at 530 gpm at 225 feet TDH and are of all stainless steel construction.

3.5.2.5 Coal Pile Runoff

Coal pile runoff collection and treatment systems have been provided in order to achieve compliance with limitations established in the NPDES permit. The existing system will be modified to provide for the coal field expansion to Unit No. 4.

The system, as it presently exists, consists of an interception trench, a pumping station, and a runoff pond. The system is designed to capture and retain runoff resulting from a design storm established by the U.S.

Environmental Protection Agency and defined as a 24-hr storm with a recurrence interval of 10 years. Runoff resulting from storms in excess of these design conditions is discharged to Tampa Bay.

To allow for Unit 4 coal storage, the coal pile runoff pond will be eliminated. The existing interception trench will be expanded to encircle the new coal storage area and the pumping station will be relocated. The modified system will then intercept the 10-yr/24-hr design storm runoff and pump it to the existing demineralizer waste sump for transfer to the wastewater pond. A collection system overflow will be provided to permit the discharge of runoff volume produced by storms in excess of the design storm (Figure 3.5-4).

3.5.2.6 Limestone Pile Runoff System

A limestone pile will be maintained on site with adequate storage capacity to ensure the reliability of the Unit 4 FGD system. Stormwater runoff control from this material storage facility will be provided. This will be done in either of two ways. One method would be to completely encircle the pile with a trench capable of intercepting and containing runoff from a 10-yr/24-hr storm. The other technique would be to enclose the limestone in a covered building, thus eliminating the pile runoff completely. If the former is opted for, an overflow will be provided for stormwater runoff resulting from storms in excess of the design storm.

3.5.3 Recycle System

The wastewater recycle system consists of pumps, piping, valving, controls, and other appurtenances for the purpose of transferring water from the wastewater retention pond to a 500,000-gallon storage tank located at the plant (Figure 3.5-3). Wastewater will then be reused for various washing and maintenance operations. The recycled water storage tank is located west of Unit No. 1, where it was previously used for service water in conjunction with two other 500,000-gallon service water tanks, and two additional 500,000-gallon demineralized water storage tanks. An inplant distribution piping system has been installed specifically for recycle purposes.

The recycle pumps discharge through a steel manifold to a 10-inch PVC recycle pipeline which is routed to the storage tank. A 10-inch propeller flow meter measures the total flow of recycled wastewater. Valving is provided in the

recycle pipeline to allow discharge of the wastewater from the retention pond into the ash settling canal.

The operation of the recycle pumps is automatically controlled by liquid level sensing probes located within the wastewater recycle storage tank and within the retention pond stilling well. The objective of the recycle pump control system is to supply the storage tank in response to withdrawals made from the tank in order to maintain a continuous supply of water for the anticipated needs. Table 3.5-3 lists the plant operations which are expected to utilize the recycled wastewater and their respective water requirements. Items 1, 2, 3, 4, and 8 are expected to occur simultaneously or in succession and represent the maximum anticipated daily water demand of 1,619,400 gpd. The wastewater recycle system was designed to meet this anticipated demand.

The wastewater recycle pumps are rated at 1,050 gpm at 68 feet TDH. Both pumps operating simultaneously will deliver approximately 1,500 gpm.

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The recycle pumps discharge through a steel manifold to a 10-inch PVC recycle pipeline which is routed to the storage tank. A 10-inch propeller flow meter measures the total flow of recycled wastewater. Valving is provided in the recycle pipeline to allow discharge of the wastewater from the retention pond into the ash settling canal.

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The wastewater recycle pumps are rated at 1,050 gpm at 68 feet TDH. Both pumps operating simultaneously will deliver approximately 1,500 gpm.

TABLE 3.5-1 CHEMICAL COMPOSITION OF FRESHWATER WASTES

		pH	CONDUCTIVITY µmhos/cm	SUSPENDED SOLIDS	DISSOLVED SOLIDS	VOLATILE TOTAL SOLIDS	NONCOMBUSTIBLE SOLIDS	T.O.C.	OIL AND GREASE	PHOSPHOROUS TOTAL as P	NITROGEN KJELDAHL as N	NITROGEN NITRATE as N	CHROMIUM TOTAL	SILICA	SODIUM	POTASSIUM	CALCIUM	MAGNESIUM	CHLORIDE	SULFATE	BROMIDE	FLUORIDE	IRON - TOTAL	IRON - DISSOLVED	VANADIUM	COPPER	ZINC	NICKEL	MANGANESE	ACIDITY to pH 4.6 as CaCO ₃	ACIDITY to pH 8.2 as CaCO ₃	TURBIDITY JTU
A	CARBON FILTER BACKWASH	764	610	167	411			4.0																								
B	BOILER CLEANING-STAGE 1 (HCL DRAIN)	13		5	10,345	5,885	4,465	210	36	0.2	315	3.2	2.4	4.7	160	60	61,500	24				10	3,200		1.4	1.0	8	1.8	35	71,600	176,000	
C	BOILER CLEANING-STAGE 2 (HCL RINSE)	2.7		5	760	390	375	7	3	0.2	0.20	0.05	11	1.5	60	23	1,000	40	0.40	75	56			0.022	0.05	0.1	0.1	0.40	215	420		
D	BOILER CLEANING-STAGE 3 (CITRIC ACID DRAIN)	3.5		15	1,580	1,040	545	230	11	0.2	0.25	0.05	11	1.8	44	9	225	30	16	5	10			0.1	0.05	0.05	0.05	0.1	180	615		
E	AIR	2.5	9,050	3,530	12,985	1,020	15,495	23	40	0.2	14	9.8	63	83	440	60	28	2,740	1.3	15	2,500	2,250	7.5	4.9	7.0	8.50	11.0	5,400	8,450	1,000		
F	PREHEATER WASH Composite of Steam and Wastewater	2.6	4,200	2,355	4,295	620	6,030	12	4.0	0.1	2.5	2.4	33	28	200	38	25	825	0.5	55	1,040	850	2.3	1.5	1.8	2.20	5.0	950	2,550	1,000		
G	PREOPERATIONAL BOILER CLEANING-STAGE 1 (hot acid drain)	1.9	20	16,045	9,775	6,290	260	8	95	4.3	4.2	45	6.8	90	40	151	30	66	960	6,600				2.5	2.8	2.4	2.8	50	68,000	71,500		
H	PREOPERATIONAL BOILER CLEANING-STAGE 2 (hot acid/rinse)	2.1	10	885	275	620	14	11	0.8	0.2	0.2	12	15	50	25		30	19	30	252				0.1	0.05	0.5	0.15	1.5	1,480	1,780		
I	PREOPERATIONAL BOILER CLEANING-STAGE 3 (citric acid drain)	2.5		10	1,515	705	620	440	11	0.3	0.15	0.1	15	2	55	30	385	40	21	10	186			0.07	0.05	0.2	0.1	1	770	1,050		
J	TOTAL CONTINUOUS WASTEWATER STREAM	714	23.31	631	156	498	0.23	1.21	0.13	0.38	0.56	225	2.0	982	38.8	31.4	87.9	0.25	61	37	1.06	0.1	0.05	1.39	0.05	0.05	0.05					
K	CONTINUOUS STREAM+TOTAL BOILER CLEANING WASTES	197		895	2,820	1,545	1,287	93.0	8.59	0.17	1.0	0.89	1376	403	920	339	12,735	53.5	369	646	663			0.35	0.24	2.20	0.41	7.21	14,535	35,910		
L	CONTINUOUS STREAM+TOTAL COMPOSITE A.P.W. WATER	269		1,902	3,583	530	4,955	10.8	346	0.11	2.05	2.04	30.96	22.95	180	3816	26.24	682	0.45	455	838	685	1.87	1.22	1.72	1.78	4.04	7.31	2,055	806		
M	CONTINUOUS STREAM+TOTAL Preoperational Boiler Cleaning Wastes	2.31		17.06	3,948	2,243	1,722	147	2.5	19.5	98	1.94	23.41	2.87	780	34.5	175	54.7	21.6	203	1,428			0.58	0.61	5.55	0.64	10.87	14,181	15,077		
N	DEMINEALIZER WASTEWATER		5,857	146	4,568	391	4,341	44.6	1	0.1	0.11	0.05	1,356	5.6	129	13.6	187	2,841	0.70	0.29	0.89	0.33	0.003	0.005	0.05	0.05	0.05				44	
O	CONTINUOUS STREAM + DEMINEALIZER WASTES		64.9	1,966	236	1,801	19.2	1.14	0.12	0.29	0.39	475	3.22	109	30.3	84.2	1,021	0.4	0.5	0.79	0.15	0.07	0.05	0.05	0.05	0.05						

* CONTINUOUS STREAM INCLUDES FLOOR DRAINAGE AND COOLING TOWER BLOWDOWN FROM ALL UNITS, PLUS PACKAGE SEWAGE TREATMENT PLANT.

NOTE-ALL UNITS IN PPM UNLESS OTHERWISE NOTED

TABLE 3.5-2

WASTEWATER RECYCLE DESIGN FLOWS

Operation	Flow (gpm)	Duration (hr/day)	Total Daily Flow (gallons)
1. Air Preheater Wash	2150	5	645,000
2. Precipitator Wash	400	24	576,000
3. Economizer Wash	100	4	24,000
4. Sparging System	160	24	230,400
5. Boiler External Wash	400	24	576,000
6. Slag Tank Wash	100	4	24,000
7. Coal Field	200	16	192,000
8. Slag Tank Aspirators	100	24	144,000

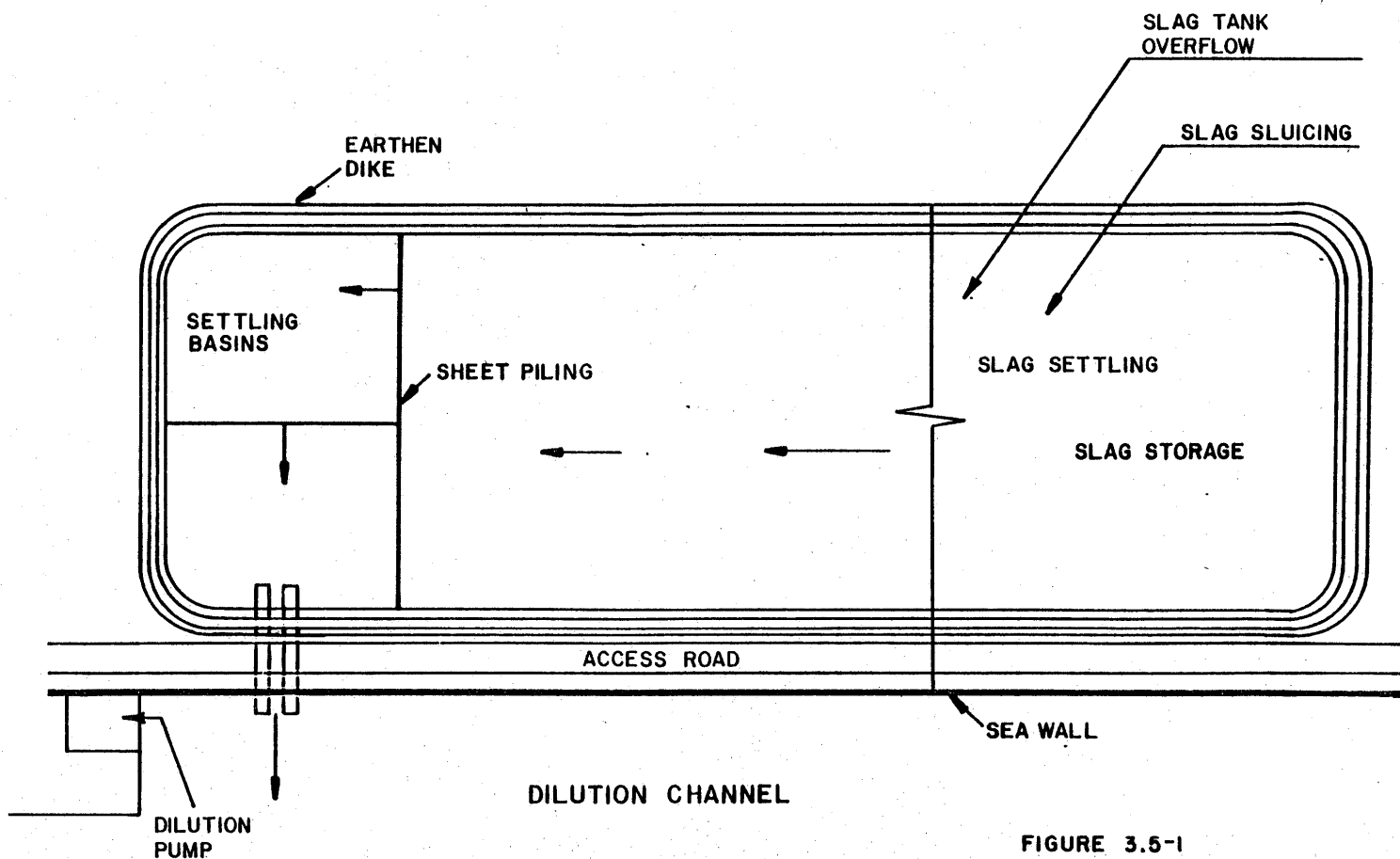
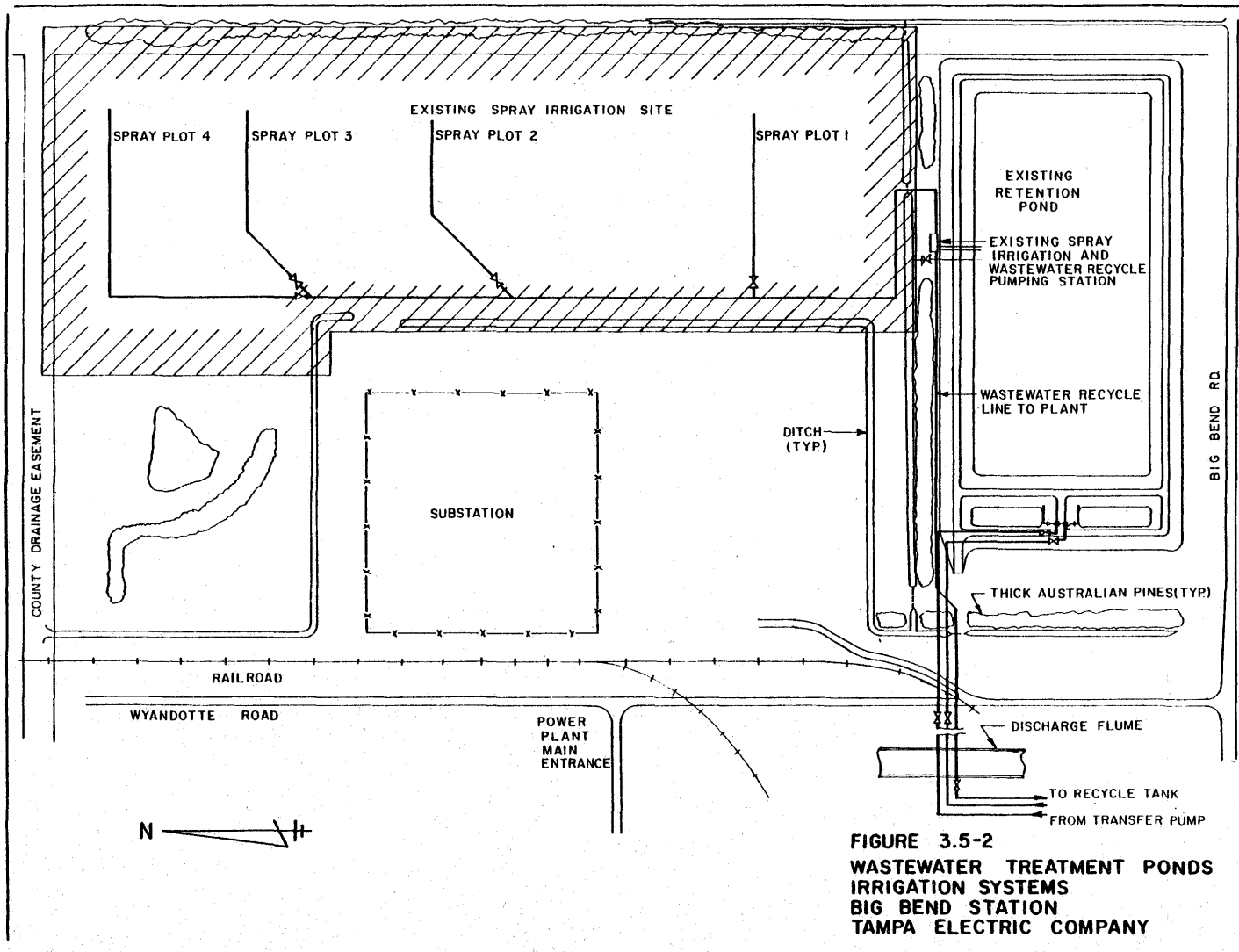
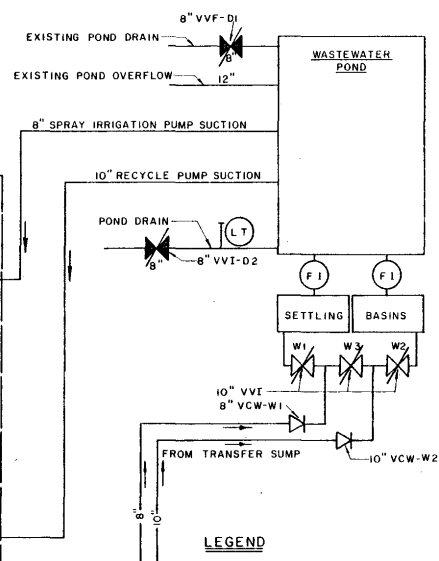
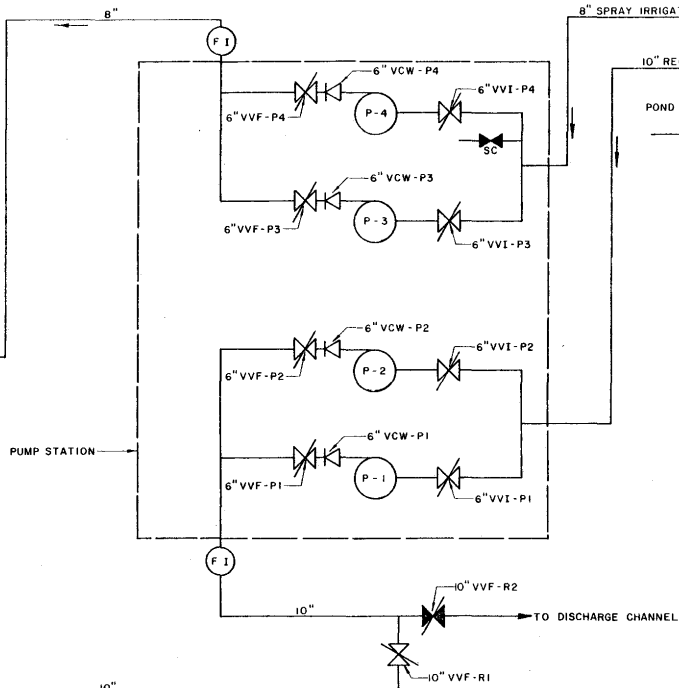
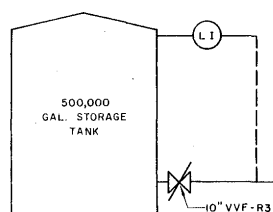


FIGURE 3.5-1
DETAIL OF SLAG POND
BIG BEND STATION
TAMPA ELECTRIC COMPANY





- ### LEGEND
- | | |
|---|---|
|  | BUTTERFLY VALVE |
|  | CHECK VALVE |
|  | REDUCER |
|  | BUTTERFLY VALVE W/POST INDICATOR
NORMALLY CLOSED |
|  | SAMPLE CONNECTION- HOSE BIBB |
|  | FLOW INDICATOR - METER |
|  | LEVEL INDICATOR, TRANSMITTER,
CONTROLS |
|  | PUMP |

FIGURE 3.5-3
FLOW DIAGRAM
WASTEWATER DISPOSAL/RECYCLE SYSTEM
BIG BEND STATION
TAMPA ELECTRIC COMPANY

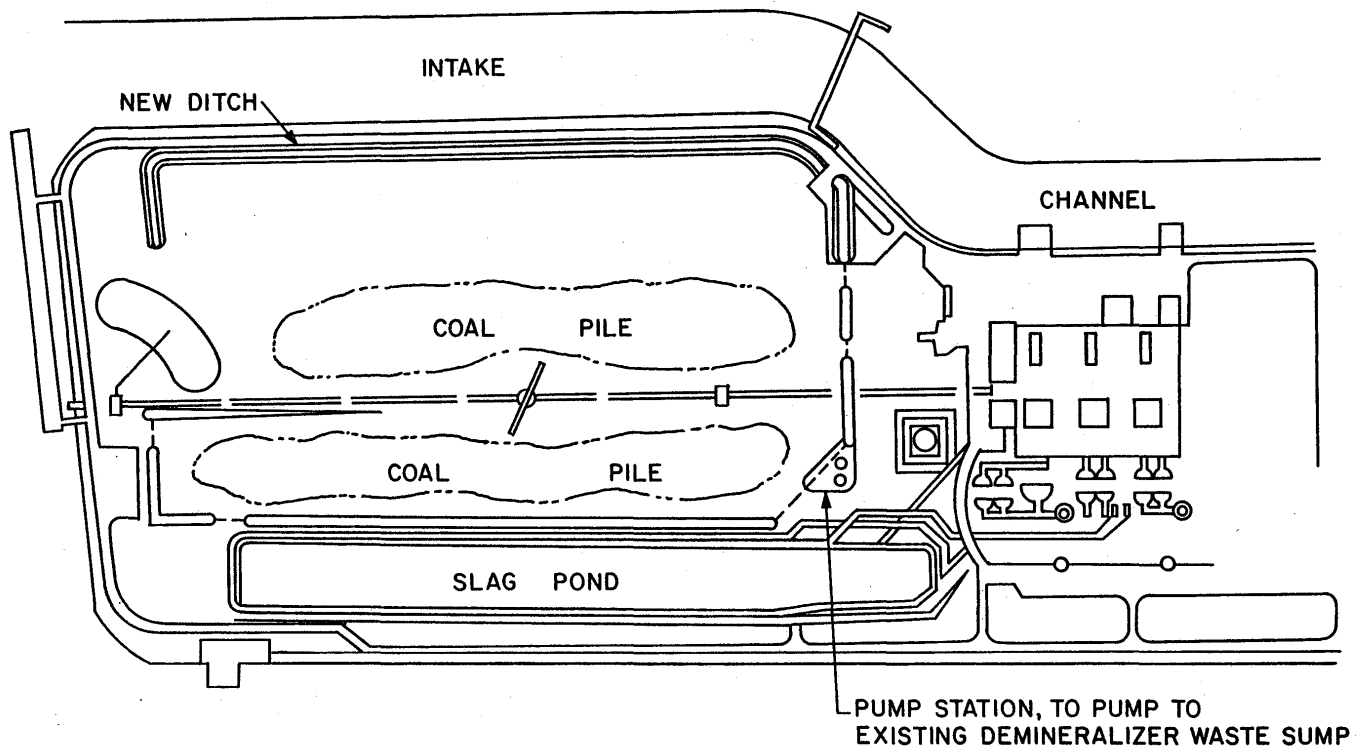


FIGURE 3.5-4
COAL PILE RUNOFF
COLLECTION & TREATMENT
SYSTEM
BIG BEND STATION
TAMPA ELECTRIC COMPANY

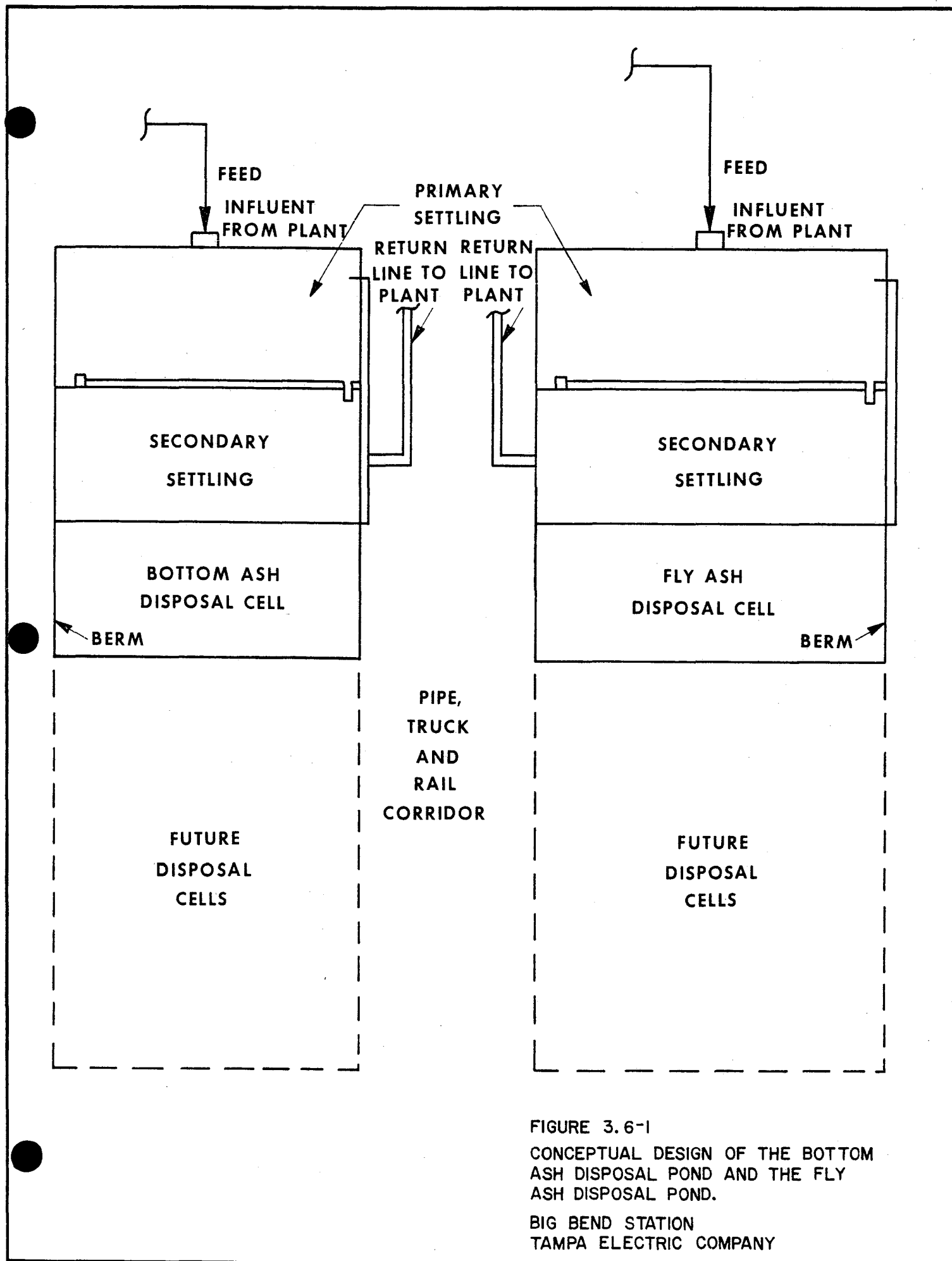


FIGURE 3.6-1
CONCEPTUAL DESIGN OF THE BOTTOM
ASH DISPOSAL POND AND THE FLY
ASH DISPOSAL POND.
BIG BEND STATION
TAMPA ELECTRIC COMPANY

3.6 SANITARY AND OTHER WASTES

3.6.1 Sanitary Wastes

Wastewater from all station sanitary fixtures is collected and conveyed to an existing package sewage treatment plant. This plant uses the extended aeration, aerobic digestion process and was installed with Unit 1 and sized to accommodate future enlargements of the station. The plant has a capacity of 4,500 gallons per day (gpd) of domestic sewage, representing an influent 5-day BOD of 9 pounds per day based on a 24-hr runoff and maximum flow rate of 9.6 gpm.

Effluent from the treatment plant is disinfected with chlorine and then discharged to the plant wastewater treatment system. Thus, its fate is ultimate disposal through spray irrigation.

The treatment plant design efficiency provided by the manufacturer is as follows:

Raw Sewage 5-Day BOD Reduction	90.0%
Suspended Solids Reduction	90.0%

These design efficiencies are in accordance with state requirements. BOD and suspended solids reduction information, as well as other data, are submitted monthly to the Hillsborough County Environmental Protection Commission and the Florida Department of Environmental Regulation.

A permit for the sewage treatment plant was granted by the Florida State Board of Health in October 1968. The Department of Pollution Control issued an operating permit, No. D.O. 29-672, on October 18, 1971. On January 19, 1976, the Department of Environmental Regulation granted a Temporary Operating Permit No. TP29-2516. On October 6, 1977, the Department of Environmental Regulation granted an Operating Permit, No. D029-5740.

Manpower projections for the operation and maintenance of Big Bend 4 indicate that a second packaged treatment plant will be required. This new plant will provide secondary treatment with design removal efficiencies of 90 percent for BOD₅ and suspended solids. The effluent from the new plant will be chlorinated and discharged to the plant wastewater system. This system will be operated in accordance with

Chapter 17-6 FAC in providing for 90 percent treatment and alternate effluent disposal.

3.6.2 Solid Wastes

Solid wastes resulting from Unit 4 operation will include bottom ash, economizer ash, pyrites, fly ash, and flue gas desulfurization (FGD) byproduct (Table 3.6-1).

Bottom ash will be collected in a water-filled bottom ash hopper and hydraulically sluiced to an ash pond. The bottom ash disposal pond will be located in the area currently occupied by an unused U-shaped cooling pond. This area is shown on Figure 3.1-1. The conceptual layout of the area is shown on Figure 3.6-1. The bottom ash will be sluiced from the plant to either of two earthen dike primary settling ponds. Overflow from the primary settling ponds will flow by gravity to a secondary settling pond. Clarified water will then be pumped back to the plant, completing the recirculating system. The major portion of the bottom ash will settle within the primary settling ponds. Once these ponds are filled, the ash will be hydraulically dredged to a final disposal cell (see Figure 3.6-1). These cells will be developed as the need for disposal volume dictates. The cells will be formed by earthen dikes. It is anticipated that the disposal cells will reach a maximum height of 35 feet. The settling ponds will be designed to store approximately 6 months of ash production between dredging. This disposal site will be designed and operated in accordance with RCRA restrictions for construction of solid waste disposal sites in flood plains (44FR, 4356; September 13, 1979, "Criteria for Classification of Solid Waste Disposal Facilities and Practices"). The estimated quantities of bottom ash produced is 25,680 tons per year. Pyrites removed from the coal prior to combustion, economizer ash, and fly ash will be sluiced to a fly ash pond as shown on Figure 3.6-1.

Unit 4 fly ash will be removed from the flue gas by electrostatic precipitation and collected in hoppers. Fly ash from Units 1 through 3 is currently collected and pneumatically transported to silos for storage and subsequent sale as a raw material in the production of cement. These same provisions will be included for Unit 4. Where fly ash is consumed solely in the production of cement, its utilization rate is directly related to the level of construction activity and thus to the economic viability of the region. A downturn in the economy may result in the need to provide for onsite disposal. In

addition, the increasing coal fired generation in Florida may cause an abundance of fly ash on the market. To guard against a decrease in fly ash demand which could jeopardize the dependability of the unit, provisions for fly ash disposal from Unit 4 have been made. At times when it may be impossible to market Unit 4 fly ash, the ash disposal pond will be utilized. The conceptual layout of the fly ash disposal area is shown in Figure 3.6-1. The solids will be sluiced from the plant to either of two lined primary settling ponds. Overflow from these ponds to a lined secondary settling pond will be by gravity. Clarified water will be pumped back to the plant, completing the recirculating system. The rate at which these settling ponds fill with solids will depend upon the viability of the fly ash market. When the ponds reach the point at which they must be cleaned, a final earthen dike disposal cell will be constructed and lined. The ash will be hydraulically dredged to the disposal cell. The area to the south will be reserved for future disposal cells, as needed.

The FGD system will utilize a two stage, forced oxidized, limestone, wet scrubbing process. The resulting FGD byproduct will consist mainly of calcium sulfate (gypsum). The FGD byproduct will be handled and stored in an area south of the Unit 4 ash pond. This facility is discussed in Section 3.9.1. The estimated annual byproduct production is 200,000 tons. It is expected that the gypsum will be of sufficient purity to be used as a raw material in the manufacture of drywall.

TABLE 3.6-1

SOLID WASTES PRODUCED BY BIG BEND UNIT 4

<u>WASTE MATERIAL</u>	<u>QUANTITY (Tons/Year)</u>
Bottom ash ⁽¹⁾	25,680
Pyrites ⁽²⁾	19,000
Fly Ash ⁽³⁾	102,700
FGD Byproduct	210,000

NOTES: Design coal of 13.5 percent ash for reference fuel
F1A quantities based on 28-year average capacity
factor of 52.57 percent.

- (1) Bottom ash assumed to be 20 percent of ash content
- (2) Pyrites assumed to be 2 percent of coal
- (3) Fly ash assumed to be 80 percent of ash content

TABLE 3.6-1

SOLID WASTES PRODUCED BY BIG BEND UNIT 4

<u>WASTE MATERIAL</u>	<u>QUANTITY (Tons/Year)</u>
Bottom ash ⁽¹⁾	25,680
Pyrites ⁽²⁾	19,000
Fly Ash ⁽³⁾	102,700
FGD Byproduct	240,000

NOTES: Design coal of 13.5 percent ash for reference fuel
F1A quantities based on 28-year average capacity
factor of 52.57 percent.

- (1) Bottom ash assumed to be 20 percent of ash content
- (2) Pyrites assumed to be 2 percent of coal
- (3) Fly ash assumed to be 80 percent of ash content

3.7 AIR EMISSIONS

The proposed Unit 4 will be fired with medium-sulfur bituminous coal. The regulations and guidelines that govern the control of pollutant discharges from a source such as Unit 4 are the New Source Performance Standards (NSPS) for Electric Utility Steam Generating Units, the Florida State Implementation Plan and Air Pollution Rules (APR), and the Best Available Control Technology (BACT) provisions of the Prevention of Significant Deterioration (PSD) Regulations. A combination of coal pretreatment, boiler design, and air pollution control devices will be used to ensure that operation of the proposed unit complies with applicable air quality regulations.

These same control systems have been evaluated by a feasibility study and a cost-benefit analysis and have been judged BACT by the applicant for pollutants subject to PSD Regulations. These pollutants are particulate matter (PM), sulfur dioxide (SO₂), oxides of nitrogen (NO_x), and carbon monoxide (CO).

The air pollution control techniques and systems that are incorporated in the facility design for the subject pollutant emissions are described below:

- o PM will be controlled by an electrostatic precipitator (ESP) installed at the exit of the air preheater
- o SO₂ emissions will be minimized by a combination of coal washing and scrubbing by means of a flue gas desulfurization system
- o NO_x and CO formation during combustion will be inhibited by proper operation and design of the Combustion Engineering, Inc. balance-draft boiler, tangentially fired furnace and combustion air control system.

3.7.1 Regulatory Requirements

The 1977 Clean Air Act Amendments (CAAA) and the regulations issued subsequently by the U.S. Environmental Protection Agency (EPA) to implement this legislation have produced fundamental changes for the regulation of air pollution in this country. Perhaps the most significant of these changes for utility sources are the technology-forcing requirements of the CAAA and subsequent regulations presented below:

- o New Source Performance Standards (NSPS) impose emission standards for new sources (Section 111, Amendments; 40 CFR 60).
- o National Emission Standards for Hazardous Air Pollutants (NESHAP) impose regulations for sources of same (Section 112, Amendments; 40 CFR 61).
- o Best Available Control Technology (BACT) is embodied in the preconstruction requirements and pertain to sources affecting Prevention of Significant Deterioration (PSD) areas (Section 165, Amendments; 43 FR 26390-26410, June 19, 1978).
- o Lowest Achievable Emission Rate (LAER) is embodied in the Nonattainment (NA) Area requirements (Section 173, Amendments; 44 FR 3274-3287, January 16, 1979).

These regulations and guidelines are detailed below in the context of the requirements on Tampa Electric Company's (TECO) proposed Big Bend Station Unit 4.

New Source Performance Standards

The NSPS constitute a set of national emission standards for stationary sources of air pollution. These standards are applicable to specific categories of sources and apply not only to new sources, but also to modified or reconstructed existing sources of air pollution. In accordance with the CAAA, these standards "shall reflect the degree of emission limitation and the percentage reduction achievable through application of the best technological system of continuous emission reduction (taking into consideration the cost of achieving such emission reduction, any non-air quality health and environmental impact and energy requirements) the Administrator determines has been adequately demonstrated."

For fossil-fuel-fired stationary sources, the CAAA mandate that the NSPS regulations shall impose both a standard establishing allowable emission limitations and a standard requiring achievement of a percentage reduction from the emissions that would have resulted from the use of fuels not subject to treatment before combustion. The original NSPS were promulgated in December 1971 (40 CFR 60, Subpart D), and were subsequently revised for electric utility steam generating units on June 11, 1979 (40 CFR 60, Subpart Da). The latter standards apply to utility boilers firing more than 250 million Btu/hr heat input of fossil fuel, for which construction started after September 18, 1978.

The NSPS for electric utility boilers impose emission standards on particulate matter (PM), sulfur dioxide (SO₂),

and oxides of nitrogen (NO_x). The allowable emission limitations and required percentage reductions for these pollutants, as apply to the proposed Big Bend Unit 4, are summarized in Table 3.7-1. The compliance provisions of the NSPS are also presented in that table.

For boilers firing bituminous coal, the SO₂ emissions to the atmosphere are limited to 1.20 lb/million Btu heat input. A 90 percent reduction in potential SO₂ emissions is required, except when emissions to the atmosphere are less than 0.60 lb/million Btu. When SO₂ emissions are less than 0.60 lb/million Btu, a 70 percent reduction in potential emissions is required. Compliance with both the allowable emissions and required emission reduction is to be determined on a continuous basis by means of continuous monitors for a 30-day rolling average. The percent reduction is based on the overall SO₂ removal by flue gas desulfurization, coal washing, coal pulverization, and sulfur retention in fly ash and bottom ash. The SO₂ standard is presented graphically in Figure 3.7-1.

The PM standard limits emissions to 0.03 lb/million Btu heat input and requires a 99 percent reduction in potential emissions for coal-fired boilers. Compliance with the emission limitation for PM is considered to assure compliance with the percentage reduction requirements. The PM standard also limits opacity to 20 percent on a 6-minute average (with the exception of one 6-minute period per hour when opacity is limited to 27 percent).

The NO_x emission standard restricts boilers firing bituminous coal to 0.60 lb/million Btu heat input; the standard also requires a 65 percent reduction in potential NO_x emissions. Again, compliance with the allowable emission limitation satisfies the percentage reduction requirements of the standard. Continuous monitors are required for measuring the emission of NO_x, and compliance with the standard is based on a 30-day rolling average.

National Emission Standards for Hazardous Air Pollutants

Section 112 of the Clean Air Act required the EPA to publish a list, to be revised periodically, that includes hazardous air pollutants for which NESHAP would be developed. Emission standards for various sources have been promulgated (40 CFR 61); Subpart B, Asbestos; C, Beryllium; D, Beryllium Rocket Motor Firing; E, Mercury; and F, Vinyl Chloride. Other pollutants currently being considered by EPA for listing include benzene, arsenic, cadmium, and polycyclic organic matter. To date the NESHAP do not affect the design or operation of the proposed Big Bend Unit 4.

Best Available Control Technology

The basic control technology requirements of the PSD regulations are the application and evaluation of BACT, defined as follows:

An emission limitation...based on the maximum degree of reduction for each pollutant...which would be emitted from any proposed major stationary source or major modification which the Administrator on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs determines is achievable...for control of such pollutant.

Major sources are exempt from BACT requirements for a given pollutant if the increase in allowable emissions for that pollutant is less than 50 ton/year, 1000 lb/day, or 100 lb/hr, whichever is most restrictive.

The Guidelines for the Evaluation of BACT were published by the EPA in December 1978 to assist states or EPA Regional Offices in making BACT determinations. The BACT requirements are intended to ensure that the control systems incorporated in the design of a proposed facility reflect the latest in control techniques employed in a particular industry and take into consideration existing air quality in the vicinity of the proposed facility. Because the NSPS for electric utility steam generators were promulgated June 11, 1979, and the associated cost-benefit analyses were performed just prior to that date, compliance with these standards may indeed be considered application of BACT in the utility industry. Notwithstanding this, an evaluation of the air pollution control techniques and systems is required, including a cost-benefit analysis of alternative control technologies capable of achieving a higher degree of emission reduction. The cost-benefit analysis requires the documentation of the materials, energy, and economic penalties associated with both the proposed and alternative control systems as well as any environmental benefits derived from both.

Lowest Achievable Emission Rate

The control technology requirement specified for sources located in or having an impact on a nonattainment area is LAER, defined in the EPA's Emission Offset Ruling as follows:

For any source, that rate of emissions based on the following, whichever is more stringent: (i) The most stringent emission limitation which is contained in the implementation plan of any State for such class or category of source, unless the owner or operator of the

proposed source demonstrates that such limitations are not achievable; or (ii) The most stringent emission limitation which is achieved in practice by such class or category of source.

Because the Big Bend Station is not located in a nonattainment area for any of the criteria pollutants, LAER is not required for any pollutant emission from the proposed Unit 4. In addition, emissions from the proposed unit will not have a significant impact on a nonattainment area, precluding application of LAER (Section 5.5.3).

Summary

Big Bend Station Unit 4 will be designed and demonstrated to be in compliance with the NSPS for electric utility steam generators. It is anticipated that the revised Florida State Implementation Plan (SIP) will incorporate these standards intact for that category of sources. The proposed unit must also include BACT in facility design for those pollutants subject to the PSD regulations.

3.7.2 Atmospheric Emissions and Proposed Control Systems

The Unit 4 steam generator will be a tangentially-fired boiler designed by Combustion Engineering, Inc. The boiler will have a maximum continuous rating of 3,300 Mlb/hr of steam at the superheater outlet, at 2,600 psig and 1,005°F. The boiler performance data is presented in Table 3.7-2 for 50, 75, and 100 percent of maximum continuous rating. Note that this boiler data is based on a design reference fuel.

Unit 4 will fire medium to high-sulfur coal. For the purposes of the air pollution control evaluation and specification of control equipment, three design coal analyses were developed detailing pertinent physical and chemical characteristics. These three design coals are representative of those fuels still under consideration for Unit 4, presenting a range of constituent concentrations. The approximate and ultimate analyses of each of the design coals are presented in Table 3.7-3 along with physical characteristics. The fuel rate is also presented based on the heating value of the coal and boiler performance. Coal F-1A was used in the specification of the particulate matter control device; coal F-2A and F-2B were included in the specification of the FGD system.

The Unit 4 boiler is considered a major source of particulate matter (PM), sulfur dioxide (SO₂), oxides of nitrogen (NO_x), and carbon monoxide (CO). The receiving, handling, and storage of coal for Unit 4 is an additional

source of both controlled and fugitive particulate emissions. Similarly, the limestone required for the FGD system is a potential source of fugitive particulate emissions. The principal air pollution control techniques and systems incorporated in the facility design and operating and maintenance procedures are itemized below:

- o Fugitive dust emissions resulting from the receiving, handling, and storage of coal and limestone will be minimized by a combination of techniques, including surface moisture content of coal in storage piles; particle size of limestone; containment and control of conveyors, transfer points, and crushing equipment; the proper maintenance of coal and limestone handling facilities.
- o PM emissions from the boiler will be controlled by an electrostatic precipitator (ESP) installed at the exit of the air preheater.
- o SO₂ emissions will be minimized by a combination of coal washing and tail-gas cleaning by means of a flue gas desulfurization (FGD) system (in compliance with the NSPS).
- o NO_x formation during combustion will be inhibited by the proper operation and design of the boiler and combustion air control system (in compliance with the NSPS).
- o CO emissions will be minimized by high-excess air operation and design of the combustion air control system.

A flow diagram of the combustion system and associated air pollution control techniques and equipment is presented in Figure 3.7-20, detailing both gaseous effluents and solid and liquid waste discharges.

This section presents details of the air pollution control techniques and systems that are included in the design and operational procedures of Unit 4.

3.7.2.1 Particulate Matter (PM)

The major source of PM emissions is the combustion of coal in the Unit 4 steam generator. This source is controlled by design of the boiler, combustion air control system, and an electrostatic precipitator. Fugitive emissions from the receiving, handling, and storage of coal and limestone are

minimized by both proper operating and maintenance procedures and containment and control of certain handling facilities.

Boiler and Combustion Air Control System

The design and operation of both the boiler and combustion air control system will minimize the production of unburned carbon and, hence, total particulate loading in the flue gas. Specifically, the maintenance of high-excess-air operation (25 percent or greater) will effectively assure complete combustion and limit the formation of unburned carbon so that flue gas concentrations will be negligible.

Electrostatic Precipitator (ESP)

Particulate matter emissions from the combustion system will be controlled by means of cold-end type electrostatic precipitator (ESP). This type of control device has received the widest application on coal-fired utility boilers and has been demonstrated to be capable of outlet grain loadings in compliance with the NSPS. The Environmental Protection Agency (EPA) obtained emission test data from utility installations firing pulverized coal. Of 22 ESP units tested, nine met the NSPS for particulates of 0.03 lb/MMBtu, even though none of the units was designed to meet that standard. Table 3.7-4 presents the results of those tests with pertinent ESP and fuel characteristics. These tests were conducted on boilers firing medium- to low-sulfur coal. High-sulfur coal produces fly ash with a low resistivity which can be readily collected with an ESP at specific collection areas (SCA) typically below 400 square feet of collection plate per thousand cubic feet of gas (ft^2/Macf).

The specification for the Unit 4 ESP has been prepared and sent out for bids. The contract was awarded in August 1979 to Belco Control Corporation. The specification requires the ESP manufacturer to guarantee an outlet PM emission of 0.03 lb/MMBtu and 20 percent opacity, in compliance with the NSPS for electric utility steam generating units. The collection efficiency will be in excess of the 99 percent reduction in the potential emissions required by the NSPS. The actual guaranteed precipitator particulate collection efficiency based on the design inlet grain loading of 1.33-2.67 grains/cu ft is 99.74 percent. The design and performance requirements presented here are based on the ESP specification.

The ESP will be of a rigid-frame European design and will be installed between the outlet of the air preheater and the inlet to the induced draft (ID) fans. It is anticipated that the ESP will have an SCA of 400 ft²/Macf. The operating conditions and guaranteed items stipulated in the specification for the ESP are detailed in Table 3.7-5. The guaranteed particulate loading/emission rate will be verified in two performance tests. The first test is to be performed within 90 days after commercial operation, and the second within twelve months of the first successful performance test. Should the ESP fail to comply with the guaranteed PM emission rate, the manufacturer will modify the initial installation to meet the performance requirements.

The specification for the ESP requires the manufacturer to guarantee the outlet grain loading for all coals under consideration for Unit 4 consumption. For the purposes of quantifying PM emissions and fly ash and bottom ash discharges, coal F-1A was used in the calculations to provide a conservatively high estimate of each parameter. These calculations were based on the following assumptions:

- o No ash is removed during crushing or pulverization of the coal.
- o The quantity of unburned carbon in the total particulate grain loading is negligible.
- o Twenty percent of the ash introduced to the boiler is discharged as bottom ash, while 80 percent is entrained in the flue gas as fly ash.
- o The outlet particulate loading from the ESP is equivalent to 0.03 lb/MMBtu (0.007 grs/acf).

Table 3.7-6 summarizes the quantities of fly ash and bottom ash in the flue gases and waste discharges, along with pertinent operating conditions and fuel characteristics.

Compliance tests for the ESP will be conducted in accordance with Section 60.48a, Subpart Da, and by procedures prescribed in Appendix A in 40 CFR 60. A continuous monitoring system for measuring opacity will be installed, calibrated, maintained, and operated at a point in the flue gas system downstream of the ESP in accordance with Section 60.47a, Subpart Da, 40 CFR 60.

Coal and Limestone Handling and Storage

Both existing and new equipment and facilities will be used for receiving, handling, and storing coal for Unit 4. The requirements for additional equipment and the design of new receiving and transfer systems have not been finalized at this time. The coal will be stored in an area adjacent to existing reserve and active coal piles. The coal will be transferred from the active pile to the Unit 4 bunkers via an existing conveyor belt which need only be extended.

To minimize the generation of fugitive particulate emissions from coal receiving, handling, and storage, the procedures presently employed for dust suppression and control will be expanded to include proposed activities. These procedures consist of turning the reserve coal piles which insures uniform surface moisture, containment of coal unloading and transfer points, and covering coal conveyors. The mean annual precipitation in Tampa is 49.4 inches, and on 107 days per year more than 0.1 inches per day falls. These factors tend to minimize dust generation from erosion and mechanical disturbance.

Fugitive particulate emissions from the receiving, handling, and storage of limestone are expected to be minimal, primarily because of the particle size of the ore as received. Containment of transfer point and conveyor systems will also minimize dust generation during handling. As previously mentioned, the annual precipitation will serve to suppress fugitive emission from storage piles.

3.7.2.2 Sulfur Dioxide

The major source of SO_2 emissions is the combustion of coal in the steam generator. These emissions are minimized by a combination of coal washing and tail-gas scrubbing by means of an FGD system.

Coal Washing

The NSPS permit the use of coal pretreatment in meeting the percentage reduction requirements of the standard. This factor and other benefits derived from coal washing have produced a resurgent interest in the process. These benefits include: 1) removal of sulfur, 2) removal of ash, 3) reduction of trace element concentration, and 4) production of a fuel of uniform quality. The major problems associated with coal washing are the costly process of dewatering the washed coal and treatment of contaminated waters.

The removal of sulfur from the coal is limited in effectiveness by the type and form of sulfur in the coal.

There are three principal forms of sulfur found in coal: sulfate, organic, and pyritic. Sulfates normally constitute a small percentage of the total sulfur in the coal and are of little significance. Organic sulfur content ranges from 20 to 60 percent of the total sulfur. This form of sulfur is molecularly bound and is distributed evenly throughout the coal. Removal of organic sulfur requires the material alteration of the coal so that the relative quantity of this sulfur form is the prime parameter which determines the effectiveness of coal washing in producing significant total sulfur reduction. Pyritic sulfur, which exists as discrete particles within the coal, can be removed by physical coal cleaning. The shapes and sizes of the pyrites in the coal may be categorized as round masses (sulfur balls); lens-shaped masses; veins; small, discontinuous veinlets; and disseminated particles or veinlets. The degree of pyrite liberation varies greatly with the form of pyritic sulfur and the overall coal composition. Some coals demonstrate high pyrite liberation by washing nominal sizes following crushing; others show little pyrite liberation when reduced to pulverized coal size (70 percent through 200 mesh).

For physical coal cleaning, various techniques are used: size reduction, air density classification, and washing, either singly or in combination. Size reduction alone may liberate pyrites in the form of sulfur balls. These can be removed manually or by air density classification. The latter technique uses the density difference between coal and pyrites. Secondary classification can then be used to retrieve coal fines entrapped in the coarse stream for return to the coal feed. Cleaning the coarse stream of coal using Baum figs or heavy-media separators, or cleaning the coal fines using air tables or wet concentrating tables, may enhance pyrite removal depending on size reduction and pyrite liberation.

Several of the coals under consideration for Unit 4 consumption are subjected to coal washing. Pending final coal selection, the percentage reduction in potential SO_2 emissions will be assumed to be 25 percent on the basis of mass of sulfur per unit heat content of the coal. This assumption is reasonable because the actual sulfur reduction of washed coals under consideration ranges from 35 to 43 percent.

Flue Gas Desulfurization System (FGD)

The SO_2 emissions from the combustion system will be controlled by means of an FGD system. The type of FGD system selected for Unit 4 is a two-stage, forced oxidized limestone nonregenerable system. Limestone systems have received the widest application on coal-fired utility

boilers. The limestone system has also been demonstrated to be capable of removal efficiencies of between 85 and 90 percent. In establishing the percentage reduction requirement of the NSPS, the EPA cited the operation of limestone and lime FGD systems in both the U.S. and Japan having removal efficiencies on the order of 90 percent. Table 3.7-7 summarizes the test results on the performance of those FGD systems.

The coals used to specify performance requirements of the FGD system are based on the typical coals F-2A and F-2B (see Table 3.7-3). Both of these coals are assumed to have been washed to produce a percentage reduction of 25 percent in potential SO₂ emissions. The final design and performance requirements of the FGD system are not expected to differ significantly from those described here, and the rates of both pollutant emissions and waste effluents from the FGD system will most likely fall within the range established below.

The removal efficiency of the FGD system is a function of the sulfur content of the raw coal and the percentage reduction in potential SO₂ emissions attributable to coal washing and retention in the fly ash and bottom ash. In accordance with Method 19, Appendix A, 40 CFR 60, the overall percentage reduction is computed by the following relationship:

$$\%R_o = 100 \left[1.0 - \left(1.0 - \frac{\%R_f}{100} \right) \left(1.0 - \frac{\%R_g}{100} \right) \right]$$

where: $\%R_o$ = overall SO₂ reduction, %
 $\%R_f$ = SO₂ removal efficiency due to fuel pretreatment, %
 $\%R_g$ = SO₂ removal efficiency of FGD system, based on the fuel analysis and FGD outlet concentration, %

The relationship was used to compute the required removal efficiency of the FGD system, based on the following assumptions:

- o The sulfur content of the coals F-2A and F-2B after washing are 3.00 and 6.00 lb/MMBtu, respectively.
- o The percentage reduction credited to coal pretreatment is 25 percent.
- o Five percent of the sulfur in the coal as-fired is retained in the ash.

To attain an overall percentage reduction of 90 percent, in compliance with NSPS, the removal efficiency of the FGD system must be 86 percent.

The conceptual design of the FGD system, although intended to be generic in nature, is based on the most common designs presently in operation or available from FGD manufacturers. Figure 3.7-3 is a flow diagram of the conceptual design of the limestone FGD system. Only one train is depicted in the diagram although three modules and one spare will be used. The duplicated modules will consist of booster fans, a quencher, an absorber, and absorber feed tanks, with the associated piping and pumps. The design data and performance requirements of the FGD system based on coals F-2A and F-2B are presented in Table 3.7-8. Design and equipment features are also presented in this table.

Flue gas exiting the ID fans is ducted to the plenum which precedes the FGD booster fans, where the flow is evenly distributed to the three modules. The booster fans are required to compensate for the pressure drop across the FGD system, ranging from 7 to 13 inches water gage (in W.G.). The flue gases then enter the quencher where the gas stream is quenched to its adiabatic saturation temperature of about 125°F. This quencher is a cyclonic flow, concurrent spray tower and also serves as the first stage of SO₂ absorption. The spray medium in this stage is a 15 percent by weight solids slurry of limestone at a pH of approximately 4.5. The flue gases are next passed through to the absorber section or second stage. In the absorber the gas contacts a spray section followed by a packed section. The contacting medium here is a 10 percent by weight solids slurry of limestone at a pH of approximately 6.5. After passing through the absorber, the gases pass through a mist eliminator, which will be a Chevron type, on which entrained droplets are impacted and, thus, removed from the stream. The reheat is provided by mixing the flue gas at about 125°F with ambient air heated to approximately 270°F by fourth-point turbine extraction steam. Additional reheat may be provided by stack gases from Unit 3 upon entering the common-flue stack.

The limestone ore, assumed to be 95 percent calcium carbonate (CaCO₃) for the purposes of preliminary design, is first crushed to about 70 percent through 200 mesh and slurried in a wet ball mill. The slurry is then sent to a limestone transfer tank where it is fed to the absorber feed tank upon demand. The recirculated slurry is then pumped through the absorber, where the dissolved CaCO₃ contacts the SO₂ in the misted stream to form calcium sulfite (CaSO₃) and

calcium sulfate (CaSO_4). These reactor products and some unused limestone are bled to the quencher or first stage to absorb some of the inlet SO_2 and to undergo forced oxidation. Because the solubility of the sulfite is low and sensitive to the acidity of the system, careful pH control is required to prevent precipitation of the crystals as a scale in the absorber and associated piping.

Internal to the system, forced aeration converts the $\text{CaSO}_3 \cdot 1/2\text{H}_2\text{O}$ to $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ (gypsum). This stream, which is approximately 15 percent solids, is then pumped to a Hydroclone Dewatering System where the sludge is dewatered to between 35 and 50 percent solids. The sludge is pumped from the hydroclone underflow tanks to the vacuum filters, where it is dewatered to 90 percent solids. The next process in the treatment of the FGD byproduct depends on its ultimate disposal. Currently, TECO plans to market the gypsum.

A summary of the mass balance across the FGD and byproduct treatment systems is presented in Table 3.7-9, detailing assumptions used to determine makeup, discharge, and emission rates. The mass balance was based on coals with a sulfur content of 3.0 and 6.0 lb/MMBtu.

Compliance with the NSPS will be demonstrated by the procedures specified in Method 19, Appendix A, 40 CFR 60. To determine potential SO_2 emissions, fuel analyses of both the raw and received coals will be established using procedures prescribed by ASTM D 270. A continuous monitoring system for measuring SO_2 emissions will be installed, calibrated, maintained, and operated at a point downstream of the FGD system.

3.7.2.3 Oxides of Nitrogen

The emission of NO_x from the combustion system will be minimized by the design of the burners and boiler to be provided by CE. The tangentially-fired boiler has been demonstrated to be capable of limiting NO_x formation to 0.6 lb/MMBtu, when firing bituminous coal. This meets the NSPS. The EPA cites several CE boilers in operation that are able to meet the NSPS, although these boilers are neither designed nor guaranteed to have NO_x emission at these levels.

The formation of thermally produced NO_x is inhibited in the CE boiler by off-stoichiometric combustion, that is, operating the burners at a fuel-rich mixture. This is accomplished by two techniques: biased-firing and

two-staged combustion. The former technique consists of operating some burners at fuel-rich mixtures and others at lean mixtures. Initial combustion then occurs in a reducing atmosphere, followed by complete combustion after substantial heat loss. The resultant lower flame temperatures inhibit the formation of thermal NOx. The latter technique, two-staged combustion, is accomplished by diverting a portion of the combustion air to over-fire air ports located above the burners. The same fuel-rich combustion takes place with the attendant heat loss, followed by complete mixing and combustion above the primary combustion zone. Although CE has incorporated over-fire air ports in the boiler design, operation of these ports has been found to be unnecessary below 90 percent MCR. Two-staged combustion will thus be employed should monitoring indicate that the NOx emissions may exceed standards. The NOx emission limitation is equivalent to an emission rate of 2598 lb/hr. Table 3.7-10 lists EPA test programs for NOx reduction.

Compliance with the NSPS for NOx will be demonstrated in accordance with Section 60.48a, Subpart Da, and by procedures prescribed in Method 19, Appendix A, 40 CFR 60. A continuous monitoring system for measuring NOx emissions will be installed, calibrated, maintained, and operated at a point downstream of the economizer outlet.

3.7.2.4 Carbon Monoxide

The only significant source of CO is the Unit 4 steam generator. CE does not include monitoring of combustibles in the design of their boilers because the CO emission is expected to be negligible. The recording and alarming of combustibles, however, may be included in the specification of the combustion air control system. Using the emission factor from the EPA document Compilation of Air Pollution Emission Factors, AP-42, the CO emission will be approximately 62 lb/hr based on coal F-1A and boiler performance data. This factor is conservatively high as it represents a consensus mean emission from both boilers of old and more recent design. The EPA test on the Alabama Power Company Barry Station No. 2 demonstrates that CO emissions typically range from 0.016 to 0.022 lb/MMBtu, which is equivalent to 70 to 95 percent reduction (see Table 3.7-10). These data generally support the AP-42 emission factor, which is used to estimate the CO emission rate.

3.7.2.5 Summary of Expected Emissions

The emissions of pollutants from the proposed Unit 4 steam generator are summarized in Table 3.7-11. The applicable NSPS for electric utility facilities are also presented for direct comparison.

Based on State of Florida Guidelines for Application for Certification of Proposed Electrical Power Generating Plant Site Form DER 17-1.122 (73) is provided.

Yes ☒ No ☐

POLLUTANT	RATE OF CONCENTRATION
<u>SULPHUR DIOXIDE</u>	<u>1.2 lb/MM BTU</u>
<u>PARTICULATE MATTER</u>	<u>0.1 lb/MM BTU</u>
<u>NITROGEN OXIDES</u>	<u>0.7 lb/MM BTU</u>

Yes ☒ No ☐ See Table 3.7-1

<u>POLLUTANT</u>	<u>RATE OF CONCENTRATION</u>
<u>SULPHUR DIOXIDE</u>	<u>1.2 lb/MM BTU-0.6 lb/MM BTU</u>
<u>PARTICULATE MATTER</u>	<u>0.03 lb/MM BTU (greater than</u> <u>or equal to</u> <u>99% removal)</u>
<u>NITROGEN OXIDES</u>	<u>0.6 lb/MM BTU</u>

Yes () No (✓)

POLLUTANT	RATE OF CONCENTRATION

D. What Emission Levels Do You Propose As Best Available Control Technology?

POLLUTANT	RATE OF CONCENTRATION
<u>SULPHUR DIOXIDE</u>	<u>1.2 lb/MM BTU (70-90% removal)</u>
<u>PARTICULATE MATTER</u>	<u>0.03 lb/MM BTU (greater than or equal to 99% removal)</u>
<u>Nox</u>	<u>0.60 lb/MM BTU</u>
_____	_____

E. Describe the Control Technology Proposed (If not available explain the reasons fully):

1. Control Device	Coal Cleaning/FGD Limestone System	Electrostatic Precipitator	No	Co
2. Efficiency*	90%	99.7%	***	****
3. Capital Cost*	\$90,000,000	\$10,000,000		
4. Life	Life of Generating Unit	Life of Generating Unit		
5. Operating Cost*	4.5 mil/kWh	0.1 mil/kWh		
6. Energy	3% of station output	1.5% of station output		
7. Maintenance Cost*	**	**		

*Estimate

**Included in operating cost

***Nox is controlled through boiler burner design which will provided a 65 percent reduction of potential Nox emissions. Capital, operating, and maintenance cost cannot be separated from total cost of boiler or burner.

****CO is controlled through combustion control system design. Capital, operating and maintenance cost cannot be separated from total cost of combustion control system.

8. Stack Parameters: *****

- a. Height: 490 Ft
- b. Diameter: 24 Ft
- c. Flow Rate: 1,778,000 ACFM
- d. Temperature: 156°F
- e. Velocity: 65.5 FPS

*****Flow rate, exist temperature and velocity are given for Unit 4 only. Unit 4 flue gas will exit an existing stack which services Unit 3.

9. Fuels: See Table 3.7-2 and 3.7-3

TYPE	HOURLY USE*		HOURLY HEAT INPUT MILLION BTU/HR.	
	AVG.	MAX.	AVG.	MAX.
<u>Coal**</u>	<u>309,000 lb/hr</u>	<u>413,000 lb/hr</u>	<u>3250</u>	<u>4330</u>
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
TYPE	DENSITY	%S	%N	%ASH
<u>Coal</u>	<u>N/A</u>	<u>2.92</u>	<u>1.08</u>	<u>13.5</u>
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

*Gaseous cu ft/hr. Liquid and Solid: lb/hr

**Based on Fuel F-1A see Table 3.7-3

10. Wastes Generated, Disposal Method, Cost of Disposal:
See Section 3.6.2

F. Show Derivation of Efficiency Estimation. See Section 3.7.2

G. An 8 1/2 x 11 in Flow Diagram Which Will, Identify the Individual Operations and/or Processes. Indicate Where Raw Materials Enter, Where Solid and Liquid Waste Exist,

Where Gaseous Emissions and/or Airborne Particles Are
Evolved. See Figure 3.7-2.

TABLE 3.7-1

NEW SOURCE PERFORMANCE STANDARDS
FOR ELECTRIC UTILITY STEAM GENERATING UNITS

<u>Pollutant</u>	<u>Emission Limitation</u>	<u>Percent Reduction Requirement</u>
SO ₂	1.2 lb/MMBtu (520ng/J)	90 (30-day rolling average)
	0.6 lb/MMBtu (260ng/J)	70 (30-day rolling average)
PM	0.03 lb/MMBtu (13ng/J)	99*
	Opacity limited to 20% (6-minute average); 27% allowed 6 min/hr**	
NOx	0.06 lb/MMBtu (260ng/J)	65*

NOTE: ng/J = nanograms per joule

*Satisfied automatically if emission limitation is met.

**A source-specific opacity standard may be established if opacity is greater than 20 percent when complying with the PM limitation.

TABLE 3.7-2

BOILER PERFORMANCE DATA
FOR BIG BEND STATION UNIT 4

<u>Parameter</u>	<u>Boiler Performance Data</u>		
Load, % maximum rating	50.	75.	100.
Steam Generation, Mlb/hr	1567.	2350.	3300.
Heat Input Rate, MMBtu/hr	2241.	3244.	4330.
Fuel Rate, Mlb/hr*	213.	309.	413.
Excess Air, %	40.	25.	25.
Flue Gas Rate, Mlb/hr**	2854.	3663.	4829.
Flue Gas Temperature, °F**	251.	248.	267.

*Based on design fuel with the following analysis:

Type	Coal
Sulfur, %	3.02
Ash, %	10.7
Moisture, %	15.0
H.H.V.	10495.

**At the preheater outlet, including air leakage.

TABLE 3.7-3

ALTERNATIVE COAL ANALYSIS

	F-1A <u>Peabody Coal</u> Elkton <u>Washed</u>	F-21 <u>Amax Coal Co.</u> Crab Orchard <u>Washed</u>	F-22 <u>Delta C&H</u> <u>Raw</u>	F-23 <u>AMCA Resor.</u> Center <u>Washed</u>	F-24 <u>Freeman United</u> Round Prairie <u>Washed</u>	F-25 <u>Mapco Coal</u> White Co. <u>Washed</u>	F-26 <u>Pyramid Min.</u> Ohio Co. <u>Raw</u>
Heating value as received, Btu/lb	10,495	11,450	11,729	11,246	11,155	11,700	11,300
Ash fusion temp - reducing							
Initial	2005	2000	2110	2050	1920	1986	1950
Softening (H=W/2)	2160	2275	2300	2110	2200	2189	2000
Fluid	2275	2450	2442	2300	2350	2366	2200
Ash fusion temp - oxidizing							
Initial	2305	2400	2380	2420	2100	2267	2110
Softening (H=W/2)	2395	2530	2538	2500	2430	2495	2220
Fluid	2535	2620	2595	2530	2530	2576	2280
Grindability - Hardgrove No.	53.0	55.0	55.0	53.5	56.0	51.0	55.0
Ultimate Analysis - % by weight							
Moisture	14.50	9.50	10.11	14.34	11.55	10.00	9.20
Ash	13.50	11.20	9.05	7.17	9.90	7.65	6.20
Sulfur	2.92	2.47	2.09	2.57	3.19	2.72	3.10
Carbon	57.00	63.50	65.49	62.27	61.99	65.12	64.40
Hydrogen	4.10	4.40	4.51	4.27	4.23	4.42	5.10
Oxygen	7.05	7.35	8.13	8.25	7.92	8.64	12.60
Nitrogen	1.08	1.50	0.48	1.10	1.14	1.26	1.60
Chlorine	0.08	0.08	0.14	0.03	0.08	0.19	0.00
Proximate Analysis - % by weight							
Moisture	14.52	9.50	10.11	14.34	11.55	10.00	10.00
Ash	13.50	11.20	9.05	7.17	9.90	7.70	12.00
Volatile Matter	30.21	32.18	33.89	34.96	36.63	34.50	34.00
Fixed Carbon	41.75	47.12	46.45	43.53	41.92	47.80	44.00
Sulfur	2.92	2.47	2.09	2.57	3.19	2.70	3.20

TABLE 3.7-3 (Cont)

	F-1A <u>Peabody Coal</u> Elkton <u>Washed</u>	F-21 <u>Amax Coal Co.</u> Crab Orchard <u>Washed</u>	F-22 <u>Delta C&H</u> <u>Raw</u>	F-23 <u>AMCA Resor.</u> Center <u>Washed</u>	F-24 <u>Freeman United</u> Round Prairie <u>Washed</u>	F-25 <u>Mapco Coal</u> White Co. <u>Washed</u>	F-26 <u>Pyramid Min.</u> Ohio Co. <u>Raw</u>
Ash Analysis - % by weight							
Ferric Oxide - Fe_2O_3	17.71	19.73	17.28	22.82	21.53	22.79	18.40
Lime - CaO	6.49	4.00	3.08	3.22	5.76	4.05	1.90
Magnesia - MgO	0.70	0.85	0.90	0.79	1.01	0.79	0.80
Sodium Oxide - Na_2O	1.37	0.33	0.38	0.18	0.46	1.15	0.50
Potassium Oxide - K_2O	1.54	2.20	2.23	1.78	2.03	1.97	1.70
Silica - SiO_2	46.74	48.42	49.79	42.48	42.72	43.95	49.20
Alumina - Al_2O_3	19.25	19.56	22.08	23.01	18.86	20.89	19.30
Titania - TiO_2	1.01	0.90	1.09	1.02	0.82	1.00	2.10
Phos. Pentoxide - P_2O_5	0.34	0.16	0.17	0.19	0.10	0.12	0.07
Sulfur Trioxide - SO_3	4.31	3.53	2.19	2.27	5.88	2.87	2.10
Maf, Btu/lb (as received)	14,127	14,823	14,509	14,328	14,201	14,208	14,300
MgO/ SO_3	0.16	0.24	0.41	0.35	1.19	0.27	0.33
Base Acid	0.42	0.39	0.33	0.47	0.51	0.47	0.38
Slay Viscosity - T250	2385	2420	2490	2350	2310	2345	2430
Coal Fired, lb/hr (est)	413,000	378,553	369,549	385,420	388,564	370,465	383,578

TABLE 3.7-4

EMISSION TEST RESULTS, ESP INSTALLATIONS ON
PULVERIZED COAL-FIRED UTILITY STEAM GENERATORS

<u>Company</u>	<u>Plant</u>	<u>Generation, MW</u>	<u>% Sulfur</u>	<u>SCA</u>	<u>lb/MMBtu</u>
PP&L	Bridger 1	500	0.6	488	.042-.046
	Centralia	680	0.5	767	.027-.040
VEPCO	Mt. Storm	570	1.9	291-300	.032-.040
		570	1.9	268-276	.024-.043
IPSCo	Neal	500	0.5	884	.007-.020
CP&L	Roxboro	657	1.1	287	.037-.039
		411	1.1	273	.013-.024
	Weatherspoon	46	1.4	435	.021-.034
		46	1.4	435	.015-.033
		74	1.4	394	.024-.031
	Cape Fear	141	0.8	325	.026-.030
		187	0.8	307	.014-.017
Appalachian Power Co.	Amos	1300	0.9	335	.040-.046
	Clinch River	250	0.7	803	.044-.047
		250	0.7	803	.046-.050

*Specific collection area (ft² per 10³ actual cubic feet per minute)

TABLE 3.7-5

ELECTROSTATIC PRECIPITATOR (ESP) SPECIFICATION

Performance Requirements

Flue gas temperature @ economizer outlet (100% MCR)	753°F
Estimated flue gas temperature range @ economizer outlet	633°F @ 50% load 753°F @ 100% load
Flue gas temperature @ air heater outlet (100% MCR) without leakage	280°F ± 55°F
Flue gas temperature @ air heater outlet (100% MCR) with leakage	267°F ± 55°F
Precipitator design temperature	340°F
Flue gas design flow @ 340°F	2,200,000 acfm
Precipitator inlet loading	1.33-2.67 grs/acf
Maximum flue gas velocity @ design flow rate	4.5 fps

Guarantees

Outlet flue gas particulate loading	0.007 grs/acf (0.03 lb/MMBtu, 20% opacity)
Draft loss, ESP inlet, excluding nozzles	0.5 in W.G.
Draft loss, air heater outlet to ID fan inlet	2.5 in W.G.

Equipment

1. Number of separate precipitator modules: four.
2. The number of separate electrical sections for each module:
five fields deep and two sections wide.

TABLE 3.7-5 (Cont)

3. Techniques to ensure uniform flow: air distribution model test, outlet balancing dampers, inlet distribution baffles and plates, uniform spacing on collector plates, and anti-sneakage baffles in hoppers.
4. System to remove collected ash: vacuum system to convey ash from collection hoppers via pipeline to storage silo.

TABLE 3.7-6

PRODUCTION RATE OF FLY AND BOTTOM ASH
FROM BIG BEND STATION UNIT 4

<u>Parameter</u>	<u>Rate (lb/hr)*</u>	<u>Annual Rate (tons/yr)*</u>
Fuel rate	413,000	950,000
Total ash	55,755	128,380
Bottom ash	11,151	25,680
Fly ash @ ESP inlet	44,604	102,700
Fly ash collected in ESP	44,474	102,400
Fly ash @ ESP outlet**	130	300

NOTE: Capacity Factor = 52.57%

*Based on coal F-1A: H.H.V., 10,495 Btu/lb; ash content, 13.5%

**Based on outlet particulate loading equivalent to 0.03 lb/MMBtu.

TABLE 3.7-7

EFFICIENCY TEST RESULTS, FGD INSTALLATIONS ON
UTILITY BOILERS

<u>Company</u>	<u>Plant</u>	<u>Location</u>	<u>Generation, MW</u>	<u>Type</u>	<u>Efficiency, %</u>
C&SOGC	Connesville	US	400	Lime	89.2
TVA	Shawnee	US	10	Lime	88.6
KP&L	Lawrence	US	125	Limestone	96.6
LG&E	Cane Run	US	178	Lime	89.8
APSC	Cholla	US	115	Limestone	92.0
SCEC	Mohave	US	170	Limestone	95.0
PEPCO	Bruce Mansfield	US	800	Limestone	85.3
EPD*	Takasago	Japan	500	Limestone	93.0
EPD	Isogo	Japan	530	Limestone	93.0
EPD	Takehara	Japan	256	Limestone	93.0
Mitsui	Miiki	Japan	175	Limestone	90.0

* EPD: Electric Power Development, Japan.

TABLE 3.7-8

FGD SYSTEM SPECIFICATION

PERFORMANCE REQUIREMENTS (at Design Conditions)

Flue gas flow @ FGD inlet	2,100,000 acfm
Flue gas temperature @ FGD inlet	340°F
Moisture @ FGD inlet	8-10%
Oxygen @ FGD inlet	5-8%
SO ₂ @ FGD inlet	31,000 lb/h (3390 ppmv)
Flue gas velocity	9.1 ft/sec
Pressure drop	11.2 L.W.C.
Liquid to gas ratio (GPM/1000 acfm)	77
Quencher loop pH	4.2 - 4.5
Absorber loop pH	6.0 - 6.5

GUARANTEE

- | | |
|---|------------|
| 1. SO ₂ @ FGD outlet (90% removal) | 3100 lb/hr |
|---|------------|

EQUIPMENT

1. Absorber type: Double loop process includes quencher loop and absorber loop. Absorber in spray tower with packing.
2. Number of modules: three for full load operation; one spare.
3. Quencher loop design: constructed of Inconel 625 for corrosion resistance.
4. Absorber loop design: constructed of Alloy 904L for corrosion resistance.
5. Precautions for corrosion, scaling, and plugging: tight water balance control, pH control, alloy construction of towers and piping, adequate mist eliminator wash (fresh make up water), automatic flushing of slurry lines on shutdown.
6. Mist eliminator design: Chevron type, two stages, constructed of polypropylene.
7. Redundant components: spare tower, spare quencher, and absorber pumps, SO₂ analyzers, pH analyzers, hydroclones, vacuum filters, conveyors: all pumps in each service have spare pump, ball mill, reagent feed tank.
8. Reheat: indirect hot-air reheat injected after tower outlets, mixed with saturated gas before entering stack.

TABLE 3.7-8 (Cont)

9. Instrumentation: nuclear density meters, pH cells with ultrasonic cleaning, SO₂ analyzers, complete sampling system for analyzing carbonates, sulfites, sulfates, pH, specify gravity.
10. Maintenance considerations: frequent inspections of spare tower (while down) for any scaling, plugging, etc. Test coupons to be installed for corrosion studies. All major equipment has been fitted with hoists and trolleys for removal of equipment for maintenance. This includes ball mills and motors, pumps, agitators, booster fans, vacuum filters.

TABLE 3.7-9
MATERIAL BALANCE FOR FGD SYSTEM FOR BIG BEND STATION UNIT 4

Parameter	Basis	Hourly Rate (lb/hr)		Annual Rate (ton/year) *	
		3.0 lb/MMBtu Sulfur Coal	6.0 lb/MMBtu Sulfur Coal	3.0 lb/MMBtu Sulfur Coal	6.0 lb/MMBtu Sulfur Coal
Sulfur (before washing)	4,330 MMBtu/hr	12,990	25,980	29,910	59,820
Sulfur (after washing)	25% reduction	9,743	19,486	22,434	44,868
SO ₂ (@ FGD inlet)	5% ash retention	18,512	37,024	42,625	85,250
SO ₂ (@ FGD outlet)	86% removal efficiency	2,592	5,184	5,968	11,937
SO ₂ (removed in FGD)	Remaining SO ₂	15,920	31,840	36,657	73,314
CaSO ₄ • 2H ₂ O	Molecular Weight Ratio	42,785	85,570	98,515	197,030
CaCO ₃ (required)	Molecular Weight Ratio	24,875	49,750	57,276	114,550
Limestone (@ 105% stoich.)	95% CaCO ₃	27,493	54,986	63,304	126,610
FGD sludge (@ filter inlet)	35% solids	126,170	252,340	290,520	581,030
FGD sludge (@ filter outlet)	90% solids	49,070	98,140	112,987	225,970

*Capacity factor: 52.57%

TABLE 3.7-10

EPA TEST PROGRAM FOR NO_x REDUCTION

<u>Test No.</u>	<u>Test Condition*</u>	<u>Emission (lb/MMBtu)</u>		
		<u>Excess Air</u>	<u>NO_x**</u>	<u>CO</u>
1	No modification	22.7	0.58	0.022
2	No modification; WW slagging	26.0	0.68	0.024
3	BF	24.2	0.33	0.019
4	OFA	25.4	0.55	0.016
5	OFA; WW slagging	25.9	0.50	0.016
6	OFA; -5° burner tilt	25.9	0.39	0.016
7	OFA; +19° burner tilt	25.1	0.43	0.023
8	Optimum conditions	27.4	0.39	0.018

*WW = water-wall; BF = biased-firing; OFA = over-fire air.

**As NO₂.

Source: EPA 1975.

TABLE 3.7-11

POLLUTANT EMISSIONS SUMMARY
BIG BEND STATION UNIT 4

<u>Pollutant</u>	<u>Pollutant Emission</u>			<u>Applicable NSPS/SIP Requirement</u>
	<u>lb/hr</u>	<u>lb/MMBtu</u>	<u>%Reduction</u>	
PM	129.9	0.03	99.7	0.03 lb/MMBtu
NOx	2598	0.60	65.0	0.60 lb/MMBtu
SO ₂ *	2592-3455	0.60-0.80	90.0	90% reduction
CO	62	0.014	NA	NA

* SO₂ emission represents range of sulfur content of coals F-2A and F-2B.

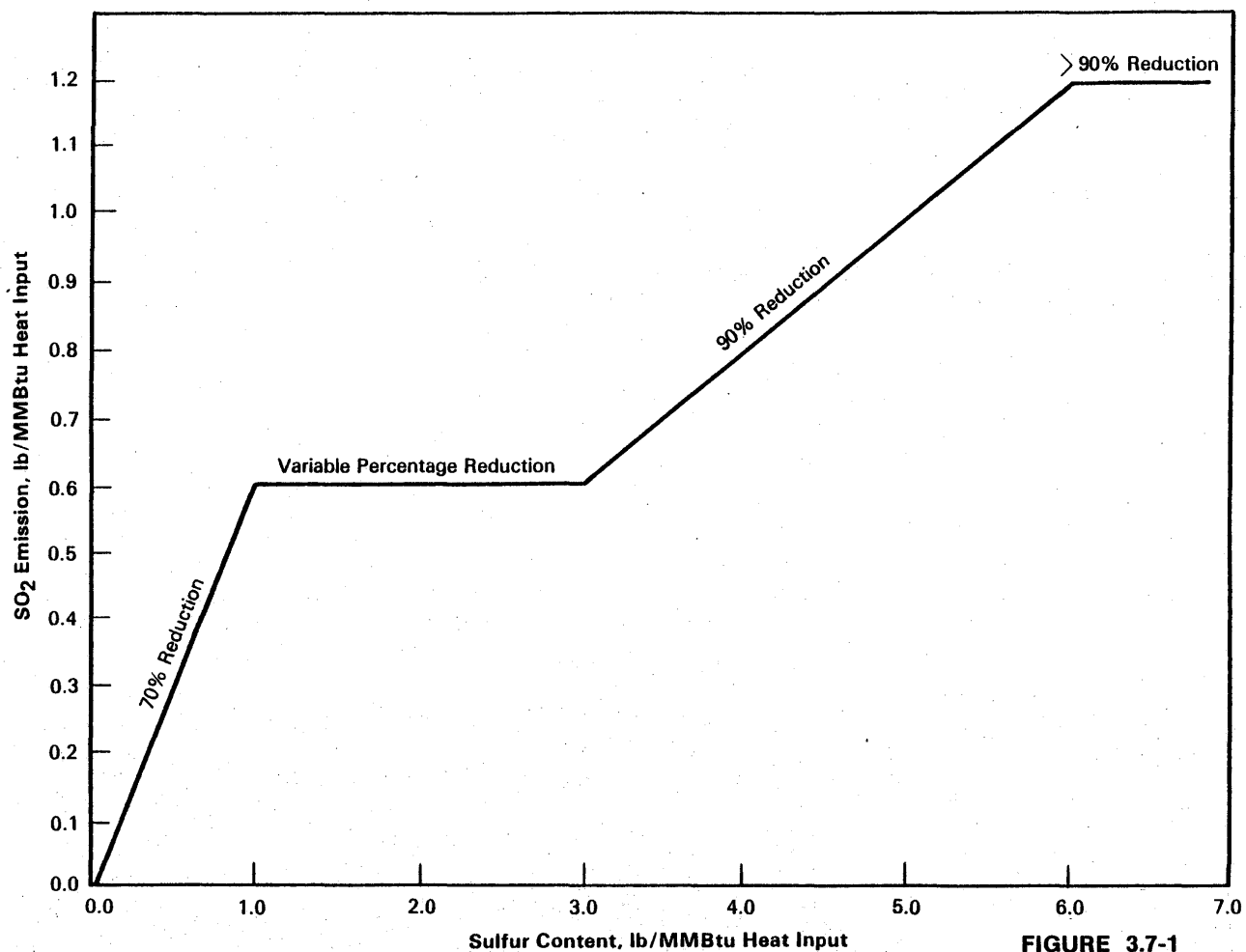
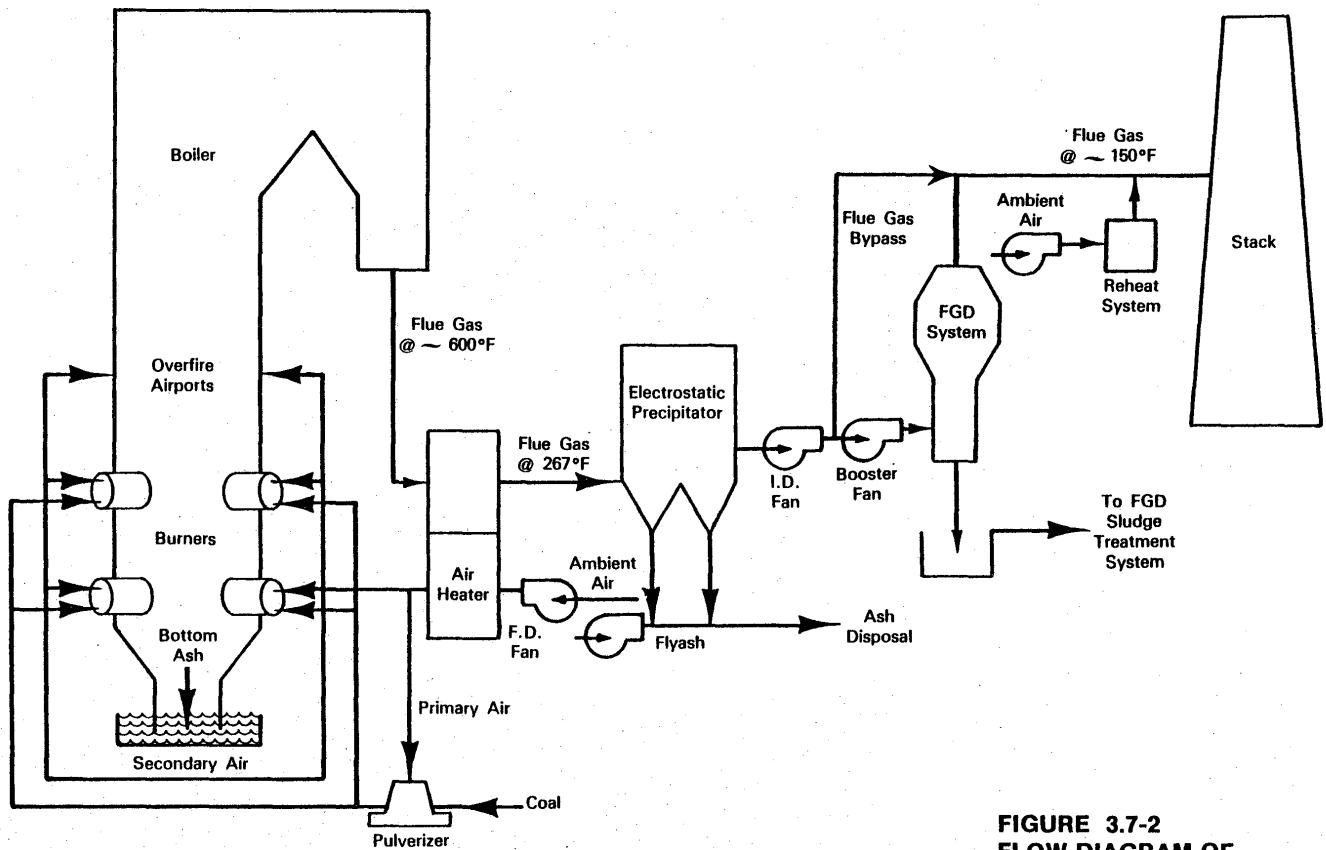


FIGURE 3.7-1
SO₂ STANDARD: NSPS
FOR ELECTRIC UTILITY STEAM
GENERATING UNITS
BIG BEND STATION
TAMPA ELECTRIC COMPANY



**FIGURE 3.7-2
FLOW DIAGRAM OF
COMBUSTION SYSTEM
AND AIR POLLUTION
CONTROL SYSTEM
BIG BEND STATION
TAMPA ELECTRIC COMPANY**



FIGURE 3.7-3
LIMESTONE FGD SYSTEM
BIG BEND STATION
TAMPA ELECTRIC COMPANY

3.8 DIRECTLY ASSOCIATED TRANSMISSION FACILITIES

The transmission line associated with Big Bend Station Unit 4 is a 230-kV line. This line will be the second circuit added to existing towers associated with Unit 3. There is no new right-of-way, and there is no need to change the land over which the line crosses.

3.8.1 Route Size

The proposed 230-kV line associated with Unit 4 is 2,970 feet long. The route is parallel to the existing Unit 3 transmission line. Commencing on the north side of the plant building, the line proceeds in a northeasterly direction over the plant intake channel, then turns easterly over TECO land for nearly 1000 feet. The line then turns approximately 25° south of east, crosses Wyandotte Road, and terminates at the existing Big Bend substation (Figure 3.1-1).

3.8.2 Land Use Impacts

Land areas to be crossed by the transmission line are zoned and are presently used for industrial purposes. The transmission portion of the Unit 4 project consists simply of installing new conductors on existing towers. Consequently, the permanent or temporary clearing of trees and vegetation is not necessary. In addition, changes in topography or the removal of manmade structures are not required. There will be no impact on landmarks or sensitive areas.

The only water to be crossed is the existing plant intake channel. No transmission structures have been, or will be, constructed within the channel. Unit 4 conductors will span the channel alongside existing conductors serving Units 1 through 3.

3.8.3 Beneficial Uses

Although at present there are no beneficial uses planned for the right-of-way, the use of the existing corridor for the Unit 4 transmission line is beneficial in that no new land is required for that purpose.

3.8.4 Visibility

Since the only modification to the existing transmission corridor is the installation of the Unit 4 conductors, the additional visual impact is minimal. The nearest frequently traveled public road is U.S. 41, approximately 0.7 miles east of the terminating substation. The proposed new line is well screened from U.S. 41.

The new conductors will be located well over 2 miles from the nearest recreation area, Apollo Beach. The nearest park is at Bullfrog Creek which is on a direct line 3 miles east of the proposed new line. All other parks are nearly 5 miles from the site. Because the addition to the towers is minor, at some distance from recreation areas, and screened by vegetation, there will be no significant effect on the visual impact.

3.8.5 Associated Transmission Structures

There will be no new transmission structures associated with Unit 4. The existing transmission towers constructed with Unit 3 are designed to support the Unit 4 conductors. These towers are self supporting steel lattice structures ranging from 142 feet to 157 feet in height. Three crossarms support the conductors with an additional static line crossarm at the top of the structure.

The Unit 4 conductors will tie into the existing Big Bend substation at an elevation of 48 feet. No substation expansion will be required.

3.9 ASSOCIATED FACILITIES

3.9.1 Flue Gas Desulfurization (FGD) System Byproduct Storage/Disposal Area

3.9.1.1 Flue Gas Desulfurization Byproduct

The FGD system will utilize the limestone process with forced oxidation which produces high quality gypsum as a byproduct. The production of FGD gypsum has the following advantages over other FGD byproducts:

- o Better settling properties
- o Improved structural properties of waste when disposed
- o Potential for utilization
- o Minimal chemical oxygen demand (COD) of the disposed material.

Gypsum (calcium sulfate) has the property of settling faster than its sulfite form. The blocky and elongated nature of the calcium sulfate crystal is responsible for its good settling and dewatering characteristics.

Moreover, gypsum is more acceptable for dry disposal. As indicated above, its good settling characteristic allows it to stack well. Furthermore, it provides safety against deep shear failure of the subgrade soils. The gypsum byproduct is expected to exhibit low permeability and moisture content, a high compression index (cc), and maximum unit dry density.

Since gypsum is a naturally occurring mineral, it appears acceptable for landfill disposal. Its minimal chemical oxygen demand (COD) alleviates any environmental concern over the deoxygenation of ground or surface water due to the disposal of this byproduct. Furthermore, hydrogen sulfide generation from FGD gypsum disposal is substantially less than that experienced by the disposal of sulfite sludges.⁽¹⁾

FGD gypsum has more potential for product utilization than any other FGD byproduct. This material has been successfully used in the production of wallboard, in cement manufacturing as a set retarder, and in agriculture as soil additive.⁽²⁾

As stated, preliminary indications show that the FGD gypsum can be a marketable product. If indeed the market is established, the gypsum produced by Unit 4 will be sold.

However, the unpredictability of a newly emerging FGD gypsum market and the general uncertainty of the national economy combine to make long-range planning for gypsum storage/disposal difficult. In an effort to deal with the uncertainty, TECO has developed a four-phase storage/disposal plan. The purpose of this plan is twofold:

1. To provide a means of gypsum storage during periods of low demand, thus increasing the reliability of Unit 4
2. To provide a long-range plan for gypsum disposal should the market fail to materialize.

3.9.1.2 The Site

The proposed FGD storage/disposal site is south and southeast of the Big Bend Station. A conceptual layout in Figure 3.9-1 shows the four areas to be utilized as needed. The area, if all is indeed required, totals 97 acres. The areas were chosen in order to preserve Newman Branch Creek and related wetlands. Most of the site is zoned as an industrial area.

During terrestrial surveys in 1974-75 and again in 1977, two sampling stations were located within the proposed FGD site. These stations are identified as Number 9, Pasture, and Number 10, Pasture Pond, in Section 2.7.1.1. A description of the terrestrial ecology of the area is found in Section 2.7.1.

The proposed site was previously used as cultivated land and pasture. A pasture pond was identified in the 1974-75 terrestrial survey. However, at the time of the 1977 study, nearly all of the pond had disappeared due to encroachment of herbaceous species into the pond (i.e., hydric succession).

Soils at this site belong to the Sunniland-Bradenton association. This association is characterized by poorly drained soils with thin sandy layers over loamy subsoil underlain by marly material.⁽³⁾

A geotechnical study of the Big Bend area conducted by Stone & Webster Engineering Corporation verified the above

soil association.⁽⁴⁾ As part of this study, penetration tests were performed at the disposal site.

Physical properties associated with these soil types suggest a bearing capacity approximately 2 tons per square foot. Moreover, the clays are very stiff and have a probable bearing capacity of approximately 2-4 tons per square foot.

Permeabilities were also appraised in the S&W study. These range from 5×10^{-3} to 10^{-5} centimeters per second for the first 15 feet of soils. A discussion of the subsurface soil and rock conditions existing at the site is provided in Section 2.4.5.1.

During the 1973 geotechnical field investigation, four shallow groundwater observation wells were installed within the proposed site. The monitoring wells were installed on an east-west line across the Phase II and Phase III areas with bottom tip elevations of -9 msl. Water levels during the February to May 1973 period were recorded. The data revealed a maximum water table elevation of +5.5 on the eastern boundary and a maximum water table elevation of +4.0 on the western site boundary. These data, taken during nondrought periods, indicate a slight hydraulic gradient toward the west so that fresh groundwater is flowing gently across the site towards Tampa Bay. However, available literature suggests that the water table drops considerably during periods of severe drought.⁽⁴⁾

Groundwater quality at the Big Bend site has been monitored by Tampa Electric Company for the last two years. Three groundwater monitoring wells, located north of the disposal site, are sampled monthly. Samples are analyzed for BOD, TS, TSS, pH, conductivity, turbidity, and vanadium.

Table 3.9-1 summarizes monitoring data from these wells for the years 1977-1978 and compares it to EPA's drinking water standards. TDS and turbidity levels are above those specified for adequate water supply. Furthermore, high conductivity values indicate that groundwater has been contaminated by inflows of saltwater.

Topographic surveys of the proposed site indicate that surface drainage is generally from east to west. The eastern boundary of the site is at an approximate elevation of +10.0, while the western boundary is at an elevation of approximately +6.0. Drainage is aided by ditches in the pasture land areas. The ultimate fate of the surface runoff from the site and the land east of the site is Tampa Bay via Newman Branch and various manmade saltwater finger canals south and southeast of the proposed area.

3.9.1.3 Storage/Disposal Methodology

The staged development plan for the storage/disposal of FGD gypsum disposal will utilize four separate areas and will meet all current federal and state solid waste disposal facilities regulations. A new phase will be developed as needed when the area in service nears its storage capacity. This program provides for long-term disposal if needed, while providing for storage and short-term disposal. If the gypsum cannot be sold, the use of small disposal areas allows for better control of rainfall runoff and housekeeping procedures.

Present plans indicate that after filtration the gypsum will be transported to the proposed site by means of a conveyor system and will be handled by bulldozer. At this stage, the gypsum should contain approximately 20 percent water and is not subject to wind erosion. Thus, the gypsum will not cause a fugitive dust problem during transport.

If permanent disposal is necessary, the material will be landfilled in a heaped fill configuration as shown in Figure 3.9-2. This technique was found to be most adequate in view of the site's geological and topographical characteristics.

Past experiences with this type of landfill have demonstrated that problems arising in the areas of groundwater pollution, slope stability, and site preparation are minimal in comparison with other disposal methods. Fugitive dust problems are not expected since the gypsum, when left undisturbed, forms a protective crust which minimizes wind erosion and dusting tendencies.⁽¹⁾

The one disadvantage of this type of fill is that it tends to be highly visible in contrast to the surrounding flat terrain. In an effort to mitigate the aesthetic impacts, it is proposed that the site be visually screened from areas of public access with vegetation. Vegetative screening has been employed at the Big Bend site with excellent results. In addition, once a disposal phase is completed, topsoil and fertilizer will be applied before revegetation begins. Ground cover species commonly used in the area, such as Paspalum notatum (Bahia grass), and Lespedeza repens (Creeping lespedeza), will be used to complement naturally occurring species.

Runoff generated at the site as a result of precipitation will be collected, treated and routed to the discharge channel by Jackson Branch.

The integrity of Newman Creek and adjacent wetlands will be protected from any potential runoff discharges by the design and placement of dikes around the disposal sites.

As shown on Figure 3.9-1, the disposal phase parcels will be placed so as to minimize disruption of the existing drainage patterns. Most of the disposal site and adjacent areas drain to Newman Branch and adjacent wetlands. Any modification to the existing drainage patterns will continue to direct nongypsum pile runoff to these wetlands. The principal concerns in the design and construction of drainage modifications will be to minimize erosion and to maintain existing water quality.

3.9.2 Parking Lot

Parking space for vehicles during construction will be provided to the east of the discharge channel, north of Big Bend Road. A portion of the existing construction parking will be dedicated to the FGD waste dewatering equipment, thus necessitating the new lot. A total parking area of 8.3 acres will be provided.

The adjacent land is used for industrial purposes. There are no known historical or archaeological sites within the area.

REFERENCES for 3.9

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3. The Florida General Soils Atlas, Florida Department of Administration Division of State Planning Bureau of Comprehensive Planning, 1975.
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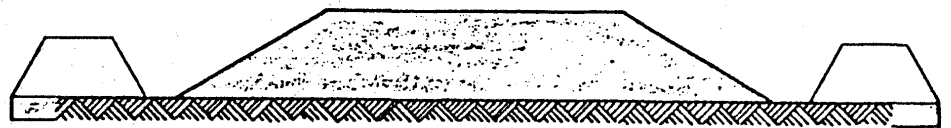
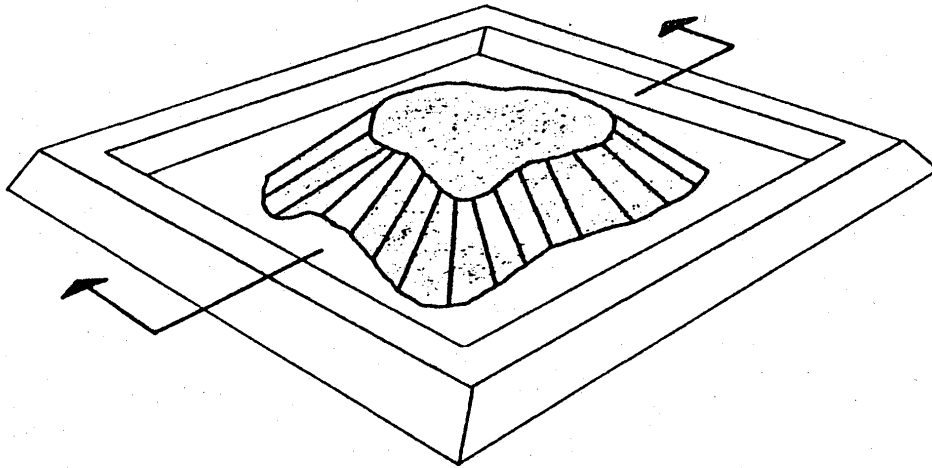
TABLE 3.9-1

BIG BEND GROUNDWATER MONITORING DATA FOR 1977-1978

Parameters	Well A	Well B	Well C	EPA Drinking Standards
BOD, mg/l	1.2	0.7	1.3	-
TSS, mg/l	69.4	85.6	85.1	-
TS, mg/l	2479	6899	21,476	-
*TDS, mg/l	2409.6	6813.4	21,392.9	500
pH	6.3-7.6	6.2-7.6	6.4-7.4	6.5-8.5
Turbidity, JTU	73	165	146	1
Conductivity, umho/cm	2610	6092	18,883	-
Vanadium, mg/l	0.08	0.10	0.15	-
Total Phosphorus, P**	0.39	2.48	5.45	-
Kjeldahl Nitrogen, N**	0.61	0.36	0.0	-
Nitrate Nitrogen, N**	0.74	0.40	1.1	-
Chromium	<0.01	<0.01	<0.01	0.05
Sodium	651	1570	1553	-
Potassium	1.4	2.1	2.0	-
Calcium	352	696	636	-
Magnesium**	133	300	666	-
Chloride**	867	1800	1856	250
Sulfate	530	1065	1315	250
Bromide	2.3	4.9	3.0	-
Fluoride	0.78	0.66	<0.05	1.4
Total Iron	1.00	1.25	1.70	0.3
Copper	<0.03	<0.03	0.03	-
Zinc	0.20	2.40	2.27	5
Manganese	0.0	0.4	1.2	0.05

* Values for TDS were obtained as follows: TDS = TS - TSS

** These values were obtained from sampling performed on 12-9-76



HEAPED FILL CONFIGURATION

FIGURE 3.9-2
BIG BEND STATION
TAMPA ELECTRIC COMPANY

3.10 ONSITE DRAINAGE SYSTEM

Storm water runoff from the existing Big Bend Station is designed to drain into subdivided plant collection areas. The drainage system is designed to perform two basic functions. The first is to convey storm water runoff from active plant areas with minimal ponding. The primary objectives in the design of the conveyance system were to minimize erosion and to maintain applicable water quality standards. The second function of the system is to retain a predicted maximum storm water runoff volume from material storage areas in order to control the discharge of pollutants. The design parameters of the retention system were based on the net runoff predicted for a 24-hour storm having a recurrence transition interval of 10 years.

3.10.1 Yard Drainage System

The plant complex is situated on dredge fill consisting typically of highly permeable sand and shell material. Some isolated areas of grass exist. The main plant road and parking lot are paved, but other roadways are not.

The present yard drainage system consists of several open, grass-lined ditches feeding into concrete catch basins which discharge to the bay. The parking lot drains to catch basins which subsequently discharge to the bay.

3.10.2 Roof Drainage System

The roof of the main plant structure is equipped with drains which convey storm water runoff to the bay. The Unit No. 4 building expansion will include similar provisions for roof drainage. Auxiliary building roofs drain to the ground with the runoff, ultimately entering the yard drainage system.

3.10.3 Material Storage Area Drainage System

Currently, the coal pile runoff system described in Section 3.5.2.5 is utilized to capture and retain runoff predicted for the maximum 10-year, 24-hour storm. The retention pond occupies an area originally intended for coal storage. Additional coal storage volume required by Unit No. 4 must be provided and will require the use of property occupied by the pond. The storm water collection trench system will be modified as described in Section 3.5.2.3 and shown on Figure 3.5-4 to accommodate the changes to the coal field.

The material storage area drainage system currently meets all NPDES requirements and will be maintained and operated to continue meeting permit limitations with the addition of Unit No. 4.

The proposed Unit No. 4 flue gas desulfurization system will require an onsite limestone storage area. The storm water runoff from the area resulting from the 10-year, 24-hour storm will be collected and retained on site, or may be completely eliminated by providing an enclosed limestone storage area.

CHAPTER 4

ENVIRONMENTAL EFFECTS OF SITE PREPARATION, PLANT AND ASSOCIATED TRANSMISSION FACILITIES CONSTRUCTION

4.1 SITE PREPARATION AND PLANT CONSTRUCTION

4.1.1 Construction Areas

4.1.1.1 Site Layout

Big Bend Station is located on filled land and upland on the eastern shore of Hillsborough Bay. The total site occupies approximately 1,187 acres of which 800 acres are in use. Construction activities including erection of permanent structures and facilities will directly affect approximately 41 acres (Figure 3.1-5). When completed, Unit 4 turbine, boiler, precipitator, limestone, storage and handling, and flue gas systems will occupy approximately 7 acres. An additional approximately 7 acres will be designated for the coal reserve and service facilities associated with Unit 4. An additional 121 acres will be used for an ash settling pond system and approximately 97 acres for FGD disposal area. An existing percolation/evaporation (P/E) wastewater pond with a spray irrigation field occupies about 40 acres and will not require enlargement.

4.1.1.2 Schedule

Site preparation activities are scheduled to commence February 1982. All permits and certifications should be received by November 1981. This will allow three months for construction mobilization. Pouring of the first permanent concrete foundation is scheduled to start in April, 1982. The principal activities and scheduled starting dates for Unit 4 are:

<u>Activity</u>	<u>Start Date</u>
Site Preparation	February, 1982
Pile Driving	March, 1982
Foundations	April, 1982
Structural Steel	July, 1982
Boiler Erection	January, 1983
Turbine Generator Erection	March, 1983
Commercial Operation	March, 1985

4.1.2 Land Impact

4.1.2.1 Land Use Activities

Big Bend Unit 4 will be located on a site already occupied by Big Bend Units 1, 2, and 3. Lands immediately adjacent to the site along the southern and eastern site boundaries are fallow or are used for agricultural purposes. Tampa Bay abuts the site to the west and a phosphate mining terminal exists on the northern boundary. The building site for Unit 4 is an area which had been used for construction of Units 1, 2, and 3. It is presently occupied by maintenance buildings for existing units which will either be eliminated or relocated onsite.

4.1.2.2 Transportation

Access roads on the site have been constructed for previous projects at Big Bend Station and are capable of handling the additional traffic caused by Unit 4 construction activities. Most of the vehicular traffic arriving at the site will come from the north via U.S. Highway 41. The estimated additional average daily one-way traffic attributable to construction for the peak year of 1984 is presented below:

<u>Item</u>	<u>No. of Vehicles</u>
Automobiles	
Employees	516
Visitors	12
Trucks	22
Total	550

Florida DOT studies⁽¹⁾ of traffic flow on US 41 conducted near Big Bend Road, indicate that approximately 18,000 cars use US 41 on a given day. The additional construction-related traffic will therefore be negligible. Construction materials will be transported to the site by truck, rail, and barge. The primary means will be individual shipments by truck. A spur from the Seaboard Coast Line Railroad to the site was constructed for previous projects and will be used for construction of Unit 4; and an additional spur will be constructed entirely within the site boundaries and consequently no offsite rail construction will be necessary.

4.1.3 Impact on Human Populations

The nearest residential developments are at Apollo Beach (approx 7,000 ft away), at the intersection of Big Bend Road and U.S. Highway 41 (approx 6,000 ft away), and in the area known as Adamsville (approx 7,200 ft away). Population density in these areas is sparse. Plant construction is not

expected to have an impact on these communities with the exception of intermittent traffic congestion.

Approximately 90 percent of the construction work force will be hired from the Tampa area. It is therefore anticipated that no special provisions for housing, education, or community services will be required. Chapter 7 has a more detailed analysis.

4.1.3.1 Noise

The major sources of construction noise will be the diesel-powered equipment operating on site during the 3-year construction program. Since the sound levels over this period will continually vary with the different phases of construction and with day-to-day changes in construction equipment usage and sound propagation conditions, they are best characterized by the equivalent sound level (L_{EQ}). The L_{EQ} is the level of a constant sound which has the same sound energy as does a time-varying sound over the same time period. As such, the L_{EQ} is representative of the long-term average sound levels expected at offsite locations.

Construction sound levels for Unit 4 were estimated by interpolating from the typical equivalent sound level contours developed by Empire State Electric Energy Research Corp. (ESEERCO). These contours were based on noise measurements taken at 15 power plant sites during the 5 major phases of construction - grading and excavation, concrete pouring, steel erection, siding and machinery installation, and plant startup and site cleanup. The typical L s were found by ESEERCO to vary over a 5 dB range during the primary construction phases, but were significantly lower during the cleanup phase since few pieces of equipment are involved. Thus, to be conservative in estimating the potential impact of construction noise for Big Bend Unit 4, the highest equivalent sound levels, typical of the grading and excavation and steel erection phases, were used. In addition, the fluctuating character of construction noise was found to remain similar during all construction phases, so that a constant relationship can be developed among the equivalent (L_{EQ}), residual (L_{90}), median (L_{50}), intrusive (L_{10}), and peak (L_1) sound levels from construction. The values of these descriptors of the construction noise were estimated for each measurement location from the relationships in the following ESEERCO expression:

$$L_{EQ} = L_1 - 8 = L_{10} - 2 = L_{50} + 3 = L_{90} + 7$$

The predicted equivalent and peak construction sound levels, as well as the measured ambient residual sound levels, are

shown in Table 4.1-1 for each ambient measurement location. The peak sound levels can be considered to be maximum sound levels expected from construction of Unit 4 at any location. Since construction activities will generally occur during the daytime hours, all predicted construction sound levels are below the maximum permissible sound levels in the Hillsborough County noise code of 60 dBA during the daytime in a residential area. In addition, at all locations except location 6, construction sound levels will generally be lower than the existing residual ambient sound levels. At location 6, the nearest residential area to the site, equivalent and peak construction sound levels are approximately 4 dB and 12 dB higher than the residual ambient levels, respectively. However, similar variations in ambient sound levels presently occur due to existing ambient noise sources. Therefore, no significant noise impact is expected at the surrounding residences from onsite construction noise.

4.1.3.2 Air Quality

Construction activities are not expected to affect adversely the ambient air quality surrounding the site.

Water spraying of all dirt roads and tracts used by construction vehicles will minimize the generation of dust. Chemical treatment may also be used for dust control.

Proper maintenance of all construction vehicles and equipment will prevent excessive emissions from affecting air quality.

4.1.4 Work Force

The estimated daily average of construction people to be employed at the site for Unit 4 are:

Average Number of Personnel Daily

<u>Year</u>	<u>Nonmanual</u>	<u>General Labor and Crafts</u>	<u>Total</u>
1982	40	290	330
1983	57	775	832
1984	55	325	380

A peak construction work force of about 980 persons is anticipated for about 2 months during 1984. The peak and daily averages include all employees of the prime contractor and subcontractors working at the site.

Based upon a survey of local union representatives,⁽²⁾ it is anticipated that the majority of the craftsmen will be from Tampa and the surrounding communities, supplemented with people from other areas during peak periods. The percentage of local people to total workers, depending on other construction activities in the area at the same time, is expected to be about 90 percent.

4.1.5 Impact on Landmarks and Sensitive Areas

There are no historic, scenic, cultural, or natural areas or state parks and recreation areas which will be disturbed by the construction of Big Bend Unit No. 4.

4.1.6 Ecological Impacts - Terrestrial

Of the 1187 acres within the property boundary of Big Bend Station (see Figure 3.1-5) approximately 41 acres will be used during construction for craft parking, equipment laydown, construction workshops, temporary storage of excavated material, and erection of the buildings making up and associated with Unit 4. All of this acreage to be used during construction of Unit 4 has been previously disturbed by construction activities associated with Units 1 through 3. Also within this previously disturbed area, a new, permanent railroad spur will be constructed (see Figure 3.1-5).

This area, designated as the Power Station(1) vegetation type, contains primarily herbaceous, low growing vegetation typical of disturbed areas in the early stages of secondary succession (Section 2.7.1.1). These species rapidly become established on disturbed lands and are commonly found within the region. Therefore, clearing of this disturbed area will not represent a lasting adverse ecological impact to this area.

The vertebrate and invertebrate fauna were not sampled in the Power Station(1) vegetation type during the onsite field studies because large portions of it were used for equipment and materials storage, or were periodically mowed. However, clearing and construction activities in the Power Station(1) vegetation type will result in displacement or elimination of all sedentary faunal species (primarily small mammals which may presently inhabit this area). This is not considered an important long-term ecological impact since these species most likely exist in more stable populations in nearby, less disturbed areas. More mobile faunal species such as birds and large mammals, which may occasionally enter this area, will tend to avoid it during the construction period. Since this area does not represent an important habitat for locally occurring faunal species, its use for construction-related activities does not constitute an important loss of wildlife habitat.

The sound levels produced by construction equipment and related activities represent a potential source of impact to wildlife in the vicinity of Big Bend Station. The ambient sound levels and those predicted to occur during construction of Big Bend-Unit 4 are presented and discussed in Section 4.1.3.1 and Table 4.1-1.

The assessment of construction noise impact on wildlife is based largely on the investigation of Fletcher and Busnel (1978). A summary of this state-of-the-art symposium indicates that "there is not overwhelming evidence that noise is not a significant adverse factor in the life of animals. But neither is there clear, definitive data demonstrating that noise is an adverse stimulus or stressor [to animals]."

Responses of vertebrate fauna to construction noise levels may vary from species to species and will depend upon the distance of the organisms from the power plant complex and

other intrusive noise sources. Species nearest the plant may undergo periodic "startle reaction" and move away from the noise source (if possible) when peak construction sound levels occur; however, most species which presently occur nearest the site are expected to have habituated to the existing sound levels resulting from Units 1-3 operation. Many of these organisms (e.g., raccoons, mice, rats, rabbits, and several bird species) coexist with man and are examples of faunal habituation to man's activities and accompanying noise (Fletcher and Busnel, 1978).

Except for organisms inhabiting the FGD byproduct storage area (the effects of this construction are discussed in Section 4.5), fauna occurring in other areas distant from the plant (i.e., at noise measurement locations 4 through 8, Table 4.1-1) should experience little, if any, change over ambient levels during construction. For this reason, no measurable effects of construction noise levels on organisms occurring near or beyond these locations are anticipated.

4.1.7 Mitigative Measures

During construction of Big Bend Unit 4, the following measures will be taken to prevent or minimize the adverse effects of construction activities upon the surrounding environment.

A Construction Impact Control and Monitoring Program (CICMP), which is described in Section 6.3, will be implemented.

The upgrading of a temporary site storm water drainage system and careful construction planning to prevent disturbing areas until necessary, will minimize site erosion. Where traffic patterns and plant layout permit, slopes will also be reseeded to minimize erosion. Natural recolonization by pioneer and early successional forms of native vegetation should supplement reseeding efforts. Where necessary, netting, straw, mulch, or pavement will be employed to stabilize top soil.

When necessary, dust generated by heavy equipment traffic will be controlled by water spraying and possibly chemical treatment. Should dust problems develop from areas cleared during construction, application of dust retardants, or planting temporary vegetation will be undertaken, as necessary.

The use of oils, petroleum hydrocarbons, and greases will be controlled during construction in accordance with applicable

state and federal regulations to prevent these materials from entering surrounding water bodies, the site drainage system, or undisturbed land areas. Typical control measures are the use of nondraining impermeable slabs (where possible) or splash pans for liquid storage containers. Cleanup measures for oil and liquid waste spills will be established.

All construction-generated trash and solid waste will be properly disposed of offsite at an approved disposal site.

Construction personnel shall use either portable chemical toilets or a temporary sanitary system which uses a package wastewater treatment system. Waste from the portable chemical toilets will be disposed of offsite by a licensed contractor at approved locations. The effluent from a package wastewater treatment system will be discharged to the existing wastewater percolation/evaporation pond. These systems will be inspected and maintained regularly to prevent accidental spills or leaks.

4.1.8 Benefits from Construction

Since Big Bend Unit 4 is being constructed on an existing power plant site, Tampa Electric Company will be able to meet their power demand requirements without having to develop a new site area.

Site restoration will begin during the latter stages of construction or upon its completion. In addition to the use of vegetation, certain areas will be surfaced with crushed stone to maintain areas frequently used by maintenance personnel and heavy equipment. Trees, shrubs, and ground cover will also be planted during site restoration. The vegetation will be chosen to satisfy three primary objectives: (1) stabilization of soils, (2) creation of an aesthetically appealing physical plant and surrounding area, and (3) establishment of wildlife habitat and food sources.

The plant species which have been tentatively chosen are selected from those native to the Big Bend site (refer to Table 2.7-1) and those which will ecologically and aesthetically complement naturally occurring species. Whenever practical, trees and shrubs will be transplanted from within TECO's property to areas undergoing site restoration. Table 4.1-2 summarizes the vegetation selected for this conceptual site restoration program.

4.1.9 Impact on Water Bodies and Uses

Construction activities that will occur in the water or affect local water bodies will be conducted primarily in the discharge canal, and will include construction of the Unit 4 discharge structure.

The discharge structure is constructed of steel sheet pile and consists of two diverging walls approximately 50 feet long. When these walls are in place, a clamshell bucket will be used to dredge approximately 700 cubic yards of material from between the walls. A silt barrier will be maintained during the operation. The material will be disposed of in an environmentally acceptable manner. A tremie concrete floor (trapezoidal 12 feet x 50 feet x 36 feet) and a rip-rap apron will protect the channel bottom from erosion by the discharge flow.

Benthic invertebrates removed in the dredge material will be considered lost to the environment. An estimated 2.5×10^6 organisms would be destroyed. Calculation of this number is based on a mean density of 8,400 organisms per square meter sampled to a depth of approximately 10 cm.⁽¹⁾ The present benthic community is dominated by species classified either as opportunistic or characteristic of thermally stressed areas.⁽³⁾ Recolonization was observed at several sampling stations following the severe winter of 1977.⁽⁴⁾ Based on this evidence, it is likely that the area will be recolonized after construction is completed.

Those fish that inhabit the area would tend to avoid areas of activity and are expected to return after construction is completed.

Manatees congregate occasionally in the warm waters of the discharge canal during the winter months. Discharge construction activities will be scheduled during the months of the year which provide minimum interference with the activities of this endangered species.

In the immediate vicinity of Unit 4, groundwater elevations will be lowered during the construction of the circulating water system by the gravity dewatering system necessary for earthwork. Based on previous field dewatering tests and calculations, this system's operation is not expected to present any noticeable effects on private or agricultural wells in the area, either in available quantity or quality of water. (See Figure 4.1-1).

After construction is complete, the dewatering system will no longer be needed and groundwater will rise to its original, natural elevation.

The intake structure for Unit 3 will be extended to provide for Unit 4 circulating water pumps. The extension will require minimal dredging and construction activity in the water will be negligible.

In summary, construction impacts will be localized and temporary and will not result in a noticeable lasting effect on the aquatic community of local water bodies.

REFERENCES for 4.1

1. Personal communication between J. Cranford, Florida DOT, and G.C. Hahn, TECO, April 6, 1979.
2. Personal communication between P.A. Boyer (S&W) and local union representatives, May 1979.
3. Tampa Electric Company, 1977. Appendix to 316 Demonstration, Vol. 1. Final Report of Ecological Surveys of the Big Bend Area. September 1977.
4. Mahadevan, S. and Culter, J.F. Report to Tampa Electric by Conservation Consultants, Inc. A continued study on the Benthic and Fauna of Big Bend, Tampa Bay (Florida) 1978.

TABLE 4.1-1

CONSTRUCTION SOUND LEVELS
BIG BEND UNIT 4
(dBA re 0.0002 Microbars)

<u>Ambient Measurement Location</u>	<u>Daytime Ambient Residual Sound Level*</u>	<u>Equivalent Construction Sound Level (L_e)</u>	<u>Peak Construction Sound Level (L_p)</u>
Location 4 - 7,500 ft NE at Adamsville	46 dBA	38 dBA	46 dBA
Location 5 - 3,800 ft ESE at Big Bend Road	53 dBA	48 dBA	56 dBA
Location 6 - 4,000 ft S at Newman Branch Road	43 dBA	47 dBA	55 dBA
Location 7 - 8,000 ft SSW at Apollo Beach Road	43 dBA	37 dBA	45 dBA
Location 8 - 8,000 ft SW at Apollo Beach Motel	45 dBA	37 dBA	45 dBA

*From Table 2.9-2

TABLE 4.1-2

VEGETATION USED IN CONCEPTUAL SITE RESTORATION
AT BIG BEND STATION

Growth Form	Species
Trees	<u>Myrica cerifera</u> - Wax Myrtle
	<u>Baccharis halimifolia</u> - Groundsel Tree
	<u>Quercus virginiana</u> - Live Oak
	<u>Sabal palmetto</u> - Cabbage Palm
Shrubs	<u>Nerium oleander</u> - Oleander
	<u>Coccoloba livifera</u> - Sea Grape
	<u>Callicarpa americana</u> - Beauty Berry
Ground	<u>Paspalum notatum</u> - Bahia Grass
Cover	<u>Stenotaphrum secundatum</u> - St. Augustine Grass

4.2 SPECIAL FEATURES

4.2.1 Temporary Site Drainage

Since the construction site is situated on dredge fill consisting primarily of sand and shell material, the soil is generally highly permeable. The site area was stripped of vegetation; however, some isolated areas of grass still exist. The main plant road is paved, but other construction roads are not.

The present drainage system consists of several open ditches which feed into concrete catch basins and discharge to the bay. The ditches are grass lined and were designed to accommodate the 10 year, 24-hr storm.

The design philosophy followed for this drainage system is to minimize the pollutants entering the storm water runoff. Areas disturbed during excavation will be stabilized as soon as practical after the excavation work is completed. Areas where oils, greases, and other petroleum hydrocarbons are stored will be constructed so that spillage from these areas will not contaminate the storm water. The system will be checked periodically during construction to assure that it is functioning properly: that is, draining the site adequately, minimizing erosion, and maintaining discharge water quality standards.

4.2.2 Garbage Disposal Services

A licensed contractor will be procured to provide garbage disposal services. Based on discussions with contractors, such as Waste Resources, Incorporated, who collects the garbage from Units 1, 2, and 3, the county landfill facilities will probably be used for disposal of the collected garbage for Unit No. 4.

Based on the construction experience from Units 1, 2, and 3 at Big Bend, this contractor indicates that the Unit 4 construction waste volumes will neither overburden his handling capacity nor his disposal facilities capacity. Should Hillsborough County close the present landfill, these contractors have stated that the county will have to supply other landfill(s). However, no problems are envisioned with the present landfill for disposal of the Unit No. 4 construction waste.

4.3 CONSTRUCTION OF DIRECTLY ASSOCIATED TRANSMISSION FACILITIES

The only construction of transmission lines for Unit 4 will be the installation of an additional 230-kV circuit on an existing power line. There will be no need to alter the land over which the line will cross during installation.

4.3.1 Permanent Changes to Vegetation, Wildlife, and Aquatic Life

Because an existing transmission line corridor will be used, no permanent change to vegetation, wildlife, or aquatic life is expected.

4.3.2 Impact on Sensitive Areas

Because an existing transmission line corridor will be used, which does not presently affect any sensitive areas, no new impacts on sensitive areas will occur.

4.3.3 New Roads

Existing transmission corridor roadways will be utilized.

4.3.4 Erosion

Because an existing, stabilized transmission line corridor will be used, erosion problems are not expected to occur. However, should any problems develop, measures such as using mulch, temporary or permanent vegetation, or erosion control fabrics will be utilized to mitigate erosion.

4.3.5 Impact on Land Use

Because an existing transmission line corridor will be used, no alteration to the existing land use will be made and therefore no impacts will occur.

4.3.6 Mitigative Measures

Section 4.3.4 describes measures that would be taken to stabilize soils should any erosion problems occur. Although fugitive dust is not expected to be a problem, a water truck would be available to spray the transmission line access roads.

Because of the short duration of the transmission line construction, noise is not expected to be a significant problem. Work will not be performed at night. The distribution and use of petroleum hydrocarbons and engine fuels will be controlled to prevent any potential for surface water or groundwater pollution.

4.4 RESOURCES COMMITTED DURING CONSTRUCTION

During construction numerous resources will be utilized. Except for the direct commitment of various construction materials, however, the impacts will be temporary, resulting in no permanent effect. The construction materials consumed will not be exotic or scarce, and their commitment is not considered to be of serious concern. It is concluded that station construction will not result in any significant irreversible or irretrievable commitments of resources other than land in the area of the plant.

4.4.1 Land Use

Unit 4 will require approximately 7 acres of land for all power plant structures. Much of the area which will be temporarily committed to laydown, craft parking, and excavated material storage during construction will be restored during or upon completion of construction activities.

4.4.2 Water Use

Construction activity in the discharge canal will result in some disruption of the aquatic ecosystem and a small increase in turbidity. The impacts will be temporary and highly localized, however, and rapid recovery of affected areas following construction completion is expected based on information collected at the plant (Mahadevan and Culter, 1978).

Sanitary, chemical, and storm water effluents will be controlled within the limits of applicable discharge criteria. Any resulting effects will be temporary and minimal.

4.5 CONSTRUCTION OF OTHER ASSOCIATED FACILITIES

FGD Storage/Disposal Area

The proposed location and disposal methodology for the FGD gypsum (CaSO_4) byproduct have been described in Section 3.9.1.2 and 3.9.1.3, respectively. If developed in its entirety, the four-parcel storage/disposal area will occupy 97 acres, and will consist of approximately 66 acres of pasture land (including less than 1 acre of pond and associated marsh) and 31 acres of agricultural land.

The pasture land, designated as Pasture Type 9 (Section 2.7.1), consists primarily of ruderal or weedy species of herbaceous vegetation and, during ecological surveys conducted in 1977, was no longer being used as a cattle grazing area. By comparison with less disturbed habitats at the Big Bend site, the pasture and pond/marsh area supported a relatively small number of vertebrate species based on the 1974-75 surveys. The species inhabiting the pasture included the hispid cotton rat, marsh rice rat, eastern cottontail, marsh rabbit, and certain field and marsh dwelling birds (see Tables 2.7-34 and 2.7-37). Results of the 1977 survey indicated that most of the Pasture Pond had disappeared and vegetation was more typically old field (i.e., drier) than marshland. There was also an increase in vertebrate species preferring old field habitats and a sharp decrease in the number of marshland species; marsh birds were notably absent from the Pasture Pond area (see Table 2.7-37).

The 31 acres of agricultural land were not sampled during either terrestrial ecological survey; however, their recent agricultural use indicates their relative importance as wildlife habitat.

Development of the proposed FGD storage/disposal area represents a long-term commitment of these pasture and agricultural lands. However, the commitment of these plant communities and wildlife habitats is more ecologically acceptable than that of other available parcels at the Big Bend site because of the following:

1. These habitats have been recently disturbed and are not unique to the Big Bend site or the surrounding area, and
2. They are among the least biologically important wildlife habitats at the site.

Mitigative measures, including revegetation and site runoff control will be implemented to minimize the effects of developing this area (see Section 3.9.1.3) .

The effects of construction noise on wildlife, as related to development of the FGD storage/disposal area, are similar to those described in Unit 4 construction in Section 4.1.5.

5. ENVIRONMENTAL EFFECTS OF PLANT OPERATION

CHAPTER 5

ENVIRONMENTAL EFFECTS OF PLANT OPERATION

5.1 EFFECTS OF OPERATION OF HEAT DISSIPATION SYSTEM - 316 DEMONSTRATION RESULTS

An assessment of the effects of the heated circulating water system during operation of Unit No. 4 has been developed as part of a demonstration document, provided for under Section 316(a) and (b) of the Federal Water Pollution Control Act (as amended). The document entitled "Big Bend Station - Unit 4: 316 Demonstration," accompanies the SCA in Amendment 1 as an Appendix.

Water quality standards applicable to the Big Bend Site are provided in Chapter 17-3 "Water Quality Standards". Section 17-3.05, "Thermal Surface Water Criteria," specifically details the thermal limits applicable to Big Bend. These are summarized below:

Coastal Waters - Heated water with a temperature at the POD more than 2°F higher than the ambient (natural) temperature of the RBW shall not be discharged into coastal waters in any zone during the months of June, July, August, and September. During the remainder of the year, heated water with a temperature at the POD more than 4°F higher than the ambient (natural) temperature of the RBW shall not be discharged into coastal waters in any zone. In addition, during June, July, August, and September, no heated water with a temperature above 92°F shall be discharged into coastal waters. Further, no heated water with a temperature above 90°F shall be discharged into coastal waters during the period October thru May.

Upon application on a case by case basis, the Department may establish a zone of mixing beyond the POD to afford a reasonable opportunity for dilution and mixture of heated water discharges with the RBW, in the following manner:

Zones of mixing for thermal discharges from nonrecirculated cooling water systems and process water systems of new sources shall be allowed if supported by a demonstration, as provided in Section 316(a), Public Law 92-500 and regulations promulgated thereunder, including 40 C.F.R. Part 122, by an applicant that the proposed mixing zone will assure the protection and propagation of a

balanced, indigenous population of shellfish, fish, and wildlife in and on the body of water into which the discharge is to be made and such demonstration has not been rebutted. It is the intent of the Commission that to the extent practicable, proceedings under this provision should be conducted jointly with proceedings before the federal government under Section 316(a), Public Law 92-500.

Zones of mixing for blowdown discharges from recirculated cooling water systems, and for discharge from non-recirculated cooling water systems of existing sources, shall be established on the basis of the physical and biological characteristics of the RBW.

When a zone of mixing is established pursuant to this Subsection 17-3.05(1)(f), F.A.C., any otherwise applicable temperature limitations contained in Section 17-3.05(1), F.A.C., shall be met at its boundary; however, the Department may also establish maximum numerical temperature limits to be measured at the POD and to be used in lieu of the general temperature limits in Section 17-3.05(1), F.A.C., to determine compliance by the discharge with the established mixing zone and the temperature limits in Section 17-3.05(1), F.A.C.

The biological effects of the thermal discharge and the circulating water intake structure of the plant are discussed in the amendment. Studies designed to complement the 316 study, such as the Fine Mesh Screen Study and the 1979 Aquatic Ecology Study, are included in the appendices of the document. As part of the 316 Demonstration effort, the need for a thermal mixing zone has been established. Section 5.9 "Variances" discusses the thermal mixing zone.

Prior to conducting the studies, the applicant organized the "Biological Review Committee" (BRC), a volunteer group of regulatory agency representatives who reviewed scopes of work for the above studies and monitored study progress. Their involvement was solicited as reviewers of the studies, in particular, to provide guidance in the design of the studies and to suggest modifications to the study work plans. The U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, Florida Department of Environmental Regulations, and the Southwest Florida Water Management District, among others, are represented on the BRC.

5.9 VARIANCES AND ALLOWANCES

The only variance to federal, state, or local ordinances applied for is provided for under Section 316 of the Federal Water Pollution Control Act (PL92-500), and requires a demonstration which shows that the selected cooling system is environmentally compatible. The cooling system is described in Section 3.4. Results of 316 Demonstration studies are an appendix to this application. Chapter 17-3 of the Florida Administrative Code includes rules which govern "Future and Existing" dischargers of heated water into receiving bodies of water. Big Bend Unit No. 4 is a future heated discharger for which there are specific numerical limits on effluent temperatures. However, for future heated discharges, the Florida Department of Environmental Regulation (FDER) may allow for a mixing zone beyond the point of discharge for dilution and mixture of the heated effluent with the receiving body of water. A mixing zone shall be allowed for once-through cooling systems, if supported by a 316 Demonstration.

It is TECO's desire, based upon its 316 Demonstration, that it be granted an operation permit by FDER and that a mixing zone enclosed by the 1°C isotherm, as shown on Figure 6.2.4-1 in the 316 Demonstration, be allowed and included in the conditions of the operating permit at 100% load. The area swept by this isotherm is 2023 hectares, as shown on Table 6.2.4-2 of the 316 Demonstration.

Although only the cooling system variance is sought at the present time, TECO reserves the right to request other variances, if the facts indicated such variances should be granted.

6.2 PROPOSED GENERATING CAPACITY - UNIT 4

The proposed Big Bend Station Unit 4 is scheduled for commercial operation in March 1985. It will be constructed adjacent to Unit 3, which began commercial operation on May 1, 1976. This new, coal-fired steam electric generating unit will have a net capacity of 417 MW. The following table shows the average capacity factor of Units 1-4 of Big Bend Station beginning in 1985:

<u>Year</u>	<u>Capacity Factor (percent)</u>
1985-1989	64
1990-1994	63
1995-1999	63
2000-2004	50
2005-2009	40
2010-2014	33

It is proposed that Unit 4 also have a once-through cooling system. Unit 4 will have a condenser, independent of Units 1, 2, and 3, which will be cooled by water withdrawn from Hillsborough Bay via the existing intake channel. Figure 6.2-1 illustrates the cooling water system of the existing three units and that proposed for Unit 4.

After passing through the Unit 4 condenser, the water will exit to the existing discharge channel and combine with water discharged from Units 1, 2, and 3. The mixture will flow westerly, returning to Hillsborough Bay.

6.2.1 Intake System

Unit 4 will draw approximately 537 cfs of circulating water from the existing, 25-feet (7.6 m) deep intake channel. Unit 4 will be provided with a screenwell structure equipped with two 268.5 cfs capacity circulating water pumps, each with its own traveling water screen. The structure will be similar to those used for the existing units, shown on Figure 6.1-3. The cooling water will be drawn through the traveling water screens and pumped through two 72-inch (1.8 m) diameter pipes to the Unit 4 condenser. The average water velocity immediately in front of the screenwell at the traveling screens will be about 1.45 fps. The combined circulating water flow rate for the four units will total 2,148 cfs. Flows in the intake channel for the units, and their respective velocities, are as follows:

	<u>Unit 1</u>	<u>Unit 2</u>	<u>Unit 3</u>	<u>Unit 4</u>
Intake Channel				
Flow rates, cfs	537	537	537	537
Cumulative flow, cfs	537	1,074	1,611	2,148
Velocity, fps	0.14	0.28	0.42	0.56

6.2.2 Discharge Structure

Pipes from the condenser will connect to a 9-foot (2.7 m) diameter pipe leading the water to the discharge structure. The Unit 4 discharge structure will resemble those for Units 1, 2, and 3, shown on Figure 6.1-4. The warm circulating water from Unit 4 will also exit to the discharge channel. The structure, designed to reduce the velocity of the discharged water, will control erosion of the far bank of the dredged discharge channel. Flow from the Unit 4 discharge structure will combine with the discharge water from the three existing units, and move westerly through the channel to the point of discharge to Tampa Bay.

6.2.3 Biocide Additions

As described in Section 6.1.3, Big Bend is equipped with one chlorinator to which Unit 4 will be connected. Liquid chlorine will be fed to the Unit 4 cooling water at a similar rate and in the same manner that it is being fed to the existing units.

The chlorine for Unit 4 will be injected for 20 minutes three times a day. Only one unit at a time will be chlorinated. The feed rate is expected to range from 5,000 to 8,000 lb/day (2,268 to 3,629 kg/day) with an average feed rate of 6,000 lb/day (2,722 kg/day).

6.2.4 Plume Characteristics

Hydrothermal modeling was performed to determine the effects of the thermal discharge on the temperature of Tampa Bay. The two types of models discussed in Section 6.1.4 were used to perform this task. Detailed descriptions of these models are presented in Appendix 5.

The final results of the hydrothermal modeling were obtained by adding the far-field residual heat to the near-field results for the area near the plant where the near-field model was applicable. For areas farther from the plant, where the near-field model was not applicable, the far-field results were used.

Results of the hydrothermal modeling are shown on Figures 6.2-2 and 6.2-3 and presented in Tables 6.2-1 to 6.2-3. Figures 6.2-2 and 6.2-3 show the surface plume at 100 percent and 64 percent load, respectively. Table 6.2-1 presents associated surface areas enclosed by various ΔT isotherms. Table 6.2-2 presents

areas that the surface plume will sweep over a complete tidal cycle. Table 6.2-3 gives the distance from the point of discharge to the point of bottom detachment of the thermal plume. This table also gives the area of bottom contact of the thermal plume.

6.2.5 Intake Design Alternative - Fine-Mesh Screening

As a result of Environmental Protection Agency (EPA) concern regarding the number of organisms entrained at Big Bend Station - Units 1 through 3, the Applicant initiated a multiphase evaluation of alternative intake technologies to identify potential design alternatives for the Unit 4 intake structure.

The evaluation consisted of several tasks, including:

1. Reviewing available intake technologies that might be applied to Big Bend Station to minimize entrainment losses.
2. Selecting organism protection systems that show promise for biological effectiveness and engineering reliability, and conducting a more detailed site-specific evaluation of these systems.
3. Initiating preliminary studies to evaluate the feasibility of the selected system.
4. Conducting studies to prove the effectiveness and reliability of the alternative system.

Results of the first three tasks indicate that a fine-mesh screening system (specifically a modified, dual-flow traveling screen) could reduce the loss of entrained organisms at Big Bend Station (Appendix 3). Consequently, more detailed studies to evaluate the fine-mesh screen concept further were commenced in early 1980.

To ensure comparability of the data to be obtained from this detailed investigation, the test facility would incorporate a full-scale prototype traveling screen identical in every way, except for width, to a screen which could be incorporated into an actual fine-mesh screening installation for Unit 4. Design of the 1980 prototype studies and analysis of the Spring 1980 data are presented in Appendix 4.

The test results show that a fine-mesh screen system could reduce the entrainment losses at Big Bend by returning viable meroplankton organisms to the Bay system. As a basis for ecological and engineering evaluations of the potential effectiveness of a fine-mesh screen at Big Bend Station, a conceptual design for such a system was developed.

The preliminary conceptual design was developed on the basis of applying fine-mesh screens to existing Unit 3 and proposed Unit 4. Sheet piling would enclose the pump screenwell area, creating a forebay between the fine-mesh screens and the pumps. A layout of the new screening structure is shown on Figure 6.2-4.

Each of the six (three for each unit) dual-flow fine-mesh screens would be fitted in the sheetpile wall and the intake flow would pass through the screens and discharge into the forebay. The discharge opening would be sized to achieve a uniform flow distribution through the two parallel screen faces. To ensure proper hydraulic conditions at the four circulating water pumps and a relatively uniform flow through each of the six screens, the forebay would extend from the seawall about 60 feet (18.3 m) into the intake channel. The pumps would also be positioned to aid proper flow distribution so that each set of two circulating pumps would draw from three screens.

Stop gates would close the discharge opening in the event that a screen must be stopped or removed for maintenance. In case of emergency conditions roller gates would be installed in the sheetpile wall between screens and would be opened to supply water to the pumps if the pressure head differential across the screens exceeds 1.5 feet (0.46 m). To screen the flow and protect the pumps and condenser under this emergency operating mode, the existing coarse-mesh (3/8 inch (9.5mm)) screens would be maintained on Unit 3 and new similar coarse-mesh screens would be installed on Unit 4.

The dual-flow screen design with 3/8-inch (9.5mm) mesh has been used successfully at Big Bend Units 1 through 3 for many years and, based on testing to date, has the necessary features for protecting small organisms when using fine screens. The number and size of the screens have been preliminarily determined on the basis of achieving a screen face velocity (approach velocity) of 0.5 fps at water level El 0.0 mlw. This velocity criterion could be changed to a higher value (up to 1.0 fps), should ongoing studies show no significant difference between the velocities being evaluated. Such a change would result in substantial capital and operating cost savings. Based on the 0.5 fps velocity criterion, six 10-foot (3.05 m) wide screens would be required. Each screen would be submerged to El -21.5 feet. Each of the 53 screen baskets would be equipped with easily replaceable 0.5 mm mesh panels and fish collection buckets. The fine-mesh requires continuous screen operation to prevent clogging and to limit the time that organisms are impinged. Since continuous operation results in greater wear of the mechanical components than does intermittent operation, as on the existing screens, more reliability would be achieved through the use of heavy duty rollers, bushings, bearings, sleeves, chains, and motors. To reduce maintenance requirements further, 9.5-mm

mesh screen panels would be provided for periods of the year when entrainment of meroplankton is not of concern.

Each fine-mesh screen would be capable of operating continuously at speeds of up to 28 fpm. On automatic control, the screen would run continuously at 7 fpm, if ongoing studies continue to indicate that this speed is adequate to protect impinged organisms. As the head differential across the screen reaches 4 inches (10 cm), and then 6 inches (15 cm), the speed would automatically increase to 14 and 28 fpm, respectively. Should studies indicate the need for different speeds than these, the controls could be modified to achieve any speed between 0 and 28 fpm.

Each screen would be equipped with a low-pressure (approximately 5-10 psi) organism spray wash header on the ascending side and a high-pressure (40 to 60 psi) spray wash header for debris removal on the descending side of the screen. Separate pumps would supply water to each header and would take suction from the fine-screened water downstream of the circulating water pumps. These nozzles would have 1/2 inch (12.7 mm) diameter orifices and would be evenly spaced at 1-foot (0.3 m) intervals over the 10-foot (3.05 m) header length to ensure uniform spray pattern across the screen baskets.

Although the low- and high-pressure sprays would wash organisms and debris into separate troughs, all troughs would manifold into a common sluiceway that would carry organisms and debris to a release point north of the intake channel (Figure 6.2-4). This design will maximize the opportunity for survival of any organisms not removed by the low-pressure spray, but subsequently removed by the debris spray.

The organism return trough would be sized to achieve a transport velocity in the range of 2 to 3 fps at a water depth of from 6 to 12 inches (15 to 30 cm). The trough would run west along the south side of the intake channel to a footbridge from which it would be supported as it traverses the channel. From this point, the trough would take one of two possible routes. In one, the trough would travel west, north, and east to a channel where it would discharge. In the other, the trough would travel north and east, discharging in the same channel. While the first route would be longer, it would avoid road crossings, which require buried pipe sections, and thus may be more suitable from a biological and engineering standpoint. Total length of the return flume would approximately range from 1,500 to 4,700 feet (457 to 1,433 m), depending on the exact routing and location of discharge in the channel.

To alleviate fouling problems in the trough, it would be divided with each half being 18-inches (0.46 m) wide by 18-inches (0.46 m) deep. With this arrangement, the flow could be

frequently diverted from one side to the other and the unused side would be drained and dried. The trough would be covered with solid removable plates to eliminate sunlight, and it could be insulated, if necessary, to minimize temperature rise as the water travels from the screen to the discharge point.

The proposed design involves expanding the Unit 3 operating deck from which the dual-flow fine-mesh screens would hang. The design is similar to the existing screen structure installed at Big Bend, except for the overall dimensions and number of screens.

As with the existing structure, the expanded operating deck would be supported on piles at El +9 feet. The channel bottom would be maintained in the screen structure area at the existing depth of El -24.5 feet.

Initially, a chain link fence similar to that currently used at Units 1 through 3 to exclude large floating debris would be incorporated into the new screen structure and would extend to El -5 feet. If, in the future, the fence is found to be inadequate to protect the fine-mesh screening medium, provisions would be incorporated to allow for installation of stationary bar racks to replace the fence. Such racks would be located approximately 14 feet (4.27 m) upstream of the fine-mesh screens. The rack structure would be inclined at a 5:1 slope and would have bar spacings of 1.5 inches (3.8 cm). A common, moveable rake would raise all debris collected on the bar racks to the operating deck and into a rail-mounted hopper. In the event that trash racks are added, provisions will be made for lateral fish passageways at the end of the structure.

Construction would be performed "in the wet" and would consist of excavation, driving necessary piles and sheeting and fabricating the operating deck. The traveling screen assembly troughs and pumps would then be installed. It may be necessary to shut down Unit 3 during pile driving or equipment installation.

As a part of the conceptual design evaluation, cost estimates were developed for installing fine-mesh screens at Big Bend Units 3 and 4. In addition, costs were developed for a duplicate system which could be installed on Units 1 and 2 if further reduction in entrainment were required. These costs are compared to the differential cost (above the costs of a conventional once-through system) for a closed-cycle cooling system. Table 6.2-4 provides a summary of this cost analysis.

The closed-cycle cooling system which will be used for comparison is a mechanical draft cooling tower. An engineering study on closed-cycle heat rejection systems for Big Bend Unit 4 was performed. The study results indicate that a mechanical draft tower would be the preferred closed-cycle system. This tower

would be of concrete construction and would utilize saltwater as the cooling medium. Tower costs are based upon a design which will achieve a maximum drift rate of 0.002 percent of the circulating water flow. Site and foundation preparations costs are included as separate items. Energy requirements and derating penalties were calculated and are included in the estimated costs. The tower requires 4.5 MW of auxiliary power year round and creates a generation loss due to increased turbine pressure of 2.2 MW on both a summer peak and annual average basis.

Table 6.2-4 presents cost differentials above the cost of a conventional once-through cooling system. The additional cost required to add a fine-mesh screen system to Units 3 and 4 is \$10,215,000. The costs to retrofit a fine-mesh screen system to Units 1 and 2 would be approximately \$7,985,000. The cost of the two systems is approximately the same; however, the cost of the shared return system is included in the Units 3 and 4 estimate. The additional cost of providing a mechanical draft tower is \$51,802,000.

TABLE 6.2-1

SURFACE AREA ENCLOSED BY ΔT ISOTHERMS
4 UNITS WITHOUT DILUTION PUMPS

<u>ΔT (°C)</u>	<u>Area (Hectares)</u>	
	<u>100% Load</u>	<u>64% Load</u>
1	1,449	1,166
2	720	559
3	457	324
4	291	154
5	150	77
6	77	43
7	43	24
8	25	15
9	15	10
10	9	-

TABLE 6.2-2

SURFACE AREA SWEEPED OVER TIDAL CYCLE BY ΔT ISOTHERMS
4 UNITS WITHOUT DILUTION PUMPS

<u>ΔT (°C)</u>	<u>Area (Hectares)</u>	
	<u>100% Load</u>	<u>64% Load</u>
1	2,015	1,610
2	983	882
3	607	526
4	389	283
5	231	134
6	130	69
7	71	37
8	43	34
9	20	10
10	10	-

TABLE 6.2-3

BOTTOM CONTACT DATA FOR THERMAL PLUME
4 UNITS WITHOUT DILUTION PUMPS

<u>Station Load (Percent)</u>	<u>ΔT (°C)</u>	<u>Distance to Isotherm (m)</u>	<u>Area Enclosed by Isotherm (Hectares)</u>
100	10.1 (Bottom Detachment)	392	8
64	9.7 (Bottom Detachment)	331	6

TABLE 6.2-4

COST COMPARISON(*) FOR FINE-MESH SCREENS
VERSUS CLOSED-CYCLE COOLING SYSTEM
(MECHANICAL DRAFT TOWER)

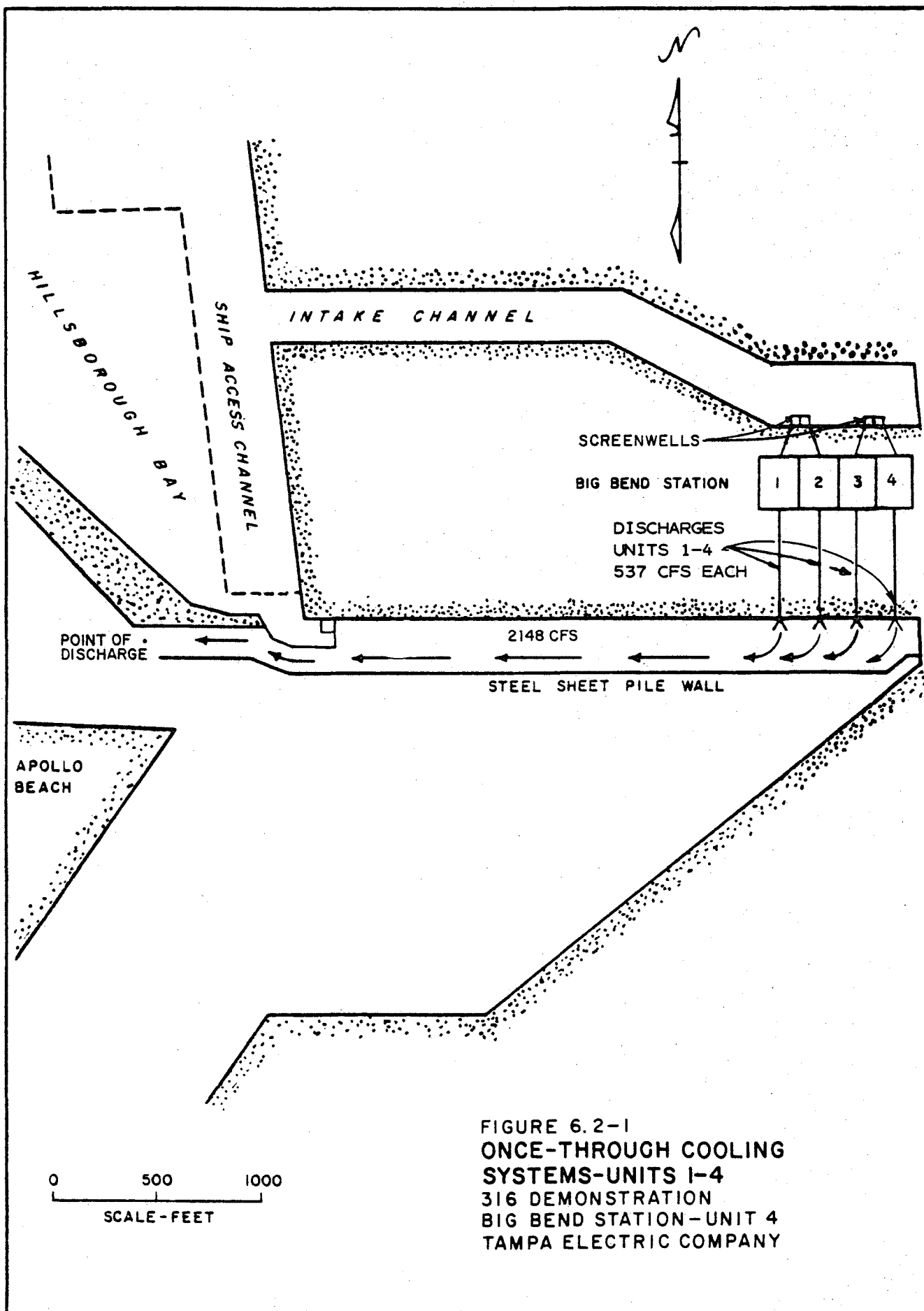
<u>Description</u>	<u>Units 3 & 4</u>	<u>Units 1 & 2</u>	<u>Cooling Tower</u>
Structural	-	-	6,042
Cooling Tower & Basin	-	-	6,481
Other Structural	-	-	12,523
Total Structural	2,080	1,670	
Electrical	100	100	1,150
Mechanical	2,550	1,760	753
Instrumentation	Incl. in Mech.	Incl. in Mech.	208
Building Services	Incl. in Mech.	Incl. in Mech.	14
Environmental	<u>Incl. in Mech.</u>	<u>Incl. in Mech.</u>	<u>32</u>
Total Direct Cost	4,730	3,530	14,680
Distributables	420	300	2,165
Indirects	410	310	600
AFI (10%)	<u>560</u>	<u>410</u>	<u>1,755</u>
Total Present Day	6,120	4,550	19,200
Escalation	1,263	939	8,000
TECO Local Charges	333	247	1,224
Administrative & General Expense	70	52	257
IDC	<u>904</u>	<u>672</u>	<u>2,692</u>
Total Capital Cost	8,690	6,460	31,373

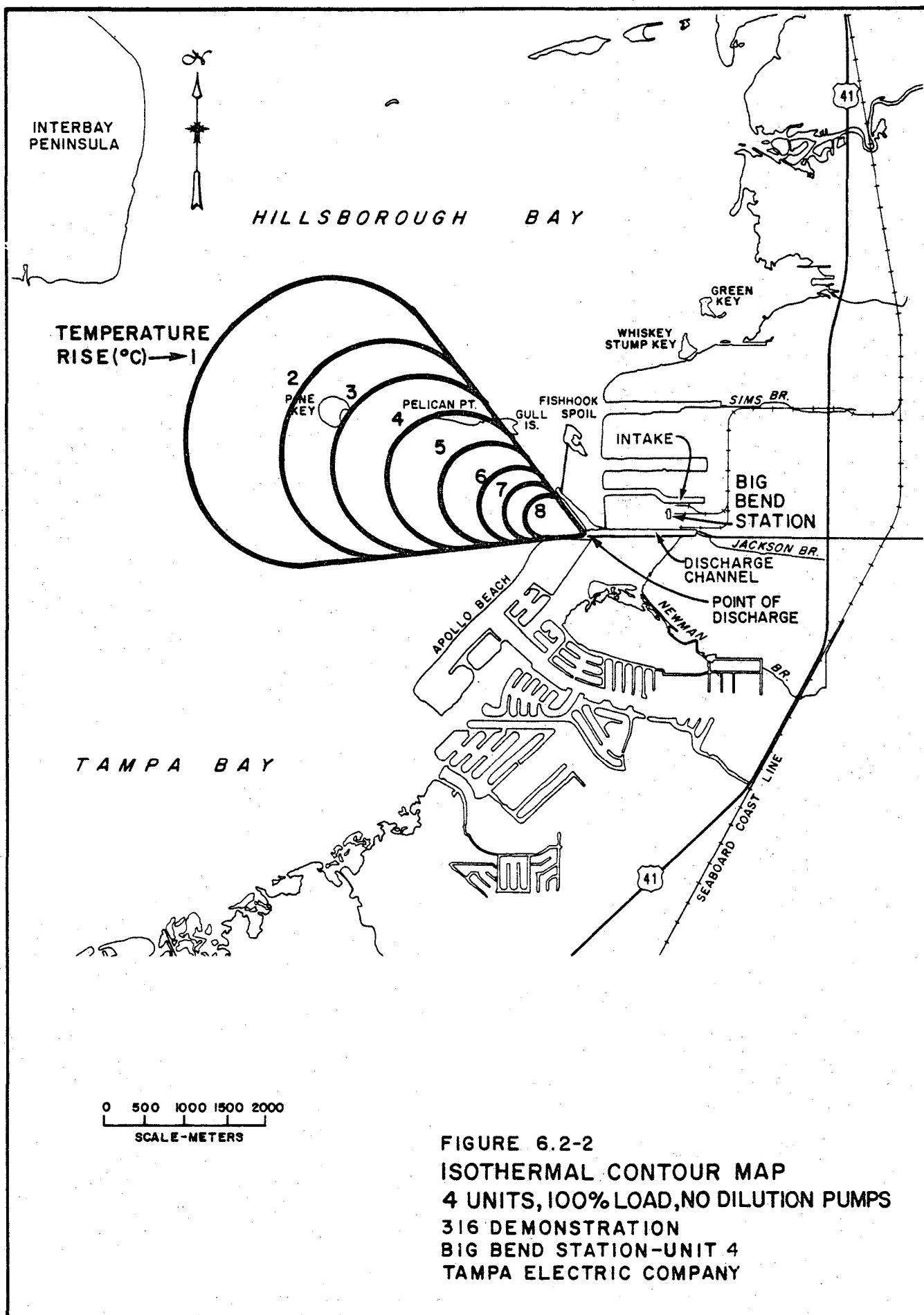
TABLE 6.2-4 (Cont)

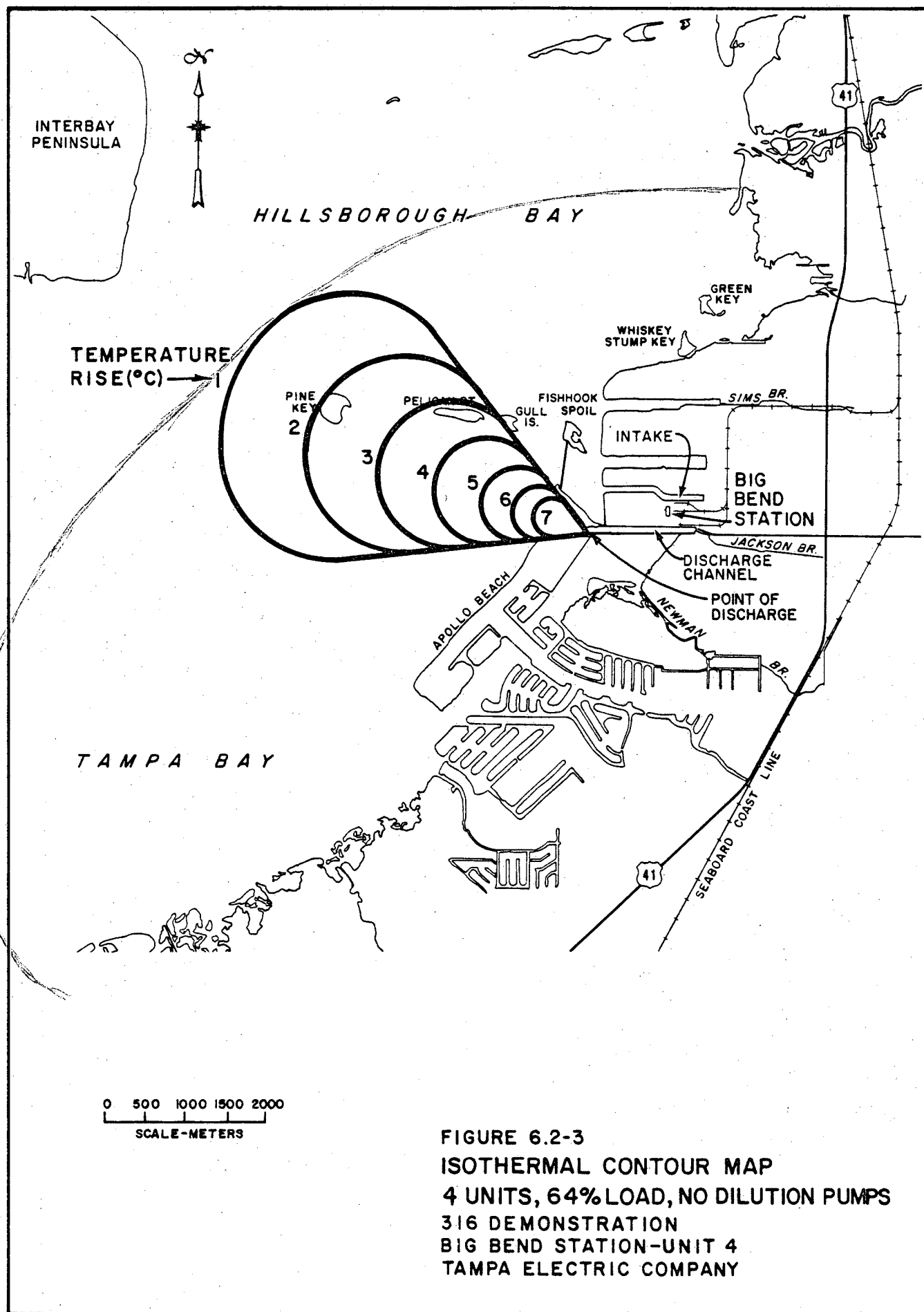
<u>Description</u>	<u>Units 3 & 4</u>	<u>Units 1 & 2</u>	<u>Cooling Tower</u>
OPERATING COST PENALTIES			
Circulating Water Pump - Additional Head Required	106	106	-
Auxiliary Power for System	414	414	12,932
Generating Loss Due to Turbine Back Pressure Annual Average	-	-	<u>6,324</u>
Totals	520	520	19,256
OPERATION AND MAINTENANCE COSTS			
Screens	30	30	-
Screenwash Pumps	7.5	7.5	-
Organism Return	<u>24</u>	<u>24</u>	-
Total	61.5	61.5	-
Escalation	<u>105.5</u>	<u>105.5</u>	-
Total Cost	167	167	195
Total Evaluated Cost (<u>Total Cost</u>) (Fixed Chg Rate)	1,005	1,005	1,173
TOTAL COSTS			
Capital	8,690	6,460	31,373
Revenue Requirements			
Operating Cost Penalties	520	520	19,256
Operation and Maintenance	<u>1,005</u>	<u>1,005</u>	<u>1,173</u>
Total Evaluated Cost	10,215	7,985	51,802

NOTE:

* Figures are in thousands of dollars.







5.2 EFFECTS OF CHEMICAL AND BIOCIDES DISCHARGES

5.2.1 Surface Water Discharges

The major surface water discharges will be as follows:

1. Circulating Water Biocides (Chlorine)
2. FGD System Chloride Bleed Stream
3. Bottom Ash System Blowdown
4. Boiler Blowdown

These discharges will be discussed and analyzed in the following sections.

5.2.1.1 Circulating Water Biocides

In order to minimize condenser biofouling, chlorine will be added to the circulating water flow. Big Bend Station presently has a 10,000 lb/day chlorinator which services the three existing units, one unit at a time, in accordance with NPDES permit requirements. This system will be adapted to service Unit 4. The average feed rates for Units 1-3 have varied from 5000 lb/day to 8000 lb/day with an average of about 6000 lb/day⁽¹⁾. Liquid chlorine is evaporated and fed by water injection to the screen well in the suction area of the circulating water pumps. Chlorine is not fed to a unit unless both pumps are in operation. The normal chlorination cycle is twenty minutes of feed, three times a day for each unit.

During chlorination, chlorine concentration is measured at the outfall of the existing units and will also be measured at the outfall of Unit 4.

The applicant has performed a chlorine minimization study in partial fulfillment of the requirements of its NPDES permit. As part of that report, historical chlorine readings for both free available chlorine (FAC) and total residual chlorine (TRC) for Units 1-3 were compiled and are shown on Tables 5.2-1, 5.2-2, and 5.2-3. Table 5.2-4 shows calculated dilution and decay factors for chlorine discharged from Unit 4. As can be seen from the table, a twenty-fold reduction has taken effect at 825 ft from the discharge structure. The distance from the Unit 4 discharge to the end of the sheet pile of the discharge channel is

approximately 4000 ft. The applicant does not expect any adverse impact from the chlorine discharge.

5.2.1.2 FGD Chloride Bleed Stream

In order to prevent a buildup of chlorides within the FGD system, the system will have a continuous average blowdown of 50 gpm. This blowdown will be neutralized and clarified prior to entering the discharge channel. This waste is categorized as a low-volume waste by the EPA and is subject to the following state and federal discharge requirements:

<u>Effluent Characteristic</u>	<u>Maximum One Day</u>	<u>Maximum 30 Day Daily Average</u>
Total Suspended Solids	100 mg/l	30 mg/l
Oil and Grease	20 mg/l	15 mg/l
pH	6-9	6-9

Since the precipitator will remove 99.97 percent of all flyash from the gas entering the FGD system, flyash contamination of the bleed stream is not expected to occur. Table 5.2-5 lists two typical water quality analyses for the makeup water to the FGD system.

Since several process variables, such as the coal to be burned and the FGD system operation using Big Bend 4 limestone, cannot be finalized until after the unit is in operation, an exact water quality of the discharge cannot be provided. However, a typical bleed stream water quality would be as follows:

TSS	1,000 ppm
TDS	113,500 ppm
Na	2,200 ppm
Mg	23,000 ppm
Ca	600 ppm
SO ₃	5,800 ppm
SO ₄	55,700 ppm
Cl	26,200 ppm
pH	6-8

After neutralization, the pH would be in the 6.5-7.0 range. After clarification, the TSS would be reduced below 30 mg/l; depending upon the coagulant added, the TDS would also be significantly reduced. The substances shown above are found in seawater, and at the low discharge rate of 50 gpm, are not expected to create a significant environmental impact.

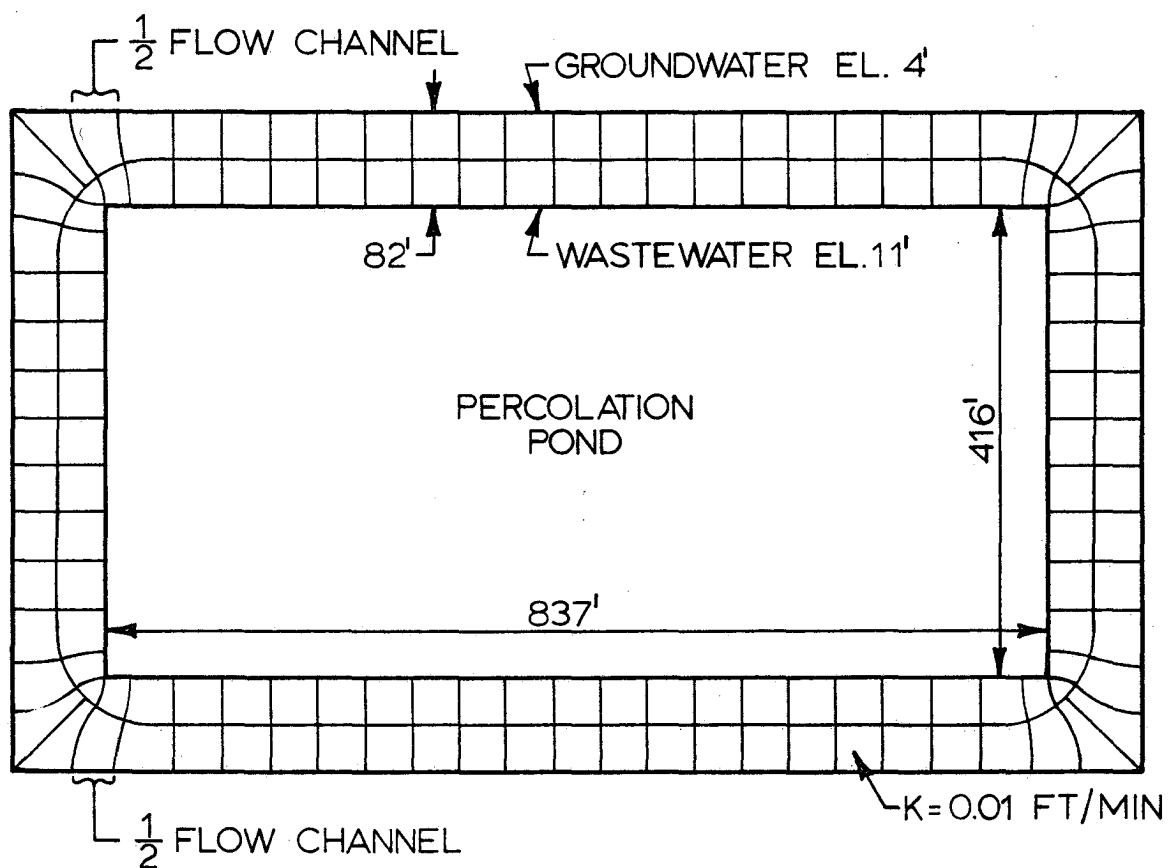
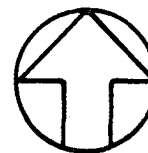


FIGURE 5.2-2
FLOW NET OF WASTEWATER POND
BIG BEND STATION
TAMPA ELECTRIC COMPANY

The applicant reserves the right to request a variance for this discharge, and/or the establishment of a mixing zone, at a later date. System variables will be better defined, which will allow for a better discharge water quality estimate.

5.2.1.3 Bottom Ash Sluice System Blowdown

As described in Section 3.5.1.6, a freshwater sluicing system will be used to transport bottom ash to the ash settling pond. This system is designed to allow recycling of the sluice water; however, to maintain proper system water chemistry, a blowdown to the bay will be required. It is not expected that this discharge will have a significant impact.

This discharge will be subject to the following state and federal discharge requirements:

Assuming a 5% of flow blowdown,

<u>Parameter</u>	<u>One Day Maximum</u>	<u>Thirty Day Daily Average</u>
TSS	100 mg/l	30 mg/l
Oil & Grease	20 mg/l	15 mg/l
pH	6-9	

The basin will be designed to meet these discharge limits.

5.2.1.4 Boiler Blowdown

As indicated in Section 3.5.1.4, approximately 30 gpm of boiler blowdown will be generated. This blowdown will be discharged to the bay via discharge channel. Table 5.2-6 provides an estimated water quality for this blowdown. It is not expected this discharge will have a significant impact.

5.2.2 Leachates

5.2.2.1 General Discussion

The primary sources of potential ground water quality impacts at the site are associated with the storage of raw materials for, and the disposal of byproducts from, Unit 4. The following areas are ground water quality impact sources that are to be built and associated with Unit 4:

1. Bottom and fly ash ponds
2. Limestone pile
3. FGD byproducts storage/disposal area.

The areas listed below are existing ground water quality impact sources that are used by existing units and are to be used by Unit 4:

1. Wastewater pond
2. Spray irrigation field
3. Coal pile
4. Dredge disposal area.

Materials in these areas may contain soluble substances which could be leached by infiltrating water and transmitted to the underlying surficial aquifer. Movement of the leachate plumes are controlled by the physical properties of the aquifer and by the chemical properties of the fluid. Figure 5.2-1 shows the location of potential sources of leachate at the site associated with Unit 4.

5.2.2.2 Ground Water Quality

Recent studies⁽³⁾ have shown that contaminant migration in ground water systems cannot be characterized by a simple homogeneous plume of contaminated water, but by complex multichemical plumes that commonly bifurcate vertically and laterally. Leachate movement through the surficial aquifer is concentrated in the upper sand layer and is affected by tidal fluctuations, permeability variations, adsorptive capacity of the aquifer, and diffusive characteristics of the leachates.

An assessment of the impact of the leachates from the operations of the proposed Unit 4 on the present day water quality of the surficial aquifer and the Floridan aquifer has been made. Water quality analyses for average sea water, for bay water at the site, for four site monitoring wells emplaced in the surficial aquifer, and for the Floridan aquifer are presented in Table 5.2-7, and compared with suggested EPA standards.

These analyses show that the surficial aquifer has saline water characteristics. This is evidenced by relatively high

concentrations of Cl, Na, SO₄, and Ca, indicating that saline water has mixed with water traveling down gradient in the surficial aquifer.

Water in the surficial aquifer at the site exceeds EPA standards for Cl, SO₄, Mn, and TDS, and exceeds the suggested standards for As. As a result, water in this aquifer at the site cannot be used for human consumption without extensive treatment based on EPA recommended limits.

Limited data exists concerning the water quality of the Floridan aquifer at the site. Table 5.2-7 lists chloride and sulfate concentrations that are based on averaging the values from several wells in the site area. As can be seen sulfate concentration exceeds recommended drinking water limits.

5.2.2.3 Bottom and Fly Ash Ponds

The bottom ash disposal area conceptual design is discussed in Section 3.6.2 and shown on Figure 3.6-1.

A lined fly ash pond will be located adjacent to the bottom ash pond (see Figure 5.2-1). The pond liner will have a permeability of 10^{-7} cm/sec and is not expected to adversely impact the surficial aquifer.

Preliminary calculations using flow nets show that approximately 250 gpm of water will seep out of the bottom ash pond into the surficial aquifer. This estimate is based on conservative values of hydraulic head, berm width, and aquifer hydraulic conductivity. The analysis indicates that almost all of the seepage will occur on the north, south, and west sides of the pond. Seepage from the east side of the bottom ash pond is restricted due to the impermeable liner in the adjacent fly ash pond.

Normal leakage at the site area from the Floridan aquifer through the Hawthorn formation and into the surficial aquifer is estimated to be 0.0065 gpm/acre. This is based on the potentiometric surface of the Floridan aquifer being 1 foot higher than that of the surficial aquifer, as discussed in Section 2.5.6. The construction of the bottom ash pond reverses the hydraulic gradient in the Hawthorn formation so that 0.16 gpm/acre will flow from the surficial aquifer into the Floridan aquifer directly beneath the pond. This estimate assumes a maximum hydraulic head differential of 29 ft between the water level in the pond and the potentiometric surface in the Floridan aquifer. Leakage

into the Floridan aquifer is estimated to be 0.013 gpm/acre for the area adjacent to the pond where the water level is raised over 10 acres in response to leakage from the pond into the surficial aquifer. Therefore, maximum leakage directly beneath the pond into the Floridan aquifer is 0.29 gpm and 0.13 gpm from the adjacent area where the groundwater table is raised. Therefore, the total leakage into the Floridan Aquifer from the bottom ash pond is estimated to be 0.42 gpm.

Table 5.2-7 lists a water quality analysis for a bottom ash leachate from a Southern Illinois coal, similar to one of the coals proposed for Unit 4, used in eastern Missouri. Migration of the leachate plume developed around the bottom ash pond will be predominantly toward the west in the downgradient direction. Movement of the plume toward the east in an upgradient direction will be minimal due to the small amount of seepage in that direction and due to the hydraulic gradient sloping from east to west.

The normal seepage velocity in the upper sandy layer at the site prior to the construction of the bottom ash pond is estimated to be 2×10^{-5} ft/min. This value is based on an average hydraulic gradient of 6×10^{-4} ft/ft, an average hydraulic conductivity of 0.01 ft/min and an average porosity of 0.35.

The construction of the bottom ash pond will cause the seepage velocity to increase to approximately 5.0×10^{-4} ft/min in the immediate vicinity of the berms. This velocity will decrease with distance from the pond as the hydraulic gradient becomes smaller and eventually will attain background rates.

5.2.2.4 Limestone Pile

The limestone pile for the FGD system will be located on the peninsula and will cover an area of approximately 1.5 acres. Consideration is being given to storing the limestone in a covered building. However, if the storage pile is not covered a runoff collection system will be installed in this area, which will intercept and contain the 10 year/24 hr storm.

If the pile is covered, leachates are not expected to be generated. However, if it is decided that the limestone pile will not be enclosed, rainwater falling on the limestone pile will cause the limestone, which is composed of calcium carbonate, to dissociate and to form free calcium

ions and free bicarbonate ions. At moderate pH values, between 6.3 and 10.2, bicarbonate ion dominates this system. At low pH values, bicarbonate reacts with free hydrogen ions and forms carbonic acid which then dominates the system. At pH values above 10.2, bicarbonate dissociates and forms carbonate which then dominates the system⁽⁴⁾.

At the site, the pH value of the bay water is 8.1 ± 0.2 , and the pH value of the water in the surficial aquifer ranges between 7 and 8, (Table 2.5-7). Therefore, at these pH values, bicarbonate will dominate the system and the dissolution of limestone will cause runoff water and water infiltrating into the groundwater system to be enriched in calcium ions and bicarbonate ions. Neither of these ionic species are limited by U.S. Public Health Standards for drinking water⁽⁵⁾. Because sea water and the bay water at the site contain significant concentrations of both of these species, and because there exists a limestone layer approximately 40 ft below grade, the impact of runoff water and infiltrating water will be negligible.

5.2.2.5 FGD Byproducts Storage/Disposal Area

The FGD storage/disposal area located on the south of the bottom ash and fly ash ponds, as shown on Figure 5.2-1, will cover a total area of approximately 97 acres to be developed in several stages. In order to contain the material, berms will be constructed around the entire area and a stormwater diversion system will be installed to transport runoff to the Jackson Branch. These berms will be designed to withstand a 100-yr flood and storm surge.

Gypsum will be the primary byproduct of the FGD system. The current plan is to sell as much of it as possible to a wallboard manufacturer. Any excess commercial grade and all noncommercial grade gypsum will be landfilled in the storage/disposal area. The landfill will be designed to minimize ponding and maximize runoff. Completed sections of the landfill will be revegetated with hydrophilic plants in order to maximize transpiration losses. This practice will limit infiltration of rainwater into the waste material and, therefore, minimize leachate production.

The physical and chemical characteristics of byproducts and leachates from three nonregenerable FGD systems were studied by Rossoff and others⁽⁶⁾. Fling and others⁽⁷⁾ studied the physical and chemical characteristics of the leachates produced from several experimental methods of waste treatment and disposal. These studies showed that the

infiltration of rainwater through FGD sludge and the subsequent infiltration of this water to the water table constitutes a major method by which the sludge can pollute the groundwater system. The permeability of the sludge is the major parameter controlling the infiltration rate of the leachate into the groundwater system.

Laboratory tests on several untreated and several chemically treated sludges performed by Rossoff and others⁽⁶⁾ have shown the coefficient of permeability of untreated sludge to be approximately 10^{-4} cm/sec (1.97×10^{-4} ft/min). As a way of predicting the permeability of the sludge at the base of the disposal area, permeability measurements also were made on sludges that were compacted under pressures of 30 and 100 psi. The compaction resulted in a decrease in the coefficient of permeability to approximately 10^{-5} cm/s (Rossoff and others, 1979).

The permeability of the waste product gypsum produced from the proposed Unit 4 operations is guaranteed by the FGD system vendor not to exceed 10^{-4} cm/sec (2×10^{-4} ft/min).

According to the hydrologic budget computed by Menke and others⁽⁸⁾, approximately 13 percent of total annual rainfall infiltrates into the groundwater system in Hillsborough County. In the FGD disposal area, runoff and transpiration losses will be maximized resulting in a lower infiltration rate. If it is assumed that 10 percent of total annual average rainfall infiltrates into the groundwater system beneath the FGD disposal area, then the recharge will be approximately 5 in/yr in that area.

Rossoff and others (1979) studied the chemical quality of sludge liquors and leachates from three FGD systems. Their laboratory leaching tests showed that in most cases 90 percent of the decrease in the concentration of major leachable species occurred before the pore volume of the column was displaced four times by an equal volume of water. The presence of fly ash in the FGD system waste altered the chemical quality of the sludge liquors and the leachates.

The water quality of FGD leachate without fly ash after five pore volume displacements has been found to exceed recommended U.S. Public Health standards for TDS, As, B, Cd, and So₄⁽⁹⁾. The exact water quality of the leachate at the site cannot be adequately predicted to be able to forecast its adherence to U.S. Water Quality standards.

405,000 ft²

5.2.2.6 Wastewater Pond

The existing wastewater pond is located north of the proposed fly ash pond and south of the spray irrigation field. It is approximately 900-ft long and 450-ft wide and is surrounded by berms which are built to a height of 12 ft above mean sea level.

The wastewater pond is underlain by the surficial aquifer. Water in the pond reaches a maximum hydraulic head of 11 ft above mean sea level. Figure 5.2-2 is a plan view flow net of the wastewater pond area and assumes that the berms are impermeable. It is estimated that 300 gpm of water seep out of the bottom of the pond into the surficial aquifer when the maximum hydraulic head differential of 7 feet is reached. This estimate is based on a conservative value for the hydraulic conductivity of the aquifer, 0.01 ft/min, and an aquifer thickness of 25 ft. The flow net shows that seepage occurs uniformly beneath the pond. However, seepage is slightly impeded toward the east in the upgradient direction.

An indirect measurement of seepage loss from the wastewater pond was performed in 1975. Inflow quantities into the pond were determined using correlations with weir overflow, and the increase in storage of the pond was obtained from stage readings. The estimated seepage, determined as the difference between these two quantities, was found to be less than 100 gpm.

Leakage directly below the wastewater pond through the surficial aquifer into the Floridan aquifer is estimated to be 0.052 gpm/acre. This assumes a hydraulic head differential of 8 ft between the water level in the pond and the potentiometric surface in the Floridan aquifer. Since the pond encompasses an area of 9.3 acres, approximately 0.48 gpm leaks into the Floridan aquifer from the wastewater pond. Leakage into the Floridan aquifer from the area adjacent to the pond is negligible because of the minor amount of hydraulic head buildup in the area outside the wastewater pond.

~ 75 gal/wk/acre

696 gal/day
9872 gal/wk

Table 5.2-7 lists an average water quality analysis of the water in the wastewater pond. This average analysis shows that the wastewater is chemically similar to the water in the surficial aquifer at the site, particularly with respect to the major cations and anions. Both waters have high TDS and high concentrations of Ca, Mg, Na, SO_4 , and Cl. The average wastewater has smaller concentrations of all the

major chemical species except Na and K. The major chemical difference between the two waters is that the pH range of the wastewater is much greater.

A gross leachate plume from the wastewater pond would be difficult to detect because of the similarity in water chemistry and the high concentration of TDS in both waters. The net movement of the effluent from the wastewater pond is towards the bay in a downgradient direction.

The normal seepage velocity in the upper sandy layer at the site is approximately 2×10^{-5} ft/min. The seepage velocity of the water seeping beneath the berms of the wastewater pond is estimated to be 2×10^{-3} ft/min.

5.2.2.7 Spray Irrigation Field

The spray irrigation field is located north of the wastewater pond and consists of four plots of naturally vegetated land that together cover an area of 29 acres, 21 acres of which are actually irrigated and 8 acres which act as a buffer zone for the surrounding land. Decanted wastewater from the wastewater pond is sprayed on one of these plots at a time at an average rate of 177,000 gpd. The spray irrigation field is designed to prevent surface runoff.

For a conservative value of 20 percent of the spray effluent infiltrating into the groundwater system at the irrigation field, it is estimated that approximately 36,000 gpd of recharge are added to the normal recharge rate in that area. As a result, a groundwater mound has formed beneath the spray irrigation field. The extent of the groundwater mound is determined by rainfall at the site, rates of spray irrigation and evapotranspiration, and the hydraulic conductivity and specific yield of the surficial aquifer in that area.

5.2.2.8 Coal Pile

The existing coal pile located on the western end of the peninsula will be expanded northward to increase the area of coal storage by approximately 25 percent. As shown on Figure 5.2-1, the peninsula is bordered on the north and the south by 25-ft deep channels opening to Tampa Bay, and by Tampa Bay on the west.

Eight sets of sulfate concentration data were obtained in 1978 from groundwater in the western end of the peninsula.

The average sulfate concentration was 995 mg/l with a standard deviation of 494 mg/l. These data, when compared with bay water chemistry in Table 5.2-7, indicate that bay water extends into the western end of the peninsula.

Runoff from coal piles is known to contain oxidation products of pyrite, marcasite, and other metallic sulfide minerals contained in coal. These oxidation products lower the pH of the runoff which facilitates the dissolution of many trace elements and the growth of certain bacteria that act as catalysts which increase the dissolution rates⁽¹⁰⁾. The amount of acid produced in a given coal pile and the subsequent dissolution of trace metals is controlled by:

- the concentration and form of pyritic sulfur in the coal
- the size and shape of the coal pile
- the method of coal preparation and cleaning before storage
- climatic conditions including rainfall intensity, duration, and pH
- the concentration of calcium carbonate and other neutralizing substances in the coal
- concentration and solubility of the trace metals in the coal
- the permeability and porosity of the coal which control the residence time of the filtrating water in the coal pile⁽¹¹⁾.

In a report⁽¹¹⁾ published by the U.S. Environmental Protection Agency, drainage from two coal storage piles was analyzed. The results showed that the drainage from both coal piles, which were composed of eastern coal, was highly acidic with pH values ranging between 2.2 and 3.1. The drainage also contained high concentrations of suspended solids, sulfates, iron, manganese, aluminum, zinc, mercury, arsenic, and selenium. Sulfate concentrations ranged between 1800 to 9600 mg/l and iron and manganese concentrations ranged between 1.8 to 45 mg/l, respectively. Table 5.2-7 lists a typical analysis of the drainage from one of the piles.

The study also showed that approximately 73 percent of the total amount of precipitation falling on one coal pile resulted in direct runoff. The remaining 27 percent either infiltrated into the ground water system or evaporated to the atmosphere. It is to be noted that these values relate to the particular site that was studied.

At the Big Bend site, a runoff collection system will intercept runoff from the coal pile and transport it to the wastewater pond for disposal. Only a small portion of precipitation will infiltrate into the ground.

A comparison of the water quality of coal pile drainage in the above study⁽¹¹⁾ with that of bay water at the Big Bend site shows that the coal pile drainage has higher concentrations of most all of the trace metals and major cations and anions.

* The water quality of the coal-pile drainage is dependent on many site-specific factors and, therefore, it is very difficult to forecast.

5.2.2.9 Environmental Assessment

5.2.2.9.1 General Discussion

The environmental impact of leachate and effluent infiltration at the site can be divided into two categories: hydrological and chemical. Hydrological impacts are related to changes in groundwater levels, whereas, chemical impacts are related to changes in groundwater chemistry.

The assessment of hydrological and chemical impacts is based on ambient hydrologic and water quality conditions at the site. The ambient average hydraulic gradient in the surficial aquifer measured at the site is to the west, toward the bay, at a rate of approximately 6×10^{-4} ft/ft. Figure 2.5-6, the piezometric surface map of the surficial aquifer at the site, shows that groundwater enters the site from the east and leaves the site as groundwater discharge into the bay or as stream flow from the drainage canals that intercept the groundwater table and drain into the bay.

Based on available water quality analyses from the site and adjacent areas, the water quality in the surficial aquifer and the Floridan aquifer at the site exceeds EPA standards for SO_4 and TDS and, therefore, is not recommended for public consumption.

Currently, the wastewater pond and the spray irrigation field allow contaminated groundwater to infiltrate into the surficial aquifer. As a result, the groundwater quality in these areas contains high concentrations of various anions and cations (see Table 5.2-7). Thus, the ambient water quality in these parts of the surficial aquifer contains higher TDS and higher concentrations of certain ionic species than the normal level of contamination in the aquifer caused by its moderately saline character.

Leachate plumes from the bottom ash pond, coal pile, and FGD byproduct storage/disposal area will be difficult to detect and delineate. Typically, leachate plumes are delineated by detecting relative increases in TDS, temperature, Cl, or SO₄. These methods will be ineffective at the site because the ambient concentrations of TDS, Cl, and SO₄ are high and because of a lack of exothermic reactions in the types of leachates that will be produced at the site. Additionally, the presence of numerous sources of SO₄, Cl, and TDS will complicate the task of identifying the origin of the leachate. If a particular leachate contains a unique ionic species not contained in the other leachates, effluents, or normal groundwater, it may be possible to detect a specific ion plume.

5.2.2.9.2 Bottom Ash Pond

Seepage from the bottom ash pond will cause the groundwater level in the surficial aquifer to rise in the vicinity of the pond forming a groundwater mound. A discussion of this including seepage rates is given in Section 5.2.2.3.

The chemical impact of leachate from the bottom ash pond infiltrating into the surficial aquifer depends on many site specific factors (see Section 5.2.2.3). A comparison of available water quality data of bottom ash leachates with the ambient water quality of the surficial aquifer (see Table 5.2-7) shows that the infiltration of bottom ash leachate into the surficial aquifer will not cause an increase in any of the ionic species common between the two sets of analyses. The bottom ash leachate at the site is expected not to have any detrimental impact on the water quality of either the surficial or the Floridan aquifers at the site.

5.2.2.9.3 Fly Ash Pond

The disposal of fly ash into the lined pond at the site will not have any hydrological or chemical impact on the groundwater system at the site.

5.2.2.9.4 FGD Byproducts Storage/Disposal Area

The quantity of leachate generated by the FGD byproducts storage disposal area will be minimized by maximizing runoff and transpiration. The amount of leachate entering the groundwater system beneath the FGD byproduct storage/disposal area will be equal to or less than the normal amount of groundwater recharge and, therefore, will not have a hydrological impact on the groundwater flow system.

The exact water quality of the FGD system leachate at the site will depend on site specific factors (see Section 5.2.2.5). The chemical impact of the FGD system leachate is not anticipated to be significant because the ambient groundwater in the surficial aquifer exceeds the recommended concentration of SO_4 and because the concentration of Ca is not limited by health standards.

5.2.2.9.5 Wastewater Pond/Spray Irrigation Field

The infiltration of wastewater effluent into the surficial aquifer at the site from the wastewater pond or the spray irrigation field will not cause any additional hydrological or chemical impact on the existing groundwater quality and flow system (see Sections 5.2.2.6 and 5.2.2.7). Leakage from the pond and infiltration from the spray field have elevated ambient water levels in the area. The effluent contains fewer TDS than does the bay water in the site area which has intruded beneath the site peninsula and cannot be estimated from the partial water quality analyses listed in Table 5.2-7. Nonetheless, the SO_4 concentration tests from the groundwater samples taken on the peninsula suggest that the concentration of TDS in the groundwater at the site is considerable.

5.2.2.9.6 Coal Pile

Most of the leachate from the coal pile will be collected in runoff drains. The amount of leachate that does infiltrate into the groundwater system will be similar to the natural quantity of groundwater recharge. As a result, the hydrological impact of coal pile leachate will be

insignificant. Coal pile leachates generally have low pH values and high concentrations of SO_4 , Fe, and several trace metals. Since the peninsula on which the plant is sited was formed by the placement of dredge spoil, the groundwater beneath the coal pile is bay water. The chemical impact of the additional amount of leachate on the intruded bay water will be minimal because of the limited extent of the proposed expansion of the existing coal pile.

5.2.3 Radionuclide Emissions

During the combustion of coal, naturally occurring radionuclides contained within the coal are released to the environment. The primary radionuclides emitted are: K-40, U-235 and decay products, U-238 and decay products, and Th-232 and decay products. Potassium 40 is present in the coal in an amount equal to 0.0118 percent of the total potassium present⁽¹⁶⁾.

According to Dvorak, et al⁽¹⁶⁾, the U-235 decay series does not contribute significantly to the radioactivity emitted. The U-238 and Th-232 decay series provide the majority of the radioactive effluents. Swanson and Madlin, et al⁽¹⁷⁾, report average values of uranium concentration in coal to be 1.0 ppm for a northern Appalachian coal and 1.4 ppm for an eastern interior coal. Thorium values of 2.8 and 2.6 ppm, respectively, were reported for the same coals. With the exception of radon gas, which will be emitted to the atmosphere during combustion, it is expected that the majority of radionuclides from the coal will be concentrated in the fly ash. Coltharp, et al⁽¹⁸⁾, found that Illinois Basin coal, similar to one of the Big Bend 4 proposed coal, produced a fly ash which had uranium and thorium contents of 30 ppm and 54 ppm, respectively, by weight. Krieger, et al⁽⁶⁾, have analyzed the radionuclide content of coal bottom ash, and fly ash from a western Kentucky coal. Their data is summarized in Table 5.2-8.

Dvorak, et al⁽¹⁶⁾, provides estimates of average radionuclide emission rates for various sized coal-fired plants. This data has been extrapolated to obtain the following values for a 417 MW unit (note that the relationship between data points is approximately linear):

<u>Emission Rates (ci/yr)</u>				
<u>Coal</u>	<u>U*</u>	<u>Rn-222</u>	<u>Th*</u>	<u>Rn-220</u>
Northern Appalachian	2.08×10^{-4}	7.5×10^{-2}	1.44×10^{-4}	6.86×10^{-2}
Eastern Interior	4.71×10^{-4}	1.05×10^{-1}	1.33×10^{-4}	3.86×10^{-2}

* All isotopes - Total quantity

The U.S. Environmental Protection Agency⁽²⁰⁾ has made preliminary projections of the health impact of radionuclide emissions from coal-fired power plants. They use a model for new plants (RCM-1) based on a 550 MW unit burning a western coal with a higher radionuclide content than coals under consideration for Big Bend 4. Tables 5.2-9 and 5.2-10 summarize the population health impact this plant would have in a suburban area.

As can be seen from these data, a plant more than twice the size of Big Bend will cause a very small increase in annual dose to an individual above natural background radiation.

Based upon the above, the applicant does not expect any significant impact to the environment from radionuclide emissions.

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Big Bend Condenser Discharge
Chlorine Concentrations
(mg/L)Unit 1

	Minimum		Average		Maximum	
	<u>FAC</u>	<u>TRC</u>	<u>FAC</u>	<u>TRC</u>	<u>FAC</u>	<u>TRC</u>
<u>1978</u>						
July	*	*	*	*	*	*
August	*	*	*	*	*	*
September	*	*	*	*	0	0.05
October	0.1	0.1	0.17	0.17	0.2	0.2
November	*	*	*	*	*	*
December	*	*	*	*	0.175	0.2
<u>1979</u>						
January	<0.01	<0.01	0.01	0.01	<0.1	<0.01
February	<0.01	<0.01	0.077	0.091	0.2	0.2
March	*	*	*	*	*	*
April	*	*	*	*	0.1	0.1
May	*	*	*	*	*	*
June	*	*	*	*	*	*
July	*	*	*	*	0.06	0.05
August	*	*	*	*	*	*
September	*	*	*	*	*	*
October	<0.05	<0.05	0.05	0.067	0.05	0.1
November	<0.05	<0.05	0.05	0.05	<0.05	0.05
December	*	*	*	*	*	*

*Data set limited due to unit outages or chlorinator outages.

Note: Chlorine measured at outfall.

TABLE 5.2-2

Amendment 3
August 1980Big Bend Condenser Discharge
Chlorine Concentrations
(mg/L)Unit 2

	Minimum		Average		Maximum	
	FAC	TRC	FAC	TRC	FAC	TRC
<u>1978</u>						
July	*	*	*	*	0	0.1
August	0	0	0	0	0	0
September	0	0	0	0.02	0	0.05
October	0.1	0.1	0.13	0.13	0.2	0.2
November	0.1	0.08	0.11	0.14	0.13	0.175
December	0	0	*	*	0	0
<u>1979</u>						
January	<0.01	<0.01	0.025	0.025	0.1	0.1
February	<0.01	<0.01	0.07	0.07	0.1	0.1
March	*	*	*	*	*	*
April	*	*	*	*	*	*
May	*	*	*	*	*	*
June	0	0	0.07	0.084	0.175	0.16
July	<0.05	0.025	0.055	0.083	0.06	0.14
August	*	*	*	*	*	*
September	*	*	*	*	*	*
October	<0.05	<0.05	0.05	0.067	0.05	0.1
November	<0.05	<0.05	0.05	0.05	<0.05	0.05
December	*	*	*	*	*	*

*Data set limited due to unit outages or chlorinator outages.

Note: Chlorine measured at outfall.

TABLE 5.2-3

Amendment 3
August 1980Big Bend Condenser Discharge
Chlorine Concentrations
(mg/L)Unit 3

	Minimum		Average		Maximum	
	FAC	TRC	FAC	TRC	FAC	TRC
<u>1978</u>						
July	*	*	*	*	0	0.5
August	0	0	0	0	0	0
September	0	0	0	0	0	0
October	0.05	0.05	0.083	0.08	0.1	0.1
November	0.05	0.05	0.07	0.10	0.1	0.125
December	0	0	*	*	0.1	0.1
<u>1979</u>						
January	<0.01	<0.01	0.01	0.01	<0.01	<0.01
February	<0.01	<0.01	0.07	0.07	0.1	0.1
March	*	*	*	*	*	*
April	0.1	0.1	0.1	0.1	0.1	0.1
May	*	*	*	*	*	*
June	0	0	0.019	0.044	0.05	0.1
July	<0.05	<0.05	0.055	0.05	0.06	<0.05
August	*	*	*	*	*	*
September	*	*	*	*	*	*
October	*	*	*	*	*	*
November	*	*	*	*	*	*
December	*	*	*	*	*	*

*Data set limited due to unit outages or chlorinator outages.

Note: Chlorine measured at outfall.

TABLE 5.2-4

Amendment 3
August 1980

Chlorine Dilution Factors

<u>Effect. Dil</u> <u>Factor</u>	<u>Distance</u> <u>(ft)</u>	<u>ft²</u>	<u>Area</u> <u>(Based on</u> <u>channel width</u> <u>of 246 ft)</u> <u>Acres</u>
2	190.8	46,934.8	1.1
3	302.4	74,389.9	1.7
4	381.6	93,869.6	2.2
5	443.0	108,979.3	2.5
6	493.2	121,324.8	2.8
7	535.6	131,762.7	3.0
8	572.4	140,804.5	3.2
9	604.8	148,779.9	3.4
10	633.8	155,914.1	3.6
11	660.0	162,367.8	3.7
12	684.0	168,259.6	3.9
13	706.0	173,679.5	4.0
14	726.4	178,697.5	4.1
15	745.4	183,369.2	4.2
16	753.2	187,739.3	4.3
17	779.9	191,844.3	4.4
18	795.6	195,714.7	4.5
19	810.5	199,375.7	4.6
20	824.6	202,848.9	4.7

TABLE 5.2-5
TYPICAL PARTIAL WATER QUALITY ANALYSES
FOR FGD SYSTEM MAKEUP

<u>Parameter</u>	<u>Sun City</u>	<u>Hillsborough County System</u>
pH	6.55	8.0
Total Hardness	232	331
Total Alkalinity	181	-
Dissolved SiO ₂	17.8	18.4
SO ₄	30	194.2
PO ₃	3.96	-
Cl	135	25.3
F	132	0.76
Ca	59.6	75.2
Mg	20.2	28.25
Fe	0.13	0.17
Na	-	12.6
As	LT 0.002	-
Ba	0.05	-
Cd	LT 0.002	-
Cr	LT 0.06	-
Cu	0.037	-
Pb	LT 0.01	-
Mn	LT 0.01	-
Se	LT 0.02	-
Ag	LT 0.01	-
Zn	0.009	-
Mg	LT 0.0002	-
TDS	809	440.8
TSS	2	9.6
TS	811	450.4

LT = Less than

TABLE 5.2-6

WATER QUALITY

<u>Parameter</u>	<u>Quantity</u>
TDS	10 ppm
TSS	4 ppm
Total S_1O_2	0.02 ppm
Metallic Impurities	
Total	5 ppm
Cu (max)	1 ppm
Fe (max)	1 ppm
Hardness	0
pH	8.5-9.0

TABLE 5.2-7

WATER-QUALITY ANALYSES

	Average Seawater ⁽¹⁾	Bay Water At Site	Surficial Aquifer at Site March, 1976 ⁽⁷⁾				Waste- water Pond (Avg)	Floridan Aquifer ⁽²⁾		Bottom-Ash Leachate ⁽³⁾	Coal Pile Drainage ⁽⁴⁾	EPA Standards ⁽⁵⁾
			West Well	East Well	South Well	North Well		1953	1974			
PO ₄ total			4.13	3.15	3.6	3.43						
SiO ₂	6.4		47.9	45.4	14.8	44.2	7.8	21	28		41	
Ca	400	342-413	692	155	176	1116	166	170	170		720	
Mg	1350	950-1300	173	51	53	384	68.2	65	52		78	
Na	10500	8000-10000	10000	18	17	300	534		50			
K	380		1.9	0.5	1.6	1.4	14.2		3.1			
Fe total	0.01	0.001-0.03	1.46	0.64	0.66	0.81	0.073	0.28	0.10	0.03	480	
Fe dissolved			0.2	0.14	0.40	0.36						
Ni	0.002		0.0	0.0	0.0	0.0	0.015			0.02	0.49	
Cu	0.003		0.01	0.01	0.01	0.01	0.011			0.004	0.12	1.0
Cd ⁽⁶⁾	0.00011		0.01		0.01	<0.01	<0.04				<0.001	0.01
Cr	0.00005	0.01	6.6	9.9	5.0	7.9	0.013			0.006	<0.005	0.05
Pb ⁽⁶⁾	0.00003	0.01	<0.05		<0.05	<0.05	<0.123				<0.01	0.05
Hg ⁽⁶⁾	0.00003		<0.002		<0.002	<0.002				<0.003	0.002	
Se ⁽⁶⁾	0.004		<0.5		<0.5	<0.5	0.065				<0.001	0.01
Zn	0.01	0.01-0.05	0.45	0.25	0.17	0.68	<0.014			0.01	2.8	6.0
Mn	0.002		0.12	0.18	0.18	0.24				0.01	4.6	0.05
Va ⁽⁶⁾			<1		<1	<1						
SO ₄	2700	2000-2700	93.2	102.8	82.7	180.7	217	510	450		4100	250
Cl	19000	15000-19000	2570	35	59	3317	467	88	100		340	250
HCO ₃	142							172	173			
N			0.56	0.89	0.22	0.78						
NO ₃		0.08	2.6	4.6	2.2	3.75						45
As ⁽⁶⁾			0.28		0.05	0.06	0.159			0.01	<0.019	
Br	65		8.6	0.1	0	12.5						
F	1.3	1-2.8	0.04	0.22	0.2	0.08		0.4	0.6			
BOD			0	0	0	0						
TDS			3641	4789	627	4329	2732	1080	1000		5100	500
TSS		21	50	35	14	59	28				420	
pH		8.1±0.2	7.00	6.96	8.35	6.4	3-10	7.3	7.3		2.3	
Oil and Grease			0	0	0	0						
Turbidity (Ftu)			28	24	32	40						

(1) Hem⁽¹²⁾

(2) Duerr⁽¹³⁾

(3) NUS Corporation⁽¹⁴⁾

(4) Cox et al⁽¹¹⁾, Plant E

(5) EPA Standards for drinking water, primary and secondary

(6) Interscience, Incorporated, Analysis dated December 15, 1975

(7) Environmental Associates, Incorporated, Analysis dated March 10, 1976.

TABLE 5.2-8

Analysis of Radionuclide Content of
Coal, Bottom Ash, and Fly Ash from a
Western Kentucky Coal
(All values in pci/g)

June 1976 Analysis

<u>Material</u>	<u>Ra226</u>	<u>U234</u>	<u>U235</u>	<u>U238</u>	<u>Th238</u>	<u>Th230</u>	<u>Th232</u>
Coal	1.98	0.80	0.04	0.78	0.21	0.71	0.19
Fly Ash	7.00	6.30	0.33	8.60	1.90	6.50	1.80
Bottom Ash	5.00	5.60	0.22	5.50	1.90	6.00	1.60

June 1977 Analysis

<u>Material</u>	<u>Ra226</u>	<u>U234</u>	<u>U235</u>	<u>U238</u>	<u>Th238</u>	<u>Th230</u>	<u>Th232</u>
Coal	0.72	0.92	0.05	0.92	0.34	0.85	0.27
Fly Ash	3.80	4.20	0.20	4.40	1.80	4.50	1.57
Bottom Ash	3.10	2.70	0.09	2.70	1.70	2.70	1.30

TABLE 5.2-9

Annual Radiation Doses from Radioactive Particulate
Emissions From the Model "New" Coal Fired Station
(550 MW Plant Burning Western Coal)

<u>Organ</u>	<u>Maximum Individual Dose (mrem/yr)</u>
Lung	1.1
Bone	2.1
Kidney	1.0
Liver	0.9
Thyroid	1.1
G.I. Tract	0.8
Other Soft Tissue	1.1

TABLE 5.2-10

Individual Lifetime Risks and Number of Fatal Cancers Due to Radioactive Particulate Emissions From the Model "New" Coal Fired Station for a Suburban Site

	<u>Risk</u>
Individual Lifetime Risks	
Maximum Individual	1.4×10^{-5}
Average Individual	4.8×10^{-7}
Expected Fatal Cancers per Year of Operation (Fatal Cancers)	1.7×10^{-2}

McBride, et al (19), provided the following human dose rate comparison between emissions from a 1000 MW coal fired plant and natural background radiation:

	<u>Dose Rate (mrem/yr)</u>	
	<u>Coal Fired Plant</u>	<u>Natural Background</u>
Whole Body	1.9	80
Lung	1.9	180
Bone	18.2	120

5.3 IMPACTS ON WATER SUPPLIES

The proposed Big Bend Unit No. 4 will have an estimated freshwater demand of 1.5 million gallons per day (mgd). The majority of this volume (≈ 1 mgd) will be required for operation of the flue gas desulfurization system.

In 1977, the first full year of three-unit operation, the average freshwater consumption at Big Bend Station was 1.16 mgd. In 1978, the average was 1.14 mgd. In 1979, full utilization was made of a wastewater recycle system, which cut potable freshwater consumption to 0.89 mgd. The recycled water is utilized for equipment washing and other instances when potable quality water is not required. The use of recycled water has cut potable water consumption by 21-23 percent. Table 5.3-1 illustrates the 1977, 1978, and 1979 water use trends at Big Bend Station.

The Applicant will rely on Hillsborough County to meet the additional freshwater demand of Big Bend Unit No. 4 (see Figure 5.3-1). Unit 4 will be designed to include an expansion of the existing recycling system, thus permitting significant savings of freshwater over that which would otherwise be required.

As described in Section 2.2.3.2, the plant is presently served by the Hillsborough County-Riverview-Gibsonton water system for its freshwater needs. The Riverview-Gibsonton system is one of four subsystems which comprise the Hillsborough County South-Central water system. The remaining subsystems are Brandon, Sun City, and Ruskin. These areas are interconnected and consequently function as a unit. Each of the areas are described as follows.

The Brandon system secures its water from 24 wells scattered throughout its service area. The wells range in diameter from 4 to 12 in and in depth from 240 to 605 ft. Their combined pumping capacity is 13.4 mgd. In 1976, the average daily demand on the system, as reported in Horizon 2000, was 3.9 mgd, with a peak day demand of 7.4 mgd. The reported peak day demand for 1979 was 11.77 mgd. The major problems associated with the Brandon system are that the distribution system lacks adequate transmission and feeder mains; there is no elevated storage; and ground storage tank volume is insignificant.

The Ruskin water system is supplied by two 10-in diameter wells with depths of 700 and 800 ft. The observed pumping capacity of the system is 1.6 mgd. The water treatment

plant capacity is 1.2 mgd. In 1976, the average daily demand, as reported in Horizon 2000, was 0.3 mgd, with a peak day flow of 0.5 mgd. The reported peak day demand for 1979 was 0.608 mgd. The available storage capacity is 175,000 gallons.

The Sun City Center water system includes nine wells with an observed pumping capacity of 3.3 mgd. In 1976, the average daily demand as reported in Horizon 2000 was 1.5 mgd, with a peak day demand of 3.1 mgd. The reported 1979 peak day demand was 3.52 mgd. The available storage capacity is 750,000 gallons.

The Riverview-Gibsonston system is supplied by seven 10-in diameter wells ranging in depth from 600 to 750 ft. The total pumping capacity of these wells is 3.2 mgd. In 1976, the average daily demand, as reported in Horizon 2000, was 2.4 mgd, with a peak day flow of 3.7 mgd. In 1979, the reported peak day flow was 3.52 mgd. Storage capacity includes 1.2 million gallons in ground storage tank volume and a 0.5 million gallon elevated tank.

A tabulation of all wells indicates that the total pumping capacity of the South Central water supply system is 21.5 mgd, as shown in Table 5.3-2. By the end of 1980, Hillsborough County plans to have added two well fields East of Brandon for an additional flow of 3.3 mgd. Furthermore, additional distribution lines should be completed by the end of the year.

In addition to investigating the capabilities of the South-Central water system as part of the Big Bend Unit No. 4 Environmental Studies, a review of possible alternate water sources was made. After preliminary review, it was concluded that treated sewage effluent from the City of Tampa, Sun City Center, and Apollo Beach were alternate sources which warranted a more detailed review. The results of investigations into these three alternatives are summarized as follows.

City of Tampa

The City of Tampa operates an advanced wastewater treatment plant at Hookers Point, which currently produces 45 mgd of treated effluent. Although the effluent is presently being discharged to Hillsborough Bay, there have been numerous discussions on the reuse potential of this water. From the Applicant's point of view, this source of water is attractive due to its dependable availability and its

excellent quality. The main problem associated with this water source is the location of the treatment plant relative to Big Bend Station. In order to supply the plant, a 15-mile-long force main would be required. Moreover, the pipeline must cross Hillsborough Bay, the Alafia River, and Bullfrog Creek in addition to numerous railroad tracks, highways, and streets. Consequently, the cost of construction, operation, and maintenance of such a pipeline for the volume of water required by Big Bend Station does not make the City of Tampa effluent a feasible option.

Apollo Beach

The privately owned Apollo Beach Wastewater Treatment Plant currently produces 0.7 mgd of secondary effluent. The plant capacity is presently being expanded to 1 mgd. The effluent is disposed of by spray irrigation on a nearby golf course. In order to convey the treated effluent to the plant, it would be necessary to construct a 3-mile pipeline from the treatment plant to the Big Bend Station. Consequently, the relatively short length of this pipeline makes this alternative attractive. However, due to the proximity of Apollo Beach to Tampa Bay, the sanitary sewage collection system experiences saltwater infiltration which in turn yields a high chloride concentration in the STP effluent. This high chloride concentration would preclude the use of this effluent in many of the processes at Big Bend Station.

Sun City Center

The Sun City Wastewater Treatment Plant is owned and operated by Hillsborough County. Currently, the plant produces 0.7 mgd of treated effluent and is presently being expanded to a capacity of 3 mgd. In order to convey the treated effluent to the plant, it would be necessary to construct a 6-mile pipeline from the treatment plant to Big Bend Station. This route parallels an existing TECO right-of-way for most of the distance. The Sun City effluent is of good quality for use at Big Bend Station. Moreover, Hillsborough County is very willing to cooperate.

From the investigations into the supply capabilities of the South-Central water system and the alternate water supply options, the Applicant has reached the following conclusions concerning a freshwater source for Big Bend Unit No. 4:

1. Without improvements in supply and transmission facilities, the Hillsborough County South-Central water system, in its present state, cannot be

considered a fully dependable supply during peak flow conditions. However, should the proposed expansions be completed, it would be the Applicant's desire to use this.

2. The most feasible alternate freshwater supply source is the secondary effluent from the Sun City Wastewater Treatment Plant. The quantity and quality available are compatible with its intended use at Big Bend Station.

Negotiations with Hillsborough County concerning the freshwater needs for Big Bend Unit No. 4 have yielded the following results and conclusions:

- o Hillsborough County is amenable to providing treated effluent from their Sun City Wastewater Treatment Plant for reuse by the Applicant.
- o Hillsborough County is in the process of studying the future requirements of the South Hillsborough System. The Big Bend Unit No. 4 requirements will be included in that study.
- o Hillsborough County will be able to meet the Big Bend Station water needs, while continuing to serve their domestic water supply customers. Attached as Figure 5.3-1 is a letter from Hillsborough County confirming their intentions to meet the Big Bend Unit No. 4 water requirements.

Since the Hillsborough County South Central water system covers an area which is out of the "5-mile radius area" and it is possible that an alternative source will come from a distance greater than 5 miles, it is apparent that water supplies or uses outside this zone may be affected. These effects, however, are not expected to be adverse due to the following factors:

1. Hillsborough County understands the water needs of the Big Bend Station, and they have been incorporated into the long-range planning process.
2. Earlier studies of the Hillsborough County system have concluded that the supply system be expanded by placing new wells to the East in the Brandon Area. This means that the water will be pumped from an area which does not experience heavy agricultural pumpage. Additionally, well field

construction in this area should not have a great effect on saltwater intrusion.

3. The reuse of treated sewage effluent will, in addition to providing relief for effluent disposal problems, be a method of resource conservation.

TABLE 5.3-1

BIG BEND STATION FRESH-WATER USE

	<u>1977</u>	<u>1978</u>	<u>1979</u>
<u>Hillsborough County Water Use</u>			
Million Gallons/Month	34.84	34.09*	26.81**
Million Gallons/Day	1.16	1.14	0.89
<u>Recycle Water Use</u>			
Million Gallons/Month	-	-	7.40
Million Gallons/Day	-	-	0.25
<u>Total Water Use: Recycle</u>			
<u>Plus County Water</u>			
Million Gallons/Month	34.84	34.09	34.21
Million Gallons/Day	1.16	1.14	1.14
<u>Percent of Reduction In County</u>			
<u>Water Use Due To Recycle</u>			
As compared to 1977	-	-	23%
As Compared to 1978	-	-	21%

* 10 Months of Data Available,
Hillsborough County Water Meter Failure

** 7 Months of Data Available,
Hillsborough County Water Meter Inoperable

TABLE 5.3-2

HILLSBOROUGH COUNTY SOUTH - CENTRAL WATER SYSTEM
SUPPLY CAPABILITIES

<u>Subsystem</u>	<u>Total Observed Pumping Capacity (mgd)</u>
Brandon	13.4
Riverview - Gibsonton	3.2
Sun City	3.3
Ruskin	<u>1.6</u>
TOTAL	21.5

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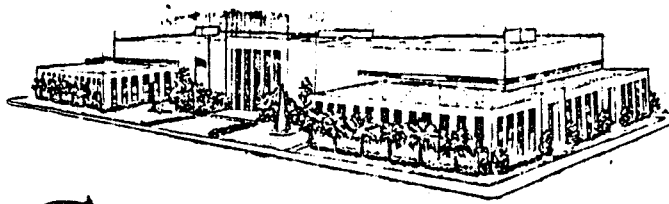
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TELEPHONE (813) 272-5000



COUNTY OF HILLSBOROUGH
Tampa, Florida 33601



JAMES F. TAYLOR, JR.
CLERK

WILLIAM C. TATUM
COUNTY ADMINISTRATOR

May 12, 1980

Mr. Ellsworth Simmons
Tampa Electric Company
P. O. Box 111
Tampa, Florida 33601

Attention: Mr. J. D. Hicks
Vice President-Operations

Dear Mr. Simmons:

Confirming our discussions held with the Tampa Electric Company representatives on February 19, 1980 in our offices, Hillsborough County will meet the fresh water supply requirements of your new Big Bend Unit #4. It is our understanding these requirements would be 1.5 million gallons a day of fresh water which would be in addition to your present consumption at Big Bend Station.

Hillsborough County is in the process of studying the future requirements of the South Hillsborough system and we will add these new requirements to that study.

It is our understanding that Tampa Electric Company is receptive to the concept of utilizing treated sewage plant effluent as an alternative to supplying this water from the county water system.

We look forward to working closely with you so that we might properly serve your needs.

Very truly yours,

William C. Tatum
County Administrator

WCT/lp

5.4 SANITARY AND OTHER WASTE DISCHARGES

Sanitary sewage at Big Bend Station is treated onsite in the existing extended aeration packaged sewage treatment plant (STP). Treatment provides 90 percent removal of biochemical oxygen demand (BOD) and suspended solids, and includes disinfection of the effluent. The effluent is discharged to the station wastewater treatment ponds located east of Wyandotte Road. A second plant will be installed with Unit 4 to accommodate the increase in station personnel. This plant will comply with Chapter 17-6 Florida Administrative Code with 90 percent treatment and alternate effluent disposal to the wastewater treatment ponds.

Estimated flow rates presented in Table 5.4-1 show that the sewage treatment plant effluent amounts to about 0.8 percent of the total flow entering the ponds.

A portion of the effluent from the wastewater treatment pond is recycled to the plant. The excess not needed for recycling is disposed of through spray irrigation as described in Section 3.5.2.4.

The effects of the spray irrigation system and seepage from the wastewater ponds are addressed in Section 5.2.

TABLE 5.4-1

ESTIMATED WASTE WATER FLOWS (gallons/day)

	Units 1-3	Unit 4	Total
Station Waste Water	378,000	153,000	531,000
STP Effluent	3,000	1,300	4,300

5.5 AIR QUALITY IMPACT

5.5.1 Increment Consumption

5.5.1.1 General

With respect to classification of Prevention of Significant Deterioration (PSD) areas, EPA has designated all airspace within 90 kilometers of Big Bend as Class II. The Class I area nearest Big Bend is the extreme southeastern edge of the Chassohowitzka Wilderness Area, which is approximately 92 kilometers from the site.

In this section, the PSD Class II increment consumption is shown for each applicable averaging time and pollutant. All interacting sources are included in the analysis.

5.5.1.2 FDER Annual Increment Consumption

Figures 5.5-1 and 5.5-2 portray the spatial 24-hour increment consumption according to the FDER definitions of baseline and projected emissions for sulfur dioxide and TSP, respectively. The spatial sulfur dioxide increment consumption in the vicinity of Big Bend indicates uniform air quality improvement in relation to sulfur dioxide since 1974, the baseline year. For TSP, the only positive increment consumption on the map is due to a small source which had a 1974 "allowable" emission rate of 133 tons of particulate matter per year. Agrico Chemical Company (Hillsborough County, NEDS No. 94-01), located 1.3 kilometers north-northwest of Big Bend, has actual annual particulate emissions of 5 tons by using baghouses with 99 percent control efficiency. The allowable particulate emissions are 27 times greater than the actual emissions of this source, so that only a "modeling" violation is predicted to occur. The maximum particulate matter increment consumption occurred at a receptor 200 meters south of Agrico. The contribution of Big Bend (with all four units at full load) to the increment consumption at that receptor was 0.0 ug/m^3 .

5.5.1.3 FDER Short-Term Increment Consumption

Figures 5.5-3 and 5.5-4 show the spacial 24-hour sulfur dioxide and TSP increment consumption due to the TECO Big Bend facility only. Short-term maximum source interaction increments are shown with the maximum Big Bend increments in tabular form only. Beyond 0.5 kilometers from Big Bend (concentrations are 0.0 ug/m^3 at 0.5 km), the area shown an improvement in the sulfur dioxide air quality and only a slight particulate matter air quality deterioration (0.3 ug/m^3) at a few receptors. The three-hour sulfur dioxide PSD increment consumption is shown in Figure 5.5-5,

which indicates only a very small area where positive increment consumption occurs. The magnitude of this consumption (67.7 ug/m^3) is still nearly a factor of eight below the allowable PSD increment of 512 ug/m^3 .

Since the major source at the site is the Big Bend generating facility, Big Bend will dominate source interactions and will determine worst case meteorological conditions for these interaction cases. Results for Big Bend alone show sulfur dioxide air quality improvement over the baseline at every point as compared to baseline concentration at the site for the 24-hour case and only a small, isolated deterioration for the 3-hour case. Days other than the critical worst days of Big Bend would create a large air quality improvement over the baseline at the site. Interacting sources therefore must be aligned with Big Bend's critical meteorological direction if they are to influence or deteriorate the sulfur dioxide air quality at the site. Thus, results of the sulfur dioxide short-term interaction indicate the largest increment consumption at the site is due solely to Big Bend, since the critical meteorology does not align other increment-consuming sources with Big Bend.

The maximum TSP 24-hour concentration from all four Big Bend units is 3.7 ug/m^3 at any location, which is below the significance level of 5 ug/m^3 .

5.5.1.4 EPA Annual Increment Consumption

The overall annual sulfur dioxide and TSP spatial increment consumptions at Big Bend are shown in Figures 5.5-6 and 5.5-7. Figure 5.5-6 shows a sulfur dioxide air quality improvement at all site receptors, whereas Figure 5.5-7 shows an increment consumption of 1.0 ug/m^3 at all site points. These values are well under the allowable TSP increment of 19 ug/m^3 .

5.5.1.5 EPA Short-Term Increment Consumption

The short-term increment consumption analysis was performed in accordance with the FDER rules for these sources, since the baseline emissions were determined to be the allowable rates. On August 7, 1977, the EPA baseline date, the allowable emissions were a 35 ton-per-hour, 3-hour cap and a 32 ton-per-hour, 24-hour cap for all units. These emission rates are consistent with the 1974 FDER baseline. The results for this section are presented in Figures 5.5-3, 5.5-4, and 5.5-5. A summary of all Class II PSD results is included in Tables 5.5-1 and 5.5-2.

5.5.2 Ambient Air Quality Standards (AAQS)

5.5.2.1 Compliance of Annual Averaged Values With AAQS

The EPA and FDER analysis to determine compliance with AAQS utilized all sources within a 50-kilometer radius, including all sources in Pinellas, Manatee, Pasco, and Hillsborough Counties. Emission rates and stack parameters were utilized at their maximum allowable values. Figures 5.5-8 and 5.5-9 portray the projected sulfur dioxide and TSP annual air quality levels, respectively, at the Big Bend site with all interacting sources.

The maximum annual sulfur dioxide concentration (18.5 ug/m^3) occurred towards downtown Tampa (see the northwest corner of the site map). The state of Florida sulfur dioxide annual AAQS is 60 ug/m^3 . The effect of Agrico Chemical's allowable emission rate on the TSP air quality at the site is to create an isolated TSP maximum of 69.3 ug/m^3 , with a background of 35 ug/m^3 , and to create an annual violation of AAQS at this point (AAQS is 60 ug/m^3). The Big Bend plant (all four units) does not contribute any TSP concentration to that particular receptor.

5.5.2.2 Short-Term Compliance With AAQS

The future 24-hour sulfur dioxide air quality at the site due only to the Big Bend facility with Unit 4 operating is shown in Figure 5.5-10. The maximum 24-hour concentration is 145 ug/m^3 .* The 24-hour AAQS is 260 ug/m^3 . The maximum 24-hour concentration, considering interaction with all sources in the vicinity of Big Bend, is 82 ug/m^3 . The addition of all other sources near Big Bend does not fully compensate for the loss of Big Bend's critical worst day or wind direction.

The 24-hour TSP concentrations due to Big Bend only are shown spatially in Figure 5.5-11. The maximum TSP concentration is 3.7 ug/m^3 which is below the significance level of 5 ug/m^3 . Further refinement and analysis were, therefore, not necessary for this pollutant (DER PSD Review, October 1978, and Federal Register, June 19, 1978).

The sulfur dioxide 3-hour concentrations due to the Big Bend facility are shown in Figure 5.5-12. The maximum concentration is 1086.5 ug/m^3 , which is below the 3-hour sulfur dioxide AAQS of 1300 ug/m^3 . The maximum interaction 3-hour concentration is 992 ug/m^3 .

* Note that slight discrepancies may exist between short-term concentrations as presented in the text and on the SYMAP figures due to refinements using the PTMPTW model.

5.5.3 Maximum Incremental Impact And Nonattainment Area Impact

Figures 5.5-13 and 5.5-14 present the sulfur dioxide and TSP annual-averaged incremental impact for Big Bend Unit 4, operating without Unit 3 (worst-case condition) (1). The maximum annual sulfur dioxide concentration is 1.0 ug/m^3 , whereas the maximum TSP concentration is much less than 1 ug/m^3 .

A short-term analysis of Unit 4 is presented in Figures 5.5-15, 5.5-16, and 5.5-17. Figure 5.5-15 shows the maximum 24-hour sulfur dioxide concentrations from the operation of Unit 4, only without Unit 3. The maximum concentration is 34.2 ug/m^3 . The maximum 24-hour impact on the Pinellas County sulfur dioxide nonattainment area is 4.0 ug/m^3 , which is below the 5 ug/m^3 level required for emission offsets.

The maximum 24-hour TSP concentration (see Figure 5.5-16) is 0.9 ug/m^3 . The Big Bend source is, therefore, not significant for TSP, and offsets are not required for the Hillsborough County TSP nonattainment area, which is 5.3 kilometers north of the plant. The 3-hour sulfur dioxide concentrations are provided in Figure 5.5-17, and the maximum concentration is 163 ug/m^3 . The sulfur dioxide impact for this source at the Pinellas County nonattainment area is 17.0 ug/m^3 , and the significance level is 25 ug/m^3 .

All air quality results are summarized in Table 5.5-3.

5.5.4 Worst Case Meteorology

Table 5.5-4 summarizes the worst days and 3-hour periods that resulted from execution of the CRSTER model. The PTMTPW computer model utilized these worst days both to refine the CRSTER results and to provide maximum interaction-caused concentrations and PSD increments with other sources in the vicinity of Big Bend.

The following PTMTPW's were executed for the purpose of resolving CRSTER results:

1. Maximum impact of Big Bend Unit 4 only (24-hour SO_2 and TSP and 3-hour SO_2 concentrations);
2. Maximum 3-hour SO_2 impact of Big Bend Unit 4 only at the Pinellas County nonattainment area;
3. Maximum impact of Big Bend Units 1-4 (24-hour SO_2 and TSP and 3-hour SO_2 concentrations).

The following PMTPW's were executed for the purpose of determining interaction-caused maximum concentrations and PSD increments:

4. Maximum 24-hour SO_2 and TSP and 3-hour SO_2 PSD Class II increment consumption, Big Bend Units 1-4 with all interacting units;
5. Maximum air quality impact with interacting sources (24-hour SO_2 and TSP and 3-hour SO_2).

5.5.5 Additional Impacts

Federal PSD regulations require an "Additional Impact Analyses," including "an analysis of the impairment to visibility, soils, and vegetation that would occur as a result of the source or modification." On the preamble to these regulations, further guidance is provided related to the required analysis: "The analysis related to a source's impact on soils, vegetation and visibility should focus primarily on such impacts in Class I areas....," and "The impact assessment should generally be qualitative in nature and designed to inform the general public of the relative impact of the source on those values."

In the vicinity of the Big Bend generating station, tomatoes are a major commercial crop. Since the AAQS and the allowable Class I and Class II PSD increments are not predicted to be exceeded due to operation of the proposed new unit, the impacts of operation upon soils and vegetation are not expected to be significant. Federal Primary AAQS were promulgated in order to protect the public health, and Secondary AAQS were promulgated in order to protect the public welfare (i.e. damage to vegetation, animals, soils, visibility, structures, etc.), both with an adequate margin of safety. As part of the Florida Sulfur Oxides Study (Environmental Research and Technology, Inc., 1978), a study was conducted in Florida of the environmental effects of ambient sulfur dioxide. The study concluded that "There is not reasonable basis in the established body of scientific information for assuming that existing federal ambient air quality legislation is not sufficiently stringent to protect Florida's environment from significant stress caused by sulfur oxides." It is noted that while the U.S. EPA has rescinded it's 24-hour and annual Secondary AAQS, the State of Florida has retained these standards, providing additional margin of safety beyond that already inherent in the federal standards.

Recently promulgated Federal NSPS for fossil-fuel fired steam generators limit the opacity of emissions from the proposed Big Bend Unit 4 to 20 percent, except for one 6-minute period per hour, when emissions are restricted to not more than 27 percent opacity (Federal Register, Vol. 44, No. 113, June 11, 1979). These opacity limits, coupled with the stringent NSPS requirements on sulfur dioxide and particulate matter emissions, will insure that impacts on and impairments to visibility will be minimal. The nearest Class I PSD area is located 92 km from Big Bend, and therefore no significant visibility impacts on such areas are expected due to operation of the proposed Big Bend Unit 4.

REFERENCE for 5.5

1. Prevention of Significant Deterioration Analysis, TECO Big Bend Unit 4. Prepared for Tampa Electric Company by Environmental Science and Engineering, Incorporated, Gainesville, Florida, 1979.

TABLE 5.5-1

FDER PREVENTION OF SIGNIFICANT DETERIORATION
 MAXIMUM INCREMENT CONSUMPTION ($\mu\text{g}/\text{m}^3$),
 TECO BIG BEND SITE

Case	Averaging Time				
	Annual*		24-Hour**		3-Hour**
	SO ₂	TSP	SO ₂	TSP	SO ₂
Big Bend Units 1-4 Only	0.0	0.0	-4.4***	0.3	67.7
With All Interacting Sources	-13.1***	24.0	-4.4***	3.7	67.7
EPA Allowable Class II Increment	20.0	19.0	91.0	37.0	512.0

Source: Environmental Science and Engineering, Inc., 1979.

* Annual includes all sources within a 50-kilometer radius.

** Short-term includes all sources within a 15-kilometer radius plus other major sources.

***Minus values indicate air quality improvement.

TABLE 5.5-2

EPA PREVENTION OF SIGNIFICANT DETERIORATION MAXIMUM
INCREMENT CONSUMPTION ($\mu\text{g}/\text{m}^3$),
TECO BIG BEND SITE

Case	Averaging Time				
	Annual*		24-Hour**		3-Hour**
	SO ₂	TSP	SO ₂	TSP	SO ₂
Big Bend Units 1-4 Only	0.0	0.0	-4.4***	0.3	67.7
With All Interacting Sources	-0.1***	26.6	-4.4**	3.7	67.7
EPA Allowable Class II Increment	20.0	19.0	91.0	37.0	512.0

Source: Environmental Science and Engineering, Inc., 1979.

* Annual includes all sources within a 50-kilometer radius.

** Short-term includes all sources within a 15-kilometer radius plus other major sources.

***Minus values indicate air quality improvement.

TABLE 5.5-3

MAXIMUM AIR QUALITY IMPACTS (mg/m³) BIG BEND SITE

Case	Averaging Time				
	Annual		24-Hour**		3-Hour**
	SO ₂	TSP	SO ₂	TSP	SO ₂
<u>Attainment Area Impact</u>					
Big Bend Unit 4 Only	1.0	<<1	34.2	0.9	163
Big Bend Units 1-4 Only	8.5	0.2	180	3.7	1,087
With All Interacting Sources	18.5	69.2***	82	128.1****	922
Florida AAQS	60	60	260	150	1,300
<u>Nonattainment Area Impact*</u>					
Big Bend Unit 4 Only	<<1	<<1	4.0	0.4	17.0
Allowable Significance Levels	1	1	5	5	25

Source: Environmental Science and Engineering, Inc., 1979.

- * SO₂ Impact at Pinellas County Nonattainment Area, and TSP Impact at Hillsborough County Nonattainment Area.
- ** Not to be exceeded more than once per year
- *** Includes background concentration of 35 ug/m³.
- **** Includes background concentration of 55 ug/m³.

TABLE 5.5-4
Worst Days/Periods Utilized in PM10 Computer Model

Regulations	Worst Day/Year	Critical Direction (Day)	Downwind Distances (KM)	Comments
SO ₂ (incremental)	220/71	90	2.3-2.7	SO ₂ + TSP 24-hour max. impact - Big Bend Unit 4 <u>only</u>
SO ₂ (incremental)	158/73 (4)	280	1.8-2.2	SO ₂ 3-hour max. impact - Big Bend Unit 4 <u>only</u>
SO ₂ , PSD (incremental)	328/71 (4)	320	at border	SO ₂ 3-hour max. impact - Big Bend Unit 4 <u>only</u>
SO ₂ (incremental)	207/72	90	5.3-5.7	SO ₂ + TSP 24-hour max. impact - Big Bend Units 1-4, all strategies
SO ₂ (incremental)	249/72 (4)	90	1.3-1.7	SO ₂ 3-hour max. impact - Big Bend Units 1-4, all strategies
PSD (interaction)	257/71	140	1.3-1.7	SO ₂ + TSP 24-hour max. increment consumption with interacting sources
PSD (interaction)	243/74 (4)	290	1.3-1.7	SO ₂ 3-hour max. increment consumption with interacting sources
	164/74 (4)	300	1.3-1.7	SO ₂ 3-hour max. increment consumption with interacting sources
SO ₂ (interaction)	238/73	180, 190	0.1-2.0	SO ₂ + TSP 24-hour max. impact with interacting sources
	226/74	340	0.1-2.0	SO ₂ + TSP 24-hour max. impact interacting sources
SO ₂ (interaction)	238/73 (5)	180, 190	0.1-2.0	SO ₂ 3-hour max. impact with interacting sources
	226/74 (4)	340	0.1-2.0	SO ₂ 3-hour max. impact with interacting sources

Source: Environmental Science and Engineering, Inc., 1979.

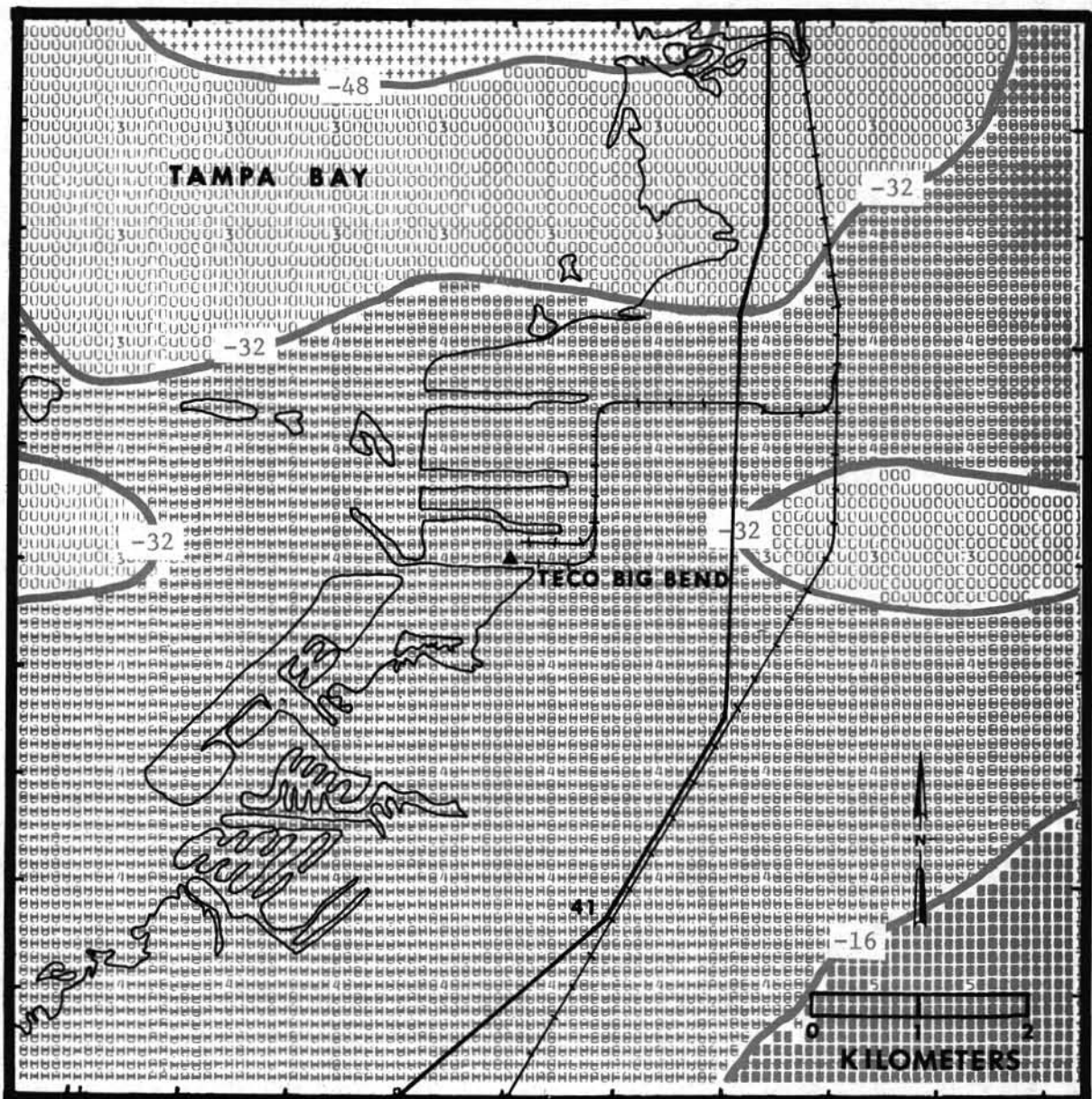


FIGURE: 5.5-1

TECO BIG BEND 4 PSD
ANNUAL AVERAGED CONCENTRATIONS (UG/CU, M)
DER PSD INCREMENT CONSUMPTION--S02--BIG BEND SITE

DATA VALUE EXTREMES ARE -45.50 -13.10

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(MAXIMUM INCLUDED IN HIGHEST LEVEL ONLY)

	1	2	3	4	5
MINIMUM	-80.00	-64.00	-48.00	-32.00	-16.00
MAXIMUM	-64.00	-48.00	-32.00	-16.00	0.0

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

LEVEL	1	2	3	4	5
PERCENTAGE	20.00	20.00	20.00	20.00	20.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5
SYMBOLS		++++++	00000000	HHHHHHHH	HHHHHHHH
		++++++	00000000	HHHHHHHH	HHHHHHHH
		++++++	00000000	HHHHHHHH	HHHHHHHH
		++++++	00000000	HHHHHHHH	HHHHHHHH
		++++++	00000000	HHHHHHHH	HHHHHHHH
FREQ.	0	5	31	77	8

0.007503 MINUTES FOR HISTOGRAM

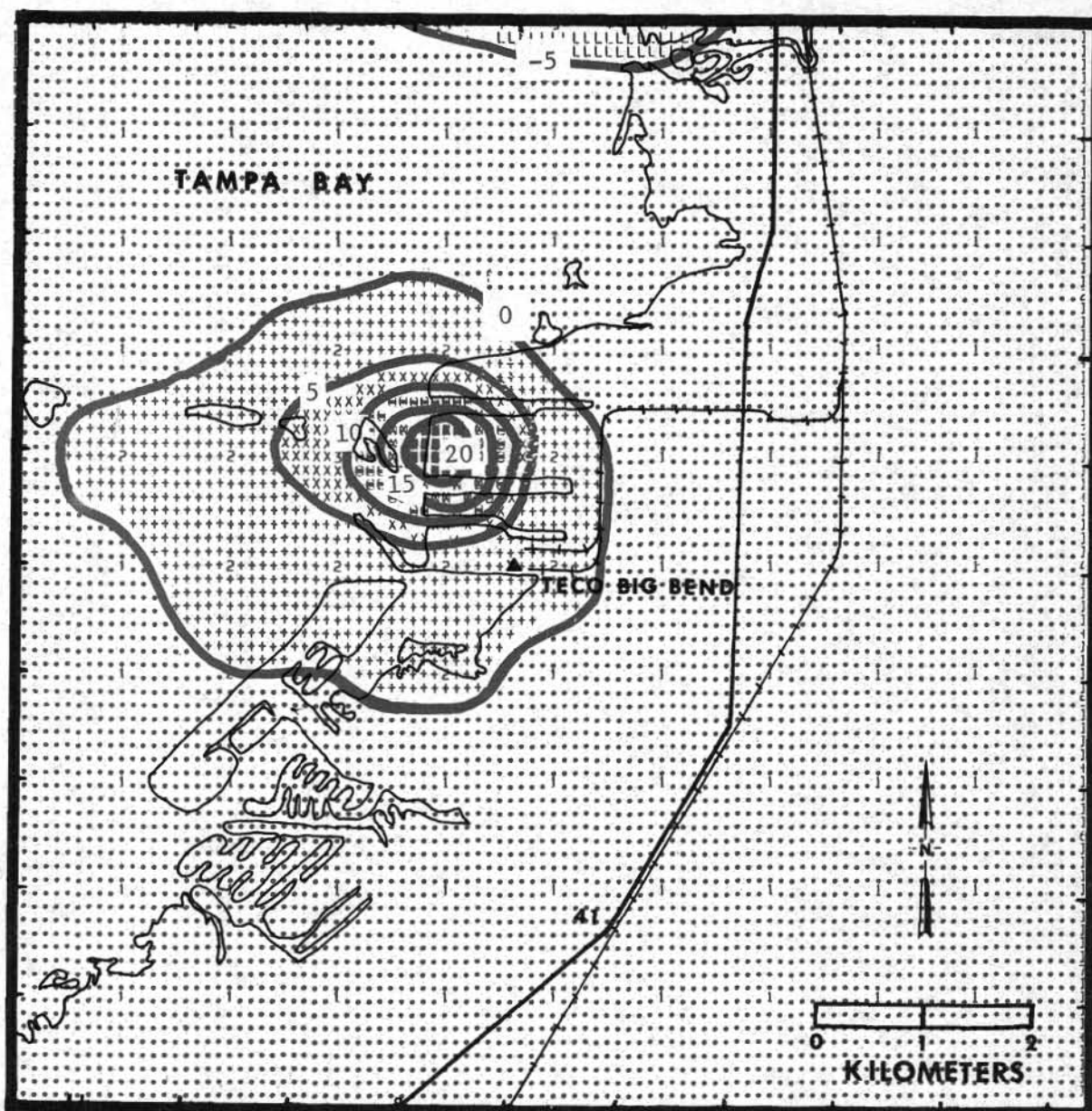


FIGURE: 5.5-2

TECO BIG BEND # PSD
ANNUAL AVERAGED CONCENTRATIONS (UG/CU. M)
DER PSD INCREMENT CONSUMPTION---TSP---BIG BEND SITE

DATA VALUE EXTREMES ARE -6.10 24.00

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(MAXIMUM INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	BELON	-5.00	0.0	5.00	10.00	15.00	20.00
MAXIMUM	-5.00	0.0	5.00	10.00	15.00	20.00	25.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

10.67	10.67	10.67	10.67	10.67	10.67
-------	-------	-------	-------	-------	-------

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6
SYMBOLS	LLLLLLLLLL	TTTTTTTTTT	XXXXXXXXXX	HHHHHHHH	HHHHHHHH	HHHHHHHH
FREQ.	3	104	12	1	0	1

0.065475 MINUTES FOR HISTOGRAM

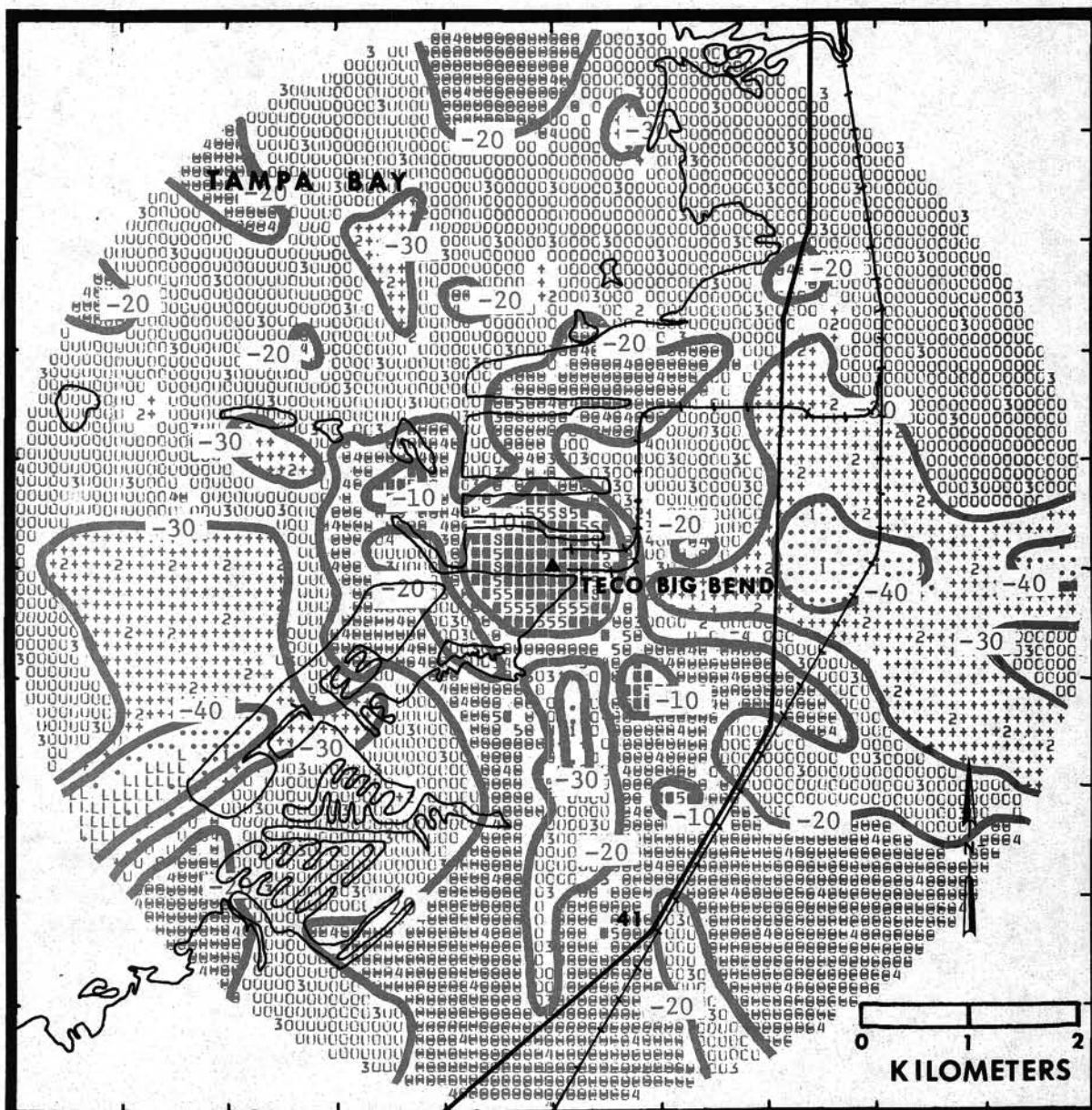


FIGURE: 5.5-3

TECO BIG BEND ONLY

HIGHEST, SECOND-HIGHEST 24-HOUR CONCENTRATIONS, UG/CU. M

SO2 24-HR INCREMENT CONSUMPTION

DATA VALUE EXTREMES ARE -60.50 0.0

TOTAL SUPERIMPOSED DATA POINTS IS 14. THESE OCCUR IN 7 LOCATIONS.

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(MAXIMUM INCLUDED IN HIGHEST LEVEL ONLY)

	BELOW	-50.00	-40.00	-30.00	-20.00	-10.00
MINIMUM	-50.00	-40.00	-30.00	-20.00	-10.00	0.0

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

	20.00	20.00	20.00	20.00	20.00
	20.00	20.00	20.00	20.00	20.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5
SYMBOLS	LLLLLLLLL	++++++	00000000	00000000	00000000
	LLLLLLLLL	++++++	00000000	00000000	00000000
	LLLLLLLLL	++++++	00000000	00000000	00000000
	LLLLLLLLL	++++++	00000000	00000000	00000000
	LLLLLLLLL	++++++	00000000	00000000	00000000
FREQ.	3	12	51	149	97

0.008766 MINUTES FOR HISTOGRAM

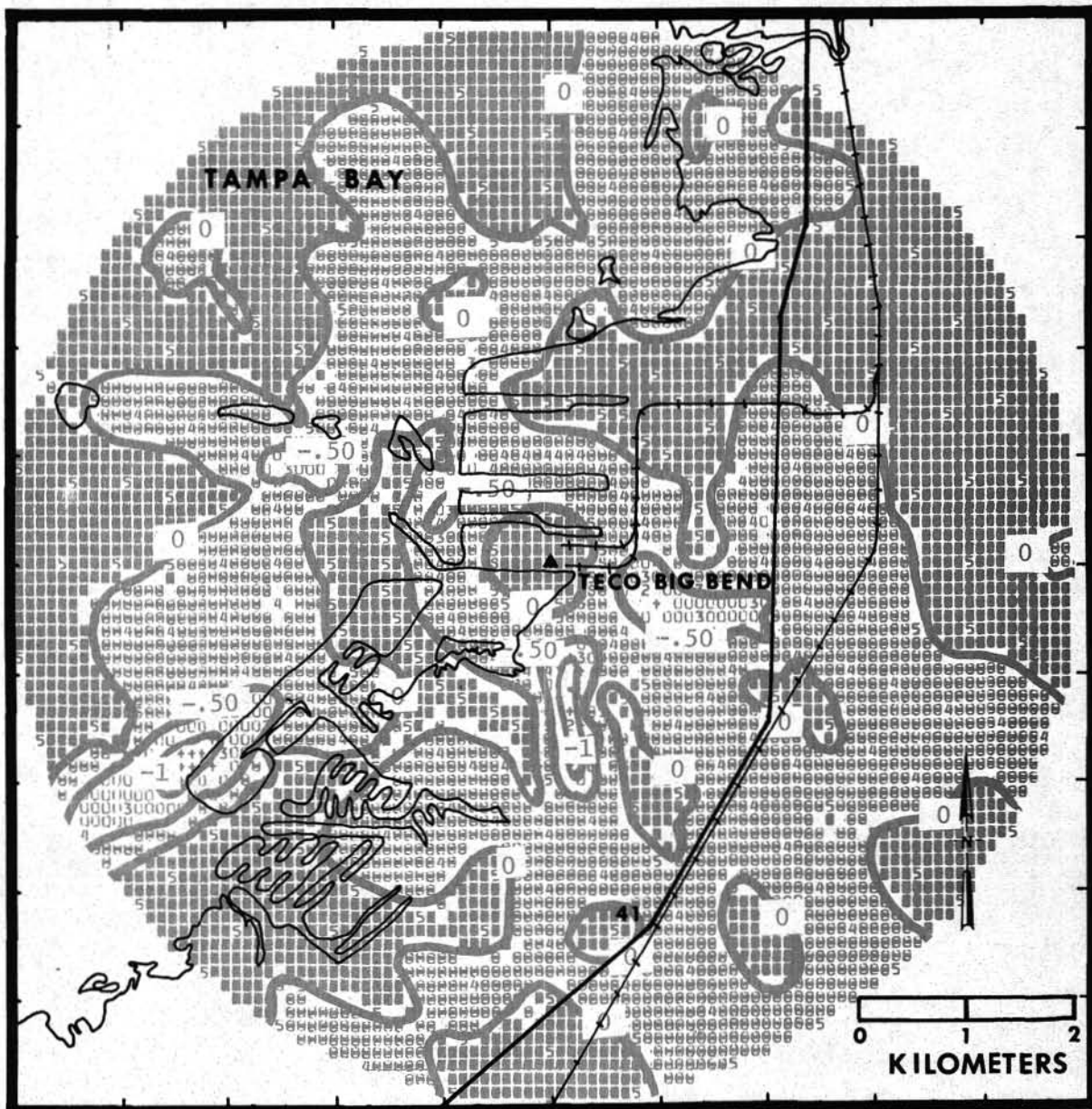


FIGURE: 5.5-4

TECO BIG BEND ONLY

HIGHEST, SECOND-HIGHEST 24-HOUR CONCENTRATIONS, UG/CM, M

TSP 24-HR INCREMENT CONSUMPTION

DATA VALUE EXTREMES ARE -1.80 0.30

TOTAL SUPERIMPOSED DATA POINTS IS 14. THESE OCCUR IN 7 LOCATIONS.

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(MAXIMUM INCLUDED IN HIGHEST LEVEL ONLY)

	2.00	1.50	1.00	0.50	0.0
MINIMUM	-2.00	-1.50	-1.00	-0.50	0.0
MAXIMUM	-1.50	-1.00	-0.50	0.0	0.50

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

	20.00	20.00	20.00	20.00	20.00
	20.00	20.00	20.00	20.00	20.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5
SYMBOLS	=====	++++++	00000000	00000000	00000000
	=====	++++++	00000000	00000000	00000000
	=====	++++++	00000000	00000000	00000000
	=====	++++++	00000000	00000000	00000000
	=====	++++++	00000000	00000000	00000000
FREQ.	1	4	16	126	213

0.003249 MINUTES FOR HISTOGRAM

FIGURE: 5.5-5

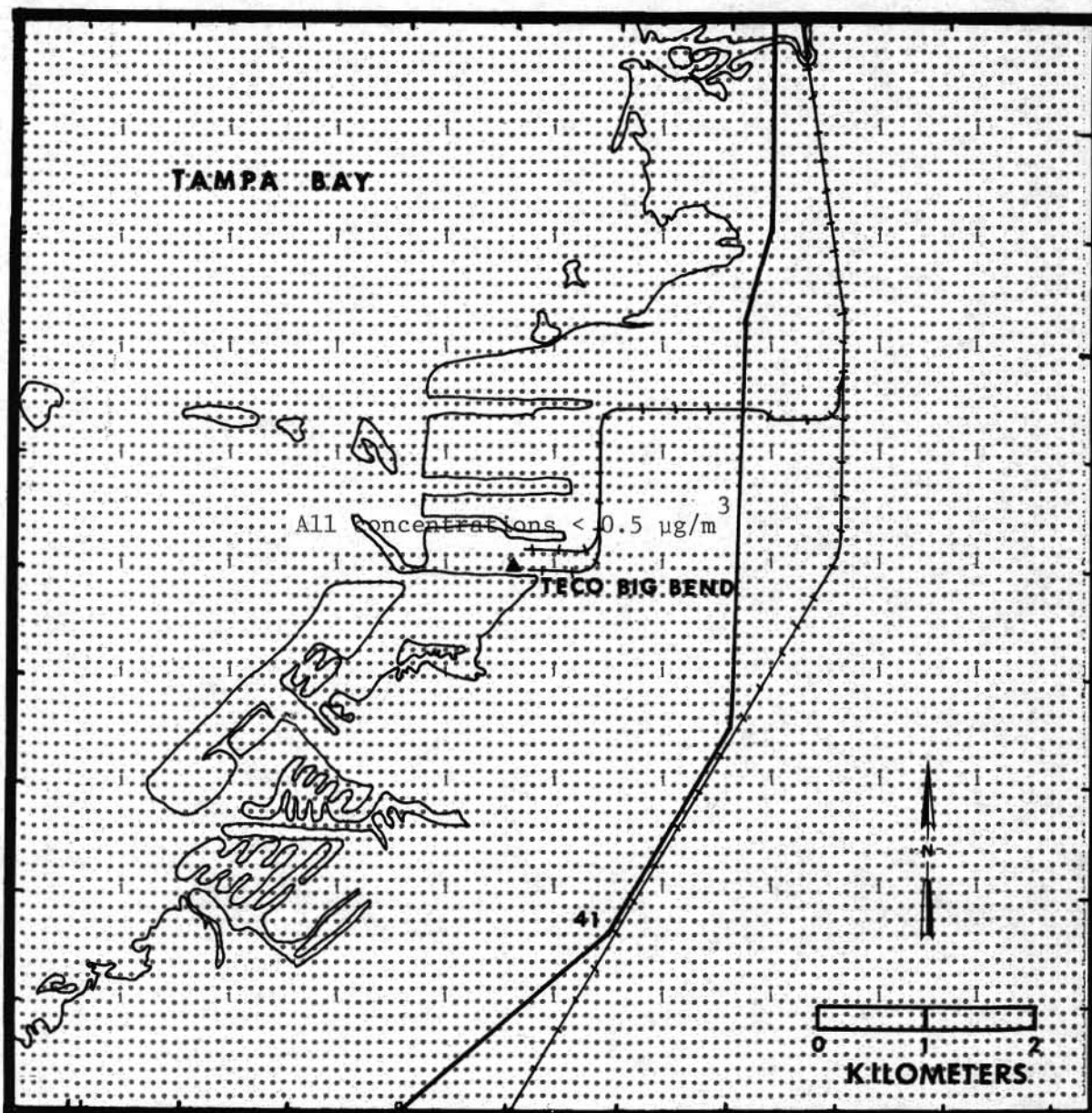


FIGURE: 5.5-6

TECO BIG BEND # PSD

ANNUAL AVERAGED CONCENTRATIONS (UG/CU. M)

EPA PSD INCREMENT CONSUMPTION---SO₂---BIG BEND SITE

DATA VALUE EXTREMES ARE -4.60 -0.10

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(MAXIMUM INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	-5.00	0.0
MAXIMUM	0.0	5.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

50.00 50.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2
SYMBOLS	1	2
FREQ.	121	0

0.005333 MINUTES FOR HISTOGRAM

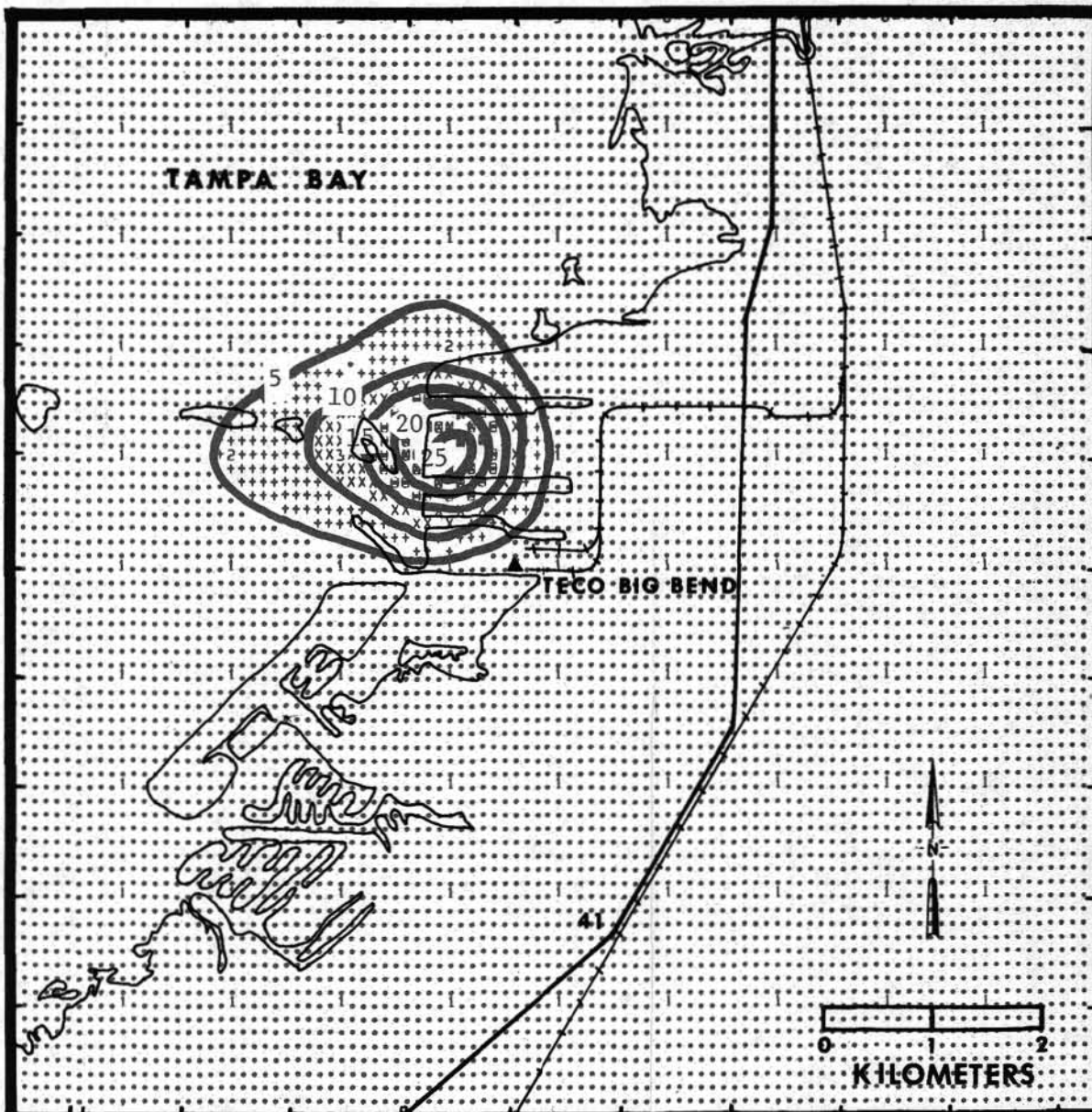


FIGURE: 5.5-7

TECO BIG BEND # PSD

ANNUAL AVERAGED CONCENTRATIONS (UG/CU. M)

EPA PROJECTED CONCENTRATIONS DUE TO NEW AND MODIFIED SOURCES--TSP--BIG B

DATA VALUE EXTREMES ARE 1.20 26.70

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(“MAXIMUM” INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	5.00	10.00	15.00	20.00	25.00	30.00
MAXIMUM	5.00	10.00	15.00	20.00	25.00	30.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

10.67	10.67	10.67	10.67	10.67	10.67
10.67	10.67	10.67	10.67	10.67	10.67

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6
SYMBOLS	117	2	1	0	0	1
FREQ.	117	2	1	0	0	1

0.029206 MINUTES FOR HISTOGRAM

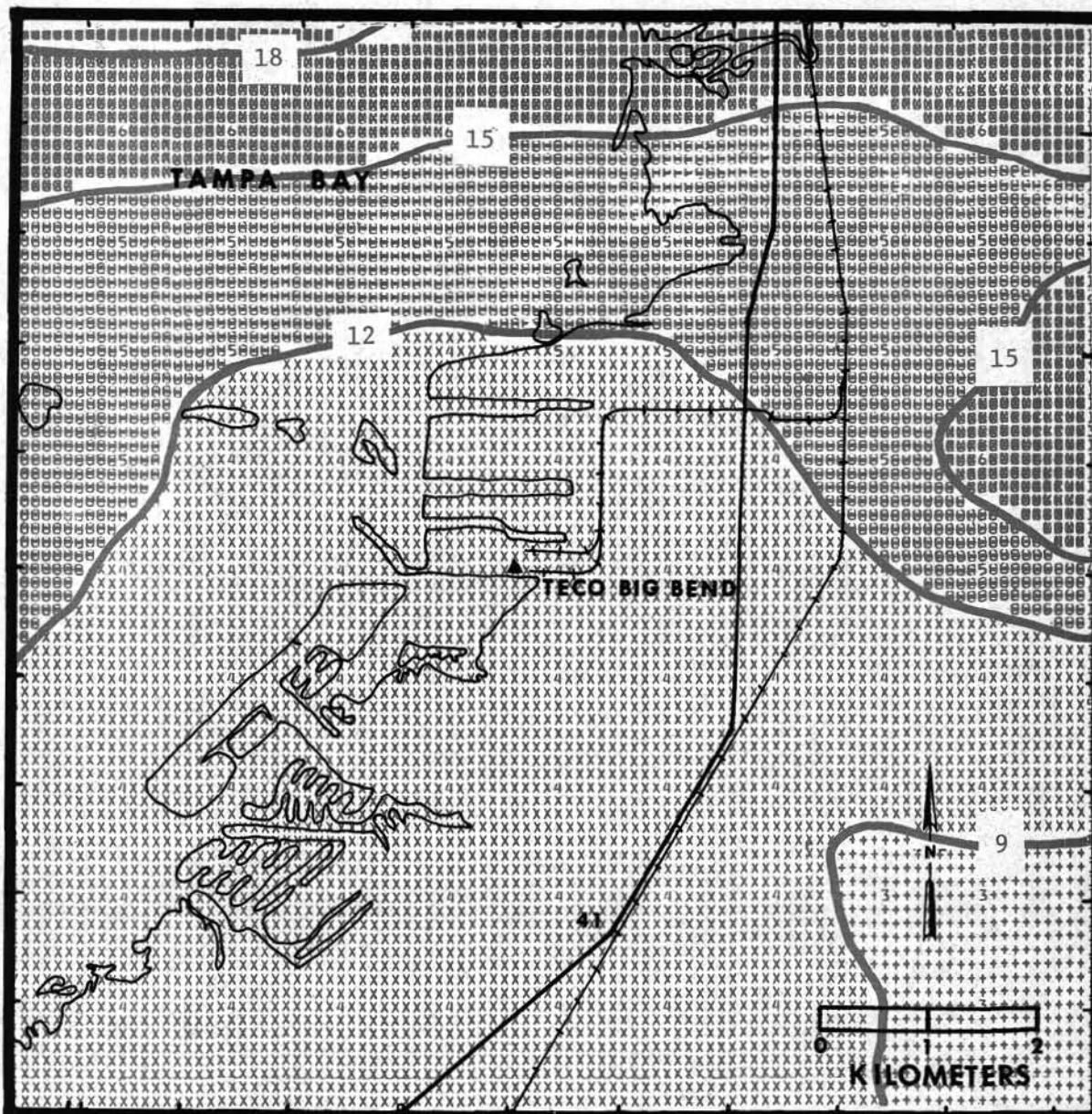


FIGURE: 5.5-8

TECO BIG BEND # PSD
ANNUAL AVERAGED CONCENTRATIONS (UG/CU. M)
DER SU2 PROJECTED--- ALL SOURCES---BIG BEND SITE

DATA VALUE EXTREMES ARE 8.30 18.50

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(MAXIMUM INCLUDED IN HIGHEST LEVEL ONLY)

	0.0	3.00	6.00	9.00	12.00	15.00	18.00
MINIMUM	0.0	3.00	6.00	9.00	12.00	15.00	18.00
MAXIMUM	3.00	6.00	9.00	12.00	15.00	18.00	21.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

	14.29	14.29	14.29	14.29	14.29	14.29	14.29
	14.29	14.29	14.29	14.29	14.29	14.29	14.29

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7
SYMBOLS	.....	.....	.....	.....	.....	.....	.....
FREQ.	0	0	7	63	27	19	5

0.017451 MINUTES FOR HISTOGRAM

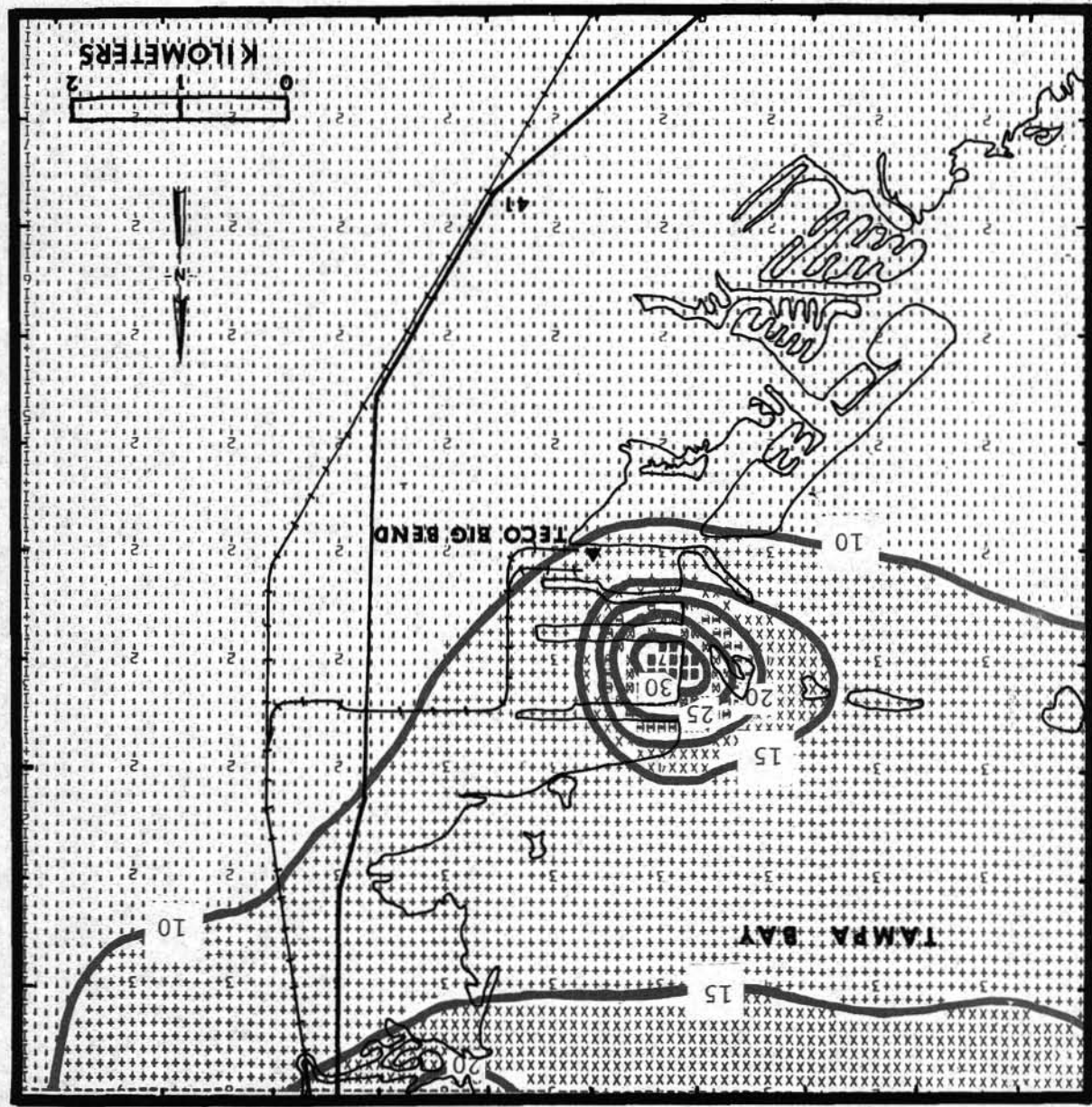


FIGURE 5.5-9

TECU BIG BLND & PSD
ANNUAL AVERAGED CONCENTRATIONS (UG/CU. M)
DER TSP PROJECTED--ALL SOURCES--BIG BEAD SILL
DATA VALUE EXTREMES ARE 5.30 34.30

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL (ONLY)

MINIMUM	MAXIMUM	PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
5.00	14.29	14.29
10.00	14.29	14.29
15.00	14.29	14.29
20.00	14.29	14.29
25.00	14.29	14.29
30.00	14.29	14.29
35.00	14.29	14.29

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7
SYMBOLS	XXXXXX	XXXXXX	XXXXXX	XXXXXX	XXXXXX	XXXXXX	XXXXXX
FREQ.	0	75	34	9	2	0	1

0.002614 MINUTES FOR HISTOGRAM

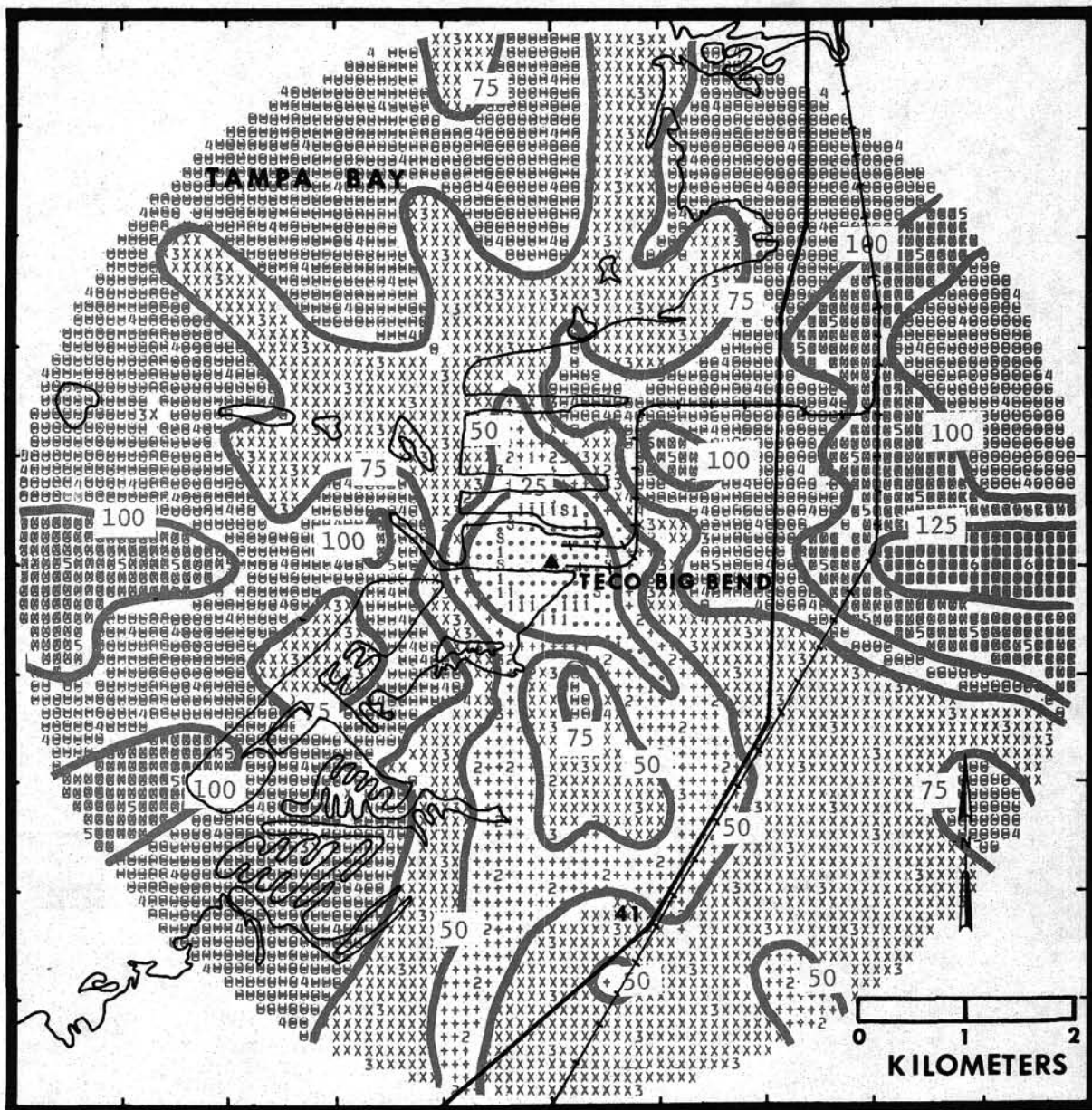


FIGURE: 5.5-10

TECO BIG BEND ONLY

HIGHEST, SECOND-HIGHEST 24-HOUR CONCENTRATIONS, UG/CU. M

SO2 24-HOUR COMPOSITE PROJECTED CONCENTRATIONS--ALL CASES

DATA VALUE EXTREMES ARE

0.0 146.30

TOTAL SUPERIMPOSED DATA POINTS IS

14. THESE OCCUR IN 7 LOCATIONS.

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(MAXIMUM INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	25.00	50.00	75.00	100.00	125.00
MAXIMUM	25.00	50.00	75.00	100.00	125.00	150.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

16.67	16.67	16.67	16.67	16.67	16.67
-------	-------	-------	-------	-------	-------

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6
SYMBOLS		++++++	XXXXXXXX	00000000	00000000	00000000
		++++++	XXXXXXXX	00000000	00000000	00000000
		++++++	XXXX3XXX	00004000	00005000	00006000
		++++++	XXXXXXXX	00000000	00000000	00000000
		++++++	XXXXXXXX	00000000	00000000	00000000
FREQ.	40	37	120	125	34	4

0.006899 MINUTES FOR HISTOGRAM

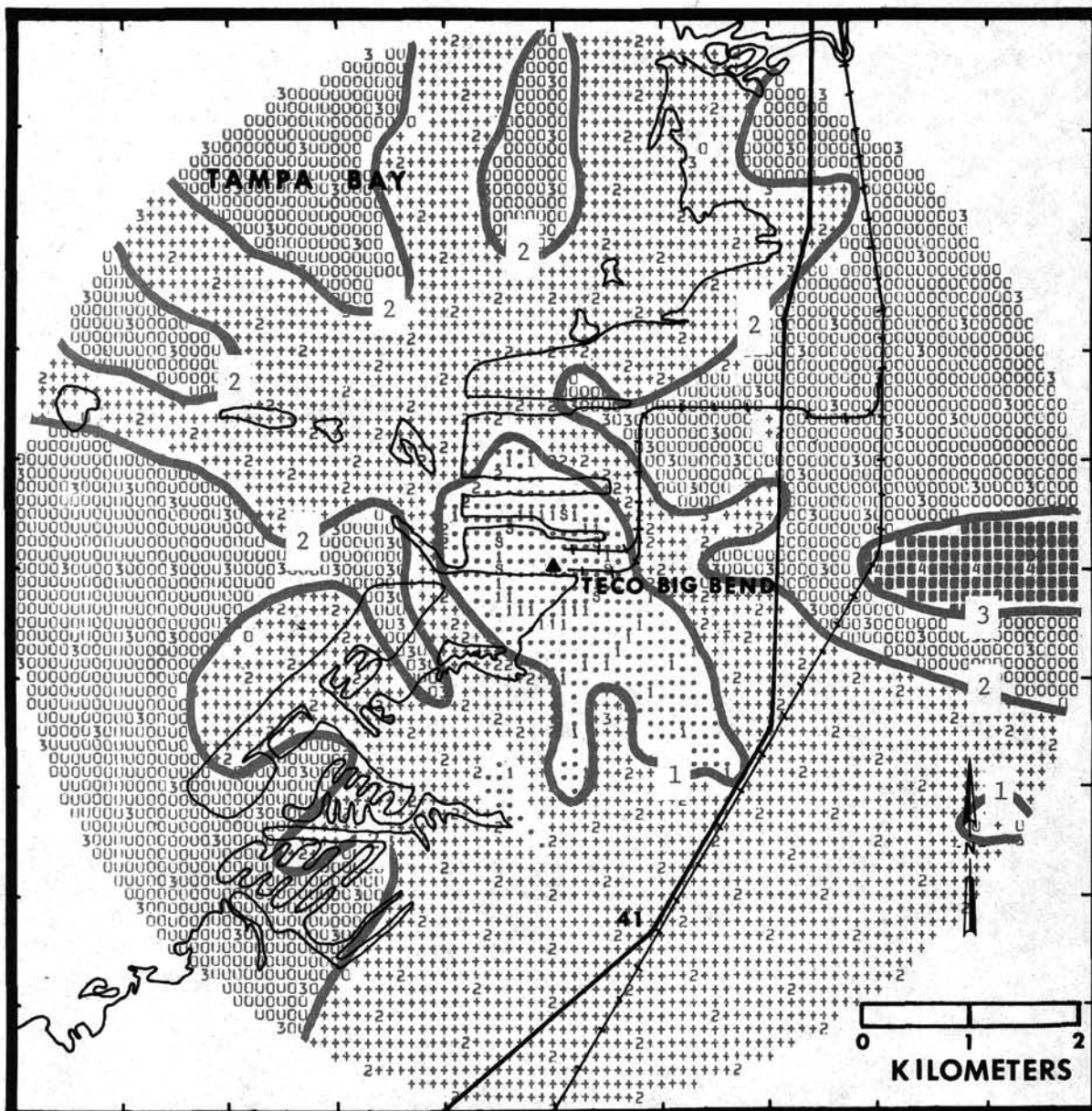


FIGURE: 5.5-11

TECU BIG BEND ONLY

HIGHEST, SECOND-HIGHEST 24-HOUR CONCENTRATIONS, $\mu\text{G}/\text{CU. M}$

TSP 24-HOUR COMPOSITE PROJECTED CONCENTRATIONS--ALL CASES

DATA VALUE EXTREMES ARE 0.0 3.60

TOTAL SUPERIMPOSED DATA POINTS IS 14. THESE OCCUR IN 7 LOCATIONS.

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(MAXIMUM INCLUDED IN HIGHEST LEVEL ONLY)

	0.0	1.00	2.00	3.00	4.00
MINIMUM	0.0	1.00	2.00	3.00	4.00
MAXIMUM	1.00	2.00	3.00	4.00	

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

	25.00	25.00	25.00	25.00
	25.00	25.00	25.00	25.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4
SYMBOLS	=====	++++++	00000000	=====
	=====	++++++	00000000	=====
	=====	++++++	00000000	=====
	=====	++++++	00000000	=====
	=====	++++++	00000000	=====
FREQ.	56	176	123	5

0.002414 MINUTES FOR HISTOGRAM

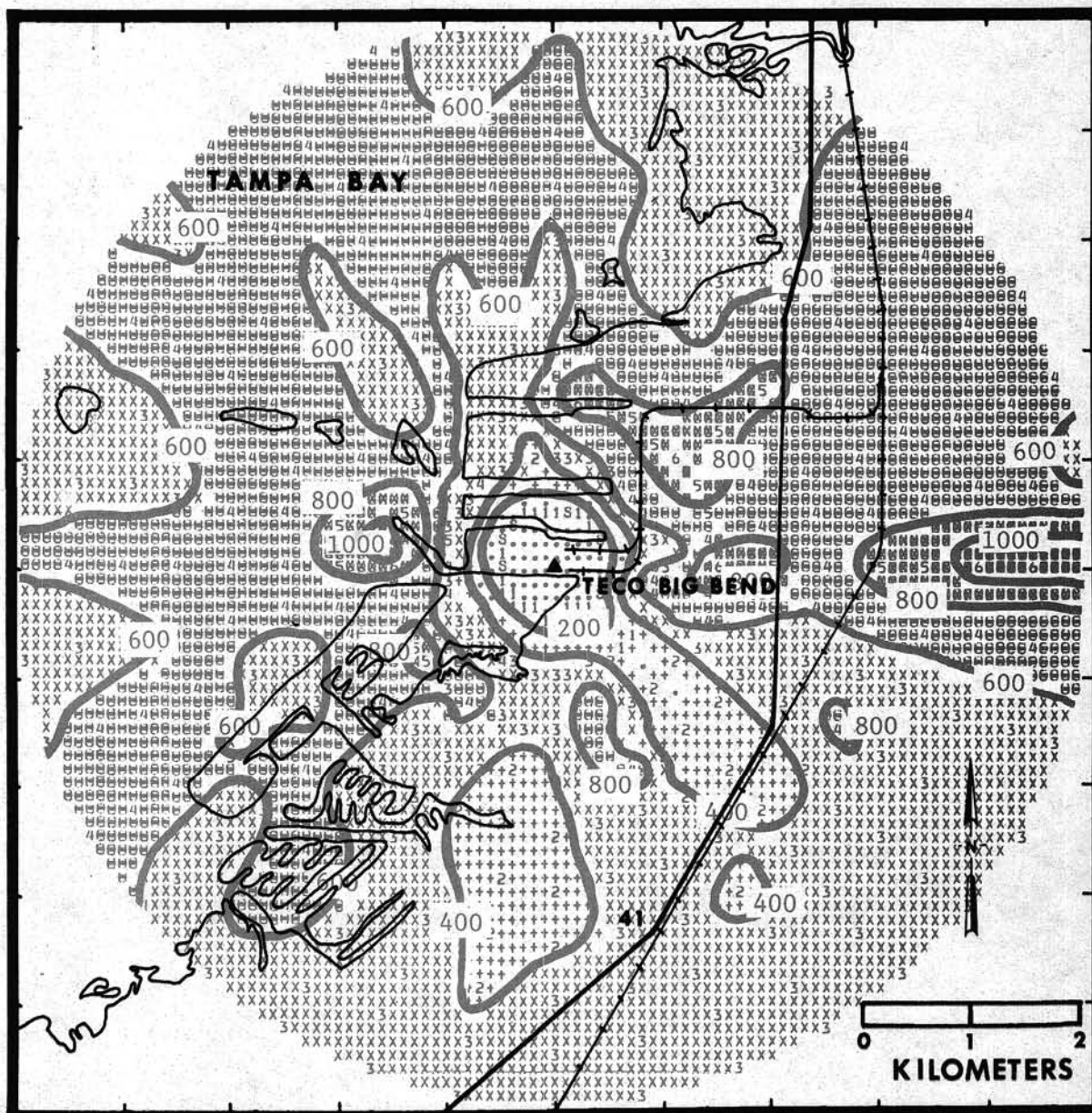


FIGURE: 5.5-12

TECO BIG BEND ONLY

HIGHEST, SECOND-HIGHEST 3-HOUR CONCENTRATIONS, UG/CU. M
 SO2 3-HOUR COMPOSITE PROJECTED CONCENTRATIONS--ALL CASES

DATA VALUE EXTREMES ARE 0.0 1086.50
 TOTAL SUPERIMPOSED DATA POINTS IS 14. THESE OCCUR IN 7 LOCATIONS.

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
 ('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	200.00	400.00	600.00	800.00	1000.00
MAXIMUM	200.00	400.00	600.00	800.00	1000.00	1200.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

16.67	16.67	16.67	16.67	16.67	16.67
-------	-------	-------	-------	-------	-------

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6
SYMBOLS	.....	++++++	XXXXXXXX	00000000	00000000	00000000
FREQ.	38	25	138	133	18	8

0.002039 MINUTES FOR HISTOGRAM

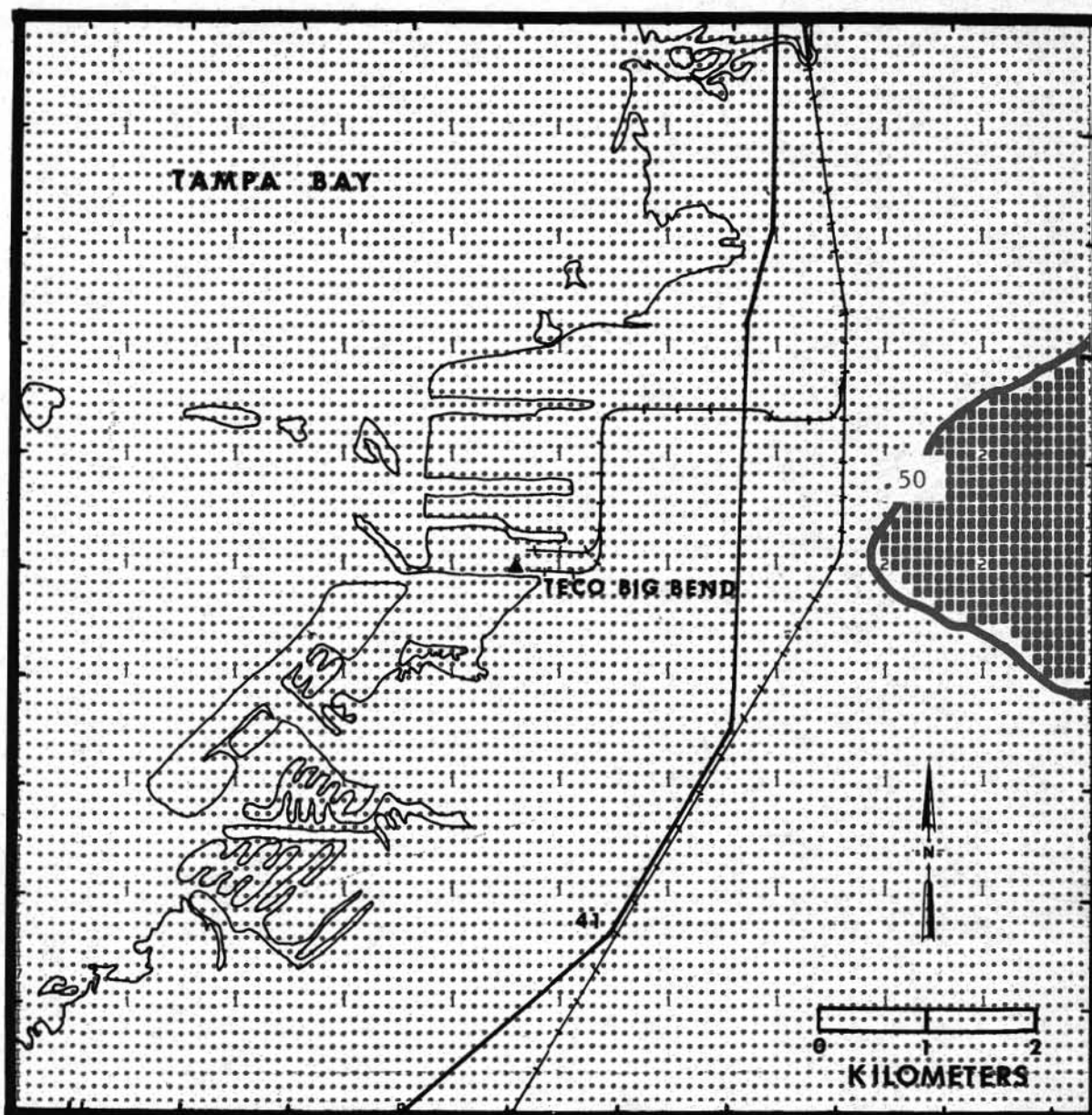


FIGURE: 5.5-13

TECO BIG BEND # PSD

ANNUAL AVERAGED CONCENTRATIONS (UG/CU. M)

BIG BEND UNIT 4 ONLY--SU2

DATA VALUE EXTREMES ARE 0.0 1.00

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(MAXIMUM INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.50
MAXIMUM	0.50	1.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

50.00	50.00
-------	-------

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2
SYMBOLS	113	8
FREQ.	113	8

0.003771 MINUTES FOR HISTOGRAM

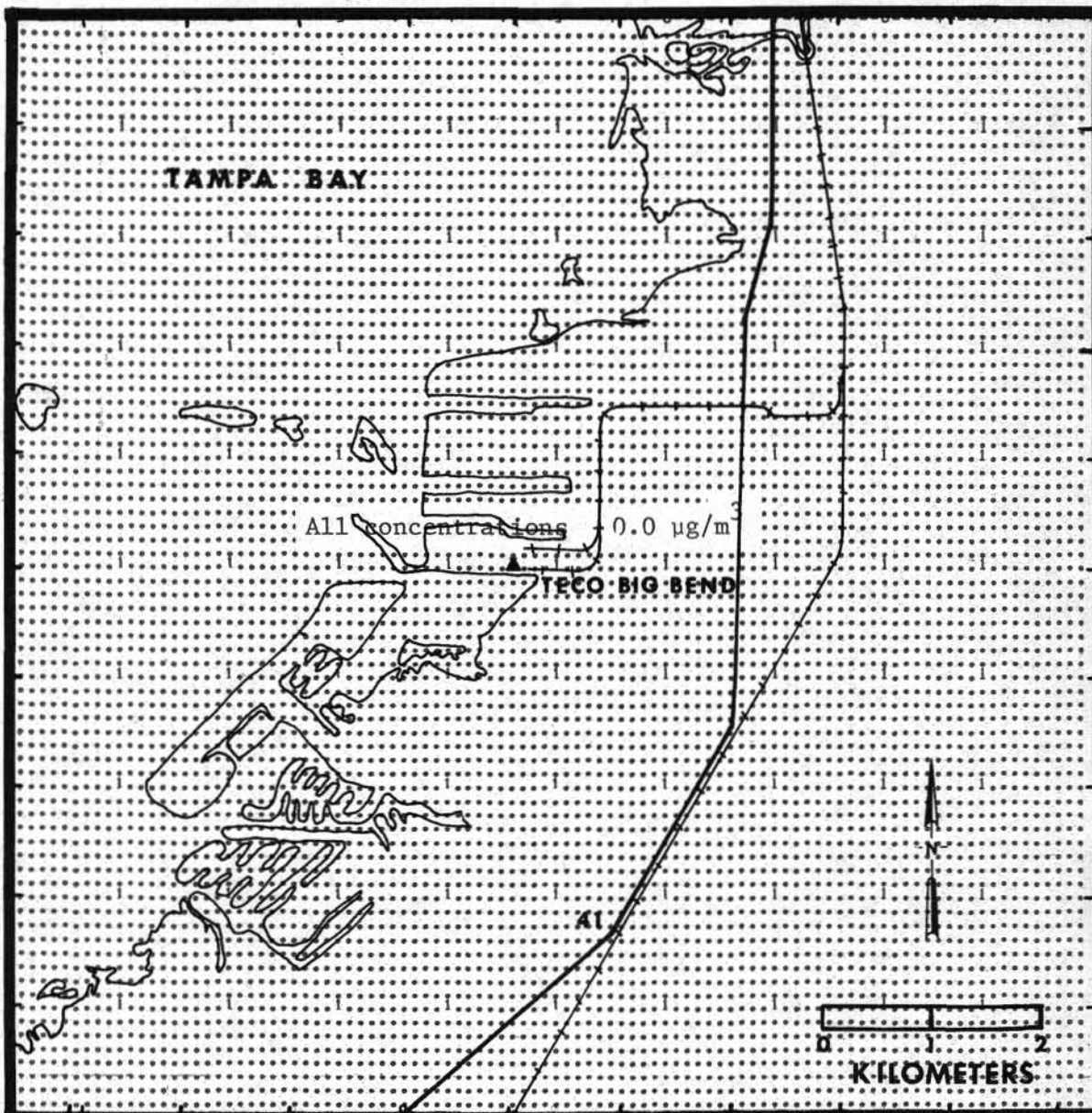


FIGURE: 5.5-14

TECO BIG BEND 4 PSD

ANNUAL AVERAGED CONCENTRATIONS (UG/CU. M)

BIG BEND UNIT 4 ONLY--TSP

DATA VALUE EXTREMES ARE 0.0 0.0

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(MAXIMUM INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0
MAXIMUM	1.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

100.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1
SYMBOLS	*****

FREQ.	121

0.002311 MINUTES FOR HISTOGRAM

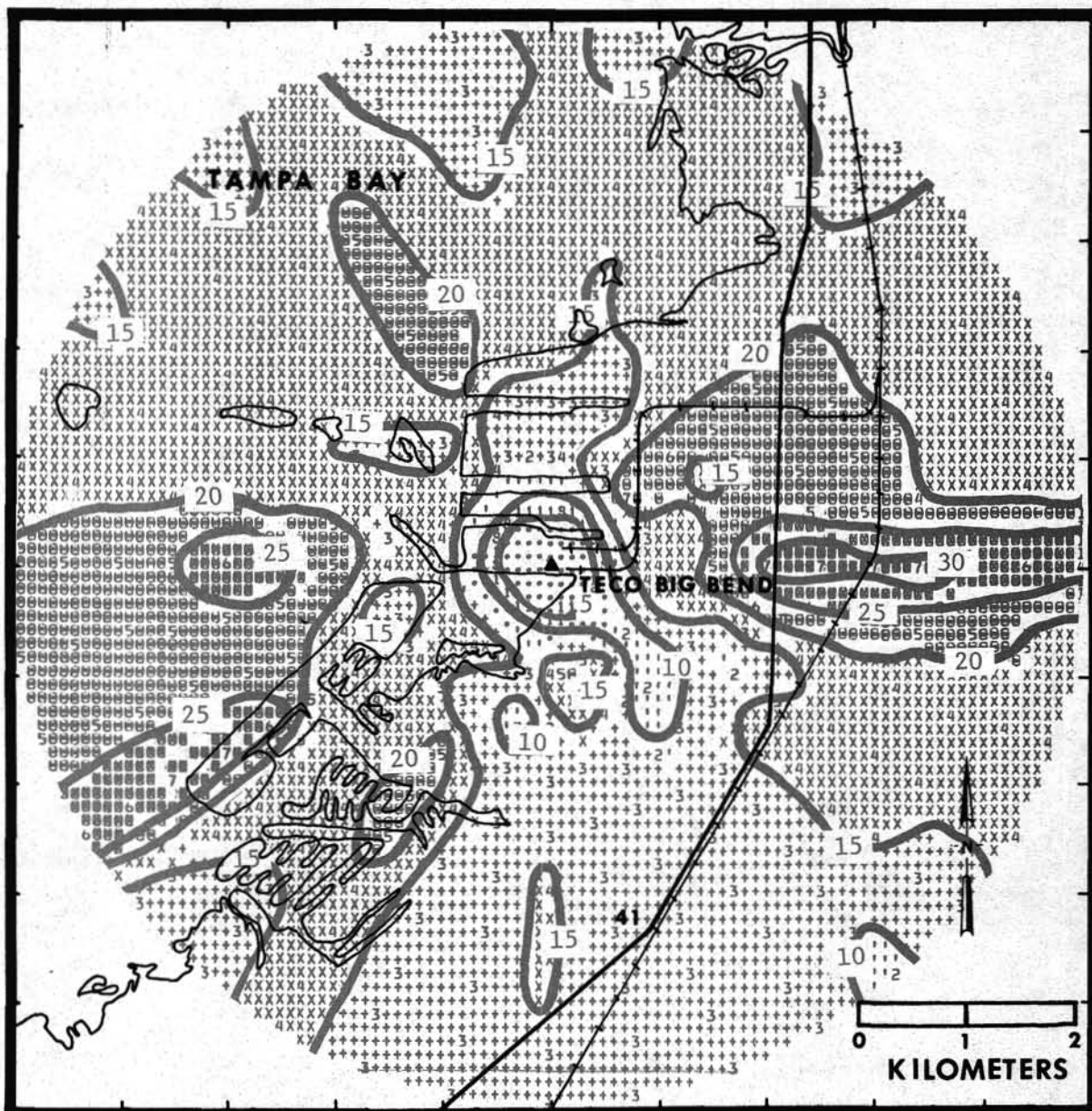


FIGURE: 5.5-15

TECO BIG BEND ONLY

HIGHEST, SECOND-HIGHEST 24-HOUR CONCENTRATIONS, $\mu\text{G}/\text{CU. M.}$

902 24-HOUR PROJECTED CONCENTRATIONS--UNIT 4 ONLY

DATA VALUE EXTREMES ARE 0.0 34.10

TOTAL SUPERIMPOSED DATA POINTS IS 14. THESE OCCUR IN 7 LOCATIONS.

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(MAXIMUM INCLUDED IN HIGHEST LEVEL ONLY)

	0.0	5.00	10.00	15.00	20.00	25.00	30.00
MINIMUM	0.0	5.00	10.00	15.00	20.00	25.00	30.00
MAXIMUM	5.00	10.00	15.00	20.00	25.00	30.00	35.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

	14.29	14.29	14.29	14.29	14.29	14.29	14.29
PERCENTAGE	14.29	14.29	14.29	14.29	14.29	14.29	14.29

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7
SYMBOLS	.....	.....	.....	.....	.....	.....	.....
FREQ.	37	11	93	150	50	12	7

0.002246 MINUTES FOR HISTOGRAM

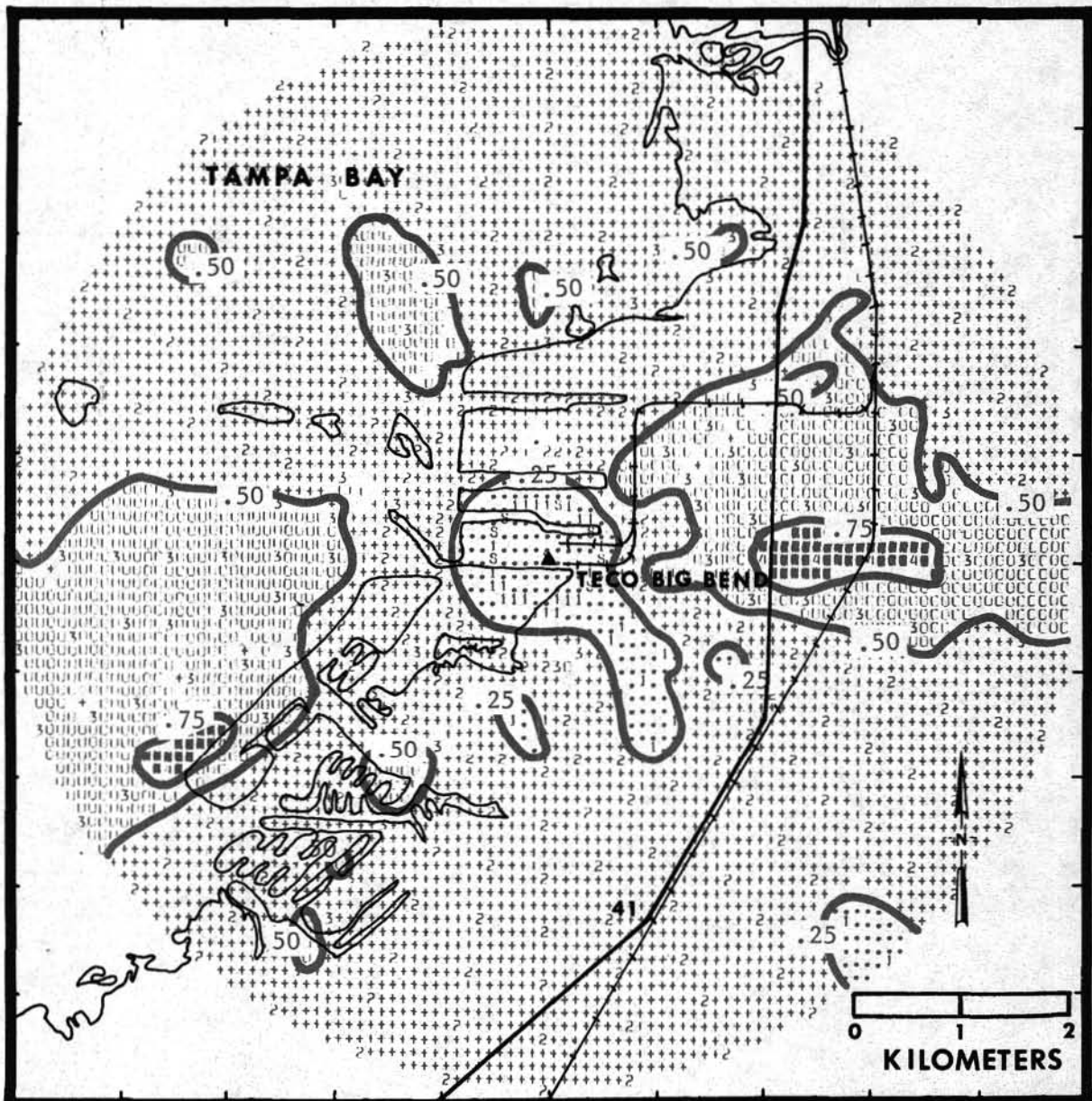


FIGURE: 5.5-16

TECU BIG BEND ONLY
 HIGHEST, SECOND-HIGHEST 24-HOUR CONCENTRATIONS, UC/CC, P
 TSP 24-HOUR PROJECTED CONCENTRATIONS--UNIT 1 ONLY

DATA VALUE EXTREMES ARE 0.0 0.90

TOTAL SUPERIMPOSED DATA POINTS IS 14. THESE OCCUR IN 7 LOCATIONS.

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
 (*MAXIMUM INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.25	0.50	0.75
MAXIMUM	0.25	0.50	0.75	1.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

25.00	25.00	25.00	25.00
-------	-------	-------	-------

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4
SYMBOLS	+++++	+++++	+++++	+++++
FREQ.	50	205	98	7

0.002983 MINUTES FOR HISTOGRAM

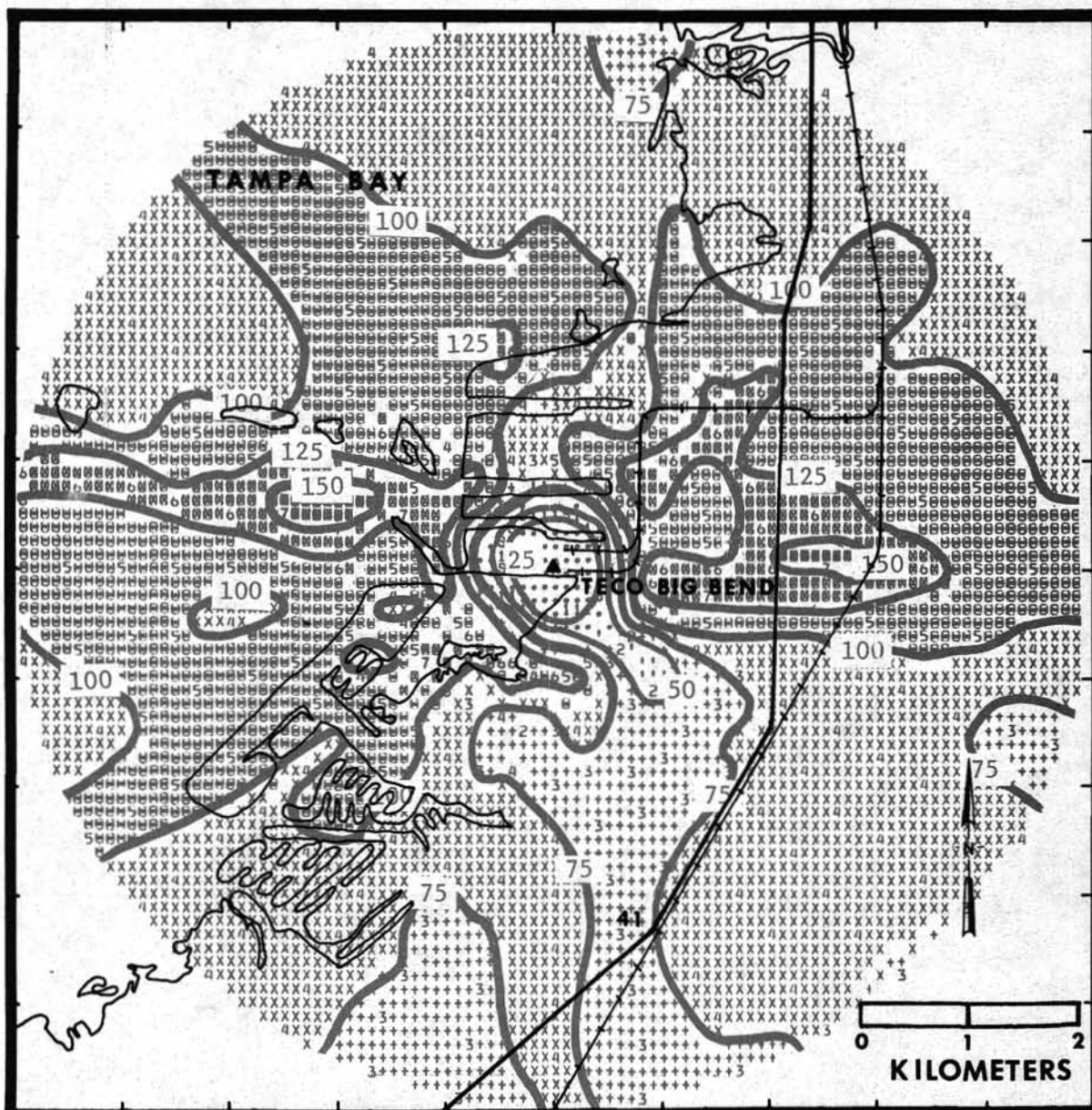


FIGURE: 5.5-17

TECO BIG BEND ONLY

HIGHEST, SECOND-HIGHEST 3-HOUR CONCENTRATIONS, UG/CU. M

SUP 3-HOUR PROJECTED CONCENTRATIONS--UNIT 4 ONLY

DATA VALUE EXTREMES ARE 0.0 160.60

TOTAL SUPERIMPOSED DATA POINTS IS 14. THESE OCCUR IN 7 LOCATIONS.

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(MAXIMUM INCLUDED IN HIGHEST LEVEL ONLY)

	0.0	25.00	50.00	75.00	100.00	125.00	150.00	175.00
MINIMUM	0.0	25.00	50.00	75.00	100.00	125.00	150.00	175.00
MAXIMUM	25.00	50.00	75.00	100.00	125.00	150.00	175.00	

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

	14.29	14.29	14.29	14.29	14.29	14.29	14.29
	14.29	14.29	14.29	14.29	14.29	14.29	14.29

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7
SYMBOLS	=====	=====	++++++	XXXXXXXX	HHHHHH	HHHHHH	HHHHHH
FREQ.	36	5	41	130	102	39	7

0.002411 MINUTES FOR HISTOGRAM

5.6 EFFECTS OF OPERATION AND MAINTENANCE OF TRANSMISSION FACILITIES

Because the only change in the transmission system for adding Unit No. 4 will be the addition of a 230-kV line to the existing towers, no adverse environmental impacts are expected. The Unit No. 4 transmission line will be installed in the existing right-of-way. There will be no new access roads for this project. The existing lines are visible from only a few frequently traveled public roads. There will be no unusual maintenance methods and only mowing is required for controlling vegetation. The added aesthetic impact on the surrounding area will be minimal since the installation involves only the addition of conductors to existing towers. As evidenced by the existing lines in this area and in other parts of TECO's system at this voltage level, there will be no noticeable electric or acoustic noise, no dangerous induced or conducted ground currents, and no measurable production of ozone.

Although there is a potential for bird mortality resulting from collision and electrocution with the high voltage transmission lines and towers associated with Unit 4, the potential for either occurrence is small for the following reasons:

1. Birds must make contact with two conductors or a conductor and the tower to be electrocuted. The powerlines (conductors) are positioned with large spaces (20 ft) between adjacent lines and also between the lines and the tower. The distance is sufficient such that even the largest birds would be unable to make simultaneous contact.
2. The transmission towers which currently carry the conductors for Unit 3 will be used for Unit 4's conductors. The Unit 4 lines will be placed at the same elevations as those for Unit 3, in a stacked configuration, and will run parallel to but on the opposite side of each tower from the Unit 3 lines. The addition of these lines to existing towers minimizes the increment in spatial obstruction to bird movement, by comparison to the construction of new transmission towers. Furthermore, the conductors for Unit 4 will extend only 2970 ft from Unit 4 to the existing Big Bend Substation.

Therefore, the proposed placement of Unit 4's widely spaced transmission lines on existing transmission towers represents a configuration which minimizes both bird electrocution and collision potential.

5.7 ASSOCIATED FACILITIES AND OTHER EFFECTS

5.7.1 Effects of Associated Facilities

FGD Disposal Area

The operational effects of the FGD storage/disposal area are expected to be similar to the construction effects which were described in Section 4.5. The noise impacts are discussed in the following section; the land use impacts are discussed in Section 5.8. Possible leachates from this site are discussed in Section 5.2.

5.7.2 Other Plant Operation Effects

5.7.2.1 Noise

The major continuous sources of operational noise from Big Bend Unit 4 will be the main transformers, boiler, forced draft fans, primary air fans, induced draft fans, flue gas desulfurization system, and noise radiated from the turbine building. The sound generated by these sources will remain relatively constant for any operating load of the unit. The PA system and the coal handling system will continue to be intermittent sources of operational noise. However, with the addition of Unit 4, the intermittent sound levels are not expected to change significantly from the intermittent sound levels currently generated by Units 1 through 3. An additional source of intermittent noise will be the bulldozer and trucks used in the FGD gypsum storage/disposal area; however, bulldozer operation in this area will be limited to daytime hours. The sound levels expected from Big Bend Unit 4 have been predicted for each of the ambient measurement locations. These levels will be combined with the sound levels from Big Bend Units 1 through 3 to estimate the total operational sound levels from the station.

Operational sound level predictions for Big Bend Unit 4 were made using manufacturer's data for the transformers, forced draft fans, and induced draft fans, and with typical sound level data from the EEI Guide⁽¹⁾ for the other sources. The noise source data was developed as sound power levels for each piece of equipment. The sound level at each ambient measurement location was calculated assuming hemispherical propagation and atmospheric absorption for standard conditions (20°C, 70 percent RH). Also, the directivity effects of stack-radiated noise from the induced draft fans and booster fans and the shielding of transformer noise by the turbine buildings were included in the calculation. Excess attenuation from meteorological and terrain effects

was not included in the calculation, but could actually cause the sound levels to be lower than predicted under many conditions. Sound power levels for the forced draft fans, PA fans, induced draft fans, and booster fans were reduced by approximately 15 dB to account for noise control treatments. Sound levels predicted for the FGD gypsum disposal area bulldozer were the maximum levels expected during use of the Phase I portion of the disposal area. At all ambient measurement locations except Location 6 these sound levels would remain the same during use of any of the disposal areas. Sound levels from Phase II of the disposal area would be lower, but predicted sound levels for Phase III and IV would be higher at Location 6 and at the nearby trailer park, respectively, than were predicted for Phase I. However, noise control options for the bulldozer would be investigated should Phase III or IV of the disposal area eventually be used.

The calculated continuous sound level contributions from Units 1 through 3 were made using sound power levels computed from the onsite measurements made at Locations 1, 2, and 3 during the ambient survey. Units 1 through 3 were generally operating between 175-350 MW during the measurements. The sound levels from Units 1 through 3 were calculated in the same manner as used for the Unit 4 calculations assuming hemispherical propagation and atmospheric absorption at standard conditions. Again, these predicted sound levels did not include the attenuating effects of meteorological and terrain conditions.

The continuous sound levels from Units 1 through 3; Unit 4; and Units 1 through 4; as well as the daytime and nighttime intermittent sound levels from Units 1 through 4 are shown in Table 5.7-1 for each ambient measurement location. All the predicted sound levels meet the maximum permissible sound level limit in the Hillsborough County noise code⁽²⁾ of 60 dBA during the daytime and 55 dBA during the nighttime in a residential area. In addition, the total continuous sound levels are lower than the average nighttime residual sound levels at Locations 4, 5, and 8 and within 4 and 2 dBA of those ambient levels at Locations 6 and 7, respectively. The nighttime intermittent sound levels are 2 to 9 dBA higher than the residual nighttime levels (see Section 2.9.1), and the daytime intermittent sound levels are 0 to 17 dBA higher than the residual daytime levels. However, similar variations in ambient sound levels presently occur due to existing ambient noise sources. Therefore, no significant noise impact is expected at the surrounding residences from the additional operational noise from Unit 4.

The operational sound levels for Big Bend Units 1 through 4 are discussed in Section 2.9.1 These levels are somewhat

less than the construction noise levels discussed in Section 4.1.5. Most of the species which presently occur near the site are expected to have habituated to the operational sound levels resulting from Units 1 through 3. Following construction of Unit 4, these species are expected to habituate again to the operational sound levels from Units 1 through 4. Intermittent noise associated with the operation of the FGD disposal/storage area may decrease the use of adjacent areas by wildlife, especially birds and larger mammals; however, their use of the area is presently relatively low because of the recent use of the land for crop and livestock forage production.

5.7.2.2 Water Use

Well water from the Riverview-Gibsonston system will supply the station demineralizer system used to provide high quality makeup to the steam generators. The total expected water requirements for this system are summarized in Section 3.3.

The average annual station consumption since May 1976 (three-unit operation) is 56,600,000 cubic feet per year (805.5 gpm). The FGD system demand is estimated to be 49,000,000 cubic feet per year (700 gpm) and represents the major portion of the Unit 4 freshwater consumption. Not inclusive of the FGD system, the water demand for 4-unit operation utilizing a recycle system will be similar to the water demands for 3-unit operation prior to installation of the recycle system. A significant quantity of recycled water can be used instead of potable water for equipment washing. The recycle water system was designed to reduce unit consumption by 40 percent.

The increase in station water use due to Unit 4 will not have a significant effect on local water supplies. If the Hillsborough County South/Central water system cannot adequately supply water, an alternate water supply will be utilized. Hillsborough County is in the process of studying their water system and are including Big Bend Unit 4 in their long range plans. Hillsborough County is also willing to work with the Applicant in developing an alternate water supply.

The Hillsborough County South 201 Facility Plan includes provisions for Big Bend Station of 1.3 MGD of secondary effluent for reuse. A copy of the facility phasing schedule is attached (Table 5.7-2). The plan states that the water may be available in June 1986. This allotment is only a

possibility since no firm commitments have been made either by TECO or Hillsborough County.

5.7.2.3 Land Use

The Big Bend Station, as well as several other industrial type facilities, is located on the shores of Tampa Bay and Hillsborough Bay to take advantage of the excellent water and surface transportation available in this area.

Big Bend Unit No. 4 will be located on a site already occupied by Big Bend Unit Nos. 1, 2, and 3. Land occupied by these units was created by a landfill operation, and lands adjacent to Big Bend Station to the north and east have been designated as industrial areas in the Horizon 2000 of Hillsborough County (see Section 2.2, Figure 2.2-7). Therefore, it is not expected that the construction of Unit No. 4 will interfere with the contemplated land use development in this area.

REFERENCES for 5.7

1. Electric Power Plant Environmental Noise Guide, Edison Electric Institute, New York, 1978.
2. Rules of the Hillsborough County Environmental Protection Commission, Chapter 1-10, Noise, Adopted June 10, 1976.
3. Hillsborough County South 201 Facility Plan, Hillsborough County. July, 1979.

TABLE 5.7-1

PREDICTED MAXIMUM OPERATIONAL SOUND LEVELS

(dBA re: 0.0002 Microbars)

Ambient Measurement Locations	Ambient Residual Sound Levels* (dBA)		Units 1, 2, 3 Continuous Sound Levels (dBA)	Unit 4 Continuous Sound Level (dBA)	Units 1, 2, 3, 4 Continuous Sound Level (dBA)	Units 1, 2, 3, 4 Intermittent Sound Level (dBA)	
	Day	Night				Day	Night
Location 4 - 7500 ft NE at Adamsville	46	43	36	39	41	46	46
Location 5 - 3800 ft LSE at Big Bend Road	53	52	45	46	49	56	55
Location 6 - 4000 ft S at Newman Branch Road	43	44	44	45	48	60	54
Location 7 - 8000 ft SSW at Apollo Beach Road	43	37	35	36	39	47	45
Location 8 - 8000 ft SW at Apollo Beach Hotel	45	42	35	36	39	45	45

*From Table 2.9-2

TABLE 5.7-2

HILLSBOROUGH SOUTH 201 FACILITIES PLAN
FACILITY PHASING SCHEDULE

Currently Being Constructed

December, 1979	Construct 1.5 MGD wastewater treatment plant
December, 1979	Construct influent force main and pumping station from Sun City Center
December, 1979	Construct effluent force main

Phase I (1979-1985)

July, 1980	Construct storage pond and extend force main to interconnect Sun City Center's existing golf courses for spray irrigation
April, 1981	Expand wastewater treatment plant to 3.0 MGD
April, 1981	Construct Operations Building
April, 1981	Extend force main to spray irrigate on Sun City Center's proposed golf courses
May, 1981	Construct influent force main to serve Ruskin
May, 1981	Construct influent force main to serve Wimauma
December, 1981	Construct Ruskin collection system
December, 1981	Construct Wimauma collection system

Phase II (1985-2000)

June, 1986	Expand wastewater treatment plant to 6.3 MGD
June, 1986	Construct influent force main to serve Apollo Beach
June, 1986	Construct effluent force main for spray irrigation at TECO R/W and Apollo Beach
June, 1986	Construct Effluent Force Main to TECO for Reuse
June, 1986	Construct effluent force main to Sun City Center
September, 1987	Construct influent force main to serve area south of Little Manatee River
September, 1991	Construct spray irrigation system for TECO R/W

NOTE: Dates listed are construction completion dates.

5.8 RESOURCES COMMITTED DURING STATION OPERATION

With the exception of aquatic ecological resources, which will be discussed and analyzed in future amendments to this application, station operation will not result in significant irreversible or irretrievable commitments of resources. Coal, water, and land will be consumed or permanently committed, but the quantities are very small in comparison with supplies. The station's other operating impacts on air, land, and water are temporary and, by design, minimal in scope.

5.8.1 Land

Land permanently committed for the Unit No. 4 permanent facility will be approximately 7 acres. Approximately 7 acres will be designated for the coal reserve, and service facilities associated with Unit 4. An additional 121 acres will be used for an ash settling pond system. The FGD disposal area consists of 97 acres. Of these, 66 acres are pasture, including pasture pond and marsh, and 31 acres are agricultural lands.

5.8.2 Water

Consumptive use of circulating cooling water includes the water lost by evaporation. The forced evaporation rate is estimated at less than 5 cfs above natural evaporation rates in Hillsborough Bay. This increase should not produce any significant effect on the quantity and quality of the water in Hillsborough Bay and will not affect any agricultural, industrial, consumer, or recreational use of the bay.

The estimated annual average sustained freshwater requirement for Unit No. 4 is 36×10^6 cu ft per year.

Freshwater requirements are currently met by purchase from Hillsborough County water supply. If the increase in station water use poses an adverse impact on the water system or the local water resources, an alternate water supply will be utilized.

5.8.3 Aquatic

5.8.3.1 Lost Resources - Aquatic

The potential for loss of aquatic biological resources due to operation of the station are discussed in the 316 Demonstration which is appended to this application.

5.8.3.2 Changes in Species Populations - Aquatic

Any changes in populations of important species (as defined in Section 2.7.2) are discussed in the 316 Demonstration which is appended to this application.

5.8.4 Materials

The projected consumption of coal by Unit 4 averaged over the life of the plant is 950,000 tons per year. The projected coal consumption for all of Big Bend Station is 3.4×10^6 tons per year during 4-unit operation.

6. ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

CHAPTER 6

ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

6.1 GENERAL

This chapter describes the programs which TECO is using to collect baseline data presented in other chapters of this Site Certification Application. It also describes the monitoring program to be implemented during construction to assess and control the environmental effects resulting from site preparation and plant construction. The baseline data gathering program will provide a suitable reference frame from which to assess accurately the construction effects.

Since commercial operation of Big Bend Station Unit 4 is presently scheduled for March 1985, more than two years beyond the anticipated date of receiving site certification, TECO has chosen the option of submitting an operational monitoring program no later than six months prior to the target startup date.

6.2 PREAPPLICATION MONITORING

This section describes the data gathering program that TECO has conducted or is conducting.

6.2.1 Water Monitoring Programs

The water quality monitoring programs presently being performed are listed in Table 6.2-1.

6.2.2 Surface Waters

6.2.2.1 Physical and Chemical Parameters

Water quality and hydrographic studies have been conducted at Big Bend during two periods, from 1970 to 1975, and in 1976 and 1977. Results from studies in both periods are reported in Section 2.5. The methodologies are described in this section.

6.2.2.1.1 1970-1975 Studies

Characteristics routinely measured at Big Bend Station during this period include air temperature, surface and bottom water temperature, Secchi disc transparency, salinity, pH, dissolved oxygen, and biochemical oxygen demand (BOD). In addition, pesticides and trace metals were reported from selected stations at various times. The sampling program was continually refined from its initiation in April 1970. The number of stations monitored, sampling frequency, and elements measured varied from year to year.

Sampling Stations

During the 1970 to 1975 study period, a total of 24 stations were sampled (some intermittently) for hydrographic data. Data from the 16 most representative and consistently sampled stations are discussed in Section 2.5. Station letters I and O denote "inside" stations (contained by land areas and/or protected from the open bay) and "outside" stations (offshore and/or exposed to the open bay), respectively (Figure 6.2-1). A listing of stations with a brief description of each is shown in Table 6.2-2.

Sampling Frequency

1970-1971

The most intensely sampled stations were I-1, I-3, and I-6. At these stations, on the average, temperature was sampled daily, and salinity, dissolved oxygen, pH, transparency, and BOD were sampled weekly. All other stations were sampled

weekly for the above characteristics. Sampling for trace metals and pesticides was conducted quarterly at selected stations.

1971-1972

Stations I-1, I-3, and I-6 were sampled as in the previous year. All other stations with the exception of I-8 (which was sampled twice a month) were sampled weekly for temperature, salinity, pH, and transparency, and twice a month for dissolved oxygen and BOD. Trace metals and pesticides were sampled as in the previous year.

1972-1973

Stations I-1, I-3, and I-6 were sampled as in 1970-1971. A second group of stations, O-1, O-2, O-6, and I-4, were sampled weekly for temperature, salinity, pH, and transparency, and twice a month for dissolved oxygen and BOD. A third group of stations, O-3, O-4, O-5, I-8, and I-9, were sampled twice a month for all above characteristics. Trace metals and pesticides were sampled as in the previous year.

1973-1974 and 1974-1975

Stations were sampled monthly for temperature, salinity, dissolved oxygen, and transparency. Trace metals and pesticides were sampled as in the previous years.

Methods and Instrumentation

Methods and instrumentation used to measure the various characteristics are listed below:

1. Temperature

- a. Tele-thermometer, Yellow Springs Instrument Co.
- b. Oxygen meter, Model 33, Yellow Springs Instrument Co.
- c. S-C-T meter, Model 54, Yellow Springs Instrument Co.

2. Salinity

- a. TC refractometer, AO Goldberg, Model 10423
- b. S-C-T meter, Yellow Springs Instrument Co.

3. Dissolved Oxygen

- a. Azide modification of iodometric method (American Public Health Association, 1965) (1)
- b. Oxygen meter, readings in ppm with temperature and salinity corrections. Yellow Springs Instrument Co., Model 54.

4. pH

- a. pH meter, Corning Model 12
- b. pH meter, Instrument Lab Inc., Portomatic Model 175.

5. Transparency

Standard oceanographic Secchi disc, 50 cm diameter, Wildlife Supply Co.

6. Biochemical Oxygen Demand (BOD)

Standard Methods (APHA, 1965) (1)

7. Chlorinated Hydrocarbon Pesticides

Gas chromatographic techniques (APHA, 1971) (2) Analyses were performed by J & W Chemical Corp., Belle Glade, Florida, or by Everglades Laboratories, Inc., West Palm Beach, Florida.

8. Trace Metals

Atomic absorption spectrophotometry or chelation extraction (APHA, 1971; Environmental Protection Agency, 1974) (2,3) Analyses were performed by J & W Chemical Corp. or Everglades Laboratories, Inc.

Temperature, salinity, dissolved oxygen, pH, and BOD concentrations were measured at the surface and just above the bottom. Pesticides and trace metals were measured in surface water only. Water for characteristics not measured by submersible probes was collected in a PVC Van Dorn type sample bottle (Wildlife Supply Co.).

6.2.2.1.2 1976-1977 Studies

Hydrographic studies conducted during this period added to the baseline chemical and physical water quality parameters

developed between 1970 and 1975 and also aided in indicating the mixing zone of the thermal effluent.

Station Locations and Sampling Frequency

Hydrographic sampling stations were determined by establishing a roughly rectangular grid system over the open bay areas, extending 2.0 mi north of the power plant's point of discharge in Hillsborough Bay, 1.0 mi south, and approximately 3.9 mi west (Figure 6.2-2). Within the grid, transects were located at 0.5 mi intervals from north to south and east to west. They extended due west from known beach locations. An additional transect (BC) was located 0.25 mi north of the point of discharge to Hillsborough Bay to provide hydrographic data for several biological stations in this area. A total of 61 stations were located in the open bay area and the remainder (16 stations) were located at the plant intake and discharge, adjacent canals, and at embayments within the vicinity of the plant. Data was collected weekly at each station at 3-ft depth intervals (1-ft intervals along "C" transect) from the surface to the bottom.

Parameter Measurement

The water quality monitoring generated over 5,000 data points each week. Consequently, a computer system was used for data storage and analyses.

Water temperature ($^{\circ}\text{C}$), conductivity/salinity (mmhos), dissolved oxygen (ppm), and pH were measured with a Martek Instruments, Inc., Mark V Digital Water Quality Analyzer.

The following data were also collected in association with sampling at each station: air temperature ($^{\circ}\text{C}$) with a Weston thermometer, wind speed (mph) with a Dwyer wind meter, wind direction, cloud cover, and water depth (ft).

Turbidity samples were collected at selected stations in conjunction with the ichthyoplankton and meroplankton sampling programs. Samples were taken during new and full moon sampling periods during the same tidal state at the surface, mid-depth, and bottom. Turbidity was measured with a Hach Model 2100 A turbidimeter and checked with a Jackson Candle Turbidimeter.

Instrument Calibration

Calibration of the Martek Instruments was conducted weekly in the laboratory utilizing the same type of power source as was used during sampling (i.e., 115-V ac or 12-V dc).

Calibration was accomplished by adjusting various potentiometers while measuring known standards.

Temperature

Water temperature was measured using a probe, which is accurate from -5.0 to 45.0°C ($\pm 0.1^{\circ}\text{C}$), with a thermo-linear array mounted in a stainless tube. Calibration was completed by preparing an ice bath and 45.0°C water bath and adjusting low and high temperature potentiometers so that readings on the digital panel meter (DPM) matched values on a calibrated Fisher -10.0 to 110.0°C mercury thermometer.

Conductivity/Salinity

Electrical conductivity was measured using a platinized nickel electrode sensor with a range of 0 to 1,000 micromhos/cm (± 10.0 micromhos/cm). Calibration was performed by disconnecting the sensor cable and adjusting a potentiometer to lowest possible readings on the DPM. The sensor was then reconnected and two solutions of known conductivity (0.0 ppt - distilled water and 30.0 ppt - 3 percent NaCl solution) were prepared in order to adjust the conductivity range.

Dissolved Oxygen

Dissolved oxygen was measured by using a polarographic gold/silver electrode system which is automatically temperature compensated. Measurable dissolved oxygen values ranged from 0 to 20 ppm (mg/l), being accurate to ± 0.05 ppm. Calibration was completed by disconnecting the sensor cable and placing a 30.0 K ohm resistor across two pins in the sensor connector and adjusting the low range potentiometer until the DPM read 0.00 ppm. The sensor cable was reconnected and the probe placed in a solution of known dissolved oxygen concentration as determined by the modified Winkler Method.^(4,5) The high range potentiometer was adjusted so the values on the DPM corresponded to the dissolved oxygen concentration of the solution.

pH

A silver-silver chloride electrode, which is automatically temperature-compensated, was used to determine pH (range 0 to 12 pH ± 0.03 pH). Calibration of pH was accomplished by the use of two pH standards (pH 4 and pH 7) to adjust the range and to match appropriate values on the DPM.

Data Reports

Monthly, 6-week, and quarterly averages of characteristics at each sampling station and depth were generated for flooding and ebbing tides. The averages (monthly) were presented in a series of quarterly reports (published by TECO in 1976 and 1977) as tables and as horizontal and vertical isopleths.

6.2.2.2 Aquatic Ecology Sampling Parameters

Aquatic biota in the area of Big Bend Station have been extensively studied since April 1970. There have been three major phases during the sampling program, occurring during the periods of 1971-1975, 1976-1977, and 1977 to the present. Sampling methodology has developed during the past nine years to address emerging regulatory concerns for the aquatic biota of the area.

A new sampling program, begun in late February, 1979, is also described here. Since no results are available at this time, the narrative which is found in Section 2.7.2 is derived from studies preceding the new program.

6.2.2.2.1 Aquatic Ecology Sampling Program 1970-1975

6.2.2.2.1.1 Plankton Sampling

The plankton sampling program was intended to provide data necessary to establish the composition of plankton populations found in the Big Bend vicinity, to relate any observed changes to variation in local physical conditions, and to indicate the impact of station operation on the plankton community.

Sample Collection

Initially, plankton were collected by passing 50 liters of sea water through a No. 12 (0.135 mm mesh size) plankton net. Stations I-1, I-3, I-6, O-4, and O-5 were sampled most consistently (Figure 6.2-3). Samples were examined under a Bausch and Lomb Dynazoom microscope. The relative abundance of phytoplankton and zooplankton were reported.

Beginning in June 1972, two samples, a one liter dipped sample and a 20 liter concentrated sample, were taken at each station. The concentrated sample was prepared by pouring 20 liters of sea water through a No. 12 plankton net and concentrating the sample to 50 milliliters. The 20-liter concentrated sample was examined immediately for identification of live organisms then preserved for enumeration. Dipped samples were placed under a fluorescent

light for at least 2 hours before examination for species diversity.

6.2.2.2.1.2 Trawl and Seine Sampling

Aquatic organisms were also collected in the Big Bend area with trawls and seines. Initially, trawl samples were taken with a 10-foot otter trawl constructed of 1 1/2-inch stretch mesh. A 1/4-inch bar-mesh liner was added in September 1973. Tows usually lasted 10 to 15 minutes. Seine samples were taken with a 150-foot beach seine with 1/2-inch and 1/4-inch mesh. The trawl and seine sampling stations are shown in Figure 6.2-4. Sampling was conducted quarterly during the period.

6.2.2.2.1.3 Vegetative Surveys

From 1970 to 1975 microscopic algae and submerged grasses were collected incidentally in trawls, on the intake screens, and noted in general observations. In 1975 a synoptic algae survey was conducted within the Big Bend embayment to gather information on the general composition and abundance of algae.

In the latter study, three sampling transects in the embayment (Figure 6.2-5) were divided into three tidal zones. The dominant algae and angiosperms present in each zone were collected and returned to the laboratory for identification. Dawes was the main taxonomic guide.⁽⁶⁾

6.2.2.2.2 Aquatic Ecology Sampling Program 1976-1977

Aquatic ecology studies conducted in the Big Bend Station area prior to 1976 were mainly qualitative, whereas studies conducted after this time were designed to more precisely determine the effects of Big Bend's operation on the local biota. The specific objectives of this program were to study and describe:

1. the numbers and kinds of phytoplankton in source and receiving waters;
2. populations of benthic organisms in thermal and control areas;
3. the numbers and kinds of fish eggs and larvae in source and receiving waters;
4. the numbers and kinds of selected meroplankton (other than ichthyoplankton) in source and receiving waters;

5. populations of fish and invertebrates in receiving and control water bodies.

6.2.2.2.2.1 Phytoplankton Sampling

Seven stations located in the Big Bend area were sampled biweekly for the duration of the program. The phytoplankton sampling stations are shown in Figure 6.2-6. Location of the stations was based on a prediction of the areal extent of Big Bend's thermal plume⁽⁷⁾ such that an adequate number of control (nonthermal) stations were sampled.

Twenty liter dip samples were taken to determine species abundance. Samples were reduced to one liter in the field by filtration through 35 um mesh net. The one liter sample was examined for live organisms and a qualitative species list was made. The sample was again filtered through a 35 um net to concentrate the sample to 500 ml. Twenty milliliters of 6 percent glutaraldehyde (buffered with 0.2 M sodium cacodylate in 0.2 M sucrose) was added to partially fix the sample. A final volume of 50 milliliters was accomplished by sedimentation. Fifty milliliters of 6 percent glutaraldehyde was then added yielding a counting volume of 100 ml and a fixative concentration of 3 percent. Ten 0.1 ml subsamples were examined. Phytoplankton were identified to species in most cases and counts were made. The mean count was corrected for volume and reported as cells/liter (for small filamentous forms, filaments/liter were reported).

One-liter dip samples were taken to determine total seston biomass. The method described by Strickland and Parsons⁽⁵⁾ was used. Basically, this involved filtering one liter of water through tared glass-fibered filters, drying to constant weight at 105°C, and determining the dry weight. The samples were then ignited at 500°C and reweighed. Total seston biomass was reported as mg/l and percent dry weight.

6.2.2.2.2.2 Benthic Sampling

The benthic community is generally considered to be an important indicator of environmental stress because of its lack of mobility, the long life of benthic organisms, and their varied sensitivity to stress. The specific objectives of the study were to:

1. evaluate changes in density and diversity (both spatially and temporally) of benthic macrofauna in relation to thermal effluent;

2. examine patterns of abundance of dominant species and pollution indicator species in thermally affected and unaffected areas;
3. relate similarities of faunal communities to thermal effluent patterns; and
4. assess the impact of the thermal discharge on the benthic community.

Twenty-two stations were chosen on the basis of proximity to the thermal discharge and the predicted thermal plume and are shown in Figure 6.2-7.

All stations were sampled at least once a quarter. Nine selected stations (I-1, I-16, BC-8, BC-7, E-6, E-5, SP-1, SP-2, and I-15) were additionally sampled once every 6 weeks to provide information on within-season variations in the benthic community structure. Sediment samples were collected once every quarter at all 22 stations. Water quality measurements were collected at each station on all sampling trips.

Sampling Gears

A petite Ponar grab was used as the sampling gear.⁽⁸⁾ The gear weighs approximately 20 kg (including a pair of additional weights) and samples an area of 0.022 m². The grab penetrates approximately 10 cm in mud substrates and slightly less in sand and harder substrates.

The Ponar grab was considered an adequate sampling gear since it appears to satisfy most of the criteria outlined by Menzies and Rowe⁽⁹⁾ in their description of a satisfactory sampling gear (i.e., undisturbed bottom sample, reasonably adequate penetration, minimum loss of collected sample, light weight, easy to operate). Also, the area sampled per grab was large enough to reasonably estimate faunal density (most other present and past studies in Tampa Bay use gears which sample a smaller area than the Ponar gear).

Sediment samples were collected by a pipe corer lined with a 7.6 cm dia PVC transparent tube. Only the top 10 cm strata of the sediment was retained for analysis.

Surface and bottom hydrographic measurements (temperature, salinity, and dissolved oxygen content) were taken with salinity-temperature and DO meters at the time of faunal collection. Sediment temperature was measured with a mercury thermometer. Transparency was estimated through the use of a Secchi disc.

Seven Ponar grab replicates were collected at each station. However, only six replicates were analyzed. The extra sample served as a backup in case of the accidental loss of a sample during processing.

Duplicate sediment samples were collected at each station. Only one sample per station was analyzed for granulometric characteristics and organic content. The other sample served as a backup in case of accidental loss of a sample and for a general verification of accuracy.

Faunal samples were washed and sieved in the field using a 0.5 mm mesh size sieve. $MgCl_2$ solution was used as a narcotizing agent. Ten percent formalin was employed as the initial fixative and preservative. A rose bengal stain was used to facilitate rapid sorting. Seventy percent isopropanol was used for final preservation of the samples.⁽¹⁰⁾ Samples were decanted before sorting to concentrate minute and floating organisms. The concentrate was sorted with a 7X binocular microscope and the organisms counted. The heavy material (containing mollusks and larger animals) was spread in a white pan, sorted, and counted.

Biomass was measured as wet weight on a species per station basis. Also, dry weight and ash-free carbon weight were measured by lumping all organisms collected at a station. Dry weight was measured after oven drying the organisms at 100°C for 24 hr. Ash-free dry weight was obtained by combusting the animals between 500°C and 550°C.

Sediment samples were dry sieved through a nest of sieves (1 phi intervals; phi = $\log_2$ of the particle diameter in mm) by means of a mechanical shaker. A flow diagram describing the laboratory analysis of sediment samples is shown in Figure 6.2-8.

Various taxonomic keys⁽¹¹⁾ were used for identification of the organisms to the species level. Taxonomic specialists confirmed the identification of some species. Reference specimens for all identified species were maintained in the laboratory.

Faunal density and biomass are reported as values per square meter. Two commonly used diversity indices, the Shannon-Weaver index⁽¹²⁾ and the Gini's (Simpson's) index,^(13,14) were used to determine species diversity. Species richness was estimated using Margalef's index⁽¹⁵⁾ and the total number of species (S) collected per station. Equitability, a measure of distribution of individuals among species, was computed by Pielou's conventional method.⁽¹⁶⁾ A measure of the similarity of benthic assemblages collected at different

locations and different times throughout the sampling program was obtained by using Morisita's index.⁽¹⁷⁾

Analysis of the sediment samples include determination of percentage volatile matter and grain size distribution. Several statistics on the grain size distribution were calculated: mean grain size, inclusive graphic standard deviation, inclusive graphic skewness, and graphic kurtosis. Formulas for the calculations were taken from Folk.⁽¹⁸⁾

6.2.2.2.3 Ichthyoplankton Sampling

The ichthyoplankton sampling program was intended to determine the number and kinds of fish eggs and larvae entrained by the plant. The species composition, seasonal distribution, and abundance of fish eggs and larvae within the study area were also determined.

Sample Collection

Ten stations in the vicinity of the plant (Figure 6.2-9) were sampled at two week intervals from January 1976 through March 1977. Samples were collected during both the day and at night on the same tide phases. Inclement weather and boat breakdown forced the postponement of sampling on several occasions. Plankton samples were collected with a 363 μ m mesh, 1 m mouth diameter, metered plankton net towed at a speed of approximately two knots behind a 24-ft outboard boat. Tows were oblique. Efforts were made to filter 100 m³ as recommended by UNESCO.⁽¹⁹⁾ The volume of water filtered was limited on numerous occasions, due to net clogging, caused either by dense phytoplankton and zooplankton blooms or by large numbers of ctenophores.

One liter glass bottles were used as cod end containers for each sample collected. Sufficient buffered formalin was added to each sample immediately after collection to give a final concentration of 5 percent. The plankton net was washed immediately after each tow to insure no cumulative net clogging or contamination occurred.

Physical data, consisting of station depth, air temperature, surface, mid-depth, and bottom water temperature, salinity and dissolved oxygen were taken at each station prior to sample collection. Surface, mid-depth, and bottom water samples were collected with a PVC Van Dorn bottle and returned to the laboratory for analysis of water turbidity.

All samples were sorted with the aid of binocular dissecting microscopes at 10-15X magnification. Each microscope was fitted with an ocular micrometer. The standard length (SL), i.e., the straight-line distance from the most anterior part

of the head to the tip of the notochord⁽²⁰⁾ measured to the nearest 0.1 mm, was recorded for the first 50 individuals of each species. If fewer than 50 individuals of a species occurred in a sample, all individuals of that species were measured. All larvae, except those of the bay anchovy, Anchoa mitchilli, were removed from each sample and placed in numbered vials. Anchovy larvae were not removed from samples because they were so numerous. They were counted, and the total number of anchovy larvae in each sample was recorded. The contents of each vial were later reexamined under an Olympus dark-field dissecting microscope at 20-25X magnification for verification of initial identifications.

Three random 10 ml aliquots were withdrawn from each sample and sorted for eggs. If there were 100 or more eggs of a particular species in each aliquot, the number of eggs contained in the aliquots was used to extrapolate the number of eggs in the entire sample on a volume basis. The entire sample was sorted for eggs of any species with fewer than 100 eggs in the first aliquot. Representative numbers of eggs of each species were placed in numbered vials for later verification of identifications.

All eggs and larvae were identified to the lowest taxon possible, based upon descriptions given in current literature. In addition, verifications were obtained from other scientists. In most cases, larval identifications are accurate to the generic level. Egg identifications are accurate at least to the family level. A complete listing of literature used to aid in egg and larval identifications is given in the Appendix to the 316 Demonstation for Units 1-3.⁽²¹⁾

6.2.2.2.2.4 Invertebrate Meroplankton Sampling

This study was primarily concerned with the identification and enumeration of decapod crustacean larvae collected at source and receiving water stations.

Sample Collection and Sorting

Samples taken for the ichthyoplankton program were also utilized for meroplankton studies; sampling methodology is discussed in Section 6.2.2.2.2.3. Supplementary oblique (January - March 1975) and vertical (April 1976 - February 1977) tows were taken with a 30 cm or 50 cm mouth diameter No. 20 mesh (75 um bar mesh) net. These tows were used for analysis of the smaller zooplankton found in the vicinity of Big Bend.

Samples were sorted using an Olympus TM300, and Bausch and Lomb Stereozoom and Stereozoom 7 dissecting microscopes.

Certain fine details were checked using a Baush and Lomb Dynazoom compound microscope. After thoroughly agitating the sample, a series of 10 ml aliquots were taken and sorted until at least 200 decapod larvae were counted. All aliquots were sorted completely. If fewer than 200 decapods were found, the entire sample was counted.

During the warm months, meroplankton abundance was very high. Samples with high numbers of meroplankton were sorted in the usual manner, but in addition, an extra set of aliquots were sorted. For the second set, decapod species for which more than 30 individuals were counted in the first set of aliquots (i.e., the dominant species) were not counted. Aliquots were taken until at least another 100 decapods were counted from the second set of aliquots.

An artificial key to the larval decapod Crustacea of the Big Bend area was presented in the Appendix to the 316 Demonstration for Units 1-3.⁽²¹⁾ The appendix also includes a bibliography of the literature used to identify decapods in the program.

6.2.2.2.5 Trawl and Seine Sampling

The trawl and seine sampling program provided quantitative and qualitative data on the fish and macroinvertebrate population in the vicinity of Big Bend. The program was designed to describe:

1. the species composition and distribution of fish and macroinvertebrate populations in the area;
2. the relative abundance of these species;
3. changes in species composition and distribution over time
4. nursery areas;
5. any changes in the biota attributable to thermal alteration of habitats.

Seine Stations

Seine sampling was conducted monthly at six stations. Sampling sites were chosen on the basis of their proximity to or distance from the thermal plume, substratum composition, and type of habitat. The station locations are shown in Figure 6.2-10 and described in Table 6.2-3.

The seine used in this study was 150 ft x 6 ft, and was constructed of 3/4-in stretch mesh multifilament nylon. A

bag (4 ft x 4 ft x 12 ft) constructed of 1/2-in stretch mesh multifilament nylon was added to the center of the seine to facilitate the collection of specimens. A 6 ft x 10 ft panel of 1/2-in stretch mesh multifilament nylon was added to the body of the seine on both sides of the bag.

The seine was deployed by boat at all but one (SB-10) of the sampling stations. One end of the net was anchored to shore. Duplicate hauls were taken at each station. It was not feasible to use the boat at station SB-10, due to the shallowness of this area. Instead, the seine was set and hauled by hand.

Trawl Stations

Trawl samples were collected along seven transects once each quarter. The transect sites were chosen on the basis of their location in relation to the thermal plume, depth, substratum composition, and habitat. Transect locations are depicted in Figure 6.2-10 and described in Table 6.2-4.

A 10 ft otter trawl constructed of 1 1/2-in stretch mesh multifilament nylon was used during this study. A 4 ft bag constructed of 1/4-in ACE nylon was added to the cod end to facilitate the capture of small specimens.

The trawl was towed approximately 5 minutes at a speed of 2-3 knots. Duplicate tows were made along each transect. The replicate tows were made in the same direction at each station.

Laboratory Methods

All specimens were preserved in the field in 10 percent buffered formalin and seawater. Specimens were sorted, identified, weighed (wet weight to the nearest 0.1 g), and measured (standard length to the nearest 1 mm) at the laboratory.

Up to 75 individuals per species per replicate were measured and sorted into 10 mm size classes. Total weight was obtained by combining the weights of all fish in every size class. If the total number of individuals of a single species exceeded 75 in one replicate, a random sample of 75 individuals was measured, sorted, and weighed. The remaining fish were counted and weighed as a group. Random samples of selected species were dissected each month and were cursorily examined for gonad development and stomach contents.

A variety of bioindices and statistical tests were utilized to aid in the interpretation of data. The bioindices

include: Shannon-Weaver index of diversity,⁽¹²⁾ Margalef's species richness index,⁽¹⁵⁾ Pielou's equitability index,⁽¹⁶⁾ and Morisita's index of similarity.⁽¹⁷⁾ The statistical tests included multiple and linear regression, and student's t-test.⁽²²⁾

6.2.2.2.3 Assessment of Natural Revegetation

Following completion of the modifications to the dilution channel and construction of the concrete breakwater at Big Bend Station, TECO began a program to study the success of intertidal revegetation in areas impacted by construction activities and plant operation. The study was conducted from March 1977 to June 1978.

Six study areas were designated (see Figure 6.2-11). Areas A and B are subtidal bay bottoms, and C, D, and E are intertidal shorelines of spoil islands. A control area was established in the subtidal region near Wolf Creek, south of Apollo Beach. Transects were established in each of the study areas. Each intertidal area (C, D, and E) had three transects with permanent sampling points marked at 5 m intervals. The subtidal transects (A, B, and Control) were staked at the MHW mark and buoyed at the offshore end in -2 m SLD of water; sampling intervals were 10 m.

Each transect was sampled quarterly with a 1 m² PVC quadrat placed at right angles to the sampling points. All plant species within each quadrat were identified and the percent cover and height range for each species determined. Counts were obtained of emergent stems for all species except grasses within the entire 1 m² quadrat. Grasses were counted by randomly sampling and counting within a 0.25 m² quadrat in the intertidal transects and two 0.01 m² quadrats in the subtidal grass meadows.

A description of the length and number of sampling points for each transect is contained in Table 6.2-5.

6.2.2.2.4 Aquatic Ecology Sampling Program 1979 - 1980

The aquatic ecology program being conducted in 1979 and 1980 is primarily intended to provide field data necessary for assessment of Big Bend's impact on local populations of aquatic organisms. A sighting program for rare and endangered species, such as the West Indian manatee, is also described. Mote Marine Laboratory of Sarasota is conducting the field work. This program will concentrate on the collection of data for a group of eleven Representative Important Species (RIS):

American Oyster
Pink Shrimp
Blue Crab
Stone Crab
Bay Anchovy
Scaled Sardine

Tidewater Silverside
Silver Perch
Spotted Seatrout
Black Drum
West Indian Manatee

6.2.2.2.4.1 Meroplankton

Starting Date, Duration, and Frequency of Program

Meroplankton sampling will be conducted for a period of one year beginning on February 27, 1979. Sampling is conducted once every two weeks during the program, with two collections on each day of sampling. The two collections should coincide as much as possible (within 4 hours) with the day's low and high slack tides, but at least one of the collections is made at night.

Sampling Locations

Locations are shown in Figure 6.2-12. Station A is located in the intake canal of Big Bend Power Station, and Station B is located in the discharge canal. Stations C and D are located in Hillsborough Bay. Station E is located in Tampa Bay.

Equipment and Technique

A pair of 1.0 m diameter, 505 μ m nets are towed simultaneously. A flow meter is mounted in each of the net mouths, and one is suspended from a net in such a manner as to be unaffected by boat or net-induced turbulence. Two consecutive tows are conducted at each station, twice each sampling day, providing eight samples for each station on each sampling date. Path of tow through the water will be oblique. Tow duration and speed will be optimized to provide filtration of at least 100 m³ of water. Volume of water passed according to each of the meters is recorded for each tow, and water volume sampled by each net will be calculated. Clogging of the nets, as determined by comparison of net meter readings with the third meter reading, is being noted.

A "passive" or stationary gear set-up is used at Station B in Big Bend's discharge canal. A previous one year study at the plant (during 1976 and 1977) used such gear positioned directly in front of the discharge flumes. In order to collect comparable discharge station data in 1979, it is preferable to deploy such a gear again. The gear employs the same mesh, meters, and system of replicate observations used for Stations A, C, D, and E.

The order in which stations are sampled during a sampling trip is systematic, and Station B is sampled immediately after Station A. Temperature, conductivity, dissolved oxygen, and depth is measured at the surface, mid-depth, and bottom, at the beginning of the replicate tows at each sampling station. In addition, time, wave height, tidal stage, and cloud cover is noted for each time of sampling.

Sample Preservation, Sorting, and Specimen
Identification

Samples are transferred from nets, retained in one liter bottles and preserved immediately in the field in an amount of buffered formalin sufficient to provide a solution concentration of 5 percent. A series of aliquots or subsamples are randomly separated from each well-mixed sample and sorted for meroplankton of RIS species. When 100 or more specimens of a species have been found, the number of that species in the entire sample is calculated on the basis of aliquot volume or subsample splitting needed to find 100 specimens. Otherwise, the entire sample is sorted to determine the number of RIS specimens collected.

Fish larvae of RIS species in a sample are classified for larval development in accordance with Hubbs.⁽²³⁾ Standard length (SL) of RIS fish larvae is measured to the nearest 0.1 mm for all individuals of a species (up to a maximum of 50) found in a sample. All fish eggs and larvae will be stored, and the aliquots shall be retained in case future sorting verification is required.

Larvae of the invertebrate RIS are identified to species and classified for developmental stage (e.g., nauplius, zoea, postlarva) according to accepted terminology adopted for each species. Invertebrate meroplankton other than those of RIS decapod crustacean species or American Oyster will not be counted. All invertebrate meroplankton will be preserved. Zoea of the dominant RIS decapod larvae in the area, the stone crab, are sorted by zoeal molt stage (Stage I-V) for all samples.

Sample sorting for meroplankton of fishes and invertebrates is being done with a dissecting microscope. A compound microscope is available for checking fine detail in identification of invertebrate meroplankton. Counts of meroplankton will be reported by species, developmental stage and volume of aliquot(s) for each sample collected. All meroplankton samples shall be stored separately as aliquoted and nonaliquoted fractions. The meroplankton RIS in their various developmental stages will be photographically documented.

6.2.2.2.4.2 Adult Fishes and Invertebrates

Sampling Duration and Frequency

Sampling was initiated on March 13, 1979. The frequency of sampling for trawls and seines is monthly, corresponding to every other meroplankton sampling trip. The frequency of sampling for impingement monitoring is every two weeks, corresponding to each meroplankton sampling trip.

Trawl Sampling

Trawl stations are located at the same places as the meroplankton sampling stations, illustrated in Figure 6.2-12. Sampling occurs once during the night, corresponding to the night meroplankton collection, and two hauls are taken. Time of day, tidal height (or depth), water temperature, conductivity, dissolved oxygen, and cloud cover are recorded for each set of trawl replicates. The gear is a 10 foot otter trawl constructed of 1 1/2 inch mesh net. The cod end consists of a 4 foot bag constructed of 1/4 inch mesh net. The net is towed five minutes at 2-3 knots.

Seine Sampling

Seine sampling locations are illustrated in Figure 6.2-12. Sampling occurs once during the day, at high tide, and no replicate hauls are taken. The gear is 150 feet x 6 feet and constructed of 3/4 inch mesh net. To facilitate collection of specimens, a 4 foot x 4 foot x 12 foot bag constructed of 1/2 inch mesh net was added to the center of the seine, and a 6 foot x 10 foot panels of 1/2 inch net was added to each side of the bag. The seine is being deployed by boat at all locations, if possible.

Impingement Sampling

The intake traveling screens at Big Bend Station are being sampled by collecting impinged organisms from the operating screens of one unit during the 24-hour period of the sampling date. The screens, sluicing troughs, and holding tanks are cleaned at the beginning of the collection day. Following this, the screens are circulated and washed twice at six hour intervals, to collect impinged organisms. Operation of the screens and collection of organisms is performed by TECO personnel, but observed and noted by Mote Marine Lab personnel. Collection hour for each group of organisms is noted.

Laboratory Methods

All specimens in a sample are identified and counted, but only a maximum of 100 specimens of each species are preserved in the field in seawater and buffered formalin sufficient to provide a 10 percent solution concentration. All preserved RIS specimens in each sample are sexed, weighed (wet, nearest 0.1 g), and measured (standard length of fishes, length of shrimps, or carapace width of crabs, nearest 1.0 mm). Photographic documentation of dominant species and RIS will be prepared.

Fish Age and Fecundity Studies

Out of each set of samples, female specimens of the following species will be randomly selected from each 10 mm size class for age and fecundity determination:

Bay Anchovy
Tidewater Silverside
Silver Perch
Black Drum
Spotted Seatrout

Age is determined by enumeration of scale annuli and is recorded along with the length and weight of each specimen. If age cannot be so determined, counting of growth rings associated with otoliths (for larger specimens) is utilized. Fecundity is being determined in the following manner. Ovaries of each specimen are to be removed and identified in some manner to correspond to the specimen's scale/age, length and weight determinations. The ovaries are fixed in Gilson's Fluid, rinsed in water, blotted dry, and each half weighed to the nearest milligram. For all species except bay anchovy, each ovary half is subsampled to determine the number of ova per unit weight. Three subsamples of ovary tissue are obtained by core or cross-section. Each subsample is weighed and the number of ova is determined with the aid of a dissecting microscope. In the case of bay anchovy, all ova are counted unless the number is excessive (greater than 500) in which case the ovaries are subsampled. General condition of the ovaries is noted for each specimen.⁽²⁴⁾ The fecundity of each specimen is calculated from the above information. The number of specimens selected from each month's sampling is chosen to ensure approximately 100 adults of each species will be studied, distributed over the duration of the 1979 Aquatic Ecology Program. For black drum and spotted seatrout, attempts will be made to obtain a representative sample from available sources. Special care is being taken in determining fecundity to account for potential multiple spawning behavior.⁽²⁴⁾

6.2.2.2.4.3 Manatee Sighting Program

The manatee program has been divided into two phases, reflecting modifications to its original objectives. In the first phase, conducted from February 28 to June 15, 1979, the incidence of manatees in the vicinity of Big Bend was established by observation from boat. In the second phase, conducted from June 15, 1979 to February 12, 1980, the number and distribution of manatees throughout Tampa Bay will be established through the addition of frequent comprehensive aerial surveys of the area. The boat survey of the first phase will be discontinued during the summer months, but will resume November 15, 1979, when manatees are expected to begin returning to Big Bend.

Phase 1 February 28 - June 14, 1979

Boat Program

Duration and Frequency of Program

Observations were taken once every two weeks, during daylight hours at a time most appropriate for observing manatee activity, on the day of meroplankton sampling. Observations of other threatened or rare and endangered species (e.g., loggerhead turtle) were noted.

Station Locations

Four stations were used to observe manatee incidence in the Big Bend area; they are shown in Figure 6.2-12. Station 1 is located near the discharge flume in the discharge canal, 2 is located 5,000 feet west of the end of the discharge canal, 4 is located northwest of Big Bend Station at the same place as meroplankton sampling Station C, and 3 is located in Apollo embayment.

Observation Methodology

Observations were made from a fore and aft anchored boat with eye elevation of about 12 feet from the water surface. The horizontal field of vision divided into six equal compass segments, using a Weems and Plath hand bearing compass to select segment landmarks, the locations of which were maintained at each station for the duration of the program. The landmarks were used to assure accurate replication. Beginning with a randomly selected segment, the number of manatee noses sighted during a two-minute period were recorded for each segment, proceeding in a clockwise direction around the compass. Three cycles of the compass were made to provide replicate observations. This procedure was repeated for each station. The "horizon"

(maximum possible distance for discriminating a manatee nose) was determined for all segments at the stations. In addition, qualitative observations (occurrence at other locations, unusual behavior, feeding observations) were recorded. Individuals identified by scars, social groupings, or other means were noted. Boats anchored or operating within the "horizon" of the observations were counted.

Phase 2 June 15, 1979 - February 12, 1980

Aerial Surveys

Initiation and Frequency of Observation

Air surveys began June 15, 1979 and will be conducted every two weeks thereafter, until November 15, 1979. After this date, flights will be made on a weekly basis until February 12, 1980. In addition, flight surveys are conducted on the passage of each cold front which occurs during this latter period. A survey conducted on the occasion of a cold front is made only if more than 48 hours from a scheduled weekly trip, and no more than two cold front surveys are conducted between any two consecutive scheduled trips. In addition, aerial survey dates do not coincide with boat survey dates.

Survey Coverage

The survey begins on the eastern Tampa Bay coastline at Bishop Harbor (north of Skyway Bridge) continuing to Port Sutton in the north. The coastline of Interbay Peninsula is surveyed to the extent possible, given the presence of MacDill Air Force Base. The survey continues north and west up the peninsula to Gandy Causeway Bridge, at which point the plane heads approximately southwest to the western shore of Tampa Bay. The survey continues in a southerly direction along this shoreline until Lewis Island/Little Bayou is reached, at which point the survey is discontinued.

Method of Observation

In general, observations are made while the plane follows the survey path defined above. However, concentrated observations are made at (1) County Park Beach, the mouth of Little Manatee River, Big Bend Power Station, the mouth of Alafia River, and Barton Power Plant; and (2) whenever a group of manatees is sighted. (Determination of minimum size of a group which requires the plane to circle was established from the information obtained in the first two aerial surveys.) At these locations or when a group is sighted, the plane circles until all manatees have been

counted, or it has been determined that no manatees are occupying the area.

The plane flies at an altitude and speed suitable to distinguish individual animals. As a guide, the altitude will be approximately 500 feet or less and air speed should not exceed 90 miles per hour.

The location, number, and approximate life stage of sighted manatees, and the location and size of visible sea grass beds is recorded. Information is recorded on standard data sheets. Each sheet includes a map, corresponding to a specific and identifiable portion of the survey path, showing the location and number of manatees observed during that portion of the flight. Grass beds are defined by outline, manatees and manatee congregations by "X" marks. Each map also has a space for recorded data which includes: date of survey, begin and end times on a 24 hour clock for the survey segment, water clarity, air temperature (°C), wind speed and direction, surface conditions, sky conditions, number of adults, number of calves, and total number of manatees. Calves are defined to be approximately one-half the length of associated individuals.

The scale of segment maps is sufficient to accurately record the location of manatees and grass beds, but not be so fine as to result in an unwieldy number of data sheets. Further, segment maps do not provide overlapping representation of an area along the survey path.

Summer Boat Program - Determination of Manatee Dive Time

As soon as possible, areas which appear to maintain summer congregations of manatees are identified from the aerial surveys. A maximum of two locations are selected for boat survey; the selected location(s) have the maximum number of manatees from among all areas in which congregations have been found.

A regular program of observation is established at the station(s), with the intent of determining manatee dive time. Individual manatees are identified by notable characteristics, and dive time (length of time recorded between successive dives) is measured through repeated observation for each individual. An identifier, notable characteristics, and measured dive times are logged for each individual manatee on separate data sheets. Air and water temperature and the presence or absence of grass beds is recorded for each measured dive time.

The maximum number of manatees are observed for this task, and the maximum number of observations are obtained for each manatee.

The Summer Program will be concluded at the latest by September 30, 1979. Termination of the program will depend on a continuing analysis of field data to obtain a mean dive time. When the variability of the mean time is judged acceptable, the program will be discontinued. Further, if mean dive time is significantly different from two minutes, the segment nose-count observation time provided for the winter boat program (next section) will be modified accordingly.

Winter Boat Program

The boat survey program conducted from February 28 to June 14, 1979, will be resumed November 15, 1979, and conducted until February 12, 1980. The number of observation stations sampled during the first phase will be retained, but relocation of stations will occur to correspond to observed congregations of manatees in the near-plant area. Relocation will be permanent; therefore, relocation will be substantiated by the results of at least two aerial surveys.

In addition, observations will be made from a position atop one of the Big Bend Power Station structures. Occasions of observation will coincide with boat survey trips. Period of observation will be sufficient to record abundance and location information for all visible manatees. Data shall be recorded for this activity in the same manner as for the aerial survey: data sheet(s) will consist of representative map(s) and recorded data.

Grass Bed Survey

The location of grass beds within Tampa Bay will be determined, giving special attention to the areas being surveyed by plane or boat. The determination will include a thorough examination of available literature, interviews of knowledgeable persons, and corroboration with aerial survey data; the survey will not include a field sampling program.

6.2.2.2.4.4 American Oyster

Duration and Frequency Study

The study is being conducted for a period of one year beginning on March 13, 1979. The spat collection units are set monthly on the date of every other meroplankton sampling trip and recovered after two weeks.

Field Methods

A standard spat collection unit, consisting of a tray of 10 exposure panels, is set on the bay bottom at each of the meroplankton sampling stations. To mark each unit's position, a rope and buoy is attached to the tray. This will also facilitate recovery of the trays. Panels are cured in flowing seawater from a laboratory running seawater system for three to five days. Panels are scrubbed clean before redeployment. A unit is submerged for a period of two weeks at each station and is replaced by another unit during the next sampling trip. This procedure will be repeated for a duration of one year.

Upon recovery, panels are removed from the tray and placed in racks in an aerated seawater tank for transport to the laboratory. If dredging or other activity in the vicinity of any sampling stations threatens to cover the collecting panels with silt, or otherwise interfere with the study, the panels will be moved only far enough to alleviate the problem while such activity persists.

Laboratory Methods

Recovered panels are held in running seawater filtered through diatomaceous earth and examined within three days. Analysis consists of counting the numbers of oysters settled on one surface of the settling panel, estimating the percentage of the area of the panel covered by spat, and making qualitative notes of the other fouling organisms found on the panel. Representative specimens of the major fouling species will be preserved in 5 percent seawater formalin for reference standards.

Mean size of the spat on a station will be estimated by measuring 50 oysters at random on the panels.

6.2.2.2.5 Thermal Effects on Benthic Communities

This ecological sampling program is designed to evaluate the potential additional thermal effects on the benthos community in the vicinity of the Big Bend Station, caused by suspension of dilution pumping which assists once-through cooling at the plant. The study, now underway, monitors any benthic community alteration attributable to the additional thermal load. The study specifically evaluates community assemblages during the thermally critical periods (summer-fall). Benthic communities make up the segment of the aquatic ecosystem most likely to provide an indication of incremental thermal effects attributable to shutdown of the dilution pump. - Mote Marine Laboratory of Sarasota is conducting this program also.

6.2.2.2.5.1 Benthos Data Collection

Initiation, Duration, and Frequency of Sampling

The field sampling was initiated May 11, 1979. Subsequent sampling occurs at six-week intervals. The final sampling shall occur on or about December 6-7, 1979.

Sampling Locations

Location of the sampling stations are shown in Figure 6.2-13. A total of 14 stations are sampled. Stations 1 and 2 are located in the discharge canal of Big Bend Power Station. Station 14 is located in Apollo Embayment. Stations 3 through 13 are located in Tampa Bay. With the exception of Stations 4, 8 and 9, all the sampling locations correspond to locations sampled in the benthos study conducted at Big Bend in 1976 and 1977. Stations 8 and 9 will be sampled to monitor benthos communities exposed to southerly drift of the plume induced by the ebb tide.

Stations are marked with buoys, where feasible, to assure sampling occurs at the same locations throughout the program. During sampling, the boat is anchored on station to allow multiple grab samples to be taken in a confined area.

Equipment, Technique, and Preservation

Samples are collected with a Petite Ponar Grab (sampling dimensions: 15 cm x 15 cm x $\pm$ 10 cm depth), narcotized in 10 percent $MgCl_2$ solution, washed in the field through a 0.5 mm sieve, stained with a rose bengal solution and fixed in 10 percent buffered formalin. Final preservation of samples is in 70 percent isopropyl alcohol.

Multiple Grab Samples

Seven grab samples are collected at each station. Six grabs are used for the analysis and the remaining sample is stored as a backup in the event of sample loss during laboratory analysis or field-laboratory transfer.

Laboratory Methods

In the laboratory, all organisms retained by the 0.5 mm sieve are decanted into light and heavy fractions. The light fraction (containing the majority of fauna) is sorted with the aid of a binocular microscope. The heavy fraction (containing primarily molluscs and larger animals) is hand sorted in a white background pan. Light and heavy fractions are preserved in 70 percent isopropyl alcohol. All

taxonomic identifications are done under a high power stereo microscope (or a compound microscope, if necessary). Taxonomic identifications are to the species level or else to the lowest possible taxon. Identifications are confirmed by external consultants or by comparison with specimens from the reference collection.

All organisms are enumerated, by taxon, and the data are recorded on standardized bench sheets. These data are transferred to computer data sheets and checked to assure valid data.

Sample Retention

Following analysis of samples, specimens from each sample (as all organisms per species collected at each station) are preserved in 70 percent isopropyl alcohol, labeled, and retained until completion of the program.

6.2.2.2.5.2 Hydrographic Data Collection

Temperature, conductivity (salinity), and dissolved oxygen content are measured at each station (at the time of sampling), at surface and bottom, utilizing a HYDROLAB in situ physico-chemical monitor. Depth at each station is recorded. Readings are taken prior to initiation of benthos sampling, recorded in a field notebook and later transferred to the appropriate computer data sheet.

6.2.2.2.5.3 Sediment Data Collection

Duplicate sediment samples (Petite Ponar Grab samples) are collected at each station on each sampling trip. One sample from each station (the other would serve as a backup) is analyzed for grain size distribution and percentage of volatile organic matter. Data is recorded on data sheets and validated. Grain size distribution, including mean and median grain size, percentage of silt-clay fraction, sorting coefficient, skewness, and kurtosis will be calculated and tabulated.

6.2.3 Groundwater

A groundwater monitoring program has been implemented at the site of the proposed generating unit. This monitoring program is part of the overall monitoring program developed for the plant waste water system. The purpose of the overall program is twofold:

1. To monitor water quality of various effluents within the treatment system

2. To monitor any changes in groundwater quality due to operation of the waste water system.

Table 6.2-1 lists the ongoing water monitoring programs at Big Bend Station.

Sewage Treatment Plant

At the sewage treatment plant, both the influent and the effluent are tested every other month for biochemical oxygen demand and total suspended solids. In addition, the effluent is also tested quarterly for fecal coliform and almost daily for pH value and total chloride residual. The sewage treatment plant effluent is directed to the waste water treatment ponds, thus its ultimate disposal is through spray irrigation.

Waste Water Pond

Effluent from the waste water pond is monitored five times per week for total solids, soluble solids, and pH value. In addition, a heavy metals analysis is taken monthly.

The ultimate fate of water within the waste water system is disposal through spray irrigation.

Groundwater Monitoring

The groundwater monitoring program to assess existing groundwater conditions at the site comprises ten water wells installed at various locations onsite. These wells range in depth from 10 ft to 25 ft. The corresponding tip elevations are 3.2 msl and 18.6 msl, respectively.

Groundwater samples from these wells are periodically pumped for testing. These samples are tested every 3 months for biochemical oxygen demand, fecal coliform, total nitrogen, and chloride. Additional tests are also performed each month to determine their total solids, soluble solids, pH, turbidity, conductivity, and vanadium.

6.2.4 Air Quality/Meteorology

The sampling methodologies utilized in obtaining data to characterize the local meteorology (Section 2.6) and background air quality (Section 2.8) are presented in this section. Methods and procedures are discussed for collection of sulfur dioxide, total suspended particulates, nitrogen dioxide, and meteorological parameters (see Table 6.2-6). In addition, a discussion of the dispersion modeling methodology is included.

6.2.4.1 Ambient Air Quality Data

Descriptions of the locations, sampling frequency, and data periods associated with the air quality monitoring program are contained in Section 2.8, together with the analysis of the collected data.

As discussed in Section 2.8.2, the two sources of ambient air quality data are the Hillsborough County Environmental Protection Commission (HCEPC) and the Tampa Electric Company (TECO) monitoring networks. The sampling program consists primarily of eight noncontinuous and five continuous sulfur dioxide (SO_2) monitors, seven high-volume sampling stations for total suspended particulate (TSP), and seven nitrogen dioxide (NO_2) monitors. Table 6.2-7 lists the various monitoring sponsors, frequencies of measurement, data period durations, and elevations.

Special aspects of the operation of the continuous SO_2 monitoring program should be noted. Continuous sulfur dioxide monitors in the vicinity of TECO Big Bend have historically been operated by both TECO and HCEPC. TECO monitors were initially installed, operated, and monitored by Environmental Science and Engineering, Inc. (ESE) as part of a joint venture between TECO, ESE, and Environmental Research and Technology, Inc. (ERT). After July 30, 1978, the monitoring network was operated by TECO's Central Testing Laboratory.

Descriptions of the sampling techniques used in the monitoring programs are given below.

Sulfur Dioxide - Noncontinuous

Sulfur dioxide sampling was conducted at all TECO stations using procedures consistent with the EPA reference method (pararosaniline method) as described in the Federal Register.⁽²⁵⁾ The principal of the method is the absorption of sulfur dioxide in a 0.04 M solution of potassium tetrachloromercurate (TCM) forming a stable dichlorosulfitomercurate complex. Pararosaniline methyl sulfonic acid is formed by the reaction between the dichlorosulfitomercurate complex, pararosaniline, and formaldehyde. The concentration of pararosaniline methyl sulfonic acid is subsequently determined spectrophotometrically.

The effects of the principal known interferences have been minimized or eliminated. Interferences by oxides of nitrogen are eliminated by sulfamic acid, heavy metals by ethylenediaminetetraacetic acid (EDTA), and phosphoric acid. After sample collection, the solutions are relatively

stable; however, recent studies show that temperatures above 22°C cause high losses of SO₂.⁽²⁶⁾ The presence of EDTA enhances the stability of SO₂ in solution. Samples stored at 5°C suffer no detectable losses of sulfur dioxide. The rate of decay is independent of the concentration of SO₂.

Beginning in July 1976, all TECO and HCEPC sulfur dioxide bubblers were equipped with temperature control devices, and constant temperature containers were utilized to store and ship samples. The TECO temperature-controlled samplers were equipped with constant recording thermometers to verify that sampling was conducted within the temperature ranges specified by the U.S. Environmental Protection Agency (EPA). These specifications require that samples be collected at 25°C (77°F) or less and maintained at 20°C (68°F) or less until analysis.

Considerable research by the EPA has been directed toward evaluation of the method. Resulting modifications, as presented in the Federal Register⁽²⁷⁾ indicate that the absorption efficiency is greater than 98 percent for sulfur dioxide concentrations greater than 25 ug/m³ within a certain temperature range.

Sulfur Dioxide - Continuous

TECO continuous sulfur dioxide monitors are Thermo Electron Model 43 pulsed fluorescent analyzers. The pulsed fluorescent method operates on the principle of sending pulsating ultraviolet light through the sample gas, which is contained in a fluorescent chamber. The ultraviolet radiation excites SO₂ molecules which then give off a characteristic decay radiation. A photomultiplier tube detects the magnitude of energy release and converts the reading into a voltage which is in direct proportion to the concentration of SO₂ in the sample stream.

The Thermo Electron analyzers were complemented with ancillary equipment in order to ensure accurate data collection. Equipment included chart recorders and several calibration systems. A complete description of the TECO monitoring system, including quality assurance, operation, maintenance, and calibration procedures, can be found in "Big Bend Monitoring Network Operations, Service and Maintenance Manual," December 1976.

The Thermo Electron Model 43 analyzer operating on the 0-0.5 ppm range was designed as an equivalent method by EPA on February 27, 1976.⁽²⁸⁾ The analyzers at several of the TECO stations were operated on the 0-1 ppm range. The manufacturer has recently submitted to EPA the necessary

documentation and has received equivalency approval on the 0-1 ppm range.⁽²⁹⁾

Total Suspended Particulate Matter

The procedure used for collection of total suspended particulate matter samples was the Federal Reference Method.⁽³⁰⁾ Air is drawn into a covered housing and through a glass fiber filter by means of a high flow rate blower at a flow rate of 40 to 60 ft³/minute. Suspended particles are collected on the filter surface. The mass concentration (ug/m³) of the suspended particulate matter in the ambient air is computed by measuring the mass of collected particles and the volume of air sampled.

The only interferences of the method are contaminants that would block the filter and cause a rapid drop in air flow at a nonuniform rate. Glass filter efficiencies are comparatively insensitive to changes in relative humidity.

Nitrogen Dioxide

During the sampling period, the "Sodium Arsenite Method of the Determination of Nitrogen Dioxide in the Atmosphere" was utilized for all NO₂ samples collected by the TECO network. This method was designated as an equivalent sampling method in the Federal Register.⁽³¹⁾ The method involves the absorption of NO₂ in a sodium hydroxide-sodium arsenite solution and spectrophotometric analysis of the resulting nitrite ion.

Quality Assurance

As described previously, all TECO monitoring stations were operated according to the promulgated Federal Reference Methods. Monitoring sites were located and evaluated for proper siting criteria by use of an Environmental Research and Technology, Inc. (ERT) developed computer program. This program incorporated recommended criteria and guidelines for siting both continuous and noncontinuous monitors. As an additional measure to ensure valid data collection, TECO had independent audits performed by environmental consulting firms during the period 1976 through 1978. Audits were performed on both the continuous and noncontinuous monitoring stations. These audits consisted of review of field procedures, inspection of monitoring sites and equipment, and operational checks of flow rates, pumps, orifices, etc. In addition, TECO laboratories were audited periodically to ensure proper data analysis and calculation.

Table 6.2-8 summarizes the audits which TECO and TECO's consultants performed on the three ambient air monitoring

networks (SO₂, TSP, and NO_x) during the data collection period. The table also shows the individuals involved in the audits and the dates the audits were performed.

6.2.4.2 Dispersion Models

Three EPA-developed atmospheric dispersion models were utilized in estimating baseline air quality. The models employed are included in the EPA's Guideline on Air Quality Models,⁽³²⁾ which recommends the use of specific models for analysis of significant deterioration and compliance with ambient air quality standards. The models utilized were: the Air Quality Display Model with Briggs Plume Rise (AQDM-Briggs), the Point Multiple Model with Wind Shear Effects (PTMTPW), and the CRSTER single source model. These models are applicable to the Big Bend area conditions and are widely used and accepted in the state of Florida. A detailed description of the models and the air quality analysis methodology can be found in the Prevention of Significant Deterioration permit application⁽³³⁾ for Big Bend Unit 4.

The AQDM-Briggs model, a long-term model, was used to estimate annual average ground level concentrations. The AQDM-Briggs predicted concentrations were not calibrated (i.e., no adjustments were made to model values).

Short-term estimates were derived utilizing the CRSTER and PTMTPW models. The CRSTER model was used to identify the worst case 24-hour and 3-hour meteorological conditions. Utilizing the critical meteorological conditions, maximum concentrations were refined by use of the PTMTPW model. Short-term estimates as provided by the models were not adjusted.

Emissions data and stack parameters for all sulfur dioxide and particulate matter sources were developed based upon information in the National Emissions Data System (NEDS) and Florida Department of Environmental Regulation (FDER) permit files. A future allowable inventory was prepared from the latest available emissions and stack data (generally 1977 NEDS forms). This inventory also included all new sources and modifications which have been permitted since January 1, 1975, based upon information in FDER permit files.

6.2.4.3 Meteorological Data

Surface meteorological data recorded at the National Weather Service (NWS) office at Tampa International Airport and the MacDill Air Force Base Weather Station were used to characterize local meteorology. In addition, upper air data at the NWS office has been utilized. Table 6.2-9 summarizes

the meteorological parameters recorded at each station, together with associated sampling frequencies and data period durations. TECO did not conduct any meteorological data collection programs for use in this application.

6.2.5 Geology

Since 1966, there have been several subsurface investigation programs at the site of the proposed generating unit to evaluate the suitability of the subsurface for power plant siting and to develop soil parameters for foundation design. The field investigation was supplemented by a review of aerial photographs of the site and by an onsite geological reconnaissance.

The subsurface investigations included rotary borings through the overburden into rock, soil and rock samples, and field tests. The borings were drilled in accordance with ASTM D1586 under continuous supervision by a qualified engineer or geologist. Standard penetration testing was performed at 2.5-ft intervals to a depth of 10 ft and at 5-ft intervals thereafter. Split-barrel samples were obtained at each test depth. Undisturbed soil samples were obtained in accordance with ASTM D1587. Core borings consisted of continuous sampling of rock in accordance with ASTM D2113, using a rotary diamond bit and core recovery barrels.

All soil and rock samples were examined closely by an experienced engineer or geologist and immediately logged. Representative soil samples were selected for laboratory testing. The laboratory tests performed during various phases of subsurface investigation include:

1. Atterberg limits
2. Grain size analysis
3. Organic content
4. Specific gravity
5. Compaction tests
6. Permeability test on reconstituted samples

Boring programs undertaken at the site for the existing Big Bend Station Units 1, 2, and 3 date back to 1966. Nine borings ranging in depths from 60 ft to 125 ft were drilled between 1966 and 1967.

Sixty soil and rock borings were drilled in 1968 for site investigation and foundation design of transmission lines. Eight of these borings were less than 40 ft in depth, and 35 borings were drilled deeper than 40 ft.

Fifteen miscellaneous borings ranging between 30 and 70 ft in depth were drilled in 1971. Forty-four borings were drilled in 1972 and 1973 for the design of a spray canal, a circulation water intake, and a shipping channel. Eleven of these borings were drilled deeper than elevation -40.

For subsurface verification for Unit 4, 11 borings were drilled in 1976 and 1977 adjacent to the existing Units 1, 2, and 3. These borings ranged up to 90 ft in depth.

A subsurface investigation involving 29 hand-auger borings and 25 rotary borings was conducted in 1974 and 1975 for locating the waste water treatment ponds. Percolation tests were performed in hand-augered borings ranging from 24 inches to 80 inches in depth, in accordance with the then existing Chapter 17-13 Sewage Disposal Facility rules of the Florida Department of Environmental Regulation. The rotary borings were drilled to depths between 15 ft and 35 ft. These boring investigations were conducted to evaluate the surface and subsurface conditions from the standpoint of supporting the wastewater treatment pond dikes.

Soil and rock information obtained from these investigations was used to develop subsurface soil and rock profiles and for verification of site geology. A detailed description of onsite soils and site geology is given in Section 2.4.

6.2.6 Archaeology

The Florida Department of State, Division of Archives, History and Records Management was contacted in 1974 to identify known and potential archaeological and historic sites within 5 miles of Big Bend Station. The Division identified 28 known sites. In 1979 TECO requested that the Division perform a "Cultural Resource Assessment" within the tracts of land selected for construction of Unit 4 and its associated facilities. The Division concluded that the project may proceed without their further involvement since the proposed development was unlikely to affect any sites listed or eligible for listing on the National Register of Historic Places.

6.2.7 Ambient Noise Survey Methodology

To provide a basis for noise impact assessment, the sound level environment in the vicinity of the Big Bend Station was determined with two ambient sound level surveys. Each survey consisted of three daytime and three nighttime sets of measurements. The first survey, with Units 1 and 2 operating, was conducted in February 1974 to quantify and characterize the existing ambient sound levels. The second

survey was conducted in January 1978 to determine whether the operation of Unit 3 and new residential development in the Apollo Beach area had significantly changed the ambient levels.

A-weighted sound level and octave band sound pressure level measurements were taken with a type 1 precision sound level meter with attached octave band filter set during both surveys. A pistonphone was used to calibrate the microphone and sound level meter. Depending on whether the measurement position was in the community or on the plant site, the minimum or average ambient levels respectively were measured during lulls in identifiable transient noises. Weather conditions were favorable for measurements. Pertinent meteorological data were measured, using hand-held equipment.

Measurements were made on the plant site at three locations approximately 1,000 ft from the station center in three directions to reliably determine the sound energy radiated from the plant. Measurements were taken at five locations in the surrounding community representative of both populated and open areas to quantify the existing ambient sound levels and to determine the dominate noise sources. The measurement locations are shown on Figure 2.9-1.

During the noise measurements, the Big Bend Station units were generally operating between 175 - 350 MW, except that Unit 2 was not operating on the night of January 17, 1978. The Big Bend Station gas turbines were not operating during any of the measurements. The results of these surveys are presented in Section 2.9.1.

6.2.8 Terrestrial Biota

From March 1974 through May 1975 terrestrial ecological investigations in the vicinity of Big Bend Station were conducted by the University of South Florida (USF). A second evaluation was conducted by USF during August, September, and October of 1977. Voucher specimens of plants and invertebrates collected at the Big Bend site are maintained at the Herbarium and the Museum of USF.

6.2.8.1 Vegetation

Sampling stations were established in twelve vegetation or community types in the vicinity of the Big Bend Station (see Figure 2.7-1). Each vegetation type was sampled seasonally, and the following parameters were determined: 1) density,

2) relative density, 3) frequency, 4) relative frequency, 5) dominance (percent cover), 6) relative dominance, and 7) importance value. Square quadrats were used to obtain density and frequency data, and line transects (10m long) were used to determine cover percentages. Quadrat size and number were determined using nested quadrats and species-area curves. When percent cover was less than 0.5 percent, it was recorded as "trace," with the exception of sample location 8, where it was recorded as "trace" when the percent cover was less than 0.2 percent.

During the 1977 survey, each sampling station previously established during 1974-75 was visited twice to update the 1974-75 checklist of plant species and to note any major changes in species composition and community condition (e.g., stress).

6.2.8.2 Mammals

Mammals were sampled seasonally within the twelve permanent sampling locations indicated in Section 6.2.10.1. Two field methods were used: (1) live trapping and (2) sighting and identification of tracks, signs, and scat. Taxonomy was according to Burt and Grossenheider⁽³⁴⁾ and Murie.⁽³⁵⁾

Small mammals were sampled using Sherman live traps baited with sunflower seeds. Traps were either spaced 20 ft apart in grids within the larger, homogeneous vegetation types or along transects in sampling locations 3, 7, 4, and 10. For captured organisms, age, sex, reproductive condition, molt, presence of ectoparasites, and general body condition were noted. Each organism was individually toe-clipped and released at the point of capture.

Large mammal traps (National wire live traps) were placed at least 50 ft apart along a transect line and baited with sardines. Large mammals were anesthetized using an injection of a ketamine hydrochloride derivative. After examination the animals were marked with numbered aluminum ear tags and released.

During the 1977 survey, each of the 1974-75 sampling locations was sampled on at least two nights, using the same equipment and methodology described above for the 1974-75 study. The numbers of trapnights for each sampling location for the 1974-75 and 1977 surveys are presented on Tables 2.7-34 through 2.7-36.

6.2.8.3 Avifauna

Birds were counted and identified either using transects within each previously designated sampling location or by

making total counts of individuals within each sampling location.

The taxonomy is according to the American Ornithologists' Union Checklist of North American Birds⁽³⁶⁾ and the 32nd Supplement to the American Ornithologists' Union Checklist of Birds.⁽³⁷⁾

6.2.8.4 Amphibians and Reptiles

Individual members of amphibian and reptile species were counted as they were encountered during general field surveys for these two groups of organisms. Taxonomy is according to Conant.⁽³⁸⁾

6.2.8.5 Invertebrates

Previously described sampling locations were sampled for invertebrate fauna between 8:30 a.m. and 1:30 p.m. Standard insect collecting equipment included an insect net, killing jar, cellophane envelopes, and alcohol-containing vials. Lepidopterans were stored in cellophane envelopes; other insects were either pinned and placed into insect boxes or stored in vials containing 70 percent alcohol. A 50-sweep technique was generally used for collecting insects. Lepidopterans and arachnids, however, were collected upon sighting within each sampling area.

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TABLE 6.2-1

WATER MONITORING PROGRAMS

Condenser Cooling Water

<u>Parameter</u>	<u>Frequency</u>	<u>Sample Type</u>	<u>Responsi- bility</u>
Flow	Continuous	Pump Logs	Plant
Temp at Condenser Outlet	Hourly	Recorder	Plant
Temp at End of Dilution Channel	Continuous	3x3 Grid Recorder	Plant
Temp at Rise Across Condenser	6/Day	Calculation	Plant
Free Available Chlorine	1/Week	Mult. Grab	Plant
Total Residual Chlorine	1/Week	Mult. Grab	Plant

Ash Pond Discharge

Flow	1/Day	Weir Reading	Plant
Oil & Grease	1/Month	Grab	CTL
TSS	1/Month	Grab	CTL
Heavy Metals	1/Quarter	Grab	CTL
pH	1/Week	Grab	CTL/Plant

Boiler Blowdown

Flow	1/Week	Instantaneous	CTL
Copper	1/Week	Grab	CTL
Iron	1/Week	Grab	CTL

Coal Pile Runoff

Flow - Discharge limitations are met by containment of 10 years/
24 hour storm.

TSS
pH

Construction Runoff

Flow - Frequency and sampling are commensurate with type of treat-
ment system.

TSS
pH

TABLE 6.2-1 (Cont)

Sewage Treatment Plant

<u>Parameter</u>	<u>Frequency</u>	<u>Sample Type</u>	<u>Responsi- bility</u>
Influent Flow	5 Days/Week	Grab	Plant
Effluent pH	5 Days/Week	Grab	Plant
Total Cl Residual	5 Days/Week	Grab	Plant
Influent & Effluent BOD	Odd No. Months	Grab	CTL
Influent & Effluent TSS	Odd No. Months	Grab	CTL
Fecal Coliform (Effluent)	Quarterly	Grab	Outside Lab
Monitoring Wells			
BOD	Quarterly	Pumping	CTL
Fecal Coliform	Quarterly	Pumping	Outside Lab
Total Nitrogen	Quarterly	Pumping	CTL
Chloride	Quarterly	Pumping	CTL

Waste Water Pond

TS (Fixed&Volatile)	5/Week	Grab	CTL
SS (Fixed&Volatile)	5/Week	Grab	CTL
pH	5/Week	Grab	CTL
Heavy Metals	Monthly	Grab	CTL

Waste Water Pond and Spray Field Monitoring Wells

TS	Monthly	Pumping	CTL
SS	Monthly	Pumping	CTL
BOD	Monthly	Pumping	CTL
pH	Monthly	Pumping	CTL
Turbidity	Monthly	Pumping	CTL
Conductivity	Monthly	Pumping	CTL
Vanadium	Monthly	Pumping	CTL

1. CTL = Central Testing Lab, Plant = Big Bend Station.

TABLE 6.2-2

DESCRIPTION OF SAMPLING STATIONS, 1970-1975

<u>Station</u>	<u>Description</u>
I-1	Mouth of Unit 1 discharge flume. Average depth is 4.9 m (16.0 ft).
I-2	At end of dilution wall, approximately 0.1 km south of Unit 1 discharge flume. Average depth is 2.4 m (8.0 ft). (Prior to construction of the dilution wall, I-2 was on a shallow flat.)
I-3	In channel northeast of northeast tip of Apollo Beach, about 0.9 km from Unit 1 discharge flume. Average depth is 3.7 m (12.0 ft). (Prior to construction of the dilution system, I-3 was located on shallow flats approximately 0.15 km southeast of present location.)
I-4	On edge of flats across from northernmost canal on Apollo Beach, approximately 1.5 km from Unit 1 discharge flume. Average depth is 3.5 m (11.5 ft).
I-6	Plant cooling water intake structure. Average depth 7.0 m (23.0 ft).
I-8	On flats at entrance to Newman Branch, approximately 0.7 km southwest of Unit 1 discharge flume. Average depth is 0.9 m (3.0 ft).
I-9	About 0.3 km due west of Unit 1 discharge flume. Average depth was 3.2 m (10.5 ft). (Discontinued after the dilution channel was constructed.)
I-14	Adjacent to boat ramp at Joe's Marina, Apollo Beach, approximately 2.3 km from Unit 1 discharge flume. Average depth is 2.7 m (9.0 ft).
I-15	At end of a finger-fill canal, approximately 2.6 km from Unit 1 discharge flume. Average depth is 2.1 m (7.0 ft).
O-1	Adjacent to southwest tip of breakwater, approximately 1.6 km from Unit 1 discharge. Average depth is 1.5 m (5.0 ft).
O-2	Adjacent to west shore of Apollo Beach, approximately 0.4 km north of the Holiday Inn, and 1.9 km from Unit 1 discharge flume. Average depth is 2.9 m (9.5 ft).

TABLE 6.2-2 (Cont)

<u>Station</u>	<u>Description</u>
O-3	At channel marker off southeastern tip of Apollo Beach, approximately 3.9 km from Unit 1 discharge flume. Average depth is 2.9 m (9.5 ft).
O-4	At a steel piling due west of 1-3, approximately 2.6 km from Unit 1 discharge flume. Average depth is 4.0 m (13.0 ft).
O-5	Seventy-five foot range marker east of Cut A channel and north of the cut to Big Bend coal dock, about 4.8 km from Unit 1 discharge flume. Average depth is 4.4 m (14.5 ft). (O-5 was situated on the edge of a ship channel and was discontinued in September 1974 in favor of O-10.)
O-6	Adjacent to coast just southeast of Whiskey Stump Key, about 3.6 km from Unit 1 discharge flume. Average depth is 1.5 m (5.0 ft).
O-10	Channel marker just north of O-5, about 4.8 km from Unit 1 discharge flume. Average depth is 4.4 m (14.5 ft).

TABLE 6.2-4

OUTLINE OF BIG BEND TRAWL TRANSECTS

<u>Station</u>	<u>Substrate Composition</u>	<u>Bottom Pattern</u>	<u>Thermal Plume⁽¹⁾</u>	<u>Average Depth (m)</u>	<u>Depth Range (m)</u>	<u>General Location</u>
TB-1	Sand	Smooth	Within	4.9	4.6 - 5.2	Discharge Canal
TB-4	Mud	Smooth	Outside	5.8	5.5 - 6.1	Intake Canal
TB-5	Sand	Smooth	Within	2.4	1.8 - 3.0	Open Bay
TB-6	Mud	Smooth	Outside	3.6	3.0 - 4.3	Open Bay
TB-7	Mud	Smooth	Within	3.3	3.0 - 3.6	Open Bay
TB-12	Mud	Irregular	(2)	3.6	2.4 - 4.6	Northern Embayment
TB-13	Mud	Irregular	Outside	4.0	3.0 - 5.2	Southern Embayment

NOTES:

(1) Refers to the thermal plume boundaries as outlined in the Section 2.5.

(2) Thermal effluent penetrates this area during an incoming tide.

TABLE 6.2-3

LIST OF BIG BEND SEINE STATIONS - 1976-1977

<u>Station</u>	<u>Substrate Composition</u>	<u>Thermal Plume(1)</u>	<u>Location</u>	<u>Comments</u>
SB-5	Sand	Outside	Open bay; SW end of Apollo Beach	Shallow area; some rocks extend beyond the littoral zone.
SB-10	Mud	(2)	Inshore; north embayment	Very shallow area; much of it exposed during a low tide. Seasonal algal growth
SB-11	Sand	Outside	Inshore; south embayment; SE end of Apollo Beach	Shallow point; bordering a ship channel.
SB-12	Sand	Within	Open bay; NW end of Apollo Beach	Shallow area; numerous sandbars.
SB-13	Sand	Outside	Inshore; west of intake canal	Shallow area; source water for the plant.
SB-14	Sand	Farfield region	Open bay; north shore of Pine Key	Sloping beach; bordering a ship channel.

NOTES:

(1) Refers to the thermal plume as outlined in Section 2.5.

(2) Discharge water penetrates this area during an incoming tide. However, due to the shallowness of this area, solar heating probably exerts a greater influence on water temperature than the thermal discharge.

TABLE 6.2-5

DESCRIPTION OF VEGETATIVE SAMPLING TRANSECTS

<u>Area</u>	<u>Transect</u>	<u>Length</u>	<u>Sampling Points</u>
A	A-1	160 m	17
	A-2	360 m	37
	A-3	360 m	37
B	B-1	210 m	22
C	C-1	35 m	8
	C-2	20 m	5
	C-3	20 m	5
D	D-1	30 m	7
	D-2	20 m	5
	D-3	20 m	5
E	E-1	45 m	10
	E-2	20 m	5
	E-3	40 m	9
Control		1,150 m	116

TABLE 6.2-6

AIR MONITORING PROGRAMS

Stack Emissions Big Bend 1-3

<u>Parameter</u>	<u>Frequency</u>	<u>Sample Type</u>	<u>Responsi- bility</u>
SO ₂	Continuous (Fuel Analysis)	Daily Composite	CTL/Plant
Opacity	Continuous	In-Stack Moni- tor	Plant
<u>Emission Tests</u>			
SO ₂	1/Year	Stack Sample	CTL
Particulates	1/Year	Stack Sample	CTL
NOx	1/Year	Stack Sample	CTL

Ambient Air Monitoring

SO ₂	Continuous	Ambient	CTL
<u>Intermittent System</u>			
SO ₂	24 Hours Every 6 Days	Ambient	CTL
TSP	24 Hours Every 6 Days	Ambient	CTL
NO ₂	24 Hours Every 6 Days	Ambient	CTL

1. CTL = TECO Central Testing Lab, Plant = Big Bend Station.

TABLE 6.2-7

AIR QUALITY MONITORING INSTRUMENTATION

<u>Pollutant</u>	<u>Monitor Designation</u>	<u>Monitor Sponsor</u>	<u>Measurement Frequency(a)</u>	<u>Data Period</u>	<u>Elevation Above Ground Level(ft)</u>
SO ₂ (noncon- tinuous)	T5	TECO	Every 6th Day	1/76-12/78	15
	T6	TECO	Every 6th Day	1/76-12/78	15
	T11	TECO	Every 6th Day	1/76-12/78	15
	T13	TECO	Every 6th Day	1/76-12/78	15
	T15	TECO	Every 6th Day	1/76-12/78	15
	T17	TECO	Every 6th Day	1/76-12/78	15
	H9	HECPC	Every 6th Day	1/76-12/78	15
	H54	HECPC	Every 6th Day	1/76-12/78	15
	T1	TECO	Continuous	2/77-4/79	15
	T4	TECO	Continuous	5/77-4/79	15
SO ₂ (continuous)	T5	TECO	Continuous	2/77-4/79	15
	T7	TECO	Continuous	2/77-4/79	15
	T8	TECO	Continuous	2/77-3/78	15
TSP	T5	TECO	Every 6th Day	1/76-12/77	15
	T6	TECO	Every 6th Day	1/76-12/78	15
	T12	TECO	Every 6th Day	1/76-12/78	15
	T17	TECO	Every 6th Day	1/78-12/78	15
	H9	HCEPC	Every 6th Day	1/76-12/78	15
	H50	HCEPC	Every 6th Day	1/76-12/78	15
	H54	HCEPC	Every 6th Day	1/76-12/77	15
NO ₂	T5	TECO	Every 3rd Day	1/76-12/78	15
	T6	TECO	Every 3rd Day	1/76-12/78	15
	T11	TECO	Every 3rd Day	1/76-12/78	15
	T13	TECO	Every 3rd Day	1/76-12/78	15
	T15	TECO	Every 3rd Day	1/76-12/78	15
	T17	TECO	Every 3rd Day	1/76-12/78 (b)	15
	T18	TECO	Every 3rd Day	1/76-12/78	15

(a) Nominal measurement frequency. Refer to Tables 2.8.1-1, 2.8.1-5, and 2.8.1-6 for actual number of sampling data points.

(b) No NO₂ data collected at T17 from 1/77 to 12/77.

TABLE 6.2-8

TECO AMBIENT MONITORING NETWORK AUDITS PERFORMED DURING THE PERIOD 1976 THROUGH 1978

Company Performing Audit	Noncontinuous* Network Audit Performed	Continuous** Network Audit Performed	Persons Performing Audit
Environmental Research & Technology, Inc.		March 2, 1977	A. Sacco, ERT M. Gillespie, ERT R. Durgan, ESE
Environmental Research & Technology, Inc.		April 1, 1977	M. Gillespie, ERT H. Chow, ERT R. Durgan, ESE
Environmental Research & Technology, Inc.		June 8, 1977	A. Sacco, ERT R. Durgan, ESE
Environmental Research & Technology, Inc.		August 24, 1977	A. Sacco, ERT R. Durgan, ESE
Science Associates, Inc.		September 12, 1977	E. Franzblau, SAI R. Durgan, ESE
Environmental Science & Engineering, Inc.	November 1977		A. Graham, ESE D. Layton, TECO
Environmental Research & Technology, Inc.		December 12, 1977	A. Sacco, ERT R. Durgan, ESE
Science Associates, Inc.		January 10, 1978	S. Burton, SAI E. Franzblau, SAI D. Brittan, EPA A. Sacco, ERT R. Durgan, ESE M. Jackson, ESE
Environmental Science & Engineering, Inc.	April 1978		M. Jackson, ESE K. Hansley, TECO
Environmental Research & Technology, Inc.		April 19, 1978	A. Sacco, ERT R. Durgan, ESE
Environmental Science & Engineering, Inc.	November 1978	November 1978	A. Graham, ESE H. Durgan, TECO

* Includes sulfur dioxide and nitrogen dioxide bubblers and total suspended particulate matter monitors.

**Includes continuous sulfur dioxide monitors.

TABLE 6.2-9

METEOROLOGICAL MONITORING INSTRUMENTATION

Parameter	Sponsor	Measurement Frequency	Elevation Above Ground Level (feet)
<u>Surface</u>			
Wind Speed	TIA	1/hr	22
Wind Direction	TIA	1/hr	22
Wet Bulb Temp	TIA	1/hr	5
Dry Bulb Temp	TIA	1/hr	5
Dewpoint	TIA	4/Day	5
Relative Humidity	TIA	Calc. from dewpoint and dry bulb temp	
Precipitation	TIA	Continuous	5
Sunlight Percen- centage (Pyranometer)	TIA	Continuous	47
<u>Upper Air</u>			
Temp Diff (Rewind Sonde Balloon)	NWS	2/Day	

TIA = National Weather Service, Tampa International Airport
 NWS = National Weather Service, Ruskin, Florida

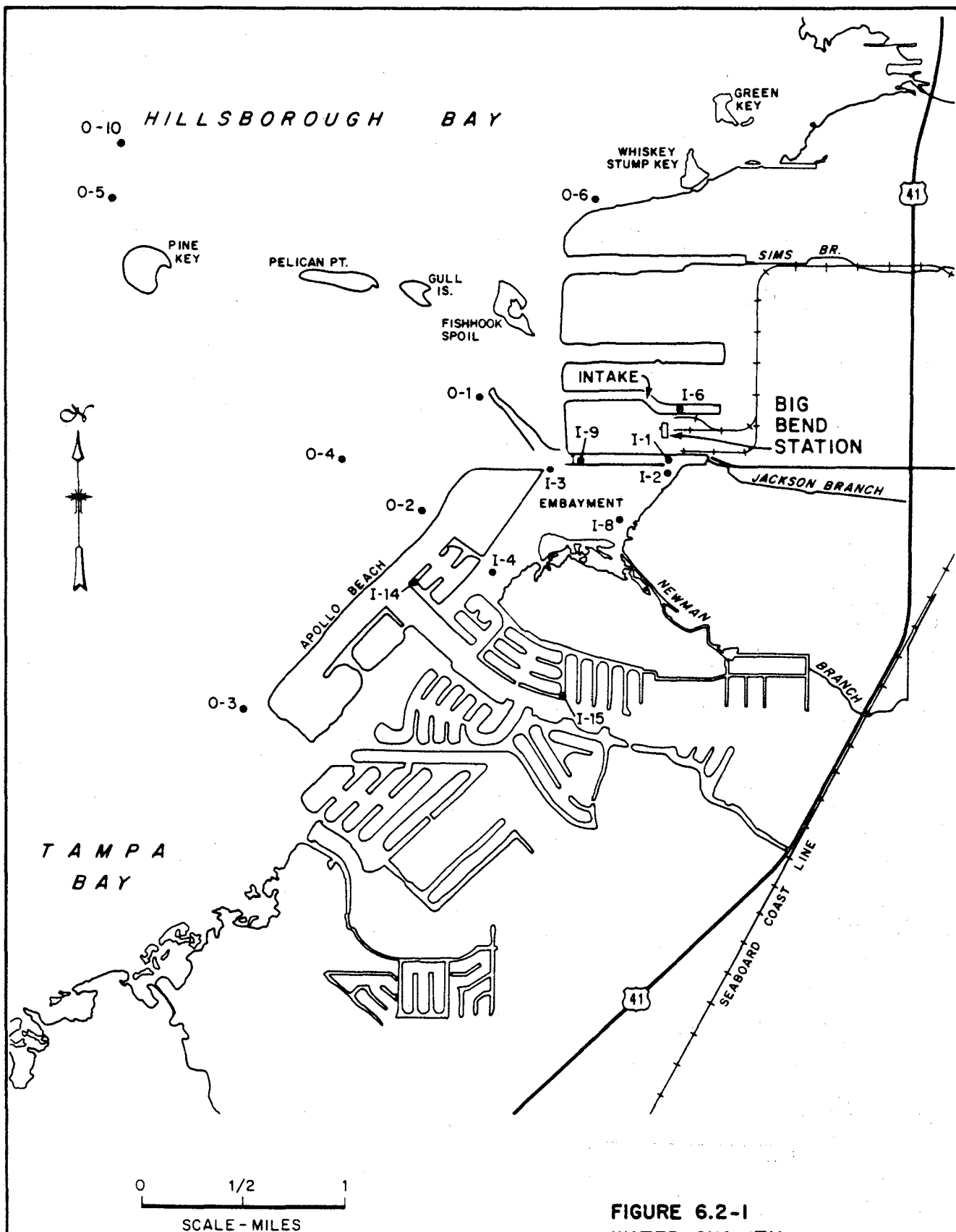


FIGURE 6.2-1
WATER QUALITY
SAMPLING STATION
BIG BEND STATION
TAMPA ELECTRIC COMPANY

SOURCE: Tampa Electric Company, 1975
 Ecological surveys of the Big
 Bend Area. Five year data
 evaluation. July, 1975

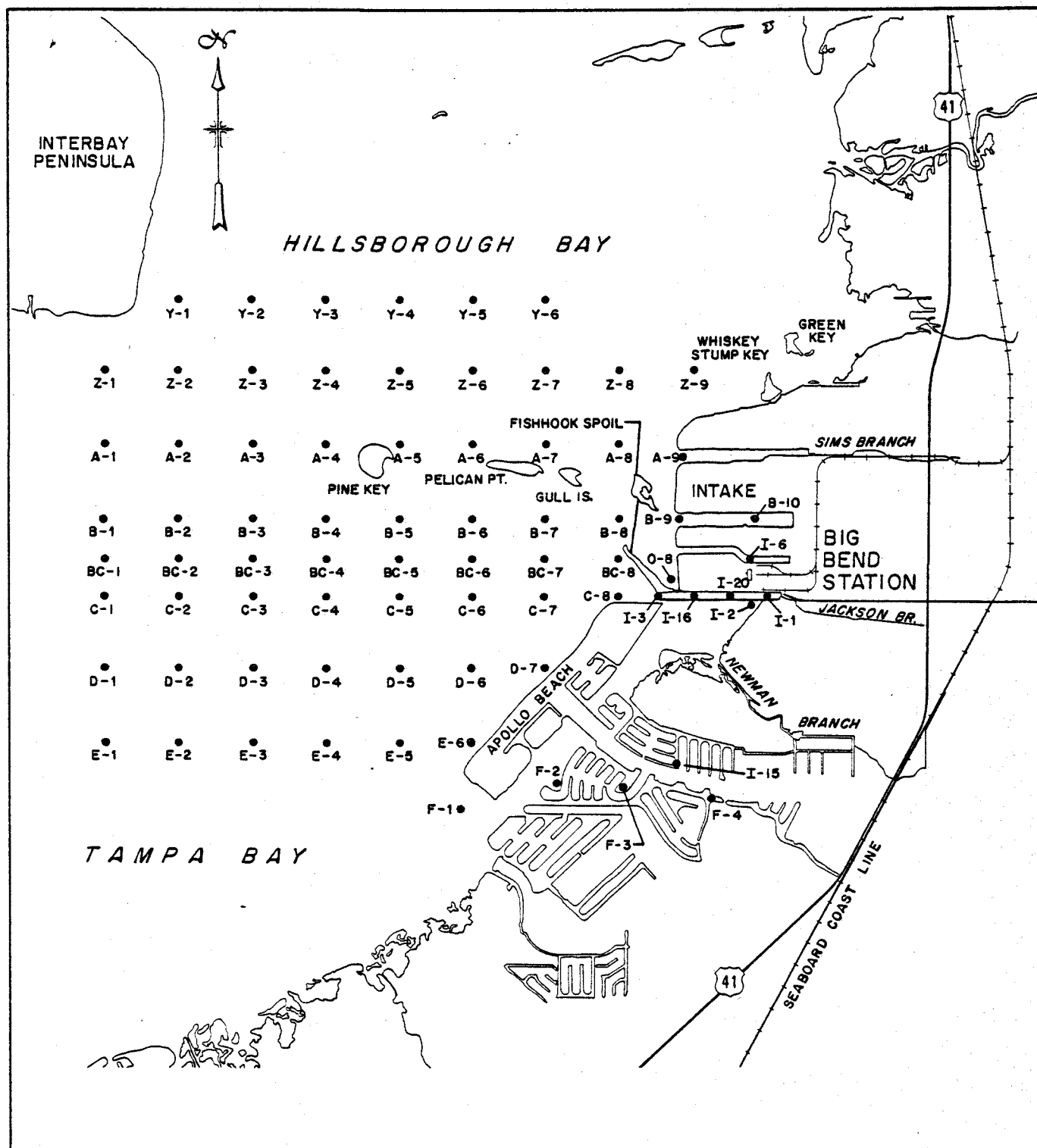


FIGURE 6.2-2
 WATER QUALITY SAMPLING STATIONS
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY

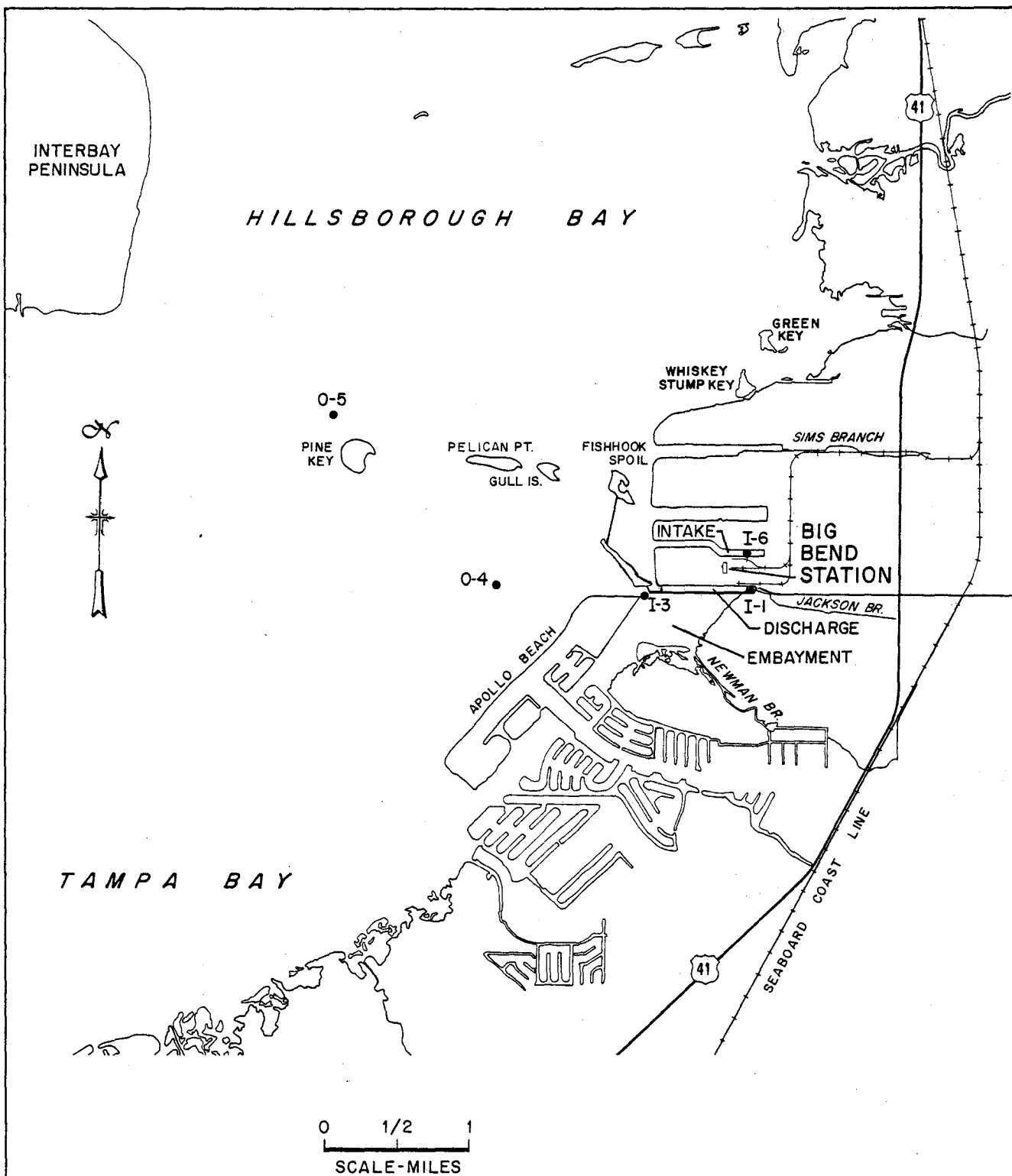


FIGURE 6.2-3
PLANKTON SAMPLING STATIONS
1970-1975
BIG BEND STATION
TAMPA ELECTRIC COMPANY

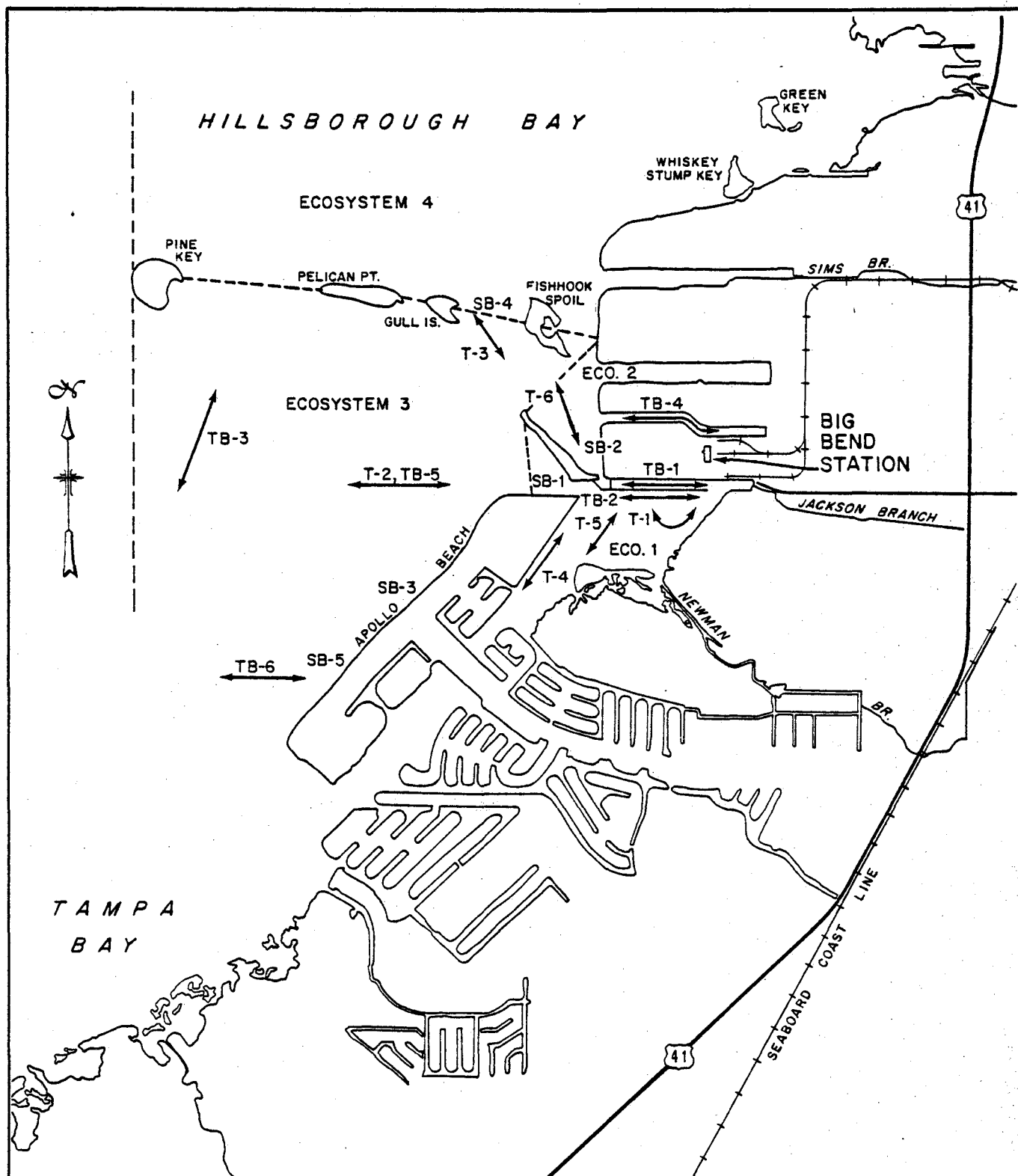


FIGURE 6.2-4
 TRAWL AND SEINE STATIONS
 1970-1975
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY

SOURCE: Ecological Surveys of the Big Bend Area;
 Five Year Data Summary TECO, 1975 page 312.



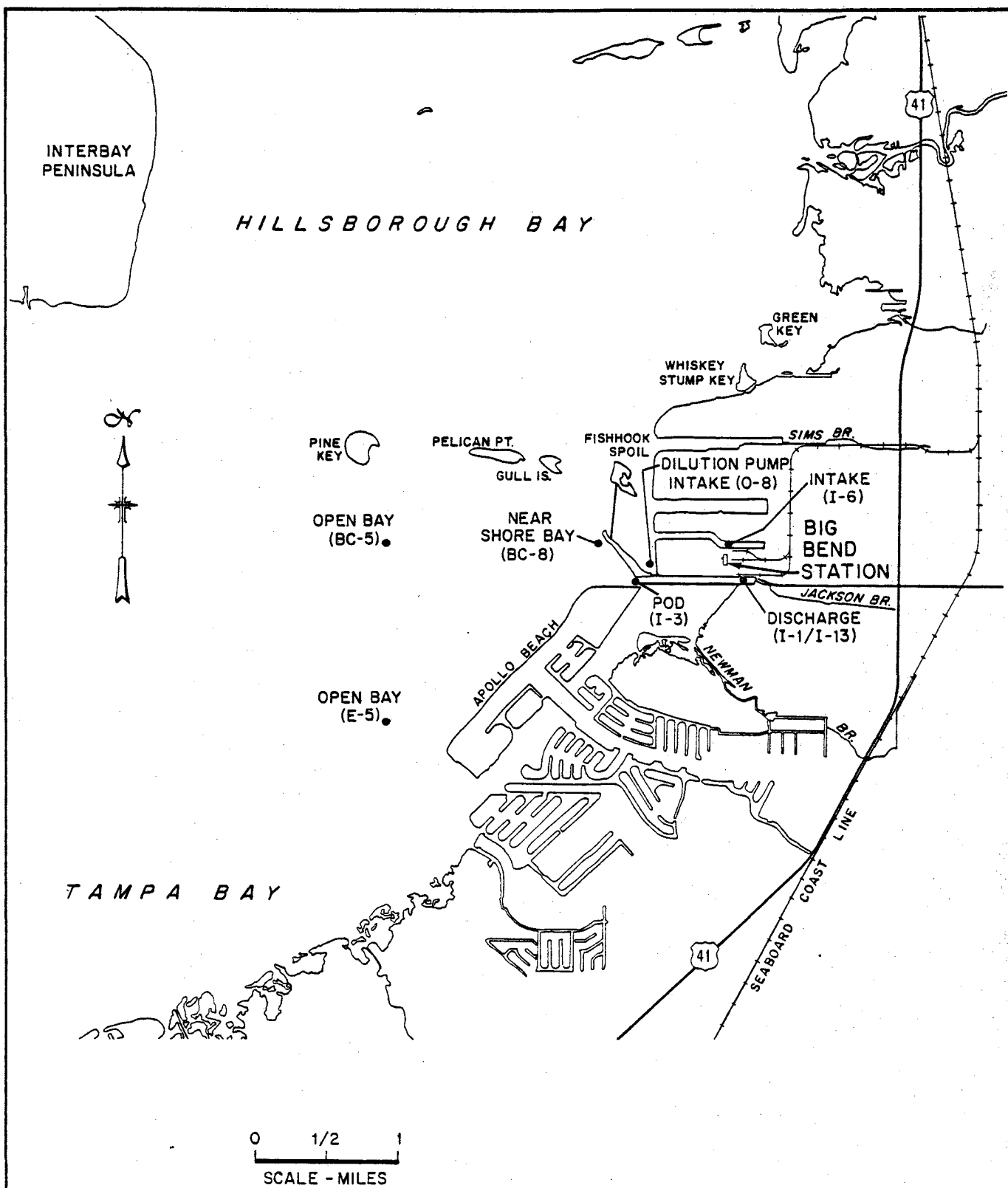
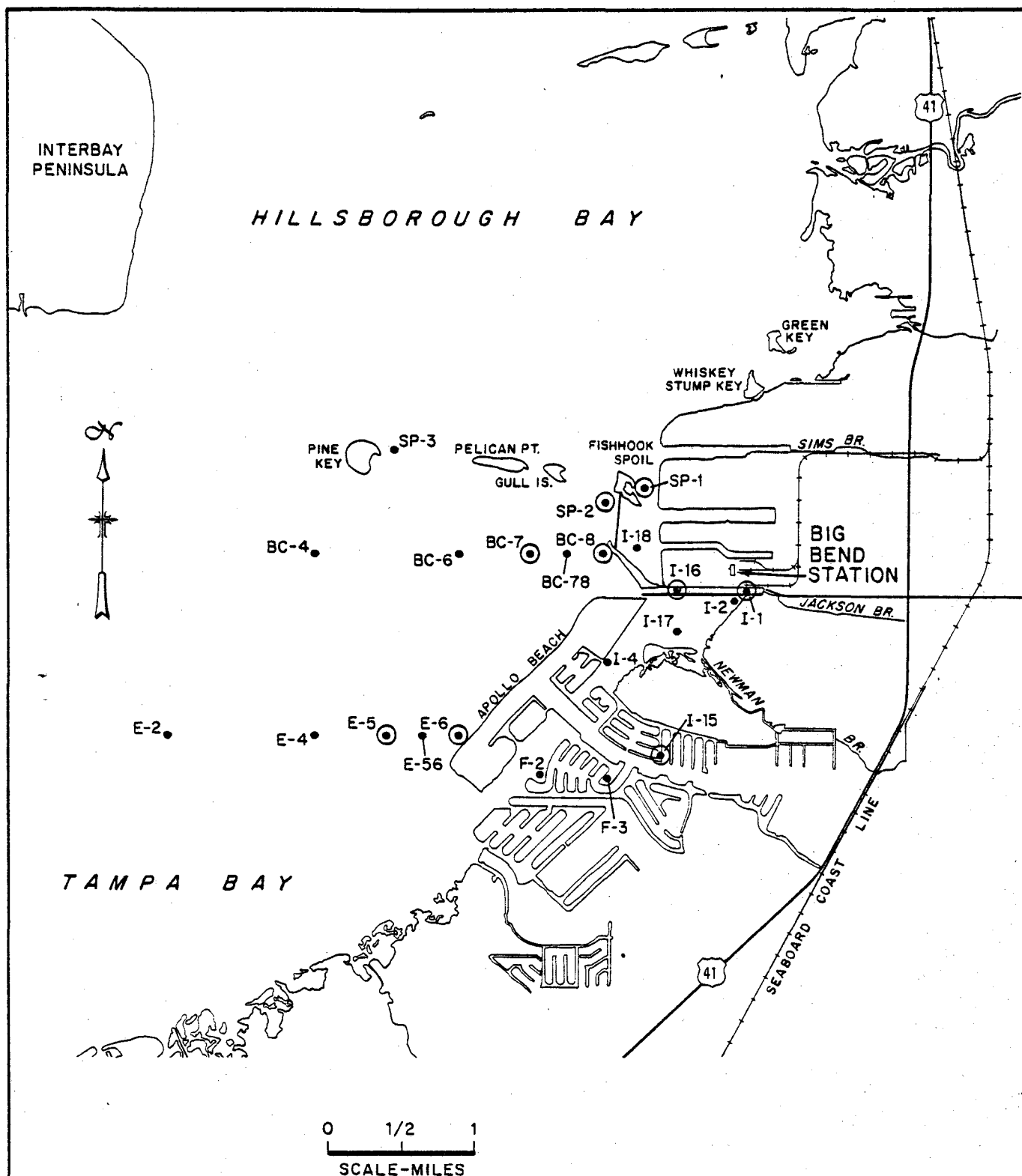


FIGURE 6.2-6
PHYTOPLANKTON STATIONS
BIG BEND STATION
TAMPA ELECTRIC COMPANY

SOURCE: Adapted from Appendix to
316 Demonstration, Volume I, page 3-13.



LEGEND

- STATIONS SAMPLED
ONCE A QUARTER
- ⊙ STATIONS SAMPLED
ONCE EVERY SIX WEEKS

FIGURE 6.2-7
BENTHOS SAMPLING STATIONS
BIG BEND STATION
TAMPA ELECTRIC COMPANY

SOURCE: Adapted from Appendix to
316 Demonstration, Volume III, page 4-10.

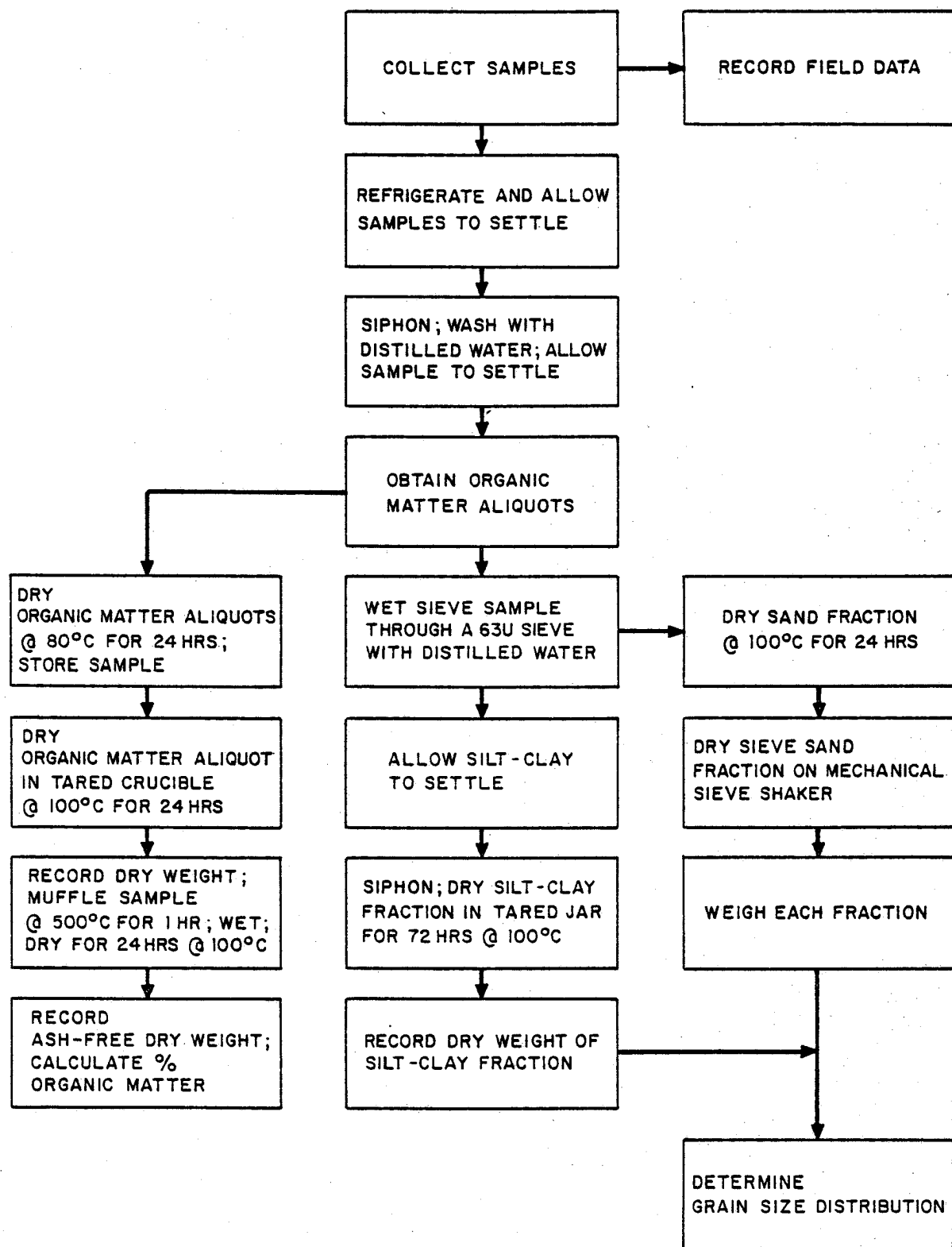


FIGURE 6.2-8
OUTLINE OF LABORATORY PROCEDURES
FOR SEDIMENT ANALYSES
BIG BEND STATION
TAMPA ELECTRIC COMPANY

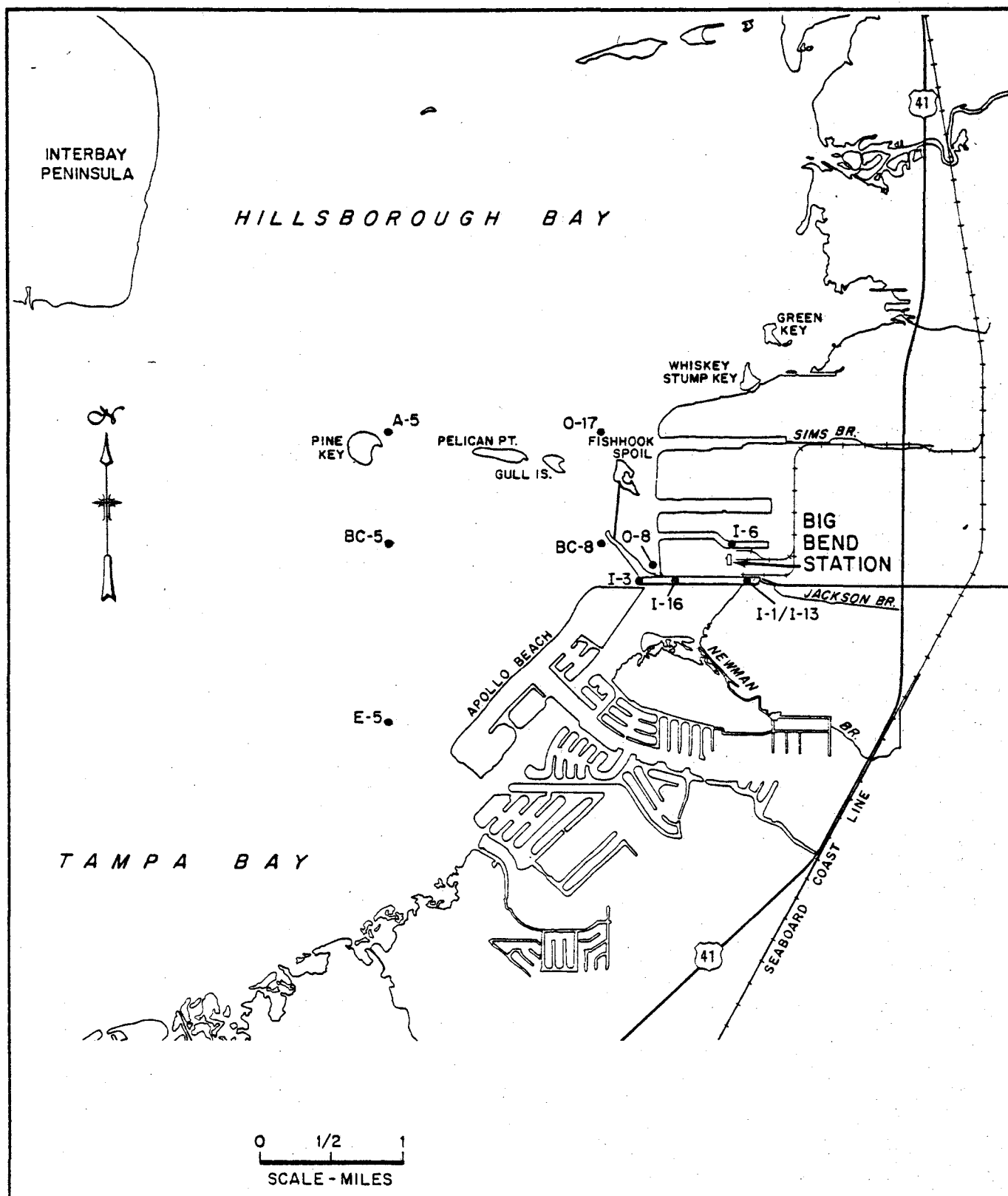
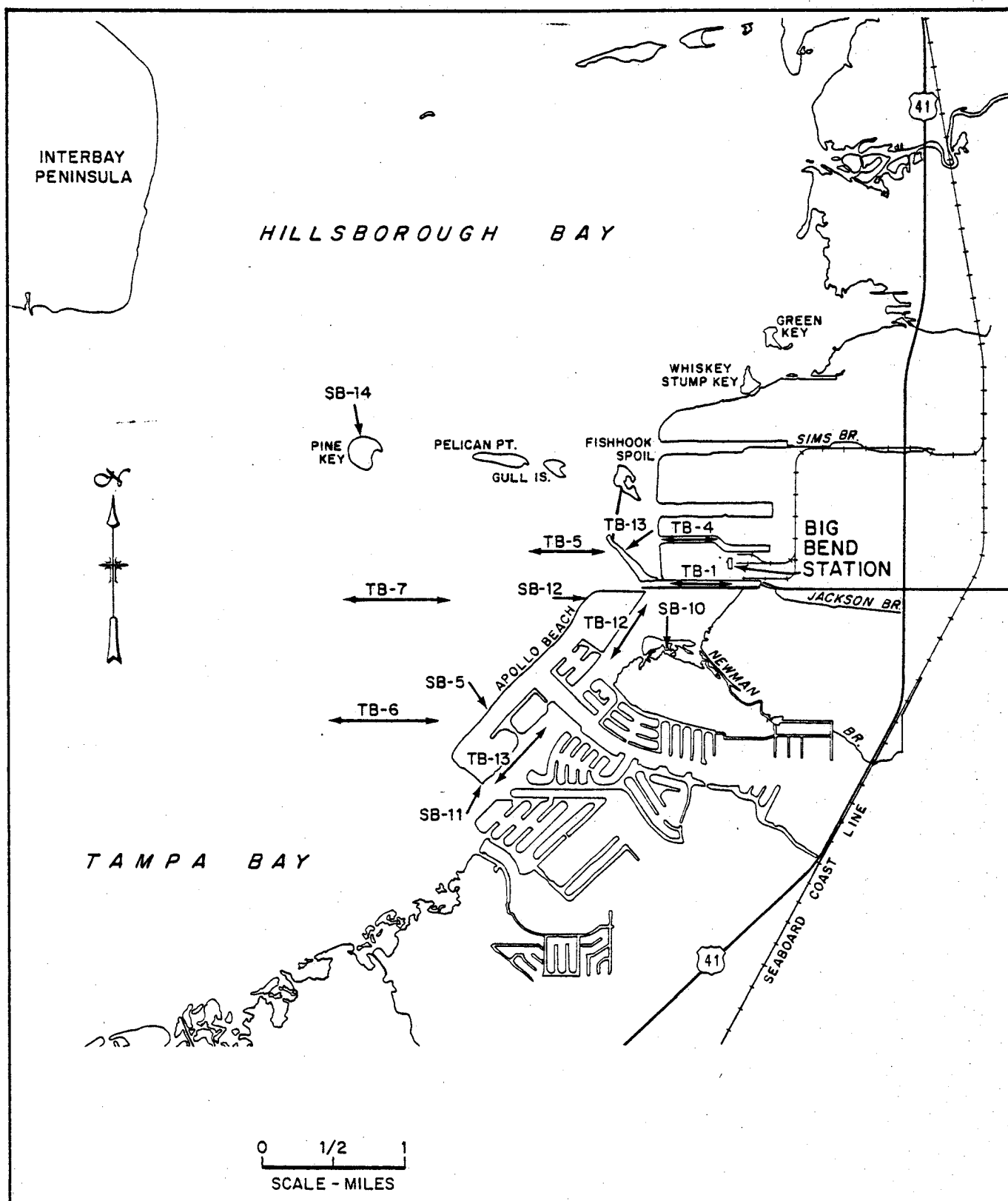


FIGURE 6.2-9
 ICHTHYOPLANKTON
 SAMPLING STATIONS
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY

SOURCE: Adapted from Appendix to
 316 Demonstration, Volume III, TECO, 1977d, page 5-12.

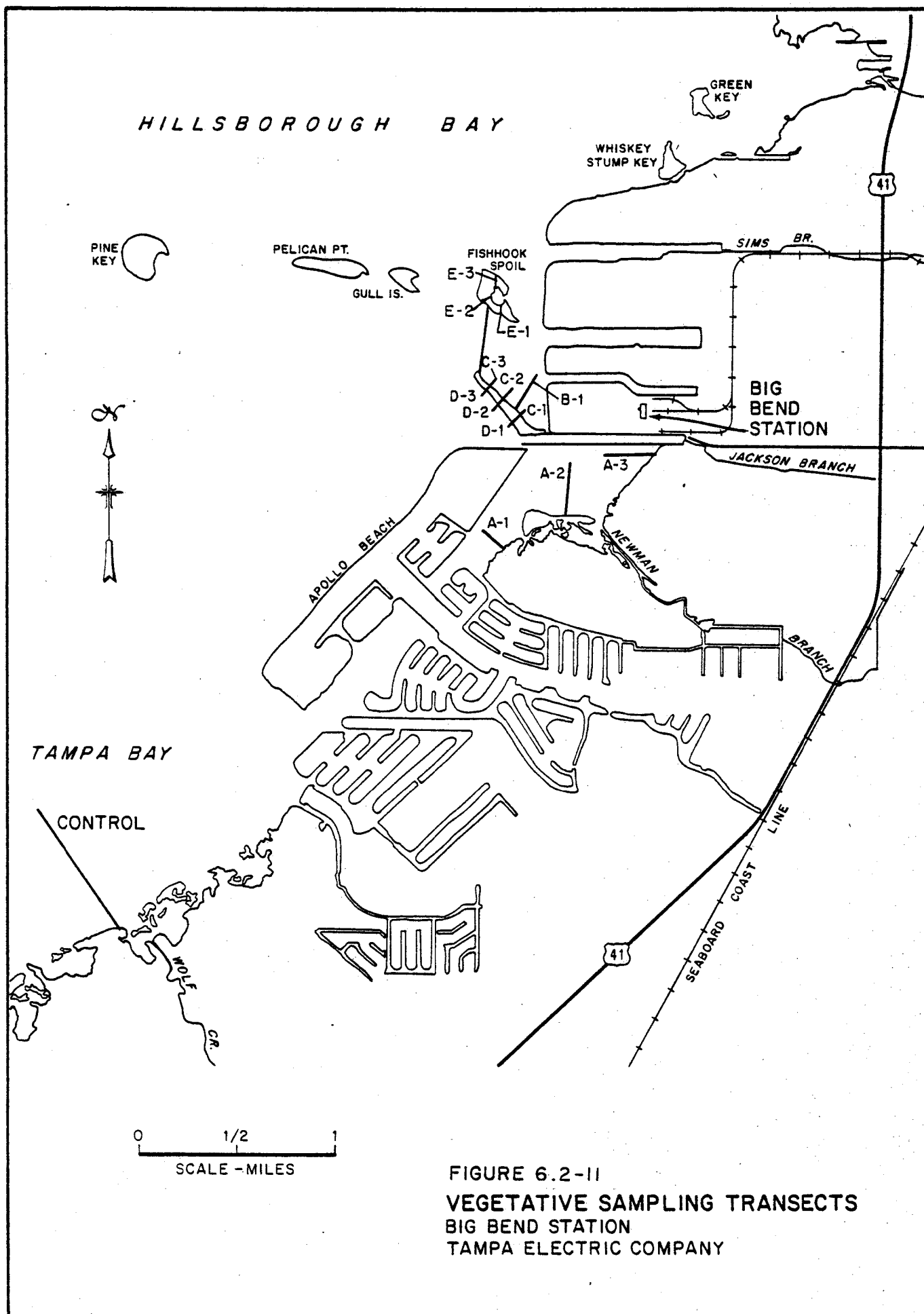


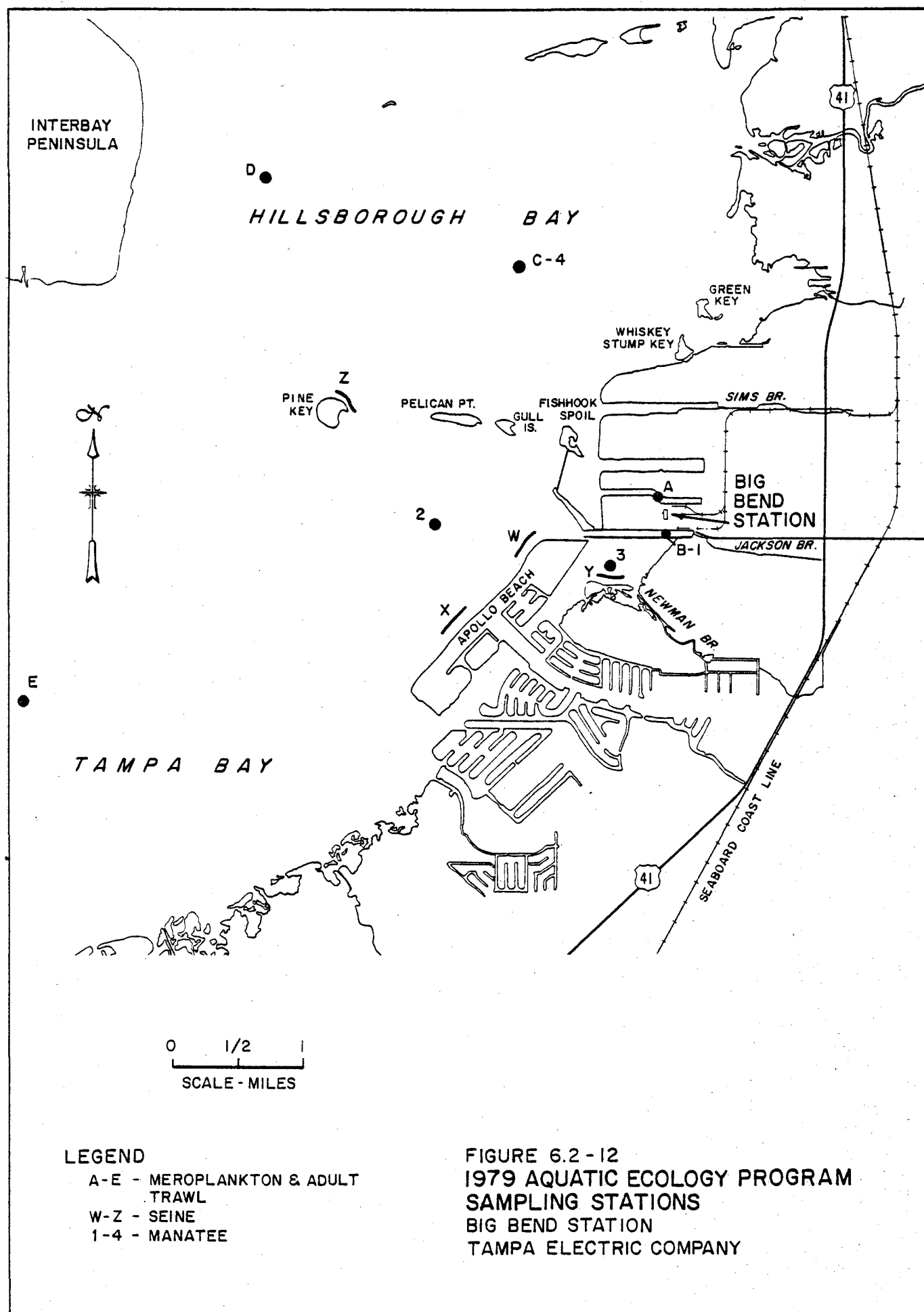
LEGEND

TB - TRAWL STATION
SB - SEINE STATION

FIGURE 6.2 - 10
TRAWL AND SEINE STATIONS
1976 - 1977
BIG BEND STATION
TAMPA ELECTRIC COMPANY

SOURCE: Appendix to 316 Demonstration,
Volume III, page 8-8.





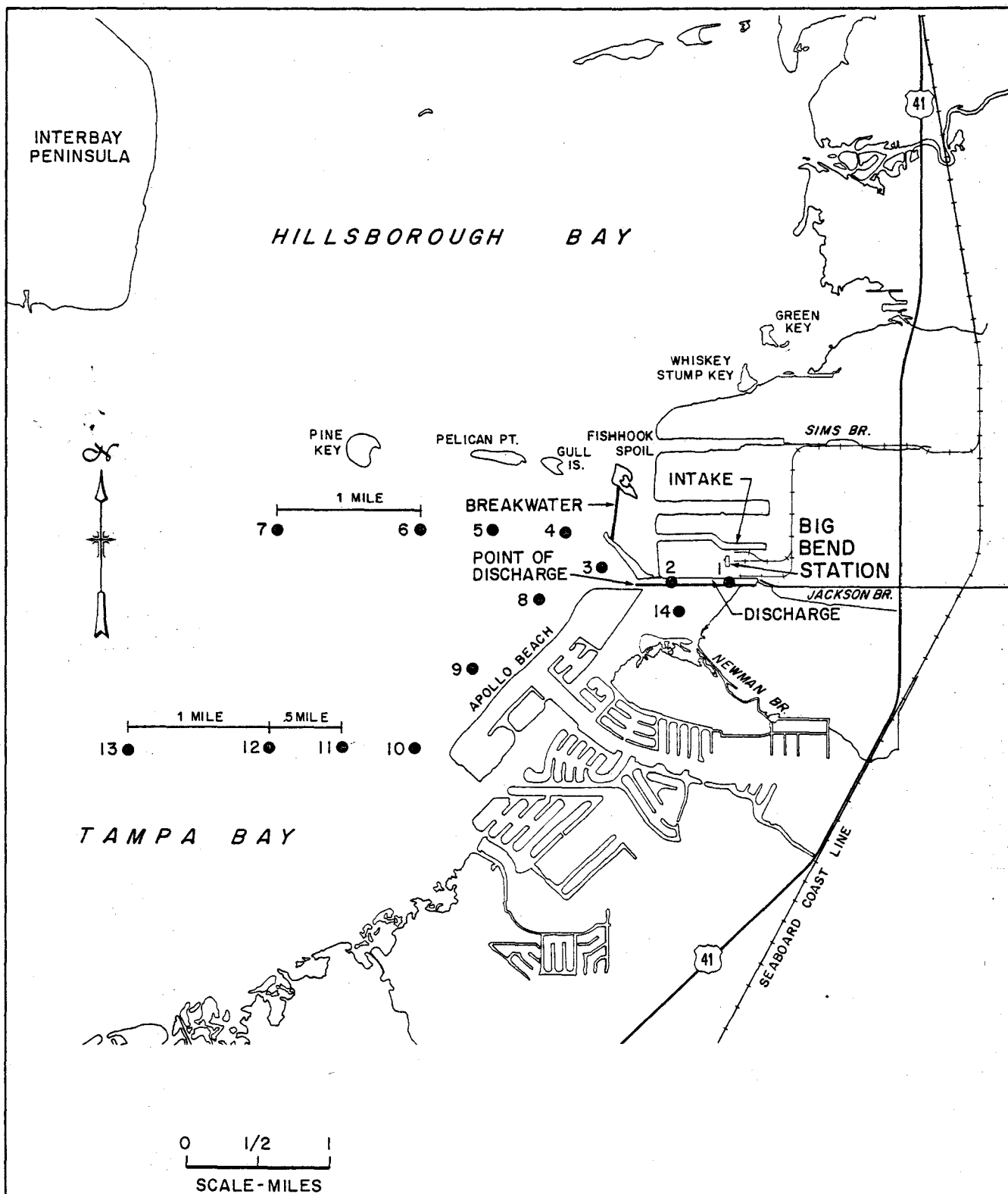


FIGURE 6.2-13
 BENTHIC SAMPLING STATIONS
 1979-1980
 BIG BEND STATION
 TAMPA ELECTRIC COMPANY

6.3 CONSTRUCTION IMPACT CONTROL AND MONITORING PROGRAM

6.3.1 Introduction

6.3.1.1 Purpose

This section defines the Construction Impact Control and Monitoring Program (CICMP), which will be used to control environmental impacts created by the construction of Unit 4 - Big Bend Station.

6.3.1.2 Applicability

This program is applicable to all contractors and personnel performing work at Unit 4 - Big Bend Station construction site.

6.3.1.3 Responsibilities

6.3.1.3.1 Site Environmental Engineer (SEE)

The Site Environmental Engineer (SEE), a TECO employee, is responsible for the implementation of this CICMP. The SEE shall assure that all environmental commitments made in licensing documents are met. He will make weekly inspections of all areas of the construction site during construction. The SEE is responsible for preparation and control of environmental problem reports (EPR) and also for developing corrective action for those problems identified in EPRs.

6.3.1.3.2 Resident Engineer

The Resident Engineer (Construction Manager) is responsible for all field engineering and design work performed at the site. The Resident Engineer will be the site liaison for the SEE.

6.3.1.3.3 Superintendent of Construction

The Superintendent of Construction is responsible for all construction performed at the site.

6.3.1.3.4 Site Contractors

Site contractors are responsible for complying with the requirements of this section. This section forms the basis for a construction site procedure which will be included in all contract bid packages for work to be performed at Unit 4 - Big Bend Station.

6.3.2 Monitoring Programs

6.3.2.1 Water Quality

6.3.2.1.1 Storm Water Runoff

Storm water runoff will be controlled by a site drainage system and selected nonpoint source erosion control measures such as hay bale dikes, mulches, erosion control fabrics, and temporary vegetation, as necessary. Exposed soil areas which will not be used during construction shall be stabilized to prevent erosion. During the weekly site inspection, SEE will note the condition of the site drainage system and will identify erosion and sediment control problems on an EPR.

6.3.2.1.2 Liquid Wastes

Liquid wastes such as waste oils, lubricating agents, and liquid cleaning agents will be collected in 55-gallon drums and either disposed of offsite or in the existing site waste disposal pond. Oil and liquid chemical storage containers shall have drip pans under the outlet or nondraining slabs or liners underneath. Liquid wastes will not be disposed of in the site drainage system. SEE will inspect all liquid chemical and petroleum hydrocarbon storage containers for leaks or spills. An EPR will be written for each significant liquid waste spill or leak.

6.3.2.1.3 Sanitary Wastes

Construction site personnel will use either portable chemical toilets or sanitary facilities provided in the construction office buildings. These facilities will be serviced by an approved sanitary waste disposal contractor. SEE will make weekly inspection of all sanitary facilities to assure that they are properly maintained.

6.3.2.1.4 Shorefront Construction and Dredging Control

When dredging and other construction activities are performed in the discharge canal, measures will be taken so that turbidity levels do not exceed Florida Department of Environmental Regulation (FDER) requirements outside the work area. Typical control measures that may be used are dredge screens or sheetpile barriers. SEE will make weekly inspections of the discharge canal by boat to assure that these measures are being implemented.

6.3.2.1.5 Groundwater

The existing groundwater monitoring program will be continued during construction. SEE will inspect the site area for potential sources of groundwater pollution and will identify any found on an EPR.

6.3.2.1.6 Sampling Programs

Sampling programs will be performed for construction site water quality as required by the U.S. Environmental Protection Agency and the Florida Department of Environmental Regulation.

6.3.2.2 Air Quality

6.3.2.2.1 Fugitive Dust

Fugitive dust will be controlled by water spraying construction roads. According to the EPA, a 50 percent reduction of fugitive dust concentrations at construction sites appears possible by watering twice daily during dry periods.^(1,2) Precautionary measures will be employed to minimize the possibility of overwatering, which could lead to transport of mud and dirt onto adjoining roadways, thus indirectly causing additional potential dust problems.⁽²⁾

Any dirt or other dust producing material which has been carried onto paved roadways will be promptly removed to reduce dust generation from these areas. The use of windbreaks, dust fences, or temporary mulch for vegetation for exposed and spoil areas will also be considered for problem areas. Speed controls will be established for the mobile construction equipment to minimize the pulverization and abrasion of the soil. SEE will make weekly inspections to assure that these measures are continually implemented and that they are effective.

6.3.2.2.2 Vehicular Emissions

Construction vehicular emissions will be visually inspected by the SEE to serve as an indication of vehicles requiring immediate maintenance. Regular maintenance of all equipment and vehicles will be performed to minimize air emissions.

6.3.2.2.3 Open Burning

Open burning in connection with land clearing will be in accordance with Chapter 17-5 Florida Administrative Code (FAC). The Division of Forestry shall be notified prior to burning. Open burning will not occur during Division of Forestry bans on burning due to fire hazard conditions.

6.3.2.3 Solid Wastes

Trash and construction debris will be collected in dumpsters or otherwise contained and disposed of offsite. Waste concrete will be used wherever possible for erosion control. SEE will make weekly inspections to assure that construction waste and debris is being properly collected and disposed of.

6.3.2.4 Noise

Construction sound levels have been predicted to be similar to or less than the existing ambient sound levels (refer to Section 4.1.3.1) from normal construction activities, and construction noise monitoring will be unnecessary. However, if valid noise complaints concerning construction activities are received, noise measurements will be made as necessary to determine the noise source and mitigative measures will be developed.

6.3.2.5 Ecological

6.3.2.5.1 Terrestrial Ecology

The following terrestrial ecological parameters will be noted by the SEE during each weekly survey of the site and any other areas used during the construction of Big Bend - Unit 4.

- o Intrusion into areas not previously indicated to be cleared or disturbed during construction
- o Unusual changes in species composition or relative abundances (e.g., sudden increase in rodent populations) which are likely to be attributable to construction activities
- o Evidence of stress to existing vegetation
- o Probable causes of vegetation stress
- o Areas of new erosion, not being mitigated at the time of the survey
- o Effectiveness of existing storm water runoff control measures, including erosion and sediment control devices

Where ecological impacts regarding any of the above parameters are noted by the SEE, they will be reported in the Environmental Problem Report, and measures will be developed and implemented to mitigate these impacts.

6.3.2.5.2 Aquatic Ecology

Construction impact which may affect the biota of local waters may be separated into two types, impacts attributable to construction in the surrounding waters and construction-related discharges. Construction in local waters will be restricted to dredging, sheet pile erection, and dewatering in the discharge canal at the location of the Unit 4 discharge flume. Sources of construction-related discharges are noted in Section 6.3.2.1.

In that these impacts will be routinely monitored as part of the water quality CICMP, it will be unnecessary to provide a specific program for aquatic ecology. The water quality CICMP is described in Section 6.3.2.1.

6.3.2.6 Traffic

Traffic will be confined to construction roads only. Areas designated for revegetation or stabilization will be clearly marked to prevent traffic movement through them.

6.3.2.7 Geology

The proposed station is to be built on driven piles with a majority of the footings embedded at shallow depths. This type of construction requires minimal earthwork, therefore geologic or soil changes arising from construction activities are not expected. Earthwork associated with the construction of the ash pond and FGD disposal area will be routinely inspected by SEE.

6.3.3 Program Implementation

6.3.3.1 Site Tour

SEE will perform weekly site tours during which all areas identified in Section 2 will be inspected.

6.3.3.2 Construction Meetings

SEE will attend weekly construction meetings to review current construction plans to assure that environmental concerns will be met.

6.3.3.3 Reports

6.3.3.3.1 Inspection Reports

Inspection Reports (Attachment No.1) will be completed for each site tour. SEE will maintain a log of all inspection reports.

6.3.3.3.2 Environmental Problem Reports (EPR)

Environmental Problem Reports (Attachment No.2) will be completed for each environmental problem identified as defined in Section 2.0. SEE shall maintain a log of all EPRs issued.

6.3.3.3.3 Monthly Reports

Monthly reports will be prepared by SEE which will describe current environmental related activities and problems onsite.

REFERENCES for 6.3

1. Compilation of Air Pollutant Emission Factors. U.S. Environmental Protection Agency. Second Edition AP-42.
2. Jutze, G. and Axetell, K. Investigation of Fugitive Dust, Volume I: Sources, Emissions, and Control. Prepared for U.S. Environmental Protection Agency by PEDCO Environmental Specialists, Inc., No. EPA-250/3-74-036-a, June 1974.

Number _____

Date _____

INSPECTION REPORT

Area	Status	Comments
Storm Water Runoff		
Liquid Wastes		
Sanitary System		
Dredging		
Groundwater		
Fugitive Dust		
Vehicular Emissions		
Solid Waste		
Noise		
Ecological		
Traffic		

FIGURE 6.3-1
INSPECTION REPORT
BIG BEND STATION
TAMPA ELECTRIC COMPANY

ENVIRONMENTAL PROBLEM REPORT

Subject

Inspection Report Number

Date

Problem Description

Problem Solution

Corrective Action Taken On _____

Site Environmental Engineer

Date

FIGURE 6.3-2
ENVIRONMENTAL PROBLEM
REPORT
BIG BEND STATION
TAMPA ELECTRIC COMPANY

6.4 OPERATIONAL MONITORING PROGRAM

Tampa Electric Company will exercise the option of submitting the operational monitoring program six months prior to the scheduled commercial operation date of Unit 4 - Big Bend Station. This option is provided for in Chapter 6, Section 6.1 of the Florida Department of Environmental Regulation Application for Certification of Proposed Electrical Power Generating Plant Site - DER Form 17-1.122 (72), 1/10/79, page 51.

CHAPTER 7

ECONOMIC AND SOCIAL EFFECTS OF PLANT CONSTRUCTION AND OPERATION

This chapter presents an assessment of the economic and social effects of Big Bend Unit No. 4.

7.1 SOCIOECONOMIC BENEFITS

Construction and operation of Big Bend Unit No. 4 will result in social and economic benefits to Hillsborough County, the TECO service area, and the public at large. The primary benefit will be the addition of 2,100 GWh (net) per year of electrical power which will be available to the service area with the completion of Unit No. 4. Forecasts of electric power demand show that, without this added capacity, demand for electrical power is expected to exceed the dependable supply in 1985. Chapter 1 provides a complete discussion of the need for Unit 4 with regard to system reliability. Direct and indirect benefits of Unit No. 4 are itemized in Table 7.1-1.

Hillsborough County will receive additional property taxes from Big Bend Unit No. 4 beginning in fiscal year 1985. In addition to taxes, TECO will pay \$35,000 dollars in certification fees to the state of Florida. Other minor fees will be paid to local and state agencies for other permits.

It is anticipated that an average of 510 construction workers (craft and nonmanual) will be required per year during the 3-year Unit No. 4 construction period. A peak of approximately 1,100 personnel is expected during a four month period in 1984, the third year of construction. Based on TECO observations and labor availability surveys from construction of the previous three Big Bend units, approximately 90 percent of the construction work force will be hired from labor organizations with jurisdiction over the Tampa area.

It is, therefore, reasonable to assume that no special provisions for housing, education, or community facilities will be necessary. Construction labor utilizing community services, e.g., roads, schools, and health services, will be primarily county taxpayers. In addition, taxes on Big Bend Unit No. 4 will compensate Hillsborough County for minimal stress which might occur on county services. The total annual property tax payments to Hillsborough County will be approximately \$3,700,000.

It is anticipated that local sources will provide construction materials, e.g., concrete, fill material, and miscellaneous building materials. Construction equipment

and vehicles will be rented from local contractors when available. In addition, construction workers are expected to make purchases in the local community but, since they will be primarily residents, this impact will not be appreciable.

Plant maintenance and operation of Big Bend Unit No. 4 are expected to create 50 permanent jobs. Salaries for this group will total approximately \$1,400,000 in 1985.

The Tampa area labor market will supply most of the skills necessary to operate the plant and, whenever possible, TECO will hire workers from the local market. Thus, much of the operating wages will be spent in the local economy and benefit the community through the creation of secondary jobs and consumption of local products and services.

No additions or improvements to the area public transportation grid are planned. TECO will maintain onsite roads.

Engineering and scientific consulting services are being provided by out-of-state firms, primarily because most of these services are specialized and were not available in the Tampa area. However, in many instances local firms are retained to provide services and goods when site or field studies are required by TECO or its consultants. The nature of these activities is usually labor intensive, so that the area receives the benefit of increased employment opportunities for engineers, scientists, and technicians.

For example, numerous special studies are being performed at the plant site to increase knowledge of local air and water quality, hydrology, and marine and terrestrial ecological systems. In most cases, a local environmental service firm or university organization has provided the necessary field and laboratory services.

TABLE 7.1-1

ANTICIPATED BENEFITS FROM THE PROPOSED FACILITY

Direct Benefits:

Expected Average Annual Generation (GWh/year)	2,100
Capacity (Net MW Continuous)	417
Anticipated 1985 Proportional Distribution of Energy ¹ :	
	<u>Percent</u>
Industrial	36
Commercial	22
Residential	35
Other	7

Indirect Benefits:

Property Taxes	1 percent/year of unit costs
Nonfederal Taxes (Including property taxes)	2.5 percent/year of unit costs
Employment (Construction Payroll Average/Year) ⁽²⁾	\$11,800,000
(Operation Payroll Average/Year) ⁽³⁾	\$ 1,400,000

(1) DSP Form 2 - Chapter 2 - 10 year Site Plan, 1-1-79 through
12-31-88.

(2) in 1982 dollars

(3) in 1985 dollars

7.2 SOCIOECONOMIC COSTS

Plant costs, temporary external costs, and long-term external costs resulting from construction and operation of Big Bend Unit No. 4 are summarized below.

7.2.1 Plant Costs

The total project costs for the proposed plant are summarized in Table 7.2-1. The present worth of operation and maintenance, fuel and capital are expressed in 1985 dollars. The cost computations have been based on a discount rate of 8.71 percent, reflecting the average cost of capital to the applicant. Of the three major cost areas, capital related costs are based on a book life of 28 years, while operating and fuel expenses are calculated on an expected plant operation of 35 years. Operation and maintenance costs are escalated at 7 percent per year. Fuel prices are assumed to escalate at an average annual rate of 12.4 percent during 1980 and 1981, a 10 percent rate between 1981 and 1985, and 7 percent afterwards.

7.2.2 External Social and Economic Costs

7.2.2.1 Temporary External Costs

Big Bend Unit No. 4 will require a peak labor force of approximately 980 workers. It is anticipated that about 90 percent of these workers will be hired from the Tampa area. It is therefore assumed that no extraordinary strains will be placed on local housing nor will inflationary housing rentals result. In addition, no extra burden is expected to be placed on community services and facilities.

The movement of workers and machines to and from the Big Bend Station will cause the greatest impact on human activities. An average of an additional 1,100 vehicles per day (550 in each direction to and from the site) will be using U.S. 41 and Big Bend Road in the peak year of 1984. This is approximately 6 percent increase above current use. Of these vehicles, about 516 will be used by construction site employees. The remainder will be used for shipments of construction material and to bring visitors to the site. Much of the traffic will occur during the morning and evening peak periods and may create some traffic congestion at the traffic light at the intersection of Big Bend Road and U.S. 41.

Section 4.1.3.1 gives specific values for expected short-term construction noise. Since construction activities will generally occur during the daytime hours, all predicted construction sound levels are below the maximum permissible sound levels in the Hillsborough County noise code of 60 dBA during the daytime in a residential area. The nearest residential area to the site will experience sound levels higher than residual ambient levels but similar variations in ambient sound levels presently occur due to existing ambient noise sources (see Section 4.1.3.1 for a more detailed discussion).

Local groundwater elevations will be lowered temporarily during construction of the circulating water system. This dewatering, however, is not expected to affect area wells. The groundwater level will rise to its natural elevation after construction of the system is complete. Sanitary wastes from all permanent station sanitary facilities will be collected and conveyed to an existing sewage treatment plant. Construction personnel shall use either portable chemical toilets or sanitary facilities provided in the construction office buildings. The waste from the portable toilets will be disposed of offsite by a licensed contractor at state-approved locations.

Unit No. 4 will require approximately 7 acres of land for all permanent structures. Approximately 41 acres will be temporarily committed to construction and laydown areas but these will be stabilized upon completion of construction. An additional 7 acres will be designated for the coal reserves and service facilities associated with Unit 4. Another 121 acres will be used for an ash settling pond system and approximately 97 acres for an FGD byproduct disposal area.

7.2.2.2 Long-Term External Costs

Big Bend Unit No. 4 will be located on a site already occupied by the Big Bend Unit Nos. 1, 2, and 3. Land adjacent to the site to the north, east, and southeast has been designated for industrial use in the Hillsborough County Horizon 2000 Plan. All 7 acres of the permanently committed land are zoned for heavy industrial use. All of the 97 acres of land which will be occupied by the FGD disposal system is zoned industrial. For these reasons, it is not expected that the presence of Big Bend Unit No. 4 will interfere with present or future land use in the area.

Impacts on regional products are expected to be minimal since a majority of the land required for Unit 4 construction and operation is not currently in active use. The primary long-term impact will result from the four phase conversion of a maximum of 97 acres of land into FGD disposal areas. The four phase schedule is proposed to ensure against excess clearing of land by allowing for development only as the need arises. Of the 97 acres, approximately 31 acres, in the Phase I, II, and III parcels, are used for agricultural purposes and the remainder are abandoned pasture. Upon development of these disposal areas, the agricultural use will be permanently displaced.

Potential markets for the FGD gypsum byproduct are currently being investigated. If sale of the gypsum is determined to be feasible and markets are located, it is likely that all four parcels of land will not be required for disposal use.

Long-term visual impacts will result from the development of the FGD disposal areas. Planting of vegetative screening around the periphery of the disposal area will effectively screen the fill from most viewing areas. In addition, upon reaching fill capacity, each parcel will be revegetated with native plant species to minimize the visual impacts of the area. At the end of Unit 4 life, it is anticipated that the disposal areas will be dedicated to use as public open space.

Most of the construction and operation workers are expected to be hired from the Tampa area, and Big Bend Unit No. 4 will require minimal public services. It is therefore not anticipated that significant stress will be placed on local government services or facilities.

Alternatives, including use of waste water, for additional water supplies are currently being investigated. The plant as proposed will use once-through cooling. Cooling towers will be evaluated in Section 9.1.1.

The impact of the plant on land-based recreational opportunities is expected to be negligible due to the previous commitment of the site and adjacent areas to industrial use. Impact on area fishing is discussed in the 316 Demonstration which is an appendix to this application.

TABLE 7.2-1

TOTAL REVENUE REQUIREMENTS
(1985 DOLLARS)

Capital	\$ 558,000,000
Fuel	1,728,000,000
Operation and Maintenance	<u>406,000,000</u>
Total Present Worth in First Year of Operation	\$2,692,000,000

Source: TECO

8. ALTERNATIVE ENERGY SOURCES AND SITES

CHAPTER 8

ALTERNATIVE ENERGY SOURCES AND SITES

8.1 ASSESSMENT OF ALTERNATIVE SITES

8.1.1 Introduction

The applicant's latest Ten Year Site Plan covers the years 1979-1988. Preferences described in this site plan are based on site selection studies designed to identify acceptable multi-unit electrical generating facility sites. The Ten Year Site Plan, based on these studies, identifies the Big Bend site as the preferred site for a 1985 electrical generating facility and the MacInnes site as a potential alternate site for this facility. The MacInnes site is also a preferred site for generation capacity addition (which is as yet unspecified and which will be needed in the early 1990s based on current forecasts). The MacInnes Site was identified on the basis of being suitable for accommodating a multi-unit electrical generating facility, similar to the applicant's existing electric generating facilities.

Based on recommendations of the U.S. Environmental Protection Agency as well as identified company needs, the applicant undertook a new site selection study (August 1979, Site Selection Study For A Coal-Fired Power Plant, 1985 Commercial Operation) to update the siting criteria and siting methodology. The results of this study are reported here. While it is the most recent study, it was purposely limited in that its objective was to locate one electrical generating unit with no consideration of potential future generating capacity expansion. This boundary condition on the siting study had a dramatic effect on the priority of the candidate sites. It becomes apparent, in the study results described below, that because of the cooling water availability criterion all Polk county sites, though appropriate for a single unit facility, would be screened from further consideration when additional future generating capacity is considered for these sites. In addition, sound economic practices would not allow the development of a single unit site.

The site selection study consisted of the following major steps: identification of the study area, screening the study area to identify candidate sites, ranking the candidate sites, and selecting the preferred and alternate sites.

8.1.2 Identification of the Study Area

The service area of the applicant consists primarily of Hillsborough County and a portion of Pasco and Polk Counties in Florida. Although a site in these service areas would probably provide the greatest ease in transmitting power to load centers, the applicant decided that the site selection study should not preclude any area in the counties adjacent to and including Hillsborough County as a potential site for the proposed facility. Therefore, the study region for the site selection study encompassed the counties of Pasco, Pinellas, Hillsborough, Polk, Manatee, and Hardee in Florida, without regard to service area boundaries.

8.1.3 Screening the Study Area to Identify Candidate Sites

The six-county area was screened for each of the following major environmental siting categories or constraints:

1. Air quality compatibility
2. Water quantity/quality suitability
3. Geotechnical suitability
4. Ecological quality suitability
5. Socioeconomic/land use compatibility.

The analysis was performed on 1.5 mile by 1.5 mile elements (an area of 1,440 acres each) in which each element was considered separately and assigned a rating based upon the predominant characteristics of that element.

Each environmental siting category had a number of descriptive criteria. A four-level rating scale was used for screening the favorability of the areas. The following list gives the general definitions for each rating level:

1. Favorable - meets all siting criteria, with only minimum modifications needed
2. Potentially favorable - meets all siting criteria, but requires moderate modifications
3. Potentially favorable with conditions - favorable with changes in economic, environmental, regulatory, institutional, or technological constraints
4. Restricted - at least one characteristic of the environmental siting criteria restricts the use of

the area, and no change in this restriction is anticipated.

The rating scale was based on the degree of modification which will result from siting the proposed facility and the importance of such modification resulting from siting a power plant in the given area. This four-level rating scale provides additional sensitivity to the selection process by retaining more areas for further analysis without greatly increasing the data requirements or complexity of the selection process.

The favorably screened environmental areas (that is, those rated 1-3 on the rating scale) were screened and rated on the basis of the favorable site requirements criteria. These criteria included the following considerations:

1. Distance to the load center
2. Distance to connection with the applicant's 230-kV transmission system
3. Availability of existing 230-kV facilities with adequate capacity
4. Alternate transmission routes to the system
5. Alternate modes of fuel delivery
6. Stability of generator connection to transmission system.

The most favorable areas indicated by the environmental screening and the site requirement screening (see Figure 8.1-1) were then further subjected to an overall evaluation based on the availability of both cooling water and land. From this process, 13 potential sites with the most favorable environmental and siting requirement characteristics for locating a 417-MWe coal-fired power plant were identified.

8.1.4 Ranking the Candidate Sites

In order to evaluate the relative suitability of the candidate sites, 21 siting characteristics were identified to serve as the basis for comparison of the sites. This list of criteria was developed by an interdisciplinary team of scientists and engineers considering the essential characteristics of a power plant site. This same team then judged the relative importance of each criterion. This initial system of weights (which range from 1 to 5, with 5 indicating the most important choice) was then reviewed

and reevaluated until consensus weights were obtained for all criteria (Table 8.1-1).

Each site was then rated for each criterion by consultants with expertise in that particular field. These ratings were based on site visits and secondary data sources. The ratings ranged from 1 to 5, with 5 indicating the most suitable choice. Site scores were then obtained by multiplying the rating by the weight for each criterion. These values were then summed for all criteria for a site to yield a total site score. The higher the numerical score, the more suitable the site (Table 8.1-2).

The total site scores indicate that site 8A is significantly higher than the other sites. Sites 7, 2, and 3A formed a group as the next highest.

8.1.5 Selecting the Preferred Site and Alternate Sites

A. Sensitivity Analysis

Because of the subjectivity inherent in the weighting/rating system for the sites, a sensitivity analysis was performed to explore the effects of variations in input data on the site suitability scores and on the overall rankings. This analysis demonstrated the degree to which selection of the recommended site was affected by reasonable changes in the weighting and rating system.

Ratings and weights in the sensitivity analysis were changed after a thorough reexamination by the project team of all rating/weighting assignments. Reasonable extremes in the weighting system can be established by having the weights modified in favor of either the environmental concerns or the construction/operational concerns. The two test weighting systems developed and the original weighting system are shown in Table 8.1-3. The original ratings were reviewed for all criteria in order to identify the highest and/or lowest reasonable ratings for the alternative sites. All those ratings that could be increased were done under Rating Change A; all those that could be decreased were done under Rating Change B. These are shown in Tables 8.1-4 and 8.1-5, respectively.

On the basis of input from the two modified sets of weights and the two rating changes, together with the original weights and ratings (Table 8.1-2), eight basic scenarios could be developed as alternatives to the original analysis.

The comparison of the site suitability scores under the nine different combinations of weights and ratings is summarized in Table 8.1-6.

The result of this analysis was that Site 8A (Big Bend) is the preferred site, with Sites 7 (Peace Creek) and 2 (Highland) ranked as the second and third sites, respectively. This analysis demonstrated the insensitivity of the recommended site to significant modification to the inputs to the site suitability calculations.

B. Cost Analysis

The objective of this aspect of the screening was to identify the most cost-effective candidate site for the proposed facility. As a result of Ranking The Candidate Sites and the Sensitivity Analysis, three sites were identified as the preferred sites. These were Sites 8A, 7, and 2 in order of their ranking. These sites were then analyzed according to the costs to construct and operate power plants at each site. Capital costs are presented first, followed by estimates of annual or recurrent costs and total annual costs above the base case (Table 8.1-7).

The results indicate that Site 8A (Big Bend) is the most cost-effective site and, therefore, the preferred site for the proposed facility in this analysis.

C. Fatal Flaw Analysis

Site 8A (Big Bend) is indicated by the selection process as the preferred site for the location of the 417-MWe unit. This site presently contains three similar units which use water from Tampa Bay for once-through cooling. The applicant proposes that this additional unit will also use the once-through cooling system.

The U.S. Environmental Protection Agency (EPA) has expressed concern over the current number of organisms entrained by the cooling system and, to a lesser extent, the impingement upon screens and the increased water temperature in the vicinity of the point of discharge. The EPA contends that the three existing units impose an impact on the biota of Tampa Bay and the addition of a fourth unit would add to the existing impact. The applicant has questioned EPA's assumptions and basis of impact determination and has undertaken biological studies aimed at resolving these questions. The applicant has begun these studies with the realization that the results may either disprove EPA's theories or support them. If the applicant's biological studies support EPA's impact conclusions and the entrainment reduction technology under study does not prove feasible, the choice of once-through cooling may represent a fatal flaw in the selection of this site which may result in additional costs. Traditionally the EPA, Fish and Wildlife Service, and National Marine Fisheries have been very wary of approving once-through cooling, while the Southwest

Florida Water Management District strongly supports this approach.

An alternative for the site is the use of saltwater cooling towers. According to the present analysis, the towers would add to the cost, visual impact, and maintenance of the proposed facility. The saltwater cooling towers for the site should be designed for drift control to prevent possible negative effects to nearby agricultural and natural systems. If the towers cannot be designed for adequate drift control, this option may also represent a fatal flaw. In that case, an alternate source of cooling tower makeup water such as nonpotable groundwater or sewage treatment plant effluent could be considered.

The site selection process has shown Site 8A (Big Bend) to be the preferred site based upon a balance between engineering/operations, environmental, and socioeconomic factors. The alternative sites in central Polk County tend to be limited by the amount of water available to them. The potential need to augment the treated wastewater source with groundwater and/or surface water may represent a fatal flaw for Site 7 (Peace Creek). The Southwest Florida Water Management District is on record as opposing the use of groundwater for cooling power plants and is reluctant to approve the use of fresh surface water for this purpose.

Additional fatal flaws may exist for Site 7 (Peace Creek). There is the possibility that an agreement cannot be made with the city of Winter Haven to use their treated wastewater. If an agreement can be reached, the power plant will be effectively concentrating the wastewater and discharging it to the environment. Any toxic materials present at low levels in the wastewater will be concentrated possibly beyond water quality standards, creating a disposal of toxic materials problem.

If cooling ponds are constructed in central Polk County, waters of the U.S. will probably be involved. The pond could become a cooling lake and possibly waters of the U.S. and hence require a 316 study and imposition of effluent guidelines on the plant discharge to the pond, rather than the discharge from the pond.

Site 2 (Highland) would make use of Lake Hancock, which will require 316 studies and be very difficult to permit due to conceptual opposition by federal agencies and Southwest Florida Water Management District. Lake Hancock may not be as reliable a source of water as will be needed over the 35-year life of the plant due to documented emptying of the lake into underground caverns at irregular intervals. This may require engineering control structures in the lake bottom which may disrupt the biological and human systems

which depend on the lake. This may represent a potential fatal flaw in the use of this site.

8.1.6 Summary

The site selection process consisted of three stages:

In the first stage, an area-wide screening process for general environmental suitability was accomplished. This screening was used to identify favorable and restricted areas for siting within the six-county area. The favorable areas were then subjected to further screening based on site requirement considerations which identified 13 candidate sites.

In the second stage, the candidate sites were evaluated and ranked by their favorability for siting according to environmental and site requirement criteria. Based on this analysis, three most favorable or prime sites were identified.

The third stage consisted of three phases: (1) A sensitivity analysis of the methodology was conducted to determine how possible changes in the subjective evaluations would alter the recommendation of the most favorable site. (2) A detailed engineering cost analysis was performed on the three prime sites to rank the sites numerically and select the top site. (3) The most favorable site was subjected to a more detailed licensability analysis in order to verify that the recommended preferred site did not have a fatal licensing flaw.

8.1.7 Conclusion

On the basis of the scope, methodology, and other criteria established for the siting study, the Big Bend site was clearly identified as the preferred location for constructing the proposed 417-MWe coal-fired power plant.

TABLE 8.1-1

SITING CHARACTERISTICS AND RELATIVE WEIGHTS

<u>Siting Criteria</u>	<u>Weight</u>
Engineering/Economic Considerations:	
Cooling Water Supply	5
Plant Service Water	3
Rail Accessibility	4
Highway Accessibility	3
Port Accessibility	5
Transmission Line Proximity	4
Site Preparation	3
Environmental Characteristics:	
Terrestrial Ecology	3
Aquatic Ecology	4
Rare and Endangered Species	5
Sulfur Dioxide	4
Particulates	4
Other Air Pollutants	3
Surface Water Quality	2
Groundwater Quality	3
Socioeconomic Considerations:	
Archaeological Resources	4
Land Use Compatibility	4
Land Availability	5
Aesthetics	2
Regional Economics	3
Community Impact (Demographic)	2

TABLE 8.1-2

SUMMARY OF SITE SUITABILITY - WEIGHTING TIMES RATING

Criteria	Criteria Weight	Ratings of Alternative Sites												
		1	2	3A	3B	3C	4	5	6	7	8A	8B	10A	10B
Cooling Water Supply	5	2	5	5	3	3	3	1	3	3	5	5	5	3
Plant Service Water	3	5	5	5	5	5	5	5	5	5	5	4	5	5
Rail Accessibility	4	5	5	3	5	4	5	2	5	4	5	4	2	5
Highway Accessibility	3	3	5	3	4	5	2	5	5	3	5	3	5	5
Port Accessibility	5	2	2	1	2	2	2	1	2	2	5	5	1	2
Transmission Line Proximity	4	1	4	4	4	4	3	2	3	4	5	2	4	4
Site Preparation	3	2	3	4	4	4	4	3	4	4	4	2	1	1
Terrestrial Ecology	3	3	5	3	4	5	4	5	4	5	2	1	3	5
Aquatic Ecology	4	3	4	4	4	5	3	4	2	5	2	1	4	4
Rare and Endangered Species	5	3	4	3	4	4	3	4	4	4	4	1	3	4
Sulfur Dioxide	4	5	4	5	5	5	5	5	5	5	4	4	5	5
Particulates	4	2	2	2	2	2	2	2	2	2	1	2	2	2
Other Air Pollutants	3	1	1	1	1	1	2	1	1	2	1	1	2	2
Surface Water Quality	2	3	2	2	2	2	2	2	1	2	4	4	2	2
Groundwater Quality	3	3	3	2	3	2	3	2	3	2	2	3	1	1
Archaeological Resources	4	4	3	4	3	3	3	3	4	3	4	3	4	3
Land Use Compatibility	4	5	2	4	2	1	3	3	2	4	4	5	2	1
Land Availability	5	4	2	4	2	3	3	2	4	3	5	5	3	3
Aesthetics	2	4	2	4	2	2	4	2	2	3	3	4	3	2
Regional Economics	3	5	5	5	5	5	5	4	4	5	5	3	5	4
Community Impact	2	4	3	3	3	3	3	2	3	4	3	4	3	2
Total Score		243	256	256	247	251	244	211	247	264	287	239	234	237

TABLE 8.1-3

VARIATIONS IN THE WEIGHTING SYSTEM

<u>Criteria</u>	<u>Original Weight</u>	<u>Environmental Based Weight</u>	<u>Construction/ Operation Based Weight</u>
Cooling Water Supply	5	4	5
Plant Service Water	3	2	4
Rail Accessibility	4	3	5
Highway Accessibility	3	2	4
Port Accessibility	5	4	5
Transmission Line Proximity	4	3	5
Site Preparation	3	2	4
Terrestrial Ecology	3	4	2
Aquatic Ecology	4	5	3
Rare and Endangered Species	5	5	4
Sulfur Dioxide	4	5	3
Particulates	4	5	3
Other Air Pollutants	3	4	2
Surface Water Quality	2	3	1
Groundwater Quality	3	4	2
Archaeological Resources	4	5	3
Land Use Compatibility	4	5	3
Land Availability	5	5	4
Aesthetics	2	3	1
Regional Economics	3	4	2
Community Impact	2	3	1

Source: Environmental Science and Engineering, 1979.

TABLE 8.1-4

RATING CHANGE A

Criteria	Sites												
	1	2	3A	3B	3C	4	5	6	7	8A	8B	10A	10B
Cooling Water Supply	2	5	5	3	3	3	1	3	3	5	5	5	3
Plant Service Water	5	5	5	5	5	5	5	5	5	5	(5)	5	5
Rail Accessibility	5	5	3	5	4	5	2	5	4	5	4	(3)	5
Highway Accessibility	3	5	3	4	5	2	5	5	3	5	3	5	5
Port Accessibility	2	2	1	2	2	2	1	2	2	5	5	1	2
Transmission Line Proximity	1	4	4	4	4	(4)	2	3	4	5	2	4	4
Site Preparation	(3)	(4)	4	4	4	4	(4)	4	4	4	2	1	1
Terrestrial Ecology	3	5	3	4	5	4	5	4	5	2	1	3	5
Aquatic Ecology	3	4	4	4	5	3	4	2	5	2	1	4	4
Rare and Endangered Species	3	4	3	4	4	3	4	4	4	4	1	3	4
Sulfur Dioxide	5	4	5	5	5	5	5	5	5	4	4	5	5
Particulates	2	2	2	2	2	2	2	2	2	1	2	2	2
Other Air Pollutants	1	1	1	1	1	2	1	1	2	1	1	2	2
Surface Water Quality	3	2	(3)	(3)	(3)	(3)	(3)	1	(3)	4	4	2	2
Groundwater Quality	3	3	2	3	2	3	2	3	2	2	3	1	1
Archaeological Resources	4	3	4	3	3	3	3	4	3	4	3	4	3
Land Use Compatibility	5	(3)	4	2	1	3	3	2	4	4	5	(3)	1
Land Availability	4	2	4	2	3	3	2	4	3	5	5	3	3
Aesthetics	(5)	2	4	2	2	4	2	2	3	3	(5)	3	2
Regional Economics	5	5	5	5	5	5	4	4	5	5	3	5	4
Community Impact	4	3	3	3	3	(4)	2	3	4	3	4	3	2

NOTE: Numbers in parentheses indicate revised rating.

Source: Environmental Science and Engineering, Inc., 1979.

TABLE 8.1-5

RATING CHANGE B

Criteria	Sites												
	1	2	3A	3B	3C	4	5	6	7	8A	8B	10A	10B
Cooling Water Supply	(1)	(4)	(4)	(2)	(2)	(2)	1	(2)	(2)	5	5	(4)	(2)
Plant Service Water	5	5	5	5	5	5	5	5	5	5	4	5	5
Rail Accessibility	5	5	3	5	(3)	5	2	5	(3)	5	4	2	5
Highway Accessibility	3	5	3	4	5	2	5	5	3	5	3	5	5
Port Accessibility	2	2	1	2	2	2	1	2	2	5	5	1	2
Transmission Line Proximity	1	4	4	4	4	3	2	3	4	5	2	4	4
Site Preparation	2	3	4	4	4	4	3	4	4	4	(1)	1	1
Terrestrial Ecology	3	5	3	4	5	4	5	4	5	2	1	3	5
Aquatic Ecology	3	4	4	4	5	3	4	2	5	2	1	4	4
Rare and Endangered Species	(2)	(3)	(2)	(3)	(3)	(2)	(3)	(3)	(3)	(3)	1	(2)	(3)
Sulfur Dioxide	5	4	5	5	5	5	5	(4)	5	4	4	5	5
Particulates	(1)	2	2	2	2	2	2	2	2	1	(1)	2	2
Other Air Pollutants	1	1	1	1	1	2	1	1	(1)	1	1	(1)	(1)
Surface Water Quality	(1)	(1)	2	2	2	2	2	1	2	4	4	(1)	(1)
Groundwater Quality	(2)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(1)	(2)	1	1
Archaeological Resources	4	3	4	3	3	3	3	4	3	4	3	4	3
Land Use Compatability	5	2	4	2	1	(2)	3	2	4	4	5	2	1
Land Availability	4	2	4	2	3	3	2	4	3	5	5	3	3
Aesthetics	4	2	4	2	2	(3)	2	2	3	3	4	3	2
Regional Economics	5	5	5	5	5	5	4	4	5	5	3	5	4
Community Impact	4	3	3	3	3	3	2	3	4	3	4	3	2

NOTE: Numbers in parentheses indicate revised rating.

Source: Environmental Science and Engineering, Inc., 1979.

TABLE 8.1-6

COMPARISON OF RESULTS FROM THE WEIGHTING AND RATING COMBINATION

Site No.	Weighting System: Rating System:	Environmental			Construction/ Operations			Original		
		A	B	Orig	A	B	Orig	A	B	Orig
1		270	244	265	215	195	210	248	224	243
2		270	247	263	243	224	236	263	241	256
3A		273	257	270	230	218	229	258	243	256
3B		259	243	256	228	216	227	249	234	247
3C		263	244	260	231	214	230	253	234	251
4		268	238	259	225	203	218	252	225	244
5		232	218	227	192	181	187	216	203	211
6		253	235	253	228	214	228	247	230	247
7		284	261	281	236	217	235	266	244	264
8A		288	279	288	267	261	267	287	279	287
8B		254	238	249	218	204	213	244	229	239
10A		255	231	247	217	197	209	242	219	234
10B		245	229	245	217	205	217	237	222	237
Total Possible Score		400	400	400	330	330	330	375	375	375

Source: Environmental Science and Engineering, Inc., 1979.

TABLE 8.1-7
COST SUMMARY

	Site 8A (Big Bend)		Site 7 (Peace Creek)		Site 2 (Highland)	
	Once-Through	Cooling Towers	Cooling Towers	Cooling Pond	Cooling Tower	Cooling Pond
Capital Costs (\$ millions)						
Land	0	0	1.3	3.4	1.3	3.4
Site Preparation and Foundation	28	28	28	28	28	28
Plant	371	397	542	542	542	542
Coal Delivery Facilities	0	0	0.8	0.8	0.3	0.3
Water Supply	0.3	0.3	0.4	0.4	0.4	0.4
Transmission System	0	0	7.0	7.0	5.2	5.2
Total	399.3	425.3	579.5	581.6	577.2	579.3
Annual Fixed Charges	57.9	61.7	84.0	84.3	83.7	84.0
Recurrent Costs (\$ millions/yr)						
Fuel (High Btu)	50.0	50.0	53.2	53.2	53.2	53.2
Transmission System Losses	0	0	0.1	0.1	0.1	0.1
County Taxes	6.4	6.5	6.6	6.6	6.6	6.6
Total/yr	56.4	56.5	59.9	59.9	59.9	59.9
Total Annual Cost	114.3	118.5	143.9	144.2	143.6	143.9
Total Annual Cost Above Base Case (Site 8A, Big Bend, Once-Through)	0	4.2	29.6	29.9	29.3	29.6

NOTE: All costs, except county taxes, are in 1985 dollars.
County taxes are present value.

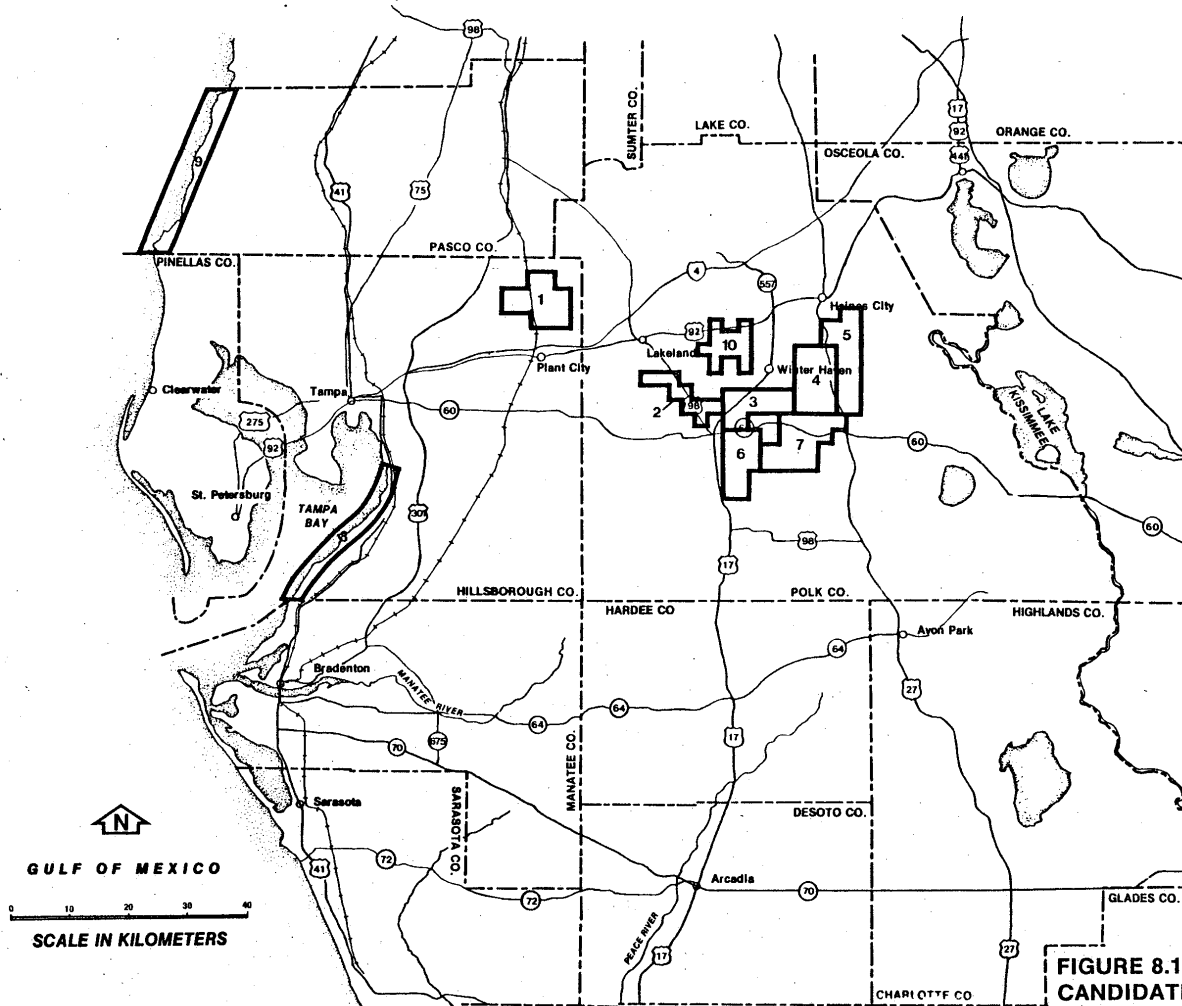


FIGURE 8.1-1
CANDIDATE STUDY AREAS
BIG BEND STATION
TAMPA ELECTRIC COMPANY

8.2 ALTERNATIVE FUEL ANALYSIS

8.2.1 Introduction

As part of the initial planning process, the applicant has conducted a generation expansion study to identify types and sources of fuel that could be used to generate electric power for future TECO generating units. At present, the possible technologies for electrical power generation include: Geothermal, Fuel Cells, Hydroelectric and Pumped Storage, Solar Thermal, Photovoltaic Cells, Municipal Solid Wastes, Fuels from Biomass, Wind Power, Magnetohydrodynamics, Coal Gasification, Coal Liquefaction, Fusion Power, Oil, Natural Gas, Nuclear (Uranium), Coal, and Possible New Developments.

8.2.2 Geothermal

At geologically favorable sites, geothermal power generation has been found to be feasible and competitive with other commercial sources of energy. Presently, the 608 MW of installed geothermal capacity in the Geysers area north of San Francisco represents the sole commercial electrical power utilization of geothermal energy in the United States, with another 600 MW of capacity expected to be added before 1983. At Cerro Prieto, Mexico, 75 MW of geothermal capacity is provided by utilizing hot brine from 2000 feet deep reservoirs.

Future plants are planned at Heber, California, Valles Caldera, New Mexico, and Roosevelt Hot Springs, Utah. States that are presently suitable for geothermal energy are the eleven westernmost continental states in addition to Texas, Louisiana, Alaska and Hawaii.

Because Florida is not in an area where geopressured fluids are known to exist, geothermal power generation was not considered by the applicant for future generating capacity.

8.2.3 Fuel Cells

Fuel cells are devices that extract hydrogen from fossil fuel and combine it with atmospheric oxygen to produce water, heat, and direct current electricity. The advantage of this direct conversion from chemical energy to electrical energy is that a much more efficient use of the input (oil or natural gas) fuel can be made, while at the same time eliminating most of the effluent problems associated with thermal electric power plants. Advanced fuel cell concepts may realize a direct fuel efficiency of around 45%, with a much higher efficiency possible if the waste heat is utilized for space heating or industrial needs. Because the only waste streams from the fuel cells will be the fuel

residue, water, and relatively small amounts of heat, handling of wastes will not pose environmental problems to the area surrounding a fuel cell generating station. This allows siting adjacent to load centers, which reduces transmission requirements and losses while providing potential for waste heat utilization. Additionally, fuel cells have a nearly constant efficiency over a broad range of load level and thus are able to be operated at variable output to match daily load cycles without sacrificing fuel efficiency. Also, because fuel cells will be built in relatively small (multiMegawatt) modular units, much shorter construction lead times will be needed for plant development, allowing a closer matching of system capacity to system load.

Although there are no commercial power applications being made of fuel cells at the present, 65 pilot 12.5-kW units have been successfully tested by utilities in Japan, Canada, and the United States. A 4.8-MW fuel cell is under development by United Technologies Corporation in cooperation with DOE and the Electric Power Research Institute and is projected to be commercially available in the early 1980s. The goal for production of second generation fuel cells with a high efficiency and a wider range of usable fuels has been set for 1985.

Fuel cells are dependent on naphtha (oil) or natural gas as input fuels, both of which are being discouraged through national policies for use in baseloaded power plants. The basic research to produce a second generation fuel cell has not been done. Therefore, development of this technology is too uncertain for the applicant to consider it as a reasonable alternative for meeting near-term energy requirements.

8.2.4 Hydroelectric and Pumped Storage

The topography and geology of Florida rule out any possibility of a reasonably sized hydroelectric and/or pumped storage facility. Therefore, hydroelectric and pumped storage were not considered for future baseload electric generating facilities.

8.2.5 Solar Thermal

There are a variety of feasible approaches for utilizing the sun's energy to drive turbine generators. For example, one proposed idea is to employ flat-plate collectors similar to those used for space heating applications to heat a Freon (or other hydrocarbon) to temperatures of approximately 270°F, which then can be used in a specially designed turbine generator. Another approach is to construct a network of specially coated pipes that have a high

absorptivity in the visible light range and a low emissivity in the infrared range. A system of Fresnel lenses or parabolic mirrors would then focus the sun's rays onto this pipe to heat the liquid metal, fused salts, or other working fluid flowing in the pipe to temperatures of up to 1000°F, which then could serve to flash water to steam for use in a conventional steam turbine. The approach receiving the most attention lately, however, is the "power tower" (or central receiver) concept. This idea envisions a large field of parabolic mirrors that continuously track the sun in order to focus the radiant energy onto an elevated receiver or boiler. In this manner, very high temperatures can be reached either to directly flash water to steam or to heat a molten salt within a thermal storage system that could then be used to provide heat for steam production on a continuous basis.

To date, there have not been any demonstrations of solar-thermal central station power production. However, DOE and EPRI are jointly developing a 10-MW central receiver pilot plant, with initial plant operation set for the early 1980s. Plans then call for a 100-MW demonstration plant in the mid-1980s and a 100-MW prototype commercial plant in the 1990s.

If solar-thermal power conversion is shown to be technically feasible and economically competitive with other power sources, consideration will then have to be given to its relative environmental impacts. The most notable of these are the large land area (many square miles) for a base-load facility and the aesthetic impact of the solar collection system. However, the applicant concludes that there are too many unknowns concerning the technical and economic feasibility and the environmental impacts of solar-thermal power production for this option to be considered a reasonable alternative to the proposed generating facility.

8.2.6 Photovoltaic Cells

Photovoltaic cells employ the special characteristics of silicon crystals to convert light directly into direct current electricity. This technology, first developed by Bell Laboratories in 1954, has found many applications in the U.S. space program and is beginning to be used for many terrestrial energy needs where power requirements are small and traditional power sources are inaccessible. A recent technological breakthrough which offers considerable promise is the photovoltaic cell constructed of dissimilar metals and employing "thin film techniques." The production method lends itself to mass production with all its attendant cost advantages but considerable development remains. However, because photovoltaic cells are currently produced by techniques that are quite costly, the construction of central station power plants utilizing this

technology is not feasible. Although DOE is engaged in a research program to produce lower-cost solar cells, there is no assurance that the required cost reductions can be obtained in time for photovoltaic cells to provide new baseload capacity by the 1990s. In addition, a photovoltaic power plant, like a solar thermal plant, would require that large land areas be removed from other uses, resulting in potentially significant environmental impacts. Thus, the applicant concludes that photovoltaic cells cannot be considered a reasonable alternative to the proposed facility.

8.2.7 Municipal Solid Wastes

Substantial sources of energy exist in the large quantities of refuse generated each year in the United States. The total animal and urban solid wastes available at a reasonable collection cost are estimated to range from 4×10^7 to 6×10^7 tons of dry organic material per year (5 lbs per person per day in urban regions). The average heat content of the dry organic material is estimated to be 8000 Btu/lb, providing an annual energy supply ranging from 6×10^{14} to 1×10^{15} Btu which is approximately six percent of the nation's present generating requirements.

Consideration of municipal solid waste as an alternative energy source for TECO is limited by stringent air quality standards and by the lack of a viable collection and preparation system. As a result of the low BTU value of municipal solid waste and the variety of materials that are present, emission problems from an incinerator are more severe than those of conventional fossil-fueled plants. Municipal solid waste has also been shown to be not as economical as conventional fuels, such as coal. Thus the applicant concludes that this alternative is not reasonable due to its costs, size limitations and environmental implications.

8.2.8 Fuels from Biomass

Several possible methods of producing fuels from biomass are currently being investigated, including anaerobic digestion of waste organics to produce methane; cultivation of energy crops for direct combustion or for anaerobic digestion; pyrolysis of waste or cultivated organics to produce fuel oil, low-Btu fuel gas, and tars; and the mining of landfills to extract naturally formed methane. Active experimentation in several of these areas is being conducted because of the large quantities of municipal and agricultural organic wastes available.

Although these projects are at different stages of development, none presently shows any promise of providing

the quantities of fuel needed to operate a baseload electric generating facility at a cost competitive with fossil fuels. Because the methane, low-Btu fuel gas, and fuel oils that might be produced from biomass could serve as substitutes for natural gas and fuel oil, their use as utility boiler fuels would likely be discouraged in favor of higher priority uses.

8.2.9 Wind Power

Wind power generators, although not a new idea, have yet to be developed to the extent that they represent a proven alternative to conventional baseload generation facilities. The DOE has funded several small wind generators to date, and recently funded a 10 MW multiunit system scheduled for completion in the mid-1980s.

Given the current state of development and the time table for future tests, wind power is as yet an unproved technology for supplying large amounts of base load capacity in the near future.

8.2.10 Magnetohydrodynamics

Based on the principle that an electric charge moving through a magnetic field produces an electromotive force, a magnetohydrodynamic (MHD) generator produces a large dc current by venting gases at high temperatures and velocities through a duct passing through a strong magnetic field. This generation technique has the advantages of utilizing high temperatures while employing few moving parts, thus maximizing the thermal efficiency and minimizing the mechanical losses. This results in an overall power conversion efficiency of 40 to 50%, compared to the efficiency of approximately 35% for conventional power plants.

The high-temperature, high-velocity gas streams utilized in an MHD generator are highly corrosive. To date, researchers have been unable to develop materials that can withstand this corrosive environment for significant lengths of time. Additionally, large-scale MHD applications will require advances in developing a superconducting electromagnet if the full potential of this technology is to be realized. These problems, coupled with the scale-up problem of reducing component costs, will require considerably more research and time to solve. Therefore, MHD cannot be considered for commercial power generation in the near future.

8.2.11 Coal Gasification

Pilot plants for coal gasification have been constructed. This method appears to be a promising alternative for fueling large central power stations, but it has not been developed to the extent that it is likely to be available as an alternative to the applicant's proposed facility. A commercial process might be available by the mid-1980s.

8.2.12 Coal Liquefaction

Development of coal liquefaction processes has not progressed to the same extent as development of coal gasification processes. One or more processes might be commercially available by the late 1980s. This will not be in time to be considered as an alternative to the applicant's proposed facility.

8.2.13 Fusion Power

A demonstration nuclear fusion plant is not expected to be built before about 1990, and a commercial power station is not expected to be available before the year 2000. Therefore, the applicant does not consider fusion power to be a viable alternative to the applicant's proposed generating facility.

8.2.14 Oil and Natural Gas

Given the current national policy to discourage utility use of residual fuel oil and natural gas as a boiler fuel in baseload generating facilities, the applicant concludes that these fuels cannot reasonably be considered for use in new large-scale electrical generating facilities.

8.2.15 Nuclear (Uranium)

The lead time required for licensing, design and construction of a nuclear-fueled generating facility is presently close to ten years. The power from the applicant's proposed generating facility is needed by the mid-1980s, therefore nuclear fuel was not considered for the proposed facility under discussion.

8.2.16 Coal

Coal, which remains the most viable energy alternative, could be obtained for the proposed facility either from the eastern United States (Alabama, Kentucky, Illinois, Tennessee, West Virginia), from western states, or from overseas.

8.2.17 Possible New Developments

There are a number of other alternative energy sources that might be mentioned, such as converting foreign natural gas to LNG and transporting it to the United States, extracting fuel oil from oil shale and tar sands, or constructing offshore generating plants that utilize ocean thermal gradients as their energy source. Various technical, economic, and institutional obstacles make the rate of development of these sources very uncertain and large uncertainties in cost and scheduling remain unresolved. Thus, the applicant does not feel that these alternatives should be considered as a reasonable alternative to the proposed generating facility.

8.2.18 Summary

After evaluating alternative fuels, for a large baseload electrical generating facility, the only energy sources which can potentially be considered by the applicant for near-term generation are limited to coal and uranium.

Assessment of other technologies or alternatives to coal and uranium is critically dependent on the time period for which the assessment is to be made because some of these technologies may not become technically and commercially mature before the late 1990s.

8.2.19 Conclusion

Due to the declining domestic reserves of oil and natural gas, coupled with the uncertainty surrounding the price and availability of these imported materials, the emerging national energy policy encourages the increased use of coal or uranium as the primary fuels available for future power generation. Therefore, based on these national policy considerations, it is assumed that in the foreseeable future, coal or uranium will be the fuel for future TECO generating facilities. Because the time-frame for the proposed generating unit is restricted, a nuclear unit could not be constructed in time to meet TECO's energy demand. Therefore, coal is the only remaining energy alternative for the proposed electrical generating facility.

9. PLANT DESIGN ALTERNATIVES

CHAPTER 9

DESIGN ALTERNATIVES

9.1 ALTERNATE CONDENSER COOLING WATER SYSTEMS

9.1.1 Closed Cycle Heat Rejection System

An alternative to the proposed once-through cooling system, which is identical to the cooling systems used in Units 1, 2, and 3 is some form of closed-cycle cooling. A study was conducted to determine the preferred type of closed-cycle heat rejection system for Big Bend Unit 4, based on an analysis of engineering, economic, and environmental considerations.

In addition, capital and operating costs of closed-cycle system alternatives were compared with those of the proposed once-through system.

The following heat rejection systems were considered in this study:

- o Once-through (with and without additional dilution pumping capability for the site)
- o Closed-cycle natural-draft cooling tower
- o Closed-cycle concrete circular mechanical-draft cooling tower (multiple fans)

The design parameters and the arrangement of the once-through system were based on the design of Big Bend Unit 3, with the exception that AL-6X (an alloy of steel) condenser tubes were considered in addition to titanium. The concrete circular tower used in the evaluation is considered representative of multiple fan mechanical-draft cooling towers. This does not preclude future consideration of rectangular towers, if warranted.

Based on the results of the study, a mechanical-draft cooling tower is the preferred alternative closed-cycle system for Big Bend Unit 4. Titanium condenser tubes have a slight economic advantage over AL-6X, but, because of more favorable operating experience with AL-6X tubes, both remain under serious consideration for the Unit 4 condenser. For titanium tubes the economically optimum cooling tower approach (to the prevailing wet bulb temperature) is 12°F, and for AL-6X tubes it is 10°F. A 17°F range was chosen to maintain both the once-through and closed-cycle system options.

The mechanical-draft cooling tower system was selected primarily on the basis of economics. The net present value of the capital and performance costs associated with the natural-draft closed-cycle system was estimated to be about \$22 million more than the mechanical-draft system. The net present value is computed by discounting annual capital and performance costs over an economic life of 28 years using a cost of capital of 8.62 percent. The higher net present value for the natural-draft system results from its significantly higher capital cost: the total capital cost of the system at the time of commercial operation, including escalation and interest during construction, is about \$17 million more than the mechanical-draft system. Although there is a performance advantage for the natural-draft system of about \$400,000/yr, this does not offset the high capital differential.

The natural-draft tower does not appear to offer any significant environmental advantages which would outweigh its greater cost. The natural-draft tower was judged to be slightly preferable to the mechanical-draft in terms of salt drift impacts, ground fogging potential, and noise, but less desirable with respect to aesthetic impacts. However, there do not appear to be any major environmental factors which would preclude use of either type of tower for closed-cycle cooling of Big Bend Unit 4.

A preliminary assessment of potential impacts of salt drift has shown that vegetation damage due to salt drift would be likely in the Palmetto-Pine and Palmetto-Juncus associations adjacent to the proposed location of the mechanical-draft cooling tower. There is also a potential for some injury to any moderately to extremely salt-sensitive species that might be present in nearby agricultural areas. Analyses have shown that the potential occurrence of ground fog will be infrequent and generally confined to the immediate site area, and that noise from the tower will conform to the noise regulations of the Hillsborough County Environmental Protection Commission.

A closed-cycle system for Big Bend Unit 4 will be substantially more expensive than the proposed once-through system. In terms of capital cost, the mechanical-draft system represents an incremental cost of about \$26 million at commercial operation date. There is also a performance penalty of about \$1,900,000/yr. The net present value of the annual capital and performance costs of the mechanical-draft system is about \$61 million more than the once-through system.

9.1.2 Alternate Makeup Water Sources

Possible makeup water sources for the alternate closed-cycle heat dissipation system are under investigation. The sources under construction are discussed below.

9.1.2.1 Hillsborough Bay

Hillsborough Bay, the source of once-through cooling water for Big Bend Units 1 through 3, is the source for the proposed Unit 4 once-through cooling system. This source is also considered the primary candidate for supplying makeup to a closed-cycle cooling system. A description of the physical and chemical characteristics of Hillsborough Bay is provided in Section 2.5.

9.1.2.2 Freshwater

The freshwater resources in the Big Bend area are limited to groundwater which is utilized for agricultural activities. The quantities of water needed to supply a closed-cycle system would place a great burden on the local groundwater resources. For this reason, investigative efforts have concentrated on finding a feasible source of sewage effluent. The use of treated sewage effluent from municipal systems remains a very promising alternative in that the quality of water is compatible with its intended use.

9.1.2.3 Brackish Groundwater Supply

A groundwater investigation is being performed to evaluate the availability of artesian brackish water as an alternative source of station makeup water. Approximately 5,000 to 7,000 gpm of makeup water at less than 20,000 ppm total dissolved solids and with temperatures less than 90°F would be required. The investigation will determine whether or not the withdrawal of brackish water from the deep artesian aquifers would be detrimental to the environment, particularly with respect to the existing quality and potentiometric surface of freshwater stored in the shallower artesian aquifers. These shallower aquifers have been used extensively for land irrigation as well as for industrial, commercial, and domestic water supply in a broad area adjacent to the plant site.

Preliminary indications are that brackish makeup water which meets and exceeds quality, quantity, and environmental requirements can probably be supplied from an approximate depth of 2,000 ft to 3,000 ft.

The following tasks, which expand the preliminary indications, are currently being performed:

1. An assessment of regulatory requirements aimed at evaluating attitudes and requirements concerning the use of brackish water.
2. An intensive program gathering site-specific hydrogeologic data from the original documentation on past boring and testing programs for previously drilled wells.

This investigation also utilizes background data from previous studies performed at Big Bend Station.

Upon completion of these tasks, a report examining the probability of acquiring sufficient water of an acceptable quality will be prepared.

If the effort yields favorable results and the need for a brackish water cooling tower makeup source becomes a reality, an additional study program will be required. This program would consist of the following:

1. The development of a computer model which will simulate well field and aquifer responses for the 33-year life of the station.
2. A field testing program which will include the construction of a production test well and several test wells.

Upon completion of this study, conclusions can be drawn on the feasibility of utilizing the brackish water source and the environmental effects of pumping the aquifer can be predicted.

9.2 INTAKE SYSTEM ALTERNATIVES

Alternative intake structure (fine mesh screening) is discussed in the 316 Demonstration which is amended to this document.

Amendment 3
August 1980

Figure 9.2-1

Modified Traveling Water Screen
With Fish Lifting Buckets And
Low Pressure Spray Wash

This drawing has been removed
from this document

9.3 AIR EMISSIONS CONTROL ALTERNATIVES

9.3.1 Sulfur Dioxide Control

Sulfur dioxide emissions from Big Bend Unit No. 4 will be controlled by coal cleaning and FGD system. The FGD system proposed for Unit No. 4 is a wet scrubbing, limestone reagent, throwaway process (Figure 9.3-1). The combination of these technologies is capable of meeting the SO₂ removal efficiencies required by the New Source Performance Standards (NSPS); which are, 90 percent for high sulfur coals down to 70 percent for low sulfur coals.

The limestone FGD system will incorporate a forced oxidation process which will produce a chemically pure gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) byproduct of approximately 80-90 percent solids by weight. The gypsum is chemically stable and may have a future reuse potential as raw material for the wallboard and cement industries. If the material must be stockpiled, it is easily handled and can be disposed of in accordance with the Resource Conservation and Recovery Act (RCRA).

The reagent used will be limestone which is readily available and inexpensive in the Tampa, Florida area.

The alternative FGD systems considered were double alkali, lime, and the Wellman-Lord regenerable process.

The double-alkali FGD system uses two alkalies; sodium in the scrubbing section, and lime in the sodium regeneration section (Figure 9.3-2). There are several features of this system which make it economically unattractive for this site. The two alkalies used in this process are expensive and not readily available. While absolute quantities of the reagents used are less for the double-alkali system as compared to the limestone system, the overall cost for reagent to operate this process is six to seven hundred percent greater than the limestone system. At the same time, its capital cost and other operation and maintenance costs are not significantly different. In addition, the waste produced by this process is nearly all calcium sulfite ($\text{CaSO}_3 \cdot 1/2\text{H}_2\text{O}$) with significant quantities of highly soluble sodium salts. This waste cannot be landfilled in accordance with RCRA without first being stabilized to prevent leaching of the salts and to prevent the calcium sulfite from exerting a chemical oxygen demand. This would significantly increase the disposal costs.

The lime FGD system uses lime as its reagent and is very similar to the limestone FGD system (Figure 9.3-3). There are several features of this system that are similar to the double-alkali system which make it economically unattractive for this site.

First is the higher cost and limited availability of the lime reagent. This would approximately double the reagent operating cost for this system over a limestone process while its capital equipment costs and other operation and maintenance costs would remain approximately equal. Second, the waste produced would be nearly all calcium sulfite ($\text{CaSO}_3 \cdot 1/2\text{H}_2\text{O}$) which has a chemical oxygen demand and is highly thixotropic. This would require that it be stabilized before it could be landfilled in accordance with RCRA and would considerably increase waste disposal costs.

The last alternative is the Wellman-Lord process. This is a regenerable process which produces a marketable end product, either elemental sulfur or sulfuric acid. In the Tampa area sulfuric acid would be the more desirable product since there are several industries which use sulfuric acid. This system uses soda ash as its reagent and the process is described on the flow diagram in Figure 9.3-4. Due to the higher reactivity of the sodium species, this system has achieved the same high removal efficiencies as the double-alkali FGD system on low sulfur coals. The technology has not been proven, however, on high sulfur coals. Since this system produces a marketable end product, waste disposal is minimized. Nevertheless, there are several features of this system which make it economically unattractive for this site. The first is the higher capital cost of the scrubbing equipment. The extensive regeneration section of the system is extremely expensive, especially in terms of operation and maintenance costs. In addition, the Wellman-Lord process is highly energy intensive which poses a severe economic penalty. The second is the high cost and limited availability of soda ash. However, due to the very low reagent consumption of the system this is not a very significant disadvantage. Third, a complete sulfuric acid production plant and tank farm facility is required in addition to the FGD system in order to produce the marketable by-product. This would require additional capital and add to operation and maintenance costs. Finally, the utility must enter into the sulfuric acid sales market, a function with which they are completely unfamiliar. Preliminary inquiries conducted have found little interest in purchasing the sulfuric acid. W. R. Grace Company, Allied Chemical Company, Swift Agricultural Chemicals Corporation, Ashland Chemical Company, and Canadian Industries Limited were contacted. All indicated that they were not interested in the outright purchase of the sulfuric acid, however, they were interested in becoming our marketing agents.

The Wellman-Lord system would incorporate a 60-day tank farm storage system but, if the tank farm became full, it would inhibit the use of the scrubber. Thus, for the Wellman-Lord

system, the operation of the scrubber would become dependent upon the utility's ability to market the sulfuric acid.

It appears that the most cost-effective approach for achieving the NSPS and complying with the Clean Air Act Amendments would be the limestone-type FGD system.

9.3.2 Particulate Control

The particulate collection equipment proposed for Big Bend Station Unit No. 4 of TECO is a rigid frame electrostatic precipitator. This precipitator will be of the 99.5+ percent removal efficiency class based upon the burning of medium-to-high sulfur coal. The precipitator will be designed to meet the NSPS of 0.03 lbs/10⁶ Btu and 20 percent opacity. The precipitator design will have provisions to incorporate future technological advances to meet the NSPS requirements if low sulfur coal is fired as boiler fuel. The rigid frame design was selected to provide added reliability over the weighted wire design. A redundant electrical field is also added to increase and assure further its reliability.

The alternative to electrostatic precipitation that was investigated was the fabric filter type particulate collection equipment. The fabric filter is capable of providing slightly higher removal efficiencies. However, the cost effectiveness of the precipitator versus the fabric filter is dependent upon the sulfur content of the fuel being used. In a low sulfur application, the fabric filter would usually be more cost effective in achieving high removal efficiencies since the precipitator required to approximate the same efficiency would be very large due to the increased resistivity of the ash. This does not hold true for a medium to high sulfur case such as TECO's application. Here, the reduced resistivity of the ash allows a much smaller precipitator to approximate the fabric filter efficiency. Thus, the precipitator becomes much more cost effective than the fabric filter for this application. Additionally, the fabric filter collection equipment would operate with a higher pressure drop loss and its operation and maintenance costs would be significantly higher for this application.

The collected fly ash will continue to be marketed to various users by TECO. Provisions for fly ash stabilization will be made so that the ash can be disposed of in accordance with RCRA should the market for the ash at some future date cease to exist and alternative methods for its disposal become necessary.

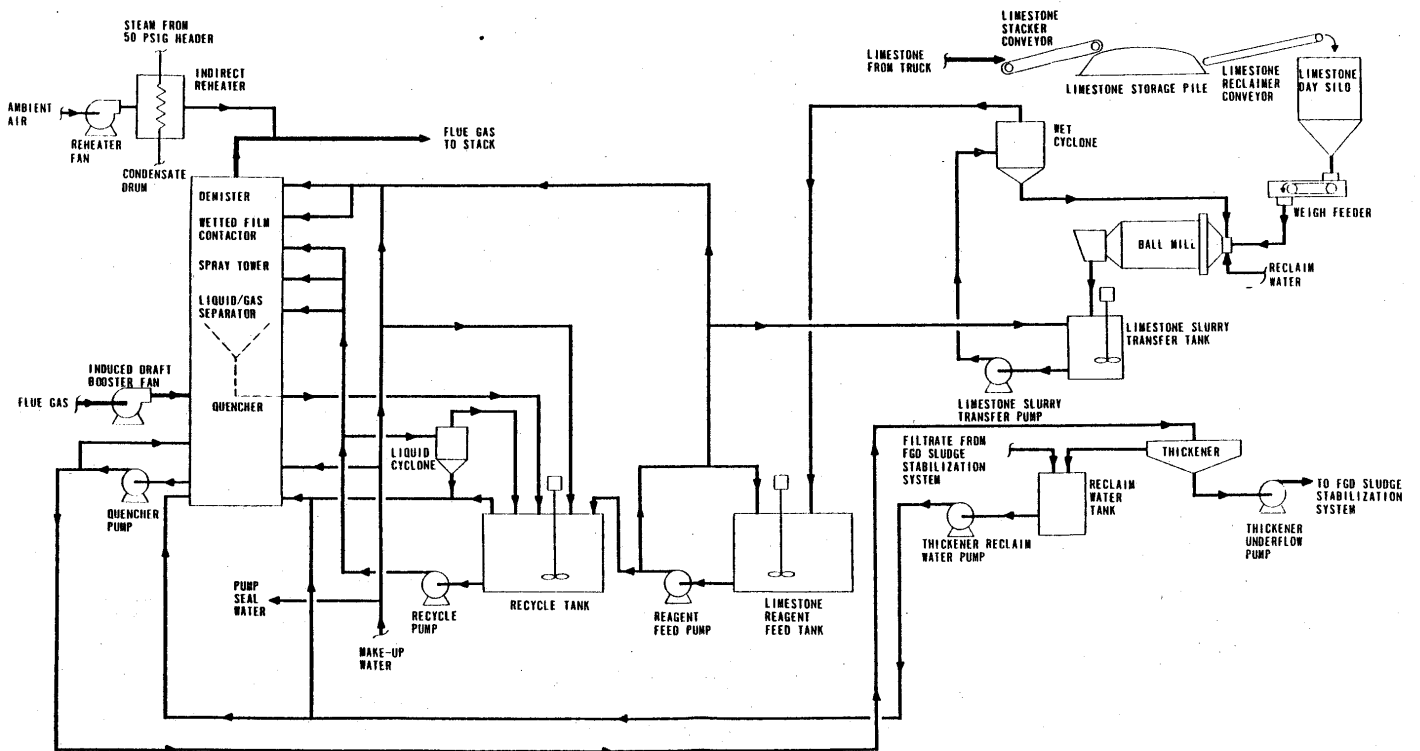


FIGURE 9.3-1
PROCESS FLOW DIAGRAM
LIMESTONE FGD SYSTEM
DOUBLE LOOP
BIG BEND STATION
TAMPA ELECTRIC COMPANY

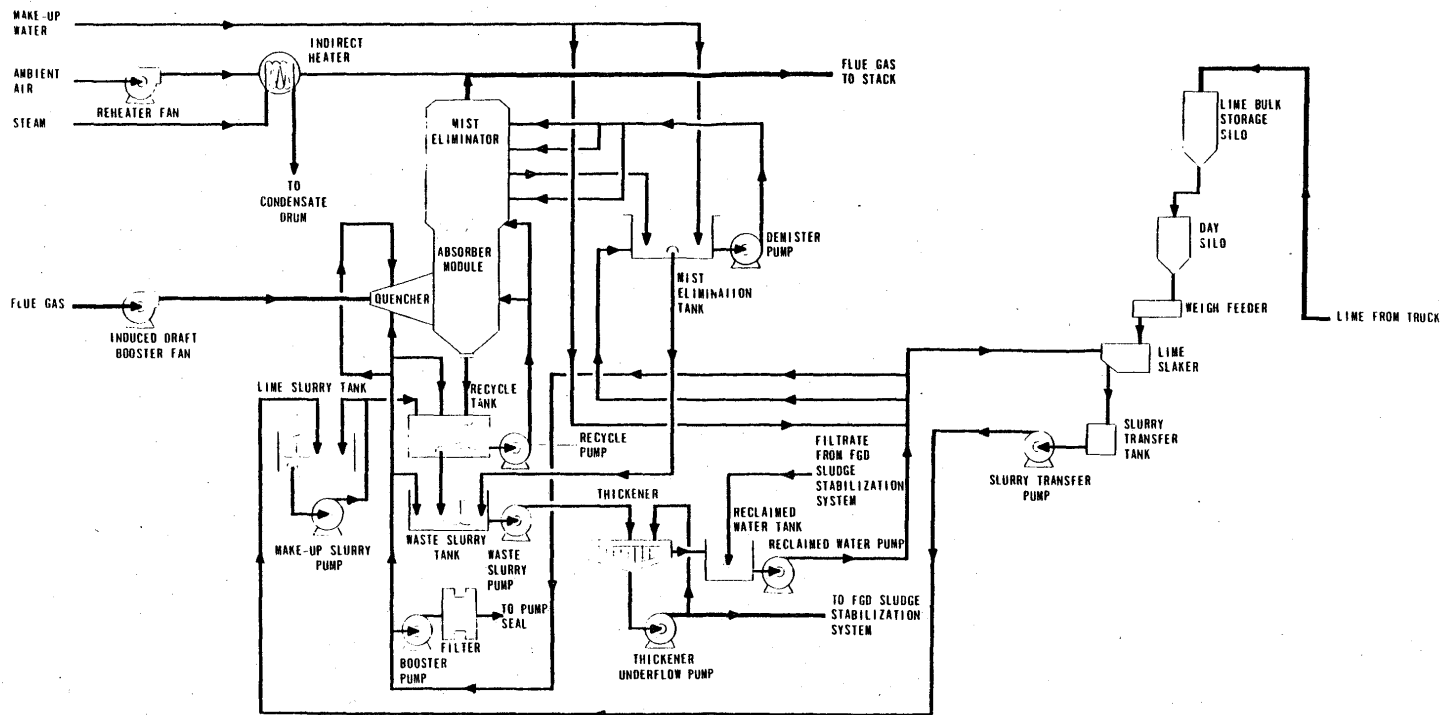


FIGURE 9.3-3
PROCESS FLOW DIAGRAM
LIME FGD SYSTEM
BIG BEND STATION
TAMPA ELECTRIC COMPANY

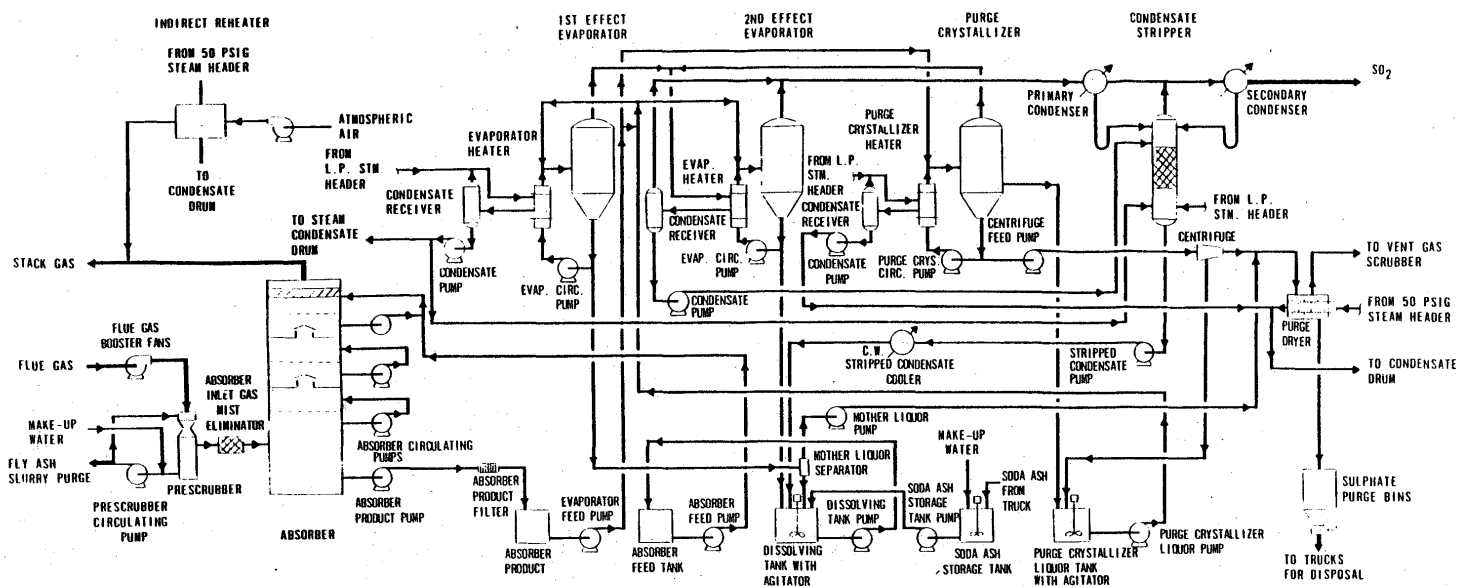


FIGURE 9.3-4
PROCESS FLOW DIAGRAM
W-L FLUE GAS DESULPHURIZATION
SYSTEM PURGE CRYSTALLIZATION
BIG BEND STATION
TAMPA ELECTRIC COMPANY



BIG BEND UNIT 4
SITE CERTIFICATION APPLICATION
NUMBER 8

POST OFFICE BOX 111 TAMPA, FLORIDA 33601 TELEPHONE (813) 879-4111

July 1, 1980

RECEIVED
JUL 3 1980
ENVIRONMENTAL
DEPARTMENT

Mr. H.S. Oven, Jr., P.E.
Florida Department of Environmental
Regulation
Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, Florida 32301

RE: Tampa Electric Company
Big Bend Station Unit 4
Site Certification Application

Dear Mr. Oven:

Enclosed please find Amendments 1 and 2 to the Big Bend 4 Site Certification Application (SCA). Amendment 1 serves to update Chapter 1 of the SCA with our most recent demand forecast as presented in our 1980-1989 Ten Year Site Plan. Amendment 2 is a response to the Department's January 10, 1980 letter concerning questions generated by the Bureau of Air Quality Management.

Copies of these amendments and this letter are being sent to all recipients of the Big Bend Unit 4 application. These items should be inserted into the back of volume 2 of the document. The attachments to Amendment 2 are revised pages to the application and should be inserted into the document as requested.

If there are any questions, please do not hesitate to call.

Sincerely,

Jerry L. Williams

Jerry L. Williams
Manager, Environmental Planning

JLW/JBR/mo
enclosure

cc: Big Bend 4 Site Certification
Application Recipients

RECEIVED

JUL 3 1980

DIV. ENVIRONMENTAL
PERMITTING

AMENDMENT 1

TAMPA ELECTRIC COMPANY
BIG BEND STATION UNIT 4
SITE CERTIFICATION APPLICATION

Amendment 1
July 1, 1980

Chapter 1

The following amendment to Chapter 1 of Site Certification Application is provided to incorporate TECO's Ten Year Site Plan for 1980 to 1989.

1980 Update of System Demand and Reliability

The following discussions provide updated information on TECO's system demand and reliability as reflected in its Ten Year Site Plan for 1980 to 1989 (see Attachment A for Chapter I-III of the Site Plan), submitted to the Florida Department of Community Affairs, Division of Local Resource Management under its Power Plant Siting Program. The numbering refers to the sections in Chapter 1 of the Site Certification Application.

1.1.1 Load Characteristics Update

The load characteristics as listed in the October 1, 1979, Site Certification Application have not changed significantly. Through 1989, TECO will remain a winter peaking utility. The summer peaks will occur in late afternoon, with winter peaks occurring in both the morning and afternoon. Form 2 of the TECO 1980 to 1989 Ten Year Site Plan in Attachment A summarizes the latest historical and projected load characteristics of the TECO system.

1.1.1.1 Load Analysis

Forms 2 through 5 of the 1980 to 1989 Ten Year Site Plan in Attachment A illustrate the most recent (November 28, 1979) energy and peak demand projections. These project nearly the same growth rates as those in the Site Certification Application.

1.1.1.2 Demand Projections

The basic assumptions of TECO's most recent (November 28, 1979) forecast are comparable to those in Appendix 1A of the Site Certification Application.

1.1.1.3 Capacity Exchanges

TECO is negotiating a contract to purchase firm capacity power from a new coal-fired generating unit beginning in 1983. This would replace the oil-fired combustion turbine peaking units that were planned for 1983 and 1984 at Big Bend Station.

TECO and Florida Power & Light Company (FP&L) have negotiated a unit power contract with a term from 1985 through 1987. FP&L will purchase power generated by Big Bend Unit 4 in amounts not exceeding limits set by TECO. The amounts will be approximately 70 percent

(1985), 50 percent (1986), and 25 percent (1987) of the Big Bend Unit 4 capacity.

These plans are illustrated in Forms 3 and 7 in Attachment A. Form 3 shows the projections of net purchases of energy, and the reduced amount of residual fuel oil used beginning in 1983. Form 7 shows the planned net firm capacity import.

In addition, TECO will participate in economy interchange transitions on an hourly basis to reduce the total system operation expense.

1.1.2 System Capacity Update

The most recent Peninsular Florida Generation Reliability Study dated October 1979, is included as Attachment B. As shown on page 9 of the study, the Peninsular Florida System loss-of-load probability ranges from 0.03 days per year (1979) to 0.18 days per year (1988).

Forms 6 and 7 in Attachment A show the projected generating capacity increases. These result from improvements to Big Bend Unit 2, the installation of Big Bend Unit 4 in 1985, and completion of an additional coal-fired unit in 1989. The 1989 unit would have a net capability of 800 megawatts (MW), of which 400 MW would be owned by TECO, with the remaining 400 MW being owned by others. As discussed in 1.1.1.3 above, the combustion turbine peaking units have been removed from the capacity expansion plans.

1.1.3 Reserve Margin Update

As described in 1.1.1.3 above, negotiations are under way to arrange for firm capacity purchase power rather than installing combustion turbine peaking units in 1983 and 1984. The reserve margins resulting from this and capacity expansion plans are shown in Form 7 of Attachment A.

ATTACHMENT "A"
TO
AMENDMENT 1
JULY 1, 1980

**TEN YEAR PLAN
FOR
ELECTRICAL GENERATING FACILITIES
AND
ASSOCIATED TRANSMISSION LINES
1-1-80 TO 12-31 89**

TECO
TAMPA ELECTRIC COMPANY

4-1-80

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CHAPTER I

DESCRIPTION OF EXISTING FACILITIES

Existing Generating Facilities are described in the following forms:

- Form 1A Existing Generating Facilities
- Form 1B Existing Generating Facilities - Land Use and Investment
- Form 1C Existing Generating Facilities - Environmental Considerations for Steam Generating Units

UTILITY TAMPA ELECTRIC COMPANY

EXISTING GENERATING FACILITIES

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Plant	Unit No.	Location	Type	Fuel Pri	Fuel Alt	Com'l In-Service Mo/Yr	Exptd Retrmnt Mo/Yr	Gen Max Nameplate KW	Net Capability Summer MW	Net Capability Winter MW	Fuel Pri	Transp Alt	Alt Fue Days Use
Francis J. Gannon		Hillsborough Co. 4/30S/19E						1,288,380	1,090	1,090			
	1		FS	HO	No	8/57	Unknown	125,000	98	98	WA	No	0
	2		FS	HO	No	10/58	Unknown	125,000	108	108	WA	No	0
	3		FS	HO	No	8/60	Unknown	179,520	150	150	WA	No	0
	4		FS	HO	No	7/63	Unknown	187,500	169	169	WA	No	0
	5		FS	C	No	9/65	Unknown	239,360	214	214	RR	WA	0
	6		FS	C	No	9/67	Unknown	414,000	337	337	RR	WA	0
	GT 1		CT	LO	No	1/69	Unknown	18,000	14	14	WA	No	0
Hookers Point		Hillsborough Co. 19/29S/19E						232,600	197	197			
	1		FS	HO	No	7/48	Unknown	33,000	29	29	WA	No	0
	2		FS	HO	No	6/50	Unknown	34,500	29	29	WA	No	0
	3		FS	HO	No	8/50	Unknown	34,500	29	29	WA	No	0
	4		FS	HO	No	10/53	Unknown	49,000	43	43	WA	No	0
	5		FS	HO	No	5/55	Unknown	81,600	67	67	WA	No	0
Big Bend		Hillsborough Co. 9/31S/19E						1,512,000	1,208	1,208			
	1		FS	C	No	10/70	Unknown	445,500	367	367	WA	No	0
	2		FS	C	No	4/73	Unknown	445,500	337	337	WA	No	0
	3		FS	C	No	5/76	Unknown	445,500	360	360	WA	No	0
	GT 1		CT	LO	No	1/69	Unknown	18,000	14	14	WA	No	0
	GT 2 & 3		CT	LO	No	11/74	Unknown	157,500	130	130	WA	No	0
TOTAL									2,495	2,495			

December 31, 1979 Status

UTILITY TAMPA ELECTRIC COMPANY

EXISTING GENERATING FACILITIES
LAND USE AND INVESTMENT

(1) Plant Name	(2) Land Area		(4) Land	(5) Plant Capital Investment (in \$1,000)		(7) Total
	Total Acres	In Use Acres		Site Improvements	Buildings & Equipment	
Hookers Point	26	26	\$ 437	\$ 7,731	\$ 32,380	\$ 40,548
Big Bend	1,227	1,227	5,314	54,587	230,608	290,509
Francis J. Gannon	103	103	350	31,343	161,579	193,272
Gas Turbine Gannon				75	1,721	1,796
Gas Turbine Big Bend	73	73	834	1,475	17,412	19,721
Miscellaneous* Production	8	8	67	835	1,404	2,306
			<u>\$7,002</u>	<u>\$96,046</u>	<u>\$445,104</u>	<u>\$548,152</u>

December 31, 1979 Status

*Production Office, Production Warehouse, Traveling Maintenance Crew,
Power Plant Construction, and Central Testing Lab

EXISTING GENERATING FACILITIES
ENVIRONMENTAL CONSIDERATIONS FOR STEAM GENERATING UNITS

(1) Plant Name	(2) Unit	(3) Flue Gas Cleaning			(6) Cooling Type
		Particulate	SOx	NOx	
Francis J. Gannon	1	NO	LS	NO	OTS
	2	NO	LS	NO	OTS
	3	NO	LS	NO	OTS
	4	NO	LS	NO	OTS
	5	EP	LS	NO	OTS
	6	EP	LS	NO	OTS
	GT 1	NO	LS	NO	---
Hookers Point	1	NO	LS	NO	OTS
	2	NO	LS	NO	OTS
	3	NO	LS	NO	OTS
	4	NO	LS	NO	OTS
	5	NO	LS	NO	OTS
Big Bend	1	EP	NO	NO	OTS*
	2	EP	NO	NO	OTS*
	3	EP	NO	NO	OTS*
	GT 1	NO	LS	NO	---
	GT 2-3	NO	LS	NO	---

*With Dilution

GT - Gas Turbine

December 31, 1979 Status.

CHAPTER II

A FORECAST OF ELECTRIC POWER DEMAND

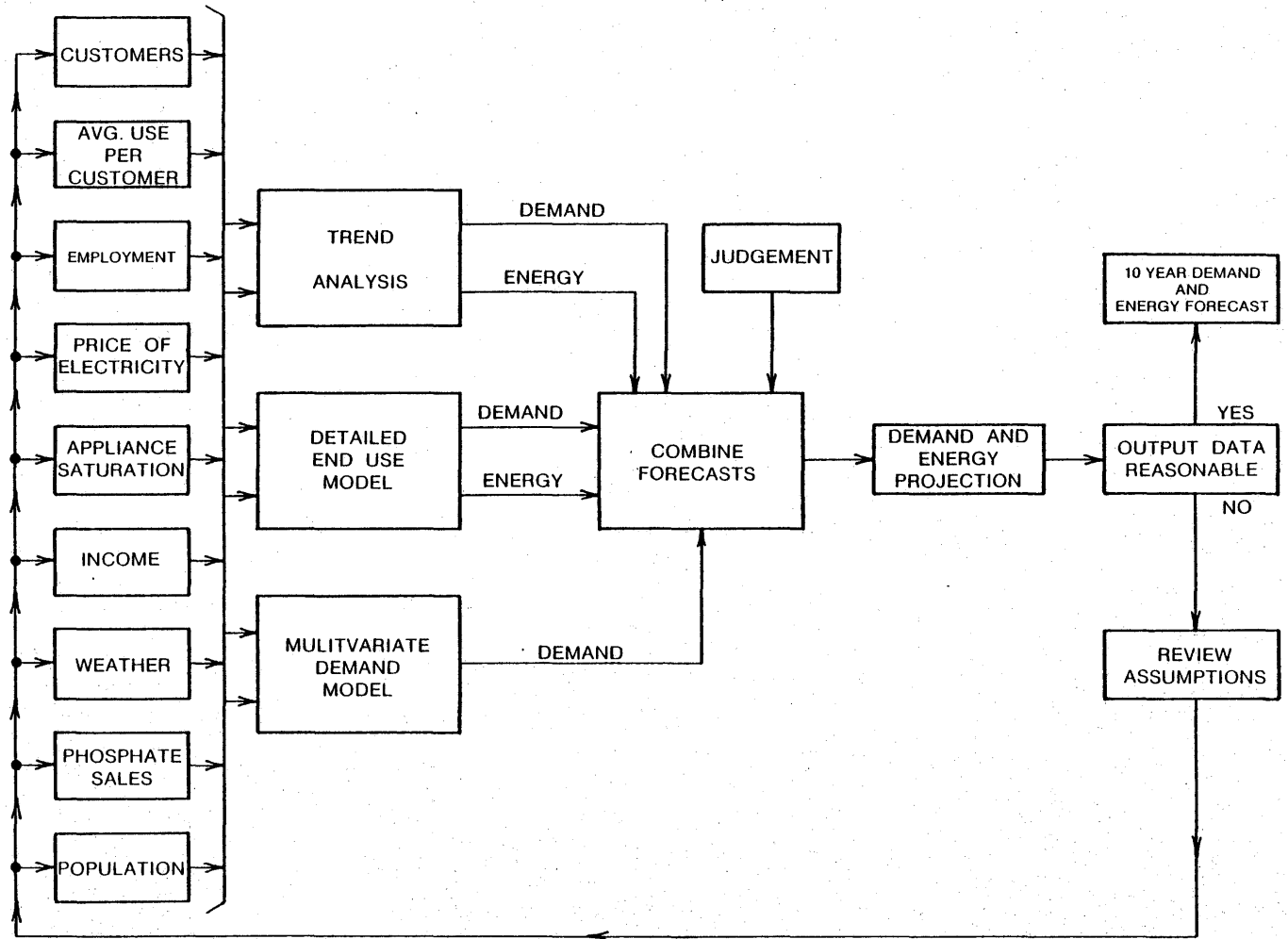
Tampa Electric Company Forecasting Methodology

The 1979-1989 Demand & Energy Forecast has been prepared using the following techniques:

1. Detailed End Use Method (Demand, Energy)
2. Trend Analysis (Demand, Energy)
3. Multivariate Method (Demand)
4. Phosphate Method (Demand, Energy)

As shown on Graph 1, many independent variables are used to drive the various methods. The output data from each of the techniques are combined and tempered with judgement to produce a single forecast. Several checks are made on load factors, growth rates (customer class & total), and usage per customer, etc. to determine the "reasonableness" of the projections. If a forecast does not satisfy this subjective check, the assumptions are reviewed and the process is repeated. This method is also used to produce low, medium and high demand and energy scenarios. The remaining portions of this section describe TECO's trend, multivariate and detailed end use models. It should be noted that phosphate sales projections are prepared independently and combined later with the three main forecasting techniques. A brief description of the phosphate method (#4) is included in this section. The attached data tables outline specific demand and energy data values for the 1979-1989 time period. At the end of the Chapter is a brief description of certain key factors that have been considered in this forecast. Some of these factors are load management, electric cars, conservation and public information policy.

GRAPH # 1
TAMPA ELECTRIC COMPANY
EXISTING FORECAST TECHNIQUE



Tampa Electric Company

Detailed End Use Demand & Energy Forecast Method #1

This Section outlines Tampa Electric's detailed end use forecasting model. This model has been in the developmental stages for two years. TECO's research effort is nearly complete with the exception of the Economic/Demographic sector which should be finished in early 1980. The entire project has been a joint effort between Tampa Electric and Battelle Memorial Institute in Columbus, Ohio.

Tampa Electric Company
Detailed End Use Demand & Energy Forecast Method #1

INTRODUCTION

This report describes the development of an integrated energy and demand forecasting system for the TECO service area. This detailed end use model forecasts annual energy consumption for the total service area and simulates load profiles by end use for typical (average) and extreme days. The hourly demand values are consistent with the energy projections derived in the first phase. The model extension described in this report enables the user to generate daily load profiles for weekdays or weekends for any month of the year and under any assumed temperature conditions.

In the following discussions the structure of the loadshape model and the derivation of the required inputs will be described. Also, a comparison of model results with actual load data will be presented.

OVERVIEW OF MODEL STRUCTURE

The basic structure of the model centers around a central definitional equation which applies to all end uses. Since this equation is repeated again and again, the resulting model is large but not complex.

In its most general form, the basic equation is given by:

$$D_{ij} = N_i * C_i * F_{ij}$$

where D_{ij} = Demand at hour j by end use component i

N_i = Number of use components of type i

C_i = Connected load per use component of type i

F_{ij} = Fraction of the connected load of use component i
which is operating at hour j

The energy consumption for any period is calculated by summing over the corresponding demand values. Thus:

$$E_i = \sum_j D_{ij}$$

where E_i = Energy consumption by use component i for a specific period

D_{ij} = Demand at hour j by use component i

It should be noted that the hourly demand equation is the product of the number of use components N_i and the hour's expected demand per use component ($C_i \times F_{ij}$). Summing the term $C_i \times F_{ij}$ over all hours in the year yields the average annual energy consumption by use component i is the product of the number of components times the average annual use.

The fraction of a use component's connected load that is operating at a specific hour is the component's use factor for that hour. The set of use factors for a given day type and month describes the component's expected operating pattern for that day. The collection of use factors necessary for the description of a use component's operation throughout the year is the component's use matrix.

Implicit in the above is the need for use factors for every hour of the year for each use component. This is accomplished by providing for four day types per month. The four day types recognized in the loadshape module are: (1) Sundays, (2) Mondays, (3) Weekdays (Tuesdays-Fridays) and (4) Saturdays. The Sunday load profile is assumed to apply to holidays. When a weekday follows a holiday, the Monday load profile is assumed to apply. Thus, a use matrix is dimensioned by hours, day types, months; and contains 1152 use factors (24 hours per day x 4 day types per month x 12 months per year). The format of a typical use matrix is shown in Figure 1.

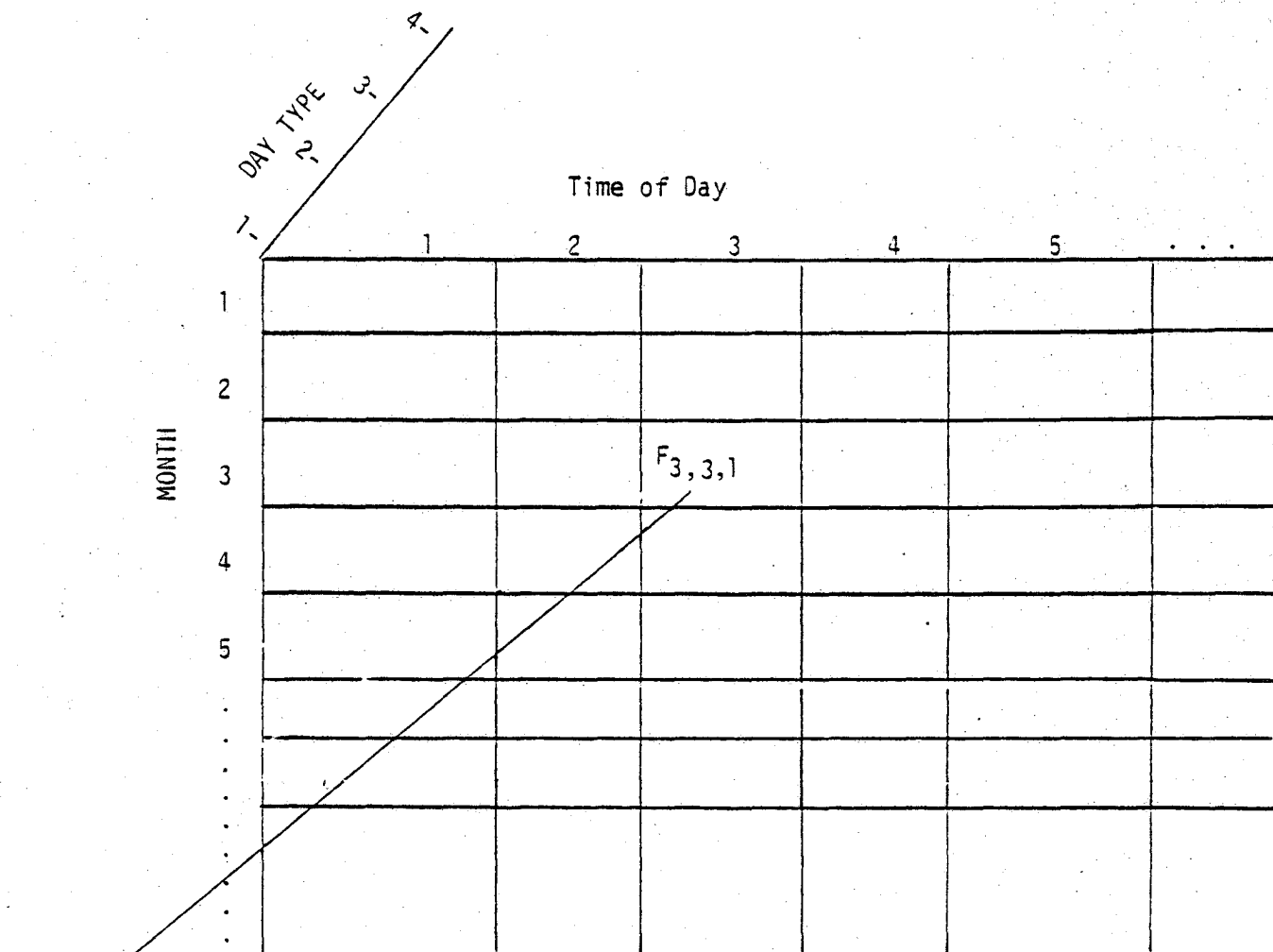
The basic demand equation presented above was somewhat modified for the commercial and industrial sectors. Due to data limitation, the actual computational procedure used in these sectors is an allocation of estimated energy use to specific time periods based upon the use pattern matrices.

Temperature Sensitive Load

Strictly speaking, the above discussion is only valid for those end use components whose use varies only with time. There are, however, end uses whose patterns of usage are both time and temperature dependent. For these end uses, the use factor matrices are modified by replacing the month dimension by a temperature dimension. Elements of these matrices denote the fraction of the use component's connected load that is expected to be operating at the corresponding time and temperature conditions. (In the absence of connected load information, average hourly demand by a use component is utilized.) The format of a use matrix for residential electric space heating is shown in Figure 2. It should be noted that multiplying each matrix element by the connected load yields a matrix whose elements are the hourly demands for the corresponding time and temperature conditions.

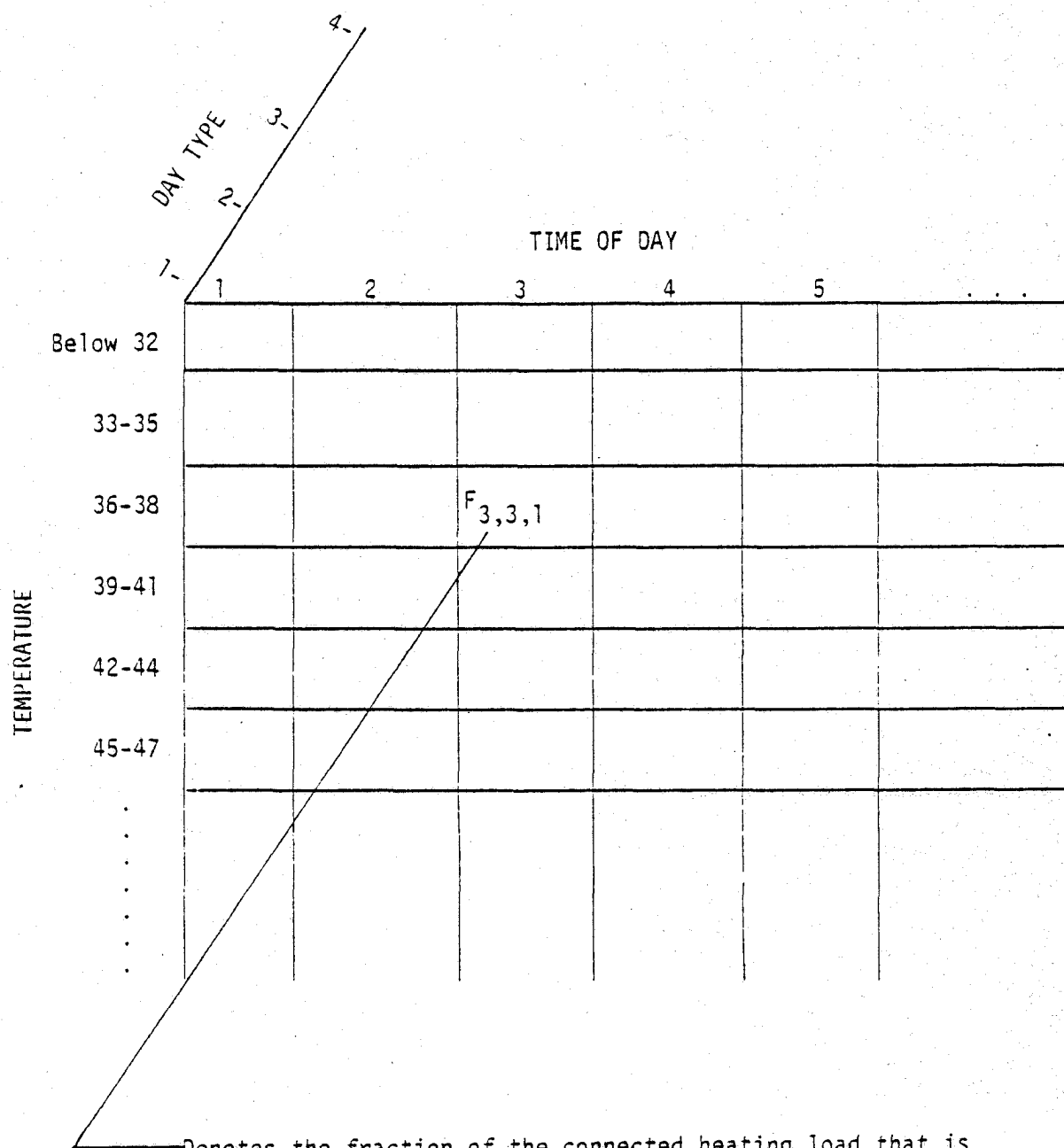
Computation of Energy Consumption

To use the above temperature sensitive use matrix to calculate energy consumption in a given time period, requires estimates of the expected frequency of the time and temperature conditions in the time period. Multiplying the expected frequency or the expected number of hours spent in each time and temperature cell (hrs) by the corresponding demand (kw) yields the expected energy consumption (kw x hr). Summing those values over all temperature and time conditions gives the total energy consumption in the specified time period. To be more specific, consider the example of calculating the energy requirements for residential electric space heating in January.



Denotes the fraction of the use component's connected load operating in March on a Sunday at 3 o'clock in the morning.

FIGURE 1. FORMAT OF TYPICAL USE MATRIX FOR A TEMPERATURE INSENSITIVE END USE



Denotes the fraction of the connected heating load that is operating when the temperature is between 36° and 38°F on a Sunday at 3 o'clock in the morning.

FIGURE 2. FORMAT OF RESIDENTIAL ELECTRIC SPACE HEATING USE MATRIX

As mentioned above, to calculate energy consumption in January the probability of encountering specific time and temperature conditions is required. These probabilities are arranged in the temperature probability matrix. The format of this matrix is given in Figure 3.

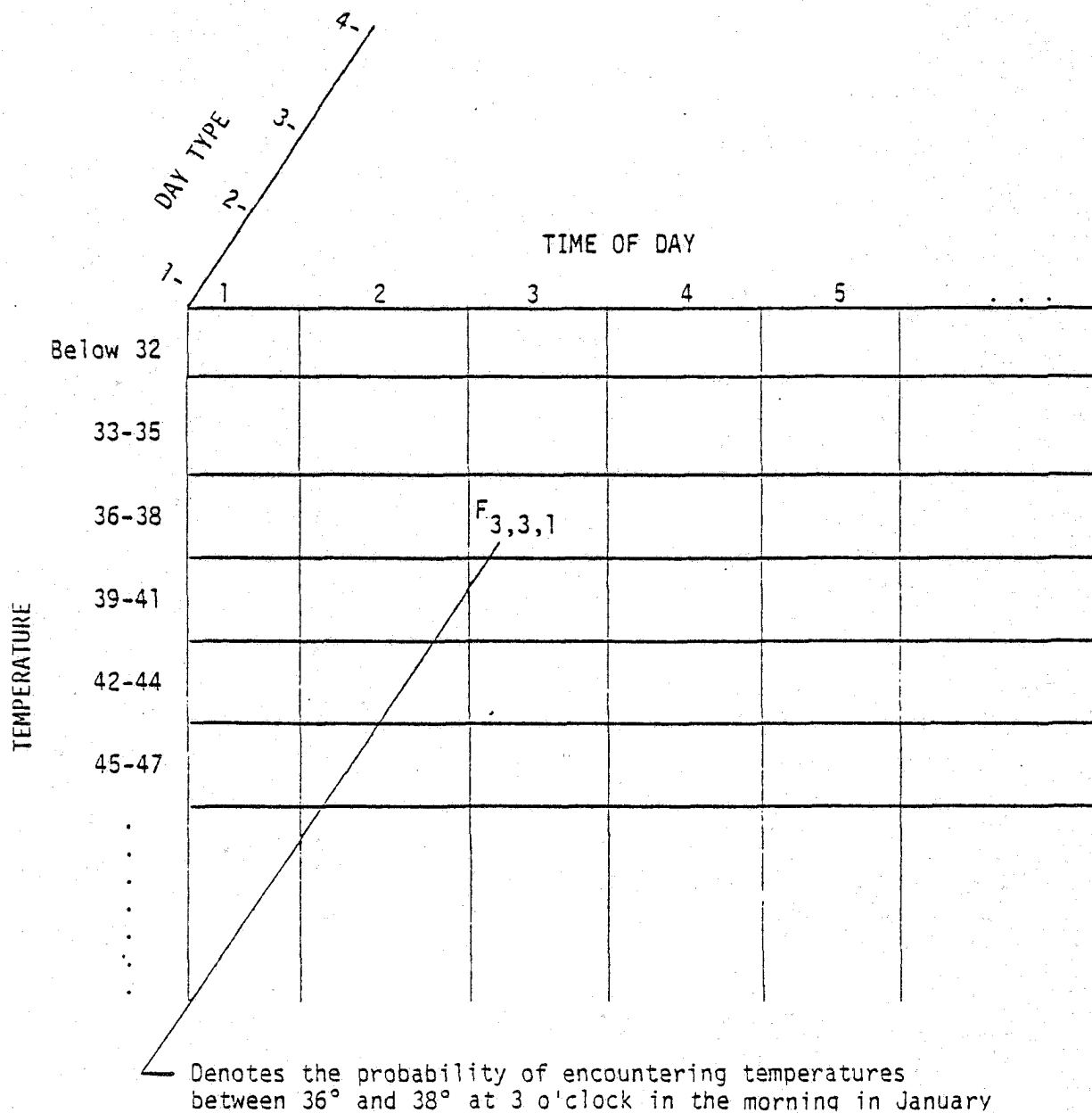


FIGURE 3. FORMAT OF TEMPERATURE PROBABILITY MATRIX

An element in the matrix denotes the probability or the relative frequency of the temperature falling into any one of the temperature ranges, given a specific time of day. It should be noted that the matrix has the property that all columns sum to 1.0.

Multiplying each matrix element by the number of days of a given day type in a month, say January, gives the expected time or duration for each temperature and time condition. Suppose there are 16 Weekdays (Tuesday through Friday) day types in January, then each time of day condition will occur exactly 16 times. Stated somewhat differently, there are 16 hours in January corresponding to 1 a.m., 2 a.m., 3 a.m., etc. Multiplying the matrix column associated with 1 a.m. by 16 yields the expected hours spent in each temperature range. Multiplying this expected duration by the demand for the corresponding time and temperature condition gives the expected energy consumption. Summing these values over all time and temperature conditions as well as the four day types produces the expected monthly energy requirements.

Although the above procedure was illustrated for electric space heating, it is completely general and is applicable to any temperature sensitive use. It should also be pointed out that the procedure is somewhat complex and requires a large number of computations. In practice the computations, however, can be greatly simplified by storing appropriate intermediate results in the model structure.

Computation of Load Profile

To derive the hourly demand curve for a single day for a specific temperature sensitive use component a path through the corresponding use matrix is required. This path must specify the temperature range for each hour of the day. The hourly demands are then calculated by merely multiplying the use factors for the specified temperature ranges by the connected load.

There are, of course, numerous ways of specifying a temperature path through the use matrix. In the model structure the user has a number of ways of deriving a temperature path (or temperature profile) from the temperature probability matrices. The first option is to select for each hour of the day the average temperature for that hour in the given month.

The second option is to select for each hour the temperature range which has the highest probability of occurring, i.e., the most likely temperature. One may also select the coldest or hottest temperature recorded for each hour. These options are denoted as an extremely cold day or an extremely hot day. Aside from the above ways of deriving a temperature profile for a single day, any other type of temperature range can be selected.

Peak Load Analysis

The model structure outlined above computes temperature insensitive hourly demand estimates for any of four day types and any month. To obtain the hourly temperature sensitive demand for any day, one must specify a temperature profile for that day. This may be done by merely selecting one of the options described above.

In order to project a peak day it is, of course, necessary to select an option which derives a colder or warmer than average day. The degree to which the temperature profile of the peak day deviates from the average or most likely day depends upon the risk one is willing to assume; i.e., should the temperature profile have a frequency of occurring once in 5 years or once in 20 years. The first step in the peak load analysis involves the definition of a design day and then deriving a temperature profile for that day. Design day temperatures for summer and winter peak days are listed below:

Selected Temperature Profile

-Peak Days-

	Jun	Jan
1 AM	77	32
2 AM	76	32
3 AM	75	32
4 AM	74	31
5 AM	75	31
6 AM	76	31
7 AM	77	30
8 AM	79	32

9 AM	82	37
10 AM	85	44
11 AM	87	49
12 Noon	88	55
1 PM	89	60
2 PM	90	62
3 PM	91	64
4 PM	92	66
5 PM	93	64
6 PM	90	62
7 PM	88	59
8 PM	85	58
9 PM	82	57
10 PM	80	57
11 PM	79	55
12 Midnight	78	54

Residential Loadshape Module

The consumption units in the residential sector are the major household appliances. The appliances treated explicitly in the model are listed in Table 1. For each appliance the demand is given by the following equation:

$$D_{ij} = N_i * C_i * F_{ij}$$

where D_{ij} = Demand at hour j by appliance of type i

N_i = Number of units of appliance of type i

C_i = Average connected load of appliance type i

F_{ij} = Fraction of connected load of appliance of type i
which is operating at hour j

From the above equation, it is clear that hourly demand values depend upon three basic factors: (1) the number of units of a given appliance, (2) the average connected load or wattage rating of that appliance, and (3) the fraction of the connected load that is operating at the given time of day.

TABLE 1. APPLIANCES TREATED EXPLICITLY IN
RESIDENTIAL SECTOR

Electric Range
Refrigerator - Frost Free
Refrigerator - Standard
Freezer - Frost Free
Freezer - Standard
Dishwasher
Clothes Washer
Electric Dryer
Electric Water Heater
Microwave Oven
TV Color
TV Black/White
Lighting
Room Air Conditioner
Central Air Conditioner
Electric Space Heating

Connected Appliance Load

Estimate of the average connected loads of the major household appliances are based upon TECO and Edison Electric Institute data. A list of average connected loads is given in Table 2.

The adjustments made to annual energy consumption by appliance area applied proportionally to the connected load and the hourly use factors. However, since the demand is proportional to the product of the use factor times the connected load there is no need to partition the effect into that affecting the connected load and the use factor, as long as the influence on the use factors is uniform. To simplify the calculation all adjustments are therefore applied to the connected load only.

Appliance Use Patterns

The second major component in the basic demand equation is the fraction of the connected load operating at any specific time. In the following discussion, this fraction is referred to as the use factor. Moreover, the collection of use factors describing the usage of an appliance over time is referred to as the use pattern. In the model appliances are classified as temperature insensitive and temperature sensitive appliances. The use factors of the temperature insensitive appliances are functions of time only, i.e., time of day, day type and month, while the use factors of the temperature sensitive appliances are functions of time i.e., time of day, day type and temperature. With the exception of air conditioners (room and central units) and electric space heating all other major appliances are assumed to be temperature insensitive. Some of the other appliances, such as refrigerators, freezers, and clothes dryers have different seasonal patterns which, in part, are a reflection of average monthly temperature.

TABLE 2. AVERAGE CONNECTED LOADS FOR APPLIANCES

Appliance	Connected Load, Watts
Electric Range	12,200
Refrigerator - Frost Free	665
Refrigerator - Standard	326
Freezer - Frost Free	440
Freezer - Standard	341
Dishwasher	1,200
Clothes Washer	512
Electric Dryer	4,856
Electric Water Heater	4,474
Microwave Oven	1,450
TV - Color	250
TV - Black/White	70
Lighting (room/person/household)	130
Room Air Conditioner	2,000
Central Air Conditioner	5,000
Electric Space Heater	6,500

Source: TECO - Estimated annual kilowatt hour consumption reference of electric appliances, National approximate wattage ratings of electric appliances prepared by the Edison Electric Institute.

Temperature Insensitive Use Patterns

With the exception of electric water heaters, all temperature insensitive use factors are based upon load research studies conducted by the Association of Edison Illuminating Companies (AEIC). Although these studies did not originate from a single data base, i.e., they were not all collected at the same time or place within a single data collection program; they are believed to be useful and adequate.

The first step in developing the appliance use patterns was the selection of these appliance load research studies which were conducted most recently and which provided the greatest amount of detail. For several appliances, average daily KWH consumption per appliance was available for each of the four day types and the twelve months. For others, daily use was only available for two day types and/or for only specific months of the year.

For most of the appliances, daily load profiles were available for the summer and winter season and in a few cases for each month of the year. Generally, hourly values were derived from graphs and in a few cases directly from tabular data provided in the appliance studies. When load profiles were not available by month, they were constructed using the general shape of the curve and the daily energy values.

In developing electric water heater use patterns hourly demand data on 70 to 90 residential customers from a load management experiment conducted by Florida Power Corporation was used. Since the data included periods during which the operation of the water heater was controlled, data for these periods were deleted. Next, the observed demand values for each hour of the four day types in a given season were averaged to yield the average demand by time of day, day type and season. These values were then divided by the connected water heater load to yield the corresponding use factors. The use pattern matrices are part of the standard output of the model and thus are not reproduced here.

Temperature Sensitive Use Patterns

Use patterns for electric space heating, room and central air conditioners in the residential sector are functions of temperature as well as of time. The first step in deriving the use pattern matrices was to merge hourly demand data for the three temperature sensitive end uses with the corresponding temperature data. Next the average demand for the observed time and temperature conditions was computed for each end use. This average demand was divided by the average connected load to give the use patterns. Regressions were performed on each column of the use pattern matrix (i.e., for each hour of the day for a given day type) to derive an equation expressing the use factor as a function of temperature. The function was subsequently used to evaluate use factors for all temperatures. The effect of this procedure is to smooth the observed data and to supply use factors for those time and temperature conditions not directly observed. Example of use pattern matrices for the three temperature sensitive end uses are shown in Table 3 through 5. Sources of temperature sensitive and temperature insensitive use patterns are given in Table 6.

TABLE 3. USE PATTERN FOR ROOM AIR CONDITIONERS
(Use factors are multiplied by 10³)

		SUNDAY																							
		1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM	9AM	10AM	11AM	NOON	1PM	2PM	3PM	4PM	5PM	6PM	7PM	8PM	9PM	10PM	11PM	12PM
60-62		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63-65		6	12	12	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66-68		36	39	38	34	26	15	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	29
69-71		69	71	68	62	54	44	33	23	12	3	0	0	0	0	0	0	0	2	11	23	35	48	62	74
72-74		106	106	102	95	86	77	67	58	50	45	41	40	41	45	51	59	69	80	92	103	113	121	125	124
75-77		149	146	139	131	122	112	104	97	93	91	93	97	104	114	126	140	155	169	183	194	201	201	196	181
78-80		194	189	181	171	161	152	145	141	140	141	150	160	175	191	210	229	249	268	283	293	297	292	274	241
81-83		244	237	225	214	203	196	190	189	193	200	214	231	252	276	302	329	354	376	394	404	404	390	361	312
84-86		293	282	269	256	245	237	234	236	244	258	277	301	329	362	395	427	459	485	505	514	510	488	445	377
87-89		341	326	311	296	285	279	278	284	296	315	341	372	408	447	487	527	564	594	615	623	615	585	529	442
90-92		382	364	347	332	321	315	317	326	343	367	399	436	479	525	572	618	659	693	715	722	709	671	604	500
ABOVE 93		423	403	384	367	357	352	356	368	389	419	457	501	550	603	657	708	754	791	815	821	804	758	678	557
		MONDAY																							
		1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM	9AM	10AM	11AM	NOON	1PM	2PM	3PM	4PM	5PM	6PM	7PM	8PM	9PM	10PM	11PM	12PM
60-62		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	53
63-65		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	64
66-68		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	31	55	80	
69-71		28	38	40	36	29	20	8	0	0	0	0	0	0	0	0	11	26	41	58	73	86	95	99	
72-74		82	94	95	90	81	68	55	44	34	27	24	25	30	40	53	69	86	105	122	137	146	148	140	116
75-77		144	157	158	151	139	124	109	95	85	79	78	83	93	109	127	150	173	195	213	226	229	218	190	139
78-80		212	227	226	219	202	184	167	152	141	137	139	148	164	185	211	240	269	295	315	325	319	295	245	163
81-83		287	304	304	292	274	252	232	215	204	200	206	219	241	270	303	339	374	405	426	433	419	379	304	187
84-86		362	380	379	365	343	318	296	277	267	266	273	292	319	355	396	438	479	514	536	539	516	461	362	210
87-89		435	455	453	437	412	385	360	340	330	330	342	365	398	440	488	538	584	622	645	645	614	541	418	231
90-92		501	523	520	502	475	445	418	398	388	389	404	431	470	518	572	628	680	721	744	740	700	612	466	247
ABOVE 93		568	590	587	566	537	505	476	455	445	449	467	498	542	597	657	718	775	819	842	835	786	683	514	264
		TUESDAY-FRIDAY																							
		1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM	9AM	10AM	11AM	NOON	1PM	2PM	3PM	4PM	5PM	6PM	7PM	8PM	9PM	10PM	11PM	12PM
60-62		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	53
63-65		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	64
66-68		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	31	55	80	
69-71		28	38	40	36	29	20	8	0	0	0	0	0	0	0	0	11	26	41	58	73	86	95	99	
72-74		82	94	95	90	81	68	55	44	34	27	24	25	30	40	53	69	86	105	122	137	146	148	140	116
75-77		144	157	158	151	139	124	109	95	85	79	78	83	93	109	127	150	173	195	213	226	229	218	190	139
78-80		212	227	226	219	202	184	167	152	141	137	139	148	164	185	211	240	269	295	315	325	319	295	245	163
81-83		287	304	304	292	274	252	232	215	204	200	206	219	241	270	303	339	374	405	426	433	419	379	304	187
84-86		362	380	379	365	343	318	296	277	267	266	273	292	319	355	396	438	479	514	536	539	516	461	362	210
87-89		435	455	453	437	412	385	360	340	330	330	342	365	398	440	488	538	584	622	645	645	614	541	418	231
90-92		501	523	520	502	475	445	418	398	388	389	404	431	470	518	572	628	680	721	744	740	700	612	466	247
ABOVE 93		568	590	587	566	537	505	476	455	445	449	467	498	542	597	657	718	775	819	842	835	786	683	514	264

TABLE 4. USE PATTERNS FOR CENTRAL AIR CONDITIONERS
(Use factors are multiplied by 10^3)

SUNDAY

	1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM	9AM	10AM	11AM	NOON	1PM	2PM	3PM	4PM	5PM	6PM	7PM	8PM	9PM	10PM	11PM	12PM
57-59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	30	42	
60-62	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	31	41	46	
63-65	15	11	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	22	37	47	52	50
66-68	30	28	20	10	0	0	0	0	0	0	0	0	0	0	0	0	16	32	46	57	63	63	54	
69-71	55	55	48	37	23	9	0	0	0	0	0	0	0	0	17	36	55	72	87	97	99	92	73	
72-74	88	91	85	74	59	43	28	14	5	0	0	3	12	26	43	64	85	106	125	140	147	143	127	93
75-77	127	134	131	120	105	88	73	59	49	45	45	52	64	80	101	125	149	172	192	204	207	196	167	115
78-80	174	186	186	176	162	145	129	115	106	102	105	114	129	149	174	200	227	252	271	281	278	257	213	140
81-83	229	247	249	242	229	212	197	184	175	174	178	190	208	232	260	291	319	346	364	369	358	325	264	166
84-86	275	299	306	302	291	276	262	251	245	245	252	266	287	313	344	375	405	430	446	446	427	382	304	185
87-89	316	345	357	356	347	336	323	314	310	312	322	339	361	389	421	453	483	506	518	513	486	430	337	199
90-92	362	397	413	416	410	401	391	384	382	387	399	417	443	473	506	539	569	590	599	588	552	483	374	215
ABOVE 93	398	438	458	465	462	456	449	444	445	452	465	486	513	545	578	612	640	659	664	647	603	524	401	225

MONDAY

	1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM	9AM	10AM	11AM	NOON	1PM	2PM	3PM	4PM	5PM	6PM	7PM	8PM	9PM	10PM	11PM	12PM
57-59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	27	48	60	60	43
60-62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	41	59	69	67	50
63-65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	35	55	71	78	74	56
66-68	0	6	15	14	7	0	0	0	0	0	0	0	0	0	0	0	10	31	52	70	82	87	82	62
69-71	13	35	43	40	31	18	3	0	0	0	0	0	0	0	0	10	40	64	86	105	118	121	112	85
72-74	56	74	80	75	64	48	32	17	4	0	0	0	2	16	34	56	80	105	128	147	158	158	145	112
75-77	113	126	127	118	104	87	71	55	43	36	34	38	48	63	83	106	132	157	179	197	205	202	182	141
78-80	183	188	182	170	154	136	119	105	94	89	89	95	106	123	145	169	194	218	236	253	258	249	222	174
81-83	267	262	249	231	212	193	177	164	156	153	156	164	178	196	219	242	266	289	306	316	316	301	266	210
84-86	347	329	308	287	266	247	233	222	218	213	223	234	250	269	290	312	332	351	364	368	361	339	298	237
87-89	420	390	361	336	313	296	284	277	275	279	288	301	317	337	356	375	393	405	412	410	396	368	323	256
90-92	501	457	420	390	367	350	341	337	340	347	359	375	392	411	430	446	459	467	468	459	438	403	351	280
ABOVE 93	569	513	468	434	410	396	389	389	395	406	421	439	457	475	492	505	513	516	510	494	467	426	370	296

TUESDAY-FRIDAY

	1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM	9AM	10AM	11AM	NOON	1PM	2PM	3PM	4PM	5PM	6PM	7PM	8PM	9PM	10PM	11PM	12PM
57-59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	27	48	60	60	43
60-62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	41	59	69	67	50
63-65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	35	55	71	78	74	56
66-68	0	6	15	14	7	0	0	0	0	0	0	0	0	0	0	0	10	31	52	70	82	87	82	62
69-71	13	35	43	40	31	18	3	0	0	0	0	0	0	0	0	18	40	64	86	105	118	121	112	85
72-74	56	74	80	75	64	48	32	17	4	0	0	0	2	16	34	56	80	105	128	147	158	158	145	112
75-77	113	126	127	118	104	87	71	55	43	36	34	38	48	63	83	106	132	157	179	197	205	202	182	141
78-80	183	188	182	170	154	136	119	105	94	89	89	95	106	123	145	169	194	218	238	253	258	249	222	174
81-83	267	262	249	231	212	193	177	164	156	153	156	164	178	196	219	242	266	289	306	316	316	301	266	210
84-86	347	329	308	287	266	247	233	222	218	218	223	234	250	269	290	312	332	351	364	368	361	339	298	237
87-89	420	390	361	336	313	296	284	277	275	279	288	301	317	337	356	375	393	405	412	410	396	368	323	256
90-92	501	457	420	390	367	350	341	337	340	347	359	375	392	411	430	446	459	467	468	459	438	403	351	280
ABOVE 93	569	513	468	434	410	396	389	389	395	406	421	439	457	475	492	505	513	516	510	494	467	426	370	296

TABLE 5. USE PATTERNS FOR RESIDENTIAL ELECTRIC SPACE HEATING
(Use factors are multiplied by 10^3)

SUNDAY

	1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM	9AM	10AM	11AM	NOON	1PM	2PM	3PM	4PM	5PM	6PM	7PM	8PM	9PM	10PM	11PM	12PM
BELOW 32	481	477	493	524	526	573	609	747	908	920	851	305	788	715	710	739	725	644	565	541	583	587	567	480
33-35	417	435	450	479	479	522	556	732	836	854	790	746	731	663	658	681	666	589	516	490	528	535	516	439
36-38	382	381	395	421	419	456	489	619	742	764	706	666	654	593	588	604	588	519	453	425	459	469	451	365
39-41	332	333	345	369	366	398	429	544	659	687	634	597	587	531	525	538	520	456	397	368	396	408	393	338
42-44	276	278	288	309	304	331	359	457	561	591	544	512	505	457	451	457	439	383	332	301	326	340	327	283
45-47	224	226	235	251	247	269	295	377	469	502	462	433	429	338	382	382	364	316	272	241	261	277	265	233
48-50	176	179	186	202	195	213	236	333	385	420	386	361	358	323	318	314	295	254	217	186	202	219	209	186
51-53	123	127	133	146	138	150	169	220	287	322	295	274	274	247	241	234	216	184	155	127	138	155	147	134
54-56	80	84	88	98	90	98	114	150	203	236	215	200	201	181	175	166	150	125	103	78	85	101	95	90
57-59	45	49	52	59	52	56	69	93	134	164	149	137	140	125	120	110	95	77	62	39	43	59	54	54
60-62	23	28	30	37	28	31	43	61	98	131	118	108	111	99	94	81	66	50	37	14	16	32	29	34
63-65	1	7	8	14	5	5	17	29	63	99	88	78	83	73	68	52	36	23	13	0	0	6	3	13
66-68	0	0	0	0	0	0	0	0	22	52	45	39	44	38	33	18	5	0	0	0	0	0	0	0

MONDAY

	1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM	9AM	10AM	11AM	NOON	1PM	2PM	3PM	4PM	5PM	6PM	7PM	8PM	9PM	10PM	11PM	12PM
BELOW 32	506	465	513	552	545	612	679	770	839	848	824	817	806	773	721	782	664	663	607	573	626	594	610	495
33-35	463	425	468	504	500	560	620	703	770	783	758	751	745	712	665	719	613	612	559	526	572	544	558	454
36-38	406	374	410	442	438	493	544	617	680	695	671	664	663	631	591	636	545	543	497	465	503	479	492	400
39-41	357	329	359	389	384	432	477	541	599	618	595	588	592	560	526	563	485	483	441	409	443	423	433	351
42-44	300	276	300	325	320	363	399	453	506	527	504	498	505	477	448	477	414	411	374	346	371	355	364	295
45-47	246	227	245	267	262	298	327	371	419	442	420	414	425	399	376	397	348	344	313	286	305	293	300	244
48-50	197	182	194	213	207	239	261	295	338	363	342	337	351	326	309	324	287	282	256	231	245	237	242	196
51-53	142	132	139	153	148	173	187	211	248	272	253	248	265	243	232	239	216	211	190	169	176	172	175	142
54-56	95	89	92	103	98	117	125	141	171	194	178	173	190	172	165	167	154	150	135	117	119	118	119	97
57-59	58	54	55	62	58	72	75	84	108	129	115	112	128	113	110	108	103	99	89	74	73	74	74	60
60-62	37	35	32	38	34	46	46	51	73	96	82	79	97	83	82	77	78	74	65	50	46	49	48	39
63-65	15	15	10	14	9	20	16	18	39	63	49	46	67	52	54	45	53	48	41	27	20	24	23	18
66-68	0	0	0	0	0	0	0	0	3	24	13	10	29	17	21	11	22	17	13	2	0	0	0	0

TUESDAY-FRIDAY

	1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM	9AM	10AM	11AM	NOON	1PM	2PM	3PM	4PM	5PM	6PM	7PM	8PM	9PM	10PM	11PM	12PM
BELOW 32	506	465	513	552	545	612	679	770	839	848	824	817	806	773	721	782	664	663	607	573	626	594	610	495
33-35	463	425	468	504	500	560	620	703	770	783	758	751	745	712	665	719	613	612	559	526	572	544	558	454
36-38	406	374	410	442	438	493	544	617	680	695	671	664	663	631	591	636	545	543	497	465	503	479	492	400
39-41	357	329	359	389	384	432	477	541	599	618	595	588	592	560	526	563	485	483	441	409	443	423	433	351
42-44	300	276	300	325	320	363	399	453	506	527	504	498	505	477	448	477	414	411	374	346	371	355	364	295
45-47	246	227	245	267	262	298	327	371	419	442	420	414	425	399	376	397	348	344	313	286	305	293	300	244
48-50	197	182	194	213	207	239	261	295	338	363	342	337	351	326	309	324	287	282	256	231	245	237	242	196
51-53	142	132	139	153	148	173	187	211	248	272	253	248	265	243	232	239	216	211	190	169	176	172	175	142
54-56	95	89	92	103	98	117	125	141	171	194	178	173	190	172	165	167	154	150	135	117	119	118	119	97
57-59	58	54	55	62	58	72	75	84	108	129	115	112	128	113	110	108	103	99	89	74	73	74	74	60
60-62	37	35	32	38	34	46	46	51	73	96	82	79	97	83	82	77	78	74	65	50	46	49	48	39
63-65	15	15	10	14	9	20	16	18	39	63	49	46	67	52	54	45	53	48	41	27	20	24	23	18
66-68	0	0	0	0	0	0	0	0	3	24	13	10	29	17	21	11	22	17	13	2	0	0	0	0

TABLE 6. SOURCES FOR APPLIANCE USE PATTERNS

Appliance	Company	Date of Study (AEIC Report where applicable)
Freezer, Frost Free and Standard	Potomac Electric Co.	1960-61 pp 91-99
Refrigerator, Frost Free and Standard	Baltimore Gas and Electric Co.	1966-67 pp L95-L115
Electric Range	Baltimore Gas and Electric Co.	1968-69 pp L11-L31
Residential Lighting	22 Utilities	1960-61 pp 105-155 1961-62 pp 147-182 "National Survey of Residential Lighting"
Television (Color)	Various	1073-74 pp L101-111 Appendix A
Television (B/W)	Potomac Electric Co.	1959-60
Electric Water Heater	Florida Power Corporation	1977-1978
Window Air Conditioner	Tampa Electric	1974-75
Central Air Conditioner	Florida Power Corporation	1977-1978
Electric Space Heater	Florida Power Corporation	1977-1978

INDUSTRIAL LOADSHAPE MODULE

Due to the lack of connected load data, the computational procedure discussed in the overview of the model cannot be applied directly in the industrial sector. Thus, the estimation of the industrial loadshape starts with the annual energy projections for the following industrial groups:

Food Products (SIC 20)
Tabacco, Printing, Etc. (SIC 21, 23-24, 27, 37, 39)
Fabricated Metals, Etc. (SIC 26, 29, 34, 38)
Basic Industries (SIC 30, 32, 33, 35, 36)
Phosphate Mining
Phosphate Chemicals
Phosphate Furnace

An allocation mechanism is then used to calculate monthly energy consumption and hourly demands by month, day type and time of day. Since the industrial demand is basically temperature insensitive, the allocation is a function of time, i.e., month, day type and time of day only. The allocation procedure is described in greater detail below.

Monthly Energy Consumption

The monthly energy consumption for each industry is calculated by applying monthly allocation factors to the annual energy consumption. The equation is as follows:

$$ME_{ij} = AE_i \times M_{ij}$$

where ME_{ij} = Energy consumption by industry i in month j

AE_i = Annual energy consumption in industry i

M_{ij} = Fraction of annual energy consumed during month j by industry i

The development of the monthly allocation factors (M_{ij}) is based upon an analysis of industrial energy sales data for the year 1975 - 1978. Table 7 lists the allocation factors for each industry that are currently in the model.

Computation of Industrial Demand Values

Once the monthly energy is computed for each industry, it is allocated to hours of the day according to the industry's use pattern. The use pattern consists of a sequence of use factors which denote the fraction of the monthly energy which is consumed during the given hour. The computation of the industrial demand values is given by:

$$D_{ijh}^d = ME_{ij} \cdot UF_{ijh}^d$$

where D_{ijh}^d = Demand by industry i in month j hour h and day type d

ME_{ij} = Energy consumption by industry i in month j

UF_{ijh}^d = Use factor denoting the fraction of monthly energy consumed by industry i in month j during hour h on day type d.

The use factors UF_{ijh}^d were developed from hourly billing data available for major industrial customers in each industry group. The first step in developing the use patterns was the deletion of atypical load data from the data base. Daily use patterns influenced by holidays, vacations, work stoppages etc. were excluded to reflect typical workdays and weekends. The typical hourly loads were then averaged for each day type and hour of the day. These values were divided by the monthly energy consumption to yield the required use factors. A sequence of use factors for the food processing industry is shown in Table 8.

COMMERCIAL LOADSHAPE MODULE

As in the industrial sector, the estimation of the loadshapes in the commercial sector is based upon an allocation of annual energy

TABLE 7. INDUSTRIAL ENERGY ALLOCATION FACTORS

Industry Group	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
SIC 20	.091	.091	.083	.086	.093	.094	.080	.074	.076	.071	.073	.087
SIC 21, 23-25, 27, 37, 39	.069	.074	.074	.075	.077	.085	.087	.094	.100	.094	.088	.084
SIC 26, 29, 34, 38	.081	.083	.082	.081	.083	.090	.085	.085	.087	.084	.079	.081
SIC 30, 32, 33, 35, 36	.079	.082	.087	.080	.077	.080	.081	.084	.084	.087	.085	.093
Phosphate Mining	.082	.081	.084	.083	.083	.075	.082	.084	.084	.089	.086	.087
Chemicals & Furnaces	.081	.076	.083	.087	.088	.083	.085	.084	.079	.087	.083	.084

TABLE 8. USE PATTERN MATRIX FOR FOOD PROCESSING INDUSTRY

INDUSTRIAL FRACTIONS OF MONTHLY ENERGY FILE PAGE 1

FRACTION OF MONTHLY ENERGY BY MONTH, DAY, HOUR, AND INDUSTRY (*100000)

JANUARY, FOOD PRODUCTS(SIC 20)

	1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM	9AM	10AM	11AM	NOON	1PM	2PM	3PM	4PM	5PM	6PM	7PM	8PM	9PM	10PM	11PM	12PM
MONDAY	85	86	87	89	89	92	93	114	122	126	132	134	140	143	142	142	143	141	140	141	140	138	137	137
TUESDAY-FR	146	146	145	142	140	133	141	148	151	155	157	157	157	159	159	159	159	157	154	154	154	152	152	153
SATURDAY	143	141	139	133	129	127	121	122	123	125	127	124	124	127	127	128	126	125	125	125	123	121	121	120
SUNDAY	120	118	116	113	108	103	103	92	92	92	92	91	90	89	87	86	86	86	84	84	84	84	84	86

FEBRUARY, FOOD PRODUCTS(SIC 20)

	1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM	9AM	10AM	11AM	NOON	1PM	2PM	3PM	4PM	5PM	6PM	7PM	8PM	9PM	10PM	11PM	12PM
MONDAY	86	88	89	91	93	95	105	126	135	143	148	150	154	158	160	161	162	157	155	157	156	157	155	156
TUESDAY-FR	162	160	157	156	155	154	154	162	172	177	177	178	178	179	178	176	176	174	172	173	172	170	167	164
SATURDAY	158	153	147	140	137	131	127	127	133	136	138	139	137	138	138	135	134	132	129	127	127	124	124	123
SUNDAY	118	117	115	112	109	106	104	103	104	106	105	101	102	103	105	104	104	103	102	103	102	103	102	102

MARCH, FOOD PRODUCTS(SIC 20)

	1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM	9AM	10AM	11AM	NOON	1PM	2PM	3PM	4PM	5PM	6PM	7PM	8PM	9PM	10PM	11PM	12PM
MONDAY	81	83	82	84	85	83	93	113	123	129	135	137	138	142	143	145	146	143	142	145	144	143	142	143
TUESDAY-FR	147	146	143	142	141	140	141	147	156	158	161	160	160	162	163	162	160	159	156	155	154	152	150	147
SATURDAY	138	135	131	129	122	117	112	112	112	114	113	113	113	114	113	111	110	109	107	106	104	104	102	100
SUNDAY	104	101	100	99	95	93	91	88	91	94	94	92	91	93	92	93	91	90	89	89	88	88	89	89

APRIL, FOOD PRODUCTS(SIC 20)

	1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM	9AM	10AM	11AM	NOON	1PM	2PM	3PM	4PM	5PM	6PM	7PM	8PM	9PM	10PM	11PM	12PM
MONDAY	72	72	73	74	75	77	85	101	112	122	129	132	132	136	142	144	151	152	152	154	154	154	154	152
TUESDAY-FR	162	160	157	156	154	153	155	165	169	170	173	174	173	176	174	172	172	170	169	169	168	166	164	162
SATURDAY	146	144	141	135	130	124	113	118	118	116	117	118	117	116	114	113	114	115	115	118	117	114	111	108
SUNDAY	106	102	100	97	94	91	87	87	84	82	80	78	78	78	78	77	77	76	76	76	78	78	77	75

MAY, FOOD PRODUCTS(SIC 20)

	1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM	9AM	10AM	11AM	NOON	1PM	2PM	3PM	4PM	5PM	6PM	7PM	8PM	9PM	10PM	11PM	12PM
MONDAY	81	81	83	83	86	93	105	115	123	125	127	126	133	137	138	140	142	145	145	146	145	145	143	142
TUESDAY-FR	146	144	143	141	141	142	143	154	158	160	161	157	163	163	157	155	157	155	155	155	154	153	150	150
SATURDAY	143	133	137	135	132	125	123	123	126	128	127	128	127	124	123	121	119	117	114	112	110	108	106	104
SUNDAY	93	96	95	92	90	87	87	88	89	89	90	90	90	90	90	88	88	86	85	86	86	86	86	87

JUNE, FOOD PRODUCTS(SIC 20)

	1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM	9AM	10AM	11AM	NOON	1PM	2PM	3PM	4PM	5PM	6PM	7PM	8PM	9PM	10PM	11PM	12PM
MONDAY	87	87	88	88	91	97	112	122	130	135	135	136	141	143	141	144	145	139	140	138	137	135	133	131
TUESDAY-FR	144	143	141	140	141	145	153	157	162	165	162	162	168	167	165	166	164	160	159	157	156	155	154	153
SATURDAY	143	143	140	139	135	131	123	127	131	133	133	131	132	132	126	127	125	125	127	123	122	119	115	113
SUNDAY	108	107	106	103	98	94	85	85	87	88	87	87	87	86	82	83	83	82	83	82	83	82	85	86

consumption in the sector. However, since commercial demand is a function of time as well as temperature, the allocation procedure is somewhat different from that used in the industrial sector.

Computation of Commercial Demand Values

Annual energy projections in the commercial sector are computed from the projected energy intensiveness and commercial employment. This annual energy is allocated to time of day, day type and temperature according to the pattern of electricity usage of a number of commercial customers. The allocation is given by:

$$DC_{ij}^d = CE \times \frac{CL_{ij}^d}{KC}$$

where DC_{ij}^d = Commercial demand for hour i, temperature j and day type d
 CE = Annual commercial energy consumption
 CL_{ij}^d = Observed demand value for commercial sample for hour i, temperature j and day type d
 KC = Scale factor to scale up demand of sample to the demand for the whole commercial sector

The scale factor KC is computed in the model as follows:

$$KC = \sum_m \sum_d N_{dm} \sum_i \sum_j P_{ij}^m \cdot CL_{ij}^d$$

where CL_{ij}^d = Demand for commercial sample for hour i, temperature j and day type d
 P_{ij}^m = Probability of temperature j occurring at hour i in month m
 N_{dm} = Number of days of day type d in month m

Note that $\sum_i \sum_j P_{ij}^m \cdot CL_{ij}^d$ is the expected daily energy consumption for month m and day type d. Therefore KC denotes the energy consumption for the commercial sample assuming average or normal weather conditions.

The factors CL_{ij}^d were developed by first summing hourly billing data available for major commercial customers to produce the demand for the commercial sample. These demand values were then merged with the corresponding hourly temperature values. Next, the demand values were assigned to the appropriate temperature ranges, time of day and day type cells in the use pattern matrix and then averaged. Just as in the development of the temperature sensitive use patterns in the residential sector, regressions were performed on each column of the use pattern matrices to derive equations of the load as functions of temperature. These functions were then used to compute demand values for all temperature ranges in the matrix. An example of the resulting loads is given in Table 9.

An examination of the loads given in Table 9 shows that only a portion of the load varies directly with temperature. However, in the model no attempt was made to separate the temperature sensitive from the temperature insensitive portion. Thus, all of the commercial load is included in the summary output table labelled temperature sensitive load.

MISCELLANEOUS LOADSHAPE MODULE

The miscellaneous sector includes those electric energy uses not included in the residential, industrial, and commercial sector. Specifically, the following are included:

- Street lighting
- Sales to Public Authorities
- Transmission and Distribution Losses.

In the following discussion the procedure for calculating the loadshapes for these categories will be described.

Street Lighting Load Profile

Annual energy consumption for street lighting is forecast as a function of population level and time. The load profile is based upon a normal lighting schedule which is determined by sunrise and sunset. Data for the 15th of the month were selected to represent the average time

TABLE 9. COMMERCIAL USE PATTERN MATRIX FOR TUESDAY THROUGH SATURDAY

COMMERCIAL USE

TUESDAY-FRIDAY

	1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM	9AM	10AM	11AM	NOON	1PM	2PM	3PM	4PM	5PM	6PM	7PM	8PM	9PM	10PM	11PM	12PM
BELOW 32	217	226	226	227	230	245	279	326	367	387	414	429	430	426	423	411	387	364	358	353	328	282	246	227
33-35	230	219	218	218	220	231	266	311	353	376	405	418	419	416	413	402	381	360	354	350	329	279	242	224
36-38	223	214	212	211	211	223	255	299	340	367	397	408	409	407	401	394	376	358	351	347	310	276	238	222
39-41	218	208	206	204	204	215	245	289	330	360	390	399	400	399	396	387	372	355	349	345	310	273	235	220
42-44	213	204	201	199	199	209	238	281	322	354	384	392	392	392	389	381	369	354	347	344	310	271	232	218
45-47	209	201	197	194	193	204	233	276	316	349	380	386	386	387	383	377	366	352	346	343	310	269	230	217
48-50	206	198	194	191	190	200	229	272	312	346	376	381	381	383	379	374	365	352	345	342	310	268	229	216
51-53	204	197	192	189	187	198	228	271	310	344	374	378	378	380	377	371	364	352	346	341	310	267	228	216
54-56	202	196	191	188	187	198	228	272	310	344	373	376	376	378	375	370	364	353	347	344	329	266	227	215
57-59	202	196	191	187	187	200	231	275	312	345	373	376	375	378	375	370	365	354	349	345	328	265	227	216
60-62	202	197	192	188	189	203	235	280	317	347	374	376	376	379	376	372	366	356	351	347	327	265	228	216
63-65	204	199	194	190	192	208	241	287	323	352	377	378	378	381	378	374	369	359	354	350	326	265	229	217
66-68	206	201	197	193	197	214	249	297	332	357	380	381	381	384	381	377	372	362	358	353	324	265	230	218
69-71	209	205	201	197	203	222	259	308	342	364	385	386	386	389	386	382	376	366	363	357	322	266	233	220
72-74	212	209	205	202	210	231	271	322	355	373	391	392	392	394	392	388	381	371	368	362	320	267	235	222
75-77	217	215	211	208	218	242	285	338	369	383	398	399	400	402	399	395	387	376	374	367	318	269	238	224
78-80	223	221	218	215	228	255	300	357	386	394	406	408	409	410	408	403	394	381	380	373	316	270	242	227
81-83	229	228	226	223	239	269	318	377	405	407	415	418	419	419	418	412	401	388	388	379	313	272	247	230
84-86	236	236	234	233	252	285	338	399	426	421	426	429	430	430	429	422	409	395	396	386	310	275	251	233
87-89	245	244	244	243	265	303	359	424	449	437	437	442	443	442	441	433	418	402	405	394	307	277	257	237
90-92	254	254	254	254	280	322	382	451	474	454	450	456	458	456	455	446	428	410	414	402	303	280	263	241
ABOVE 93	263	265	266	267	297	343	408	480	501	473	464	471	473	470	470	460	439	419	424	410	300	284	269	245

SATURDAY

	1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM	9AM	10AM	11AM	NOON	1PM	2PM	3PM	4PM	5PM	6PM	7PM	8PM	9PM	10PM	11PM	12PM
BELOW 32	240	230	225	230	226	235	247	292	344	397	415	395	414	362	350	346	332	332	331	322	296	252	251	245
33-35	231	221	216	220	215	222	234	274	322	373	394	379	395	352	342	337	326	325	326	319	298	251	244	237
36-38	223	213	208	211	205	211	223	258	303	351	375	365	378	343	335	330	321	320	322	317	300	251	238	231
39-41	217	206	202	203	196	201	214	245	286	332	358	352	363	336	329	324	317	315	319	315	301	251	233	225
42-44	211	200	197	196	189	194	207	235	272	316	344	341	350	329	324	319	314	312	316	314	302	251	229	220
45-47	206	196	192	191	184	188	201	227	261	303	332	332	339	324	320	316	312	309	314	313	303	251	225	216
48-50	203	193	189	186	180	183	198	221	253	292	322	325	330	320	317	313	310	308	313	313	304	252	223	213
51-53	200	191	187	183	177	181	196	218	248	284	314	319	322	318	315	311	310	307	313	313	304	252	221	210
54-56	199	190	186	182	176	180	196	218	245	279	309	315	317	316	314	310	310	307	314	314	304	252	219	209
57-59	198	190	186	181	176	181	197	219	245	276	305	313	313	316	315	311	311	309	315	316	303	253	219	208
60-62	199	192	187	182	178	183	201	224	249	276	304	313	311	317	316	312	314	311	317	318	303	253	220	208
63-65	200	194	189	184	181	188	206	231	254	279	306	314	312	319	318	315	317	315	320	321	301	254	221	208
66-68	203	198	193	187	185	194	213	240	263	285	309	317	314	322	322	319	321	319	324	324	300	255	223	210
69-71	207	203	197	191	191	201	222	251	274	293	315	321	318	327	326	324	326	325	329	328	298	256	226	212
72-74	211	209	203	197	199	211	233	266	289	304	323	328	324	332	332	329	331	331	335	333	296	256	229	215
75-77	217	217	210	204	207	222	245	282	306	318	333	336	332	339	339	336	338	339	341	338	294	257	234	219
78-80	224	225	217	212	218	235	259	301	326	335	346	346	341	347	347	344	346	348	348	344	292	259	239	224
81-83	231	235	226	221	230	249	275	323	348	354	361	357	353	357	355	354	354	357	356	350	289	260	245	229
84-86	240	246	236	232	243	266	293	347	374	376	378	370	366	367	365	364	364	368	365	357	286	261	252	235
87-89	250	257	247	243	257	284	313	374	402	401	397	385	382	379	376	375	374	379	375	364	282	262	259	242
90-92	260	271	259	256	274	303	334	403	433	428	419	402	399	392	388	387	386	392	385	372	278	264	268	250
ABOVE 93	272	285	273	271	291	325	357	434	467	459	442	420	419	406	402	401	398	405	396	381	274	265	277	259

of sunrise and sunset for each month of the year. Street lights are assumed to come on 30 minutes after sunset and turn off 30 minutes before sunrise. Table 10 shows the resulting lighting use patterns for July through December.

Sales to Public Authorities Load Profile

The annual sales to public authorities are projected as a function of residential customers or households and time. Due to the lack of connected load data, the estimation of the loadshapes for sales to public authorities is based upon an allocation of the annual energy. The demand profile for sales to public authorities is a function of time of day and temperature. Thus, the energy allocation procedure for this sector is identical to that described in the commercial sector. Mathematically the allocation is given by:

$$DS_{ij}^d = SPA * \frac{DL_{ij}^d}{KS}$$

where. DS_{ij}^d = Demand by sales to public authorities class for hour i, temperature j and day type d

SPA = Annual sales to public authorities

DL_{ij}^d = Observed demand value for sample of customers in the sales to public authority class for hour i, temperature j and day type d

KS = Scale factor to scale up demand of sample to the demand for the whole class. The scale factor is computed in the same manner as the scale factor KC for the commercial sector.

The factors DL_{ij}^d were developed from hourly billing data available for major customers in the sales to public authorities class.

TABLE 10. STREET LIGHTING USE PATTERNS JULY - DECEMBER
(Use factors are multiplied by 10⁴)

STREET LIGHTING, JULY

	1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM	9AM	10AM	11AM	NOON	1PM	2PM	3PM	4PM	5PM	6PM	7PM	8PM	9PM	10PM	11PM	12PM
MONDAY	10000	10000	10000	10000	10000	2200	0	0	0	0	0	0	0	0	0	0	0	0	0	300	10000	10000	10000	10000
TUESDAY-FRI	10000	10000	10000	10000	10000	2200	0	0	0	0	0	0	0	0	0	0	0	0	0	300	10000	10000	10000	10000
SATURDAY	10000	10000	10000	10000	10000	2200	0	0	0	0	0	0	0	0	0	0	0	0	0	300	10000	10000	10000	10000
SUNDAY	10000	10000	10000	10000	10000	2200	0	0	0	0	0	0	0	0	0	0	0	0	0	300	10000	10000	10000	10000

STREET LIGHTING, AUGUST

	1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM	9AM	10AM	11AM	NOON	1PM	2PM	3PM	4PM	5PM	6PM	7PM	8PM	9PM	10PM	11PM	12PM
MONDAY	10000	10000	10000	10000	10000	5000	0	0	0	0	0	0	0	0	0	0	0	0	0	3500	10000	10000	10000	10000
TUESDAY-FRI	10000	10000	10000	10000	10000	5000	0	0	0	0	0	0	0	0	0	0	0	0	0	3500	10000	10000	10000	10000
SATURDAY	10000	10000	10000	10000	10000	5000	0	0	0	0	0	0	0	0	0	0	0	0	0	3500	10000	10000	10000	10000
SUNDAY	10000	10000	10000	10000	10000	5000	0	0	0	0	0	0	0	0	0	0	0	0	0	3500	10000	10000	10000	10000

STREET LIGHTING, SEPTEMBER

	1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM	9AM	10AM	11AM	NOON	1PM	2PM	3PM	4PM	5PM	6PM	7PM	8PM	9PM	10PM	11PM	12PM
MONDAY	10000	10000	10000	10000	10000	7500	0	0	0	0	0	0	0	0	0	0	0	0	0	9200	10000	10000	10000	10000
TUESDAY-FRI	10000	10000	10000	10000	10000	7500	0	0	0	0	0	0	0	0	0	0	0	0	0	9200	10000	10000	10000	10000
SATURDAY	10000	10000	10000	10000	10000	7500	0	0	0	0	0	0	0	0	0	0	0	0	0	9200	10000	10000	10000	10000
SUNDAY	10000	10000	10000	10000	10000	7500	0	0	0	0	0	0	0	0	0	0	0	0	0	9200	10000	10000	10000	10000

STREET LIGHTING, OCTOBER

	1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM	9AM	10AM	11AM	NOON	1PM	2PM	3PM	4PM	5PM	6PM	7PM	8PM	9PM	10PM	11PM	12PM
MONDAY	10000	10000	10000	10000	10000	10000	0	0	0	0	0	0	0	0	0	0	0	0	0	4800	10000	10000	10000	10000
TUESDAY-FRI	10000	10000	10000	10000	10000	10000	0	0	0	0	0	0	0	0	0	0	0	0	0	4800	10000	10000	10000	10000
SATURDAY	10000	10000	10000	10000	10000	10000	0	0	0	0	0	0	0	0	0	0	0	0	0	4800	10000	10000	10000	10000
SUNDAY	10000	10000	10000	10000	10000	10000	0	0	0	0	0	0	0	0	0	0	0	0	0	4800	10000	10000	10000	10000

STREET LIGHTING, NOVEMBER

	1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM	9AM	10AM	11AM	NOON	1PM	2PM	3PM	4PM	5PM	6PM	7PM	8PM	9PM	10PM	11PM	12PM
MONDAY	10000	10000	10000	10000	10000	10000	3700	0	0	0	0	0	0	0	0	0	0	0	0	6700	10000	10000	10000	10000
TUESDAY-FRI	10000	10000	10000	10000	10000	10000	3700	0	0	0	0	0	0	0	0	0	0	0	0	6700	10000	10000	10000	10000
SATURDAY	10000	10000	10000	10000	10000	10000	3700	0	0	0	0	0	0	0	0	0	0	0	0	6700	10000	10000	10000	10000
SUNDAY	10000	10000	10000	10000	10000	10000	3700	0	0	0	0	0	0	0	0	0	0	0	0	6700	10000	10000	10000	10000

STREET LIGHTING, DECEMBER

	1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM	9AM	10AM	11AM	NOON	1PM	2PM	3PM	4PM	5PM	6PM	7PM	8PM	9PM	10PM	11PM	12PM
MONDAY	10000	10000	10000	10000	10000	10000	7300	0	0	0	0	0	0	0	0	0	0	0	0	8800	10000	10000	10000	10000
TUESDAY-FRI	10000	10000	10000	10000	10000	10000	7300	0	0	0	0	0	0	0	0	0	0	0	0	8800	10000	10000	10000	10000
SATURDAY	10000	10000	10000	10000	10000	10000	7300	0	0	0	0	0	0	0	0	0	0	0	0	8800	10000	10000	10000	10000
SUNDAY	10000	10000	10000	10000	10000	10000	7300	0	0	0	0	0	0	0	0	0	0	0	0	8800	10000	10000	10000	10000

Transmission and Distribution Losses

To calculate transmission and distribution losses, transmission and distribution loss factors are applied to total energy and demand. The loss factors included in the model are 2.2% for transmission and 3.2% for distribution. These factors are utilized in the calculations as follows:

$$DL_j = D_j * DLF$$

$$TL_j = (DLF+1) * D_j * TLF$$

where DL_j = Distribution losses in hour j

D_j = Total demand for hour j

DLF = Distribution loss factor

TL_j = Transmission losses in hour j

TLF = Transmission loss factor

It should be noted that in the above procedure the transmission loss factor is applied to the total demand (i.e., the sum of the demand estimates for all end uses) and the distribution losses.

MODEL CALIBRATION AND RESULTS

To establish credibility in the demand estimation mechanism and the underlying data base, the model was used to simulate demand profiles for a number of historical days. Although the demand profiles are calculated by first estimating the load profiles for the end users and then summing over them, the lack of detailed load data prevents comparisons by end use and customer class. Thus all comparisons were made to total system output.

In the simulations the actual temperature profiles for the selected days were used to compute the temperature sensitive load. For summer and winter two types of days were examined: an average day, defined

as one where the average temperature is approximately the same as the long-term average, and the peak day. In calculating the load profiles for the peak days adjustments to the average price response to residential heating and cooling were made. Thus in the estimation of the January peak no price elasticity was applied to residential electric space heating. Similarly, only one-half of the average price response in residential cooling was applied in estimating the June peak. These assumptions are consistent with the general experience that the peak is less sensitive to price than the demand under normal conditions. Comparisons of the load profiles calculated in the model and the actual demand values are shown in Figures 4 through 7.

An examination of the four comparisons shows that the calculated results track the actual demand values quite well. This is noteworthy since the four load shapes not only differ in magnitude but also in the profiles themselves.

While the above comparisons do not prove the validity of the model structure or the underlying data base, they do, however, increase one's confidence in the model structure and the adequacy of the data. This is particularly true since the model does track for widely differing temperature profiles.

As pointed out above, the model calculates the total system load profile by summing the hourly demands for each end use. Although these demand profiles cannot be verified independently, the fact that their sum tracks the historical values does lend credibility to the individual components. The aggregation of the hourly demands to the major customer classes for the summer and winter peak days are shown in Tables 11 and 12.

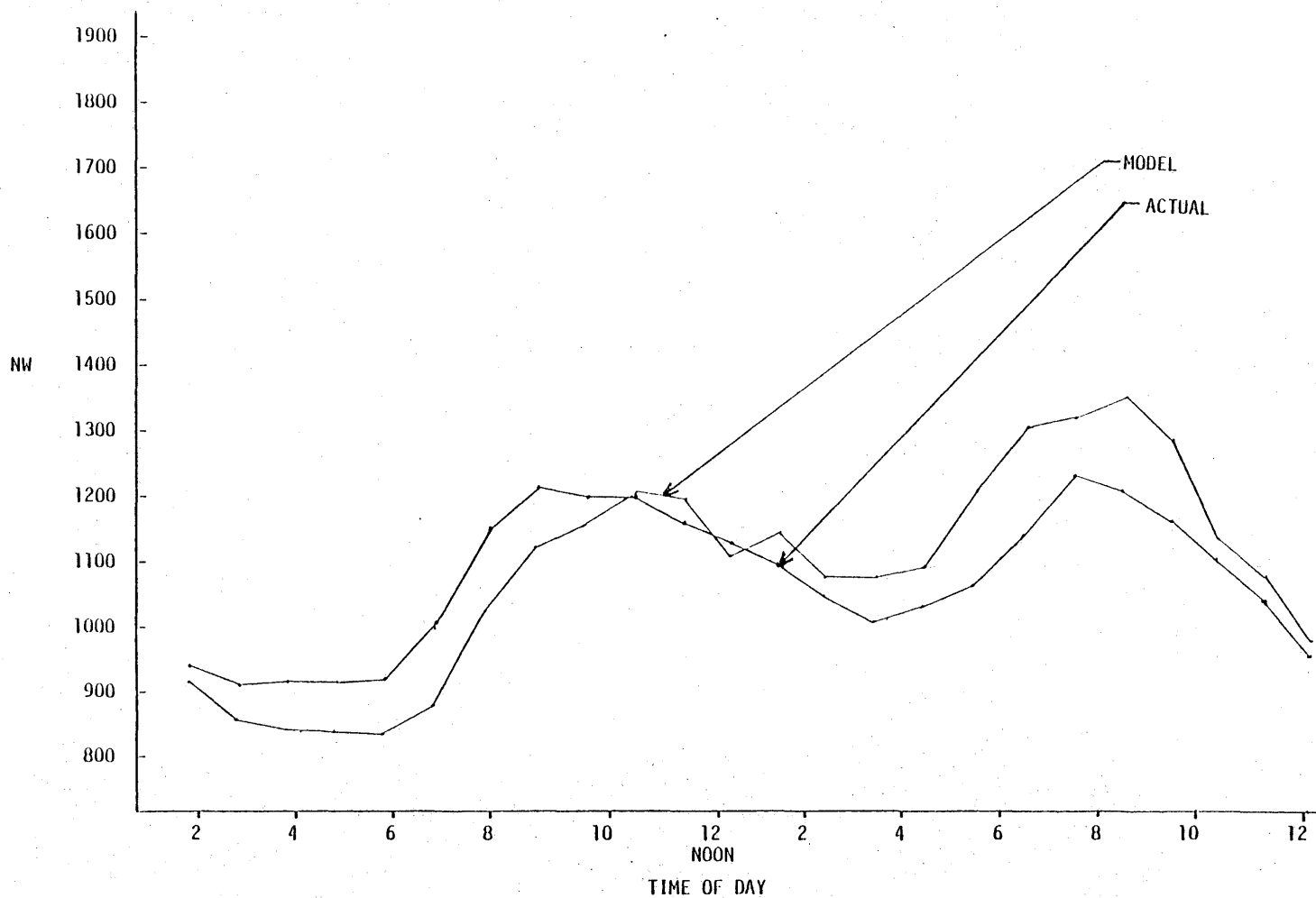


FIGURE 4. COMPARISON OF ACTUAL LOAD PROFILE WITH MODEL RESULTS FOR AN AVERAGE JANUARY WEEKDAY - (January 13, 1978)

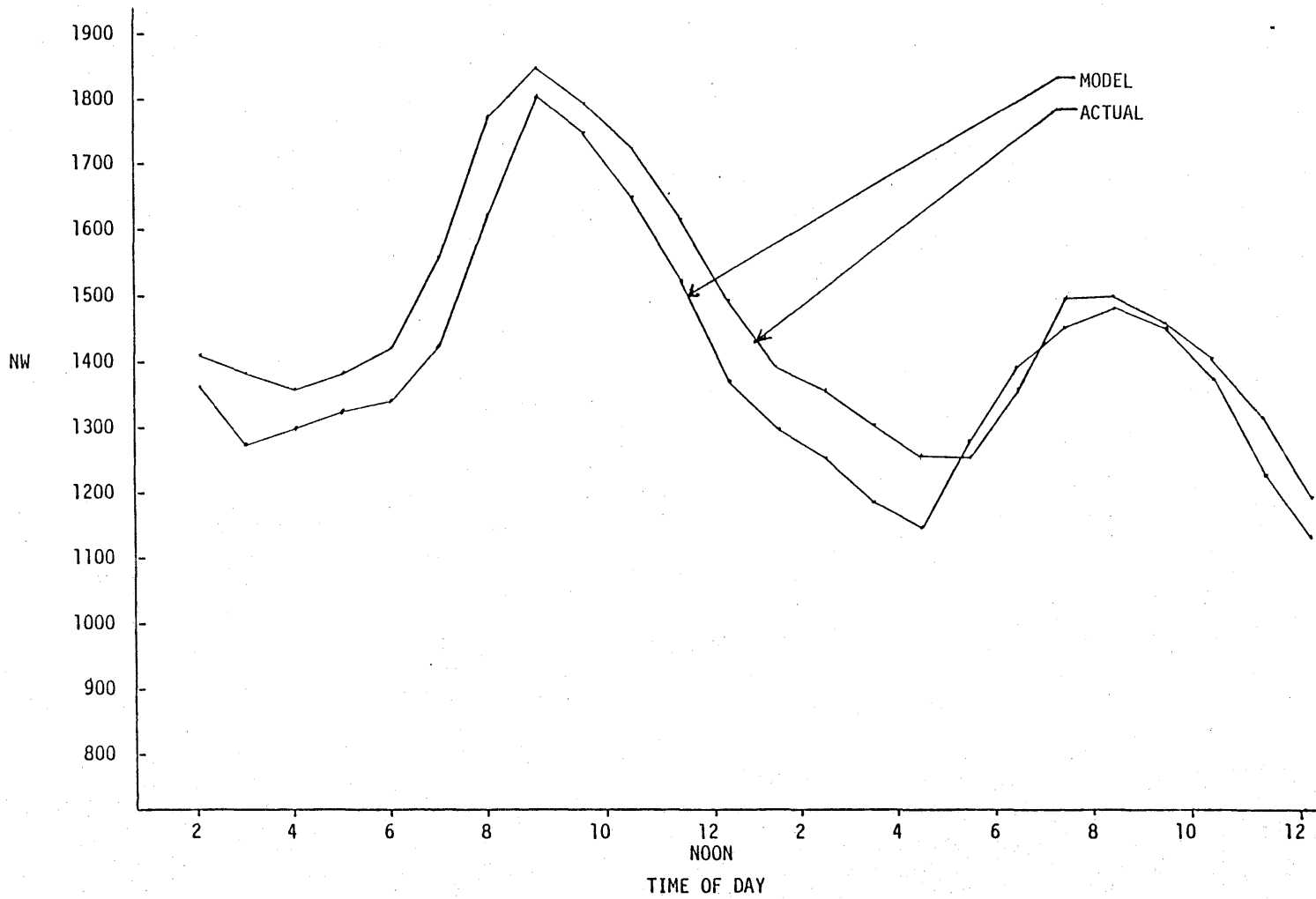


FIGURE 5. COMPARISON OF ACTUAL LOAD PROFILE WITH MODEL RESULTS FOR JANUARY PEAKDAY (January 16, 1978)

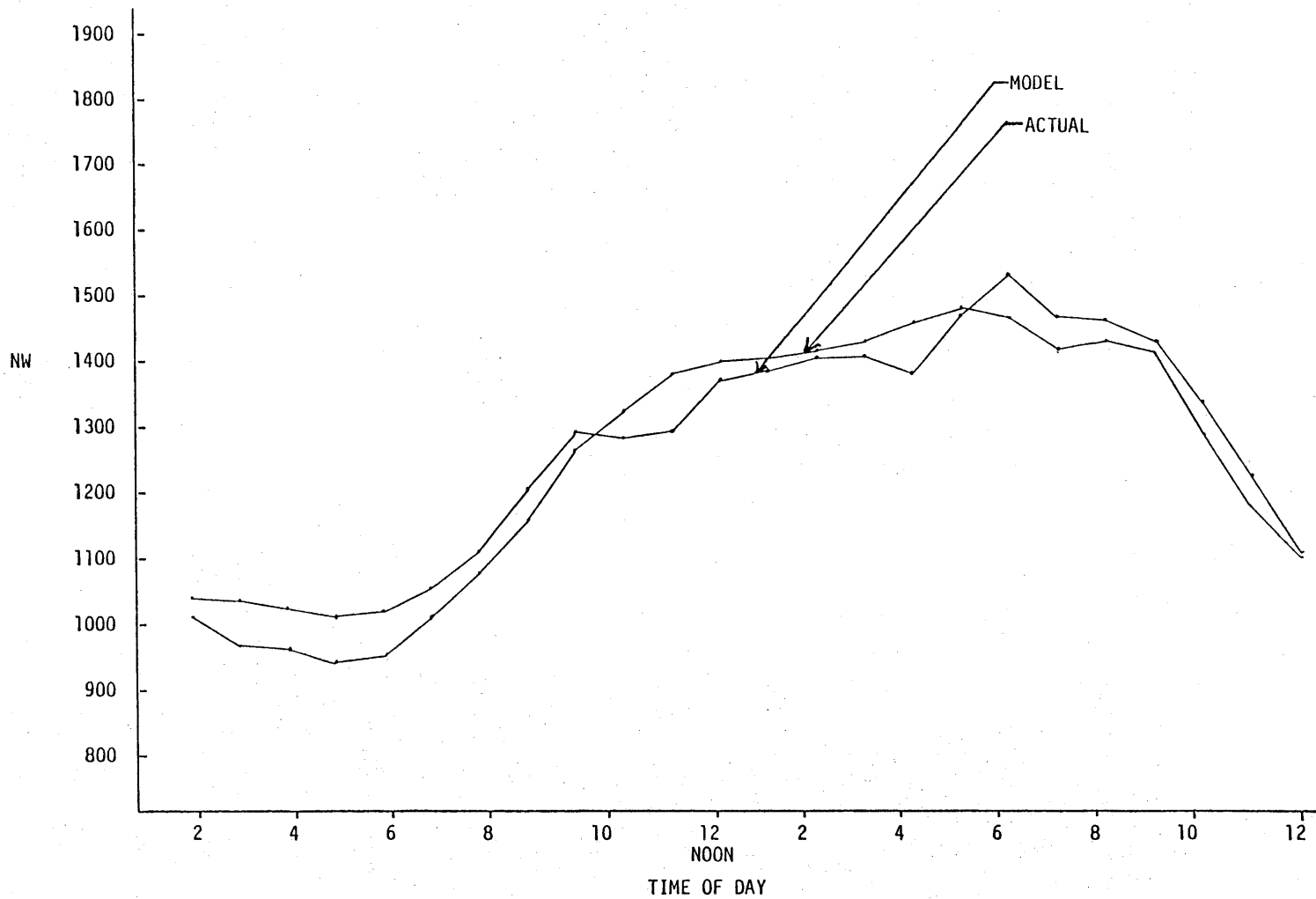


FIGURE 6. COMPARISON OF ACTUAL LOAD PROFILE WITH MODEL RESULTS FOR AN AVERAGE JUNE WEEKDAY (June 20 and 21, 1978)

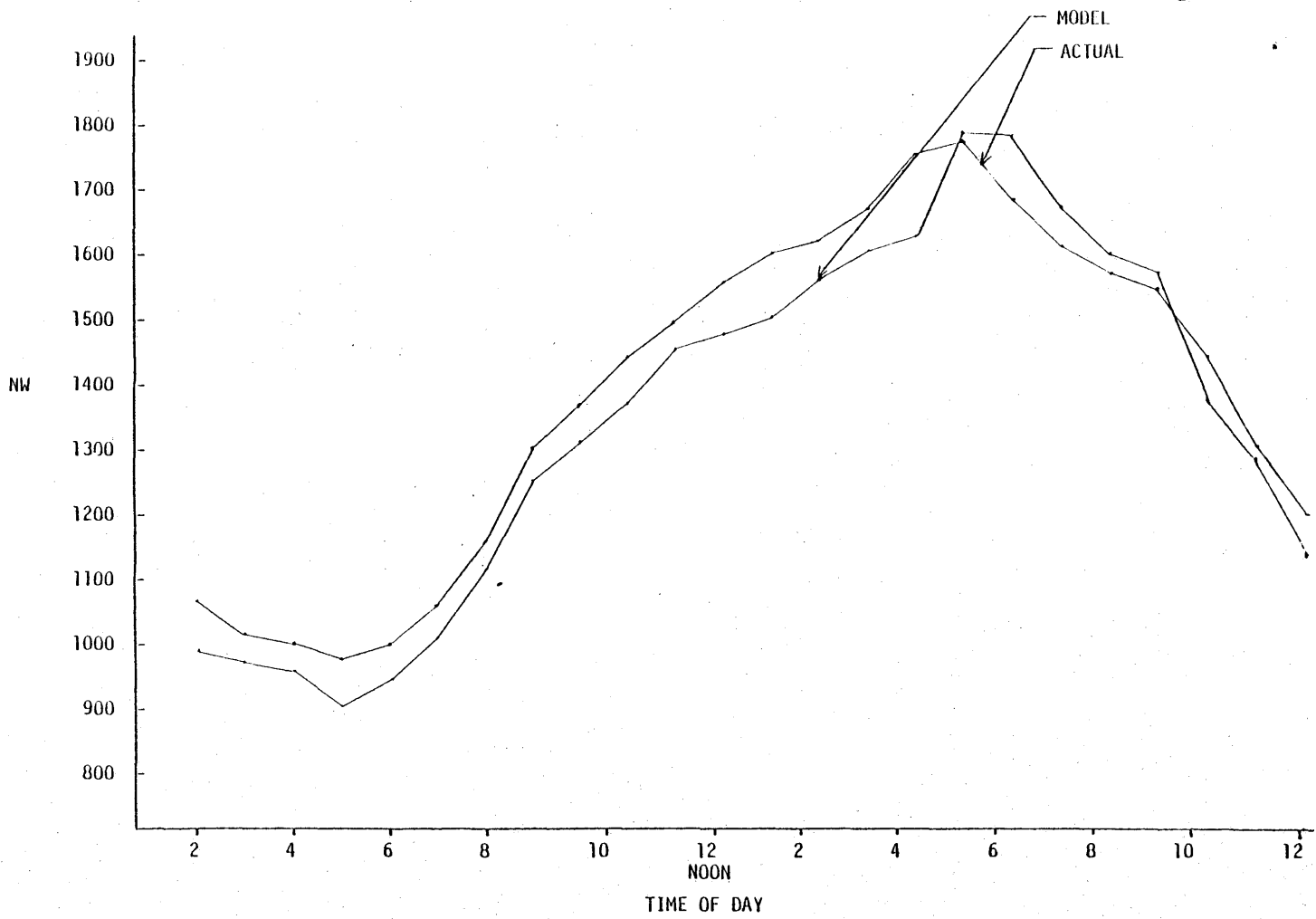


FIGURE 7. COMPARISON OF ACTUAL LOAD PROFILE WITH MODEL RESULTS FOR JUNE PEAKDAY (June 26, 1978)

TABLE 11. HOURLY LOAD CONTRIBUTIONS BY CUSTOMER CLASS FOR WINTER PEAK DAY

JANUARY, TUESDAY-FRIDAY

	HOURLY(1)	HOURLY(2)	HOURLY(3)	HOURLY(4)	HOURLY(5)	HOURLY(6)	HOURLY(7)
TOTAL	1,372,085	1,282,100	1,312,201	1,344,457	1,350,380	1,437,615	1,643,451
RESIDENTIAL	603,400	524,042	555,339	585,486	588,424	662,963	839,811
NONPHOSPHATE INDUSTRIAL	103,543	104,377	104,446	102,200	101,519	100,455	104,437
PHOSPHATE INDUSTRIAL	357,161	360,535	359,665	361,834	364,106	358,794	343,922
COMMERCIAL	179,198	170,881	173,881	171,637	173,906	185,247	210,955
MISCELLANEOUS	57,616	56,266	54,411	53,567	52,387	55,592	59,886
LOSSES	71,165	66,498	68,060	69,733	70,040	74,564	85,243

HOURLY DEMAND FOR PEAK DAY (IN KW), JANUARY, TUESDAY-FRIDAY, 1978

	HOURLY(8)	HOURLY(9)	HOURLY(10)	HOURLY(11)	HOURLY(12)	HOURLY(13)	HOURLY(14)
TOTAL	1,415,523	1,757,656	1,661,045	1,538,867	1,373,321	1,304,622	1,263,432
RESIDENTIAL	986,630	923,907	820,358	688,309	528,230	459,085	416,521
NONPHOSPHATE INDUSTRIAL	104,121	109,688	112,296	113,130	112,837	114,141	113,583
PHOSPHATE INDUSTRIAL	327,041	314,515	313,170	313,089	316,166	319,040	320,839
COMMERCIAL	246,432	257,078	267,663	284,298	284,298	284,298	286,566
MISCELLANEOUS	57,019	61,405	61,405	60,224	60,561	60,392	60,392
LOSSES	94,165	91,164	86,153	79,816	71,230	67,666	65,530

JANUARY, TUESDAY-FRIDAY

	HOURLY(15)	HOURLY(16)	HOURLY(17)	HOURLY(18)	HOURLY(19)	HOURLY(20)	HOURLY(21)
TOTAL	1,191,639	1,150,148	1,294,951	1,401,712	1,455,824	1,446,227	1,452,288
RESIDENTIAL	355,234	309,059	445,849	553,257	594,579	613,849	589,889
NONPHOSPHATE INDUSTRIAL	112,205	110,176	111,000	111,318	109,674	111,220	112,082
PHOSPHATE INDUSTRIAL	316,271	326,150	333,733	340,096	353,568	359,187	363,467
COMMERCIAL	285,810	285,054	279,005	269,176	263,883	260,858	248,005
MISCELLANEOUS	60,224	60,055	58,199	55,163	59,211	64,026	63,520
LOSSES	61,805	59,654	67,165	72,702	75,509	77,086	75,325

JANUARY, TUESDAY-FRIDAY

	HOURLY(22)	HOURLY(23)	HOURLY(24)
TOTAL	1,381,306	1,239,181	1,130,324
RESIDENTIAL	569,385	469,618	384,017
NONPHOSPHATE INDUSTRIAL	110,585	109,484	103,602
PHOSPHATE INDUSTRIAL	366,814	365,204	364,668
COMMERCIAL	200,370	171,637	162,564
MISCELLANEOUS	62,508	58,966	57,447
LOSSES	71,644	64,272	58,626

TABLE 12. HOURLY LOAD CONTRIBUTION BY CUSTOMER CLASS FOR SUMMER PEAK DAY

HOURLY DEMAND FOR PEAK DAY (IN KW), JUNE, MONDAY, 1978

	HOURLY(1)	HOURLY(2)	HOURLY(3)	HOURLY(4)	HOURLY(5)	HOURLY(6)	HOURLY(7)
TOTAL	1,002,343	989,637	977,850	916,965	960,451	1,021,136	1,127,776
RESIDENTIAL	299,932	286,493	279,466	233,722	256,092	291,535	352,085
NONPHOSPHATE INDUSTRIAL	88,835	89,283	96,373	89,797	93,202	95,799	100,146
PHOSPHATE INDUSTRIAL	338,975	342,160	339,357	337,960	332,564	329,786	333,035
COMMERCIAL	150,027	156,515	154,247	147,442	164,076	182,979	217,760
MISCELLANEOUS	64,532	63,858	63,689	60,484	64,701	68,075	66,251
LOSSES	51,999	51,329	50,718	47,560	49,815	52,963	58,494

JUNE, MONDAY							
	HOURLY(8)	HOURLY(9)	HOURLY(10)	HOURLY(11)	HOURLY(12)	HOURLY(13)	HOURLY(14)
TOTAL	1,262,849	1,329,138	1,383,047	1,464,485	1,489,844	1,509,463	1,570,287
RESIDENTIAL	403,674	432,388	465,854	522,591	555,933	566,305	604,250
NONPHOSPHATE INDUSTRIAL	104,568	105,788	107,290	109,726	111,711	115,243	114,603
PHOSPHATE INDUSTRIAL	337,634	339,206	339,218	326,314	329,331	338,568	342,447
COMMERCIAL	275,225	304,713	326,640	344,031	333,445	330,421	342,519
MISCELLANEOUS	76,250	78,105	81,310	85,865	82,154	80,636	85,022
LOSSES	65,590	68,438	71,734	75,958	77,273	78,291	81,446

JUNE, MONDAY							
	HOURLY(15)	HOURLY(16)	HOURLY(17)	HOURLY(18)	HOURLY(19)	HOURLY(20)	HOURLY(21)
TOTAL	1,613,460	1,642,488	1,799,977	1,791,172	1,683,745	1,616,888	1,479,971
RESIDENTIAL	639,840	660,726	804,819	810,812	725,955	658,650	600,364
NONPHOSPHATE INDUSTRIAL	109,420	111,043	111,963	109,428	109,554	109,595	109,827
PHOSPHATE INDUSTRIAL	355,500	367,156	370,760	374,859	375,482	380,791	382,611
COMMERCIAL	341,006	335,714	334,957	319,835	306,981	294,883	235,907
MISCELLANEOUS	84,010	82,660	84,178	83,335	78,443	79,623	74,501
LOSSES	83,645	85,190	93,359	92,902	87,330	83,344	76,761

JUNE, MONDAY			
	HOURLY(22)	HOURLY(23)	HOURLY(24)
TOTAL	1,370,213	1,294,867	1,136,237
RESIDENTIAL	534,054	479,064	346,288
NONPHOSPHATE INDUSTRIAL	110,368	109,913	106,581
PHOSPHATE INDUSTRIAL	375,570	371,227	376,975
COMMERCIAL	201,126	184,491	174,662
MISCELLANEOUS	78,028	73,473	72,798
LOSSES	71,068	66,639	58,933

TAMPA ELECTRIC COMPANY

Trend Analysis Demand & Energy Forecast Method #2

This forecast technique has been used extensively in the past and, until the oil embargo of 1973, worked quite satisfactorily. After 1973, there has been some difficulty applying the trend analysis or curve fitting technique due to a lack of a consistent trend line.

Traditionally, the method develops a simple correlation between a dependent variable and an independent variable. In the electric utility industry, this can be total energy sales correlated against the years the sales were made. With time as the independent variable, a forecast can be made by simply substituting a future year into the resulting curve fitted equation. The trend technique can be modified by examining different time intervals (staggered or overlapped) to produce different equations (1968-1973 and 1970-1975). The results can be compared and, with subjective reasoning and knowledge of historical growth patterns, a forecast can be made which may not necessarily follow a specific curve fit.

Considering the unpredictable nature of energy usage over the last few years, more and more, judgment and the analysis of growth patterns is being added to the forecast technique. Some of the forecast parameters that have been projected using the method are as follows:

1. Residential Customers
2. Street & Highway Lighting Energy Sales
3. Energy Sales to Public Authorities
4. Small Light & Power Energy Sales
5. Large Light & Power Energy Sales
6. Average Usage per Customer

The residential energy sales is derived by multiplying the residential customers and average KWH usage per customer projections. The small light and power and large light and power energy estimates are made by identifying and extrapolating certain historical relationships between the two energy classes. Miscellaneous sales is based on a simple trend line of historical data. The combination of these items is the major ingredient of the total energy sales projection. A peak KW demand forecast is made by combining total sales with an estimate of the system load factor (which is expected to decline slightly).

The energy forecast was prepared by a team that has nearly a half century of utility experience. This team has spent years studying and analyzing the behavior of the TECO system during growth and no-growth periods. The experience, knowledge and judgement of this team has played a key role in preparing this forecast and has been used to temper the trend line equations. The overall method may be somewhat subjective, but it represents the best possible way to adapt trend analysis to growth patterns that are not clearly defined, especially the 1970-1979 time period.

TAMPA ELECTRIC COMPANY

Multivariate Demand Model Forecast Method #3

The Tampa Electric Company Demand Model consists of three regression equations for load other than phosphate. One equation is for the base load which, by definition, is that load on the system that is independent of temperature. The remaining two equations described the seasonal peak loads that are sensitive to temperature. One equation describes the summer temperature demand, and the other describes the winter temperature demand. From regression analysis, the following relationships have been determined:

$$\text{Base Load} = -388 + 5.7 (\# \text{ Residential Customers}) - 5611 \left[\frac{\text{Price of Electricity}}{\text{CPI}} \right] \quad \bar{R}^2 = .97$$

$$\text{Temp. Sensitive Demand (Summer)} = (\text{°F} - 65) \left[16.6 + .15 (\# \text{ A/C's}) - 895 \left[\frac{\text{Price of Electricity}}{\text{CPI}} \right] \right] \quad \bar{R}^2 = .88$$

$$\text{Temp. Sensitive Demand (Winter)} = (65 - \text{°F}) [-1.4 + .205 (\# \text{ Electric Heaters})] \quad \bar{R}^2 = .86$$

Base Load - That component of demand (MW) that is insensitive to changes in temperature.

Temperature Sensitive Demand - That load component (MW) which is sensitive to temperature due to heating or air conditioning on the system.

Residential Customers - The average number of residential customers (in thousands).

CPI - Consumer Price Index.

°F - Average 24-hour temperature prevailing in the summer or winter at the time of the system peak load.

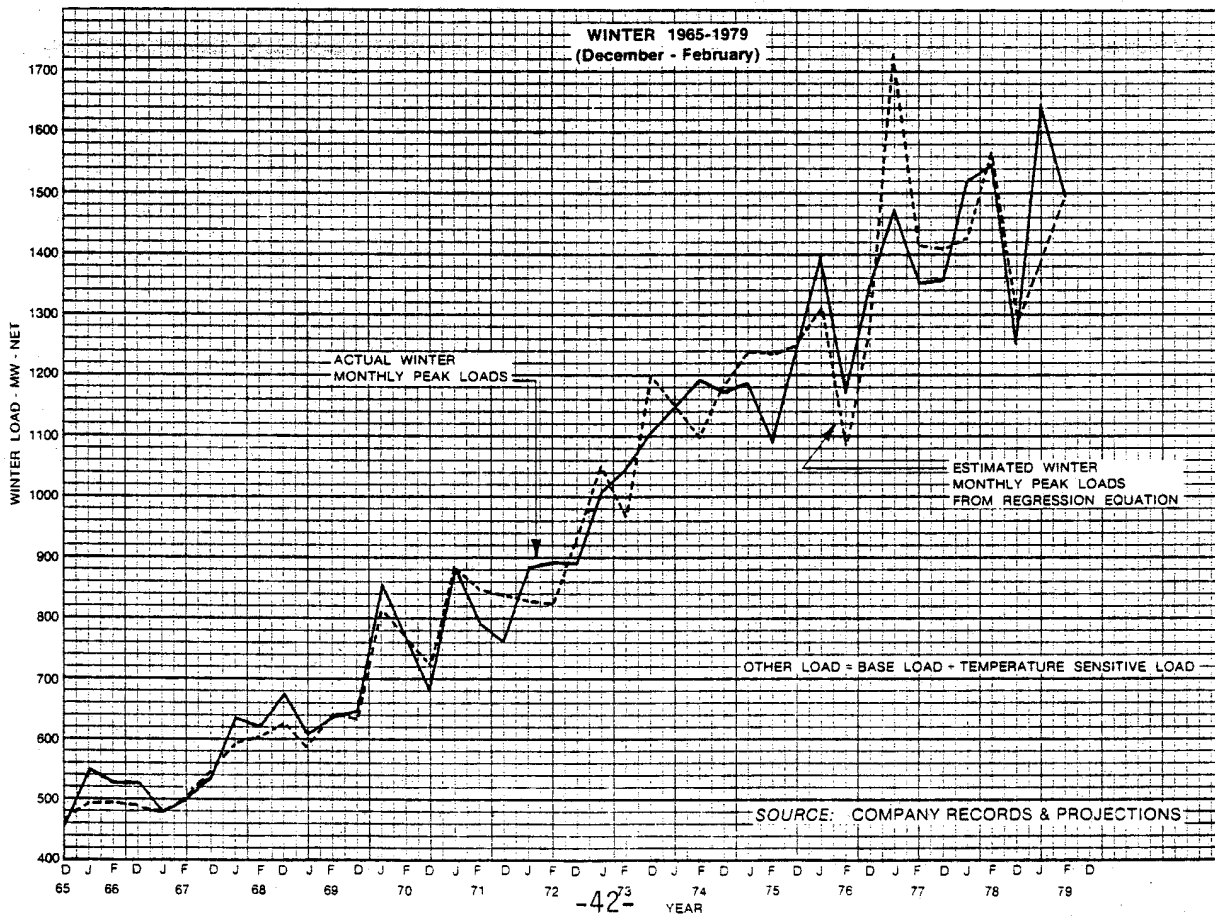
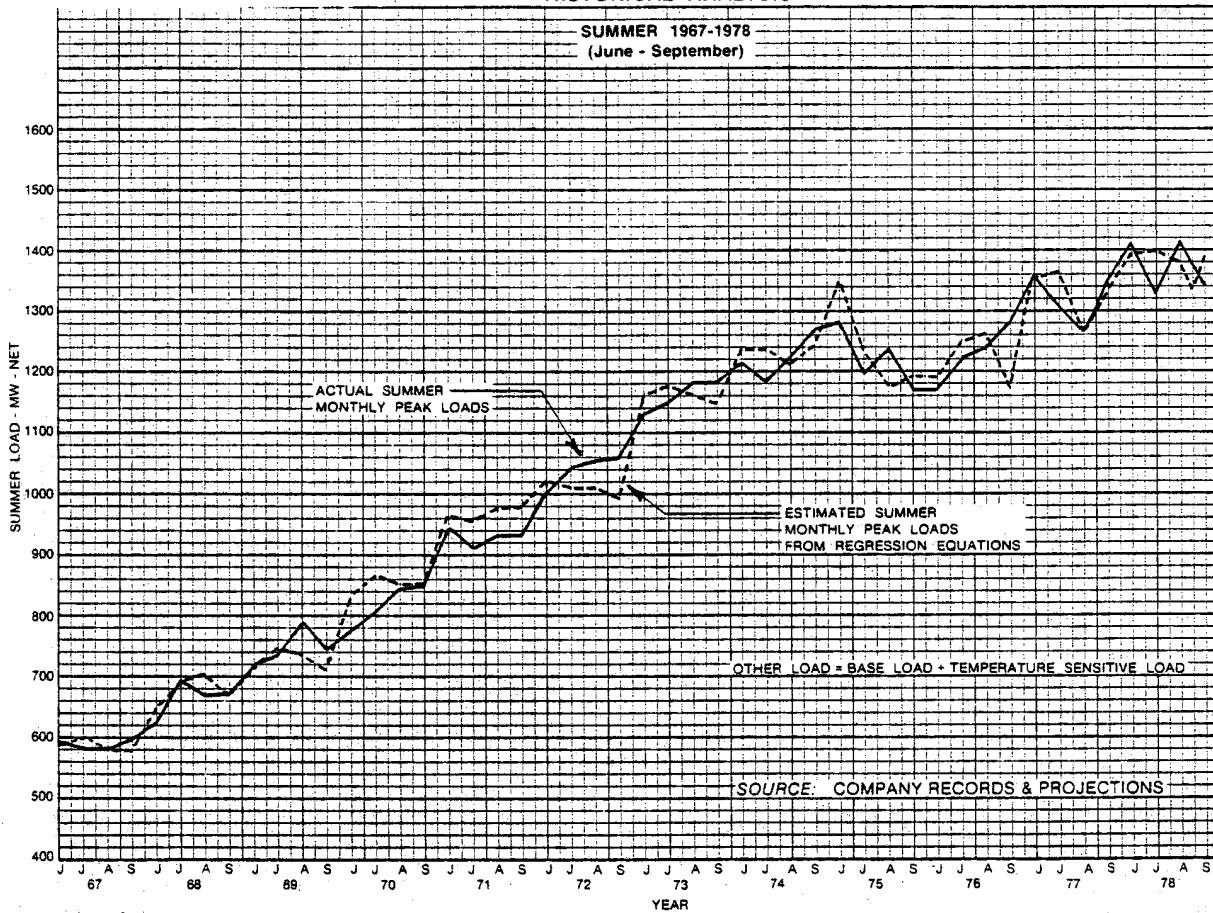
A/C - Number of residential electric air conditioners (in thousands).

Electric Heaters - Number of residential electric heaters (in thousands).

A comparison of the regression equations against the actual data showed that they provide a very close approximation to the actual system loads including the post oil embargo time period. This is because the equations are sensitive to price and are able to react to the events that occurred after Embargo.

The following graphs illustrate the actual and estimated peak demand and the degrees of of "fit" of the multivariate model to historical data.

**TAMPA ELECTRIC COMPANY
MULTIVARIATE DEMAND MODEL
HISTORICAL ANALYSIS**



In order to develop the above equations, many different variables were examined, but were not used. Some were as follows:

1. Average Usage per Customer
2. Population
3. Unemployment
4. KWH Sales
5. GNP
6. Income
7. Assorted Lagged and Dummy Variables.

Once the historical relationships of peak demand to certain variables have been quantified through regression analysis, the next step is to make some forecast assumptions of the future movement of independent variables (such as customers and appliance saturation). With the multi-variate model, the following items have been analyzed in order to make a forecast:

1. Customers (Residential)
2. Weather (Average 24-Hour Temperature)
3. Appliance Saturation (A/C and Heating)
4. Price of Electricity Relative to Price of Other Goods and Services.

The customer forecast has been made by using population projections from the University of Florida Bureau of Economic and Business Research. Population forecasts, modified by house hold formations, can be used to give a customer forecast.

The weather data that is used in the forecast process should be the temperatures (summer and winter) that are most likely to occur in future at the weather per se, but rather, to make a statistical estimation on the type of weather most likely to occur at the time of a system peak. A thirty year average of weather has been used for this analysis.

The appliance saturation of electric heaters and air conditioners is determined from a knowledge of past trends and the number and type of new customer additions.

Finally, the relationship of the price of electricity to the price of other goods and services must be estimated. The variable can be assumed to increase in the next 5 years (which assumes that increases in the cost of electricity will be greater than increases in the price of other consumer commodities). This ratio can, of course, be assumed to increase or decrease to illustrate the effects of price on load forecasts.

Other sections of this demand and energy report illustrate, in detail, the assumptions that have been used to drive the multivariate demand model.

TAMPA ELECTRIC COMPANY

Phosphate Demand & Energy Forecast Method #4

Preparing the phosphate demand and energy sales forecast requires an intimate knowledge of the phosphate industry. The forecast is prepared by the Phosphate Sales Department, who maintains close contact with each customer and is familiar with their expansion and closeout plans. of

Some of the primary ingredients in preparing the forecast are as follows:

1. Knowledge of expansion/closeout plans on the mining, furnaces and chemical plants.
2. Familiarity with historical and projected industry trends.
3. Close working relationships with key phosphate personnel.
4. Awareness of past and future government legislation that may affect the industry.
5. Familiarity with the worldwide demand for phosphate products.
6. Knowledge of geological limitations of the industry in the TECO service area.
7. Correlation of electric energy consumption with the historical activity of the industry.

From the above information, it can be seen that the preparation of the Phosphate Forecast is largely subjective and is based on a detailed knowledge of the industry.

NEW TECHNOLOGIES

For the 1980-1990 Demand & Energy Forecast, several developing technologies have been examined to determine their impact on future load projections. These technologies are as follows:

- 1) Electric vehicles
- 2) Load Management
- 3) Solar heating & cooling equipment
- 4) Conservation

New Technologies

Electric Vehicles

Predicting when electric vehicle saturation will reach a significant level in the United States is a difficult task. Electric vehicles (EV's) have been in existence since the turn of the century. Thomas Edison predicted a battery technology breakthrough in his lifetime. Today, after much research, the EV picture is only slightly more optimistic.

There are significant factors which deter the growth of EV's. Initial cost of an EV is greater than a comparable internal combustion engine (ICE) vehicle. Even with soaring oil prices, the cost effectiveness of EV's is dubious. Performance is another deterrent as EV's are significantly inferior in overall performance to ICE vehicles.

A technological breakthrough as mentioned by Edison could increase EV performance enough to compete with ICE vehicles. Also, a rapid increase in the price of oil relative to electricity would increase EV popularity. Either of these circumstances would bring to light the effective means of saving petroleum which EV's provide. In addition, utility load factors would improve.

According to Dr. Robert J. Fedor of Gould, Inc., a technological breakthrough forecast is obscure due to several problems. First, historical evidence and complexities involved with battery development tend to promote a pessimistic view of battery technology. Second, the present cost effectiveness of EV's leave manufacturers reluctant to commit the necessary funds for full scale research, development and production. Finally, a reluctant U.S. Government will need to provide incentives for auto manufacturers to get the ball rolling.

The impact of EV's on utility system loads is summarized by three major factors according to a recent EPRI research project.

- 1) Electric vehicles using high performance batteries may have a significant impact on automobile stock by the year 2000.
- 2) "The main uncertainties about EV's reflect the 'cost' of technology rather than the development of it."
- 3) "Even under optimistic assumptions, electric vehicles will not add significantly to electric utility loads before 2000."

The EPRI report also states that if all the predicted automobiles on the road in the year 2000 (141 million) were electric, this would only add 10% to utility peak demands. For this reason and the general state of electric vehicle progress as stated above, the impact of EV's have not been taken into account in this forecast.

NEW TECHNOLOGIES

LOAD MANAGEMENT

For this 1979-1989 forecast, load management impacts have not been included. Load management, however, has been examined separately in this section to determine the potential impact on the published demand and energy projections. For purpose of this report, the following assumptions have been made:

1. Controlled load per appliance at peak
 - A. Central Electric Heat = 1.3 KW
 - B. Central Electric A/C = 0.5 KW
 - C. Electric Water Heater (Summer) = 0.3 KW
 - D. Electric Water Heater (Winter) = 0.6 KW
2. 1990 Penetration of Load Management Hardware = 33%
3. Control period not to exceed 15 minutes/hour per customer
4. Maximum control period - 8 to 10 hours
5. Heating/cooling equipment to be controlled in conjunction with water heaters

Based on the above assumptions, it is possible that load management could reduce the 1990 summer and winter demand by 2 to 5% of the 1990 peak demand requirements. At the present time, a detailed study of load management is being made to determine the economic feasibility of this new technology. The results of this study should be available during Fall, 1980.

Solar appliances have been examined to determine the impact on the 10-year demand and energy forecast. Some of the major assumptions that were used in the study are as follows:

Existing Buildings*

- Assume 25 percent of all buildings could be retro-fitted with solar systems
- Assume that the ultimate market penetration levels which will be achieved in various solar energy applications over the next decade are:
 - 10 percent for solar hot water heating
 - 2 percent for solar space heating
 - 0.5 percent for solar space cooling in residential buildings
 - 2 percent for solar cooling in commercial buildings

New Buildings*

- 50 percent of all new buildings will be suitable candidates for installation of solar systems.
- Market capture rates, i.e., percent of annual starts, based on economic factors alone are:
 - 30 percent for hot water heating
 - 4 percent for space heating
 - 1 percent for space cooling in residential buildings
 - 5 percent for space cooling in commercial buildings

(These rates are taken to be representative of the situation over the next decade and thus are applied uniformly over each of the next ten years.)

Using the detailed end use model, the above assumptions result in 150 GWH of electrical energy that could be delivered by solar devices for heating/cooling and water heating by 1988. This represents about 1% of TECO's total energy sales and is not considered to be a major reduction in the overall forecast. Solar devices are not expected to impact on peak KW demand, as this analysis assumes that future solar equipment will have standby electrical power which may be in use at the time of the system peak (e.g., cold, cloudy, winter day).

*Source - Solar Energy Utilization in Florida, Florida Energy Committee, June 1975.

New Technologies

Conservation

Conservation programs have been indirectly factored into this forecast through price elasticity which results in decreased consumption as customers install better insulation and more efficient appliances. Currently, TECO has two energy conservation programs. The first is an Energy Efficiency Award plan for builders who meet certain criteria for new housing construction. The second is an Audit program where existing dwellings are analyzed for energy efficiency (by computer) and the results are given to the homeowner for possible improvement. Both programs are designed to help our customers react to higher price by reducing overall energy consumption. Tampa Electric is a strong advocate of conservation and believes that this technology has a permanent place in our energy future.

History and Forecast of Energy Consumption

A History and Forecast of Energy Consumption in gigawatt hours by customer classification within the Company's service area is presented in Form 2. The data presented in Form 2 is presented in Graph 2.

History and Forecast of Peak Loads

A History and Forecast of Peak Loads in megawatts for both the summer and winter seasons of the forecast year is presented in Form 4. A graphical display of the historical and forecasted peak loads is presented for both seasons on Graph 3.

Monthly Forecast of Peak Loads for Years 1 and 2

A Monthly Forecast of Peak Loads in megawatts for years 1 and 2 of the forecast is provided in Form 5. This forecast is given both including and excluding loads from interruptible customers.

Forecast of Peak Loads for Major Load Centers

This type of peak load forecast is not prepared by Tampa Electric Company. We do meter and estimate future load growth on substations and transmission circuits, but it has never been necessary for Tampa Electric Company to combine substation loads to determine an aggregate load for major load centers as defined in the instructions.

Public Information Policy

The Company's public information efforts are aimed at helping the consumer understand the economic effects of supplying electricity while protecting the environment, and at helping him to manage his energy use with the ultimate goal of reduced use. No information or advertising efforts were directed at increasing the rate of growth of demand or consumption. In 1979, approximately 25,000 of TECO's 313,000 customers were given Kilowatt-Hour Calculator Kits designed to help them manage their energy use. In addition, TECO continued its Home Energy Survey program which enables consumers to modify their homes to reduce energy waste, and also continued its Energy Efficiency Awards to builders who construct energy-efficient dwellings. Public-information and community-relations channels were used to support all of the above.

UTILITY Tampa Electric Company

HISTORY AND FORECAST OF ENERGY USE

(1) Year	(2) GWH	(3) Rural & Residential		(5) Commercial		(7) Industrial	
		(4) Average 1/ No. of Customers	Average KWH Consumption Per Customer	(6) Average 1/ No. of Customers	(8) Average 1/ No. of Customers		
1970	2019	186153	10849	1041	19496	2772	661
1971	2200	195702	11242	1166	20362	2718	645
1972	2416	207213	11657	1335	21440	2784	639
1973	2843	221251	12852	1525	22861	3004	624
1974	2828	233356	12118	1640	25076	3102	614
1975	2906	239215	12150	1767	26539	3297	598
1976	2911	243548	11952	1804	27221	3564	599
1977	3139	249362	12590	1904	28119	4008	579
1978	3313	258971	12792	2030	29226	4080	576
1979	3325	270939	12271	2084	30640	4101	558
1980	3470	281250	12338	2181	31794	4142	550
1981	3556	289411	12287	2252	32717	4333	550
1982	3643	297809	12233	2326	33666	4455	550
1983	3734	306451	12185	2401	34643	4571	550
1984	3827	315343	12136	2479	35648	4607	550
1985	3921	324494	12083	2560	36683	4643	550
1986	4019	333910	12036	2642	37699	4682	550
1987	4118	343599	11985	2728	38793	4721	550
1988	4237	353569	11984	2828	39918	4767	550
1989	4360	363829	11984	2930	41077	4815	550

1/ Use average of end-of-month customers for the calendar year.

December 31, 1979 Status

UTILITY Tampa Electric Company

HISTORY AND FORECAST OF ENERGY USE

(9)	(10)	(11)	(12)	(13)	(14)	(15)
	Street & Highway Lighting	Other Sales to Ultimate Consumers	Total Sales to Ultimate Consumers	Sales For Resale 1/ GWH	Utility Use & Losses GWH	Net Energy For Load GWH
Year	GWH	GWH	GWH		GWH	GWH
1970	29	313	6174	0	368	6542
1971	30	367	6481	0	365	6846
1972	32	402	6969	0	460	7429
1973	35	436	7843	0	448	8291
1974	33	429	8032	0	453	8485
1975	32	467	8469	0	546	9015
1976	35	487	8801	0	492	9293
1977	35	516	9602	0	526	10128
1978	36	576	10035	0	461	10496
1979	37	595	10141	0	583	10724
1980	37	619	10449	0	596	11045
1981	38	639	10818	0	618	11436
1982	39	659	11122	0	635	11757
1983	39	681	11426	0	652	12078
1984	40	703	11656	0	665	12321
1985	41	726	11891	0	679	12570
1986	42	749	12134	0	693	12827
1987	43	774	12384	0	707	13091
1988	43	802	12677	0	724	13401
1989	44	831	12980	0	741	13721

1/ To Class III and Class V Systems.

December 31, 1979 Status

ENERGY SOURCES AND FUEL REQUIREMENTS

December 31, 1979 Status

ENERGY SOURCES			Actual 1978	Actual 1979	1980	1981	1982	1983
(1)	PURCHASES & INTERCHANGE	GWH	(242)	(264)	0	0	0	896
(2)	NUCLEAR	GWH	0	0	0	0	0	0
(3)	COAL	GWH	8,105	8,446	8,369	8,791	8,855	8,766
(4)	RESIDUAL - TOTAL	GWH	2,591	2,504	2,645	2,612	2,860	2,385
(5)	Steam	GWH	2,591	2,504	2,645	2,612	2,860	2,385
(6)	CC	GWH	0	0	0	0	0	0
(7)	CT	GWH	0	0	0	0	0	0
(8)	DISTILLATE - TOTAL	GWH	45	38	31	33	42	31
(9)	CT	GWH	45	38	31	33	42	31
(10)	Diesel	GWH	0	0	0	0	0	0
(11)	NATURAL GAS - TOTAL	GWH	0	0	0	0	0	0
(12)	Steam	GWH	0	0	0	0	0	0
(13)	CC	GWH	0	0	0	0	0	0
(14)	CT	GWH	0	0	0	0	0	0
(15)	Diesel	GWH	0	0	0	0	0	0
(16)	OTHER	GWH	0	0	0	0	0	0
(17)	NET ENERGY FOR LOAD	GWH	10,499	10,724	11,045	11,436	11,757	12,078
FUEL REQUIREMENTS								
(18)	NUCLEAR	BTUx10 ¹²	0	0	0	0	0	0
(19)	COAL	1000 TON	3,575	3,691	3,670	3,848	3,876	3,840
(20)	RESIDUAL - TOTAL	1000 BBL	4,712	4,585	4,826	4,778	5,242	4,170
(21)	Steam	1000 BBL	4,712	4,585	4,826	4,778	5,242	4,170
(22)	CC	1000 BBL	0	0	0	0	0	0
(23)	CT	1000 BBL	0	0	0	0	0	0
(24)	DISTILLATE - TOTAL	1000 BBL	118	100	78	83	107	78
(25)	CT	1000 BBL	118	100	78	83	107	78
(26)	Diesel	1000 BBL	0	0	0	0	0	0
(27)	NATURAL GAS - TOTAL	1000 MCF	0	0	0	0	0	0
(28)	Steam	1000 MCF	0	0	0	0	0	0
(29)	CC	1000 MCF	0	0	0	0	0	0
(30)	CT	1000 MCF	0	0	0	0	0	0
(31)	Diesel	1000 MCF	0	0	0	0	0	0
(32)	OTHER	BTUx10 ⁶	0	0	0	0	0	0
(33)	ANNUAL AVG. FOSSIL NET H.R.	BTU/KWH	10,533	10,549	10,530	10,517	10,544	10,542

ENERGY SOURCES AND FUEL REQUIREMENTS

December 31, 1979 Status

ENERGY SOURCES			1984	1985	1986	1987	1988	1989
(1)	PURCHASES & INTERCHANGE	GWH	1,495	535	454	1,026	1,639	421
(2)	NUCLEAR	GWH	0	0	0	0	0	0
(3)	COAL	GWH	8,614	10,065	10,477	10,288	10,079	11,573
(4)	RESIDUAL - TOTAL	GWH	2,187	1,948	1,875	1,758	1,664	1,707
(5)	Steam	GWH	2,187	1,948	1,875	1,758	1,664	1,707
(6)	CC	GWH	0	0	0	0	0	0
(7)	CT	GWH	0	0	0	0	0	0
(8)	DISTILLATE - TOTAL	GWH	25	22	21	19	19	20
(9)	CT	GWH	25	22	21	19	19	20
(10)	Diesel	GWH	0	0	0	0	0	0
(11)	NATURAL GAS - TOTAL	GWH	0	0	0	0	0	0
(12)	Steam	GWH	0	0	0	0	0	0
(13)	CC	GWH	0	0	0	0	0	0
(14)	CT	GWH	0	0	0	0	0	0
(15)	Diesel	GWH	0	0	0	0	0	0
(16)	OTHER	GWH	0	0	0	0	0	0
(17)	NET ENERGY FOR LOAD	GWH	12,321	12,570	12,827	13,091	13,401	13,721

FUEL REQUIREMENTS

(18)	NUCLEAR	BTUx10 ¹²	0	0	0	0	0	0
(19)	COAL	1000 TON	4,441	4,423	4,955	4,559	4,420	5,101
(20)	RESIDUAL - TOTAL	1000 BBL	3,829	3,421	3,294	3,092	2,938	2,979
(21)	Steam	1000 BBL	3,829	3,421	3,294	3,092	2,938	2,979
(22)	CC	1000 BBL	0	0	0	0	0	0
(23)	CT	1000 BBL	0	0	0	0	0	0
(24)	DISTILLATE - TOTAL	1000 BBL	64	55	54	49	48	49
(25)	CT	1000 BBL	64	55	54	49	48	49
(26)	Diesel	1000 BBL	0	0	0	0	0	0
(27)	NATURAL GAS - TOTAL	1000 MCF	0	0	0	0	0	0
(28)	Steam	1000 MCF	0	0	0	0	0	0
(29)	CC	1000 MCF	0	0	0	0	0	0
(30)	CT	1000 MCF	0	0	0	0	0	0
(31)	Diesel	1000 MCF	0	0	0	0	0	0
(32)	OTHER	BTUx10 ⁶	0	0	0	0	0	0
(33)	ANNUAL AVG. FOSSIL	BTU/KWH	10,539	10,530	10,530	10,530	10,530	10,530
	NET H.R.							

HISTORY AND FORECAST OF SEASONAL PEAK DEMAND AND ANNUAL NET ENERGY FOR LOAD

(1) Year	(2) Summer Peak Demand Net MW		(4) Net Energy For Load - GWH	(5) Load Factor % *	(6) Year	(7) Winter Peak Demand Net MW	
	Interruptible	Total				Interruptible	Total ^{3/}
1970	165	1098	6542	68.0	1970-71	150	1105
1971	178	1194	6846	65.5	1971-72	142	1110
1972	145	1302	7429	65.0	1972-73	171	1300
1973	139	1441	8291	65.7	1973-74	152	1366
1974	146	1527	8485	63.4	1974-75	155	1458
1975	147	1565	9015	65.8	1975-76	155	1693
1976	134	1568	9293	67.5	1976-77	178	1784
1977	193	1720	10128	67.2	1977-78	206	1891
1978	169	1780	10496	67.3	1978-79	175	1988
1979	182	1805	10724	67.8	1979-80	194	2007
1980	212	1860	11045	67.8	1980-81	196	2047
1981	216	1920	11436	68.0	1981-82	197	2122
1982	220	1984	11757	67.6	1982-83	197	2199
1983	225	2064	12078	66.8	1983-84	197	2284
1984	225	2124	12321	66.2	1984-85	197	2362
1985	225	2188	12570	65.6	1985-86	197	2448
1986	225	2247	12827	65.2	1986-87	197	2537
1987	225	2309	13091	64.7	1987-88	197	2630
1988	225	2372	13401	64.5	1988-89	197	2726
1989	225	2439	13721	64.2	1989-90	197	2825

December 31, 1979 Status

* Load factor based on summer peak loads

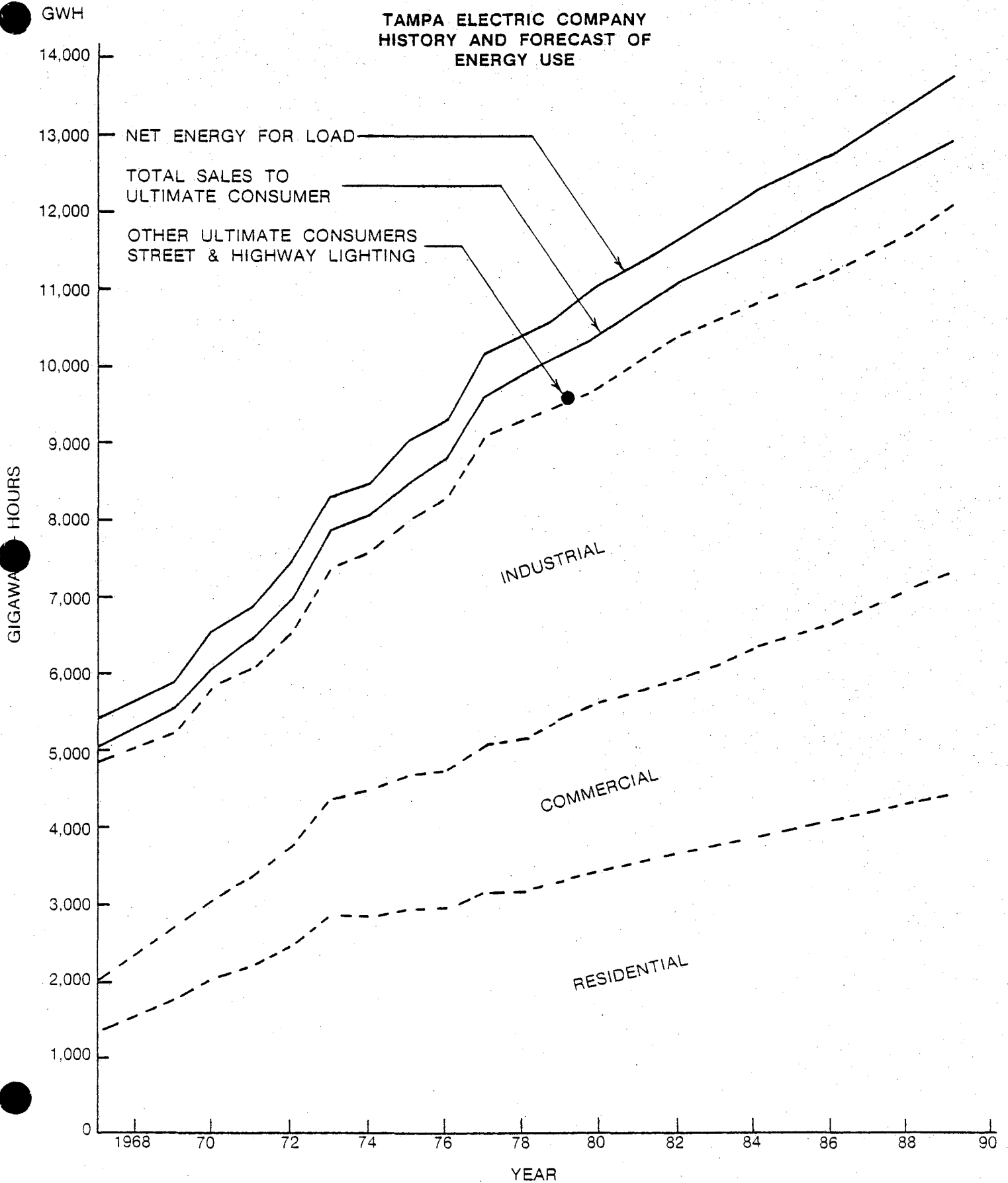
PREVIOUS YEAR ACTUAL AND TWO-YEAR FORECAST OF PEAK DEMAND
AND NET ENERGY FOR LOAD BY MONTH

(1)	(2)	(3)	(4)	(5)	(6)	(7)
	ACTUAL		FORECAST			
	1979		1980		1981	
MONTH	PEAK DEMAND MW	NEL GWH	PEAK DEMAND MW	NEL GWH	PEAK DEMAND MW	NEL GWH
JAN	1988	927	2007	941	2047	974
FEB	1860	825	1925	857	1964	888
MAR	1512	832	1679	834	1714	864
APR	1579	829	1597	841	1649	871
MAY	1619	892	1670	917	1724	949
JUN	1768	941	1772	993	1830	1028
JUL	1805	1005	1816	1018	1875	1054
AUG	1791	987	1831	1016	1890	1051
SEP	1801	936	1860	984	1920	1019
OCT	1707	880	1743	895	1800	927
NOV	1710	804	1780	836	1844	866
DEC	1628	866	1880	913	1948	945
TOTAL		10724		11045		11436

December 31, 1979 Status

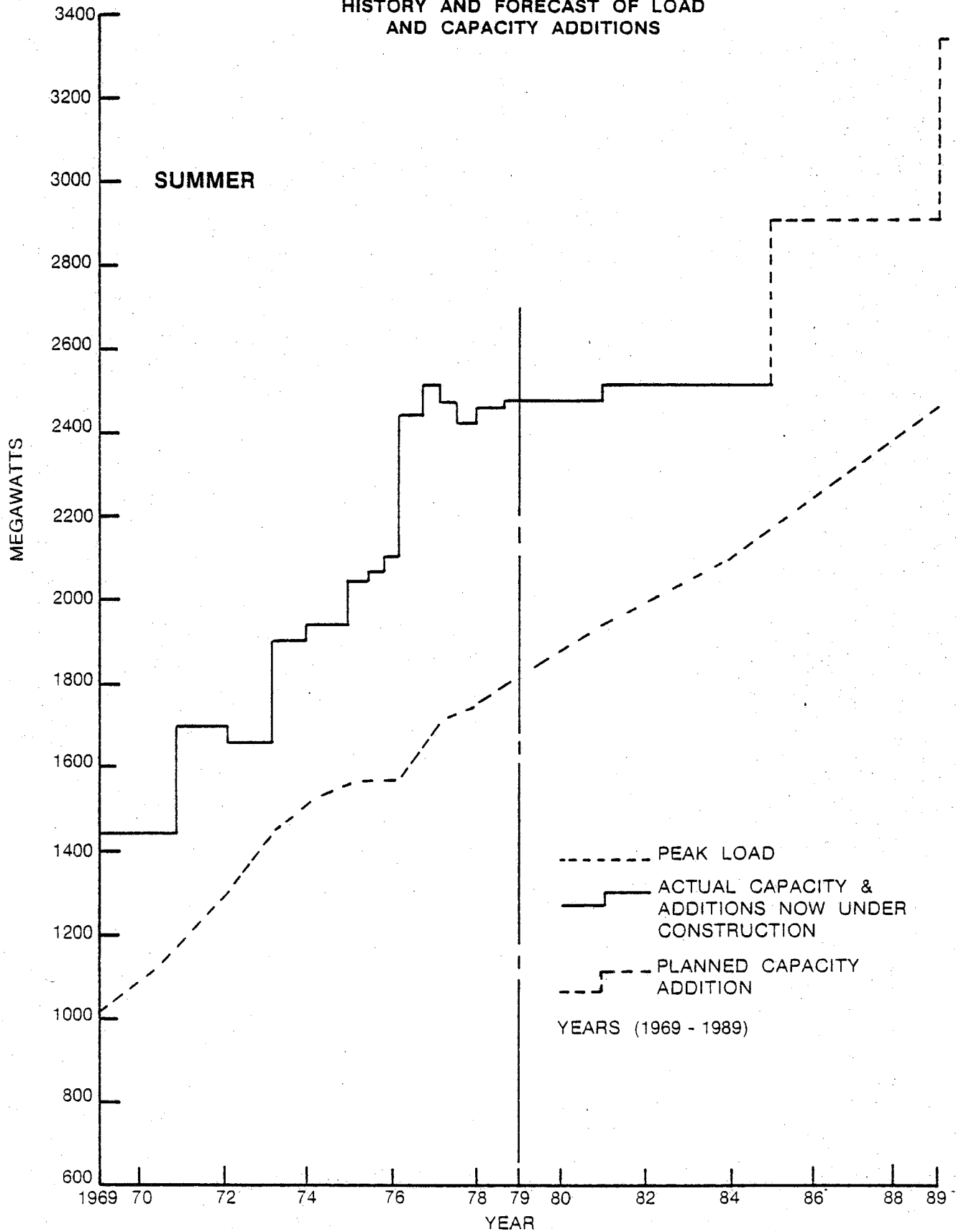
GRAPH 2

TAMPA ELECTRIC COMPANY
HISTORY AND FORECAST OF
ENERGY USE



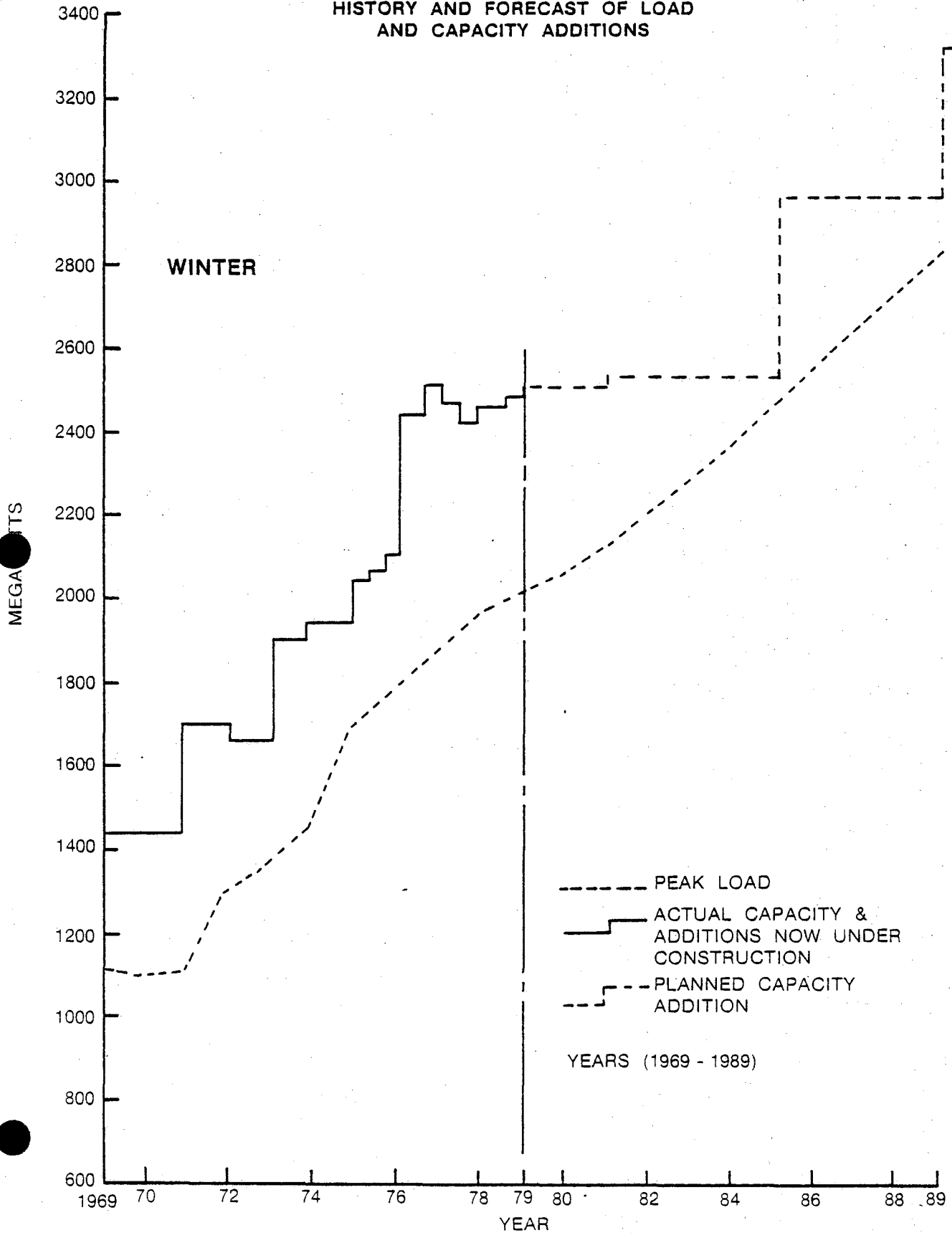
GRAPH 3
SHEET 1 OF 2

TAMPA ELECTRIC COMPANY
HISTORY AND FORECAST OF LOAD
AND CAPACITY ADDITIONS



GRAPH 3
SHEET 2 OF 2

TAMPA ELECTRIC COMPANY
HISTORY AND FORECAST OF LOAD
AND CAPACITY ADDITIONS



CHAPTER III

FORECAST OF FACILITIES REQUIREMENTS

DOCUMENTATION OF FACILITY CHANGES

Main Objectives

The objective of the proposed generating facilities presented in Form 6 is to give economical reliable service to Tampa Electric Company customers.

Reliability Analysis

Measurement of Tampa Electric Company's capability to serve load is accomplished with the Loss-of-Load Probability reliability analysis. Based on historical data of system performance and current judgment, a Loss-of-Load Probability index of reliability for serving firm load has been selected and is used as a design criteria for evaluating adequacy of future Tampa Electric Company generating systems.

Using this design criteria, the system load and generation system is modeled for each future year, with additional generating facilities being added as required. A period of five to twenty years is studied with various combinations of base load and peaking generation being added to the existing system. This results in several possible alternatives for generation expansion, each being acceptable on a reliability basis.

Economic Analysis

The generation expansion alternatives are compared on an economic basis to determine which plan will result in the lowest overall revenue requirements. Capital dollar estimates are obtained for each generation addition based on the type of unit required, fuel used, site location, year required in service, etc. For comparison purposes, the fixed charges resulting from such capital expenditures in each alternative is expressed in "present-worth" dollars.

A production cost model is run for the years involved on each alternate to arrive at an estimate for the operating cost under each plan. These estimates are also expressed in "present-worth" dollars and combined with the fixed charge requirements to obtain the total "present-worth" of the revenue requirements on each alternate generation expansion plan.

Results

The plan presented in this submittal represents the results of applying the previously described planning process. The plan has factored into it sound management judgments of the many risks and uncertainties involved in the decision to build generation facilities.

The plan recognizes that with existing technology, there are only two alternatives for base loaded generation: coal or nuclear. Each of these alternatives has uncertainties associated with environmental and regulatory requirements and fuel availability.

Combustion turbines have been excluded as an alternative for peaking purposes due to the uncertainty of distillate fuel availability. Coal based synthetic fuels offer a replacement possibility for oil in the future which would allow the use of combustion turbines in the generation planning process.

Any coal fired generation facilities will have to meet requirements of the New Source Performance Standards (NSPS) issued by the Environmental Protection Agency (EPA). There are uncertainties associated with the equipment necessary to meet the NSPS requirements. The equipment is expensive and will have difficult operating characteristics which will decrease the plant availability.

Tampa Electric Company has established an adequate supply of coal for the next ten years. However, we foresee an increase in the cost above and beyond that of normal inflation due to decreasing availability of strip reserves and increasing dependence on coal produced by more expensive underground mining techniques. Combine this fact with a national switch to coal-fueled generation which will create supply and demand inequalities, and the result is coal price uncertainty.

In the case of nuclear, the constantly changing licensing and technical requirements of state and federal regulatory agencies have caused large uncertainties in the capital requirements for a nuclear generating facility. Uncertainties also exist with nuclear fuel, including availability and cost of uranium ore, enrichment cost, and the reprocessing of spent fuel. Even with these uncertainties, Tampa Electric Company considers nuclear generation to be an economical means of producing electricity. Although current conditions limit the attractiveness of nuclear power in the near term, in the long term, both coal and nuclear generating facilities will be considered and evaluated both on an independent and joint participation basis.

Interruptible Loads

Interruptible loads are not included in the reliability calculations which are used for determining future requirements of additional generating capability. Interruptible loads will be

served from our system reserves as much as possible without compromising firm load system reliability.

Environmental Considerations

Future generating units will be designed to be consistent with the acceptable environmental and ecological standards. The necessary pollution control features are being incorporated into the early states of the facility design.

Availability of Purchase Power

A firm capacity purchase power contract is being negotiated to replace the combustion turbines that were being considered in 1983 and 1984. The purchase power contract under negotiation would be from a new coal unit which would have the effect of serving the load growth and displacing some oil on TECO's existing system due to a lower fuel cost differential. For purposes of reliability, adequate power is normally available for short periods through ties with Florida Power Corporation, Florida Power and Light Company, and City of Lakeland for emergencies.

In addition, TECO will participate in economy interchange transactions on an hourly basis to reduce the total system operation expense.

Sale of Power

A unit power contract from TECO's Big Bend Unit No. 4 to Florida Power and Light Company (FP&L) has been negotiated with a term beginning approximately May 1985 and continuing through December 1987. The capacity to FP&L will be in accordance with the schedule of need as determined by FP&L but not to exceed an amount set by TECO which will allow TECO to assure reliable service to its customers. The amount of the Big Bend No. 4 capacity that will be available is approximately 70, 50 and 25 percent in the years 1985, 1986, and 1987 respectively.

UTILITY TAMPA ELECTRIC COMPANY

PLANNED AND PROSPECTIVE GENERATING FACILITY ADDITIONS AND CHANGES

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Plant Name	Unit No.	Location	Type	Fuel Pri	Fuel Alt	Const Start Mo/Yr	Com'l In-Service Mo/Yr 1/	Gen Max Nameplate KW	Net Summer MW	Capabiltiy Winter MW	Fuel Pri	Transp Alt	Status
Big Bend		Hillsborough Co. 4/30S/19E							442	442			
<u>Existing Unit Upgrades</u>													
	2		FS	C	No	2/81	4/81	0	25	25			A
<u>New Unit Addition</u>													
	4		FS	C	No	11/81	3/85	486,000	417	417	WA	No	L
MacInnes*		Hillsborough Co.							800	800			
<u>New Unit Addition</u>													
	1		FS	C	No	6/85	3/89	Unknown	800	800	WA	No	P
TOTAL ADDITIONS AND CHANGES									1242	1242			

*Note: The MacInnes unit is a prospective joint generating facility, with TECO retaining approximately 400 MW.

December 31, 1979 Status.

1/ Or retirements in parentheses.
Show retirements as negative values in parentheses.

UTILITY TAMPA ELECTRIC COMPANY

FORECAST OF CAPACITY, DEMAND, AND SCHEDULED MAINTENANCE
AT TIME OF SUMMER PEAK 1/

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Year	Total Installed Capacity MW	Firm Capacity Import MW	Total Available Capacity MW	Peak Demand MW	Margin Before Maintenance MW	% of PK.	Scheduled Maintenance MW	Margin After Maintenance MW	% of PK.
1980	2495		2495	1860	635	34	367	268	14
1981	2520		2520	1920	600	31	367	233	12
1982	2520		2520	1984	536	27	367	169	9
1983	2520	350	2870	2064	806	39	367	439	21
1984	2520	350	2870	2124	746	35	367	379	18
1985	2937	58	2995	2188	807	37			
1986	2937	142	3079	2247	832	37			
1987	2937	246	3183	2309	878	38			
1988	2937	350	3287	2372	915	39			
1989	3337		3337	2439	898	37			

1/ Capacity additions and changes must be made by May 31 to be considered in effect at the time of the Summer peak. All values are Summer Net MW.

December 31, 1979 Status

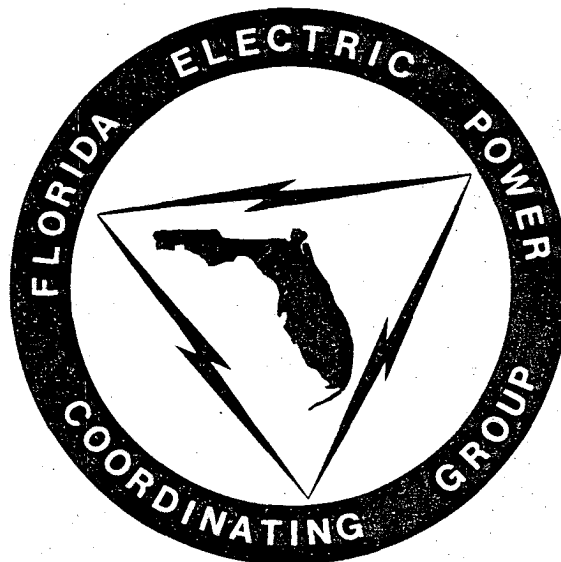
UTILITY TAMPA ELECTRIC COMPANYFORECAST OF CAPACITY, DEMAND, AND SCHEDULED MAINTENANCE
AT TIME OF WINTER PEAK 1/

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Year	Total Installed Capacity MW	Firm Capacity Import MW	Total Available Capacity MW	Peak Demand MW	Margin Before Maintenance MW	% of PK.	Scheduled Maintenance MW	Margin After Maintenance MW	% of PK.
1980-81	2495		2495	2047	448	22	137	311	15
1981-82	2520		2520	2122	398	19	137	261	12
1982-83	2520		2520	2199	321	15	137	184	8
1983-84	2520	350	2870	2284	586	26	137	449	20
1984-85	2520	350	2870	2362	508	22	137	371	16
1985-86	2937	142	3079	2448	631	26			
1986-87	2937	246	3183	2537	646	25			
1987-88	2937	350	3287	2630	657	25			
1988-89	2937	350	3287	2726	561	21			
1989-90	3337		3337	2825	512	18			

1/ Capacity additions and changes must be made by November 30 to be considered in effect at the time of the Winter peak. All values are Winter Net MW.

December 31, 1979 Status

ATTACHMENT "B"
TO
AMENDMENT 1
JULY 1, 1980



Peninsular Florida
Generation Reliability Assessment Study
1979 - 1988

System Planning Committee
Generation Task Force

October 1979



POST OFFICE BOX 111 TAMPA, FLORIDA 33601 TELEPHONE (813) 879-4111

November 9, 1979

Mr. J. S. Bell, Chairman
System Planning Committee
Florida Power & Light Company
P. O. Box 529100
Miami, Florida 33152

Dear Sam:

SUBJECT: Generation Reliability Assessment Study

The Generation Task Force was requested to appraise the adequacy and reliability of the planned generation system in Peninsular Florida as reported by the individual utilities in their current 10-year site plans. The results were presented to the committee on July 19, 1979.

The Generation Task Force submits this report to the committee for final approval.

I would like to thank each member of the Generation Task Force plus Sam Nixon (FPC) and Russ Busser (FP&L) for their valuable assistance in preparing the reliability assessment.

Respectfully submitted,

G. D. Jennings, Chairman
Generation Task Force

Delia Perez (FPL)
D. K. Smith (LAK)
G. F. Erickson (OUC)
Karl Wieland (FPC)

enclosure

TABLE OF CONTENTS

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Appendix B	----	Generation Data	
Appendix C	----	Reliability Methods	

EXECUTIVE SUMMARY

The System Planning Committee authorized the Generation Task Force to commence work April 1, 1979, to "... appraise the adequacy and reliability of the planned generation system in Peninsular Florida" as described in the 1978-79 Scope Document. The appraisal is to be based upon the most recent load forecasts and generation expansion plans submitted to the Florida Department of Administration - Division of State Planning.¹

The Peninsular Florida electric utility systems modeled in this study include the following:

- Florida Power Corporation (FPC)
- Florida Power & Light Company (FPL)
- Fort Pierce Utilities Authority (FTP)
- Gainesville Alachua County Regional Utilities Board (GVL)
- City of Homestead (HST)
- Jacksonville Electric Authority (JEA)
- Lakeland Department of Electric & Water Utilities (LAK)
- Lake Worth Utilities Authority (LWU)
- Orlando Utilities Commission (OUC)
- Seminole Electric Cooperative (SEC)
- City of Tallahassee (TAL)
- Tampa Electric Company (TEC)
- Vero Beach Municipal Utilities (VER)

Gulf Power Company was not included in the study.

¹ In selected cases, the data used in this study reflects updated information from that submitted in the 1979 Ten Year Power Plant Site Plans.

One of the responsibilities of the Generation Task Force is to evaluate the current methods and techniques and select an index for assessing the generation reliability in "Peninsular Florida." A survey of adequacy and reliability methods is included in Appendix C. Loss of load probability (LOLP) is still the most widely accepted approach in the utility industry today and is the generation reliability index which best met the purpose and objective of the study. LOLP measures the frequency in number of days per year that the available generation will be insufficient to meet the firm peak load. However, this index does not measure the ultimate reliability of service to a customer, i.e., power outages due to transmission and/or distribution problems are not considered in LOLP.

This study takes a large integrated look at Peninsular Florida's generation reliability, allowing for comparison to the generally accepted industry standard of 0.1 days per year. Table 1 and Figure 1 summarize the results, showing that the LOLP fluctuates within a reasonable range of the industry standard of 0.1 days/year for the 1979 to 1988 period.

The relationship between percent reserves and LOLP is dependent on system characteristics. As units are added and retired from year to year, the system characteristics change and the relationship between LOLP and reserves varies. Reserve levels ranged from a minimum of 21.2% corresponding to an LOLP of 0.09 in 1983 to a maximum of 26.2% reserves and an LOLP of 0.13 in 1986. The trend appears to be moving in a direction of requiring higher reserve levels to maintain an equal level of reliability in later years.

In addition to reserve levels, LOLP is dependent on other system characteristics as mentioned previously. These characteristics are described by the following parameters: unit forced outage rate, maintenance schedule, timing of unit addition, etc. Of particular interest is this last parameter; in order to determine the impact of delays of unit in-service dates, the analysis assumed there would be a one year delay in all base load units added in the 1983 to 1988 period. By delaying unit additions, there is a significant shift in Florida's level of reliability with LOLP increasing by a factor of two to seven, depending upon characteristics and number of units which are delayed.

TABLE 1
RELIABILITY ANALYSIS
1979-1988

<u>Year</u>	<u>Capability At Time of Annual Peak (MW)</u>	<u>Annual Peak (MW)</u>		<u>Firm Load Reliability</u>	
		<u>Total Load</u>	<u>Firm Load</u>	<u>% Reserve</u>	<u>LOLP Days/Year</u>
1979	21,410	17,497	16,996	26.0	0.03
1980	22,363	18,667	18,106	23.5	0.07
1981	23,526	19,614	19,047	23.5	0.06
1982	24,836	20,579	19,978	24.3	0.12
1983	25,367	21,562	20,933	21.2	0.09
1984	27,034	22,591	21,929	23.3	0.10
1985	28,474	23,630	22,945	24.1	0.06
1986	30,276	24,710	23,995	26.2	0.13
1987	31,059	25,802	25,060	23.9	0.12
1988	32,886	26,911	26,144	25.8	0.18

L.O.L.P.
(DAYS PER
YEAR)

PENINSULAR FLORIDA
L.O.L.P. VS. ANNUAL PEAK
1979 - 1988

- 5 -

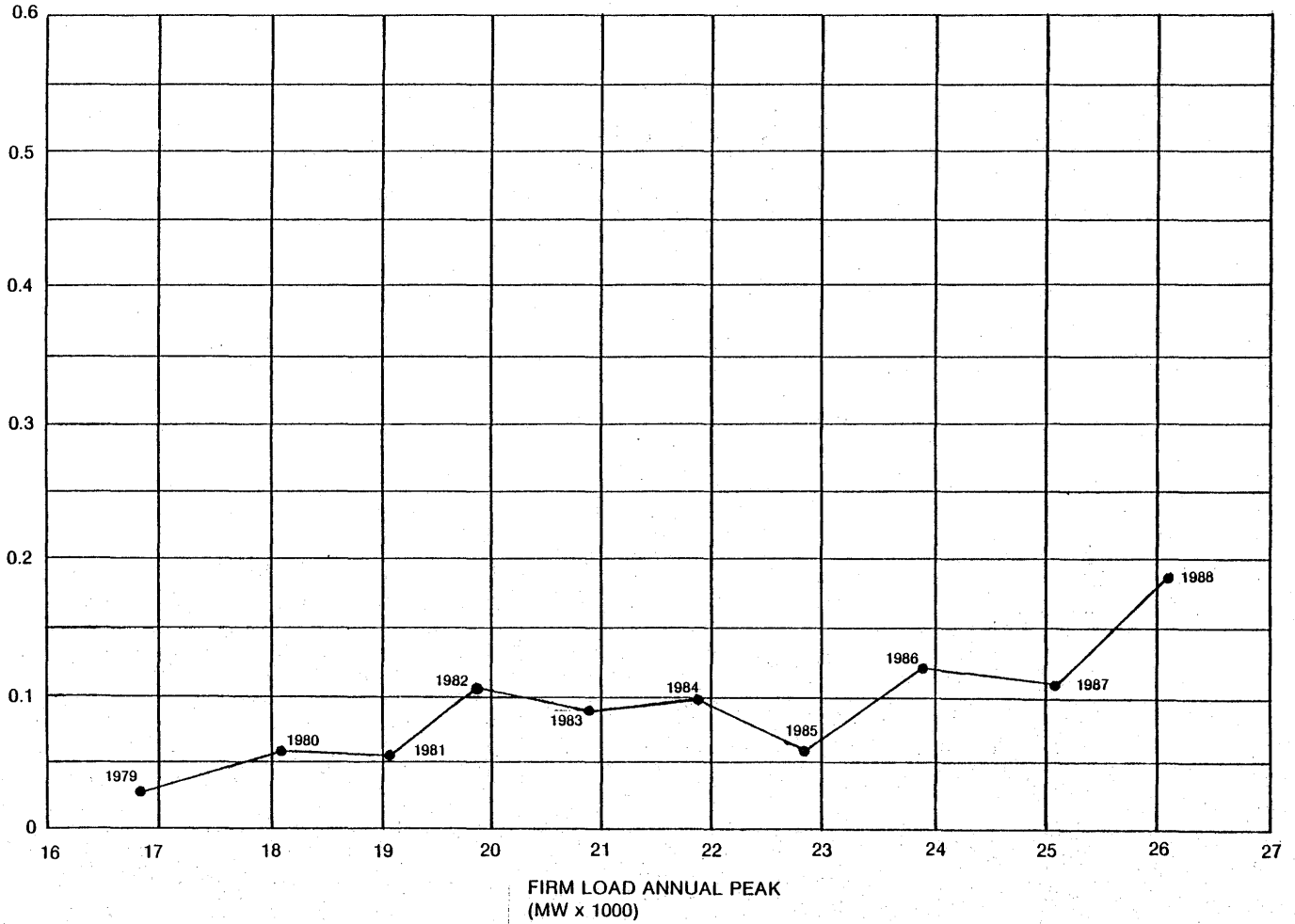


FIGURE 1

II. METHODS & PROCEDURES

The Task Force agreed to utilize the General Electric Optimized Generation Planning (OGP) computer program to calculate the Loss of Load Probability (LOLP) for the study period of 1979 through 1988. Building upon the existing OGP data base, the following parameters had to be reviewed and updated:

Load Data

- Annual Peak Load by Utility
- Month/Annual Peak Multipliers by Utility
- Monthly Diversity Factors
- Daily Peak Load Shapes for Total System by Month
- Load Uncertainty Factors for Total System

Generation Unit Data (Existing & Future)

- Capability
- Forced Outage Rates
- Planned Outage Rates
- In-Service Dates
- Retirement Dates

Whenever possible, data reported to the Florida Electric Power Coordinating Group (FCG) staff was utilized. This included the Annual Peak Loads by Utility, Unit Capabilities, In-Service Dates, and Retirement Dates. Through specific data requests, each participating utility provided their Month/Annual Peak Load Multipliers and Unit Forced Outage and Planned Outage Rates plus any known changes to their official Ten Year Site Plans. The FCG Load and Energy Task Force was requested to provide the remaining Load Data

including Daily Peak Load Shapes, Monthly Diversity Factors, and Load Uncertainty Factors for the total combined system.

Appendix A, "Load Data" and Appendix B, "Generation Data" provide a complete listing of the study data.

III. RESULTS

The Peninsular Florida annual peak load is estimated to be 17,497 megawatts in 1979, increasing to 26,911 megawatts in 1988. The average annual growth rate for the ten-year period is 4.9%. Interruptible load accounts for 501 megawatts in 1979 and increases to 767 megawatts in 1988. The system reliability analysis which follows is based upon the projected firm load.

At year end 1978, the Peninsular Florida generation system capacity totaled 21,410 net megawatts with the following generation mix:

	<u>MW</u>	<u>%</u>
Nuclear	2,905	13.6
Coal	2,036	9.5
Oil	12,451	58.1
Combustion Turbines	<u>4,018</u>	<u>18.8</u>
	21,410	100.0

Generation additions during the ten-year period (1979-1988) total 11,809 megawatts with 7,819 megawatts being coal fired. Retirements total 358 megawatts, all oil fired capacity. The resulting generation mix projected for year end 1988 is as follows:

	<u>MW</u>	<u>%</u>
Nuclear	3,707	11.3
Coal	9,855	30.0
Oil	14,168	43.1
Combustion Turbines	<u>5,131</u>	<u>15.6</u>
	32,861	100.0

The adequacy and reliability of the Peninsular Florida generation system is measured by the reliability index LOLP. The system LOLP was calculated and found to be in the range of 0.03 days/year (1979) and 0.18 days/year (1988). In comparison with the generally acceptable level of 0.1 days/year, the Peninsular Florida generation system reliability is acceptable. The following is a summary of the annual system capability, peak load, reserves, and LOLP for the study period.

Year	Capability At Time of Annual Peak (MW)	Annual Peak (MW)		Firm Load Reliability	
		Total Load	Firm Load	% Reserve	LOLP Days/Year
1979	21,410	17,497	16,996	26.0	0.03
1980	22,363	18,667	18,106	23.5	0.07
1981	23,526	19,614	19,047	23.5	0.06
1982	24,836	20,579	19,978	24.3	0.12
1983	25,367	21,562	20,933	21.2	0.09
1984	27,034	22,591	21,929	23.3	0.10
1985	28,474	23,630	22,945	24.1	0.06
1986	30,276	24,710	23,995	26.2	0.13
1987	31,059	25,802	25,060	23.9	0.12
1988	32,886	26,911	26,144	25.8	0.18

Sensitivity analyses of reserve margin, generation unit unavailability and construction delays were performed to gain further understanding of the base case results.

The reserve margins were analyzed through variations in the peak load levels. Figure 2 is a graph of LOLP and reserves for 1987, the system exposure to loss of load increases very rapidly

when reserves are lower than 22%. The LOLP in 1987 is expected to be 0.12 days/year with reserves of 23.9%; however, if the peak load increases by 4.2% over the expected load, resulting in reserves of 19%, the LOLP will increase to 0.90 days/year.

Generation system reliability is dependent on unit planned and forced outage rates (unavailability). Figure 3 reflects the significant impact an overall shift in unit unavailability can have on the system LOLP. The 1987 system LOLP increases from 0.12 to 0.45 days/year with a 10% increase, and decreases to 0.04 with a 10% decrease in unavailability.

The impact of a potential delay of one year, for all base load units scheduled for service from 1983 to 1988, is shown in Figure 4. There is a significant shift in Florida's level of reliability with LOLP increasing by a factor of two to seven depending on the characteristics of the unit and how many units are delayed each year.

FIGURE 2
PENINSULAR FLORIDA
BASE CASE
L.O.L.P. VS. RESERVES
(1987)

L. O. L. P.
(DAYS
PER YEAR)

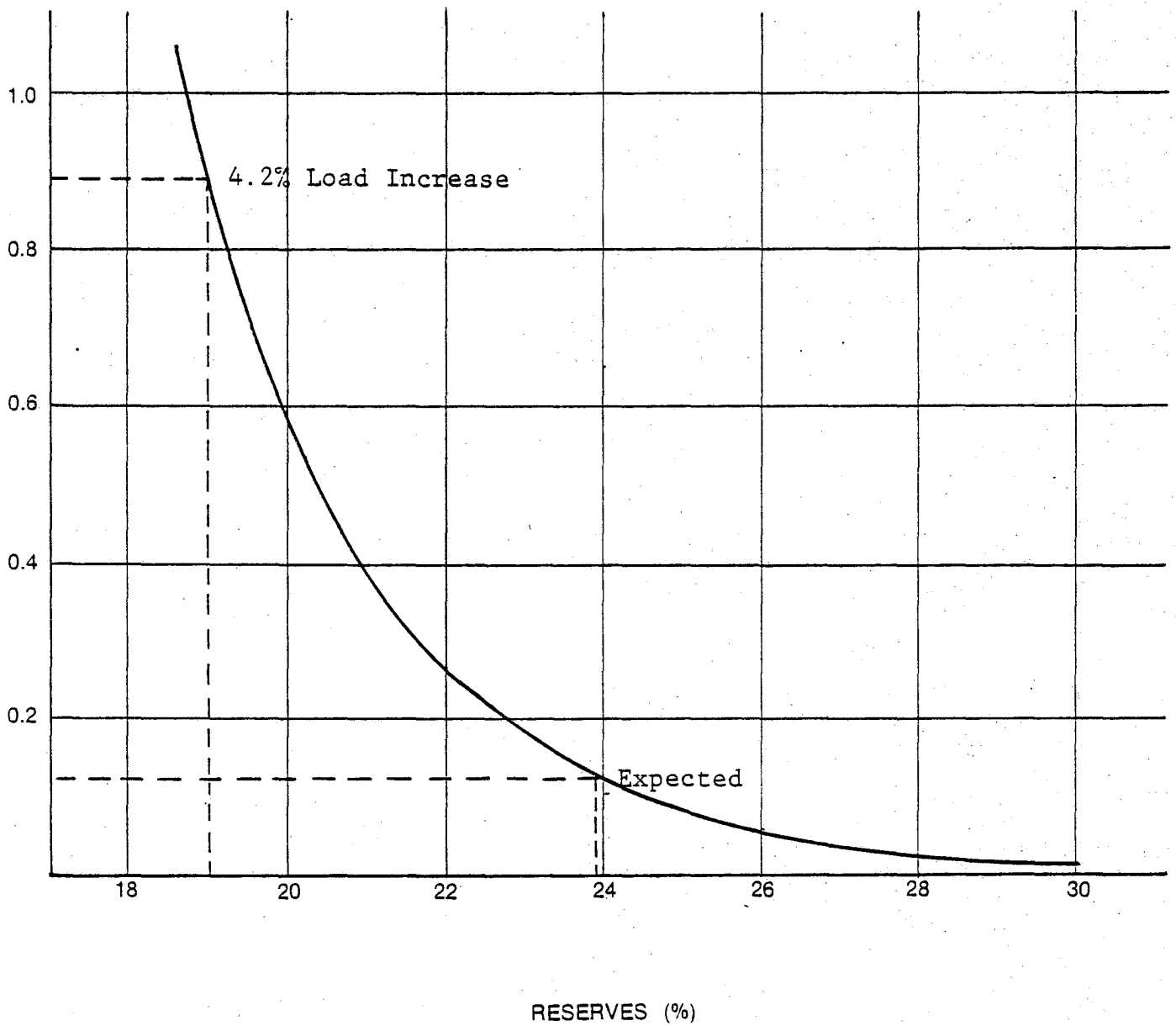
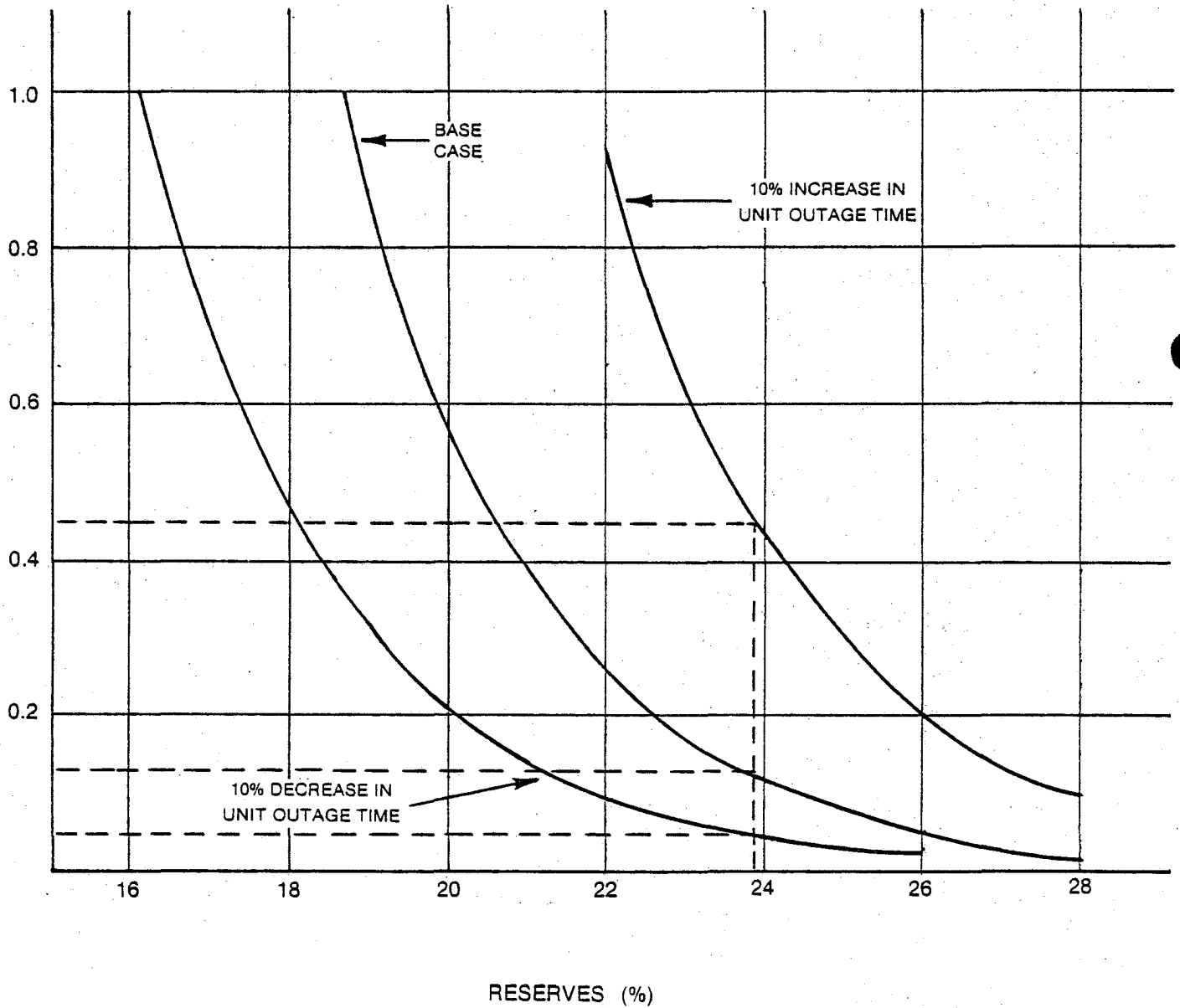


FIGURE 3
PENINSULAR FLORIDA
AVAILABILITY SENSITIVITY ANALYSIS
L.O.L.P. VS. RESERVES
(1987)

L. O. L. P.
(DAYS
PER YEAR)



PENINSULAR FLORIDA
BASE LOAD UNIT DELAY SENSITIVITY
(L.O.L.P. VS. YEAR)

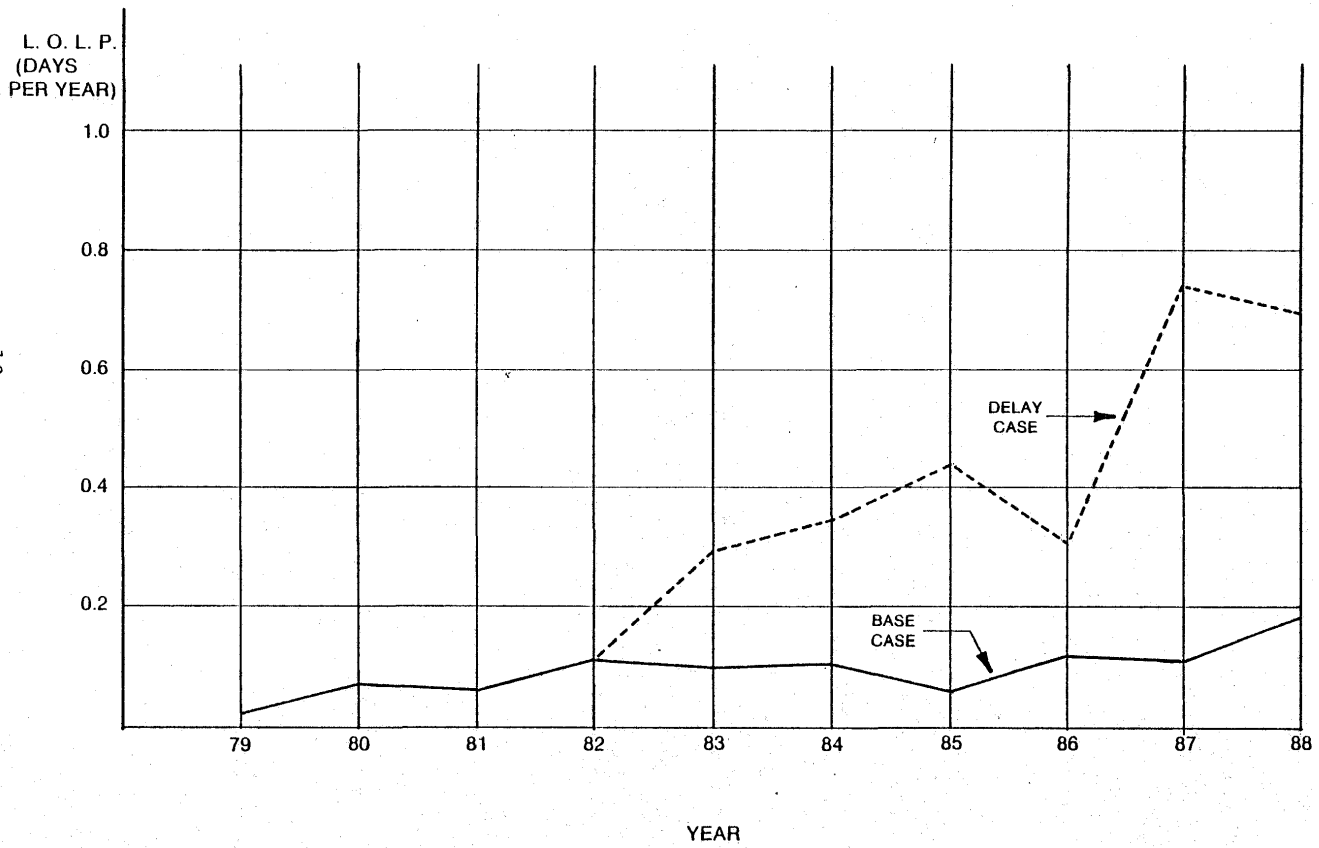


FIGURE 4

IV. DISCUSSION

A. Loss-of-Load Probability (LOLP)

LOLP is a reliability index expressed in units of Days per Year and is the expected value of the number of days that there will be insufficient generation capacity available to serve the expected firm load. The analysis is based upon net generation capability and diversified system net daily peak loads. Transmission and distribution limitations are not accounted for, and thus, this does not reflect the ultimate reliability of service to a customer.

B. Load Uncertainty

The load levels as forecasted are considered uncertain due to weather conditions only. The probabilities of falling short or exceeding the forecasted loads can be found in Appendix A.

C. Maintenance Scheduling

Planned maintenance requirements are input to the OGP program as a percent of time. The program groups like units and schedules outage time on a monthly basis to optimize system reliability for the total Peninsular Florida system. The maintenance requirements in percent of time are included in Appendix B for all units.

D. Forced Outage Rates

Forced outage rates combined with the unit capabilities are used to calculate outage probability tables or the probability of losing the reserve capacity for the generation system configuration which is accumulated to determine the annual LOLP. The forced outage rate for each unit is included in Appendix B.

E. Multi-Area Reliability Analysis

The Peninsular Florida electric power system is of such complexity, a multi-area evaluation approach should be considered. Appendix C was prepared as an introduction to this concept for information only. Future Generation Task Force studies will pursue this subject in more detail.

APPENDIX A

LOAD DATA

UTILITY SYSTEM ANNUAL PEAK LOADS - MW

Year	FPC	FPL	FTP	GVL	HST	JEA	LWU	LAK	OUC	SEC	TAL	TEC	VER	Total*
1979	3873	8546	73	183	38	1393	65	262	486	1105	278	1960	70	17497
1980	4200	9069	77	194	40	1481	68	314	509	1228	295	2055	75	18667
1981	4460	9423	81	206	42	1582	71	339	533	1366	316	2104	80	19614
1982	4730	9770	85	218	44	1687	75	367	558	1507	336	2159	85	20579
1983	4980	10123	89	230	46	1797	79	389	583	1663	358	2235	91	21562
1984	5240	10473	94	244	49	1911	83	412	609	1835	380	2323	97	22591
1985	5480	10818	99	258	51	2044	87	437	635	2025	406	2411	104	23630
1986	5730	11163	104	272	53	2182	91	463	663	2235	432	2501	111	24710
1987	5960	11510	109	287	56	2327	96	491	691	2466	460	2588	118	25802
1988	6190	11843	115	304	59	2477	101	516	721	2721	489	2678	126	26911
AAGR	5.3	3.7	5.2	5.8	5.0	6.6	5.0	7.8	4.5	10.5	6.5	3.3	6.7	4.9

*Diversified

LOAD FORECAST PROBABILITY DISTRIBUTION

<u>Probability</u>	<u>Percent of Peak Load</u>
0.05	93.0
0.20	96.0
0.50	100.0
0.20	105.0
0.05	107.0

Source: Load and Energy Task Force

MONTHLY DIVERSITY FACTORS

<u>Month</u>	<u>Diversity Factor</u>	<u>Month</u>	<u>Diversity Factor</u>
January	0.972	July	0.984
February	0.968	August	0.981
March	0.966	September	0.985
April	0.985	October	0.984
May	0.973	November	0.979
June	0.981	December	0.975

Source: Load and Energy Task Force

*Note: The September Diversity Factor was mistakenly input as 0.965. However, due to the cost and time required for correction and minimal estimated impact, the study was not rerun.

INTERRUPTIBLE LOAD

<u>Year</u>	<u>MW</u>	<u>Year</u>	<u>MW</u>
1979	501	1984	662
1980	561	1985	685
1981	567	1986	715
1982	601	1987	742
1983	629	1988	767

APPENDIX B

GENERATION DATA

PLANNED ADDITIONS, CONVERSION AND RETIREMENTS
1979 - 1988

<u>YEAR</u>	<u>UTILITY</u>	<u>UNIT DESIGNATION</u>	<u>SIZE (MW)</u>	<u>UNIT* TYPE</u>	<u>REMARKS</u>
1979	FPC	ANCLOTE 2	466	OIL	ADDITION
	FPC	CRYSTAL RIVER 1	383	COAL	CONVERSION
1980	FPC	CRYSTAL RIVER 2	50	COAL	INCREASED RATING
	JEA	KENNEDY 6	54	C.T.	REACTIVATION
	FPL	MARTIN 1	775	OIL	ADDITION
	FPC	SUWANNEE P1	51	C.T.	ADDITION
	FPC	SUWANNEE P2	51	C.T.	ADDITION
	FPC	SUWANNEE P3	51	C.T.	ADDITION
	HST	IVEY 20	7	DIE	ADDITION
	HST	IVEY 21	7	DIE	ADDITION
1981	FPL	MARTIN 2	775	OIL	ADDITION
	FPC	SUWANNEE P4	51	C.T.	ADDITION
	FPC	SIMPLE CYCLE A1,A2,A3	150	C.T.	ADDITION
	GVL	DEERHAVEN 2	235	COAL	ADDITION
	LAK	McINTOSH 3	334	COAL	ADDITION
	GVL	J. R. KELLY 6	-14	OIL	RETIREMENT
1982	FPC	CRYSTAL RIVER 4	640	COAL	ADDITION
	OUC	LAKE HIGHLAND 1-3	-90	OIL	RETIREMENT

*Notes:

C.C. - Combined Cycle
C.T. - Combustion Turbine
NUC - Nuclear
DIE - Diesel

PLANNED ADDITIONS, CONVERSIONS AND RETIREMENTS
1979 - 1988

<u>YEAR</u>	<u>UTILITY</u>	<u>UNIT DESIGNATION</u>	<u>SIZE (MW)</u>	<u>UNIT* TYPE</u>	<u>REMARKS</u>
1983	FPL	ST. LUCIE 2	802	NUC	ADDITION
	SEC	SEMINOLE 1	600	COAL	ADDITION
	FPC	SIMPLE CYCLE B1, B2	100	C.T.	ADDITION
	FPC	SIMPLE CYCLE C1	100	C.T.	ADDITION
	TEC	BIG BEND GT 4 & 5	100	C.T.	ADDITION
	LAK	LARSEN 4	-19	OIL	RETIREMENT
	FTP	KING 5	-7	OIL	RETIREMENT
1984	FPC	CRYSTAL RIVER 5	640	COAL	ADDITION
	TEC	BIG BEND GT 6 & 7	100	C.T.	ADDITION
	TAL	PURDOM 1,3,4	-28	OIL	RETIREMENT
1985	FPL	MARTIN COAL 1	700	COAL	ADDITION
	FPC	UNKNOWN 1	660	COAL	ADDITION
	TEC	BIG BEND 4	417	COAL	ADDITION
	SEC	SEMINOLE 2	600	COAL	ADDITION
	FPC	AVON PARK 2	-42	OIL	RETIREMENT
	TAL	HOPKINS 3	50	C.T.	ADDITION
	JEA	UNKNOWN 1,2,3	150	C.T.	ADDITION
1986	LWU	SMITH 1	-7	OIL	RETIREMENT
	JEA	UNKNOWN 4,5,6	150	C.T.	ADDITION
	FPC	SUWANNEE 1-2	-67	OIL	RETIREMENT
	OUC	LAKE HIGHLAND 1,2	-26	C.T.	RETIREMENT

*Notes:

C.C. - Combined Cycle
C.T. - Combustion Turbine
NUC - Nuclear
DIE - Diesel

PLANNED ADDITIONS, CONVERSIONS AND RETIREMENTS
1979 - 1988

<u>YEAR</u>	<u>UTILITY</u>	<u>UNIT DESIGNATION</u>	<u>SIZE (MW)</u>	<u>UNIT* TYPE</u>	<u>REMARKS</u>
1987	JEA	JOINT COAL 1	600	COAL	ADDITION
	FPL	MARTIN COAL 2	700	COAL	ADDITION
	FPC	UNKNOWN 2	660	COAL	ADDITION
	OUC	UNKNOWN 1	400	COAL	ADDITION
	TAL	UNKNOWN 1	200	COAL	ADDITION
1988	FTP	KING 6	-18	OIL	RETIREMENT
	LWU	SMITH 2	-7	OIL	RETIREMENT
	LAK	LARSEN 1	-11	C.T.	RETIREMENT
	LAK	LARSEN 2	-11	C.T.	RETIREMENT
	LAK	LARSEN 3	-11	C.T.	RETIREMENT

*Notes:

C.C. - Combined Cycle
C.T. - Combustion Turbine
NUC - Nuclear
DIE - Diesel

PENINSULAR FLORIDA GENERATION

RELIABILITY STUDY

Utility	Plant	Unit No.	Unit Type	In- Service	Retirements Through 1988	Net Capability-MW		Mature Outage Rate - %	
						Summer	Winter	Forced	Planned
FPC	Anclote	1	FS	11/74	----	466	506	2.0	9.0
FPC	Anclote	2	FS	6/79	----	466	506	2.0	10.0
FPC	Avon Park	2	FS	11/52	6/85	42	44	0.5	6.0
FPC	Avon Park	1	CT	12/68	----	26	35	15.8	1.0
FPC	Avon Park	2	CT	3/69	----	26	35	15.8	1.0
FPC	Bartow	1	FS	9/58	----	114	114	2.2	8.0
FPC	Bartow	2	FS	8/61	----	116	116	0.7	9.0
FPC	Bartow	3	FS	7/63	----	210	215	3.6	7.0
FPC	Bartow	1-4	CT	7/72	----	168	204	21.6	2.7
FPC	Bayboro	1-4	CT	4/73	----	160	208	3.2	1.0
FPC	Crystal River	1	FS	10/66	10/78	383	383	8.4	8.0
FPC	Crystal River	11	C	5/79	----	383	383	8.4	16.0
FPC	Crystal River	2	C	11/69	3/77	383	413	8.0	12.0
FPC	Crystal River	22	C	4/79	----	383	413	8.0	8.0
FPC	Crystal River (827p)	3	N	3/77	----	744	758	13.0	12.0
FPC	Crystal River	4	C	12/82	----	640	640	8.0	12.0
FPC	Crystal River	5	C	4/84	----	640	640	8.0	12.0
FPC	DeBary	1	CT	2/76	----	42	52	38.5	2.7
FPC	DeBary	2	CT	3/76	----	42	52	38.5	2.7
FPC	DeBary	3	CT	12/75	----	42	52	38.5	2.7
FPC	DeBary	4	CT	4/76	----	42	52	38.5	2.7
FPC	DeBary	5	CT	12/75	----	42	52	38.5	2.7
FPC	DeBary	6	CT	4/76	----	42	52	38.5	2.7
FPC	Higgins	1	FS	6/51	10/81	39	40	5.8	6.0
FPC	Higgins	2	FS	6/53	10/81	39	41	1.8	6.0
FPC	Higgins	3	FS	1/54	10/81	41	42	4.7	6.0
FPC	Higgins	1	CT	3/69	----	27	30	15.7	1.0
FPC	Higgins	2	CT	4/69	----	27	30	15.7	1.0
FPC	Higgins	3	CT	12/70	----	30	35	15.7	1.0
FPC	Higgins	4	CT	1/71	----	30	35	15.7	1.0

PENINSULAR FLORIDA GENERATION

RELIABILITY STUDY

Utility	Plant	Unit No.	Unit Type	In- Service	Retirements Through 1988	Net Capability-MW		Mature Outage Rate - %	
						Summer	Winter	Forced	Planned
FPC	Intercession	1-6	CT	5/74	----	264	330	3.1	1.0
FPC	Port St. Joe	1	CT	12/70	----	14	17	25.6	1.0
FPC	Rio Pinar	1	CT	11/70	----	14	17	35.2	1.0
FPC	Suwannee River	1	FS	11/53	6/86	34	34	2.6	7.0
FPC	Suwannee River	2	FS	11/54	6/86	33	33	3.0	7.0
FPC	Suwannee River	3	FS	10/56	----	80	80	3.7	8.0
FPC	Suwannee River	1	CT	10/80	----	51	51	3.1	1.0
FPC	Suwannee River	2	CT	10/80	----	51	51	3.1	1.0
FPC	Suwannee River	3	CT	10/80	----	51	51	3.1	1.0
FPC	Suwannee River	4	CT	5/81	----	51	51	3.1	1.0
FPC	Turner	3	FS	11/55	----	71	72	4.0	7.0
FPC	Turner	4	FS	5/59	----	72	75	8.0	7.0
FPC	Turner	1-2	CT	10/70	----	28	34	8.3	1.0
FPC	Turner	3-4	CT	8/74	----	124	162	31.7	2.7
FPC	Simple Cycle YC	1	CT	10/83	----	100	100	3.1	1.0
FPC	Unknown	1	C	10/85	----	660	660	13.0	15.0
FPC	Unknown	2	C	10/87	----	660	660	13.0	15.0
FPC	Simple Cycle YA	1	CT	10/81	----	50	50	3.1	1.0
FPC	Simple Cycle YA	2	CT	10/81	----	50	50	3.1	1.0
FPC	Simple Cycle YA	3	CT	10/81	----	50	50	3.1	1.0
FPC	Simple Cycle YB	1	CT	10/83	----	50	50	3.1	1.0
FPC	Simple Cycle YB	2	CT	10/83	----	50	50	3.1	1.0

PENINSULAR FLORIDA GENERATION

RELIABILITY STUDY

Utility	Plant	Unit No.	Unit Type	In-Service	Retirements Through 1988	Net Capability-MW		Mature Outage Rate - %	
						Summer	Winter	Forced	Planned
FPL	Cape Canaveral	1	FS	4/65	----	367	370	7.6	10.5
FPL	Cape Canaveral	2	FS	5/69	----	362	366	7.6	10.5
FPL	Ft. Myers	1	FS	11/58	----	137	139	15.3	7.0
FPL	Ft. Myers	2	FS	7/69	----	367	370	7.6	10.5
FPL	Ft. Myers	1-12	CT	5/74	----	672	828	3.0	10.0
FPL	Lauderdale	4	FS	9/57	----	137	139	15.3	7.0
FPL	Lauderdale	5	FS	4/58	----	137	139	15.3	7.0
FPL	Lauderdale	1-12	CT	8/70	----	426	486	3.0	10.0
FPL	Lauderdale	13-24	CT	8/72	----	426	486	3.0	10.0
FPL	Manatee	1	FS	10/76	----	764	775	9.1	10.5
FPL	Manatee	2	FS	12/77	----	764	775	9.1	10.5
FPL	Martin	1	FS	6/80	----	775	775	9.1	10.5
FPL	Martin	2	FS	6/81	----	775	775	9.1	10.5
FPL	Port Everglades	1	FS	5/60	----	204	206	15.3	7.0
FPL	Port Everglades	2	FS	4/61	----	204	206	15.3	7.0
FPL	Port Everglades	3	FS	6/64	----	367	370	7.6	10.5
FPL	Port Everglades	4	FS	4/65	----	367	370	7.6	10.5
FPL	Port Everglades	1-5	D	1/69	----	14	14	10.0	5.0
FPL	Port Everglades	1-12	CT	8/71	----	426	486	3.0	10.0
FPL	Putnam	2	CC	8/77	----	223	259	15.0	8.5
FPL	Putnam	1	CC	5/78	----	223	259	15.0	8.5
FPL	Riviera	3	FS	5/62	----	272	275	7.6	10.5
FPL	Riviera	4	FS	3/63	----	272	275	7.6	10.5
FPL	Sanford	3	FS	5/59	----	137	139	15.3	7.0
FPL	Sanford	4	FS	8/72	----	362	366	7.6	10.5
FPL	Sanford	5	FS	6/73	----	362	366	7.6	10.5
FPL	St. Lucie	1	N	12/76	----	777	795	12.5	15.4
FPL	St. Lucie (802p)	2	N	6/83	----	747	747	12.5	15.4
FPL	Riviera	1	FS	11/46	----	40	41	15.3	7.0
FPL	Riviera	2	FS	11/53	----	69	71	15.3	7.0

PENINSULAR FLORIDA GENERATION

RELIABILITY STUDY

<u>Utility</u>	<u>Plant</u>	<u>Unit No.</u>	<u>Unit Type</u>	<u>In- Service</u>	<u>Retirements Through 1988</u>	<u>Net Capability-MW</u>		<u>Mature Outage Rate - %</u>	
						<u>Summer</u>	<u>Winter</u>	<u>Forced</u>	<u>Planned</u>
FPL	Turkey Point	1	FS	4/67	----	367	370	7.6	10.5
FPL	Turkey Point	2	FS	4/68	----	367	370	7.6	10.5
FPL	Turkey Point	3	N	11/72	----	666	696	12.5	15.4
FPL	Turkey Point	4	N	9/73	----	666	696	12.5	15.4
FPL	Turkey Point	1-5	D	1/69	----	13.5	13.5	10.0	5.0
FPL	JEA/FPL Coal (600p)	1	C	5/87	----	300	300	16.0	13.5
FPL	Martin Coal	1	C	1/85	----	700	700	16.0	13.5
FPL	Martin Coal	2	C	1/87	----	700	700	16.0	13.5

PENINSULAR FLORIDA GENERATION

RELIABILITY STUDY

<u>Utility</u>	<u>Plant</u>	<u>Unit No.</u>	<u>Unit Type</u>	<u>In- Service</u>	<u>Retirements Through 1988</u>	<u>Net Capability-MW</u>		<u>Mature Outage Rate - %</u>	
						<u>Summer</u>	<u>Winter</u>	<u>Forced</u>	<u>Planned</u>
FTP	King	5	FS	1/53	12/83	7	7	3.0	3.0
FTP	King	6	FS	1/58	12/88	18	18	5.0	7.7
FTP	King	7	FS	1/64	----	35	35	5.0	7.7
FTP	King	8	FS	5/76	----	51	51	5.0	7.7
FTP	King	1	D	4/70	----	2	2	3.0	3.0
FTP	King	2	D	4/70	----	3	3	3.0	3.0

PENINSULAR FLORIDA GENERATION

RELIABILITY STUDY

<u>Utility</u>	<u>Plant</u>	<u>Unit No.</u>	<u>Unit Type</u>	<u>In- Service</u>	<u>Retirements Through 1988</u>	<u>Net Capability-MW</u>		<u>Mature Outage Rate - %</u>	
						<u>Summer</u>	<u>Winter</u>	<u>Forced</u>	<u>Planned</u>
GVL	Crystal River (827p)	3	N	3/77	----	12	12	12.0	13.0
GVL	Deerhaven	1	FS	8/72	----	81	83	1.5	3.0
GVL	Deerhaven	1	CT	8/76	----	20	26	6.1	4.0
GVL	Deerhaven	2	CT	8/76	----	20	26	7.1	4.0
GVL	J. R. Kelly	6	FS	3/58	1/81	14	14	2.5	4.0
GVL	J. R. Kelly	7	FS	8/61	----	23	23	2.9	4.0
GVL	J. R. Kelly	8	FS	4/65	----	44	45	2.8	4.0
GVL	J. R. Kelly	1	CT	5/68	----	14	14	18.2	4.0
GVL	J. R. Kelly	2	CT	9/68	----	14	14	11.1	4.0
GVL	J. R. Kelly	3	CT	2/69	----	14	14	11.8	4.0
GVL	Deerhaven	2	C	1/81	----	235	235	7.0	7.1

PENINSULAR FLORIDA GENERATION

RELIABILITY STUDY

<u>Utility</u>	<u>Plant</u>	<u>Unit No.</u>	<u>Unit Type</u>	<u>In- Service</u>	<u>Retirements Through 1988</u>	<u>Net Capability-MW</u>		<u>Mature Outage Rate - %</u>	
						<u>Summer</u>	<u>Winter</u>	<u>Forced</u>	<u>Planned</u>
HST	Ivey	1	D	10/71	----	2	2	5.0	5.0
HST	Ivey	2-3	D	3/70	----	2	2	5.0	5.0
HST	Ivey	7	D	1/54	----	1	1	5.0	5.0
HST	Ivey	8-9	D	1/54	----	3	3	5.0	5.0
HST	Ivey	10	D	1/54	----	3	3	5.0	5.0
HST	Ivey	11-12	D	1/65	----	4	4	5.0	5.0
HST	Ivey	13-17	D	11/72	----	2	2	5.0	5.0
HST	Ivey	18	D	4/75	----	9	9	5.0	5.0
HST	Ivey	19	D	2/75	----	9	9	5.0	5.0
HST	Ivey	20-21	D	4/80	----	7	7	5.0	5.0

PENINSULAR FLORIDA GENERATION

RELIABILITY STUDY

Utility	Plant	Unit No.	Unit Type	In-Service	Retirements Through 1988	Net Capability-MW		Mature Outage Rate - %	
						Summer	Winter	Forced	Planned
JEA	Kennedy	8	FS	7/55	----	43	45	2.2	4.6
JEA	Kennedy	9	FS	1/58	----	43	45	0.70	8.5
JEA	Kennedy	10	FS	12/61	----	130	134	4.60	5.0
JEA	Kennedy	1	CT	2/69	2/78	12.5	13	11.57	4.98
JEA	Kennedy	2	CT	2/69	2/78	12.5	13	11.91	5.12
JEA	Kennedy	3	CT	7/73	----	53.5	53.5	31.3	2.4
JEA	Kennedy	4	CT	1/75	----	54.5	54.5	26.20	2.4
JEA	Kennedy	5	CT	1/75	----	53.5	53.5	30.0	2.4
JEA	Kennedy	6	CT	7/73	3/78	54.5	54.5	24.12	10.37
JEA	Northside	1	FS	11/66	----	262	262	6.2	4.6
JEA	Northside	2	FS	3/72	----	262	262	7.4	5.8
JEA	Northside	3	FS	7/77	----	460	460	5.0	5.3
JEA	Northside	1	CT	10/68	10/75	11.5	14	9.86	4.24
JEA	Northside	2	CT	10/68	10/75	11.5	14	15.59	6.70
JEA	Northside	3	CT	1/75	----	51.25	61.25	12.7	2.4
JEA	Northside	4	CT	1/75	----	51.25	61.25	12.7	2.4
JEA	Northside	5	CT	1/75	----	51.25	61.25	14.5	2.4
JEA	Northside	6	CT	1/75	----	51.25	61.25	14.50	2.4
JEA	Southside	1	FS	11/50	----	27	27	1.1	8.5
JEA	Southside	2	FS	1/51	----	29	32	3.5	8.5
JEA	Southside	3	FS	1/55	----	46	48	3.7	8.5
JEA	Southside	4	FS	11/58	----	70	72	3.7	8.5
JEA	Southside	5	FS	9/64	----	144	146	0.5	4.6
JEA	Southside	1	CT	2/69	2/78	12.5	15	7.87	3.38
JEA	Southside	2	CT	2/69	2/78	12.5	15	6.88	2.96
JEA	JEA/FPL Coal (600p)	1	C	5/87	----	300	300	16.00	13.5
JEA	Unknown	1-3	CT	5/85	----	150		13.8	2.4
JEA	Unknown	4-6	CT	5/86	----	150		13.8	2.4

PENINSULAR FLORIDA GENERATION

RELIABILITY STUDY

<u>Utility</u>	<u>Plant</u>	<u>Unit No.</u>	<u>Unit Type</u>	<u>In- Service</u>	<u>Retirements Through 1988</u>	<u>Net Capability-MW</u>		<u>Mature Outage Rate - %</u>	
						<u>Summer</u>	<u>Winter</u>	<u>Forced</u>	<u>Planned</u>
LAK	Larsen	4	FS	1/50	3/83	19	19	6.8	9.6
LAK	Larsen	5	FS	1/56	----	25	25	2.2	9.6
LAK	Larsen	6	FS	1/59	----	25	25	5.1	9.6
LAK	Larsen	7	FS	1/66	----	49	52	5.0	9.6
LAK	Larsen	1-3	CT	1/62	3/88	33	39	10.0	5.8
LAK	McIntosh	1	FS	1/70	----	92	93	1.9	9.6
LAK	McIntosh	2	FS	4/76	----	104	102	1.9	9.6
LAK	McIntosh	1	D	1/69	----	5	6	1.0	3.8
LAK	McIntosh	1	CT	1/73	----	20	23	10.0	3.8
LAK	McIntosh (334p)	3	C	10/81	----	200	200	8.0	10.0
LAK	Unknown (OUC 400p)	1	C	5/87	----	150	150	12.0	15.0

PENINSULAR FLORIDA GENERATION

RELIABILITY STUDY

<u>Utility</u>	<u>Plant</u>	<u>Unit No.</u>	<u>Unit Type</u>	<u>In- Service</u>	<u>Retirements Through 1988</u>	<u>Net Capability-MW</u>		<u>Mature Outage Rate - %</u>	
						<u>Summer</u>	<u>Winter</u>	<u>Forced</u>	<u>Planned</u>
LWU	Tom G. Smith	1	FS	1/61	1/86	7	8	4.0	5.0
LWU	Tom G. Smith	2	FS	3/63	3/88	7	8	4.0	5.0
LWU	Tom G. Smith	3	FS	11/67	----	25	26	2.0	7.0
LWU	Tom G. Smith	4	FS	8/71	----	33	35	2.0	7.0
LWU	Tom G. Smith	1-5	D	12/65	----	10	10	1.0	2.0
LWU	Tom G. Smith	1	CT	8/76	----	29	32	10.0	15.0
LWU	Tom G. Smith	5	CC	3/78	----	30	35	5.0	12.0

PENINSULAR FLORIDA GENERATION
RELIABILITY STUDY

<u>Utility</u>	<u>Plant</u>	<u>Unit No.</u>	<u>Unit Type</u>	<u>In- Service</u>	<u>Retirements Through 1988</u>	<u>Net Capability-MW</u>		<u>Mature Outage Rate - %</u>	
						<u>Summer</u>	<u>Winter</u>	<u>Forced</u>	<u>Planned</u>
OUC	Crystal River (827p)	3	N	3/77	----	13	13	13.0	12.0
OUC	Indian River	1	FS	2/60	----	90	92	1.0	14.0
OUC	Indian River	2	FS	12/64	----	204	208	2.5	16.0
OUC	Indian River	3	FS	2/74	----	318	321	4.0	18.0
OUC	Lake Highland	1	FS	9/49	12/82	30	31	0.1	8.0
OUC	Lake Highland	2	FS	9/54	12/82	30	31	0.1	8.0
OUC	Lake Highland	3	FS	6/56	12/82	30	31	0.1	8.0
OUC	Lake Highland	1-2	CT	12/58	12/86	26	32	0.1	6.0
OUC	McIntosh (334p)	3	C	10/81	----	134	134	8.0	10.0
OUC	Unknown (400p)	1	C	5/87	----	150	150	12.0	15.0

PENINSULAR FLORIDA GENERATION

RELIABILITY STUDY

<u>Utility</u>	<u>Plant</u>	<u>Unit No.</u>	<u>Unit Type</u>	<u>In- Service</u>	<u>Retirements Through 1988</u>	<u>Net Capability-MW</u>		<u>Mature Outage Rate - %</u>	
						<u>Summer</u>	<u>Winter</u>	<u>Forced</u>	<u>Planned</u>
SEC	Seminole	1	C	5/83	----	600	600	7.3	7.7
SEC	Seminole	2	C	5/85	----	600	600	7.3	7.7
SEC	St. Lucie (802p)	2	N	6/83	----	48	-	-	-
SEC	Crystal River (827p)	3	N	3/77	----	14	-	-	-

PENINSULAR FLORIDA GENERATION

RELIABILITY STUDY

<u>Utility</u>	<u>Plant</u>	<u>Unit No.</u>	<u>Unit Type</u>	<u>In- Service</u>	<u>Retirements Through 1988</u>	<u>Net Capability-MW</u>		<u>Mature Outage Rate - %</u>	
						<u>Summer</u>	<u>Winter</u>	<u>Forced</u>	<u>Planned</u>
TAL	Crystal River (827p)	3	N	3/77	----	11	11	12.0	13.0
TAL	Hopkins	1	FS	5/71	----	78	80	0.5	4.0
TAL	Hopkins	2	FS	10/77	----	225	238	0.5	4.0
TAL	Hopkins	1	CT	2/70	----	14	15.5	0.2	3.5
TAL	Hopkins	2	CT	9/72	----	26.5	30	0.2	1.8
TAL	Purdum	1-2	FS	1/52	5/84	14	16	2.0	5.0
TAL	Purdum	3	FS	1/52	5/84	7	8	1.0	5.5
TAL	Purdum	4	FS	4/54	5/84	7.4	7.6	0.6	4.0
TAL	Purdum	5	FS	4/58	----	22	22	0.4	4.5
TAL	Purdum	6	FS	1/61	----	22	22	0.4	4.5
TAL	Purdum	7	FS	6/66	----	45.5	45.5	2.5	5.0
TAL	Purdum	1	CT	12/63	----	11	11.5	0.2	2.0
TAL	Purdum	2	CT	5/64	----	11	11.5	0.2	2.0
TAL	Hopkins	3	CT	5/85	----	50	50	0.2	2.0
TAL	Unknown	1	C	4/87	----	200	200	0.2	4.0

PENINSULAR FLORIDA GENERATION

RELIABILITY STUDY

Utility	Plant	Unit No.	Unit Type	In- Service	Retirements Through 1988	Net Capability-MM		Mature Outage Rate - %	
						Summer	Winter	Forced	Planned
TEC	Big Bend	1	C	11/70	----	362	362	8.0	15.0
TEC	Big Bend	2	C	4/73	----	338	338	8.0	15.0
TEC	Big Bend	3	C	5/76	----	362	362	8.0	15.0
TEC	Big Bend	1	CT	1/69	----	14	14	1.0	6.0
TEC	Big Bend	2-3	CT	11/74	----	130	130	8.0	8.0
TEC	Gannon	1	FS	9/57	----	98	98	5.0	10.0
TEC	Gannon	2	FS	11/58	----	108	108	5.0	10.0
TEC	Gannon	3	FS	10/60	----	150	150	5.0	10.0
TEC	Gannon	4	FS	11/63	----	169	169	5.0	10.0
TEC	Gannon	5	C	11/65	----	229	229	12.0	15.0
TEC	Gannon	6	C	11/67	----	338	338	20.0	15.0
TEC	Gannon	1	CT	1/69	----	14	14	1.0	6.0
TEC	Hookers Point	1	FS	7/48	----	28	28	5.0	8.0
TEC	Hookers Point	2	FS	6/50	----	29	29	5.0	8.0
TEC	Hookers Point	3	FS	8/50	----	28	28	5.0	8.0
TEC	Hookers Point	4	FS	10/53	----	42	42	5.0	8.0
TEC	Hookers Point	5	FS	6/55	----	66	66	10.0	8.0
TEC	Big Bend	4-5	CT	3/83	----	100	100	5.0	8.0
TEC	Big Bend	6-7	CT	3/84	----	100	100	5.0	8.0
TEC	Big Bend	4	C	3/85	----	417	417	14.0	15.0

PENINSULAR FLORIDA GENERATION

RELIABILITY STUDY

<u>Utility</u>	<u>Plant</u>	<u>Unit No.</u>	<u>Unit Type</u>	<u>In- Service</u>	<u>Retirements Through 1988</u>	<u>Net Capability-MW</u>		<u>Mature Outage Rate - %</u>	
						<u>Summer</u>	<u>Winter</u>	<u>Forced</u>	<u>Planned</u>
VER	Municipal Plant	1	FS	11/61	----	12	12	5.0	7.6
VER	Municipal Plant	2	FS	8/64	----	17	17	5.0	7.6
VER	Municipal Plant	3	FS	9/71	----	33	33	5.0	7.6
VER	Municipal Plant	4	FS	5/76	----	56	56	5.0	7.6

APPENDIX C

RELIABILITY METHODS

APPENDIX C

A survey of Adequacy and Reliability Methods and Techniques and Generation Planning Programs Applicable to Multi-Area Systems

A. Adequacy and Reliability Methods

1. Percent Reserve Method

This method is probably the oldest and most simple. It is easily computed and is sensitive to only two factors (capacity and load). It is, however, insensitive to forced outage rates, unit sizes and load characteristics.

2. Loss of Largest Unit Method

This method is similar to the previous one except that the capacity of the largest unit is added to the load prior to computing the reserve. Like the previous method, it is easily computed and is sensitive to capacity, load and unit size. It is, however, insensitive to forced outage rates and load characteristics.

3. Loss of Load Probability Method (LOLP)

This method is the most widely accepted and used one in the industry. It is sensitive to unit size, forced outage rates, planned outage rates and load characteristics. It is more clearly defined as the expected value of the frequency of capacity deficiency. Each deficiency in capacity to serve the daily peak load is given an equal weighting regardless of the amount of the deficiency.

4. Loss of Energy Probability Method (LOEP)

This method is similar in computational techniques to the LOLP method. It is sensitive to the same parameters. Each deficiency in capacity is weighted by the percentage of load energy that must be interrupted by the deficiency. It provides a measure of the frequency of unserved load times the magnitudes of the unserved load.

5. Frequency and Duration Method

This method calculates the same risk index as LOLP (days/year), calculates the frequency in which deficiencies occur and the expected duration of the outage. It does, however, require two additional data sets and increases the computation time.

B. Generation Planning Programs

1. Large-Scale Mathematical Programming Models

These models sacrifice a certain amount of detail to make a regional utility system fit the computer program.

2. Hour-by-Hour Simulation Models

These models can be very costly because of the amount of detail involved. OGP and other production simulation programs are examples of this type of model.

3. Regional Electric Utility Operational Model (GE and EPRI)

This is a production simulation model designed specifically for use on very large power generation systems the size of an FPC region or NERC coordinating council. This model is an extension of existing generation planning models. A major asset of this model is the flexibility to consider dollar costs alone or a weighted combination of dollar costs and environmental emissions. Up to four service areas can be analyzed, including interconnections to capture the impact of power pooling and related activities.

Examples of Use of Various Adequacy and Reliability Methods for Multi-Area Analysis

1. CAPCO Group, August 1969, Use of LOLP

Each member must maintain a minimum reliability level to assure an adequate overall level of reliability for the group of one day in ten years.

The reliability index is determined from a frequency distribution of daily capacity margins.

The load model consists of 12 monthly peak-hour load duration curves representing daily peak loads for a total of 252 days. The group composite load consisted of the sum of the individual utility monthly peak-hour loads with no diversity.

A probabilistic capacity model, representing each unit, its random outage rate, its seasonal or condition derating and its scheduled maintenance is developed. All generating units were lumped into a single system. Scheduled maintenance was done on a coordinated "one-system" basis.

The load and capacity models are merged over a period of one year to give a frequency distribution of daily capacity margins. The point at which the daily capacity margin approaches zero would indicate the level of the reliability index.

This application of the LOLP method assumes the system generators are on the same electrical bus; therefore, no transmission system effects are included.

2. Patton and Holditch, Electric Power Institute, January 1968

The method used here is frequency/duration. It is a theoretical treatment of two systems with a transmission line between the two.

It uses two measures of reliability. One is the expected rate at which total available system generating capacity is insufficient to supply the load (capacity deficiency rate). The other is the expected duration of capacity deficient periods. The product of these quantities is the expected capacity deficient time per year.

The basic method for estimating the expected capacity deficiency rate of a single system can be extended to study interconnected systems by modifying the reliability of the generating system by the reliability characteristics of the transmission line connecting the systems.

3. Vassell and Tibberts, American Electric Power Service Corp., January 1971.

This is an application of the LOLP method to interconnected systems. Capacity margin distribution curves are developed for each system. These distributions, either with or without consideration of transmission limitation, are combined using convolution equations. A looped system is converted to an equivalent radial system to reduce the complexity of the solution.

4. Multi-Area LOLP

In Appendix A of the previous generation reliability report dated August 23, 1978, the method of calculating the annual loss-of-load probability (LOLP) was presented. The example used in this write-up was for an isolated power system, or single area, without considering any interconnections. The basic difference between the single area and the multi-area LOLP method is to take into consideration the benefits that interconnecting has on increasing the reliability of both areas.

The multi-area LOLP method takes into consideration that the reliability contribution benefits are a function of the benefits that the receiving power systems achieve and the ability of the sending systems to supply power.

The general characteristics of reserve values of interconnections is that the incremental benefit from a small interconnection is large because of the relatively good likelihood that each power system can supply extra capacity when needed. As the interconnection becomes larger, the likelihood that each power system can supply large amounts of power becomes less and the reserve value of the interconnection saturates.

The reserve values of the interconnections are also related to the base LOLP risk index criteria. When the LOLP is small, for example 0.1 days/year, the greater systems have higher reserves and therefore have a greater likelihood of being able to supply large amounts of extra capacity to neighboring utilities.

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**DIV. ENVIRONMENTAL
PERMITTING**

AMENDMENT 2

**TAMPA ELECTRIC COMPANY
BIG BEND STATION UNIT 4
SITE CERTIFICATION APPLICATION**

BIG BEND 4 SITE CERTIFICATION APPLICATION

RESPONSES TO FDER LETTER OF JANUARY 10, 1980

QUESTION 1

The 1971-75 meteorological data base used to model short-term impacts of the proposed facility contains mixing height errors which were corrected by the National Climatic Center and incorporated into a revised data base for the period 1970-74. These latter data should be used in all short-term (3-hour and 24-hour) impact evaluations including evaluations of PSD and nonattainment area impacts.

RESPONSE

In order to assess the effects of the mixing height error on predicted SO₂ concentrations, the PTMTPW scenarios as found in Appendix D of the TECO PSD application were re-run using the revised mixing height data. For the days and periods in question (207/72 and 249/72/4), the corrected mixing heights were for each hour identical to or greater than those used previously. Only the first five hours of the 24-hour case were affected. All hours of the 3-hour case were affected.

For the 24-hour averaging time, no concentration differences greater than roundoff error were observed based upon the modeling results. For the 3-hour averaging period, the corrected concentrations were from 84 ug/m³ to 115 ug/m³ lower than those calculated with the erroneous mixing height data, depending upon receptor location.

RESULT OF MIXING HEIGHT CHANGE

No.	E (km)	Receptor N (km)	Concentrations (ug/m ³)			
			Previous Met. Data		Corrected Met. Data	
			3-hour	24-hour	3-hour	24-hour
1	362.9	3075.0	812.5	149.5	700.1	149.6
2	363.0	3075.0	863.0	149.6	748.2	149.6
3	363.1	3075.0	364.1	149.6	759.1	149.6
4	363.2	3075.0	837.7	149.5	744.7	149.5
5	363.3	3075.0	801.1	149.2	717.3	149.2

Note: Three-hour concentrations based upon Day 249, Period 4, 1972.
Twenty-four hour concentrations based upon Day 207, 1972.

Note: This comparison was made using stack parameters as found in Appendix D of the TECO PSD application. The emissions modeled do not correspond to 100 percent load and these output are not used in determining the maximum impacts as reported in Volume 1 of the application.

In the Big Bend 4 PSD application, it was determined that the worst case 24-hour and 3-hour SO₂ impacts occurred under conditions of Units 1-4 all operating at 100 percent load. Stack parameters from Table 2.1 of the PSD application were input to the CRSTER model along with the revised mixing height data to re-determine the worst 24-hour and 3-hour periods. These periods had previously been calculated as 207/72 and 249/72/4, respectively. The worst periods calculated with the revised mixing heights were 124/72 (24-hour) and 180/74/4 (3-hour).

The CRSTER output was refined by the PTMTPW model to predict concentrations at points 0.1 km apart in a 100-point (1.0 km x 1.0 km) square grid. When the worst day was not clear from CRSTER, more than one PTMTPW was run to ensure that the actual worst day and highest, second highest concentration was identified. The recalculated highest, second highest 24-hour and 3-hour ground level SO₂ concentrations were 187 ug/m³ and 1075 ug/m³, respectively. Compared to the previously calculated values these represent a decrease of 12 ug/m³ for the 3-hour period, and an increase of 2 ug/m³ for the 24-hour period. The location of the receptor receiving the maximum 3-hour impact was shifted to the opposite side of the plant due to a change in the controlling hour of meteorology. Results are summarized in the chart below.

This analysis demonstrates that the error in mixing heights caused no significant error in predicted concentrations, and that the conclusions of the Big Bend 4 PSD application are not affected.

MAXIMUM AIR QUALITY IMPACTS (SO₂)

Load Scenario	Averaging Time	Worst Day	Receptor Location		Concentration (ug/m ³)
			E (km)	N (km)	
Units 1-4 at 100% (Determined with erroneous mixing height data)	24-hour	207/72	367.0	3075.0	185
	3-hour	249/72/4	363.1	3075.0	1087
Units 1-4 at 100% (Revised mixing height data)	24-hour	124/72	366.3	3074.8	187
	3-hour	180/74/4	360.2	3075.0	1075

QUESTION 2

More extensive documentation is needed on the selection of worst-case operating conditions for modeling purposes. Modeling results summarizing worst-case baseline, incremental, and projected operating conditions for both 3-hour and 24-hour impacts should be presented, and scenarios other than those listed should be examined. Of particular interest are scenarios involving Stack #2 only, such as Unit #4 at 100 percent load with Unit #3 at 100, 75, and 50 percent loads.

RESPONSE

When two stacks are situated close enough together to be modeled as a single point, the maximum ground level impact of each plume will occur at the same point when the effective stack heights are equal. In the case of TECO Big Bend, the physical stack heights are equal, thus points of maximum impacts will coincide when the plume rise for each stack is the same.

The Big Bend 4 PSD application had previously determined that when all Units were operating under the same load conditions the maximum impact occurred at 100 percent load. Reduced emissions from lower load conditions were not sufficiently compensated for by decreased plume rise to result in higher ground level concentrations. For this reason, the search for further worst-case operating conditions was limited to identifying the highest load conditions that would result in equal plume rise from the two Big Bend stacks.

According to Briggs¹, rise of a buoyant plume is a function of (1) the average wind speed at stack level, (2) a factor representing the magnitude of the restoring acceleration per unit vertical displacement for adiabatic motion in the atmosphere, and (3) a buoyancy flux parameter, F. For the two stacks of concern, the first two parameters are identical for identical meteorological conditions.

One functional form of the buoyancy flux parameter is:

$$F = g V_s r_s^2 ((T_s - T_a)/T_s)$$

g = gravitational acceleration

V_s = stack exit velocity

r_s = stack diameter

T_s = absolute temperature of stack effluent

T_a = absolute temperature of ambient air

In this case, g, T_a, and r_s for each stack are identical. Thus, F for each stack will be dependent on T_s and V_s; and the plume rises will be equal when F for each stack is equal.

The exit velocity and temperature of each stack at the Big Bend facility will be a function of the output of the two boilers sharing each stack (Units 1 and 2 through Stack 1; Units 3 and 4 through Stack 2). Conservation of mass and energy and the assumption of ideal gas behavior leads to the following functions for the combined velocity and temperature resulting from the mixture of the streams from the individual boilers.

¹ Briggs, Gary. Plume Rise, Air Resources Atmospheric Turbulence and Diffusion Laboratory, Oak Ridge, Tennessee (1969).

$$T_c = \frac{T_1 T_2 (V_1 + V_2)}{V_1 T_2 + V_2 T_1}$$

$$v_c = \frac{V_1 + V_2}{A}$$

V = exit velocity

T = absolute temperature

A = area of stack cross section

V = volumetric flow rate

1, 2 = conditions of streams from individual boilers

c = conditions of combined stream

These equations were used to develop a computer code which identified equal plume rise conditions for 256 combinations of the load scenarios described in Table 2.1 of the PSD application (100%, 75%, 50%, and 0%). The combination of Units 1, 3, and 4 at 100 percent load with Unit 2 at 75 percent load was identified as producing both equal plume rise conditions and maximum SO₂ emissions, thus resulting in worst-case air quality impacts for the interaction case.

CRSTER and PTMTPW models were executed for these conditions to determine worst (highest, second-highest) 24-hour and 3-hour periods and corresponding ground level concentrations. Where the worst day was not clear, each suspected day was input to PTMTPW to ensure accurate determination of the highest, second highest concentration. Where more than one location was suspected of receiving the greatest impact, both were investigated with the PTMTPW model. The calculated 24-hour and 3-hour SO₂ concentrations were 181 ug/m³ and 1006 ug/m³, in both cases less than the maximum concentrations produced when Units 1-4 are all operating at 100 percent load, namely 187 ug/m³, and 1075 ug/m³. The condition of equal plume rise does not represent a worse case than the previously determined (Units 1-4 at 100 percent) worst case. Therefore, it is concluded that the emission scenario of all four units operating at 100 percent load is the worst-case situation for Big Bend.

MAXIMUM AIR QUALITY IMPACTS (SO₂)

Load Scenario	Averaging Time	Worst Day	Receptor Location		Concentration (ug/m ³)
			E (km)	N (km)	
Units 1-4 at 100% (Determined with erroneous mixing height data)	24-hour	207/72	367.0	3075.0	185
	3-hour	249/72/4	363.1	3075.0	1087
Units 1-4 at 100% (Revised mixing height data)	24-hour	124/72	366.3	3074.8	187
	3-hour	180/74/4	360.2	3075.0	1075

QUESTION 3

Since the ratio of stack height to building height for the proposed unit is only 1.86, which is well below the generally accepted "Good Engineering Practice" ratio of 2.5, the potential for building-induced downwash should be examined. The consultant or applicant should also perform a Froude number evaluation to assess the potential for stack-tip downwash.

RESPONSE

After construction of the proposed Unit #4, the tallest structure at Big Bend with the potential for influencing stack emissions will be the boiler house for Unit #4. This building will have approximate dimensions of 130' x 218' and will be approximately 223' high. The formula defining Good Engineering Practice (GEP) stack height is (40 CFR 51):

$$H_{GEP} = H_s + 1.5 L$$

H_s = Height of structure or nearby structure

L = lesser dimension of height or width of the structure or nearby structure

Therefore, GEP for Big Bend would be:

$$H_{GEP} = 223 + 1.5 (218) = 550 \text{ ft.}$$

However, the majority of the structures at Big Bend influencing stack emissions are the three existing boiler areas for Units #1, #2, and #3, which are located adjacent to each other. These structures are all 183' high, with overall dimensions of 445' x 190'. GEP for these structures is 458 ft. Viewing the Big Bend structure in its entirety with the addition of Unit 4, dimensions are approximately 660' x 190', with an average height of about 200'. Therefore, GEP would approximate 485 ft. The existing stacks at Big Bend are 490 feet tall.

Based on the above analysis, and considering the existing stack heights, downwash potential at Big Bend is considered slight. The GEP equation does not consider the buoyance of the effluent gases, which will greatly increase the effective stack height for the emissions. In addition, the new Unit #4 will have the potential to cause downwash only when winds are directed from the south, which occurs about 6 percent of the time in Tampa, and when wind speeds are sufficiently high to severely reduce plume rise.

Concerning the subject of Froude number evaluation to assess the potential for stack tip downwash, ESE has researched the issue and concludes that the Froude number is not a direct indicator of the potential for stack tip downwash. This conclusion is based on conversation with Mr. G. A. Briggs concerning his discussion of this topic in Plume Rise (1969). Briggs references wind tunnel studies that indicate stack tip downwash is slight as long as the stack efflux velocity is greater than 1.5 times the wind velocity at stack height. In a very buoyant plume ($Fr < 1.0$), buoyant forces may counteract some of the adverse pressure forces and permit relaxation of the above criterion. If this criterion is met, however, stack tip downwash should not occur regardless of the magnitude of the Froude number.

QUESTION 4

The estimated volume of flue gas to be discharged from Big Bend Unit #4 appears to be from 519,016 ACFM to 652,780 ACFM too large at 100% load. This error makes the velocity of the flue gas from 19.1 F/S to 24.1 F/S too high. A similar situation exists for the 50% and 75% load conditions. The end result is that the plume rises have been over-predicted and the ground level concentrations under-predicted. Therefore, the mathematical modeling must be redone.

RESPONSE

All dispersion modeling has been performed using the flue gas flow rates given on Table 2.1 of Volume 1 of the PSD application. This discussion will be limited to the 100 percent load case as an example. Design coal parameters and preliminary boiler data were used early last year to calculate the maximum flue gas flow rate given in this table of 1,778,000 acfm.

In response to this question, the maximum flue gas flow rate has now been recalculated using latest design data. The result is very close to the original value. The calculation is summarized below.

Fuel - Elkton (F-1A) Excess Air - 25% (15% in Table 2-2 of the PSD is in error).

Products of Combustion

	<u>lbs/lb. fuel</u>	<u>ft³/lb. fuel</u>
CO ₂	2.0862	17.932
H ₂ O	.6510	13.666
SO ₂	.0584	.3447
O ₂	.4499	5.3174
N ₂	<u>7.5036</u>	<u>101.3548</u>
Weight Wet	10.749	138.6185
Weight Dry	10.098	

Heat Input Rate = 4692 MMBTU/hour

Fuel Rate = 447,070 lbs/hour

$$447,070 \text{ lbs fuel/hour} \times 138.6185 \text{ ft}^3/\text{lb fuel} \times \frac{1}{60} \times \frac{280+460}{60+460} = 1,469,853 \text{ acfm @ } 280^\circ \text{ F}$$

$$447,070 \text{ lbs fuel/hour} \times 10,749 \frac{\text{lbs}}{\text{lbs fuel}} = 4,805,555 \text{ lbs/hour}$$

$$4,805,555 \text{ lbs/hour} + 7.77\% \text{ leakage*} = 5,178,947 \text{ lbs/hour}$$

$$\text{Volume} = 1,469,853 \text{ acfm @ } 280^\circ \text{ F} = 1,032,870 \text{ scfm}$$

$$\text{Air Leakage} = 373,392 \text{ lbs/hour} \times \frac{1 \text{ ft}^3}{.076 \text{ lb}} \times \frac{1}{60} = 81,884 \text{ scfm}$$

$$\text{Total} = 1,032,870 + 81,884 = 1,114,754 \text{ scfm} = 1,558,512 \text{ acfm @ } 267^\circ \text{ F}$$

Gas to FGD	(acfm)	1,558,512 @ 267° F
	(scfm)	1,114,754

Saturated Gas	(acfm)	1,262,395 @ 125° F
	(scfm)	1,122,128

Reheat Air	(acfm)	524,691 @ 270° F
	(scfm)	373,753

Total Gas to Stack	(acfm)	1,772,043 @ 156° F
	(scfm)	1,495,881

* Air preheater leakage, air side to gas side

QUESTION 5

The performance of the proposed flue gas desulfurization device is questionable. Projections indicate a maximum removal efficiency of about 72% on the basis of the specifications. The pH of the scrubbing solution could be the key. It would appear that a pH higher than specified is necessary. It is our observation that this could be the result of a typographical error, since the pH of the scrubbing solution is lower at the inlet than the outlet.

RESPONSE

The Bureau of Air Quality Management staff has indicated their projection of 72% removal was based on calculations found in the McIlvaine Scrubber Manual. The equations used, page 128.7, subsection 4.72, are quoted as semi-theoretical, and it is noted that the particular data are not to be interpreted as evidence of long-term reliable operation.

However, these equations were utilized to examine removal efficiencies predicted by this method. These calculations are based on a double loop FGD system operating on Elkton (F-1A) coal producing calcium sulfate dihydrate as a product of forced oxidation. Results of these calculations (see below) indicated total predicted SO₂ removal of 95.6%.

First Loop:

Normal Conditions

$$L/G = 20$$

$$\text{Velocity} = 9.1 \text{ ft./sec.}$$

$$\text{pH} = 4.5$$

$$\text{SO}_{2i} = 2426 \text{ PPM}$$

Fraction SO_2 removed =

$$\begin{aligned} & 1 - \text{EXP} (-0.000098(20)^{.92}(9.1)^{.19} \times \text{EXP} (4.5 - (.00017 \times 2426))) \\ &= 1 - \text{EXP} (-0.000098(20)^{.92}(9.1)^{.19} (59.595)) \\ &= 13\% \end{aligned}$$

$$\text{SO}_{2o} = 2426 (1 - .13) = 2110 \text{ PPM}$$

Second Loop:

$$L/G = 60$$

$$\text{Velocity} = 9.1 \text{ ft./sec.}$$

$$\text{pH} = 6.5$$

$$\text{SO}_{2i} = 2110$$

Fraction SO_2 removed =

$$\begin{aligned} & 1 - \text{EXP} (-0.000098(60)^{.92}(9.1)^{.19} \times \text{EXP} (6.5 - (.00017 \times 2110))) \\ &= 1 - \text{EXP} (-0.000098(60)^{.92}(9.1)^{.19} (464.6)) \\ &= 95\% \end{aligned}$$

$$\text{SO}_{2o} = 2110 (1 - .95) = 105.5 \text{ PPM}$$

$$\text{TOTAL REMOVED} = \frac{2426 - 105.5}{2426} = 95.6\%$$

QUESTION 6

The data provided for the electrostatic precipitator is insufficient to make a determination of its estimated performance.

RESPONSE

Table 4-2 (ESP Specification) of Volume 2 of the PSD Application has been revised with additional specific information concerning the electrostatic precipitator. This revised table has been included in Amendment 3 to the PSD application.

QUESTION 7

The applicant has failed to adequately address fugitive emissions of particulate matter from the coal, fly ash and limestone facilities. Emissions of particulate matter from all controllable points must be addressed and appropriately included in the PSD modeling. The control technology to be applied to controllable emission points for the coal, fly ash, and limestone handling facilities must be addressed as part of the BACT application.

RESPONSE

Fugitive emissions from coal, fly ash handling, and limestone operations are addressed in Amendments 2 and 3 to the PSD Application. Both PSD increment consumption and BACT controls are discussed in detail in these amendments.

QUESTION 8

The explanation of the use of boiler operation to control particulate and nitrogen oxide emission is somewhat difficult to understand and appears somewhat ambiguous.

RESPONSE

Specific features of the boiler design are intended to minimize the formation and ultimate discharge of combustibles and nitrogen oxides from the Tampa Electric Company's Big Bend Station Unit 4. Similarly, operational procedures have been developed and will be optimized to control the emission of these pollutants. These design features and operational techniques are discussed below, detailing their effectiveness in controlling specific pollutant emissions, and their impact on other pollutant discharges.

Combustibles

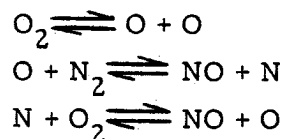
Combustibles consist of unburned carbon (UC) and carbon monoxide (CO). These constituents of the boiler flue gas are formed in an oxygen deficient atmosphere in either the primary or secondary combustion zones of the boiler. This oxygen deficiency results from substoichiometric air-to-fuel ratios and poor air-fuel mixing. To minimize the formation of UC and CO, the following boiler design and operational features are employed:

- o the turbulent atmosphere generated in Combustion Engineering's tangentially-fired boilers promotes proper air-fuel mixing, and
- o the high-excess-air operation (approximately 25% excess air) ensures sufficient oxygen in both the primary and secondary combustion zones.

These features ensure sufficient oxygen and proper mixing to essentially complete oxidation of combustibles to carbon dioxide. In addition, there is flexibility in boiler design, including variable-tilt burners and individual air registers, to allow for optimization of the combustion process during both steady-state and transient operating conditions. These design and operational features are the only recognized control techniques for UC and CO.

Nitrogen Oxides

Most of the nitrogen oxides (NO_x), consisting of nitrogen oxide (NO) and nitrogen dioxide (NO_2), in the boiler flue gas is formed by the high temperature reactions of molecular nitrogen and oxygen present in the combustion air via the following reactions;



Additional NO_x results from the oxidation of organically bound nitrogen in the fuel. The formation of NO is favored at high temperature: equilibrium concentrations of NO at flame temperature are on the order of 300 ppm while that of NO_2 are negligible. The major factors affecting the formation of NO_x in the combustion process are combustion temperature, availability of oxygen, air-fuel mixtures, and heat release. The NO_x control technique included in boiler design and operational procedures is comprised of off-stoichiometric combustion, which may be accomplished by:

- o biased-firing, consisting of operating selected burners at fuel-rich mixtures and others at fuel-lean mixtures, or
- o two-stage combustion, consisting of fuel-rich combustion at the burners and introduction of remaining combustion air above the primary combustion zone via over-fire air ports.

These techniques reduce NO_x formation by initiating combustion in a reducing atmosphere followed by complete combustion after substantial heat loss. Combustion Engineering has indicated that NO_x emissions can be maintained in compliance with the NSPS by means of bias-firing alone but has incorporated over-fire air ports for supplementary control.

Although the off-stoichiometric combustion techniques promote the formation of combustibles, sufficient excess air is introduced via alternative burners or the over-fire air ports to ensure complete combustion. In other words, excess air to boiler is maintained at high levels (up to 25%) while only the distribution of total air is altered. The table below demonstrates the impact of NO_x control techniques on emissions of both NO_x and CO. Note that both bias-firing and two-stage combustion results in coincidental reductions emissions of the two pollutants. Therefore, the proposed control techniques for NO_x and combustibles have been demonstrated to be both effective and complementary.

EPA TEST PROGRAM FOR NO_x REDUCTION

<u>Test Condition</u>	<u>Excess Air (%)</u>	<u>Emission (lb/MMBtu)</u>	
		<u>NO_x</u>	<u>CO</u>
No modification	22.7	0.58	0.022
Biased-firing	24.2	0.33	0.019
Two-stage combustion	25.4	0.55	0.016
Two-stage combustion (with water-wall slagging)	25.9	0.50	0.016
Two-stage combustion (-5° burner tilt)	25.9	0.39	0.016
Two-stage combustion (+19° burner tilt)	25.1	0.43	0.023

Source: EPA 1975. Program for Reduction of NO_x from Tangential Coal-fired Boilers. EPA-650/2-73-005a.

QUESTION 9

The application fails to address hydrocarbon emissions from the proposed facility or the impact of these on the Hillsborough County nonattainment area.

RESPONSE

Hydrocarbon emissions are addressed in Amendment No. 1 to the PSD Application. These emissions are calculated based on an emission rate of 0.01 lbs hydrocarbon per ton of coal burned, as recommended in a memorandum from the Office of Air Quality Planning and Standards to EPA Region VIII on January 23, 1978. The boiler is the only source of hydrocarbon emissions from the addition of Big Bend 4.

QUESTION 10

The quantities and sulfur content of #2 fuel oil to be consumed during start-up and normal operation (flame stabilization) were not included in the application or modeling.

RESPONSE

The normal sulfur content of #2 fuel oil to be consumed during start-up and flame stabilization is 0.3%. Worst case sulfur content is expected to be 0.5%.

Conservatively assuming 6 hours of oil firing per start-up and 15 cold starts each year, 336,000 gallons of #2 oil will be required for Unit 4 start-up on an annual basis.

According to Combustion Engineering, flame stabilization will be required when the unit is operated at or below 65 MW. This will require approximately 70 gallons of #2 oil per hour. Based on the following table, it can be seen that the percentage of time Big Bend Unit 4 can be expected to operate at or below 65 MW is quite low.

BIG BEND UNIT 4

<u>Year of Life</u>	<u>% of Time At Or Below 170 MW</u>
0 - 15	3
16 - 20	10
21 - 25	11
26 - 30	18

QUESTION 11

The use of additives for conditioning of the fuel, fly ash, or flue gas was not discussed. In addition, the impact of the additives on particulate and nitrogen oxide (in the case of ammonia based additives) emissions was neither presented nor utilized in the application.

RESPONSE

At the present time there are no plans for the use of fuel, fly ash, or flue gas conditioning additives in association with the operation of Unit 4.

QUESTION 12

If cooling towers are opted for then these will be subject to both BACT and PSD requirements. Ambient particulate concentrations and drift impacts must be included in the application.

QUESTION 17

The cooling tower impact should be included.

RESPONSE

Cooling tower drift and particulate impacts are currently under study. A report will be forwarded to the Department in the near future.

QUESTION 13

An almost confusing number of fuel analyses were used in the calculation of emissions and ambient impacts from the facility. It is significant to note that the specification for design coals F-2A and F-2B do not match those under consideration specifically with regard to sulfur content.

QUESTION 14

The calculations in the air quality portion of the application appear to contain some errors and should be reviewed by the applicant for correctness.

RESPONSE

From conferences with the Department it appears Questions 13 and 14 have been generated due to some confusion concerning the fuel analyses presented in the application. This confusion was most likely compounded in part by Table 3.7-3 of the Site Certification Application being in error. A revised Table 3.7-3 is provided as Attachment A and should be inserted as directed into the Site Certification Application.

Basically there are two sets of fuel analyses presented in the Application. Table 3.2-1 presents the analyses of actual fuels which are being considered for Unit 4. The revised Table 3.7-3 presents "design" analyses which were used in specifying pollution control equipment. These "design" coals were formulated based on parameters of the actual fuels which represented worst case conditions for pollution control device performance. Similarly, the fuel analysis noted in Table 3.7-2 was the design fuel for the boiler.

It is significant to note that the ambient impacts presented in the Application were based on Maximum Allowable New Source Performance Standards Emission Limitations and not fuel analyses. Therefore, the predicted ambient impacts are conservative with respect to emission rates.

QUESTION 15

The application does not adequately address emissions of pollutants subject to NESHAPS.

RESPONSE

Fossil-fired steam generators are not sources designated for applicability with NESHAPS. However, in response to this question we have undertaken a limited investigation into potential impacts from the combustion of coal.

An EPA publication, EPA-600/2-79-019e June 1979, by Monsanto Research Corporation entitled "Source Assessment: Dry Bottom Industrial Boilers Firing Pulverized Bituminous Coal" includes a table entitled "Arithmetic Mean of Proximate and Ultimate Analyses and Elemental Composition for Appalachian Coal Region Samples." The coal utilized for Big Bend 4 will likely come from Bureau of Mines Region 9. Appalachian Coal is Bureau of Mines Region 1-8, 13 and border geographically on Region 9. The following table summarizes the elemental composition of those NESHAPS in elemental forms in coal.

Beryllium	2.1 PPM	-	.00021%
Mercury	0.14 PPM	-	.000014%
Arsenic	26.0 PPM	-	.0026%
Cadmium	0.68 PPM	-	.000068%

QUESTION 16

The quantity of fluoride in the coals and resultant emissions (if any) were not addressed. The impacts of any fluoride emissions on ambient air and monthly grass samples should be included if fluoride levels in the coal exceed 0.1% by weight.

RESPONSE

An EPA publication, EPA-600/2-79-019e June 1979, by Monsanto Research Corporation, entitled "Source Assessment: Dry Bottom Industrial Boilers Firing Pulverized Bituminous Coal," includes a table entitled "Arithmetic Mean of Proximate and Ultimate Analysis and Elemental Composition for Appalachian Coal Region Samples." The coal utilized for Big Bend 4 will likely come from Bureau of Mines Region 9, Appalachian Coal is Bureau of Mines Regions 1-8, 13 and borders geographically on Region 9.

The table referenced above indicates an elemental flourine composition in coal of 78 PPM, or about .0078% flourine. Since this is far below the 0.1% value indicated in this question, impacts of flourine emissions on ambient air have not been examined.

ATTACHMENT "A"
TO
AMENDMENT 2
JULY 1, 1980

TAMPA ELECTRIC COMPANY
BIG BEND UNIT 4
SITE CERTIFICATION APPLICATION

INSTRUCTIONS	
INSERT	REMOVE
1. Revised Page 3.7-5 2. Revised Table 3.7-3	1. Existing Page 3.7-5 2. Existing Table 3.7-3

Because the Big Bend Station is not located in a nonattainment area for any of the criteria pollutants, LAER is not required for any pollutant emission from the proposed Unit 4. In addition, emissions from the proposed unit will not have a significant impact on a nonattainment area, precluding application of LAER (Section 5.5.3).

Summary

Big Bend Station Unit 4 must be designed and demonstrated to be in compliance with the NSPS for electric utility steam generators. It is anticipated that the revised Florida State Implementation Plan (SIP) will incorporate these standards intact for that category of sources. The proposed unit must also include BACT in facility design for those pollutants subject to the PSD regulations.

3.7.2 Atmospheric Emissions and Proposed Control Systems

The Unit 4 steam generator will be a tangentially-fired boiler designed by Combustion Engineering, Inc. The boiler will have a maximum continuous rating of 3,300 Mlb/hr of steam at the superheater outlet, at 2,600 psig and 1,005°F. The boiler performance data is presented in Table 3.7-2 for 50, 75, and 100 percent of maximum continuous rating. Note that this boiler data is based on a design fuel because the coal selection has yet to be finalized.

Unit 4 will fire medium to high-sulfur Midwestern bituminous coal. At this time, several coals are still under consideration with the final selection expected in the fall of this year. For the purposes of the air pollution control evaluation and specification of control equipment, three design coal analyses were developed detailing pertinent physical and chemical characteristics. These three design coals are representative of those fuels still under consideration for Unit 4, presenting a range of constituent concentrations. The approximate and ultimate analyses of each of the design coals are presented in Table 3.7-3 along with physical characteristics. The fuel rate is also presented based on the heating value of the coal and boiler performance. Coal F-1A was used in the specification of the particulate matter control device; coal F-2A and F-2B were included in the specification of the FGD system.

The Unit 4 boiler is considered a major source of particulate matter (PM), sulfur dioxide (SO₂), oxides of nitrogen (NO_x), and carbon monoxide (CO). The receiving, handling, and storage of coal for Unit 4 is an additional source of both controlled and fugitive particulate emissions. Similarly, the limestone required for the FGD system is a potential source of fugitive particulate emissions. The principal air pollution control techniques

TABLE 3.7-3

DESIGN COAL ANALYSIS

Parameters	F-1A		F-2A		F-2B	
	As Received	Dry Basis	As Received	Dry Basis	As Received	Dry Basis
Heating Value (Btu/lb)	10,495	12,275	11,300	12,626	11,050	12,628
Ultimate Analysis (% wt.)						
Moisture	14.50	-	10.50	-	12.50	-
Carbon	57.00	66.67	62.50	69.80	61.50	70.30
Hydrogen	4.10	4.80	4.30	4.80	4.10	4.68
Nitrogen	1.08	1.26	1.30	1.45	1.20	1.37
Sulfur	2.92	3.42	3.50	3.90	3.50	4.00
Ash	13.50	15.79	10.50	11.73	10.00	11.40
Oxygen	7.05	8.25	7.20	8.10	7.10	8.10
Chlorine	0.08	0.09	0.20	0.22	0.10	0.11
Proximate Analysis (% wt.)						
Moisture	14.52	-	10.50	-	12.50	-
Ash	13.50	15.79	10.50	11.73	10.00	11.40
Volatile Matter	30.21	35.33	34.50	38.54	34.50	39.40
Fixed Carbon	41.75	48.83	44.50	49.72	43.00	49.10
Sulfur	2.92	3.42	3.50	3.91	3.50	4.00
Ash Analysis (% wt.)						
P ₂ O ₅	0.34	-	0.13	-	0.16	-
SiO ₂	46.74	-	45.60	-	44.70	-
Fe ₂ O ₃	17.71	-	20.70	-	19.00	-
Al ₂ O ₃	19.25	-	19.20	-	20.70	-
TiO ₂	1.01	-	0.90	-	1.10	-
CaO	6.49	-	4.90	-	4.50	-
MgO	0.70	-	0.94	-	1.00	-
SO ₃	4.31	-	4.70	-	5.50	-
K ₂ O	1.54	-	2.20	-	2.50	-
Na ₂ O	1.37	-	0.50	-	0.50	-
Coal Fired	413,000	-	-	-	-	-

AMENDMENT 3

**TAMPA ELECTRIC COMPANY
BIG BEND STATION UNIT 4
SITE CERTIFICATION APPLICATION**

Amendment 3
August 1980

Responses to the Florida Department of Environmental Regulation letter dated October 12, 1979, from Hamilton S. Owen, Jr., Administrator, Power Plant Siting, to Chris H. Bentley, Director, Division of Administrative Hearings concerning Tampa Electric Company, Power Plant Siting Application Big Bend Station Unit 4.

QUESTION 1

Chapter 2 appears to be complete, but insufficient in several aspects. In Section 2.3, the Department wishes to know whether there are any nationally significant historical, scenic, cultural or national landmarks affected, regardless of their radius from the Big Bend site. More data should be included in the application in support of the conclusions set forth in pages 2.5-4, 2.5-5, and 2.5-6.

RESPONSE

See revised Section 2.3 for information on historic and cultural landmarks.

In a telephone conversation on December 5, 1979, Hamilton S. Owen, Jr., FDER Administrator for Power Plant Siting, stated that the references containing the studies and quoted on pages 2.5-4, 2.5-5 and 2.5-6 are sufficient support of the conclusions.

QUESTION 2

Page 2.2-2 states that 20 acres of the site are improperly zoned at the present time. It appears that the applicant does not intend to rectify this situation prior to certification. Accordingly, the area must also be deleted from the application by the applicant, or the Department must consider it not available and review the flue gas desulfurization disposal sites, as if the 20 acres were not included. The improper zoning will undoubtedly pose problems at the land use hearings.

RESPONSE

Figure 3.9-1 has been corrected and the FGD disposal site has been modified to lie entirely on presently owned TECO property. This land is zoned for industrial use. Accordingly the following pages in the application have been revised: 2.2-2, 2.2-3, 3.9-2, 4.1-1, 4.5-1, 7.2-2 and 7.2-3. Figure 3.1-4, Site Boundaries and Topography, has been revised to show the new site boundaries.

QUESTION 3

Figures 2.1-1 and 2.1-2, while generally indicating the site, do not satisfy the application form requirement of submission of a map which indicates the plant perimeter and the site, including abutting and adjacent properties. Figure 3.1-4 gives some of this information, but the detail scale is so small that interpretation of the Big Bend property boundaries is difficult. If the interpretation is correct, TECO does not own some of the land proposed to be utilized as future expansion of the ash disposal pond area, nor part of the FGD byproduct storage area. Licensing and zoning/land use assurances for non-utility owned lands may be difficult. Also, from the somewhat unclear and tiny Horizon 2000 Plan included in the application, it appears that part of the area designated as the FGD byproduct storage area has been designated on the land-use plan as urban residential. This will bear further review and better maps will be necessary. Also, although Section 2.2.2 of the application discusses zoning, it also mentions a potential zoning problem. A map indicating delineation of the zoning areas is thus considered necessary for the immediate site vicinity. The application form specifies indication of zoning restrictions for the area within 5 miles of the stack - while a minor incompleteness, we still need this information as well. Again, a map would be preferable.

RESPONSE

Figure 2.1-3, Adjacent Property Owners, and Figure 2.1-4, Local Zoning around Big Bend Station, have been incorporated into the application, and page 2.1-1 has been updated. It should be noted that the Horizon 2000 Plan allows for industrial land use within an area generally designated urban residential. In addition, the modified FGD byproduct and ash disposal areas lie within TECO properties and are zoned for industrial use.

QUESTION 4

Section 2.5.2, "Water Withdrawals," fails to discuss the fresh water withdrawals necessary for plant operation. Also, there is no discussion of "...consumptive use (rates) in relation to other existing and proposed consumptive uses....," with regard to fresh water withdrawals.

RESPONSE

See revised Section 2.5.2 for information on water withdrawals.

QUESTION 5

Chapter 3, in general, reflects the lack of substance apparent throughout this application. More detail is required in Subsection 3.2-2, so as to specify how coals will be transported to the stacker-reclaimer, and how the existing coal pile runoff system will be modified. More specifics should be provided as to the facilities for handling coal delivered by railroad, and existing coal handling and storage facilities should be identified and discussed.

RESPONSE

Section 3.2.2, Fuel Handling and Storage, has been revised to include more detail on the existing coal handling facilities. As stated in the application, coal is delivered to Big Bend Station in covered barges. This mode of fuel transportation will continue to be utilized. It is possible, however, that in the future the economics of transporting other types of coal from regions not accessible to water borne transportation may dictate the need for rail delivery. At this time, there are no plans for installing a rail delivery system. The conceptual plan is that if rail delivery was indeed required, facilities would be provided for unloading coal onto the existing system.

Refer to the response to Question 15 for a discussion of the coal pile runoff collection system.

QUESTION 6

Page 3.3-1 fails to discuss the availability in any quantitative terms of water from the Hillsborough County-Riverview-Gibsonton water system. Data should be provided on the Hillsborough County-Riverview-Gibsonton system capacity and its ability to meet additional demands.

RESPONSE

It is the applicant's interpretation that in accordance with DER Form 17-1.122 (72), the sources and quality of water for each input should be indicated in Section 3.3, not the availability of the water. It is felt that a discussion of availability including possible adverse impacts on the supply source is more appropriate in Section 5.3 and 5.7. Refer to Questions 21 and 24 and revised Section 5.3 for further discussion of fresh water availability.

QUESTION 7

Page 3.3-3 notes that a study is currently under way to determine the feasibility of utilizing alternative water sources. These studies should be completed and plans finalized before the application is considered sufficient.

RESPONSE

Refer to response to Question 21, 24, and 32 and revised Section 5.3 for discussion of fresh water availability and a summary of the investigation into alternate water supplies.

QUESTION 8

Page 3.4-1 reflects that the application is incomplete and insufficient until the 316 Demonstration is provided.

RESPONSE

The applicant agrees with the Department that the application is incomplete and insufficient until the 316 Demonstration results are provided. This deficiency was mutually recognized and was indicated in the transmittal letter which accompanied the original application submittal. The 316 Demonstration Report is submitted as part of this amendment to the SCA.

QUESTION 9

The Department would like to see the study referred to on page 3.7-1, paragraph 2.

RESPONSE

The study referred to on page 3.7-1, paragraph 2 is the Big Bend Unit 4 "Prevention of Significant Deterioration (PSD) Application."

QUESTION 10

Page 3.7-5 indicates that coal selection is yet to be finalized. The application should be considered insufficient until this is done.

RESPONSE

The applicant is in the process of negotiating for economical long term fuel supplies. The analyses of fuels still under negotiation are presented in revised Table 3.2-1. Final selections cannot be made until negotiations are complete.

QUESTION 11

Table 3.7-8, page 2, cautions "FGD system specification has yet to be prepared. The performance requirements and guarantees are tentative." In light of this, the application should be considered insufficient until such time as final plans are arranged.

RESPONSE

The Big Bend Unit 4 FGD System Specification has been prepared and the system has been selected. The performance requirements and guarantees for the Unit 4 FGD system specification are presented in the revised Section 3.7.2.2, Flue Gas Desulfurization System (FGD) .

QUESTION 12

The Department would like to see the geo-technical study by Stone & Webster noted on page 3.9-2.

RESPONSE

The Department has been provided the geo-technical study noted on page 3.9-2 of the Application document.

QUESTION 13

The Department would like to know the rate of groundwater flow and the hydraulic gradient noted on page 3.9-3.

RESPONSE

During a 1973 Geotechnical Investigation, the water table along the north edge of the proposed FGD Storage/Disposal Area was monitored by means of four shallow wells. The data collected reveals a hydraulic gradient on the order of 6×10^{-4} ft/ft. This gradient indicates groundwater flow from east to west. From permeability estimates made during the Geotechnical Study, the transmissivity of the surficial aquifer is estimated to be 1060 gpd/ft and the flow rate is estimated to be on the order of 0.6 gpd per foot of width of the aquifer.

QUESTION 14

What are the proposed means for controlling fugitive particulate from gypsum during transportation as noted on page 3.9-4?

RESPONSE

See revised Subsection 3.9.1.3 for information on gypsum transportation.

QUESTION 15

The application should be considered insufficient as to page 3.10-1 until the water collection trench system can be finalized.

RESPONSE

The revised storm water collection system for the coal pile is shown on Figure 3.5-4 and discussed in revised Section 3.5.2.5.

QUESTION 16

Section 4.1.9(sic), "Impact on Water Bodies and Uses", fails to discuss the impact on nearby groundwater users, etc, of the temporary dewatering during construction.

RESPONSE

Temporary dewatering during construction will be limited to the dewatering necessary for the installation of the circulating water system. The maximum amount of excavation requiring dewatering at any one time will be 200-ft long by 16-ft wide by 16-ft deep. With a current groundwater (bay water infiltration) elevation at +1.5 msl, the excavation would require lowering the groundwater elevation to -10 msl within the sheet piled area of construction. Zero drawdown at 100 ft from the excavation is shown on Figure 4.1-1. Within the zone of influence, the applicant does not expect any impact from the dewatering.

QUESTION 17

Section 4.1.9 describes dredging that will be necessary for installation of an additional dilution pump and discharge structure. However, no joint application to the DER/Corps of Engineers was submitted or required by Section 4.1.2(e) of DER Form 17-1.122(72). The application is incomplete with respect to dredge and fill permitting due to the omission of the Joint Application, Department of Army/Florida Department of Environmental Regulation for Activities in Waters of the State, SAJ Form 983. This joint application should be filed together with the accompanying supporting information and drawings, as requested in the joint application booklet. A copy of the booklet will be sent to TECO. Items that should be addressed in the joint application are:

1. The dredging at the Unit 4 discharge structure
2. The dredging at the dilution pump
3. The construction of both the discharge structure and the dilution pump
4. The ash disposal site
5. Stormwater drainage from the plant site, the coal field, and the disposal site.

RESPONSE

COE permit application will be submitted August 1980.

QUESTION 18

The Application should be considered insufficient as to Subsection 4.2.2.

RESPONSE

See revised Subsection 4.2.2 for information on garbage disposal services.

QUESTION 19

Sections 5.1 and 5.2 are incomplete as noted in the transmittal letter.

RESPONSE

See revised Sections 5.1 and 5.2.

QUESTION 20

The Department needs the Dilution Pump Viability Study, the Benthic Communal Thermal Impact Study, and the Fine Mesh Screen Study identified on page 5.1-1.

RESPONSE

The Dilution Pump Viability Study, the Benthic Community Thermal Impact Study, and the Fine Mesh Screen Study are provided as appendices to the 316 Demonstration which is an appendix to the Site Certification Application.

QUESTION 21

Subsection 5.3 is incomplete. The Department needs to know where the remainder of the fresh water needs for Unit 4 will be satisfied. The applicant should identify other possible sources for the FGD System water needs and should substantiate the conclusion that consumption is not expected to have adverse effects on the Hillsborough County water supply.

RESPONSE

See revised Section 5.3 for a detailed discussion of the Hillsborough County water system which includes a summary of investigations into alternate water supplies.

QUESTION 22

Similarly, page 5.5-5 states that impacts are not expected to be significant. The applicant should identify possible impacts and support its conclusion.

RESPONSE

On page 5.5-5 a discussion is presented on flue gas emission impacts other than those on air quality. The Federal PSD Regulations which require an additional impact analysis including an analysis of the impairment to visibility, soils, and vegetation that would occur as a result of the source or modification were used as a guideline in preparing the discussion. These regulations advise that: "The analysis related to a source's impacts on soils, vegetation, and visibility should focus primarily on such impacts in Class I areas...", and the "impact assessment should generally be qualitative in nature and designed to inform the general public of the relative impact of the source of those values." The applicant has concluded that possible impacts to soils or vegetation due to flue gas emissions should not be significant. This conclusion is based on the air quality modeling performed for Unit 4. These predictions showed that the allowable Class I and Class II PSD increments will not be exceeded. In addition, ambient air quality standards (AAQS) will not be exceeded due to the operation of the new unit. These standards, which have been adopted by the State of Florida, were promulgated to protect the public health (primary) and to protect the public welfare (secondary). Protecting the public welfare includes avoidance of damage to vegetation, soils, animals, structures, etc.

The applicant has also concluded that impairment to visibility will be minimal due to the proposed new unit's compliance with NSPS opacity limits, sulfur dioxide emission limits, and particulate matter emission limits. Direct visual emission will be minimal due to compliance with the opacity limits and the TSP emission limits. The potential effect on visibility due to the conversion of gaseous sulfur oxides to sulfate aerosols will be mitigated by the sulfur dioxide emission control equipment.

QUESTION 23

Section 5.8.3.1, 5.8.3.2, and 5.9 will not be completed until submission of the mid-1980 Amendment. These sections refer to Aquatic Resources affected by the once-through-cooling (OTC) system, and also thermal variances that would be required for further OTC use.

RESPONSE

See revised Section 5.8.3.1, 5.8.3.2, and 5.9, and the appended 316 Demonstration to the SCA.

QUESTION 24

Page 5.7-3 states that increase in station water use is not expected to have significant effect on local water supplies. The applicant should discuss availability and support its conclusion. On that same page, land use fails to identify the area to the south.

RESPONSE

Refer to revised Section 5.3 for discussion on water availability. With regard to the land use discussion on page 5.7-3, all areas currently proposed for construction of Unit 4 and its associated facilities are zoned for industrial use. Please refer to the response to Question 3 and Figure 2.1-4.

QUESTION 25

On page 5.8-1 the applicant should discuss effects other than from consumptive use on water and should be required to substantiate through estimates of availability and source information, why it concludes that there will not be a serious depletion of groundwater resources.

RESPONSE

Refer to revised Section 5.3 for discussion on water availability.

QUESTION 26

The Department should receive the water quality and hydrographic studies mentioned on page 6.2-1.

RESPONSE

The water quality and hydrographic studies mentioned on page 6.2-1 are listed below. The Department should have copies of these documents. However, if copies are desired, the applicant will provide them for the Department's use.

Tampa Electric Company. 1977a. Big Bend Station 316 Demonstration, September 1977.

Tampa Electric Company. 1975a. Ecological Surveys of the Big Bend Area. Five year data evaluation. July 1975.

Tampa Electric Company. 1975b. Prospectus For Ecological Studies at Big Bend Steam Electric Station. 316 Demonstration. Prepared by Conservation Consultants, Inc., Palmetto, Florida.

Tampa Electric Company. 1977b Appendix to 316 Demonstration, Vol I Final Report of Ecological Surveys of the Big Bend Area. September 1977.

QUESTION 27

The Department should receive the reports of the subsurface investigation program identified in page 6.2-32, the sound level environmental surveys noted in page 6.2-32, and the terrestrial ecological investigations on page 6.2-34.

RESPONSE

Under separate cover the applicant will loan the Department copies of the subsurface investigations and the terrestrial ecology studies, so that they may be used in their analysis. The sound level survey reports consist solely of data sheets and would not provide any information not included in the Application.

QUESTION 28

Section 6.2.3, Groundwater, fails to provide a monitoring program for impacts of temporary dewatering during site preparation and construction.

RESPONSE

As indicated in response to Question 16, the zone of influence is relatively small and completely contained within the property boundary. The applicant, therefore, concludes that no groundwater monitoring program will be required during construction.

QUESTION 29

Section 7.2.2.1, "External Costs," Assumptions concerning temporary dewatering impacts, needs substantiation.

RESPONSE

Refer to the Response to Question No. 16 for the substantiation of external cost associated with temporary dewatering activities. Within the zone of influence, the Applicant does not expect any impact from the dewatering.

QUESTION 30

With regard to the construction impact control and monitoring program, the Department would like to know whether the program appears in the individual contract and how it is enforceable.

RESPONSE

All contractors working on TECO projects are subject to TECO policies regarding environmental protection. Contractor activities are fully monitored by TECO personnel. Moreover, individual contracts require that all contractors comply with any applicable local, state, and federal laws and regulations.

QUESTION 31

The applicant should substantiate its conclusion on page 7.2-2, that local groundwater elevation lowering will not affect area wells.

RESPONSE

Refer to the response to FDER Questions 16 and 28 for further discussion. In addition, there are no wells within or within close proximity to the construction dewatering zone of influence.

QUESTION 32

The application should be considered insufficient until the Department has received the results of the investigation into additional alternative water supplies.

RESPONSE

The applicant has completed an examination of potential alternate water sources for Big Bend Station. This investigation has shown secondary effluent from the Hillsborough County owned Sun City Wastewater Treatment Plant to be the most feasible option available. More discussion is provided in the revised Section 5.3, Impacts on Water Supplies.

QUESTION 33

Section 5.4 disposal site for clean-out residuals from ash ponds and slag ponds is not clearly shown.

RESPONSE

The existing units at Big Bend employ "Wet Bottom" boilers. The term "Wet Bottom" refers to the physical state of the slag (ash) as it leaves the boiler. The molten slag flows by gravity from the boilers' spilling into slag tanks, where it is rapidly quenched with saltwater solidifying and shattering into small pieces. These pieces of slag are sluiced with saltwater to a settling pond.

The slag produced in these boilers is a marketable byproduct used for many applications, such as a sand blasting grit and as an asphalt aggregate. The slag is steadily removed from the settling pond for sale at about the same rate of addition. The slag pond is located south of the coal field as shown on Figure 3.1-1.

Big Bend Unit 4 will have a "Dry Bottom" boiler. As with the term "Wet Bottom", the term "Dry Bottom" refers to the physical state of the ash as it leaves the boiler. This fine particle ash will be removed from the boiler in a solid state. Water will be used to sluice the ash in a closed loop recycle system. The ash will be sluiced to the ash disposal area southeast of the plant (see Figure 3.1-1), where it will be disposed of in accordance with all applicable regulations.

QUESTION 34

RCRA restrictions for construction of solid waste disposal sites in flood plains are finalized and must be considered; see 44 FR, 43561, September 13, 1979, "Criteria for Classification of Solid Waste Disposal Facilities and Practices."

RESPONSE

The applicant is aware that RCRA restrictions for construction of solid waste disposal sites in flood plains are finalized and must be considered. It should be noted that these regulations do not prohibit the location of a solid waste facility in a flood plain; however, they provide restrictions, which must be and are being considered in the design of the facility. The applicant is also aware of the proposed guidelines for "Landfill Disposal of Solid Waste" (44 FR, No. 59, 19138, March 26, 1979).

QUESTION 35

Leachate Effect Studies, regarding coal and ash storage areas, should be conducted with a view that satisfies the requirements of Chapter 17-7, FAC and the federal criteria contained in 44 FR September 13, 1979.

RESPONSE

All applicable state and federal criteria have been reviewed and applied as part of the leachate studies.

QUESTION 36

There is no mention of the potential hazards from radionuclides associated with the ash piles from coal-fired boilers. Radiation levels from these ash piles have been shown in some cases to exceed that which is emitted from waste gypsum piles, currently thought to be hazardous under 44 FR December 18, 1978, Hazardous Waste, (AH).

RESPONSE

See Section 5.2.3, "Radionuclide Emissions," for information on radionuclides.

JOINT APPLICATION
DEPARTMENT OF THE ARMY/FLORIDA DEPARTMENT OF ENVIRONMENTAL REGULATION
FOR
ACTIVITIES IN WATERS OF THE STATE OF FLORIDA

Refer to Instruction Pamphlet for explanation of numbered items and attachments required.

1. Application number (To be assigned)	2. Date Day Mo. Yr.	3. For official use only																
4. Name, address and zip code of applicant Tampa Electric Company Contact: Lynn F. Robinson, Engineer P.O. Box 111 Night Phone: (813)949-4951 Tampa, FL 33601 Alternate: John B. Ramil, Engineer Night Phone: (813)885-1570																		
Telephone Number <u>(813) 879-4111</u>																		
5. Name, address, zip code and title of applicant's authorized agent for permit application coordination Not applicable Telephone Number _____																		
6. Describe the proposed activity, its purpose and intended use, including a description of the type of structures, if any, to be erected on fills, or pipe or float-supported platforms, and the type, composition and quantity of materials to be discharged or dumped and means of conveyance. See Attachment A <table style="width: 100%; border: none;"><tr><td></td><td style="text-align: center;">Dredged/Excavated</td><td></td><td style="text-align: center;">Filled/Deposited</td></tr><tr><td>Volume of Material:</td><td style="text-align: center;"><u>1110</u> CY</td><td style="text-align: center;"><u>-</u> CY</td><td style="text-align: center;"><u>-</u> CY</td></tr><tr><td></td><td style="text-align: center;">Waterward of O.H.W. or M.H.W.</td><td style="text-align: center;">Landward of O.H.W. or M.H.W.</td><td style="text-align: center;">Waterward of O.H.W. or M.H.W.</td></tr><tr><td></td><td></td><td></td><td style="text-align: center;">Landward of O.H.W. or M.H.W.</td></tr></table>				Dredged/Excavated		Filled/Deposited	Volume of Material:	<u>1110</u> CY	<u>-</u> CY	<u>-</u> CY		Waterward of O.H.W. or M.H.W.	Landward of O.H.W. or M.H.W.	Waterward of O.H.W. or M.H.W.				Landward of O.H.W. or M.H.W.
	Dredged/Excavated		Filled/Deposited															
Volume of Material:	<u>1110</u> CY	<u>-</u> CY	<u>-</u> CY															
	Waterward of O.H.W. or M.H.W.	Landward of O.H.W. or M.H.W.	Waterward of O.H.W. or M.H.W.															
			Landward of O.H.W. or M.H.W.															
7. Proposed use Private ☒ Public ☐ Commercial ☐ Other ☐ (Explain in remarks)																		
8. Name and address including zip code of adjoining property owners whose property also adjoins the waterway. The proposed activity is entirely on Tampa Electric Company property. The adjoining properties are also owned by Tampa Electric Company.																		
9. Location where proposed activity exists or will occur Street address _____ Longitude <u>82°24'16"</u> Latitude <u>27°47'42"</u> (If known) Sec. <u>14 & 15</u> Twp. <u>31S</u> Rge. <u>19E</u> <u>Florida</u> <u>Hillsborough</u> <u>-</u> <u>Ruskin</u> State County In City or Town Near City or Town																		
10. Name of waterway at location of the activity Hillsborough Bay																		

11. Date activity is proposed to commence February 1, 1982

Date activity is expected to be completed March 1, 1985

12. Is any portion of the activity for which authorization is sought now complete? Yes [] No [X]

If answer is "Yes" give reasons in the remarks section. Month and year the activity was completed _____

_____. Indicate the existing work on the drawings.

13. List all approvals or certifications required by other Federal interstate, state or local agencies for any structures, construction, discharges, deposits or other activities described in this application, including whether the project is a Development of Regional impact.

Issuing Agency Type of Approval Identification No. Date of Application Date of Approval

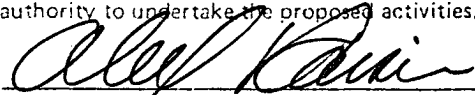
See Attachment B

14. Has any agency denied approval for the activity described herein or for any activity directly related to the activity described herein? Yes [] No [X] (If "Yes" explain in remarks)

15. Remarks (see Instruction Pamphlet for additional information required for certain activities)

See Attachment A

16. Application is hereby made for a permit or permits to authorize the activities described herein. I agree to provide any additional information/data that may be necessary to provide reasonable assurance or evidence to show that the proposed project will comply with the applicable State Water Quality Standards or other environmental protection standards both during construction and after the project is completed. I also agree to provide entry to the project site for inspectors from the environmental protection agencies for the purpose of making preliminary analyses of the site and monitoring permitted works, if permit is granted. I certify that I am familiar with the information contained in this application, and that to the best of my knowledge and belief such information is true, complete, and accurate. I further certify that I possess the authority to undertake the proposed activities.


Signature of Applicant

8/1/80
Date

18 U.S.C. Section 1001 provides that: Whoever, in any manner within the jurisdiction of any department or agency of the United States knowingly and willfully falsifies, conceals, or covers up by any trick, scheme, or device a material fact or makes any false, fictitious or fraudulent statements or representations or makes or uses any false writing or document knowing same to contain any false, fictitious or fraudulent statement or entry, shall be fined not more than \$10,000 or imprisoned not more than five years, or both.

The application must be signed by the person who desires to undertake the proposed activity; however, the application may be signed by a duly authorized agent if accompanied by a statement by that person designating the agent and agreeing to furnish upon request, supplemental information in support of the application.

FEE: Attach Checks/Money Orders on front
Payable to Department of Environmental Regulation
\$200 Standard form projects
\$20 Short forms and Chapter 403 projects only

Attachment A

The proposed works are the intake and discharge structures to be constructed for Big Bend Unit 4. The proposed structures will be located in the existing dredged intake and discharge channels that bound the Big Bend Station on the north and south, respectively. The Big Bend Station currently has three coal-fired generating units in operation; Unit 4 is scheduled to go into service in 1985.

The Unit 4 intake structure will be located in the 240 foot wide plant intake channel, adjacent to the existing Unit 3 structure. Approximately 420 cubic yards of sand and silt material will be dredged from a 50 foot by 55 foot area to accommodate the structure. Tampa Electric Company is presently conducting studies to determine which intake screening technology will best meet the conditions prescribed in Section 316 of the Federal Water Pollution Control Act. Thus, the final intake structure design and method of construction cannot be detailed at this time. During construction, the applicable water quality standards will be maintained through the use of a silt barrier, or other technology. The dredged material will be disposed of in an environmentally acceptable manner. Once the structure is completed it will supply 537 cubic feet per second of condenser cooling water to Unit 4.

The Unit 4 discharge structure will be located in the 350 foot wide plant discharge channel, adjacent to the existing Unit 3 structure. Approximately 690 cubic yards of sand and silt will be dredged from an area extending 80 feet in the channel with an end width of approximately 65 feet, tapering to roughly 25 feet at the existing bulkhead.

The discharge structure is constructed of steel sheet pile and consists of two diverging walls approximately 50 feet long. When these walls are in place, a clamshell bucket will be used to dredge the material from between the walls. A silt barrier will be maintained during the construction. The material will be disposed of in an environmentally acceptable manner. A tremie concrete floor (trapezoidal 12 feet x 50 feet x 36 feet) and a rip-rap apron will protect the channel bottom from erosion by the discharge flow.

Attachment B

Permits, Licenses and Application

<u>Type of Permits of Approvals</u>	<u>Statutory Mandate</u>	<u>Administering Agency</u>	<u>Date of Application (Proposed)</u>	<u>Approval Date (Expected)</u>
<u>FEDERAL</u>				
Environmental Impact Statement	National Environmental Policy	EPA	(8/81)	(9/81)
NPDES	FWPCA (S.402)	EPA	(11/79)	(10/81)
PSD	CAA (S.160-169)	EPA	(3/80)	(9/80)
316 Demonstration	FWPCA (S.316)	EPA	(8/80)	(10/80)
<u>STATE</u>				
Site Certification Application	Florida Electrical Power Plant Siting Act	DER	(8/80)	(9/81)
BACT	Ch.403.061, F.S.	DER	(8/79)	(9/81)
<u>LOCAL</u>				
Dredge or Fill Material Permit	Ch.78-527, Laws of Florida	TPA	(1/81)	(1/82)

TPA - Tampa Port Authority

INFORMATION NEEDED ON AFFIDAVIT OF OWNERSHIP OR CONTROL

1. The affidavit of ownership or control should be signed by at least one owner of the property, lessee, or easement holder.
2. If subdivided, the property should be described by lot number, block number (if any), name of subdivision, and plat book number and page where recorded.
3. If unplatted, the property should be described by section, township, and range, and subdivision of section.
4. If the description is based on courses and distances not following the plane coordinates, the point of beginning should be identified.

Please contact this office should clarification or further instructions be necessary.

AFFIDAVIT OF OWNERSHIP OR CONTROL

TO THE DEPARTMENT OF ENVIRONMENTAL REGULATION:

I hereby certify that I am the (check one):

record owner X

lessee _____

record easement holder _____

applicant to record owner for easement _____

of the below described property situated in _____ County, Florida; and that said property is all the property that is contiguous to and landward of the area in which the work proposed in the permit application is to be conducted. Furthermore, I certify that as record owner, lessee, or record easement holder I have or will have prior to undertaking the work all necessary approvals or permission from all other persons with a legal interest in said property to conduct the work proposed in the permit application.

LEGAL DESCRIPTION

See Exhibit "A"



A. Kaiser, Vice President-Energy Supply

Sworn to and subscribed before me at Tampa Electric Company
Hillsborough County, Florida, this 8 day

of August, 1980.


NOTARY PUBLIC

My commission expires:

Notary Public, State of Florida at Large
My Commission Expires Aug. 30, 1983

EXHIBIT "A"

That part of Sections 9 and 10, Township 31 South, Range 19 East, and lands lying west thereof in Hillsborough County, Florida, more particularly described as follows:

Commencing at the Southwest corner of Section 10, Township 31 South, Range 19 East, Hillsborough County, Florida; run thence North $88^{\circ}56'28''$ West along the South boundary of said Section 9 and its westerly projection into Tampa Bay a distance of 3698.63 feet to a point on the Hillsborough County Bulkhead Line in Tampa Bay as established March 23, 1960; run thence North $04^{\circ}44'18''$ West along said Bulkhead Line a distance of 1919.77 feet, more or less, to a point on said Bulkhead Line 650 feet South of the westerly projection of the North boundary of the S 1/2 of said Section 9; run thence Easterly along a line 650 feet south of and parallel to the westerly projection of the North boundary of the S 1/2 of said Section 9 and the North boundary of the S 1/2 of said Section 9 (South $89^{\circ}48'37''$ East) a distance of 3893.51 feet to a point on the East boundary of said Section 9; run thence Easterly along a line 650 feet south of and parallel to the North boundary of the S 1/2 of said Section 10 (South $89^{\circ}22'33''$ East) a distance of 1323.65 feet to a point on the East boundary of the W 1/2 of the SW 1/4 of said Section 10; run thence South $01^{\circ}02'24''$ West along the East boundary of the W 1/2 of the SW 1/4 of said Section 10 a distance of 1972 feet to the South boundary of said Section 10; run thence North $89^{\circ}14'31''$ West along the South boundary of said Section 10 a distance of 1326.07 feet to the point of beginning.

LESS THAT PART FOR PUBLIC ROAD.

ALSO

That part of Sections 9 and 10, Township 31 South, Range 19 East, and lands lying West thereof in Hillsborough County, Florida, more particularly described as follows:

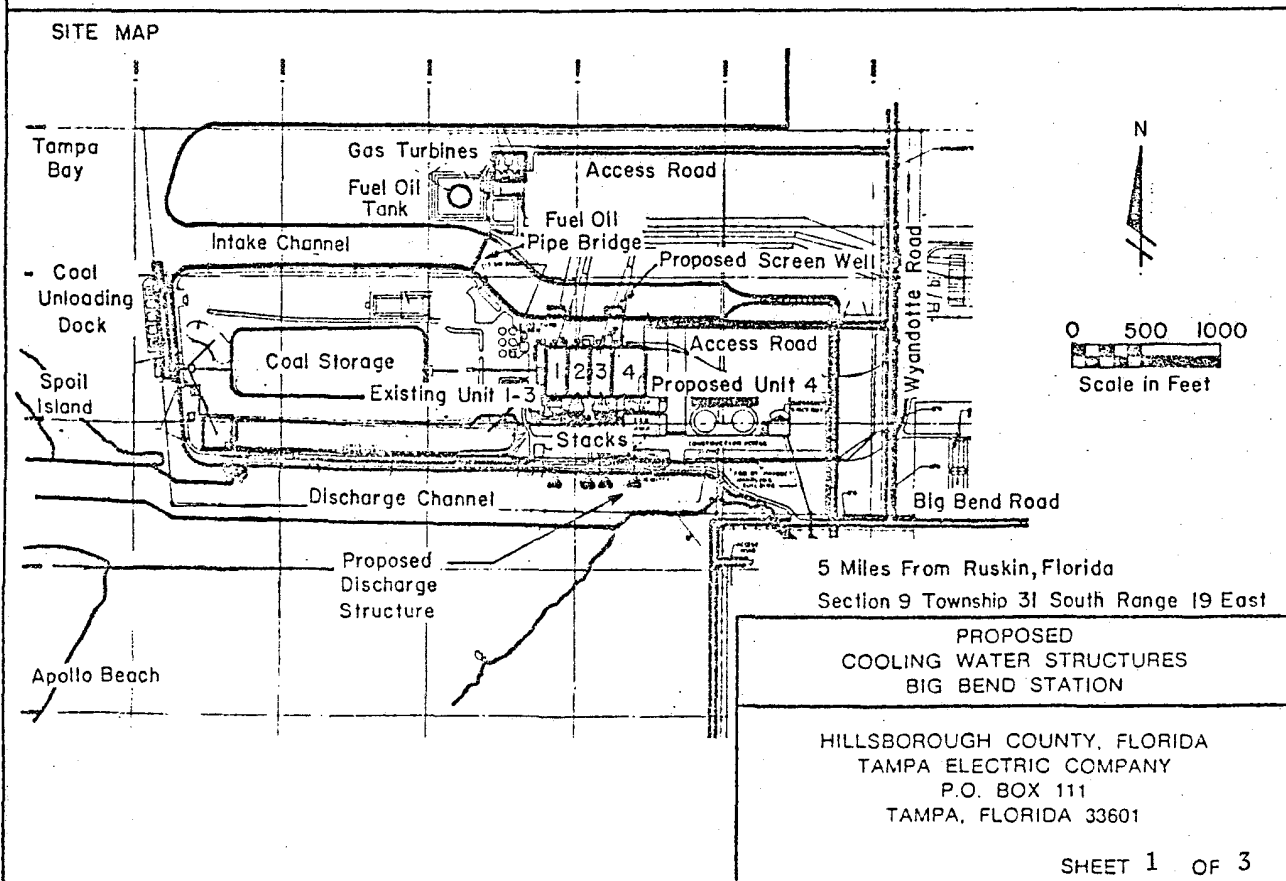
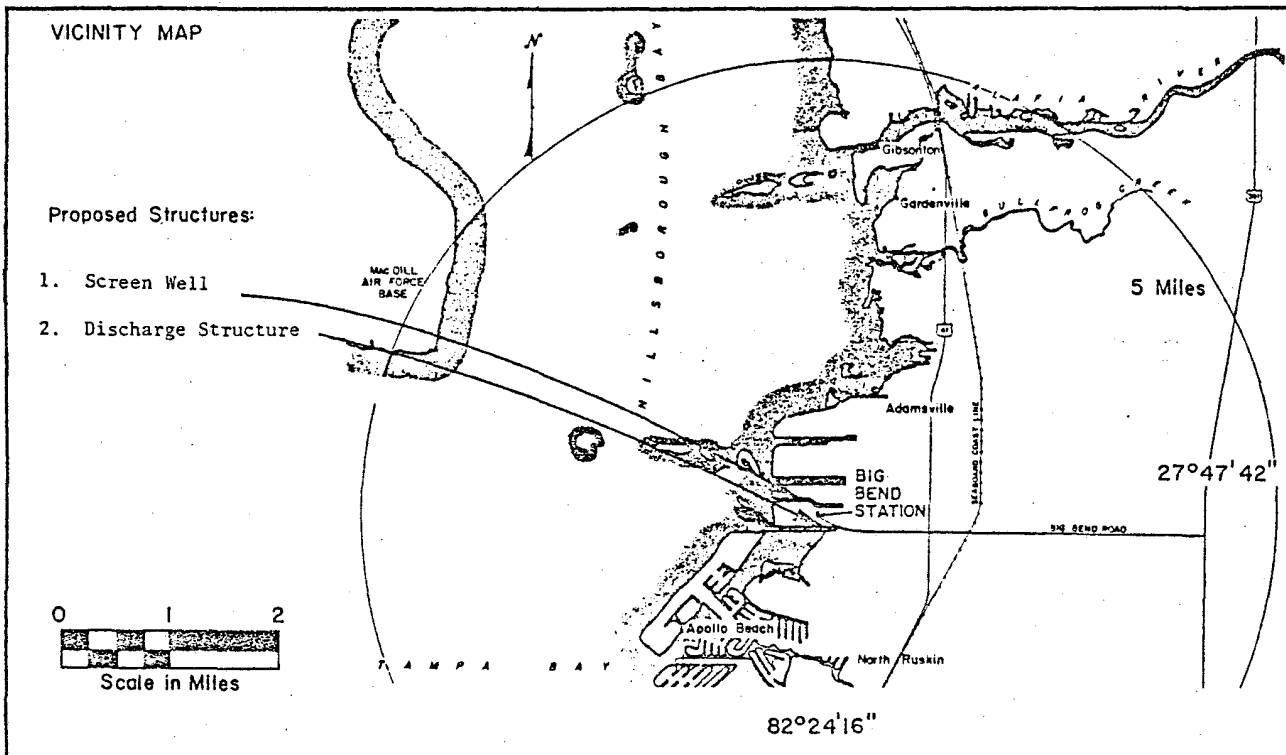
Commence at the Northeast corner of the West 1/2 of the Southwest 1/4 of Section 10, Township 31 South, Range 19 East, Hillsborough County, Florida; run thence North $89^{\circ}22'33''$ West along the North boundary of said West 1/2 of the Southwest 1/4 of Section 10 a distance of 253.99 feet to a point on the West right of way line for Wyandotte Road for the Point of Beginning; run thence South along said West right of way line to a point 650 feet South of the North boundary of said West 1/2 of the Southwest 1/4 of Section 10; run thence North $89^{\circ}22'33''$ West a distance 1067.56 feet more or less to a point on the West boundary of Section 10, said point being 650 feet South of the Northwest corner of the Southwest 1/4 of said Section 10; run thence North $89^{\circ}48'37''$ West along a line 650 feet South of and parallel to the Westerly projection of the North boundary of the South 1/2 of said Section 9 and its Westerly projection a distance of 3893.51 feet to a point on the Hillsborough County Bulkhead Line in Tampa Bay as established March 23, 1960; run thence North $04^{\circ}44'18''$ West a distance of 652.35 feet to the intersection of the Westerly projection of the North boundary of the South 1/2 of said Section 9; run thence South $89^{\circ}48'37''$ East along the Westerly projection of the North boundary of the South 1/2 of said Section 9 and its North boundary a distance of 3960 feet to the Northeast corner of the South 1/2 of said Section 9; run thence South $89^{\circ}22'33''$ East along the North boundary of the West 1/2 of the Southwest 1/4 of said Section 10 a distance of 1068.85 feet more or less to the Point of Beginning.

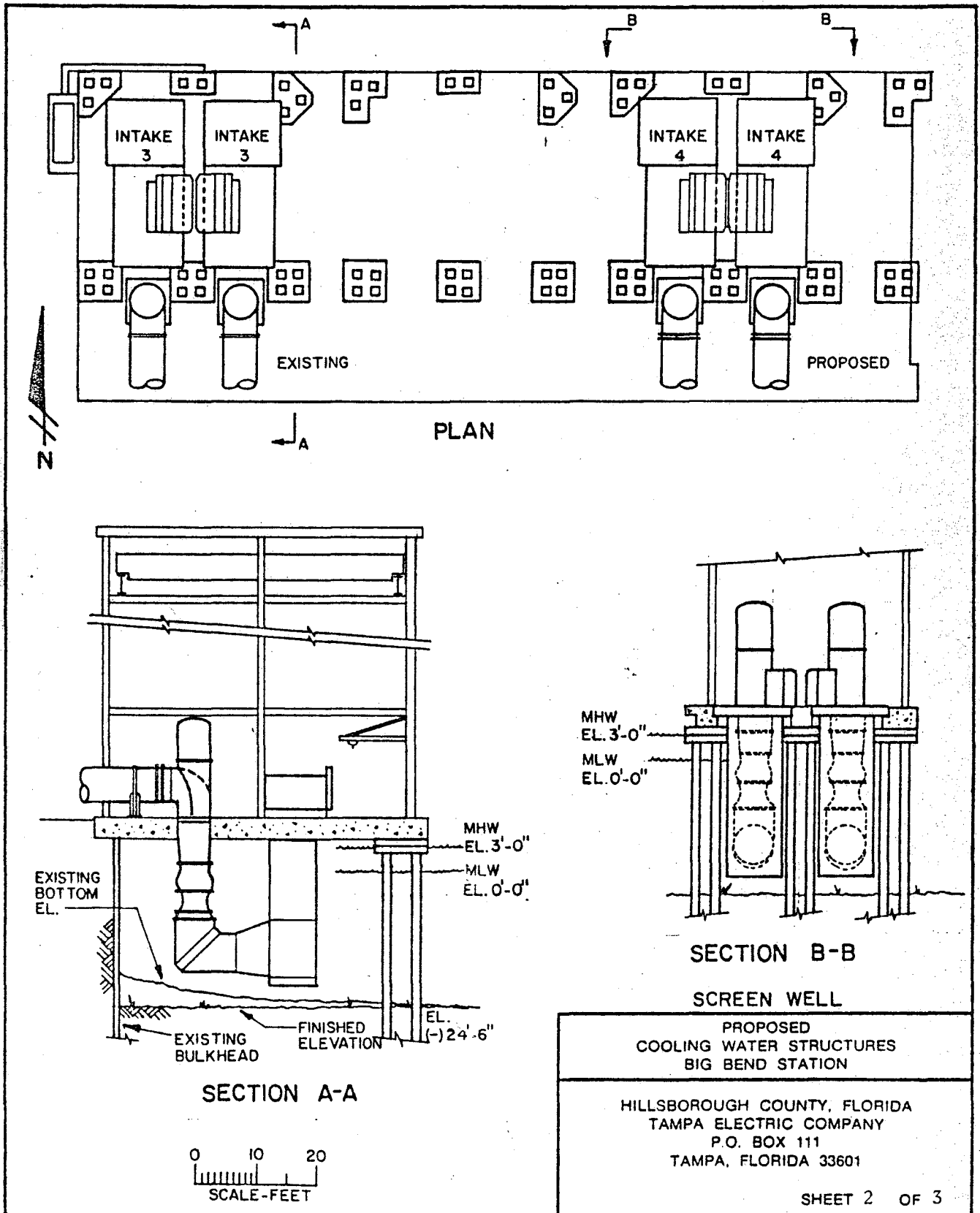


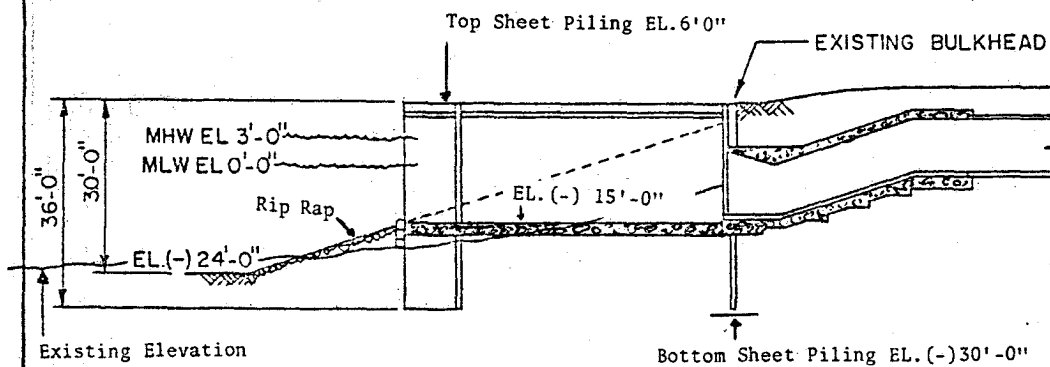
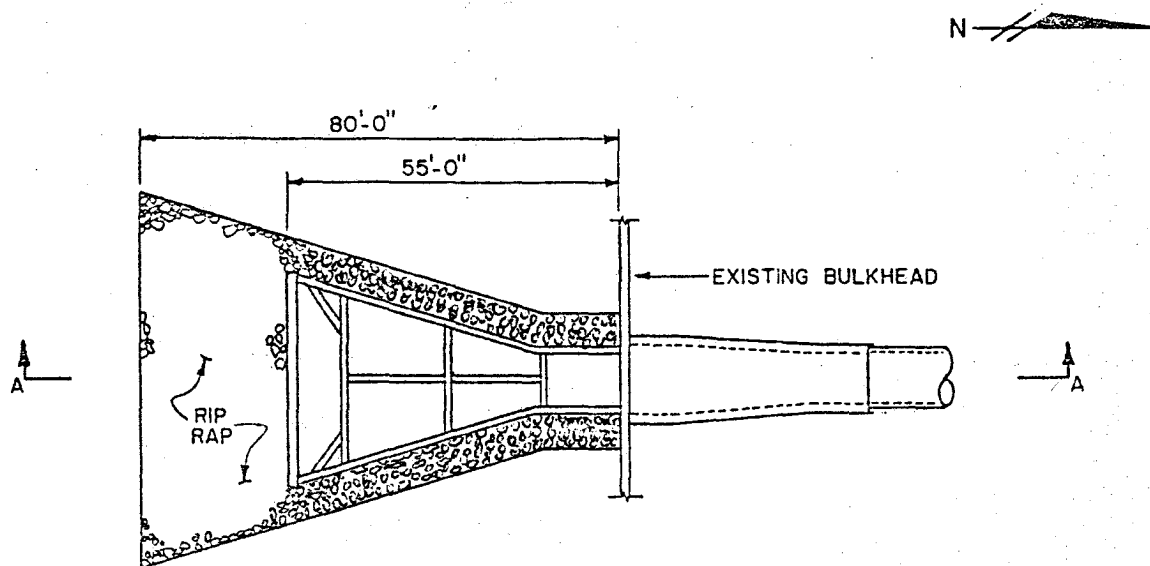
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AERIAL PHOTOGRAPH OF BIG
BEND STATION AND ADJACENT
AREA

HILLSBOROUGH COUNTY,
FLORIDA







0 10 20
SCALE-Feet

DISCHARGE STRUCTURE

PROPOSED
COOLING WATER STRUCTURES
BIG BEND STATION

HILLSBOROUGH COUNTY, FLORIDA
TAMPA ELECTRIC COMPANY
P.O. BOX 111
TAMPA, FLORIDA 33601

SHEET 3 OF 3



POST OFFICE BOX 111 TAMPA, FLORIDA 33601 TELEPHONE (813) 879-4111

August 18, 1980

Mr. Hamilton S. Oven, Jr., P.E.
Florida Department of Environmental
Regulation
Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, Florida 32301

Dear Mr. Oven:

Enclosed please find 35 copies of Amendment 4 to the Big Bend 4 Site Certification Application. This Amendment consists of a response to your letter of 13 August, 1980 to Chris H. Bentley, Division of Administrative Hearings. A revised Joint Department of the Army/Florida Department of Environmental Regulation Permit Application for activities in waters of the State of Florida is also included. Also as noted in your letter dated August 13 the enclosed responses to the FDER's comments and questions should provide a complete and sufficient application.

Document control receipts have been provided with each amendment. It is most important that each application recipient complete the receipt and return it so that we may keep our records up to date.

If there are any questions, please do not hesitate to contact me.

Sincerely,

J.L. Williams, P.E.
Manager, Environmental Planning

JLW:JBR:mo
enclosure

cc: Big Bend 4 Site Certification
Application Recipients

Application No. _____

TAMPA ELECTRIC COMPANY
BIG BEND UNIT 4
SITE CERTIFICATION APPLICATION
DOCUMENT CONTROL RECEIPT

Name _____

Title _____

Affiliation _____

☐

Receipt of Amendment 4 is acknowledged, and it is certified
that the revisions to the document have been made.

Signature

Date

If Applicable:

☐

Document Transfer

Custody of this document has been transferred to:

Name _____

Title _____

Affiliation _____

Return to:

Melissa Overstreet
Environmental Planning
Tampa Electric Company
P.O. Box 111
Tampa, Florida 33601