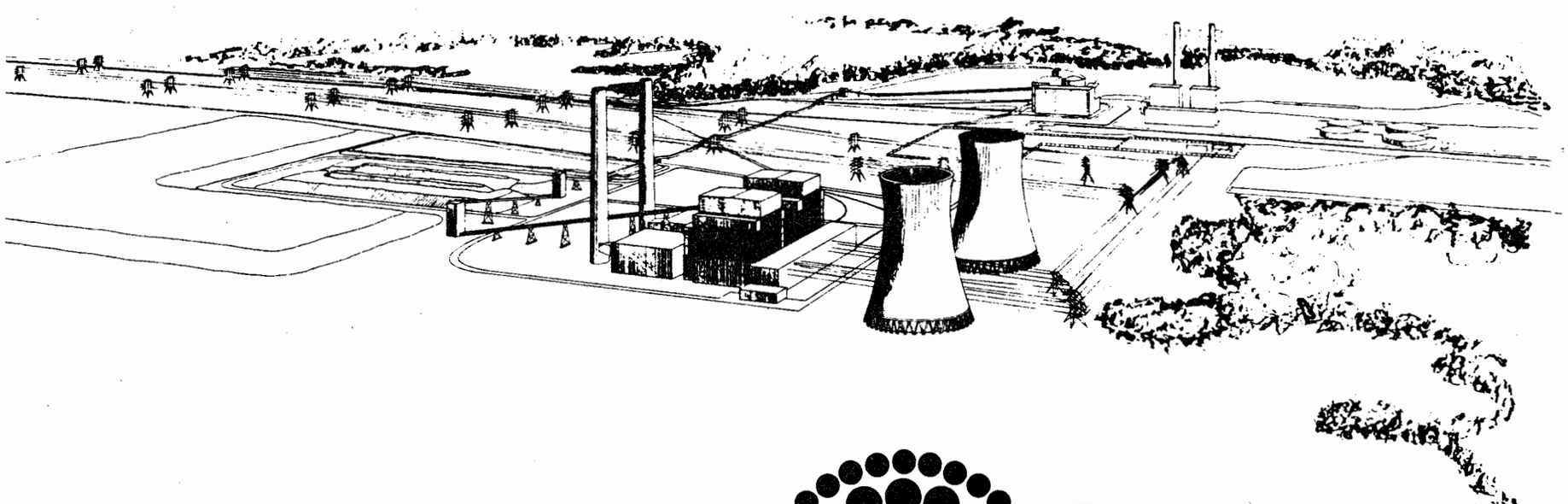
Site Certification Application

Crystal River Units No. 4 & 5



Vol. 1

Florida Power
CORPORATION

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OUTLINE OF REVISIONS INCLUDED IN VOLUME 4
OF THE
FPC CRYSTAL RIVER UNITS 4 AND 5 SITE CERTIFICATION APPLICATION

Submittal Date	Submittal Description
December 1977	Site Certification Application, Volume 1-3. Submitted to FDER.
June 14, 1978	SCA Volume 4. Submitted to FDER containing additional supporting information that reflected developments since December 1977.
July 14, 1978	SCA Volume 4. Revised again and re-issued to reflect further developments and information subsequent to the June 14, 1978 submittal.
July 21, 1978	One additional section (Section 5.8.3) was added to Volume 4 to complete all revisions to the SCA to date.
	Volume 4 was issued as a supplement to SCA Volumes 1-3, Volume 4 is to be read separately from Volumes 1-3. Certain sections have been revised since December 1977. Volume 4 reflects those revisions, but it is not designed to physically replace any sections of the original SCA Volumes.
	A summary of the contents of the most up-to-date version of SCA Volume 4 follows:
June 14, 1978	Chapter 1 is contained in its entirety in Volume 4 and includes updated graphics. Chapter 1 reflects the most recent changes as of May 30, 1978.
June 14, 1978	Section 2.4. Geology was revised and included in the June 14, 1978 submittal. This section should be read instead of the Section in Volume 1.
July 14, 1978	Section 2.5. Groundwater was revised subsequent to the June 14th submittal.
July 14, 1978	Section 2.10.2. Natural Sea Salt was added to Volume 4. Figures 2.10-5 through 2.10-7 were also added in the latest revisions.

Submittal Date	Submittal Description
July 14, 1978	Chapter 3. The Plant is included in its entirely in the June 14th SCA Volume 4. Sections 3.3 and 3.10 of Chapter 3 were, again revised on July 14 to reflect salt water cooling towers and other changes.
July 14, 1978	Section 4.1.1. Construction Areas and Activities. Two pages were revised in this section for the July 14th Volume 4.
July 14, 1978	Section 4.2.2. Water Quality. Whole section revised.
July 14, 1978	Section 4.3.3. Other Impacts on Biota. Whole section revised.
July 14, 1978	Section 5.1.1. Physical Effects on Groundwater Withdrawal. Whole section was revised to show new Geraghty and Miller test well report.
July 14, 1978	Section 5.1.2. Biological Effects of Groundwater Withdrawal. Whole section revised to reflect new wellfield data in Geraghty and Miller report.
July 14, 1978	Section 5.1.4. Cooling Tower Drift. This section was revised to reflect the decision to use saltwater cooling towers for CR Units 4 and 5.
July 14, 1978	Section 5.1.2. Biological impacts of Impingement and Entrainment. This section was added to Chapter 5 to reflect the new design of the intake structures for CR Units 4 and 5.
June 14, 1978	Section 5.2.1. Summary of Wastewater Disposal Systems. Whole section revised.
July 14, 1978	Section 5.2.2. Cooling Systems Blowdown. Revised due to change to saltwater cooling towers.
July 14, 1978	Section 5.2.6. Cooling System Intake. Reflects new intake design.
July 14, 1978	Section 5.3. Impacts on Groundwater Systems. Revised to reflect use of saltwater cooling towers.
June 14, 1978	Section 5.4. PSD Analysis--Air Quality. Whole section revised.
June 14, 1978	Section 5.6.5. Transportation. Section added to respond to FDER comments.

Submittal Date	Submittal Description
July 21, 1978	Section 5.8.5. Control Technology. Changed to show use of saltwater cooling towers.
July 14, 1978	Section 6.2. Plant Construction and Operation Monitoring. Section added to Chapter 6 to show FPC's proposed monitoring programs for the construction period.
July 14, 1978	Section 7.2. Costs and Benefits of the Project to Power Users and to Florida Power Corporation. This section was revised to show any changes in costs or benefits to Florida Power due to the use of saltwater cooling towers.
June 14, 1978	Section 8A. Ecological Comparison of Crystal River and Phosphate Zone Sites. This section was issued as a supplement to Chapter 8 in order to add more depth to the comparisons between the Crystal River site and the phosphate zone sites.
July 14, 1978	Section 9.4.3. Alternatives Considered. This section is revised to show the effect of choosing saltwater cooling water as the preferred cooling water source.
June 14, 1978	Lake Rousseau Report. Included in its entirety to explain the data that resulted from the study of Lake Rousseau as an alternative source for cooling water for CR Units 4 and 5.

AN EXPLANATION OF THE REVISIONS TO
FLORIDA POWER CORPORATION'S SITE CERTIFICATION APPLICATION
FOR CRYSTAL RIVER UNITS 4 AND 5

Chapter 1 Need for Power: Included in original SCA submitted on December 14, 1977.

Chapter 1-Need for Power, completely revised June 14, 1978, to reflect an updated in-service date for Unit 5 and current system information.

Chapter 2 The Site: Included in original SCA submitted on December 14, 1977.

Section 2.4- Geology, revised June 14, 1978, to reflect new information obtained from core borings made on the site.

Section 2.5.1- Groundwater, revised July 14, 1978, to incorporate well test information.

Section 2.10.2- Natural Sea Salt, added July 14, 1978, to present information on natural salt deposition.

Chapter 3 The Plant: Included in original SCA submitted on December 14, 1977.

Chapter 3 - The Plant, completely revised June 14, 1978.

Section 3.3 - Plant Water Use, revised July 14, 1978, to reflect salt water cooling towers as the primary alternative.

Section 3.4 - Heat Dissipation System, revised July 14, 1978, to reflect salt water cooling towers as the primary alternative.

Section 3.10 - Onsite Drainage and Erosion Control, revised July 14, 1978, submittal.

Chapter 4 Environmental Effects of Site Preparation, Plant and Associated Transmission Facilities Construction: Included in original submittal of SCA on December 14, 1977.

Section 4.1.1 - Construction Areas and Activities, two pages, revised July 14, 1978, to reflect drilled pier construction for foundation support rather than concrete grouting and construction of surface (salt) water intake.

Section 4.2.2 - Water Quality, revised July 14, 1978, to reflect changes in impacts due to drilled pier construction.

Section 4.3.3 - Other Impacts on Biota, revised July 14, 1978, to reflect changes in impacts due to drilled pier construction.

Chapter 5 Environmental Effects of Plant Operation: Included in original submittal of SCA on December 14, 1977.

Section 5.2.1 - Summary of Wastewater Disposal Systems, revised June 14, 1978.

Section 5.4 - PSD Analysis-Air Quality, revised June 14, 1978 to reflect the control strategy developed as a result of the EPA PSD permit.

Section 5.6.5 - Transportation, revised June 14, 1978, to respond to DER comments.

Section 5.1.1 - Physical Effects on Groundwater Withdrawal, and

Section 5.1.2 - Biological Effects of Groundwater Withdrawal, revised July 14, 1978 to reflect the test well data.

Section 5.1.4 - Cooling Tower Drift, modified July 14, 1978, to show effects of salt water drift from saltwater cooling towers.

Section 5.1.5 - Biological Impacts of Impingement and Entrainment, revised July 14, 1978, to reflect salt water intake from the existing discharge canal.

Section 5.2.2 - Cooling System Blowdown, changed July 14, 1978, to reflect impacts of saltwater cooling tower blowdown.

Section 5.2.6 - Cooling System Intake, modified July 14, 1978, to reflect new intake design.

Section 5.3 - Impacts on Groundwater Systems, revised July 14, 1978, to reflect impacts associated with plant service water usage.

Section 5.8.5 - Control Technology revised July 21, 1978, to show use of salt water from existing discharge canal as the cooling system.

Chapter 6 Environmental Measurement and Monitoring Program:

Section 6.1 - Baseline Measurements and Monitoring Program, included in original submittal of SCA on December 14, 1977.

Section 6.2 - Plant Construction and Operation Monitoring, originally submitted on June 14, 1978.

Chapter 7 Economic and Social Effects of Plant Construction and Operation: Included in original submittal dated December 14, 1977.

Section 7.2 - Costs and Benefits of the Project to Power Users and to Florida Power Corporation, revised July 14, 1978, to show changes caused by salt water cooling towers.

Chapter 8 Alternative Energy Sources and Sites: Included in original submittal on December 14, 1977.

Section 8A - Ecological Comparison of Crystal River and Phosphate Zone Sites, submitted June 14, 1978.

Chapter 9 Plant Design Alternatives: Included in original SCA submitted on December 14, 1977.

Section 9.4.3 - Alternatives Considered, revised July 14, 1978, to show saltwater cooling towers as the preferred alternative.

Lake Rousseau Report: Submitted June 14, 1978, in Volume 4, as a comprehensive analysis of using Lake Rousseau as a cooling water source.

INSTRUCTION SHEET
FOR UPDATING VOLUME 4
(July 14, 1978)

The following list indicates the additional revisions which should be incorporated into Volume 4 of the Florida Power Corporation Site Certification Application for Crystal River Units 4 and 5. Some of the revised sections are replacements for sections already in the Volume; other sections are additional revisions of the original Volumes 1 through 3 of the SCA. These revised pages should be inserted into the Volume 4 in proper numerical order.

New Sections/Graphics	Instructions
Table of Contents	Replace existing Table of Contents with revised Table of Contents.
2.5.1 Hydrology Groundwater and 2.10.2 Natural Sea Salt	Insert Sections 2.5.1 and 2.10.2 after Section 2.4.5, Flooding.
Figure 3.1-4	Replace Figure 3.1-4, page 3-5, with revised Figure 3.1-4.
Figure 3.1-6	Replace Figure 3.1-6, page 3-8, with revised Figure 3.1-6
Figure 3.3-1	Replace Figure 3.3-1, page 3-26, with revised Figure 3.3-1.
Table 3.3-1	Replace Table 3.3-1, pages 3-27 to 3-30, with revised Table 3.3-1.
Section 3.3 Plant Water Use	Replace Section 3.3, pages 3-31 to 3-36, with revised Section 3.3.
Section 3.4 Heat Dissipation System	Replace Section 3.4, pages 3-37 to 3-43, with revised Section 3.4.
Figure 3.5-1	Replace Figure 3.5-1, page 3-45, with revised Figure 3.5-1.
Figure 3.9-2	Replace Figure 3.9-2, page 3-88, with revised Figure 3.9-2.

INSTRUCTION SHEET
FOR UPDATING VOLUME 4
(July 14, 1978)
(continued, page 2 of 2)

New Sections/Graphics	Instructions
Section 3.10 On-Site Drainage and Erosion Control	Replace Section 3.10 with revised Section 3.10.
Section 4.0	Insert the following revised pages for Section 4.0 after the last page (3-96) of Chapter 3: Section 4.1, pages coded 4.1-1 and 4.1-2 Section 4.2-2, page coded 4.2-2 Section 4.3-3, pages coded 4-3.5 to 4-3.7
Sections 5.1.1, 5.1.2, 5.1.4, 5.1.5	Insert revised Section 5.1.1, Physical Effects of Groundwater Withdrawal; Section 5.1.2, Biological Effects of Groundwater Withdrawal; 5.1.4, Cooling Tower Drift; and 5.1.5, Biological Impacts of Impingement and Entrainment after revised Section 4.3.3.
Section 5.2.2 Cooling System Blowdown	Replace Section 5.2.2, pages coded 5.2-3 and 5.2-4 with revised Section 5.2.2.
Section 5.2.6 Cooling System Intake	Add Section 5.2.6 (coded 5.2-9) after Section 5.2.5 (following page coded 5.2-8).
Section 7.2 Costs and Benefits of the Project to Power Users and to Florida Power Corporation	Add Section 7.2 (pages coded 7.2-1 through 7.2-6) after Section 6.2.4 (following page coded 6.2-7).
Section 9.4.3 Alternatives Considered	Add Section 9.4.3 (pages coded 9.4-4 through 9.4-8) after Section 8A (following page coded VTB8.A-1).

The Site Certification Application for the proposed Crystal River Units 4 and 5 was submitted on December 14, 1977 to Florida Department of Environmental Regulation. Since then, Environmental Science and Engineering, Inc. has compiled additional information and has received comments from various state agencies. The following sections present additional supporting information to the Site Certification Application.

Section	Title
1.0	PURPOSE OF PROPOSED FACILITY AND ASSOCIATED TRANSMISSION
2.4	GEOLOGY
	2.4.1 Site Description
	2.4.2 Physiography
	2.4.3 Stratigraphy
	2.4.4 Soils
	2.4.5 Flooding
2.5	HYDROLOGY
	2.5.1 Ground Water
2.10	OTHER ENVIRONMENTAL FEATURES
	2.10.1 Natural Sea Salt
3.0	THE PLANT
4.0	SITE PREPARATION AND ASSOCIATED FACILITIES CONSTRUCTION/RESULTING ENVIRONMENTAL ENVIRONMENTAL EFFECTS
4.1	SITE PREPARATION AND PLANT CONSTRUCTION
	4.1.1 Construction Areas and Activities
	4.2.2 Water Quality
	4.3.3 Other Impacts on Biota
5.1	HEAT DISSIPATION SYSTEM
	5.1.1 Physical Effects of Groundwater Withdrawal
	5.1.2 Biological Effects of Groundwater
	5.1.4 Cooling Tower Drift
	5.1.5 Biological Impacts of Impingement and Entrainment
5.2	IMPACTS ON SURFACE WATERS
	5.2.2 Cooling System Blowdown
	5.2.6 Cooling System Intake
5.3	IMPACTS ON GROUNDWATER SYSTEMS
5.4	PSD ANALYSIS - AIR QUALITY
	5.6.5 Transportation

Section	Title
6.2	PLANT CONSTRUCTION AND OPERATION MONITORING
	6.2.1 Air
	6.2.2 Wastewater
	6.2.3 Groundwater
	6.2.4 Archaeology
7.2	COSTS AND BENEFITS OF THE PROJECT TO POWER USERS AND TO FLORIDA POWER CORPORATION
	7.2.1 Costs Attributable to Proposed Crystal River Units 4 and 5
9.4	WATER SOURCE AND INTAKE ALTERNATIVES
	9.4.3 Alternatives Considered
8.A	ECOLOGICAL COMPARISON OF CRYSTAL RIVER AND PHOSPHATE ZONE SITES (Addendum to Chapter 8)
	SECONDARY COOLING TOWER MAKEUP ALTERNATIVES: REPORT OF THE LAKE ROUSSEAU STUDIES

INSTRUCTION SHEET
FOR UPDATING VOLUME 4
(July 14, 1978)

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Table 3.3-1	Replace Table 3.3-1, pages 3-27 to 3-30, with revised Table 3.3-1.
Section 3.3 Plant Water Use	Replace Section 3.3, pages 3-31 to 3-36, with revised Section 3.3.
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INSTRUCTION SHEET
FOR UPDATING VOLUME 4
(July 14, 1978)
(continued, page 2 of 2)

New Sections/Graphics	Instructions
Section 3.10 On-Site Drainage and Erosion Control	Replace Section 3.10 with revised Section 3.10.
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Sections 5.1.1, 5.1.2, 5.1.4, 5.1.5	Insert revised Section 5.1.1, Physical Effects of Groundwater Withdrawal; Section 5.1.2, Biological Effects of Groundwater Withdrawal; 5.1.4, Cooling Tower Drift; and 5.1.5, Biological Impacts of Impingement and Entrainment after revised Section 4.3.3.
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Section 7.2 Costs and Benefits of the Project to Power Users and to Florida Power Corporation	Add Section 7.2 (pages coded 7.2-1 through 7.2-6) after Section 6.2.4 (following page coded 6.2-7).
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	5.1.2 Biological Effects of Groundwater
	5.1.4 Cooling Tower Drift
	5.1.5 Biological Impacts of Impingement and Entrainment
5.2	IMPACTS ON SURFACE WATERS
	5.2.2 Cooling System Blowdown
	5.2.6 Cooling System Intake
5.3	IMPACTS ON GROUNDWATER SYSTEMS
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	6.2.1 Air
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CHAPTER 1

CHAPTER 1

PURPOSE OF PROPOSED FACILITY AND ASSOCIATED TRANSMISSION

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1.0 PURPOSE OF PROPOSED FACILITY AND ASSOCIATED TRANSMISSION

1.1 SYSTEM DEMAND AND RELIABILITY

1.1.1 LOAD CHARACTERISTICS

1.1.1.1 LOAD ANALYSIS

Florida Power Corporation's history and forecast of energy use by customer class is shown in Tables 1.1-1 and 1.1-2, and the history and forecast of net seasonal peak demands is shown in Table 1.1-3. The forecasts shown have been adjusted to account for partial ownership of Crystal River 3 by Seminole Electric Cooperative and some of the municipal systems currently served by Florida Power. There is also an adjustment to account for the announced plans of Seminole Electric to build two 600 MW coal units in the mid-1980's. Methods used in making these adjustments are discussed in detail in Section 1.1.1.2.

Figure 1.1-1 shows a per unitized annual load duration curve* that is expected to be typical of the Florida Power system for future years. Some small variations are expected in this curve from year to year, but the variations will not be particularly significant.

Figure 1.1-2 shows historical and predicted annual peak demands as well as the historical and projected generating capacity of Florida Power Corporation.

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* Annual Load Duration Curve - a curve on a chart showing percentage of power supplied plotted against percentage of time of occurrence and illustrating the varying magnitude of the load during the period covered.

TABLE 1.1-1

HISTORY OF ENERGY USE

	RURAL & RESIDENTIAL						COMMERCIAL		INDUSTRIAL	
Year	GWH	Average No. of Customers	Average KWH Consumption Per Customer	FPC % Increase*	Nat'l Avg KWH Consumption Per Customer	National % Increase*	GWH	Average No. of Customers	GWH	Average No. of Customers
1958	844	211421	3991	15.0	3351	6.0	431	28746	592	817
1959	953	230289	4137	3.7	3575	6.7	504	30237	719	881
1960	1115	248533	4488	8.5	3818	6.8	562	31754	828	936
1961	1213	257901	4704	4.8	3976	4.1	617	33072	780	976
1962	1386	269131	5150	9.5	4220	6.1	720	34152	907	762
1963	1543	278238	5546	7.7	4389	4.0	814	34857	999	720
1964	1714	288498	5942	7.1	4653	6.0	918	35836	1049	860
1965	1803	299961	6011	1.2	4878	4.8	1020	36951	1191	936
1966	2066	313205	6597	9.7	5211	6.8	1136	38228	1353	1007
1967	2213	328350	6739	2.2	5522	6.0	1250	39064	1581	1061
1968	2671	347466	7688	14.1	5985	8.4	1426	40953	1732	1131
1969	3196	368804	8666	12.7	6516	8.9	1628	43089	1891	1209
1970	3696	392593	9415	8.6	6995	7.4	1844	45033	1912	1248
1971	4133	421165	9814	4.2	7297	4.3	2134	49072	2030	1313
1972	4717	459002	10277	4.7	7598	4.1	2403	53606	2197	1384
1973	5793	505546	11459	11.5	7981	5.0	2836	58455	2350	1456
1974	5286	541702	9758	-14.8	7822	- 2.0	2935	60478	2422	1486
1975	5412	557893	9701	- 0.6	8077	3.3	3188	60598	2479	1466
1976	5751	579044	9932	2.4	8267	2.4	3298	62277	2690	1489

* Percent (%) increase of average KWH consumption per customer

TABLE 1.1-1

FORECAST OF ENERGY USE

	RURAL & RESIDENTIAL						COMMERCIAL		INDUSTRIAL	
Year	GWH	Average No. of Customers	Average KWH Consumption Per Customer	FPC % Increase*	Nat'l Avg KWH Consumption Per Customer	National % Increase*	GWH	Average No. of Customers	GWH	Average No. of Customers
1977	6521	603204	10811	8.9	N/A	N/A	3602	64692	2772	1644
1978	6624	622812	10636	- 1.6			3845	65400	2945	1692
1979	7042	647292	10879	2.3			4142	66876	3129	1740
1980	7473	671556	11128	2.3			4416	68388	3317	1800
1981	7904	692844	11408	2.5			4703	69888	3516	1872
1982	8330	713424	11676	2.3			5003	71364	3722	1944
1983	8736	734100	11900	1.9			5242	72800	3939	2000
1984	9136	755000	12101	1.7			5465	74300	4164	2050
1985	9531	774900	12300	1.6			5666	75800	4401	2100
1986	9935	794800	12500	1.6			5856	77300	4639	2150
1987	10298	814100	12650	1.2			6036	78800	4871	2200
1988	10661	832900	12800	1.2			6207	80300	5100	2250
1989	10979	851100	12900	0.8			6364	81700	5319	2300
1990	11280	867700	13000	0.8			6523	83100	5505	2350
1991	11549	881600	13100	0.8			6676	84400	5670	2400
1992	11818	895300	13200	0.8			6813	85700	5811	2450
1993	12086	908700	13300	0.8			6943	86900	5945	2500
1994	12354	921900	13400	0.8			7070	88100	6070	2550
1995	12627	935300	13500	0.7			7198	89300	6191	2600
1996	12856	948800	13550	0.4			7330	90600	6315	2650
1997	13066	962500	13575	0.2			7453	91900	6441	2700

* Percent (%) increase of average KWH consumption per customer

TABLE 1.1-2

HISTORY OF ENERGY USE

Year	Street & Highway Lighting GWH	Other Sales to Ultimate Consumers GWH	Total Sales to Ultimate Consumers GWH	Sales for Resale GWH	Utility Use, Losses, Billing Lag GWH	Net Energy for Load GWH
1958	7	103	1977	353	302	2632
1959	9	115	2300	389	304	2993
1960	11	116	2632	327	341	3300
1961	13	131	2754	377	329	3460
1962	13	145	3171	435	385	3991
1963	14	153	3523	478	402	4403
1964	17	167	3865	540	386	4791
1965	21	186	4221	598	406	5225
1966	17	207	4779	691	452	5922
1967	49	205	5298	783	491	6572
1968	56	226	6111	925	591	7627
1979	60	244	7019	1068	626	8713
1970	64	261	7777	1252	826	9855
1971	68	286	8651	1432	878	10961
1972	72	305	9694	1828	1156	12678
1973	77	326	11382	2191	1244	14817
1974	83	292	11018	2296	1088	14402
1975	86	290	11455	2489	1293	15237
1976	93	337	12169	2648	1215	16032

TABLE 1.1-2

FORECAST OF ENERGY USE

Year	Street & Highway Lighting GWH	Other Sales to Ultimate Consumers GWH	Total Sales to Ultimate Consumers GWH	Sales for Resale GWH	Utility Use, Losses, Billing Lag GWH	Net Energy for Load GWH
1977	97	376	13368	2853	1319	17540
1978	103	418	13935	3081	1500	18516
1979	110	463	14886	3328	1596	19810
1980	117	513	15836	3561	1693	21090
1981	124	560	16807	3810	1794	22411
1982	132	605	17792	4057	1892	23741
1983	141	648	18706	3288	1811	23805
1984	150	687	19602	2810	1935	24347
1985	161	721	20480	2398	1924	24802
1986	172	750	21352	2004	2000	25356
1987	180	777	22162	2087	2071	26320
1988	188	800	22956	2165	2140	27261
1989	196	822	23680	2237	2201	28118
1990	204	841	24353	2302	2257	28912
1991	211	859	24965	2360	2308	29633
1992	217	876	25535	2414	2359	30308
1993	224	894	26092	2467	2407	39066
1994	230	912	26636	2519	2454	31609
1995	236	930	27182	2570	2500	32252
1996	242	948	27691	2616	2545	32852
1997	247	967	28174	2655	2589	33418

TABLE 1.1-3

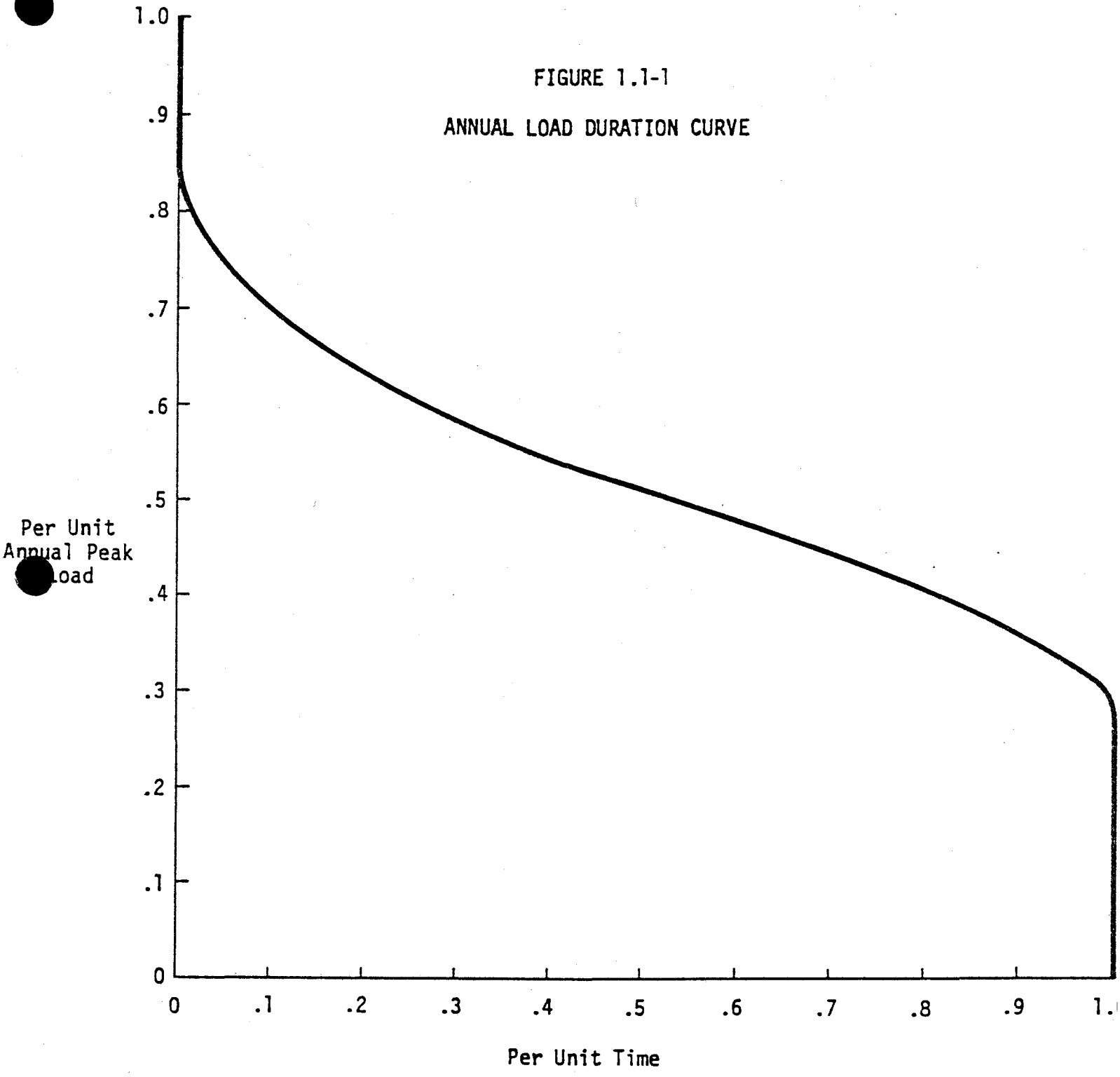
HISTORY AND FORECAST OF SEASONAL DEMANDS

Year	Summer Peak Demand Net MW	Year	Winter Peak Demand Net MW
1958	454*	1958-59	601*
1959	538*	1959-60	662*
1960	580*	1960-61	756*
1961	616*	1961-62	805*
1962	727*	1962-63	960*
1963	822*	1963-64	1034*
1964	912*	1964-65	1003*
1965	971*	1965-66	1242*
1966	1104*	1966-67	1220*
1967	1254*	1967-68	1388*
1968	1487*	1968-69	1551*
1969	1710*	1969-70	1979*
1970	1988*	1970-71	2152*
1971	2143*	1971-72	2114*
1972	2564*	1972-73	2671
1973	2862	1973-74	2989
1974	2835	1974-75	3010
1975	2975	1975-76	3530
1976	3223	1976-77	3899
1977	3407	1977-78	4150
1978	3700	1978-79	4450
1979	3950	1979-80	4750
1980	4190	1980-81	5050
1981	4440	1981-82	5360
1982	4710	1982-83	5660
1983	4750	1983-84	5760
1984	4950	1984-85	6050
1985	5030	1985-86	6140
1986	5160	1986-87	6310
1987	5380	1987-88	6580
1988	5500	1988-89	6730
1989	5590	1989-90	6860
1990	5770	1990-91	7080
1991	5740	1991-92	7090
1992	5900	1992-93	7290
1993	5850	1993-94	7290
1994	6010	1994-95	7490
1995	6060	1995-96	7580
1996	6200	1996-97	7770
1997	6340	1997-98	7930

* Gross MW - Net MW not available

FIGURE 1.1-1

ANNUAL LOAD DURATION CURVE



1.1.1.2 DEMAND PROJECTIONS

The first step in making a forecast is to arrive at a set of assumptions on which to base the forecast. These assumptions are first determined by a committee from the System Planning and Consumer Research Departments and then submitted to top management for approval and/or change as required. The following is the set of assumptions upon which the forecast shown in Section 1.1.1.1 is based:

1. Normal weather conditions will prevail.

2. The economy of the service area will continue to improve at a slow, steady rate.

3. No significant loss of energy sales to solar energy will occur until the late 1980's.

4. Personal income will increase at a rate equal to or greater than the CPI; rate increases, if any, will be equal to or less than the CPI. No effects of rate increases will be included in the forecast.

5. We will continue to serve all of the wholesale load which we now serve as well as the energy required for the load growth of the existing wholesale customers, except the load and energy responsibility which will be assumed by Seminole Electric Cooperative.

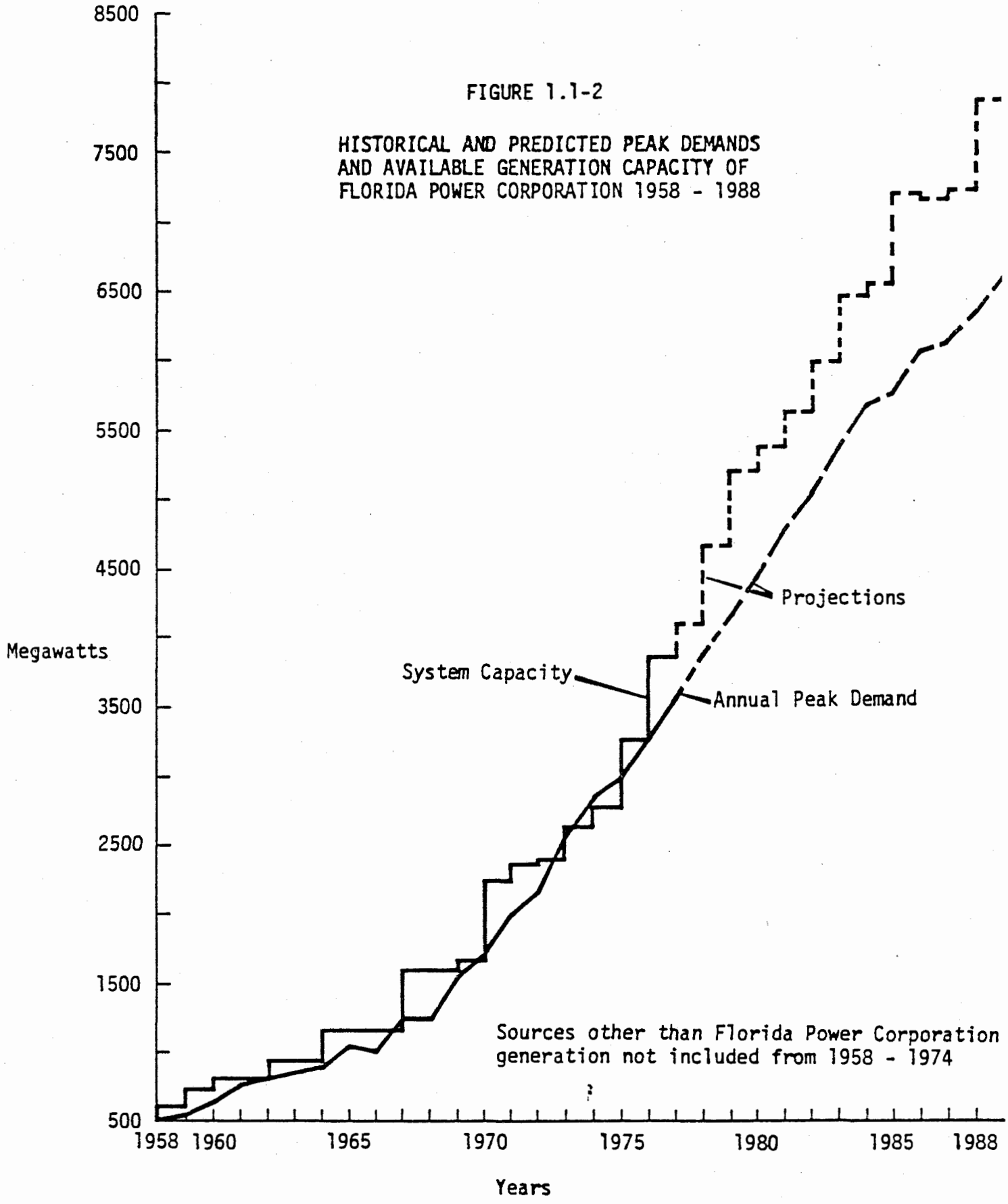


FIGURE 1.1-2
HISTORICAL AND PREDICTED PEAK DEMANDS
AND AVAILABLE GENERATION CAPACITY OF
FLORIDA POWER CORPORATION 1958 - 1988
8500
7500
6500
5500
4500
3500
2500
1500
500
Megawatts
Projections
System Capacity
Annual Peak Demand
Sources other than Florida Power Corporation
generation not included from 1958 - 1974
1958
1960
1965
1970
1975
1980
1985
1988
Years

6. Unavailability of fossil fuels will cause an increase in use of electricity for space heating.

7. The population projection made by the Bureau of Economic and Business Research of the University of Florida in Bulletin No. 41 is reasonably accurate.

8. There will be no impact of load management reflected in the forecast.

9. Improvements in insulation levels and equipment efficiency and increased emphasis on conservation will result in reduced sales beginning in the mid-1980's.

Customer projections in the forecast shown are based on the population projections published by the Bureau of Economic and Business Research in Bulletin No. 41, dated July, 1977. A linear regression of average annual residential customers and the population estimates of the 32 counties which constitute the service area yields the equation "Average Annual Residential Customers - (0.2699) x (Service Area Population) - 185600." This equation has a coefficient of determination of 0.9897.

The equation derived in this manner was used in conjunction with the population projections as a basis for the residential customer forecast. A similar regression of average annual residential customers and average annual commercial customers yields the equation "Commercial Customers = (0.0944) x (Residential Customers) + 7615." This equation has a coefficient of determination of 0.9966. This equation was used as a basis for the

commercial customer forecast. The remaining classes of customers represent a very small portion of the total and were forecast using trends.

The key indicator used in forecasting residential sales is annual kilowatt-hour consumption per customer. This indicator is forecast by two different methods, and the results are compared for consistency. The first method is a projection based on past trends, with some judgment of the effects of future events applied rather than using strictly rigorous mathematical methods. The second method used can be described as a disaggregate method. Sales to a "typical" residential customer are broken down by appliance such as air conditioning, heating, refrigeration, water heating, etc. The usage for each appliance is then combined with projections of appliance saturation to produce a forecast of kilowatt-hour sales per customer. The usage per appliance is based on in-house load research conducted over past years, when available, and on EEI published data when in-house data is not available. The kilowatt-hour sales per customer obtained by these two methods are then compared and a final estimate made.

Commercial kilowatt-hour sales are also estimated by two different methods. Historical growth rates of total commercial sales are used to make projections of future growth rates. Sales figures obtained in this manner are compared to figures obtained by projecting historical kilowatt-hour sales per customer for future years and necessary adjustments made to form the final forecast.

Sales to the industrial, public authorities, and street and highway lighting classes are obtained by projections of historical growth rates.

The sales for resale class is forecast in two categories--Rural Electric Administrations (REA's) and municipals, and the total is obtained by adding the two. In past years, sales to the REA category have been closely related to the sales to the residential category. A regression of these two variables yields the equation "REA = (0.2383) x (Florida Power Corporation Residential Customers) - 325,700,000" and a coefficient of determination of 0.9951. In making the projections, however, the fact has been considered that the REA's serve in the more rural areas and therefore have greater potential for growth. Therefore, the final sales figures are a result of the regression equation tempered by judgment.

Similarly, sales to the municipal class have historically followed total sales excluding the sales to municipals. Using logic similar to that used for the REA sales, the municipal utilities serve in areas that are somewhat restricted, and therefore sales to this category are restrained in the later years of the forecast. The coefficient of determination for sales to municipals and total sales less municipals is 0.9775.

At this point in the forecasting process, total sales and total average annual customer forecasts have been determined, and therefore, annual kilowatt-hour sales per customer can be calculated. A regression of the variables, annual kilowatt-hour sales per customer, and kilowatt demand per customer yields equations with coefficients of determination of 0.99 and 0.88 for summer and winter data, respectively. The equation derived

for summer demand per customer is "KW/Customer, Summer = (2.5014×10^{-4}) x (KWH/Customer) - 0.6290," and the winter equation is "KW/Customer, Winter = (2.0981×10^{-4}) x (KWH/Customer) + 0.1597." These equations again tempered by judgment are used to determine the seasonal demand forecast. The annual load factor is then calculated to check the forecast for reasonableness.

At this time, a complete forecast has been determined which includes sales and demand of all wholesale load per assumption No. 5. However, it is known that several of the wholesale customers now own part of Crystal River Unit 3. The total of this unit now owned by the municipals is approximately 18.77 megawatts (MW) and Seminole Electric owns about 14.02 MW of the unit. An adjustment ot these two categories is made by subtracting 164,400 MWH (18.77 x 8760) from the municipal sales and 122,800 MWH (14.02 x 8760) from the REA sales. The demand forecast is adjusted by subtracting 33 MW from the total.

Seminole Electric has announced plans to build two 600 MW coal units in the mid-1980's. Seminole Electric has furnished Florida Power with projections concerning the amount of load they intend to serve from these two units. This information has been used to adjust Florida Power Corporation's demand forecasts. At the present time, Seminole plans to sell a portion of the output of each of these two units to other utility companies. The amount sold could be as high as 400 MW from each unit when it is placed in service, but the amount sold will steadily decrease over a ten-year period. In the mid-1990's the full combined rating of both units will be used to serve the Seminole load. The following is a year by year schedule of the amount that Seminole expects to sell from their units and the amount available to serve their own load:

Year	Sold From Unit 1 (MW)	Sold From Unit 2 (MW)	Available To Serve Load (MW)
1983	400	N/A	200
1984	400	N/A	200
1985	400	400	400
1986	300	400	500
1987	300	400	500
1988	300	300	600
1989	200	300	700
1990	200	300	700
1991	100	200	900
1992	100	200	900
1993	0	100	1100
1994	0	100	1100
1995	0	0	1200
1996	0	0	1200
1997	0	0	1200

The amounts shown in the "Available to Serve Load" column have been subtracted from the load forecast to account for Seminole taking over responsibility for their own load. The in-service dates of the Seminole units are June 1, 1983, and June 1, 1985, and all changes in their capacity are assumed to occur on June 1 of each year. Sales to this category have also been adjusted by amounts consistent with their peak demand and load shape. Using this schedule, by 1986, Florida Power would have responsibility for only the peak 250-300 MW of the Seminole load. Due to the load duration curve associated with the Seminole load, there would be a very small amount of energy associated with this amount of peak demand. Therefore, sales to the REA category have been reduced by an amount consistent with the demand assumptions, and their load duration curve in the years 1983 through 1985, and are assumed to be zero in 1986 and each year thereafter.

Table 1.1-4 shows past and projected customer and sales growth rates in the most important categories and Table 1.1-5 shows past and projected demand growth rates. As can be seen from the table, future growth rates are projected to be considerably lower than historical rates. The lower customer growth rate is due to a reduction in the expected population growth rate for the Florida Power service area.

During the period 1967-1977, a tremendous growth in air conditioning saturation and other electric appliances took place that resulted in large sales and demand growth rates. Future growth in saturation of air conditioning is expected to be small simply because about 85% of the customers already have air conditioning. We do expect substantial increases in electric heat saturation that will produce a relatively high growth rate of winter demand but, due to the nature of heating requirements in Florida, will not result in substantial sales growth. The combined effects of a lower customer growth rate and reduced growth in kilowatt-hour sales per customer result in future growth rates of sales and demand that are substantially lower than historical.

Tables 1.1-6 and 1.1-7 show the accuracy of past forecasts made by Florida Power. In reviewing these tables, it is important to remember that forecasts are made to normal weather conditions. In many of the cases where the forecasts proved inaccurate, a large part of the deviation can be attributed to abnormal weather conditions.

It is also important to remember that the numbers shown in the forecast columns are expected values and are subject to a considerable amount of

TABLE 1.1-4

CUSTOMER GROWTH RATES
(%)

	1957-1967	1967-1977	1977-1987	1987-1997	1977-1997
Residential	5.41	6.27	3.04	1.69	2.36
Total	5.20	5.42	2.96	1.68	2.32

SALES GROWTH RATES
(%)

	1957-1967	1967-1977	1977-1987	1987-1997	1977-1997
Residential	12.64	11.41	4.68	2.41	3.54
Commercial	13.48	11.16	5.30	2.31	3.70
Industrial	10.53	5.78	5.80	2.83	4.31
Total (before Seminole adjustment)	11.30	10.31	5.40	2.56	3.97
Total (after Seminole adjustment)	N/A	N/A	4.10	2.43	3.26

N/A - not applicable

TABLE 1.1-5

DEMAND GROWTH RATES

Summer

	1957-1967	1967-1977	1977-1987	1987-1997	1977-1997
Before Seminole Adjustment	11.53	10.91	5.61	2.52	4.05
After Seminole Adjustment	N/A	N/A	4.67	1.66	3.15

DEMAND GROWTH RATES

Winter

	1956-57/1966-67	1966-67/1976-77	1976-77/1986-87	1986-87/1996-97	1976-77/1996-97
Before Seminole Adjustment	7.96	12.89	5.74	2.79	4.25
After Seminole Adjustment	N/A	N/A	4.93	2.10	3.51

N/A - not applicable

TABLE 1.1-6

COMPARISON OF FORECAST AND ACTUAL PEAK DEMANDS

Year	Season	1971 Forecast (Net MW)	% Deviation*	1972 Forecast (Net MW)	% Deviation	1973 Forecast (Net MW)	% Deviation	Actual Adjusted** Demand (Net MW)
1971-72	Winter	2250	7.0					2103
1972	Summer	2410	- 3.5					2497
1972-73	Winter	2520	- 9.5	2630	- 5.5			2784
1973	Summer	2640	-12.0	2830	- 5.7			3000
1973-74	Winter	2790	- 6.7	2950	- 1.3	3100	3.7	2989
1974	Summer	2880	1.6	3160	11.5	3330	17.5	2835
1974-75	Winter	3090	2.7	3280	9.0	3440	14.3	3010
1975	Summer	3130	5.2	3510	18.0	3720	25.0	2975
1975-76	Winter	3390	- 5.8	3640	1.1	3860	7.2	3600
1976	Summer	3390	4.2	3890	19.6	4160	27.9	3253
1976-77	Winter	3700	-15.3	4010	- 8.2	4350	- 0.4	4369
1977	Summer	3630	4.6	4300	23.9	4640	33.7	3470

* % deviation is deviation of forecast over actual

** Actual demand adjusted to include load curtailed at the time of system peak

TABLE 1.1-7

COMPARISON OF FORECAST AND ACTUAL PEAK DEMANDS

Year	Season	1974 Forecast (Net MW)	% Deviation*	1975 Forecast (Net MW)	% Deviation	1976 Forecast (Net MW)	% Deviation	Actual Adjusted** Demand (Net MW)
1974-75	Winter	3300	9.6					3010
1975	Summer	2890	- 2.9					2975
1975-76	Winter	3520	- 2.2	3170	-11.9			3600
1976	Summer	3220	- 1.0	3070	- 5.6			3253
1976-77	Winter	3800	-13.0	3530	-19.2	3860	-11.7	4369
1977	Summer	3450	- 0.6	3320	- 4.3	3440	- 0.9	3470

* % deviation is deviation of forecast over actual

** Actual demand adjusted to include load curtailed at the time of system peak

variability. Facility planning is not a deterministic process based on these numbers alone but is a stochastic process that takes load variability into account.

1.1.1.3 POWER EXCHANGES

It is the policy of Florida Power Corporation to participate in mutually advantageous firm power exchanges with other electric utilities. This exchange of power can have the effect of facilitating the generation expansion plans of both participating utilities. A firm exchange of power enables the selling utility to take advantage of the economies of scale by building larger and more economical units and enables the buying utility not only to defer capital investment but also to obtain peak generating capacity that is more efficient than combustion turbines. Thus, the exchange enables both utilities to supply their customers with reliable electric service for the lowest possible cost. At the present time, Florida Power Corporation has a contract with the City of Tallahassee that allows for the purchase of 130 MW during the winter season of 1977-78. After this period, the purchase amount drops to 90 MW for the remainder of the contract period. The contract as it now stands is due to expire in April, 1979, but it is in the process of being extended until 1983. An agreement has also been signed with the Gainesville/Alachua County Regional Utilities Board that calls for purchase of 150 MW during the period 1981-83.

In addition to these, agreements are also being negotiated with the City of Lakeland and Orlando Utilities Commission that will allow for firm power purchases in the late 1970's and early 1980's time frame.

Florida Power is making every effort to take advantage of all of the capacity available in the state of Florida in order to reduce the amount of additional generation facilities that must be added in future years. Florida Power Corporation and Seminole Electric Cooperative presently have a joint venture generating plant. Seminole Electric owns part of Florida Power Corporation's Crystal River Unit 3. At this time, there are no firm commitments for future joint ownership of generating facilities between Florida Power Corporation and Seminole. The 1984 and 1987 units of Florida Power still could develop into jointly owned units as could the 1985 Seminole unit. It is Florida Power Corporation's position to actively consider joint ownership for future units.

1.2 SYSTEM CAPACITY

Florida Power uses three computer programs in the process of planning generation capacity. These three programs are System Power Reliability known as SPREL, Production Costing known as PROCOS, and the Corporate Model.

As the name implies, SPREL is primarily a reliability program that calculates the loss of load probability (LOLP)*. SPREL is used to calculate the LOLP for each year; and if the predetermined criteria for LOLP is exceeded in any year, the program calculates the amount of generation that must be added in order to meet the criteria. The LOLP is calculated from a forecast of weekly peak demands and variances and projected forced outage rates and scheduled outages for each generating unit. One of the most important

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* Loss of Load Probability (LOLP) - is the probability that load exceeds capacity of a particular proposed generation system.

inputs into the SPREL program is the LOLP criteria. An LOLP of one day in 10 years has been generally accepted throughout the electric utility industry as a reasonable design goal, and this criteria is being used at Florida Power. This means there would be, on the average, one day in 10 years during which Florida Power would not be able to serve all of its firm load during peak conditions. For generation capacity planning purposes, it has been determined that a criteria of 2.5 days per year dependency upon interruptible loads and interconnections is equivalent to the one day in 10 years LOLP for firm loads. After the SPREL program has been used to determine the quantity and timing of required generation additions, expansion plans are developed for each reasonable combination of potential capacity additions. In order to evaluate these alternate expansion plans on a basis of equal reliability, SPREL is used again to test and adjust each plan so that they do yield equal reliability.

The next step in generation capacity planning is to determine, from a production costing standpoint, the cost to operate the system for each alternative expansion plan. The Production Costing model, PROCOS, is used to make this determination. Major inputs to PROCOS are a probabilistic weekly demand and energy load model, estimated availability, heat rates and expected maintenance schedules for each unit, projected fuel cost for each type of fuel, and expected firm interchange information. Using this information, PROCOS determines the cost to operate the system for each alternate expansion plan.

This production costing information along with a capital cost estimate of each alternate plan and kilowatt-hour sales forecast is input into

the Corporate Model, which is a computer model of the financial operation of the company. The Corporate Model is used to determine the overall cost to the customer for each of the alternate expansion plans.

By going through this three-step process, the expansion plan that results in an acceptable system reliability at the lowest overall cost to the customer is selected for future implementation.

1.3 RESERVE MARGINS

The proposed generation expansion plan of Florida Power Corporation includes the following:

Year	Generating Capacity**	Additions (MW)			Reserve (%)
1978	4668	742	Crystal River 3	3/77	12.5
		(28)	Turner 2 Retired	9/77	
		130	Purchase (Tallahassee)	11/77- 3/78	
1979	5193	515	Anclote 2	4/78	16.7
		50	Crystal River 2 (ID Fan)		
		90	Purchase (Tallahassee)	4/78- 3/79	
1980	5363	*130	Purchase (Tallahassee)	4/79- 3/80	12.9
		*130	Purchase (Orlando)	11/79-10/80	
1981	5618	150	Combustion Turbines	10/80	11.2
		150	Purchase (Gainesville)	1/81-12/83	
		*100	Purchase (Tallahassee)	4/80- 3/81	
		*115	Purchase (Orlando)	11/80-10/81	
1982	5983	400	Combustion Turbines	10/81	11.6
		* 80	Purchase (Tallahassee)	4/81- 3/82	
		*100	Purchase (Orlando)	11/81-10/82	
1983	6443	640	Coal (Crystal River 4)	10/82	13.8
1984	6543	250	Combined Cycle	10/83	13.6
1985	7183	640	Coal (Crystal River 5)	10/84	18.7
1986	7139	(44)	Avon Park 2 Retired	6/85	16.3
1987	7198	250	Combined Cycle	10/86	14.1
		(124)	Higgins 1,2,3 Retired	6/86	
		(67)	Suwannee 1,2 Retired	6/86	
1988	7838	640	Coal Unit	10/87	19.1

* Contracts presently under negotiation

** Generating capacity at time of winter peak is calculated as follows:

For generating capacity 1979, 5193 MW is obtained by subtracting the 130 MW Tallahassee purchase which expires 3/78 from the 1978 generating capacity of 4668 MW and then adding 515 MW for Anclote 2, 50 MW for Crystal River 2, and 90 MW for Tallahassee purchase. Subsequent years are calculated in the same manner, recognizing the effective terms of purchase capacity commitments.

The attached Tables 1.1-8, 1.1-9, 1.1-10 and Figures 1.1-3, 1.1-4, and 1.1-5 are based upon the proposed generation expansion plan and demonstrate the effects of adding one 640 MW coal unit in 1982, and another in 1984, on the Florida Power system and on peninsular Florida. As evident from the above generation expansion plan, the addition of these two 640 MW coal units is a very important part of the overall Florida Power Corporation expansion plan through 1985. However, these units represent only one-half of the required capacity additions during the time period 1978 through 1985. The remaining additional capacity required is furnished by Anclote 2, 550 MW combustion turbines, 250 MW combined cycle, and purchases of firm capacity from neighboring utilities. Reductions in the previously stated forecasts in the period 1978-1985 are not probable. However, in such a case, reduction of the generation expansion plan would be through delay and/or cancellation as required of the combustion turbine units which require a much shorter lead time than steam type units. Thus, even if the load grows at a lower rate than predicted, the two coal units are still required and will result in a system that produces the lowest overall cost to the customer. Table 1.1-8 shows reserves and LOLP if both units are added. Table 1.1-9 shows comparable figures if the 1982 unit is omitted and the 1984 unit is retained. Table 1.1-10 shows the effects of omitting both units. In all cases, there are no scheduled outages of Florida Power Corporation units during the peak periods shown. Figures 1.1-3 through 1.1-5 present the same information on peninsular Florida and Florida Power Corporation reserves and on Florida Power Corporation's LOLP in graphical form.

TABLE 1.1-8

CAPACITY, DEMANDS, AND RESERVES FOR
PENINSULAR FLORIDA AND FLORIDA POWER CORPORATION

(with both proposed units included)

Year	Capacity		Winter* Peak Demand		Reserves				FPC LOLP Days/Year
					State		FPC		
	State	FPC **	State	FPC	MW	%	MW	%	
1978	23181	4668	16643	4150	6538	39.3	518	12.5	3.92
1979	23802	5193	17669	4450	6106	34.6	743	16.7	3.26
1980	23787	5363	18749	4750	5038	26.9	613	12.9	4.62
1981	24435	5618	19909	5050	4526	22.7	568	11.2	3.94
1982	25884	5983	21078	5360	4806	22.8	623	11.6	2.99
1983	27568	6443	22258	5660	5310	23.9	783	13.8	2.62
1984	29120	6543	23244	5760	5876	25.3	783	13.6	1.69
1985	29778	7183	24457	6050	5321	21.7	1133	18.7	1.67
1986	29725	7139	25489	6140	4236	16.6	999	16.3	3.69

* Winter peak is assumed to occur in January of each year

** FPC capacity includes firm power purchases where applicable and is that value of capacity in the month of January for each respective year.

TABLE 1.1-9

CAPACITY, DEMANDS, AND RESERVES FOR
PENINSULAR FLORIDA AND FLORIDA POWER CORPORATION

(with 1982 unit omitted)

Year	Capacity		Winter* Peak Demand		Reserves				FPC LOLP Days/Year
					State		FPC		
	State	FPC**	State	FPC	MW	%	MW	%	
1978	23181	4668	16643	4150	6538	39.3	518	12.5	3.92
1979	23802	5193	17669	4450	6106	34.6	743	16.7	3.26
1980	23787	5363	18749	4750	5038	26.9	613	12.9	4.62
1981	24435	5618	19909	5050	4526	22.7	568	11.2	3.94
1982	25884	5983	21078	5360	4806	22.8	623	11.6	10.21
1983	26928	5803	22258	5660	4670	21.0	143	2.7	13.51
1984	28480	5903	23244	5760	5236	22.5	143	2.5	9.39
1985	29138	6543	24457	6050	4681	19.1	493	8.1	8.39
1986	29085	6499	25489	6140	3596	14.1	359	5.8	17.23

* Winter peak is assumed to occur in January of each year

** FPC capacity includes firm power purchases where applicable and is that value of capacity in the month of January for each respective year.

TABLE 1.1-10

CAPACITY, DEMANDS, AND RESERVES FOR
PENINSULAR FLORIDA AND FLORIDA POWER CORPORATION

(with 1982 and 1984 units omitted)

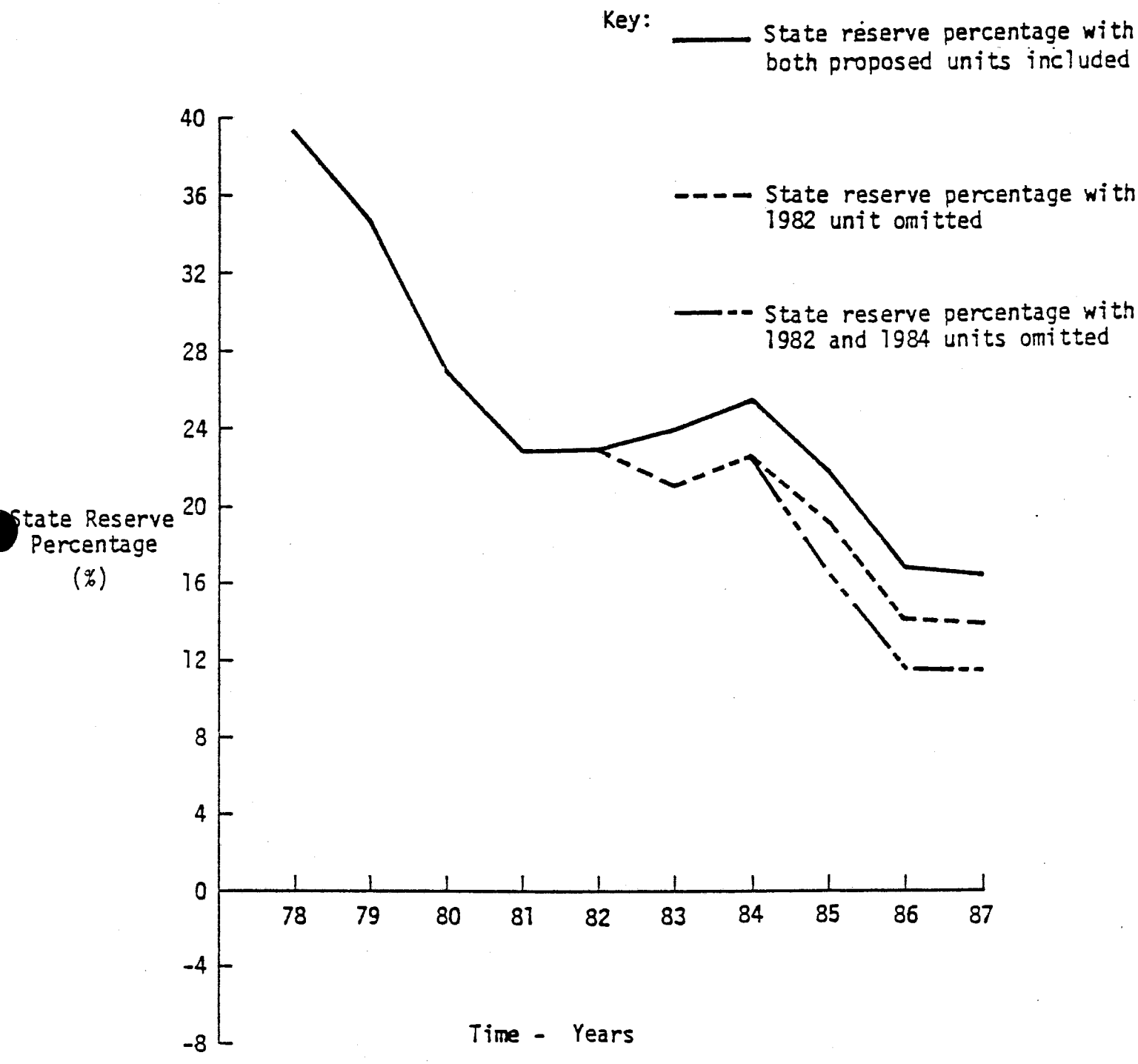
Year	Capacity		Winter* Peak Demand		Reserves				FPC LOLP Days/Year
					State		FPC		
	State	FPC**	State	FPC	MW	%	MW	%	
1978	23181	4668	16643	4150	6538	39.3	518	12.5	3.92
1979	23802	5193	17669	4450	6106	34.6	743	16.7	3.26
1980	23787	5363	18749	4750	5038	26.9	613	12.9	4.62
1981	24435	5618	19909	5050	4526	22.7	568	11.2	3.94
1982	25884	5983	21078	5360	4806	22.8	623	11.6	10.21
1983	26928	5803	22258	5660	4670	21.0	143	2.7	13.51
1984	28480	5903	23244	5760	5236	22.5	143	2.5	22.28
1985	28498	5903	24457	6050	4041	16.5	-147	- 2.4	30.85
1986	28445	5859	25489	6140	2956	11.6	-281	- 4.6	48.98

* Winter peak is assumed to occur in January of each year

** FPC capacity includes firm power purchases where applicable and is that value of capacity in the month of January for each respective year.

FIGURE 1.1-3

PENINSULAR FLORIDA PERCENT RESERVES



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were of poor quality.

FIGURE 1.1-4

FLORIDA POWER CORPORATION
PERCENT RESERVES

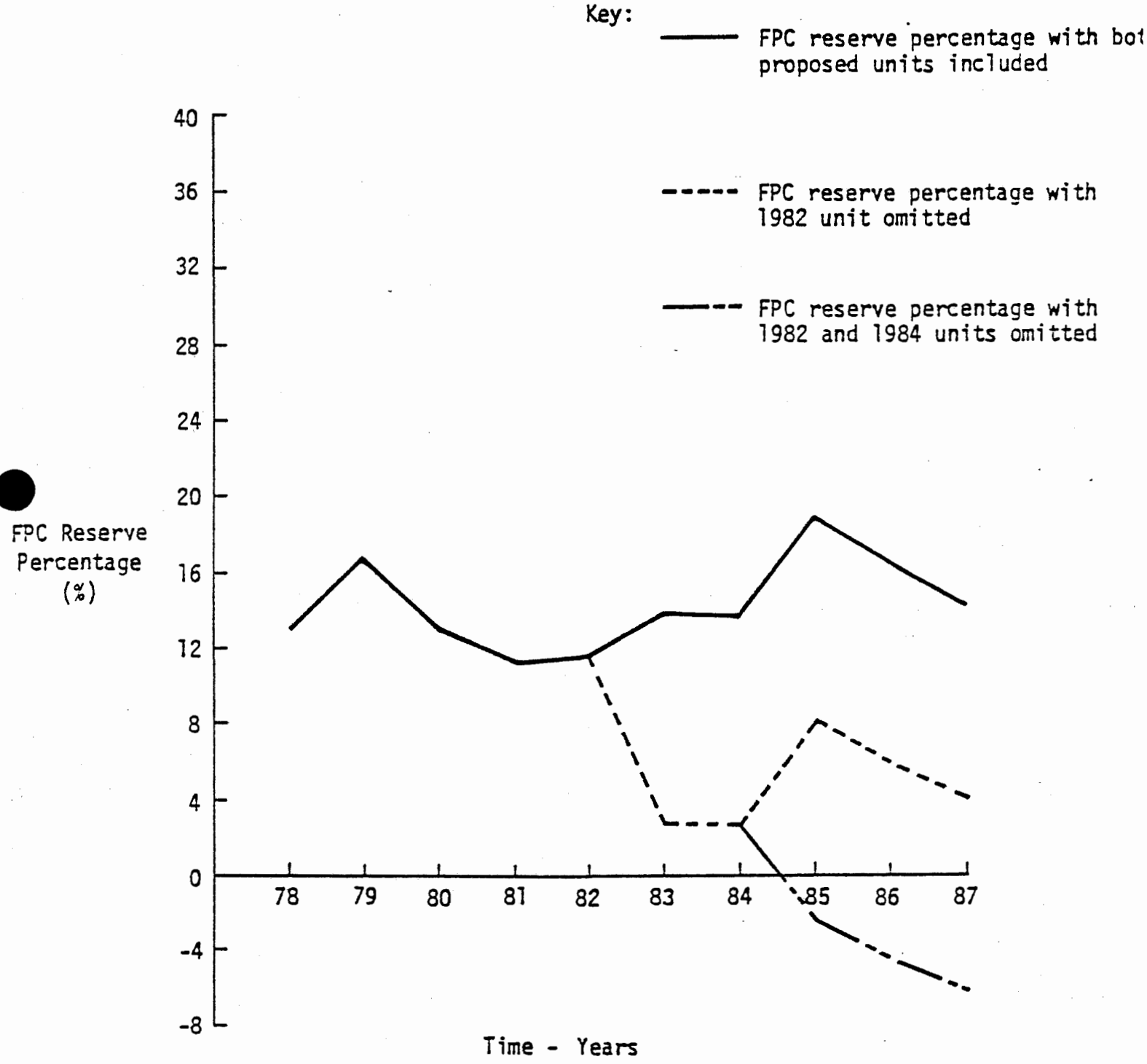
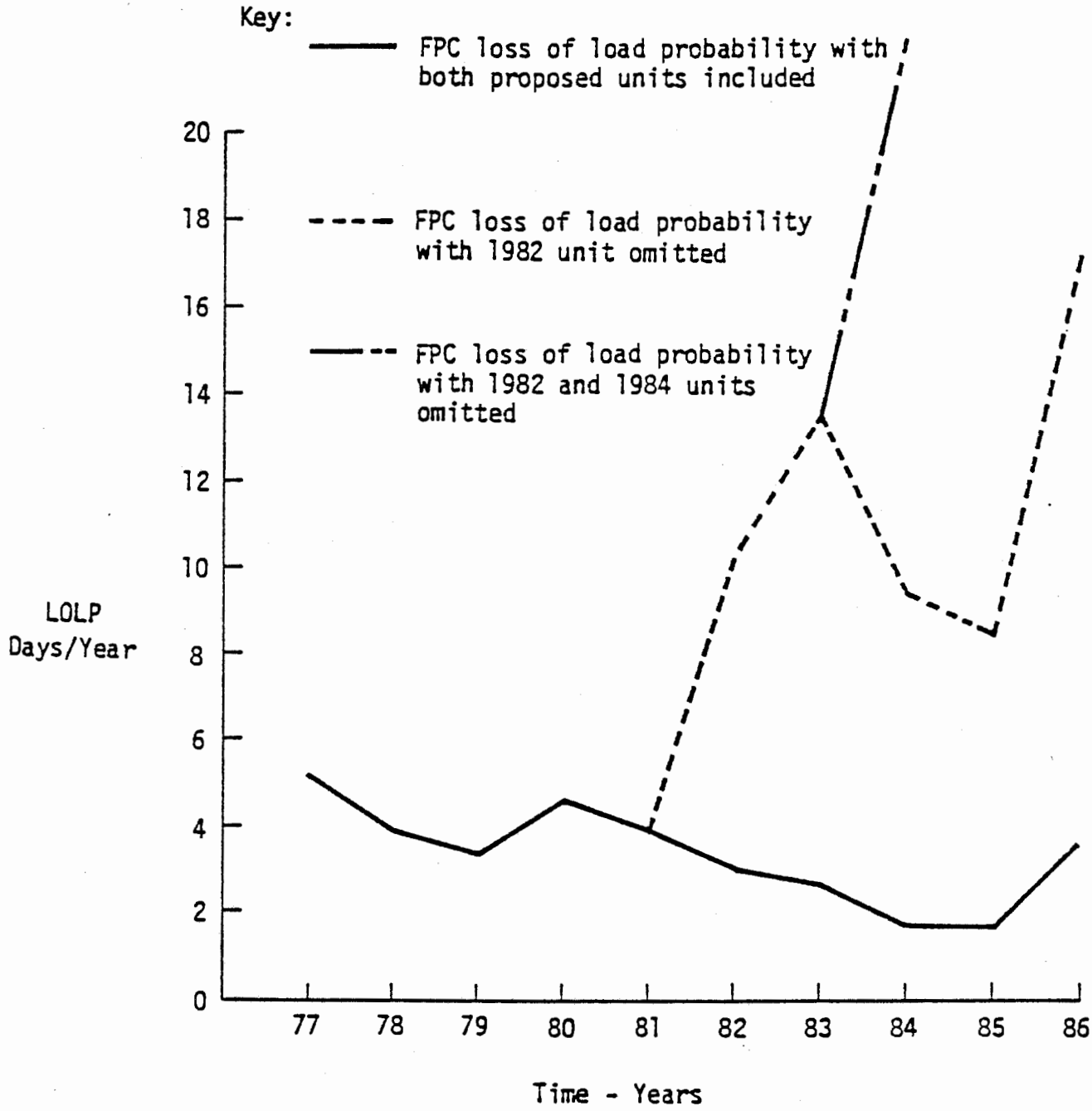


FIGURE 1.1-5

FLORIDA POWER CORPORATION
LOSS OF LOAD PROBABILITY



As can be seen from the tables and figures, Florida Power Corporation's reserves and LOLP have unacceptable values without the addition of these two proposed units. A discussion of Florida Power's LOLP criteria and how it is used in conjunction with interconnections and interruptible load for planning purposes is contained in Section 1.1.2.

1.4 OTHER OBJECTIVES

At the present time, the sole objective of these two units is to produce electricity.

1.5 CONSEQUENCES OF DELAY

If the proposed project were delayed, the loss of load probability for the Florida Power Corporation system would greatly exceed acceptable values. A loss of load probability of one day in 10 years for firm load calculated on an interconnected system basis has been generally accepted as a reasonable goal by the electric utility industry. A value of approximately 2.5 days per year dependency upon tie lines and/or interruptible loads has been determined as an acceptable equivalent index for the Florida Power Corporation system. If the proposed unit is not installed in 1982 as planned, this index will jump from 2.99 to 10.2. The following tabulation illustrates the continued effect on system reliability in terms of days/year if <u>only</u> the proposed 1982 unit was deleted from the proposed generation expansion plan. This table includes the addition of 550 MW of additional peaking capacity to the Florida Power Corporation system prior to the addition of the proposed 1982 unit, as well as firm capacity purchases from other utilities during the time period 1979-1983 and subsequent 640 MW coal capacity additions in 1984, 1987, and every second year thereafter. For further details see Section 1.1.3.

Year	As Planned System Loss of Load Probability Days/Year	As Planned System With 1982 Unit Not Installed Loss of Load Probability Days/Year
1982	2.99	10.21
1983	2.62	13.51
1984	1.69	9.39
1985	1.67	8.39
1986	3.69	17.23
1987	1.41	7.28
1988	2.00	9.44
1989	1.23	5.96
1990	0.97	4.53
1991	3.06	12.40

One can see from the tabulation above that for the subsequent 10-year period without installation of the proposed 1982 unit the loss of load probability far exceeds acceptable values, even if all other proposed generation additions were installed as planned and on schedule.

These tabulations include the addition of 550 MW of additional peaking capacity to the Florida Power Corporation system prior to the addition of the proposed 1982 unit. Florida Power feels that if any units were delayed or omitted from the generation expansion plan it would be the 550 MW of oil burning combustion turbines. The following tabulations show the effect on system reliability in terms of days/year if only the 550 MW of combustion turbines were omitted from the proposed generation expansion plan.

Year	As Planned System Loss of Load Probability Days/Year	As Planned System With 550 MW Combustion Turbines Omitted Loss of Load Probability Days/Year
1980	4.62	6.61
1981	3.94	13.98
1982	2.99	18.20
1983	2.62	13.73
1984	1.69	9.76
1985	1.67	8.47
1986	3.69	17.67
1987	1.41	7.43
1988	2.00	8.87
1989	1.23	6.30
1990	0.97	4.46
1991	3.06	12.34

As seen in these tabulations, if the combustion turbines are delayed or omitted from the generation expansion plan and the 1982 and 1984 units are added, the loss of load probability far exceeds acceptable values; and not once do they fall within the Florida Power system criteria of 2.5 days per year. The addition of the 1982 and 1984 coal units is essential and considered a "bare bones" minimum requirement on the Florida Power system. If neither the 550 MW of combustion turbines nor the 1982 and 1984 coal units are installed as planned, the loss of load probability exceeds 48 days per year by 1984 and 71 days per year by 1991.

These figures, as are all loss of load probability figures, are an index of system reliability. They are not to be interpreted as a prediction of the actual days of load interruption or emergency tie line interchange expected during some future year. They are strictly probability figures; that is to say, for example, if the year 1982 were to repeat over and over, it is expected that on the average there would be 2.99 days per year that the Florida Power system would be lacking sufficient generation to cover its total load and thus be dependent upon emergency interchange availability

and the shedding of interruptible loads. Without the proposed 1982 unit, this figure rises in excess of 10 days per year.

If in a given situation the sum total of available emergency power and interruptible load on the system is insufficient to cover the deficit, the loss of firm loads within the Florida Power system is inevitable. As a general practice, the electrical utilities within the United States have attempted to minimize such loss of firm load due to generation capacity deficiencies to one day in 10 years. Joint studies conducted within the state of Florida indicate that with the proposed generation facilities plan this reliability goal can be accomplished. If, on the other hand, the recommended capacities are delayed, the figures indicate there would probably be more frequent instances of blackouts and/or brownouts within the Florida Power Corporation service area. Outages due to lack of generation capacity have a much more severe impact upon the communities served by the company than do interruptions to individual customers or small groups of customers.

CHAPTER 2

CHAPTER 2

THE SITE: A DESCRIPTION OF THE EXISTING ENVIRONMENT

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2.0 THE SITE

2.1. SITE LOCATION AND LAYOUT

Figure 2.1-1 presents the site of the proposed facility relative to the State of Florida, Citrus County, and major municipalities.

The property owned by the Applicant consists of 1918.22 ha (4738 acres) located at T17S,R16E and includes portions of Sections 28-37. Approximately 129.15 ha (319 acres) are presently occupied by CR Units 1, 2, and 3 and support facilities. An additional 135.63 ha (335 acres) of the property are proposed for the construction of CR Units 4 and 5, support facilities, and another access road. With the exception of the access road to the existing units, the remaining acreage is undeveloped.

SITE LOCATION

DISTANCES IN KILOMETERS (MILES)

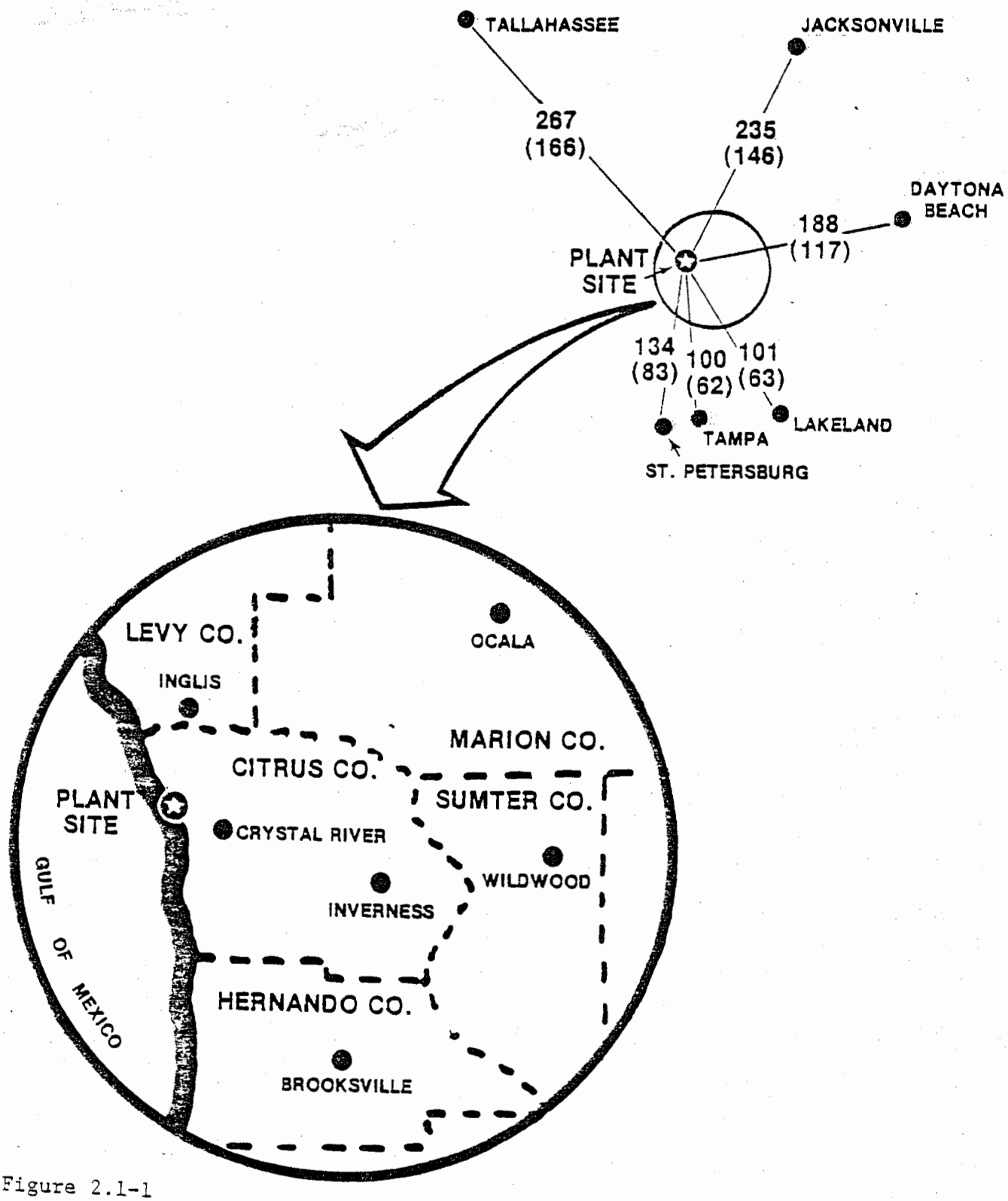


Figure 2.1-1

2.2 REGIONAL DEMOGRAPHY, LAND, AND WATER USE

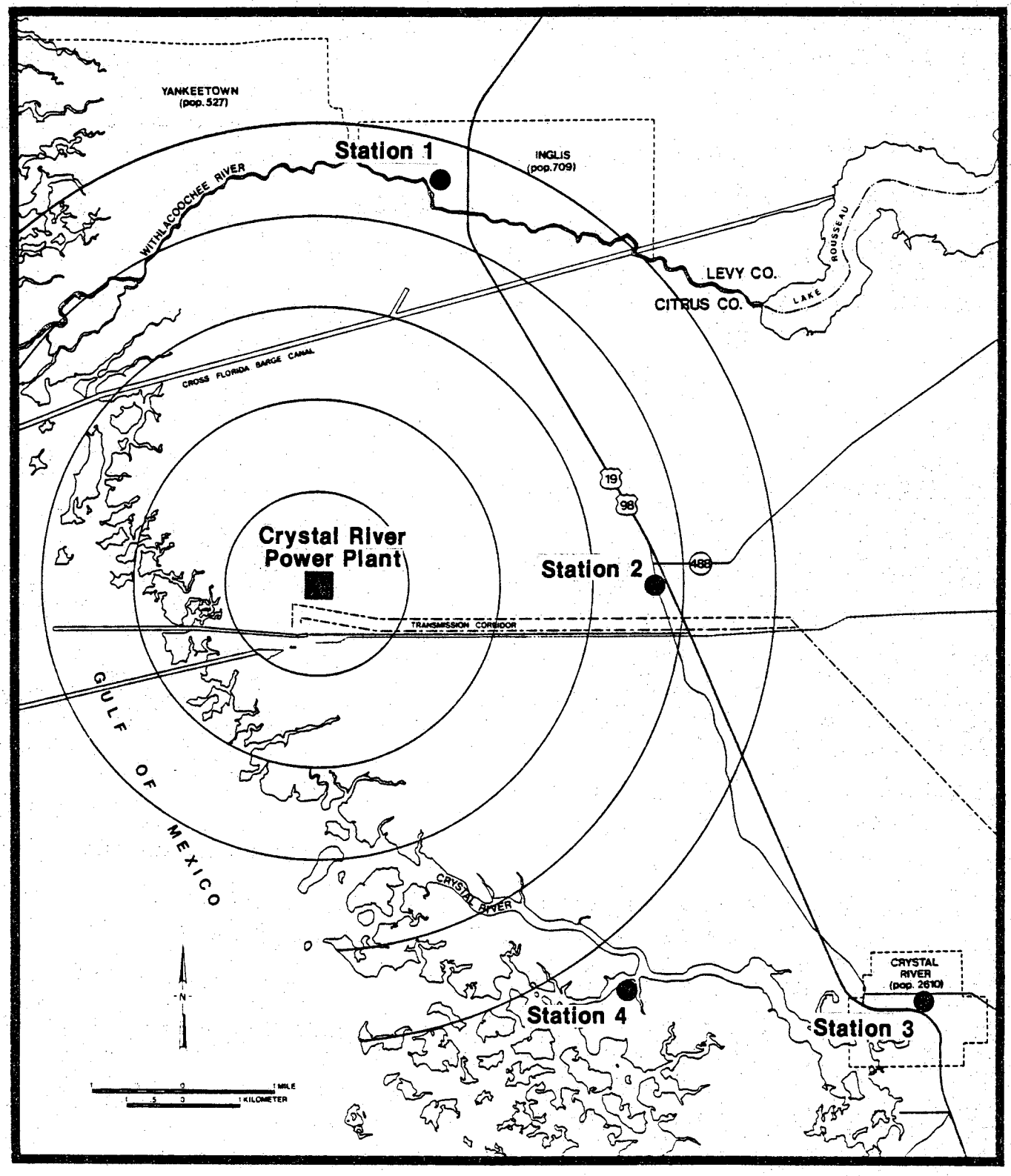
2.2.1 FIVE-MILE RADIUS MAP

Figure 2.2.1-1 shows the 8 kilometer (5 mile) radius area from the proposed plant site with concentric circles of 1,2,3,4, and 8 kilometer (5 mile) radii centered at the stack location. As shown in the figure, the 8 kilometer (5 mile) radius area lies primarily within the unincorporated area of Citrus County with only a small portion extending into the southern part of Levy County. Also, due to the coastal location of the proposed site, approximately one-third of the 8 kilometer (5 mile) area extends into the Gulf of Mexico and much of the land lying to the south of the proposed site is marshland which is unsuitable for development. The property holdings of the Applicant at the proposed site lie wholly within the five-mile radius area and account for approximately 13.5 percent of the total land area within the 8 kilometer (5 mile) area.

As shown in Figure 2.2.1-1, the only incorporated areas lying within five miles of the proposed facilities are small portions of Yankeetown and of Inglis, which are both located in Levy County. Construction and operation of the proposed facilities will have little effect due to the towns' small size and lack of any significant supportive services and facilities.

The effects of the construction and operation of the proposed facilities will primarily be centered in Citrus County and particularly in the area of the city of Crystal River which is located approximately 12.8 km (eight miles) southeast of the site. Crystal River is the only

SITE LOCATION (5 MILE RADIUS)



-------- TOWN BOUNDARY

·· EXISTING STACKS

⁘ PROPOSED STACKS

SOURCE: ESE, 1977

Figure 2.2.1-1

(Rev. 5/78)

municipality located in proximity to the proposed site which is of sufficient size to offer supportive services and facilities such as food stores, restaurants, gasoline service stations, retail shopping establishments, and housing.

2.2.2 POPULATION OF CITRUS COUNTY AND THE FIVE-MILE RADIUS AREA

Table 2.2.2-1 lists the populations of Citrus and Levy counties and their incorporated areas as of the April 1, 1970, Census and the July 1, 1976, estimates from the Division of Population Studies, Bureau of Economic and Business Research, University of Florida.

Citrus County is located in the northern portion of Florida's West Coast growth corridor and has been experiencing substantial population growth over the past twenty-six years. During this period, population growth in this corridor has pushed northward from the metropolitan areas of Hillsborough and Pinellas counties through both Pasco and Hernando counties into Citrus County (see Figure 2.1.1-1).

From 1960 to 1970, the population in Citrus County increased from 9,268 to 19,196 persons, representing an increase of over 107 percent. This growth rate was almost three times faster than the state's overall increase of 37 percent during the same decade. The county has only two incorporated areas, the city of Crystal River and the city of Inverness. Crystal River is located in the coastal lowlands area of the county along the headwaters of the Crystal River. Inverness is located in the east-central interior portion of the county and is the county seat. As of the 1970 Census, Crystal River had a population of 1,696 persons and Inverness contained 2,299 persons, with the remaining 15,201 persons (79 percent of the total county population) residing in the unincorporated areas of the county.

Table 2.2.2-1 Estimates of Population for Citrus and Levy Counties and their Municipalities: July 1, 1976.

	April 1, 1970 (census)	July 1, 1976 (estimate)	Total Change 1970-1976	
			Number	Percent
FLORIDA	6,791,418	8,551,814	1,760,396	25.9
CITRUS	19,196	35,627	16,431	85.6
Crystal River	1,696	2,610	914	53.9
Inverness	2,299	3,047	748	32.5
Unincorporated	15,201	29,970	14,769	97.2
LEVY	12,756	15,787	3,031	23.8
Bronson	698	812	114	16.3
Cedar Key	714	880	166	23.2
Chiefland	1,965	2,058	93	4.7
Inglis	449	709	260	57.9
Otter Creek	230	183	-47	-20.4
Suwanne River	35	42	7	20.0
Williston	1,939	2,025	86	4.4
Yankeetown	490	527	37	7.6
Unincorporated	6,236	8,551	2,315	37.1

*The five-mile radius area includes portions of these municipalities and unincorporated areas.

Source: Florida Estimates of Population--Municipalities-Counties-State--July 1, 1976, Division of Population Studies, Bureau of Economic and Business Research, University of Florida, February, 1977.

Since 1970, the rate of population growth in Citrus County has continued to be three times that of the state's. Citrus County has been the fastest growing county in the state in terms of percentage population change. Between April 1, 1970, and July 1, 1976, the population of the county increased by almost 86 percent, representing an average annual growth of 13.7 percent compared to the overall state average of 4.1 percent. As of July 1, 1976, the total resident population of Citrus County was estimated to be 35,627 persons, while the city of Crystal River contained 2,610 residents and the city of Inverness had 3,047 residents. Therefore, over the past six years, the vast majority of population growth in the county has occurred in its unincorporated areas.

According to projections prepared by the Division of Population Studies, Bureau of Economic of Business Research, University of Florida, the population of Citrus County is expected to continue to increase substantially in the future, but at a slightly slower rate than it has since 1970. These projections indicate that the county's population will reach 47,400 persons by the year 1980, 71,000 persons by the year 1990, and 82,200 persons by the year 2000.

As stated earlier, the 8 kilometer (5 mile) radius area from the proposed facilities site is primarily comprised of the unincorporated area of Citrus County with a small part of the area extending into Yankeetown and Inglis in Levy County. The area currently is sparsely populated

with small farms, a few clusters of mobile homes, and some single family residences along the Withlacoochee River in the extreme northern fringe of the area.

Based on a housing unit survey conducted in the area, no people were living within the 4.8 kilometer (3 mile) radius of the proposed site. Also, assuming an average of 2.5 persons per housing unit, it is estimated that approximately 500 persons presently reside within the 4.8 kilometer to 8 kilometer (3 to 5 mile) radii from the proposed stack locations.

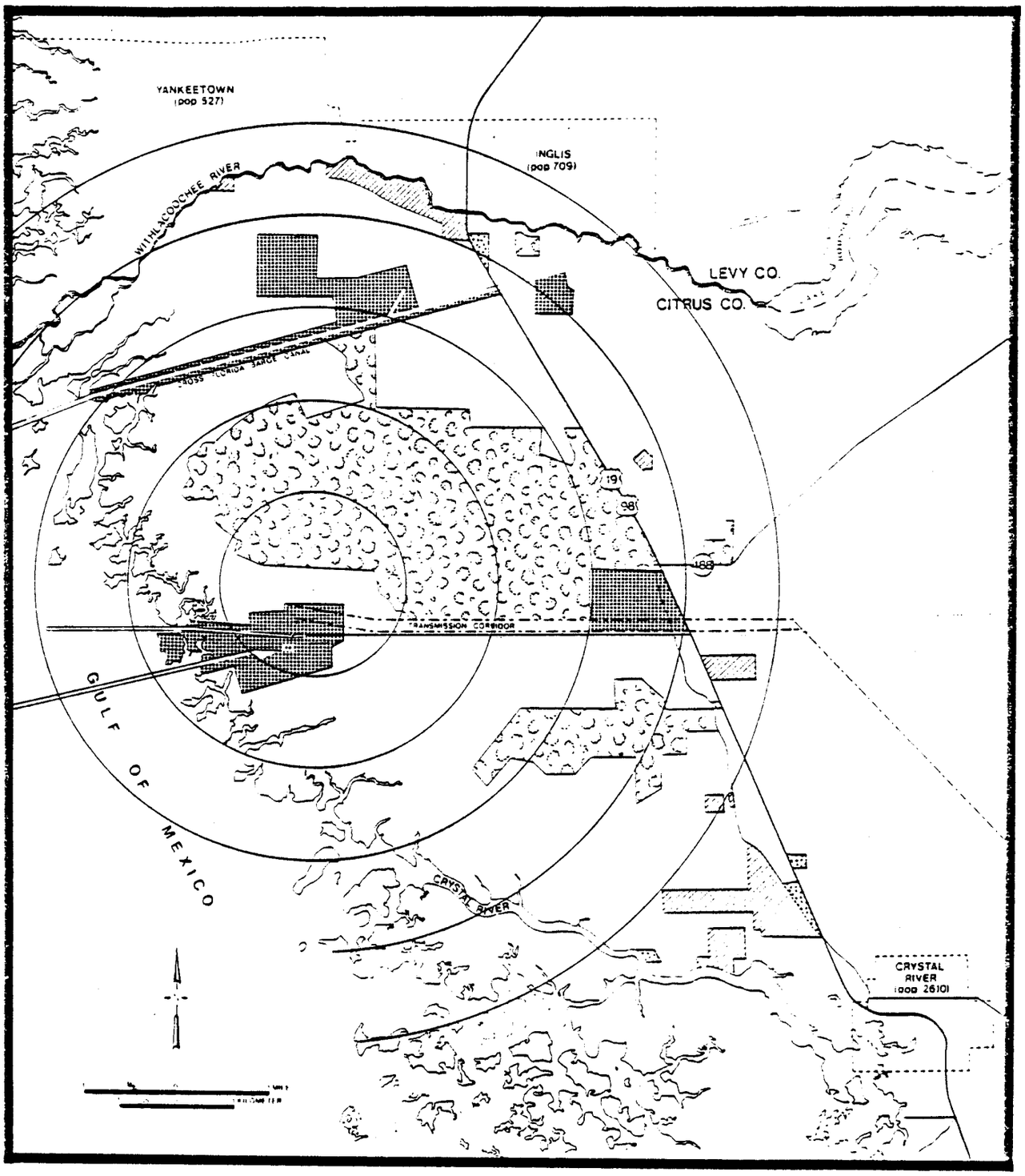
2.2.3 PRESENT AND PROJECTED LAND USE

Present land use within a 4.8 kilometer (3 mile) radius of the site is limited primarily to agriculture, most of which is pine plantation, the existing FPC power plants, and the Cross Florida Barge Canal (see Figure 2.2.3-1). Approximately 2,190 hectares (5,400 acres) are devoted to agriculture, 1,930 hectares (4,760 acres) in pine plantation, and 180 hectares (440 acres) in small farms and improved pasture. The existing FPC facilities occupy approximately 129.15 hectares (319 acres), the Cross Florida Barge Canal approximately 110 hectares (280 acres), with the rest of the land remaining undeveloped.

Between the third and fourth-mile radii are 390 hectares (970 acres) of agriculture, 420 hectares (1,030 acres) of industrial land use, 2 hectares (5 acres) of commercial development, and about 8 hectares (20 acres) of residential use. Within the 8 kilometer (5 mile) radius are portions of Yankeetown, Inglis, and small scattered areas of agricultural, industrial, commercial and residential use; a total of about 910 hectares (2,250 acres). The largest concentration of residential uses, comprised of approximately 50 hectares (120 acres) of unincorporated Citrus County and portions of Yankeetown and Inglis, occurs along the north and south banks of the Withlacoochee River.

Due to the general nature of the land, no major land use changes are expected in the 8 kilometer (5 mile) radius within the next thirty years. The proposed project would convert vacant land to industrial use.

PRESENT LAND USE (5 MILE RADIUS)



MINING, INDUSTRIAL
AGRICULTURE
COMMERCIAL
RESIDENTIAL

TOWN BOUNDARY
EXISTING STACKS
PROPOSED STACKS

Figure 2.2.3-1

SOURCE: WITHLACOOCHEE REGIONAL PLANNING COUNCIL UPDATED: ESE 1977

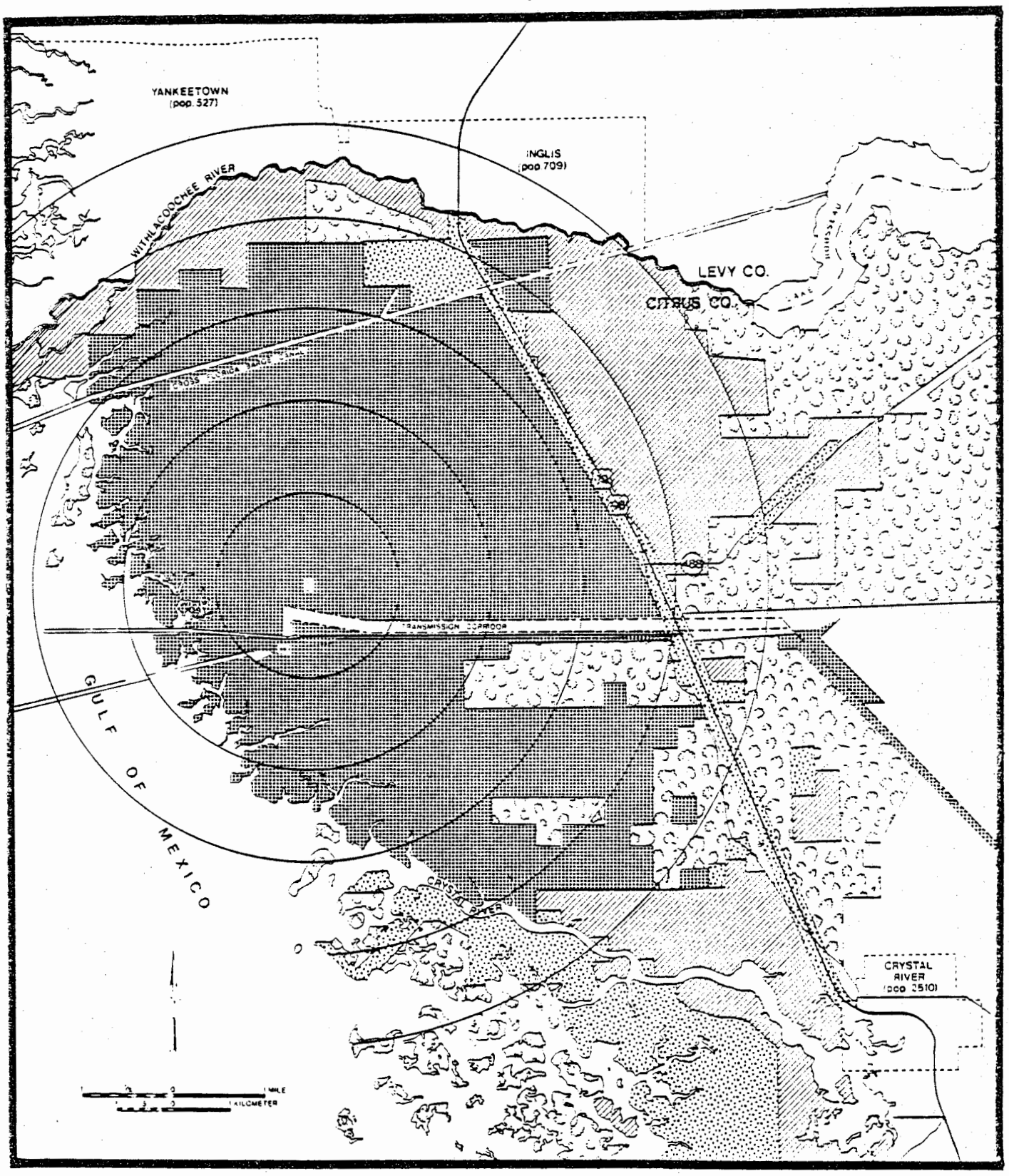
Commercial development will probably take place along U.S. 19-98, but will be concentrated at the outer perimeter of the 8 kilometer (5 mile) radius closer to the municipalities of Crystal River and Inglis.

An increase in residential development can also be expected, particularly along the Withlacoochee River from U.S. 19-98 to Lake Rousseau. About 1,940 hectares (4,800 acres) in this area have been subdivided and improved, but a recent survey revealed less than ten homes and no signs of new construction.

2.2.4 ZONING RESTRICTIONS

As shown in Figure 2.2.4-1, the proposed site is currently zoned for mining and industrial use, as are all lands within its 4.8 kilometer (3 mile) radius, with the exception of approximately 260 hectares (650 acres), which are zoned for agricultural use. An additional 2,020 hectares (4,980 acres) are zoned for mining/industrial use in the 6.4 kilometer (4 mile) radius, with 460 hectares (1,130 acres) zoned for agriculture, 380 hectares (950 acres) zoned for commercial use, and 780 hectares (1,930 acres) zoned for single family units and duplex housing. Between the 6.4 to 8 kilometer (4 and 5 mile) radii from the site, approximately 420 hectares (1,560 acres) are zoned for industrial use, 770 hectares (1,900 acres) for agricultural use, 340 hectares (830 acres) for commercial use, 2,520 hectares (6,220 acres) for residential use, and 630 hectares (1,560 acres) occupied by the incorporated areas of Yankeetown and Inglis.

CURRENT ZONING (5 MILE RADIUS)



MINING, INDUSTRIAL

AGRICULTURE

COMMERCIAL

RESIDENTIAL

------- TOWN BOUNDARY

·· EXISTING STACKS

PROPOSED STACKS

Figure 2.2.4-1

SOURCE: CITRUS COUNTY ZONING MAPS, SURVEYORS ASSOCIATES, REVISED, 9/1/76

2.2.5 PRESENT MAJOR WATER USES

The current major uses of water within the 8 kilometer (5 mile) radius are discussed in section 2.5.3.1. Large quantities of estuarine water are also used for once-through cooling at existing Units 1, 2, and 3.

2.3 REGIONAL HISTORIC, SCENIC, CULTURAL, AND NATURAL LANDMARKS

The stretch of land between the north bank of the Crystal River and the south bank of the Withlacoochee has a well authenticated history. Shell mounds and artifacts found in both places and along the coastline between attest that the area was inhabitated by the Timucuan Indians. They farmed small crops in the summer and camped along the rivers in the winter.

Written records indicate that the army of Panfilo de Narvaez encountered the Timucuans in 1528 while he was exploring the area for gold. Finding neither gold nor harborages, Narvaez returned to the coast near St. Marks.

Following the departure of Narvaez, a period of 300 years passed in which there was no written record of white exploration of the Withlacoochee. During this time the United States government issued a decree that would force the Creek Indians of Georgia and Alabama to move west of the Mississippi. Reluctant to leave their native areas, small bands of Creeks, who became known as Seminoles, broke away from the main tribe and moved south to central Florida. They hunted in the Annuttiliga Hammock along the Gulf coast, south of the Withlacoochee. As the Timucuans before them, they settled along the coast and the river banks through the winter months where ample food was available, and lived peacefully until the white man entered the Indian occupied lands in the early 1830's. The year 1835 marked the beginning of the

Seminole War. By 1843, the Indians were either shipped west by the government or had moved further south to the Everglades. By 1844, the area was surveyed and under white occupation.

During the Indian wars, a farming settlement known as Red Level flourished along the present U.S. 19. The small rural community still exists today, though there is little reminder of the original settlement save the old cemetary.

The prize stands of red cedar found in the hammocks along the coast were the main attractor for white settlement in the Withlacoochee region. Between 1855 and 1890, large tracts of land were purchased for the timber, which was cut, hauled to the river by oxen, and shipped to the pencil factories in Cedar Key and Crystal River. In the early 1870's, the Chambers sawmill, located on the large island at the mouth of the Withlacoochee was the largest sawmill operating on the west coast of Florida.

By 1890, the phosphate industry was active in the area. The Standard and Hernando Railroad Company was formed to transport phosphate from the mines to a point on the Withlacoochee which is the present site of the Town of Inglis. Port Inglis was established when the Port Inglis Terminal Company set up facilities on Chambers Island at the mouth of the river. The town flourished until World War I halted import of products from Europe. Without the pyrite from which sulphur was obtained, phosphate manufacturing in the area ceased. The railroad

was abandoned and the last evidence of the phosphate operation disappeared when, in 1926, the Florida Power Corporation constructed the Inglis electrical generating facility on the site of the old dryer plant.

2.3.1 ARCHEOLOGY

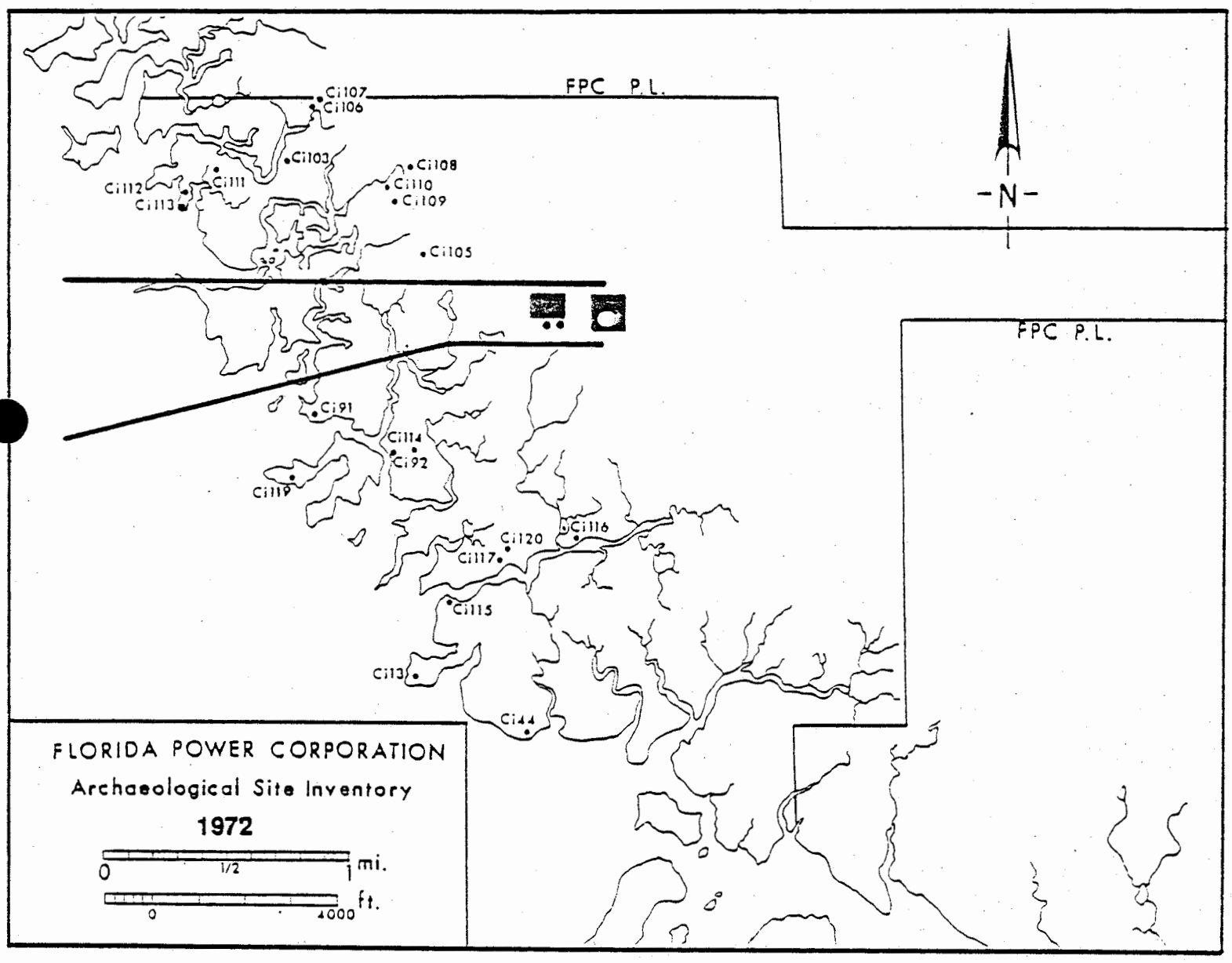
There are twenty known archeological sites on the FPC Crystal River property, all of which are recorded in the archeological site files of the Florida Division of Archives. Eighteen of the sites were recorded as the result of an archeological and historical inventory of the Crystal River plant property conducted by the Division of Archives, History, and Records Management, Bureau of Historic Sites and Properties for FPC in May, 1972. The remaining two sites had been previously recorded. All sites on the plant property are shell middens ranging from possibly as early as 2000 BC to approximately 1000 AD, and occur along the coastline and river banks of the northwestern and southwestern portions of the property. (see Figure 2.3.1-1).

There are no known historical or cultural sites on the property.

The area of scenic and natural significance is the western boundary of the property—the Gulf coastline and the coastal marsh and forested wetlands which make up the system. The significance of the wetland system and the impacts upon it are discussed in Sections 2.5 and 2.7.

Of the 20 archeological sites on the FPC property, only four would possibly be impacted by the construction of an additional power facility, depending upon final selection of site location and layout. Of the four, one, site 8Ci105, is badly deteriorated to a state where it is no longer likely to yield any meaningful data (Hutto and

ARCHAEOLOGICAL SITE INVENTORY



SOURCE: FPC

Figure 2.3.1-1

Steiner, 1972), and no cultural artifacts were retrieved. Sites 8Ci108 and 109 are both very small, undisturbed middens but yielded no cultural artifacts in the survey. Site 8Ci110 yielded only one artifact.

Site selection alternative 1 would destroy three sites, 8Ci108, 109, and 110 with the construction of the plant run-off pond. Alternative site 2 would also disturb three sites. The construction storage area would include the locations of 8Ci109 and 110, and the 500 KV substation tie would pass through 8Ci105. It has been noted, however, that 8Ci105 is already badly deteriorated, thus the impact upon it would not be considered as great as it would upon an undisturbed site.

Site selection alternatives 3 and 1c are both in areas where there are no known archeological sites. They are also located further inland than 1 and 2. As was discussed earlier in this section and is graphically represented in Figure 2.3.1-1, Indian occupation on the FPC property was focused along the coastline and river banks. The probability of encountering additional unknown sites decreases as one moves inland; hence, 1c would be a more desirable site than 3, as it would minimize the chances of this happening.

Site 1c is also preferred over site 3, based upon impact on areas of scenic and cultural significance. Location of the plant at site 1c would displace no coastal marshes and would minimize displacement of

coastal wetland forests. Site 1c has been selected by the Applicant as the proposed location of the generating facility.

2.4 GEOLOGY

2.4.1 SITE DESCRIPTION

The proposed FPC plant site is located just north of two existing FPC power plants in Citrus County in the area between the Withlacoochee River to the north and the Crystal River to the south. The site is approximately one mile inland from the Gulf of Mexico.

2.4.2 PHYSIOGRAPHY

The geomorphology in this area is defined by two well developed coastal marine terraces which parallel the coast and mark the landward extent of two Pleistocene seas, the Pamlico and Wicomico, with shorelines at 25 and 100 feet above mean sea level, respectively. The site is located within the Pamlico marine plain.

The Pamlico is the lowest of the coastal terraces, extending inland from the coast to approximately the 7.62 meter (25 foot) contour which marks the base of a 3 to 6 meters (10 to 20-foot) escarpment. At the site, the plain is 13 to 16 kilometers (8 to 10 miles) wide.

The present coast of Citrus County is submerged, as evidenced by the extensive coastal marshes. According to Vernon (1951), this condition indicates a rising sea level that is out of adjustment to the land mass. As a result, the limestones that underlie the coast are being eroded along coastal margins to form a fairly continuous limestone escarpment 1 to 1.5 meters (3 to 5 feet) above mean sea level. This escarpment passes through the proposed site from the northwest to the southeast.

The surface of the proposed site is comprised of a thin veneer of sands overlying a broad limestone shelf. This limestone shelf comprises the top of the Floridan aquifer and is greatly fractured. This fracturing, combined with the discharge from the Floridan aquifer, gives rise to numerous springs scattered throughout the coastal hammock. Most of the streams in the area, such as the Crystal River and the Homosassa River, are spring fed.

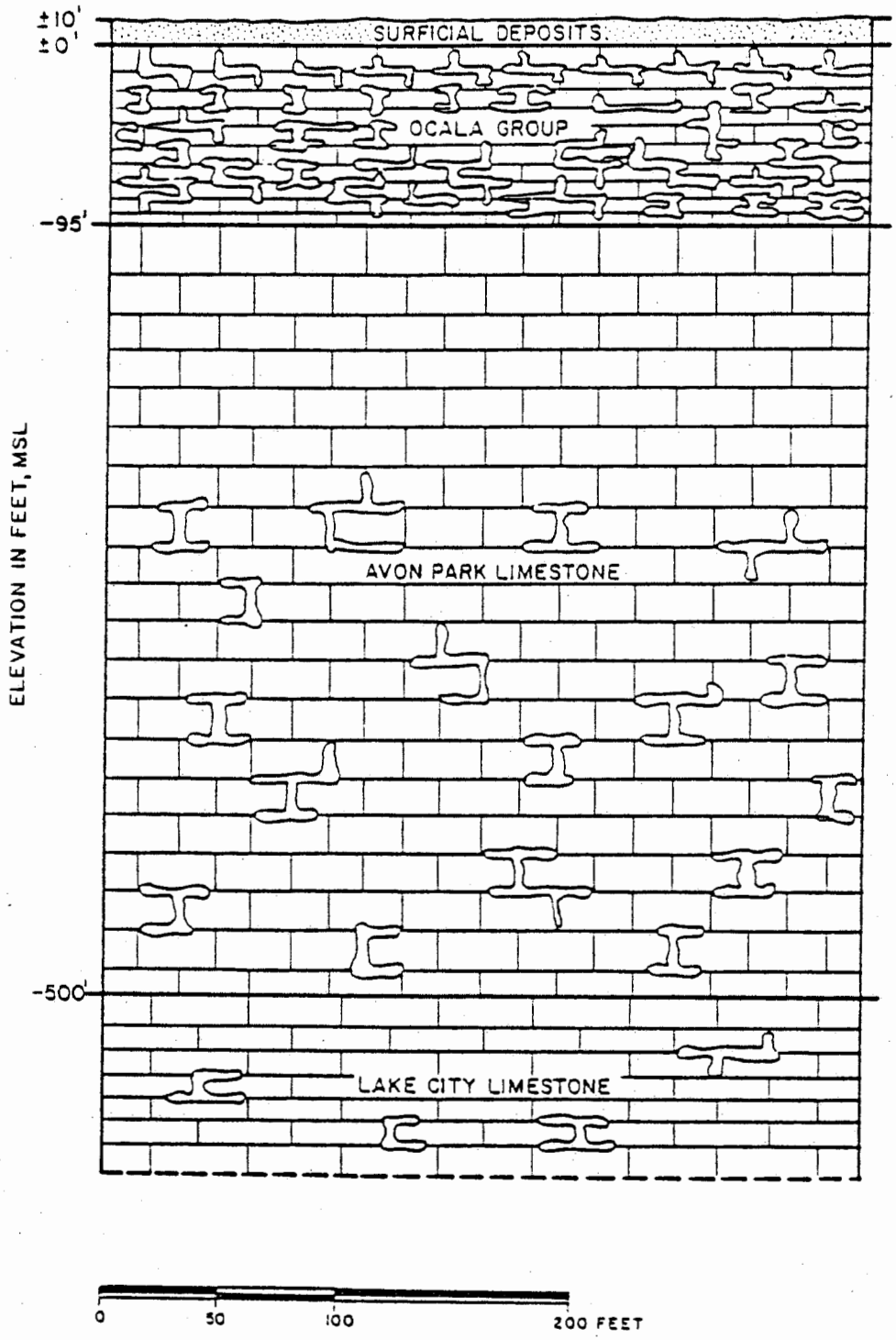
As evidenced by the absence of defined stream channels and surface water drainage features, the Pamlico marine plain allows relatively little rainwater runoff in the area of the proposed FPC plant.

2.4.3 STRATIGRAPHY

The Floridan aquifer is the upper sequence of rock formations which underlies the study area and contains large volumes of fresh water. The Floridan is comprised of the Ocala Group, Avon Park Limestone, and the Lake City Limestone (see Figure 2.4.3-1). This figure shows the approximate geologic column at the plant site.

Limestone and dolostone are the primary constituents of the Floridan aquifer. These rocks have recently undergone extensive solution activity during the geologic past when the sea level was much lower. As a result, solution cavities have developed in the upper portion of the aquifer. The most extensive solution zone is believed to have occurred in the Ocala Group and at the contact between the Ocala Group and

TYPICAL GEOLOGICAL COLUMN AT THE STUDY SITE



SOURCE: GERAGHTY AND MILLER, INC. 1977.

Figure 2.4.3-1

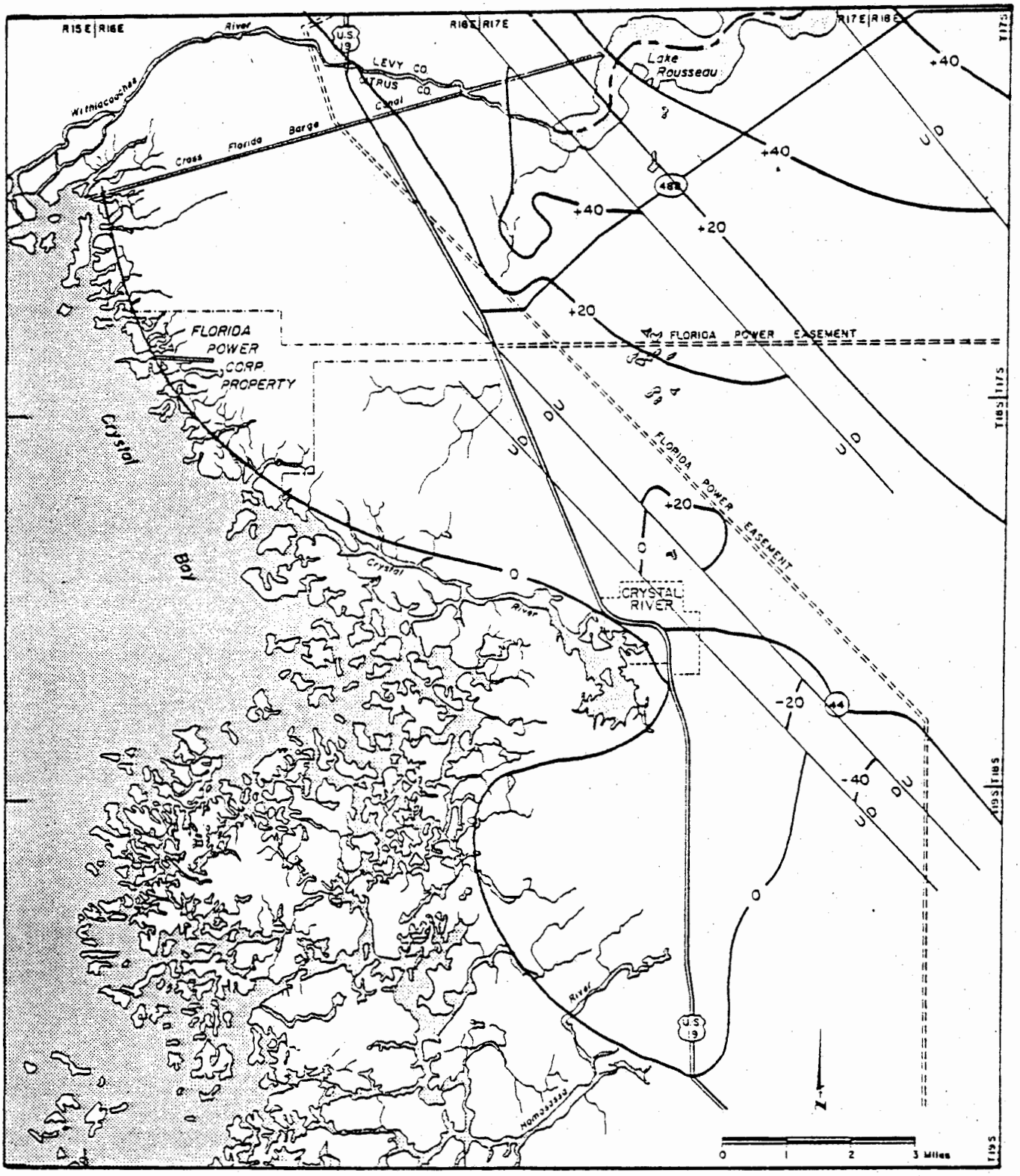
Avon Park Formation. However, large cavities have been encountered within the Avon Park Formation, and it is believed that large volumes of water flow through this formation (Geraghty and Miller, 1977).

The top of the Floridan aquifer occurs at or near land surface in the coastal zone (Figure 2.4.3-1) where it is overlain by a thin veneer of surficial deposits composed chiefly of sand. Inland, these surficial deposits increase in thickness. Analysis of data from soil borings drilled along FPC's powerline right-of-way indicates that the rock in the coastal zone is directly overlain by deposits composed of sand; however, in the inland areas, a relatively thin sandy layer is present at the base of the surficial deposits which separates the rock from the sand. The elevation of the top-of-rock of the Floridan aquifer is shown in Figure 2.4.3-2 (Geraghty and Miller, 1977).

2.4.3.1 STRUCTURE

The principal structural features in this area are believed to have formed as a result of the Ocala Uplift. Due to the uplifting, extensive fracturing and faulting occurred parallel to the strike of the Uplift, as shown in Figure 2.4.3-2. In addition, differential forces associated with the uplifting also caused minor fractures that developed at right angles to the primary fractures. Therefore, a well-developed fracture system is present throughout the area, with the major axes striking northwest/southeast and the minor axes striking northeast/southwest.

ELEVATION OF THE TOP OF THE ROCK OF THE FLORIDAN AQUIFER



— +20— LINE OF EQUAL ELEVATION, IN FEET, MEAN SEA LEVEL

Figure 2.4.3-2

SOURCE: GERAGHTY AND MILLER, INC., 1977

Prior to 1951, faulting was not recognized in Florida; but upon Vernon's publication of Bulletin 33 of the Florida Geological Survey, a well defined system of high-angle faulting was mapped along the east side of Citrus and Levy counties.

The westernmost extension of the mapped faulting lies 4.8 kilometers (3 miles) east of the plant site. All faulting common to Levy and Citrus Counties is oriented along steeply dipping (greater than 60 degree) northwest- trending fault planes which have produced displacements of 6 to 49 meters (20 to 160 feet).

Supplemented by photogeologic studies, subsurface explorations in the form of test borings and a seismic refraction survey eliminate the possibility that faulting exists beneath the proposed plant site because:

1. Correlation of marker horizons delineated by rock cores negates any inference that vertical displacement exists in the subsurface. Marker beds exist at expected elevations in points of investigation (drill holes).
2. Seismic profiles also showed no anomalous changes in elevations of velocity layers.

The nearest faulting occurs at a distance of 4.8 kilometers (3 miles) to the east of the site. Stratigraphic correlation and continuity of seismic refraction profiles negate the possible existence of subsurface faults at the site.

2.4.3.2 SEISMICITY

Weston Geophysical Research, Inc. conducted the seismic study which involved a thorough literature search and examined available seismograms to determine the epicentral distribution of earthquakes in the southeastern United States, their focal depth, intensity and/or magnitude, and attenuation characteristics. Regional tectonics and fault patterns were investigated for possible association with known epicenters. This study indicates that the State of Florida is seismically inactive and that the closest area to the site of significant seismic activity is Charleston, South Carolina. Attenuation data available for this area indicates that the site experienced an observed intensity no higher than Intensity V (Modified Mercalli). The maximum ground motion at the site due to this earthquake probably did not exceed 0.025 g.

The site is located in Seismic Zone 1 (Department of Army, Navy, and Air Force, 1973) which is rated as probable to expect only minor damage. The area is considered seismically stable.

2.4.4 SOILS

Soils on and around the site are nearly level and poorly drained. In the eastern portion of the site, the dominant soil association is the Broward-Boca association. These are sandy soils underlain by limestone. While these soils present severe restrictions to development because of wetness and a relatively shallow depth to limerock, they are the most dependable soils on the property. To the west, the soils are extremely wet, classified as either freshwater swamp or saltwater marsh. These soils are subject to frequent and prolonged flooding.

2.4.5 FLOODING

Because of the extreme flatness of the site and the proximity to the Gulf of Mexico, the area is subject to flooding. The most extensive flooding to be expected at the site will be produced by abnormally high tides resulting from hurricane surge and over-riding wind waves. The U.S. Army Corps of Engineers estimates the elevation of the "mean annual flood" (a flood with a 43 percent chance of occurring in any given year) at the mouth of the Withlacoochee River to be 1 meter (3 feet) above mean sea level. The U.S.G.S. estimates the 100-year flood elevation at the site to be approximately 3.4 meters (11 feet) above mean sea level. Hurricane surge and wind waves at the plant site have been described in detail in "Report- Verification Study of Dames and Moore's Hurricane Storm Surge Model with Application of Crystal River Unit No. 3 Nuclear Plant--Crystal River, Florida--for Florida Power Corporation" (1973). The maximum storm tide computed by Dames and Moore is 9 meters (29.4 feet) above mean low water. This value includes a 0.6 meters (2-foot) reduction due to backwater effects. Maximum tidal setup will occur when hurricane winds blow onshore, tracking normal to offshore bottom contours (southwest to northeast). Assuming wind vectors normal to the coast, the maximum wave height that can traverse the fill bordering Unit 3 is 4.6 meters (15.0 feet).

2.5.1 GROUND WATER

Most of the area groundwater flow is concentrated in a moderately thin zone just below the water table (Faulkner, 1973). The upper rock of the Avon Park Formation impedes the downward movement of water causing the preferred flow path of water recharged to the aquifer to be in the horizontal direction in the highly permeable sections of the Ocala Group.

Large quantities of water flow through the groundwater system and break out in the numerous springs in the area. Discharges at Crystal River Springs have averaged 2241 mld (592 mgd) (U.S.G.S., 1976) during the last 12 years. Ground water is also discharged from springs and seeps located along the coast, but is not recorded. From a flow-net analysis of the area, Geraghty and Miller (1977) estimate that these additional unrecorded springs discharges between Crystal River and the Cross-Florida Barge Canal could be on the order of 9.46 mld (250 mgd).

2.5.1.1 AQUIFER CHARACTERISTICS

Generally, controlled pumping tests are conducted and analyzed by appropriate mathematical models to determine transmissivity, storage coefficient, and leakance. However, because there have been no pumping tests in or near the study area, values for these coefficients are not available.

Geraghty and Miller used an indirect technique to estimate the aquifer transmissivity. A flow-net analysis of the ground water discharging into Crystal River between the 5-foot and 10-foot contours on the potentiometric surface for May, 1977, yielded an average transmissivity of about 17,300,000 lpd/m liters per day per meter (15 mgd/ft.). This value is comparable to that found for the Silver Springs area by Faulkner (1973) and is indicative of a very permeable aquifer.

No determinations are available of the storage coefficient or leakance in the area. However, because the upper portion of the aquifer near the plant site is under water-table conditions, the storage coefficient is estimated to be on the order of .05 to .20 by Geraghty and Miller. This means that for every unit volume of rock, approximately 5 to 20 percent of that volume is water which can be released from storage under the influence of gravity.

The upper portion of the aquifer is composed of a network of solution features that serve to transmit large quantities of water under natural or man-imposed gradients. The permeability of the deeper portion of the aquifer is not known. The deeper portion of the aquifer may also possess a high transmissivity (Geraghty and Miller, 1977) due to deeper solution channel systems which have developed in the geologic past. These systems are being indicated by the cavities encountered in two of the four 61 meters(200 ft.)deep borings from the nuclear plant site.

2.5.1.2 WATER-LEVEL CHANGES

The water levels in the Floridan Aquifer fluctuate seasonally. The lowest point generally occurs in May after the dry season and the highest point occurs in September after the wet season. Figure 2.5.1-1 shows the water-level fluctuations in two U.S.G.S. (United States Geological Survey) observation wells and in a well located further inland near Lecanto. The locations of these wells are shown in Figure 2.5.1-2. Note than the water-level fluctuations are greater in the inland areas than along the coast. The fluctuations near the coast are generally less than 1 meter (3 feet), but further inland they may be as much as 1.5 to 2 meters (5 to 6 feet) (Geraghty and Miller, 1977).

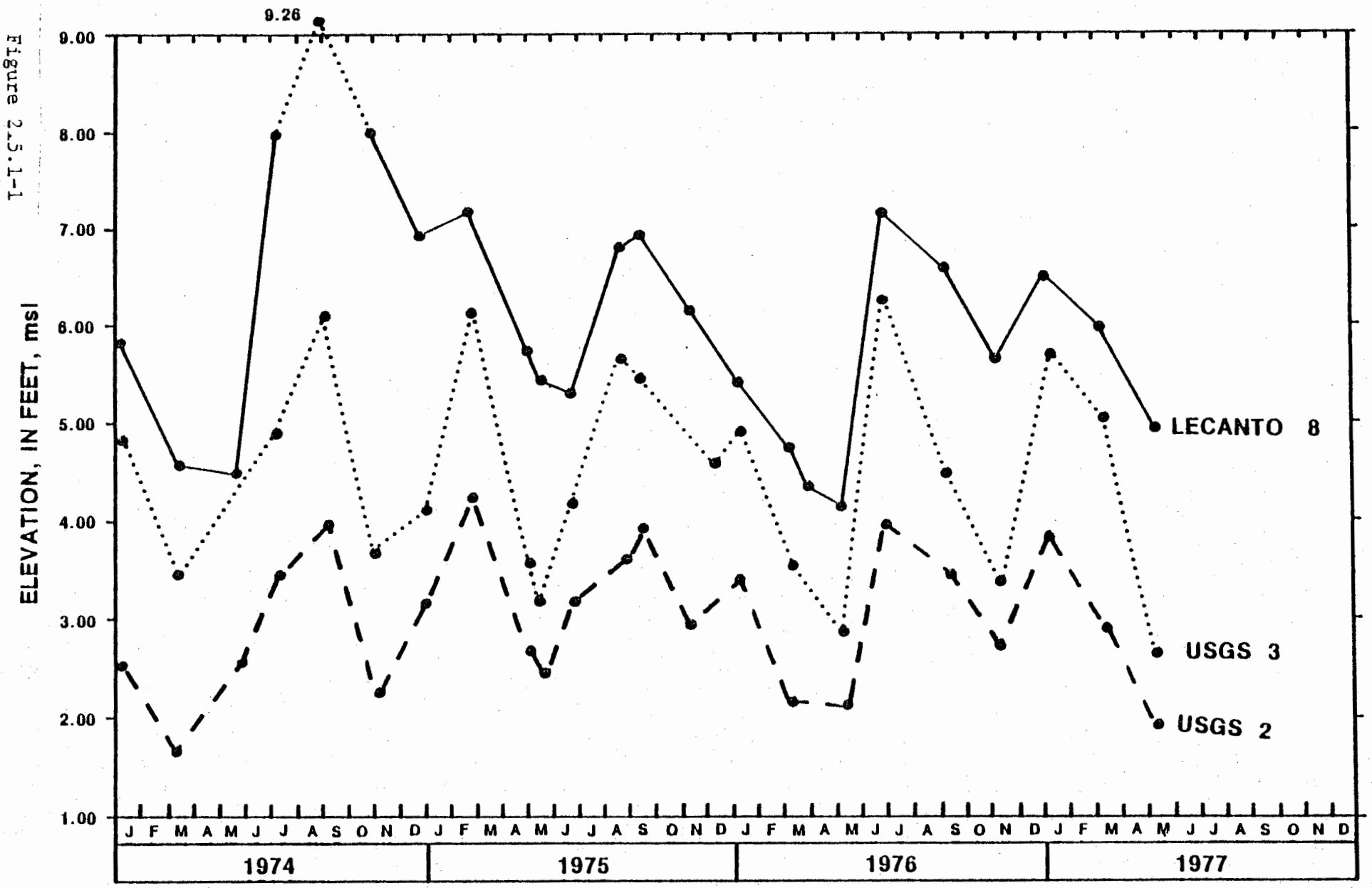
Figures 2.5.1-3 and 2.5.1-4 show the elevations of the regional potentiometric surfaces of the upper Floridan Aquifer in May and September, 1975, respectively. Ground water moves perpendicular to the lines of equal elevation of the potentiometric surface, from points of higher elevation to points of lower elevation. In the study area, groundwater flow is generally in a southerly to westerly direction.

The wide spacing between the contour lines in the figures discussed above is primarily a result of the high transmissivity of the aquifer. If the aquifer were not so transmissive, larger frictional losses would result and the gradient would be steeper in order to maintain the same amount of flow (Geraghty and Miller, 1977).

In the area at the westernmost tip of Lake Rousseau, the close configuration of the contour lines (i.e., trough in the potentiometric surface

Figure 2.5.1-1

FLUCTUATION OF WATER LEVELS IN WELLS USGS 2, USGS 3, AND LECANTO 8



SOURCE: GERAGHTY AND MILLER, INC., 1977

LOCATION OF WELLS USGS 1, USGS 2, USGS 3 AND LECANTO 8

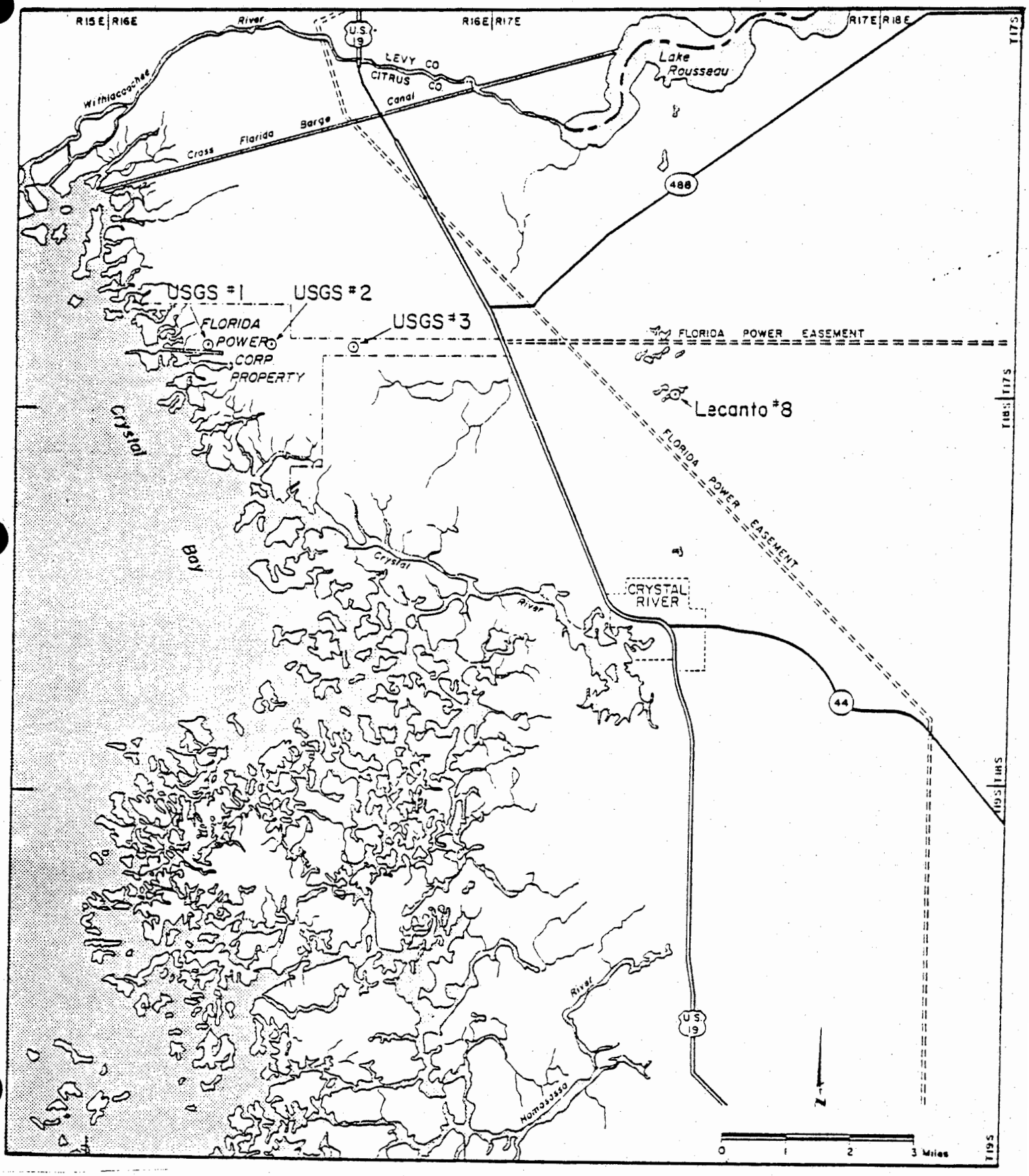
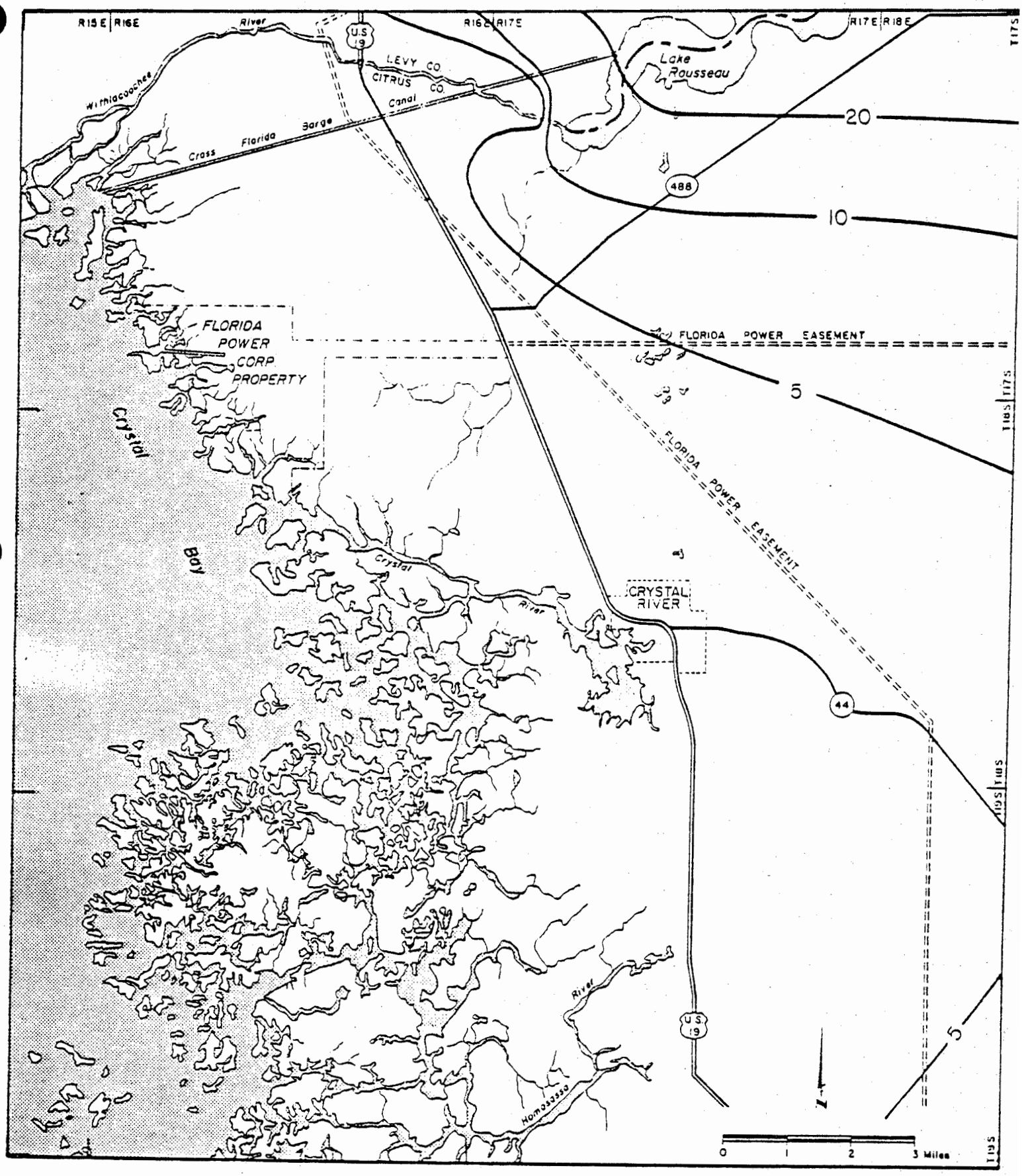


Figure 2.5.1-2

SOURCE: GERAGHTY AND MILLER, INC., 1977

ELEVATION OF THE POTENTIOMETRIC SURFACE OF THE UPPER FLORIDAN AQUIFER, MAY, 1975

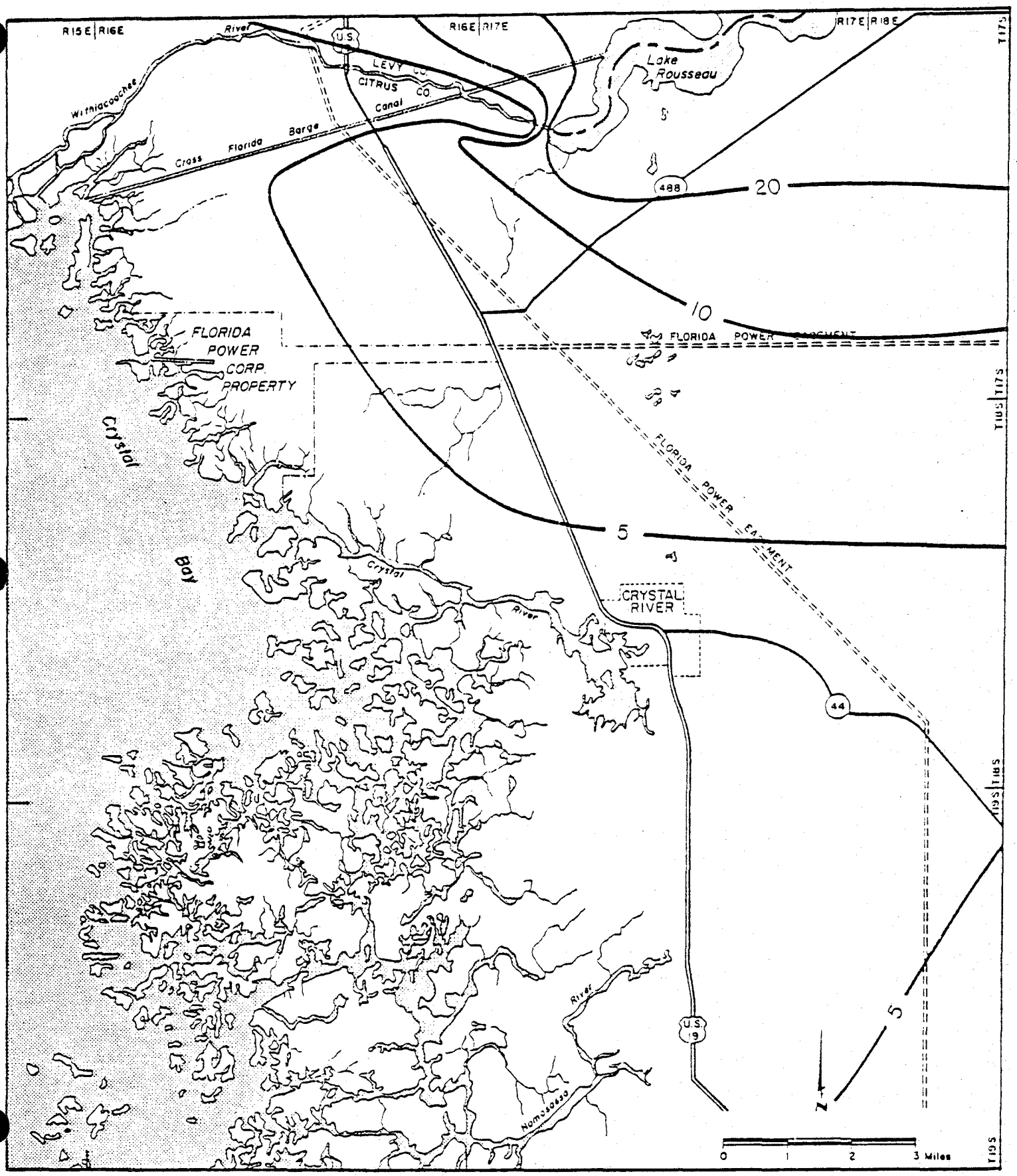


—10— LINE OF EQUAL ELEVATION, IN FEET, MEAN SEA LEVEL

Figure 2.5.1-3

SOURCE: GERAGHTY AND MILLER, INC., 1977

ELEVATION OF THE POTENTIOMETRIC SURFACE OF THE UPPER FLORIDAN AQUIFER, SEPTEMBER, 1975



—10— LINE OF EQUAL ELEVATION, IN FEET, MEAN SEA LEVEL

Figure 2.5.1-4

SOURCE: GERAGHTY AND MILLER, INC., 1977

paralleling the Cross-Florida Barge Canal) indicates that ground water is discharged into the canal. In September, 1975, the trough was much more pronounced than in May, 1975. The discharge to the river was significant in September, but limited in May, 1975, a low-flow period.

2.5.1.3 WATER BUDGET

One method for demonstrating the volumes of water flowing through the groundwater system is to analyze the elements of the water budget. The water budget is based upon the principle of conservation of mass and can be expressed mathematically as:

$$P - ET - R - GR = \text{delta } S$$

where P is precipitation, ET is evapotranspiration loss, R is surface-water runoff, GR is recharge to the groundwater system, and delta S is change in storage in the groundwater system. Over long periods of time the average elevation of the potentiometric surface has been more or less the same. As a consequence, the change in storage can be assumed to equal zero. At the proposed wellfield site very little surface runoff occurs; therefore, the value for this term in the water-budget equation is also assumed equal to zero. Thus, the evapotranspiration loss plus the recharge to ground water must equal the precipitation. The long-term precipitation averages about 1400 millimeters (55 inches) per year and the evapotranspiration losses are assumed to range between 760 millimeters and 1,020 millimeters (30 and 40 inches) per year. Based on these assumptions, the rate of recharge to ground water is calculated to range between 380 and 640 millimeters (15 and 25 inches) per year (Geraghty and Miller, 1977). FPC has applied for and been denied a test well permit to further refine the impact of the proposed well field.

Groundwater Withdrawals

In 1976, groundwater withdrawals in Citrus County for industrial, agricultural, and municipal purposes totaled 87.8 million liters per day (23.2 million gallons per day). Approximately half of this amount is used for irrigation and only 14.9 million liters per day (3.9 million gallons per day) is used for municipal purposes. There is no concentration of withdrawals in any one area. Table 2.5.1-1 presents the present and projected future water demands in Citrus County. The total demand in the county by 2035 is expected to be about 197 million liters per day (52 million gallons per day), roughly half of which will be for municipal demand and the other half for agriculture. Industrial demand, excluding power plants, is expected to be approximately 7.6 million liters per day (2 million gallons per day).

There are no public water supply systems within a 8.00 kilometer (5 mile) radius of the plant site. There are three systems which are just outside lie close to the 8.00 kilometer (5 mile) radius. These are: the Yankeetown public water system [9.7 kilometers (6 miles) north of the site], the Indian Waters Subdivision water system [9.7 kilometers (6 miles) southeast of the site], and the Thunderbird Mobile Park system [9.7 kilometers (6 miles) east-southeast of the site]. The Yankeetown system consists of three 102 millimeter (4-inch) diameter wells ranging in depth from 16.8 to 21.3 millimeters (55 to 70 feet) and serving 55 connections. Capacities range from 190 to 389 liters (50 to 100 gallons) per minute (50 to 100 gallons per minute). The Indian Waters

Table 2.5.1-1. Present and Projected Future Water Demands in Citrus County in Millions of Liters Per Day (Millions of Gallons Per Day).

	Water Demand 1975	Projected Water Demand 1985	Projected Water Demand 2035
Municipal	14.8 (3.9)	25.7 (6.8)	87.4 (23.1)
Industrial*	31.0 (8.2)	29.1 (7.7)	7.6 (2.0)
Agricultural	42.0 (11.1)	45.4 (12.0)	101.1 (26.7)
Totals	87.8 (23.2)	100.3 (26.5)	196.1 (51.8

*Excludes power plant demands.

Source: Water Resources Management Study, Hydrologic and Engineering Evaluation of the Four River Basins Area, West Central Florida, 1977.

Subdivision system consists of one 152 millimeter (6 inch) diameter well, 34.4 meters (113 feet) deep, providing 757 liters per minute (200 gallons per minute. No information is available concerning the Thunderbird Mobile Park system.

2.5.1.4 SALTWATER INTERFACE

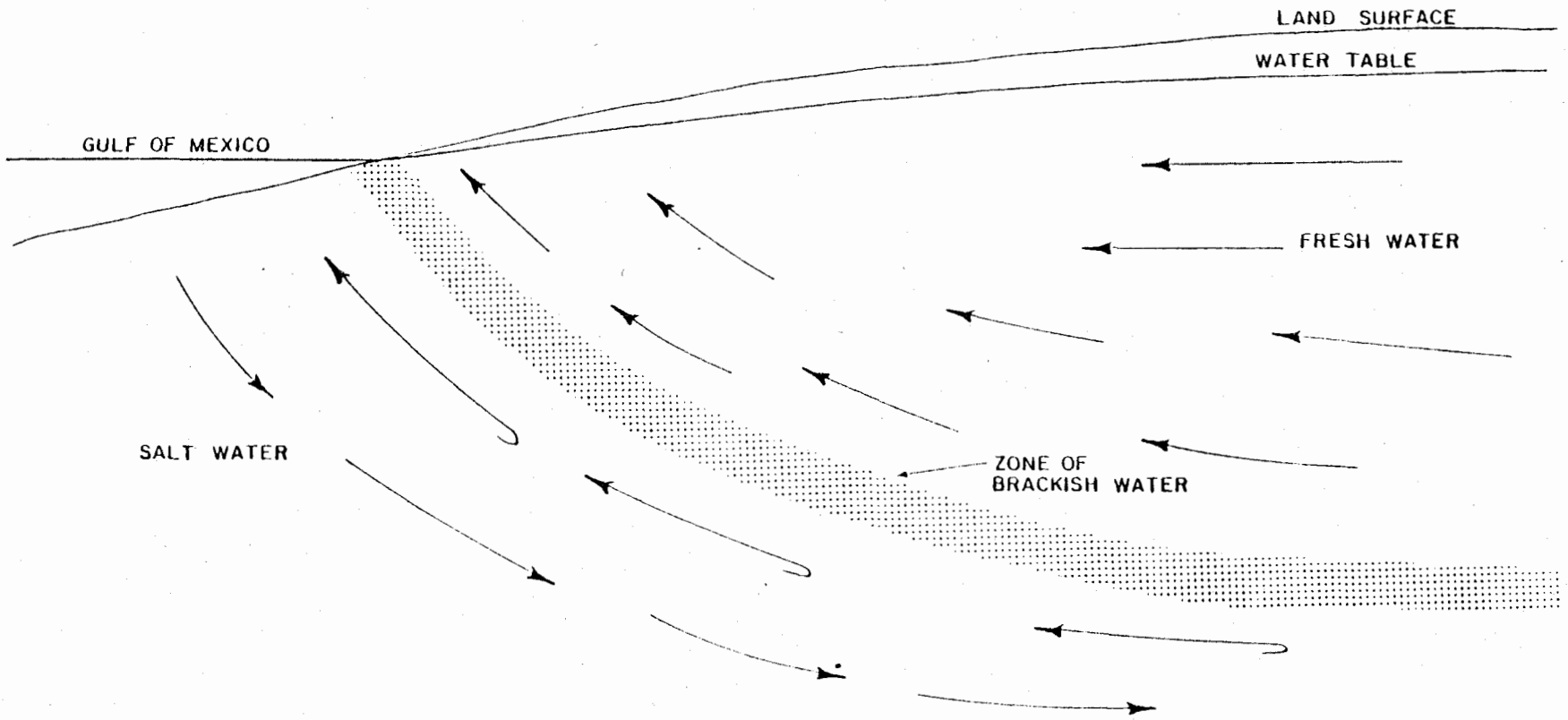
Due to the density differences between fresh water and salt water, salt water supports a wedge of fresh water near the coast. This freshwater zone is thinnest at the coast and is thickest inland. The transitional zone between the salt water and the fresh water and contains brackish water with a chloride content ranging between 250 and 19,000 mg/l (milligrams per liter). The thickness of this transitional zone varries spacially. Since the salt/freshwater interface is under dynamic conditions, as illustrated in Figure 2.5.1-5, it moves under natural and man-induced stresses in the system (Geraghty and Miller, 1977).

The construction of FPC's receiving canal in 1966 is an example of a man-induced stress on the hydrolic system. The canal was dug perpendicular to the coast for several thousand feet to a depth of approximately 4.26 meters (14 feet) below mean sea level. This provided a short circuit (and drain) for the groundwater system, causing flow from the aquifer to the canal. The water levels in the aquifer declined. This lowering caused the interface to establish a new equilibrium further inland.

The interface movement resulting from the construction of the canal is

Figure 2.5.1-5

SCHEMATIC CROSS SECTION SHOWING THE DYNAMIC RELATIONSHIP BETWEEN FRESH AND SALTY GROUND WATER



SOURCE: GERAGHTY AND MILLER, INC., 1977

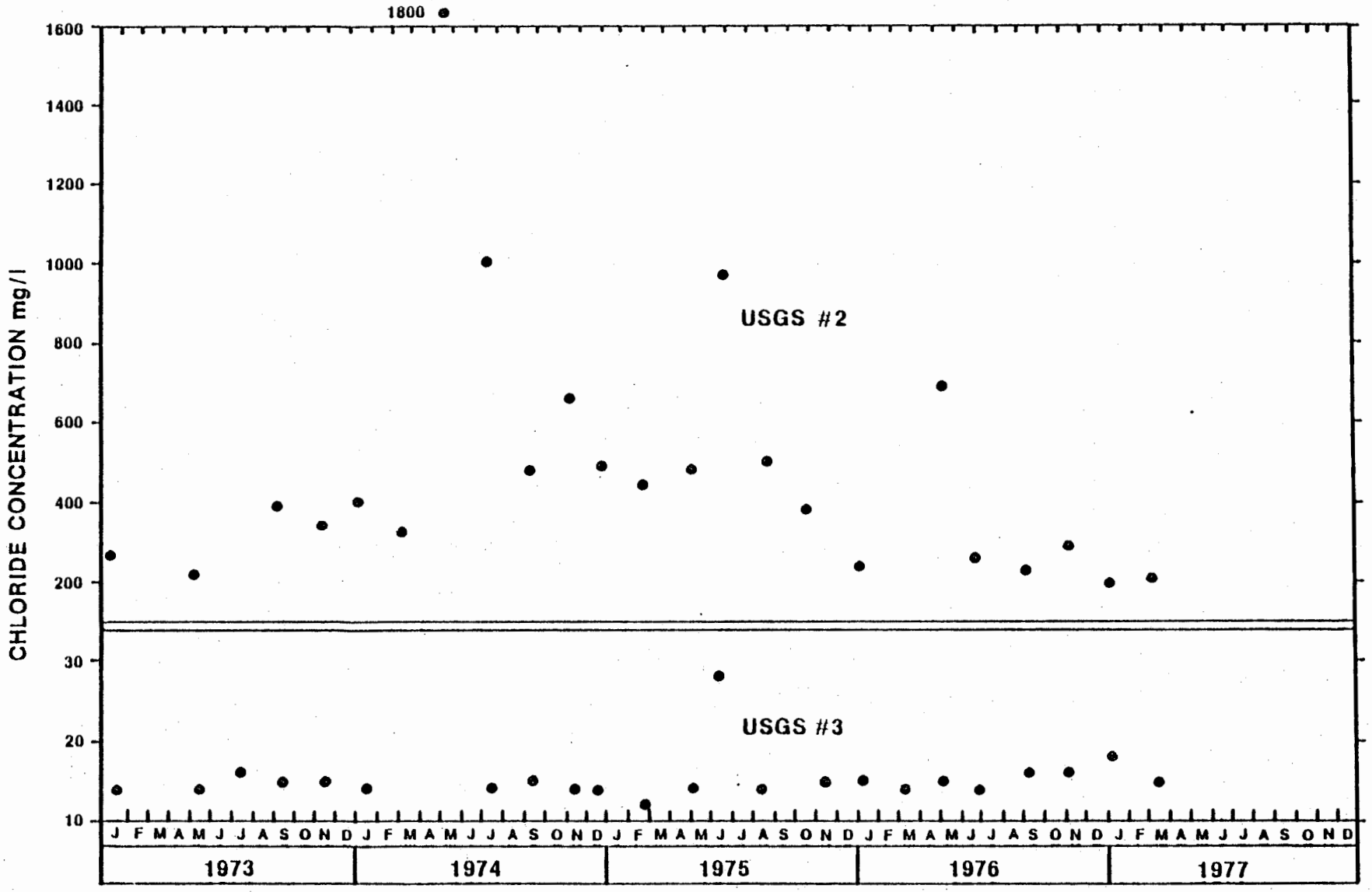
demonstrated by an increase in chloride concentrations from water sampled in U.S.G.S. Well #1 (USGS 1). This well was drilled in 1965 to a depth of 21.3 meters (70 feet) and cased to 18.3 meters (60 feet). The initial chloride content of the water from the well was 1,740 mg/l. In 1971, after canal construction, the chloride had risen to over 5,000 mg/l. Studies conducted by Faulkner (1972) indicate that similar conditions occurred north of the plant site after construction of the Cross-Florida Barge Canal.

Figure 2.5.1-6 shows the fluctuation in chloride concentration recorded in well USGS 2, which is cased to 20.4 meters (67 feet) and drilled to 26.8 meters (88 feet), and well USGS 3, which is cased to 12.8 meters (42 feet) and drilled to 14.3 meters (47 feet). Because well USGS 3 is further inland and shallower than well USGS 2, its water quality is better and its chloride concentrations have generally been less than 20 mg/l. Well USGS 2, on the other hand, appears to be located in the proximity of the interface, which occasionally moves inland of this well. An increase in chloride concentration is usually observed in this well during the dry season when groundwater discharge is at a minimum. When the rainy season arrives, increased groundwater flow towards the Gulf pushes the interface seaward again, and the chloride concentration is reduced.

Geraghty and Miller (1977) concluded that no trend was apparent in the chloride data that would indicate that saltwater intrusion is occurring on a permanent basis.

Figure 2.5.1-6

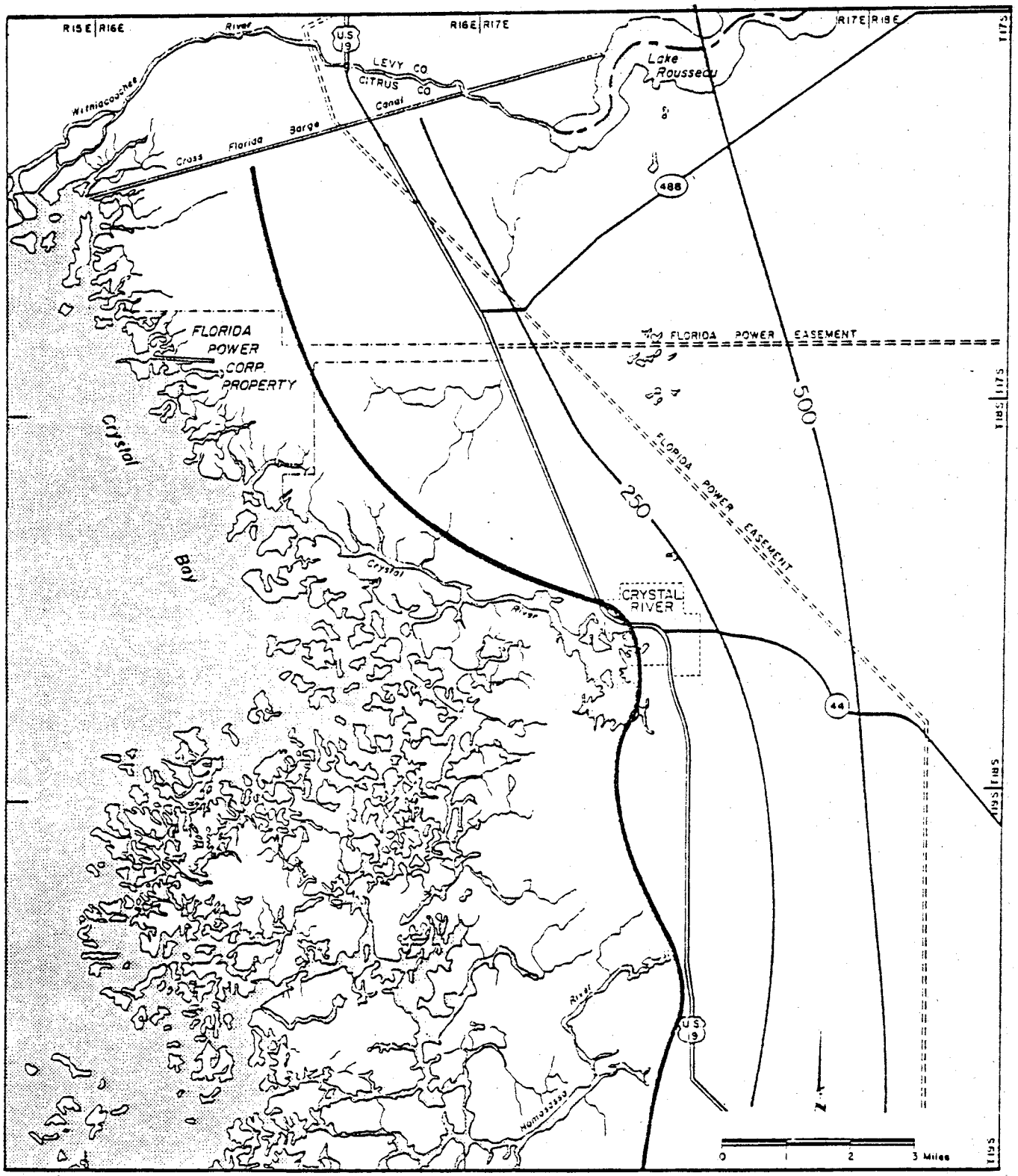
FLUCTUATION IN CHLORIDE CONCENTRATIONS IN WELLS USGS 2 AND USGS 3



SOURCE: GERAGHTY AND MILLER, INC. 1977

Figure 2.5.1-7 shows the estimated depth to the base of potable water in the Floridan aquifer in the study area. The position of the 250-mg/l isochlor at a depth of 30.5 meters (100 feet) below mean sea level was determined from wells recently drilled by the U.S.G.S. and is considered reliable. However, the position of the isochlor at depths of 76 to 152 meters (250 to 500 feet) is less reliable due to the wide scatter of the control wells used in the determinations.

DEPTH TO BASE OF POTABLE WATER IN THE FLORIDAN AQUIFER



—250— LINE OF EQUAL DEPTH TO BASE OF POTABLE WATER, IN FEET BELOW LAND SURFACE

POSITION OF 250 MG/L ISOCHLOR AT DEPTH OF 100 FEET BELOW MEAN SEA LEVEL

Figure 2.5.1-7

SOURCE: GERAGHTY AND MILLER, INC., 1977

2.5.2 SURFACE WATER

The major surface water features in the vicinity of the proposed plant include the Withlacoochee River-Cross Florida Barge Canal Complex to the north, Crystal River to the south, and the Gulf of Mexico to the west. Numerous small ponds and wet depressions, as well as several small unnamed intermittent streams, are scattered about the area.

Rainfall in the area averages about 1,422 millimeters (56 inches) annually and varies throughout the year. Rainfall is greatest in the summer months, due primarily to thunderstorms. Rainfall is lower in the winter and spring months when precipitation is usually the result of slow-moving frontal systems. Figure 2.5.2-1 shows the average monthly rainfall in the area measured at Inverness, Florida, 40 kilometers (25 miles) southeast of the site.

Runoff in the area ranges from 0 to 510 millimeters (0 to 20 inches) annually and is generally highest near the coast (Kenner, 1966). Here, runoff is supplemented by discharges from the Floridan aquifer, which is close to the land surface in the area. The numerous springs in the area (Rainbow Springs, Homosassa Springs, Chassahowitzka Springs, etc.) are discharges from the Floridan aquifer.

The U.S.G.S. maintains flow measurement stations and water level recorders on surface waters in the area. Table 2.5.2-1 summarizes the major characteristics of gages on streams in the area and Table 2.5.2-2 summarizes the characteristics of gaged lakes in the area.

AVERAGE MONTHLY RAINFALL AT INVERNESS, FLORIDA (1899-1975)

AVERAGE ANNUAL RAINFALL-56.29 INCHES

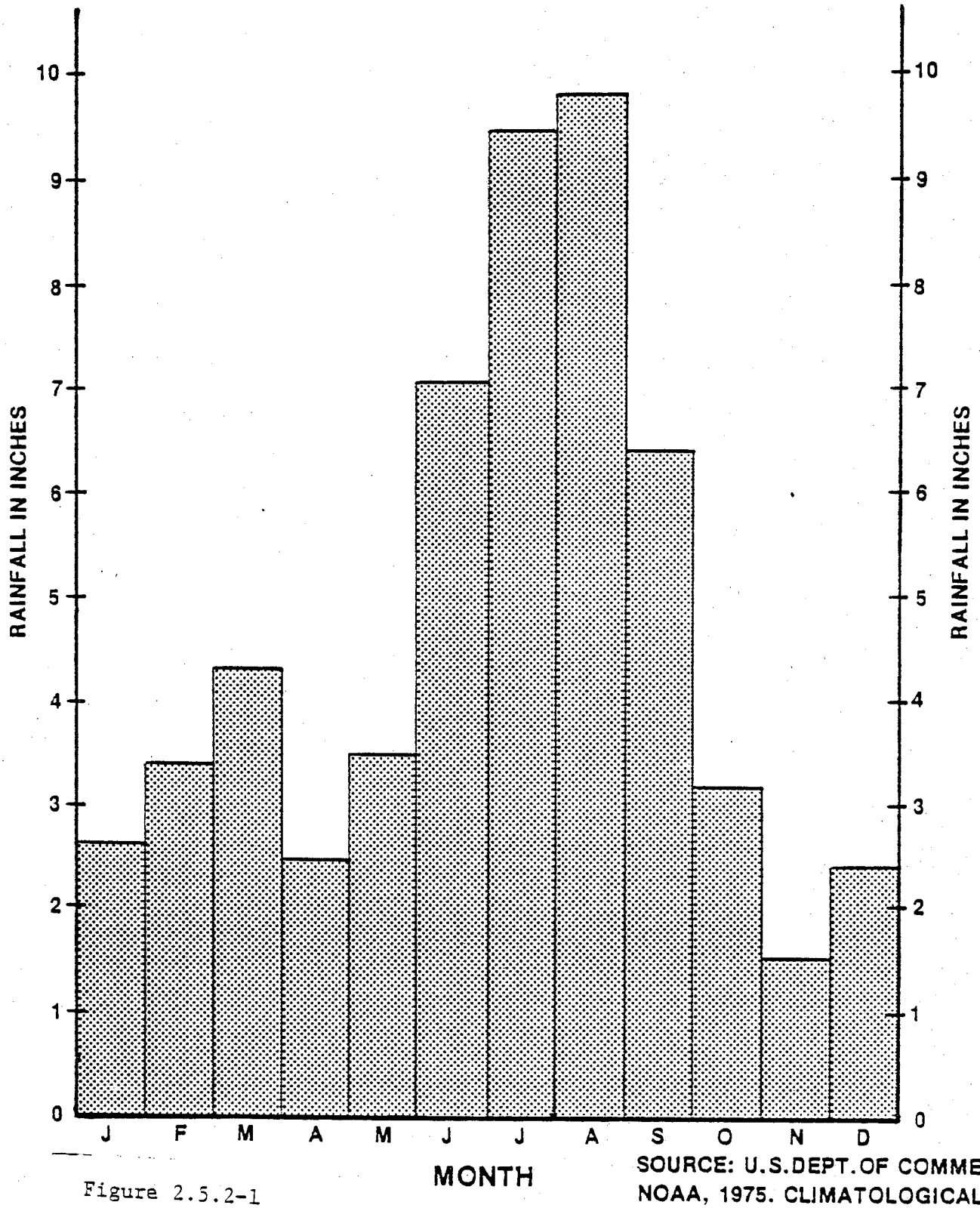


Figure 2.5.2-1

SOURCE: U.S.DEPT.OF COMMERCE, NOAA, 1975. CLIMATOLOGICAL DATA FOR FLORIDA

Table 2.5.2-1. U.S.G.S. Streamgaging Network in Vicinity of Proposed Plant

Station Name	USGS ID Number	Period of Record	Ave. Flow cfs	Max. cfs	Min. cfs
Crystal River near River, Florida	02310750	2/64 to Present	916	4340	-1520
Withlacoochee River near Holder, Florida	02313000	8/28-2/29 8/31 to Present	1132	8660	112
Rainbow Springs near Dunnellon, Florida	02313100	10/30-11/64 12/64 to Present	748	1230	487
Withlacoochee River at Dunnellon, Florida	02313200	2/63 to Present	--	--	--
Withlacoochee River at Inglis Dam, near Dunnellon, Florida	02313230	10/69 to Present	481	3980	70
Withlacoochee River below Inglis Dam, near Dunnellon, Fla.	02313231	6/64 to Present	--	--	--
Cross-Florida Barge Canal at Inglis Lock, near Inglis, Florida	02313237	1/70 to Present	--	138	0
Withlacoochee River bypass channel near Inglis, Florida	02313250	1/70 to Present	1103	1740	53
Withlacoochee River bypass channel below structure, near Inglis, Florida	02313251	12/69 to Present	--	--	--
Withlacoochee River near Crackertown, Florida	02313265	4/67 to Present	--	--	--

Source: USGS Water Resources Data for Florida, 1976.

Table 2.5.2-2. Lake Stages in Vicinity of Proposed Plant.

	USGS ID Number	Drainage Area	Surface Area	Period of Record	Maximum Elevation (msl)	Maximum Elevation (date)	Minimum Elevation (msl)	Minimum Elevation (date)
		523,180 ha.	1,686 ha.		8.54 m.		6.61 m.	
Lake Rousseau near Dunnellon, Florida	02313229	2,020 sq. mi.	4,163 acres	Jun. 1964-Present	28.01 ft.	6/26/71	21.70 ft.	10/11/72

Source: U.S.G.S. Water Resources Data for Florida, 1976.

Major streams in the area include the Withlacoochee River-Cross Florida Barge Canal Complex, Rainbow Springs, and the Crystal River. The major lake in the area is Lake Rousseau (an artificial impoundment on the Withlacoochee River).

2.5.2.1 LOWER WITHLACOOCHEE-CROSS FLORIDA BARGE CANAL COMPLEX

The Withlacoochee River rises in the Green Swamp area of west central Florida at an elevation of approximately 38 meters (125 feet) above mean sea level (msl). The river meanders in a predominantly northwest direction for some 257 kilometers (160 miles) before discharging into the Gulf of Mexico. At the mouth, the Withlacoochee drains some 518,000 hectares (2,000 square miles). From the headwaters in Polk County to the town of Lacoochee in Pasco County, the river has a relatively steep slope of 0.5 meters (1.6 feet) per mile. Between Lacoochee and Dunnellon in Marion County, the slope is reduced to 6 centimeters (0.2 feet) per mile. From Dunnellon to the Gulf, the slope averages 24 centimeters (0.8 feet) per mile (U.S. Army Corps of Engineers, 1976).

The average flow of the Withlacoochee River at its mouth is approximately 51,535 liters per second (lps) (1,820 cfs) with a maximum and minimum flow of 258,890 liters per second (9,130 cfs) and 23,502 liters per second (830 cfs), respectively. Statistical flow data for the Withlacoochee River at Holder are summarized below. The drainage area is 442,890 hectares (1,710 square miles) at Holder.

Minimum daily flow	3,200 lps	113 cfs
Average annual discharge	33,130 lps	1,170 cfs
Average runoff per square mile	19 lps	0.68 cfs
Mean annual flood	99,106 lps	3,500 cfs
Maximum flood of record	244,650 lps	8,640 cfs

In view of the magnitudes of the stream flows and their geographic locales, the Withlacoochee and Crystal Rivers have little effect on surface water elevations at the plant site. However, freshwater inflows, particularly those of the Withlacoochee, play a significant role in the dispersion and movement of the near-shore waters of the Gulf.

2.5.2.2 LAKE ROUSSEAU

Lake Rousseau is an artificial impoundment of the Withlacoochee River northeast of the proposed plant site. The lake lies in a gap in a sandy ridge, known as the Brooksville Ridge, which parallels the Gulf Coast. The Brooksville is a korst highland characterized by sandy terrain and sandhill vegetation. Lake Rousseau was created in 1909 by the construction of an earthen dam. A concrete control structure consisting of two spillway bays with vertical lift gates presently exists. The initial purpose of the lake was for hydroelectric generation; however, the lake is used primarily for recreation today.

The normal surface area of the lake is 1,481 hectares (3,657 acres). Average pool elevation of Lake Rousseau is 8.2 meters (27 feet) above msl. Since 1964, the maximum stage of the lake was 8.54 meters (28.01 feet) above msl (June 26, 1971), the minimum stage was 6.61 meters (21.7 feet) above msl (October 11, 1972) (U.S.G.S., 1976). Figure 2.5.2-2 shows the inflow-duration curve for Lake Rousseau.

The flow of water into Lake Rousseau is gauged by the U.S.G.S. at Rainbow Springs, on the Withlacoochee River at Holder and on the Withlacoochee River at Dunnellon. The gauge at Dunnellon is in the backwater of

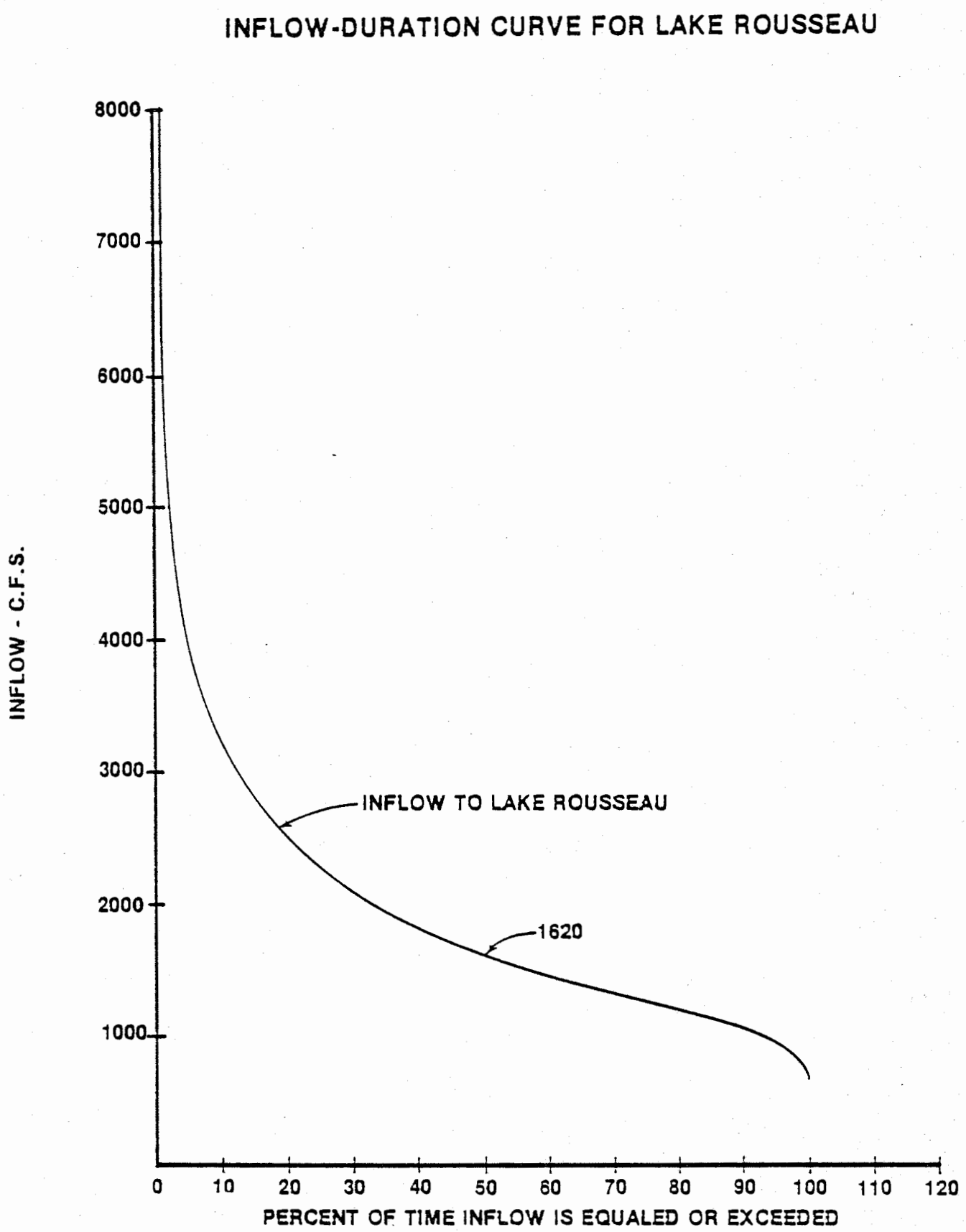


Figure 2.5.2-2

SOURCE: ARMY CORPS OF ENGINEERS, 1976.
CROSS-FLORIDA BARGE CANAL RESTUDY REPORT.

Lake Rousseau. Therefore the inflow is considered the sum of flows at Rainbow Springs and Holder (Rabon, 1966). No significant tributaries downstream of Holder occur. The discharge of Rainbow Springs for any month can be predicted within 15 percent expected accuracy two-thirds of the time (one standard deviation) using the 1931-1965 flow records. The regularity of Rainbow Springs discharge indicates that the total flows into Lake Rousseau vary with the discharge at Holder, and the discharge of the Withlacoochee River at Holder varies greatly.

The quantity of water available to Lake Rousseau (hydrologic budget) at any time is equal to:

(Inflow + Precipitation + Seepage) - (Outflow + Evapotranspiration + Infiltration + Consumptive Demand)

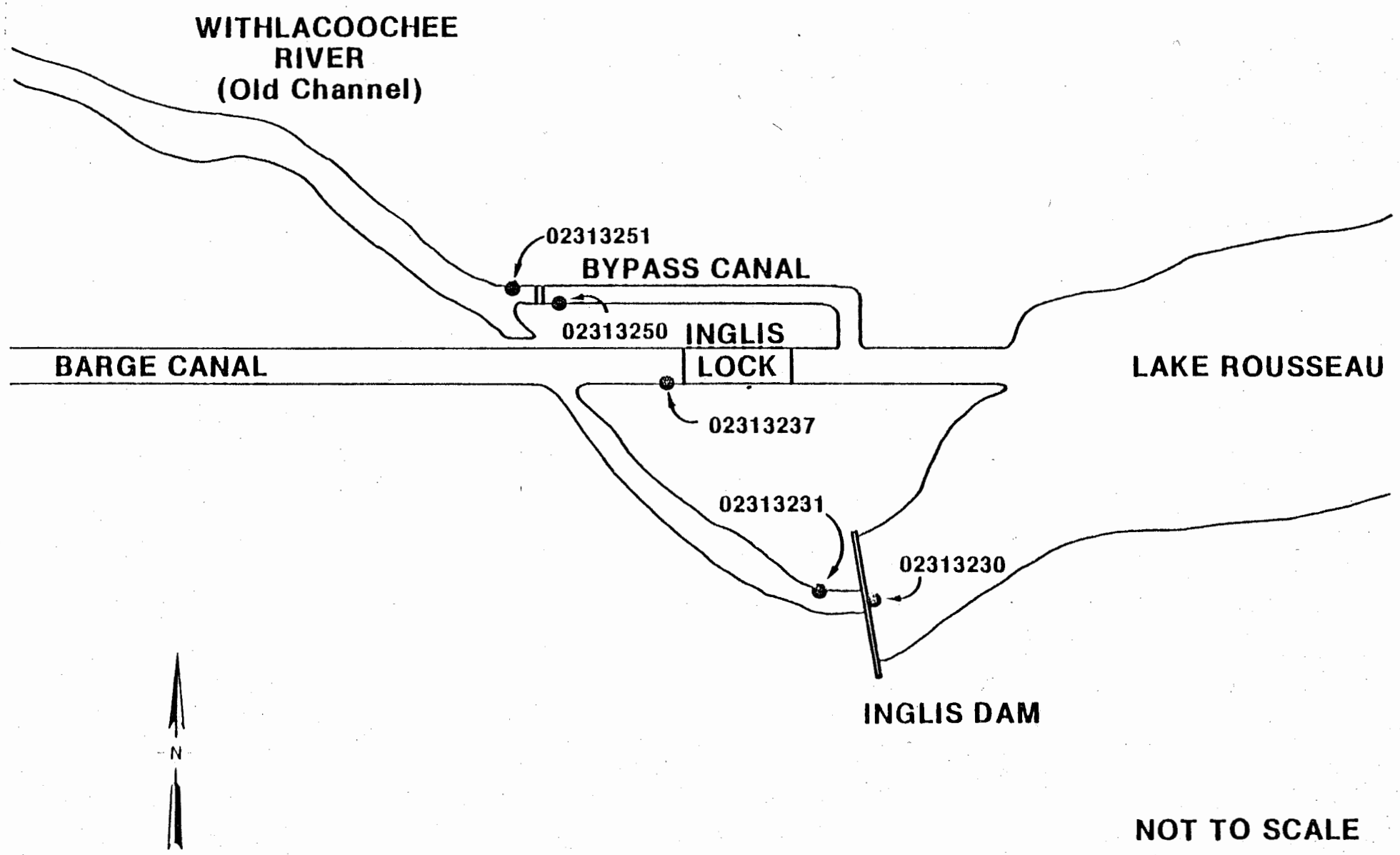
This equation can be analyzed by daily, monthly, or annual terms. Flood levels of Lake Rousseau are controlled by tainter gates at Inglis Dam.

Presently very little is known about the circulation of Lake Rousseau. Dissolved oxygen data indicates decreasing vertical exchange and mixing downstream of the Withlacoochee River. Near Inglis Dam D.O. stratification indicates little vertical mixing taking place and a tendency towards oxygen depletion most of the year.

The flow of the lower Withlacoochee River near the plant site has been altered by the installation of canals and structures associated with the partially completed Cross-Florida Barge Canal. A schematic diagram of the lower Withlacoochee is shown in Figure 2.5.2-3.

Figure 2.5.2-3

Schematic Diagram of the Lower-Withlacoochee Cross-Florida Barge Canal Complex



In December, 1969, flow over the Inglish Dam was stopped and diverted into the barge canal. Some discharge still occurs through the dam (leakage) and averages 13,620 lps (481 cfs) (U.S.G.S., 1975). The diverted flow maintains water levels in the barge canal and Inglis Lock, as well as in the old river channel. Diverted flow which enters the old river channel does so through the Withlacoochee River Bypass Channel. Flow through this bypass channel began on December 17, 1969, and has averaged 31,233 lps (1103 cfs) since that time. Flow in the barge canal itself is minimal, with most flow being diverted into the bypass channel. The U.S.G.S. maintains discharge and stages gages throughout the lower Withlacoochee-Barge Canal Complex. The location of these gages is provided on Figure 2.5.2-3. Prior to the installation of the Barge Canal and associated works, discharge of the Withlacoochee River averaged about 50,970 lps (1800 cfs). The estimated capacity of the Withlacoochee Bypass Channel is approximately 45,306 lps (1600 cfs). Seasonal high discharges to the lower river can no longer occur because of the small capacity of the bypass channel. Therefore, the long term average discharge before construction of the barge-canal complex cannot be maintained. The future long-term average discharge to the lower river through the bypass channel is estimated to be 40,492 lps (1430 cfs) (Bush, 1972). The average discharge through the bypass channel since its installation is 31,233 lps (1103 cfs).

2.5.2.3 CRYSTAL RIVER

The Crystal River is a tidally influenced spring-fed stream which rises at a group of springs in and around the community of Crystal River in an

embayment known locally as Kings Bay. From Kings Bay the river flows easterly some 11.3 kilometers (7 miles) to the Gulf of Mexico. The estimated drainage area is 20,720 hectares (80 square miles) (Cherry, 1970). The channel, which ranges in depth from 0.6 meters (2 feet) to more than 6 meters (20 feet), is relatively wide and in many places, weed-choked. Fresh water flow in the river is due to springs in Kings Bay, numerous springs east of the bay, seeps in the many canals excavated into the limestone bedrock, and springs in the smaller tributaries. Flow in the Crystal River is measured by the U.S.G.S. at the upstream confluence of the Salt River and Crystal River. Over the period of 1965 to 1975 discharges averaged 25,937 lps (916 cfs).

The maximum flow carried by the river channel during normal tides is about 113,264 lps (4,000 cfs). During hurricane Donna in 1964 the flow was estimated at more than 283,160 lps (10,000 cfs). Due to the unusually high hurricane tides, reverse flow of the spring over 42,474 lps or 1,500 cfs occurred. Reverse spring flows are not peculiar in the Crystal River and are related to tidal amplitudes. Since the springs occur at or below mean sea level their discharge is primarily controlled by tide height. Large discharges occur during seasonal low tidal amplitudes and are not reflective of rainfall periods (Cherry, et al., 1970). The estimated average annual minimum flow in the river is 12,742 lps (450 cfs) (U.S. Army Corp. of Engineers, 1977).

Due to the estuarine nature of the Crystal River, the water chemistry varies from nearly marine at the mouth to fresh at the head. There is little vertical density or salinity stratification in the water column,

but considerble longitudinal variation. The vertical homogenity and mixing are driven by the tidal currents (ESE, 1977).

2.5.2.4 SITE HYDROLOGY

Of the 1,411 millimeters (56 inches) of rain which falls in the area each year, most is stored in small depressions and eventually returned to the atmosphere by evapotranspiration. Cherry, et al. (1970) report that between 55 and 75 percent of the annual rainfall is evaporated. The remainder percolates through the thin sands and provides recharge to the Florida aquifer. The recharge water generally moves laterally and is discharged through numerous coastal and offshore springs.

The hydrology on the site is characterized by the free interconnection between surface waters and the Florida aquifer. The Gulf of Mexico, 1.6 kilometers (1 mile) west of the site, has a wide, marshy shoreline which comprises the westernmost portion of the site. The U.S.G.S. maintains a water level and discharge gage on the Crystal River, about 8 kilometers (5 miles) southeast of the site. The mean tidal range at this gage is approximately 1.1 meters (3.50 feet).

The tide is semidiurnal with two high tides and two low tides occurring each lunar day (about 25 hours). In 1976 the mean higher highwater (MHHW) elevation at the gage was 0.53 meters (1.74 feet) above mean sea level while the mean lower low water (MLLW) was 0.23 meters (0.77 feet) below mean sea level. Since U.S.G.S. records began in 1964, the highest water recorded at the Crystal River gage was 1.7 meters (5.48 feet) above mean sea level, which occurred September 11, 1964, during a

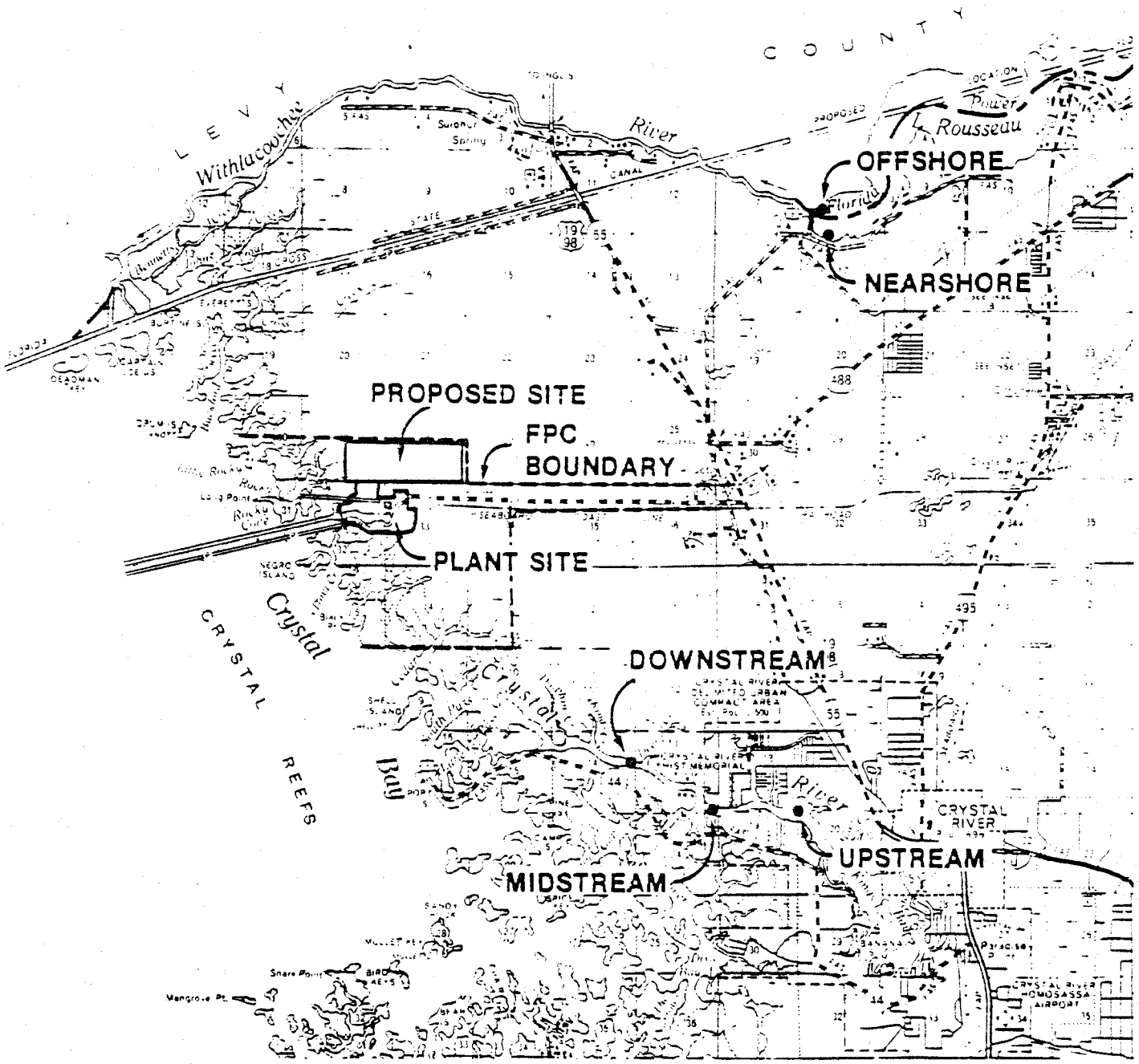
hurricane. U.S.G.S. Crystal River stage heights are fairly representative of the plant site.

In the western portions of the site, tidal waters are present. The eastern upland portion of the site is influenced by fresh water. The transitional boundary separating the brackish tidal waters and predominantly fresh upland water occurs at approximately the 1 meter (3-foot) msl contour. Above the 1 meter (3-foot) contour, fresh water occurs as small swampy depressions and bayheads. Defined drainage channels are virtually nonexistent on the site. The larger of these areas are shown on Figure 2.5.2-4. Numerous small pockets of fresh water exist in other vegetation types but are too small to accurately delineate.

Because of the free connection between the surface marshes in the area and the Floridan aquifer, water levels in the marshes are subject to water level changes in the Floridan aquifer. Cherry, et. al. (1970) report that the seasonal water level fluctuation in the area averages 1 meter (3 feet). During the wet summer months, recharge to the aquifer is greatest; therefore water levels in the marshes and bayheads rise to a point that some interconnection and exchange of water occurs. In the drier winter months, recharge is reduced and water levels drop accordingly.

Perhaps the most conspicuous hydrologic features near the site are the two man-made canals built by FPC to provide for the intake and discharge of cooling waters. These canals have drained wetlands adjacent to them.

FLORIDA POWER CORPORATION CRYSTAL RIVER SITE



- WATER QUALITY SAMPLING LOCATIONS (AUGUST 29,30,1977)

Figure 2.5.2-4

In addition, the canals have allowed some further inland penetration of the salt water wedge (Geraghty and Miller, 1977).

2.5.2.5 SURFACE WATER QUALITY

The State of Florida, Department of Environmental Regulation (DER) has classified all the surface waters in the state, according to quality and usage into the following five categories:

Class I--Public water supply

Class II--Shellfish harvesting

Class III--Recreation and propagation of fish and wildlife

Class IV--Agricultural and industrial water supply

Class V--Navigation, utility, and industrial use

The offshore Gulf waters are presently Class II waters, while the upland surface waters are all Class III.

The Florida DER has also prepared draft Water Quality Management plans for the area. These plans break the west central Florida area into easily analyzed hydrologic units called segments, based on drainage divides. Generally, the plans assess the water quality within each segment and make recommendations concerning assimilation capacities and waste load allocations. The proposed site is located in the northern portion of segment 24.4AA. The plans assess water quality in the Crystal River and the lower Withlacoochee River/Cross-Florida Barge Canal.

Generally, water quality in the Crystal River is considered good except for periodically high concentrations of total nitrogen. In the period

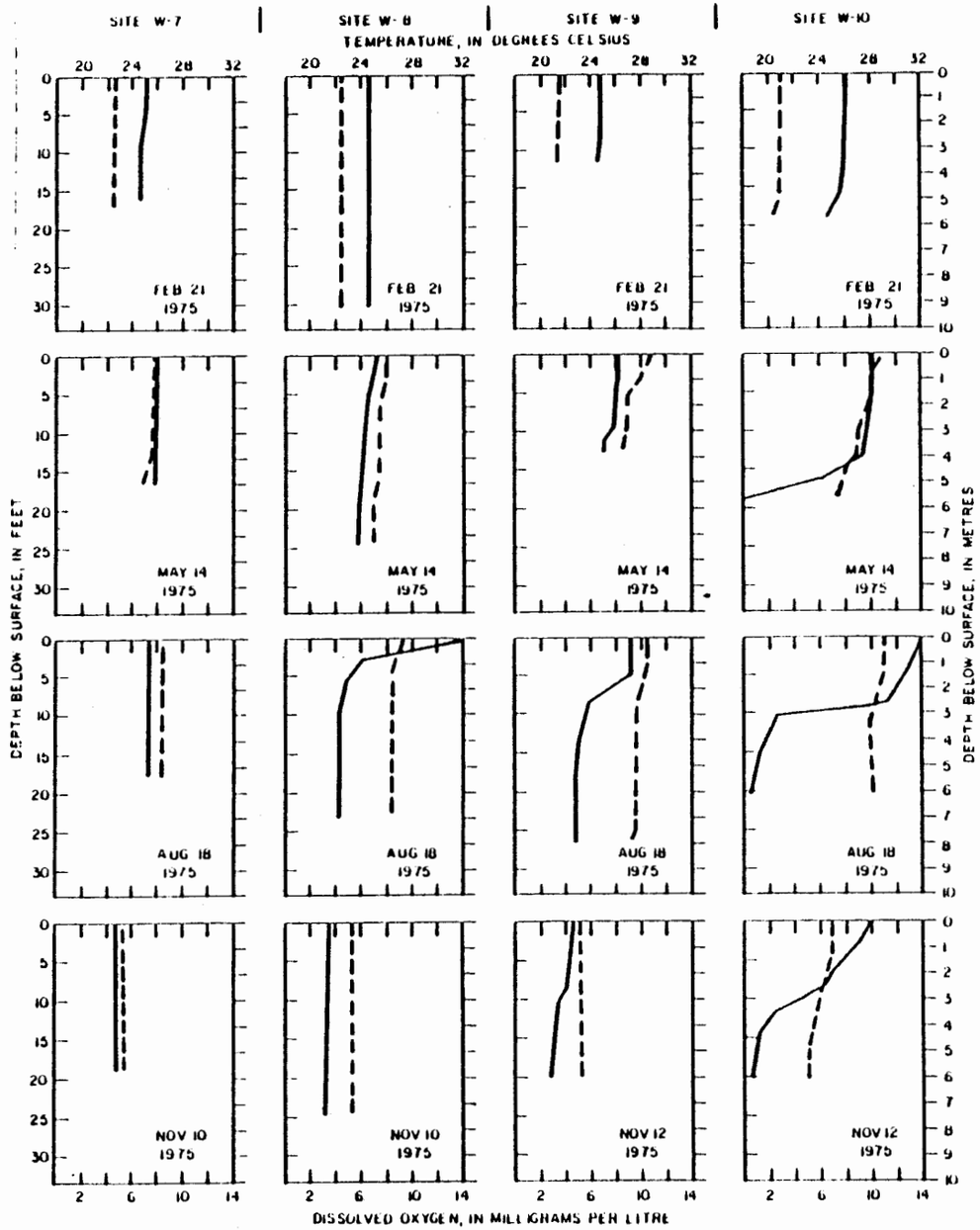
November, 1972, to November, 1975, total nitrogen concentrations in Crystal River averaged 0.35 mg/l. Segment 24.4AA is classified as an "effluent limited segment", meaning that potential discharges must have at least standard secondary treatment.

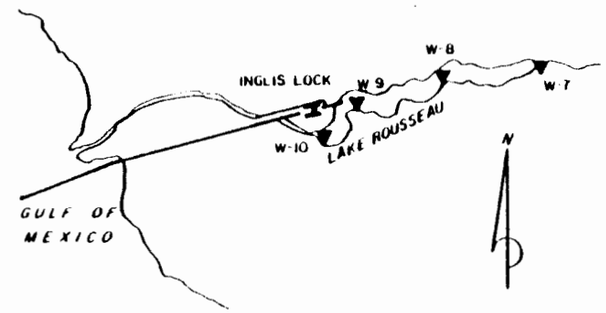
The other major surface water feature of the area is the lower Withlacoochee River which is designated as segment 23.1AA. This is a "water quality limited" segment, meaning that potential discharges must receive something above standard secondary treatment. According to the Withlacoochee River Basin Water Quality Management Plan (Florida DER, 1975), water quality in the lower Withlacoochee is good with the exception of coliform bacteria levels, which from Holder to the month are "unacceptably high" (average 1624 org./100 ml, 49 samples, 9/68-1/74). Dissolved oxygen is acceptable near the mouth but decreases upstream. In the Cross-Florida Barge Canal, the plan recognizes high total nitrogen concentrations (1.13 mg/l, average of 2 samples, 11/73-1/74) and high coliform bacteria levels. Of 27 samples taken in the canal between March, 1970 and June, 1971, 10 had dissolved oxygen concentrations of less than 5.0 mg/l. The average of the 27 samples was 5.6 mg/l. Figure 2.5.2-5 shows seasonal vertical DO and temperature profiles of the Withlacoochee River and Lake Rousseau.

The quality of water in Lake Rousseau is dependent upon the quality of the Withlacoochee River inflow waters (Environmental Research and Technology, 1976).

Water samples were collected at Lake Rousseau and Crystal River in late

Figure 2.5.2-5





EXPLANATION

- - - - - - - - TEMPERATURE

———————— DISSOLVED OXYGEN

(DAYTIME MEASUREMENTS)

PROFILES OF TEMPERATURE AND DISSOLVED OXYGEN IN LAKE ROUSSEAU

SOURCE: U.S.G.S. WATER-RESOURCES INVESTIGATIONS NO. 76-23

August, 1977, (ESE, 1977). Results of all analyses are presented in Table 2.5.2-4. The surface sample data for Lake Rousseau is comparable to data taken in August, 1975, by U.S.G.S. (Env. Research and Tech, 1976). Unfortunately the U.S.G.S. has not collected vertical samples except for dissolved oxygens. The variability of other water quality parameters in deeper portions of the lake is undocumented. A DO sag which occurs most of the year near the Inglis Dam is probably due to benthic demand.

On a seasonal basis there is a potential for resuspension of very fine sediments. Water quality in the lake is generally good; however, high concentrations of suspended material may occur due to seasonal processes.

The DER attributes the low dissolved oxygen values in the area to natural causes and states that some "additional dissolved oxygen demand may result from aquatic weed control." High coliform levels in the lower Withlacoochee may be attributed to runoff from agricultural areas and possibly septic tank leakage. The nitrogen, DO, and coliform problems in the Cross-Florida Barge Canal are attributed to the "decaying aquatic environment of the reservoirs above."

In Lake Rousseau, none of the parameters analyzed by ESE for August samples show evidence of water quality degradation. In the Crystal River, samples were taken during a falling tide; therefore, only the downstream site exhibits moderately saline conditions. Accordingly,

Table 2.5.2-3. Water Quality Analysis--Crystal River and Lake Rousseau
(Samples taken August 29, 30, 1977)

	Water Temp (°C)	Salinity (parts/ 1,000)	pH (Units)	Dissolved Oxygen (mg/l)	Turbidity (NTU)	Color (CPO)	Total Solids (mg/l)	Susp. Solids (mg/l)	Dissolved Solids (mg/l)	Alkalinity (mg/l@ $CaCO_3$
Crystal River										
Upstream (Surface	25.2	0	7.3	6.8	0.7	10	860	<5	855	100
Upstream (Depth)	25.8	0	7.4	6.0	1.4	0	980	<5	975	100
Midstream (Surface)	26.4	0	7.4	6.6	3.0	5	2,100	12.7	2,087	105
Midstream (Depth)	26.2	0	7.4	7.1	3.7	5	2,300	9.6	2,290	108
Downstream (Surface)	26.5	0	7.4	6.1	2.3	0	3,600	7.7	3,592	112
Downstream (Depth	27.0	2.3	7.1	5.8	2.6	10	4,020	11.3	4,009	109
Lake Rousseau										
Near Shore (Surface)	28.0	NA	7.7	7.2	1.4	5	130	<5	125	86
Near Shore (Depth)	28.0	NA	7.5	7.2	1.7	10	159	12.2	147	80
Off Shore (Surface)	27.2	NA	7.6	7.1	2.1	5	140	7.0	133	84
Off Shore (Depth)	27.2	NA	7.6	6.8	2.2	10	140	24.5	115	86

Table 2.5.2-3. (Continued)

	$NO_3 + NO_2$ (MgN/1)	NH_3 (mgN/1)	TKN (mgN/1)	Ortho PO_4 (mgP/1)	Total PO_4 (mgP/1)	BOD (mg/1)	Hardness (mg/1@ $CACO_3$
Crystal River							
Upstream (Surface	.019	<.02	0.52	.096	0.16	<1.0	228
Upstream (Depth)	.011	<.02	0.33	.024	0.14	<1.0	234
Midstream (Surface)	.006	<.02	0.50	.011	0.11	<1.0	418
Midstream (Depth)	.013	<.02	2.60	.016	0.16	<1.0	438
Downstream (Surface	.054	.032	.66	.016	0.10	<1.0	672
Downstream (Depth	.016	.027	.015	.015	0.099	<1.0	786
Lake Rousseau							
Near Shore (Surface	0.16	<.02	0.22	.002	0.090	<1.0	102
Near Shore (Depth)	.008	<.02	0.34	.003	0.13	1.1	128
Off Shore (Surface)	<.004	<.02	0.68	<.002	0.16	<1.0	108
Off Shore (Depth)	.018	<.02	0.36	<.002	0.093	1.0	86

values of hardness, dissolved solids, and suspended solids increase downstream. All other parameters are within acceptable limits and do not vary significantly among the three locations.

Discharge Basin

There are four principal sources of water entering the discharge basin. These include the Gulf Shelf water, thermal discharges from Units 1, 2, and 3, fresh water from the Withlacoochee River Barge Canal, and local rainfall runoff. These sources contribute to the temperature and salinity characteristics of the basin. The Gulf Shelf water entering the basin from the west northwest is of primary importance. Salinity characteristics of the Gulf Shelf water are relatively stable (averaging 31 $^{o}/oo$, however, temperature conditions vary seasonally with a mean range of about 11°C (Behrens, 1975).

Water comprising the thermal effluent of the existing power plants is, for the most part, of Gulf shelf origin (Carder, et. al, 1974). The average salinity of the discharge water is 28.5 $^{o}/oo$.

Slight salinity reductions occur occasionally as a result of dilution by river water during periods of high runoff. At such times salinity decreases are in the order of 50 percent. The effluent temperature fluctuates according to ambient Gulf water temperatures and power plant load. Under normal conditions, a mean temperature rise of 11.5°C can be expected when both fossil fuel units are in operation (Behrens, 1975).

The most significant salinity variations in the discharge basin result

from the discharge of fresh water from the Withlacoochee Barge Canal Complex. The Withlacoochee Bypass discharges from Lake Rousseau into the Withlacoochee River then to the Gulf while the main spillway discharges into the Cross-Florida Barge Canal and into the Gulf. There appears to be an initial lag period between the time of rainfall and the increase in discharge from the reservoir.

The effects of direct precipitation on temperature and salinity conditions in the discharge basin are primarily short lived and difficult to measure. They would be expected to be significant, particularly after the heavy afternoon thunder showers which occur frequently throughout the summer. However, the magnitude of the effect of direct rainfall on temperature and salinity changes within the basin has not been determined.

Turbidity in the Gulf waters has been measured on several occasions. These results generally indicate higher turbidity during times of strong winds or tidal current flows with local sources of resuspended bottom sediments contributing heavily to the turbidity pattern during strong tidal flows. The turbidity also occurs as a result of the Withlacoochee River Cross-Florida Barge Canal network. During slack water fine sediments from these sources are deposited, especially in the shallow grassy areas where they then provide a readily available source of fine sediments for resuspension when turbulent water velocities become sufficiently great at peak ebb tide or during periods of strong winds.

An extensive study (Fox and Moyer, 1972) of solids, distribution, and turbidity at six stations (one in the intake canal and the others along

the discharge canal) was performed. Only general trends can be noted, in this study. The force of the water as it leaves the condenser plays an important role in the solids distribution. Material is constantly being eroded from the banks and bottom of the canal. The increase in total solids at the point of discharge probably was due to the added turbulence of the water at this point. Total solids were markedly lower in the discharge basin than at the mouth of the discharge canal.

Water Quality Parameters

Investigations have been carried out to determine seasonal patterns in water quality parameters in the Gulf coastal waters adjacent to FPC. (Gibson et. al.) Nutrient concentrations for this study gave a ranking silica of amplitudes as follows:

$$NH_3\text{-}N < NO_3\text{-}N < SiO_2 - 4^{-P}$$

silica silicate was the only nutrient that showed an obvious trend, with the highest concentrations being found at stations proximal to the Crystal River and Cross Florida Barge Canal stations. The lowest concentrations were found at the most seaward stations. Nitrate-nitrogen concentrations followed variations in precipitation rather closely. Such a relationship was less evident for other nutrients measured.

Salinities for the same study (Gibson, et.al.) showed wide variability with season and location. The highest salinities were generally recorded at the most seaward stations and the lowest at the Cross Florida Barge Canal and Crystal River stations. Salinities ranged from

18°/oo to 31°/oo at stations along the intake dike; d8°/oo 0/oo, at the Cross Florida Barge Canal; and 3.5°/oo to 6°/oo at the Crystal River station.

Ambient surface and discharge water temperature also fluctuated on a seasonal basis (Gibson, et al.). Ambient temperatures at the intake ranged from 11.0°C in February to 24.5°C in April, a range of 13.5°C over the sampling period. Discharge temperatures closely followed variations in ambient temperature but averaged 4.1°C higher.

Chlorophyll a measured in this study (Gibson, et al.) ranged from .78 mg m^3 to 5.11 mg m^3 for stations near the plant intake and discharge structures. The highest concentrations of chlorophyll a, were found near the mouth of the barge canal. Mean values at that point were 1.5 times higher than the average of stations A-I near the plant.

Studies have been carried out (Odum and Snedaker, 1972) to determine the magnitudes of phosphorus in its various forms (dissolved, particulate, organic, inorganic, etc) in the bay and canals. The analysis indicated a relatively constant ratio among phosphorous fractions both in the intake and discharge canals. Total phosphorus was approximately 49 percent particulate, 34 percent dissolved organic, and 17 percent dissolved inorganic. Readings taken in the outer bay were generally twice those of the inner bay.

2.6 METEOROLOGY

On-site measurements are available at Crystal River from a meteorological tower which conforms to Atomic Energy Commission accuracy specifications. There are two instrumentation levels on the tower, at 10 meters and 53 meters, from which horizontal wind speed and direction are measured as well as delta-T or lapse rate data. In addition, ambient temperature is measured on the lower level while precipitation and barometric pressure are measured from the surface.

Currently, all meteorological data goes onto strip charts, although the year 1975 had been fully digitized and available on a magnetic tape. The data for this section was developed from 1975 data. Long-term averages are available from Tampa International Airport, the nearest representative national weather bureau.

2.6.1 TEMPERATURE

Table 2.6.1-1 presents the monthly means and extremes of temperature, which are characteristic of the Crystal River site. On site temperatures for 1975 ranged from -2.5°C in December to 33.3°C in August. The mean annual temperature was 21.0°C, whereas the 30-year Cedar Key mean annual temperature was 21.7°C. Temperature extremes in a 30-year period are taken from Tampa as the most representative station from which that type of data is available.

Table 2.6.1-1. Monthly Means and Extremes of Temperature (°C) for Crystal River, Florida

	On-Site, 1975					Cedar Key, 1941-70	Tampa, 1947-76	
Month	Mean Daily Max.	Mean Daily Min.	Mean	Highest	Lowest	Mean	Highest	Lowest
January	20.9	11.9	16.3	25.6	0.0	13.8	28.9	-5.0
February	21.2	13.6	17.4	26.4	3.9	14.9	31.1	-4.4
March	21.8	12.9	17.6	28.1	3.1	17.6	32.8	1.1
April	24.9	16.2	21.0	29.4	6.1	21.7	33.9	4.4
May	28.1	20.4	24.5	31.9	16.7	25.2	36.7	9.4
June	29.4	22.5	26.1	31.1	20.8	27.6	36.7	16.1
July	28.6	23.1	26.3	31.2	20.6	28.0	36.1	17.2
August	30.2	22.4	26.1	33.3	20.8	28.1	36.7	19.4
September	29.2	21.4	24.9	33.1	15.6	27.2	35.6	15.0
October	27.6	19.1	22.8	30.8	12.5	23.2	34.4	4.4
November	22.6	13.3	17.6	29.7	1.9	18.3	32.2	-5.0
December	18.6	8.8	13.8	25.8	-2.5	14.7	30.0	-7.8
Annual	25.2	16.9	21.0	33.3	-2.5	21.7	36.7	-7.8

2.6.2 PRECIPITATION AND HUMIDITY

Dewpoint or humidity data are not recorded on-site. However, average humidity data are summarized for Tampa four times a day and are presented with the precipitation means and extremes in Table 2.6.2-1. Precipitation can vary greatly from one year to another as can temperature. For this reason, a long-term mean was included from Cedar Key. Also monthly and annual precipitation extremes are included from Tampa as are the average humidity values. As expected, the lowest humidity values coincide with the warmest time of day and vice versa. These on-site values may be slightly higher than those experienced in Tampa.

2.6.3 WIND AND STABILITY

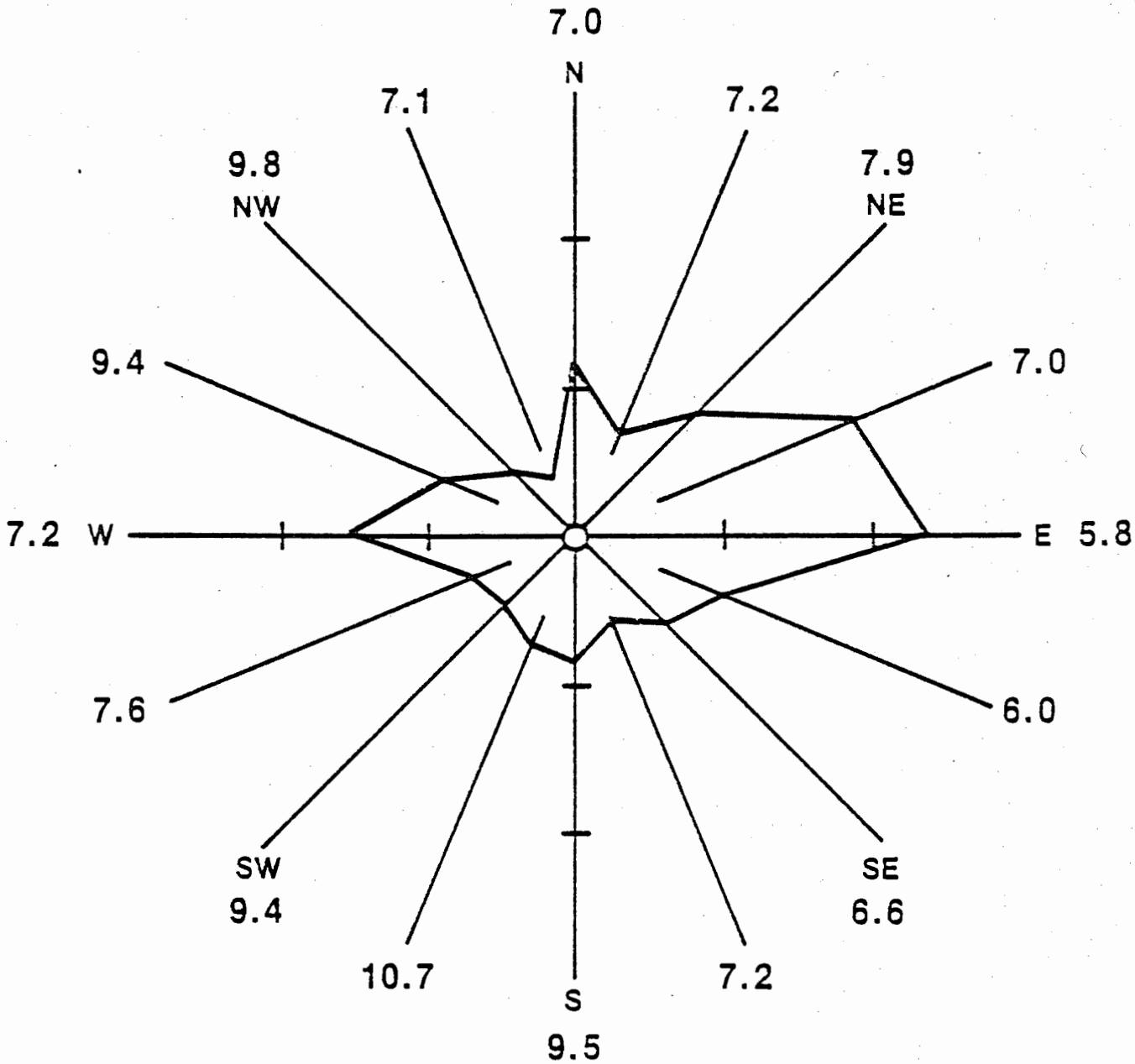
Wind variables are measured at two on-site levels: 10 meters and 53 meters grade. Annual and monthly wind roses (for the lower level wind instruments) are presented in Figure 2.6.3-1. On an annual basis, winds at the site prevail from the east to east-northeast. However, the warmer months show appreciable sea breezes from the west and southwest. Increasing amounts of northerly winds are most evident in the cooler months. Stabilities were determined by Pasquill's method of incorporating wind speed, cloud cover, cloud ceiling, and solar elevation. Hourly cloud cover and ceiling data for 1975 were available from Tampa, while all other variables were observed on-site. Annual wind rose-stability tabulations were determined from wind speed and direction at the 10 meter level with stabilities as determined above. These (variables) are presented in Table 2.6.3-1. Monthly and annual frequencies of Pasquill's stability classes are portrayed in Table 2.6.3-2.

Table 2.6.2-1. Monthly Means and Extremes of Precipitation (Millimeters) and Relative Humidity for Crystal River, Florida

Month	Precipitation				Humidity* Hour (LT)			
	On-Site 1975	Cedar Key, 1941-70 Mean	Tampa, 1947-76 Maximum	Tampa, 1947-76 Minimum	0100	0700	1300	1900
January	47	68	204	T	84	86	59	73
February	123	79	202	5	81	84	55	68
March	17	98	321	2	81	85	54	66
April	15	68	167	T	81	86	49	60
May	27	52	207	4	80	84	51	61
June	98	107	349	47	82	85	59	67
July	175	208	523	57	84	86	62	71
August	168	195	472	60	86	89	63	74
September	224	162	331	33	85	89	61	74
October	87	70	187	6	84	87	56	71
November	51	36	155	T	84	86	54	73
December	45	60	169	5	83	86	57	73
Annual	1078	1201	1945	734	83	86	57	69

T = Trace WBO
* Tampa, 1964-76

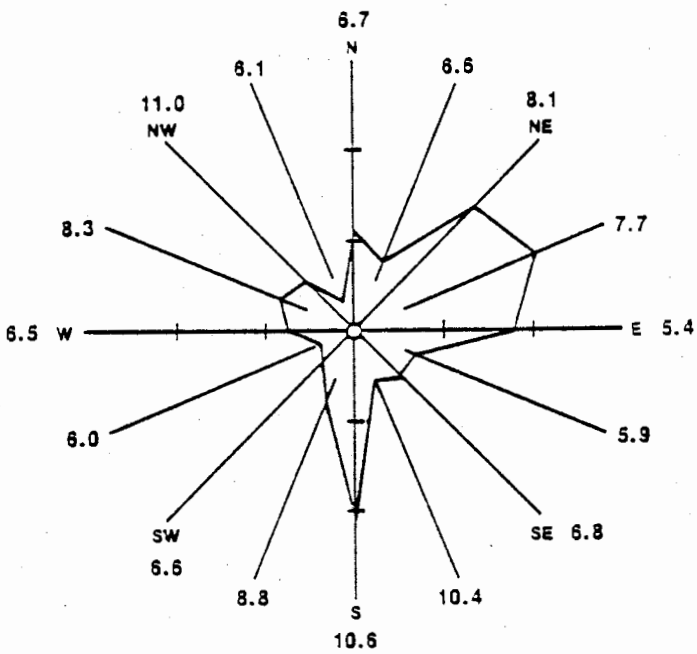
MONTHLY AND ANNUAL WIND ROSES FOR THE FPC CRYSTAL RIVER SITE,1975. TICK MARKS ON ROSE REPRESENT 6%. AVERAGE WIND SPEED IN KNOTS IS GIVEN FOR EACH SECTON.



ANNUAL

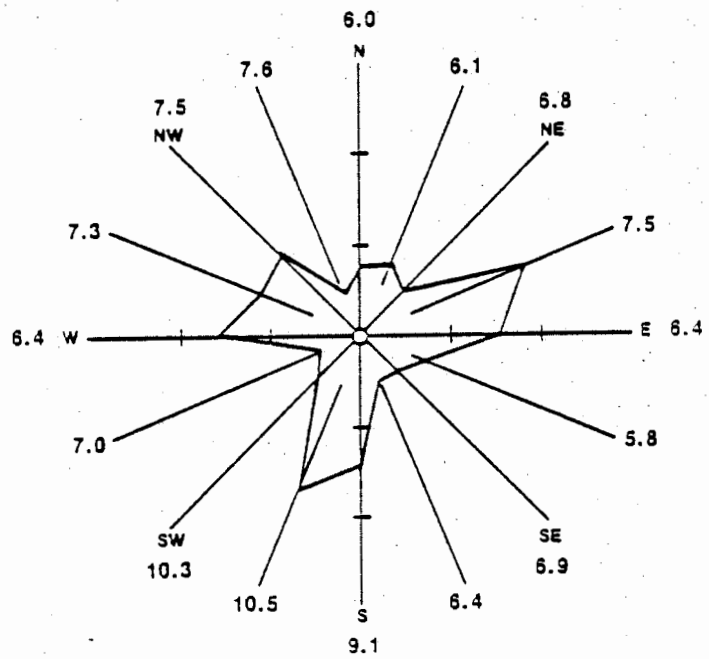
CALM - 2.4%

Figure 2.6.3-1



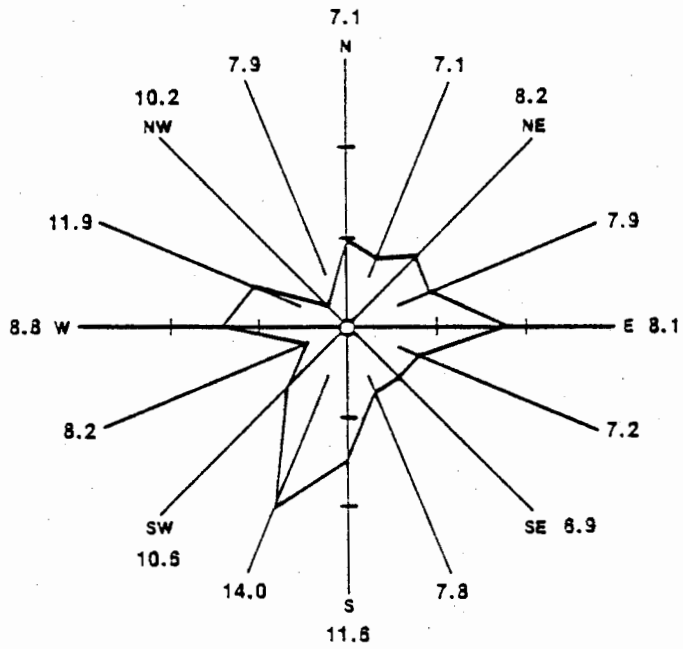
JANUARY

CALM - 2.6%



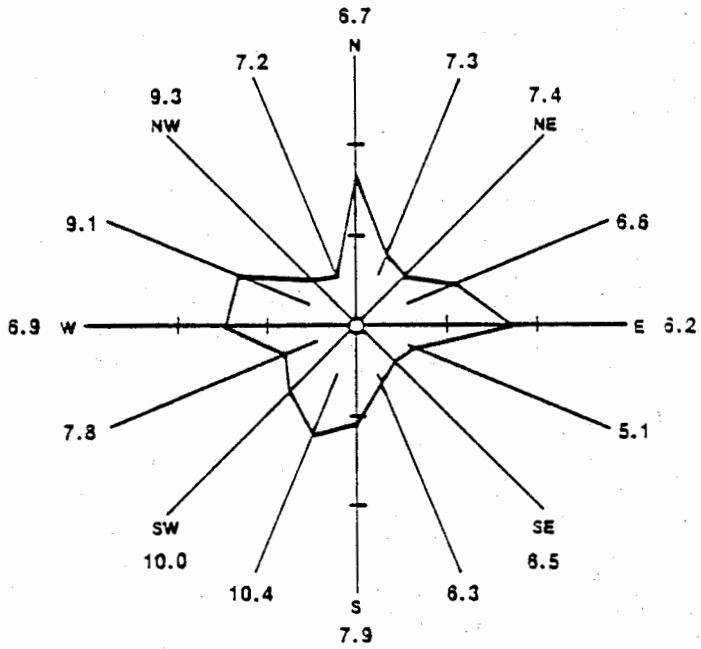
FEBRUARY

CALM - 3.4



MARCH

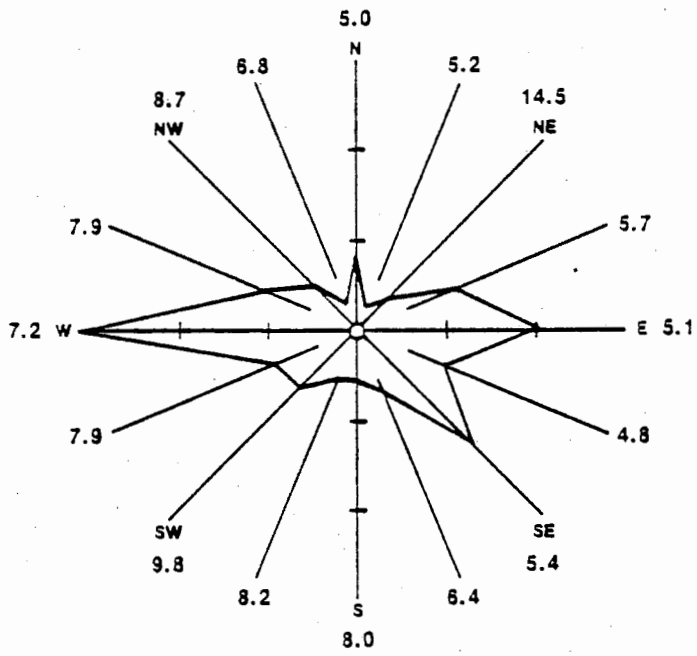
CALM - 1.7%



APRIL

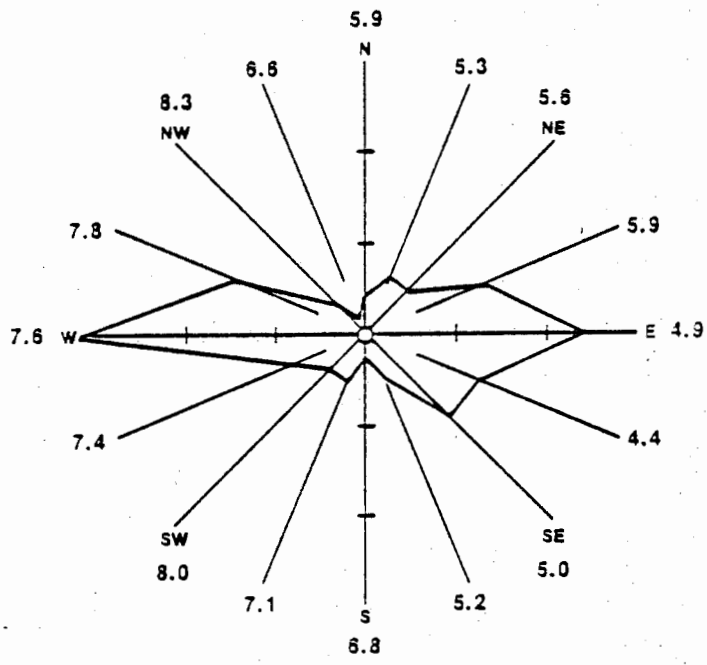
CALM - 1.7%

Figure 2.6.3-1
(Continued)



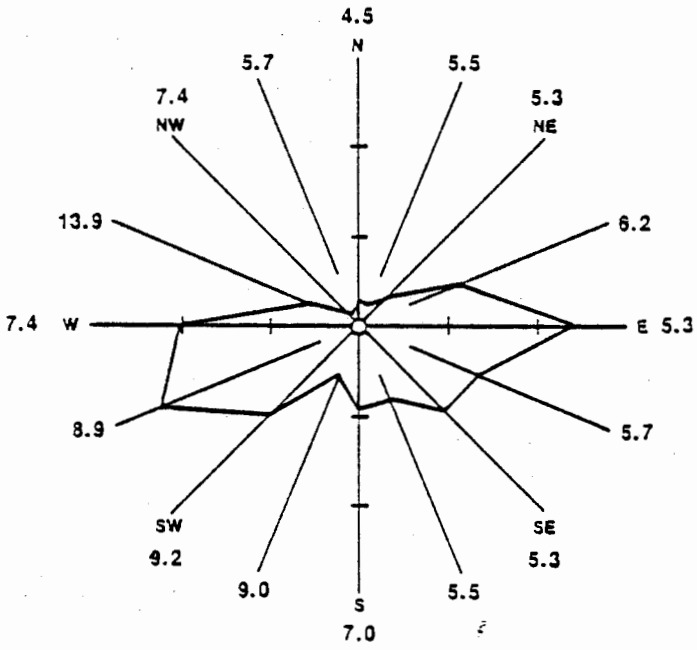
MAY

CALM - 3.5%



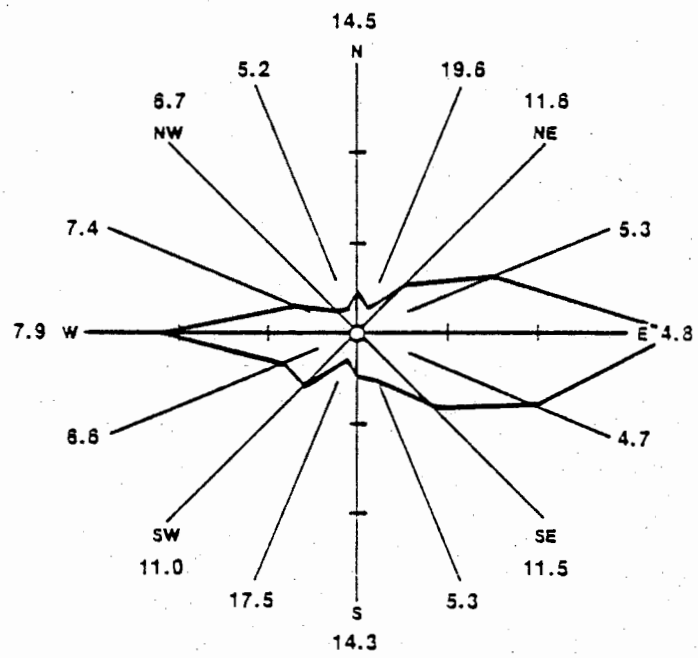
JUNE

CALM - 2.5%



JULY

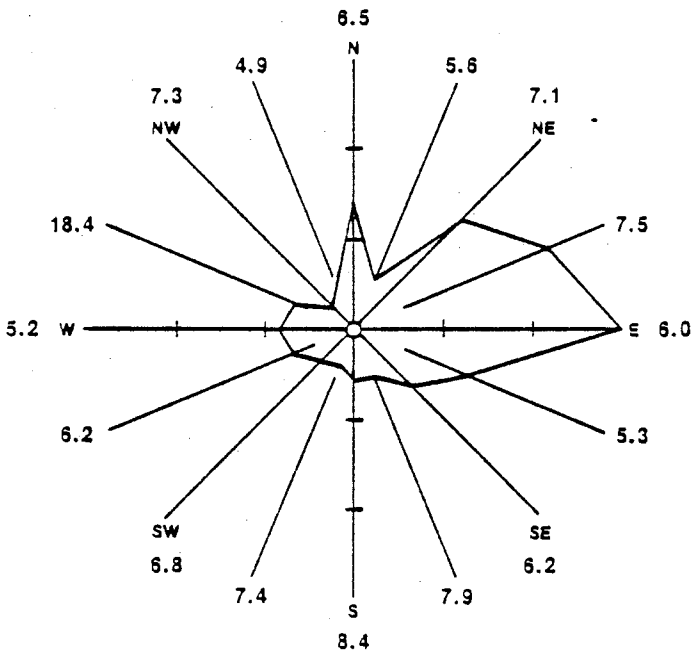
CALM - 0.9%



AUGUST

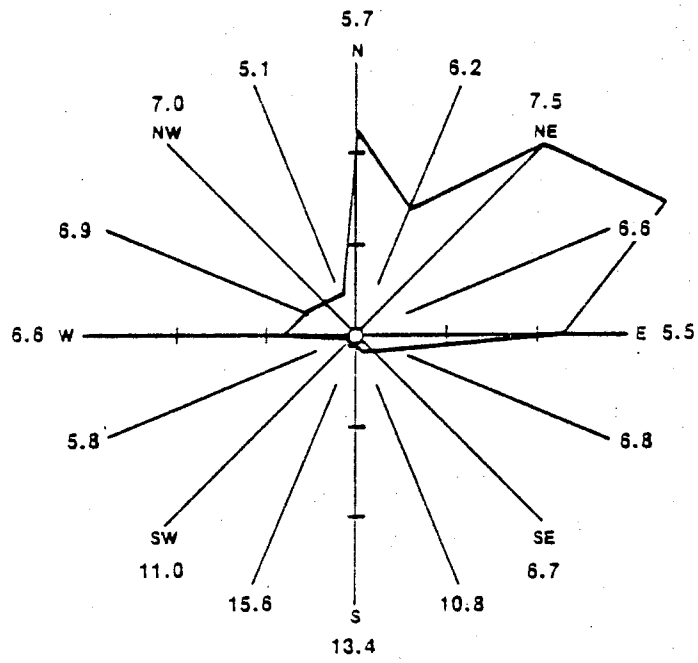
CALM - 2.8%

Figure 2.6.3-1
(Continued)



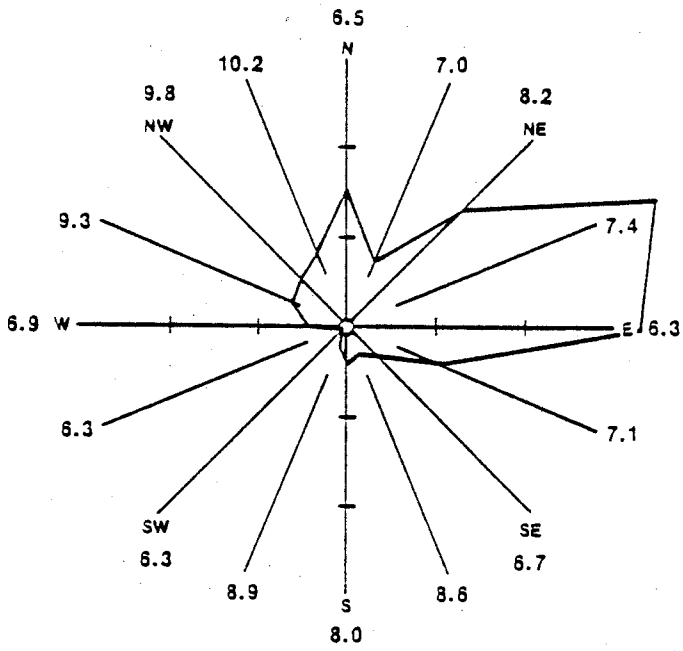
SEPTEMBER

CALM - 3.8%



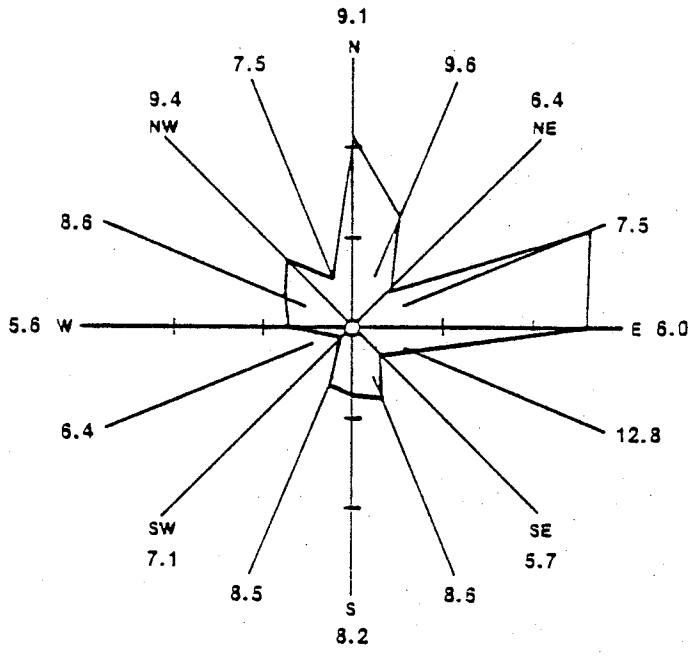
OCTOBER

CALM - 3.4%



NOVEMBER

CALM - 1.0%



DECEMBER

CALM - 2.2%

Figure 2.6.3-1
(Continued)

Table 2.6.3-1

RELATIVE FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION, CRYSTAL RIVER, FLORIDA

SPEED(KTS)

DIRECTION	0 - 3	4- 6,	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.000030	0.000115	0.0	0.0	0.0	0.0	0.000144
NNE	0.000030	0.000115	0.0	0.0	0.0	0.0	0.000144
NE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENE	0.000174	0.000115	0.0	0.0	0.0	0.0	0.000289
E	0.000642	0.000802	0.0	0.0	0.0	0.0	0.001444
ESE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SE	0.000030	0.000115	0.0	0.0	0.0	0.0	0.000144
SSE	0.000060	0.000229	0.0	0.0	0.0	0.0	0.000289
S	0.000030	0.000115	0.0	0.0	0.0	0.0	0.000144
SSW	0.000030	0.000115	0.0	0.0	0.0	0.0	0.000144
SW	0.000149	0.000573	0.0	0.0	0.0	0.0	0.000722
WSW	0.000294	0.000573	0.0	0.0	0.0	0.0	0.000866
W	0.000418	0.001603	0.0	0.0	0.0	0.0	0.002022
WNW	0.000030	0.000115	0.0	0.0	0.0	0.0	0.000144
NW	0.000030	0.000115	0.0	0.0	0.0	0.0	0.000144
NNW	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	0.001947	0.004696	0.0	0.0	0.0	0.0	

RELATIVE FREQUENCY OF OCCURRENCE OF A STABILITY = 0.006643

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH A STABILITY = 0.001374

RELATIVE FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION, CRYSTAL RIVER, FLORIDA (CON'T)

SPEED(KTS)

DIRECTION	0 - 3	4- 6,	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.000903	0.001718	0.001031	0.0	0.0	0.0	0.003652
NNE	0.000880	0.001145	0.001145	0.0	0.0	0.0	0.003170
NE	0.001013	0.001489	0.001031	0.0	0.0	0.0	0.003532
ENE	0.000692	0.002405	0.002634	0.0	0.0	0.0	0.005732
E	0.002410	0.003665	0.002062	0.0	0.0	0.0	0.008137
ESE	0.001356	0.001145	0.001489	0.0	0.0	0.0	0.003991
SE	0.001246	0.001374	0.000687	0.0	0.0	0.0	0.003308
SSE	0.000770	0.001374	0.000573	0.0	0.0	0.0	0.002717
S	0.000724	0.003207	0.001374	0.0	0.0	0.0	0.005306
SSW	0.000491	0.003321	0.003436	0.0	0.0	0.0	0.007248
SW	0.000761	0.004123	0.004238	0.0	0.0	0.0	0.009122
WSW	0.000656	0.004467	0.006070	0.0	0.0	0.0	0.011193
W	0.001526	0.008361	0.011797	0.0	0.0	0.0	0.021684
WNW	0.000220	0.002520	0.003207	0.0	0.0	0.0	0.005947
NW	0.000156	0.000916	0.001145	0.0	0.0	0.0	0.002217
NNW	0.000170	0.001260	0.000115	0.0	0.0	0.0	0.001544
TOTAL	0.013973	0.042492	0.042034	0.0	0.0	0.0	

RELATIVE FREQUENCY OF OCCURRENCE OF B STABILITY = 0.098500

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH B STABILITY = 0.002176

RELATIVE FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION, CRYSTAL RIVER, FLORIDA (CON'T)

SPEED(KTS)

DIRECTION	0 - 3	4- 6,	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.000303	0.001947	0.003092	0.0	0.0	0.0	0.005342
NNE	0.000066	0.001947	0.002405	0.0	0.0	0.0	0.004418
NE	0.000161	0.001260	0.006758	0.000229	0.0	0.0	0.008408
ENE	0.000365	0.003780	0.011912	0.000802	0.0	0.0	0.016858
E	0.001450	0.004352	0.012026	0.001374	0.0	0.0	0.019203
ESE	0.001143	0.002291	0.005383	0.000115	0.0	0.0	0.008932
SE	0.000322	0.002520	0.002520	0.000344	0.0	0.0	0.005705
SSE	0.000223	0.003092	0.003207	0.0	0.0	0.0	0.006523
S	0.000173	0.001603	0.005040	0.000687	0.000115	0.0	0.007618
SSW	0.000146	0.000802	0.005841	0.002176	0.000115	0.0	0.009079
SW	0.000398	0.001260	0.005612	0.002291	0.0	0.000115	0.009675
WSW	0.000303	0.001947	0.007788	0.001260	0.0	0.0	0.011298
W	0.001023	0.005727	0.019013	0.000229	0.0	0.0	0.025992
WNW	0.000192	0.002176	0.011568	0.000802	0.0	0.0	0.014738
NW	0.000023	0.000687	0.003551	0.000687	0.0	0.0	0.004948
NNW	0.000122	0.000115	0.001489	0.000115	0.0	0.0	0.001840
TOTAL	0.006414	0.035506	0.107204	0.011110	0.000229	0.000115	

RELATIVE FREQUENCY OF OCCURRENCE OF C STABILITY = 0.160577

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH C STABILITY = 0.001374

RELATIVE FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION, CRYSTAL RIVER, FLORIDA (CON'T)

SPEED(KTS)

DIRECTION	0 - 3	4- 6,	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.000762	0.005841	0.011453	0.003436	0.000115	0.000229	0.021836
NNE	0.000512	0.001374	0.008132	0.001489	0.0	0.000229	0.011737
NE	0.000441	0.002978	0.016264	0.006528	0.000115	0.000229	0.026555
ENE	0.000600	0.004352	0.019585	0.006987	0.0	0.000115	0.031639
E	0.001527	0.007788	0.013401	0.004581	0.0	0.000115	0.027411
ESE	0.000930	0.003551	0.008132	0.001603	0.0	0.000115	0.014331
SE	0.000344	0.003665	0.006987	0.001947	0.0	0.000229	0.013172
SSE	0.000556	0.002863	0.006185	0.005154	0.000458	0.0	0.015216
S	0.000196	0.002634	0.009850	0.013973	0.001947	0.000344	0.028944
SSW	0.000276	0.001374	0.006643	0.014660	0.002634	0.001374	0.026963
SW	0.000145	0.000916	0.003894	0.009621	0.000229	0.000229	0.015034
WSW	0.000414	0.002062	0.006872	0.003780	0.0	0.000115	0.013242
W	0.000768	0.006070	0.010423	0.004696	0.000115	0.000229	0.022301
WNW	0.000421	0.002291	0.012141	0.006987	0.002062	0.000458	0.024359
NW	0.000283	0.001603	0.006299	0.007674	0.002978	0.000229	0.019067
NNW	0.000529	0.001947	0.003092	0.004238	0.000229	0.0	0.010035
TOTAL	0.008705	0.051311	0.149352	0.097354	0.010881	0.004238	

RELATIVE FREQUENCY OF OCCURRENCE OF D STABILITY = 0.321842

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH D STABILITY = 0.001718

RELATIVE FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION, CRYSTAL RIVER, FLORIDA* (CON'T)

SPEED(KTS)

DIRECTION	0 - 3	4- 6,	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.006882	0.022220	0.009277	0.0	0.0	0.0	0.038379
NNE	0.004424	0.013401	0.008017	0.0	0.0	0.0	0.025842
NE	0.005893	0.011568	0.013401	0.0	0.0	0.0	0.030861
ENE	0.009676	0.034704	0.023250	0.0	0.0	0.0	0.067630
E	0.025470	0.055893	0.005269	0.0	0.0	0.0	0.086632
ESE	0.010870	0.021991	0.003092	0.0	0.0	0.0	0.035953
SE	0.004868	0.023021	0.002176	0.0	0.0	0.0	0.030065
SSE	0.001562	0.008017	0.002520	0.0	0.0	0.0	0.012099
S	0.001670	0.005727	0.002062	0.0	0.0	0.0	0.009458
SSW	0.000896	0.002863	0.001489	0.0	0.0	0.0	0.005248
SW	0.000828	0.001718	0.001947	0.0	0.0	0.0	0.004493
WSW	0.000949	0.003780	0.002749	0.0	0.0	0.0	0.007478
W	0.003266	0.012255	0.005956	0.0	0.0	0.0	0.021477
WNW	0.001845	0.006643	0.005040	0.0	0.0	0.0	0.013527
NW	0.001434	0.005841	0.003436	0.0	0.0	0.0	0.010711
NNW	0.003192	0.006872	0.002520	0.0	0.0	0.0	0.012584
TOTAL	0.083724	0.236513	0.092200	0.0	0.0	0.0	

RELATIVE FREQUENCY OF OCCURRENCE OF E STABILITY = 0.412438

*Note: F stability is combined with E stability in this table.

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH E STABILITY = 0.017753

RELATIVE FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION, CRYSTAL RIVER, FLORIDA (CON'T)

SPEED(KTS)

DIRECTION	0 - 3	4- 6,	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.008921	0.031841	0.024854	0.003436	0.000115	0.000229	0.069395
NNE	0.005896	0.017982	0.019700	0.001489	0.0	0.000229	0.045296
NE	0.007548	0.017295	0.037453	0.006758	0.000115	0.000229	0.069397
ENE	0.011446	0.045356	0.057382	0.007788	0.0	0.000115	0.122086
E	0.031213	0.072500	0.032757	0.005956	0.0	0.000115	0.142540
ESE	0.014317	0.028977	0.018096	0.001718	0.0	0.000115	0.063223
SE	0.006810	0.030695	0.012370	0.002291	0.0	0.000229	0.052395
SSE	0.003236	0.015577	0.012484	0.005154	0.000458	0.0	0.036910
S	0.002874	0.013286	0.018326	0.014660	0.002062	0.000344	0.051551
SSW	0.001896	0.008476	0.017409	0.016837	0.002749	0.001374	0.048740
SW	0.002264	0.008590	0.015691	0.011912	0.000229	0.000344	0.039029
WSW	0.002609	0.012828	0.023480	0.005040	0.0	0.000115	0.044070
W	0.006986	0.034017	0.047188	0.004925	0.000115	0.000229	0.093460
WNW	0.002778	0.013744	0.031955	0.007788	0.002062	0.000458	0.058785
NW	0.001932	0.009163	0.014431	0.008361	0.002978	0.000229	0.037094
NNW	0.004037	0.010194	0.007216	0.004352	0.000229	0.0	0.026027
TOTAL	0.114763	0.370518	0.390791	0.108464	0.011110	0.004352	

TOTAL RELATIVE FREQUENCY OF OBSERVATIONS = 1.000000

TOTAL RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE = 0.024396

Table 2.6.3-2. Frequency of Occurrence of Pasquill's Stability Classes,
Crystal River Site, 1975.

	Pasquill's Stability Class (%)				
Month	"A"	"B"	"C"	"D"	"E"
January	0.1	5.5	12.1	43.1	39.2
February	0.1	6.4	11.6	46.3	35.6
March	0.0	4.1	15.5	51.3	29.2
April	0.8	10.3	18.3	28.5	42.1
May	0.9	15.7	20.6	19.5	43.3
June	1.5	17.2	20.8	18.2	42.2
July	0.4	11.3	21.2	36.3	30.8
August	2.2	18.0	15.3	18.8	45.7
September	1.4	14.4	9.7	33.1	41.4
October	0.4	7.9	17.5	25.9	48.3
November	0.0	3.5	15.7	31.4	49.4
December	0.0	3.5	13.8	35.5	47.2
Annual	0.7	9.9	16.1	32.2	41.2

2.6.4 SEVERE STORMS

Thunderstorms are the most frequent of severe storms affecting the site and occur on an average of 80 days per year. Nearly 60 percent of these occur from June through August, triggered by moisture and heat convection within a tropical air mass, a nearby frontal system (squalls), or frequently a combination of both.

Tropical cyclones have invaded the 80-kilometer coastal strip from the site northward along the Gulf very infrequently over the last 30 years. However, from statistics compiled by Simpson and Lawrence (1971), the chance in any given year that a tropical cyclone will enter this strip is one in five. There is only a 6 percent chance that this storm will be of hurricane strength (33 mps) and it is very unlikely that its winds will exceed 56 mps, the speed of a great hurricane. Tropical cyclones will approach Crystal River only from early June through late October.

Statistics compiled by the Pantz (1969) show that less than 12 tornadoes (or waterspouts) were spotted within the 1° latitude by 1° longitude square encompassing the site during the years 1955-67. This averages out to less than one per year. The tornado recurrence interval for a specific point on the site is estimated by the methodology of Thom (1963) to be roughly every 1250 years. The most common tornado month is June.

2.6.5 MIXING DEPTHS

The monthly and average mixing depths for Tampa as estimated by Holzworth are listed in Table 2.6.5-1. The highest afternoon mixing depths occur in the spring, while the lowest morning depths occur in winter. At the site, the mean high humidity and low-level cloudiness prevent mean mixing depth subsidence below 300 meters.

Table 2.6.5-1. Mean Diurnal Mixing Depth* (Meters), Tampa International Airport, Tampa, Florida

Month	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

* 5-year averaged data 1960-1964

2.7 TERRESTRIAL ECOLOGY

2.7.1 INTRODUCTION AND ORGANIZATION

2.7.1.1 ORGANIZATION AND APPROACH

For the purpose of highlighting the important ecological and environmental elements in the areas of concern, the analysis of the baseline terrestrial environment of the proposed FPC power plant site is divided into "Ecosystem Analysis" and "Important Species Analysis."

The "Ecosystem Analysis" section describes the structure of the system in terms of community types, species present, and current environmental conditions, as well as the ecological forces and trends which have determined the present ecological conditions and will determine the future environment. The natural values and values to man of these on-site ecosystem components are also discussed. Information developed from these existing ecological conditions observed in summer, 1977, is used to describe the predicted future environment without the plant.

"Important Species Analysis" is a discussion of recognized commercially and recreationally valuable species, rare and endangered species, and species whose continued presence is critical to the functioning of the existing ecosystem.

2.7.1.2 DEFINITIONS AND SOURCES

The community descriptions have been derived largely from the Wildlife Study of the Cross-Florida Barge Canal Restudy Report (Florida Game and Fresh Water Fish Commission, 1976). One exception is the ruderal

category, which is defined as "an area where the natural vegetative cover has been disturbed or artificially maintained by man in an early stage of succession." Ruderal areas include old fields, pastures and cropland, ditches, transmission corridors, and similar areas. Small swamps and marshes occur within these areas, but they differ from the natural state in that they are maintained as early successional shrub swamps, or are composed largely of invader species from other systems.

The second exception is the coastal hydric hammock. The categories in the Wildlife Study do not adequately describe the strip of coastal wetland forest which runs along the Gulf Coast of Florida. The hydroperiod and soil moisture content are greater than those of true mesic hammock or coastal hammock, yet the soil type and species content are not those of hydric hammock. This coastal hydric hammock system is well described by Wharton, et al. (1976), who classify it as "Hydric Hammock--North Florida Type."

Conversion tables are included for the vegetation maps to translate into the corresponding Level III categories of the Florida Land Use and Cover Classification System. This standardized, state-wide system developed by the Division of State Planning (1976) is now used by a wide variety of state and local agencies. It is included to provide means of standardization for all review agencies.

As discussed in this section the plant includes all of the property owned by the Applicant north of the existing access road and discharge

canal from Highway 19 to the outer edge of the emergent vegetation (salt marsh) in the Gulf of Mexico.

Throughout this discussion an asterisk appears after the common names of animals which were observed on the site.

2.7.2 ECOSYSTEM ANALYSIS

2.7.2.1 ECOLOGICAL STRUCTURE

Plant Communities

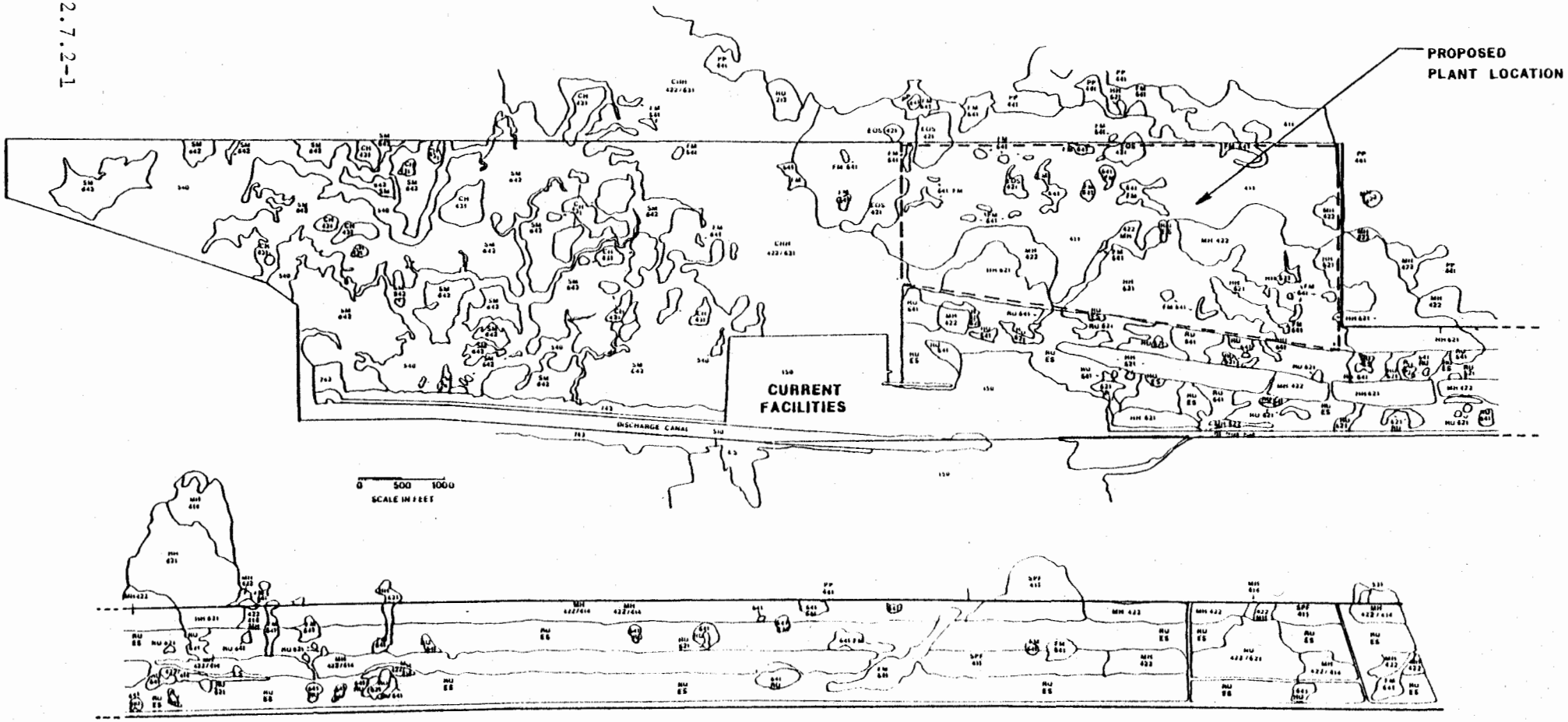
The plant site (Figure 2.7.2-1) can be divided into five general geographic areas based upon combinations of elevation, substrates, and physiognomy (general appearance) of the dominant vegetation. The shore area on the west is composed of salt marsh with numerous interspersed islands supporting the coastal hammock type of vegetation. Between this salt marsh and the proposed actual plant location is a belt of coastal hydric hammock, which is an extension of the wetland forest belt south of the existing power plant units.

The southern half of the remaining proposed site is dominated by plant communities which are variants of the southern mixed hardwoods association (Monk, 1965). Mesic hammock forest occupies about half of this area wherever the limestone shelf lies at the land surface. Where the surface layer of limestone is missing, the hydric hammock variant occurs in the resulting low areas.

The northern section of the proposed site, in which the limestone is overlain by a somewhat deeper sand layer, is primarily slash pine flatwoods with lesser amounts of evergreen oak scrub and freshwater marsh. The transmission corridor contains primarily ruderal vegetation (61 percent), but some areas of natural vegetation also occur.

Figure 2.7.2-1

VEGETATION MAP OF PROPOSED PLANT SITE AND ACCESS CORRIDOR



SYMBOL	CLASSIFICATION	FLORIDA LAND USE AND COVER CLASSIFICATION SYSTEM NUMBER	NAME
SM	Saltwater Marsh	642	Saltwater Marsh
FM	Freshwater Marshes and Prairies	641	Freshwater Marsh
SPF	Slash Pine Flatwoods	411	Pine Flatwoods
EOS	Evergreen Oak Scrub	421	Xeric Oak Hardwood Forest
MH	Mesic Hammock	422 434	Other Hardwood Forest Other Coniferous Forest
HH	Hydric Hammock	621	Freshwater Swamp
CH	Coastal Hammock	431	Mixed Forest
CHH	Coastal Hydric Hammock*	422 631	Other Hardwood Forest Mixed Wetland Forest
PP	Pine Plantation	443	Coniferous Planted Forest
HU	Hydric**	—	Special Types
ES	Early Successional Water	—	No Equivalent
—	Water	500's	Water

*Type is derived from Hydric Hammock. North Florida type of hardwoods (Lee et al. 1978b).

**Hydric includes fresh early successional freshwater marsh, shrub swamp, pasture, or other specified systems.

The land outside of the property to the north and east has been largely cleared and planted in slash pine plantations and improved pasture (Figure 2.7.2-2). The area to the south of the site is primarily salt marsh and coastal hydric hammock.

Vegetative composition of the site is generally typical of the region (Table 2.7.2-1 and 2.7.2-2). Plant communities which occur inland in the vicinity but not on-site are mixed swamp, cypress dome, deciduous oak and longleaf pine sandhills, xeric hammock, and longleaf pine flatwoods. Only those communities found on-site will be described further. Table 2.7.2-3 lists the characteristic species of each of the communities.

Evergreen Oak Scrub

Evergreen oak scrub occupies the driest sites on the site, in small patches (less than three acres) where the depth of surficial sands is generally greater than 1 meter (three feet). Characteristic species are shrubby evergreen oaks under 6 meters (20 feet tall). Sand-live oak and myrtle oak are the principal species on-site. Saw palmetto forms a very dense shrub layer, and persimmon is common. No quantitative data was gathered in this community type.

Pine Flatwoods

Upland areas with sands from 0.3 to 1 meter (one to three feet) deep or with a fractured limestone substrate support slash pine flatwoods. Results of the summer survey are shown in Table 2.7.2-4. The canopy is

REGIONAL VEGETATION MAP

Figure 2.7.2-2

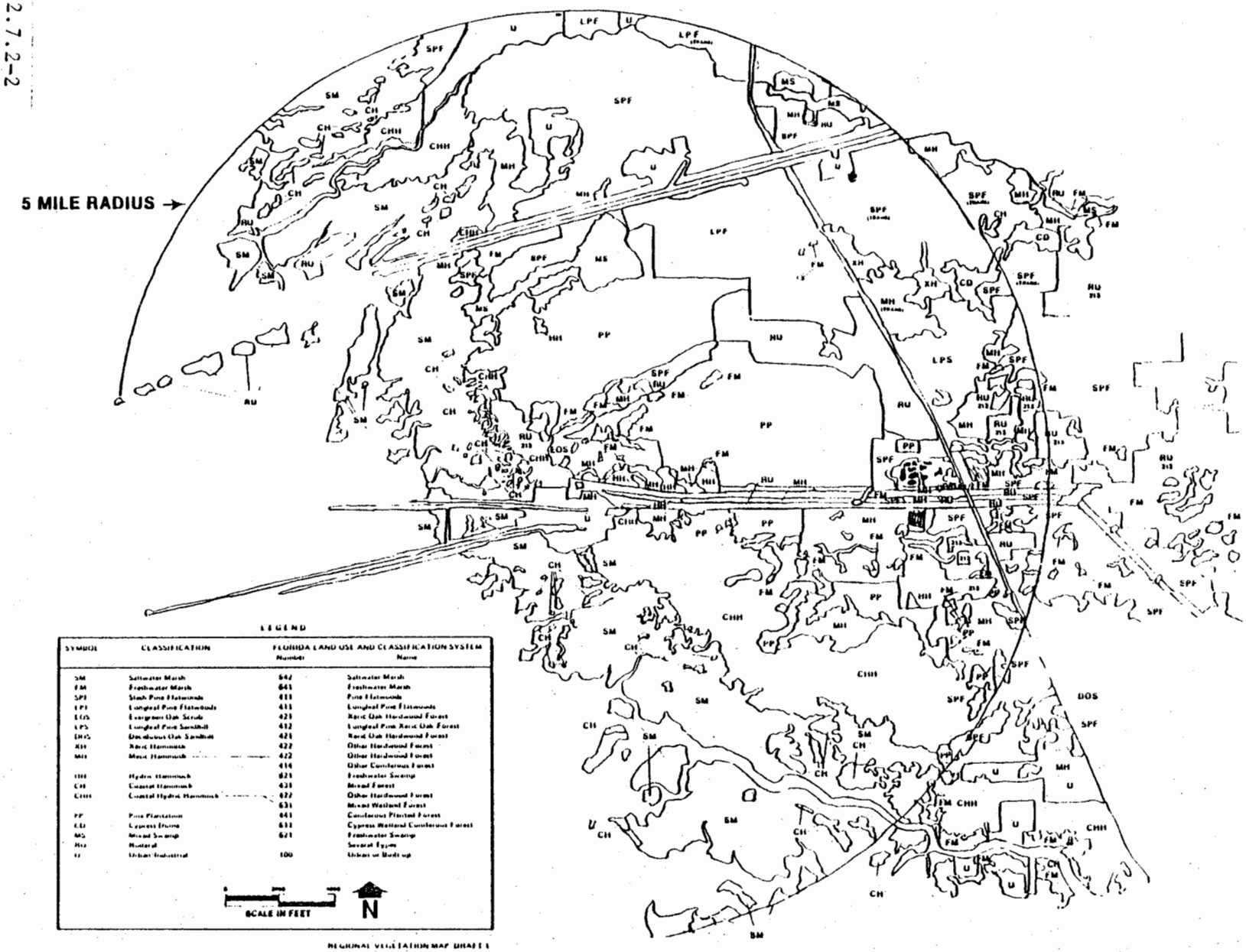


Table 2.7.2-1. Plant Community Composition of Proposed Plant and Region in Acres and Percent of Vegetated Area

A. Proposed Plant Site

Location	Community								Ruderal			Wetlands	Total	Area[3]
	Slash Pine Flatwoods 411[2]	Evergreen Oak Scrub 421	Mesic Hammock 422/414	Hydric Hammock 621	Coastal Hammock 431	Coastal Hydric Hammock 422/631	Salt Water Marsh 642	Fresh Water Marsh 641	Succession 621	Succession 641	Plantation ---	441	600's	
Primary Site Area	134.4 16.9	11.0 1.4%	64.9 8.2%	81.1 10.2%	31.1 3.9%	108.6 13.6%	243.3 30.6%	15.1 1.9%	12.5 1.6%	16.4 2.1%	68.0 8.5%	9.3 1.2%	477.0 59.9%	795.7
Access Area and Transmission Corridor[1]	24.0 5.4%	-- --	125.7 28.1%	4.6 1.0%	-- --	-- --	-- --	20.5 4.6%	34.2 7.7%	14.5 3.2%	223.1 50.0%	-- --	73.8 16.5%	446.6
Total for Entire Site	158.4 12.8%	11.0 0.9%	190.6 15.3%	85.7 6.9%	31.1 2.5%	108.6 8.7%	243.3 19.6%	35.6 2.9%	46.7 3.8%	30.9 2.5%	291.1 23.4%	9.3 0.7%	550.8 44.3%	1,242.3

[1]The area east of the northern extension of the plant site and west of Highway 19.
[2]Florida Land Use and Cover Classification System category designation.
[3]Total area includes only vegetated areas. Does not include 138.2 acres of disturbed industrial area or 164.1 acres of water.

Table 2.7.2-2 Plant Community Composition Within a Five-Mile Radius of Plant Site

	Land Cover Category	Acres	Percent of Land Area
Slash and Longleaf Pine Flatwoods	411	6,490	20.2%
Evergreen Oak Scrub and Sandhills	411/412	610	1.9%
Mesic Hammock	422/414	2,600	8.1%
Hydric Hammock	621	105	0.3%
Coastal Hammock	431	785	2.4%
Coastal Hydric Hammock	422/631	3,440	10.7%
Salt Water Marsh	642	7,450	23.2%
Fresh Water Marsh	641	700	2.2%
Mixed Swamp	621	615	1.9%
Cypress Dome	611	100	0.3%
All Ruderal Areas	(mainly 213)	2,345	7.4%
Pine Plantation	441	4,350	13.6%
Xeric Hammock	422	175	0.5%
Urban	100's	1,560	4.9%
Water[4]	500's	750	2.3%
Total Wetlands[5]	600's	12,460	38.8%
TOTAL AREA[4]		32,075	

[4] Exclusive of rivers and coastal waters

[5] Including wetlands within ruderal areas

Table 2.7.2-3. Plant Communities of the Proposed Plant Site[1]

I. Evergreen Oak Scrub

A. Definition. Stands of evergreen oaks less than 6 m (18 ft) tall with little or no shiny lyonia or gallberry, and no pine trees. No tree overstory or understory layer. Well drained, sandy soils.

B. Characteristic species.

Sand-live oak	*Quercus geminata*	S[2]
Myrtle oak	*Quercus myrtifolia*	S
Saw palmetto	*Serenoa repens*	S
Chapmans oak	*Quercus chapmanii*	S
Rusty lyonia	*Lyonia ferruginea*	S

II. Slash Pine Flatwoods

A. Definition. Stands with slash pine 1 to 20 m (3 to 80 ft) tall, few hardwood trees, and understory cover of at least 25 percent. Poorly drained, acidic sands. Often maintained by periodic fires.

B. Characteristic species.

Slash pine	*Pinus elliottii*	T
Loblolly bay	*Gordonia lasianthus*	T
Saw palmetto	*Serenoa repens*	S
Gallberry	*Ilex glabra*	S
Shiny lyonia	*Lyonia lucida*	S
Rusty lyonia	*Lyonia ferruginea*	S
Shiny blueberry	*Vaccinium myrsinites*	S
Wax myrtle	*Myrica cerifera*	S
Sandweed	*Hypericum fasciculatum*	S
Wire grass	*Aristida stricta*	H

III. Mesic Hammock

A. Definition. Southern mixed hardwood forest, with pignut hickory, oaks, sweetgum, and cabbage palm to 10 to 20 m (40 to 70 ft) tall. Few or no ashes or black gum. Stands lacking poison ivy or sweetgum are classified as xeric hammock. Soils never flooded, rarely soggy. Climax community with fire rare.

B. Characteristic species.

Live oak	*Quercus virginiana*	T
Water oak	*Quercus nigra*	T
Cabbage palm	*Sabal palmetto*	T
Sweetgum	*Liquidambar styraciflua*	T
Pignut hickory	*Carya glabra*	T

Table 2.7.2-3. Plant Communities of the Proposed Plant Site.[1]
(Continued, page 2 of 4)

Saw palmetto	Serenoa repens	S
Sparkleberry	Vaccinium arboreum	S
Grape	Vitis rotundifolia	V
Poison ivy	Rhus radicans	V
Partridge berry	Mitchella repens	H
Yellow jessamine	Gelsemium sempervirons	V

IV. Hydric Hammock

A. Definition. Southern mixed hardwood forest, with sweetgum and cabbage palm, but with no pignut hickory, few ashes. Poorly drained to flooded soils. Intergrades with mesic hammock, mixed swamp, and bayhead.

B. Characteristic species.

Cabbage palm	Sabal palmetto	T
Sweet gum	Liquidambar styraciflua	T
Diamond-leaf oak	Quercus laurifolia	T
Red maple	Acer rubrum	T
Carolina ash	Fraxinus carolinianum	T
Winged elm	Ulmus alata	T
Swamp chestnut oak	Quercus michauxii	T
Poison ivy	Rhus radicans	V
Greenbriar	Smilax spp.	V
Wax myrtle	Myrica cerifera	S

V. Coastal Hammock

A. Definition. Mixed hardwood/conifer forests with southern red-cedar, pignut hickory, yaupon, and buckthorn. A variant of mesic hammock found only on elevated limestone islands in Gulf coast salt marshes. The canopy height of the gnarled trees is limited to about 10 m (30 ft) by salt spray, winds, hurricanes, and storm tides.

B. Characteristic species.

Cabbage palm	Sabal palmetto	T
Southern red-cedar	Juniperus silicicola	T
Pignut hickory	Carya glabra	T
Paper mulberry	Broussonetia papyrifera	T
Yaupon	Ilex vomitoria	S
Carolina holly	Ilex ambigua	S
Snowberry	Symphoricarpos albus	S
False willow	Baccharis angustifolia	S
Florida privet	Forestiera segregata	S
Myrsine	Rapanea guianensis	S

Table 2.7.2-3. Plant Communities of the Proposed Plant Site.[1]
(Continued, page 3 of 4)

Wild coffee	Psychotria ligustrifolia	H

VI. Coastal Hydric Hammock

A. Definition. Wetland forests with an evergreen oak appearance, dominated by southern red-cedar, cabbage palm, diamond-leaf oak, sweetgum, and live oak. Soils are poorly drained, "hummocky" sands or peat over limestone, subject to constant seepage (Wharton, et al., 1976).

B. Characteristic species.

Cabbage palm	Sabal palmetto	T
Southern red-cedar	Juniperus silicicola	T
Sweetgum	Liquidambar styraciflua	T
Diamond-leaf oak	Quercus laurifolia	T
Live oak	Quercus virginiana	T
Sweet bay	Magnolia virginiana	T
Southern magnolia	Magnolia grandiflora	T
Ironwood	Carpinus caroliniana	S
Wax myrtle	Myrica cerifera	S

VII. Freshwater Marsh

A. Definition. Generally treeless, seasonally or permanently flooded areas with emergent vegetation dominated by maidencane or sawgrass. Soils range from thin marl over limestone to deep mucks or peats.

B. Characteristic species.

Sawgrass	Cladium jamaicense	H
Maidencane	Panicum hemitomon	H
Creeping rush	Juncus repens	H
Smartweed	Polygonum hydropiperoides	H

VIII. Saltwater Marsh

A. Definition. Treeless saltwater or brackish tidal areas with emergent vegetation dominated by grasses and rushes in essentially monospecific bands. Soils deep organic mucks.

B. Characteristic species.

Smooth cordgrass	Spartina alterniflora	H
Black needlerush	Juncus roemerianus	H
Saltgrass	Distichlis spicata	H

Table 2.7.2-3. Plant Communities of the Proposed Plant Site.[1]
(Continued, page 4 of 4)

IX. Pine Plantation

A. Definition. Planted pine stands with combined understory and shrub layer cover of 25 percent or less. Occurs on varied, well to poorly drained soils which have been cleared and grubbed of native vegetation.

B. Characteristic species.

Slash pine	*Pinus elliottii*	T
Loblolly pine	*Pinus taeda*	T
Saw palmetto	*Serenoa repens*	S
Gallberry	*Ilex glabra*	S

X. Ruderal

A. Definition. Any of several types which are artificially maintained in an early successional stage. Varied, often disturbed soils of mixed drainage. Maintained by mechanical or chemical means, burning, or grazing. Shrub layer lacking to dense; no overstory or understory.

B. Characteristic species.

Pasture grasses	*Paspalum*, *Cynodon*, etc.	H
Dog fennel	*Eupatorium capillifolium*	H
Coastal-plain willow	*Salix caroliniana*	S
Blackberry	*Rubus* spp.	H
Grape	*Vitis* spp.	V
Morning glory	*Ipomoea* spp.	V

[1]Adapted primarily from Florida Game and Fresh Water Fish Commission (1976)

[2]Characteristic growth form as follows: T=tree; S=shrub; H=herb; V=vine.

Table 2.7.2-4. Plant Species Found in Pine Flatwoods Section of Proposed Site During Summer, 1977 Survey (page 1 of 2)

		Importance Value	Density/ Acre	Frequency %	Total Basal Area (ft^3)	Mean DBH (inches)
Overstory and Understory Strata						
Slash pine	*Pinus elliottii*	251.0	763	100	6.0	3
Wax myrtle	*Myrica cerifera*	22.0	44	21	0.0	2
Cabbage palm	*Sabal palmetto*	10.7	9	4	0.4	9
Southern red-cedar	*Juniperus silicicola*	8.2	18	8	0.0	2
Persimmon	*Diospyros virginiana*	4.1	9	4	0.0	1
Winged sumac	*Rhus copallina*	4.1	9	4	0.0	1
Total		300.1	852	--	6.4	--

		Frequency %	Cover %
Shrub Strata			
Saw palmetto	*Serenoa repens*	100	21
Wax myrtle	*Myrica cerifera*	100	10
Gallberry	*Ilex glabra*	50	4
Slash pine	*Pinus elliottii*	25	4
Winged sumac	*Rhus copallina*	25	3
Persimmon	*Diospyros virginiana*	25	1
Bracken fern	*Pteridium aquilinum*	25	0
Total		--	43

Table 2.7.2-4. Plant Species Found in Pine Flatwoods Section of Proposed Site During Summer, 1977 Survey (Continued, page 2 of 2)

		Frequency %	Cover %
Herbaceous Strata			
Wax myrtle	*Myrica cerifera*	75	2
Greenbriar	*Smilax* spp.	75	0
Paspalum	*Paspalum* sp.	50	8
Saw palmetto	*Serenoa repens*	50	2
Gallberry	*Ilex glabra*	50	2
Red maple	*Acer rubrum*	50	2
Wire grass	*Aristida stricta*	25	1
Persimmon	*Diospyros virginiana*	25	1
Winged sumac	*Rhus copallina*	25	1
Black-eyed Susan	*Rudbeckia hirta*	25	1
Poison ivy	*Rhus radicans*	25	0
Panic grass 1	*Panicum* sp.	25	0
Panic grass 2	*Panicum* sp.	25	0
Dactyloctenium	*Dactyloctenium aegyptium*	25	0
Fleabane	*Pluchea rosea*	25	0
Blackberry	*Rubus* sp.	25	0
Dahoon	*Ilex cassine*	25	0
Southern red-cedar	*Juniperus silicicola*	25	0
Eryngo	*Eryngium integri folium*	25	0
Rattlesnake master	*Eryngium yuccafolium*	25	0
Beak rush	*Rhyncospora* sp.	25	0
Rabbit tobacco	*Pterocaulon undulatum*	25	0
Aster	*Aster* sp.	25	0
Musky mint	*Hyptis alata*	25	0
Morning glory	*Ipomoea sagittata*	25	0
Horseweed	*Erigeron canadensis*	25	0
Total		--	21

overwhelmingly slash pine (importance value 251 out of a total 300), with cabbage palm and southern red cedar as associates. See Chapter 6 for an explanation of the derivation of importance values. Wax myrtle, persimmon, and winged sumac are common understory species.

The on-site pine flatwoods apparently were cut-over or burned about 15 years ago. A few pines remained which are currently about 25 to 38 cm (10 to 15 inches) in diameter at breast height (DBH), and the area was naturally reseeded by these individual trees. Today, young pines have formed a dense canopy (852 trees/acre) about 4.5 meters (15 feet) tall. This dense canopy and the dense saw palmettos have restricted the associated herbaceous and shrubby vegetation to a limited number of common flatwoods species.

Hammocks

The southern portion of the proposed site contains both upland (mesic hammock) and wetland (hydric hammock) elements of the southern mixed hardwood forest as described by Monk (1965) and Quarterman and Keever (1962). Diamond-leaf oak, cabbage palm, and sweetgum are common throughout both elements, while slash pine and live oak occur in mesic hammock, and red maple, black gum, and red bay occur in hydric hammock.

The results of sampling along four transects (Table 2.7.2-5) show that dominance is shared fairly equally by diamond-leaf oak, cabbage palm, and slash pine. Basswood, water oak, and blackgum are subdominants. This heterogenous species composition indicates a large amount of

Table 2.7.2-5. Plant Species Found in Mesic Hammock/Hydric Hammock Section of Proposed Site During Summer, 1977 Survey

		Importance Value	Density/ Acre	Frequency %	Total Basal Area (ft^3)	Mean DBH (inches)
Overstory and Understory Strata						
Slash pine	*Pinus elliottii*	53.7	106	38	4.4	4
Diamond-leaf oak	*Quercus laurifolia*	51.5	58	35	8.3	8
Cabbage palm	*Sabal palmetto*	51.5	48	38	8.6	10
Live oak	*Quercus virginiana*	19.2	19	6	4.2	10
Sweetgum	*Liquidambar styraciflua*	19.2	32	16	1.8	5
Black gum	*Nyssa biflora*	15.8	23	13	1.8	13
Basswood	*Tilia americana*	14.0	16	13	1.8	7
Water oak	*Quercus nigra*	10.1	13	13	0.7	6
Wax myrtle	*Myrica cerifera*	10.0	19	13	0.1	2
Carolina laurel-cherry	*Prunus caroliniana*	10.0	13	13	0.6	5
Red bay	*Persea borbonia*	8.5	13	9	0.6	3
Green ash	*Fraxinus pennsylvanica*	5.3	6	3	0.9	8
Southern red-cedar	*Juniperus silicicola*	4.8	6	6	0.3	5
Red maple	*Acer rubrum*	4.5	6	6	0.1	4
Myrtle-leaf holly	*Ilex myrtifolia*	4.2	6	6	0.1	2
Persimmon	*Diospyros virginiana*	3.1	6	3	0.1	3
Chapmans oak	*Quercus chapmanii*	2.8	3	3	0.3	7
Tough bumelia	*Bumelia tenax*	2.8	3	3	0.3	7
Southern magnolia	*Magnolia grandiflora*	2.6	3	3	0.2	6
Large gallberry	*Ilex coriacea*	2.2	3	3	0.1	3
Ironwood	*Carpinus caroliniana*	2.1	3	3	0.0	2
Stiffcornel dogwood	*Cornus stricta*	2.1	3	3	0.0	1
Total		300.0	408	--	33.5	--

Table 2.7.2-5. Plant Species Found in Mesic Hammock/Hydric Hammock Section of Proposed Site During Summer, 1977 Survey (Continued, page 2 of 4)

		Frequency %	Cover %
Shrub Strata			
Wax myrtle	*Myrica cerifera*	38	4
Saw palmetto	*Serenoa repens*	25	3
Persimmon	*Diospyros virginiana*	12	2
Stiffcornel dogwood	*Cornus stricta*	12	2
Myrtle-leafed oak	*Quercus myrtifolia*	12	1
Dahoon	*Ilex cassine*	12	1
Winged sumac	*Rhus copallina*	12	0
Beautyberry	*Callicarpa americanus*	12	0
Greenbriar	*Smilax* spp.	12	0
Total		--	13
Herbaceous Strata			
St.-John's-wort	*Hypericum* sp.	50	0
Greenbriar	*Smilax* spp.	50	0
Wax myrtle	*Myrica cerifera*	38	2
Saw palmetto	*Serenoa repens*	38	1
Panic grass	*Panicum* sp.	50	1
Paspalum	*Paspalum* sp.	25	6
Sawgrass	*Cladium jamaicense*	25	3
Broomsedge	*Andropogon virginicus*	25	1
Gallberry	*Ilex glabra*	25	1
Dahoon	*Ilex cassine*	25	1
Black-eyed susan	*Rudbeckia hirta*	25	0
Persimmon	*Diospyros virginiana*	25	0

Table 2.7.2-5. Plant Species Found in Mesic Hammock/Hydric Hammock Section of Proposed Site During Summer, 1977 Survey (Continued, page 3 of 4)

		Frequency %	Cover %
Grape	Vitis rotundifolia	25	0
Widespread maiden fern	Thelypteris normalis	25	0
Red maple	Acer rubrum	25	0
Passion flower	Passiflora incarnata	25	0
Yellow jessamine	Gelsemium sempervirons	25	0
Myrtle-leafed oak	Quercus myrtifolia	12	3
Rattlesnake master	Eryngium yuccafolia	12	1
Sedge	Carex sp.	12	1
Live oak	Quercus virginiana	12	1
Red bud	Cercis canadensis	12	1
Winged sumac	Rhus copallina	12	0
Partridge pea	Cassia fasciculata	12	0
Hoary pea	Tephrosia spicata	12	0
Goldenrod	Solidago sp.	12	0
Aster	Aster sp.	12	0
Horseweed	Erigeron canademsis	12	0
Rabbit tobacco	Pterocaulon undulatum	12	0
Dayflower	Commelina sp.	12	0
Buttonbush	Cephalanthus occidentalis	12	0
Ressurection fern	Polypodium polypodioides	12	0
Lizards tail	Saururus cernuus	12	0
Diamond-leafed oak	Quercus laurifolia	12	0
Water oak	Quercus nigra	12	0
Poison ivy	Rhus radicans	12	0
Basswood	Tilia americana	12	0
Bedstraw	Galium sp.	12	0
Partridge berry	Mitchella repens	12	0
Sweetgum	Liquidambar styraciflua	12	0

Table 2.7.2-5. Plant Species Found in Mesic Hammock/Hydric Hammock Section of Proposed Site During Summer, 1977 Survey (Continued, page 4 of 4)

		Frequency %	Cover %
Blackberry	*Rubus* sp.	12	0
Unknown 5		12	0
Coontie	*Zamia integrifolia*	12	0
Unknown 6		12	0
Arrowhead	*Sagittaria* sp.	12	0
Spanish moss	*Tillandsia usneoides*	--	--
Wild pine	*Tillandsia fasciculata*	--	a[1]
Needle-leaved wild pine	*Tillandsia setacea*	--	a
Wild pine	*Tillandsia polystachia*	--	c
Green-fly orchid	*Epidendron conopseum*	--	r
Total		--	23

[1]Epiphytic species (living on branches of other plants) listed only as a=abundant; c=common; o=occasional; r=ra

interspersion of hydric hammock, mesic hammock, and pine flatwoods vegetation. Delineation of wetland and upland areas is based largely upon the presence of such indicator species (Florida Department of State Planning, 1976) as red maple, black gum, and red bay, or slash pine and live oak, as well as the presence or absence of standing water.

Although tree density (408 trees/acre) in this area is much less than in the flatwoods, the total basal area of the tree stems and the number of tree species are much greater (33.5 ft^2 and 22 species). Presumably because of the interpersion of habitats, the number (53) of herb species found in this area was greater than in any of the other communities.

Freshwater Marshes

Freshwater marshes on the site generally are isolated "pothole" marshes less than 1 hectare (three acres) in size. Sawgrass is dominant (Table 2.7.2-6) with a fairly low number of associated species, including isolated black gum and red maple saplings. Water in these marshes is very clear with almost no occurrence of algae or floating mats.

Pine Plantations

Pines in the plantations have been planted about 1.5 meters (5 feet) apart in rows 3.6 meters (12 feet) apart to give a density of 580 trees/acre. These young (10 years old) trees have reached heights of 2 to 3.6 meters (7 to 12 feet) but have not yet formed a solid canopy. The ground cover of the open areas is composed of species common to pine flatwoods and ruderal areas (Table 2.7.2-7).

Table 2.7.2-6. Plant Species Found in Freshwater Marsh on Proposed Site During Summer, 1977, Survey

		Large[1] Marshes			Small[2] Marshes		
		Frequency %	Cover %	Density/ m^2	Frequency %	Cover %	Density/ m^2
Sawgrass	*Cladium jamaicense*	100	15	9.6	43	3	2.4
Red maple	*Acer rubrum*	71	3	0.8	--	-	--
Fleabane	*Pluchea rosea*	71	1	5.0	57	0	4.5
Creeping rush	*Juncus repens*	71	1	3.1	71	2	3.8
Centella	*Centella asiatica*	44	7	5.7	57	0	2.9
Maidencane	*Panicum hemitomon*	44	2	0.9	--	-	--
Black gum	*Nyssa biflora*	44	2	0.1	--	-	--
Beak rush	*Rhyncospora* sp.	44	1	5.3	57	4	9.9
Soft rush	*Juncus effusus*	44	1	0.6	71	0	2.4
Hedge-hyssop	*Gratiola virginiana*	44	0	18.0	14	0	1.1
Musky mint	*Hyptis alata*	44	0	0.7	14	0	0.1
Smartweed	*Polgonum hydropiperoides*	44	0	1.6	28	0	1.2
Panic grass	*Panicum* sp.	28	0	0.7	14	0	0.1
Morning glory	*Ipomoea sagittata*	28	0	0.6	28	0	0.6
St.-John's-Wort	*Hypericum fasciculatum*	14	1	0.1	--	-	--
Water-hyssop	*Bacopa carolinianum*	14	0	1.1	--	-	--
Winged loosestrife	*Lythrum lanceolatum*	14	0	0.3	--	-	--
Sand cordgrass	*Spartina bakeri*	14	0	0.1	--	-	--
Slash pine	*Pinus elliottii*	14	0	0.1	--	-	--
Unknown 7		14	0	0.1	--	-	--
Unknown 8		14	0	0.1	--	-	--
Milkweed	*Asclepias lanceolata*	14	0	0.1	14	0	0.1
Climbing hempweed	*Mikania scandens*	14	0	0.1	--	-	--
Lizards Tail	*Saururus cernuus*	14	0	0.1	--	-	--
Arrowhead	*Sagittaria lancifolia*	14	0	0.1	14	3	0.1
Water-dropwort	*Oxypolis filiformis*	--	-	--	28	3	3.6
Spike rush	*Eleocharis* sp.	--	-	--	28	3	1.7

Table 2.7.2-6. Plant Species Found in Freshwater Marsh on Proposed Site During Summer, 1977, Survey (Continued)

		Large[1] Marshes			Small[2] Marshes		
		Frequency %	Cover %	Density/ m^2	Frequency %	Cover %	Density/ m^2
Broomsedge	*Andropogon virginicus*	--	-	--	14	0	1.7
Aster	*Aster* sp.	--	-	--	14	0	0.4
Unknown 4-1		--	-	--	14	0	2.7
Wax myrtle	*Myrica cerifera*	--	-	--	14	2	0.1
Greenbriar	*Smilax* sp.	--	-	--	14	0	0.1
Naiad	*Najas* sp.	--	-	--	14	0	1.4
Milkweed	*Asclepias* sp.	--	-	--	14	0	0.2
TOTAL		--	34	--	--	20	--

[1]Greater than or equal to one acre.
[2]Less than one acre.

Table 2.7.2-7. Plant Species Found in The Ground Cover Of Pine Planatations of Proposed Site During Summer, 1977 Survey

Common Name	Scientific Name	% Cover	Total Basal
Broomsedge	*Andropogon virginicus*	20	
Panic grass	*Panicum* sp.	1	
Dallis grass	*Paspalum dilatatum*	1	
Soft rush	*Juncus effusus*	1	
Sedge	*Scirpus* sp.	1	
Sweetgum	*Liquidambar styraciflua*	1	
Gallberry	*Ilex glabra*	1	
Wax myrtle	*Myrica cerifera*	1	
Winged sumac	*Rhus copallina*	1	
Partridge pea	*Cassia fasiculata*	1	
Fleabane	*Pluchea rosea*	1	
Horseweed	*Erigeron canadensis*	t	
Panic grass	*Panicum* sp.	t	
Deers tongue	*Trilisa odoratissima*	t	
Milkpea	*Galactia elliottii*	t	
St.-John's-wort	*Hypericum perforatorum*	t	
Aster	*Aster* sp.	t	
Musky mint	*Hyptis alata*	t	

Ruderal Areas

The transmission corridors are dominated by such herbaceous and shrubby species as dogfennel, fleabane, broomsedge, milkweeds, partridge pea, and winged sumac (Table 2.7.2-8), most of which are common old field early successional species. Low areas within the corridors consist of either fresh marsh or shrub swamp. These marshes are similar to wet prairies and have a mix of marsh species (i.e., sawgrass, smartweed, softrush) and species of nearby upland areas. The swamps are maintained in a low, shrubby state with Carolina willow, buttonbush, red maple seedlings, and invading upland shrubs.

Salt Marsh

On the west, the site is bordered by a strip of salt marsh about 1.6 km (one mile) in width. The outer edge is composed of an almost pure band of smooth cordgrass, but the bulk of the marsh is dominated by black needle-rush (Young, 1974).

Along the inner margin, the marsh grades into the coastal hydric hammock. In this edge zone, salt grass is the dominant species. Several channels extend as far as 182 meters (600 feet) into the hammock from the salt marsh area. These channels are bordered by species of both fresh and salt marsh areas. Among these are salt grass, saltwort, glasswort, creeping rush, arrowhead, and sawgrass.

Hydric Hammock

Table 2.7.2-9 lists the vegetative composition of the coastal hydric hammock as found during the summer, 1970 survey. Cabbage palm, live

Table 2.7.2-8. Plant Species Found in Ruderal Areas of Proposed Site During Summer, 1977, Survey (page 1 of 3)

		Early Successional		Fresh Marsh 641		Swamp 621	
		Frequency %	Cover %	Frequency %	Cover %	Frequency %	Cover %
False willow	Baccharis angustifolia	100	1.8	20	1.0	50	2.5
Soft rush	Juncus effusus	80	9.0	60	2.3	--	--
Broomsedge	Andropogon virginicus	80	5.2	40	1.2	100	5.5
Beak rush	Rhyncospora sp.	60	2.0	20	0.0	--	--
Panic grass	Panicum 1	60	0.6	20	0.0	--	--
Centella	Centella asiatica	60	0.2	40	31.7	--	--
Unknown 4		60	0.0	40	0.4	--	--
Morning glory	Ipomoea arvensis	60	0.0	20	0.0	50	0.0
Winged sumac	Rhus copallina	40	5.0	--	--	50	5.0
Coastal-plain willow	Salix caroliniana	40	1.2	20	1.0	50	7.5
Unknown 1		40	1.2	--	--	--	--
Sawgrass	Cladium jamaicense	40	0.4	60	14.0	--	--
Foxtail grass	Setaria geniculata	40	0.2	--	--	--	--
Sedge	Scirpus sp.	40	0.0	--	--	--	--
Ironweed	Vernonica noveboracensis	40	0.0	60	0.6	50	1.5
St.-John's-wort	Hypericum perforatorum	40	0.0	--	--	--	--
Bulrush	Scirpus cyperinus	20	2.0	20	0.3	--	--
Black-eyed susan	Rudbeckia hirta	20	0.2	--	--	50	0.0
Euphorbia	Euphorbia supina	20	0.2	--	--	--	--
Deers tongue	Trilisa odoratissima	20	0.0	--	--	--	--
Horseweed	Erigeron canadensis	20	0.0	--	--	--	--
Goldenrod	Solidago sp.	20	0.0	--	--	--	--
Water Pennywort	Hydrocotyle umbellata	20	0.0	20	0.0	--	--
Common morning glory	Ipomoea purpurea	20	0.0	--	--	--	--
Dogfennel	Eupatorium compositifolium	20	0.0	20	0.0	--	--

Table 2.7.2-8. Plant Species Found in Ruderal Areas of Proposed Site During Summer, 1977, Survey (Continued page 2 of 3)

		Early Successional		Fresh Marsh 641		Swamp 621	
		Frequency %	Cover %	Frequency %	Cover %	Frequency %	Cover %
Fleabane	*Pluchea rosea*	20	0.0	20	0.0	50	0.0
Rosinweed	*Silphium integrifolium*	20	0.0	--	--	--	--
Wild sensitive plant	*Cassia nictitans*	20	0.0	--	--	--	--
Milkpea	*Galactia elliottii*	20	0.0	--	--	--	--
Blackberry	*Rubus* sp.	20	0.0	--	--	--	--
Greenbriar	*Smilax* spp.	20	0.0	--	--	--	--
Beautyberry	*Callicarpa americana*	20	0.0	--	--	--	--
Saw palmetto	*Serenoa repens*	20	0.0	20	0.2	--	--
Southern red-cedar	*Juniperus silicicola*	20	0.0	20	1.0	--	--
Red maple	*Acer rubrum*	20	0.0	20	1.0	--	--
Fimbrystylis	*Fimbrystylis autumnalis*	--	--	60	5.0	50	0.0
Sand cordgrass	*Spartina bakeri*	--	--	20	0.0	--	--
Walter millet	*Echinochloa walteri*	--	--	20	1.0	50	0.5
Saltgrass	*Distichlis spicata*	--	--	40	0.4	--	--
Sedge	*Scirpus* sp.	--	--	20	0.0	--	--
Panic grass	*Panicum* sp.	--	--	20	0.0	50	0.0
Cattail	*Typha latifolia*	--	--	20	1.0	--	--
Smartweed	*Polygonum hydropiperoides*	--	--	40	0.0	--	--
Musky mint	*Hyptis alata*	--	--	40	1.1	100	5.0
Creeping rush	*Juncus repens*	--	--	40	0.0	--	--
Prickly lettuce	*Lactuca scariola*	--	--	20	0.0	--	--
Water hyssop	*Bacopa caroliniana*	--	--	20	0.0	--	--
Carolina ash	*Fraxinus caroliniana*	--	--	60	0.4	--	--
Late boneset	*Eupatorium serotinum*	--	--	20	0.2	--	--
Grape	*Vitis rotundifolia*	--	--	--	--	100	5.5

Table 2.7.2-8. Plant Species Found in Ruderal Areas of Proposed Site During Summer, 1977, Survey (Continued page 3 of 3)

		Early Successional		Fresh Marsh 641		Swamp 621	
		Frequency %	Cover %	Frequency %	Cover %	Frequency %	Cover %
Lizards tail	*Saururus annuus*	--	--	--	--	50	1.5
Rose-mallow	*Hibiscus* sp.	--	--	--	--	50	5.0
Widespread maiden fern	*Thelypteris normalis*	--	--	--	--	50	0.5
Wild bean	*Phaseolis polystachios*	--	--	--	--	50	0.0
Hedge hyssop	*Gratiola virginiana*	--	--	--	--	50	0.0
Pepper-vine	*Ampelopsis arborea*	--	--	--	--	50	0.0
Aster	*Aster* sp.	--	--	--	--	50	10.0
TOTAL		--	35.2	--	64.8	--	45.0

Table 2.7.2-9. Plant Species Found in Coastal Hydric Hammock Section of Proposed Site During Summer, 1977 Survey (page 1 of 3)

		Importance Value	Density/ Acre	Frequency %	Total Basal Area (ft^3)	Mean DBH (inches)
Overstory and Understory Strata						
Cabbage palm	*Sabal palmetto*	121.7	141	81	36.7	11
Southern red-cedar	*Juniperus silicicola*	53.5	93	53	6.4	5
Live oak	✓*Quercus virginiana*	38.1	21	22	16.5	18
Diamond-leaf oak	✓*Quercus laurifolia*	13.3	21	19	0.6	4
Southern magnolia	*Magnolia grandiflora*	10.9	12	13	2.1	8
Wax myrtle	*Myrica cerifera*	9.9	15	16	0.1	2
Sweetgum	*Liquidambar styraciflua*	6.9	15	6	0.4	4
American elm	✓*Ulmus americana*	6.6	9	9	0.5	5
Red bay	*Persea borbonia*	6.1	9	9	0.2	3
Basswood	✓*Tilia americana*	5.8	6	6	1.3	10
Red maple	✓*Acer rubrum*	5.4	6	6	1.0	10
Green ash	*Fraxinus pennsylvatica*	5.0	6	6	0.7	8
Myrtle-leaf holly	*Ilex myrtifolia*	4.7	9	6	0.0	1
Coastal-plain willow	*Salix caroliniana*	3.8	9	3	0.2	3
Ironwood	*Carpinus caroliniana*	2.5	3	3	0.4	8
Water oak	✓*Quercus nigra*	2.0	3	3	0.0	2
Carolina laurel-cherry	*Prunus caroliniana*	2.0	3	3	0.0	2
Carolina ash	*Fraxinus caroliniana*	2.0	3	3	0.0	1
TOTAL		300.2	384	--	67.1	--

Table 2.7.2-9. Plant Species Found in Coastal Hydric Hammock Section of Proposed Site During Summer, 1977 Survey (Continued, page 2 of 3)

		Frequency %	Cover %
Shrub Strata			
Southern red-cedar	*Juniperus silicicola*	40	2
Diamond-leaf oak	*Quercus laurifolia*	40	2
Wax myrtle	*Myrica cerifera*	40	1
Poison ivy	*Rhus radicans*	20	4
Live oak	*Quercus virginiana*	20	3
Cabbage palm	*Sabal palmetto*	20	3
Spoonleaf yucca	*Yucca filamentosa*	20	2
Myrtle-leafed holly	*Ilex myrtifolia*	20	1
Carolina ash	*Fraxinus caroliniana*	20	1
Sweet gum	*Liquidambar styraciflua*	20	1
Saw palmetto	*Serenoa repens*	20	0
Virginia creeper	*Parthenocissus quinquefolia*	20	0
Total		--	20
Herbaceous Strata			
Saw palmetto	*Serenoa repens*	40	0
Wax myrtle	*Myrica cerfera*	60	2
Green briar	*Smilax* sp.	60	0
Sawgrass	*Cladium jamaicense*	40	4
Southern red-cedar	*Juniperus silicicola*	40	1
Beautyberry	*Callicarpa americana*	40	1
Red bay	*Persea borbonia*	40	0
Diamond-leafed oak	*Quercus laurifolia*	40	0

Table 2.7.2-9. Plant Species Found in Coastal Hydric Hammock Section of Proposed Site During Summer, 1977 Survey (Continued, page 3 of 3)

		Frequency %	Cover %
Herbaceous Strata			
Swamp lily	*Crinum americana*	40	0
Spoonleaf yucca	*Yucca filamentosa*	20	1
Grass 1		20	1
Swamp chestnut oak	*Quercus michauxii*	20	1
Pokeweed	*Phytolacca americana*	20	1
Live oak	*Quercus virginiana*	20	1
Sensitive fern	*Onaclea sensibilis*	20	1
Passion flower	*Passiflora incarnata*	20	0
Poison ivy	*Rhus radicans*	20	0
Yellow jessamine	*Gelsemium sempervirons*	20	0
Sweet bay	*Magnolia virginiana*	20	0
Widespread maiden fern	*Thelypteris normalis*	20	0
Ressurrection fern	*Polypodium polypoidioides*	--	c[1]
Spanish moss	*Tillandsia usneoides*	--	o
Wild pine	*Tillandsia fasciculata*	--	r
Needle-leaved wild pine	*Tillandsia setacea*	--	o
Green-fly orchid	*Epidendron conopseum*	--	r
Total		--	14

[1] Epiphytic species (living on branches of other plants) listed only as a-abundant, c-common, o-occasional, r-rare.

oak, and southern red-cedar comprise 71 percent of the dominance as measured by the importance value index. Live oak is represented by a few large individuals (45 cm or 18 inch mean DBH) which furnish much of the canopy cover, while diamond-leaf oak is represented by numerous small individuals (10 cm or 4 inches mean DBH).

On the seaward edge of this hammock community, southern red-cedar and cabbage palm are dominant in a somewhat open canopy. There is a general increase in the number of broad-leaf tree species and increase in canopy cover with increasing distance inland. Although density/cover of all three strata are not significantly different from those of the other areas studied, the basal area/acre value of 20.4 square meters (67 square feet) was almost double the value of the other hammock and ten times that of the flatwoods. This higher value is a result of the presence of larger trees and is to some degree an indication of an older system.

Within the salt marsh itself are several islands containing a flora similar to the coastal portion of the coastal hydric hammock. This is the cabbage palm, southern red-cedar dominated coastal hammock. The substrate is somewhat drier and the land surface higher than in the coastal hydric hammock. Associated species include yaupon, poison ivy, pigment hickory, and live oak. The canopy height of the gnarled and twisted trees is only about 9.1 meters (30 feet) (U.S. Army Corps of Engineers, 1976).

The presence of so many vegetation types, the subtle differences among these, and the high degree of interspersion combine to provide a wide range of habitats which can be utilized by a similarly large variety of animal species.

Animal Communities

The aquatic and terrestrial systems of the region support a variety of fauna (Table 2.7.2-10) related to the diversity of habitats. Sixteen species of mammals, 60 species of birds, 20 species of reptiles, and 11 species of amphibians were observed in the area of concern during the 1977 field survey. The preferred habitat and relative abundance of these species and of other expected animals are listed in Table 2.7.2-10. Qualitative small mammal trapping data is presented in Table 2.7.2-11. Of the 422 expected species, 34 are considered rare and endangered and 13 are important as furbearers, game, or marketable food resources.

The quality and quantity of habitat are among the most important factors influencing the abundance and diversity of animal populations in a given area. Prime wildlife habitat must have not only an adequate acreage but also sufficient habitat interspersion so that wildlife can meet all their needs in a small area. Because of the interspersion and extensive variety of plant communities present at the site, this area is considered good habitat for a number of species (Tables 2.7.2-10). Larger mammals, such as white-tailed deer, black bear, and feral swine, are found in the vicinity and may utilize the various ecosystems. These

Table 2.7.2-10. Relative Abundance and Preferred Habitat of Vertebrates Known or Expected to Occur on or in the Vicinity of the Proposed Plant Site, Citrus County (Page one of sixteen)

Order / Family / Species	Common Name	Species Observed	Pine/Oak Sandhill Scrub	Mesic & Xeric Hammock	Coastal & Hydric Hammock	Cypress Dome	Pine Flatwoods	Pine Plantation	Mixed Swamp	Fresh Marsh	Salt Marsh	Pasture & Developed (Ruderal)
Marsupialia												
Didelphidae												
Didelphis marsupialis	Opossum	*	X	X	X	X	X	X	X	X		X
Insectivora												
Soricidae												
Sorex longirostris	Southeastern shrew		X	X	X		X					
Blarina brevicauda	Shorttail shrew	*	X	X	X		X		X	X		X
Cryptotis parva	Least shrew		X	X	X		X			X		
Talpidae												
Scalopus aquaticus	Eastern mole	*	X	X			X	X				
Chiroptera												
Vespertilionidae												
Pipistrellus subflavas	Eastern pipistrel								X			
Eptesicus fuscus	Big brown bat											X
Lasiurus borealis	Red bat			X	X				X			X
Lasiurus seminolus	Seminole bat			X	X				X			
Lasiurus intermedius	Yellow bat		X	X								X
Lasiurus cinereus	Hoary bat								X			
Nycticeius humeralis	Evening bat		X	X	X				X			
Plecotus rafinesquei	Big-eared bat				X							
Molossidae												
Tadarida brasiliensis	Mexican freetail bat											X
Edentata												
Dasypodidae												
Dasypus novemcinctus	Nine-banded armadillo	*	X	X			X	X	X	X		X
Lagomorpha												
Leporidae												
Sylvilagus floridanus	Eastern cottontail	*	X	X			X					X
Sylvilagus palustris	Marsh rabbit	*	X								X	
Rodentia												
Sciuridae												
Sciurus carolinensis	Gray squirrel	*	X	X	X	X	X	X	X			X
Sciurus niger	Fox squirrel		X				X					X
Glaucomys volans	Southern flying squirrel		X	X	X							
Geomyidae												
Geomys pinetis	Southeastern pocket gopher		X					X				X

Table 2.7.2-10. Relative Abundance and Preferred Habitat of Vertebrates Known or Expected to Occur on or in the Vicinity of the Proposed Plant Site, Citrus County (Continued, page two of sixteen)

Order / Family / Species	Common Name	Species Observed	Pine/Oak Sand-hill Scrub	Mesic & Xeric Hammock	Coastal & Hydric Hammock	Cypress Dome	Pine Flatwoods	Pine Plantation	Mixed Swamp	Fresh Marsh	Salt Marsh	Pasture & Developed (Ruderal)
Cricetidae												
Oryzomys palustris	Rice rat			X	X	X				X	X	
Reithrodontomys humulis	Harvest mouse		X	X			X					
Peromyscus polionotus	Old-field mouse		X	X			X			X		X
Peromyscus gossypinus	Cotton mouse	*	X	X	X	X	X	X	X	X	X	X
Peromyscus nuttalli	Golden mouse		X	X	X		X					
Peromyscus floridana	Florida mouse	*	X	X				X				X
Sigmodon hispidus	Cotton rat	*	X	X	X		X	X		X	X	X
Neotoma floridana	Eastern woodrat			X	X	X			X	X		
Pitymys pinetorum	Pine vole						X					
Neofiber alleni	Round-tailed muskrat						X			X		
Muridae												
Rattus norvegicus	Norway rat											X
Rattus rattus	Black rat											X
Mus musculus	House mouse											X
Carnivora												
Canidae												
Urocyon cinereoargenteus	Gray fox	*	X				X		X			
Canis familiaris	Feral dog		X	X	X		X	X				X
Ursidae												
Ursus americanus	Black bear		X				X		X			
Procyonidae												
Procyon lotor	Raccoon	*	X	X	X		X	X	X	X	X	X
Mustelidae												
Mustela frenata	Longtail weasel		X	X	X				X			
Mustela vison	Mink										X	
Mephitis mephitis	Striped skunk		X				X	X				
Lutra canadensis	River otter	*							X	X		

Table 2.7.2-10. Relative Abundance and Preferred Habitat of Vertebrates Known or Expected to Occur on or in the Vicinity of the Proposed Plant Site, Citrus County (Continued, page three of sixteen)

Order / Family / Species	Common Name	Species Observed	Pine/Oak Sandhill Scrub	Mesic & Xeric Hammock	Coastal & Hydric Hammock	Cypress Dome	Pine Flatwoods	Pine Plantation	Mixed Swamp	Fresh Marsh	Salt Marsh	Pasture & Developed (Ruderal)
Felidae												
Felis concolor	Florida panther		X	X	X				X			
Lynx rufus	Bobcat	*	X	X			X					
Felis catus	Feral cat	*										
Artiodactyla												
Suidae												
Sus scrofa	Feral swine						X	X	X	X		X
Cervidae												
Odocileus virginianus	White-tailed deer	*	X	X	X		X	X	X	X		X

Table 2.7.2-10. Preferred Habitat and Seasonal Occurrence of Vertebrates Known or Expected to Occur in the Vicinity of the Proposed Plant Site, Citrus County (Continued, page four of sixteen)

Order Species	Common Name	Species Observed	Pine/Oak Sand-hill Scrub	Mesic & Xeric Hammock	Coastal & Hy-eric Hammock	Cypress Dome	Pine Flatwoods	Pine Plantation	Mixed Swamp	Fresh Marsh	Salt Marsh	Pasture & Developed (Ruderal)
Gaviiformes												
Gavia immer	Common loon										X	
Gavia stellata	Red-throated loon										X	
Podicipediformes												
Podiceps grisegena	Red-necked grebe										X	
Podiceps auritus	Horned grebe										X	
Podiceps podilymbus	Pied-billed grebe										X	
Pelecaniformes												
Pelecanus erythrorhynchos	White pelican										X	
Pelecanus occidentalis	Brown pelican	*									X	
Morus bassanus	Gannet										X	
Phalacrocorax auritus	Double-crested cormorant										X	
Anhinga anhinga	Anhinga	*								X		
Fregata magnificens	Magnificent frigatebird										X	
Ciconiiformes												
Ardea herodias	Great blue heron	*							X	X	X	
Butorides striatus	Green heron				X	X			X	X	X	
Florida caerulea	Little blue heron	*			X				X	X	X	X
Bubulcus ibis	Cattle egret	*	X		X					X		X
Casmerodius albus	Great egret								X	X	X	
Egretta thula	Snowy egret	*			X					X	X	
Hydranassa tricolor	Louisiana heron				X					X	X	
Nyticorax nycticorax	Black-crowned night heron				X						X	
Nyctanassa violacea	Yellow-crowned night heron				X						X	
Ixobrychus exilis	Least bittern									X		
Botaurus lentiginosus	American bittern									X		
Mycteria americana	Wood stork				X					X	X	
Plegadis falcinellus	Glossy ibis									X		
Eudocimus, albus	White ibis	*			X	X			X	X	X	
Anseriformes												
Branta bernicla	Brant's goose								X	X		
Chen caerulescens	Snow goose				X						X	
Dendrocygna bicolor	Fulvous whistling duck				X							
Anas platyrhynchos	Mallard									X		
Anas rubripes	Black duck										X	
Anas fulvigula	Mottled duck									X	X	
Anas strepera	Gadwall									X	X	
Anas acuta	Pintail									X	X	

Table 2.7.2-10. Preferred Habitat and Seasonal Occurrence of Vertebrates Known or Expected to Occur in the Vicinity of the Proposed Plant Site, Citrus County (Continued, page five of sixteen)

Order Species	Common Name	Species Observed	Pine/Oak Sandhill Scrub	Mesic & Xeric Hammock	Coastal & Hydric Hammock	Cypress Dome	Pine Flatwoods	Pine Plantation	Mixed Swamp	Fresh Marsh	Salt Marsh	Pasture & Developed (Ruderal)
Anseriformes (continued)												
Anas crecca carolinensis	Green-winged teal									X	X	
Anas discors	Blue-winged teal									X		
Anas penelope	European widgeon										X	
Anas americana	American widgeon									X		
Anas clypeata	Northern shoveler									X	X	
Aix sponsa	Wood duck					X			X	X		
Aytha americana	Redhead										X	
Aytha collaris	Ring-necked duck									X		
Aytha valisineria	Canvasback										X	
Aytha marila	Greater scaup										X	
Aytha affinis	Lesser scaup										X	
Bucephala clangula	Common goldeneye										X	
Bucephala albeola	Bufflehead										X	
Oxyura jamaicensis	Ruddy duck										X	
Lophodytes cucullatus	Hooded merganser										X	
Mergus merganser	Common merganser										X	
Mergus serrator	Red-breasted merganser										X	
Falconiformes												
Cathartes aura	Turkey vulture	*	X		X	X	X	X	X	X	X	X
Coragyps atratus	Black vulture	*	X		X	X	X	X	X	X	X	X
Elanoides forficatus	Swallow-tailed kite	*		X			X		X			
Ictinia misisippiensis	Mississippi kite				X	X			X			
Accipiter striatus	Sharp-shinned hawk		X	X	X		X	X	X		X	
Accipiter cooperii	Cooper's hawk		X	X			X	X	X		X	
Buteo jamaicensis	Red-tailed hawk	*	X		X		X	X		X		X
Buteo lineatus	Red-shouldered hawk	*	X	X	X	X	X	X	X			X
Buteo platypterus	Broad-winged hawk			X	X							
Buteo lagopus	Rough-legged hawk											X
Haliaeetus leucocephalus	Bald eagle	*	X		X		X	X			X	
Circus cyaneus	Marsh hawk						X			X	X	
Pandion haliaetus	Osprey	*			X	X			X		X	
Falco peregrinus	Peregrine falcon										X	
Falco columbarius	Merlin						X				X	X
Falco sparverius	American kestrel		X				X					X
Galliformes												
Colinus virginianus	Bobwhite	*	X	X	X	X	X	X	X			X
Meleagris gallopavo	Turkey		X	X	X	X	X		X			

Table 2.7.2-10. Preferred Habitat and Seasonal Occurrence of Vertebrates Known or Expected to Occur in the Vicinity of the Proposed Plant Site, Citrus County (Continued, page six of sixteen)

Order Species	Common Name	Species Observed	Pine/Oak Sandhill Scrub	Mesic & Xeric Hammock	Coastal & Hydric Hammock	Cypress Dome	Pine Flatwoods	Pine Plantation	Mixed Swamp	Fresh Marsh	Salt Marsh	Pasture & Developed (Ruderal)
Gruiformes												
Grus canadensis	Sandhill crane									X		X
Aramus guarauna	Limpkin								X			
Rallus elegans	King rail									X		
Rallus longirostris	Clapper rail	*									X	
Rallus limicola	Virginia rail									X		
Porzana carolina	Sora									X	X	
Coturnicops noveboracensis	Yellow rail									X	X	
Laterallus jamaicensis	Black rail									X	X	
Porphyrula martinica	Purple gallinule									X		
Gallinula chloropus	Common gallinule									X		
Fulica americana	American coot									X	X	
Charadriiformes												
Haematopus palliatus	American oystercatcher										X	
Haematopus mexicanus	Black-necked stilt										X	
Charadrius semipalmatus	Semipalmated plover										X	
Charadrius melodus	Piping plover										X	
Charadrius wilsonia	Wilson's plover										X	
Charadrius vociferus	Killdeer	*	X								X	X
Charadrius alexandrinus	Snowy plover										X	
Pluvialis squatarola	Black-bellied plover										X	
Arenaria interpres	Ruddy turnstone										X	
Philohela minor	American woodcock				X				X			
Capella gallinago	Common snipe									X	X	X
Numenius americanus	Long-billed curlew										X	
Numenius phaeopus	Whimbrel										X	
Bartramia longicauda	Upland sandpiper											X
Actitis macularia	Spotted sandpiper										X	
Tringa solitaria	Solitary sandpiper								X	X		
Tringa melanoleucus	Greater yellowlegs										X	
Tringa flavipes	Lesser yellowlegs										X	
Catoptrophorus semipalmatus	Willet										X	
Calidris canutus	Red knot										X	
Calidris melanotos	Pectoral sandpiper									X	X	X
Calidris fuscicollis	White-rumped sandpiper										X	
Calidris minutilla	Least sandpiper										X	

Table 2.7.2-10. Preferred Habitat and Seasonal Occurrence of Vertebrates Known or Expected to Occur in the Vicinity of the Proposed Plant Site, Citrus County (Continued, page seven of sixteen)

Order Species	Common Name	Species Observed	Pine/Oak Sand-hill Scrub	Mesic & Xeric Hammock	Coastal & Hydric Hammock	Cypress Dome	Pine Flatwoods	Pine Plantation	Mixed Swamp	Fresh Marsh	Salt Marsh	Pasture & Developed (Ruderal)
Gruiformes (continued)												
Calidris alpina	Dunlin										X	
Calidris pusillus	Semipalmated sandpiper										X	
Calidris mauri	Western sandpiper										X	
Calidris alba	Sanderling										X	
Limnodromus griseus	Short-billed dowitcher										X	
Limnodromus scolopaceus	Long-billed dowitcher										X	
Limosa fedoa	Marbled godwit										X	
Phalaropus fulicarius	Red phalarope										X	
Lobipes lobatus	Northern phalarope										X	
Larus marinus	Great black-backed gull										X	
Larus argentatus	Herring gull	*									X	
Larus delawarensis	Ring-billed gull										X	
Larus atricilla	Laughing gull										X	
Larus philadelphia	Bonaparte's gull										X	
Gelochelidon nilotica	Gull-billed tern										X	
Sterna forsteri	Forster's tern										X	
Sterna hirundo	Common tern	*									X	
Sterna fuscate	Sooty tern										X	
Sterna dougallii	Roseate tern										X	
Sterna albifrons	Least tern	*									X	
Sterna maxima	Royal tern										X	
Sterna caspia	Caspian tern										X	
Sterna sandvicensis	Sandwich tern										X	
Chlidonias niger	Black tern									X	X	
Rynchops nigra	Black skimmer	*									X	
Columbiformes												
Columba livia	Rock dove	*										X
Zenaida asiatica	White-wing dove		X				X	X				X
Zenaida macroura	Mourning dove	*	X	X	X	X	X	X				X
Columbina passerina	Ground dove	*	X	X		X	X	X				X
Cuculiformes												
Coccyzus americanus	Yellow-billed cuckoo	*	X	X	X	X	X		X			
Coccyzus erythropthalmus	Black-billed cuckoo								X			

Table 2.7.2-10. Preferred Habitat and Seasonal Occurrence of Vertebrates Known or Expected to Occur in the Vicinity of the Proposed Plant Site, Citrus County (Continued, page eight of sixteen)

Order Species	Common Name	Species Observed	Pine/Oak Sand-hill Scrub	Mesic & Xeric Hammock	Coastal & Hy-dric Hammock	Cypress Dome	Pine Flatwoods	Pine Plantation	Mixed Swamp	Fresh Marsh	Salt Marsh	Pasture & Developed (Ruderal)
Strigiformes												
Tyto alba	Barn owl			X	X							X
Otus asio	Screech owl		X	X	X		X		X			X
Bubo virginianus	Great horned owl		X	X			X	X				
Athene cunicularia	Burrowing owl		X									X
Strix varia	Barred owl	*	X	X	X	X	X	X	X			
Asio flammeus	Short-eared owl						X				X	
Caprimulgiformes												
Caprimulgus carolinensis	Chuck-will's widow		X	X	X		X	X				
Caprimulgus vociferus	Whip-poor-will		X	X	X		X					
Chordeiles minor	Common nighthawk	*	X			X	X	X	X			X
Apodiformes												
Chaetura pelagica	Chimney swift		X									X
Archilochus colubris	Ruby-throated hummingbird			X					X			
Coraciiformes												
Megaceryle alcyon	Belted kingfisher	*		X	X	X			X	X	X	
Piciformes												
Colaptes auratus	Common flicker	*	X	X	X		X	X	X			X
Dryocopus pileatus	Pileated woodpecker	*	X	X	X	X	X	X	X			X
Centurus carolinus	Red-bellied woodpecker	*	X	X	X	X	X	X	X			X
Melanerpes erythrocephalus	Red-headed woodpecker		X	X					X			X
Sphyrapicus varius	Yellow-bellied sapsucker	*	X	X	X		X	X	X			
Picoides villous	Hairy woodpecker	*	X	X	X		X	X	X			
Picoides pubescens	Downy woodpecker		X	X	X		X	X	X			X
Picoides borealis	Red-cockaded woodpecker		X				X	X				
Passeriformes												
Tyrannus tyrannus	Eastern kingbird						X	X				X
Tyrannus dominicensis	Gray kingbird				X						X	
Tyrannus verticalis	Western kingbird											X
Myiarchus crinitus	Great crested flycatcher	*	X	X	X		X	X	X			X
Sayornis phoebe	Eastern phoebe		X	X	X		X	X	X	X		X
Empidonax virescens	Acadian flycatcher			X	X				X			
Contopus virens	Eastern wood pewee						X		X			
Iridoprocne bicolor	Tree swallow	*	X				X	X	X	X		X
Riparia riparia	Bank swallow											X
Stelgidopteryx ruficollis	Rough-winged swallow		X									X

Table 2.7.2-10. Preferred Habitat and Seasonal Occurrence of Vertebrates Known or Expected to Occur in the Vicinity of the Proposed Plant Site, Citrus County (Continued, page nine of sixteen)

Order Species	Common Name	Species Observed	Pine/Oak Sand-hill Scrub	Mesic & Xeric Hammock	Coastal & Hydric Hammock	Cypress Dome	Pine Flatwoods	Pine Plantation	Mixed Swamp	Fresh Marsh	Salt Marsh	Pasture & Developed (Ruderal)
Passeriformes (continued)												
Hirundo rustica	Barn swallow		X									X
Petrochelidon pyrrhonota	Cliff swallow									X	X	
Progne subis	Purple martin		X	X	X		X			X	X	X
Cyanocitta cristata	Blue jay	*	X	X	X	X	X	X	X			X
Aphelocoma coerulescens	Scrub jay		X									
Corvus brachyrhynchos	Common crow	*	X	X	X	X	X	X	X			X
Corvus ossifragus	Fish crow	*	X	X	X	X	X	X	X		X	X
Parus carolinensis	Carolina chickadee		X	X	X	X	X	X	X			
Parus bicolor	Tufted titmouse	*	X	X	X	X	X	X	X			X
Sitta carolinensis	White-breasted nuthatch			X	X		X		X			
Sitta pusilla	Brown-headed nuthatch		X				X	X				
Certhia familiaris	Brown creeper			X								
Troglodytes aedon	House wren		X	X	X		X	X	X			X
Troglodytes troglodytes	Winter wren			X	X				X			X
Thryomanes bewickii	Bewick's wren			X								
Thryothorus ludovicianus	Carolina wren	*	X	X	X	X	X	X	X			X
Cistothorus palustris	Long-billed marsh wren										X	
Cistothorus platensis	Short-billed marsh wren									X		X
Mimus polyglottos	Mockingbird	*	X		X	X	X	X				X
Dumetella carolinensis	Gray catbird	*	X	X	X		X	X	X			
Toxostoma rufum	Brown thrasher	*	X	X	X				X			X
Turdus migratorius	American robin		X	X	X		X	X	X			X
Catharus guttatus	Hermit thrush	*		X	X		X		X			
Catharus ustulatus	Swainson's thrush			X	X							
Catharus minimus	Gray-cheeked thrush			X								
Catharus fuscescens	Veery			X					X			
Hylocichla mustelina	Wood thrush			X					X			
Sialia sialis	Eastern bluebird		X				X	X				X
Polioptila caerulea	Blue-gray gnatcatcher	*	X	X	X	X	X	X	X			X
Setophaga ruticilla	American redstart	*	X	X			X		X			
Passer domesticus	House sparrow	*										X
Dolichonyx oryzivorus	Bobolink											X
Sturnella magna	Eastern meadowlark	*										X
Agelaius phoeniceus	Redwing blackbird	*	X	X	X		X		X	X	X	X
Icterus spurius	Orchard oriole											X

Table 2.7.2-10. Preferred Habitat and Seasonal Occurrence of Vertebrates Known or Expected to Occur in the Vicinity of the Proposed Plant Site, Citrus County (Continued, page ten of sixteen)

Order Species	Common Name	Species Observed	Pine/Oak Sand-hill Scrub	Mesic & Xeric Hammock	Coastal & Hydric Hammock	Cypress Dome	Pine Flatwoods	Pine Plantation	Mixed Swamp	Fresh Marsh	Salt Marsh	Pasture & Developed (Ruderal)
Passeriformes (continued)												
Icterus galbula	Northern oriole											X
Euphagus carolinus	Rusty blackbird				X				X			
Quiscalus major	Boat-tailed grackle	*	X		X		X				X	X
Quiscalus quiscula	Common grackle		X	X			X		X		X	X
Molothrus ater	Brown-headed cowbird											X
Piranga olivacea	Scarlet tanager			X								
Piranga rubra	Summer tanager	*	X	X	X	X	X	X	X			X
Cardinalis cardinalis	Cardinal	*	X	X	X	X	X		X			X
Cuiraca caerulea	Blue grosbeak		X				X					X
Passerina cyanea	Indigo bunting								X			
Passerina ciris	Painted bunting											X
Carduelis pinus	Pine siskin											X
Carduelis tristis	American goldfinch		X	X	X		X	X	X			X
Loxia curvirostra	Red crossbill						X	X				
Pipilo erythrophthalmus	Rufous-sided towhee	*	X	X	X		X					X
Passerculus sandvicensis sandvicensis	Savannah sparrow						X					X
Ammodramus savannarum	Grasshopper sparrow											X
Ammodramus henslowii	Henslow's sparrow						X					
Ammospiza caudacuta	Sharp-tailed sparrow										X	
Ammoxpiza leconteii	LeConte's sparrow									X		X
Ammospiza maritima	Seaside sparrow										X	
Pooecetes gramineus	Vesper sparrow						X					
Aimophila aestivalis	Bachman's sparrow		X				X					
Junco hyemalis hyemalis	Dark-eyed junco											X
Spizella passerina	Chipping sparrow		X				X					
Spizella pusilla	Field sparrow											X
Zonotrichia leucophrys	White-crowned sparrow											X
Zonotrichia albicollis	White-throated sparrow		X		X		X					X
Melospiza lincolnii	Lincoln's sparrow											X
Melospiza georgiana	Swamp sparrow				X		X		X	X	X	
Regulus satrapa	Golden-crowned kinglet		X				X	X				
Regulus calendula	Ruby-crowned kinglet		X	X	X		X	X	X			
Anthus spinoletta	Water pipit											X
Anthus spragueii	Sprague's pipit											X

Table 2.7.2-10. Preferred Habitat and Seasonal Occurrence of Vertebrates Known or Expected to Occur in the Vicinity of the Proposed Plant Site, Citrus County (Continued, page eleven of sixteen)

Order Species	Common Name	Species Observed	Pine/Oak Sand-hill Scrub	Mesic & Xeric Hammock	Coastal & Hydric Hammock	Cypress Dome	Pine Flatwoods	Pine Plantation	Mixed Swamp	Fresh Marsh	Salt Marsh	Pasture & Developed (Ruderal)
Passeriformes (continued)												
Bombycilla cedrorum	Cedar waxwing		X	X			X					
Lanius ludovicianus	Loggerhead shrike	*	X				X					X
Sturnus vulgaris	Starling	*										X
Vireo griseus	White-eyed vireo	*	X	X	X	X	X	X	X			X
Vireo flavifrons	Yellow-throat vireo		X	X	X		X		X			X
Vireo altiloquus	Black-whiskered vireo				X							
Vireo solitarius	Solitary vireo		X	X	X		X	X	X			X
Vireo olivaceus	Red-eyed vireo	*	X	X	X	X	X		X			
Vireo philadelphicus	Philadelphia vireo								X			
Mniotilta varia	Black and white warbler		X	X	X		X	X				
Protonotaria citrea	Prothonotary warbler	*		X	X	X	X		X			
Limnothlypis swainsonii	Swainson's warbler			X								
Helmitheros vermivorus	Worm-eating warbler			X								
Vermivora chrysoptera	Golden-winged warbler			X								
Vermivora pinus	Blue-winged warbler											X
Vermivora bachmanii	Bachman's warbler				X				X			
Vermivora peregrina	Tennessee warbler								X			
Vermivora celata	Orange-crowned warbler		X	X	X				X			
Parula americana	Northern parula	*	X	X	X	X	X	X	X			X
Dendroica petechia	Yellow warbler								X	X		
Dendroica trigrina	Cape May warbler						X	X				X
Dendroica caerulescens	Black-throated blue warbler		X						X			
Dendroica coronata	Yellow-rumped warbler		X	X	X		X	X	X			X
Dendroica fusca	Blackburnian warbler		X									
Dendroica dominica	Yellow-throated warbler		X	X	X	X	X	X	X			
Dendroica pensylvanica	Chestnut-sided warbler		X									
Dendroica striata	Blackpoll warbler		X						X			
Dendroica pinus	Pine warbler		X	X		X	X	X	X			X
Dendroica kirtlandii	Kirtland's warbler			X								
Dendroica discolor	Prairie warbler		X		X		X					
Dendroica palmarum	Palm warbler		X	X			X	X			X	
Seiurus aurocapillus	Ovenbird		X	X					X			
Seiurus noveboracensis	Northern waterthrush								X			

Table 2.7.2-10. Preferred Habitat and Seasonal Occurrence of Vertebrates Known or Expected to Occur in the Vicinity of the Proposed Plant Site, Citrus County (Continued, page twelve of sixteen)

Order Species	Common Name	Species Observed	Pine/Oak Sand-hill Scrub	Mesic & Xeric Hammock	Coastal & Hy-dric Hammock	Cypress Dome	Pine Flatwoods	Pine Plantation	Mixed Swamp	Fresh Marsh	Salt Marsh	Pasture & Developed (Ruderal)
Passeriformes (continued)												
Seiurus motacilla	Louisiana waterthrush								X			
Oporornis agilis	Connecticut warbler				X				X			
Geothlypis trichas	Common yellowthroat	*	X	X	X	X	X		X	X	X	
Icteria virens	Yellow-breasted chat	*							X			
Wilsonia citrina	Hooded warbler			X	X							
Melospiza melodia	Song sparrow	*					X					

Table 2.7.2-10. Relative Abundance and Preferred Habitat of Vertebrates Known or Expected to Occur in the Vicinity of the Proposed Plant Site, Citrus County (Continued, page thirteen of sixteen)

Order Family Species	Common Name	Species Observed	Pine/Oak Sandhill Scrub	Mesic & Xeric Hammock	Coastal & Hydric Hammock	Cypress Dome	Pine Flatwoods	Pine Plantation	Mixed Swamp	Fresh Marsh	Salt Marsh	Pasture & Developed (Ruderal)
Caudata												
Sirenidae												
Siren lacertina	Greater siren		X	X	X	X			X	X		
Siren intermedia	Lesser siren		X			X	X		X	X		
Pseudobranchus striatus axanthus	Narrow-sriped dwarf siren		X			X	X			X		
Pseudobranchus striatus lustricolus	Gulf hammock dwarf siren					X	X					
Ambystomatidae												
Ambystoma cingulatum	Flatwoods salamander					X	X					
Ambystoma talpoideum	Mole salamander		X	X	X							
Ambystoma tigrinum trigrinum	Tiger salamander		X	X								
Salamandridae												
Notophthalamus viridescens piaropicula	Peninsula newt		X	X	X	X	X			X	X	
Notophthalamus perstriatus plethodontidae	Striped newt		X	X	X	X	X			X		
Plethodontidae												
Desmognathus auriculatus	Southern dusky salamander			X	X	X	X					
Pseudotriton montanus	Mud salamander			X								
Plethodon glutinosus	Slimy salamander	*		X	X	X	X					
Eurycea quadridigitata	Dwarf salamander				X	X	X					
Amphiumidae												
Amphiuma means means	Two-toed congo eel				X	X	X		X	X		
Anura												
Pelobatidae												
Scaphiopus holbrooki	Eastern spadefoot toad		X	X	X		X					
Leptodactylidae												
Eleutherodactylus planirostris planirostris	Greenhouse frog			X			X					
Ranidae												
Rana areolata	Gopher frog		X	X								X
Rana catesbeiana	Bullfrog		X	X	X	X	X			X		X
Rana clamitans	Bronze frog	*		X	X	X	X		X			
Rana grylio	Pig frog	*	X	X		X	X			X	X	X
Rana heckscheri	River frog				X	X	X		X			
Rana utricularia	Southern leopard frog	*	X	X	X	X	X		X	X	X	X
Microhylidae												
Gastrophryne carolinensis	Eastern narrow-mouth toad	*	X	X	X	X	X	X		X		X

Table 2.7.2-10. Relative Abundance and Preferred Habitat of Vertebrates Known or Expected to Occur in the Vicinity of the Proposed Plant Site, Citrus County (Continued, page fourteen of sixteen)

Order / Family / Species	Common Name	Species Observed	Pine/Oak Sandhill Scrub	Mesic & Xeric Hammock	Coastal & Hydric Hammock	Cypress Dome	Pine Flatwoods	Pine Plantation	Mixed Swamp	Fresh Marsh	Salt Marsh	Pasture & Developed (Ruderal)
Bufonidae												
Bufo querecius	Oak toad	*	X	X			X					
Bufo terrestris terrestris	Southern toad	*	X	X	X	X	X	X	X	X		X
Hylidae												
Acris gryllus dorsalis	Florida cricket frog	*	X	X	X	X	X			X	X	X
Hyla crucifer bartramiana	Florida peeper			X	X	X	X					
Hyla cinerea cinerea	Green treefrog	*	X	X	X	X	X		X	X	X	
Hyla femoralis	Pine woods treefrog		X			X	X	X				
Hyla gratiosa	Barking treefrog		X	X	X	X	X					X
Hyla squirella	Squirrel treefrog	*	X	X	X	X	X	X	X	X	X	
Hyla versicolor	Gray treefrog			X	X				X			
Pseudacris nigrita nigrita	Southern chorus frog						X	X				X
Pseudacris nigrita verrucusa	Florida chorus frog					X						
Pseudacris ornata	Ornate chorus frog		X	X		X	X					X
Limnaoedus ocularis	Little grass frog	*		X	X	X	X			X		
Testudines												
Chelydridae												
Chelyolra serpentina serpentina	Snapping turtle									X	X	
Kinosternidae												
Stenotherus odoratus	Musk turtle		X	X	X	X	X			X	X	X
Stenotherus minor	Loggerhead musk turtle					X				X		
Kinosternon bauri bauri	Striped mud turtle		X	X	X	X	X		X	X	X	X
Kinosternon subrubrum steindachneri	Florida mud turtle	*				X	X			X		
Emydidae												
Terrapene carolina bauri	Florida box turtle	*		X	X		X	X		X		
Malaclemys terrapin	Diamondback terrapin										X	
Chrysemys floridana	Florida cooter		X	X	X	X	X			X	X	X
Chrysemys concinna suwanniensis	Suwannee cooter										X	
Chrysemys scripta	Yellow-bellied turtle					X			X	X		
Deirochelys reticularia	Chicken turtle		X				X			X		
Testudinidae												
Gopherus polyphemus	Gopher tortoise	*	X	X								X
Cheloniidae												
Chelonia mydas mydas	Atlantic green turtle										X	
Eretmochelys imbricata imbricata	Atlantic hawksbill										X	
Caretta caretta	Atlantic loggerhead										X	
Lepidochelys kempi	Atlantic ridley										X	

Table 2.7.2-10. Relative Abundance and Preferred Habitat of Vertebrates Known or Expected to Occur in the Vicinity of the Proposed Plant Site, Citrus County (Continued, page fifteen of sixteen)

Order / Family / Species	Common Name	Species Observed	Pine/Oak Sand-hill Scrub	Mesic & Xeric Hammock	Coastal & Hydric Hammock	Cypress Dome	Pine Flatwoods	Pine Plantation	Mixed Swamp	Fresh Marsh	Salt Marsh	Pasture & Developed (Ruderal)
Dermochelyidae												
Dermochelys coriacea	Atlantic leatherback										X	
Trionychidae												
Trionyx ferox ferox	Florida soft-shelled turtle									X		
Crocodylia												
Alligatoridae												
Alligator mississippiensis	American alligator	*					X		X	X	X	
Squamata												
Iguanidae												
Anolis carolinensis	Green anole	*	X	X	X	X	X	X				
Sceloporus undulatus	Fence lizard	*	X	X	X			X				
Sceloporus woodi	Florida scrub lizard		X	X								
Scincidae												
Leiolopisma laterale	Ground skink	*	X	X	X	X	X	X	X			X
Eumeces fasciatus	Five-lined skink			X								
Eumeces laticeps	Broad-headed skink	*		X	X	X	X		X			
Eumeces inexpectatus	Southeastern five-lined skink		X	X	X	X	X	X				
Eumeces egregius onocrepis	Peninsula mole skink		X	X	X							
Teiidae												
Cnemidophorus sexlineatus	Six-lined racerunner	*	X	X				X				X
Anguidae												
Ophisaurus ventralis	Eastern glass lizard	*	X	X	X	X	X	X		X		X
Ophisaurus longicauda	Slender glass lizard		X									
Ophisaurus compressus	Island glass lizard				X		X					
Rhineura floridana	Worm lizard		X	X	X							
Colubridae												
Natrix fasciata pictiventris	Banded water snake	*	X	X	X	X	X		X	X	X	X
Natrix fasciata clarki	Gulf salt marsh snake										X	
Natrix cyclopion	Green water snake									X	X	
Natrix rigida	Glossy water snake	•				X	X					
Natrix taxispilotta	Brown water snake								X			
Liodytes alleni	Striped swamp snake					X	X			X	X	
Seminatrix pygaea	Black swamp snake		X	X	X	X	X			X		X
Thamnophis sauritus sackeni	Peninsula ribbon snake		X	X	X	X	X		X	X		
Thamnophis sauritus nitae	Blue-striped ribbon snake				X						X	
Thamnophis sirtalis similis	Blue-striped garter snake	*									X	
Virginia striatula	Rough earth snake					X	X					
Storeria occipitomaculata	Red-bellied snake	*		X	X		X					
Storeria dekayi	Brown snake				X		X			X	X	X

Table 2.7.2-10. Relative Abundance and Preferred Habitat of Vertebrates Known or Expected to Occur in the Vicinity of the Proposed Plant Site, Citrus County (Continued, page sixteen of sixteen)

Order Family Species	Common Name	Species Observed	Pine/Oak Sand-hill Scrub	Mesic & Xeric Hammock	Coastal & Hydric Hammock	Cypress Dome	Pine Flatwoods	Pine Plantation	Mixed Swamp	Fresh Marsh	Salt Marsh	Pasture & Developed (Ruderal)
Anguidae (continued)												
Heterodon platyrhinos	Eastern hognose snake		X	X	X							X
Heterodon simus	Southern hognose snake		X	X								X
Diadophis punctatus	Ringneck snake	*	X	X	X	X	X	X	X			X
Rhadinaea flavilata	Pinewoods snake			X		X	X	X				
Farancia erytrogramma	Rainbow snake				X	X			X	X		
Farancia abacura	Mud snake				X	X	X		X	X		
Coluber constrictor	Black racer	*	X	X	X	X	X	X	X	X	X	X
Masticophis flagellum	Eastern coachwhip	*	X	X	X							
Opheodrys aestivus	Rough green snake		X	X	X	X	X	X	X	X	X	
Elaphe guttata guttata	Corn snake		X	X	X		X					
Elaphe obsoleta williamsi	Gulf hammock rat snake	*		X	X						X	
Pituophus melanoleucus mugitus	Florida pine snake		X	X								
Drymarchon corais couperi	Indigo snake	*	X	X	X	X	X	X		X	X	
Lampropeltis getulus getulus	Eastern kingsnake				X	X	X			X		
Lampropeltis triangulum elapsoides	Scarlet kingsnake		X		X	X	X	X				
Cemophora coccinea	Scarlet snake		X	X	X		X					
Stilosoma extenuatum	Short-tailed snake		X	X								
Tantilla relicta neilli	Florida crowned snake		X	X	X			X				
Elapidae												
Micrurus fulvius fulvius	Eastern coral snake		X	X	X		X	X				
Viperidae												
Agkistrodon piscivorus conanti	Florida cottonmouth	*			X	X	X		X	X	X	
Sistrurus miliarius barbouri	Dusky pigmy rattlesnake		X	X	X	X	X	X				X
Crotalus horridus atricacudatus	Canebrake rattlesnake				X	X			X			
Crotalus adamanteus	Eastern diamondback rattlesnake	*	X	X	X		X	X		X	X	X

Table 2.7.2-11. Qualitative Small Mammal Trapping From Habitats at The Proposed Site: August, 1977

Community/Number of Trap Nights	Cotton Rat	Cotton Mouse	Florida Mouse	Short-tail Shrew
Pine Flatwoods (68 Trap Nights)	7	6	—	1
Hydric Hammock (94 Trap Nights)	—	29	—	1
Coastal Hydric Hammock (94 Trap Nights)	—	31	—	1
Evergreen Oak Scrub (18 Trap Nights)	—	1	2	—

species, along with many bird species, are more mobile and may utilize a variety of different habitats depending on season, food supply, available cover, breeding/nesting requirements, and climate. Other species are more restricted and their ranging habits are confined to a specific area or habitat. Some of these exclusives occurring in the region include rufous-sided towhee (sandpine scrub and pine flatwoods); hispid cotton rat (pine flatwoods); broad-head skink (mixed swamp); and Gulf hammock rat snake (mesic and coastal hammock). With an increase in the variety of plant communities, there is a greater number of microhabitats. These microhabitats are often times utilized by a very diverse fauna; i.e., narrow-mouth toad,* slimy salamander,* and Florida red-bellied snake.*

Interfaces between different plant communities are also important to wildlife. These areas, known as "edges," support a denser, more diverse fauna (Odum, 1971). The large continuous coastal hammock forest of western Florida and the adjoining salt marsh support a variety of game and non-game species. On forested lands, forest edge and successional thickets may harbor greater concentrations of deer, songbirds, quail, and rabbits. In general, the interspersion of plant communities and increased edge has provided a suitable habitat for a very diversified fauna.

On the project area, the abundance of browse and mast producing species, combined with the extensive variety of ecotones and plant communities, provide a substantial amount of food and potential denning and nesting

sites for many species. Acorns are a major source of food for many species of wildlife for much of the year (Goodrum, et al., 1971). Acorn production, although not evenly distributed in the plant communities, is considerable because of the large number of well-formed oak trees. Wildlife species on the site known to utilize acorns as a staple food source include deer, turkey, gray and fox squirrel, quail, blue jay, and a host of other species. Browse species, i.e., greenbriar,* sumac,* grasses,* and legumes,* as well as non-acorn mast producing species (dogwood,* persimmon,* grape,* maple,* poison ivy,* and wax myrtle*) can be important to wildlife. Production of fruit by small trees, shrubs, and vines may exceed acorn production.

Salt Marsh

Vertebrate wildlife diversity in salt marshes is relatively low compared to other habitates due to the changing conditions placed upon inhabitants by fluctuating water levels, varying salinity, and exposure. The marsh, however, does provide important support for some species such as breeding and resting grounds, particularly for waterfowl. Animal activity is directly related to tidal fluctuations (Johnson, et al., 1974). Most of these species have mechanisms enabling them to escape tidal flooding. In the salt marsh, the detritus food chain predominates. Animals occurring in the salt marsh may be exclusives (marsh wrens, clapper rails, willet, seaside sparrow and diamondback terrapin), as well as ubiquitous forms (raccoons, river otter, mink and crows) which utilize a large variety of habitats. Many species are occasional

inhabitants utilizing the marsh either seasonally or on a short-term (daily) basis.

Few species of herptiles occur regularly in the salt marsh. Characteristic reptiles of the salt marsh include the ornate diamondback terrapin, blue-striped garter snake,* blue-striped ribbon snake, and Gulf Salt marsh snake. Occasional inhabitants are the American alligator,* Suwannee cooter, eastern indigo snake, and a few species of frogs. Some breeding bird species which commonly occur are long-billed marsh wren, seaside sparrow, clapper rail,* and common yellow-throat.* These hawks, gulls, white ibis,* blackbirds, grackles,* herons, belted kingfishes,* terns, and black skimmers* utilized the salt marshes extensively as feeding grounds.

Fresh Marsh

Although fresh marshes occupy a very small acreage in the proposed power plant site, these areas are nevertheless very important to wildlife, particularly as feeding and watering sites. These wetlands are used extensively by wildlife whenever succulent emerging vegetation is present. White-tailed deer, marsh rabbit, and a variety of small mammals regularly feed in such areas. Various herons and egrets frequently prey upon small vertebrate and invertebrate populations found in these wetlands. Many of the species typical of freshwater marshes were not observed, probably because of the small size and ephemeral nature of these systems on the project area.

Pine Flatwoods

Most wildlife of the on-site pine flatwoods use the ground stratum for feeding, nesting, and cover. Generally, pine flatwoods do not support sizable populations of game species except where disturbance has occurred and where there is an interspersion of other vegetative types (Ripley, et al., 1962).

The pine flatwoods have an incomplete canopy cover, and as a result, numerous species of shrubs and herbaceous plants are found in scattered areas. These ground species may include saw-palmetto, wire grass, gallberry, blueberry, huckleberry, numerous grasses, sedges, and forbs. These plants produce a large amount of fruit and leafy material. Herbivorous and omnivorous animals feed extensively on these materials. In some sections of the pine flatwoods, the palmetto is dense and retards the growth of many important food plants. Palmetto foliage provides cover and nesting sites, but is relatively low in food value to wildlife. In other sections, the ground stratum is relatively free of palmetto and gallberry and contains various legumes, grasses, and other low herbaceous plants. These plants are important food sources for such species as quail, dove, cotton rat, cottontail rabbit, deer, and many passerine birds. Acorn production is very limited in the pine flatwoods.

The most commonly encountered herptiles were the six-lined racerunner, oak toad, black racer, Florida box turtle, and gopher tortoise. Bird species observed were rufous-sided towhee, carolina wren, bobwhite

quail, ground dove, mourning dove, blue-gray gnatcatcher, and red-bellied woodpecker. The hispid cotton rat is characteristic and was collected during the study. Other mammals frequently encountered were the nine-banded armadillo, cotton mouse, raccoon, eastern cottontail rabbit, shorttail shrew, eastern mole, and gray squirrel.

Pine Plantation

Faunal associations of the pine plantation are similar to those found in the pine flatwoods. In terms of wildlife production, pine plantations are most productive during the first 5 to 7 years, before canopy closure occurs and while herbaceous vegetation is still abundant. As canopy closure occurs, ground vegetation is shaded out and the abundance and diversity of wildlife decreases (Smith, 1958; Bailey and Alexander, 1960). Wildlife frequenting such homogeneous forest stands as pine plantation are generally found around the edges and openings where habitat diversity is greatest (Umber and Harris, 1974; Pearson, 1968).

Species of wildlife observed were generally the same as those occurring in the pine flatwoods.

Evergreen Oak Scrub

Conditions of the evergreen oak scrub community are extremely dry and hot because of the absence of overstory and the less dense understory vegetation. Typically this community occurs on higher well-drained fine sands. Food producing plants are rather sparse in the understory and herbaceous plants are essentially absent in the ground stratum. Some

acorn production does occur in these areas. Species of wildlife within this association have made several adaptations to the dry, hot conditions by being active only at night, utilizing subterranean retreats, or being armored. The gopher tortoise is an example of these adaptations. The den of the gopher tortoise is often used as a retreat or hibernaculum by such species as black pine snake, indigo snake, gopher frog, Florida mouse, and diamondback rattlesnake.

The reptiles and amphibians of these areas was rather depauperate with the gopher tortoise, sixlined racerunner, black racer and oak toad the only species encountered. Other herptiles known to occur in this habitat are sand skink, crowned snake, worn lizard, brown mole skink, short-tailed lizard, scrub lizard, and slender glass lizard. The scrub jay, the only characteristic bird of this habitat, was not encountered on-site. Other common species which were observed included the brown thrasher, mockingbird, white-eyed vireo, and carolina wren. Two Florida mice were trapped in these areas. No other mammals were observed in this community although they probably occur.

Mesic Hammock

The mesic hammock association occurs on somewhat higher land in moderately moist soils. Canopy cover reaches almost a maximum; subsequently herbaceous vegetation is usually sparse with blueberry prevalent in scattered localities. The wildlife of the mesic hammock share some components with that of the hydric hammock. The relatively

moist environment in the mesic hammock allows the presence of creatures which must have considerable moisture available for their survival.

Herptiles found in this habitat were the slimy salamander, eastern garter snake, Gulf Hammock rat snake, eastern indigo snake, the Florida red-bellied snake, the eastern diamondback rattlesnake and the broad-headed skink. The barred owl and turkey are characteristic year-round resident birds. An assortment of birds were observed in this habitat (Table 2.7.2-10). Mammals which were frequently encountered were grey squirrel, cotton mouse, raccoon, and nine-banded armadillo.

Hydric Hammock (Hydric and Coastal Hydric Hammock)

Because of the vegetative diversity and alteration of dry and wet habitats, these forested communities offer a greater diversity of microhabitats than most other ecosystems in the study area. Along with mixed swamp these habitats may often serve as wildlife reservoirs (when surrounding lands are stressed by draughts, fire, or human disturbance). The fauna of these habitats is generally a mix of species of aquatic habitats as well as the more upland, xeric habitats. Mast production is considerable and herbaceous growth is abundant in most sections.

Few exclusive species of herptiles occur in hydric hammocks. The most commonly encountered species were green tree frog, green anole, and narrow-mouthed toad. Other species observed were Gulf Hammock rat snake, broad-headed skink, and slimy salamander.

Bird usage of hydric hammock varies seasonally. Breeding summer residents include swallow-tailed kite,* red-eyed vireo,* acadian flycatcher, and prothonotary warbler.* Among the assortment of other birds which use these habitats are eastern kingbird,* great crested flycatcher,* carolina wren,* yellow-billed cuckoo,* northern parula warbler, pileated woodpecker,* and red-billed woodpecker.* Mammals commonly noted in these areas were deer, raccoon, river otter, and cotton mouse. In addition, these habitats and mixed swamp may be the last retreat for the Florida panther and black bear in some sections of the southeast (Wharton, et al., 1976).

Ruderal Areas

These are areas where most or all native vegetation has been removed or altered by human activity. This habitat is characterized by plant communities which are in some form of the early successional process. Food plants mainly consist of various grasses and sedges. Bare substrate is often present with rubble and exposed limestone rock occurring. Cover and denning sites are very sparse. The fauna of such areas were rather depauperate. Birds found in this habitat included the mocking bird, loggerhead shrike, meadow lark, and killdeer. No mammals were observed in these areas. The eastern diamondback rattlesnake and the gopher tortoise were the only sensitive species encountered.

Wellfield Site

The natural communities of the wellfield area are not described in as much detail as those of the plant site because the specific location has

not been approved. It is assumed that the well will be within the existing powerline corridor east of Highway 19 and will extend over an east-west linear area of about 4,876 meters (16,000 feet). It is also estimated that the potential area of impact would include an area of about 1.6 km (1 mile) of the field in any direction (ESE, 1977).

Plant communities in this well field area are slash pine flatwoods, freshwater marsh, mesic hammock, and ruderal areas (improved pasture and the transmission corridor). Progressing eastward, the hammocks and flatwoods acquire a more xeric nature, grading into xeric hammock and sandhill type vegetation. Slash pine flatwoods and pasture account for over 75 percent of the cover. The marshes in this area are generally larger, deeper, and more permanently flooded than are those at the site. Consequently, they appear to have greater species diversity and higher productivity.

Animal habitat in this area is less diverse than on-site, with fewer ecotones (edges). The area should provide better habitat for species of open communities and poorer habitat for species of heavily wooded communities than the plant site. Because of the larger size, greater depth, and prolonged inundation, these marshes are better quality habitat for wading birds and waterfowl than the marshes on-site. The western end of the wellfield area near Highway 19 is beginning to undergo commercial and residential development.

2.7.2.2 FUNCTION/DYNAMICS

Plant/Soil/Water Relationships

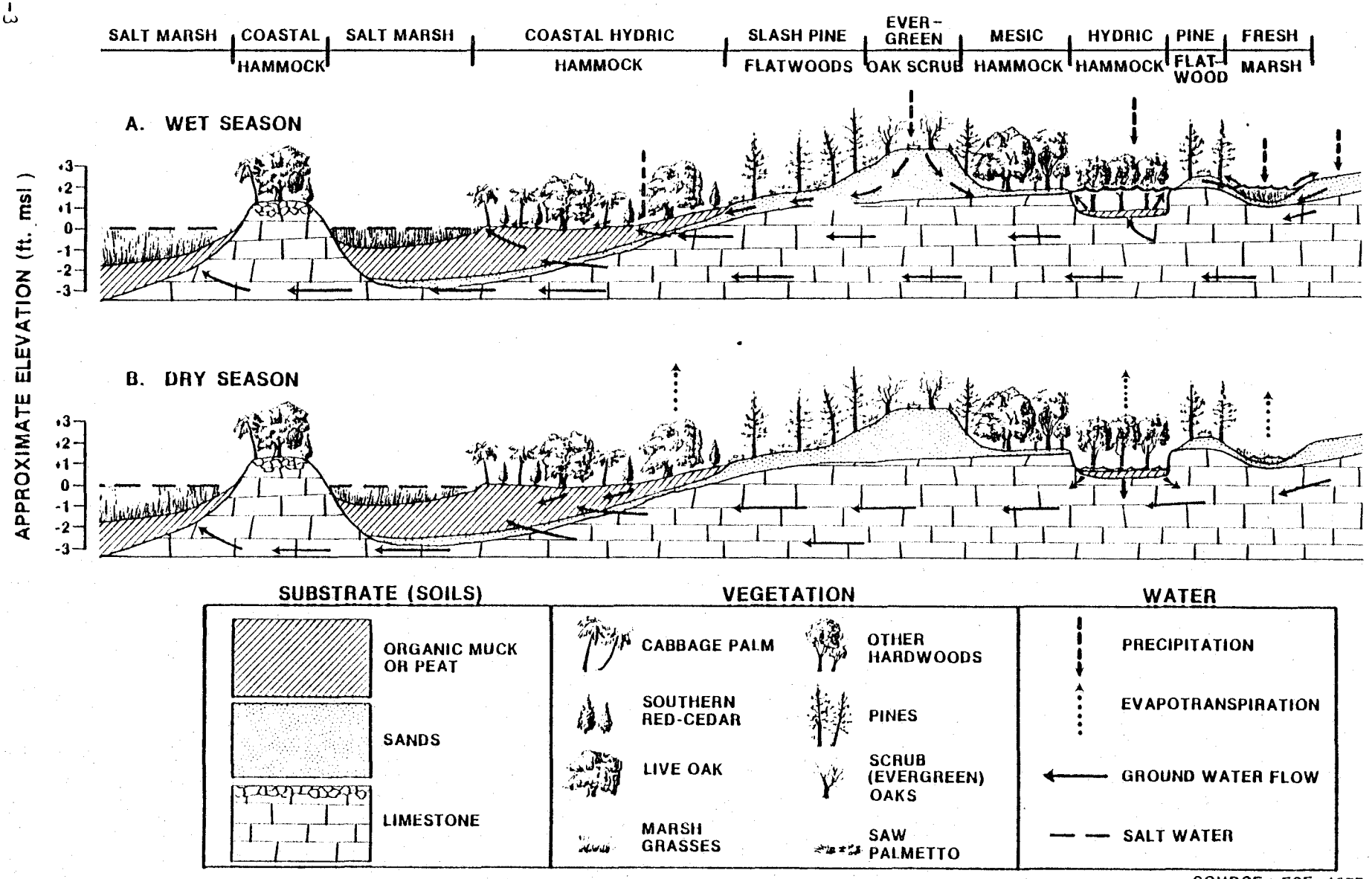
The plant communities of Florida have consistently been found to be closely related to the prevalent soil types and the depth and duration of flooding (Pessin, 1933; Lassle, 1958; Monk, 1966, 1968; Wharton, et al., 1976). This pattern also exists on the proposed site, but the proximity of the limestone substrate to the surface here tends to compress a wide variety of soil and moisture conditions into a small geographic area. These conditions provide for a high diversity of plant communities.

Pine flatwoods generally occur in low, level sandy areas with acidic soils and a relatively high water table, while mesophytic hardwoods (mesic hammock) occur on well drained sands overlain by organic matter with water table depths in excess of 101.6 centimeters (40 inches). Hydrophytic hardwoods (hydric hammocks and mixed swamps) and marshes are often found on peats and mucks from 0.6 to 3.0 meters (2 to 10 feet) deep. Scrub areas may have well drained sands over 30 meters (100 feet) in depth (Snedaker and Lugo, 1969).

Figure 2.7.2-3 illustrates that these classic examples of soil conditions are not apparent on the site because of the very thin and poorly developed soils which were noted during the field survey. In this case it appears that vegetation is largely influenced by relatively minor differences in the depth and type of surficial soils.

Figure 2.7.2-3

CONCEPTUALIZED PLANT/SOIL/WATER RELATIONSHIPS OF THE PROPOSED PLANT SITE



SOURCE: ESE, 1977

Hydric hammock is distinguished from mesic hammock as areas where the top 0.3 to 0.6 meters (1 to 2 feet) of substrate has dissolved or subsided, leaving a sink-like depression. Sands and mucks in these hammocks are very thin, ranging from less than 20 centimeters (8 inches) to about 0.6 meters (2 feet) where mesic hammock grades into flatwoods. This area appears to be largely internally drained through dissolution cavities, since few surface drainage patterns exist. Consequently, the water balance of these hammocks is probably closely associated with the ground water flow through the Floridan aquifer, which may retard the drying of hydric hammocks in the dry season. Water levels in hydric hammocks, judging by water marks on tree trunks, are in the range of 0.3 to 0.6 meters (2 feet) during the wet season.

Pine flatwoods occur where the sands are slightly deeper, 0.3 to 1 meters (1 foot to 3+ feet), and where the underlying rock seems less consolidated. Drainage from this area is probably largely subsurface along the top of the confining layer. The areas of evergreen oak scrub occur where the sands are greater than three feet in depth.

Freshwater marshes on the site are generally small depressions in the pine flatwoods. Only rarely is there a buildup of organic material [the deepest observed was 15 centimeters (6 inches)]. Most of the marshes have a layer of clay or marl less than 5 centimeters (2 inches) in thickness over the hard calcareous substrate. Although the smaller marshes have the appearance of borrow pits, the soil profile is similar to that of the larger marshes. These marshes are probably maintained by

surface and subsurface drainage of the surrounding areas, and lose more water through evapotranspiration than by percolation into deeper layers.

The ruderal areas in the transmission corridor were found to have soil depths of 7.6 to 38 centimeters (3 to 15 inches) before an inpenetrable layer was reached. No differences between the ruderal swamp, marsh, and upland areas were readily apparent.

The coastal hydric hammock differs from the rest of the site area by having definable surface drainage and a relatively deep organic layer [to 1 meter (3+ feet)]. In some areas a sand layer [to 0.6 meters (2 feet thick)] lies between the organic layer and the limestone. Coastal hydric hammock soils are generally poorly drained with the water table maintained by more or less constant discharge of springs (Wharton, et al., 1976). Rainfall usually results in some surface flooding.

Coastal hydric hammock is subject to periodic salt-water flooding during storm events (Wharton, et al., 1976). As a result, chlorides may accumulate in the soil during dry periods and may restrict occurrence to certain salt tolerant species.

In the salt marsh the sand/organic soils are of the salt water marsh association (Florida Division of State Planning, 1974), and are generally flooded by tidal waters. Distribution of species is generally

governed by depth of flooding and salinity content (Kurz and Wagner, 1957; Adams, 1963).

Successional and Community Relationships

Figure 2.7.2-4 represents the degree of relationship of those on-site communities which were sampled, as based upon Sorenson's Index for the similarity of species composition (see Chapter 6).

From the figure, it can be seen that the fresh marshes in the natural areas are essentially similar, regardless of size, while the marshes in the ruderal areas are more similar floristically to the upland early successional or old field areas.

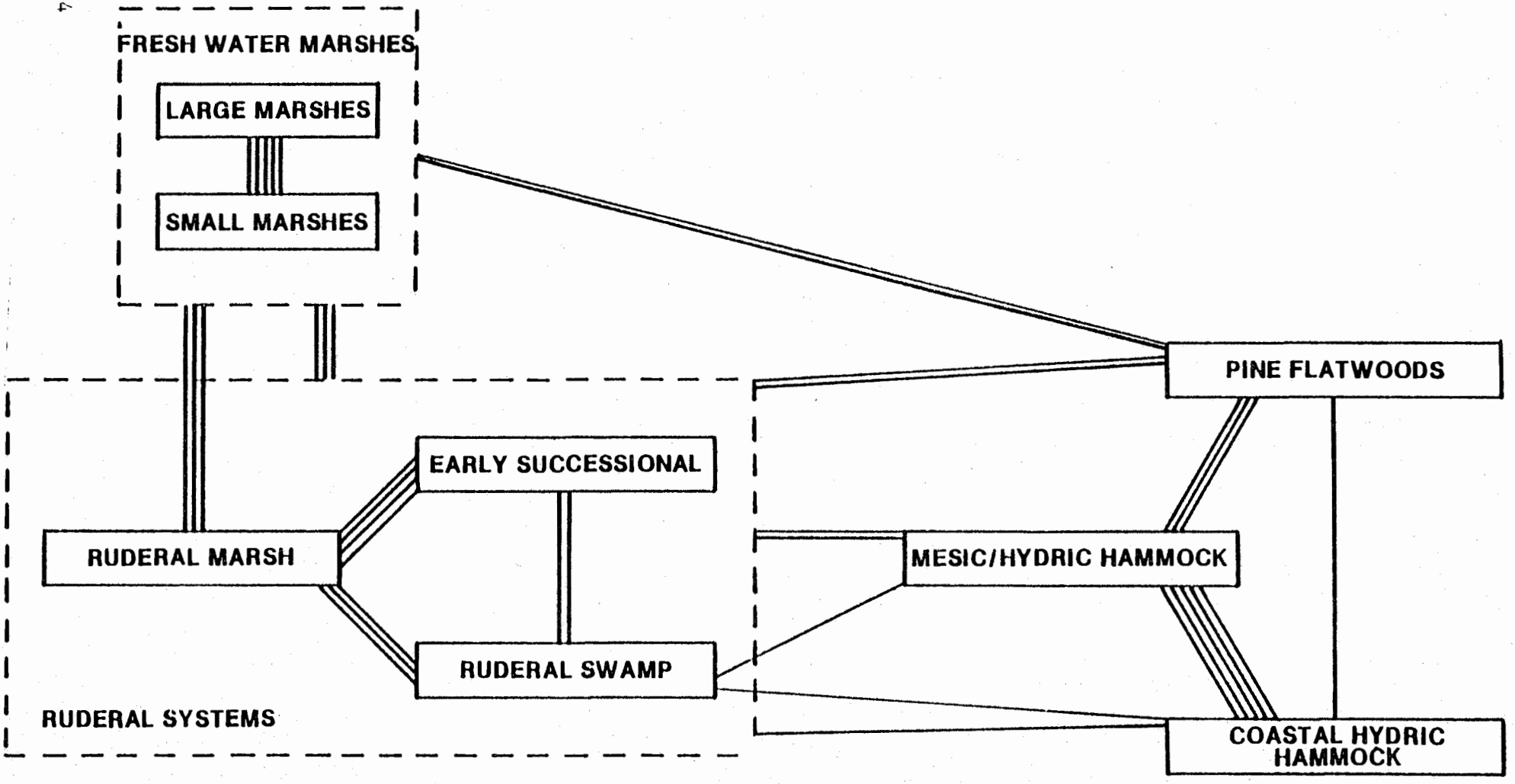
The limited similarity of the shrub swamps in the transmission corridor and of the mature wetland forest swamps implies that the three subtypes of the ruderal area do not have a close affinity to the more natural areas on the site and thus represent an altered and somewhat artificial system.

The three forest types appear to represent a continuum, with pine flatwoods and coastal hydric hammock similar to mesic/hydric hammock, but not to each other.

Although this analysis does not yield a statistically valid comparison of the vegetative communities on-site, it does give a general picture of the community relationships.

Figure 2.7.2-4

SIMILARITY OF ON-SITE PLANT COMMUNITIES BASED ON SPECIES COMPOSITION.
NUMBER OF LINES CONNECTING TWO SPECIES TYPES IS PROPORTIONAL TO DEGREE OF SIMILARITY.
BROKEN LINES CONTAIN BROAD ASSEMBLAGES OF TYPES EXPLAINED IN THE TEXT. (AFTER MONK, 1968)



SOURCE: ESE, 1977

Each of these types has been described as a discrete community occurring in a particular environmental condition. However, because of the complex interaction of many factors, including time, there can be considerable overlap of these types, as seen by the degree of species similarity. Over a sufficiently long period of time, a plant community may alter its environment to such a point that the process of successions, which involves a change in community structure and function, occurs (Oosting, 1956).

A generalized schematic of this successional trend (Monk, 1965, 1968; Quarterman and Keever, 1962; Florida Game and Fresh Water Fish Commission, 1976; Veno, 1976; Wharton, et al., 1976) for the site is shown in Figure 2.7.2-5. Human activity has resulted in substantial past clearing of the area so that most of the site is in a relatively early stage of development.

Calculation of the age of individual trees by tree ring analysis (Figure 2.7.2-6) shows that most of the trees in the pine flatwoods area are between 4 and 15 years old, with a very even age distribution. This distribution, along with a lack of hardwood seedlings, indicates that recent disturbance has returned this area to an early pine flatwoods stage.

The younger age of trees in the mesic/hydric hammock than of trees of the same species in the coastal hydric hammock (Figure 2.7.2-6)

Figure 2.7.2-5

GENERALIZED TREND OF PLANT SUCCESSION ON PROPOSED SITE. (AFTER MONK, 1968).

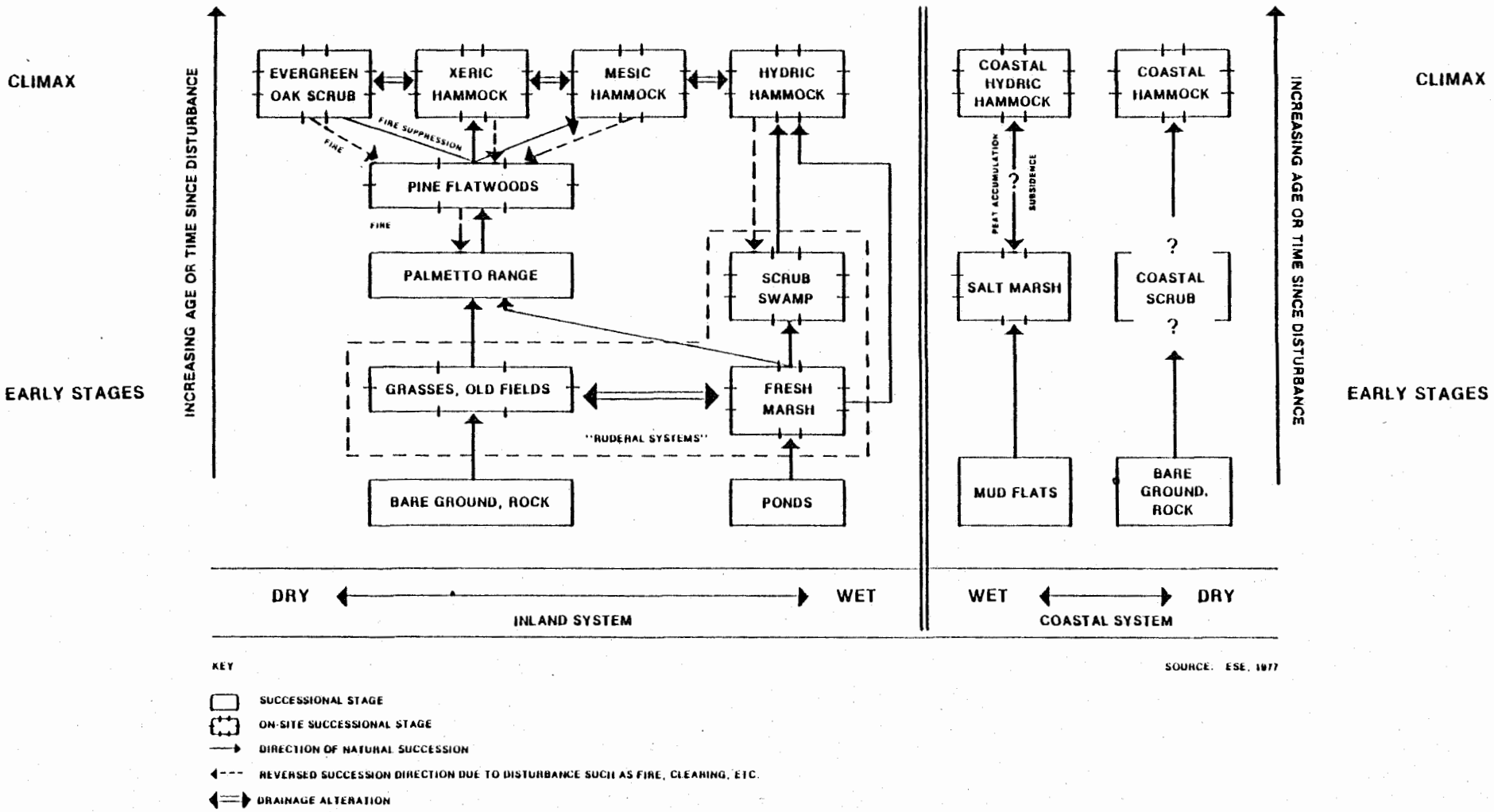
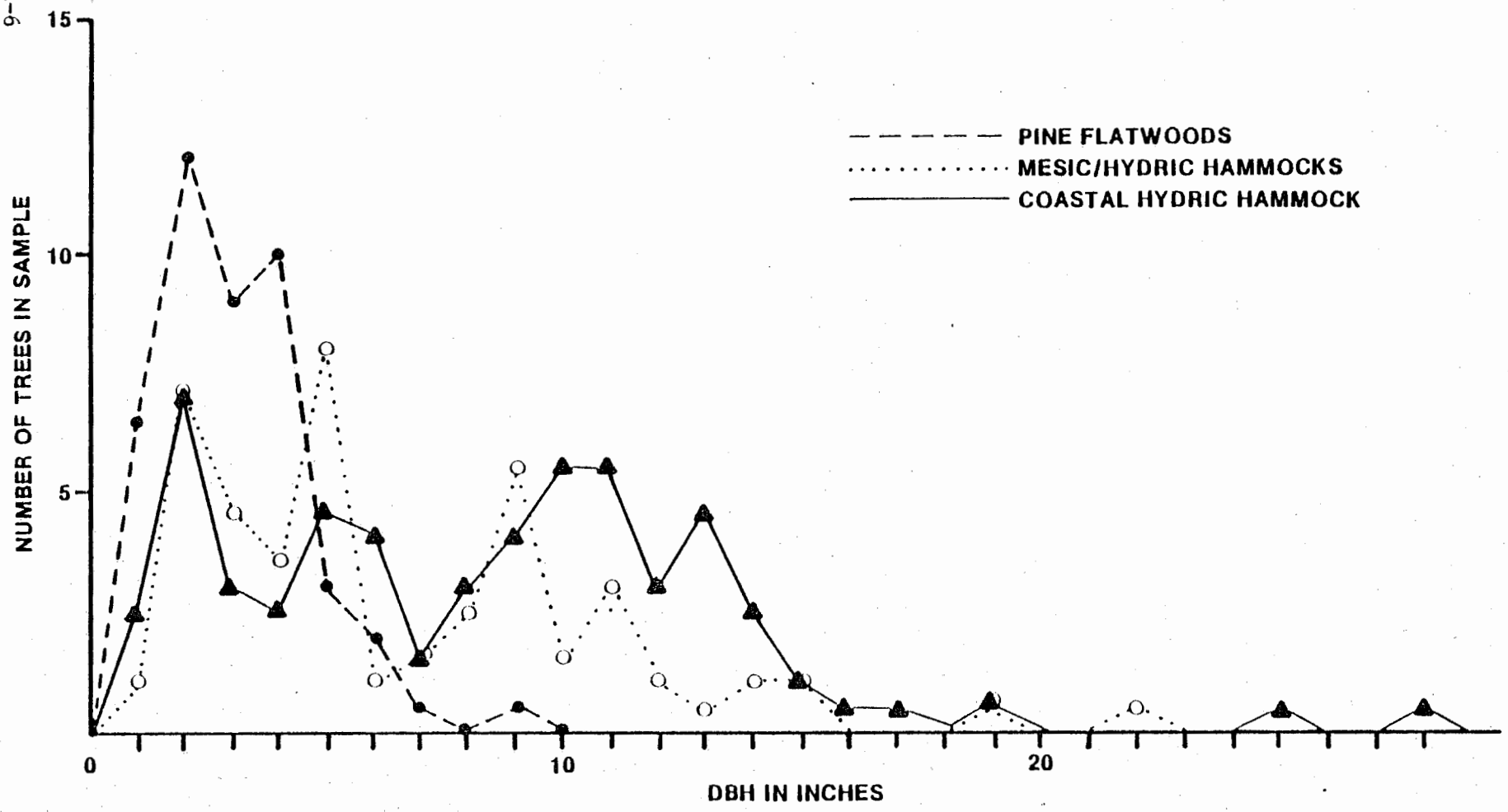


Figure 2.7.2-6

SIZE DISTRIBUTION OF MAJOR OVERSTORY TREES (SLASH PINE, CABBAGE PALM, SOUTHERN RED CEDAR, ALL OAKS) IN THREE AREAS OF THE SITE



SOURCE: ESE, 1977

indicates that this area has been more recently disturbed and is not an old-age mature climax stand. However, both areas can be considered in the climax stage since the dominant overstory trees are reproducing.

Although the coastal hydric hammock and the mesic/hydric hammock areas are floristically similar, it should not be deduced that they are necessarily a part of the same successional series. In the figures, they are treated as parallel successional patterns occurring in predominantly coastal and predominantly inland environments respectively, although intergradation undoubtedly can occur (Wharton, et al., 1976).

Animal succession proceeds with the same general pattern as plant succession--increase in diversity and specialization of organisms with time (Beckwith, 1954; Hirth, 1959; Johnston and Odum, 1959). However, patterns of change are not as dramatic as from one plant seral stage to the next stage. The presence or absence of animals is a function of vegetative types and the amount of cover. In many cases, the plant composition will change, but the effective cover or general tree life form will remain the same and resulting animal populations will be generally the same. The greatest differences in animal succession occur from grassland/pasture to shrub and from shrub to forest.

Given natural succession at the plant site, the animal communities will change little in the salt marsh and mesic/hydric hammock as compared to the longleaf/slash pine flatwood communities over the next 15 years. As

mentioned in the previous section, the marshes are in a relatively stable state and little change is expected in the vegetation and in animal communities. Since the mesic/hydric hammocks are not old-age mature climax stands, the understory and ground cover are more extensive than would be expected in a more mature stand. However, the changes which occur in the lower strata have a more long-term effect and will not drastically alter the present animal fauna.

The pine flatwood communities have recently been logged, and the area is in a disclimax shrub and early forest growth state. With the further development of pines (providing fire does not occur in the area) and a subsequent reduction of shrub and understory areas, the species normally associated with these areas will change. Based on general patterns seen in eastern North American forests, the density of birds and mammals should decline in this mid-successional period (Hirth, 1959; Johnston and Odum, 1956; Pearson, 1959). The condition of the pine flatwoods is now conducive to granivorous, insectivorous, and fructivorous birds. As succession proceeds, the insectivorous and fructivorous species will increase, as well as the omnivorous birds. The changes in mammal populations will be more quantitative than qualitative since most of the later seral stages of mammals are present.

Species Interaction

Many organisms of a given community often have dependent associations and similar niche requirements. The relationships of these organisms with these dependencies and overlapping habitat requirements results in

a particular animal community. It is this assemblage that gives an ecosystem its characteristic structure and function. The intricate interactions involved in a particular assemblage of organisms can be best described by a schematic of food chains and particular species associations.

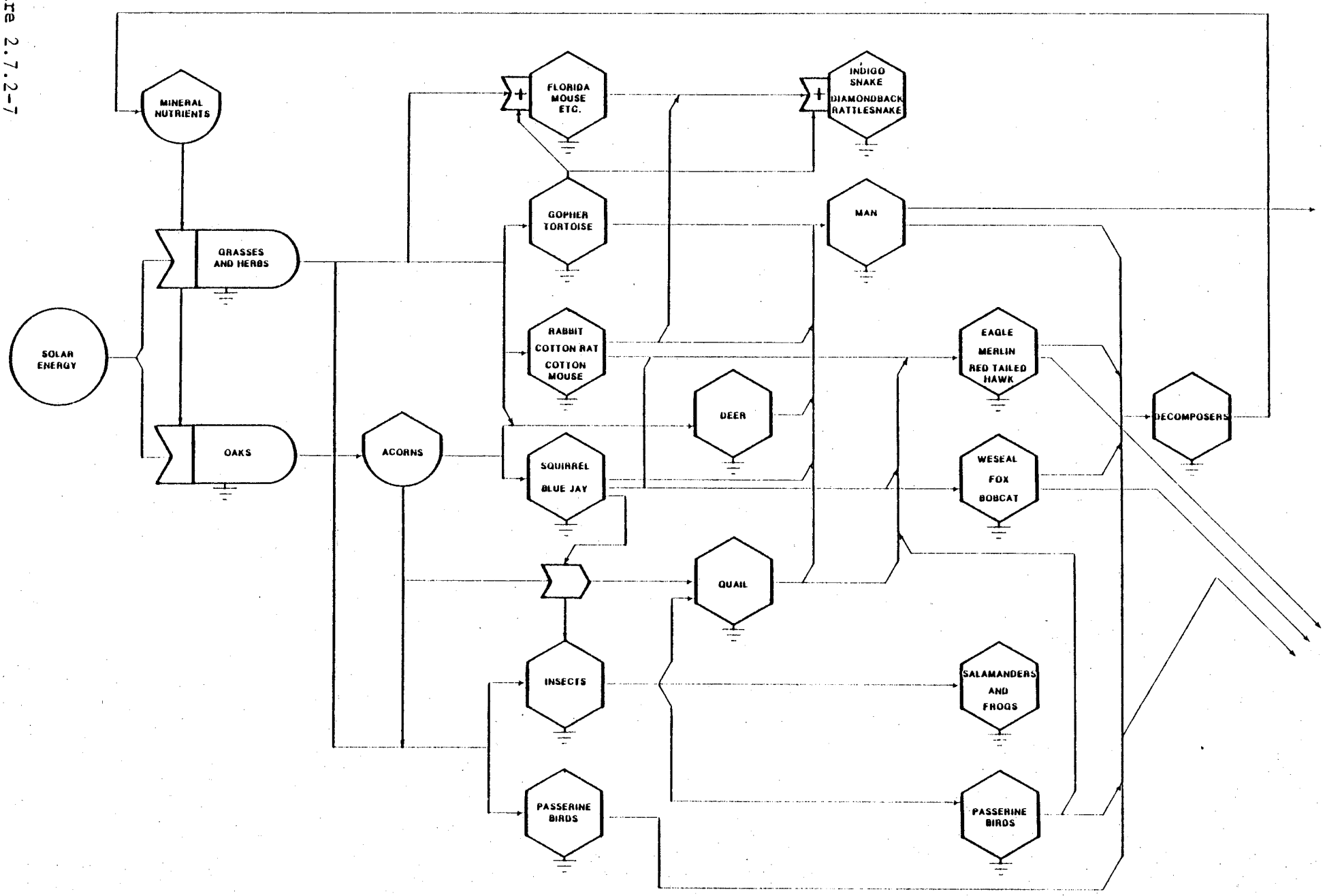
Figure 2.7.2-7 typifies the types of interactions that occur or can be expected to occur at the proposed site. This diagram is a generalized representative. Because the feeding behavior of some species involves them in more than one trophic level, a food web rather than a food chain, is depicted.

Food chains commonly contain three to five trophic levels: a plant (primary producer), a herbivore (primary consumer), and one or more carnivores (secondary consumers). The several interacting food chains represented in this diagram describe the food web of the site. The panicum grass/cotton mouse/diamondback rattlesnake relationship is typical of the grazing (herbivore) food chain (Figure 2.7.2-7).

Panicum grass is a primary producer, using solar energy for the manufacture of food. A herbivore, the cotton mouse, utilizes the food produced by green plants and thus fulfills the role of a primary consumer. These primary consumers are in turn fed upon by such animals as the diamondback rattlesnake, the secondary consumers. The decomposers operate at all levels and serve as a pathway for the recycling of mineral nutrients back to lower trophic levels. These types of interactions are often more complex and involve the same animals at different

A TYPICAL FOOD WEB AND SPECIES-ASSOCIATIONS FOUND AT THE PROPOSED PLANT SITE.

Figure 2.7.2-7



SOURCE: SNEDAKER AND LUGO, 1969.

trophic levels. For example, quail may feed on grasses and also on insects and thus are primary consumers and secondary consumers, respectively (Figure 2.7.2-7).

Some organisms, such as man, fox, bobcat, and red-tailed hawk, are more mobile and thus may remove some food (energy) from one ecosystem to another. Other symbiotic relations involve organisms in such association as competition, amensalism, parasitism, mutualism, commensalism, and neutralism. A typical interaction occurs between squirrels, jays, and quail (Figure 2.7.2-7). They all feed on acorns and thus are seemingly in direct competition. Squirrels and jays may be in direct competition for acorns still on the tree; however, quail cannot eat the fruit until the shell has been cracked and dropped to the ground by these arboreal species. Thus the quail are dependent upon the activity of other animals. Another example of species interactions is the use of the gopher tortoise burrow as a retreat by such species as the Florida mouse and the indigo snake. These animals may not be able to survive in certain habitats without the presence of the gopher tortoise. These symbiotic relationships are extensive and apparently involve most organisms of the forested ecosystems.

Influencing Factors and Stresses

As noted previously, the primary natural factors influencing the development and function of the natural systems are soil and moisture factors, and proximity to the coast; however, a large portion of the proposed site has been periodically altered by man's activities.

Wells (1942), Boyce (1954), Martin (1959), and Lassle and Monk (1961), showed that vegetational zonation in coastal forest communities is correlated to salt spray intensity. The coastal hydric hammock community on site appears to have these same zonal characteristics with decreasing canopy height and cover plus an elimination of non-tolerant species near the coast. These studies are based on Atlantic coast systems with beach, dune, and surf zones. Variation in wind pattern, lower elevation, and the presence of a wide marsh band at this Gulf Coast site may decrease salt spray intensity and thus increase the relative importance of other factors such as saltwater flooding, soil salinity, and hydroperiod. The coastal portions of the system at the site appear to have numerous fallen branches and trees, particularly cabbage palms. Whether this is a natural occurrence or a sign of increased stress is not known. Possible influences could be a submerging coastline and alterations in surface or ground water drainage patterns.

Stumps in the coastal hydric hammock indicate that selective logging has historically occurred. Other parts of the coastal hydric hammock system have been logged extensively for cedar (Wharton, et. al., 1976).

Upland areas have also been influenced by clearing and fire. Fire is a common natural event in the Florida pine flatwoods (Edminston, 1965; Snedaker and Lugo, 1972). Aerial photographs of the site taken in 1967 show that the upland areas had been recently cleared. Areas east and north of the site have since been planted as pine plantations, while the

on-site area has undergone natural secondary succession to its current state. No fire or clearing has since occurred.

Fire and clearing affects wildlife in the area through immediate, short-term stress, depending on the season and the intensity of the fire (Dames and Moore, 1974). Clearing produces similar effects, but may also lead to long-term habitat and population loss of less mobile species, such as the gopher tortoise and its associates. Early successional communities (like those created on-site) provide habitat for rabbits, quail, rodents, snakes, and other wildlife which would otherwise decline with continued succession and absence of fire (Snedaker and Lugo, 1972).

Animal populations also are influenced by the density of the vegetation. The dense pine and palmetto areas on the site would favor small, ground-dwelling species such as rodents and snakes, while the open pine plantations would favor larger mammals and the soaring raptors (i.e. red-tail hawk).

Fire ants (Solenopeis sp.) have also been reported as a possible stress factor on animal populations near the proposed site. The ants occurred primarily along windrows and field edges in pine plantations and old fields (Dames and Moore, 1974). Ground dwelling or nesting wildlife are susceptible to fire ant predation, with consequent lowered nesting success and population declines. Fire ants were not observed to be a problem during 1977 field surveys. This may have been due to sampling

in different locations, prior fire ant eradication programs, or habitat changes due to natural succession.

Air pollution does not appear to be a problem in the general area, although one assemblage of plants was noted in which leaf injury patterns similar to those of air pollution injury were seen. These few plants, in an area of about 100 square meters near the northeast corner of the existing ash pond, had the following appearance:

Grape--mild chlorosis (yellowing) of the leaves with brown spotting;

Vetch--necrotic (brown) tip burn of leaves;

Wild lettuce--mild chlorosis with white spotting of intervein portions of leaves;

Greenbriar--red leaves with brown and green spotting;

Saw palmetto--yellow leaves with brown, black, and white spotting;

Blackberry--chlorosis of leaf margins and intervein areas.

These symptoms are common in a wide variety of natural circumstances, and are certainly not specific to atmospheric causes. Their occurrence in a wide variety of species in a narrow geographic area, however, is indicative of some type of stress. Sulfur dioxide leaf damage is often evidenced by chlorotic streaking with stippled reddish-brown spots, and pale, collapsed or necrotic spots; ozone damage by collapsed necrotic areas and red-brown spots; PAN injury by glazed appearance and collapsed underside; floride damage by necrotic tip burn and chlorotic banding (Brandt and Heck, 1968; National Environmental Research Center, 1973; Jacobson and Hill, 1970). Other factors known to

cause similar symptoms include: bacterial, viral, and fungal diseases; insect infestation (National Environmental Research Center, 1973); temperature, wind burn (Brandt and Heck, 1968); salt spray (Boyce, 1954); and nutritional status and senescence. Since the concentrated symptoms appear only in a small area, it is likely that the cause is an isolated event and not atmospheric in nature, although air pollution can not be ruled out. It is also possible that the proximity of the ash pond may be a factor.

2.7.2.3 VALUE AND SERVICE

Wildlife Production

Overall, the area can be considered excellent wildlife habitat. The proposed site supports small game species, namely gray squirrel and bobwhite quail. There is also large game such as white-tailed deer. Other game species present are rabbit, mourning dove, and feral swine, although populations of any one species are not large. The hydric hammocks in the area are good year-round habitat for wood duck, furnishing nesting trees and ample food. Apparently, there are very few wild turkey in the area because of the lack of suitable acreage of prime habitat. Non-game species which occur in the area include flying squirrel, alligator, fox, raccoon, river otter, bald eagle, osprey, and a multitude of wading birds and passerine birds. The herpetofauna is rich and reflects the diversity of habitat.

Forest Products

Approximately 61 percent of the land area of Citrus County is commercial forest, holding volumes of 330 million board feet of sawtimber and

99 million cubic feet of growing stock (Snyder and Knight, 1970). About 20 percent of this land is in pine, with various oak associations comprising the remaining stands. Although 14 percent of the area within a 8 km (5-mile) radius of the proposed site has recently been planted in slash pine plantations, this area does not appear to be prime timber land. Site quality index is a term relating the height which a stand will attain at a certain age, usually rotation (harvest) age (Westveld and Peck, 1951). Barnes (1955) has established that Florida slash pine plantations of (10 to 15 years of age and tree heights of 3.05 to 4.57 meters (10 to 15 feet) (such as those near the site) have low (poor) site quality index values of 30 or 40, as opposed to values of 80 in high quality stands. Barnes and Ralston (1952) found that the best height growth in slash pine plantations occurred when the depth to the fine textured sands and clays was between 76.2 to 101.6 centimeters (30 and 40 inches), with a sharp decrease in growth of lesser depths. These results imply that the thin surface sands of the site may not be suitable for good pine production, although more inland areas may be suitable.

Historically, Southern red cedar was an important resource which attracted pencil factories to the region. Today, the remaining cedars are again beginning to reach a commercially harvestable size and can be considered a valuable, although reduced, resource (Wharton, et. al., 1976).

Soil and Water Conservation and Flood Control

Because there are no major surface water drainage patterns on the site and because much of the drainage is internal, the forest communities at the site currently do not play a significant role in "classical" flood control. However, the vegetative cover does provide important services in soil retention and erosion control in an area which already has very thin soils. The plant communities also are important in building up the soil layers through cycling of nutrients and production of organic humus. Carlisle, et. al. (1966) have shown that litterfall can account for 60 percent of internal nutrient input (phosphorus, potassium, calcium, magnesium) to the forest floor. Community type also has an effect on the amount of organic matter in the soil. Wells, et al. (1972) have found litterfall in hardwood stands to be 70 percent higher than that in pine stands. Odum (1960) found that although litter increased during the first years of field succession, the amount of organic matter in the topsoil actually declined.

Coastal hydric hammocks have been described as functioning as a buffer system between the estuary and the upland terrestrial systems (Wharton, et. al., 1976). During hurricanes and storm events, the hammocks reduce seawater flooding and velocity levels in inland areas. Conversely, the hammocks also reduce sudden influxes of fresh water (surface runoff due to high rainfall) into the estuaries, thereby reducing salinity fluctuations.

Other Values

The site is not unique in its recreation and aesthetic value. Although the site does have some potential for hunting and wildlife observations, these activities are not now, and are not expected to be, permitted because of the proximity of the existing power plant complex.

The forested areas do offer a visual buffer zone screening the appearance of the existing plants from some vantage points.

2.7.3 IMPORTANT SPECIES ANALYSIS

2.7.3.1 INTRODUCTION

This section discusses those plants and animals which to fall within any of the four categories of important species defined by the Florida Department of Environmental Regulation (1977). In this section the species are discussed under the following headings: Commercially and Recreationally Important Species; Rare and Endangered Species; and Functionally Critical Species.

2.7.3.2 COMMERCIALLY AND RECREATIONALLY IMPORTANT SPECIES

Introduction

Important species of the proposed power plant site include game animals and resident fur-producing species. Common small game species of wildlife consist of bobwhite quail, cottontail rabbit, and grey squirrel. Populations of white-tailed deer are present in much of the area and some adjoining lands. The land seasonally attracts a few migratory species such as woodcock, common snipe, various ducks and rails. A wide variety of fur-bearing mammals can be expected to occur on the site. The definite status of some of these species within the project boundaries is unknown.

Important plant species of the site have been identified as those tree species which have been harvested in this area for forest products historically or currently. These are slash pine and southern red cedar. Although other species may be considered to have a monetary value in terms of the value of storm protection or natural water purification, these values have been discussed previously and are not covered here.

Plants

Slash Pine

Slash pine, the dominant tree species of on-site flatwoods and pine plantations, is a major pulp source in Florida (Knight and McClure, 1971). Within a five mile radius of the plant about 4,350 acres (14 percent) are currently in pine plantation with another 4,460 acres (14 percent) of slash pine flatwoods of potential timber value. Except for a few older "seed trees," the plantations and flatwoods on-site contain young trees from about 4 to 15 years old. Estimated pulpwood volume of the plantations at harvest is about 27 cords or 1,800 cubic feet (site index tables, Bennett and Clutter, 1968). Since tree density in the flatwood is so great, timber potential is probably limited unless thinning occurs.

Southern Red-Cedar

Historically, this species has been logged from the coastal hammocks by pencil companies (Wharton, et al., 1976), but it is also valuable for fence posts, panels, and other building supplies. Trees currently in the coastal hydric hammock on-site include many between 2.54 and 25.4 centimeters (10 inches) diameter at breast height (DBH), which could be suitable for some of these uses. In other communities on-site, the trees are generally less than 7.62 centimeters (3 inches) DBH and thus of little current value. Based upon analysis of past growth rate, it is anticipated that these small trees will reach a commercial size of 2.54 to 50.8 centimeters (20 inches) DBH in about 40 to 80 years if undisturbed.

Animals

Bobwhite Quail

The bobwhite quail occurs throughout Florida usually around cut-over country, forest fringes, and old fields. Quail population in this area of Florida are fragmented because of insufficient acreage of quality habitat. There are, however, some sections of the proposed power plant site which offer good habitat. The best habitat occurs in the disturbed pine flatwoods and around a few small fields. In these two habitats, two large coveys of bobwhite quail were sighted during the summer field survey. Within these areas a fairly good blend of escape, nest, brood and forage cover exists. These quality habitats would seem short-lived unless understory vegetation is restricted. In addition, adjoining lands have recently been replanted to pine and presently offer good quail habitat.

White-Tailed Deer

The white-tailed deer occurs through the southeast and is abundant in much of Florida. The preferred habitat of deer is the brushy stages of second-growth deciduous forest. Present conditions in the vicinity of the project are condusive to supporting some populations of deer. No deer were observed, but tracks were noted daily along most unimproved dirt roads. Present population levels appear to be moderate.

Squirrel

Three species of squirrel can be expected to occur in the forest communities of Florida: grey squirrel, fox squirrel, and southern flying

squirrel. Of these three, only the grey and fox squirrel are significant as a hunting resource. The grey squirrel is an inhabitant primarily of mixed hardwoods whereas the fox squirrel generally prefers open woodlands and field-forest edges. Mesic and xeric hammocks are reported to be the best quality habitat for grey squirrel in the area with hydric, coastal, and loblolly pine hammock next in importance (Florida Game and Fresh Water Commission, 1976). These habitats are well represented on the site. Grey squirrels were sighted daily in many of these vegetative communities. The proposed site is considered poor habitat for fox squirrel.

Rabbit, Turkey, and Feral Swine

Apparently rabbit, turkey and feral swine population are not significantly large in the area. The major reason for these depauperate populations include: lack of suitable habitat; encroachment by man; land clearing for the purpose of development; and disjunct habitats.

Fur-Bearing Mammals

Fur-bearing mammals of western coastal Florida are opossum,* raccoon,* grey fox,* river otter,* mink, and bobcat. The opossum is common in nearly all wooded areas and coastal marshes. In mixed woodlands, raccoons prefer bottomlands for denning sites, and they forage over upland habitats and aquatic systems. Reported (Florida Game and Fresh Water Fish Commission, 1976) densities for opossums are 1 per 7.8 hectares (19 acres) in mixed swamp and raccoons are 1 per 96.4 hectares (217 acres)

in mixed swamp. The grey fox is more often found in lowlands adjacent to dense bottomland forest. The bobcat is primarily found in hardwood bottomlands and swamps as well as forested areas adjacent to these systems. Otter and mink are primarily riverine, swamp, or salt marsh species. Densities of grey fox, river otter, mink, and bobcat are poorly known for the area, however, Day (1973) reported densities of one mink and one otter per 16 hectares (40 acres) in a Louisiana salt marsh. It can be expected that most of these animals may occur on the site. Habitats are quite diverse and it would appear suitable to support relatively abundant populations.

2.7.3.3 RARE AND ENDANGERED SPECIES

Introduction

Rare and Endangered Species have been identified from both federal and state listings. These include the federal listings of the U.S. Fish and Wildlife Service (United States List of Endangered Fauna, 1974; Threatened Wildlife of the United States, 1973; Proposed Endangered Status on Some 1700 U.S. Vascular Plant Taxa, 1976). State listings included those of the Florida Game and Freshwater Fish Commission (1974) and the Florida Committee on Rare and Endangered Plants and Animals (1976). The species which were identified from these sources have been defined by one or more (depending upon source) of the following categories:

1. Endangered species (E)—those species in danger of extinction throughout all or a significant portion of their range,
2. Threatened species (T)--those species which are likely to become endangered in the foreseeable future throughout all or a significant portion of their range;

3. Rare species (R)--those species which are potentially at risk and should be monitored because of limited geographic ranges or sparse distributions;
4. Species of special concern (SC)--those species which should be monitored because of vulnerability to exploitation or environmental changes;
5. Status undertermined (SU)--those species which are likely to fall into one of the above categories, but for which sufficient data are not available.

Plants

Table 2.7.3-1 lists those plant species on the state and federal lists of rare and endangered species which have been reported for Citrus County and its contiguous counties, and which could possibly occur in the vicinity of the plant site if suitable habitat were present. The following paragraphs discuss the preferred habitats and likelihood of occurrence of each species.

Dwarf Spleenwort

This tropical fern reaches its northern limits in Florida, where small populations have been found only in eastern Citrus, Alachua, Marion, and Hernando counties. Found only in mesic and hydric hammocks, it is adapted to deeply shaded limestone substrates (Florida Committee, 1976). As such, it can not tolerate removal of the forest cover. Although possible habitat does occur in the hydric and mesic hammocks on site, this species was not observed during field surveys, and is not thought to occur on-site.

Table 2.7.3-1. Rare and Endangered Plant Species Reported in the Crystal River Region

Species	Common Name	Status		Reported Occurrence		Habitat
		Florida	Federal	Citrus County	Contiguous Counties*	
Asplenium pumilum	Dwarf spleenwort	E	---	X		Calcareous rock--moist hammock
Blechnum occidentale	Sink-hole fern	E	---		X	Deep-shaded ravines & sinkhole
Dicerandra frutescens	....	---	E		X	Deciduous oak sandhills
Sium floridanum	Water Parsnip	---	E		X	Mixed swamps & flooded areas
Zamia integrifolia	Coontie	T	E	X		All hammock & deciduous oak sandhills
Rhapidophyllum hystrix	Needle palm	T	T		X	Swamps & moist hammocks
Smilax smallii	Jackson-vine	T	---		X	Mixed swamp/bayheads
Isoetes flaccida	Quillwort	---	T	X		Moist areas & swamps
Persea humilis	Silkbay	---	T		X	Sand pine & deciduous oak sandhills
Adiantum capillus-veneris	Venus-hair fern	R	---	X		Mixed swamp & moist calcareous hammocks
Drosera intermedia	Water sundew	R	---	X		Ponds & bogs
Eriogonum floridanum	Scrub buckwheat	R	---		X	Dry sandy pinelands
Hartwrightia floridana	Hartwrightia	R	T		X	Swamps--North Florida
Leitnerio floridana	Corkwood	R	---	X		Sawgrass marshes along rivers
Liatris provinciales	Godfrey's blazing star	R	E		X	Coastal sands--dry pinelands
Litsea aestivalis	Pond spice	R	T		X	Pond & swamp margins, woodland
Salix floridana	Florida willow	R	E		X	Moist calcareous hammocks & swamps
Vicia ocalensis	Ocala vetch	R	E		X	Fields, roadsides, pine flatwoods
Epidendrum conopseum	green fly orchid	T		on site		

*Marion, Levy, Sumter, and Hernando counties.

Sink-hole Fern

This is another tropical fern which has been found in only four locations in the United States; one in Louisiana and three in Florida. Although not reported for Citrus County, its presence in Alachua County to the north and Hernando County to the south indicates that it could occur on the site (Florida Committee, 1976). Habitat consists of loamy soils over limestone in shaded moist hammocks (Wherry, 1964). Although not sighted on the site, potential habitat does occur in the various hardwood hammocks.

Dicerandra

This mint is endemic to the deciduous oak sandhils of the relic dunes of the central Florida ridge in Highlands and nearby Marion counties (Florida Game and Fresh Water Fish Commission, 1976). It is doubtful if this species ranges into western Citrus County. Suitable habitat does not occur on the site.

Water Parsnip

Water parsnip has been reported in Leon, Levy, Marion, and Putnum counties. It occurs in swamps, flooded areas, and muddy waters (Florida Game and Fresh Water Fish Commission, 1976). The clear marshes with hard, clean bottoms on the site are probably very poor habitat for this species.

Coontie

The fairly widely distributed coontie is the only species listed which was found during field surveys of the site. This member of the primitive cycad family was used as a food source by the Seminole Indians (Long and Lakela, 1971).

Occurrence on the site is occasional, with scattered individuals located in the mesic, hydric, and coastal hydric hammocks. Its on-site density may be relatively low on a regional level, since numerous individuals were also observed in the coastal hydric hammocks south of the property and at the archeological museum near Crystal River. It was also seen in xeric hammocks to the east of the site. The Florida Game and Fresh Water Fish Commission reports that this species is common to abundant in mesic, xeric, and coastal hammocks and sandhills throughout the coastal part of the state.

Venus-Hair Fern

This species has been reported for Citrus and surrounding counties, where it may occur in low numbers and small colonies (Florida Game and Fresh Water Fish Commission, 1976). It occurs on damp limestone rocks or occasionally in muck soils in hardwood hammocks and swamps (Cobb, 1963; Florida Game and Fresh Water Fish Commission, 1976). Although suitable habitat occurs on-site, this distinctive fern was not found during field surveys. On-site soils may be too acidic or saline for this species, thus precluding it from otherwise suitable habitat.

Water Sundew

Water sundew occurs throughout central Florida and the panhandle, as well as in Citrus County where it is locally abundant in marshes and ponds in the vicinity of Lake Rousseau (Florida Game and Fresh Water Fish Commission, 1976). However, intensive searching for this species during the field surveys did not locate it on the site, or in drainage ditches and marshes in the vicinity of the site. Therefore, it is improbable that this small, insectivorous plant occurs on the site.

Quillwort

This inconspicuous species belongs to a family related to the ferns and the horsetails. It is generally considered to be a primitive form of vascular plant (Cobb, 1963). Occurring throughout central Florida, it has been found in an ash swamp south of the Withlacoochee River in Citrus County (Florida Game and Fresh Water Fish Commission, 1976). This species may occur in the calm waters or edges of the hammocks and freshwater marshes on the property. Its small size makes observation of this species difficult.

Silkbay; Scrub Buckwheat

Endemic to the evergreen oak-sand pine scrub and deciduous oak sandhills of the Central Florida Ridge area east of Ocala in Marion County, the range of these species extend from Putnam County south (Kurz and Godfrey, 1962). Although small areas of evergreen oak scrub occur on-site, the sands are probably not sufficiently deep for these species. Thus, the possible occurrence of these species on-site is very unlikely.

Needle Palm

The needle palm is found in swamps and mesic hammocks throughout north central Florida from Clay to Brevard counties and has been reported in eastern Marion County (Florida Game and Fresh Water Fish Commission, 1976). It is unlikely that this species occurs on the site because of the distance from its center of distribution. No individuals were identified upon the Florida Power Corporation property, although possibly suitable habitat was noted.

Jackson-vine

Jackson-vine mainly occurs in north central Florida and the panhandle from Marion County to Okaloosa County, in its preferred habitats of mixed swamp, floodplain, forest, and bayheads (Radford, et al., 1968). The wetland forests on the plant site do not correspond exactly to these preferred habitats although there could be a possibility of this species occurring on the property.

Hartwrightia

This species has been reported for the interior central and north peninsular regions of Florida, including Marion County. This tall, slender member of the daisy family occurs in swamps. Potential for on-site occurrence is rated as low since the known range does not extend to the site.

Corkwood

The corkwood is a small tree which inhabits sawgrass marshes bordering

Gulf Coast rivers and streams as far south as the Gulf Hammock area of Levy County. Suitable habitat for this species probably does not exist on the site.

Godfrey's Blazing Star

Suitable habitat does not occur on the site. This species is restricted to sandy coastal soils such as beaches and dunes along the west coast of Florida.

Pond Spice; Florida Willow

The preferred habitats of these shrubs, pond and swamp margins and low wet woodlands, occurs on-site. Thus, it is fairly likely that either species may occur on-site.

Ocala Vetch

This legume has been found in isolated sites near Ocala in Marion County. It is not expected to occur as far west as the site.

Animals

Today there are several hundred animals that are considered threatened by human activities such as habitat destruction, competition from introduced species, pesticides, and other forms of human interference. This analysis is based on direct observations, habitat association analysis, and literature sources.

General references used were Rare and Endangered Plants and Animals from the Cross Florida Barge Canal Restudy Report (1976) (Florida Game and Fresh Water Fish Commission, 1976) and Florida Committee on Rare and Endangered Plants and Animals (1977) unless otherwise stated. Of the 34 animal species listed, 6 were sighted as rare or endangered species during the 1977 field survey. The following discussion presents a brief analysis of status and likelihood of occurrence for each of these 34 species, as shown in Table 2.7.3-2.

Short-Tailed Snake

The range of the short-tailed snake is confined entirely to peninsular Florida from Highlands to Columbia counties. This species occurs chiefly in long-leaf pine/turkey oak associations and infrequently in upland oaks proximal to the former. The short-tail snake is a burrowing animal, seldom occurring above ground except during the spring and fall. Encroachment by man into preferred habitat is the greatest threat to this species. In some instances, thermal stress caused by removal of overstory in sandhills communities have expirated certain populations of this snake (Campbell, 1975). The forest associations inhabited by this species are not currently present on the proposed site.

Suwannee Cooter

The Suwannee cooter is found only in Florida and is restricted to rivers and spring runs on the Gulf of Mexico. The optimum habitat is in fresh to brackish water with abundant submergent vegetation. Currently, there is very little suitable habitat at the proposed site. Preservation of

Table 2.7.3-2. Rare and Endangered Animal Species which May Occur on the Crystal River Property

Species	Common Name	Status FAS	Status USFW	Status FCFC	Preferred Habitat	Likelihood of Occurrence
Amphibians and Reptiles						
Pseudobranchus striatus lustricolus	Gulf Hammock dwarf siren	SU	---	---	Slow-moving vegetated water	----
Notophtalmus perstriatus	Stripted newt	R	---	---	Pineflats & sandhils, ponds	Likely
Rana areolata aesopus	Florida gopher frog	T	---	T	Fields, sandhills, xeric hammocks	Likely
Chrysemys concinna suwanniensis	Suwannee cooter	T	---	T	Fresh-brackish rivers & spring runs	Marginal
Gopherus polyphemus	Copher tortoise	T	---	T	Fields, sandhills, xeric hammocks	Present
Stilosome extenuatum	Short-tailed snake	E	---	E	Longleaf pine, turkey oak	Marginal
Drymarchon corais couperi	Eastern indigo snake	T	---	T	Fields, sandhills, xeric hammocks	Present
Alligator mississippiensis	American alligator	T	E	E	Ponds & marshes	Present
Birds						
Mycteria americanum	Wood stork	E	---	---	Swamps, ponds, marshes	Likely
Accipiter cooperii	Cooper's hawk	SC	---	---	Secluded woodlands	Likely
Buteo brachyurus	Short-tailed hawk	R	---	---	Field/woodland ecotones	Likely
Haliaeetus leucocephalus leucocephalus	Southern bald eagle	T	E	E	Shores of large water bodies	Likely
Pandion haliaeetus caroliniensis	American osprey	T	---	---	Shores of large water bodies	Present
Falco peregrinus	Peregrin falcon	E	E	E	Coastal areas	Marginal
Falco sparverius paulus	Little kestrel	T	---	---	Open fields & pinewoods	Likely
Thallasseus maximus	Royal tern	SC	---	---	Spoil islands, berms, flats	Likely
Rynchops niger	Black skimmer	SC	---	---	Spoil islands, berms, flats	Present
Dendrocopos villosus audubonii	Southern hairy woodpecker	SC	---	---	Pinewoods, swamps, & hammocks	Likely
Dendrocopos borealis hylonomus	Red-cockaded woodpecker	E	E	T	Mature pine flatwoods	Marginal
Aphelocoma coerulescens coerulescens	Florida scrubjay	T	---	---	Oak scrub	Likely
Telmatodytes palustris marianae	Marian's marsh wren	SC	---	---	Salt marsh	Likely
Dendroica discolor paludicola	Florida prairie warbler	SC	---	---	Coastal hamock and mangroves	Marginal
Ammospize maritima fisheri	Louisiana seaside sparrow	T	---	---	Salt marsh	Likely
Ammospize maritima peninsulae	Scott's seaside sparrow	SC	---	---	Salt marsh	Likely

Table 2.7.3-2. Rare and Endangered Animal Species which May Occur on the Crystal River Property (Continued, page 2 of 2)

Species	Common Name	Status FAS	Status USFW	Status FGFC	Preferred Habitat	Likelihood of Occurrence
Mammals						
Sorex longirostris longirostris	Southeastern shrew	R	---	---	Floodplain forests & swamps	Likely
Sorex longirostris cionis	Homosassa shrew	R	---	---	Floodplain forests & swamps	Marginal
Eptesicus fuscus	Big brown bat	R	---	---	Open areas	Likely
Plecotus rafinesquii	Southeastern big-eared bat	R	---	---	Forested hammocks	----
Sciurus niger shermani	Sherman's fox squirrel	T	---	T	Open pine flatwoods	Likely
Peromyscus floridanus	Florida mouse	T	---	T	Variable	Present
Ursus americanus floridanus	Florida black bear	T	---	E	Large forest expanses	Likely
Mustela frenata peninsulae	Florida weasel	R	---	T	Variable	Likely
Mustela vison lutensis	Florida mink	R	---	---	Salt marsh	Likely
Felis concolor coryi	Florida panther	E	E	E	Large forest expanses	Marginal

preferred habitat and protection from extensive trapping and shooting are the best protective measures.

Gopher Tortoise and Commensals

The gopher tortoise is locally distributed in the Coastal Plain from South Carolina and Florida to eastern Louisiana. In Florida, it may be encountered widely in northern sections with relict, scattered populations occuring in suitable habitats in the south. Preferred habitat consists of old field areas, long-leaf pine sandhill, live oak hammock, and beach scrub, usually with abundant herbaceous cover of several types. A few burrows may occur in maintained pastures, mixed swamp, mesic hammock, pine flatwoods or scrub but generally these habitats are not utilized. Some important burrow symbionts, which may occur in these same habitats, include the pine snake, indigo snake, Florida mouse, and gopher frog. Other commensals include a large number of invertebrates, eastern diamondback rattlesnake, and various mammals. In xeric habitats (e.g., scrub, xeric hammock, and sandhills) the loss of gopher tortoise burrows as a refuge and hibernacula could adversely effect commensal organisms. Reasons for decline include destruction of habitat, fire prevention, unfavorable alteration of habitat by forestry, collection for food or for pet trade and possibly the practice of introducing gasoline into gopher burrows to drive out snakes.

Because of the very dense ground cover vegetation and the paucity of preferred habitat, quantitative inventories were not attempted. However, qualitative random searches were employed in the most suitable habitats.

A total of eight active tortoise burrows were found, six in scrub oak and two in early successional communities. In addition, two gopher tortoises were encountered, one in pine flatwoods and one on an unimproved dirt road. All scrub oak communities which contained active gopher tortoise burrows were located within the pine flatwoods. The two burrows in early successional communities were found within the power line corridor. Commensal organisms recorded on site consisted of the eastern diamondback rattlesnake, indigo snake, and Florida mouse.

Striped Newt

The striped newt is found in southeastern Georgia and northern Florida. This newt occurs as an adult and larva in pine flatwood and sandhill ponds and the eft stage in well-drained sandy areas. No newts were encountered at the site; however, there is good habitat for adults and larval forms in some ponds in the pine flatwoods and for the eft stage in well drained portions of the flatwoods. Draining and filling of flatwood ponds contribute to the scarcity of this animal.

American Alligator

The American alligator inhabits marshes and swamps throughout the coastal states in the southeast and occurs regularly in Citrus County, particularly Lake Rousseau. Two alligators were sighted in the fly-ash pond at the Florida Power Corporation power plant and it is likely that they also utilize the swamp and pond habitats in the vicinity. General surveys indicate there are no large numbers of alligators in the area of the proposed site. General protective measures for the alligator

include increased enforcement of anti-poaching laws and preservation of wetland habitats. Currently, stream channelization, drainage of wetlands, and other drastic alterations of natural waterways constitute one of the major limiting factors.

Eastern Indigo Snake

The eastern indigo snake occurs locally in peninsular Florida, in a few widely scattered areas of the Georgia Coastal Plain, and in parts of the Florida panhandle. This snake occupies a wide variety of habitat types. In xeric habitats, the shelter provided by gopher tortoise burrows apparently constitutes a critical factor for the survival of this snake. Because of the diversity of habitat and the large population of rodents on the site, this area is considered good habitat. One indigo snake has been observed near a mesic hammock (Voigts; Personal Communications, 1977). As with other animals associated with tortoise burrows, the snake collectors' practice of pouring gasoline into these burrows may have deleterious effects on this snake. In addition, clearing of forest lands for development, replanting to pine or other uses contribute to the scarcity of this animal.

Gulf Hammock Dwarf Siren

This siren's known range is a relatively small area of the Gulf Hammock region of Florida located at the junction of the peninsula and the panhandle. Preferred habitat seems to be still or slow-moving watercourses with abundant aquatic vegetation. The status of this species is uncertain at this time.

Wood Stork

The wood stork is locally common in southern swamps, freshwater marshes, and ponds. The only nesting colonies of wood stork occur in Florida, however, there are no confirmed rookeries located in the vicinity of the proposed power plant. Suitable nesting and roosting habitat occur in the coastal hammock of the area. Human encroachment and habitat destruction constitute the greatest threat to this species.

Peregrine Falcon

This duck hawk is quite rare throughout its range. It is an occasional winter resident in Florida, principally habitating coastal areas. Due to the scarcity of this bird it is unlikely that it would occur in the area. Reasons for its decline are related to poisoning and inhibition of reproduction by pesticides, nest molestation, and shooting.

Red-Cockaded Woodpecker

The red-cockaded woodpeckers' present range extends throughout much of the southern Atlantic and Gulf states. This woodpecker is indigenous to pinelands, usually nesting and roosting in mature long-leaf pine flatwoods. Nests are usually constructed in living pines infected with a fungal disease known as "red-heart." Pine flatwoods are not currently mature enough for habitation by this woodpecker nor was there any observed incidence of red heart disease at the site. The decline of this species is due to its specialized habitat requirements conflicting with current widespread forestry practices such as intensive even-aged

management in pine forest and culling of substandard trees. If nest trees are left undisturbed, the red-cockaded woodpecker may survive.

Southern Bald Eagle

In the southeast, the southern bald eagle nests primarily in the estuarine areas of the Atlantic and Gulf coasts and along the lower Mississippi Valley. Wintering populations are frequently found along estuaries, rivers, and near lakes. No nests were observed on the proposed power plant site, although they do occur in the vicinty. One mature eagle was observed hunting for fish at Lake Rousseau. Pesticides, illegal shooting, and human disturbance have caused its decline.

American Osprey

The Americal osprey is abundant along the coastal area of Crystal River. Ospreys were seen in the esturaries of Crystal River and are likely to be found on the site of the proposed power plant. One nest was sighted which was apparently active the preceding spring. The primary cause for decline of the American osprey is pesticide poisoning.

Little Kestrel and Florida Scrub Jay

Both of these species are known to occur in the vicinity of Crystal River. The kestrel is oriented to open-field or open pine forests. The scrub jay is restricted to oak scrub communities. Likely habitat for the kestrel is found along the power lines at the Florida Power Corporation power plant. Preferred habitat for the scrub jay is very limited on the site, however, scrub oak is associated with the pine

Seaside Sparrows and Mariana Marsh Wren

Various seaside sparrows and the Mariana marsh wren occur in the salt marshes of Florida. Likely habitat occurs in the salt marsh adjacent to the proposed power plant. The greatest threat to these species is exploitation and destruction of coastal habitats.

Short-Tailed Hawk

This hawk occurs throughout peninsular Florida as far north as the lower Suwannee River, middle St. Johns River, and in coastal portions of the panhandle. Nesting and roosting areas include mature cypress, riparian hardwoods, mangrove or pines, usually in woods adjacent to open prairies or marshlands. Likely habitat occurs at the site, particularly along the coastal hammock/salt marsh ecotone. Destruction of riparian hardwoods and mature cypress could seriously reduce this hawks' nesting habitat.

Cooper's Hawk

The Cooper's hawk is an uncommon permanent breeding resident throughout Florida with most birds occurring in the northern half of the state. It nests in secluded woods, more often in pine than hardwood. It is likely to occur in pine, oak, pine hardwoods, and the edges of other woods. Suitable nesting and roosting habitat occurs in the various forest types on the site. Primarily feeding on birds, the number of Cooper's hawks has been decreasing, apparently because of widespread use of pesticides.

Royal Tern and Black Skimmer

The royal tern and black skimmer are year-round residents of Florida. Although rookeries of these species are located on off-shore spoil islands either may occur on the vicinity of the project area. Fifteen black skimmers were sighted on the fly-ash disposal pond. Reasons for the decline of these species are development of rookery areas, continued disturbance of nesting areas by man, and degradation of bays and estuaries.

Southern Hairy Woodpecker

The range of the southern hairy woodpecker extends throughout Florida in a variety of habitats. Major habitats utilized include pinelands, deciduous swamp hammocks, and cypress stands. There is suitable habitat at the site and this subspecies is likely to occur there. The reasons for the scarcity of this woodpecker in Florida are uncertain. It is probable, however, that large scale destruction of mature forest is a contributing factor.

Florida Prairie Warbler

The Florida prairie warbler breeds in the Florida Keys, north to Volusia County and on the Gulf Coast to Levy County. Mangroves are typical habitat, but some numbers are found in coastal hammocks. Although no specimens were observed, suitable habitat occurs in the various hammocks.

Florida Panther

The Florida panther is now primarily restricted to Florida with other small populations occurring along some large swamp-river systems in various parts of the southeast. Recent sightings have occurred in Alabama (Endangered and Threatened Plants and Animals of Alabama, 1976) and individuals have been observed in the vicinity of Valdosta, Georgia (Louman, 1975) and the Okeefenokee Swamp (Belden, 1977). In Florida, Layne (1974) included the following counties as having valid reports: Dade, Broward, Palm Beach, Collier, Glades, Hendry, Highlands, Manatee, Pinellas, Martin, St. Lucie, Brevard, Polk, Levy, Alachua, Duval, Walton, and Sarasota.

The panther may be found in a variety of terrestrial habitats, although it prefers large unbroken tracts of land. This subspecies could occur along the continuous coastal hammock of western Florida. Man is the major limiting factor to this animal.

Sherman's Fox Squirrel

The range of the Sherman's fox squirrel is limited to peninsular Florida and, perhaps, southeastern Georgia. Open pine flatwoods seem to be the most frequently used habitat, but sand scrub, long-leaf/deciduous oak, bayheads, sandhills, and borders of cypress swamps are also used. Although no individuals were observed on the site, one road kill was collected on State Highway 44 approximately 9 miles east of Crystal River. This section of road is bordered by a deciduous oak sandhill community. Although optimum habitat is not found at the site, fox

squirrels may inhabit some pine flatwoods and various field-forest ecotones. The destruction of primeval pine forest by loggers is probably the greatest cause for the decline of this animal.

Florida Black Bear

Originally the Florida black bear ranged throughout Florida. Present populations are mainly centered in Apalachicola, Osceola, and Ocala National Forests, with remanent populations occurring in various parts of the state. According to Hamilton (1943) secluded swamps and forests are areas of preferred habitation for bears. The Cross Florida Barge Canal Restudy Report (Florida Game and Fresh Water Fish Commission, 1976) cited the probable occurrence of one bear in the vicinity of Inglis, Florida. It is not unlikely that bears may occur in the area of the proposed site. As the densely forested areas of Florida are increasingly being utilized by man, the status of the Florida black bear becomes increasingly uncertain.

Southeastern Shrew

This shrew is found in parts of 15 states, mainly east of the Mississippi River, from Illinois to Alabama and northern Florida. In Florida, this subspecies has been reported from various localities including Homossassa Springs, and Citrus County (Davis, 1957). The preferred habitat of the southeastern shrew is river floodplains and swamps, especially annually flooded areas with an abundance of fallen, decaying logs and thick understory vegetation. This shrew is likely to

occur in some areas of the site, especially in the more moist situations. The destruction of preferred habitat is the greatest danger to the southeastern shrew.

Homossassa Shrew

This shrew is known to occur only in the vicinity of Homossassa Springs in Citrus County, Florida. Preferred habitat is the floodplain forest associated with the Homossassa River. The Homossassa shrew is unlikely to occur in project area; however, there is currently suitable habitat. Reduction of habitat by channelization of streams and drainage of swamps is the greatest threat to this species.

Big Brown Bat

The big brown bat ranges from northern South America, including the Carribbean Islands, north through the United States to Alaska and northern Canada. This bat is known to feed over fields, lakes, and tree-lined streets. Big brown bats have been collected in cypress bays in the Okeefenokee region (Harper, 1927). Howell (unpublished manuscript) reported specimens from Citrus County. The status of this bat in the project area is uncertain at this time.

Southeastern Big-Eared Bat

This bat is distributed over middle and southeastern United States. Over most of its range it is associated with cave habitats, however, in Florida, preferred habitat is hammock-type vegetation within forested regions. Pearson (1954) reported the southeastern big-eared bat in Levy

County and Howell (unpublished manuscript) and Neill (1953) recorded it in Marion County. The status of this bat in the area of the site is uncertain at this time.

Florida Weasel

The Florida weasel ranges throughout the southern two-thirds of peninsular Florida, excluding most of the southern tip. Apparently the weasel lacks any distinct habitat preference (Moore, 1945 and 1949). There has been one recent sighting of this subspecies in a coastal hammock near Inglis, Florida. One of the state's rarest carnivores, the weasel may occur in the area of the proposed site.

Florida Mink

The present range of the Florida mink is the northern third of the state in gulf coastal marshes. This subspecies may frequent the salt marshes adjacent to the proposed power plant. Since it is peripherially distributed in Florida and the preferred habitat is being encroached upon by man, it will continue to diminish in numbers.

2.7.3.4 FUNCTIONALLY CRITICAL SPECIES

Introduction

Functionally critical species include those which are critical to the structure and function of the ecological system, and those which are important for the well-being of species in one of the preceding categories. These criteria include those species whose absence would destroy the integrity of a system, but not those dominants which could be replaced functionally by other currently existing species.

Plants

Live Oak, Cabbage Palm, Southern Red Cedar

These three species are the backbone (71 percent of the dominance) of the coastal hammock and coastal hydric hammock communities. These species are vital to the survival of these hammocks because of their relatively high resistance to oceanic salt spray and occasional salt water inundation (Wharton, et al., 1976). These species, especially live oak, tend to shelter other species which grow in the hammock, and give it a high degree of floristic diversity. Because these species are more tolerant to salinity, these three species increase in dominance with increased proximity to the shore.

Live oak and red cedar have slow growth rates. Consequently, the large trees within the hammock are of a substantial age [48.26 centimeters (19 inches) DBH live oak measured at 87 years old: 40.6 centimeters (16 inches) DBH red cedar measured at 114 years old]. Replacement times for such a community would be substantially longer than the actual age of an individual tree because of the antecedent successional stages necessary for proper growth conditions.

Diamond-leaf oak is also a major dominant on the coastal hydric hammock. Since its tolerance to salt has not been documented, it is not regarded as a critical species. Rather, it is regarded as being dependent upon the presence of the other species for survival. Diamond-leaf oak trees in this community are also substantially smaller [9.4 centimeters (3.7 inches) mean DBH versus 45.7 centimeters (18.0 inches) mean DBH].

Black Rush

This species is dominant in the salt marsh, where it accounts for at least 46 percent (Dames and Moore, 1974) of the vegetative cover. As such, it is responsible for much of the functional properties of the salt marsh system.

2.7.4 PREDICTED FUTURE ENVIRONMENT WITHOUT THE PROPOSED PLANT

It is anticipated that there would be little to alter the present course of succession if the plant were not constructed. The transmission corridors are expected to be maintained in early successional stages by periodic mowing. A certain amount of additional disturbance will probably occur around the edges of the site through normal expansion of maintenance roads and other associated structures.

The site will probably be protected from fire over the foreseeable future by the wetlands on the west, and by fire prevention measures intended to protect the adjacent industrial complex and pine plantations. Regardless of the exclusion of fire, the marshes and hardwood forests are not expected to undergo major changes. The trees in the mesic and hydric hammocks should increase in size, but no change in species composition is expected, because the dominant climax species are currently present as seedlings.

The primary changes on the site would be due to succession in the pine flatwoods. Edminston (1963) has shown that pine flatwoods in central Florida may have 60 percent hardwoods in their canopy, 60 percent in the sapling zone, and 80 percent in the seedlings zone within 35 years of fire suppression. The flatwoods will then be characterized by a pine canopy, with a substantial hardwood understory, and a more open shrub and ground cover layer. A corresponding change in the associated animal community will occur as species more characteristic of the hardwood hammocks begin to replace those of early succession and pine flatwoods systems.

It is estimated that the slash pine of the flatwoods should be approaching a harvestable size in about 15 to 25 years. Exact growth rates will depend on factors such as the amount of thinning which may occur. Harvesting trees would cause a return to an earlier successional state.

2.8 AQUATIC ECOLOGY

In the immediate vicinity of the proposed power plant site are three major aquatic habitat types: salt marsh, coastal hydric hammock, and freshwater marsh. The coastal zone is dominated by salt marsh. Within the marsh, Juncus roemarianus (black needlerush) and Spartina alterniflora (cordgrass) are the two principal floral types present. These grasses are of major importance in primary production, the initial link in any food web--the capture and conversion of energy from the sum to chemical-bond energy which, in turn, can be used by other organisms. There are two major food webs these grasses support; one involves those organisms which feed on the living plant (herbivores) and the second are those which feed on the detrital material produced by the plant (detritivores) (Keefe, 1972). The marsh also plays a major role as a nursery ground for fish and is an important habitat for various invertebrates, a major food source for some fish species.

Inland from the marsh there is a hydric hammock system which is essentially freshwater dominated. The principal flora in the area is live oak, southern red cedar, and cabbage palm. Here freshwater invertebrates and insect larvae dominate which, in turn, supplement the diets of various terrestrial organisms. Farther inland, east of the western boundary of proposed site no. 3 and approximately 1,500 feet north of the power line corridor is a series of freshwater marshes. These marshes support a food web similar to that of the hydric hammock. However, due to their ephemeral nature, their long term ecological

importance is unclear. North of the power plant's corridor and west of their eastern boundary the freshwater marsh system encompasses 2.0 percent of Florida Power Corporation's land, or 15.1 acres. The coastal hydric hammock is contained in 108.6 acres or 13.1 percent of the area. The salt marsh is approximately twice the combined area of freshwater marsh and coastal hydric hammock containing 243.3 acres or approximately 29.3 percent of the area. The remaining acreage is pine plantation and other types of terrestial habitats (see section 2.7).

2.8.1 MARSH

Flora: One of the major roles the wetlands have in any area is its contribution to primary production. This is accomplished via grasses such as *Juncus roemarianus* (black needlerush), which dominates the marsh in the Crystal River area, and *Spartina alterniflora* (cordgrass), which is located along the seaward edge and creekbanks of the marsh. Based on a 10 month study by Young (1975) in the Crystal River marsh system the *Juncus* and *Spartina* standing crop are 540 gr(dry)/m^2 and 580 gr(dry)/m^2 respectively. Standing crop refers to the dry weight (biomass) of the species.

These values are well in the range expected based on documented biomass values of these grasses in other areas (Keefe, 1972). A comparative study of *Spartina* standing crop was done by Young during the months of May and September at Jacksonville Electric Authority's

Northside Generating Station. No significant differences were noted between the Crystal River site and the Jacksonville site for either month. In the Crystal River marsh system, Spartina's standing crop has a peak in August and a minimum value in February. Spartina begins flowering the end of July or first of August and can continue to flower through the early part of November. The standing crop for Juncus, based on monthly values, varies between 420 and 540 gr/m^2 throughout the year. Gross production is defined here as being the increase in weight (net production) plus respiration. Respiration is defined as the energy required for maintenance activities. Over the same 10 month study period referenced earlier these values for Juncus are 12.6 $gr/m^2/day$ and 4.6 $gr/m^2/day$ respectively. For Spartina these values are 18.3/day for gross production and 3.5 $gr/m^2/day$ for respiration. During late winter/early spring Juncus is the more productive of the two grasses. During the summer season, however, Spartina photosynthesis exceeds that of Juncus. Thus, both grasses are important in maintaining a high productivity level in the marshes throughout the year.

These marsh grasses also play an important role as producers of detritus. This detritus is the organic remains of dead and broken grass parts (stems, blades, roots) and is a major source of nutrients for a number of organisms. The individuals which feed predominately

on this detrital material are referred to as detritivores. Based on the same 10 month study by Young (1975) the combined detritus for these two grasses is 650 gr/m^2. The conversion rate over a square meter of Spartina on a daily basis of standing crop to detritus is 4.5 gr. For Juncus the daily conversion is slightly higher, 5.6 gr/m^2.

Fauna: The species composition within the marsh is part of a highly complex system. This complexity and the variability in species diversity within the marsh is, in part, due to various physical interactions. Among these interactions are periodic inundation by saline water, input from freshwater sources, and periodic drops in water levels resulting in "dry land" (water depth at high tide averages .5m; Young, 1975). A further complication arises in the Crystal River area as a result of an existing thermal plume which inundates a portion of the marsh. The resident fauna have been subjectively placed into four categories, which are:

1. Terrestrial and brackish water microarthropoda;
2. Brackish and marine benthic marcoinvertebrates;
3. Brackish and marine zooplankton; and
4. Brackish and marine fishes.

Table 2.8.1-1 describes the microarthropod population found in the vicinity of Crystal River marsh system. These organisms are important in the breakdown of detrital material and as prey for various carnivores. Detritivores are numerically the largest group in

Table 2.8.1-1. Microarthropods in the Vicinity of the Crystal River Marsh System

Trophic Level and Order or Group
Herbivores
Orthoptera (grasshoppers, katydids, crickets, roaches, mantids, walking sticks)
Heteroptera
Homoptera (cicadas, leafhoppers, aphids)
Thysanoptera (thrips)
Coleoptera (beetles, weevils)
Detritivores
Crustacea
Arachnida (mites)
Collembolsa (springtails)
Diptera (trueflies)
Carnivores
Arachnida (spiders, pseudoscorpions)
Hymenoptera (ants, bees, wasps, sawflies)

Spartina. Homoptera (cicadas, leafhoppers, and aphids) and Heteroptera, both of which are herbivores, and Hymenoptera (ants, bees, wasps, and sawflies; carnivores) are three specific orders that have been found to be statistically more abundant in Juncus marsh than in Spartina. Approximately .6 gr/m^2 of grass standing crop is used by insects per day (Young, 1975). Based on a 10 month study by McMahan (1975), within the Juncus marsh herbivores make up a majority of the microarthropod community. Unfortunately McMahan reported his information and apparently reduced his data only as far as the taxonomic level of order. This, reduces the inter- and intra-descriptive capabilities of such samples and limits the ability to reach any comprehensive conclusions. However, a few broad generalizations can be made. Both S (total species per sample) and S/1000 (species observed per 1,000 individuals present) has revealed statistically more numbers of microarthropods in the Juncus than in Spartina. The eveness index (e = Shannon-Weaver index of diversity = H/ln S) showed a statistically more uniform distribution of species in Spartina marsh (McMahan, 1975). This suggests that the Spartina habitat supports a more balanced and diverse microarthropod community. This may in part, be the result of the Spartina habitat being the more stable of the two systems or at least less variable in terms of either biotic or environmentally induced stress.

Macroinvertebrates: The macroinvertebrate components of the marsh system can be broken down into three major categories, which are:

1. Mollusca: Gastropoda;
2. Annelida: Polychaeta; and
3. Arthropoda: Decapoda.

These organisms are a major food source for other trophic levels. They also play a major role in the assimilation of the detrital material produced by the grasses. The estimated biomass for these organisms in the thermally influenced area is 16.3 gr/m^2, 92.5 percent of which is crabs, specifically Vca (Fiddler crab). In the unimpacted area the biomass is 11.7 gr/m^2, of which 89.7 percent is crabs. A comparative study of abundance of Littorina irrorata (gastropod; marsh periwinkle) and Vca sp. was conducted during the months of May and September at Jacksonville Electric Authority's Northside Generating Station. No significant differences were noted between the Jacksonville site and the Crystal River site for either month (Young, 1975).

Zooplankton: Zooplankton are microscopic or one-celled animals which are suspended in the water column. Larval forms of several larger organisms are temporarily members of the zooplankton community. Due to a lack of information on zooplankton within the marsh proper the discussion on these organisms will be based on work done primarily by Cuzon du Rest (1963) on salt marshes of southern Louisiana and Maturo et al. (1974) on Crystal River estuarine system.

The single most important zooplankton in Cuzon du Rest's work was the copepod Acartia tonsa which accounted for an average of 83 perent of those individuals counted. This organism has been a major component in the zooplankton community in several studies (Woodmansee, 1958; Hopkins, 1966; Maturo, et al., 1974). Acartia tonsa is both euryhaline and eurythermal being found at temperatures from 5-35°C and salinities of 0.3 to greater than 30 ppt. Decapod larvae including zoea and megalaps of the blue crab were most abundant during the spring though representatives from the group were obtained throughout the year. Ctenophores and combjellies, which are zooplanktons, are also an apparently significant predator of zooplankton. Though taken throughout the year, highest concentrations were obtained during the summer months. Hallquist (1974) collected ctenophores throughout the year in the Crystal River estuary. Standing crops varied from .05 ml/m^3 in the winter to 23.77 ml/m^3 during the summer. No data was available for the fall. Hallquist concluded "that even under optimum feeding conditions the ctenophore population at Crystal River was not large enough to have a significant effect upon zooplankton standing crop" during the time period he sampled. Whether this is a valid point in the marsh system has yet to be determined. Many zooplankton appear to be primarily herbivorous filter feeders ingesting the suspended organic matter in the water column which includes raw nutrients as well as food in the form of phytoplankton. Acartia tonsa appears to have two annual peaks in biomass—one in April and a smaller one in August. It has been estimated in Louisiana by Day (1973) that A. tonsa has approximately 10 generations per year,

produces 20 gr of organic material/m^2/yr and respires 80.5 gr/m^2/yr. For the total zooplanton population annual respiration is 100.6 gr/m^2 and production of organic material is 25 gr/m^2. In warmer waters the number of annual generations may increase resulting in increased values for production and respiration.

Percent per day production values for zooplankton in the Crystal River estuary, based on work by Alden and Hearne (1974) produced seasonal averages of 10.9 percent, 9.8 percent, 14.6 percent, and 22.8 percent for fall, winter, spring, and summer, respectively. This can be restated as the time period required for a turnover in biomass, and that in approximately 11, 10, 14.5, and 23 days for the various seasons, there is a turnover in the zooplankton biomass. Again, whether these values can be related to the Crystal River marsh system is yet to be determined. McKellar (1975) determined zooplankton respiration in the Crystal River estuary on a per unit body weight basis and found significant changes from winter to summer (0.006 gr/gr/day and 0.028 gr/gr/day, respectively).

Fish: Table 2.8.1-2 describes the various fish found in the Crystal River marsh system. Salt marshes may serve as nursery grounds for the juveniles and young of many species of fish (Harrington and Harrington, 1961)—not only commercial and recreational species such as the red drum, striped mullet, and black drum, but also various small fish

Table 2.8.1-2. Fish Previously Caught in the Crystal River Marsh Area

Species	Common Name
Carcharhinus limbatus	Blacktip shark
Sphyrna tiburo	Bonnethead
Dasyatis sabina	Atlantic stingray
Lepisosteus oculatus	Spotted gar
Elops saurus	Ladyfish
Myrophis punctatis	Speckled worm eel
Brevoortia patronus	Gulf menhaden
Harengula pensacolae	Scaled sardine
Opisthonema oglinum	Threadfin herring
Anchoa hepsetus	Striped anchovy
Anchoa mitchilli	Bay anchovy
Synodus foetens	Inshore lizardfish
Arius felis	Sea catfish
Opsanus beta	Gulf toadfish
Hyporhamphus unifasciatus	Halfbeak
Strongylura marina	Atlantic needlefish
Strongylura notata	Redfin needlefish
Adinia xenica	Diamond killifish
Cyprinodon variegatus	Sheepshead killifish
Floridicthys carpio	Goldspotted killifish
Fundulus grandis	Gulf killifish
Fundulus similis	Longnose killifish
Lucania parva	Rainwater killifish
Gambusia affinis	Mosquito fish
Poecilia latipinna	Sailfin molly
Menidia beryllina	Tidewater silverside
Syngnathus floridae	Dusky pipefish
Echenis naucrates	Sharksucker
Caranx hippos	Crevalle jack
Oligoplites saurus	Leatherjacket
Selene vomer	Lookdown
Trachinotus falcatus	Permit
Lutjanus griseus	Grey snapper
Eucinostomus argenteus	Spotfin mojarra
Eucinostomus gula	Silver jenny
Eucinostomus letroyi	Mottled mojarra
Orthopristes chrysoptera	Pigfish
Archosargus probatocephalus	Sheepshead
Lagodon rhomboides	Pinfish
Bairdiella chrysura	Silver perch
Cynoscion nebulosus	Spotted sea trout
Leiostomus xanthurus	Spot
Pogonias cromis	Black drum

Table 2.8.1-2. Fish Previously Caught in the Crystal River Marsh Area (Continued, page 2 of 2)

Species	Common Name
Sciaenops ocellata	Red drum
Chaetodipterus faber	Spadefish
Mugil cephalus	Striped mullet
Mugil curema	White mullet
Mugil trichodon	Fantail mullet
Polydactylus octonemus	Atlantic threadfin
Bathygobius soporator	Frillfin goby
Gobiosoma robustum	Code goby
Microgobius gulosus	Clown goby
Scomberomorus maculatus	Spanish mackerel
Prionotus tribulus	Big-headed sea robin
Paralicthys albigutta	Gulf flounder
Achirus lineatus	Lined sole
Symphurus plagiusa	Black cheek tonguefish
Sphoerides nephelus	Southern puffer
Chilomyuterus schoepfi	Striped burrfish

important as prey for higher predators. Salt marsh tidal creek fish populations are influenced by the existing thermal plume. During the summer months, those creeks influenced by the thermal plume have been shown by McMahon (1975) to have a biomass of 2.2. gr/m^2 and a numerical abundance of .46 individuals/m^2. These were 24 percent and 7 percent of the biomass and abundance of an uninfluenced marsh creek. During the colder months, an observed unaffected creek had a numerical abundance of .58 individuals/m^2, a 15 percent higher value than its thermally impacted counterpart. However, there was a 12 percent higher biomass during this same time period in the thermally influenced creek. The mean biomass for the uninfluenced creek over a 10-month study period was 8.3 gr/m^2 as opposed to 5.2 gr/m^2 in the heated creek. Mean abundances for the two creek types were 3.67 individuals/m^2 and .47 individuals/m^2, respectively. Based on these values, there appears to be fewer fish in the heated creek; however, those present apparently are larger than those in the uninfluenced creek.

The apparent biomass enhancement in fall and winter in the heated area may very well make up for the summer exclusion in terms of productivity, condition factors, and enhanced reproduction. The species responsible for the increased biomass were striped mullet, red drum, black drum, and sea catfish. Gulf killifish, longnose killifish, striped mullet, fantail mullet, spotfin mojarra, and tidewater silverside made up approximately 80 percent of the fish population in the unimpacted creek. Whether these were all juveniles or what percentage

of the population were juveniles was not specified. In the thermally influenced water body the species were the same, with the exception of fantail mullet, which is replaced with black drum. A total of 55 species were observed in the uninfluenced creek, and 38 species in the thermally influenced creek.

Diversity indices for species have been developed to assist scientists in evaluating and comparing communities. The need for such devices results from the fact that all communities do not have the same number of species or number of individuals per species. A broad range of diversity indices have been developed in an attempt to overcome various shortcomings of previous mathematical descriptions. These range from merely counting the number of species to the popularized Shannon-Weaver function ($H = \sum_{i=1}^{s} (p_i)(\log_2 p_i)$; where H is the index of species diversity, S is the number of species, and p_i is the proportion of total samples belonging to ith species.

Margalefs theory is based on community maturity and the comparison of a "more mature" versus "less mature" system. The state of maturation of a given habitat can be described in terms of standing crop and energy relations such as food chain lengths and the ratio of production to biomass. The status of various populations within the community can also be ascertained based on their degree of fluctuations, life cycles, feeding relations, life span of individuals, mechanisms for population control, and the like. Diversity indices given as

species per 1,000 individuals and Margalif's diversity index $\frac{S-1}{\ln N}$ were lower for the thermally impacted creek. A general trend for both areas was a lower index in the winter, spring, and early summer, and a higher index during the late summer/fall period, which implies a more diverse group of fish with no single species or small group of species dominating the system.

Mid-carnivores, those individuals which prey on other organisms and, in turn, are preyed upon, are the dominant trophic level for the fish community from May through August, with herbivores dominating from October to January. Mid-carnivores are also of noticeable importance in the overall energy flow of the salt marsh tidal creek system at Crystal River.

Numerous authors (Reid, 1954; Springer and Woodburn, 1960; Sykes and Finucane, 1966; Carr and Giesel, 1975; others) have found that many of the young-of-the-year appear in estuaries during the spring and early summer months. At the Crystal River marsh site specifically many of the juveniles appear during the summer months. Mugil cephalus (striped mullet) and Sciaenops ocellata (red drum), two important commercial species, arrive in late fall. The arrival time of Anchoa mitchilli (bay anchovy), Fundulus grandis (gulf killifish), and Sciasenops ocellata (red drum deviated greatly between thermally impacted and unimpacted creeks). Bay anchovy juveniles were collected

from June through October in the uninfluenced area, with most of these collected in July and August. In the heated area, most of the juveniles of this species were collected in November, though juveniles continued to be sampled through February. The gulf killifish young arrived in the creeks from late spring until early fall. In the heated area, young of this species continued to appear through January. Red drum juveniles first appeared in the unheated area in October. In the thermal area, however, juveniles did not appear until January. These facts point out that there are deviations in the arrival time and species composition of fish in the affected and unaffected areas.

Important Species

Below is a brief description of a few of the more "important" species. Importance was based on abundance and/or biomass ranking in the fish community, function as a commercial or recreational organism, importance as a potential food source, or having a limited habitat within the United States coastal waters.

Menidia beryllina (Cope) (tidewater silverside)—This species was the most abundant species collected by Homer (1975) and ranked second in total biomass in the thermally unimpacted creek. The species was never abundant in the thermally influenced creek. Over 90 percent of the total abundance and biomass of this species was obtained during the warm months. Springer and Woodburn (1960) determined *M. beryllina* to be among the most common and ubiquitous species in the Tampa Bay

area. Carr and Giesel (1975), in their study at a power plant in Jacksonville, Florida, also found this to be the most abundant fish species in unheated waters, while thermally impacted waters had nominal numbers during the late summer months. Based on energy flow diagrams developed by Homer (1975), "The silverside provides food for many other fish and probably for many species of birds."

Pogonias cromis (Linnaeus)(black drum)—Pogonias cromis has never been found to be very abundant in the marshes of Florida. In Texas it is found most commonly in bays. Based on Homer's work (1975), this species was found in the unaffected creek in May, September, and December. In the thermally inundated creek, however, it was collected from July through October and ranked second in total biomass in this system.

Mugil cephalus (Linnaeus)(striped mullet)—The striped mullet supports west Florida's largest fin fishery and ranks second only to red snapper (Lutjanus aya) in dollar value (Homer, 1975); 75 percent of the total United States production of mullet is caught in Florida (Futch, 1966). Homer (1975) found this species to make up 36% of the total unimpacted creek fish biomass and 67 percent in the heated creek. However, the species exhibited a certain amount of avoidance of the impacted creek during the warm months. Springer and Woodburn (1960) collected this species during all seasons with the greatest abundance occurring during February through May. Juveniles were first noted in November. Sykes and Finucane (1960), working in the same

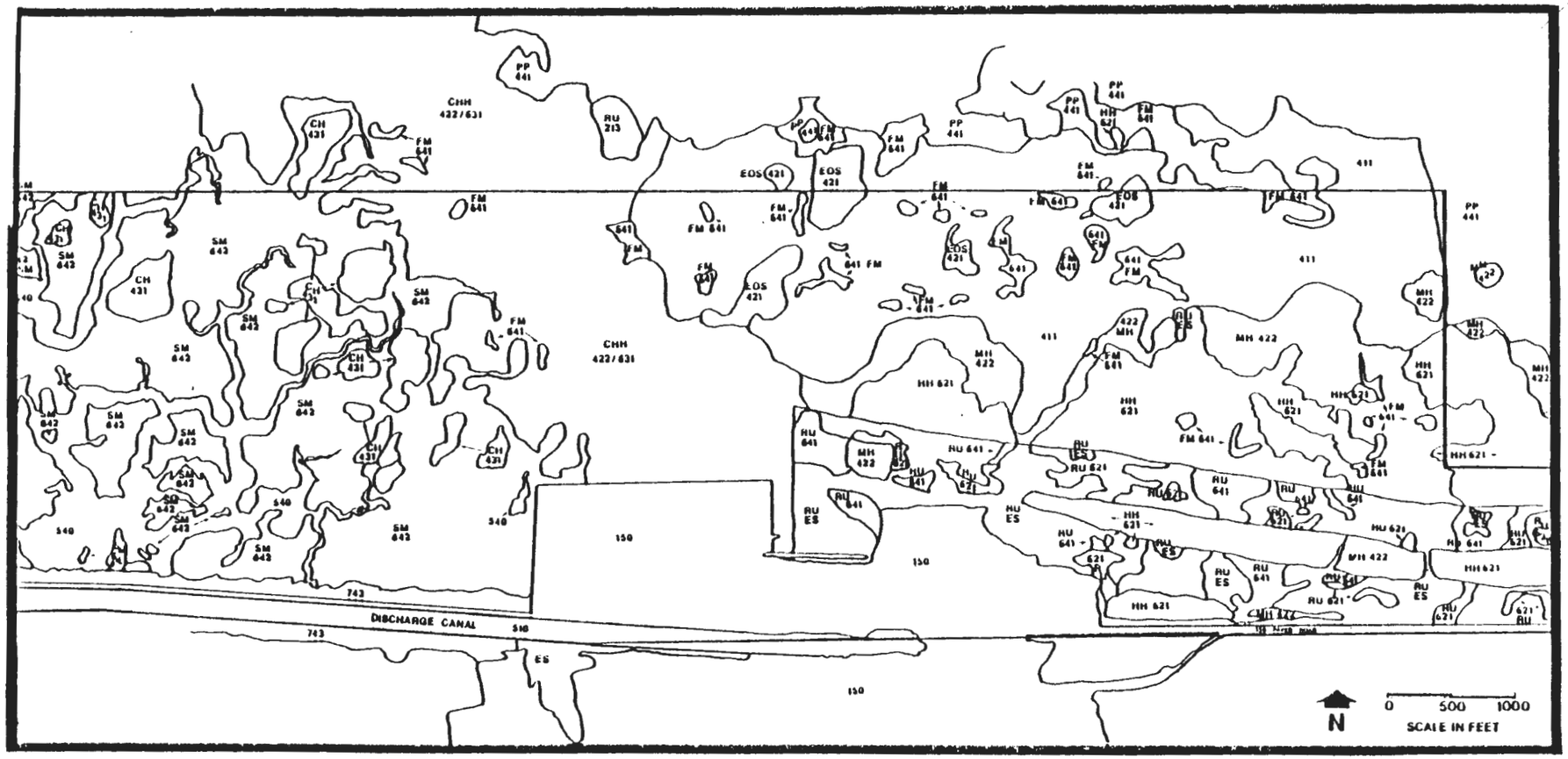
area (Tampa Bay), observed a winter time period of juvenile mullet arrival (December through February). "Although no studies have been undertaken in Florida to gather quantitative data on mullet stocks, it is probable that marshes play an important role during various times of their life history" (Homer, 1975).

Mugil trichodon (Poeg)(fantail mullet)—According to Briggs (1958), this species occurs only along Florida's Gulf Coast, Bermuda, and Brazil. Based on Homer's study (1975), *M. trichodon* enters the creeks by May and remains abundant in the non-heated creeks through December. "Virtually no fantail mullet were found in the thermally affected creeks during the warm months." It appears that thermal addition may have a detrimental effect on this species. It is not known what contribution this species makes to the Florida mullet industry, however, more juveniles of this species were found in the marshes than juveniles of *M. cephalus* (Homer, 1975).

2.8.2 PROPOSED CONSTRUCTION SITE

The western boundary of FPC's Site Proposal Number 1C is adjacent to the eastern boundary of the wetland area (Figure 2.8.2-1). These wetlands are more appropriately described as a hydric hammock. This system is bordered by salt marsh on the west and pine plantations on the east (see vegetation map). The major floral types are red bay, water oak, and sweet gum (see Section 2.7.2). Here the salt water intrusion and tidal influence are negligible and the fresh water component, specifically ground water, is the prime contributor. The creeks and ponds have a litter-covered bottom and contain small fish and freshwater invertebrates (Table 2.8.2-1). Environmental Science and Engineering, Inc., ran three transects north to south across the proposed site location. Figure 2.8.2-2 shows the location of osprey nests and aquatic sampling sites. Sampling occurred whenever a water body was encountered with up to a maximum of five samples per transect. There were a number of water habitats at the transect to the west. Most of the systems appeared stagnant, based on observations; however, no water quality parameters were taken. Furthermore, there was no evidence of any water movement via streams or the like. All water systems appeared to have some life forms present, and the abundance of mosquitos at this transect demonstrated their usage of the area as breeding grounds. Habitats sampled varied from marsh-like systems to coarse sandy substrate ponds to ponds partially filled with litter. Due to the extremely small numbers of organisms found, any statistical analysis would be inappropriate. Areas on the other two transects had regions with flora frequently associated with freshwater

WETLANDS MAP



		FLORIDA LAND USE AND COVER CLASSIFICATION SYSTEM	
SYMBOL	CLASSIFICATION	NUMBER	NAME
SM	Saltwater Marsh	642	Saltwater Marsh
FM	Freshwater Marshes and Prairies	641	Freshwater Marsh
SPI	Slash Pine Flatwoods	411	Pine Flatwoods
EOS	Evergreen Oak Scrub	421	Xeric Oak Hardwood Forest
MH	Mesic Hammock	422	Other Hardwood Forest
		414	Other Coniferous Forest
HH	Hydric Hammock	621	Freshwater Swamp
CH	Coastal Hammock	431	Mixed Forest
CHH	Coastal Hydric Hammock*	422	Other Hardwood Forest
		631	Mixed Wetland Forest
PP	Pine Plantation	441	Coniferous Planted Forest
RU	Ruderal**	—	Several Types
ES	Early Successional Water	—	No Equivalent
—	Water	500's	Water

*Type is derived from Hydric Hammock. North Florida type of hardwood (Carr et al. 1978a).

**Ruderal areas include early successional freshwater marsh, shrub/scrub, pasture, or other operational system.

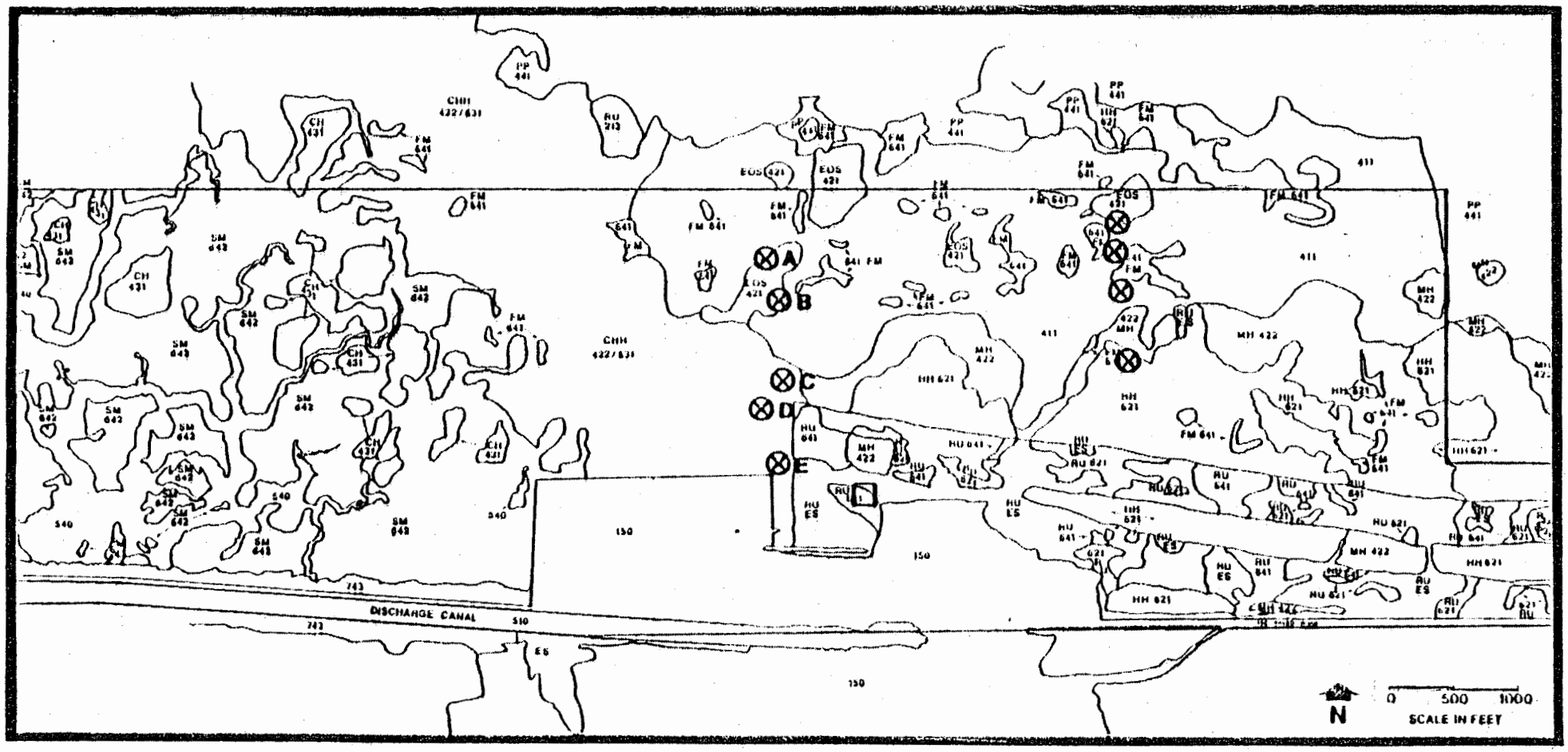
Figure 2.8.2-1

(e.g., sawgrass, arrowhead, pickeral weed), however, no standing water was observed on either transect. Terrestrial ecologists from Environmental Science and Engineering, Inc., examined the site at a later date and noted numerous systems with water present in these general areas. For the most part these were small ponds with a coarse clean sand substrate with few life forms evident.

Table 2.8.2-1. Organisms Collected at Proposal Site Number 3

Scientific Name	Common Name	Total No. of Individuals Observed
Dytiscidae		
Cybister sp.	Diving beetle	1
Gyrinidae		
Dineutus sp.	Whirlgig beetle	3
Hydrophilidae	Water scavenger beetle	2
Odonata	Dragonfly	1
Oligochaeta		
Plesiopora.	Worm	1
Gastropoda		
Physa sp.	Snail	1
Bivalvia (extremely small identification not possible)	Clam	1 (3 empty shells)
Juvenile fish		
Poecillidae or	Top minnow	
Cyprinodont	Killifish	3

LOCATION OF OSPREY NESTS AND AQUATIC SAMPLING SITES



OSPREY NEST

AQUATIC SAMPLING SITES

Figure 2.8.2-2

2.9 AMBIENT AIR

2.9.1 AMBIENT AIR STANDARDS

The ambient air quality of an area can be described in terms of quantitative standards. These standards, called Ambient Air Quality Standards (AAQS), were promulgated by regulatory agencies to protect the health and welfare of the general public. The applicable AAQS's which were established by the State of Florida are presented in Table 2.9.1-1. The major AAQS's to be evaluated for a fossil fuel field steam electric plant, located in a rural area, are those for total suspended particulate matter (TSP) and sulfur dioxide. Compliance with these standards is evaluated at ground level.

Existing levels of air quality must be determined in order to assess the impact of a proposed air pollution source, such as a major coal-fired electric generation plant. The most accurate method is to measure the air pollutants directly. Such procedures are accurate; however, they have limitations when determining existing ambient air quality over wide areas. In order to obtain spatial resolution of ambient air quality over such areas, many ambient monitors would be required.

The cost-effectiveness of such monitoring would not justify its use. When determining the existing environment on baseline, certain regulatory criteria allow the incorporation of air pollution sources which have started construction before the criteria was established.

Table 2.9.1-1 State of Florida Air Quality Standards

Pollutant	Average Time	Frequency Parameter	Concentration ug/m^3	Concentration ppb
Sulfur Dioxide	3-hour	Annual Maximum	1,300[a]	500
	24-hour	Annual Maximum	260[a]	100
	1-year	Arithmetic Mean	60	20
Suspended Particulate Matter	24-hour	Annual Maximum	150[a]	--
	24-hour	Annual Geometric Mean	60	--

[a] Not to be exceeded more than once per year.

To obtain the necessary spatial resolution while also incorporating existing air pollution sources, atmospheric dispersion models are utilized. Such models are mathematical algorithms which simulate dispersion of air pollutants in the atmosphere. An in-depth discussion of atmospheric dispersion models is presented in the Appendices.

The proposed new coal-fired units at FPC's Crystal River Plant necessitated both ambient air monitoring and atmospheric dispersion modeling for the determination of existing (baseline) ambient air quality. This section discusses the results of these analyses.

2.9.2 AMBIENT AIR SAMPLING PROGRAM

An ambient air sampling program for total suspended particulate matter (TSP) and sulfur dioxide was initiated in May, 1977. This program was to determine baseline conditions in the vicinity of the proposed site. Four sampling stations were established near the proposed site. Sampling methods for this program are discussed in Chapter 6.

Presented in Table 2.9.2-1 are the observed TSP and sulfur dioxide non-continuous concentrations for the period May 7, 1977, through September 28, 1977. Continuous sulfur dioxide concentrations, which are presented in Table 2.9.2-2, were obtained from July 1, 1977, through September 9, 1977.

The TSP data obtained is indicative of the areas where monitoring was performed. Stations 1 and 2 are rurally located with minor sources of TSP in the general vicinity. These sources are primarily local dolomite mining and processing operations along with the existing FPC facility. Also, minor sources of fugitive dust are generated from unpaved roads in the area. Station 4, which recorded the lowest TSP concentrations, is located in a salt marsh near a small marina. This station, when impacted, is primarily influenced by one or two sources. The generally higher geometric standard deviation of this station is a statistical indicator of source receptor influence. The geometric standard deviation represents the slope of a log-normal distribution. Since TSP is generally log-normally distributed (Larsen, 1971; ESE, 1975), a higher slope indicates an infrequent source impact for rural areas,

Table 2.9.2-1. Summary of Non-continuous[a] 24-Hour TSP and SO_2 Ambient Air Quality Data, Florida Power Corporation Crystal River Site, May 7, 1977 through September 28, 1977.

Pollutant	Station Number	Number of Samples	Mean	Observed 24-Hour Maximum	Observed 24-Hour 2nd Maximum	Geometric STD Deviation
Total Suspended Particulate	1	25	33[b]	69	61	1.43
	2	20	33[b]	80	67	1.68
	3	25	51[b]	94	85	1.32
	4	17	29[b]	56	54	1.92
Sulfur Dioxide	1	25	4[c]	8	5	1.38
	3	25	5[c]	21	10	1.66

[a]Monitor, operated on a once every sixth day schedule.
[b]Geometric mean.
[c]Arithmetic mean.

Table 2.9.2-2. Summary of the Continuous SO_2 Data, Florida Power Corporation, Crystal River, Florida, July 1 through September 9, 1977. Results in ug/m^3.

Station Number	Percent Data Recovery (%)	Arithmetic Mean	Maximum 3-Hour Concentration	2nd Maximum 3-Hour Concentration	Maximum 24-Hour Concentration	2nd Maximum 24-Hour Concentration
2	84	32	416	375	105	103
4	89	7	158	131	48	48

i.e., at lower frequencies of occurrence, concentrations are higher. Hence, Station 4 exhibits a source influence under certain meteorological conditions. The data obtained at Station 3 is representative of a typical small urban area, like Crystal River. The station is located adjacent to U.S. 19/98, a busy highway. Station 3 exhibited the highest concentrations, while the geometric standard deviation is the lowest (therefore many small sources contribute to the impact at this station). In summary, the observed TSP concentrations are within the ambient air quality standards. Any additional air pollution sources would have a considerable margin of compliance.

Sulfur dioxide, a gaseous air pollutant, was measured non-continuously; i.e., once every sixth day at Stations 1 and 3. These stations are located at the furthest point from the largest sulfur dioxide source in the area, FPC's Crystal River facility. Due to their location and sampling frequency, all observed sulfur dioxide concentrations are below the minimum detectable limit of the method (25 ug/m^3) (CFR, 1976). The data from these stations should be considered as indicators of background sulfur dioxide concentrations.

The continuous monitors are located at distances and directions where maximum impact is expected to occur. In addition, the continuous monitors measure temporal resolution of air pollutant concentrations and allow greater sampling frequency than non-continuous monitors. Consequently, observed sulfur dioxide concentrations from Stations 2 and 4 were significantly greater than the non-continuous stations.

Station 2 observed the highest sulfur dioxide concentrations. For the period of sampling (summer), mesoscale meteorological conditions include a large number of sea breezes, generally west-to-east winds. Such sea breezes created by convection are believed to produce maximum impact cases due to fumigation (Lyons, 1977). During the sampling period, northwesterly winds were infrequent. As a consequence, maximum sulfur dioxide concentrations were half as great as those at Station 2. Frontal systems which frequently occur in the fall and winter months will create impact cases at Station 2. These data will be supplemented with additional ambient observations. In summary, the sulfur dioxide data presented above indicate compliance with AAQS's.

2.9.3 DISPERSION MODELING

Modeling (refer for Chapter 6 for methods) for existing (baseline) air quality was performed in accordance with the definition of baseline air quality in the Clean Air Act Amendments of 1977 (PL95-95, August 7, 1977). According to the act, the existing air quality at the time of the first application for permit is considered the baseline. The baseline also includes additional sources not yet built, but for which construction commenced prior to January 6, 1975. Existing FPC Units 1 and 2, in the process of converting from oil- to coal-fired units by a notice of effectiveness issued by the FEA, fall into this category since the conversion process was initiated prior to 1975. Currently, Unit 1 is converting to coal firing, while Unit 2 has been converted to coal.

Recent promulgations by EPA and Congress have established ambient air quality levels for TSP and sulfur dioxide which cannot be exceeded (40CFR53, 1976; PL95-95, August 7, 1977). These limitations, which are termed Prevention of Significant Deterioraton (PSD) increments, propose stricter limitations than do the AAQS's. (Refer to Chapter 8 for a more detailed discussion.) Associated with these PSD requirements are baseline concentrations above which only certain air quality is available. For the purposes of this discussion, baseline concentration as defined by the above legislation must be determined.

Maximum baseline concentrations were obtained by modeling Units 1 and 2 at their maximum allowable emissions; i.e., 6.17 pounds of sulfur dioxide per million Btu heat input and 0.1 pounds TSP per million Btu

heat input. In addition to the site, baseline concentrations were also determined in the Chassahowitzka National Wilderness Area. This area has been designated as a Class I area by the 1977 Clean Air Act Amendments (PL95-95, August 7, 1977). The respective Class I and Class II PSD increments are applicable to the impact of new units on the baseline environment.

Overpredictions of ambient air quality is inherent in the methodology (see appendices) utilized to determine maximum estimated baseline TSP and sulfur dioxide concentrations. Since only one year of on-site meteorological data was available for model predictions, sources were aligned with other sources in the area and with the Class I area. Maximum predictions were then performed utilizing critical meteorology. In addition, model estimates consist of the highest maximum concentrations even though the allowable short-term AAQS's and PSD increments can be exceeded once per year; i.e., allowing evaluation based on the highest and second highest concentrations.

To estimate maximum annual and 24-hour TSP concentrations in the study area, a background concentration was incorporated with modeling results. This background was based on the ambient air quality modeling presented in Table 2.9.2-1.

2.9.4 BASELINE AIR QUALITY

The results of the baseline determination is presented in Table 2.9.4-1. Baseline concentrations were determined at the maximum in the study area, the Class II area where the proposed units are predicted to have maximum impact, and the Class I (Chassahowitzka Wilderness Area) areas where the proposed new units will have maximum impact.

Based on observed ambient air quality data and atmospheric dispersion modeling, it can be concluded that the AAQS's for TSP and sulfur dioxide are not being exceeded in the study area. In addition, it would also appear that the new proposed plant would have the PSD increments available.

Table 2.9.4-1. Maximum Estimated Baseline Concentrations (ug/m^3) in the Vicinity of FPC's Crystal River Site, and at the Chassahowitzka Wilderness Area. Units 1 and 2 at Maximum Allowable Emission of 6.17 lb SO_2 Btu and 0.1 lb TSP/10^6 Btu.

Pollutant	Average Time		
	Annual	24-Hour	3-Hour
Sulfur Dioxide			
Baseline Class II (At Maximum Impact of Proposed Units)	15	213	90
Baseline Class I	2	91	417
Maximum for Area	17	223	924
Particulate Matter*			
Baseline Class II (At Maximum Impact of Proposed Units)	32	35	NA
Baseline Class I	30	32	NA
Maximum for Area	36	126	NA

*Background TSP concentration of 30 ug/m^3 applied to modeling results (geometric standard deviation of 1.4).

Note: An annual geometric mean of 60 corresponds to an arithmetic mean of 64 ug/m^3 and a geometric standard deviation of 1.4.

2.10 OTHER ENVIRONMENTAL FEATURES

2.10.1 NOISE

Sound is the perception of oscillations by the ear drum. These oscillations, or alternating regions of high and low pressure, are produced in the atmosphere by the vibration of an object.

Sound usually is described in terms of three wave variables: amplitude, frequency and duration. Amplitude is a measure of the maximum excursion a sound wave makes from the average of the pressure or displacement of the wave. Frequency denotes the pitch of a pure tone and is the time required for the sound wave to oscillate between a positive and negative value of maximum amplitude. Duration is simply how long the sound persists.

The energy associated with a sound wave is described in terms of intensity. The intensity is proportional to the inverse square of the distance between the source and the receptor for spherically symmetrical waves. An energy flux is the average energy that flows through a unit area in unit time.

A system of measurement has been developed in which the average (rms) pressure excursions are measured against a reference pressure of 20 micronewtons per square meter. A logarithmic scale has been designed with the sound pressure level (SPL) measured in decibels (dB) where:

$$SPL = 20 \log \frac{P}{.00002}$$

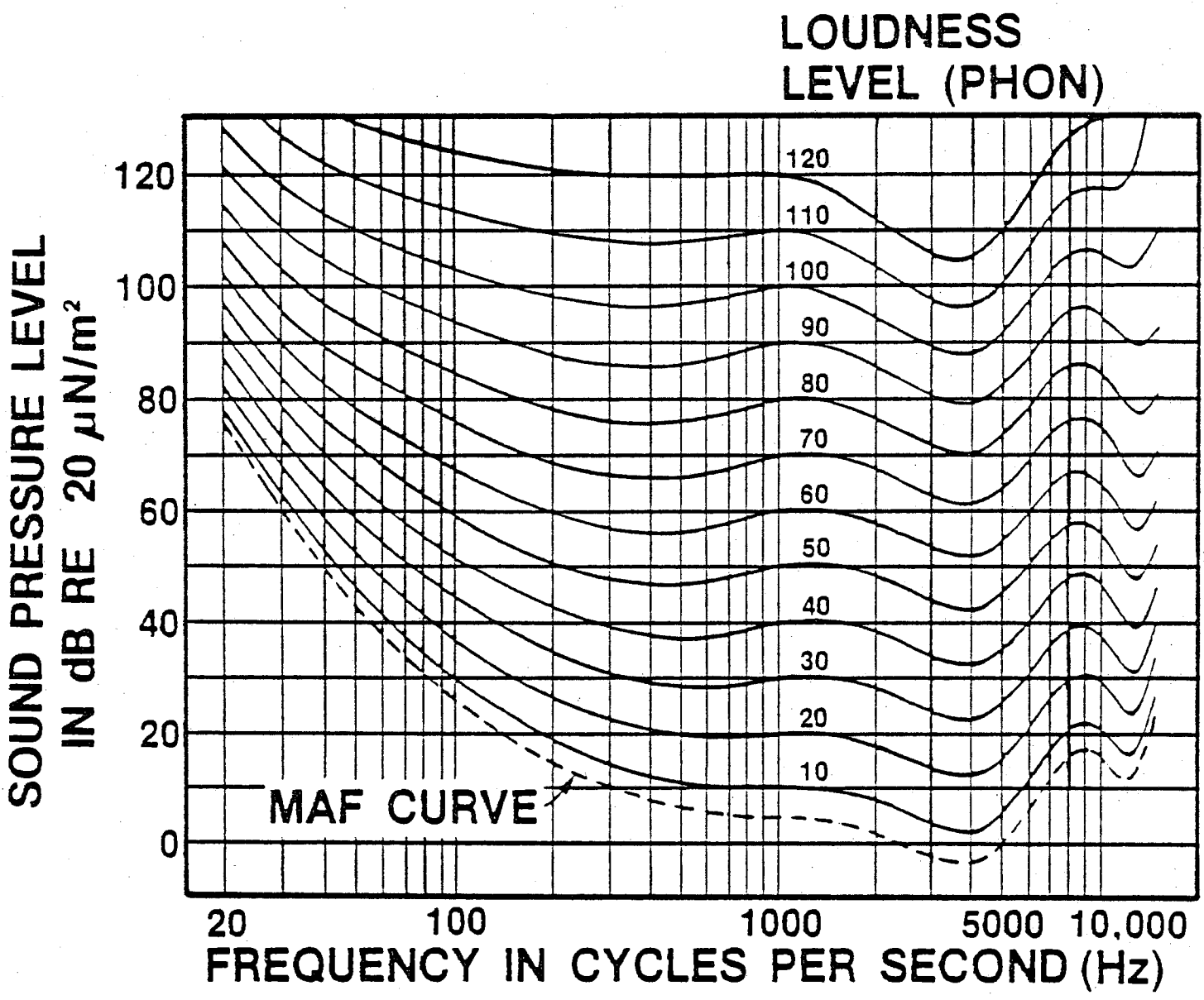
The pressure (P) is the root-mean-square sound pressure in micronewtons per square meter.

The human ear perceives sound between the frequencies of 16 Hertz and 20,000 Hertz (AIHA, 1975). However, the ear does not perceive sounds of equal pressure level throughout the range of perception as equally loud (see Figure 2.10.1-1). Sounds in the lower and higher frequencies are not heard as easily as sounds in the mid range.

Noise is defined as sound that is objectionable regardless of its level. This is basically a subjective measurement. Noise can be excessive, erratic, intermittent, or statistically random.

A system of sound measurement based upon the response of the human ear has been developed. The quantity measured is the sound level (L) and the units are decibels (dB). The sound level follows a power law such that a 10 dB increase is perceived as a doubling of loudness. The addition of two equal but random noise sources results in a 3 dB increase in the total sound level. Figure 2.10.1-2 presents various sources and their sound levels on the A scale, which most nearly approximates the response of the human ear. Sound level decreases as a result of obstructions such as trees and natural buffer zones that attentuate the pressure waves. Sound levels may, however, be increased by obstructions that tend to reflect sound pressure.

EQUAL LOUDNESS CONTOURS FOR PURE TONES



SOURCE: ROBINSON AND DADSON, 1956

Figure 2.10.1-1

TYPICAL A-WEIGHTED SOUND LEVELS

AT A GIVEN DISTANCE FROM NOISE SOURCE	DECIBELS RE 20 $\mu N/m^2$	ENVIRONMENTAL
	140	
50 HP SIREN (100')		
	130	
JET TAKEOFF (200')	120	
RIVETING MACHINE	110	CASTING SHAKEOUT AREA
CUT OFF SAW PNEUMATIC PEEN HAMMER	100	ELECTRIC FURNACE AREA
TEXTILE WEAVING PLANT SUBWAY TRAIN (20')	90	BOILER ROOM PRINTING PRESS PLANT
PNEUMATIC DRILL(50')	80	TABULATING ROOM INSIDE SPORT CAR (50 MPH)
FREIGHT TRAIN (100') VACUUM CLEANER (10') SPEECH (1')	70	
	60	NEAR FREEWAY (AUTO TRAFFIC) LARGE STORE ACCOUNTING OFFICE
LARGE TRANSFORMER 200	50	PRIVATE BUSINESS OFFICE LIGHT TRAFFIC (100') AVERAGE RESIDENCE
	40	MIN LEVELS — RESIDENTIAL AREAS IN CHICAGO AT NIGHT
SOFT WHISPER	30	STUDIO (SPEECH)
	20	STUDIO FOR SOUND PICTURES
	10	
THRESHOLD OF HEARING YOUTHS 1000-4000 Hz	0	

SOURCE: PETERSON AND GROSS, 1974

Figure 2.10.1-2

Environmental noise can be measured with a sound level meter and expressed in terms of its frequency distribution, or by a scale which electronically attenuates certain frequencies to match the characteristics of the human ear (A-scale) or some other receptor. Most guidelines for environmental noise are defined in terms of the A-scale and are expressed as one of the following statistical measures (FHWA, 1973, and U.S. EPA, 1974):

1. L_{10} - the sound level which is exceeded 10 percent of the time during a measurement period.
2. L_{50} - the sound level which is exceeded 50 percent of the time during a measurement period.
3. $L_{eq}(t)$ - the sound level equal in cumulative energy to all time-varying noise produced during a specific time period.
4. $L_{eq}(24)$ - the sound level equal in cumulative energy to all time-varying noise produced during a 24-hour period.
5. $L_{eq}(dn)$ - the equivalent sound level for day and night (10:00 pm to 7:00 am) in which the equivalent nighttime level has been biased by the addition of ten decibels.

Health and Welfare Effects

Noise has been shown (U.S. EPA, 1974) to cause the following three types of effects on people and their activities.

1. Effects on hearing;
2. Effects on general mental state as evidenced by annoyance;
3. Interference with specific activities such as speech or sleep.

Noise is believed to cause stress and its related disorders. It was previously assumed that protection against hearing loss provided sufficient protection against stress-related disorders. It is now known that levels below those believed to affect hearing are sufficient to produce in human beings physiological symptoms that are related to stress (U.S. EPA, 1974).

Guidelines

Highway traffic has long been recognized as a major contributor to environmental noise. The U.S. Department of Transportation has published Design Noise Level criteria based upon land use (DOT, 1972). The suggested criteria are the L_{10}'s for various land use categories and are reproduced in Table 2.10.1-1.

The U.S. EPA has published noise level limitations requisite to protect the public against hearing loss or activity interference for various land use categories (EPA, 1974). Sound levels, which are given as $L_{eq}(24)$and $L_{31}(dn)$, are yearly averages on an energy basis (see Table 2.10.1-2). These values are for long-term exposures and take into consideration the cumulative effects of noise. Noise level limitations chosen to protect the public against hearing loss have been set

Table 2.10.1-1 Federal Highway Administration Design Noise Level/Land Use Relationships

Land Use Category	Design Noise Level - L10*	Description of Land Use Category
A	60 dBA (Exterior)	Tracts of lands in which serenity and quiet are of extraordinary significance and serve an important public need, and where the preservation of those qualities is essential if the area is to serve its intended purpose. Such areas could include amphitheaters, particular parks or portions of parks, or open spaces which are dedicated or recognized by appropriate local officials for activities requiring special qualities of serenity and quiet.
B	70 dBA (Exterior)	Residences, motels, hotels, public meetings rooms, schools, churches, libraries, hospitals, picnic areas, recreation areas, playgrounds, active sports areas, and parks.
C	75 dBA (Exterior)	Developed lands, properties, or activities not included in categories A and B above.
D	Variable	For requirements on undeveloped lands, see paragraphs 5a(5) and (6), Federal Highway Administration policy and procedure manual.
E	55 dBA	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, and auditoriums.

* L10 represents the level which can be exceeded not more than 10 percent of the time.

Source: U.S. Department of Transportation, 1972.

Table 2.10.1-2 Yearly Average* Equivalent Sound Levels Identified as Requisite Required to Protect the Public Health and Welfare with an Adequate Margin of Safety

Land Use	Measure	Indoor			Outdoor		
		Activity Interference	Hearing Loss Consideration	To Protect Against Both Effects (b)	Activity Interference	Hearing Loss Consideration	To Protect Against Both Effects (b)
1 Residential with outdoor space and farm residences	Ldn	45		45	55		55
	Leq(24)		70			70	
2 Residential with no outside space	Ldn	45		45			
	Leq(24)		70				
3 Commercial	Leq(24)	(a)	70	70(c)	(a)	70	70(c)
4 Inside Transportation	Leq(24)	(a)	70	(a)			
5 Industrial	Leq(24)(d)	(a)	70	70(c)	(a)	70	70(c)
6 Hospitals	Ldn	45		45	55		55
	Leq(24)		70			70	
7 Educational	Leq(24)	45		45	55		55
	Leq(24)(d)		70			70	
8 Recreational Areas	Leq(24)	(a)	70	70(c)	(a)	70	70(c)

Table 2.10.1-2 Yearly Average* Equivalent Sound Levels Identified as Requisite to Protect the Public Health and Welfare with an Adequate Margin of Safety (Continued, page 2 of 2)

Land Use	Measure	Indoor			Outdoor		
		Activity Interference	Hearing Loss Consideration	To Protect Against Both Effects (b)	Activity Interference	Hearing Loss Consideration	To Protect Against Both Effects (b)
9 Farm Land and General Unpopulated Land	Leq(24)				(a)	70	70(c)

Code:

a. Since different types of activities appear to be associated with different levels, identification of a maximum level for activity interference may be difficult except in those curcumstances where speech communication is a critical activity.

b. Based on lowest level.

c. Based only on hearing loss.

d. An $L_{eq(8)}$ of 75dB may be identified in these situations so long as the exposure over the remaining 16 hours per day is low enough to result in a negligible contribution to the 24-hour average, i.e., no greater than an L_{eq} of 60 dB.

Note: Explanation of identified level for hearing loss: the exposure period which results in hearing loss at the identified level is a period of 40 years.

*Refers to energy rather than arithmetic averages.

such that 96 percent of the population will not experience a hearing threshold shift of more than 5 dBA at 4000 Hertz (cycles per second) in 40 years of continual exposure.

2.10.1.1 NOISE AT THE SITE

The Florida Power Corporation property near Crystal River, Florida, contains two fossil-fired units and one nuclear power plant. Noise sources include fuel transportation, coal-handling and transfer facilities, coal crushers, furnace firing, turbines, generators, draft fans, transformers, and numerous other power-plant associated operations. There is a certain amount of construction at the site which is also a primary noise source. A noise monitoring survey was conducted on October 18, 1977. The purpose of this survey was to determine the existing ambient noise levels in the vicinity of the Crystal River site in order to estimate the noise impacts of the proposed action.

The monitoring survey was conducted at eleven stations in the study area to obtain a representative measure of the existing sound levels and to evaluate the rate of sound level reduction with distance.

The locations of the eleven monitoring stations are shown in Figure 2.10.1-3. The site locations and site descriptions are included in Table 2.10.1-3. All of the stations were located on property owned by FPC and were concentrated in the vicinity of the existing facilities.

Calculated values for L_{10}, L_{50} and L_{eq} at each monitoring station

LOCATION OF NOISE MEASUREMENT SITES
AT FLORIDA POWER CORPORATION CRYSTAL RIVER PLANT, OCTOBER 18, 1977

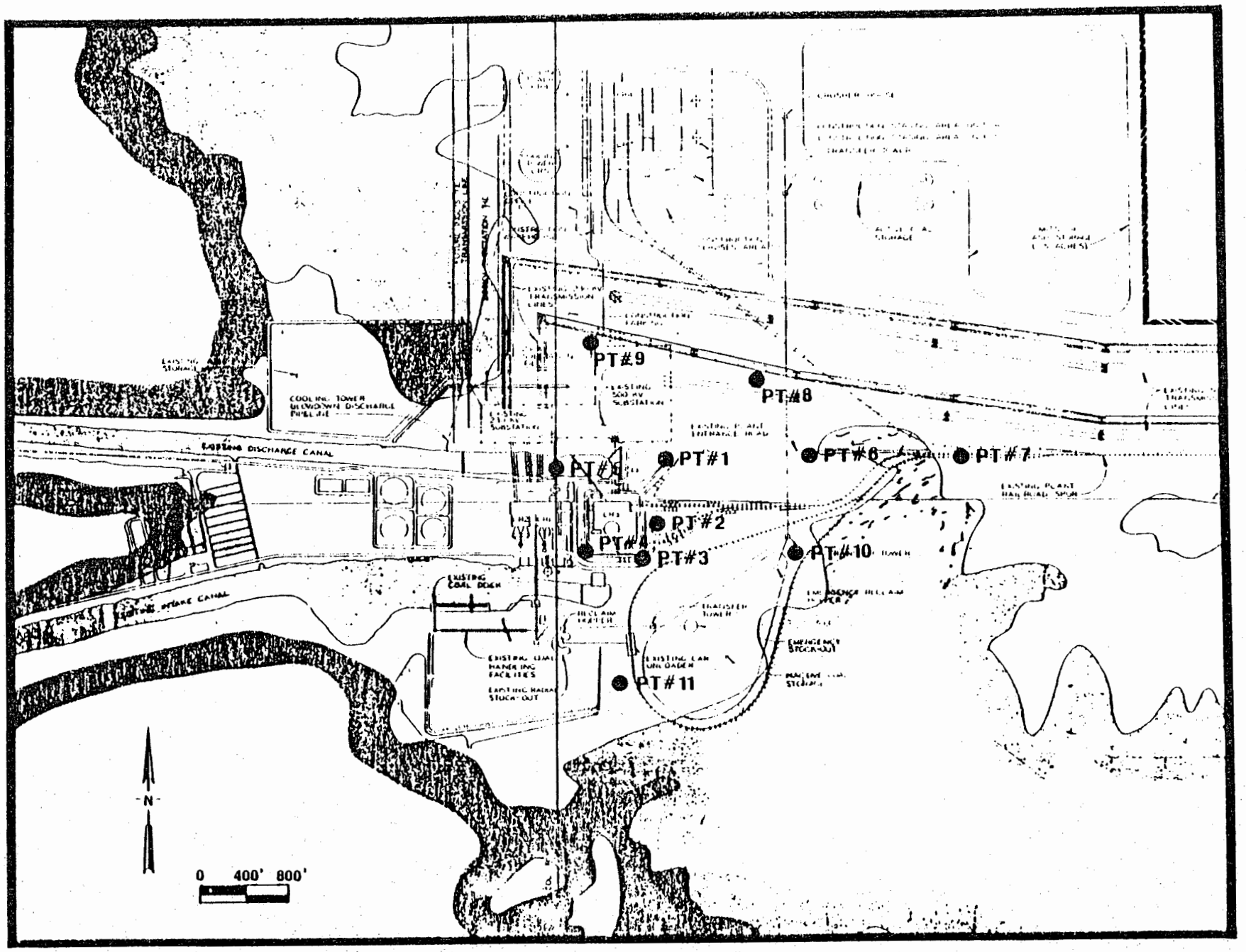


Figure 2.10.1-3

Table 2.10.1-3. Locations and Characteristics of Noise Monitoring Stations (page 1 of 2).

Station No.	Location and Description	Noise Sources	Lake Use*
1	Northeast corner of existing FPC facility adjacent to access road and guard house. Fossil fuel plant is mostly shielded by the Nuclear plant.	Nuclear facility Traffic noise Construction work	5/C
2	East side of Nuclear plant about 9/meters from building. Construction work is south of this station.	Humming noise from nuclear plant. Construction equipment major contributor.	5/C
3	Southeast corner of Nuclear plant. Construction work in close vicinity.	Nuclear plant construction equipment.	5/C
4	Southwest corner of Nuclear plant and across from fossil fuel-fired plant. Nuclear plant is about 15 meters away and fossil fuel-fired plant is about 54 meters away.	Major contributor is the fossil fuel plant. Humming from Nuclear plant-also exhaust fan.	5/C
5	North perimeter of both plants across the water discharge canal.	Fossil fuel plant. Nuclear plant.	5/C
6	East of facility, 4/10 of a kilometer on main access road. Wooded area on south road border. North of road is mostly brush.	Construction work is main contributor to noise. Plant facility is secondary. Also traffic noise.	5/C

Table 2.10.1-3. Locations and Characteristics of Noise Monitoring Stations (page 2 of 2).

Station No.	Location and Description	Noise Sources	Lake Use*
7	East of facility 0.8 kilometers on main access road. Wooded area on South road border. North of road is mostly brush.	Traffic	5/C
8	Northeast of plant 0.4 kilometers. Much undergrowth in area.	Both Nuclear and fossil fuel plants.	5/C
9	North of plant 0.4 kilometers vegetation between here and plant but dense vegetation elsewhere.	Both Nuclear and fossil fuel plants.	5/C
10	Southeast of plant 0.4 kilometers construction underway between here and facility.	Construction is the major contributor.	5/C
11	South of plant 0.4 kilometers construction is underway to the Northeast from here.	Both Nuclear and fossil fuel plants. Construction work.	5/C

*Source: Environmental Science and Engineering, Inc., 1977.

are summarized in Table 2.10.1-4. Comparison of the values shown in Table 2.10.1-1 and the health and welfare levels in Table 2.10.1-2 indicate the following conclusions.

1. No noise measurements were made at any monitoring stations that exceeded the criteria for industrial land use.
2. If station 4 (Figure 2.10.1-3) is considered to be five meters from the center of the plant, the "drop off" rate may be depicted as shown in Figure 2.10.1-4. The points do not lie on the straight line shown because there are several point sources at the center, and the buildings and vegetation cause varying degrees of attenuation. The line shown is quite conservative away from present plant facilities. According to the data, point 7 is virtually equal to noise floor measurements and is almost out of the sphere of influence of the plant. The residential areas to the south and southeast of the plant are remote and unaffected by the existing facility. The only effects which the existing facility has on these areas is traffic induced noise.

NOISE MEASUREMENTS (Leq) AS A FUNCTION OF DISTANCE FROM EXISTING FPC CRYSTAL RIVER FACILITY, OCTOBER 18, 1977.

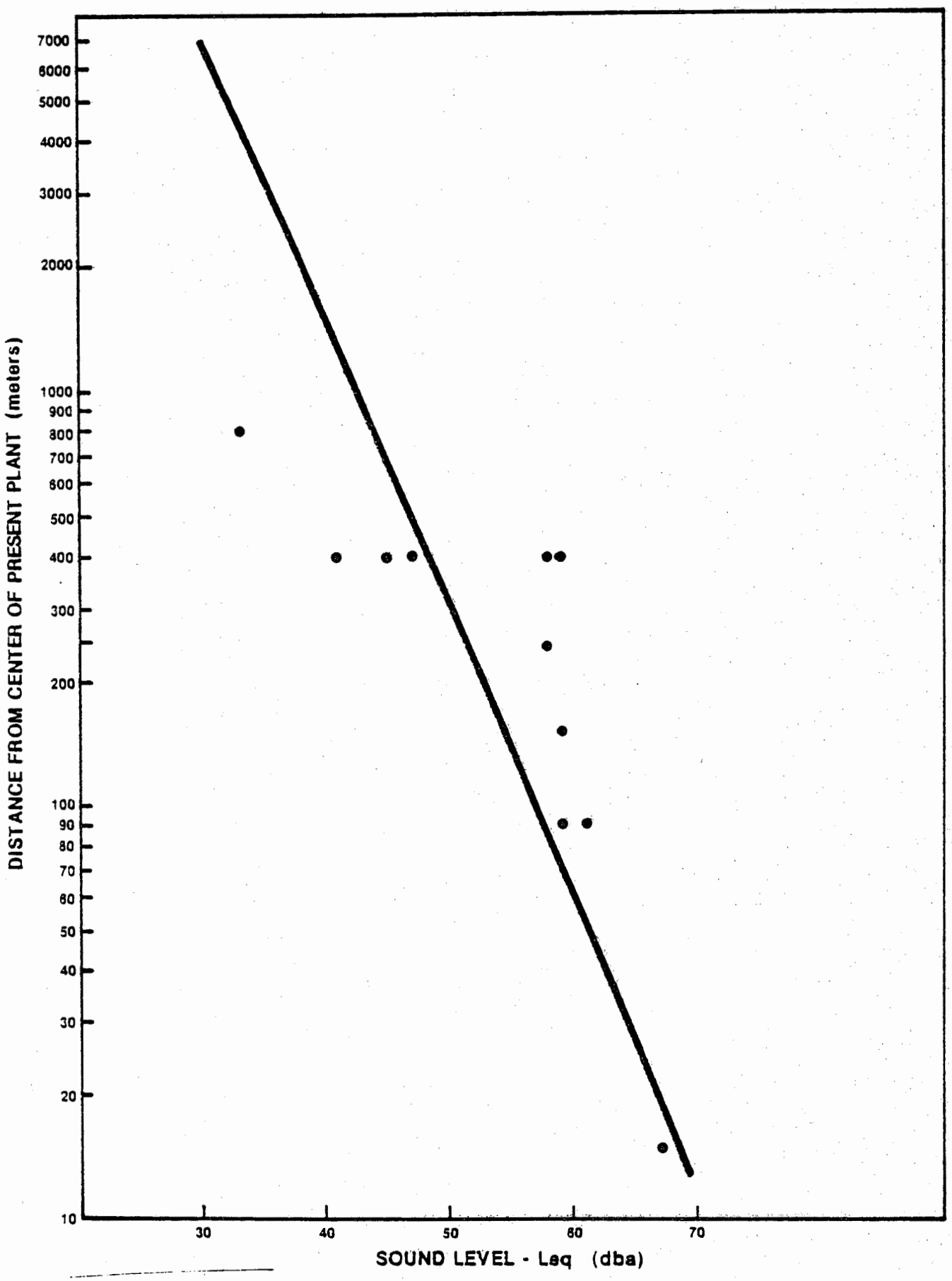


Figure 2.10.1-4

Table 2.10.1-4. Noise Levels Measured at FPC Site, Crystal River, October 18, 1977.

Station Number	L_{10}	L_{50}	L_{eq}
1	59	57	58
2	61	59	59
3	63	61	61
4	67	67	67
5	61	59	59
6	41	41	41
7	37	33	33
8	45	45	45
9	49	47	47
10	59	57	58
11	61	59	59

INSTRUCTION SHEET
FOR UPDATING VOLUME 4
(July 14, 1978)

The following list indicates the additional revisions which should be incorporated into Volume 4 of the Florida Power Corporation Site Certification Application for Crystal River Units 4 and 5. Some of the revised sections are replacements for sections already in the Volume; other sections are additional revisions of the original Volumes 1 through 3 of the SCA. These revised pages should be inserted into the Volume 4 in proper numerical order.

New Sections/Graphics	Instructions
Table of Contents	Replace existing Table of Contents with revised Table of Contents.
2.5.1 Hydrology Groundwater and 2.10.2 Natural Sea Salt	Insert Sections 2.5.1 and 2.10.2 after Section 2.4.5, Flooding.
Figure 3.1-4	Replace Figure 3.1-4, page 3-5, with revised Figure 3.1-4.
Figure 3.1-6	Replace Figure 3.1-6, page 3-8, with revised Figure 3.1-6
Figure 3.3-1	Replace Figure 3.3-1, page 3-26, with revised Figure 3.3-1.
Table 3.3-1	Replace Table 3.3-1, pages 3-27 to 3-30, with revised Table 3.3-1.
Section 3.3 Plant Water Use	Replace Section 3.3, pages 3-31 to 3-36, with revised Section 3.3.
Section 3.4 Heat Dissipation System	Replace Section 3.4, pages 3-37 to 3-43, with revised Section 3.4.
Figure 3.5-1	Replace Figure 3.5-1, page 3-45, with revised Figure 3.5-1.
Figure 3.9-2	Replace Figure 3.9-2, page 3-88, with revised Figure 3.9-2.

INSTRUCTION SHEET
FOR UPDATING VOLUME 4
(July 14, 1978)
(continued, page 2 of 2)

New Sections/Graphics	Instructions
Section 3.10 On-Site Drainage and Erosion Control	Replace Section 3.10 with revised Section 3.10.
Section 4.0	Insert the following revised pages for Section 4.0 after the last page (3-96) of Chapter 3: Section 4.1, pages coded 4.1-1 and 4.1-2 Section 4.2-2, page coded 4.2-2 Section 4.3-3, pages coded 4-3.5 to 4-3.7
Sections 5.1.1, 5.1.2, 5.1.4, 5.1.5	Insert revised Section 5.1.1, Physical Effects of Groundwater Withdrawal; Section 5.1.2, Biological Effects of Groundwater Withdrawal; 5.1.4, Cooling Tower Drift; and 5.1.5, Biological Impacts of Impingement and Entrainment after revised Section 4.3.3.
Section 5.2.2 Cooling System Blowdown	Replace Section 5.2.2, pages coded 5.2-3 and 5.2-4 with revised Section 5.2.2.
Section 5.2.6 Cooling System Intake	Add Section 5.2.6 (coded 5.2-9) after Section 5.2.5 (following page coded 5.2-8).
Section 7.2 Costs and Benefits of the Project to Power Users and to Florida Power Corporation	Add Section 7.2 (pages coded 7.2-1 through 7.2-6) after Section 6.2.4 (following page coded 6.2-7).
Section 9.4.3 Alternatives Considered	Add Section 9.4.3 (pages coded 9.4-4 through 9.4-8) after Section 8A (following page coded VTB8.A-1).

The Site Certification Application for the proposed Crystal River Units 4 and 5 was submitted on December 14, 1977 to Florida Department of Environmental Regulation. Since then, Environmental Science and Engineering, Inc. has compiled additional information and has received comments from various state agencies. The following sections present additional supporting information to the Site Certification Application.

Section	Title
1.0	PURPOSE OF PROPOSED FACILITY AND ASSOCIATED TRANSMISSION
2.4	GEOLOGY
	2.4.1 Site Description
	2.4.2 Physiography
	2.4.3 Stratigraphy
	2.4.4 Soils
	2.4.5 Flooding
2.5	HYDROLOGY
	2.5.1 Ground Water
2.10	OTHER ENVIRONMENTAL FEATURES
	2.10.1 Natural Sea Salt
3.0	THE PLANT
4.0	SITE PREPARATION AND ASSOCIATED FACILITIES CONSTRUCTION/RESULTING ENVIRONMENTAL ENVIRONMENTAL EFFECTS
4.1	SITE PREPARATION AND PLANT CONSTRUCTION
	4.1.1 Construction Areas and Activities
	4.2.2 Water Quality
	4.3.3 Other Impacts on Biota
5.1	HEAT DISSIPATION SYSTEM
	5.1.1 Physical Effects of Groundwater Withdrawal
	5.1.2 Biological Effects of Groundwater
	5.1.4 Cooling Tower Drift
	5.1.5 Biological Impacts of Impingement and Entrainment
5.2	IMPACTS ON SURFACE WATERS
	5.2.2 Cooling System Blowdown
	5.2.6 Cooling System Intake
5.3	IMPACTS ON GROUNDWATER SYSTEMS
5.4	PSD ANALYSIS - AIR QUALITY
	5.6.5 Transportation

Section	Title
6.2	PLANT CONSTRUCTION AND OPERATION MONITORING
	6.2.1 Air
	6.2.2 Wastewater
	6.2.3 Groundwater
	6.2.4 Archaeology
7.2	COSTS AND BENEFITS OF THE PROJECT TO POWER USERS AND TO FLORIDA POWER CORPORATION
	7.2.1 Costs Attributable to Proposed Crystal River Units 4 and 5
9.4	WATER SOURCE AND INTAKE ALTERNATIVES
	9.4.3 Alternatives Considered
8.A	ECOLOGICAL COMPARISON OF CRYSTAL RIVER AND PHOSPHATE ZONE SITES (Addendum to Chapter 8)
	SECONDARY COOLING TOWER MAKEUP ALTERNATIVES: REPORT OF THE LAKE ROUSSEAU STUDIES

2.5 HYDROLOGY

2.5.1 GROUND WATER

Most of the area groundwater flow is concentrated in a moderately thin zone just below the water table (Faulkner, 1973). The upper rock of the Avon Park Formation impedes the downward movement of water, causing the preferred flow path of water recharged to the aquifer to be in the horizontal direction in the highly permeable sections of the Ocala Group.

Large quantities of water flow through the groundwater system and break out in the numerous springs in the area. Discharges at Crystal River Springs have averaged 2.24 million cubic meters (592 million gallons) per day (USGS, 1976) during the last 12 years. Although it is not recorded, ground water is also discharged from springs and seeps located along the coast. From a flow-net analysis of the area, Geraghty and Miller (1977) estimate that these additional unrecorded spring discharges between Crystal River and the Cross-Florida Barge Canal could be approximately 9.46 mld (250 mgd).

AQUIFER CHARACTERISTICS

Geraghty and Miller (1977) used an indirect technique to estimate the aquifer transmissivity. A flow-net analysis of the ground water discharging into Crystal River between the 5-foot and 10-foot contours on the potentiometric surface for May, 1977, yielded an average transmissivity of about 17,300,000 liters per day per meter (15 million gallons per day per foot). This value is comparable to that found for the Silver Springs area by Faulkner (1973) and is indicative of a very permeable aquifer.

In June 1978 an aquifer test was performed at the proposed well field site by Geraghty and Miller. The aquifer coefficients estimated from a flow net analysis and that obtained as a result of the pumping test are:

	Estimated	Actual
Transmissivity	1.86×10^8 lpd/meter, (1.5×10^7 gpd/foot)	563,700 lpd/meter, (45,390 gpd/foot)
Storage coefficient	0.2-0.0002	0.0003
Leakance	---	(0.028 gpd/foot), 3.74 lpd/cubic meter

A detailed analysis of the aquifer test is included as an appendix to this chapter.

The difference in the values obtained by the flow-net analysis and the aquifer test are thought to be the result of local variations in the hydrogeologic system. The flow-net analysis can only give an <u>average</u> figure for transmissivity. Solution channels or highly permeable rock zones may act as conduits which carry the water to discharge areas (such as springs or seeps) along the coast. Areas between the solution channels may exhibit much lower permeability and therefore much lower transmissivities.

No determinations are available of the storage coefficient or leakance in the area. However, because the upper portion of the aquifer near the plant site is under water-table conditions, the storage coefficient is estimated to be on the order of .05 to .20 by Geraghty and Miller. This means that for every unit volume of rock, approximately 5 to 20 percent of that volume is water which can be released from storage under the influence of gravity.

The upper portion of the aquifer is composed of a network of solution features that serve to transmit large quantities of water under natural or man-imposed gradients. The permeability of the deeper portion of the aquifer is not known. The deeper portion of the aquifer may

2.10.2 NATURAL SEA SALT

Figures 2.10-5, 2.10-6, and 2.10-7 indicate the trends for salt concentration and deposition as a function of distance from the coastal boundary. The corrosion rate caused by natural sea drift falls off rapidly with increasing distance from the sea. Studies show that in coastal areas, the corrosion rates of iron, stainless steel, and aluminum decrease by factors of 10, 3, and 21, respectively, as the distance increases from about 25 meters (80 feet) to about 250 meters (800 feet) inland (Roffman, et al., 1973). High precipitation rates tend to wash off the salt and thus reduce the corrosion rate, but high humidity and fog keep the surface wet and enhance corrosion. Structures in warm areas, with long periods of exposure to sunshine, experience less corrosion due to the fast evaporation of the droplets.

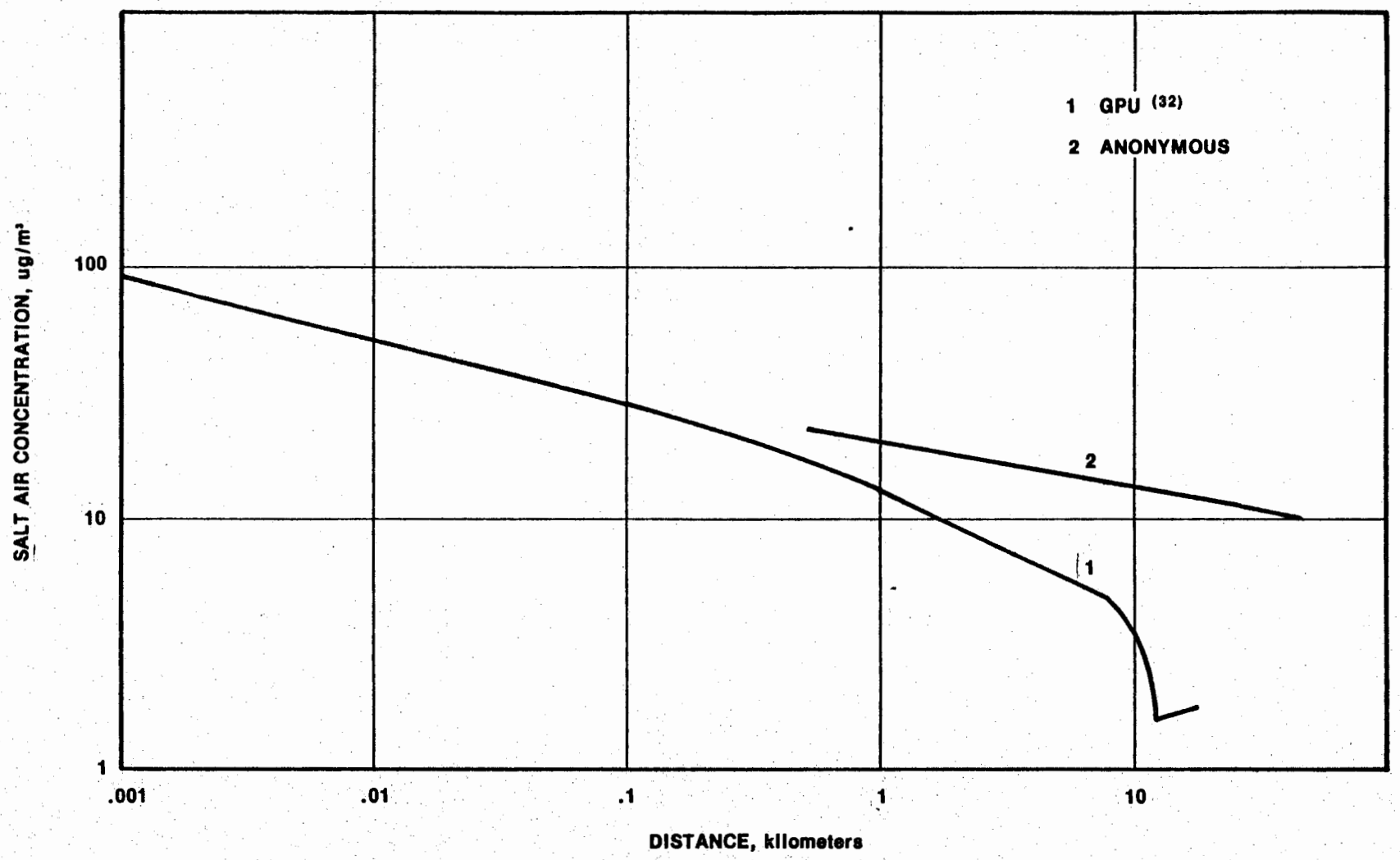


Figure 2.10-5
AIR CONCENTRATION OF SALT DRIFT AS A FUNCTION OF DISTANCE FROM THE SEA

SOURCE: WESTINGHOUSE ELECTRIC, 1973

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CITRUS COUNTY, FLORIDA

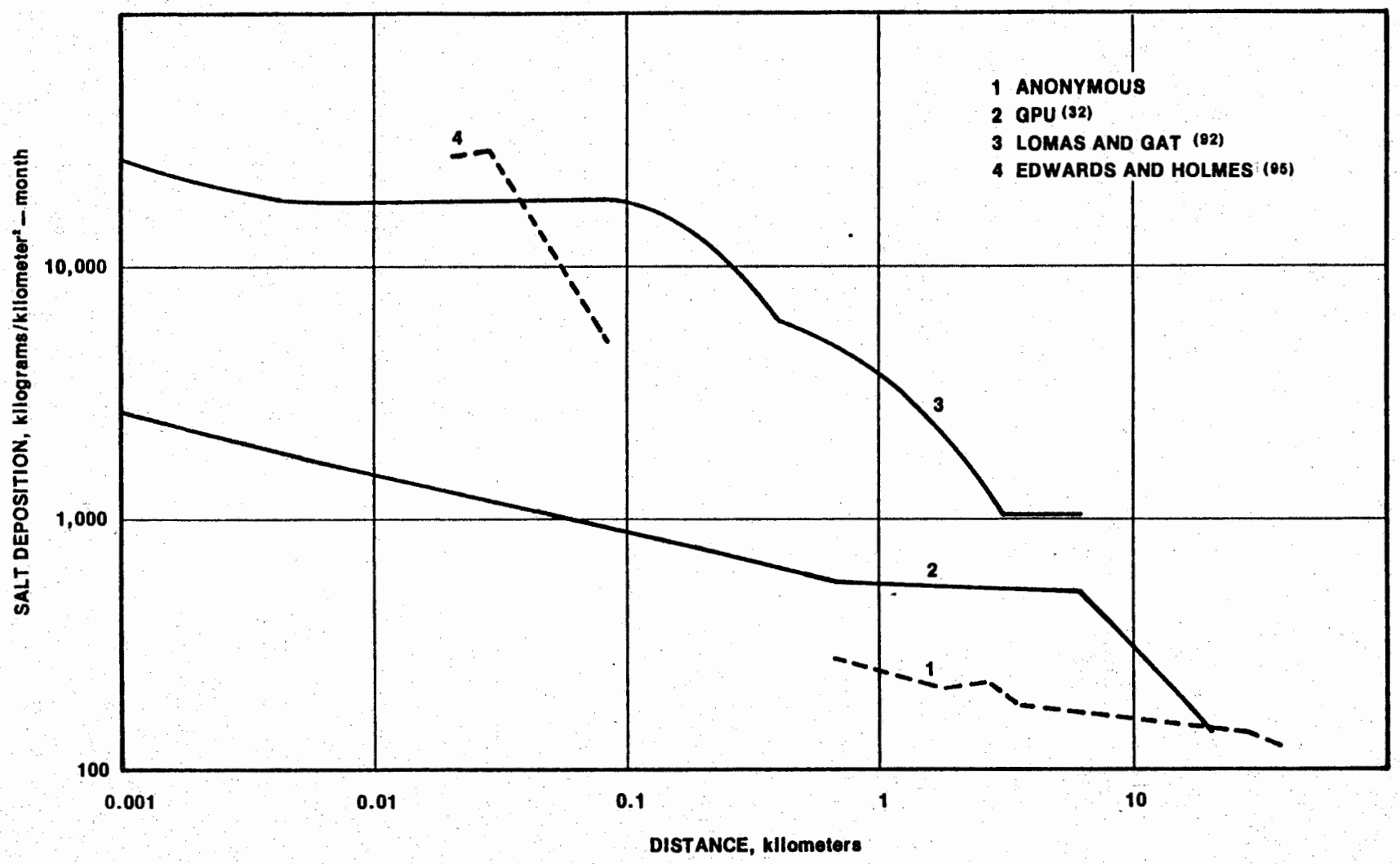

Figure 2.10-6
NATURAL DRIFT DEPOSITION RATE AS A FUNCTION OF DISTANCE FROM THE SEA

SOURCE: WESTINGHOUSE ELECTRIC, 1973

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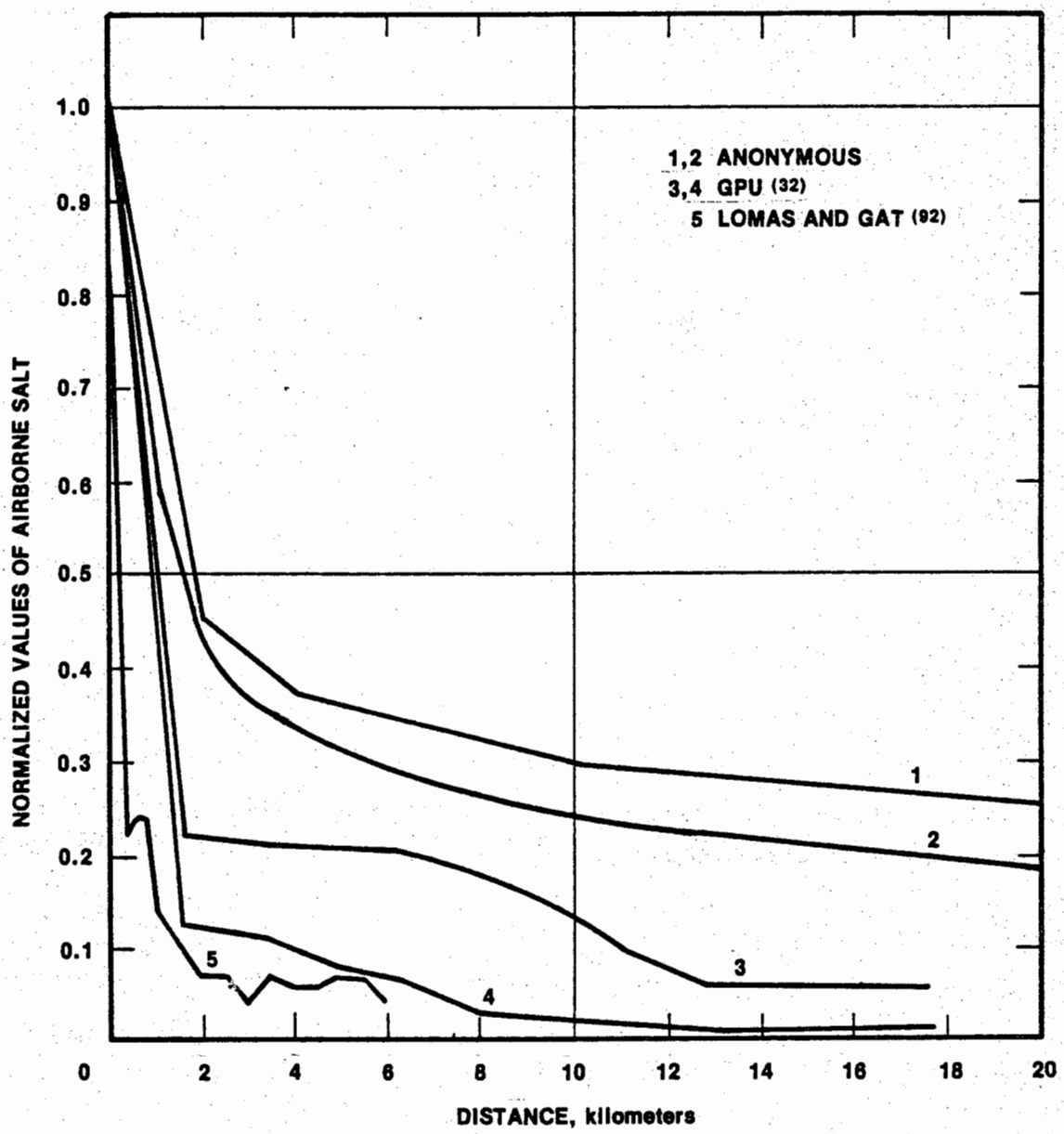


Figure 2.10-7
NORMALIZED AIRBORNE SALT VALUES AS A FUNCTION OF THE DISTANCE INLAND (WITH AN INITIAL VALUE OF ONE AT SEA SHORE)

SOURCE: WESTINGHOUSE ELECTRIC, 1973

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

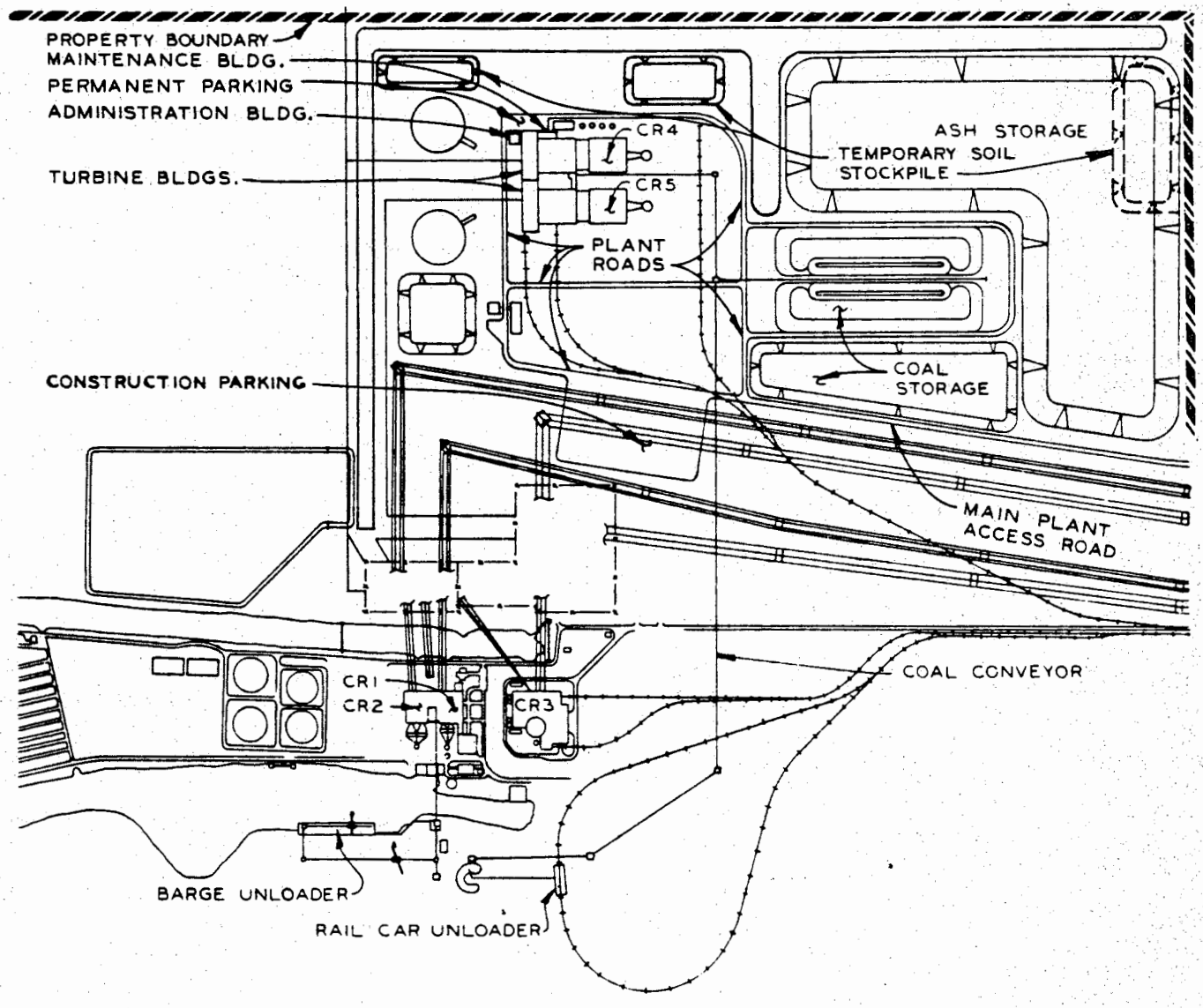


Figure 3.1-4
FACILITY LAYOUT

SOURCE: BLACK AND VEATCH, 1976 (7/78)

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

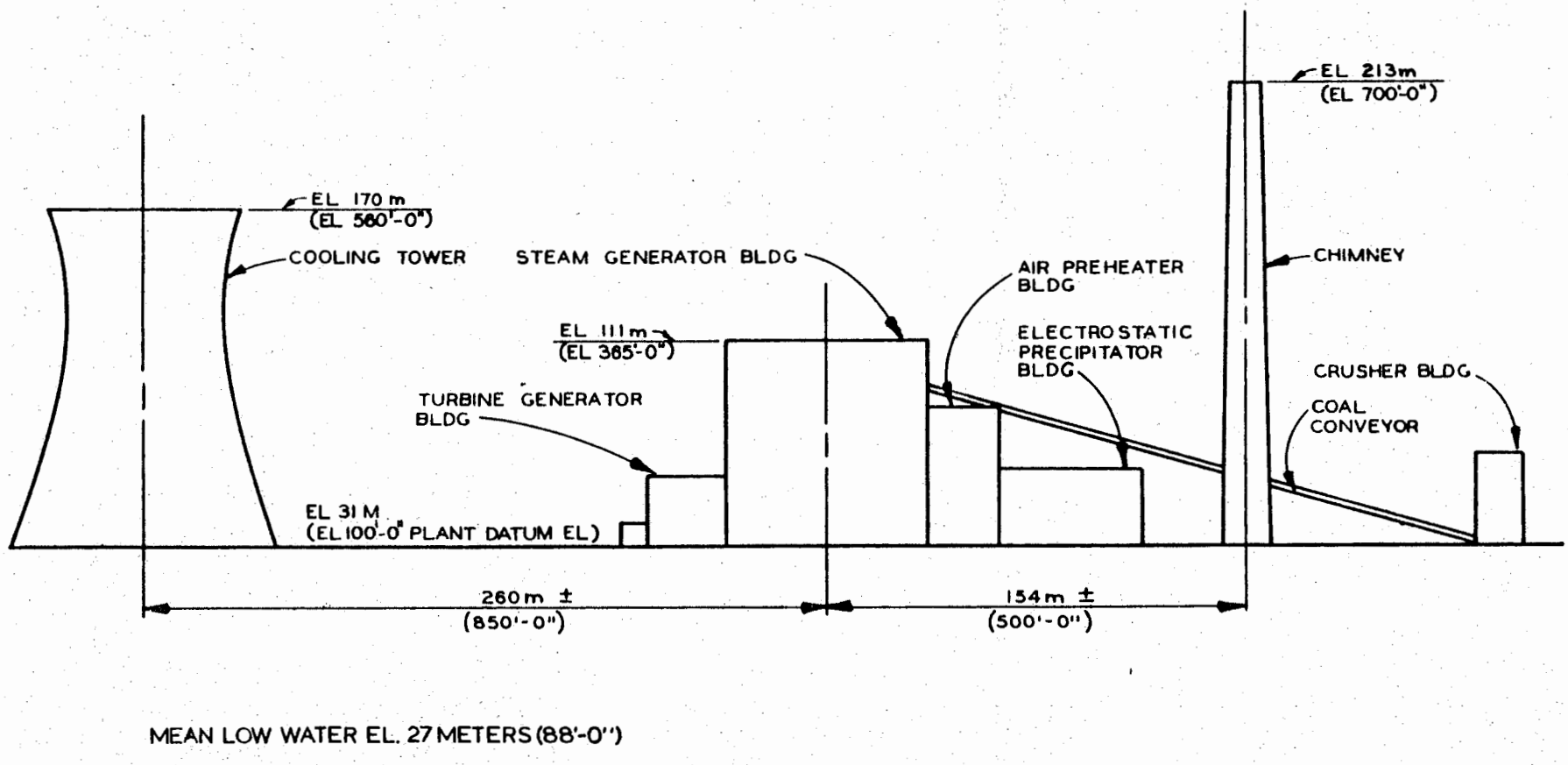
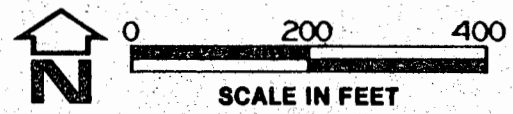


Figure 3.1-6
UNIT 4 AND 5 PLANT PROFILE



SOURCE: BLACK AND VEATCH, 1978 (7/78)

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

OUTLINE OF REVISIONS INCLUDED IN VOLUME 4
OF THE
FPC CRYSTAL RIVER UNITS 4 AND 5 SITE CERTIFICATION APPLICATION

Submittal Date	Submittal Description
December 1977	Site Certification Application, Volume 1-3. Submitted to FDER.
June 14, 1978	SCA Volume 4. Submitted to FDER containing additional supporting information that reflected developments since December 1977.
July 14, 1978	SCA Volume 4. Revised again and re-issued to reflect further developments and information subsequent to the June 14, 1978 submittal.
July 21, 1978	One additional section (Section 5.8.3) was added to Volume 4 to complete all revisions to the SCA to date.
	Volume 4 was issued as a supplement to SCA Volumes 1-3, Volume 4 is to be read separately from Volumes 1-3. Certain sections have been revised since December 1977. Volume 4 reflects those revisions, but it is not designed to physically replace any sections of the original SCA Volumes.
	A summary of the contents of the most up-to-date version of SCA Volume 4 follows:
June 14, 1978	Chapter 1 is contained in its entirety in Volume 4 and includes updated graphics. Chapter 1 reflects the most recent changes as of May 30, 1978.
June 14, 1978	Section 2.4. Geology was revised and included in the June 14, 1978 submittal. This section should be read instead of the Section in Volume 1.
July 14, 1978	Section 2.5. Groundwater was revised subsequent to the June 14th submittal.
July 14, 1978	Section 2.10.2. Natural Sea Salt was added to Volume 4. Figures 2.10-5 through 2.10-7 were also added in the latest revisions.

Submittal Date	Submittal Description
July 14, 1978	Chapter 3. The Plant is included in its entirely in the June 14th SCA Volume 4. Sections 3.3 and 3.10 of Chapter 3 were, again revised on July 14 to reflect salt water cooling towers and other changes.
July 14, 1978	Section 4.1.1. Construction Areas and Activities. Two pages were revised in this section for the July 14th Volume 4.
July 14, 1978	Section 4.2.2. Water Quality. Whole section revised.
July 14, 1978	Section 4.3.3. Other Impacts on Biota. Whole section revised.
July 14, 1978	Section 5.1.1. Physical Effects on Groundwater Withdrawal. Whole section was revised to show new Geraghty and Miller test well report.
July 14, 1978	Section 5.1.2. Biological Effects of Groundwater Withdrawal. Whole section revised to reflect new wellfield data in Geraghty and Miller report.
July 14, 1978	Section 5.1.4. Cooling Tower Drift. This section was revised to reflect the decision to use saltwater cooling towers for CR Units 4 and 5.
July 14, 1978	Section 5.1.2. Biological impacts of Impingement and Entrainment. This section was added to Chapter 5 to reflect the new design of the intake structures for CR Units 4 and 5.
June 14, 1978	Section 5.2.1. Summary of Wastewater Disposal Systems. Whole section revised.
July 14, 1978	Section 5.2.2. Cooling Systems Blowdown. Revised due to change to saltwater cooling towers.
July 14, 1978	Section 5.2.6. Cooling System Intake. Reflects new intake design.
July 14, 1978	Section 5.3. Impacts on Groundwater Systems. Revised to reflect use of saltwater cooling towers.
June 14, 1978	Section 5.4. PSD Analysis--Air Quality. Whole section revised.
June 14, 1978	Section 5.6.5. Transportation. Section added to respond to FDER comments.

Submittal Date	Submittal Description
July 21, 1978	Section 5.8.5. Control Technology. Changed to show use of saltwater cooling towers.
July 14, 1978	Section 6.2. Plant Construction and Operation Monitoring. Section added to Chapter 6 to show FPC's proposed monitoring programs for the construction period.
July 14, 1978	Section 7.2. Costs and Benefits of the Project to Power Users and to Florida Power Corporation. This section was revised to show any changes in costs or benefits to Florida Power due to the use of saltwater cooling towers.
June 14, 1978	Section 8A. Ecological Comparison of Crystal River and Phosphate Zone Sites. This section was issued as a supplement to Chapter 8 in order to add more depth to the comparisons between the Crystal River site and the phosphate zone sites.
July 14, 1978	Section 9.4.3. Alternatives Considered. This section is revised to show the effect of choosing saltwater cooling water as the preferred cooling water source.
June 14, 1978	Lake Rousseau Report. Included in its entirety to explain the data that resulted from the study of Lake Rousseau as an alternative source for cooling water for CR Units 4 and 5.

AN EXPLANATION OF THE REVISIONS TO
FLORIDA POWER CORPORATION'S SITE CERTIFICATION APPLICATION
FOR CRYSTAL RIVER UNITS 4 AND 5

Chapter 1 Need for Power: Included in original SCA submitted on December 14, 1977.

Chapter 1-Need for Power, completely revised June 14, 1978, to reflect an updated in-service date for Unit 5 and current system information.

Chapter 2 The Site: Included in original SCA submitted on December 14, 1977.

Section 2.4- Geology, revised June 14, 1978, to reflect new information obtained from core borings made on the site.

Section 2.5.1- Groundwater, revised July 14, 1978, to incorporate well test information.

Section 2.10.2- Natural Sea Salt, added July 14, 1978, to present information on natural salt deposition.

Chapter 3 The Plant: Included in original SCA submitted on December 14, 1977.

Chapter 3 - The Plant, completely revised June 14, 1978.

Section 3.3 - Plant Water Use, revised July 14, 1978, to reflect salt water cooling towers as the primary alternative.

Section 3.4 - Heat Dissipation System, revised July 14, 1978, to reflect salt water cooling towers as the primary alternative.

Section 3.10 - Onsite Drainage and Erosion Control, revised July 14, 1978, submittal.

Chapter 4 Environmental Effects of Site Preparation, Plant and Associated Transmission Facilities Construction: Included in original submittal of SCA on December 14, 1977.

Section 4.1.1 - Construction Areas and Activities, two pages, revised July 14, 1978, to reflect drilled pier construction for foundation support rather than concrete grouting and construction of surface (salt) water intake.

Section 4.2.2 - Water Quality, revised July 14, 1978, to reflect changes in impacts due to drilled pier construction.

Section 4.3.3 - Other Impacts on Biota, revised July 14, 1978, to reflect changes in impacts due to drilled pier construction.

Chapter 5 Environmental Effects of Plant Operation: Included in original submittal of SCA on December 14, 1977.

Section 5.2.1 - Summary of Wastewater Disposal Systems, revised June 14, 1978.

Section 5.4 - PSD Analysis-Air Quality, revised June 14, 1978 to reflect the control strategy developed as a result of the EPA PSD permit.

Section 5.6.5 - Transportation, revised June 14, 1978, to respond to DER comments.

Section 5.1.1 - Physical Effects on Groundwater Withdrawal, and

Section 5.1.2 - Biological Effects of Groundwater Withdrawal, revised July 14, 1978 to reflect the test well data.

Section 5.1.4 - Cooling Tower Drift, modified July 14, 1978, to show effects of salt water drift from saltwater cooling towers.

Section 5.1.5 - Biological Impacts of Impingement and Entrainment, revised July 14, 1978, to reflect salt water intake from the existing discharge canal.

Section 5.2.2 - Cooling System Blowdown, changed July 14, 1978, to reflect impacts of saltwater cooling tower blowdown.

Section 5.2.6 - Cooling System Intake, modified July 14, 1978, to reflect new intake design.

Section 5.3 - Impacts on Groundwater Systems, revised July 14, 1978, to reflect impacts associated with plant service water usage.

Section 5.8.5 - Control Technology revised July 21, 1978, to show use of salt water from existing discharge canal as the cooling system.

Chapter 6 Environmental Measurement and Monitoring Program:

Section 6.1 - Baseline Measurements and Monitoring Program, included in original submittal of SCA on December 14, 1977.

Section 6.2 - Plant Construction and Operation Monitoring, originally submitted on June 14, 1978.

Chapter 7 Economic and Social Effects of Plant Construction and Operation: Included in original submittal dated December 14, 1977.

Section 7.2 - Costs and Benefits of the Project to Power Users and to Florida Power Corporation, revised July 14, 1978, to show changes caused by salt water cooling towers.

Chapter 8 Alternative Energy Sources and Sites: Included in original submittal on December 14, 1977.

Section 8A - Ecological Comparison of Crystal River and Phosphate Zone Sites, submitted June 14, 1978.

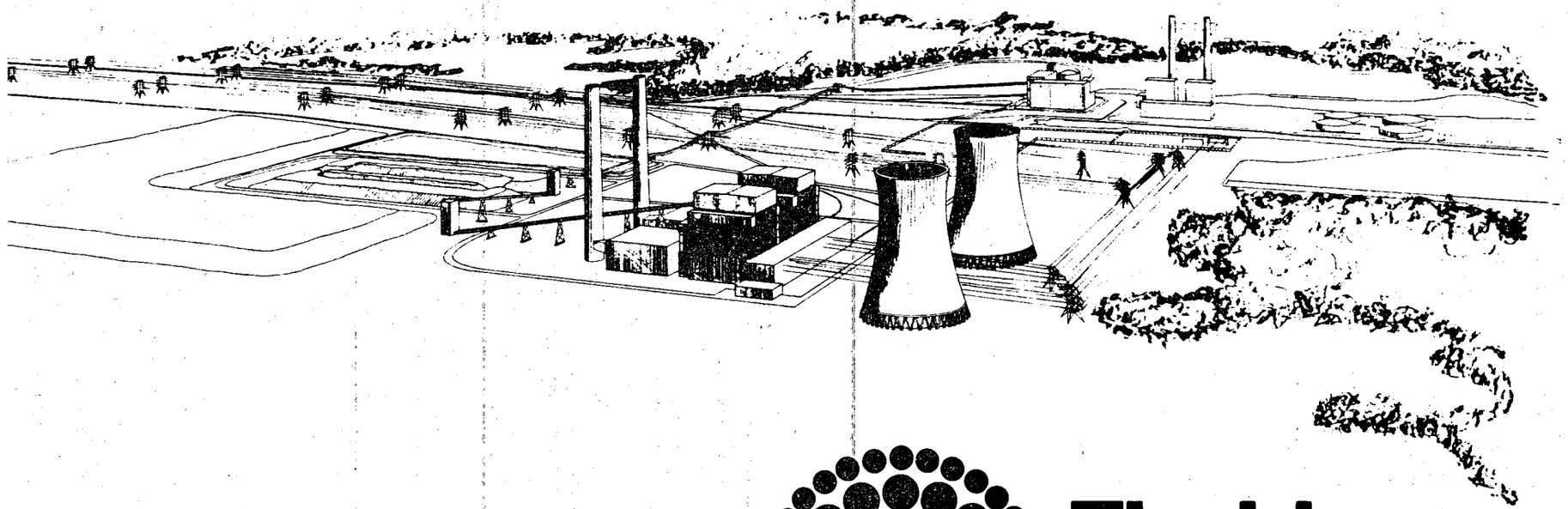
Chapter 9 Plant Design Alternatives: Included in original SCA submitted on December 14, 1977.

Section 9.4.3 - Alternatives Considered, revised July 14, 1978, to show saltwater cooling towers as the preferred alternative.

Lake Rousseau Report: Submitted June 14, 1978, in Volume 4, as a comprehensive analysis of using Lake Rousseau as a cooling water source.

Site Certification Application

Crystal River Units No. 4 & 5



Vol. 2

Florida Power
CORPORATION

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THE PLANT

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3.1 ARRANGEMENT AND EXTERNAL APPEARANCE

3.1.1 Site Arrangement

The building layout and site boundary for Units 4 and 5 at Crystal River are shown in Figures 3.1-1 and 3.1-2. The site includes approximately 15 420 000 m^2 (3810 acres) of land. Figure 3.1-3 is an artist's perspective of the plant site.

The installation of Units 4 and 5 is a reasonable and logical expansion of the power plant site which now comprises Units 1, 2, and 3. The total cleared area for Units 1, 2, and 3 is approximately 1 291 000 m^2 (319 acres). Existing facilities are used to the maximum practical extent to minimize impacts and costs. The plant layout is developed to facilitate plant operation and maintenance.

As shown in Figure 3.1-4, the central building complex for Units 4 and 5 will be located north of the central complex containing Units 1, 2, and 3. Approximately 1 356 000 m^2 (335 acres) will be cleared for the construction of Units 4 and 5. The cooling towers for Units 4 and 5 will be located west of the units. The existing coal handling facilities will be expanded to accommodate the requirements for Units 4 and 5 with a portion of the coal storage area remaining entirely within the existing track loop and the remainder of the active storage east of the proposed units. The solid waste products for all Units 4 and 5 will be stored in areas located east and southeast of the main plant complex.

Figure 3.1-5 shows the relationship of the site boundary to plant access roads and the transmission towers within the transmission corridor.

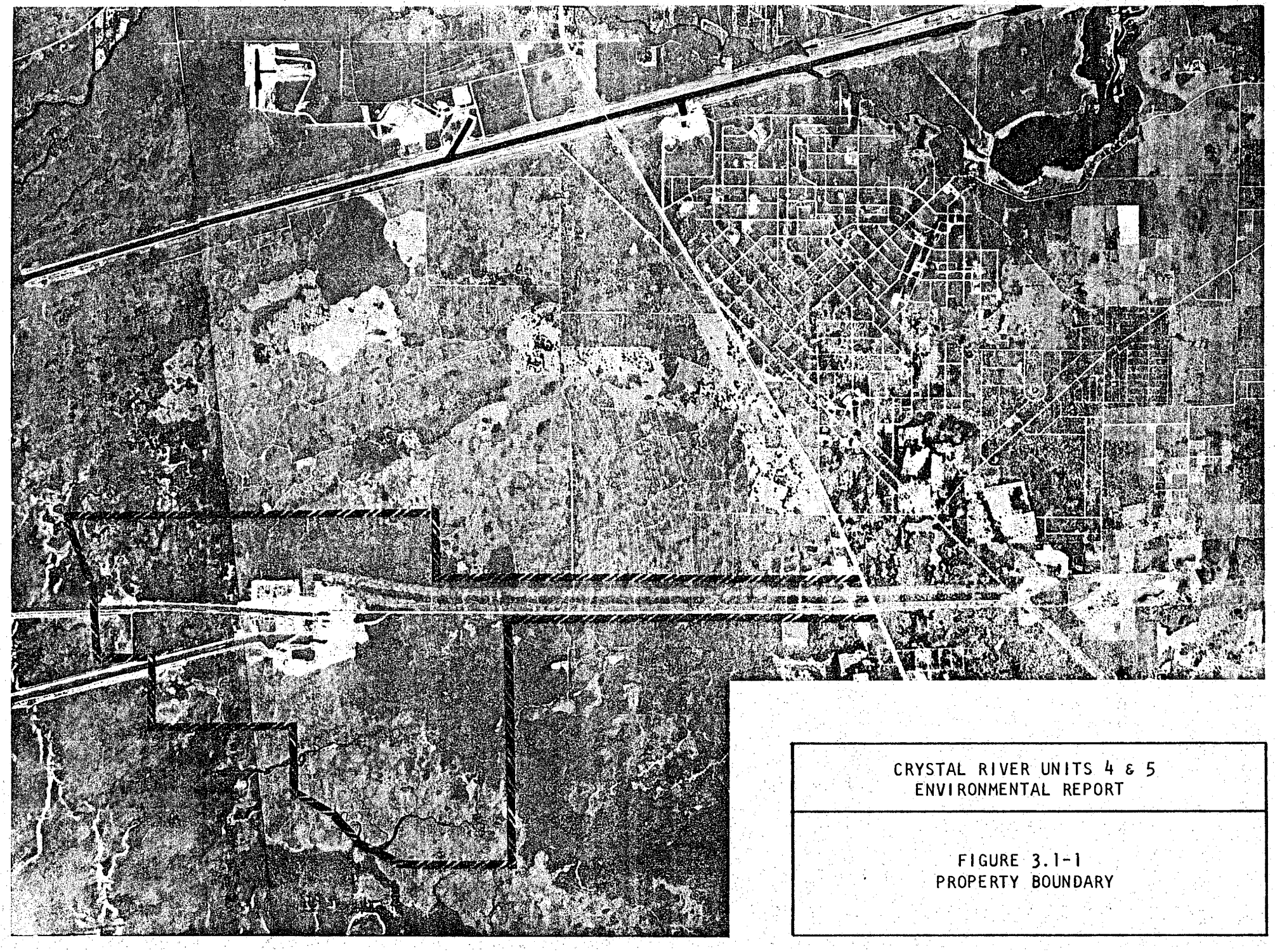
3.1.2 External Appearance

The general external appearance of the plant has been developed in an attempt to achieve maximum compatibility with existing facilities. New structures will be architecturally similar in design, color, and materials to those of Units 1 and 2. The upper portions of enclosed main buildings will be enclosed with wall panels, with masonry wall panels used to enclose the lower or base portions. Smaller buildings in outlying areas utilize masonry, precast concrete, or wall panel enclosures compatible in appearance with the main buildings.

Figure 3.1-3 shows that there will be four chimneys onsite, the existing two for Units 1 and 2 and an additional two for Units 4 and 5. The chimneys on Units 1 and 2 are 152 m (500 FT) tall and the chimneys on the proposed units will be approximately 183 m (600 FT) tall. The steam generator housing for Units 1 and 2 is approximately 64 m (210 FT) high and the housing for Units 4 and 5 will be approximately 81 m (265 FT) high. Directly west of the steam generator structure is the long lower building which contains the turbine generators. The turbine generator building will be totally enclosed with wall panels on the upper portion and masonry

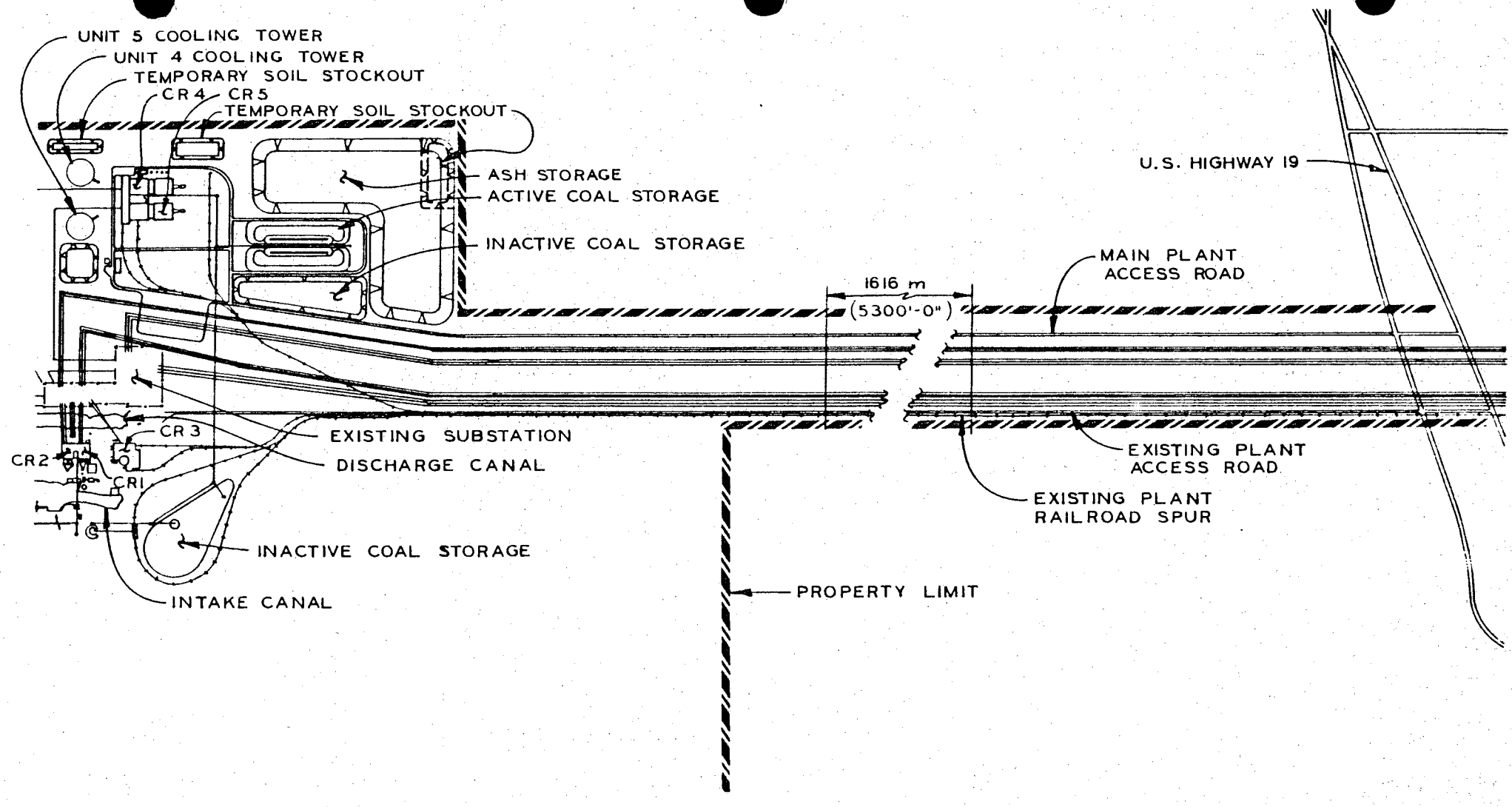
or wall panels on the base portions. The cooling towers will be natural draft, approximately 140 m (460 FT) tall, and 113 m (370 FT) in diameter at the base. The relative locations of the chimneys and cooling towers are shown in profile in Figure 3.1-6. Other facilities such as crusher building, coal piles, and containment for solid waste storage areas will generally be less than 31 m (100 FT) high.

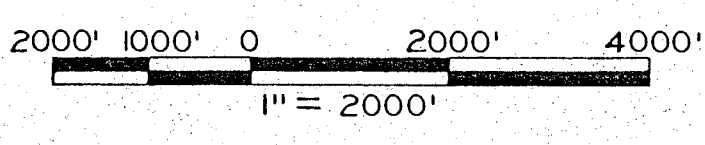
The 100 foot elevation shown on Figure 3.1-6 is the plant datum elevation. The Mean Low Water Level for the plant datum is 27 m (88 FT).



CRYSTAL RIVER UNITS 4 & 5
ENVIRONMENTAL REPORT

FIGURE 3.1-1
PROPERTY BOUNDARY

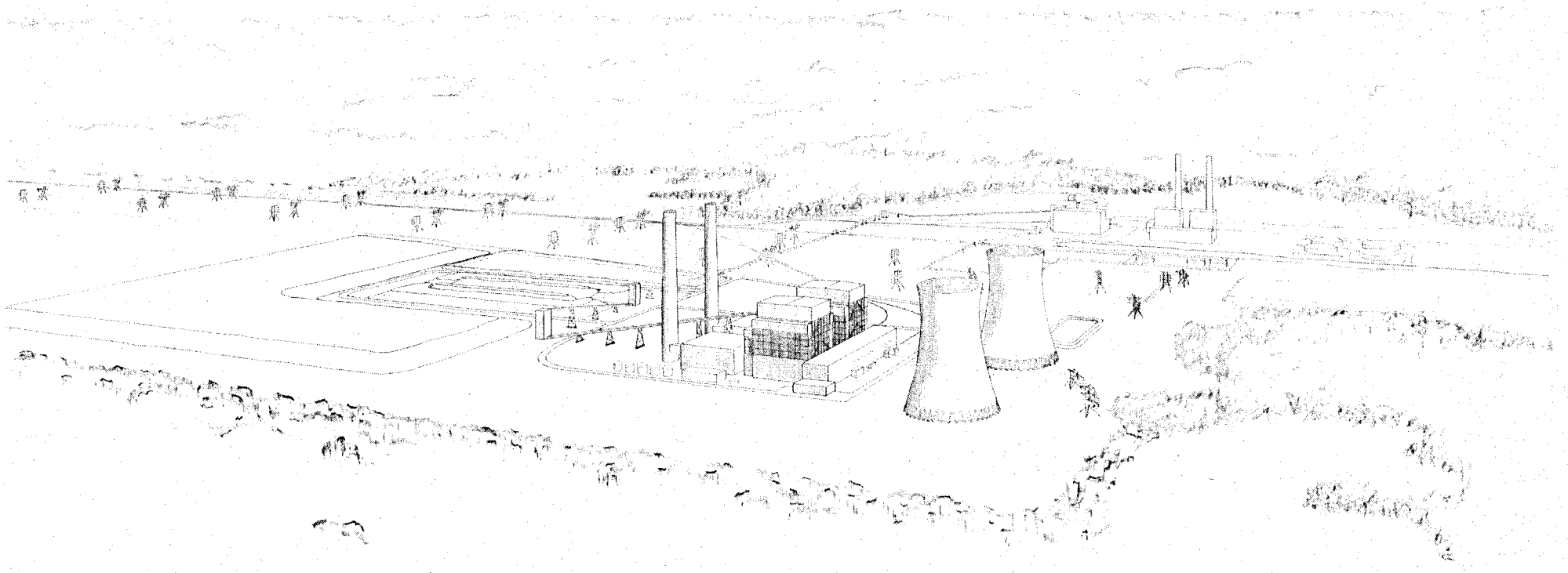




1" = 610 METERS

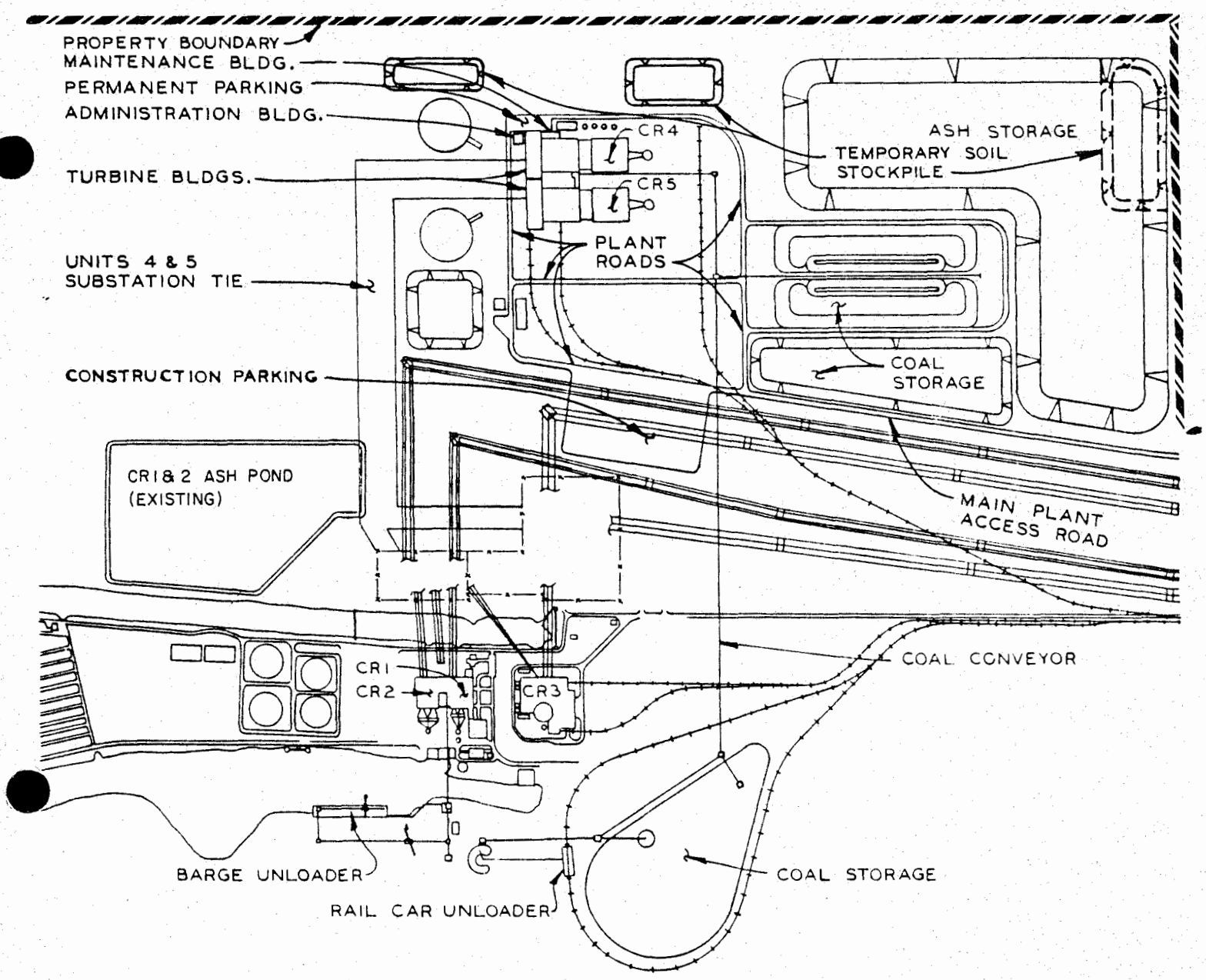
CRYSTAL RIVER UNITS 4 & 5
ENVIRONMENTAL REPORT

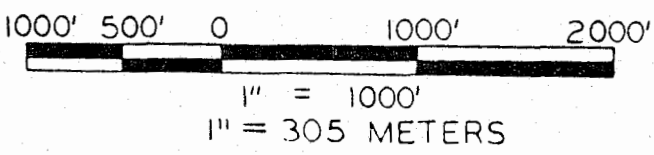
FIGURE 3.1-2
CRYSTAL RIVER SITE LAYOUT



CRYSTAL RIVER UNITS 4 & 5
ENVIRONMENTAL REPORT

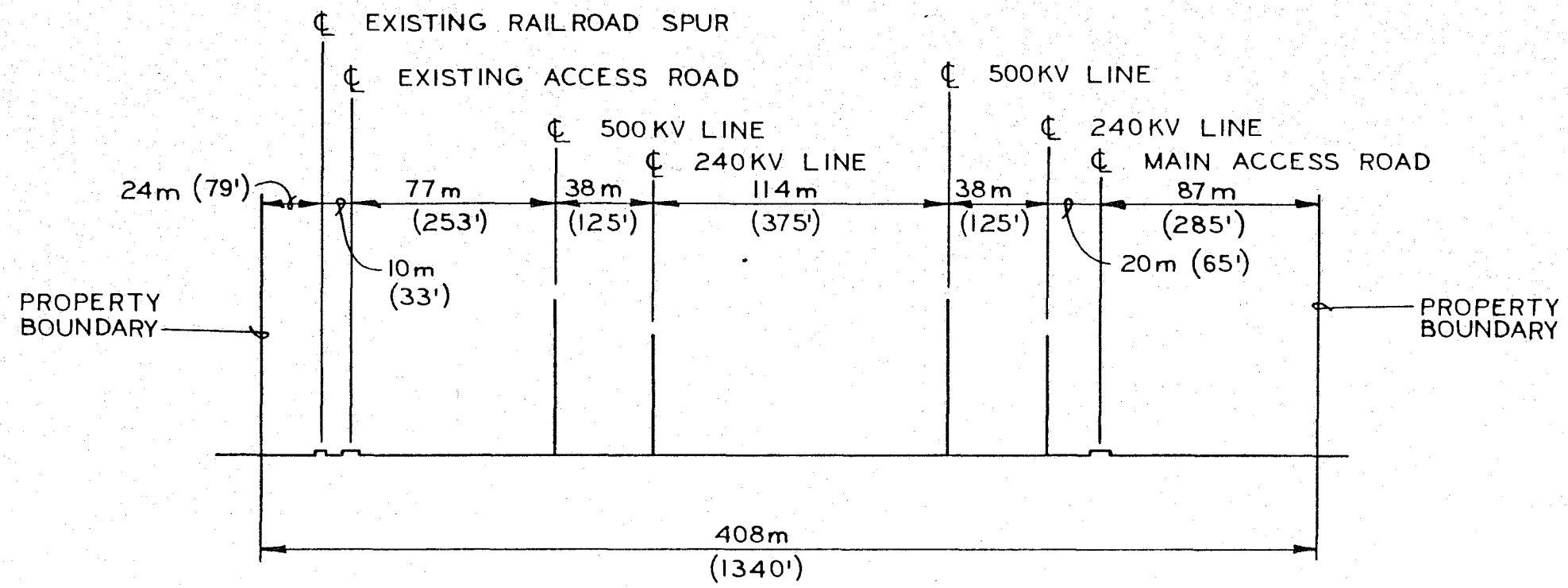
FIGURE 3.1-3
ARTIST'S PERSPECTIVE
CRYSTAL RIVER SITE

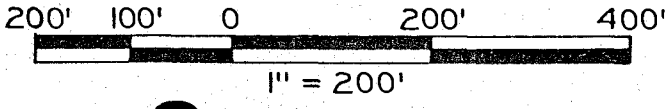




CRYSTAL RIVER UNITS 4 & 5
ENVIRONMENTAL REPORT

FIGURE 3.1-4
CRYSTAL RIVER FACILITY LAYOUT

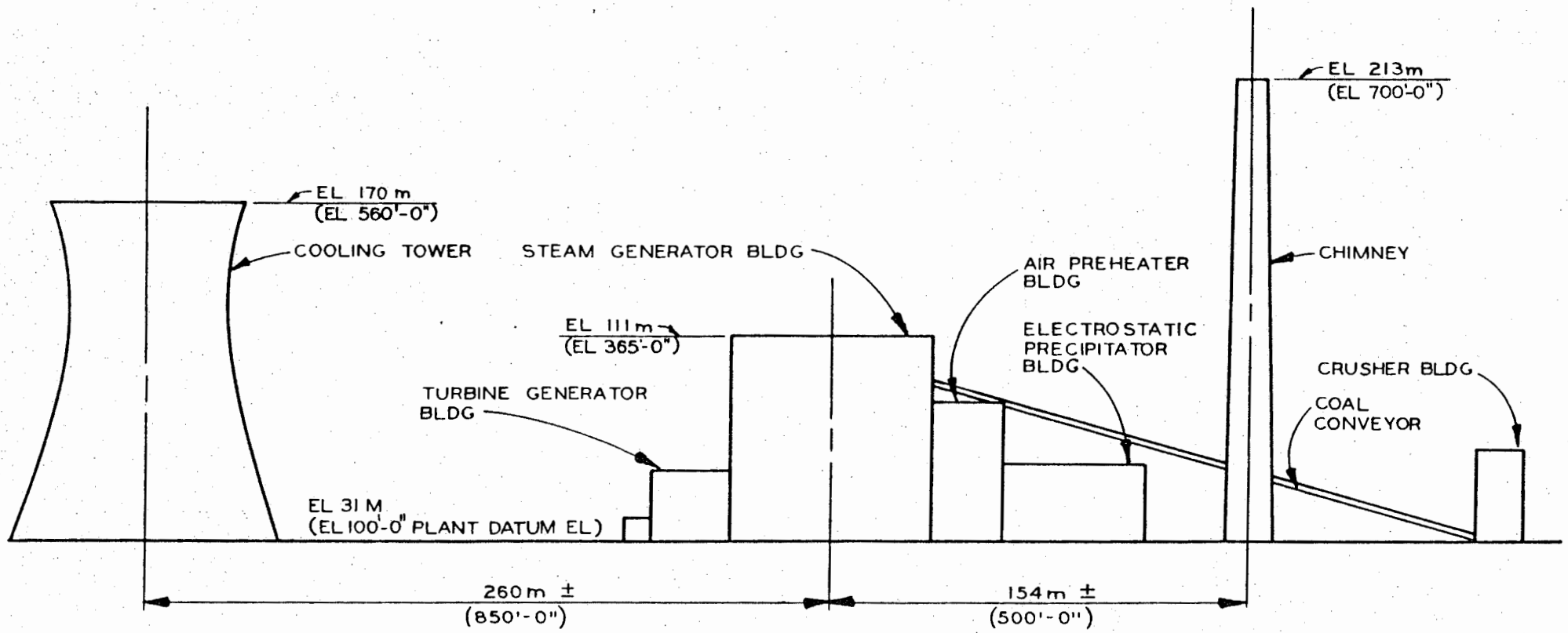




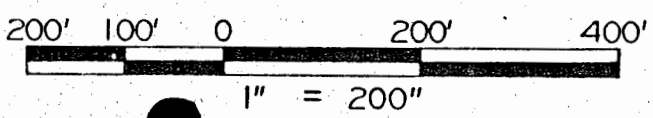
1" = 70 METERS

CRYSTAL RIVER UNITS 4 & 5
ENVIRONMENTAL REPORT

FIGURE 3.1-5
ELEVATION LOOKING WEST
1829m (6000') EAST OF CONVEYOR CROSSING



NOTE: MEAN LOW WATER = EL 88' - 0"



1" = 70 METERS

CRYSTAL RIVER UNITS 4 & 5
ENVIRONMENTAL REPORT

FIGURE 3.1-6
UNIT 4 & 5 PLANT PROFILE

3.2 FUEL

3.2.1 Fuel Types and Quantities

The coal supplies for the Crystal River Plant Units 4 and 5 have not at the present time been committed. Present plans are to utilize coal, or a blend of coals, which will meet the EPA sulfur emission standards without the use of flue gas scrubbers.

The coals which will provide this compliance with the EPA standards are found in two geographical portions of the country; principally in the far western coal fields, and in the Appalachian coal fields. The Appalachian coals are generally a high quality, high BTU, high ash fusion, low sulfur coal. The western coals are generally lower quality, low BTU, high ash, high moisture, but extremely low sulfur coals.

The proposed design coal for the Crystal River Units 4 and 5 is a 50/50 blend of a typical Appalachian and western coal. The fuel and ash analyses for the 50/50 design blend are shown in Tables 3.2-1 and 3.2-2, respectively.

At the rated net output (640 MW), and the design blend coal heating value of approximately 23 923 kJ/kg (10,285 BTU/LB), the coal consumption will be approximately 294 000 kg (648,000 LB) per hour for each unit. The average coal consumption per year over the 30-year life of Units 4 and 5 will be approximately 1 700 000 metric

tons (1,870,000 tons) per year for each unit based on a 0.66 annual average capacity factor.

Auxiliary fuel for furnace warm-up and coal ignition during start-up will be fuel oil. Diesel fuel and gasoline will be used to power the emergency fire pumps and mobile coal and ash handling equipment. Average fuel oil consumption will be approximately 10 600 m^3 (2,800,000 GAL) per year for each unit based on 200 starts per year.

3.2.2 Fuel Transportation

In order to maintain a diversity of supply, approximately 50 per cent of the coal will be transported to the Crystal River site by unit trains and 50 per cent will be transported to the site in oceangoing barges.

The Appalachian coal will be transported in 70 to 110 car unit trains of approximately 90.7 metric ton (100 ton) capacity cars. An average of about four to six trains per week will be required to supply 50 per cent of the coal assuming the present projections for plant capacity.

The western coals will be transported from the coal fields by unit rail trains to the Mississippi River, loaded in river barges, and transported down the Mississippi to the New Orleans, Louisiana

area. The coal will then be transloaded into oceangoing transportation units that will carry the coal across the Gulf of Mexico to the Crystal River site. The existing coal receiving facilities at the Crystal River site are designed for unloading barges of about 13 608 metric tons (15,000 tons) capacity. An average of about three barges per week will be required.

Fuel oil and gasoline auxiliary fuels will be received at the plant by truck or rail, depending on the supplier.

3.2.3 Coal Handling Facilities

3.2.3.1 Existing Facilities--The coal handling facilities at the plant for Units 1 and 2 include a barge and tug mooring dock, Dravo clamshell type barge unloader, Dravo stacker-reclaimer, and an integrated single belt conveyor system connecting the barge unloader and stacker-reclaimer. In addition to the barge unloading facilities, a railcar unloading facility is provided to serve the existing units. This installation includes a railroad loop track for coal delivery and unit train turnaround, an elevated structure for bottom dumping of railcars, and a belt conveyor linking the dump structure with a radial stacker. The radial stacker will generate a coal pile which can be moved by mobile equipment to a reclaim hopper and associated conveyor. The reclaim hopper conveyor will discharge to the transfer house located at the tailpoint of the stockout and reclaim system

yard belt. These facilities are physically located south and southeast of the existing units as shown in Figure 3.2-1. Figure 3.2-2 schematically illustrates the existing facilities.

3.2.3.2 Units 4 and 5 Facilities--The existing coal yard and terminal facilities will be modified and expanded to improve the capability and reliability of the system for the four-unit installation.

Additions to the existing facilities for Units 4 and 5 will include the following:

1. A new stockout and reclaim system for the active storage piles serving the new units;
2. A coal blending facility;
3. Additional coal crushing facilities;
4. An emergency stockout system to allow barge or train deliveries to continue in the event the primary stockout systems are unavailable;
5. An emergency reclaim system serving the new units;
6. A series of conveyors linking the unloading, active storage, blending, and crusher facilities in the coal yard area and a dual belt system connecting the coal yard and the silos in each generating unit. The conveyor system would include associated transfer facilities at belt intersections.

The physical locations of the above listed facilities are shown on Figure 3.2-1, and are schematically illustrated in Figure 3.2-2.

3.2.4 Fuel Storage

3.2.4.1 Existing Facilities--The existing Crystal River Plant Units 1 and 2 utilize three types of coal storage: in-plant storage, active storage, and inactive storage. During normal operation, coal is

dumped from the train cars, or removed from the barges, and transported by a system of conveyors and hoppers to the in-plant storage silos. When the in-plant storage silos are full, the coal is diverted to the active storage piles by the stacker-reclaimer. Active storage provides a buffer between rapid but intermittent unloading of coal trains and barges, and slower but steady coal consumption by the plant. The inactive storage is used for periods when the supply of coal is interrupted such as for equipment failures, labor disputes, or variations between coal purchase contractual commitments.

3.2.4.2 Units 4 and 5 Facilities--Units 4 and 5 will utilize the same three types of coal storage as those for Units 1 and 2.

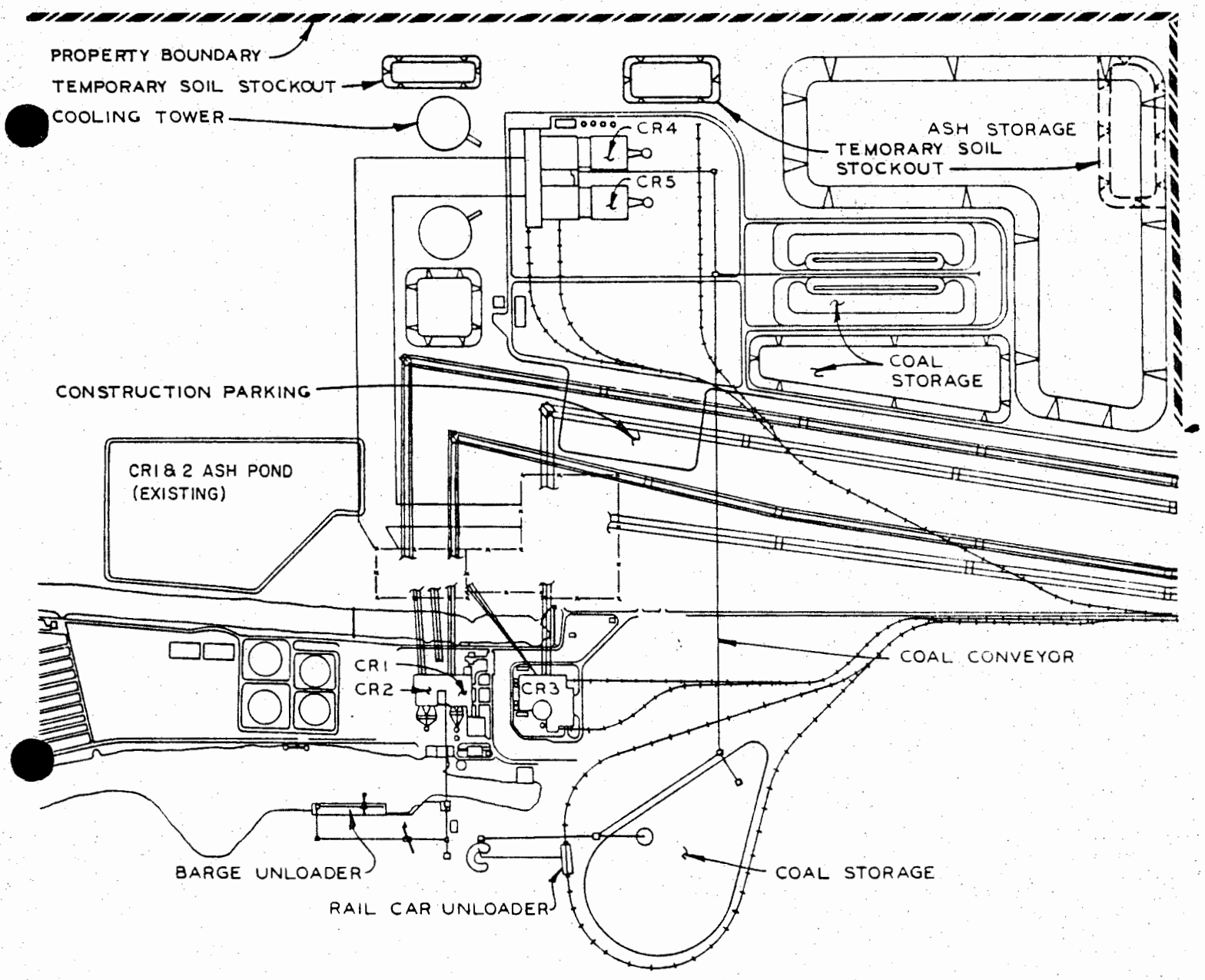
In-plant storage will be provided in 7 or 8 silos for each unit. Both active and inactive storage will be provided in two locations; in the railroad loop track and in the area adjacent to the ash storage area. The railroad loop track storage area will provide for approximately 27 200 metric tons (30,000 tons) of active storage and approximately 572 000 metric tons (630,000 tons) of inactive storage. This area will cover approximately 74 900 m^2 (18.5 acres). The area adjacent to the ash storage area will also provide approximately 27 200 metric tons (30,000 tons) of active storage and 572 000 metric tons (630,000 tons) of inactive

storage. This area will cover approximately 155 800 m^2 (38.5 acres). The storage near the ash disposal area includes 80 900 m^2 (20 acres) for stacker-reclaimer configuration. The total storage provided by both areas is 1 198 000 metric tons (1,320,000 tons).

The total active storage of 54 400 metric tons (60,000 tons) will provide approximately 3 days' fuel requirements for both units at rated net output. This coal storage will be located in the reclaim areas of the new stockout equipment. The average resident time of coal in the active storage areas, based on the present projections of plant capacity, will be 50 to 60 hours.

The inactive storage piles will be generated by mobile equipment and will provide for approximately 1 140 000 metric tons (1,260,000 tons) of storage.

Fuel oil will be stored in two lined, diked areas in steel cylindrical plate storage tanks.



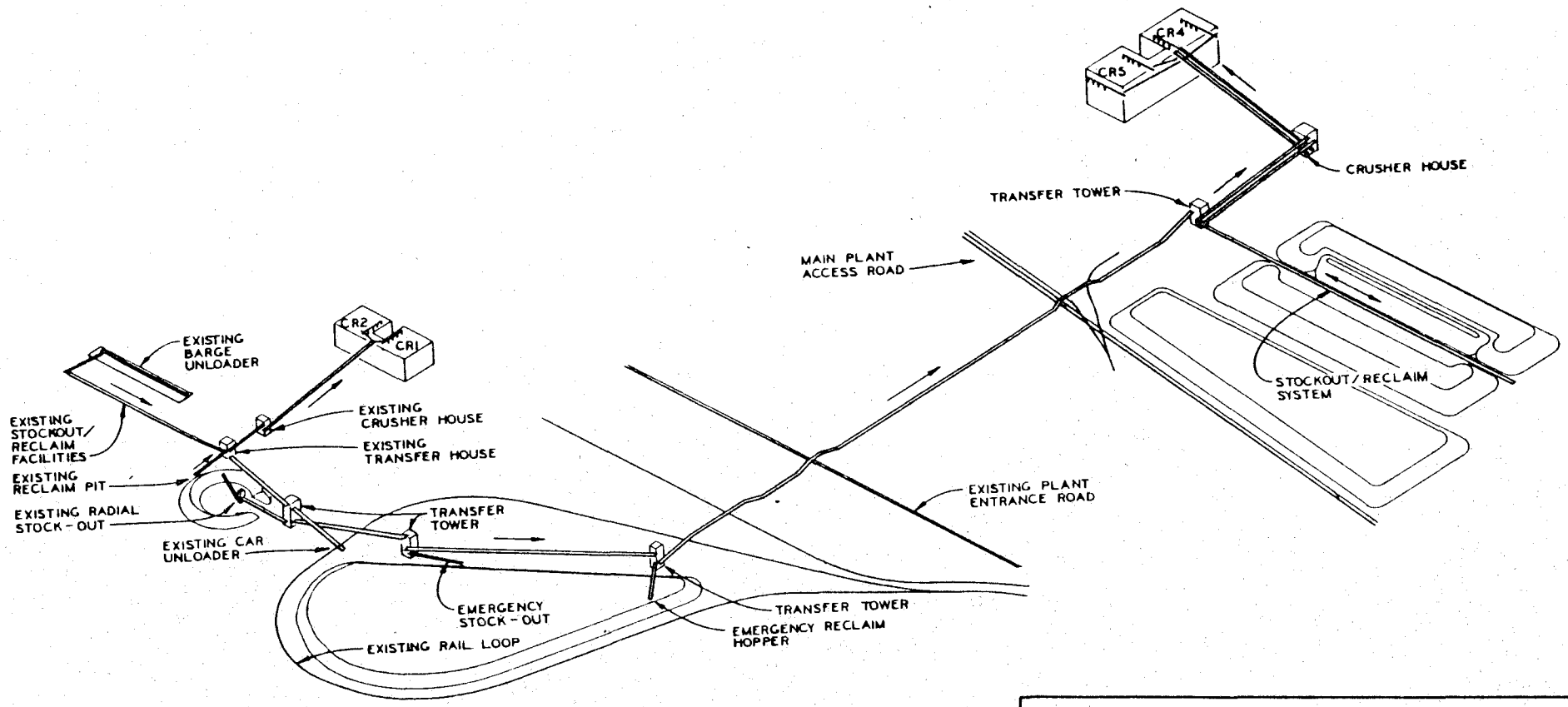
1000' 500' 0 1000' 2000'

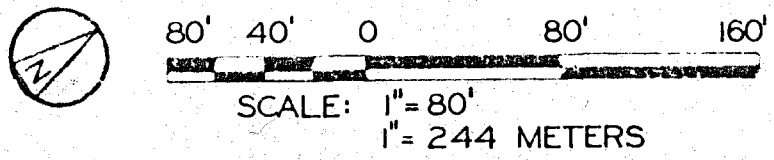
1" = 1000'

1" = 305 METERS

CRYSTAL RIVER UNITS 4 & 5
ENVIRONMENTAL REPORT

FIGURE 3.2-1
COAL HANDLING FACILITIES
CRYSTAL RIVER SITE





CRYSTAL RIVER UNITS 4 & 5
ENVIRONMENTAL REPORT

FIGURE 3.2-2
COAL HANDLING FACILITIES
ISOMETRIC

Table 3.2-1. Fuel Analysis--Units 4 and 5 Design Basis Coal Blend

	Design Basis Coal Blend	
	Typical	Range
Proximate Analysis, Per Cent		
Moisture	18.5	4.0-32.0
Ash	7.9	4.4-15.4
Volatile Matter	31.0	24.6-32.1
Fixed Carbon	42.6	32.1-53.0
Ultimate Analysis, Per Cent		
Carbon	58.8	
Hydrogen	3.9	
Nitrogen	1.1	
Chlorine	0.03	
Sulfur	0.49	
Ash	7.9	
Oxygen	9.28	
Heating Value, kJ/kg (BTU/LB)		
As received	23 923 (10,285)	17 910-30 237 (7700-13,000)

Table 3.2-2. Ash Analysis--Units 4 and 5 Design Basis Coal Blend

	Design Basis Coal Blend	
	Typical	Range
Constituent, Per Cent		
Phosphorous Pentoxide, P_2O_5	1.1	0.4-2.0
Silica, SiO_2	40.2	34.0-45.0
Ferric Oxide, Fe_2O_3	7.1	6.0-8.0
Titanium Oxide as TiO_2	1.0	
Alumina, Al_2O_3	18.2	13.0-24.0
Lime, CaO	15.3	10.5-20.0
Magnesia MgO	3.7	2.0-6.0
Potassium Oxide, K_2O	1.2	0.8-1.5
Sodium Oxide, Na_2O	1.5	0.5-2.8
Sulfur Trioxide as SO_3	9.3	6.0-13.7
Undetermined	1.4	0.7-1.1
Ash Fusion Temperatures, C (F)		
Initial Deformation, Reducing	1 127-1 232	(2060-2250)
Initial Deformation, Oxidizing	1 132-1 288	(2070-2350)
Softening, h = w, Reducing	1 160-1 260	(2120-2300)
Softening, h = w, Oxidizing	1 182-1 316	(2160-2400)
Softening, h = 1/2w, Reducing	1 171-1 277	(2140-2330)
Softening, h - 1/2w, Oxidizing	1 193-1 338	(2180-2440)
Fluid, Reducing	1 193-1 288	(2180-2350)
Fluid, Oxidizing	1 216-1 357	(2220-2475)

3.3 PLANT WATER USE

Water will be used for a variety of purposes at Crystal River Units 4 and 5. Figure 3.3-1 is a schematic flow diagram of plant water supplies, treatment, process consumption, recycle, and discharge. Table 3.3-1 presents this annual average daily quantity of water used and discharged for normal and peak operating conditions and for temporary shutdown plant conditions as defined below:

1. Normal (or average) operating conditions is defined as both generating units operating at the annual average load factor of 66 percent and annual average evaporative conditions; existing for a 24-hour period; i.e., 21.7°C (71°F) dry bulb temperature and 77 percent relative humidity.
2. Peak (or maximum) operating condition is defined as both generating units operating at 100 percent load factor and maximum atmospheric evaporative conditions existing for the cooling towers during a 24-hour period; i.e., 32.8°C (91°F) dry bulb temperature and 55 percent relative humidity.
3. Temporary shutdown is defined as both units being shut down for maintenance or other reasons.

The quantities for rainfall and evaporation from site areas have been generated by using the average annual figures of approximately 1,400 mm/year (55 in/year) for rainfall and 1,220 mm/year (48 in/year) for evaporation (Climatic Atlas of the United States, 1968).

The frequency and duration of peak water use days cannot be predicted accurately because of its dependency on the weather as well as electric system operating conditions external to the Florida Power system. Peak water use occurs, as defined previously, when both generating units operate at 100 percent load factor and when maximum atmospheric evaporative conditions exist for the cooling towers during a 24-hour period. These conditions require a high dry bulb air temperature and a large range between wet bulb and dry bulb air temperatures (i.e., low humidity). These atmospheric conditions are most likely to occur for intermittent periods during the months of April through September.

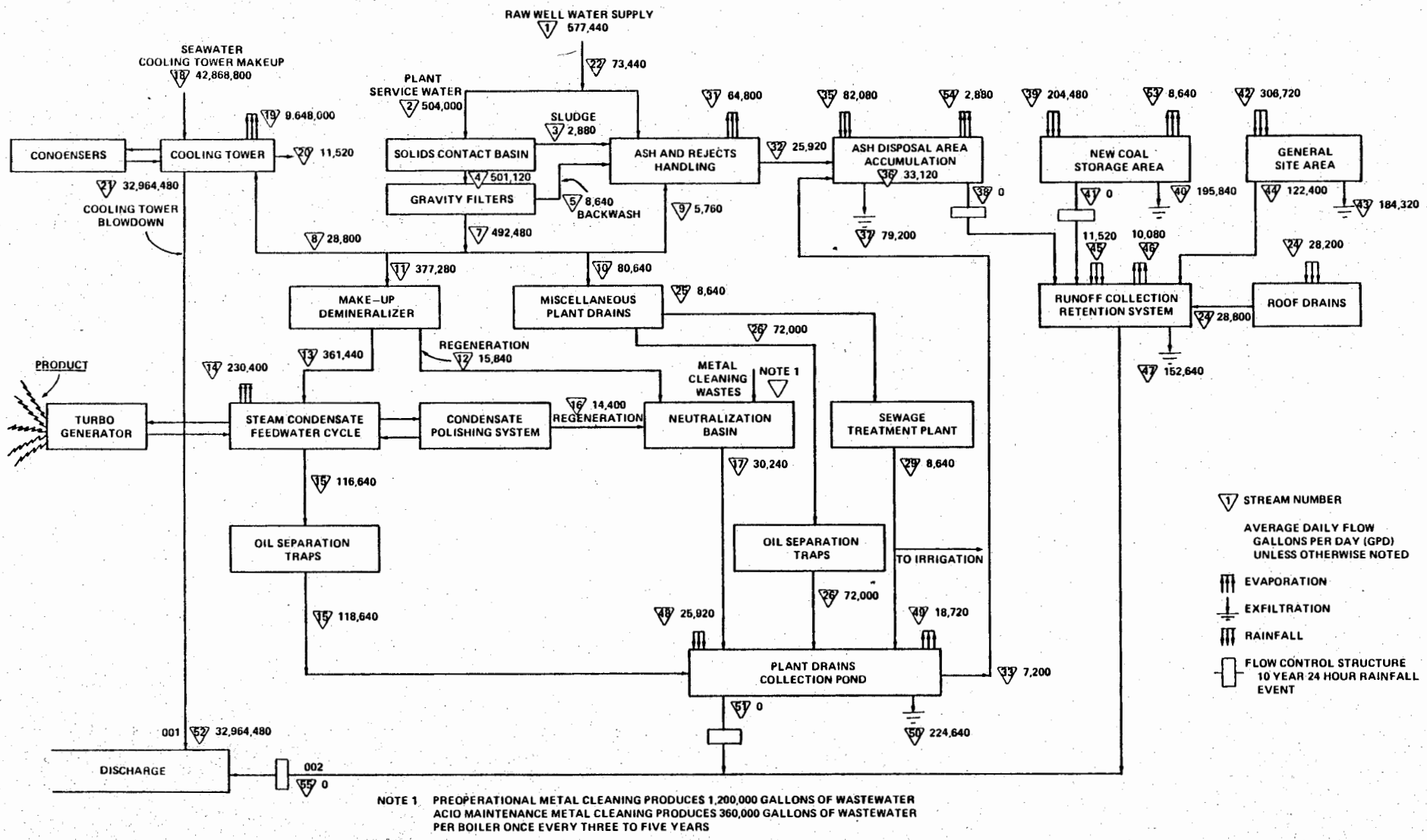


Figure 3.3-1
PLANT WATER USE DIAGRAM

SOURCE: ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1978

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

Table 3.3-1 Crystal River Units 4 and 5 Site and Plant Water Use

Stream Number	Description	Peak		Normal		Temporary Shutdown	
		dm^3/s	(gpm)	dm^3/s	(gpm)	dm^3/s	(gpm)
1	Raw Well Water Supply	35.5	(563)	25.3	(401)	4.8	(77)
2	Water Pretreatment System Makeup	30.6	(485)	22.1	(350)	4.8	(77)
3	Solids Contact Basin Sludge	0.2	(3)	0.1	(2)	0	(0)
4	Solids Contact Basin Effluent	30.4	(482)	22.0	(348)	4.8	(77)
5	Filter Backwash Wastewater	0.4	(6)	0.4	(6)	0	(0)
6	Water Pretreatment System Wastes	0.6	(9)	0.5	(8)	0	(0)
7	Gravity Filter Effluent	30.0	(476)	21.6	(342)	4.8	(77)
8	Circulating Water Pump Bearing Water	1.3	(20)	1.3	(20)	0	(0)
9	Ash Handling System Service Water Uses	0.3	(4)	0.3	(4)	0	(0)
10	Miscellaneous Station and Potable Water Uses	3.5	(56)	3.5	(56)	3.5	(56)
11	Demineralizer Makeup	24.9	(396)	16.5	(262)	1.3	(21)
12	Demineralizer Regeneration Wastes	1.0	(16)	0.7	(11)	0.7	(11)
13	Condensate-Feedwater-Steam Cycle Makeup	23.9	(380)	15.8	(251)	0.6	(10)
14	Steam Cycle Evaporative Losses	15.4	(245)	10.1	(160)	0	(0)
15	Steam Cycle Liquid Losses	7.8	(123)	5.1	(81)	0	(0)
16	Condensate Polisher Wastes	0.7	(12)	0.6	(10)	0.6	(10)
17	Neutralization Basin Effluent	1.7	(28)	1.3	(21)	1.3	(21)
18	Cooling Towers Makeup (saltwater)*	3,083	(48,880)	1,878	(29,770)	0	(0)
19	Cooling Towers Evaporation	711.5	(11,280)	433.4	(6,870)	0	(0)
20	Cooling Towers Drift	0.8	(13)	0.5	(8)	0	(0)
21	Cooling Towers Blowdown	2,371	(37,587)	1,441	(22,892)	0	(0)
22	Raw Well Water to Ash Handling Systems	4.9	(78)	3.2	(51)	0	(0)

Table 3.3-1 Crystal River Units 4 and 5 Site and Plant Water Use, (Continued, page 2 of 3)

Stream Number	Description	Peak		Normal		Temporary Shutdown	
		dm^3/s	(gpm)	dm^3/s	(gpm)	dm^3/s	(gpm)
24	Rainfall to Roof Drains	1.3	(20)	1.3	(20)	1.3	(20)
25	Sanitary Wastes	0.4	(6)	0.4	(6)	0.4	(6)
26	Miscellaneous Plant Drains	3.2	(50)	3.2	(50)	3.2	(50)
29	Sewage Treatment Plant Effluent	0.4	(6)	0.4	(6)	0.4	(6)
31	Bottom Ash Hopper Evaporation	4.2	(67)	2.9	(45)	0	(0)
32	Water Entrained in Ash from Ash Handling	1.6	(24)	1.1	(18)	0	(0)
33	Water for Ash Dust Suppression and Compaction	0.4	(7)	0.3	(5)	0	(0)
35	Active Ash Storage Area Rainfall	3.6	(57)	3.6	(57)	3.6	(57)
36	Active Ash Storage Area Water Accumulation	2.0	(31)	1.4	(23)	0	(0)
37	Active Ash Storage Area Exfiltration	3.5	(55)	3.5	(55)	3.5	(55)
38	Active Ash Storage Area Runoff to Collection Ditch System	0	(0)	0	(0)	0	(0)
39	New Coal Storage Area Rainfall	9.0	(142)	9.0	(142)	9.0	(142)
40	New Coal Storage Area Exfiltration	8.6	(136)	8.6	(136)	8.6	(136)
41	New Coal Storage Area Runoff to Runoff Collection and Retention System (RCRS)	0	(0)	0	(0)	0	(0)
42	General Site Area Rainfall	13.4	(213)	13.4	(213)	13.4	(213)
43	General Site Area Exfiltration	8.1	(128)	8.1	(128)	8.1	(128)
44	General Site Area Runofff to Runoff Collection and Retention System	5.3	(85)	5.3	(85)	5.3	(85)
45	Direct Rainfall on Runoff Collection and Retention System	0.5	(8)	0.5	(8)	0.5	(8)

Table 3.3-1 Crystal River Units 4 and 5 Site and Plant Water Use, (Continued, page 3 of 3)

Stream Number	Description	Peak		Normal		Temporary Shutdown	
		dm^3/s	(gpm)	dm^3/s	(gpm)	dm^3/s	(gpm)
46	Runoff Collection and Retention System Evaporation	0.4	(7)	0.4	(7)	0.4	(7)
47	Runoff Collection and Retention System Exfiltration	6.7	(106)	6.7	(106)	6.7	(106)
48	Plant Drains Collection Pond Rainfall	1.1	(18)	1.1	(18)	1.1	(18)
49	Plant Drains Collection Pond Evaporation	1.0	(15)	1.0	(15)	1.0	(15)
50	Plant Drains Collection Pond Exfiltration	12.4	(203)	9.5	(156)	4.9	(80)
51	Plant Drains Collection Pond Overflow to Runoff Collection and Retention System	0	(0)	0	(0)	0	(0)
52	Plant Discharge 001	2,370	(37,587)	1,444	(22,892)	0	(0)
53	New Coal Storage Area Evaporation	0.4	(6)	0.4	(6)	0.4	(6)
54	Active Ash Storage Area Evaporation	0.1	(2)	0.1	(2)	0.1	(2)
55	Runoff Collection and Retention System Discharge 002	0†	(0)†	0†	(0)†	0†	(0)†

*Based on 1.3 cycles of concentration.

†During heavy rainfall events of greater than 10-year, 24-hour occurrence, overflow from the plant drains collection pond to the runoff collection retention system may be expected.

Note: During heavy rainfall events of greater than 10-year, 24-hour occurrence, overflow from the runoff retention and collection systems will discharge to the discharge cooling canal for Crystal River Units 1, 2, and 3.

Sources: Black and Veatch, 1978.
Environmental Science and Engineering, Inc., 1978.

3.3.1 WATER SOURCES

The water required to operate Crystal River Units 4 and 5 will be obtained from two primary sources, sea water and ground water.

GROUND WATER

Raw ground water for plant fresh water uses will be obtained from a well field along the Florida Power Corporation Central Florida transmission line right-of-way. A maximum design flow 130 dm^3/second (2100 gpm, 3 mgd) is required to guarantee freshwater flow rates under all contingencies. The aquifer characteristics obtained from a pumping test (see Section 2.5.1) have indicated that a linear well field consisting of 21 wells with 500 feet of space between wells and 100 gpm capacity for each well is necessary. This well field would achieve a 3 mgd flow and meet the rules and regulations of the Southwest Florida Water Management District (Chapter 16J F.A.C.). Final design of the well field is dependent upon the evaluation results of additional test drilling and pumping. Water quality data representative of the proposed well field water is presented in Table 3.3-2. Water quality data obtained from samples collected prior to and during the aquifer test indicate similar shallow well water quality to that observed in Table 3.

The well water will be pumped to the station to provide makeup to the ash handling system and plant service water.

Raw well water requirements for Units 4 and 5 will require a peak flow of about 35.5 dm^3/s (563 gpm, 0.81 mgd), and a normal flow of about 25.3 dm^3/s (401 gpm, 0.58 mgd). During temporary shutdown of the two units, raw well water demand will be about 4.8 dm^3/s (77 gpm, 0.11 mgd).

Table 3.3-2 Well Water Analyses

	Existing Well 3	Existing FPC Well 4		Existing FPC Well 5	
	4/13/76	4/13/76	11/30/76	4/13/76	8/18/76
Calcium*	147	173	160	167	153
Magnesium*	70	74	82	74	82
Sodium*	10	9	9	10	10
M-alkalinity*	208	237	234	232	226
Sulfate*	5	5	5	5	5
Chloride*	13	13	11	13	13
Nitrate*	--	--	--	--	--
Silica†	414	--	4.4	4.3	3.9
Specific Conductance, umhos/cm	435	485	430	475	440
pH	7.8	7.6	7.8	7.6	7.7

*mg/l as $CaCO_3$.
†mg/l as SiO_2

Source: Black and Veatch, 1976.

GULF COASTAL WATER

Salt water extracted from the existing discharge canal will serve as makeup for the plant cooling towers (circulating water system). The expected quantities of circulating water makeup are defined in Sections 3.3.3 and 3.3.4.

3.3.2 WATER TREATMENT

PLANT SERVICE WATER

Raw ground water which has been lime softened and chlorinated will be used as plant service water.

A solids contact-type clarifier-softener and gravity filter system will be used. Lime, coagulent, and coagulant aids will be used in dosages that have not yet been determined to produce the finished plant service water. Service water will be used as feed water to the demineralization system and for general plant uses including potable water, pump seal water, and ash crusher seal water.

The flow requirements of service water to the demineralization system and other plant uses are indicated in Table 3.3-1 and Figure 3.3-1. Wastes produced by this treatment process are described in Section 3.5.2.

MAKE-UP DEMINERALIZED WATER

Demineralized water is plant service water which has been further processed to a high quality suitable for use as makeup to the condensate-feedwater-steam cycle. The demineralization process will consist of ion exchange by three cation-anion exchanger pairs with degasification after the primary anion exchanger.

The expected peak flow to the demineralization system is 24.9 dm^3/s (396 gpm, 0.57 mgd) and the expected normal flow is 16.5 dm^3/s (262 gpm, 0.38 mgd). During temporary shutdown of the units, the only demineralized water requirement will be that required for regeneration of the demineralization and condensate polishing systems ion exchange resins. Wastes produced by regeneration are described in Section 3.5.3.

CONDENSATE POLISHING SYSTEM

A condensate polishing system is planned for removal of suspended and dissolved solids from the condensate. This technology will result in maintenance of a higher quality water in the condensate-feedwater-steam cycle and will extend the interval of steam generator cleaning to a period of three to five years.

This system will also consist of cation-anion exchanger pairs. Assuming that each resin bed will be regenerated 50 times per year, this system will require an annual average flow of 7.6 liters (2 gallons) per minute of demineralized water for regeneration. The wastes produced by regeneration are described in Section 3.5.

3.3.3 STATION CONSUMPTIVE USES

Consumptive use of fresh and salt waters are primarily due to evaporation, blowdown, and drift losses from the plant processes, losses due to storage in waste sludges and solids, and evaporation and exfiltration of stormwater runoff from impervious surfaces and storage areas.

COOLING TOWERS

Makeup to the plant cooling towers (circulating water systems) will be Gulf Coastal salt water pumped from the existing discharge canal for Crystal River Units 1, 2, and 3. This water is required to replace circulating water lost by evaporation, drift, and blowdown (discharge of water to maintain water quality to in turn maintain the cleanliness and efficiency of the heat rejection system). Cooling tower makeup will be treated with chemical additives to control algae growth and scaling and to allow operation with a minimum quantity of salt water makeup, as described in Section 3.5.

The expected peak cooling tower makeup requirement is approximately 3,083 dm^3/s (48,880 gpm, 70.4 mgd) and the expected normal makeup requirement is approximately 1,878 dm^3/s (29,770 gpm, 42.9 mgd). The actual makeup will depend upon the water quality (as calcium hardness) and therefore the cycles of concentration, as described in Section 3.4. During temporary shutdown, no makeup water will be required for the plant cooling towers.

Cooling tower consumptive use from evaporation and drift at peak conditions will be 712 dm^3/s (11,280 gpm, 16.2 mgd), and 0.8 dm^3/s (13 gpm, 18,720 gpd), respectively, and 433 dm^3/s (6,870 gpm, 9.9 mgd), and 0.5 dm^3/s (8 gpm, 11,520 gpd) for normal conditions.

STEAM-CONDENSATE-FEEDWATER CYCLE WATER USE

Consumptive water uses for the steam cycle, including steam soot-blowing and miscellaneous evaporative cycle losses, will be approximately

15.4 dm^3/s (245 gpm) at the peak condition and 10.1 dm^3/s (160 gpm, 0.23 mgd) at the normal condition. Boiler blowdown will be 7.8 dm^3/s (123 gpm, 0.18 mgd), and 5.1 dm^3/s (81 gpm), respectively. There will be no consumptive water uses for the steam cycle during temporary shutdown.

ASH AND REJECTS HANDLING SYSTEM WATER USE

Consumptive water uses for the ash and rejects handling systems include evaporative losses from the bottom hopper, water accumulated in the solid ash and rejects material in the ash landfill, and evaporative and seepage losses from this ash landfill area. The flows for these consumptive uses at the peak, normal, and temporary shutdown conditions are indicated in Table 3.3-1. Make-up sluicing water used in the hydraulic ash and rejects handling systems will be raw well water. Water pretreatment system sludges dewatered in the ash dewatering bin will also provide make-up water. Plant service water will be used for crusher seals.

Fly ash will be handled dry. Bottom ash, precipitator ash, mill rejects (pyrites), and the calcium carbonate sludge contained in the water pretreatment wastewater will be dewatered prior to storage in an above grade landfill area, as described in Section 3.6. Water will be recycled to the hydraulic ash sluicing systems. Plant wastewater from the plant drains collection pond will be utilized for dust suppression and compaction in the ash landfill area. Approximately 1.4 dm^3/s (23 gpm, 33,120 gpd) of water will be stored in the ash landfill at normal rates and 2.0 dm^3/s (31 gpm, 44,640 gpd) at peak rates.

SANITARY WATER USE

The maximum consumption of plant service water for potable and sanitary uses will occur with Unit 4 operating and Unit 5 under construction. An estimated maximum consumption of 1.1 dm^3/s (26,000 gpd) is expected.

During commercial operation of Units 4 and 5, an estimated 26 m^3 (6,900 gpd) of water will be consumed by the operating crew, temporary assigned personnel, and visitors.

MISCELLANEOUS PROCESS WATER USE

Normal plant cleaning and maintenance activities, equipment and pipe leakage, and relief valve drains will result in an estimated 3.1 dm^3/s (50 gpm, 72,000 gpd) consumptive use for peak and normal conditions.

DEMINERALIZED REGENERATION WATER USE

The demineralized water makeup system and the condensate polishing system ion exchange resins must be regenerated periodically. Water requirements for regeneration are 1.0 dm^3/s (16 gpm, 23,040 gpd) and 0.7 dm^3/s (12 gpm, 17,280 gpd), respectively for peak use and 0.7 d^3/s (11 gpm, 15,840 gpd) and 0.6 dm^3/s (10 gpm, 14,400 gpd) for normal use.

PLANT SERVICE WATER TREATMENT

Sludge from the solids contact basin and backwash from the gravity filters consume approximately 0.6 dm^3/s (9 gpm, 12,960 gpd) at peak operation and 0.5 dm^3/s (8 gpm, 11,520 gpd) under normal operating conditions. This water is recycled to the ash and rejects handling system as make-up sluice water.

3.4 HEAT DISSIPATION SYSTEM

3.4.1 COOLING SYSTEM DESCRIPTION

Each generating unit has a main cooling system and an auxiliary cooling system that will utilize a common recirculating water system with a natural draft cooling tower for final heat dissipation. The major components of the cooling system for each unit include one hyperbolic natural draft cooling tower, three vertical, wet pit circulating water pumps, two condensers, circulating water piping, blowdown pumps, piping and discharge structure, and make-up water intake structure with traveling screens, pumps and piping.

Each cooling tower will be located approximately 120 meters (400 feet) west of its associated turbine building. Each tower will be approximately 110 meters (370 feet) in diameter at the base and 140 meters (460 feet) high.

The main steam cycle for each unit will reject 3.5×10^{12} joules ($3,300 \times 10^6$ Btu) per hour, and the auxiliary equipment will reject approximately 0.2×10^{12} joules (200×10^6 Btu) per hour at full load operating conditions. The total heat load for both main units and auxiliary units at full load operating conditions will be 7.4×10^{12} joules ($7,000 \times 10^6$ Btu) per hour.

The cooling towers will be designed to reject to the atmosphere the total heat load for all units at full load operating conditions. The following design conditions have been selected:

Cooling Range	11.7°C (21°F)
Approach	6.7°C (12°F)
Wet Bulb	26.1°C (79°F)

The salt water intake structure serving both units will be located on the north bank of the existing cooling water discharge canal as shown in Figure 3.10-1. The structure will be designed to supply a flow of 67,000 gpm. The structure will be approximately 50 feet wide and will be divided into three cells. Each inlet cell will be equipped with a half capacity (33,500 gpm) pump, a 15-foot traveling screen and a high pressure screen wash pump (Figure 3.4-1 and 3.4-2). The water velocity entering the structure at low water level and maximum flow will not exceed 0.5 feet per second. Two pumps will be capable of supplying the total makeup for both units operating at full load.

Stop logs will be provided to permit each cell to be isolated and dewatered when required. Trash racks upstream of the screens will be designed to prevent heavy trash and debris from coming in contact with the traveling screens.

Cooling tower blowdown will be taken from the cold side of the circulating water system and will be discharged directly into the existing discharge canal for Crystal River Units 1, 2, and 3. The maximum temperature of this discharge will be 34.4°C (94°F).

The quantity of cooling tower makeup and blowdown depends on the quality of the water. Preliminary water quality (calcium hardness) data indicate that the cooling towers can be expected to operate at 1.3 to 2.0 cycles of concentrations. The amount of makeup and blowdown, under peak conditions, for this range of operation is as follows:

Cycles of Concentration	Quantity of Makeup	Quantity of Blowdown
1.3	3083 dm^3/s (48,800 gpm)	2371 dm^3/s (37,587 gpm)
1.5	2134 dm^3/s (33,840 gpm)	1423 dm^3/s (22,560 gpm)
2.0	1423 dm^3/s (22,560 gpm)	711 dm^3/s (11,270 gpm)

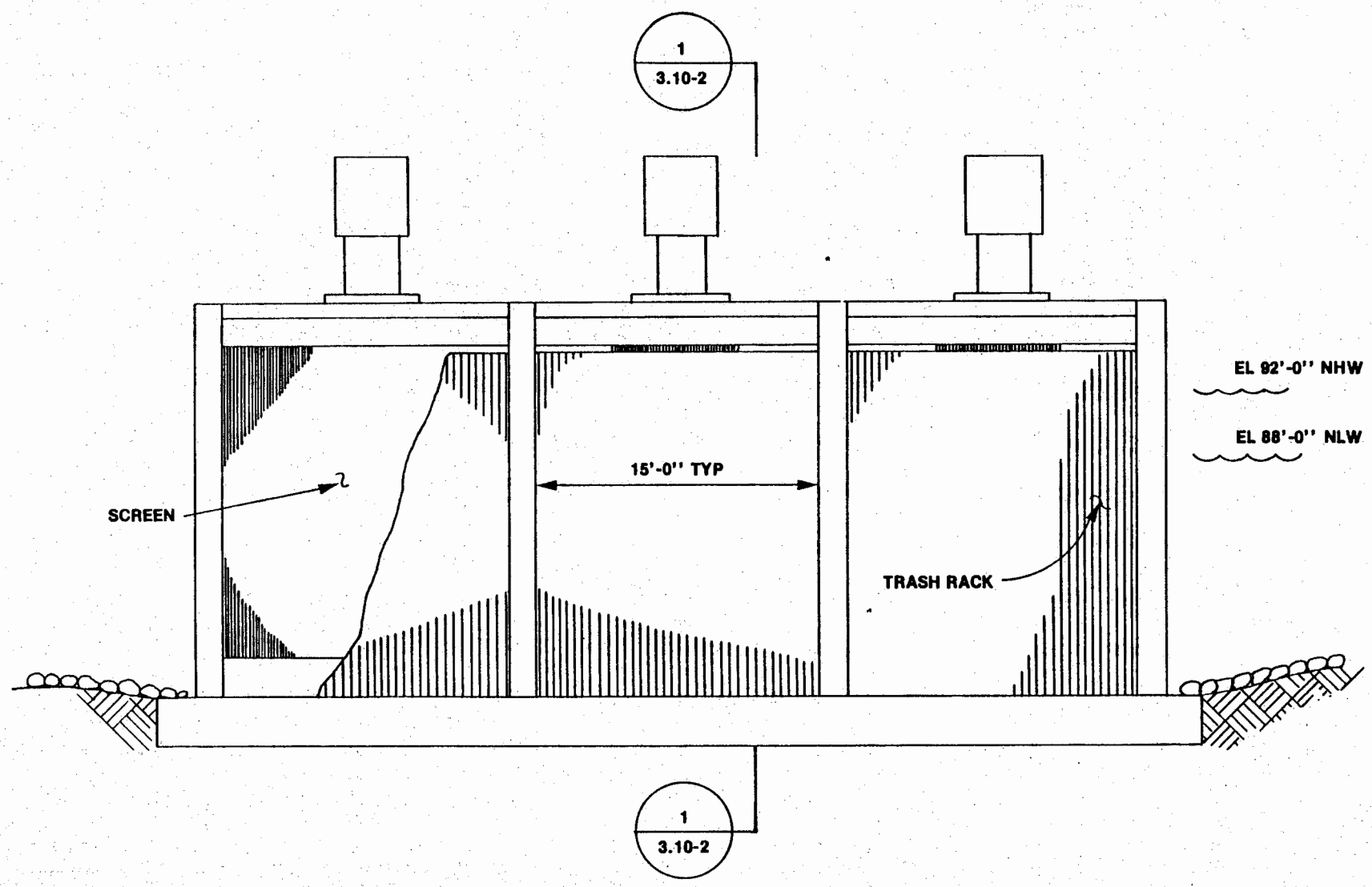


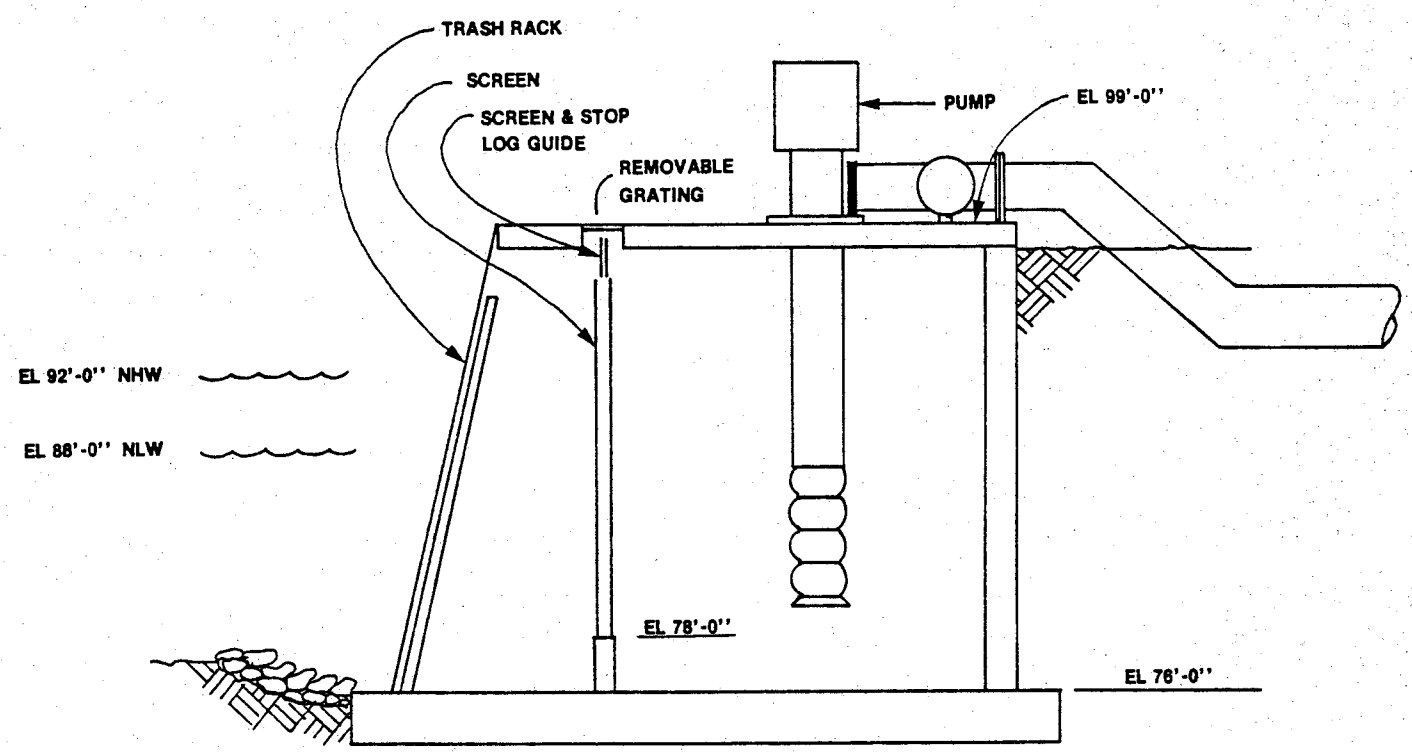
Figure 3.4-1
COOLING TOWER MAKE-UP INTAKE STRUCTURE

SOURCE: BLACK AND VEATCH, 1976

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA



SECTION 1

Figure 3.4-2
COOLING TOWER MAKE-UP INTAKE STRUCTURE

SOURCE: BLACK AND VEATCH, 1976

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

3.4.2 COOLING WATER DESCRIPTION

Gulf Coastal salt water will be used to replace cooling tower losses due to blowdown, evaporation, and drift. The water use for both units at 1.3 cycles of concentration is as follows:

	Peak Conditions			Normal Conditions		
	gpm	gpd	cmd	gpm	gpd	cmd
Blowdown	37,587	54,125,280	205,020	22,892	32,964,480	124,865
Evaporation	11,280	16,243,200	61,527	6,870	9,648,000	36,545
Drift	13	18,720	71	8	11,520	45
Makeup	48,880	70,387,200	266,618	29,770	42,868,800	162,382

The average monthly seawater temperatures for the cooling water intkae and the discharge canals for the once-through cooling systems from Crystal River Units 1, 2, and 3 is presented in Table 3.4-1. The temperature of the discharge canal water represents the temperature of cooling tower makeup water. The expected range of cooling tower blowdown temperatures from Crystal River Units 4 and 5 is presented in Table 3.4-2.

Quality data for salt water in the area is presented in Table 3.4-3. The quality of the salt water makeup water determines the quantity of blowdown that will be necessary to maintain desired chemical conditions in the cooling system. These units will be operated to maintain a maximum calcium hardness of 1,000 mg/l. Given the quality of sea water in Table 3.4-3, the towers will be operated at approximately 1.3 to 2.0 cycles of concentration. The expected quality of the blowdown water is presented in Table 3.4-4.

SCALE AND CORROSION CONTROL

Chemical corrosion inhibitors will not be used. Salt water makeup will be treated by an alkaline-organic phosphate method of conditioning that will conform to the following quality control limits:

Table 3.4-1 Monthly Inlet and Discharge Sea Water Temperatures for Crystal River Units 1, 2, and 3

Month	Intake Canal Average Temperature		Discharge Canal Average Temperature*	
	°F	°C	°F	°C
January	57	13.9	71.5	21.9
February	62	16.7	76.5	24.7
March	56	18.3	79.5	26.4
April	75	23.9	89.5	31.9
May	79	26.1	93.5	34.2
June	84	30.0	98.5	36.9
July	85	31.7	99.5	37.5
August	85	29.4	99.5	37.5
September	83	28.3	97.5	36.4
October	75	26.1	89.5	31.9
November	66	18.9	80.5	26.9
December	60	15.6	74.5	23.6

* Based on Units 1, 2, and 3 operating at maximum capability.

Source: Black and Veatch, 1978.

Unit 1 - 310,000 gpm
Unit 2 328,000 "
Unit 3 680,000 "
1,897.92 Mgd

Table 3.4-2 Temperature Range of Cooling Tower Blowdown for Crystal River Units 4 and 5

Month	Lowest		Highest	
	°F	°C	°F	°C
January	49	9.4	86	30.0
February	49	9.4	86	30.0
March	55	12.8	88	31.1
April	62	16.7	90	32.2
May	70	21.1	90	32.2
June	76	24.4	94	34.4
July	83	28.3	94	34.4
August	83	28.3	94	34.4
September	76	24.4	92	33.3
October	64	17.8	90	32.2
November	53	11.7	89	31.7
December	51	10.6	88	31.1

* Based on Units 1, 2, and 3 operating at maximum capability.

Source: Black and Veatch, 1978.

Table 3.4-3 Gulf Coastal Salt Water Quality Data

	Range (mg/l)
Total Dissolved Solids	15,008 - 36,080
Vol. Dissolved Solids	2,348 - 7,884
Chloride as Cl	7,990 - 17,090
Calcium Hardness	610 - 1,000
BOD_5	0 - 15
COD	0 - 328
Total Iron	0 - 4.6
Total Copper	0 - 0.59
Total Zinc	0 - 0.15
Total Boron	0 - 5.9
Total Chromium	0 - 0.11
Total Lead	0 - 0.42
Total Arsenic	0 - Trace
Total Mercury	0 - 0.8
Turbidity	0 - 80
pH	7.5 - 8.2
Conductivity (umhos/cm)	23,100 - 49,500

NOTE: Values derived from monthly grab samples at four locations in existing intake and discharge cooling water canals over a sampling period of one year. Calcium hardness data obtained separately.

Table 3.4-4 Quality of Cooling Tower Blowdown for Crystal River Plant Units 4 and 5

Constituent	Cooling Tower Blowdown
Ca, mg/l as $CaCO_3$	1,300
Mg, mg/l as $CaCO_3$	5,330
Na, mg/l as $CaCO_3$	24,024
M Alk, mg/l as $CaCO_3$	157
SO_4, mg/l as $CaCO_3$	2,909
Cl, mg/l as $CaCO_3$	27,587
NO_3, mg/l as $CaCO_3$	1
SiO_2, mg/l as such	1
TSS, mg/l as such	30
Cl_2, mg/l as such	0.2 average 0.5 maximum
T-PO_4, mg/l as P	25
pH	8.0 to 8.5
Maximum Temperature, °C (°F)	34.4° (94°)

Source: Black and Veatch, 1978.

pH	8.0 to 8.5
M-Alk	200 mg/l
Calcium Hardnesss as $CaCO_3$	1,300 mg/l

A proprietory organic phosphate scale inhibitor will be used as a chelate to prevent excess scale formation. Mechanical, on-line condenser tube cleaning systems also will be used to control scale formation and biological growths. Periodic sulfuric acid treatment will be used for descaling. Dosages will be determined based on operating experience.

There will be a residual phosphate concentration of 25 mg/l in the blowdown as a result of using the organic phosphate scale inhibitor.

BIOLOGICAL CONTROL

The circulating water will be shock chlorinated to control the growth of fouling organisms, algae and bacterial slimes in the condenser and cooling tower. Shock chlorination will be carefully controlled to prevent the chlorination of two condensers simultaneously and will be limited to one to three periods per day of chlorine solution feed. Actual solution feed will be limited to 15 minutes or less per period. The chlorine feed rates will be controlled to limit the maximum concentration of free available chlorine in the blowdown to less than 0.5 mg/l and the average concentration during shock chlorination to less than 0.2 mg/l. Neither free available chlorine nor total residual chlorine will be discharged from either unit in any concentration for more than two hours in any one day.

The following is a summary of the anticipated chemical dosages for scale and biological control:

	Peak Operation		Normal Operation	
	kg/day	lb/day	kg/day	lb/day
Scale Inhibitor	5,121	11,289	3,118	6,875
Chlorine	116	255	116	255
66° Baume Sulfuric Acid	Intermittent use to be determined based on operational experience.			

3.5 CHEMICAL AND BIOCIDE WASTES

This section describes the chemicals and biocides utilized during the operation of various plant systems. Section 3.4 describes the plant heat dissipation system which is the major wastewater source. Miscellaneous minor chemical wastes are described in Section 3.6.

The expected quantity and quality of each chemical and biocide utilized and any resulting waste streams are presented in the following subsections. A summary of expected chemical additive feed rates for various plant streams at 100 per cent (peak) and 66 per cent (normal) plant loads is given on Figure 3.5-1. A summary of plant effluent characteristics is presented in Table 3.5-1.

3.5.1 Circulating Water System

Makeup to the circulating water system will be raw well water from a new well field. This makeup water will be treated with sulfuric acid to control alkalinity in the circulating water slightly on the scale forming side of chemical stability. A proprietary organic phosphate scale inhibitor will also be fed to inhibit scale formation. The circulating water will be shock chlorinated on a scheduled basis to control bacterial slimes and algae. The estimated amounts of chemicals required for the normal two-unit plant operation will be 116 kg/d (255 PPD) of chlorine both for 100 per cent and 66 per cent plant loads; 14 660 and 8 910 kg/d (32,300 and 19,625 PPD) of 66° Baumé sulfuric acid for

100 per cent and 66 per cent loads, respectively; and 300 kg/d (660 PPD) and 180 kg/d (400 PPD) of the organic phosphate scale inhibitor for 100 per cent and 66 per cent loads, respectively.

The condenser discharge will be cooled in natural draft cooling towers. Wastewater discharged from the cooling towers will consist of cold-side blowdown and drift.

3.5.1.1 Blowdown--The blowdown rate for the cooling towers will be controlled to limit the concentration of the dissolved solids in the circulating water to values which are within acceptable water quality limits to allow satisfactory plant operation. The expected blowdown quantities for 100 per cent and 66 per cent plant loads are 136 and 82.6 dm^3/s (2160 and 1310 GPM), respectively, as given in Table 3.5-1. The blowdown, taken from the cold-side of the tower system, will be routed to the existing discharge canal. A short-term maximum total residual chlorine concentration of about 0.5 mg/l, with a zero free residual chlorine, is expected in the blowdown to the discharge canal. The expected quality of the cooling tower blowdown is shown in Table 3.5-1.

3.5.1.2 Drift--Drift losses from the cooling towers are estimated to total 2.5 dm^3/s (40 GPM) maximum for the two-unit plant. The quality of cooling tower drift will be the same as the quality of the cooling tower blowdown shown in Table 3.5-1.

3.5.2 Water Pretreatment System

The water pretreatment system will selectively lime soften raw well water for makeup to the demineralization system and service water system, including potable water uses. Pretreatment will include lime softening, clarification, filtration, and chlorination. The chemicals expected to be used are hydrated lime [93 per cent $Ca(OH)_2$], chlorine, and a polyelectrolyte. The following lists the expected quantities of these chemicals used during operation at 100 per cent and 66 per cent load, respectively: hydrated lime, 440 kg/d (970 PPD) and 320 kg/d (700 PPD); chlorine, 4 kg/d (9 PPD) and 3 kg/d (6 PPD); and polyelectrolyte, 1.0 kg/d (2.3 PPD) and 0.8 kg/d (1.7 PPD). The wastewater from the water pretreatment system is expected to average 0.5 dm^3/s (8 GPM) from the solids contact basin sludge blowoff and gravity filter backwash. This wastewater will be routed to the bottom ash dewatering bins where the suspended solids will be separated from the fluid and disposed with the bottom ash solids to a landfill, as discussed in Section 3.6. The liquid portion of the water pretreatment system wastewater will act as makeup to the bottom ash sluice system. No discharge of water pretreatment system wastewater is expected.

3.5.3 Demineralization System

The demineralization system will process pretreated well water to provide high quality water suitable for use as makeup to the

condensate-feedwater-steam cycles and other miscellaneous uses requiring high quality water. The wastewater from this system will consist of unreacted sulfuric acid and sodium hydroxide plus the sodium and sulfate salts of the ions removed from the ion exchange resins during regeneration. The average daily regenerant chemicals required are estimated at 160 kg/d (355 PPD) of 100 per cent sodium hydroxide and 510 kg/d (1120 PPD) of 66° Baumé sulfuric acid at 100 per cent load. At 66 per cent plant load, the caustic and acid requirements are approximately 110 kg/d (235 PPD) and 340 kg/d (740 PPD), respectively.

The regenerant wastewaters are expected to average 1 and 0.7 dm^3/s (16 and 11 GPM) for 100 per cent and 66 per cent plant loads, respectively, and will be routed to the neutralization basin where the wastewater pH will be adjusted to between 6.5 and 9.0. An estimated 75 kg/d (160 PPD) to 115 kg/d (250 PPD) of 100 per cent sodium hydroxide will be required for neutralization to produce a solution within the desired pH range. The neutralization basin effluent will be batch discharged to the plant drains collection pond.

3.5.4 Condensate Polishing System

The condensate polishing system will process condensate to provide protection to the cycle against condenser tube leaks or poor quality makeup and allow faster unit restarts. Chemicals utilized for

regeneration of this system will be the same as those used for the demineralization system: sodium hydroxide and sulfuric acid. Based on full flow polishing of both units' condensate, the daily regenerant chemicals required are estimated at 75 kg/d (160 PPD) of 100 per cent sodium hydroxide and 250 kg/d (540 PPD) 66° Baumé sulfuric acid at 100 per cent load. At 66 per cent load, the caustic and acid requirements are approximately 50 kg/d (110 PPD) and 160 kg/d (360 PPD), respectively.

The condensate polishing system wastewaters are similar to those produced in the demineralization system. The regenerant wastewaters are expected to average 0.7 and 0.6 dm^3/s (12 and 10 GPM) for 100 per cent and 66 per cent plant loads, respectively, and will also be routed to the neutralization basin for pH adjustment. An estimated 25 kg/d to 35 kg/d (50 PPD to 75 PPD) of 100 per cent sodium hydroxide will be required for neutralization of these wastewaters. These wastewaters are discharged to the plant drains collection pond in the same manner as the demineralization system wastewaters.

3.5.5 Cycle Chemical Feed System

Hydrazine, ammonia, and trisodium phosphate are expected to be fed to the Units 4 and 5 condensate-feedwater-steam cycles to minimize scaling or corrosion. Hydrazine consumption is estimated at 1.8 kg/d (4 PPD) at 100 per cent plant load and 1.4 kg/d (3 PPD) at 66 per cent load, both as 100 per cent hydrazine. Ammonia consumption

is estimated to be 41 kg/d (90 PPD) at 100 per cent load and 27 kg/d (60 PPD) at 66 per cent load, both as 100 per cent ammonia. Trisodium phosphate consumption is estimated to be less than 0.4 kg/d (1 PPD) at all plant loads.

Wastewaters containing small amounts of these chemicals are possible due to cycle leaks and boiler blowdown. These wastewaters will be collected in the plant drains system and routed to the plant drains collection pond.

3.5.6 Sewage Treatment Plant System

A package, activated sludge sewage treatment plant of the extended aeration type, as described in Section 3.6, will be utilized to treat sanitary wastes from plant personnel. Chlorine will be utilized to provide disinfection of this plant effluent.

The estimated chlorine consumption for the sewage treatment plant is 0.4 kg/d (1 PPD), independent of generating plant load. The effluent from the sewage treatment plant will be discharged to the existing discharge canal via the cooling tower blowdown conduit. An expected analysis of the sewage treatment plant effluent is shown in Table 3.5-1.

3.5.7 Auxiliary Steam System

An auxiliary steam system may be installed which would utilize auxiliary electric powered boilers. These boilers would be utilized

during cold unit start-ups on an intermittent basis only. The chemicals to be fed to these boilers include hydrazine for oxygen scavenging and trisodium phosphate for pH and scale control. Trisodium phosphate may also be utilized to increase the conductivity of the boiler feedwater. Chemical consumption, although very small, is not predictable, due to the intermittent operation of the auxiliary steam system.

Wastewater from the auxiliary boilers will be boiler blowdown which will be directed to the plant drains system and thus to the plant drains collection pond.

3.5.8 Chemical Cleaning

Normal chemical cleaning operations are maintenance procedures which are performed infrequently and do not contribute wastewater or require consumption of water during normal operation.

Prior to initial operation, the boiler and preboiler systems will be alkaline and acid cleaned. Alkaline cleaning of these systems will be carried out utilizing a sodium phosphate solution. An indeterminate amount of alkaline cleaning solution will be required, along with subsequent solution flushing water. Preoperational acid cleaning will be performed using a solution of hydroxyacetic-formic acid (HAF) for the preboiler system, and either inhibited hydrochloric acid or HAF for the boiler cleaning.

An acid neutralization step follows the acid drain step in the boiler cleaning operation. An indeterminate amount of acid cleaning solution and chemical neutralization and flushing water will be required.

Subsequent chemical cleaning will be restricted to acid cleaning of the boiler after every 3 to 5 years of operation.

Demineralized water will be utilized to make up the chemical cleaning solutions and to flush the solutions following each cleaning step.

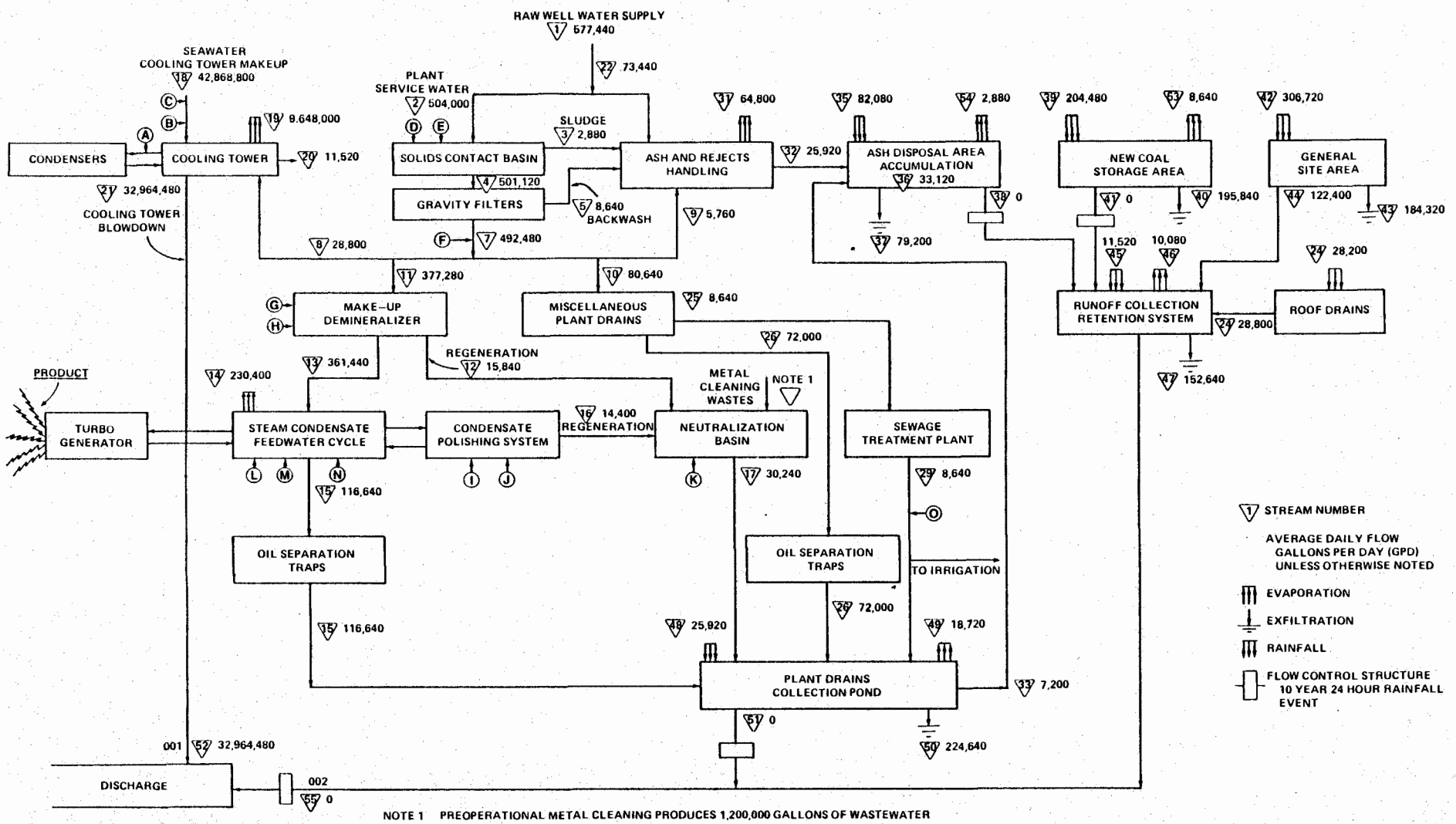
Chemical cleaning wastewaters (metal cleaning wastes) will be treated in the neutralization basin for pH adjustment prior to their release to the plant drains collection pond.

3.5.9 Plant Drains Collection Pond

The plant drains collection pond influents will include neutralization basin wastewaters originating from the demineralization and condensate polishing systems and boiler blowdown and cycle losses carried via the miscellaneous plant drains. The plant drains collection pond will not require chemical additions for further treatment of the wastewaters introduced.

The plant drains collection pond will be sized to contain all wastewater influents up to and including those resulting from a

10 year, 24 hour rainfall event of 213 mm (8.37 IN.) without a discharge (Hershfield, 1961). The pond will be adequate to provide 24 hour retention time of all wastewaters entering during a 10 year, 24 hour rainfall event. The estimated area and volume of the plant drains collection pond are 26 000 m^2 (6.5 acres) and 24 000 m^3 (19.5 acre-feet), respectively. There will normally be no discharge expected from the pond, as evaporation and exfiltration exceeds the wastewater influents during normal conditions and the pond is sized to contain the wastewater resulting from the 10 year, 24 hour rainfall event. However, the plant drains collection pond will be provided with a discharge structure designed to prevent the discharge of any floating material during abnormally high rainfall events. Any possible discharge will be routed to the cooling tower blowdown conduit and thus to the existing discharge canal.



NOTE 1 PREOPERATIONAL METAL CLEANING PRODUCES 1,200,000 GALLONS OF WASTEWATER
ACID MAINTENANCE METAL CLEANING PRODUCES 360,000 GALLONS OF WASTEWATER
PER BOILER ONCE EVERY THREE TO FIVE YEARS

Figure 3.5-1
PLANT CHEMICAL USE DIAGRAM

LEGEND

KEY	CHEMICAL	Kg/d (PPD) 66% LF	Kg/d (PPD) 100% LF
A	CHLORINE	116 (255)	116 (256)
B	66° BE SULFURIC ACID	NA	NA
C	ORGANIC PHOSPHATE	3,118 (6,875)	5,121 (11,289)
D	LIME (93% $Ca(OH)_2$)	320 (700)	440 (970)
E	POLYELECTROLYTE	8 (1.7)	10 (2.3)
F	CHLORINE	2.7 (6)	4.1 (9)
G	100% SODIUM HYDROXIDE	110 (235)	180 (385)
H	66° BE SULFURIC ACID	340 (740)	510 (1,120)
I	100% SODIUM HYDROXIDE	50 (110)	75 (160)
J	66° BE SULFURIC ACID	160 (360)	250 (540)
K	100% SODIUM HYDROXIDE	100 (210)	150 (325)
L	HYDRAZINE	1.4 (3)	1.8 (4)
M	AMMONIA	27 (60)	41 (90)
N	TRISODIUM PHOSPHATE	4 (1)	4 (1)
O	CHLORINE	4 (1)	4 (1)

SOURCE: ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1978

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

Table 3.5-1. Crystal River Plant Effluent Characteristics Units 4 & 5

Constituent	Cooling Tower Blowdown	Sewage Treatment Plant Effluent
Ca, mg/l as $CaCO_3$	1000	70
Mg, mg/l as $CaCO_3$	443	110
Na, mg/l as $CaCO_3$	60	90
M Alk, mg/l as $CaCO_3$	200	200
SO_4, mg/l as $CaCO_3$	1219	25
Cl, mg/l as $CaCO_3$	78	35
NO_3, mg/l as $CaCO_3$	6	10
SiO_2, mg/l as such	26	4
TSS, mg/l as such	0	<25
BOD_5, mg/l as such	0	<25
Cl_2, mg/l as such	0.2*	2.0
pH	7.2	9.6
Flow, dm^3/s (GPM)	82.6 (1310) avg 136 (2160) max	0.4 (6) avg 0.4 (6) max

NOTE: The sewage treatment plant effluent is combined with the cooling tower blowdown prior to discharge into the existing discharge canal. The combined discharge will exhibit characteristics essentially the same as the tower discharge listed.

*The chlorine residual will normally be zero. See Section 3.4 for details.

3.6 SANITARY AND OTHER WASTE SYSTEMS

3.6.1 Sanitary Waste System

The sewage treatment plant will be a 1.3 dm^3/s (30,000 GPD) packaged, activated sludge unit which employs the extended aeration process method of treatment. The facility will be designed to achieve 90 per cent reduction of BOD_5 and suspended solids. The process equipment will be installed in a concrete basin, with separate aeration and clarification sections. A comminutor will be provided to reduce the size of solids at the inlet to the plant. A chlorine contact chamber and a gas solution chlorination system will be provided for disinfection of the effluent. Chlorine consumption is described in Section 3.5.

The maximum hydraulic and biological loading will occur with Unit 4 operating and Unit 5 under construction. Under these conditions, an estimated maximum of 1.1 dm^3/s (26,000 GPD) of sewage containing 25 kg (57 LB) of BOD_5 will be expected. During commercial operation of Units 4 and 5, the sewage treatment plant will treat an estimated 26 m^3 (6900 GAL) of sewage per day containing approximately 6.4 kg (14 LB) of BOD_5, based on an estimated operating crew of 132, independent of electric generating plant load.

The sewage treatment plant effluent will be quite similar to service water in quality, with slightly increased total dissolved

and suspended solids. The effluent, which is characterized in Table 3.5-1 of Section 3.5, will discharge into the cooling tower blowdown line. The cooling tower blowdown line will discharge to the existing discharge canal.

3.6.2 Chemical Laboratory Wastes

The principal chemical reagents to be used in the laboratory will include sodium and ammonium hydroxide; hydrochloric, nitric, sulfuric, and ethylenediaminetetraacetic acids; and sodium carbonate. Small quantities of various other chemicals will also be used for analytical testing.

The total quantity of chemical laboratory wastes is expected to be 380 dm^3 (100 GAL) per day, independent of generating plant load.

The chemical laboratory wastes will be handled by the miscellaneous plant drains system which discharges to the plant drains collection pond, as described in Section 3.3.

3.6.3 Solid Wastes Quantities and Disposal

Solid wastes resulting from plant operation will include bottom ash, coal pulverizer rejects, economizer ash, precipitator fly ash, and water pretreatment system sludge.

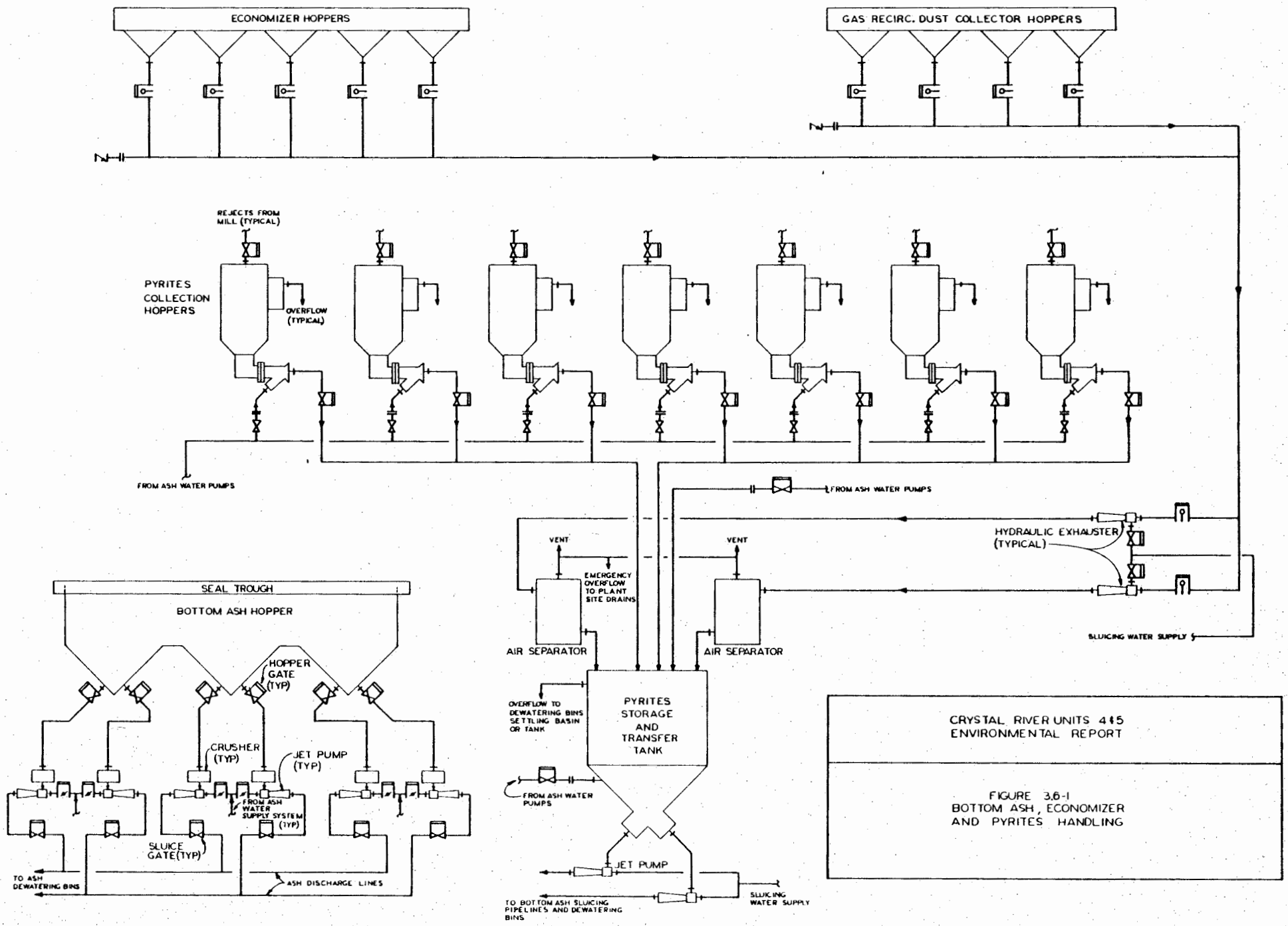
Bottom ash will be collected in a water-sealed hopper and hydraulically sluiced to ash dewatering bins. Coal pulverizer rejects (pyrites) will be collected in small hoppers adjacent to each pulverizer. The pyrites will then be hydraulically conveyed from each pulverizer hopper to an intermediate pyrites storage and holding tank. Economizer ash will be removed from the economizer and gas recirculation dust collector hoppers with a vacuum produced by hydraulic exhausters. The resulting economizer ash-water mixture will be sluiced to the pyrites holding tank for eventual removal to the ash dewatering bin. Figure 3.6-1 summarizes schematically the bottom ash, pyrites, and economizer ash collection systems. The water pretreatment sludge will be pumped directly to the dewatering bins.

In the dewatering bins, the ash in the ash-water mixtures will be settled and the transport water will be removed through gravity decanting and dewatering elements. The transport water will be reclaimed, clarified, and returned to the ash handling system. A schematic diagram of the ash dewatering and transport water reclaim systems is shown on Figure 3.6-2.

Fly ash collected in the precipitator hoppers will be pneumatically conveyed by a vacuum system to a storage silo located on the plant site. The vacuum required to remove and transport the fly ash will be produced by mechanical vacuum pumps. A schematic arrangement of the fly ash collection system is shown on Figure 3.6-3.

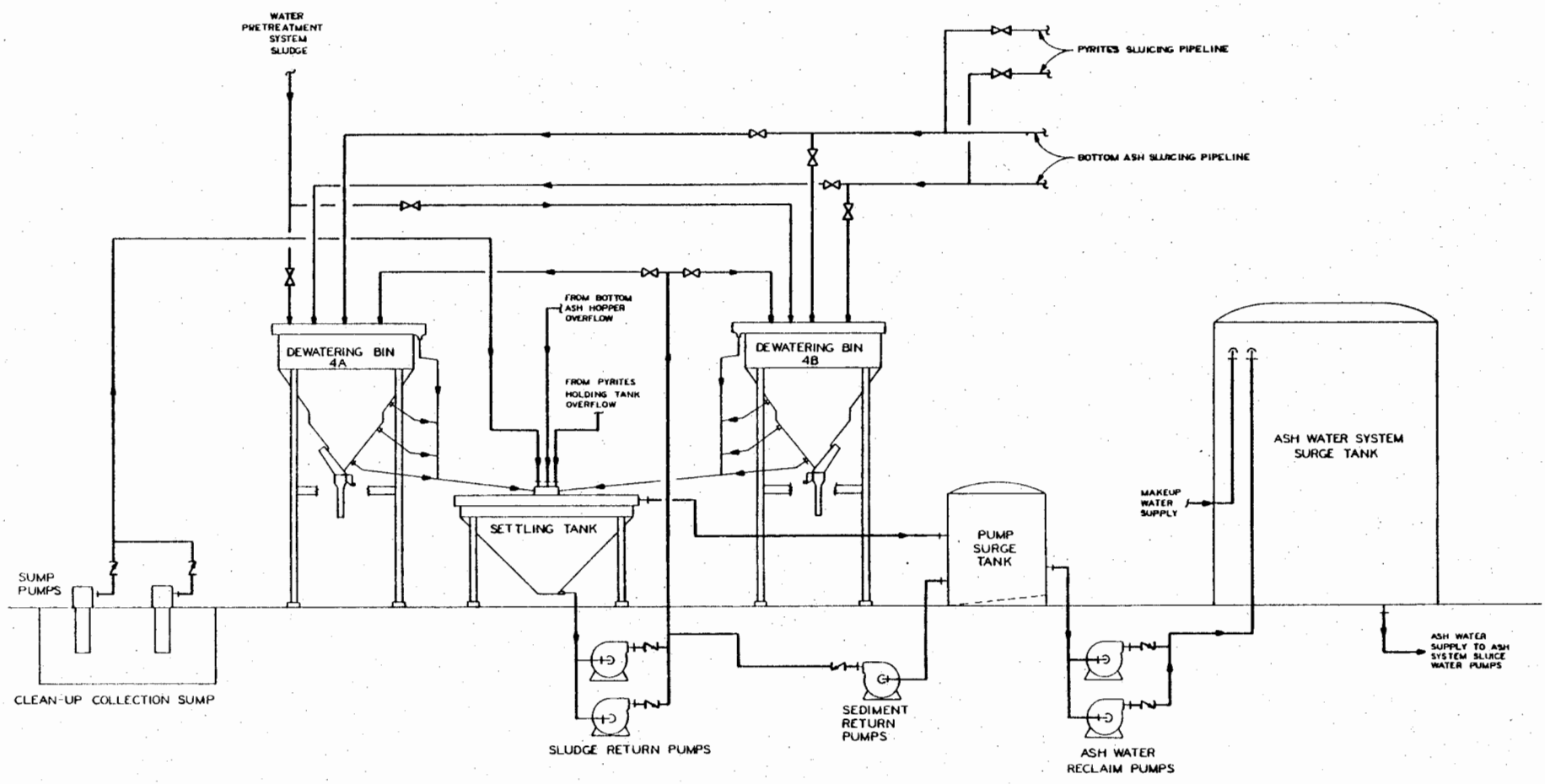
The expected quantity of solids for disposal, based on both units operating at 66 per cent capacity, will be approximately 784 000 kg/d (1,730,000 PPD), while at 100 per cent capacity 1 187 000 kg/d (2,620,000 PPD) are expected. Table 3.6-1 lists the expected quantities of each type of solid waste at both 66 per cent and 100 per cent load factors, based on the fuel supply described in Section 3.2.

Dewatered bottom ash, pulverizer rejects, economizer ash, pretreatment system sludge, and dry precipitator fly ash produced during the operating life of Units 4 and 5 will be transported by truck or conveyor to an onsite storage area. The total storage development will consist of approximately 480 900 m^2 (120 acres) at a total depth of 12.2 m (40 FT). The storage area will be developed in 80 150 m^2 (20 acre) segments. Each segment will be filled to a height of 12.2 m (40 FT) above existing grade. The storage pile slopes will be dressed with soil material of sufficient depth to support vegetation. At the time the segment is developed to design height, the top surface will be sloped to drain and dressed with soil materials. The soil material used for cover will be stockpiled in unused portions of the ash storage area. A toe canal will be constructed along the perimeter of the active storage segment to receive surface stormwater runoff. This drainage system is further described in Section 3.10. Runoff from developed areas which have been restored with vegetation and from undisturbed areas will drain to the natural watershed of the site area.



CRYSTAL RIVER UNITS 4 & 5
ENVIRONMENTAL REPORT

FIGURE 3.6-1
BOTTOM ASH, ECONOMIZER AND PYRITES HANDLING



CRYSTAL RIVER UNITS 4 & 5
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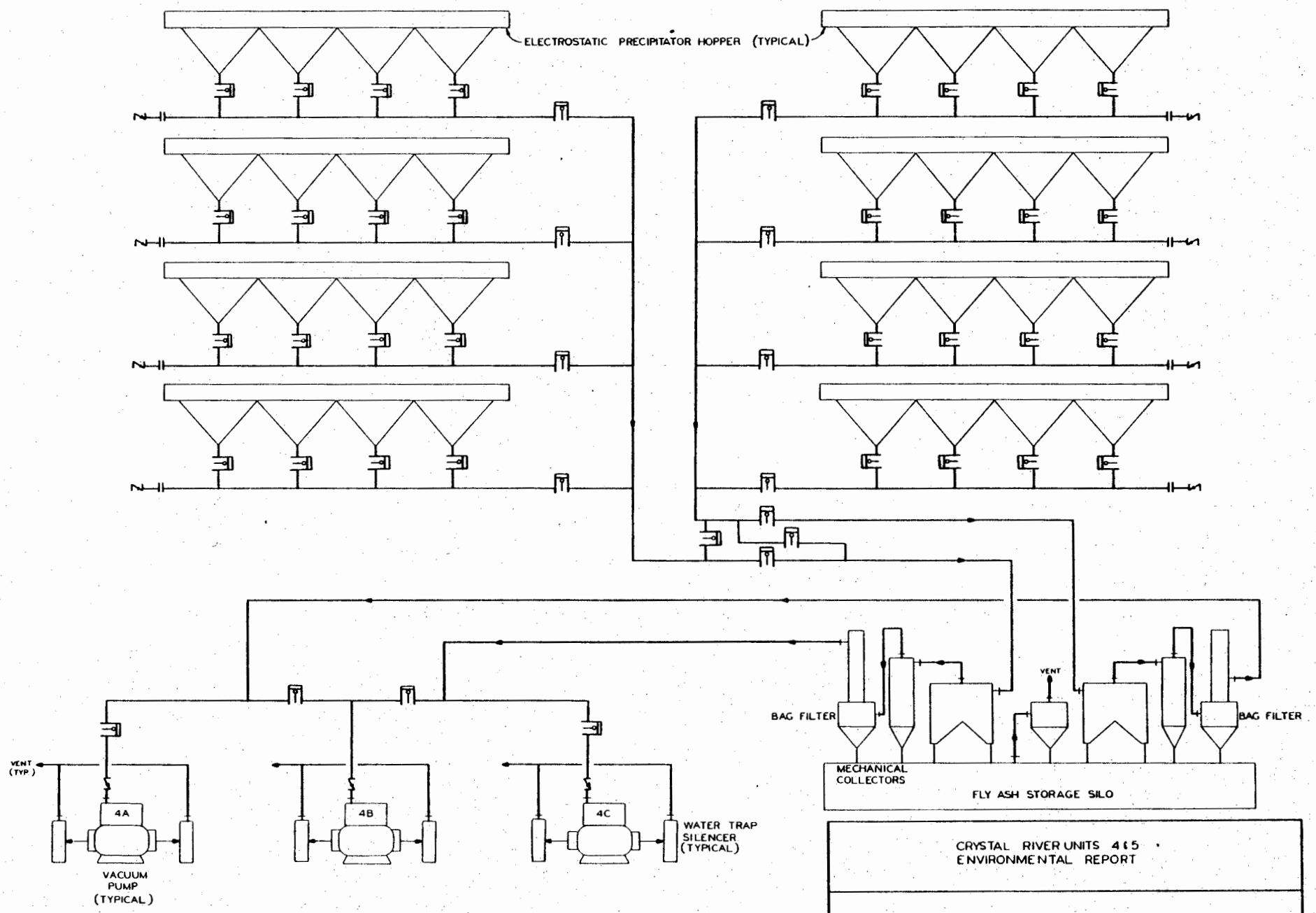
FIGURE 3.6-2
ASH DEWATERING BINS



CRYSTAL RIVER UNITS 4 & 5
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FIGURE 3.6-3
FLY ASH HANDLING

TABLE 3.6-1. Crystal River Plant Solid Waste Quantities Units 4 & 5

Constituent	66% Capacity		100% Capacity	
	Mg/day	(10^3 LB/day)	Mg/day	(10^3 LB/day)
Bottom Ash*	147	(324)	223	(492)
Economizer Fly Ash*	29	(65)	44	(98)
Precipitator Fly Ash*	560	(1234)	849	(1872)
Pulverizer Rejects*	47	(103)	70	(154)
Pretreatment System Solid Waste	.7	(1.5)	1.0	(2.1)
Total Solids to Ash Storage	783.7	(1727.5)	1187	(2618.1)
Total Volume of Solids to Storage	528 m^3	(18,630 FT^3)		

*Ash and rejects quantities based on design coal blend.

3.7 AIR EMISSIONS

3.7.1 Design Requirements

3.7.1.1 Introduction--Crystal River Units 4 and 5 consist of two fossil fuel-fired steam generators. Each unit will operate at a net electrical output capacity of 640 MW and will burn approximately 294 000 kg (648,000 LB) per hour of coal based on the typical coal analysis (Section 3.2). Combustion at this load will produce approximately 3 277 209 kg (7,224,887 LB) per hour of combustion gases which will consist primarily of nitrogen, carbon dioxide, water vapor, oxygen, particulate matter, sulfur dioxide, and nitrogen oxides. The constituents of the combustion gas are shown in Table 3.7.1.

3.7.1.2 Regulations--Both the U.S. Environmental Protection Agency and the Department of Environmental Regulation of Florida have adopted regulations establishing air pollutant emission rates which are applicable to Crystal River Units 4 and 5. The emission limitations are described in 40 CFR Part 60, Standards of Performance for New Stationary Sources and Chapter 17-Z (e), Rules of the Department of Environmental Regulation (EDR). The applicable emission rate limitations from both the EPA and the EDR regulations are summarized as follows.

Pollutant	Emission Rate Limitation
Sulfur Dioxide	0.516 Mg/J* (1.2 LB/MBTU)
Particulate Matter	0.043 Mg/J* (0.1 LB/MBTU)
Nitrogen Dioxide	0.301 Mg/J* (0.7 LB/MBTU)
Opacity	20 per cent**

3.7.1.3 Emission Control--Based on the typical coal analysis and the Standards of Performance for New Stationary Sources, equipment will be installed to control oxides of nitrogen and particulate matter.

3.7.1.3.1 Oxides of Nitrogen (NO_x)--The steam generators will be designed to operate such that the oxides of nitrogen emission rate expressed as nitrogen dioxide, will not exceed 0.301 kg of nitrogen dioxide per GJ (0.7 LB of nitrogen dioxide per million BTU) of heat input.

3.7.1.3.2 Particulate Matter--The typical ash content of the coal is about 7.9 per cent with a range of 5.8 to 12.0 per cent by weight, which corresponds to an ash production rate of about 3.302 Mg/J (7.68 LB per million BTU). The approximate fly ash production, based on 90 per cent of the total ash being fly ash is as follows.

---

*Mega grams per joule of heat input.

Pounds per million BTU of heat input.

**The opacity shall not exceed 20 per cent except that 40 per cent opacity shall be permissible for not more than 2 minutes in any hour.

	Total Ash Production per cent by weight	Fly Ash Production Mg/J	(LB/MBTU)
Typical	7.9	2.971	(6.91)
Minimum	5.8	2.183	(5.08)
Maximum	12.0	4.515	(10.50)

A precipitator with 99.6 per cent efficiency will be used for each unit to collect fly ash so that particulate emissions do not exceed 0.043 Mg/J (0.1 LB per million BTU) heat input.

3.7.1.3.3 Sulfur Dioxide (SO_2)--The typical sulfur content of the design coal is about 0.49 per cent with a design range of 0.4 to 0.6 per cent. Based on 100 per cent of the sulfur being converted to sulfur dioxide and a typical coal heating value of 23 923 Mg/J (10,258 BTU/LB) the typical sulfur dioxide production is about 0.408 Mg/J (0.95 LB per million BTU) with a range of 0.335 to 0.503 Mg/J (0.78 to 1.17 LB per million BTU).

Sulfur dioxide removal is not required since the range of emission rate is within present federal and state regulations which limit the sulfur dioxide emission rate to 0.516 Mg/J (1.2 LB per million BTU) heat input.

3.7.1.4 Stack Effluent Parameters--A chimney height of approximately 183 m (600 FT) and a diameter of 6.86 m (22.5 FT) for each unit is adequate to satisfy dispersion requirements. Each chimney will

be capable of discharging approximately 1 038 m^3/s (2,200,000 ACFM) of flue gas at 126.7 C (260 F) and 28.1 m/s (99.2 FPS). The flue gas flowrate and emissions are shown in Table 3.7-2.

3.7.2 System Description

3.7.2.1 General--Oxides of nitrogen will be controlled by design and operation of the steam generator. Some particulate must be removed from the combustion gas to allow the steam generator to comply with the existing regulations for emissions and ambient air quality. The combustion gas of each unit leaves the steam generator and enters the air heater at about 343.3 C (650 F). The air heater transfers heat from the hot combustion gas to the steam generator combustion air. The combustion gas then enters the precipitator for particulate removal. Based on the upper design ash content and 20 per cent opacity limitation, a precipitator of 99.6 per cent efficiency is necessary to meet applicable standards. The cleaned combustion gas then passes to the induced draft fans and is discharged via a single 183 m (600 FT) high chimney.

3.7.2.2 Oxides of Nitrogen Control--In the combustion process nitrogen oxides (NO_x) are formed in the high temperature regions of the boiler in and around the flame zone by oxidation of both atmospheric nitrogen and nitrogen in the fuel. Formation of NO_x can

be reduced by reducing peak combustion temperatures which is accomplished by limiting the amount of excess air available to the fuel and staging combustion.

In the combusion process nitrogen oxides (NO_x) are formed in the high temperature regions of the boiler in and around the flame zone by oxidation of both atmospheric nitrogen and nitrogen in the fuel. Formation of NO_x can be reduced by reducing peak combustion temperatures which is accomplished by limiting the amount of excess air available to the fuel and staging combustion.

NO_x from Units 4 and 5 steam generators will be controlled to meet emission standards by utilizing features to minimize NO_x formation during combustion. These design features will include one or more of the following:

1. Dual register burners (staged combustion).
2. Compartmented windbox (improved combustion control).
3. Large furnace and widely spaced burners (reduced temperatures).
4. Tangental firing.
5. Overfire air.
6. Limiting heat input per burner.

The large furnace and widely spaced burners increase the burner firing zone absorption area and decrease peaking combustion temperatures, thus minimizing NO_x formation.

The steam generators will be designed to operate such that the oxides of nitrogen emission rate expressed as nitrogen dioxide will not exceed 0.301 kg of nitrogen dioxide per GJ (0.7 lb of nitrogen per million BTU) of heat input.

3.7.2.3 Particulate Removal--Particulate matter generated during combustion will be removed in the electrostatic precipitator.

The electrostatic precipitator for the new boiler would normally operate with average air heater outlet temperatures of 110 C to 130 C (230 F to 266F). Wide variations in resistivity could be expected for this temperature range for the fuel listed in Table 3.2-1. The temperature range within the gas steam leaving the air heater might vary as much as 11 C to 17 C (20 F to 30 F) above and below the average temperature. Different sections of the electrostatic precipitator could therefore be expected to experience temperatures varying between 93 C and 149 C (200 F and 300 F). Thus, the electrostatic precipitator could at any given time be experiencing wide variations in particle resistivity. The electrostatic precipitator would be designed with a greater number of fields (greater depth) and larger collecting surface to allow for the variations in resistivity that will be experienced.

Suggested design parameters for the electrostatic precipitator installation are shown on Table 3.7-3.

At full load the maximum design ash content of the coal, more than 99.6 per cent of the fly ash will be removed from the combustion gases leaving the furnace.

3.7.2.4 Emission From Existing Units 1 and 2--Units 1 and 2 are coal-fired units with nominal capacity rating 400 MW and 500 MW, respectively. The flue gas flow rates and emissions are shown in Table 3.7-4.

Unit 3 is a nuclear power unit.

Table 3.7-1. Combustion Products*

Combustion Product	Unit 4		Unit 5		Total	
	kg/h	(LB/H)	kg/h	(LB/H)	kg/h	(LB/H)
H_2O	195 955	(432,000)	195 955	(432,000)	391 910	(864,000)
CO_2	634 133	(1,398,000)	634 133	(1,398,000)	1 268 266	(2,796,000)
N_2	2 282 515	(5,032,000)	2 282 515	(5,032,000)	4 565 030	(10,064,000)
O_2	159 214	(351,000)	159 214	(351,000)	318 428	(702,000)
SO_2	2 880	(6,350)	2 880	(6,350)	5 760	(12,700)
NO_2	2 118	(4,670)	2 118	(4,670)	4 236	(9,340)
Cl_2	91	(200)	91	(200)	182	(400)
	303	(667)	303	(667)	606	(1,334)
TOTAL	3 227 209	(7,224,887)	3 227 209	(7,224,887)	6 554 418	(14,449,774)

*Based on peak coal consumption of 294 000 kg (648,000 LB) per hour per unit, 20 per cent excess air at 60 per cent relative humidity, and 26.7 C (80 F) dry bulb (0.013 kg of moisture per kg of dry air).

Table 3.7-2. Flue Gas Flowrates and Emissions At Peak Load

	Unit 4 (640 MW)	Unit 5 (640 MW)
Heat Input		
GJ/h (10^6 BTU/H)	7 032 (6665)	7 032 (6665)
Gas Temp C(F)	126.7 (260)	126.7 (260)
Gas Flow		
kg/h (LB/H)	3 277 209 (7,224,887)	3 277 209 (7,224,887)
acms (ACFM)	1 038 (2,200,000)	1 038 (2,200,000)
Stack Exit Velocity		
m/s (FPS)	28.1 (92.2)	28.1 (92.2)
Stack I.D., m (FT)	6.86 (22.5)	6.86 (22.5)
Stack Height, m (FT)	182.9 (600 FT)	182.9 (600 FT)
Pollutant Emissions		
SO_2, kg/h (LB/H)	3 537 (7798)	3 537 (7798)
Particulate Emissions		
kg/h (LB/H)	303 (667)	303 (667)

Table 3.7-3. Suggested Design Parameters For Electrostatic Precipitator

Precipitator efficiency (%)	99.6	
Gas flow, acms (ACFM)	1 048	(2,221,000)
Gas temperature, C (F)	130	(266)
Gas velocity, m/s (FPS)	0.91	(3)
Effective front end area, m^2 (FT^2)	1 146	(12,339)
Plate heights, m (FT)	9.75	(32)
Effective width, m (FT)	117.65	(386)
Aspect ratio (four 2.74 m [9 FT] and one 3.66 m [12 FT] field)	1.5	
Field depth, m (FT)	14.63	(48)
Effective volume, m^3 (FT^3)	16 794	(593,000)
Duct width, m (IN.)	0.23	(9)
Number of ducts	515	
Total plate area, m^2 (FT^2)	146,975	(1,582,080)
Collecting area, m^2/acms ($FT^2/10^3$ ACFM)	140	(712)
Number of transformer rectifiers	80	
Number of bus sections	160	
Total power required, MW	5.4	
Estimated precipitator dimensions, each (two precipitator/unit)		
Length, m (FT)	17.68	(58)
Width, m (FT)	64.01	(210)
Height, m (FT)	15.24	(50)
Overall height, m (FT) (including hoppers)	21.34	(70)

Table 3.7-4. Flue Gas Flow Rates and Emissions At Max Load

	Unit 1 (400 MW)	Unit 2 (500 MW)
Heat Input		
GJ/h (10^6 BTU/H)	4 104 (3,890)	4 975 (4,715)
Gas Temp C (F)	149 (300)	149 (300)
Gas Flow		
kg/h (LB/H)	1 994 751 (4,387,600)	2 417 824 (5,330,300)
acms (ACFM)	692 (1,465,900)	839 (1,776,800)
Stack Exit Velocity		
m/s (FPS)	.70 (138)	.75 (147)
Stack I.D., m (FT)	4.57 (15)	4.88 (16)
Stack Height, m (FT)	151 (497)	151 (497)
Pollutant Emissions		
SO_2, kg/h (LB/H)	10 887 (24,000)	13 154 (29,000)
Particulate		
kg/h (LB/H)	176 (389)	214 (472)

3.8 DIRECTLY ASSOCIATED TRANSMISSION LINES

No additional transmission lines are required. Crystal River Units 4 and 5 will be served by the existing transmission line systems.

3.9 DIRECTLY ASSOCIATED FACILITIES

3.9.1 Arrangement

3.9.1.1 Railroad--Rail access into the Units 4 and 5 complex will be provided from a switch at the existing plant railroad. This railroad will provide for delivery of construction materials and equipment. The location and arrangement of the railroad is shown on Figure 3.9-1.

3.9.1.2 Access Roads--Vehicular access into the Units 4 and 5 complex will be provided from an intersection at Highway 19. The road will continue into the complex north of the existing transmission lines as shown in Figure 3.9-1.

3.9.1.3 Parking Lots--Parking space for vehicles will be provided south of Units 4 and 5 complex in the vicinity of the transmission lines. Approximately 56 658 m^2 (14 acres) of parking space will be required during construction of the plants. Additional permanent parking 4 047 m^2 (one acre) will be provided adjacent to the Administration Building.

3.9.1.4 Administration Building--Space for administrative personnel will be provided in an Administration Building located as shown on Figure 3.9-2. This building will be adjacent to the north end of the Turbine Building.

3.9.1.5 Maintenance Building--Space for maintenance of plant equipment will be provided in a Maintenance Building. This building will be located east of the Administration Building and north of the Turbine Building as shown on Figure 3.9-2.

3.9.2 Adjacent Land Use

The land adjacent to the north and east property boundaries is currently undeveloped pasture land. The land to the west of the Units 4 and 5 plant complex is Florida Power Corporation property to the Gulf of Mexico, and will remain undeveloped.

South of the Units 4 and 5 plant comples are the Units 1, 2 and 3 sites. The property adjacent to the south porperty is currently undeveloped.

3.9.3 Visibility

The relatively flat topography in the area surrounding the plant site, and the wooded areas adjacent to Highway 19 virtually hide the plant from public view from the east. From the Gulf of Mexico to the west, the tops of the Generation Building, cooling towers, and chimneys will be visible.

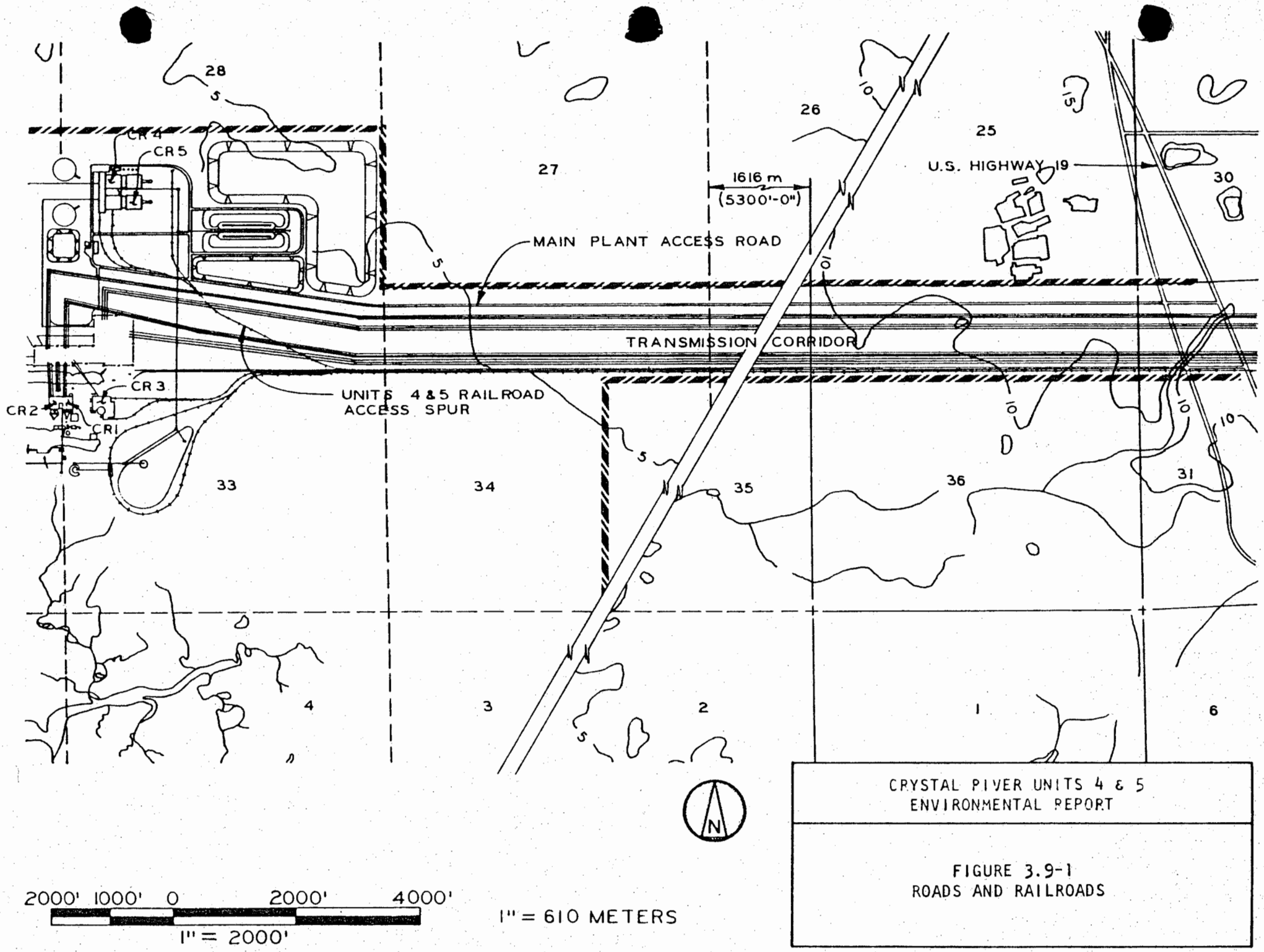

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FIGURE 3.9-1
ROADS AND RAILROADS

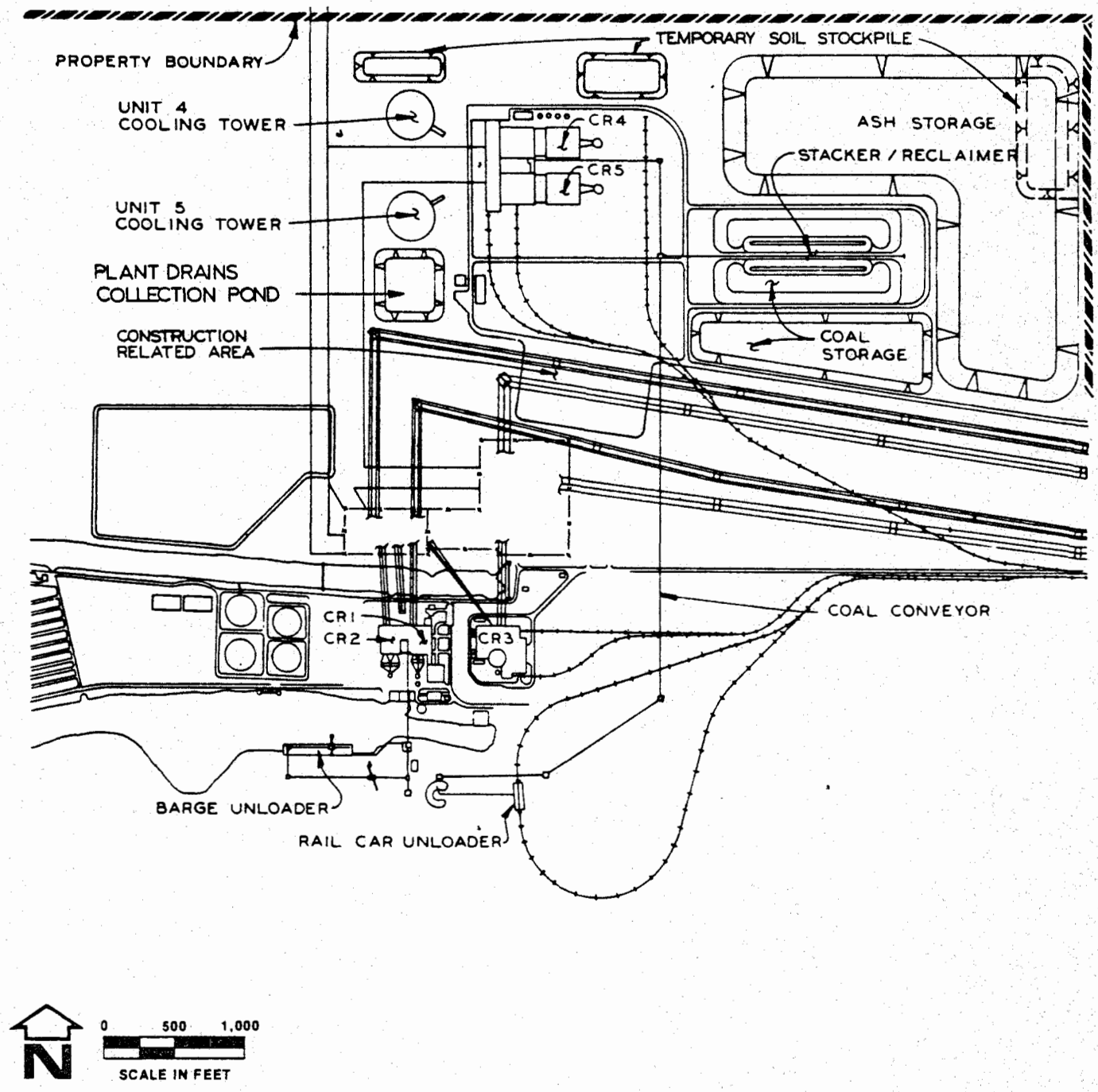

Figure 3.9-2
ASSOCIATED FACILITIES

SOURCE: BLACK AND VEATCH, 1976 (7/78)

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PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

3.10 ONSITE DRAINAGE AND EROSION CONTROL

3.10.1 RUNOFF COLLECTION DITCH SYSTEM

The runoff collection ditch system is designed to provide drainage for the rainfall runoff from the general developed areas of the site and overflow runoff in excess of the 10-year, 24-hour storm from the active and inactive coal storage area and the active ash disposal area. The ditch system will be installed as soon as construction activities begin on the site. Initially, the system will serve as the final erosion control and sedimentation basin for construction runoff. After construction is completed, the ditch will serve as a retention/exfiltration basin for runoff from impervious services in the general plant area.

The runoff collection ditch system collection canal layout is shown in Figure 3.10-1. A typical cross-section of the canal is shown in Figure 3.10-2. The canal bottom will be located at or near estimated high groundwater levels. Side slopes will be built up above existing grade. Channel side slopes will be approximately 1:10. Side slopes will be seeded or sodded to control erosion.

The canal will discharge into the existing cooling water discharge canal for Crystal River Units 1, 2, and 3. A flow control structure with an overflow spillway as shown in Figures 3.10-3 and 3.10-4 will be provided so that control of drainage will be possible in the event that high turbidity, oil spills, or other type of water quality degradation occurs. The runoff ditch collection system will consequently function primarily as a holding and exfiltration pond. The system will be designed to retain the volume of runoff for the 10-year, 24-hour rainfall event under high water table conditions.

The runoff collection ditch system will receive rainfall runoff from the material storage piles only for rainfall runoff in excess of the

10-year, 24-hour storm. All discharges from these areas will pass through a flow control structure with an oil skimmer. Yard drainage from generation and related facility areas is conveyed to the collection canal by subgrade catch basins, piping, and ditch, dike, and culvert systems. Manholes will be provided in areas with long piping runs.

Road and railroad embankments will be sloped to drain into the ditches which will collect and transport the drainage to the collection canal. Intermediate culverts will convey drainage flow through embankment fills.

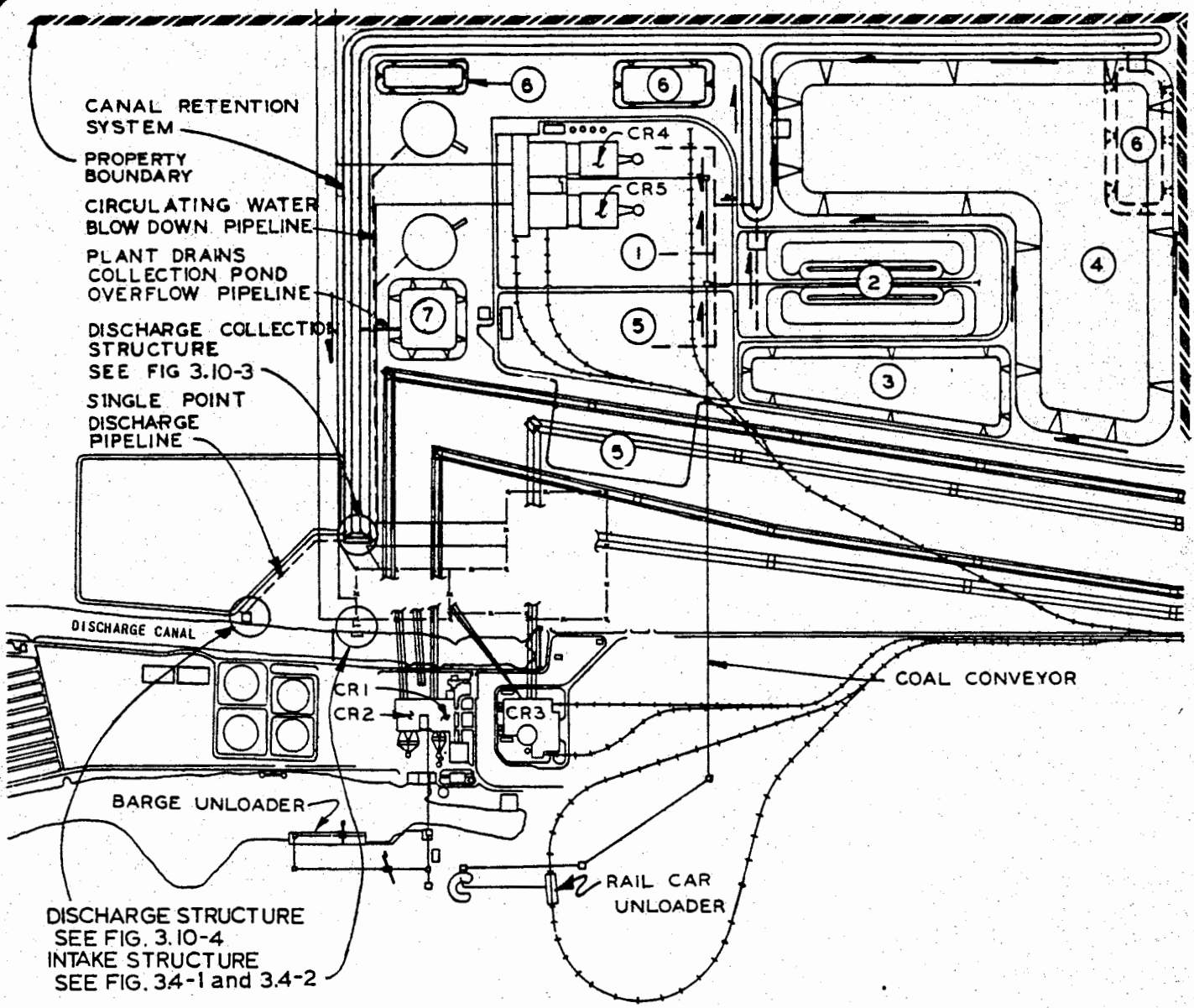
Rainfall stored within the diked oil storage tank area will be discharged to the perimeter collection canal after it has flowed through an oil-water separator.

3.10.2 CONSTRUCTION RUNOFF AND EROSION CONTROL

Control of construction runoff and erosion has been addressed in Site Preparation Specification 7645.71.0500. The construction contractor will be responsible for conforming to all federal and state regulations concerning stormwater discharge and wastewater discharge during construction.

The perimeter runoff collection ditch system will be constructed as soon as site work is initiated. A temporary drainage system will be provided and maintained in the vicinity of the generating complex and laydown areas. This system will be designed to minimize effects of construction runoff and siltation by controlled collection, retention, and overflow until permanent drainage facilities are completed and functional.

Seeding of cleared lands will be required once excavation, trenching, bank fill, embankments, rough grading, surfacing, and paving are completed in the vicinity of the seeding. Final acceptance of the project by the company shall include a good stand of healthy grass on all areas seeded. Specifications for types of fertilizer, seed, mulch, seed bed preparation, and topsoil are provided. Mulch will be applied at a rate of 2 tons per acre. A minimum of 6 inches of topsoil will be provided on seeded areas. Approximately 1,000 pounds per acre of fertilizer and 60 pounds per acre of seed will be applied. Planted seed will be compacted, watered, and otherwise maintained to obtain a satisfactory growth. Eroded areas will be refilled prior to final acceptance of work. Treated sewage effluent will be used when possible to water seeded areas. The contractor will guarantee all seeding work for one year after completion and will replace, at the contractor's expense, all turf that dies.



MAJOR PLANT RELATED DRAINAGE AREAS

1. GENERAL COMPLEX FILL AREA
2. ADJACENT ACTIVE COAL HANDLING AREA
3. ADJACENT INACTIVE COAL STORAGE AREA
4. ASH DISPOSAL AREA
5. CONSTRUCTION RELATED AREA
6. TEMPORARY SOIL STOCKPILE
7. PLANT DRAINS COLLECTION POND

LEGEND

- - - DRAINAGE PIPING
← PRIMARY DISCHARGE
□ RUNOFF CONTROL STRUCTURE

LOCATIONS

← FLOW DIRECTION

Figure 3.10-1
ON-SITE DRAINAGE SYSTEM

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SOURCE: BLACK AND VEATCH, 1976 (7/78)

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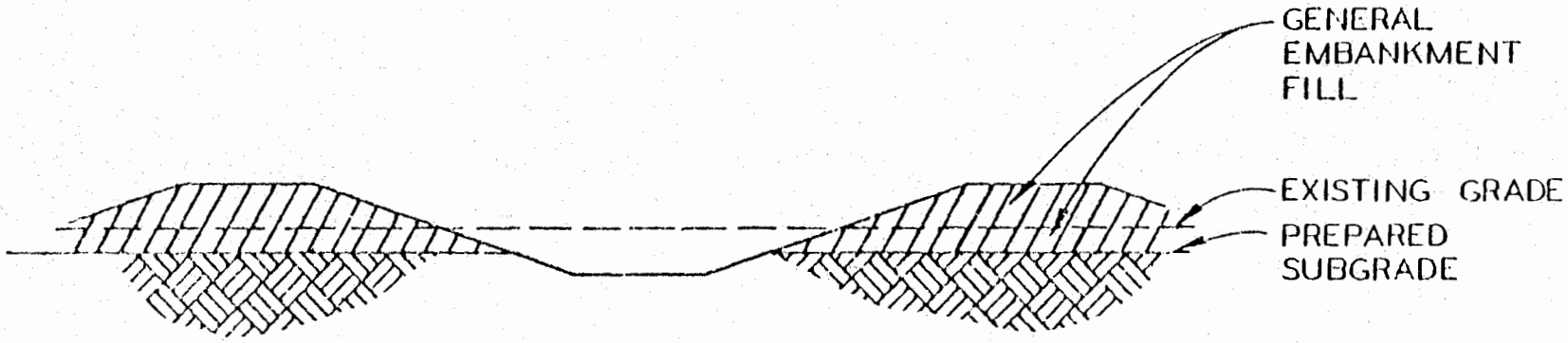

TYPICAL SECTION
COLLECTION CANAL

Figure 3.10-2
GRADING AND DRAINAGE

SOURCE: BLACK AND VEATCH, 1976

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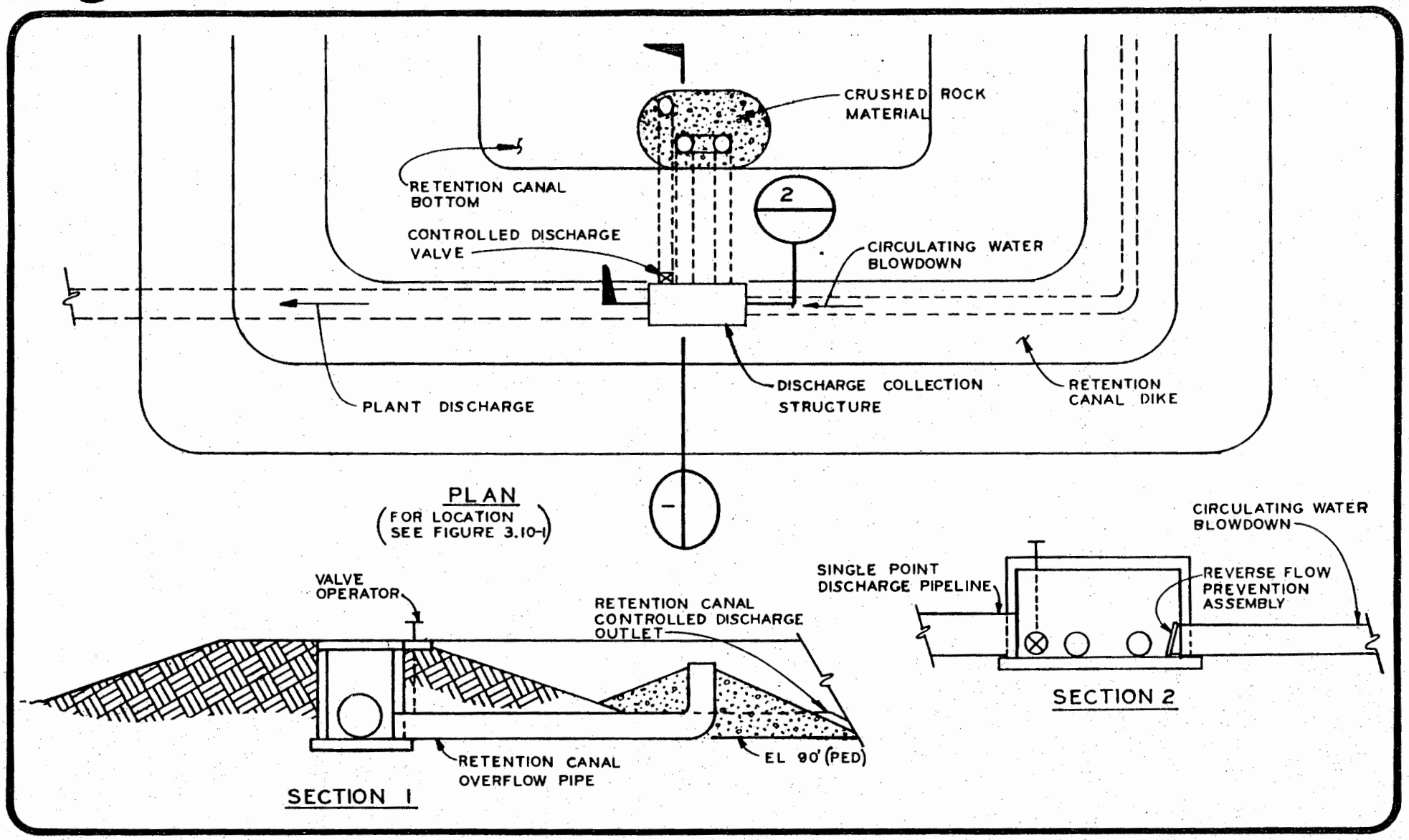

Figure 3.10-3
DISCHARGE COLLECTION STRUCTURE

SOURCE: BLACK AND VEATCH, 1976

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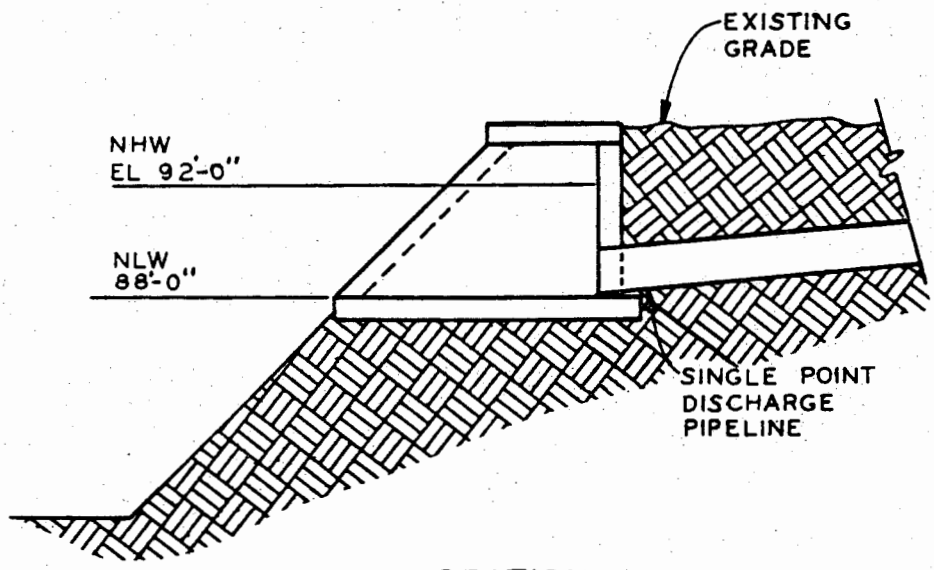
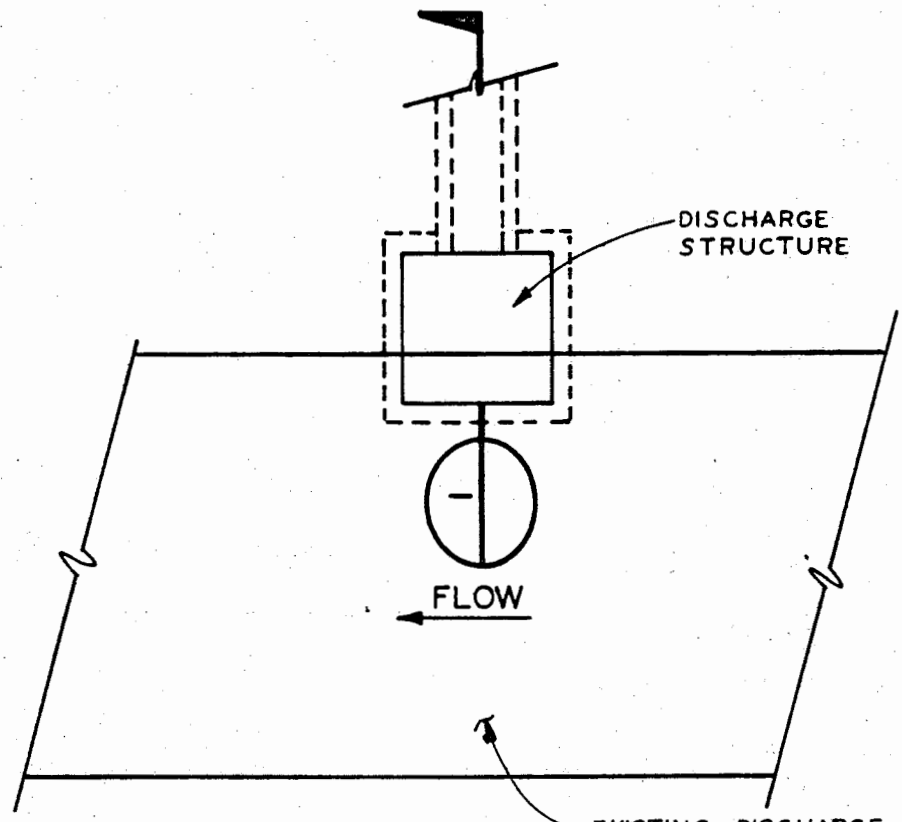
CITRUS COUNTY, FLORIDA



SECTION I



PLAN
(FOR LOCATION SEE FIGURE 3.10-1)

Figure 3.10-4
DISCHARGE CANAL
DISCHARGE STRUCTURE

SOURCE: BLACK AND VEATCH, 1976

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

CHAPTER 4

CHAPTER 4

SITE PREPARATION AND PLANT AND ASSOCIATED FACILITIES CONSTRUCTION: RESULTING ENVIRONMENTAL EFFECTS

4.0 SITE PREPARATION AND PLANT AND ASSOCIATED FACILITIES CONSTRUCTION/RESULTING ENVIRONMENTAL EFFECTS

4.1 SITE PREPARATION AND PLANT CONSTRUCTION

4.1.1 CONSTRUCTION AREAS AND ACTIVITIES

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4.0 SITE PREPARATION AND PLANT AND ASSOCIATED FACILITIES CONSTRUCTION/RESULTING ENVIRONMENTAL EFFECTS

4.1 SITE PREPARATION AND PLANT CONSTRUCTION

4.1.1 CONSTRUCTION AREAS AND ACTIVITIES

Construction of the proposed units will begin by clearing 26 hectares (65 acres) within the proposed plant area. A minimum of approximately 5.54 hectares (13.7 acres) of this area will be required to prepare foundations for the facility and cooling towers. The remaining land area will include construction parking, field offices, and laydown areas. A total of 135 hectares (333 acres) will be cleared for construction of Units 4 and 5, including the permanent ash storage area which will be used for laydown area during construction.

An access road 6.7 kilometers (4.1 miles) long will be constructed from U.S. Highway 19 to the plant construction area. The road will be located on the north side of the transmission corridor and will occupy about 12 hectares (30 acres). Construction traffic for the new facilities will travel along this road. Florida Power Corporation proposes an additional access road because security must be maintained for the nuclear Unit 3, and heavy construction traffic on the existing road should be limited.

Grading and filling will elevate the plant area from approximately 28 meters (94 feet--plant datum) to approximately 30 meters (99 feet) which is approximately 3.4 meters (11 feet) above mean low water. Cooling towers, the turbine generator building, the air pre-heater building, electrostatic precipitators, stacks and coal crusher building will be the primary structures requiring subsurface grouting and surface fill. Approximately 0.6 meters (2.0 feet) of overburden (organic, muck

or silt material only) will be removed in the vicinity of these structures to expose load-bearing formations.

The fill for supporting plant structures will necessitate approximately 140,000 cubic meters (180,000 cubic yards) of material. The fill, which will be either coarse and/or Brookville limestone, will be obtained primarily from local sources. For general fill, overburden from the site and nearby limestone and dolomite mines will be used.

Support of plant foundation will be accomplished with drilled piers. Drilled piers, constructed of reinforced concrete and approximately 48 inches in diameter, are placed to bedrock depth. Approximately 200 drilled piers will be placed through the Inglis formation to a depth of approximately 15 meters (50 feet).

Heavy equipment such as the turbine generator, steam generator, and materials such as structural steel will be transported to the construction area by rail. Trucks will deliver the remaining equipment and supplies. During construction activities, approximately 45 to 50 trucks will arrive daily. These trucks will haul concrete, lumber, fuel, and other supplies.

Water will be needed for hydrostatic testing of tanks, cleaning, drinking, sanitary facilities, soil compaction, and fugitive emissions control. The water supply for these purposes will be obtained from the existing freshwater wells for Crystal River Units 1, 2, and 3 and/or a new well field. It is estimated that less than 150,000 liters per day (40,000 gallons per day) will be required for these purposes. Electrical power needed for construction activities will be obtained from the existing distribution lines in the area.

A small amount of dredging will be necessary for the construction of a saltwater makeup intake structure, a cooling tower blowdown structure, and a canal retention system. The amount of material dredged from the discharge canal will be less than 160 cubic yards. All dredging will take place during a period of one month.

4.1.2 CONSTRUCTION WORK FORCE AND SCHEDULE

Tables 4.1.2-1 and 4.1.2-2 present manpower requirements and the construction schedule. The construction period for each unit will be 48 months.

Table 4.1.2-1. Construction Manpower Requirements, Unit Nos. 4 and 5 (Personnel per Month)

	1978	1979	1980	1981	1982	1983	1984	1985
January	--	125	300	825	890	850	520	200
February	--	125	325	825	910	800	520	160
March	50	125	400	825	945	750	500	120
April	50	150	500	850	1000	700	480	80
May	75	150	550	850	1015	650	460	40
June	75	150	600	870	1030	625	440	20
July	75	150	625	870	1025	600	420	--
August	75	175	650	890	1020	600	400	--
September	100	200	675	910	1015	600	380	--
October	125	225	775	930	985	600	340	--
November	125	250	800	900	955	560	300	--
December	125	275	825	920	900	560	240	--

Source: Florida Power Corporation.

TABLE 4.1.2-2

CONSTRUCTION SCHEDULE

4.1.3 SOURCES OF POSSIBLE ENVIRONMENTAL IMPACT

4.1.3.1 AIR EMISSIONS

Various construction activities associated with the site development, including land clearing, open burning, heavy machinery operation, truck traffic and road construction, will generate air pollutants. Because of the nature of these operations, emissions are extremely difficult to quantify accurately. Therefore, this discussion will address only the qualitative air pollution aspects of these construction activities.

The most significant air pollutant generated by heavy construction operations will be particulate matter, also termed fugitive dust. The quantities of dust emitted are dependent on a number of factors, including the frequency of operations, specific operations being conducted, weather, and soil conditions. The majority of generated dusts, however, are typically of large particle size and settle near the source. In addition, some of the operations, such as land clearing, are intermittent and usually of short duration.

Some of these dusts, however, will remain suspended in the atmosphere. Suspended dust emissions from heavy construction operations have been estimated to be 3.0 metric tons per hectare (1.2 tons per acre) per month of activity (U.S. Environmental Protection Agency, 1975).

Open burning, also a significant source of air pollutants during construction, will emit quantities of particulate matter, carbon monoxide hydrocarbons, sulfur oxides, and nitrogen oxides. The burning of

cleared land debris, primarily trees and scrub underbrush in the area, will be conducted for periods of short duration. Pollutant emissions depend on the moisture of the debris, the amount of material per acre, and the way the refuse is arranged (piles or rows).

The following emission factors for open burning of forest residues (U.S. EPA, 1975) have been estimated: particulate, 7.6 kilograms per metric ton (17 pounds per ton) refuse burned; carbon monoxide, 40 kilograms per metric ton (90 pounds per ton); and hydrocarbons, 11 kilograms per metric ton (24 pounds per ton).

Exhausts of heavy machine and truck traffic will be a minor source of air pollutants, mainly carbon monoxide, particulate matter, nitrogen oxides, hydrocarbons, and sulfur oxides. These exhaust emissions will be of relatively small quantities because of the amount of construction traffic expected.

4.1.3.2 NOISE SOURCES

During the site development and construction phase of the project, noise will be created by both traffic and equipment. The transient nature of these sources precludes rigorous determination of noise sources. Nevertheless, an estimate of worst-case noise can be made for an analysis of impacts.

Studies have been conducted to determine noise levels generated by the equipment used during various phases of construction (U.S. EPA, 1971).

The 15-meter (50-foot) levels for general noncontrolled noise from construction equipment are presented in Table 4.1.3-1. A good approximation of a worst-case noise emission can be determined by selecting four sources which are assumed to operate simultaneously at a single location. The sound pressure levels of these four pieces of equipment can be combined into a single source by adding energy levels from each source. It is estimated that two sources at 80 dBA, one at 85 dBA, and one at 91 dBA would be operating simultaneously for the worst-case construction impact. Noise from the construction phase will not be a problem at any sensitive receptor. The conclusions from the foregoing are presented in Section 4.2.4.

4.1.3.3 WATER DISCHARGES

The proposed plant site will require clearing, grading, and leveling which will be confined to those areas required for the construction of permanent plant facilities and temporary support facilities. The soil type is Broward, a thin surface layer of coastal sand with frequent limestone outcroppings. The soil is highly permeable with a minimum percolation rate of 0.51 meters per hour (20 inches per hour). Existing surface drainage is primarily into the groundwater table, which is at a maximum depth of 0.6 meters (2 feet) below the surface. The groundwater table depth also corresponds to the mean low water (mlw) elevation due to the nearness of the plant site to the coast.

The summer rainy season which is from June through September, is characterized by high intensity, localized thunderstorms. These thunderstorms

Table 4.1.3-1. General Noncontrolled Noise From Construction Equipment

Equipment	Noise Levels (dBA)*
Earthmoving	
Front Loader	79
Backhoes	85
Dozers	80
Tractors	80
Scrapers	88
Graders	85
Trucks	91
Paver	89
Materials Handling	85
Concrete Mixer	82
Concrete Pump	83
Crane	83
Derrick	88
Stationary	
Pumps	76
Generators	78
Compressors	81
Impact	
Pile Drivers	101
Jack Hammers	88
Pneumatic Tools	86
Other	
Saws	78
Vibrator	76

* All noise levels in dBA measured at a distance of 50 feet from the equipment.

Source: "Noise from Construction Equipment and Operations, Building Equipment and Home Appliances"; U.S. Environmental Protection Agency; prepared by Bolt, Beranek and Newman, December, 1971.

have an average return frequency of two days, with rainfall intensities ranging from 0.64 centimeters to 8.0 centimeters per hour (0.25 to 3.0 inches per hour). The winter wet season, which occurs from October through May, is characterized by frontal systems of less intensity than the summer thundershowers.

Runoff from the plant site is currently minimal because of the excellent percolation of the Broward soil and the nearness of the watertable to the surface. However, prior to construction, the site is to be filled to an elevation of approximately 3.7 meters (12 feet) above mlw. This filling will decrease the percolation rate and increase runoff from the site. Runoff will be greater during the summer wet season and will be accompanied by an increased suspended sediment load. Sanitary wastes can be a potential source of water contamination if they are not disposed of pursuant to Florida regulations. Such wastes will be handled by portable chemical facilities or a sanitary sewage system. The latter will become available in the early stages of Unit 4 construction. Other chemical and petroleum wastes will be disposed of in accordance with state and federal regulations.

4.1.3.4 SOLID WASTES

Solid wastes other than land clearing debris will include scrap lumber, scrap metal, crating and cardboard from equipment containers, paper and plastic from packaging, field-office wastes, and other trash. An estimated 1,800 cubic meters (2,400 cubic yards) of such wastes will be generated from construction.

4.1.3.5 TRANSPORTATION

[During the construction phase, additional traffic in the site area will be generated by the construction work force and deliveries of equipment and supplies. The construction work force will use private vehicles, automobiles, pick-up trucks, etc., for transportation to and from the site. In 1982, when the construction work force is at a peak, it is estimated that approximately 2,000 trips per day will be generated by the construction employees. Also, during the peak construction, approximately 50 delivery vehicles are expected to access the site daily. U.S. Highway 19 will be the major roadway receiving the additional traffic generated by the construction activities. Except for some minor slowdowns in flows due to turning at the site access road, the impact on the highway traffic is expected to be minimal based on highway usage projections and capacities developed by the Withlacoochee Regional Planning Council.

During construction, some of the heavy equipment and materials will be transported to the site by rail. The exact number and schedule for these trains is unknown at the present time; however, traffic delays on U.S. Highway 19 due to these train crossings will be less than two minutes per delivery arrival and per departure.]

4.1.4 MITIGATING MEASURES

4.1.4.1 AMBIENT AIR QUALITY

Modern methods of dust control and dust emission prevention will mitigate the effects of construction in the vicinity of the proposed site. Air quality control rules of the State of Florida for fugitive dust emissions and open burning will also be met (Florida Department of Environmental Regulation, CH. 17-2.04 (3) F.A.C.; and Florida Division of Forestry, CH. 51-2 F.A.C.).

To achieve full compliance with these regulations, the following mitigative control will be implemented during construction:

1. All reasonable precautions will be taken to prevent fugitive dust emissions. Such precautions will include using, where practicable asphalt, oil, water or dust suppression chemicals for the control of dust from grading and clearing operations and on dirt roads.
2. Open burning will comply with these conditions.
   a. Burning will be performed between 9:00 a.m. (Eastern Standard Time) and one hour before sunset; at other times, a forced draft system will be used.
   b. The burning location will be at least 50 yards from the nearest occupied building or public highway.
   c. Piles will be no larger than can be burned within the designated time.
   d. Moisture content and composition will be favorable for good burning.

e. Smoke emissions will not exceed 40 percent opacity or Number 2 on the Ringelmann chart, except during startup.

4.1.4.2 WATER QUALITY

To minimize construction runoff and siltation in nearby surface waters, detention ponds will be constructed as necessary. Cleared and filled areas will be diked, as practicable, to minimize potential discharges. Sanitary waste disposed of on site will receive secondary treatment and will be discharged to an evaporation/percolation pond.

4.1.4.3 SOLID WASTES

Waste materials, such as scrap lumber and metal, will be recycled. Periodically, these materials will be stockpiled in areas where salvage operations can transport them off site. Other solid wastes will be land-filled in the existing area.

4.2 UNAVOIDABLE ENVIRONMENTAL IMPACT

4.2.1 AIR QUALITY

The heavy construction activities will have a short-term impact in the immediate vicinity, primarily on suspended particulate matter levels. These levels are expected to increase during construction, both on site and in the vicinity of the proposed facility. Ambient air quality standards for particulate matter are not expected to be exceeded beyond a few hundred feet from the operations (Kosky, 1975). Permanent or long-term impacts related to heavy construction activities are not expected.

Short-term impacts will also result from open burning. Since these operations will be conducted during periods of excellent dispersion and will be of short duration, no permanent or long-term impacts are expected.

The isolation of the site and the prevailing meteorology will substantially reduce air quality impact. In addition, the methods that will be used for fugitive emissions control are estimated to reduce emissions by 80 to 50 percent (Dunbar, 1975; Kosky, 1975).

Air pollution impacts from increased traffic will be associated primarily with the new access road. Since nearby U.S. Highway 19 is a major four-lane highway, facility-related traffic will not significantly influence carbon monoxide levels.

4.2.2 WATER QUALITY

During construction, turbidity and sediment loading to the nearby marsh areas will not occur from runoff. The use of state-of-the-art erosion techniques (berms, mulch, sodding, and detention/infiltration ponds) during construction will mitigate adverse effects on the adjacent surface waters. Construction of the stormwater retention areas at the plant site will abate the runoff sediment load impact on the marsh. A small amount of dredging activity in the discharge canal will increase the turbidity in the canal and adjacent areas. This impact will be extremely short-term, i.e., no longer than one month in duration.

The changes in surface water chemistry or quality due to construction activities will be minor. There probably will be less organic material in the waters because of the removal of the vegetation and the filtration effects of the surface fill mat. The pH of the water to the south and west of the site may be increased slightly (i.e., become more basic) because of the presence of the limestone fill material which has a much smaller pebble size relative to the underlying limestone rockbed. Also, the mineralization of the water may increase slightly because the organic overburden has been removed, and the small, pebble-sized fill material allows the water to be in more direct contact with minerals (i.e., calcium and magnesium ions). These possible water quality changes should not cause a violation of any promulgated water quality standards.

Major hydraulic or dragline dredging operations and the use of explosives are not expected during the construction period.

4.2.3 SOLID WASTES

The impacts of solid wastes will be limited to land utilization for those materials that cannot be recycled. Since an existing area will be used, impacts are minimal.

4.2.4 NOISE

[As discussed in Section 4.1.3, maximum noise emissions were estimated under the assumption that four major sources would be in operation at any time. The four sources were assumed to produce sound levels of 91 dBA, 85 dBA, 80 dBA, and 80 dBA at 15 meters.

Since the precise location of each source with respect to others at any given time cannot be pinpointed, it is difficult to predict sound levels at receptors near the plant. At more distance locations, analyses were performed by combining the effects of each and every source and creating a single larger source. This combined source exhibits a sound level of 93 dBA at 15 meters.

It was assumed that a 6 dBA drop per doubling of distance between the source and receptor would be realized. The following results from this worst-case analysis were obtained:

Distance Between Source and Receptor (dBA)	Sound Level (dBA)
.5	63
1.0	57
5.0	43

A further decrease due to vegetation between the source and receptors can be expected. For the purposes of noise analyses, a 5 dBA reduction in noise per 30 minutes of thick plantings and a 2 dBA reduction in noise per 30 meters of sparse plantings are allowable (Bolt, Beranek,

[and Newman, 1973). A maximum of 10 dBA may be deducted due to attenuation by vegetation, and this figure may be applied to the values above.

The distance to the nearest sensitive receptor from the center of the proposed construction activities is 8 kilometers. At this distance, the maximum sound level will be 39 dBA due to geometric attenuation alone. With the additional effect due to the existence of vegetation, the sound level will be 29 dBA, which will be indiscernible.

Judgements regarding the annoyance or average noise potential are made by evaluating the description known as the Noise Pollution Level (NPL). NPL is defined as the sum of the A-weighted average sound level and 2.56 times the standard deviation of that sound leve. A qualitative evaluation of NPL with respect to annoyance is presented in Table 4.2.4-1.

Assuming a standard deviation in sound level of 5 dBA, the NPL expected at the nearest sensitive receptor is 42 dB. This level clearly is acceptable according to the criteria listed in Table 4.2.4-1. A receptor would have to be located within 0.2 km of the construction site before the NPL would be "normally unacceptable."

The foregoing analysis excludes a consideration for barriers such as those provided by existing structures.

[Table 4.2.4-1. Qualitative Relationship Between NPL and Annoyance from Construction Activities

Clearly Acceptable: The noise exposure is such that both the indoor and outdoor environments are pleasant.	NPL less than 62 dB
Normally Acceptable: The noise exposure is great enough to be of some concern but common building constructions will make the indoor environment acceptable, even for sleeping quarters, and the outdoor environment will be reasonably pleasant for recreation and play.	NPL between 62 and 74 dB
Normally Unacceptable: The noise exposure is significantly more severe so that unusual and costly building constructions are necessary to ensure some tranquility indoors, and barriers must be erected between the site and prominent noise sources to make the outdoor environment tolerable.	NPL between 74 and 88 dB
Clearly Unacceptable: The noise exposure at the site is so severe that the construction costs to make the indoor environment acceptable would be prohibitive and the outdoor environment would still be intolerable.	NPL greater than 88 dB

Source: EPA, 1971.]

[Noise resulting from construction activities may disturb some wildlife species and cause them to avoid certain areas of the site. This disturbance may interrupt feeding and reproductive activities within 0.5 kilometers of the construction site. The significance of this impact is considered low because of the limited degree of disturbance, the ability of the animals to adapt, and the commonness of the majority of the species. These impacts are considered reversible.]

4.2.5 TRANSPORTATION

Movement of construction traffic and heavy machinery will result in unavoidable soil compaction. Mochring (1970) has documented three major effects of heavy logging machinery on soils: compaction, puddling, and soil displacement. Resulting increased surface runoff may favor wetland vegetation in low-lying areas. However, Perry (1964) and Hatchell and Roberts (1969) have postulated an extended recovery time for such soils with a resulting decrease in natural productivity and in the rate of succession. Since most of the areas temporarily affected are in currently disturbed transmission corridors, the significance of the impact is considered low.

An increase in "road-kills" of species, such as rabbits, turtles, and armadillos will likely result from the increased traffic to and from the site. The significance and the magnitude of this impact are considered low in terms of the numbers of animals which will be killed relative to the natural population levels. In addition, since construction activities are primarily confined to daylight hours, the probability of "road-kills" is minimized.

U.S. Highway 19 will be the major road impacted by construction activities. Based upon its current use as a major transportation corridor, the impact of increased traffic to and from the site will be minimal.

4.3 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

4.3.1 COMMITMENTS OF MATERIALS AND ENERGY

The quantities of construction materials needed for the proposed plants have not been computed at this time. Concrete, reinforcing and structural steel, and fill material are the main resources which will be committed. The majority of these materials will not be recoverable and will constitute an irreversible commitment. Some of these materials, however, will be suitable for recycling.

Many of the materials used in the construction process, such as building forms, temporary structures, and unused materials, will be sold or re-used following the construction period.

Irretrievable energy commitments will include electrical energy, and diesel and other fuel oils.

4.3.2 COMMITMENTS OF LAND AND BIOTA

About 117 hectares (289 acres) of land will be required for the plant and its associated facilities. The loss of plant communities will be experienced in the approximate areas listed in Table 4.3.2-1.

The access road will claim about 8.5 hectares (21 acres) of ruderal land, 2.4 hectares (6 acres) of mesic/hydric hammock, and 0.8 hectares (2 acres) of freshwater marsh. The rail spur will need 0.4 hectares (1 acre) of hydric hammock and 1.2 hectares (3 acres) of ruderal land. The regional significance of these impacts is low because of the small land area or percentage of habitat involved.

The land clearing will cause a loss of timber volume that is estimated to be about 4.6 cubic meters per hectare (163 cubic feet per acre) of pulpwood; 0.1 cubic meter per hectare (1.4 cubic feet per acre) of slash pine; and 250,000 to 375,000 board feet (2,000 to 4,000 board feet per acre) of hardwoods and conifers. This loss is not significant because of the low commercial value due to the small tree size, and the high proportion of rough trees (non-commercial species and unacceptable trees of commercial species). The agricultural value of the land is low.

The loss of natural communities is of low significance because of the relatively early successional status and disturbed state of most of the land to be cleared (see Section 2.7.2).

Table 4.3.2-1. Plant Community Areas to be Impacted by Construction

Habitat	Hectares	Percent of Total Land Within the 8 Kilometer (5-Mile) Radius
Coastal hydric hammock	2.4 (6 acres)	2
Hydric hammock	22 (55 acres)	52
Mesic hammock	24 (60 acres)	23
Slash pine flatwoods	47 (116 acres)	2.6
Evergreen oak scrub	3.2 (8 acres)	79
Freshwater marsh	6.5 (16 acres)	2.3
Ruderal land	10 (25 acres)	1

However, individuals of the rare plant species coontie (Section 2.7.3) may be destroyed. The magnitude and significance of this impact is considered low since the species is relatively abundant in the region. However, impacts on such species are cumulative in that they contribute to the general reduction of populations from other human activities. The projected ash storage area is not sufficient to contain all of the ash produced during the plant life. The Applicant intends to actively market the trash. However, if the ash cannot be sold then approximately 61 hectares (150 acres) of the Applicant's existing property will be dedicated to ash storage.

4.3.2.1 WILDLIFE HABITAT

A significant impact of the development of the property will be the loss of habitat for wildlife.

Construction activities will ultimately affect about 102 hectares (255 acres) of wildlife habitat at the plant site. The construction of roads, railroad spurs, and other construction activities may also cause destruction of about 23 hectares (56 acres) of habitat. Most wildlife will leave the immediate vicinity of construction as human activities increase. The clearing process will destroy resident "non-important" wildlife populations, especially small mammals and various herpetofauna. Some of the more mobile species of wildlife (i.e., opossum, raccoon, and deer) will leave the area. Those wildlife that are displaced will either move into adjoining, less suitable habitats or they will migrate to an area similar to that from which they have been displaced. Since most lands are at or near carrying capacity for wildlife, the net result

of the removal of wildlife habitat, given a period of time for population stabilization, will reduce wildlife population in the region in proportion to the reduced habitat area.

The major wildlife habitats to be impacted are the on-site pine flatwoods, evergreen oak scrub, fresh water marsh communities, and mesic and hydric hammocks. The clearing operation will destroy habitat for a number of wildlife species.

The major impacts on rare and endangered animals will involve gopher tortoise, indigo snake, Florida mouse, and possibly the scrub jay. The on-site habitat of the gopher tortoise, Florida mouse, and scrub jay will be eliminated by the clearing operation for plant construction. Since the area of suitable habitat for the gopher tortoise is very small, the extent of this impact is low. Because the indigo snake occupies a variety of habitats, the plant construction will not drastically reduce areas of habitation for this snake. The impact on rare and endangered animals should not be significant because of the relatively small area to be affected.

In general, the significance of this wildlife habitat loss is not great because of the commonness of most species involved. All populations in the area are currently self-sustaining. The magnitude of the impact of these activities on the site is great because the changes will render most of the site unusable by wildlife; however, the areawide magnitude of these changes is not great because of the current abundance of

available forest habitat. These impacts are irreversible and are a long-term loss of natural wildlife resources to the site and the area.

Loss of or impact on aquatic habitats from the construction of Units 4 and 5 should be minimal. Assuming adequate control of erosion during construction, the only loss would be a few shallow temporary ponds which were completely dry at the time of the site visit (August, 1977). The plant site has been shifted to the east to avoid destruction of marsh and mesic forest further west on the Applicant's property. (See Figure 2.7.2-1.)

4.3.3 OTHER IMPACTS ON BIOTA

It is felt that the transmissivity of the aquifer is sufficiently high to preclude significant restriction of subsurface flow at the site. While there remains a low probability that grouting could alter groundwater flow sufficiently to reduce the freshwater subsidy of a small portion of the coastal hydric hammock nearest to the construction site, the use of drilled piers will significantly reduce the probability of any adverse impact to the groundwater flow. The use of drilled pier construction makes the probability of impacts to groundwater flow negligible.

Construction of the rail spur and access road may also affect nearby plant communities through alteration of surface drainage. The magnitude of this effect will depend upon construction design, such as the number and placement of culverts, which has not been developed at this time. The magnitude and significance are low.

Because of the large area of pine plantations adjoining the proposed plant site, the overall effect of clearing operations on site may have an impact on wildlife from surrounding areas. The major impact on off-site wildlife will be to reduce food supplies and denning sites for some of the more wide-ranging species. Habitat alterations near areas of large tracts of monocultured, even-aged (pine plantation) forest that include the destruction of upland oaks may eliminate or reduce the home range of various species. Oaks adjoining upland pine sites are essential in providing food for wildlife and offer diversity in habitat in homogeneous pine plantation (Goodrum *et al.*, 1971). It can be anticipated that predatory and foraging animals which utilize these areas will have to adjust to the diminished food supplies. This will cause either a decreased carrying capacity for ranging species (i.e., deer, bobcat, and raccoon) or a shift in feeding areas to surrounding habitats. This impact on the terrestrial ecology of the area, although difficult to estimate, is considered minimal because of the relatively small acreage to be cleared.

IMPACTS DUE TO CONSTRUCTION OF ACCESS ROAD

The construction of the access road will result in the destruction of 2.4 hectares (6.0 acres) of forested lands, 0.8 hectare (2.0 acres) of fresh marsh, and 8.5 hectares (21.0 acres) of ruderal areas. Modification to existing faunal communities will be determined primarily by the type and extent of permanent changes in habitat along the proposed corridor. It can be anticipated that the major impact will occur where existing forested lands will be cleared to facilitate construction of the access road. Such clearing can affect faunal communities; however, because of the relatively narrow strip required for the corridor, most effects should be minimal. Fencing the road would decrease wildlife mobility.

The loss of some mast-producing species may adversely affect squirrels and other species that depend on acorns, nuts, and other hardwood mast. Clearing operations in the forested areas of the access road will stimulate more growth of browse species such as herbaceous plants, trees, and shrubs; however, the overall effect may be negative because of the loss of mast production and denning sites.

IMPACTS DUE TO TRANSPORTATION

The increased traffic along the access road because of the plant operation will increase "road kills" of wildlife. The net result of the construction of this second access road with its subsequent vehicular traffic will be to create an artificial barrier, thus forming an insular wildlife habitat. Because of traffic and other human activity along these roads, species such as deer are less likely to cross into the median area. In addition, some wildlife will not cross this barrier because of insufficient cover.

The initial disturbance of existing vegetation during construction is the most immediate impact to wildlife. The road construction will not

significantly alter the present ecological functions and attributes of the edge community. Those forested areas which are cleared will have functional characteristics of an early successional state (Odum, 1971). The creation of a barrier and the resulting insular habitat is the most significant impact; however, the magnitude of this impact is considered moderate for the route and low for the surrounding area. The impact of forest clearing is low for the site and surrounding area. These impacts will be long-term and reversible.

4.3.4 IMPACTS ON SENSITIVE AREAS

The coastal hydric hammock should be regarded as a sensitive area because of its wetland nature, old-age trees, and natural values (Section 2.7.2). It is the only sensitive area likely to be impacted by the project. Impacts will include clearing of 2.5 hectares (6.3 acres), a loss of a protective vegetation buffer, and increased potential for exotic species introduction. Florida Power Corporation will mitigate impacts to a large extent by refraining from mowing or use of biocide following construction and allowing maximum practical regrowth. Other impacts are probably minor in magnitude and regional significance. However, all of these impacts are cumulative and in aggregate may impact the system.

CHAPTER 5

CHAPTER 5

ENVIRONMENTAL IMPACT OF PLANT OPERATION AND ASSOCIATED TRANSMISSION FACILITIES

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5.1.1 PHYSICAL EFFECTS OF GROUNDWATER WITHDRAWAL

Florida Power Corporation proposes to obtain fresh water for Crystal River Units 4 and 5 from a well field about 8.2 kilometers (5 miles) east of the plant site (see Figure 5.1-1). The tentative design of the well field is in the form of an east/west line along the northern boundary of section 32, township 17S, range 17E. The west well will be located on the Florida Power transmission line right-of-way about 300 meters (1,000 feet) east of the northwest corner of section 32. The 21 wells will be spaced approximately 150 meters (500 feet) apart.

The wells will be drawing water from the Floridan Aquifer. Maximum pumpage from the well field will be about 7,950 liters per minute (2,100 gallons per minute, or 3 million gallons per day). Average pumpage will be approximately 1,518 liters per minute (401 gallons per minute or 0.58 million gallons per day).

Hydrologic coefficients were determined by a pump test in order to assess the impacts of the proposed well field on the aquifer system. The average transmissivity was determined to be about 563,700 liters per day per meter (45,390 gallons per day per foot). The coefficient of storage was determined to be approximately 0.0003 and the leakance about 3.74 liters per day per cubic meter (0.028 gallons per day per cubic foot) (Geraghty and Miller, 1978).

A flow net analysis performed prior to the pump test determined that the transmissivity of the aquifer system is in the range of 1.86×10^8 liters per day per meter (1.5×10^7 gallons per day per foot) (Geraghty and Miller, 1977). The discrepancy between the two transmissivity values is believed to be due to local variations in the hydrogeologic system. The flow net analysis gives an average transmissivity value which is based on the total groundwater flow to the Crystal River. Much of the groundwater flow may take place through open solution channels or other zones of very high permeability which are adjacent to low permeability zones. The hydrogeologic system for the proposed well

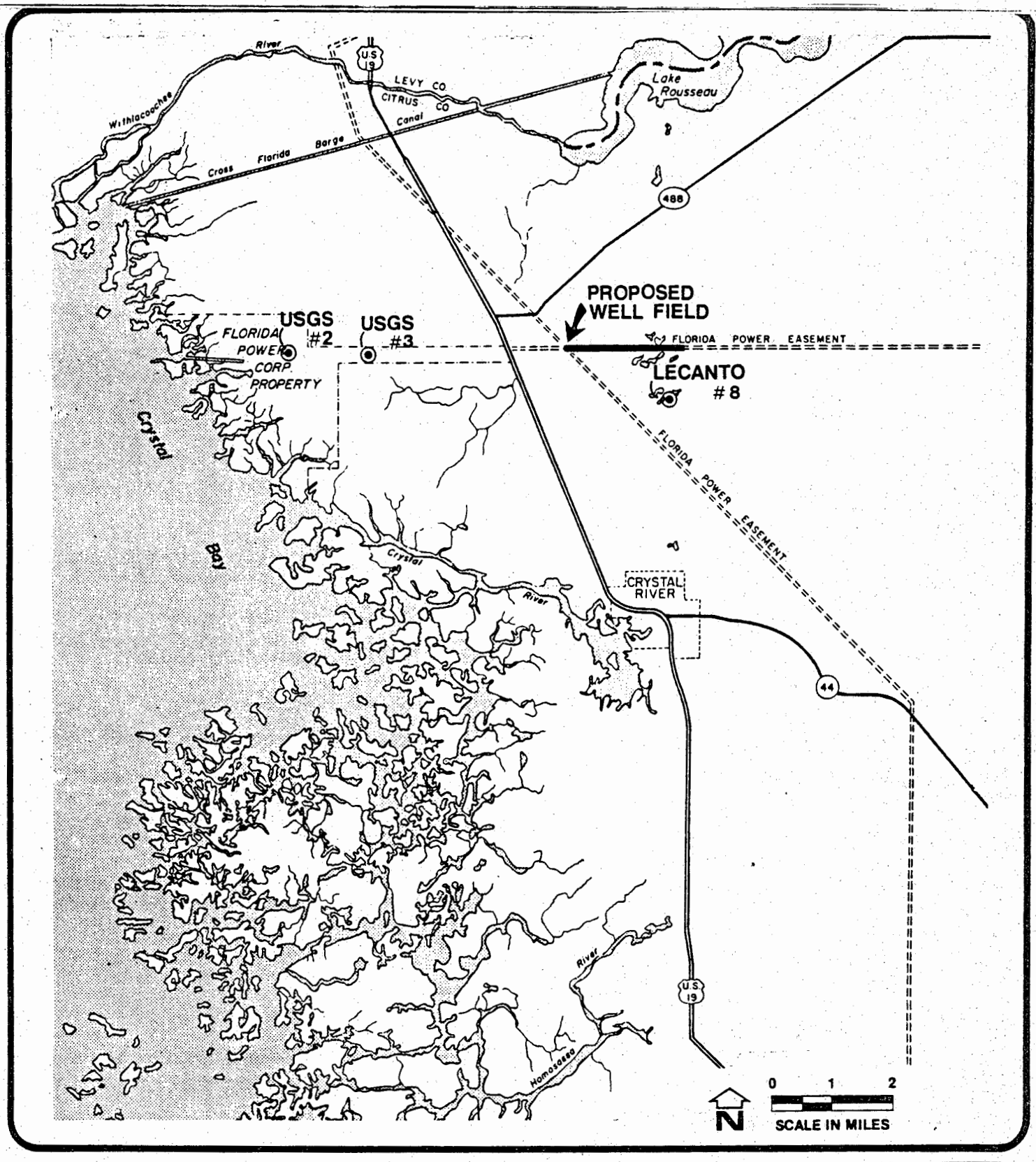

Figure 5.1-1
LOCATION OF PROPOSED WELL FIELD AND USGS OBSERVATION WELLS

SOURCE: GERAGHTY AND MILLER, INC., 1977
ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1978 (7/78)

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field site can only be defined by an extensive test drilling program; the variation in transmissivity is not apparent from analysis of the regional flow characteristics. If solution channels are encountered in the well field, then the transmissivity will be much higher locally. However, without this additional data on the variation in transmissivity, the aquifer test values are used to estimate the impacts of water withdrawal from the well field.

Based on the aquifer test data, the well field will require 21 wells, each yielding 380 liters per minute (100 gallons per minute) to provide the required 11 million liters per day (3 million gallons per day) maximum for plant use without exceeding the SWFWMD (Chapter 16J F.A.C.) rules and regulations.

The cone of depression from pumping at the well field has been computed in order to estimate the effect of groundwater withdrawal on the potentiometric surface of the upper Floridan Aquifer. The potentiometric map utilized to describe baseline conditions is the map prepared by the U.S. Geological Survey for May, 1975.

The potentiometric surface map is illustrated in Figure 5.1-2. The 0.3-meter (1-foot) contours have been estimated from the 5- and 10-foot contours shown on the USGS potentiometric map for May, 1975, and from water levels in USGS observation wells in the area.

The water surface elevation in the upper part of the Floridan Aquifer in the vicinity of the proposed well field fluctuates between 1.2 and 2.7 meters (4 and 9 feet) above mean sea level.

It should be emphasized that in the following discussion of groundwater withdrawal impacts, the computed drawdowns are theoretical. Assumptions and estimates based on the best available information have been required. These assumptions are clearly identified in the text. Drawdowns have been calculated by using the Hantush and Jacob equation (Walton, 1970).

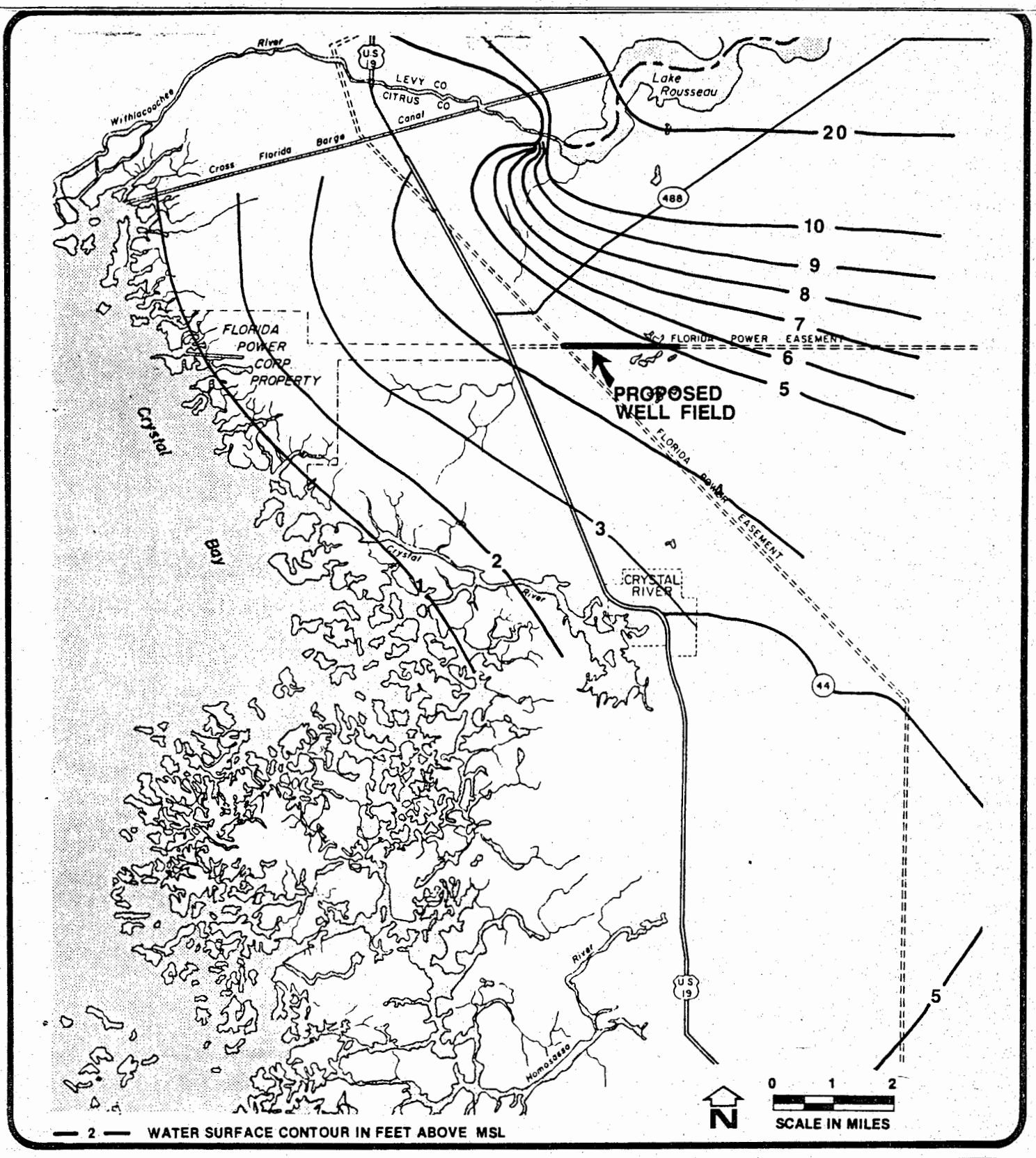

Figure 5.1-2
POTENTIOMETRIC SURFACE OF UPPER FLORIDAN AQUIFER, MAY 1975

SOURCE: GERAGHTY AND MILLER, INC., 1977
ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1978 (7/78)

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The following assumptions were made in the calculations:

1. The water-bearing formation is isotropic (homogeneous);
2. The water-bearing formation has a uniform thickness;
3. The water-bearing formation has an infinite areal extent;
4. The system consists of a leaky artesian aquifer without water released from storage in the aquitard;
5. No recharge occurs during pumping;
6. The wells penetrate and receive water from the full thickness of the aquifer; and
7. Water is removed from storage instantaneously.

Values used in the computations are:

1. Transmissivity (T) = 52,000 liters per day per meter (45,000 gallons per day per foot;
2. Storage coefficient (s) = 0.0003;
3. Leakance P'/M' = 0.003 liters per day per cubic meter (0.028 gallons per day per cubic foot);
4. Discharge rate (Q) = 30 liters per minute (100 gallons per minute); and
5. Drawdowns in the well field are calculated at steady state conditions.

The calculated cone of depression for a maximum pumpage of 3 mgd is shown in Figure 5-1.3. Expected water level drawdowns are as follows:

Location	Drawdown
Well field (maximum drawdown)	1.8 meters (6 feet)
100 meters (330 feet) north of production wells (FPC property line)	0.8 meters (2.6 feet)

The configuration of the May 1975 potentiometric water surface with the effects of pumpage from the proposed well field is shown in Figure 5-1.4.

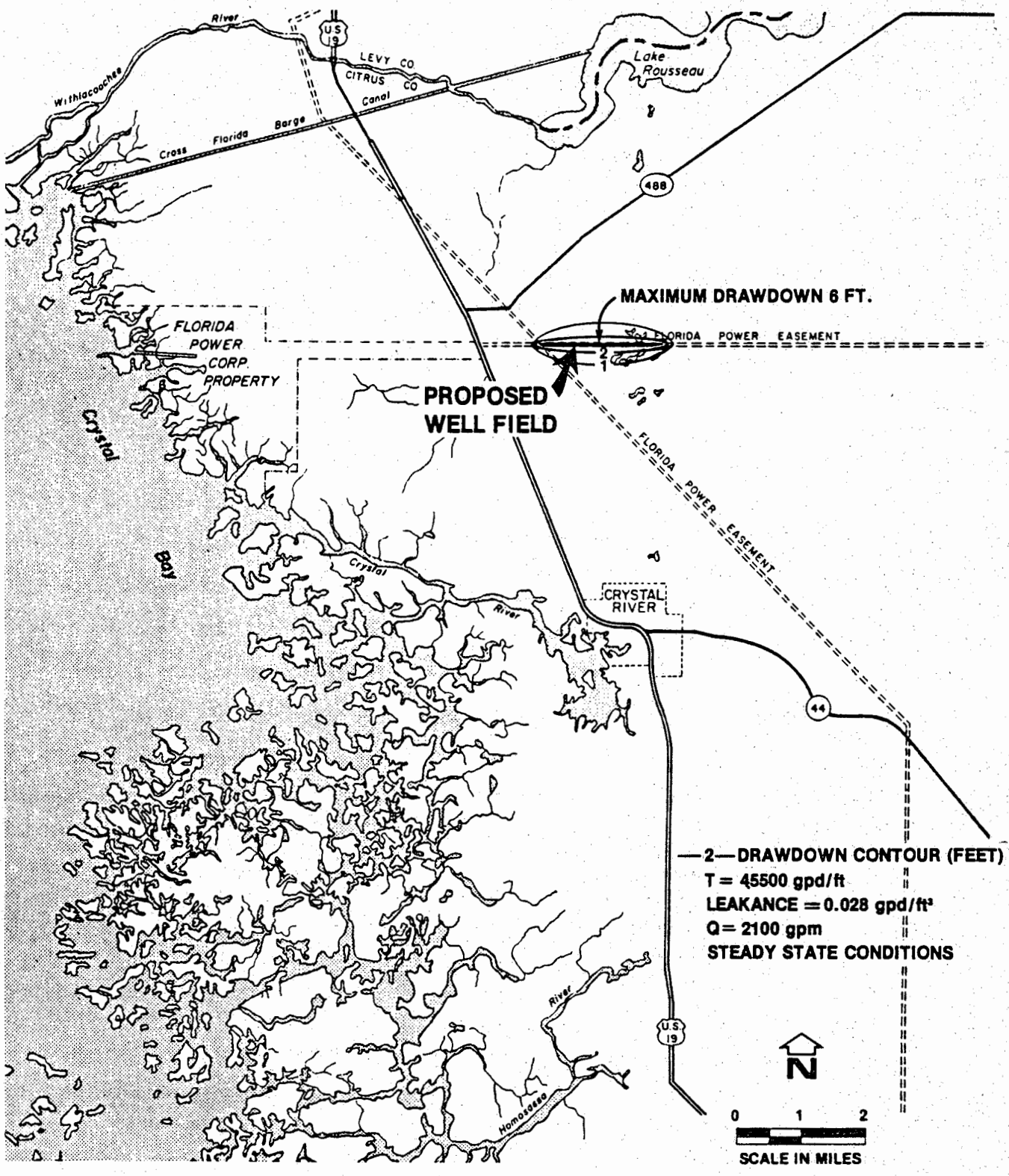

Figure 5.1-3
CONE OF DEPRESSION FOR CONCEPTUAL WELLFIELD

SOURCE: GERAGHTY AND MILLER, INC., 1977;
ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1978 (7/78)

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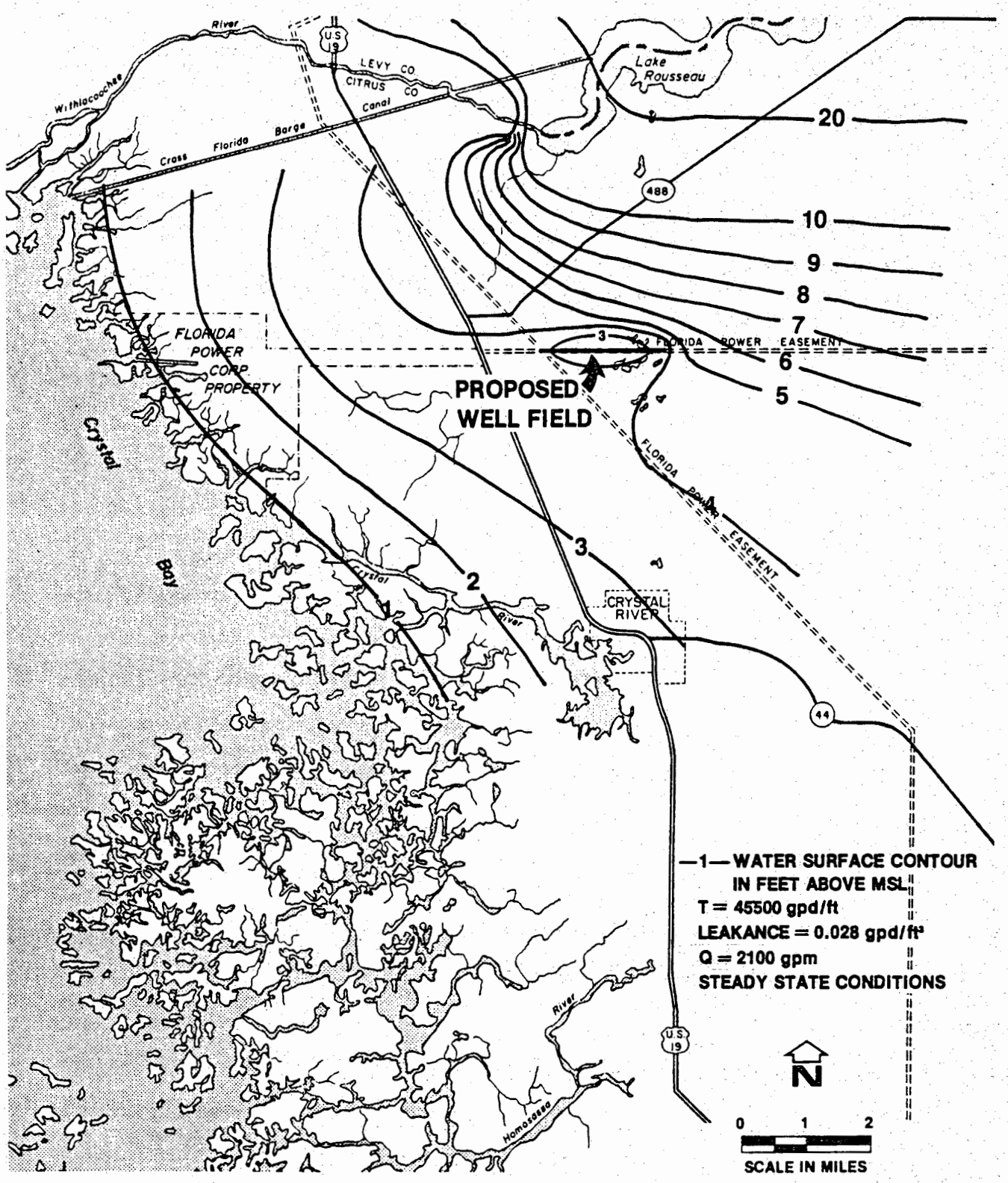

Figure 5.1-4
ELEVATION OF THE POTENTIOMETRIC WATER SURFACE OF THE UPPER FLORIDAN AQUIFER, MAY 1975, SHOWING THE EFFECTS OF PUMPING AT THE PROPOSED WELL FIELD
SOURCE: GERAGHTY AND MILLER, INC., 1977;
ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1978 (7/78)

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Water levels in the vicinity of the well field are drawn down approximately 0.6 meters (2 feet). Maximum drawdown occurs in the wells toward the center of the line. The minimum water level elevation at times of seasonal low water level conditions (May) will be at approximately mean sea level.

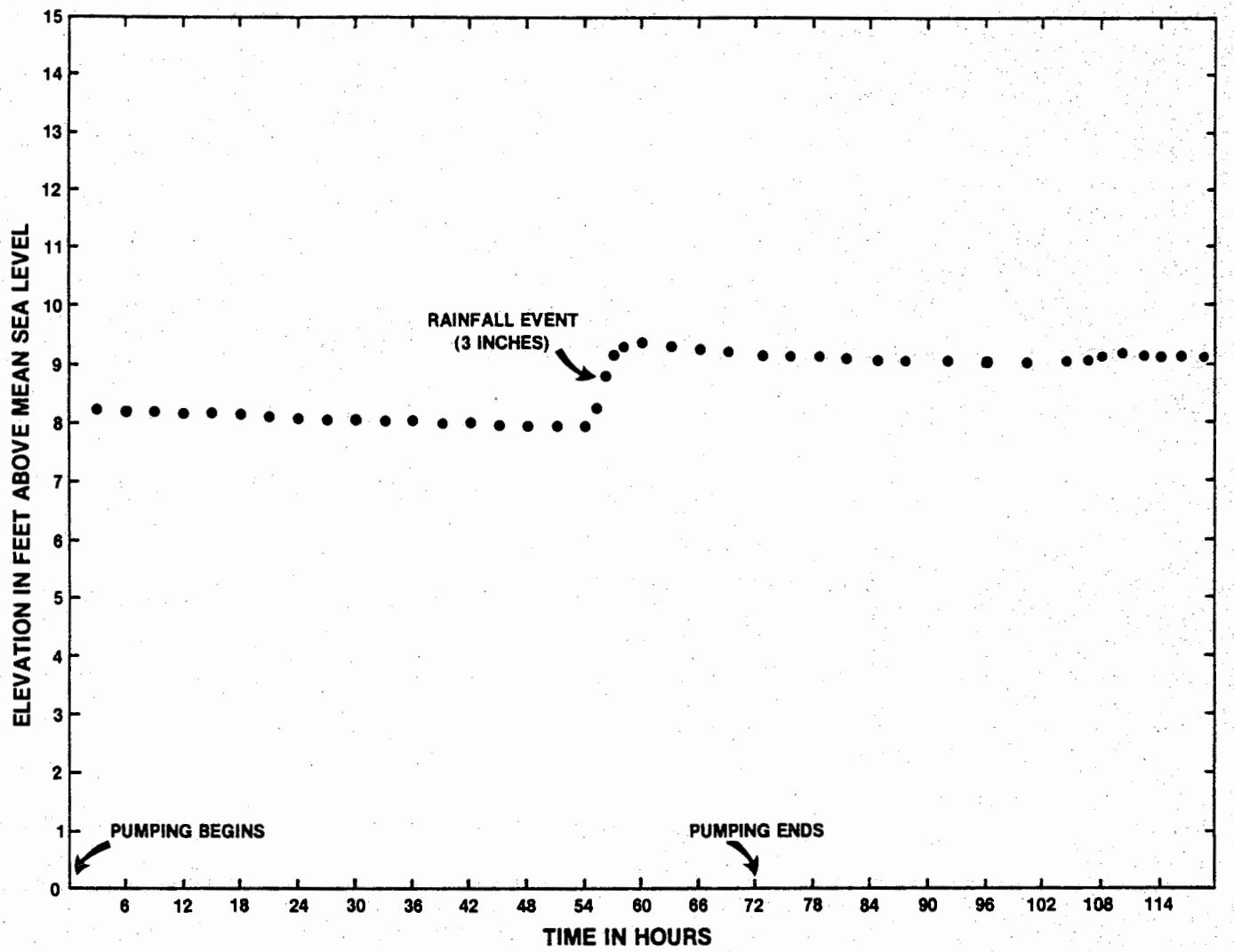
During periods of normal usage the groundwater yield from the well field will be reduced to about 1518 liters per minute (401 gallons per minute or 0.58 million gallons per day). The cone of depression will be reduced proportionately in areal extent.

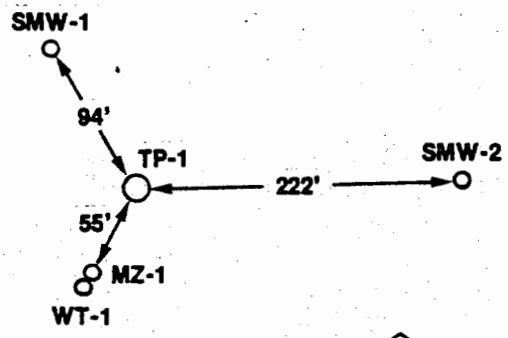
WATER QUALITY

Geologic, geophysical, and water quality data from the aquifer test at the well field site suggest that rock layers beneath the productive zone in the well field form a protective low permeability zone which will inhibit upconing of highly mineralized water (Geraghty and Miller, 1978). If fracture systems exist in the area and extend through this low permeability zone, then conditions of high vertical permeability, (which will allow upward movement of highly mineralized water) may occur locally. However, a situation where fracture systems extend through the low permeability zone would probably affect only individual wells rather than the entire well field. Good well field management can minimize any water quality deterioration from this source.

WATER TABLE

The static water level in the water table (unconfined aquifer) at the time of the aquifer test in June 1978 was 0.4 meter (1.3 feet) higher than the water level in the pumped zone (Geraghty and Miller, 1978). Water level information from the aquifer test indicates that the water table was not drawn down appreciably during the 72 hours of pumping (see Figure 5.1-5). As a long-term effect of pumpage, water levels in the water table aquifer may be drawn down slightly in the well field due to increased leakage into the confined aquifer. However, due to the small magnitude of the cone of depression and water level drawdowns, lowering





LOCATION MAP N

Figure 5.1-5
WATER LEVELS IN WELL No. WT-1 (WATER TABLE WELL) DURING THE JUNE 1978 AQUIFER TEST

SOURCE: GERAGHTY AND MILLER, INC., 1978

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the water table will be minimized and will be confined to a small area. The area in which drawdowns are greater than 1 foot is approximately 2.6 square kilometers (1 square mile) (see Figure 5.1-3).

EFFECTS ON SURFACE WATER

Surface waters in the area consist of karst-type depressions and scattered small wet areas. As noted in Chapter 2, there is a conspicuous absence of defined stream channels in the area. Cherry (1970) reports that between 55 and 75 percent of the annual rainfall in the area is returned to the atmosphere via evaporation. The remainder percolates through the thin sands and recharges the Floridan Aquifer. Thus, there is virtually no surface runoff in the wellfield area. The water surface in the ponds and lakes in the area is probably at approximately the same level as the water table and is perched slightly above the potentiometric surface in the Floridan Aquifer.

Potential water level declines in surface water bodies will be confined to areas in and immediately adjacent to the Florida Power Corporation well field. The impacts are difficult to assess since nothing is known about the presence or absence of clays or other poor permeability zones directly beneath the surface water bodies in question. In the absence of clays or poor permeability materials, the surface water bodies will respond to well field pumpage in essentially the same manner as the water table aquifer.

EFFECT ON GROUNDWATER AVAILABILITY

The groundwater availability analysis compares the proposed withdrawals from the aquifer system with the estimated groundwater flow to the Gulf through Crystal River and the area containing the well field and plant site.

The U.S. Geologic Survey gaging station at Crystal River records an average of about 2,200 million liters per day (590 million gallons per

day) of water flowing to the Gulf of Mexico. Geraghty and Miller (1977) calculate that another 950 million liters per day (250 million gallons per day) of water flows to the Gulf in the area north of the gaging station at Crystal River (excluding the flow at the Crystal River gage) and south of the Withlacoochee River (excluding the flow to the Withlacoochee). The projected maximum well field demand is less than 1 percent of the flow at Crystal River and about 1 percent of the estimated flow between the Crystal and Withlacoochee Rivers. The annual average water usage is less than one-fifth of the design maximum flow of the well field.

5.1.2 BIOLOGICAL EFFECTS OF GROUNDWATER WITHDRAWAL

The possible biological effects of groundwater withdrawal would primarily involve the biological communities associated with fresh water marshes. As previously discussed, these freshwater areas may be connected with ground water and may experience changes in water level due to withdrawals.

GENERAL DISCUSSION

Impacts of wellfield groundwater withdrawal on vegetation and wildlife should not be significant. Impacts could result from surface water table lowering and consequent drainage of temporary or permanent wetlands. Estimates of these water level changes are based on the calculations in Section 5.1.1. The seasonal fluctuations of three nearby wells (reported by Geraghty and Miller, 1977) and their relation to land surface elevation have also been considered. The analysis has indicated that wet season water tables may be altered only above the land surface in depressed wetland areas. This would most likely occur within one mile south and west of the well field site. Changes such as transitions from permanent marshes (pickerelweed, waterlily) to seasonally flooded marsh (smartweed, arrowhead, sawgrass) to wet prairies may occur when the water table drops below ground surface temporarily, then permanently. The consequent impacts would be changes in species composition, productivity, food web relations, wildlife habitat, and habitat for rare and endangered plants such as sundews. However, withdrawals from the aquifer should not lower the water table sufficiently to alter permanently the character of these marshes.

Minor effects on wildlife could result from reductions in seasonal wetland habitat in the surrounding area where there are presently several ponds, marshes, and prairies. Associated with these areas are many aquatic or semi-aquatic groups of birds, mammals, reptiles, and amphibians. If the character of the marshes and ponds is changed, a qualitative change may occur in the faunal communities.

Possible changes include an insignificant decrease in seasonal habitat for waterfowl, shore birds, and wading birds; a loss of breeding area for some amphibians (e.g., green tree frogs, newts); and an insignificant decrease in suitable habitat for certain aquatic reptiles (e.g., banded water snake, ribbon snake). Generally, the fauna could adapt to the characteristics of drier ecosystems.

ESTIMATED EFFECTS

The impacts due to drawdowns would be confined to areas in the vicinity of the well site. Drawdown rates elsewhere should cause only minor changes in marshes.

The cypress domes north of the well field should not be affected. Since the land-surface elevation is about 6 to 8 meters (20 to 25 feet) and the water table about 3 to 5 meters (10 to 15 feet), these are probably perched upon impervious confining layers and unaffected by changes in water table elevation.

Effects on wildlife would be proportional to effects on surface waters. With small amounts of surface drawdown, less wet habitat and fewer associated organisms would be affected.

5.1.3 DETERMINATION OF MAXIMUM FOG POTENTIAL

A potential fogging condition exists when water vapor emissions from a cooling tower condense in the vicinity of the tower. This is accomplished, in meteorological terminology, by increasing the mixing ratio of the air near the tower until saturation occurs.

The saturation deficit of a moist air parcel is defined as the amount of additional moisture required to bring that parcel to saturation at constant temperature and pressure. The maximum fogging potential of a parcel exists when there is both a small saturation deficit of moisture and no dense fog occurring. If natural fog has already formed, saturation has been reached. Since all additional moisture will condense out immediately upon addition to the environment, there is no longer a potential for fog formation.

The maximum fogging potential for the Crystal River site was determined using ESE's FOGPTL computer model. The model determines the tabular and relative frequency distributions of wind speed and direction, both seasonally and annually, for each hour that the potential for cooling tower fog occurs. Hourly visibility data as well as ambient and dew point temperature data must be available to run the model. The Crystal River site tower records both temperatures, but visibility data are not collected. For this reason, hourly data were used from Tampa, Florida, for 1964, as the most representative location having these data.

Fog is most likely to occur when there is a saturation deficit of 0.4 grams or less of water vapor per cubic meter. From the Tampa data, both the frequency of occurrence of saturation deficits of 0.4 grams or less per cubic meter, and the frequency of occurrence of dense fog (0.6 km or less visibility) were compared. These variables, as well as the maximum fogging potential, are summarized by season in Table 5.1.3-1. A potential for cooling tower induced fog exists approximately 344 hours a year. Nearly 95 percent of this fog occurs from September through February.

The wind speed and direction is entered into a frequency distribution for each hour of fogging potential. This distribution indicates the areas around the tower which are most likely to be affected on a seasonal basis.

Table 5.1.3-2 portrays the annual wind distribution of maximum fogging potential hours. From a breakdown of wind directions into six wind-speed classes, it is evident that the great majority of these conditions experience wind speeds from 4 to 6 knots (1 meter/sec = 1.9425 knots). When these occurrences are divided by all hours, the relative frequency of occurrence of wind distribution of fogging potential is calculated (see Table 5.1.3-3). This information is illustrated in Figure 5.1.3-1.

The figure shows how often maximum fogging is likely to occur in the vicinity of the proposed site. Fog formed in the tower would be most likely to occur in the southwestern quadrant from the tower. Therefore,

Table 5.1.3-1. Number of Hours of Saturation Deficit $\leq$ 0.4 g/m^3, of Dense Fog, and of Maximum Fogging Potential--Tampa, Florida, 1964, 24 Observations Per Day

Season	Saturation Deficit	Dense Fog	Maximum Fogging Potential
Winter (DJF)	190	24	166
Spring (MAM)	10	2	8
Summer (JJA)	12	0	12
Autumn (SON)	179	21	158
Annual	391	47	344

Source: Environmental Science and Engineering, Inc., 1977.

Table 5.1.3-2. Wind Distribution of Maximum Fogging Potential

Wind Direction	Wind Speed Class (KTS) 0-3	4-6	7-10	11-16	17-21	GT21	TOTAL
N	1	18	29	3	1	0	52
NNE	0	15	18	4	0	0	37
NE	1	17	21	6	0	0	45
ENE	2	27	32	9	0	0	70
E	1	17	16	0	0	0	34
ESE	2	9	6	1	0	0	18
SE	2	4	10	1	0	0	17
SSE	0	5	9	1	0	0	15
S	1	6	21	6	2	0	36
SSW	0	0	1	2	0	0	3
SW	0	1	0	0	0	0	1
WSW	0	1	1	0	0	0	2
W	0	0	1	1	0	0	2
WNW	0	0	1	0	0	0	1
NW	0	0	0	0	0	0	0
NNW	0	1	1	0	0	0	2
CALM	9						9

Hours with heavy fog (3/8 mile or less visibility) = 47
Hours of saturation deficit less than or equal to 0.4 g/cu. meter = 391

Maximum fogging potential hours = 344

Source: Environmental Science and Engineering, Inc., 1977.

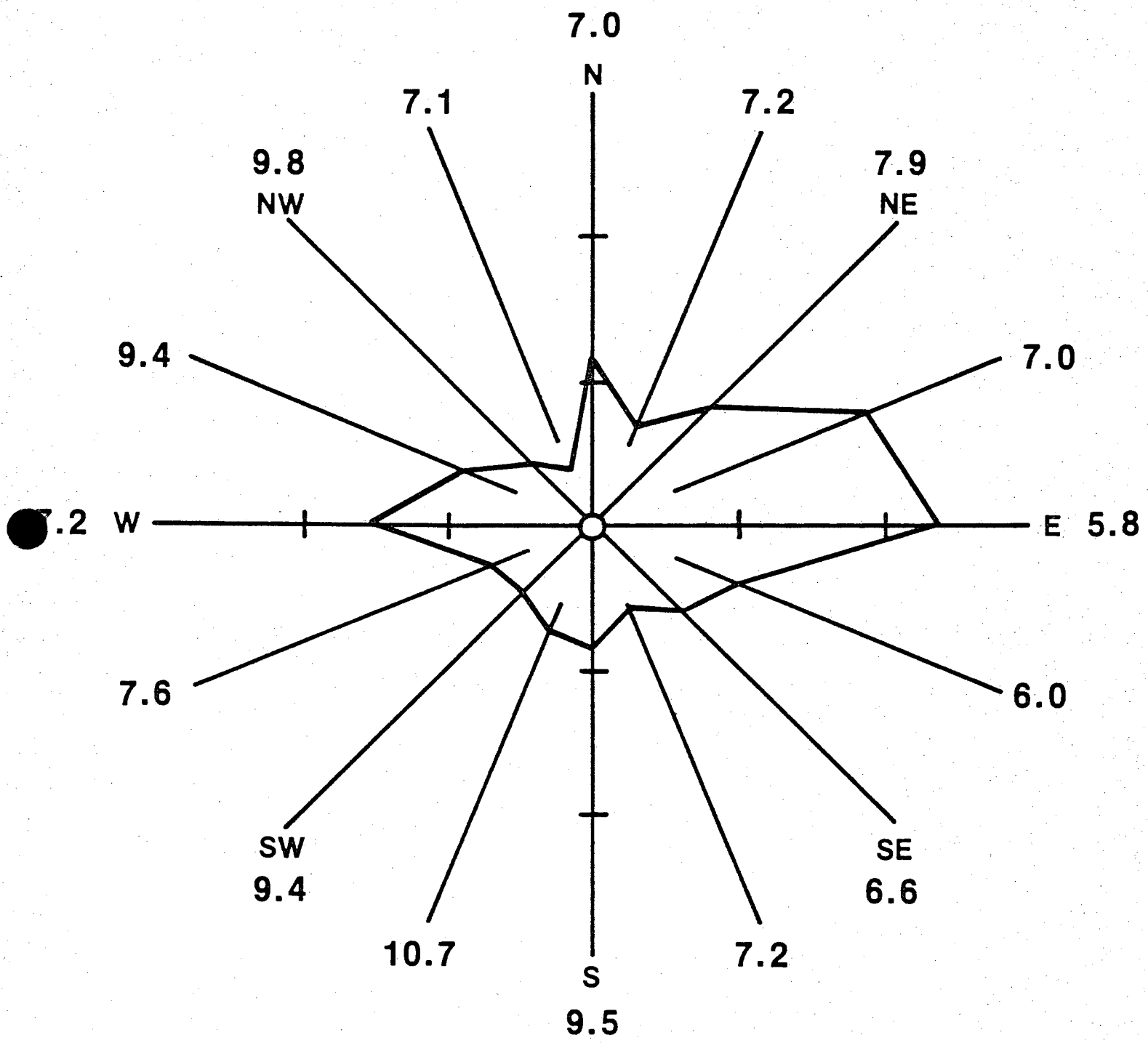
Table 5.1.3-3. Relative Wind Distribution of Maximum Fogging Potential

Wind Direction	Wind Speed Class (KTS) 0-3	4-6	7-10	11-16	17-21	GT21	TOTAL
N	0.00011	0.00205	0.00330	0.00034	0.00011	0.0	0.00592
NNE	0.0	0.00171	0.00205	0.00046	0.0	0.0	0.00421
NE	0.00011	0.00194	0.00239	0.00068	0.0	0.0	0.00512
ENE	0.00023	0.00307	0.00364	0.00102	0.0	0.0	0.00797
E	0.00011	0.00194	0.00182	0.0	0.0	0.0	0.00387
ESE	0.00023	0.00102	0.00068	0.00011	0.0	0.0	0.00205
SE	0.00023	0.00046	0.00114	0.00011	0.0	0.0	0.00194
SSE	0.0	0.00057	0.00102	0.00011	0.0	0.0	0.00171
S	0.00011	0.00068	0.00239	0.00068	0.00023	0.0	0.00410
SSW	0.0	0.0	0.00011	0.00023	0.0	0.0	0.00034
SW	0.0	0.00011	0.0	0.0	0.0	0.0	0.00011
WSW	0.0	0.00011	0.00011	0.0	0.0	0.0	0.00023
W	0.0	0.0	0.00011	0.00011	0.0	0.0	0.00023
WNW	0.0	0.0	0.00011	0.0	0.0	0.0	0.00011
NW	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NNW	0.0	0.00011	0.00011	0.0	0.0	0.0	0.00023
CALM	0.00102						0.00102

Total number of hours read = 8784

Source: Environmental Science and Engineering, Inc., 1977.

MONTHLY AND ANNUAL WIND ROSES FOR THE FPC CRYSTAL RIVER SITE,1975. TICK MARKS ON ROSE REPRESENT 6%. AVERAGE WIND SPEED IN ROOTS IS GIVEN FOR EACH SECTON.



ANNUAL

CALM - 2.4%

Figure 5.1.3-1

a majority of the resulting impact will be toward the Gulf of Mexico. The value at each direction represents the frequency of occurrence in that direction and not the distance downwind that the plume would flow.

[Fogging Effects on Air Traffic

The occurrence of visible fog droplets from a cooling tower is chiefly a nighttime phenomenon. The reason for this is that the highest relative humidities occur at night when the air is relatively stable. If a visible plume were to form, therefore, it would take one of two possible forms: first, under light wind conditions, the plume would propagate downwind at a fixed level. For a natural draft cooling tower, this would be essentially the top of the tower. The light wind would prevent the fog from accumulating in the vicinity of the stack. Under the highest relative humidities, the "clouds" could persist for a few kilometers before evaporating. The second condition covers calm wind conditions. The cooling tower's extra heat and water vapor may create small cumulus clouds in the vicinity of the tower during the night or very humid mornings. For both wind conditions, the stratification of the atmosphere is usually quite stable and the visible plume will be restricted from growing vertically. The resulting effect on air traffic is very small when considering that nearly all air traffic is at least 500 feet above the surface, which is above the tower's effective plume height. The sole exception is near airports, where air traffic descends to lower levels to land. There are no such facilities within several kilometers of the Crystal River towers.]

Conclusions

The above methodology for tabulating the maximum fogging potential in the vicinity of a cooling tower derives its results from meteorological considerations only and may be conservative in nature. Actual occurrences of ground-level fogging are also affected by an elevated release point. Since cooling towers at Units 4 and 5 will be 140 meters in height, the visible plume may have ample time to disperse. Because of relatively high ambient temperatures, it is highly improbable that an icing condition will ever develop.

5.1.4 COOLING TOWER DRIFT

A study (Black and Veatch, 1978) was made to determine the amount of deposition from salt drift in the vicinity of the two proposed natural drift cooling towers. The towers will be built adjacent to their respective power-generating units and will stand 140 meters (460 feet) above grade. Efficient drift eliminators on both towers will be used, and the mass fraction of circulating salt water which will be carried out from the tower as drift will not exceed 0.0005 percent.

The two towers are close together and will have some interaction of drift and fog. However, for the purposes of this analysis, the towers were assumed to be at the same location. The resulting estimates of maximum salt concentrations will be more conservative (tend to overestimate the actual concentrations) than considering slightly separated towers.

Salt deposition due to the operation of the proposed towers is determined by the Oak Ridge Fog and Drift Code, which is a dispersion model with moist plume rise calculations being performed for several different relative humidity conditions, Pasquill stability classes, and wind speeds. A variable number of years of meteorological surface observation data are read into the model to determine the deposition and drift in an "average year". One distinctive advantage of the model is the capability of obtaining contour maps of the amount of salt drift, fog, ice fog, and the amount of salt in the air.

Five selected drift particle sizes for use in the model were 31, 58, 110, 210, and 800 microns, with each size comprising one fifth of the drift particles. Meteorological data utilized in the model were a 10-year record from Tampa, Florida, the nearest and most representative weather office where all required surface observations are available.

The maximum salt deposition expected at the site is 12.8 grams/meters^2/year (114 pounds per acre per year) and will occur 0.3 kilometers

(0.2 miles west of the towers (see Figure 5.1-6). At distances beyond 1.3 kilometers (0.8 miles), only residual drift from the smallest particles will be observed. The maximum deposition rate beyond this point seldom will exceed 1.7 grams/meters^2/year (15 pounds per acre per year).

With a background level of salt deposition of 3.4 grams/meters^2/year (30 pounds per acre per year), the total deposition of nearly all areas within 0.8 kilometers (0.5 miles) of the towers will not exceed 9 grams/meters^2/year (80 pounds per year).

The effects of saltwater drift from a natural draft cooling tower can be divided into two categories:

1. The effects upon the site environs, and
2. The effects upon the station structures and equipment.

Salt drift droplets contain almost the same concentration of chemicals that are found in the circulating water, including the inhibitors. The drift is deposited in the form of droplets or solid particles, depending on the atmospheric conditions, and leaves precipitants of chemicals on different surfaces located in downwind directions from the tower. The chemicals can cause damage to the biota and structures, depending upon the concentration and composition of these chemicals.

A comparison of natural background salt levels and salt drift from cooling towers reveals that the deviations between the two can reach a factor of ten or more, depending upon the location and atmospheric conditions. Under high-humidity conditions and low-wind speeds, the salt drift can match the natural background a short distance inland. With relative humidities less than 70 percent, the salt deposition from the tower will be smaller by a factor of 10 or more. The ocean is considered a vast ground level area source while the towers are considered elevated points or line sources. In coastal areas, the natural background levels of salt will have already determined to a large degree the biotic composition and community parameters.

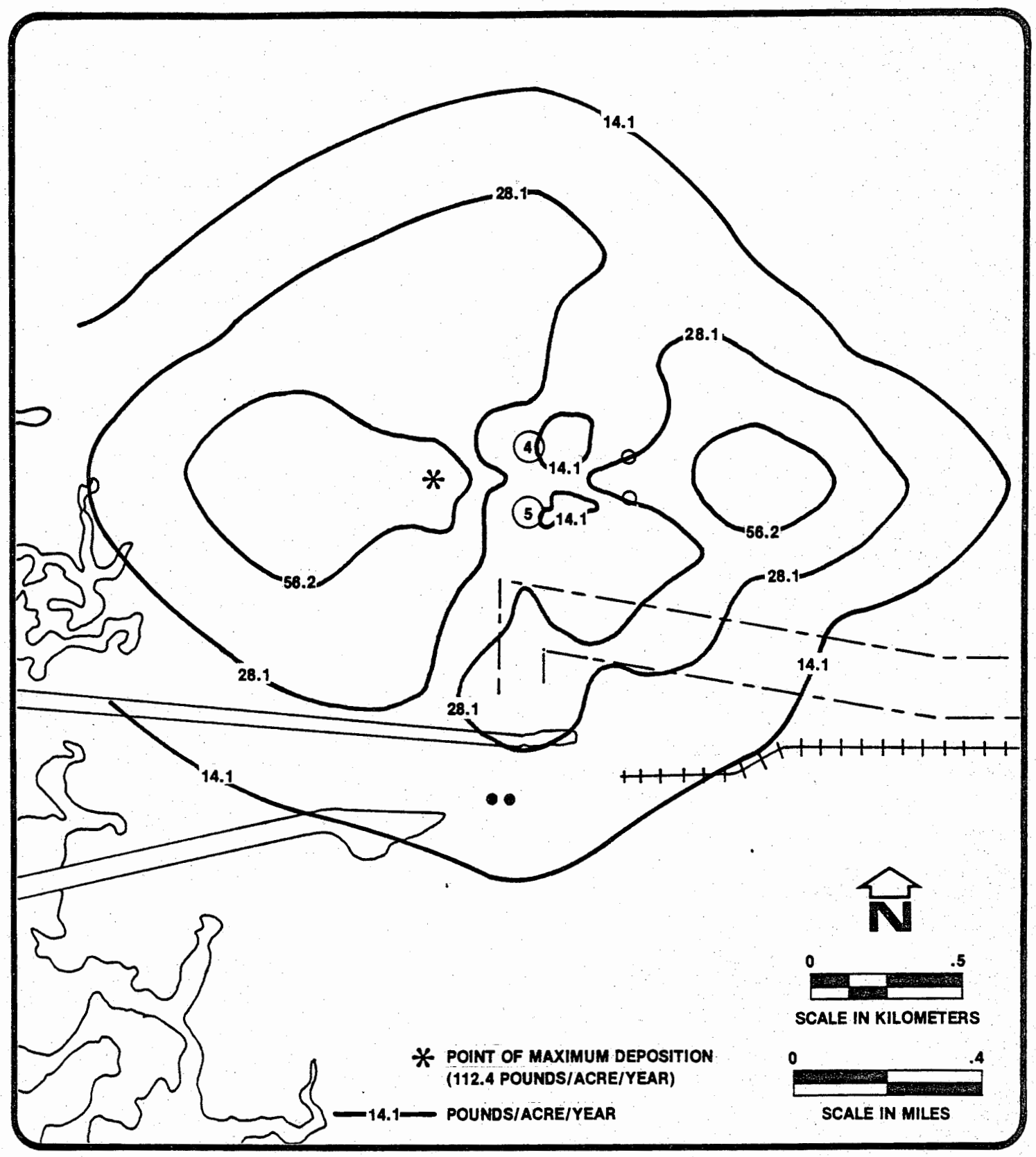


Figure 5.1-6
ANNUAL AVERAGE SALT DEPOSITION AMOUNTS FROM PROPOSED UNITS 4 AND 5 COOLING TOWERS

SOURCE: BLACK AND VEATCH, 1977

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

Although the environmental effects of saltwater cooling towers vary depending upon sensitivity and diversity of local conditions, experience with existing saltwater cooling towers indicates that the environmental problems would be confined up to several hundred meters from the cooling tower. Some adverse effects are expected only in the immediate proximity of the tower and within the boundaries of the site. These effects are due to localized phenomena, e.g., blowout in the case of counterflow toweres and wake effects. Blowout consists of a spray of droplets removed from the water falling into the tower basin, and is carried out by air movement in the lower portion of the tower. Hence, metal structures, high-voltage power lines, and buildings must be protected by suitable coatings, and reported by saltwater cooling tower users. Also, parking lots should not be placed at short distances downwind of the tower.

There are two plants currently in operation in the United States which use natural draft towers with brackish water as makeup. The B.L. England Unit 3 of Atlantic City Electric Company, a 160-megawatt plant in New Jersey; and Chalk Point of Potomac Electric Power Company, a 1,260-megawatt facility in Maryland, both use hyperbolic natural draft cooling towers (Kaplan, 1977). The Chalk Point towers take in saltwater as high as 26 parts per thousand (Pell, 1975) and the B.L. England towers use water with a salt concentration as high as 22 parts per thousand (Kaplan, 1977). Measurements of salt drift for these towers indicate that a lower ratio of drift to circulating water volumes than guaranteed by the maufacturers has been produced (Monjoie and Sobel, 1976; Kaplan, 1977). Monjoie and Sobel reported a measured drift rate of about .0005 percent for the B.L. England plant. EPA researchers working with test facilities at Turkey Point, Florida, found no statistically significant increase in background salt concentrations of approximately 900 kilograms (2,000 pounds) per day for the entire plant site (Shirazi, et al., 1977).

Studies conducted for Unit 3 concluded that no detrimental effects would result to the site environs from operation of a natural draft saltwater

cooling tower at Crystal River. This conclusion has been verified through full-scale tests conducted at the Atlantic City Electric B.L. England Station and the Potomac Electric Power Company Chalk Point Station.

At Crystal River, the effects of saltwater drift on the station structures and equipment, particularly the substation, are of prime importance. The effects of salt deposition upon structures depend upon the types of structural materials and amount of salt accumulated on their surfaces. The amount of salt deposition depends upon source strength, distance from the source, wind speed and direction, time the droplets remain upon the surface, relative humidity, and amount of precipitation (Roffman, et al., 1973). The design engineers, Black and Veatch, have indicated that any additional salt drift (30 lbs/acre/year) beyond natural background would cause operational problems at the new or existing facility.

5.1.5 BIOLOGICAL IMPACTS OF IMPINGEMENT AND ENTRAINMENT

IMPINGEMENT

The cooling-water intake site for Units 4 and 5 will be located on the north bank of the discharge canal presently serving Units 1, 2, and 3. This 15-meter (50-foot) wide structure will consist of three cells, each having a pump capacity of 2,110 lps (33,500 gpm). Two pumps will supply the total makeup water requirements for Units 4 and 5, since the design flow rate for normal operation is 4,230 lps (67,000 gpm). Each cell will have a 4.6-meter (15-foot) wide traveling screen which passes over two horizontal axles. Screen backwash will be accomplished by pumps leading to high-pressure spray nozzles.

These small-mesh screens are run in both manual and automatic modes. The automatic operation is a consequence of greater "upstream" hydraulic head or water pressure gradient as impingement of organisms on the screens increases with time. The intake pumps will create an intake water velocity of 0.04-0.15 meters/second (0.12 = 0.5 foot/second maximum flow rate at lowest water level), which complies with current EPA intake velocity design criteria of 0.15 meter/second (0.5 foot/second). The net flow of water downstream in the discharge canal, from Units 1, 2, and 3, is currently 0.43 meter/second (1.4 feet/second). The present discharge flow rate from these three units in normal operation is 0.08 million lps (1.322 million gpm). Located immediately in front of and for the protection of the traveling screens will be barrier nets, floating booms, and/or trash racks to deflect various debris, flotsam, and large swimming organisms.

The existing data relative to screenwash impingement and the Crystal River electric generating facility is contained in two separate studies of Units 1, 2, and 3 intake waters. The first study was a 1969-1971 Florida Department of Natural Resources screenwash monitoring program, reported by Grimes (1971) and Mountain (1972). The second study, conducted by the University of Florida, was reported by Snedaker (1974) and will serve as the "touchstone" for most comments concerning impingement for Units 1, 2, and 3.

Within the intake canal, the small, juvenile, and weak-swimming species became impinged throughout the year, whereas the strong-swimming, larger species were impinged in the colder months of the year. Of the 164 species Snedaker (1974) recorded during his 52-week study, eight of the ten most abundant species were relatively slow-swimming fishes or macroinvertebrates and accounted for 95.6 percent of the total biomass collected during this period. Seven species of fishes and invertebrates were collected during each of these 52 weeks. Four of these were slow-swimming forms which were among the ten most abundant species mentioned above. They included the polka-dot batfish (*Ogcocephalus radiatus*), the striped burrfish (*Chilomycterus schoepfi*), the blue crab (*Callinectes sapidus*), and the Cephalopoda (squids). Fish of commerical or recreational importance accounted for only 7.8 percent of the total biomass collected during the study.

To facilitate analyses, Snedaker (1974) arranged the impinged species into their respective habitat groups, as follows:

- Migratory species (pulsed impingement)
- Grass-mat dwellers and/or trackers
- Bottom dwellers (over mud or sand)
- Large, fast-swimming--top, midwater
- Large, fast-swimming--bottom
- Slow, weak-swimming forms
- Schooling species
- Sessile species (macroinvertebrates)

Impingement was found to be a source-dependent process, a function of habitat, area, season, time-of-day, tide, and fuel barge movements. As mentioned above, in terms of biomass, the impinged organisms were dominated by species of little or no commercial significance. Top and mid-water swimmers tend to be impinged on the downstream screens.

There is currently a lack of baseline research on impingement-prone species now resident in the discharge canal. No known studies exist for fishes and other nekton to be found there. In a study of fishes taken in dropnet collections from nearshore intake and discharge waters, Adams

(1974) found over 40 percent of the species recovered in his study never occurred in the discharge area. The species composition of fishes was less "rich" in the discharge waters.

In terms of source areas for nekton (and, therefore, impingement-prone) species, the situation is quite different in the discharge canal as compared to the intake canal waters. Based on on-site observations, the most common and/or abundant fishes of the discharge canal tend to be larger, schooling forms, which include the following:

Sharks (eps. *Carcharinus limbatus*, but uncommon)
Mullet (*Mugil spp.*)
Ladyfish (*Elops saurus*)
Tidewater silverside (*Menidia beryllina*)
Pinfish (*Lagodon rhomboides*)
Spotted seatrout (*Cynoscion nebulosus*)
Atlantic croaker (*Micropogon undulatus*)
Red drum (*Sciaenops ocellata*)
Spot (*Leiostomus xanthurus*)
Silver perch (*Bairdiella chrysura*)
Jacks (*Caranx spp.*)

The discharge canal constitutes a physical "dead-end" for upstream swimmers. Benthic sediments collected halfway down the discharge canal have been examined and sieved, revealing no macroinvertebrate organisms. Large numbers of spot and pinfish have been recovered by cast-netting. The subsequent dissection of hundreds of specimens revealed empty gut cavities, indicating no feeding activity. During the colder, winter months, fishes such as red drum (redfish, channel bass) are subject to intense recreational angling pressure. Fishermen frequent the discharge canal during this period, seeking those fishes attracted to the warmer power plant discharge effluent (Adams, personal observations).

In summary, those species available for impingement as a consequence of Units 4 and 5 intake operations would be of a vastly different composition than those identified as impinged by Units 1, 2, and 3 intakes.

Since those species available for interaction with the new intake structure would generally be larger, faster-swimming forms, it is anticipated that the impingement which does occur would be much less, relative to water volume and flow, than seen at the Units 1, 2, and 3 intake structures. Also, there would be less impingement due to the intake volume and velocities of Units 4 and 5.

ENTRAINMENT

Potential impacts relating to the entrainment of plankton populations include: (1) reduced levels and permanent loss of production that would otherwise be available to the system; (2) alteration of the trophic structure of the biological community as a result of significant losses of plankton species; and (3) losses of commercially important species that are known to spend part of their life cycle as members of the plankton community. Mortality of entrained plankton populations occurs through mechanical damage of the organism and thermal shock resulting from elevation of water temperatures.

Zooplankton entrainment investigations examining the effects of withdrawal of cooling waters for the existing Crystal River electric generating facility (Units 1, 2, and 3) have indicated that mechanical damage, which seems to have a greater effect on larger zooplankton species (e.g. Labidocera sp. and Acartia tonsa), accounts for a smaller percentage of mortality than that induced by elevated temperatures (maturo, et al., 1974). The aforementioned study reported entrainment mortalities ranging from 0 - 45.6 percent. The lowest number of deaths were found to occur within the cooler months of the year, and near exponential increases were recorded when the discharge temperatures rose above 35°C during late summer.

According to Jensen, et al. (1969) the rate of change in temperature may be of greater significance to the survivial of these organisms than the amplitude of the change. A rapid change in temperature does not allow sufficient time for necessary physiological adjustments. Since many of the zooplankton individuals inhabiting the discharge canal have entered the system through the condensors of Units 1, 2, and 3, they have

already been subjected to a rapid temperature change which may have been as great as 8°C during certain months of the year. It is anticipated that near 100 percent mortality will occur when these individuals are further subjected to additional rapid increases in temperature through entrainment in intake waters being withdrawn from the discharge canal for Units 4 and 5.

Secondary impacts related to the chemical constituents of cooling tower waters include the effects of increased salinity due to evaporation and the addition of chlorine as a biocide. Entrained plankton as well as plankton in the immediate vicinity of the blowdown discharge will be affected by these factors.

Maturo, et al. (1974) recorded apparent general temperature-salinity interactions where low salinity/high temperature and high salinity/low temperature combinations resulted in increased copepod mortalities. These potential impacts are considered to be minimal or insignificant. This assumption is based on: (1) the predicted 100 percent mortality following initial entrainment through the condensors of Units 4 and 5; (2) the predicted high velocities and rapid mixing of blowdown discharge and discharge canal waters.

The residual chlorine concentration in blowdown discharge water is predicted to be approximately 0.2 mg/l which falls below the Environmental Protection Agency's specified level of 0.5 mg/l. The concentratives will approach zero-free residual chlorine upon dilution by discharge canal waters. Although low chlorine concentrations have been shown to produce adverse effects on phytoplankton (Carpenter, et al., 1972; Gentile, et al., 1973) the impact in considered to be low in both magnitude and significance.

Several studies to date which have addressed the survivability of young/small fish entrained through a power plant have shown inconclusive results. However, one of the more recent investigations (March 1971, 1973) showed that most fish larvae and early juveniles entrained through a Connecticut River power plant were dead when they reached the end of a

2.25 kilometer-long (1.14 mile-long) discharge canal. Examination of entrained alewives, herring, white perch, carp, eels, spottail shiner, darters, and shad revealed a mortality of 100 percent for nine out of ten collection series (one showing 92.5 percent mortality at the last downstream collection station). Marcy estimated that approximately 80 percent of the total mortality was caused by mechanical damage and 20 percent was attributed to heat shock and prolonged exposure to temperatures above 28°C. There was "no measurable mortality due to injection of sodium hypochlorite as a biocide." The majority of dead specimens were physically mangled, a condition more obvious in larger specimens. Increases in mechanical injury directly proportional to the size of entrained fishes have been reported by Markowski (1962), Oglesby and Allee (1969), and Marcy (1971). It has been noted that high negative pressures created with the cooling water by pump impeller blades may be largely responsible for destruction of fish tissue.

Considering the present thermal loading and mechanical impact of Units 1, 2, and 3 discharge water prior to use in Units 4 and 5 condenser cooling system, it is anticipated that 100 percent mortality will occur for all fishes of unscreenable (entrainable) size which enter the Units 4 and 5 intakes. Nevertheless, the overall impact of Units 4 and 5 on entrainment are not considered significant.

5.2 SANITARY AND OTHER WASTES

5.2.1 SANITARY WASTE DISPOSAL

The sewage treatment plant effluent will be similar to service water in quality, with slightly increased total dissolved and suspended solids concentrations. The effluent is secondarily treated utilizing an activated sludge process. The expected water quality of the sanitary waste effluent is characterized in Chapter 3. The effluent will be discharged at a rate of 0.4 l/sec (6 gpm) into the cooling tower blowdown line which will discharge into the existing discharge canal. The effluent meets state water quality standards for secondary treated effluent from sewage treatment facilities. It is not expected to adversely affect the marine water quality of the discharge canal, especially after dilution in 7,522 million lpd (1,990 mgd) of turbulent discharge from Units 1, 2, and 3. The sludge will be deposited in the active ash storage area where leaching into the ground water may occur during rainfall events or groundwater fluctuations.

5.2.2 CHEMICAL LABORATORY WASTES

Chemical reagents needed for analytical testing will be discharged to the plant drains collection pond at a rate of 6.7 l/sec (100 gpd). This effluent is expected to exfiltrate into the groundwater table in conjunction with other in-plant operation wastewaters (less evaporation). Impact on the groundwater quality is speculative, and is expected to be of localized significance. Although the wastewaters would be neutralized, large concentrations of metals may be present and could enter the groundwater system through the exfiltration process. Since the ground water in the area generally flows west (Geraghty and Miller, 1977), drinking water supplies should not be influenced.

5.2.2 COOLING SYSTEM BLOWDOWN

The primary source of chemical and biocide discharge to surface waters will be the release of cooling system blowdown to the existing discharge canal. The quantity released to the canal will amount to 2,371 dm^3/s (37,587 gallons per minute) during peak conditions and 1,441 dm^3/s (22,892 gallons per minute) during normal operating conditions. This discharge will be diluted in the canal by a flow of 87,064 dm^3/s (1,380,000 gallons per minute) of seawater used in Crystal River Units 1, 2, and 3 for once-through cooling.

The chemical characteristics of blowdown water from Units 4 and 5 have been discussed in Chapter 3. The only constituents having significant potential for ecological impact are chlorine, organic phosphates, and sulfuric acid. Shock chlorination, used for control of bacterial slimes and algae, will involve chlorine solution feeds of 15 or less minutes duration, repeated one to three times per day for each unit. One unit will be chlorinated at a time, with intervening periods of no chlorination, and no chlorine will be discharged for more than two hours per day from either unit. The blowdown to the discharge canal will have a maximum total residual chlorine concentration of about 0.5 milligrams per liter (short-term), and will approach zero-free residual chlorine.

Low chlorine concentrations have been shown to produce adverse effects on phytoplankton (Carpenter, et al., 1972; Toetz, et al., 1977). However, the effects may be temporary, with full recovery of the phytoplankton (Hirayama and Hirano, 1970; Goldman and Davidson, 1977). The dilution of roughly 1,000 to 1 which will occur in the 2.5-kilometer (1.5-mile) long discharge canal should minimize the impacts of residual chlorine on aquatic ecosystems from Units 4 and 5. It is difficult to predict, however, whether there will be synergistic effects on indigenous fish species resulting from the addition of Units 4 and 5 to the existing influences of Crystal River Units 1, 2, and 3.

The use of organic phosphate scale inhibitor will yield a phosphate residual in the blowdown which will not exceed the EPA phosphorus limit of 5 parts per million. The phosphorus content will be diluted to between 5 and 7 parts per billion in the discharge canal, and should have negligible impact on aquatic ecosystems.

The cooling tower blowdown will be taken from the cold side of the circulating water system and will result in blowdown temperatures less than the discharge canal water temperature during the summer months (see Table 5.2.2). The blowdown jet velocity will be 3.7 meters/second (12 feet per second) during normal operation. Mixing of this thermal jet with the turbulent discharge canal (approximately 2.0 feet per second towards the Gulf) will occur rapidly across the canal width. The blowdown thermal load ranges from 2.28×10^6 joules/hour (2.16×10^9 Btu/hour) in January to 2.49×10^6 joules/hour (2.36×10^9 Btu/hour) in June, July and August. The worst case maximum percentage increase in thermal-load blowdown into the discharge canal is .063 percent during peak operation at low tide. The energy balance results in Table 5.2.2 indicate that the thermal impact of the blowdown relative to the existing discharge canal thermal regime will not be significant.

The increase in salinity of the blowdown (1.3 cycles of concentration) is not expected to have a significant potential for the formation of salinity stratification in the discharge canal due to the high turbulence of the system. If stratification does occur, either thermal or saline, it will be localized to the discharge point and short-lived.

Table 5.2.2 Units 4 and 5 Blowdown Discharge Thermal Impacts

	Water Temperature (°F)			Thermal Capacity (BTU's)				Blowdown Thermal Influence on Discharge Canal System (%)			
				Discharge Canal ($x\ 10^{10}$)		Blowdown ($x\ 10^{7}$)		Normal Operation		Peak Operation	
Month	Canal	Blow-Down		Low Tide	High Tide	Normal Op.	Peak Op.	Low Tide	High Tide	Low Tide	High Tide
Jan	71.5	86	+14.5	5.7	8.7	2.2	3.6	.038	.025	.063	.041
Feb	76.5	86	+ 9.5	6.1	9.3	2.2	3.6	.036	.024	.059	.039
Mar	79.5	88	+ 8.5	6.3	9.7	2.2	3.7	.035	.023	.058	.038
Apr	89.5	90	+ 0.5	7.1	10.9	2.3	3.8	.032	.021	.053	.035
May	93.5	90	- 3.5	7.4	11.4	2.3	3.8	.031	.020	.051	.033
Jun	98.5	94	- 4.5	7.8	12.0	2.4	3.9	.031	.020	.050	.033
Jul	99.5	94	- 5.5	7.9	12.1	2.4	3.9	.030	.020	.050	.033
Aug	99.5	94	- 5.5	7.9	12.1	2.4	3.9	.030	.020	.050	.033
Sep	97.5	92	- 5.5	7.7	11.8	2.3	3.8	.030	.020	.050	.033
Oct	89.5	90	+ 0.5	7.1	10.9	2.3	3.8	.032	.021	.053	.035
Nov	80.5	89	+ 8.5	6.4	9.8	2.3	3.7	.035	.023	.058	.038
Dec	74.5	88	+13.5	5.9	9.1	2.2	3.7	.038	.025	.062	.041

Source: Environmental Science and Engineering, Inc., 1978.

5.2.6 COOLING SYSTEM INTAKE

The intake design allows for a minimum flow across the intake screen of 0.15 meters/second (0.5 fps) in a quiescent water body. The mean cross sectional velocity in the discharge at the proposed locations of Units 4 and 5 intake structures or at peak operating conditions for Units 1, 2, and 3 is 0.42 meters/second (1.4 fps). Modifications of this maximum velocity will occur during certain mixes between operating conditions for Units 1, 2, 3, 4 and 5 and tide stage.

5.3 CHEMICAL AND BIOCIDE DISCHARGES

5.3.1 EFFECTS ON SURFACE WATERS AND AQUATIC LIFE

Chemicals and biocides discharged into surface waters are limited to chlorine, organic phosphates, and H_2SO_4, to maintain pH near 7.2. The environmental effects of these discharges are expected to be well below detection. The discharges are small, and before reaching coastal waters, they are diluted by 7,522 mlpd (1987 mgd) of once-through seawater flowing from the existing three units through a 2.5-kilometer (1.5-mile) long discharge canal into Class II coastal waters. For example, if 7.6 mlpd (2 mgd) blowdown with maximum allowable average concentration of 0.2 ppm chlorine is discharged into 7,522 mlpd (1,987 mgd), the concentration becomes about 0.2 ppb even with no breakdown of chlorine.

There have been some demonstrations of adverse effects on phytoplankton by low chlorine levels, but these are at levels one hundred times greater than those expected at the site (Carpenter, et al., 1972; Toetz, et al., 1977). However, these effects appear to be temporary, with full recovery of the phytoplankton (Hirayama and Hirano, 1970; Goldman and Davidson, 1977). These low levels would be reached a maximum of 4 hours per day (2hrs/unit), with no chlorine added during most of each day.

Similarly, the anti-sealing phosphates (assuming all are trisodium phosphate) will give a phosphorous concentration of 4.92 ppm (EPA limit 5 ppm), diluted to 7 ppb in the discharge canal.

5.3.2 EFFECTS ON GROUND WATER AND BIOTA

The potential exists for contamination of ground water and soils by percolation of sluice water and runoff. Sources of contamination are ash handling, runoff from coal piles, and fly and bottom ash. No surface discharges are planned from any of these sources.

Fly ash at a TVA coal-fired plant was enriched at least ten times over normal soil levels in arsenic (As), copper (Cu), lead (Pb), and vanadium (V). Fly ash was also enriched to a lesser degree in cadmium (Cd), cobalt (Co), chromium (Cr), cesium (Cs), europium (Eu), mercury (Hg), antimony (Sb), uranium (U) and zinc (Zn). Several elements are concentrated preferentially in fly ash, but only calcium (Ca) is appreciably more concentrated in bottom ash (Lindberg, et al., 1975 Klein, et al., 1975). Up to 85 percent of ash from pulverized coal is fly ash (TVA/EPA, 1977). Thus, fly ash is of greater concern than bottom ash because of its greater volume and higher metals concentration. However, fly ash will be handled dry and covered with other materials to help minimize leaching.

Contamination of freshwater aquifers by seepage is not probable because the plant will be located directly on the coast, and the potentiometric surface slopes toward the sea, (refer to Section 5.1.1).

Gaps in present research make prediction of effects difficult. It is not known which metals will be leached from the ash. Some of the leached metals may form insoluable precipitates which would not be carried from

the site, and others may be adsorbed by soils and not distributed widely. For example, Wentink and Etzel (1974) found that columns of soil removed all copper (Cu), chromium (Cr), and 99.7 percent of zinc (Zn) from combined solutions of up to 300 mg/l of each metal in distilled water or tap water. However, there are indications that such adsorption cannot be relied on. In New York ground water in a seepage plume extended 1200 meters from a metal-plating waste pond and contained up to 40 ppm Cr^{6+} and 10 ppm Cd (Perlmutter and Zieber, 1970, via EPA, 1973). Metals concentrations in the wastes considered in that study were probably very high, but the case does demonstrate movement of chromium (Cr) into ground water. Wentink and Etzel (1974) found complete adsorption of chromium (Cr) by soil. Similarly, EPA (1973) mentions an unreferenced case in New Jersey where "high concentrations" of chromium (Cr) and zinc (Zn) were included among groundwater contaminants from an unspecified type of waste lagoon.

Contrasts to these studies demonstrate the complexity of soil-metal interactions and the difficulty of predicting precise site-specific information. Emig (1973) showed that Cu, Zn, and Cr from acid bath electroplating wastes were completely removed by three Indiana soils. Jennett and Linnemann (1977) suggest that a soil will sorb 100 percent of its cationic exchange capacity of metals if the metals are applied slowly over a long period of time. They found also that Pb and Zn, once sorbed, could not be removed by ordinary rainwater, but metals could be removed by strong chelating agents such as humic acids.

The runoff from coal piles will be similar to acid mine drainage. Miller, et al. (1974), present the following data for Toms Run Basin, a coal mining area in Pennsylvania (from Merritt and Enrich, 1970).

		pH	Fe(ppm)	SO_4(ppm)
Lower Aquifer:	non-mining	6.3-6.8	3-16	4-13
	mining area	2.9-5.4	25-160	30-620
Upper Aquifer:	non-mining	6.5-6.7	10-15	10-15
	mining area	3.0-3.5	20-70	39-80

Clearly acids, metals, and sulfates are carried through the soils.

The soils referred to above were not limestones, like those of the Crystal River site. While limestone should increase the pH of percolating waters, the change is not sufficient to precipitate metals (Boyer and Gleason, 1977). Limestone dissolution could take place. By enlarging fractures and cavities in the rocks, the acid leachate could cause structural weakening of the site. Such an occurrance in Polk County (Florida) led to a loss of 17 million liters of gypsum leachings through a sinkhole in early 1975 (Miller, et al., 1977).

The acidity of the coalpile runoff could aid transport through soil of metals that might be leached from the ash pile. Limestone may not provide adequate pH increase to prevent this occurrence. It should be

remembered that in the laboratory an acid wash is used to desorb metals from soil. For Cu, Zn, Pb, and Cd in soil, low absorption or no absorption occurs below pH 5 to 7 (Haung, et al., 1977).

Retention ponds disposing of water by exfiltration perhaps represent the best technology for a region where rainfall exceeds evaporation. Sealed ponds would require clarification of water with surface discharge. Similar problems would arise in sludge disposal.

In addition to runoff from the sources listed above, wastes from the demineralizer and condensate polisher, service water treatment, testing laboratory, boiler blowdown, and occasional cleaning of the boilers would also flow to retention ponds. The volumes and composition of these wastes are detailed in Section 3.5. In general, the wastes are relatively benign, and acid and alkaline wastes pass first through the neutralization basin. The most toxic are the high Cu and Fe in the metal cleaning wastes produced at startup. As discussed above, these metals may or may not be removed by precipitation or by soil adsorption.

There is little data concerning the ecological effects of low pH and metals in soil and pore water on marsh vegetation. Lee, et al., (1976) hydroponically grew eight species of marsh plants in combined concentrations of 0.0, 0.5 or 1.0 ppm each of Cd, Cr, Nickel (Ni), Pb, and Zn. Metals did not reduce growth except possibly for *Scirpus validus* and *Spartina patens*. While Cr, Ni, Pb, and Zn contents of fly

ash are substantially in excess of 1 ppm, concentrations in ash pile leachate and runoff are not known.

Metal concentrations of 100 ppm can be toxic to Spartina alterniflora (Dunstan, et al., 1974 a.b., via Lee, et al., 1976). Cu killed seedlings in two weeks; Zn, Hg, Pb, or methyl mercury killed 35 to 50 percent after eight weeks. Cd had no adverse effect after eight weeks.

Normal levels of heavy metals in soils may have wide ranges. Arsenic levels are usually less than 10 ppm and rarely above 70 ppm; copper levels are usually less than 60 ppm; lead averages about 15 ppm and seldom exceeds 50 ppm (Motto, et al., 1970; Taskey, 1970). Available or soluble levels may run about 10 percent of total levels (Taskey, 1970). Arsenic has been found toxic to citrus at soluble levels of 2 ppm (Liebig, et al, 1959), and it damages rice at 0.2 ppm in poorly drained soils (Epps and Sturgis, 1939). Arsenic also has greatest toxic effects in acid sandy soils (Arnott and Leaf, 1967). Copper has been shown to inhibit growth in solutions of 150 ppm to 250 ppm (Motto, et al.,1970), although lead concentrations in soil of 12 ppm to 680 ppm produced no consistent effects on bromegrass (Marten and Hammond, 1966). General effects of these heavy metals are reduced root and short growth, general deformity, and thick, darkened roots. Germination may be affected with higher concentrations (Taskey, 1970). Jordan (1975) found that zinc-cadmium interactions caused greater damage to vegetation in Pennsylvania than did either zinc or cadmium alone. Seedling growth of

red oak and aspens was reduced at zinc levels above 1 ppm and cadmium levels above 5 ppm.

Therefore, it appears that the levels of heavy metals in the ash products could damage vegetation if they are carried in the leachate, if concentrations down-gradient remain high, and if they enter the root zone. Whether these conditions will exist is unknown at this time. However, arsenic is generally more effective at preventing the establishment of vegetation than in killing established plants (Taskey, 1970). Impacts on existing vegetation may be negligible if the heavy metals remain at the lower portion of the root zone, rather than accumulating near the surface where younger, more sensitive plants are rooted.

Heavy metals concentration and soil acidity may hinder reestablishment of vegetation on the reclaimed ash storage areas. This effect should be overcome if a sufficiently thick overburden cap and adequate drainage are provided.

5.4 AIR QUALITY

5.4.1 LONG-TERM ANALYSIS

Figure 5.4.1-1 illustrates isopleths of annual average ground-level concentrations of sulfur dioxide for baseline conditions, as estimated by the AQDM (see Chapter 6). Figure 5.4.1-2 presents isopleths of annual average sulfur dioxide concentrations predicted for 1984 with the proposed Units 4 and 5 in operation. Comparison of Figures 5.4.1-1 and 5.4.1-2 show that annual average sulfur dioxide concentrations are expected to increase slightly in 1984, compared to the baseline year.

Figure 5.4.1-3 gives the resultant increases in annual average sulfur dioxide levels due to the addition of Units 4 and 5. Since no major changes in sulfur dioxide emissions will occur in the area from the baseline until year 1984, Figure 5.4.1-3 is the expected degradation of air quality. The maximum degradation in the area is 4 ug/m^3. The point of maximum annual average sulfur dioxide impact of the proposed units is seven kilometers east of the plant site.

Figure 5.4.1-4 presents isopleths of annual average ground-level concentrations of total suspended particulate (TSP) matter estimated for the baseline year. The concentrations reflect an annual average TSP level of 30 ug/m^3. Figure 5.4.1-5 presents isopleths of annual average TSP concentrations predicted for 1984 with the proposed new facility in operation.

ISOPLETHS OF PREDICTED ANNUAL AVERAGE GROUND-LEVEL SULFUR DIOXIDE CONCENTRATIONS (μg/m³), CITRUS COUNTY, FLORIDA, BASELINE

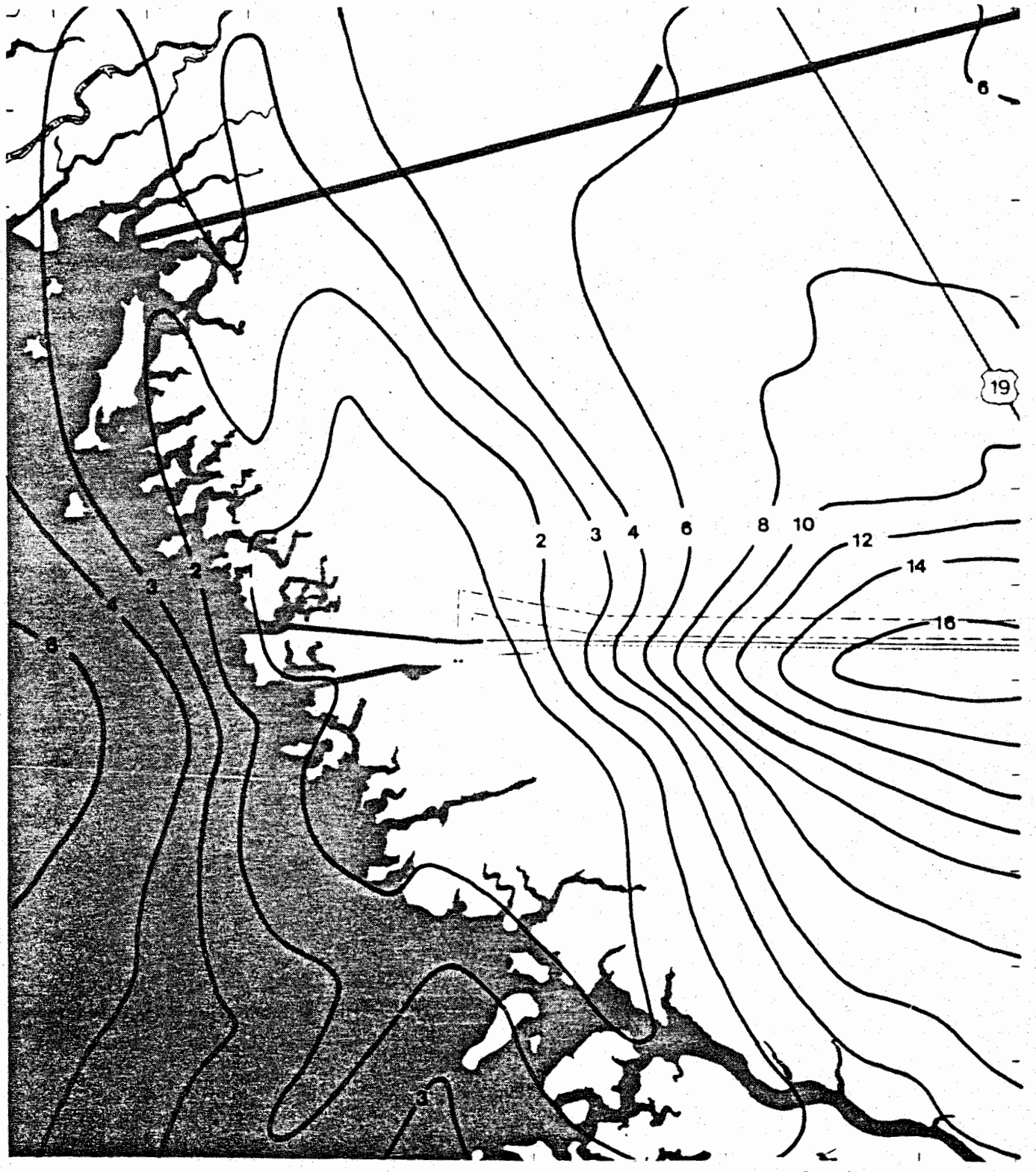
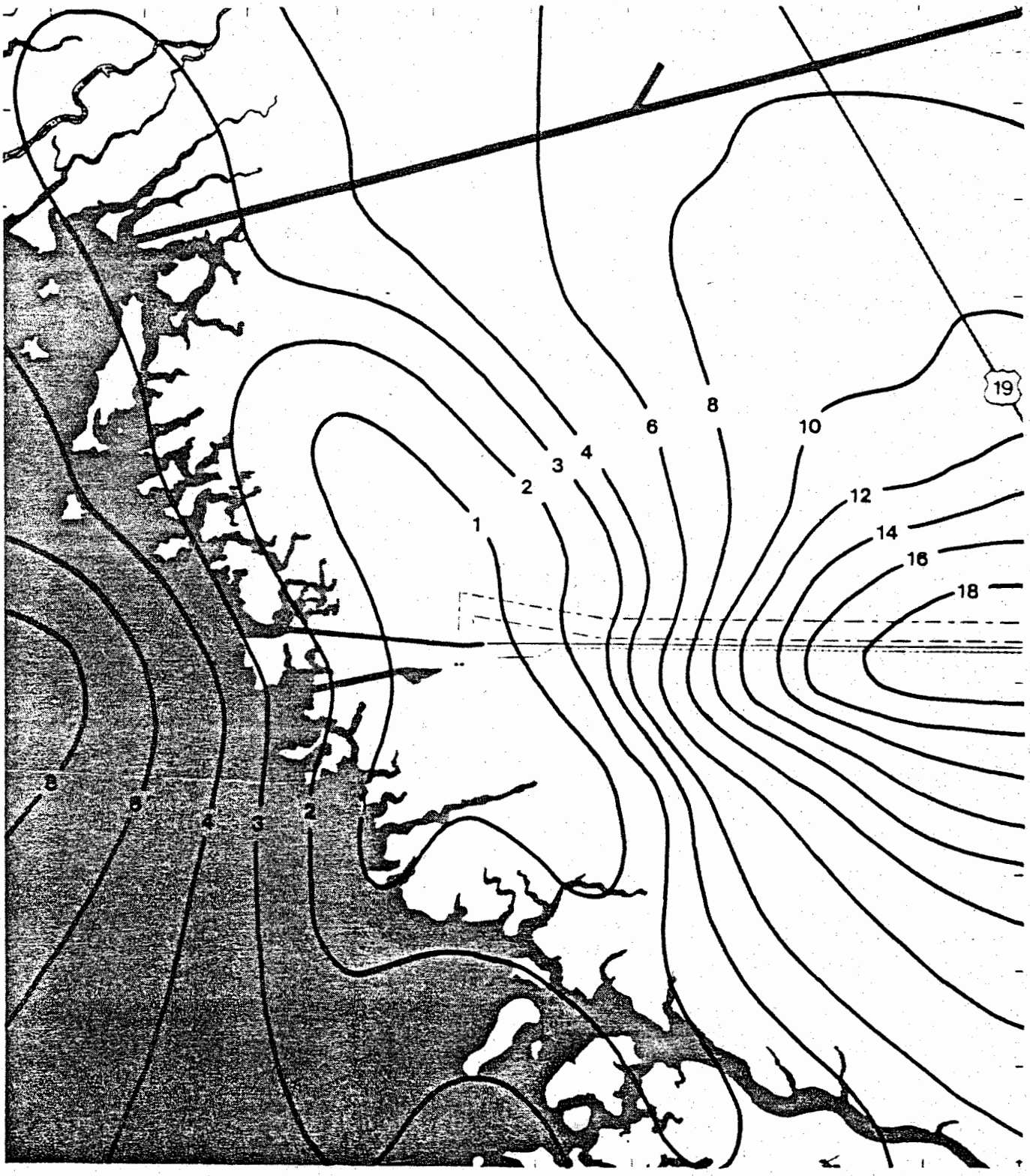


Figure 5.4.1-1

ISOPLETHS OF PREDICTED ANNUAL AVERAGE GROUND-LEVEL SULFUR DIOXIDE CONCENTRATIONS (μg/m³), CITRUS COUNTY, FLORIDA, 1984. WITH FPC'S UNITS 4 AND 5 IN OPERATION



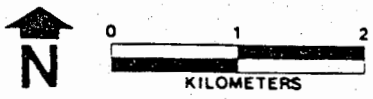
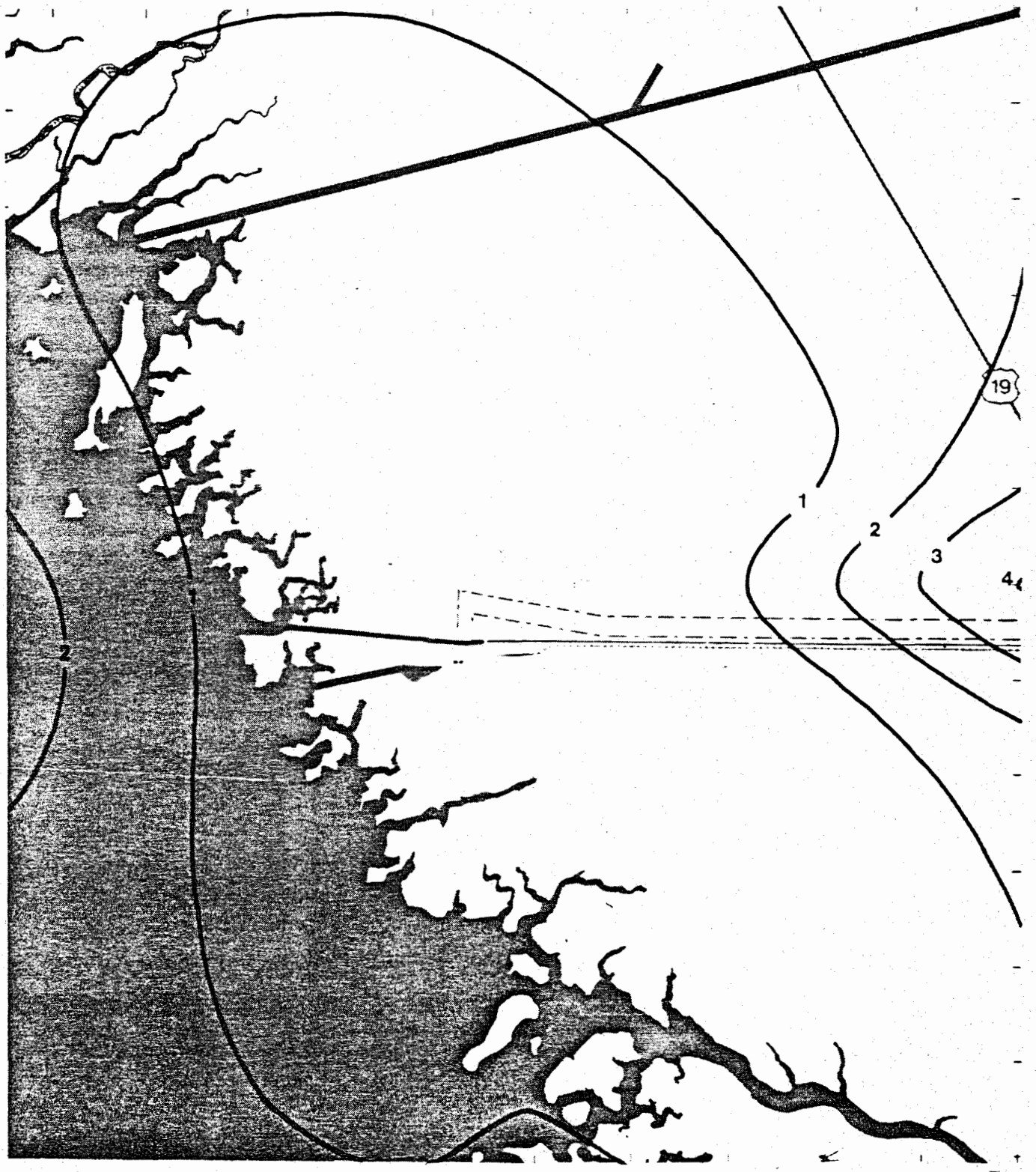


Figure 5.4.1-2

ISOPLETHS OF THE INCREMENTAL CONTRIBUTIONS TO PREDICTED ANNUAL AVERAGE GROUND-LEVEL SULFUR DIOXIDE CONCENTRATIONS (μg/m³), FLORIDA POWER CORPORATIONS' UNITS 4 AND 5, CITRUS COUNTY, FLORIDA, 1984



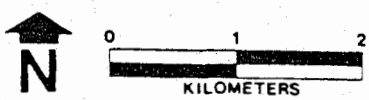


Figure 5.4.1-3

ISOPLETHS OF PREDICTED ANNUAL AVERAGE GROUND-LEVEL TOTAL SUSPENDED PARTICULATE MATTER CONCENTRATIONS ($\mu g/m^3$), CITRUS COUNTY, FLORIDA, BASELINE

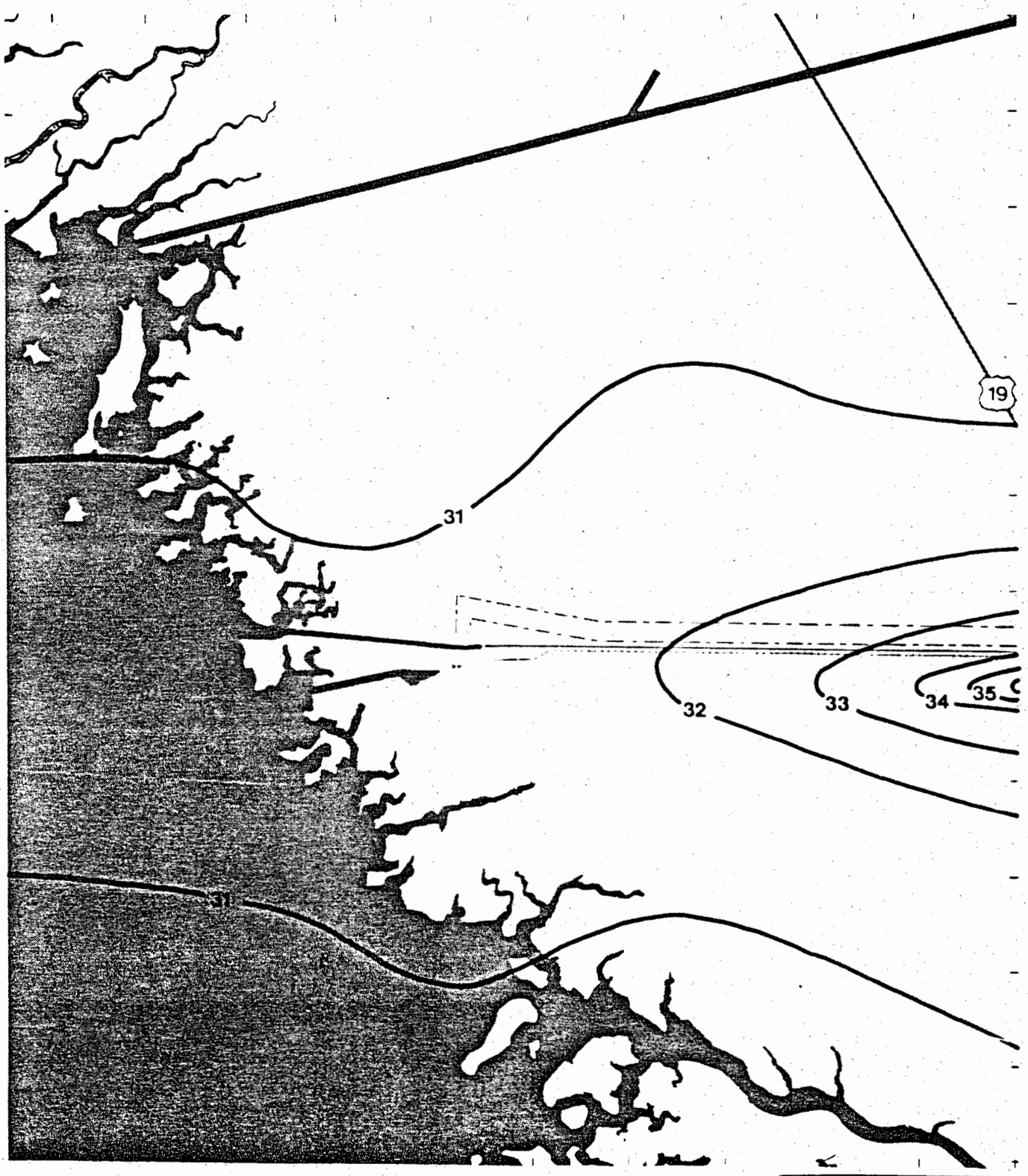


Figure 5.4.1-4

ISOPLETHS OF PREDICTED ANNUAL AVERAGE GROUND-LEVEL TOTAL SUSPENDED PARTICULATE MATTER CONCENTRATIONS (μg/m³), WITH FPC'S UNITS 4 AND 5 IN OPERATION, CITRUS COUNTY, FLORIDA, 1984

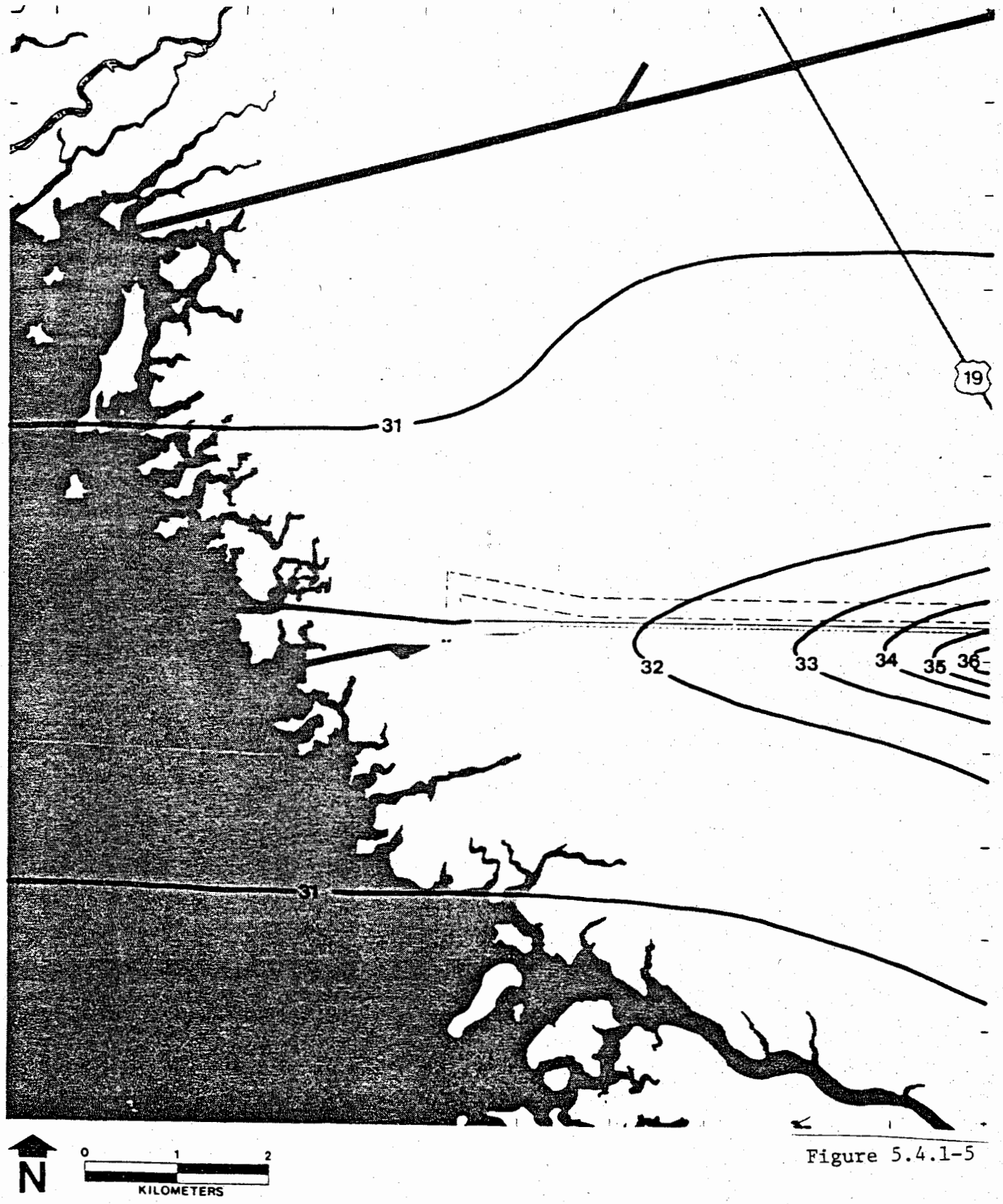


Figure 5.4.1-5

Figure 5.4.1-6 shows the resultant increases predicted in TSP air quality levels with Units 4 and 5 in operation. No major changes in TSP emissions are expected to occur from 1974 to 1984, with the exception of Units 4 and 5. The maximum increase occurs seven kilometers east of the plant site and is predicted to be less than 1 ug/m^3.

Table 5.4.1-1 summarizes the maximum estimated annual sulfur dioxide and TSP concentrations for the various emission scenarios. The incremental impact of Units 4 and 5 is shown with the two points of concern for the study: the point of maximum concentration in the study area, and the point at which the proposed facility's impact is greatest. The values listed for TSP in the table are annual geometric mean concentrations and should be distinguished from the values represented in the isopleth figures, which are annual arithmetic mean concentrations.

INCREMENTAL CONTRIBUTIONS TO PREDICTED ANNUAL AVERAGE GROUND-LEVEL TOTAL SUSPENDED PARTICULATE MATTER CONCENTRATIONS (μg/m³), FLORIDA POWER CORPORATIONS' UNITS 4 AND 5, CITRUS COUNTY, FLORIDA, 1984

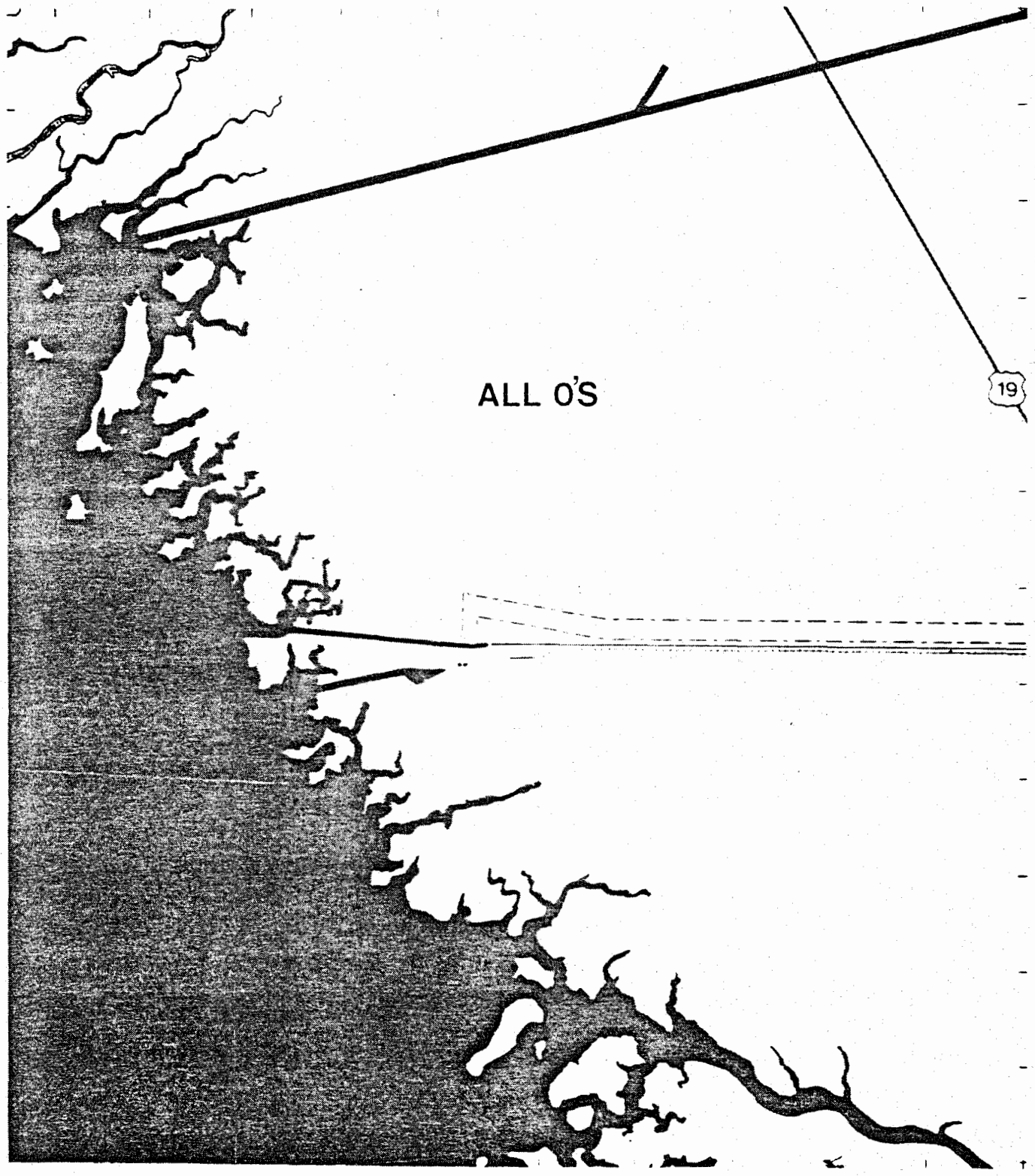


Figure 5.4.1-6

Table 5.4.1-1. Summary of Significant Deterioration Analysis, Class II Areas, Florida Power Corporation, Crystal River Units 4 and 5, Citrus County, Florida

	Maximum Concentration (ug/m^3)				
	SO_2			TSP*	
Scenario	Annual Average	24-Hour	3-Hour	Annual Average	24-Hour
Incremental Impact Crystal River Units 4 and 5	4	53	261	<1	4
Maximum in Area					
1974 Baseline	17	223	1,168	36	126
1984 with Units 4 and 5	19	275	1,380	37	123
Increase from Baseline	2	52	212	1	-3
State of Florida AAQS's	60	260	1,300	60	150
Allowable Federal Increment	20	91	512	19	37

* Concentrations include a background level of 30 ug/m^3.
Source: Environmental Science and Engineering, Inc., 1977.

5.4.2 SHORT-TERM ANALYSIS

Isopleths of predicted maximum 24-hour sulfur dioxide and TSP concentrations due only to operation of the proposed facility are presented in Figures 5.4.2-1 and 5.4.2-2, respectively. Maximum concentrations within 5 km of the plant site, as estimated by the CRSTER model, are shown. The highest 24-hour maximum is indicated in each figure. The concentrations shown represent the maximum 24-hour concentrations expected to occur at each location in an annual period due only to the new source. The highest 24-hour concentration was predicted to be 53 ug/m^3 for sulfur dioxide and 4 ug/m^3 for TSP. The 3-hour maximum sulfur dioxide concentration was estimated to be 261 ug/m^3.

The maximum 24-hour short-term TSP level estimated to exist in the study area during the baseline year is 126 ug/m^3. This value, which is in compliance with both the Federal Primary Ambient Air Quality Standard (AAQS) (260 ug/m^3) and the Florida AAQS (150 ug/m^3) includes a short-term background TSP concentration of 30 ug/m^3.

The maximum 24-hour sulfur dioxide concentration estimated to exist in the baseline year is 223 ug/m^3. This maximum occurs in the vicinity of FPC's Crystal River Units 1 and 2. The maximum 3-hour sulfur dioxide concentration estimated under baseline conditions is 1,168 ug/m^3. The highest predicted concentrations are less than the AAQS. Two short-term maximum concentrations are of concern for future years with the proposed facility in operation. These are 24-hour and 3-hour sulfur dioxide maxima which were determined to be 275 ug/m^3 and 1,380 ug/m^3,

ISOPLETHS OF PREDICTED INCREMENTAL MAXIMUM 24-HOUR SULFUR DIOXIDE CONCENTRATIONS (μg/m³), CRYSTAL RIVER RIVER UNITS 4 AND 5, CITRUS COUNTY, FLORIDA. (1984)

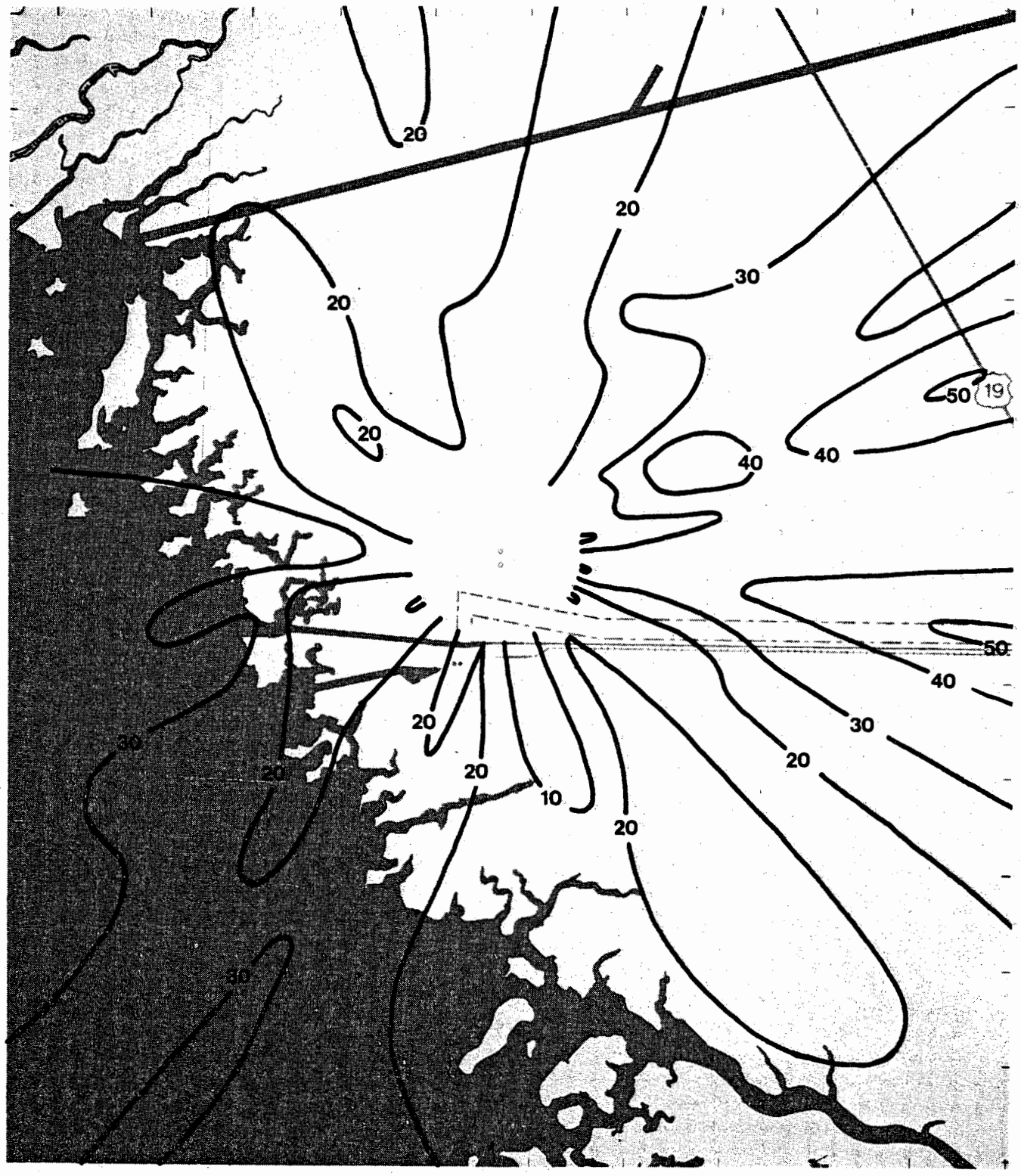


Figure 5.4.2-1

ISOPLETHS OF PREDICTED INCREMENTAL MAXIMUM 24-HOUR TSP CONCENTRATIONS (μg/m³), CRYSTAL RIVER UNITS 4 AND 5, CITRUS COUNTY, FLORIDA (1984)

N

0 1 2
KILOMETERS

Figure 5.2.2-2

respectively. Both of these maxima which were predicted in the vicinity of the Crystal River site are violations of Florida's AAQS. These maxima are within a few kilometers of the proposed site and are due largely to the impact of the existing Crystal River Units 1 and 2. The maxima are obtained by first determining the maximum incremental 24-hour concentration due only to the new source; then, utilizing the worst-case meteorology, aligning the winds in order to obtain maximum contributions from other sources.

The Clean Air Act Amendments of 1977 require that all national wilderness areas which exceed 2,050 hectares (5,000 acres) in size be designated as Class I areas for PSD purposes. Therefore, Chassahowitzka National Wilderness Area is required to be a Class I area. The allowable PSD increments for Class I areas are:

Particulate Matter:	
Annual geometric mean	5 ug/m^3
24-hour maximum	10 ug/m^3
Sulfur Dioxide:	
Annual arithmetic mean	2 ug/m^3
24-hour maximum	5 ug/m^3
3-hour maximum	25 ug/m^3

The distance from the proposed source to the Chassahowitzka National Wilderness Area boundary is approximately 21 kilometers (13 miles).

Presented in Table 5.4.2-1 is the maximum predicted baseline, incremental, and 1984 estimated sulfur dioxide and TSP concentrations. The 24-hour and 3-hour sulfur dioxide increments are expected to be exceeded.

Table 5.4.2-1. Summary of Significant Deterioration Analysis, Class I Area--Chassahowitzka National Wilderness Area, Florida Power Corporation's Units 4 and 5, Citrus County, Florida

Scenario	Maximum Concentration (ug/m^3)				
	Sulfur Dioxide			Total Suspended Particulate*	
	Annual Average	24-Hour	3-Hour	Annual Average	24-Hour
Crystal River Units 4 and 5 Incremental Impact	<<1	21	117	<<1	2
Maximum in Class I Area					
1974 Baseline	2	98	417	30	32
1984 with Units 4 and 5	2	117	534	30	34
Increase Since Baseline	0	19	117	0	2
Allowable Federal Increment	2	5	25	5	10

* Background TSP concentration of 30 ug/m^3 added to modeling results.
Source: Environmental Science and Engineering, Inc., 1977.

5.4.3 SULFUR DIOXIDE CONTROL STRATEGY

The preceeding air quality analyses indicate that violation of Florida's AAQS and PSD increments may result from the construction of Units 4 and 5. As a result FPC will be required to implement a control strategy to meet AAQS and PSD increments in order to construct new coal-fired generating facilities.

On November 30, 1977 FPC filed an Air Pollutant Emissions Report with the Environmental Protection Agency. In this application FPC has committed to the 2nd control strategy illustrated in Table 5.4.3-1. This strategy reduces the SO_2 emissions from Units #1 and #2 from 6.17 lbs of SO_2 per 10^6BTU to 4.8 lbs of SO_2 per 10^6BTU while allowing Units Nos. 4 and 5 to operate at the NSPS limits of 1.2 lbs of SO_2 per 10^6BTU.

There are two control strategy options available to achieve compliance with AAQS's and PSD increments. The first option would be to decrease sulfur dioxide emissions from Units 4 and 5 below New Source Performance Standards (1.2 lb $SO_2/10^6$ Btu NSPS). The second option would be to reduce baseline concentrations sufficiently to allow Units 4 and 5 to operate at NSPS emission limitations. In order to reduce baseline concentrations, FPC's Crystal River Units 1 and 2 must reduce emissions below the maximum allowable emission limitations of 6.17 lb $SO_2/10^6$ Btu.

Table 5.4.3-1 presents two alternative control strategies, either of which, if implemented by Florida Power Corporation, would achieve compliance with state and federal AAQS and PSD increments. Also contained in the table are the resultant ambient sulfur dioxide air quality concentrations for the alternate control strategies.

Table 5.4.3-1. Summary of Sulfur Dioxide Control Strategy Evaluation for Florida Power Corporation's Crystal River Units 4 and 5, Citrus County, Florida

Control Strategy	Maximum Sulfur Dioxide Concentration (ug/m^3)			
	Class II Maximum		Class I Maximum	
	24-Hour	3-Hour	24-Hour	3-Hour
Units 1 and 2 at 6.17 lb $SO_2/10^6$ Btu and Units 4 and 5 at 0.26 lb $SO_2/10^6$ Btu				
Units 4 and 5 increment	12	56	4.6	25
1974 Baseline	223	1,168	98	417
1984 with Units 4 and 5	234	1,214	112	442
Increase Above Baseline	11	46	4	25
Units 1 and 2 at 4.8 lb $SO_2/10^6$, and Units 4 and 5 at 1.2 lb $SO_2/10^6$ Btu				
1974 Baseline	223	1,168	98	417
1984 with Units 4 and 5	225	1,120	97	441
Increase Above Baseline	2	-48	-1	24
Allowable Increment	91	512	5	25

Source: Environmental Science and Engineering, Inc., 1977.

5.4.4 CONCLUSIONS

From review of the tables, the following salient conclusions can be drawn from the PSD analysis:

1. Annual average sulfur dioxide levels are expected to increase by 1984 due to the proposed facility; however, the maximum impact of the proposed source is only 4 ug/m^3. The maximum increase in sulfur dioxide levels above the baseline in the study area is predicted to be 20 percent of the allowable annual PSD Class II increment.
2. Short-term sulfur dioxide levels are expected to increase in the study area by 1984. The proposed new source contributes a maximum of 53 ug/m^3, 24-hour average, and 261 ug/m^3, 3-hour average, to these increases. The maximum increases in the area above baseline for short-term sulfur dioxide levels represent about 60 percent of the 24-hour Class II increment and about 50 percent of the 3-hour Class II increment.
3. Both maximum annual average and short-term TSP levels are expected to increase in the study area. The maximum impact of the proposed source was predicted to be less than 1 ug/m^3, annual geometric mean, and 4 ug/m^3, 24-hour maximum. Maximum increases in TSP levels during the period following the baseline year for the area were predicted to be 0 percent of the annual TSP Class II increment and 11 percent of the 24-hour TSP Class II increment.

4. In combination with existing Units 1 and 2, the new units are calculated to cause a violation of the Florida 24-hour and 3-hour sulfur dioxide AAQS's. These standards are exceeded by 6 percent.

5. Short-term sulfur dioxide levels estimated in the Chassahowitzka National Wilderness Area for Units 4 and 5 will exceed the 24-hour and 3-hour increments by 320 percent and 370 percent, respectively.

6. If a control strategy of Units 1 and 2 at emissions of 6.17 lb $SO_2/10^6$ Btu are utilized, both Florida AAQS and Federal Class I PSD increments will be met. Under this control strategy, a maximum of 13 percent of the Class II increment would be used by the proposed units.

7. If a control strategy of Units 1 and 2 at emissions of 4.8 lb $SO_2/10^6$ Btu are utilized, both Florida AAQS and Federal Class I PSD increments will be met. Under this strategy only 2 percent of the Class II increment would be used.

It must be emphasized that the above conclusions are based on only one year of meteorological data. Since sources and source impacts were aligned to "worst case" meteorology, these analyses are conservative. Additional analysis with a larger meteorological data base may change the above conclusions.

5.4.5 ECOLOGICAL IMPACTS

Air emissions are not expected to have significant impacts on the regional vegetation. The predicted maximum sulfur dioxide concentrations from Units 1, 2, 4, and 5 are 0.11 ppm (275 ug/m^3) for a 24-hour period and 0.53 ppm (1,380 ug/m^3) for a 3-hour period. Alfalfa is one of the most sensitive species to sulfur dioxide, with threshold acute injury levels of 0.55 ppm for two hours and 0.25 ppm for eight hours. Thus, theoretical maximum levels of sulfur dioxide barely approach the acute injury threshold levels for the most sensitive species, and normal operational levels should not have a noticable impact on vegetation.

Chronic injury may occur at concentrations between 0.1 ppm and 0.3 ppm for the more sensitive species (Brandt and Heck, 1968). Interaction with other substances also lowers sulfur dioxide threshold levels and increases injury. Interactions of sulfur dioxide and nitrogen dioxide at levels of 0.05 to 0.25 ppm sulfur dioxide and 0.05 to 0.25 ppm nitrogen dioxide have produced greater than additive effects on aspens, radishes, soybeans, tobacco, and tomatoes after 4-hour exposures (ASA, Inc., 1976). At the predicted 3-hour maximums of 0.53 ppm SO_2/0.11 ppm NO_2, and 24-hour maximums of 0.11 ppm SO_2/0.02 ppm NO_2, the air emissions have potential for causing injury to some vegetation. However, normal operating levels are expected to cause no injury or damage.

5.5 DIRECTLY ASSOCIATED TRANSMISSION SYSTEM

The existing transmission lines serving Units 1, 2, and 3 at the site are adequate to transmit the power to be generated by proposed Units 4 and 5. The only transmission lines necessary for the proposed units are the interconnects to existing lines leaving the site. Figures contained in Chapter 3 indicate that the route of these interconnects runs slightly to the west of the proposed units.

Since the entire route of these lines lies over areas to be cleared, filled, and graded for site development, no additional impacts to terrestrial or aquatic communities are expected as a result of construction. The applicant plans to allow vegetation to grow up under the lines as long as this practice is safe and does not prevent accessibility. When the vegetation becomes too high, it will be trimmed mechanically. The applicant does not intend to use herbicides for vegetative control under these lines or on the site.

Studies by Scherer, et al. (1973), and Frydman, et al. (1973), have shown that the maximum concentrations of ozone (less than 0.02 ppm) produced by transmission lines of up to 765 KV are insufficient to cause impacts to neighboring vegetation, since threshold injury levels lower than 0.05 ppm (98 ug/m^3) for 4 hours have not been demonstrated (ASA, Inc., 1976).

5.6 DIRECTLY ASSOCIATED FACILITIES

Aspects of plant operation considered in this section include coal handling, bottom and fly ash handling, noise from the plant, and traffic from barges, trains, and road vehicles. This section describes possible impact from these operations.

5.6.1 COAL HANDLING

Transfering, storing, and crushing of coal are potential sources of particulate. The quantity of emissions, and consequently the environmental impact, depend on many factors. Meteorological conditions such as wind speed and humidity are the primary factors which influence particulate emissions from coal storage. Coal transfer and process for combustion can also be significant sources if left uncontrolled.

The proposed controls for the facility, wetting agents for open areas and bag filters for enclosed operations (conveyors, transfer points, silos, and crushers), will significantly reduce fugitive particulate emissions. Bag filters will control particulate emissions to 99.9 percent (U.S. EPA, 1972) and wetting agents will control dusts as much as 90 percent (Amick, et al., 1974). In addition, the particulate generated will ordinarily have sufficient size to settle out within the plant boundary.

Presently ambient air quality of the area indicates a large degree of compliance with federal and state Ambient Air Quality Standards, AAQS, (see Section 2.9). The addition of coal-handling generated particulate matter is not expected to degrade the air quality in the area.

5.6.2 BOTTOM AND FLY ASH HANDLING

The proposed equipment and procedures for handling bottom and fly ash will reduce the possibility of these materials becoming airborne. Bottom ash, which will be handled in a water slurry, will not generate dust. Fly ash will be transfered to the ash area in covered conveyors. Wetting agents will insure that fly ash is not emitted from the site. Without such controls, violation of AAQS for TSP could result under unfavorable meteorological conditions; i.e., high wind speed and little precipitation.

5.6.3 NOISE

Major noise sources associated with the proposed facility are the cooling towers, coal transfer and crushing operations, turbine and boiler noise, and other miscellaneous sources (vehicular traffic, ash handling, etc.). The existing facilities have some of these sources. As a consequence, the impact of the new facilities will be an increment over an existing noise source.

To determine worst-case noise impacts, a 50-foot distance from the center of the plant sound pressure level of 90 dBA is estimated. With

a 6 dB reduction every time the distance doubles (see Section 4.2.2), the worst-case impact at 6 kilometers would be 46 dBA. Using the simplified sound-level reduction curve developed in Section 2.10 (Figure 2.10.1-4), a reduction to 45 dBA is estimated. These sound pressure levels are consistent with those found by Teplitzky (1977), for cooling towers. These levels are comparable to urban predawn background noise.

5.6.4 TRANSPORTATION

[Maintenance and operation of the proposed plants will generate additional flows of traffic in the site area. Once the proposed plants are in operation, the daily number of private vehicle trips will decrease compared to the construction phase. There will be an overlapping period between 1983 and 1985 when Unit 4 is in operation and construction is still underway on Unit 5. During this period, the average labor force for construction of Unit 5 will be 535 workers; and the average labor force for maintenance and operation of Unit 4 will be 112 workers. Assuming that some workers will participate in car pools and the majority of workers will remain on site during the noon hour, plant labor force during this period will generate approximately 1,300 trips per day. By 1985 this figure will be reduced to approximately 265 trips per day to and from the site, representing only a maintenance and operation labor force.

[The number of truck deliveries per day will also decrease after 1985, when all construction is completed. At this time, the majority of deliveries will be by barge and rail rather than by highway.

The impact of the road traffic will be primarily experienced on U.S. Highway 19-98, which is the only major road leading to the site. This highway was completely four-laned in both directions from the plant site and can accommodate up to 22,500 cars a day. Projections of highway usage developed by the Withlacoochee Regional Planning Council, which take into account the construction and operation of Crystal River Units 4 and 5, show that U.S. 19-98 south of Crystal River will reach maximum traffic load in the year 1987, north of Crystal River in 2010, and in the vicinity of Red Level in 2056. The proposed access road will also receive heavy amounts of traffic. It will be a 2-lane, 24-foot wide paved road designed specifically to handle the anticipated traffic gaenerated during plant operation, and maintenance will be minimal.

Low sulfur coal for Crystal River Units 4 and 5 will be delivered to the plant site by barge from the west and by unit train from the Appalachian area in approximately equal tonnages. The total requirements of these two units will be about 3,200,000 tons annually, or about 1,600,000 tons by water and 1,600,000 tons by rail. Unit trains from the Appalachian Region to Crystal River are capable of hauling 7,000 tons in seventy 100-ton cars. This will result in the need for about 229 unit train deliveries annually to supply the 1,600,000-ton Appalachian coal requirements.

[Rail deliveries for existing Units 1 and 2, also in 7,000-ton unit trains, are expected to arrive at the rate of about 130 trains annually. This, when combined with the anticipated rail delivery for Crystal River Units 4 and 5, will bring the annual total to 359 loaded trains or about one train per day. When considering return of empty cars, there will be a total of two 70-car trains crossing U.S. 19 almost every day.

The rail cars and motive power units will be dedicated full-time to unit train coal movement to Crystal River. Terms of the tariff with the railroad will not provide for any switching at the plant site and will require unloading and release of the train within a 4-hour period during which time the engines will never be uncoupled from the cars. Upon completion of unloading, the train will leave the plant site on a return trip to the original coal loading mine or tipple.

A 70-car train coupled with engines and caboose will be less than 3/4-mile in length with permissible speed on our spur being 25 miles per hour. The terms of our agreement with the State Road Department limit obstruction of traffic on U.S. 19 to 5-minute intervals; however, at the allowable train speed and with a 3/4-mile train length, crossing can be completed in less than 2 minutes. Combined with the expected one train per day delivery, this would result in traffic on U.S. 19 being delayed by the unit trains under 2 minutes on each arrival and for another less than 2-minute interval within the next 4 hours on departure of the train.

[Unloading can be accomplished on a 24 hour per day, 7 day per week schedule. Since the unit trains will be in continuous service between the plant and the original loading point, crossing of U.S. 19 may occur at any time during the day or night.

Both road and rail traffic will produce some road kills, but it is unlikely that this would have a detectable effect on wildlife populations.

Manatees, which are known to occur in this area, seldom have been sighted near the power plant. It is believed that they prefer the warmer water of the discharge canal rather than the water of the intake canal. However, if a manatee should happen to be in the intake canal while coal barges are being transported to or from the dockside coal-handling facilities, a collision between the barge and the manatee would more than likely result in the manatee's death.]

5.7 RESOURCES COMMITTED AND UNAVOIDABLE ENVIRONMENTAL IMPACTS

The most important commitments of natural resources involved in the operation of the proposed facility are: (1) fuels, (2) water consumed, (3) soil loadings with chemicals, and (4) air quality increments used.

Fuels consumed by the plant will include coal from deposits in the western and eastern United States as well as other fossil fuels (see Chapter 3). Most of the fossil fuel used will be burned to produce power. Other fossil fuel derivatives will be used for start-up, lubricants, solvents, and paints. Yearly average amounts of coal burned by Units 4 and 5 during their 30-year projected life will be approximately 3.4 million metric tons (3.74 million tons). Coal, including lignite, consumed by power generation in the United States in 1975 equalled 368 million metric tons (U.S. Department of Commerce, 1976). Thus, projected coal consumption per year for Units 4 and 5 would be about 1 percent of all coal usage for electric generation in 1975. Current energy policies will probably encourage the use of coal in electric generation, causing yearly consumption to rise. Therefore, in future years the percentage of total coal use per year by Units 4 and 5 should decline. Figures are not available for the number of coal-burning units planned for the 1980's and their projected fuel consumption.

Maximum fuel-oil usage for furnace warm up and coal ignition during start up will be 10.6 million liters (2.8 million gallons) per year for each unit, based on an average of 200 starts per year.

The facility will also consume fossil fuels indirectly. Fuels will be burned elsewhere to provide energy for manufacturing spare parts and transporting materials and people. On a tertiary level, the facility will contribute to other fuel use by providing power to high growth areas in the state. The presence of power will stimulate manufacturing, transportation, and construction. Figures for these uses are not available.

The proposed facility will consume fresh ground water. Raw water requirements of Units 4 and 5 will be a peak of 51,900 liters per minute (13,700 gallons per minute) and an average of 31,800 liters per minute (8,400 gallons per minute). Drawdowns for eight-well and five-well fields were calculated. An estimated groundwater budget for the area is presented in Section 5.1.1. These figures were derived in the absence of test well data since a test well permit was denied by the water management district.

Projected average groundwater use by the facility is 45 million lpd (12 million gpd). Freshwater demands for Citrus County for 1985 are estimated to be 100 million lpd (26.5 million gpd), excluding power plants (Geraghty and Miller, 1977). Estimated groundwater budgets (see Section 5.1.1) indicate that about 4 percent of available ground water would be used by the plant. An estimated 1,325 million lpd

(355 million gpd) will be available in the chosen computational area (see Section 5.1.1).

Water committed to plant needs will not be available for other uses during the operating life of the plant. This commitment is not irreversible, but amounts to a 30- to 40-year agreement.

Water will also be consumed in other areas of the state and the county to provide support material and services to the facility.

Plant operation will consume an increment of water pollution, which will be unavailable to other users, as follows:

1. Blowdown and sewage produced at the site,
2. Acid mine drainage at other coal mining sites, and
3. Local sewage near the site from worker dwellings.

Blowdown and sewage discharges projections are given in Chapter 3. Because of the dilution factor provided by the discharge of Units 1, 2, and 3, the impacts of these discharges are not likely to be significant. No estimates are available for secondary additions resulting from the facility.

Soils on the site will be exposed to leachates from exfiltration of storage and disposal areas. This fluid will contain many materials such as arsenic, copper, lead, vanadium, cadmium, cobalt, and chromium. Concentrations are discussed in Section 5.2. Changes in the

concentrations of these materials in the soil will take place. Presumably, these concentrations will linger for a long period of time.

Air quality increments allowed in various areas are presently defined by federal law (P.L. 95-95). Operation of the proposed facility will consume some parts of these increments, which will then be unavailable for other purposes. Three hour, twenty-four hour, and annual emissions for Units 4 and 5 are estimated to be 1.2 lbs per million Btu sulfur dioxide and 0.1 lb per million Btu TSP. Annual calculations are for 72 percent load.

Air Quality increments allowed in various areas are presently defined by federal law (see Chapter 8). Operation of the proposed facility will consume some parts of allowable Prevention of Significant Deterioration (PSD) increments (see Section 5.4) which will then be unavailable for other purposes. The following Class II increments will be consumed at the point of maximum impact:

	Averaging Time		
Pollutant	Annual Average	24-Hour	3-Hour
Total Suspended Particulates	< 1%	11%	N/A
Sulfur Dioxide	20%	60%	50%

A portion of the Class I (Chassahowitzka Wilderness Area) increment will also be consumed for TSP. Worst case estimates indicate that 100 percent of the sulfur dioxide Class I PSD increment will be consumed. This air quality deterioration will primarily occur at the Class I area when winds originate from the north. The frequency of occurrence of these wind directions is approximately 7 percent or 26 days per year. These effects will end when the plant serves its useful life.

5.8 MITIGATIVE MEASURES

Mitigative measures to reduce environmental impact can be demonstrated by the Applicant's site selection, arrangement on the site, and control technology. These are discussed in the following sections

5.8.1 SITE SELECTION

The selection of the Crystal River site presents several environmental advantages. These include:

1. No new extensive transmission lines are required. Impacts to potential transmission line corridors are therefore avoided. Typical transmission corridors require about 5 hectares (12 acres) of land per mile.
2. Dredging impacts are minimized by the presence of coal delivery canals at the site. Impacts to aquatic and terrestrial ecosystems are consequently minimized.
3. Existing discharge flows from Units 1, 2, and 3 will serve to dilute blowdown and sanitary discharge from Units 4 and 5 (Chapter 5).
4. The proximity of the proposed units to other facilities operated by the Applicant presents an advantageous flexibility in air pollution control strategies. This situation is even more important since the Applicant will control the majority of emission sources in the vicinity.

5.8.2 ARRANGEMENT ON THE SITE

The Applicant has chosen to arrange the new facilities on the site in such a way as to minimize environmental impacts. Proposed facilities have been planned to avoid displacing wetlands and valuable habitats such as the salt marsh and coastal hydric hammocks. As indicated in Chapter 9, other arrangements of the facility were feasible, but the Applicant chose a plan which would minimize impacts to more sensitive terrestrial systems. Also, in the proposed arrangement the facilities are farther removed from coastal archeological sites than in other plans which were considered.

5.8.3 CONTROL TECHNOLOGY

Plant design incorporates a number of mitigative features.

The Applicant's plans to use closed-cycle cooling represent a large reduction in the impacts of thermal addition to the nearby estuary. Natural draft cooling towers which have been chosen produce less noise, less drift, and consume less fuel than mechanical draft towers.

Fresh water obtained from wells is proposed as the source of cooling water for the facility. This plan eliminates impacts due to entrainment and entrapment which would be unavoidable if surface water were used. Commitment of fresh water to the facility could represent some advantages to long-term water resource allocations. Unlike some water commitments, power plant water use is limited to the life of the plant. The water will again become available when the plant has completed its useful life. Consequently, the committed water can be viewed as a "bank account" which will be available if future need develops.

Control of water discharge by the use of retention ponds and chemical treatment will substantially reduce impacts to aquatic communities in the receiving waters.

Burning low-sulfur coals will result in less degradation of air quality than burning high-sulfur coals. Scrubbers are not planned. This measure will reduce solid wastes from the facility by eliminating

scrubber sludge. Since stack emissions are hotter when scrubbers are not used, the potential dispersion of air pollutants will be greater. The use of scrubbers results in a reduction of the electrical generation which can take place for a given amount of fuel. If other control technology is used, this lost fuel would be made available for other uses.

The improved fuel efficiency of the newer units allows more electricity to be produced with fewer air emissions for a given amount of fuel.

CHAPTER 6

ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

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6.0 ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

6.1 BASELINE MONITORING AND RELATED INFORMATION

Investigations, to determine the nature of existing environments, were conducted through literature searches and field studies. Past studies of the Crystal River site in connection with Units 1, 2, and 3 provided many references. Literature concerning similar habitats in the state and the southeastern U.S. were also useful.

Studies directly concerned with the Site Certification Application are delineated in the following text.

6.1.1 SURFACE WATER

Information concerning surface water hydrology in the area was obtained from 15 published reports. Most of these were either USGS reports or reports dealing with the hydrology of the Cross-Florida Barge Canal. The USGS Water Resources Data for Florida (1975 and 1976) provided information concerning the discharges of major streams in the area as well as water quality analyses. All measurements were obtained by the USGS. Several other reports (i.e., Rabon, 1966; Kaufman, 1975; Kenner, 1966) provided statistical interpretations of data contained in the Water Resources Data books. Cherry (1970) provided a general overview of hydrology in the region and a water budget analysis. Bush (1972) reported on saltwater movement in the lower Withlacoochee River based on chemical analyses of water taken from 11 sites on the lower Withlacoochee-Cross Florida Barge Canal Comple. Tidal data was also obtained from this report based on water level recordings taken at Crackertown, Florida, since 1967.

The reports concerning the hydrology of the Cross-Florida Barge Canal (i.e., U.S. Army Corps of Engineers, 1976 (2); Meta Systems, 1976) provided detailed statistical interpretations of discharges in the lower Withlacoochee River. Much of this information was not totally relevant to the study area. The Corps of Engineer's Water Resources Study of the Four River Basins Area (1977) provided some more recent information concerning the discharge characteristics of both the Withlacoochee River and the Crystal River.

Information concerning flooding in the area was obtained from two sources, an Army Corps of Engineers's Flood Hazard Information Study for the lower Withlacoochee (1976) and USGS Flood-Prone Area Maps (1954) for the study site. The Corps of Engineers' report was not wholly representative of the study area in that structures associated with the barge canal serve to dampen flooding effects at the mouth of the Withlacoochee. The 100-year flood elevation of the site was estimated by the USGS through the use of readily available information on past floods rather than from detailed field surveys and inspections.

Additional information concerning the physical characteristics of Lake Rousseau and Crystal River were obtained during studies conducted in August, 1977, by ESE (ESE, 1977).

6.1.2 WATER QUALITY

Most of the baseline data discussed in Subsection 2.5.2 concerning the water quality in the estuary, intake, and discharge canals was taken from existing literature.

Water quality parameters investigated by Gibson, et al., were discussed. This investigation was initiated in 1973 to determine seasonal patterns of phytoplankton standing crop and production and water quality in Gulf coastal waters adjacent to the Florida Power Corporation generating facility at Crystal River. Water samples were collected bi-weekly for the six-month period from November, 1973, to April, 1974. Sampling locations were chosen to include points in the intake canal, discharge canal, discharge basin, and to estimate the impact of the two principal freshwater sources on the region. Nutrient concentrations were assayed using a 2-Channel Technicon Autoanalyzer (AII) through procedures outlined by Hopkins, et al. Salinities were measured using a Beckman salinometer, temperature was measured with a mercury thermometer, and chlorophyll a by the procedures of Strickland and Parsons (1968).

Phosphorus values discussed were taken from Odum and Snedaker. This report discussed the processes within the plume-receiving ecosystem at Crystal River. Preliminary analysis was performed for phosphorus, chlorophyll a, and pheo-pigments. These results, as well as those results of benthic studies, are presented in order to develop a model of the system.

Solids and turbidity data discussed were taken from Fox and Moyer. The specific objectives of this study were to determine, by using various parameters, the direct and indirect effects of chlorinated cooling water on the microbiota of the receiving waters. In order to measure the effects of chlorination, the following assays were performed: temperature, dissolved oxygen, chlorophyll a, primary productivity, Adenosine Triphosphate (ATP), total bacterial populations, total solids, suspended solids, volatile solids, secchi disc, and chlorine.

Temperature and salinity data discussed were taken from Behrens, 1975. This report presents and analyzes salinity and temperature data collected from April, 1974, through March, 1975, in the Florida Power discharge basin at Crystal River, Florida, with respect to seasonality and plume acreages.

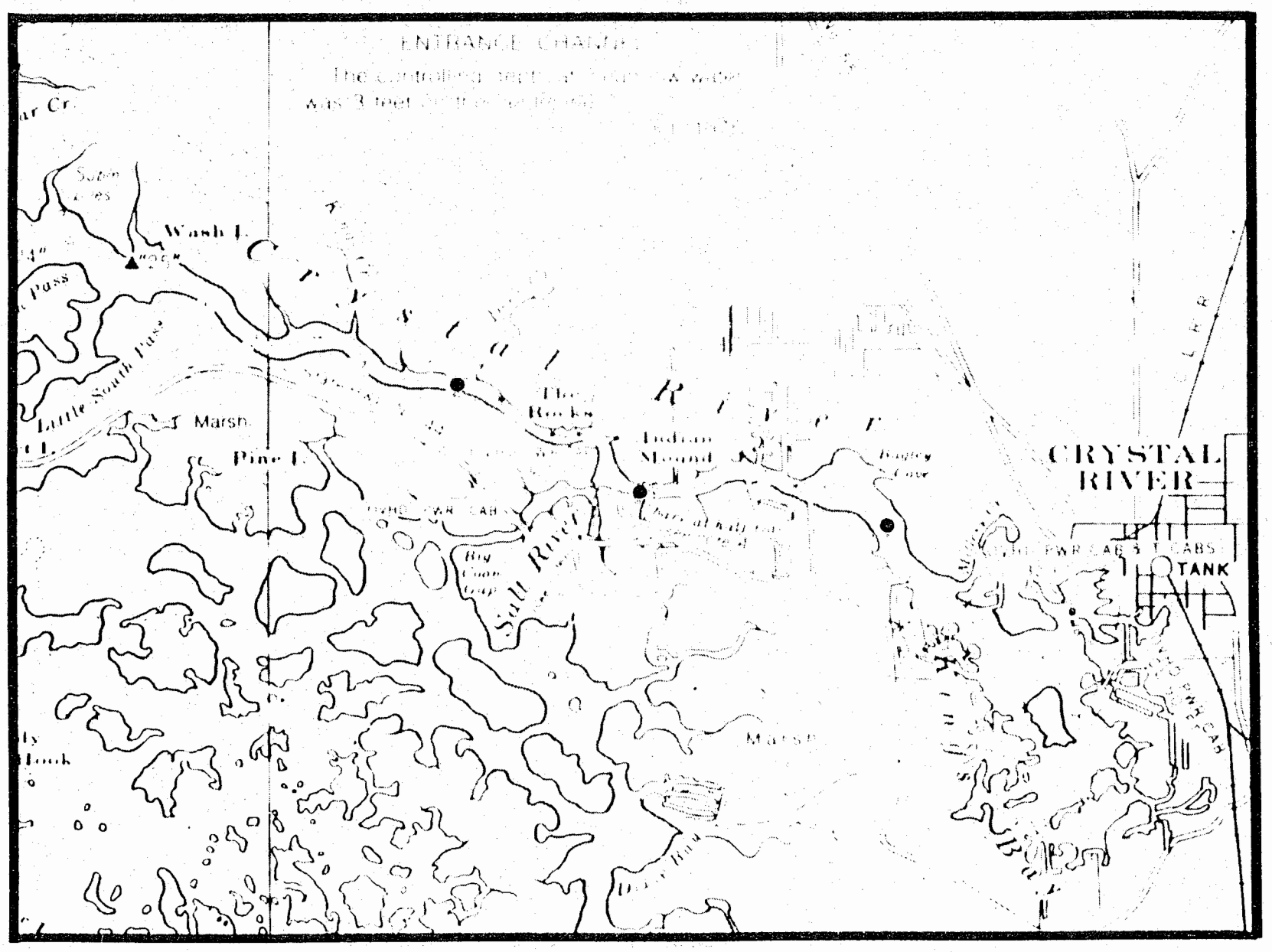
Additional information concerning the quality of surface waters in the vicinity of the proposed site was obtained from Florida Department of Environmental Regulation Water Quality Management Plans for the Tampa Bay Area (1976) and the Withlacoochee River Basin (1975). These plans evaluated numerous water quality analyses of selected sites on the Crystal River and the Withlacoochee River against the water quality standards which have been adopted for these waters. On the basis of these evaluations, qualitative determinations were reported concerning the water quality in these streams.

The baseline data presented for Crystal River and Lake Rousseau in Chapter 2 was collected by ESE late in August, 1977 (Figures 6.1.2-1 and 6.1.2-2).

Site locations on Crystal River were situated 1 mile above, 1 mile below, and at the proposed intake site. Grab samples were taken from the surface and from near the bottom at each of these sites and returned to ESE for analysis. Analyses which were performed and analytical methodologies used can be seen in Table 6.1.2-1. In situ analyses were also performed at the surface and near the bottom at each of the three sites. In situ methodologies are presented in Table 6.1.2-2.

There were two site locations at Lake Rousseau: a nearshore site situated near the proposed intake site, and an offshore site situated approximately one-quarter mile east of Inglis Dam (Figure 6.1.2-2, Lake Rousseau site locations). Grab samples were taken from the surface and from near bottom at each of these sites and returned to ESE for analysis. Analyses which were performed and analytical methodologies used can be seen in Table 6.1.2-1. In situ analyses were also performed at the surface and near the bottom at both sites. In situ methodologies are presented in Table 6.1.2-2.

SAMPLING SITES FOR CHEMICAL SAMPLES



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NAUTICAL MILES

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Figure 6.1.2-1

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SAMPLING SITES FOR CHEMICAL SAMPLES

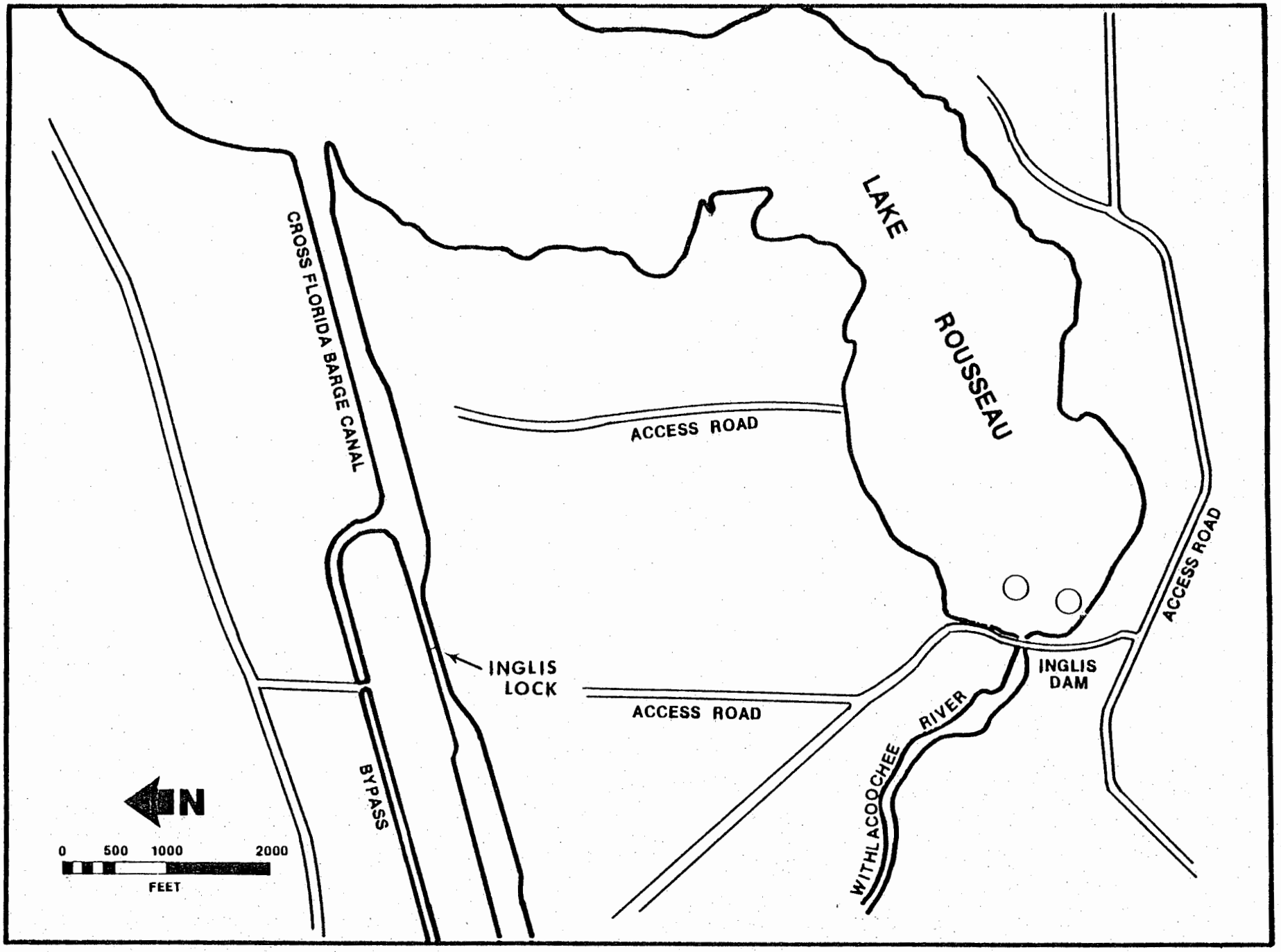


Figure 6.1.2-2

Table 6.1.2-1. Chemical Analysis of Water Samples

Parameter	Method	Reference
Ammonia	NH_3 selective ion probe	SM, 1975
Total Kjeldahl nitrogen	Kjeldahl digestion automated phenate method	EPA, 1976 EPA, 1976
Nitrate and nitrite	Automated Cd reduction method	EPA, 1976 ASTM, 1976
Dissolved orthophosphate	0.45 um filtration, automated ascorbic acid method	EPA, 1976
Total phosphorus	Persulfate digestion, automated ascorbic acid method	EPA, 1976
Alkalinity	Titrimetric method	EPA, 1976
Color	Colorimetric	EPA, 1976
Turbidity	Nephelometer and Secchi disk	EPA, 1976
Suspended solids	Gravimetric	EPA, 1976
Dissolved solids	Gravimetric	EPA, 1976
Total solids	Gravimetric	EPA, 1976
Biochemical oxygen demand	DO probe	EPA, 1976
Hardness	Titrimetric	EPA, 1976

ASTM, 1976 = Annual Book of ASTM Standards, Part 31, Water, ASTM.

EPA, 1976 = Methods for Chemical Analysis of Water and Wastes, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio.

SM, 1976 = Standard Methods for the Examination of Water and Wastewater, APHA, WPCF, AWWA.

Table 6.1.2-2. In Situ Analysis of Water

Parameter	Method	Reference
Temperature	Thermistor	EPA, 1976
pH	Hydrogen ion electrode	EPA, 1976
Dissolved oxygen	DO probe	EPA, 1976
Salinity	Electrical conductivity method	SM, 1975

EPA, 1976 = Methods for Chemical Analysis of Water and Wastes, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio.

SM, 1975 = Standard Methods for the Examination of Water and Wastewater, APHA, WPCF, AWWA.

6.1.3 ECOLOGICAL PARAMETERS

6.1.3.1 SALT MARSH

Information gathered on the salt marsh biota was based on the existing literature. Reference to Homer, McMahan, McKellar, and Young is from a ten-month study undertaken during the period May, 1974, to February, 1975, in the Crystal River region of Florida. Homer discussed the seasonal variation, biomass, diversity, and trophic structure of fish in the salt marsh tidal creeks. He also gives a brief discussion of the various predominant species collected. McMahon discusses briefly the microarthropod population present in the area. As mentioned in Section 2.7, the limited degree to which these organisms were identified precluded detailed conclusions relating population interaction or relationships with other trophic levels.

McKellar summarized the outer bay ecosystem at Crystal River, Florida, in terms of metabolism and energy flow models. He also discussed total system turnover times based on system metabolism and organisms' biomasses.

Young extensively discusses the salt marshes and the effects of thermal innundation in terms of plant standing crop, net production, respiration, total metabolism, decomposition, diversity, and selected animal members (specifically, the marsh periwinkle, *Littorina irrorata*, and the fiddler crab, *Vea* sp.). Effects were incorporated into energy flow diagrams to better understand the system on a community level. These results were compared to those found in the literature. There

were also two sampling periods, May and September, at Jacksonville, Florida, on the St. John's River for comparisons of Spartina, Littorina irrorata, and Vea sp. abundances.

Keefe reviewed studies on fresh and saltwater marsh production and discussed their high productivity in comparison to terrestrial and phytoplankton communities. The role of the marsh flora as a food source was also discussed. She also points out the failure in recent research to ascertain the value of marsh detritus to the adjoining water body.

Cuzon du Rest studied the distribution of zooplankton in the salt marshes of southeastern Louisiana. This study was done in terms of seasonal (temporal) distribution and geographic (spacial) variance in salinity from nearly fresh water to nearly marine water (the total range was from 0.5 ppt to 25.4 ppt). Monthly abundances were determined for the numerically important species. Day carried du Rest's work one step further and determined respiration/production rates, as well as that quantity lost to higher trophic levels via waste for the single most abundant zooplankton, the copepod (Acartia tonsa). This species was also found to be the major component in other areas, specifically Florida, based on work done by Hopkins at St. Andrews Bay and Woodmansee in Biscayne Bay, who ascertained the number of generations of A. tonsa in a given year to be about 11.

Maturo, et al. (1974) characterized the zooplankton population in the Crystal River estuary. This was based on the distribution and structure of the zooplankton populations from July, 1972, to July, 1973. Sites were categorized as inshore, intermediate, and offshore. Salinity and temperature, and other environmental readings were taken with each sample. Within this report, Alden and Hearne discuss zooplankton production based on A. tonsa. Two methods were used to determine production. The first was based on computation of turnover time, which in turn was based on instantaneous death rates estimated from population age structures observed in the field and development time as determined by laboratory experimentation. A second method, based on metabolism, was also used. Here, using the proper assumptions, production is equivalent to the carbon assimilated less the carbon respiratory cost [which is equal to milliliters of oxygen consumed times 1.4 (density of oxygen) times .375 (ratio of carbon to oxygen in glucose)] divided by the carbon weight of the animals). Also within this report, Hallquist discussed ctenophore standing crop and predation. Standing crop was determined as a volume per cubic millimeter. Predation was determined in two ways: the first is based on the theory that feeding rate is a function of copepod concentration and ctenophore size; and the second on production values (specifically, total carbon ingested divided by total carbon available as zooplankton standing crop).

Carr and Giesel sampled marshland creeks near a steam-electric station near Jacksonville, Florida. The purpose of their study was to compare fish population in thermally impacted marshland creeks to a population

by the plant's effluent. Using a seine to collect samples, 48 different species were collected. Abundances and biomass per unit area for utilizable (defined here as those fishes used by man either as food or for various fish products) juveniles as well as values for the entire fish population over the time period of the study (June, July, and September) were ascertained. One major shortcoming of this report was its failure to statistically analyze differences at the various sites.

Harrington, in his paper on ecology, discusses food selection of fishes in different habitats, including a salt marsh. He explains how the selection of prey shifts both spacially and temporally from the onset of flooding through the progress of a mosquito brood.

Reid and Springer's reports reviewed the general ecological trends of fish communities in Florida. Reid's work was done in the vicinity of Cedar Key. Springer's report was done in the Tampa Bay area. Both authors point out that juveniles appear in the estuary during the late spring and early summer months. Sykes reconfirms this time of occurrence in his work on the appearance of juveniles of the dominant commercial fishes of the Gulf of Mexico.

6.1.3.2 PROPOSED CONSTRUCTION SITE

Information concerning FPC's site proposal number 3 was based on a single field effort undertaken by members of the aquatic group of Environmental Science and Engineering, Inc. Three transects which ran south to north were sampled (see Figure 6.1.3-1). One transect ran along the western boundary of the proposed site (Transect 1), one

along the eastern boundary (Transect 3), and the third midway between the two (Transect 2). The distances between the transects were approximately .8 km (0.5 miles), and the total length of each was .8 km (0.5 miles).

At various wet sites along each transect, a ponar sample was taken and, where it appeared applicable, dip net samples were taken. Ponar samples were sieved through a #30 mesh, all samples were preserved in 10 percent formalin, and returned to the lab where they were identified.

Site A on Transect 1 was the farthest site north and was taken in what appeared to be a permanent marsh; Site B was one of two small (approximately 3 meters in diameter), shallow, sandy bottom ponds in an open area; Site C had standing water approximately 46 cm deep with a litter-covered bottom; Site D was a "permanent pond" in thick woods with a leaf litter bottom; Site E was a habitat similar to that found at Site C. Small fish, tadpoles, dytiscids, hemipterans, and frogs were observed at the various sites.

Transect 2 would have been inaccessible except for a road which ran just west of and parallel to the transect. This road was traveled and, when possible, stops were made and short excursions were undertaken east to cross the proposed transect. A total of four such walks were made. Five of six "water holes" were observed; three or four were small wallows (less than 2 meters in diameter), and two appeared to be

major water reserves (greater than 3 meters in diameter with flora frequently associated with water systems observed in the vicinity, e.g., sawgrass, arrowhead, pickeral weed, and spatter dock). All were dry. No streams or stream-like systems were noted.

Transect 3 was inaccessible with the exception of the very northern border and just south .4 km (1/8 mile) of the southern border. However, based on these two observations, (observations at Transect 2, and gross observations in the general vicinity of Transect 3), no water is believed to be present.

At a later date members of the terrestrial group of Environmental Science and Engineering surveyed the area and noted several water bodies in the general vicinity of Transects 2 and 3. However, minimal faunal activity was noted in these systems, and the substrate appeared to be hard limestone with minimal litter present.

6.1.3.3 TERRESTRIAL ECOLOGY

Wharton, et al. (1976) have described the forested wetlands of the region in a general sense, while Pearson (1954) has described the mammals of the similar Gulf Hammock area in Levy County, which occurs about 16 km north of the site.

Numerous studies have been carried out by the U.S. Forest Service and the Florida Game and Fresh Water Fish Commission as part of the Cross Florida Barge Canal Restudy Report (U.S. Army Corps of Engineers, 1976). While most of the information was gathered along more easterly reaches of the canal, specific data on such items as forest stand composition and endangered species occurrence were gathered for the western end of the canal, which terminates about three miles north of the plant site.

Studies carried out between 1969 and 1976 during the environmental assessment of the Crystal River Unit 3 nuclear plant were primarily concerned with the salt marsh and estuarine systems. Terrestrial studies were largely confined to surveys of food webs and dietary habits of species in which radioactive nucleotides could accumulate (Pruit, 1974).

A study of potential salt spray impacts near the site (Dames-Moore, 1974) developed limited specific data on species present at the site.

Vegetative Parameters

The above studies and additional literature were used to obtain regional information. Field studies to develop site specific information took place from August 22 to August 27, 1977. The following methods of vegetation analysis were used.

Overstory vegetation was inventoried for the pine flatwoods, coastal hydric hammock, and mesic/hydric hammock complex along the transect lines shown in Figure 6.1.3-1. The point-quarter method of Cottam and Curtis (1956) was used with eight points randomly selected on each transect line. Species:area curves (Oosting, 1956) were used to insure that an adequate number of points were sampled.

Data collected were used to generate importance values, as formulated by Curtis and McIntosh (1951). Density, basal area, and average diameter at breast height were derived for pine plantations by sampling and computing tree diameter, the average distance between trees, and the average distance between rows.

Importance values and other parameters have been generated for overstory vegetation as follows:

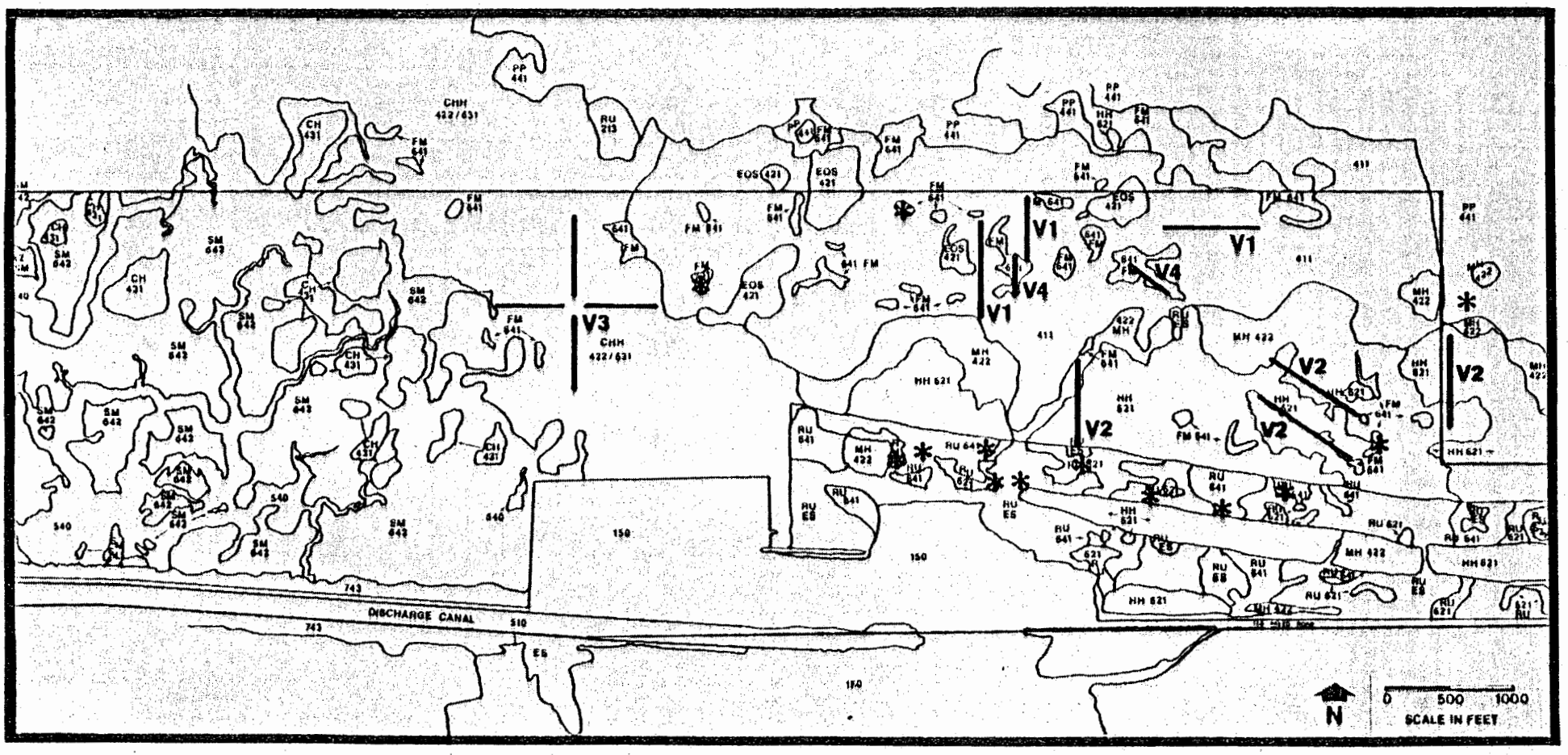
1. Relative density of species A =

$$\frac{\text{\# individuals of species A}}{\text{total \# individuals of all species}} \quad 100$$

2. Relative dominance of species A =

$$\frac{\text{total basal area of species A}}{\text{total basal area of all species}} \quad 100$$

SAMPLING AREA LOCATIONS FOR VEGETATION



V1 VEGETATION SURVEY LINE - PINE FLATWOODS
V2 VEGETATION SURVEY LINE - MESIC/HYDRIC HAMMOCK
V3 VEGETATION SURVEY LINE - COASTAL HYDRIC HAMMOCK
V4 VEGETATION SURVEY LINE - FRESH WATER MARSH
* VEGETATION - SPOT SAMPLE

Figure 6.1.3-1

3. Relative frequency of species A =

$$\frac{\text{frequency of species A}}{\text{sum of all frequencies for all species}} \quad 100$$

4. Importance value =

rel. density + rel. dominance + rel. frequency

Shrub vegetation includes all plants with height over 30 cm and a stem circumference of less than 2 cm. Ground cover includes all vegetation of height less than 1 meter. Both of these were sampled in 12.6 square-meter circular plots for estimated percent cover and frequency in two plots on each transect. Plots in marsh and ruderal areas were located at approximately 40 meter intervals. Only one plot per stand was used when stand width was less than 40 meters.

The floristic similarity of plant communities sampled was expressed using Sorensen's community coefficient index of similarity (Mueller-Dombois and Ellenberg, 1974). This method compares the number of species common to both communities to the total number of species found in both communities, thus:

$$IS = \frac{2C}{A + B} \times 100$$

where C is the number of species common to both commmunities, A is the total number of species found in community A, and B is the total number of species found in community B.

Age of trees, at the site, was estimated from the number of annual rings found in core borings of trunks or observed on cut-over tree stumps. Phloroglucinol dye was used to help identify rings.

Vegetative communities at the site were mapped from 1 inch:500 feet black and white aerial photographs, and ground-truthed and refined during the field survey. The map has been compared to the draft wetlands map of the National Wetlands Inventory (U.S. Fish and Wildlife Service, 1977) and found to be in good general agreement. Minor differences are felt to be the result of higher resolution photographs and increased ground truthing used in the site survey. The regional vegetation map was prepared from a 1 inch:2000 feet black and white aerial photograph. In addition to the information gathered by the methods above, qualitative observations were recorded about each community in regard to hydroperiod, evidence of fire, human disturbance, and various other factors. Estimates of depth of surface soils were made by inserting a 1/4 inch diameter brass rod into the soils.

Taxonomic determinations were based primarily upon the following sources: Kurz and Godfrey, 1962; Long and Lakela, 1971; Radford, et al., 1968; Ricketts, 1966; and Wherry, 1964.

Fauna

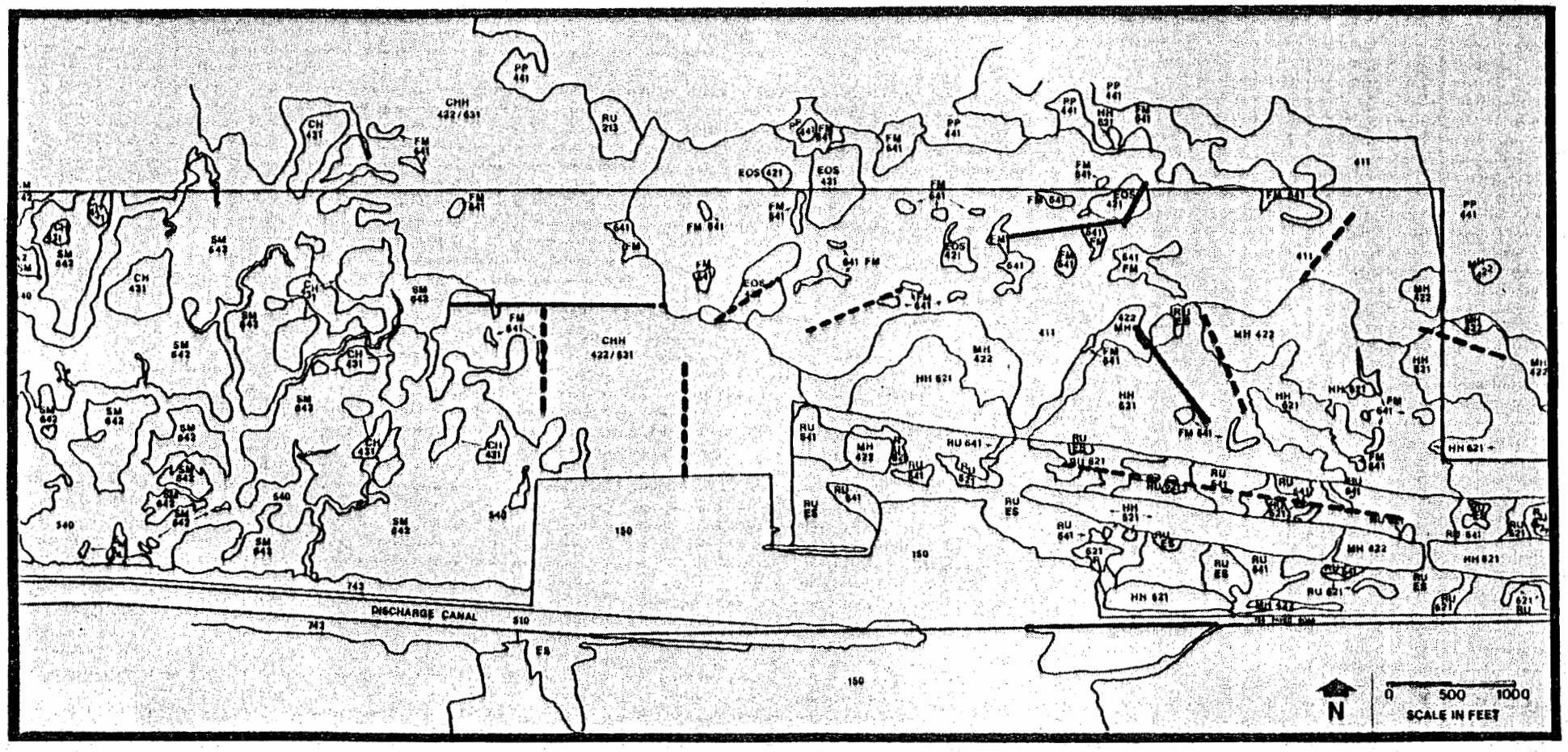
The primary objective of the faunal sampling program was to verify the mammal, bird, reptile, and amphibian species occurring in the area and to determine the relative abundance of each species. Strict quantitative techniques involving mammal trapping, drift nets, mist nets, etc., were determined to be unnecessary for the proposed project. Instead, diurnal and nocturnal visual/auditory searches were made throughout the site, with frequency of observation recorded

for each species. Qualitative trapping efforts were conducted to establish the presence of small mammal populations in various habitats. In addition, habitat evaluations were made to determine the possible habitat utilization by important species and rare and endangered animals. A literature survey was conducted for the area of the plant site.

Small mammal trapping was accomplished with a Sherman live trap, victor mouse trap, victor rattrap, and a pitfall. One trap liner with 20 stations was placed in a longleaf pine/evergreen oak scrub, mesic/hydric hammock, and coastal hydric hammock communities (Figure 6.1.3-2). Stations were located 10 miles apart and each had one Sherman live trap and two victor snap traps. In addition, 7 pitfall traps (a number 10 galvanized can) were placed along each line. Nine traps were baited with a mixture of peanut butter and oatmeal and prebaited for 2 days. Lines were inspected daily and rebaited for 3 days. All species caught were noted as were the habitat types.

Habitat evaluation was made in each type found at the site. Primary objectives were to evaluate tracts of lands for their suitability as habitat for the more important species, namely deer, squirrel, quail, turkey, and rare and endangered animals. Habitat evaluation was made in each major ecosystem based on various types of cover, availability of food, water sources, and denning sites or nesting areas. Information was generated by walking transects and recording habitat conditions and species observed. Information on food sources was

SAMPLING AREA LOCATIONS FOR FAUNA



TRAP LINES

HABITAT EVALUATION AND SPECIES INVENTORY

Figure 6.1.3-2

primarily taken from the vegetative sampling. It should be pointed out that the purpose of these techniques was to give a practical means for assessment of habitats with regard to some of the more important species. In addition, areas with dense understory and ground cover of palmetto were only partially inventoried because of the limited accessibility. Preferred habitat, number observed, seasonal occurrence (birds only), and relative abundance have been given for each species. Relative abundance is classed as follows:

A = Abundant; encountered nearly every time preferred habitat was visited.

C = Common; encountered most of the time in preferred habitat.

U = Uncommon; may be encountered irregularly in preferred habitat.

R = Rare; encountered very infrequently in preferred habitat.

A literature survey was conducted by ESE personnel to search out any references pertinent to the general physiographic region and to the plant site in particular. Perhaps the best work on the fauna of this section of Florida is presented in the Cross Florida Barge Canal Restudy Report (1976). Nomenclature for the mammals follows that of Burt and Grossenheider (1964). Scientific and common names for the birds are those recommended by the Thirty-second Supplement to the American Ornithologists Union (1973) Checklist of North American Birds. The herpetofauna nomenclature was taken from Conant (1975).

6.1.4 GROUNDWATER

Descriptions of the ground water hydrology in the area were obtained from two reports. The first is Geraghty and Miller's Evaluation of Groundwater Resources (1977) at the plant site. This report provided the bulk of the groundwater informtion contained herein. Basically, the report provided a fairly comprehensive summary of previous groundwater investigations in the area. The other report (Faulkner, 1972) provided some extensive data concerning the geohydrology of the barge canal area. The data presented in this publication is not totally representative of the site and was not extensively utilized.

Data concerning rainfall in the vicinity of the site was obtained from the U.S. Department of Commerce (1975) from records kept at Inverness, Florida, 24 miles southeast of the proposed site.

6.1.5 AIR

The FPC Crystal River power plant is located in a rural area, isolated from other large point sources. Background values of sulfur dioxide, the major pollutant of electric generating plants, are assumed negligible in the vicinity of the site. No natural sources of sulfur dioxide that would constitute any appreciable concentration levels exist in the area.

Until recently very little background information for total suspended particulate matter in this area existed. Currently an ambient air sampling program for both sulfur dioxide and particulate matter has been operating since May, 1977, around the site location.

Ambient air quality data pertinent to the application are available from a four-station SO_2 and TSP ambient sampling network. TSP is measured with Federal Reference Method (FRM) Hi-Volume samples at each station. These monitors are operated on a once-every-sixth-day schedule, which corresponds with the schedule maintained by the regulatory agencies. Thermally controled FRM bubblers are operated at two stations. The SO_2 monitoring schedule also corresponds to that established by the regulatory agencies. FRM Equivalent Monitors are operated on a continuous basis at two stations. These monitors are Thermo Electron Model 43's with automatic zero and span. All calibrations are either composed with National Bureau of Standards or a primary standard. Procedures for sampling are explained in the appendices.

Local meteorological data are acquired at the site by an instrumental two-level tower. Data on wind speed and direction at two levels, plus ambient temperature, lapse rate, precipitation, and barametric pressure are measured continuously on or near the tower on strip charts. The sensors are routinely calibrated and maintained in accordance with Atomic Energy Commission sensitivity specifications for "met" towers (Unit 3 at Crystal River is a nuclear unit). Additional information on the meteorological tower can be found in the appendices.

On-site meteorological data was used in the dispersion modeling. The primary source was data from the 10-meter (33-foot) level of the meteorological tower. The tower, which is located southwest of the existing Crystal River units, is operated continuously. Precipitation data are gathered at ground level near the tower.

Cloud cover and cloud ceiling data for the determination of Pasquill's stability classes were taken from the U.S. Weather Bureau office at Tampa. This was the most representative location where data are available. Cloud cover and ceiling are recorded each hour by a trained observer at the U.S. Weather Bureau office.

Three EPA-developed guassian dispersion models were utilized for all modeling. The Air Quality Display model with Briggs plane rise equation was used for the annual estimates. Short-term impacts were estimated with the single source CRSTER model and multi-source Point Multiple

model (PTMTP-W). These models are currently considered the "state-of-the-art" tools available for prediction of ambient air quality concentrations. A description of these models is contained in the appendices.

6.1.6 GEOLOGY

Geological data was obtained principally from four reports. The most useful of these was the Vernon (1951) study of geology in Citrus and Levy counties. The information contained in the Vernon report was obtained through logs of wells in the area as well as air-photo analysis of surficial features. Most of the data is not specific to the study area, but to the region.

Other geologic information was obtained from the Geraghty and Miller (1977) report, the Department of the Army, Navy and Air Force Seismic Design Manual (1973), and Faulkner's (1973) study of geology in the Ocala, Florida, area. All of these supplied only general information. The Geraghty and Miller report provided information on the stratigraphy of the study area based on existing well logs. The Department of Army, Navy, and Air Force report provided the relative probability of earthquakes in the study area.

6.1.7 ARCHAEOLOGY

In 1972, the Department of State, Division of Archives, History and Record Management, Bureau of Historic Sites and Properties conducted an archeological and historical survey under contract with the Florida Power Corporation. The agreement provided, basically, for the employment of two survey archeologists for a period of 2 1/2 months. They were to completely field check all FPC property in the Crystal River tract, and to devote any remaining time to survey those areas within a five mile radius of the plant site. FPC provided survey vehicles (four-wheel drive truck and a boat), storage and office facilities, and logistic and interpretive assistance.

Prior to field examination, the Florida State Master Site Files, local histories, records, old maps, etc. were reviewed to ascertain whether anything of known historical importance was located on or within a five mile radius of the Crystal River tract. Only two sites were previously recorded in the area.

The survey focused on the coastline and associated estuarine and river-line drainage within the specified 5 mile radius. The survey area extended from a point south of the mouth of Crystal River, north to a point north of the Withlacoochee River, in Levy County. Survey trips were made up Crystal River, Withlacoochee River, and several of the larger tidal drainages. Survey transportation was restricted to four-wheel drive and a boat. The surface surveys were accomplished by walking over those areas which were determined, (through the initial

research), to be the most likely locations of sites. Each site was recorded with the Florida Master Site File.

6.1.8 NOISE

The ambient noise baseline survey was conducted on October 18, 1977. Normally, the following selection criteria are employed (Bolt, Beranek and Newman, Inc., 1973) in determining noise monitoring stations:

1. Critical Noise Sensitive Sites:

   Such as schools, hospitals or churches on or near major thoroughfares;

2. Residential Areas; and

3. Remote Areas for "Noise Floor:"

   These should yield the lowest ambient noise level.

There are no areas fitting the first two categories within several miles of the existing and proposed plant sites. Noise floor levels are encountered between the plant and any noise sensitive sites. Thus, the scope of the baseline study included only the plant site and its immediate vicinity.

Stations were chosen in order to ascertain noise levels on the present plant site, the future plant site, and at various distance from each. It was the objective of this study to determine the "noise drop-off" characteristics from the present plant in order to gauge the future effects of the proposed facility.

A General Radio 1933 Precision Type noise monitor was utilized for execution of the monitoring survey. Each station was monitored one time while the plant was under normal operating conditions. Noise

measurements were taken every ten seconds and recorded. After fifty readings were taken and recorded, a test was made to determine whether or not the quantity L_{10} could be estimated within 2dBA of the actual level with 95 percent confidence. This test required that the first, fifth, and tenth highest readings be recorded in the same or in adjacent sound level categories.

If the criteria were not met, then fifty more measurements were made and the criteria were applied to the fifth, tenth, and seventeenth highest readings.

Each data sheet represented one set of noise readings at each station. The levels (L_{10} and L_{50}) exceeded 10 percent and 50 percent of the time were discerned and the standard deviation (of a distribution assumed to be normal) was estimated. The power equivalent (L_{eq}) sound level was then calculated according to the equation:

$$L_{eq} = L_{10} - 1.28\ S + 0.115\ X^2$$

or

$$L_{eq} = L_{50} + 0.115\ S^2$$

where:

S = standard deviation of all measurements from mean measurement

CHAPTER 7

ECONOMIC AND SOCIAL EFFECTS OF PLANT CONSTRUCTION AND OPERATION

7.2 COSTS AND BENEFITS OF THE PROJECT TO POWER USERS AND TO FLORIDA POWER CORPORATION

7.2.1 COSTS ATTRIBUTABLE TO PROPOSED CRYSTAL RIVER UNITS 4 AND 5

The cost-benefit analysis of the proposed project utilizes cost information that was originally developed to evaluate the choice between low-sulfur and high-sulfur coal (see Chapter 8). The annual costs of capital, fuel, and operation/maintenance have been determined for Crystal River Units 4 and 5 in each year of operation. The cost estimates assume the use of saltwater cooling towers. The present worth of these power generation costs for each unit has been determined by discounting back to April 1, 1978, using the estimated cost of capital to Florida Power (11.1 percent). The figures for the low-sulfur coal option, which is the only relevant case here, are shown in the upper portion of Table 7.2-1.

The assumptions underlying the estimated power generation costs are discussed in Chapter 8. Two especially significant quantities are the rates of escalation in fuel costs and operation/maintenance costs. The delivered cost of coal is assumed to rise by 10 percent per year between 1977 and 1980, and by 5 percent per year after 1980. Operation/maintenance costs are assumed to escalate indefinitely at a rate of 6 percent per year. Thus, the estimated power generation costs assume continued inflation in the U.S. economy. This point becomes important when placing a dollar value on the electricity produced.

The total costs attributable to the construction and operation of Crystal River Units 4 and 5 include a number of elements other than power generation expenditures. It is necessary to account for the costs of transmitting and distributing the electricity generated, plus the general administrative expenses and tax payments incurred by Florida Power. In addition, the proposed power generation units must contribute to the net income available for dividend payments to Florida Power stockholders. The information utilized to estimate these additional costs is presented in Table 7.2-2.

Table 7.2-1 Summary of Incremental Costs Associated with Crystal River Units 4 and 5

	Present Worth of Expenditures in Millions of April 1978 Dollars		
	Unit 4	Unit 5	Total
POWER GENERATION COSTS			
Capital	292.8	191.6	484.4
Fuel	700.5	644.0	1,344.5
Operation/Maintenance***	54.8	51.0	105.8
SUBTOTAL	(1,048.1)	(886.6)	(1,934.7)
SHARES OF OTHER COSTS ATTRIBUTABLE TO UNITS 4 AND 5			
Transmission, Distribution, and Administration*	87.8	80.8	168.6
Capital Costs Other than Power Generation Facilities †	20.4	13.4	33.8
Taxes Payable Currently**	129.4	119.1	248.5
Dividend Payments ††	110.3	101.5	211.8
SUBTOTAL	(347.9)	(314.8)	(662.7)
TOTAL PRESENT WORTH	1,396.0	1,201.4	2,597.4

* Assumed equal to 11.63 percent of fuel plus O/M costs.
† Assumed equal to 7 percent of capital costs for power generation.
** Assumed equal to 17.13 percent of fuel plus O/M costs.
†† Assumed equal to 14.60 percent of fuel plus O/M costs.
*** Operation/maintenance costs do not include contingencies associated with the operation of saltwater coding towers; only normal costs are included.

Sources: Florida Power Corporation, 1978.
Environmental Science and Engineering, Inc., 1978.

Table 7.2-2 presents a summary of revenue and expense statistics for Florida Power in 1977 and 1976. The portions of operating income devoted to dividend payments, net interest payments, and retained earnings are indicated by the figures in parentheses. The procedure used in assigning non-production costs to the proposed Crystal River units is to express the actual costs for 1977 and 1976 as percentages of production and maintenance costs, and then to apply the percentages to the future production costs for the proposed units. For example, the total cost of power transmission, distribution, and administration was equal to 12.23 percent of production and maintenance cost in 1977, and 11.02 percent in 1976 (see the lower portion of Table 7.2-2). The average of these two figures, 11.625 percent, can be applied to the sum of fuel and operation/maintenance costs for the proposed units to estimate the share of future transmission, distribution, and administrative costs attributable to these units. The present worth of each of these additional cost elements is listed in the lower portion of Table 7.2-1.

The additional cost elements shown in the lower portion of Table 7.2-1 do not include interest payments or funds used for new construction (indicated by asterisks in Table 7.2-2), since these items are already covered by the capital costs listed elsewhere in Table 7.2-1. However, estimates are included for capital costs other than power generation facilities. The shares of these costs attributable to the proposed Crystal River Units 4 and 5 are assumed to equal 7 percent of the capital costs for power generation.

The outcome of these computations is that the total present worth of expenditures associated with construction and operation of the proposed units is estimated at $2,597 million in April 1978 dollars (shown in the bottom line of Table 7-2.1). The present worth of Unit 4, at approximately $1.4 billion, is substantially above the worth of $1.2 billion assigned to Unit 5. The difference is due to sharing of facilities with Unit 4 and to the fact that costs occur later for Unit 5 than for Unit 4. These present worth values are intended to cover all costs

1980 would imply that not all of the fuel cost increment will be passed on to Florida Power consumers.

Each of the proposed units is expected to generate an average of 3,300 Gwh of electricity per year over its 30-year active life. (Utilization of the full 640-Mw net capacity would imply power generation at a rate of 5,610 Gwh per year.) Using each of the four escalation rates listed in Table 7.2-4, the average price of electric power has been determined for every year between 1982 and 2013, based on a 1977 price of $0.0383 per kwh generated. These future prices have been multipled by 3,300 Gwh, discounted back to April 1, 1978 (using the cost of capital as the discount rate), and summed to yield a present value of electricity sales in millions of dollars. The resulting figures for each power generation unit, given each rate of price escalation, are presented in the first two columns of Table 7.2-5.

The total present worth of electricity sales in each case is presented in the third column of Table 7.2-5. The fourth column gives the present worth of project cost (from Table 7.2-1), which is the same for all four cases. The ratio of sales to cost is presented in the last column of Table 7.2-5. This ratio indicates the benefit-cost status of the project to Florida Power as a corporate entity (but not necessarily to its employees, customers, stockholders, etc.). A ratio of unity would mean that all project costs would be covered by revenues over the long run, including a reasonable return to investors. If Florida Power were a typical profit-making enterprise, a ratio greater than unity would mean that the project could be expected to yield excess profits. However, given that the company is a regulated public utility (and that any future electricity prices will be regulated prices), a value greater than unity probably indicates that the proposed project would be subsidizing other, less efficient power generation units.

The last column of Table 7.2-5 shows that the benefit-cost ratio of the project for Florida Power will be almost exactly unity in two different scenarios: (1) if electricity prices escalate at a uniform rate of 4.5

Table 7.2-5 Present Worth of Electricity Sales and Florida Power Corporation Expenditures Attributable to Crystal River Units 4 and 5

		Present Worth of Sales, in Millions of April, 1978 Dollars			Present Worth of Expenditures (Millions of Dollars) April, 1978	Sales/ Expenditures Ratio
		Unit 4	Unit 5	Total		
Assumed Rate of Escalation in the Average Sale Price of Electricity per kwh						
Case I:	4% per year	$1,262.1	$1,143.1	$2,405.2	$2,597.4	0.93
Case II:	4.5% per year	$1,361.0	$1,241.6	$2,602.6	$2,597.4	1.00
Case III:	5% per year	$1,469.7	$1,350.4	$2,820.1	$2,597.4	1.09
Case IV:	6.7% until 1980 4% after 1980	$1,362.3	$1,233.8	$2,596.1	$2,597.4	1.00

Source: Environmental Science and Engineering, Inc, 1978.

percent per year; or (2) if the price escalation rate is 6.7 percent until 1980 and 4 percent per year thereafter. A price escalation rate of 5 percent will yield a benefit-cost ratio of 1.086, whereas the ratio will be only 0.926 if electricity prices escalate at 4 percent per year.

According to these figures, it will not be necessary for Florida Power to pass on the full increases in fuel cost and operation/maintenance cost to consumers in order to break even on the proposed units. In both of the scenarios involving benefit-cost ratios near unity, the assumed escalation in electricity prices would be less than the escalation in fuel and operation/maintenance costs (except that the operation/maintenance escalation rate would be exceeded slightly during 1977-1980 in Case IV). However, it may be more likely that both the Consumer Price Index and the average price of electricity will escalate at 5 percent per year or more so that the proposed Crystal River Units 4 and 5 will occupy a role of subsidizing other facilities operated by Florida Power. In any case, it appears highly unlikely that the proposed Crystal River Units 4 and 5 will fail to yield sufficient revenue to cover all expenses attributable to these facilities.

9.4.3 ALTERNATIVES CONSIDERED

Water source alternatives considered ranged from salt water to brackish water to fresh water. For purposes of discussion, water sources were categorized as fresh water or salt water. The following sources were considered:

Fresh Water	Salt Water
Crystal River	Gulf of Mexico
Withlacoochee River	Withlacoochee Reach of Barge Canal
Lake Rousseau	Saline Aquifer (deep wells)
Freshwater Aquifer (shallow wells)	

Intake structure alternatives depend on the selection of the water source. Alternative structures considered were applicable only to surface water sources, and were as follows:

- Vertical traveling screens
- Double entry vertical traveling screens
- Perforated pipe
- Inclined traveling screens
- Horizontal traveling screens

Freshwater Alternatives

Freshwater sources include the Crystal River, 4.8 kilometers (3 miles) to the south, and the Withlacoochee River and Lake Rousseau, 6.4 and 5.8 kilometers (4 and 3.6 miles) to the north and northwest, respectively, and a well field 9.2 kilometers (5.7 miles) to the east of the plant site (Figure 9.4-1). In each case, 76.2-centimeter (30-inch) diameter reinforced concrete pipe would be used to convey the raw water to the plant site.

Crystal River

Crystal River as a source of cooling water was considered with an intake structure at a site approximately 4 kilometers (2.5 miles) downstream (west) of the town of Crystal River. The Crystal River runs from several head springs at Kings Bay, westward to the Gulf of Mexico. The maximum flow during normal tides is about 112 cubic meters (4,000 cubic feet) per second, 9,780,000 cubic meters (2,584 million gallons) per day. Interactions of wind and tidal forces result in complex mixing processes between fresh spring water and estuarine water causing large salinity variations (ESE, 1977). The river contains many aquatic weeds including Hydrilla. A wide variety of aquatic organisms are found in the river including freshwater and estuarine forms. The endangered manatee is common in the river. The river acts typically as a home for many planktonic eggs, larvae, and juveniles of many estuarine species. Preliminary studies suggest that at some seasons of the year, young, entrainable forms of Anchoa .sp. (anchovies) and Callinectes sapidus (blue crabs) are present at the proposed intake site.

The Crystal River pumping facility for cooling water makeup consists of an intake structure housing either three vertical traveling screens or three double entry traveling screens with three 50 percent capacity vertical pumps, each rated at 28 cubic meters (7,500 gallons) per minute. Approximately 16,500 meters (54,000 feet) of piping are required to convey the river water to the plant site.

Lake Rousseau

Lake Rousseau is an artificial impoundment of the Withlacoochee River which was created by Florida Power Corporation in 1909 for hydroelectric power generation. During the 1960's, the lake became part of the U.S. Army Corps of Engineers Cross Florida Barge Canal project. The lake was modified for the barge canal project with the construction of the Inglis Lock, the Withlacoochee River Bypass Canal and the Gulf of Mexico reach of the barge canal (which lies west of the lake). The construction of

the present structures at the Inglis Lock and bypass canal were completed in 1969. The barge canal project has been terminated by President Carter due to environmental and political controversy. Studies and discussions are in progress to decide final disposition of the barge canal project including those structures on or abutting Lake Rousseau.

An area of the lake east of the Inglis Dam has been chosen by Florida Power as the general location of a proposed cooling water intake structure. This area extends from the dam upstream about 2.4 kilometers (1.5 miles) and has been the site of detailed multidisciplinary studies by ESE (1978).

The lake is part of a system modified by the construction of the Withlacoochee Reach of the Cross Florida Barge Canal. Opening of the canal and a northern bypass for the Withlacoochee River has considerably reduced the flow of water through the southwestern arm of the lake where an intake is presently proposed. Drawing the water volume estimated by Black and Veatch (1977) for cooling would increase the flow in this arm of the lake. This would perhaps resuspend sediments currently stored on the lake bed but ultimately may cause hydrodynamic conditions in the lake to be more like those before the Inglis Bypass was opened.

The bathymetry of Lake Rousseau is shown as a drowned river valley. Depth contours are widely spaced from the shoreline to the old river channel. At the river channel the isobaths are closely spaced indicating a V-shaped channel. The old river channel meanders tortuously through Lake Rousseau indicating a complete lack of structural and bedrock control. Several meander "necks" and "cutoffs" (as defined by Thornbury, 1954) indicate that the Withlacoochee was developing a valley flat prior to its flooding.

By planimetry the volume of Lake Rousseau [at 8.2 meters (27 feet) mean sea level] was found to be in excess of 3.1×10^7 cubic meters (25,000 acre-feet). The surface area of the lake, excluding marshy areas, is approximately 1,200 hectares (3,000 acres). Compared to the

annual excess flow through the lake of 9.0 x 10^8 cubic meters per year (730,000 acre-feet/year, Geraghty and Miller, 1977), the storage volume is small. This fact is critical in assessing the availability of water in the lake for consumptive use (ESE, 1978).

Sufficient water appears to be available from Lake Rousseau for cooling purposes. Based on USGS figures, the proposed project would require a maximum consumptive use of 76,000 cubic meters (20 million gallons) per day; and according to USGS figures, this is 3.3 percent of the Withlacoochee River 100-year low flow (ESE, 1977).

Shallow Well Fields

Well fields were discussed as an alternative in a report prepared by Geraghty and Miller, Inc. (1977), consulting groundwater geologists and hydrologists.

The well field would be located 8.7 kilometers (5.4 miles) east of the plant site to minimize the potential for horizontal saltwater intrusion. The characteristics of the aquifer in the area, as estimated by Geraghty and Miller from a flow net analysis, should be adequate to support the proposed withdrawal.

An aquifer test performed by Geraghty and Miller (1978) obtained much lower transmissivity values suggesting that groundwater flow to Crystal River may occur through solution channels or local zones of high permeability.

If high transmissivity zones were encountered in the well field, the field could require as few as five wells. However, in the absence of verification of this transmissivity data and based upon aquifer coefficients from the aquifer test, the conceptual well field would require a linear arrangement of 139 wells spaced 152 meters (500 feet) apart in order to produce the desired yield of 76 million liters per day (20 million gallons per day) and comply with Southwest Florida Water

Management District Rules and Regulations. Each well would produce 380 liters per minute (100 gallons per minute). The transmission line would amount to approximately 21 kilometers (13 miles) of pipe in the well field itself and another 8 kilometers (5 miles) of pipe to convey the water to the plant site.

Withlacoochee River

The Withlacoochee River is 6.4 kilometers (4 miles) to the north of the Crystal River plant site. It drains an area of approximately 518,000 hectares (1,280,000 acres) in its 256-kilometer (159-mile) course. Average discharge is about 1,938 cubic meters (512,000 gallons) per minute. Most of this flow goes into Lake Rousseau which has inundated a stretch of the old river channel. The majority of the inflow to Lake Rousseau goes into the barge canal and is then diverted above the Inglis Lock into the Withlacoochee Bypass Canal and is discharged back into the existing river channel downstream from Lake Rousseau. About 723 cubic meters (191,000 gallons) per minute below the Inglis Dam is diverted back into the barge canal.

Although no pumping facilities design is available at this time, it is assumed that it would be similar to the one proposed for the Crystal River pumping facility.

Saltwater Alternatives

Sources of saltwater cooling are (1) the Gulf of Mexico, (2) the Withlacoochee Reach of the Cross Florida Barge Canal, and (3) the saline aquifer (deep wells).

9.4.3 ALTERNATIVES CONSIDERED

5.1.4 COOLING TOWER DRIFT

Since the proposed cooling tower will operate with fresh water, salt drift will not be a large problem. The Applicant does not intend to use chromium compounds as biocides and plans to limit chlorine concentrations in the blowdown. Chemical characteristics of the projected blowdown are presented in Chapter 3. Calcium and sulfate make up the majority of dissolved materials with concentrations of 1,000 and 1,219 mg/l as $CaCO_3$.

Using the projected drift rate of 15/lpm (40 gpm) as presented in Chapter 3, the estimated amounts of calcium and sulfate in drift are:

.151 kilograms per minute (calcium)

.176 kilograms per minute (sulfate)

Drift deposition rates were determined for average worst-case meteorological conditions. These include a high relative humidity, moderate wind speed, and a constant atmospheric stability. A drift model developed by Hanna (1974), was utilized to determine the distance from the tower at which particles of various sizes would strike the ground. Plume rise for moist plumes was calculated by combining a dry buoyancy term (due to temperature difference of moist and dry ambient air) with a wet buoyancy term (due to the differences in mixing ratio between the tower-exit air and ambient air). Plume centerline and radius are calculated using the methods of Briggs (1972).

The model utilized the following assumptions:

1. Particle temperature is equal to ambient temperature.

2. A particle settles within the plume from the centerline and then breaks free from the plume. Ambient relative humidity then influences the trajectory of the particle.

3. Rate of evaporation is determined from standard cloud physics.

In the worst-case model, a relative humidity of 90 percent enables part of the particle to evaporate during descent. An initial upward velocity of 1.5 m/sec was assumed. The formula for plume rise is:

$$H = 2.9\ (F/us)^{1/3}$$

where F is the buoyancy flux (m^4/sec^3); u is the wind speed (m/sec) assumed to be 5.0; and, s is the atmospheric stability (sec^{-2}), a function of the lapse rate and ambient temperature. Plume height, calculated as shown above, was 186 meters (610 feet).

With the model by Hanna (1974), and nomographs of Hosler (1973), the information presented in Table 5.1.4-1 was developed. This information is for a single cooling tower. Figures are for deposition of calcium and sulfate in roughly equal proportions. The land area receiving each particular rate of deposition is given in the left column. The zone indicated is the rough boundary of this area measured from the base of the tower.

Table 5.1.4-1 Deposition of Calcium and Sulfate from a Single Cooling Tower

Area of surrounding land receiving each deposition rate (hectare)	Zone in kilometers from tower base	Deposition rate (kilograms per hectare per week)
4,000	3.7 to 10	.24
3,200	2.0 to 3.7	.4
400	0.8 to 2.0	1.2

Source: Environmental Science and Engineering, Inc.

Literature concerning salt-drift effects is summarized in Chapter 9. Current research does not reveal large effects from drift due to salt-water towers. It appears improbable that drift from freshwater towers, as used here would be significant in the absence of toxic materials like chromium or zinc.

5.1.2 BIOLOGICAL EFFECTS OF GROUNDWATER WITHDRAWAL

In general, the potential effects of groundwater withdrawal are primarily one biological communities associated with surface fresh waters. These freshwater areas may be connected with ground water and may experience changes in water level due to withdrawals.

5.1.2.1 GENERAL DISCUSSION

Impacts of well field groundwater withdrawal on vegetation and wildlife can be significant. Impacts could result from surface water table lowering and consequent drainage of temporary or permanent wetlands. Estimates of these water level changes are based on the calculations in Section 5.1.1, seasonal fluctuations of three nearby wells (Geraghty and Miller, 1977), and their relation to land surface elevation (USGS topographic maps). The analysis indicated that wet season water tables may be as much as 2 feet above land surface in depressed wetland areas south and west of the well field site. Significant drawdowns could lower the water table sufficiently to permanently alter the character of these marshes. Such changes might be from permanent marshes (pickeralweed, waterlily) to seasonally flooded marsh (smartweed, arrowhead, sawgrass) to wet prairies as the water table drops below ground surface temporarily, then permanently. Severe drawdowns could lead to development of pine flatwoods vegetation or to use of the area as pasture (Florida Game and Freshwater Fish Commission, 1976). Consequent impacts are changes in species composition, productivity, food web relations, wildlife habitat, and habitat for such rare and endangered plants as sundews.

The effect on wildlife could be a reduction in wetland habitat in the surrounding area where there are presently numerous ponds, marshes, and prairies. Associated with these areas are many aquatic or semi- aquatic groups of birds, mammals, reptiles, and amphibians. If the character of the marshes and ponds is changed, a qualitative change may occur in the faunal communities.

Possible changes include a decrease in habitat for waterfowl, shore, and wading birds; a loss of breeding area for some amphibians (e.g., green tree frogs, newts); and a decrease in suitable habitat for certain aquatic reptiles (e.g., banded water snake, ribbon snake). Generally, the fauna could adapt to the characteristics of drier ecosystems. Where soils overlaying limestone are less than 1/3-meter deep, a degree of vegetation loss could result.

5.1.2.2 ESTIMATED EFFECTS

Impact due to drawdown from the proposed wellfield would be confined to nearby area (see Section 5.1.1.4). Drawdown rates outside of this area should cause only minor changes in marshes.

The cypress domes north of the well field should not be affected. Since the land-surface elevation is about 6 to 8 meters (20 to 25 feet) and the water table about 3 to 5 meters (10 to 15 feet), these are probably

perched upon impervious confining layers and unaffected by such changes.

Effects on wildlife would be proportional to effects on surface waters. With small amounts of surface drawdown, less wet habitat and fewer associated organisms would be affected.

5.0 ENVIRONMENTAL IMPACT OF PLANT OPERATION AND ASSOCIATED TRANSMISSION FACILITIES

This chapter will discuss primary and secondary impacts of operation of the electric power generating facilities, and was based upon design information available (November 7, 1977, Black and Veatch, Chapter 3).

5.1 HEAT DISSIPATION SYSTEM

The heat dissipation system proposed in Chapter 3 used fresh ground water flowing in natural draft cooling towers. As a result, no aquatic organisms would be entrained or impinged. Since water ejected from the cooling system would be only coolside blowdown, no thermal impacts are expected in the receiving water body. Impacts might be associated with the withdrawal of ground water and the atmospheric discharges of the cooling tower.

5.1.1 PHYSICAL EFFECTS OF GROUNDWATER WITHDRAWAL

Water for the proposed FPC power plant at Crystal River will be obtained from a well field about 8.2 km (5 miles) east of the plant site (see Figure 5.1.1-1). The tentative design of the well field is in the form of an east/west line along the north boundary of section 32, township 17S, range 17E. The west well will be on the FPC power line right-of-way about 300 meters (1,000 feet) east of the northwest corner of section 32. The wells will be spaced approximately 300 meters (1,000 feet) apart.

LOCATION OF PROPOSED WELL FIELD AND USGS OBSERVATION WELLS

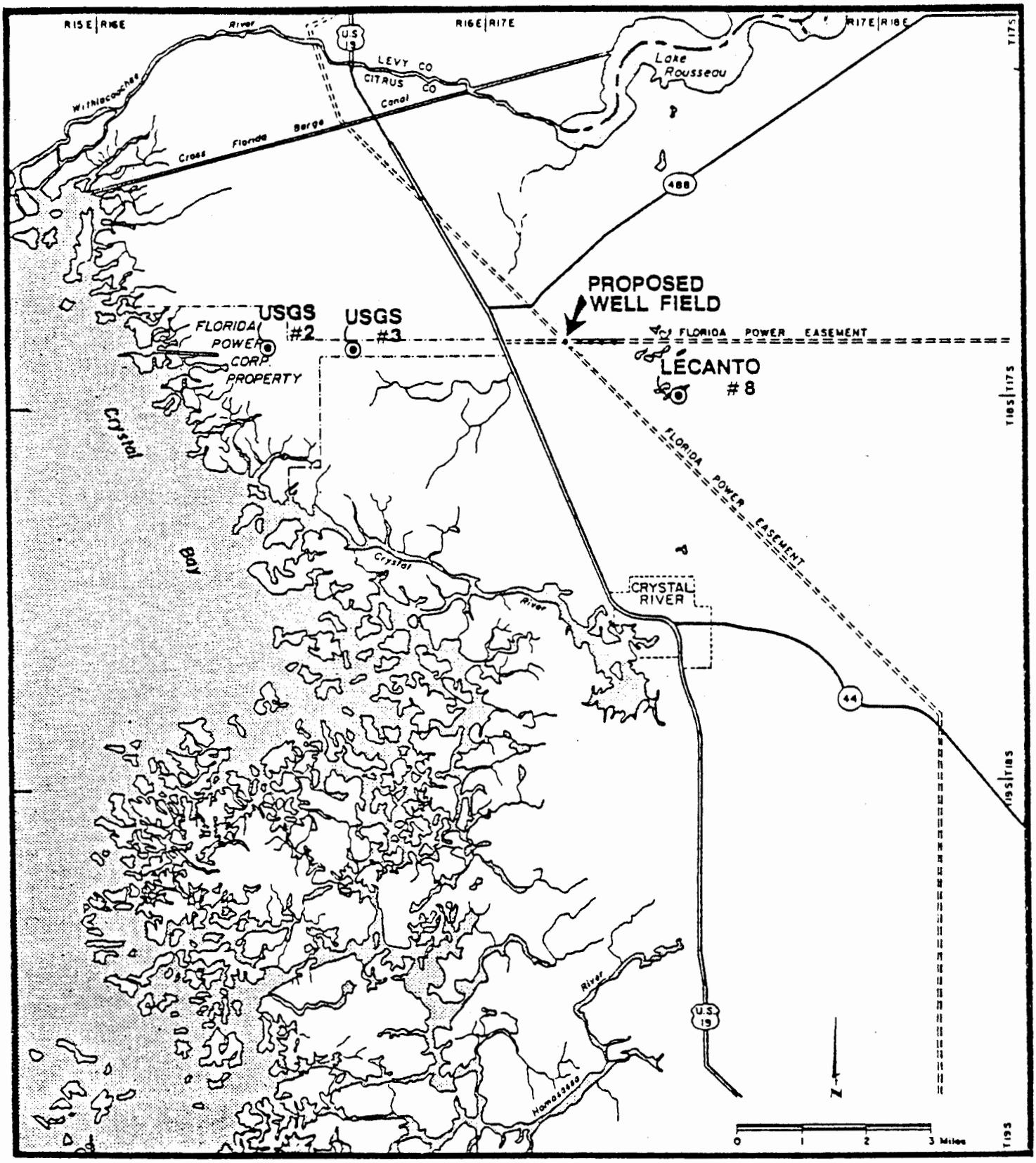


Figure 5.1.1-1

The wells will be drawing from the Floridan Aquifer, a limestone aquifer with intensive solution channeling. Peak pumpage is expected to be 51,860 liters per minute (lpm) (13,700 gpm, or 19.7 mgd) and normal pumpage will be about 31,800 lpm (8,400 gpm, or 12.1 mgd). During temporary shut down, the pumpage will be about 3,060 lpm (80 gpm or 0.1 mgd) (Black and Veatch, 1977).

Water levels in an USGS observation well (285701082345201, Lecanto #8) tapping the water table level within a mile of the proposed well field have fluctuated from 1.13 to 2.82 meters (3.71 to 9.26 feet) above mean sea level.

The impact on the hydrology in the vicinity of the proposed FPC well field is based on aquifer characteristics derived from a flow net analysis, and estimated from the geology and geomorphology of the area. (Geraghty and Miller, 1977). The exact transmissivity of the Floridan Aquifer cannot be stated because pumping tests have not been conducted yet. However, from a flow net analysis, Geraghty and Miller calculated the value to be 18.6×10^7 lpd/m (1.5×10^7 gpd/ft). This is fairly representative of transmissivities in the area. A transmissivity value of 1.0×10^7 gpd/ft was used in order to conservatively estimate the drawdowns. Higher transmissivity will have the effect of spreading drawdown over a larger area, but reducing the magnitude of drawdown.

It is not known whether the material overlying the top of the Floridan Aquifer is impermeable enough to act as a confining layer. This is an important consideration. In a situation where the aquifer is unconfined the water is released from storage by gravity drainage, and the coefficient of storage (S) is equal to the specific yield of the material making up the aquifer. In such a case the storage coefficient is high, generally from 0.01 to 0.35 (Johnson, 1966). In a confined aquifer the storage coefficient is low, generally ranging from 0.001 to 0.000001 (Johnson, 1966), and the drawdown is much greater.

Two values for the storage coefficient were used, one represents an unconfined aquifer (S = 0.2) and the other represents a confined aquifer in the area (S = 0.0002). The unconfined aquifer condition is considered closest to the actual field situation at the well field. The second storage vlaue (S = 0.0002) was used in an attempt to simulate a "worst case" situation. In the worst case, the aquifer is assumed to lie under a relatively impermeable confining layer.

Drawdowns (i.e., water level declines) were calculated using the peak pumping rate 78 million lpd (20 mgd) for a period of 100 days. Peak

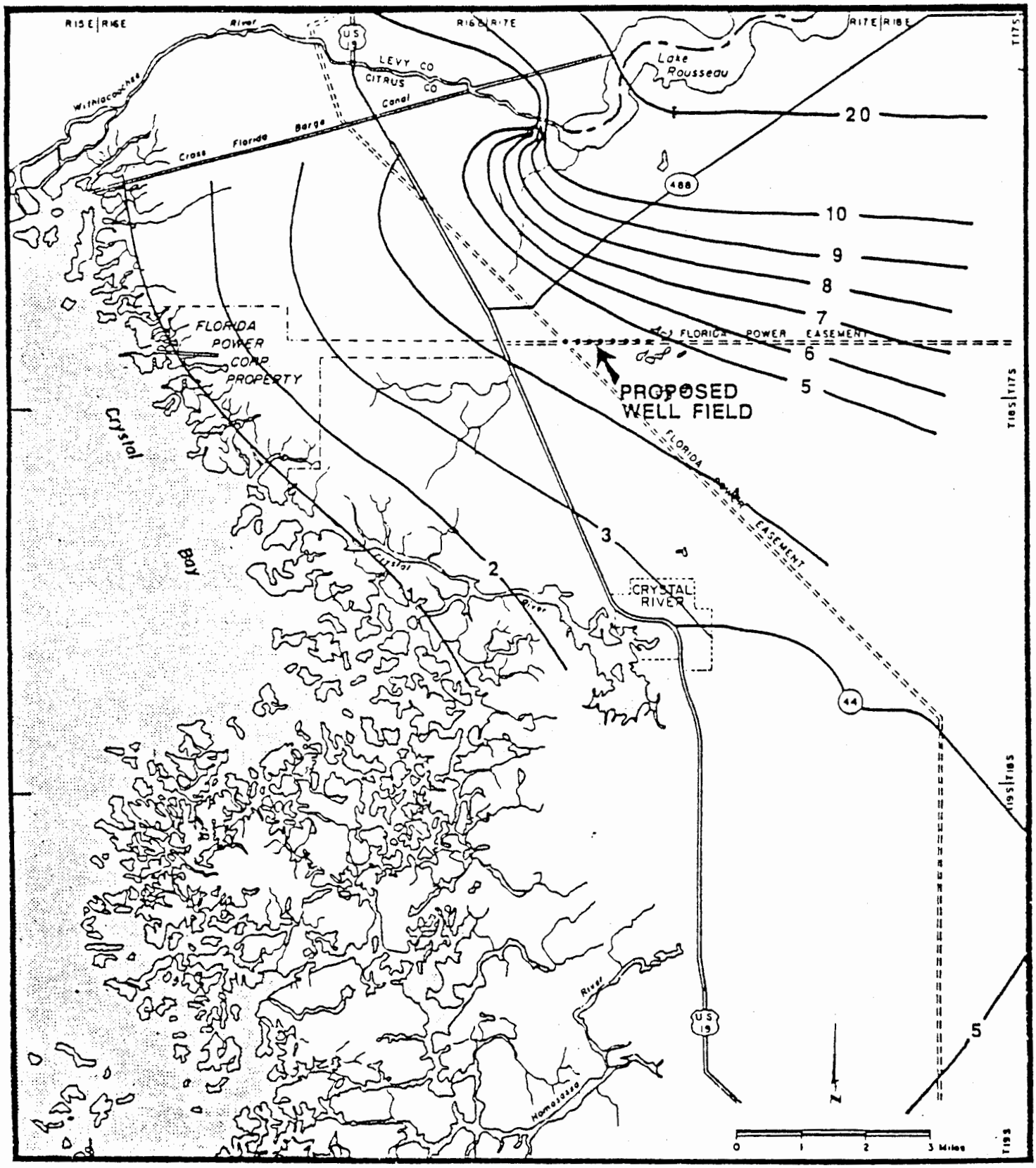
pumping rate is not likely to be continued for this length of time. These values were used in order to estimate worst-case impacts rather than to simulate the normal well field conditions. The two sets of drawdown conditions represent (1) a reasonable estimate of actual aquifer conditions (unconfined aquifer) under worst case pumping rates, and (2) the maximum or worst case doawdown conditions (confined aquifer).

The cone of depression from the pumping has been used to estimate the effect of groundwater withdrawal on the potentiometric surface of the upper Floridan Aquifer. The potentiometric map used is the May, 1975, map prepared by the USGS. Historical water level records from other wells in the vicinity indicate that the minimum water levels are approximately 0.3 meters (1 foot) lower than those shown on the May, 1975, map. Thus, this 1975 map represents a low water condition.

The potentiometric surface map is illustrated in Figure 5.1.1-2. The 0.3 meter (1 foot) contours have been estimated from the 5- and 10-foot contours as shown on the USGS potentiometric map for May, 1975, and water levels in USGS observation wells in the area.

The water surface elevation in the upper part of the Floridan Aquifer in the vicinity of the proposed well field fluctuates between 1.2 and 2.7 meters (4 and 9 feet) above mean sea level (msl).

POTENTIOMETRIC SURFACE OF UPPER FLORIDAN AQUIFER,
MAY, 1975. 8 WELLS.



— 2 — WATER SURFACE CONTOUR IN FEET ABOVE MSL

Figure 5.1.1-2

In the following discussion of groundwater withdrawals impacts, the reader should keep in mind that the computed drawdowns are theoretical in nature. Assumptions and most realistic estimates are necessary and are used to compute the numbers shown in the following paragraph. Assumptions are clearly identified in the text.

Drawdowns are calculated for a wellfield design of eight and five wells for both confined and unconfined aquifers using the Theis equation (Walton, 1970).

The following assumptions were made in the calculations:

1) The water bearing formation is isotropic (homogeneous);
2) The water bearing formation has a uniform thickness;
3) The water bearing formation has an infinite areal extent;
4) No recharge occurs during pumping;
5) The wells penetrate and receive water from the full thickness of the aquifer; and
6) Water is removed from storage instantaneously.

Values used in the computations are:

1) Transmissivity (T) = 12.4×10^7 lpd/m (10,000,000 gpd/ft);

2) Storage coefficient (S) = 0.2 (unconfined aquifer) and 0.0002 (confined aquifer);

3) Discharge rate (Q) = 78 mld (20 mgd)

4) Time (t) = 100 days.

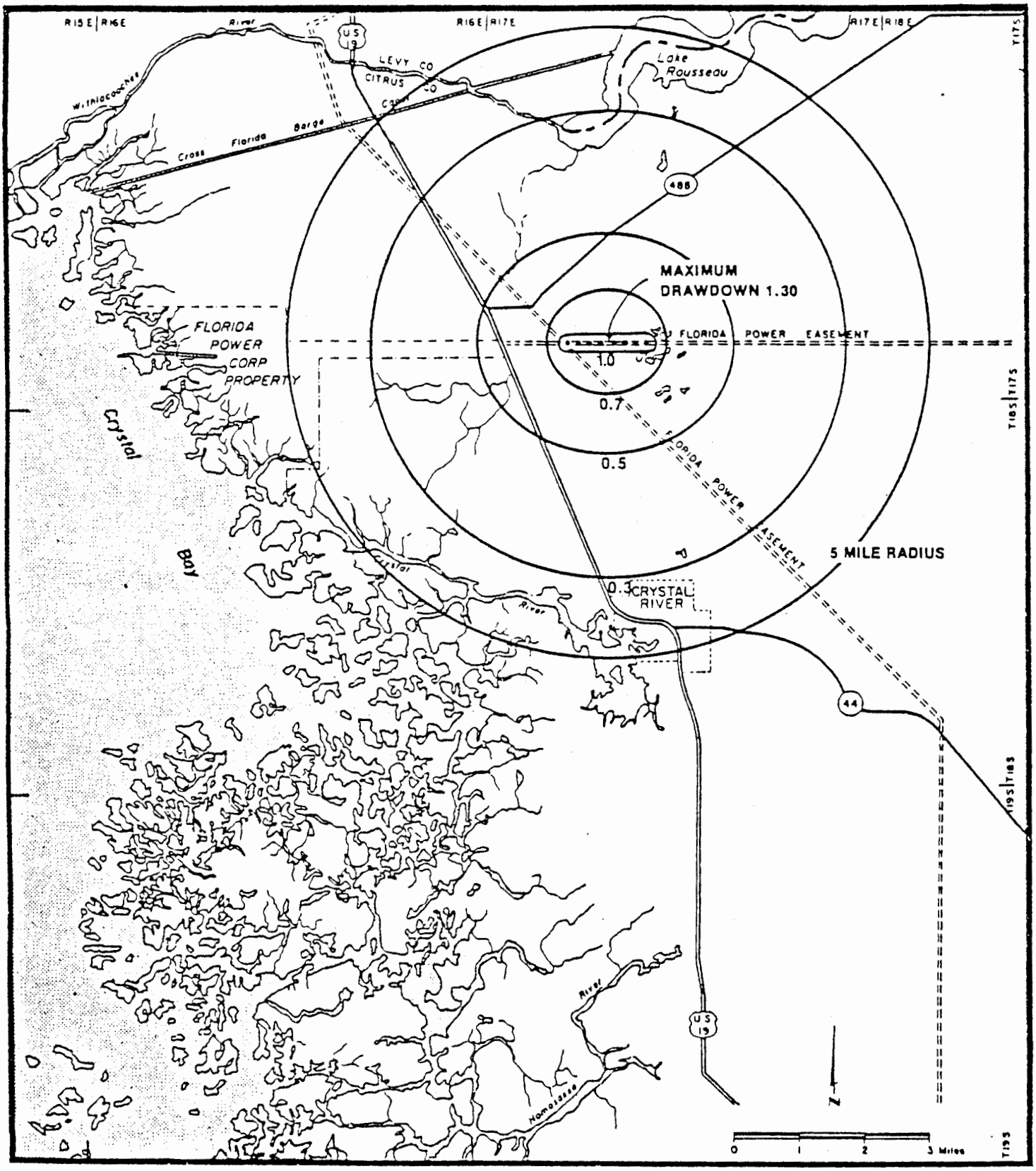
These aquifer values represent reasonable estimates for the well field area based on existing knowledge. The discharge rate represents the peak loading conditions. A month-by-month comparison of minimal natural recharge periods (low rainfall periods) and low groundwater level periods indicates that the "worst case" occurs for a 60-day period in April and May. In some years, this critical period could extend into March and June. Therefore, the 100 days of continuous pumping was selected for this analysis.

5.1.1.1 EIGHT WELL-FIELD

Unconfined Aquifer Situation

The cone of depression expected for an unconfined aquifer situation (S = 0.2) is shown in Figure 5.1.1-3. Expected drawdowns are as follows:

CONE OF DEPRESSION IN AN UNCONFINED AQUIFER SITUATION
PUMPING AT A RATE OF 20 mgd FOR 100 DAYS . 8 WELLS.



— 0.5 — DRAWDOWN CONTOUR (FEET)
T = 10' gpd/ft
S = 0.2
t = 100 DAYS
Q = 20 mgd

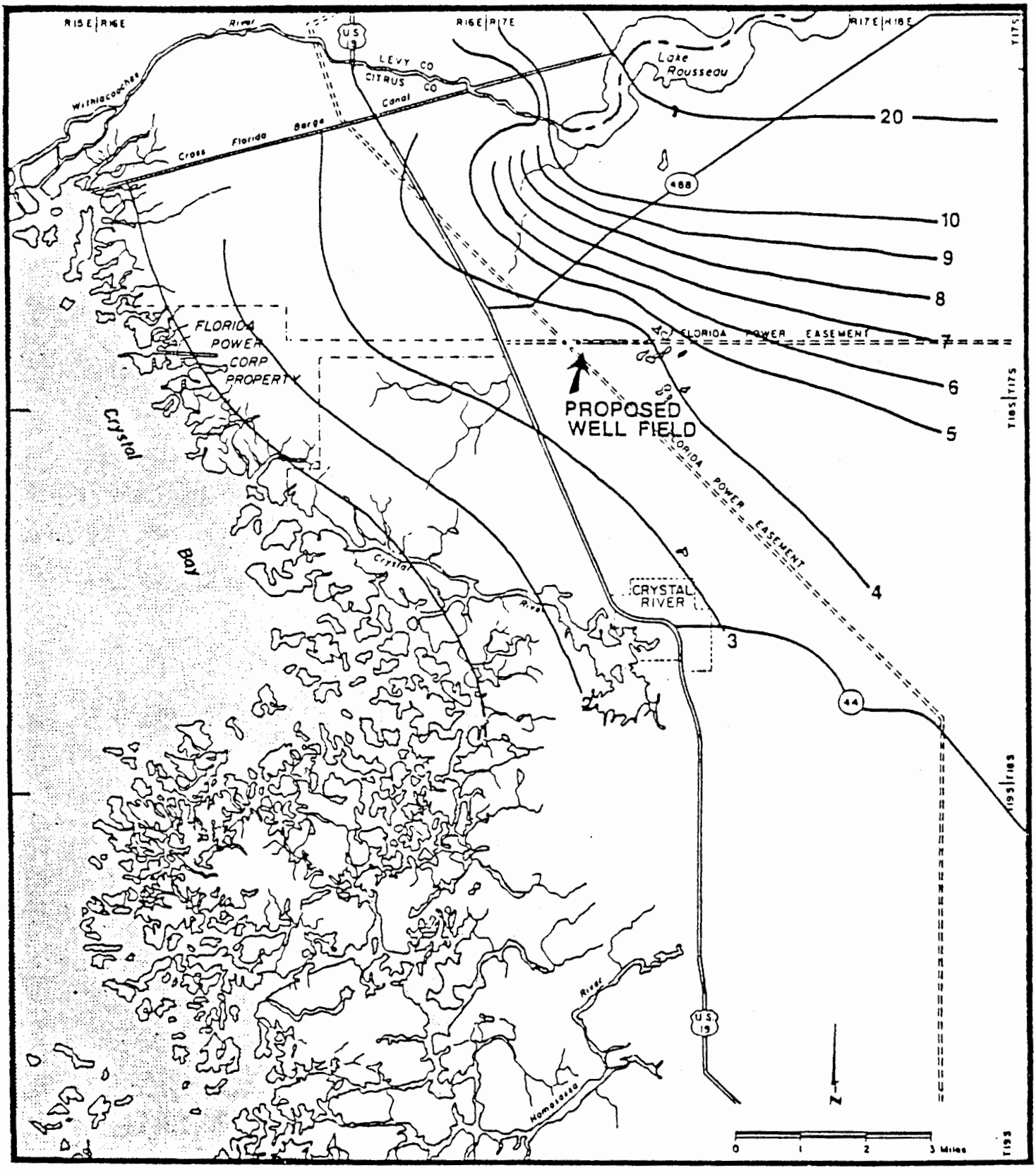
Figure 5.1.1-3

Location	Drawdown (meters)
well field (maximum drawdown)	0.4 (1.3 feet)
250 feet north or south of well field (FPC right-of-way boundary)*	0.3 (1 foot)

* three and five feet for unconfined and confined aquifers, respectively, at the property boundary is the maximum drawdown permitted by SWFWMD regulations.

The configuration of the May, 1975, potentiometric water surface with the effects of pumpage from the proposed well field is shown in Figure 5.1.1-4. Water levels in the vicinity of the well field are drawn down about 0.3 m (1 foot). This is reflected in a shift of the water surface contours as compared to the May, 1975, potentiometric surface map. The maximum drawdown occurs in the two middle wells. The water level elevation at eigher well during pumping will be slightly over 0.9 m (3 feet) msl.

ELEVATION OF THE POTENTIOMETRIC WATER SURFACE OF THE UPPER FLORIDAN AQUIFER, MAY, 1975, SHOWING THE EFFECTS OF PUMPING AT THE PROPOSED WELL FIELD. UNCONFINED AQUIFER SITUATION. 8 WELLS.



— 1 — WATER SURFACE CONTOUR IN FEET ABOVE MSL

T = 10' gpd/ft

S = 0.0002

t = 100 DAYS

Q = 20 mgd

Figure 5.1.1-4

Confined Aquifer Situation

The cone of depression for a confined aquifer situation (S = 0.0002) is shown in Figure 5.1.1-5. Expected drawdowns are as follows:

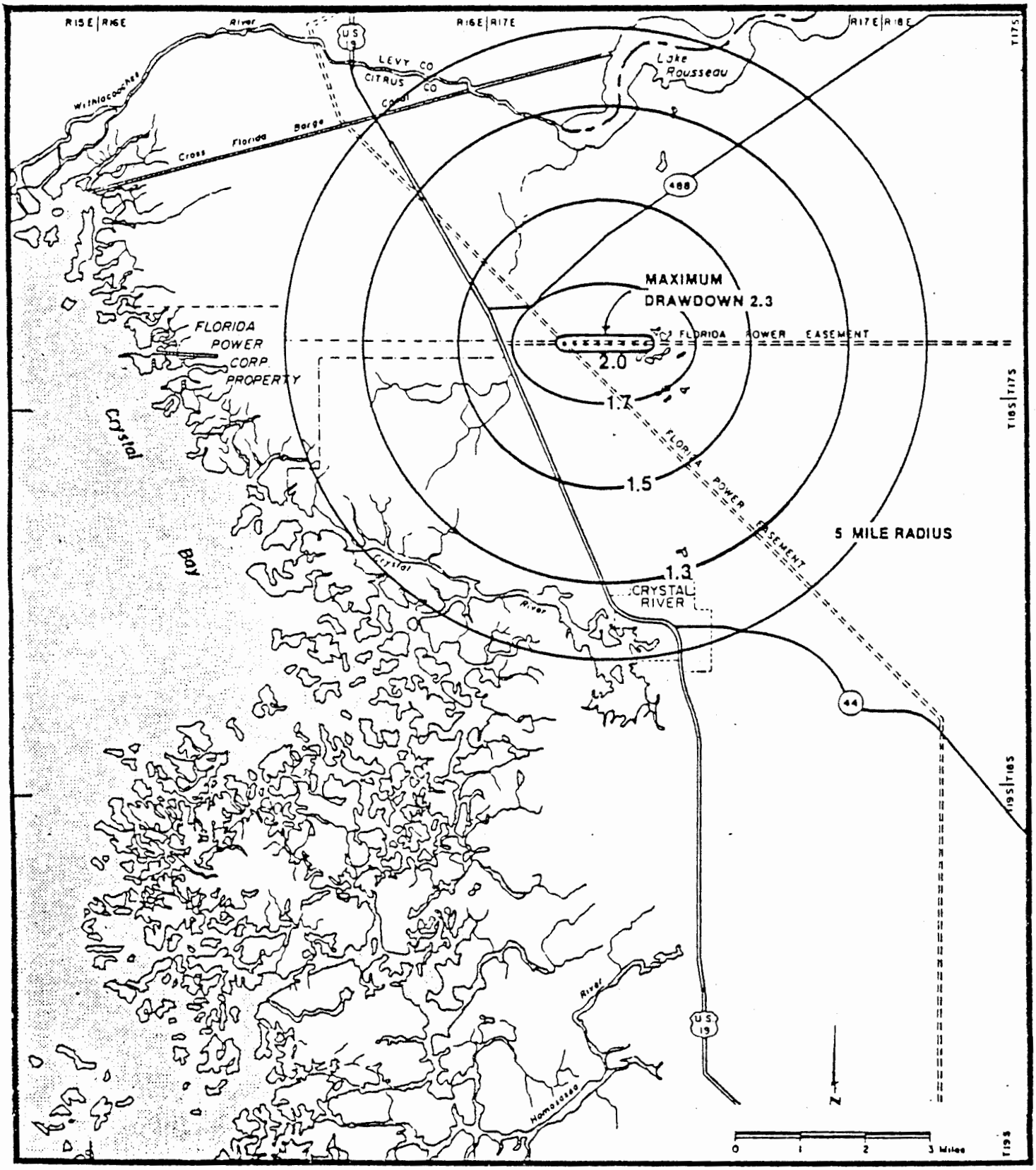
Location	Drawdown (meters)
well field (maximum drawdown)	0.70 meters (2.3 feet)
250 feet north or south of the well field (FPC right-of-way boundary)	0.64 meters (2.1 feet)

The configuration of the May, 1975, potentiometric water surface with the effects of pumpage from the proposed well field is shown in Figure 5.1.1-6. The water surface contours have shifted up-gradient, reflecting a water level decline of about 0.6 m (2 feet) in the vicinity of the well field.

As stated earlier, the confined aquifer situation represents a hypothetical "worst case".

The maximum drawdown in the well field is 0.7 m (2.3 feet) in the center two wells. Considering the effects of pumpage on the May, 1975, map, this drawdown results in a water surface elevation of about 0.67 m (2.2 feet) above msl at the center of the well field.

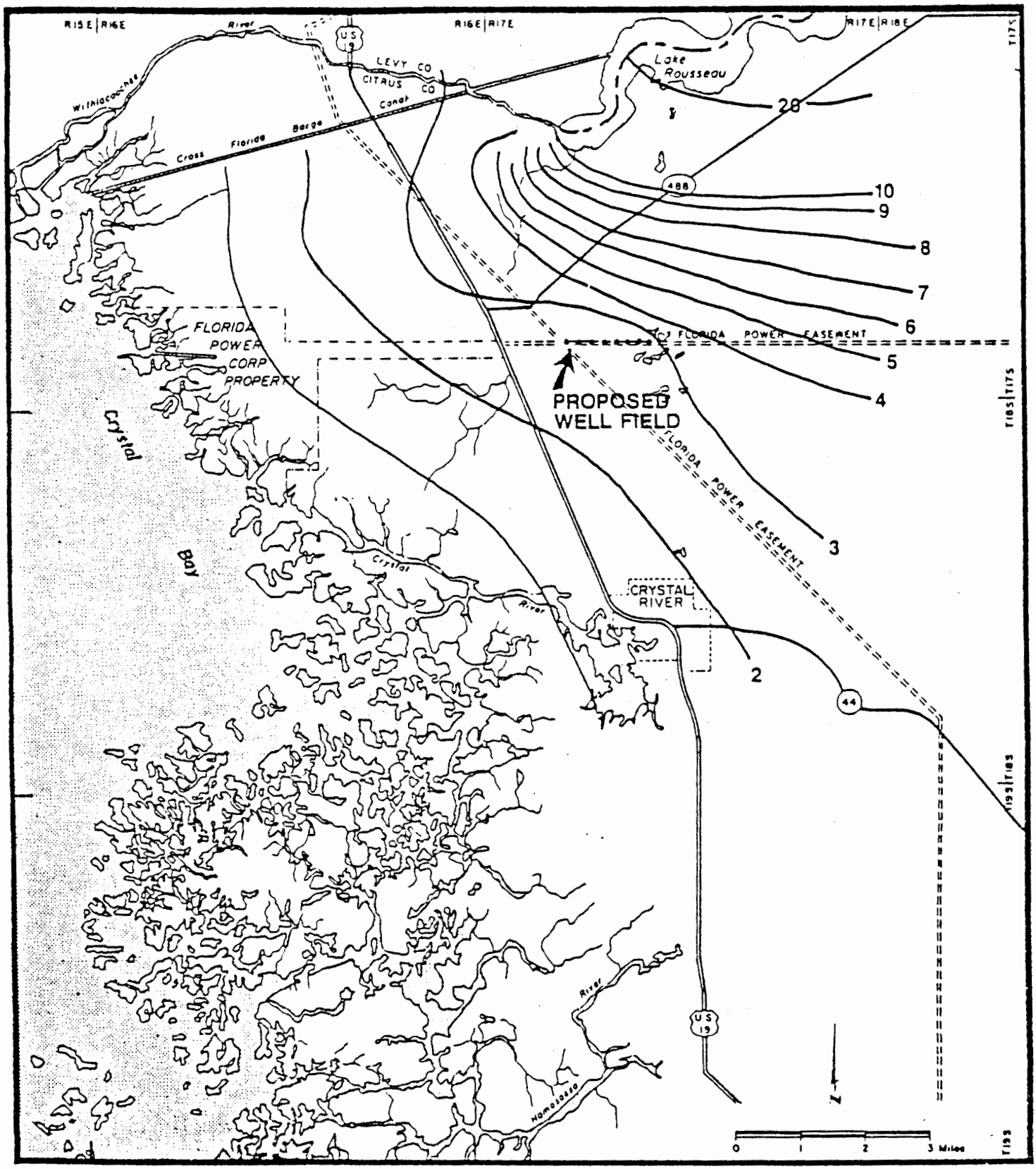
CONE OF DEPRESSION IN A CONFINED AQUIFER SITUATION
PUMPING AT A RATE OF 20 mgd FOR 100 DAYS. 8 WELLS.



— 1.5— DRAWDOWN CONTOUR (FEET)
T = 10⁴ gpd/ft
S = 0.0002
t = 100 DAYS
Q = 20 mgd

Figure 5.1.1-5

ELEVATION OF THE POTENTIOMETRIC SURFACE OF THE UPPER FLORIDAN AQUIFER, MAY, 1975 SHOWING THE EFFECTS OF PUMPING AT THE PROPOSED WELL FIELD. CONFINED AQUIFER SITUATION. 8 WELLS.



— 2 — WATER SURFACE CONTOUR IN FEET ABOVE MSL

T = 10' gpd/ft

S = 0.0002

t = 100 DAYS

Q = 20 mgd

Figure 5.1.1-6

When hydrologic characteristics of the aquifer system are ascertained by a pumping test at the well field site, the data will then be available to.re-evaluate the number shown in the previous paragraph and to design the well field in a way as to minimize the local and regional drawdowns.

5.1.1.2 FIVE-WELL FIELD

The assumptions about aquifer characteristics and the units used in computing drawdowns are the same for the five-well field except for the number of wells and the pumping rate for each well. Each well would have a pumping rate of 10,600 lpm (2,800 gpm). The expected maximum drawdowns in the well field area for this five-well situation are slightly greater than for the eight-well concept.

Unconfined Aquifer

The cone of depression expected for an unconfined aquifer situation (S = 0.2) is shown in Figure 5.1.1-7. Expected drawdowns are as follows:

Location	Drawdown (meters)
well field (maximum drawdown)	0.49 (1.6 feet)
250 feet north or south of well field (FPC right-of-way boundary)	0.37 (1.2 feet)

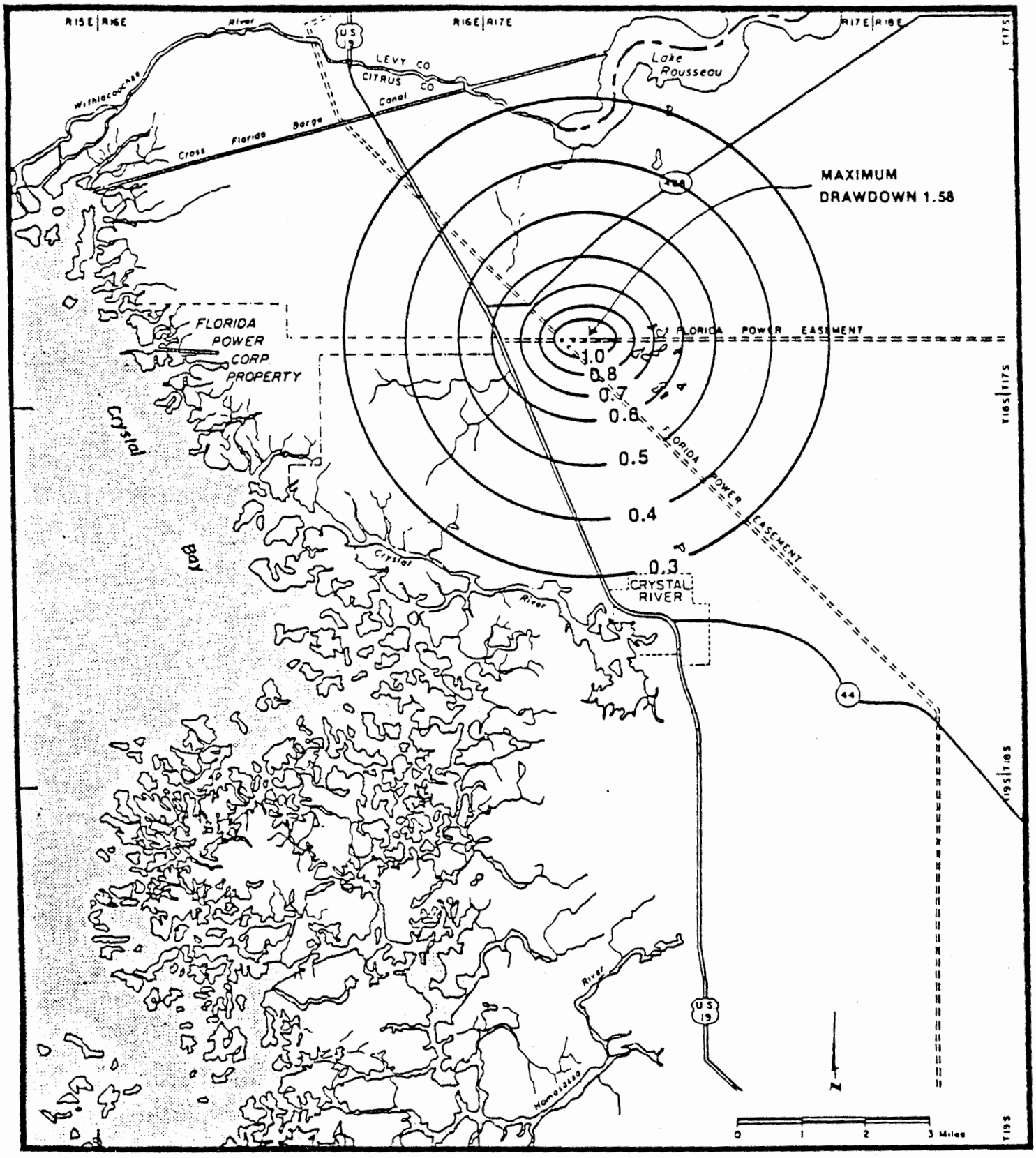
The configuration of the May, 1975, potentiometric water surface with the effects of pumpage from the proposed well field is shown in Figure 5.1.1-8.

Confined Aquifer Situation

The cone of depression for a confined aquifer situation (S = 0.0002) is shown in Figure 5.1.1.9. Expected drawdowns are as follows:

Location	Drawdown (meters)
well field (maximum drawdown)	0.82 (2.7 feet)
250 feet north or south of well field (FPC right-of-way boundary)	0.70 (2.3 feet)

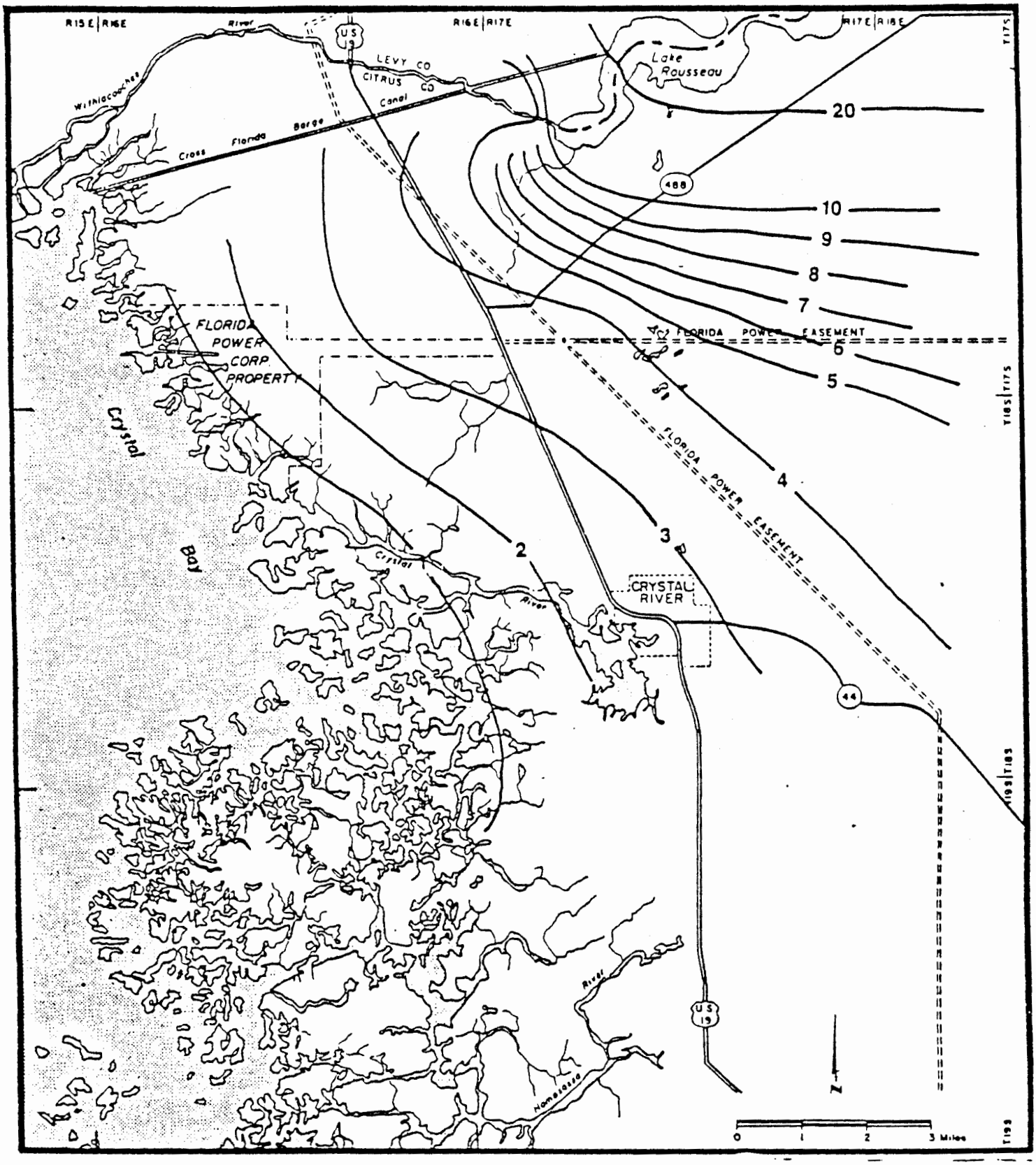
CONE OF DEPRESSION IN AN UNCONFINED AQUIFER SITUATION. 5 WELLS.



— 1.0 — DRAWDOWN CONTOUR (FEET)
T=10' gpd/ft
S=0.2
t=100 DAYS
Q=20 mgd

Figure 5.1.1-7

ELEVATION OF THE POTENTIOMETRIC SURFACE OF THE UPPER FLORIDAN AQUIFER, MAY, 1975, SHOWING THE EFFECTS OF PUMPING AT THE PROPOSED WELL FIELD. UNCONFINED AQUIFER SITUATION. 5 WELLS.



— 5 — WATER SURFACE CONTOUR IN FEET ABOVE MSL

T = 10' gpd/ft

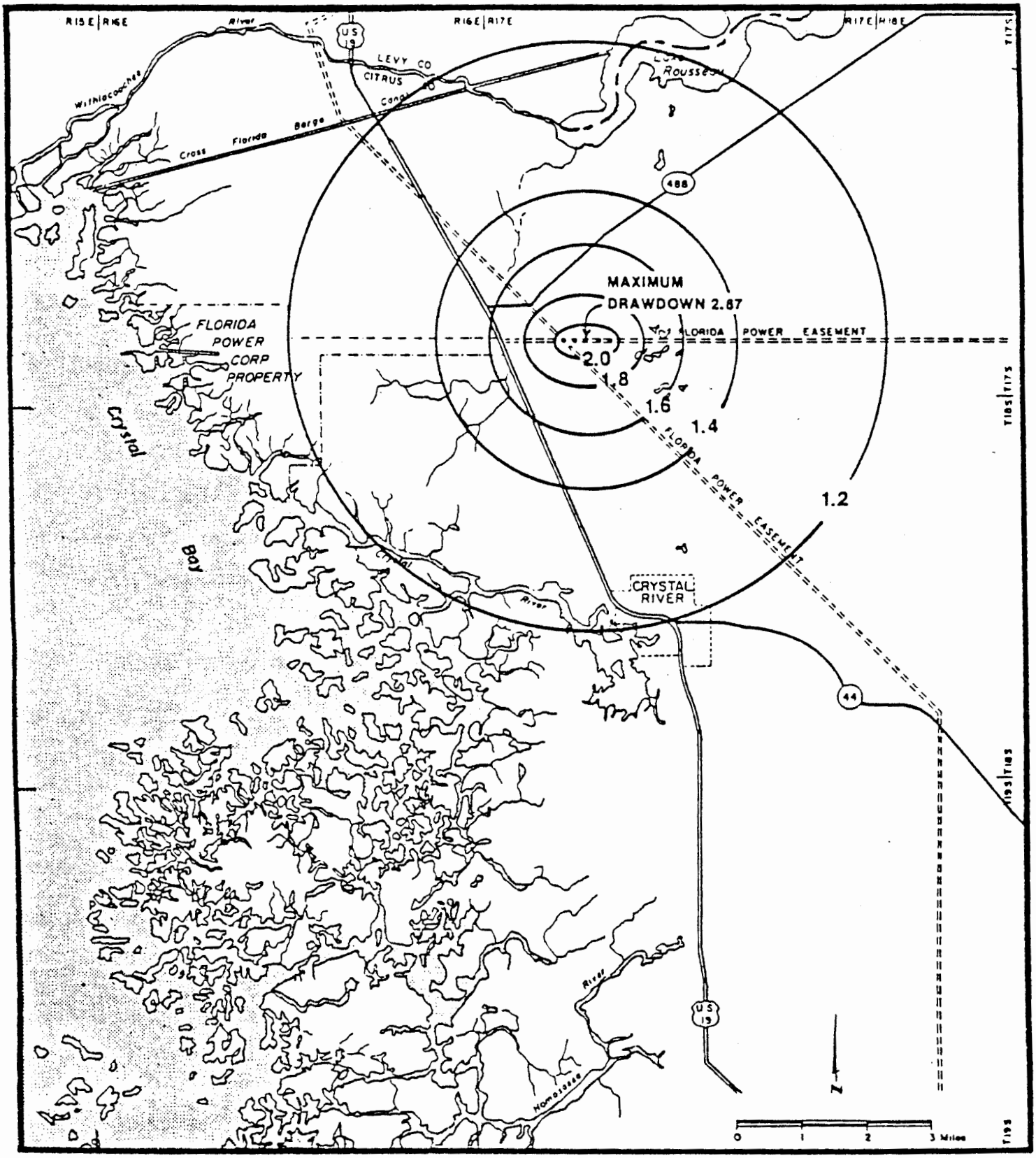
S = 0.2

t = 100 DAYS

Q = 20 mgd

Figure 5.1.1-8

CONE OF DEPRESSION IN A CONFINED AQUIFER SITUATION. 5 WELLS.



— 2.0 — DRAWDOWN CONTOUR (FEET)

T = 10' gpd/ft

S = 0.0002

t = 100 DAYS

Q = 20 mgd

Figure 5.1.1-9

The configuration of the May, 1975, potentiometric water surface with the effects of pumpage from the proposed well field is shown in Figure 5.1.1-10.

DISCUSSION

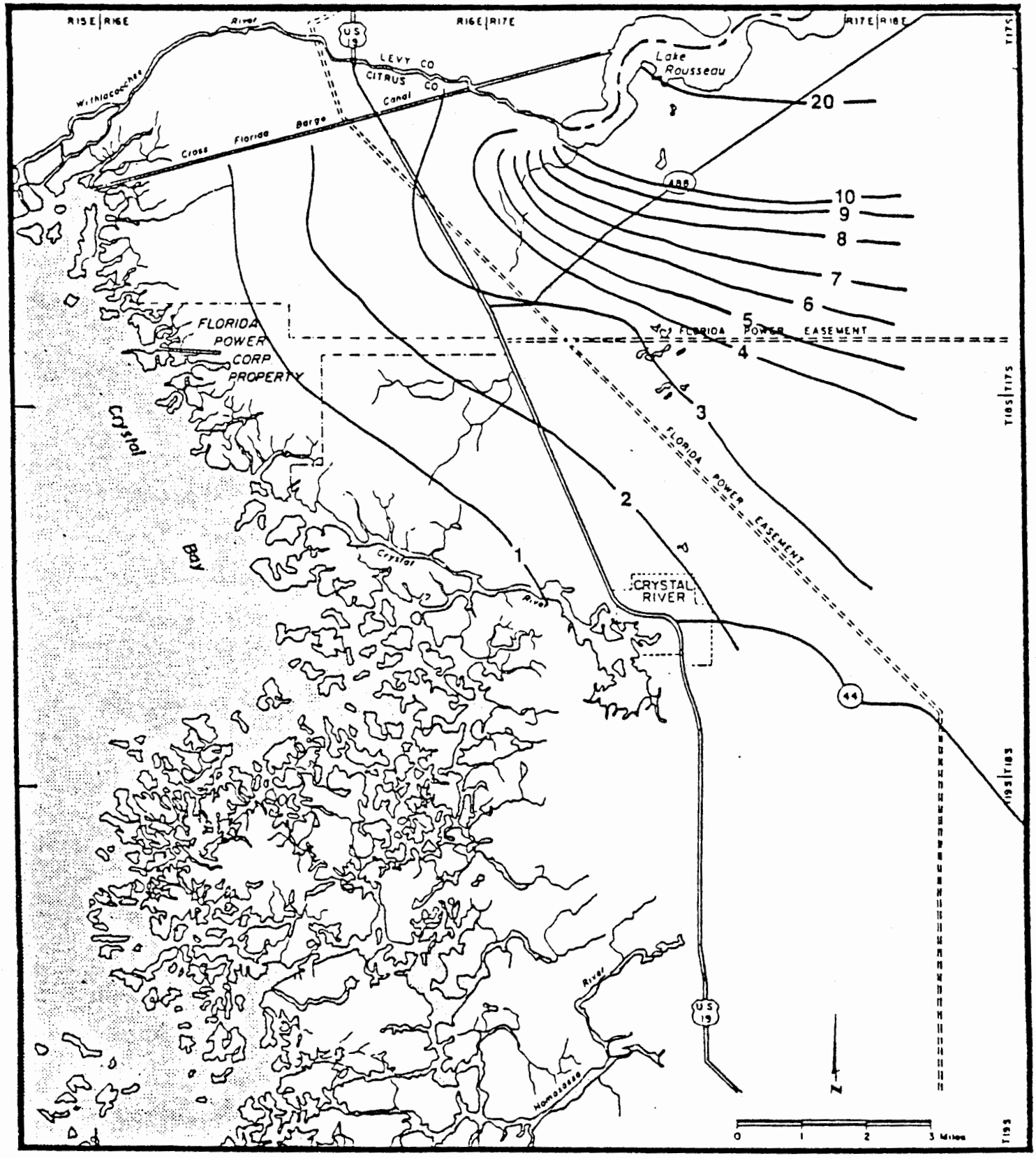
Figures 5.1.1-3, 5.1.1-5, 5.1.1-7, and 5.1.1-9 show that maximum drawdowns in a well field consisting of five wells are slightly greater than with eight wells. The difference is about 0.09 meters (0.3 feet) in an unconfined aquifer situation and 0.12 meters (0.4 feet) in a confined aquifer situation. The differences become less as the distance from the wells increases.

5.1.1.3 EFFECTS ON GROUNDWATER AVAILABILITY

This analysis compares the proposed withdrawals from the aquifer system to the estimated groundwater flow to the Gulf through the well field and site areas.

This area extends from a point just northwest of the USGS gaging station on Crystal River to just south of the Withlacoochee River and the Cross

ELEVATION OF THE POTENTIOMETRIC SURFACE OF THE UPPER FLORIDAN AQUIFER, MAY, 1975



— 5 — WATER SURFACE CONTOUR IN FEET ABOVE MSL
T = 10' gpd/ft
S = 0.2
t = 100 DAYS
Q = 20 mgd

Figure 5.1.1-10

Florida Barge Canal (see Figures 5.1.1-11 and 5.1.1-12). The point north (downstream) of the gaging station was chosen in order to exclude the gaged groundwater flow to the river, which was used in Geraghty and Miller's flow net analysis. The northern boundary was placed to exclude groundwater flow to the Withlacoochee River and Cross-Florida Barge Canal. This area includes the well field and the plant site.

The groundwater flow through this area was computed using 1.5- and 3-meter (5- and 10-foot) contours for the May, 1975, and the September, 1975, potentiometric water surface maps. These maps are assumed to represent an average high- and low-water condition. The average flow from the two is assumed to be the average groundwater flow for the year.

In computing the flow, a transmissivity value of 18.6×10^7 lpd/m (1.5×10^7 gpd/ft) was used (Geraghty and Miller, 1977). The width of the flow cell was taken at the 1.5-m (5-foot) contour and the average gradient was determined by measuring the distance between the 1.5- and 3-m (5- and 10-foot) contours. The values are as follows:

LOCATION OF FLOW CELL USED IN WATER BUDGET, MAY 1975 MAP

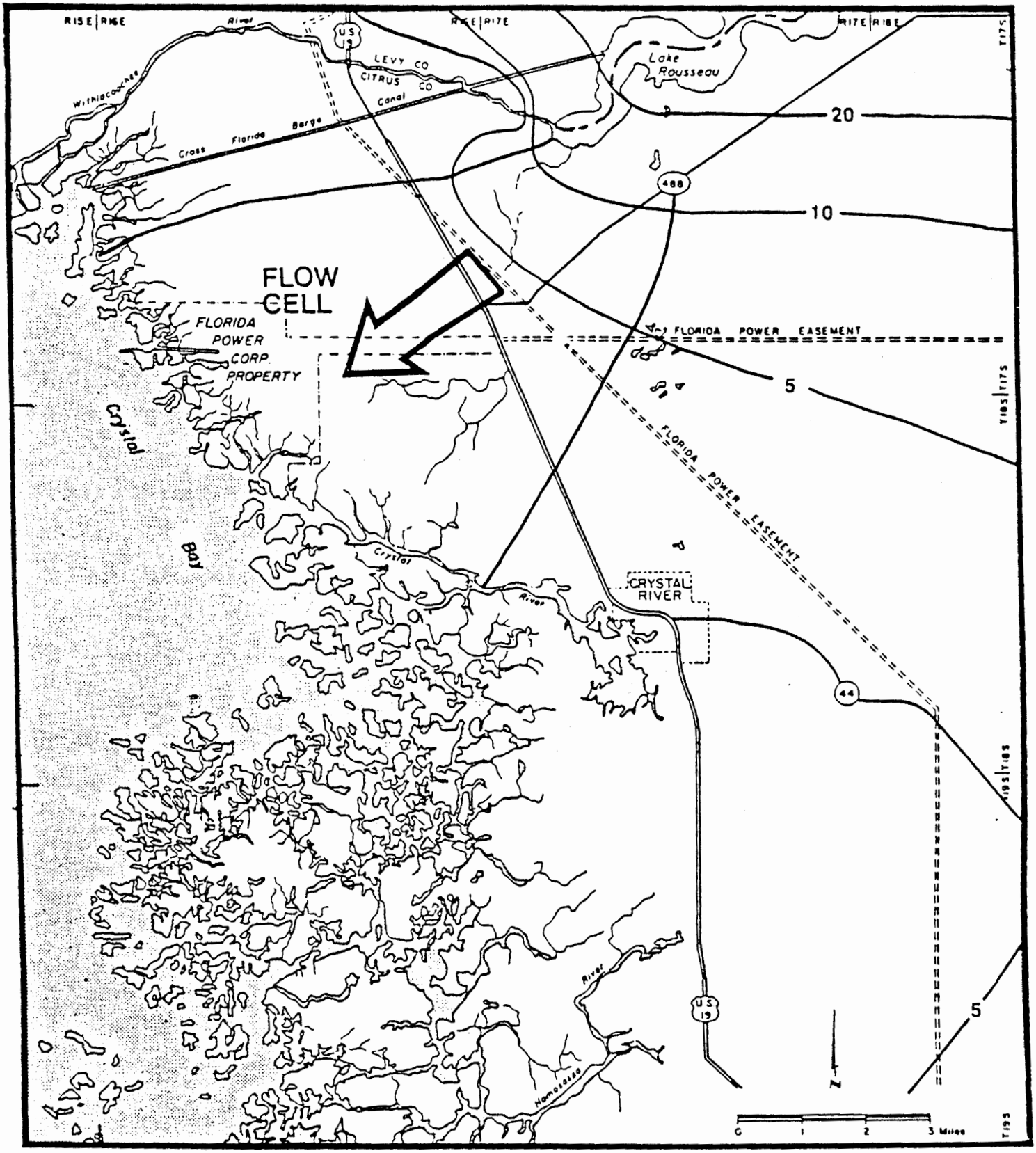


Figure 5.1.1-11

LOCATION OF FLOW CELL USED IN WATER BUDGET, SEPTEMBER, 1975 MAP

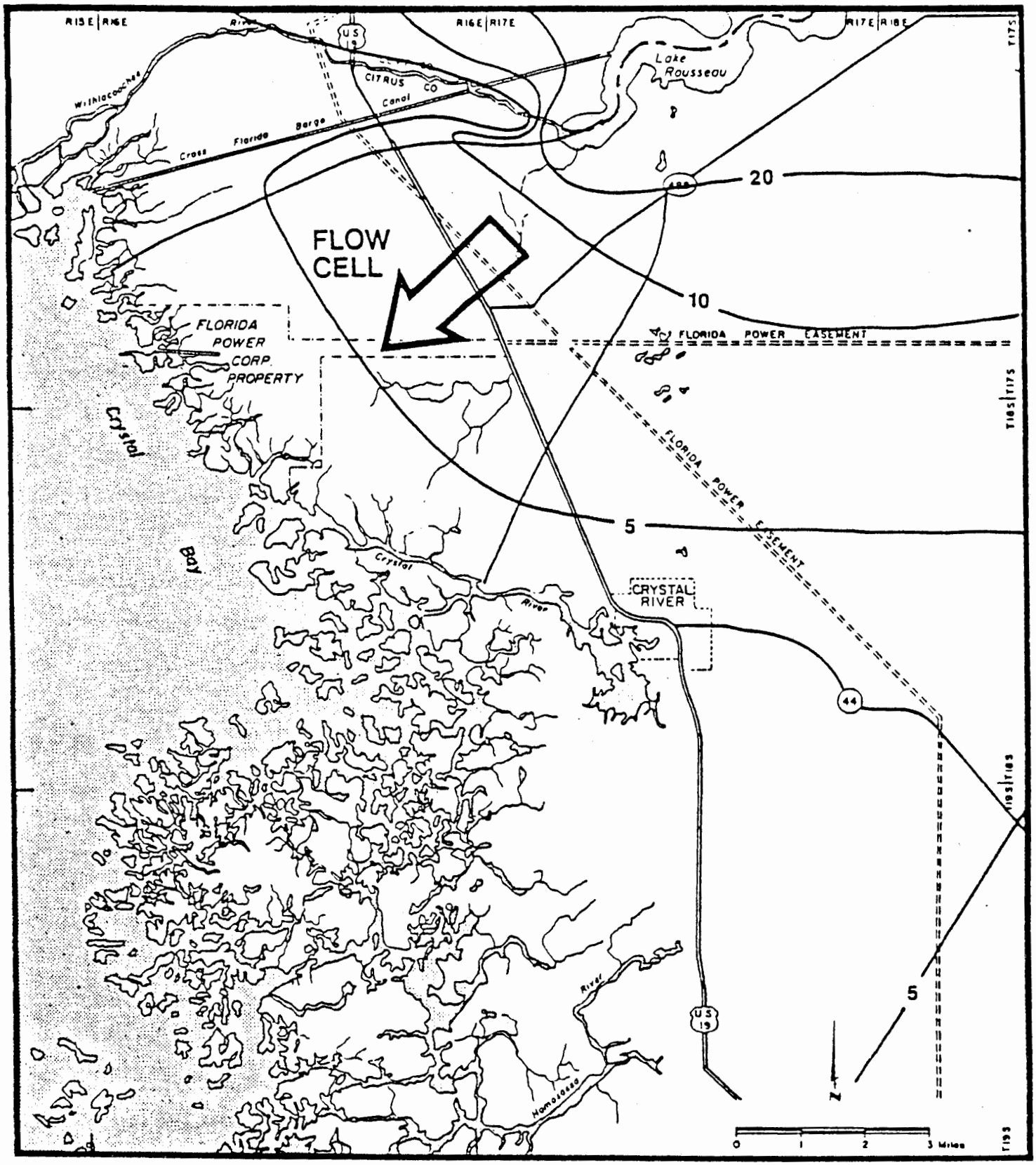


Figure 5.1.1-12

Map	Width of Cell (m)	Gradient (m/m)	Discharge (lpd)
May, 1975	6700 (22,000 ft)	0.00160	2.00×10^9 (5.28×10^8 gpd)
Sept, 1975	9750 (32,000 ft)	0.00028	5.07×10^8 (1.34×10^8 gpd)

An average of 1.25×10^9 lpd (3.31×10^8 gpd) of ground water is flowing through this area each day.

An additional 6.8×10^7 lpd (1.8×10^7 gpd) is recharged to the aquifer between the 5-foot contour and the coast based on a recharge rate of 15 inches a year.

Thus, a total of 1.32 to 10^9 lpd (3.49×10^8 gpd) of ground water is discharged to the Gulf of Mexico in the plant area. Pumpage from the proposed well field would amount to 4.3 percent of this value. This analysis means that the withdrawal represents 4.3 percent of the flow entering the Gulf in this area excluding the gaged flow in Crystal River and flow in the Withlacoochee River.

5.1.1.4 EFFECTS ON GROUND-WATER QUALITY

If the assumptions about the aquifer conditions listed in Section 5.1.1 are correct, and if the well field is designed properly (i.e., well depth, well spacing, and well pump capacity), there should be no problems with vertical or lateral movement of salt water.

However, it is recognized that the horizontal and vertical position of the salt water-fresh water interface is dependent on the dynamic or static conditions of the ground water system. Domenico (1972) deals with the principles of the dynamic interface and gives examples. Because in the absence of actual test data, no well field site-specific information is available, no evaluation was made of the change in the dynamic conditions, resulting from pumpage, on the ground water quality in and near the well field.

To be able to get a very rough idea of what the effects of pumping on the ground water quality could be, static ground water conditions were assumed. If static ground water conditions prevail, the position of the interface is described by the Ghyben-Herzberg (G-H) principle. According to the Ghyben-Herzberg principle, for every foot of fresh water above mean sea level there exists approximately 40 feet of fresh water below mean sea level. This principle is entirely based on the assumption that the hydrogeologic environment is completely homogeneous and isotropic. This assumption is unrealistic because the Florida Aquifer is layered.

At the site the upper geologic formation is the Ocala, underlain by the Avon Park. It is likely that the hydraulic conductivity will be much less in a vertical direction than in the horizontal direction. Nevertheless, in the following paragraphs, the potential theoretical upconing of mineralized water at the well field is estimated. Under existing conditions, the depth of fresh water under the well field fluctuates from 40 to 108 meters (160 to 360 feet).

In the unconfined aquifer with the 8 well design, the G-H principle indicates that at least 37 meters (120 feet) of fresh water would lie below the well during pumping. Based on this criteria, the wells should be less than 37 m (120 feet) deep to minimize the possibility of salt water intrusion.

In the confined condition with the 8 well design, the depth of fresh water underlying the area of maximum drawdown is about 27 m (90 feet). This would require that the wells be designed to a level of less than 27 m (90 feet) to minimize salt water intrusion problems at the well.

In the case of the well field design with 5 wells, the expected change in the thickness of fresh water at the point of maximum drawdown within the well field is a decrease of 3 to 6 meters (10 to 20 feet) according to the Ghyben-Herzberg principle.

As a further caution as to the applicability of the G-H principle to the actual field situation, field tests conducted in southwest Florida by the U. S. Geological Survey document that the G-H principle generally under estimates the thickness of fresh water in the Floridan Aquifer on the coastal zones.

In addition, Vernon (1951) has shown the existence of a series of faults in the well field area; a further indication of the inhomogeneity and anisotropy of the hydrogeologic environment.

These were probably based on the lineaments (linear trend) of land-forms in the area which trend northwest. Fractures or faults in the

well field area could have two effects:

(1) The horizontal permeability may be increased in the northwest-southeast direction, resulting in an elongation of the cone of depression in this direction. This tends to minimize the influence of pumpage in the direction of the coast.

(2) The vertical permeability may be increased, perhaps significantly, possibly providing a direct connection between the upper and lower zones of the aquifer. This may have the undesirable effect of allowing poorer quality water from the lower zone to move up into the well field, increasing the chloride and sulfate concentrations.

An aquifer pump test and associated water quality determinations will help to clarify the relative significance of possible faults and fractures in the area.

5.1.1.5 EFFECTS ON SURFACE WATER

Surface waters in the area consist of karst-type depressions and scattered small wet areas. As noted in Chapter 2, there is a conspicuous absence of defined stream channels in the area. Cherry (1970) reports that between 55 and 75 percent of the annual rainfall in the area is returned to the atmosphere via evaporation. The remainder percolates through the thin sands, recharging the Floridan Aquifer. Thus, there is virtually no surface runoff in the well field area.

From available literature and examination of topographic maps and close proximity of rock to surface in the area, it is probable that

surface waters are directly connected to the aquifer (i.e.; unconfined aquifer).

When an aquifer test is performed, specific aquifer characteristics of the well field site can be accurately defined and impacts more precisely determined. Localized seams of impermeable material (i.e., clay) may be present in the area, creating a "confined aquifer" condition. Both unconfined and confined aquifer situations are discussed in order to evaluate the effects on surface waters.

Unconfined Aquifer

In an unconfined aquifer situation, water levels in adjacent depressions would decline as a result of aquifer pumping. Because of the free connection between surface and ground water in an unconfined aquifer, this decrease would approach the same as shown on Figure 5.1.1-4 (ground water level drawdown--unconfined aquifer). In the immediate vicinity of the well field, water levels will decline, at most, approximately 0.4m to 0.5m (1.3 to 1.6 feet) depending on the number of wells pumping, pumping rates, duration of pumping, distance between surface waters and wells, and rainfall. At the plant, surface waters can be expected to decline approximately 0.30 m (0.10 feet) under maximum pumping conditions and the assumptions listed in Section 5.1.1.

Confined Aquifer

This situation assumes an impermeable confining layer between the water table aquifer and the Floridan Aquifer. Although drawdowns in the Floridan Aquifer would be greater in this case, the effects

of pumping on surface water levels would be less than those associated with an unconfined aquifer situation. Some decline in surface water levels would be observed, however, because: (1) the confining layer, in reality, would not be totally impermeable; and (2) the areal extent and thickness of the confining layer would vary.

Surface Water Quality

The maximum decline in surface water levels would be those associated with an unconfined aquifer situation. A maximum water level decline of less than 0.03 m (0.10 feet) at the coast is not enough to allow inland pentration of brackish surface water from the Gulf. Surface water quality would be unaffected by withdrawals from such an aquifer.

The loss of some mast-producing species may adversely affect squirrels and other species that depend on acorns, nuts, and other hardwood mast. Clearing operations in the forested areas of the access road will stimulate more growth of browse species such as herbaceous plants, trees, and shrubs; however, the overall effect may be negative because of the loss of mast production and denning sites.

4.3.3.2 IMPACTS DUE TO TRANSPORTATION

The increased traffic along the access road because of the plant operation will increase "road kills" of wildlife. The net result of the construction of this second access road with its subsequent vehicular traffic will be to create an artificial barrier, thus forming an insular wildlife habitat. Because of traffic and other human activity along these roads, species such as deer are less likely to cross into the median area. In addition, some wildlife will not cross this barrier because of insufficient cover.

The initial disturbance of existing vegetation during construction is the most immediate impact to wildlife. The road construction will not significantly alter the present ecological functions and attributes of the edge community. Those forested areas which are cleared will have functional characteristics of an early successional state (Odum, 1971). The creation of the insular habitat is the most significant impact; however, the magnitude of this impact is considered moderate for the route and low for the surrounding area. The impact of forest clearing is low for the site and surrounding area. These impacts will be long-term and reversible.

impact on wildlife from surrounding areas. The major impact to off-site wildlife will be to reduce food supplies and denning sites for some of the more wide-ranging species. Habitat alterations near areas of large tracts of monocultured, even-aged (pine plantation) forest that include the destruction of upland oaks may eliminate or reduce the home range of various species. Oaks adjoining upland pine sites are essential in providing food for wildlife and offer diversity in habitat in homogeneous pine plantation (Goodrum et al., 1971). It can be anticipated that predatory and foraging animals which utilize these areas will have to adjust to the diminished food supplies. This will cause either a decreased carrying capacity for ranging species (i.e., deer, bobcat, and raccoon) or a shift in feeding areas to surrounding habitats. This impact on the terrestrial ecology of the area, although difficult to estimate, is considered minimal because of the relatively small acreage to be cleared.

4.3.3.1 IMPACTS DUE TO CONSTRUCTION OF ACCESS ROAD

The construction of the access road will result in the destruction of 2.4 hectares (6 acres) of forested lands, 0.8 hectares (2 acres) of fresh marsh, and 8.5 hectares (21 acres) of ruderal areas. Modification to existing faunal communities will be determined primarily by the type and extent of permanent changes in habitat along the proposed corridor. It can be anticipated that the major impact will occur where existing forested lands will be cleared to facilitate construction of the access road. Such clearing can affect faunal communities; however, because of the relatively narrow strip required for the corridor, most effects should be minimal. Fencing the road would decrease wildlife mobility.

4.3.3 OTHER IMPACTS ON BIOTA

It is felt that the transmissivity of the aquifer is sufficiently high to preclude significant restriction of subsurface flow at the site. However, since detailed knowledge of the geohydrology of the site is lacking, there remains a possibility that filling and grouting could alter groundwater flow sufficiently to reduce the freshwater subsidy of a portion of the coastal hydric hammock adjacent to the grouting. This could lead to a gradual drying of soils and long-term shift to a more mesic vegetation type. Reduction of this flow could also result in a loss of flushing action, leading to a build-up of salt in the soil, and possible elimination of plant species less tolerant of saline soils on a short-term basis and a long-term shift to a more salt-tolerant system. Due to the long time period for vegetative succession, the impact could be considered irreversible. Regional significance is moderate. Although the stand represents only 3.1 percent of the coastal hydric hammock acreage, it comprises about 10 percent of the coastline length of coastal hydrick hammock within the 8-kilometer (5-mile) radius.

Construction of the rail spur and access road may also affect nearby plant communities through alteration of surface drainage. The magnitude of this effect will depend upon construction design, such as the number and placement of culverts, which has not been developed at this time. The magnitude and significance are low.

Because of the large area of pine plantations adjoining the proposed plant site, the overall effect of clearing operations on site may have a

4.2.2 WATER QUALITY

Turbidity and sediment loading from runoff during construction to the nearby marsh areas is expected to be minimal. The use of state-of-the-art erosion techniques (berms, mulch, sodding, and detention/infiltration ponds) during construction will mitigate adverse effects on the adjacent surface waters. Construction of the stormwater retention areas at the plant site should lessen the runoff sediment load impact on the marsh.

Hydraulic or dragline dredging operations and the use of explosives are not expected during the construction period.

4.0 SITE PREPARATION AND PLANT AND ASSOCIATED FACILITIES CONSTRUCTION/RESULTING ENVIRONMENTAL EFFECTS

4.1 SITE PREPARATION AND PLANT CONSTRUCTION

4.1.1 CONSTRUCTION AREAS AND ACTIVITIES

Construction of the proposed units will begin by clearing 26 hectares (65 acres) within the proposed plant area. A minimum of approximately 5.6 hectares (13.7 acres) of this area will be required to prepare foundations for the facility and cooling towers. The remaining land area will include construction parking, field offices, and laydown areas. A total of 126 hectares (314 acres) will be cleared for construction of Units 4 and 5, including the permanent ash storage area which will be used for laydown area during construction.

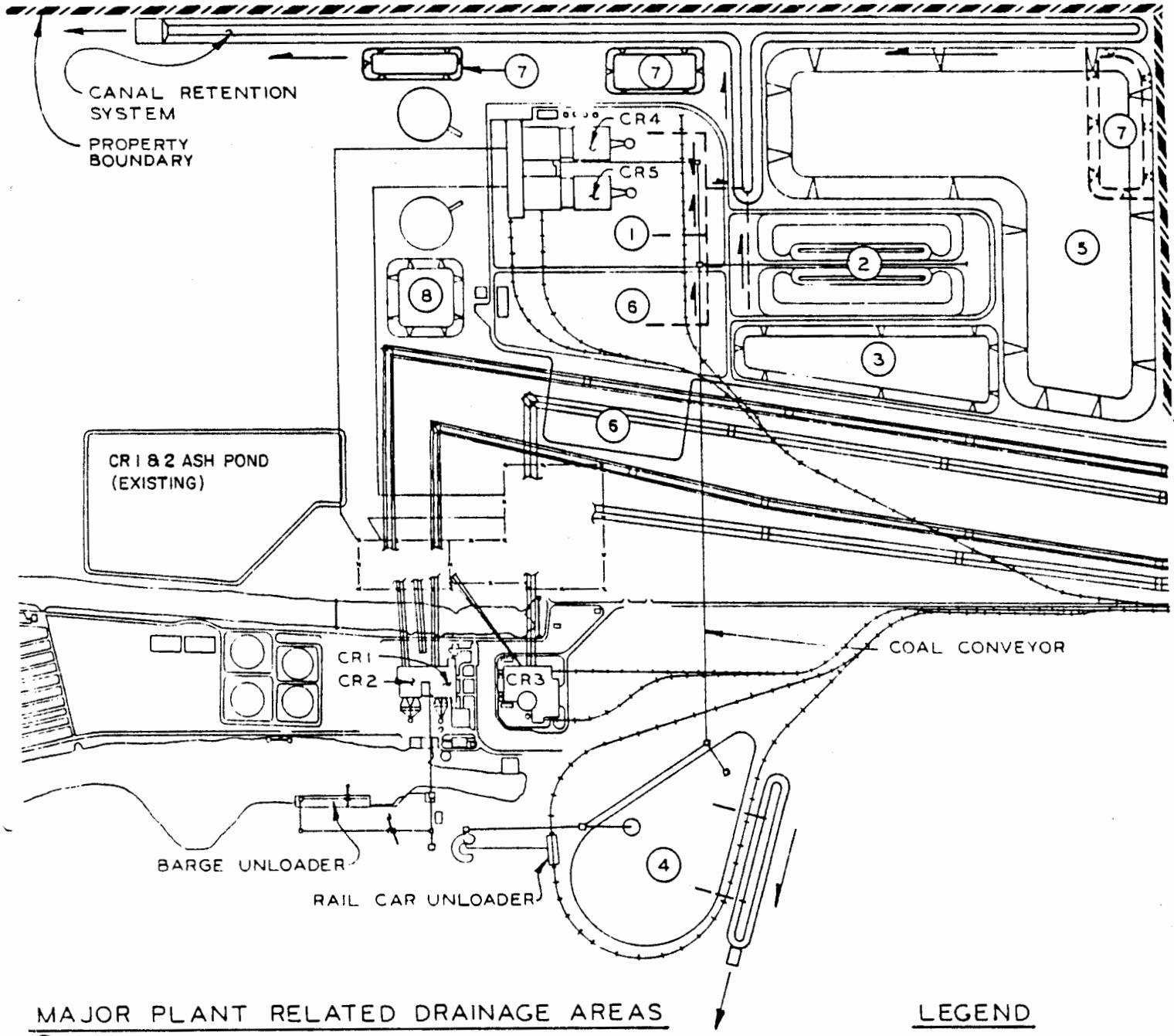
An access road 6.7 kilometers (4.1 miles) long will be constructed from U.S. Highway 19 to the plant construction area. The road will be located on the north side of the transmission corridor and will occupy about 12.1 hectares (30 acres). Construction traffic for the new facilities will travel along this road. The Applicant proposes an additional access road because security must be maintained for the nuclear Unit 3, and heavy construction traffic on the existing road should be limited.

Grading and filling will elevate the plant area to approximately 3.7 meters (12 feet) above mean low water. Cooling towers, the turbine generator building, the air pre-heater building, electrostatic

precipitators, stacks and coal crusher building will be the primary structures requiring subsurface grouting and surface fill. The elevating of these structures will necessitate approximately 400,000 cubic meters (520,000 cubic yards) of material. The fill will be obtained primarily from the site and local sources.

Heavy equipment such as the turbine generator and materials such as structural steel will be transported to the construction area by rail. Trucks will deliver the remaining equipment and supplies. During construction activities approximately 45 to 50 trucks will arrive daily. These trucks will haul concrete, lumber, fuel and other supplies.

Water will be needed for hydrostatic testing of tanks, cleaning, drinking, sanitary facilities, soil compaction, and fugitive emissions control. The water supply for these purposes will be obtained from the existing freshwater wells for Crystal River Units 1, 2, and 3. It is estimated that less than 15,140 liters per day (40,000 gallons per day) will be required for these purposes. Electrical power needed for construction activities will be obtained from the existing generating plants.



MAJOR PLANT RELATED DRAINAGE AREAS

1. GENERAL COMPLEX FILL AREA
2. ADJACENT ACTIVE COAL HANDLING AREA
3. ADJACENT INACTIVE COAL STORAGE AREA
4. REMOTE INACTIVE COAL STORAGE AREA
5. ASH DISPOSAL AREA
6. CONSTRUCTION RELATED AREA
7. TEMPORARY SOIL STOCKPILE
8. PLANT DRAIN COLLECTION POND

LEGEND

- - - DRAINAGE PIPING

PRIMARY DISCHARGE LOCATIONS

FLOW DIRECTION

N

1000' 500' 0 1000' 2000'

1" = 1000'

1" = 305 METERS

CRYSTAL RIVER UNITS 4 & 5
ENVIRONMENTAL REPORT

FIGURE 3.10-1
ON-SITE DRAINAGE SYSTEM

interval. The retention canal system in addition to stormwater runoff will receive discharge input from internal generation systems further defined in Section 3.3 of this report.

3.10 ONSITE DRAINAGE

3.10.1 General Drainage System Description

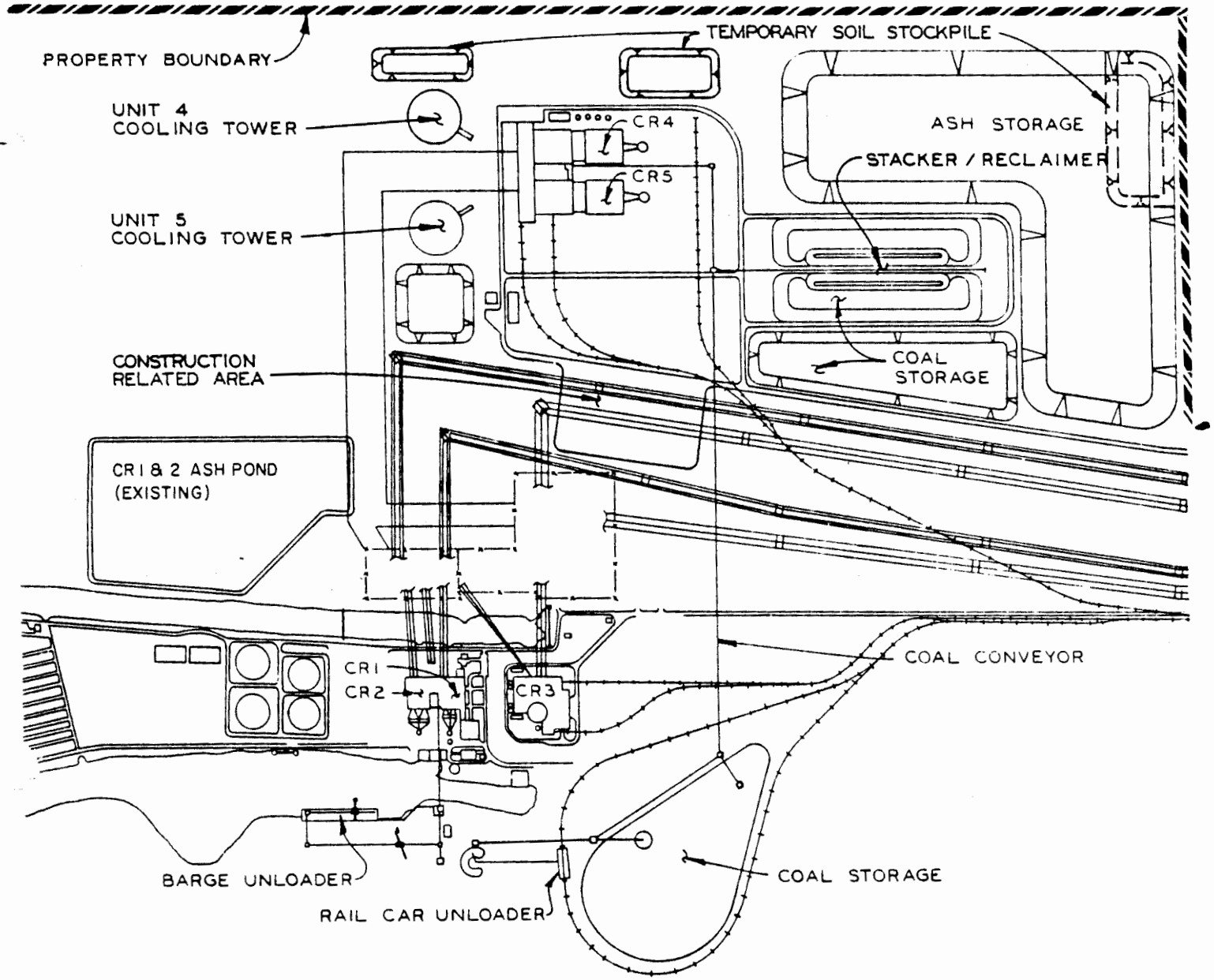
Storm water runoff from the Crystal River Units 4 and 5 site is designed to drain from subdivided plant collection areas. Major collection areas are as follows: generation complex fill area, adjacent active coal handling area, adjacent inactive coal storage area, remote inactive coal storage area, active ash disposal area, and construction related areas. The runoff from these areas will be collected in catch basins and subsequently drained into a system of retention canals. The retention canals will contain the accumulated runoff to allow settlement of suspended solids prior to discharge to the existing site watersheds. Precipitation runoff not collected in the design drainage system will drain to the natural watersheds of the site area.

3.10.2 Drainage System Design Criteria

The drainage system is designed to perform two functions. The initial function is to convey stormwater runoff from active plant areas with minimal ponding. The secondary objective of the system will be to retain design surface stormwater runoff.

The design of the drainage piping system will be based on a stormwater runoff event having a recurrence interval of 25 years.

The design of the retention system is based on net runoff for a design storm event of 24 hour duration and 10 year recurrence



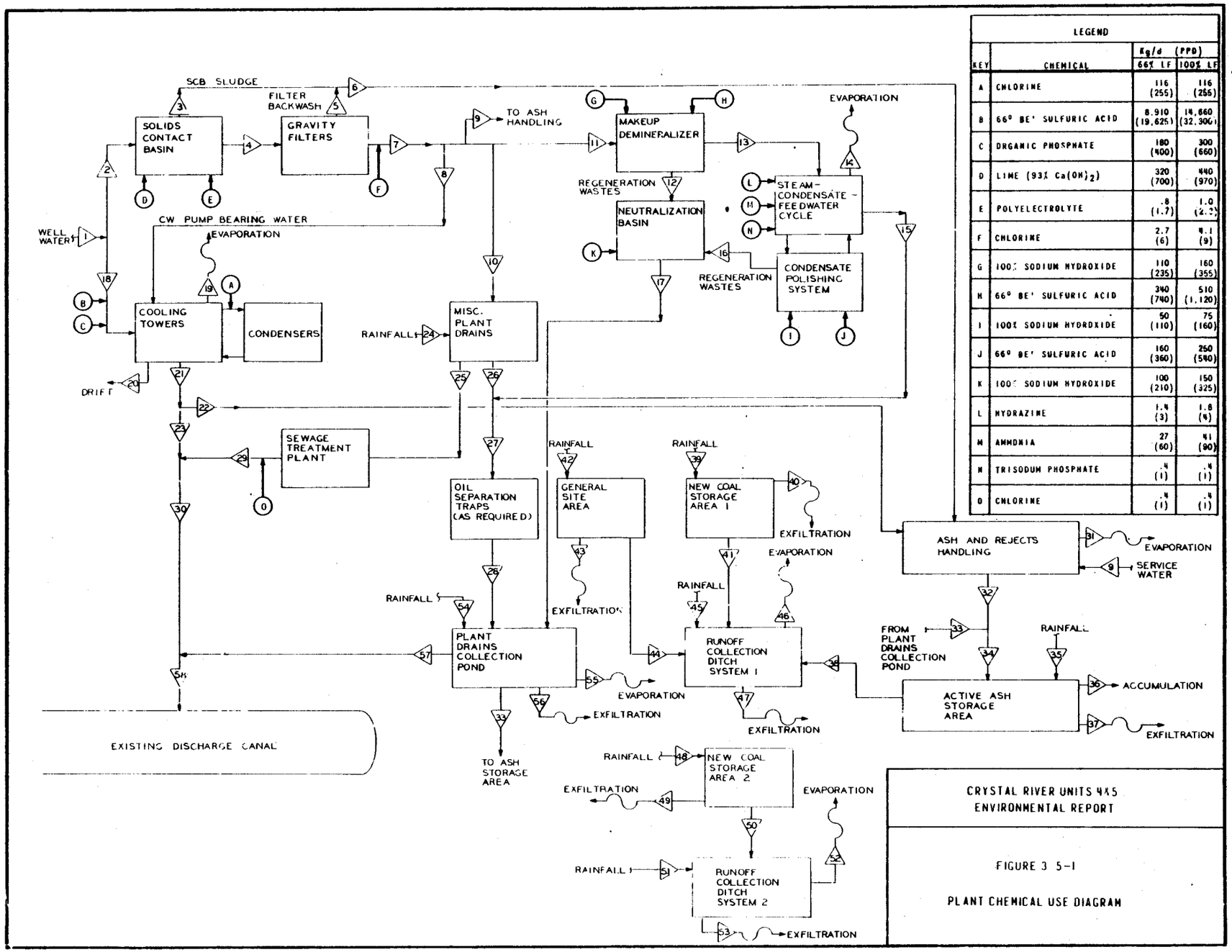
1000' 500' 0 1000' 2000'

1" = 1000'

1" = 305 METERS

CRYSTAL RIVER UNITS 4 & 5
ENVIRONMENTAL REPORT

FIGURE 3.9-2
ASSOCIATED FACILITIES



LEGEND			
		Kg/d (PPD)	
KEY	CHEMICAL	66% LF	100% LF
A	CHLORINE	116 (255)	116 (255)
B	66° BE' SULFURIC ACID	8,910 (19,625)	14,660 (32,300)
C	ORGANIC PHOSPHATE	180 (400)	300 (660)
D	LIME (93% $Ca(OH)_2$)	320 (700)	440 (970)
E	POLYELECTROLYTE	.8 (1.7)	1.0 (2.2)
F	CHLORINE	2.7 (6)	4.1 (9)
G	100% SODIUM HYDROXIDE	110 (235)	160 (355)
H	66° BE' SULFURIC ACID	340 (740)	510 (1,120)
I	100% SODIUM HYDROXIDE	50 (110)	75 (160)
J	66° BE' SULFURIC ACID	160 (360)	250 (540)
K	100% SODIUM HYDROXIDE	100 (210)	150 (325)
L	HYDRAZINE	1.4 (3)	1.8 (4)
M	AMMONIA	27 (60)	41 (90)
N	TRISODUM PHOSPHATE	.4 (1)	.4 (1)
O	CHLORINE	.4 (1)	.4 (1)

CRYSTAL RIVER UNITS 4&5
ENVIRONMENTAL REPORT

FIGURE 3 5-1

PLANT CHEMICAL USE DIAGRAM

3.4 HEAT DISSIPATION SYSTEM

3.4.1 Cooling System Description

Approximately 3 693 GJ (3500 million BTU) per hour would be dissipated by the cooling system of each unit while operating at full load. The steam cycle would reject approximately 3 482 GJ (3300 million BTU) per hour and the auxiliary equipment would reject approximately 211 GJ (200 million BTU) per hour. The major components associated with each cooling system include the cooling tower, condenser, circulating water pumps, and piping.

The waste heat would be rejected to the atmosphere via one natural draft cooling tower per unit located approximately 121.9 m (400 FT) west of the turbine buildings. Each tower would be designed to dissipate the total plant heat load with a range of 11.7 C (21 F) and a 6.7 C (12 F) approach to the 26.1 C (79 F) design wet bulb. Approximate tower dimensions are 113 m (370 FT) in diameter at the base and a height of 140 m (460 FT). Circulating water would be pumped from the cooling tower through the main condenser and back to the cooling tower via underground piping. The pumping system would consist of three one-third capacity vertical wet pit pumps. The system layout with respect to other plant structures is shown on Figure 3.4-1.

3.4.2 Cooling Water Description

The condenser cooling water systems will utilize open-recirculating water systems with cooling towers. Makeup will be supplied

as required for evaporative, drift, and blowdown losses. Makeup water will be raw well water. This source will allow operation of the circulating water systems at about six cycles of concentration.

The quantity of blowdown required to maintain acceptable cooling tower chemistry is dependent upon makeup water quality, unit loading, and atmospheric conditions. At maximum evaporation of approximately 347 dm^3/s (5500 GPM) per unit, maximum drift of approximately 1.26 dm^3/s (20 GPM) per unit, and operating at six cycles of concentration, the required blowdown from each unit will be approximately 68.2 dm^3/s (1080 GPM). The heat dissipation system water requirements during peak and normal conditions are summarized on Table 3.4-1.

Over the lifetime of the units, assuming a 66 per cent average annual load factor and average atmospheric conditions, the required blowdown will average 41.3 dm^3/s (655 GPM) per unit.

The blowdown will have the same analysis as the circulating water and will have an expected quality as shown on Table 3.5-1 in Section 3.5.

Shock chlorination will be used in the circulating water systems for control of bacterial slimes and algae. The chlorination

system will be controlled to limit free available chlorine to an average concentration of less than 0.2 mg/L and a maximum concentration of less than 0.5 mg/L in the blowdown discharged to meet the limits set by the EPA. Chlorine consumption is detailed in Section 3.5.

In addition, the chlorination system will be controlled so that neither free nor total residual chlorine is discharged from any one of the units for more than 2 hours in any one day.

Blowdown will be discharged to the existing discharge canal and will be taken from the cold side of the circulating water system.

There will be a phosphate residual in the blowdown as a result of using an organic phosphate material for scale control. The organic phosphate consumption is presented in Section 3.5. There will be no treatment required for cooling tower blowdown before discharging to the existing discharge canal.

The circulating water blowdown will be reused to the maximum extent possible in the bottom ash handling system. It is anticipated that the quantity of cooling tower blowdown will at most times exceed the bottom ash system makeup requirements so that it will be necessary to discharge most of the circulating water blowdown to the existing discharge canal. The point of entry to the discharge canal is as shown on Figure 3.4-1.

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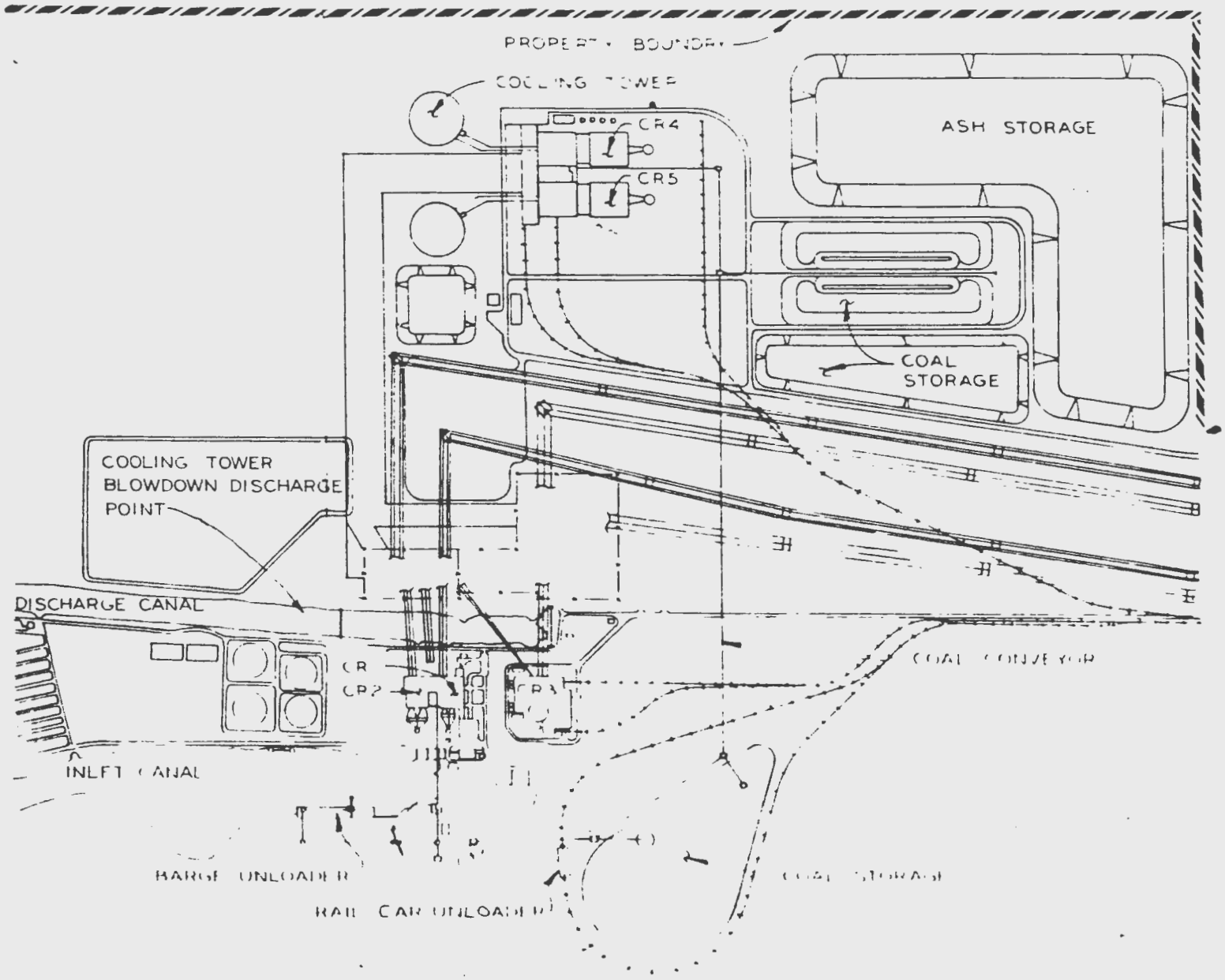
were of poor quality.



1000' 500' 0 1000' 2000'

1" = 1000'

1" = 305 METERS

CRYSTAL RIVER UNITS 4 & 5
ENVIRONMENTAL REPORT

FIGURE 3.4-1

COOLING TOWER LOCATION

Table 3.4-1. Heat Dissipation System Consumptive Use--Each Unit

Item	Parameter
Circulating Water Flow Rate	
Condenser, dm^3/s (GPM)	20 087 (318,000)
Auxiliary Cooling, dm^3/s (GPM)	1 263 (20,000)
Peak Heat Load on Cooling Towers	
Main Condenser, GJ/h (BTU/H)*	3 482 (3300 x 10^6)
Station Service Water System, GJ/h (BTU/H)	211 (200 x 10^6)
Cooling Tower Makeup†	
Peak, dm^3/s (GPM)	416 (6590)
Normal, dm^3/s (GPM)	253 (4010)
Cooling Tower Blowdown†	
Peak, dm^3/s (GPM)	68 (1080)
Normal, dm^3/s (GPM)	41 (655)
Evaporation and Drift from Cooling Towers	
Peak, dm^3/s (GPM)**	348 (5520)
Normal, dm^3/s (GPM)††	212 (3365)

*Heat load at peak load conditions (VWO, OP).

†Estimated based upon six cycles of concentration in circulating water.

**Maximum evaporation at peak heat load and 26.1 C (79 F) wet bulb.

††Average evaporation at 66 per cent heat load, 77 per cent relative humidity, and 21.7 C (71 F) dry bulb.

3.3 PLANT WATER USE

Water will be used for a variety of purposes at Crystal River Units 4 and 5. Figure 3.3-1 is a flow diagram showing the areas of plant water use and discharge. Table 3.3-1 presents the quantities of water used and discharged at normal, peak, and temporary shutdown plant conditions.

1. Normal (or average) operating condition is defined as both generating units operating at the annual average load factor of 66 per cent and annual average evaporative conditions existing; 21.7 C (71 F) dry bulb temperature and 77 per cent relative humidity.
2. Peak (or maximum) operating condition is defined as both generating units operating at 100 per cent load factor and maximum atmospheric evaporative conditions existing for the cooling towers.
3. Temporary shutdown is defined as both units being shut down for maintenance or other reasons.

On all the above conditions, the quantities for rainfall and evaporation from site areas have been generated by using the average annual figures of approximately 1 400 mm/yr (55 IN./YR) for rainfall and 1 220 mm/yr (48 IN./YR) for evaporation (Climatic Atlas of the United States, 1968).

3.3.1 Water Requirements and Sources

Raw water for plant uses will be obtained from a well field along the FPC Central Florida transmission line right-of-way. Five wells, each with a capacity of approximately 190 dm^3/s (3000 GPM), are estimated to be needed to provide the water required. Although test well data is unavailable, well drawdown is expected to be less than 0.30 m (1 FT).

The well water will be pumped to the station to provide makeup to the plant cooling towers and supply to the water pretreatment system (solids contact basin).

Raw water requirements for Units 4 and 5 will require a peak flow of about 864 dm^3/s (13,700 GPM) and a normal flow of about 530 dm^3/s (8400 GPM). During temporary shutdown of the two units, raw water demand will be about 5 dm^3/s (80 GPM).

3.3.2 Water Utilization

3.3.2.1 Service Water--Service water will be pretreated well water which has been lime softened and clarified in a solids contact basin, followed by filtration and chlorination. Service water will be used as makeup to the demineralization system and for general plant uses including potable water, pump seal water, and ash crusher seal water.

The flow requirements of service water to the demineralization system and other plant uses are indicated in Table 3.3-1.

3.3.2.2 Cooling Towers--Makeup to the plant cooling towers (circulating water systems) will be untreated well water. This water is required to make up that portion of the circulating water lost by evaporation, drift, and blowdown (discharge of water to maintain water quality to in turn maintain the integrity of the heat

rejection system). Cooling tower makeup will receive chemical additives as in Section 3.5 to allow operation with a minimum quantity of raw water makeup, as described in Section 3.5.

The expected peak makeup requirement is approximately 833 dm^3/s (13,200 GPM) and the expected normal makeup requirement is approximately 506 dm^3/s (8020 GPM). During temporary shutdown, no makeup water will be required to the plant cooling towers.

3.3.2.3 Demineralized Water--Demineralized water will be service water which has been further processed to a high quality suitable for use as makeup to the condensate-feedwater-steam cycle. The demineralization process will consist of ion exchange by three cation-anion exchanger pairs with degasification after the primary anion exchanger.

The peak and normal demineralization system flows are indicated in Table 3.3-1. During temporary shutdown of the units, the only demineralized water requirement will be that required for regeneration of the demineralization and condensate polishing systems ion exchange resins.

3.3.2.4 Ash and Rejects Handling Systems--Water utilized in the ash and rejects handling systems will be primarily cooling tower blowdown water. Water pretreatment system wastewater will also be directed

to these systems and service water will be used for crusher seals. No import of raw well water for use in the ash and rejects handling systems is anticipated.

Fly ash will be handled dry and bottom ash, mill rejects (pyrites), and the calcium carbonate sludge contained in the water pretreatment wastewater will be dewatered prior to storage in an above grade landfill area, as described in Section 3.6. Plant wastewater from the plant drains collection pond will be utilized for dust suppression and compaction in the ash landfill area.

The peak and normal water reuse requirements for ash and rejects handling are presented in Table 3.3-1.

3.3.2.5 Precipitation--Rainfall on roof areas, general site areas, and coal and ash storage areas will result in drainage water. The rainfall on specific areas of the plant site, based on the annual average rainfall of 1 400 mm (55 IN.) (Climatic Atlas of the United States, 1968), are presented in Table 3.3-1.

3.3.3 Station Consumptive Uses

Consumptive water is defined as water imported to the site, either well water or water resulting from precipitation, that is not returned directly to a surface receiving body or stream. Consumption consists primarily of evaporation and drift losses from the

plant processes, and plant runoff water to natural seepage and evaporation. Minor losses include water retained in plant solid wastes.

3.3.3.1 Cooling Towers--Consumptive water uses for the cooling towers (circulating water systems) will be due to evaporation and drift. Cooling tower evaporation and drift at peak conditions will be approximately 694 dm^3/s (11,000 GPM) and 2.5 dm^3/s (40 GPM), respectively, and 423 dm^3/s (6700 GPM) and 1.9 dm^3/s (30 GPM) at the normal conditions. There will no consumptive water uses for the cooling towers during temporary shutdown condition.

3.3.3.2 Steam Cycle--Consumptive water uses for the steam cycle, including steam soot-blowing and miscellaneous cycle losses, will be approximately 15.4 dm^3/s (245 GPM) at the peak condition and 10.1 dm^3/s (160 GPM) at the normal condition. There will be no consumptive water uses for the steam cycle during temporary shutdown.

3.3.3.3 Ash and Rejects Handling System--Consumptive water uses for the ash and rejects handling systems include evaporative losses from the bottom hopper, water accumulated in the solid ash and rejects material in the ash landfill, and evaporative and seepage losses from this ash landfill area. The flows for these consumptive uses at the peak, normal, and temporary shutdown conditions are indicated in Table 3.3-1.

3.3.3.4 Plant Drainage Systems--Miscellaneous plant drains, including plant floor and roof drains, boiler blowdown, and neutralization basin effluent, will be routed to the plant drains collection pond. The incoming flow rates are presented in Table 3.3-1. The pond is sized to contain inflowing water resulting from a 10 year, 24 hour rainfall event. Seepage and evaporative losses, presented in Table 3.3-1, will normally exceed the influent flows.

For general site areas, coal storage areas, and active ash storage areas, dike and ditch systems will be constructed to contain rainfall runoff flows. The design of these ditches will be such as to contain the runoff resulting from up to a 10 year, 24 hour rainfall event of 213 mm (8.37 IN.) (Hershfield, 1961). Evaporative and seepage losses from the respective site, active ash, and coal storage areas, and from the ditch systems are indicated in Table 3.3-1.

3.3.4 Wastewater Effluent Streams

Wastewater to be discharged from the new site will be routed to the existing discharge canal which empties into the Gulf of Mexico.

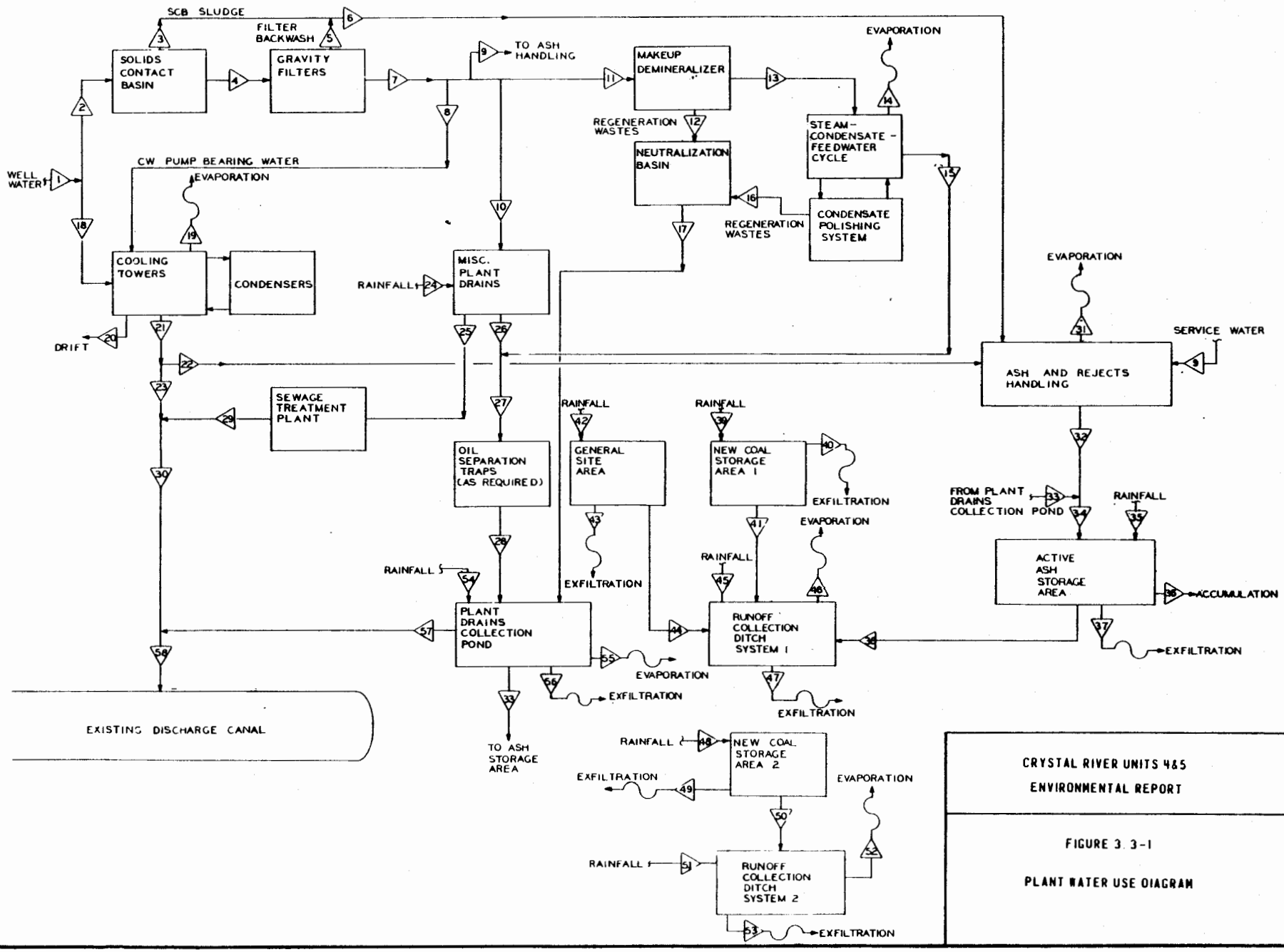
Discharge will consist of combined cooling tower blowdown and sewage treatment plant effluent and, in high rainfall situations, will also contain plant drains collection pond overflow. Descriptions of the normal waste streams are presented in Section 3.5 of this report.

The quantities of water to be discharged at the peak, normal, and temporary shutdown conditions are indicated in Table 3.3-1.

REFERENCES

1. Climatic Atlas of the United States, U.S. Environmental Science Services Administration, June 1968, GPO C52.2: c 61/2, p. 43.

2. Hershfield, David M., Rainfall Frequency Atlas of the United States, U.S. Weather Bureau, May, 1961, GPO C30.28: 40, p. 53.



CRYSTAL RIVER UNITS 4&5

ENVIRONMENTAL REPORT

FIGURE 3.3-1

PLANT WATER USE DIAGRAM

Table 3.3-1. Crystal River Units 4 & 5 Environmental Report Plant Water Quantities

Stream Number	Description	Peak		Normal		Temporary Shutdown	
		dm^3/s	(GPM)	dm^3/s	(GPM)	dm^3/s	(GPM)
1	Makeup Water from Wells	862.1	(13,665)	528.0	(8,370)	4.8	(77)
2	Water Pretreatment System Makeup	30.6	(485)	22.1	(350)	4.8	(77)
3	Solids Contact Basin Sludge	0.2	(3)	0.1	(2)	0	(0)
4	Solids Contact Basin Effluent	30.4	(482)	22.0	(348)	4.8	(77)
5	Filter Backwash Wastewater	0.4	(6)	0.4	(6)	0	(0)
6	Water Pretreatment System Wastes	0.6	(9)	0.5	(8)	0	(0)
7	Gravity Filter Effluent	30.0	(476)	21.6	(342)	4.8	(77)
8	Circulating Water Pump Bearing Water	1.3	(20)	1.3	(20)	0	(0)
9	Ash Handling System Service Water Uses	0.3	(4)	0.3	(4)	0	(0)
10	Miscellaneous Station and Potable Water Uses	3.5	(56)	3.5	(56)	3.5	(56)
11	Demineralizer Makeup	24.9	(396)	16.5	(262)	1.3	(21)
12	Demineralizer Regeneration Wastes	1.0	(16)	0.7	(11)	0.7	(11)
13	Condensate-Feedwater-Steam Cycle Makeup	23.9	(380)	15.8	(251)	0.6	(10)

Table 3.3-1 (Continued). Crystal River Units 4 & 5 Environmental Report Plant Water Quantities

Stream Number	Description	Peak		Normal		Temporary Shutdown	
		dm^3/s	(GPM)	dm^3/s	(GPM)	dm^3/s	(GPM)
14	Steam Cycle Evaporative Losses	15.4	(245)	10.1	(160)	0	(0)
15	Steam Cycle Blowdown	7.8	(123)	5.1	(81)	0	(0)
16	Condensate Polisher Wastes	0.7	(12)	0.6	(10)	0.6	(10)
17	Neutralization Basin Effluent	1.7	(28)	1.3	(21)	1.3	(21)
18	Cooling Towers Makeup	831.5	(13,180)	505.9	(8,020)	0	(0)
19	Cooling Towers Evaporation	694.0	(11,000)	422.7	(6,700)	0	(0)
20	Cooling Towers Drift	2.5	(40)	1.9	(30)	0	(0)
21	Cooling Towers Blowdown	136.3	(2,160)	82.6	(1,310)	0	(0)
22	Cooling Towers Blowdown to Ash Handling Systems	4.9	(78)	3.2	(51)	0	(0)
23	Cooling Tower Blowdown to be Discharged	131.4	(2,082)	79.4	(1,259)	0	(0)
24	Rainfall to Roof Drains	1.3	(20)	1.3	(20)	1.3	(20)
25	Sanitary Wastes	0.4	(6)	0.4	(6)	0.4	(6)
26	Miscellaneous Plant Drains	4.4	(70)	4.4	(70)	4.4	(70)
27	Miscellaneous Plant Wastes and Boiler Blowdown	12.2	(193)	9.5	(151)	4.4	(70)

Table 3.3-1 (Continued). Crystal River Units 4 & 5 Environmental Report Plant Water Quantities

Stream Number	Description	Peak		Normal		Temporary Shutdown	
		dm^3/s	(GPM)	dm^3/s	(GPM)	dm^3/s	(GPM)
28	Miscellaneous Plant Wastes to Plant Drains Collection Pond	12.2	(193)	9.5	(151)	4.4	(70)
29	Sewage Treatment Plant Effluent	0.4	(6)	0.4	(6)	0.4	(6)
30	Combined Cooling Tower Blowdown and Sewage Treatment Plant Effluent to Plant Discharge	131.8	(2,088)	79.8	(1,265)	0.4	(6)
31	Bottom Ash Hopper Evaporation	4.2	(67)	2.9	(45)	0	(0)
32	Water Entrained in Ash from Ash Handling	1.6	(24)	1.1	(18)	0	(0)
33	Water for Ash Dust Suppression and Compaction	0.4	(7)	0.3	(5)	0	(0)
34	Water in Disposed Ash	2.0	(31)	1.4	(23)	0	(0)
35	Active Ash Storage Area Rainfall	3.3	(52)	3.3	(52)	3.3	(52)
36	Active Ash Storage Area Water Accumulation	2.0	(31)	1.4	(23)	0	(0)
37	Active Ash Storage Area Exfiltration	1.3	(21)	1.3	(21)	1.3	(21)
38	Active Ash Storage Area Runoff to Collection Ditch System 1	2.0	(31)	2.0	(31)	2.0	(31)

Table 3.3-1 (Continued). Crystal River Units 4 & 5 Environmental Report Plant Water Quantities

Stream Number	Description	Peak		Normal		Temporary Shutdown	
		dm^3/s	(GPM)	dm^3/s	(GPM)	dm^3/s	(GPM)
39	New Coal Storage Area 1 Rainfall	8.4	(134)	8.4	(134)	8.4	(134)
40	New Coal Storage Area 1 Exfiltration	3.4	(54)	3.4	(54)	3.4	(54)
41	New Coal Storage Area 1 Runoff to Runoff Collection Ditch System 1	5.0	(80)	5.0	(80)	5.0	(80)
42	General Site Area Rainfall	13.4	(213)	13.4	(213)	13.4	(213)
43	General Site Area Exfiltration	8.1	(128)	8.1	(128)	8.1	(128)
44	General Site Area Runoff to Runoff Collection Ditch System 1	5.3	(85)	5.3	(85)	5.3	(85)
45	Rainfall on Runoff Collection Ditch System 1	1.1	(17)	1.1	(17)	1.1	(17)
46	Runoff Collection Ditch System 1 Evaporation	0.9	(15)	0.9	(15)	0.9	(15)
47	Runoff Collection Ditch System 1 Exfiltration	12.5	(198)	12.5	(198)	12.5	(198)
48	New Coal Storage Area 2 Rainfall	4.5	(71)	4.5	(71)	4.5	(71)
49	New Coal Storage Area 2 Exfiltration	1.8	(28)	1.8	(28)	1.8	(28)
50	New Coal Storage Area 2 Runoff to Runoff Collection Ditch System 2	2.7	(43)	2.7	(43)	2.7	(43)

Table 3.3-1 (Continued). Crystal River Units 4 & 5 Environmental Report Plant Water Quantities

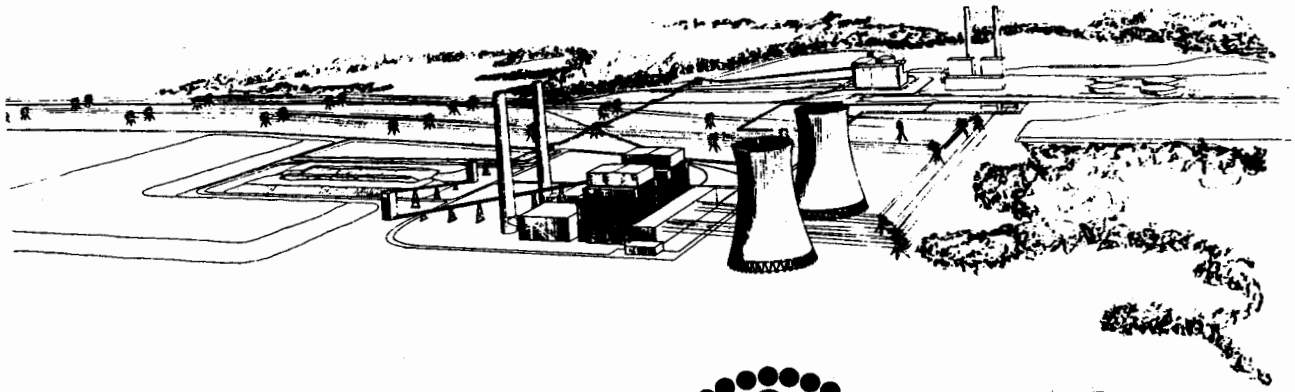
Stream Number	Description	Peak		Normal		Temporary Shutdown	
		dm^3/s	(GPM)	dm^3/s	(GPM)	dm^3/s	(GPM)
51	Rainfall on Runoff Collection Ditch System 2	0.3	(4)	0.3	(4)	0.3	(4)
52	Runoff Collection Ditch System 2 Evaporation	0.2	(3)	0.2	(3)	0.2	(3)
53	Runoff Collection Ditch System 2 Exfiltration	2.8	(44)	2.8	(44)	2.8	(44)
54	Plant Drains Collection Pond Rainfall	1.1	(18)	1.1	(18)	1.1	(18)
55	Plant Drains Collection Pond Evaporation	1.0	(16)	0.8	(13)	0.4	(7)
56	Plant Drains Collection Pond Exfiltration	13.6	(216)	10.8	(172)	6.4	(102)
57	Plant Drains Collection Pond Overflow to Plant Discharge	0*	(0*)	0*	(0*)	0*	(0*)
58	Final Plant Discharge to Existing Discharge Canal	131.8	(2,088)	79.8	(1,265)	0.4	(6)

*During heavy rainfall events of greater than 10 year, 24 hour occurrence, overflow from the plant drains collection pond to the plant discharge may be expected.

NOTE: During heavy rainfall events of greater than 10 year, 24 hour occurrence, overflow from the plant site and material storage collection systems will discharge to the natural watershed area east of the plant.

Site Certification Application

Crystal River Units No. 4 & 5



Vol. 3

Florida Power CORPORATION

CHAPTER 8

CHAPTER 8

ALTERNATE ENERGY SOURCES AND SITES

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8.0 ALTERNATIVE ENERGY SOURCES AND SITES

8.1 MANAGEMENT ALTERNATIVES

8.1.1 CONSTRAINT IDENTIFICATION

The Applicant has forecasted that net energy use by its customers will increase from 17,540 GWH in 1977 to 26,320 GWH in 1987, and 33,418 GWH in 1997. Winter peak demand for power will increase from 4,150 net MW in 1977 to 7,930 net MW in 1997. These forecasts have been obtained by computer modeling studies incorporating the following assumptions:

1. Normal weather conditions will prevail.
2. The economy of the Applicant's service area will continue to improve at a slow, steady rate.
3. There will be no significant loss of energy sales to solar energy until the late 1980's.
4. Personal income will increase at a rate equal to or greater than the Consumer Price Index. Power rate increases, if any, will be equal to or less than the CPI. (No effects of rate increases are included in the forecasts).
5. The Applicant will continue to serve the wholesale load which is now served, and will supply the energy required for load growth of existing wholesale customers, except for substitutions due to outside ownership of part of Crystal River Unit No.3, and expansion of generating capacity by Seminole Electric Company.
6. Unavailability of fossil fuels will increase the use of electricity for space heating.
7. The population projection made by the Bureau of Economic and Business Research of the University of Florida in Bulletin No. 41 is reasonably accurate.

8. There will be no impact of load management.

9. Improvements in insulation levels and equipment efficiency and increased emphasis on conservation will result in reduced electric power sales beginning in the mid-1980's.

The number of residential customers in the Applicant's service area has been established as a function of population, and projected into the future on the basis of population forecasts prepared by the Bureau of Economic and Business Research at the University of Florida. The number of commercial customers was related to residential customers and projected similarly. Annual kilowatt-hour consumption per residential customer was forecasted using two methods, one involving a trend projection tempered by judgment, and the other based on an analysis of appliance use and saturation. Two estimates of sales per commercial customer were also prepared and reconciled. Other sales categories were forecasted by historical trend projection, analysis of relationships to residential sales, and assumptions expressing changes in sales patterns.

The resulting sales and demand forecasts are presented in Tables 8.1.1-1 and 8.1.1-2. Substantially lower growth rates than prevailed in the past are projected for all classes of users, due to the anticipated slowdown in population growth, the saturation of residential customers with appliances, and the reduction in sales to Seminole Electric Company. The average annual growth rate of net energy during 1977-87 would be only 0.56 times the comparable rate for 1967-77 (without the Seminole Electric adjustment), whereas this ratio has been estimated at 0.60 for Florida as

Table 8.1.1-1. History and Forecast of Energy Use

	Energy Sales in GWH					
	Rural and Residential	Commercial	Industrial	Other Sales to Ultimate Consumers	Total Sales to Ultimate Consumers	Sales for Resale
Sales By Year						
1968	2,671	1,426	1,732	282	6,111	925
1977	6,521	3,602	2,772	473	13,368	2,853
1987	10,298	6,036	4,871	957	22,162	2,087
1997	13,066	7,453	6,441	1,214	28,174	2,655
Average Annual Percent Changes						
1967-77	11.41%	11.16%	5.78%	--	--	--
1977-87	4.68%	5.30%	5.80%	--	--	--
1987-97	2.41%	2.31%	2.83%	--	--	--

Table 8.1.1-2. History and Forecast of Seasonal Demands

	Summer Peak Demand Net MW	Winter Peak Demand Net MW
Year		
1968	1,487	1,551
1977	3,407	4,150
1987	5,380	6,580
1997	6,340	7,930
Average Annual Percent Change		
1967-77	10.97%	12.89%
1977-87	4.48%	4.93%
1987-97	1.66%	2.10%

a whole (1977 Ten-Year Plan, State of Florida, May 1, 1977). Thus, the forecasts are regarded as conservative.

A 515 MW fossil steam unit is presently under construction at Anclote; and the Applicant plans to bring three combustion turbine plants with a combined capacity of 550 MW on-line by the end of 1981. However, a rapid reduction in reserves would occur in 1982 and subsequent years without major additions to generating capacity (see below). The management alternatives open to the Applicant are the following: (1) not to generate or purchase additional power; (2) to purchase the required energy from other sources; (3) to uprate and continue operation of older units, or reactivate retired plants; (4) to enter into a joint project for providing new generating capacity; (5) to construct smaller units than the facilities proposed; and (6) to construct the proposed power generating facilities.

8.1.2 OMISSION OF PROPOSED PROJECT WITHOUT SUBSTITUTE ENERGY SOURCES

The modeling studies conducted by the Applicant have included computations of loss of load probability (LOLP) under various alternatives. The LOLP is calculated from a forecast of weekly peak demand and variances, and the projected forced outage rates and scheduled outages for each generating unit. A LOLP value of one day in 10 years has been generally accepted throughout the electric utility industry as a reasonable design goal. For purposes of generating capacity planning, it has been determined that a criterion of 2.5 days per year dependency upon interruptible loads and interconnections is equivalent to one day in ten years LOLP for firm loads.

The projected system dependency in terms of loss of load probability is presented for various alternatives in Table 8.1.2-1. As shown in the upper portion of the table, the addition of 640 MW units in 1982 and 1984, as proposed, would bring the LOLP close to the desired value of 2.5 days per year by 1983, and would lower it below this criterion in the two subsequent years. However, if the 1982 unit were omitted, the LOLP would be between 8 and 18 in the years beginning with 1983. Omission of the 1984 unit as well as the 1982 unit would create a situation of negative reserves in 1985 and 1986, with LOLP values exceeding 30. These projections are dependent on the assumption that no new combustion turbine units will be brought on-line after 1981; however, such an assumption is consistent with national energy conservation policies.

Omission of the proposed power generating facilities, with no substitution of alternative power sources, would thus result in a system having greatly increased loss of load probability, which would jeopardize the Applicant's service area and act as a detriment to the interconnected systems of the State of Florida. Unlike distribution-initiated service interruptions, which affect only a small number of individual customers, blackouts or brownouts due to lack of overall system capacity impact large segments of the service area simultaneously. Such outages create situations which are not only expensive to customers but endanger the health and safety of the community.

Table 8.1.2-1. Projected System Dependency Under Various Alternatives

	Capacity in MW	Winter Peak Demand, MW	Reserves MW	Reserves %	LOLP Days/Year
With Both Proposed Units Included					
1978	4,668	4,150	518	12.9%	3.92
1981	5,618	5,050	568	11.2%	3.94
1982	5,983	5,360	623	11.6%	2.99
1983	6,443	5,660	783	13.8%	2.62
1984	6,543	5,760	783	13.6%	1.69
1985	7,183	6,050	1,133	18.7%	1.67
1986	7,139	6,140	999	16.3%	3.69
With 1982 Unit Excluded					
1982	5,983	5,360	623	11.6%	2.99
1983	5,803	5,660	143	2.7%	13.51
1984	5,903	5,760	143	2.5%	9.39
1985	6,543	6,050	493	8.1%	8.39
1986	6,499	6,140	359	5.8%	17.23
1991	—	—	—	—	12.4
With Both Proposed Units Excluded					
1984	5,903	5,760	143	2.5%	9.39
1985	5,903	6,050	-147	-2.4%	30.85
1986	5,263	6,140	-281	-4.6%	48.98

8.1.3 PURCHASES OF REQUIRED ENERGY FROM OTHER SOURCES

The Applicant has maintained a policy of participating in mutually advantageous firm power exchanges with other electric utilities. Such exchanges allow the selling utility to take advantage of economies of scale, while enabling the buyer to defer capital investment and obtain efficient peak generating capacity. The Applicant is currently under contract for purchases from one utility and intends to enter agreements with three others for power exchanges during the next six years. However, it is very unlikely that additional purchases of the magnitude necessary to eliminate the proposed generating facilities would be feasible. The excess capacity in nearby utility service areas is limited, and by 1981 the reserves for the State of Florida as a whole will be approaching the 20 percent level which is commonly considered minimal for maintenance of reliable service.

8.1.4 REACTIVATION AND/OR UPRATING OF OLDER PLANTS

A program of uprating older plants or reactivating retired units would have only limited benefits, for the following reasons. Existing turbines and generators can be uprated by only modest amounts. If the original equipment is replaced, so that essentially a new unit is constructed, the unit would be subject to recent legislation requiring offstream cooling and stack emission controls. Such steps might require more additional land for cooling facilities and solid waste storage areas than is available at the site. On the other hand, older equipment is relatively inefficient and unreliable, so that such facilities generally cannot be utilized for baseload generation, as opposed to peaking capacity. Thus,

uprating and reactivation of older plants is clearly not a feasible means of fulfilling a major proportion of the capacity needs demonstrated by the Applicant.

8.1.5 JOINT PROJECTS

Joint projects are not unknown to the Applicant, as 10 percent of the recently-completed nuclear generating capacity at Crystal River is owned by four other utilities. However, there are no favorable opportunities for large-scale joint projects at the present time. Three of the smaller utility companies whose service areas abut the Applicant's service area have already planned for major increments in generating capacity. The Applicant will participate indirectly in these projects through power exchanges, but could not join with these companies in fulfilling capacity requirements at the present date. Also, the largest utility in Florida is currently bringing on-line over 1200 MW of new capacity in counties near the Applicant's service area, which would appear to rule out joint projects in these districts in the near future.

8.1.6 CONSTRUCTION OF SMALLER UNITS THAN THE PROPOSED FACILITIES

The demand forecasts demonstrate that at least 1,000 MW of additional generating capacity is needed for the Applicant's service area by 1984, and that a substantial proportion should be provided by 1982. Three potential unit sizes have been considered by the Appplicant, on the assumption that the most efficient means of obtaining the needed capacity would be the construction of two units. These sizes were 550 MW, 600 MW, and 640 MW. The 600 MW size was developed from a conceptual viewpoint,

whereas the other two unit sizes represent standard turbines presently available to the industry. Studies by the Applicant have indicated that the incremental savings in variable cost associated with the 640 MW size, resulting from substitution of coal-fired power generation for oil-fired plants, would outweigh the incremental fixed costs of the larger unit. The 640 MW size was therefore selected as the most economical system alternative.

The possiblity of siting the two 640 MW power generating units at different locations was rejected on the basis of both economic costs and environmental considerations. A number of the facilities needed to serve the two units would have to be duplicated if the units were sited apart. Some examples are access roads, solid waste disposal areas, coal handling systems, water treatment facilities, and power transmission corridors. Provision of such facilities at two separate locations would result in much greater environmental impacts, all else being equal, than the use of a single site. The economies of scale obtainable by constructing the units at the same location were clearly substantial. This alternative was therefore selected in spite of the possibility of minimizing transmission distances through the use of separate sites.

8.1.7 CONSTRUCTION OF THE FACILITIES AS PROPOSED

The construction of two linked 640 MW units, to be completed respectively in late 1982 and late 1984, was judged the best feasible management alternative in terms of system reliability, capacity, and cost. The units would come on-line at the appropriate times to meet growing energy demands and reverse the recent upward trend in system dependency.

8.2 ALTERNATIVE ENERGY SOURCES

8.2.1 CONSTRAINT IDENTIFICATION

The possible means of power generation include nuclear, coal, oil, gas, hydroelectric, solar, and geothermal. The primary constraints which apply to the Applicant regardless of present plans and customer needs are: (1) the physiography of the siting region; (2) the current state of technology; (3) government policies regarding conservation of scarce resources; and (4) fuel availability. The topography and geology of Florida rule out the development of hydroelectric power and/or the use of pumped storage. Solar, geothermal, and other new-line power generation alternatives have not been developed to the point at which they could feasibly be utilized for large-scale power generation in Florida. The use of oil for electric power generation is being curtailed by government regulation. And finally, the availability of natural gas is doubtful. The recoverable reserves of natural gas may be much larger than is commonly believed, so that the present shortage situation could perhaps be alleviated in the future. However, this possibility can by no means be counted upon in planning long-term commitments. The energy sources which can potentially be considered by the Applicant are therefore limited to coal and nuclear power.

8.2.2 NUCLEAR

The lead time required for licensing, design, and construction of a nuclear power generating facility is presently close to 10 years. Based upon the foregoing analysis of need for power, the Applicant must have

the two proposed units on-line by 1982 and 1984. In addition, there are numerous regulatory and financial uncertainties surrounding construction of nuclear units and disposition of used nuclear fuel. Thus, nuclear power has not been considered a feasible alternative for the facilities under discussion.

8.2.3 COAL

Coal, the only remaining energy alternative, could be obtained for the proposed power generating units from either the eastern province (Alabama, Kentucky, Tennessee, West Virginia) or from the western states. An economic analysis has been conducted by the Applicant to establish the relative favorability of low-sulfur versus high-sulfur coal for the proposed power generating facilities. The computations were based upon two 640-megawatt units at the Crystal River site with fresh-water cooling towers. However, the cost elements considered would be common to most of the feasible cost/plant options. The issue addressed was the trade-off between higher fuel costs with low-sulfur coal, versus higher capital and operating costs with high-sulfur coal due to the extensive use of scrubbers for sulfur removal. Low-sulfur coal was defined as a product which yields 0.6 pounds of sulfur or less per million Btu (mmBtu) when burned. The assumptions involved were the following:

1. Fixed charge rate = 14.0 percent. Cost of capital = 11.1 percent.
2. Operation and maintenance cost for low sulfur units will be 1.8 mills per kilowatt-hour in 1982 and will escalate at 6 percent per year over the life of the unit.

3. Operation and maintenance cost for a high-sulfur unit will be twice that of a low-sulfur unit.
4. Fuel costs for the year beginning October 1, 1978, will be $1.74 per mmBtu for high-sulfur coal and $1.94 mmBtu for low-sulfur coal.
5. Fuel prices will escalate at 10 percent per year through 1980 and 5 percent per year thereafter.
6. The heat rate for a high sulfur unit will be 9,800 BTU/kilowatt-hour, versus 9,400 BTU/kilowatt-hour for a low-sulfur unit.
7. A high-sulfur unit must be 5 percent larger than a low-sulfur unit in order to achieve the same net output.
8. Plant life will be 30 years.

The computed total costs, expressed as the present worth of operations commencing in 1982 and 1984, are presented in Table 8.2.3-1. Variable costs are cited for the first year and last year of operation. In the case of Unit 1, which would be on-line in 1982, it is found that the low-sulfur coal option would involve a present-worth saving of approximately $100 million in 1982 dollars relative to the high-sulfur plant. Although the absolute magnitude of the saving is dependent upon the assumed discount rate (equal to the cost of capital), the relative saving is not highly sensitive to this assumption since the ratio of high-sulfur costs to low-sulfur costs is fairly constant over all years of operation. (The former exceeds the latter by 4.5 percent to 7 percent.) In the case of Unit 2, the low-sulfur option is credited with a present-worth saving of $90 million in 1984 dollars.

Table 8.2.3-1. Hypothetical Cost Comparison of Power Generation Units Utilizing Low-Sulfur and High-Sulfur Coal

Unit 1	Low-Sulfur Coal			High-Sulfur Coal		
	Annual Cost		Present Worth In 1982 $	Annual Cost		Present Worth In 1982 $
	First Year (1982)	Last Year (2011)		First Year (1982)	Last Year (2011)	
Capital	54.4	54.4	469.3	64.5	64.5	556.0
Fuel	84.1	346.0	1,124.9	78.6	323.5	1,051.6
Operation and Maintenance	5.9	32.2	88.0	11.9	64.4	176.0
TOTAL PRESENT WORTH			1,682.2			1,783.6

Unit 2	Low-Sulfur Coal			High-Sulfur Coal		
	Annual Cost		Present Worth In 1984 $	Annual Cost		Present Worth In 1984 $
	First Year (1984)	Last Year (2013)		First Year (1984)	Last Year (2013)	
Capital	43.9	43.9	378.7	52.3	52.3	451.0
Fuel	92.8	381.8	1,241.1	86.7	356.8	1,159.7
Operation and Maintenance	6.7	36.1	98.8	13.3	72.2	197.6
TOTAL PRESENT WORTH			1,718.6			1,808.3

Along with the economic advantages indicated in Table 8.2.3-1, low-sulfur coal avoids some uncertainties involving the use of scrubbers for sulfur removal. A disadvantage of low-sulfur coal, however, is the possibility of shortages in the future. The figures in Table 8.2.3-1 involve an implicit assumption that the delivered cost of low-sulfur coal will always be 11.1 percent higher per BTU than the delivered cost of high-sulfur coal. Further calculations, maintaining all other assumptions, indicate that the break-even point for the low-sulfur version of Unit 1 relative to the high-sulfur version would be a coal price differential of 22.6 percent. That is, if the delivered cost of low-sulfur coal does not exceed that of high-sulfur coal by more than 22.6 percent, the present worth of the low-sulfur operation will be less than or equal to the high-sulfur operation. Other computations by the Applicant dealing with coal delivery to the alternative power plant sites under consideration have indicated that the cost differential for most of the sites would be between 20 percent and 25 percent, if the most economical combination of rail and barge transportation were utilized in each case. Thus, the probable total costs of equivalent low-sulfur and high-sulfur operations would be about the same regardless of where the units were located within the siting region. The use of low-sulfur coal has nevertheless been judged preferable, and has been assumed throughout the site evaluation process described here.

8.3 ASSESSMENT OF ALTERNATIVE SITES

8.3.1 INTRODUCTION

The following text presents an evaluation of alternative sites for the two 640-megawatt fossil-fueled power generating units proposed by the Applicant. The region considered for potential site locations included the entire state of Florida north of 27°00' North latitude and east of 85°30' West longitude, although the Applicant's service area constitutes only a portion of this region.

The Applicant has conducted a large number of studies pertaining to site selection over the past several years, which have included aerial and field surveys, geologic studies, ecological investigations, water resource studies, and a detailed site analysis utilizing a computer model. The most extensive study, which was concerned with siting a nuclear unit, initially considered 185 sites. The list was later reduced to 50 sites on the basis of map analysis. Since nuclear and fossil-fuel plants have many of the same requirements, the list of sites analyzed in the nuclear study was taken as a starting point in evaluating possible sites for the facilities discussed here. Several new sites were added, and a considerable number were deleted due to changes in land use, environmental conditions, or public policies since the time of the nuclear study. The resulting list of approximately 30 sites has been analyzed intensively with respect to the criteria described below.

Rather than reviewing the entire site selection process, only 11 potential sites are discussed here. This list has been obtained by

eliminating all sites that were found in the course of the selection process to be either: (1) infeasible, or (2) clearly inferior to another site in the same geographic area. The resulting group of 11 sites include all those which can be described in retrospect as serious possibilities for the proposed power plant development. The following text describes the criteria used in evaluating potential sites, the characteristics of the 11 sites chosen for discussion, the relative favorable characteristics of the sites in terms of cost and air quality, and the manner in which the preferred alternative was selected.

8.3.2 GENERAL SITING CRITERIA

8.3.2.1 INTRODUCTION

In the initial screening process, relatively few factors were considered as absolute constraints upon the inclusion of candidate sites. A site was required to contain an adequate acreage of dry land for placement of the proposed facilities and could not involve gross conflicts with existing land use or social/cultural values. The site had to be potentially accessible by rail and highway, and preferably also by barge. The other criterion for initial consideration was that potential sources of cooling system makeup water and service water had to be available at or near the site.

Since there are a large number of land parcels within the siting region that possess these basic qualifications, why the studies conducted by the Applicant have considered nearly 200 individual sites. However, as the description of alternatives will indicate, there are few highly favorable sites for power generation in Florida, due to constraints involving air

quality, water supply, aquatic ecology, wildlife habitat, and existing patterns of land and water use.

The specific criteria used to evaluate candidate sites are grouped here for purposes of discussion into three categories: general siting criteria, engineering criteria, and environmental criteria. The first category refers to land suitability and access to transportation and transmission facilities.

8.3.2.2 LAND ACREAGE AND OWNERSHIP

The area of land required for the proposed power generating units is calculated as follows:

Generating plant	12 ha	(30 acres)
Access, parking, and construction laydown	53 ha	(130 acres)
Coal storage and handling	40.5 ha	(100 acres)
Cooling towers	5 ha	(12 acres)
Cooling ponds, up to	607.5 ha	(1,500 acres)
Fly and bottom ash storage	101 ha	(250 acres)
Total, with cooling towers	211.5 ha	(522 acres)
Total, with cooling ponds	814 ha	(2,010 acres)

These computations indicate that about 202.5 hectares (500 acres) are needed if the proposed facilities utilize cooling towers, whereas the power generating units with cooling ponds would require approximately 810 hectares (2,000 acres). Even if cooling towers are assumed, the land requirements are somewhat indefinite because of possible variations in ash-sludge storage. More space than 101.25 hectares (250 acres) could be required if no user is found for residual ash.

Land acquisition costs have been considered as a criterion but are generally not a major source of cost differentials among alternative sites. More important is the possibility of land acquisition problems due to multiple ownership of the site area and/or existing residents at the site. The most-preferred situation is one in which the site consists of few individual parcels; the least-preferred situation would be one in which land condemnation proceedings are necessary.

8.3.2.3 TOPOGRAPHY AND GEOLOGY

Topography presents few obstacles to power plant development in Florida due to the generally level terrain. However, wet areas should be avoided for engineering as well as environmental reasons. Areas which are subject to flooding by storm runoff or ocean surges are obviously unfavorable. Avoidance of areas with known seismic activity is not a highly relevant criterion in Florida.

Geologic criteria relate to the ability of soils to support power plant structures, and the suitability of the site for construction of ponds and material storage areas. The critical variables in the former case are the depth to competent bedrock and the existence of solution activity, which is widespread throughout Florida. With regard to ponds and storage areas, there should preferably be impervious soils available for use as linings. The site should permit construction of ponds and storage areas in such a fashion that threats to public safety and surface water quality will not be created.

8.3.2.4 TRANSPORTATION AND POWER TRANSMISSION FACILITIES

Highway access to a site is required for transportation of materials and personnel. The proximity of a site to supplies of construction labor is also potentially important. Rail access, preferably involving direct linkage to a major carrier, is required for purposes of fuel delivery. Water access has not been considered an absolute necessity; but the potential for utilizing barge transportation has been treated as an important positive factor (see the discussion elsewhere).

A lack of adequate highway or rail access to a potential site has been treated as a negative factor with regard to both project cost and environmental impact, where the latter relates to the land use conversions involved in creating new transportation corridors. The same is true regarding barge transportation except that no access might be possible (dredging would be an important category of environmental impact in this case). An even more important cost consideration, in general, is the influence of transportation facilities and site location on delivered fuel. Given the projected coal consumption of the proposed facilities, a $1 per ton difference in the delivered cost of coal would amount to a differential of $4,000,000 or more in annual operating costs.

The candidate sites included in the selection process were not limited to locations near the Applicant's existing transmission lines. However, any new transmission corridors required as part of site alternatives have been treated as elements of project cost and environmental impact in the same fashion as transportation corridors. At least two 230 kv lines, or

one 500 kv line would be required for the proposed facilities. Possible problems of right-of-way acquisition have also been considered. The line transmission losses which would be involved in serving the Applicant's customers from the various sites were an important source of cost differentials. For the more remote sites considered, the losses would amount to very significant percentages of total generating capacity.

8.3.3 ENGINEERING SITING CRITERIA

The two proposed 640 MW power generating units would be on-line in late 1982 and 1984, respectively. Other basic design criteria which would apply at any of the alternative sites are as follows:

1. Unit life: 30 years;
2. Average annual load factor: 66 percent;
3. Net unit heat rate: 9,400 Btu/kwh (assuming low-sulfur coal);
4. Fuel consumption: roughly 4,000,000 tons per year of low sulfur coal;
5. Cooling system: fresh-water cooling towers (cooling ponds and once-through cooling with salt water were considered as options in some cases).

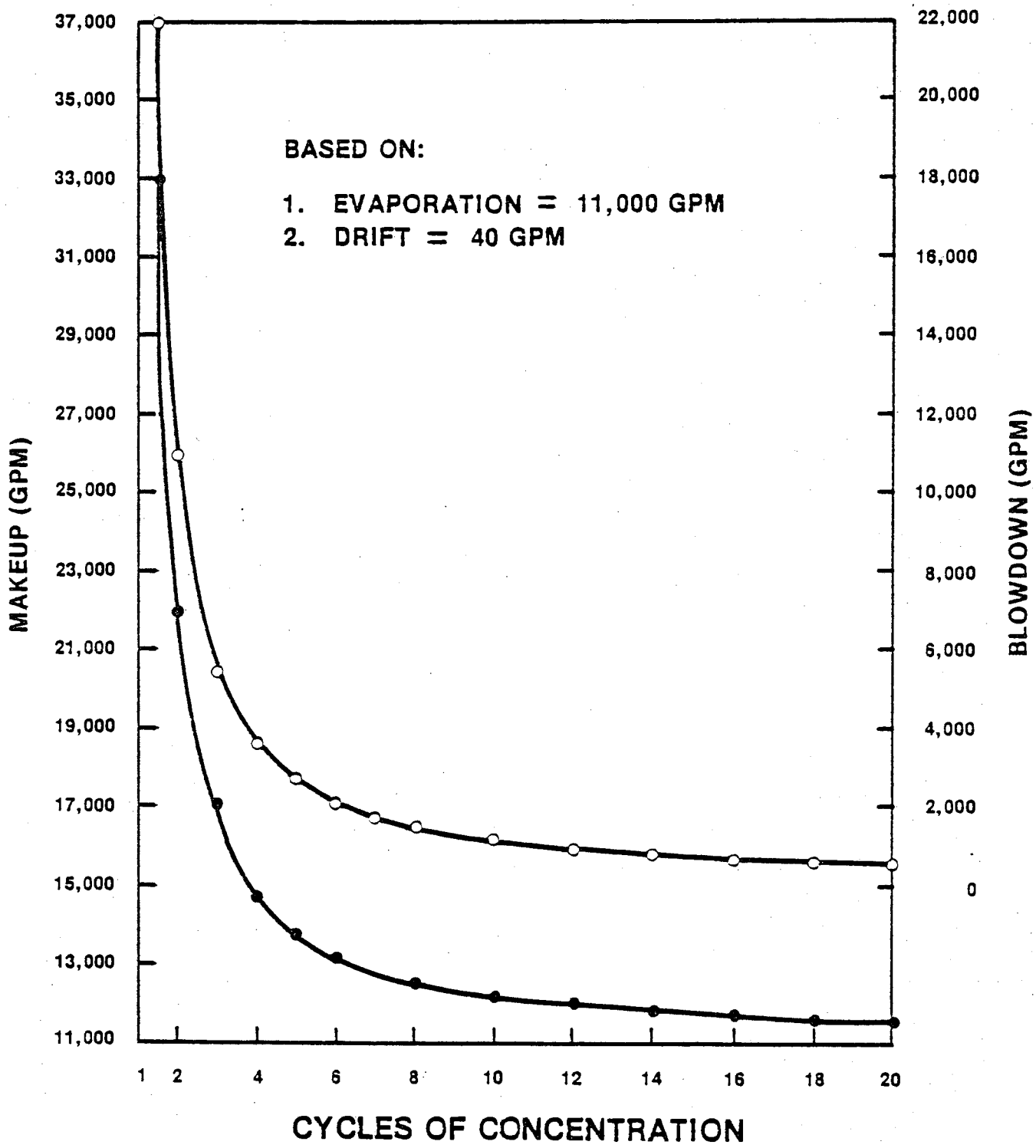
Each 640 MW unit would produce about 5.2 billion Btu per hour, of which two-thirds would be waste heat that must be dissipated by the cooling system. Thus, the required capacity of cooling units for each plant would be about 3.5 billion Btu per hour. Assuming that cooling towers were utilized, heat dissipation for both 640 MW units would require evaporation of 41,640 lpm (11,000 9pm), with an additional 151 lpm (40gpm) lost in drift. The amount of cooling system makeup water

required under these conditions would depend upon the water quality of the source utilized (which would determine the allowable cycles of concentration). The prevailing relationship is diagrammed in Figure 8.3.3-1. Under the conservative assumption that only 5 cycles of concentration could be maintained, the cooling tower makeup requirement would average 49,000,000 liters (9,200 gallons) per minute, or about 49,000,000 liters (13 million gallons) per day. The maximum makeup requirement would be approximately 75.7 mld (20 mgd).

In addition to cooling system makeup water, service water would be required for drinking, cooling of bearings, and other uses. Cycle makeup water would be required for conversion to steam. Withdrawals for these uses would average about 3 mld (0.8 mgd) and would reach a maximum of approximately 1.5 mgd. In addition, if scrubber systems were used to control stack emissions, an additional 5.7 mld (1.5 mgd) would be needed. All of these water uses would require various levels of treatment.

A maximum freshwater withdrawal rate of 87 mld (23 mgd, obtained by summing the figures just cited, has been utilized in the site evaluation process (cooling ponds could involve somewhat smaller withdrawals if losses due to percolation are low). As is discussed below, the impacts most commonly associated with withdrawals of this magnitude from surface waters are alterations of hydroperiod (with possible salinity effects) and entrainment of aquatic organisms. A guideline utilized in Florida is that maximum withdrawal rates from surface water bodies should not exceed 5 percent of the minimum observed 30-day flow, or the estimated 100-year

MAXIMUM MAKEUP AND BLOWDOWN VS. CYCLES OF CONCENTRATION IN CIRCULATION WATER FOR PROPOSED POWER GENERATING UNITS



SOURCE: FLORIDA POWER CORPORATION

Figure 8.3.1-1

minimum monthly flow. On the other hand, reliance upon groundwater supplies could affect adversely the yields of nearby wells, and could possibly risk saltwater intrusion in coastal areas. The quantity and quality of available water supplies have thus been highly important in site selection.

The wastewaters yielded by power generation include cooling system blowdown water, boiler wash, backwash, plant runoff, and runoff from storage and waste disposal areas. These wastewaters must be disposed without damage to aquatic ecosystems or groundwater resources. The design of wastewater disposal systems would be expected to vary considerably among site alternatives. Such systems could include deep well injection, percolation/evaporation, or surface water discharge, with varying levels of treatment. The evaluation of site alternatives with regard to wastewater has focused upon the feasibility and expense of disposing residuals in such a manner as to comply with all applicable water quality standards. The water quality characteristics of primary concern for discharges from steam electric generating plants are dissolved solids concentrations and temperature, although other constituents such as biocides and corrosion inhibitors can be important.

8.3.4 ENVIRONMENTAL SITING CRITERIA

The environmental criteria employed in the site selection process have dealt with air quality, water resources, aquatic and terrestrial ecology, population and land use, historical and archeological sites, recreational resources, other socioeconomic considerations, and public safety. The

most detailed criteria were those pertaining to air and water resources, since these involved specific quantitative standards established by federal and state agencies.

8.3.4.1 AIR QUALITY AND EMISSIONS

Both the federal and state governments have promulgated regulations relating to the quality of ambient air. These regulations are a major factor in obtaining approval of a site for a fossil-fueled power plant. The federal and state air quality criteria which were considered in the evaluation of alternatives are presented in the following discussion.

Federal air quality limitations which can significantly affect power plant siting are the National Ambient Air Quality Standards (NAAQS) and the Prevention of Significant Deterioration regulations. The NAAQS were promulgated by the U.S. Environmental Protection Agency on April 30, 1971 (40 CFR Part 50). Prevention of Significant Deterioration(PSD) regulations were also promulgated by the EPA (40 CFR Part 52). More recently, however, the Congress of the United States has passed amendments to the Clean Air Act which included new provisions for PSD. The President signed into law the Clean Air Act Amendments (PL 95-95) on August 7, 1977.

The NAAQS were established to protect the health and welfare of the citizens of the United States. A distinction was established between protection of public health only, and protection of public health and welfare. The former objective would be addressed by "primary" standards, whereas the latter would be addressed by "secondary" standards. Thus, secondary NAAQS have been designed to prevent occurrences such as impairment of visibility, corrosion and damage to plants as well as public health impacts. Table 8.3.4-1 presents the NAAQS for total suspended particulate matter, sulfur dioxide, and nitrogen dioxide. These are the major air pollutants emitted from a fossil fuel steam electric power plant.

A new fossil-fueled power plant (exceeding 250 mm Btu/hr) must meet the emission limitation standards known as New Source Performance Standards (promulgated by the USEPA in 40 CFR Part 60). Meeting these standards does not guarantee that NAAQS will not be violated, although the New Source Performance Standards make it highly unlikely that a new fossil-fueled power plant will violate NAAQS due entirely to its own emissions. NAAQS violations could occur primarily through source interaction and contribution to an existing air quality problem. Since a new source cannot cause or contribute to a violation of the NAAQS (except under provisions allowed in nonattainment areas, PL 95-95, Section 129), compliance with NAAQS must be evaluated in the site selection process.

The 1977 amendments to the Clean Air Act have significantly modified PSD requirements previously established by the EPA. The major air quality

Table 8.3.4-1. National and State of Florida Ambient Air Quality Standards (ug/m^3) (40 CFR Part 50, Chapter 17-2 FAC)

Air Pollutant	Standard	Averaging Time		
		Annual Average	24-Hour*	3-Hour*
Total Suspended Particulate Matter (TSP)	National Primary	75**	260	---
	National Secondary	60**	150	---
	State of Florida	60**	150	---
Sulfur Dioxide (SO_2)	National Primary	80	365	---
	National Secondary	---	---	1,300
	State of Florida	60	260	1,300
Nitrogen Dioxide (NO_2)	National Primary	100	---	---
	National Secondary	100	---	---
	State of Florida	100	---	---

* Not to be exceeded more than once per year
** Annual geometric mean

limiting features of Section 127 are the maximum allowable increases in concentrations of TSP and sulfur dioxide. A new fossil fuel power plant cannot result in any increases relative to baseline conditions which exceed the allowable increments for that area (or for a nearby area, in the case of Class I). All areas of the country are classified as either Class I, II, or III with the exception of national parks (exceeding 2,430 hectares or 6,000 acres), national wilderness areas (exceeding 4,050 hectares or 10,000 acres) and other federally designated lands (discussed in Sections 162 and 164, PL 95-95). Initially, for Florida, all areas of the state have been designated as Class II with the exception of the St. Marks, Bradwell Bay, Okefenokee, and Chassahowitza National Wilderness Areas and the Everglades National Park, which have been designated Class I. Table 8.3.4-2 presents the allowable air quality increments for Class I and II areas.

Similar to the federal requirements, the State of Florida (Department of Environmental Regulation) has promulgated ambient air quality standards (AAQS) and a limitation on significant degradation. The AAQS established by the state, which are presented in Table 8.3.4-1, are numerically equal to the federal secondary NAAQS (except for the annual and 24-hour sulfur dioxide standard). Since these standards are slightly more restrictive than the federal NAAQS, consideration of the state standards take precedence in evaluating compliance.

The regulation of significant degradation by the State of Florida currently does not involve specific air quality limiting increments. Rather, significant degradation is evaluated on a case by case basis by the DER.

Table 8.3.4-2. Prevention of Significant Deterioration Increments (PL 95-95 Section 127)

Classification	Air Pollutant	Maximum Allowable Increases Over Baseline (ug/m^3) Averaging Time		
		Annual Average	24-Hour*	3-Hour*
Class I	TSP	5**	10	---
	SO_2	2	5	25
Class II	TSP	19**	37	---
	SO_2	20	91	512

* Not to be exceeded more than once per year
** Annual geometric mean

BASELINE: Ambient concentrations existing at time of first application, and sources which have commenced construction prior to January 6, 1975.

Requirements for determination of significant degradation include a public notice and hearing, and a demonstration that degradation (any air pollutant concentration above baseline) is not contrary to public interest. If any increase above baseline is projected, the source under review must utilize latest reasonable available control technology (LRACT). However, the present rules expire on December 31, 1977. The DER is currently holding workshops to develop new regulations governing significant degradation. If no new regulations are promulgated, a non-degradation rule will become effective. The non-degradation rule would allow no air pollutant increases over baseline.

In order to evaluate alternative power plant sites with respect to these regulations, existing emission sources and air quality data were considered. Since Florida has generally favorable atmospheric dispersion conditions and minor terrain features, existing air quality and sources will be the major determinants of compliance with air quality regulations. Consequently, alternative sites were evaluated primarily on these two factors.

The present study has considered the potential effects of cooling tower fogging and salt drift on agriculture, local terrestrial habitats, and transportation. While there are no quantitative limiting standards for such effects, they must be evaluated since their importance may be great in some instances.

8.3.4.2 AQUATIC ECOLOGY

Impacts of power generating facilities on aquatic organisms can involve all of the water resource effects noted below, with the possible exception of groundwater contamination. Entrapment of organisms by intake structures is another potential impact. Certain types of water resource effects, such as thermal discharges, can possibly be beneficial to some aquatic communities; but there is usually at least an initial presumption that changes relative to baseline conditions will be negative.

Quantitative criteria generally do not exist for evaluating the impacts of alternative powerplant sites on aquatic ecosystems. The procedure utilized in the selection studies, where possible, has been to review available baseline information, assess the probably magnitude of effects, and evaluate the overall importance of these impacts. The major factors considered in establishing importance are the existence of rare, endangered, or diminishing aquatic species, and the relationship of aquatic ecology to water uses, especially recreation and commercial fisheries.

8.3.4.3 TERRESTRIAL ECOLOGY

Terrestrial habitats, altered by the construction of power plant facilities are often subject to further impact by aspects of permanent operations such as noise, air quality degradation, and cooling tower drift. Destruction of habitats is frequently the most significant environmental impact produced by construction of transmission and transportation corridors. The key factors that are considered when evaluating alternative powerplant sites are: (1) the sensitivity of habitats to impact (for example, the need to maintain a minimum habitat

size); (2) the existence of species which are endangered or otherwise given protected status; and (3) the relative uniqueness of the habitats in question. The preferred site would be one in which the existing terrestrial ecosystems are not notably diverse, interesting, or valued for hunting, and are widely represented in the surrounding area.

8.3.4.4 POPULATION AND LAND USE

Fossil-fueled power plants should be sited if possible in areas of low population density, in order to minimize nuisances to the public involving noise, air quality impact, transportation system usage, and other factors. Sites should not be located near sensitive areas that are incompatible with power plant construction and operation, such as parks, wilderness areas, wildlife refuges, national parks, wild and scenic rivers, and locations that may be candidates for future recognition as scenic or recreation areas. Preferably, power plant developments should avoid areas of high natural productivity (marshes, coastal zones), and should not occupy prime agricultural land. Consistency with existing zoning and land use plans is an important criterion in areas where such expressions of public preference exist.

8.3.4.5 HISTORICAL AND ARCHEOLOGICAL SITES

The existence of significant historical or archeological resources at a site would not necessarily disqualify the site as a power plant location but would constitute a negative factor. At the least, monetary costs and delays could result from the need for site exploration and excavation.

8.3.4.6 RECREATION

Protection of scarce recreational resources is a high priority objective in power plant siting and in environmental impact assessment generally. To a considerable extent, impacts on recreation are covered by the above mentioned criteria for air quality, water quality, and ecology. The explicit recognition of recreational value primarily involves placing an especially heavy emphasis upon protection of land areas and water bodies used for this purpose. Under no circumstances should a power generating facility displace an appreciable share of the recreational resources in an area.

8.3.4.7 OTHER SOCIOECONOMIC IMPACTS

Some of the social and economic factors which are potentially important for power plant siting are the following: (1) employment and income created by facility construction and operation; (2) social impacts of imported construction labor; (3) increase in local tax revenues due to the power generating facility, versus the impact of the facility on the total cost of providing public services; (4) effects of the powerplant construction project upon local labor force conditions and wage rates; and (5) desirable and undesirable influences of the project upon regional growth and land use. No absolute criteria exist for evaluating power plant sites in terms of these factors, but they can support or detract from a specific site to a considerable extent.

8.3.4.8 WATER RESOURCES CRITERIA

The State of Florida has initiated a Comprehensive Planning Process to guide and implement orderly, long-range, economic, social and physical development (Chapter 23, Florida Statutes). The Water Element of the

Comprehensive Plan proposes goals, objectives, and policies designed for optimal management of water resources in Florida (Executive Order 76-29).

The criteria set forth in the Water Element of the proposed Comprehensive Plan were used to evaluate alternative sites for Florida Power Corporation's new generating facilities. These general policy criteria are designed to:

1. Encourage all reasonable beneficial uses of water;
2. Protect water quality;
3. Protect floodplains and other wetlands;
4. Protect soil fertility and prevent erosion;
5. Maximize the production of agricultural and natural plant communities;
6. Maintain the natural hydroperiod as much as practical;
7. Prevent flood damages;
8. Prevent salt water intrusion;
9. Provide for growth and development in areas inherently suited for such activities; and
10. Protect the functional integrity of coastal ecosystems.

The federal government and the State of Florida have promulgated extensive rules and regulations relating to the management of water resources in Florida that provide a means of enforcing the general policy criteria set forth in the proposed Water Element of the Comprehensive Plan. The following is a summary of major legislation which provides for these rules and regulations.

Federal References

The following is a statement of policy of the Water Resources Planning Act (PL 89-90):

In order to meet the rapidly expanding demands for water throughout the nation, it is hereby declared to be the policy of the Congress to encourage the conservation, development, and utilization of water and related land resources of the U.S. on a comprehensive and coordinated basis by the Federal Government, states, localities, and private enterprise with the cooperation of all affected Federal agencies, states, local governments, individuals, corporations, business enterprises, and other concerned.

The Water Resources Planning Council shall maintain a continuing study of the relationship of regional or river basin plans and programs to the requirements of larger regions of the Nation and the adequacy of administrative and statutory means for the coordination of the water and related land resources policies and programs of the several Federal agencies.

The State must provide for comprehensive planning with respect to intra- or interstate water resources and invest the needs for water and water related activities taking into account prospective demands for all purposes; and provide, where comprehensive statewide development planning is being carried on, for full coordination between comprehensive water resources planning and other statewide planning programs.

PL 92-500, Federal Water Pollution Control Act Amendments of 1972.

GOALS AND POLICY

1. It is the national goal that the discharge of pollutants into the navigable waters be eliminated by 1985.

2. It is the national goal that wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water be achieved by July 2, 1983.

3. It is the national policy that the discharge of toxic pollutants in toxic amounts be prohibited.

4. It is the policy of the Congress to recognize, preserve, and protect the primary responsibilities and rights of States to prevent, reduce, and eliminate pollution, to plan the development and use (including restoration, preservation, and enhancement) of land and water resources, and to consult with the Administrator in the exercise of his authority under this act.

PL 85-624, The Fish and Wildlife Coordination Act

This legislation provides that wildlife conservation shall receive equal consideration with other features of water resource development programs through the effectual and harmonious planning, development, maintenance, and coordination of wildlife conservation and rehabilitation.

The Title II -- Flood Control section of PL 89-298 authorizes the Secretary of the Army, acting through the Chief of Engineers to construct, operate and maintain any water resource development project, including single and multiple purpose project, involving, but not limited to, navigation, flood control, and shore protection.

The Coastal Zone Management Act of 1972 (PL 92-583) states that the Congress finds and declares that it is the national policy to preserve, protect, develop, and where possible, to restore or enhance, the resources of the nation's coastal zone for this and succeeding generations.

All Federal agencies engaged in programs affecting the coastal zone shall cooperate and participate with state and local governments and regional agencies in effectuating the purposes of this title.

The Act has among its purposes:

To encourage and assist the states to exercise effectively their responsibilities in the coastal zone through the development and implementation of management programs to achieve wise use of the land and water resources of the coastal zone giving full consideration to ecological, cultural, historic, and aesthetic values as well as to needs for economic development.

To encourage the participation of the public, of Federal, State and local governments and of regional agencies in the development of coastal zone management programs.

The Wild and Scenic Rivers Act (PL 90-542) states:

a. It is hereby declared to be the policy of the U.S. that certain selected rivers of the nation which, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations.

b. The Congress declares that the established national policy of dam and other construction at appropriate sections of the rivers of the U.S. needs to be complemented by a policy that would preserve other selected rivers or sections thereof in their free-flowing condition to protect the water quality of such rivers and to fulfill other vital national conservation purposes.

The Estuarine Areas Protection and Restoration Act (PL 90-454) states: Congress finds and declares that many estuaries in the U.S. are rich in a variety of natural, commercial, and other resources, including environment, and natural beauty, and are of immediate and potential value to the present and future generations of Americans. It is, therefore, the purpose of this Act to provide a means for considering the need to protect, conserve and restore these estuaries in a manner that adequately

and reasonably maintains a balance between the national need for such protection in the interest of conserving the natural resources and natural beauty of the nation and the need to develop these estuaries to further the growth and development of the nation.

It is declared to be the policy of Congress to recognize, preserve, and protect the responsibilities of the States in protecting, conserving, and restoring the estuaries in the U.S.

In planning for the use or development of water and land resources, all Federal agencies shall give consideration to estuaries and their natural resources and their importance for commercial and industrial developments. All project plans and reports affecting such estuaries and resources submitted to the Congress shall contain a discussion by the Secretary of the Interior of such estuaries and such resources and the effects of the project on them and his recommendations thereon.

The Secretary of the Interior shall encourage states and local subdivisions thereof to consider, in their comprehensive planning and proposals for financial assistance, the needs and opportunities for protecting and restoring estuaries in accordance with the purposes of this Act.

<u>PL 90-448, Housing and Urban Development Act of 1968, Title XIII -- National Flood Insurance Act of 1968</u> states: It is the purpose of this title to: (1) encourage state and local governments to make appropriate

land use adjustments to restrict the development of land which is exposed to flood damage and minimize damage caused by flood losses; (2) guide the development of proposed future construction, where practicable, away from locations which are threatened by flood hazards; (3) encourage lending and credit institutions, as a matter of national policy, to assist in furthering the objectives of the Flood Insurance Program.

The Safe Drinking Water Act (PL 93-523) has as its objectives: to assure that water supply systems serving the public meet minimum national standards for the protection of public health and to foster development of underground injection control program plans and programs to assist in implementing the Safe Drinking Water Act.

Congress intends that qualified states have the primary responsibility for assuring that safe drinking water is available to consumers.

The states should also:

a. Formulate and adopt state drinking water standards at least as stringent as EPA's Federal Standards;

b. Adopt a program to certify laboratories which perform drinking water analyses;

c. Conduct surveillance programs, such as sanitary surveys of water systems, and obtain information necessary to the granting and review of variances and exemptions to public water supplies;

d. Review the design, construction or modification of drinking

water treatment facilities to assure their capability to produce water which meets applicable standards;

e. Establish enforcement programs adequate to assure that individual water supplies perform properly;

f. Set up and operate the data-keeping and reporting programs required by EPA regulations.

The purpose of the Flood Disaster Protection Act of 1973 (PL 93-234) is to:

a. Substantially increase the limits of coverage authorized under the national flood insurance program;

b. Provide for the expeditious identification of, and the dissemination of information concerning, flood-prone areas;

c. Require states or local communities, as a condition of future federal financial assistance, to participate in the flood insurance program and to adopt adequate floodplain ordinances with effective enforcement provisions consistent with federal standards to reduce or avoid future flood losses; and

d. Require the purchase of flood insurance by property owners who are being assisted by federal programs or by federally supervised, regulated, or insured agencies or institutions in the acquisition or improvement of land or facilities located, or to be located, in identified areas having special flood hazards.

The Water Supply Act of 1958 (PL-85-500 Title III) states: It is hereby declared to be the policy of the Congress to recognize the primary

primary responsibilities of the State and local interests in developing water supplies for domestic, municipal, industrial, and other purposes and that the Federal Government should participate and cooperate with States and local interests in developing such water supplies in connection with the construction, maintenance, and operation of Federal navigation, flood control, irrigation, or multiple purpose projects.

The National Environmental Policy Act of 1969 (PL 91-190) sets forth as goals:

To fulfill the responsibilities of each generation as trustee of the environment for succeeding generations; to assure for all Americans safe, healthful, productive, aesthetically and culturally pleasing surroundings; to attain the widest range of beneficial uses of the environment without degradation risk to health or safety, or other undesirable and unintended consequences; to preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity and variety of individual choices; to achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities; to enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

It also directs all federal agencies to utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision-making which may have an impact on man's environment; to

identify and develop methods and procedures, in consultation with the Council on Environmental Quality, which will insure that presently unquantified environmental amenities and values may be given appropriate consideration in decision-making along with economic and technical considerations; to include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on:

a. The environmental impact of the proposed action;

b. Any adverse environmental effects which cannot be avoided should the proposal be implemented;

c. Alternatives to the proposed action;

d. The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity;

e. Any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

Florida Statutes

Chapter 373, Florida Statutes, proffers the following declaration of policy for water management in the state:

1. The waters in the state are among its basic resources. Such waters have not heretofore been conserved or fully controlled so as to realize their full beneficial use.

2. It is further declared to be the policy of the legislature:

a. To provide for the management of water and related land resources;

b. To promote the conservation, development and proper utilization of surface and ground water;

c. To develop and regulate dams, impoundments, reservoirs, and other works and to provide water storage for beneficial purposes;

d. To prevent damage from floods, soil erosion, and exessive drainage;

e. To preserve natural resources, fish and wildlife;

f. To promote recreational development, protect public lands, and to assist in maintaining the navigability of rivers and harbors; and

g. Otherwise to promote the health, safety and general welfare of the people of this state. (S. 373.016, Florida Statutes).

The Legislature recognizes that the water resources problems of the state vary from region to region, both in magnitude and complexity. It is therefore, the intent of the Legislature to vest in the Department (Environmental Regulation) or its successor agency the power and responsibility to accomplish the conservation, protection, management, and control of the waters of the state and with sufficient flexibility and discretion to accomplish these ends through delegation of appropriate powers to the various water management districts.

It is the finding of the Legislature that cooperative efforts between municipalities, counties, water management district, and the Department (Environmental Regulation) are mandatory in order to meet the water needs of rapidly urbanizing areas in a manner which will supply adequate and dependable supplies of water where needed without resulting in adverse effects upon the areas from whence such water is withdrawn.

Chapter 403, Florida Statutes, Florida Air and Water Pollution Control Act declares the public policy of this state to be to conserve the waters of the state and to protect, maintain, and improve the quality thereof for public water supplies for the propagation of wildlife, fish and other aquatic life, and for domestic, agricultural, industrial, recreational, and other beneficial uses, and to provide that no wastes be discharged into any waters of the state without first being given the degree of treatment necessary to protect the beneficial uses of such water.

It is declared that local and regional air and water pollution control programs are to be supported to the extent practicable as essential instruments to provide for a coordinated statewide program of air and water pollution prevention, abatement and control for the securing and maintenance of appropriate levels of air and water quality.

The Legislature finds and declares that control, regulation, and abatement of the activities which are causing or may cause pollution of the air or water resources in the state and which are or may be detrimental to human, animal, aquatic, or plant life, or to property be increased to

insure a continued safe environment, to insure purity of air and water, to insure domestic water supplies, to insure protection and preservation of the public health, safety, welfare, and economic well-being, to insure and provide for recreational and wildlife needs as the population increases and the economy expands, and to insure a continuing growth of the economy and industrial development.

Section 252.44 Florida Statues: The appropriate state agencies, in conjunction with the Division (of Disaster Preparedness) shall keep land uses and construction of structures and other facilities under continuing study and identify areas which are particularly susceptible to severe land shifting, subsidence, flood, or other catastrophic occurrence, man-made or natural. The studies shall concentrate on means of reducing or avoiding the dangers caused by their occurrences or the consequences thereof.

Chapter 298, Florida Statutes, proffers the following policy for water management districts: Water management districts are established for the purpose of preserving and protecting water resources, for sanitary or agricultural purposes, or when the same may be conducive to the public health, convenience or welfare, or of public utility or benefit by drainage, irrigation, or water management.

Section 298.74 Florida Statutes, (Drainage of Lakes) prohibits draining or drawing water from any lake greater than two square miles so as to lower the level thereof without first obtaining the written consent of

all owners of property abutting on or bound by said lake (Everglades drainage district excluded).

Chapter 380, Florida Statutes, the Florida Environmental Land and Water Management Act of 1972, states that in order to protect the natural resources and environment of this state as provided in s. 7, Article II of the State Constitution, insure a water management system that will reverse the deterioration of water quality and provide optimum utilization of our limited water resources, facilitate orderly and well-planned development and protect the health, welfare, safety, and quality of life of the residents of this state, it is necessary to plan adequately for and guide growth and development within this state. In order to accomplish these purposes, it is necessary that the state establish land and water management policies to guide and coordinate local decisions relating to growth and development.

Chapter 160, Florida Statutes, directs the Regional Planning Councils to act in an advisory capacity to the constitutent local governments in regional, metropolitan, county and municipal planning matters involving water resources.

Chapter 370, Florida Statutes, directs the Department of Natural Resources, Division of Resource Management, to coordinate the activities of all public bodies, authorities, agencies and special districts charged with the development of waterways with the state. The Division should also foster, promote and guide development of an integrated system of

waterways within the state, utilizing where practical, the natural bodies of water lying thereon.

Chapter 372, Florida Statutes, directs the Game and Fresh Water Fish Commission to provide for the development and management of recreational sites in the water conservation areas of the Florida Everglades when such development can be accomplished without endangering the water quality and quantity of supply and where environmental impact will be minimal.

Chapter 582, Florida Statutes, states that it is the policy of the Legislature to provide for control and prevention of soil erosion, and for the prevention of floodwater and sediment damages, and for furthering the conservation, development and utilization of soil and water resources, and the disposal of water, and thereby to preserve natural resources, control floods, prevent impairment of dams and reservoirs, assist in maintaining the navigability of rivers and harbors, preserve wildlife, protect the tax base, protect public lands, and protect and promote the health, safety and general welfare of the people of this state.

Section 258.36, Florida Statutes, the Land Conservation Act of 1972, provides for purchase of environmentally sensitive areas, including aquifer recharge areas.

Chapter 23, Florida Statutes, directs that a Comprehensive State Plan be developed which will provide long-range guidance for the orderly social, economic, and physical growth of the state by setting forth goals,

objectives and policies. (s. 23.0114, Florida Statutes). Executive Order 76-29 directs that a Water Resources Element should be included within the State Comprehensive Plan.

Chapter 163, Florida Statutes, The Local Government Comprehensive Planning Act requires all local governments to prepare comprehensive plans which shall include a conservation element for the conservation, development, utilization and protection of natural resources in the area, including as the situation may be, air, water, estuarine marshes, soils, beaches, shores, floodplains, rivers, lakes, harbors, forests, fisheries and wildlife, minerals, and other natural and environmental resources.

Water quality criteria established by the State of Florida (F.A.C. Chapter 17-3) and the federal government (P.L. 92-500, Section 304) are listed in the Table 8.3.4-3 Thermal criteria established by F.A.C. Chapter 17-3.05 are listed as follows:

Zone	Streams	Lakes	Coastal		Open
			Summer	Winter	
North	90° F Max	90° F Max	92° F Max	90° F Max	97° F Max
	T + 5° F	T + 3° F	T + 2° F	T + 4° F	T + 17° F
Penin-sula	92° F Max	92° F Max	92° F Max	90° F Max	97° F Max
	T + 5° F	T + 3° F	T + 2° F	T + 4° F	T + 17°

The doctrine of "reasonable beneficial use" as established in Chapter 373, Florida Statutes was used to provide general criteria for consumptive use of waters at alternative sites. Proposed withdrawal from surface waters were tested against a guideline of 5 percent of minimum observed 30 day flow. Withdrawals greater than 5 percent were classified as excessive.

Proposed groundwater withdrawals were evaluated on the basis of whether or not significant effects on the potentiometric surface would occur. This evaluation was subjective.

Table 8.3.4-3 WATER QUALITY PARAMETERS

Constituent or Property	Source or Cause	Significance	EPA Criterion*	Florida Standard† (Class III)
Acidity	Strong mineral acids, weak inorganic and organic acids, CO_2 and hydrolyzing salts such as ferrous or aluminum sulfates. Industrial processes, acid mine drainages, natural organic acids.	Quantitative capacity of water to neutralize a strong base. Contributes to corrosiveness and influences certain chemical and biological processes. High values could be harmful to aquatic organisms. Reported as equivalent of calcium carbonate, since the acids present are not generally known.	No criterion	No standard
Alkalinity(Alk)	Caused primarily by bicarbonate, carbonate, and hydroxide. Other weak acid radicals like borate, phosphate, and silicate may contribute to alkalinity.	Buffers natural pH changes. Very high alkalinity is associated with excessive hardness of dissolved solids. Low alkalinity may be detrimental to aquatic life. Components of alkalinity such as carbonate and bicarbonate will reduce toxicity of some heavy metals. Reported as equivalent of calcium carbonate.	20 mg/l @ $CaCO_3$, except where natural concentrations are less.	No standard
Aluminum(Al)	Usually present only in negligible quantities in natural waters except where the waters have been in contact with the more soluble rocks of high aluminum content. Acid waters often contain large amounts.	May be troublesome in industrial feed waters forming scale on boiler tubes. High concentrations usually indicate the presence of acid mine drainage or industrial waste.	No criterion	No standard

Table 8.3.4-3 WATER QUALITY PARAMETERS

Constituent or Property	Source or Cause	Significance	EPA Criterion*	Florida Standard† (Class III)
Arsenic(As)	Natural arsenic-bearing minerals. Found in some ground waters, in wastes from industry and mining activity, and residues from some insecticides and herbicides. Significant amount found in phosphate rock matrix.	Small concentrations in drinking water can accumulate in man and other animals until lethal dosage is reached. Toxicity varies with the chemical form, trivalent inorganic arsenic being the most toxic to aquatic invertebrates. A limit of 50 μg/l is generally protective of aquatic life.	0.05 mg/l for domestic water supply, 0.10 mg/l for crop irrigation.	Shall not exceed 0.05 mg/l
Ammonia Nitrogen(N)	Includes nitrogen in the form of NH_3 and NH_4^+. Found in many waters but usually only in trace amounts. Found also in waters polluted with sewage and other organic waste.	A biological degradation product of nitrogenous organic matter. High levels usually indicate organic pollution. Toxicity to fish is dependent on the pH of the water; 2.5 mg/l ammonia nitrogen can be harmful in the 7.4 to 8.5 pH range. Promotes growth of algae and other aquatic plants, and can contribute to eutrophication (aquatic nutrient).	0.02 mg/l as unionized ammonia (NH_3). (0.37 mg/l total ammonia at 25°C and pH 8.0, 35 mg/l total ammonia at 25°C and pH 6.0).	No standard
Biochemical Oxygen Demand (BOD)	Organic material from natural sources such as decaying vegetation. Organic pollution from industrial or municipal wastes.	A measure of the oxygen required to oxidize the organic material present in the water. Utilized to determine the biodegradable organic pollution load of a wastewater. Reported in mg/l meaning mg of dissolved oxygen consumed per liter of water. Consumption of oxygen will adversly affect aquatic organisms.	No criterion	Shall not be altered to exceed values which would cause dissolved oxygen to be depressed below the limits listed below and, in no case, shall it be great enough to produce nuisance conditions.

Table 8.3.4-3 WATER QUALITY PARAMETERS

Constituent or Property	Source or Cause	Significance	EPA Criterion*	Florida Standard† (Class III)
Chromium(Cr)	Few if any waters contain chromium from natural sources. Natural waters can probably contain only traces of chromium as a cation unless the pH is very low. When chromium is present in water, it is usually the result of pollution by industrial wastes such as metal pickling, plating, manufacturing of paints, dyes, explosives, ceramics, paper, glass, and photography processing.	Toxicity to aquatic life varies widely with the species, temperature, pH, and other factors. Fish are relatively tolerant but some invertebrates are quite sensitive. Hexavalent chromium is more toxic than trivalent.	0.10 mg/l for fresh water aquatic life, 0.05 mg/l for domestic water supply.	Shall not exceed 0.50 mg/l hexavalent or 1.0 mg/l total chromium in effluent discharge and shall not exceed 0.05 mg/l after reasonable mixing in the receiving streams.
Color	Yellow-to-brown color of some water is usually caused by organic matter extracted from leaves, roots, and other organic substances. Objectionable color in water also results from industrial wastes and sewage.	Water for domestic and some industrial uses should be free from perceptible color. Limits light penetration in water, thus preventing growth of some organisms. Measured on chloroplatinate standards units (CPU).	Increased color (in combination with turbidity) should not reduce the depth of the compensation point for photosynthetic activity by more than 10% from the seasonally established norm for aquatic life.	No standard

Table 8.3.4-3 WATER QUALITY PARAMETERS

Constituent or Property	Source or Cause	Significance	EPA Criterion*	Florida Standard† (Class III)
Copper(Cu)	Copper is a fairly common trace constituent of natural water. Small amounts may be introduced into water by solution of copper and brass water pipes. Oxides and sulfates of copper are used for pesticides, algicides, and fungicides.	Copper imparts a disagreeable metalic taste to water. Copper is not considered to be a cumulative systemic poison like lead and mercury; most copper ingested is excreted by the body and very little is retained. Copper is essential in trace amounts for plant growth. Toxicity to aquatic life is dependent on alkalinity and organic content of water. Juvenile fish are more sensitive than adults. Concentrations below 25 mg/l are not acutely lethal to most common fish species.	For freshwater aquatic life, 0.1 times a 96-hour LC 50 as determined through nonaerated bioassay using a sensitive aquatic resident species.	Shall not exceed 0.5 mg/l
Dissolved Oxygen(DO)	Dissolved in water from air and from oxygen given off in the process of photosynthesis by aquatic plants. Oxygen is utilized by all higher aquatic organisms in respiration.	Dissolved oxygen increases the palatability of water. Amount necessary to support fish life varies with species and age, with temperature, and concentration of other constituents in the water. High dissolved oxygen is necessary to assimilate organic waters.	Sufficient to maintain aerobic conditions in the water column and, except as affected by natural phenomena, at the sediment-water interface. A minimum concentration to maintain good fish populations is 5.0 mg/l.	Shall not average less than 5.0 mg/l in a 24-hour period and never less than 4.0 mg/l. Normal daily and seasonal fluctuations above these levels shall be maintained.

Table 8.3.4-3 WATER QUALITY PARAMETERS

Constituent or Property	Source or Cause	Significance	EPA Criterion*	Florida Standard† (Class III)
Dissolved Solids	Inorganic salts, dissolved organic matter, and other dissolved materials in water. Major inorganic anions are carbonates, chlorides, and sulfates. Major inorganic cations are sodium, potassium, calcium, and magnesium.	Excessive levels in drinking water may have adverse physiological effects. High levels are corrosive to metallic materials. Aquatic organisms tolerate a wide range of dissolved solids.	250 mg/l for chlorides and sulfates in domestic water supply.	Shall not exceed 500 mg/l as a monthly average nor exceed 1000 mg/l at any time.
Fecal Coliform	Enteric bacteria of warmblooded animals shed in the feces.	Indicative of recent fecal pollution either from livestock, wild animals, or untreated or improperly treated domestic sewage. Although not themselves pathogenic, fecal coliform are potentially associated with disease transmission.	Based on a minimum of not less than five samples taken over a 30-day period, should not exceed a log mean of 200 per 100 ml, nor should more than 10% of the total samples taken during any 30-day period exceed 400 per 100 ml, in bathing waters.	Shall not exceed a monthly geometric mean of 500 per 100 ml nor exceed 750 per 100 ml in 10% of the samples, in those waters not normally used for body contact recreation.
Fluoride(F)	Dissolved in small to minute quantities from most rocks and soils. Enters many waters from fluoridation of municipal supplies. Major component of phosphate rock matrix.	Fluoride in drinking water reduces the incidence of tooth decay when the water is consumed during the period of enamel calcification. However, it may cause mottling of the teeth depending on the concentration of fluoride, the age of the child, amount of drinking water consumed, and susceptibility of the individual. In extreme conditions can cause debilitating fluorosis of humans or animals.	No criterion	Shall not exceed 10.0 mg/l nor interfere with other beneficial uses.

Table 3.3.4-3 WATER QUALITY PARAMETERS

Constituent or Property	Source or Cause	Significance	EPA Criterion*	Florida Standard† (Class III)
Iron(Fe)	Iron is dissolved from rocks and soils. Ferrous iron can persist in low pH, low DO waters. Ferric iron is insoluble. Humic compounds in water complex iron, making it inactive. Pollution sources are industrial wastes, mine drainage, and iron-bearing groundwaters.	Iron is a trace element required by both plants and animals. On exposure to air in normal basic water, ferrous iron is oxidized to a reddish-brown ferric floc. In large quantity, the iron floc may smother aquatic life. Direct toxicity depends on the pH, the presence of organic matter, and the organism in question.	0.3 mg/l for domestic water supply, 1.0 mg/l for freshwater aquatic life.	Shall not exceed 0.30 mg/l.
Mercury(Hg)	Used as a germicidal or fungicidal agent for medical and agricultural purposes. Chemical forms include dimethyl mercury, methyl mercuric ion, metallic mercury, mercuric ion, and mercurous ion.	Cause of Minemota disease in man. Intoxication may be acute or chronic. Microbial conversion of inorganic mercury to highly toxic methyl or dimethyl mercury is known to occur. Bioaccumulation observed in aquatic organisms. Chronic exposure may induce reproductive failure.	2.0 μg/l for domestic water supply, 0.05 μg/l for freshwater aquatic life and wildlife.	None detectable in effluent discharge.
Nitrate Nitrogen(NO_3)	Final degradation product from the decomposition of proteinacous organic matter. Pollution sources are domestic and industrial wastewater, septic tanks, feedlots, and fertilizer runoff. Atmospheric fallout and nitrogen fixation are important sources.	Very high levels may cause methemoglobinemia in infants. Nitrate is an important aquatic plant nutrient, stimulating the growth of algae and macrophytes. A major factor in eutrophication of non-phosphorous limited waters.	10 mg N/l for domestic water supply.	No standard

Table 8.3.4-3 WATER QUALITY PARAMETERS

Constituent or Property	Source or Cause	Significance	EPA Criterion*	Florida Standard† (Class III)
Oil and Grease	Includes numerous organic components of varying properties. Pollution sources include sewage, industrial effluent, oil spills, highway runoff. Natural sources include plant and animal waxes, oils, fats, fatty acids.	Imparts unpleasant taste and odor to drinking water. May drown waterfowl from exposure, kill fish by coating the gills, and asphyxiate benthic forms. May cause high BOD and oxygen depletion. Toxicity of petroleum oils to aquatic life is compounded and species specific.	For domestic water supply: virtually free of oil and grease, particularly from tastes and odors of petroleum products. For aquatic life: 1% of the lowest continuous flow 96-hour LC 50 to several important, highly susceptible fresh water species. Levels of petrochemicals in the sediments deleterious to biota should not be allowed. Surface water shall be free of floating oils of petroleum, vegetable, or animal origin.	Shall not exceed 15 mg/l, nor may visible oil, defined as iridescence, be present to cause taste and odors, nor interfere with other beneficial uses.
Organic Nitrogen	Amino acids, proteins, and polypeptides. Derived from living organisms and their life processes and from organic wastes and sewage.	Increases nutrient content of water through decomposition and formation of other nitrogen forms. Excessive concentrations may be associated with nitrogenous wastes or high plant production within the stream. Decomposition exerts a significant oxygen demand.	No criterion	No standard
Orthophosphate	Sewage, phosphate mining, industrial effluents, natural mineral deposits, detergents, and fertilizers.	Nutrient essential to aquatic life but will contribute to eutrophication (over enrichment) of natural waters resulting in noxious conditions under certain	No criterion for freshwater	No standard

Table 8.3.4-3 WATER QUALITY PARAMETERS

Constituent or Property	Source or Cause	Significance	EPA Criterion*	Florida Standard† (Class III)
Orthophosphate (continued)		conditions. This is the form of phosphate most readily usable by aquatic plants and hence will most readily stimulate aquatic plant growth. Retention within a lake or reservoir depends on mass loading, volume of euphotic zone, detention time, and biological cycling.		
pH	Hydrogen ions derived from ionization of weak and strong acids. Hydrogen ion concentration is expressed in terms of pH where pH = -log (H+). Acid generating salts and dissolved gases such as SO_2 and CO_2 increase the number of hydrogen ions. Carbonates, bicarbonates, hydroxides, phosphates, silicates, and borates reduce the number of hydrogen ions. pH ranges between 0 and 14.	Corrosiveness of water increases outside the neutral range of 6.5–7.5. Different organisms demonstrate a varying degree of tolerence to high or low pH conditions, but in general, departure from near neutral conditions reduces species diversity of aquatic populations. Toxicity of weak acids and bases is pH dependent. Natural causes may result in very low pH (organic acids) or very high pH (excessive algae photosynthesis).	5 to 9 for domestic water supply, 6.5 to 9.0 for freshwater aquatic life.	Shall not be caused to vary more than one (1.0) unit above or below normal pH of the waters; and lower value shall be not less than 6.0, and upper value not more than 0.5.
Phenols	Phenolic compounds arise from distillation of coal and wood, chemical plants, livestock chips, oil refineries, human and other organics wastes, degradation of pesticides. Some compounds are refractory to biological degradation and are therefore persistent.	May be directly toxic to fish and fish-food organisms. Phenols taint fish flesh and exert high oxygen demand. Chlorinated phenols cause undesirable odors in drinking water. Some phenols may be carcinogenic.	1 μg/l for domestic water supply and to protect against fish flesh tainting.	Shall not exceed 0.001 mg/l (1 μg/l).

Table 8.3.4-3 WATER QUALITY PARAMETERS

Constituent or Property	Source or Cause	Significance	EPA Criterion*	Florida Standard† (Class III)
Specific Conductance	A measurement of the electrolyte concentration in a water sample. This measurement can be related to the concentration of dissolved solids and the total ionic concentration; chiefly mineral constituents dissolved from weathering of rocks and soils. Measured in inverse units of electrical resistance, micromhos/cm.	Rainwater and surface water are low in conductivity. Groundwater, domestic wastes, and industrial wastes increase specific conductance. Very high levels are detrimental to aquatic life by altering osmotic potential.	No criterion	Shall not be increased more than 100% above background levels or to a maximum level of 500 micromhos per centimeter for fresh water streams.
Sulfate(SO_4)	Dissolved from rocks and soils containing gypsum, iron sulfides, and other sulfur compounds. Usually present in mine waters and in some industrial waters. Major amonic constituent of water.	Sulfate in water containing calcium forms hard scale in steam boilers. In large amounts, sulfate in combination with other ions gives bitter taste to water. USPHS drinking water standards recommend that the sulfate content should not exceed 250 mg/l. May promote the growth of sulfate reducing bacteria which generate toxic hydrogen sulfide.	No criterion	No standard
Suspended Solids	Soil erosion, algae growth, decay of vegetation, industrial and municipal wastes.	Solid material that will not settle out of water under the conditions under which the sample is taken (e.g., flowing stream, quiescent pool). Detrimental to aquatic organisms in extremely high levels. Affects aesthetic appeal of waters. Reduces light penetration. Related to turbidity.	Should not reduce the depth of the compensation point for photosynthetic activity by more than 10 percent.	No standard

Table 8.3.4-3 WATER QUALITY PARAMETERS

Constituent or Property	Source or Cause	Significance	EPA Criterion*	Florida Standard† (Class III)
Temperature	Solar radiation, heat radiation, heat from groundwater inflow, and heat from thermal (cooling water) effluents. Shallow wells show some seasonal fluctuations in water temperature. Seasonal fluctuations in temperatures of surface waters are comparatively large, depending on the depth of water, but do not reach the extremes of air temperature.	Affects usefulness of water for most purposes. For every 1°C increase in temperature, aquatic metabolism increases approximately 10%. Solubility of oxygen decreases with increasing temperature while oxygen requirements parallel metabolic rates. Chemical toxicity is frequently a function of temperature. Geographic range of most aquatic species is largely determined by temperature extremes and seasonal patterns.	Two upper limiting temperatures are recognized, based on the important sensitive species: (1) a maximum for short term exposure to lethal temperatures, (2) a weekly average temperature based on cold shock, optimum growth, reproduction or other site-specific requirements.	Heated water with a temperature more than 5°F higher than the ambient temperature of any stream shall not be discharged into such stream. At all times, the discharge temperature shall be controlled so that at least 2/3 of the width of the stream's surface remains at ambient temperature. Further, no more than 1/4 of the cross-section shall be heated. Natural daily seasonal temperature variations must be maintained. Heated water above 92°F shall not be discharged, regardless of ambient temperature.
Total Organic Carbon(TOC)	Certain industrial wastes, sewage, natural decay of vegetation, and aquatic organisms.	A measure of the amount of carbon originating from organic matter only. Provides a measure of the amount of oxygen consuming organic substances in a water and hence the capacity to assimilate wastes. Often related to organic color.	No criterion	No standard
Total Phosphate	Includes orthophosphate, hydrolizable phosphates, and organically-bound phosphate. Sewage,	Nutrient essential to aquatic life. In certain waters, will contribute to eutrophication when	No criterion for fresh water	No standard

Table 8.3.4-3 WATER QUALITY PARAMETERS

Constituent or Property	Source or Cause	Significance	EPA Criterion*	Florida Standard† (Class III)
Total Phosphate (Continued)	detergents, fertilizer, phosphate mining, industrial wastes, and weathering of mineral deposits all contribute to total phosphorous loading.	present in over-supply. Flowing water may tolerate more phosphate than lakes or reservoirs. Critical levels may be 25 μg P/l in lakes and 100 μg P/l in streams, but are subject to high geographic variation.		
Turbidity	Colloidal suspensions of sediment, precipitates, and other small particles. Soil erosion, sediment disturbance, growth and decay of algae, and industrial and municipal wastes may all contribute to turbidity.	Should be less than 5 units for domestic use. Directly lethal to some aquatic forms. Inhibits light penetration and reduces depth of photosynthetic compensation point thereby limiting food resources. Interferes with recreational use and aesthetic enjoyment of water resources. May interfere with fish movements.	No criterion	Shall not exceed 50 JTU

* U.S. Environmental Protection Agency, 1976. Quality Criteria for Water.

† Chapter 17-3, State of Florida Administrative Code.

8.3.5 EVALUATION OF CANDIDATE SITES

8.3.5.1 DESCRIPTION OF CANDIDATE SITES

Gulf County Site

Several sites near Port St. Joe (in the Florida panhandle) have received consideration in site selection studies by the Applicant. The locations have included sites along the coast at Palm Point, between Port St. Joe and Beacon Hill, and 1.6 kilometers (1 mile) northwest of Mexico Beach. The most favorable potential site, and the one considered here, is on the south side of the Gulf County Canal near its confluence with the Intracoastal Waterway.

A once-through cooling system, drawing water from the Intracoastal Waterway and discharging into the Gulf County Canal, has been proposed for the Gulf County site. Off-stream cooling could utilize the same water source. Another possibility would be freshwater from wells. The groundwater is the softest and least mineralized in the state, and a high rainfall and an aquifer of unconsolidated quartz sand and gravel make a good supply of groundwater probable.

Road access to the site is favorable, as Routes 71 and 382 run near the eastern boundary. Dredging of a short access canal and turning basin would allow coal barges to reach the site via the Gulf County Canal. The geographic location of the site is favorable for receiving high sulfur coal barged down the Mississippi River. There is rail access at Port St. Joe, which might possibly be extended to the site by a 4 kilometers (2 1/2 miles) spur at little or no cost to the Applicant. As discussed later, the existing railroad service and freight structure cause this

site to be considerably more expensive to serve by rail than any of the other sites considered.

A 230 kv power line extending east from Port St. Joe is presently under construction. Location of the proposed power generating units at the Gulf County site would require extensive additional improvements to the transmission system. Due to the great distance of this site from the load centers served by the Applicant, the line transmission losses would amount to a very significant proportion of the total power generated.

The site seems to offer no major difficulties of topography or geology. Surficial quarternary rock is underlain by blue-grey clay, then shoal river formation, and, at about 122 meters (400 feet), chipola limestone. No earthquakes have been reported along the west coast of Florida. The area is subject to relatively frequent storms, bringing both high winds and flooding of low-lying areas. On the average, tropical storms (winds exceeding 34 knots) occur every 1.4 years, and hurricanes occur every 3.8 years.

The Intracoastal Waterway is considerably altered from natural conditions, and the Gulf County Canal is completely artificial. No data have been located describing the water quality and flow regime of these waterways. The effects of withdrawals from the Intracoastal Waterway upon currents and aquatic systems cannot be predicted with accuracy at present. However, a power plant at the site under discussion could clearly have adverse impacts upon St. Joseph Bay, which receives flow from the

Gulf County Canal. The Bay is about 24 kilometers (15 miles) long and 8 kilometers (5 miles) wide, with a surface area of 17,732 hectares (43,782 acres). The single opening to the Gulf of Mexico is about 3.2 kilometers (2 miles) wide, and tidal range averages about 0.5 meters (1.4 feet). Most of the Bay has been classified by the State of Florida Department of Environmental Regulation as suitable for shellfish propagation and harvesting. Some sludge deposits and oxygen depression presently occur within a 1.6 to 2.4 kilometers (1-1 1/2 mile) radius of the canal outlet because of paper mill waste discharges. Heated water discharged into the canal would flow 8 kilometers (5 miles), cooling considerably, before entering St. Joseph Bay. However, super-saline water would not be diluted. The effects of thermal and saline additions to the Bay could be serious, since there is considerable doubt whether the flushing rates for the Bay would be adequate to dissipate these effluents.

The site is wholly owned by the St. Joe Paper Company. It is about two-thirds covered by planted pine, with the remainder consisting of fresh-water marsh. Both these habitats are widely represented in the area. Population density in the region is low, and there are no buildings on the site, which is presently used for tree farming. The nearest population center is Port St. Joe (population equals 4,401), located 32 kilometers (2 miles) to the southwest. There is some industrial development on the Gulf County Canal to the north of Port St. Joe. The only known place of historic or archaeological interest in the area is the town of Port St. Joe, which was the site of the first State Constitutional Convention in 1878.

With regard to air quality, there are presently major sources of particulates (TSP) near the proposed Gulf County site, the most significant being the St. Joe Paper Company pulp mill in Port St. Joe. A new steam electric power plant could comply readily with NAAQS and PSD requirements pertaining to sulfur dioxide concentrations; but the situation regarding particulates would have to be investigated closely. Also, this site has lower dispersion potential than sites further east and south in Florida.

St. Marks

The St. Marks site is located in Wakulla County about 1.2 kilometers (3/4 mile) southeast of Newport, 0.8 kilometers (1/2 mile) east of St. Marks River, and 3.2 kilometers (2 miles) northeast of St. Marks. The site lies in the river flood plain at an average elevation of about 5.2 meters (17 feet). The only sources of water are wells and the St. Marks River. The quality of ground and surface waters is not known, but ground water apparently contains sulfur. The average flow of the St. Marks River (1956-1973) 18,860 lps (666 cfs) at a point about 9.7 kilometers (6 miles) upstream from the site and the minimum of record is 8,778 lps (310 cfs). The proposed power generating facilities would require about one-tenth of the minimum flow, so that alteration of hydroperiod could be a major problem. Other uses of this water are not known. The city of Tallahassee has facilities in the area.

Road access is good; State Road 59 runs along the eastern boundary of the site. The Seaboard Coastline Railroad serves St. Marks, and access could be provided to the site by construction of about 4 kilometers (2 1/2 miles) of new track. Barge access to the site would require extensive

dredging. There is an existing 230 kw transmission line nearby, but the site is quite distant from the major areas of power need, so that transmission losses would be considerable.

The geologic foundation at the site is sandy, chalky limestone. Although the cooling requirements of the proposed facilties would amount to 5 percent of the average flow of the St. Marks River, the effects on the estuary to the south would be moderated by the fact that the St. Marks joins with the larger Wakulla River about 6.4 kilometers (4 miles) downstream from the site. The estuary and a great deal of the neighboring coast is within St. Marks National Wildlife Refuge. Although the plant would not necessarily have major negative impacts on the estuary, the sensitivity of the area would mandate a careful demonstration of no-effect.

County maps show no buildings on the site. Marsh hammocks and saw palmetto-pine cover the site. Both habitats are extensive in the area. The site is located within the Aucilla Wildlife Management Area, and is 0.8 kilometers (1/2 mile) from the border of the St. Marks National Wildlife Refuge. Population density in the region is generally low, but the site is only 0.8 kilometers (1/2 mile) from the community of Newport, and only 3.2 kilometers (2 miles) from St. Marks (population equals 366). The archeological and historical resources of the site are unknown.

Air quality in the vicinity of the St. Marks site is affected by some sources of TSP and sulfur dioxide, which include the 151 MW oil-fired

power plant operated by the City of Tallahassee just south of the proposed site. More important, the nearby St. Marks Wilderness Area has become a Class I air management area by virtue of the recent Clean Air Act Amendments. This fact could severely constrain future power plant development.

Levy County

The southern Levy County site lies on the east bank of the Suwannee River, about 12.9 kilometers (8 miles) west of Chiefland (population equals 1,965), and 2.4 kilometers (1 1/2 miles) south of Manatee State Park. Road access is provided by paved County Road 347 along the eastern boundary. Barges could reach the site via the Suwannee River; but the increase in river traffic caused by barging of coal to the site might constitute a significant impact. Rail service by the Seaboard Coastline Railroad through Chiefland would require at least 32.2 kilometers (20 miles) of new track.

A second potential site in this area is located about 9.7 kilometers (6 miles) to the north. This site also occupies the east bank of the Suwannee River and lies between the town of Suwannee River (population equals 115) and Manatee Springs State Park. Road and rail access would be from the U.S. 19 corridor about 4 kilometers (2 1/2 miles) away.

The nearest 230 kw transmission line is located in western Alachua County, about 40 kilometers (25 miles) away from either site. A 69 kv line extends into Chiefland from the east. Cooling water for either site would be available from the Suwannee River. The average annual flow at

Wilcox (immediately north of the town of Suwannee River) is 249,180 lps (8,800 cfs). The minimum daily flow for 17 years of record is 92,592 lps (3,270 cfs). The proposed power generating facilities would require less than 1 percent of this minimum flow.

Both potential sites are located on the Chiefland limestone plain, a flat rolling surface formed by erosion of Eocene limestone and leveled by deposition of fine argillaceous sand. The southern site includes several small intermittent ponds, suggesting sink holes; but the northern site lacks such features.

Aquatic vertebrates of special concern which have been reported in the Suwannee River are the following:

Endangered:	Florida manatee
	river redhorse
	American alligator
Rare:	Suwannee bass
Depleted:	Atlantic sturgeon.

The effects of the proposed power generating facilities on river and estuarine ecosystems would be limited by the fact that water withdrawals would average only about 0.35 percent of total river flow.

Construction of power plant facilities at the southern site might entail destruction of some freshwater marsh (presently 6 percent of the site), cypress dome communities (14 percent), and cypress-sweet gum-tupelo (13 percent of the site). Freshwater marsh is extensive throughout the

surrounding area. The remainder of the southern site is covered by planted pine (43 percent of area) and mesophytic hardwoods (22 percent). The northern site appears to lack aquatic habitats, and is covered by forest (of unknown composition) with some open fields. According to one siting report, the vicinity of the two Levy County sites could not be considered a typical wilderness habitat. Within the area there is hunting for white-tailed deer, grey and fox squirrels, wild hog, and rabbits. Levy County is included within the range of Florida panther (an endangered species), but this animal is not considered likely to occur at either site. No endangered species of birds are among the 99 known to occupy Manatee Springs State Park. However, two permanent residents, the American osprey and white ibis, are listed as "status-undetermined" species.

Old Town, site of one of the largest early Indian villages in Florida, lies on the west bank of the river about 5.6 kilometers (3 1/2 miles) northwest of the northern site. This is the nearest point of known historic or archaelogical interest. Both sites are very close to Manatee Springs State Park 729 hectares (1,800 acres). The southern site borders Lower Clay Landing, a cluster of 8 homes, and lies 2.4 kilometers to 3.2 kilometers (1 1/2 to 2 miles) north of Fowler Bluff, a concentration of about 50 buildings, most of them seasonal dwellings. There are one to two houses on the opposite bank.

The Suwannee River is used for sport fishing, commercial catfishing, and a dwindling sturgeon fishery industry. The river is also used for power boating and water skiing, and has been proposed both as a state canoe

trail and as a federal Wild and Scenic River. On the whole, the sites on the Suwannee River would be among the most sensitive in terms of possible public and governmental reaction.

There are presently no major sources of air pollutants in the vicinity of the proposed sites, and the area is classified as Class II. Therefore, construction of new generating facilities should not exceed NAAQS and should meet PSD increments under current conditions. However, if the area became a Wild and Scenic River and thus was shifted to a Class I area, the proposed facility might have to be limited in total capacity.

Crystal River

This site is in Citrus County on the north shore of the Crystal River estuary about 123 kilometers (70 miles) north of St. Petersburg. The property is owned by the Applicant, which operates 3 existing power plants at the site: a 383 MW oil unit, a 498 MW coal unit, and an 825 MW nuclear unit. All use once-through cooling with salt water. For the proposed new power generating facility, there are several theoretically possible sources of makeup water for cooling towers or ponds, which are described in the following paragraphs.

First, wells could be drilled along the present power line rights-of-way. This alternative would require a water pipeline of about 9 kilometers (5.6 miles) in length. The Southwest Florida Water Management District is opposed to this use of well water and has denied permission for drilling of test wells (SWFWMD Resolution No. 529).

Second, surface water could be withdrawn from the Crystal River or Lake Rousseau. Because Lake Rousseau appears preferable in terms of water quality, discharge, and avoidance of environmental impact, only Lake Rousseau has been considered in the latter stages of facility planning. Lake Rousseau was created by the construction of Inglis Dam across the Withlacoochee River in 1909. More recently, the lake was intended to be part of the Cross Florida Barge Canal. The section of the Canal between Lake Rousseau and the Gulf was constructed before the project was discontinued. The Canal cuts across the Withlacoochee River below Inglis Dam and reaches Lake Rousseau about 2.4 kilometers (1 1/2 miles) above the dam. Most of the flow of the Withlacoochee River is shunted through the lock. This arrangement leaves both the western area of Lake Rousseau behind Inglis Dam, and the section of the Withlacoochee River downstream from the dam, separated from the principal through-flow. Water withdrawals from behind the dam to serve the proposed new power generating facilities would increase flow through the western arm of the lake by approximately 10 percent, but would amount to substantially less than 1 percent of the total flow of the Withlacoochee River.

Third, sea water could be used for once-through cooling, as in the present units. This step would require modification of existing intake and discharge canals.

Fourth, sea water could be used for off-stream cooling.

Fifth, the Barge Canal section below the Withlacoochee River could be utilized as a water source and possibly as a cooling pond (Using this

source might involve construction of a salinity barrier and a gate to admit high flows from the Withlacoochee).

The Crystal River site is underlaid by a thin veneer of Pleistocene and Recent sediments over Inglis and Avon Park limestone. The groundwater table is at 3 meters (10 foot) depth, and bedrock is encountered at 6 meters (20 feet). An existing network of vertical solution channels probably does not compromise the soundness of the rock. The site at which the proposed facilities would be located, to the northeast of the existing power generating units, presently consists of pine forest. There are some wet areas which should be avoided. It is considered unlikely that faunal species of special concern occur at the site, because of the highly altered state of the habitats present. However, bald eagles and ospreys are among birds observed on the site.

Facilities for barge delivery of coal are already present at the site. In the absence of modifications, the barge access arrangements would be somewhat limiting on the barge loads that can be handled; but unloading capacity *per se* is more than adequate. The Crystal River site is presently served by both 230 KV and 500 KV transmission lines that extend east and south to the major urban centers of central Florida. These lines could easily accommodate the additional power loads generated by the proposed facilities. Crystal River is fairly well located relative to the load centers of the Applicant's system.

The Crystal River site is favorable in terms of land use. Beyond the boundaries of the Applicant's holdings (which exceed 1,620 hectares or

4,000 acres) there are few sensitive land uses within several miles in any direction. The area consists primarily of wetlands, scrub, pasturage, planted pine, and some industrial land uses. The Crystal River site is considered especially favorable in terms of public acceptance of new power generation facilities.

There are two important considerations regarding air quality impact at the Crystal River site. First, the existing fossil-fuel plants at Crystal River predate the New Source Performance Standards and thus exceed the allowable sulfur dioxide emissions under these standards by a factor of 5. Second, the Chassahowitzia Wilderness Area, located 21 kilometers (13 miles) south of the site, is now a Class I area with regard to air quality. These two factors may make it difficult for a new power generating facility to meet NAAQS and PSD requirements, unless the baseline air concentrations at Chassahowitzia are reduced (e.g., by substituting some low sulfur fuel for high sulfur fuel at the existing plants).

Anclote

The Anclote site is located in the extreme southwest portion of Pasco County on the north shore of the Anclote River estuary, two miles north of Tarpon Springs (population equals 7,118). Three miles directly off-shore are the Anclote Keys which include an undeveloped state park and a national wildlife refuge. The Applicant presently operates a 515 MW facility at this site; and another unit of similar capacity will be on-line in 1978. Both of these facilities are oil-fired and utilize salt water for once-through cooling. Fuel is delivered to the site via pipeline.

The geology of the site involves 0 to 6 meters (0 to 20 feet) of unconsolidated sand overlying weathered limestone, with well-developed organic sediments occurring in scattered wet areas. Solution-collapse features are common. The site contains longleaf and slash pines and a xeric hardwood scrub. There are also limited areas of freshwater marsh and more mesic hardwoods. Saltwater marshes and mangroves are found along the coast. The area is heavily influenced by man and is considered unlikely to contain rare or endangered faunal species. However, bald eagles are among the birds seen near the site. Raccoons are much in evidence and may, perhaps, prevent the establishment of viable rookeries.

The principal advantages of the Anclote site for power generation are its proximity to the Pinellas County load center and its position within the existing transmission system. Its disadvantages involve water supply, land availability, and the presence of nearby urban development. Relatively little land would be available at the site without extensive condemnation proceedings. This fact, along with the existing stress upon freshwater resources in the vicinity of the site, would limit the available cooling options to saltwater cooling towers or once-through cooling. The latter would appear to be ruled out by the limited ability of the shallow waters in Anclote Anchorage to absorb additional heat loads, as well as by government policies. Saltwater cooling towers could involve high operating expenses and possible problems of salt drift in nearby developed areas.

Coal could potentially be brought to the site by either barge or rail. However, since barge docking and unloading facilities presently do not exist at the site, dredging would be required. The impacts of dredging and barge transportation on aquatic ecosystems could be significant.

The existing power generation facilities at Anclote are subject to New Source Performance Standards, so that the construction of a new facility would probably not cause a violation of either NAAQS or PSD air increments in the general vicinity of the plant. However, since the Anclote site is close to urban areas that are already subject to air quality stress, a new source could worsen existing air quality problems.

Phosphate Mining Site

The phosphate mine site under consideration is the 4,455 hectares (11,000 acre) IMC property located directly west of Homeland and approximately 8 kilometers (5 miles) southwest of Bartow (population 12,891) in Polk County, Florida. The site has been selected in order to take advantage of land that has already been disrupted due to mining operations, for which the development of power generating facilities would, in fact, result in reclamation of the existing land. A second critical feature of proposed plans involving this site would be the use of sanitary wastewater from Tampa's sewage disposal plant as cooling tower makeup water. A 64 kilometer (40-mile) pipeline costing roughly twenty million in current dollars would be required and might involve some environmental impacts. However, this reuse of waste water would benefit water quality in the bay area as well as conserving freshwater resources inland.

The topography of the general area around the phosphate mining site is characterized by numerous depressions that are solution-related. However, geologic studies indicate that the underlying rock materials would be competent for support of heavy structures. The site has been highly altered by phosphate strip mining and agriculture so that almost no natural habitat remains. Of the total site area, 52.9 percent is pasture and cleared land of low natural fertility; 37.5 percent consists of abandoned mining areas with associated ponds and slime pits; 8.9 percent supports mesophytic hardwood growth, and 0.6 percent is citrus grove. The site formerly had been covered by pine flatwoods. The only game mammals known to occur on the site are marsh and cottontail rabbits. Game birds are limited to ducks, bobwhite quail, and mourning doves. Despite the large areas of pond and marsh habitat, the site is not an area of concentration for either doves or waterfowl (DNR, 1971). The bald eagle, Florida grasshopper sparrow, and Florida burrowing owl are known to occur in the general vicinity of the site, but are considered unlikely to nest in such a highly disturbed area.

The phosphate mining site has very good highway and rail access, although there is no water access. A transportation alternative which might prove favorable is the barging of coal to Tampa, and rail shipment for the last 64 kilometers (40 miles). A backhaul arrangement could possibly be established involving outbound shipment of phosphate products. The location of the site is highly favorable with regard to the anticipated pattern of demand for power, and moderately favorable in terms of proximity to existing transmission corridors. There are no historic, scenic, cultural, or natural landmarks within the vicinity of the site, although the Peace

River to the south has been designated as a Canoe Trail by the state. The site is rated highly in terms of: (1) the value of the land in question for alternative uses, which is low; (2) the nature of surrounding land uses; and (3) the overall degree of ecological impact that would be produced by power plant development.

Air quality would be problematic at the phosphate mining site; however, the area contains major industrial source of TSP and SO_2, resulting in elevated ambient concentrations. Violations of NAAQS for TSP have been observed. The vicinity of the site has been designated an Air Quality Maintenance Area for TSP and SO_2 by the State DER, so that special review is required for new sources. Although the exact situation cannot be known without detailed study, it appears that the proposed facility might cause or contribute to NAAQS violations unless extra controls were implemented. Also, the air quality increment for Class II might not be available for the facility.

Lake Jessup

The Lake Jessup site is located in Seminole County on the southeastern shore of Lake Jessup, about 4 kilometers (2 1/2 miles) north of Oviedo and 19 kilometers (12 miles) northeast of Orlando. This site has been included here due to the desirability of an alternative in the Orlando area which would utilize municipal wastewater for cooling system makeup. Relatively little information is available for the Lake Jessup site, or for the possibility of utilizing municipal wastewater in this case. The City of Orlando operates two 30 mld (8 mgd) sewage treatment plants whose combined flow would fall somewhat short of the cooling water makeup

requirements of the proposed facilities (although the shortfall might be small by 1984). Orlando wastewater might, therefore, have to be supplemented by water from other municipal treatment plants, from Lake Jessup, or from other sources. The costs and environmental impacts associated with piping Orlando wastewater to the Lake Jessup site are uncertain at the present time.

The Lake Jessup site under consideration is composed of land parcels owned by as many as 40 different individuals. The site contains orange groves and truck farms, along with limited areas of marsh and scrub forest. There are a small number of existing residences. The area surrounding the site is generally rural in character, but has a moderately high population density. Most of the site itself is well drained and contains dark soils of high organic content. Unlithified sediments of the Fort Preston Formation are exposed on the site, and there are peat deposits of unknown thickness. Structural contours on geologic maps indicate that Eocene limestones lie at 23 meters to 30.5 meters (75 to 100 feet) beneath the surface. Deep foundations would probably be required for construction of the proposed power generating facilities.

An existing bituminous road runs along the southern edge of the property. Railroad service is presently available only at Ovido, about 4 kilometers (2 1/2 miles) to the south, but a dismantled spur right-of-way reaches the southern edge of the site. It appears unlikely that barging of coal to the site via Lake Jessup would be feasible, due to limited depth and other constraints. Labor availability and other labor force factors

relevant to the proposed power plant construction project have been rated very highly by the Applicant.

The probable impacts of the proposed project at Lake Jessup upon water, land, and air resources are relatively unknown. The project, if sited carefully, should have only limited effects upon terrestrial fauna and flora due to the fact that most of the land has been altered from natural conditions for purposes of agriculture. The loss of prime agricultural land would be a significant impact in itself, however. Water quality in Lake Jessup would be a serious concern; and extensive hydrological studies would be required to prevent either alteration of hydroperiod or contamination of ground water. The site is only 2.4 kilometers (1 1/2 miles) from the Econolockhatchee River, which has been designated as a State Canoe Trail. However, the site is not within the surface drainage basin of this water body. Regarding air quality, the Lake Jessup site is perhaps as favorable as any of the other alternatives discussed here, because of the absence of industrial emissions or Class I areas in the immediate vicinity.

DeBary

The DeBary site is located on the east bank of the St. Johns River in Volusia County near the town of DeBary. Other nearby communities are Orange City, Deltona, and Deland. Since 1976, the Applicant has operated a 336 MW combustion turbine plant at the site, and more than 1,250 MW of additional generating capacity is located in the vicinity. The land area at the site consists of sandy hills and some freshwater marsh underlain

by limestone. Secondary and remnant channels of the St. Johns River dissect the eastern portion of the site, and there are some surface depressions due to solution activity. The area immediately surrounding the 810 hectare (2,000 acre) site consists of sandy hills and stands of slash pine, with very little developed land.

The primary vegetative associations at the DeBary site, in order of importance, are sand pine scrub, brush flatwoods, brush swamp, prairie, mesophytic hardwoods and freshwater marsh. The existing fauna in the vicinity of the site are known to include more than 41 species of mammals, 192 species of birds, 33 species of amphibians, and 58 species of reptiles. The presence of rare or endangered species has not been determined. A 1973 study by the State of Florida found no significant archaeological or cultural resources at the site proper, although two potentially important sites were identified at the south end of Pine Island which would require further examination. The Wekiva River, a state Canoe Trail, enters the St. Johns River 1.6 kilometer (1 mile) below the site; and Huntoon Island State Park is two miles downstream.

The DeBary site is potentially favorable in terms of transportation, since a rail line crosses the property, and barge access is possible via the St. Johns River. Construction of barge terminal facilities would require substantial dredging, however. The barge traffic generated by the proposed power generating plant might also create navigational and other problems on the river due to the volume of existing traffic. A disadvantage involving the river is the fact that a substantial portion of the site is subject to flooding under extreme conditions.

The DeBary site is well situated relative to the anticipated future power needs within the Applicant's service area. No new transmission corridors would be required. The size of the site would permit the use of either cooling towers or cooling ponds. On the other hand, the site is questionable in terms of water supply, wastewater disposal, and air quality degradation. Water quantity and quality have become serious issues in the St. Johns River basin. The long-term average discharge of the St. Johns is 85,000 lps (3,000 cfs), and the average for the driest month (May) is 51,000 lps (1,800 cfs). However, the lowest monthly flow of record is only 1,980 lps (70 cfs). Withdrawals by the proposed facilities for cooling water makeup could therefore approach 50 percent of discharge on rare occasions.

Disposal of wastewater from the power plant operations into the St. Johns could be unacceptable given the recreational use of the river in this vicinity. Evaporation/percolation ponds could pose a threat to groundwater supplies, due to the permeability of the limestone substrate and the fact that recharge to the Floridan aquifer occurs at the site. Finally, ambient air quality near the site is likely to be degraded due to the existing power plants in the area, so that air quality might prove to be a serious constraint.

Palatka North and Palatka South

Two sites in Putnam County near the Palatka urban area (population 18,610) are discussed here, one about 8 kilometers (5 miles) northeast of Palatka and one approximately 5.6 kilometers (3 1/2 miles) southeast of the city. Both sites front on the St. Johns River. These sites are

outside the Applicant's service district, but are less distant from the primary areas to be served than several of the other alternatives under consideration. The major advantages of these sites are that direct barge access to East Coast ports would be possible via the St. Johns River (control depth 4 meters or 13 feet), and that rail delivery from points outside Florida would be less costly than for any of the other alternatives.

The Palatka North site consists primarily of a large dairy farm. The adjacent land is pine woods with a large cypress dome directly to the west. Some cypress occurs on the site, but only in a few low areas. A significant land use problem is the fact that the riverfront near the site is lined with upper-income homes. The Palatka South site is primarily forested with some open fields and marshy areas. Nine houses and a boat ramp at Stoke Landing presently exist on the site. Deep foundations would probably be required for construction of the proposed facilities at the Palatka South site. Undifferentiated Pleistocene and recent deposits overlie older deposits, and Eocene limestones begin at about the 61 meter (200 foot) depth.

Both the Palatka North and Palatka South sites would be served by the Seaboard Coastline Railroad, with 3.2 to 4.8 kilometers (2 to 3 mile) rail spurs required in each case. A significant factor in terms of cost and environmental impact is that a transmission corridor exceeding 64 kilometers (40 miles) in length, and probably another shorter corridor, would be required in order to link either site to the Applicant's existing transmission system. The flows in the St. Johns River are

probably adequate for its use as a source of cooling system makeup water, although salinity and entrainment of aquatic life might pose problems. The possibility of water quality impacts as a result of power plant operation would have to be studied carefully.

The only existing major source of air emissions near the Palatka North site is the Hudson Pulp and Paper Company facility west of Palatka. However, the Seminole Electric Cooperative plans a 600 MW coal-fired power plant at a location near Bostwick. This expansion may consume PSD increments that otherwise would be available for the Applicant's facility, in addition to which there might be a possiblity of NAAQS violations. With regard to the Palatka South site, the Hudson and Seminole emissions would be more distant, but air quality would be affected by a 580 MW combined cycle facility operated by Florida Power and Light Company at a nearby location. Thus, NAAQS would also have to be examined closely in this case.

8.3.5.2 COST COMPARISON OF ALTERNATIVE SITES

The total cost of providing electrical services is no longer the only criterion considered in power plant siting and design. Government regulations and policies aimed at minimizing environmental impacts, along with growing awareness of these concerns on the part of the public and the industry, have created a situation in which many factors can override cost considerations. However, close attention must obviously be paid to cost in order to establish site feasibility.

Table 8.3.5-1 presents a summary cost comparison of all the sites discussed above, using the Crystal River site as a base. That is, all costs are presented as increments relative to the corresponding cost for the Crystal River site (with negative increments written in parentheses). Three major categories of cost are considered, on an annualized basis: power transmission, fuel delivery and cooling. Most of the omitted elements, such as site acquisition and site development costs, would not affect significantly the outcome of the comparison. However, an excluded element which could have a major bearing on the comparison is the existence of cost differentials due to different air emission control requirements at the various sites. (This factor is discussed later). The data are necessarily quite rough because the Applicant has not made detailed cost comparisons of all of the sites, and because a large number of uncertainties are involved.

The transmission cost element covers both the required investment in new transmission facilities, on an annualized basis, and the anticipated line transmission losses. An average cost of $550,000 per mile of new transmission corridor is assumed; but actual costs obviously could deviate from this figure depending upon the conditions encountered. The valuations placed on the transmission losses are based upon estimates of future demand for power in each of the five major regions served by the Applicant.

Fuel delivery is potentially a very important cost element and is perhaps the factor that involves the greatest degree of uncertainty. However,

Table 8.3.5.-1 Comparative Costs for Power Plant Site Alternatives
Millions of Dollars

	Transmission	Fuel Delivery	Cooling	Total
Gulf County	26	8-10	(10)	24-26
St. Marks	11-14	4-5	0	15-19
Levy County (2 sites)	7-9	0	0	7-9
Crystal River	0	0	0	0
Anclote	2	3-4	0	5-6
Phosphate Mining Zone	(3.3)	4-5	4.6	5-6
Lake Jessup	2	0	3-4	5-6
DeBary	0	0	0	0
Palatka North	9-10	(1-2)	0	7-9
Palatka South	8-9	(1)	0	7-9

Source: Environmental Science and Engineering, Inc.

the present computations have been simplified by two findings cited in the earlier discussion of fuels, namely that: (1) low-sulfur coal provides greater overall economy than high sulfur coal, at least for facilities located at Crystal River; and (2) the least expensive means of delivering low-sulfur coal to Crystal River under present conditions is apparently by rail rather than barge. On the basis of these findings, the cost comparisons have been made under the the assumption that all coal shipments, amounting to 4,000,000 tons per year, will be by rail. This approach would not be strictly valid if the relative favorability of barge versus rail tranportation were different at other sites than at Crystal River, or if the least-cost alternative at other sites were to involve high-sulfur coal rather than low-sulfur coal. Its validity also depends on the mix of Eastern versus Western coals. In any case, the chosen procedure is to assume rail transporation in the cost computations but to treat water transportation potential as an important "plus" for the sites listed below.

<u>Full Water Access Advantage</u>

Gulf County

Crystal River

Palatka (North and South)

<u>Partial Water Access Advantage</u>

St Marks

Levy County (2 sites)

Anclote

Phosphate zone

DeBary

The sites listed as having a "partial" advantage are cases in which reliance upon barge transportation could be problematic, due to: dredging requirements (St. Marks, Anclote); the existing volume of barge traffic (DeBary); or other anticipated impacts. The phosphate zone site is also included because of its potential for barge/rail shipments involving deep-draft barges to Tampa. (Deep-draft barging to Tampa and then trans-loading to other vessels might, in fact, be the most favorable arrangement for sites which do have water access, in the event that water transportation proves to be more attractive than rail for low-sulfur coal deliveries). Regarding rail transportation, the prevailing rate structure is such that all shipments to Florida are charged as if they must pass through Jacksonville, whether or not this is actually the case. Three representative rates for coal shipments from Eastern Kentucky are the following:

to Crystal River: $17.37/ton

to Bartow (phosphate zone): $18.53/ton

to Port St. Joe: $21.98/ton

The cost comparisons in Table 8.3.5-1 assume that freshwater cooling towers would be utilized at all of the alternative sites except Gulf County, in which case there would be once-through cooling. Cooling ponds could potentially be substituted for towers at several of the sites; but this might produce only limited savings, due to the precautions which would be required in constructing and operating the ponds. The only nonzero cost increments for sites other than Gulf County apply to the two cases in which municipal wastewater effluent would be the primary source of cooling tower makeup water. The use of treatment plant effluent would

involve an increment of approximately one milion dollars in operating costs, in addition to the costs associated with pipeline construction.

The total increments shown in the last column of Table 8.3.5-1 indicate that the Crystal River and DeBary sites are most favorable in terms of cost, and that the Gulf County and St. Marks sites are by far the least favorable. The latter result is due to the remoteness of these sites relative to the centers of demand and the existing power transmission system. It is striking that the inherent cost disadvantage of the Gulf County site is only partially offset by the assumed use of oncethrough cooling (which might not be feasible in any case), and that the site would be one of the two worst in terms of cost even if the transportation differential turned out to be zero. The overall cost comparisons presented in Table 8.3.5-2 suggest a categorization of the sites into four groups, as shown below.

SITE RATINGS ACCORDING TO COST*

Unacceptable

Gulf County

St. Marks

Marginal

Levy County (2 sites)

Palatka North

Palatka South

Moderately Favorable

Anclote

Phosphate zone

Lake Jessup

Highly Favorable

Crystal River

DeBary

*Excluding differential costs due to air emission controls.

The group containing Gulf County and St. Marks has been termed "unacceptable" because of the fact that the cost increments for these sites relative to Crystal River would amount to considerably more than 10 percent of the total annual project costs at the latter location (see the data in Table 8.3.5-1). Sites in the "marginal" category remained eligible for consideration if they were especially favorable in other respects. As for sites in the "moderately favorable" and "highly favorable" cost categories, the differences between these in terms of cost have been considered less important than distinctions involving environmental impact and social acceptance.

8.3.5.3 AIR QUALITY COMPARISON OF ALTERNATIVE SITES

The factors affecting the degree of air emission control required at the alternative sites have already been discussed on an individual basis. These factors could not be included in the cost comparisons without detailed studies to determine the emission controls required in each case. However, Table 8-3.5-1 presents a summary evaluation of the sites in terms of the probability that the proposed power generating facilities could be approved at a given site without additional expenditures beyond the level required to comply with New Source Performance Standards and Latest Reasonable Available Control Technology. These judgments are

Table 8.3.5-2 Air Quality Constraints for Alternative Sites

Probability of Approval Without Additional Cost	Site	Probable Magnitude of Additional Cost Required To Meet NAAQS and PSD
80% or Better	Levy County (2 sites) Lake Jessup	None
50% - 65%	Gulf County Palatka South DeBary	None
0% - 20%	Anclote Palatka North	Small
0%	St. Marks (Wakulla Co.) Crystal River Phosphate Zone (Polk Co.)	Small to Large

Source: Environmental Science and Engineering, Inc.

necessarily subjective, but are based on all available information regarding air quality and applicable standards.

It is important from Table 8.3.5-2 that air emission control requirements could reduce or negate some of the cost differences noted earlier, in particular the cost advantage of the Crystal River site and the disadvantages of the "marginal" sites (the Levy County and Palatka alternatives). The extent of these offsetting effects is relatively uncertain, however.

8.3.5.4 FURTHER SCREENING OF SITE ALTERNATIVES

The two most remote site locations, relative to the Applicant's service area, were eliminated from further consideration on the basis of cost differentials. The group of sites ranking next in terms of remoteness and comparative cost, namely the locations in Levy County and the sites near Palatka, also lacked sufficient compensating factors to warrant further consideration, although air quality would be relatively favorable in these cases with the exception of Palatka North. A major disadvantage in terms of environmental impact is that new transmission corridors would be required for all four of these sites, with the total length possibly exceeding 97 kilometers (60 miles) for the Palatka alternatives.

The Palatka North site would tend to involve land use conflicts and site acquisition problems, whereas site development could pose difficulties at South Palatka. Surface water quality would be a serious issue in both cases due to the recreational use of the St. Johns River and the commercial fisheries operating in the area. With regard to Levy County,

the sites on the Suwannee River would be generally unfavorable given the strong local sentiment in support of preserving natural amenity and water quality, and the resultant controversy that would be generated by any large new power plant project.

The Anclote site was judged to be inferior to other alternatives with comparable cost characteristics, despite its favorable location within the Applicant's service area, because of the limitations of the site land, the proximity of urban development, and the lack of satisfactory cooling arrangements. Given the conditions described earlier, the Anclote site would appear to offer a choice between: (1) undesirably large thermal discharges to coastal waters: (2) salt drift problems; or (3) large scale condemnation proceedings to secure an adequate buffer around the power generation facilities. The latter two choices would involve additional cost elements not included in the accounting presented earlier.

Regarding the Lake Jessup site, the possibility of a power generating facility near Orlando which utilizes municipal wastewater for cooling system makeup would be favorable in terms of both water conservation and efficient coverage of the Applicant's service area. However, this alternative has been considered less desirable, on balance, than the phosphate zone alternative, which would also utilize municipal wastewater. Population density in the area surrounding the Lake Jessup site is moderately high, and there are some residents at the

site itself. Land acquisition could be problematic, unlike the phosphate mining site, since the land involved is parceled among as many as 40 owners. Conversion of the Lake Jessup site to power generation use would displace valuable existing uses (citrus groves and truck farming). Although neither the Lake Jessup site nor the phosphate mining site would have barge access, the barge/rail arrangements possible for the phosphate mining site would be considered a plus for the latter. The Lake Jessup site is far better than the phosphate mining site in terms of air quality and the extra emission controls required in the latter case could create an appreciable difference in total project costs. Nevertheless, the phosphate mining site has been considered preferable in view of the much greater public acceptance which is likely in this case, plus the factors just mentioned.

The DeBary site has been eliminated in the final screening on the grounds that it would be somewhat less favorable than the Crystal River alternative. Air quality would apparently impose greater constraints at Crystal River than at DeBary. On the other hand, water supply and wastewater disposal would be especially problematic at DeBary. Direct comparison with Crystal River in this regard is difficult due to the indefinite nature of present plans. However, regardless of the water supply, cooling, treatment and disposal arrangements utilized, the adverse impacts of power generation upon surface and ground waters would tend to be more serious at the DeBary site due to the greater persistence and ramification of impacts within freshwater systems. This is a general liability of inland versus coastal power plant locations. The greater

amenability of the Crystal River site to the use of barge transportation is also considered an advantage relative to the DeBary site. Lastly, location of the proposed power generating facilities at DeBary would involve greater impact upon terrestrial ecology than would be the case for carefully-sited facilities at Crystal River.

8.3.5.5 FINAL SITE SELECTION

The two most preferred alternatives, namely Crystal River and the phosphate mining site, differ in a number of fundamental respects so that the outcome of any comparison is dependent upon the weightings placed on various factors. The following is a brief account of the considerations involved in selecting one of these sites as the preferred alternative.

Construction of the proposed power generating facilities would involve a somewhat greater impact upon terrestrial ecology at Crystal River than at the phosphate mining site, due to the extremely disrupted condition of the latter area. This conclusion is somewhat conjectural since the ecology of the phosphate zone property has not been studied intensively. On the other hand, the phosphate zone alternative would involve construction of a 64 kilometer (40-mile) pipeline and a new power transmission corridor exceeding 8 kilometers (5 miles) in length. Since the routing of these facilities is unknown, their terrestrial impacts are uncertain, but probably would more than compensate for any discrepancy between the phosphate zone and Crystal River sites in terms of on-site impact (including the impact of fresh water pipelines at Crystal River, if constructed).

The existence of direct barge access to the Crystal River site would constitute an advantage in terms of transportation flexibility. Both sites are perhaps equally favorable, on balance, with regard to highway access, nearby land uses, public acceptance, and "general licensability." Air quality would be a critical concern at both sites, with possibly greater expense involved at the phosphate mining site.

Regardless of the source of cooling system makeup water utilized at the Crystal River site, the phosphate zone alternative would appear to be more favorable with regard to water supply. If groundwater were utilized at Crystal River, the withdrawals would consist almost entirely of freshwater that otherwise would be lost to the Gulf of Mexico; but the withdrawals could lower the piezomeric surface and thus affect water availability further inland. If Lake Rousseau were utilized as the primary water source, there might be some risk of entrainment of organisms or other impacts upon aquatic ecology and recreation. (This question is currently being studied). Finally, if saltwater cooling towers were utilized at Crystal River, there would be additional cost elements not expressed in the above cost comparisons, plus the fact that the technology involved is considered by the Applicant to be somewhat unproven. In contrast, the phosphate zone alternative would utilize an essentially "free" source of cooling system makeup water. This wastewater can, in fact, be assigned a negative value at its present outfall (Hookers Point), so that a social benefit would result from its removal to another location.

The Crystal River site would be preferable to the phosphate zone in terms of the disposal of cooling system blowdown and other wastewaters from power generation and scrubber operation. Groundwater contamination would be a possibility in either case if evaporation/percolation ponds were utilized. However, the degree of contamination would tend to be worse in the phosphate zone case due to the high pollutant concentrations present in the municipal wastewater used for cooling. More importantly, the water quality effects produced in the phosphate zone could affect inland water supplies over a substantial area, whereas contaminated groundwater at the Crystal River site would join the aquifer flow directly to the Gulf of Mexico. Roughly the same arguments would apply with regard to surface water discharges.

Nevertheless, due to the use of municipal wastewater, the phosphate zone alternative would tend on balance to be socially preferable to the Crystal River alternative in terms of water resources. Thus, the relevant question is whether the net water resource benefit would be sufficient to justify: (1) less flexibility in fuel delivery than under the Crystal River alternative; (2) possibly greater impacts on terrestrial ecology; (3) the use of relatively unproven cooling arrangements; and (4) an extra expenditure of approximately five to six million dollars per year.

With regard to the third item, it is true that municipal wastewater is currently being used as cooling system makeup by the City of Lakeland. However, reliance upon municipal wastewater at the scale implied by the proposed plans would involve a number of technological uncertainties.

One additional question is the level of effluent quality to be achieved by the new Tampa sewage treatment system which will come on-line in 1978.

The Applicant has determined that the disadvantages and risks associated with the phosphate zone alternative, relative to the Crystal River site, outweigh the potential water resource benefits of the former at the present time. Crystal River is, therefore, the preferred site alternative for the facilities proposed here. Pending further study, the phosphate mining site could well emerge as the most favorable site for the next phase of major power plant development.

8.4 JUSTIFICATION (RATIONALE) FOR PROPOSED FINAL SITE, ENERGY SOURCE AND COOLING WATER SOURCE

8.4.1 INTRODUCTION

The following text presents a condensed description of the applicant's justification or rationale for selecting the site, fuel source and cooling water source.

8.4.2 RATIONALE FOR SITE SELECTION

Beginning the early part of 1976, the applicant proceeded to select a final site for the Company's proposed 1980's Generation Units. The applicant adhered to the following procedures in reaching its final decision for determination of the final site location and energy source: (1) identified potential power plant sites; (2) selected evaluation criteria; (3) established evaluation criteria weighting factors; and, (4) ranked sites for certain fuel type/delivery options. Eventually the applicant identified seventeen (17) potential sites resulting in sixty-six (66) unique options when cooling, fuel types, fuel delivery alternatives were considered.

Finally the applicant completed its evaluation of twenty-six (26) options; thirteen (13) options associated with delivery of low sulfur coal from New Orleans and thirteen (13) options associated with delivery of high sulfur coal from New Orleans. In reaching the final thirteen sites the evaluation criteria considered included:

Accessibility

Air Quality

Ecology

Facilities/Labor

General Licensability

Geology

Historical/Archaeological/Recreational

Hydrology/Water Availability

Land Use

Protection - Natural Phenomena

Plant Design and Layout

Thermal Discharge/Dredging

Transmission/Substation Design/Layout

Water Quality/Chemical Waste

Scheduling and Planning

Load Requirements and System Needs

The eventual thirteen (13) potential sites which surfaced as a consequence of the aforementioned studies were:

1. Phosphate Zone (IMC)/Cooling Tower
2. Hardee County Phosphate/Cooling Tower
3. Crystal River Plant/Cooling Tower
4. Gulf County Canal/Once Thru
5. Gulf County Canal/Cooling Tower
6. Palm Point (Gulf County)/Once Thru
7. Northern Division/Cooling Tower

8. Palm Point (Gulf County)/Cooling Tower

9. Northern Division/Cooling Pond

10. Beacon Hill Beach (Gulf County)/Once Thru

11. Bartow Plant/Cooling Tower

12. Beacon Hill Beach (Gulf County)/Cooling Tower

13. Carrabelle (Franklin County)/Cooling Tower

The evaluation criteria leading to the eventual selection of the above referenced thirteen sites utilized a technique of ranking sites relative to one another but did not provide the traditional economic evaluation of site dependent factors in terms of difference in initial capital investment and in expected operating costs related primarily to delivered fuel cost, transmission losses, etc.

Henceforth the applicant proceeded to economically evaluate the five (5) most desirable sites which included:

1. Phosphate Zone (IMC)
2. Hardee County Phosphate
3. Crystal River Plant
4. Gulf County Canal
   a. Once Thru Cooling
   b. Cooling Towers
5. Palm Point
   a. Once Thru Cooling
   b. Cooling Towers

The economic factors considered were the differential costs that could be identified as site related and relative, one site to another. The factors were:

1. Differential land costs
2. Differential transmission costs
3. Differential system transmission losses
4. Differential fuel delivery cost
5. Differential cooling water and related engineering costs

The economic analysis dictated that low or high sulfur coal delivered from New Orleans to the Crystal River site resulted in lowest cost.

8.4.3 RATIONALE FOR FUEL SELECTION

Prior to the applicant reaching a final decision on a fuel source for the proposed 1980 units various alternatives were considered, specifically: coal, oil, gas and uranium were all considered as possible energy sources.

Coal was the eventual choice for a variety of reasons. The price and uncertain availability of oil and natural gas eliminated those fuels from consideration. The cost and availability of uranium made it an attractive choice, but the regulatory and financial uncertainties surrounding construction coupled with governmental indecision regarding the disposition of used nuclear fuel prohibited any further nuclear plant commitment at the time. As a result the

feasible choice of fuel was either low or high sulfur coal. Low sulfur coal was chosen for several reasons. First, it was chosen because it had economic advantages, and, secondly, low sulfur coal was chosen because of the uncertainties surrounding the use of scrubbers for sulfur removal.

The applicant's design of Crystal River 4 and 5 is proceeding on the applicant's 1977 corporate policy decision that the SO_2 limitations will be met by burning coal with a sufficiently low sulfur content. However, for future flexibility, space will be allocated for the installation of FGD equipment, or other alternative processes should the need arise.

Flue gas desulfurization equipment has been installed with varying degrees of success on utility boilers. At best, the equipment is costly to purchase and expensive to operate and maintain. FGD systems also create a major disposal problem for the sludge resulting from the process.

The estimated FGD system capital cost for CR 4, for instance, based on 1977 dollars is $47 million or $73 per KW. The auxiliary power required is approximately 4% of the unit capability or 28,000 KW. Thus the auxiliary power requirement results in a net reduction in unit capability at a capacity charge of $480 per KW.

This amounts to additional capital costs of $13,440,000 with an annual revenue requirement of $1,882,000.

At a levelized energy cost of 0.0379 $/KWH and an average annual capacity factor of 65%, the annual energy cost will be $6,042,000. In addition to the foregoing, there are additional maintenance costs of approximately $1,500,000 per year to ID fans, ductwork, etc. because of handling the corrosive flue gas. Additionally, it can be expected that FGD would result in reduction in unit availability of from 4% to 5%, amounting to 13 days per year at $114,000 per day and totalling $1,482,000 per year.

Waste sludge from the FGD operation would triple the volume of solid waste disposal requirements. Estimated sludge quantities for the life of CR 4 amount to 8,000 acre-feet. This sludge material must be concentrated, stabilized and stored in environmentally acceptable disposal areas. Assuming the sludge could be stored to a height of 20 feet, an additional disposal area of 400 acres would be required for this unit. It would require the use of site property which is classified as wetland and transitional wetland to accommodate this waste material in addition to the waste from ash disposal of all coal units on the site.

The installation of a flue gas desulfurization system would adversely affect the initial cost, availability, reliability, net

capability, operation and maintenance of Crystal River 4 and Crystal River 5 as well. Table 8.4.4-2 is a tabulation of major expenditures that are required for such a system. Despite statements to the contrary, FGD is concluded strongly by the applicant to still be in the developmental stages and requires considerable refinement before it is sufficiently proven for power plant applications. In addition, the significant penalties described herein are not considered to be in the interest of the applicant's customers, and are not required by current regulations.

Table 8.4.4-1 Crystal River 4 Flue Gas Desulfurization System Estimated Costs

	Capital Cost	Annual Cost
Initial Cost	$47,000,000	$ 6,580,000
Capacity Cost	13,440,000	1,882,000
Energy Cost		6,042,000
Maintenance Cost		1,500,000
*Additional Personnel		1,250,000
Linestone		4,500,000
Replacement Energy Cost		1,482,000
TOTAL	$60,440,000	$23,236,000

*50 additional operations and maintenance personnel.

8.4.4 APPLICANT'S POSITION ON COOLING WATER SOURCE

The once-thru cooling system is by far the most economical alternative cooling system for the proposed new plant. However, permitting and licensing restraints preclude this option. Therefore, the applicant's choice for the next best acceptable alternative is the natural draft cooling tower system. Considering the fresh water and salt water cooling tower options, the fresh water tower is regarded as acceptable while the salt water tower lacks substantial operational experience in the United States.

The applicant's approach to the design of new generating facilities stresses adherence to proven design and operating technology. High reliability of new coal fired units is essential to the applicant's customers, as well as contributing to the national energy independence effort. In consideration of various cooling options, the applicant conducted a survey of utility experience with salt and brackish water cooling towers. The survey findings have resulted in the strong conclusion that cooling towers using salt or brackish water makeup do not represent a proven technology and, therefore, cannot be considered to be an acceptable cooling alternative for new generating capacity. The survey results are particularly applicable to Crystal River 4 and 5 design timing.

The survey included the relatively few generating units with capacities larger than 200 megawatts and has an approximate data base of

114 unit years of operation of which 31 are mechanical draft and 83 are natural draft. Of this total, about 35% of the operational experience is from the rather small 240 megawatt, Stella Station located in England which has two towers for four units. For natural draft towers, in today's climate a strongly more favorable economic alternative, there are only five unit-years of domestic operating experience. A number of problems associated with salt and brackish water tower applications have occurred such as increased condenser tube leakage, poor thermal performance, disintegration of tower fill material, marine fouling of the water distribution system and development of a small crack in a natural draft tower shell. While these problems have not been catastrophic to date, they are not indicative of a proven technology contributory to the high reliability required of new generating facilities.

An example of a major problem that would potentially result from use of high salinity water as opposed to fresh water makeup is corrosion-caused deterioration directly affecting reliability and operating life of the cooling tower system. It is concluded that there is a relatively high probability of such occurrence.

Based on the current utility operating experience on large power plants, salt water cooling towers can be considered operational, but hardly a proven technology based on many years of experience. The consequence of a major outage and/or significant reduction in

plant reliability resulting from high maintenance of the cooling tower would be a severe and costly-to-customers impact on the applicant's generating system. In that such a narrow base of operating experience exists, the actual degree of such a risk cannot be accurately determined. Short of this determination based on fact, good judgment results in the conclusion that the reliability risk is higher than acceptable. Therefore, the applicant will continue surveillance in this area to track the latest experience for possible future applications.

CHAPTER 9

CHAPTER 9

PLANT DESIGN ALTERNATIVES

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9.0 PLANT DESIGN ALTERNATIVES

9.1 INTRODUCTION

The purpose of the present section is to summarize the many investigations conducted to determine the most favorable design alternatives for the proposed power generating units 4 and 5 at Crystal River. The guiding principle of these studies is that design features should minimize all categories of environmental impact subject to reasonable constraints upon cost and technical feasibility. The proposed power generating facilities must meet all quantitative standards established by state and federal agencies for all air and water impacts, and also must be consistent with public policies, objectives, and guidelines pertaining to a wide variety of ecological and social values.

Alternatives have been developed and evaluated critically for every major aspect of plant design; but the present discussion is limited to those aspects which related directly or indirectly to environmental impact. An attempt has been made in each case to include all alternatives, or generic classes of alternatives, which might be technically feasible. The level of detail in which these alternatives have been evaluated has depended upon the magnitude of the issues involved, the information available, and the degree of difficulty encountered in establishing relative favorability. In some cases, a single alternative emerges as clearly the most favorable; but in other cases the choice depends upon the weightings assigned to various incommensurable

factors. The assignment of such weightings has generally been beyond the scope of the investigations reported here.

9.2 COOLING SYSTEM ALTERNATIVES

9.2.1 OBJECTIVE AND REQUIREMENTS

This section describes the cooling requirements for the proposed Crystal River Units 4 and 5 and presents an analysis and ranking of the alternative cooling systems available. The analysis considers technical, environmental, and economic considerations associated with each alternative. Quantitative information is used, when available, to rank alternatives. In many cases, however, quantitative information is not available. In these cases, the ranking of alternatives is based on the subjective interpretation of available information and the best professional judgment of the project team.

9.2.1.1 REQUIREMENTS FOR COOLING SYSTEMS AND EVALUATION CRITERIA

The addition of two coal-fired generating units (Crystal River Units 4 and 5) in the vicinity of the existing Crystal River Plant Units 1, 2, and 3, is being considered by Florida Power Corporation. Each new unit is projected to have a net expected capacity of 600 to 660 Mw. A four flow tandem-compound turbine generator has been selected. At peak loading rates, the cooling system for each unit would be required to reject approximately 3300 x 10^6 Btu per hour.

The project criteria used in studying design alternatives include: criteria for economic evaluations; load models for the new units and the existing coal-fired units (Crystal River 1 and 2); costs for fuel,

capacity, and energy; wet and dry bulb temperature data; and ambient water temperature data.

9.2.1.2 CRITERIA FOR ECONOMIC EVALUATIONS Economic evaluations were developed for a single generating unit (Unit 4). Evaluations for a second generating unit (Unit 5) can be developed by appropriate adjustment of the Unit 4 data.

Commercial operation of Unit 4 is scheduled for October, 1982. The evaluation period for Unit 4 will be 30 years beginning in October, 1982, and ending in September, 2012.

Estimates of capital costs for Unit 4 will be developed in constant (1977 or 1976) dollars as noted without considering the effects of inflation. Costs for alternative flue gas scrubbers and associated equipment, cooling towers, and common facilities which could be prorated to a second unit, if constructed, will be shown separately in all estimates. The annual fixed charge rate on the plant investment is 17.0 percent for 1976 studies and 14.0 percent for 1977 studies. The present worth discount rate is 12.0 percent for 1976 and 11.0 for 1977 studies.

Construction overhead, including interest during construction, financing, and administrative costs is estimated to be 25 percent. Escalation rates for price inflation are 7 percent per year compounded monthly to the anticipated date of delivery for equipment and materials, and 7 percent per year compounded monthly to the midpoint of the

anticipated construction period for field construction. When capital costs for specific items are expected to deviate significantly in escalation from the above average, the escalation factors will be adjusted accordingly, with a notation about the cause made in the estimate.

Escalation will be calculated only for the project estimate and will be separately stated as an adjustment to the constant dollar base costs of equipment and construction. Escalation will not be calculated for system studies except as required for annual cost analyses.

Load Model--New Units

The load model for purposes of siting studies is shown on Table 9.2.1-1.

Load Model--Existing Units

The load model of the existing coal-fired units (Crystal River 1 and 2) is shown on Table 9.2.1-2. The load model will be utilized for site related studies involving facilities common to a four unit plant (cooling water, coal delivery and storage, ash and rejects generation, etc.).

Fuel Costs

The fuel costs of coal are projected as shown on Table 9.2.1-3 for the first 7 years of operation. Fuel costs after 1988 are assumed to

Table 9.2.1-1 Load Model--Each Unit

Net Plant Output (Mw)	Hours of Operation				
	1982-1986	1987-1991	1992-1996	1997-2001	2002-2012
660-600	1,300	1,300	1,100	800	600
600-540	4,000	4,000	3,700	3,400	3,000
540-480	700	700	600	600	600
480-420	300	300	200	200	200
420-360	200	200	200	200	200
360-300	100	100	200	200	200
300-120	600	600	800	800	700
Total Hours On-Line	7,200	7,200	6,800	6,200	5,500
Average Output While On-Line	0.88	0.88	0.85	0.84	0.84
Annual Capacity Factor*	0.72	0.72	0.66	0.59	0.52
Average Output While On-Line Over Operating Lifetime*				0.855	
Average Annual Capacity Factor Over Operating Lifetime*				0.624	

* Capacity Factor and Output based on 660 Mw net expected capability.

Source: Black and Veatch, Report to Florida Power Corporation (FPC) entitled "Site Study for Two 600 Mw Coal-Fired Units, Cooling Systems," dated November 17, 1976.

Table 9.2.1-2 Combined Load Model for Existing Crystal River Units 1 and 2

Percent Capacity	Net Plant Output		Years				
	Unit 1	Unit 2	1977-1981	1982-1986	1987-1991	1992-1997	1997-2001
	Mw	Mw					
100-90	379	491	800	700	300	200	200
100-90	379-341	491-442	3900	3300	2100	1300	1300
90-80	341-303	442-393	1000	1100	2000	2200	2200
80-70	303-265	393-344	700	700	1000	1400	1400
70-60	265-227	344-295	400	600	700	800	800
60-50	227-189	295-246	400	500	500	600	600
Total Hours On-line			7200	6900	6600	6500	6500
Average Output While On-line			.88	.86	.83	.80	.80
Annual Capacity Factor			.72	.68	.63	.59	.59
Average Output While On-line Over Operating Lifetime						0.84	
Average Annual Capacity Factor Over Operating Lifetime						0.65	

Source: Black and Veatch, 1976.

Table 9.2.1-3 Fuel Costs of Coal

Year	Fuel Costs ($/M Btu)
1982	2.20
1983	2.31
1984	2.43
1985	2.55
1986	2.67
1987	2.81
1988	2.95

Source: Black and Veatch, 1976.

escalate at the rate of 5.0 percent per year (annually compounded) for the remaining plant life.

Capacity Cost

The capacity costs for 1982 commercial operation has been established at $450 per kw for 1976 studies and $480 kw for 1977 studies (System Basis Average) and $300 per kw (Incremental Basis). System basis capacity costs are assumed to escalate at the rate of 7.0 percent per year (annually compounded) for the new plant, base load generation additions.

Energy Cost

The energy costs consist of a portion for fuel costs and a portion for operating and maintenance costs. The projected energy cost for the 30-year evaluation period is shown on Table 9.2.1-4.

Temperature Data

Wet bulb and dry bulb air temperature data and ambient inlet water temperature data used in development of cost estimates is presented in Tables 9.2.1-5 and 9.2.1-6, respectively.

Table 9.2.1-4 Energy Costs

Year	Present Worth Factor*	Energy Charges			Present Worth of Energy Costs ($/kwh)
		Fuel † ($/kwh)	Operating** ($/kwh)	Total ($/kwh)	
1982	0.8929	0.02046	0.00138	0.02184	0.01950
1983	0.7972	0.02148	0.00149	0.02297	0.01831
1984	0.7118	0.02256	0.00160	0.02416	0.01720
1985	0.6355	0.02368	0.00174	0.02542	0.01615
1986	0.5674	0.02487	0.00188	0.02675	0.01518
1987	0.5066	0.02611	0.00203	0.02814	0.01426
1988	0.4523	0.02742	0.00219	0.02961	0.01339
1989	0.4039	0.02879	0.00237	0.03116	0.01259
1990	0.3606	0.03023	0.00256	0.03279	0.01182
1991	0.3220	0.03174	0.00276	0.03450	0.01111
1992	0.2875	0.03333	0.00298	0.03631	0.01044
1993	0.2567	0.03499	0.00322	0.03821	0.00981
1994	0.2292	0.03674	0.00348	0.04022	0.00922
1995	0.2046	0.03858	0.00376	0.04234	0.00866
1996	0.1827	0.04051	0.00406	0.04457	0.00814
1997	0.1631	0.04253	0.00439	0.04692	0.00765
1998	0.1456	0.04466	0.00474	0.04940	0.00719
1999	0.1300	0.04689	0.00511	0.05200	0.00676
2000	0.1161	0.04924	0.00552	0.05476	0.00636
2001	0.1037	0.05170	0.00597	0.05767	0.00598

Table 9.2.1-4 Energy Costs (Continued)

Year	Present Worth Factor*	Energy Charges Fuel † ($/kwh)	Operating** ($/kwh)	Total ($/kwh)	Present Worth of Energy Costs ($/kwh)
2002	0.0926	0.05429	0.00644	0.06073	0.00562
2003	0.0826	0.05700	0.00696	0.06396	0.00528
2004	0.0738	0.05985	0.00752	0.06737	0.00497
2005	0.0659	0.06284	0.00812	0.07096	0.00468
2006	0.0588	0.06599	0.00877	0.07476	0.00440
2007	0.0525	0.06928	0.00947	0.07875	0.00413
2008	0.0469	0.0725	0.01022	0.08297	0.00389
2009	0.0419	0.07639	0.01104	0.08743	0.00366
2010	0.0374	0.08021	0.01193	0.09214	0.00345
2011	0.0334	0.08422	0.01288	0.09710	0.00324
2012	0.0298	0.08843	0.01391	0.10234	0.00305

Present Worth Factors = 8.0850

* Present worth discount rate of 12.00 percent per year.
† Fuel costs shown are based on a projected net plant heat rate of 9,700 Btu/kwh.
** Operating and maintenance costs escalated at 8 percent per year--compounded.

Source: Black and Veatch, 1976.

Table 9.2.1-5 Average Monthly Temperatures

Month	Dry Bulb* (°F)	Wet Bulb** (°F)
January	61.4	55
February	63.3	58
March	63.7	62
April	69.8	66
May	76.2	71
June	78.9	74
July	79.3	75
August	79.0	75
September	76.8	74
October	73.0	69
November	63.7	63
December	56.8	57
Annual	69.0	67

Note: The above data on dry bulb and wet bulb temperatures are for different years and cannot be compared directly. However, these data are not used simultaneously in this study and are considered representative for the uses made of the data.

* Source: Crystal River Site, 1975 Meteorological Data.
** Source: Black & Veatch Report to Florida Power Corporation entitled Cooling Channel for Crystal River Plant, dated October 1, 1971.

Table 9.2.1-6 Mean Inlet Water Temperatures

Month	Mean Temperature °F
January	57
February	62
March	65
April	75
May	79
June	84
July	85
August	85
September	83
October	75
November	66
December	60

Source: Crystal River Unit 3 Environmental Report.

9.2.2 HEAT DISSIPATION SYSTEMS CONSIDERED ECONOMICALLY AND TECHNICALLY FEASIBLE

Preliminary analysis of alternative cooling systems was conducted on the basis of general technical and economic feasibility. In addition, these alternatives were evaluated on the basis of the general acceptance of the technology by the Utility Industry in the United States and Florida. Cooling systems which were considered feasible are:

1. Once-through cooling;
2. Mechanical draft wet cooling towers;
3. Natural draft cooling towers; and
4. Power spray modules.

9.2.2.1 ONCE-THROUGH COOLING SYSTEMS

A once-through cooling systems is considered feasible because it is the primary method of cooling used by utilities in the State of Florida. At the present time there are six major fossil fuel steam electric generating facilities using once-through cooling on the Gulf Coast.

Existing units at the proposed site also use once-through cooling. Since a once-through system at the proposed site would require only minor modifications of the existing intake and cooling structures, a once-through cooling system for the proposed units would be the alternative cooling system with the lowest cost.

9.2.2.2 MECHANICAL DRAFT WET COOLING TOWER SYSTEMS

Mechanical draft wet cooling tower systems utilize evaporative cooling to provide the necessary condenser cooling for the steam generator. Mechanical towers utilize fans to provide the air flow for the interaction of the air and water. As far as cooling tower systems are concerned, mechanical draft towers have been the major method for providing closed cycle cooling in the utility industry. In Florida, mechanical draft cooling tower systems have mainly been utilized on smaller facilities (30-150 Mw). At the present time, one cooling tower of approximately the same size as the proposed units is in operation using mechanical draft. Presented in Section 9.2.6 is a discussion of mechanical draft cooling tower systems.

9.2.2.3 NATURAL DRAFT COOLING TOWER SYSTEMS

Similar to mechanical draft wet cooling tower systems, natural draft cooling towers use evaporative cooling. The air flow through a natural draft cooling tower, however, is provided by the density difference between atmospheric air and that inside the tower, which has been warmed by the hot water from the plant condensers. In order to achieve this buoyancy differential, natural draft cooling towers are presently designed to be hyperbolic in shape and have high exhaust heights.

Natural draft cooling towers are rapidly gaining acceptance in the power industries in areas of high humidity, primarily because these offer an economic advantage over other alternatives which have substantial energy costs, e.g., mechanical draft cooling towers. In Florida

at the present time there are no existing natural draft cooling towers on major fossil fuel steam electric power plants. However, new power plants in Florida are expected to use natural draft cooling towers. One proposed facility located in the Florida Panhandle will use natural draft hyperbolic cooling towers. Natural draft cooling towers are discussed in Section 9.2.5.

9.2.2.4 POWER SPRAY MODULES

Although power spray modules occupy much more space than natural draft cooling towers, both designs are based on the same principles. Power spray modules are also economically competitive with cooling towers in many areas. They also require relatively small land areas and are accepted by the industry.

9.2.3 HEAT DISSIPATION SYSTEMS NOT CONSIDERED ECONOMICALLY OR TECHNICALLY FEASIBLE

Analysis of heat dissipation systems has determined that the following systems are not considered feasible on the proposed site:

1. Cooling ponds; and
2. Dry and wet dry cooling towers.

9.2.3.1 COOLING PONDS

Cooling ponds continuously circulate power plant cooling water through a large lake or pond. The proposed facilities would require a cooling pond of 1,200 acres. This estimate is derived from the requirement of approximately 1 acre cooling pond area per megawatt. As a consequence, large areas of natural habitat could be destroyed. Florida Power Corporation does not control sufficient land area suitable for the pond.

9.2.3.2 DRY AND WET-DRY COOLING TOWERS

The dry systems are based upon indirect contact between the air and the hot water, and heat transfer takes place through convection and conduction. The wet-dry systems make use of both direct and indirect contact between the air and the water, and the heat transfer takes place through evaporation, convection, and conduction.

The dry and wet-dry systems are generally more expensive than wet systems due to high capital and operating costs. Maintenance costs for common control are particularly high. The dry system also works best

where fluids to be cooled are at a higher temperature than the circulating water for the proposed Units 4 and 5.

9.2.4 ONCE-THROUGH COOLING SYSTEM ALTERNATIVES

9.2.4.1 DESCRIPTION OF EXISTING ONCE-THROUGH COOLING SYSTEM

Cooling water for the existing Crystal River Units 1, 2, and 3 is delivered to the site through an intake canal which is 150 feet wide and has been dredged to a depth of 15 feet below mean low water level to accommodate oceangoing barges. This canal extends 6.5 miles into the Gulf of Mexico and includes a spoil bank on the north side of the canal to prevent discharge water from being recycled through the cooling water system. The water velocity in the intake canal for the existing units is 1.3 feet per second at ebb tide.

The three existing units all use once-through cooling water systems. The cooling water from those units is discharged into a discharge canal which extends into the Gulf of Mexico. The discharge canal is approximately 1.5 miles long, 125 feet wide, and has been dredged to 10 feet below the mean low water level. A spoil bank on the south side of the discharge canal extends out 1 mile from the shore. The water from the existing units is mixed in the canal before discharge into the Gulf. The water velocity in the discharge canal with all of the existing units operating is approximately 2.4 feet per second. The combined discharge volume for the three units is 1,987 mgd, and the net temperature rise at the end of the discharge canal is 14.5°F (8.1°C) above the intake water temperature.

The existing intake canal also serves as a navigation channel for coal supply barges. A project is underway to deepen this canal to 20 feet

below mean low water for navigation purposes. In addition, work is planned to extend the south bank of the existing discharge canal 1 mile and to extend the north bank 2 miles farther into the Gulf of Mexico. This extension is required to reduce the thermal impacts caused by the operation of Units 1, 2, and 3 and to minimize the potential for recirculation of heated discharge water into the intake canal.

9.2.4.2 TURBINE GENERATOR ALTERNATIVE FOR UNITS 4 AND 5

In an analysis of alternative cooling systems, a four flow, tandem-compound turbine generator capable of delivering 670 Mw net expected capacity has been selected for use. An optimization analysis which considered fuel cost, electrical energy cost, capital cost of equipment, turbine-generator heat rejection rate, condenser head loss, turbine back pressure, and circulating water flow rates was used to determine condensing and once-through cooling system design and cost estimates. Additional system variables and the range of values used in the optimization analysis are presented in Table 9.2.4-1.

The optimum system parameters for a once-through cooling system were determined to be as follows:

Flow Rate	460,000 gpm
	662 mgd
Condenser Surface Area	300,000 sq. ft.
Peak Condenser Pressure	2.85 in. Hg, absolute

Table 9.2.4-1 Circulating Water System Parameter Values Used for Once-Through System Evaluation

Item	Parameter Value
Condenser	
Tube length, feet	40
Tube diameter, inches	1.0
Tube material	90-10 copper-nickel
Tube gauge	18
Water velocity, feet/second	8.0
Piping	
Material	Fiberglass reinforced plastic
Diameter, inches	96 to 120
Number	2
Water velocity, feet/second	8 to 10
Intake System	
Pump type	Vertical
Capacity, percentage each	25
Number	4
Screen type	Traveling

The major components of the plant cooling system include the inlet and discharge canals, intake structure, circulating water piping, condenser, and auxiliary cooling system. The alternatives considered in the planning process for each of these major components are discussed in the following paragraphs.

9.2.4.3 INTAKE STRUCTURE DESIGN ALTERNATIVES

Three alternative methods of locating the intake structure in the canal were considered:

1. Inlet flush with the canal shoreline;
2. Inlet set off the canal shoreline in the open water of the canal;
3. Inlet set back from the canal with a new branched open channel from the existing canal.

The following alternative types of inlet structures were also considered:

1. Vertical traveling screen;
2. Inclined traveling screen;
3. Perforated pipe;
4. Horizontal traveling screen.

A comparative analysis of these alternatives is not available at this time. Cost estimates for once-through cooling systems have been developed assuming vertical traveling screens as the intake structure.

9.2.4.4 CIRCULATING WATER PIPING

The circulating water piping to and from the unit condensers would consist of two 108-inch fiberglass reinforced plastic pipes. The piping to each unit would be placed in a common trench at a depth of 3 to 5 feet below grade. The crossing ofcanals, if required, would be accomplished by either excavating under the canal or using a bridge crossing. Cost estimates developed for once-through cooling are based upon excavation under the canal.

9.2.4.5 CONDENSER

The main condenser for each unit would consist of two single-pass surface condensers with a total surface area of 300,000 square feet. The condenser would be designed to remove 3,300 x 10^6 Btu per hour while operating under peak loading conditions with an inlet water temperature of 87°F (31°C). Under these extreme conditions, the peak pressure is expected to reach 2.85 inches Hg absolute. The temperature rise under peak loading conditions would be 14.4°F (8.0°C) at a flow rate of 460,000 gpm (662 mgd).

9.2.4.6 AUXILIARY COOLING SYSTEMS

Water would be supplied to the auxiliary cooling system heat exchangers via the circulating water system. The estimated flow is 20,000 gpm (29 mgd). The auxiliary cooling water would be discharged into the station discharge canal via the circulating water discharge piping.

9.2.4.7 INTAKE AND DISCHARGE CANAL ALTERNATIVES

The once-through cooling alternatives would utilize the existing intake and discharge canals to the greatest extent possible. However, the existing canal cross sectional area must be modified to handle the greater flow volumes. Each new power unit will require 480,000 gpm (691 mgd). The main condenser system requires 460,000 gpm (662 mgd) and the auxiliary cooling system requires 20,000 gpm (29 mgd). Consequently, the existing flow of 1,380,000 gpm (1,987 mgd) will be increased to 2,294,000 gpm (3,303 mgd). Deepening of the intake canal to 18 feet below mean low water and the discharge canal to 15 feet below mean low water would be required. These modifications will maintain the existing hydraulic characteristics of Units 1, 2, and 3. Intake canal flow velocities would be increased from 1.3 to 1.6 feet per second on the ebb tide. Flood tide velocities would be higher. Velocities on the ebb tide in the discharge canal would be 2.5 feet per second.

Intake velocities in excess of 1.3 feet per second will result in impingement problems. However, it has been determined by the engineering consultants that it is not economically feasible to reduce intake velocities below 1.6 feet per second.

The Units 4 and 5 will have a temperature rise of 14.5°F at an intake ambient temperature of 87°F. This temperature rise is the same as the combined discharge of Units 1, 2, and 3. However, with Units 4 and 5 operating at maximum power the volume of water and the amount of heat discharged would increase by 70 percent. This higher discharge will

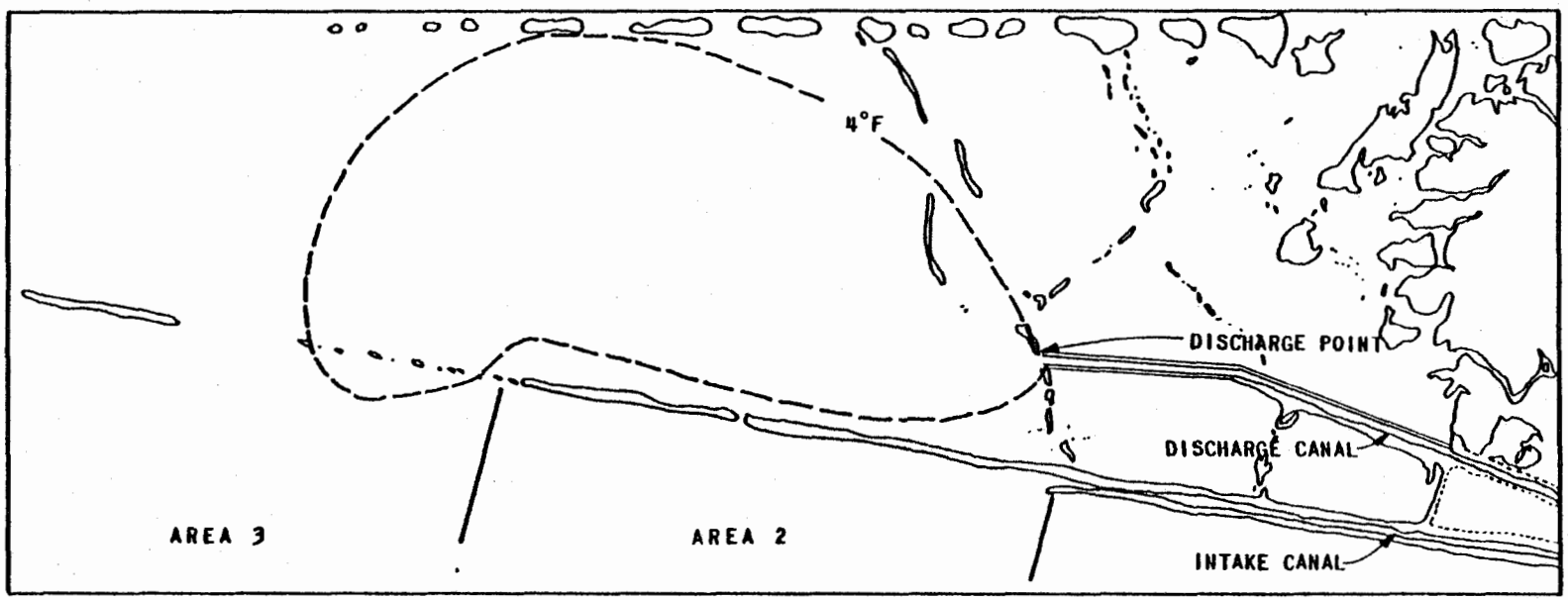
increase the possibility that heated water will be recirculated into the station condensers under certain environmental conditions. The 4°F isotherm boundaries are shown in Figure 3-4 (Black and Veatch, 1976). It was conservatively assumed that a 1°F rise at the station inlet would occur on an annual average. The cost analysis demonstrated that it is not economically feasible to build a dike to prevent circulation. The annual fuel costs due to a delta 1°F temperature at the station intake is $265,000. The annualized construction cost of a diversion dike to prevent recirculation is $2,176,000 (Black and Veatch, 1976).

Three alternative configurations for intake and discharge canal layout were considered. These designs are discussed for each alternative location of the generating units.

9.2.4.8 SITE 1 LOCATION

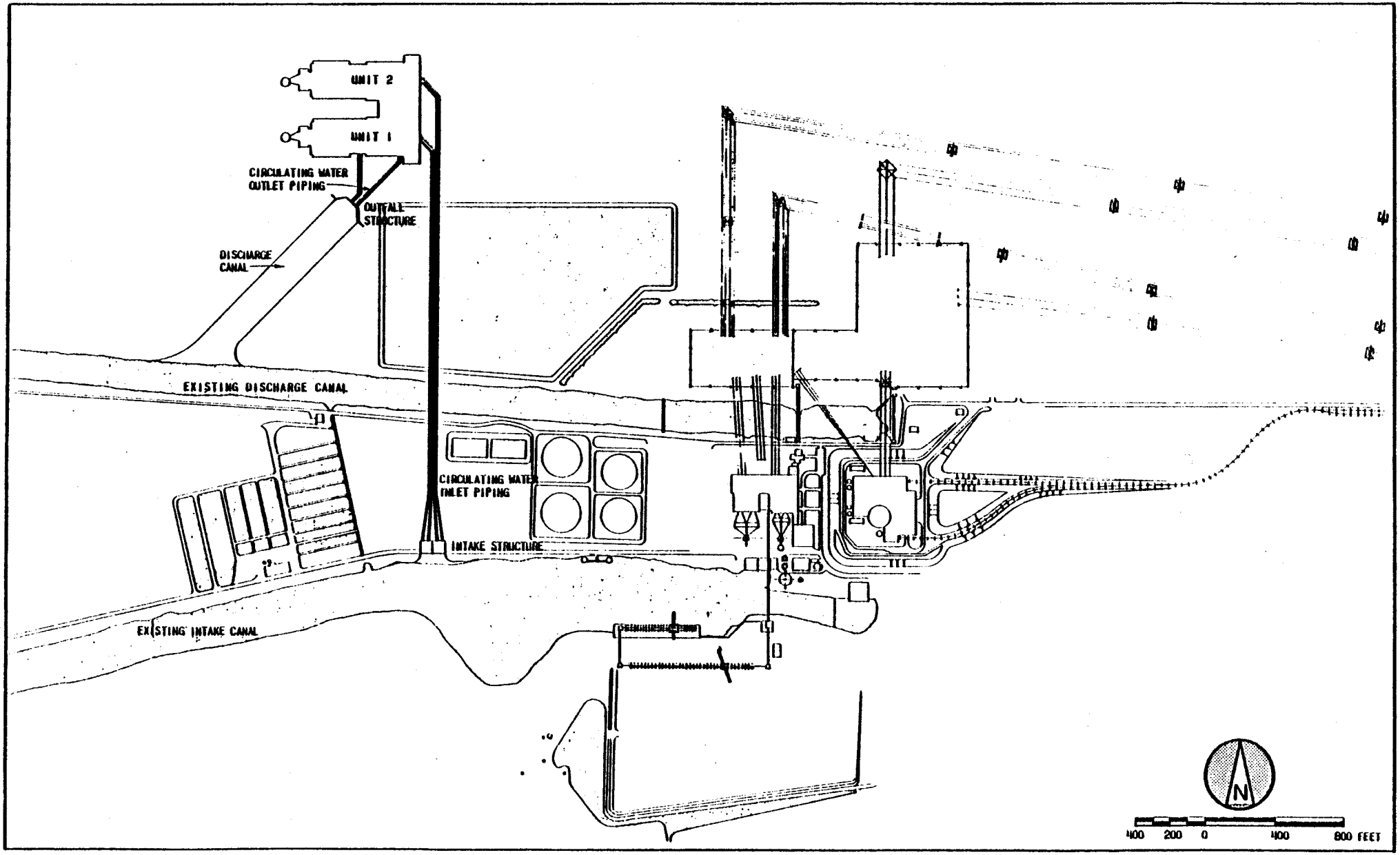
Inlet and Discharge Canals--The layout for Site 1 location is shown in Figure 3-3 (Black and Veatch, 1976). An intake canal depth of 18 feet below mean low water is required to maintain a flow velocity of 1.6 feet per second. This will be accomplished after deepening the existing canal for deeper draft.

The existing discharge canal would have to be dredged an additional 5 feet to a depth of 15 feet below mean low water level. Dredging would start at the point of discharge of Site 4 circulating water and proceed westward at approximately 4,200 feet. In addition, a spur to the existing canal would be extended northeast approximately 1,250 feet,



PREDICTED TEMPERATURE INCREMENT ABOVE AMBIENT IN THE DISCHARGE AREA, FULL TIDAL CYCLE ALL 5 UNITS AT 100% POWER

FIGURE 3-4



ONCE THROUGH COOLING
SITE I

FIGURE 3-3

terminating at the site outfall structure. The discharge canal velocity would be 2.5 feet per second at ebb tide with all units in operation.

Intake Structure--The intake structure would be located flush with the north bank of the existing intake canal.

Circulating Water Piping--Units 4 and 5 will require 3,000 feet and 3,600 feet of 108-inch fiberglass reinforced pipe, respectively.

9.2.4.9 SITE 2 LOCATION

The once-through cooling system for Site 2, is identical in concept to the once-through system at existing units 1, 2, and 3. Those features which are unique to Site 2 and differ significantly from Site 1 are as follows:

Intake and Discharge Canal--The point at which the heated circulating water enters the discharge canal is about 800 feet east of the Site 1. Therefore, an additional 800 feet of dredging for a total of 5,000 feet would be required. The intake canal will require dredging to 18 feet below mean low water.

Circulating Water Piping--The circulating water piping to and from the unit condenser would consist of two 108-inch fiberglass reinforced plastic pipes. Each pipe would be approximately 1,200 feet in length.

9.2.4.10 SITE 3 LOCATION

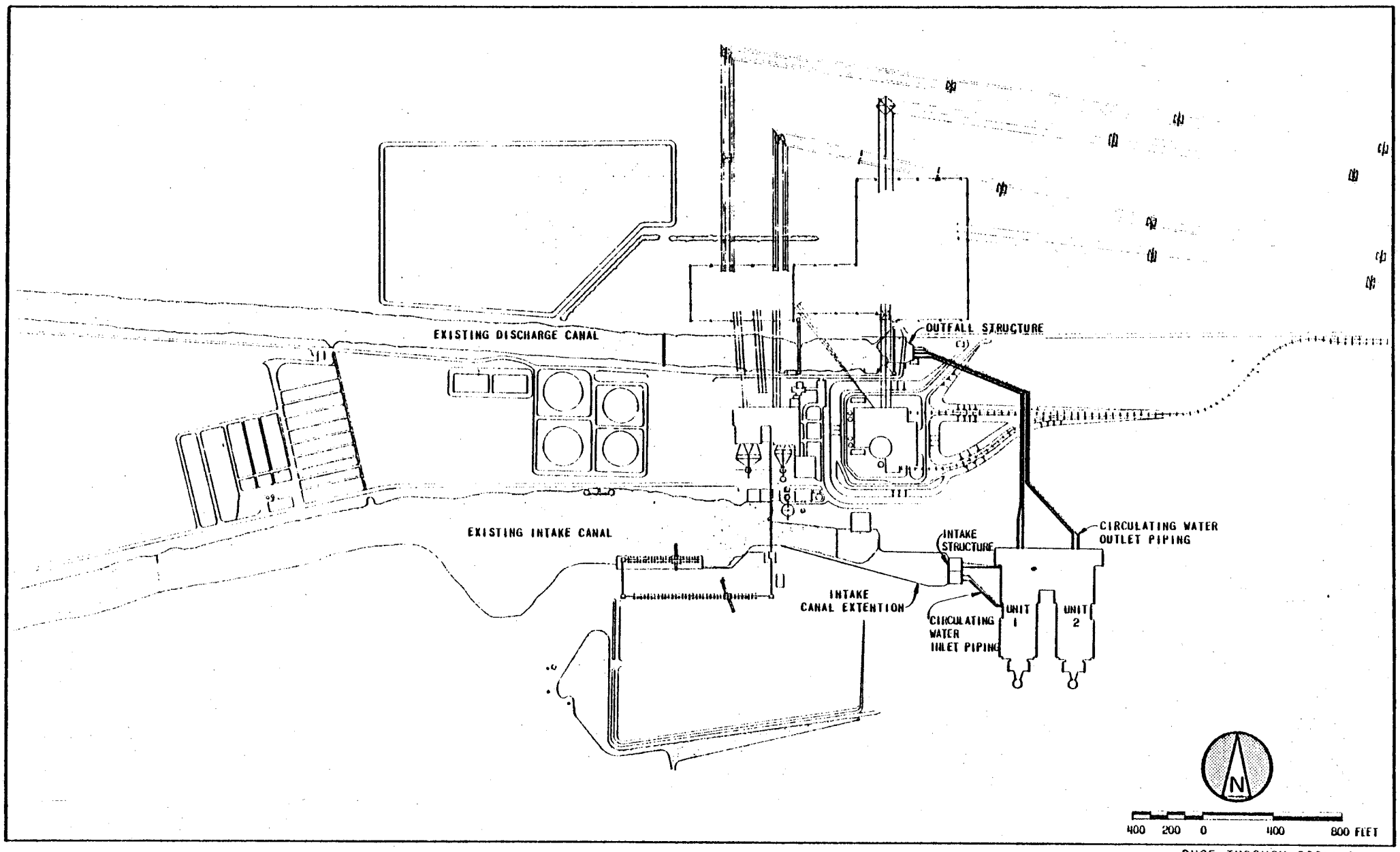
The once-through cooling system for Site 3, as shown in Black and Veatch Figure 7-1 (1976), is identical in concept to the once-through system at Site 1. Those features which are unique to Site 3 and differ significantly from Site 1 are as follows:

Discharge Canal--The point at which the heated circulating water enters the discharge canal is at the extreme east end of the existing discharge canal. This will necessitate dredging the entire discharge canal to 15 feet below mean low water level, which would result in an increase in dredging of 3,200 feet compared to Site 1. The total dredging required will be 7,400 feet.

Circulating Water Piping--The circulating water piping to and from the unit condensers would consist of two 108-inch fiberglass reinforced plastic pipes. Each pipe would be approximately 2,000 feet in length for Unit 1 and 2,800 feet in length for Unit 2.

9.2.4.11 ENVIRONMENTAL EVALUATION OF ONCE-THROUGH COOLING SYSTEM ALTERNATIVES

The once-through cooling system presently proposed for Crystal River Units 4 and 5 would use the existing intake and discharge canals with some modifications. Dredging would be necessary to deepen the intake canal to 18 feet and discharge canal to 15 feet to accommodate coal barges and to provide the volumes of water needed for once-through



ONCE THROUGH COOLING
SITE 3

FIGURE 7-1

cooling design. Velocities in both the intake and discharge canal would be increased.

Studies associated with the existing three units of the proposed site have determined a number of impacts associated with once-through cooling. Generally speaking, the major environmental effects of once-through cooling fall into three groups. These are:

1. Impingement, or the impacts associated with the screens which strain larger organisms from the incoming water;
2. Entrainment, or the impacts associated with passage through the power plant of smaller organisms than those affected by impingement; and
3. Impacts associated with organisms which are exposed to the heated plume from the plant.

Other alterations in the environment include those brought about by changes in existing circulation patterns and biocide treatments. Recent studies indicate that potentially toxic bromates may be produced by a sunlight-induced reaction in chlorinated seawater (Macalady, et al., 1977).

Impingement studies were conducted for Units 1 and 2 by Snedaker (1974) and are presently underway for Unit 3. Screenwash sampling was also conducted by the Florida Department of Natural Resources in 1969. This data is summarized in Grimes (1971). Grimes reported some 59 species of fish and some 15 species of macro-invertebrates were impinged. Among these were pink shrimp, blue crabs, stone crabs, and a number of

commercially or recreationally valuable fish species. These species of economic importance accounted only for about 8 percent of the impinged biomass reported by Snedaker for samples from 1972, 1973, and 1974.

If once-through cooling is employed for Units 4 and 5, total numbers and weights of impinged organisms would undoubtedly increase since both flow rate and water volume used by the power complex would increase under present designs. Increased flow rate may increase the incidence of impingement for some organisms which presently may be able to avoid the screens. Increased volumes may be expected to increase the total number of species impinged.

Entrainment effects are mainly concentrated on those organisms which are small in size and drift with water masses. The consequences of entrainment range from death to decreased growth and reduced reproductive capacity. Maturo, et al., (1974) estimated that between 2,000 and 5,100 pounds per day of biomass were entrained by Units 1 and 2 and that about twice these figures would be entrained by Units 1, 2, and 3 operating together. Assuming that Units 4 and 5 might entrain about as much as Units 1 and 2, the total entrainment for all five units using once-through cooling might be as high as 6,000 to 15,300 pounds per day. All of the individuals are not killed by entrainment however. Mortality varies with species, age, sex, and other factors (Alden, 1976). A study of juvenile fish entrained by units 1 and 2 (FPC, N.D.) provided an estimate that 2.4×10^8 individuals could be entrained in the worst case. Juvenile fish entrained by five units would be about three times

this number. The biomass of the individuals killed or injured by the plant is not lost to the estuarine consumers. The consumer species may change to those more likely to receive sinking, non-moving prey (Alden, 1976). Maturo, et al. (1974) found in statistical analyses of zooplankton populations that increased flow rates were associated with negative effects on planktonic juveniles of fish and macroinvertebrates.

The extent of the thermal plume for Units 1 and 2 has been studied by Palmer and Carder (1975). Others have studied the effects of the plume upon organisms which are under its influence. Van Tine (1974) found that the biomass of algae and seagrasses was higher in the intake estuary than in the discharge estuary during most of the year. On an annual basis the standing crop was about 43 percent higher on the intake side. This study was conducted with Units 1 and 2 in operation. A larger plume resulting from all five units with once-through cooling would increase this area of impact. Re-entrainment of discharge water, as predicted by Black and Veatch (1976), would multiply entrainment mortalities since weakened organisms may pass through again. Re-entrainment would also have the effect of increasing the temperature of the thermal plume. Generally, estuarine organisms are well equipped by evolutionary processes to withstand thermal stress; however, the effects of higher temperatures are related in a complex manner to the length of time of exposure, seasonality, and other environmental factors. An organism may be tolerant to one temperature, if it is not subjected for a long period of time, and be killed if exposed for a longer period.

Dredging operations required by the design for once-through cooling as proposed by Black and Veatch (1976) would also have adverse environmental effects. Communities of bottom dwelling organisms would be covered by spoil disposal. Increased sediments in the water as a result of dredging would be dispersed to settle on other communities despite efforts toward containment.

Odum, et al. (1975) examined the system of power plants and the estuary at Crystal River from a systems standpoint. Energy cost benefit analyses by this group indicated that when all energies contributed by man and nature are considered, energy flow associated with once-through cooling are about 1 percent of those required for cooling towers. Units 1, 2, and 3 were considered in that group of studies.

Stated simply, Odum's conclusions are based on the fact that resources must be mined and processed elsewhere to produce cooling towers. These activities consume energy and produce various types of pollution elsewhere. When the entire process is considered, the total pollution produced versus the benefits derived were thought to be less beneficial to the system when cooling towers are used.

While the conclusions reached in that study may indeed be scientifically valid, our present societal structure does not choose to make decisions regarding environmental impacts in that manner. Even if impacts of Units 4 and 5 with once-through cooling were no more than those associated

with Units 1, 2, and 3, present state and federal legal structure may forbid use of once-through cooling for the new units.

9.2.4.12 MITIGATION OF IMPACTS

The impacts of once-through cooling do not appear to be easily reduced since these impacts are connected with the huge volume of flow required. The Gulf of Mexico is the only body of water in the vicinity of the site large enough to be used either as a source or a receiving body. Taking water from the Withlacoochee Reach of the Cross Florida Barge Canal has been suggested. It is not clear without detailed studies by what degree impingement and entrainment could be reduced under this plan. The destiny of the body of water is uncertain as a part of the decision regarding disposition of the Barge Canal. It is not known whether the modifications thus far suggested will even be implemented in the Withlacoochee Reach or if they would be completed in time to meet the needs of the applicant.

Modifications could be undertaken to decrease the impact of once-through cooling when the intake structure is considered. Statistical studies of impingement at FPC Anclote Unit 1 have shown that the dilution pumps at that site may be helpful in reducing impingement. Dilution pumps are nothing more than large pumps which are rather gentle in water movement. These allow a bypass of the condenser cooling cycle for intake water and associated organisms. Anclote Unit 1 also has a bypass system which allows organisms washed from the intake screens to be routed in a

concrete channel over to the discharge side. It is not clear how helpful this bypass is in saving impinged organisms.

Systems which somehow divert organisms away from the screens by noise, bubblers, etc. have not proven very effective (EPA, 1976). Sloped or horizontal screens with some bypass system to reduce impingement could be used. It does not seem economically feasible to reduce intake velocities to the recommended 0.5 feet per second (15 centimeters per second) for the volume of water required.

With the present system proposed by Black and Veatch (1976), the five units in operation on the same intake canal may increase total impingement over what it would be, were the units geographically separate. Fish and macroinvertebrates tired or injured by the intakes at Units 4 and 5 could be more easily impinged by the other three units.

A number of suggestions have been advanced to alter the present configuration of the canals. These all revolve around drawing water further offshore or discharging water further from shore. These measures will not necessarily lessen impacts since other populations would be affected. These populations would require study before any conclusions about relative impacts could be reached.

Many estuarine organisms found inshore are more tolerant to thermal stress than closely related offshore species. The offshore species may, in fact, be more heavily impacted by entrainment (Hearne, 1977).

Furthermore, inshore systems have already adjusted to the stress, and changing the placement of the plume would require a new adjustment process.

Considering all factors, once-through cooling for Crystal River Units 4 and 5 would not appear to be the best available technology. It is highly unlikely that Units 4 and 5 would be licensed to operate by the regulatory agencies. The status of Units 1, 2, and 3 is still undetermined. The Southwest Florida Water Management District has suggested that the once-through cooling system for power plants could be combined with a desalinization process (SWFMD, 1977). This would allow power plants to produce fresh water instead of consuming it.

9.2.5 NATURAL DRAFT COOLING TOWER SYSTEM

9.2.5.1 GENERAL DESCRIPTION OF A NATURAL DRAFT COOLING TOWER SYSTEM

The major components of a natural draft cooling tower system include the turbine generator, the condenser, the natural draft cooling tower, sources of intake water, intake structure, circulatory water piping, and an auxiliary cooling system. Costs of a natural draft system with salt-water or freshwater make up were developed for analysis of alternative cooling systems. The information presented is for one unit unless otherwise noted.

Turbine Generator and Condenser

A study was performed to determine the optimum condenser size by using a salt water make up system. The results, based upon current project economic criteria, determined that the optimum condenser is a two pass arrangement with a surface area of approximately 400,000 square feet. With this alternative, the temperature rise would be 22°F and the pressure would be 3.54 inches Hg absolute under peak loading conditions. A 90-10 copper-nickel tubing is expected to perform satisfactorily with salt water at 1.3 cycles of concentration (approximately 50,000 ppm salt) or fresh water at 6 cycles of concentration. The circulatory water flow rate would be approximately 304,000 gpm (438 mgd).

Circulating Water, Make-up, and Blowdown Piping

The circulating water flow rate for the natural draft cooling tower heat dissipation system would be 304,000 gpm (438 mgd) requiring one

supply pipe and one return pipe, each consisting of a 108-inch fiberglass reinforced plastic pipe. Each pipe would be placed in a trench at a depth of 3 to 5 feet below grade.

The cooling tower makeup piping for salt water would be approximately 48 inches in diameter to transport 25,000 gpm (36 mgd) from a new intake structure on the existing intake canal to the cooling tower basin. A new conveyor bridge would be designed to support the makeup piping in order to permit the piping to cross the existing discharge canal. The blowdown piping would be approximately 54 inches in diameter and would transport 20,000 gpm (29 mgd) from the tower basin to the discharge canal. The cooling tower makeup system for fresh water is discussed in Section 9.3.2, Freshwater Alternatives.

Auxiliary Cooling Systems

Auxiliary once-through cooling system would supplement the salt water cooling tower alternative. Saltwater would also be supplied to the auxiliary cooling system heat exchangers via the new station intake system. The estimated flow will be 20,000 gpm (29 mgd). The auxiliary cooling water would be discharged into the existing discharge canal. For the freshwater tower, the auxiliary cooling water system would be a part of the closed cycle freshwater cooling system.

Water Supply Requirements

The natural draft cooling tower heat dissipation system would require about 25,000 gpm (36 mdg) of saltwater makeup per unit to replace water

lost in the system due to evaporation and blowdown. In addition, approximately 20,000 gpm (29 mgd) of salt water would be required for each unit auxiliary cooling system resulting in a station makeup requirement of 45,000 gpm (65 mgd) for a saltwater tower. The cooling tower blowdown and auxiliary cooling water would be returned to the discharge canal. Therefore, the flow rate through the existing intake canal would increase by about 90,000 gpm (130 mgd) with both of the new plants in operation. The freshwater towers would require approximately 13,700 gpm (19.7 mgd) for makeup and auxiliary cooling for both units.

Cooling Tower Design

One natural draft cooling tower per unit would be used. The tower would be designed to dissipate 3300 x 10^6 Btu per hour with a range of 22°F, assuming 79°F wet bulb and an approach of 15°F. Under the above design conditions, the water which is supplied to the unit condensers would be 94°F. The cooling tower would be approximately 400 feet high and 325 feet in diameter at the base.

A wet, natural draft cooling tower incorporates direct contact between the cooling medium (air) and the circulating water. Heat is transferred primarily through evaporation of the circulating water. The draft through a natural-draft tower depends upon three parameters: (1) the density difference between the warm moist air in the tower and the ambient; (2) the pressure difference due to the chimney height; and (3) the induced draft due to the wind velocity. Two types of flow, crossflow and counterflow, are utilized in natural-draft towers. A

crossflow tower incorporates a horizontal air flow through the fill and the falling water, while the counterflow tower incorporates a vertical air flow through the fill. The saltwater system would be operated at a maximum of 1.3 cycles of concentration while the freshwater system would be operated at about 6 cycles of concentration. Water treatment measures for the control of corrosion, scale and biological fouling have not been specified at this time. The basic components of natural draft cooling towers are as follows:

1. Tower frame or hyperbolic turret;
2. Water distribution system;
3. Fill or packing material;
4. Drift eliminators;
5. Inlet louvers; and
6. A water collecting basin.

Tower Framework

The structural design of the tower framework is based upon aerodynamic, thermal, and economical considerations. It is designed to support the weight of the internal components in the cooling tower as well as the weight of the circulating water. The framework also must be strong enough to withstand high wind and seismic loads. The structural framework of the natural-draft cooling tower is a hyperboloid shell made of reinforced concrete. A hyperboloid shape is necessary to support the stress with minimum structure and for aerodynamic considerations. Minimum heights are approximately 75 m; however, large towers reach heights of about 160 m with base diameters of 120 m.

Water Distribution System

The function of this system is to provide a uniform distribution of the heated water above the fill or packing material. The water distribution pipes are made of either treated redwood, cast iron, carbon steel, PVC, fiberglass, or asbestos cement. When the cement is used, the pipes are lined internally with an epoxy for erosion protection. Spray nozzles are made of plastic.

Fill or Packing Material

The function of the fill material is to disperse the water into many small droplets or filaments to increase the air-water interfacial area and the contact time. The "water breaking" process is essential in removing heat from the water. Two types of fill, film and splash, are in common use. The film fill breaks the water into thin filaments. The splash type fill produces many small droplets. The fill can be made of materials such as redwood, fir, asbestos cement, and various types of plastic compounds.

Drift Eliminators

Located above the fill are drift eliminators. They serve as a baffle that causes a sudden change in the direction of the air stream and thereby reduces the quantity of water droplets lost into the atmosphere. Water droplets are heavier than the air and experience a centrifugal force due to the change in the flow direction. They are separated from the air stream and move toward the drift eliminator

surface. The water droplets, which are impacted on the drift eliminators, are drained back into the tower basin through the fill. The baffle action along with the pressure drop through the drift eliminators provide a uniform flow through the fill. Drift eliminators of asbestos cement and plastic, which have sine wave and convoluted shapes, respectively, have been used in recent years and are regarded as very efficient in reducing drift losses. Materials used for drift eliminators are typically redwood, treated fir, asbestos cement and various types of plastics.

Inlet Louvers

The function of inlet louvers is to provide a uniform air flow into the tower. To prevent water losses, they are designed for proper slope, spacing, and width. Construction materials are generally either treated redwood, asbestos cement, or plastics.

Water Collecting Basin

The cooled water, which falls through the fill, is collected at the bottom of the cooling tower in a basin. From the basin it is pumped back to the condenser system or discharged via the blowdown system.

Cooling Tower Blowdown

Approximately 20,000 gpm (29 mgd) of blowdown will be discharged from each unit. The salinity of the discharge at the expected maximum of 1.3 cycles of concentraton will be approximately 50,000 mg/l.

Advantages/Disadvantages

Presented as Table 9.2.5-1 are the advantages and disadvantages of natural draft cooling towers.

9.2.5.2 COMPARISON OF FRESHWATER VERSUS SALTWATER COOLING SYSTEMS

As previously discussed, the design and performance analyses of cooling systems are based upon thermodynamic principles and atmospheric conditions. The same major components are required for freshwater and saltwater systems. In the case of saltwater cooling systems, it is necessary to consider the incremental effects of salt concentration upon the design and performance characteristics. The major influences of salt water on the performance of cooling towers are as follows:

1. A reduction in evaporative heat loss due to the fact that vapor pressure of saltwater is lower than freshwater;
2. Lower heat transfer in the condenser due to the lower specific heat, lower thermal conductivity, higher viscosity, and higher density of saltwater than freshwater; and
3. Increased corrosion.

The design specifications for any saltwater system must be modified to maintain performance and counteract corrosion. There are several design strategies for developing a satisfactory design for salt water cooling towers. However, the net result is that there is an increment in the capital and operating costs of salt water towers relative to those of freshwater towers. The specific problems that the design engineer must

Table 9.2.5-1. Advantages/Disadvantages of Natural Draft Cooling Towers

Advantages	Disadvantages
1. Produce cooling effects similar to those provided by mechanical draft towers without the mechanical parts and the power required to run them.	1. Resistance of fill and drift eliminators to air flow must be kept at a minimum.
2. Negligible maintenance costs.	2. Substantial height is necessary to produce the draft.
3. Low probability of failure.	3. Inlet hot water temperature must be hotter than the air dry bulb temperature.
4. Independent of wind velocity.	4. Control of outlet water temperature is difficult.
5. Can be utilized with trememdous water circulation rates.	
6. Use comparatively small ground areas compared to other methods of cooling.	
7. No loss of efficiency, since the stream of air is in the opposite direction to that of the falling water with the coldest air meeting the colder water first.	

overcome in developing a saltwater cooling system are discussed in the following paragraphs.

Make-up Water Requirements

A saltwater system would operate at a maximum of 1.3 cycles of concentration and would require 25,000 gpm (36 mgd) per unit saltwater makeup. A freshwater system operating under the same thermal load requirements would operate at much greater cycles of concentration and would require only 6,944 gpm (10 mgd) of make-up water per unit.

Blowdown Volume and Quality

The volume of blowdown water from a saltwater cooling tower will be 3 to 4 times as great as from a freshwater cooling tower. The salinity of saltwater blowdown would be approximately 50,000 mg/l. Total dissolved solids in the blowdown of a freshwater tower would be an order of magnitude less. The mass discharges of free residual chlorine, corrosion inhibitors, biocides, and scale control chemicals from a saltwater system would be significantly larger than from a freshwater system.

9.2.5.3 WATER TREATMENT NEEDS FOR SALTWATER VERSUS FRESHWATER SYSTEMS

Scale Treatment

Calcium, magnesium, and silica dissolved in cooling water are responsible for the formation of scale on heat transfer surfaces. The primary cause of scale formation is the fact that the solubility of the scale-forming salts ($CaCO_3$, $MgCO_3 \cdot 3H_2O$, $Mg(OH)_2$, and $CaSO_4$) decreases

with an increase in temperature. On the other hand, the solubility of these salts is increased by the presence of other ions in solution (this is the "salt effect").

Sulfuric acid treatment is a common practice to prevent scale formation in freshwater cooling systems. However, the "salt effect" in salt water systems may make acid treatment unnecessary. The decision whether or not to use acid treatment must be made on an individual basis once operating characteristics are developed.

Corrosion Treatment

Corrosion treatment is very critical to the long-term operation of a cooling system. Freshwater cooling systems are generally protected with non-chromate inhibitors in a wide variety of proprietary formulations. The high chloride concentrations in saltwater systems accelerate corrosion and inhibit the formation of protective coatings by chemical inhibitors. Corrosion treatment for saltwater systems is much more complicated and expensive than for freshwater systems. The potential for discharge of concentrations of environmentally undesirable chemicals is also higher in a saltwater system.

Fouling Treatment

Fouling is the deposition of suspended material from the recirculating water. Fouling leads to reduced heat transfer, increased resistance to water flow, and severe localized corrosion. The sources of fouling are: (1) silt and other suspended materials in the makeup waters;

(2) airborne particulate matter deposited into the tower via the incoming air; (3) leakages and spills from the operating plant; (4) suspended materials resulting from deterioration of the cooling tower timber; and (5) biological growths. Biological fouling, the most serious fouling problem, will be discussed in a later subsection.

When estuarine water is used, the amount of suspended materials is often high, causing increased fouling problems especially in the basin where the flow rate is low. Screening of entraining waters may not be sufficient to control fouling, and chemical treatment may be necessary. Airborne particulate matter may include a variety of materials, depending upon the location, and industrial and agricultural activities in the vicinity of the tower. Since these particles cannot be controlled externally, chemical treatment of the water is necessary. If wood is used, fouling due to deterioration should be controlled by chemical treatment.

If ground waters are used for freshwater makeup, fouling should be minimal due to the expected low concentrations of suspended organic material. Studies are being initiated to determine the suspended solids characteristics of potential surface water sources.

Biological Fouling

Sunlight, increases in temperature, concentration of bacteria food and airborne contaminants in a cooling tower environment result in the growth of algae, fungi, and bacteria. Algae will primarily be limited

to those areas of the cooling tower exposed to sunlight. Slime is composed of bacteria, fungi, yeast and in some cases protozoa. It is found in the darker areas since the slime constituents do not synthesize their own food (like algae), but get it from the cooling waters. Slime deposits can retard heat transfer and cause serious pitting on metal surfaces. Anaerobic bacteria that feed on wood can cause serious wood deterioration problems.

Seawater fouling organisms are generally larger than those in fresh water. Some of these organisms are sea-weeds, sea-acorns, mussels and other testaceans. These marine organisms can reach sizes big enough to cause blockage of pumps, cooling water channels and pipes.

A variety of inorganic chemicals, such as chlorine and bromine, and a wide range of organic compounds are employed to control biological growth in the recirculating cooling water. These biocides are supposed to kill or inhibit the growth of these undesirable organisms. Many of these compounds kill bacteria at high concentrations and inhibit their growth in lower concentrations, but stimulate their growth in extremely dilute concentrations. Proper concentrations of chlorinated phenols, acrolins and quaternary ammonium compounds are efficient biocides, but chlorine is the most widely used because it is usually the most economical method of treatment. Chlorine concentrations should be kept below 0.5 ppm to prevent cooling tower wood deterioration, and also to prevent adverse environmental effects on aquatic life at the discharge. In case chlorination in low concentrations is unsuccessful in reducing

or eliminating bacteriological fouling, a combination of chlorination and other biocide treatment can be employed.

Chlorination can be applied constantly in low concentrations or intermittently in higher concentrations (shock treatment). A continuous low degree of chlorination of 0.1 ppm is preferred to an intermittent supply of several ppm. By using the latter procedure, organisms such as mussels and barnacles, which can close themselves when conditions in the water are not good and open up when conditions improve (chlorine concentration drops), might cause clogging problems. Where wood materials are being used in cooling towers, shock treatment is recommended to preserve the wood.

Salinity in high concentrations has been proven to be quite toxic to marine organisms. The high salinity in the basin may serve as a biocide to some marine organisms. Mussels and barnacles will probably only close themselves, and some micro-organisms may tolerate these salt concentrations, but for other organisms these concentrations may be detrimental.

The potential for biological fouling appears to be equally severe for saltwater and surface freshwater cooling systems due to the presence of a fresh water clam (Corbicula). Intensive biocide treatment would be required to control either freshwater or saltwater biota.

Turbine Generator--Condenser Design

The fact that specific heat and thermal conductivity decrease with increasing salinity, whereas viscosity increases with salinity means that condensers must be larger and circulating water flows greater in order to maintain a given heat removal rate when saltwater rather than freshwater is used. The cooling tower and pump capacity must be increased in size to accommodate the larger flow rates. Pump horsepower must be increased to circulate larger volumes of denser, more viscous saltwater. Construction materials must be selected which are resistant to corrosive attack.

Cooling Tower Design

The fact that the vapor pressure of water decreases as salinity increases requires that saltwater cooling towers have either a larger tower volume, or increased air flow rate, or both than freshwater towers of the same water flow rate and inlet and outlet temperatures. Air flow rate is generally increased to attain equivalent performance.

Natural draft towers in the United States have used freshwater almost exclusively. At present, there are two large saltwater natural draft towers in this country. These towers have accumulated about five unit-years of operation time. This operating experience is not sufficient to assess over the life of the facility the amount of corrosion which will occur. Consequently, there is a greater risk to overall plant reliability for saltwater cooling towers. The Applicant's position statement on saltwater cooling towers is presented in Section 8.4.4.

9.2.5.4 ALTERNATIVE SITE LOCATIONS

Conceptual studies were conducted in 1976 to assess alternative locations for expanding generation facilities at the Crystal River site.

SITE 1

The natural draft cooling tower layout for Site 1 is presented in Figure 4-3 (Black and Veatch, 1976).

SITE 2

The natural draft cooling tower arrangement for Site 2 is presented in Figure 6-1 (Black and Veatch, 1976). The towers would be located approximately 400 feet west of the central plant complex. Each circulating water pipe to and from the condensers would be approximately 1,200 feet in length.

SITE 3

The natural draft cooling tower arrangement for Site 3 is presented in Figure 8-1 (Black and Veatch, 1976). The towers would be located approximately 400 feet north of the central plant complex. Each circulating water pipe to and from the unit condensers will be approximately 1,200 feet in length.

9.2.5.5 ENVIRONMENTAL CONSIDERATIONS

In general the effects of cooling towers on the environment include the following factors:

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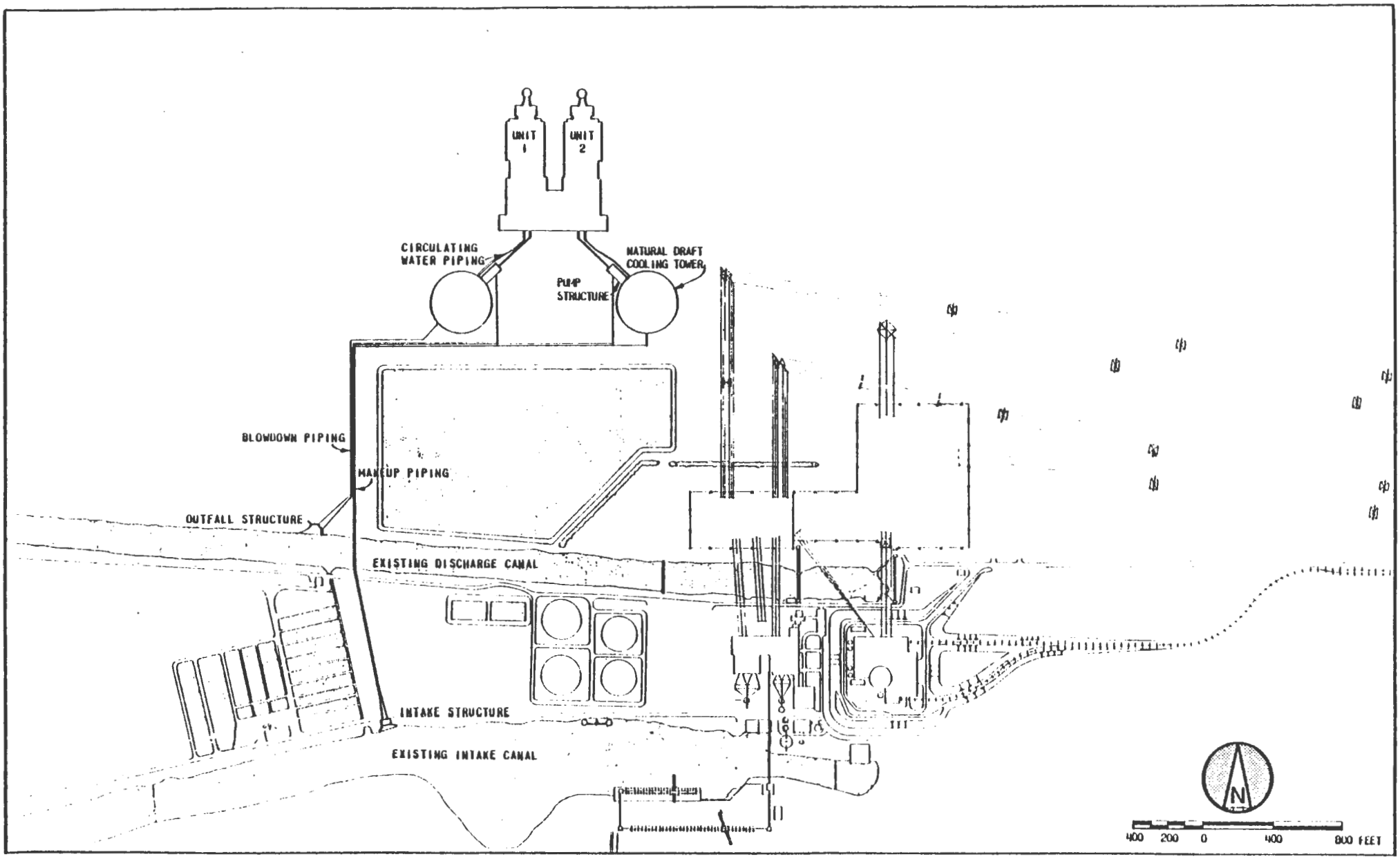
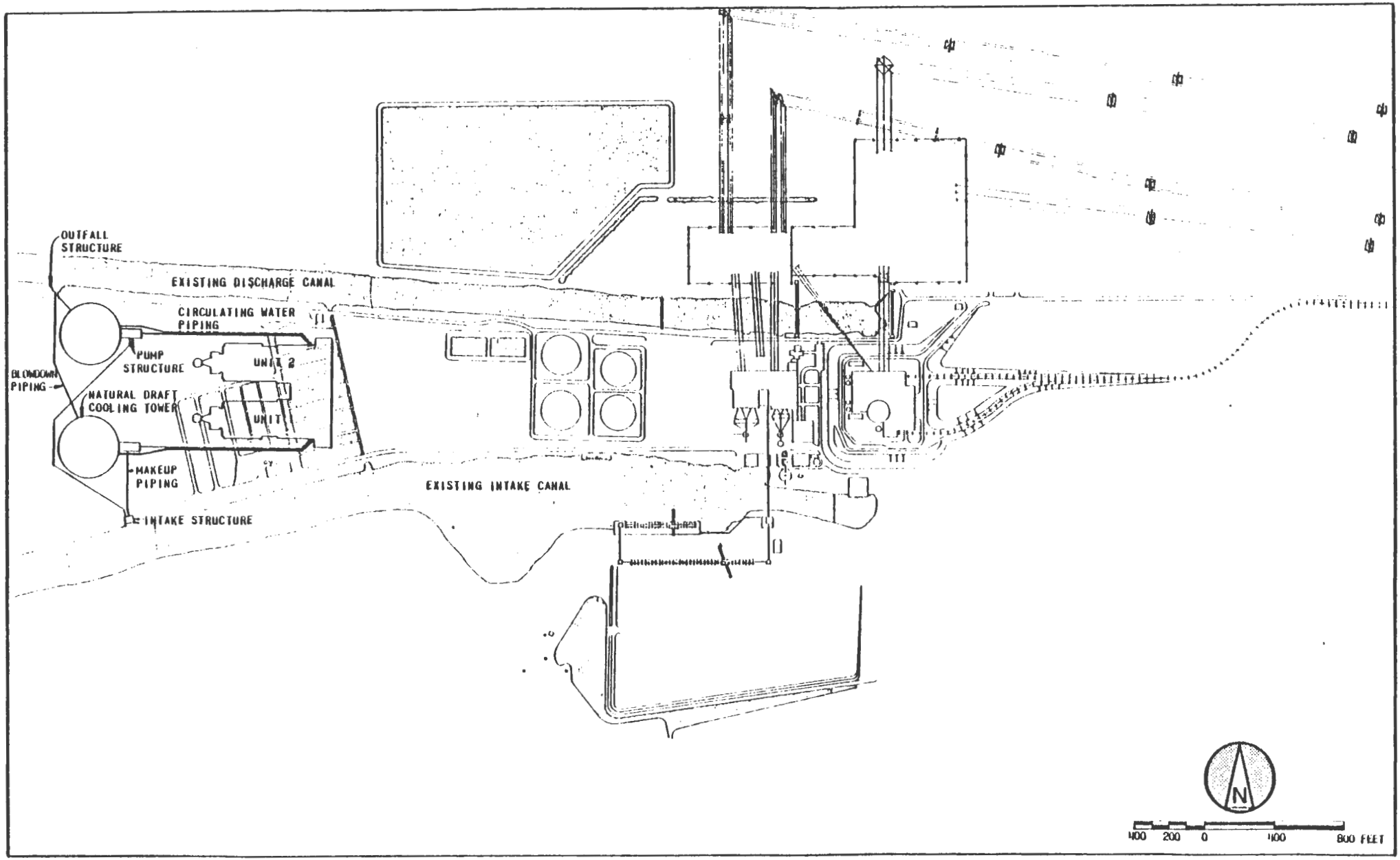


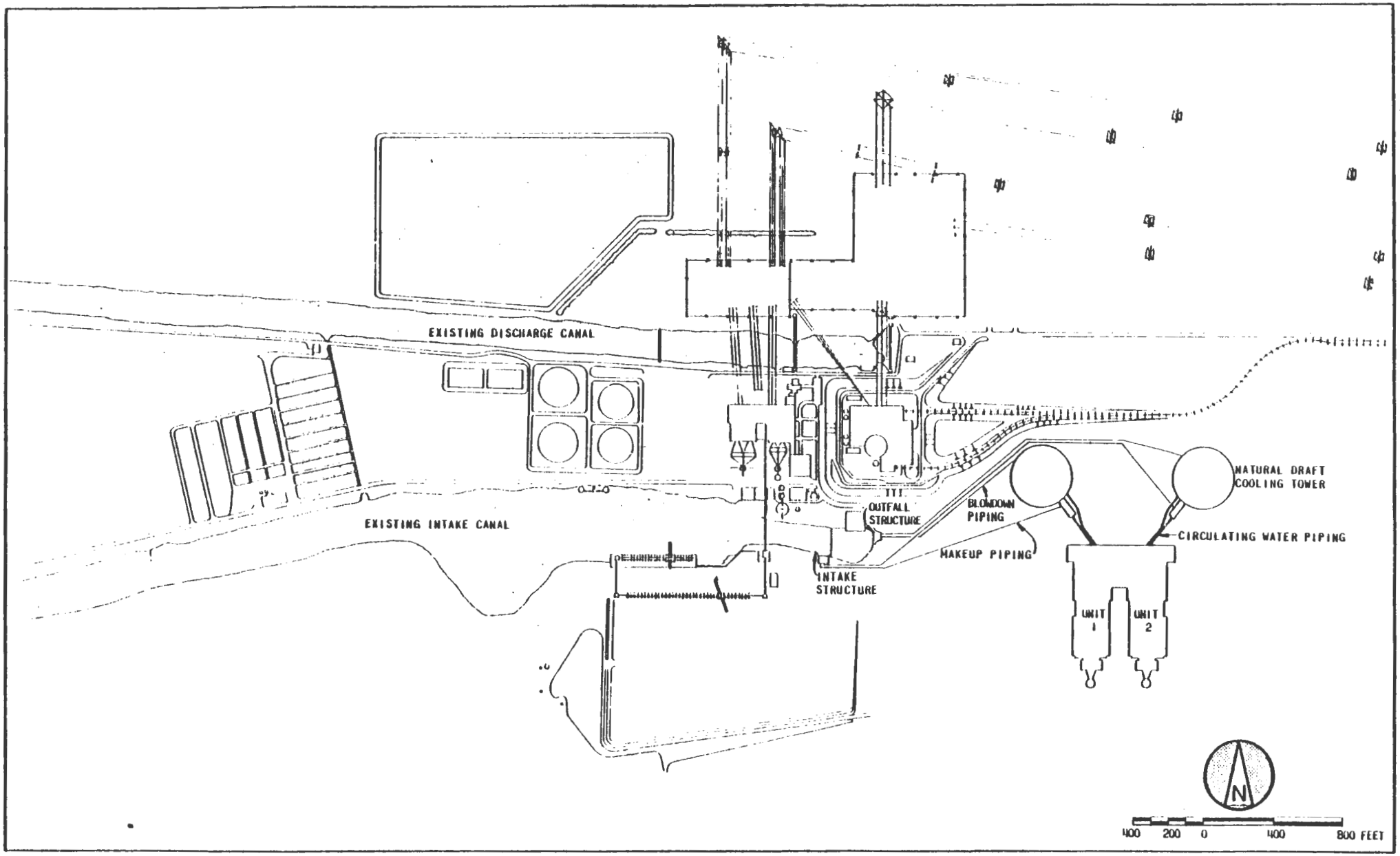
NATURAL DRAFT COOLING TOWERS
SITE I

FIGURE 4-3



NATURAL DRAFT COOLING TOWERS
SITE 2

FIGURE 6-1



NATURAL DRAFT COOLING TOWERS
SITE 3

FIGURE B-1

1. Fogging;
2. Icing caused by cold weather fogging;
3. Deposition of chemically laden drift particles, especially when salt water makeup water is used;
4. Consumptive use of water;
5. Climate modification due to the atmospheric discharge of heat and water vapor;
6. Effects on receiving water as a result of blowdown discharge;
7. Acid rainout due to mingling of cooling towers and stack gas plumes.

These factors are those summarized recently by EPA researchers (Shirazi, et al., 1977). To these factor 8 (noise) also may be added.

Factor 6 will be discussed in a later section which deals with the discharge of cooling water for the proposed site (Section 9.4.3). Factor 2 is not a realistic concern for the climate of the Crystal River area. Factor 4 is discussed in the later Section 9.3.2.

Fogging problems were found to be related to climatic conditions which are conducive to natural fog formation. Shirazi, et al. (1977), reported the work of EG&G, Inc., 1971, which related the potential for fogging and climate modifications in the United States.

The proposed site is in an area which has a low potential for fogging and climatic modifications based on a number of meteorological criteria.

This conclusion is based on typical cooling tower designs and is general in nature, but does assign a low probability of such problems to the area of Florida near the proposed site.

Acid rainout (factor 7) is not considered to be likely at the proposed site if cooling towers are used. The plant stacks are planned to be much higher than the air exits for either mechanical or natural draft towers. Since low sulfur coals are planned as fuel and scrubbers will probably not be used, the gases leaving the stacks will be about 270°F. The spatial differences in discharge points, temperature and velocity differences, and the meteorology of the site suggest that acid rains are not likely. This aspect will be covered in more detail in Chapter 5 of this document.

Noise from cooling towers can be a problem in some areas. Several methods for the estimation of sound emissions can be found in Teplitzky (1977). Since the nearest residences are more than 2 miles from the proposed site, it does not appear likely that noise will be an important impact for either natural or mechanical draft towers (see Section 2.2.3 for nearby residences).

Salt or brackish water from the Gulf of Mexico or Crystal River would bring forth some concerns connected with deposition of salt on the surrounding area (factor 3).

Salt Drift

There are two plants presently in operation in the United States which use natural draft towers with brackish water as makeup. The B.L. England Unit 3 of Atlantic City Electric Company, a 160 megawatt plant in New Jersey; and Chalk Point of Potomac Electric Power Company, a 1,260 megawatt facility in Maryland both use hyperbolic natural draft cooling towers (Kaplan, 1977). The Chalk Point towers take in saltwater as high as 13 parts per thousand (Pell, 1975) and the B.L. England towers use water with a salt concentration as high as 22 parts per thousand (Kaplan, 1977). Measurements of drift for these towers has found that a lower ratio of drift to circulating water volumes has been produced than guaranteed by the manufacturers (Monjoie and Sobel, 1976; Kaplan, 1977). Monjoie and Sobel reported a measured drift rate of about .0005 percent for the B.L. England plant. EPA researchers working with test facilities at Turkey Point found no increase in background salt concentrations by a statistically significant amount at any sampling station (Shirazi, et al., 1977).

Salt drift effects have not been a source of concern for state and federal agencies involved with the present generating stations which use saltwater cooling and natural draft towers (Kaplan, 1977).

The ecological effects of salt drift are not well known. Literature exists mainly for salt effects on vegetation in zones where salt spray

is high naturally (Boyce, 1954; Oostiry, 1942) and for effects of salt on agricultural crops (Mulchi and Armbruster, 1975).

At Crystal River the only commercial plants nearby are pines in plantations. Moser (1975) subjected white pines and Japanese black pines to salt drift for 48 hours. White pine showed detrimental effects after two months of growth. Salt exposure for this experiment was much higher than the projected salt drift from cooling towers operating at the proposed site. Extrapolating from Black and Veatch (1977) projections, salt drift could be no higher than 20-30 pounds per acre per year. Moser's experiments with pines used salt drifts of at least 200 pounds per acre per year, although the exact amount is somewhat unclear. Edwards, et al. (1975) identified a number of plants which were affected by salt spray. Many of these occur near the proposed site. Unfortunately figures are not available for the salt tolerance of naturally occurring plants at the site. Studies would need to be conducted at the site similar to those of Devine (1975) to determine more precisely the effects of salt drift at Crystal River. If freshwater towers are used, this effect would be eliminated.

9.2.6 MECHANICAL DRAFT COOLING TOWER

9.2.6.1 GENERAL DESCRIPTION OF A MECHANICAL DRAFT COOLING TOWER SYSTEM

A detailed optimization study utilizing round mechanical draft crossflow cooling towers as the station's heat dissipator was performed as described for the natural draft tower system. The results show the optimum to be close to the natural draft selection. Hence, for purposes of this study, it is assumed that the condenser size, circulating water flow rate, and tower approach will be as described for the natural draft selection. The only difference would be the tower design and circulating water piping. The major components of freshwater and saltwater mechanical draft cooling towers are essentially the same.

Cooling Tower Design

Two mechanical draft cooling towers per unit would be used. The towers would be designed to dissipate 3,300 x 10^6 Btu per hour per unit with a range of 21°F, 79°F wet bulb, and an approach of 15°F. Under the above conditions the temperature of the water to the condensers would be 94°F. The saltwater tower would operate at 1.3 cycles of concentration with a makeup rate to offset evaporation and blowdown of approximately 25,000 gpm. A freshwater tower would operate with six cycles of concentration and 6,900 gpm makeup per tower. Each tower would be approximately 225 feet in diameter and 60 feet high. Cost estimates for the saltwater and freshwater system have been developed.

The mechanisms (evaporation and convection) whereby heat exchange takes place in a mechanical draft cooling tower are identical to a natural draft tower. The mechanical-draft cooling tower incorporates the use of fans to provide the flow through the cooling tower and to eliminate the need for the great height of the natural-draft towers. The air flow rate is controlled to satisfy the cooling tower design requirements. Present mechanical-draft units are typically 15 to 30 meters (m) high. Future towers will be built to greater heights. The mechanical systems available are forced-draft and induced-draft counter/crossflow types.

Multifan freshwater mechanical draft cooling towers have been used extensively throughout the United States for power plant heat dissipation systems. There are two primary types of mechanical draft tower arrangements; the in-line fan and the clustered fan arrangement.

The in-line fan arrangement is commonly referred to as a conventional cooling tower and has been used in numerous applications. However, the clustered fan arrangement offers distinct advantages over the conventional cooling tower. These advantages are as follows:

1. A consolidated plume which minimizes the effects of fog and drift. This is especially important at Crystal River because the tower will operate with saltwater where drift could become troublesome.
2. Improvement in site arrangement which results in reduction in circulating water piping lengths and system head losses.

3. A more predictable performance because the effects of recirculation are greatly reduced.

The clustered fan arrangement generally is about 20 to 30 percent higher in initial capital cost than in-line arrangement. However, savings in piping length (because the towers can be located closer to the central plant complex and closer together) make the total system cost about equal. Therefore, because of its inherent advantages for the Crystal River site, only the clustered fan arrangement will be considered in this analysis.

The basic components of mechanical draft cooling towers are similar to the previously discussed natural draft towers. Two exceptions are the tower framework and the fans.

Tower Framework

The structural framework of a wood mechanical-draft tower consists of columns, diagonal braces and longitudinal and transverse ties; all are surfaced on four sides and through-bolted at all column intersections. Materials recommended for use are pressure-treated redwood, treated fir, concrete asbestos cement and reinforced fiberglass or Polyvinylchloride (PVC). In the case of wood construction, the wood is treated with acid copper chromate or chromated copper arsenate. The fan deck is made of treated redwood, fir, or plywood panels or PVC. Full transverse or longitudinal partition walls are provided between each cell and are made of pressure-treated plywood, treated fir, treated redwood, PVC, or

asbestos cement. Fan stacks are made of treated plywood, fiberglass transite, or concrete.

Fans

In mechanical-draft cooling towers, a fan provides the desired flow of air through the tower. The fan can be located at the top of the cooling tower above the drift eliminators or at the bottom of the cooling tower. In the former case, the induction principle is applied and the fan pulls air through the fill and the drift eliminators. In the latter case, which usually applies to small towers, the fan pushes air up the tower through the fill and the drift eliminators. Blades are made of fiberglass covered with a polyester resin or aluminum coated with an epoxy or other synthetic resin selected for their corrosion and erosion resistance properties. Blade diameters in large modern European towers attain a maximum length of 26 m.

Freshwater Versus Saltwater Cooling Systems

The discussion of the natural draft cooling tower is also directly applicable to the mechanical draft system.

9.2.6.2 ALTERNATIVE SITE LOCATIONS

Site 1

The mechanical draft cooling towers would be located approximately 400 feet south of the central plant complex.

Site 2

The mechanical draft cooling towers would be located approximately 400 feet west of the central plant complex. The circulating water piping to and from the condensers would consist of a single 108-inch fiberglass reinforced plastic pipe. The supply pipe would be about 1,200 feet long and the return pipe about 1,500 feet.

Site 3

The mechanical draft cooling towers would be located approximately 400 feet north of the central plant complex. The circulating water piping to and from the unit condensers consists of a single 108-inch fiberglass reinforced plastic pipe; the supply is about 500 feet long, the return pipe is about 1,000 feet long.

9.2.6.3 ENVIRONMENTAL CONSIDERATIONS

The differences between natural and mechanical draft cooling towers with regard to environmental impact primarily involve the factors of noise, salt drift, and power consumption.

Noise from a mechanical draft tower should be greater than from a natural draft since fan sounds would be present in the mechanical draft tower. Even so, for the proposed secluded site, it does not seem likely that noise would be of critical concern. Future development around the site during the plant's time of operation could change this (see other sections of this document). This noise is not thought to have adverse

effects on wildlife (Edmonds, et al., 1975), because the noise is steady and is related to sounds of falling water.

Salt drift has not been as well studied for mechanical draft towers in operation. EPA's test facility at Turkey Point is of the mechanical draft type (Shirazi, et al., 1977; Henderson and Dowdell, 1975). Salt deposition was not found to be significant with this nonoperational tower (Hindawi, et al., 1976). Black and Veatch (1976) estimates indicate that salt drift quantities may be higher for the mechanical draft tower than for the natural draft tower.

As is the case with the natural draft cooling tower, use of fresh makeup water would eliminate concerns with salt drift.

Greater power consumption associated with mechanical draft towers would have an environmental impact. If more power is used in the cooling process, this power is lost to human use while contributing to air and water impacts.

9.2.7 POWER SPRAY MODULES WITH DILUTION

9.2.7.1 GENERAL DESCRIPTION

The power spray module with dilution system is different from the systems previously discussed because it does not function as a closed system. The system is basically a once-through system with power spray modules (PSM) positioned in the discharge canal to cool the water before it is discharged into the Gulf. Prior to reaching the point of discharge (POD) sufficient dilution water is added to reduce the discharge temperature in order to meet Florida effluent standards.

Operating Experience

The PSM discussed in this section is manufactured by Ceramic Cooling Tower Company and is in operation at several installations including the Commonwealth Edison Company Quad-Cities Nuclear Station. Thermal performance tests conducted during the summer of 1975 show the system to be operating at 100 percent performance.

Spray module systems similar to the PSM system are also in operation at various installations. However, for purposes of this study, the PSM is considered to be representative of the various systems presently being utilized.

Economic Limitations of Power Spray Modules

It is not economically feasible to provide sufficient cooling with a PSM system alone to meet the State of Florida thermal effluent

standards; i.e., 2°F in the summer and 4°F in the winter. It would require 24,000 feet of canal to accomplish this degree of cooling. The temperature of the discharge water can be reduced to within 6°F of summer ambient with sprays, and dilution water can be added to accomplish another 2°F of cooling. Thus the discharge temperature would be reduced to within 4°F and 8°F of ambient in the summer and winter, respectively. These temperatures exceed the State of Florida effluent standards; however, to achieve any further cooling would require substantial additional investment and operating costs which would make this arrangement so costly that it would not be feasible to consider.

Site 1 Location

Inlet and Discharge Canals

The existing inlet canal will be required to accommodate a dilution flow rate of one million gpm. Therefore, it will be necessary to widen the existing intake canal approximately 75 feet in order to maintain a canal velocity of 1.6 feet per second based on 18 feet of depth. Another approach would be to construct another canal running parallel on the north side of the existing intake canal. This method would produce unpredictable dilution temperatures because of the potential of recirculating heated discharge water. This section will therefore only consider widening of the existing intake for cost analysis. The discharge canal would be required to accommodate the four pass PSM system and therefore, would have to be widened to at least 160 feet and extended 3,400 feet into the Gulf.

Power Spray Modules

In order to reduce the temperature of the effluent from the new units to within 4°F and 8°F of ambient in the summer and winter, respectively, 176 PSM units are required. If the modules are placed four abreast, a channel length of 7,040 feet will be utilized by the spray system (the entire discharge canal length plus an additional 3,400 feet). Each module would have a 75 horsepower electric motor for a total energy requirement of 13,200 horsepower.

Dilution Canal and Pumps

A dilution canal, running north from the existing intake canal to the discharge canal and having dimensions of 125 feet wide, 10 feet deep, and 3,300 feet long would be required. The canal would supply dilution water to three dilution pumps which would be located on the south bank of the discharge canal. Each dilution pump would be rated at 334,000 gpm.

System Design

The PSM system is comprised of a series of self-contained spray modules spanning the width and length of the channel. Each unit consists of a circulating pump and a group of four deflector type spray nozzles spaced 40 feet on centers. The entire unit is supported by a series of floats and moored in place in the channel. Each module operates independently and the module pump requires a 75 horsepower motor drive. The modules are placed side-by-side in the channel. For Crystal River, the modules would be placed four abreast in the channel (four pass).

Site 2 Location

For this site, the sprays will begin about 800 feet further east, and the dilution canal will likewise be placed 800 feet to the east. All other features remain essentially unchanged.

Site 3 Location

Ideally, it would be desirable to start the sprays as far east in the discharge canal as possible. However, in order to prevent the drift from reaching the substation, it would be necessary to begin the sprays 400 feet west of the substation. As a result, the spray system would start 2,200 feet farther east than was possible for Site 1. Hence, a significant amount of dredging will be saved as compared to Site 1.

9.2.7.2 ENVIRONMENTAL CONSIDERATIONS

This cooling system would require additional dredging to accommodate a dilution flow rate of one million gpm (Black and Veatch, 1977). Both the existing intake and discharge canals would require widening under the design outlined by Black and Veatch. Dredging would result in the destruction of some terrestrial habitat, and the resulting turbidity changes and siltation in the open Gulf would have adverse impacts on estuarine organisms already under thermal stress from Units 1, 2, and 3. Salt drift from the PSM system would result in effects similar to either natural or mechanical draft cooling towers. Concentrations of the drift would occur near the discharge canal and would be low.

With the amounts of water necessary, it is not feasible to use fresh water in a PSM system to mitigate any salt drift problems.

9.2.8 ECONOMIC ANALYSIS OF ALTERNATIVE COOLING SYSTEMS

9.2.8.1 COMPARATIVE COSTS

Cost comparisons were developed for saltwater cooling at alternative sites 1, 2, and 3 in 1976. In 1977, as conceptual planning for the facility progressed, freshwater and saltwater cost comparisons were developed for site 1c.

In general, the capital and annual costs of cooling towers and cooling systems increase as the salt content of the water is increased, due to:
(1) larger condenser size, flow rate, and higher material costs;
(2) increased cooling tower size to handle the higher flow rate required to compensate for lower heat transfer efficiency of salt water; and
(3) higher operational costs (Roffman, 1973).

Site 1 Location

Capital Costs

The capital costs for each of the alternative cooling systems are presented in Table 9.2.8-1.

Annual Costs

The annual costs for each of the alternative systems are presented on Table 9.2.8-2. The fuel costs for the natural draft and mechanical draft cooling towers are based on increases of unit heat rates by 21 and 30 Btu/kwh respectively, over the once-through and PSM cooling system. The decrease in plant efficiency is due to the higher circulating water inlet temperatures.

Table 9.2.8-1 Capital Cost Summary*
Alternative Cooling Systems, Site 1 (Per Unit)

Item	Mechanical Draft Tower	Natural Draft Tower	Spray/ Dilution System	Once-Through Cooling
Condenser	$ 4,000	$ 4,000	$ 3,000	$ 3,000
Intake System	936	936	4,000	2,000
Piping System	1,416	1,151	2,173	2,173
Cooling Tower	5,319	7,000	--	--
Pumping System	1,220	1,220	1,564	1,164
Spray System	--	--	3,960	--
Canal Work	--	--	3,862	968
Total Direct Costs	12,891	14,307	18,559	9,305
Differential Costs	3,586	5,002	9,254	Base

*All values presented in thousands of dollars (1977).

Source: Black and Veatch, 1976.

Table 9.2.8-2 Annual Cost Summary*
Alternative Cooling Systems, Site 1 (Per Unit)

Item	Mechanical Draft Tower	Natural Draft Tower	Spray/ Dilution System	Once-Through Cooling
Fuel	$ 470	$ 326	Base	Base
Energy	1,939	1,405	2,142	718
Demand Charges	404	313	444	149
Fixed Charges †	3,616	4,013	5,206	2,610
Total Annual Cost	6,429	6,057	7,792	3,477
Differential Annual Costs	2,952	2,580	4,315	Base

*All values presented in thousands of dollars.
†Fixed charges are based on capital costs that are escalated to 1981 and include indirect costs. These costs are as follows:

Total Direct Costs (from Table 4-1)	12,891	14,307	18,559	9,305
Escalation and Indirect Costs	8,379	9,300	12,063	6,048
Total Capital Costs	21,270	23,607	30,622	15,353

Source: Black and Veatch, 1976.

Site 2 Location

Capital Costs

The capital costs for each of the alternative cooling systems for Site 2 are presented in Table 9.2.8-3.

Annual Costs

The annual costs for each of the alternative cooling systems for Site 2 are presented in Table 9.2.8-4. Decrease in plant efficiency for the cooling tower plans is the same as for Site 1.

Site 3 Location

Capital Costs

The capital costs for each of the alternative cooling systems for Site 3 are presented in Table 9.2.8-5.

Annual Costs

The annual costs for each of the alternative cooling systems for Site 3 are presented on Table 9.2.8-6. The decrease in plant efficiency for the cooling tower plans is the same as for Site 1.

Site 1c Location

Capital Costs

The capital costs for each of the alternative cooling systems for Site 1c are presented in Table 9.2.8-7.

Annual Costs

The annual costs for each of the alternative cooling systems for Site 1c are presented on Table 9.2.8-8.

Table 9.2.8-3 Capital Cost Summary*
Alternative Cooling Systems, Site 2 (Per Unit)

Item	Mechanical Draft Tower	Natural Draft Tower	Spray/ Dilution System	Once-Through Cooling
Condenser	$ 4,000	$ 4,000	$ 3,000	$ 3,000
Intake System	936	936	4,000	2,000
Piping System	1,201	1,006	504	504
Cooling Tower	5,319	7,000	--	--
Pumping System	1,220	1,220	1,564	1,164
Spray System	--	--	3,906	--
Canal Work	--	--	3,463	442
Total Direct Costs	12,676	14,162	16,491	7,110
Differential Costs	5,566	7,052	9,381	Base

*All values presented in thousands of dollars.

Source: Black and Veatch, 1976.

Table 9.2.8-4 Annual Cost Summary*
Alternative Cooling Systems, Site 2 (Per Unit)

Item	Mechanical Draft Tower	Natural Draft Tower	Spray/ Dilution System	Once-Through Cooling
Fuel	$ 470	$ 326	Base	Base
Energy	1,939	1,405	2,142	718
Demand Charges	404	313	444	149
Fixed Charges †	3,556	3,972	4,626	1,994
Total Annual Cost	6,369	6,016	7,212	2,861
Differential Annual Costs	3,508	3,155	4,351	Base

*All values presented in thousands of dollars.
†Fixed charges are based on capital costs that are escalated to 1981 and include indirect costs. These costs are as follows:

Total Direct Costs (from Table 6-1)	12,676	14,162	16,491	7,110
Escalation and Indirect Costs	8,239	9,205	10,719	4,622
Total Capital Costs	20,915	23,367	27,211	11,732

Source: Black and Veatch, 1976.

Table 9.2.8-5 Capital Cost Summary*
Alternative Cooling Systems, Site 3 (Per Unit)

Item	Mechanical Draft Tower	Natural Draft Tower	Spray/ Dilution System	Once-Through Cooling
Condenser	$ 4,000	$ 4,000	$ 3,000	$3,000
Intake System	936	936	4,000	2,000
Piping System	983	698	1,436	1,436
Cooling Tower	5,319	7,000	--	--
Pumping System	1,220	1,220	1,564	1,164
Spray System	--	--	3,960	--
Canal Work	--	--	3,888	1,076
Total Direct Costs	12,458	13,854	17,848	8,676
Differential Costs	3,782	5,178	9,172	Base

*All values presented in thousands of dollars.

Source: Black and Veatch, 1976.

Table 9.2.8-6 Annual Cost Summary*
Alternative Cooling Systems, Site 3 (Per Unit)

Item	Mechanical Draft Tower	Natural Draft Tower	Spray/ Dilution System	Once-Through Cooling
Fuel	$ 470	$ 326	Base	Base
Energy	1,939	1,510	2,142	718
Demand Charges	404	313	444	149
Fixed Charges †	3,495	3,886	5,006	2,434
Total Annual Cost	6,308	6,035	7,592	3,301
Differential Annual Costs	3,007	2,734	4,291	Base

*All values presented in thousands of dollars.

†Fixed charges are based on capital costs that are escalated to 1981 and include indirect costs. These costs are as follows:

Total Direct Costs (from Table 6-1)	12,458	13,854	17,848	8,676
Escalation and Indirect Costs	8,098	9,005	11,601	5,639
Total Capital Costs	20,556	22,859	29,449	14,315

Source: Black and Veatch, 1976.

Table 9.2.8-7 Capital Cost Summary*
Alternative Cooling Systems, Site 1C (Per Unit)

Item	Mechanical Draft Tower (Saltwater)	Natural Draft Tower (Saltwater)	Spray/ Dilution System	Once-Through Cooling	Natural Draft Tower (Freshwater)	Mechanical Draft Tower (Freshwater)
Condenser	$5,000	$ 5,000	$3,300	$ 3,300	$ 4,500	$4,500
Auxiliary Cooling	--	--	Base	Base	1,374	1,374
Intake System	1,030	1,030	3,116	1,558	--	--
Piping System	928	760	7,498	7,498	684	928
Cooling Tower	6,300	8,400	--	--	7,560	6,000
Pumping System	1,800	1,800	2,457	1,638	1,620	1,620
Spray System	--	--	4,350	--	--	--
Canal and Outfall	--	--	1,730	403	--	--
Well Field Pipeline	1,040	1,040	1,040	1,040	2,498	2,498
Comparative Direct Costs	16,098	18,030	23,491	15,437	18,236	16,920
Differential Costs	661	2,593	8,054	Base	2,799	1,483

*All values presented in thousands of dollars (1977).

Source: Black and Veatch, 1977.

Table 9.2.8-8 Annual Costs*
Alternative Cooling Systems, Site 1C (Per Unit)

Item	Mechanical Draft Tower (Saltwater)	Natural Draft Tower (Saltwater)	Spray/ Dilution System	Once-Through Cooling	Natural Draft Tower (Freshwater)	Mechanical Draft Tower (Freshwater)
Fuel	$ 726	$ 455	Base	Base	$ 455	$ 726
Energy	2,803	2,087	3,288	1,754	2,046	2,803
Demand Charge	1,302	1,141	835	417	1,121	1,302
Fixed Charges †	3,654	4,133	5,385	3,539	4,181	3,879
Total Annual Cost	8,485	7,816	9,508	5,710	7,803	8,710
Differential Annual Cost	2,775	2,106	3,798	Base	2,093	3,000

*All values presented in thousands of dollars (1977)
†Fixed charges are based on capital costs that are escalated to 1981 and include indirect cost. These costs are as follows:

Total Direct Cost:	16,098	18,030	23,491	15,437	18,236	16,920
Escalation and Indirect Cost	10,263	11,494	14,976	9,841	11,625	10,786
Total Capital Cost	26,360	29,524	38,467	25,278	29,861	27,706

Source: Black and Veatch, 1977.

9.2.8.2 RANKING

Site 1 Location

The ranking of the alternative cooling systems based on total capital costs are as follows:

Rank	Total Capital Cost Description	Differential Cost
		$
1	Once-through Cooling	Base
2	Mechanical Draft Tower	3,586,000
3	Natural Draft Tower	5,002,000
4	Spray/Dilution System	9,254,000

Site 2 Location

A ranking of the alternative cooling systems based on total capital costs is as follows:

Rank	Total Capital Cost Description	Differential Cost
		$
1	Once-through	Base
2	Mechanical Draft Tower	5,566,000
3	Natural Draft Tower	7,052,000
4	Spray/Dilution System	9,381,000

Site 3 Location

The ranking of the alternative cooling systems based on total capital costs are as follows:

Rank	Total Capital Cost Description	Differential Cost
		$
1	Once-through Cooling	Base
2	Mechanical Draft Tower	3,782,000
3	Natural Draft Tower	5,178,000
4	Spray/Dilution System	9,172,000

Site 1c Location

The ranking of the alternative cooling systems based on total capital costs are as follows:

Rank	Description	Total Capital Cost Differential Cost
		$
1	Once-through Cooling	Base
2	Mechanical Draft, Salt water	661,000
3	Mechanical Draft, Fresh water	1,483,000
4	Natural Draft, Salt water	2,593,000
5	Natural Draft, Fresh water	2,799,000
6	Spray/Dilution System	8,054,000

Site 1 Location

The ranking of the alternative systems based upon total annual costs are as follows:

Rank	Description	Total Annual Cost Differential Cost
		$
1	Once-through Cooling	Base
2	Natural Draft Tower	2,580,000
3	Mechanical Draft Tower	2,952,000
4	Spray/Dilution System	4,315,000

Site 2 Location

A ranking of the alternative cooling systems based upon total annual costs is as follows:

Rank	Description	Total Annual Cost Differential Cost
		$
1	Once-through	Base
2	Natural Draft Tower	3,155,000
3	Mechanical Draft Tower	3,508,000
4	Spray/Dilution System	4,351,000

Site 3 Location

The ranking of the alternative cooling systems based upon total annual costs are as follows:

Rank	Description	Total Annual Cost Differential Cost
		$
1	Once-through Cooling	Base
2	Natural Draft Tower	2,734,000
3	Mechanical Draft Tower	3,007,000
4	Spray/Dilution System	4,291,000

Site 1c Location

The ranking of the alternative cooling systems based on total annual costs are as follows:

Rank	Description	Total Annual Cost Differential Cost
		$
1	Once-through Cooling	Base
2	Natural Draft, Fresh water	2,093,000
3	Natural Draft, Salt water	2,106,000
4	Mechanical Draft, Salt water	2,775,000
5	Mechanical Draft, Fresh water	3,000,000
6	Spray/Dilution System	3,798,000

Conclusions

Once-through cooling is the most economical alternative for the proposed units at any of the sites discussed above. Natural draft cooling towers using either fresh water or salt water are the second most economical alternatives, since they are essentially equivalent in cost. Maintenance costs are not presented in the above discussion. For Site 1c (Table 9.2.8-8), it is likely that fresh water towers have lower maintenance costs than salt water applications.

9.2.8.3 ENVIRONMENTAL CONSIDERATIONS

The following cooling systems are evaluated in this section:

1. Once-through cooling;
2. Natural draft cooling towers (fresh);
3. Natural draft cooling towers (salt);
4. Mechanical draft cooling towers (fresh);
5. Mechanical draft cooling towers (salt); and
6. Power spray modules with dilution (salt).

In Table 9.2.8-9 these systems are listed with the relative advantages and disadvantages of each. These factors were compiled assuming that the best available technology would be applied to minimize impacts.

Table 9.2.8-9. Analysis of Alternative Cooling Systems: Environmental Considerations

	Advantages	Disadvantages
Once-through Cooling (estuarine water)	1. Low costs 2. No fresh water consumption* 3. Possibility of desalinization process	1. New dredging required 2. Impingement of large numbers of finfish and shellfish 3. Entrainment of large amounts of planktonic forms 4. Increased size of area swept by present thermal plume 5. Biocide additions
Natural Draft Cooling Towers with Freshwater Makeup	1. No salt drift 2. Area is rated low for fogging potential 3. Reduced volume of water means fewer organisms will be entrained if surface fresh waters are used	1. Consumptive use of fresh water 2. If groundwater is used, potential for salt water intrusion exists 3. Noise 4. Biocide and antiscaling chemical additions (fewer biocides if groundwater is used)
Natural Draft Cooling Towers with Saltwater Makeup	1. No consumption of fresh water* 2. Area rated low for fogging potentials	1. Potential for salt drift 2. Noise 3. Potential for increased technical problems due to corrosion 4. Biocide and chemical additions 5. Somewhat more flow required than if freshwater used. Increased entrainment of saltwater organisms

Table 9.2.8-9. Analysis of Alternative Cooling Systems: Environmental Considerations (Continued, page 2 of 2)

	Advantages	Disadvantages
Mechanical Draft Cooling Towers with Freshwater Makeup	1. No salt drift 2. Area rated low for fogging potential 3. Reduced volume of water flow than if saltwater is used. Fewer organisms would be entrained if surface fresh waters are used	1. Increased noise over natural draft tower 2. Higher initial and operating costs than natural draft tower 3. Consumes more power than natural draft tower. The power produced contributes to air pollution and discharge impact
Mechanical Draft Cooling Towers with Saltwater Makeup	1. No consumption of fresh water* 2. Area rated low for fogging potential	1. Increased noise over natural draft 2. Potential for salt drift greater than natural draft 3. Higher initial and operating costs than natural draft 4. Consumes more power than natural draft. Power produced contributes to higher air and water emissions 5. More water would be needed than if freshwaters are used. Leads to larger entrainment
Power Spray Modules (saltwater only)		1. Salt drift near canal 2. High costs 3. Large volumes of water needed. Leads to large impingement and entrainment 4. New dredging required

* Fresh water would still be required for boiler makeup and service water.

9.3 WATER SOURCE AND INTAKE SYSTEM ALTERNATIVES

9.3.1 WATER USE REQUIREMENTS

9.3.1.1 CONDENSER COOLING WATER

Cooling water is required for the generating unit main condenser and the auxiliary cooling system. The alternative cooling systems are described in Section 9.2. Salt water could be supplied from the Gulf of Mexico; fresh water from Lake Rousseau; or ground water from well fields. Crystal River could supply brackish water.

9.3.1.2 STEAM SUPPLY MAKEUP

High purity water is required for makeup to the steam generator. The steam flow at rated load is estimated to be 4.91×10^6 pounds per hour per unit. One percent of this value is assumed to be required for replacement of leakage. An additional quantity is required to replace steam lost during each soot blowing cycle. A total of 251 gpm as an average daily flow is required per unit for steam supply makeup.

9.3.1.3 ASH HANDLING WATER

Bottom ash will be transported to a dewatering bin in a water slurry. This water will be delivered from the service water system and will be recycled. Fly ash will be transported dry to silos.

9.3.1.4 POTABLE WATER AND GENERAL PLANT USE

Potable water is required for sanitary services, cafeteria, drinking, washrooms and showers. General plant use includes wash water and fire service.

The estimated service water demands for Units 4 and 5 are tabulated in detail in Chapter 3 of this report.

9.3.2 WATER SOURCE ALTERNATIVES

9.3.2.1 SALT WATER ALTERNATIVE

Salt water systems for condenser cooling are discussed in Section 9.2: Cooling System Alternatives.

9.3.2.2 FRESH WATER ALTERNATIVES

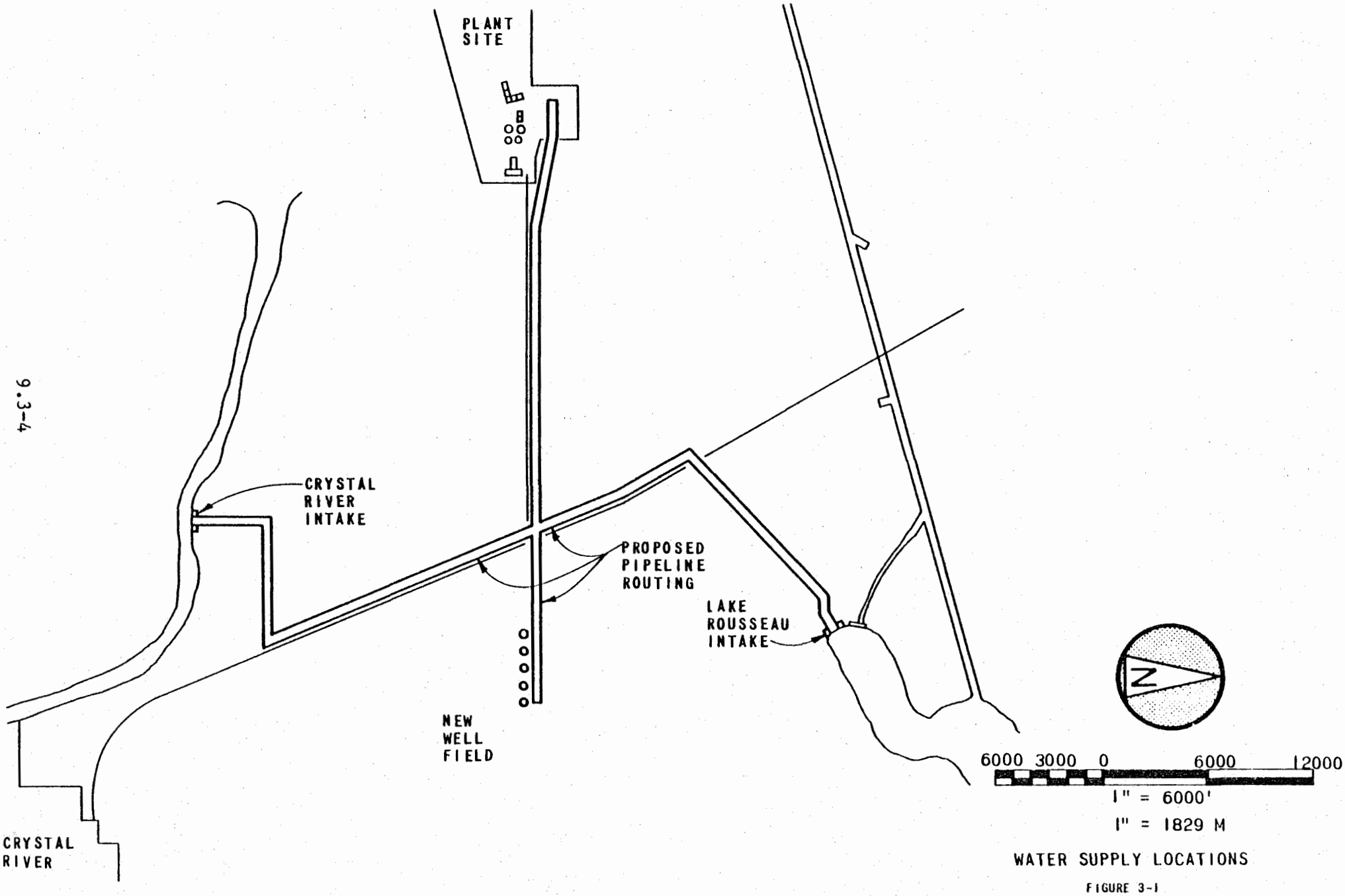
Three sources of fresh water, including Crystal River, Lake Rousseau, and well fields, are considered as alternatives (Figure 3-1, Black and Veatch, 1976). In each case, 30-inch diameter reinforced concrete pipe will be used to convey the raw water to the plant site. A conservative estimate of station water requirements for both units is summarized in Table 9.3.2-1.

The estimated capital costs for providing water to the plant site are presented in Table 9.3.2-2.

The annual operating and total annual costs are presented in Table 9.3.2-3. A discussion of the information considered in developing these cost estimates is also included.

Crystal River

Water samples were collected by Florida Power Corporation at three points on Crystal River at low, flood, high, and ebb tide conditions. The water quality data listed in Table 9.3.2-4 is from the sample point nearest the proposed intake structure location. Comparison of the listed concentration values indicates the tidal influence. The daily variations in water quality and the poor quality of the water makes this



WATER SUPPLY LOCATIONS

FIGURE 3-1

Table 9.3.2-1 Estimated Station Water Requirements Crystal River Units 4 and 5

Requirement	Water Source: Crystal River gpm Avg.	Crystal River gpm Max.	Lake Rousseau gpm Avg.	Lake Rousseau gpm Max.	Well Field gpm Avg.	Well Field gpm Max.
Cooling Tower Makeup	9,200	13,750	8,300	12,400	8,850	13,200
Service Water	400	1,000	400	1,000	400	1,000
Raw Water	100	300	100	300	100	300
Total	9,700	15,050	8,800	13,700	9,350	14,500

Source: Black and Veatch, 1977

Table 9.3.2-2 Comparative Capital Costs - Alternative Water Supply Sources--Crystal River Units 4 and 5

Requirement	Water Source		
	Crystal River	Lake Rousseau	Well Field
Piping From Wells	$1,685,000	$ 0	$4,275,000
Piping From Intake	5,405,000	4,800,000	0
Intake Structure	531,000	525,000	0
Wells	154,000	0	604,000
Subtotal	7,775,000	5,325,000	4,879,000
Differential	2,896,000	446,000	Base
Escalation (23 percent)	660,000	103,000	Base
Subtotal	3,556,000	549,000	Base
Interest During Construction (15 per cent)	534,000	82,000	Base
Indirect Costs (8.7 per cent)	309,000	48,000	Base
Total	4,339,000	579,000	Base

Source: Black and Veatch, 1977

Table 9.3.2-3 Comparative Costs--Alternative Water Supply Sources--Crystal River Units 4 and 5

Requirement	Water Source		
	Crystal River	Lake Rousseau	Well Field
Operating Costs			
Energy	$ 75,000	$ 21,000	$ Base
Chemical	88,000	Base	146,000
Demand Charges	7,000	2,000	Base
Fixed Charges at 14 per cent	616,000	95,000	Base
Total	786,000	118,000	146,000
Differential	668,000	Base	28,000

Source: Black and Veatch, 1977

Table 9.3.2-4 Crystal River Water Analyses

Constituent	Low	Flood	High	Ebb
Calcium[a]	163	130	200	140
Magnesium[a]	312	300	353	345
Sodium[a]	1838	1806	4289	2092
Potassium[a]	47	42	83	52
M-alkalinity[a]	127	133	183	134
Sulfate[a]	212	215	464	246
Chloride[a]	2021	1930	4323	2249
Silica[b]	6.4	6.4	6.0	6.2
Specific Conductance, umhos	3817	3846	6061	4464
pH	8.1	8.1	8.1	8.1

[a]mg/l as $CaCO_3$

[b]mg/l as SiO_2

Source: Black and Veatch, 1977

an undesirable source of cooling tower makeup and an unsatisfactory source for service water. With Crystal River as the source, control of cooling water quality would be difficult. Total dissolved solids concentrations, as well as chloride and sulfate concentrations, make the water unsuitable as a potable water supply.

With Crystal River as the source of makeup, a maximum of five cycles of concentration can be maintained in the cooling water system. The estimated maximum and average station water requirements for Crystal River source are presented in Table 9.3.2-1.

Extensive pretreatment of the river water source would be required prior to use as service water. Clarification, lime softening, and filtration would not provide a water suitable for potable use or for supply to the ion exchange system. To produce suitable water, an additional step such as reverse osmosis would be required. The variable river water quality would make control of process equipment difficult.

If Crystal River is the makeup source for the cooling water system, an alternate source of service water, such as extension of the existing well system, has to be considered. Two new wells of 1,500 gpm capacity each would be installed to provide the source for service water under this plan. Each well could provide the anticipated maximum service and raw water required for both units, as shown in Table 9.3.2-1. The wells would be approximately 2,000 feet apart and 250 to 300 feet in depth. The well water conduit to the plant site, sized to convey the flow from

one well, would be 12 inches in diameter and would be completely segregated from the existing well field pipeline. Approximately 32,000 feet of piping are required for conveyance.

The Crystal River pumping facility for cooling water makeup consists of an intake structure housing either three vertical traveling screens or three double entry traveling screens with three 50 percent capacity vertical pumps, each rated at 7,500 gpm. Approximately 54,000 feet of piping are required to convey the river water to the plant site.

The Crystal River source has the highest capital cost of the three water supply sources considered, as well as the highest total annual cost.

Lake Rousseau

Water quality data for Lake Rousseau are presented in Table 9.3.2-5. These data were taken from analysis of the sample collected by Florida Power Corporation and from data compiled by the USGS during 1975. The minimum and maximum concentrations found in these data are tabulated, along with the analysis of a sample deemed typical. The lake water is of acceptable quality to serve requirements, with pretreatment of the service water supply.

An average of nine cycles of concentration can be maintained in the cooling water system when using Lake Rousseau as the makeup water source. The estimated maximum and average station water requirements from the Lake Rousseau source are presented in Table 9.3.2-1.

Table 9.3.2-5 Lake Rousseau Water Analyses

Constituent	Minimum	Maximum	Typical
Calcium[a]	97.5	115	106
Magnesium[a]	19.3	21.8	21
Sodium[a]	6.5	7.6	7.4
Potassium[a]	0	0.3	0.2
M-alkalinity[a]	97	121	108
Sulfate[a]	16.6	22.9	19
Chloride[a]	4.5	10.4	7
Silica[b]	-	-	1.0
Nitrate	5	7.3	6.3
Specific Conductance, umhos	235	330	266
pH	7.2	8.4	7.8

[a]mg/l as $CaCO_3$

[b]mg/l as SiO_2

Source: Black and Veatch, 1977.

The chemical characteristics of Lake Rousseau, as listed in USGS data from 1966 through 1975 and as represented by the water sample, are quite consistent. The service water supply would require pretreatment through use of lime softening, clarification, and filtration. Possible organic contamination must be removed by pretreatment before use as potable water and as supply to the demineralization system. Although Lake Rousseau is an acceptable service water source, the possible organic content makes it less suitable than well water.

The Lake Rousseau supply system includes an intake structure with three vertical traveling screens or three vertical double entry traveling screens, both equipped with weed rakes to improve weed removal, and three 50 percent capacity vertical pumps, each rated at 7,500 gpm. Approximately 48,000 feet of piping are required from the intake to the plant site.

The estimated capital cost of the Lake Rousseau supply is less than the river water supply, but greater than the capital costs for the well water supply. The total annual cost for the lake water supply is the lowest of the three water supplies.

Well Field

Well water chemical characteristics based on data provided by Florida Power Corporation are tabulated on Table 9.3.2-6. These data were derived from analyses of samples from three existing wells. The wells

Table 9.3.2-6 Well Water Analyses

	Well 3	Well 4		Well 5	
	4/13/76	4/13/76	11/30/76	4/13/75	8/18/75
Calcium[a]	147	173	160	167	153
Magnesium[a]	70	74	82	74	82
Sodium[a]	10	9	9	10	10
M-alkalinity[a]	208	237	234	232	226
Sulfate[a]	5	5	5	5	5
Chloride[a]	13	13	11	13	13
Nitrate	-	-	-	-	-
Silica[b]	414	-	4.4	4.3	
3.9					
Specific Conductance umhos	435	485	430	475	440
pH	7.8	7.6	7.8	7.6	7.7

[a]mg/l as $CaCO_3$

[b]mg/l as SiO_2

Source: Black and Veatch, 1977.

are the present source of fresh water supply to the Crystal River Plant. An expansion of the well field to provide a supply to the new generating units would be expected to yield water of similar characteristics.

These analyses indicate some variations in water quality between wells, in addition to some variations for each well. Use of the raw well water as the makeup to the cooling water system would allow up to six cycles of concentration to be maintained. The estimated maximum and average station water requirements from the well source are presented in Table 9.3.2-1.

Operation of the existing pretreatment system on the present well water supply demonstrates the expected success of providing a suitable service water by lime softening and filtration. The water supply has been satisfactory as supply to the existing demineralization system and potable water systems. The service water system for the new generating units would require a similar pretreatment process if well water is used.

A five well addition to the existing well field is proposed. The wells would be located approximately 1,000 feet apart, with a capacity of approximately 2,700 gpm each, and would be 150 to 250 feet in depth. A booster pump station would be required. The pump station would include three 50 percent capacity horizontal centrifugal pumps, rated at 8,000 gpm each. The piping system would include about 30,000 feet of line to convey the water from the field to the plant site.

The estimated capital cost of this well water supply is shown in Table 9.3.2-2. The annual operating and total annual costs are listed in Table 9.3.2-3.

9.3.2.3 ENVIRONMENTAL CONSIDERATIONS

The proposed site for Units 4 and 5 is such that a variety of water sources are available. These include:

1. The Gulf of Mexico through the existing intake canal or some modification of the intake canal;
2. The Withlacoochee Reach of the Cross Florida Barge Canal, in its present form or with modifications proposed by various groups;
3. Crystal River;
4. Well fields; and
5. Lake Rousseau.

All these water sources would exhibit some impacts if drawn upon by the power plant. Impacts are, of course, intimately connected to the type of cooling system used and the intake design using the best available technology. There will, as a result, be some overlap between this section and the others concerning these topics. The major criteria which were considered in the development of this section are entrainment, impingement, water availability, water quality, and circulation. The impacts on the ecology of these waters would include impingement of larger organisms on the screens and entrainment of smaller organisms into the power plant condenser and other structures. Water availability in each source as compared to the need of the applicant must also be considered. Another aspect to be discussed is the possible disruption of existing patterns of water quality and circulation in the source body of water.

Cooling towers would require much less water to be entrained while once-through cooling and power spray modules would require considerably more

water (Black and Veatch, 1977). Generally, the more water taken in by the cooling system, the more organisms would be entrained. Entrainment would be less for cooling towers. Impingement could be substantially reduced if cooling towers are used, since the required volume of water can be provided with lower intake velocities (EPA, 1976; Boreman, 1977). Circulation, water quality, and water availability impacts are generally directly proportional to the volume of water that will be withdrawn for consumptive use.

Saltwater Sources

The two sources of saltwater makeup are (1) the Gulf of Mexico, and (2) the Withlacoochee Reach of the Cross Florida Barge Canal. Crystal River is a brackish source.

The Gulf of Mexico near the plant site has been extensively studied for impacts associated with once-through cooling used in Units 1, 2, and 3. In this area, the Gulf ranges in salinity from about 18 ppt to 27 ppt and in temperature from 14 to 30°C (Grimes, 1971). Freshwater sources include the Crystal River 4.8 km to the south and the Withlacoochee River and Cross Florida Barge Canal 6.4 and 5.8 km to the north, respectively. The mean tidal range for the area is about 1 meter. The bottom is gradually sloping in a manner typical of the drowned limestone plateau of west-central Florida. In-shore shallow flats are often exposed at low tide. These areas are bottom dominated by dense summer growths of marine grasses. More seaward, the depth drops to about 2 meters and phytoplankton or drifting green plants take over more of a role in primary

production. Coastal marshes are extensive and dominated by Juncus (McKellar, 1974).

The Gulf of Mexico can provide the necessary quantities of water for cooling tower makeup water or for the use of power spray modules with dilution. Whatever the cooling system used, many commercially, recreationally, and ecologically important planktonic forms would be entrained and subjected to thermal and mechanical stress within the power plant (FPC, n.d.; Maturo, et al., 1974). Present technology could not prevent this entrainment in any manner which would be economically feasible.

The use of saline estuarine water in cooling tower makeup would require larger volumes of estuarine water than if fresh water were used. Black and Veatch (1976) estimate that some 45,000 gpm (64.8 mgd) would be required for a natural draft tower using estuarine water, while less than 10,000 gpm (14.4 mgd) would be needed for fresh water from Crystal River, Lake Rousseau, or well fields (Black and Veatch, 1977). This is because estuarine water contains larger quantities of dissolved solids and can be cycled through the tower fewer times before "blowdown" or discharge. Use of Gulf waters for cooling towers would therefore involve the entrainment of significant quantities of important organisms.

The Withlacoochee Reach of the Cross Florida Barge Canal was produced by the Corps of Engineers as part of the initial construction of the Gulf Reach of the Cross Florida Barge Canal. Fresh water enters this section

of the canal by infiltration from the surficial aquifer, by seepage through the Inglis Dam and the Inglis Lock, and by discharge of high river flow over the Inglis Dam spillway. Saline water from the open Gulf is exchanged with fresh water as a result of tidal and wind forces.

Use of the existing Withlacoochee Reach of the Cross Florida Barge Canal would involve the same entrainment problems as using Gulf of Mexico water through the present intake canal. Future modifications to the canal reach could reduce this factor, but plans for the disposition of the area are uncertain and do not allow the applicant to plan realistically. The availability of water in this source depends upon technical decisions yet to be made by the state and federal governments on the disposition of the Barge Canal property.

The Crystal River runs from several head springs at Kings Bay, westward to the Gulf of Mexico. The maximum flow during normal tides is about 4,000 cubic feet per second (2,584 mgd). Interactions of wind and tidal forces result in complex mixing processes between fresh spring water and estuarine water causing large salinity variations (ESE, 1977). The river contains many aquatic weeds including Hydrilla. A wide variety of aquatic organisms are found in the river including freshwater and estuarine forms. The endangered manatee is common in the river. The river acts typically as a home for many planktonic eggs, larvae, and juveniles of many estuarine species. Preliminary studies suggest that at some seasons of the year, young, entrainable forms of Anchoa sp. (anchovies) and

Callinectes sapidus (blue crabs) are present at the proposed intake site (ESE, 1977). Crystal River does not have a water supply sufficient for use of power spray module cooling. The 1,000,000 gpm (1,440 mgd) described by Black and Veatch (1976) amounts to about 2,300 cubic feet per second (1,486 mgd). A maximum water supply of about 4,000 cubic feet per second (2,584 mgd) is available at Crystal River (ESE, 1977).

Cooling towers with Crystal River makeup water would not require as large a volume of water as cooling with estuarine waters (9,700 gpm/14 mgd average, 15,000 gpm/22 mgd maximum) (Black and Veatch, 1977). However, salinity fluctuations require a larger volume of makeup water from the Crystal River than would be needed from either Lake Rousseau or the well fields.

An intake structure at the presently proposed site on Crystal River would have an impact on an area of freshwater marsh. This area is populated by sawgrass and cattails and provides habitats for a number of freshwater fish including the sailfin molly and the mosquito fish (ESE, 1977). The other water source alternatives would not require construction through existing wetlands.

Freshwater Sources

Sources of fresh water available are (1) Lake Rousseau, and (2) well fields. Neither of these sources could be expected to provide enough water for power spray module cooling, but would seem adequate to supply cooling tower makeup.

Lake Rousseau is a manmade lake constructed for hydroelectric power generation by Florida Power Corporation in the first decade of the twentieth century. The valley of the Withlacoochee was flooded by a dam near Inglis. The lake is also known as Inglis Reservoir. It is a rather large lake measuring some 14 miles in length. Aquatic weeds and submerged snags make the lake difficult to navigate for recreational use (ESE, 1977).

Lake Rousseau impacts would be mainly entrainment of planktonic forms if impingement is considerably reduced, as expected, by proper intake design. Studies are underway to estimate the numbers and types of organisms which would be entrained and any disruption of present circulation patterns in the lake which might result (ESE, 1977).

The life habits of the expected species of freshwater fish in Lake Rousseau are such that few drifting eggs, larvae, and entrainable juveniles would be present in the deeper sections of the lake presently proposed as an intake site (ESE, 1977).

If a best available technology intake is designed (as discussed in Section 9.3.3) entrainment could be considerably reduced. Organisms entrained could be limited to forms which occupy many important positions in the lake food web, but are not considered commmercially or recreationally valuable in themselves (ESE, 1977a; ESE, 1977b). The intake could be placed in deep offshore waters of low biological productivity (ESE, 1977).

The lake is part of a system modified by the construction of the Withlacoochee Reach of the Cross Florida Barge Canal. Opening of the canal and a northern bypass for the Withlacoochee River has considerably reduced the flow of water through the southwestern arm of the lake where an intake is presently proposed. Drawing the water volume estimated by Black and Veatch (1977) (8,800 gpm/13 mgd average; 13,700 gpm/20 mgd maximum), for use in natural draft cooling towers would increase the flow in this arm of the lake. This would perhaps resuspend sediments currently stored on the lake bed but ultimately may cause hydrodynamic conditions in the lake to be more like those before the Inglis Bypass was opened.

Sufficient water appears to be available from Lake Rousseau for cooling purposes. Based on USGS figures, the proposed project would require a maximum consumptive use (20 mgd) of 3.3 percent of the Withlacoochee River 100-year low flow (ESE, 1977).

Projected consumptive use requirements for competing users of all fresh water in Citrus County are listed in Table 9.3.2-7 (Corps of Engineers, 1977). The total projected nonpowerplant requirements for groundwater and surface water to the year 2035 is 51.8 mgd. Projected cooling tower makeup needs for the proposed project will increase consumptive use requirements in Citrus County to 71.8 mgd. Consequently, power plant usage represents approximately 28 percent of the total surface and groundwater demand. Agricultural and municipal consumptive use will account for 69 percent of demand.

Table 9.3.2-7. Present and Projected Future Fresh Water Demands in Citrus County, in MGD

	Groundwater Demand 1975	Projected Water Demand 1985	Projected Water Demand 2035
Municipal	3.9	6.8	23.1
Industrial*	8.2	7.7	2.0
Agricultural	11.1	12.0	26.7
TOTAL	23.2	26.5	51.8

* Excludes power plant demands.

Source: Water Resources Management Study, Hydrologic and Engineering Evaluation of the Four River Basins Area, West Central Florida, 1977.

The concentrations of dissolved solids in Lake Rousseau are lower than either Crystal River or well fields (Black and Veatch, 1977; ESE, 1977). As mentioned before, this factor partially determines the amount of water needed. Black and Veatch indicate that less water would be needed from Lake Rousseau (8,800 gpm/13 mgd average and 13,700 gpm/20 mgd maximum) than from well fields (9.350 gpm/14 mgd average and 14,500 gpm/21 mgd maximum).

It would appear that Lake Rousseau waters with lower levels of dissolved solids would need a lower amount of antiscaling chemical treatment. Impacts would be reduced on the discharge side as a result (see Section 9.4.3).

Information gained by ESE attendance at a recent conference on the problems and biology of the asiatic clam, Corbicula, indicate that this organism may cause technical problems if Lake Rousseau is used for cooling tower makeup water. Corbicula is known to occur in the lake (ESE, 1977). Corbicula fluminea is an opportunistic species recently introduced into United States' waters. It is a species with high reproductive capacity and fast growth which has the ability to colonize power plant condensers. The clam reduces water flow through condenser tubes and prevents laminar flow. The organism is resistant to biocides and can withstand chlorination far above the limits allowed by EPA. Young clams can attach in flows up to 7 feet per second. Problems may result in discharge waters when many of the clams die at once. The Savannah Nuclear

Plant must be shut down periodically for maintanance due to infestations of Corbicula.

Well fields were discussed as an alternative in a report prepared by Geraghty and Miller, Inc., consulting groundwater geologists and hydrologists (1977). The following descriptions are largely based on that report.

The Floridan Aquifer, composed of limestone and dolostone, occurs at or near the land surface in the coastal zone of the proposed site. The thin veneer of surface deposit, chiefly sand, near the coast, increases in thickness inland. Most of the ground water flow takes place in a rather thin zone below the water table (Faulkner, 1973). Large quantities of water infiltrate through the surface sands, enter the rock aquifer system, and flow down gradient to coastal discharges. Recent information from the SWFWMD also indicates that a deeper circulation system is present which discharges further offshore.

The hydraulic characteristics of an aquifer can be described mathematically by three values. These are:

1. Transmissivity, which expresses the ease of water flow through the system;
2. Storage coefficient, which is dimensionless and indicates the amount of water released from storage in the system; and
3. Leakance, which quantifies the ability of the water to move vertically to enter or leave the system.

Well fields would need to be located 5.4 miles east of the plant site to minimize the potential for horizontal salt water intrusion. Since the Applicant's request to drill test wells was denied, test well information was not available for the site of the proposed well field. Geraghty and Miller estimated these parameters. Based on these estimates, it was concluded that large volumes of water were available (Geraghty and Miller, 1977).

Impacts which could take place with groundwater use include horizontal salinity intrusion, vertical upwelling of highly mineralized water through confining zones, consumptive use of freshwater, lowering of surfical water table and interference with surface water flows. Questions of entrainment and impingement of organisms as associated with use of surface water do not apply to groundwater since the organisms are simply not present. Geraghty and Miller estimate that in 1976, groundwater withdrawals in Citrus County for industrial, agricultural, and municipal purposes totaled 23.2 million gallons per day (see Table 9.3.2-7). Withdrawals are not concentrated in any one area. This demand is expected to increase in the year 2035 to about 52 million gallons per day disregarding power plant use. The Applicant would require approximately 20 million gallons per day for use as makeup water for cooling towers.

The characteristics of the aquifer in the area, as estimated by Geraghty and Miller, should be adequate to support the proposed withdrawal. At this time there is little quantitative evidence to support this conclusion since test wells have not been allowed. Additional information needs to be generated in order to assess the capacity of the aquifer.

Impacts are dependent upon the following information:

1. Aquifer characteristics:
   a. Transmissivity;
   b. Storage coefficient;
   c. Thickness, composition, and extent of clay layers between pumping zone and surface waters;
   d. Aquifer leakance values.
2. Wellfield design:
   a. Pumping rates;
   b. Number of wells;
   c. Spacing of wells;
   d. Penetration of aquifer;
   e. Proximity of wells to surface waters;
   f. Duration of pumping at each well.

Many of these points depend upon information from test pumping. Saline groundwater has also been suggested for cooling tower makeup. This would not amount to a consumptive use of freshwater. High concentrations of minerals present in such water would allow fewer cycles through cooling towers and technical problems may result from corrosion. No power plants are known which presently employ this source of cooling water.

Desalinization

The Southwest Florida Water Management District would prefer that instead of consuming fresh water, power plants examine the use of once-through cooling with estuarine water coupled with a desalination process. This

would allow power plants to produce fresh water rather than consume it (SWFWMD, 1977). The costs of this process and the associated technology needed would require study to determine if this alternative is feasible.

9.3.3 INTAKE STRUCTURES

Only freshwater and brackish water source intake structures are discussed here. The intake structures for saltwater source are examined in Section 9.2: Cooling System Alternatives.

9.3.3.1 STRUCTURE REQUIREMENTS

The design makeup flow for both cooling towers is 13,750 gpm. Other station water requirements are estimated to be 1,300 gpm. Thus, the intake structure system should be sized to accommodate a design flow of 15,050 gpm.

Lake Rousseau is expected to have a severe weed problem. Both floating seasonal weeds and a submerged type of vegetation must be controlled at the intake site. Eleven years of record show the lake minimum level to be about 22 feet above msl and maximum level to be about 28 feet above msl.

The Crystal River intake system will be supplemented by two 1,500 gpm wells that would supply potable water to the plant site. Eleven years of record show the river minimum level to be about 3 feet below msl and maximum level to be about 6 feet above msl.

9.3.3.2 STRUCTURE DESIGN

Lake Rousseau

Vertical Traveling Screens--The vertical traveling screen intake structure would require three 3-foot wide screens at an approach water

depth of 12 feet. Each screen would be placed in approximately a 5-foot, 6-inch wide pump bay.

The overall intake structure would be approximately 20 feet wide by 25 feet long by 20 feet high. The structure would also house the trash racks and mechanical rake to protect the screens from heavy debris, as well as the stop logs.

A differential controller would control the operation of the screens. The controller would start the screen drive and the spray pump at a predetermined headloss across the screens.

The entire intake system is remotely operated except for the mechanical trash rake and debris disposal. When trash removal is required, an operator must operate the mechanical rake and dispose of the trash and the accumulated screened debris.

Double Entry Vertical Traveling Screens—The open water type double entry vertical traveling screens are mounted on a platform. The platform would be about 25 feet by 35 feet and would be located over approximately 15 feet of water. The platform would support the three 8,000 gpm pumps and three 3-foot wide screens, each directly connected to a pump.

Perforated Pipe—The perforated pipe intake system would require two perforated pipes approximately 42 inches in diameter. The pipes would

be located in approximately 8 to 15 feet of water, approximately 2 feet from the bottom and pin jointed to the main feeder pipes that supply water to the pump structure. The feeder pipes would be approximately 36 inches in diameter and about 200 feet long.

Backwash for the perforated pipes would be done by a valving arrangement that would allow two of the pumps to backwash one of the perforated pipes at a time. A differential head controller would be used to determine when backwashing of the perforated pipes is required. The pump structure would be located on shore and would support the three 8,000-gpm pumps.

Crystal River

Conventional

Vertical Traveling Screens--The vertical traveling screen intake structure would consist of three 5-foot wide screens at an approach water depth of 8 feet. Each screen would be placed in approximately a 5-foot, 6-inch wide pump bay.

The overall structure would be approximately 20 feet wide by 25 feet long by 20 feet high. The remaining components of the vertical traveling screen intake would be the same as for Lake Rousseau except for the material used for the components. The brackish water of Crystal River requires the use of corrosion-resistant material for the screens and framing.

Double Entry Vertical Traveling Screens--The double entry vertical traveling screen for Crystal River would be located in a conventional concrete structure. The overall arrangement is similar to the double entry vertical traveling screen for Lake Rousseau. The only difference would be the corrosion-resistant materials and coatings of the components for the Crystal River intake.

Perforated Pipe--The perforated pipe intake system for Crystal River will be the same as Lake Rousseau. A perforated pipe intake system operates more efficiently in a river because the current carries the backwashed debris away thus reducing the number and length of backwashes.

One difference from Lake Rousseau would be the orientation of the perforated pipes. The perforated pipes would be oriented parallel with the Crystal River current and offset somewhat so potential damage due to a water craft could only occur to one perforated pipe.

9.3.3.3 SITING CONSIDERATIONS

The location of either the conventional intake or the perforated pipe intake along the lake or river shoreline affects the length of the pump discharge piping required, the water depth in the area, access for operation and maintenance, and the potential for siltation; it also provides protection of the intake structure from debris and river traffic.

Construction of the cells and the unloading facilities will tend to

reduce Crystal River velocities in this area and could result in increased siltation around the intake structure.

The amount of induced siltation should be considered in determining the elevation of the structure, in providing means of minimizing siltation at the intake, or in determining the extent of dredging that will be necessary. Raising the elevation of the intake would require either a wider conventional structure to maintain low approach velocities or a larger system of smaller pipes in a perforated pipe system.

Locating the conventional intake apart from the mooring cells would tend to maintain flow across the face of the structure and help clear fish and debris and reduce siltation across the face of the trash racks. A location close to the mooring cells would have the added advantage of making the structure less noticeable and more aesthetically acceptable.

At Crystal River, placing an inlet to the conventional intake structure or the perforated pipe near the river bottom at mid-channel would provide makeup water at the lowest possible levels and would diminish or eliminate the potential for siltation at normal levels. The longer intake pipes and deeper pump structure would increase the cost of construction and difficulty of inspection and maintenance.

A bridge to the conventional intake structure is required for service personnel and debris removal and could be used for support of the pump discharge piping.

Closing a portion of the intake system for maintenance would increase intake velocities. Maintenance can best be scheduled when the plant is not operating at full load so that velocities do not exceed acceptable limits.

9.3.3.4 ENVIRONMENTAL CONSIDERATIONS

Both EPA (EPA, 1976) and U.S. Fish and Wildlife Service (F&WS, 1977) emphasize that the best way to minimize power plant impacts on important aquatic resources is by locating the plant near water where such resources are scarce. These agencies suggest that the best available knowledge of the source water be used by the planner to properly place the intake vertically and horizontally and to arrive at the design which will least affect the aquatic system. In addition, both agencies would like to see designs which limited intake velocities to about 5 feet per second (15 centimeters per second). This is generally considered to be a flow velocity which most species of fish can resist and avoid impingement.

Placement and design of the intake structure should be fitted to the water needs of the cooling system and the source body of water.

Large Volume, Saltwater Intakes

Many designs for intake structures which might mitigate environmental impacts are prohibitively expensive for cooling systems which require large amounts of water. Such systems include once-through cooling and power spray modules with dilution. For these cooling systems the existing intake canal is indicated as the technically feasible source water (Black and Veatch, 1976). Other methods of obtaining water would require rather large alterations, including additional dredging. Such possibilities would include new canals, lengthy pipe systems, and modification of the Withlacoochee Reach.

Depth placement of the intake structure in the intake canal does not appear to be useful in limiting entrainment. Zooplankton populations were not found to be vertically stratified at Crystal River (Maturo, et al., 1974). Designs should be concerned mainly with limiting impingement.

An inlet flush with the side of the canal would be superior to an inlet placed at the end of an open channel. The flow in the intake canal would help direct finfish and shellfish past the screens instead of into them. With additional intake structures on the bank of the intake canal, it does seem possible that impingement could increase at Units 1, 2, and 3. Organisms tired or injured by the intake of Units 4 and 5 would be more easily carried into the screens of the remaining units.

Designs such as inclined or horizontal traveling screens or perforated pipe intakes would also serve to reduce impingement. These methods would be expensive but would allow moving organisms some alternate route away from the screens.

If vertical screens are to be used, the impacts can be minimized by operating the screens continuously and providing a path for gentle and rapid return of impinged creatures to the water. Vertical screens could also be placed at an angle to the flow and lead fish into a bypass system.

Lower Volume Intake

Water volumes required for cooling tower makeup are considerably less than that required for the systems described above (Black and Veatch, 1976). The perforated pipe intake design for Lake Rousseau which is

discussed in Section 9.3.3 could be modified for use in any of the alternative source waters. This design allows low approach velocities as recommended and allows organisms to avoid the intake by swimming in any direction except directly into the inlet holes. Problems may be encountered with this design due to slime, algae, or weed fouling. Proposed backwash will help overcome this problem.

This design could greatly mitigate entrainment if the intake pipes are placed at the depth of the least productive waters. Studies are currently underway to identify the waters of lowest biological value in Lake Rousseau for this purpose.

If a pump platform is used with the perforated pipe intake, care should be taken to withdraw water from a point away from the base of the platform. The platform itself would act as habitat and protection for eggs and larvae of freshwater fish. If the intake is away from the platform, these organisms can be avoided.

9.3.4 ALTERNATIVE INTAKE SYSTEMS

This section presents the relative advantages and disadvantages of the various intake systems for the proposed facilities. Included in the analyses are intake water sources with best available technology designs for intake structures. Textual discussions of these advantages and disadvantages are also presented in Section 9.3.2 (Water Source Alternatives) and Section 9.3.3 (Intake Structure Alternatives).

The water sources considered are:

1. The Gulf of Mexico through existing intake canals;
2. The Withlacoochee Reach of the Cross Florida Barge Canal, in its present form or with modifications proposed by various groups;
3. Crystal River;
4. Well fields; and
5. Lake Rousseau.

Results are presented in Table 9.3.4-1.

Table 9.3.4-1. Environmental Assessment of Alternative Intake Systems

Water Source	Advantages	Disadvantages
Gulf of Mexico through existing canals	1. Lower costs 2. No consumptive use of fresh water	1. Entrainment of important species 2. Impingement of important species (for once-through or PSM) 3. If cooling towers are used salinity contributes to technical problems and larger volume of water needed than fresh sources
Withlacoochee Reach of Cross Florida Barge Canal	1. Systems altered would be of lower value 2. No consumptive use of fresh water	1. Uncertainty of future plans for the area 2. If cooling towers are used a lower volume of water will be needed than for freshwater sources but technical problems may arise
Crystal River	1. Water of lower salinity than above sources	1. Consumptive use of fresh water 2. Entrainment of important species 3. Requires alteration of wetlands 4. Percentage of water to be used is higher than for Lake Rousseau

Table 9.3.4-1. Environmental Assessment of Alternative Intake Systems (Continued, page 2 of 2)

Water Source	Advantages	Disadvantages
Lake Rousseau	1. Entrainment may be reduced by placing intake in waters of low biological productivity 2. Percentage of water used is lower than at Crystal River 3. May improve circulation in southwestern arm of the lake 4. Dissolved solids lower than for Crystal River or well fields would mean less water required for cooling towers	1. Consumptive use of fresh water 2. Potential for fouling problems from Asiatic Clam, Corbicula.
Well Fields	1. No entrainment or impingement	1. Potential for salt water intrusion not clear 2. Water availability not clear without test data

9.4 WASTEWATER DISCHARGE SYSTEM ALTERNATIVES

9.4.1 OBJECTIVE AND REQUIREMENTS

The objective of this analysis is to categorize the various wastewaters produced by the operation of the plant and to discuss methods for their disposal. The requirements are that all waters discharged from the plant site will be of a quality that complies with existing regulatory requirements, and that reuse of water will be incorporated to the greatest extent practical.

9.4.2 SOURCES OF WASTEWATER DISCHARGES

The sources of wastewaters include circulating water, ash and sludge handling, rainwater runoff, and low volume wastewaters which consist of water pretreatment, ion exchange regeneration, metal cleaning, plant drains, sanitary waste, and boiler blowdown.

9.4.3 CIRCULATING WATER

9.4.3.1 SALT WATER

If seawater is used as circulating water for condenser cooling, either on a once-through basis or as makeup to a cooling tower system, it will either evaporate or be returned to the sea. In either case, shock chlorination would be required for control of biofouling of the condenser and cooling tower.

9.4.3.2 FRESH WATER

Quantity and Quality

At maximum evaporation of 11,000 gpm, (15.8 mgd), maximum drift of 40 gpm (0.06 mgd), and operating at six cycles of concentration, the

required blowdown from both units will be 2,160 gpm (3.1 mgd). Over the lifetime of the units, assuming 66 percent average annual load factor and average atmospheric conditions, the required blowdown will average 655 gpm (0.9 mgd) per unit.

The expected quality of freshwater tower blowdown is as follows:

Calcium, mg/l as $CaCO_3$	1,000
Magnesium, mg/l as $CaCo_3$	443
Sodium, mg/l as $CaCO_3$	60
M-alkalinity, mg/l as $CaCO_3$*	200
Sulfate, mg/l as $CaCO_3$	1,219
Chloride, mg/l as $CaCO_3$	78
Nitrate, mg/l as $CaCO_3$	6
Silica, mg/l as SiO_2	26

*Based on feeding H_2SO_4 to control alkalinity to 200 mg/l as$CaCO_3$, and utilizing an organic phosphate scale inhibitor.

Cooling water is continuously treated as necessary to adjust pH in order to limit scale formation. Organic phosphates are also added to inhibit scale. It has been common practice to add metals to prevent corrosion, but this is not planned.

In order to control bacterial, fungal, and algal growth, and to prevent fouling by invertebrates, biocides are added to the cooling water. This is discussed in the next section.

9.4.3.3 BIOCIDE TREATMENT

Shock chlorination will be used in the circulating water systems for control of bacterial slimes and algae. The chlorination system will be controlled to limit free available chlorine to an average concentration of less than 0.2 mg/l and a maximum concentration of less than 0.5 mg/l in the blowdown discharged to meet the limits set by the EPA. In addition, the chlorination system will be controlled so that neither free nor total residual chlorine is discharged from any one of the units for more than two hours in any one day.

Blowdown to be discharged to the existing discharge canal will be taken from the cold side of the circulating water system as required by EPA regulations.

There will be a phosphate residual in the blowdown as a result of using an organic phosphate material for scale control.

9.4.3.4 TREATMENT AND DISPOSAL

No treatment is required for cooling tower blowdown before discharging to the existing discharge canal. Some of the circulating water blowdown will be used in the bottom ash handling system. Most of it will be discharged to the existing discharge canal.

Alternative disposal methods of cooling tower blowdown include injection wells and complete reuse and recycling. Neither of these alternatives were considered to be economically viable or necessary.

9.4.4 OTHER WASTEWATERS

9.4.4.1 CHEMICAL WASTES

Quantity and Quality

Acidic and caustic chemical wastes will result from regeneration of ion exchange resins and from chemical cleaning operations (metal cleaning wastes).

It is estimated that the wastewaters from the makeup demineralizer will average 10 gpm, based on an average demineralized water demand of 173 gpm. The condensate polishing system wastewaters, assuming 50 regenerations of each resin bed per year, are estimated to average 2 gpm. The preoperational chemical cleaning wastes are estimated to be 1,200,000 gallons in volume, with subsequent gallons of wastewater for each cleaning operation. Besides pH, potential causes of pollution are oil and grease, TSS, iron, copper and other metals, phosphates, organic compounds, and BOD from organic emulsifiers.

An acid wash is done every 3 to 5 years to remove scale and corrosion products from the boiler. The composition of this fouling depends upon boiler water composition and additives, boiler tube materials and leaked contaminants. The effluent is analyzed before each treatment is selected. Contents of the approximately 360,000 gallons of cleaning water cannot be known ahead of time, but materials commonly found include calcium carbonate, calcium sulfate, $Ca_x(PO_4)_x$, silicates, $Mg(OH_2)$, iron and copper oxides, zinc, nickel, aluminum, oil, and

suspended solids.

Treatment and Disposal

A neutralization basin of approximately 100,000 gallons capacity will be produced for treatment of chemical wastes prior to their ultimate disposal. A basin of this capacity would be sufficient to accomodate the wastewaters produced during regeneration of the ion exchange systems, and would handle the largest volume of chemical cleaning solution wastes at any one time.

The neutralization basin would be a reinforced concrete basin lined with chemical resistant membrane, brick, and mortar. A chemical waste mixer, mounted on the walkway spanning the open-topped basin, would be provided to hasten neutralization of the chemical wastes. Sulfuric acid and sodium hydroxide, as required for neutralization, would be available from the demineralization system regeneration equipment.

The neutralized chemical wastewaters would be conveyed to the Plant Drains Collection Pond for ultimate disposal. Pumping may be needed due to the distance. The Plant Drains Collection Pond would not normally overflow, as the exfiltration rate from the pond is expected to substantially exceed influent flows. During high rainfall events, the Plant Drains Collection Pond could overflow into the cooling tower blowdown conduit. The large quanities of rainfall runoff are expected to make any contributions from the neutralized chemical wastes insignificant.

9.4.4.2 WATER PRETREATMENT WASTE

Quantity and Quality

A sludge consisting mainly of calcium carbonate produced in the solids contact unit, and backwash water from the gravity filters, will require disposal. Using the well water analysis presented in the Water Supply and Treatment System Analysis, 2.9 pounds of precipitate, predominantly calcium carbonate, will be formed per 1,000 gallon throughput. Assuming a five percent solids concentration in the sludge, a waste flow of about 2 gpm will result at the annual average service water demand condition of 259 gpm.

Assuming the gravity filters are backwashed weekly for 10 minutes at a rate of 15 gpm per square foot of filter area, the annual backwash waste flow is estimated at 6 gpm.

Treatment and Disposal

A desirable disposal point for the pretreatment system wastewater is the bottom ash system. The solid portion of the sludge, after dewatering, will be disposed with the bottom ash to the landfill. An estimated 1,100 pounds per day of pretreatment system solids will be disposed of in this manner. The pretreatment wastewater may need to be pumped from the pretreatment sludge sump to the ash system because of the elevations and distance.

9.4.4.3 ASH HANDLING

Quantity and Quality

Makeup water will be required for the ash water recirculation system to

replace evaporation losses and the water entrained in the ash. At the annual average load condition, the estimated water losses from the bottom ash handling systems are as follows:

Evaporation losses	45 gpm
Entrained water in ash	18 gpm
Total makeup required	63 gpm

Cooling tower blowdown will be used as a source of makeup water. Wastewater from the water pretreatment system will also be utilized. A small amount of service water will be required for the crusher seals and other services.

Treatment and Disposal

A dewatering operation will take place prior to transporting the ash to ultimate disposal. The decanted water will be recirculated and reused. None of the systems considered will involve direct discharge of ash handling water. Since the ash disposal area will be relatively flat, a perimeter ditch and dike system will be constructed to contain rainfall runoff which comes from the active ash disposal area.

The only wastewater from the ash systems that will require disposal will be rainfall runoff from the active ash storage area. The rainfall inside the active ash storage will be contained within the ditch and the dike and will be allowed to evaporate and exfiltrate within the area. The area within the dike will be about 20 acres in size. The annual average rate of wastewater runoff generated by precipitation within the active ash storage area will be about 31 gpm.

The maximum 10-year, 24-hour rainfall event of 8.37 inches will result in approximately 3,160 gpm of runoff which will be contained within the active ash storage area ditch and dike. A rainfall event of greater than 8.37 inches in a 24-hour period will overflow the active ash storage ditch and dike entering the general site drainage system.

9.4.4.4 MISCELLANEOUS PLANT DRAINS

Quantity and Quality

Miscellaneous plant drains include wastewater from the plant roof and floor drain system and various equipment drains. Wastewater from the floor drain system results from plant cleaning and maintenance activies and from miscellaneous sources including equipment or pipe leakage, boiler blowdown, and relief valve drains. Roof drain wastewater results from rainfall.

Annual average flow rates of the contributors to the miscellaneous plant drains are as follows:

Boiler Cycle Losses	58 gpm
Plant Floor and Equipment Drains	50 gpm
Roof Drains	20 gpm
Total	128 gpm

During a 10-year, 24-hour rainfall event, the average miscellaneous plant drain wastewater flow will rise to about 1,200 gpm.

Treatment and Disposal

Oil separation traps will be installed in all drains subject to contamination by oil or grease. The traps will be emptied by scavenging equipment for off-site disposal. The miscellaneous plant drainage system will be pumped to the Plant Drains Collection Pond. Normally, exfiltration from this pond is expected to exceed the input. Size of the Plant Drains Collection Pond will be adequate to handle a 10-year, 24-hour rainfall event in order to meet EPA requirements for runoff limitations.

The sources and quantities of plant wastewater directed to the pond at the annual average conditions are as follows:

Miscellaneous Plant Drains	128 gpm
Neutralization Basin Effluent	12 gpm
Pond Precipitation	11 gpm
Total	151 gpm

Based on the 10-year, 24-hour rainfall event of 8.37 inches, the following are the maximum inflowing amounts to the Plant Drains Collection Pond.

Miscellaneous Plant Drains	1,200 gpm
Neutralization Basin Effluent	12 gpm
Pond Precipitation	630 gpm
Total	1,842 gpm

The Plant Drains Collection Pond will be about four acres in area in order to provide the necessary exfiltration. A minimum effective depth of about 2 feet is required to give a 24-hour retention time maximum flows. The pond will have a discharge and monitoring structure designed to prevent discharge of floating material. Discharge will be directed to the cooling tower blowdown conduit and then to the existing discharge canal. The structure will have provision either for grab sampling or for continuous monitoring as required by the EPA or Florida Department of Environmental Regulation.

9.4.4.5 COAL STORAGE AREA RUNOFF

Quantity and Quality

Rainfall runoff from the coal storage areas on an average annual basis is as follows:

New Coal Storage Area 1	80 gpm
New Coal Storage Area 2	43 gpm

Using the 10-year, 24-hour rainfall event of 8.37 inches as a basis, the maximum runoff from the coal storage areas can be estimated as follows:

New Coal Storage Area 1	5,930 gpm
New Coal Storage Area 2	3,140 gpm

There is expected to be some pickup of suspended and dissolved solids in the wastewater from the coal, especially in the initial runoff water.

Treatment and Disposal

All coal storage area runoff will be directed to a perimeter ditch sized to contain a 10-year, 24-hour rainfall event to meet EPA discharge regulations for coal pile runoff.

It is expected that the exfiltration from the coal area rainfall runoff perimeter ditch will exceed the input in all but very heavy rainfall situations. The ditch will be equipped with overflows which discharge into the general site area drainage when rainfall runoff exceeds the holding capacity of the ditch.

9.4.4.6 GENERAL SITE AREA RUNOFF

Quantity and Quality

Rainfall runoff from the general site areas on an average annual basis is estimated at 85 gpm. Using the 10-year, 24-hour rainfall event of 8.37 inches as a basis, the maximum runoff from the general site areas can be estimated at 4,730 gpm. The runoff water may pick up some dissolved and suspended solids, especially in areas disturbed by construction.

Treatment and Disposal

General site area runoff will be directed to perimeter ditches. The ditches will be sized to contain a 10-year, 24-hour rainfall event.

9.4.4.7 SANITARY WASTES

Quantity and Quality

The maximum loading originating from Units 4 and 5 will occur with Unit 4 operating and Unit 5 under construction. Under these conditions, the estimated maximum hydraulic loading figures will be as follows:

estimated maximum hydraulic loading figures will be as follows:

100	permanent personnel at 35 gpd	3,500 gpd
50	temporary personnel at 25 gpd	1,250 gpd
40	visitors at 25 gpd	1,000 gpd
1,000	construction personnel at 20 gpd	20,000 gpd
Total		25,750 gpd

Biological loading will be approximately 0.075 pounds of BOD_5 per day for permanent personnel and approximately 0.045 pounds of BOD_5 per day for temporary personnel, visitors, and construction personnel, or a total of approximately 57 pounds of BOD_5 per day.

Treatment and Disposal

Consideration will be given to constructing a new sewage treatment plant for Units 4 and 5, or alternatively, transporting sewage to the existing sewage treatment plant.

New Sewage Treatment Plant - Plan I

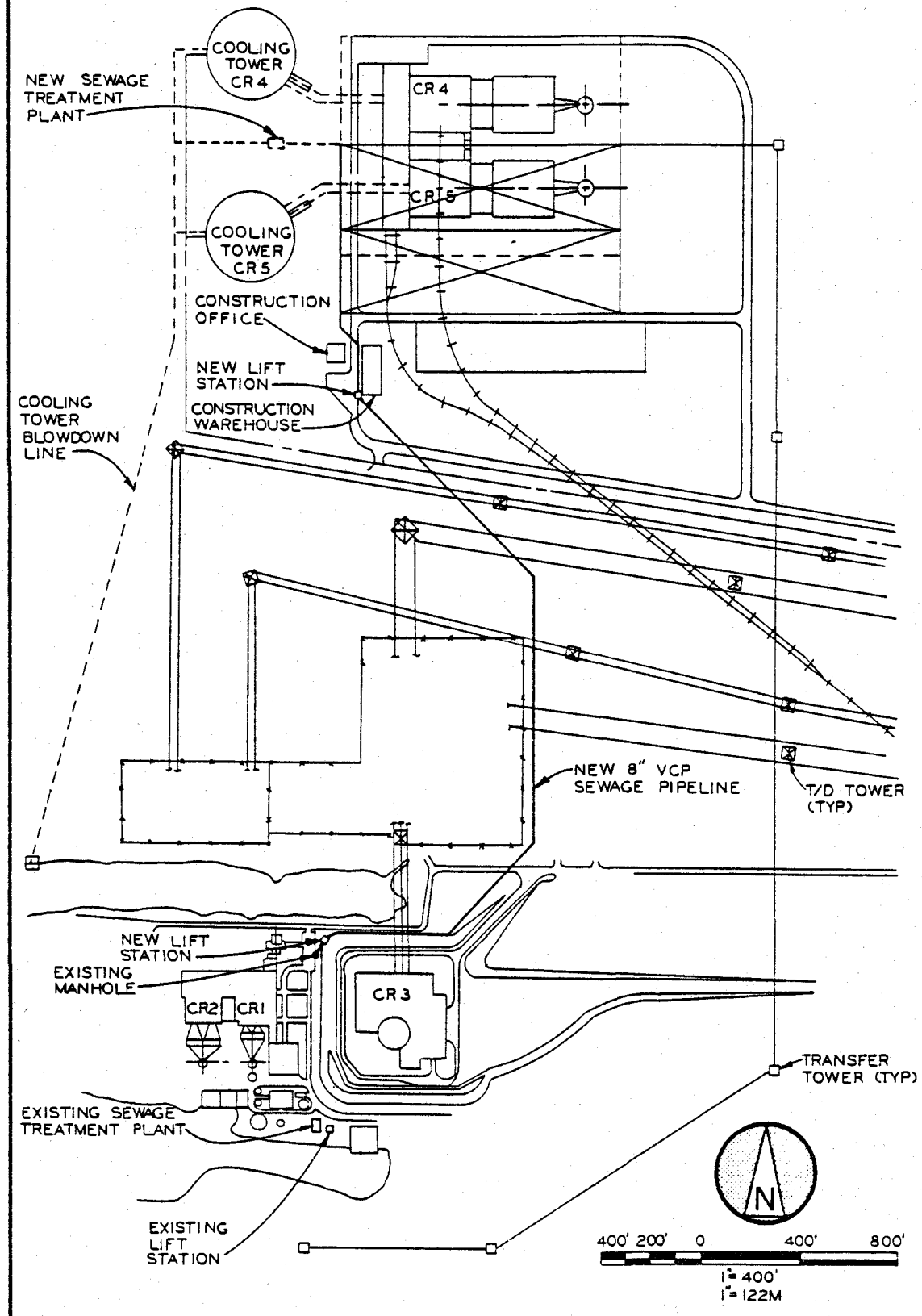
Under this plan, a new sewage treatment plant would be installed to serve Units 4 and 5 only. The facility would be designed to achieve 90 percent reduction of BOD_5 and suspended solids, in accordance with the requirements of the DER. Chlorination would be provided to disinfect the plant effluent. The plant would be a 30,000-gallon per day packaged, activate sludge unit which employs the extended aeration process method of treatment. Black and Veatch Figure 7-1 (September, 1977) shows a possible location of this new sewage treatment plant.

Transporting Sewage to Existing Sewage Treatment Plant - Plan II

The existing facility has a capacity of 30,000 gallons per day. The current average hydraulic load from Units 1, 2, and 3 is about 8,000 gpd with reported maximum flows of 11,000 gpd. The existing plant is capable of handling the additional wastes from Units 4 and 5 under most situations. However, with the maximum loading from operation of Units 1, 2, 3, and 4, and construction of Unit 5, the existing sewage treatment could be overloaded by several thousand gallons per day.

Transporting the sewage to the existing facility would require 2,700 more feet of 8-inch vitrified clay pipe than would a new sewage treatment plant. It is estimated that at least 12 additional manholes and two lift stations would be required to transport the sewage. Black and Veatch Figure 7-1 (September 1977) shows the possible routing of this sewage piping. No significant additional operator attention and cleanup facilities would be required if the existing facility were utilized.

Capital costs for these plans are shown in Table 9.4.4-1. The operating costs and the comparative annual costs for the two plans are shown in Table 9.4.4-2. A new sewage treatment plant could be located in the cooling tower area and the plant effluent, which would meet DER regulations, would discharge into the cooling tower blowdown line which in turn would discharge to the existing discharge canal. Following completion of construction, the average sewage flow expected from Units 4 and 5 will be about 6 gpm.



SEWAGE TREATMENT AND TRANSPORTATION

FIGURE 7-1

Table 9.4.4-1 Comparative Capital Costs--Alternative Sanitary Waste Treatment Systems

Item	Plan I New Sewage Treatment Plant	Plan II Transporting Sewage to Existing Sewage Treatment Plant
Sewage	$ 50,000	$ 0
Operator's Wash Station	5,000	0
Sewage Piping and Manholes	Base	101,000
Lift Stations	Base	30,000
Subtotal	55,000	131,000
Interest During Construction at 42 per cent	23,000	55,000
Indirect Costs at 8.7 per cent	5,000	11,000
Total	83,000	197,000
Differential	Base	114,000

Source: Black and Veatch, 1977

Table 9.4.4-2 Comparative Annual Costs--Alternative Sanitary Waste Treatment Systems

Item	Plan I New Sewage Treatment Plant	Plan II Transporting Sewage to Existing Sewage Treatment Plant
Operating Costs		
Energy	$ 1,500	$ 500
Operating Personnel	10,000	Base
Subtotal	11,500	500
Differential Operating Costs	11,000	Base
Demand Charge	800	300
Fixed Charge at 14 per cent	Base	16,000
Total	11,800	16,300
Differential	Base	4,500

Source: Black and Veatch, 1977

9.4.5 DISCHARGE STRUCTURES

If saltwater is used for condenser circulation, the discharge structure requirements will be as discussed in Cooling System Alternatives, Section 9.2 of this document. If fresh water is used, the cooling tower blowdown discharge will also be located at the existing circulating water discharge canal. The maximum blowdown rate would be 2,750 gpm if water from Crystal River is utilized, and about half this magnitude if Lake Rousseau water is used.

If Lake Rousseau water is used for cooling tower makeup, one pipe approximately 10 inches in diameter will be required for blowdown. A 12 inch diameter pipe will be required if Crystal River water is utilized. The location of the discharge at the existing discharge canal will be such that the cooling tower blowdown can gravity feed into the canal.

9.4.6 INTEGRATED WASTEWATER MANAGEMENT

Suitable reuse and handling of waste waters can reduce costs and minimize potentially harmful effluents. Table 9.4.6-1 summarizes sources of wastewater and their flow rates, characteristics, and possible reuses. Figures 9.4.6-1 and 9.4.6-2 suggest alternate methods of handling wastewater.

The first alternative differs from the second in the following ways:

1. Boiler blowdown is recycled to the demineralizer because this blowdown is usually as clean as water coming into the plant.
2. There is no neutralization basin so the demineralizer wastes can be neutralized in the ash pond. The volume of the proposed basin is 100,000 gallons. This is larger than needed for demineralizer and polisher wastes, but too small for the occasional metal cleaning wastes. The ash ponds are large enough to handle even for the 1,200,000 gallons at start up. Furthermore, some ash ponds have proper characteristics to precipitate the high copper and iron of these wastes. Should prolonged rains cause overflow, metals content could be down to 1 ppm.
3. Rain runoff from roofs is treated like grounds runoff and not introduced into plant drains. Roof runoff contains few pollutants except TSS, while plant drains receive grease and oils, various cleaning wastes, detergents, etc. It will be easier to manage zero-discharge of these wastes if they are not diluted with rainwater.

4. There is no plant drains collection pond. Instead, water flows directly to the ash pond.
5. Grounds runoff and coal pile runoff are kept separate since the coal runoff must be well contained. General runoff will usually have only TSS and potential for erosion. It would not seem necessary to gather all this runoff into a pond. Proper grading and a good ground cover can slow this runoff, lowering TSS and preventing erosion. This stratagem would be aided if sewage plant effluent were used to water the ground cover, and one minor source of pollution would be eliminated.

It is anticipated that by elimination of some ponds a financial savings will be made. Reducing the constant inflows to the ash pond by the amount of the boiler blowdown and roof runoff (20 gpm) will give better ash pond level control and reduce the possibility of discharge. All of the environmentally worst wastes are emptied to the ash pond, and zero discharge is planned. Sewage plant effluent irrigation both eliminates this discharge and fertilizes the ground cover, helping to control runoff.

Table 9.4.6-1 Sources of Wastewater: Their Flow Rates, Characteristics, and Possible Reuses

Source	Volume	Content	Possible Reuses
Cooling blowdown, fresh water	0.9-3 MGD	pH 6-7, TDS, low level organic phosphates and chlorine	ash transport
Cooling blowdown, salt water	37 MGD	Salts 31 ppt, phosphates, chlorine	?
Demineralizer, condensate polisher	12 GPM	H_2SO_4, N_2OH, concentrated minerals from freshwater inflow	Neutralizing, ash transport
Boiler cycle losses	58 GPM	High pH but low poise, still rather pure water	Recycle to demineralizer as possible
*Plant floor and equipment drains, all miscellaneous cleaning, etc.	50 gpm	Oils, grease, pH, metals, no PCB's, phosphates, TSS	Ash transport
Roof drains	Average 20 GPM	TSS, rather clean	Most uses
*Ash handling if 20 acres, 680 GPM exfiltrate, net rain gain 12.4 GPM	18 GPM entrained in ash	TSS, pH, metals, oil and grease	Recycle from pond for ash transport, entrained is lost
*Coal runoff--Area 1 --Area 2	Average 80 GPM Average 43 GPM	TSS, pH, metals, oil and grease	Neutralizing, ash handling
Sewage	Average <13 GPM	Nutrients, BOD, TSS	Irrigation of grounds, ash handling
*Metal cleaning	1,200,000 (3.7 acre/ft) at start up 360,000 every 3-5 years	pH, TSS, oil and grease, metals	Neutralizing, ash handling

WASTEWATER FLOWS ALTERNATE 1

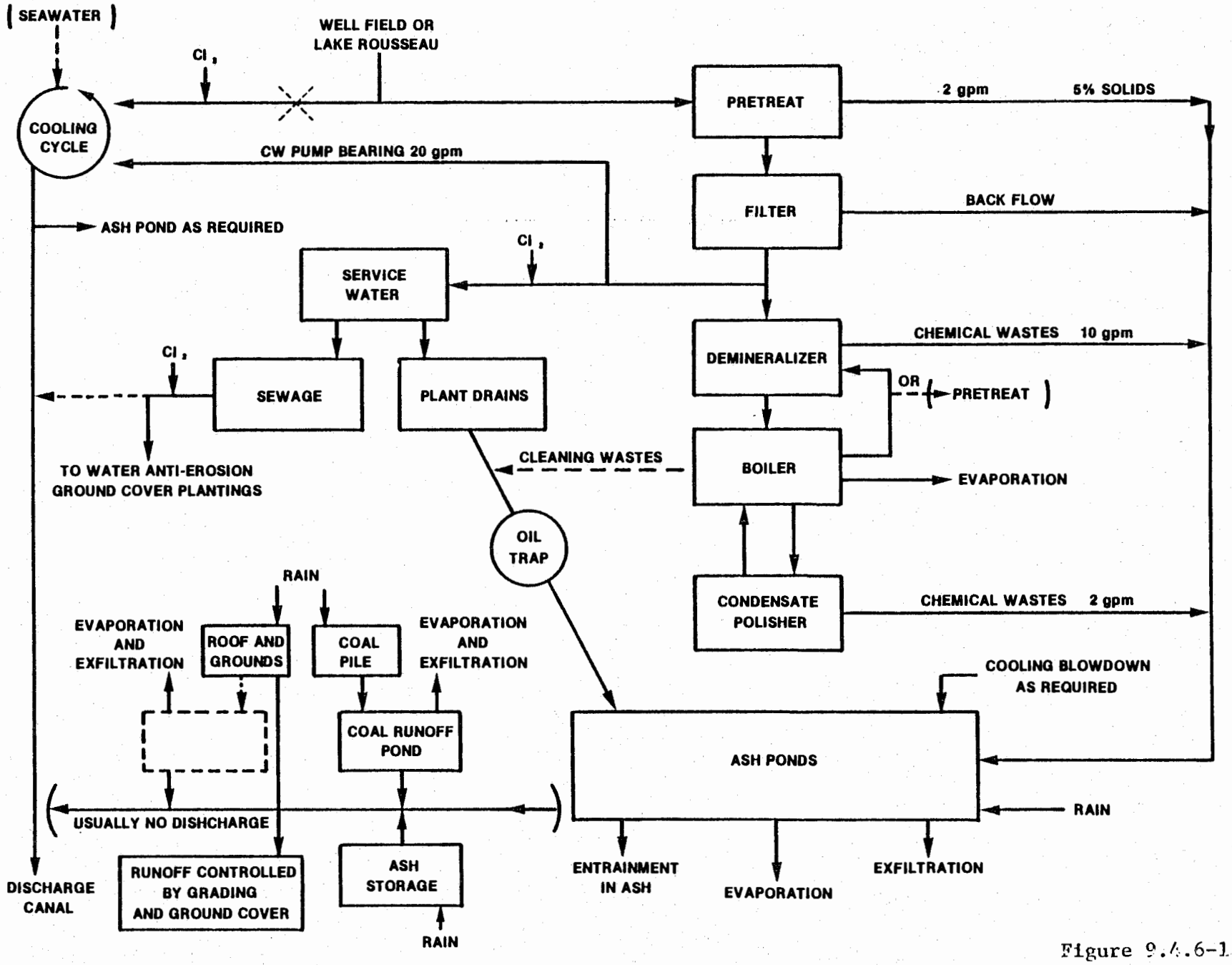


Figure 9.4.6-1

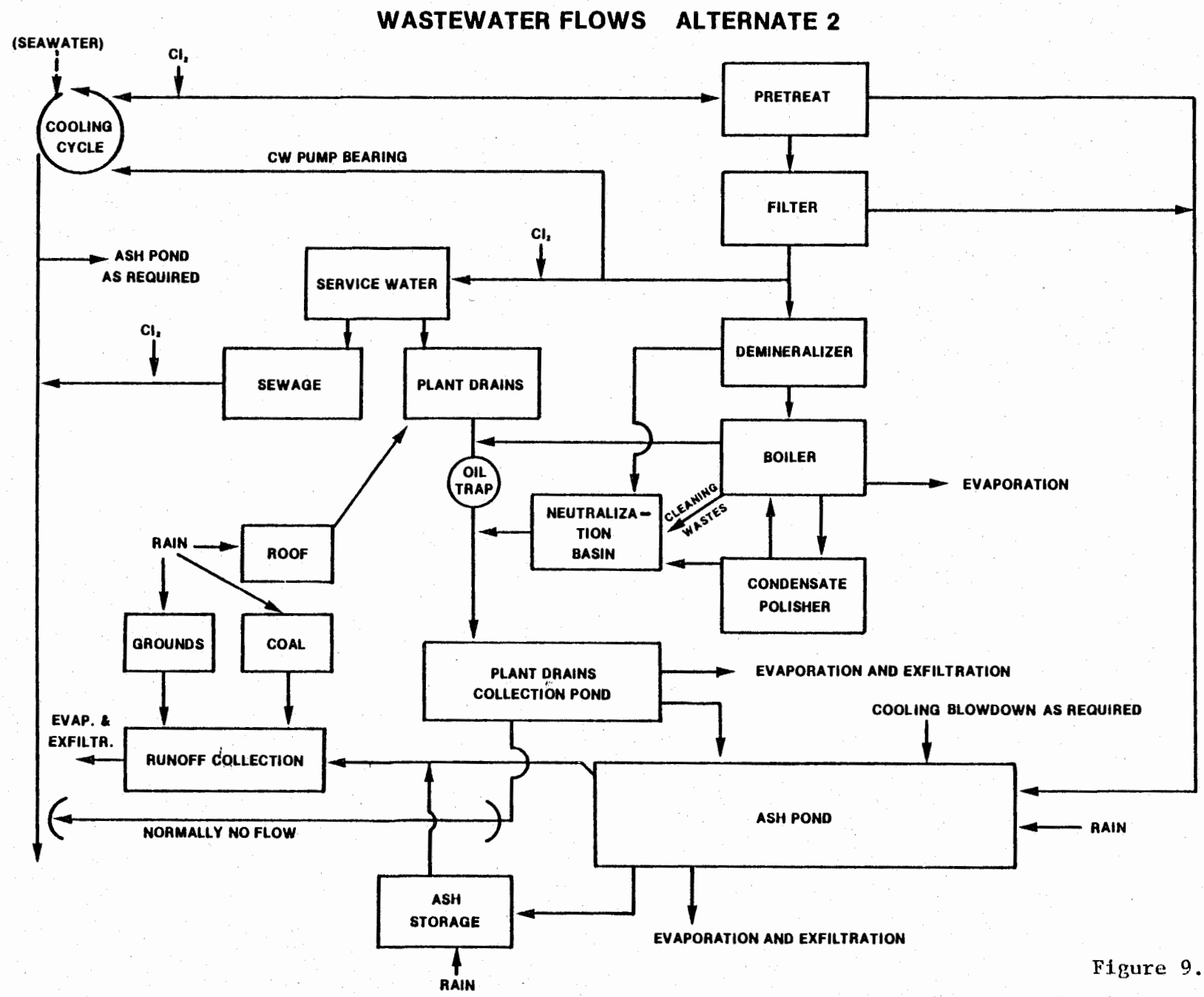

WASTEWATER FLOWS ALTERNATE 2
(SEAWATER)
Cl_2
COOLING CYCLE
PRETREAT
CW PUMP BEARING
FILTER
Cl_2
ASH POND AS REQUIRED
SERVICE WATER
Cl_2
DEMINERALIZER
SEWAGE
PLANT DRAINS
BOILER
OIL TRAP
EVAPORATION
NEUTRALIZA-TION BASIN
CLEANING WASTES
RAIN
ROOF
CONDENSATE POLISHER
GROUNDS
COAL
PLANT DRAINS COLLECTION POND
EVAPORATION AND EXFILTRATION
COOLING BLOWDOWN AS REQUIRED
EVAP. & EXFILTR.
RUNOFF COLLECTION
ASH POND
RAIN
NORMALLY NO FLOW
ASH STORAGE
EVAPORATION AND EXFILTRATION
RAIN

Figure 9.4.6-2

9.4.7 ENVIRONMENTAL CONSIDERATIONS

9.4.7.1 CHARACTERIZATION AND VOLUME OF WASTEWATERS

There are two potential sources of fresh water for cooling, and sea water is a third possibility. Fresh water would be evaporated to a calcium concentration of about 1,000 ppm, allowing five or more cycles of concentration. The rate of blowdown would be 3 mgd or less. Sea water would probably go through 1.3 cycles of concentration. This would produce about 37 mgd of water at 31 ppt (intake = 24 ppt). For either source, the evaporation rate is about 11 mgd maximum.

Cooling water is continuously treated as necessary to adjust pH in order to limit scale formation. Organic phosphates are also added to inhibit scale. It has been common practice to add higher phosphates and metals to prevent corrosion, but this is not planned because EPA does not allow any discharge of corrosion inhibitors. In order to control bacterial, fungal, and algal growth, and to prevent fouling by invertebrates, biocides are added to the cooling water.

9.4.7.2 BIOCIDE TREATMENT SYSTEMS

The usual biocide for prevention of fouling is chlorine gas or hypochlorite. Shock treatment has been in common use and is now required by EPA in preference to continuous treatment. Discharge limit is an average of 0.2 ppm for no more than 2 hours per day (40 CFR 423.15 i and j).

Chlorine is highly toxic, but a summary of all available data suggests that 0.2 ppm is generally safe (Becker and Thatcher, 1973). As with all toxins, some species are much more sensitive to chlorine and are killed by considerably lower concentrations. Carpenter, et al. (1972) found that chlorine added at 0.1 ppm to cooling water intake with undetectable concentrations (<0.05 ppm) at discharge, reduced phytoplankton productivity in the discharge by 79 percent. There is some suggestion that this is just a temporary lag in growth (Hirayama and Hirano, 1970); still, concentrations should be kept as low as possible. More recently, Toetz, et al. (1977) found that even at the very low initial concentration of 0.028 ppm (and actual exposure therefore less), chlorine depressed by 50 percent the nitrate uptake by phytoplankton.

However, these demonstrations are all of short-term effects. From laboratory experiment models of chlorination effects on marine phytoplankton, Goldman and Davidson (1977) concluded that chlorine toxicity is a function of biomass and that ". . . phytoplankton not killed by chlorination are capable of renewed growth once recovered, with no apparent permanent effects on growth rates." (species was Phaeodactylum tricornutum). Probably the most serious potential effect of chlorination arises from the still unknown fate and toxicity of organochlorine compounds.

Adding chlorine during the day might minimize effects, because ultraviolet speeds chlorine breakdown in sea water (Hostgaard-Jensen, et al., 1977). The effects of these bromine compounds and the effects generally of chlorination on marine ecosystems are almost completely unknown. The

best available guide for residual chlorine remains the data of Brungs (1973--fresh water) and Becker and Thatcher (1973), cited above.

Chlorine can be chemically reduced by adding sodium bisulfate or sulfur dioxide, but the additions must be carefully gauged to avoid overcompensation and a new pollution problem. Such treatment is seldom performed, both because of the expense and because chlorine concentrations are usually low enough to be presumed safe and meet EPA requirements.

Ozone has been used in place of chlorine for disinfection and sterilization, but there is little experience with it in this country. It is a powerful oxident sometimes used as sewage biocide. Even with the high organic content of sewage, 3.5 ppm ozone for 20 minutes gives essentially complete kill (Bollyky and Siegel, 1977). Presumably the only byproduct is dissolved oxygen. The O_3 can be electrically generated as needed, so that the hazards of transport are less than with chlorine. However, ozone treatment may be more expensive than chlorine treatment. The concentrations used by Bollyky and Siegel (1977) were lower than previously thought effective, but cost data were not given. If the cost differential is small and if there are no detrimental side effects, ozone treatment should receive serious consideration.

Other methods of fighting fouling include osmotic shock, heating and drying of tubes, continuously running sponge rubber balls through the tubes, and antifouling paints. All of these have been tried, but are usually less effective than chlorination. However, some plants in

the United States have found that the sponge rubber balls alone provide adequate cleaning. Environmentally, this would be the preferred cleaning method, because no biocides would be used. There is also an advantage in that balls with abrasive bands can be used to scrape scale from condenser tubes. However, the initial costs are relatively high, and the U.S. EPA estimates that the investment is not repaid unless other methods cannot achieve 80 percent cleanliness of tubes. Usually, other methods can maintain 95 percent cleanliness. If Lake Rousseau water were used for cooling, such a physical cleaning method might be justified by the potential of Corbicula fouling.

Toxins such as acrolein have been suggested as a slimicide. Normal dosage is approximately 0.2 to 1.0 ppm, but shock treatments of 3.0 to 5.0 ppm are sometimes used. Acrolein is highly flammable and quite toxic to mammals. Thiocyanates are effective against many micro-organisms, and methylene-bis-thiocyanate is especially attractive because it supposedly is rendered harmless after 1 hour at pH 8. It would be an especially well-suited possibility in this situation with fresh water emptied into sea water.

Another potent biocide, 2,2-dibromo-3-nitrolo propionamide (DBNPA), would also hydrolyze rapidly in sea water. Its half-life is only two hours at pH 8, and rapidly decreases to only 2.5 seconds at pH 11.

Other biocides sometimes used include mixtures of chlorinated phenols. Toxicities of these compounds vary widely not only because of species

differences, but also because of antagonistic and synergistic interactions with other substances. Even well below toxic levels, these phenols will give a disagreeable taste to the flesh of fish.

In summary, the best antifouling treatments from an environmental standpoint are the sponge rubber balls, which involve no biocides, and ozone, which leaves only dissolved oxygen. Unfortunately, the physical method is rather expensive and not always adequate by itself. Ozone has been used in some sewage plants, but apparently never by power plants. It is thought to be rather expensive, but no cost data are available.

Chlorine is effective, inexpensive, and very widely used. During long use, no obvious great environmental detriment has become apparent, although some recent research finds large effects from very low concentrations. Residual chlorine could be reduced with SO_2 or sodium bisulfate before discharge, although there is a danger of over-treatment and a new pollutant. Chlorine would seem to be the favored treatment, unless ozone becomes financially feasible.

Of the other biocides, DBNPA and methylene-bis-thiocyanate seem most promising for use at Crystal River because they are rapidly inactivated at the pH of sea water. However, no data are presently available on breakdown products or their effects.

9.4.7.3 DISCHARGE TO SEA

Blowdown from cooling towers could be discharged into the existing canal carrying once-through sea water from the three power plants presently on the site. This 1.5-mile long discharge canal carries 1,987 mgd. Added materials therefore would be diluted and mixed well before reaching open coastal waters. Cooling towers using salt water, which produce the maximum increase in salt load, would add the salt from 11 mgd of sea water to the canal. Thus, 1,987 mgd + 37 mgd would have the salt content of 1,987 + 48 mgd, a salinity increase of 0.54 percent from about 24 ppt to 24.13 ppt. This is substantially below the limits of any detectable salinity effect on ecosystems. Blowdown would be drawn from the cool side of the cooling tower, so that there would be no temperature increase relative to the present discharge.

9.4.7.4 DISCHARGE VIA INJECTION WELLS

This alternative is expensive compared to surface discharge, and there is no reason to dispose of water resources in this way when other discharge methods appear acceptable. According to the EPA Administrator's Decision Statement 110.5, before using injection wells all alternatives must be explored and found less satisfactory with regard to environmental protection. This is not the case here, for discharge of blowdown to the sea appears to offer little potential for harm. Furthermore, new state laws in response to Section C of the Safe Drinking Water Act (PL 93-523) should be pending.

9.4.7.5 ZERO DISCHARGE

Techniques are available whereby part of the circulating water is continually desalinated and recirculated. All water received is evaporated off, with only salts to dispose of. Costs run approximately $1.00 per 1,000 gallons for electrodialysis or reverse osmosis, totalling at least $328,000 per year for freshwater sources (0.9 mgd desalinated).

The volume of water saved would be extremely small compared to freshwater resources of the region, and would not justify the expense of zero discharge. Environmental effects of discharge can be minimal, and zero discharge appears not to be cost-effective.

Alternatively, the blowdown could be recirculated to other uses where water quality is not very critical. However, such use is limited to sluice water for ash transport, involving only 0.07 mgd.

9.4.7.6 CONCLUSIONS

The best method of disposal appears to be via the existing seawater discharge canal. Salinity increments after dilution would be less than 0.2 ppt. The only other additions would be chlorine, a low level of organic phosphate (scale retardant) and a pH lower than sea water. The levels of these will be low so that they will constitute very small increments to existing discharge.

Zero discharge significantly increases costs without noticeable savings to either the coastal ecosystem or regional water resources. It is thus

not cost-effective. Local surface and ground water resources are large and currently little used. Some of the blowdown probably will be used in ash handling, but this would be a small portion of total discharge.

9.5 ATMOSPHERIC POLLUTION CONTROL SYSTEM ALTERNATIVES

9.5.1 REQUIREMENTS

The immediate increased use of coal in conventionally-fired boilers is an integral part of any national energy scenario through the year 2000. There can be a substantial impact upon the public health and welfare due to as much as a six-fold increase in coal-fired generation (Balzhiser, 1977). Therefore, the increased use of coal-fired boilers will necessitate improvement of emission control technology.

As of the present time, New Source Performance Standards (NSPS) have been promulgated for emissions of sulfur dioxide, nitrogen oxides, and particulate emanating from coal-fired power generation units. Values of the NSPS in effect as well as tighter standards are being considered for the future. Interest in fine particulate matter, sulfates, trace elements, and polycyclics is increasing.

The constraints presented by energy crisis and the NSPS have impelled the development of advanced energy generation systems and novel pollution control methods. Some of the more progressive energy schemes employ simultaneous pollutant removal techniques.

Most alternative energy production and emission control methods are now in various stages of research and development. All are characterized by uncertainties in capital requirements, operating costs, and performance. EPRI has performed comparative analyses for energy and pollutant control options for which design data is available (Balzhiser, 1977).

Of interest in this study is the category of direct-fuel utilization. Low sulfur coal is considered to be the option which offers the lowest combined costs and presents the fewest uncertainties in terms of stage of technical development and performance. For this reason, utility companies choose to burn low sulfur coal in conventionally fired boilers when that alternative is available.

9.5.1.1 LOW SULFUR COAL

Low sulfur coal can be obtained by the development of exploitation of naturally occurring coal deposits in the Eastern and Western United States. It can also be obtained by the beneficiation and refinement of higher sulfur coals.

9.5.1.2 NATURALLY OCCURRING LOW SULFUR COAL

Low sulfur Eastern and Western coals which, when burned, emit less than 1.2 pounds of sulfur dioxide per million Btus of heat input, meet new plant emission standards and most State Implementation Plan (SIP) limits (CTAB, 1975).

In the East, certain low sulfur coals are generally reserved for the domestic steel industry or for exporting. However, seams of low sulfur coal considered to have limited metallurgical value are available at premium prices.

In the West, development of low sulfur coal is inhibited by limited water resources, transportation problems, and the environmental effects of strip mining.

Most of the Western reserves underlie federally owned lands. Plans to lease government owned areas to mining companies have been frustrated by opposition on the grounds that the National Environmental Policy Act (NEPA) requirements for an Environmental Impact Statement (EIS) have not been fulfilled (Balzhiser, 1977).

The prospects are encouraging for obtaining low sulfur coal if it is mined (U.S. Department of the Interior, Bureau of Mines, 1975). Much of the Western coal, however, is of sub-bituminous grade and is of lower heat content and contains a higher ash than Eastern coals.

9.5.2 SULFUR DIOXIDE CONTROL ALTERNATIVES

Sulfur dioxide control alternatives may be categorized as follows:

1. Burning of low sulfur coal, whether naturally occurring or upgraded.
2. Removal of sulfur dioxide from the flue gas. Flue gas desulfurization can be accomplished through non-resource recovery methods or by regenerative processes.
3. Removal of sulfur dioxide at the combustion stage.

Roughly half of the recoverable coal from Montana and Wyoming can meet the present NSPS without desulfurization of any kind. Of the portion which would cause emissions greater than allowed by the NSPS, most would require treatment levels between 1 percent and 40 percent (Figure 9.5.2-1). If the stringent standards in Balzhiser (1977) are adopted, over 75 percent of all Montana and Wyoming coal will require desulfurization.

The above analysis discusses mainly Western coal. Eastern coal will be discussed in a subsequent chapter. Undoubtedly, what happens with respect to Western coal mining will affect the Eastern price structure and electric utility decision making.

At the present time, low sulfur fuel is considered to be the best sulfur control alternative if it can be obtained, due to the following reasons:

1. Lower costs;
2. Less uncertainty in technology;

STATISTICAL DISTRIBUTION OF PERCENT CONTROLS REQUIRED FOR ALL RECOVERABLE RESOURCES IN MONTANA AND WYOMING

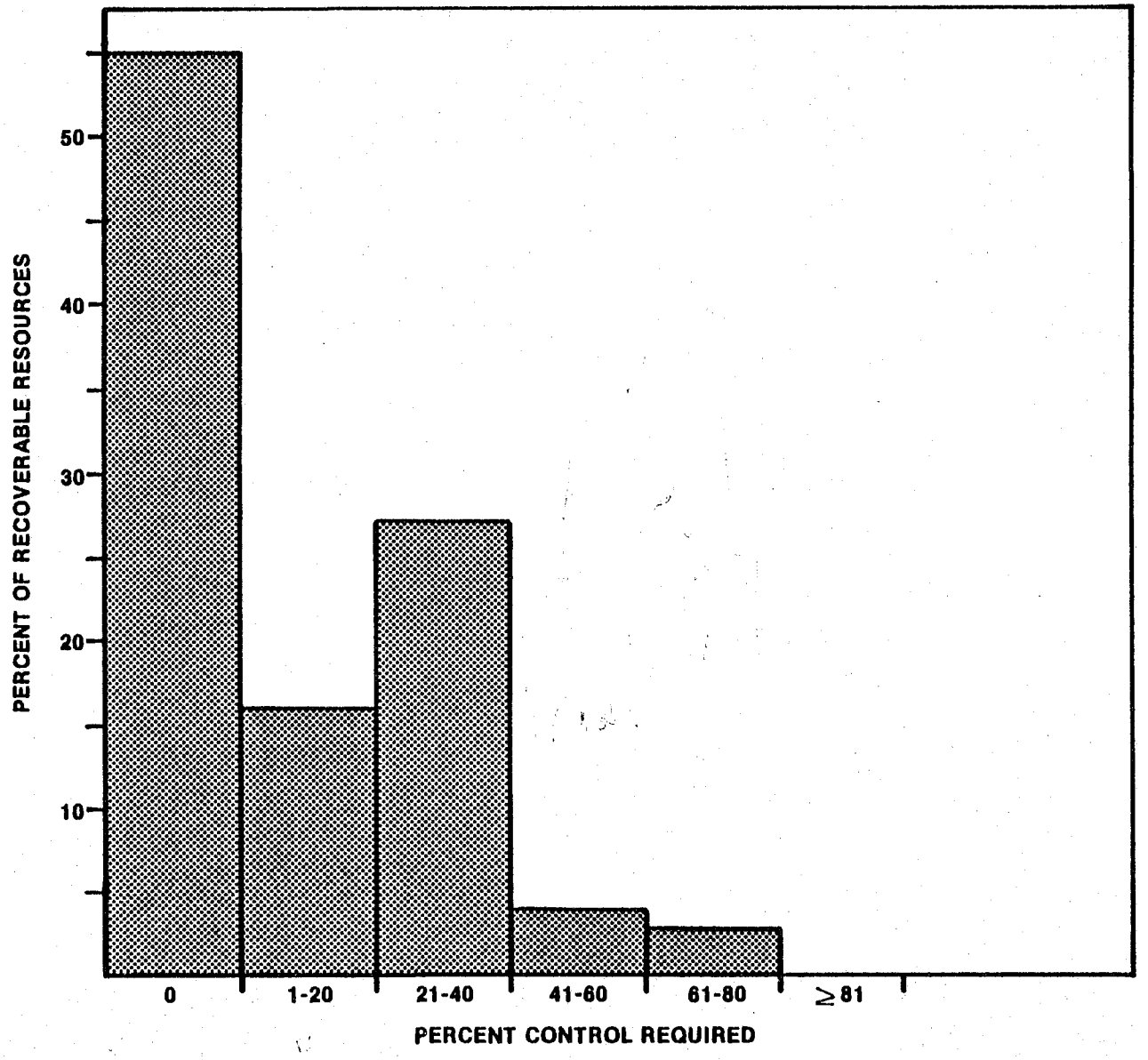


FIGURE 9.5.2-1

SOURCE: RENNE, 1976

3. It works;
4. It does not preclude future control alternatives should low sulfur fuel become scarce; and
5. It allows utilities more time to study the problems at other facilities before committing to a specific positive control alternative.

9.5.2.1 COAL BENEFICIATION

When low sulfur coal is not available, a significant amount of high sulfur coal can be beneficiated in order to meet the NSPS requirements. The only widely used method for treating coal to reduce its sulfur content is known as the sink-float method. This alternative is feasible when a large portion of the sulfur is present as iron pyrite.

Where organic sulfur is high (such as in northern West Virginia and Western Pennslyvania coals), the float-sink method does not reduce sulfur sufficiently to meet NSPS.

If applicable, beneficiation is the least costly sulfur dioxide control. It requires the lowest investment by a utility and displaces a substantial portion of the ash at the utility site to the mine site as refuse (CTAB, 1975).

According to the CTAB report, coal beneficiaton in conjunction with FGD is the "most economical best all around choice" for meeting the NSPS

quickly. In the report named above, it was assumed that lime/limestone FGD is reliable and available.

Capital and operating costs for various cases are shown in Tables 9.5.2-1 and 9.5.2-2, respectively. The desirability of using either naturally occurring low sulfur coal and beneficiated coal, when possible, is clearly indicated.

Assumptions in the foregoing discussion were that regenerative processes were not available for immediate use on a large scale, and that advanced power generating systems will not be available in the immediate future.

An estimated 13 percent of the United States coal reserves can meet the present NSPS. With coal beneficiation, approximately 28 percent of the coal reserves can meet the pollution criteria, and with chemical cleaning, 48 percent of the coal reserves become available without further treatment (Balzhiser, 1977).

9.5.2.2 SOLVENT REFINED COAL

Solvent refining is a method of chemically cleaning coal in order to remove the organic sulfur constituent. The most advanced process is one which includes a hydrogenation step. This generates a product of 16,000 Btus per pound from coal ranging between 8,000 and 12,000 Btus per pound (Balzhiser, 1977). The material produced is chemically and physically different from coal, but preliminary combustion tests indicate that it will be a suitable boiler fuel and meet the current NSPS. While claims

Table 9.5.2-1 Capital Costs for Commercially Available Continous SO_x Control Technologies ($/kw).[a]

Control Technology		To the Utility	To the Coal Producer
Lime/limestone FGD	FGD Units	$54-69	
	Sludge Disposal	$10-50[b]	
	Total	$64-119	
Lime/limestone FGD with high coal beneficiation	FGD Units	$36-49	
	Sludge Disposal	$ 3-14[b]	$16-23
	Total	$39-63	
Lime/limestone FGD with moderate coal beneficiation	FGD Units	$42-54	
	Sludge Disposal	$ 4-20[b]	$7-11
	Total	$46-74	
Low sulfur coal[c]		$5-15	No increment for low over high sulfur coal
Coal beneficiation		Nil	$7-23

[a]Based on a new 1000 Mw plant using 3% sulfur Northern Appalachian Coal, meeting New Source Performance Standards.

[b]The utility may in some instances contract for sludge disposal, lowering its capital investment, while generally raising the operating cost.

[c]Coal meeting new source performance standards, i.e., 1.2 lb SO_x per million Btu.

Source: CTAB, 1975.

Table 9.5.2-2 Potential Capacities and Operating Costs of Commercially Available Continous SO_x Controls.

Control Technology	Lead Time (Years)	Potential Capacity by 1980	Increase In Generating Costs (Mills/kwh)
Low sulfur coal[a]	3-6	20,000-40,000 Mw	4-7
Coal benefication	3-4	200-300 million tons coal per year[b]	0.5-2
Lime/limestone FGD	4-7	45,000-55,000 Mw	4-6[c]
-OR-		-OR-	
Lime/limestone FGD With Lower Sulfur Coal	4-7	Somewhat more than 45,000-55,000 Mw for FGD alone	3-5[d]

[a]Coal meeting New Source Performance Standards, i.e., 1.2 lb SO_x per million Btu.

[b]Only a minor fraction of the product meets SO_x emission standards.

[c]Based on a new 1,000 Mw plant using 3% sulfur Northern Applachian Coal, and meeting New Source Performance Standards.

[d]Use of the combined strategy instead of FGD alone reduces the sludge disposal and FGD capacities needed, thus increasing the capacity available by 1980.

Source: CTAB, 1975.

are made that the economics look favorable, an in-depth analysis needs to be made regarding hydrogenation costs and hidden energy costs.

TRW, Batelle, and Atlantic Richfield companies are all developing chemical coal cleaning processes in which inorganic solvents are utilized. The Electric Power Research Institute (EPRI) is preparing to fund a project to combine organic and inorganic sulfur removal.

9.5.2.3 DYNAMIC EMISSION CONTROLS

Dynamic Emission Controls (DEC) are not built-in control methods, but rely upon the use of meteorological as well as ambient pollutant data as decision-making tools. Fuel and load switching are used to keep ambient emission standards from being violated.

Similarly, the use of tall stacks will effect significant reductions in ambient sulfur dioxide concentrations (Smith and Frankenberg, 1975).

The economics of DEC are very appealing, but it might be difficult to enforce their use. DEC is not now available to FPC as an alternative.

Tall stacks for control of pollutants do not provide for compliance with the NSPS. Also, limitations regarding stack height with respect to building height rule out this alternative.

9.5.2.4 HIGH SULFUR COAL--FLUE GAS DESULFURIZATION

Flue gas desulfurization (FGD) involves the removal of sulfur dioxide from the combustion gases by a positive control device. FGD processes are broken down into two major categories. They are:

1. Throwaway processes, where resource recovery is not practiced;
2. Regenerative processes, where the removal media is regenerated and the sulfur recovered.

There are cases where recovery is an economically marginal consideration in one location, but is very favorable somewhere else.

Throwaway Processes

Throwaway processes are characterized by the use of either lime or limestone to remove sulfur at various points within the process. Several methods can be used. They are:

1. Use of lime or limestone slurry in a scrubber;
2. Use of lime to causticize an alkaline scrubbing solution while removing sulfur;
3. Injection of lime or limestone directly into the furnace;
4. Fluidized Bed Combustion (FBC), which is in the developmental stage.

Several other methods can be used, including use of Nahcolite ore and bag filters (Genco, et al., 1975), but are at the pilot plant stage.

Wet Lime/Limestone Scrubbing

Lime and limestone FGD processes can chemically remove as much as 90 percent of the sulfur oxides from power plant flue gases by reaction

with a slurry of lime or limestone in a scrubber. Heavy concentration of industries, and the market for gypsum, have resulted in a large number of successful commercial applications in Japan. The U.S. EPA, in 1971, felt that FGD processes, particularly lime and limestone scrubbing, were commercially feasible in the United States. Table 9.5.2-3 is a summary of the operational and planned installations employing FGD. There are more units on the list which use wet lime/ limestone scrubbing than any other technique.

In the United States, wet lime/limestone scrubbing is a throwaway process, producing a sulfite/sulfate sludge which must be disposed. In Japan, a further oxidation step is employed and quality gypsum is produced.

The results of commercial applications in the United States are mixed. Lime scrubbing is practiced at Duquesne Light Company's Elrama and Phillips Power Stations. Problems enumerated have included (Pernick and Knight, 1976):

1. Deposit accumulation in spray nozzles;
2. Corrosion/erosion problems with recycle pumps;
3. Deposits in scrubber vessel in venturi throat dampers, lower cone and elsewhere;
4. Unacceptable reliability; and
5. Duct deterioration.

Table 9.5.2-3 Number and Total Mw of FGD Systems

Status	No. of Units	Mw
Operational		
Active	23	4,693
Inactive	5	605
Under construction	18	6,171
Planning		
Contract awarded	10	3,761
Letter of intent	8	2,325
Requesting/evaluating bids	5	2,577
Considering FGD systems	46	24,007
Total	115	44,139

The company is now using magnesium oxide modified lime in order to improve performance, thus adding to costs and to sludge disposal problems.

With the problems which can occur, many utilities still consider lime/limestone FDG to be in the development stage.

Because the U.S. EPA approves of FGD, and because FGD has demonstrated success outside the United States, utilities have searched hard for ways to make FGD work. These include (Beychok, 1974):

1. Having redundant units on hand as "spares" to avoid outages;
2. Liberal use of standby pumps, centrifuges, and other rotating machinery;
3. Employment of experienced chemical staff to operate what are esentially chemical processes; and
4. Planning and staffing for aggressive corrective maintenance during the startup of a major new unit.

In the previously mentioned study by the CTAB (1975), lime/limestone FGD was considered to be commercially available. The costs are shown in Tables 9.5.2-1 and 9.5.2-2. Capital costs are substantial and operating costs are close to those resulting from use of low sulfur coal. Total annual cost (which includes cost of capital) would be greater for lime/limestone FGD than for low sulfur coal. The lead time is longer than for low sulfur coal. The Applicant's position on FGD is presented in Section 8.4.3.

In order to meet the immediate needs of sulfur dioxide control on a national scale, the CTAB recommended a combination of coal beneficiation coupled with lime/limestone FGD.

Double Alkali Scrubbing

The double alkali process, which has several variations, involves scrubbing flue gas with a soluble alkali such as sodium hydroxide, ammonia, or sodium sulfite, and regenerating the absorbent with an insoluble alkali such as lime. The double alkali process has the potential advantage of soluble alkali scrubbing with limited scaling, plugging, and erosion problems (Marten, 1977).

As in the case of lime/limestone scrubbing, most of the proven experience lies with Japanese installations. Nippon Kokan K.K., Showa Denko, and Kureha Chemical successfully demonstrated on a commercial scale before 1974 that double alkali scrubbing worked (Beychok, 1974).

In the United States, the process is at the research and development stage. Utah Power and Light's 100 Mw Unit 3 (Gadsby Station) was fitted with a pilot scale sodium hydroxide/lime process in 1971. A 20 Mw prototype double alkali system was operated between February, 1975, and July, 1976, at Gulf Power's Scholz Number 1 plant in Chattahoochee, Florida (Marten, 1977).

Government funded research is being conducted by the Bechtel Corporation at TVA's Shawnee Power Station, Paducah, Kentucky. Test results on

parallel venturi scrubber/turbulent contact absorber installations (10 Mw each) are promising. Lime and limestone are being used for the second step (EPA, 1976).

Limestone Addition

The injection of limestone into the furnace as a sulfur removal method was practiced at Kansas City Power and Light's Hawthorne and Lawrence Stations. The method was advocated by Combustion Engineering. Many problems, including sulfur dioxide removal efficiencies between 20 and 35 percent, have caused abandonment of this type of control.

Fluidized Bed Combustion

FBC is a modern outgrowth of limestone addition. Sulfur is captured by the limestone and calcium sulfate is formed in a bed which is maintained at temperatures between 1600 and 1650°F (Balzhiser, 1977). ERDA, EPA, and EPRI are supporting research and development in Atmospheric Fluidize Bed Combustion (AFBC). Scale up of a modular unit to 100-200 Mw is expected in the early 1980's by ERDA in Morgantown, West Virginia.

Regnerative Processes

Regenerative processes are characterized by regeneration of the removal medium and by recovery of the sulfur. Lime/limestone scrubbing falls under this category when gypsum is produced. When chemicals or methods besides lime and limestone are used, economics always dictate regeneration/recovery.

The regenerable processes offer several advantages over the throwaway methods. These include (Murthy, et al., 1976):

1. There is no sludge or filter cake to dispose of;
2. Pure sulfur dioxide, sulfur, or sulfuric acid is produced; and
3. There are significantly reduced quantities of secondary waste streams.

The disadvantages are due to:

1. Up to 5 percent increased energy input for supplying reducing gases;
2. Higher investment and operating costs.

Most types of FGD processes are in the developmental stage.

One of the major problems plaguing many regenerative processes is the need for reducing agents such as hydrogen sulfide, hydrogen, carbon monoxide, and coal. Those FGD processes requiring a reducing gas or solid are listed in Table 9.5.2-4.

A status summary of regenerative processes is presented in Table 9.5.2-5. The list is by no means exhaustive, considering Japanese experience. The only feasible alternatives for FPC are:

1. Magnesium oxide scrubbing,
2. Catalytic oxidation,
3. Sodium sulfite scrubbing,
4. Sulfuric acid scrubbing.

Table 9.5.2-4. FGD Processes Which Require A Reducing Gas or Solid

Gas or Solid	Type of FGD Process
1. Hydrogen Sulfide for direct use in process	a. Citrate b. Stauffer c. Catalytic--IFP D. Westvaco
2. Hydrogen	a. Shell (SFGD) b. Alakalized alumina
3. Carbon Monoxide	a. Consol-aqueous potassium salts
4. Hydrogen Sulfide for Claus Plant[a]	a. Wellman-Lord b. Stone and Webster/Ionics c. Ammonia Scrubbing d. Bergbau-Forschung (if RESOX is not used) e. Shell
5. Coal (coke)	a. Foster Wheeler's RESOX process in FW-BF b. Al-ACP c. $MgSO_4$ regeneration (MgO process)

a. Note that concentrated SO_2 from processes 4(a) through 4(e) can be converted to sulfur by the RESOX process or the ASARCO-Phelps Dodge direct sulfur process.

Source: Murthy, 1976.

Table 9.5.2-5. Brief Status Summary on Regenerative Processes[a]

Process Name	Year, Installation Site, Vendor, Size, and Type of Boiler	Status
MgO scrubbing	1972, Mystic, Boston Edison, Chemico, 150 Mw, oil	Shut down since June, 1974
	1974, Dickerson, Potomac Electric, Chemico, 100 Mw, coal	Shut down since July, 1975
	1975?, Eddystone, Philadelphia Electric, UEC, 120 Mw, coal	Shut down for modification
Wellman-Lord	1975?, D.H. Mitchell, NIPSCO, Davy Powergas/ Allied Chemical, 115 Mw, coal	Under construction
Cat-Ox	1972, Wood River, Illinois Power Company, Monsanto, 110 Mw, coal	Shut down since 1974
Chiyoda CT-101	1975, Scholz power plant, Gulf Power Company, Chiyoda, 23 Mw, coal	Operating since June, 1975
Citrate[b]	1973, Pfizer's Vigo Chemical Complex, McKee/Peabody, 1 Mw slipstream coal	Shut down September, 1974, after data collection
Phosphate	1974, Norwalk Harbor Station, Connecticut Power and Light Company, Stauffer, 0.1 Mw, oil	Shut down June, 1974, after data collection

Table 9.5.2-5. Brief Status Summary on Regenerative Processes[a] (Continued)

Process Name	Year, Installation Site, Vendor, Size, and Type of Boiler	Status
Catalytic-IFP	No data in open literature	No data in open literature
Consol-potassium salts	1972, Cromby, Philadelphia Electric Company, Consol/Bechtel, 10 Mw, coal	Shut down since 1972 after data collection (a smaller plant, 1000 acfm was operated until 1975)
Al-ACP	1971, Mohave, So. California Edison, Al, 0.5 Mw, oil	Shut down 1972 after data collection on open-loop system
FW-BF	1975, Scholz power plant, Gulf Power Company, Foster Wheeler, 20 Mw, coal	Started commissioning January, 1975, many problems

Table 9.5.2-5. Brief Status Summary on Regenerative Processes[a] (Continued)

Process Name	Year, Installation Site, Vendor, Size, and Type of Boiler	Status
Westvaco	1970, Westvaco Research Center, Westvaco, 0.2 Mw, oil	Shut down 1974 after data collection
SFGD	1974, Big Bend Station, Tampa Electric, Shell, 0.6 Mw, slipstream, coal	Tests are in progress

a. Installations in the United States only are discussed in this table.

b. Extensive pilot plant studies on a lead smelter gas are being conducted by USBM Salt Lake City Metallurgy Research Center.

Source: Murthy, 1976.

Regenerative processes hold some promise in the future for Florida. The electric power industry can conceivably sell recovered sulfur, sulfur dioxide, or sulfuric acid to the phosphate industry, which in turn can use the product to acidulate phosphate rock for the production of fertilizer. The quantity of sulfur which electric companies can produce is on the order of magnitude of requirements of the phosphate industry.

Magnesium Oxide Scrubbing

This process was the first commercially demonstrated sulfur removal-regeneration process. It operates similarly to lime scrubbing with the exception that a slurry of magnesium oxide was used instead.

Spent magnesium sulfite/sulfate from the Boston Edison Mystic Station was transported to a regeneration plant in Rumford, Rhode Island. Sulfuric acid was produced and magnesium oxide was regenerated. The unit at Boston Edison was shut down in 1974 after the closing of the regeneration plant. Adoption of magnesium oxide scrubbing in Florida would require a central regenerating plant.

Catalytic Oxidation

Catalytic oxidation employs a vanadium pentoxide catalyst which converts sulfur dioxide to sulfur trioxide. A solution of sulfuric acid is the ultimate product. The process was demonstrated on a 110 Mw coal-fired unit at Illinois Power Company. At the time, the effort required to make the process work was not realized and the result was that

installation, though theoretically quite feasible, was shut down. It could probably work if sufficient funds are provided and the will to make it work exists (Murthy, 1976).

Sulfuric Acid Scrubbing

The Chiyoda CT-101 process employs dilute sulfuric acid scrubbing. Liming follows the scrubbing step and an oxidation step. The process has been employed successsfuly in many Japanese plants, including a 250 Mw unit. High quality gypsum is produced, therefore, the Japanese are very satisfied with it. Estimated investment for the process is $80 to $100 per kw (Murthy, 1976).

Gulf Power Company in Florida has installed this system at the Scholz Power Plant on a 23 Mw unit. Results have not been analyzed yet.

Sodium Sulfite Scrubbing

The Wellman-Lord process employs a sodium sulfite scrubbing solution. The resulting bisulfite liquor is thermally regenerated in an evaporator-crystallizer to yield sulfur dioxide and recycle sodium sulfite.

The process was demonstrated by MKK, Japan, before 1974 (Beychok, 1974). The sulfur product was concentrated sulfur dioxide.

The first demonstration in the United States is at the Northern Indiana Public Service Company (NIPSCO) on a 115 Mw coal-fired unit. The 85

percent sulfur dioxide from the Wellman-Lord generator feeds an Allied Chemical reduction process which yields greater than 99.5 percent pure sulfur. Capital costs are $117 per kw and the operating cost is 6.3 mills per kilowatt hour (Murthy, 1976). It is assumed that these include credit for the sulfur dioxide.

This process is possible in Florida, but not economically attractive.

9.5.3 PARTICULATE CONTROL ALTERNATIVES

Particulate control can be effected by the use of the following methods:

(1) Wet scrubbers,

(2) Fabric filters,

(3) Mechanical separators,

(4) Electrostatic precipitators.

Process controls such as the use of excess oxygen and the use of low ash coal can reduce particulate emissions, but not to the levels required by NSPS. Very often, as discussed previously, specification of low sulfur coal results in high ash coal (Western coals). Increased oxygen for more complete combustion will increase nitrogen oxides and sulfur trioxide conversion. It should not be required in a modern installation.

9.5.3.1 WET SCRUBBERS

Wet scrubbers remove dust by impaction and interception of particles onto fine water droplets. Their use has been limited in the past because of excessive energy consumption, large water volumes, required water treatment, and sludge disposal.

When used in conjunction with gas absorption and chemical reaction, scrubbers can be feasible particulate control devices. Tests conducted by Environmental Science and Engineering, Inc. (1973), on the magnesium oxide venturi scrubber at Boston Edison's Mystic Station indicated that 90 percent particulate removal can be accomplished during simultaneous sulfur dioxide removal. Tests conducted by EPA, however, (Statnick,

1975) indicate that for fine particles, the efficiencies can actually be negative. A collection efficiency of 92.5 percent was achieved on particles in the 3.1 micron range. However, in the 0.30 micron particle range, a collection efficiency of -100 percent was experienced. The probable reason given for the poor performance was failure of the mist eliminator.

Better results were obtained at TVA's Shawnee Wet Limestone Scrubbing Test Facility. Good total collection efficiencies were observed on the venturi scrubber (greater than 90 percent), however, the efficiency dropped markedly in the submicron range. In a Turbulent Contact Absorber (TCA), overall efficiencies of greater than 99 percent were observed. The collection efficiency of submicron particles was greater than 90 percent at a pressure of 10 inches.

Unless coupled with sulfur dioxide collection, scrubbers are uneconomic solutions to particulate control. Even with sulfur dioxide control, mist must be controlled to insure good performance.

9.5.3.2 FABRIC FILTERS

Fabric filter media, such as baghouses, operate on the principles of impaction, interception, and diffusion of particles onto a filter cake. Baghouses have demonstrated higher collection efficiencies than electrostatic precipitators, particularly in the submicron range (Balzhiser, 1977), but suffer from the following disadvantages:

(1) High maintenance costs, and

(2) Large spatial requirements.

At efficiencies of less than 99 percent, fabric filters are not competitive with electrostatic precipitators. However, efficiencies above 99 percent can be achieved with fabric filters and applications in congested areas may increase (Babcock and Wilcox, 1972).

9.5.3.3 MECHANICAL SEPARATORS

Mechanical separators such as cyclones depend upon centrifugal separation, and subsequent impaction, of particles from a gas stream. Particles of less than 10 microns are collected with efficiencies of less than 90 percent (Babcok and Wilcox, 1972). The use of mechanical collectors is possible only in conjunction with more sophisticated controls.

9.5.3.4 ELECTROSTATIC PRECIPITATORS

Electrostatic precipitators produce an electric charge on the particles to be collected, and then propel the charged particles by electrostatic forces to the collecting electrodes. The precipitator operation involves four basic steps (Babcock and Wilcox, 1972):

(1) An intense, discharging field is maintained between the discharge electrode and the collecting electrodes.

(2) The carrier gases are ionized by the intense, discharging field. These gas ions, in turn, charge the entrained particles.

(3) The negatively charged particles, still in the presence of an electrostatic field, are attracted to the positively (grounded) charged collecting electrodes.

(4) The collected dust is discharged by rapping into storage hoppers.

The collection efficiency of the electrostatic precipitator is related to the time of particle exposure to the electrostatic field, the strength of the field, and the resistivity of the dust particle. An efficiency of 99 percent is obtained at a cost generally favorable in comparison with other types of equipment. A very high percentage of particulate-removal units installed in commercial boiler plants since 1970 are electrostatic precipitators. Because of their inherent advantages in handling large volumes of flue gases with low pressure drop, efforts at EPRI and elsewhere are underway to improve their performance in the fine particulate range (Balzhiser, 1977).

9.5.4 NITROGEN OXIDES CONTROL ALTERNATIVES

Nitrogen oxides (NO_x) are formed by the oxidation of amine compounds in the fuel, or by conditions of high temperature, pressure, and oxygen concentrations during combustion.

The extent to which power plants contribute to total NO_x emissions can be discerned from Table 9.5.4-1. Coal-, oil-, and gas-fired units account for over half of the NO_x emission from stationary combustion sources, and over one-third of the NO_x emissions from all sources.

Table 9.5.4-1 Major Industrial Sources of NO_x Emissions

Rank	Source	Mass NO_x metric ton/yr	% emissions, stationary sources	% emissions, all sources
1.	Coal-fired steam utility generators	3,495,000	30.8	15.6
2.	Fuel-burning reciprocating engines	2,132,000	18.8	9.54
3.	Oil-fired industrial/commercial boilers	1,245,000	11.0	5.57
4.	Oil-fired steam utility generators	1,114,000	9.80	4.98
5.	Gas-fired steam utility generators	835,100	7.35	3.74
6.	Coal-fired industrial/commercial boilers	734,600	6.45	3.29
7.	Gas-fired industrial/commercial boilers	491,400	4.32	2.20
8.	Fuel-burning turbine engines	253,300	2.23	1.13
9.	Cement manufacture	91,310	0.803	0.408
10.	Industrial/commercial space heating	80,560	0.709	0.360
11.	Crude distillation of petroleum	69,640	0.613	0.312
12.	Glass manufacture	68,160	0.600	0.305
13.	Catalytic cracking of petroleum	60,730	0.534	0.272
14.	Coal refuse piles (and abandoned mines)	30,590	0.269	0.137
15.	Nitric acid manufacture	27,050	0.238	0.121
16.	Vacuum distillation of petroleum	25,100	0.221	0.112
17.	Ethylene manufacture	24,020	0.211	0.107
18.	Wood-waste incineration	23,960	0.211	0.107
19.	High-density polyethylene manufacture	13,930	0.123	0.0623
20.	Propylene manufacture	12,600	0.111	0.0563
21.	Benzene manufacture	10,770	0.0947	0.0482
22.	C_4 hydrocarbons manufacture	10,450	0.0919	.0467
23.	Brick kilns and dryers	8,680	0.0764	0.0388
24.	Mineral-wool manufacture	8,061	0.0709	0.0361
	Others	503,989	4.43	2.25
	TOTAL	11,370,000	100.17*	50.85

* Because of rounding.

SOURCE: Monsanto Research Corporation--Dayton Laboratory (Dayton, Ohio), "Source Assessment Overview Matrix," September 21, 1976: EPA contract no. 68-02-1874.

Control of nitrogen oxides from coal-fired units at the present time is accomplished by use of low nitrogen fuel or by modified combustion techniques. The status of current control technology is summarized in Table 9.5.4-2. It is interesting that flue gas recirculation is considered to be ineffective as an NO_x control method when applied at coal-fired units. Reduced combustion-air preheating and steam or water injection are considered to be noncompetitive in comparison with the other alternatives presented. The other control alternatives can be used separately or in combination to effect compliance with present day NO_x standards. They present no great problems from a technical point of view. In fact, Combustion Engineering guarantees that its equipment can meet the 0.6 pound NO_x per million BTUs that was expected in the summer of 1977 (Ricci, 1977). These units are almost identical to their older design furnaces, except the new units are larger, and have over-fire air.

In summary, no difficult decisions need to be made for NO_x control by the utility. Guarantees from manufacturers should suffice to insure that NO_x standards are met at the present time.

Table 9.5.4-2 Summary of Current NO_x Control Methods

Method	NO_x Reduction		
	Gas	Oil	Coal
Flue-gas recirculation	60%	20%	Not effective
Reduced combustion-air preheat	50%	40%	Not effective
Steam or water injection	60%	40%	Not effective
Staged combustion	55%	40%	40%
Low excess air	20%	20%	20%
Reduced heat-release rate	20%	20%	20%
Combined staging, low excess air, and reduced heat release	50%	35%	40%
Change to fuel with lower % N	Not effective	40%	20%

SOURCE: EPA report No. 650/2-74-066

9.6 SOLID WASTE DISPOSAL SYSTEM ALTERNATIVE

9.6.1 REQUIREMENTS

Coal-burning power plants produce large quantities of solid wastes. With increased use of coal in the future, impacts on solid waste production will also increase. The primary sources of solid wastes from coal-fired power plants are:

1. Bottom ash from furnace;
2. Fly ash from flue gas dust control equipment;
3. Sludge disposal from non-regenerative sulfur dioxide removal systems;
4. Coal pulverizer rejects.

Typical wastes quantities from coal fired plants are given in Table 9.6.1-1. Values are for 3 percent sulfur coal. Florida Power Corporation expects about half of the ash for the "No Control" case at Unit 4.

If beneficiated coal is used, a large portion of the waste disposal can be accomplished before the coal is received by mine disposal. The major point made in the table is that if only high sulfur coal is available at the mine, then coal beneficiation will provide the best option from a waste disposal point of view. If a substantial portion of the sulfur is of an organic nature, then moderate beneficiation followed by FGD will provide the second best option. The worst situation is no beneficiation, large scale FGD, and no regeneration. If gypsum can be produced

Table 9.6.1-1. Gross Surface Wastes for Commercially Continuous SO_x Emission Control Technologies*

	Limestone Requirements (tons/year)	Gross Wastes (tons/year) at the Utility		Gross Wastes (tons/year) at the Mine
		Ash	Sludge	Coal Refuse
No Controls † (for comparison)		600,000		
Coal Beneficiation † (highest level for comparison)		165,000		720,000
Lime FGD (alone)	230,000	600,000	500,000	
Lime FGD (with moderate coal beneficiation)	100,000	220,000	240,000	500,000
Lime FGD (with high level coal beneficiation)	66,000	165,000	155,000	720,000

* Based on a new 1000 Mw plant using 3 percent sulfur Northern Appalachian coal, meeting New Source Performance Standards.

† Does not meet New Source Performance Standards.

SOURCE: Commerce Technical Advisory Board (CTAB), 1975.

as a by-product, then the disposal requirements are similar to the "No Control" case.

Disposal of coal ash has been accomplished throughout the years by ponding or landfilling. Now, however, there is concern about leaching, and the advent of soluble FGD wastes causes even more concern. Therefore, disposal methods must be selected which protect the integrity of streams, ground water, and other aquatic systems.

9.6.2 BOTTOM ASH DISPOSAL

Bottom ash here is considered to be furnace slag. The material is relatively insoluble and usually poses no disposal problems. Slag can be disposed of as landfill or sold as road base material, granular material for roofing, aggregate for use in concrete blocks and preformed concrete, asphalt mix material, insulation, and grit for sandblasting (Babcock and Wilcox, 1977).

The market conditions for the sale of ash cannot be foreseen at the present time; therefore, plans are to dispose of it by on-site landfill. The alternatives in disposal techniques are conveyor belt transport or truck transport. Economically, it has been determined that conveyor transport is the best alternative.

9.6.3 FLY ASH DISPOSAL

The possibility of selling fly ash exists. Fly ash can also be landfilled. Alternatives are designed to prevent dispersal of the fly ash

in transport to the disposal site. Dustless unloaders and wetting methods can be used to alleviate fly ash dispersal.

9.6.4 SCRUBBER WASTE SOLIDS DISPOSAL

If a FGD system is used, there is a potential for the generation of tremendous quantities of solid waste. Assuming that limestone or lime scrubbing is used, then the alternatives are sludge treatment followed by disposal or byproduct generation. "Options relating to sludge disposal entail large trade-offs in capital vs. operating costs. The broad range of capital required depends on the variability in the price and location of land for disposal, on the disposal method chosen, and on whether the utility chooses to contract with an outside organization for sludge disposal" (CTAB, 1975).

Alternative methods for byproduct generation have existed for years and more are being developed. Market conditions are important considerations before decisions can be made to manufacture gypsum from sludge. So far it has proved attractive only in Japan, where there is little disposal space and a high demand for gypsum.

Extensive research is being conducted to determine the ramifications of FGD waste treatment methods (Jones, 1977). Overall, the alternatives are:

1. Pond disposal;
2. Landfill disposal;
3. Mine disposal;

4. Ocean disposal;

5. Gypsum production.

9.6.4.1 POND DISPOSAL

The material in FGD sludge does not settle easily, and is high in soluble compounds and COD. Ponding is possible if an impervious liner of clay or synthetic material is used to separate the sludge from ground water.

The problem with pond disposal is that ultimately the area must be reclaimed. Pond settling of untreated FGD sludge typically results in a concentrated slurry of less than 50 percent solids (Princiotta, 1975) which exhibits highly liquid behavior. Further dewatering to about 65-70 percent solids is required before physical stability is attained, and optimum compaction is achieved at about 80 percent solids (Rossoff, et al., 1974).

The wastes are very difficult to pump when there are more than 50 percent solids (Rossoff and Rossi, 1974). Since the pond is used as the primary dewatering mechanism, only those approaches that would greatly improve settling properties of the solids are applicable. Examples include: process modifications to increase the size of the sulfite crystals, oxidation to produce gypsum, and chemical treatment (Jones, 1977).

The Aerospace Corporation (Rossoff, et al., 1974) has established ponding costs varying from $5.50 and $10 per metric ton of dry solids, excluding pond reclamation costs.

9.6.4.2 LANDFILL DISPOSAL

The procedures for landfill disposal are similar to those for pond reclamation. Therefore, the sludge must be of a consistency that settles and thickens easily. The Duquesne Light Company has experimented with a fixing agent followed by a thickening operation. According to a report, the final product is excellent for landfilling (Pernick, 1977). Many other candidate fixing agents are being studied (EPA, 1976).

The problems are ameliorated somewhat if low sulfur Western coal is used, because more of the sludge is in the sulfate (gypsum) form (Jones, 1977).

9.6.4.3 MINE DISPOSAL

Mine disposal of FGD wastes is logical in that coal cars leave empty from power plants after coal delivery. The major problems arise because of possible leaching of these wastes from the mine site. Certain types of mines in various locations do hold promise and are being investigated for their suitability in handling sludge by the Radian Corporation (U.S. Bureau of Mines Contract S0144135) and Arthur D. Little, Inc. (EPA Contract 68-03-2334).

9.6.4.4 OCEAN DISPOSAL

While ocean disposal is a possibility, many problems are indicated (Jones, 1977):

1. Ocean floor sedimentation;
2. Suspended solids;
3. Sulfate rich, high COD wastes;
4. Trace contaminants.

Several options are open which appear promising. These are:

1. Dispersed disposal of sulfate-rich FGD wastes on the Continental Shelf.
2. Concentrated disposal of treated, brick-like FGD wastes on the Continental Shelf.
3. Dispersed disposal of sulfate-rich FGD wastes in the deep ocean.
4. Concentrated disposal of both sulfate-rich and treated FGD wastes in the deep ocean (Jones, 1974).

No doubt permits would be required, as well as environmental impact statements, before this alternative can be considered viable.

9.6.4.5 GYPSUM PRODUCTION

The prevailing attitude in the United States automatically ties FGD, by lime and limestone scrubbing, to sludge formation with insurmountable disposal problems. In Japan, a simple oxidation step makes it possible to produce dry gypsum, which is sold as a byproduct (Beychok, 1974).

Processes developed by Chiyoda, Mitsubishi, Nippon K.K., Show Dneko, and Kureha Chemical were in use in Japan as of 1974 for gypsum production.

In the sludge disposal problems discussed previously, the solutions were very often based upon the use of fixing agents, thickening, and even oxidation, to produce calcium sulfate. Probably by the time all costs are considered, including fixing and pond reclamation in the disposal alternatives, the revenues from gypsum production can offset the added cost of its production. Thus, in the long run, it might be the best all-around solution for the disposal of FGD slurry.

Gulf Power Corporation has employed a dilute sulfuric acid scrubbing process [Chujoda (T-101)] at its Scholz Generation Station in Chattahochee, Florida. Gypsum is produced as a by-product. Their costs should be analyzed as well as the marketability of the gypsum produced.

Gypsum production is a feasible alternative which has not been greatly promoted by EPA or the power industry so far. The economics have not yet made it appear attractive. However, new attention given to the environmental problems of sludge disposal, and the costs of fixing agents and thickening, may cause both groups to give this alternative a higher priority.

9.7 TRANSMISSION FACILITIES ALTERNATIVES

9.7.1 EXISTING FACILITIES

The Crystal River site presently is served by two 500 kv transmission lines and four 230 kv transmission lines, all of which enter the site from the east. There is one 500 kv substation and one 230 kv substation.

The 500 kv substation is a three position ring bus arrangement with one transmission line exiting north (Crystal River, Central Florida), one transmission line exiting east, and one nuclear generation tie exiting south. The 230 kv substation consists of a four bay breaker and one-half arrangement with four transmission lines exiting north (double circuit Curlew Line, and double circuit Central Florida Line), two fossil-fuel generation ties exiting south, and two reserve auxiliary ties exiting south (one to fossil-fuel generation--Crystal River Units 1 and 2, and one to nuclear generation--Crystal River Unit 3). The substations are located so that all of the tie lines to existing power generation units are 600 feet (180 meters) in length or less.

9.7.2 FUTURE REQUIREMENTS

The proposed addition of two 640 Mw units at the Crystal River site will not require construction of any new transmission corridors, substations, or transmission lines other than ties to the existing substation. Transmission planning has been based on the assumption that the first of the new generation units would be connected to the 230 kv substation and

the second unit to the 500 kv substation. There would be one 230 kv reserve auxiliary transformer for the two new coal-fired units. The addition of these units would require the lines and some expansion of the existing substation facilities.

9.7.3 ALTERNATIVE TRANSMISSION SYSTEMS

The relevant criteria when evaluating alternative transmission systems in this case were that the length of the lines should be minimized, environmentally sensitive areas should be avoided, and transmission line crossings should be minimized for reasons of safety. Four transmission alternatives have been considered, corresponding to the four potential sitings of the power generating units.

Under the first alternative, serving Plant Site 1 with cooling tower, the tie lines would extend south from the power generation units, then would part and head east to the two substations. Both would exceed 3,000 feet (910 meters) in length. The line to the 500 kv substation would necessarily cross all four of the existing 230 kv lines serving the Crystal River complex. Both of the tie lines would cross wetland areas due to the location of the power generating units within the present coastal marsh.

The second alternative, involving Plant Site 2 with cooling towers, would require a 1,500 foot (455 meter) tie extending east and northeast to the 230 kv substation, and a line approximately 1 mile (1,500 meters) long to the 500 kv substation. The latter would cross the existing

230 kv lines and would extend across a fragile wetland area. The third alternative would serve Plant Site 3, located southeast of the existing power generation units, and would require tie lines of 2,500 and 3,800 feet (760 meters and 1,150 meters, respectively). No power line crossings would be required in this case, and environmentally sensitive areas would not be affected.

The fourth alternative would involve Plant Site 1C, in which the power generation units would be located directly north of the 500 kv substation. The tie lines in this case would extend west and south and would have total lengths of 3,300 and 4,300 feet (1,000 and 1,300 meters). No major effects to the coastal forest will result, however, the line to the 500 kv substation would again have to cross the existing 230 kv lines.

9.8 PLANT LOCATON AND LAYOUT ALTERNATIVES AT THE PROPOSED SITE

9.8.1 PLANT LOCATION ALTERNATIVES

The six primary requirements which had to be satisfied in the plant site selection are as follows (from Black and Veatch, 1976).

1. The plant site shall be compatible with applicable laws, regulations, and environmental standards.
2. The plant site shall be located to be accessible to fuel supply, water supply, and electrical transmission lines.
3. The plant site shall be located to take advantage of the existing substations, roads, railroad trackage, cooling water system, and coal handling facilities.
4. The plant site shall be located to provide sufficient area for construction laydown.
5. The plant site shall be located so that it does not interfere with the operation of the existing units during plant construction.
6. The plant site shall be located and plant facilities arranged such that plant operations will not affect the safety and security of the nuclear plant (Crystal River Unit 3).

The principal element of the selection requirements was the physical space requirements and arrangements needed for each of the following major plant functional systems (from Black and Veatch, 1976).

1. Two 600 MW (net capacity) coal-fired steam generating units including office, maintenance, warehousing, and personnel facilities.

2. Flue gas emissions control systems including electrostatic precipitators and a separate chimney for each unit. Site planning included provisions for future SO_2 scrubbers.
3. Space allocation for closed cycle cooling systems incorporating round natural draft towers and associated underground piping systems for condenser cooling and cooling tower makeup and blowdown water.
4. Coal delivery and handling systems including facilities for both rail and ocean-barge delivery of coal, and for storing, processing, and conveying coal to the steam generating units.
5. Electrical transmission system to the existing plant substation complex. Site planning included allocation of space for transformers and for transmission lines to both the existing 500 kv and 230 kv substations. Future transmission lines leaving the substations would parallel the existing line corridor or will exit the site to the northeast.
6. Plant water treatment and storage systems including facilities for pretreatment, demineralization, and storage of plant systems makeup water and underground piping corridors for supply pipelines from an offsite well field.
7. Ash handling systems including facilities for collecting and holding ash prior to transport offsite or to onsite disposal areas.
8. Space for future installation of SO_2 scrubber additive receiving, storage, and preparation systems as well as

facilities to collect and prepare the process sludge for onsite disposal.

9. Ash disposal area suitable for disposal of ash and rejects materials produced by a four-unit station (two new units and existing Crystal River Units 1 and 2) for the life of the plant. The site layout would include provisions for expansion of the disposal area to accommodate disposal of sludges from future SO_2 scrubbers.

10. Wastewater systems including facilities for storage and treatment of plant system wastes.

11. Construction areas including materials laydown and subassembly work spaces, shop and personnel buildings, warehousing, and access roads.

12. Railroad trackage from the existing plant entrance track to serve construction areas and the coal train unloading facility.

9.8.2 ALTERNATIVE LOCATIONS DESCRIPTIONS

On the basis of the previously mentioned criteria, three locations on Florida Power Corporation's Crystal River property were identified as feasible site alternatives, Figure 9.8.2-1 (Site 1, Site 2, and Site 3). Subsequent concern over coastal wetlands and additional cost analysis lead to the evaluation of three additional variations of the Site 1 location. These three additional locations are as follows:

1. Plan 1a. Relocation of generation facilties about 240 feet east of the initial Site 1 location in order to move all facilities out of the coastal salt marsh.
2. Plan 1b. Relocation of generation facilities about 1,300 feet northeast of the Site 1 location, so that all facilities would be out of the salt marsh and impacts on the coastal wetland forest would be reduced.
3. Plan 1c. Relocation of generation facilities about 2,800 feet northeast of the Site 1 location, so that all facilities would be out of the coastal salt marsh and coastal wetland forest.

On the basis of reduced impact on wetland areas and lowest cost, Plan 1c was selected as the preferred variation, and was subjected to further analysis. It is identified as Site 1c throughout the rest of this section, and it is the preferred site location on the property.

As the generation facilities of the Site 1 location and alternative plans are moved east from the wetlands, a consequent reduction in available space occurs. Therefore, each of the variations, Plan 1a, 1b, 1c,

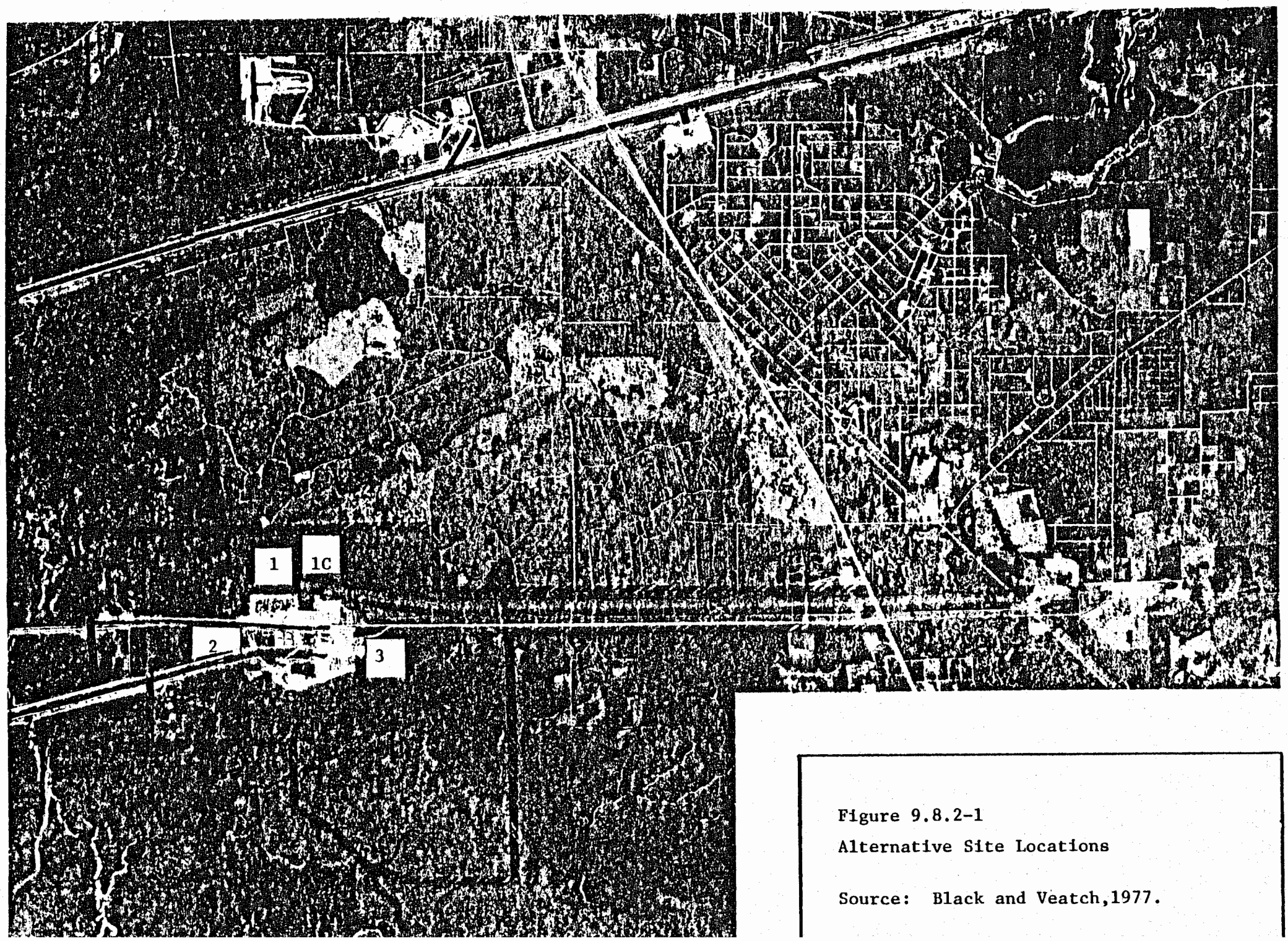


Figure 9.8.2-1

Alternative Site Locations

Source: Black and Veatch,1977.

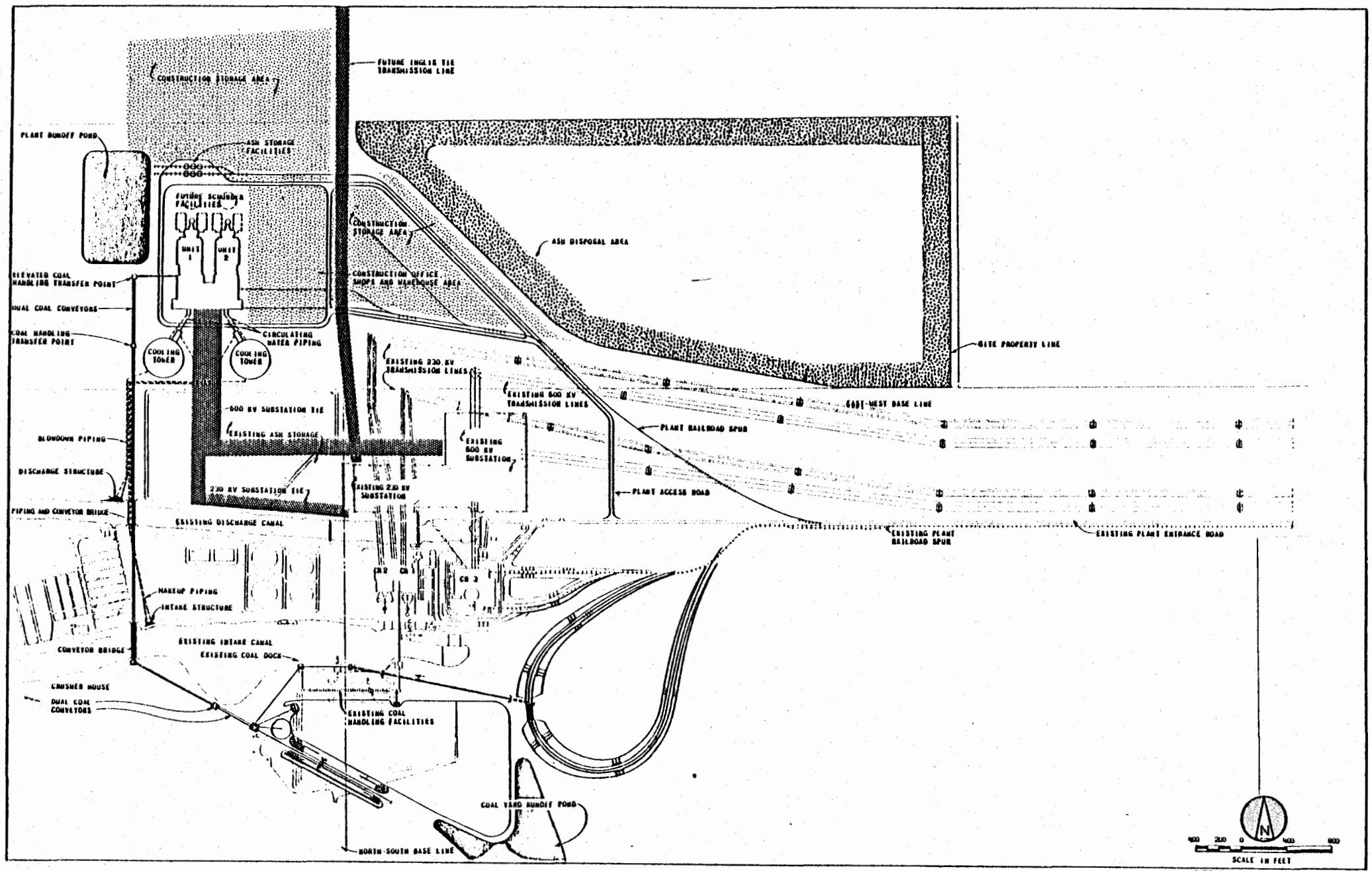
embodies a further reduction in the size of the ash and sludge storage area on-site.

Off-property site alternatives north (near the Cross Florida Barge Canal) and east (along the access road) of the existing units were also considered in the preliminary analysis. These sites were determined to be less desirable than the on-property sites because of an additional 8 to 10 million dollars in direct construction costs for a two-unit development (Black and Veatch, 1977). These costs include additional coal handling equipment, road and railroad construction, cooling system make-up and discharge pipelines and transmission ties to existing substations. Purchase costs of additonal site property (499 to 518 acres) would add to total costs.

Tables 9.8.2-1 through 9.8.2-2 list, respectively, major advantages and disadvantages of each site location, the site evaluation ratings of the consulting engineers, and a cost evaluation of the alternative sites.

9.8.2.1 SITE 1--DESCRIPTION, ADVANTAGES, AND DISADVANTAGES

Site 1 would be located to the north and west of the present ash disposal pond for the existing Crystal River Units 1 and 2 (Drawing 3-2, Black and Veatch, 1977). The generation facilities would be located approximately 2,000 feet northwest of Units 1 and 2, and the borrow pit/ash disposal area would be located to the north of the existing transmission lines. Additional coal storage facilities would be located immeditely west of the existing coal storage facility.



SITE I WITH NATURAL DRAFT COOLING TOWERS

DRAWING 3-2

Table 9.8.2-2 Alternative Locations Summary Matrix

Site	Costs (1,000's)	Access and Interference: Advantages	Access and Interference: Disadvantages	Security and Safety: Advantages	Security and Safety: Disadvantages
1	424,635	1. Most distant from existing plants. 2. Minimal interference to existing plants. 3. Excellent access to roads, railroad, transmission tie lines, and discharge canal.		1. Will not be potential fire/explosion hazard to nuclear unit. 2. Allows rapid employee exit from property. 3. Will not disrupt security of existing units.	
2	427,575		1. Access during construction difficult. 2. Access for delivery of operational materials difficult.		1. Increased difficulty of security on three-part site. 2. Poor employee exit from property.
3	420,490	1. Excellent access. 2. Minimal operational interference with existing units.	1. Some interference with existing units during construction.		1. Transmission tie line must cross coal handling facility. 2. Disruption of CR3 security during construction.
1C	422,427	1. Minimal interference with existing units. 2. Excellent access.		1. Minimal interference with existing security. 2. Excellent employee exit.	

Table 9.8.2-1 Alternative Locations Summary Matrix

Site	Costs (1,000's)	Location and Development		Environment	
		Advantages	Disadvantages	Advantages	Disadvantages
1	424,635	1. Near to ash/slush disposal area. 2. Isolated from neighbor lands. 3. Room for four-unit expansion. 4. Second nuclear unit possible.	1. Transmission tie towers in existing ash pond--pond management problems.		1. Location in coastal wetlands. 2. Higher runoff potential. 3. Elimination of storm buffer zone. 4. Aesthetic impact on Gulf side.
2	427,575	1. Short routing for makeup discharge pipe, coal conveyors, and transmission tie lines. 2. Isolated from neighbor lands.	1. Construction materials must cross discharge canal--delays and accidents.	1. Reduced displacement of natural systems.	1. Ash pond located in coastal wetlands. 2. High runoff potential. 3. Potential accidental release of contaminants to discharge canal.
3	420,490	1. Proximity to coal and ash disposal areas. 2. Isolated from neighbor lands.	1. Precludes second nuclear unit.		1. Location in coastal wetlands. 2. Aesthetic impact on Gulf side. 3. Runoff potential.
1C	422,427	1. Minimal routing for roads, transmission tie lines, and railroad. 2. Excellent constructability.	1. Proximity to neighbor lands. 2. Not enough ash storage space. 3. Reduced space for retention ponds. 4. Limited area for laydown area.	1. No disruption of coastal wetlands. 2. Least total wetlands disruption. 3. Retains visual buffer to Gulf. 4. Retains storm buffer zone.	1. Possibility of increased discharge due to lack of space for retention ponds.

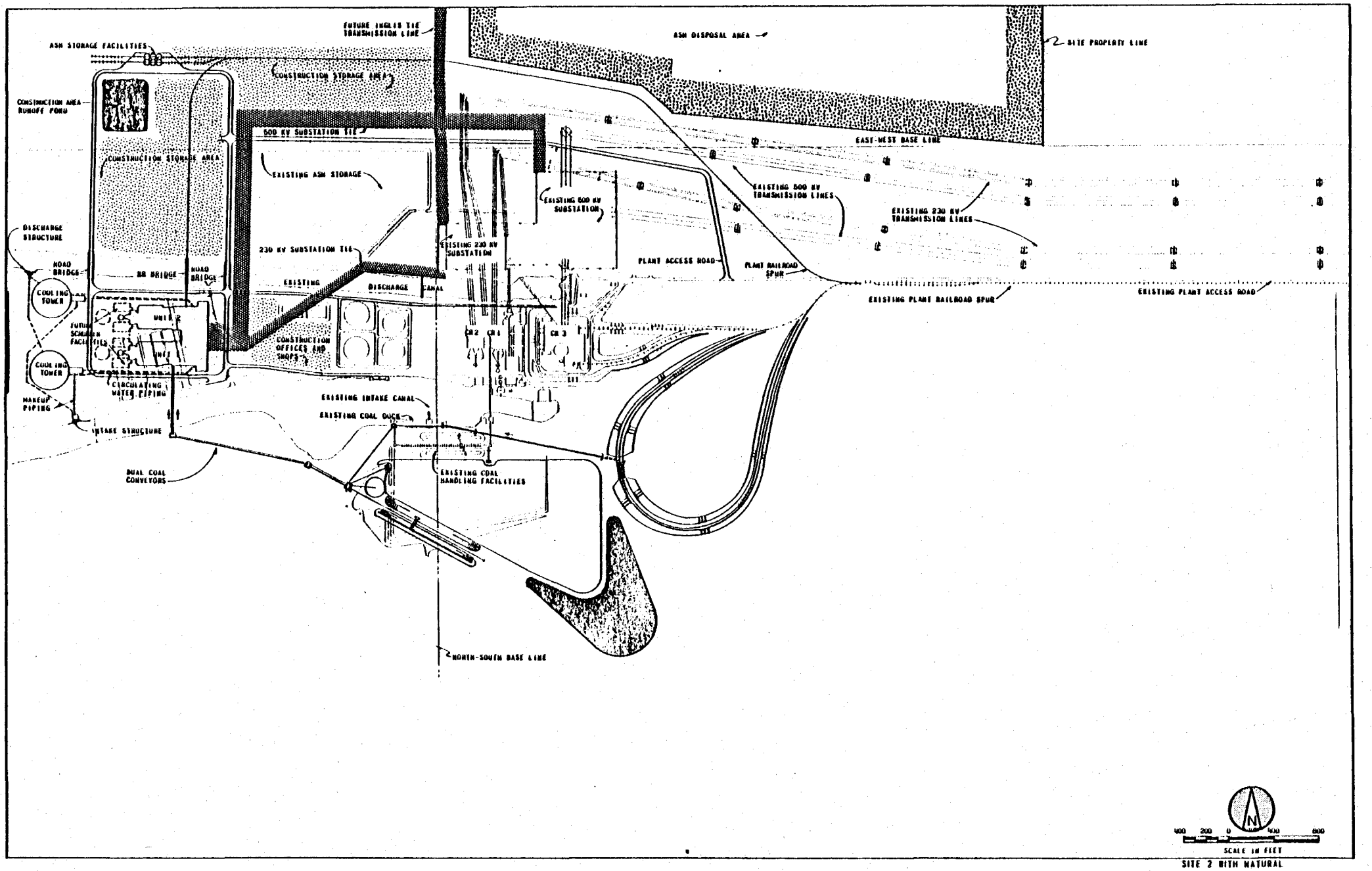
The major advantages of Site 1 are that it is most isolated from the existing Crystal River plant facilities. The site minimizes interferences with existing plant operations, access, and security of the existing units. Accesssibility of roads, railroads, and transmission tie lines is also good.

The major disadvantages of Site 1 are that the generation facilities, cooling towers, plant runoff pond, and construction areas would be located within coastal marsh and forested wetlands. The makeup water pipeline must cross the existing discharge canal, presenting increased exposure for accidental line rupture and may require specialized operating procedures.

The installation of tower structures for transmission tie lines within the existing ash disposal pond would create a need for pond management and reclamation, if this disposal area were to remain in service after construction of the new units.

9.8.2.2 SITE 2--DESCRIPTION, ADVANTAGES AND DISADVANTAGES

The generation facilities would be located between the existing intake and outfall canals approximately 2,700 feet to the west of Unit 2 (Drawing 3-4, Black and Veatch, Site Arrangement). The area has been used for experimental mariculture. The coal handling and storage facilities would be located identically to the Site 1 arrangement, and the ash disposal area would be located in approximately the same location.



SITE 2 WITH NATURAL DRAFT COOLING TOWERS

DRAWING 3-4

The advantages of this site are the short routing distances that are required for makeup discharge pipelines, coal handling conveyers, and transmission tie lines to the existing substations. There would be less displacement of natural vegetation and communities than for Sites 1 or 3.

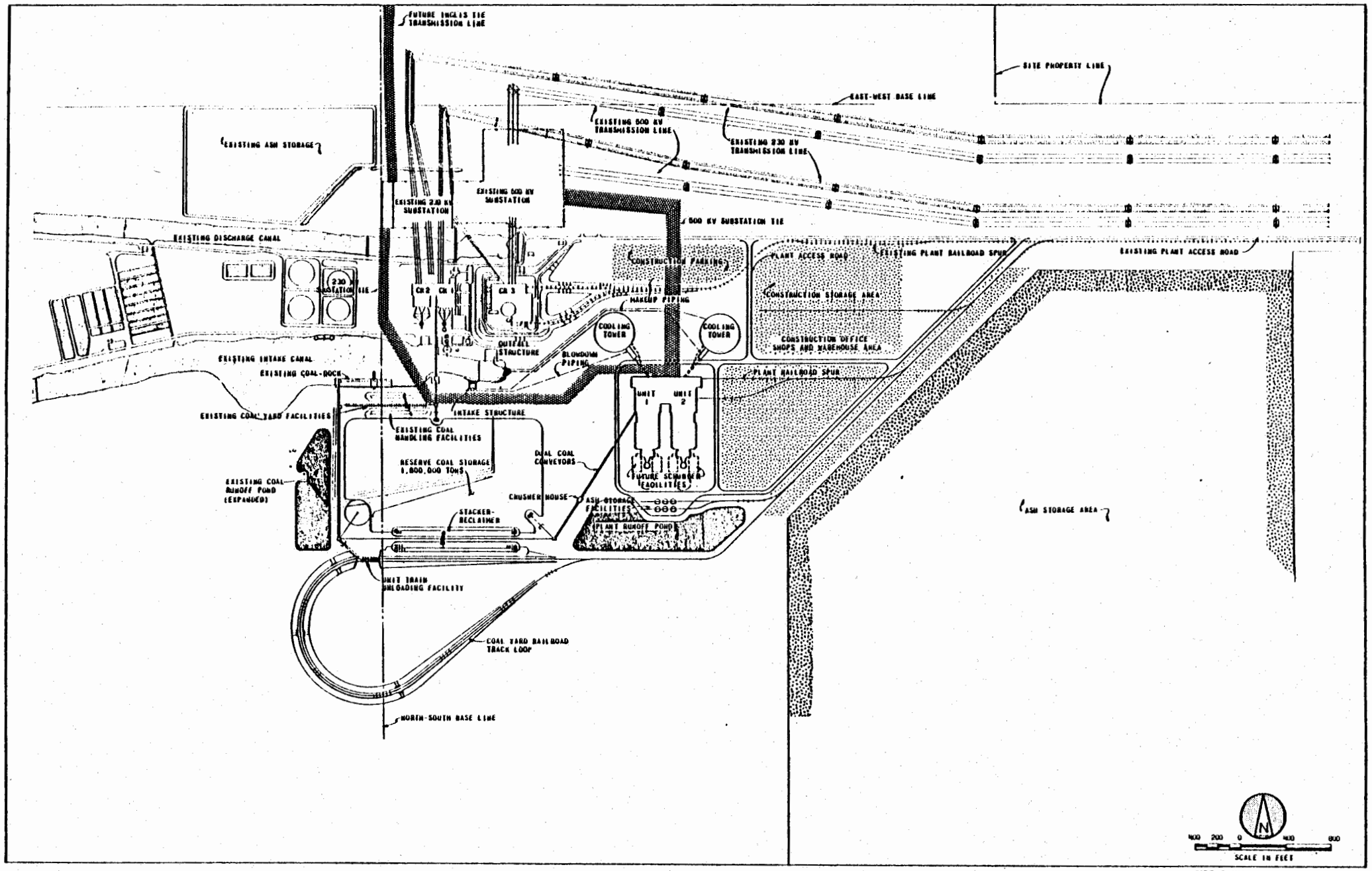
The major disadvantage of this site would be that the between-canals location makes access to the plant difficult. All construction materials must cross over the discharge canal from the storage and work areas, with resultant potential for scheduling problems and inefficiency.

Future operations would be adversely impacted because of restricted access, increased distance to ash and sludge disposal areas, and more complicated ash-sludge handling and materials delivery operations. Plant security would be more complex because of the canals splitting the site into three units.

Movement of materials over the discharge canal would increase the potential for accidental release of contaminating substances into the canal.

9.8.2.3 SITE 3--DESCRIPTION, ADVANTAGES, AND DISADVANTAGES

Generation facilities for Site 3 would be located approximately 1,500 feet southeast of the existing Crystal River Unit 3 (Drawing 3-6, Black and Veatch, 1977). Coal handling and storage facilities are identical



SITE 3 WITH NATURAL DRAFT COOLING TOWERS

DRAWING 3-6

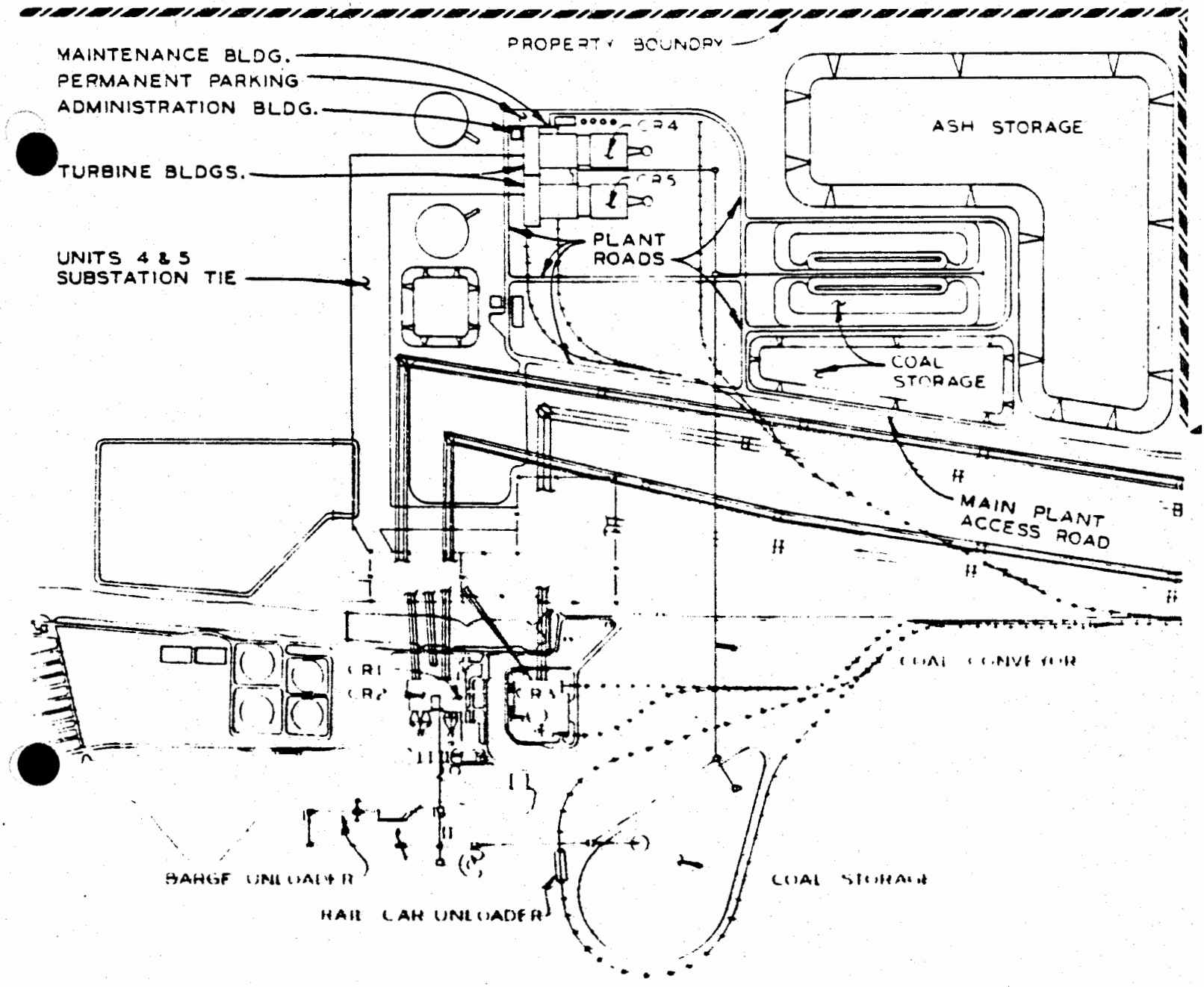
to those of the Site 1 arrangement, but the ash disposal area is located in the southeast portion of the property.

The advantages of this site include the fact that access to this site is excellent. Interference with access and operations of the existing coal-fired units is minimized. The facility is in proximity to the coal storage and ash disposal areas.

The disadvantages of this site include extensive amounts of coastal marsh and wetland forest that would be displaced. Crossing of coal handling yards by the transmission tie lines to the 230 kv substation presents potential safety hazards and interference with plant operations. Construction activity would create some disruptions in operation and security of the existing nuclear plant, and the site location rules out the future operation of a second nuclear plant near the existing plant.

9.8.2-4 SITE 1c--DESCRIPTION, ADVANTAGES, AND DISADVANTAGES

Site 1c represents a relocation of Site 1 so that all facilities would be located outside of the coastal marsh and forest wetlands. The generation facilities would be located about 2,800 feet northeast of the Site 1 location (Figure 9.8.2-2). New coal storage and handling facilities would be located between the generation facilities and the ash area. The ash storage area would be in approximately the same location as for Site 1, but would be reduced from about 200 acres to 105 acres.



1000' 500' 0 1000' 2000'

1" = 1000'

1" = 305 METERS

CRYSTAL RIVER UNITS 4 & 5
ENVIRONMENTAL REPORT

Figure 9.8.2-2
Site 1c with Natural Draft Cooling Towers

The advantages of this site include the fact that no coastal marshes or coastal wetland forests will be displaced, and all facilities will be located as far as possible on the property from the coastal wetlands. Transmission tie line, railroad, and road routings will be minimized. Interference with operation and security of all existing units will be minimized during construction and operations. Access and suitability for construction are excellent.

The major disadvantages of this site include the fact that the site does not meet the space requirements for the ash storage area. Thus a second ash storage (location unspecified) will be needed in the future to contain the ash generated by the facility. Because the site fabrication and storage-laydown yard areas available for construction are limited, the west end of the ash storage area will have to be used as a construction storage-laydown area. Two separate coal handling and storage areas will be required, thus increasing handling costs and personnel required. Space for the plant and coal runoff ponds is limited.

9.8.2.5 ENVIRONMENTAL CONSIDERATIONS

The primary environmental considerations for both site location and site layout is the physical space required and the extent and type of natural systems to be displaced. A sizable amount of the property at Crystal River owned by Florida Power Corporation is considered to be wetlands. The most important of these wetlands are the saltwater marsh and the coastal forested wetlands (Coastal Hydric Hammock), because of their intimate association with the estuarine system. These serve as a buffer

between the marine and terrestrial systems, serving to reduce impacts of one upon the other and to provide an orderly flow of energy and materials from one to the other.

Prime consideration in site location should be given to minimizing displacement of, and impacts to, these wetlands. Secondary consideration should be given to minimizing impacts on other wetlands and sensitive areas of less regional importance.

Visual and aesthetic considerations also exist. The appearance of the coastline, as seen from the Gulf of Mexico, must be considered.

Excavation activities, ash pond seepage, and coal storage area seepage selection process should include evaluation of changes in ground water quality, flow pattern, and potential sink development.

Potential for release of contaminants into estuarine waters is also an environmental consideration. Such aspects as runoff potential, and accidental spillage, should be addressed. Location of sources of air emissions, including stacks and cooling towers, can influence rate and location of drift and emission deposition. Proximity to other sources, and synergistic effects of nearby sources, may be added considerations.

9.8.3 PLANT LAYOUT ALTERNATIVES

9.8.3.1 REQUIREMENTS

Layout selection criteria are, in general, identical to those used in the plant location selection process. In particular, the recommended site layout had to meet the following requirements:

1. Most economical arrangement,
2. Generating facility in the most advantageous location in respect to the coal supply and transmission lines,
3. Minimizes system interferences,
4. Considers existing site features, and
5. Provides for construction storage and staging areas.

9.8.3.2 ALTERNATIVE LAYOUTS DESCRIPTION

Generating Facility

Mirror image arrangement.

Unit 4 and Unit 5 arrayed as mirror images along the center baseline.

Slide-along arrangement.

Units 4 and 5 arrayed as identical side-by-side units along the center baseline.

Coal Handling and Storage Facilities

Site 1C plan.

Supply would be from the east, with the active storage and stacker-reclaimer about 800 feet east of Unit 5 and the inactive storage within the coal yard railroad track loop south of the existing access road.

This alternative was recommended because of lower capital costs and increased active storage area. The space available for ash and sludge storage is reduced, however.

Site 1C alternate plan.

The supply would be from the east with active storage, stacker-reclaimer, and inactive storage area all located within the coal yard railroad track loop south of the existing access road.

With the supply from the west, all facilities would remain near the existing coal facilities, with coal conveyed to the west side of the plant around the existing facilities. Increased costs and interference with existing units are disadvantages.

Access Roads

The alternatives would include:

1. Upgrading the existing road, and
2. Building a new access road.

If the first alternative is chosen, the existing access road would be upgraded and used for both construction and operations traffic. The advantages are the maximum use of existing facilities and minimization of environmental disturbance. The disadvantages are interference with operation and access to existing facilities.

If the second alternative is chosen, a separate access road for Units 4 and 5 would be constructed along the property boundary to the north of the existing transmission lines.

This alternative was recommended because of minimal interference and proximity to the cooling water makeup pipeline. Some of the existing vegetation would be removed.

Railroad Intersections

Plan A.

Elevate U.S. Highway 19 to cross over the rail spur to the plants. The existing access road would be simultaneously upgraded for divided access to the highway.

Estimated direct capital costs would be $1,385,000. Highway vehicular traffic would be disrupted during construction, but rail traffic would be largely unhindered. This plan may be linked to the access road alternative of upgrading the existing access road.

Plan B.

Elevate the plant rail spur to cross Highway 19, and move existing road intersection 300 feet north of its existing location.

Direct capital costs are estimated at $1,175,000. Plan B offers less disruption to vehicular traffic, but more for rail traffic.

Borrow Pits

Borrow Area 1.

Approximately 600 acres southeast of Unit 3 has been proposed as a possible borrow area.

This area is located largely within the coastal forested wetlands, and is not currently scheduled for other use. Groundwater hydrology could be affected, with solution sinks developing between this and the intake and discharge canal areas.

Borrow Area 2.

This consists of about 105 acres to be subsequently used as the initial ash storage area for Units 4 and 5. The area is less sensitive environmentally, as it is located in upland areas and wetlands of lower regional importance. Topsoils are very thin in this area.

Ash and Sludge Storage Areas

Currently, only a 105-acre storage area east of the plants is proposed. Additional alternative sites to contain the majority of the potential ash and sludge generated have not been identified at this time. Since there is probably insufficient upland area remaining on the property, additional sites presumably would be located in upland areas outside of the property or within the coastal wetland forest on the property.

Retention and Percolation Basins

Specific locations for percolation and retention basins have not yet been described. They will be located generally to the south and west of the new units.

Other Systems

No alternative layouts have been proposed for the cooling towers, circulating water system, electrical substation and transmission, makeup and discharge water, ash and sludge handling systems, or construction facilities.

9.8.3.3 ENVIRONMENTAL CONSIDERATIONS

The same environmental considerations apply to plant layout selection as apply to site location selection.

9.8.4 ENVIRONMENTAL ASSESSMENT OF PLANT LOCATION AND LAYOUT ALTERNATIVES

Environmental considerations dictate that Site 1c be the preferred site. It is the only site which is mainly outside of the coastal wetland areas (Saltwater Marsh and Coastal Hydric Hammock forest--see Vegetation Map, Section 2.7). Secondary effects upon the estuary due to increased runoff and erosion, loss of biological filtration, and accidental spillage are reduced. This location permits retention of the buffer strip or barrier afforded by the coastal forest, thus retaining its value as a hurricane surge buffer and an aesthetic visual screen. Possibilities of water quality impacts due to accidental spillage and dredge and fill activities would be highest for sites 1 and 2, and lowest for site 1c. Site 1c is underlain by some "non-coastal" wetlands, but these are considered to be of less regional importance than the coastal wetlands.

Sites 1, 2, and 3 all cause significant displacement of coastal wetlands. Each of these sites also has a higher potential for release of contaminants and pollutants into the estuarine system. Run-off potential is higher due to proximity to the shore and removal of the coastal wetland forest buffer zone. Site 2 has a potential for accidental spillage of materials into the discharge canal during movement across the canal. Site 1 adversely affects aesthetic appeal because of its high visibility from the Gulf.

Location of the ash storage area location north of the access road would lessen the potential of a seepage of pollutants to the estuary because of the greater distance involved. Splitting of the coal storage facilities

may increase the difficulty of controlling seepage and runoff problems. However, a smaller area of coastal wetlands would be displaced.

Displacement of a natural system through relocation of railroad spurs and access roads would be minor, although the recommended new access road would affect the narrow visual barrier to the north of the existing transmission lines. It would also cross some small swamp and marsh systems.

9.9 COAL HANDLING SYSTEMS

9.9.1 INTRODUCTION

The major elements which must be included in any coal handling system for the existing and proposed fossil steam generating facilities at Crystal River are barge and rail delivery, barge and rail unloading, primary stock out, reserve and active storage, crusher system and plant supply system. Coal is unloaded from barges and/or unit trains, and is either delivered directly to the generating units or stocked out to active storage or reserve storage. Active storage is required to provide for short-term variations between coal usage and supply, particularly during periods when car or barge unloading and yard operations might be curtailed. Long-term storage is needed to level variations between coal purchase contractual commitments and station usage. The primary stockout and reclaim systems, serving active storage, must be designated so that coal is available for automatic reclaiming without resorting to coal dozers or other mobile reclaim equipment. The emergency stockout system, serving reserve storage, will allow barge or train deliveries to continue in the event that the primary stockout systems are unavailable. Other major coal handling facilities are the emergency reclaim hoppers, the crusher system, the coal sample system, and the interconnected network of conveyors, surge bins, and feeders.

9.9.2 EXISITING AND COMMITTED FACILITIES

Coal supplies for Crystal River Units 1 and 2 have in the past been received by barge. The existing facilities are designed for unloading

of ocean-going barges with net capacities of up to 15,000 short tons and loaded drafts of up to 14 feet. There is a barge and tug mooring dock, a clamshell type barge unloader, a stacker-reclaimer, and a belt conveyor system connecting the barge unloader and stacker-reclaimer. The rated capacity of the unloading and stockout systems is 1,500 tons per hour, and the capacity of the reclaiming and coal preparation systems is 600 tons per hour. Active storage for the existing units is located adjacent to the barge dock, and a reserve storage area of roughly 16 acres is located further south.

The fuels contractor for the plant (Electric Fuels) has recently contracted for the installation of a railcar unloading facility to serve the existing units, which will be in service by 1978. As presently designed, this installation would include the following components:

1. A railroad loop track for coal delivery and unit train turnaround. The track would branch to the south from the existing Crystal River Unit 3 plant spur, rise about 30 feet to the unloading point, and then descend to grade at the original turnout point. The unloading loop as proposed would include approximately 4,800 feet of new track.
2. An elevated structure for bottom dumping of railcars having power operated hopper doors. The dump structure would be about 100 feet long and would include multiple hoppers served by a single collecting conveyor.
3. A belt conveyor linking the dump structure with the existing coal handling system at the tailpoint of the barge dock belt.

The proposed system would be rated at 1,500 tons per hour on the collecting and crosstie conveyors.

9.9.3 REQUIREMENTS FOR NEW FACILITIES

The following paragraphs describe the general design criteria for a future coal handling system which would serve the two existing coal-fired units at Crystal River plus the two proposed new units.

First, the projected consumption of coal during peak years of generation is approximately 7,000,000 tons per year. (Assuming that the coal supplies utilized for the existing and new units will average 11,500 and 10,285 Btu per pound, respectively, the existing units will require about 2,200,000 tons per year and the new units will require 4,400,000 tons.) The on site reserve storage capacity should equal about a 90-day supply. This capacity is estimated conservatively at 1,800,000 tons, which would cover about 32 acres assuming an average pile depth of 40 feet. Coal supplies intended for the existing power generation units must necessarily be segregated from supplies for the new units (consisting of low-sulfur coal). Allowing for this factor and for mobile equipment access, the total land requirements for reserve storage would amount to about 37 acres.

Second, the volume of active storage should equal a 3-day supply of coal for both the new and existing units. Separate storage and reclaim facilities for the two sets of units would be appropriate. For operation at 90 percent of capacity, utilizing the worst coals, the

3-day fuel requirements would be about 27,000 tons for the existing units and 54,000 tons for the new units.

Third, the levelized four unit coal consumption during peak years would be about 600,000 tons per month. Periods of above average deliveries can be expected to raise the peak delivery rate to between 630,000 and 660,000 tons per month, and between 15,000 and 22,000 tons per day. The extent of reliance on barge versus rail transportation for obtaining coal supplies has not been determined. The procedure utilized in developing and evaluating alternatives has been to assume that both the barge unloading facilities and the rail facilities should be sufficient to meet the full needs of the plant. Given this assumption, the effective production rating of both the barge terminal and the rail terminal should be on the order of 1,500 tons per hour; and the capacity of conveyor systems, feeders, reclaimers, etc., should be 3,000 to 3,500 tons per hour.

Fourth, the coal handling arrangements should involve an integrated system with the ability to stock-out from either unit train or barge unloading facilities to the active storage area or segregated reserve storage area serving each pair of units.

Fifth, coal storage areas should if possible be located away from coastal marsh and coastal wetland forest areas.

9.9.4 BARGE UNLOADING FACILITIES

The peak barge unloading capability with the existing clamshell type unloader and associated conveyors is about 17,000 tons per day under optimum conditions. The unloader is probably adequate for sustained delivery rates to about 325,000 tons per month without seriously jeopardizing machine design or maintenance procedures. Thus, depending upon the proportions of annual coal requirements to be delivered by barge, the existing facilities may be marginal for the demands of the four coal-fired units. Two alternative methods of upgrading the terminal unloading operations have been proposed.

9.9.4.1 PLAN 1

Add a second barge unloader and extend the existing dock approximately 88 feet to the east to accommodate longer barges, compensate for the decreased travel of the dual machines, and provide space for machine erection while maintaining unloading operations for the existing units. The second machine would be similar in design and unloading capabilities to the existing unloader. The paired machines, operating in separate holds of a barge, would raise the effective production rating of the terminal to an average of about 1,700 tons per hour.

9.9.4.2 PLAN 2

Replace the existing barge unloader with a high capacity, continuous ladder type barge unloader rated at 3,000 tons per hour (free digging capacity). The existing dock would be extended approximately 132 feet to the east to provide erection space accommodating the trailing

surge-bin and yard conveyor loadout structure required by this type of unloader.

Improvements to the existing unloading facilities under either plan would include the installation of a second conveyor system paralleling the existing conveyor. The discharge point of the new conveyor would be designed to feed either the existing stacker-reclaimer yard belt or a new 3,000 ton per hour conveyor extending to the active storage and stockout systems provided for the new units. If retained under Plan 1, the existing unloader would be modified somewhat, but still might be limiting upon barge unloading operations involving coals dedicated to the existing power generation units. The relative advantages of Plan 1 would involve operation flexibility, redundancy, and the ability to use existing dock trackage without modification. The advantages of the ladder type unloader would include better control of fugitive dust, greater efficiency in free digging and cleanup modes, and less indeterminacy regarding maintenance costs.

A cost comparison of the two barge unloading alternatives has indicated that Plan 2 would be higher in terms of capital cost ($8,150,000 versus $4,810,000 for Plan 1) but lower in terms of other annualized costs ($573,000 versus $1,016,000 for Plan 1). The total annualized cost of Plan 2 would be $2,517,000, and the annual cost of Plan 1 would be $2,163,000. Thus, the addition of a second clamshell type barge unloader is the most economical alternative if increased barge unloading capability is required for future terminal operations.

9.9.5 RAIL UNLOADING FACILITIES

The engineering studies for the proposed power generating facilities at Crystal River have considered a large number of coal handling alternatives. The most significant aspects of coal handling, in terms of variation among different alternatives, are the car unloading system, the construction of new rail trackage, and the location of coal storage areas. Four different car unloading systems have been evaluated, as follows:

9.9.5.1 CONVENTIONAL ROTARY DUMP SYSTEM

This system would use integral or conventional hopper cars equipped with rotary couplers. The trains would be dumped (without uncoupling of locomotive, individual cars, or the caboose) by inverting each rail car as it passes through the dumper. A concrete pit structure located underground beneath the car dumper would contain receiving hoppers, feeders, and collecting belts.

9.9.5.2 "ROTOSIDE" ROTARY DUMP SYSTEM

This method differs from conventional rotary dump systems in that cars are individually uncoupled and lifted in an arc during dumper rotation, and that trains are typically broken into segments or "cuts" for marshalling through the dumper installation. As in the conventional rotary dump system, an automatic, electrically-powered train positioner would be required.

9.9.5.3 AUTOMATED BOTTOM DUMP HOPPER

This system uses dedicated bottom dump hopper cars equipped with automated door mechanisms that unload into an underground receiving hopper. The cars can have either transverse or longitudinal door opening patterns. Unloading is accomplished by moving the train through the unloading facilities at less than 1/2 mile per hour, and bottom dumping the car contents as the train passes over receiving hoppers.

9.9.5.4 BOTTOM DUMP TRESTLE SYSTEM

This arrangement is similar to the preceding system except that unloading is accomplished by moving the train across an elevated trestle instead of receiving hoppers. The trestle would be roughly 600 feet long and located approximately 50 feet above the coal storage ground level. The reclaim system would utilize one of the following methods of loading: (a) dual rotary plow feeders over paired conveyors located in underground tunnels; (b) dual conveyors fed by multiple vibratory type pile discharger-feeder mechanisms; (c) a "trencher" type, bucket-wheel reclaimer operating on a berm structure adjacent to the trestle.

The "Rotoside" rotary dumper would have the disadvantage, relative to other systems, that railcars must be uncoupled and individually dumped. On the other hand, this system is advantageous in that special railcars are not required, that random cars can be dumped without interrupting cycle time, and that there are no limitations on train crews or motive power. The bottom dump elevated trestle system is uniquely advantageous in that a failure of the site unloading equipment will not halt the

train unloading operation, that only small crews are required for train unloading, and that the system itself provides partial active storage/ reclaim capability. However, dust control is especially difficult with this system.

A cost comparison of these unloading systems has indicated that the "Rotoside" rotary dumper would involve the lowest annual cost, due to the fact that this system was low in terms of fixed charges. The conventional rotary dumper system and the dump hopper system would involve differential annual costs of $208,000 and $389,000, respectively, whereas the differential annual costs for the elevated trestle alternative would vary between $1,100,000 and $1,500,000 depending on the reclaim system utilized.

9.9.6 SITING OF COAL HANDLING FACILITIES

The selection and siting of coal handling facilities must obviously be coordinated with the siting of the power generating unis and related facilities such as ash storage ponds. Table 9.9.6-1 summarizes the key characteristics of eleven alternative coal handling plans which have been considered in the design process. Each plan involves one of the four plant sites (discussed previously), one of the rail unloading options, and a specific arrangement of rail lines and coal storage areas. The last four columns describe the locations of the major land-extensive facilities relative to the existing reserve storage area (which is just south of the existing active storage area and barge unloading dock).

Table 9.9.6-1 Characteristics of Alternative Coal Handling Plans

	Type of Coal Unloading Facility	Type of Rail Access	Location of Facilities Relative to Existing Reserve Storage Area			
			Unloading Facility	Rail Lines	New Active Storage	New Reserve Storage
Plans Serving Site 1 or 2						
I	Trestle Dump	Loop	South	South, Southwest	South	South
II	"Rotoside" Rotary Dumper	Ladder	South	South, Southwest	South	South and East
III	Trestle Dump	Loop	East	East, Southeast	South	South and East
IV	Conventional Rotary Dumper or Bottom Dump Hopper	Loop	South	South, Southwest	West	West
VII	Bottom Dump	Loop	East	East	West	West
IX	Bottom Dump	Loop	East	East	South	Southeast

Table 9.9.6-1 Characteristics of Alternative Coal Handling Plans (Continued)

	Type of Coal Unloading Facility	Type of Rail Access	Location of Facilities Relative to Existing Reserve Storage Area			
			Unloading Facility	Rail Lines	New Active Storage	New Reserve Storage
Plans Serving Site 3						
V	Trestle Dump	Loop	South	South, Southwest	Southeast	South
VI	"Rotoside Rotary Dumper	Ladder	South	South, Southwest	South	South and East
VIII	Bottom Dump Hopper	Loop	South	South, Southwest	South	South and East
Plans Serving Site 1C						
X	Bottom Dump Hopper	Loop	East	East	South or East	East
XI	Bottom Dump Hopper	Loop	East	East	Northeast	East

The location of facilities is critical since nearly all the land to the west and south of the existing reserve storage area is presently either coastal marsh or coastal wetland forest. Encroachment upon these areas would constitute a serious environmental impact, as discussed elsewhere. Table 9.9.6-1 serves to indicate that it is rather difficult to provide adequate coal storage and rail access at the Crystal River site without utilizing wetland areas. However, the alternative ultimately selected does accomplish this objective.

Many of the alternatives listed in Table 9.9.6-1 were ruled out when the fuel subsidiary company decided to proceed with construction of a rail loop and bottom dump unloading facility east of the present reserve storage area. Only Plans VII thorugh XI remained viable, barring major alteration or replacement of the facilities now under construction. Next, the overall site evaluation process described earlier yielded the conclusion that site 1C would be the best location for the new power generating units.

The remaining choice was between coal handling Plans X and XI, which differed only with regard to the location of the active storage area for the new units. It was found that insufficient land was available for this facility near the rail unloading area, if adequate reserve storage was to be provided without encroaching significantly upon wetlands. The new active storage area has therefore been sited north of the access road and transmission corridor, near the new generating units, even though this has cut into the land available for ash storage and

construction laydown. It is apparent from Table 9.9.6-1 that this chosen alternative (Plan XI) is preferable to all other alternatives in terms of ecosystem protection. A large proportion of the reserve storage provided in this alternative would be located within the rail loop required for unloading operations.

9.9.7 OTHER COAL HANDLING FACILITIES

The present discussion has focused primarily upon facilities that would constitute major points of difference among alternatives. Some of the other facilities deserving mention are the stacker-reclaimer unit, the crushers, the emergency stockout system, and the conveyors. All of the alternatives have assumed the use of a slewing type stacker-reclaimer at the new active storage area rather than a trench type, due to the need for a longer track and power control system in the latter case to achieve comparable storage capability. The use of silos for active coal storage was determined to be economically unfeasible, although attractive in many respects. A similar decision was made with regard to ground level storage with gravity feed to underground conveyors.

A crusher structure with two 800 ton per hour crushers would be included in the coal handling system, and would contain chutes, crusher surge bin, feeders to regulate flow to the crushers, and bypass chutework to divert coal directly to the plant supply system. The conveyors associated with unit train unloading facilities should match the unloading systems in capability. A 3,500 ton per hour rate will be required when the unloading system that is presently under construction

is modified for expansion to serve the new generating units. (A 1,750 ton per hour conveying rate would have been adequate for the trestle dump unloading system.) The emergency stockout system will include a fixed boom cantilevered conveyor and telescopic dust chute capable of building a conical coal pile of about 15,000 tons. The alternative provisions for coal dust control are discussed elsewhere in this document.

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Attachment 1. Program Review and Statistical Evaluation Synopsis;
Attachment 2. Water Quality Summary;
Attachment 4. Example of Physical Plant Data Format. Data is stored on computer tape;
Attachment 5. Synopsis of Research Publications of the Hydrographic Study;
Attachment 6. Thesis of Mr. Ronald Klausewitz containing Thermal Plume Model Verification;
Attachment 7. Source of Cooling Water Study;
Attachment 8. Summary of Phytoplankton Data;
Attachment 9. "Evaluations of Interactions between a Power Generation Facility and a Contiguous Estuarine Ecosystem." Samuel C. Snedaker and staff;
Attachment 10. Map of Approximate Macrophyte Standing Crop. Martin vanTine;
Attachment 11. Juvenile Fish Entrapment Study;
Attachment 12. Intake Velocity Measurements Taken at the Travelling Screens of Units 1 and 2;
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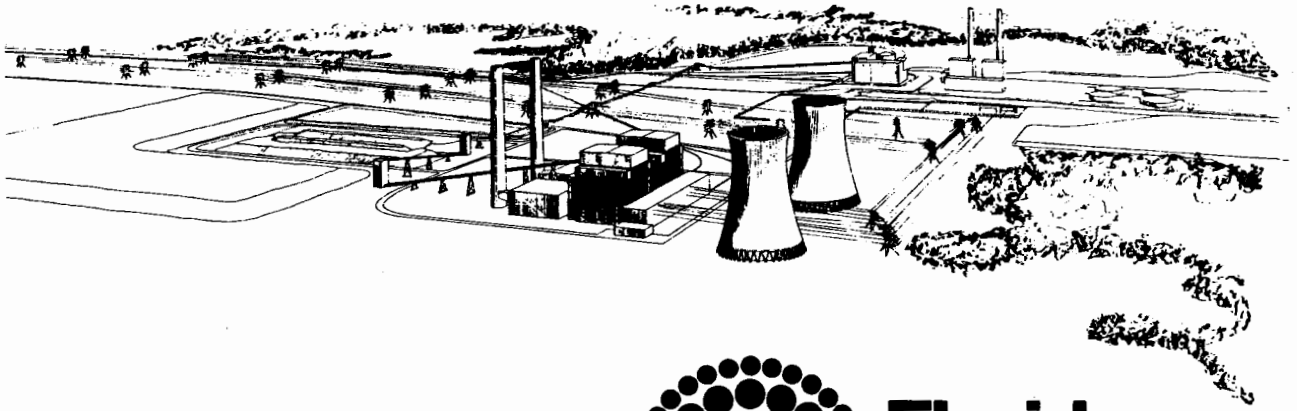
Site Certification Application

Crystal River Units No. 4 & 5



Vol. 4

Florida Power
CORPORATION

OUTLINE OF REVISIONS INCLUDED IN VOLUME 4
OF THE
FPC CRYSTAL RIVER UNITS 4 AND 5 SITE CERTIFICATION APPLICATION

Submittal Date	Submittal Description
December 1977	Site Certification Application, Volume 1-3. Submitted to FDER.
June 14, 1978	SCA Volume 4. Submitted to FDER containing additional supporting information that reflected developments since December 1977.
July 14, 1978	SCA Volume 4. Revised again and re-issued to reflect further developments and information subsequent to the June 14, 1978 submittal.
July 21, 1978	One additional section (Section 5.8.3) was added to Volume 4 to complete all revisions to the SCA to date.
	Volume 4 was issued as a supplement to SCA Volumes 1-3, Volume 4 is to be read separately from Volumes 1-3. Certain sections have been revised since December 1977. Volume 4 reflects those revisions, but it is not designed to physically replace any sections of the original SCA Volumes.
	A summary of the contents of the most up-to-date version of SCA Volume 4 follows:
June 14, 1978	Chapter 1 is contained in its entirety in Volume 4 and includes updated graphics. Chapter 1 reflects the most recent changes as of May 30, 1978.
June 14, 1978	Section 2.4. Geology was revised and included in the June 14, 1978 submittal. This section should be read instead of the Section in Volume 1.
July 14, 1978	Section 2.5. Groundwater was revised subsequent to the June 14th submittal.
July 14, 1978	Section 2.10.2. Natural Sea Salt was added to Volume 4. Figures 2.10-5 through 2.10-7 were also added in the latest revisions.

Submittal Date	Submittal Description
July 14, 1978	Chapter 3. The Plant is included in its entirely in the June 14th SCA Volume 4. Sections 3.3 and 3.10 of Chapter 3 were, again revised on July 14 to reflect salt water cooling towers and other changes.
July 14, 1978	Section 4.1.1. Construction Areas and Activities. Two pages were revised in this section for the July 14th Volume 4.
July 14, 1978	Section 4.2.2. Water Quality. Whole section revised.
July 14, 1978	Section 4.3.3. Other Impacts on Biota. Whole section revised.
July 14, 1978	Section 5.1.1. Physical Effects on Groundwater Withdrawal. Whole section was revised to show new Geraghty and Miller test well report.
July 14, 1978	Section 5.1.2. Biological Effects of Groundwater Withdrawal. Whole section revised to reflect new wellfield data in Geraghty and Miller report.
July 14, 1978	Section 5.1.4. Cooling Tower Drift. This section was revised to reflect the decision to use saltwater cooling towers for CR Units 4 and 5.
July 14, 1978	Section 5.1.2. Biological impacts of Impingement and Entrainment. This section was added to Chapter 5 to reflect the new design of the intake structures for CR Units 4 and 5.
June 14, 1978	Section 5.2.1. Summary of Wastewater Disposal Systems. Whole section revised.
July 14, 1978	Section 5.2.2. Cooling Systems Blowdown. Revised due to change to saltwater cooling towers.
July 14, 1978	Section 5.2.6. Cooling System Intake. Reflects new intake design.
July 14, 1978	Section 5.3. Impacts on Groundwater Systems. Revised to reflect use of saltwater cooling towers.
June 14, 1978	Section 5.4. PSD Analysis--Air Quality. Whole section revised.
June 14, 1978	Section 5.6.5. Transportation. Section added to respond to FDER comments.

Submittal Date	Submittal Description
July 21, 1978	Section 5.8.5. Control Technology. Changed to show use of saltwater cooling towers.
July 14, 1978	Section 6.2. Plant Construction and Operation Monitoring. Section added to Chapter 6 to show FPC's proposed monitoring programs for the construction period.
July 14, 1978	Section 7.2. Costs and Benefits of the Project to Power Users and to Florida Power Corporation. This section was revised to show any changes in costs or benefits to Florida Power due to the use of saltwater cooling towers.
June 14, 1978	Section 8A. Ecological Comparison of Crystal River and Phosphate Zone Sites. This section was issued as a supplement to Chapter 8 in order to add more depth to the comparisons between the Crystal River site and the phosphate zone sites.
July 14, 1978	Section 9.4.3. Alternatives Considered. This section is revised to show the effect of choosing saltwater cooling water as the preferred cooling water source.
June 14, 1978	Lake Rousseau Report. Included in its entirety to explain the data that resulted from the study of Lake Rousseau as an alternative source for cooling water for CR Units 4 and 5.

AN EXPLANATION OF THE REVISIONS TO
FLORIDA POWER CORPORATION'S SITE CERTIFICATION APPLICATION
FOR CRYSTAL RIVER UNITS 4 AND 5

Chapter 1 Need for Power: Included in original SCA submitted on December 14, 1977.

Chapter 1-Need for Power, completely revised June 14, 1978, to reflect an updated in-service date for Unit 5 and current system information.

Chapter 2 The Site: Included in original SCA submitted on December 14, 1977.

Section 2.4- Geology, revised June 14, 1978, to reflect new information obtained from core borings made on the site.

Section 2.5.1- Groundwater, revised July 14, 1978, to incorporate well test information.

Section 2.10.2- Natural Sea Salt, added July 14, 1978, to present information on natural salt deposition.

Chapter 3 The Plant: Included in original SCA submitted on December 14, 1977.

Chapter 3 - The Plant, completely revised June 14, 1978.

Section 3.3 - Plant Water Use, revised July 14, 1978, to reflect salt water cooling towers as the primary alternative.

Section 3.4 - Heat Dissipation System, revised July 14, 1978, to reflect salt water cooling towers as the primary alternative.

Section 3.10 - Onsite Drainage and Erosion Control, revised July 14, 1978, submittal.

Chapter 4 Environmental Effects of Site Preparation, Plant and Associated Transmission Facilities Construction: Included in original submittal of SCA on December 14, 1977.

Section 4.1.1 - Construction Areas and Activities, two pages, revised July 14, 1978, to reflect drilled pier construction for foundation support rather than concrete grouting and construction of surface (salt) water intake.

Section 4.2.2 - Water Quality, revised July 14, 1978, to reflect changes in impacts due to drilled pier construction.

Section 4.3.3 - Other Impacts on Biota, revised July 14, 1978, to reflect changes in impacts due to drilled pier construction.

Chapter 5 Environmental Effects of Plant Operation: Included in original submittal of SCA on December 14, 1977.

Section 5.2.1 - Summary of Wastewater Disposal Systems, revised June 14, 1978.

Section 5.4 - PSD Analysis-Air Quality, revised June 14, 1978 to reflect the control strategy developed as a result of the EPA PSD permit.

Section 5.6.5 - Transportation, revised June 14, 1978, to respond to DER comments.

Section 5.1.1 - Physical Effects on Groundwater Withdrawal, and

Section 5.1.2 - Biological Effects of Groundwater Withdrawal, revised July 14, 1978 to reflect the test well data.

Section 5.1.4 - Cooling Tower Drift, modified July 14, 1978, to show effects of salt water drift from saltwater cooling towers.

Section 5.1.5 - Biological Impacts of Impingement and Entrainment, revised July 14, 1978, to reflect salt water intake from the existing discharge canal.

Section 5.2.2 - Cooling System Blowdown, changed July 14, 1978, to reflect impacts of saltwater cooling tower blowdown.

Section 5.2.6 - Cooling System Intake, modified July 14, 1978, to reflect new intake design.

Section 5.3 - Impacts on Groundwater Systems, revised July 14, 1978, to reflect impacts associated with plant service water usage.

Section 5.8.5 - Control Technology revised July 21, 1978, to show use of salt water from existing discharge canal as the cooling system.

Chapter 6 Environmental Measurement and Monitoring Program:

Section 6.1 - Baseline Measurements and Monitoring Program, included in original submittal of SCA on December 14, 1977.

Section 6.2 - Plant Construction and Operation Monitoring, originally submitted on June 14, 1978.

Chapter 7 Economic and Social Effects of Plant Construction and Operation: Included in original submittal dated December 14, 1977.

Section 7.2 - Costs and Benefits of the Project to Power Users and to Florida Power Corporation, revised July 14, 1978, to show changes caused by salt water cooling towers.

Chapter 8 Alternative Energy Sources and Sites: Included in original submittal on December 14, 1977.

Section 8A - Ecological Comparison of Crystal River and Phosphate Zone Sites, submitted June 14, 1978.

Chapter 9 Plant Design Alternatives: Included in original SCA submitted on December 14, 1977.

Section 9.4.3 - Alternatives Considered, revised July 14, 1978, to show saltwater cooling towers as the preferred alternative.

Lake Rousseau Report: Submitted June 14, 1978, in Volume 4, as a comprehensive analysis of using Lake Rousseau as a cooling water source.

The Site Certification Application for the proposed Crystal River Units 4 and 5 was submitted on December 14, 1977 to Florida Department of Environmental Regulation. Since then, Environmental Science and Engineering, Inc. has compiled additional information and has received comments from various state agencies. The following sections present additional supporting information to the Site Certification Application.

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1.0	PURPOSE OF PROPOSED FACILITY AND ASSOCIATED TRANSMISSION
2.4	GEOLOGY
	2.4.1 Site Description
	2.4.2 Physiography
	2.4.3 Stratigraphy
	2.4.4 Soils
	2.4.5 Flooding
2.5	HYDROLOGY
	2.5.1 Ground Water
2.10	OTHER ENVIRONMENTAL FEATURES
	2.10.1 Natural Sea Salt
3.0	THE PLANT
4.0	SITE PREPARATION AND ASSOCIATED FACILITIES CONSTRUCTION/RESULTING ENVIRONMENTAL ENVIRONMENTAL EFFECTS
4.1	SITE PREPARATION AND PLANT CONSTRUCTION
	4.1.1 Construction Areas and Activities
	4.2.2 Water Quality
	4.3.3 Other Impacts on Biota
5.1	HEAT DISSIPATION SYSTEM
	5.1.1 Physical Effects of Groundwater Withdrawal
	5.1.2 Biological Effects of Groundwater
	5.1.4 Cooling Tower Drift
	5.1.5 Biological Impacts of Impingement and Entrainment
5.2	IMPACTS ON SURFACE WATERS
	5.2.2 Cooling System Blowdown
	5.2.6 Cooling System Intake
5.3	IMPACTS ON GROUNDWATER SYSTEMS
5.4	PSD ANALYSIS - AIR QUALITY
	5.6.5 Transportation

Section	Title
6.2	PLANT CONSTRUCTION AND OPERATION MONITORING
	6.2.1 Air
	6.2.2 Wastewater
	6.2.3 Groundwater
	6.2.4 Archaeology
7.2	COSTS AND BENEFITS OF THE PROJECT TO POWER USERS AND TO FLORIDA POWER CORPORATION
	7.2.1 Costs Attributable to Proposed Crystal River Units 4 and 5
9.4	WATER SOURCE AND INTAKE ALTERNATIVES
	9.4.3 Alternatives Considered
8.A	ECOLOGICAL COMPARISON OF CRYSTAL RIVER AND PHOSPHATE ZONE SITES (Addendum to Chapter 8)
	SECONDARY COOLING TOWER MAKEUP ALTERNATIVES: REPORT OF THE LAKE ROUSSEAU STUDIES

CHAPTER 1

PURPOSE OF PROPOSED FACILITY AND ASSOCIATED TRANSMISSION

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1.0 PURPOSE OF PROPOSED FACILITY AND ASSOCIATED TRANSMISSION

1.1 SYSTEM DEMAND AND RELIABILITY

1.1.1 LOAD ANALYSIS

Florida Power Corporation's history and forecast of energy use by customer class is shown in Tables 1.1-1 and 1.1-2, and the history and forecast of net seasonal peak demands is shown in Table 1.1-3. The forecasts shown have been adjusted to account for partial ownership of Crystal River Unit 3 by Seminole Electric Cooperative, Inc. and some of the municipal systems currently served by Florida Power. There is also an adjustment to account for the announced plans of Seminole Electric to build two 600 Mw coal units in the mid-1980's. Methods used in making these adjustments are discussed in detail in Section 1.1.2.

Figure 1.1-1 shows a per unit annual load duration curve* that is expected to be typical of the Florida Power system for future years. Some small variations are expected in this curve from year to year, but the variations will not be particularly significant.

Figure 1.1-2 shows historical and predicted annual peak demands as well as the historical and projected generating capacity of Florida Power Corporation.

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* Annual Load Duration Curve--a curve on a chart showing percentage of power supplied plotted against percentge of time occurrence and illustrating the varying magnitude of the load during the period covered.

Table 1.1-1 History of Energy Use

	Rural & Residential						Commercial		Industrial	
Year	Gwh	Average No. of Customers	Average Kwh Consumption Per Customer	FPC % Increase*	Nat'l Avg Kwh Consumption Per Customer	National % Increase*	Gwh	Average No. of Customers	Gwh	Average No. of Customers
1958	844	211,421	3,991	15.0	3,351	6.0	431	28,746	592	817
1959	953	230,289	4,137	3.7	3,575	6.7	504	30,237	719	881
1960	1,115	248,533	4,488	8.5	3,818	6.8	562	31,754	828	936
1961	1,213	257,901	4,704	4.8	3,976	4.1	617	33,072	780	976
1962	1,386	269,131	5,150	9.5	4,220	6.1	720	34,152	907	762
1963	1,543	278,238	5,546	7.7	4,389	4.0	814	34,857	999	720
1964	1,714	288,498	5,942	7.1	4,653	6.0	918	35,836	1,049	860
1965	1,803	299,961	6,011	1.2	4,878	4.8	1,020	36,951	1,191	936
1966	2,066	313,205	6,597	9.7	5,211	6.8	1,136	38,228	1,353	1,007
1967	2,213	328,350	6,739	2.2	5,522	6.0	1,250	39,064	1,581	1,061
1968	2,671	347,466	7,688	14.1	5,985	8.4	1,426	40,953	1,732	1,131
1969	3,196	368,804	8,666	12.7	6,516	8.9	1,628	43,089	1,891	1,209
1970	3,696	392,593	9,415	8.6	6,995	7.4	1,844	45,033	1,912	1,248
1971	4,133	421,165	9,814	4.2	7,297	4.3	2,134	49,072	2,030	1,313
1972	4,717	459,002	10,277	4.7	7,598	4.1	2,403	53,606	2,197	1,384
1973	4,793	505,546	11,459	11.5	7,981	5.0	2,836	58,455	2,350	1,456
1974	5,286	541,702	9,758	-14.8	7,822	-2.0	2,935	60,478	2,422	1,486
1975	5,412	557,893	9,701	- 0.6	8,077	3.3	3,188	60,598	2,479	1,466
1976	5,751	579,044	9,932	2.4	8,267	2.4	3,298	62,277	2,690	1,489

* Percent (%) increase of average KWH consumption per customer.

Table 1.1-1 History of Energy Use (Continued, page 2 of 2)

Year	Street and Highway Lighting Gwh	Other Sales to Ultimate Consumers Gwh	Total Sales to Ultimate Consumers Gwh	Sales for Resale Gwh	Utility Use, Losses, Billing Lag Gwh	Net Energy for Load Gwh
1958	7	103	1,977	353	302	2,632
1959	9	115	2,300	389	304	2,993
1960	11	116	2,632	327	341	3,300
1961	13	131	2,754	377	329	3,460
1962	13	145	3,171	435	385	3,991
1963	14	153	3,523	478	402	4,403
1964	17	167	3,865	540	386	4,791
1965	21	186	4,221	598	406	5,225
1966	17	207	4,779	691	452	5,922
1967	49	205	5,298	783	491	6,572
1968	56	226	6,111	925	591	7,627
1969	60	244	7,019	1,068	626	8,713
1970	64	261	7,777	1,252	826	9,855
1971	68	286	8,651	1,432	878	10,961
1972	72	305	9,694	1,828	1,156	12,678
1973	77	326	11,382	2,191	1,244	14,817
1974	83	292	11,018	2,296	1,088	14,402
1975	86	290	11,455	2,489	1,293	15,237
1976	93	337	12,169	2,648	1,215	16,032

Source: Florida Power Corporation, 1978.

Table 1.1-2 Forecast of Energy Use

	Rural & Residential						Commercial		Industrial	
Year	Gwh	Average No. of Customers	Average Kwh Consumption Per Customer	FPC % Increase*	Nat'l Avg Kwh Consumption Per Customer	National % Increase*	Gwh	Average No. of Customers	Gwh	Average No. of Customers
1977	6,521	603,204	10,811	8.9	N/A	N/A	3,602	64,692	2,772	1,644
1978	6,624	622,812	10,636	- 1.6			3,845	65,400	2,945	1,692
1979	7,042	647,292	10,879	2.3			4,142	66,876	3,129	1,740
1980	7,473	671,556	11,128	2.3			4,416	68,388	3,317	1,800
1981	7,904	692,844	11,408	2.5			4,703	69,888	3,516	1,872
1982	8,330	713,424	11,676	2.3			5,003	71,364	3,722	1,944
1983	8,736	734,100	11,900	1.9			5,242	72,800	3,939	2,000
1984	9,136	755,000	12,101	1.7			5,465	74,300	4,164	2,050
1985	9,531	774,900	12,300	1.6			5,666	75,800	4,401	2,100
1986	9,935	794,800	12,500	1.6			5,856	77,300	4,639	2,150
1987	10,298	814,100	12,650	1.2			6,036	78,800	4,871	2,200
1988	10,661	832,900	12,800	1.2			6,207	80,300	5,100	2,250
1989	10,979	851,100	12,900	0.8			6,364	81,700	5,319	2,300
1990	11,280	867,700	13,000	0.8			6,523	83,100	5,505	2,350
1991	11,549	881,600	13,100	0.8			6,676	84,400	5,670	2,400
1992	11,818	895,300	13,200	0.8			6,813	85,700	5,811	2,450
1993	12,086	908,700	13,300	0.8			6,943	86,900	5,945	2,500
1994	12,354	921,900	13,400	0.8			7,070	88,100	6,070	2,550
1995	12,627	935,300	13,500	0.7			7,198	89,300	6,191	2,600
1996	12,856	948,800	13,550	0.4			7,330	90,600	6,315	2,650
1997	13,066	962,500	13,575	0.2			7,453	91,900	6,441	2,700

* Percent (%) increase of average KWH consumption per customer

Table 1.1-2 Forecast of Energy Use (continued, page 2 of 2)

Year	Street and Highway Lighting Gwh	Other Sales to Ultimate Consumers Gwh	Total Sales to Ultimate Consumers Gwh	Sales for Resale Gwh	Utility Use, Losses, Billing Lag Gwh	Net Energy for Load Gwh
1977	97	376	13,368	2,853	1,319	17,540
1978	103	418	13,935	3,081	1,500	18,516
1979	110	463	14,886	3,328	1,596	19,810
1980	117	513	15,836	3,561	1,693	21,090
1981	124	560	16,807	3,810	1,794	22,411
1982	132	605	17,792	4,057	1,892	23,741
1983	141	648	18,706	3,288	1,811	23,805
1984	150	687	19,602	2,810	1,935	24,347
1985	161	721	20,480	2,398	1,924	24,802
1986	172	750	21,352	2,004	2,000	25,356
1987	180	777	22,162	2,087	2,071	26,320
1988	188	800	22,956	2,165	2,140	27,261
1989	196	822	23,680	2,237	2,201	28,118
1990	204	841	24,353	2,302	2,257	28,912
1991	211	859	24,965	2,360	2,308	29,633
1992	217	876	25,535	2,414	2,359	30,308
1993	224	894	26,092	2,467	2,407	39,066
1994	230	912	26,636	2,519	2,454	31,609
1995	236	930	27,182	2,570	2,500	32,252
1996	242	948	27,691	2,616	2,545	32,852
1997	247	967	28,174	2,655	2,589	33,418

Source: Florida Power Corporation, 1978.

Table 1.1-3 History and Forecast of Seasonal Demands

Year	Summer Peak Demand Net Mw	Year	Winter Peak Demand Net Mw
1958	454*	1958-59	601*
1959	538*	1959-60	662*
1960	580*	1960-61	756*
1961	616*	1961-62	805*
1962	727*	1962-63	960*
1963	822*	1963-64	1,034*
1964	912*	1964-65	1,003*
1965	971*	1965-66	1,242*
1966	1,104*	1966-67	1,220*
1967	1,254*	1967-68	1,388*
1968	1,487*	1968-69	1,551*
1969	1,710*	1969-70	1,979*
1970	1,988*	1970-71	2,152*
1971	2,143*	1971-72	2,114*
1972	2,564*	1972-73	2,671
1973	2,862	1973-74	2,989
1974	2,835	1974-75	3,010
1975	2,975	1975-76	3,530
1976	3,223	1976-77	3,899
1977	3,407	1977-78	4,150
1978	3,700	1978-79	4,450
1979	3,950	1979-80	4,750
1980	4,190	1980-81	5,050
1981	4,440	1981-82	5,360
1982	4,710	1982-83	5,660
1983	4,750	1983-84	5,760
1984	4,950	1984-85	6,050
1985	5,030	1985-86	6,140
1986	5,160	1986-87	6,310
1987	5,380	1987-88	6,580
1988	5,500	1988-89	6,730
1989	5,590	1989-90	6,860
1990	5,770	1990-91	7,080
1991	5,740	1991-92	7,090
1992	5,900	1992-93	7,290
1993	5,850	1993-94	7,290
1994	6,010	1994-95	7,490
1995	6,060	1995-96	7,580
1996	6,200	1996-97	7,770
1997	6,340	1997-98	7,930

*Gross Mw--Net Mw not available.

Source: Florida Power Corporation, 1978.

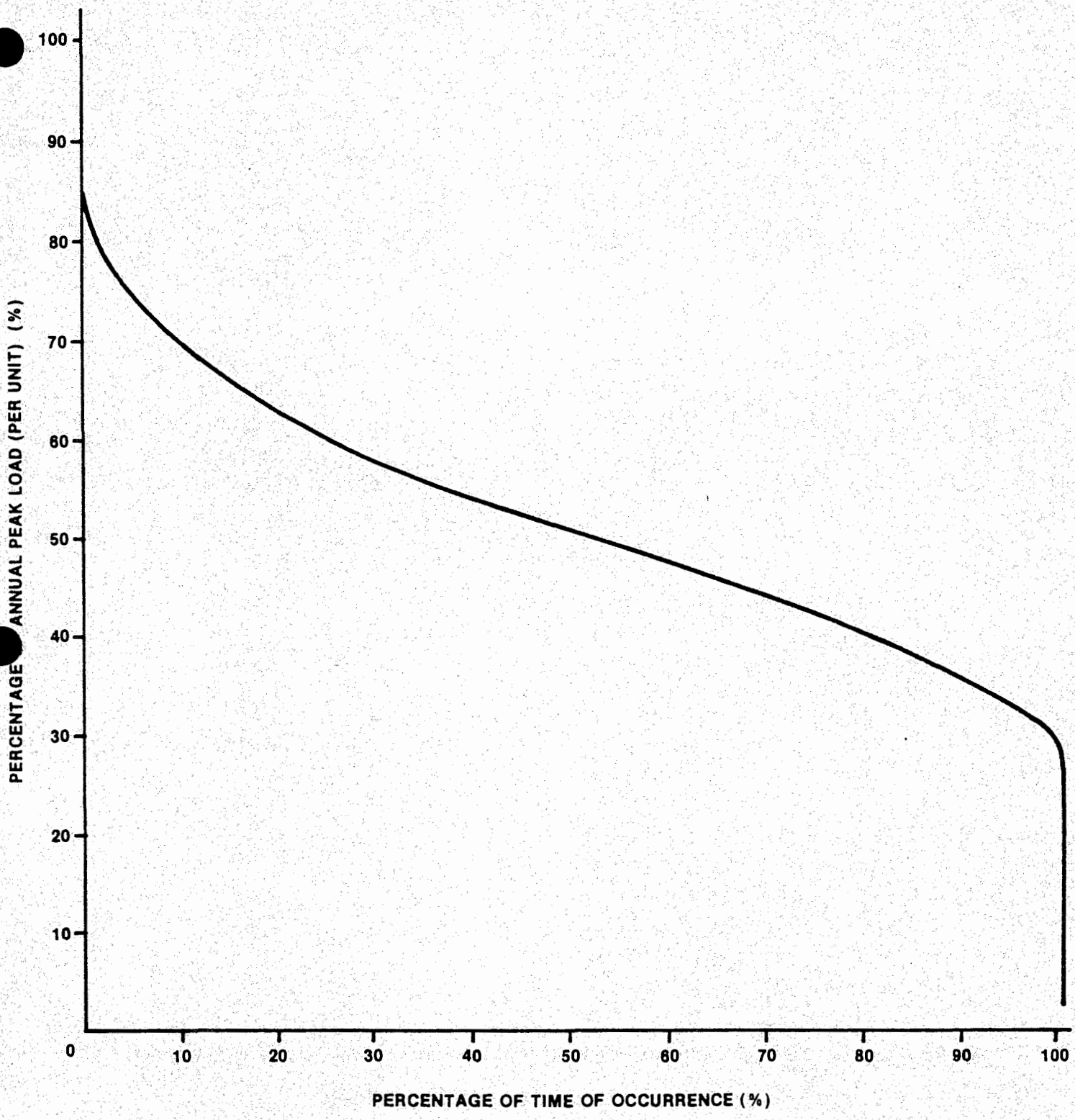

Figure 1.1-1 ANNUAL LOAD DURATION CURVE

SOURCE: FLORIDA POWER CORPORATION, 1978.

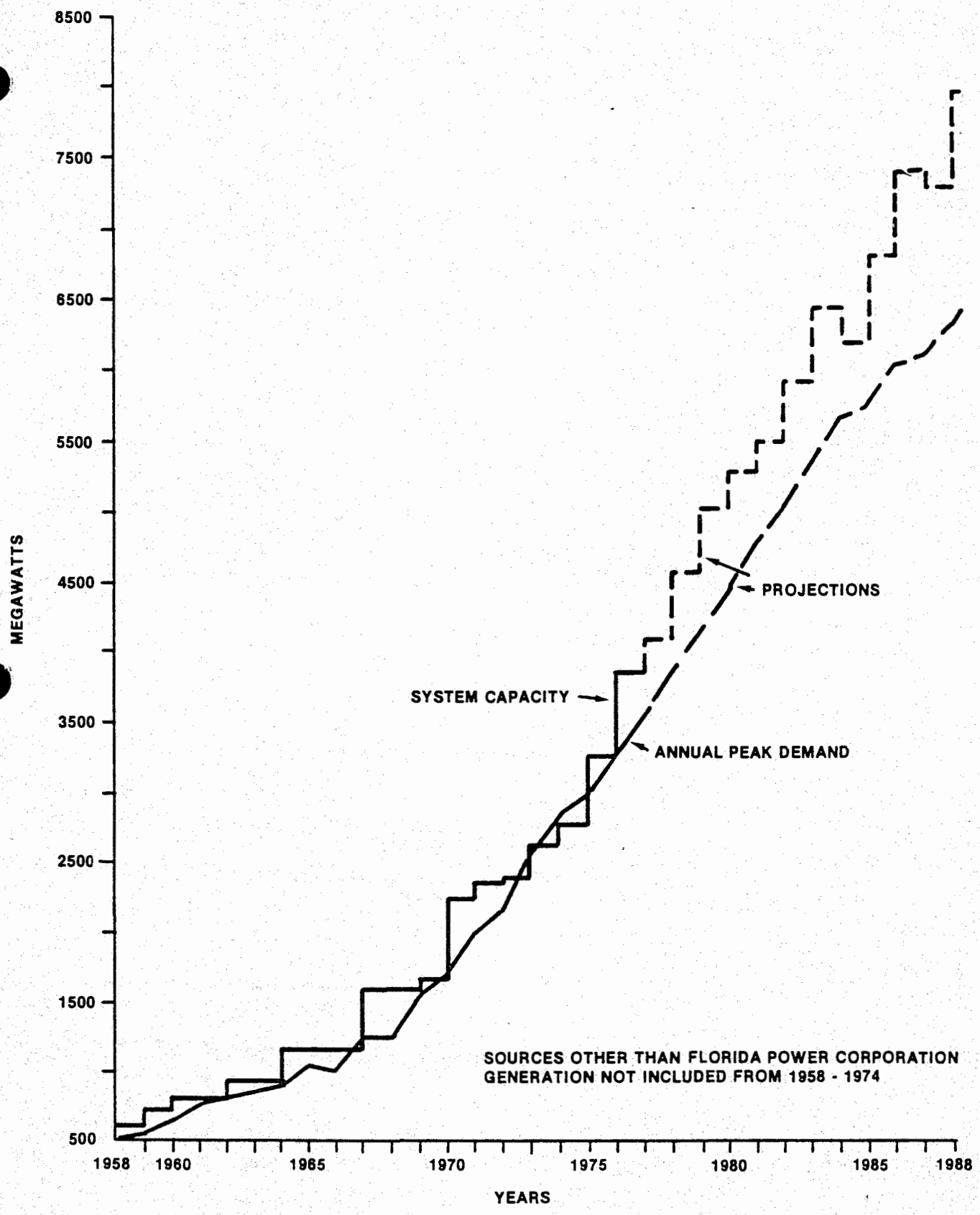

Figure 1.1-2 HISTORICAL AND PREDICTED PEAK DEMANDS AND AVAILABLE GENERATION CAPACITY OF FLORIDA POWER CORPORATION 1958 - 1988

SOURCE: FLORIDA POWER CORPORATION, 1978

1.1.2 DEMAND PROJECTIONS

The first step in making a forecast is to arrive at a set of assumptions on which to base the forecast. These assumptions are first determined by a committee from the System Planning and Consumer Research Departments and then submitted to Florida Power executive management for approval and/or change as required. The following is the set of assumptions upon which the forecasts of energy use shown in Section 1.1.1 are based:

1. Normal weather conditions will prevail.
2. The economy of the service area will continue to improve at a slow, steady rate.
3. No significant loss of energy sales to solar energy will occur until the late 1980's.
4. Personal income will increase at a rate equal to or greater than the CPI; rate increases, if any, will be equal to or less than the CPI. No effects of rate increases will be included in the forecast.
5. Florida Power will continue to serve all of the wholesale load which they now serve as well as the energy required for the load growth of the existing wholesale customers, except the load and energy responsibility which will be assumed by Seminole Electric.
6. Unavailability of fossil fuels will cause an increase in use of electricity for space heating.
7. The population projections made by the Bureau of Economic and Business Research of the University of Florida in Population Studies, Bulletin No. 41, July, 1977, are reasonably accurate.
8. There will be no impact of load management reflected in the forecast.
9. Improvements in insulation levels and equipment efficiency and increased emphasis on conservation will result in reduced sales beginning in the mid-1980's.

Customer projections in the forecast shown are based on the population projections published by the Bureau of Economic and Business Research, University of Florida, in Population Studies, Bulletin No. 41, dated July, 1977. A linear regression of average annual residential customers and the population estimates of the 32 counties which constitute the service area yields the equation "Average Annual Residential Customers - (0.2699) x (Service Area Population) - 185600." This equation has a coefficient of determination of 0.9897.

The equation derived in this manner was used in conjunction with the population projections as a basis for the residential customer forecast. A similar regression of average annual residential customers and average annual commercial customers yields the equation "Commercial Customers = (0.0944) x (Residential Customers) + 7615." This equation has a coefficient of determination of 0.9966. This equation was used as a basis for the commercial customer forecast. The remaining classes of customers represent a very small portion of the total and were forecast using trends.

The key indicator used in forecasting residential sales is annual kilowatt-hour consumption per customer. This indicator is forecast by two different methods, and the results are compared for consistency. The first method is a projection based on past trends, with some judgment of the effects of future events applied rather than using strictly rigorous mathematical methods. The second method used can be described as a disaggregate method. Sales to a "typical" residential customer are broken down by type of appliance such as air conditioning, heating, refrigeration, water heating, etc. The usage for each appliance is then combined with projections of appliance saturation to produce a forecast of kilowatt-hour sales per customer. The usage per appliance is based on in-house load research conducted over past years, when available, and on Edison Electric Institute published data when in-house data is not available. The kilowatt-hour sales per customer obtained by these two methods are then compared and a final estimate made.

Commercial kilowatt-hour sales are also estimated by two different methods. Historical growth rates of total commercial sales are used to make projections of future growth rates. Sales figures obtained in this manner are compared to figures obtained by projecting historical kilowatt-hour sales per customer for future years and necessary adjustments made to form the final forecast.

Sales to the industrial, public authorities, and street and highway lighting classes are obtained by projections of historical growth rates.

The sales for resale class is forecast in two categories--Rural Electric Administrations (REA's) and municipals, and the total is obtained by adding the two. In past years, sales to the REA category have been closely related to the sales to the residential category. A regression of these two variables yields the equation "REA = (0.2383) x (Florida Power Corporation Residential Customers) - 325,700,000" and a coefficient of determination of 0.9951. In making the projections, however, the fact has been considered that the REA's serve in the more rural areas and therefore have greater potential for growth. Therefore, the final sales figures are a result of the regression equation tempered by judgment.

Similarly, sales to the municipal class have historically followed total sales excluding the sales to municipals. Using logic similar to that used for the REA sales, the municipal utilities serve in areas that are somewhat restricted, and therefore sales to this category are restrained in the later years of the forecast. The coefficient of determination for sales to municipals and total sales less municipals is 0.9775.

At this point in the forecasting process, total sales and total average annual customer forecasts have been determined, and therefore, annual kilowatt-hour sales per customer can be calculated. A regression of the variables, annual kilowatt-hour sales per customer, and kilowatt demand per customer yields equations with coefficients of determination of 0.99 and 0.88 for summer and winter data, respectively. The equation

derived for summer demand per customer is "kw/Customer, Summer = (2.5-14 x 10^{-4}) x (kwh/Customer) - 0.6290," and the winter equation is "kw/Customer, Winter = (2.0981 x 10^{-4}) x kwh/Customer) + 0.1597." These equations again tempered by judgment are used to determine the seasonal demand forecast. The annual load factor is then calculated to check the forecast for reasonableness.

At this time, a complete forecast has been determined which includes sales and demand of all wholesale load per assumption No. 5. However, it is known that several of the wholesale customers now own part of Crystal River Unit 3. The total of this unit now owned by the municipals is approximately 18.77 megawatts (Mw) and Seminole Electric Cooperative, Inc. owns about 14.02 Mw of the unit. An adjustment to these two categories is made by subtracting 164,400 mwh (18.77 x 8760) from the municipal sales and 12,800 mwh (14.02 x 8760) from the REA sales. The demand forecast is adjusted by subtracting 33 Mw from the total.

Seminole Electric Cooperative, Inc. has announced plans to build two 600 Mw coal units in the mid-1980's. Seminole Electric Cooperative, Inc. has furnished Florida Power Corporation with projections concerning the amount of load they intend to serve from these two units. This information has been used to adjust Florida Power Corporation's demand forecasts. At the present time, Seminole Electric plans to sell a portion of the output of each of these two units to other utility companies. The amount sold could be as high as 400 Mw from each unit when it is placed in service, but the amount sold will steadily decrease over a ten-year period. In the mid-1990's the full combined rating of both units will be used to serve the Seminole load. The following is a year-by-year schedule of the amount that Seminole expects to sell from their units and the amount available to serve their own load:

Year	Sold From Unit 1 (Mw)	Sold From Unit 2 (Mw)	Available to Serve Load (Mw)
1983	400	N/A	200
1984	400	N/A	200
1985	400	400	400
1986	300	400	500
1987	300	400	500
1988	300	300	600
1989	200	300	700
1990	200	300	700
1991	100	200	900
1992	100	200	900
1993	0	100	1,100
1994	0	100	1,100
1995	0	0	1,200
1996	0	0	1,200
1997	0	0	1,200

The amounts shown in the "Available to Serve Load" column have been subtracted from the Florida Power Corporation load forecast to account for Seminole Cooperative taking over responsibility for their own load. The in-service dates of the Seminole Cooperative units are June 1, 1983, and June 1, 1985, and all changes in their capacity are assumed to occur on June 1 of each year. Sales to this category have also been adjusted by amounts consistent with their peak demand and load shape. Using this schedule, by 1986, Florida Power Corporation would have responsibility for only the peak 250-300 Mw of the Seminole load. Due to the load duration curve associated with the Seminole load, there would be a very small amount of energy associated with this amount of peak demand. Therefore, sales to the REA category have been reduced by an amount consistent with the demand assumptions, and their load duration curve in the years 1983 through 1985, and are assumed to be zero in 1986 and each year thereafter.

Table 1.1-4 shows past and projected customer and sales growth rates in the most important categories and Table 1.1-5 shows past and projected demand growth rates. As can be seen from the table, future growth rates are projected to be considerably lower than historical rates. The lower customer growth rate is due to a reduction in the expected population growth rate for the Florida Power service area.

During the period 1967-1977, a tremendous growth in air conditioning saturation and other electric applicances took place that resulted in large sales and demand growth rates. Future growth in saturation of air conditioning is expected to be small simply because about 85 percent of the customers already have air conditioning. In addition, substantial increases in electric heat saturation which would produce a relatively high growth rate of winter demand are not expected due to the nature of heating requirements in Florida. The combined effects of a lower customer growth rate and reduced growth in kilowatt-hour sales per customer result in future growth rates of sales and demand that are substantially lower than historical.

Tables 1.1-6 and 1.1-7 show the accuracy of past forecasts made by Florida Power. In reviewing these tables, it is important to remember that forecasts are made to normal weather conditions. In many of the cases where the forecasts proved inaccurate, a large part of the deviation can be attributed to abnormal weather conditions.

It is also important to remember that the numbers shown in the forecast columns are expected values and are subject to a considerable amount of variability. Facility planning is not a deterministic process based on these numbers alone but is a stochastic process that takes load variability into account.

Table 1.1-4 Florida Power Corporation Customer Growth Rates and Sales Growth Rates

CUSTOMER GROWTH RATES*
(%)

	1957-1967	1967-1977	1977-1987	1987-1997	1977-1997
Residential	5.41	6.27	3.04	1.69	2.36
Total	5.20	5.42	2.96	1.68	2.32

SALES GROWTH RATES*
(%)

	1957-1967	1967-1977	1977-1987	1987-1997	1977-1997
Residential	12.64	11.41	4.68	2.41	3.54
Commercial	13.48	11.16	5.30	2.31	3.70
Industrial	10.53	5.78	5.80	2.83	4.31
Total (before Seminole adjustment)	11.30	10.31	5.40	2.56	3.97
Total (after Seminole adjustment)	N/A	N/A	4.10	2.43	3.26

*Growth rates are computed as compound annual percent changes.
N/A--Not applicable.

Source: Florida Power Corporation, 1978.

Table 1.1-5 Demand Growth Rates

	SUMMER DEMAND GROWTH RATES*				
	1957-1967	1967-1977	1977-1987	1987-1997	1977-1997
Before Seminole Adjustment	11.53	10.91	5.61	2.52	4.05
After Seminole Adjustment	N/A	N/A	4.67	1.66	3.15

	WINTER DEMAND GROWTH RATES*				
	1956-57/1966-67	1966-67/1976-77	1976-77/1986-87	1986-87/1996-97	1976-77/1996-97
Before Seminole Adjustment	7.96	12.89	5.74	2.79	4.25
After Seminole Adjustment	N/A	N/A	4.93	2.10	3.51

*Growth rates are computed as compound annual percent change.

N/A--Not applicable.

Source: Florida Power Corporation, 1978.

Table 1.1-6 Comparison of Forecast and Actual Peak Demands

Year	Season	1971 Forecast (Net Mw)	Percent Deviation*	1972 Forecast (Net Mw)	Percent Deviation	1973 Forecast (Net Mw)	Percent Deviation	Actual Adjusted** Demand (Net Mw)
1971-72	Winter	2250	7.0					2103
1972	Summer	2410	- 3.5					2497
1972-73	Winter	2520	- 9.5	2630	- 5.5			2784
1973	Summer	2640	-12.0	2830	- 5.7			3000
1973-74	Winter	2790	- 6.7	2950	- 1.3	3100	3.7	2989
1974	Summer	2880	1.6	3160	11.5	3330	17.5	2835
1974-75	Winter	3090	2.7	3280	9.0	3440	14.3	3010
1975	Summer	3130	5.2	3510	18.0	3720	25.0	2975
1975-76	Winter	3390	- 5.8	3640	1.1	3860	7.2	3600
1976	Summer	3390	4.2	3890	19.6	4160	27.9	3253
1976-77	Winter	3700	-15.3	4010	- 8.2	4350	- 0.4	4369
1977	Summer	3630	4.6	4300	23.9	4640	33.7	3470

*Percent deviation is deviation of forecast over actual.
**Actual demand adjusted to include load curtailed at the time of system peak.

Source: Florida Power Corporation, 1978.

Table 1.1-7 Comparison of Forecast and Actual Peak Demands

Year	Season	1974 Forecast (Net Mw)	Percent Deviation*	1975 Forecast (Net Mw)	Percent Deviation	1976 Forecast (Net Mw)	Percent Deviation	Actual Adjusted** Demand (Net Mw)
1974-75	Winter	3300	9.6					3010
1975	Summer	2890	- 2.9					2975
1975-76	Winter	3520	- 2.2	3170	-11.9			3600
1976	Summer	3220	- 1.0	3070	- 5.6			3253
1976-77	Winter	3800	-13.0	3530	-19.2	3860	-11.7	4369
1977	Summer	3450	- 0.6	3320	- 4.3	3440	- 0.9	3470

*Percent deviation is deviation of forecast over actual.
**Actual demand adjusted to include load curtailed at the time of system peak.

Source: Florida Power Corporation, 1978.

1.1.3 POWER EXCHANGE

It is the policy of Florida Power Corporation to participate in mutually advantageous firm power exchanges with other electric utilities. This exchange of power can have the effect of facilitating the generation expansion plans of both participating utilities. A firm exchange of power enables the selling utility to take advantage of the economies of scale by building larger and more economical units and enables the buying utility not only to defer capital investment but also to obtain peak generating capacity that is more efficient than combustion turbines. Thus, the exchange enables both utilities to supply their customers with reliable electric service for the lowest possible cost. At the present time, Florida Power Corporation has a contract with the City of Tallahassee that allows for the purchase of 130 Mw during the winter season of 1977-78, with subsequent capacity schedules shown in Section 1.3. An agreement has also been signed with the Gainesville/Alachua County Regional Utilities Board that calls for purchase of 150 MW during the period of 1981-83.

In addition to these, agreements are also being negotiated with the City of Lakeland and Orlando Utilities Commission that will allow for firm power purchases in the late 1970's and early 1980's time frame.

Florida Power is making every effort to take advantage of all of the capacity available in the State of Florida in order to reduce the amount of additional generation facilities that must be added in future years. Florida Power Corporation and Seminole Electric Cooperative presently have a joint venture generating plant. Seminole Electric owns part of Florida Power Corporation's Crystal River Unit 3. At this time, there are not firm commitments for future joint ownership of generating facilities between Florida Power Corporation and Seminole. The 1985 and 1987 units of Florida Power still could develop into jointly owned units as could the 1985 Seminole unit. It is Florida Power's position to actively pursue joint ownership.

1.2 SYSTEM CAPACITY

Florida Power Corporation uses two computer programs in the process of planning generation capacity. These two programs are the Production Costing and Reliability Model known as PROMOD and the Corporate Model.

PROMOD is a reliability program that calculates the loss of load probability (LOLP).* PROMOD is used to calculate the LOLP for each year; and if the predetermined criteria for LOLP is exceeded in any year, the program calculates the amount of capacity that must be added in order to meet the criteria. The LOLP is calculated from a forecast of hourly peak demands and projected forced outage rates and scheduled outages for each generating unit. One of the most important inputs into the PROMOD program is the LOLP criteria. An LOLP of one day in 10 years has been generally accepted throughout the electric utility industry as a reasonable design goal, and this criteria is being used at Florida Power Corporation. This means there would be, on the average, one day in 10 years during which Florida Power would not be able to serve all of its firm load. For generation capacity planning purposes, it has been determined that a criteria of 2.5 days per year including dependency upon interruptible loads and interconnections is equivalent to the one day in 10 years LOLP for firm loads. After the PROMOD program has been used to determine the quantity and timing of required generation additions, expansion plans are developed for each reasonable combination of potential capacity additions. In order to evaluate these alternate expansion plans on a basis of equal reliability, PROMOD is used again to test and adjust each plan so that they do yield equal reliability.

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*Loss of Load Probability (LOLP)--is the probability that load exceeds capacity of a particular proposed generation system.

The next step in generation capacity planning is to determine, from a production costing standpoint, the cost to operate the system for each alternative expansion plan. The Production Costing Model, PROMOD, is also used to make this determination. Major inputs to PROMOD are an hourly demand and energy load model, estimated unit availability, heat rates and expected maintenance schedules for each unit, projected fuel cost for each type of fuel, and expected firm interchange information. Using this information, PROMOD determines the cost to operate the system for each alternate expansion plan.

This production costing information along with a capital cost estimate of each alternate plan and kilowatt-hour sales forecast is input into the Corporate Model, which is a computer model of the financial operation of the company. The Corporate Model is used to determine the overall cost to the customer for each of the alternate expansion plans.

By going through this three-step process, the expansion plan that produces an acceptable system reliability at the lowest overall cost to the customer and still maintains a fair rate of return to the stockholder is selected for future implementation.

1.3 RESERVE MARGINS

The proposed generation expansion plan of Florida Power Corporation is presented in Table 1.3-1.

Tables 1.3-2, 1.3-3, 1.3-4, and Figures 1.3-1, 1.3-2, and 1.3-3 are based upon the proposed generation expansion plan and demonstrate the effects of adding one 640 Mw coal unit in 1982, and another in 1984, on the Florida Power system and on the peninsula of Florida. As evident from the generation expansion plan, the addition of these two 640 Mw coal units is an important part of the overall Florida Power Corporation expansion plan through 1985. However, these units represent only one-half of the required capacity additions during the time period 1978 through 1985. The remaining additional capacity required is furnished by Anclote 2, 250 Mw combustion turbines, 300 Mw combined cycle, and purchases of firm capacity from neighboring utilities. Reductions in the previously stated forecasts in the period 1978-1985 are unlikely. However, in such a case, reduction of the generation expansion plan would be through delay and/or cancellation as required of the combustion turbine units which require a much shorter lead time than steam type units. Thus, even if the load grows at a lower rate than predicted, the two coal units are still required and will result in a system that produces the lowest overall cost to the customer. Table 1.3-2 shows reserves and LOLP if both units are added. Table 1.3-3 shows comparable figures if the 1982 unit is omitted and the 1984 unit is retained. Table 1.3-4 shows the effects of omitting both units. In all cases, there are no scheduled outages of Florida Power units during the peak periods shown. Figures 1.3-1 through 1.3-3 present the same information on peninsular Florida and Florida Power Corporation reserves and on Florida Power's LOLP in graphical form.

In the following tables and figures, Florida Power's actual LOLP calculated for 1978 is 12.2 days per year, which is significantly higher than the accepted criteria. The planned LOLP for 1978 was 2.7 days per

Table 1.3-1. Florida Power Corporation General Expansion Plan

Year	Generating Capacity †	Additions (Mw)		Date	Reserves (%)
1978	4,554	742	Crystal River 3	3/77	9.7
		(28)	Turner 2 Retired	9/77	
		130	Purchase (Tallahassee)	11/77- 3/78	
		(28)	Kissimmee, St. Cloud, and Sebring	1/78-12/78	
1979	5,055	513	Anclote 2	7/78	13.6
		90	Purchase (Tallahassee)	4/78- 3/79	
1980	5,275	50	Crystal River 2 (ID Fan)	4/79	11.1
		130	Purchase (Tallahassee)	4/79- 3/80	
		*130	Purchase (Orlando)	11/79-10/80	
1981	5,530	150	Combustion Turbines	10/80	9.5
		150	Purchase (Gainesville)	1/81-12/83	
		100	Purchase (Tallahassee)	4/80- 3/81	
		*115	Purchase (Orlando)	11/80-10/81	
1982	5,985	300	Combined Cycle	10/81	11.7
		*200	Purchase (Lakeland)	10/81-11/82	
		* 90	Purchase (Orlando)	11/81-10/82	
		80	Purchase (Tallahassee)	4/81- 3/82	
1983	6,485	640	Coal (Crystal River 4)	10/82	14.6
		*170	Purchase (Lakeland)	12/82-11/83	
		60	Purchase (Tallahassee)	4/82- 3/83	
1984	6,235	100	Combustion Turbines	10/83	8.2
		30	Purchase (Tallahassee)	4/83- 3/84	
1985	6,845	640	Coal (Crystal River 5)	4/84	13.1
1986	7,441	640	Coal Unit	10/85	21.2
		(44)	Avon Park 2 Retired		
1987	7,374	(67)	Suwannee 1, 2 Retired	6/86	16.9
1988	8,014	640	Coal Unit	10/87	21.8

* Contracts presently under negotiation.

† Generating capacity at time of winter peak is calculated as follows: For generating capacity 1979, 5055 Mw is obtained by subtracting the 130 Mw Tallahassee purchase which expires 3/78 from the 1978 generating capacity of 4582 Mw and then adding 513 Mw for Anclote 2 and 90 Mw for Tallahassee purchase. Subsequent years are calculated in the same manner, recognizing the effective terms of purchase capacity commitments.

Source: Florida Power Corporation, 1978.

Table 1.3-2. Capacity, Demands, and Reserves for Peninsular Florida and Florida Power Corporation (With Both Proposed Units Included)

Year	Capacity		Winter † Peak Demand		Reserves				FPC LOLP Days/Year
					State		FPC		
	State	FPC *	State	FPC	Mw	%	Mw	%	
1978	23,448	4,554	17,311	4,150	6,137	35.4	404	9.7	12.2
1979	23,546	5,055	18,475	4,450	5,071	27.4	605	13.6	4.6
1980	24,483	5,275	19,598	4,750	4,885	24.9	525	11.1	3.1
1981	26,270	5,530	20,769	5,050	5,501	26.5	480	9.5	3.1
1982	26,910	5,985	21,895	5,360	5,015	22.9	625	11.7	2.3
1983	29,015	6,485	22,996	5,660	6,019	26.2	825	14.6	2.8
1984	28,401	6,235	24,082	5,760	4,319	17.9	475	8.2	1.7
1985	31,412	6,845	25,232	6,050	6,180	24.5	795	13.1	1.5
1986	31,934	7,441	26,390	6,140	5,544	21.0	1,301	21.2	0.7
1987	33,374	7,374	27,592	6,310	5,782	21.0	1,064	16.9	1.3

* FPC capacity includes firm power purchases where applicable and is that value of capacity in the month of January for each respective year.
† Winter peak is assumed to occur in January of each year.

Source: Florida Power Corporation, 1978.

Table 1.3-3. Capacity, Demands, and Reserves for Peninsular Florida and Florida Power Corporation (With Crystal River 4 Omitted and Crystal River 5 Included)

Year	Capacity		Winter † Peak Demand		Reserves				FPC LOLP Days/Year
					State		FPC		
	State	FPC *	State	FPC	Mw	%	Mw	%	
1978	23,448	4,554	17,311	4,150	6,137	35.4	404	9.7	12.2
1979	23,546	5,055	18,475	4,450	5,071	27.4	605	13.6	4.6
1980	24,483	5,275	19,598	4,750	4,885	24.9	525	11.1	3.1
1981	26,270	5,530	20,769	5,050	5,501	26.5	480	9.5	3.1
1982	26,910	5,985	21,895	5,360	5,015	22.9	625	11.7	2.9
1983	28,375	5,845	22,996	5,660	5,379	23.4	185	3.3	9.0
1984	27,761	5,595	24,082	5,760	3,679	15.3	-165	-2.85	5.6
1985	30,772	6,205	25,232	6,050	5,540	22.0	155	2.55	5.3
1986	31,294	6,801	26,390	6,140	4,904	18.6	661	10.8	2.9
1987	32,734	6,734	27,592	6,310	5,142	18.6	424	6.7	4.7

* FPC capacity includes firm power purchases where applicable and is that value of capacity in the month of January for each respective year.
† Winter peak is assumed to occur in January of each year.

Source: Florida Power Corporation, 1978.

Table 1.3-4. Capacity, Demands, and Reserves for Peninsular Florida and Florida Power Corporation (With Crystal River 4 and Crystal River 5 Omitted)

Year	Capacity		Winter † Peak Demand		Reserves				FPC LOLP Days/Year
					State		FPC		
	State	FPC *	State	FPC	Mw	%	Mw	%	
1978	23,448	4,554	17,311	4,150	6,137	35.4	404	9.7	12.2
1979	23,546	5,055	18,475	4,450	5,071	27.4	605	13.6	4.6
1980	24,483	5,275	19,598	4,750	4,885	24.9	525	11.1	3.1
1981	26,270	5,530	20,769	5,050	5,501	26.5	480	9.5	3.1
1982	26,910	5,985	21,895	5,360	5,015	22.9	625	11.7	2.9
1983	28,375	5,845	22,996	5,660	5,379	23.4	185	3.3	9.0
1984	27,761	5,595	24,082	5,760	3,679	15.3	-165	-2.9	12.2
1985	30,132	5,565	25,232	6,050	4,900	19.4	-485	-8.0	13.8
1986	30,654	6,161	26,390	6,140	4,264	16.2	21	0.3	9.1
1987	32,094	6,094	27,592	6,310	4,502	16.3	-216	-3.4	14.1

* FPC capacity includes firm power purchases where applicable and is that value of capacity in the month of January for each respective year.
† Winter peak is assumed to occur in January of each year.

Source: Florida Power Corporation, 1978.

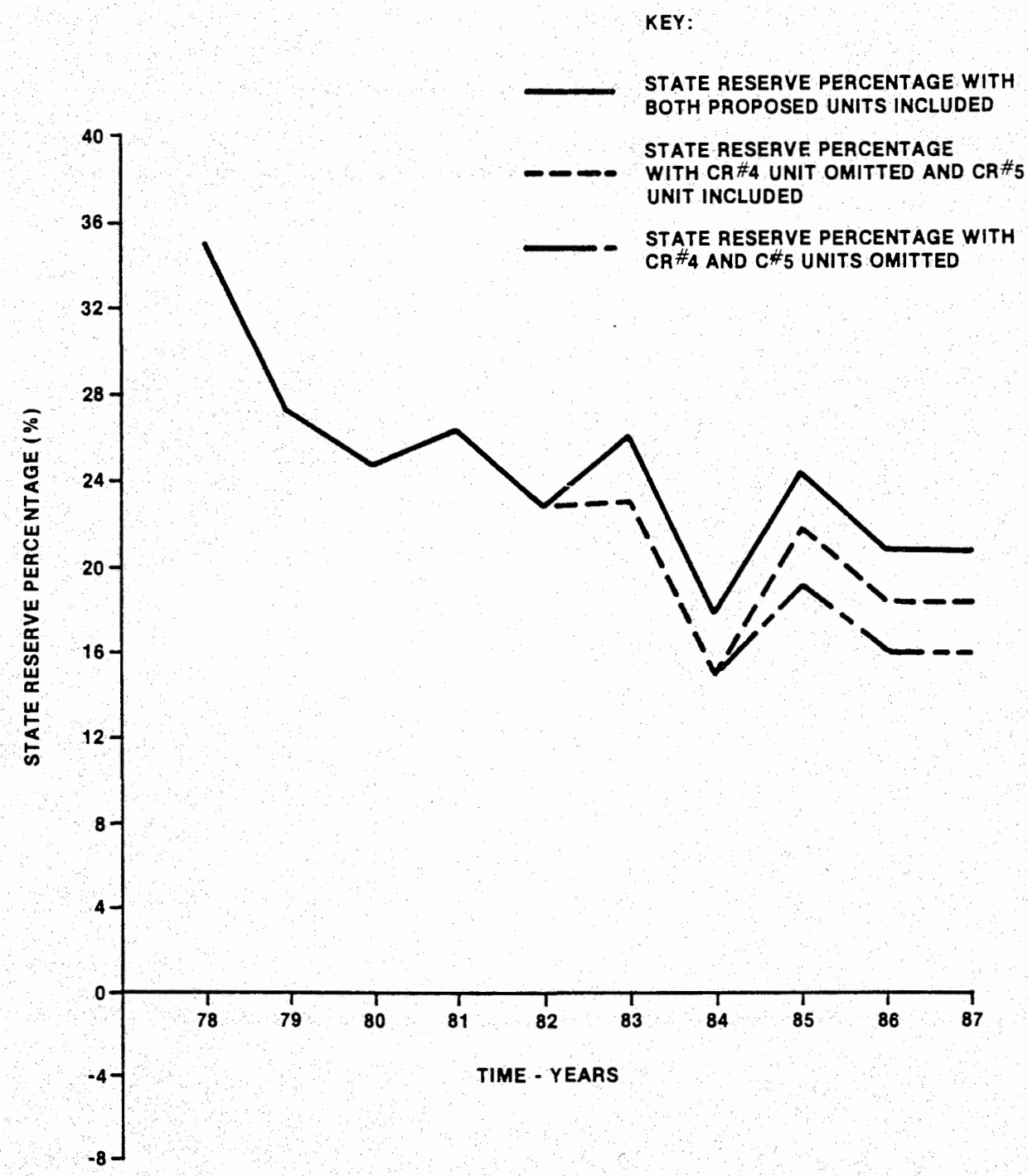

Figure 1.3-1 PENINSULAR FLORIDA PERCENT RESERVES

SOURCE: FLORIDA POWER CORPORATION , 1978

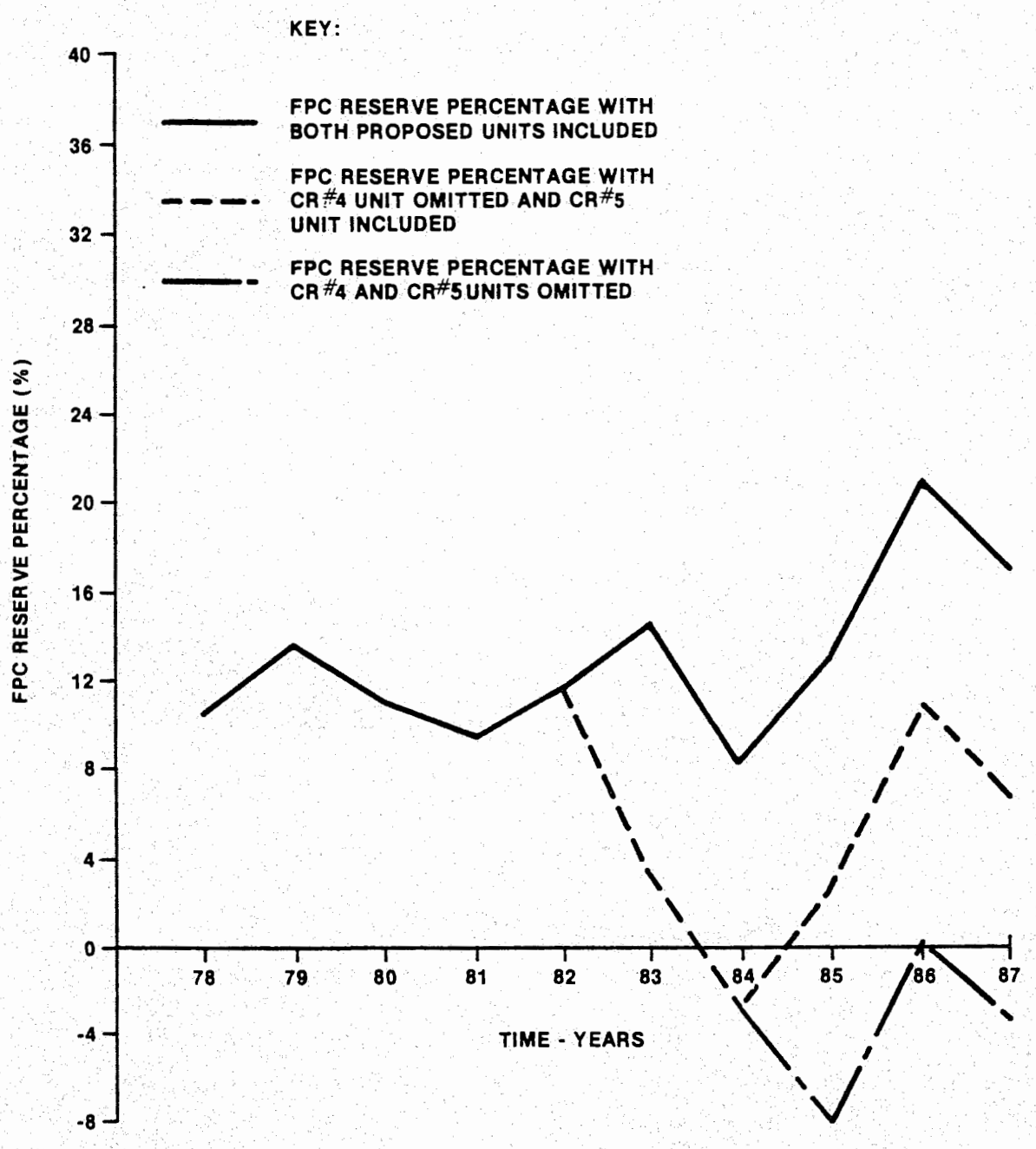

Figure 1.3-2 FLORIDA POWER CORPORATION PERCENT RESERVES

SOURCE: FLORIDA POWER CORPORATION, 1978.

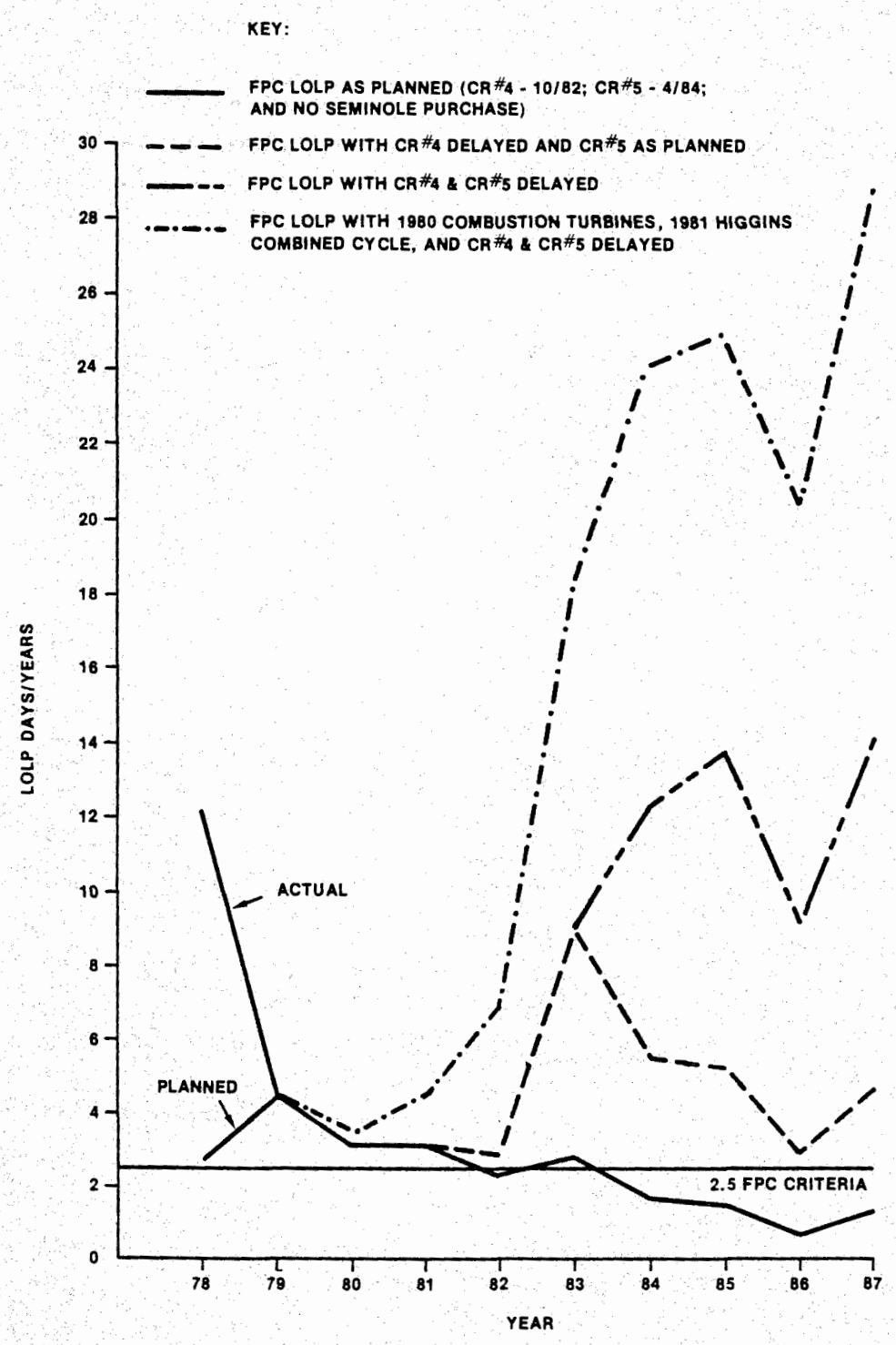

Figure 1.3-3 FLORIDA POWER CORPORATION LOSS OF LOAD PROBABILITY

SOURCE: FLORIDA POWER CORPORATION, 1978

year with normal maintenance and operation. However, due to the abnormally high forced maintenance for Crystal River Unit 3 and the unplanned unavailability of Anclote 2, the actual 1978 LOLP is much higher than planned.

As can be seen from the tables and figures, Florida Power's reserves and LOLP have unacceptable values without the additional capacity provided by the two proposed units. A discussion of Florida Power's LOLP criteria and how it is used in conjunction with interconnections and interruptible load for planning purposes is contained in Section 1.2.

1.4 OTHER OBJECTIVES

At the present time, the sole objective of the two proposed units is to produce electricity.

1.5 CONSEQUENCES OF DELAY

As discussed previously, one method used by the electric utility industry to evaluate the adequacy of reserve capacity levels in generation expansion planning is loss of load probability. In this context, LOLP can also be used to describe and evaluate the effects of changes in system generation capacities. An LOLP index of one day in ten years for firm load calculated on an interconnected system basis has been generally accepted as a reasonable goal by the electric utility industry. A value of approximately 2.5 days per year dependency upon tie lines and/or interruptible loads has been determined as an acceptable equivalent index for the Florida Power Corporation system and is used as the basis for evaluating the consequences of generation capacity changes.

Tables 1.3-2 and 1.3-3 and Figure 1.3-3 show that if the proposed project were delayed, the LOLP index for the Florida Power Corporation system would greatly exceed acceptable values in the period 1983 to 1987. If the proposed unit is not installed in 1982 as planned, this index will jump from 2.8 to 9.0 in 1983. Figure 1.3-3 illustrates the continued effect on system reliability in terms of days/year if <u>only</u> the proposed Crystal River 4 unit was deleted from the proposed generation expansion plan. This graph includes the addition of 450 Mw of additional peaking and combined cycle capacity to the Florida Power Corporation system prior to the addition of the proposed Crystal River 4 unit, as well as firm capacity purchases from other utilities during the time period 1979-1983 and subsequent 640 Mw coal capacity additions in 1984, 1985, and every second year thereafter. The details of the Florida Power Corporation generation expansion plan were presented in Section 1.3.

One can see from Figure 1.3-3 that for the subsequent 7-year period without installation of the proposed Crystal River 4 unit the LOLP

exceeds acceptable values, even if all other proposed generation additions and firm capacity purchases were installed as planned and on schedule. The deviation of LOLP from acceptable values would be even greater if the proposed Crystal River 5 unit were also omitted.

Figure 1.5-1 shows the effects on Florida Power Corporation's LOLP of delaying the other proposed generation additions and firm capacity purchases from other utilities even if Crystal River Units 4 and 5 are installed as planned. Since the other proposed generation additions have not yet been licensed, there is a possibility that the 450 Mw of additional peaking and combined cycle capacity that they represent may be delayed due to licensing or construction problems. Figure 1.5-1 shows the effect on system reliability in terms of days/year if only the 450 Mw of combustion turbines and combined cycle units were omitted (or indefinitely delayed) from the proposed generation expansion plan. As shown in Figure 1.5-1, if the combustion turbines and combined cycle units are delayed or omitted from the generation expansion plan and the Crystal River 4 and Crystal River 5 units are added, the loss of load probability exceeds acceptable values. If the 1980 combustion turbines and 1981 combined cycle units are not installed, the loss of load probability exceeds 6 days/year in 1983 and never reaches Florida Power's LOLP criteria of 2.5 days/year until 1986.

As mentioned previously, Florida Power Corporation plans to purchase firm capacity from neighboring utilities (Section 1.3). All previous figures and discussions include these firm purchases which reach peaks of 550 Mw and 370 Mw in 1981 and 1982, respectively. Since some of these purchases are based on the addition of new units by other utilities, there is a possibility that these purchases could be delayed. Also, Figure 1.5-1 shows the effect on system reliability in terms of days/year if only the Lakeland, Gainesville, and Orlando purchases were omitted from the proposed generation expansion plan. As shown in Figure 1.5-1, the omission of the Lakeland, Gainesville, and Orlando purchases has the effect of doubling the "as planned" system loss of load probability during the time period 1981 through 1983.

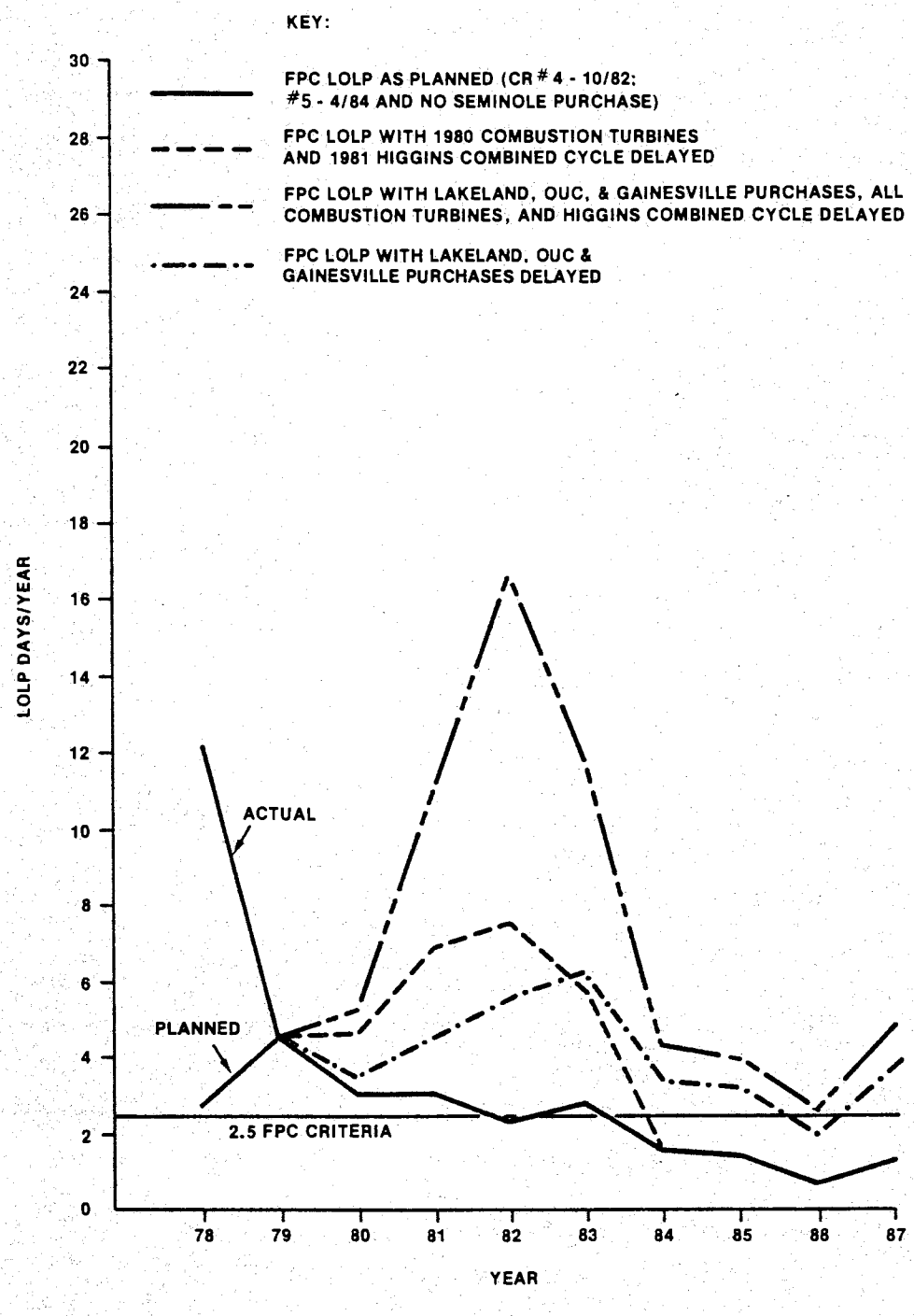

Figure 1.5-1 FLORIDA POWER CORPORATION LOSS OF LOAD PROBABILITY

SOURCE: FLORIDA POWER CORPORATION, 1978

In addition, Figure 1.5-1 shows the effect on the Florida Power Corporation system loss of load probability if the 1980 combustion turbines and the 1981 combined cycle units are not installed along with the omission of the Lakeland, Gainesville, and Orlando purchases. As seen from this figure, the loss of load probability exceeds 16 days/year in 1982, even with the addition of Crystal River 4 in October of that same year.

The addition of Crystal River 4 and Crystal River 5 coal units is essential and considered a minimum requirement for the Florida Power Corporation system. If neither the 450 Mw of combustion turbines and combined cycle units nor the Crystal River 4 and Crystal River 5 coal units are installed as planned, the loss of load probability exceeds 24 days per year by 1984 and 28 days per year by 1987 (Figure 1.3-3).

As shown in Figure 1.5-2, a possible alternative to the Florida Power Corporation facility expansion plan is the delay of Crystal River 5 until October, 1985, with the purchase of 300 Mw from Seminole Electric Cooperative, Inc., from October, 1983 to October, 1986 and the delay of the Florida Power Corporation 1985 coal unit until October, 1986. Also shown in Figure 1.5-2 is the effect on the Florida Power Corporation LOLP if the Crystal River 5 and Seminole units are delayed. It should be noted that the Seminole delay not only deprives the Florida Power Corporation system of 300 Mw of planned capacity purchase but also increases the Florida Power Corporation load responsibility by 200 Mw. In this case, the Florida Power Corporation LOLP rises to 5.5 days/year in 1984 and exceeds 10 days/year by 1987. It is important to note that there are substantial risks associated with the reliance on firm purchases from other utilities (Lakeland, Gainesvile, and Orlando) during the time period 1979 to 1984. As shown in Figure 1.5-1, if these purchases are delayed, in 1982 the Florida Power Corporation LOLP exceeds 7 days/year even with the addition of Crystal River 4 in October, 1982 and 5 days/ year in 1983. Since the possibility exists that these purchases (Lakeland, Gainesville, Orlando, and Seminole) may not materialize as scheduled and that problems in the licensing and construction of

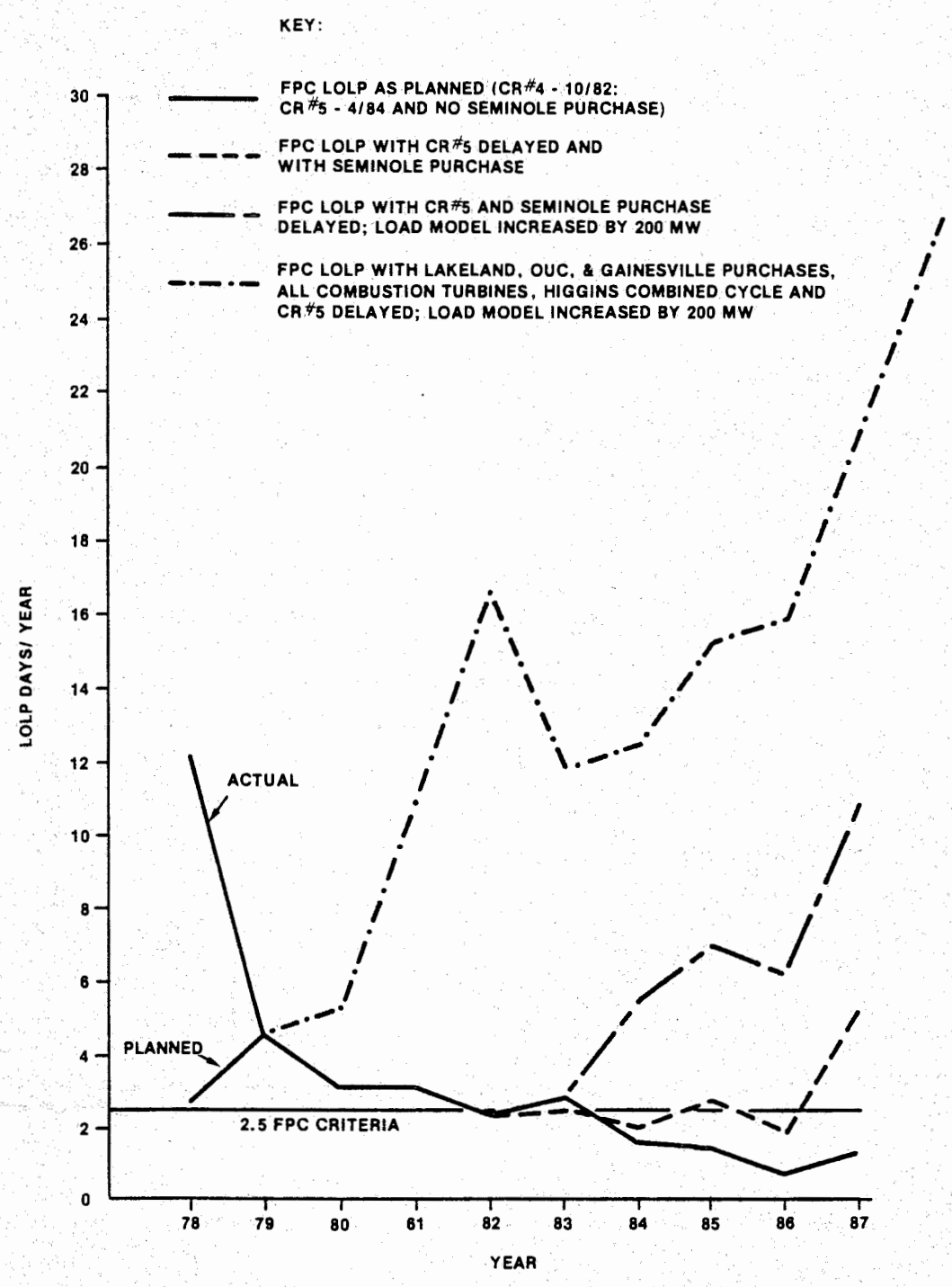

Figure 1.5-2 FLORIDA POWER CORPORATION LOSS OF LOAD PROBABILITY

SOURCE: FLORIDA POWER CORPORATION, 1978

1980 combustion turbines and 1981 combined cycle units may also result in delays, therefore flexibility in the scheduling to bring Crystal River 5 on-line as early as possible must be maintained in order to assure a reliable supply of electric service to our customers.

These figures, as are all loss of load probability figures, are an index of system reliability. They are not to be interpreted as a prediction of the actual days of load interruption or emergency tie line interchange expected during some future year. They are strictly probability figures; that is to say, for example, if the year 1983 were to repeat over and over, it is expected that on the average there would be 2.8 days per year that the Florida Power system would be lacking sufficient generation to cover its total load and thus be dependent upon emergency interchange availability and the shedding of interruptible loads. Without the proposed Crystal River 4 unit, this figure rises to 9 days per year.

If in a given situation the sum total of available emergency power and interruptible load on the system is insufficient to cover the deficit, the loss of firm loads within the Florida Power system is inevitable. As a general practice, the electrical utilities within the United States have attempted to minimize such loss of firm load due to generation capacity deficiencies to one day in ten years. Joint studies conducted within the state of Florida indicate that with the proposed generation facilities plan this reliability goal can be accomplished. If, on the other hand, the recommended capacities are delayed, the figures indicate there would probably be more frequent instances of blackouts and/or brownouts within the Florida Power Corporation service area. Outages due to lack of generation capacity have a much more severe impact upon the communities served by the company than do interruptions to individual customers or small groups of customers.

SECTION 2.4

GEOLOGY

2.4 GEOLOGY

2.4.1 SITE DESCRIPTION

The proposed Florida Power plant site is located just north of two existing Florida Power power plants in Citrus County in the area between the Withlacoochee River to the north and the Crystal River to the south. The site is approximately 1.6 kilometers (1 mile) inland from the Gulf of Mexico.

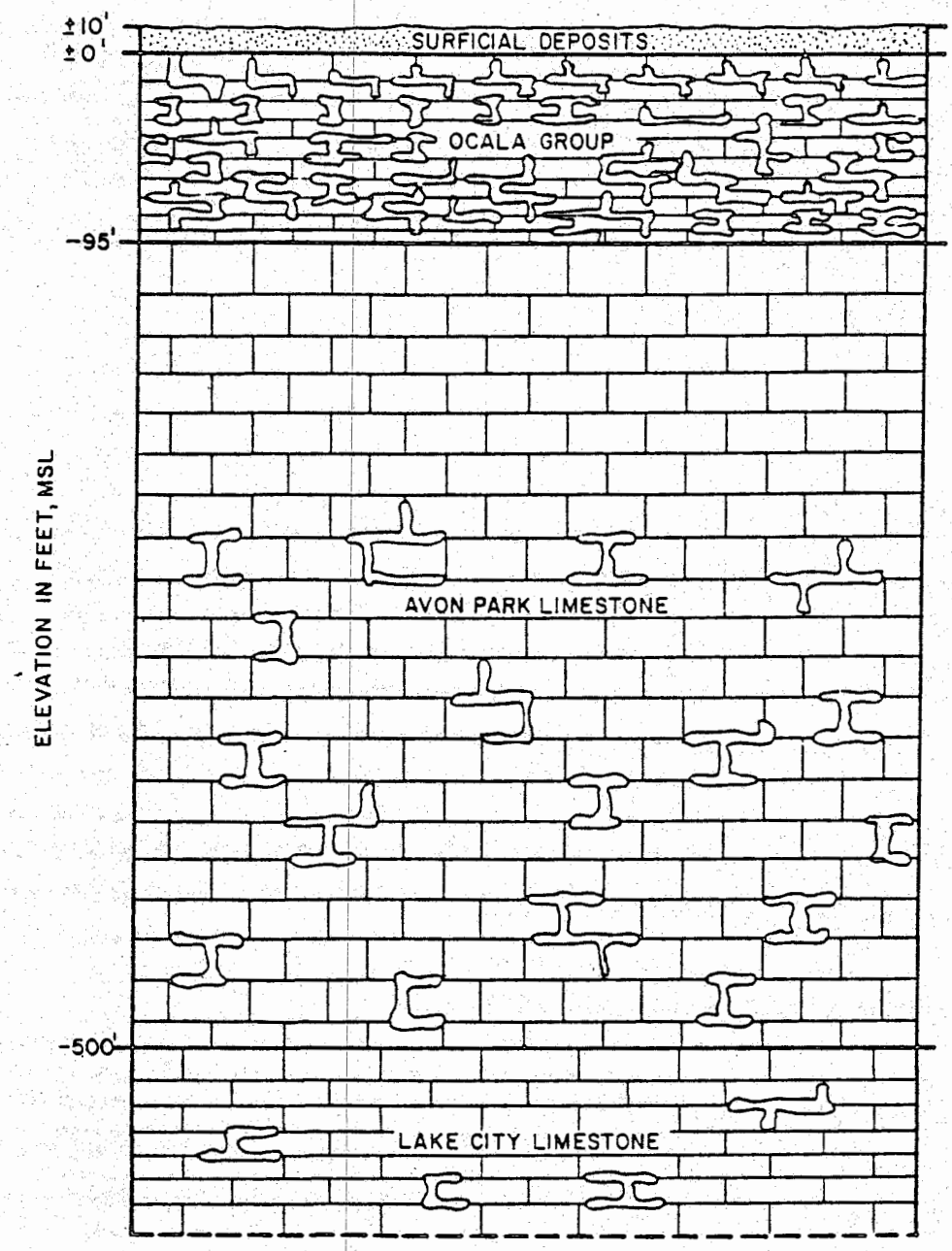

Figure 2.4-1
TYPICAL GEOLOGICAL COLUMN AT THE STUDY SITE

N

0 50 100
SCALE IN FEET

SOURCE: GERAGHTY AND MILLER, INC., 1977

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2.4.2 PHYSIOGRAPHY

The geomorphology in this area is defined by two well-developed coastal marine terraces which parallel the coast and mark the landward extent of two Pleistocene seas, the Pamlico and Wicomico, with shorelines at 7.6 meters (25 feet) and 30 meters (100 feet) above mean sea level, respectively. The site is located within the Pamlico marine plain.

The Pamlico is the lowest of the coastal terraces, extending inland from the coast to approximately the 7.6-meter (25-foot) contour which marks the base of a 3- to 6-meter (10- to 20-foot) escarpment. At the site, the plain is approximately 13 to 16 kilometers (8 to 10 miles) wide.

The present coast of Citrus County is submerged, as evidenced by the extensive coastal marshes. According to Vernon (1951), this condition indicates a rising sea level that is out of adjustment to the land mass. As a result, the limestones that underlie the coast are being eroded along coastal margins to form a fairly continuous limestone escarpment 1 to 1.5 meters (3 to 5 feet) above mean sea level. This escarpment passes through the proposed site from the northwest to the southeast. The surface of the proposed site is comprised of a thin veneer of sands overlying a broad limestone shelf. This limestone shelf comprises the top of the Floridan aquifer and is greatly fractured. This fracturing, combined with the discharge from the Floridan aquifer, gives rise to numerous springs scattered throughout the coastal hammock. Most of the streams in the area, such as the Crystal River and the Homosassa River, are spring fed.

As evidenced by the absence of defined stream channels and surface water drainage features, the Pamlico marine plain allows relatively little rainwater runoff in the area of the proposed Florida Power plants.

2.4.3 STRATIGRAPHY

The Floridan aquifer is the upper sequence of rock formations which underlies the study area and contains large volumes of fresh water. The Floridan aquifer is comprised of the Ocala Group, Avon Park Limestone, and the Lake City Limestone. Figure 2.4-1 shows the approximate geologic column at the proposed plant site.

Limestone and dolostone are the primary constituents of the Floridan aquifer. These rocks have recently undergone extensive solution activity during the geologic past when the sea level was much lower. As a result, solution cavities have developed in the upper portion of the aquifer. The most extensive solution zone is believed to have occurred in the Ocala Group and at the contact between the Ocala Group and Avon Park Formation. However, large cavities have been encountered within the Avon Park Formation, and it is believed that large volumes of water flow through this formation (Geraghty and Miller, 1977).

The top of the Floridan aquifer occurs at or near land surface in the coastal zone (Figure 2.4-1) where it is overlain by a thin veneer of surficial deposits composed chiefly of sand. Inland, these surficial deposits increase in thickness. Analysis of data from soil borings drilled in the plant site area, and adjacent transmission corridor indicates that the rock in the coastal zone is directly overlain by deposits composed of sand; however, in the inland areas, a relatively thin sandy layer is present at the base of the surficial deposits which separates the rock from the sand. Table 2.4-1 presents representative soil boring data for the plant site area. The top-of-rock elevation of the Floridan aquifer is shown in Figure 2.4-2 (Geraghty and Miller, 1977).

STRUCTURE

The principal structural features in this area are believed to have formed as a result of the Ocala Uplift. Due to the uplifting, extensive

Table 2.4-1 Plant Site Area Soil Boring

	Mean Meters (feet)	Maximum Meters (feet)	Minimum Meters (feet)
Depth of water table below surface	0.64 (2.1)	1.1 (3.7)	0.37 (1.2)
Upper soil layer thickness	0.85 (2.8)	3.2 (10.5)	0.0 (0.0)
Thickness of Inglis member	14.6 (47.8)	16.2 (53.0)	13.3 (13.7)
Depth to Avon Park formation	15.2 (50.0)	16.9 (55.3)	13.6 (44.7)

Source: Environmental Science and Engineering, Inc., 1978.

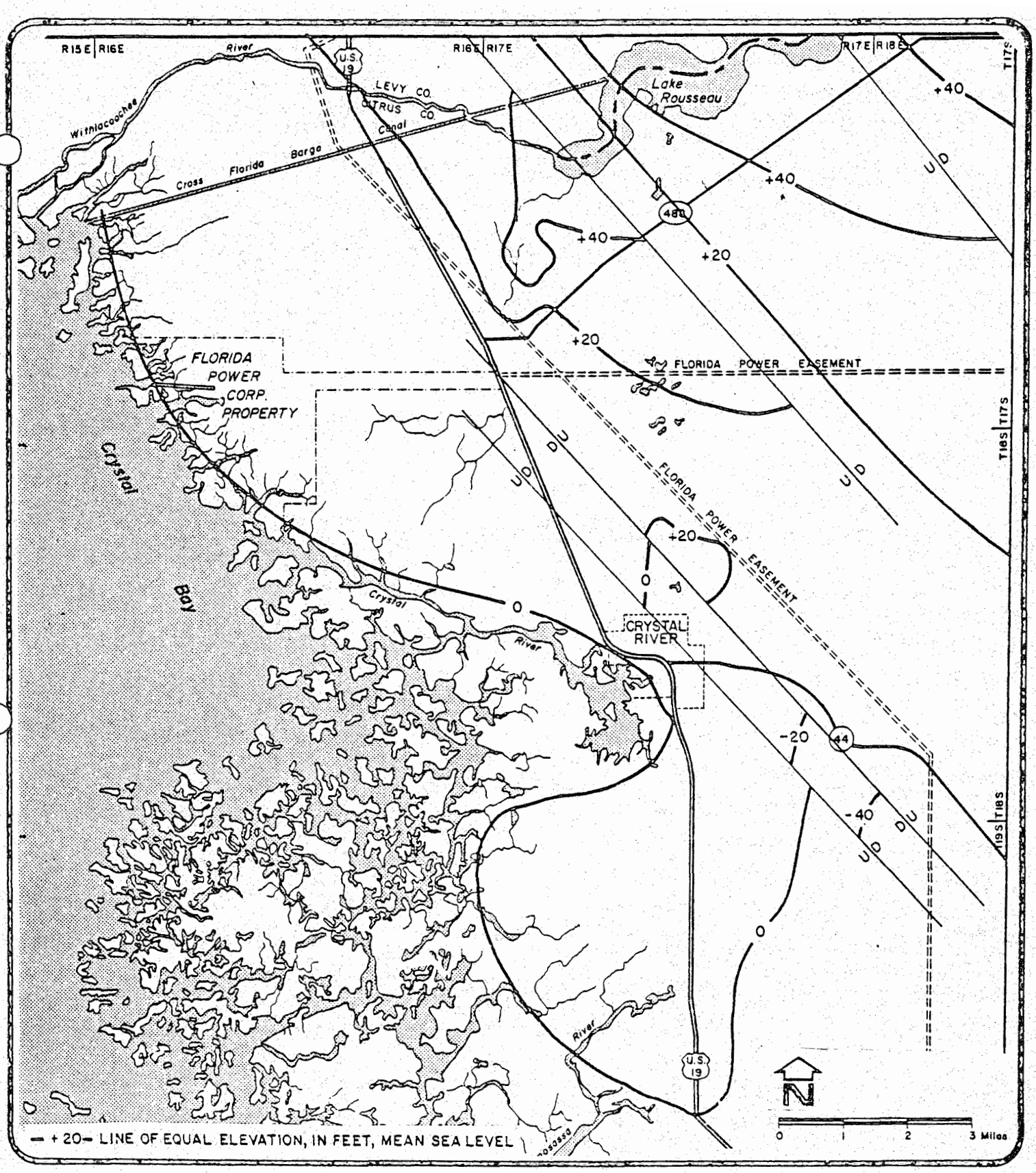

Figure 2.4-2
ELEVATION OF THE TOP ROCK OF THE FLORIDAN AQUIFER

SOURCE: GERAGHTY AND MILLER, INC., 1977

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fracturing and faulting occurred parallel to the strike of the Uplift, as shown in Figure 2.4-2. In addition, differential forces associated with the uplifting also caused minor fractures that developed at right angles to the primary fractures. Therefore, a well-developed fracture system is present throughout the area, with the major axes striking northwest/southeast and the minor axes striking northeast/southwest.

Prior to 1951, faulting was not recognized in Florida; but upon Vernon's publication of Bulletin 33 of the Florida Geological Survey, a well-defined system of high-angle faulting was mapped along the east side of Citrus and Levy counties.

The westernmost extension of the mapped faulting lies 4.8 kilometers (3 miles) east of the plant site. All faulting common to Levy and Citrus counties is oriented along steeply dipping (greater than 60 degree), northwest-trending fault planes which have produced displacements of 6 to 49 meters (20 to 160 feet).

Supplemented by photogeologic studies, subsurface explorations in the form of test borings and a seismic refraction survey eliminate the possibility that faulting exists beneath the proposed plant site because:

1. Correlation of marker horizons delineated by rock cores negates any inference that vertical displacement exists in the subsurface. Marker beds exist at expected elevations in points of investigation (drill holes).
2. Seismic profiles also showed no anomalous changes in elevations of velocity layers.

The nearest faulting occurs at a distance of 4.8 kilometers (3 miles) to the east of the site. Stratigraphic correlation and continuity of seismic refraction profiles negate the possible existence of subsurface faults at the site.

SEISMICITY

Weston Geophysical Research, Inc. conducted the seismic study which involved a thorough literature search and examined available seismograms

to determine the epicentral distribution of earthquakes in the southeastern United States, their focal depth, intensity and/or magnitude, and attenuation characteristics. Regional tectonics and fault patterns were investigated for possible association with known epicenters. This study indicates that the State of Florida is seismically inactive and that the closest area to the site of significant seismic activity is Charleston, South Carolina. Attenuation data available for this area indicate that the site experienced an observed intensity no higher than Intensity V (Modified Mercalli). The maximum ground motion at the site due to this earthquake probably did not exceed 0.025 gram.

The site is located in Seismic Zone 1 (Department of Army, Navy, and Air Force, 1973) which is rated as probable to expect only minor damage. Therefore, the area is considered seismically stable.

2.4.4 SOILS

Soils on and around the site are nearly level and poorly drained. In the eastern portion of the site, the dominant soil association is the Broward-Boca association. These are sandy soils underlain by limestone. While these soils present severe restrictions to development because of wetness and a relatively shallow depth to limerock, they are the most dependable soils on the property. To the west, the soils are extremely wet, classified as either freshwater swamp or saltwater marsh. These soils are subject to frequent and prolonged flooding.

2.4.5 FLOODING

Because of the extreme flatness of the site and the proximity to the Gulf of Mexico, the area is subject to flooding. The most extensive flooding to be expected at the site will be produced by abnormally high tides resulting from hurricane surge and over-riding wind waves. The U.S. Army Corps of Engineers estimates the elevation of the "mean annual flood" (a flood with a 43 percent chance of occurring in any given year) at the mouth of the Withlacoochee River to be 1 meter (3 feet) above mean sea level. The USGS estimates the 100-year flood elevation at the site to be approximately 3.4 meters (11 feet) above mean sea level. Hurricane surge and wind waves at the plant site have been described in detail in "Report-Verification Study of Dames and Moore's Hurricane Storm Surge Model with Application of Crystal River Unit No. 3 Nuclear Plant--Crystal River, Florida--for Florida Power Corporation" (1973). The maximum storm tide computed by Dames and Moore is 8.96 meters (29.4 feet) above mean low water. This value includes a 0.6-meter (2-foot) reduction due to backwater effects. Maximum tidal setup will occur when hurricane winds blow onshore, tracking normal to offshore bottom contours (southwest to northeast). Assuming wind vectors normal to the coast, the maximum wave height that can traverse the fill bordering Unit 3 is 4.6 meters (15.0 feet).

2.5 HYDROLOGY

2.5.1 GROUND WATER

2.5 HYDROLOGY

2.5.1 GROUND WATER

Most of the area groundwater flow is concentrated in a moderately thin zone just below the water table (Faulkner, 1973). The upper rock of the Avon Park Formation impedes the downward movement of water, causing the preferred flow path of water recharged to the aquifer to be in the horizontal direction in the highly permeable sections of the Ocala Group.

Large quantities of water flow through the groundwater system and break out in the numerous springs in the area. Discharges at Crystal River Springs have averaged 2.24 million cubic meters (592 million gallons) per day (USGS, 1976) during the last 12 years. Although it is not recorded, ground water is also discharged from springs and seeps located along the coast. From a flow-net analysis of the area, Geraghty and Miller (1977) estimate that these additional unrecorded spring discharges between Crystal River and the Cross-Florida Barge Canal could be approximately 9.46 mld (250 mgd).

AQUIFER CHARACTERISTICS

Geraghty and Miller (1977) used an indirect technique to estimate the aquifer transmissivity. A flow-net analysis of the ground water discharging into Crystal River between the 5-foot and 10-foot contours on the potentiometric surface for May, 1977, yielded an average transmissivity of about 17,300,000 liters per day per meter (15 million gallons per day per foot). This value is comparable to that found for the Silver Springs area by Faulkner (1973) and is indicative of a very permeable aquifer.

In June 1978 an aquifer test was performed at the proposed well field site by Geraghty and Miller. The aquifer coefficients estimated from a flow net analysis and that obtained as a result of the pumping test are:

	Estimated	Actual
Transmissivity	1.86×10^8 lpd/meter, (1.5×10^7 gpd/foot)	563,700 lpd/meter, (45,390 gpd/foot)
Storage coefficient	0.2-0.0002	0.0003
Leakance	---	(0.028 gpd/foot), 3.74 lpd/cubic meter

A detailed analysis of the aquifer test is included as an appendix to this chapter.

The difference in the values obtained by the flow-net analysis and the aquifer test are thought to be the result of local variations in the hydrogeologic system. The flow-net analysis can only give an average figure for transmissivity. Solution channels or highly permeable rock zones may act as conduits which carry the water to discharge areas (such as springs or seeps) along the coast. Areas between the solution channels may exhibit much lower permeability and therefore much lower transmissivities.

No determinations are available of the storage coefficient or leakance in the area. However, because the upper portion of the aquifer near the plant site is under water-table conditions, the storage coefficient is estimated to be on the order of .05 to .20 by Geraghty and Miller. This means that for every unit volume of rock, approximately 5 to 20 percent of that volume is water which can be released from storage under the influence of gravity.

The upper portion of the aquifer is composed of a network of solution features that serve to transmit large quantities of water under natural or man-imposed gradients. The permeability of the deeper portion of the aquifer is not known. The deeper portion of the aquifer may

2.10.2 NATURAL SEA SALT

2.10.2 NATURAL SEA SALT

Figures 2.10-5, 2.10-6, and 2.10-7 indicate the trends for salt concentration and deposition as a function of distance from the coastal boundary. The corrosion rate caused by natural sea drift falls off rapidly with increasing distance from the sea. Studies show that in coastal areas, the corrosion rates of iron, stainless steel, and aluminum decrease by factors of 10, 3, and 21, respectively, as the distance increases from about 25 meters (80 feet) to about 250 meters (800 feet) inland (Roffman, et al., 1973). High precipitation rates tend to wash off the salt and thus reduce the corrosion rate, but high humidity and fog keep the surface wet and enhance corrosion. Structures in warm areas, with long periods of exposure to sunshine, experience less corrosion due to the fast evaporation of the droplets.

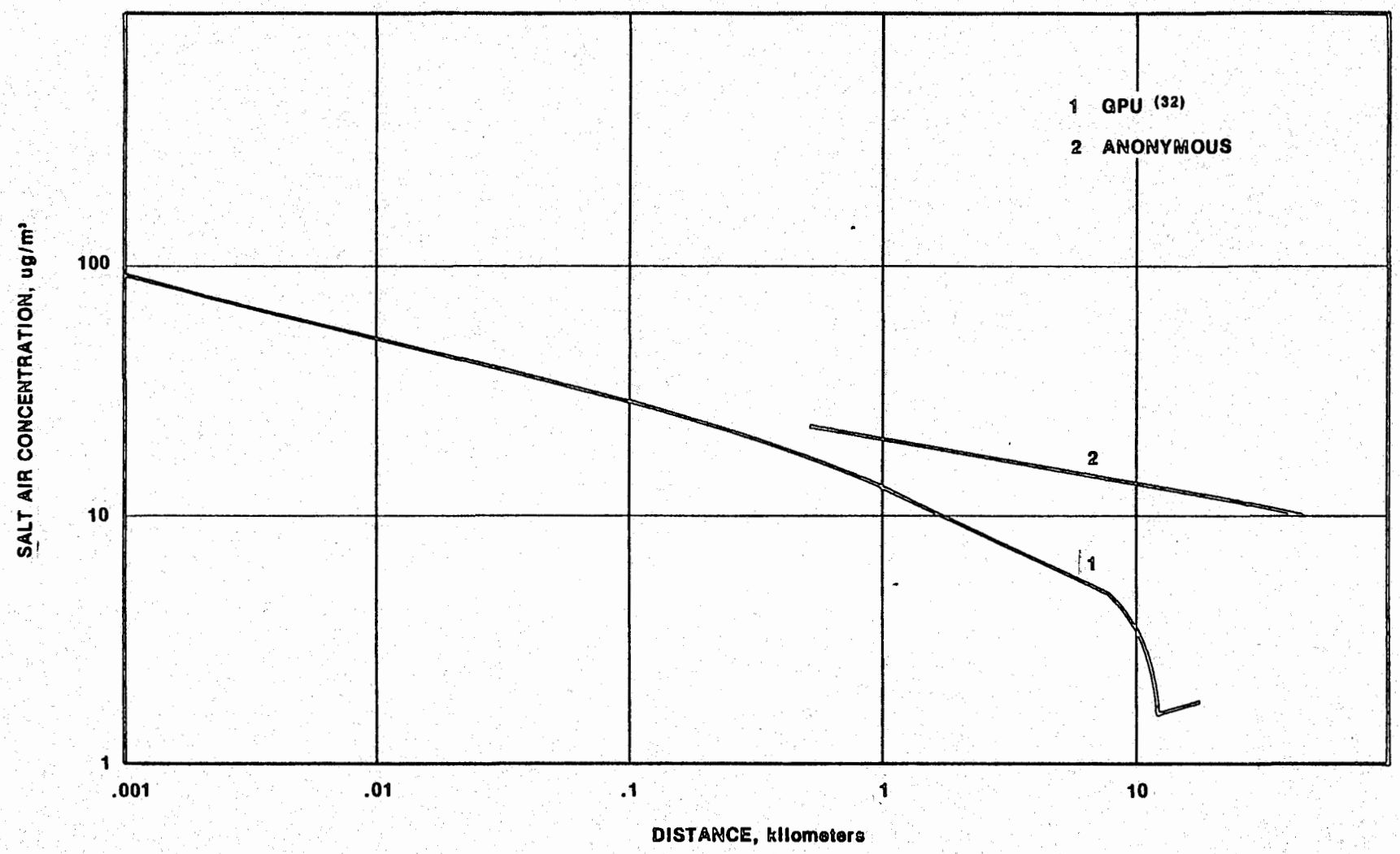

Figure 2.10-5
AIR CONCENTRATION OF SALT DRIFT AS A FUNCTION OF DISTANCE FROM THE SEA

SOURCE: WESTINGHOUSE ELECTRIC, 1973

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CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

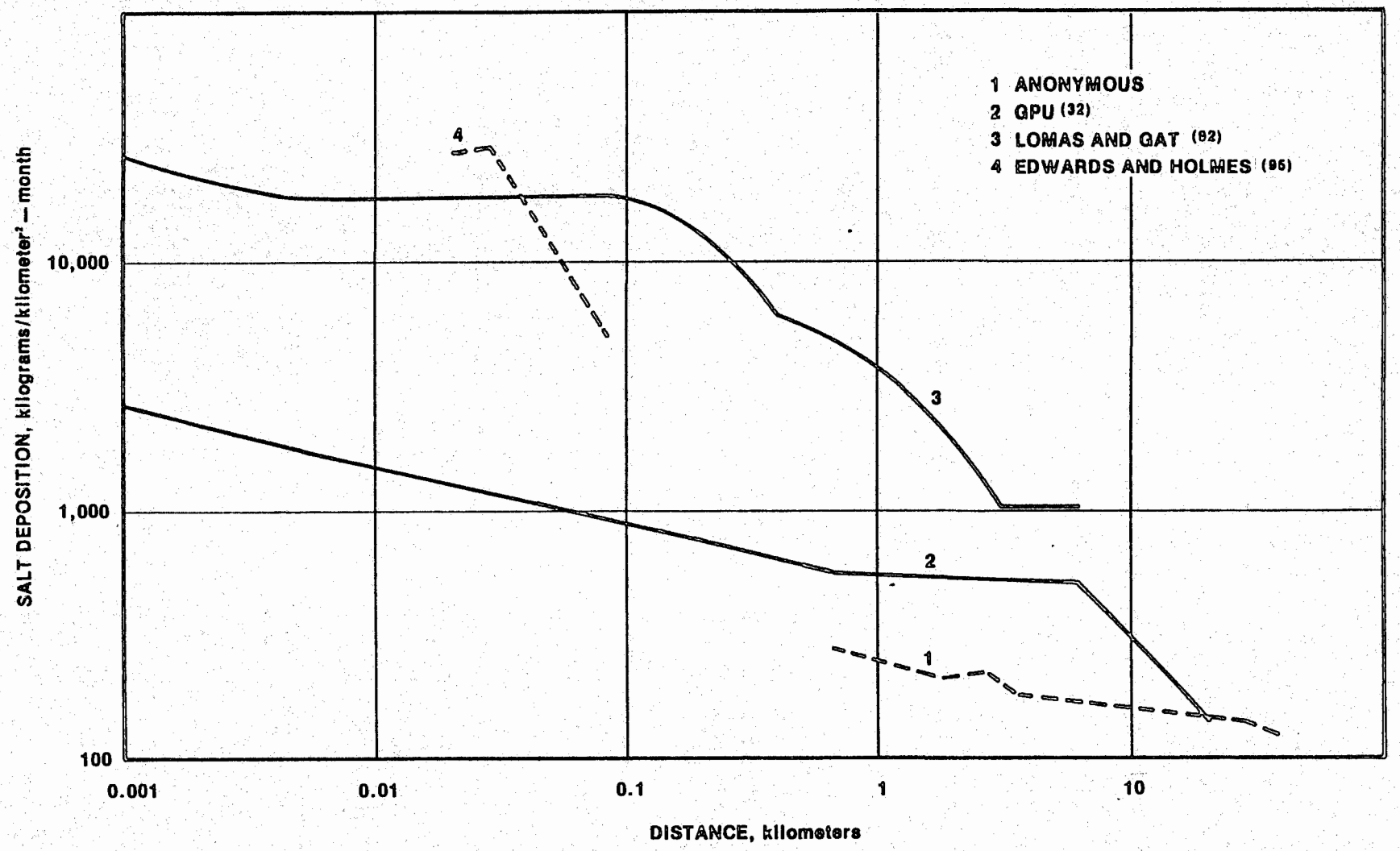

Figure 2.10-6
NATURAL DRIFT DEPOSITION RATE AS A FUNCTION OF DISTANCE FROM THE SEA

SOURCE: WESTINGHOUSE ELECTRIC, 1973

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

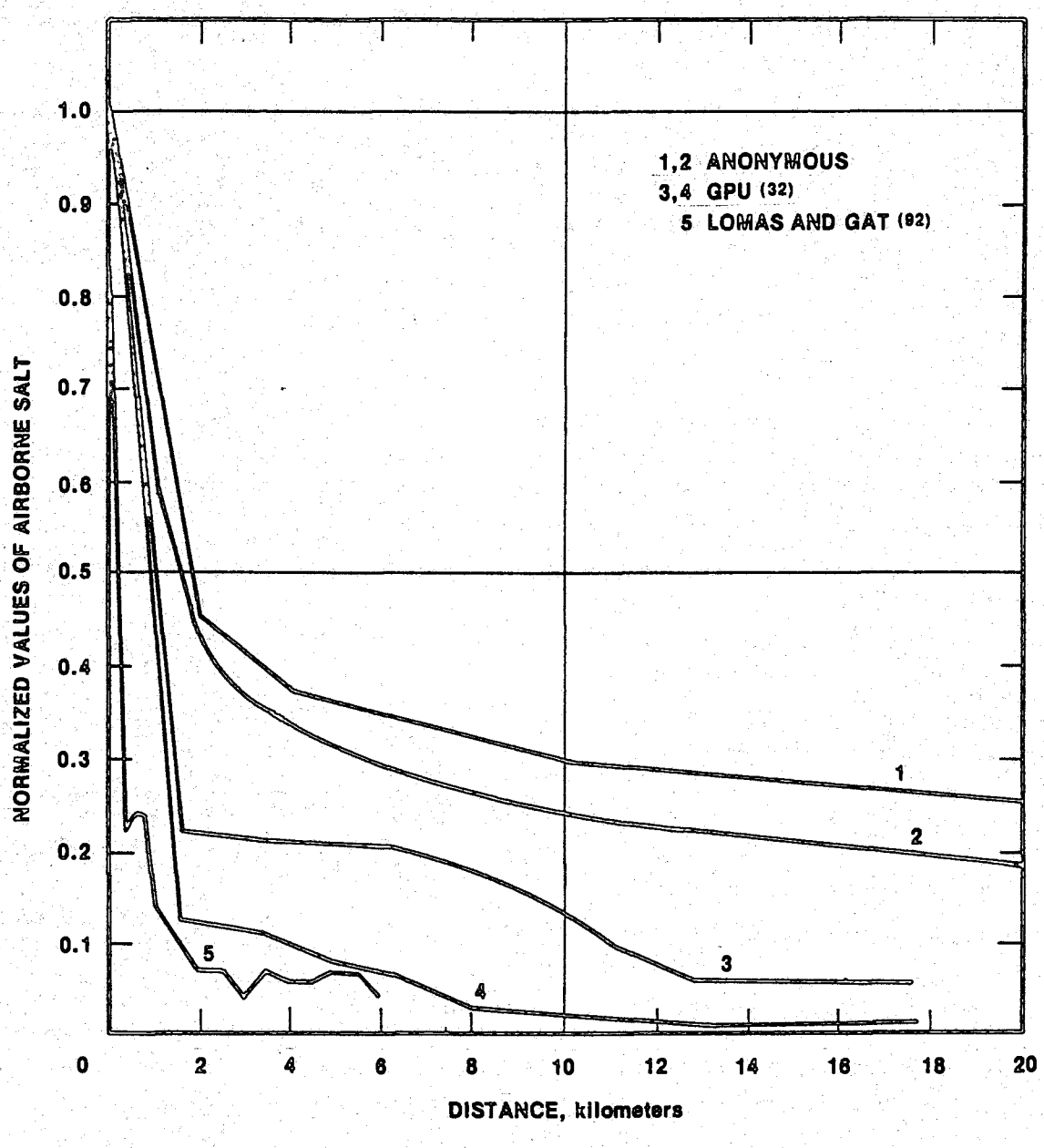

Figure 2.10-7
NORMALIZED AIRBORNE SALT VALUES AS A FUNCTION OF THE DISTANCE INLAND (WITH AN INITIAL VALUE OF ONE AT SEA SHORE)

SOURCE: WESTINGHOUSE ELECTRIC, 1973

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

CHAPTER 3

THE PLANT

CHAPTER 3

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3.0 THE PLANT

3.1 ARRANGEMENT AND EXTERNAL APPEARANCE

3.1.1 SITE ARRANGEMENT

The site boundary and building layout for Units 4 and 5 at Crystal River are shown in Figures 3.1-1 and 3.1-2. The site includes approximately 1,540 hectares (3,810 acres) of land. Figure 3.1-3 is an artist's perspective of the plant site.

The installation of Units 4 and 5 is a reasonable and logical expansion of the power plant site which now comprises Units 1, 2, and 3. The total cleared area for Units 1, 2, and 3 is approximately 1,290 hectares (319 acres). Existing facilities are used to the maximum practical extent to minimize impacts and costs. The plant layout is developed to facilitate plant operation and maintenance.

As shown in Figure 3.1-4, the central building complex for Units 4 and 5 will be located north of the central complex containing Units 1, 2, and 3. Approximately 136 hectares (335 acres) will be cleared for the construction of Units 4 and 5. The cooling towers for Units 4 and 5 will be located west of the units. The existing coal handling facilities will be expanded to accommodate the requirements for Units 4 and 5 with a coal storage east of the proposed units. The solid waste products for all Units 4 and 5 will be stored in areas located east and southeast of the main plant complex.

Figure 3.1-5 shows the relationship of the site boundary to plant access roads and the transmission towers within the transmission corridor.

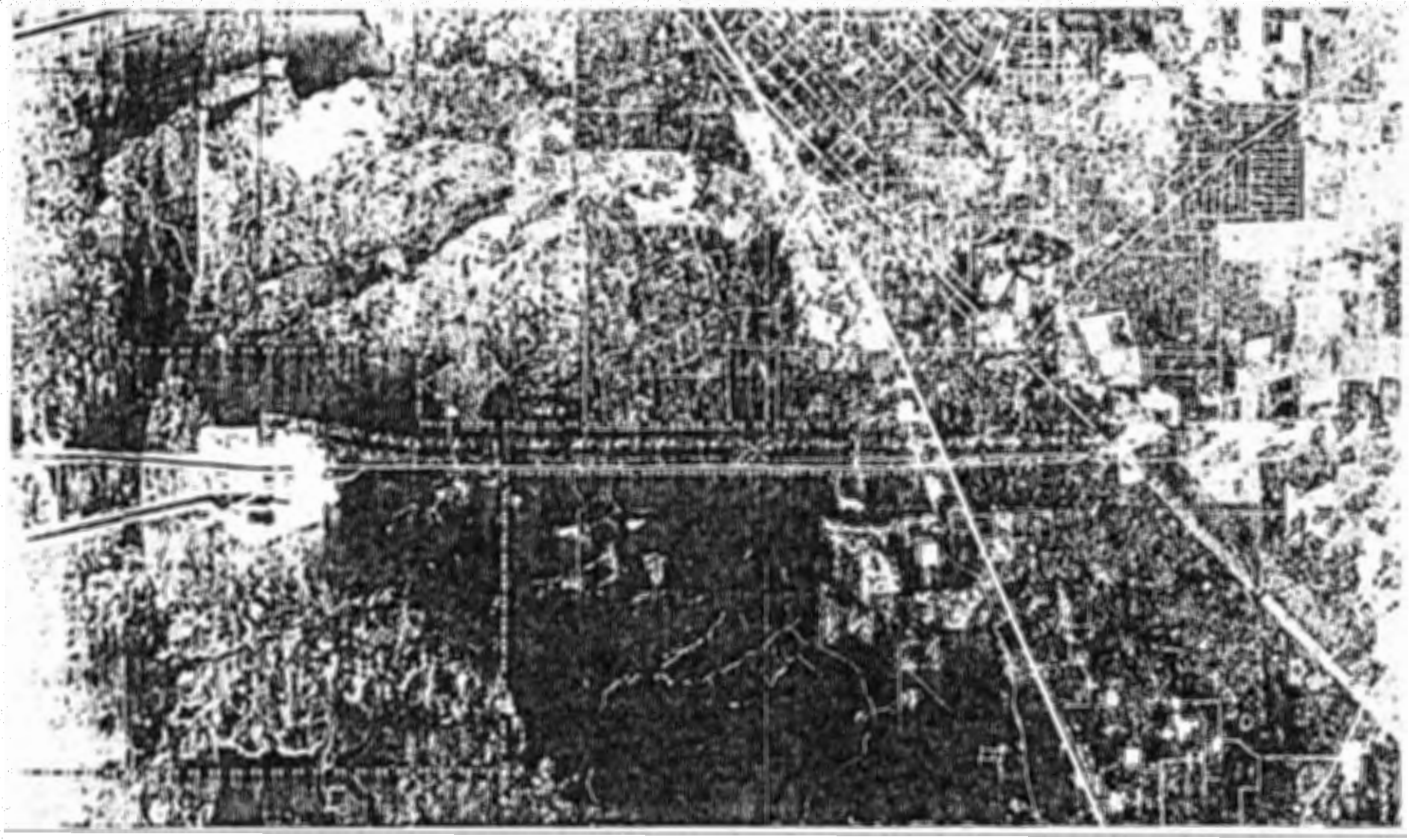


Figure 3.1-1
PROPERTY BOUNDARY

SOURCE: ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1978

N

0 6,000 12,000
SCALE IN FEET

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

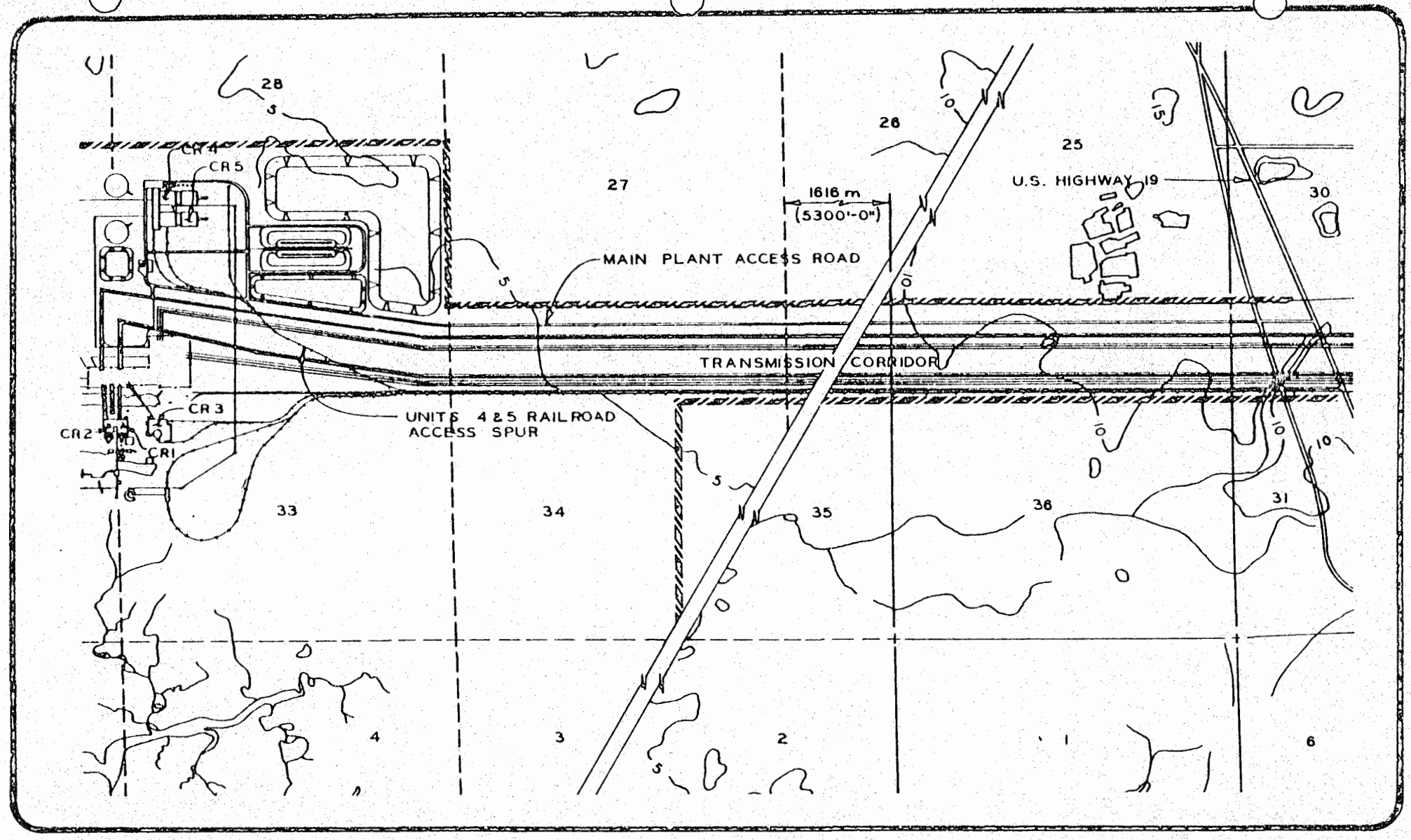


Figure 3.1-2
CRYSTAL RIVER SITE LAYOUT

0 2000 4000
SCALE IN FEET

SOURCE: BLACK AND VEATCH, 1976

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

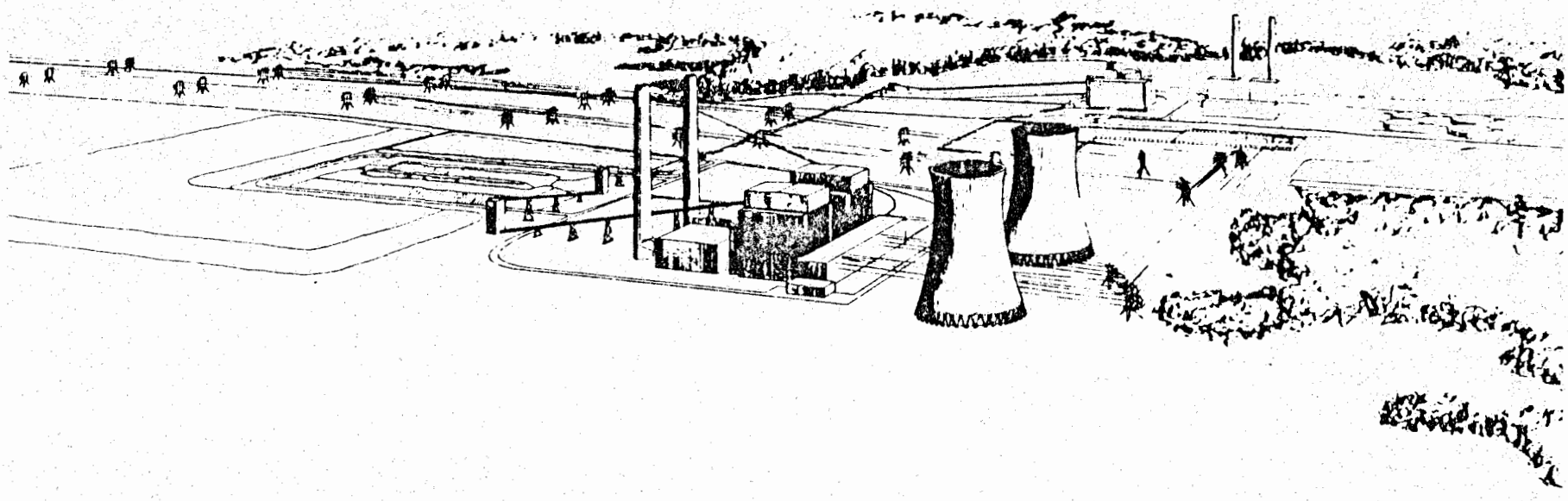


Figure 3.1-3
ARTIST'S PERSPECTIVE OF CRYSTAL RIVER SITE

SOURCE: BLACK AND VEATCH, 1976

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

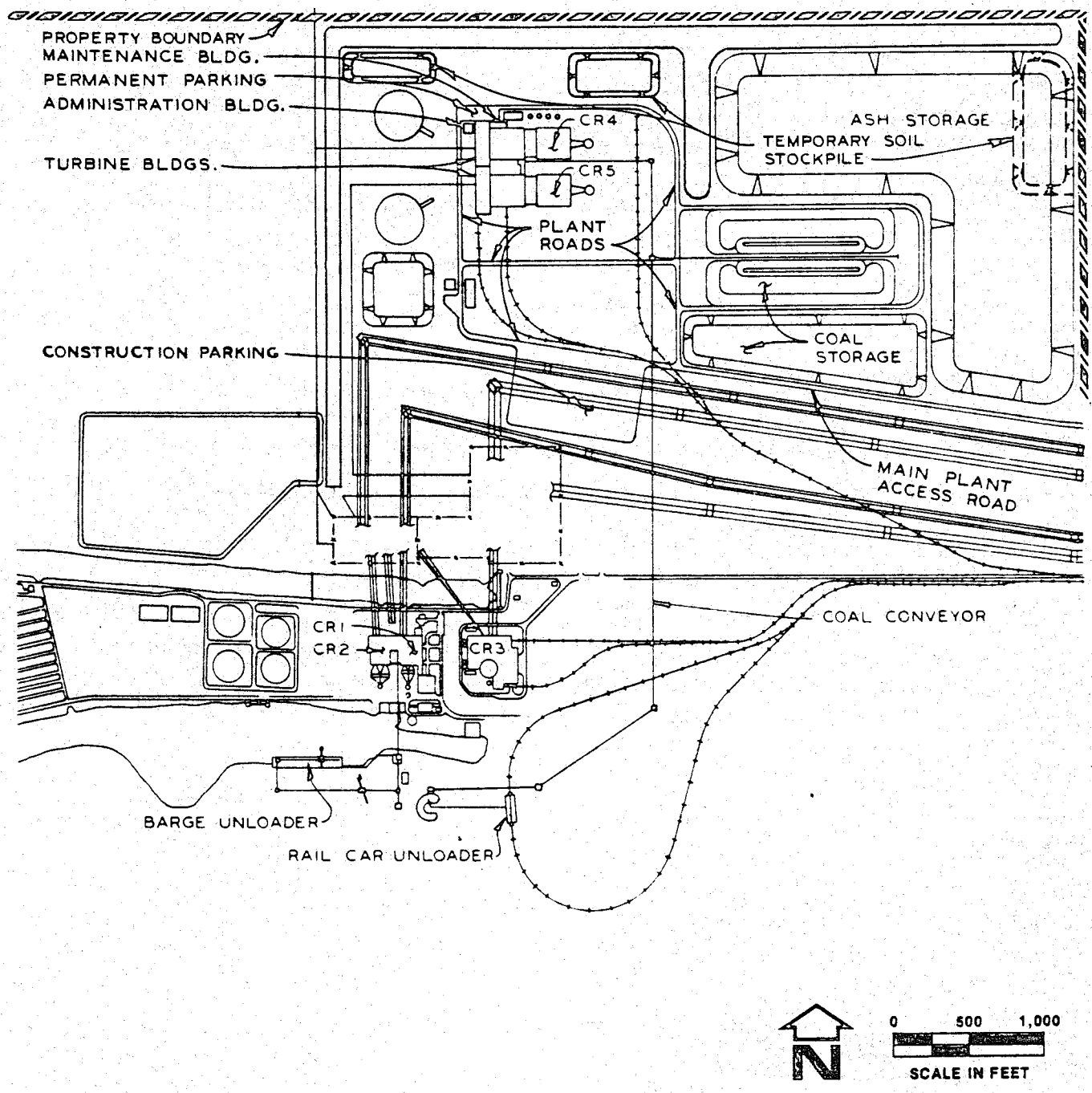


Figure 3.1-4
FACILITY LAYOUT

SOURCE: BLACK AND VEATCH, 1976 (7/78)

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

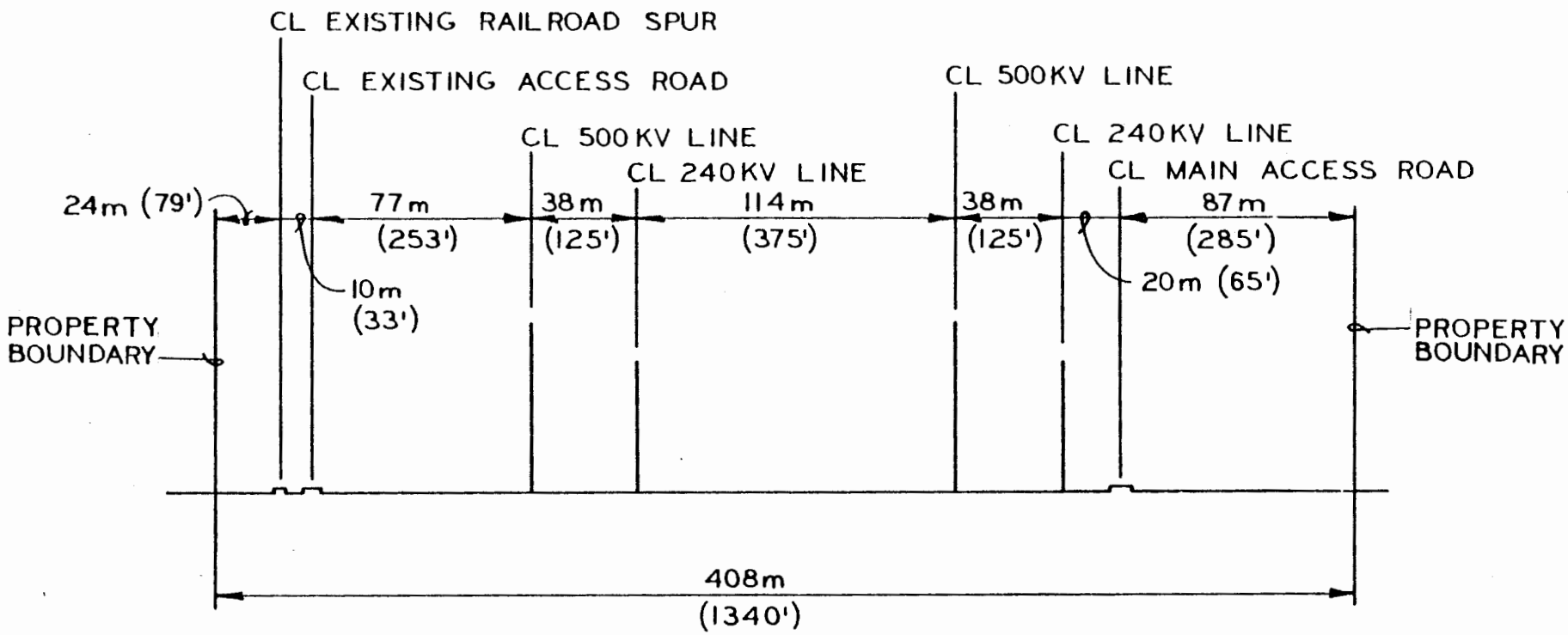


Figure 3.1-5
ELEVATION LOOKING WEST

SOURCE: BLACK AND VEATCH, 1976

N

0 200 400
SCALE IN FEET

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

3.1.2 EXTERNAL APPEARANCE

The general external appearance of the plant has been developed in an attempt to achieve maximum compatibility with existing facilities. New structures will be architecturally similar to Units 1 and 2 in design, color, and materials. The upper portions of enclosed main buildings will be enclosed with wall panels, with masonry wall panels used to enclose the lower or base portions. Smaller buildings in outlying areas utilize masonry, precast concrete, or wall panel enclosures compatible in appearance with the main buildings.

Grounds around the office building will be seeded and landscaped to prevent erosion and to complement with the surrounding environment. Other areas will be seeded and landscaped as required to prevent erosion.

Figure 3.1-3 shows that there will be four chimneys on-site, the existing two for Units 1 and 2 and an additional two for Units 4 and 5. The chimneys on Units 1 and 2 are 152 meters (500 feet) tall and the chimneys on the proposed units will be approximately 183 meters (600 feet) tall. The steam generator housing for Units 1 and 2 is approximately 64 meters (210 feet) high and the housing for Units 4 and 5 will be approximately 81 meters (265 feet) high. Directly west of the steam generator structure is the long lower building which contains the turbine generators. The turbine generator building will be totally enclosed with wall panels on the upper portion and masonry or wall panels on the base portions. The cooling towers will be natural draft, approximately 140 meters (460 feet) tall, and 113 meters (370 feet) in diameter at the base. The relative locations of the stacks and cooling towers are shown in profile in Figure 3.1-6. Other facilities such as a crusher building, coal piles, and containment for solid waste storage areas will generally be less than 31 meters (100 feet) high.

The 100-foot elevation shown on Figure 3.1-6 is the plant datum elevation. The Mean Low Water Level for the plant datum is 27 meters (88 feet).

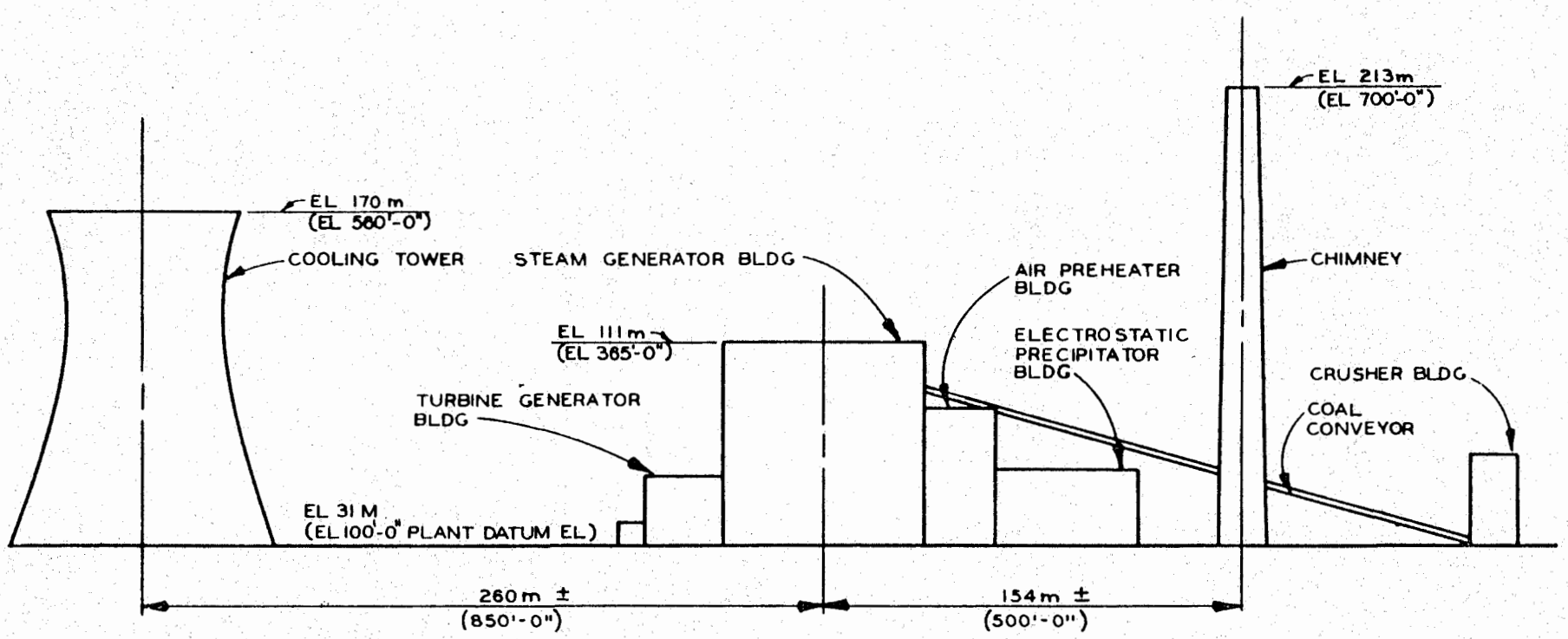
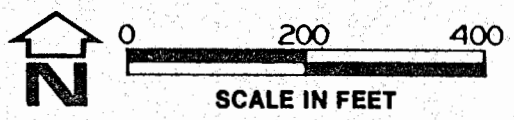


Figure 3.1-6
UNIT 4 AND 5 PLANT PROFILE



SOURCE: BLACK AND VEATCH, 1976 (7/78)

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

3.2 FUEL

3.2.1 FUEL TYPES AND QUANTITIES

The coal supplies for the Crystal River Plant Units 4 and 5 have not at the present time been committed. Present plans are to utilize coal, or a blend of coals, which will meet the EPA sulfur emission standards without the use of flue gas scrubbers.

The coals which will provide this compliance with the EPA standards are found in two geographical portions of the country; principally in the far western coal fields, and in the Appalachian coal fields. The Appalachian coals are generally a high quality, high Btu, high ash fusion, low sulfur coal. The western coals are generally of lower quality, low Btu, high ash, high moisture, but extremely low sulfur coals.

The proposed design coal for the Crystal River Units 4 and 5 is a 50/50 blend of a typical Appalachian and western coal. The various coals used to select the design blend are listed in Table 3.2-1. Fuel and ash analyses for the design blends are shown in Table 3.2-2. A 50/50 weight blend of Eastern Province and Campbell County, Wyoming coals (Nos. 1 and 7) were selected as the basis for the performance guarantee.

At the rated net output (640 Mw), and the design blend coal heating value of approximately 23,923 kJ/kilograms (10,285 Btu per pound), the coal consumption will be approximately 294,000 kilograms (648,000 pounds) per hour for each unit. The average coal consumption per year over the 30-year life of Units 4 and 5 will be approximately 1,700,000 metric tons (1,870,000 tons) per year for each unit based on a 0.66 annual average capacity factor.

Auxiliary fuel for furnace warm-up and coal ignition during start-up will be fuel oil. Diesel fuel and gasoline will be used to power the emergency fire pumps and mobile coal and ash handling equipment.

Table 3.2-1 Alternative Coal Sources

	Typical	Range Minimum	Range Maximum
Type (1) Eastern Province Ala., C. Ky., Tenn., Southern W. Va.			
Moisture, %	7.0	4.0	12.0
Volatile matter, %	30.0	(28.0)	--
Fixed carbon, %	51.0	--	--
Ash, %	16.4	--	(16.0)
Carbon, %	77.0	--	--
Hydrogen, %	4.4	--	--
Nitrogen, %	1.4	--	--
Sulfur, %	0.50	--	0.8
Chlorine, %	0.05	--	(0.15)
Oxygen, % (by difference)	7.65	--	--
Gross calorific value, Btu/lb	12,450	11,000	13,000
Hardgrove Grindability Index	45	38	65

Ash Fusibility, %	Red.	Oxid.	Reduction	
ID	2,250	2,350	--	--
ST	2,300	2,400	2,200	2,700+
HT	2,330	2,440	--	--
FT	2,350	2,475	--	--

Ash Analysis, %			
P_2O_5	0.40	--	--
SiO_2	45.0	--	--
Fe_2O_3	8.0	--	18.0
Al_2O_3	24.0	--	--
TiO_2	1.0	--	--
CaO	10.5	--	--
MgO	2.0	--	--
K_2O	1.50	--	--
Na_2O	0.50	--	0.80
SO_3	6.0	--	--

Table 3.2-1 Alternative Coal Sources (Continued, page 2 of 8)

	Typical	Range Minimum	Range Maximum
Type (2)			
Utah			
Moisture, %	7.0	4.0	12.0
Volatile matter, %	39.8	--	--
Fixed carbon, %	46.2	--	--
Ash, %	8.0	(5.0)	(16.0)
Carbon, %	69.2	--	--
Hydrogen, %	5.1	--	--
Nitrogen, %	1.4	--	--
Sulfur, %	0.7	(0.4)	(1.0)
Chlorine, %	0.05	(0.02)	(0.10)
Oxygen, % (by difference)	8.55	--	--
Gross calorific value, Btu/lb	12,000	10,500	12,500
Hardgrove Grindability Index	45	40	56

Ash Fusibility, %	Red.	Oxid.	Reduction	
ID	2,130	2,210	--	--
ST	2,230	2,350	2,000	2,600
HT	2,250	2,390	--	--
FT	2,340	2,500	--	--

Ash Analysis, %			
P_2O_5	0.5	--	--
SiO_2	47.2	--	--
Fe_2O_3	5.8	--	--
Al_2O_3	22.4	--	--
TiO_2	1.1	--	--
CaO	10.6	--	--
MgO	0.8	--	--
K_2O	0.4	--	--
Na_2O	4.5	2.0	6.0
SO_3	6.2	--	--

Table 3.2-1 Alternative Coal Sources (Continued, page 3 of 8)

	Typical	Range Minimum	Range Maximum
Type (3) Colorado			
Moisture, %	12.0	8.0	16.0
Volatile matter, %	35.4	--	--
Fixed carbon, %	46.6	--	--
Ash, %	6.0	(4.0)	(12.0)
Carbon, %	64.0	--	--
Hydrogen, %	4.0	--	--
Nitrogen, %	0.7	--	--
Sulfur, %	0.4	(0.3)	(0.8)
Chlorine, %	0.01	(0.01)	(0.06)
Oxygen, % (by difference)	12.29	--	--
Gross calorific value, Btu/lb	11,275	10,000	12,000
Hardgrove Grindability Index	49	44	55

Ash Fusibility, %	Red.	Oxid.	Reduction	
ID	2,460	2,470	--	--
ST	2,465	2,500	2,200	2,700+
HT	2,470	2,540	--	--
FT	2,520	2,600	--	--

Ash Analysis, %			
P_2O_5	0.6	--	--
SiO_2	37.5	--	--
Fe_2O_3	4.7	--	--
Al_2O_3	28.4	--	--
TiO_2	1.3	--	--
CaO	9.6	--	--
MgO	3.3	--	--
K_2O	0.6	--	--
Na_2O	2.5	0.4	3.0
SO_3	10.7	--	--

Table 3.2-1 Alternative Coal Sources (Continued, page 4 of 8)

	Typical		Range Minimum	Range Maximum
Type (4)				
Wyoming				
Moisture, %	21.5		18.0	24.0
Volatile matter, %	32.5		--	--
Fixed carbon, %	40.0		--	--
Ash, %	6.0		(3.0)	(12.0)
Carbon, %	55.5		--	--
Hydrogen, %	3.9		--	--
Nitrogen, %	0.8		--	--
Sulfur, %	0.5		(0.3)	(1.0)
Chlorine, %	0.05		(0.01)	(0.05)
Oxygen, % (by difference)	11.75		--	--
Gross calorific value, Btu/lb	9,650		9,200	11,000
Hardgrove Grindability Index	50		44	55
Ash Fusibility, %	Red.	Oxid.	Reduction	
ID	2,100	2,130	--	--
ST	2,280	2,310	2,120	2,650
HT	2,440	2,480	--	--
FT	2,600	2,650	--	--
Ash Analysis, %				
P_2O_5	0.6		--	--
SiO_2	49.8		--	--
Fe_2O_3	6.9		--	--
Al_2O_3	16.8		--	--
TiO_2	0.5		--	--
CaO	8.3		--	--
MgO	4.6		--	--
K_2O	0.5		--	--
Na_2O	0.2		0.1	1.0
SO_3	10.3		--	--

Table 3.2-1 Alternative Coal Sources (Continued, page 5 of 8)

	Typical	Range Minimum	Range Maximum
Type (5)			
Carbon Co., Wyoming			
Moisture, %	12.0	9.0	15.0
Volatile matter, %	37.0	--	--
Fixed carbon, %	41.0	--	--
Ash, %	10.0	(7.0)	(15.0)
Carbon, %	60.0	--	--
Hydrogen, %	4.1	--	--
Nitrogen, %	0.9	--	--
Sulfur, %	0.6	(0.3)	(1.0)
Chlorine, %	0.03	(0.01)	(0.05)
Oxygen, % (by difference)	12.37	--	--
Gross calorific value, Btu/lb	10,000	9,500	10,500
Hardgrove Grindability Index	47	42	52

Ash Fusibility, %	Red.	Oxid.	Reduction	
ID	2,070	2,100	--	--
ST	2,155	2,320	2,800	2,300
HT	2,200	2,340	--	--
FT	2,245	2,420	--	--

Ash Analysis, %			
P_2O_5	0.8	--	--
SiO_2	38.0	--	--
Fe_2O_3	9.5	--	--
Al_2O_3	23.9	--	--
TiO_2	0.9	--	--
CaO	13.2	--	--
MgO	3.5	--	--
K_2O	1.3	--	--
Na_2O	0.4	0.3	3.0
SO_3	9.0	--	--

Table 3.2-1 Alternative Coal Sources (Continued, page 6 of 8)

	Typical	Range Minimum	Range Maximum
Type (6)			
New Mexico			
Moisture, %	15.0	12.0	21.0
Volatile matter, %	35.4	--	--
Fixed carbon, %	38.8	--	--
Ash, %	10.8	(10.0)	(20.0)
Carbon, %	55.7	--	--
Hydrogen, %	4.1	--	--
Nitrogen, %	1.0	--	--
Sulfur, %	0.6	(0.5)	(1.2)
Chlorine, %	0.02	(0.02)	(0.06)
Oxygen, % (by difference)	12.78	--	--
Gross calorific value, Btu/lb	9,700	8,750	10,000
Hardgrove Grindability Index	45	40	48

Ash Fusibility, %	Red.	Oxid.	Reduction	
ID	2,280	2,399	--	--
ST	2,400	2,510	2,250	2,700+
HT	2,440	2,535	--	--
FT	2,520	2,620	--	--

Ash Analysis, %			
P_2O_5	0.1	--	--
SiO_2	53.6	--	--
Fe_2O_3	5.4	--	--
Al_2O_3	22.7	--	--
TiO_2	1.0	--	--
CaO	4.3	--	--
MgO	1.5	--	--
K_2O	1.1	--	--
Na_2O	2.0	0.2	3.0
SO_3	6.3	--	--

Table 3.2-1 Alternative Coal Sources (Continued, page 7 of 8)

	Typical	Range Minimum	Range Maximum
Type (7)			
Campbell Co., Wyoming			
Moisture, %	30.0	27.0	32.0
Volatile matter, %	32.1	--	--
Fixed carbon, %	32.1	--	--
Ash, %	5.8	(6.5)	(11.0)
Carbon, %	48.50	--	--
Hydrogen, %	3.40	--	--
Nitrogen, %	0.70	--	--
Sulfur, %	0.48	--	--
Chlorine, %	0.02	(0.01)	(0.06)
Oxygen, % (by difference)	11.10	--	--
Gross calorific value, Btu/lb	8,125	7,700	8,600
Hardgrove Grindability Index	52	50	60

Ash Fusibility, %	Red.	Oxid.	Reduction	
ID	2,060	2,070	--	--
ST	2,120	2,160	2,000	2,300
HT	2,140	2,180	--	--
FT	2,180	2,220	--	--

Ash Analysis, %			
P_2O_5	2.0	--	--
SiO_2	34.0	--	--
Fe_2O_3	6.0	--	--
Al_2O_3	13.0	--	--
TiO_2	1.0	--	--
CaO	20.0	--	--
MgO	6.0	--	--
K_2O	0.8	--	--
Na_2O	2.8	1.0	4.0
SO_3	13.7	--	--

Table 3.2-1 Alternative Coal Sources (Continued, page 8 of 8)

	Typical	Range Minimum	Range Maximum
Type (8)			
Illinois--Deep Mined			
Moisture, %	10.00	7.0	10.0
Volatile matter, %	32.00	--	--
Fixed carbon, %	45.00	--	--
Ash, %	13.00	(7.0)	(16.0)
Carbon, %	62.00	--	--
Hydrogen, %	4.40	--	--
Nitrogen, %	1.20	--	--
Sulfur, %	4.20	(2.0)	(5.0)
Chlorine, %	0.18	(0.10)	(0.30)
Oxygen, % (by difference)	5.02	--	--
Gross calorific value, Btu/lb	11,000	10,500	12,500
Hardgrove Grindability Index	55	50	60

Ash Fusibility, %	Red.	Oxid.	Reduction	
ID	1,950	2,320	--	--
ST	2,010	2,380	2,000	2,300
HT	2,030	2,435	--	--
FT	2,150	2,510	--	--

Ash Analysis, %			
P_2O_5	0.20	--	--
SiO_2	37.40	--	--
Fe_2O_3	26.60	15.0	28.0
Al_2O_3	16.00	--	--
TiO_2	1.00	--	--
CaO	8.10	--	--
MgO	1.00	--	--
K_2O	1.65	--	--
Na_2O	1.20	0.50	1.40
SO_3	6.70	--	--

Source: Black and Veatch, 1978.

Table 3.2-2 Alternative Florida Power Corporation Performance Coals Weight Blends, 50/50 Basis

Type Coal	1 & 2	1 & 6	1 & 7*	2 & 4	2 & 6	2 & 7	6 & 7
Moisture, %	7.0	11.0	18.5	14.5	11.0	18.5	22.5
Volatile Matter, %	34.9	32.7	31.0	36.1	37.6	36.0	33.7
Fixed Carbon, %	49.1	45.9	42.6	42.4	42.0	38.6	35.5
Ash, %	9.0	10.4	7.9	7.0	9.4	6.9	8.3
Carbon, %	69.1	62.3	58.8	62.3	62.4	58.8	52.1
Hydrogen, %	4.7	4.3	3.9	4.5	4.6	4.2	3.7
Nitrogen, %	1.4	1.2	1.1	1.1	1.2	1.1	0.9
Chlorine, %	0.05	0.03	0.03	0.05	0.03	0.03	0.02
Sulfur, %	0.60	0.55	0.49	0.60	0.65	0.59	0.54
Oxygen, %	8.15	10.22	9.28	9.95	10.72	9.88	11.94
Gross Calorific Value, Btu/lb	12,225	11,075	10,285	10,825	10,850	10,060	8,910
Hardgrove Grindability Index	45	45	48	47	45	48	48
Ash Analysis, %							
SiO_2	46.0	49.0	40.2	48.4	50.9	40.7	44.3
Al_2O_3	23.3	23.3	18.2	19.8	22.5	17.8	18.1
TiO_2	1.0	1.0	1.0	0.8	1.0	1.1	1.0
Fe_2O_3	7.0	6.6	7.1	6.3	5.6	5.9	5.7
CaO	10.5	7.1	15.3	9.5	6.8	15.2	11.8
MgO	1.5	1.7	3.7	2.6	1.2	3.4	2.6
Na_2O	2.28	1.31	1.50	2.48	3.01	3.67	2.38
K_2O	1.01	1.28	1.20	0.43	0.82	0.60	0.96
SO_3	6.1	6.2	9.3	8.1	6.3	9.9	9.8
P_2O_5	0.44	0.24	1.1	0.55	0.28	1.24	1.00

*Performance guarantee shall be based on this blend.

Source: Black and Veatch, 1978.

Average fuel oil consumption will be approximately 10,600 cubic meters (2,800,000 gallons) per year for each unit based on 200 starts per year.

3.2.2 FUEL TRANSPORTATION

In order to maintain a diversity of supply, approximately 50 percent of the coal will be transported to the Crystal River site by unit trains and 50 percent will be transported to the site in oceangoing barges.

The Appalachian coal will be transported in 70 to 110 car unit trains of approximately 90.7-metric ton (100-ton) capacity cars. An average of about 4 to 6 trains per week will be required to supply 50 percent of the coal assuming the present projections for plant capacity factors.

The western coals will be transported from the coal fields by unit rail trains to the Mississippi River, loaded in river barges, and transported down the Mississippi to the New Orleans, Louisiana area. The coal will then be loaded into oceangoing transportation units that will carry the coal across the Gulf of Mexico to the Crystal River site. The existing coal-receiving facilities at the Crystal River site will be used. This system is designed to unload barges of up to 13,608 metric tons (15,000 tons) capacity. An average of about 3 barges per week will be required.

Fuel oil and gasoline auxiliary fuels will be received at the plant by truck or rail, depending on the supplier.

3.2.3 COAL HANDLING FACILITIES

EXISTING FACILITIES

The coal-handling facilities at the plant for Units 1 and 2 include a barge and tug mooring dock, Dravo clamshell-type barge unloader, Dravo stacker-reclaimer, and an integrated single-belt conveyor system connecting the barge unloader and stacker-reclaimer. In addition to the barge unloading facilities, a railcar unloading facility is provided to

serve the existing units. This installation includes a railroad loop track for coal delivery and unit train turnaround, an elevated structure for bottom dumping of railcars, and a belt conveyor linking the dump structure with a radial stacker. The radial stacker will generate a coal pile which can be moved by mobile equipment to a reclaim hopper and associated conveyor. The reclaim hopper conveyor will discharge to the transfer house located at the tailpoint of the stockout and reclaim system yard belt. These facilities are physically located south and southeast of the existing units as shown in Figure 3.2-1.

UNITS 4 AND 5 FACILITIES

The existing coal yard and terminal facilities will be modified and expanded to improve the capability and reliability of the system for the four-unit installation. Figure 3.2-2 schematically illustrates how the proposed facilities will be added to existing facilities.

Additions to the existing facilities for Units 4 and 5 will include the following:

1. A new stockout and reclaim system for the active storage piles serving the new units;
2. A coal-blending facility;
3. Additional coal-crushing facilities;
4. An emergency stockout system to allow barge or train deliveries to continue in the event the primary stockout systems are unavailable;
5. An emergency reclaim system serving the new units; and
6. A series of conveyors linking the unloading, active storage, blending, and crusher facilities in the coal yard area and a dual belt system connecting the coal yard and the silos in each generating unit. The conveyor system would include associated transfer facilities at belt intersections.

The physical locations of the above listed facilities are shown on Figure 3.2-1.

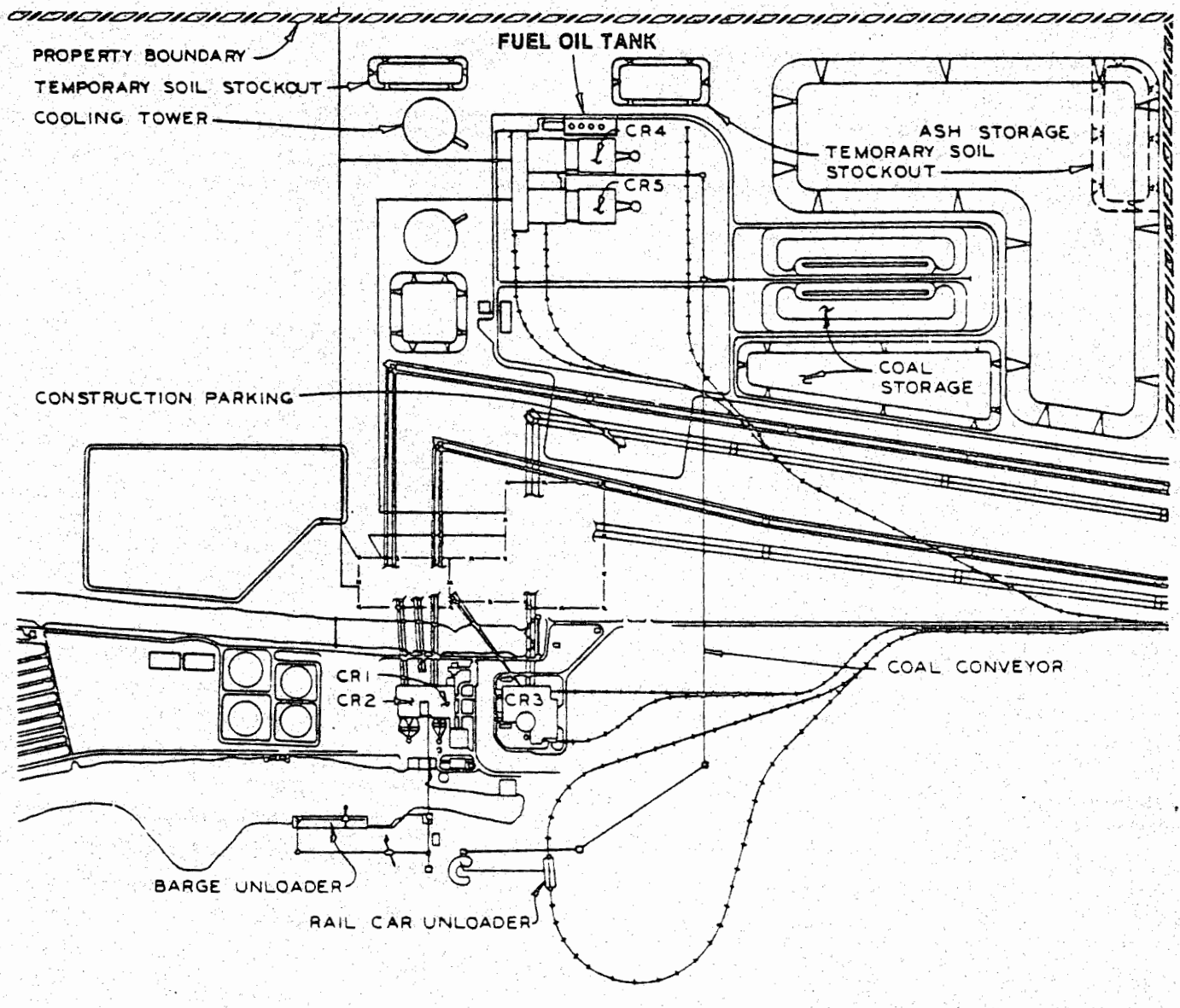


Figure 3.2-1
COAL HANDLING FACILITIES

0 1000 2000
SCALE IN FEET

SOURCE: BLACK AND VEATCH, 1978

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

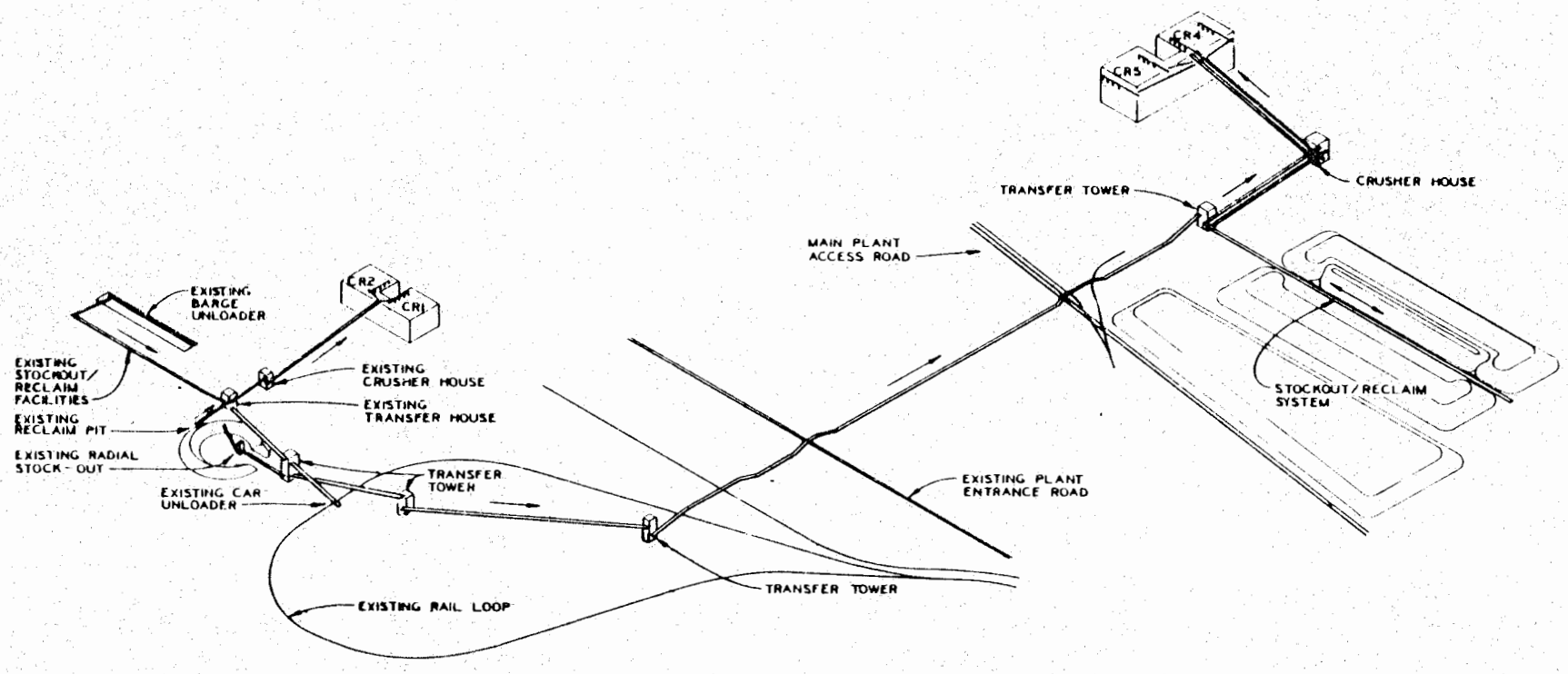


Figure 3.2-2
COAL HANDLING FACILITIES — ISOMETRIC

N

0 80 160
SCALE IN FEET

SOURCE: BLACK AND VEATCH, 1976

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

3.2.4 FUEL STORAGE

EXISTING FACILITIES

The existing Crystal River Plant Units 1 and 2 utilize three types of coal storage: in-plant storage, active storage, and inactive storage. During normal operation, coal is dumped from the train cars, or removed from the barges, and transported by a system of conveyors and hoppers to the in-plant storage silos. When the in-plant storage silos are full, the coal is diverted to the active storage piles by the stacker-reclaimer. Active storage provides a buffer between rapid but intermittent unloading of coal trains and barges, and slower but steady coal consumption by the plant. The inactive storage is used for periods when the supply of coal is interrupted such as for equipment failures, labor disputes, or variations between coal purchase contractual commitments.

UNITS 4 AND 5 FACILITIES

Units 4 and 5 will utilize the same three types of coal storage as those for Units 1 and 2.

In-plant storage will be provided in 6 or 7 silos for each unit. Both active and inactive storage will be provided in the area adjacent to the ash storage area. This area will provide approximately 39,000 metric tons (43,000 tons) of active storage and 776,300 metric tons (885,000 tons) of inactive storage. This storage area will cover approximately 111,000 square meters (27.5 acres). An additional storage of 80,000 square meters (20 acres) will be located adjacent to the stacker-reclaimer system.

The total active storage of 39,000 metric tons (43,000 tons) will provide approximately 8 days' fuel requirements for both units operating at 90 percent capacity. The average resident time of coal in the active storage areas based on the present projections of plant capacity factor will be 50 to 60 hours.

The inactive storage piles will be generated by mobile equipment and will provide for approximately 776,300 metric tons (855,000 tons) of storage.

Fuel oil will be stored in two steel cylindrical plate storage tanks located within two clay-lined areas north of Unit 4.

3.3 PLANT WATER USE

Water will be used for a variety of purposes at Crystal River Units 4 and 5. Figure 3.3-1 is a schematic flow diagram of plant water supplies, treatment, process consumption, recycle, and discharge. Table 3.3-1 presents this annual average daily quantity of water used and discharged for normal and peak operating conditions and for temporary shutdown plant conditions as defined below:

1. Normal (or average) operating conditions is defined as both generating units operating at the annual average load factor of 66 percent and annual average evaporative conditions; existing for a 24-hour period; i.e., 21.7°C (71°F) dry bulb temperature and 77 percent relative humidity.
2. Peak (or maximum) operating condition is defined as both generating units operating at 100 percent load factor and maximum atmospheric evaporative conditions existing for the cooling towers during a 24-hour period; i.e., 32.8°C (91°F) dry bulb temperature and 55 percent relative humidity.
3. Temporary shutdown is defined as both units being shut down for maintenance or other reasons.

The quantities for rainfall and evaporation from site areas have been generated by using the average annual figures of approximately 1,400 mm/year (55 in/year) for rainfall and 1,220 mm/year (48 in/year) for evaporation (Climatic Atlas of the United States, 1968).

The frequency and duration of peak water use days cannot be predicted accurately because of its dependency on the weather as well as electric system operating conditions external to the Florida Power system. Peak water use occurs, as defined previously, when both generating units operate at 100 percent load factor and when maximum atmospheric evaporative conditions exist for the cooling towers during a 24-hour period. These conditions require a high dry bulb air temperature and a large range between wet bulb and dry bulb air temperatures (i.e., low humidity). These atmospheric conditions are most likely to occur for intermittent periods during the months of April through September.

Figure II-11 Solar Insolation (cal./cm^2-min.) at Lake Rousseau, December 7, 1977

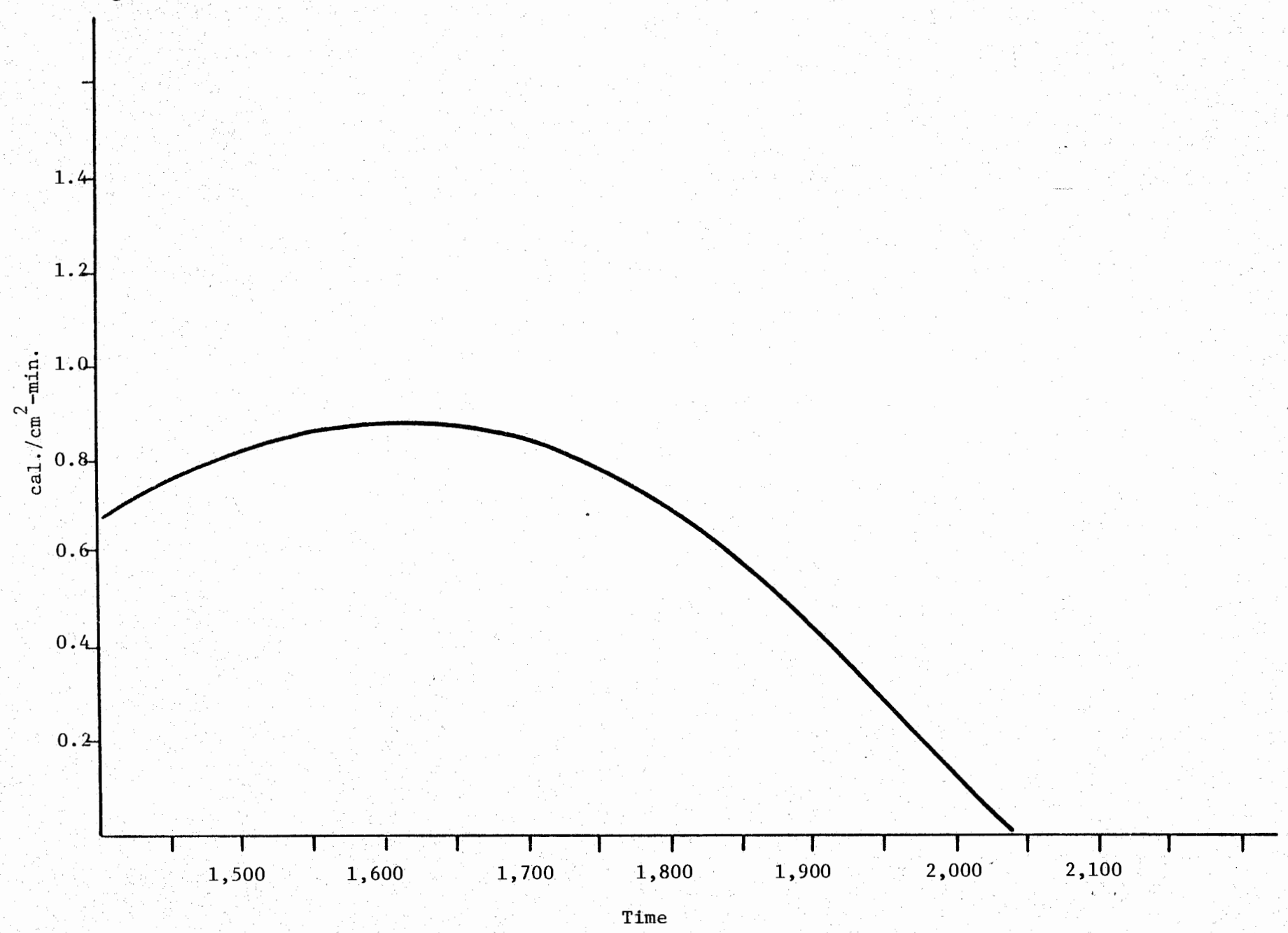


Figure II-12 Solar Insolation (cal./cm^2-min.) at Lake Rousseau, December 8, 1977

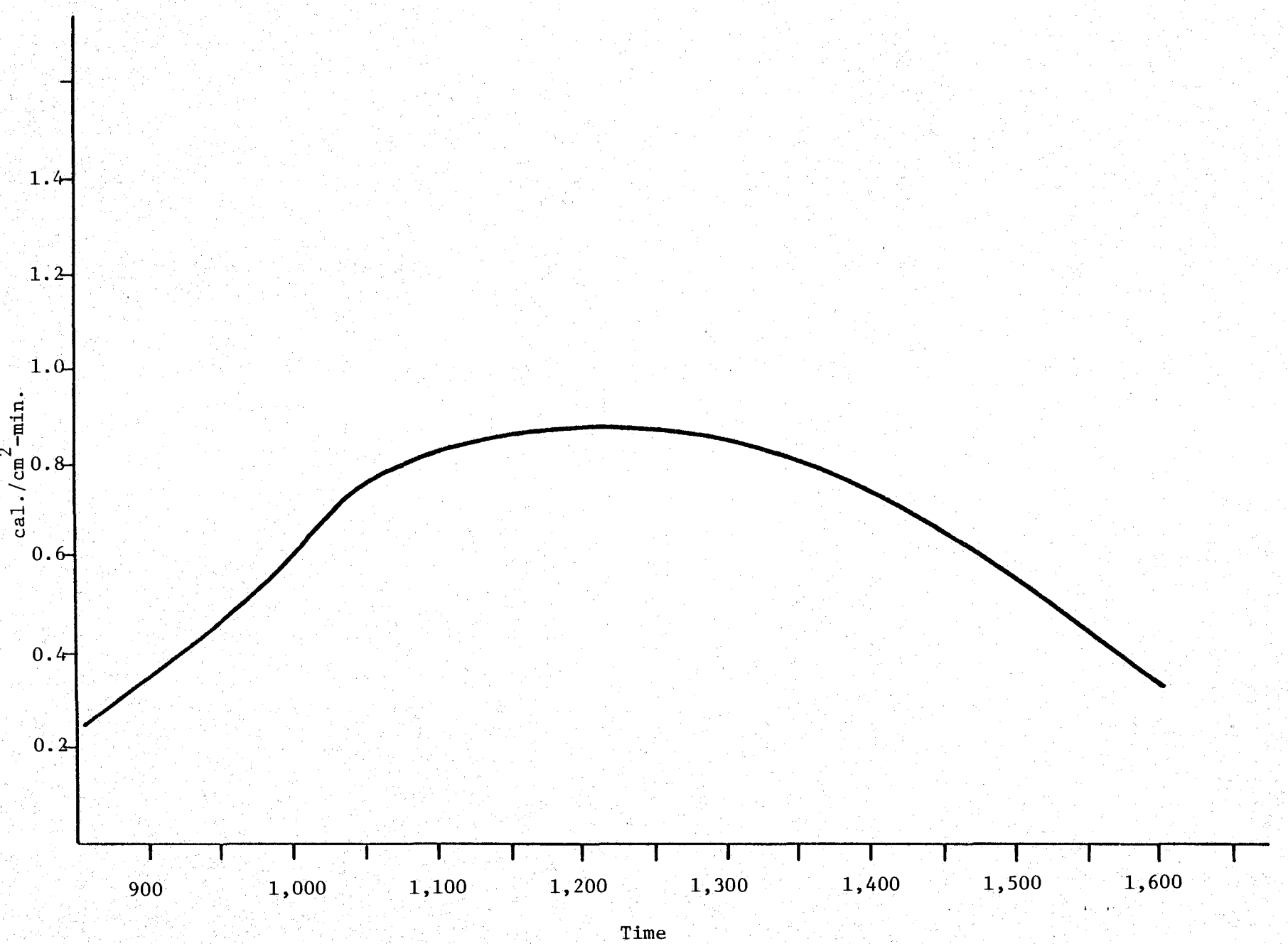


Figure II-13 Solar Insolation cal/cm^2-min) at Lake Rousseau, February 15, 1978

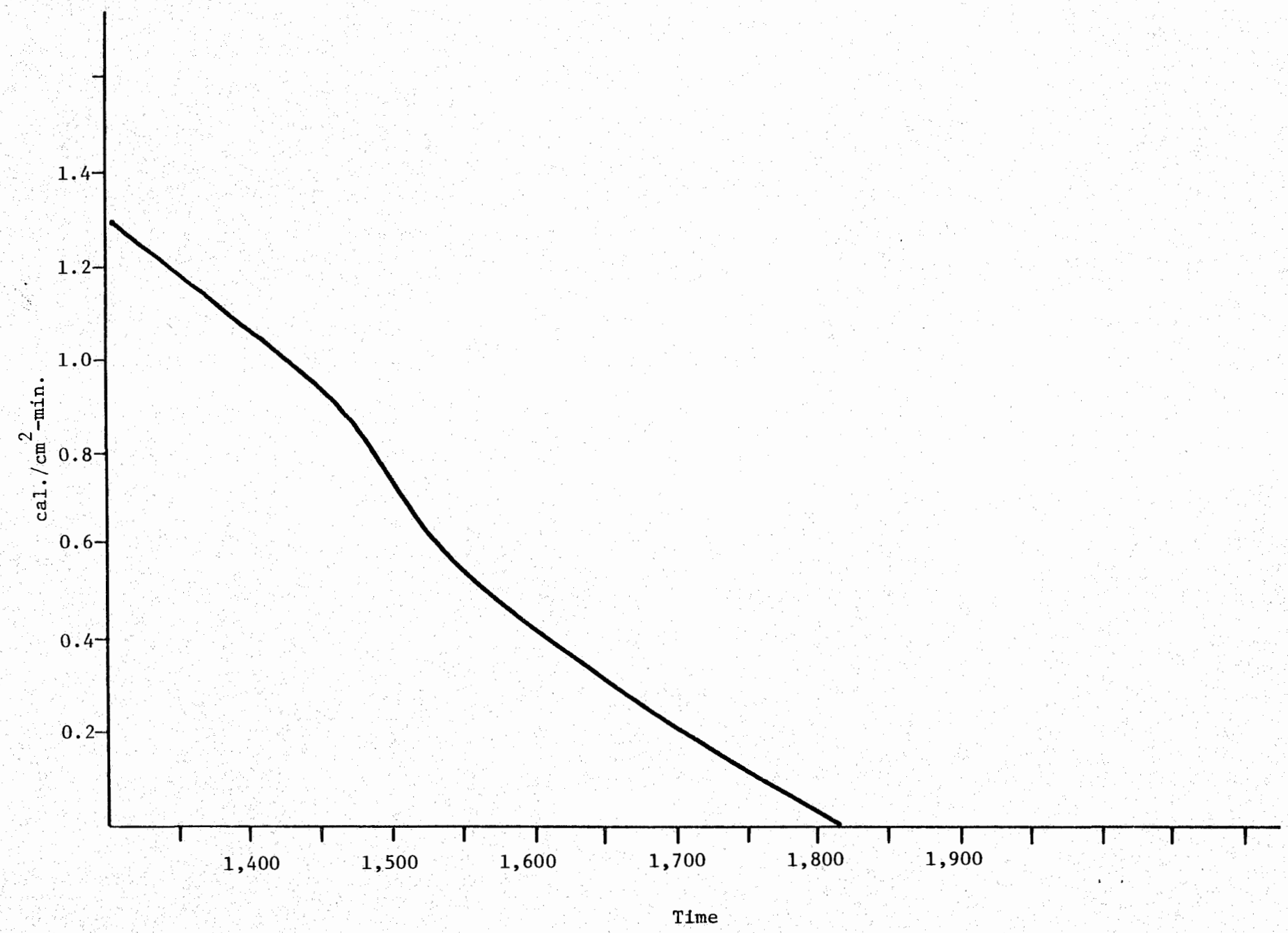


Figure II-14 Solar Insolation (cal./cm^2-min.) at Lake Rousseau, February 16, 1978

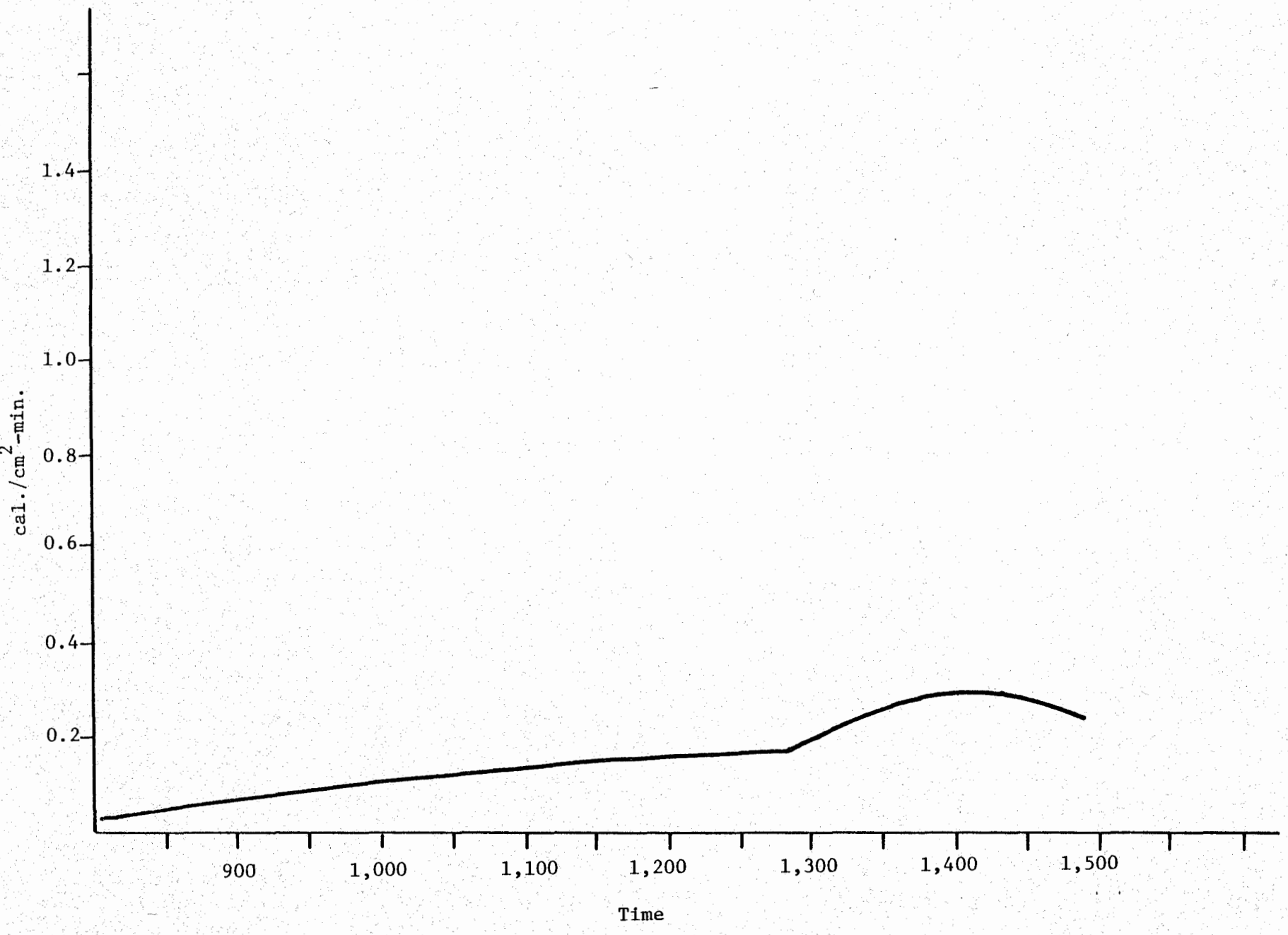


Figure II-15 Solar Insolation (cal./cm^2-min.) at Lake Rousseau, April 18, 1978

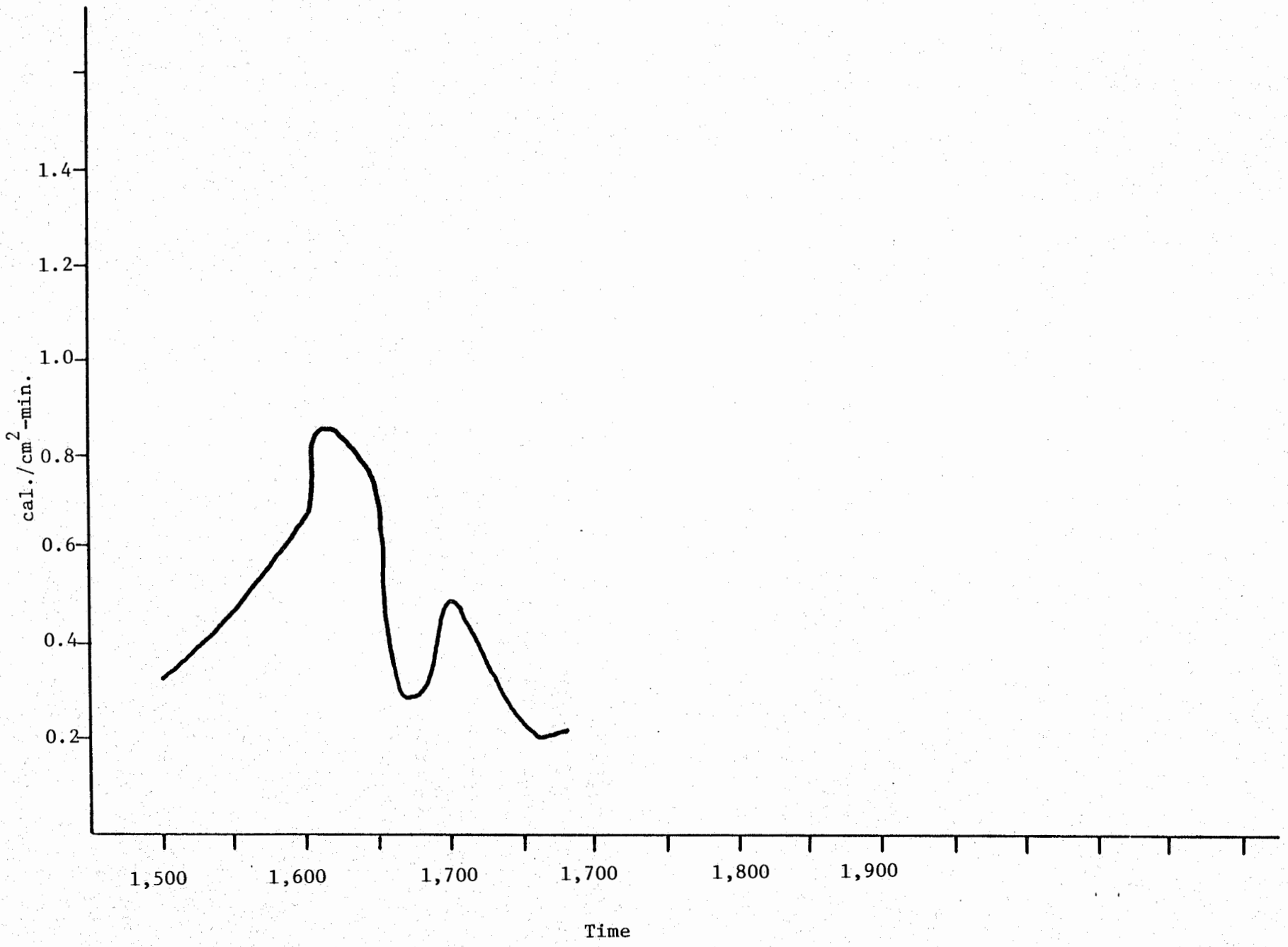


Figure II-16 Solar Insolation (cal./cm^2-min.) at Lake Rousseau, April 19, 1978

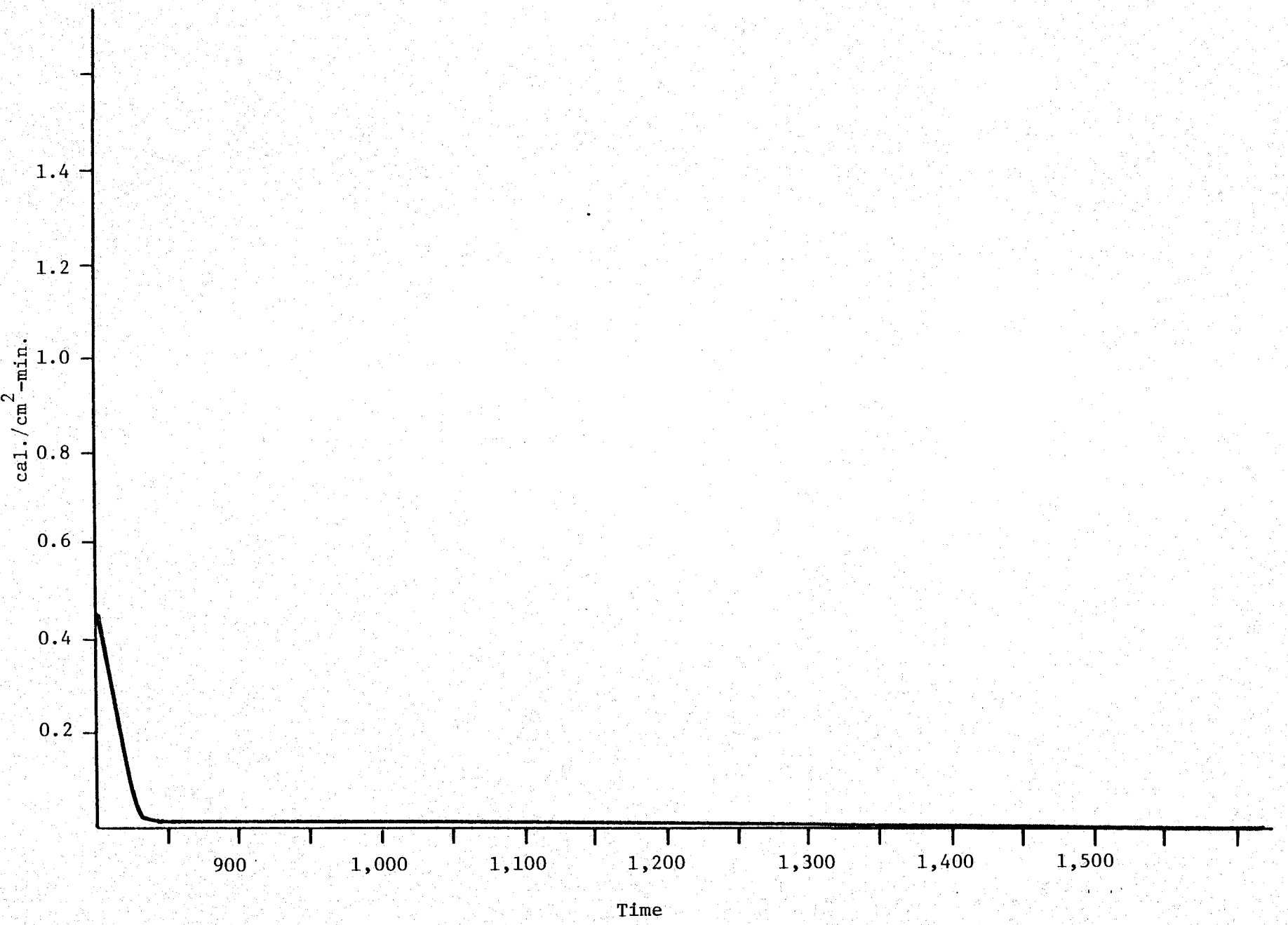


Figure II-17 Solar Insolation (cal./cm^2-min.) at Lake Rousseau, April 20, 1978

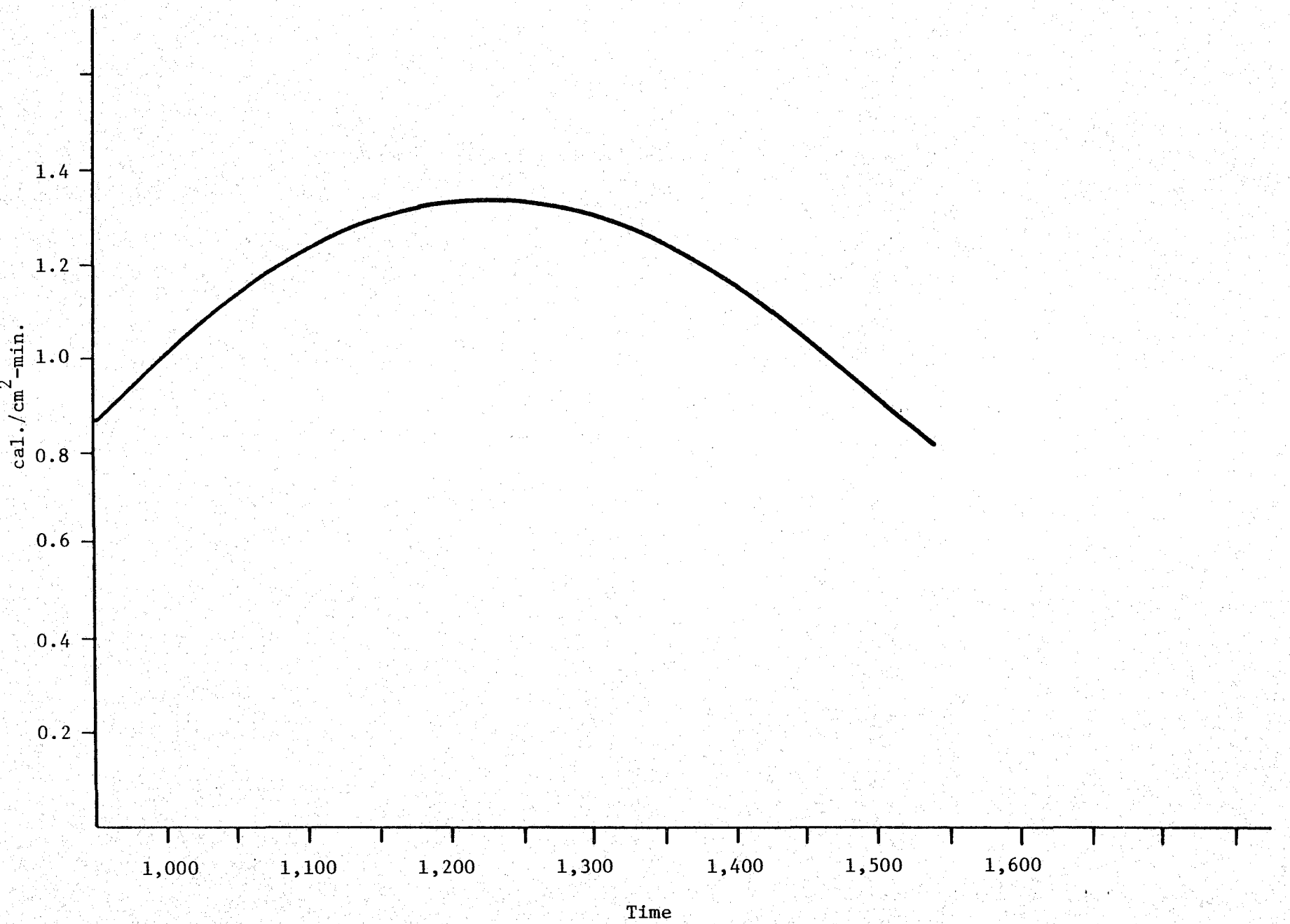


Table II-24 Extinction Coefficients (m^{-1}) of Light Penetration Determined From Secchi Disc and Submersible Photometer Observations Made on Lake Rousseau

Station No.	Oct., 1977 S*	Dec., 1977 S	Dec., 1977 P**	Feb., 1978 S	April, 1978 S	April, 1978 P
1	0.83	0.74	0.65	0.40	0.96	1.39
2	0.83	0.77	0.64	0.42	0.98	1.23
3	0.86	0.72	0.71	0.41	1.00	1.30
4	0.89	0.77	0.64	0.51	1.09	1.18

*S designates extinction coefficients calculated from Sechhi disc observations using the methodology of Poole and Atkins (1929).
**P designates extinction coefficients calculated from submersible photometer readings.

Source: Environmental Science and Engineering, Inc., 1978.

Table II-25 Compensation Depth* as a Function of Light Extinction Coefficients Calculated for Lake Rousseau

Light Extinction Coefficient		Compensation Depth (Meters)
0.40		11.53
0.41	F(S)†	11.24
0.42		10.98
0.51		9.04
0.64		7.20
0.65	D(P)**	7.09
0.71		6.49
0.72		6.40
0.74	D(S)†	6.23
0.77		5.99
0.83		5.55
0.86	O(S)†	5.36
0.89		5.18
0.96		3.31
0.98	A(S)†	3.74
1.00		3.54
1.09		3.90
1.39		4.80
1.23	A(P)**	4.70
1.30		4.61
1.18		4.22

* Defined as depth to which one percent of surface insolation extends (Westlake, 1963; Odum, 1971). Limit of euphotic zone.

† S designates extinction coefficients calculated from Secchi disc observations using the methodology of Poole and Atkins (1929).

** P designates extinction coefficients calculated from submersible photometer readings.

Source: Environmental Science and Engineering, Inc., 1978.

each sampling period and reported in the water chemistry section of this report were found to have the greatest values, ranging from 90 to 100 CPU's in April when the compensation depths were minimal. Suspended solids levels remained relatively constant throughout the four sampling periods.

Suspended Solids

Two programs were conducted for sampling of the vertical gradient in suspended solids in the water column. The first program was carried out at four stations chosen as potential cooling water intake sites as part of the bimonthly water quality monitoring program. Additional vertical gradient samples of the near bottom were collected during the lake circulation and sediment programs in conjunction with the simultaneous wind data program.

Figure II-18 shows the sample stations where sampling was conducted at various times during the circulation and sediment programs and where sampling was conducted bimonthly. Data for all the stations are presented in Table II-26.

The wind data for samples collected February 14, 1978, are presented in Table II-9 in conjunction with discussion on the circulation study. Wind data for samples collected April 21, 1978, are presented in Figure II-19 and Table II-27.

It is evident from the data and field observations that surface and mid-depth suspended solids concentrations are relatively low and constant in time (5 to 8 milligrams per liter), which is a typical freshwater lake feature. Suspended solids concentrations increase several orders of magnitude in or near the floc layer. The northern portion of the western embayment has significantly higher suspended solids concentrations at depth than stations near Inglis Dam.

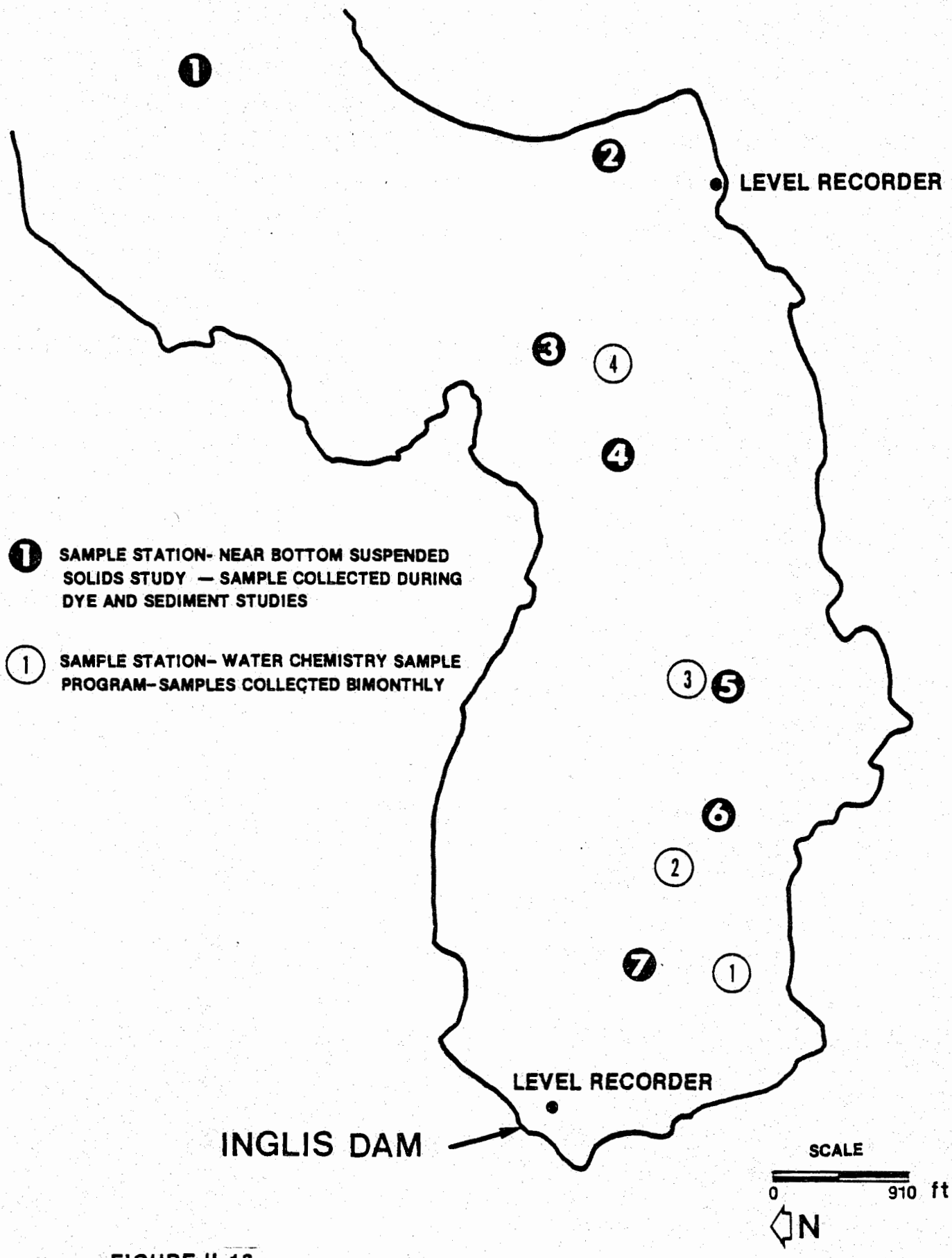


FIGURE II-18
SUSPENDED SOLIDS SAMPLE LOCATIONS, OCTOBER 1977, TO MAY 1978, LAKE ROUSSEAU, FLORIDA

Table II-26. Suspended Solids Concentrations (mg/l) in Lake Rousseau

Depth (meters)	Sampling Stations and Sample Collection Date																			
	1*					2*					3*					4†				
	10/77	12/77	2/78	4/78	5/78	10/77	12/77	2/78	4/78	5/78	10/77	12/77	2/78	4/78	5/78	10/77	12/77	2/78	4/78	5/78
0																				
1																				
2								5												
3			43					37					15							
4																6	5	5	5	
5																				
6																				
7																				
8																5	5	5	5	
9																				
10																				
11																				
12																				

Table II-26. Suspended Solids Concentrations (mg/l) in Lake Rousseau (continued, page 2 of 3)

Depth (meters)	Sampling Stations and Sample Collection Date																			
	4*					3†					5*					6*				
	10/77	12/77	2/78	4/78	5/78	10/77	12/77	2/78	4/78	5/78	10/77	12/77	2/78	4/78	5/78	10/77	12/77	2/78	4/78	5/78
0																				
1																				
2																				
3																				
4						5	5	5	5										5	
5																			114	
6				5															1,370	
7				24																
8			4,500												6					
9															7					
10																				
11																				
12						19	6	8	5											

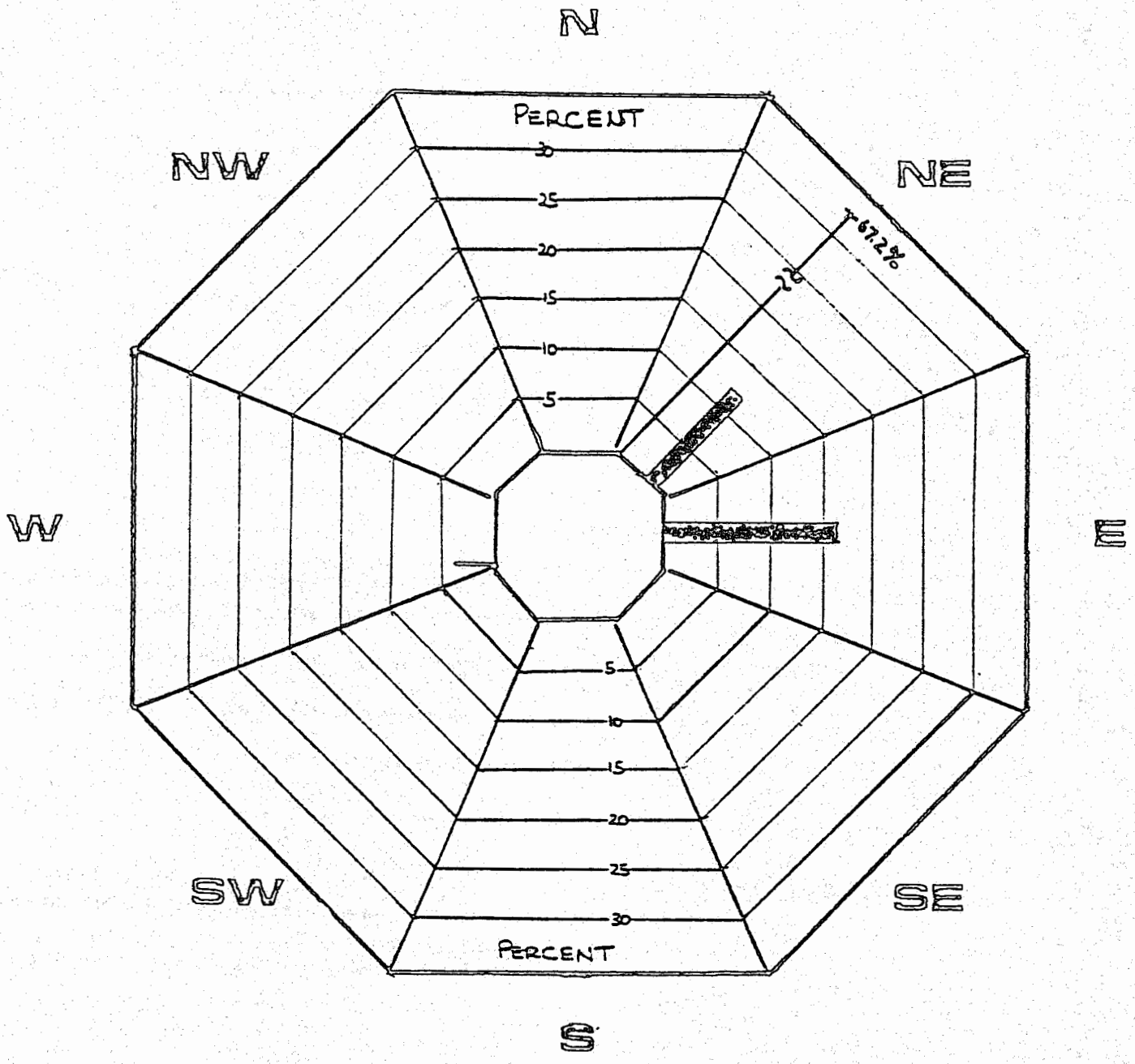
Table II-26. Suspended Solids Concentrations (mg/l) in Lake Rousseau (continued, page 3 of 3)

Depth (meters)	Sampling Stations and Sample Collection Date														
	2†					7*					7†				
	10/77	12/77	2/78	4/78	5/78	10/77	12/77	2/78	4/78	5/78	10/77	12/77	2/78	4/78	5/78
0															
1															
2											10	5	5	5	5
3	5	6	5	5							5	5	5	5	5
4															
5															
6															
7										6					
8										10					
9															
10	5	5	5	5											
11															
12															

* Sampling stations where samples were collected at various times during the circulation and sediment studies.

† Sampling stations where samples were collected bimonthly.

Source: Environmental Science and Engineering, Inc., 1978.



LEGEND

VELOCITIES	MPH
———	0-7.5
═══	8-14
▓▓▓	14

IN THE WIND DIAGRAM THE LENGTH OF THE BAR DENOTES THE PERCENT OF THE TIME THAT WINDS OF EACH TYPE HAVE BEEN MOVING FROM OR NEAR THE GIVEN DIRECTION

WIND DATA IS BASED ON 24 - ONE HOUR OBSERVATIONS OVER A ONE DAY PERIOD FROM 3/31/78 TO 4/1/78 BY ENVIRONMENTAL SCIENCE AND ENGINEERING, INC. AT LAKE ROUSSEAU, FLORIDA

FIGURE II-19
WIND ROSE DIAGRAM--AVERAGE DIRECTION , DURATION, AND VELOCITY OF WINDS AT LAKE ROUSSEAU, FLORIDA

Table 3.3-1 Crystal River Units 4 and 5 Site and Plant Water Use

Stream Number	Description	Peak		Normal		Temporary Shutdown	
		dm^3/s	(gpm)	dm^3/s	(gpm)	dm^3/s	(gpm)
1	Raw Well Water Supply	35.5	(563)	25.3	(401)	4.8	(77)
2	Water Pretreatment System Makeup	30.6	(485)	22.1	(350)	4.8	(77)
3	Solids Contact Basin Sludge	0.2	(3)	0.1	(2)	0	(0)
4	Solids Contact Basin Effluent	30.4	(482)	22.0	(348)	4.8	(77)
5	Filter Backwash Wastewater	0.4	(6)	0.4	(6)	0	(0)
6	Water Pretreatment System Wastes	0.6	(9)	0.5	(8)	0	(0)
7	Gravity Filter Effluent	30.0	(476)	21.6	(342)	4.8	(77)
8	Circulating Water Pump Bearing Water	1.3	(20)	1.3	(20)	0	(0)
9	Ash Handling System Service Water Uses	0.3	(4)	0.3	(4)	0	(0)
10	Miscellaneous Station and Potable Water Uses	3.5	(56)	3.5	(56)	3.5	(56)
11	Demineralizer Makeup	24.9	(396)	16.5	(262)	1.3	(21)
12	Demineralizer Regeneration Wastes	1.0	(16)	0.7	(11)	0.7	(11)
13	Condensate-Feedwater-Steam Cycle Makeup	23.9	(380)	15.8	(251)	0.6	(10)
14	Steam Cycle Evaporative Losses	15.4	(245)	10.1	(160)	0	(0)
15	Steam Cycle Liquid Losses	7.8	(123)	5.1	(81)	0	(0)
16	Condensate Polisher Wastes	0.7	(12)	0.6	(10)	0.6	(10)
17	Neutralization Basin Effluent	1.7	(28)	1.3	(21)	1.3	(21)
18	Cooling Towers Makeup (saltwater)*	3,083	(48,880)	1,878	(29,770)	0	(0)
19	Cooling Towers Evaporation	711.5	(11,280)	433.4	(6,870)	0	(0)
20	Cooling Towers Drift	0.8	(13)	0.5	(8)	0	(0)
21	Cooling Towers Blowdown	2,371	(37,587)	1,441	(22,892)	0	(0)
22	Raw Well Water to Ash Handling Systems	4.9	(78)	3.2	(51)	0	(0)

Table 3.3-1 Crystal River Units 4 and 5 Site and Plant Water Use, (Continued, page 2 of 3)

Stream Number	Description	Peak		Normal		Temporary Shutdown	
		dm^3/s	(gpm)	dm^3/s	(gpm)	dm^3/s	(gpm)
24	Rainfall to Roof Drains	1.3	(20)	1.3	(20)	1.3	(20)
25	Sanitary Wastes	0.4	(6)	0.4	(6)	0.4	(6)
26	Miscellaneous Plant Drains	3.2	(50)	3.2	(50)	3.2	(50)
29	Sewage Treatment Plant Effluent	0.4	(6)	0.4	(6)	0.4	(6)
31	Bottom Ash Hopper Evaporation	4.2	(67)	2.9	(45)	0	(0)
32	Water Entrained in Ash from Ash Handling	1.6	(24)	1.1	(18)	0	(0)
33	Water for Ash Dust Suppression and Compaction	0.4	(7)	0.3	(5)	0	(0)
35	Active Ash Storage Area Rainfall	3.6	(57)	3.6	(57)	3.6	(57)
36	Active Ash Storage Area Water Accumulation	2.0	(31)	1.4	(23)	0	(0)
37	Active Ash Storage Area Exfiltration	3.5	(55)	3.5	(55)	3.5	(55)
38	Active Ash Storage Area Runoff to Collection Ditch System	0	(0)	0	(0)	0	(0)
39	New Coal Storage Area Rainfall	9.0	(142)	9.0	(142)	9.0	(142)
40	New Coal Storage Area Exfiltration	8.6	(136)	8.6	(136)	8.6	(136)
41	New Coal Storage Area Runoff to Runoff Collection and Retention System (RCRS)	0	(0)	0	(0)	0	(0)
42	General Site Area Rainfall	13.4	(213)	13.4	(213)	13.4	(213)
43	General Site Area Exfiltration	8.1	(128)	8.1	(128)	8.1	(128)
44	General Site Area Runofff to Runoff Collection and Retention System	5.3	(85)	5.3	(85)	5.3	(85)
45	Direct Rainfall on Runoff Collection and Retention System	0.5	(8)	0.5	(8)	0.5	(8)

Table 3.3-1 Crystal River Units 4 and 5 Site and Plant Water Use, (Continued, page 3 of 3)

Stream Number	Description	Peak		Normal		Temporary Shutdown	
		dm^3/s	(gpm)	dm^3/s	(gpm)	dm^3/s	(gpm)
46	Runoff Collection and Retention System Evaporation	0.4	(7)	0.4	(7)	0.4	(7)
47	Runoff Collection and Retention System Exfiltration	6.7	(106)	6.7	(106)	6.7	(106)
48	Plant Drains Collection Pond Rainfall	1.1	(18)	1.1	(18)	1.1	(18)
49	Plant Drains Collection Pond Evaporation	1.0	(15)	1.0	(15)	1.0	(15)
50	Plant Drains Collection Pond Exfiltration	12.4	(203)	9.5	(156)	4.9	(80)
51	Plant Drains Collection Pond Overflow to Runoff Collection and Retention System	0	(0)	0	(0)	0	(0)
52	Plant Discharge 001	2,370	(37,587)	1,444	(22,892)	0	(0)
53	New Coal Storage Area Evaporation	0.4	(6)	0.4	(6)	0.4	(6)
54	Active Ash Storage Area Evaporation	0.1	(2)	0.1	(2)	0.1	(2)
55	Runoff Collection and Retention System Discharge 002	0†	(0)†	0†	(0)†	0†	(0)†

*Based on 1.3 cycles of concentration.

†During heavy rainfall events of greater than 10-year, 24-hour occurrence, overflow from the plant drains collection pond to the runoff collection retention system may be expected.

Note: During heavy rainfall events of greater than 10-year, 24-hour occurrence, overflow from the runoff retention and collection systems will discharge to the discharge cooling canal for Crystal River Units 1, 2, and 3.

Sources: Black and Veatch, 1978.
Environmental Science and Engineering, Inc., 1978.

3.3.1 WATER SOURCES

The water required to operate Crystal River Units 4 and 5 will be obtained from two primary sources, sea water and ground water.

GROUND WATER

Raw ground water for plant fresh water uses will be obtained from a well field along the Florida Power Corporation Central Florida transmission line right-of-way. A maximum design flow 130 dm^3/second (2100 gpm, 3 mgd) is required to guarantee freshwater flow rates under all contingencies. The aquifer characteristics obtained from a pumping test (see Section 2.5.1) have indicated that a linear well field consisting of 21 wells with 500 feet of space between wells and 100 gpm capacity for each well is necessary. This well field would achieve a 3 mgd flow and meet the rules and regulations of the Southwest Florida Water Management District (Chapter 16J F.A.C.). Final design of the well field is dependent upon the evaluation results of additional test drilling and pumping. Water quality data representative of the proposed well field water is presented in Table 3.3-2. Water quality data obtained from samples collected prior to and during the aquifer test indicate similar shallow well water quality to that observed in Table 3.

The well water will be pumped to the station to provide makeup to the ash handling system and plant service water.

Raw well water requirements for Units 4 and 5 will require a peak flow of about 35.5 dm^3/s (563 gpm, 0.81 mgd), and a normal flow of about 25.3 dm^3/s (401 gpm, 0.58 mgd). During temporary shutdown of the two units, raw well water demand will be about 4.8 dm^3/s (77 gpm, 0.11 mgd).

Table 3.3-2 Well Water Analyses

	Existing Well 3	Existing FPC Well 4		Existing FPC Well 5	
	4/13/76	4/13/76	11/30/76	4/13/76	8/18/76
Calcium*	147	173	160	167	153
Magnesium*	70	74	82	74	82
Sodium*	10	9	9	10	10
M-alkalinity*	208	237	234	232	226
Sulfate*	5	5	5	5	5
Chloride*	13	13	11	13	13
Nitrate*	--	--	--	--	--
Silica†	414	--	4.4	4.3	3.9
Specific Conductance, umhos/cm	435	485	430	475	440
pH	7.8	7.6	7.8	7.6	7.7

*mg/l as $CaCO_3$.
†mg/l as SiO_2

Source: Black and Veatch, 1976.

GULF COASTAL WATER

Salt water extracted from the existing discharge canal will serve as makeup for the plant cooling towers (circulating water system). The expected quantities of circulating water makeup are defined in Sections 3.3.3 and 3.3.4.

3.3.2 WATER TREATMENT

PLANT SERVICE WATER

Raw ground water which has been lime softened and chlorinated will be used as plant service water.

A solids contact-type clarifier-softener and gravity filter system will be used. Lime, coagulent, and coagulant aids will be used in dosages that have not yet been determined to produce the finished plant service water. Service water will be used as feed water to the demineralization system and for general plant uses including potable water, pump seal water, and ash crusher seal water.

The flow requirements of service water to the demineralization system and other plant uses are indicated in Table 3.3-1 and Figure 3.3-1. Wastes produced by this treatment process are described in Section 3.5.2.

MAKE-UP DEMINERALIZED WATER

Demineralized water is plant service water which has been further processed to a high quality suitable for use as makeup to the condensate-feedwater-steam cycle. The demineralization process will consist of ion exchange by three cation-anion exchanger pairs with degasification after the primary anion exchanger.

The expected peak flow to the demineralization system is 24.9 dm^3/s (396 gpm, 0.57 mgd) and the expected normal flow is 16.5 dm^3/s (262 gpm, 0.38 mgd). During temporary shutdown of the units, the only demineralized water requirement will be that required for regeneration of the demineralization and condensate polishing systems ion exchange resins. Wastes produced by regeneration are described in Section 3.5.3.

CONDENSATE POLISHING SYSTEM

A condensate polishing system is planned for removal of suspended and dissolved solids from the condensate. This technology will result in maintenance of a higher quality water in the condensate-feedwater-steam cycle and will extend the interval of steam generator cleaning to a period of three to five years.

This system will also consist of cation-anion exchanger pairs. Assuming that each resin bed will be regenerated 50 times per year, this system will require an annual average flow of 7.6 liters (2 gallons) per minute of demineralized water for regeneration. The wastes produced by regeneration are described in Section 3.5.

3.3.3 STATION CONSUMPTIVE USES

Consumptive use of fresh and salt waters are primarily due to evaporation, blowdown, and drift losses from the plant processes, losses due to storage in waste sludges and solids, and evaporation and exfiltration of stormwater runoff from impervious surfaces and storage areas.

COOLING TOWERS

Makeup to the plant cooling towers (circulating water systems) will be Gulf Coastal salt water pumped from the existing discharge canal for Crystal River Units 1, 2, and 3. This water is required to replace circulating water lost by evaporation, drift, and blowdown (discharge of water to maintain water quality to in turn maintain the cleanliness and efficiency of the heat rejection system). Cooling tower makeup will be treated with chemical additives to control algae growth and scaling and to allow operation with a minimum quantity of salt water makeup, as described in Section 3.5.

The expected peak cooling tower makeup requirement is approximately 3,083 dm^3/s (48,880 gpm, 70.4 mgd) and the expected normal makeup requirement is approximately 1,878 dm^3/s (29,770 gpm, 42.9 mgd). The actual makeup will depend upon the water quality (as calcium hardness) and therefore the cycles of concentration, as described in Section 3.4. During temporary shutdown, no makeup water will be required for the plant cooling towers.

Cooling tower consumptive use from evaporation and drift at peak conditions will be 712 dm^3/s (11,280 gpm, 16.2 mgd), and 0.8 dm^3/s (13 gpm, 18,720 gpd), respectively, and 433 dm^3/s (6,870 gpm, 9.9 mgd), and 0.5 dm^3/s (8 gpm, 11,520 gpd) for normal conditions.

STEAM-CONDENSATE-FEEDWATER CYCLE WATER USE

Consumptive water uses for the steam cycle, including steam soot-blowing and miscellaneous evaporative cycle losses, will be approximately

15.4 dm^3/s (245 gpm) at the peak condition and 10.1 dm^3/s (160 gpm, 0.23 mgd) at the normal condition. Boiler blowdown will be 7.8 dm^3/s (123 gpm, 0.18 mgd), and 5.1 dm^3/s (81 gpm), respectively. There will be no consumptive water uses for the steam cycle during temporary shutdown.

ASH AND REJECTS HANDLING SYSTEM WATER USE

Consumptive water uses for the ash and rejects handling systems include evaporative losses from the bottom hopper, water accumulated in the solid ash and rejects material in the ash landfill, and evaporative and seepage losses from this ash landfill area. The flows for these consumptive uses at the peak, normal, and temporary shutdown conditions are indicated in Table 3.3-1. Make-up sluicing water used in the hydraulic ash and rejects handling systems will be raw well water. Water pretreatment system sludges dewatered in the ash dewatering bin will also provide make-up water. Plant service water will be used for crusher seals.

Fly ash will be handled dry. Bottom ash, precipitator ash, mill rejects (pyrites), and the calcium carbonate sludge contained in the water pretreatment wastewater will be dewatered prior to storage in an above grade landfill area, as described in Section 3.6. Water will be recycled to the hydraulic ash sluicing systems. Plant wastewater from the plant drains collection pond will be utilized for dust suppression and compaction in the ash landfill area. Approximately 1.4 dm^3/s (23 gpm, 33,120 gpd) of water will be stored in the ash landfill at normal rates and 2.0 dm^3/s (31 gpm, 44,640 gpd) at peak rates.

SANITARY WATER USE

The maximum consumption of plant service water for potable and sanitary uses will occur with Unit 4 operating and Unit 5 under construction. An estimated maximum consumption of 1.1 dm^3/s (26,000 gpd) is expected.

During commercial operation of Units 4 and 5, an estimated 26 m^3 (6,900 gpd) of water will be consumed by the operating crew, temporary assigned personnel, and visitors.

MISCELLANEOUS PROCESS WATER USE

Normal plant cleaning and maintenance activities, equipment and pipe leakage, and relief valve drains will result in an estimated 3.1 dm^3/s (50 gpm, 72,000 gpd) consumptive use for peak and normal conditions.

DEMINERALIZED REGENERATION WATER USE

The demineralized water makeup system and the condensate polishing system ion exchange resins must be regenerated periodically. Water requirements for regeneration are 1.0 dm^3/s (16 gpm, 23,040 gpd) and 0.7 dm^3/s (12 gpm, 17,280 gpd), respectively for peak use and 0.7 d^3/s (11 gpm, 15,840 gpd) and 0.6 dm^3/s (10 gpm, 14,400 gpd) for normal use.

PLANT SERVICE WATER TREATMENT

Sludge from the solids contact basin and backwash from the gravity filters consume approximately 0.6 dm^3/s (9 gpm, 12,960 gpd) at peak operation and 0.5 dm^3/s (8 gpm, 11,520 gpd) under normal operating conditions. This water is recycled to the ash and rejects handling system as make-up sluice water.

3.4 HEAT DISSIPATION SYSTEM

3.4.1 COOLING SYSTEM DESCRIPTION

Each generating unit has a main cooling system and an auxiliary cooling system that will utilize a common recirculating water system with a natural draft cooling tower for final heat dissipation. The major components of the cooling system for each unit include one hyperbolic natural draft cooling tower, three vertical, wet pit circulating water pumps, two condensers, circulating water piping, blowdown pumps, piping and discharge structure, and make-up water intake structure with traveling screens, pumps and piping.

Each cooling tower will be located approximately 120 meters (400 feet) west of its associated turbine building. Each tower will be approximately 110 meters (370 feet) in diameter at the base and 140 meters (460 feet) high.

The main steam cycle for each unit will reject 3.5×10^{12} joules ($3{,}300 \times 10^{6}$ Btu) per hour, and the auxiliary equipment will reject approximately 0.2×10^{12} joules (200×10^{6} Btu) per hour at full load operating conditions. The total heat load for both main units and auxiliary units at full load operating conditions will be 7.4×10^{12} joules ($7{,}000 \times 10^{6}$ Btu) per hour.

The cooling towers will be designed to reject to the atmosphere the total heat load for all units at full load operating conditions. The following design conditions have been selected:

Cooling Range	11.7°C (21°F)
Approach	6.7°C (12°F)
Wet Bulb	26.1°C (79°F)

The salt water intake structure serving both units will be located on the north bank of the existing cooling water discharge canal as shown in Figure 3.10-1. The structure will be designed to supply a flow of 67,000 gpm. The structure will be approximately 50 feet wide and will be divided into three cells. Each inlet cell will be equipped with a half capacity (33,500 gpm) pump, a 15-foot traveling screen and a high pressure screen wash pump (Figure 3.4-1 and 3.4-2). The water velocity entering the structure at low water level and maximum flow will not exceed 0.5 feet per second. Two pumps will be capable of supplying the total makeup for both units operating at full load.

Stop logs will be provided to permit each cell to be isolated and dewatered when required. Trash racks upstream of the screens will be designed to prevent heavy trash and debris from coming in contact with the traveling screens.

Cooling tower blowdown will be taken from the cold side of the circulating water system and will be discharged directly into the existing discharge canal for Crystal River Units 1, 2, and 3. The maximum temperature of this discharge will be 34.4°C (94°F).

The quantity of cooling tower makeup and blowdown depends on the quality of the water. Preliminary water quality (calcium hardness) data indicate that the cooling towers can be expected to operate at 1.3 to 2.0 cycles of concentrations. The amount of makeup and blowdown, under peak conditions, for this range of operation is as follows:

Cycles of Concentration	Quantity of Makeup	Quantity of Blowdown
1.3	3083 dm^3/s (48,800 gpm)	2371 dm^3/s (37,587 gpm)
1.5	2134 dm^3/s (33,840 gpm)	1423 dm^3/s (22,560 gpm)
2.0	1423 dm^3/s (22,560 gpm)	711 dm^3/s (11,270 gpm)

48.8
x 2
97.6

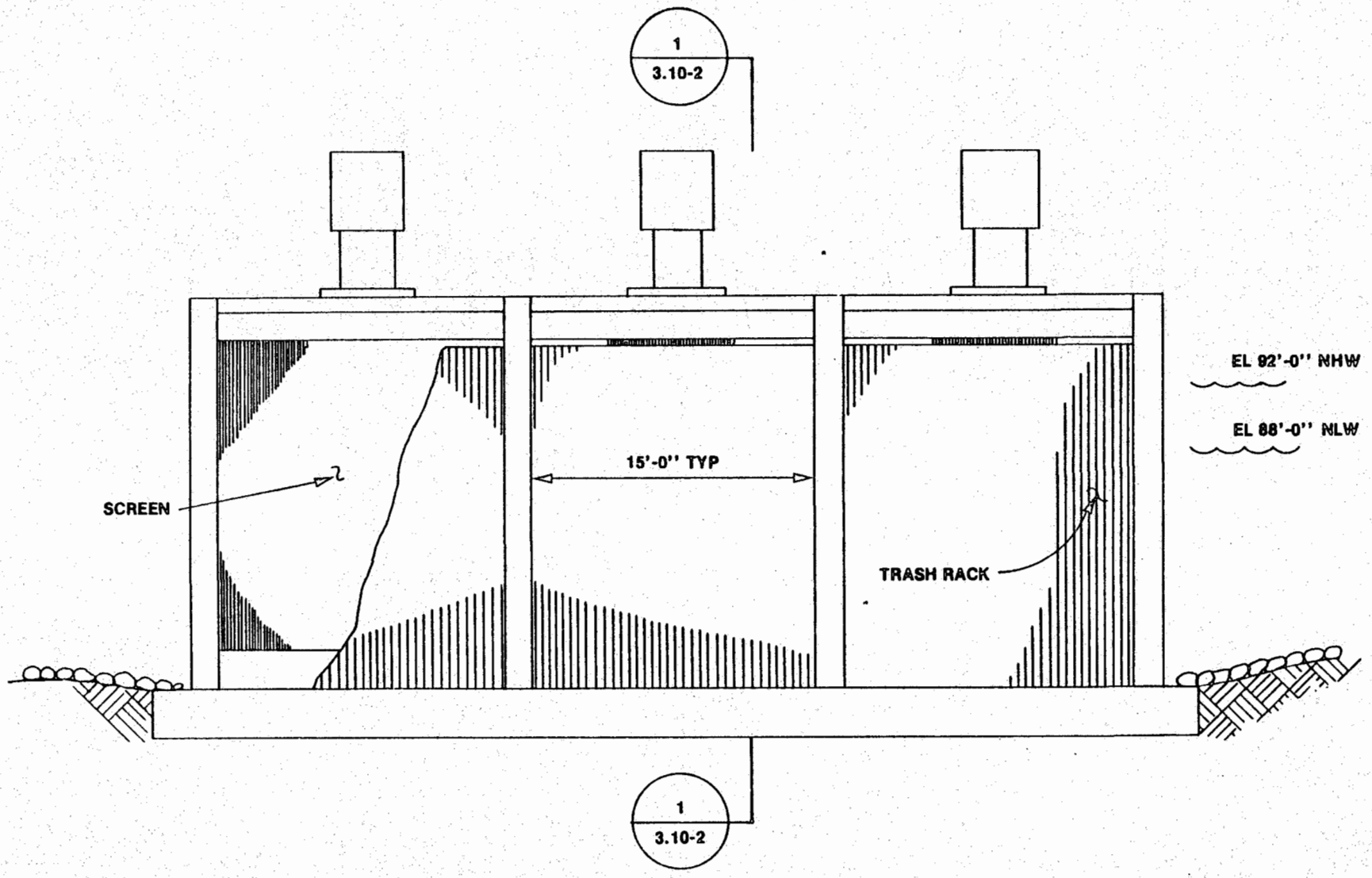


Figure 3.4-1
COOLING TOWER MAKE-UP INTAKE STRUCTURE

SOURCE: BLACK AND VEATCH, 1976

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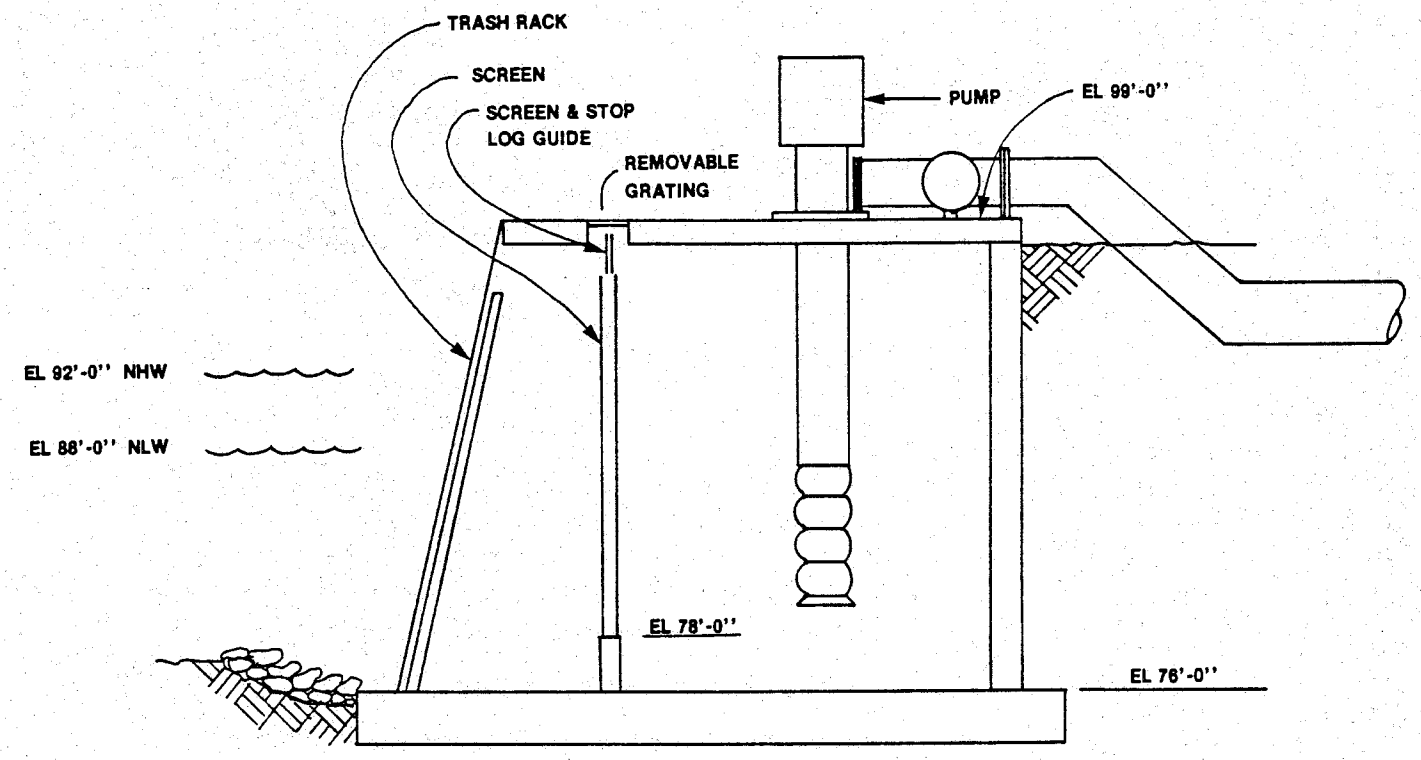
CITRUS COUNTY, FLORIDA



SECTION 1

Figure 3.4-2
COOLING TOWER MAKE-UP INTAKE STRUCTURE

SOURCE: BLACK AND VEATCH, 1976

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CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

3.4.2 COOLING WATER DESCRIPTION

Gulf Coastal salt water will be used to replace cooling tower losses due to blowdown, evaporation, and drift. The water use for both units at 1.3 cycles of concentration is as follows:

	Peak Conditions			Normal Conditions		
	gpm	gpd	cmd	gpm	gpd	cmd
Blowdown	37,587	54,125,280	205,020	22,892	32,964,480	124,865
Evaporation	11,280	16,243,200	61,527	6,870	9,648,000	36,545
Drift	13	18,720	71	8	11,520	45
Makeup	48,880	70,387,200	266,618	29,770	42,868,800	162,382

The average monthly seawater temperatures for the cooling water intkae and the discharge canals for the once-through cooling systems from Crystal River Units 1, 2, and 3 is presented in Table 3.4-1. The temperature of the discharge canal water represents the temperature of cooling tower makeup water. The expected range of cooling tower blowdown temperatures from Crystal River Units 4 and 5 is presented in Table 3.4-2.

Quality data for salt water in the area is presented in Table 3.4-3. The quality of the salt water makeup water determines the quantity of blowdown that will be necessary to maintain desired chemical conditions in the cooling system. These units will be operated to maintain a maximum calcium hardness of 1,000 mg/l. Given the quality of sea water in Table 3.4-3, the towers will be operated at approximately 1.3 to 2.0 cycles of concentration. The expected quality of the blowdown water is presented in Table 3.4-4.

SCALE AND CORROSION CONTROL

Chemical corrosion inhibitors will not be used. Salt water makeup will be treated by an alkaline-organic phosphate method of conditioning that will conform to the following quality control limits:

Table 3.4-1 Monthly Inlet and Discharge Sea Water Temperatures for Crystal River Units 1, 2, and 3

Month	Intake Canal Average Temperature		Discharge Canal Average Temperature*	
	°F	°C	°F	°C
January	57	13.9	71.5	21.9
February	62	16.7	76.5	24.7
March	56	18.3	79.5	26.4
April	75	23.9	89.5	31.9
May	79	26.1	93.5	34.2
June	84	30.0	98.5	36.9
July	85	31.7	99.5	37.5
August	85	29.4	99.5	37.5
September	83	28.3	97.5	36.4
October	75	26.1	89.5	31.9
November	66	18.9	80.5	26.9
December	60	15.6	74.5	23.6

* Based on Units 1, 2, and 3 operating at maximum capability.

Source: Black and Veatch, 1978.

Table 3.4-2 Temperature Range of Cooling Tower Blowdown for Crystal River Units 4 and 5

Month	Lowest		Highest	
	°F	°C	°F	°C
January	49	9.4	86	30.0
February	49	9.4	86	30.0
March	55	12.8	88	31.1
April	62	16.7	90	32.2
May	70	21.1	90	32.2
June	76	24.4	94	34.4
July	83	28.3	94	34.4
August	83	28.3	94	34.4
September	76	24.4	92	33.3
October	64	17.8	90	32.2
November	53	11.7	89	31.7
December	51	10.6	88	31.1

* Based on Units 1, 2, and 3 operating at maximum capability.

Source: Black and Veatch, 1978.

Table 3.4-3 Gulf Coastal Salt Water Quality Data

	Range (mg/l)
Total Dissolved Solids	15,008 - 36,080
Vol. Dissolved Solids	2,348 - 7,884
Chloride as Cl	7,990 - 17,090
Calcium Hardness	610 - 1,000
BOD_5	0 - 15
COD	0 - 328
Total Iron	0 - 4.6
Total Copper	0 - 0.59
Total Zinc	0 - 0.15
Total Boron	0 - 5.9
Total Chromium	0 - 0.11
Total Lead	0 - 0.42
Total Arsenic	0 - Trace
Total Mercury	0 - 0.8
Turbidity	0 - 80
pH	7.5 - 8.2
Conductivity (umhos/cm)	23,100 - 49,500

NOTE: Values derived from monthly grab samples at four locations in existing intake and discharge cooling water canals over a sampling period of one year. Calcium hardness data obtained separately.

Table 3.4-4 Quality of Cooling Tower Blowdown for Crystal River Plant Units 4 and 5

Constituent	Cooling Tower Blowdown
Ca, mg/l as $CaCO_3$	1,300
Mg, mg/l as $CaCO_3$	5,330
Na, mg/l as $CaCO_3$	24,024
M Alk, mg/l as $CaCO_3$	157
SO_4, mg/l as $CaCO_3$	2,909
Cl, mg/l as $CaCO_3$	27,587
NO_3, mg/l as $CaCO_3$	1
SiO_2, mg/l as such	1
TSS, mg/l as such	30
Cl_2, mg/l as such	0.2 average 0.5 maximum
T-PO_4, mg/l as P	25
pH	8.0 to 8.5
Maximum Temperature, °C (°F)	34.4° (94°)

Source: Black and Veatch, 1978.

pH	8.0 to 8.5
M-Alk	200 mg/l
Calcium Hardnesss as $CaCO_3$	1,300 mg/l

A proprietory organic phosphate scale inhibitor will be used as a chelate to prevent excess scale formation. Mechanical, on-line condenser tube cleaning systems also will be used to control scale formation and biological growths. Periodic sulfuric acid treatment will be used for descaling. Dosages will be determined based on operating experience.

There will be a residual phosphate concentration of 25 mg/l in the blowdown as a result of using the organic phosphate scale inhibitor.

BIOLOGICAL CONTROL

The circulating water will be shock chlorinated to control the growth of fouling organisms, algae and bacterial slimes in the condenser and cooling tower. Shock chlorination will be carefully controlled to prevent the chlorination of two condensers simultaneously and will be limited to one to three periods per day of chlorine solution feed. Actual solution feed will be limited to 15 minutes or less per period. The chlorine feed rates will be controlled to limit the maximum concentration of free available chlorine in the blowdown to less than 0.5 mg/l and the average concentration during shock chlorination to less than 0.2 mg/l. Neither free available chlorine nor total residual chlorine will be discharged from either unit in any concentration for more than two hours in any one day.

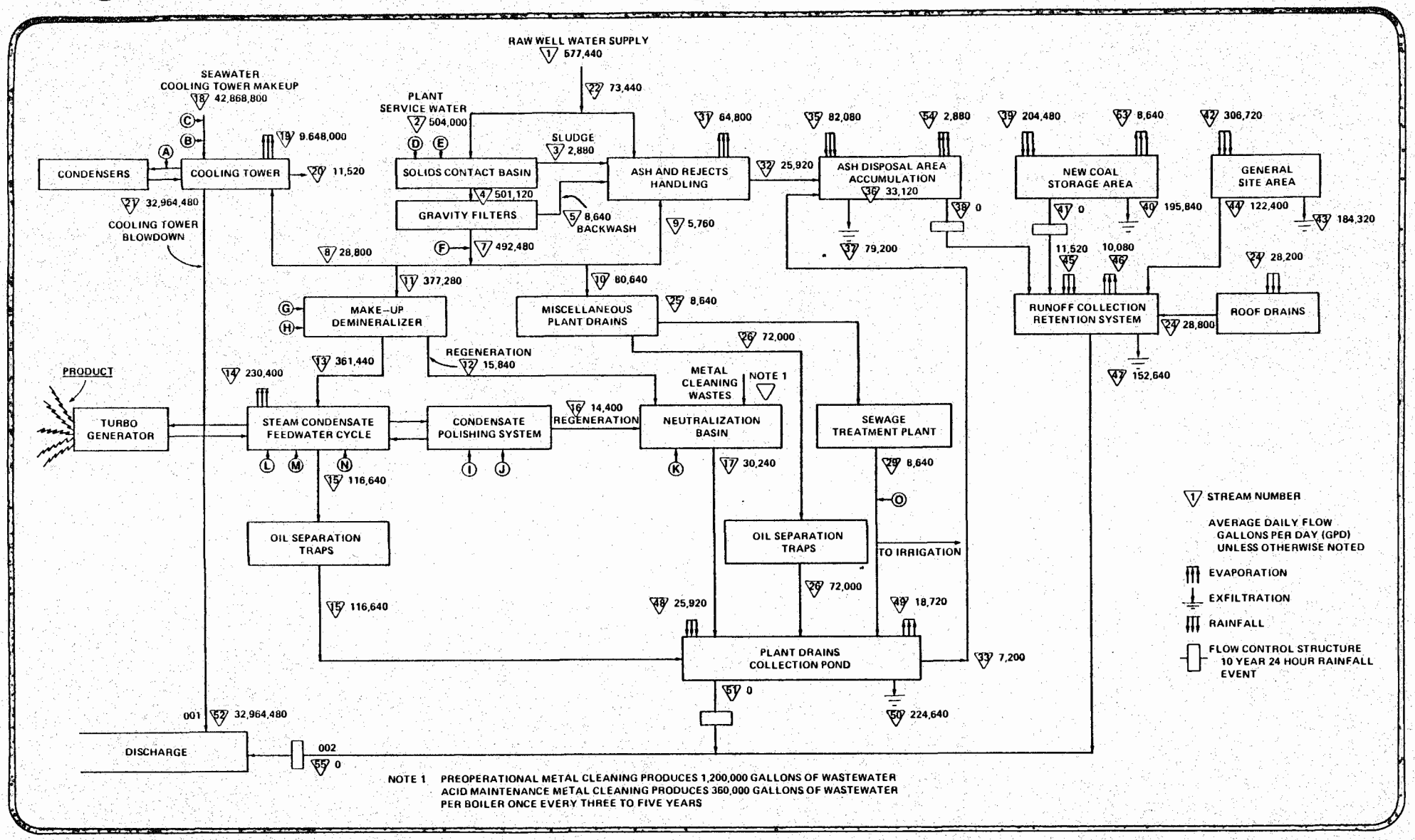
The following is a summary of the anticipated chemical dosages for scale and biological control:

	Peak Operation		Normal Operation	
	kg/day	lb/day	kg/day	lb/day
Scale Inhibitor	5,121	11,289	3,118	6,875
Chlorine	116	255	116	255
66° Baume Sulfuric Acid	Intermittent use to be determined based on operational experience.			

3.5 CHEMICAL AND BIOCIDE WASTES

This section describes the wastewaters generated during start-up, operation, and maintenance phases of various plant systems and planned methods of treatment and disposal.

The expected quantity and quality of each chemical and biocide utilized and any resulting waste streams are presented in the following subsections. A summary of expected chemical additive feed rates for various plant streams at 100 percent (peak) and 66 percent (normal) plant loads is given in Figure 3.5-1.



NOTE 1 PREOPERATIONAL METAL CLEANING PRODUCES 1,200,000 GALLONS OF WASTEWATER
ACID MAINTENANCE METAL CLEANING PRODUCES 360,000 GALLONS OF WASTEWATER
PER BOILER ONCE EVERY THREE TO FIVE YEARS

Figure 3.5-1
PLANT CHEMICAL USE DIAGRAM

LEGEND

KEY	CHEMICAL	Kg/d (PPD) 66% LF	Kg/d (PPD) 100% LF
A	CHLORINE	116 (255)	118 (256)
B	66° BE' SULFURIC ACID	NA	NA
C	ORGANIC PHOSPHATE	3,118 (6,875)	5,121 (11,289)
D	LIME (93% $Ca(OH)_2$)	320 (700)	440 (970)
E	POLYELECTROLYTE	8 (1.7)	1.0 (2.3)
F	CHLORINE	2.7 (6)	4.1 (9)
G	100% SODIUM HYDROXIDE	110 (235)	160 (355)
H	66° BE' SULFURIC ACID	340 (740)	510 (1,120)
I	100% SODIUM HYDROXIDE	50 (110)	75 (160)
J	66° BE' SULFURIC ACID	160 (360)	250 (540)
K	100% SODIUM HYDROXIDE	100 (210)	150 (325)
L	HYDRAZINE	1.4 (3)	1.8 (4)
M	AMMONIA	27 (60)	41 (90)
N	TRISODIUM PHOSPHATE	4 (1)	4 (1)
O	CHLORINE	4 (1)	4 (1)

SOURCE: ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1978

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

3.5.1 CIRCULATING WATER SYSTEM

Cooling tower blowdown discharges are discussed in Section 3.4. Operational controls are described that will limit free available chlorine or total residual chlorine concentrations to less than those required by 40 CFR, Section 423, as discussed in Section 3.4.

No additional treatment of cooling tower blowdown is planned prior to its discharge into the existing discharge canal. The use of corrosion inhibitors or biocides other than chlorine is not planned.

3.5.2 BOILER BLOWDOWN

Boiler blowdown at peak and normal conditions will be 7.8 and 5.1 liters per second (123 and 81 gallons per minute) and 670 and 440 cubic meters (0.18 and 0.12 million gallons) per day, respectively. Plant floor and equipment drains will collect and discharge wastewaters from normal plant cleaning and maintenance activities, equipment and pipe leakage, and relief valve drains at an estimated rate of 3.2 liters per second (50 gallons per minute) and 270 cubic meters (72,000 gallons) per day during peak and normal load plant conditions.

Hydrazine, ammonia, and trisodium phosphate will be fed to Units 4 and 5 condensate-feedwater-steam cycles to minimize scaling and corrosion. Hydrazine consumption is estimated at 1.8 kilograms (4 pounds) per day at peak plant load and 1.4 kilograms (3 pounds) per day at normal plant load, both as 100 percent hydrazine. Ammonia consumption is estimated to be 41 kilograms (90 pounds) per day at peak plant load and 27 kilograms (60 pounds) per day at normal plant load, both as 100 percent ammonia. Trisodium phosphate consumption is estimated to be less than 0.5 kilogram (1 pound) per day at all plant loads.

An auxiliary steam system may be installed which would utilize auxiliary electric powered boilers for cold unit start-ups. The chemicals fed to these boilers include hydrazine for oxygen scavenging and trisodium phosphate for pH and scale control. Chemical consumption is very small compared to the main units and unpredictable due to the intermittent operation of the auxiliary steam system.

Wastewaters containing phosphates, iron, copper, ammonia, suspended solids, and high pH are generated by boiler blowdown. These wastewaters will be discharged to the plant drains collection pond.

3.5.3 ASH TRANSPORT WATER

Water is used to hydraulically sluice and transport bottom ash, economizer ash, and pyrites from collection hoppers to ash dewatering bins as described in Section 3.6.2. Reclaimed water is recycled back to the collection hoppers for reuse. Water used in the system will either evaporate or will be accumulated in the ash and land-filled. Ash transport water is not discharged to surface waters.

3.5.4 METAL CLEANING WASTES

Metal cleaning wastes are any cleaning compounds, rinse waters, and other waterborne residues derived from cleaning metal process equipment such as boiler tubes, air preheaters, and boiler firesides. These wastes typically contain concentrations of iron, copper, TSS, and oil and grease.

PREOPERATIONAL CLEANING

The watersides of the boiler and preboiler systems will be alkaline-and acid-cleaned and rinsed prior to initial start-up to remove contaminants remaining from construction and installation. Alkaline cleaning will use a sodium phosphate solution and subsequent flushing water. Preoperational acid cleaning will use a solution of hydroxyacetic-formic acid (HAF) for the preboiler system, and either inhibited hydrochloric acid of HAF for the boiler. An acid neutralization step is required, followed by flushing with demineralized water. Approximately 4,500 cubic meters (1,200,000 gallons) of wastewater will be generated over a period of several days and discharged to the neutralization basin.

MAINTENANCE ACID CLEANING

Acid cleaning is a maintenance procedure which must be performed at 3- to 5-year intervals to remove accumulated scale from the boiler. This operation requires complete shut-down of one unit and will generate approximately 1,400 cubic meters (360,000 gallons) of wastewater that will be discharged to the neutralization basin over a period of five days.

3.5.5 LOW-VOLUME WASTE SOURCES

Low-volume waste sources include ion exchange regeneration wastes, laboratory chemical wastes, cooling tower basin cleaning wastes, floor drains, and plant service water treatment system wastes.

PLANT SERVICE WATER SYSTEM

The plant service water pretreatment system will lime-soften raw well water for makeup to the demineralization system and service water system, including potable water uses. Pretreatment will include lime softening, clarification, filtration, and chlorination. The chemicals expected to be used are hydrated lime [93 percent $Ca(OH)_2$], chlorine, and a polyelectrolyte. The following lists the expected quantities of these chemicals used during peak and normal load plant operation, respectively: hydrated lime, 440 kilograms (970 pounds) per day and 320 kilograms (700 pounds) per day; chlorine, 4 kilograms (9 pounds) and 3 kilograms (6 pounds) per day; and polyelectrolyte, 1.0 kilogram (2.3 pounds) and 0.8 kilograms (1.7 pounds) per day.

The plant service water pretreatment system will produce a calcium carbonate sludge from the solids contact unit and backwash water from the gravity filters that will require disposal. Approximately 1.3 kilograms (2.9 pounds) of precipitate will be formed per 3.785 cubic meters (1,000 gallons) throughout for the quality of raw well water specified in Table 3.4-1.

Assuming a 5 percent solids concentration in the solids contact unit sludge, a flow of 0.126 liters per second (2 gallons per minute) 10.9 cubic meters (2,880 gallons) per day will result at the annual average service water demand of 22 liters per second (350 gallons per minute) or 1,900 cubic meters (0.5 million gallons) per day. Gravity filter backwash will generate an estimated 0.38 liters per second (6 gallons per minute) or 32.7 cubic meters (8,640 gallons) per day, assuming that they are backwashed weekly.

The total wastewater from the water pretreatment system is expected to average 0.5 liters per second (8 gallons per minute) or 43.6 cubic feet (11,520 gallons) per day. This wastewater will be pumped to the bottom ash dewatering bins where the suspended solids will be separated from the fluid and disposed with the bottom ash solids to a landfill as discussed in Section 3.6. An estimated 663.7 kilograms (1,462 pounds) per day of pretreatment system solids will be disposed of in this manner. The liquid portion of the water pretreatment system wastewater will be used as makeup to the bottom ash sluice system. Discharge of water pretreatment system wastewater to navigable water will not occur.

DEMINERALIZATION SYSTEM

The demineralization system will process pretreated well water to provide high-quality water suitable for use as makeup to the condensate-feedwater-steam cycles and other miscellaneous uses requiring high-quality water. The wastewater from this system will consist of unreacted sulfuric acid and sodium hydroxide plus the sodium and sulfate salts of the ions removed from the ion exchange resins during regeneration. The average daily regenerant chemicals required are estimated at 161 kilograms (355 pounds) per day of 100 percent sodium hydroxide and 508 kilograms (1,120 pounds) per day of 66° Baume sulfuric acid at peak load plant conditions. At normal plant load, the caustic and acid requirements are approximately 107 kilograms (235 pounds) per day and 336 kilograms (740 pounds) per day, respectively.

The regenerant wastewaters are expected to average 1.0 and 0.69 liters per second (16 and 11 gallons per minute) for peak and normal plant loads, respectively, and will be routed to the neutralization basin where the wastewater pH will be adjusted to between 6.5 and 9.0. Neutralized wastewaters will then be discharged to the plant drains collection pond.

CONDENSATE POLISHING SYSTEM

The condensate polishing system will process condensate providing protection to the steam cycle against condenser tube leaks or poor-quality makeup, and allowing faster unit restarts. Chemicals utilized for regeneration of this system will be the same as those used for the demineralization system: sodium hydroxide and sulfuric acid. Based on full-flow polishing of both units' condensate, the daily regenerant chemicals required are estimated at 75 kilograms (160 pounds) per day of 100 percent sodium hydroxide and 250 kilograms (540 pounds) per day 66° Baume sulfuric acid at peak load. At normal load, the caustic and acid requirements are approximately 50 kilograms (110 pounds) per day for 160 kilograms (360 pounds) per day, respectively.

The condensate polishing system wastewaters are similar to those produced in the demineralization system. The regenerant wastewaters are expected to average 0.76 and 0.63 liters per second (12 and 10 gallons per minute) for peak and normal plant loads, respectively, and will also be routed to the neutralization basin for pH adjustment. An estimated 23 kilograms to 34 kilograms (50 pounds to 75 pounds) per day of 100 percent sodium hydroxide will be required for neutralization of these wastewaters. These wastewaters are discharged to the plant drains collection pond in the same manner as the demineralization system wastewaters.

CHEMICAL LABORATORY WASTES

The principal chemical reagents to be used in the laboratory will include sodium and ammonium hydroxide; hydrochloric, nitric, sulfuric, and ethylenediaminetetraacetic acids; and sodium carbonate. Small quantities of various other chemicals will also be used for analytical testing.

The total quantity of chemical laboratory wastes is expected to be 0.38 cubic meters (100 gallons) per day, independent of generating plant load.

The chemical laboratory wastes will be collected by the miscellaneous plant drains system and discharged to the plant drains collection pond.

3.5.6 MATERIAL STORAGE RUNOFF

Material storage runoff is defined as the rainfall runoff from or through any coal, ash, or other material storage pile. The material storage runoff at the proposed site will be flow-segregated from general site drainage and will only discharge runoff in excess of the 10-year, 24-hour storm event.

NEW COAL STORAGE AREA

A new coal storage area is located southeast of the proposed new units. Approximately 19 hectares (47 acres) will be dedicated to active and inactive coal storage as well as the operation area required by conveyors, transfer stations, and a stacker-reclaimer. The area will be diked and drained by a 1.2-hectare (3-acre) perimeter drainage ditch. The storage area will not be lined with impervious material. The drainage system for the area will be designed to store all rainfall runoff generated up to the 21.3-centimeter (8.37-inch) 10-year, 24-hour rainfall event. The stored rainfall will be disposed of by evaporation and exfiltration. Excess rainfall will be discharged into the runoff collection ditch system via a raised drop inlet overflow structure fitted with an oil skimmer.

ACTIVE ASH STORAGE AREA

The ash storage area is located east of the proposed site of the new units. The total ash storage area is 235 hectares (95 acres). It will be operated as a landfill and will be designed to have approximately 8.1 hectares (20 acres) in active use at any one time as described in Section 3.6.2.

The active area will be designed and operated to retain all rainfall up to the 21.3-centimeter (8.37-inch), 10-year, 24-hour rainfall event within a diked area. The stored runoff will evaporate and exfiltrate. Runoff resulting from a rainfall event in excess of the 10-year, 24-hour

storm event will discharge into the runoff collection ditch system via a raised drop inlet overflow structure fitted with an oil skimmer.

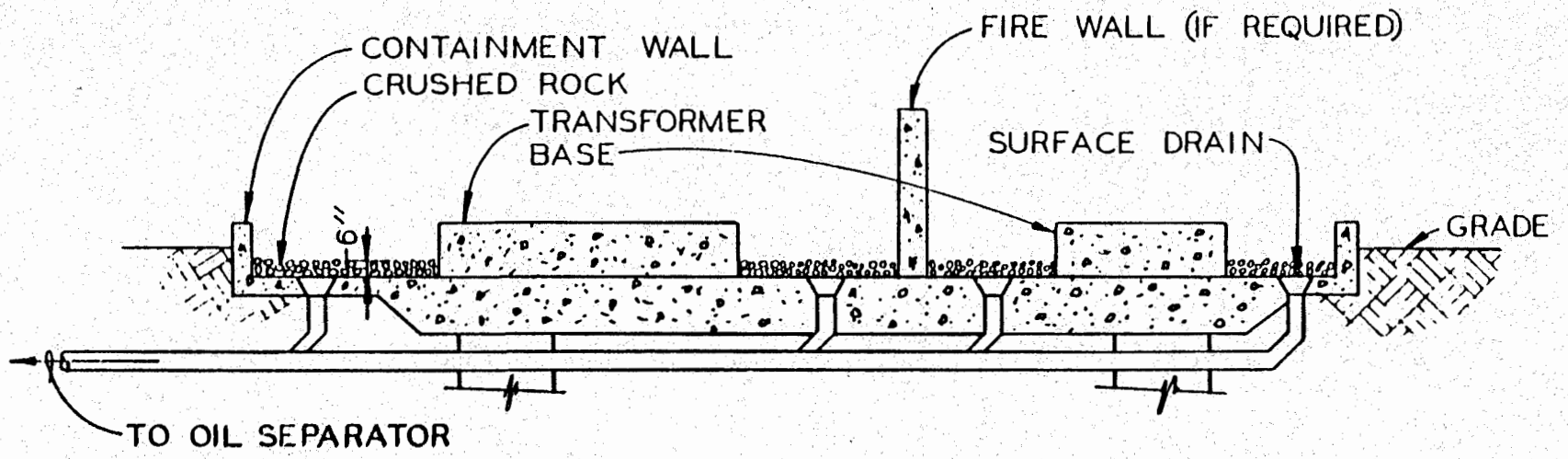


Figure 3.5-2
TRANSFORMER OIL RECOVERY

SOURCE: BLACK AND VEATCH, 1976

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

3.5.7 TRANSFORMER OIL SPILL PREVENTION AND RECOVERY

Equipment containing PCB's shall be contained entirely within an impervious, segregated drainage area designed to contain and recover any spill of PCB-bearing material that may occur.

The main and auxiliary transformers for both units will be mounted on concrete surfaces sloped to area drains in a manner to provide swift drainage of spilled transformer oil. Drain piping will be routed to an oil-water separator structure (Figure 3.5-2). The piping and separator will be sized to safely handle and recover a complete oil spill from the largest single transformer for either unit plus inflow from the 21.3-centimeter (8.37-inch), 10-year, 24-hour rainfall event and inflow from the fire protection deluge system.

3.5.8 FUEL OIL SPILL PREVENTION AND RECOVERY

Aboveground fuel oil storage tanks are required. The tanks are located north of Crystal River Unit 4. A fuel unloading facility is also required. Fuel oil storage tanks will be diked in a manner to provide sufficient capacity for containment of the entire volume of the tank in the event of a spill, plus a reserve capacity for impounded rainfall from the 21.3-centimeter (8.37-inch), 10-year, 24-hour design storm. A 30-centimeter (1-foot) thick clay blanket will form the liner for the bottom and interior slopes of the fuel oil containment dike. A buried drain pipe and valve will provide drainage of the containment dike. Rainfall drainage will be routed through an oil separator structure to remove oil from normal leakage and small spills (see Figure 3.5-3).

The truck unloading area will have a reinforced concrete apron that will be curbed and the surface sloped to drain into a catch basin. The catch basin will drain to the tank containment dike.

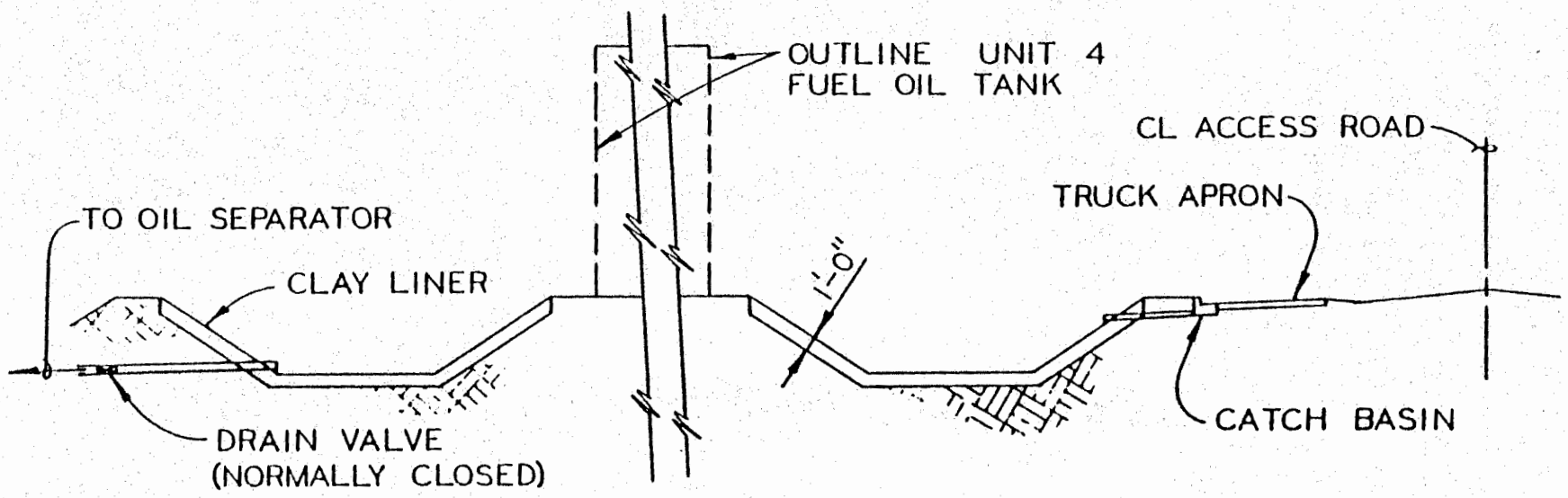


Figure 3.5-3
FUEL OIL RECOVERY

SOURCE: BLACK AND VEATCH, 1976

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

3.5.9 WASTE TREATMENT AND DISPOSAL SYSTEMS

GENERAL CONCEPT

Segregation and reuse of waste streams is the primary concept behind the design of the waste treatment and disposal systems for the proposed facility. Cooling tower blowdown is recycled to the hydraulic ash systems; low-volume wastes and metal-cleaning units are segregated and pretreated; material storage pile runoff is segregated for general site runoff; oil-water separators are used to recover oil spills, treat rainfall runoff, and pretreat process wastewaters.

NEUTRALIZATION BASIN

A neutralization basin with a volume of 380 cubic meters (100,000 gallons) is planned for pretreatment of metal-cleaning wastes and low-volume wastes. This basin will be used for neutralization of wastes on a batch basis. The basin will be sized to contain the largest volume of chemical cleaning solution wastes expected in one batch.

The basin will be constructed of reinforced concrete with a chemical-resistant membrane brick and mortar. A mixer will be mounted on a walkway spanning the open-topped basin. Sulfuric acid and sodium hydroxide will be available from the demineralizer system regeneration equipment.

The basin will require several days to fill during normal plant operations as discharges will primarily consist of ion-exchange regeneration wastes. These wastes will tend to be self-neutralizing and will require minimal additional chemical addition. Neutralized regeneration wastes will be pumped to the plant drains collection pond to evaporate and exfiltrate.

Batch neutralization of preoperational chemical-cleaning wastes will produce approximately 3,200 kilograms (7,000 pounds) of precipitate metal hydroxides. Acid cleaning will produce about 950 kilograms

(2,100 pounds) of precipitate every 3 to 5 years. The precipitate and neutralized supernatent will be discharged to the plant drains collection pond to evaporate and infiltrate.

3.5.10 PLANT DRAINS COLLECTION POND

The plant drains collection pond influents will include neutralization basin wastewaters, boiler blowdown, low-volume wastes, and cycle losses carried via the miscellaneous plant drains. The plant drains collection pond will not require chemical additions for further treatment of the wastewaters introduced.

The plant drains collection pond will be sized to contain all wastewater influents and direct rainfall from two consecutive 10-year, 24-hour rainfall events of 21.3 centimeters (8.37 inches) each without a discharge (Hershfield, 1961). The estimated area and volume of the plant drains collection pond are 2.6 hectares (6.5 acres) and 24,000 cubic meters (19.5 acre-feet), respectively. There will normally be no discharge expected from the pond, as evaporation and exfiltration exceeds the wastewater influents during normal conditions and the pond is sized to contain the wastewater resulting from the 10-year, 24-hour rainfall event. However, the plant drains collection pond will be provided with a discharge structure designed to prevent the discharge of any floating material during high rainfall events. Any possible discharge will be routed to the cooling tower blowdown conduit and thus to the existing discharge canal.

3.6 SANITARY AND OTHER WASTE SYSTEMS

3.6.1 SANITARY WASTE SYSTEM

The sewage treatment plant will be an 11.3-cubic meter (30,000-gallon) per day packaged, activated sludge unit which employs the extended aeration process method of treatment. The facility will be designed to achieve 90 percent reduction of BOD_5 and suspended solids. The process equipment will be installed in a concrete basin, with separate aeration and clarification sections. A comminutor will be provided to reduce the size of solids at the inlet to the plant. A chlorine contact chamber and a gas solution chlorination system will be provided for disinfection of the effluent. Chlorine consumption is estimated to be .9 kilograms (2 pounds) per day independent of the plant generating load. The design of the sewage system will allow operation with one aeration chamber-clarifier chamber pair which are dewatered during periods of normal load that occur during commercial operation of Units 4 and 5, as defined below.

The maximum hydraulic and biological loading will occur with Unit 4 operating and Unit 5 under construction. Under these conditions, an estimated maximum of 97 cubic meters (25,750 gallons) per day of sewage containing 25 kilograms (57 pounds) of BOD_5 was calculated as follows:

100 permanent personnel @ 35 gpd	3,500 gpd
50 temporary personnel @ 25 gpd	1,250 gpd
40 visitors @ 25 gpd	1,000 gpd
1,000 construction personnel @ 20 gpd	20,000 gpd
	25,750 gpd

During commercial operation of Units 4 and 5, the sewage treatment plant will treat an estimated 26 cubic meters (8,640 gallons) of sewage per day containing approximately 8 kilograms (18 pounds) of BOD_5, based on an estimated operating crew of 132, plus temporary assigned personnel and visitors independent of electric generating plant load.

The disinfected effluent from the sewage treatment plant will be pumped to the plant drains collection pond. Hydraulic loading rates to this pond will be designed to allow complete percolation of the effluent. Provisions will be made in the effluent pumping system to use the disinfected effluent for irrigation of landscape vegetation and grasses and ground cover used to stabilize exposed soils against erosion.

3.6.2 SOLID WASTE HANDLING AND DISPOSAL

Solid wastes resulting from plant operation will include bottom ash, coal pulverizer rejects, economizer ash, precipitator fly ash, and water pretreatment system sludge.

Bottom ash will be collected in a water-sealed hopper and hydraulically sluiced to ash dewatering bins. Coal pulverizer rejects (pyrites) will be collected in small hoppers adjacent to each pulverizer. The pyrites will then be hydraulically conveyed from each pulverizer hopper to an intermediate pyrites storage and holding tank. Economizer ash will be removed from the economizer and gas recirculation dust collector hoppers with a vacuum produced by hydraulic exhausters. The resulting economizer ash-water mixture will be sluiced to the pyrites holding tank for eventual removal to the ash dewatering bin. Figure 3.6-1 summarizes schematically the bottom ash, pyrites, and economizer ash collection systems. The water pretreatment sludge will be pumped directly to the dewatering bins.

In the dewatering bins, the ash in the ash-water mixtures will be settled and the transport water will be removed through gravity decanting and dewatering elements. The transport water will be reclaimed, clarified, and returned to the ash handling system. A schematic diagram of the ash dewatering and transport water reclaim systems is shown in Figure 3.6-2.

Fly ash collected in the precipitator hoppers will be pneumatically conveyed by a vacuum system to a storage silo located on the plant site. The vacuum required to remove and transport the fly ash will be produced by mechanical vacuum pumps. A schematic arrangement of the fly ash collection system is shown on Figure 3.6-3.

The expected quantity of solids for disposal, based on both units operating at average capacity, will be approximately 784,000 kilograms (1,730,000 pounds) per day, while at peak capacity 1,187,000 kilograms

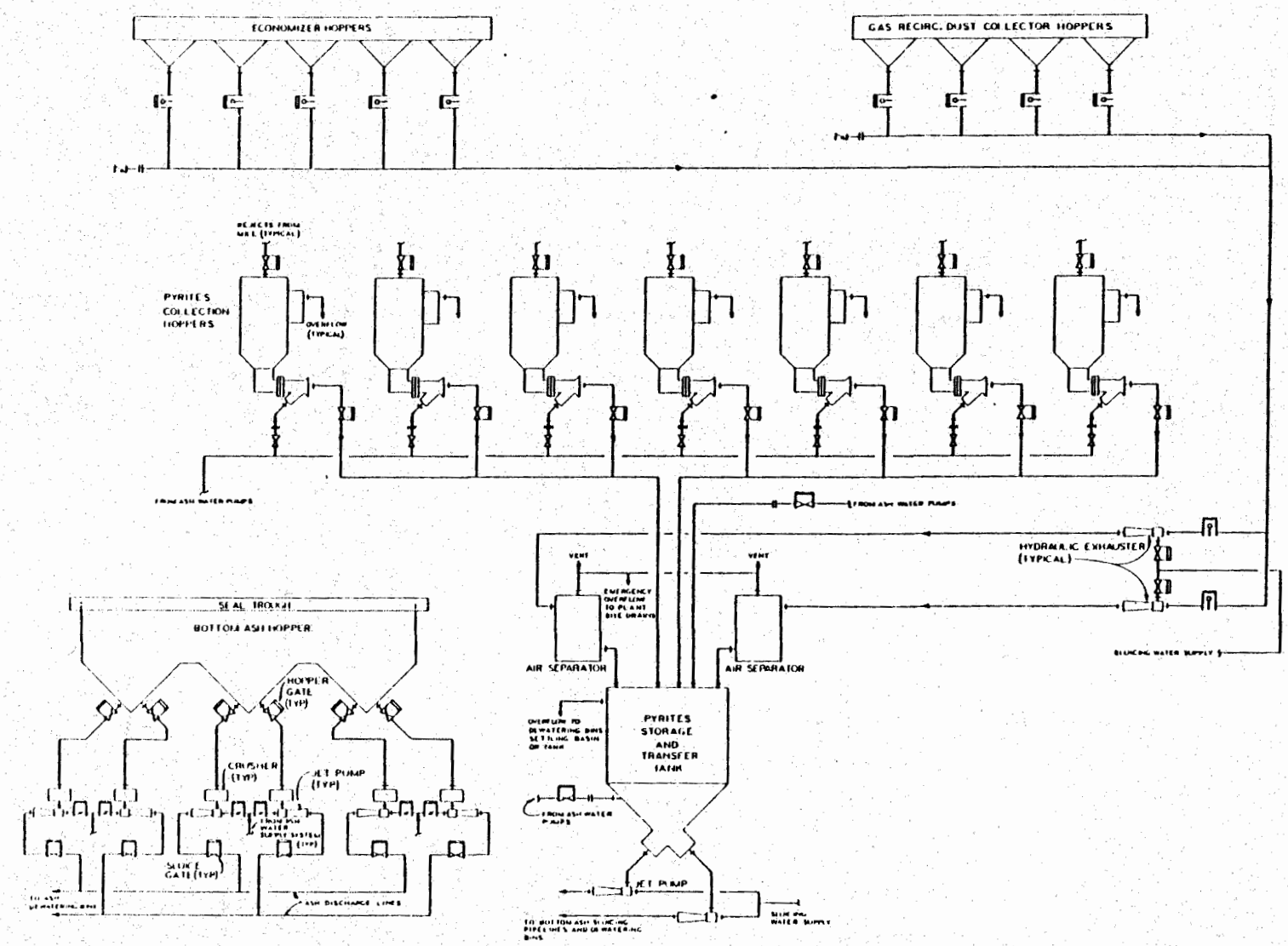


Figure 3.6-1
BOTTOM ASH, ECONOMIZER, AND PYRITES HANDLING

SOURCE: BLACK AND VEATCH, 1976

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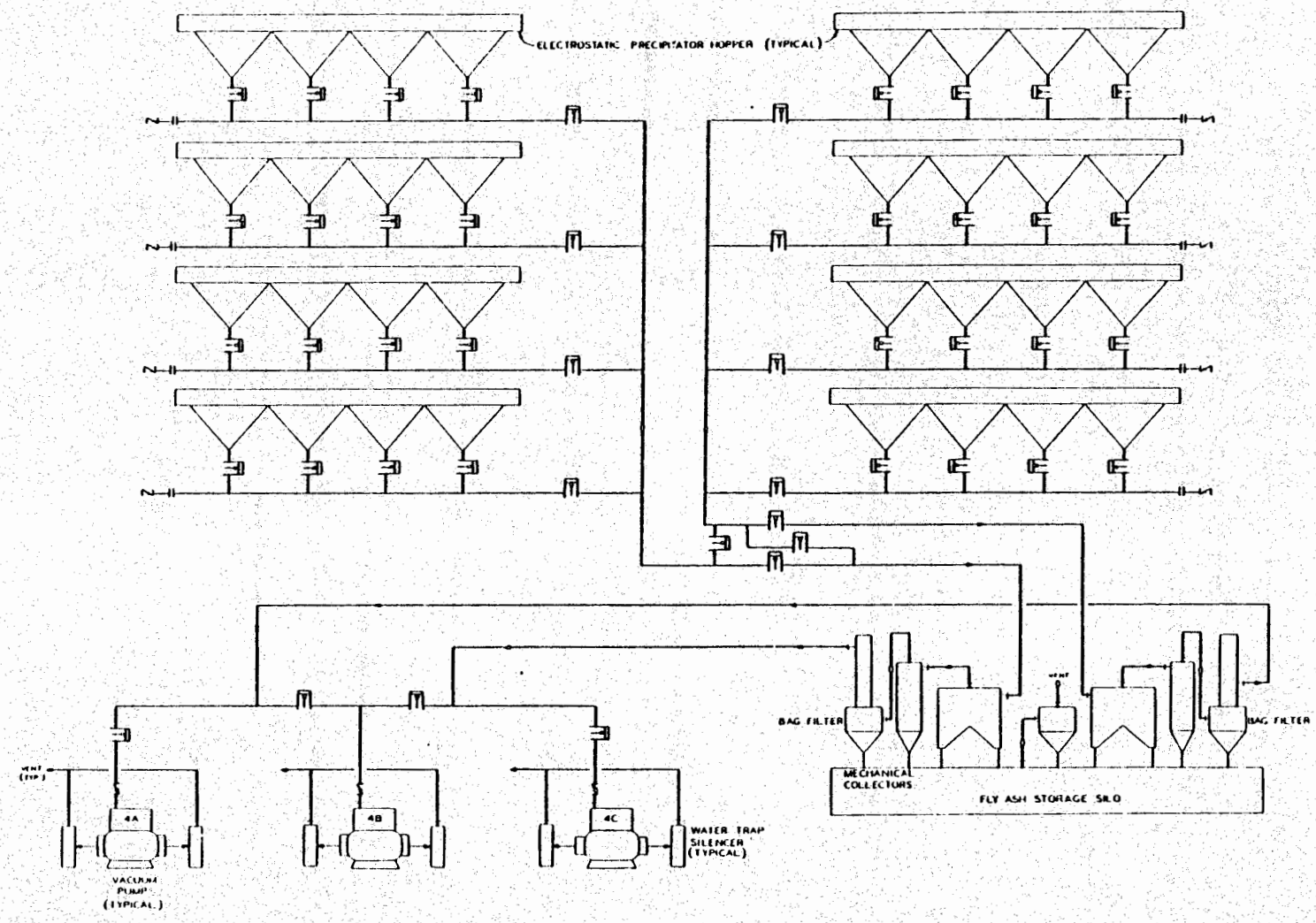

Figure 3.6-3
FLY ASH HANDLING

SOURCE: BLACK AND VEATCH, 1976

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(2,620,000 pounds) per day are expected. Table 3.6-1 lists the expected quantities of each type of solid waste at both average and peak load factors, based on the fuel supply described in Section 3.2.

Dewatered bottom ash, pulverizer rejects, economizer ash, pretreatment system sludge, and dry precipitator fly ash produced during the operating life of Units 4 and 5 will be transported by truck or conveyor to an on-site storage area. The total storage development will consist of approximately 380,700 square meters (95 acres) at a total depth of 12 meters (40 feet). The storage area will be developed in eighty 150-square meter (20-acre) segments. Each segment will be filled to a height of 12 meters (40 feet) above existing grade. The storage pile slopes will be dressed with soil material of sufficient depth to support vegetation. At the time the segment is developed to design height, the top surface will be sloped to drain and dressed with soil materials. The soil material used for cover will be stockpiled in unused portions of the ash storage area. The active ash storage will be compacted and sloped to insure minimum infiltration. A toe canal will be constructed along the perimeter of the active storage segment to receive surface stormwater runoff. The stormwater runoff in excess of the 10-year, 24-hour storm event will be diverted to the canal retention system.

The on-site ash storage area will be sufficient for the storage of all bottom ash, pulverizer rejects, economizer ash, pretreatment system sludge, and precipitator fly ash produced during the first 24 years of operating life of Units 4 and 5. This conclusion is based on the average generation capacity with the fuel supply described in Section 3.2. Fly ash from these units will be handled dry. This will enable selling fly ash for such purposes as: mineral filler in asphalt paving, additive in concrete and concrete products, Pozzolin insoil stabilization, raw material in lightweight aggregate, grouting agent, fill for development, and agricultural applications. If 26.5 percent of fly ash from Units 4 and 5 is sold, then the on-site storage area will be sufficient for the storage of all ash and pretreatment system sludge

Table 3.6-1. Crystal River Plant Solid Waste Quantities, Units 4 and 5

Constituent	Average (66%) Capacity Mg/Day	Average (66%) Capacity (10^3 Lb/Day)	Peak (100%) Capacity (Mg/Day)	Peak (100%) Capacity (10^3 Lb/Day)
Bottom Ash*	147	(324)	223	(492)
Economizer Fly Ash*	29	(65)	44	(98)
Precipitator Fly Ash*	560	(1,234)	849	(1,872)
Pulverizer Rejects*	47	(103)	70	(154)
Pretreatment System Solid Waste	.7	(1.5)	(1.0)	(2.1)
Total Solids to Ash Storage	783.7	(1,727.5)	1,187.0	(2,618.1)
Total Volume of Solids to Storage	528 m^3	(18,630 ft^3)		

* Ash and rejects quantities based on design coal blend.

Source: Black and Veatch, 1978.

for 30 years operating life at average capacity. Refer to Section 9.8.2 in Chapter 9 for more discussion on ash disposal.

3.7 AIR EMISSIONS

3.7.1 DESIGN REQUIREMENTS

STEAM GENERATOR

Crystal River Units 4 and 5 consist of two fossil fuel-fired steam generators. Each unit will operate at a net electrical output capacity of 640 Mw and will burn approximately 294,000 kilograms (648,000 pounds) per hour of coal based on the typical coal analysis (Section 3.2). Combustion at this load will produce approximately 3,277,209 kilograms (7,224,887 pounds) per hour of combustion gases which will consist primarily of nitrogen, carbon dioxide, water vapor, oxygen, particulate matter, sulfur dioxide, and nitrogen oxides. The constituents of the combustion gas are shown in Table 3.7-1.

Both the U.S. Environmental Protection Agency and the Department of Environmental Regulation of Florida have adopted regulations establishing air pollutant emission rates which are applicable to Crystal River Units 4 and 5. The emission limitations are described in 40 CFR Part 60.40, Standards of Performance for Fossil-Fuel Fired Steam Generators and Chapter 17-2.04(e)1.F.AC, Rules of the Department of Environmental Regulation (DER). The applicable emission rate limitations from both the EPA and the DER regulations are summarized as follows:

Pollutant	Emission Rate Limitation
Sulfur Dioxide	520 Nanograms per joule (1.2 lb per million Btu)
Particulate Matter	43 Nanograms per joule (0.1 lb per million Btu)
Nitrogen Dioxide	300 Nanograms per joule (0.7 lb per million Btu)
Opacity	20 percent*

*The opacity shall not exceed 20 percent except that 40 percent opacity shall be permissible for not more than 2 minutes in any hour.

Table 3.7-1. Combustion Products*

Combustion Product	Unit 4		Unit 5		Total	
	kg/h	(lb/h)	kg/h	(lb/h)	kg/h	(lb/h)
H_2O	195,955	(432,000)	195,955	(432,000)	391,910	(864,000)
CO_2	634,133	(1,398,000)	634,133	(1,398,000)	(1,398,000)	(2,796,000)
N_2	2,282,515	(5,032,000)	2,282,515	(5,032,000)	4,565,030	(10,064,000)
O_2	159,214	(351,000)	159,214	(351,000)	318,428	(702,000)
SO_2	2,880	(6,350)	2,880	(6,350)	5,760	(12,700)
NO_2	2,118	(4,670)	2,118	(4,670)	4,236	(9,340)
Cl_2	91	(200)	91	(200)	182	(400)
	303	(667)	303	(667)	606	(1,334)
TOTAL	3,227,209	(7,224,887)	3,227,209	(7,224,887)	6,554,418	(14,449,774)

*Based on peak coal consumption of 294,000 kilograms (648,000 pounds) per hour per unit, 20 percent excess air at 60 percent relative humidity, and 27°C (80°F) dry bulb (0.013 kilograms of moisture per kilogram of dry air).

Source: Black & Veatch, 1978.

Based on the typical coal analysis and the Standards of Performance for New Stationary Sources, equipment will be installed to control oxides of nitrogen and particulate matter.

The steam generators will be designed to operate such that the oxides of nitrogen emission rate expressed as nitrogen dioxide, will not exceed 300 nanograms of nitrogen dioxide per joule (0.7 pounds of nitrogen dioxide per million Btu) of heat input.

The typical ash content of the coal is about 7.9 percent with a range of 5.8 to 12.0 percent by weight, which corresponds to an ash production rate of about 3,300 nanograms per joule (7.7 pounds per million Btu). The approximate fly ash production, based on 90 percent of the total ash being fly ash is as follows:

Total Ash Production		Fly Ash Production	
percent by weight		Nanograms/joule	(lb/MBtu)
Typical	7.9	2,970	(6.9)
Minimum	5.8	2,180	(5.8)
Maximum	12.0	4,520	(10.5)

A precipitator with 99.6 percent efficiency will be used for each unit to collect fly ash so that particulate emissions do not exceed 43 nanograms/joule (0.1 pounds per million Btu) heat input.

The typical sulfur content of the design coal is about 0.49 percent with a design range of 0.4 to 0.6 percent. Based on 100 percent of the sulfur being converted to sulfur dioxide and a typical coal heating value of 23,850 joules/megagram (10,258 Btu/lb) the typical sulfur dioxide production is about 410 nanograms per joule (0.95 pounds per million Btu) with a range of 34 to 50 nanograms per joule (0.78 to 1.2 pounds per million Btu).

Sulfur dioxide removal is not required since the range of emission rate is within present federal and state regulations which limit the sulfur dioxide emission rate to 520 nanograms per joule (1.2 pounds per million Btu) heat input.

A stack height of approximately 183 meters (600 feet) and a diameter of 6.86 meters (22.5 feet) for each unit is adequate to satisfy dispersion requirements. Each chimney will be capable of discharging approximately 1,038 m^3/s (2,200,000 ACFM) of flue gas at 127°C (260°F) and 28.1 m/s (99.2 f/s). The flue gas flowrate and emissions are presented in Table 3.7-2.

COAL AND ASH HANDLING

The coal and ash handling system will generate particulate matter from handling western coal and dry fly ash. Observed unloading operation of Western coals at a number of utilities indicates that there is considerable dust emission even though western coals have a relatively high total moisture content. The probable cause of high dust emission is due to the more friable nature of western sub-bituminous coals as compared to midwestern or eastern bituminous coals. The emissions become more severe as the coal moves through a typical handling system. Natural drying action takes place in handling as the size of the coal is reduced. This causes significantly greater dust emissions in transfer and silo areas. The handling of mideastern and eastern coals in the systems does not create as much dust as do western coals, although the emissions are sufficient to require dust collecting equipment.

The major emission points will be the coal conveyor transfer points, crusher house, coal silos, fly ash silos, fly ash vacuum pump discharge and emergency reclaim hopper.

Coal transfer will be by covered conveyor from the existing coal handling area to Units 4 and 5 storage. At the storage area, coal will be blended and transferred to the crusher house by covered conveyor. A total of four transfer points are designed.

The crusher house and the in-plant coal storage silos are the remaining coal emission points. In-plant storage will be provided by six or seven silos per unit.

Table 3.7-2. Flue Gas Flow Rates and Emissions at Peak Load

Heat Input	Unit 4 (640 Mw)	Unit 5 (640 Mw)
GJ/h (10^6 Btu/h)	7,032 (6,665)	7,032 (6,665)
Gas Temp C(F)	126.7°C (260°C)	126.7 (260)
Gas Flow		
kilograms/hour (lb/h)	3,277,209 (7,224,887)	3,277,209 (7,224,887)
acms (ACFM)	1,038 (2,200,000)	1,038 (2,200,000)
Stack Exit Velocity		
meters/second (feet/second)	28.1 (92.2)	28.1 (92.2)
Stack I.D., meters (feet)	6.86 (22.5)	6.86 (22.5)
Stack Height, meters (feet)	182.9 (600)	182.9 (600)
Pollutant Emissions		
SO_2, kilograms/hour (pounds/hour)	3,537 (7,798)	3,537 (7,798)
Particulate Emissions		
kilogram/hour pounds/hour	303 (667)	303 (667)

Source: Black & Veatch, 1978.

The fly ash will be handled dry to enable possible commercial sale. As a consequence, possible fly ash emission may occur in the storage and transfer. Two points of discharge that have been identified are the fly ash silo and fly ash discharge system.

Regulated emission limitations for coal and fly ash handling are contained in the Environmental Protection Agency Regulations 40 Code of Federal Regulations, part 60 subpart Y, and the Florida Department of Environmental Regulations' rules contained in Chapter 17-2 F.A.C. Presented in Table 3.7-3 are the applicable regulations.

Table 3.7-3 Applicable Regulations for Coal and Ash Handling System

Particulate Emission Point	Number of Emission Points	Applicable Regulation	Type of Limitation
Transfer Point	4	Ch. 17-2.04(2) 40 CFR 60.252(c)	Process weight Visible emissions
Coal Crusher	1	Ch. 17-2.04(2) 40 CFR 60.252(c)	Process weight Visible emissions
Coal Storage Silos	4	Ch. 17-2.04(2) 40 CFR 60.252(c)	Process weight Visible emissions
Fly Ash Silos	2	Ch. 17-2.04(2) 40 CFR 60.252(c)	Process weight Visible emissions
Fly Ash Vacuum Pump Discharge	2	Ch. 17-2.04(2) 40 CFR 60.252(c)	Process weight Visible emissions
Emergency Reclaim Hopper	1	Ch. 17-2.04(2) 40 CFR 60.252(c)	Process weight Visible emissions
Coal Storage Area		Ch. 7-2.04(3)	Fugitive dust
Fly Ash Disposal		Ch. 7-2.04(3)	Fugitive dust

Source: Black and Veatch, 1978.

3.7.2 CONTROL SYSTEMS DESCRIPTION

STEAM GENERATOR

General

Oxides of nitrogen will be controlled by design and operation of the steam generator. Some particulate must be removed from the combustion gas to allow the steam generator to comply with the existing regulations for emissions and ambient air quality. The combustion gas of each unit leaves the steam generator and enters the air heater at about 343.3°C (650°F). The air heater transfers heat from the hot combustion gas to the steam generator combustion air. The combustion gas then enters the precipitator for particulate removal. Based on the upper design ash content and 20 percent opacity limitation, a precipitator of 99.6 percent efficiency is necessary to meet applicable standards. The cleaned combustion gas then passes to the induced draft fans and is discharged via a single 183-meter (600-foot) high stack.

Oxides of Nitrogen Control

In the combustion process, nitrogen oxides (NO_x) are formed in the high temperature regions of the boiler in and around the flame zone by oxidation of both atmospheric nitrogen and nitrogen in the fuel. Formation of NO_x can be reduced by reducing peak combustion temperatures, which is accomplished by limiting the amount of excess air available to the fuel and staging combustion.

NO_x from Units 4 and 5 steam generators will be controlled to meet emission standards by utilizing features to minimize NO_x formation during combustion. These design features will include one or more of the following:

1. Dual register burners (staged combustion);
2. Compartmented windbox (improved combustion control);
3. Large furnace and widely-spaced burners (reduced temperatures);
4. Overfire heat; and
5. Limiting heat input per burner.

The large furnace and widely-spaced burners increase the burner firing zone absorption area and decrease peaking combustion temperatures, thus minimizing NO_x formation.

The steam generators will be designed to operate such that the oxides of nitrogen emission rate expressed as nitrogen dioxide will not exceed 300 nanograms of nitrogen dioxide per joule (0.7 pound of nitrogen per million Btu) of heat input.

Particulate Control

Particulate matter generated during combustion will be removed in the electrostatic precipitator.

The electrostatic precipitator for the new boiler would normally operate with average air heater outlet temperatures of 110°C to 130°C (230°F to 266°F). Wide variations in resistivity could be expected for this temperature range for the fuel listed in Table 3.2-1. The temperature range within the gas steam leaving the air heater might vary as much as 11°C to 17°C (20°F to 30°F) above and below the average temperature. Different sections of the electrostatic precipitator could therefore be expected to experience temperatures varying between 93°C and 149°C (200°F and 300°F). Thus, the electrostatic precipitator could at any given time be experiencing wide variations in particle resistivity. The electrostatic precipitator would be designed with a greater number of fields (greater depth) and larger collecting surface to allow for the variations in resistivity that will be experienced.

Suggested design parameters for the electrostatic precipitator installation are shown in Table 3.7-4.

At full load, the maximum design ash content of the coal, more than 99.6 percent of the fly ash will be removed from the combustion gases leaving the furnace.

Table 3.7-4 Suggested Design Parameters for Electrostatic Precipitator

Precipitator efficiency (%)	99.6	
Gas flow, acms (ACFM)	1,048	(2,221,000)
Gas temperature, C (F)	130	(226)
Gas velocity, meters per second (feet per second)	0.91	(3)
Effective front end area, meters^2 (feet^2)	1,146	(12,339)
Plate heights, meters (feet)	9.75	(32)
Effective width, meters (feet)	117.65	(386)
Aspect ratio [four 2.74 meters (9 feet) and one 3.66 meters (12 feet) field]	1.5	
Field depth, meters (feet)	14.63	(48)
Effective volume, meters^3 (feet^3)	16,794	(593,000)
Duct width, meters (inches)	0.23	(9)
Number of ducts	515	
Total plate area, meters^2 (feet^2)	146,975	(1,582,000)
Collecting area, meters^2/acms (feet^2/10^3 ACFM)	140	(712)
Number of transformer rectifiers	80	
Number of bus sections	160	
Total power required, Mw	5.4	
Estimated precipitator dimensions, each (two precipitator/unit)		
Length, meters (feet)	17.68	(58)
Width, meters (feet)	64.01	(210)
Height, meters (feet)	15.24	(50)
Overall height, meters (feet) (including hoppers)	21.34	(70)

Source: Black and Veatch, 1977.

COAL AND ASH HANDLING

General

Control of dust will be accomplished by use of either of the following methods:

1. Dust suppression by application of a wetting agent, or
2. Dust collection in a dry state by air transport to a bag filter unit.

Wetting agent type dust suppression systems consisting of pre-engineered modules which incorporate both water handling components and automatic spray controls are available. A typical spray solution contains 3,000 parts of water to one part of an organic ether detergent. The rate of spray application is about 3.4 liters per metric ton (1.2 gallons per ton) of coal which increases total surface moisture by about 0.5 percent.

Dry dust collection is accomplished by removal of dust laden air from enclosed transfer points into a duct system which terminates into a bag filter unit. The collection process creates a slight negative pressure within enclosed transfer points. This pressure is effective in reducing the expiration of dust along skirt seals, other points of potential dust leakage, and at points of loading impact in the conveyor system.

At the collection point over 99 percent collection efficiency can be achieved with a properly maintained bag filter. Bag filters operate by passing dust laden air through a fabric at low velocity. The fabric is arranged in envelope (pillowcase style) or tubular shapes within the collection areas. Removal is obtained by build up of a cake or mat on the fabric dirty air surface. Good collection efficiencies can be maintained for dust partaicle sizes to 1 micron and smaller.

As dust is collected on the fabric, resistance to air flow increases. Periodically, the fabric is cleaned by rapping, shaking, or air pulse vibration of the bag to drop the bulk of the adhering material to an underlying collection hopper. Typically, units for coal dust collection are designed with air (cfm) to cloth (square feet) ratios of 7-9 to 1

for air pulse type units and 3-5 to 1 for shaker type units. Fabric material for coal dust collection is generally polypropylene, polyester, or polyesterdacron felt.

Pulse or reverse jet type removal systems require external source of package unit compressed air systems. Shaker or rapper type units are self-contained but are subject to slightly higher maintenance costs for the mechanical linkage systems.

Fabric collectors are limited to air conditions dry enough to prevent condensation or free moisture deposits on the fabric. Bonding tendencies of the moist dust particles gradually seal the fabric, rendering it useless, and eventually lead to bag replacement. The sealing characteristics of coal dust are somewhat variable, depending upon inherent moisture content and chemical composition of the coal, and the presence of inerts (limestone or clay) in the material. When spray systems are used in conjunction with bag filter units, care must be taken in the positioning of spray nozzles (wet type suppression system) to ensure that free moisture is not entrained in the air entering the filter units.

Proposed Control System

The suggested design specification for the bag filter units are based upon an assumed inlet loading of 0.4 grams/1,000m^3/second (13 grams per acfm). An efficiency of 99.9 percent is the recommended performance requirement. Presented in Table 3.7-5 is the estimated emissions from the coal and ash handling discharge points.

Sulfur Dioxide

As indicated earlier, low-sulfur coal will be utilized to meet sulfur dioxide emission limitations. Sufficient space will be provided in the design for flue gas desulfurization (FGD) systems. The use of FGD will require as a minimum 800 additional acres for sludge disposal. In the event FGD is necessary, alternate sludge disposal sites will be provided.

Table 3.7-5 Particulate Emissions from Coal and Ash Handling

Source	Number of Discharges	Flow Rate Per Discharge		Emissions Per Discharge	
		m^3/sec	(cfm)	grams/sec	(lbs/hr)
Transfer Points	4	1.9	(4,100)	0.13	(0.5)
Crusher House	1	7.1	(15,000)	0.2	(1.7)
Coal Storage Silo	4	2.8	(5,900)	0.1	(0.7)
Fly Ash Silo	2	9.0	(19,000)	0.28	(2.2)
Fly Ash Vacuum Pump Discharge	2	1.4	(3,000)	0.04	(0.3)
Emergency Reclaim Hopper	1	3.3	(7,000)	0.1	(0.8)

Source: Black and Veatch, 1978.

3.8 DIRECTLY ASSOCIATED TRANSMISSION LINES

No additional transmission lines are required. Crystal River Units 4 and 5 will be served by the existing transmission line systems.

3.9 DIRECTLY ASSOCIATED FACILITIES

3.9.1 ARRANGEMENT

RAILROAD

Rail access into the Units 4 and 5 complex will be provided from a switch at the existing plant railroad. This railroad will provide for delivery of construction materials and equipment. The location and arrangement of the railroad is shown on Figure 3.9-1.

ACCESS ROADS

Vehicular access into the Units 4 and 5 complex will be provided from an intersection at Highway 19-98. The road will continue into the complex north of the existing transmission lines as shown in Figure 3.9-1.

PARKING LOTS

Parking space for vehicles will be provided south of Units 4 and 5 complex in the vicinity of the transmission lines. Approximately 6 hectares (14 acres) of parking space will be required during construction of the plants. Additional permanent parking of about 0.5 hectare (1 acre) will be provided adjacent to the Administration Building.

ADMINISTRATION BUILDING

Space for administrative personnel will be provided in an Administration Building located as shown on Figure 3.9-2. This building will be adjacent to the north end of the Turbine Building.

MAINTENANCE BUILDING

Space for maintenance of plant equipment will be provided in a Maintenance Building. This building will be located east of the

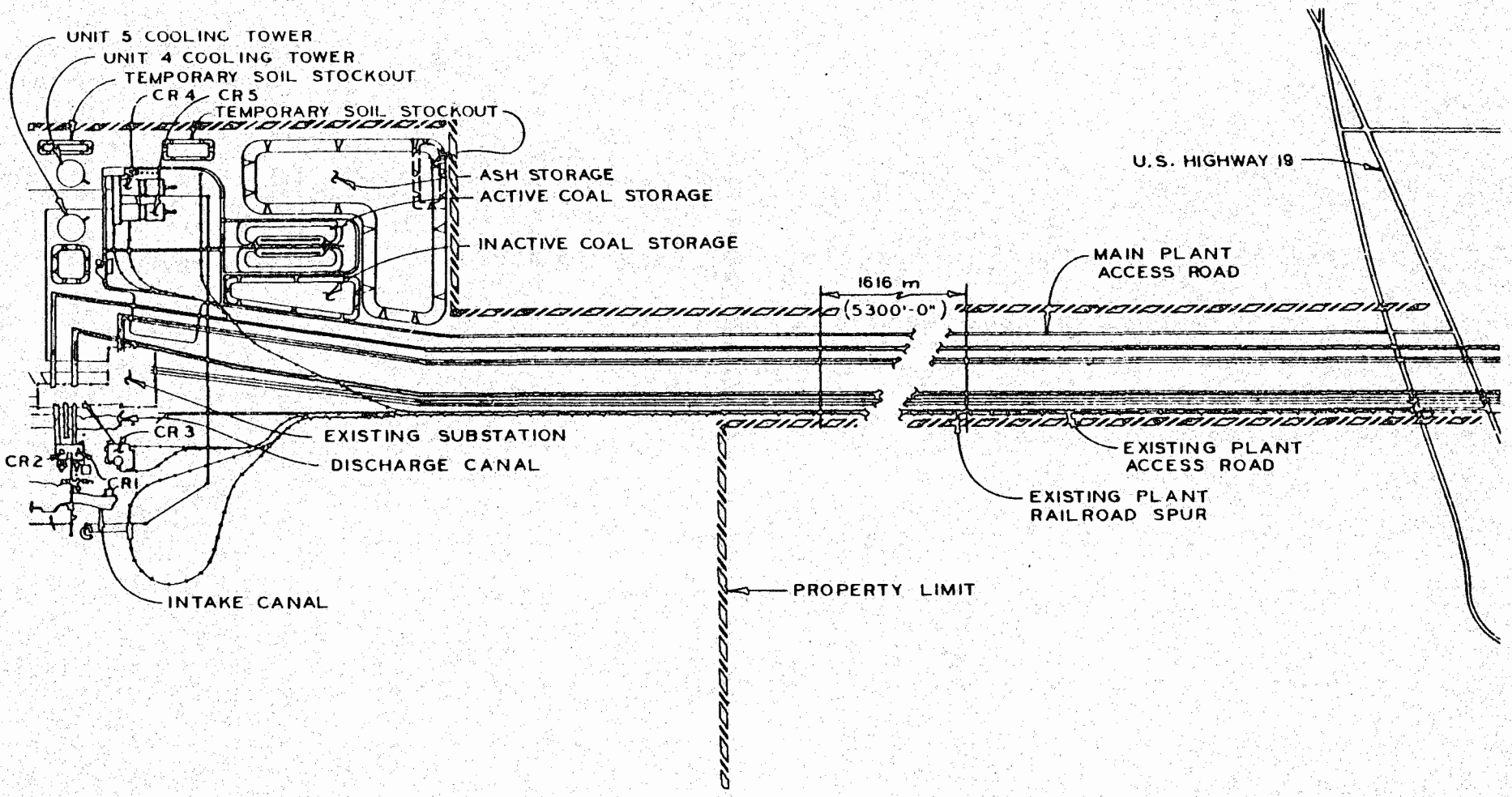

Figure 3.9-1
ROADS AND RAILROADS

0 2000 4000
SCALE IN FEET

SOURCE: BLACK AND VEATCH, 1978

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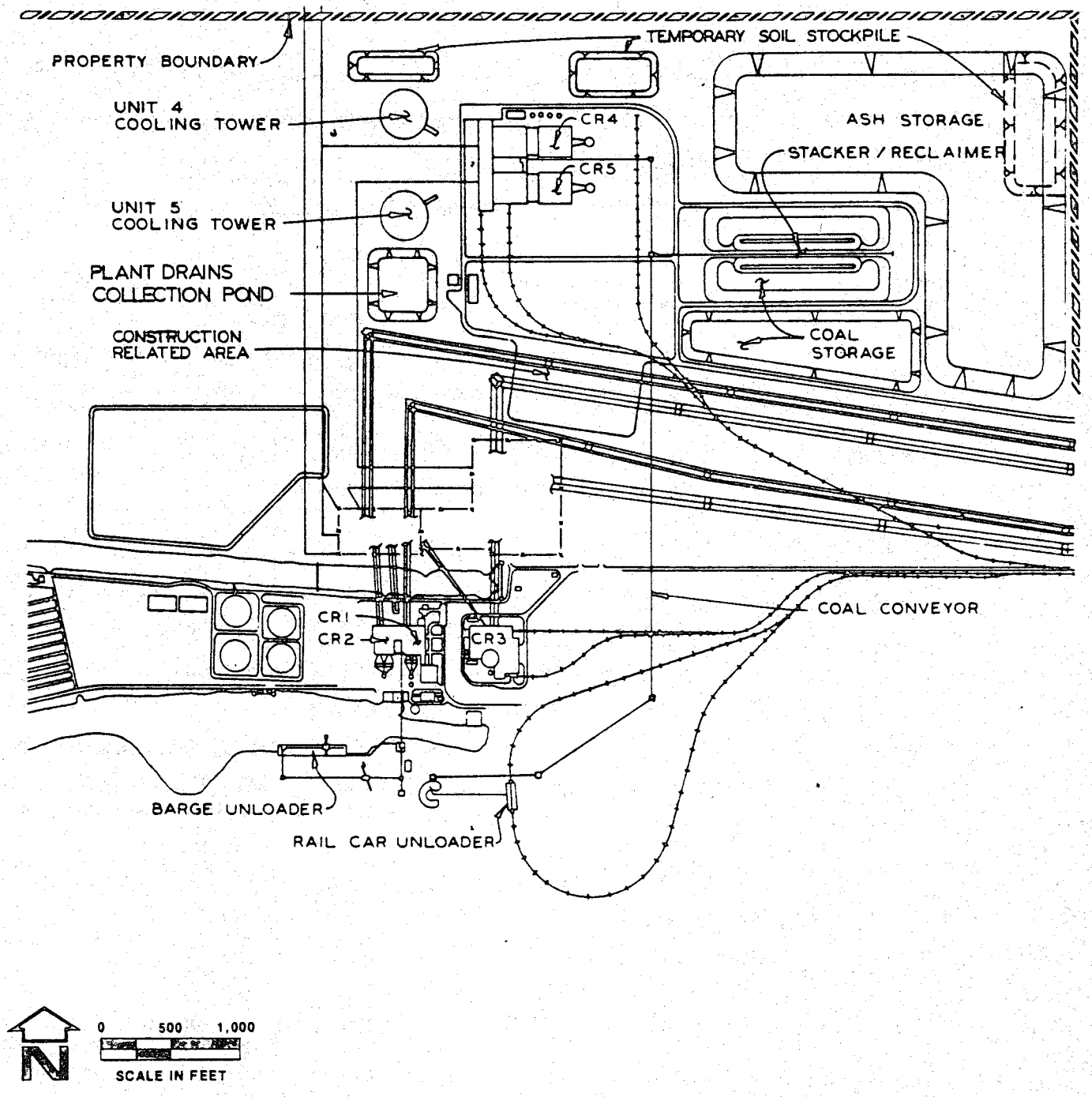


Figure 3.9-2
ASSOCIATED FACILITIES

SOURCE: BLACK AND VEATCH, 1976 (7/78)

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

Administration Building and north of the Turbine Building as shown in Figure 3.9-2.

3.9.2 ADJACENT LAND USE

The land adjacent to the north and east property boundaries is currently undeveloped pasture land. The land to the west of the Units 4 and 5 plant complex is Florida Power Corporation property and will remain undeveloped.

South of the Units 4 and 5 plant complexes are the Units 1, 2, and 3 sites. The property adjacent to the south property is currently undeveloped.

3.9.3 VISIBILITY

The relatively flat topography in the area surrounding the plant site and the wooded areas adjacent to Highway 19-98 shield the plant from public view from the east. From the Gulf of Mexico to the west, the tops of the Generation Building, cooling towers, and stacks will be visible.

3.10 ONSITE DRAINAGE AND EROSION CONTROL

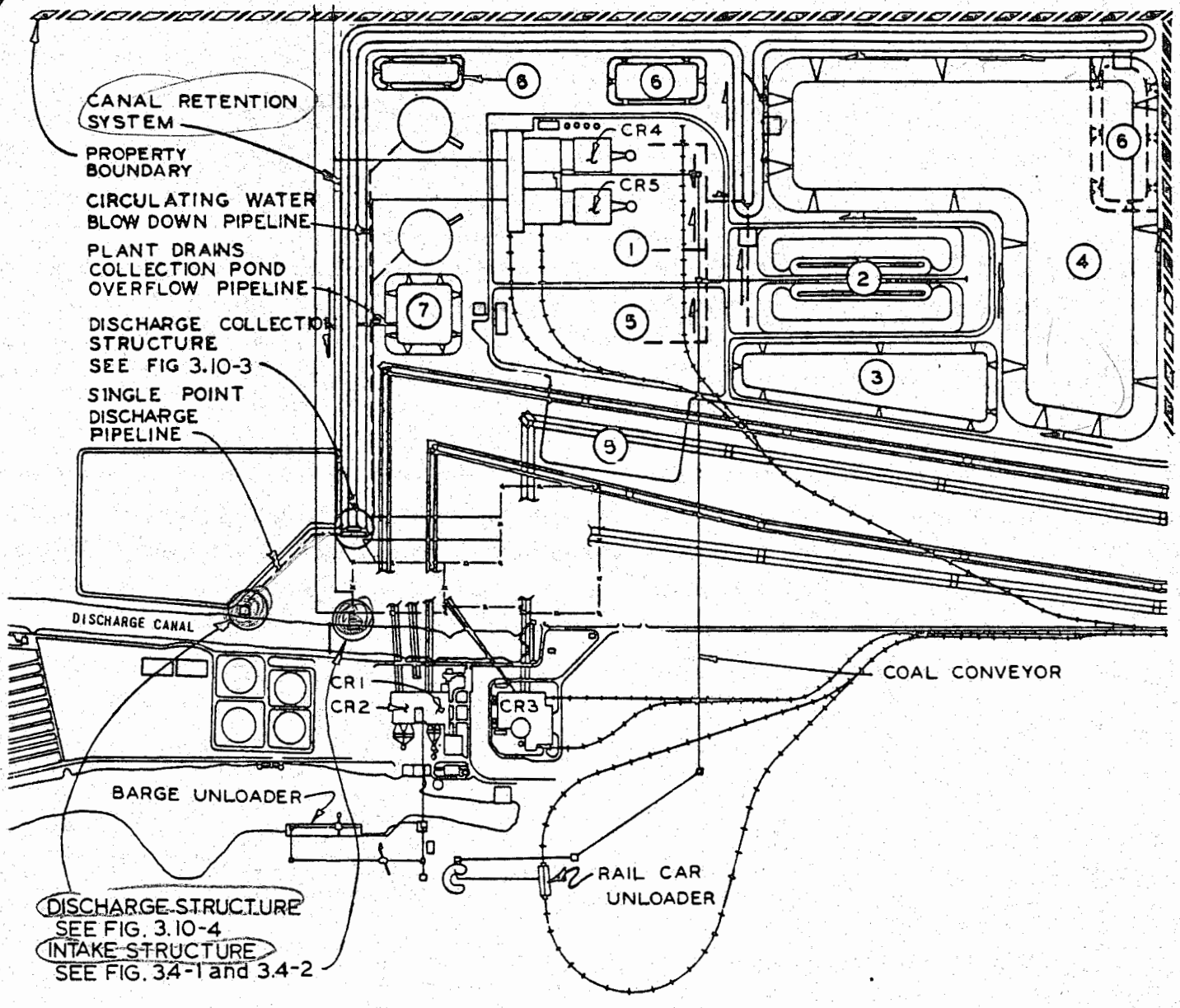
3.10.1 RUNOFF COLLECTION DITCH SYSTEM

The runoff collection ditch system is designed to provide drainage for the rainfall runoff from the general developed areas of the site and overflow runoff in excess of the 10-year, 24-hour storm from the active and inactive coal storage area and the active ash disposal area. The ditch system will be installed as soon as construction activities begin on the site. Initially, the system will serve as the final erosion control and sedimentation basin for construction runoff. After construction is completed, the ditch will serve as a retention/exfiltration basin for runoff from impervious services in the general plant area.

The runoff collection ditch system collection canal layout is shown in Figure 3.10-1. A typical cross-section of the canal is shown in Figure 3.10-2. The canal bottom will be located at or near estimated high groundwater levels. Side slopes will be built up above existing grade. Channel side slopes will be approximately 1:10. Side slopes will be seeded or sodded to control erosion.

The canal will discharge into the existing cooling water discharge canal for Crystal River Units 1, 2, and 3. A flow control structure with an overflow spillway as shown in Figures 3.10-3 and 3.10-4 will be provided so that control of drainage will be possible in the event that high turbidity, oil spills, or other type of water quality degradation occurs. The runoff ditch collection system will consequently function primarily as a holding and exfiltration pond. The system will be designed to retain the volume of runoff for the 10-year, 24-hour rainfall event under high water table conditions.

The runoff collection ditch system will receive rainfall runoff from the material storage piles only for rainfall runoff in excess of the



MAJOR PLANT RELATED DRAINAGE AREAS

1. GENERAL COMPLEX FILL AREA
2. ADJACENT ACTIVE COAL HANDLING AREA
3. ADJACENT INACTIVE COAL STORAGE AREA
4. ASH DISPOSAL AREA
5. CONSTRUCTION RELATED AREA
6. TEMPORARY SOIL STOCKPILE
7. PLANT DRAINS COLLECTION POND

LEGEND

- - - DRAINAGE PIPING
PRIMARY DISCHARGE
RUNOFF CONTROL STRUCTURE

LOCATIONS

FLOW DIRECTION

Figure 3.10-1
ON-SITE DRAINAGE SYSTEM

N

SOURCE: BLACK AND VEATCH, 1976 (7/78)

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PROPOSED
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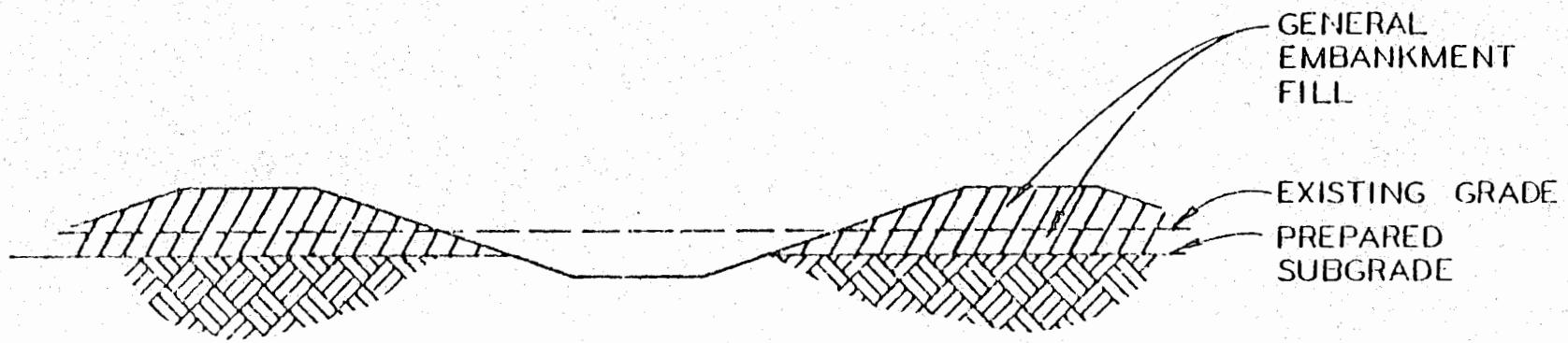

TYPICAL SECTION
COLLECTION CANAL

Figure 3.10-2
GRADING AND DRAINAGE

SOURCE: BLACK AND VEATCH, 1976

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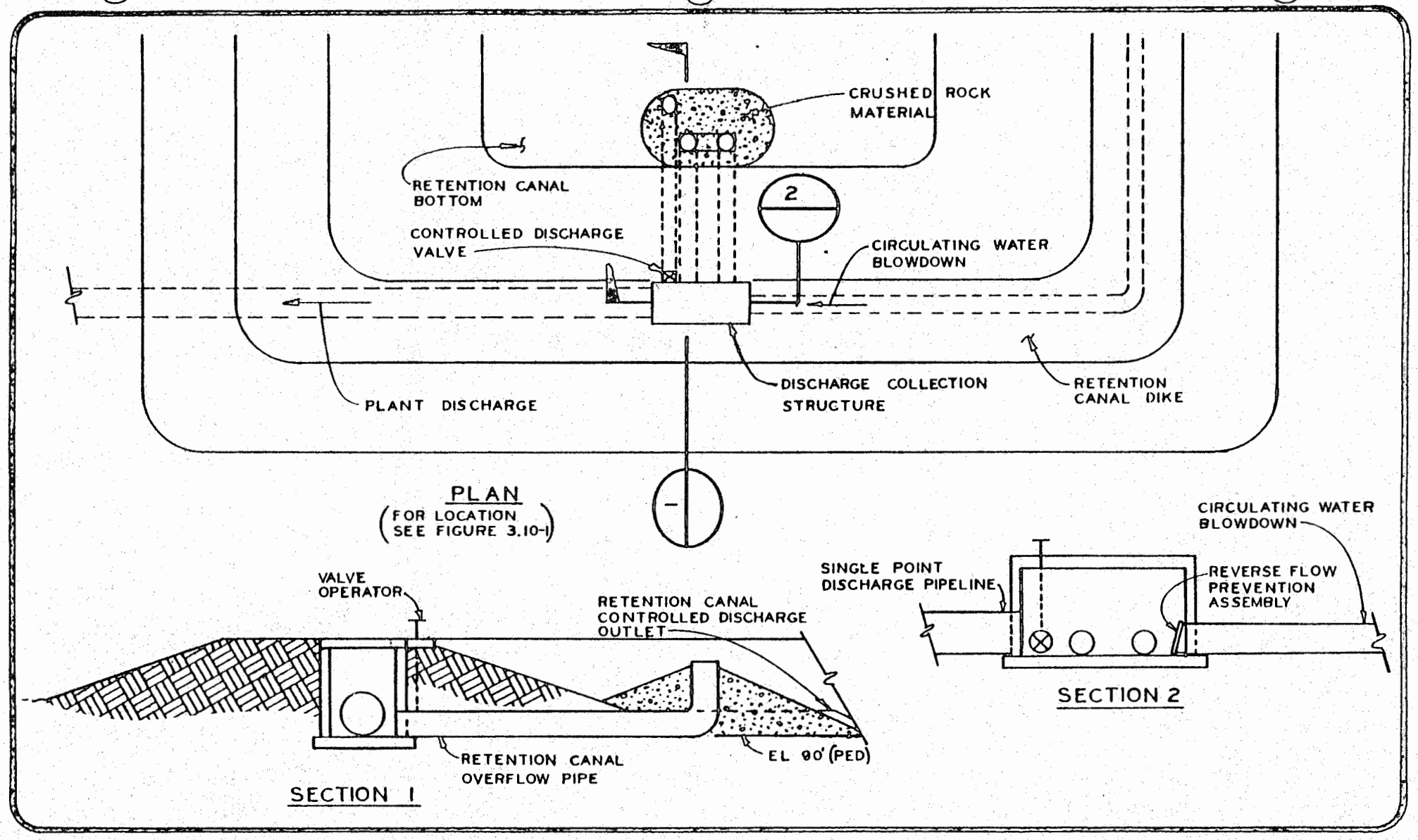

Figure 3.10-3
DISCHARGE COLLECTION STRUCTURE

SOURCE: BLACK AND VEATCH, 1976

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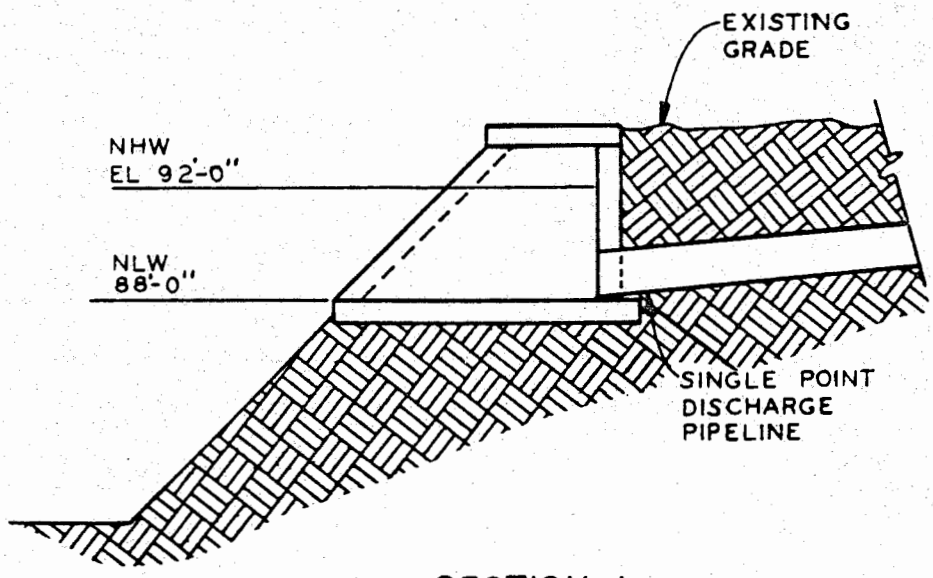
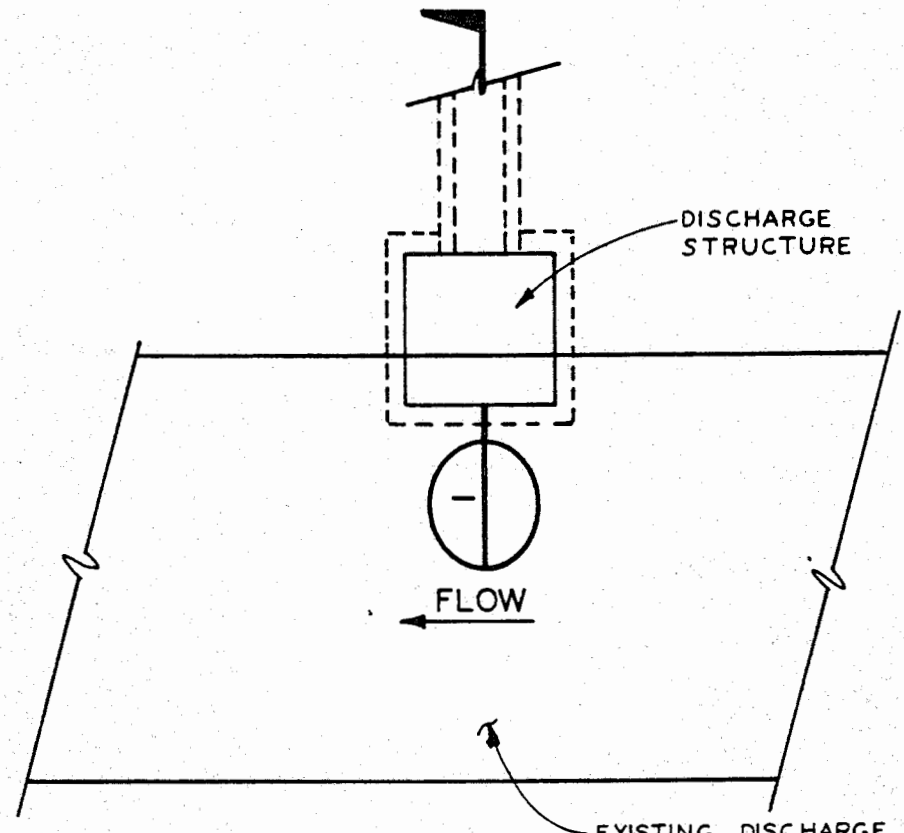


SECTION I



PLAN
(FOR LOCATION SEE FIGURE 3.10-1)

Figure 3.10-4
DISCHARGE CANAL
DISCHARGE STRUCTURE

SOURCE: BLACK AND VEATCH, 1976

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PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

10-year, 24-hour storm. All discharges from these areas will pass through a flow control structure with an oil skimmer. Yard drainage from generation and related facility areas is conveyed to the collection canal by subgrade catch basins, piping, and ditch, dike, and culvert systems. Manholes will be provided in areas with long piping runs.

Road and railroad embankments will be sloped to drain into the ditches which will collect and transport the drainage to the collection canal. Intermediate culverts will convey drainage flow through embankment fills.

Rainfall stored within the diked oil storage tank area will be discharged to the perimeter collection canal after it has flowed through an oil-water separator.

3.10.2 CONSTRUCTION RUNOFF AND EROSION CONTROL

Control of construction runoff and erosion has been addressed in Site Preparation Specification 7645.71.0500. The construction contractor will be responsible for conforming to all federal and state regulations concerning stormwater discharge and wastewater discharge during construction.

The perimeter runoff collection ditch system will be constructed as soon as site work is initiated. A temporary drainage system will be provided and maintained in the vicinity of the generating complex and laydown areas. This system will be designed to minimize effects of construction runoff and siltation by controlled collection, retention, and overflow until permanent drainage facilities are completed and functional.

Seeding of cleared lands will be required once excavation, trenching, bank fill, embankments, rough grading, surfacing, and paving are completed in the vicinity of the seeding. Final acceptance of the project by the company shall include a good stand of healthy grass on all areas seeded. Specifications for types of fertilizer, seed, mulch, seed bed preparation, and topsoil are provided. Mulch will be applied at a rate of 2 tons per acre. A minimum of 6 inches of topsoil will be provided on seeded areas. Approximately 1,000 pounds per acre of fertilizer and 60 pounds per acre of seed will be applied. Planted seed will be compacted, watered, and otherwise maintained to obtain a satisfactory growth. Eroded areas will be refilled prior to final acceptance of work. Treated sewage effluent will be used when possible to water seeded areas. The contractor will guarantee all seeding work for one year after completion and will replace, at the contractor's expense, all turf that dies.

4.0 SITE PREPARATION AND PLANT AND ASSOCIATED FACILITIES CONSTRUCTION/RESULTING ENVIRONMENTAL EFFECTS

4.1 SITE PREPARATION AND PLANT CONSTRUCTION

4.1.1 CONSTRUCTION AREAS AND ACTIVITIES

4.0 SITE PREPARATION AND PLANT AND ASSOCIATED FACILITIES CONSTRUCTION/RESULTING ENVIRONMENTAL EFFECTS

4.1 SITE PREPARATION AND PLANT CONSTRUCTION

4.1.1 CONSTRUCTION AREAS AND ACTIVITIES

Construction of the proposed units will begin by clearing 26 hectares (65 acres) within the proposed plant area. A minimum of approximately 5.54 hectares (13.7 acres) of this area will be required to prepare foundations for the facility and cooling towers. The remaining land area will include construction parking, field offices, and laydown areas. A total of 135 hectares (333 acres) will be cleared for construction of Units 4 and 5, including the permanent ash storage area which will be used for laydown area during construction.

An access road 6.7 kilometers (4.1 miles) long will be constructed from U.S. Highway 19 to the plant construction area. The road will be located on the north side of the transmission corridor and will occupy about 12 hectares (30 acres). Construction traffic for the new facilities will travel along this road. Florida Power Corporation proposes an additional access road because security must be maintained for the nuclear Unit 3, and heavy construction traffic on the existing road should be limited.

Grading and filling will elevate the plant area from approximately 28 meters (94 feet--plant datum) to approximately 30 meters (99 feet) which is approximately 3.4 meters (11 feet) above mean low water. Cooling towers, the turbine generator building, the air pre-heater building, electrostatic precipitators, stacks and coal crusher building will be the primary structures requiring subsurface grouting and surface fill. Approximately 0.6 meters (2.0 feet) of overburden (organic, muck

or silt material only) will be removed in the vicinity of these structures to expose load-bearing formations.

The fill for supporting plant structures will necessitate approximately 140,000 cubic meters (180,000 cubic yards) of material. The fill, which will be either coarse and/or Brookville limestone, will be obtained primarily from local sources. For general fill, overburden from the site and nearby limestone and dolomite mines will be used.

Support of plant foundation will be accomplished with drilled piers. Drilled piers, constructed of reinforced concrete and approximately 48 inches in diameter, are placed to bedrock depth. Approximately 200 drilled piers will be placed through the Inglis formation to a depth of approximately 15 meters (50 feet).

Heavy equipment such as the turbine generator, steam generator, and materials such as structural steel will be transported to the construction area by rail. Trucks will deliver the remaining equipment and supplies. During construction activities, approximately 45 to 50 trucks will arrive daily. These trucks will haul concrete, lumber, fuel, and other supplies.

Water will be needed for hydrostatic testing of tanks, cleaning, drinking, sanitary facilities, soil compaction, and fugitive emissions control. The water supply for these purposes will be obtained from the existing freshwater wells for Crystal River Units 1, 2, and 3 and/or a new well field. It is estimated that less than 150,000 liters per day (40,000 gallons per day) will be required for these purposes. Electrical power needed for construction activities will be obtained from the existing distribution lines in the area.

A small amount of dredging will be necessary for the construction of a saltwater makeup intake structure, a cooling tower blowdown structure, and a canal retention system. The amount of material dredged from the discharge canal will be less than 160 cubic yards. All dredging will take place during a period of one month.

4.2.2 WATER QUALITY

4.2.2 WATER QUALITY

During construction, turbidity and sediment loading to the nearby marsh areas will not occur from runoff. The use of state-of-the-art erosion techniques (berms, mulch, sodding, and detention/infiltration ponds) during construction will mitigate adverse effects on the adjacent surface waters. Construction of the stormwater retention areas at the plant site will abate the runoff sediment load impact on the marsh. A small amount of dredging activity in the discharge canal will increase the turbidity in the canal and adjacent areas. This impact will be extremely short-term, i.e., no longer than one month in duration.

The changes in surface water chemistry or quality due to construction activities will be minor. There probably will be less organic material in the waters because of the removal of the vegetation and the filtration effects of the surface fill mat. The pH of the water to the south and west of the site may be increased slightly (i.e., become more basic) because of the presence of the limestone fill material which has a much smaller pebble size relative to the underlying limestone rockbed. Also, the mineralization of the water may increase slightly because the organic overburden has been removed, and the small, pebble-sized fill material allows the water to be in more direct contact with minerals (i.e., calcium and magnesium ions). These possible water quality changes should not cause a violation of any promulgated water quality standards.

Major hydraulic or dragline dredging operations and the use of explosives are not expected during the construction period.

4.3.3 OTHER IMPACTS ON BIOTA

4.3.3 OTHER IMPACTS ON BIOTA

It is felt that the transmissivity of the aquifer is sufficiently high to preclude significant restriction of subsurface flow at the site. While there remains a low probability that grouting could alter groundwater flow sufficiently to reduce the freshwater subsidy of a small portion of the coastal hydric hammock nearest to the construction site, the use of drilled piers will significantly reduce the probability of any adverse impact to the groundwater flow. The use of drilled pier construction makes the probability of impacts to groundwater flow negligible.

Construction of the rail spur and access road may also affect nearby plant communities through alteration of surface drainage. The magnitude of this effect will depend upon construction design, such as the number and placement of culverts, which has not been developed at this time. The magnitude and significance are low.

Because of the large area of pine plantations adjoining the proposed plant site, the overall effect of clearing operations on site may have an impact on wildlife from surrounding areas. The major impact on off-site wildlife will be to reduce food supplies and denning sites for some of the more wide-ranging species. Habitat alterations near areas of large tracts of monocultured, even-aged (pine plantation) forest that include the destruction of upland oaks may eliminate or reduce the home range of various species. Oaks adjoining upland pine sites are essential in providing food for wildlife and offer diversity in habitat in homogeneous pine plantation (Goodrum et al., 1971). It can be anticipated that predatory and foraging animals which utilize these areas will have to adjust to the diminished food supplies. This will cause either a decreased carrying capacity for ranging species (i.e., deer, bobcat, and raccoon) or a shift in feeding areas to surrounding habitats. This impact on the terrestrial ecology of the area, although difficult to estimate, is considered minimal because of the relatively small acreage to be cleared.

IMPACTS DUE TO CONSTRUCTION OF ACCESS ROAD

The construction of the access road will result in the destruction of 2.4 hectares (6.0 acres) of forested lands, 0.8 hectare (2.0 acres) of fresh marsh, and 8.5 hectares (21.0 acres) of ruderal areas. Modification to existing faunal communities will be determined primarily by the type and extent of permanent changes in habitat along the proposed corridor. It can be anticipated that the major impact will occur where existing forested lands will be cleared to facilitate construction of the access road. Such clearing can affect faunal communities; however, because of the relatively narrow strip required for the corridor, most effects should be minimal. Fencing the road would decrease wildlife mobility.

The loss of some mast-producing species may adversely affect squirrels and other species that depend on acorns, nuts, and other hardwood mast. Clearing operations in the forested areas of the access road will stimulate more growth of browse species such as herbaceous plants, trees, and shrubs; however, the overall effect may be negative because of the loss of mast production and denning sites.

IMPACTS DUE TO TRANSPORTATION

The increased traffic along the access road because of the plant operation will increase "road kills" of wildlife. The net result of the construction of this second access road with its subsequent vehicular traffic will be to create an artificial barrier, thus forming an insular wildlife habitat. Because of traffic and other human activity along these roads, species such as deer are less likely to cross into the median area. In addition, some wildlife will not cross this barrier because of insufficient cover.

The initial disturbance of existing vegetation during construction is the most immediate impact to wildlife. The road construction will not

significantly alter the present ecological functions and attributes of the edge community. Those forested areas which are cleared will have functional characteristics of an early successional state (Odum, 1971). The creation of a barrier and the resulting insular habitat is the most significant impact; however, the magnitude of this impact is considered moderate for the route and low for the surrounding area. The impact of forest clearing is low for the site and surrounding area. These impacts will be long-term and reversible.

5.1.1 PHYSICAL EFFECTS OF GROUNDWATER WITHDRAWAL

5.1.1 PHYSICAL EFFECTS OF GROUNDWATER WITHDRAWAL

Florida Power Corporation proposes to obtain fresh water for Crystal River Units 4 and 5 from a well field about 8.2 kilometers (5 miles) east of the plant site (see Figure 5.1-1). The tentative design of the well field is in the form of an east/west line along the northern boundary of section 32, township 17S, range 17E. The west well will be located on the Florida Power transmission line right-of-way about 300 meters (1,000 feet) east of the northwest corner of section 32. The 21 wells will be spaced approximately 150 meters (500 feet) apart.

The wells will be drawing water from the Floridan Aquifer. Maximum pumpage from the well field will be about 7,950 liters per minute (2,100 gallons per minute, or 3 million gallons per day). Average pumpage will be approximately 1,518 liters per minute (401 gallons per minute or 0.58 million gallons per day).

Hydrologic coefficients were determined by a pump test in order to assess the impacts of the proposed well field on the aquifer system. The average transmissivity was determined to be about 563,700 liters per day per meter (45,390 gallons per day per foot). The coefficient of storage was determined to be approximately 0.0003 and the leakance about 3.74 liters per day per cubic meter (0.028 gallons per day per cubic foot) (Geraghty and Miller, 1978).

A flow net analysis performed prior to the pump test determined that the transmissivity of the aquifer system is in the range of 1.86×10^8 liters per day per meter (1.5×10^7 gallons per day per foot) (Geraghty and Miller, 1977). The discrepancy between the two transmissivity values is believed to be due to local variations in the hydrogeologic system. The flow net analysis gives an average transmissivity value which is based on the total groundwater flow to the Crystal River. Much of the groundwater flow may take place through open solution channels or other zones of very high permeability which are adjacent to low permeability zones. The hydrogeologic system for the proposed well

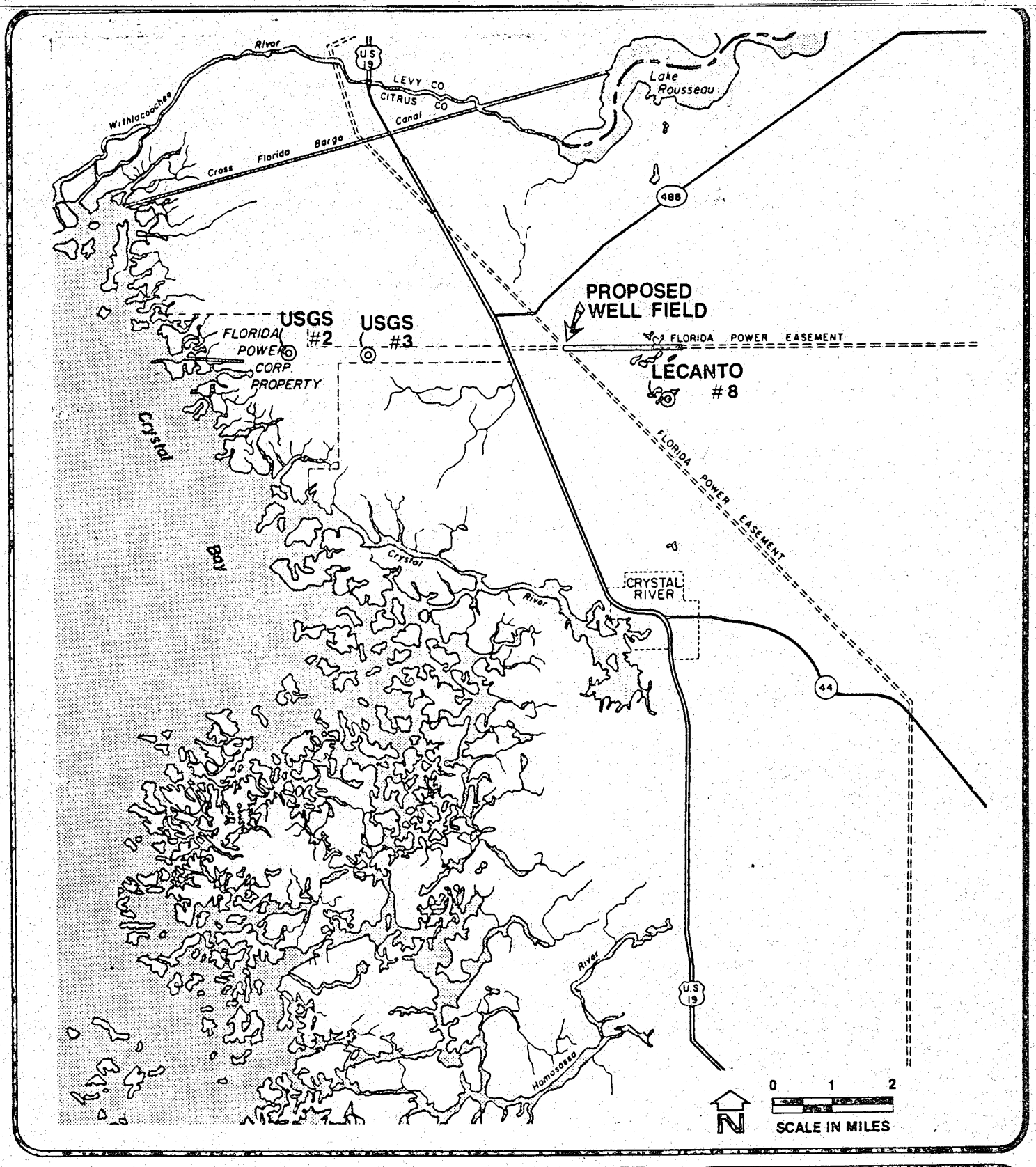

Figure 5.1-1
LOCATION OF PROPOSED WELL FIELD AND USGS OBSERVATION WELLS

SOURCE: GERAGHTY AND MILLER, INC., 1977
ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1978 (7/78)

FLORIDA POWER CORPORATION

PROPOSED
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field site can only be defined by an extensive test drilling program; the variation in transmissivity is not apparent from analysis of the regional flow characteristics. If solution channels are encountered in the well field, then the transmissivity will be much higher locally. However, without this additional data on the variation in transmissivity, the aquifer test values are used to estimate the impacts of water withdrawal from the well field.

Based on the aquifer test data, the well field will require 21 wells, each yielding 380 liters per minute (100 gallons per minute) to provide the required 11 million liters per day (3 million gallons per day) maximum for plant use without exceeding the SWFWMD (Chapter 16J F.A.C.) rules and regulations.

The cone of depression from pumping at the well field has been computed in order to estimate the effect of groundwater withdrawal on the potentiometric surface of the upper Floridan Aquifer. The potentiometric map utilized to describe baseline conditions is the map prepared by the U.S. Geological Survey for May, 1975.

The potentiometric surface map is illustrated in Figure 5.1-2. The 0.3-meter (1-foot) contours have been estimated from the 5- and 10-foot contours shown on the USGS potentiometric map for May, 1975, and from water levels in USGS observation wells in the area.

The water surface elevation in the upper part of the Floridan Aquifer in the vicinity of the proposed well field fluctuates between 1.2 and 2.7 meters (4 and 9 feet) above mean sea level.

It should be emphasized that in the following discussion of groundwater withdrawal impacts, the computed drawdowns are theoretical. Assumptions and estimates based on the best available information have been required. These assumptions are clearly identified in the text. Drawdowns have been calculated by using the Hantush and Jacob equation (Walton, 1970).

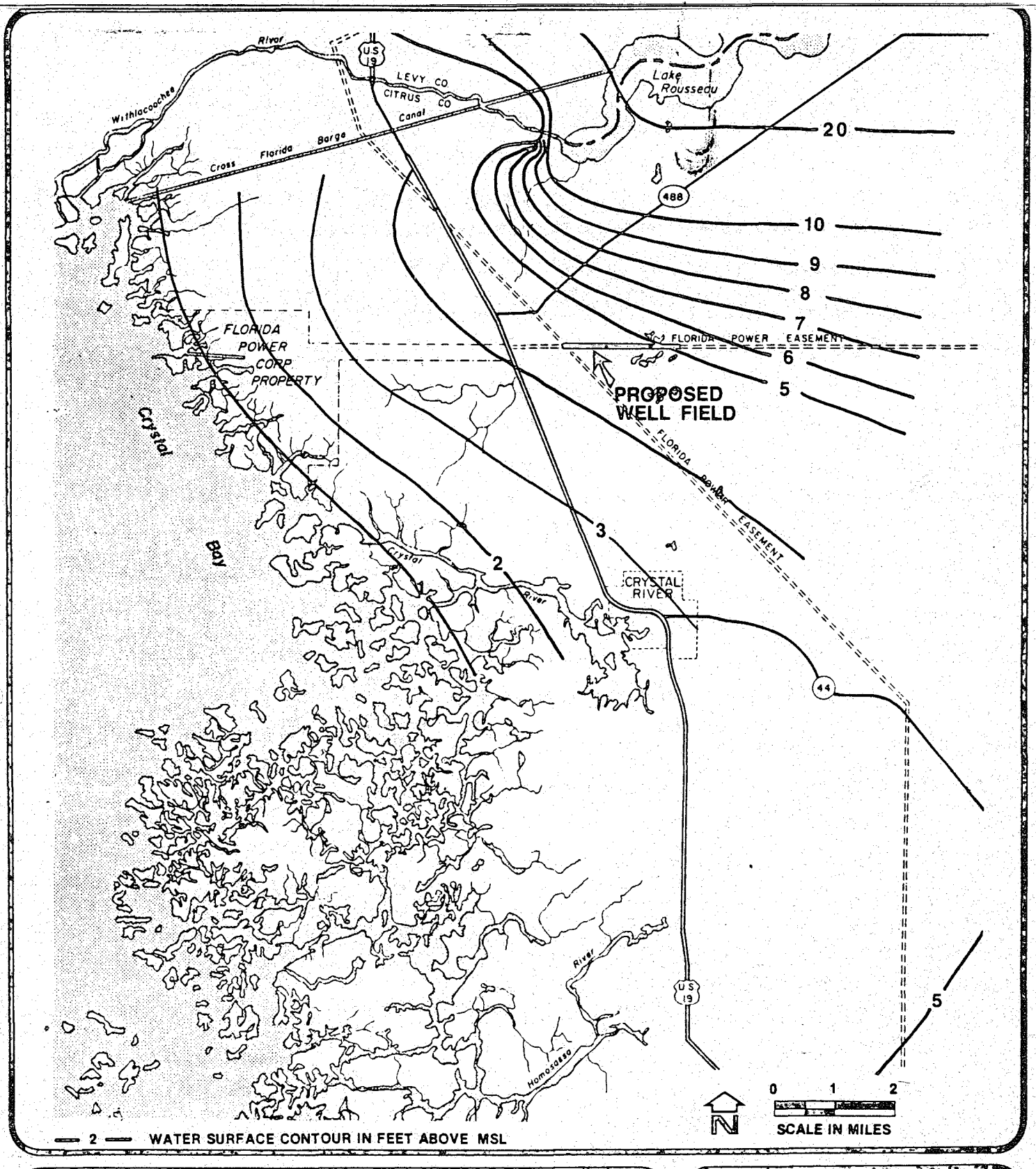

Figure 5.1-2
POTENTIOMETRIC SURFACE OF UPPER FLORIDAN AQUIFER, MAY 1975

SOURCE: GERAGHTY AND MILLER, INC., 1977
ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1978 (7/78)

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The following assumptions were made in the calculations:

1. The water-bearing formation is isotropic (homogeneous);
2. The water-bearing formation has a uniform thickness;
3. The water-bearing formation has an infinite areal extent;
4. The system consists of a leaky artesian aquifer without water released from storage in the aquitard;
5. No recharge occurs during pumping;
6. The wells penetrate and receive water from the full thickness of the aquifer; and
7. Water is removed from storage instantaneously.

Values used in the computations are:

1. Transmissivity (T) = 52,000 liters per day per meter (45,000 gallons per day per foot;
2. Storage coefficient (s) = 0.0003;
3. Leakance P'/M' = 0.003 liters per day per cubic meter (0.028 gallons per day per cubic foot);
4. Discharge rate (Q) = 30 liters per minute (100 gallons per minute); and
5. Drawdowns in the well field are calculated at steady state conditions.

The calculated cone of depression for a maximum pumpage of 3 mgd is shown in Figure 5-1.3. Expected water level drawdowns are as follows:

Location	Drawdown
Well field (maximum drawdown)	1.8 meters (6 feet)
100 meters (330 feet) north of production wells (FPC property line)	0.8 meters (2.6 feet)

The configuration of the May 1975 potentiometric water surface with the effects of pumpage from the proposed well field is shown in Figure 5-1.4.

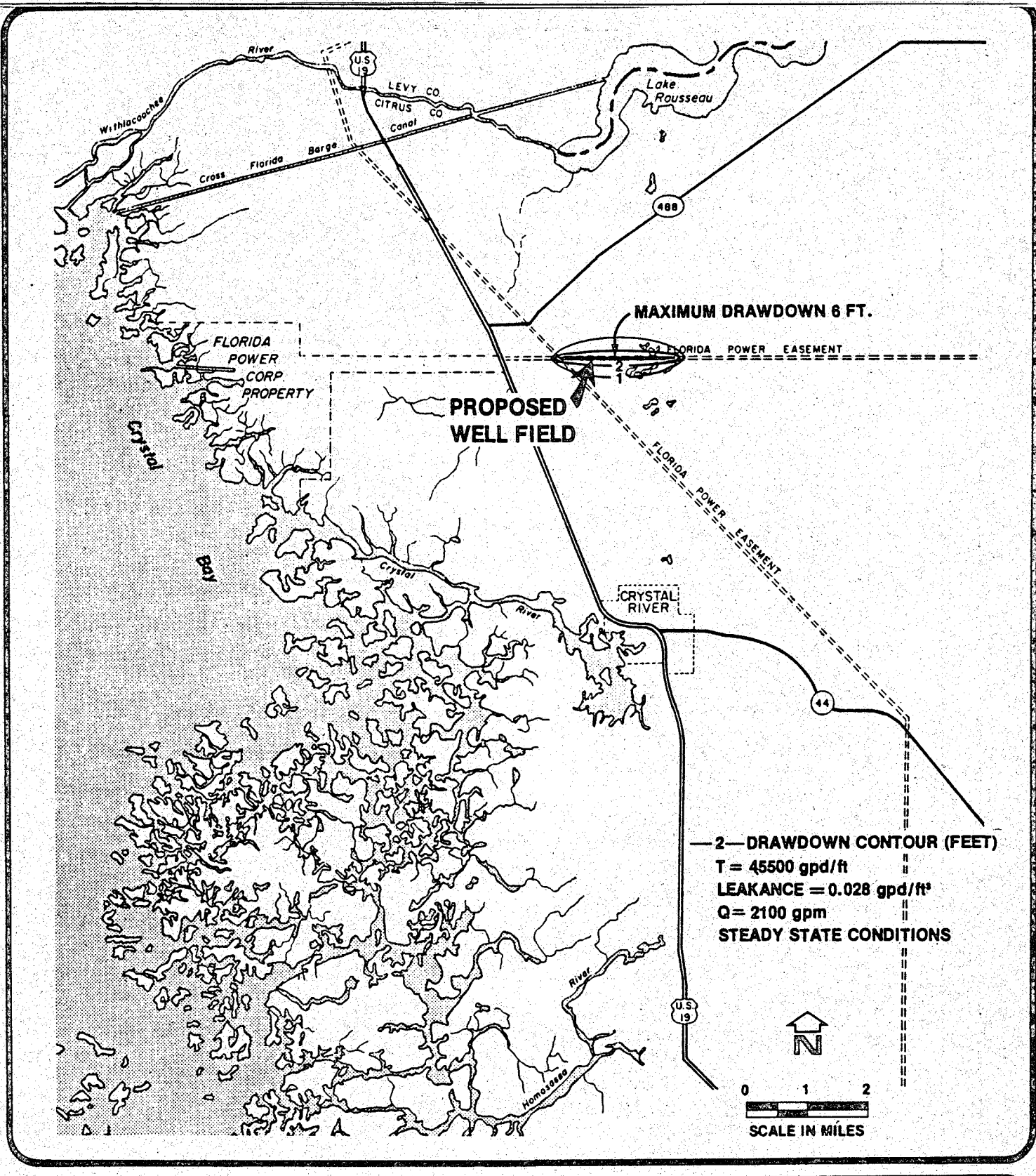

Figure 5.1-3
CONE OF DEPRESSION FOR CONCEPTUAL WELLFIELD

SOURCE: GERAGHTY AND MILLER, INC., 1977;
ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1978 (7/78)

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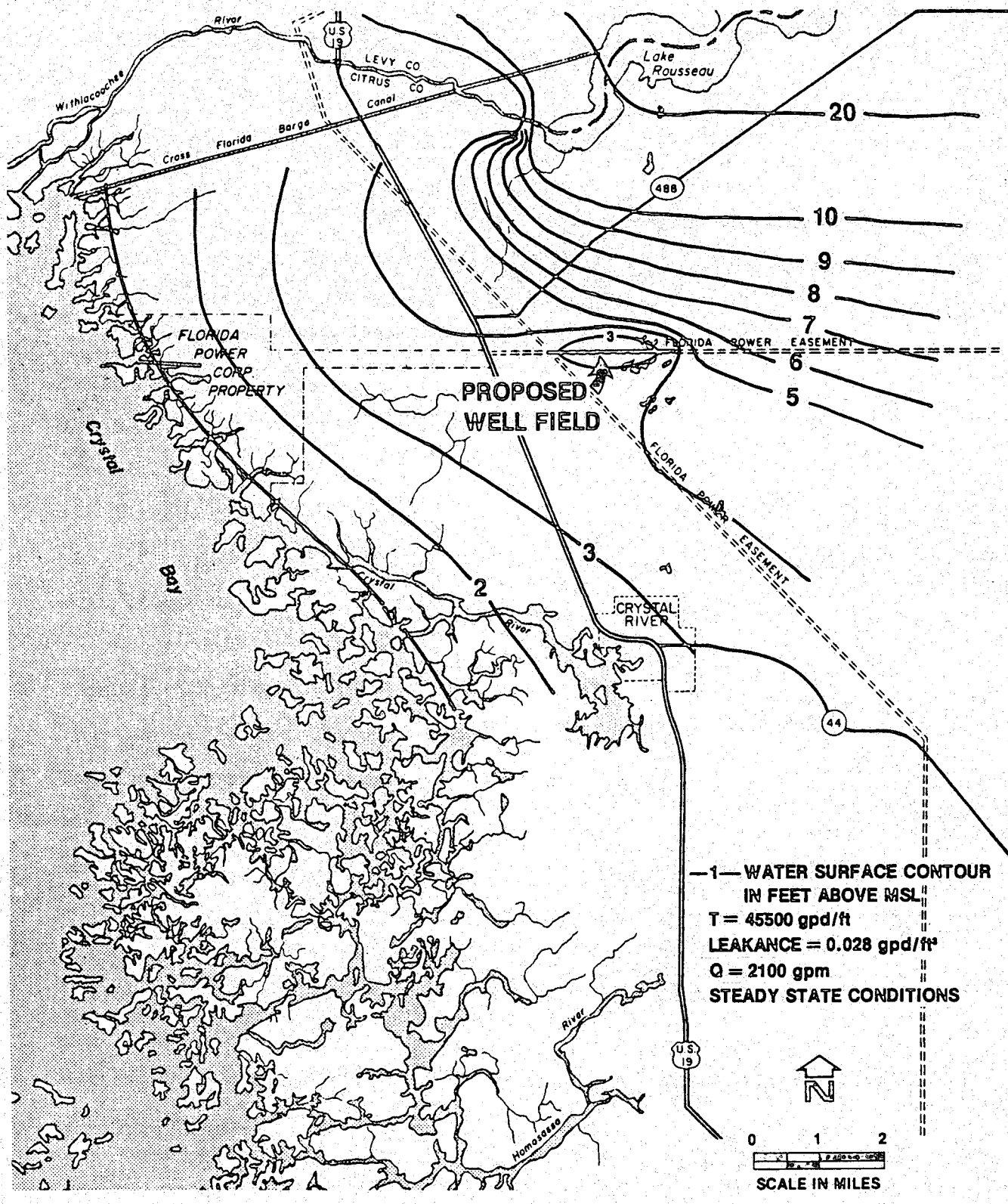

Figure 5.1-4
ELEVATION OF THE POTENTIOMETRIC WATER SURFACE OF THE UPPER FLORIDAN AQUIFER, MAY 1975, SHOWING THE EFFECTS OF PUMPING AT THE PROPOSED WELL FIELD
SOURCE: GERAGHTY AND MILLER, INC., 1977;
ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1978 (7/78)

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Water levels in the vicinity of the well field are drawn down approximately 0.6 meters (2 feet). Maximum drawdown occurs in the wells toward the center of the line. The minimum water level elevation at times of seasonal low water level conditions (May) will be at approximately mean sea level.

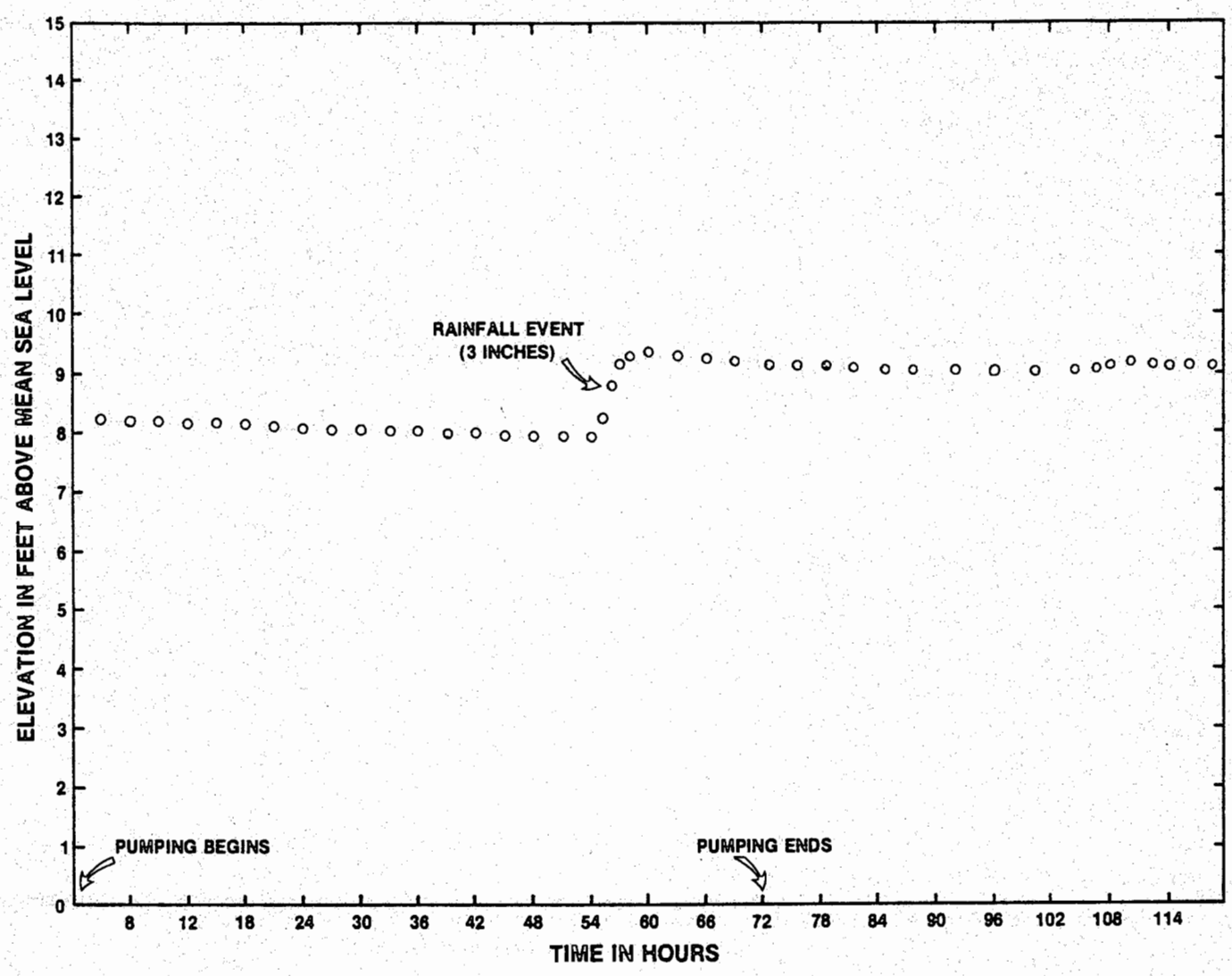
During periods of normal usage the groundwater yield from the well field will be reduced to about 1518 liters per minute (401 gallons per minute or 0.58 million gallons per day). The cone of depression will be reduced proportionately in areal extent.

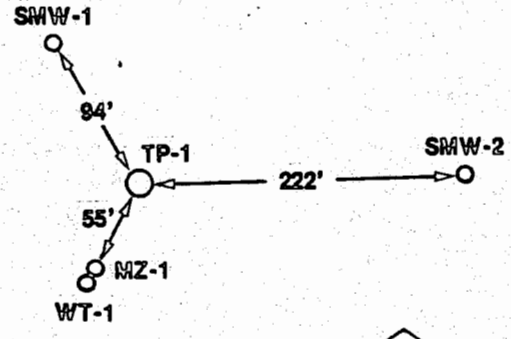
WATER QUALITY

Geologic, geophysical, and water quality data from the aquifer test at the well field site suggest that rock layers beneath the productive zone in the well field form a protective low permeability zone which will inhibit upconing of highly mineralized water (Geraghty and Miller, 1978). If fracture systems exist in the area and extend through this low permeability zone, then conditions of high vertical permeability, (which will allow upward movement of highly mineralized water) may occur locally. However, a situation where fracture systems extend through the low permeability zone would probably affect only individual wells rather than the entire well field. Good well field management can minimize any water quality deterioration from this source.

WATER TABLE

The static water level in the water table (unconfined aquifer) at the time of the aquifer test in June 1978 was 0.4 meter (1.3 feet) higher than the water level in the pumped zone (Geraghty and Miller, 1978). Water level information from the aquifer test indicates that the water table was not drawn down appreciably during the 72 hours of pumping (see Figure 5.1-5). As a long-term effect of pumpage, water levels in the water table aquifer may be drawn down slightly in the well field due to increased leakage into the confined aquifer. However, due to the small magnitude of the cone of depression and water level drawdowns, lowering





LOCATION MAP

Figure 5.1-5
WATER LEVELS IN WELL No. WT-1 (WATER TABLE WELL) DURING THE JUNE 1978 AQUIFER TEST

SOURCE: GERAGHTY AND MILLER, INC., 1978

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the water table will be minimized and will be confined to a small area. The area in which drawdowns are greater than 1 foot is approximately 2.6 square kilometers (1 square mile) (see Figure 5.1-3).

EFFECTS ON SURFACE WATER

Surface waters in the area consist of karst-type depressions and scattered small wet areas. As noted in Chapter 2, there is a conspicuous absence of defined stream channels in the area. Cherry (1970) reports that between 55 and 75 percent of the annual rainfall in the area is returned to the atmosphere via evaporation. The remainder percolates through the thin sands and recharges the Floridan Aquifer. Thus, there is virtually no surface runoff in the wellfield area. The water surface in the ponds and lakes in the area is probably at approximately the same level as the water table and is perched slightly above the potentiometric surface in the Floridan Aquifer.

Potential water level declines in surface water bodies will be confined to areas in and immediately adjacent to the Florida Power Corporation well field. The impacts are difficult to assess since nothing is known about the presence or absence of clays or other poor permeability zones directly beneath the surface water bodies in question. In the absence of clays or poor permeability materials, the surface water bodies will respond to well field pumpage in essentially the same manner as the water table aquifer.

EFFECT ON GROUNDWATER AVAILABILITY

The groundwater availability analysis compares the proposed withdrawals from the aquifer system with the estimated groundwater flow to the Gulf through Crystal River and the area containing the well field and plant site.

The U.S. Geologic Survey gaging station at Crystal River records an average of about 2,200 million liters per day (590 million gallons per

day) of water flowing to the Gulf of Mexico. Geraghty and Miller (1977) calculate that another 950 million liters per day (250 million gallons per day) of water flows to the Gulf in the area north of the gaging station at Crystal River (excluding the flow at the Crystal River gage) and south of the Withlacoochee River (excluding the flow to the Withlacoochee). The projected maximum well field demand is less than 1 percent of the flow at Crystal River and about 1 percent of the estimated flow between the Crystal and Withlacoochee Rivers. The annual average water usage is less than one-fifth of the design maximum flow of the well field.

5.1.2 BIOLOGICAL EFFECTS OF GROUNDWATER WITHDRAWAL

5.1.2 BIOLOGICAL EFFECTS OF GROUNDWATER WITHDRAWAL

The possible biological effects of groundwater withdrawal would primarily involve the biological communities associated with fresh water marshes. As previously discussed, these freshwater areas may be connected with ground water and may experience changes in water level due to withdrawals.

GENERAL DISCUSSION

Impacts of wellfield groundwater withdrawal on vegetation and wildlife should not be significant. Impacts could result from surface water table lowering and consequent drainage of temporary or permanent wetlands. Estimates of these water level changes are based on the calculations in Section 5.1.1. The seasonal fluctuations of three nearby wells (reported by Geraghty and Miller, 1977) and their relation to land surface elevation have also been considered. The analysis has indicated that wet season water tables may be altered only above the land surface in depressed wetland areas. This would most likely occur within one mile south and west of the well field site. Changes such as transitions from permanent marshes (pickerelweed, waterlily) to seasonally flooded marsh (smartweed, arrowhead, sawgrass) to wet prairies may occur when the water table drops below ground surface temporarily, then permanently. The consequent impacts would be changes in species composition, productivity, food web relations, wildlife habitat, and habitat for rare and endangered plants such as sundews. However, withdrawals from the aquifer should not lower the water table sufficiently to alter permanently the character of these marshes.

Minor effects on wildlife could result from reductions in seasonal wetland habitat in the surrounding area where there are presently several ponds, marshes, and prairies. Associated with these areas are many aquatic or semi-aquatic groups of birds, mammals, reptiles, and amphibians. If the character of the marshes and ponds is changed, a qualitative change may occur in the faunal communities.

Possible changes include an insignificant decrease in seasonal habitat for waterfowl, shore birds, and wading birds; a loss of breeding area for some amphibians (e.g., green tree frogs, newts); and an insignificant decrease in suitable habitat for certain aquatic reptiles (e.g., banded water snake, ribbon snake). Generally, the fauna could adapt to the characteristics of drier ecosystems.

ESTIMATED EFFECTS

The impacts due to drawdowns would be confined to areas in the vicinity of the well site. Drawdown rates elsewhere should cause only minor changes in marshes.

The cypress domes north of the well field should not be affected. Since the land-surface elevation is about 6 to 8 meters (20 to 25 feet) and the water table about 3 to 5 meters (10 to 15 feet), these are probably perched upon impervious confining layers and unaffected by changes in water table elevation.

Effects on wildlife would be proportional to effects on surface waters. With small amounts of surface drawdown, less wet habitat and fewer associated organisms would be affected.

5.1.4 COOLING TOWER DRIFT

5.1.4 COOLING TOWER DRIFT

A study (Black and Veatch, 1978) was made to determine the amount of deposition from salt drift in the vicinity of the two proposed natural drift cooling towers. The towers will be built adjacent to their respective power-generating units and will stand 140 meters (460 feet) above grade. Efficient drift eliminators on both towers will be used, and the mass fraction of circulating salt water which will be carried out from the tower as drift will not exceed 0.0005 percent.

The two towers are close together and will have some interaction of drift and fog. However, for the purposes of this analysis, the towers were assumed to be at the same location. The resulting estimates of maximum salt concentrations will be more conservative (tend to overestimate the actual concentrations) than considering slightly separated towers.

Salt deposition due to the operation of the proposed towers is determined by the Oak Ridge Fog and Drift Code, which is a dispersion model with moist plume rise calculations being performed for several different relative humidity conditions, Pasquill stability classes, and wind speeds. A variable number of years of meteorological surface observation data are read into the model to determine the deposition and drift in an "average year". One distinctive advantage of the model is the capability of obtaining contour maps of the amount of salt drift, fog, ice fog, and the amount of salt in the air.

Five selected drift particle sizes for use in the model were 31, 58, 110, 210, and 800 microns, with each size comprising one fifth of the drift particles. Meteorological data utilized in the model were a 10-year record from Tampa, Florida, the nearest and most representative weather office where all required surface observations are available.

The maximum salt deposition expected at the site is 12.8 grams/meters^2/year (114 pounds per acre per year) and will occur 0.3 kilometers

(0.2 miles west of the towers (see Figure 5.1-6). At distances beyond 1.3 kilometers (0.8 miles), only residual drift from the smallest particles will be observed. The maximum deposition rate beyond this point seldom will exceed 1.7 grams/meters^2/year (15 pounds per acre per year).

With a background level of salt deposition of 3.4 grams/meters^2/year (30 pounds per acre per year), the total deposition of nearly all areas within 0.8 kilometers (0.5 miles) of the towers will not exceed 9 grams/meters^2/year (80 pounds per year).

The effects of saltwater drift from a natural draft cooling tower can be divided into two categories:

1. The effects upon the site environs, and
2. The effects upon the station structures and equipment.

Salt drift droplets contain almost the same concentration of chemicals that are found in the circulating water, including the inhibitors. The drift is deposited in the form of droplets or solid particles, depending on the atmospheric conditions, and leaves precipitants of chemicals on different surfaces located in downwind directions from the tower. The chemicals can cause damage to the biota and structures, depending upon the concentration and composition of these chemicals.

A comparison of natural background salt levels and salt drift from cooling towers reveals that the deviations between the two can reach a factor of ten or more, depending upon the location and atmospheric conditions. Under high-humidity conditions and low-wind speeds, the salt drift can match the natural background a short distance inland. With relative humidities less than 70 percent, the salt deposition from the tower will be smaller by a factor of 10 or more. The ocean is considered a vast ground level area source while the towers are considered elevated points or line sources. In coastal areas, the natural background levels of salt will have already determined to a large degree the biotic composition and community parameters.

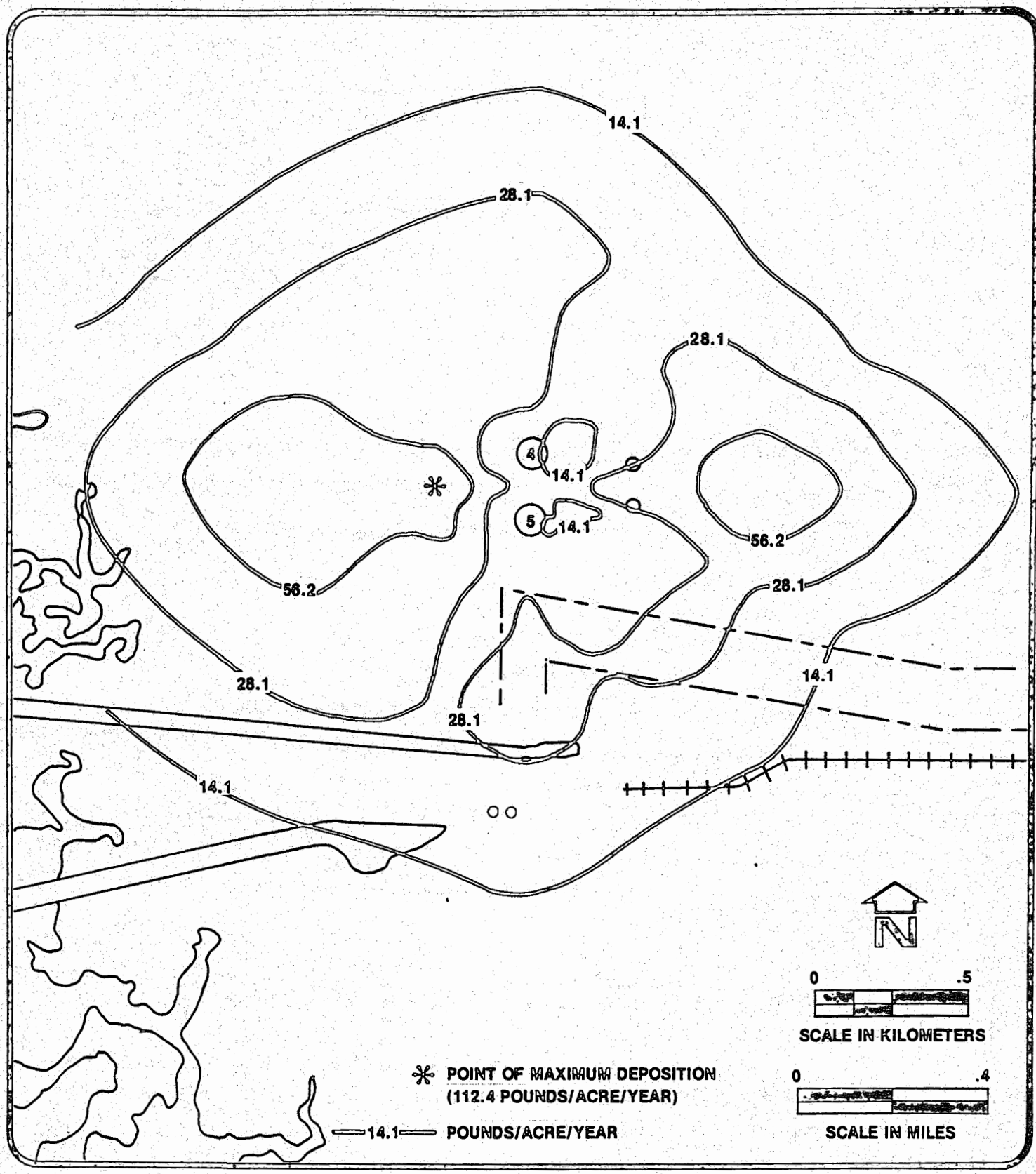

Figure 5.1-6
ANNUAL AVERAGE SALT DEPOSITION AMOUNTS FROM PROPOSED UNITS 4 AND 5 COOLING TOWERS

SOURCE: BLACK AND VEATCH, 1977

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Although the environmental effects of saltwater cooling towers vary depending upon sensitivity and diversity of local conditions, experience with existing saltwater cooling towers indicates that the environmental problems would be confined up to several hundred meters from the cooling tower. Some adverse effects are expected only in the immediate proximity of the tower and within the boundaries of the site. These effects are due to localized phenomena, e.g., blowout in the case of counterflow toweres and wake effects. Blowout consists of a spray of droplets removed from the water falling into the tower basin, and is carried out by air movement in the lower portion of the tower. Hence, metal structures, high-voltage power lines, and buildings must be protected by suitable coatings, and reported by saltwater cooling tower users. Also, parking lots should not be placed at short distances downwind of the tower.

There are two plants currently in operation in the United States which use natural draft towers with brackish water as makeup. The B.L. England Unit 3 of Atlantic City Electric Company, a 160-megawatt plant in New Jersey; and Chalk Point of Potomac Electric Power Company, a 1,260-megawatt facility in Maryland, both use hyperbolic natural draft cooling towers (Kaplan, 1977). The Chalk Point towers take in saltwater as high as 26 parts per thousand (Pell, 1975) and the B.L. England towers use water with a salt concentration as high as 22 parts per thousand (Kaplan, 1977). Measurements of salt drift for these towers indicate that a lower ratio of drift to circulating water volumes than guaranteed by the maufacturers has been produced (Monjoie and Sobel, 1976; Kaplan, 1977). Monjoie and Sobel reported a measured drift rate of about .0005 percent for the B.L. England plant. EPA researchers working with test facilities at Turkey Point, Florida, found no statistically significant increase in background salt concentrations of approximately 900 kilograms (2,000 pounds) per day for the entire plant site (Shirazi, et al., 1977).

Studies conducted for Unit 3 concluded that no detrimental effects would result to the site environs from operation of a natural draft saltwater

cooling tower at Crystal River. This conclusion has been verified through full-scale tests conducted at the Atlantic City Electric B.L. England Station and the Potomac Electric Power Company Chalk Point Station.

At Crystal River, the effects of saltwater drift on the station structures and equipment, particularly the substation, are of prime importance. The effects of salt deposition upon structures depend upon the types of structural materials and amount of salt accumulated on their surfaces. The amount of salt deposition depends upon source strength, distance from the source, wind speed and direction, time the droplets remain upon the surface, relative humidity, and amount of precipitation (Roffman, et al., 1973). The design engineers, Black and Veatch, have indicated that any additional salt drift (30 lbs/acre/year) beyond natural background would cause operational problems at the new or existing facility.

5.1.5 BIOLOGICAL IMPACTS OF IMPINGEMENT AND ENTRAINMENT

5.1.5 BIOLOGICAL IMPACTS OF IMPINGEMENT AND ENTRAINMENT

IMPINGEMENT

The cooling-water intake site for Units 4 and 5 will be located on the north bank of the discharge canal presently serving Units 1, 2, and 3. This 15-meter (50-foot) wide structure will consist of three cells, each having a pump capacity of 2,110 lps (33,500 gpm). Two pumps will supply the total makeup water requirements for Units 4 and 5, since the design flow rate for normal operation is 4,230 lps (67,000 gpm). Each cell will have a 4.6-meter (15-foot) wide traveling screen which passes over two horizontal axles. Screen backwash will be accomplished by pumps leading to high-pressure spray nozzles.

These small-mesh screens are run in both manual and automatic modes. The automatic operation is a consequence of greater "upstream" hydraulic head or water pressure gradient as impingement of organisms on the screens increases with time. The intake pumps will create an intake water velocity of 0.04-0.15 meters/second (0.12 = 0.5 foot/second maximum flow rate at lowest water level), which complies with current EPA intake velocity design criteria of 0.15 meter/second (0.5 foot/second). The net flow of water downstream in the discharge canal, from Units 1, 2, and 3, is currently 0.43 meter/second (1.4 feet/second). The present discharge flow rate from these three units in normal operation is 0.08 million lps (1.322 million gpm). Located immediately in front of and for the protection of the traveling screens will be barrier nets, floating booms, and/or trash racks to deflect various debris, flotsam, and large swimming organisms.

The existing data relative to screenwash impingement and the Crystal River electric generating facility is contained in two separate studies of Units 1, 2, and 3 intake waters. The first study was a 1969-1971 Florida Department of Natural Resources screenwash monitoring program, reported by Grimes (1971) and Mountain (1972). The second study, conducted by the University of Florida, was reported by Snedaker (1974) and will serve as the "touchstone" for most comments concerning impingement for Units 1, 2, and 3.

Within the intake canal, the small, juvenile, and weak-swimming species became impinged throughout the year, whereas the strong-swimming, larger species were impinged in the colder months of the year. Of the 164 species Snedaker (1974) recorded during his 52-week study, eight of the ten most abundant species were relatively slow-swimming fishes or macroinvertebrates and accounted for 95.6 percent of the total biomass collected during this period. Seven species of fishes and invertebrates were collected during each of these 52 weeks. Four of these were slow-swimming forms which were among the ten most abundant species mentioned above. They included the polka-dot batfish (*Ogcocephalus radiatus*), the striped burrfish (*Chilomycterus schoepfi*), the blue crab (*Callinectes sapidus*), and the Cephalopoda (squids). Fish of commerical or recreational importance accounted for only 7.8 percent of the total biomass collected during the study.

To facilitate analyses, Snedaker (1974) arranged the impinged species into their respective habitat groups, as follows:

Migratory species (pulsed impingement)
Grass-mat dwellers and/or trackers
Bottom dwellers (over mud or sand)
Large, fast-swimming--top, midwater
Large, fast-swimming--bottom
Slow, weak-swimming forms
Schooling species
Sessile species (macroinvertebrates)

Impingement was found to be a source-dependent process, a function of habitat, area, season, time-of-day, tide, and fuel barge movements. As mentioned above, in terms of biomass, the impinged organisms were dominated by species of little or no commercial significance. Top and mid-water swimmers tend to be impinged on the downstream screens.

There is currently a lack of baseline research on impingement-prone species now resident in the discharge canal. No known studies exist for fishes and other nekton to be found there. In a study of fishes taken in dropnet collections from nearshore intake and discharge waters, Adams

(1974) found over 40 percent of the species recovered in his study never occurred in the discharge area. The species composition of fishes was less "rich" in the discharge waters.

In terms of source areas for nekton (and, therefore, impingement-prone) species, the situation is quite different in the discharge canal as compared to the intake canal waters. Based on on-site observations, the most common and/or abundant fishes of the discharge canal tend to be larger, schooling forms, which include the following:

Sharks (eps. *Carcharinus limbatus*, but uncommon)
Mullet (*Mugil spp.*)
Ladyfish (*Elops saurus*)
Tidewater silverside (*Menidia beryllina*)
Pinfish (*Lagodon rhomboides*)
Spotted seatrout (*Cynoscion nebulosus*)
Atlantic croaker (*Micropogon undulatus*)
Red drum (*Sciaenops ocellata*)
Spot (*Leiostomus xanthurus*)
Silver perch (*Bairdiella chrysura*)
Jacks (*Caranx spp.*)

The discharge canal constitutes a physical "dead-end" for upstream swimmers. Benthic sediments collected halfway down the discharge canal have been examined and sieved, revealing no macroinvertebrate organisms. Large numbers of spot and pinfish have been recovered by cast-netting. The subsequent dissection of hundreds of specimens revealed empty gut cavities, indicating no feeding activity. During the colder, winter months, fishes such as red drum (redfish, channel bass) are subject to intense recreational angling pressure. Fishermen frequent the discharge canal during this period, seeking those fishes attracted to the warmer power plant discharge effluent (Adams, personal observations).

In summary, those species available for impingement as a consequence of Units 4 and 5 intake operations would be of a vastly different composition than those identified as impinged by Units 1, 2, and 3 intakes.

Since those species available for interaction with the new intake structure would generally be larger, faster-swimming forms, it is anticipated that the impingement which does occur would be much less, relative to water volume and flow, than seen at the Units 1, 2, and 3 intake structures. Also, there would be less impingement due to the intake volume and velocities of Units 4 and 5.

ENTRAINMENT

Potential impacts relating to the entrainment of plankton populations include: (1) reduced levels and permanent loss of production that would otherwise be available to the system; (2) alteration of the trophic structure of the biological community as a result of significant losses of plankton species; and (3) losses of commercially important species that are known to spend part of their life cycle as members of the plankton community. Mortality of entrained plankton populations occurs through mechanical damage of the organism and thermal shock resulting from elevation of water temperatures.

Zooplankton entrainment investigations examining the effects of withdrawal of cooling waters for the existing Crystal River electric generating facility (Units 1, 2, and 3) have indicated that mechanical damage, which seems to have a greater effect on larger zooplankton species (e.g. Labidocera sp. and Acartia tonsa), accounts for a smaller percentage of mortality than that induced by elevated temperatures (maturo, et al., 1974). The aforementioned study reported entrainment mortalities ranging from 0 - 45.6 percent. The lowest number of deaths were found to occur within the cooler months of the year, and near exponential increases were recorded when the discharge temperatures rose above 35°C during late summer.

According to Jensen, et al. (1969) the rate of change in temperature may be of greater significance to the survivial of these organisms than the amplitude of the change. A rapid change in temperature does not allow sufficient time for necessary physiological adjustments. Since many of the zooplankton individuals inhabiting the discharge canal have entered the system through the condensors of Units 1, 2, and 3, they have

already been subjected to a rapid temperature change which may have been as great as 8°C during certain months of the year. It is anticipated that near 100 percent mortality will occur when these individuals are further subjected to additional rapid increases in temperature through entrainment in intake waters being withdrawn from the discharge canal for Units 4 and 5.

Secondary impacts related to the chemical constituents of cooling tower waters include the effects of increased salinity due to evaporation and the addition of chlorine as a biocide. Entrained plankton as well as plankton in the immediate vicinity of the blowdown discharge will be affected by these factors.

Maturo, et al. (1974) recorded apparent general temperature-salinity interactions where low salinity/high temperature and high salinity/low temperature combinations resulted in increased copepod mortalities. These potential impacts are considered to be minimal or insignificant. This assumption is based on: (1) the predicted 100 percent mortality following initial entrainment through the condensors of Units 4 and 5; (2) the predicted high velocities and rapid mixing of blowdown discharge and discharge canal waters.

The residual chlorine concentration in blowdown discharge water is predicted to be approximately 0.2 mg/l which falls below the Environmental Protection Agency's specified level of 0.5 mg/l. The concentratives will approach zero-free residual chlorine upon dilution by discharge canal waters. Although low chlorine concentrations have been shown to produce adverse effects on phytoplankton (Carpenter, et al., 1972; Gentile, et al., 1973) the impact in considered to be low in both magnitude and significance.

Several studies to date which have addressed the survivability of young/small fish entrained through a power plant have shown inconclusive results. However, one of the more recent investigations (March 1971, 1973) showed that most fish larvae and early juveniles entrained through a Connecticut River power plant were dead when they reached the end of a

2.25 kilometer-long (1.14 mile-long) discharge canal. Examination of entrained alewives, herring, white perch, carp, eels, spottail shiner, darters, and shad revealed a mortality of 100 percent for nine out of ten collection series (one showing 92.5 percent mortality at the last downstream collection station). Marcy estimated that approximately 80 percent of the total mortality was caused by mechanical damage and 20 percent was attributed to heat shock and prolonged exposure to temperatures above 28°C. There was "no measurable mortality due to injection of sodium hypochlorite as a biocide." The majority of dead specimens were physically mangled, a condition more obvious in larger specimens. Increases in mechanical injury directly proportional to the size of entrained fishes have been reported by Markowski (1962), Oglesby and Allee (1969), and Marcy (1971). It has been noted that high negative pressures created with the cooling water by pump impeller blades may be largely responsible for destruction of fish tissue.

Considering the present thermal loading and mechanical impact of Units 1, 2, and 3 discharge water prior to use in Units 4 and 5 condenser cooling system, it is anticipated that 100 percent mortality will occur for all fishes of unscreenable (entrainable) size which enter the Units 4 and 5 intakes. Nevertheless, the overall impact of Units 4 and 5 on entrainment are not considered significant.

SECTION 5.2

IMPACTS TO SURFACE WATERS

5.2 IMPACTS ON SURFACE WATERS

5.2.1 SUMMARY OF WASTEWATER DISPOSAL SYSTEMS

The proposed power generating Units 4 and 5 at Crystal River will yield wastewaters from a variety of different sources, as detailed in Chapter 3. This sub-section will summarize these wastewaters and the manner in which they will be disposed as background to the discussion of potential impacts on surface and ground water systems.

The process wastewaters from the proposed units will include: sludge and backwash water from the service water pretreatment system; regenerant wastewaters from the demineralization and condensate polishing systems; boiler blowdown; hydraulic sluice waters; sewage treatment plant effluent; cleaning and maintenance wastewaters; and cooling system blowdown. Chemical cleaning wastes will be generated on an intermittent basis, and there will be major volumes of rainfall runoff from the plant and material storage areas. A critical feature of the project design is the manner in which these wastewaters will be released to the environment or otherwise disposed. Table 5.2-1 presents a water balance for each of the major facilities that will receive or transmit wastewaters; these are the ash handling and storage areas, the coal storage area, the plant drains collection pond, the canal retention system, and the existing discharge canal. With the exception of cooling tower drift, all release of wastewaters to the environment will take place through these facilities.

All of the flow rates shown in Table 5.2-1 pertain to normal plant operation (66 average capacity factor), and thus represent long-term averages. Most of the figures would be higher for peak operating conditions, with the exception of rainfall, surface runoff, and maintenance wastewaters. An important aspect of the proposed design is that none of the facilities listed in Table 5.2-1 other than the discharge canal will release effluents directly to the surface water system (except during infrequent storms, as discussed elsewhere). The active ash storage area

Table 5.2-1 Water Balance of Waste Disposal and Material Storage Areas

	Normal Flow dm^3/s	GPM
I. Ash Handling and Active Ash Storage Areas		
INFLOWS		
Service water pretreatment wastewaters	0.5	8
Service and hydraulic sluice water	3.8	60
Rainfall	3.6	57
OUTFLOWS		
Evaporation	-3.0	-47
Exfiltration	-3.5	-55
Runoff (to canal retention system)		0
NET MOISTURE ACCUMULATION	1.5	23
II. New Coal Storage Area		
INFLOWS		
Rainfall	9.0	142
OUTFLOWS		
Exfiltration	-8.6	-136
Evaporation runoff (to canal retention system)	-8.4	-6
	0.0	0
	0.0	0
III. Plant Drains Collection Pond		
INFLOWS		
Cleaning and maintenance wastewaters	3.1	50
Demineralization and condensate polishing wastes (from neutral basin)	1.3	21
Sewage treatment plant wastes	0.4	6
Boiler blowdown*	5.1*	81*
Direct rainfall	1.1	18
OUTFLOWS		
Flow to ash storage area	-0.3	-5
Evaporation	-0.8	-13
Exfiltration	-10.0	-158
	0.0	0
IV. Canal Retention System		
INFLOWS		
Runoff from general site area	5.4	85
Runoff from new coal storage area		0
Runoff from ash storage area		0
Direct rainfall	0.5	8
Runoff from plant roof drains	1.3	20
OUTFLOWS		
Evaporation	-0.4	-6
Exfiltration	-6.8	-107
	0.0	0

Table 5.2-1 Water Balance of Waste Disposal and Material Storage Areas (Continued)

	Normal Flow	
	dm^3/s	GPM
V. Existing Discharge Canal (to Gulf of Mexico)		
Cooling system blowdown (minus diversion to ash handling system)	80.8	1281

Source: Black and Veatch, 1977

will accumulate moisture at an average rate of 1.5 dm^3/s (23 gallons per minute), due to additions of waste material. All major outflows except the discharge of cooling system blowdown water to the existing discharge canal will consist of evaporation and exfiltration. Exfiltration will be the dominant mechanism of wastewater release, accounting for an average total flow of 28.8 dm^3/s, (456 gallons per minute) from the facilities listed, as opposed to an overall evaporation rate of 4.5 dm^3/s (72 gallons per minute). A large portion of evaporative losses will involve the bottom ash hopper at the ash handling area.

The plant drains collection pond, which will receive a variety of wastewaters, will be designed to contain all inflows associated with a 10-year, 24-hour storm event (involving 8.37 inches of rain). During storm events which involve overflow, the pond will retain stormwater for roughly 24 hours and will remove floating materials. Discharge from the pond will be directed to the canal retention system and thus will be subject to additional retention (possibly with no discharge to surface waters). There will normally be no discharge from the plant drains collection pond. The canal retention system, which will receive surface runoff from the plant site, roof drains and storage areas developed as part of the present project, will also be designed to contain all runoff from a 10-year, 24-hour storm. In actuality, a substantially greater storm may be required to produce overflow, since the hydrophilic nature of fly ash will minimize runoff from the ash storage area.

5.2.2 COOLING SYSTEM BLOWDOWN

5.2.2 COOLING SYSTEM BLOWDOWN

The primary source of chemical and biocide discharge to surface waters will be the release of cooling system blowdown to the existing discharge canal. The quantity released to the canal will amount to 2,371 dm^3/s (37,587 gallons per minute) during peak conditions and 1,441 dm^3/s (22,892 gallons per minute) during normal operating conditions. This discharge will be diluted in the canal by a flow of 87,064 dm^3/s (1,380,000 gallons per minute) of seawater used in Crystal River Units 1, 2, and 3 for once-through cooling.

The chemical characteristics of blowdown water from Units 4 and 5 have been discussed in Chapter 3. The only constituents having significant potential for ecological impact are chlorine, organic phosphates, and sulfuric acid. Shock chlorination, used for control of bacterial slimes and algae, will involve chlorine solution feeds of 15 or less minutes duration, repeated one to three times per day for each unit. One unit will be chlorinated at a time, with intervening periods of no chlorination, and no chlorine will be discharged for more than two hours per day from either unit. The blowdown to the discharge canal will have a maximum total residual chlorine concentration of about 0.5 milligrams per liter (short-term), and will approach zero-free residual chlorine.

Low chlorine concentrations have been shown to produce adverse effects on phytoplankton (Carpenter, et al., 1972; Toetz, et al., 1977). However, the effects may be temporary, with full recovery of the phytoplankton (Hirayama and Hirano, 1970; Goldman and Davidson, 1977). The dilution of roughly 1,000 to 1 which will occur in the 2.5-kilometer (1.5-mile) long discharge canal should minimize the impacts of residual chlorine on aquatic ecosystems from Units 4 and 5. It is difficult to predict, however, whether there will be synergistic effects on indigenous fish species resulting from the addition of Units 4 and 5 to the existing influences of Crystal River Units 1, 2, and 3.

The use of organic phosphate scale inhibitor will yield a phosphate residual in the blowdown which will not exceed the EPA phosphorus limit of 5 parts per million. The phosphorus content will be diluted to between 5 and 7 parts per billion in the discharge canal, and should have negligible impact on aquatic ecosystems.

The cooling tower blowdown will be taken from the cold side of the circulating water system and will result in blowdown temperatures less than the discharge canal water temperature during the summer months (see Table 5.2.2). The blowdown jet velocity will be 3.7 meters/second (12 feet per second) during normal operation. Mixing of this thermal jet with the turbulent discharge canal (approximately 2.0 feet per second towards the Gulf) will occur rapidly across the canal width. The blowdown thermal load ranges from 2.28×10^6 joules/hour (2.16×10^9 Btu/hour) in January to 2.49×10^6 joules/hour (2.36×10^9 Btu/hour) in June, July and August. The worst case maximum percentage increase in thermal-load blowdown into the discharge canal is .063 percent during peak operation at low tide. The energy balance results in Table 5.2.2 indicate that the thermal impact of the blowdown relative to the existing discharge canal thermal regime will not be significant.

The increase in salinity of the blowdown (1.3 cycles of concentration) is not expected to have a significant potential for the formation of salinity stratification in the discharge canal due to the high turbulence of the system. If stratification does occur, either thermal or saline, it will be localized to the discharge point and short-lived.

Table 5.2.2 Units 4 and 5 Blowdown Discharge Thermal Impacts

	Water Temperature (°F)			Thermal Capacity (BTU's)				Blowdown Thermal Influence on Discharge Canal System (%)			
				Discharge Canal ($x\ 10^{10}$)		Blowdown ($x\ 10^{7}$)		Normal Operation		Peak Operation	
Month	Canal	Blow-Down		Low Tide	High Tide	Normal Op.	Peak Op.	Low Tide	High Tide	Low Tide	High Tide
Jan	71.5	86	+14.5	5.7	8.7	2.2	3.6	.038	.025	.063	.041
Feb	76.5	86	+ 9.5	6.1	9.3	2.2	3.6	.036	.024	.059	.039
Mar	79.5	88	+ 8.5	6.3	9.7	2.2	3.7	.035	.023	.058	.038
Apr	89.5	90	+ 0.5	7.1	10.9	2.3	3.8	.032	.021	.053	.035
May	93.5	90	- 3.5	7.4	11.4	2.3	3.8	.031	.020	.051	.033
Jun	98.5	94	- 4.5	7.8	12.0	2.4	3.9	.031	.020	.050	.033
Jul	99.5	94	- 5.5	7.9	12.1	2.4	3.9	.030	.020	.050	.033
Aug	99.5	94	- 5.5	7.9	12.1	2.4	3.9	.030	.020	.050	.033
Sep	97.5	92	- 5.5	7.7	11.8	2.3	3.8	.030	.020	.050	.033
Oct	89.5	90	+ 0.5	7.1	10.9	2.3	3.8	.032	.021	.053	.035
Nov	80.5	89	+ 8.5	6.4	9.8	2.3	3.7	.035	.023	.058	.038
Dec	74.5	88	+13.5	5.9	9.1	2.2	3.7	.038	.025	.062	.041

Source: Environmental Science and Engineering, Inc., 1978.

5.2.6 COOLING SYSTEM INTAKE

5.2.6 COOLING SYSTEM INTAKE

The intake design allows for a minimum flow across the intake screen of 0.15 meters/second (0.5 fps) in a quiescent water body. The mean cross sectional velocity in the discharge at the proposed locations of Units 4 and 5 intake structures or at peak operating conditions for Units 1, 2, and 3 is 0.42 meters/second (1.4 fps). Modifications of this maximum velocity will occur during certain mixes between operating conditions for Units 1, 2, 3, 4 and 5 and tide stage.

SECTION 5.3

IMPACTS ON GROUNDWATER SYSTEMS

5.3 IMPACTS ON GROUNDWATER SYSTEMS

5.3.1 INTRODUCTION

Referring to Table 5.2-1, it is apparent that exfiltration of water from storage (i.e., infiltration into the soil) is proposed to be the major mechanism for disposal of wastewaters other than cooling system blowdown. Of the total wastewater input to the four storage areas listed in Table 5.2-1, 83 percent will normally be removed by exfiltration, versus 13 percent removed by evaporation, and 4 percent retained in the stored materials. Reliance upon exfiltration is a basic feature of the project design and could not be altered (e.g., through lining of the coal or ash storage areas with impermeable materials) without changing the waste disposal system and perhaps, in fundamental respects, the plant layout. For these reasons, the possibility of negative environmental impacts or economic costs due to change in groundwater quality must be considered in some detail.

The overburden soils at the ash and coal yard consist of very loose to medium dense organic material, sand, and silt. The thickness of the overburden varies from less than .6 meter (2 feet) up to 3.0 meters (10 feet). The underlying Inglis limestone is jointed and highly variable in consistency, and contains numerous voids attributable to solutioning and alteration by weathering. The voids are either water-filled or filled with sand, silt, or clay to some degree. The remaining formations beneath the Inglis member are an unconsolidated zone, characterized by a few centimeters (inches) to a few meters (feet) of residual soil or water-filled cavity, and the Avon Park formation. The latter is a dolomite unit which has undergone minor solutioning, with fewer voids and higher strength than the Inglis formation.

Brackish ground water occurs in the ash and coal yard area at or near elevation 28 meters (92 feet, plant datum; the Mean Low Water Level of the Gulf of Mexico is roughly 88 feet, plant datum). The water table ranges in depth from approximately 0.4 meters (1.2 feet) to 1.1 meters

(3.7 feet) below the existing ground surface. However, in localized areas standing water is present, which indicates a perched water table condition above the organic soil layer.

Wastewaters percolating into the soil at the proposed plant site would tend to flow west and south, toward the Gulf of Mexico, for two reasons. First, the overall flow of the Floridan aquifer in this vicinity is to the west and south, as discussed earlier. The total groundwater flow to the Gulf between Crystal River and the Withlacoochee River is estimated at 355 million gallons per day. Second, the brackish upper layer of groundwater is influenced by tidal action. To the extent that this influence continues after preparation of the ash, coal, and wastewater storage areas, any effluents percolating into the soil would tend to be diluted by groundwater charged from the Gulf at high tides, and to be discharged to the Gulf at low tides. Thus, although the relative velocities of lateral versus vertical groundwater movement cannot be predicted, there is very little likelihood that water percolating from the storage areas will flow north or east. This holds true even if acid leachates from the coal and ash storage areas result in some dissolution of the limestone substrate at the site.

5.3.2 LEACHATE FROM COAL AND ASH STORAGE

Exfiltration of rainwater from the coal storage and active ash storage areas, including the percolation of runoff from these areas after discharging to the canal retention system, will account for about 40 percent of the total wastewater input to the groundwater system at the plant site (see Table 5.2-1). Additional leaching of wastes from stored ash and coal may occur due to groundwater fluctuations.

Rainfall percolating through coal piles tends to become contaminated by leaching out the oxidation products of metallic sulfides. Decomposition of the sulfide-containing minerals results in the production of high concentrations of acidity, which in turn stimulates oxidation and furthers acid production. Runoff samples from coal piles studied by Nichols (1974), Anderson (1976), and Cox and Ruane (1967) have been found to contain elevated concentrations of acidity (as $CaCO_3$), suspended solids, total dissolved solids, iron manganese, and a variety of trace metals. The findings of the Cox and Ruane study are considered here in order to illustrate the characteristics of coal pile runoff/leachate. The data can only provide a general indication of conditions at Crystal River Units 4 and 5, however, since the coal supplies for these units are presently indefinite and are likely to differ in significant respects from the coals studied by Cox and Ruane.

Table 5.3-1 summarizes the runoff water quality for two eastern coals. The observed pH values ranged from 2.2 to 3.1, and the acidity levels (concentrations as $CaCO_3$ in milligrams per liter) varied between 300 milligrams per liter and 7,100 milligrams per liter. Concentrations of suspended solids and dissolved solids were also high, the former due to the suspension of coal fines during rainfall events. Iron and manganese concentrations in the coalpile runoff were in excess of Florida state water quality criteria.

The concentrations of trace elements observed by Cox and Ruane are listed in Table 5.3-2. The cadmium, beryllium, and chromium levels

Table 5.3-1 Chemical Characteristics of Coalpile Runoff

Plant		pH	Acidity (mg/l $CaCO_3$)	Sulfate (mg/l)	Dissolved Solids (mg/l)	Suspended Solids (mg/l)	Fe (mg/l)	Mn (mg/l)
J	Range	2.3-3.1	300-7100	1800-9600	2500-16000	8.0-2300	240-1800	8.9-45
	Mean	2.79	3400	5160	7900	470	940	28.7
	N	19	18	18	18	18	19	19
E	Range	2.5-3.1	860-2100	1900-4000	2900-5000	38-270	280-480	2.4-10.0
	Mean	2.67	1360	2780	3600	190	380	4.13
	N	6	6	6	6	6	6	6
E (Discrete Storm)	Range	2.5-2.7	300-1400	870-5500	1200-7500	69-2500	62-380	0.88-5.4
	Mean	2.63	710	2300	2700	650	150	2.3
	N	14	14	14	14	14	14	14

Source: Doye B. Cox and R. J. Ruane, TVA, 1967.

Table 5.3-2 Trace Metals in Coalpile Runoff

Plant		Cu	Zn	Cd	Al	Ni
				mg/l		
J	Range	0.43-1.4	2.3-16	<.001-<.001	66.0-440	0.74-4.5
	Mean	0.86	6.68	<.001	260	2.59
	N_D	0	0	19	0	0
	N	19	19	19	19	19
E	Range	0.01-0.46	1.1-3.7	<.001-0.003	22.0-60.0	0.24-0.46
	Mean	0.23	2.18	0.002	43.3	0.33
	N_D	0	0	2	0	0
	N	6	6	6	6	6

		Cr	Hg	As	Se	Be
				mg/l		
J	Range	<.005-.011	<.0002-.0025	.005-0.6	<.001-.03	0.03-0.07
	Mean	.007	.0004	0.17	0.006	0.044
	N_D	11	12	0	4	0
	N	17	20	19	18	18
E	Range	<.005-.011	0.003-.007	0.006-0.046	<.001-.001	<.01-0.03
	Mean	0.007	0.004	0.02	0.001	0.014
	N_D	3	0	0	3	3
	N	6	5	4	4	4

N_D = Number of samples below detection limits.

Source: Doye B. Cox and R.J. Ruane, TVA, 1967.

shown are well below the established criteria and pose no threat to aquatic communities or man. The observed aluminum concentrations are high relative to natural waters, but the significance of this fact is questionable (since aluminum is not covered by finalized criteria for toxic substances). The mercury concentrations exceed established water quality criteria, and selenium, arsenic, zinc, and copper concentrations are also above EPA-recommended levels.

Table 5.3-3 presents heavy metal concentrations from a southeastern coal. Heavy metal concentrations from clay, gypsum, and silica leachate are also listed as references. The coal lechate had the highest concentrations of the heavy metals analyzed with the exception of lead. All of the metal concentrations except lead exceeded the EPA water quality criteria.

The majority of exfiltration from the ash disposal area will not result in direct ash leachate. At any given time, only 8 of the 38 hectares (20 of the 95 acres) dedicated to ash disposal will be active. Runoff from this area and inactive areas will be channeled to collection and retention canals within 38 hectares (95 acres) where exfiltration will occur. Compaction and sloping of ash lifts will maximize runoff the minimize direct ash area exfiltration.

The active ash storage area will tend to yield groundwater pollutants in roughly the same fashion as the new coal storage area. Up to 85 percent of ash from pulverized coal is fly ash (TVA/EPA, 1977). Fly ash tends to be of greater concern than bottom ash because of its greater volume and higher metals concentrations. Fly ash at a TVA coal-fired plant was found to be enriched by a factor of at least ten, relative to normal soil, in arsenic (As), copper (Cu), lead (Pb), and vanadium (V). Fly ash was also enriched to a lesser degree in cadmium (Cd), cobalt (Co), chromium (Cr), cesium (Cs), europium (Eu), mercury (Hg), antimony (Sb), uranium (U), and zinc (Zn). Several elements are concentrated preferentially in fly ash, but only calcium (Ca) is appreciably more concentrated in bottom ash (Lindberg, et al., 1975; Klein, et al., 1975).

Table 5.3-3 Concentrations of Heavy Metals from Material Leachates

Source of Leachate	Metal Concentrations (ug/l)							
	Cd	Cu	Fe	Pb	Mn	Hg	Ni	Zn
Coal	5.1	220	20,159	7.6	15,661	5.7	658	1,225
Clay	0.45	<1.0	266	6.2	<55	2.4	<2.0	<15
Gypsum	0.71	2.6	266	23	<55	0.65	44	40
Silica	0.40	<1.0	2.89	1.7	<55	1.8	<2.0	<15

Source: Environmental Science and Engineering, Inc., 1977.

Gaps in present research make the prediction of leachate effects difficult. It is not known which metals will be leached from stored ash. Some of the leached metals may form insoluble precipitates which are not carried from the site, and others may be adsorbed by soils and thus not widely distributed. For example, Wentink and Etzel (1974) found that columns of soil removed all copper (Cu), chromium (Cr), and 99.7 percent of zinc (Zn) from combined solutions of up to 300 milligrams per liter of each metal in distilled or tap water. However, other studies indicate that adsorption may be incomplete and/or may depend on special factors. Jennett and Linnemann (1977) suggest that a soil will adsorb 100 percent of its cationic exchange capacity of metals if the metals are applied slowly over a long period of time. They also found that Pb and Zn, once adsorbed, could not be removed by ordinary rainwater, but metals could be removed by strong chelating agents such as humic acids.

The ability of acids, metals, and sulfates from coal leachate to pass through the soil is indicated by the following data for coal mine drainage in the Toms Run Basin, Pennsylvania (from Merritt and Enrich, 1970).

		pH	Fe(ppm)	SO_4(ppm)
Lower Aquifer:	non-mining	6.3-6.8	3-16	4-13
	mining area	2.9-5.4	25-160	30-620
Upper Aquifer:	non-mining	6.5-6.7	10-15	10-15
	mining area	3.0-3.5	20-70	39-80

Limestone soils found at the Crystal River site should increase the pH of percolating waters from coal piles, but not to sufficiently precipitate metals (Boyer and Gleason, 1977). The acidity of the coalpile runoff could aid transport through soil of metals that might be leached from the ash pile. Limestone may not provide adequate pH increase to prevent this occurrence. In summary, it is very difficult to predict the transport of pollutants into the ground water from the proposed coal and ash storage areas at Crystal River, but the loadings of metals and perhaps other contaminants may be substantial.

5.3.3 EXFILTRATION FROM THE PLANT DRAINS COLLECTION POND

The plant drains collection pond will receive a variety of wastewaters as described in Chapter 3. On the average, roughly 90 percent of these wastewaters will leave the pond by exfiltration. Thus, the plant drains collection pond may deliver significant loadings of pollutants to the groundwater system. The following paragraphs will summarize the nature of these potential pollutants by source.

SANITARY WASTES

A package sewage treatment plant will be utilized to treat domestic wastes from the plant. The effluent, which will meet state water quality standards for secondarily-treated sanitary wastewaters, will amount to about 3 percent of the normal inflow to the plant drains collection pond. The pollutant loadings will include organics, suspended solids, nutrients, and minor concentrations of metals typically found in treated domestic wastewater.

NEUTRALIZATION BASIN EFFLUENT

The neutralization basin will be utilized to treat wastewaters from the demineralization and condensate polishing systems. The regenerant wastes from the demineralization system will include unreacted sulfuric acid and sodium hydroxide plus the sodium and sulfate salts of ions removed from the ion exchange resins during regeneration. Similar wastewaters will be yielded by the condensate polishing system. The overall wastewater pH will be adjusted to between 6.5 and 9.0 in the neutralization basin, first by self-neutralization and then by the addition of necessary chemicals (e.g., sodium hydroxide). Effluent from the neutralization basin will account for approximately 11 percent of the normal average inflow to the plant drains collection pond.

BOILER BLOWDOWN

Boiler blowdown and cycle leaks may contain residuals from the chemical feed (hydrazine, ammonia, and trisodium phosphate) as well as low concentrations of iron, copper, calcium, and suspended solids. The boiler blowdown will also convey to the plant drains collection pond an appreciable heat load, which will be relatively unimportant due to the moderate flow magnitude involved (5.1 dm^3/s, or 81 gallons per minute, under normal conditions).

MISCELLANEOUS PLANT DRAINS

An average flow of approximately 3.1 dm^3/s (50 gallons per minute) will be drawn from the service water system for use in general cleaning and maintenance activities. This flow will be collected by the miscellaneous plant drains and delivered as wastewater to the plant drains collection pond. Its chemical composition will be variable depending upon the cleaning activities conducted. The overall concentrations of materials which could potentially affect groundwater quality (e.g., metals) should ordinarily be moderate. However, the wastewater flow from plant drains will include about 0.004 dm^3/s (0.07 gallons per minute) of chemical reagents used for analytical testing in the plant laboratory, which will contain high metals concentrations.

CHEMICAL CLEANING OPERATIONS

Prior to start-up of each power generation unit, the boiler and preboiler systems will be alkaline and acid cleaned. Indeterminate amounts of alkaline cleaning solution, acid cleaning solution, chemical

neutralization compounds, and flushing water will be required. Subsequent chemical cleaning will be restricted to acid cleaning of the boiler after every three to five years of operation. All metal cleaning wastes will be treated in the neutralization basin for pH adjustment prior to disposal in the plant drains collection pond. These wastewaters may contain high concentrations of metals (e.g., copper and iron) but should not significantly affect groundwater conditions due to the very small volumes generated on an annual basis.

5.3.4 INFLOWS TO THE ASH HANDLING AREA

Various wastewaters will be involved in the conveyance and disposal of solid wastes. Bottom ash, coal pulverizer rejects, and economizer ash will be hydraulically sluiced to dewatering bins, using primarily water drawn from the cooling system blowdown circuit. Most of the transport water will be removed, reclaimed, clarified, and returned to the ash handling system, but some moisture will be conveyed with the solid wastes to disposal areas. Wastewater from the water pretreatment system (solids contact basin sludge blowoff and gravity filter backwash) will also be routed to the bottom ash dewatering bins, where most of the liquid will be reclaimed and used as makeup to the bottom ash sluice systems. The wastewaters which are not recycled in these operations will have the potential of contributing pollutants to the groundwater at the solid waste disposal area, but the probable magnitude of contributions will be very small.

5.3.5 SIGNIFICANCE OF GROUNDWATER IMPACTS

The wastewaters listed in the previous sub-sections will introduce unknown quantities of pollutants into the soil at the storage and disposal areas under discussion. Some of these materials may be removed by precipitation or soil adsorption, whereas other groundwater pollutants may be transported long distances. Given the substantial westward gradient in the potentiometric surface of the upper Floridan aquifer, there is virtually no probability that groundwater contamination will occur to the east or north of the developed plant site area, as discussed earlier. Thus, the proposed power generating Units 4 and 5 should not affect the groundwaters underlying any developable land other than that owned by Florida Power Corporation. The two major issues to be considered in evaluating the significance of groundwater impacts, then, are the long-term commitment of resources implied by changes in groundwater quality, and the possible effects of these changes on vegetation in the vicinity of the plant site.

Florida Power has no plans to utilize groundwater withdrawals from the Crystal River power generating site itself. Therefore, deterioration of groundwater quality near Units 4 and 5 would involve no economic loss as long as the site is occupied by Florida Power. If the site is eventually converted to another use, however, the lingering groundwater effects of Florida Power's operations could amount to a long-term commmitment of groundwater resources that limits their future use. The inherent value of groundwater supplies at the plant site is clearly low, due to the brackish surface component and the probability of saltwater intrusion if pumpage were conducted on any significant scale. Thus, the resource commitment aspect of groundwater quality deterioration at the plant site is attributed only minor importance as an environmental impact.

Geraghty and Miller, Inc. (1977) estimated a total groundwater flow to the Gulf between Crystal River and the Withlacoochee River at approximately 1.34 million cubic meters/day (355 million gallons/day) or approximately 66,000 cubic meters/day/kilometer (28 million

gallons/day/linear mile). The groundwater flow toward the Gulf would dilute any leachates formed and exfiltrated from coal and ash storage areas, plant drains collection pond, and canal retention system. The magnitude of dilution, based on the estimated groundwater flow, may be from 10 to 20 times the exfiltration rate. Such a dilution would tend to mitigate potential groundwater and surface water impacts.

Regarding vegetative impacts, there is little information concerning the ecological effects of low pH and metals in soil and pore water on marsh vegetation. Lee, et al. (1976), hydroponically grew eight species of marsh plants in combined concentrations of 0.0, 0.5, or 1.0 ppm each of cadmium, chromium, nickel, lead, and zinc. Metals did not reduce growth except possibly for Scirpus validus and Spartina patens. Fly ash contains chromium, nickel, lead, and zinc in concentrations exceeding 1 ppm. However, the concentrations of these metals in ash pile leachate and runoff are not known.

Metal concentrations of 100 ppm can be toxic to Spartina alterniflora (Dunstan, et al., 1974 a.b., via Lee, et al., 1976). Copper killed seedlings in two weeks; zinc, mercury, lead, or methyl mercury killed 35 to 50 percent after eight weeks. Cadmium had no adverse effect after eight weeks.

Normal levels of heavy metals in soils may have wide ranges. Arsenic levels are usually less than 10 ppm and rarely above 70 ppm; copper levels are usually less than 60 ppm; lead averages about 15 ppm and seldom exceeds 50 ppm (Motto, et al., 1970; Taskey, 1970). Available or soluble levels may run about 10 percent of total levels (Taskey, 1970). Arsenic has been found toxic to citrus at soluble levels of 2 ppm (Liebig, et al., 1959), and it damages rice at 0.2 ppm in poorly drained soils (Epps and Sturgis, 1939). Arsenic also has greatest toxic effects in acid sandy soils (Arnott and Leaf, 1967). Copper has been shown to inhibit growth in solutions of 150 ppm to 250 ppm (Motto, et al., 1970), although lead concentrations in soil of 12 ppm to 680 ppm produced no consistent effects on bromegrass (Marten and Hammond, 1966). General effects of these heavy metals are reduced root and short growth, general

deformity, and thick, darkened roots. Germination may be affected with higher concentrations (Taskey, 1970). Jordan (1975) found that zinc-cadmium interactions caused greater damage to vegetation in Pennsylvania than did either zinc or cadmium alone. Seedling growth of red oak and aspens was reduced at zinc levels above 1 ppm and cadmium levels above 5 ppm.

Therefore, it appears that the levels of heavy metals in the ash products could damage vegetation if they are carried in the leachate, if concentrations down-gradient remain high, and if they enter the root zone. Whether these conditions will exist is unknown at this time. However, arsenic is generally more effective at preventing the establishment of vegetation than in killing established plants (Taskey, 1970). Impacts on existing vegetation may be negligible if the heavy metals remain at the lower portion of the root zone, rather than accumulating near the surface where younger, more sensitive plants are rooted.

Heavy metals concentration and soil acidity may hinder re-establishment of vegetation on the reclaimed ash storage areas. This effect should be overcome if a sufficiently thick overburden cap and adequate drainage are provided.

It is probable that any impacts from leachate formed from coal and ash storage and other wastewater streams will be confined to an area adjacent to the leachate source. As the leachate moves further through the strata; concentration will decrease to mitigate the impact.

SECTION 5.4

PSD ANALYSIS-AIR QUALITY

5.4 PSD ANALYSIS--AIR QUALITY

5.4.1 CLASS II PSD ANALYSIS

LONG-TERM ANALYSIS

Annual average impacts for both baseline and 1984 conditions were determined utilizing a five-year (1971-75) hourly meteorological record from Tampa International Airport. Because of the five-year record, these data were preferred over the one-year, on-site data mentioned earlier in Chapter 2.8 (Climatology and Dispersion Meteorology).

Prevention of Significant Deterioration (PSD) analysis was made in both the vicinity of the Crystal River site, designated Class II, and at the Chassahowitzka National Wilderness Area, nearly 21 kilometers (13 miles) south of the proposed plant site and designated as a Class I area. In the figures and tables to follow, both the SO_2 and TSP maximum impacts and PSD increments are determined and compared with the allowable PSD increment and most restrictive Ambient Air Quality Standards (AAQS).

Annual average SO_2 and TSP baseline concentrations are shown in Figures 5.4-1 and 5.4-2, respectively. The SO_2 maximum of 5 ug/m^3 lies approximately 6 kilometers (4 miles) east of the existing Crystal River units. The ground-level TSP concentrations in Figure 5.4-3 are negligible except for an excluded ambient background concentration.

Figures 5.4-3 and 5.4-4 portray the annual average SO_2 and TSP concentrations with operation of the proposed units. Both figures are only slightly different from the baseline maps, representing only a small change in the annual SO_2 and TSP air quality at the site. The SO_2 and TSP incremental impacts for the proposed units only are shown in Figures 5.4-5 and 5.4-6, respectively.

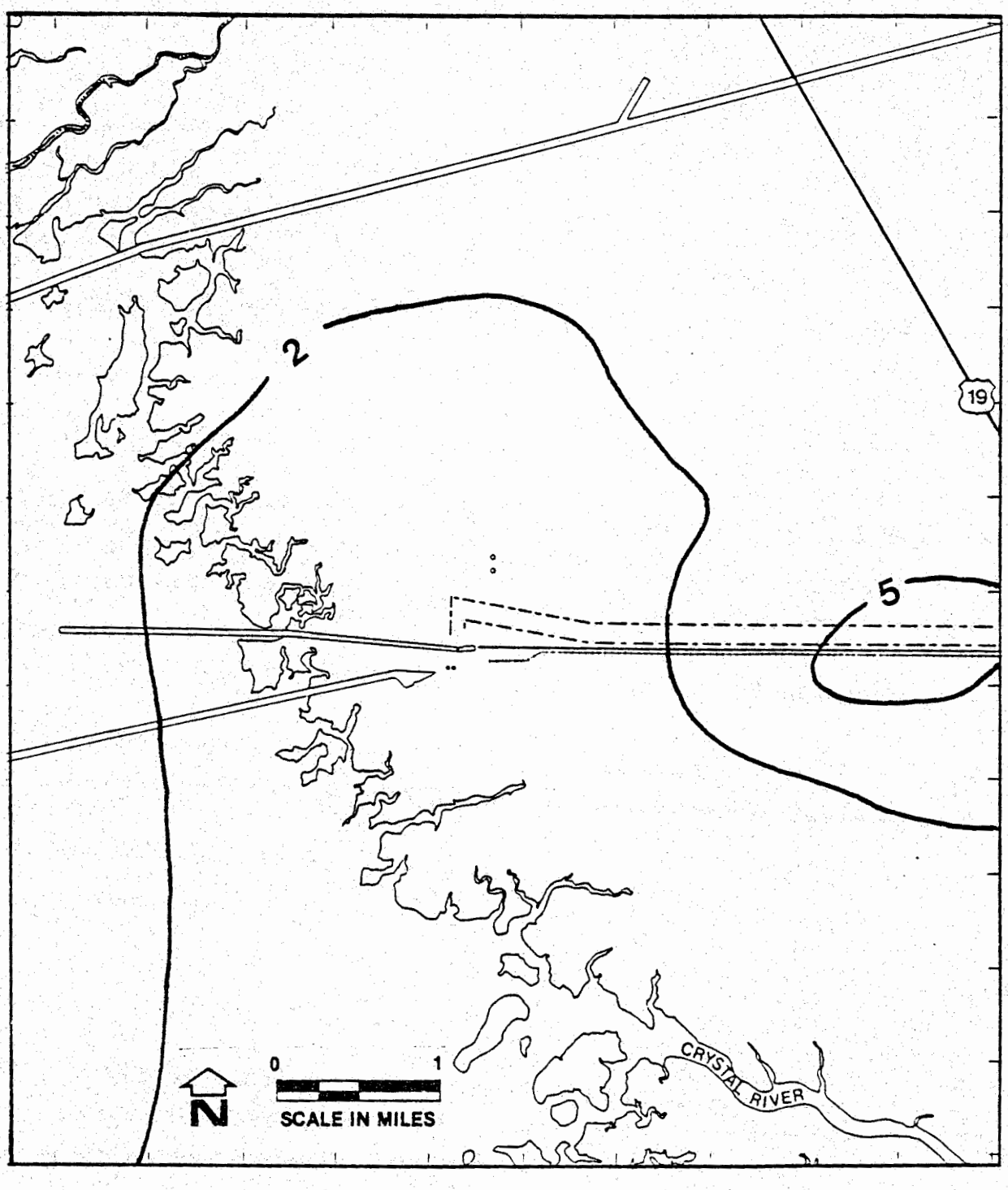

Figure 5.4-1
ESTIMATED ANNUAL AVERAGE SULFUR DIOXIDE BASELINE CONCENTRATIONS (ug/m³) IN THE VICINITY OF FLORIDA POWER CORPORATION CRYSTAL RIVER, 1974
SO_2 BASELINE
SOURCE: ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1978

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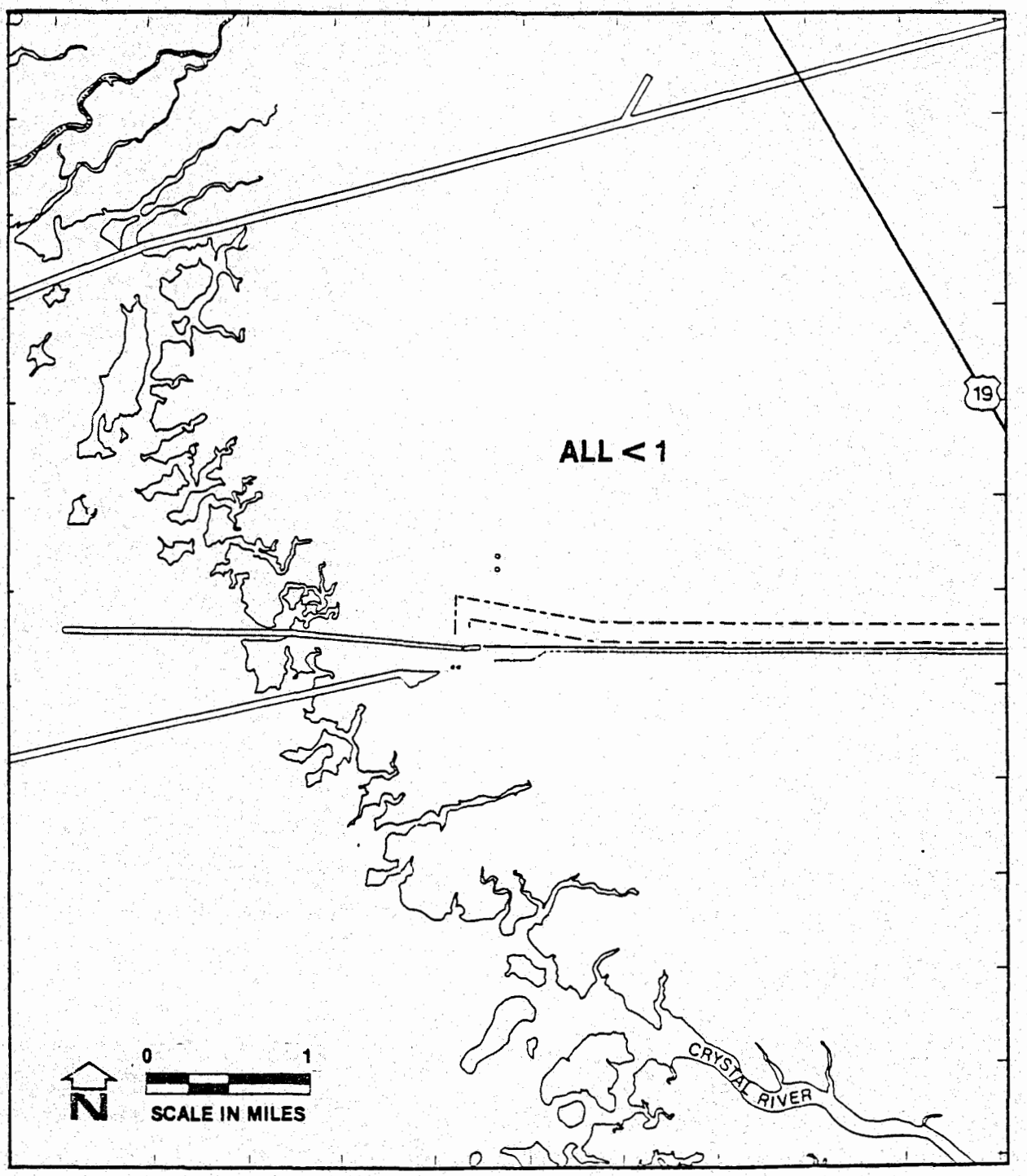

Figure 5.4-2
ESTIMATED ANNUAL AVERAGE TOTAL SUSPENDED PARTICULATE BASELINE CONCENTRATIONS (ug/m³) IN THE VICINITY OF FLORIDA POWER CORPORATION CRYSTAL RIVER, 1974
TSP BASELINE
SOURCE: ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1978

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Table 5.4-1 summarizes the maximum annual and short-term SO_2 and TSP concentrations and PSD increments for all Class II areas. The table will be discussed in the following section.

SHORT-TERM ANALYSIS

Maximum short-term concentrations were determined by utilizing a five-year CRSTER model to calculate the worst days and periods for each scenario. Once these days were determined, further resolution of maximum impacts and PSD increments was determined using the PTMTP-W model. As per current EPA modeling guidelines, the highest and second-highest concentrations were used to determine compliance with all AAQS and PSD increments. Table 5.4-1 shows that the maximum 24-hour SO_2 concentration from Units 4 and 5 is 45 ug/m^3, while the three-hour maximum is 583 ug/m^3. The 1984 values represent the maximum concentrations after the proposed units are on line. Existing Units 1 and 2 are run at the strategy of 2.0 pounds SO_2 per million Btu and 0.1 pound TSP per million Btu heat input. Units 4 and 5 are run at their maximum allowable rate of 1.2 pounds SO_2 per million Btu and 0.1 pound TSP per million Btu heat input. The maximum increase over the baseline concentration is taken at the receptor where this increment is a maximum, regardless of whether or not it was the maximum concentration. The maximum three-hour SO_2 increment of 198 ug/m^3 is the critical Class II increment and is 40 percent below of the allowable 512 ug/m^3. All other increments and concentrations are well below allowable limits.

PARTICULATE DEPOSITION

In order to determine the effect on the amount and the location of particulate matter deposition due to Units 4 and 5, a modified version of the methodology described by Bosanquet, et. al., (1950) was used. Since the main concern for this determination is the larger particles, no credit for plume buoyancy was given in the computation of the plume rise. It was assumed that the larger particles would begin to fall out

Table 5.4-1 Summary of Significant Deterioration Analysis, Class II Areas, Florida Power Corporation, Crystal River Units 4 and 5, Citrus County, Florida

	Maximum Concentration (ug/m^3)				
	SO_2			TSP*	
Scenario	Annual Average	24-Hour	3-Hour	Annual Average	24-Hour
Incremental Impact Crystal River Units 4 and 5	3	45	291	<1	4
Maximum in Area					
1974 Baseline	5	65	583	30	56
1984 with Units 4 and 5	6	69	395	36	58
Maximum Increase Over Baseline at Worst Receptor	1	12	198	6	2
State of Florida AAQS's	60	260	1,300	60	150
Allowable Federal Increment	20	91	512	19	37

* Concentrations include a background level of 30 ug/m^3.
Source: Environmental Science and Engineering, Inc., 1977.

of the plume after their initial momentum because the stack velocity had been dampened by the atmosphere. This assumption constituted the only deviation from Bosanquet's procedure. Once the effective plume height had been determined, the deposition rate was computed from a weighted average of the particle size distribution, the fall velocity of the particles as determined from their sizes and densities, and the wind speed at stack height. Since the wind speed is the most critical factor in the location of the dustfall, different speeds were considered. The local deposition under the conditions of strong winds is relative in signficance. As might be expected, the highest dustfall rate occurs under the conditions of low wind speed. The maximum deposition rate which is estimated to occur 7 kilometers (4 miles) from the site, is less than 0.5 $mg/m^2/day$. At 14 kilometers (8.7 miles), the maximum deposition rate is estimated at less than 0.2 $mg/m^2/day$. Such deposition, however, would only occur downwind from Units 4 and 5. The impacts from the estimated deposition rates would not be detectable.

5.4.2 CLASS I PDS ANALYSIS

The Clean Air Act Amendments of 1977 require that all national wilderness areas which exceed 2,050 hectares (5,000 acres) in size be designated as Class I areas for PSD purposes. Therefore, Chassahowitzka National Wilderness Area is required to be a Class I area. The allowable PSD increments for Class I areas are:

Particulate Matter:	
Annual geometric mean	5 ug/m^3
24-hour maximum	10 ug/m^3
Sulfur Dioxide:	
Annual arithmetic mean	2 ug/m^3
24-hour maximum	5 ug/m^3
3-hour maximum	25 ug/m^3

The distance from the proposed source to the Chassahowitzka National Wilderness Area boundary is approximately 21 kilometers (13 miles).

Presented in Table 5.4.2 is the maximum predicted baseline, incremental, and 1984 estimated sulfur dioxide and TSP concentrations. The three-hour maximum increment attained was 25 ug/m^3 which is exactly equal to the allowable limit. This critical increment determined the fuel strategy to be used in the entire modeling effort for Units 1 and 2. The other SO_2 and TSP increments are well below the allowable Class I increments.

Table 5.4-2 Summary of Significant Deterioration Analysis, Class I Area--Chassahowitzka National Wilderness Area, Florida Power Corporation's Units 4 and 5, Citrus County, Florida

Scenario	Maximum Concentration (ug/m^3)				
	Sulfur Dioxide			Total Suspended Particulate*	
	Annual Average	24-Hour	3-Hour	Annual Average	24-Hour
Crystal River Units 4 and 5 Incremental Impact	<<1	10	52	<<1	1
Maximum in Class I Area					
1974 Baseline	1	30	99	30	32
1984 with Units 4 and 5	1	20	116	30	32
Increase Since Baseline	<<1	<1	25	<<1	1
Allowable Federal Increment	2	5	25	5	10

* Background TSP concentration of 30 ug/m^3 added to modeling results.
Source: Environmental Science and Engineering, Inc., 1977.

5.4.3 CONCLUSIONS

Utilizing an SO_2 final strategy in the existing Crystal River Units 1 and 2 of 2.0 pounds per million Btu heat input, and 1.2 pounds SO_2 per million Btu heat input in the proposed units, all the annual average and short-term SO_2 and TSP AAQS and PSD increments, with the exception of the three-hour Class I increment, will be met. The three-hour Class I increment of 25 ug/m^3 was utilized as the limiting SO_2 fuel strategy on the existing units.

SECTION 5.6.5

TRANSPORTATION

5.6.5 TRANSPORTATION

Both road and rail traffic will produce some road-kills of wildlife, but it is unlikely that this would have a detectable effect on wildlife populations.

Barge traffic in the intake canal could impact the Florida manatee, which occurs in the area. Populations of this species are thought to move between the Withlacoochee and Crystal Rivers. Less than 25 sightings of manatees in or near the power plant canals have been recorded by the U.S. Fish and Wildlife Service in the past three years (Irvin, 1977, personal communication). Sightings were reported by aerial surveys and from researchers working on studies near the existing plants.

Manatees appear to prefer the Crystal River area to the discharge canals. Insofar as they frequent the canals, the heated effluent of the discharge canal would appear to provide a greater attraction than the intake canal. Barge movements would provide a hazard to manatees only in the intake canal and in the adjacent coastal waters. However, it is likely that the increased traffic due to power generating Units 4 and 5 will result in a somewhat greater incidence of manatee injury or mortality than present conditions.

5.8.3 CONTROL TECHNOLOGY

Plant design incorporates a number of mitigative features. Florida Power's plans to use closed-cycle cooling represent a large reduction in the impacts of thermal addition to the nearby estuary. In addition, the use of natural draft cooling towers will produce less noise, less drift, and consume less fuel than mechanical draft towers.

The proposed source of cooling water for the facility is water from the existing discharge canal serving Crystal River Units 1, 2, and 3. Since the water at the point of intake has been discharged by the other units, this plan actually represents the reuse of wastewater and eliminates the commitment of additional natural waters for cooling purposes on the site.

Several aspects of using this water source will minimize the potential biological impacts due to impingement and entrainment. First, the intake water velocity of 0.04-0.15 meter/second (0.12-0.5 foot/second) complies with current EPA intake velocity design criteria. Also, the intake flow rate for normal operation represents only approximately five percent of the total flow rate in the discharge canal. Barrier nets, floating brooms, and/or trash racks will located immediately in front of each intake traveling screen to deflect various debris, including the larger organisms. Probably the most important aspects of this plan for minimizing biological impacts are that the water has previously been used in the cooling systems of Units 1, 2, and 3 and that the discharge canal at the intake structure location and above is a relative barren biological or feeding area. Most organisms in the intake area have already been killed by the thermal and mechanical impacts of Units 1, 2, and 3, or would generally be larger, faster-swimming species of fishes which could avoid impingement. As a consequence, the quantity of living fishes and other organisms available for impingement or entrainment is much less than would normally be available for such a surface water intake system or as currently occurs for Units 1, 2, and 3 intakes.

Burning low-sulfur coals will result in less degradation of air quality than burning high-sulfur coals. Scrubbers are not necessary when using low-sulfur coals, and therefore are not planned for Units 4 and 5. Without the use of scrubbers, stack emissions are hotter and the potential dispersion of air pollutants is greater. Also the potential volume of solid wastes from the facility will be reduced by eliminating scrubber sludge.

The use of scrubbers results in a reduction of the electrical generation which can take place for a given amount of fuel. If other control technology is used, this lost fuel would be made available for other uses. Consequently, the improved fuel efficiency of the newer units allows more electricity to be produced with fewer air emissions for a given amount of fuel.

SECTION 6.2

PLANT CONSTRUCTION AND OPERATION MONITORING

6.2 PLANT CONSTRUCTION AND OPERATION MONITORING

During site preparation, facility construction, and facility operation, the environmental parameters of air and water will be monitored for levels relative to those projected in Chapters 4 and 5. In addition, a plan of action will be implemented if an archaeological discovery is made.

The impacts related to the other environmental areas: i.e., aquatic and terrestrial ecology, geology, solid wastes, and noise will not be of significant magnitude to warrant additional monitoring during these phases of the project.

6.2.1 AIR

During site preparation and facility construction, the significant air emissions will be fugitive dust from land clearing and grading and smoke from burning of the land-clearing wastes. Both of these emissions are classified as particulate matter and can be measured by the Federal Reference Method (FRM) High-Volume samplers (40 CFR Part 50).

Once Units 4 and 5 are operating, the significant air emissions to be monitored will be the particulate matter and sulfur dioxide from the combustion of coal in the two coal-fired steam-generators. In addition to the FRM High-Volume sampling technique for sampling particulate matter, a FRM sulfur dioxide reference method and equivalent methods for sulfur dioxide have been promulgated. Both methods can be utilized to measure the air emissions during plant operations.

Three sampling stations are proposed as the construction and operation air monitoring network. These stations are the same as three of the baseline monitoring program (stations 1, 2, and 4; station 3 will not be continued; see Figure 2.9-1). Each station will measure ambient concentrations of total suspended particulate matter and sulfur dioxide (sulfur dioxide monitoring will be required only during operation). A minimum sampling will be scheduled once every sixth day, and monitoring will continue for the life of the units.

The meteorological monitoring data available from the existing meteorological station will continue to be used by Florida Power. The tower will monitor those parameters stated in Section 6.1.5.

6.2.2 WASTEWATER

The water quality monitoring program will consist of sampling at the following six potential discharge sources during plant operation:

#001	Cooling Tower Blowdown
#002	Plant Drains
#003	Ash Disposal Area
#004	Coal Storage Area
#005	General Plant Runoff
#006	Sewage Treatment Plant

All sampling and analytical procedures will be those contained in 40 CFR 136.

The cooling tower blowdown will be discharged to the existing discharge canal as shown in Figure 6.2-1. The wastewater will contain chlorine and phosphate as algicide and scale inhibitors and will concentrate the solids content of the cooling water. Prior to mixing with the cooling canal water, the discharge will be sampled for the following parameters at the frequency indicated:

pH--Once per week
Flow--Continuous
Temperature--Once per week
Total Residual Chlorine--Once per week
Phosphate--Once per week

The wastewater from floor drains, washwaters, sewage treatment plant effluent and the neutralization pond wastes will be collected in the plant drains-retention pond which will be sized for these wastewaters and direct rainfall for less than or equal to a 10-year, 24-hour storm event. During rainfall events greater than this design storm, the pond will discharge into the runoff collection ditch and then into the cooling water discharge canal. The plant drains-retention pond discharge will be sampled for the following parameters at the frequency indicated:

pH--Once per week
Flow--During all discharge periods

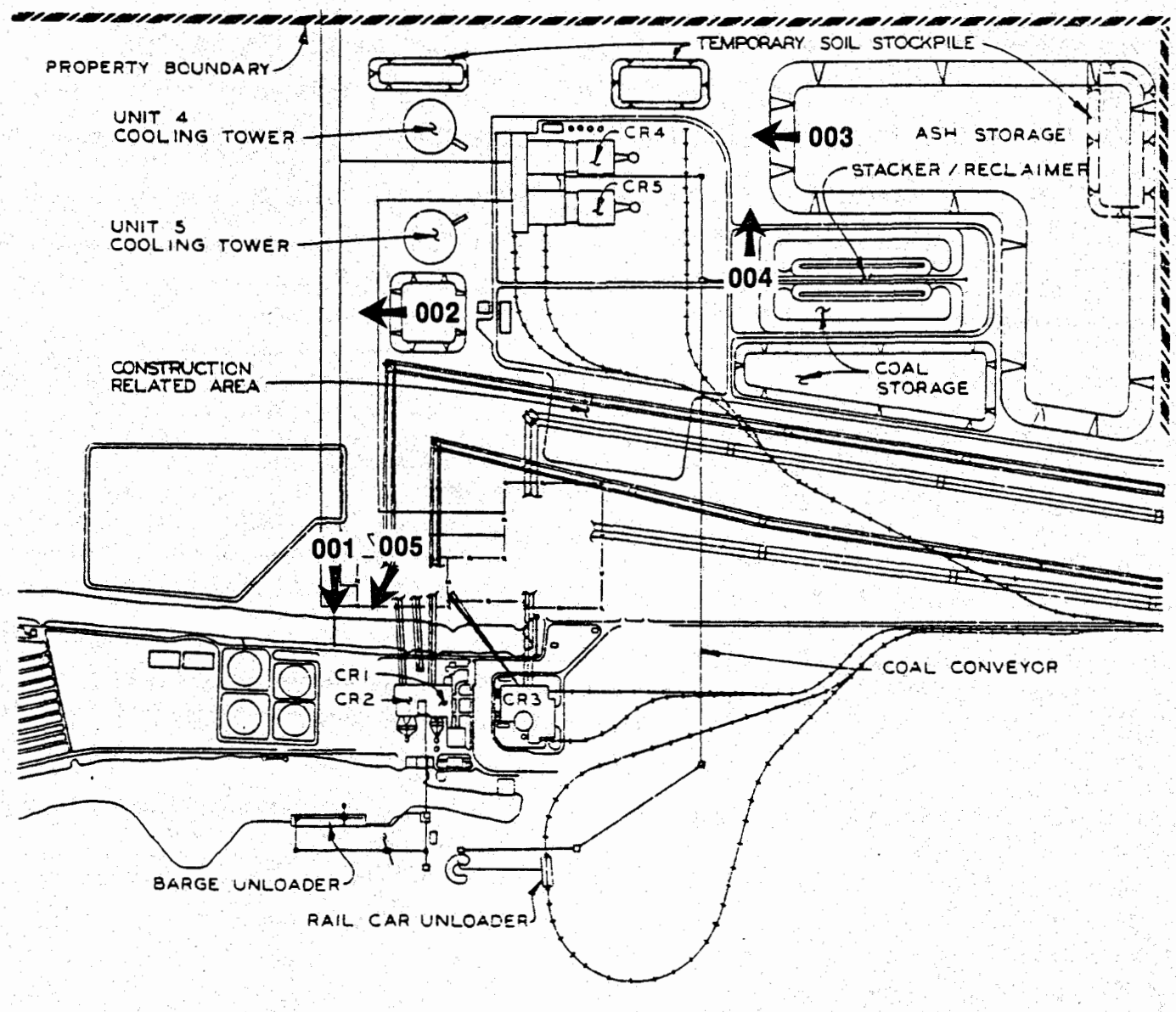

Figure 6.2-1
EFFLUENT SAMPLING LOCATIONS

N

0 1000 2000
SCALE IN FEET

SOURCE: BLACK AND VEATCH, 1976

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Total suspended solids--Once per week
Oil and grease--Once per week
Copper, Total--Once per week
Iron, Total--Once per week

The ash disposal area will be a diked storage area with sufficient capacity to maintain the direct runoff from all storms, equal to or less than a 10-year, 24-hour storm event. During storms of a greater size, the runoff will be discharged to the canal retention system and then into the existing cooling water discharge canal. The diked area or its discharge will be sampled for the following parameters at the frequency indicated:

pH--Once per week
Flow--During all discharge periods
Total suspended solids--Once per week
Oil and grease--Once per week
Heavy metals (cadmium, chromium, copper, iron, lead, mercury, nickel, selenium, and zinc) and sulfates--Once per year and once per week for specific indicators/parameters, such as sulfates, iron, and specific conductivity.

The new coal storage areas will be diked to retain runoff for rainfall events equal to or greater than a 10-year, 24-hour storm. During storm events of a greater size, the runoff from these two areas will discharge into the runoff collection ditch which flows into the cooling water discharge canal. The standing water in the areas or the discharge when it occurs will be sampled for the following parameters at the frequency indicated:

pH--Once per week
Flow--During all discharge periods
Total suspended solids--Once per week
Heavy metals (cadmium, chromium, coppper, iron, lead, mercury, nickel, selenium, and zinc) and sulfates--Once per year and once per week for specific indicators/parameters, such as sulfates, iron, and specific conductivity.

The canal retention system will receive discharges from the plant roof drains, the plant drains collection pond, the ash disposal area, and the coal storage areas during rainfall events greater than a 10-year, 24-hour storm. In addition, the canal retention system will receive the general stormwater runoff from the remaining facility areas and will have a capacity to store the runoff from rainfall events equal to or less than a 10-year, 24-hour storm. The water in the ditch or the discharge when it occurs will be monitored for the following parameters:

pH--Once per week
Flow--During all discharge periods
Total suspended solids--Once per week

The effluent from the facility's sewage treatment plant will be discharged to the plant drains collection pond. The effluent will be monitored for the following parameters at the frequency indicated:

Flow--Once per week
BOD_5--Once per month
Total suspended solids--Once per month
Chlorine residual--5 days per week
Fecal coliform--Once per quarter

6.2.3 GROUNDWATER

The groundwater monitoring program consists of a network of seven wells--one upgradient (northeast) and six downgradient (southwest) of the ash pond, coal storage areas, plant drains collection pond, and the canal retention system. The locations of these wells are shown in Figure 6.2-2.

Wells 1 and 3 will be shallow wells [3 to 4.5 meters (10 to 15 feet) deep] to monitor infiltration into the upper groundwater level, whereas all other wells will be 9 to 12 meters (30 to 40 feet) deep into the limestone strata. These wells will be useful in determining the strength of the leachates immediately downgradient of the two significant impoundment areas--the ash disposal and the coal storage areas. Wells 5 and 6 are located upgradient of the existing ash and coal storage areas and will be useful in determining the reduction in levels of critical parameters in the leachate. All wells will be constructed according to Chapter 17-21 F.A.C., Rules and Regulations Governing Water Wells in Florida.

Initially, the wells will be sampled once per month for the following parameters: water level, pH, chlorides, cadmium, chromium, copper, iron, lead, mercury, nickel, selenium, sulfide-sulfite-sulfate compounds, zinc, total suspended solids, and specific conductivity.

However, once the range of the groundwater quality is determined, the analysis of the monthly samples will be reduced to water level, pH, iron, chlorides, sulfate compounds, and specific conductivity.

These parameters will serve as indicators of the relative changes in the groundwater quality. Annually, the complete series of analyses will be performed to document yearly trends.

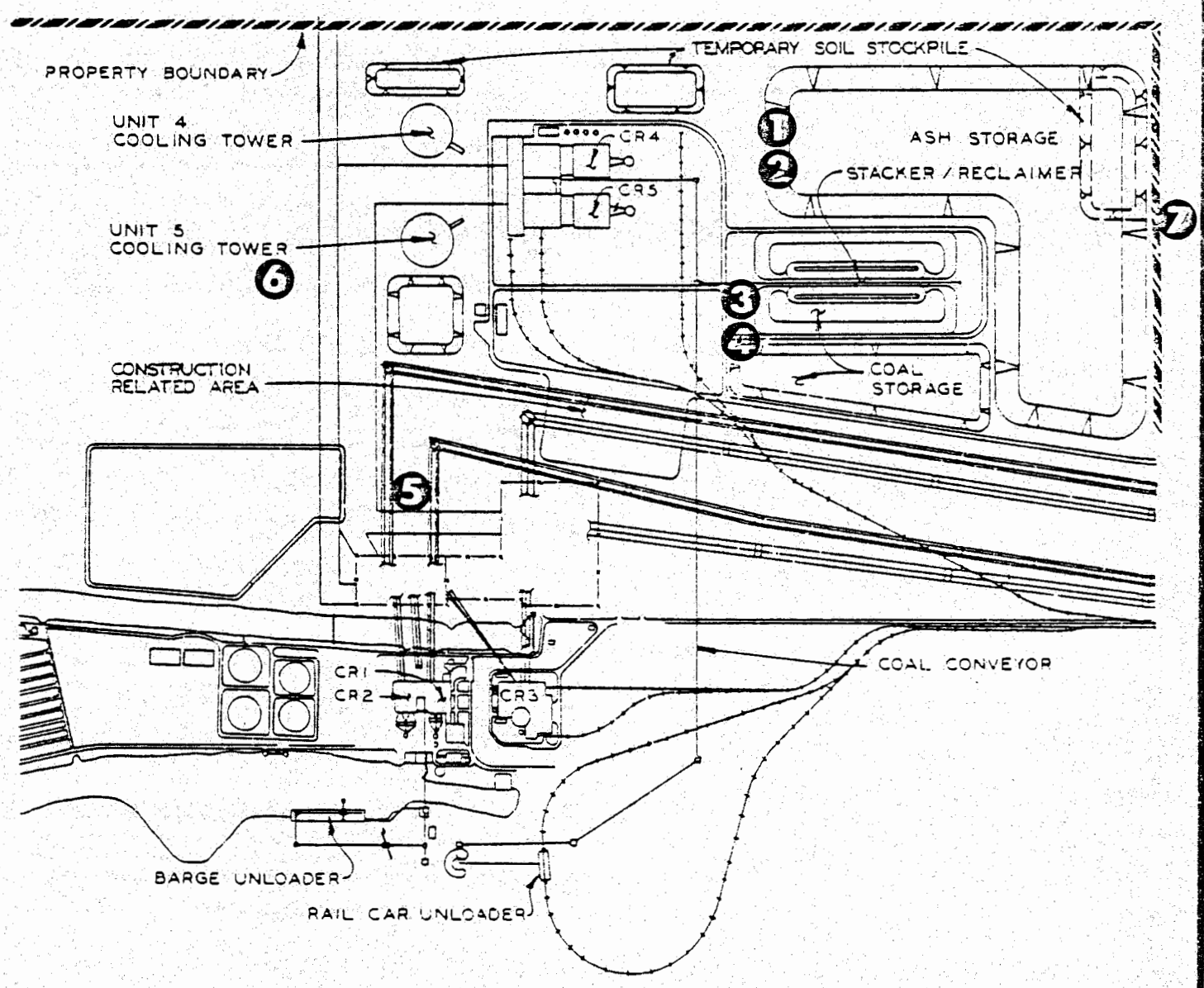

Figure 6.2-2
GROUNDWATER SAMPLING LOCATIONS

N

0 1000 2000
SCALE IN FEET

SOURCE: BLACK AND VEATCH, 1976

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6.2.4 ARCHAEOLOGY

During construction activities, normal archaeological monitoring and safeguards will be followed to protect possible discoveries. The state historic preservation officer will be notified if a potential historical site or find is discovered. Work will be stopped in the immediate area and will not be resumed until the approval of the Florida Division of Archives, History, and Records Management is received.

7.2 COSTS AND BENEFITS OF THE PROJECT TO POWER USERS AND TO FLORIDA POWER CORPORATION

7.2.1 COSTS ATTRIBUTABLE TO PROPOSED CRYSTAL RIVER UNITS 4 AND 5

7.2 COSTS AND BENEFITS OF THE PROJECT TO POWER USERS AND TO FLORIDA POWER CORPORATION

7.2.1 COSTS ATTRIBUTABLE TO PROPOSED CRYSTAL RIVER UNITS 4 AND 5

The cost-benefit analysis of the proposed project utilizes cost information that was originally developed to evaluate the choice between low-sulfur and high-sulfur coal (see Chapter 8). The annual costs of capital, fuel, and operation/maintenance have been determined for Crystal River Units 4 and 5 in each year of operation. The cost estimates assume the use of saltwater cooling towers. The present worth of these power generation costs for each unit has been determined by discounting back to April 1, 1978, using the estimated cost of capital to Florida Power (11.1 percent). The figures for the low-sulfur coal option, which is the only relevant case here, are shown in the upper portion of Table 7.2-1.

The assumptions underlying the estimated power generation costs are discussed in Chapter 8. Two especially significant quantities are the rates of escalation in fuel costs and operation/maintenance costs. The delivered cost of coal is assumed to rise by 10 percent per year between 1977 and 1980, and by 5 percent per year after 1980. Operation/maintenance costs are assumed to escalate indefinitely at a rate of 6 percent per year. Thus, the estimated power generation costs assume continued inflation in the U.S. economy. This point becomes important when placing a dollar value on the electricity produced.

The total costs attributable to the construction and operation of Crystal River Units 4 and 5 include a number of elements other than power generation expenditures. It is necessary to account for the costs of transmitting and distributing the electricity generated, plus the general administrative expenses and tax payments incurred by Florida Power. In addition, the proposed power generation units must contribute to the net income available for dividend payments to Florida Power stockholders. The information utilized to estimate these additional costs is presented in Table 7.2-2.

Table 7.2-1 Summary of Incremental Costs Associated with Crystal River Units 4 and 5

	Present Worth of Expenditures in Millions of April 1978 Dollars		
	Unit 4	Unit 5	Total
POWER GENERATION COSTS			
Capital	292.8	191.6	484.4
Fuel	700.5	644.0	1,344.5
Operation/Maintenance***	54.8	51.0	105.8
SUBTOTAL	(1,048.1)	(886.6)	(1,934.7)
SHARES OF OTHER COSTS ATTRIBUTABLE TO UNITS 4 AND 5			
Transmission, Distribution, and Administration*	87.8	80.8	168.6
Capital Costs Other than Power Generation Facilities †	20.4	13.4	33.8
Taxes Payable Currently**	129.4	119.1	248.5
Dividend Payments ††	110.3	101.5	211.8
SUBTOTAL	(347.9)	(314.8)	(662.7)
TOTAL PRESENT WORTH	1,396.0	1,201.4	2,597.4

* Assumed equal to 11.63 percent of fuel plus O/M costs.
† Assumed equal to 7 percent of capital costs for power generation.
** Assumed equal to 17.13 percent of fuel plus O/M costs.
†† Assumed equal to 14.60 percent of fuel plus O/M costs.
*** Operation/maintenance costs do not include contingencies associated with the operation of saltwater coding towers; only normal costs are included.

Sources: Florida Power Corporation, 1978.
Environmental Science and Engineering, Inc., 1978.

Table 7.2-2 presents a summary of revenue and expense statistics for Florida Power in 1977 and 1976. The portions of operating income devoted to dividend payments, net interest payments, and retained earnings are indicated by the figures in parentheses. The procedure used in assigning non-production costs to the proposed Crystal River units is to express the actual costs for 1977 and 1976 as percentages of production and maintenance costs, and then to apply the percentages to the future production costs for the proposed units. For example, the total cost of power transmission, distribution, and administration was equal to 12.23 percent of production and maintenance cost in 1977, and 11.02 percent in 1976 (see the lower portion of Table 7.2-2). The average of these two figures, 11.625 percent, can be applied to the sum of fuel and operation/maintenance costs for the proposed units to estimate the share of future transmission, distribution, and administrative costs attributable to these units. The present worth of each of these additional cost elements is listed in the lower portion of Table 7.2-1.

The additional cost elements shown in the lower portion of Table 7.2-1 do not include interest payments or funds used for new construction (indicated by asterisks in Table 7.2-2), since these items are already covered by the capital costs listed elsewhere in Table 7.2-1. However, estimates are included for capital costs other than power generation facilities. The shares of these costs attributable to the proposed Crystal River Units 4 and 5 are assumed to equal 7 percent of the capital costs for power generation.

The outcome of these computations is that the total present worth of expenditures associated with construction and operation of the proposed units is estimated at $2,597 million in April 1978 dollars (shown in the bottom line of Table 7-2.1). The present worth of Unit 4, at approximately $1.4 billion, is substantially above the worth of $1.2 billion assigned to Unit 5. The difference is due to sharing of facilities with Unit 4 and to the fact that costs occur later for Unit 5 than for Unit 4. These present worth values are intended to cover all costs

Table 7.2-2 Recent Revenue and Expenses of Florida Power Corporation (x $1,000.00)

	1977	1976
SUMMARY OF REVENUES AND EXPENSES		
Production and maintenance expenses	317,218	305,329
Transmission, distribution, administration	38,789	33,635
Taxes payable currently	79,876	27,730
Deferred income taxes and investment tax credit (net)*	41,045	53,895
Depreciation*	54,440	41,440
Operating income	124,770	89,410
(Dividend payments)	(46,830)	(44,117)
(Net interest payments)	(49,093)	(42,722)
(Retained earnings)*	(28,847)	(2,571)
TOTAL OPERATING REVENUE	656,138	551,439
SELECTED EXPENSES AS PERCENTAGES OF PRODUCTION AND MAINTENANCE COST		
Transmission, distribution, administration	12.23%	11.02%
Taxes payable currently	25.18%	9.08%
Dividend payments	14.76%	14.45%
TOTAL	52.17%	34.55%

* These items constitute sources of funds used for construction. The figures for retained earnings do not include income other than operating revenues.

Source: Ten Year Statistical Report, 1976-1977; Florida Power Corporation.
Environmental Science and Engineering, Inc., 1978.

attributable to the proposed Crystal River Units 4 and 5, including the normal profits required to keep a private corporation such as Florida Power in operation.

7.2.2 BENEFITS OF THE PROJECT TO FLORIDA POWER CORPORATION

The sale of electricity produces benefits for both Florida Power and its customers. Benefits to Florida Power can be estimated in a more straightforward fashion than benefits to consumers and thus are considered first. A major complicating factor is the difficulty of forecasting accurately forecasting the future price of electricity. All computations of future benefits are very sensitive to the price assumed (referring to the weighted average charge per kilowatt-hour for all classes of power users). Therefore, it is necessary to consider several different price escalation rates in the analysis.

The benefits of the proposed project to Florida Power consist simply of the revenues yielded by sale of electricity from Crystal River Units 4 and 5. Table 7.2-3 presents operating statistics for Florida Power which have been used to compute the average price of electricity in 1977. Total operating revenues in that year were equal to 4.12 cents per kilowatt-hour of electricity sold, but only 3.83 cents per kilowatt-hour generated, purchased, or interchanged (the difference due to company use and losses of energy). The latter type of figure is appropriate for valuing the net output of a new generating facility.

Regarding the escalation of electricity prices over time, four separate cases have been considered as shown in Table 7.2-4. The first three cases involve constant escalation rates of 4 percent, 4.5 percent, and 5 percent, respectively, for all years subsequent to 1977. The fourth case involves an escalation rate of 6.7 percent until July 1, 1980, and 4 percent thereafter. The fourth case is intended to be consistent with recent trends in electric rates, and with the assumed escalation in fuel cost. Between 1975 and 1977, the average price of electricity sold by Florida Power increased at a rate of 6.7 percent per year. The cost analysis has assumed that the delivered cost of coal to Florida Power will increase by 10 percent per year until 1980. Thus, a continuation of the 6.7 percent rate of increase in electricity prices during 1977 to

Table 7.2-3 Selected Operating Statistics for Florida Power Corporation

Total energy generated, purchased, and interchanged	17,133.8 Gwh
Company use and losses	1,198.8 Gwh
Total energy sold	15,935.0 Gwh
Total operating revenues	$656,138,000
Revenue per kwh sold	$0.0412
Revenue per kwh generated, purchased, and interchanged	$0.0383

Source: Ten Year Statistical Report, 1976-1977; Florida Power Corporation

Table 7.2-4 Assumed Escalation Rates of Quantities Used in the Cost-Benefit Computations

Average Price of Electricity:	
Case I	4%
Case II	4.5%
Case III	5%
Case IV	6.7% before 1980 4% after 1980
Operation and Maintenance	6%
Fuel	10% before 1980 5% after 1980

Source: Environmental Science and Engineering, Inc.

1980 would imply that not all of the fuel cost increment will be passed on to Florida Power consumers.

Each of the proposed units is expected to generate an average of 3,300 Gwh of electricity per year over its 30-year active life. (Utilization of the full 640-Mw net capacity would imply power generation at a rate of 5,610 Gwh per year.) Using each of the four escalation rates listed in Table 7.2-4, the average price of electric power has been determined for every year between 1982 and 2013, based on a 1977 price of $0.0383 per kwh generated. These future prices have been multipled by 3,300 Gwh, discounted back to April 1, 1978 (using the cost of capital as the discount rate), and summed to yield a present value of electricity sales in millions of dollars. The resulting figures for each power generation unit, given each rate of price escalation, are presented in the first two columns of Table 7.2-5.

The total present worth of electricity sales in each case is presented in the third column of Table 7.2-5. The fourth column gives the present worth of project cost (from Table 7.2-1), which is the same for all four cases. The ratio of sales to cost is presented in the last column of Table 7.2-5. This ratio indicates the benefit-cost status of the project to Florida Power as a corporate entity (but not necessarily to its employees, customers, stockholders, etc.). A ratio of unity would mean that all project costs would be covered by revenues over the long run, including a reasonable return to investors. If Florida Power were a typical profit-making enterprise, a ratio greater than unity would mean that the project could be expected to yield excess profits. However, given that the company is a regulated public utility (and that any future electricity prices will be regulated prices), a value greater than unity probably indicates that the proposed project would be subsidizing other, less efficient power generation units.

The last column of Table 7.2-5 shows that the benefit-cost ratio of the project for Florida Power will be almost exactly unity in two different scenarios: (1) if electricity prices escalate at a uniform rate of 4.5

Table 7.2-5 Present Worth of Electricity Sales and Florida Power Corporation Expenditures Attributable to Crystal River Units 4 and 5

		Present Worth of Sales, in Millions of April, 1978 Dollars			Present Worth of Expenditures (Millions of Dollars) April, 1978	Sales/ Expenditures Ratio
		Unit 4	Unit 5	Total		
Assumed Rate of Escalation in the Average Sale Price of Electricity per kwh						
Case I:	4% per year	$1,262.1	$1,143.1	$2,405.2	$2,597.4	0.93
Case II:	4.5% per year	$1,361.0	$1,241.6	$2,602.6	$2,597.4	1.00
Case III:	5% per year	$1,469.7	$1,350.4	$2,820.1	$2,597.4	1.09
Case IV:	6.7% until 1980 4% after 1980	$1,362.3	$1,233.8	$2,596.1	$2,597.4	1.00

Source: Environmental Science and Engineering, Inc, 1978.

percent per year; or (2) if the price escalation rate is 6.7 percent until 1980 and 4 percent per year thereafter. A price escalation rate of 5 percent will yield a benefit-cost ratio of 1.086, whereas the ratio will be only 0.926 if electricity prices escalate at 4 percent per year.

According to these figures, it will not be necessary for Florida Power to pass on the full increases in fuel cost and operation/maintenance cost to consumers in order to break even on the proposed units. In both of the scenarios involving benefit-cost ratios near unity, the assumed escalation in electricity prices would be less than the escalation in fuel and operation/maintenance costs (except that the operation/maintenance escalation rate would be exceeded slightly during 1977-1980 in Case IV). However, it may be more likely that both the Consumer Price Index and the average price of electricity will escalate at 5 percent per year or more so that the proposed Crystal River Units 4 and 5 will occupy a role of subsidizing other facilities operated by Florida Power. In any case, it appears highly unlikely that the proposed Crystal River Units 4 and 5 will fail to yield sufficient revenue to cover all expenses attributable to these facilities.

SECTION 8A

ECOLOGICAL COMPARISON OF CRYSTAL RIVER AND PHOSPHATE ZONE SITES
(Addendum to Chapter 8)

ECOLOGICAL COMPARISON OF CRYSTAL RIVER AND PHOSPHATE ZONE SITES

In a general sense, the regions surrounding the Crystal River and the Polk County phosphate mine plant site alternatives contain the same floral and faunal assemblages. One hundred and sixteen plant species have been identified on the Crystal River site (ESE, 1977), while a similar study in the region of the phosphate mine site found 144 species (CF Development Corp., 1976). Table 8A-1 shows the number of animal species expected to be found near each site. It can be seen that both regions have similar faunal diversities and that both have similar numbers of rare or endangered species.

Of the 426 animal species which may be found on the Crystal River site, 107 were sighted during a three-day survey in August 1977 (ESE, 1977). Such a large species diversity is not unusual, considering the interspersion of several habitat types on this site. The community types on this site include pine flatwoods, evergreen oak scrub, freshwater marsh, ruderal transmission corridors, pine plantation, mesic hammock, hydric hammock, coastal hydric hammock, coastal hammock, and salt marsh. The ruderal and flatwoods areas here are in early succession states and consequently are not unique or of great value. The hammock areas, on the other hand, do contain large old-age trees, and represent mature complex systems. This is especially true of the coastal hydric hammock.

According to the Florida Power 1978 Ten-Year Site Plan, about one-third of the mine site consists of mined lands. About one-half of the area is pasture and cleared land, about 10 percent in hardwoods, and 1 percent in citrus. Due to its low diversity of habitat, its cleared expanses, and its industrial activity, this site would be expected to contain a much lower diversity of wildlife than is present. Some adaptive species such as quail, mourning dove, and eastern cottontail rabbit are abundant. Isolated or perched freshwater marshes, which usually constitute about 20 to 30 percent of the natural flatwoods in the region, are found on the site. Their precise extent would depend on how much of the pasture constitutes relaimed land. In any event, the wildlife value of

Table 8A-1 Number of Faunal Species Found in Polk and Citrus Counties

	Polk County	Citrus County
Mammals	42 (8)*	47 (10)
Birds	306 (32)	274 (24)
Reptiles	57 (7)	69 (5)
Amphibians	24 (1)	36 (3)

* Numbers in parentheses refer to number of species on the list of the Florida Committee on Rare and Endangered Plants and Animals (1977).

Sources: Archbold Biological Station, 1977.
Environmental Science and Engineering, Inc., 1977.

the marshes would probably be considered relatively low because of the altered nature and the depression of the water table in the region.

Reclaimed areas do, however, have high potential as wildlife habitat, especially around the old mine pit lakes (Archbold Biological Station, 1977). Rare or endangered species which are found here include the Florida sandhill crane, Audubon's caracara, and many wading birds. The area would have less potential for rare and endangered reptiles and amphibians.

The phosphate mine is within two miles of the Peace River. Drainage from the site historically went to this river through two creeks which have since been altered by mining. Drainage from the western portion of the site at one time went to Hookers Prairie and the South Prong of the Alafia River, but adjacent mining has altered this as well. The only significant hardwoods on the site are remnants of a creek bottom mixed swamp or bayhead which has since been largely isolated.

The alternative site in Polk County would probably present a lesser impact on wildlife and mature or unique natural ecosystems than would the Crystal River site. However, off-site impacts might counteract this advantage to some extent. Such impacts could result from effects of seepage, spills, or air emissions on the Peace River and its floodplain vegetation, construction of pipelines to bring water to the site from as far away as Tampa, and construction of new transmission systems to tie in with existing lines as far away as Lakeland. Pipeline and transmission corridors could thus alter more habitat than the site itself. Proper alignment of such corridors could, however, result in minimal habitat disruption by crossing primarily pasture and rangeland areas.

9.4.3 ALTERNATIVES CONSIDERED

9.4.3 ALTERNATIVES CONSIDERED

Water source alternatives considered ranged from salt water to brackish water to fresh water. For purposes of discussion, water sources were categorized as fresh water or salt water. The following sources were considered:

Fresh Water	Salt Water
Crystal River	Gulf of Mexico
Withlacoochee River	Withlacoochee Reach of Barge Canal
Lake Rousseau	Saline Aquifer (deep wells)
Freshwater Aquifer (shallow wells)	

Intake structure alternatives depend on the selection of the water source. Alternative structures considered were applicable only to surface water sources, and were as follows:

- Vertical traveling screens
- Double entry vertical traveling screens
- Perforated pipe
- Inclined traveling screens
- Horizontal traveling screens

Freshwater Alternatives

Freshwater sources include the Crystal River, 4.8 kilometers (3 miles) to the south, and the Withlacoochee River and Lake Rousseau, 6.4 and 5.8 kilometers (4 and 3.6 miles) to the north and northwest, respectively, and a well field 9.2 kilometers (5.7 miles) to the east of the plant site (Figure 9.4-1). In each case, 76.2-centimeter (30-inch) diameter reinforced concrete pipe would be used to convey the raw water to the plant site.

Crystal River

Crystal River as a source of cooling water was considered with an intake structure at a site approximately 4 kilometers (2.5 miles) downstream (west) of the town of Crystal River. The Crystal River runs from several head springs at Kings Bay, westward to the Gulf of Mexico. The maximum flow during normal tides is about 112 cubic meters (4,000 cubic feet) per second, 9,780,000 cubic meters (2,584 million gallons) per day. Interactions of wind and tidal forces result in complex mixing processes between fresh spring water and estuarine water causing large salinity variations (ESE, 1977). The river contains many aquatic weeds including Hydrilla. A wide variety of aquatic organisms are found in the river including freshwater and estuarine forms. The endangered manatee is common in the river. The river acts typically as a home for many planktonic eggs, larvae, and juveniles of many estuarine species. Preliminary studies suggest that at some seasons of the year, young, entrainable forms of Anchoa sp. (anchovies) and Callinectes sapidus (blue crabs) are present at the proposed intake site.

The Crystal River pumping facility for cooling water makeup consists of an intake structure housing either three vertical traveling screens or three double entry traveling screens with three 50 percent capacity vertical pumps, each rated at 28 cubic meters (7,500 gallons) per minute. Approximately 16,500 meters (54,000 feet) of piping are required to convey the river water to the plant site.

Lake Rousseau

Lake Rousseau is an artificial impoundment of the Withlacoochee River which was created by Florida Power Corporation in 1909 for hydroelectric power generation. During the 1960's, the lake became part of the U.S. Army Corps of Engineers Cross Florida Barge Canal project. The lake was modified for the barge canal project with the construction of the Inglis Lock, the Withlacoochee River Bypass Canal and the Gulf of Mexico reach of the barge canal (which lies west of the lake). The construction of

the present structures at the Inglis Lock and bypass canal were completed in 1969. The barge canal project has been terminated by President Carter due to environmental and political controversy. Studies and discussions are in progress to decide final disposition of the barge canal project including those structures on or abutting Lake Rousseau.

An area of the lake east of the Inglis Dam has been chosen by Florida Power as the general location of a proposed cooling water intake structure. This area extends from the dam upstream about 2.4 kilometers (1.5 miles) and has been the site of detailed multidisciplinary studies by ESE (1978).

The lake is part of a system modified by the construction of the Withlacoochee Reach of the Cross Florida Barge Canal. Opening of the canal and a northern bypass for the Withlacoochee River has considerably reduced the flow of water through the southwestern arm of the lake where an intake is presently proposed. Drawing the water volume estimated by Black and Veatch (1977) for cooling would increase the flow in this arm of the lake. This would perhaps resuspend sediments currently stored on the lake bed but ultimately may cause hydrodynamic conditions in the lake to be more like those before the Inglis Bypass was opened.

The bathymetry of Lake Rousseau is shown as a drowned river valley. Depth contours are widely spaced from the shoreline to the old river channel. At the river channel the isobaths are closely spaced indicating a V-shaped channel. The old river channel meanders tortuously through Lake Rousseau indicating a complete lack of structural and bedrock control. Several meander "necks" and "cutoffs" (as defined by Thornbury, 1954) indicate that the Withlacoochee was developing a valley flat prior to its flooding.

By planimetry the volume of Lake Rousseau [at 8.2 meters (27 feet) mean sea level] was found to be in excess of 3.1×10^7 cubic meters (25,000 acre-feet). The surface area of the lake, excluding marshy areas, is approximately 1,200 hectares (3,000 acres). Compared to the

annual excess flow through the lake of 9.0×10^8 cubic meters per year (730,000 acre-feet/year, Geraghty and Miller, 1977), the storage volume is small. This fact is critical in assessing the availability of water in the lake for consumptive use (ESE, 1978).

Sufficient water appears to be available from Lake Rousseau for cooling purposes. Based on USGS figures, the proposed project would require a maximum consumptive use of 76,000 cubic meters (20 million gallons) per day; and according to USGS figures, this is 3.3 percent of the Withlacoochee River 100-year low flow (ESE, 1977).

Shallow Well Fields

Well fields were discussed as an alternative in a report prepared by Geraghty and Miller, Inc. (1977), consulting groundwater geologists and hydrologists.

The well field would be located 8.7 kilometers (5.4 miles) east of the plant site to minimize the potential for horizontal saltwater intrusion. The characteristics of the aquifer in the area, as estimated by Geraghty and Miller from a flow net analysis, should be adequate to support the proposed withdrawal.

An aquifer test performed by Geraghty and Miller (1978) obtained much lower transmissivity values suggesting that groundwater flow to Crystal River may occur through solution channels or local zones of high permeability.

If high transmissivity zones were encountered in the well field, the field could require as few as five wells. However, in the absence of verification of this transmissivity data and based upon aquifer coefficients from the aquifer test, the conceptual well field would require a linear arrangement of 139 wells spaced 152 meters (500 feet) apart in order to produce the desired yield of 76 million liters per day (20 million gallons per day) and comply with Southwest Florida Water

Management District Rules and Regulations. Each well would produce 380 liters per minute (100 gallons per minute). The transmission line would amount to approximately 21 kilometers (13 miles) of pipe in the well field itself and another 8 kilometers (5 miles) of pipe to convey the water to the plant site.

Withlacoochee River

The Withlacoochee River is 6.4 kilometers (4 miles) to the north of the Crystal River plant site. It drains an area of approximately 518,000 hectares (1,280,000 acres) in its 256-kilometer (159-mile) course. Average discharge is about 1,938 cubic meters (512,000 gallons) per minute. Most of this flow goes into Lake Rousseau which has inundated a stretch of the old river channel. The majority of the inflow to Lake Rousseau goes into the barge canal and is then diverted above the Inglis Lock into the Withlacoochee Bypass Canal and is discharged back into the existing river channel downstream from Lake Rousseau. About 723 cubic meters (191,000 gallons) per minute below the Inglis Dam is diverted back into the barge canal.

Although no pumping facilities design is available at this time, it is assumed that it would be similar to the one proposed for the Crystal River pumping facility.

Saltwater Alternatives

Sources of saltwater cooling are (1) the Gulf of Mexico, (2) the Withlacoochee Reach of the Cross Florida Barge Canal, and (3) the saline aquifer (deep wells).

SECONDARY COOLING TOWER MAKEUP ALTERNATIVES:

REPORT OF THE LAKE ROUSSEAU STUDIES

SECONDARY COOLING TOWER MAKEUP ALTERNATIVES:

REPORT OF THE LAKE ROUSSEAU STUDIES

JUNE, 1978

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I. INTRODUCTION

OBJECTIVES

Environmental Science and Engineering, Inc. (ESE) has been contracted by Florida Power Corporation (FPC) to perform environmental studies and analyses in pursuit of approval of Crystal River Units 4 and 5. As part of this program, which is directed by EPA Region IV under the third party EIS process, ESE must evaluate alternative sources of cooling water. The purpose of this report is to present information on Lake Rousseau as an alternative source of cooling tower makeup.

A preliminary survey of Lake Rousseau and the Crystal River was conducted by ESE in September, 1977, and the results were presented in a report entitled "Secondary Cooling Tower Makeup Alternatives: Report of the Preliminary Studies of Lake Rousseau and Crystal River." After publication of the report, Lake Rousseau was selected as the more feasible source of cooling water and further study of Crystal River was discontinued. In September 1977, Florida Power funded a detailed Lake Rousseau study designed by ESE to evaluate the environmental impacts of water withdrawals from the lake and to recommend an optimal location for the proposed intake structure.

SITE LOCATION

The location of the study area is shown in Figure I-1. Lake Rousseau, which is an artificial impoundment of the Withlacoochee River, was dammed by Florida Power in 1909 for hydroelectric power generation. During the 1960's, the lake became part of the U.S. Army Corps of Engineers Cross-Florida Barge Canal project. The lake was modified for the barge canal project with the construction of the Inglis Lock, the Withlacoochee River bypass canal, and the Gulf of Mexico reach of the barge canal (which lies west of the lake). The construction of the present structures at the Inglis Lock and bypass canal were completed in 1969. Because of environmental and political controversy, the barge canal project has been terminated by President Carter. Studies are in progress to decide final disposition of the barge canal project, including the structures on or abutting Lake Rousseau.

An area of the lake east of the Inglis Dam has been chosen by Florida Power as the general location of a proposed cooling water intake structure. This western embayment area of the lake (see Figure I-1) extends upstream about 2.4 kilometers (1.5 miles) from the dam and has been the site of detailed multidisciplinary studies by ESE. Bimonthly biological and water chemistry field sampling trips were conducted in October 1977, December 1977, February 1978, and April 1978. Physical systems studies such as bathymetry and water circulation experiments have been conducted to observe the lake during selected meteorological and seasonal conditions. In the following sections, summaries of the important data collected are presented.

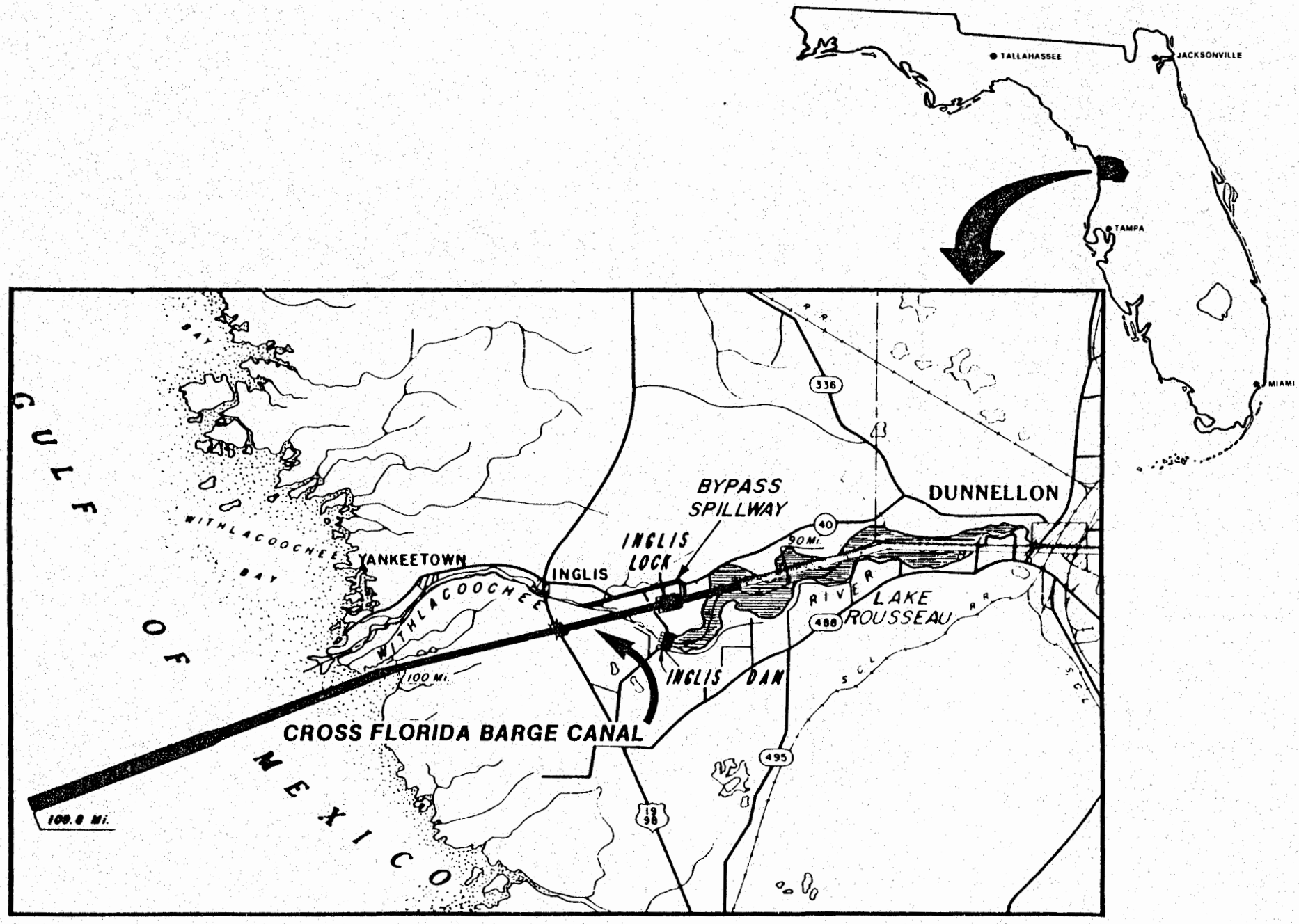


FIGURE I-1
LAKE ROUSSEAU STUDY AREA

II. ENVIRONMENTAL SETTING

WATER RESOURCES, PHYSICAL SYSTEMS

HYDROLOGY

BATHYMETRY

A bathymetric survey of Lake Rousseau has been conducted in support of the lake studies. The completed map (see foldout pocket map) shows the lake topography from the Inglis Dam to the confluence of the Withlacoochee River and the Blue Run at Dunnellon. This mapped area corresponds closely with the 100-year, modified flood-pool boundaries reported by Geraghty and Miller, et al. (1977). During field mapping, the lake was regulated by the Army Corps of Engineers at approximately 8.38 meters msl (27.5 feet msl). The pool elevation is controlled by the operation of spillways at Inglis Dam and by the Cross Florida barge canal bypass.

The bathymetric maps of Lake Rousseau demonstrate that the lake geomorphology is that of a drowned river valley. The isobaths (depth contours) are widely spaced from the shoreline to the old river channel. At the river channel the close spacing of the isobaths represent a well-defined channel. The old river channel, which meanders through Lake Rousseau, indicates a complete lack of structural and bedrock control. Several meander "necks" and "cutoffs" (as defined by Thornbury, 1954) provide evidence that the Withlacoochee was developing a valley flat prior to its flooding.

The average depth of Lake Rousseau at pool elevation [8.38 meters msl (27.5 feet msl)] was calculated from the ESE survey to be 2.6 meters (8.7 feet) and the surface area, excluding marshy areas, was calculated by planimetry to be 1,170 hectares (2,889 acres). The volume of the lake was calculated to be more than 3,100,000 cubic meters (25,000 acre-feet) (see Table II-1).

Table II-1 Lake Rousseau Water Management Data

Storage (excluding marsh areas)*	
Surface Area	2,889 acres
Volume @ 27.5 ft. msl pool elevation	25,092 acre-feet
Average Depth	8.7 feet
Inflow Data	
Average Annual Inflow †	1,863 cfs
Rainbow Springs	
Average Annual Consecutive 7-day, Low Flow (1965-1974)**	685 cfs
Average Annual Consecutive 30-day, Low Flow (1965-1974)**	694 cfs
Withlacoochee River at Holder	
Average Annual Consecutive 7-day Low Flow (1933-1974)††	391 cfs
Average Annual Consecutive 30-day Low Flow (1933-1974)††	437 cfs

SWFWMD Minimum Wet Season Flow Requirements 1956-1975*** (cfs)

Oct.	888
Nov.	817
Dec.	750
Sept.	851

SWFWMD Minimum Dry Season Flow Requirements 1956-1975*** (cfs)

Jan.	916	May	734
Feb.	902	Jun.	778
Mar.	821	Jul.	863
Apr.	789	Aug.	950

* From ESE Bathymetric Survey.
† Average of 20 years record USGS data Withlacoochee River at Holder plus Rainbow Springs, 1955-1974.
** Mean of low flows during (1965-1974).
†† Mean of low flows during (1933-1974)
***Calculated in accordance with SWFWMD Rules and Regulations, 16J-0.15.

Sources: USGS, 1974.
Environmental Science and Engineering, Inc., 1977.

HYDROLOGIC BUDGET

The hydrologic budget of Lake Rousseau was evaluated to determine the availability of water for consumptive use. This section presents an analysis of the existing and historical hydrologic regimes and treats the data as estimations and predictions of potential flows.

The Withlacoochee River is the major source of surface water inflow to Lake Rousseau. The USGS considers this inflow the total of the flows on the Withlacoochee at Holder combined with the spring discharge as measured at Rainbow Springs. Discharges of the Withlacoochee at Dunnellon display backwater effects of Lake Rousseau and cannot be used for inflow computations (USGS, 1966). Table II-2 presents the monthly and annual average discharges of the Withlacoochee River at Holder plus Rainbow Springs from 1932 to 1975.

The flows discharged from Lake Rousseau from 1909 until 1969 were measured by the USGS at the Inglis Dam. Since completion of the Cross-Florida Barge Canal in 1969, discharges from the lake have been gaged at the bypass canal, at the Army Corps of Engineers Lock, and at the Inglis Dam.

Since the future status of the barge canal is unclear, all discussions of outflow in this analysis relate to the sum of the three outflows described above (i.e., locks, bypass canal, and Inglis dam). The sum of these three outflows are considered to apply to all future minimum flow requirements except in the case of a fully operational canal (where 350 cfs are allocated to the Lower Withlacoochee). Some flow does go through the Inglis Lock and varies from 0 to 50 cfs. Most of the outflow from Lake Rousseau is diverted through the bypass canal associated with the barge canal. The bypass canal ultimately discharges back into the Withlacoochee River at a point downstream from the barge canal and prior to Inglis.

Table II-2. Estimated Monthly and Annual Discharge, in Cubic Feet Per Second of Withlacoochee River, at Dunnellon, Florida (Calculated as Flows on Withlacoochee River at Holder plus Rainbow Springs).

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Annual
1932	1500	1144	1110	920	928	898	829	728	919	836	804	1075	975
1933	783	830	814	702	745	831	1001	976	817	1367	2151	4682	1307
1934	4740	2413	1718	1457	1273	1230	1165	1455	2685	6689	4393	3186	2717
1935	2912	1809	1416	1386	1265	1058	948	936	843	1024	1473	3083	1513
1936	3657	2357	1742	1813	2774	3427	2789	1895	1650	1841	1837	1639	2284
1937	1797	1583	1366	1287	1262	1353	1633	1551	1360	1263	1926	3070	1621
1938	2891	2317	2374	1935	1568	1322	1135	945	1108	1871	1914	1929	1779
1939	2135	2234	1760	1454	1291	1096	1022	1054	1145	1763	2640	3064	1723
1940	2692	1744	1419	1277	1280	1280	1190	1122	1108	1695	1882	1848	1546
1941	1453	1074	960	1124	1432	1815	2414	1898	1303	1368	2065	1721	1552
1942	1507	1637	1726	2087	1934	2320	2251	1607	1685	2334	2200	2193	1949
1943	1804	1369	1253	1197	1092	958	1058	997	918	1603	2780	3312	1538
1944	2391	1578	1266	1157	1001	961	939	809	778	951	1519	1938	1275
1945	1810	2604	1698	1412	1259	1052	928	846	884	2459	5315	5618	2162
1946	4264	2488	1945	2056	1890	2614	1849	1514	1351	1547	2435	2528	2211
1947	3015	2137	1536	1419	1358	1666	1911	1525	1380	1785	2690	3269	1977
1948	3956	3022	2253	1940	2403	2345	1954	1525	1344	1466	3465	4250	2492
1949	3566	2426	1920	1636	1439	1197	1161	1268	1379	1379	2289	4847	2035
1950	5180	3029	2129	1892	1550	1429	1232	1067	1022	1171	1429	4571	2144
1951	4403	2811	2156	2128	1921	1617	1466	1371	1157	1193	1417	1630	1940
1952	2044	1699	1905	1611	1751	2198	2241	1605	1487	1403	1367	1445	1729
1953	1783	1789	1425	1377	1300	1235	1440	2000	1405	1492	2439	4185	1822
1954	5452	2550	3338	3679	2512	1979	1566	1361	1275	1339	1681	1355	2429
1955	1255	1256	1218	1155	1185	1061	936	854	851	951	1212	1709	1136
1956	1551	1090	1006	977	1035	849	799	724	645	652	731	818	906
1957	1011	1398	939	728	720	745	937	956	1133	1169	1832	2326	1158
1958	2737	1653	1186	1432	1684	3105	3327	2218	1556	1743	1983	1594	2020
1959	1551	1887	1576	2020	1940	2861	4999	3827	3050	3766	4750	4962	3101
1960	4930	3832	2660	2202	2425	4994	7937	3831	2683	2924	6315	6177	4242
1961	7140	3979	2568	2353	2285	1858	1520	1279	1297	1383	1631	1809	2429
1962	1455	1291	1167	1146	1129	1040	926	745	807	1067	1090	1363	1101
1963	1475	1237	1093	1108	1482	1890	1457	1053	1017	1091	1223	1238	1272
1964	1266	1092	1150	1631	2647	2255	2129	1947	1419	1614	2294	3841	1935
1965	4336	2374	2057	1938	1904	2013	1617	1372	1497	1773	3678	3582	2349
1966	2844	2124	1891	1891	2164	2911	2298	1771	1894	2997	3389	3578	2479
1967	3824	2385	1780	1681	1694	1600	1339	1124	1147	1275	1960	2798	1884
1968	1879	1324	1238	1162	1082	1119	912	880	1140	2047	2272	3378	1536
1969	2903	2659	2683	3692	4201	3818	3035	1911	1739	1636	1965	1895	2678
1970	1755	1494	1295	1327	1634	1356	1192	1017	1053	1169	1947	2505	1479
1971	2062	1604	1426	1297	1466	1340	1555	1226	1296	1218	1256	1355	1425
1972	1174	1123	1284	1392	1675	1517	1563	1315	1145	1243	1461	1818	1393
1973	1800	1326	1275	1296	1170	1110	1022	907	1088	2279	3190	2701	1597
1974	2000	1442	1301	1215	1137	1013	890	825	767	818	982	1303	1141
1975	1433	1399	1175	1132	1036	914	857	1010	1403	1865	2056	1902	1349

Source: USGS, Water Resources Division, 1976.

Some water (70 cfs) continues to leak through Inglis Dam at all times and proceeds through the stretch of the Withlacoochee River between Lake Rousseau and the barge canal where it is discharged. The quantity of water flow does from time-to-time increase to values nearly equal to those of the bypass canal (on the order of 1,000 cfs).

An earthen dam is located between the barge canal and the lower Withlacoochee River and serves as a salt water intrusion control structure.

The hydrologic budget of a water body is calculated according to the following equation:

$$(1) \quad \Delta S = (I+P+G) - (O+ET+S)$$

where ΔS is the change in storage volume, I is inflow, P is precipitation, G is groundwater infiltration, O is outflow, ET is evapotranspiration, and S is seepage loss.

Several studies (Geraghty and Miller, et al., 1977; Meta Systems, 1976; USGS, 1966) have reported that the variability of Lake Rousseau outflows can be explained by inflows. To test this assumption, various statistical techniques can be employed. Table II-3 lists regression parameters of a linear correlation between the inflow and outflow data from 1965-1974. The correlation coefficient, r, is a bivariate measure of association which can range from +1 for perfect association to -1 for perfect negative association. The significance of r in Table II-3 is to measure the interrelationship of the historical inflow and outflow data. Since the r values shown are approximately equal to 1, it appears that the inflow data represent nearly total cause of the outflow data. If inflow was the entire cause of the outflow, r and r^2 (coefficient of determination) would equal 1. The r and r^2 values for all months display high degrees of association.

A least squares analysis of the data resulted in the regression line plotted in Figure II-1. For comparison, the line of equal flows is shown. The ellipse represents the 95 percent confidence region for the

Table II-3. Regression Parameters: Flow at Inglis Dam on Flow at Holder and Rainbow Springs Discharge, Period of Record 1965-1974

Month	r	r^2*	b_0**	b_1**	b_2**	Standard Error of Estimate
January	.998	.996	-458.	.929	1.669	60.63
February	.999	.999	581.	1.128	- .099	37.19
March	.997	.995	-574.	.838	2.026	73.33
April	.998	.996	-886.	.652	2.686	48.30
May	.998	.997	- 3.	.912	1.013	20.43
June	.987	.974	249.	1.097	.463	46.17
July	.992	.985	193.	.905	.707	55.21
August	.997	.994	-683.	.964	1.925	61.68
September	.964	.929	54.	.825	1.147	135.44
October	.993	.987	710.	.869	.202	54.02
November	.998	.997	107.	.952	.864	28.05
December	.996	.993	-164.	.448	1.662	26.96

*r^2 is the coefficient of determination, which is a statistical measure of the proportion of inflow determined by variation of the outflow. r^2 ranges from zero (meaning none of the variation of inflow can be explained by the outflow) to one (in which inflow variation is all explained by outflow).

**b_0, b_1, and b_2 are linear model parameter estimates which are incorporated in Bivariate Predictive Linear Model equation:

$$Y_j = b_0 + b_1X_{j1} + b_2X_{j2} + e_j$$

where: X_{j1} is the flow (cfs) during month j for the Withlacoochee River at Holder;
X_{j2} is the flow (cfs) during month j of Rainbow Springs;
Y_j is the flow (cfs) during month j at Inglis Dam;
e_j is an error term for month j reflecting other factors affecting flows.

Source: Meta Systems, Inc., 1976.

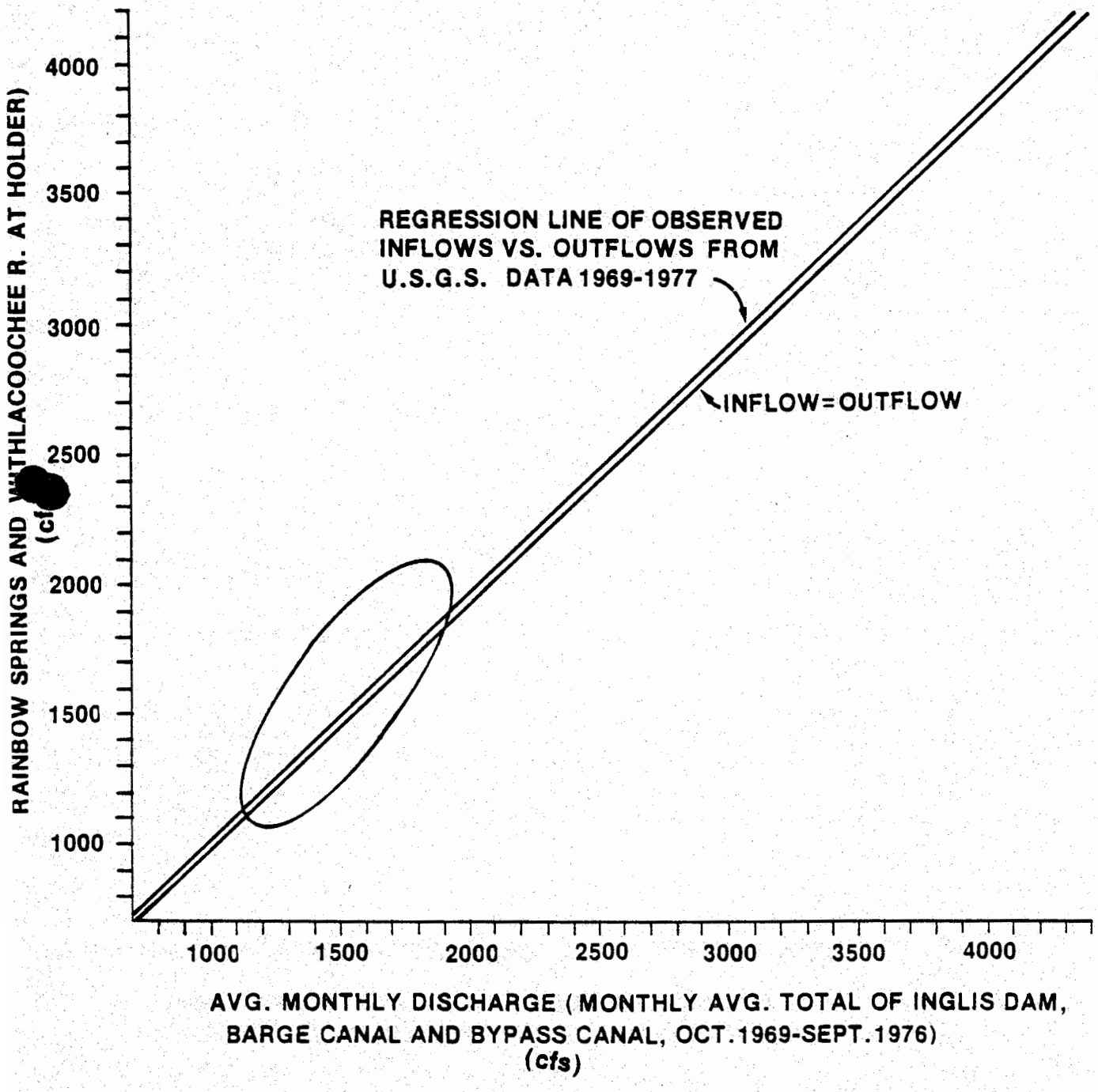


FIGURE II -1

BIVARIATE INFLOW - OUTFLOW RELATIONSHIPS OF LAKE ROUSSEAU

bivariate mean in accordance with the procedures of Sokal and Rohlf (1969).

The USGS (1966) reported that discharges below 57 cms (2,000 cfs) showed the greatest deviation from a linear response (inflow=outflow). In the present analysis, the confidence region occurs between 30 cms (1,050 cfs). and 59 cms (2,100 cfs) for inflow data and 31 cms (1,100 cfs) and 54 cms (1,925 cfs) for outflow data. The inflow-outflow relationship, therefore, appears more predictable and closer to a linear function than previously thought.

The near equality between inflows to and outflows from Lake Rousseau implies that on the average the evapotranspiration, precipitation, seepage, and infiltration terms are either negligible or compensatory. Therefore, the hydrologic equation describing the change in storage of Lake Rousseau can be reduced to $\Delta S = I-O$.

Table II-4 is a summary of capacity rating data for Lake Rousseau for a range of gage heights. Based on 21 months of data and the capacity rating table, the change in storage bears no relationship to the inflows (USGS, 1966). To test the USGS finding, Figure II-2 plots monthly average gage heights versus time for the water years 1972-1976. The 1- through 5-month lowest flows are bracketed on the time scale and show no correlation with gage heights.

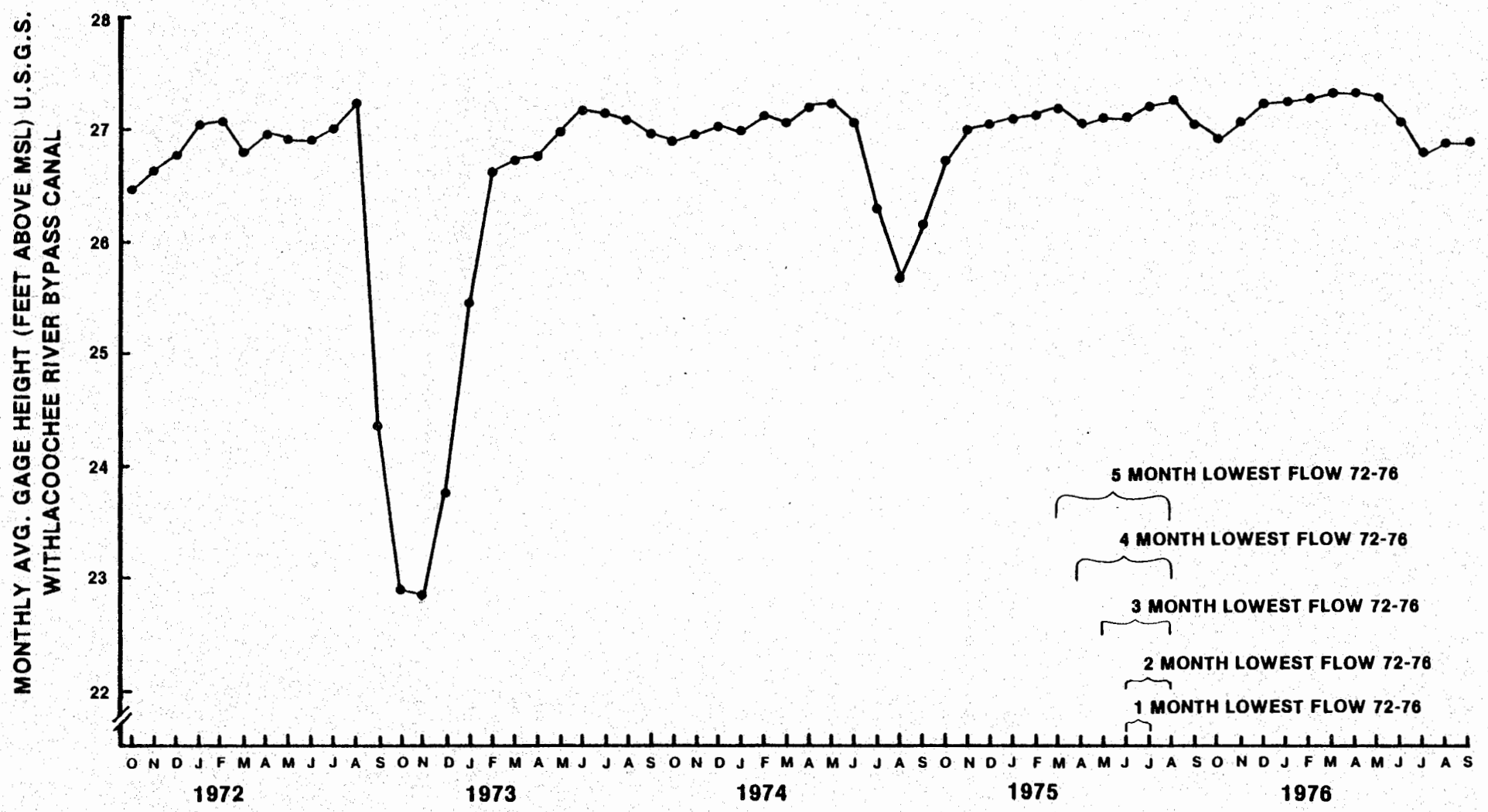
Lake levels are presently controlled by the Army Corps of Engineers at the Inglis Lock and are normally maintained at 8.38 meters msl (27.5 feet msl). During circulation studies of Lake Rousseau in February 1978, lake levels were observed to fluctuate over 5 centimeters (2 inches) by wind set-up and depression. This observation demonstrates that the lake levels presently fluctuate due to outflow regulation and wind-water interactions. Regulation of levels during extreme low flows is not necessary (USGS, 1966). During such times, the lake may be

Table II-4 Capacity Rating Table for Lake Rousseau Near Dunnellon, Florida (after Preliminary Report on Flood Control Problems, Withlacoochee River, Florida--1961, by Connell and Associates)

Gage Height Feet	Capacity Acre-Feet	Gage Height Feet	Capacity Acre-Feet	Gage Height Feet	Capacity Acre-Feet	Gage Height Feet	Capacity Acre-Feet	Gage Height Feet	Capacity Acre-Feet
20.00	0	22.00	4400	24.00	9600	26.00	15600	28.00	22800
20.10	220	22.10	4640	24.10	9900	26.10	15960	28.10	23220
20.20	440	22.20	4880	24.20	10200	26.20	16320	28.20	23640
20.30	660	22.30	5120	24.30	10500	26.30	16680	28.30	24060
20.40	880	22.40	5360	24.40	10800	26.40	17040	28.40	24480
20.60	1100	22.50	5600	24.50	11100	26.50	17400	28.50	24900
20.60	1320	22.60	5840	24.60	11400	26.60	17760	28.60	25320
20.80	1540	22.70	6080	24.70	11700	26.70	18120	28.70	25740
20.80	1760	22.80	6320	24.80	12000	26.80	18480	28.80	26160
20.90	1980	22.90	6560	24.90	12300	26.90	18840	28.90	26580
21.00	2200	23.00	6800	25.00	12600	27.00	19200	29.00	27000
21.10	2420	23.10	7080	25.10	12900	27.10	19560	29.10	27500
21.30	2860	23.20	7360	25.20	13200	27.20	19920	29.20	2800
21.30	2860	23.30	7640	25.30	13500	27.30	20280	29.30	28500
21.40	3080	23.40	7920	25.40	13800	27.40	20640	29.40	29000
21.50	3300	23.50	8200	25.50	14100	27.50	21000	29.50	29500
21.60	3520	23.60	8480	25.60	14400	27.60	21360	29.60	30000
21.70	3740	23.70	8760	25.70	14700	27.70	21720	29.70	30500
21.80	3960	23.80	9040	25.80	15000	27.80	22080	29.80	31000
21.90	4180	23.90	9520	25.90	15300	27.90	22440	29.90	31500

Note: Datum is mean sea level.
Datum applies to tenths of a foot throughout.

Source: USGS, 1966.



SOURCE: U.S.G.S., WATER RESOURCES DATA FOR FLORIDA, 1972-1976

FIGURE II-2

MONTHLY GAGE HEIGHTS 1972 - 1976 AT THE WITHLACOOCHEE RIVER BYPASS CANAL

maintained at the above mentioned levels while a continuous flow of water enters from Rainbow Springs and the Upper Withlacoochee and a virtually equal flow exits via Inglis Dam, the barge canal locks, and the bypass canal to the Lower Withlacoochee.

The summary of Lake Rousseau water management data presented in Table II-1 includes the key area, volume, and inflow characteristics of the lake. Inflow volumes compared to the storage volume of Lake Rousseau are relatively large (average residence time = 6.8 days) because the storage capacity is not sufficient to retain high flows. Consequently, high flow rates proceed through the lake unattenuated (USGS, 1966). Also periods of extreme low flow [such as the lowest monthly flow, 20 cms (700 cfs), January, 1933] are not critical to the storage volume since pool elevation is maintained by control structures.

The variability of flows into Lake Rousseau is controlled by the combined discharges of the Withlacoochee River (as measured at Holder) and Rainbow Springs. Rainbow Springs is a first order spring with annual average discharges of 20 cms (723 cfs), average annual maximum discharges of 35 cms (1230 cfs), and average annual minimum discharges of 14 cms (487 cfs) (1932-1964). Flows of the Withlacoochee River at Holder display greater variability, as is characteristic of surface water flows in Central Florida. Consecutive 7-day and 30-day low flow conditions for each year between 1933 and 1974 are shown in Table II-5.

The groundwater discharge rates from Rainbow Springs exhibit a normal distribution and low variability. Therefore, during low flow conditions, a substantial amount of water enters Lake Rousseau from this source. Low flow data from the Withlacoochee River exhibit a lognormal distribution and a great variability. For this reason, the low flows during some years will be many times higher than the low flows for the other years. Frequencies, probabilities, and magnitudes of monthly low flow conditions of the Withlacoochee at Dunnellon are presented in Table II-6.

Table II-5 Consecutive 7-day and 30-day Low Flows Occurring in Water Years 1933 through 1974

Year	Holder Withlacoochee River 7-day low (cfs)	Holder Withlacoochee River 30-day low (cfs)	Rainbow Springs 7-day low (cfs)	Rainbow Springs 30-day low (cfs)
1933	164	196		
1934	308	465		
1935	214	258		
1936	355	486		
1937	535	570		
1938	324	344		
1939	324	368		
1940	281	346		
1941	314	351		
1942	621	694		
1943	215	267		
1944	176	194		
1945	153	160		
1946	557	620		
1947	567	602		
1948	467	552		
1949	341	368		
1950	331	354		
1951	416	433		
1952	418	432		
1953	514	536		
1954	517	566		
1955	220	233		
1956	119	131		
1957	135	148		
1958	489	540		
1959	617	670		
1960	1,200	1,310		
1961	464	501		
1962	151	165		
1963	397	425		
1964	392	458		
1965	473	499	825	830
1966	788	877	814	821
1967	373	391	690	695
1968	193	244	606	610
1969	549	576	644	692
1970	479	500	728	730
1971	208	330	678	680
1972	409	485	648	652
1973	356	380	643	649
1974	298	312	578	580
N*	42	42	10	10
$\overline{X}$†	391	437	685	694
SD(X)**	201	215	82.1	81.6

*N is the number of samples.
†$\overline{X}$ is the mean.
** SD(X) is the standard deviation.

Source: Meta Systems, 1976.

Table II-6 Frequency, Probability, and Magnitude of Monthly Discharges (cfs), Low Flow of Withlacoochee River at Dunnellon, Florida, Water Years 1932-1965 (Withlacoochee River at Holder Plus Rainbow Springs)

Percent Probability	Recurrence Interval	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
2.9	35.0	783	830	814	702	720	745	799	724	645	652	731	818
5.7	17.5	1,010	1,070	939	728	745	831	829	728	778	836	804	1,080
8.5	11.7	1,260	1,090	960	920	928	849	926	745	807	951	1,090	1,240
11.4	8.75	1,270	1,090	1,010	977	1,000	898	928	809	817	951	1,210	1,360
14.3	7.00	1,450	1,140	1,090	1,110	1,040	958	936	846	843	1,020	1,220	1,360
17.2	5.83	1,460	1,240	1,110	1,120	1,090	961	937	854	851	1,070	1,370	1,440
20.0	5.00	1,480	1,260	1,150	1,150	1,130	1,040	939	936	884	1,090	1,420	1,590
22.8	4.38	1,500	1,290	1,170	1,160	1,180	1,050	948	945	918	1,170	1,430	1,630
25.7	3.89	1,510	1,370	1,290	1,160	1,260	1,060	1,000	956	919	1,170	1,470	1,640
28.6	3.50	1,550	1,400	1,220	1,200	1,260	1,060	1,020	976	1,020	1,190	1,520	1,710
31.4	3.18	1,550	1,580	1,250	1,280	1,260	1,100	1,060	997	1,020	1,260	1,630	1,720
34.2	2.92	1,780	1,580	1,270	1,290	1,270	1,200	1,140	1,050	1,110	1,340	1,680	1,810
37.2	2.69	1,800	1,640	1,370	1,380	1,280	1,230	1,160	1,050	1,110	1,370	1,830	1,850
40.0	2.50	1,800	1,650	1,420	1,390	1,290	1,240	1,160	1,070	1,130	1,370	1,840	1,930
42.9	2.33	1,180	1,700	1,420	1,410	1,300	1,280	1,190	1,120	1,140	1,380	1,880	1,940
45.7	2.19	2,040	1,740	1,420	1,420	1,360	1,320	1,230	1,270	1,160	1,380	1,910	2,190
48.5	2.06	2,140	1,790	1,540	1,430	1,430	1,350	1,440	1,280	1,280	1,400	1,930	2,330
Median	2.00	2,260	1,800	1,560	1,440	1,440	1,390	1,450	1,320	1,280	1,430	1,950	2,430

Recurrence Interval = $\frac{n+1}{m}$, where m=34 years, n=order number.

Source: USGS, 1966, with additional computations by ESE.

The low discharge frequency relationships, probabilities for return periods, and confidence limits are presented in Table II-7. The discharge frequencies of annual floods from the combined Rainbow Springs and Withlacoochee River inflows, which are presented in Figure II-3, also exhibit a log-normal distribution.

The present discussion can be extended from the existing and historical conditions to future projections of conditions based upon hydrologic and demographic factors. Municipal use of Lake Rousseau waters in future years can be predicted from population growth and per capita consumption. Industrial and agricultural uses at some future date cannot be forecast with any precision.

During Cross-Florida Barge Canal studies, the flows of water through Lake Rousseau were investigated for natural conditions (no canal 1985-2035) and for different degrees of lock usage. The natural flows were determined from historical records. Consumptive uses for municipal, agricultural, and industrial purposes were projected by regression analysis (Meta Systems, 1976) of existing trends. Table II-8 lists estimated mean flows discharged from Lake Rousseau for ten-year intervals from 1985 to 2035. The mean outflows decline progressively due to consumptive use at a rate of 0.02 cms (0.55 cfs) per year. At this rate, the decline in the average annual outflow is 0.79 cms (28 cfs) over a 50-year period and is quite small (1.8 percent) compared to the overall flow.

Included in Table II-8 are low flows which would be encountered during a drought equal in magnitude to that of June 1956 to May 1957. The values reflect the low flows of such a drought if it occurred during 2035 (difference is due to consumptive uses). The flows would not affect the operating level of the lake, but would cut the average flow through the Withlacoochee in half. A frequency analysis of historical data indicates that there is a probability greater than 0.50 that such a drought will occur once in 50 years (Meta Systems, 1976). Therefore, the chances are about 50 percent that a long-term user like a power

Table II-7 Low Discharge Frequency Relationships and Probabilities for the Return Periods

Low Discharge--Frequency Relationships* Return Period	F†	Withlacoochee at Holder 1932-74 cfs	Rainbow Springs 1965-74 cfs
Once in 2 years	0.50	1,027	774
Once in 4 years	.25	754	713
Once in 10 years	.10	571	657
Once in 25 years	.04	461	615
Once in 50 years	.02	402	587
Once in 100 years	.01	355	562

*Assuming normal populations for flow from springs discharges and log normal populations for other stream flows.
†Probability that stated flow level will not be exceeded in any given year.

Fifty Percent Confidence Limits for Return Periods and Confidence Limits of Observed Minimum Annual Flow

	Withlacoochee at Holder	Rainbow Springs
Length of record, years	43	10
Minimum annual flow, cfs	333	654
Fifty percent confidence limit		
Lower limit, years	32	8
Upper limit, years	150	35

Source: Meta Systems, 1976.

Figure II-3

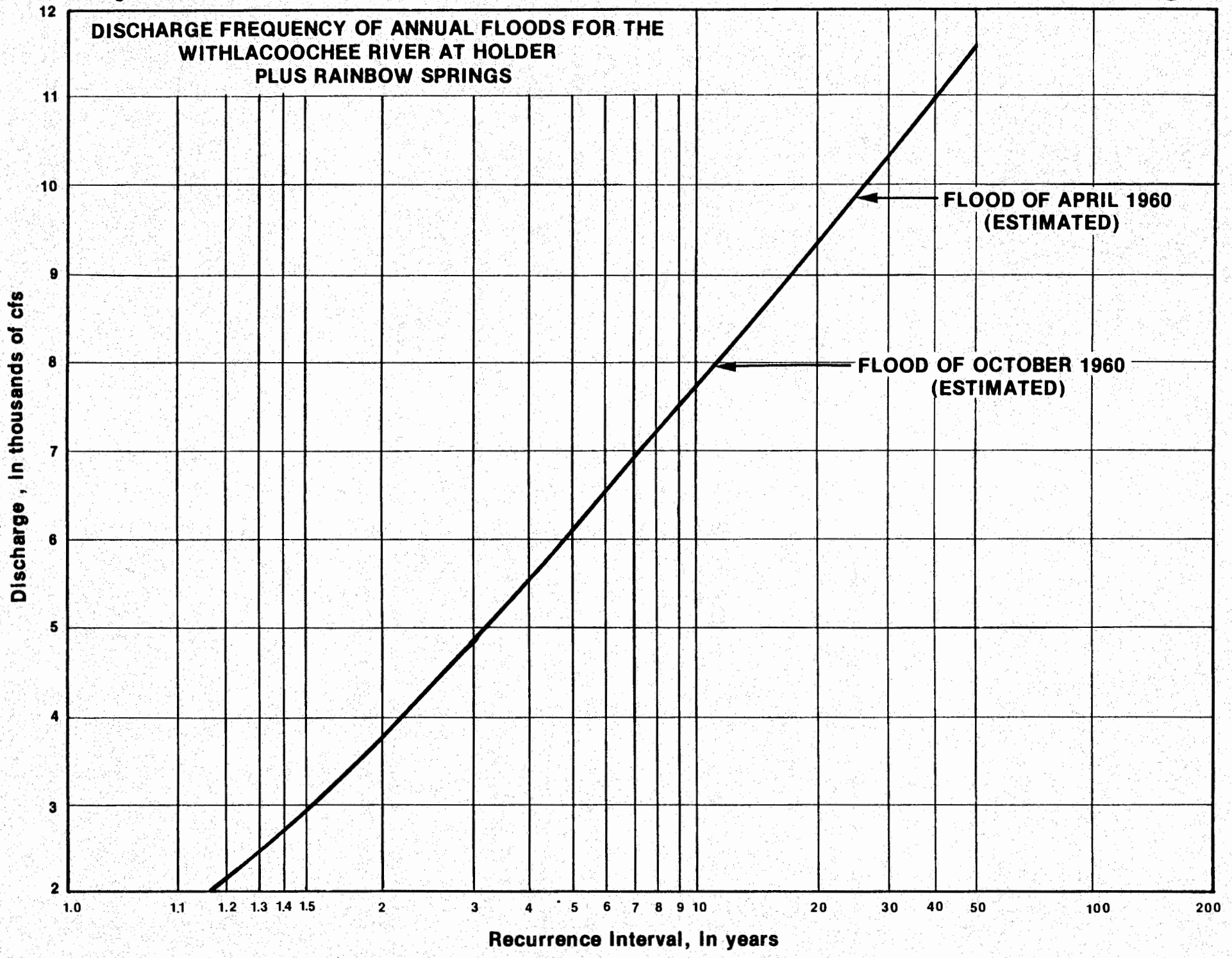

DISCHARGE FREQUENCY OF ANNUAL FLOODS FOR THE
WITHLACOOCHEE RIVER AT HOLDER
PLUS RAINBOW SPRINGS
FLOOD OF APRIL 1960
(ESTIMATED)
FLOOD OF OCTOBER 1960
(ESTIMATED)
Discharge, in thousands of cfs
12
11
10
9
8
7
6
5
4
3
2
1.0
1.1
1.2
1.3
1.4
1.5
2
3
4
5
6
7
8
9
10
20
30
40
50
100
200
Recurrence Interval, in years

Table II-8 Mean Outflows of Lake Rousseau (as Calculated Without Inglis Lock and Withlacoochee Bypass). Calculations by Regression Analysis* (cfs)

	AT INGLIS DAM				
Year	Jan-Mar (cfs)	Apr-Jun	Jul-Sep	Oct-Dec	Mean Annual
1985	1705	1258	1636	1612	1553
1995	1697	1249	1629	1606	1545
2005	1691	1241	1622	1601	1539
2015	1686	1234	1616	1597	1533
2025	1681	1228	1612	1594	1529
2035	1677	1224	1608	1591	1525

Flows (cfs) During Simulated Drought in 2035*

AT INGLIS DAM				
Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Mean Annual
630	661	633	1192	780

* Includes depletions due to projected consumptive losses obtained by regression analyses.

Source: Meta Systems, 1976.

plant would experience critical conditions such as those above once during the lifetime of the plant.

Historical inflow data from water years 1932-1975 were analyzed in order to calculate available water (based on inflows, precipitation, infiltration, SWFWMD minimum required outflows, evaporation, and seepage) from Lake Rousseau. The results are summarized in Table II-9. The methodology is discussed in Chapter VII.

The average annual available water (after allotting the minimum flow requirements to the Lower Withlacoochee) ranged from 115 cfs in 1956 to 3420 cfs in 1960. The average monthly flows ranged from 671 cfs for January to 1885 cfs for September.

Eighteen out of 528 months exhibited an available flow less than or equal to 0 cfs. Of these occurrences, 7 took place during the water years 1932 and 1933, while 8 took place during the water years 1956 and 1957. The three other instances were associated with relatively dry years.

Table II-9 Matrix of Monthly and Annual Available Water* from Lake Rousseau (cfs) for Water Years 1932-1975

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Annual
1932	609	322	360	0	20	82	24	0	153	0	0	216	148
1933	0	14	55	0	0	15	222	223	27	549	1310	3876	516
1934	3840	1581	961	537	371	403	378	743	1941	5842	3460	2340	1866
1935	2037	978	657	894	363	225	155	188	69	182	532	2251	711
1936	2756	1526	985	385	1887	2620	2001	1148	879	996	896	788	1209
1937	912	756	617	1017	360	535	847	805	601	412	1021	2229	843
1938	2005	1506	1617	534	667	496	330	201	358	1027	957	1100	900
1939	1249	1405	1002	358	383	267	234	319	384	936	1717	2219	873
1940	1791	917	666	212	382	457	394	364	344	860	927	1009	694
1941	550	243	218	1177	537	992	1630	1142	534	511	1133	880	796
1942	616	823	983	291	1031	1509	1446	863	940	1481	1255	1349	1049
1943	902	538	504	234	184	144	257	257	1719	784	1858	2475	821
1944	1480	748	508	499	92	155	140	60	0	104	599	1088	456
1945	941	1775	940	1146	346	219	125	90	132	1626	4405	4778	1377
1946	3371	1658	1206	511	1012	1794	1050	789	584	706	1492	1691	1232
1947	2129	1307	777	1019	469	856	1120	775	595	934	1778	2432	1183
1948	3076	2200	1500	739	1494	1515	1157	778	568	615	2536	3407	1632
1949	2681	1607	1168	971	530	368	387	512	608	535	1388	3998	1229
1950	4289	2301	1370	1204	639	608	436	318	251	321	471	3770	1332
1951	3517	1981	1412	689	1013	795	674	616	387	332	471	791	1057
1952	1153	895	1158	456	878	1385	1440	875	706	530	428	596	875
1953	897	959	671	2765	399	416	665	1249	636	654	1534	3348	1183
1954	4564	2733	2610	238	1608	1155	765	623	485	490	758	494	1377
1955	360	430	454	64	282	236	132	100	81	106	262	873	282
1956	657	263	250	62	125	14	5	0	0	0	0	0	115
1957	121	570	180	0	0	0	139	233	355	324	899	1527	362
1958	1838	827	426	534	784	2303	2538	1471	772	899	1044	778	1185
1959	691	1063	831	1111	1033	2066	4213	3111	2276	2925	3814	4155	2274
1960	4049	3009	1907	1285	1537	4224	7133	3080	1931	2098	5378	5411	3420
1961	6260	3152	1807	1438	1380	1026	722	530	518	530	728	984	1590
1962	553	476	417	229	224	215	125	0	48	212	161	566	269
1963	576	415	339	210	588	1062	654	319	233	251	261	446	446
1964	364	275	402	731	1755	1453	1332	1199	631	790	1358	3021	1109
1965	3439	1547	1314	1022	1005	1190	822	615	745	941	2762	2779	1515
1966	1928	1300	1140	981	1265	2079	1510	1033	1120	2147	2455	2784	1646
1967	2927	1558	1025	767	799	768	532	370	386	430	1037	1975	1048
1968	979	2154	488	244	178	296	108	137	372	1206	1353	2562	840
1969	2018	1841	1927	2778	3301	3011	2233	1168	957	788	1041	1095	1847
1970	871	672	556	419	742	537	393	276	276	304	1031	1790	656
1971	1172	778	670	386	575	514	761	476	528	358	328	558	592
1972	291	299	529	478	779	708	761	580	364	374	527	995	557
1973	905	522	536	389	266	299	225	159	317	1438	2239	1910	767
1974	2003	618	565	292	232	193	84	77	37	0	51	492	387
1975	530	572	423	217	133	85	61	278	621	1015	1128	1105	514
Mean	1770	1162	835	671	719	893	910	580	579	854	1338	1885	1018

*After allocation of minimum flow requirements to the lower Withlacoochee.

Source: Environmental Science and Engineering, Inc., 1978.

CIRCULATION

The water circulation in the western embayment of Lake Rousseau is driven largely by the wind and, to a much lesser extent, by flows induced by the discharges of the Inglis Dam. Withdrawal of large quantities of water for cooling tower make-up or other consumptive use would affect the existing circulation of the lake. An understanding of the present conditions is required to determine the extent of such effects. Since the lake is filled with drowned trees and infested with hydrilla, it does not lend itself to routine field data collection techniques, such as current meters, free-drifting current drogues, or bottom drifters. To characterize the existing circulation features, a program employing a fluorescent tracer, wind measurements, and water surface elevation monitoring was used.

On February 14, 1978, at 1000 hours EST, a slug of Rhodamine WT fluorescent dye was released in 4.5 meters (15 feet) of water adjacent to the drowned river channel. The dye was mixed with lake bottom waters at the injection point and tracked by using a fluorometer. Measurements of dye concentration were made on a sampling grid 24 and 48 hours following injection. Simultaneously water surface fluctuations were graphed on water level recorders at two locations, one near the Inglis Dam and the other 1.9 kilometers (1.2 miles) east of the dam on a privately-owned dock (see Figure II-4). Also, wind speeds and directions were continuously recorded by using a portable meteorological station positioned atop the controller's building at the Inglis Lock. Figures II-4 and II-5 show dye concentration isopleths after 24 and 48 hours, respectively. Table II-10 lists the hourly wind data.

A short time after the dye was injected on the lake bottom, it was observed at the surface. Since the specific gravity of the dye had been matched to that of the lake water, it is apparent that some vertical mixing was taking place. At the time the wind was westerly and gusting to 25 miles per hour (see wind rose in Figure II-6). A surface patch of dye and oranges was released after the bottom injection was completed.

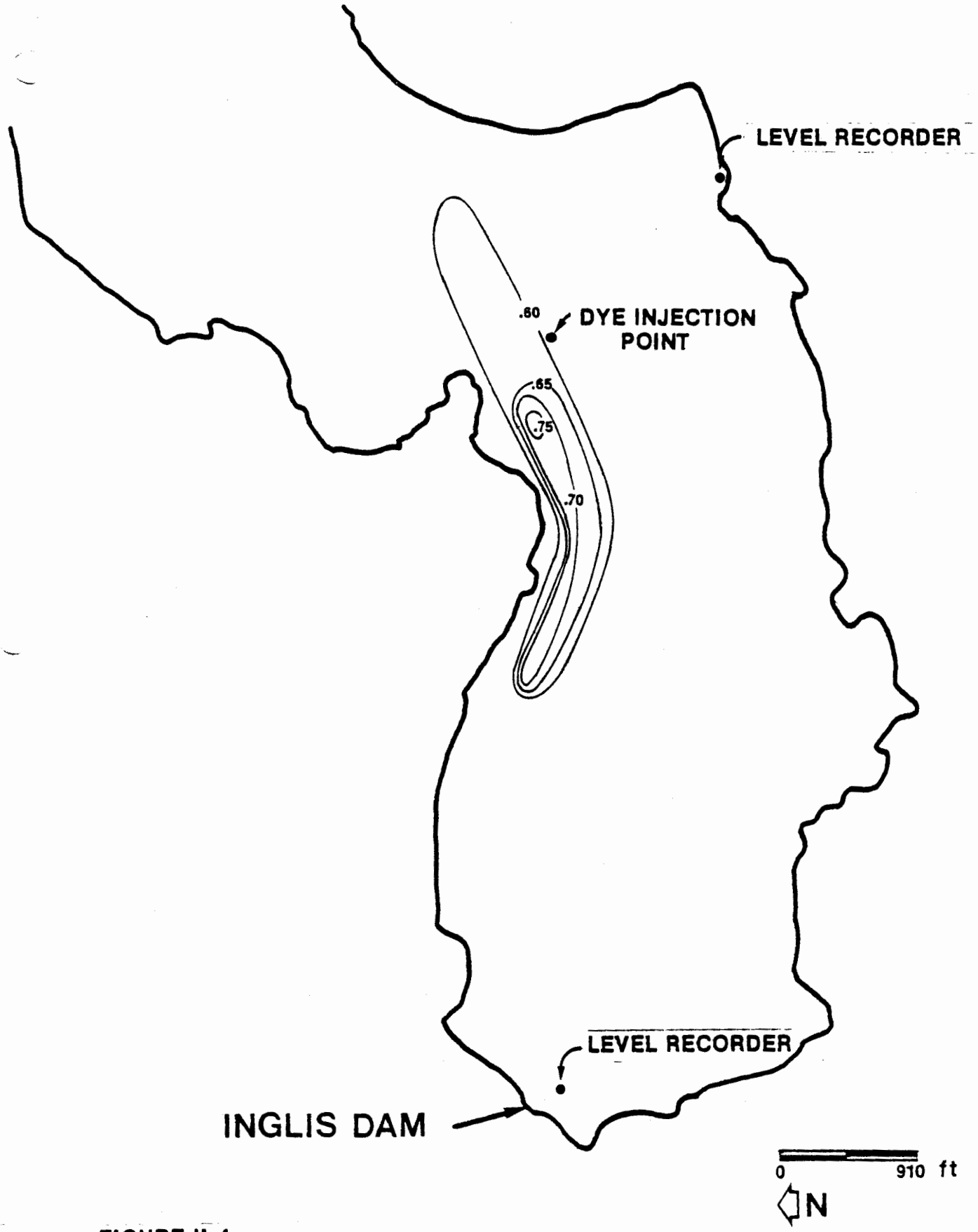


FIGURE II-4
FLUORESCENT DYE CONCENTRATION ISOPLETHS, FEBRUARY 15, 24 HOURS AFTER DYE INJECTION
(CONCENTRATION IN PARTS PER BILLION)
SUBSURFACE - depths 3'-bottom

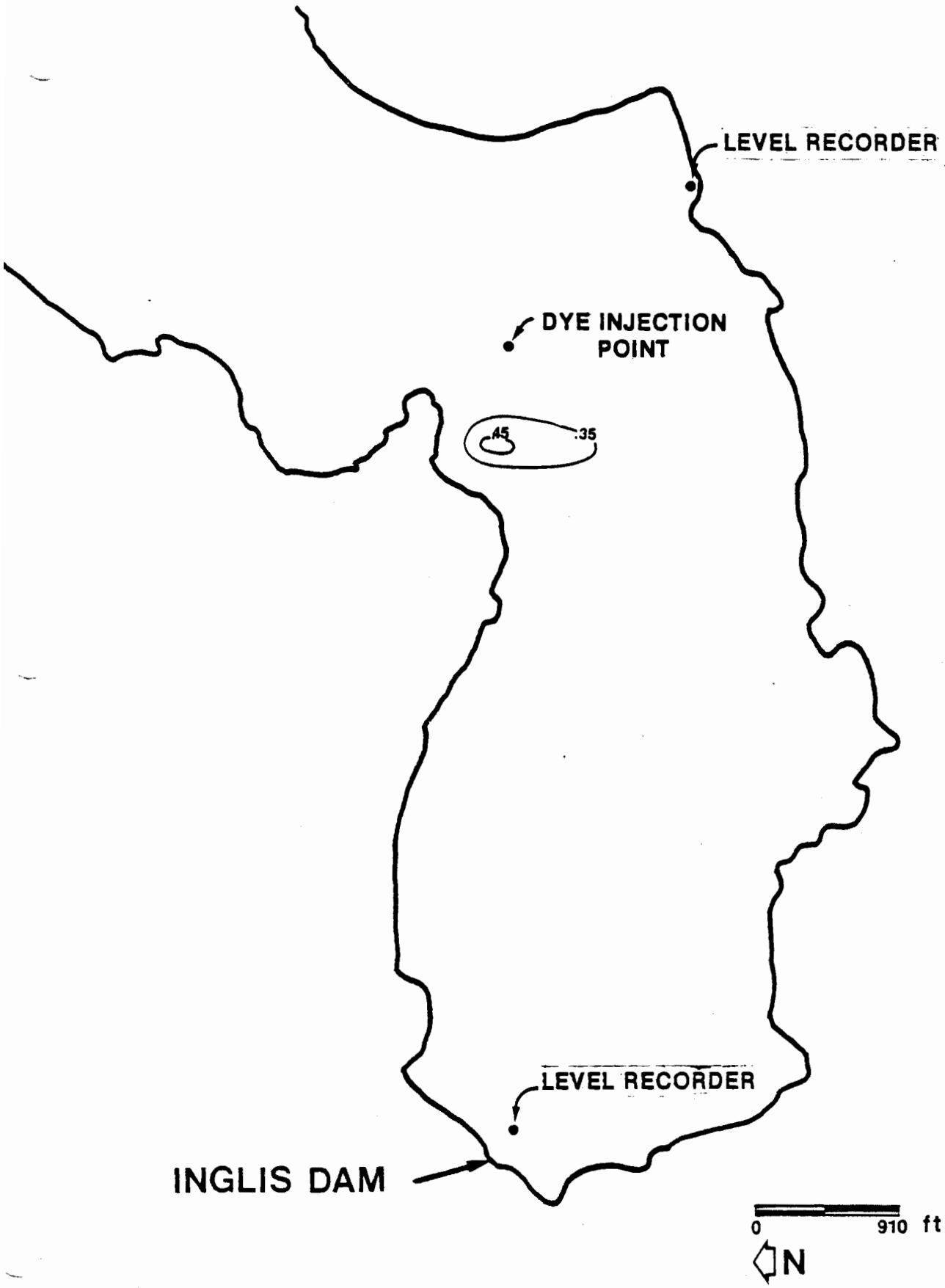


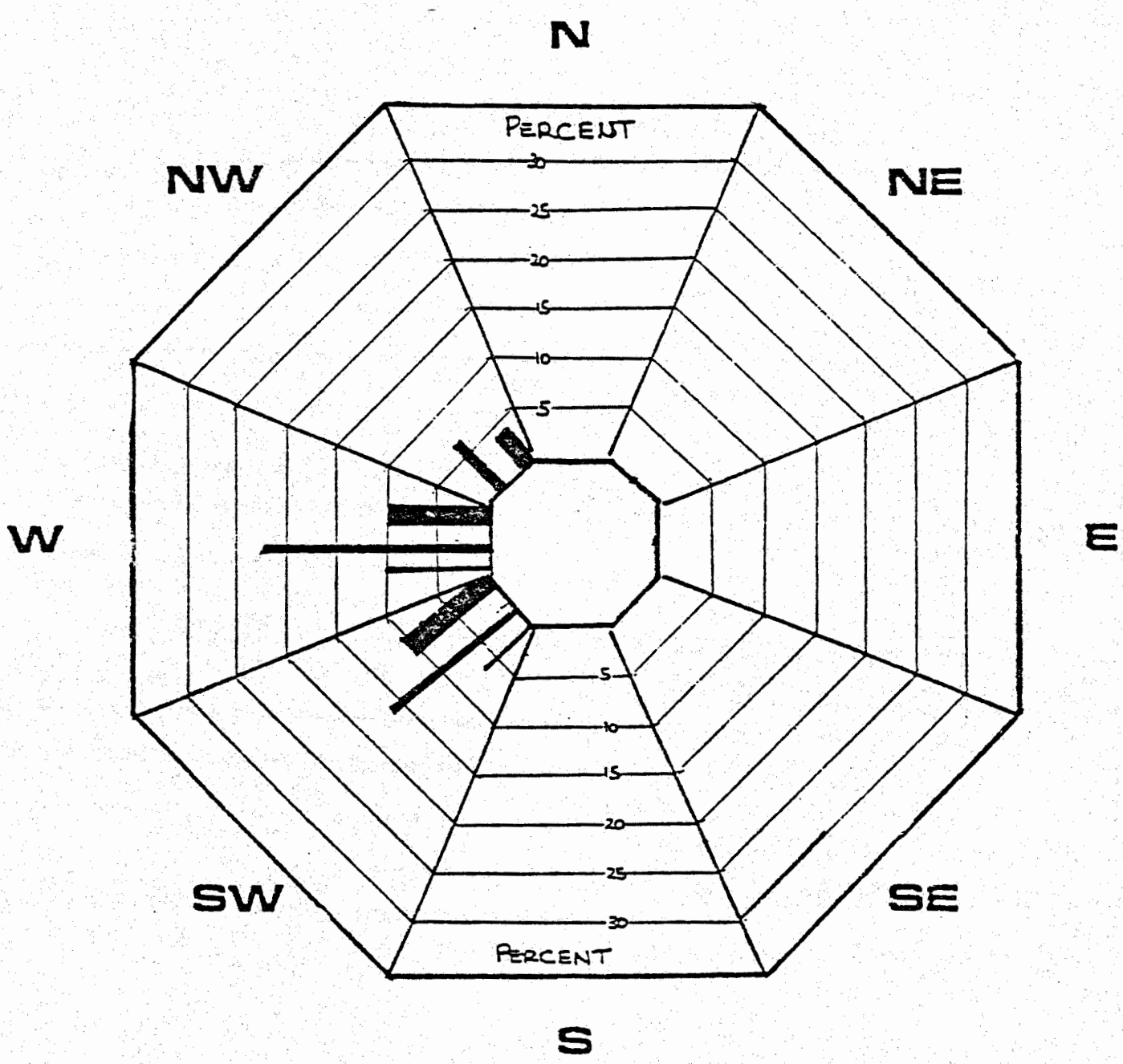
FIGURE II-5.
FLUORESCENT DYE CONCENTRATION ISOPLETHS, FEBRUARY 16, 1978,
48 HOURS AFTER DYE INJECTION
(concentration in parts per billion)
SUBSURFACE - depths 3′- bottom

Table II-10 Diurnal Measurements During Winter Circulation Study, February 13, 1978 to February 16, 1978

Hour	Wind Direction* (Degrees) 2/13	2/14	2/15	2/16	Wind Speed (mph) 2/13	2/14	2/15	2/16
1:00 A.M.		245	10	65		11	3	9.5
2:00		245	10	20		10	4	6
3:00		255	25	80		9.5	3	10
4:00		250	50	80		6.5	3	10
5:00		260	360	355		8	3	6.5
6:00		280	35	320		9.5	4	10.5
7:00		275	10	90		7.5	5.5	10
8:00		295	55	110		11	4.5	11.5
9:00		285	30	105		13.5	4.5	7
10:00		295	90	110		11	8.5	11.5
11:00		290	105	155		14.5	8.5	9.5
12:00 Noon		285	70	140		16.5	4.5	10
1:00 P.M.	225	260	85	15	15.5	16	9.5	7
2:00	240	270	95		22.5	13.5	9	
3:00	230	260	65		14	15	4.5	
4:00	235	250	20		18.5	15	6.5	
5:00	235	260	255		18	12	7	
6:00	235	250	235		10.5	10	5	
7:00	240	275	275		8	6	3.5	
8:00	240	260	350		6	3	2	
9:00	260	315	85		8.5	3.5	4.5	
10:00	245	290	50		9	2.5	3	
11:00	245	280	40		8	4	7	
12:00 Midnight	235	165	65		7.5	2.5	9	

* 0° = North wind; 90° = East wind; 180° = South wind; 270° = West wind.

Source: Environmental Science and Engineering, Inc., 1978.



LEGEND

VELOCITIES	MPH
———	0-7.5
▬▬▬	8-14
▬▬▬	14

IN THE WIND DIAGRAM THE LENGTH OF THE BAR DENOTES THE PERCENT OF THE TIME THAT WINDS OF EACH TYPE HAVE BEEN MOVING FROM OR NEAR THE GIVEN DIRECTION

WIND DATA IS BASED ON 24 - ONE HOUR OBSERVATIONS OVER A ONE DAY PERIOD FROM 2/13/78 TO 2/14/78 BY ENVIRONMENTAL SCIENCE AND ENGINEERING, INC. AT LAKE ROUSSEAU, FLORIDA

FIGURE II-6
WIND ROSE DIAGRAM
AVERAGE DIRECTION, DURATION AND VELOCITY OF WINDS AT LAKE ROUSSEAU, FLORIDA

The surface dye patch and the oranges immediately were blown eastward. The bottom patch moved westward toward the wind and the shoreline [about 274 meters (900 feet) away]. Figure II-4 shows that the most concentrated dye (70-75 ppb) could be found west of the injection point 24 hours later.

The process responsible for this occurrence was the wind-induced circulation that was established in the lake during the first 24 hours after dye injection. Since the wind blew predominantly from the west the first day at an average speed of about 10 miles per hour, considerable drag was exerted on the water surface. Differences observed in the lake surface from the level recorder near the dam and the eastern level recorder were in excess of 1 centimeter (0.4 inch). The wind shear on February 14, 1978, caused a tilting or "piling-up" of water at the eastern end of the lake. This piling-up induced a subsurface counterflow of water to the west. The return flow did not appear to be limited to bottom water but rather to most of the water column except the top layer. The concentrated zone of dye was found close to the north shore on February 15, 1978--24 hours after dye injection. This shallow area was densely overgrown with hydrilla.

On February 16, 1978, 48 hours after dye injection, the most concentrated dye was found in the same vicinity as on February 15, 1978. The period between 24-hour dye measurements was influenced by variable wind speed and direction. However, the wind did not blow strongly enough nor from the same direction long enough to establish currents which could remove the dye from the nearshore hydrilla.

Some characteristic features of the circulation in Lake Rousseau have been observed:

1. The wind, if of sufficient speed and regularity, exerts stress on the lake surface which piles up water and induces subsurface return flows counter to the wind direction.
2. The considerable drag force exerted by the dense growths of hydrilla in the nearshore zone tends to reduce water flows.

The long axis of the entire lake is oriented east-west. Strong winds which blow across this open fetch will create much larger surface set-up referred to as a longitudinal seiche event. A seiche results from a resonant coupling which occurs when the propagation speed of the wind is nearly equal to the speed of the waves in the lake. The stresses induced will raise the water level at one end of the lake and lower it at the other. The western embayment is most likely a node since fluctuations (magnitude and frequency) of the water surface occurred simultaneously at both gages.

LAKE SEDIMENTATION

The major factors affecting the rate of sedimentation include: (1) sources of sediments, (2) bathymetry, and (3) circulation.

Some sources of sediment are aeolian, in situ development, local shoreline runoff, and sediment loads from major rivers, streams, or creeks. Wind-blown materials, such as leaves, dust, and dirt, are incorporated into the sediments of a lake. It is assumed that for Lake Rousseau these wind-blown materials are minor factors relative to the total sediment regime. In situ sources resulting from annual phytoplankton activities and numerous types of aquatic vegetation provide detritus which can be a major source of the organic fraction of lake sediments. Local shoreline runoff, as well as the sediment load of the Withlacoochee River, can provide sources of both fine and coarse sediments.

The sedimentation process is affected by bathymetry. Littoral zones are most likely to have fine sediments winnowed out due to wave action. Deeper areas of a lake generally are more conducive to the settling of sediments.

Circulation also influences the sedimentation rate in Lake Rousseau. Since a large volume of water passes through the lake daily, some suspended sediments may not settle in the lake. Along the old river channel, the potential for higher velocities, and therefore local scouring, exists. As a result, sedimentation rates in such areas are low.

Since factors affecting the rate of sedimentation are not uniform throughout the lake, it is important to look at lake sediment profiles in different areas. In addition, it is necessary to determine within these sediment profiles the horizons that can be related to an historical date. This process will enable the sedimentation rate to be defined by measuring the amount of sediment between different horizons and the top of the sediment.

It has been assumed that measurement of the sedimentation rate over a short period of time for a given body of water can be used to estimate the long-term rate of storage volume loss in the lake. Sedimentation rates can also be used in determining the significance of given flow rates and circulation in a body of water.

Ten core samples were taken in Lake Rousseau at predetermined sites by using 5-centimeter (2-inch) PVC pipe. The site locations are shown in Figure II-7, and a summary of information on each sediment core is presented in Table II-11. Selected sediment cores (cores 5, 7, and 10) are presented in Figures II-8 and II-9. As shown in Table II-11 and Figure II-9, core 7 had numerous living specimens of Corbicula fluminea (Asiatic clam) on the surface.

To determine a time horizon in the cores which would correspond to the 1909 flooding, the percentage of volatile solids was determined. Three different cores (1, 2, and 10) were analyzed by using fractions spaced along a section of the core where gross appearances suggested the pre-flood substrate. Core 1 showed a steady decline in the percentage of volatile solids from the fraction nearest the surface to fraction C, 22.5 centimeters (8.85 inches) from the top. Volatile solids in core 2 steadily declined over all four fractions. Fraction A, 27.5 centimeters (10.8 inches) from the top of the core, was considered the pre-1909 surface. At site 10, the exponential curve began to level off sharply 28.75 centimeters (11.31 inches) from the surface at fraction B.

The distribution of cesium-137 activity was investigated in selected cores to determine a 1960 time horizon. Cesium-137 has a half-life of 30 years; and in the decay process, nuclei release gamma radiation. The naturally occurring cesium-137 level is very low. However, extensive nuclear testing in the late 1950's/early 1960's caused higher concentrations in sediments (Pennington, et al., 1973).

The absence of fine sediments in the upper section of cores 4, 5, 7, 8, and 9 indicates scouring of sediments. Therefore, these cores are from

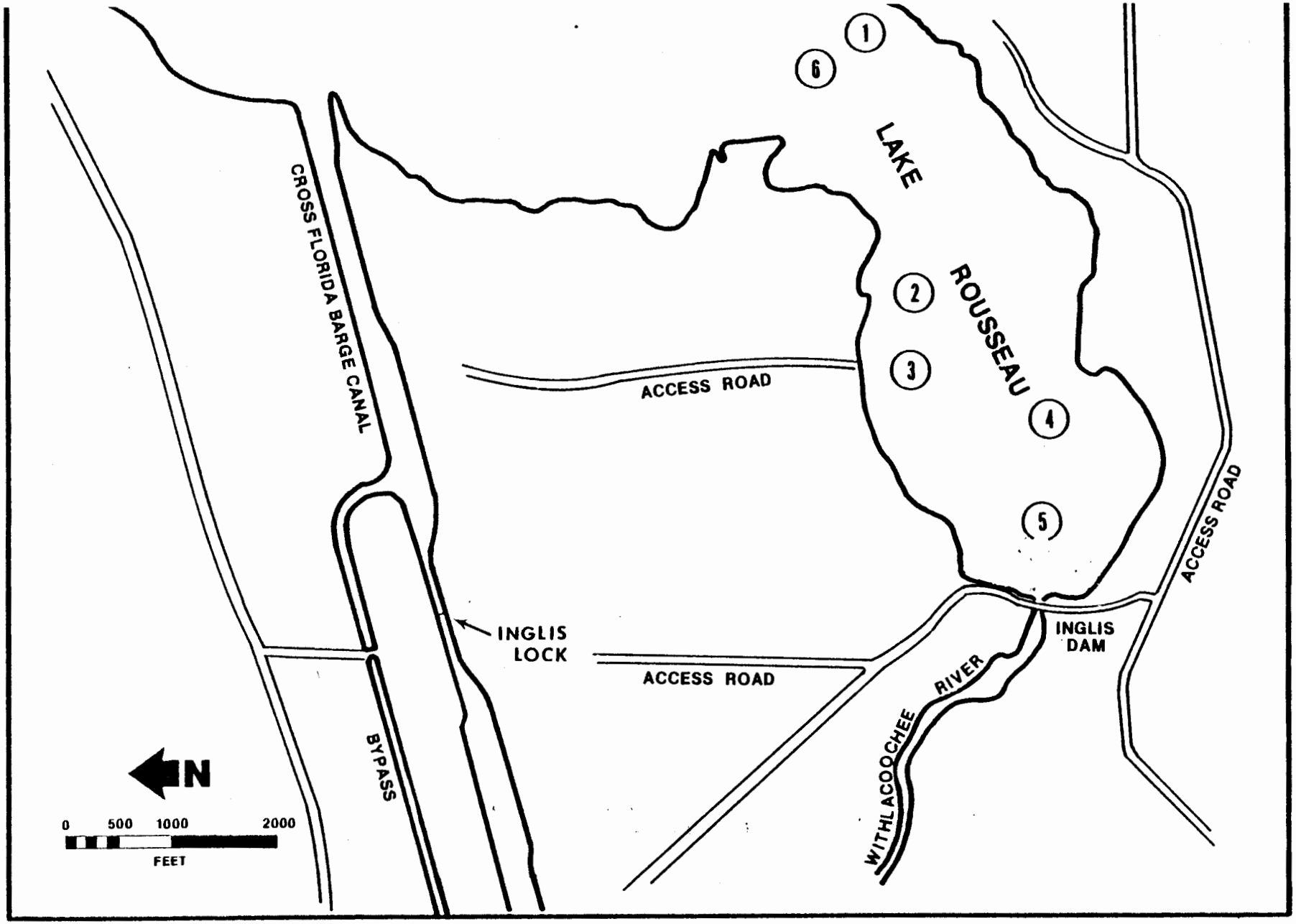


FIGURE II-7
LOCATIONS OF CORE SAMPLING SITES

CORE 7

CORE 10

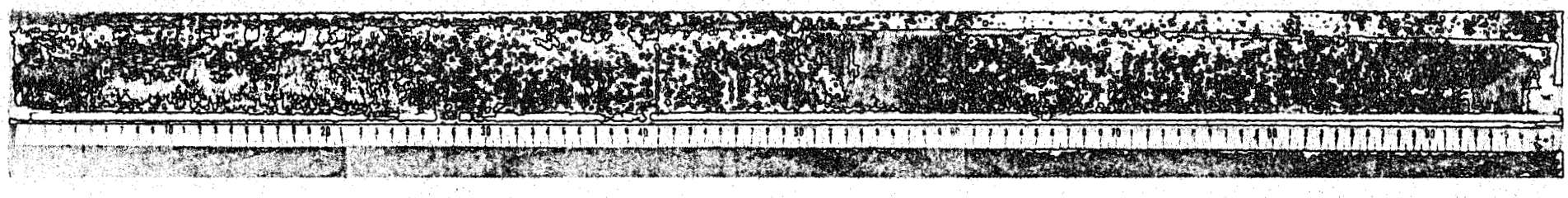


FIGURE II-8
SELECTED CORES (CORES 7 AND 10) COLLECTED AT
LAKE ROUSSEAU, MAY 3 AND 5, 1978

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

CORE 5

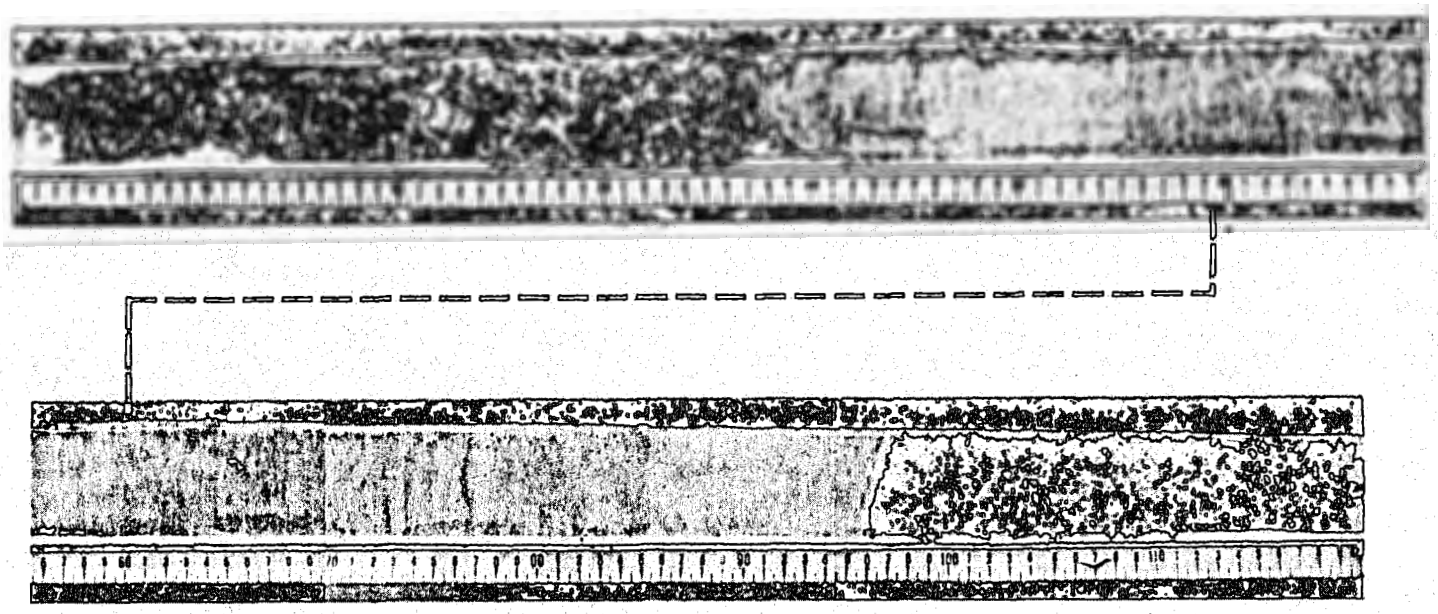


FIGURE II-9
CORE 5 COLLECTED AT LAKE ROUSSEAU, MAY 3 AND 5, 1978

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

Table II-11. Summary of Data on Sediment Cores Taken in Lake Rousseau

Core No.	Core Location	Characteristics	Additional Remarks	Average* Sedimentation Rate (1909-1978)
1	Off eastern shore about 1,700 meters (5,500 feet) east of Inglis Dam and 1,500 meters (5,000 feet) south of Cross Florida Barge Canal	Sandy layer with overlying silt and/or organics	Volatile solids and Cs-137 dating. Zone of sedimentation	13.2 centimeters (5.24 inches)
2	150 meters (500 feet) from northern shore, in 4.5 meters (15 feet) of water	Sandy layer with overlying silt and/or organics	Volatile solids and Cs-137 dating. Zone of sedimentation	11.4 centimeters (4.48 inches)
3	150 meters (500 feet) from northern shore, in 4.5 meters (15 feet) of water	Sandy layer with overlying silt and/or organics	Includes roots and twigs	
4	Western embayment; 300 meters (1,000 feet) from southern shore line	Primarily sand with dark laminations throughout		
5	Western embayment, in old river bed	Primarily sand with dark laminations throughout		
6	Off eastern shore about 1,700 meters (5,500 feet) east of Inglis Dam and 1,500 meters (5,000 feet) south of Cross Florida Barge Canal	Sandy layer with overlying silt and/or organics		
7	Mouth of barge canal as it enters Lake Rousseau	Primarily sand with dark laminations throughout	Living specimens of Corbicula and shell fractions present	
8	Barge canal	Primarily sand with dark laminations throughout	Aquatic vegetation present	
9	Barge canal	Primarily sand with dark laminations throughout		

Table II-11. Summary of Data on Sediment Cores Taken in Lake Rousseau (continued)

Core No.	Core Location	Characteristics	Additional Remarks	Average* Sedimentation Rate (1909-1978
10	Northeast of barge canal in thick bed of hydrilla	Sandy layer with overlying silt and/or organics	Hydrilla causes overestimation of deposition. Volatile solid dating only. Surface mixing evident.	14.1 centimeter (5.55 inches)

* Calculated by assigning all computation to 1909-1978 layer.

Source: Environmental Science and Engineering, 1978.

an area where fine sediments are readily removed or not deposited. Since a 1960 layer could not develop under scouring conditions, the distribution of cesium-137 was not tested in these cores.

Core 10 indicated extensive surface-mixing due to the fine nature of the material. This mixing resulted in the 1960 layer being mixed with other layers and thus preventing practical use of this core.

Cores 1 and 2 were selected for cesium-137 testing as they were the least disturbed in the two respective areas where they were collected. Fractions were collected in a manner similar to that used for volatile solids. For both cores 1 and 2, the major peak was approximately midway through the silt layer which separates the surface organics from the coarser sand layer. Both peaks were of the same magnitude. Site 1 had a second peak deeper in the sand layer which is believed to be the result of contamination as the deeper fractions were the first ones collected from a given core. In core 1, the cesium-137 horizon was 5 centimeters (2 inches) from the surface, whereas in core 2, the cesium-137 layer was 11.25 centimeters (4.429 inches) from the surface.

A summary of the results of the core analyses is presented in Table II-11. The sedimentation rates calculated by the volatile solids and the cesium-137 methods are nearly the same at sites 1 and 2 so the overall average rate is listed. The value of the overall sedimentation rate at site 10 is somewhat higher than at sites 1 and 2, perhaps due to the presence of hydrilla.

It is apparent that there are zones of sedimentation, scouring, winnowing, and mottling. Compaction which occurs during sample recovery was assigned to the organic layer (after 1909) and therefore causes overestimation of the deposition rate.

An important finding is the confirmation of living specimens of *Corbicula* which may be a nuisance to the operation of an intake structure.

The conclusions based upon this study are:

1. Where continuous sedimentation occurs, average deposition rates between 3.8 centimeters (1.5 inches) per decade for no compaction and 13 centimeters (5.1 inches) per decade with full compaction will occur.
2. The sedimentation rates for the entire lake are below the values given above. For the entire lake, only absolute limits can be estimated. For no compaction, the sedimentation rate lies between zero and 3.8 centimeters (1.5 inches) per decade. With compaction, the sedimentation rate lies between zero and 13 centimeters (5.1 inches) per decade. The losses in lake storage volume are between zero to 1.4 percent per decade for no compaction and zero to 4.7 percent per decade for full compaction.
3. Although the data produced by this study are complicated by areas of scouring and sediment mixing, the results do not dispel previous impressions concerning changes in flow in the western embayment of the lake. The opening of the Withlacoochee bypass in the 1960's (near the cesium peak) diverted a great portion of the flow which once went through Inglis Dam. As a result, one would expect far less sediment has entered the western embayment since that date, but also that lower velocities would allow the settling of finer material. A more detailed study would be required to completely validate this hypothesis.

WATER CHEMISTRY

FIELD DATA

Water quality samples were collected bimonthly at four stations in Lake Rousseau between October 27, 1977, and April 20, 1978 (see Figure VII-3 in the Methodology chapter for sample station locations). This intensive survey of the existing water chemistry has been conducted for the following purposes:

1. The measurement of water quality at representative stations and depths is necessary for evaluation of the biological integrity of the water column.
2. The distribution of chemical constituents and gradients of physico-chemical parameters supplies information which can be used to evaluate the horizontal and vertical circulation of lake waters.
3. Particular chemical parameters (such as iron, manganese, calcium hardness, dissolved solids, and suspended solids) will affect pretreatment requirements for plant service water and cycles of concentration for cooling water. The annual distribution of these parameters is required to develop service water system design criteria, impact assessments of cooling tower blowdown and water treatment sludge disposal; and cost estimates for construction and operation.

Tables II-12, II-13, II-14, and II-15 list water quality data collected in the field and analyzed in the laboratory for the months of October 1977, December 1977, February 1978, and April 1978, respectively. The quality of water in the lake is strongly influenced by the groundwater discharges of Rainbow Springs as the springs are a major source of inflow waters (see Hydrologic Budget section). The groundwater flow from the Floridan Aquifer at Rainbow Springs is highly mineralized due to the limestone and dolomite water-bearing strata. The slightly soluble $CaCO_3$ causes the spring water to range from hard to very hard. Whenever Rainbow Springs discharge dominates inflow, dissolved solids (calcium-bicarbonate) increase in upper Lake Rousseau

Table II-12. Water Quality Data, Lake Rousseau, October, 1977

	Sta. 1 2.0 m	Sta. 1 3.0 m	Sta. 2 3.0 m	Sta. 2 10.0 m	Sta. 3 4.0 m	Sta. 3 12.0 m*	Sta. 4 4.0 m	Sta. 4 8.0 m	Sta. 4 4.0 m (D)†
Date (da/mo/yr)	27/10/77	27/10/77	27/10/77	27/10/77	27/10/77	27/10/77	27/10/77	27/10/77	27/10/77
Sample Time	1800	1735	1810	1830	1900	1915	1935	2000	1935
pH (Standard Units)	6.8	---	7.1	7.3	7.7	7.6	8.0	7.8	7.8
Turbidity (NTU)	1.3	2.4	1.6	2.5	2.0	19	1.9	1.6	2.3
Color (CPU)	25	25	30	30	25	25	25	30	25
Total Solids (mg/l)	160	147	148	146	154	208	154	150	142
Suspended Solids (mg/l)	10	< 5.0	< 5.0	< 5.0	< 5.0	19	< 5.0	< 5.0	7
Dissolved Solids (mg/l)	150	145	146	143	152	189	152	148	135
Calcium (mg/l as Ca)	46	47	45	46	46	46	46	45	45
Hardness (mg/l-$CaCO_3$)	144	150	142	138	142	137	148	136	136
Alkalinity (mg/l-$CaCO_3$)	91	92	92	92	93	93	91	92	92
Sulfate (mg/l-SO_4)	39	40	41	41	41	42	41	17	40
Chloride (mg/l-Cl)	5.7	5.6	5.1	5.7	5.1	5.4	4.8	5.4	5.1
NO_3 + NO_2 (mg/l-N)	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.004
NH_3 (mg/l as N)	< .03	< .03	.12	.06	< .03	.03	< .03	< .03	< .03
TKN (mg/l as N)	.76	.59	.11	.69	.11	.56	.38	.78	.51
Mn (ug/l as Mn)	< 55	< 55	< 55	< 55	< 55	< 55	< 55	< 55	< 55
O-PO_4 (mg/l as P)	.010	.009	.007	.009	.006	.007	.006	.006	.006
T-PO_4 (mg/l as P)	.18	.17	.17	.20	.14	1.4	.14	.18	.17
BOD (mg/l)	1.3	1.5	1.6	< 1.0	1.6	1.1	1.3	< 1.0	1.0
TOC (mg/l as C)	3.5	2.6	5.1	6.3	5.7	14.5	5.3	5.3	9.3
Fe (ug/l as Fe)	< 80	< 80	< 80	< 80	< 80	< 80	< 80	< 80	< 80

* Bottom sediments entrained in sample resulted in aberrant measurements.
† D designates duplicate.

Source: Environmental Science and Engineering, Inc., 1977.

Table II-13. Water Quality Data, Lake Rousseau, December, 1977

	Sta. 1 2.0 m	Sta. 1 3.0 m	Sta. 2 3.0 m	Sta. 2 10.0 m	Sta. 3 4.0 m	Sta. 3 12.0 m	Sta. 3 4.0 m (D)*	Sta. 4 4.0 m	Sta. 4 8.0 m
Date (da/mo/yr)	8/12/77	8/12/77	8/12/77	8/12/77	8/12/77	8/12/77	8/12/77	8/12/77	8/12/77
Sample time	1315	1315	1330	1330	1400	1400	1400	1440	1440
pH (Standard Units)	7.1	7.2	7.0	7.3	7.3	7.4	7.3	7.1	7.1
Turbidity (NTU)	1.8	1.7	1.7	1.9	1.4	1.9	1.8	1.2	1.6
Color (CPU)	15	15	15	15	20	20	15	20	20
Total Solids (mg/l)	158	162	160	160	160	158	166	158	158
Suspended Solids (mg/l)	< 5	< 5	6	< 5	< 5	6	5	< 5	< 5
Dissolved Solids (mg/l)	158	160	154	158	156	152	161	156	156
Calcium (mg/l as Ca)	30	30	29	30	30	30	30	30	30
Hardness (mg/l-$CaCO_3$)	115	117	113	117	117	119	115	117	115
Alkalinity (mg/l-$CaCO_3$)	90	91	90	91	91	91	91	91	92
Sulfate (mg/l-SO_4)	27	26	25	26	27	25	26	26	26
Chloride (mg/l-Cl)	5.4	5.4	5.7	5.7	5.7	5.9	5.1	5.7	5.7
NO_3 + NO_2 (mg/l-N)	0.030	0.022	0.022	0.023	0.027	0.028	0.026	0.039	0.045
NH_3 (mg/l as N)	<0.03	<0.03	<0.03	<0.03	0.03	<0.03	<0.03	<0.03	<0.03
TKN (mg/l as N)	0.5	0.6	0.4	0.3	0.3	0.4	0.5	0.8	0.3
Mn (ug/l as Mn)	< 55	< 55	< 55	< 55	< 55	< 55	< 55	< 55	< 55
O-PO_4 (mg/l as P)	0.004	0.005	0.003	0.003	0.003	0.006	0.005	0.006	0.005
T-PO_4 (mg/l as P)	0.14	0.22	0.10	0.12	0.13	0.16	0.16	0.09	0.11
BOD (mg/l)	3.3	6.0	5.4	4.7	3.7	3.6	4.8	4.0	5.7
TOC (mg/l as C)	5.0	3.3	3.4	4.0	4.5	3.5	4.5	5.2	4.5
Fe (ug/l as Fe)	< 80	< 80	< 80	< 80	< 80	< 80	< 80	< 80	< 80

*D designates duplicate.

Source: Environmental Science and Engineering, Inc., 1977.

Table II-14. Water Quality Data, Lake Rousseau, February, 1978

	Sta. 1 2.0 m	Sta. 1 3.0 m	Sta. 2 10.0 m	Sta. 2 3.0 m	Sta. 3 4.0 m	Sta. 3 12.0 m	Sta. 3 4.0 m (D)*	Sta. 4 4.0 m	Sta. 4 8.0 m
Date (da/mo/yr)	14/02/78	14/02/78	15/02/78	14/02/78	14/02/78	14/02/78	14/02/78	14/02/78	14/02/78
Sample Time	1930	1930	725	1900	1820	1820	1820	1730	1730
pH (Standard Units)	8.1	8.2	7.8	8.2	8.2	8.1	8.3	8.1	8.3
Turbidity (NTU)	1.0	0.8	0.6	0.7	0.9	1.6	1.0	0.8	0.6
Color (CPU)	30	30	30	30	30	30	30	30	30
Total Solids (mg/l)	176	174	207	180	178	183	179	180	173
Suspended Solids (mg/l)	< 5	< 5	< 5	< 5	< 5	8	< 5	< 5	< 5
Dissolved Solids (mg/l)	174	172	205	178	176	175	177	178	171
Calcium (mg/l as Ca)	46.1	46.6	46.3	46.4	46.6	47.9	47.9		47.0
Hardness (mg/l-$CaCO_3$)	132	136	136	132	136	136	136	149	133
Alkalinity (mg/l-$CaCO_3$)	99.9	99.1	99.4	102	94.1	98.9	99.5	99.0	98.0
Sulfate (mg/l-SO_4)	42.0	43.7	38.6	41.3	40.0	40.3	40.0	38.6	39.3
Chloride (mg/l-Cl)	8.6	8.5	8.0	8.5	8.5	8.5	8.4	8.9	9.4
NO_3 + NO_2 (mg/l-N)	0.018	0.006	0.021	0.023	0.010	0.007	0.008	0.033	0.027
NH_3 (mg/l as N)	<0.03	<0.03	<0.03	<0.05	0.06	<0.03	<0.03	<0.03	<0.03
TKN (mg/l as N)	0.3	0.4	0.8	0.3	0.3	0.3	0.3	0.3	0.3
Mn (ug/l as Mn)	22	22	22	22	<20	22	22	22	22
O-PO_4 (mg/l as P)	0.006	0.007	<0.002	0.023	0.010	0.006	0.007	0.013	0.010
T-PO_4 (mg/l as P)	0.11	0.14	0.20	0.12	0.12	0.17	0.12	0.14	0.14
BOD (mg/l)	1.3	1.5	1.6	1.3	< 1.0	1.4	1.2	1.0	0.8
TOC (mg/l as C)	7.2	< 1.0	0.5	1.5	2.5	4.3	< 1.0	3.9	3.4
Fe (ug/l as Fe)	< 80	< 80	< 80	< 80	< 80	< 80	< 80	< 80	< 80

*D designates duplicate.

Source: Environmental Science and Engineering, Inc., 1978

Table II-15. Water Quality Data, Lake Rousseau, April, 1978

	Sta. 1 2.0 m	Sta. 1 3.0 m	Sta. 2 3.0 m	Sta. 2 10.0 m	Sta. 3 4.0 m	Sta. 3 4.0 (D)*	Sta. 3 12.0 m	Sta. 4 4.0 m	Sta. 4 8.0 m
Date (da/mo/yr)	20/4/78	20/4/78	20/4/78	20/4/78	20/4/78	20/4/78	20/4/78	20/4/78	20/4/78
Sample time	1435	1435	1405	1405	1340	1340	1340	1300	1300
Turbidity (NTU)	0.7	0.8	0.8	0.9	0.8	0.9	0.9	0.7	0.9
Color (CPU)	90	90	100	90	100	90	100	100	90
Total Solids (mg/l)	166	168	166	172	168	172	174	172	178
Suspended Solids (mg/l)	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	5
Dissolved Solids (mg/l)	164	166	164	170	166	170	172	170	176
Calcium (mg/l as Ca)	43	43	45	44	46.1	43	45	47.6	47.6
Hardness (mg/l-$CaCO_3$)	144	148	148	144	145	148	148	150	148
Alkalinity (mg/l-$CaCO_3$)	106	97	98	99	101	97	107	89	100
Sulfate (mg/l-SO_4)	14.7	15.4	15.4	14.1	14.7	15.4	14.1	14.7	14.7
Chloride (mg/l-Cl)	7.5	7.5	7.5	7.2	7.0	7.0	7.4	7.0	7.0
NO_3 + NO_2 (mg/l-N)	0.048	0.051	0.098	0.060	0.052	0.050	0.058	0.051	0.043
NH_3 (mg/l as N)	<0.03	<0.03	<0.04	<0.04	<0.03	<0.03	0.03	<0.03	0.03
TKN (mg/l as N)	0.4	0.4	0.4	0.4	0.5	0.4	0.4	0.5	0.6
Mn (ug/l as Mn)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
O-PO_4 (mg/l as P)	0.023	0.025	0.025	0.026	0.024	0.023	< 0.002	0.021	0.024
T-PO_4 (mg/l as P)	0.09	0.11	0.10	0.09	0.09	0.07	0.09	0.08	0.09
BOD (mg/l)	< 1.0	< 1.0	< 1.0	1.0	1.1	< 1.0	1.5	1.0	< 1.0
TOC (mg/l as C)	13.0	16.1	14.0	15.3	11.9	13.8	13.9	15.1	14.3
Fe (ug/l as Fe)	176	176	200	176	176	176	176	176	176

*D designates duplicate.

Source: Environmental Science and Engineering, Inc., 1978.

(USGS, 1976). However, the regulated lake levels in the vicinity of Inglis Dam stabilize the dissolved solids concentrations. Hardness as $CaCO_3$ ranges from 150 ppm to 113 ppm. The highest values occurred in April 1977.

Dissolved oxygen and temperatures are reported in the Biological Systems section of this report. The USGS (1976) reported that near the Inglis Dam dissolved oxygen concentrations ranged from 14 ppm to 0 ppm vertically and averaged 6 ppm. Dissolved oxygen peaks were encountered in May and appeared to correspond with the rapid increase in rooted plants (hydrilla, particularly) and phytoplankton populations in the spring. Also, the hypolimnion was encountered between 2.7 and 3 meters (9 and 10 feet). The decrease is probably due to the synergistic effects of light penetration, plant and animal respiration, and decomposition of organic sediments.

Some saline water can intrude through the locks into Lake Rousseau (USGS, 1976; Bush, 1973); however, it leads to only transitory increases in specific conductivity since the water is flushed back down the bypass canal. Dissolved solids data collected for this report do not show any evidence of saline intrusion.

Existing consumptive use of Lake Rousseau water is primarily for irrigation of melons (see Table II-49). The water has a low sodium and salinity content and therefore is useful for agricultural purposes (USGS, 1976). Overall, the quality of water in Lake Rousseau is excellent and meets the EPA requirements for fishing and swimming. The color and bacteriological counts (not determined for this report) limit use of Lake Rousseau water for domestic supplies without treatment. Domestic supplies draw from ground water.

The distribution of chemical species and density gradients (thermal stratification) indicates that stable stratification does not occur in the fall or winter. The circulation of water during these seasons is determined by wind action and discharge from the Inglis Dam.

A number of water quality parameters have been averaged for the Withlacoochee River Basin (USGS, 1976). The data collected in October 1977, December 1977, February 1978, and April 1978 compare reasonably with the averages taken throughout the basin. Iron concentrations during this period are below average (average is 180 ppb) and manganese concentrations are above average (average over the basin is 9 ppb).

WATER RESOURCES, BIOLOGICAL SYSTEMS

RESULTS AND DISCUSSION

PHYSICAL PARAMETERS

Concentrations of dissolved oxygen measured in Lake Rousseau during October 1977, December 1977, February 1978, and April 1978 are presented in Tables II-16, II-17, II-18, and II-19, respectively. In October, dissolved oxygen levels, determined by Winkler titration, ranged from 4.90 to 8.85 ppm. Little evidence of significant vertical stratification with respect to dissolved oxygen was apparent, although slight decreases with depth were generally observed. Dissolved oxygen concentrations measured in December via Winkler titration ranged from a low of 7.50 to 9.35 ppm. Concentrations across the lake were uniform, and no evidence of vertical stratification was noted. Higher concentrationss ranging from 10.70 to 11.90 ppm, were measured in February, and no stratification was observed. Successive increases in dissolved oxygen levels over the first three sampling periods probably resulted primarily from decreased water temperatures and associated increases in oxygen solubility. Accordingly, the lowest dissolved oxygen concentrations, ranging from 3.88 to 6.90 ppm, were recorded during April when the highest water temperatures were observed. As during previous months, no significant vertical stratification was evidenced.

Temperature and conductivity data collected in October 1977, December 1977, February 1978, and April 1978 are presented in Tables II-20, II-21, II-22, and II-23, respectively. The data presented in these tables were collected at four sampling stations in Lake Rousseau (see Figure VII-3 in the Methodology section for the location of these sampling stations). In December, February, and April, water temperatures were fairly uniform, whereas in October slight decreases in temperature with depth were noted. Temperatures varied between 20.0 and 22.1°C in October, between 16.3 and 19.9°C in December, between 11.0 and 14.2°C in February, and between 23.1 and 24.9°C in April.

Table II-16 Dissolved Oxygen Concentrations (ppm) Measured in Lake Rousseau, October 26 through 27, 1977

Station	Depth (m)	Sampling Interval*/Method							
		Dusk 1		Night	Dawn		Day	Dusk 2	
		Winkler	Probe	Probe	Winkler	Probe	Probe	Winkler	Probe
1	0				7.02			7.70	
	1.0	---	6.5	8.6	6.96	6.8	7.3	6.75	---
	2.0	---	6.9	7.0	6.80	6.4	7.1	5.83	---
	3.0	---	6.4	7.1	6.89	6.3	6.9	5.25	---
2	0				6.94			6.35	
	1.0	8.13	7.0	8.2	7.05	7.8	7.6	6.53	---
	4.0	---	6.2	7.5	7.14	6.7	7.0	7.20	---
	7.0	6.53	6.1	6.2	6.96	6.0	4.9	7.15	---
	10.0	6.50	6.0	6.1	6.09	5.7	4.6	4.93	---
3	0				7.42			7.25	
	1.0	7.90	8.9	9.1	7.41	8.0	8.7	8.50	---
	4.0	---	7.1	7.1	6.89	7.0	7.0	8.50	---
	8.0	---	5.9	6.6	6.28	5.6	6.4	6.13	---
	12.0	6.53	5.4	6.4	5.90	4.0	0.7	6.33	---
4	0				7.70			4.90	
	1.0	8.85	9.0	9.2	7.64	8.1	8.2	8.48	---
	3.0	---	8.2	8.6	7.71	7.7	7.3	7.75	---
	6.0	---	6.5	8.4	6.18	6.2	5.8	6.93	---
	8.0	---	0.9	5.5	7.62	5.7	5.7	---	---

*Sampling Intervals:
Dusk 1: 1757 to 2105, October 26, 1977.
Night: 2307 to 0430, October 26 and 27, 1977.
Dawn: 0710 to 0829, October 27, 1977.
Day: 1300 to 1735, October 27, 1977.
Dusk 2: 1730 to 2020, October 27, 1977.

Note: --- Indicates that the sample (or measurement) was not taken.

Source: Environmental Science and Engineering, Inc., 1977.

Table II-17 Dissolved Oxygen Concentrations (ppm) Measured in Lake Rousseau, December 6 through 8, 1977

Station	Depth (m)	Sampling Interval*/Method							
		Dusk 1		Dawn		Day	Dusk 2		Night
		Winkler	Probe	Winkler	Probe	Probe	Winkler	Probe	Probe
1	0	8.40		8.45			8.25		
	1.0	8.68	9.5	8.75	9.1	9.2	8.38	---	9.2
	2.0	7.78	9.5	8.40	9.1	9.2	8.83	---	9.1
	3.0	8.48	9.5	8.15	9.0	9.2	9.35	---	9.0
2	0	9.10		8.05			8.40		
	1.0	8.68	8.7	8.40	9.1	9.2	8.48	---	9.5
	4.0	7.78	8.7	8.33	9.0	9.2	8.53	---	9.4
	7.0	8.63	8.6	9.33	8.8	8.6	8.63	---	9.4
	10.0	7.50	8.6	8.18	9.1	8.6	9.00	---	9.3
3	0	8.75		8.40			8.70		
	1.0	8.48	9.2	8.18	9.2	8.9	9.18	---	9.5
	4.0	8.43	9.2	8.43	9.1	8.7	9.08	---	9.5
	8.0	8.28	8.6	8.23	9.2	8.7	8.30	---	9.0
	12.0	8.60	8.2	8.30	9.0	8.6	8.28	---	9.4
4	0	8.65		8.35			8.90		
	1.0	8.93	9.1	8.50	9.4	9.3	8.75	---	9.4
	3.0	8.28	9.1	8.43	9.2	8.0	8.73	---	9.4
	6.0	8.58	9.0	8.55	9.1	8.8	8.68	---	9.4
	8.0	8.10	7.4	8.40	8.7	---	8.28	---	9.2

*Sampling Intervals:
Dusk 1: 1700 to 1900, December 6, 1977.
Dawn: 0740 to 0850, December 7, 1977.
Day: 1400 to 1645, December 7, 1977.
Dusk 2: 1755 to 1905, December 7, 1977.
Night: 2310 to 0240, December 7 and 8, 1977.

Note: — Indicates that the sample (or measurement) was not taken.

Source: Environmental Science and Engineering, Inc., 1977.

Table II-18 Dissolved Oxygen Concentrations (ppm) Measured in Lake Rousseau, February 14 through 16, 1978

Station	Depth (m)	Sampling Interval*/Method					
		Dusk		Dawn		Day	Night
		Winkler	Probe	Winkler	Probe	Probe	Probe
1	0	11.00		10.90			
	1.0	11.00	11.0	10.95	10.4	10.4	10.4
	2.0	11.45	10.9	10.90	10.7	10.8	10.2
	3.0	11.40	10.8	10.95	10.0	11.0	10.0
2	0	11.20		10.90			
	1.0	10.85	10.5	10.75	10.4	10.8	10.3
	4.0	11.35	10.8	11.45	10.6	11.1	10.8
	7.0	11.15	10.8	11.10	9.4	11.0	11.0
	10.0	11.20	10.0	10.80	8.6	10.7	10.6
3	0	11.90		11.10			
	1.0	11.20	10.8	11.10	10.6	10.6	10.5
	4.0	11.35	10.5	11.00	10.8	11.2	11.0
	8.0	11.40	10.1	11.20	10.6	10.4	10.7
	12.0	11.30	9.8	10.85	8.8	9.9	9.9
4	0	10.90		10.50			
	1.0	11.00	11.2	10.85	11.7	10.4	10.8
	3.0	10.90	11.3	10.90	11.0	10.9	11.3
	6.0	11.15	11.0	10.90	11.0	11.2	11.0
	8.0	10.70	10.6	10.85	10.6	11.1	10.4

*Sampling Intervals:
Dusk: 1730 to 1945, February 14, 1978.
Dawn: 0710 to 0835, February 15, 1978.
Day: 1400 to 1805, February 15, 1978.
Night: 2245 to 0245, February 15 and 16, 1978.

Source: Environmental Science and Engineering, Inc., 1978.

Table II-19 Dissolved Oxygen Concentrations (ppm) Measured in Lake Rousseau, April 19 and 20, 1978

Station	Depth (m)	Sampling Interval*/Method					
		Dusk		Dawn		Day	Night
		Winkler	Probe	Winkler	Probe	Probe	Probe
1	0	5.98	6.2	5.30	—	—	6.2
	1.0	6.03	—	5.48	6.7	6.7	6.3
	2.0	4.97	—	5.60	6.7	7.1	6.4
	3.0	6.01	—	5.33	6.5	6.6	6.3
2	0	6.43		—	—	7.7	6.3
	1.0	6.45	—	5.70	7.0	7.7	6.5
	4.0	5.92	—	5.93	6.9	8.0	6.8
	7.0	4.41	—	5.00	5.2	7.4	6.0
	10.0	4.38	—	3.88	4.3	6.6	5.6
3	0	6.70		5.95	—	6.3	6.7
	1.0	6.60	—	5.83	6.6	6.3	6.9
	4.0	5.85	—	5.28	6.4	6.6	7.2
	8.0	5.01	—	4.25	5.1	6.7	7.3
	12.0	4.95	—	3.63	4.7	6.6	7.0
4	0	6.90	—	5.80	—	6.6	6.9
	1.0	6.71	—	5.58	6.7	6.7	6.9
	3.0	6.72	—	5.95	7.1	7.0	7.1
	6.0	—	—	5.30	7.3	7.2	7.3
	8.0	6.58	—	4.50	7.3	7.1	7.3

*Sampling Intervals:
Dusk: 1712 to 1900, April 19, 1978.
Dawn: 0615 to 0830, April 19, 1978.
Day: 1415 to 1745, April 19, 1978.
Night: 2345 to 0400, April 19 and 20, 1978.

Note: — Indicates that the sample (or measurement) was not taken.

Source: Environmental Science and Engineering, Inc., 1978.

Table [illegible]-20 Water Temperature and Specific Conductan[illegible] Values Measured in Lake Rousseau, October 26-27, [illegible]977.
[STATION = Sampling Station (see Figure VII-1), TIME_ON = Sampling Time, DEPTH = Sampling D[illegible]th (meters), TEMP = Water Temperature (°C), COND = Specific Conductance (micromhos cm^{-1})]

TRIP=OCTOBER STATION=1

DATE	TIME_ON	DEPTH	TEMP	COND
271077	1730	1		
271077	1730	2		
271077	1730	3		
271077	1705	1	21.5	
271077	1705	2	21.5	
271077	1705	3	21.5	
271077	710	1	21.0	320
271077	710	2	21.0	318
271077	710	3	21.0	423
261077	2307	1	22.0	340
261077	2307	2	22.0	322
261077	2307	3	21.5	410
261077	1757	1	20	255
261077	1757	2	22	260
261077	1757	3	22	400

TRIP=OCTOBER STATION=2

DATE	TIME_ON	DEPTH	TEMP	COND
271077	1620	1	21.5	
271077	1620	4	21.7	
271077	1620	7	21.4	
271077	1620	10	21.4	
271077	733	1	21.0	330
271077	733	4	21.0	600
271077	733	7	21.2	820
271077	733	10	21.0	999
271077	31	1	21.8	310
271077	31	3	21.8	390
271077	31	7	21.2	370
271077	31	10	21.2	365
261077	1838	1	22.0	290
261077	1838	4	22.0	360
261077	1838	7	22.0	350
261077	1838	10	21.9	350

Table VII-20 Water Temperature and Specific Conductance Values Measured in Lake Rousseau, October 26-27, 1977. [STATION = Sampling Station (see Figure VII-1), TIME_ON = Sampling Time, DEPTH = Sampling Depth (meters), TEMP = Water Temperature (°C), COND = Specific Conductance (micromhos cm^{-1})] (continued, page 2 of 2)

TRIP=OCTOBER STATION=3

DATE	TIME_ON	DEPTH	TEMP	COND
271077	1525	1	22.0	370
271077	1525	4	21.7	
271077	1525	8	21.5	
271077	1525	12	21.5	
271077	753	1	21.2	450
271077	753	4	21.2	770
271077	753	8	21.2	1000
271077	753	12	21.2	1140
271077	125	1	21.0	290
271077	125	4	21.0	390
271077	125	8	21.0	375
271077	125	12	21.0	370
261077	1922	1	22.1	290
261077	1922	4	21.9	375
261077	1922	8	21.4	370
261077	1922	12	21.4	370

TRIP=OCTOBER STATION=4

271077	1350	1	22.0	430
271077	1350	4	22.0	550
271077	1350	6	21.5	620
271077	1350	8	21.5	620
271077	815	1	21.2	600
271077	815	3	21.3	799
271077	815	6	21.3	900
271077	815	8	21.0	999
271077	230	1	21.5	280
271077	230	3	22.0	380
271077	230	6	21.5	370
271077	230	8	21.5	490
261077	2020	1	22.0	280
261077	2020	3	22.0	400
261077	2020	6	21.5	380

Table II-21 Water Temperature, Specific Conductance, and pH Values Measured in Lake Rousseau, December 6-[illegible]1977. [STATION = Sampling Station (see Figure VII-1), TIME_ON = Sampling Time, DEPTH = Sampling Depth (meters), TEMP = Water Temperature (°C), COND = Specific Conductance (micromhos cm^{-1})]

TRIP=DECEMBE STATION=1

DATE	TIME_ON	DEPTH	TEMP	COND	PH
61277	1700	1	19.8	380	7.2
61277	1700	2	19.9		
61277	1700	3	19.6		
71277	740	1	18.3	365	7.2
71277	740	2	18.2		
71277	740	3	18.0		
71277	740				
71277	1615	1	18.0	390	7.7
71277	1615	2	18.0	390	7.7
71277	1615	3	18.0	400	7.6
81277	205	1	17.0	370	7.5
81277	205	2	16.8	370	7.6
81277	205	3	16.8	375	7.4

TRIP=DECEMBE STATION=2

DATE	TIME_ON	DEPTH	TEMP	COND	PH
61277	1745	1	19.5	370	7.1
71277	755	1	18.3	350	7.2
71277	755	3	18.3		
71277	755	7	18.3		
71277	755	10	18.0		
71277	1545	1	17.0	360	7.6
71277	1545	3	18.0	370	7.7
71277	1545	7	18.0	380	7.7
71277	1545	9	18.0	390	7.6
81277	105	1	17.0	370	7.3
81277	105	3	17.0	370	7.4
81277	105	7	17.0	370	7.5
81277	105	9	17.0	410	7.5

Table II-21 Water Temperature, Specific Conductance, and pH Values Measured in Lake Rousseau, December 6-8, 1977. [STATION = Sampling Station (see Figure VII-1), TIME_ON = Sampling Time, Depth = Sampling Depth (meters), TEMP = Water Temperature (°C), COND = Specific Conductance (micromhos cm^{-1})] (continued, page 2 of 2)

TRIP=DECEMBE STATION=3

DATE	TIME_ON	DEPTH	TEMP	COND	PH
61277	1810	1	19.5	430	7.2
61277	1810	4	19.5		
61277	1810	8	19.0		
61277	1810	12	19.0		
71277	815	1	17.9	345	7.2
71277	815	4	17.1		
71277	815	8	17.1		
71277	815	12	16.8		
71277	1455	1	18.0	360	7.6
71277	1455	4	18.0	360	7.6
71277	1455	8	18.0	360	7.6
71277	1455	11	18.0	370	7.8
81277	15	1	17.0	390	7.3
81277	15	4	16.6	365	7.4
81277	15	8	16.5	380	7.5
81277	15	11	16.3	360	7.4

TRIP=DECEMBE STATION=4

DATE	TIME_ON	DEPTH	TEMP	COND	PH
61277	1845	1	19.8	430	7.3
61277	1845	3	19.5		
61277	1845	6	19.5		
61277	1845	8	19.5		
71277	840	1	18.0	380	7.2
71277	840	3	18.2		
71277	840	6	17.0		
71277	840	7	17.0		
71277	1400	1	18.5	400	7.2
71277	1400	3	18.5	397	7.5
71277	1400	6	18.0	400	7.8
71277	2310	1	17.6	380	7.2
71277	2310	3	17.0	380	7.5
71277	2310	6	17.0	355	7.2
71277	2310	8	16.5		

Table II-22 Water Temperature and Specific Conductance Values Measured in Lake Rousseau, February 14-16, 1978. [STATION = Sampling Station (see Figure VII-1), TIME_ON = Sampling Time, DEPTH = Sampling Depth (meters), TEMP = Water Temperature (°C), COND = Specific Conductance (micromhos cm^{-1})]

TRIP=FEBRUAR STATION=1

DATE	TIME_ON	DEPTH	TEMP	COND
140278	1930	1	12.0	210
140278	1930	2	12.2	210
140278	1930	3	12.2	210
150278	710	1	12.0	210
150278	710	2	11.5	210
150278	710	3	11.0	270
150278	1725	1	13.5	211
150278	1725	2	13.5	212
150278	1725	3	13.5	212
160278	200	1	13.0	212
160278	200	2	13.0	212
160278	200	3	13.0	217
160278	200			

TRIP=FEBRUAR STATION=2

DATE	TIME_ON	DEPTH	TEMP	COND
140278	1900	1	12.2	211
140278	1900	3	12.3	215
140278	1900	7	12.2	218
140278	1900	10	12.2	227
150278	725	1	11.0	207
150278	725	3	11.2	215
150278	725	7	11.5	218
150278	725	10	11.5	250
150278	1640	1	13.5	212
150278	1640	3	12.7	211
150278	1640	7	12.0	210
150278	1640	10	11.9	212
160278	115	1	13.0	213
160278	115	3	13.0	218
160278	115	7	12.0	212
160278	115	10	12.0	212

Table II-22 Water Temperature and Specific Conductance values Measured in Lake Rousseau, February 14-16, 1978. [STATION = Sampling Station (see Figure VII-1), TIME_ON = Sampling Time, DEPTH = Sampling Depth (meters), TEMP = Water Temperature (°C), COND = Specific Conductance (micromhos cm^{-1})] (continued, page 2 of 2)

TRIP=FEBRUAR STATION=3

DATE	TIME_ON	DEPTH	TEMP	COND
140278	1820	1	12.3	211
140278	1820	4	12.3	217
140278	1820	8	12.4	217
140278	1820	11	12.3	220
150278	750	1	11.0	208
150278	750	4	11.5	212
150278	750	8	11.5	218
150278	750	12	11.5	225
150278	1535	1	14.2	218
150278	1535	4	12.2	215
150278	1535	8	12.0	215
150278	1535	12	12.0	220
160278	0	1	13.8	210
160278	0	4	12.5	210
160278	0	8	12.0	210
160278	0	11	12.0	213

TRIP=FEBRUAR STATION=4

DATE	TIME_ON	DEPTH	TEMP	COND
140278	1730	1.0	13.0	220
140278	1730	3.0	13.0	218
140278	1730	6.0	13.0	220
140278	1730	7.6	12.8	220
150278	820	1.0	11.5	210
150278	820	3.0	12.0	215
150278	820	6.0	12.0	260
150278	820	8.0	12.0	275
150278	1400	1.0	14.0	220
150278	1400	3.0	12.8	218
150278	1400	6.0	12.2	215
150278	1400	8.0	12.1	218
150278	2245	1.0	14.0	219
150278	2245	3.0	12.5	218
150278	2245	6.0	12.0	215
150278	2245	8.0	12.0	220

Table II-23 Water Temperature and Specific Conductance Values Measured in Lake Rousseau, April 18 and 19, 1978 [STATION = Sampling Station (see Figure VII-1), TIME ON = Sampling Time, DEPTH = Sampling Depth (meters), WAT TEMP = Water Temperature (°C), COND = Specific Conductance (micromhos cm^{-1})]

DATE	TIME_ON	DEPTH_M	WAT_TEMP	COND
180478	1712	1.0	.	270
180478	1712	2.0	.	265
180478	1712	3.0	.	250
190478	1710	1.0	24.0	.
190478	1710	2.0	24.0	.
190478	1710	3.0	23.9	.
190478	1710	.	.	.
190478	555	1.0	23.9	270
190478	555	2.0	23.9	270
190478	555	3.0	23.9	270
190478	555		23.7	.
200478	315	1	23.6	.
200478	315	2	23.5	.
200478	315	3	.	.
200478	315	.		
200478	210	1	23.9	275
200478	210	3	23.9	280
200478	210	7	23.9	290
200478	210	10	23.7	280
190478	615	1.0	23.9	.
190478	615	3.0	23.8	.
190478	615	7.0	23.6	.
190478	615	10.0	23.1	.
190478	1625	1.0	24.2	270
190478	1625	3.0	24.2	220
190478	1625	7.0	24.0	230
190478	1625	10.0	23.9	240
180478	1745	1.0	24.5	.
180478	1745	3.0	24.2	.
180478	1745	7.0	23.7	.
180478	1745	10.0	23.7	.

Table II-23 Water Temperature and Specific Conductance Values Measured in Lake Rousseau, April 18 and 19, 1978 [STATION = Sampling Station (see Figure VII-1), TIME ON = Sampling Time, DEPTH = Sampling Depth (meters), WAT TEMP = Water Temperature (°C), COND = Specific Conductance (micromhos cm^{-1})] (Continued, page 2 of 2)

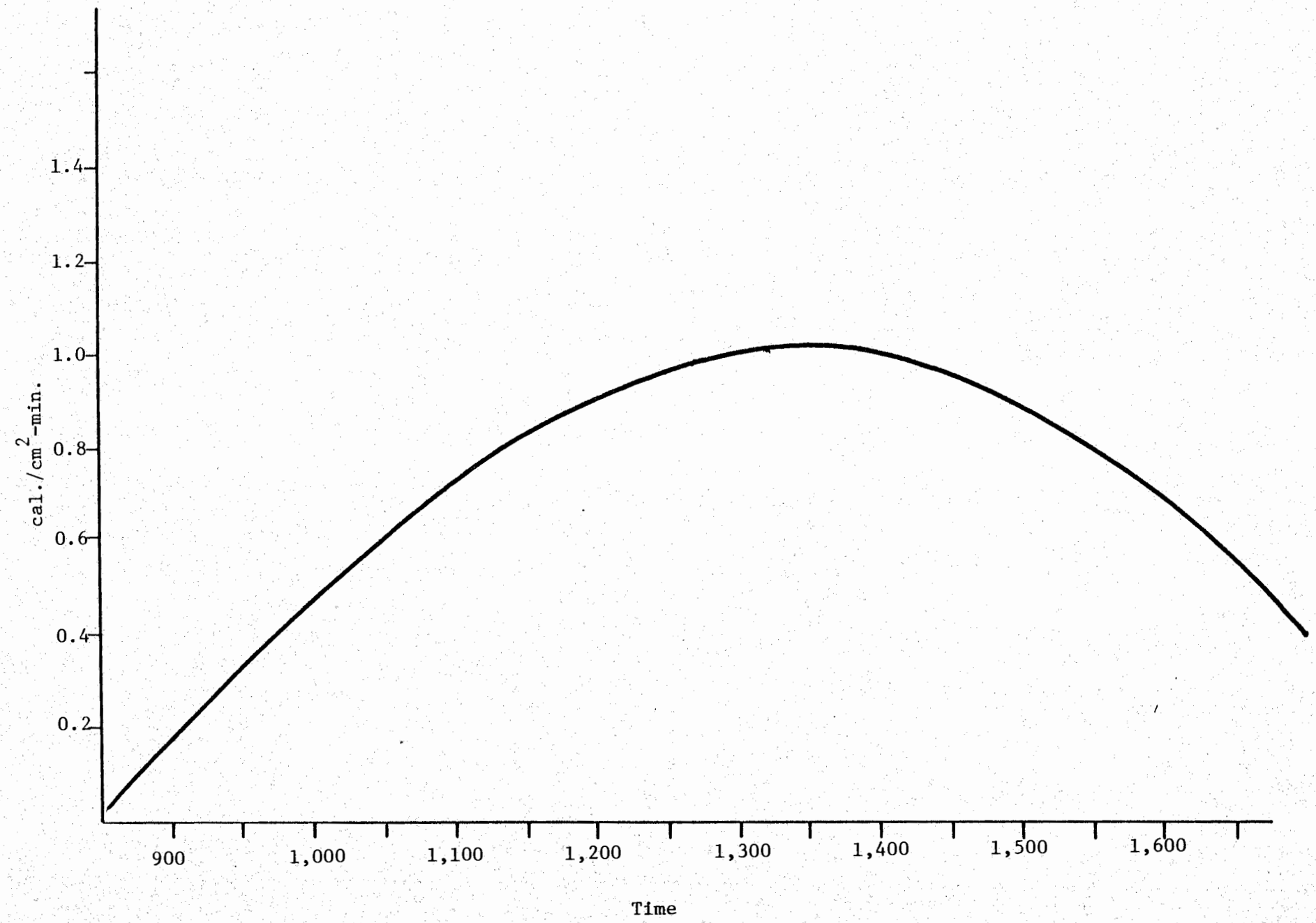
DATE	TIME_ON	DEPTH_M	WAT_TEMP	COND
180478	1805	1.0	24.8	240
180478	1805	4.0	24.6	255
180478	1805	8.0	24.0	250
180478	1805	11.5	24.0	245
190478	55	1.0	23.9	.
190478	55	4.0	23.9	.
190478	55	8.0	23.9	.
190478	55	12.0	23.9	.
190478	645	1.0	24.1	260
190478	645	4.0	24.1	260
190478	645	8.0	23.9	240
190478	645	12.0	23.6	.
190478	1522	1.0	24.1	.
190478	1522	4.0	24.2	.
190478	1522	8.0	24.1	.
190478	1522	12.0	24.1	.
180478	1835	1.0	24.9	215
180478	1835	3.0	24.9	225
180478	1835	6.0	.	240
180478	1835	8.0	.	250
190478	720	1.0	24.1	240
190478	720	3.0	24.1	280
190478	720	6.0	24.1	280
190478	720	8.0	24.1	290
190478	1415	1.0	24.2	.
190478	1415	3.0	24.2	.
190478	1415	6.0	24.2	.
190478	1415	8.0	24.2	.
190478	2345	1.0	23.9	.
190478	2345	3.0	23.9	.
190478	2345	6	23.9	.
190478	2345	8	23.8	.

In October the specific conductance of surface waters ranged from 255 to 600 micromhos cm^{-1}, and values increased with depth at all stations. The highest value, 1140 micromhos, was found in bottom waters at Station 3. Conductance values ranged from 350 to 430 micromhos cm^{-1} in December and were similar throughout the water column. Values of 207 to 275 micromhos cm^{-1} were measured in February. The range of conductance measurements taken during April was from 215 to 290 micromhos cm^{-1}. No between-station variation in the physical water quality parameters measured from station to station was noted over the first four sampling periods.

Solar insolation for the Lake Rousseau study area was recorded for each bimonthly sampling period. Records of solar radiation are useful in evaluating measurements of photosynthesis (productivity) and associated parameters. Solar insolation data are given in Figures II-10 through II-17.

For the proper interpretation of data on productivity and for defining the euphotic and aphotic zones of a water body, the measurement of light penetration through the water column is necessary. Measurements of light attenuation made with a Secchi disc and/or a submersible photometer yielded the light extinction coefficients presented in Table II-24. A number of sources (Westlake, 1963; Odum, 1971; U.S. Geological Survey, 1973) have defined the compensation level as the depth at which the intensity of light is 1 percent of the intensity at the surface. The compensation depth is the depth at which the energy fixed in the process of photosynthesis equals the energy required in metabolism of the organisms present. Compensation depths derived from calculated light extinction coefficients are presented in Table II-25. These depths were found to remain relatively uniform among stations during each sampling period. Monthly fluctuations, however, were recorded ranging from an average depth of 3.62 meters in April to 10.69 meters in February. Penetration of light through the water column is influenced not only by the water itself, but also by absorption of suspended particles and dissolved compounds or color. Water color measurements taken during

Figure II-10 Solar Insolation (cal./cm.^{2}-min.) at Lake Rousseau, October 27, 1977



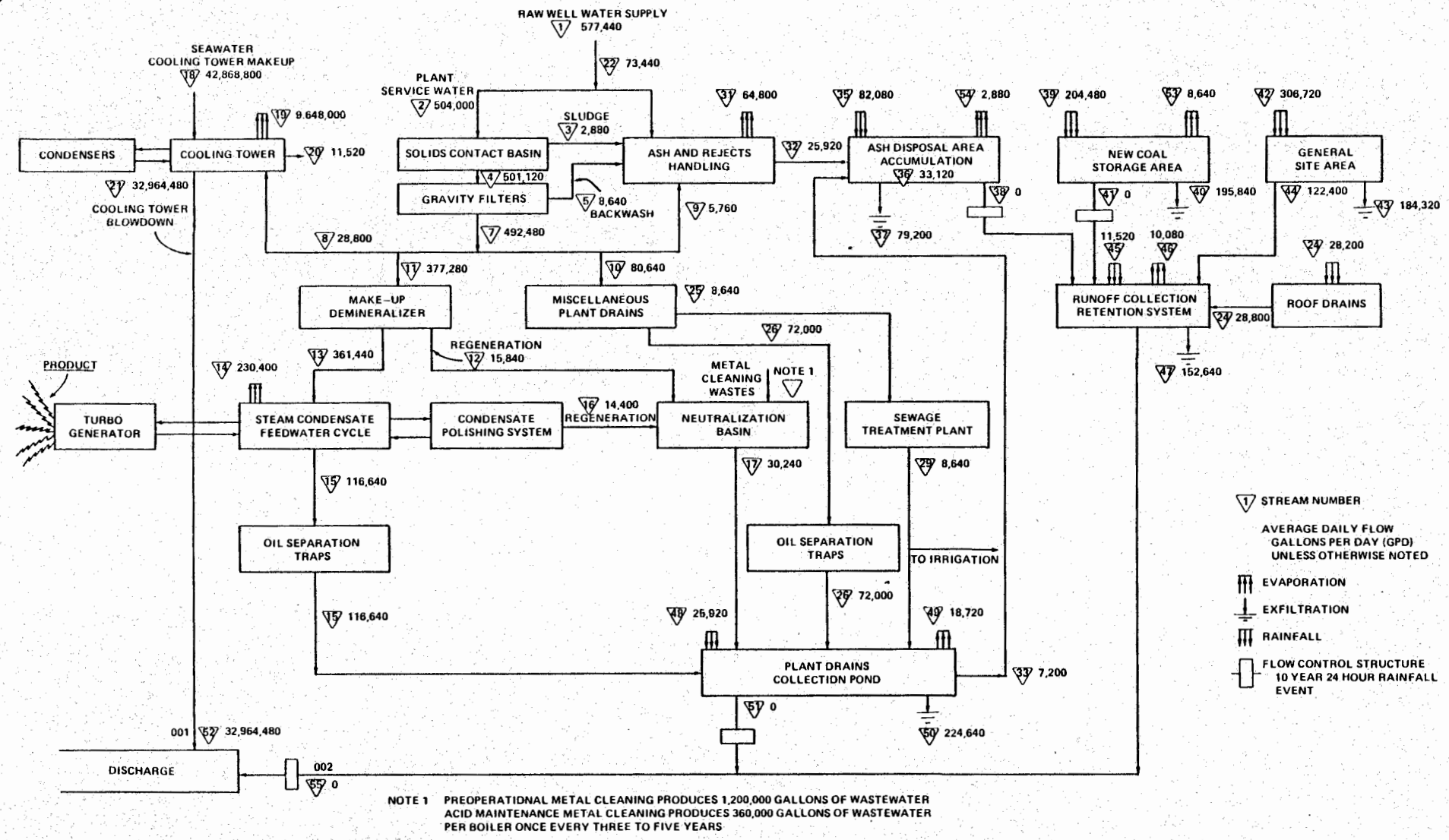


Figure 3.3-1
PLANT WATER USE DIAGRAM

SOURCE: ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1978

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

Table II-27 Wind Measurements During Spring Circulation Study, April 21, 1978

Hour		Wind Direction (degrees)*				Wind Speed (miles/hour)		
1:00	a.m.			30				2.6
2:00				30				2.9
3:00				27				4.0
4:00				27				2.3
5:00				27				2.0
6:00				27				2.3
7:00				25				2.0
8:00				27				2.1
9:00				30				2.5
10:00				33				3.2
11:00		Start	70	33		Start	9.7	7.3
12:00	noon	3/31/78	80	33		3/31/78	9.2	5.0
1:00			93	30			10.5	9.2
2:00			93	30			11.0	9.6
3:00			270	27			6.0	10.5
4:00			30	25			9.2	12.5
5:00			30	30			11.0	9.7
6:00			30	30			7.3	10.0
7:00			33	27	End		13.0	8.0
8:00			35		4/1/78		3.0	3.5
9:00			33				2.3	
10:00			30				3.9	
11:00			31				2.5	
12:00	midnight		20				2.6	

*Degrees: 0° and 360° = north.

Source: Environmental Science and Engineering, Inc., 1978.

The floc layers in areas of the upper arm of Lake Rousseau were observed to be approximately .9 to 1.2 meters (3 to 4 feet) in depth. These thick floc layers could be a result of aquatic weed control programs carried out during previous years.

The floc layer at Stations 1, 2, 3, 4*, and 4 (see Figure II-18) was measured to range from 15 to 20 centimeters (6 to 8 inches) in depth from October 1977 to April 1978. Samples taken in the shallow areas of the western embayment with vegetation also had a floc layer of the same relative thickness.

The May 1978 samples collected at Stations 5 and 7 (see Figure II-18) have low suspended solids (6 to 10 milligrams per liter) and no floc layer at depth. The suspended solids concentrations are low along the sandy bottom of the old river channel near the Inglis Dam. The cores taken at these stations also had no floc, muck, or peat on the surface. This confirms that the influence of the flow through the Inglis Dam is sufficient in keeping the area scoured of biogenic material such as plant cells, fibers, and vegetative debris that contribute to high suspended solids concentrations.

The influence of the wind on suspended solids concentrations is considered minimal due to resulting low-bottom velocities. Although evidence exists that a counter directional bottom current is developed during cross-wind conditions, the high resistance to flow through the shallow vegetated areas inhibits excessive suspended solids inputs into the old river channel.

BIOLOGICAL PARAMETERS

Emphasis in the aquatic portion of the study was upon entrainable organisms. Discussions with state and federal agencies and with Florida Power indicated that an intake structure could be designed which would reduce potential impingement. The volumes of water required are such that impingeable organisms could be screened out of areas where flow rates are as high as the recommended maximum of one-half foot per second.

Freshwater fish present in the lake do not produce planktonic larvae which would be susceptible to entrainment. Therefore, the primary emphasis of the biological sampling was on phytoplankton and zooplankton rather than sampling for fish larvae or a survey of fish populations.

Phytoplankton

Although it appears that entrainment of phytoplankton communities may not be a serious consideration in Lake Rousseau, due to the inherent natural rapid turnover rates of these organisms, a knowledge of phytoplankton populations is useful in characterization of the water body. Algal associations, levels of primary production, and depths to which primary production occurs are indicative of the trophic state of the aquatic system in which they are encountered.

Photosynthetic Pigments

Chlorophyll a was used in this study as an estimator of phytoplankton biomass. This pigment constitutes, on the average, 1.5 percent of the dry weight organic matter (ash-free weight) of planktonic algae (American Public Health Association, 1975). Chlorophyll a levels measured in samples taken on Lake Rousseau are presented in Tables II-28, II-29, II-30, and II-31 for the October 1977, December 1977, February 1978, and April 1978 surveys, respectively. Overall concentrations were low on

Table II-28 Chlorophyll a* Concentrations Measured in Samples Taken from Lake Rousseau; October 27, 1977

Station	Depth (meters)	Chlorophyll a Concentration (mg/m^3) Day	Night	Mean
1	1	1.42	0.98	1.20
	2	1.38	0.76	1.07
	3	3.47	1.29	2.38
	Avg.	2.09	1.01	1.55
2	1	1.43	0.75	1.09
	3	1.33	1.38	1.36
	7	0.84	1.02	0.93
	10	0.62	0.62	0.62
	Avg.	1.06	0.94	1.00
3	1	1.65	0.93	1.29
	4	0.89	1.29	1.09
	8	0.93	1.07	1.00
	12	2.76	1.51	2.14
	Avg.	1.56	1.20	1.38
4	1	2.31	1.56	1.94
	3	0.66	0.80	0.73
	6	0.49	0.85	0.67
	8	0.53	—	0.53
	Avg.	1.00	1.07	1.04
Overall Mean		1.38	1.06	1.20
Standard Deviation		0.87	0.30	0.55

*Corrected for phaeopigments.

Source: Environmental Science and Engineering, Inc., 1977.

Table II-29 Chlorophyll a* Concentrations Measured in Samples Taken from Lake Rousseau; December 8, 1977

Station	Depth (meters)	Chlorophyll a Concentration (mg/m^3) Day	Night	Mean
1	1	1.51	1.51	1.51
	2	2.05	1.87	1.96
	3	0.68	2.35	1.52
	Avg.	1.41	1.91	1.66
2	1	BDL**	1.25	0.63
	3	0.53	BDL	0.27
	7	BDL	2.67	1.34
	10	1.25	0.27	0.76
	Avg.	0.45	1.05	0.75
3	1	1.69	1.51	1.60
	4	1.87	2.94	2.41
	8	BDL	—	BDL
	12	0.36	1.02	0.69
	Avg.	0.98	1.82	1.40
4	1	1.78	1.34	1.56
	3	0.98	1.51	1.25
	6	BDL	1.07	0.54
	Avg.	0.92	1.31	1.12
Overall Mean		0.91	1.49	1.15
Standard Deviation		0.78	0.84	0.68

*Corrected for phaeopigments.
**BDL = Below Detectable Level (0.2 mg/m^3).

Source: Environmental Science and Engineering, Inc., 1977.

Table II-30 Chlorophyll a* Concentrations Measured in Samples Taken from Lake Rousseau; February 15 and 16, 1978

Station	Depth (meters)	Chlorophyll a Concentration (mg/m^3) Day	Night	Mean
1	1	0.36	0.65	0.51
	2	0.62	0.18	0.40
	3	0.45	0.77	0.61
	Avg.	0.48	0.53	0.51
2	1	0.27	1.60	0.94
	3	0.80	0.89	0.85
	7	0.18	1.34	0.76
	10	0.71	0.62	0.67
	Avg.	0.49	1.11	0.80
3	1	0.45	0.53	0.49
	4	0.27	0.98	0.63
	8	0.27	1.16	0.72
	12	0.27	1.96	1.12
	Avg.	0.32	1.16	0.74
4	1	—	0.18	0.18
	3	0.98	0.53	0.76
	6	0.98	0.45	0.72
	8	0.98	0.36	0.67
	Avg.	0.98	0.38	0.68
Overall Mean		0.54	0.81	0.67
Standard Deviation		0.30	0.52	0.22

*Corrected for phaeopigments.

Source: Environmental Science and Engineering, Inc., 1978.

Table II-31 Chlorophyll a* Concentrations Measured in Samples Taken from Lake Rousseau; April 19 and 20, 1978

Station	Depth (meters)	Chlorophyll a Concentration (mg/m^3) Day	Night	Mean
1	1	0.20	0.98	0.59
	2	0.47	0.36	0.42
	3	0.74	0.62	0.68
	Avg.	0.47	0.65	0.56
2	1	0.27	1.53	0.40
	3	0.53	0.62	0.58
	7	0.20	0.20	0.20
	10	0.20	0.36	0.28
	Avg.	0.30	1.43	0.37
3	1	0.53	0.36	0.45
	4	0.27	0.36	0.32
	8	0.71	1.36	0.54
	12	0.45	1.36	1.41
	Avg.	0.49	1.36	0.43
4	1	0.71	0.36	0.54
	3	0.71	1.07	0.89
	6	1.16	0.27	0.72
	8	1.16	0.20	0.68
	Avg.	0.94	0.48	0.71
Overall Mean		0.55	0.48	0.51
Standard Deviation		0.32	0.26	0.18

*Corrected for phaeopigments.

Source: Environmental Science and Engineering, Inc., 1978.

all three sampling dates and averaged 1.20 mg/m^3 in October, 1.15 mg/m^3 in December, 0.67 mg/m^3 in February, and .51 mg/1^3 in April. Chlorophyll a values typically range from 0.50 mg/m^3 or less in oligotrophic bodies of water to 20 mg/m^3 and above in eutrophic waters. No observable trends were noted between daytime and nighttime samples, between sampling stations, or with depth differences as a result of the variability of the data.

Phytoplankton Concentration and Composition

In October, phytoplankton concentrations in Lake Rousseau were moderate with an average of 8,287 cells/ml and little variance between stations. On this sampling date, members of the division Chrysophyta predominated in abundance, comprising 42 percent of all planktonic algae enumerated, followed by the Chlorophyta which accounted for 35 percent of the abundance. Ankistrodesmus convolutus, a chlorophyte, was the dominant species at all stations. Other abundant species in October include the diatoms, Synedra acus, Melosira ambigua, and Nitzschia holsatica; the blue-green, Oscillatoria geminata; and the flagellate, Rhodomonas sp. A listing of the taxa observed in October and their concentrations is given in Table II-32.

Phytoplankton numbers were lower in December with an average of 925 cells/ml. In December, Chrysophyta (which constituted 68 percent of the phytoplankton counted) was again the most abundant division. Numerically important species include Chromulina sp. (a chrysophyte), Fragillaria construens, Cyclotella glomerata, and Melosira ambigua (diatoms), and Rhodomonas sp. In Table II-33, the taxa of planktonic algae encountered in December and their concentrations are presented.

An average phytoplankton concentration of 2,934 cells/ml was recovered during February. Sixty-two percent and 35 percent of the individuals counted belonged to the division Pyrrophyta and Chrysophyta, respectively. Rhodomonas c.f. lacustris, a pyrrhophyte, was the dominant species with Cyclottela invisitatus, a chlorophyte, exhibiting the

Table II-32 Occurrence and Concentrations of Phytoplankton Taxa Observed in Depth-Composited Samples Taken from Lake Rousseau, October 27, 1977

Taxa	Concentration (cells/milliliter) Station 1	Station 2	Station 3	Station 4	Mean
Cyanophyta					
Anabaena sp.	45	20	19	24	27
Aphanocapsa delicatissima	20	35	6	24	21
Chroococcus sp.	10	10	—	—	5
Coelosphaerium	—	—	—	5	1
Gomphosphaeria aponina	5	5	—	—	3
Lyngbya nana	—	35	95	85	54
Merismopedia glauca	10	—	—	5	4
Oscillatoria geminata	1170	875	970	1039	1014
Oscillatoria sp.	—	10	—	—	3
Euglenophyta					
Euglena sp.	35	90	38	47	53
Phacus pyrum	5	5	6	—	4
Trachelomonas ovata	—	5	—	—	1
Trachelomonas verrucosa	—	5	—	—	1
Trachelomonas volvocina	—	—	—	5	1
Pyrrhophyta					
Ceratium hirundinella	5	5	13	5	7
Cryptomonas sp.	80	165	334	541	280
Peridinium quadridens	5	35	19	19	20
Rhodomonas sp.	225	360	353	785	431
Chlorophyta					
Ankistrodesmus convolutus	2800	2405	1985	2120	2328
Ankistrodesmus falcatus	160	105	107	108	120
Chlamydomonas sp.	15	45	38	75	43
Closterium c.f. *archerianum*	—	5	—	5	3
Coelastrum microporum	—	—	—	5	1
Dyctyosphaerium pulchellum	—	15	—	—	4
Elakatothrix gelatinosa	5	—	—	—	1
Golenkinia radiata	5	30	—	5	10
Lagerheimia chodati	—	10	—	5	4
Lagerheimia citriformis	—	5	—	—	1
Mougiotia sp.	280	455	—	334	267
Oocystis sp.	10	25	13	5	13
Pediastrum duplex				5	1
Scenedesmus abundans	—	20	19	9	12
Scenedesmus bijuga	5	10	19	—	9

Table II-32 Occurrence and Concentrations of Phytoplankton Taxa Observed in Depth-Composited Samples Taken from Lake Rousseau, October 27, 1977 (Continued, page 2 of 2)

Taxa	Concentration (cells/milliliter) Station 1	Station 2	Station 3	Station 4	Mean
Chlorophyta (continued)					
Scenedesmus denticulatus	—	10	—	—	3
Scenedesmus dimorphus	10	—	6	5	5
Scenedesmus quadricauda	15	5	6	9	9
Schroederia setigera	10	20	13	47	23
Sphaerocystis	—	—	6	9	4
Staurastrum sp.	10	10	13	9	11
Tetraedron minimum	10	—	—	—	3
Tetraedron regulare	20	30	6	52	27
Tetraedron trigonum	—	20	6	9	9
Treubaria setigerum	—	—	6	5	3
Chrysophyta					
Achnanthes sp.	—	20	—	—	5
Amphora sp.	—	5	6	9	5
Cocconeis placentula	10	10	13	14	12
Cyclotella	105	110	164	103	121
Cymbella	—	10	6	5	5
Dinobryon sertularia	—	—	13	14	7
Epithemia zebra	—	5	25	—	8
Gomphonema sp.	5	—	—	9	4
Mallomonas tonsurata	10	25	19	47	25
Melosira ambigua	680	895	882	451	727
Melosira granulata	155	195	126	28	126
Navicula sp.	25	40	57	5	32
Nitzschia acicularis	90	90	164	141	121
Nitzschia holsatica	440	540	668	343	498
Nitzschia palea	—	20	—	—	5
Nitzschia sp.	20	15	88	61	46
Ophiocytium capitatum	—	—	6	—	2
Stephanodiscus sp.	—	—	13	52	16
Rhopolodia sp.	5	—	—	—	1
Synedra acus	1265	1875	2010	1448	1650
Synedra ulna	15	55	25	33	32
Synura sp.	10				3
Total Number Species	40	49	41	47	44
Total No./ml	7805	8795	8381	8168	8287

Note: — Indicates that species was not observed.

Source: Environmental Science and Engineering, Inc., 1978.

Table II-33 Occurrence and Concentrations of Phytoplankton Taxa Observed in Depth-Composited Samples Taken from Lake Rousseau, December 27, 1977

Taxa	Concentration (cells/milliliter) Station 1	Station 2	Station 3	Station 4	Mean
Cyanophyta					
Gomphosphoeria aponina	—	4	—	—	1
Lyngbya nana	—	34	6	17	14
Oscillatoria geminata	—	4	—	7	3
Oscillatoria sp.	—	—	3	—	<1
Phormidium c.f. *molle*	—	—	—	2	<1
Euglenophyta					
Euglena sp.	34	15	28	10	22
Trachelomonas globularis	—	4	—	—	1
Trachelomonas ovata	—	—	3	—	<1
Misc. flagellates	43	42	47	60	48
Pyrrhophyta					
Glenodinium sp.	—	4	3	5	3
Rhodomonas sp.	189	76	87	146	125
Chlorophyta					
Ankistrodesmus convolutus	16	—	—	7	6
Ankistrodesmus falcatus	19	8	6	10	11
Closterium c.f. *archeriaxum*	6	4	—	2	3
Cosmarium sp.	—	4	—	—	1
Gloeocystis major	—	4	—	—	1
Oocystis sp.	—	11	—	5	4
Pediastrum tetras	—	—	3	—	<1
Scenedesmus bijuga	3	8	—	2	4
Scenedesmus quadricauda	—	—	3	5	2
Schroederia setigera	53	38	37	43	43
Staurastrum sp.	—	4	—	—	1
Tetraedron regulare	—	4	—	—	1
Tetraedron trigonum	—	4	—	—	1
Tetraedron trilobum	—	—	—	2	<1
Chrysophyta					
Amphora sp.	—	—	6	—	2
Chromulina (sp.)	546	239	183	211	295
Cocconeis placentula	—	23	16	7	12

Table II-33 Occurrence and Concentrations of Phytoplankton Taxa Observed in Depth-Composited Samples Taken from Lake Rousseau, December 27, 1977 (Continued, page 2 of 2)

Taxa	Concentration (cells/milliliter) Station 1	Station 2	Station 3	Station 4	Mean
Chrysophyta (continued)					
Cyclotella glomerata	31	156	3	53	61
Cymbella sp.	—	4	—	—	1
Epithamia zebra	3	11	9	2	6
Fragillaria construens	37	277	112	26	113
Gomphonema sp.	—	8	3	2	3
Mallomonas tonsurata	12	15	6	12	11
Melosira ambigua	6	194	37	2	60
Melosira granulata	—	19	16	14	12
Melosira varians	—	—	6	—	2
Navicula sp.	6	49	3	7	16
Nitzschia acicularis	—	4	—	—	1
Nitzschia palea	6	—	—	—	2
Nitzschia sp.	—	34	—	5	10
Rhizosolenia sp.	—	—	3	—	<1
Stephanodiscus sp.	6	11	—	2	5
Synedra acus	3	23	9	10	11
Synedra ulna	—	23	3	2	7
Total Number Species	17	33	25	26	25
Total Ct/ml	1019	1362	641	678	925

Note: — Indicates that species was not observed.

Source: Environmental Science and Engineering, Inc., 1978.

second highest abundance. Together the above two species accounted for 70 percent of the total mean number of individuals occurring in February. Other relatively abundant species during this sampling period were Cryptomonas c.f. erosa, a flagellate, and Chromulina c.f. globusa, another chrysophyte. Table II-34 gives the taxa and concentrations of phytoplankton encountered during February.

Phytoplankton abundance in April was similar to concentrations found during February, with an average of 3,965 cells/milliliter. However, as in October and December, the Chrysophytes predominated, comprising 90 percent of the total cell count. Cyclotella atomus was the dominant Chrysophyta species at all stations. Additional important, but less important, species occurring during April include Chromulina c.f. ovalis, Melosira ambigua, and Cyclotella invisitatus of the division Chrysophyta and Cryptomonas erosa, a pyrrhophyte. Information concerning taxonomic composition and phytoplankton concentrations observed during April is given in Table II-35.

Very little between-station variation in phytoplankton species dominance, abundance, and community taxonomic composition was observed during the four sampling periods. Changes in community structure between sampling episodes appear to be primarily associated with changes in environmental conditions (i.e., lower temperatures in December) and natural seasonal fluctuations in community dominance (i.e., from diatoms to flagellates). The existence of relatively few dominant species, accounting for a major percentage of the total mean number of individuals enumerated, suggests that competitive processes within the phytoplankton community may be an additional important regulator of plankton populations in Lake Rousseau. Successful competitive exclusion requires a certain degree of environmental stability in terms of physical and chemical conditions. Chemical and physical parameters measured in Lake Rousseau to date suggest that the lake's aquatic environment may provide the necessary stability.

Table II-34 Occurrence and Concentration of Phytoplankton Observed in Depth-Composited Samples Taken from Lake Rousseau, February 15, 1978

Taxa	Concentration (cells/milliliter) Station 1	Station 2	Station 3	Station 4	Mean
Cyanophyta					
Lyngbya nana	3	6	--	--	2
Euglenophyta					
Euglena spp.	--	16	--	--	4
Trachelomonas verrucosa	3	--	--	--	4
Pyrrhophyta					
Chrysococcus cf. rufescens	--	--	9	22	8
Cryptomonas cf. erosa	205	326	205	322	264
Glenodinium cf. penardi	20	--	--	--	5
Peridinium qudridens	3	9	9	9	8
Rhodomonas cf. lacustris	1,333	1,466	1,097	1,748	1,411
Miscellaneous flagellates	112	124	121	118	119
Chlorophyta					
Ankistrodesmus convolutus	3	--	3	--	2
Chlamydomonas spp.	59	81	65	90	74
Coelosphaerium microporum	--	--	--	3	<1
Oocystis spp.	--	--	--	3	<1
Pediastrum tetras	--	3	--	3	2
Scenedesmus quadricauda	--	--	--	3	<1
Schroederia setigera	--	--	--	3	<1
Tetraedron minimum	--	--	3	3	2
Chrysophyta					
Achnanthes minutissima	--	25	25	--	13
Chromulina cf. globosa	164	96	260	217	184
Cocconeis placentula	9	9	16	43	19
Cyclottela invisitatus	747	735	595	484	640
Dinobryon sertularia	22	--	--	--	6
Cymbella spp.	3	--	3	--	2
Fragillaria construens	--	43	--	25	17
Melosira ambigua	93	78	71	81	81
Melosira granulata	31	--	9	40	20

Table II-34 Occurrence and Concentration of Phytoplankton Observed in Depth-Composited Samples Taken from Lake Rousseau, February 15, 1978 (page 2 of 2)

Taxa	Concentration (cells/milliliter) Station 1	Station 2	Station 3	Station 4	Mean
Chrysophyta (continued)					
Navicula spp.	6	3	9	12	8
Nitzschia palea	6	--	3	--	2
Nitzschia spp.	9	--	3	6	5
Mallomonas tonsurata	9	40	31	56	34
Synedra acus	6	3	--	--	2
Total Number Species	20	16	18	20	19
Total Ct/Ml	2,846	3,063	2,537	3,291	2,934

Note: -- Indicates that species was not observed.

Source: Environmental Science and Engineering, Inc., 1978.

Table II-35 Occurrence and Concentration of Phytoplankton Taxa Observed in Depth-Composited Samples Taken from Lake Rousseau, April 19, 1978

Taxa	Concentration (cells/milliliter) Station 1	Station 2	Station 3	Station 4	Mean
Euglenophyta					
Trachelomonas ovata	--	4	--	--	1
Pyrrhophyta					
Cryptomonas cf. erosa	52	105	132	273	141
Glenodinium cf. penardi	5	--	--	9	4
Miscellaneous flagellates	5	9	23	24	15
Chlorophyta					
Actinastrum hantzschii	--	8	--	75	21
Ankistrodesmus convolutus	38	64	66	85	63
Chlamydomonas spp.	108	135	38	56	84
Golenkenia radiata	--	--	--	5	1
Micractinium pusillum	9	17	33	19	20
Oocystis spp.	--	4	--	5	2
Pleurotaenium spp.	--	--	--	5	1
Scenedesmus abundans	--	--	--	5	1
Scenedesmus denticulatus	5	--	--	--	1
Scenedesmus quadricauda	--	--	--	5	1
Schroederia setigera	14	59	28	99	50
Selenastrum gracile	5	--	--	--	
Tetraedron minimum	--	4	--	--	1
Chrysophyta					
Atthya zachariasi	--	9	5	5	5
Chromulina cf. globosa	9	12	19	9	12
Chromulina cf. ovalis	230	387	310	757	421
Cocconeis placentula	19	17	19	--	14
Cyclotella atomus	1,546	2,654	2,312	3,365	2,469
Cyclotella invisitatus	146	144	249	202	185
Cyclotella meneghiniana	5	22	5	14	12
Dinobryon divergens	47	28	--	--	19
Epithamia zebra	--	--	5	--	1
Fragillaria construens	--	157	--	28	46
Fragillaria intermedia	14	--	--	--	4
Gromphonema spp.	--	8	--	--	2
Mallomonas cf. akrokomas	9	4	--	24	9
Mallomonas tonsurata	9	13	19	--	10

Table II-35 Occurrence and Concentration of Phytoplankton Taxa Observed in Depth-Composited Samples Taken from Lake Rousseau, April 19, 1978 (page 2 of 2)

Taxa	Concentration (cells/milliliter) Station 1	Station 2	Station 3	Station 4	Mean
Chrysophyta (continued)					
Melosira ambigua	230	197	273	282	246
Melosira granulata	42	—	33	56	33
Melosira varians	--	5	--	--	1
Navicula spp.	9	4	--	14	7
Nitzschia acicularis	14	17	42	38	28
Nitzschia holsaltca	--	--	33	--	8
Nitzschia spp.	--	4	14	33	13
Synedra ulna	9	12	19	9	12

Note: -- Indicates that species was not observed.

Source: Environmental Science and Engineering, Inc., 1978.

Plankton Metabolism

Levels of plankton metabolism averaged for the water column and measured during the four bimonthly surveys are presented in Table II-36. Productivity in the water column was low on these dates, with respiration being the dominant metabolic function at all stations.

The overall range of respiration in the water column was from 0.99 gO_2/m^2 per day at Station 2 in April to 15.96 gO_2/m^2 per day at Station 2 in October. Levels of gross production ranged from 0.88 gO_2/m^2 per day at Station 1 during February to 7.87 gO_2/m^2 per day at Station 2 in October. Gross production at Station 3 was consistently higher than most of the other stations for each sampling period. Net production was not detected in phytoplankton communities inhabiting the sampling stations during October and December. Observable levels of net production were measured in February and April at all stations except Station 3. The highest values (2.15 g O_2/m^2 per day) were recorded at Station 4 in April and the lowest levels (0.15 g O_2/m^2 per day) occurred at Station 2 during February and seem to correspond to solar radiation for that date (see Figure II-13).

Brezonik (1976) suggests that the quantitative or qualitative assignment of any lake into a trophic class is problematic since it is difficult to assess a system in terms of a multidimensional concept. Different parameters, when regarded separately, may indicate entirely different trophic states for the same lake because most environmental variables operate somewhat independently. Therefore, assignment of a trophic state requires that a number of variables be considered. Table II-37 presents a comparison of selected indicators of water body trophic states and measurements of the same characteristics recorded for Lake Rousseau during this study. On the basis of this comparison Lake Rousseau could be defined as a mesotrophic system.

Table II-36 Estimated Levels of Plankton Metabolism in Lake Rousseau Within the Euphotic Zone

Date	Station No.	Gross Production (gO_2/m^2-day)	Net Production (gO_2/m^2-day)	Respiration (gO_2/m^2-day)	R/R Ratio GP_{24}/R_{24}	Limit of Euphotic Zone (Meters)	Depth (Meters)
October 26-27, 1977	1	4.29	NC†	8.80	0.49	Bottom	4.0
	2	7.87	NC	15.96	0.49	5.6	10.0
	3	7.14	NC	10.06	0.71	5.4	11.5
	4	3.41	NC	12.69	0.27	5.2	8.0
December 7-8, 1977	1	ND*	NC	1.52	NC	Bottom	4.0
	2	2.48	NC	7.99	0.31	6.0	10.0
	3	5.06	NC	8.26	0.61	6.4	11.5
	4	4.11	NC	3.92	1.05	6.0	8.0
February 15-16, 1978	1	0.88	0.38	2.19	0.40	Bottom	4.0
	2	2.14	0.15	7.24	0.30	Bottom	10.0
	3	2.88	NC	5.63	0.51	11.2	11.5
	4	1.14	0.99	1.44	0.79	Bottom	8.0
April 19-20, 1978	1	1.35	0.16	1.19	1.14	Bottom	4.0
	2	1.79	0.80	0.99	1.80	4.7	10.0
	3	1.91	NC	2.19	0.88	4.6	11.5
	4	5.07	2.15	2.93	1.73	4.2	8.0

*ND = Not detectable.
†NC = Not calculable.

Source: Environmental Science and Engineering, Inc., 1978.

Table II-37 Comparison of Selected Characteristics of Water Body Trophic States and Measurements of the Same Characteristic Taken in Lake Rousseau During the Study Period

Water Body	pH	Chlorophyll a (mg/m3).	Total Organic Nitrogen (mgN/1)	Dominant Algae
Oligotrophic*	Neutral-slightly alkaline	1.3-3.2	0.09-.36	Diatoms, especially Cyclotella and chrysophytes, especially Dinobryon and some Melosira
Mesotrophic*	Neutral-slightly alkaline	1.8-9.0	0.34-1.3	Dinoflagellates (Pyrcophyta), especially Ceratium spp. and many other algae
Eutrophic*	Usually alkaline	3.5-9.3	0.50-4.5	Diatoms (Chrysophyta) and blue-greens (Cyanophyta)
Lake Rousseau †	Primarily slightly alkaline	Below detectable level--0.18-3.47	0.11-0.8	Pyrrhophyta, especially Rhodomonas; Diatoms (Chrysophyta, especially Cyclotella and Melosira); and the Chlorophyte Ankistrodesmus

Sources: * Brezonik, 1976.
† Environmental Science and Engineering, Inc., 1978.

In the case of Lake Rousseau, it appears that much of the total productivity of the system is associated with large quantities of benthic macrophytes. This stand of vegetation appears to be trapping the majority of nutrients available and thus leaving very little residual to stimulate water column production. The low water column productivity measured is perhaps a result of these factors.

Zooplankton

A knowledge of zooplankton community structure was considered essential to this study in order to gain insight into possible effects of withdrawal of water from Lake Rousseau for consumptive purposes. The importance of these organisms is threefold: (1) they are a critical link in trophic structure between phytoplanktonic primary producers and larger nekton species of the environment, (2) community taxonomic structure may be indicative of the overall health of the aquatic system, and (3) they can be utilized to predict possible intake structure entrainment effects.

Taxonomic Composition and Quantitative Measurements

Three major taxonomic groups were found to dominate the zooplankton populations of Lake Rousseau: two subclasses of the Crustacea, the Cladocera and Copepoda, and Rotifera. Other numerically less significant groups occurring include Protozoa and Ostracoda. To date, 5 copepod, 14 cladoceran, and 18 rotiferan species have been recovered. Additionally, 2 protozoan taxa and 1 ostracod type have been identified. A complete species list is presented in Table II-38. The mean total number of zooplankton per cubic meter, percent Copepoda, percent Cladocera, and percent Rotifera collected from each station depth during the day and during the night is presented in Tables II-39, II-40, II-41, and II-42, for October, December, February, and April, respectively. Information from these tables was utilized to prepare Table II-43, which gives the monthly ranges of mean total number of zooplankton per cubic meter

Table II-38. List of Zooplankton Species Recovered from Lake Rousseau During the Study

Taxa
Copepoda
Calanoida
Diaptomus dorsalis
Cyclopoida
Cyclops panamensis
Eucyclops agilis
Mesocyclops edax
Tropocyclops prasinus
Copepodites-Cyclopoid
Cladocera
Alona karov
Alona sp.
Bosmina longirostris
Ceridaphnia sp.
Chydorus sphaericus
Chydorus sp.
Daphnia ambigua
Diaphanosoma brachyurum
Eubosmia tubicin
Kurzia sp.
Lantonopsis occidentalis
Macrothrix hirustocornis
Sida crystallina
Simocephalis sp.
Ostracoda
Sp. A
Rotifera
Ascomorpha sp.
Asplancha sp.
Brachionus havanaensis
Brachionus sp.
Camptocercus rectirostris
Conochilodes sp.
Conochilus unicornis
Conochilus unicornis var. solitarius
Euchlanis sp.
Filinia longisita
Keratella sp.
Lecone c.f. luna
Platyias quadricornis
Platyias patulus

Table II-38. List of Zooplankton Species Recovered from Lake Rousseau During the Study (continued)

Taxa
Rotifera (continued)
Polyarthra c.f. vulgaris
Synchaeta sp.
Trichocerca multicrinis
Trichocerca similis
Protozoa
Rhizapoda
Actinopoda
Insects
Diptera
Chaoborus
Miscellaneous
Hydrocarina
Ephemoptera

Source: Environmental Science and Engineering, Inc., 1978.

Table II-39. Mean Total Number of Zooplankton/m^3, Percent Copepoda, Percent Cladocera, and Percent Rotifera Collected During the Day and During the Night in October, 1977.

		Day				Night			
Station	Depth (meters)	Mean Total No./m^3	Percent Copepoda	Percent Cladocera	Percent Rotifera	Mean Total No./m^3	Percent Copepoda	Percent Cladocera	Percent Rotifera
1	1	10,258 (6,736)*	69	25	6	14,979 (12,690)	72	27	0.6
	2	9,145 (1,684)	59	34	7	----- (-----)	--	--	---
	3	19,836 (9,437)	68	30	2	12,250 (4,763)	69	30	0.9
2	1	1,284 (876)	69	22	4	13,094 (8,197)	80	19	0.8
	3	----- (-----)	--	--	---	22,538 (9,606)	77	21	1
	7	12,100 (1,711)	74	24	0.5	7,934 (3,046)	66	27	7
	10	9,906 (3,119)	76	23	1	11,337 (7,098)	82	15	1
3	1	8,131 (9,494)	75	17	7	6,038 (-----)	85	10	0.5
	4	7,341 (2,683)	78	18	3	18,606 (10,684)	78	19	3
	8	----- (-----)	--	--	---	----- (-----)	--	--	---
	12	2,905 (-----)	78	19	3	10,258 (5,272)	80	19	0.8
4	1	----- (-----)	--	--	---	10,538 (3,516)	68	29	2
	3	6,773 (3,838)	62	37	1	23,380 (-----)	75	24	1
	6	7,472 (1,487)	58	41	1	4,332 (-----)	71	22	5
	8	6,797 (4,364)	77	19	4	----- (-----)	--	--	---

* Numbers in parentheses equal standard deviations; (--) only one sample taken.

NOTE: (1) Percentages may not add up to 100 since numerically less important taxa are not included in calculations.
(2) --- indicates data not collected.

Source: Environmental Science and Engineering, Inc., 1977.

Table II-40. Mean Total Number of Zooplankton/m^3, Percent Copepoda, Percent Cladocera, and Percent Rotifera Collected During the Day and During the Night in December, 1977.

		Day				Night			
Station	Depth (meters)	Mean Total No./m^3	Percent Copepoda	Percent Cladocera	Percent Rotifera	Mean Total No./m^3	Percent Copepoda	Percent Cladocera	Percent Rotifera
1	1	140,649 (117,564)*	16	82	0.9	104,953 (104,243)	12	87	0.4
	2	221,647 (-------)	11	88	0.5	89,375 (55,748)	14	85	1
	3	76,227 (40,076)	14	84	2	109,662 (61,048)	19	80	0.5
2	1	60,150 (46,160)	19	74	6	84,079 (44,701)	14	85	1
	3	36,965 (21,430)	16	76	8	75,885 (44,937)	16	83	1
	7	52,572 (25,618)	18	81	15	42,421 (6,547)	18	80	2
	10	10,889 (6,180)	34	62	3	68,930 (41,27)	17	82	1
3	1	25,244 (6,998)	20	75	5	92,482 (33,718)	15	84	1
	4	30.474 (14,511)	12	84	4	83,146 (61,407)	20	79	0.7
	8	44,182 (11,391)	20	79	0.5	95,763 (48,723)	16	79	0.4
	12	42,354 (16,498)	17	81	1	101,887 (------)	11	86	3
4	1	31,482 (32,186)	23	74	3	------ (------)	--	--	---
	3	83,524 (8,819)	9	89	1	52,415 (44,002)	19	80	1
	6	21,507 (12,732)	11	87	2	27,849 (7,940)	20	78	2
	8		--	--	---	------ (-----)	--	--	---

* Numbers in parentheses equal standard deviations; (--) only one sample taken.

NOTE: (1) Percentages may not add up to 100 since numerically less important taxa are not included in calculations.
(2) --- indicates data not collected.

Source: Environmental Science and Engineering, Inc., 1977.

Table II-41. Mean Total Number of Zooplankton/m^3, Percent Copepoda, Percent Cladocera, and Percent Rotifera Collected During the Day and During the Night in February, 1978.

		Day				Night			
Station	Depth (meters)	Mean Total No./m^3	Percent Copepoda	Percent Cladocera	Percent Rotifera	Mean Total No./m^3	Percent Copepoda	Percent Cladocera	Percent Rotifera
1	1	11,600 (3,908)	22	71	3	21,440 (9,555)	16	83	1
	2	22,018 (1,281)	14	82	3	34,079 (22,310)	13	86	0.5
	3	4,901 (510)	20	77	2	18,508 (6,875)	15	84	0.4
2	1	16,428 (3,749)	16	76	8	27,981 (4,022)	28	72	0.4
	3	15,420 (2,626)	16	78	4	25,478 (3,217)	29	69	0.9
	7	4,683 (130)	28	61	11	12,659 (2,371)	21	76	1
	10	2,157 (234)	42	44	11	7,102 (2,078)	37	52	4
3	1	12,511 (10,152)	19	77	4	17,518 (64)	23	76	0.1
	4	6,344 (2,567)	25	74	0	15,178 (5,950)	31	66	0.2
	8	7,779 (3,882)	30	65	5	5,138 (1,255)	39	56	0.9
	12	4,277 (2,911)	17	69	14	3,650 (258)	47	44	2
4	1	6,842 (-----)	19	80	0	14,035 (419)	18	80	0
	3	13,239 (138)	16	82	1	6,033 (2,227)	13	84	0
	6	4,423 (825)	18	80	1	4,086 (3,021)	33	61	0.7
	8	6,934 (1,545)	15	74	7	2,441 (862)	52	40	1

* Numbers in parentheses equal standard deviations; (--) only one sample taken.

NOTE: (1) Percentages may not add up to 100 since numerically less important taxa are not included in calculations.
(2) --- indicates data not collected.

Source: Environmental Science and Engineering, Inc., 1978.

Table II-42. Mean Total Number of Zooplankton/m^3, Percent Copepoda, Percent Cladocera, and Percent Rotifera Collected During the Day and During the Night in April, 1978.

		Day				Night			
Station	Depth (meters)	Mean Total No./m^3	Percent Copepoda	Percent Cladocera	Percent Rotifera	Mean Total No./m^3	Percent Copepoda	Percent Cladocera	Percent Rotifera
1	1	10,776 (1,418)	14	76	0.4	27,325 (6,465)	5	90	0.7
	2	9,829 (3,151)	6	74	0.7	33,362 (17,139)	6	91	0.5
	3	12,723 (2,805)	10	82	2	21,062 (5,899)	7	87	2
2	1	11,563 (2,877)	11	58	6	14,457 (123)	13	81	1
	3	------ (-----)	--	--	---	24,308 (9,229)	7	97	1
	7	11,427 (1,683)	14	78	2	21,146 (5,281)	11	80	1
	10	7,154 (206)	38	53	2	13,418 (747)	60	35	1
3	1	10,529 (3,841)	13	56	3	16,863 (5,335)	11	84	1
	4	19,679 (8,441)	10	74	2	16,768 (2,361)	10	79	0.8
	8	17,689 (4,613)	17	80	1	25,827 (909)	12	78	2
	12	14,196 (5,404)	11	81	2	35,376 (17,585)	11	82	0.8
4	1	17,732 (2,747)	12	66	1	13,578 (1,377)	13	73	1
	3	12,620 (3,266)	14	61	4	17,053 (5,251)	9	76	2
	6	10,898 (6,289)	9	57	7	16,091 (1,521)	10	75	1
	8	8,968 (342)	10	68	1	11,511 (517)	9	73	3

* Numbers in parentheses equal standard deviations; (--) only one sample taken.

NOTE: (1) Percentages may not add up to 100 since numerically less important taxa are not included in calculations.
(2) --- indicates data not collected.

Source: Environmental Science and Engineering, Inc., 1978.

Table II-43. Monthly Ranges of Mean Total Number of Zooplankton/m^3 Recovered During the Day and During the Night

Collection	Mean Total of Number of Zooplankton/m^3	
	Day	Night
October 1977	1,284 - 19,836	4,332 - 23,380
December 1977	10,889 - 221,647	27,849 - 109,662
February 1978	2,157 - 16,482	2,441 - 34,079
April 1978	7,154 - 19,679	11,511 - 35,376

Source: Environmental Science and Engineering, Inc., 1978.

recovered in day and night samples. Abundance was generally greater in samples collected during the night.

In October, February, and April, the density of zooplankton at each station was relatively low. An increase in mean number of individuals was observed during December when populations of zooplankton at all stations were captured in moderate numbers.

In October, species of the division Copepoda predominated, comprising 58 to 80 percent of the mean total number of individuals per cubic meter. Cladocerans accounted for 19 to 37 percent of the October samples. Diaptomus dorsalis, Cyclops panamensis, and Mesocyclops edax were the dominant copepods at all stations and depths and Bosminia longirostris was the most abundant cladoceran.

In December, February, and April, cladoceran species were dominant, representing 62 to 89 percent, 40 to 86 percent, and 35 to 90 percent of the mean total number of individual samples, respectively.

The dominant species of copepods and cladocerans encountered at all stations during December were essentially the same as those occurring in February. However, three additional numerically important species of cladocerans were present; specifically, Ceriodaphnia sp., Daphnia ambigua, and Diaphanosoma brachyurum. In February and April only, Cyclops panamensis, Diaptomus dorsalis, and Bosminia longirostris remained as the dominant species.

All of the numerically abundant zooplankton species recovered in Lake Rousseau have been reported to occur in other lakes in Florida (Confer, 1971; Cowell, et al., 1975; Nordlie, 1976). Because many rotifers and cladocerans are unspecialized feeders and have rather short life cycles, they usually are the dominant taxa in eutrophic lakes (Cowell, et al., 1975; Blancher, unpublished data). Copepods tend to have longer life cycles and typically dominate Oligotrophic systems which have more stable environmental conditions that do not favor the "opportunistic"

rotifer and cladoceran characteristics (Allan, 1976). On the basis of the above information and zooplankton data collected during this study, it appears that Lake Rousseau could be classified as a mesotrophic system, which is in agreement with the classification based upon phytoplankton and chemical parameters. The study is also in agreement with an ongoing survey of six Florida lakes of different trophic levels under study by researchers at the University of Florida (Blanchard, Personal Communication).

Analysis of variance was used to determine differences between zooplankton populations with station and depth. Each station-depth was treated as a representative station for the purposes of analyses. Mean numbers of copepods, cladocerans, rotiferans, and total number of individuals were designated as dependent variables and were compared with month, run (day or night collections), station, and depth as independent variables. Prior to analysis the dependent variables were transformed by using logarithm (count + 1) in order to insure that the data approximately satisfied the requisite assumptions of normality and equal variances. All data sets were first examined by using a multivariable Analysis of Variance (MANOVA) as an initial "screening" process. The basic premise was that low significance levels in the MANOVA would indicate that the independent variables were important in describing at least one of the dependent variables. Station-depth and run effects were found to be significant at alpha = 0.05. The interaction of station-depth-run was not seen to be significant for the data and was not considered in further analyses.

A univariate Analysis of Variance (ANOVA) was used to further examine the station-depth and run effects. Mean counts of Copepoda, Cladocera, Rotifera, and total number of individuals used in the ANOVA's are given in Tables II-44, II-45, II-46, and II-47, respectively. The depth designations in the above mentioned tables correspond to the sample depths given in Table VII-7. The difference in numbers of individuals collected in samples collected at night and in the day has been discussed and is illustrated in previously presented tables. Consequently, the mean counts will not be presented here. Both station-depth and run

Table II-44. Comparison of Mean Abundance of Copepods Utilized in the Statistical Analyses

Depth	Station 1	Station 2	Station 3	Station 4
1	7,876 (9,925)	5,955 (5,581)	4,965 (4,667)	3,912 (3,471)
2	6,181 (7,163)	7,887 (6,759)	6,301 (7,182)	4,946 (5,217)
3	7,571 (8,034)	4,884 (3,643)	5,731 (5,523)	2,478 (1,732)
4		5,810 (4,537)	4,274 (3,749)	1,899 (2,029)

NOTE: Numbers in parentheses are standard deviations.

Source: Environmental Science and Engineering, Inc., 1978.

Table II-45. Comparison of Mean Abundance of Cladocerans Utilized in the Statistical Analyses

Depth	Station 1	Station 2	Station 3	Station 4
1	34,113 (54,774)	21,353 (27,381)	18,814 (25,731)	11,275 (10,706)
2	40,270 (54,760)	24,392 (23,007)	17,402 (24,070)	21,362 (27,142)
3	26,220 (34,720)	14,968 (15,809)	25,565 (28,425)	9,137 (8,455)
4		10,012 (20,216)	17,912 (24,889)	4,376 (3,300)

NOTE: Numbers in parentheses are standard deviations.

Source: Environmental Science and Engineering, Inc., 1978.

Table II-46. Comparison of Mean Abundance of Rotiferans Utilized in the Statistical Analyses

Depth	Station 1	Station 2	Station 3	Station 4
1	423 (552)	823 (1,712)	571 (633)	273 (438)
2	534 (639)	894 (1,507)	402 (591)	371 (481)
3	403 (512)	426 (476)	302 (230)	299 (311)
4		305 (370)	506 (890)	232 (206)

NOTE: Numbers in parentheses are standard deviations.

Source: Environmental Science and Engineering, Inc., 1978.

Table II-47. Comparison of Mean Abundance of Total Number of Individuals Utilized in the Statistical Analysis

Depth	Station 1	Station 2	Station 3	Station 4
1	42,747 (63,757)	28,629 (32,238)	24,839 (29,801)	16,506 (13,051)
2	47,481 (61,635)	33,432 (26,080)	24,692 (29,244)	27,353 (30,050)
3	34,396 (41,076)	20,618 (18,278)	32,729 (35,760)	12,695 (9,669)
4		16,361 (23,507)	23,215 (28,091)	7,330 (3,521)

NOTE: Numbers in parentheses are standard deviations.

Source: Environmental Science and Engineering, Inc., 1978.

effects were found to be significant (alpha = 0.05) for copepods, cladocerans, and total numbers.

Duncan's New Multiple Range Test was used to determine location of significant differences in each data set. General conclusions indicated from these analyses are:

1. The deeper samples contain fewer average numbers of zooplankton (see Tables II-44, II-45, II-46, and II-47).
2. Station 1 has the greatest average abundance of zooplankton, station 4 exhibits the lowest abundance of individuals, and stations 2 and 3 are intermediate.
3. Samples collected during the night have a greater average abundance of zooplankton than samples collected during the night.

Monthly average zooplankton biomass (ash free dry weight) ranged from 0.79 g/m^3 during February to 6.00 g/m^3 in December. Mean ash free dry weight of samples collected from station 1, station 2, station 3, and station 4 were 3.386 g/m^3, 1.939 g/m^3, 2.14 g/m^3, and 4.14 g/m^3, respectively.

The above described statistical methods were applied to the biomass data. No statistical differences were evidenced as a result of these analyses.

Model-Intake Studies

Abundance and biomass of zooplankton samples collected at Station 3 by using the model intake sampling technique were similar to abundance and biomass of samples collected with the high velocity plankton pump. The mean total number of individuals per cubic meter and biomass (ash-free dry weight) for model intake samples are given in Table II-48.

A second statistical model was utilized to relate the dependent variables to the method of sampling as well as the other independent

Table II-48. Mean Total Zooplankton/m^3 and Biomass (Ash-Free Dry Weight) for Model Intake Samples Collected During October, December, February, and April at Station 3.

Month	Depth (meters)	Day		Night	
		Mean Total Number/m3	Biomass (g/m3)	Mean Total Number/m3	Biomass (g/m3)
1	4	-----	----	9,465 (7,107)	1.40 (0.44)
	12	8,776 (5,955)	0.63 (0.15)	12,373 (5,620)	1.29 (0.33)
2	4	-----	----	71,295 (49,989)	6.33 (1.32)
	12	-----	----	62,040 (36,590)	3.60 0.80)
3	4	6,232 (1,746)	0.53 (0.53)	7,832 (1,035)	0.41 (0.36)
	12	1,839 (865)	0.20 (0.05)	4,183 (1,775)	0.15 (0.06)
4	4	16,499 (-----)	0.22 (----)	23,281 (135)	0.40 (0.16)
	12	18,194 (3,592)	0.54 (0.07)	26,850 (-----)	0.76 (----)

NOTE: --- Data not collected
Numbers in parentheses are standard deviations

Source: Environmental Science and Engineering, Inc., 1978.

variables. The statistical techniques were similar to those utilized for the previously described model. The primary objective of the analysis was to determine whether a difference exists in mean numbers of zooplankton captured by the two sampling techniques (i.e., the model intake velocity and the velocity of the plankton pump during normal collection procedures). No significant overall differences between the two sampling methods with respect to zooplankton counts were evidenced as a result of these analyses. This suggests that the zooplankton in abundance in the lake are not "good avoiders" and would probably be entrained even by an intake structure designed for low intake velocities.

Results of the statistical analyses reported and biological measurements of the zooplankton and phytoplankton communities in Lake Rousseau suggest that the most desirable location for the proposed intake structure would be in the area of lowest biological productivity, which has been defined as Station 4 at a depth of 4 meters. Placement at this site would limit the entrainment impacts of withdrawal of water for consumptive purposes. In addition, the effect of macrophytic vegetation on the intake structure, primarily clogging, would be minimal. Station 1 and any other areas exhibiting similar biological characteristics are considered to be the least desirable locations for placement of the intake structure since the data suggest that biological activity is greatest at these locations. Stations 3 and 4 represent intermediate areas in terms of desirability. The deepest waters of all stations are more preferable than shallow locations because of the indicated decrease in biological productivity with depth.

SOCIOECONOMICS

LAND USE

The proposed pipeline to supply cooling tower make-up, service water, and raw water from Lake Rousseau to Crystal River Units 4 and 5 is routed from the southwest tip of the lake, west along Riverwood Drive approximately 0.8 kilometers (0.5 miles), southwest along Aspen Avenue 3.62 kilometers (2.25 miles) to U.S. 19-98, southeast on U.S. 19-98 3.1 kilometers (1.9 miles) to the proposed access road for Units 4 and 5, then west 6.6 kilometers (4.4 miles) to the proposed plant site (see Figure II-20). It is proposed to bury the pipeline on the north side of Riverwood Drive and Aspen Avenue. The pipeline will undercut U.S. 19-98 and parallel the southbound lane on the west side, then along the south side of the proposed access road to the plant site.

Riverwood Drive is a 2-lane, unimproved road maintained by the Citrus County Road Department with a 15-meter (50-foot) right-of-way. The proposed pipeline is 76 centimeters (30 inches) wide and requires a trench with a maximum width of 2 meters (5 feet) in order to adequately bury the pipe. The trench will parallel the road with the outside wall of the trench no farther than 7.6 meters (25 feet) from the center line of the right-of-way and the inside wall no less than 3.6 meters (12 feet) from the center line of the right-of-way.

Road front property on both sides of Riverwood Drive is zoned for agricultural use but is currently undeveloped, with the exception of the Army Corps of Engineers Dam fill area at the southern tip of Lake Rousseau and one residence of frame construction with small-scale farming activities on the north side of the Riverwood Drive-Erne Road intersection (see Figure II-21).

Aspen Avenue is a 7.3-meter (24-foot) wide, 2-lane paved road with a 15-meter (50-foot) right-of-way (see Figure II-22). It serves as the main thoroughfare for the 1,416-hectare (3,500-acre) Crystal Manor subdivision. Crystal Manor was platted by Florida General Equities of

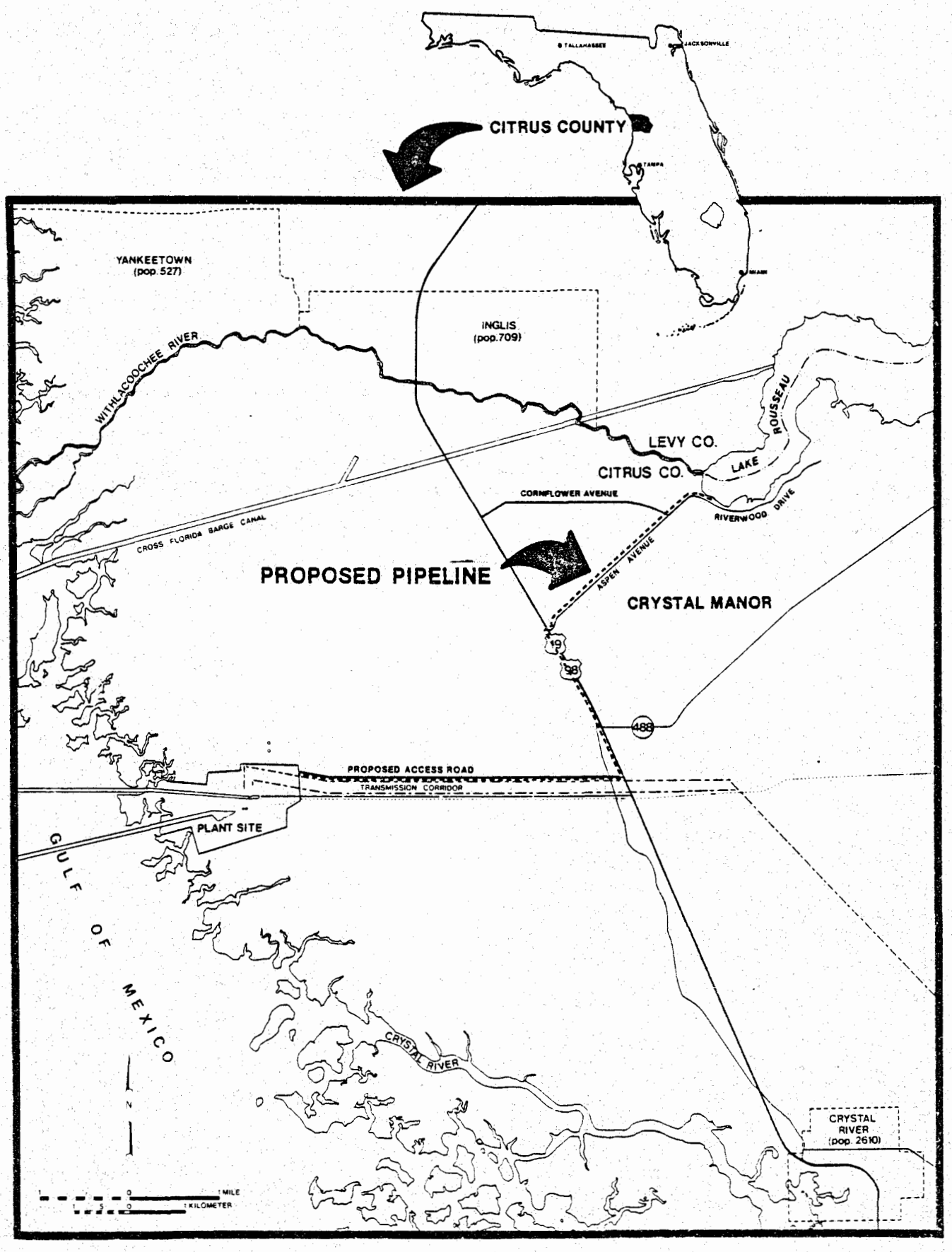
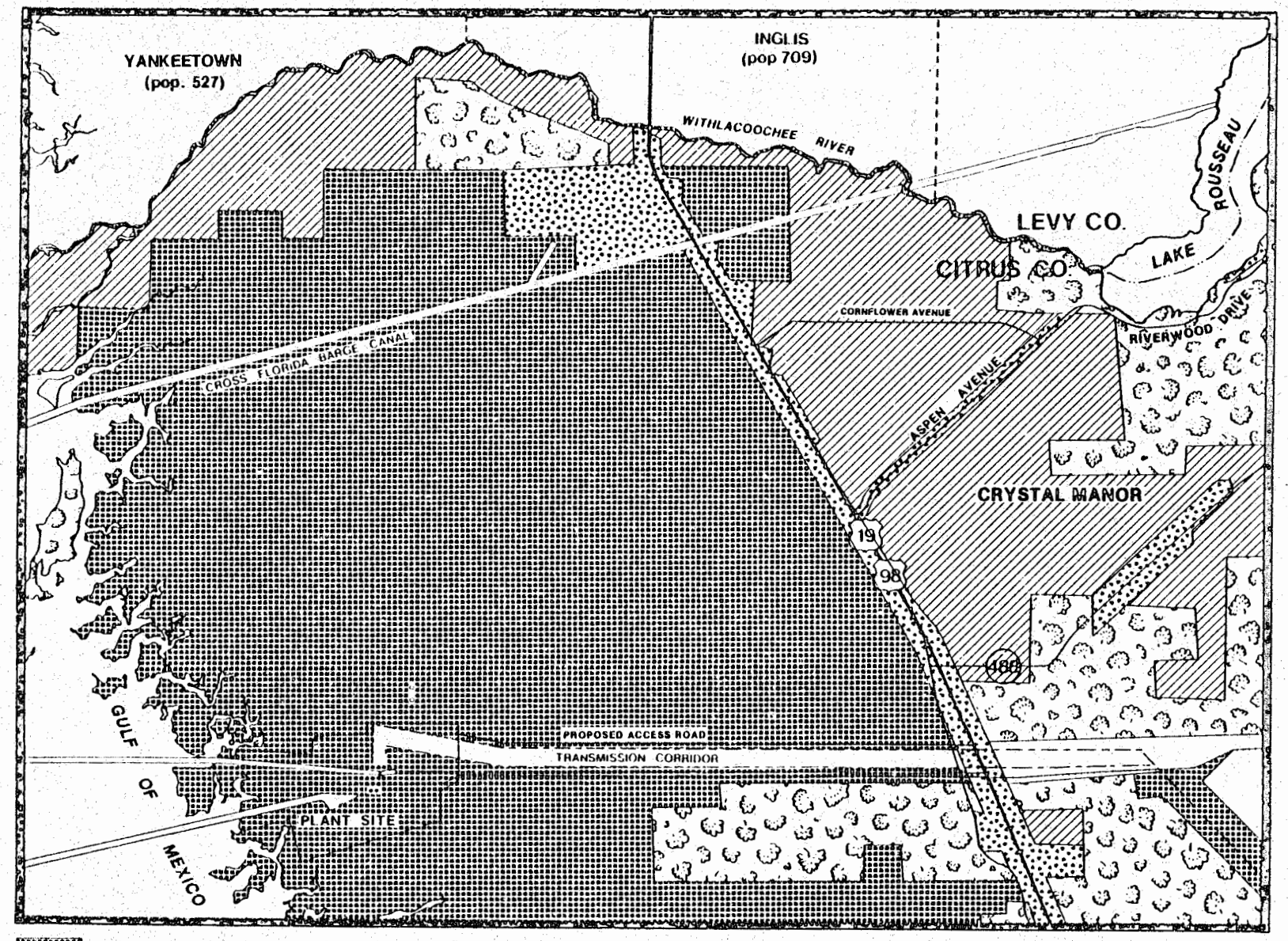


FIGURE II-20
GENERAL LOCATION OF PROPOSED PIPELINE



MINING, INDUSTRIAL

AGRICULTURE

COMMERCIAL

RESIDENTIAL

N

1 1/2 0 1
MILES

1 .5 0 1
KILOMETERS

SOURCE: CITRUS COUNTY ZONING MAPS, SURVEYORS ASSOCIATES, REVISED, 9/1/76

FIGURE II-21
CURRENT ZONING RESTRICTIONS

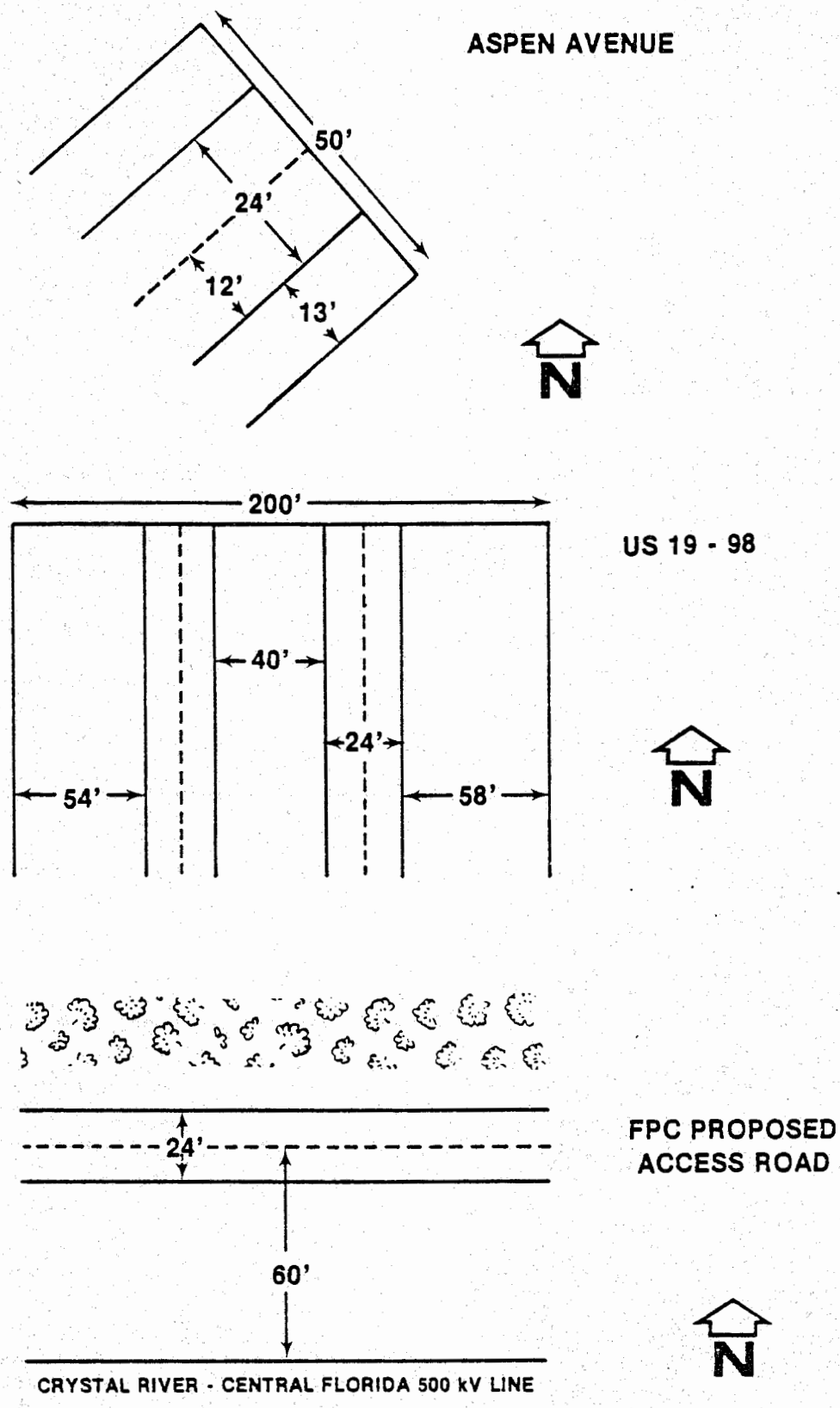


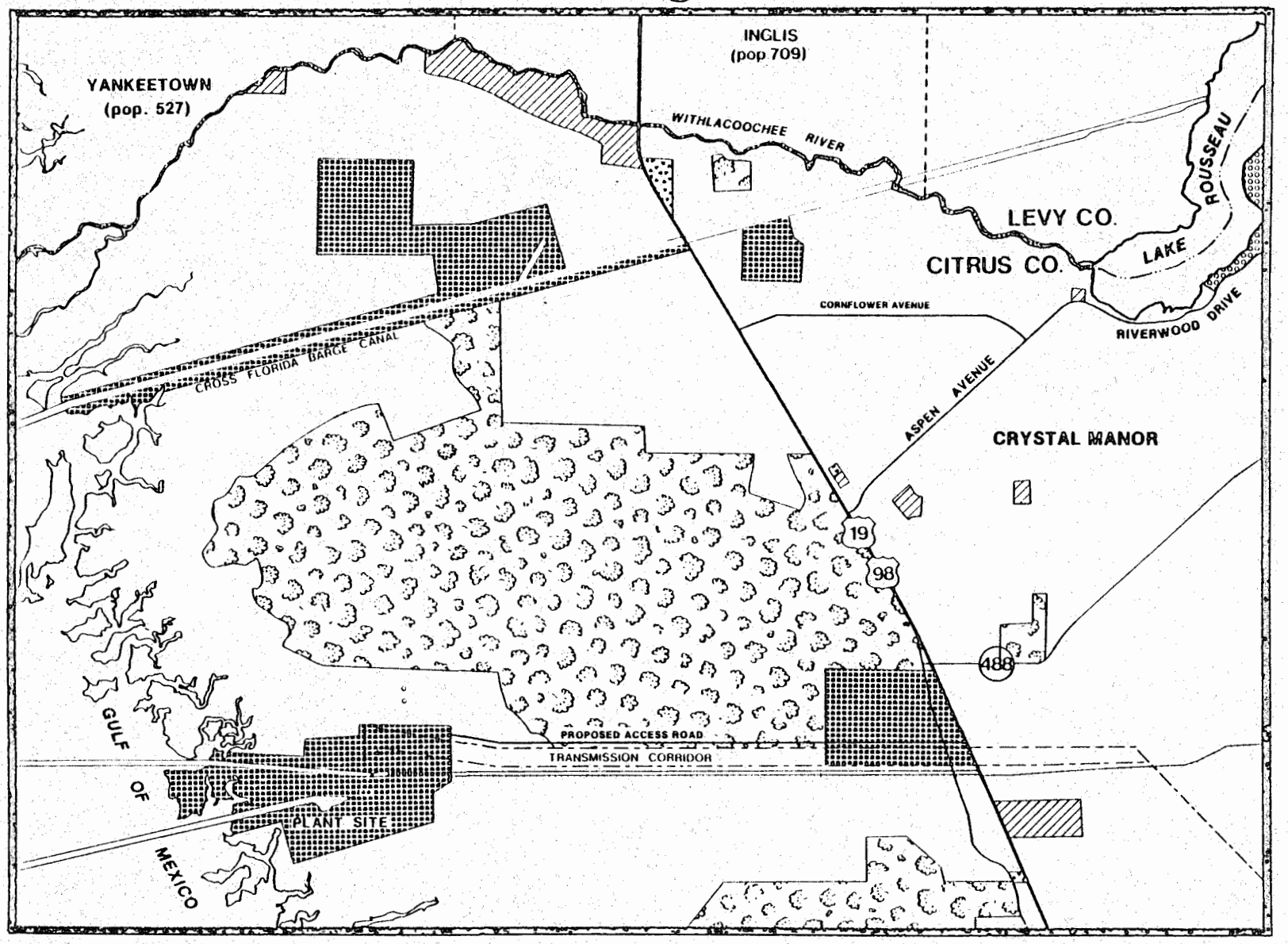
FIGURE II-22
RIGHTS OF WAY FOR PROPOSED PIPELINE

Miami and recorded with the Citrus County Tax Assessor in July, 1970. The latest addition to Crystal Manor was Unit 3, recorded in January 1974. The 2,800 lots, which vary slightly in size, average about 0.4 hectare (1 acre) each, most of which were sold through interstate land sales on 10-year contracts for deed. As of February 1978, 99 percent of the lots were sold; however, the majority of the contracts for deed will not be executed until 1983, with all contracts executed by 1986 (Jahnig, 1978).

All roads within Crystal Manor were constructed by Florida General Equities, which held the responsibility for their maintenance for one year. With the exception of two phases off Cornflower Avenue in the northeast section of the subdivision, all Crystal Manor roads, including Aspen Avenue, are presently maintained by the Citrus County Road Department. Eventually, the two phases off Cornflower Avenue will also be maintained by the county.

At present, there are very few houses in Crystal Manor. One residential unit of cinder block construction, which is located on North Bellflower Street approximately 0.6 kilometer (0.4 mile) north of Aspen Avenue faces U.S. 19-98 with a small family business adjacent to it. Another five residences of cinder block construction, averaging about 520 square meters (1,700 square feet) of living space, are in the Basswood Court area approximately 0.4 kilometer (0.25 mile) southeast of Aspen Avenue near the entrance to Crystal Manor. Four additional cinder block residences of approximately 460 to 520 square meters (1,500 to 1,700 square feet) are located midway between Aspen Avenue and S.R. 488 on Elm and Maple Avenues (see Figure II-23).

All of Crystal Manor is zoned for residential use, except a few strips of commercial use along U.S. 19-98 and a commercial strip one lot deep on either side of Aspen Avenue. At present there is no development, commercial or otherwise, along Aspen Avenue. A logical assumption is that commercial development of Aspen Avenue will not take place until there is sufficient residential development in the area to support it.



MINING, INDUSTRIAL
AGRICULTURE
COMMERCIAL
RESIDENTIAL
COMMERCIAL RESIDENTIAL MIX

N

1 1/2 0 1
MILES

1 .5 0 1
KILOMETERS

SOURCE: WITHLACOOCHEE REGIONAL PLANNING COUNCIL UPDATED: ESE 1977

FIGURE II-23
PRESENT LAND USE

Therefore, all properties along Aspen Avenue which will be affected by the proposed pipeline are presently undeveloped and will remain in that state for approximately 5 to 8 years.

The proposed pipeline will undercut U.S. 19-98 where it intersects Aspen Avenue and will parallel the highway on the western side for approximately 3.2 kilometers (2.0 miles). U.S. 19-98 is a federal 4-lane divided highway with a 60-meter (200-foot) right-of-way. The double north- and south-bound lanes are each 7.3 meters (24 feet) wide with a 12-meter (40-foot) median. The right-of-way to the east of the northbound lane is 18 meters (58 feet), while the right-of-way to the west of the southbound lane, where the proposed pipeline will be laid, is 16 meters (54 feet).

All properties abutting the highway on the western side are zoned commercial from the Withlacoochee River to the city limits of Crystal River, which will include the 3.1-kilometer (1.9-mile) strip impacted by the proposed pipeline. Properties on the eastern side of the highway from Aspen Avenue to Basewood Avenue (Crystal Manor), approximately 1.6 kilometer (1 mile), are zoned for residential use. From Basewood Avenue south approximately 1.6 kilometer (1 mile) to the proposed FPC access road, abutting properties are commercially zoned.

The lands on the western side of U.S. 19-98 from Aspen Avenue to the S.R. 488 intersection are improved pasture, part of the Hollinsworth Ranch. Adjacent to the ranch and extending to the FPC access road is a limerock quarry operation with an office building and a single-family residence on the site. All lands on the eastern side of the highway are undeveloped from Aspen Avenue south to the northeast corner of the U.S. 19-98 and the proposed FPC access road intersection, where there are two mobile homes and one small frame house.

The proposed FPC access road will be a 2-lane, 7-meter (24-foot) wide paved road, with the center line 18 meters (60 feet) north of the center of the towers of the Crystal River-Central Florida transmission line.

This is the northernmost line in the transmission corridor which parallels the existing FPC access road. The proposed access road, like the existing access road, will be on Florida Power Corporation property and will be constructed and maintained by Florida Power. Abutting lands on the north and the south are zoned for industrial use. Paralleling the proposed road to the north is a small strip of wooded area; to the south is the Crystal River-Central Florida 500 kv transmission line.

WATER USE

Consumptive water use in the Crystal River area is regulated by the Southwest Florida Water Management District (SWFWMD). Permits are required for a well greater than or equal to 15.24 centimeters (6 inches) in diameter, or an average daily withdrawal of 380,000 liters (100,000 gallons) or more.

Table II-49 shows all consumptive use permits issued within 8 kilometers (5 miles) of the southern tip of Lake Rousseau. The majority of permits are for irrigation, primarily of peanuts, watermelon, and citrus. The total average daily withdrawal for agricultural use is 1,112,000 liters (294,000 gallons), of which 511,000 liters (135,000 gallons) is surface water from Lake Rousseau. Agriculture, representing about 3 percent of the total water use in the area, is the smallest category of water use, with the exception of the new Four Rivers Community Hospital (Permit #2774294), with an average daily withdrawal of 265,000 liters (70,000 gallons), or less than 1 percent of the total.

Industry consumes almost 29 times the water necessary for agricultural purposes. More specifically, mining activities are the greatest consumptive use of water in the area and exceed all other uses combined, including the power industry. The majority of water use in this category is attributed to one consumer, Gulf Coast Aggregates (Permit #7500115), which requires an average of 26,604,000 liters (7,028,000 gallons) a day for limerock processing. The total figure for consumptive water use by mining activities is an average daily withdrawal of 26,977,360 liters (7,126,630 gallons), which represents 80 percent of the water use in the area.

Although consumptive use by the power industry is limited to FPC's 5 ground wells (Permit #27704249) and represents only 19 percent of the industrial water use category, it is nevertheless the second largest consumptive use permit issued in the area. With an average daily withdrawal of 5,135,300 liters (1,356,600 gallons), the power industry

Table II-49. Consumptive Water Use--Lake Rousseau Area

SWFWMD Consumptive Use Permit No.		Ave. Daily Withdrawal 1,000 Liters/Day	Ave. Daily Withdrawal (1,000 Gallons/Day)	Max. Daily Withdrawal 1,000 Liters/Day	Max. Daily Withdrawal (1,000 Gallons/Day)
7600337	Agriculture (Surface Withdrawal)	159	(42)	2,839	(750)
7703510	Agriculture (Surface Withdrawal)	83	(22)	1,533	(405)
7601725	Agriculture (Surface Withdrawal)	269	(71)	3,271	(864)
7601270	Agriculture	11	(3)	34	(9)
7601271	Agriculture	363	(96)	3,271	(864)
7601272	Agriculture	227	(60)	3,785	(1,000)
2774294	Hospital	265	(70)	7,571	(2,000)
7500115	Industry (Mining)	26,604	(7,028)	48,453	(12,800)
7600359	Industry (Mining)	373.4	(98.6)	1,140	(300)
27704249	Industry (Power)	5,135.3	(1,356.6)	13,105.9	(3,462.2)
TOTAL		33,489.7	(8,847.2)	(84,999)	(22,454.2)

Source: SWFWMD Consumptive Use Permitting Office, 1978.

consumes more than 4.5 times as much water as agriculture and accounts for approximately 15 percent of the area's total consumptive water use.

Although the communities of Yankeetown and Inglis depend upon ground water for their water supplies, they have not been included in the above discussion. All homes in Inglis (population 709) are on individual wells since there is no community well. The Yankeetown community well, which is beyond the 8-kilometer (5-mile) distance from Lake Rousseau, withdraws a daily average of 1,020,000 liters (270,000 gallons) with a capacity of 3,400,000 liters (900,000 gallons) per day.

Lake Rousseau (commonly referred to as the Backwaters), the Cross Florida Barge Canal, and the Lower Withlacoochee River are the primary water bodies in the area. They are fed by Rainbow Springs and the Withlacoochee River upstream of the Blue Run. The Gulf of Mexico must also be considered a water resource; however, it is outside an 8-kilometer (5-mile) radius from Lake Rousseau, and the coastal area near the FPC plant site, predominantly marshlands, holds little value as a recreational or transportation resource.

Lake Rousseau, created in 1909 by the Florida Power Corporation when the Withlacoochee River was dammed, is the only reservoir in the area. The lake, or Backwaters, is comprised of approximately 1,481 hectares (3,657 acres) and extends eastward from the U.S. Army Corps of Engineers Dam to the Dunnellon city limits, a distance of about 16 kilometers (10 miles).

The fact that Lake Rousseau is a man-made lake has been the determining factor of its use over the years. The land was not cleared before the area was flooded so the lake abounds with stumps, both submerged and exposed. These pose a great hazard to power boating and completely eliminate the possibility of water skiing, but at the same time create some of the best freshwater fishing conditions in the region. Small power boats have little trouble maneuvering the waters, and the lack of fast-moving boats and skiiers improves fishing conditions.

Access is available to the lake through approximately ten launching sites, some public and some private, most in need of renovation. There are approximately six campground/fish camp operations surrounding the lake and several are in the process of expanding their operations. A typical fish camp has camp or RV sites and/or rental cottages, and offers boat rental as well as guide service and taxidermy pick-up for the sportsman.

The lake has been gaining steadily in prominence with fishermen and has been the subject of several recent articles in national sportsfishing magazines. Largemouth bass, chain pickerel, bluegill, redear or shellcracker, warmouth, and speckled perch are commonly pulled from the lake channel, and backwater catfish have become so plentiful that catfishing in the lake is now open to commercial fishermen. Bait fish include shad and river shiners; gar and mudfish, although not considered a desirable catch, also populate the lake.

According to local fishermen, fishing in Lake Rousseau is popular and successful all year, as indicated by the year-round operation of camps. Although there are no statistics to support it, the local opinion is that fishing not up to par is when the level of the lake is fluctuating. The situations cited were associated with the lowering of the lake level to repair or clean the Army Corps of Engineers Dam; however, there is a general consensus that fishing picks up once the level of the lake is stabilized.

Fish camp operators also noted that an increased growth in hydrilla and/or water hyacinths usually results in a decrease in the use of the lake for fishing, and consequently, in a decline in business for those commercial operations serving the fishing community.

In addition to fish, the lake also boasts populations of alligator, turtle, and waterfowl. Duck hunting is popular in season. Birds evident in the area include the eagle, osprey, and white ibis.

The portion of the Withlacoochee River extending from the Army Corps of Engineers Dam to the Cross Florida Barge Canal is referred to as the Old Withlacoochee River. It is pastoral in character and is now used by groups and individuals as an unofficial recreational area for swimming, fishing, camping, and canoeing. The Old Withlacoochee River Canoe Trail, beginning at the dam, is part of the Florida Canoe Trail System. The banks along the river are used extensively by the Boy Scouts of America for rustic camping, with units from as far away as Leesburg traveling to the area.

The Lower Withlacoochee River, which extends from the Cross Florida Barge Canal Locks westward to the Gulf of Mexico, supports such sports as fishing, pleasure boating (power, canoeing, and sailing), and hunting. There is a public launching ramp in Inglis and a launching point and campground at the western terminus of S.R. 40. There are several overnight lodging establishments along the river which also offer such services as canoe and small boat rental and mooring sites for large sailing craft. There are also two marina operations which sell fuel to boaters and buy and sell marine equipment. Both establishments serve commercial fishing craft as well as the pleasure boater.

Fish caught in and around the river include but are not limited to sheepshead, mullet, redfish, and tarpon. Some tarpon in the 100-pound class have been taken. Spawning occurs in several of the larger creeks near the mouth of the river, specifically Bennets Creek.

In the swamp area to the south of the river, some hunting takes place, particularly for quail, rabbit, hog, and deer. There is very little commercial water transportation in the area. The U.S. Coast Guard maintains a floating station on the Lower Withlacoochee at Yankeetown, just south of the intersection of S.R. 40 and 40A. There is dockage area for one cutter [approximately 12 meters (40 feet)] and several small craft.

Upriver from the Coast Guard station is a Tennaco barge landing and fossil fuel depot near the eastern city limits of Yankeetown. The depot

served as a storage area for fuel supply for Crystal River Units 1 and 2, but its use has been discontinued since the plants are being converted to coal-fired units. Consequently, barge traffic on the river, which was limited to the delivery of fossil fuel, has ceased.

Commercial transportation on the Withlacoochee Reach of the Cross Florida Barge Canal is much the same as that on the Lower Withlacoochee. According to the Coast Guard station at Yankeetown, there has been one barge and one tugboat in the Reach in the past two years. They were serving a dolomite mine on the north side of the canal, west of U.S. 19-98, which has not been in operation for the last year.

ARCHAEOLOGY MONITORING

In the event that any archaeological sites that were not identified in the preliminary survey are encountered during construction activities, it is strongly recommended that FPC notify ESE immediately. It is important that the site be disturbed as little as possible until a qualified archaeologist is present to determine the significance of the discovery.

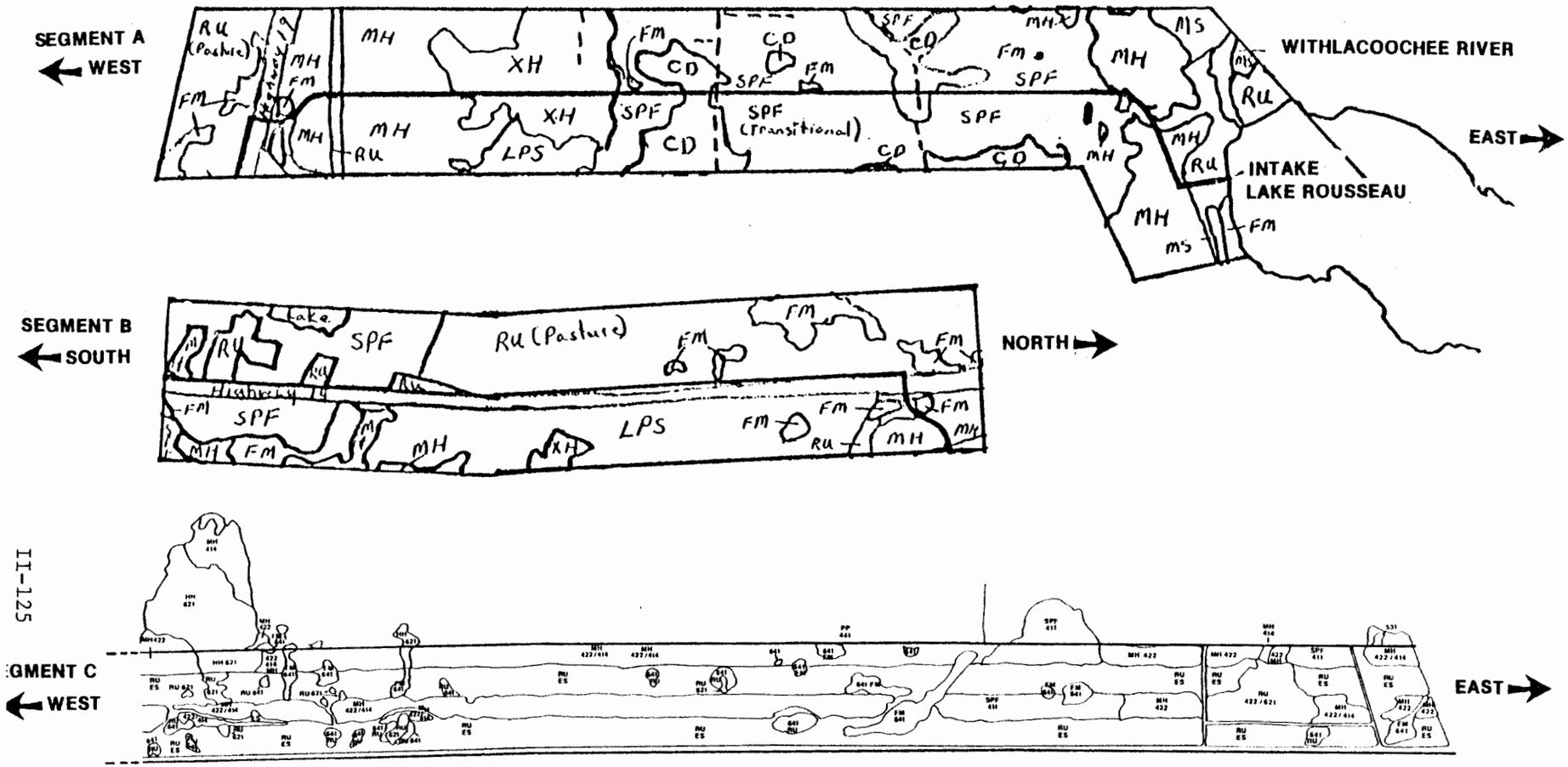
TERRESTRIAL ECOLOGY

VEGETATIVE ASSOCIATIONS ALONG THE PIPELINE CORRIDOR

Figure II-24 illustrates the vegetative associations which occur in a corridor extending 300 meters (1,000 feet) to either side of the pipeline route. Within this corridor, ten primary types of vegetation occur in the amounts shown in Table II-50. The acreages are approximations based upon the natural systems and consequently do not reflect the incidence of roads, right-of-ways, ditches, and other structural modifications.

Within the actual corridor [approximately 20 meters (65 feet) in width] which will experience direct construction activity, the following plant communities are represented: slash pine flatwoods, improved pasture, cypress domes, xeric hammocks, mesic hammocks, hydric hammocks, freshwater marshes and ditches, and ruderal roadside and early successional vegetation. Of these, all but cypress domes and xeric hammocks are described in Chapter 2 of the Site Certification Application for the plant site. Table II-51 describes these two additional associations.

Cleared or altered areas are characteristic of the entire corridor. To the east of Highway 19 (Segment A on Figure II-24), paved roads, drainage ditches, and a few houses have already been installed in the preliminary stages of a residential development that may eventually cover the surrounding area. Much of the pine flatwoods have been cleared and are now in an early stage of secondary succession with gallberry, waxmyrtle, persimmon, and saw palmetto prevalent. Drainage ditches 1.5 to 2.4 meters (5 to 8 feet) deep pass through both flatwoods and cypress domes. These domes have the uneven profile characteristic of drained and degraded domes. The marshes in this portion of the route are dominated primarily by willows and buttonbush and appear to be related to ditching, construction, and borrow activities. The mesic and xeric hammocks along this portion of the corridor also appear degraded and lack a normal diversity of species. Large live oaks and diamondleaf

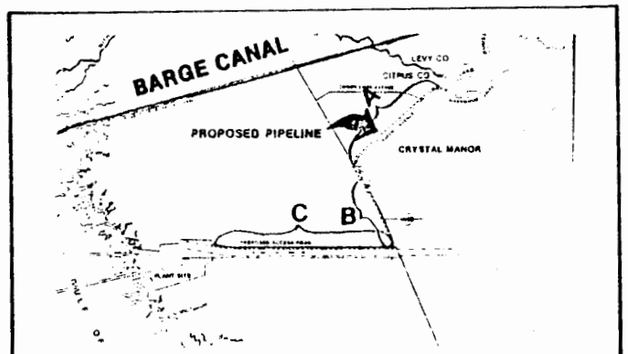


LEGEND

SYMBOL	CLASSIFICATION	FLORIDA LAND USE AND CLASSIFICATION SYSTEM Number	Name
SM	Saltwater Marsh	642	Saltwater Marsh
FM	Freshwater Marsh	641	Freshwater Marsh
SPF	Slash Pine Flatwoods	411	Pine Flatwoods
LPF	Longleaf Pine Flatwoods	411	Longleaf Pine Flatwoods
EGS	Evergreen Oak Scrub	421	Xeric Oak Hardwood Forest
LPS	Longleaf Pine Sandhill	412	Longleaf Pine Xeric Oak Forest
DOS	Deciduous Oak Sandhill	421	Xeric Oak Hardwood Forest
XH	Xeric Hammock	422	Other Hardwood Forest
MH	Mesic Hammock	422	Other Hardwood Forest
		414	Other Coniferous Forest
HH	Hydric Hammock	621	Freshwater Swamp
CH	Coastal Hammock	431	Mixed Forest
CHH	Coastal Hydric Hammock	422	Other Hardwood Forest
		631	Mixed Wetland Forest
PP	Pine Plantation	441	Coniferous Planted Forest
CD	Cypress Dome	613	Cypress Wetland Coniferous Forest
MS	Mixed Swamp	621	Freshwater Swamp
RU	Ruderal		Several Types
U	Urban Industrial	100	Urban or Built up

0 500 1000
SCALE IN FEET

FIGURE II-24
VEGETATION MAP OF PROPOSED PIPELINE CORRIDOR



BARGE CANAL LOCATION OF PIPELINE SEGMENTS

Table II-50. Plant Community Composition Within 300 Meters (1,000 Feet) of the Proposed Lake Rousseau Pipeline

Community	Land Cover Category*	Hectares	Acres	Percent of Land Area†
Slash Pine Flatwoods	411	148.9	367.9	20.4
Longleaf Pine Sandhill	412	50.30	124.2	6.9
Xeric Hammock	421	29.8	73.7	4.1
Mesic Hammock	422/414	135.0	333.4	18.5
Hydric Hammock	621	9.67	23.9	1.3
Cypress Dome	611	28.7	70.9	3.9
Mixed Swamp	621	5.95	14.7	0.8
Freshwater Marsh	641	39.2	96.9	5.3
Improved Pasture	213	66.86	165.1	9.2
Pine Plantation	441	154.2	380.8	21.2
Other Ruderal Areas	---	60.02	148.2	8.2
TOTAL		728.60	1,799.7	

*Florida Land Use and Cover Classification System.
†Exclusive of Aquatic Systems.

Source: Environmental Science and Engineering, Inc., 1978.

Table II-51. Plant Communities of the Proposed Pipeline Corridor Not Found at the Plant Site

I. Cypress Dome

A. Definition. Pond cypress stands less than 15 acres; dome-shaped with smaller trees toward edges. Overstory of pond cypress and some slash pine to 25 meters (80 feet) tall, with shrub layer of gallberry, shiny lyonia and buttonbush, and varied ground layer. Occupies shallow depressions of poorly-drained acid sands in flatwoods. With drainage or fire prevention, succession tends toward flatwoods or bay heads.

B. Characteristic Species

		Growth Form*
Pond cypress	*Taxodium ascendens*	T
Black gum	*Nyssa biflora*	T
Slash pine	*Pinus elliottii*	T
Shiny lyonia	*Lyonia lucida*	S
Buttonbush	*Cephalanthus occidentalis*	S
Virginia chain fern	*Woodwardia virginica*	H
Maidencane	*Panicum hemitomon*	H
Cinnamon fern	*Osmunda cinnamomea*	H

II. Xeric Hammock

A. Definition. Stand dominated by evergreen oaks over 6 meters (20 feet) tall, with American holly restricted to this habitat. Occurs as transition zone between flatwoods and mesic hammock on well-drained sandy soils. Shade is not very dense in this generally climax community.

B. Characteristic Species

		Growth Form*
Laurel oak	*Quercus hemisphaerica*	T
Live oak	*Quercus virginiana*	T
Sand live oak	*Quercus geminata*	T
Pignut hickory	*Carya glabra*	T
Saw palmetto	*Serenoa repens*	S
Sparkleberry	*Vaccinium arboreum*	S
American holly	*Ilex opaca*	S
Partridgeberry	*Mitchella repens*	H
Frost grape	*Vitis vulpina*	V
Resurrection fern	*Polypodium polypodioides*	E
Spanish moss	*Tillandsia usneoides*	E

*Characteristic growth form as follows: T=tree; S=shrub; H=herb; V=vine; E=epiphyte.

Source: Florida Game and Fresh Water Fish Commission, 1976.
Environmental Science and Engineering, Inc., 1978.

oaks occur within the 300-meter (1,000-foot) corridor, but the area of construction consists only of areas previously cleared as right-of-way, with few large trees.

The portion parallel to Highway 19 (Segment B) passes primarily through the ruderal right-of-way of the highway and is bordered by improved pastures with a few ephemeral marshes used as pasture.

Segment C along the transmission line corridor is described in the Site Certification Application for the plant site. The vegetation in this segment is largely early successional and ruderal. Seasonal freshwater marshes do occur within the area of construction, but also are of largely ruderal nature. A narrow strip [90 meters (300 feet)] of natural flatwoods and hammock vegetation occurs along the north side of the corridor area; however, the vegetation to the north of this strip has also been cleared and converted to pine plantation.

In summary, most of the area along the proposed corridor has been cleared or altered previously. The sections to be directly affected by construction are largely ruderal areas which are adjacent to road-beds and have been cleared and drained. Much of the area currently shown as natural is in a temporarily halted state of transition to residential development.

ANIMAL COMMUNITIES ALONG THE PIPELINE CORRIDOR

Animal communities along the corridor are typical of this area of Florida and include freshwater marsh, lake, cypress dome, ruderal, hydric hammock, mesic hammock, xeric hammock, pine flatwoods, and pine plantation. Table 2.7-10 of the Site Certification Application for the proposed plant site lists the species associations for these biotic communities along the corridor, except for the lake. The species associations for the lake habitat are listed in Table II-52.

A major factor in determining the structure of the animal community is the plant community type; however, the degree of disturbance by man along the corridor is also a contributing factor. Many of the forested areas have been disturbed by man, so that much of the understory vegetation is in an early successional stage. The corridor area is a mosaic of grassland, forested lands, and wetlands, much of which has been disturbed. These communities harbor an assemblage of animals similar to that of the plant site, although ranging habits and population densities would be different.

The corridor areas provide good habitat for species of open areas (cattle egrets, cotton rats, quail, mourning doves, fox squirrels, and fence lizards). Although the number of exclusive species (i.e., meadowlark and cotton rat) is low, a large number of ubiquitous species such as foxes, raccoons, rabbits, and box turtles occur in both forested and non-forested lands.

The corridor provides poorer habitat for species of heavily wooded areas. Although exclusive species such as warblers, chickadees, woodpeckers, grey squirrels, cotton mine, tree frogs, and skinks may occur, their abundances would be low compared to those on the plant site.

The wildlife at the eastern end of the corridor is greatly influenced in diversity and abundance by Lake Rousseau and the associated wetlands. The change in habitat type from upland to aquatic promotes greater local

Table II-52 Vertebrates Known or Expected to Occur in Lake Habitat Along the Proposed Corridor

Order / Family / Species	Common Name
MAMMALS	
Marsupialia	
Didelphidae	
Didelphis marsupialis	Opossum
Chiroptera	
Vespertilionidae	
Myotis austroriparius	Southeastern myotis
Carnivora	
Procyonidae	
Procyon lotor	Raccoon
Mustelidae	
Lutra canadensis	River otter
BIRDS	
Podicipediforms	
Podiceps podilymbus	Pied-billed grebe
Pelecaniformes	
Pelecanus occidentalis	Brown pelican
Anhinga anhinga	Anhinga
Ciconiiformes	
Ardea herodias	Great blue heron
Butorides striatus	Green heron
Florida caerulea	Little blue heron
Bubulcus ibis	Cattle egret
Casmerodius albus	Great egret
Egretta thula	Snowy egret
Hydranassa tricolor	Louisiana heron
Nyticorax nycticorax	Black-crowned night heron
Nyctanassa violacea	Yellow-crowned night heron
Ixobrychus exilis	Least bittern
Botaurus lentiginosus	American bittern
Mycteria americana	Wood stork
Plegadis falcinellus	Glossy ibis
Eudocimus, albus	White ibis
Anseriformes	
Anas platyrhynchos	Mallard
Anas rubripes	Black duck
Anas fulvigula	Mottled duck
Anas strepera	Gadwall
Anas acuta	Pintail
Anas crecca carolinensis	Green-winged teal
Anas discors	Blue-winged teal
Anas americana	American widgeon
Anas clypeata	Northern shoveler
Aix sponsa	Wood duck
Aytha collaris	Ring-necked duck
Aytha valisineria	Canvasback
Aytha affinis	Lesser scaup
Bucephala clangula	Common goldeneye
Bucephala albeola	Bufflehead
Oxyura jamaicensis	Ruddy duck
Lophodytes cucullatus	Hooded merganser
Mergus serrator	Red-breasted merganser
Falconiformes	
Cathartes aura	Turkey vulture
Coragyps atratus	Black vulture
Buteo lineatus	Red-shouldered hawk
Haliaeetus leucocephalus	Bald eagle
Pandion haliaetus	Osprey
Gruiformes	
Aramus guarauna	Limpkin
Rallus elegans	King rail
Rallus limicola	Virginia rail
Porzana carolina	Sora
Porphyrula martinica	Purple gallinule
Gallinula chloropus	Common gallinule
Fulica americana	American coot

Table II-52 Vertebrates Known or Expected to Occur in Lake Habitat Along the Proposed Corridor (Continued, page 2 of 3)

Order / Family / Species	Common Name
BIRDS, cont.	
Charadriiformes	
Charadrius vociferus	Killdeer
Capella gallinago	Common snipe
Larus argentatus	Herring gull
Larus delawarensis	Ring-billed gull
Larus atricilla	Laughing gull
Sterna forsteri	Forster's tern
Sterna albifrons	Least tern
Apodiformes	
Archilochus colubris	Ruby-throated hummingbird
Coraciiformes	
Megaceryle alcyon	Belted kingfisher
Piciformes	
Dryocopus pileatus	Pileated woodpecker
Passeriformes	
Iridoprocne bicolor	Tree swallow
Progne subis	Purple martin
Corvus ossifragus	Fish crow
Cistothorus palustris	Long-billed marsh wren
Seiurus motacilla	Louisiana waterthrush
Oporornis agilis	Connecticut warbler
Geothlypis trichas	Common yellowthroat
Icteria virens	Yellow-breasted chat
Wilsonia citrina	Hooded warbler
Agelaius pheoniceus	Redwing blackbird
Euphagus carolinus	Rusty blackbird
Quiscalus major	Boat-tailed grackle
Melospiza georgiana	Swamp sparrow
Melospiza melodia	Song sparrow

Order / Family / Species	Common Name
AMPHIBIANS	
Caudata	
Sirenidae	
Siren lacertina	Greater siren
Siren intermedia	Lesser siren
Pseudobranchus striatus axanthus	Narrow-striped dwarf siren
Salamandridae	
Notophthalamus viridescens piaropicula	Peninsula newt
Plethodontidae	
Eurycea quadridigitata	Dwarf salamander
Amphiumidae	
Amphiuma means means	Two-toed congo eel
Anura	
Ranidae	
Rana areolata	Gopher frog
Rana catesbeiana	Bullfrog
Rana clamitans	Bronze frog
Rana grylio	Pig frog
Rana heckscheri	River frog
Rana utricularia	Southern leopard frog
Microhylidae	
Gastrophryne carolinensis	Eastern narrow-mouth toad
Bufo terrestris terrestris	Southern toad
Hylidae	
Acris gryllus dorsalis	Florida cricket frog
Hyla cinerea cinerea	Green treefrog
Hyla gratiosa	Barking treefrog
Hyla squirella	Squirrel treefrog

Table II-52 Vertebrates Known or Expected to Occur in Lake Habitat Along the Proposed Corridor (Continued, page 3 of 3)

Order / Family / Species	Common Name
REPTILES	
Testudines	
Chelydridae	
Chelyolra serpentina serpentina	Snapping turtle
Kinosternidae	
Stenotherus odoratus	Musk turtle
Kinosternon bauri bauri	Striped mud turtle
Emydidae	
Chrysemys floridana	Florida cooter
Chrysemys concinna suwanniensis	Suwannee cooter
Chrysemys scripta	Yellow-bellied turtle
Deirochelys reticularia	Chicken turtle
Trionychidae	
Trionyx ferox ferox	Florida soft-shelled turtle
Crocodylia	
Alligatoridae	
Alligator mississippiensis	American alligator
Colubridae	
Natrix fasciata pictiventris	Banded water snake
Natrix cyclopion	Green water snake
Natrix rigida	Glossy water snake
Natrix taxispilotta	Brown water snake
Liodytes alleni	Striped swamp snake
Seminatrix pygaea	Black swamp snake
Thamnophis sauritus sackeni	Peninsula ribbon snake
Thamnophis sirtalis similis	Blue-striped garter snake
Storeria dekayi	Brown snake
Farancia abacura	Mud snake
Viperidae	
Agkistrodon piscivorus conanti	Florida cottonmouth

Sources: Florida Committee on Rare and Endangered Plants and Animals, 1976.
U.S. Department of the Interior, 1977.
Florida Game and Fresh Water Fish Commission, 1977.
Environmental Science and Engineering, Inc., 1978.

diversity in habitats and therefore greater diversity of vertebrate animals. However, the quality of habitat is of reduced value to some wildlife because of the degree of disturbance, particularly along the shoreline which is utilized by a diversity of fauna including both upland and lake-associated species. Many upland species frequent such areas either as a feeding or watering site.

The lake is a feeding and nesting area for some waterfowl and shore birds. Two heron rookeries are located near Lake Rousseau. These colonies consist of little blue heron, great egret, Louisiana heron, snowy egret, and cattle egret. The osprey is a characteristic summer breeding bird. Eagles use the lake as a feeding and nesting site.

IMPORTANT SPECIES

Several game species, including rabbits, squirrels, mourning dove, bobwhite quail, turkey, feral swine, and white-tailed deer are found in the area. Of these species, squirrels, cottontail rabbit, mourning dove, and bobwhite quail have the greatest potential as a hunting resource in the immediate area of the proposed pipeline. Although no estimates are available on populations of these species in the immediate habitats surrounding the corridor, populations should be fairly abundant. The most favorable game species habitat occurs near forest ecotones and where man's disturbance is not so severe.

RARE AND ENDANGERED PLANTS AND ANIMALS

PLANT SPECIES

In the Crystal River Units 4 and 5 Site Certification Application, eighteen plant species listed by the Florida Committee on Rare and Endangered Plants and Animals were identified as potentially occurring in the region. For many of these species (dicerandra, silkbay, scrub buckwheat, Ocala vetch, Hartwrightia, corkwood, and Godfrey's blazing star), there is not suitable habitat within the corridor or their known ranges do not extend to the corridor. Their probabilities of occurrence are considered to be extremely low.

Several other species do occur in the types of hammocks that are found along the corridor, but require generally more moist conditions, greater shade and cover, and more exposed limestone than occur along the route. Therefore, the probabilities of occurrence of dwarf spleenwort, sink-hole fern, Venus'-hair fern, Jackson vine, and needle palm are low.

Potentially suitable habitat for water parsnip, water sundew, quillwort, pond spice, and Florida willow does occur within the 300-meter (1,000 foot) corridor along the marshes, ponds, ditches, and domes. Water sundew and quillwort are locally abundant in ponds and bogs in the vicinity of Lake Rousseau (Florida Game and Fresh Water Fish Commission, 1976). None were found along the corridor, however, and past disturbance and drainage make it moderately unlikely that these species occur here.

Cootie is a common plant species in flatwoods and hammocks of the region. Although not found in this survey, it probably occurs in low numbers along the route. Its abundance, though, is probably lower than in more undisturbed portions of the region.

ANIMAL SPECIES

Eighteen species of animals which are listed by the Florida Committee on Rare and Endangered Plants and Animals have ranges which include the proposed pipeline route (Table II-53). Although some species may occur in the general area of the proposed corridor, their area would be less preferred habitat than more isolated areas. None of these species were observed along the corridor. The osprey, bald eagle, and American alligator were observed on or near Lake Rousseau.

Table II-53. Rare and Endangered Animal Species which May Occur in the Vicinity of the Proposed Pipeline Corridor

Species	Common Name	Status* FCREPA	Status* USDI	Status* FGFWFC	Preferred Habitat	Likelihood of Occurrence
Amphibians and Reptiles						
Alligator mississippiensis	American alligator	T	E	E	Ponds & marshes	Present
Birds						
Pelecanus occidentalis	Brown pelican	T	E	T	Estuary & lake & salt marsh	Present
Florida caerulea	Little blue heron	SC	---	---	Coastal hammock, fresh & salt marsh	Present
Casmerodius albus	Great egret	SC	---	---	Salt marsh & fresh marsh	Likely
Egretta thula	Snowy egret	SC	---	---	Estuary, salt & fresh marsh	Present
Hydranassa tricolor	Louisiana heron	SC	---	---	Estuary, salt & fresh marsh	Likely
Nycticorax nycticorax	Black-crowned night heron	SC	---	---	Coastal hammock, fresh & salt marsh	Likely
Nyctanassa violacea	Yellow-crowned night heron	SC	---	---	Coastal hammock, fresh & salt marsh	Likely
Mycteria americana	Wood stork	E	---	E	Swamps, ponds, marshes	Likely
Eudocimus albus	White ibis	SC			Wetlands	Likely
Accipiter cooperii	Cooper's hawk	SC	---	---	Secluded woodlands	Likely
Haliaeetus leucocephalus leucocephalus	Southern bald eagle	T	E	E	Shores of large water bodies	Present
Pandion haliaetus carolinensis	American osprey	T	---	---	Shores of large water bodies	Present
Falco sparverius paulus	Little kestrel	T	---	---	Open fields & pinewoods	Likely
Dendrocopos villosus audubonii	Southern hairy woodpecker	SC	---	---	Pinewoods, swamps, & hammocks	Likely
Dendrocopos borealis hylonomus	Red-cockaded woodpecker	E	E	T	Mature pine flatwoods	Marginal
Aphelocoma coerulescens coerulescens	Florida scrubjay	T	---	---	Oak scrub	Marginal
Mammals						
Eptesicus fuscus	Big brown bat	R	---	---	Open areas	Likely
Sciurus niger shermani	Sherman's fox squirrel	T	---	T	Open pine flatwoods	Likely

* Status categories for listed species are based on the following sources: FCREPA (Florida Committee on Rare and Endangered Plants and Animals); USDI (United States Department of the Interior); and FGFWFC (Florida Game and Fresh Water Fish Commission).

Sources: Florida Committee on Rare and Endangered Plants and Animals, 1976.
U.S. Department of the Interior, 1977.
Florida Game and Fresh Water Fish Commission, 1977.
Environmental Science and Engineering, Inc., 1977.

EXISTING ENVIRONMENTAL STRESSES

The predominant stresses along the corridor are associated with transition to other land uses. The northeastern segment has been subjected to clearing, drainage, and road construction preliminary to housing development and to dam and access area construction at Lake Rousseau. The central segment along Highway 19 has largely been converted to pasture grasses as improved pasture and roadside grade. The southwestern portion has been cleared as a transmission line corridor. Currently all of these areas are in a stable condition or are undergoing the process of secondary succession in which shrubby species such as gallberry, saw palmetto, wax-myrtle, persimmon, willow, and buttonbush are assuming predominance. It is presumed that the growth in the transmission line corridor and along Aspen Avenue will again be cleared or cut before the next stage of succession occurs.

III. UNAVOIDABLE ENVIRONMENTAL IMPACTS

WATER RESOURCES, PHYSICAL SYSTEMS

HYDROLOGY

The impacts of withdrawal by Florida Power of 20 to 30 cfs (average to peak) were evaluated for three scenarios. For each scenario, the critical months are those when drought conditions occur and persist for a long period of time. Therefore, emphasis is placed upon the lowest monthly inflow conditions during such drought conditions. The three scenarios examined are:

1. Impacts without drawdown control. Under this condition, the lake would be kept at a constant level, while water is diverted from the Lower Withlacoochee by consumption at Lake Rousseau.
2. Impacts with drawdown control. Under this situation, drawdown of the lake would be exercised when withdrawal by Florida Power would be the cause of outflows less than the minimum flow requirements. This would mean that 20 to 30 cfs would be removed from lake storage while the inflows to the lake would be allowed to exit to the receiving streams with no consumptive losses.
3. Impacts with canal. Should the barge canal be utilized, there will be many instances when minimum flow requirements will not be met even without water usage by Florida Power. Canal alternatives always include a minimum fixed allocation for the Withlacoochee. In this evaluation, it is assumed that 350 cfs will be assigned to the Lower Withlacoochee River. The impacts of Florida Power are evaluated with respect to their effects upon the canal rather than on the Lower Withlacoochee.

WATER AVAILABILITY--NO CANAL

Constant Pool Level

The usage of 20 cfs of water from Lake Rousseau will lower the average available water (above the minimum flows required for the Withlacoochee) for all uses from 1,018 cfs to 988 cfs. Based on historical flow data, during the worst year out of 44 years (similar to 1956), similar consumption would result in a lowering of the average available water (after allotment of required flow to Withlacoochee) for all uses from 115 cfs to 95 cfs. During 18 out of 528 months, there will be no water available for any uses after the minimum required river flows (listed in Table II-1) are met. Use of 30 cfs from Lake Rousseau would increase the number of occurrences to 23.

Variable Pool Level

If drawdown is utilized during drought conditions for the purposes of supplying Florida Power with water while maintaining minimum flow requirements to the Withlacoochee, the available water (while avoiding a depletion of the lake) for other purposes during the seven most critical continuous months (in 44 years) would be reduced from 62 cfs to 42 cfs (32 cfs when 30 cfs are utilized). These values are beyond the projected water usages through 2035.

WATER AVAILABILITY--WITH CANAL

If the Florida Barge Canal is operated in the future at 100 percent of the design rate (456 cfs through the locks while allocating 350 cfs to the Withlacoochee), a reduction in lockage rates of 4.4-6.6 percent (at 20-30 cfs usage rate by Florida Power), will occur during the 11 most critical months of a 2-year drought (similar to 1956-1957). Thus during those most critical months, the consumption of 20 or 30 cfs of water by Florida Power would reduce the amount available for lockage by this amount without impact on water flow to the Withlacoochee.

WATER RESOURCES, BIOLOGICAL SYSTEMS

ENTRAINMENT EFFECTS

In Lake Rousseau, entrainment impacts brought about by the placement of a water intake structure will primarily be limited to members of the plankton community. Major concerns relating to plankton entrainment include: (1) reduced levels and permanent loss of production that would otherwise be available to the system; (2) alteration of the trophic state of the water body as a result of significant losses of phytoplankton and zooplankton; and (3) losses of commercially important species that are known to spend part of their life cycles as members of the plankton community. Although entrainment of plankton species is inevitable in the immediate area of withdrawal of water, all of the above impacts are considered to be minimal or insignificant. This assessment is based on: (1) the relatively low levels of productivity presently occurring in Lake Rousseau in the water column; (2) the low densities of zooplankton even at the most productive stations; and (3) the abundant evidence based on life history information (Scott and Crossman, 1973; Lippson and Moran, 1974, and references therein; and Chew, 1974) that ichthyoplankton do not occur in the lake.

Eggs of most freshwater fish are demersal, i.e., they remain near the bottom and are attached to aquatic vegetation or are located in nests. If the intake structure is placed at one of the recommended locations, effects of withdrawal should not be felt in any of the above habitats. Any unavoidable loss in productivity or biomass through entrainment will ultimately be returned (by blowdown discharge) to another aquatic system (the Gulf of Mexico) for utilization.

A secondary entrainment impact would be the loss of biomass and productivity potentially available to the Withlacoochee River and other

aquatic environments receiving water from Lake Rousseau. Biomass would be diverted from these areas to the Gulf of Mexico via the power plant. Based on percentages of flow, this biomass diverted would be relatively low. The species composition in the existing situation changes rapidly as the habitats become more saline. This results in the mortality of plankton populations entering the Withlacoochee's saline area from Lake Rousseau. Given the rapid turnover and extreme variability of plankton populations in estuarine waters, it is unlikely that effects on populations in the Lower Withlacoochee would be detectable even by large-scale sampling programs.

EFFECTS ON AQUATIC BIOTA

The predicted minimal alterations of hydrological, chemical, and physical systems under average flow conditions would not significantly impact the biological communities of Lake Rousseau. Under drought conditions similar to those of 1956, impacts would be unavoidable but would not necessarily be related to the intake structure.

Any substantial reductions in water level associated with drawdown conditions, although maintaining minimum flow requirements, could result in exposure and losses of macrophytic vegetation. Although much of the vegetation is not suitable as a food source, it does appear to contribute significantly to the available oxygen levels in Lake Rousseau. Additionally, decaying vegetative materials place an oxygen demand on the system and increase nutrient loading which could ultimately lead to eutrophication of the system. A decrease in the volume of water would alter the structure of the biological community in terms of numbers of individuals, species present, and productivity.

SOCIOECONOMICS

LAND USE

Due to the generally undeveloped nature of the properties fronting the proposed pipeline route, the impacts of the project on land use are practically negligible. For those few parcels which are developed (five residences, one ranch, and one quarry operation) the burying of the pipeline will be no more than a temporary inconvenience. Individual property access roads will be temporarily obstructed by the burial of the pipeline; however, this inconvenience will be removed as soon as the pipe is laid and the cover dirt is replaced.

Another impact of a temporary nature will be the disruption of traffic on U.S. 19-98 when the pipeline must be laid across it. This is a minor problem, quite easily solved. Since U.S. 19-98 is a 4-lane divided highway, the traffic can easily be rerouted to the opposite lane to create a temporary 2-lane bypass of the section under construction.

There will be no long-term effects of the pipeline on land use. The line will be buried in Florida Power utility and public transportation rights-of-way and thus will cause no changes in existing or future land use patterns.

Foreseeable future effects of the pipeline on land use will be temporary and will involve maintenance and/or repair of the pipeline. The impact of repair work, like the impacts during the initial construction period, will involve temporary obstruction of private property access and/or impeding of traffic. Such inconveniences will be relieved as soon as the repair work is completed.

WATER USE

Effects of the project on consumptive water use are discussed in the preceding sections on hydrology and water availability.

The proposed project will have little or no effect on the recreational value of Lake Rousseau.

ARCHAEOLOGY

An intensive archaeological and historical survey of the proposed pipeline corridor revealed no new aboriginal sites and only one historical site in the survey zone. The historical site, which is of minimal importance, represents a temporary home site circa early 20th century. Due to its late time period, short occupation span, and general non-distinctive nature, no recommendations were made for its protection.

The previously known aboriginal site 8Ci70 located in the survey area, is of minimal importance due to its minor artifact content and redeposited nature, i.e., dredge spoil. Close examination of the site revealed no new artifacts.

According to the archaeologist (Willis, 1978), construction of the pipeline and access road as proposed will have minimal impact on the cultural resources of the area. A copy of the archaeological/historical survey report was submitted to the Florida Division of Archives, History, and Records Management on May 18, 1978. Development approval from that office is pending.

TERRESTRIAL ECOLOGY IMPACTS

CONSTRUCTION AND MAINTENANCE

Impacts of major line construction activities generally include loss of natural cover, loss of topsoil, faster or increased runoff, lowering of water tables, increased erosion, increased fluctuation in streamflow and water levels, increased downstream flooding and sediment loads, increased turbidity and sedimentation in receiving waters, and loss of habitat (Darnell, et al., 1976). Other impacts may include direct loss of wildlife.

For the Lake Rousseau pipeline, all of the above impacts are considered to be low in both magnitude and significance. This assessment is based on: (1) the magnitude of previous unrelated removal of natural cover, (2) the existence or proposed existence of roads along the entire pipeline, and (3) the lack of well-defined surface drainage systems in the area. Construction and maintenance will necessitate clearing a few trees and possibly some shrubby wetland vegetation along the route. Since most of this area has already been cleared and will continue to be maintained at an early successional state, the systems should recover to a similar state in a very short time, with no significant long-term reduction in species diversity, productivity, successional pattern, or other ecosystems function. A short-term loss of productivity, biomass, and habitat is regarded as insignificant on a regional scale. No rare or endangered species or major wetlands are expected to be noticeably affected. Neither the construction, operation, nor the continued presence of the pipeline are expected to cause alterations to drainage or water levels (see Section IIIA) sufficient to affect significantly vegetation or wildlife in the area.

Impacts on the faunal communities will be determined by the extent of permanent changes in the habitat surrounding the proposed pipeline corridor. In relation to wildlife, land-clearing activities for construction of the pipeline will destroy approximately 16 hectares (40 acres) of wildlife habitat. Such clearing will eliminate the

existing faunal communities; however, because of the relatively small area required for the development of the corridor, most of this loss is considered of low magnitude.

Secondary impacts will result where adjacent forested lands are cleared along the right-of-way to facilitate the construction of the pipeline. This impact is not significant since the area to be cleared is small. The overall impact to rare and endangered species of wildlife should not be significant because of the small area affected and the availability of suitable habitat in nearby areas.

In general, the significance of this wildlife habitat loss is not great because most of the species involved are very common. Most populations in the area are currently self-sustaining. The magnitude of the impact of these activities on the site is small since proposed changes will not significantly change the ecological function of the corridor. The area-wide magnitude of these changes is not great because of the current abundance of available habitat. These impacts are reversible and will not involve a long-term loss of natural wildlife resources to the site and the area.

BARRIERS

It is anticipated that the proposed pipeline or intake structures would not present a barrier of sufficient magnitude to impact any species.

WATER USAGE

Since water levels in Lake Rousseau will not be altered by pumping (Section IIIA), no effect of water consumption on terrestrial vegetation and associated wildlife is predicted.

IV. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

WATER CONSUMPTION

The long-term use of Lake Rousseau by Florida Power Corporation as the source of secondary cooling tower makeup for Units 4 and 5 will reduce the average flow rate through the Withlacoochee River by 20 cfs or 13 mgd. This amount is equal to 1.1 percent of the long-term average flow into Lake Rousseau.

The commitment of this amount of water will reduce the amount of water available (beyond the requirements of the Withlacoochee) for other consumptive uses by the same amount. Although 20 cfs is only 2 percent of the average available water (1,018 cfs), this amount becomes critical during severe droughts and limits the amount of water available for other purposes if minimum flow requirements are strictly enforced.

At any given time if another source of water were utilized or if the plant were shut down, the system would revert to its former flows.

LOSS OF TERRESTRIAL BIOTA

Construction of the pipeline will involve the loss of biomass, habitat, and natural cover of about 16 hectares (40 acres) of largely ruderal or early successional vegetation. The existing vegetation and habitat will be functionally replaced (with a return to similar species diversity, productivity, successional trends, nutrient cycling, etc.) following construction. Therefore, this impact will not constitute either an irreversible or irretrievable commitment of resources. Loss of biomass and productivity during and following construction will be of low magnitude and significance.

LOSS OF AQUATIC BIOTA

The long-term use of Lake Rousseau by Florida Power Corporation as the source of secondary cooling tower makeup sources for Units 4 and 5 will result in the mortality of the aquatic organisms contained within the 20 cfs of water withdrawn. The number of individuals will be relatively small since the water will be drawn from a region of low productivity. This effect would persist until plant operation ceased. As discussed previously, most of the aquatic productivity in Lake Rousseau is the result of benthic vegetation. The water column contributes only a small portion of the total production of the lake.

The result of the water withdrawal will be that 20 cfs of water will no longer exit through the bypass canal to the Withlacoochee and ultimately to the gulf. At any time that withdrawal by Florida Power is discontinued, the system and its population should revert to their former levels.

V. ENVIRONMENTAL IMPACTS OF WATER WITHDRAWAL

ALTERATION OF LAKE CIRCULATION DUE TO PROPOSED INTAKE STRUCTURE

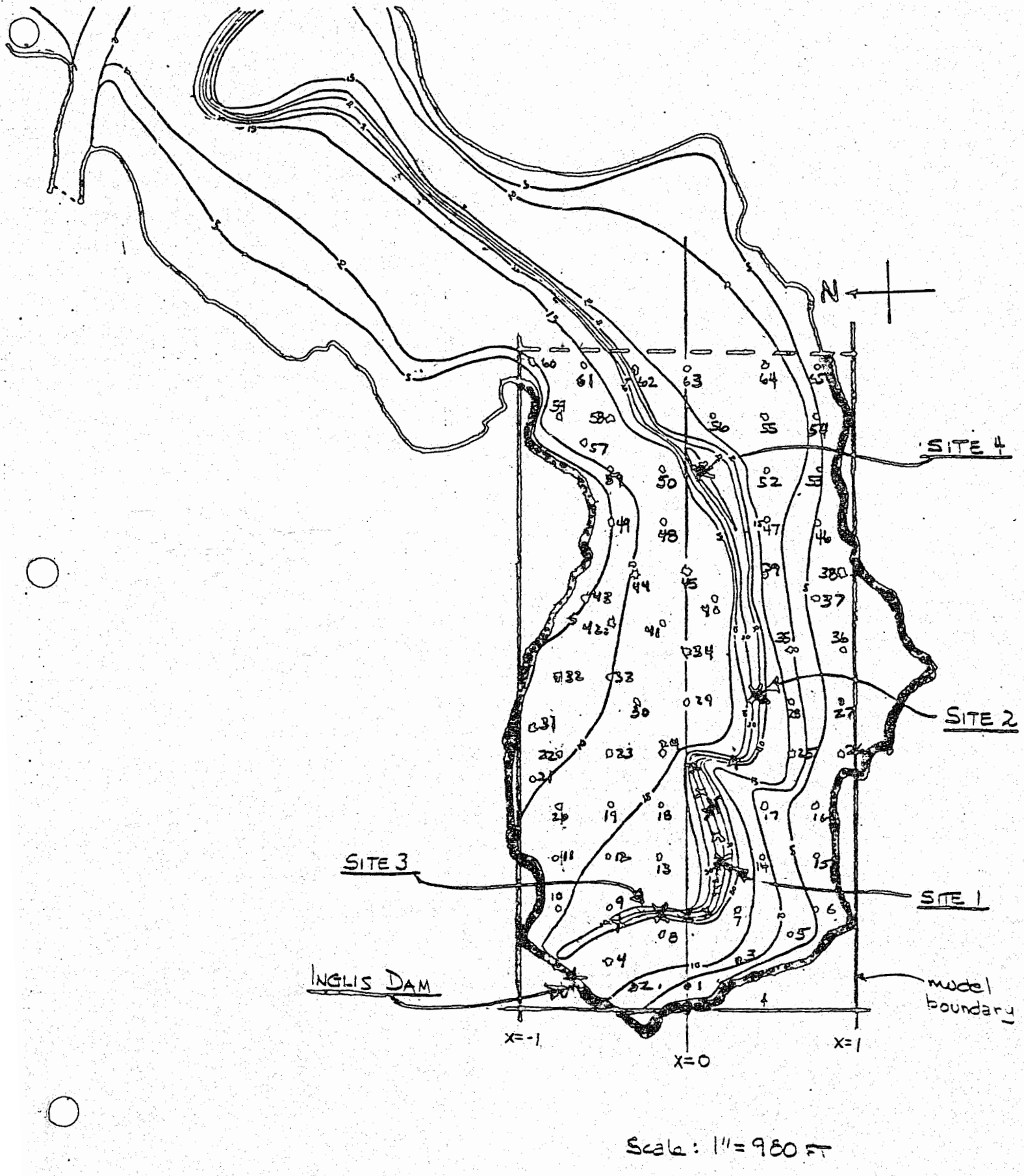
CIRCULATION

A potential flow model was applied to the western embayment to evaluate the potential changes in circulation from the continuous withdrawal of 20 mgd through a cooling water intake structure located in the lake. Figure V-1 shows the model boundaries and sink locations (dam and cooling water intake) relative to the actual physical boundaries of Lake Rousseau.

The model is utilized only as a first-order approach to evaluate the relative change in magnitude of current velocities and direction with respect to four proposed cooling water intake sites (see Figure V-1). It is necessary to establish the limitations of the potential flow model. The following assumptions were made:

1. No Friction--The model is based on the Laplace equation and therefore cannot account for the existence of or variations in bottom friction.
2. Uniform Depth--The model assumes the lake to be of uniform depth.
3. Model Boundary: Semi-Infinite Rectangular Region--Although the lake has an irregular boundary, the model assumes a rectangular region of constant cross-section and semi-infinite length. This was compensated (relative to graphical display of velocities) by placing model coordinates relative to existing physical boundaries (see Figure V-1).
4. Steady State--No time variations are taken into account.
5. No Wind Stress--The model is not capable of coupling wind stress at the free surface to the circulation.
6. Uniform Flow--No variations in velocity with depth (depth averaged velocity). The flow in the deeper old river channel was simulated hydraulically by using a series of sinks along the channel.

Figure V-1. Lake Rousseau Potential Flow Model Boundary Conditions, Model Station Locations, and Water Withdrawal Sites



7. Uncalibrated Model--The model has not been calibrated; therefore, the results from the model must be carefully scrutinized and can be regarded as only a good first-order approximation of the true flow field.

The model was applied for existing conditions and for each of the four proposed cooling water intake sites. Comparisons of relative current velocity changes, as well as graphical comparison of the circulation trends were made, for each of the four proposed sites to determine the optimum site for the cooling water intake relative to circulation impacts. Site 1 was chosen as the optimal site. Existing circulation trends and modified circulation trends are shown in Figures V-2 and V-3, respectively. Current velocities are compared for these two cases in Table V-1. In the region near the Inglis Dam, the relative velocities have decreased by approximately 20 percent due to the influence of the cooling water intake at site 1 (located between stations 13 and 14). The velocities above site 1 increase to an average maximum of 41 percent at stations 24 to 30, then level to an overall average increase in velocities of approximately 36 percent in the far field. The velocities are assumed constant with depth, but in reality the maximum occurs at or near the surface, then decreases to a minimum at the bottom, unless counter currents are developed due to the wind-neglecting wind effects.

In conclusion, the optimum location for the cooling water intake is at site 1. Placing the intake structure at this site will increase and improve the overall circulation in the western embayment towards the Inglis Dam. The relative increase in magnitude of the velocities is approximately 0.02 cm/sec and is not considered sufficient to resuspend suspended solids in the floc/muck layer in the upper reaches of the western embayment and to transport them towards the intake structure. Currents in the shallows would not be affected due to their distances from the intake structure and the drag exerted by hydrilla.

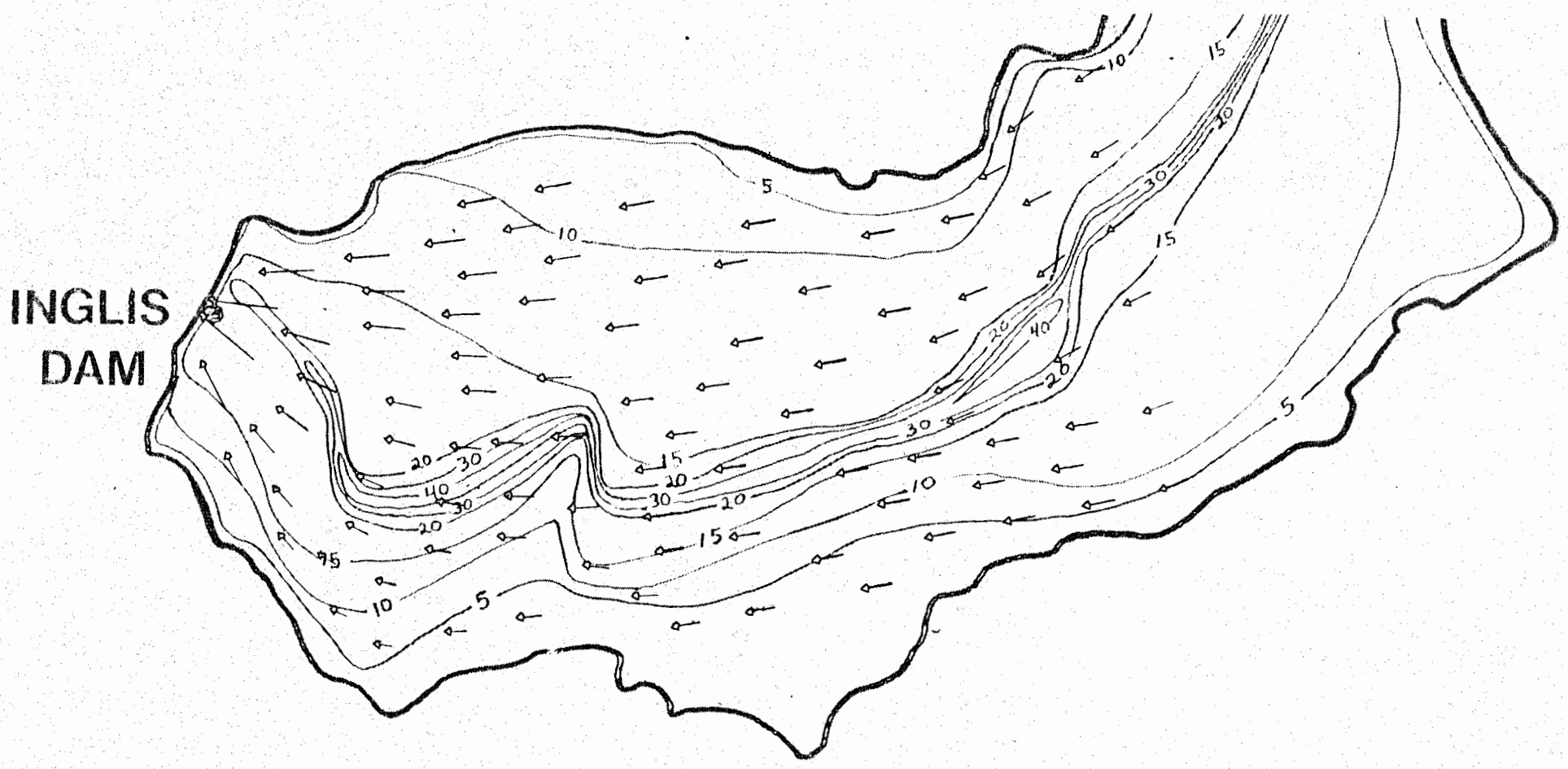


Figure V-2. Existing Circulation--Potential Flow Model, Lake Rousseau

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

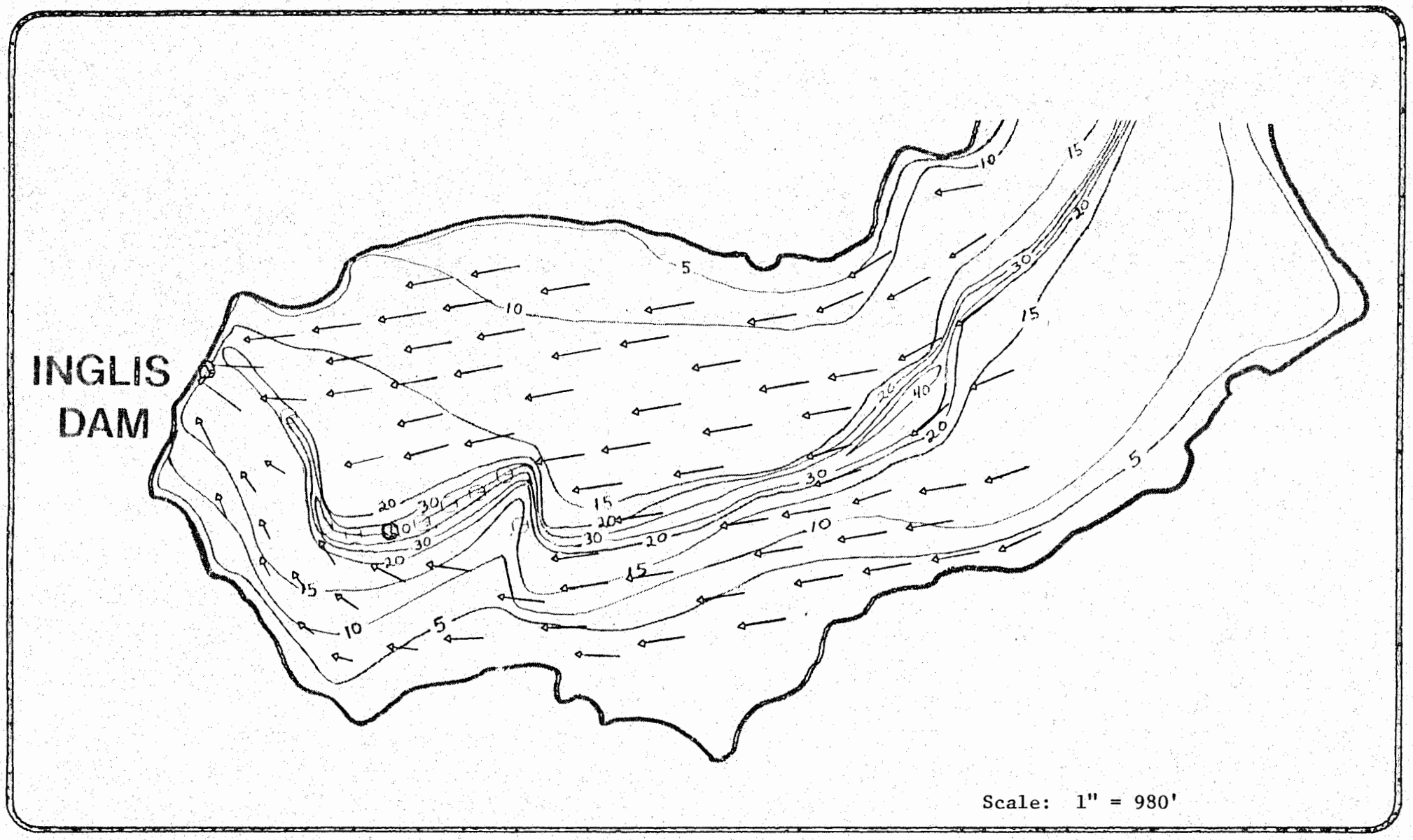


Figure V-3. Proposed Cooling Water Intake Site 1 Circulation--
Potential Flow Model, Lake Rousseau

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

Table V-1 Comparison of Current Velocities for Proposed Cooling Water Intake Site and Existing Conditions

Model Station*	Current Velocity (cm/sec) Existing	Current Velocity (cm/sec) Site 1	Velocity Change [- (decrease); + (increase)] Absolute Magnitude (cm/sec)	Velocity Change [- (decrease); + (increase)] Percentage
1	0.075	0.046	-0.029	-39
2	0.126	0.076	-0.050	-40
3	0.048	0.036	-0.012	-25
4	0.170	0.107	-0.063	-37
5	0.034	0.033	-0.001	-3
6	0.035	0.037	+0.002	+6
7	0.053	0.052	-0.001	-2
8	0.091	0.044	-0.047	-52
9	0.118	0.090	-0.028	-24
10	0.131	0.103	-0.028	-21
11	0.105	0.095	-0.010	-10
12	0.096	0.088	-0.008	-8
13	0.080	0.077	-0.003	-4
14	0.054	0.073	+0.019	+35
15	0.046	0.057	+0.011	+24
16	0.055	0.074	+0.019	+36
17	0.060	0.087	+0.027	+45
18	0.076	0.091	+0.015	+20
19	0.085	0.091	+0.006	+7
20	0.091	0.094	+0.003	+3
21	0.087	0.094	+0.007	+8
22	0.083	0.095	+0.012	+14
23	0.079	0.095	+0.016	+20
24	0.074	0.099	+0.025	+34
25	0.061	0.088	+0.027	+44
26	0.060	0.083	+0.023	+38
27	0.064	0.089	+0.025	+39
28	0.065	0.092	+0.027	+42
29	0.071	0.099	+0.028	+39
30	0.074	0.097	+0.023	+31
31	0.080	0.095	+0.015	+19
32	0.076	0.096	+0.020	+26
33	0.075	0.096	+0.02	+28
34	0.071	0.097	+0.026	+37
35	0.070	0.094	+0.024	+34
36	0.066	0.092	+0.026	+39
37	0.068	0.094	+0.026	+38
38	0.068	0.094	+0.026	+38

Table V-1 Comparison of Current Velocities for Proposed Cooling Water Intake Site and Existing Conditions (Continued, page 2 of 2)

Model Station*	Current Velocity (cm/sec) Existing	Current Velocity (cm/sec) Site 1	Velocity Change [- (decrease); + (increase)] Absolute Magnitude (cm/sec)	Velocity Change [- (decrease); + (increase)] Percentage
39	0.069	0.095	+0.026	+37
40	0.070	0.095	+0.025	+36
41	0.072	0.096	+0.024	+33
42	0.073	0.096	+0.023	+32
43	0.073	0.096	+0.023	+32
44	0.072	0.096	+0.024	+33
45	0.071	0.096	+0.025	+35
46	0.069	0.095	+0.026	+38
47	0.070	0.095	+0.025	+36
48	0.071	0.095	+0.024	+34
49	0.072	0.096	+0.024	+33
50	0.071	0.095	+0.024	+34
51	0.071	0.095	+0.024	+34
52	0.070	0.095	+0.025	+36
53	0.070	0.095	+0.025	+36
54	0.070	0.095	+0.025	+36
55	0.070	0.095	+0.025	+36
56	0.071	0.095	+0.024	+34
57	0.071	0.095	+0.024	+34
58	0.071	0.095	+0.024	+34
59	0.071	0.095	+0.024	+34
60	0.071	0.095	+0.024	+34
61	0.071	0.095	+0.024	+34
62	0.071	0.095	+0.024	+34
63	0.071	0.095	+0.024	+34
64	0.070	0.095	+0.024	+36
65	0.070	0.095	+0.024	+36

*See Figure V-1.

Source: Environmental Science and Engineering, Inc., 1977.

BIOLOGICAL IMPACT OF WATER WITHDRAWAL

Entrainment effects and other biological impacts are discussed in Chapter III. The modeling effort to determine alterations of circulation (see previous section) has some degree of biological importance. The results of these simulations indicate that only small currents would be produced in the shallow areas of the lake. Predictions of low velocities in the shallow areas, coupled with the frictional losses (not included in the model) of shallow hydrilla stands, indicate little probability that fish eggs and larvae would be drawn from those regions.

EFFECTS UPON THE WATER BUDGET

The Southwest Florida Water Management District (SWFWMD) has established minimum rates of flows and lake levels for streams and other watercourses in their district. These minimum flow criteria are applied to all consumptive use permit applicants. The minimum rates are determined as:

> "For each month, the five lowest monthly mean discharges for the preceding 20 years shall be averaged. Minimum rates of flow shall be established as 70 percent of these values for the four wettest months and 90 percent of these values for the remaining 8 months. The determination shall be based on available data, or in the absence of such data, it shall be established by reasonable calculations approved by the Board."

The minimum flow requirements as defined above are listed in Table II-1.

In addition to these minimum flow requirements, there is a cap on allowable withdrawals:

> "The withdrawal of water: (a) From a stream or other watercourse must not reduce the rate of flow by more than 5 percent at the time and point of withdrawal."

From the future projections of consumptive uses as they affect flows through the lake, it appears that the demands are small relative to the natural hydrologic regime. However, reactivation of the barge canal project, which is unlikely at this time, could alter this assumption.

In the following sections impacts are evaluated from the vantage point of the three scenarios which were explained in the hydrology section of Chapter III.

IMPACTS WITHOUT DRAWDOWN CONTROL - NO CANAL

Impacts of withdrawal were assessed by using the data in Table II-1 in Chapter II. Under the assumptions that the pool level will be maintained at its present level, that the barge canal and locks will not be utilized, and that other consumption will be small compared to the needs of Florida Power Corporation, the following impacts on the hydrologic budget and the Withlacoochee will occur.

During average annual, seven-day, low flow conditions, a total of at least 1,076 cfs will be entering Lake Rousseau. This flow of 1,076 cfs is the sum of the annual seven-day minima of Rainbow Springs and the Withlacoochee. These minima may or may not occur simultaneously. With the removal of 20 to 30 cfs (1.9 to 2.8 percent) of the inflow by Florida Power, there will be a quantity of water remaining which will fulfill the minimum outflow requirements of any month in the year.

In an average month, the average withdrawal rate of 20 cfs (13 mgd) would reduce the discharge into the Withlacoochee from 1,863 cfs to 1,843 cfs. Without consumption, the system would discharge 222 percent of the minimum flow requirement for an average month. The additional withdrawal would reduce the value to 220 percent of the minimum flow requirement. This withdrawal also amounts to 1.1 percent of the actual flow.

During the worst month (which is equal to the worst month in 44 years) of a drought as severe as the one which occurred during 1932 to 1933, a continuous withdrawal rate equal to the peak value of 30 cfs (20 mgd) would reduce the discharge into the Withlacoochee from 701 cfs to 671 cfs. Without any withdrawal, the system would meet only 76.5 percent of the minimum flow requirement for the month. The additional withdrawal would reduce the value to 73.3 percent of the minimum flow requirement. This withdrawal also amounts to 4.3 percent of the actual flow.

Based upon the historical data, the withdrawal of 30 cfs would result in 25 instances out of 528 during which the minimum flow requirements would not be met. Twenty-one of these events would be during four out of the 44 years, i.e., during the droughts. From the minimum requirements point of view, none of these occurrences would be worse than the case mentioned above. The withdrawal of only 20 cfs would lower the number of occurrences by two.

Thus the probability of maintaining minimum flow requirements, a constant pool level, and a Florida Power Corporation usage rate of 30 cfs during a given month is, on the average, 95.3 percent. At 20 cfs this probability is 95.6 percent. However, difficulties can occur during droughts which appear to occur with some regularity at intervals of 20 to 25 years.

Based on the above analysis, no significant impact is foreseen on the flows into the Withlacoochee River by the withdrawal of 30 cfs or 20 cfs. The impacts of naturally occurring droughts will be much more severe, but will not be significantly aggravated by water usage in Units 4 and 5 at Crystal River.

IMPACTS WITH DRAWDOWN TO MEET MINIMUM FLOW REQUIREMENTS - NO CANAL

If no deviations from minimum flow requirements are allowed, it will be necessary to make up for the withdrawals by Florida Power Corporation from storage. It is possible to meet minimum flow requirements every month, even during droughts, by lowering the pool level within Lake Rousseau.

During average annual, seven-day and 30-day low flow conditions, no drawdown will be necessary to meet the minimum outflow requirements. Certaily during average flow conditions the same conclusion holds.

During the three random, one-month occurrences mentioned above, a reduction in storage less than or equal to 1,785 acre-feet would take place at a consumption rate of 30 cfs. This reduction represents a decline in volume of 7.1 percent. At 20 cfs, a reduction in water volume of 1,190 acre-feet and 4.7 percent would occur.

During droughts such as those which occurred in 1932 to 1933 and 1956 to 1957, the declines in storage would be much more significant. As shown in Figure V-4, use of storage (30 cfs) during months when the minimum flow requirements could not otherwise be met would result in a decline in storage of 4,800 acre-feet or 19.1 percent of the present pool level. At a usage rate of 20 cfs, the decline in storage would be 2,600 acre-feet or 10.4 percent.

A drought such as that which occurred during 1956 to 1957 would result in a more severe decline in storage. The decline at a consumption rate of 30 cfs is shown in Figure V-5. Over a period of seven months, the volume of Lake Rousseau would drop by 11,400 acre-feet or 45.4 percent. At a 20 cfs withdrawal rate, the decline would be 7,200 acre-feet or 28.7 percent.

A further analysis was made in order to determine the usage rate required to deplete Lake Rousseau while maintaining the minimum flow

Figure V-4 Volume of Lake Rousseau During Drought of Equal Magnitude to That of 1932-1933 at a Consumption Rate of 30 cfs

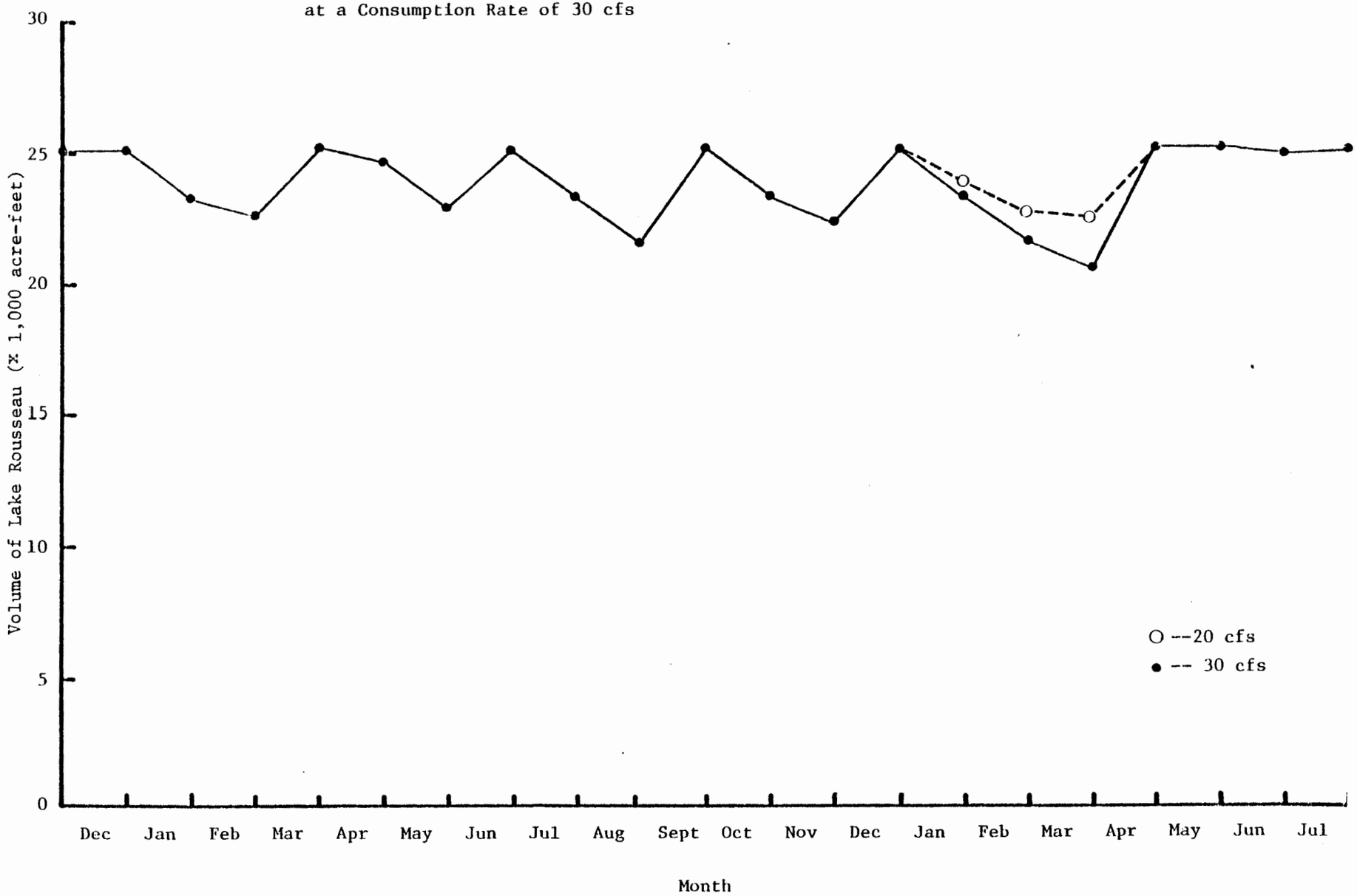
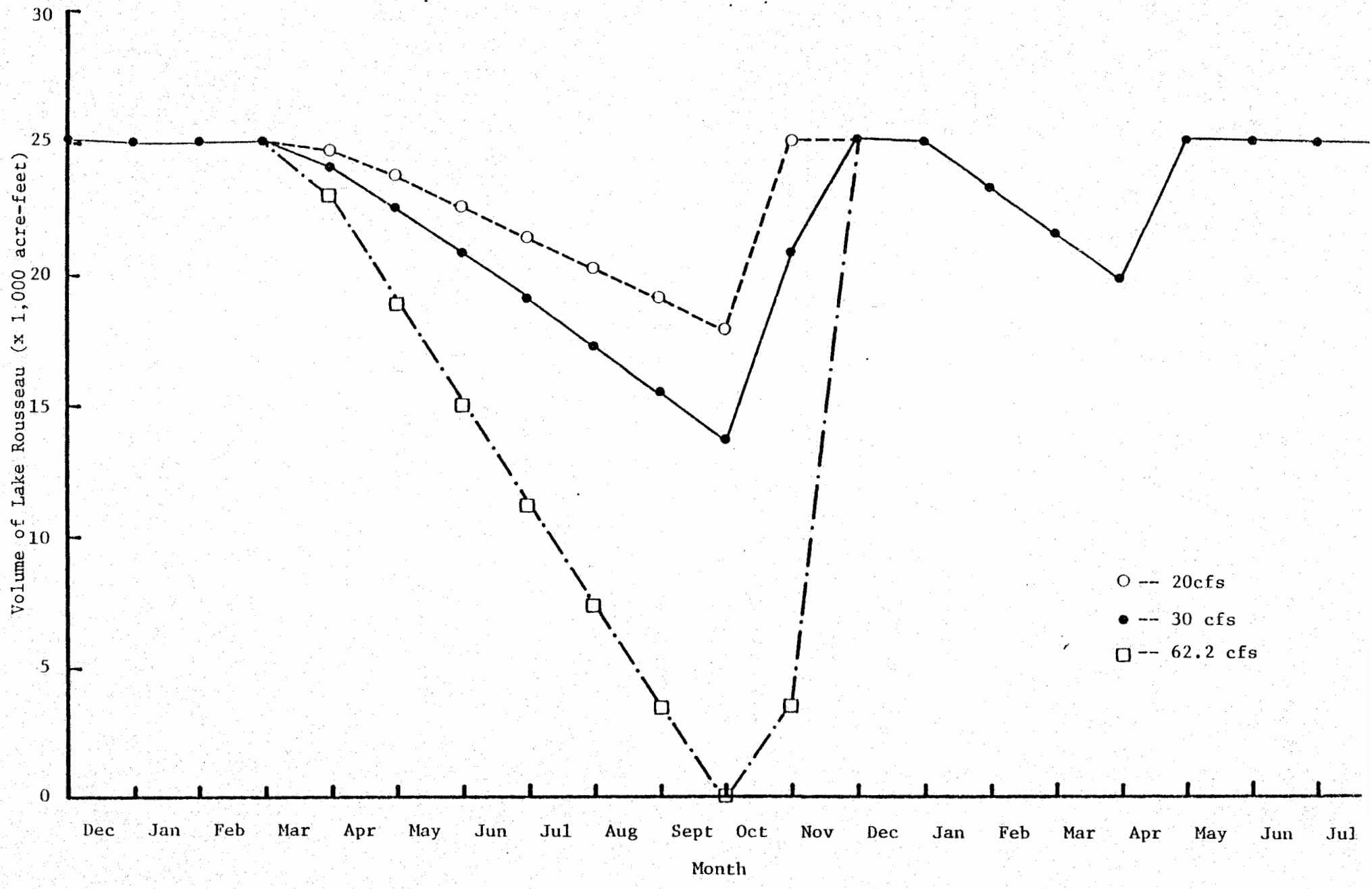


Figure V-5 Volume of Lake Rousseau During Drought of Equal Magnitude to That of 1956-1957 at a Consumption Rate of 30 cfs



requirements. During the most critical period of the worst drought in 44 years, a usage rate of 62.2 cfs would have been required to cause one depletion. Thus the average annual consumption rate which would cause one depletion of Lake Rousseau in 50 years is probably about 60 cfs.

A 30 cfs consumption rate during a severe drought would have minor hydrologic impacts on the Withlacoochee and major impacts on Lake Rousseau. At a 20 cfs consumption rate during a similar drought, the effects upon the hydrologic budget of the Withlacoochee would also be minor, whereas the impact upon the budget of Lake Rousseau would be moderate.

During the non-drought periods, the impacts of withdrawal of either 20 cfs or 30 cfs from Lake Rousseau on the hydrologic budget of the lake and of the Withlacoochee would be minor or insignificant.

IMPACTS WITH CANAL

The final disposition of the Cross-Florida Barge Canal has not been determined. One of the main alternatives within the original Barge Canal Plan involved the allocation of a minimum of 350 cfs to the Withlacoochee. Use of Lake Rousseau water by Florida Power would affect the lockage rates at Inglis (see Table V-2).

During a drought as severe as that of 1956 to 1957, the major impact of water withdrawal by Florida Power Corporation would be on the lockage rates at Inglis. The allotment of 350 cfs to the Withlacoochee would mean that Florida Power would have to compete with the Inglis locks for the remainder.

As shown in Table V-2, design lockage rates can be maintained about half of the time during a severe drought. Based on these data, withdrawal by Florida Power would rarely result in a lockage less than 100.0 percent (i.e., the flow of 456 cfs and 36 passes per day). During the times when the design rate would not be met, Florida Power would cause a further reduction in lock rate of 4.4 percent at a consumption rate of 20 cfs and 6.6 percent at a rate of 30 cfs.

During the worst month (April, year 1), the amount of water used by Florida Power (at 30 cfs) would almost equal the amount remaining for lockage. At 20 cfs, this amount would be about one-half of the quantity of water remaining for lockage.

Table V-2. Projected Lockage Rates During Drought of Equal Magnitude to the One Which Occurred During 1956-1957 (at 2035 Consumption Rates)

Month	Water Year 1				Water Year 2			
	Runoff* cfs	Lockage with FPC† % @ 20 cfs	Lockage with FPC† % @ 30 cfs	Lockage Without FPC† %	Runoff* cfs	Lockage with FPC† $ @ 20 cfs	Lockage with FPC† % @ 30 cfs	Lockage Without FPC† %
Oct	1580	100.0	100.0	100.0	1213	100.0	100.0	100.0
Nov	1095	100.0	100.0	100.0	1406	100.0	100.0	100.0
Dec	939	100.0	100.0	100.0	963	100.0	100.0	100.0
Jan	748	82.9	80.7	87.3	599	50.2	48.0	54.6
Feb	1039	100.0	100.0	100.0	781	90.1	87.9	94.5
Mar	559	41.4	39.3	45.8	526	34.2	32.0	38.6
Apr	413	9.4	6.6	13.8	551	39.7	37.5	44.1
May	557	41.0	38.8	45.4	849	100.0	100.0	100.0
Jun	578	45.6	43.4	50.0	1119	100.0	100.0	100.0
Jul	621	55.0	52.9	59.4	1062	100.0	100.0	100.0
Aug	429	12.9	10.7	17.3	1514	100.0	100.0	100.0
Sept	854	100.0	100.0	100.0	2092	100.0	100.0	100.0

* Outflow from Lake Rousseau through Inglis Dam (no lockage).
† As percentage of design rate (36 passes per day) when flow of 350 cfs are allocated to Withlacoochee and 456 cfs flow through Inglis Locks.

Source: Meta Systems, 1976.
Environmental Science and Engineering, Inc., 1978.

VI. UNAVOIDABLE ADVERSE ENVIRONMENTAL IMPACTS

HYDROLOGICAL IMPACTS

WITHOUT CANAL

The only possible adverse impact, which is a drawdown of 4.5 percent in the lake volume, can be avoided by a prudent combination of a small relaxation (less than 3 percent) of minimum flow requirements coupled with some drawdown during the most critical months of a very severe drought.

WITH CANAL

A reduction of 4.4 percent (from design rate) in barge canal lockage rate (as discussed in Chapter V) is unavoidable during the worst months of a severe drought. This reduction will be 6.6 percent if a peak consumption rate of 30 cfs is maintained by Florida Power. The reason that an adverse impact upon the barge canal lockage rates is unavoidable during a severe drought is that 350 cfs is allocated to the lower Withlacoochee, and this flow will have to be maintained under any circumstances.

BIOLOGICAL

Information on unavoidable adverse environmental impacts is contained in Chapters III, IV, and V.

VII. METHODOLOGY, LITERATURE AND OTHER TECHNIQUES

WATER RESOURCES, PHYSICAL SYSTEMS

HYDROLOGY

HYDROLOGIC BUDGET

The storage volume of Lake Rousseau has been determined by field mapping of the lake (see pocket map). Aerial photographs with a scale of 1 inch = 200 feet were taken of the lake between Dunnellon and the Inglis Dam and Lock in December, 1977. These large-scale photographs allowed identification of individual partially drowned trees in the lake. During field mapping these numerous trees were used as horizontal control points. The high resolution of the photographs also allowed accurate delineations of marsh areas and the shoreline. The water surface elevation of Lake Rousseau is maintained at +8.4 meters msl (+27.5 feet msl) by the Army Corps of Engineers. All depths were drawn on that datum. Water depths were recorded along bathymetric transects by using a Raytheon DE-179 surveying fathometer.

Heavy aquatic weed growth, stumps, and logs cover all but the deep channel areas of Lake Rousseau. Due to the poor navigability of the lake, an airboat was used for profiling. Bottom layers of heavy suspended solids (floc or fluff) cover most of the lake bottom. The floc layer ranges from 0.15 meters to 1.2 meters (6 inches to 4 feet) in thickness. True depth measurements (hard bottom) were taken by increasing the fathometer sensitivity to record three distinct traces: depth to the top of hydrilla, depth to the top of the floc layer, and depth to the true bottom. The true depth was used for storage volume computations. Marshy areas could not be mapped. Numerous probings through marsh areas (floating mats of grasses, hyacinths, and other plant mats) showed variable depths of .3 to 2.1 meters (1 to 7 feet). Since the marsh areas could not be mapped, and the water depths below them are variable, they were not included in volume computations.

Historical discharge data used for hydrologic computations were compiled from United States Geological Survey Reports, Water Resource Data for Florida, Part 1, Surface Water Records. Hydrologic investigations of Lake Rousseau by the USGS, water supply studies completed for the Army Corps of Engineers, and reports submitted by the Corps during the barge canal assessments have all been used to aid in formulating this hydrologic interpretation of Lake Rousseau.

Determination of Available Water From Lake Roussseau

Monthly available water ($AW_{m,n}$) for the period 1932 to 1975 was calculated from the water budget equation:

$$AW_{m,n} = (I_{m,n} + P_{m,n} + G) - (O_m + E_m + S) \quad (1)$$

where m = month (October, November, ..., August, September)

n = water year (1932, 1933, ..., 1974, 1975)

$I_{m,n}$ = monthly water inflow to Lake Rousseau from Rainbow Springs plus Withlacoochee River for the water years 1932 to 1975

$P_{m,n}$ = monthly precipitation in the Inverness area for the water years 1932 to 1975 (cfs) applied to area of Lake Rousseau

G = monthly groundwater infiltration rate (cfs)

O_m = monthly minimum flow requirement (cfs)

E_m = monthly evaporation rate from northern lakes (cfs) applied to area of Lake Rousseau

S = monthly seepage rate to groundwater system (cfs)

Calculation of $I_{m,n}$

In Chapter II, Table II-9, a 44 x 12 matrix of monthly inflow data over the period from 1932 to 1975, shows contributions from Rainbow Springs as well as the Withlacoochee River.

Calculation of $P_{m,n}$

Precipitation data from the Inverness area during the period 1932 to 1975 was utilized. The number of inches per month over the lake area was converted to give the following monthly precipitation contributions in cfs:

$$P_{m,n} = \text{ppt. as } \frac{\text{in}}{\text{mon}} \times \frac{\text{ft}}{12 \text{ inches}} \times 2{,}889 \text{ acres} \times \frac{43{,}560 \text{ ft}^3}{\text{acre-ft}} \times \frac{\text{month}}{30 \text{ days}} \times \frac{\text{day}}{24 \text{ hr}} \times \frac{\text{hr}}{60 \text{ min}} \times \frac{\text{min}}{60 \text{ sec}} \quad (2)$$

$$= 4.05 \frac{\text{cfs-month}}{\text{in}} \times \text{ppt. as } \frac{\text{in}}{\text{mon}}$$

Table VII-1 presents the resulting 44 x 12 matrix of $P_{m,n}$.

Calculation of O_m

The quantity O_m was calculated in accordance with the minimum flow requirements of the Southwest Florida Water Management District (SWFWMD) Rules and Regulations, Section 16J-0.15.

For each month, the five lowest monthly mean inflows for the 20-year period (1956 to 1975) were averaged. These calculations are summarized in Table VII-2.

Minimum flow requirements were calculated as 70 percent of the inflow values for the four wettest months, and 90 percent of these values for the remaining eight months. The resulting data vector is presented in Table VII-3.

Calculation of E_m

Values for E_m were obtained from average monthly evaporation data calculated for southern lakes in the United States. The data vector for

Table VII-1. Matrix of Contribution of Rainfall to Hydrologic Budget of Lake Rousseau (cfs) Data from Inverness

Year	October	November	December	January	February	March	April	May	June	July	August	September
1932	11.7	6.5	9.7	1.7	6.3	19.2	2.3	16.8	34.5	13.0	34.1	9.1
1933	7.2	15.9	0.6	7.2	12.8	19.1	27.7	5.5	11.1	70.1	27.7	61.7
1934	3.2	2.2	3.4	4.1	11.8	7.7	20.0	47.2	57.4	36.5	36.0	10.7
1935	27.9	1.4	1.2	5.3	11.8	1.8	13.5	10.9	26.6	41.6	27.7	35.5
1936	1.7	1.3	10.7	21.9	27.4	27.9	19.0	12.4	29.5	38.6	28.0	16.7
1937	24.1	5.4	10.9	5.6	22.4	17.3	20.5	12.9	41.6	33.3	64.4	26.7
1938	18.2	21.4	2.9	4.2	13.5	8.9	2.4	15.1	50.6	40.1	12.2	38.8
1939	17.1	2.7	1.9	5.2	6.7	5.9	18.7	23.9	40.1	56.9	45.6	23.2
1940	2.0	5.4	6.8	11.8	15.5	12.4	10.7	0.8	36.9	48.7	13.5	28.7
1941	0.0	0.9	18.3	14.1	18.9	12.3	23.2	2.7	32.4	26.5	37.3	26.7
1942	11.7	18.2	17.1	17.5	11.2	24.4	2.1	15.1	56.1	31.1	24.1	24.2
1943	0.9	0.7	10.8	1.0	6.3	20.5	6.3	19.2	28.1	65.0	46.9	30.5
1944	2.4	2.3	2.3	11.1	5.2	29.2	7.9	10.1	16.6	37.1	48.8	18.3
1945	34.1	3.0	1.8	14.1	0.6	2.3	3.9	3.4	49.4	51.1	59.3	27.8
1946	9.8	1.2	20.9	15.5	36.0	15.2	8.2	34.5	33.5	42.5	26.2	30.6
1947	17.1	1.5	0.5	3.0	24.5	25.0	16.3	8.5	15.9	33.1	57.3	31.1
1948	23.1	10.0	5.6	27.3	4.7	4.7	10.3	11.9	24.9	33.2	40.4	24.7
1949	18.3	13.1	7.5	3.1	4.8	6.3	32.5	3.0	29.2	39.5	67.6	19.0
1950	12.3	4.3	1.4	0.1	3.1	13.5	10.8	9.9	29.8	33.9	11.3	67.0
1951	18.3	1.5	15.8	2.1	6.1	12.7	15.4	4.1	30.8	22.9	23.2	28.8
1952	11.7	28.3	12.5	2.6	41.2	21.7	6.4	29.4	19.5	10.6	28.6	18.8
1953	16.9	1.6	5.7	10.1	13.0	15.6	31.9	7.7	31.8	46.4	64.3	31.3
1954	15.1	14.6	31.6	6.6	10.2	10.9	6.3	21.1	11.1	34.7	46.0	7.0
1955	8.4	6.3	10.7	11.2	10.6	10.0	3.3	5.4	30.8	39.0	19.0	32.4

Table VII-1. Matrix of Contribution of Rainfall to Hydrologic Budget of Lake Rousseau (cfs) Data from Inverness (continued)

Year	October	November	December	January	February	March	April	May	June	July	August	September
1956	9.4	1.9	3.8	8.5	4.0	0.0	12.8	14.6	28.9	24.2	19.6	9.9
1957	23.1	1.1	1.1	2.7	9.2	21.0	9.3	25.9	22.9	36.3	38.6	29.6
1958	4.2	3.0	6.4	25.8	14.0	32.6	17.7	11.8	17.4	30.1	40.1	11.5
1959	42.9	5.2	15.1	15.0	7.4	40.3	20.9	42.9	26.8	32.9	43.4	20.9
1960	22.4	5.6	7.2	7.0	26.1	64.8	12.6	8.2	48.8	31.9	58.3	61.7
1961	23.0	1.7	9.2	9.0	9.3	3.1	9.4	9.8	22.1	65.6	31.0	3.1
1962	0.1	13.8	9.9	7.0	9.4	10.4	5.5	8.9	41.9	39.9	29.3	30.8
1963	4.0	6.9	6.4	26.2	19.9	6.6	4.1	24.9	17.4	7.2	44.6	35.9
1964	0.8	12.1	12.4	24.1	22.0	33.1	9.5	11.1	12.7	32.8	59.6	48.3
1965	6.4	1.5	17.2	8.1	15.4	12.0	11.7	1.6	48.8	52.5	51.9	24.8
1966	7.4	4.8	10.1	13.5	15.2	3.4	18.7	21.1	26.9	35.1	34.2	34.3
1967	6.0	1.5	4.5	10.2	19.2	2.7	0.0	5.3	40.4	45.6	38.9	4.9
1968	2.5	1.0	10.1	6.1	10.2	12.3	3.0	16.4	32.5	50.3	43.1	11.8
1969	18.4	10.5	4.0	10.2	13.8	27.5	4.7	16.2	19.0	44.7	25.9	27.7
1970	18.6	6.8	21.4	16.0	21.7	15.8	8.3	18.3	24.4	53.3	18.5	13.2
1971	13.0	4.3	4.4	12.6	22.5	9.0	13.3	9.0	32.7	41.3	24.2	31.1
1972	19.9	4.8	4.8	9.6	17.6	26.4	5.3	23.6	20.0	35.4	15.0	5.1
1973	7.9	25.2	21.2	16.7	9.9	24.1	9.5	10.8	29.7	18.2	38.9	36.8
1974	2.8	5.3	25.8	1.1	9.5	15.3	1.3	10.7	70.6	38.2	21.1	16.9
1975	0.0	1.6	8.4	8.5	11.1	5.9	10.9	27.0	18.5	40.7	33.8	30.8

Sources: National Climatic Center, Volumes 6-79, 1932-1978.
Environmental Science and Engineering, Inc., 1978.

Table VII-2. Average Monthly Minimum Inflows to Lake Rousseau during the Period 1956-1975

m	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
$I_{min(ave)(cfs)}$	1018	1002	912	877	816	864	959	1056	1215	1268	1167	1071

Wet Months----------

Table VII-3. Monthly Minimum Outflow Requirements from Lake Rousseau

m	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
$O_{m(cfs)}$	916	902	821	789	735	778	863	950	851	887	817	750

Table VII-4. Average Monthly Evaporation Rate from Lake Rousseau

m	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
$E_{m(cfs)}$	8.1	12.1	14.2	18.2	24.3	23.1	21.0	19.4	16.6	16.2	11.7	10.1

Source: Environmental Science and Engineering, Inc., 1978.

evaporation is presented in Table VII-4. The same conversion factors were employed as in the $P_{m,n}$ calculation.

Calculation of G and S

Infiltration and seepage data for Lake Rousseau are very unreliable or are unknown. The potentiometric surface of the Floridan Aquifer in the vicinity of Lake Rousseau is shown in Figures VII-1 and VII-2. The heights of the surface near the lake are nearly equal to the pool level. Effects of the dam and the barge canal are evident in the contours. Based upon the near equality of the inflows and outflows of Lake Rousseau, it can be assumed that the net water transport between infiltration and seepage is relatively small.

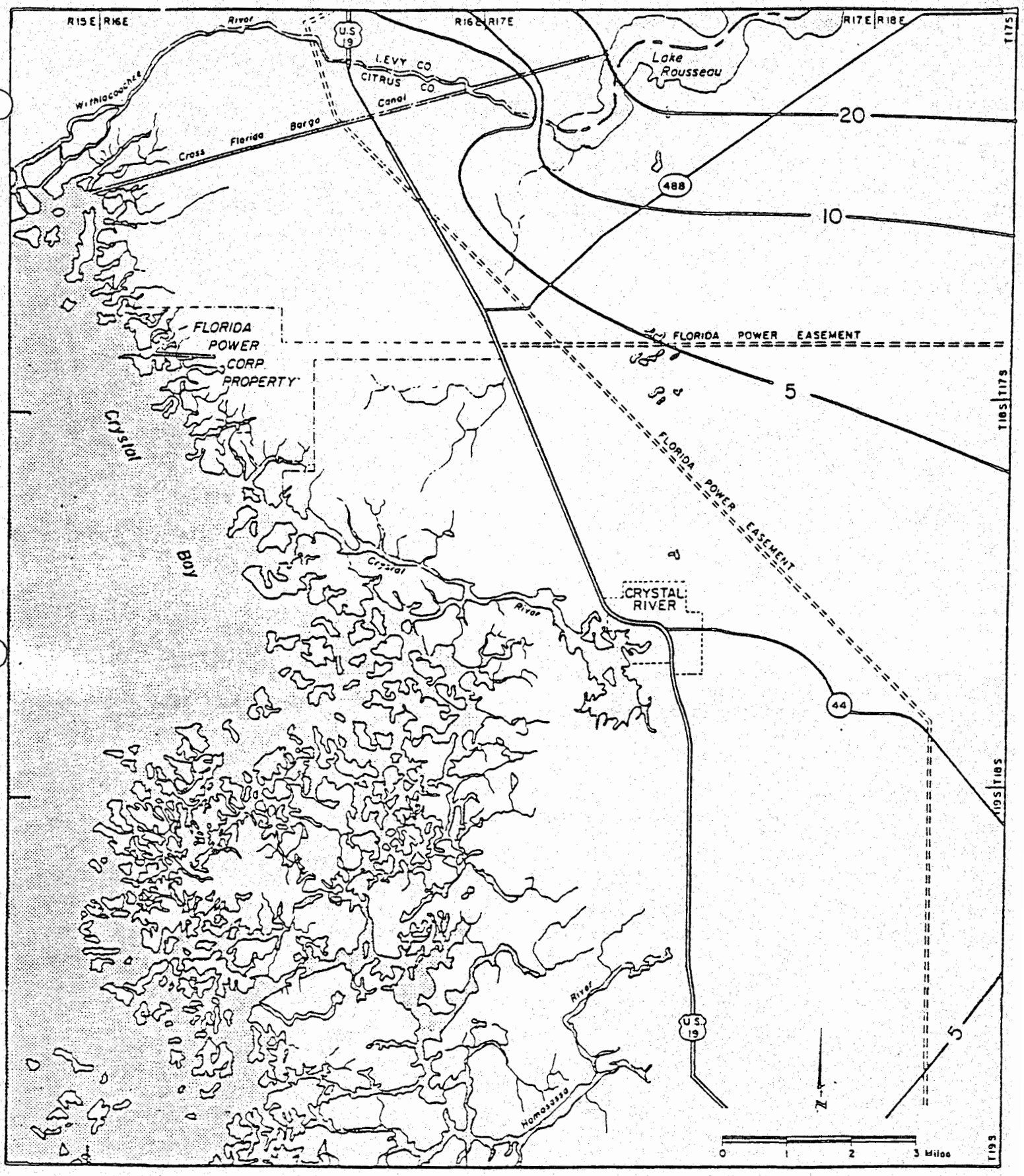
Calculation of $AW_{m,n}$

The available water during the period 1932 to 1975 was calculated in accordance with equation (1). The matrices $I_{m,n}$ and $P_{m,n}$ were summed; the vectors O_m and E_m were subtracted from each row of the resulting matrix. Table II-9 in Chapter II, Hydrologic Budget section, the final matrix $AW_{m,n}$, represents the amount of water available for usage during the period 1932 to 1975.

LAKE CIRCULATION AND SUSPENDED SOLIDS STUDIES

Synchronous water level monitoring, wind speed and direction recordings, fluorescent dye tracing, and suspended solids sampling were employed during various wind conditions in order to understand the movement of water in Lake Rousseau and to identify the natural resuspension of lake flocculent (fluff) layers.

Water levels were monitored at two stations during the studies; near the Inglis Dam and at a privately owned dock approximately 0.6 kilometer

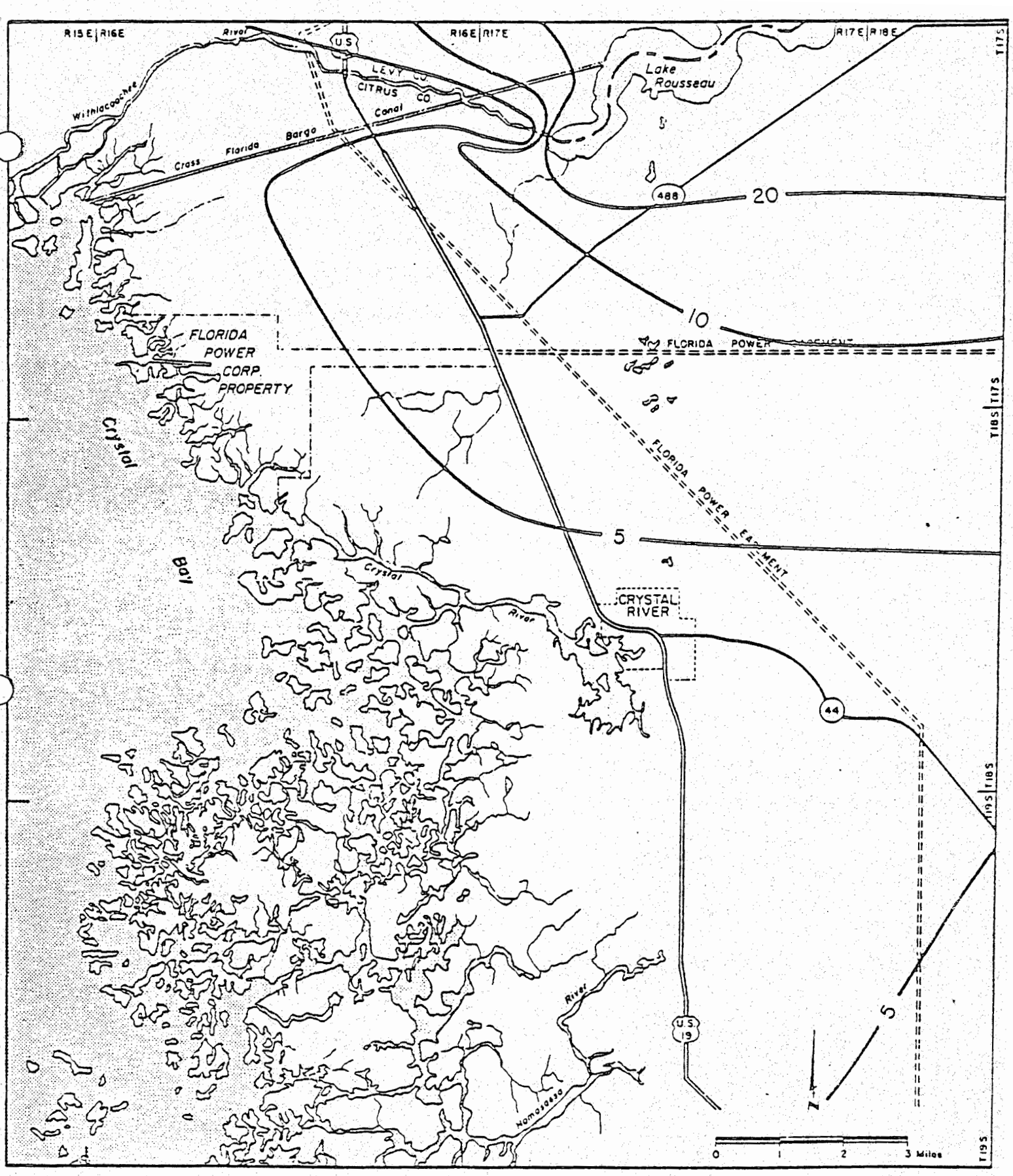


—10— LINE OF EQUAL ELEVATION, IN FEET, MEAN SEA LEVEL

SOURCE: GERAGHTY AND MILLER, INC., 1977

FIGURE VII-1

ELEVATION OF THE POTENTIOMETRIC SURFACE OF THE UPPER FLORIDAN AQUIFER, MAY, 1975



—10— LINE OF EQUAL ELEVATION, IN FEET, MEAN SEA LEVEL

SOURCE: GERAGHTY AND MILLER, INC., 1977

FIGURE VII-2

ELEVATION OF THE POTENTIOMETRIC SURFACE OF THE UPPER FLORIDAN AQUIFER, SEPTEMBER, 1975

(1 mile) upstream. The monitoring stations were constructed of 15-centimeter (6-inch) PVC pipe capped on the bottom ends to form water stilling wells. A 1.6-centimeter (5/8-inch) orifice was drilled near each end cap. Leupold-Stevens Type F level recorders with 0.3-meter (1-foot) range gears were housed atop the stilling wells.

Wind speeds and directions were continuously recorded during the studies at the Inglis Lock by using a Climet portable meteorological tower. The data was reduced to hourly values and converted to wind roses and tabulated for inspection.

Rhodamine WT fluorescent dye (a xanthene dye) was used as a tracer. The specific gravity of the dye was adjusted with methyl alcohol to match an average specific gravity of the lake water. With the use of a circulating pumping system, lake bottom waters were pumped aboard a small boat, dye was injected into the water, and the water was immediately returned to the bottom. Quantities of dye mixtures, injected as patches, varied between 2.3 and 4.5 liters (1/2 and 1 gallon). Once dye was injected it was tracked at 24-hour intervals by using a Turner Designs Field Fluorometer equipped with a submersible pump. Background fluorescence of the lake water was measured prior to dye injections so that only the dye was tracked. Sampling locations were accurately located by using an aerial photograph with a scale of 1 inch = 200 feet. Partially submerged drowned trees on the lake were readily identified in the photograph and were used as station markers. Dye concentration isopleths were drawn for each day of field data obtained.

During dye measurements, water samples were collected for suspended solids analyses. These samples were obtained from bottom floc layers and at .3-meter (1-foot) intervals above the floc by using the submersible pump attached to the fluorometer. Data collection was streamlined by using the same sampling station locations for dye and suspended solids studies and collecting wind data.

LAKE SEDIMENTOLOGY

At each of the 10 core sites, PVC coring pipe was driven into the sediment to the limit of penetration. The end of the pipe was sealed to prevent any loss of material, and the core was withdrawn from the substrate. The ends of the core were then sealed and the core was labeled to indicate station, water depth, and depth of penetration. Core samples were carefully split, measured, and described in the laboratory. Sample fractions 1.25 centimeters (.492 inches) wide spaced 2.5 centimeters (.98 inches) apart were removed from cores 1, 2, and 10, and analyzed for percent volatile solids. Fractions were weighed, dried at 120°C for 12 hours, reweighed, baked at 625°C for 1 hour, and reweighed. Percentages were determined by using the equation $\frac{DW - BW}{DW}(100) = PVS$ where DW is the dried weight of the fraction, BW is the baked weight of the fraction, and PVS is the percent volatile solids. The level at which values began to stabilize was considered to be the pre-flood surface.

Fractions for cesium testing were collected in a manner similar to that used for volatile solids, with each fraction being 1.25 centimeters (.492 inches) wide and spaced at 2.5 centimeters (.98 inches) intervals. Each fraction was homogenized, weighed, and sealed in a petri dish. Individual fractions were then placed in a gamma-ray spectrometer, and counts were made for 7,000 seconds. These, in turn, were converted to disintegration per minute (dpm) per gram of sample by using the following equation: $\frac{\frac{cts}{sec}(60) - Bkg}{eff.} \frac{1}{wt} = \frac{dpm}{g}$ where cts is the actual count made on the sample, sec is the number of seconds the sample was counted (7,000 seconds), Bkg is the predetermined background radiation present (determined for this study to be 0.8095 counts per minute), eff is the efficiency coefficient for cesium in terms of counts per minute per disintegration per minute (.0031 $\frac{cpm}{dpm}$), and wt is the actual weight (g) of the sample.

WATER CHEMISTRY

Lake Rousseau was sampled bi-monthly (October, December, and February) at four stations. Grab samples taken from the bottom and from mid-depth by using a Van Dorn sampler were returned to the ESE laboratory for analysis. Parameters and analytical methodologies are given in Table VII-5.

In addition, vertical profiles were performed of the *in situ* measurements listed in Table VII-6. All methodologies and holding times for water samples listed in EPA publications and *Standard Methods for the Analysis of Water and Wastewater* were used.

Table VII-5. Chemical Analysis of Water Samples

Parameter	Method	Reference
Ammonia	NH_3 selective ion probe	EPA, 1974
Total Kjeldahl Nitrogen	Kjeldahl digestion automated phenate method	EPA, 1974
Nitrate and nitrite	Automated Cd reduction method	EPA, 1974
Dissolved orthophosphate	0.45 um filtration, automated ascorbic acid method	EPA, 1974
Total phosphorus	Automated ascorbic acid method	EPA, 1974
Alkalinity	Titrimetric method	EPA, 1974
Color	Platinum Cobalt method	EPA, 1974
Turbidity	Nephelometer	EPA, 1974
Suspended solids	Gravimetric	EPA, 1974
Dissolved solids	Calculation	EPA, 1974
Total solids	Gravimetric	EPA, 1974
Biochemical oxygen demand	DO probe	EPA, 1974
Hardness	Titrimetric	EPA, 1974
Chloride	Titrimetric	EPA, 1974
Total organic carbon	Beckman TC Analyzer	EPA, 1974
Sulfate	Turbidimetric	EPA, 1974
Calcium	Atomic absorption direct aspiration	EPA, 1974
Iron	Atomic absorption, direct aspiration	EPA, 1974
Manganese	Atomic absorption, direct aspiration	EPA, 1974

Source: Environmental Protection Agency, 1974.

Table VII-6. *In situ* Analysis of Water

Parameter	Method	Reference
Temperature	Thermistor	EPA, 1974
pH	Hydrogen ion electrode	EPA, 1974
Dissolved oxygen	DO probe	EPA, 1974
Salinity	Electrical conductivity method	APHA, 1975

Source: Environmental Protection Agency, 1974.
American Public Health Association, 1975.

WATER RESOURCES, BIOLOGICAL SYSTEMS

PHYSICAL PARAMETERS

Four stations (see Figure VII-3) were established to evaluate the biological, chemical, and physical characteristics in the detailed study area of Lake Rousseau.

Station 1, the shallowest station sampled [depth of 4 meters (13 feet)], was located near the southwest shore and closest to Inglis Dam. Station 2 [in 10 meters (33 feet) of water] was in the drowned Withlacoochee River channel near a potential intake structure site. Station 3, also located in the Withlacoochee River Channel [in approximately 12 meters (39 feet) of water], is considered a possible site for the intake structure. This station was established in the deepest part of the detailed study area. Station 4 was the easternmost station sampled [water depth of approximately 8 meters (26 feet)] and was closest to the barge canal.

Among the physical parameters monitored bimonthly are dissolved oxygen, water temperature, air temperature, pH, conductivity, wind direction and velocity, solar insolation, and light penetration through the water column. Depths at which the parameters were measured, and the associated biotic data collected, are given in Table VII-7.

Two methods of dissolved oxygen determination, iodometric titration and electrometric, were utilized in this study. Dissolved oxygen was determined for duplicate water samples by the Azide Modification of the Winkler Iodometric technique (American Public Health Association, 1975). Due to the number of samples taken and a need for compactness, a mini-Winkler kit described by Smith (1976) was used. This kit utilizes 125-milliliter sample bottles rather than standard 300-milliliter bottles. Surface samples were collected by siphoning from a bucket, while samples from depth were taken with a Kemmerer or Van-Dorn sampler. Care was taken to minimize turbulence, and bottles were rinsed on site

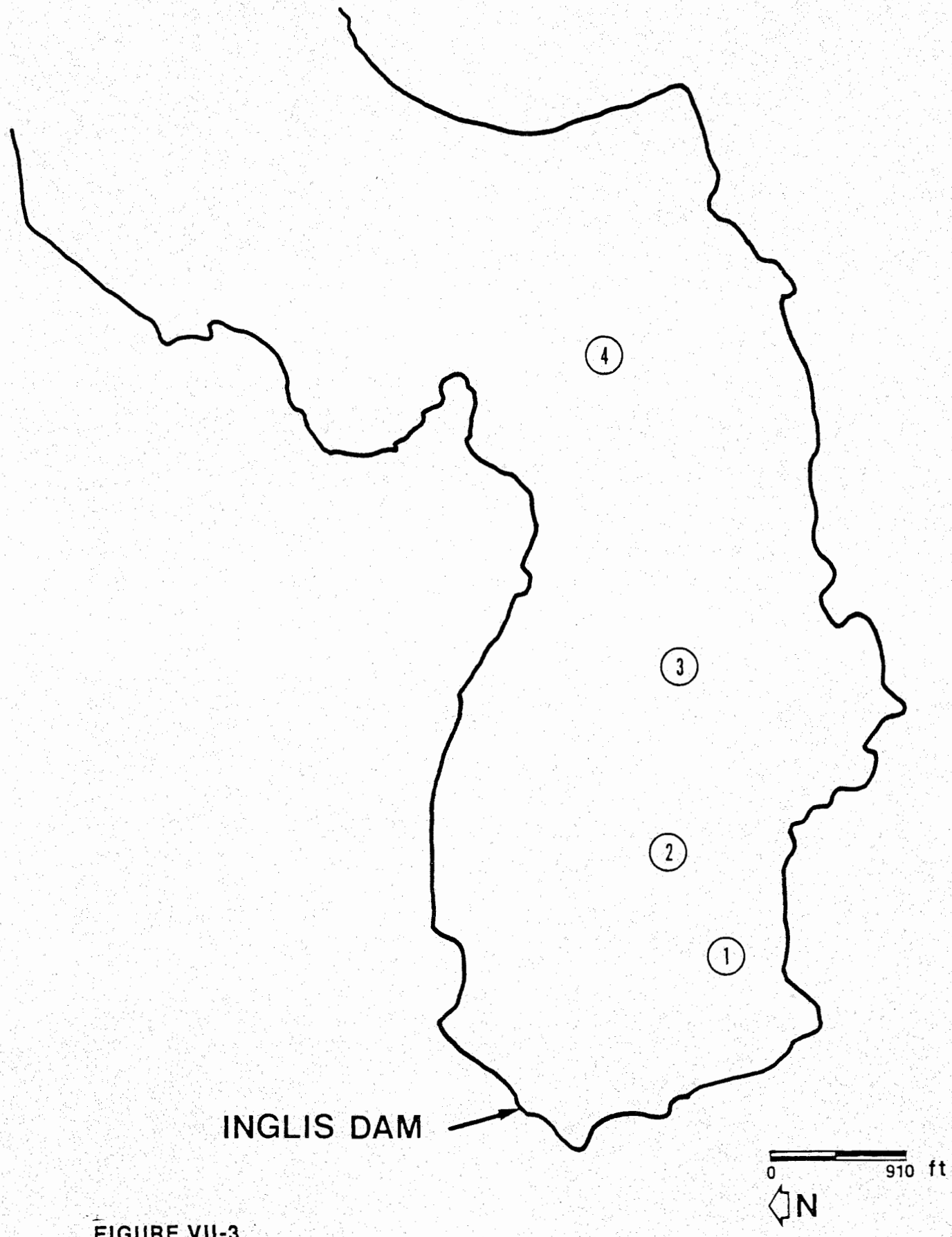


FIGURE VII-3
LOCATION OF BIOLOGICAL SAMPLING STATIONS ON LAKE ROUSSEAU

Table VII-7. Lake Rousseau Sampling Depths

Sampling Depths (Meters) for Vertical Profiles and Pump Sampling

Station 1	Station 2	Station 3	Station 4
1	1	1	1
2*	3*	4**	3*
3*	7	8	6
--	10*	12**	8*

* Depths for chemistry sampling.
** Depths for chemistry sampling and model intake sampling.

NOTE: Additional samples were taken at the surface of each station for dusk and dawn Winkler dissolved oxygen determinations.

"Light-Dark Bottle" Suspension and Incubation Depths (Meters)

Station 1	Station 2	Station 3	Station 4
0	0	0	0
1.5	2	2	3
3.0	4	4	6
---	6	8	8

Source: Environmental Science and Engineering, Inc., 1977.

and flushed two to three times. Samples were fixed in the field with 0.5 milliliters each of manganous sulfate and alkali-azide-iodide reagent. Following acidification with 0.5 milliliter of concentrated sulfuric acid at the field lab, 100-milliliter subsamples were titrated with 0.0125 N sodium thiosulfate using soluble starch as an endpoint indicator. Titrating with this normality thiosulfate allows an almost direct reading of milliliters of titrant as milligrams per liter (ppm) dissolved oxygen.

Oxygen determinations were also made by membrane electrode (Yellow Springs Instruments Model 57). The use of the oxygen probe facilitated vertical profiles of dissolved oxygen concentration, provided comparative data on the two techniques, and served as a basis for comparison with other studies utilizing membrane electrodes.

Water temperature measurements were made by using the thermistor thermometer built into the Y.S.I. dissolved oxygen probe. Conductivity was determined with a Beckman RS5-3 portable salinometer or a Yellow Springs Instrument Model 33 S-C-T meter. For pH determinations, a Beckman, Orion, or Leeds Northrup portable pH meter was used.

Air temperatures were measured with a laboratory thermometer, and wind velocities were monitored with a Dwyer W-1 hand-held wind gauge.

Solar insolation during study periods was recorded in langleys by a Leeds-Northrup (Speedomax H) mechanical pyranometer. The penetration of incident solar radiation through the water column was determined from Secchi disc observations. Light extinction coefficients were calculated from Secchi disc data via the formula of Poole and Atkins (1929):

$$K = 1.7/d$$

where: d = depth at which the disc disappeared (meters), and

K = light extinction coefficient (meters^{-1})

These light extinction coefficients were periodically checked against those obtained from measurements made with a Montedoro submersible photometer.

BIOLOGICAL PARAMETERS

PHYTOPLANKTON

Photosynthetic Pigments

Chlorophyll a was used in this study as an estimator of algal standing stock. This pigment is an essential part of the photosynthetic machinery and constitutes approximately 1 to 2 percent of the dry weight of organic material in all planktonic algae (American Public Health Association, 1975).

Samples for pigment analyses were collected once during the day and once at night in conjunction with zooplankton pump sampling. Collections were made in 1-liter volumes from each pump sampling depth at each station (see Table VII-4). In the field, lab samples were passed through 0.45 u Millipore filters and the filters stored in the dark on dry ice prior to being transported to the ESE laboratory where they were stored (14-day maximum) at -17°C. The pigments were extracted into 10 milliliters of 90 percent acetone and steeped overnight in the dark. The absorbance of the pigment extracts was then measured in a 4-centimeter cuvette on a Beckman DB Spectrophotometer in accordance with the trichromatic procedure described by the Environmental Protection Agency (1973). Chlorophyll a was measured at 663 nanometers, chlorophyll b at 645 nanometers, and chlorophyll c at 630 nanometers. The measurement at 750 nanometers was used as a turbidity correction for all pigment analyses. Extract chlorophyll levels were determined by inserting the absorbance measurements into the following equations (United National Education, Scientific, and Cultural Organization, 1966):

$$Ca = 11.64D_{663} - 2.16D_{645} + 0.10D_{630}$$
$$Cb = -3.94D_{663} + 20.97D_{645} - 3.66D_{630}$$
$$Cc = -5.53D_{663} - 14.81D_{645} + 54.22D_{630}$$

where Ca, Cb, and Cc are the concentrations (mg/l) of chlorophylls a, b, and c, respectively, in the extract; and D_{663}, D_{645}, and D_{630} are

the 1-centimeter OD's (absorbances) at the respective wavelengths after subtracting the 750 nm blank. Final values of Ca, Cb, and Cc are divided by four to adjust for the 4-centimeter path length used.

The concentration of pigment in the original water sample expressed in mg/m^3, is calculated as follows:

$$\text{mg chlorophyll } \underline{a}/m^3 = \frac{\text{Ca x volume of extract (liters)}}{\text{Volume of sample } (m^3)}$$

Because chlorophyll degradation products may interfere with chlorophyll determinations, phaeopigments were estimated and a corrected chlorophyll a value calculated by following the recommended procedures of the Environmental Protection Agency (1973). After the trichromatic absorbance readings, two drops of dilute hydrochloric acid were added to the cuvette and the absorbance was again read at 663 nanometers and 750 nanometers. Each 750-nanometer reading was then subtracted from the corresponding 663-nanometer reading and the concentrations of phaeophytin-corrected chlorophyll a and phaeopigments calculated from the following formulae:

$$\text{chlorophyll } \underline{a} \ (mg/m^3) = \frac{26.7\ (663b - 663a) \times E}{V \times L}$$

$$\text{phaeopigments } (mg/m^3) = \frac{26.7\ (1.7 \times 663a - 663b) \times E}{V \times L}$$

where 663b is the 1-centimeter corrected OD_{663} before acidification; 663a is the OD_{663} after acidification; E the volume of acetone used for the extraction (ml); V the volume of water filtered (liters); and L the path length of the cuvette (cm).

Phytoplankton Concentration and Composition

Phytoplankton samples were collected from each of the pump sampling depths at each station. The one-liter samples were preserved in a solution of 5 percent (volume/volume) formalin neutralized to pH 7.8 with sodium tetraborate. In the laboratory, aliquots of equal volume

from each depth at each station were mixed. Composite samples prepared in this manner for each station were then analyzed, with portions of each of the original sample being kept for reference.

The Utermohl technique (Lund, et al., 1958) utilizing the inverted microscope and sedimentation chambers was used for organism counts and identifications. The use of the inverted scope, which enables plankton to be settled and examined directly in the Utermohl sedimentation chamber, minimizes the necessary working distance and results in greater resolution and facilities taxonomic work. By minimizing sample manipulation, this technique also allows the enumeration of both nannoplankton and macroplankton without biasing counts against the more fragile forms (Lund, et al., 1958; United States Geological Survey, 1973).

Ten-milliliter aliquots were settled. Counts and most identifications were made at a magnification of 400. Counts were converted to cells per milliliter. A minimum of 100 cells were counted from each sample. This procedure yields an accuracy of approximately ± 20 percent at the 95 percent confidence interval (Lund, et al., 1958). Among the principal taxonomic references used for phytoplankton identification were Eddy (1930), Pascher (1913), Patrick and Reimer (1966), Smith (1924, 1926), Van Heurck (1890), and Weber (1971).

Plankton Metabolism

The metabolism of the plankton community was estimated by the light- and dark-bottle technique (United States Geological Survey, 1973; American Public Health Association, 1975). In this method samples are isolated in standard 300-milliliter BOD bottles and incubated in situ. Clear (light) and covered (dark) bottles are suspended at various depths in the water column and the concentration of dissolved oxygen in the bottles measured at the beginning and end of the incubation period. Increases in dissolved oxygen in the light bottles result from the photosynthetic oxygen production of entrained plants (phytoplankton) and yield an estimate of "net production" over the incubation period. "Respiration" is reflected over the incubation period by dissolved oxygen

decreases in the bottles which have been covered to exclude light. In the absence of light only respiration takes place, since light is not available for photosynthesis. Together "net production" and "respiration" rates may be used to estimate "gross planktonic production."

The incubation period used on bimonthly surveys was 24 hours. Dark bottles were prepared by covering BOD bottles with a layer of black electrical tape and a second layer of silver duct tape. Bottle tops were covered with a double layer of aluminum foil during incubation. Light bottles, dark bottles, and initial bottles (taken to establish initial dissolved oxygen concentrations) were filled in duplicate from each of the sampling depths. Initial bottles were then fixed for the determination of dissolved oxygen while light and dark bottles were suspended and incubated at the depth from which they were filled. Following incubation, light and dark bottles were also fixed for dissolved oxygen determination. The Azide Modification of the Winkler Iodometric technique was used for all oxygen measurements. The following formulae were used in calculations:

Gross primary productivity (g O_2/m^3/time) = (LB - DB)/t

Net primary productivity (g O_2/m^3/time) = (LB - IB)/t

Respiration (g O_2/m^3/time) = (IB - DB)/t

where:

LB is the dissolved oxygen concentration in g/m^3 (mg/l at specific gravity of 1.0) in the light bottle after incubation;

DB is the dissolved oxygen concentration in g/m^3 in the dark bottle after incubation;

IB is the initial dissolved oxygen concentration in g/m^3 prior to incubation; and

t is the incubation period.

ZOOPLANKTON

<u>High Velocity Pump Sampling</u>

Duplicate zooplankton samples were collected from each sampling depth at each station by using a three horsepower centrifugal pump. At maximum

throttle, the speed used for sampling, the flow rate through the 5-centimeter (2-inch) diameter intake hose was approximately 290 liters/second (77 gallons/second). The intake hose was fitted with a coarse screen and horizontal baffle which prevented direct vertical draw and allowed sampling at a discrete depth. Pump discharge was passed through a #10 (153 micron pore size) plankton net. Uniform sample volumes were collected by maintaining a constant pumping rate for a fixed period of time. In October, approximately 868 liters (229 gallons) of water were strained in this manner for each sample. Preliminary analyses of these samples indicated that smaller volumes would be sufficient, and on subsequent sampling dates approximately 578 liters (153 gallons) were strained. Following collection, nets were rinsed and the samples transferred to one-liter containers and preserved in a solution of 4 to 5 percent (volume/volume) formalin neutralized to pH 7.8 with sodium tetraborate.

Model Intake Structure Sampling

A model intake structure was used to simulate flow conditions of the proposed cooling tower intake structures and aid in the evaluation of entrainment effects on Lake Rousseau's zooplankton community. Samples were collected by using the previously described pump assembly with the addition of a 25-centimeter (10-inch) diameter PVC pipe which was attached to the end of the intake hose. With this attachment, the intake velocity of the pump apparatus approximated that projected for the proposed intake structure, 15.2 centimeters (0.5 feet) per second.

Using this model intake structure, duplicate samples were collected at two depths, 4 meters and 12 meters (13 feet and 39 feet), at Station 3. Samples were collected and preserved in the same manner as those collected in "high velocity pump sampling" described above.

Analysis

In the laboratory, aliquots used for counting were obtained by using a Folsom plankton splitter. Organisms were enumerated and identified under a dissecting microscope. Between one hundred and five hundred organisms were identified from each sample. Among the major taxonomic references used were Ward and Whipple (1959), Gosner (1971), and Wilson (1932).

To obtain dry weights, each sample was washed in tap water, filtered onto a preweighed filter, and placed in a tared crucible. Samples were then dried to a constant weight (60 to 80°C) and weighed on a micro-analytical balance. After the dry weight was determined, the crucibles were placed in a muffle furnace at 500°C for one hour. Samples were then cooled, rewet with tap water, brought again to constant weight at 105°C, and weighed. Subtracting the weight of crucible and ash from the previously determined dry weight gave the ash-free weight.

SOCIOECONOMICS

ARCHAEOLOGY METHODOLOGY

Prior to actual field examination of the proposed pipeline route, research was conducted in the Florida State Master Site Files, Tallahassee; the P.K. Yonge Library of Florida History, Gainesville; and the Levy and Citrus County Courthouses. Previous surveys in the area, local histories, records, old maps, etc., were reviewed to locate whether any sites of known historical importance on or adjacent to the survey area. One known aboriginal site of minimal importance, 8Ci70, is located in the survey area in the NE 1/4 of the NW 1/4 of Section 17, Township 17 South, Range 17 East. A second aboriginal site, 8Ci74, is located just north of the pipeline right-of-way. This site, which consists only of several flint chips is also of minimal importance. Location of this site is in the SW 1/4 of the SW 1/4 of Section 8, Township 17 South, Range 17 East (see Figure VII-4).

The field examination consisted of a walkover surface survey conducted by Raymond F. Willis, archaeologist. The survey focused on the proposed site for the pumping station, the Riverwood Drive north and south rights-of-way from the pumping station site to Aspen Avenue, the western right-of-way of Aspen Avenue, and the northern right-of-way of the FPC access road. These areas were determined and noted (by the Florida Division of Archives, History, and Records, Management, Bureau of Historic Sites and Properties) to be the most likely locations of sites.

All portions of the survey area were covered on foot. Shovel-cut test pits were dug in promising locations, and a close visual examination was made of all exposed earth surface within the area. Parallel ditching along the Aspen Avenue pipeline right-of-way and heavy equipment scars along the transmission line access road provided opportunities to examine large areas of exposed ground surface. No new aboriginal sites were located during this survey. The location of the previously mentioned site, 8Ci70, on the survey property at the southwestern edge of Lake

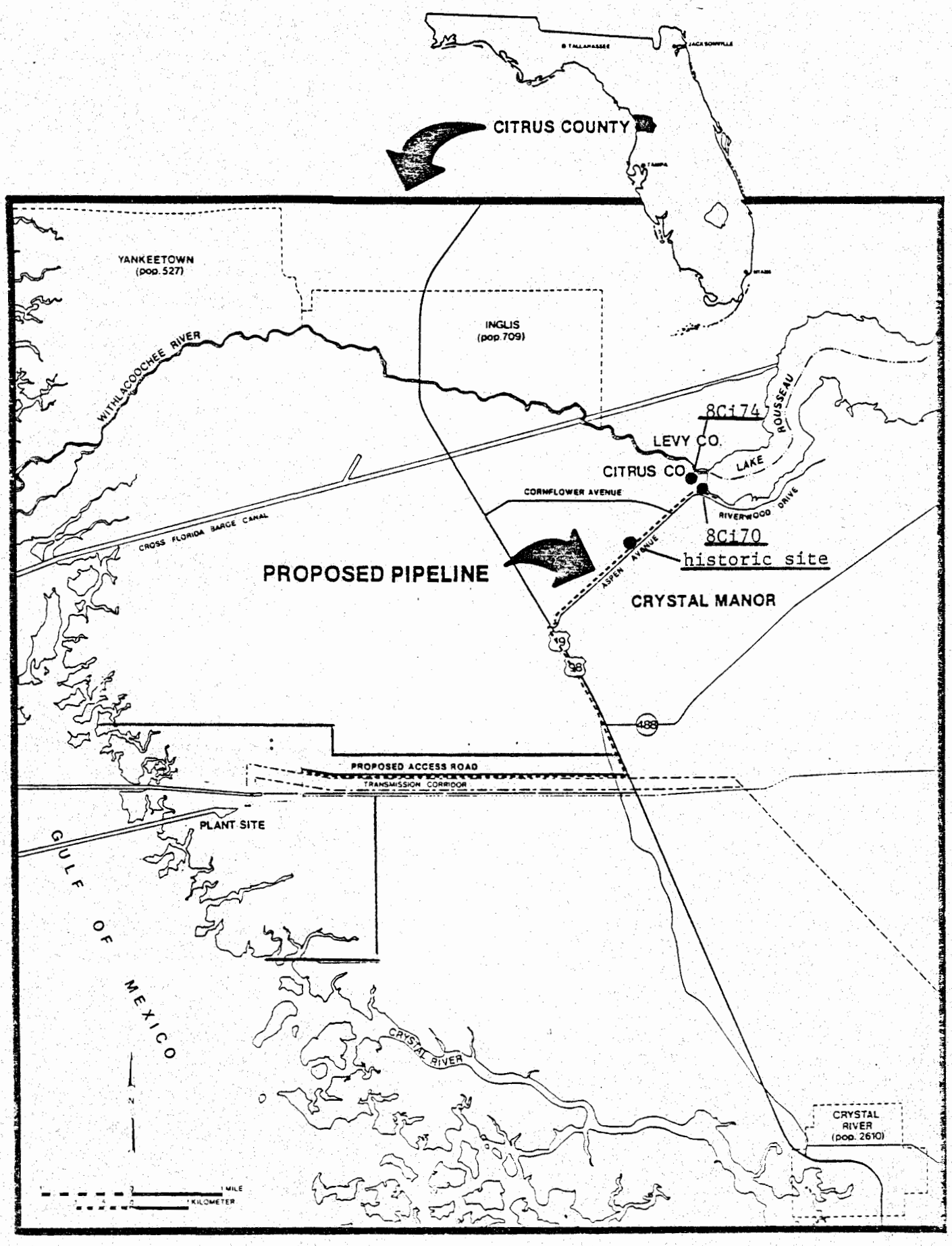


FIGURE VII-4
ARCHAEOLOGICAL-HISTORICAL SITE LOCATIONS

Rousseau, is of minor importance due to its minor artifact content and redeposited nature, i.e., dredge spoil. Close examination of this area provided no additional artifacts.

One historical site was located on the north side of Aspen Avenue approximately 110 meters (360 feet) southwest of its intersection with Basswood Avenue (see Figure VII-4). This site consisted of an early 20th century habitation, the only remains of which are two garbage pit depressions, scattered brick, screw-top bottles, agate-enameled metal dishpans, bedsprings, and ceramic turpentine pot fragments. Due to its late time period, short occupation span, and general non-distinctive nature, no surface collection was taken.

TERRESTRIAL ECOLOGY

Vegetation was mapped from 1"=500' black and white aerial photographs for the area following the transmission line corridor and from 1"=2,000' black and white aerial photographs for the rest of the corridor, supplemented by low-altitude color Ektachrome photographs.

A 1-day field survey on the ground and an aerial survey by small plane were made to characterize the vegetation and to search for endangered species.

Descriptions of vegetative associations are based upon and supplement to those in the Crystal River Units 4 and 5 Site Certification Application and the Cross Florida Barge Canal Restudy Report (Florida Game and Fresh Water Fish Commission, 1976). Evaluation of rare and endangered species in the region is based upon the Florida Committee on Rare and Endangered Species (1976), Endangered and Threatened Wildlife and Plants (U.S. Fish and Wildlife Service, 1977), and the Cross Florida Barge Canal Restudy Report.

VIII. WATER PRETREATMENT

The main water quality criteria for open recirculating cooling systems are that turbidity be below 50 jtu, iron or manganese be below 0.5 ppm, and sulfides (as H_2S) be below 5 ppm. The Lake Rousseau water is well within all of these parameters. The next consideration is calcium hardness and alkalinity which would affect scale formation in the cooling system.

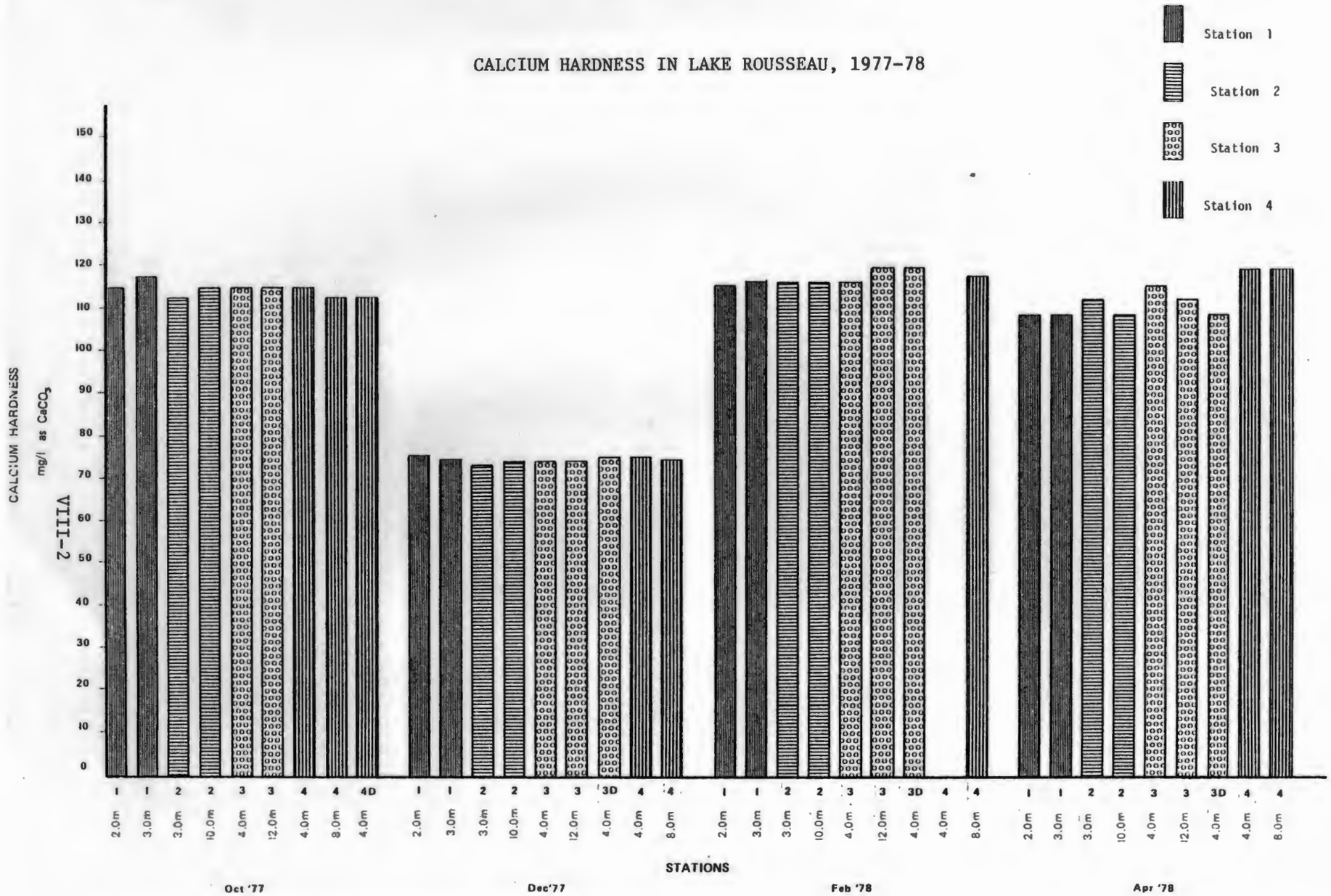
The calcium hardness and alkalinity in Lake Rousseau is relatively constant, as demonstrated by Figures VIII-1 and VIII-2. The concentration of calcium hardness for the month of December declined by 35 percent from the consistent average concentrations of hardness found during the months of October, February, and April. Data taken for Lake Rousseau are presented in Tables II-11, II-12, II-13, and II-14 in Chapter II.

Total hardness and color concentrations found during this period also declined from the average. A decrease in total hardness is normally associated with a similar decrease in alkalinity, which is inconsistent with the data obtained for December.

Lake Rousseau is fed by two primary sources, Rainbow Springs and the Withlacoochee River. In the USGS Water Resources Data (1976), Rainbow Springs had an average hardness of 59.5, an alkalinity of 51.5, and an average color less than 5. These values are relatively consistent during the year. By comparison, the Withlacoochee is variable, with hardness ranging from 110 to 160, alkalinity from 88 to 119, and color values from 15 to 200.

Although sampling was not conducted on the two primary sources feeding Lake Rousseau during this period, it can be assumed that the marked decrease in hardness detected during the month of December was caused

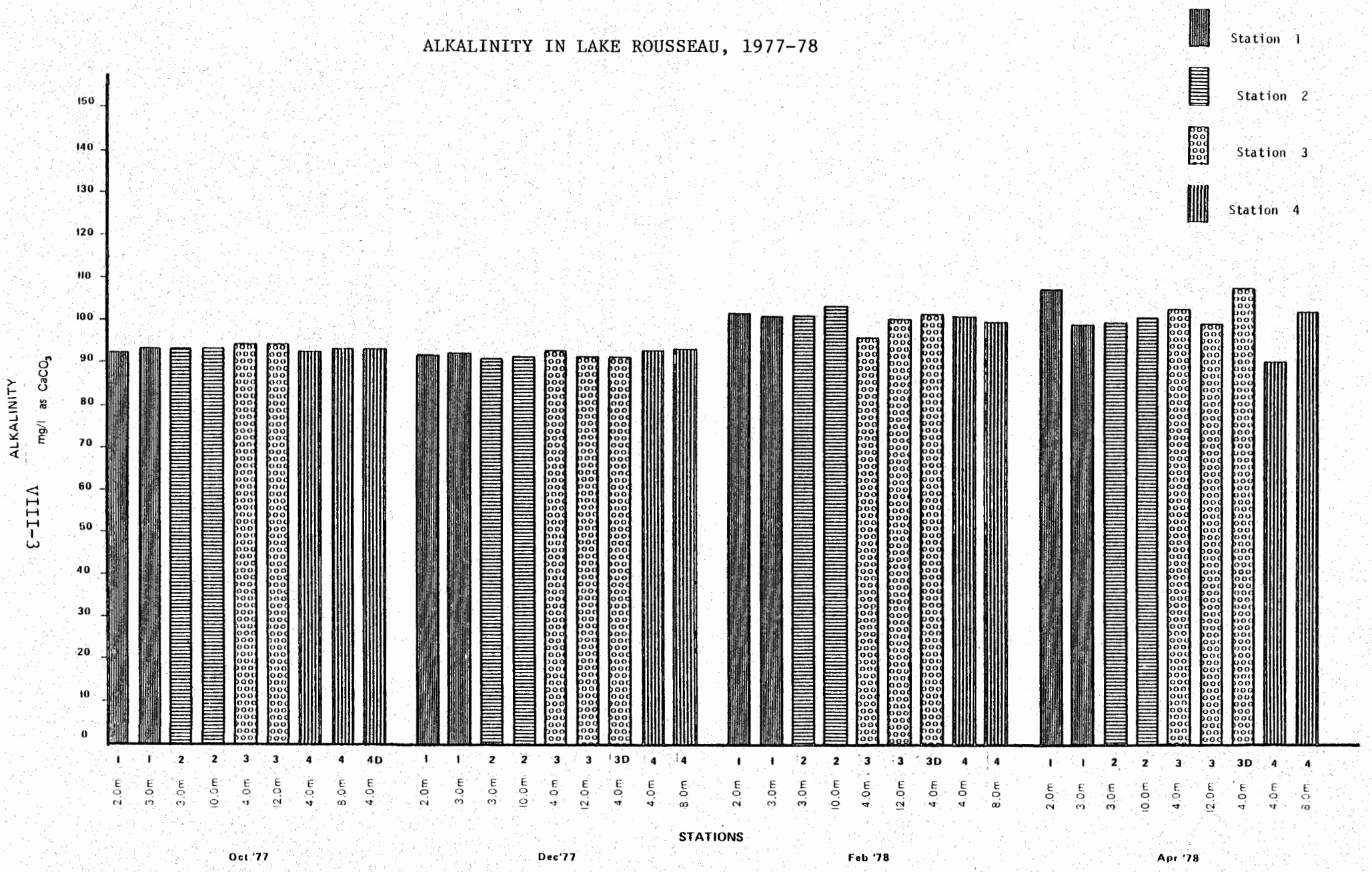
CALCIUM HARDNESS IN LAKE ROUSSEAU, 1977-78



Source: Environmental Science and Engineering, Inc., 1978.

Figure VIII-1

ALKALINITY IN LAKE ROUSSEAU, 1977-78



Source: Environmental Science and Engineering, Inc., 1978.

Figure VIII-2

by a variation in the Withlacoochee. This assumption is based on the fact that Rainbow Springs is relatively constant in quality and that the noted December decrease in hardness in Lake Rousseau was associated with a relatively constant alkalinity. In all probability, the flow from the Withlacoochee increased due to runoff from a rain storm and thereby caused a dilution of the hardness in Lake Rousseau.

The quality in Lake Rousseau is relatively constant, based on the data obtained during the test period. Factors affecting change in the quality of the lake will be caused by variations in the Withlacoochee, storm runoff, and impoundments of the water. Storm runoff apparently lowers the hardness content of the lake, which will have a positive effect on the makeup cooling water. Therefore, the worst case for the cooling tower is during periods of dry weather. This case is probably exemplified by the data collected during the October and April sampling periods. The rainfall during October was 18 millimeters (0.7 inches), and 1.5 millimeters (0.06 inches) in April. In addition, the data obtained for the months of October, February, and April may be considered normal operating conditions.

From the biological studies conducted on Lake Rousseau, it was determined that Corbicula fluminea inhabit the lake. Corbicula is one of five major fouling freshwater bivalves. Corbicula have been known to reach densities which can cause the shutdown of power-generating stations.

The Savannah, Georgia nuclear plant must be shut down periodically due to Corbicula infestations. Plant efficiencies have been reduced to 5 percent of capacity due to condenser heads being plugged with Corbicula. The actual blockage of condenser tubes results in a reduction of heat exchange. This blockage, along with the physical lodging of the shells which can cause pitting and erosion of the tubes and in turn cause leaks, can greatly reduce the working efficiency of the system. Within pipes, Corbicula reduces water flow by reducing bore size and producing turbulent rather than laminar flow. They also cause high

deposition at outflows and affect water quality by mass mortalities. Design criteria for Lake Rousseau should minimize any Corbicula problems.

The design criterion suggested by Black and Veatch, the design engineers, was to limit the cycles of concentration in the cooling tower when the calcium hardness reached 1,000 mg/l as $CaCO_3$.

The cycles of concentration are defined as the degree of concentration of the circulating water compared to the makeup water.

$$\text{Cycles of concentration} = \frac{Ca_c}{Ca_{mu}}$$

where Ca_c = Calcium hardness of the circulating water;

Ca_{mu} = Calcium hardness of the makeup water.

In the worst condition of calcium hardness (119 mg/l as $CaCO_3$) which was found in the sampling regime, 8 cycles of concentration can be reached with the use of Lake Rousseau as makeup water (Environmental Science and Engineering, Inc., 1978).

To verify the cycles of concentration, another method can be used. Assuming that the calcium hardness entering the cooling tower must equal the calcium hardness leaving the cooling tower, a balance equation could be used. Black and Veatch, the design engineers, have stated that the maximum evaporation from the cooling tower would be 5,500 gpm, the maximum drift would be 6.5 gpm, and the calcium hardness of the cooling tower blowdown would be limited to 1,000 mg/l. With the use of this information, it can be shown that 8 cycles of concentration can be reached.

The Langelier index on the worst case of the sample regime shows that the natural lake water has a Langelier saturation index of approximately zero. This value is for a low rainfall period in April when the hardness reached a value of 119 mg/l (as $CaCO_3$), and the total dissolved solids were 178 mg/lg at a depth of 8 meters (26 feet).

This index value indicates that the natural water is neither corrosive nor scaling. Since the lake is a surface water supply which has some natural and man-made variability in quality, the Langelier index was calculated for water quality conditions found during each sampling period. The lowest calcium hardness in the sample regime gave a Langelier saturation index of negative one. A Langelier index from +1 to -1 indicates relative stability of the source water.

Due to the high quality of the Lake Rousseau water, very little pre-treatment is required to produce acceptable cooling water. The initial makeup water will probably not require treatment other than the addition of phosphate sequestering agents for lessening of scale formation. The major problem in water quality will occur due to the concentrating effect of the recirculating cooling towers. Close monitoring of the water in the cooling towers will be required for pH and carbonate hardness. Addition of sulfuric acid will also be required for pH adjustment due to the concentrating effect of the cooling towers.

Another major design consideration is the presence of Corbicula in Lake Rousseau. Corbicula are normally infaunal, but under some conditions will show vertical travel. The most effective method of controlling Corbicula is proper design of the intake structure. Extensive screening using a .45-centimeter (3/16-inch) mesh screen has proven effective at the power plant on the Altamaha River, Georgia. Closed loops in the cooling water transmission lines as a method of concentrating Corbicula have also proven effective. When the plant is down, the loops can be designed for easy removal and cleaning. Another mechanical method is to use condenser heads larger than .78 centimeter (5/16 inch) to prevent a major portion of the tube blockage.

Chlorine has proven effective against Corbicula if a residual of 0.5 mg/l is maintained. For the large flows involved in these plants, this method may not be cost-effective. However, chlorination should be considered during the principal breeding periods, which are spring (April and May) and fall (September and October). Periodic shock

chlorination will be necessary to reduce bacterial growth in the cooling system. For shock chlorination, it is suggested that a chlorine residual of 1 mg/l be maintained for a 4-hour period on the cooling water returned to the cooling tower.

All methods of water treatment will need to be balanced against limits for chlorination established for the operating units at Crystal River which discharge to the present canal.

IX. SUMMARY OF FINDINGS AND CONCLUSIONS

WATER AVAILABILITY

Based upon historical flow data, it is generally concluded that there is sufficient water flowing through Lake Rousseau to meet the Southwest Florida Water Management District (SWFWMD) minimum flow requirements for the Lower Withlacoochee while 20-30 cfs (13-20 mgd) are utilized by Florida Power Corporation as make-up for the cooling towers associated with Units 4 and 5 in Crystal River, Florida. The average consumption rate of 20 cfs represents 1.1 percent of the total average flow into Lake Rousseau.

Impacts of water withdrawal can be evaluated according to the following three situations:

1. With No Barge Canal (Constant Pool Level)
   a. It will be possible to meet the minimum flow requirements of SWFWMD 95.3-95.6 percent of the months over a 44-year period. Without Florida Power water usage, these requirements will be met 96.7 percent of the months.
   b. During the most severe month of the worst drought (50-year), such as the one which occurred in 1956-1957, 20-30 cfs would be diverted for usage by Florida Power. This water withdrawal would reduce the outflow to the Withlacoochee by 1.8-2.9 percent.
   c. During the worst month of a drought such as the one above, the monthly flow rate to the Lower Withlacoochee will be 701 cfs (76.5 percent of the minimum flow requirement) without the Florida Power water usage. With water withdrawal by Florida Power, the flow to the Withlacoochee would be at least 671 cfs (73.3 percent of the minimum flow requirement). The peak usage rate during the worst month would be 4.3 percent of the total flow.
2. With No Barge Canal (With Variable Pool Level)
   a. No drawdown is required to meet SWFWMD minimum flow requirements except during droughts.

b. During droughts, the minimum flow requirement can be met with a probability of 96.7 percent while Florida Power uses 20-30 cfs. This is equal to the probability of meeting the requirements without Florida Power.

c. During the most critical months, the inflow to Lake Rousseau would be allocated to the Lower Withlacoochee while Florida Power would draw its needs from the stored volume of Lake Rousseau.

d. At a withdrawal rate equal to the average consumption rate of 20 cfs, a 25 percent reduction in lake volume would occur during the worst month of a drought (such as 1956-1957).

3. With the Barge Canal

It is assumed that the barge canal would operate at a design lockage rate of 456 cfs or 36 passes per day.

a. At all times the Lower Withlacoochee would receive at least an allocation of 350 cfs with or without Florida Power.

b. The lockage rate of the barge canal can be maintained at 100 percent of the design flow (456 cfs) at all times except during severe droughts. The usage of 20-30 cfs by Florida Power would not significantly affect the number of times when the lockage rate of the barge canal will fall below 100 percent. It would, however, further reduce the lockage rate by 4.4-6.6 percent when it does fall below 100 percent.

c. The withdrawal by Florida Power would have an impact upon the barge canal lockage rates during severe droughts and not on the Lower Withlacoochee.

The quality of the water from Lake Rousseau indicates that it is a suitable source for use as cooling tower make-up. The primary constraints are calcium hardness which will, according to seasonal data collected, allow at least eight cycles of concentration. During droughts, this figure could be somewhat lower since the contribution of Rainbow Springs to Lake Rousseau will be greater relative to the Withlacoochee River.

Control of Corbicula may be required, based on its presence and propensity for attraction and growth within intake structures.

The influence of the wind on suspended solids concentrations is considered minimal due to resulting low velocities in the bottom of Lake Rousseau. It has been possible, based upon core studies, to find locations which experience low sedimentation rates and are away from flocculent materials. Therefore, any constraints caused by suspended solids will not be restrictive enough to require a great deal of treatment.

HYDROLOGICAL EFFECTS OF WITHDRAWAL

The hydrological effects of diverting an average of 1.1 percent of the water from the bypass canal to Florida Power via the western embayment of Lake Rousseau would be quite small. An insignificant effect would occur on the hydrology of the Inglis Bypass which presently feeds the Lower Withlacoochee River at a point upstream from Inglis. No effect would be felt on the portion of the Withlacoochee between Inglis Dam and the Cross-Florida Barge Canal because Inglis Dam has been virtually closed and the minimal seepage of 70 cfs is probably a function of pool height which can be kept at an adequate level at all times. Within the western embayment, the currents affected or induced by withdrawal of 20-30 cfs by Florida Power would not have any discernible effects upon the shallows if the intake structure were located in the old river channel.

ENTRAINABLE ORGANISMS

Statistical modeling revealed that, for the months sampled, station 4 at a depth of 4 meters was significantly lower in zooplankton populations. Generally, it appears that water column productivity in the lake contributes much less to the total productivity than do benthic macrophytes. These two conclusions seem to indicate that biological impacts may be mitigated by careful placement of the intake structure. Of course, biological entrainment is not the only impact to be considered. Prudent analyses of impacts associated with physical flows should be balanced against entrainment, costs, construction impacts, and other factors to arrive at the most feasible location for the intake structure.

Analyses of the low velocity model intake sampling device and the unmodified pump sampler did not indicate any significant differences between the two. This result indicated that among the zooplanktens captured, the study could not detect with statistical significance, swimming abilities which would allow these organisms to avoid an intake structure with inlet flow rates of 0.5 feet per second. For the species which appeared, this result is as expected.

The fact that neither the model intake sampling device nor the pump sampler captured more motile larval forms indicates that such organisms were either not present or extremely rare during the sampling periods.

INTAKE STRUCTURES

Based upon suspended solids, sedimentation rates, and potential flow modeling, the best location for an intake structure appears to be offshore in a deep area (within the old river bed) and near Inglis Dam. These considerations would affect the economics of the system in operation. Economies based upon capital costs of installation suggest a nearshore shallow location near the dam. Thus far, the biological studies seem to indicate that an offshore, relatively deep location away from the dam is biologically preferable yet most costly.

A consideration of all the above factors suggests that an offshore, deep location near the dam would be the preferred alternative.

An intake structure can be designed with screens placed at a suitable distance to prevent the larger aquatic organisms from being entrained. The intake structure can be placed in a zone of low sedimentation and low floc and suspended solids. Zones with these characteristics are known to exist in Lake Rousseau.

Problems with Corbicula in the intake structures can be controlled by screening. This method has been successfully demonstrated by use of 3/16-inch mesh screen.

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EPA 904/9-80-048b
July 1980

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Environmental Impact Statement

Draft

Florida Power Corporation
Crystal River Units 4 and 5

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Chapter 6 Environmental Measurements and Monitoring Programs

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CHAPTER 6

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6.0 ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

6.1 BASELINE MONITORING AND RELATED INFORMATION

Investigations were conducted through literature searches and field studies to determine the nature of existing environments. Past studies of the Crystal River site in connection with Units 1, 2, and 3 provided many references. Literature concerning similar habitats in the State of Florida and the southeastern United States were also useful. Studies directly concerned with the Site Certification Application are delineated in the following text.

6.1.1 SURFACE WATER

Information concerning surface water hydrology in the area was obtained from 15 published reports. Most of these were either USGS reports or reports dealing with the hydrology of the Cross-Florida Barge Canal. The USGS Water Resources Data for Florida (1975 and 1976) provided information concerning the discharges of major streams in the area, as well as water quality analyses. All measurements were obtained by the USGS. Several other reports (i.e., Rabon, 1967; Kaufman, 1975; Kenner, 1966) provided statistical interpretations of data contained in the Water Resources Data books. Cherry (1970) provided a general overview of hydrology in the region and a water budget analysis. Bush (1972) reported on saltwater movement in the lower Withlacoochee River based on chemical analyses of water taken from 11 sites on the lower Withlacoochee-Cross Florida Barge Canal. Tidal data was also obtained from this report based on water level recordings taken at Crackertown, Florida, since 1967.

The reports concerning the hydrology of the Cross-Florida Barge Canal (i.e., U.S. Army Corps of Engineers, 1976; Meta Systems, 1976) provided detailed statistical interpretations of discharges in the lower Withlacoochee River. Much of this information was not totally relevant to the study area. The Corps of Engineer's Water Resources Study of the Four River Basins Area (1977) provided some more recent information concerning the discharge characteristics of both the Withlacoochee River and the Crystal River.

Information concerning flooding in the area was obtained from two sources, an Army Corps of Engineers's Flood Hazard Information Study for the lower Withlacoochee (1976) and USGS Flood-Prone Area Maps (1954) for the study site. The Corps of Engineers' report was not wholly representative of the study area, in that structures associated with the barge canal serve to lessen flooding effects at the mouth of the Withlacoochee. The 100-year flood elevation of the site was estimated

through the use of readily available information on past floods rather than from detailed field surveys and inspections.

Additional information concerning the physical characteristics of Lake Rousseau and Crystal River was obtained during studies conducted in August 1977 (Environmental Science and Engineering, Inc., 1977).

6.1.2 WATER QUALITY

Most of the baseline data discussed in Subsection 2.5.2 concerning the water quality in the estuary, intake, and discharge canals was taken from existing literature.

Water quality parameters investigated by Gibson, et al. (1974), were discussed. This investigation was initiated in 1973 to determine seasonal patterns of phytoplankton standing crop and production and water quality in Gulf coastal waters adjacent to the Florida Power Corporation generating facility at Crystal River. Water samples were collected bi-weekly for the six-month period from November 1973 to April 1974. Sampling locations were chosen to include points in the intake canal, discharge canal, and discharge basin, and to estimate the impact of the two principal freshwater sources on the region. Nutrient concentrations were assayed, using a 2-Channel Technicon Autoanalyzer (AII), following procedures outlined by Hopkins (1966). Salinities were measured using a Beckman salinometer, temperature was measured with a mercury thermometer, and chlorophyll a by the procedures of Strickland and Parsons (1968).

Phosphorus values discussed were taken from Odum and Snedaker (1971). This report discussed the processes within the plume-receiving ecosystem at Crystal River. Preliminary analysis was performed for phosphorus, chlorophyll a, and phaeo-pigments. These results, as well as those of benthic studies, are presented in order to develop a model of the system.

Solids and turbidity data discussed were taken from Fox and Moyer (1970). The specific objectives of this study were to determine, by using various parameters, the direct and indirect effects of chlorinated cooling water on the microbiota of the receiving waters. In order to measure the effects of chlorination, the following assays were performed: temperature, dissolved oxygen, chlorophyll a, primary

productivity, Adenosine Triphosphate (ATP), total bacterial populations, total solids, suspended solids, volatile solids, secchi disc, and chlorine.

Temperature and salinity data discussed were taken from Behrens and Carder, 1975. This report presents and analyzes salinity and temperature data collected from April 1974, through March 1975, in the Florida Power discharge basin at Crystal River, Florida, with respect to seasonality and plume acreages.

Additional information concerning the quality of surface waters in the vicinity of the proposed site was obtained from Florida Department of Environmental Regulation Water Quality Management Plans for the Tampa Bay Area (1976) and the Withlacoochee River Basin (1975). These plans evaluated numerous water quality analyses of selected sites on the Crystal River and the Withlacoochee River against the water quality standards which have been adopted for these waters. On the basis of these evaluations, qualitative determinations were reported concerning the water quality in these streams.

The baseline data presented for Crystal River and Lake Rousseau in Chapter 2 was collected by ESE in late August 1977 (Figures 6.1-1 and 6.1-2).

Site locations on Crystal River were situated 1.6 kilometers (1 mile) above, 1.6 kilometers (1 mile) below, and at the proposed intake site. Grab samples were taken from the surface and from near the bottom at each of these sites and returned to ESE for analysis. Analyses which were performed and analytical methodologies used can be seen in Table 6.1-1. In situ analyses were also performed at the surface and near the bottom at each of the three sites. In situ methodologies are presented in Table 6.1-2.

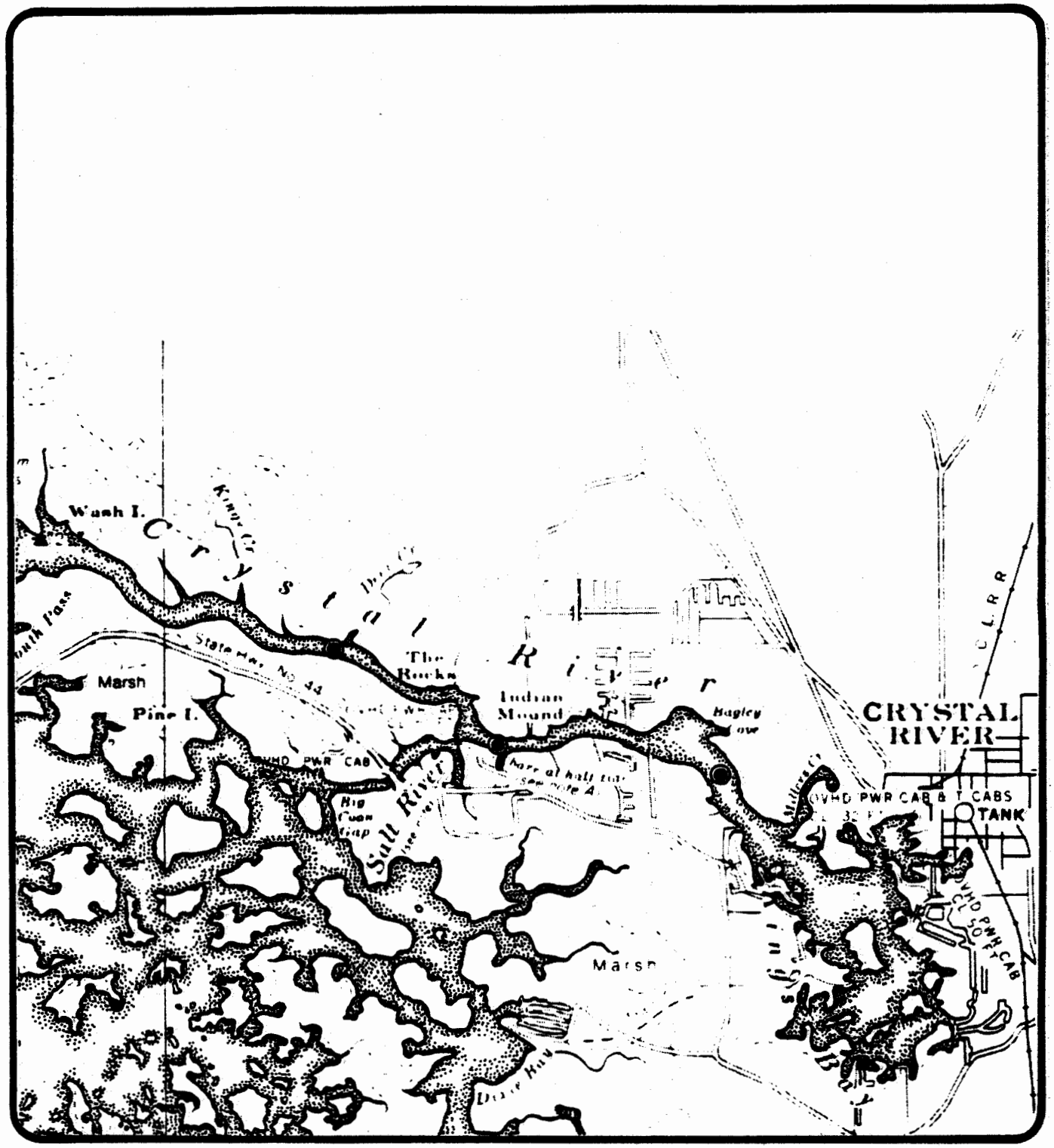


Figure 6.1-1
CHEMICAL SAMPLING SITES, CRYSTAL RIVER

N 0 1
SCALE IN MILES

SOURCE: ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1977

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

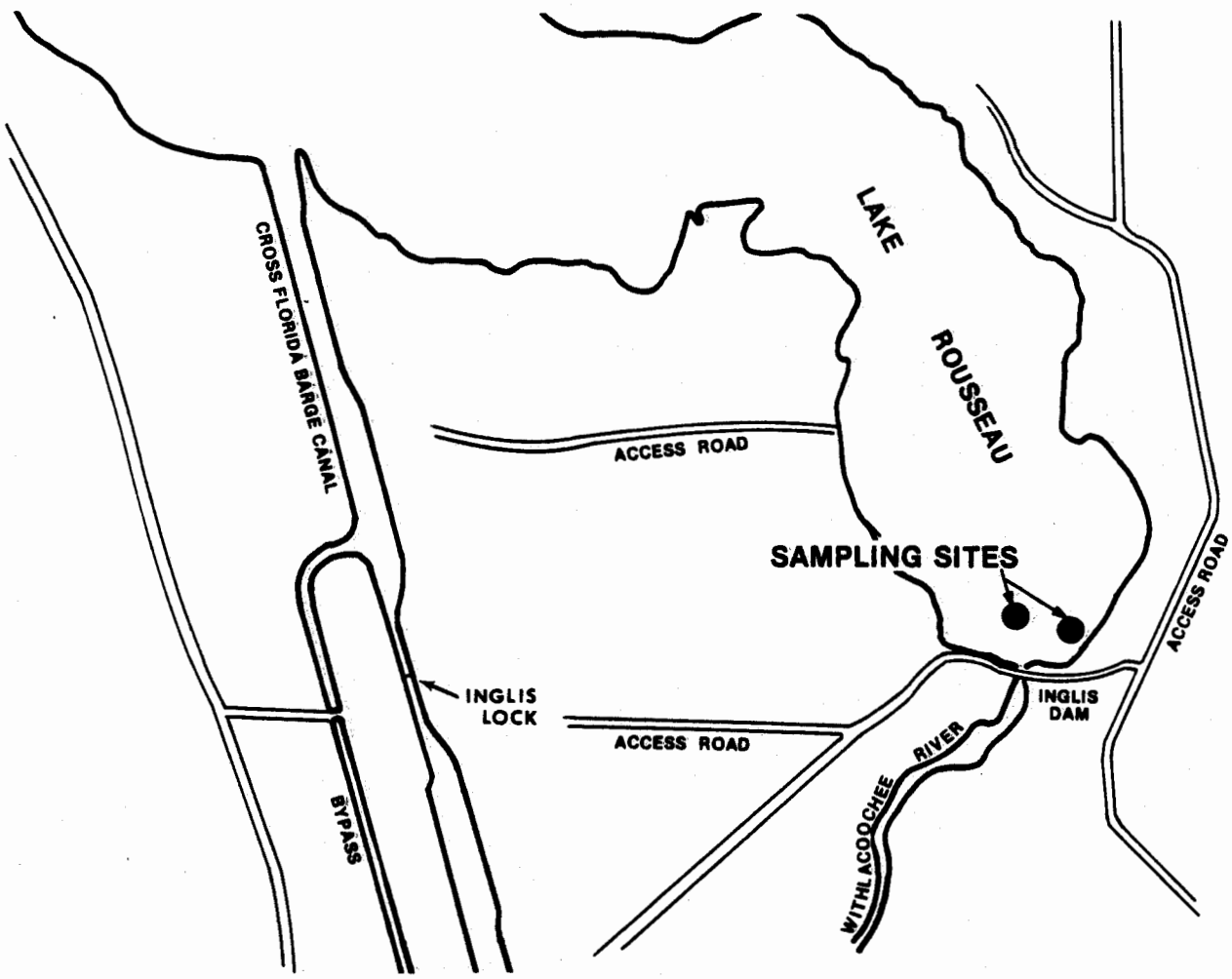


Figure 6.1-2
CHEMICAL SAMPLING SITES, LAKE ROUSSEAU

N

0 500 1000 2000
FEET

SOURCE: ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1977

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

Table 6.1-1 Chemical Analysis of Water Samples

Parameter	Method	Reference
Ammonia	NH_3 selective ion probe	SM, 1975
Total Kjeldahl nitrogen	Kjeldahl digestion automated phenate method	EPA, 1976 EPA, 1976
Nitrate and nitrite	Automated Cd reduction method	EPA, 1976 ASTM, 1976
Dissolved orthophosphate	0.45 um filtration, automated ascorbic acid method	EPA, 1976
Total phosphorus	Persulfate digestion, automated ascorbic acid method	EPA, 1976
Alkalinity	Titrimetric method	EPA, 1976
Color	Colorimetric	EPA, 1976
Turbidity	Nephelometer and Secchi disk	EPA, 1976
Suspended solids	Gravimetric	EPA, 1976
Dissolved solids	Gravimetric	EPA, 1976
Total solids	Gravimetric	EPA, 1976
Biochemical oxygen demand	DO probe	EPA, 1976
Hardness	Titrimetric	EPA, 1976

ASTM, 1976 = Annual Book of ASTM Standards, Part 31, Water, ASTM.

EPA, 1976 = Methods for Chemical Analysis of Water and Wastes, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio.

SM, 1976 = Standard Methods for the Examination of Water and Wastewater, APHA, WPCF, AWWA.

Source: Environmental Science and Engineering, Inc., 1978.

Table 6.1-2 In-Situ Analysis of Water

Parameter	Method	Reference
Temperature	Thermistor	EPA, 1976
pH	Hydrogen ion electrode	EPA, 1976
Dissolved oxygen	DO probe	EPA, 1976
Salinity	Electrical conductivity method	SM, 1975

EPA, 1976 = Methods for Chemical Analysis of Water and Wastes, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio.

SM, 1975 = Standard Methods for the Examination of Water and Wastewater, APHA, WPCF, AWWA.

Source: Environmental Science and Engineering, Inc., 1980.

There were two site locations at Lake Rousseau: a nearshore site situated near the proposed intake site, and an offshore site situated approximately .4 kilometer (.25 mile) east of Inglis Dam (Figure 6.1-2, Lake Rousseau site locations). Grab samples were taken from the surface and from near bottom at each of these sites and returned to ESE for analysis. Table 6.1-1 presents the analyses which were performed, and analytical methodologies used. In situ analyses were also performed at the surface and near the bottom at both sites. In situ methodologies are presented in Table 6.1-2.

6.1.3 ECOLOGICAL PARAMETERS

SALT MARSH

Information gathered on the salt marsh biota was based on the existing literature. Reference to Hosner, McMahan, McKellar, and Young is from a ten-month study undertaken during the period from May 1974 to February 1975, in the Crystal River region of Florida. Hosner discussed the seasonal variation, biomass, diversity, and trophic structure of fish in the salt marsh tidal creeks. He also gives a brief discussion of the various predominant species collected. McMahon discusses briefly the microarthropod population present in the area. As mentioned in Section 2.7, the limited degree to which these organisms were identified precluded detailed conclusions relating population interaction or relationships with other trophic levels.

McKellar summarized the outer bay ecosystem at Crystal River, Florida, in terms of metabolism and energy flow models. He also discussed total system turnover times based on system metabolism and organisms' biomasses.

Young extensively discusses the salt marshes and the effects of thermal inundation in terms of plant standing crop, net production, respiration, total metabolism, decomposition, diversity, and selected animal members (specifically, the marsh periwinkle, *Littorina irrorata*, and the fiddler crab, *Vea* sp.). Effects were incorporated into energy flow diagrams to better understand the system on a community level. These results were compared to those found in the literature. There were also two sampling periods, May and September, at Jacksonville, Florida, on the St. John's River for comparisons of *Spartina*, *Littorina irrorata*, and *Vea* sp. abundances.

Keefe (1972) reviewed studies on fresh and saltwater marsh production and discussed their high productivity in comparison to terrestrial and phytoplankton communities. The role of the marsh flora as a food source

was also discussed. She points out the failure in recent research to ascertain the value of marsh detritus to the adjoining water body.

Cuzon du Rest (1963) studied the distribution of zooplankton in the salt marshes of southeastern Louisiana. This study was done in terms of seasonal (temporal) distribution and geographic (spatial) variance in salinity from nearly fresh water to nearly marine water (the total range was from 0.5 ppt to 25.4 ppt). Monthly abundances were determined for the numerically important species. Day (1973) carried du Rest's work one step further and determined respiration/production rates, as well as that quantity lost to higher trophic levels via waste for the single most abundant zooplankton, the copepod (Acartia tonsa). This species was found to be the major component in other areas, specifically Florida, based on work done by Hopkins (1966) at St. Andrews Bay and Woodmansee in Biscayne Bay. Hopkins ascertained the number of generations of A. tonsa in a given year to be about 11.

Maturo, et al. (1974), characterized the zooplankton population in the Crystal River estuary. The characterization was based on the distribution and structure of the zooplankton populations from July 1972 to July 1973. Sites were categorized as inshore, intermediate, and offshore. Salinity, temperature, and other environmental readings were taken with each sample. Within this report, Alden and Hearne discuss zooplankton production based on A. tonsa. Two methods were used to determine production. The first was based on computation of turnover time, which in turn was based on instantaneous death rates estimated from population age structures observed in the field and development time as determined by laboratory experimentation. A second method was used, based on metabolism. Here, using the proper assumptions, production is equivalent to the carbon assimilated less the carbon respiratory cost [which is equal to milliliters of oxygen consumed times 1.4 (density of oxygen) times .375 (ratio of carbon to oxygen in glucose) divided by the carbon weight of the animals)]. Also within this report, Hallquist discussed ctenophore standing crop and predation.

Standing crop was determined as a volume per cubic millimeter. Predation was determined in two ways: the first is based on the theory that feeding rate is a function of copepod concentration and ctenophore size; and the second on production values (specifically, total carbon ingested divided by total carbon available as zooplankton standing crop).

Carr and Giesel (1975) sampled marshland creeks near a steam-electric station near Jacksonville, Florida. The purpose of their study was to compare fish populations in thermally impacted marshland creeks to a population by the plant's effluent. Using a seine to collect samples, 48 different species were collected. Abundances and biomass per unit area for utilizable (defined here as those fishes used by man either as food or for various fish products) juveniles as well as values for the entire fish population over the time period of the study (June, July, and September) were ascertained. One major shortcoming of this report was its failure to statistically analyze differences at the various sites.

Harrington (1961), in his paper on ecology, discusses food selection of fishes in different habitats, including a salt marsh. He explains how the selection of prey shifts both spatially and temporally from the onset of flooding through the progress of a mosquito brood.

Reid (1954) and Springer's (1960) reports reviewed the general ecological trends of fish communities in Florida. Reid's work was done in the vicinity of Cedar Key, while Springer's report was done in the Tampa Bay area. Both authors point out that juveniles appear in the estuary during the late spring and early summer months. Sykes (1966) reconfirms this time of occurrence in his work on the appearance of juveniles of the dominant commercial fishes in the Gulf of Mexico.

AQUATIC HABITATS ON THE PROPOSED CONSTRUCTION SITE

Information concerning Florida Power's proposed location 1c was based on a single field effort undertaken by members of the aquatic group from Environmental Science and Engineering, Inc. Three transects, which ran south to north, were sampled. One transect ran along the western boundary of the proposed site (Transect 1), one along the eastern boundary (Transect 3), and the third ran midway between the two (Transect 2). The distances between the transects were approximately .8 kilometer (0.5 mile), and the total length of each was .8 kilometer (0.5 mile).

At various wet sites along each transect, a ponar sample was taken and, where it appeared applicable, dip net samples were taken. Ponar samples were sieved through a #30 mesh, all samples were preserved in 10 percent formalin, and returned to the lab where they were identified.

Site A on Transect 1 was the site farthest north and samples were taken in what appeared to be a permanent marsh; Site B was one of two small [approximately 3 meters (10 feet) in diameter], shallow, sandy bottom ponds in an open area; Site C had standing water approximately 46 centimeters (18 inches) deep with a litter-covered bottom; Site D was a "permanent pond" in thick woods with a leaf litter bottom; Site E was a habitat similar to that found at Site C. Small fish, tadpoles, dytiscids, hemipterans, and frogs were observed at the various sites.

Transect 2 would have been inaccessible except for a road which ran just west of and parallel to the transect. This road was traveled and, when possible, stops were made and short excursions were undertaken east to cross the proposed transect. A total of four such walks were made. Five of six "water holes" were observed; three or four were small wallows [less than 2 meters (7 feet) in diameter], and two appeared to be relatively major water reserves [greater than 3 meters (10 feet) in diameter with flora frequently associated with water systems observed in

the vicinity, e.g., sawgrass, arrowhead, pickeral weed, and spatter dock]. All were dry. No streams or stream-like systems were noted.

Transect 3 was inaccessible with the exception of the very northern border and just south [.2 kilometer (.13 mile)] of the southern border. However, based on these two observations (observations at Transect 2 and gross observations in the general vicinity of Transect 3), no water is believed to be present.

At a later date, members of the terrestrial group of Environmental Science and Engineering, Inc., surveyed the area and noted several water bodies in the general vicinity of Transects 2 and 3. However, minimal faunal activity was noted in these systems, and the substrate appeared to be hard limestone with minimal litter present.

TERRESTRIAL COMMUNITIES

Wharton, et al. (1976), described the forested wetlands of the region in a general sense, while Pearson (1954) described the mammals of the similar Gulf Hammock area in Levy County, which occurs about 16 kilometers (10 miles) north of the site.

Numerous studies have been carried out by the U.S. Forest Service and the Florida Game and Fresh Water Fish Commission as part of the Cross Florida Barge Canal Restudy Report (U.S. Army Corps of Engineers, 1976). While most of the information was gathered along the more easterly reaches of the canal, specific data on such items as forest stand composition and endangered species occurrence were gathered for the western end of the canal, which terminates about 5 kilometers (3 miles) north of the plant site.

Studies carried out between 1969 and 1976 during the environmental assessment of the Crystal River Unit 3 nuclear plant were primarily concerned with the salt marsh and estuarine systems. Terrestrial studies

were largely confined to surveys of food webs and dietary habits of species in which radioactive nucleotides could accumulate (Pruit, 1971).

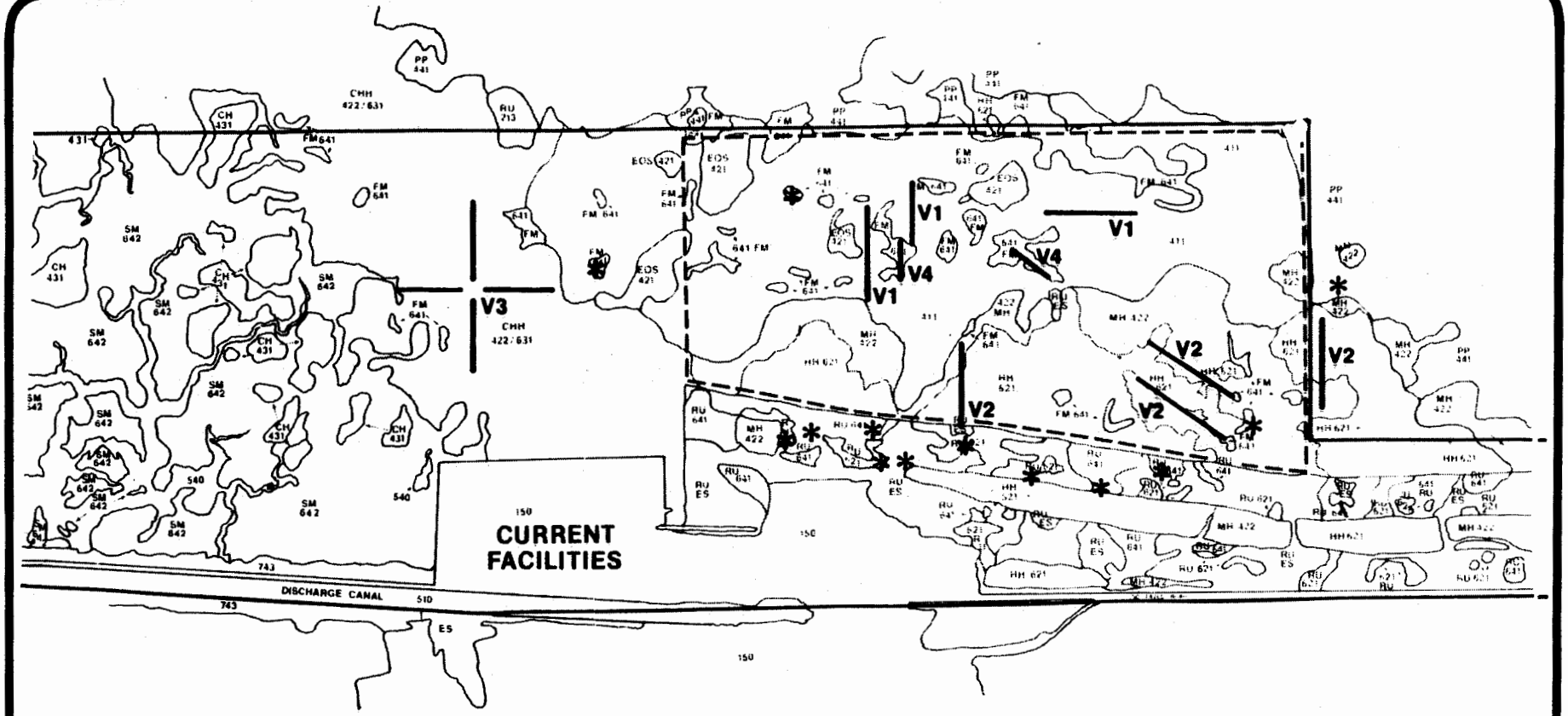
A study of potential salt spray impacts near the site (Dames & Moore, 1974) developed limited specific data on species present at the site.

Vegetative Parameters

The above studies and additional literature were used to obtain regional information. Field studies to develop site specific information took place from August 22 to August 27, 1977. Methods of vegetation analysis used are discussed in the following sections.

Overstory vegetation was inventoried for the pine flatwoods, coastal hydric hammock, and mesic/hydric hammock complex along the transect lines shown in Figure 6.1-3. The point-quarter method of Cottam and Curtis (1956) was used with eight points randomly selected on each transect line. Species:area curves (Oosting, 1956) were used to insure that an adequate number of points were sampled.

Data collected were used to generate importance values, as formulated by Curtis and McIntosh (1951). Density, basal area, and average diameter at breast height were derived for pine plantations by sampling and computing tree diameter, the average distance between trees, and the average distance between rows.



V1 VEGETATION SURVEY LINE - PINE FLATWOODS
V2 VEGETATION SURVEY LINE - MESIC/HYDRIC HAMMOCK
V3 VEGETATION SURVEY LINE - COASTAL HYDRIC HAMMOCK
V4 VEGETATION SURVEY LINE - FRESH WATER MARSH
* VEGETATION - SPOT SAMPLE

Figure 6.1-3
SAMPLING AREA LOCATIONS FOR VEGETATION

SOURCE: ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1977

N

0 500 1000 1500 2000
SCALE IN FEET

FLORIDA POWER CORPORATION

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CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

Importance values and other parameters have been generated for overstory vegetation as follows:

$$\text{Relative density of species A} = \frac{\text{\# individuals of species A}}{\text{total \# individuals of all species}} \times 100$$

$$\text{Relative dominance of species A} = \frac{\text{total basal area of species A}}{\text{total basal area of all species}} \times 100$$

$$\text{Relative frequency of species A} = \frac{\text{frequency of species A}}{\text{sum of all frequencies for all species}} \times 100$$

Shrub vegetation includes all plants with height over 30 centimeters (12 inches) and a stem circumference of less than 2 centimeters (.8 inch). Ground cover includes all vegetation of height less than 1 meter. Both of these were sampled in 12.6-square meter (135-square feet) circular plots for estimated percent cover and frequency in two plots on each transect. Plots in marsh and ruderal areas were located at approximately 40-meter (130-foot) intervals. Only one plot per stand was used when stand width was less than 40 meters (130 feet).

The floristic similarity of plant communities sampled was expressed using Sorensen's community coefficient index of similarity (IS) (Mueller-Dombois and Ellenberg, 1974). This method compares the number of species common to both communities to the total number of species found in both communities, thus:

$$IS = \frac{2C}{A + B} \times 100$$

where C is the number of species common to both communities, A is the total number of species found in community A, and B is the total number of species found in community B.

Age of trees at the site was estimated from the number of annual rings found in core borings of trunks or observed on cut-over tree stumps. Phloroglucinol dye was used to help identify rings.

Vegetative communities at the site were mapped from 1 inch:500 feet black and white aerial photographs, and ground-truthed and refined during the field survey. The map has been compared to the draft wetlands map of the National Wetlands Inventory (U.S. Fish and Wildlife Service, 1977) and found to be in good general agreement. Minor differences are felt to be the result of higher resolution photographs and increased ground truthing used in the site survey. The regional vegetation map was prepared from a 1 inch:2000 feet black and white aerial photograph. In addition to the information gathered by these methods, qualitative observations were recorded about each community in regard to hydroperiod, evidence of fire, human disturbance, and various other factors. Estimates of depth of surface soils were made by inserting a .63 kilometer (.25 inch) diameter brass rod into the soils.

Taxonomic determinations were based primarily upon the following sources: Kurz and Godfrey, 1962; Long and Lakela, 1971; Radford, et al., 1968; Rickett, 1966; and Wherry, 1964.

Fauna

The primary objective of the faunal sampling program was to verify the mammal, bird, reptile, and amphibian species occurring in the area and to determine the relative abundance of each species. Strict quantitative techniques involving mammal trapping, drift nets, mist nets, etc., were determined to be unnecessary for the proposed project. Instead, diurnal and nocturnal visual/auditory searches were made throughout the site, with frequency of observation recorded for each species. Qualitative trapping efforts were conducted to establish the presence of small mammal populations in various habitats. In addition, habitat evaluations were made to determine the possible habitat utilization by important species and rare and endangered animals. A literature survey was conducted for the area of the plant site.

Small mammal trapping was accomplished with a Sherman live trap, victor mouse trap, victor rattrap, and a pitfall. One trap line with 20 stations was placed in a longleaf pine/evergreen oak scrub, a mesic/hydric hammock, and in coastal hydric hammock communities (Figure 6.1-4). Stations were located 10 meters (33 feet) apart, and each had one Sherman live trap and two victor snap traps. In addition, 7 pitfall traps (a # 10 galvanized can) were placed along each line. Nine traps were baited with a mixture of peanut butter and oatmeal and prebaited for 2 days. Lines were inspected daily and rebaited for 3 days. All species caught were noted, as were the habitat types.

Habitat evaluation was made for each type found at the site. Primary objectives were to evaluate tracts of lands for their suitability as habitat for the more important species, namely deer, squirrel, quail, turkey, and rare and endangered animals. Habitat evaluation was made in each major ecosystem based on various types of cover, availability of food, water sources, and denning sites or nesting areas. Information was generated by walking transects and recording habitat conditions and species observed. Information on food sources was taken primarily from the vegetative sampling. The purpose of these techniques was to give a practical means for assessment of habitats with regard to some of the more important species. In addition, areas with dense understory and ground cover of palmetto were only partially inventoried because of the limited accessibility. Preferred habitat, number observed, seasonal occurrence (birds only), and relative abundance have been given for each species. Relative abundance is classed as follows:

A = Abundant; encountered nearly every time preferred habitat was visited.

C = Common; encountered most of the time in preferred habitat.

U = Uncommon; may be encountered irregularly in preferred habitat.

R = Rare; encountered very infrequently in preferred habitat.

A literature survey was conducted for references pertinent to the general physiographic region and to the plant site in particular. Perhaps

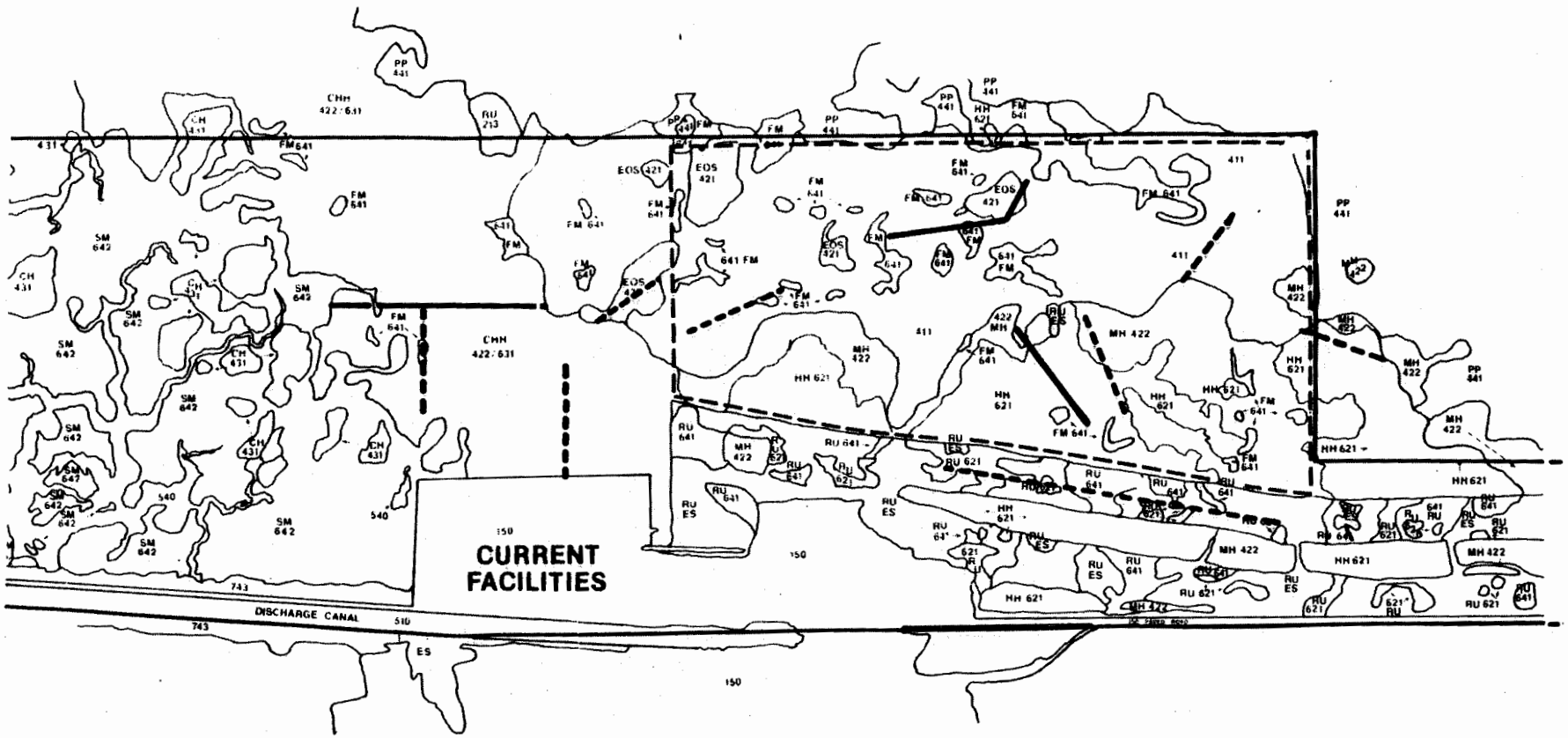

Figure 6.1-4
SAMPLING AREA LOCATIONS FOR FAUNA

SOURCE: ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1977

N

0 500 1000 1500 2000
SCALE IN FEET

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the best work on the fauna of this section of Florida is presented in the Cross Florida Barge Canal Restudy Report (1976). Nomenclature for the mammals follows that of Burt and Grossenheider (1964). Scientific and common names for the birds are those recommended by the Thirty-Second Supplement to the American Ornithologists Union Checklist of North American Birds (1973). The herpetofauna nomenclature was taken from Conant (1975).

Rare and Endangered Fauna

The primary objective of the rare and endangered species methods was to identify those rare and endangered species which have ranges that include the Crystal River proposed power plant site, Units 4 and 5. Sources used for delineation of species were both federal and state listings.

The U.S. Fish and Wildlife Service publications include the existing listings at the time of the document's preparation (United States List of Endangered Fauna, 1974; Threatened Wildlife of the United States, 1973; Endangered and Threatened Wildlife and Plants, 1977) and the proposed listing (Proposed Endangered Status on Some 1700 U.S. Vascular Plant Taxa, 1976). In addition, each publication of the Federal Register since 1977 was checked in order to verify additional species listed as rare and endangered. State listings included those of the Florida Game and Freshwater Fish Commission (1974) and the Florida Committee on Rare and Endangered Plants and Animals (1976).

References used for preferred habitat, likelihood of occurrence, and ecology of the species were the Cross Florida Barge Canal Restudy Report (Florida Game and Fresh Water Fish Commission, 1976) and Florida Committee on Rare and Endangered Plants and Animals (1977) unless otherwise stated. Other general references included Conant (1975), Robins, et al. (1966), Burt and Grossenheider (1964), and Archbold Report, Volume I, II, and III (1977).

In addition to the general survey work for each species, special surveys and data reviews were conducted for three species for which on-site population estimates are difficult. These are the eastern indigo snake, the short-tailed snake, and the Florida manatee.

Eastern Indigo Snake

The eastern indigo snake occurs locally in peninsular Florida, in a few widely scattered areas of the Georgia Coastal Plain, and in parts of the Florida panhandle. This snake occupies a wide variety of habitat types. The indigo snake is a species of high humidity requirements, however, it can survive in xeric environments, if gopher tortoise burrows are present (Kochman, 1976). According to the Cross Florida Barge Canal Restudy Report (Florida Game and Fresh Water Fish Commission, 1976) the occurrence of indigo snake in similar type habitats as found on the proposed site is as follows:

Coastal Hammock--Occasional,
Hydric Hammock--Frequent,
Mesic Hammock--Occasional,
Xeric Hammock--Occasional,
Slash Pine Flatwoods--Occasional,
Pine Plantation--Infrequent, and
Evergreen Oak Scrub--Occasional.

During ecological surveys of these types of habitats on the property, the indigo snake was not observed; however, it has been reported to occur on the site (Voigts, 1977). The proposed site is considered good habitat for indigo snakes because of the diversity of habitat; the numerous area of thickets, brush piles, and other organic debris; and the apparently large populations of rodents and other herpetiles.

In response to specific questions by the Environmental Protection Agency and the United States Fish and Wildlife Service concerning population studies and site specific information on the indigo snake, various authorities (Dr. Roy McDirmid and Dr. Howard W. Campbell) were contacted. It was found that no site specific information was available

nor were there presently proven methods for precisely estimating population densities of this species. Dr. Howard Campbell (1978) recommended searches be conducted in likely habitat to roughly evaluate populations of indigo snake.

Short-Tailed Snake

The short-tailed snake is a burrowing animal, seldom occurring above ground except during the spring and fall. Encroachment by man into preferred habitat is the greatest threat to this species. In some instances, thermal stress caused by removal of overstory in sandhills communities have extirpated certain populations of this snake (Campbell, 1975).

The range of the short-tailed snake is confined entirely to peninsular Florida from Highlands to Columbia counties. This species occurs chiefly in longleaf pine/turkey oak associations and infrequently in upland oaks proximal to the former (Campbell, 1976). Two specimens were reported (Florida Game and Freshwater Fish Commission, 1976) to have been collected in sandpine and evergreen oak scrub. This is the first confirmed record of this species occurring in evergreen oak scrub. Longleaf pine-turkey oak ridges, upland hammock, and sand pine scrub are cited (Campbell, 1976 and Highton, 1956) as preferred habitat for this species; however, such forest associations are not found on the site.

The only confirmed record of this species in Citrus County is several miles to the east of the proposed site and in a more xeric habitat (Campbell, 1976).

Methods for collecting these animals include pit fall traps with diversionary drift fences, hop nets, and nocturnal road driving. Nocturnal road driving was the method employed to census this species. The short-tailed snake was not encountered on the site.

As with other secretive forms, the scarcity of information on the short-tailed snake makes it particularly difficult to assess impacts or to predict the occurrence of this species.

Methods

The objective of the field sampling was to verify the species occurrence on the site and to evaluate traces of land for their suitability as habitat for the various species. Before field sampling, a list of endangered species was prepared which included preferred habitats and other relevant parameters. Species listed by the United States Department of Interior as Rare and Endangered as well as the gopher tortoise and commensal organisms were the species of major concern. In regard to secretive forms of rare and endangerd fauna, it was determined that habitat association was the best means for predicting their occurrence on the site. Field sampling was conducted as discussed and approved in the plant of study.

Habitat evaluation was made in each major ecosystem based on various types of cover, availability of food, water sources, and denning sites or nesting areas. These parameters were determined from such factors as tree stand characteristics and species composition in both overstory and understory. Additional factors noted, included herbaceous ground cover, organic ground cover (leaf, logs, sticks, etc.), rock abundance, moisture conditions of the soil, and snags. Vegetative data were noted in field by the wildlife biologists and compared with data generated during the vegetative survey. Information was gathered by walking transects and recording habitat condition at an interval of 30 meters. The various systems were rated as good, average, or poor habitat in regard to a particular species. In addition to gathering data on ecological parameters, species of wildlife observed were also recorded. Searches for snakes and other secretive fauna were made while walking transects. This included investigation of wood piles, thickets, and other organic debris. The intent of this survey was to identify any of

those sensitive species which might occur in these habitats, including the indigo snake.

In order to reevaluate the status of the indigo snake on the site, an additional survey was conducted specifically for this species. The survey consisted of searching those areas where indigo snakes or identifiable evidence were likely to occur. In moist habitats (mesic, hydric, and coastal hydric hammock) searches were concentrated in areas of dense understory and ground cover vegetation adjoined by clearings and grassy openings. Also investigated were stumps, logs, rock piles and burrows (pine flatwoods and evergreen oak scrub) gopher tortoise burrows were checked for evidence of indigo snakes. The areas surrounding these burrows were also surveyed.

Field Sampling

Field sampling began on the morning of August 22, 1977 and continued through the evening of August 26, 1977. The morning of each day was spent either setting or baiting traps for small mammals. Each day from approximately 1300 hours until 1500 hours qualitative random searches were employed in the most suitable habitat for gopher tortoise burrows. The afternoons, usually beginning around 1500 hours and lasting until dark, were used to walk transects recording both habitat conditions and species of wildlife. Two transects were inventoried daily beginning with number one on August 22, and ending with number six on August 24. Number seven transect was inventoried on August 25. Two night surveys were conducted by driving along unimproved dirt roads on the property. An additional investigation for the indigo snake was made on August 11, 1978.

Florida Manatee

A dialogue has been carried on with personnel of the Gainesville Field Station National Fish and Wildlife Lab concerning Manatee populations near the proposed site and the potential impacts of Units 4 and 5 upon the endangered Florida Manatee. Individuals at the Gainesville Fish and

Wildlife facility have been collecting data concerning the presence of manatee over a larger area which includes the power plant site. Available information is presently in two forms (Powell, 1978).

One source is a study which receives reports of manatee sightings from members of the general public. Anyone who has seen a manatee is asked to report the sighting by notices posted in appropriate areas. Information from these reports is collected by the Gainesville laboratory and is in the process of being computerized. At present, only the data from 1974 through 1976 has been computerized. Data are entered with a coordinate system which allows printouts of site specific information to be obtained (Scott, 1978).

Another source of information is from overflights of the discharge area which Fish and Wildlife personnel have undertaken on a biweekly basis as a part of a regular census of manatee population in the Crystal River area. Data from these studies have not been developed (Powell, 1978).

A printout of Citrus County sightings was obtained from the 1974 to 1976 data bank. Table 6.1-3 presents a list of sightings reported near the existing power plant facility. The reported years cover a period of time when numerous researchers from the University of Florida were at work in the estuary surrounding the power plant site. It is safe to assume the area was more extensively observed than many other comparable areas during the same period and that scientifically trained observers were more likely to file reports of the sightings than were members of the general public. In short, the number of sightings of manatee in the vicinity of the facility is believed to be a result of more extensive observation and reporting for this particular study rather than an indication of any concentration of manatee in the area.

As mentioned previously, the data from the aerial survey have not yet been compiled. Mr. Powell of U.S. Fish and Wildlife who has been conducting these studies indicated that his initial impression before

Table 6.1-3. Manatee Sightings Reported Near the Crystal River Site to U.S. Fish and Wildlife for 1974-1976

Month	Year	Down*	Across	Number	Respondent
March	1975	482	592	1	B. Obry
March	1975	482	592	1	S. Rednour
March	1975	482	592	2	M. Osterling
June	1975	480	599	1	M. Homer
February	1975	479	595	1	M. Homer
March	1975	479	595	2	M. Homer
August	1975	479	596	1	C. Taylor
June	1975	478	595	1	P. Purcell

* The site of the present Crystal River facilities is about 480 down and 590 across in the Fish and Wildlife computer mapping system. For purposes of comparison, it may be useful to note that the coordinates of the Crystal River head springs are 496 down, 571 across.

Source: U.S. Fish and Wildlife Services, 1978.

intensive study of the data indicated several trends. The manatee do not appear to be using the warm waters of the discharge in cold weather as extensively as has been observed at other sites. The nearby Crystal River spring waters have been reported to be a haven for the manatee (Hartman, 1971). It appears that the manatee are so strongly drawn to the ancestral meeting place at the Crystal River springs that they bypass the power plant discharge waters as a permanent residence. The researchers do feel that when the manatee are moving during fall and spring, they may use the discharge water as a temporary haven during sudden cold weather periods (Powell, 1978).

The Gainesville laboratory also collects the bodies of dead manatees which are found. No manatee bodies have been collected from the power plant area nor have any of the bodies found in the Citrus County area shown signs of power plant-related injuries (Scott, 1978).

6.1.4 GROUNDWATER

Descriptions of the ground water hydrology in the area were obtained from two reports. Geraghty and Miller's Evaluation of Groundwater Resources (1977) at the plant site provided a fairly comprehensive summary of previous groundwater investigations in the area. The other report (Faulkner, 1972) provided some extensive data concerning the geohydrology of the barge canal area. The data presented in this publication are not totally representative of the site and were not used extensively.

Data concerning rainfall in the vicinity of the site were obtained from the U.S. Department of Commerce (1975) from records kept at Inverness, Florida, 39 kilometers (24 miles) southeast of the proposed site.

6.1.5 AIR

The FPC Crystal River power plant is located in a rural area, isolated from other large point sources. Background values of sulfur dioxide, the major pollutant of electric generating plants, are assumed negligible in the vicinity of the site. No natural sources of sulfur dioxide that would constitute any appreciable concentration levels exist in the area.

Until recently, very little background information existed for total suspended particulate matter in this area. An ambient air sampling program for both sulfur dioxide and particulate matter around the site location has been operating since May 1977.

Ambient air quality data pertinent to the application are available from a four-station SO_2 and TSP ambient sampling network and are presented in Chapter 2. TSP is measured with Federal Reference Method (FRM) High-Volume samplers at each station. These monitors are operated on a once-every-sixth-day schedule, which corresponds with the schedule maintained by the regulatory agencies. Thermally-controlled FRM bubblers for sulfur dioxide are operated at two stations. The sulfur dioxide monitoring schedule also corresponds to that established by the regulatory agencies. FRM Equivalent Monitors are operated on a continuous basis at two stations. These monitors are Thermo Electron Model 43 with automatic zero and span. All calibrations are composed either with National Bureau of Standards or with a primary standard. Procedures for sampling are explained in the appendices.

Local meteorological data are acquired at the site by an instrumental two-level tower and were utilized in the Climatology section. Data on wind speed and direction at two levels, plus ambient temperature, lapse rate, precipitation, and barometric pressure are measured on strip charts, continuously, on or near the tower. The sensors are calibrated and maintained routinely in accordance with Atomic Energy Commission

Commission sensitivity specifications for "met" towers (Unit 3 at Crystal River is a nuclear unit). Additional information on the meteorological tower can be found in the appendices.

A 5-year meteorological record from Tampa, Florida, was used in the dispersion modeling. This information was reduced into both long-term and short-term modeling formats applicable to current EPA models.

Cloud cover and cloud ceiling data for the determination of Pasquill's stability classes were taken from the U.S. Weather Bureau office at Tampa. This office was the most representative location where 5 years of data are available. Cloud cover and ceiling are recorded each hour by a trained observer at the U.S. Weather Bureau office.

Three EPA-developed Guassian dispersion models were utilized for all modeling. The Air Quality Display model with Briggs plane rise equation was used for the annual estimates. Short-term impacts were estimated with the single source CRSTER model and multi-source Point Multiple model (PTMTP-W). These models are currently considered the "state-of-the-art" tools available for prediction of ambient air quality concentrations. A description of these models is contained in the appendices.

6.1.6 GEOLOGY

Geological data were obtained principally from four reports. The most useful of these was the Vernon (1951) study of geology in Citrus and Levy counties. The information contained in the Vernon report was obtained through logs of wells in the area as well as through air-photo analysis of surficial features. Most of the data is not specific to the study area, but to the region.

Other geologic information was obtained from the Geraghty and Miller (1977) report, the Department of the Army, Navy and Air Force Seismic Design Manual (1973), and Faulkner's (1973) study of geology in the Ocala, Florida, area. All of these reports supplied only general information. The Geraghty and Miller report provided information, based on existing well logs, on the stratigraphy of the study area. The Department of Army, Navy, and Air Force report provided the relative probability of earthquakes in the study area.

6.1.7 ARCHAEOLOGY

In 1972, the Department of State, Division of Archives, History and Record Management, Bureau of Historic Sites and Properties conducted an archeological and historical survey under contract with the Florida Power Corporation. Basically, the agreement provided for the employment of two survey archaeologists for a period of 2-1/2 months. They were to field-check completely all Florida Power property in the Crystal River tract and to devote any remaining time to surveying the areas within an 8-kilometer (5-mile) radius of the plant site. Florida Power provided survey vehicles (four-wheel drive truck and a boat), storage and office facilities, and logistical and interpretive assistance.

Prior to field examination, the Florida State Master Site Files, local histories, records, old maps, etc., were reviewed to ascertain whether anything of known historical importance was located on or within an 8-kilometer (5-mile) radius of the Crystal River tract. Only two sites were previously recorded in the area.

The survey focused on the coastline and associated estuarine and riverine drainage within the specified 8-kilometer (5-mile) radius. The survey area extended from a point south of the mouth of Crystal River, north to a point in Levy County north of the Withlacoochee River. Survey trips were made up Crystal River, Withlacoochee River, and several of the larger tidal drainages. Survey transportation was restricted to four-wheel drive and a boat. The surface surveys were accomplished by walking over those areas which were determined through the initial research to be the most likely locations of sites. Each site was recorded with the Florida Master Site File.

6.1.8 NOISE

The ambient noise baseline survey was conducted on October 18, 1977. Normally, in determining noise monitoring stations, the following selection criteria (Bolt, Beranek, and Newman, 1973) are employed:

1. Critical Noise Sensitive Sites (e.g., schools, hospitals, or churches on or near major thoroughfares);
2. Residential Areas; and
3. Remote Areas for "Noise Floor" (these should yield the lowest ambient noise level).

Within several kilometers of the existing and proposed plant sites, there are no areas fitting the first two categories. Noise floor levels are encountered between the plant and any noise-sensitive sites. Thus, the scope of the baseline study included only the plant site and its immediate vicinity.

Stations were chosen in order to ascertain noise levels on the present plant site, the future plant site, and at various distance from each. The objective of this study was to determine the "noise drop-off" characteristics from the present plant in order to gauge the future effects of the proposed facility.

A General Radio 1933 Precision Type noise monitor was used for execution of the monitoring survey. Each station was monitored one time while the plant was under normal operating conditions. Noise measurements were taken every ten seconds and recorded. After 50 readings were taken and recorded, a test was made to determine whether or not the quantity L_{10} could be estimated with 95 percent confidence within 2 dBA of the actual level. This test required that the first, fifth, and tenth highest readings be recorded in the same or in adjacent sound level categories.

If the criteria were not met, then 50 more measurements were made and the criteria were applied to the fifth, tenth, and seventeenth highest readings.

6.2 PLANT CONSTRUCTION AND OPERATION MONITORING

During site preparation, facility construction, and facility operation; the environmental parameters of air and water will be monitored for levels relative to those projected in Chapters 4 and 5. In addition, a plan of action will be implemented if an archaeological discovery is made.

The impacts related to the other environmental areas; i.e., aquatic and terrestrial ecology, geology, solid wastes, and noise, will not be of significant magnitude to warrant additional monitoring during these phases of the project.

6.2.1 AIR

During site preparation and facility construction, the significant air emissions will be fugitive dust from land clearing and grading and smoke from burning of the land-clearing wastes. Both of these emissions are classified as particulate matter and can be measured by the Federal Reference Method (FRM) High-Volume samplers (40 CFR Part 50).

Once Units 4 and 5 are operating, the significant air emissions to be monitored will be the particulate matter and sulfur dioxide from the combustion of coal in the two coal-fired steam-generators. In addition to the FRM High-Volume sampling technique for sampling particulate matter, an FRM sulfur dioxide reference method and equivalent methods for sulfur dioxide have been promulgated. Both methods can be utilized to measure the air emissions during plant operations.

Three sampling stations are proposed as the construction and operation air monitoring network. These stations are the same as three of the baseline monitoring program stations (stations 1, 2, and 4; station 3 will not be continued; see Figure 2.9-1). Each station will measure ambient concentrations of total suspended particulate matter and sulfur dioxide (sulfur dioxide monitoring will be required only during operation). A minimum sampling will be scheduled once every sixth day, and monitoring will continue for the life of the units.

The meteorological monitoring data available from the existing meteorological station will continue to be used by Florida Power. The tower will monitor those parameters stated in Section 6.1.5.

6.2.2 WASTEWATER

The water quality monitoring program will consist of sampling at the following six potential discharge sources during plant operation:

#009 and 010	Cooling Tower Blowdown
#011	New Coal Storage Area
#012	Ash Disposal Area
#013	Runoff Collection Retention System

All sampling and analytical procedures will be those contained in 40 CFR 136.

The cooling tower blowdown will be discharged to the existing discharge canal as shown in Figure 6.2-1. The wastewater will contain chlorine and phosphate as algicide and scale inhibitors and will concentrate the solids content of the cooling water. Prior to mixing with the cooling canal water, the discharge will be sampled for the following parameters at the frequency indicated:

pH--Once per day
Flow--Continuous
Temperature--Continuous
Chlorine Residuals (Free and Total)--Once per week including time of release
Phosphorus (as P)--Once per week
Calcium--Once per week
Conductivity--Continuous

The wastewater from miscellaneous plant drains, steam condensate feed cycle, and the neutralization basin will be collected in the plant drains collection pond. The pond is designed for evaporation and percolation of all incident rainfall and influent wastewater except for a relatively small volume which will be routed to the ash disposal area for ash dust suppression and compaction; thus, it is not necessary to equip the pond with a design storm overflow structure.

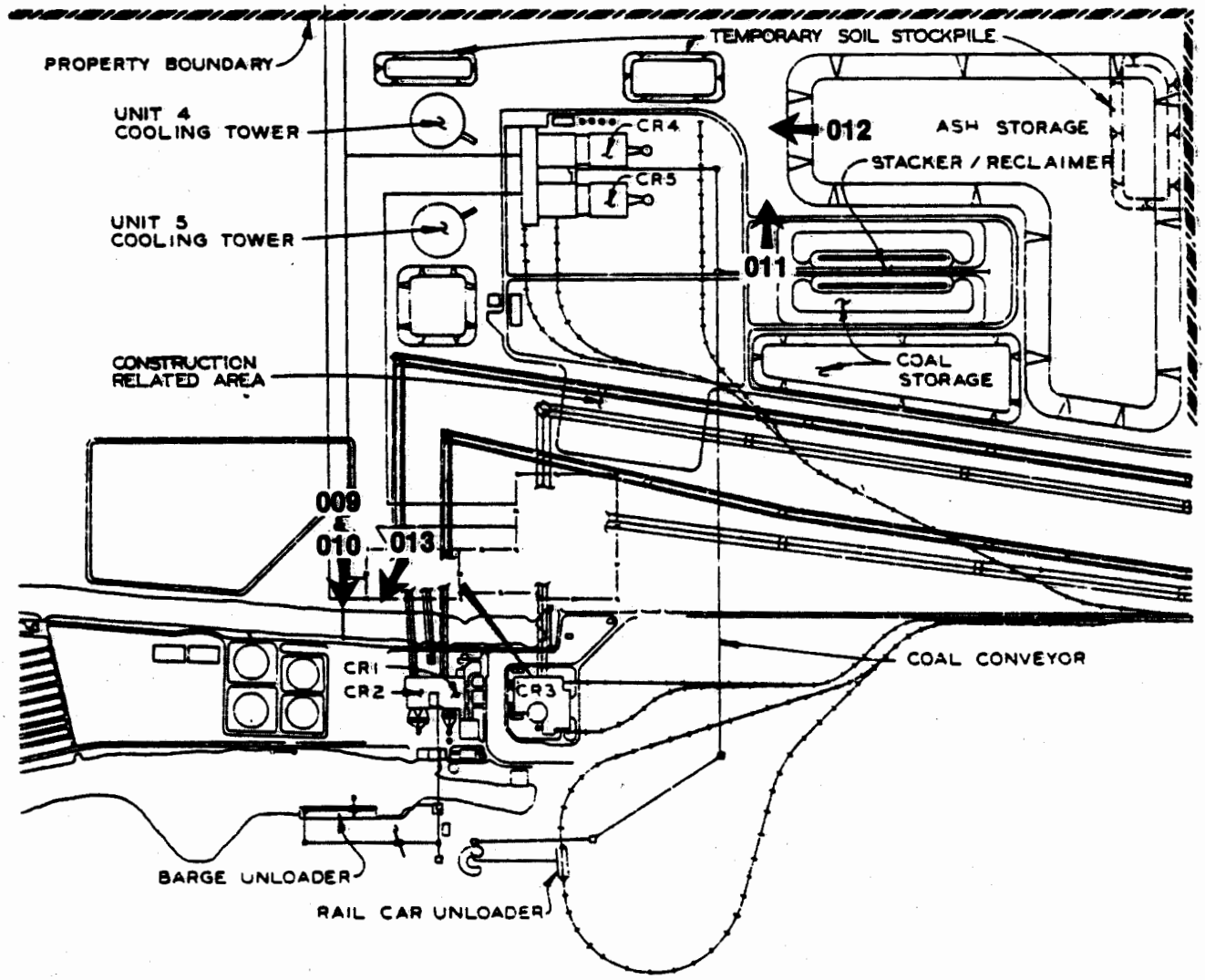

Figure 6.2-1
EFFLUENT SAMPLING LOCATIONS.

N

0 1000 2000
SCALE IN FEET

SOURCE: BLACK AND VEATCH, 1980.

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

The new coal storage area will be diked to retain runoff equivalent to a quantity of rainfall equal to or less than a 10-year, 24-hour storm. Runoff in excess of this design criteria will discharge into the runoff collection ditch which flows into the cooling water discharge canal. The standing water in the areas or the discharge when it occurs will be sampled for the following parameters at the frequency indicated:

Flow--Weir reading once per week during discharge periods

Total suspended solids--Once per week

Heavy metals (cadmium, chromium, copper, iron, lead, mercury, nickel, selenium, and zinc) and arsenic--Once per month during periods of discharge; otherwise, samples will be taken from the pond once in the 3-month monitoring period.

The ash disposal area will be a diked storage area with sufficient capacity to retain the direct runoff from a storm equal to or less than a 10-year, 24-hour storm event. Runoff in excess of this design criteria will be discharged to the canal retention system and then into the existing cooling water discharge canal. The diked area or its discharge will be sampled for the following parameters at the frequency indicated:

Flow--Weir reading once per week during discharge periods

Total suspended solids--Once per week

Heavy metals (cadmium, chromium, copper, iron, lead, mercury, nickel, selenium, and zinc) and arsenic--Once per month during periods of discharge; otherwise, samples will be taken from the pond once in the 3-month monitoring period.

The canal retention system will receive discharges from the plant roof drains, and runoff from the ash disposal area and the coal storage areas which exceed the design criteria of those areas. In addition, the canal retention system will receive the general stormwater runoff from the remaining facility areas and will have a capacity to store the runoff from rainfall events equal to or less than a 10-year, 24-hour storm.

The water in the ditch or the discharge when it occurs will be monitored for the following parameters:

pH--Once per day

Flow--Weir reading once per day during discharge periods

Total suspended solids--Twice per week

Oil and grease--Once per week

Heavy metals (cadmium, copper, iron, lead, mercury, nickel, selenium, and zinc) and arsenic--Once per month during periods of discharge; otherwise, samples will be taken from the pond once within the 3-month monitoring period.

Disinfected sewage treatment plant effluent will be routed to a dedicated percolation pond, sized to allow percolation of the entire effluent flow.

6.2.3 GROUND WATER

Groundwater monitoring is incorporated into a leachate monitoring and testing program designed to comply with requirements of the FDER Special Conditions of Certification, as revised in September 1978, and the requirements of the EPA Environmental Impact Statement and NPDES permit for Crystal River Units 4 and 5. Although it is specifically concerned with leachate from the ash landfill, the program will effectively monitor shallow ground water throughout the project site. The program, to be conducted by Environmental Science and Engineering, Inc., consists of the following major phases:

- Phase I--Baseline Monitoring, Groundwater Quality and Hydraulics
- Phase II--Leachate Formation and Control, and Attenuation Testing
- Phase III--Zone-of-Discharge Analysis
- Phase IV--Evaluation of Performance of Demonstration Landfill Cells
- Phase V--Geophysical Survey and Mapping of Solution Cavities
- Phase VI--Design and Construction of Ash Landfill

PHASE I: BASELINE MONITORING

This phase includes a year-long water quality study with provisions for subsequent annual sampling, as well as an analysis of aquifer hydraulics.

A network of 15 observation wells, 12 shallow and 3 deep, has been constructed onsite as shown in Figure 6.2-2. Table 6.2-1 provides well construction data. The wells are located both upgradient and downgradient of the ash disposal area, new coal storage area, plant drains collection pond, and runoff retention system.

Key water quality parameters will be monitored monthly and extended water quality parameters will be monitored quarterly as indicated in

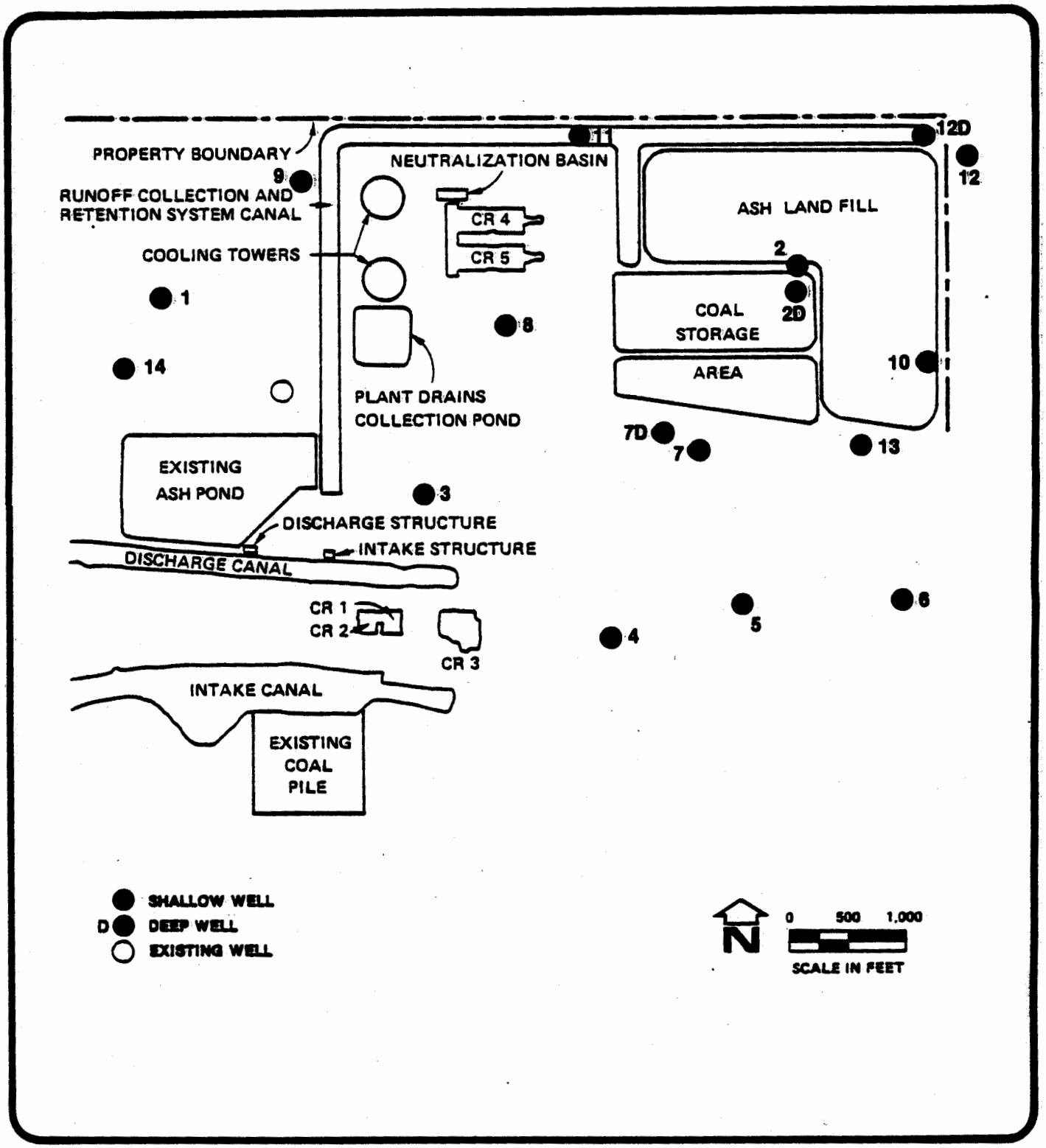

Figure 6.2-2
LOCATION OF OBSERVATION WELLS FOR LEACHATE MONITORING PROGRAM FOR CRYSTAL RIVER UNITS 4 AND 5.

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1980.

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

Table 6.2-1 Construction Details of Observation Wells for Leachate Monitoring Program for Crystal River Units 4 and 5

Well Number*	Well Diameter	Well Depth	Casing Depth
OW-1	2"	20'	18.5'
OW-2	4"	20'	18.5'
OW-2D	2"	58'	53.8'
OW-3	4"	20'	18.5'
OW-4	2"	23'	23.0'
OW-5	2"	20'	18.5'
OW-6	2"	20'	18.5'
OW-7	4"	20'	18.5'
OW-7D	4 1/2"†	45'	42.4'
OW-8	2'	20'	18.5'
OW-9	2"	20'	18.5'
OW-10	2"	20'	18.5'
OW-11	2"	20'	18.5'
OW-12	4"	20'	18.5'
OW-12D	2"	53'	47.3'
OW-13	2"	20'	18.5'
OW-14	2"	20'	18.5'
OW-15	4"	20'	18.5'

*See Figure 6.2-2 for location.
†Upper 17.4' of hole has 4" casing; 2" casing from 17.4' to bottom of hole.

Table 6.2-2. Wells 7, 7D, 12, and 12D will be sampled in the water quality study.

Hydraulic aquifer analysis will be based on wet and dry season monitoring of observation wells for water level and specific conductivity, and on tide data, barometric pressure, pan evaporation, and rainfall. Data will be used to construct water table elevation maps, to assess hydraulic homogeneity in the shallow aquifer, to determine the degree of tidal coupling between the aquifer and the Gulf of Mexico, and to establish aquifer response to rainfall.

PHASE II: LEACHATE TESTING

This phase will consist of the following five related efforts:

Ash shake tests will generate a synthetic leachate from ash representative of that to be produced at Units 4 and 5. Actual leachate characteristics may be predicted using the synthetic leachate.

Soils testing will utilize limestone fill base and subsoil from the ash landfill site to establish baseline metals concentrations and to determine the ability of the subsoil to remove metals from leachate.

Clay testing will be performed on locally available clays to determine their suitability for use as liners for the ash landfill.

Permeability and compaction testing of ash, subsoil, and clay potentially suitable as liners will be analyzed to establish the compaction and mixtures necessary for suitable permeabilities.

Column leaching tests will assess leachate attenuation through columns of potential liner materials.

Table 6.2-2 Groundwater Quality Parameters

Key Water Quality Indicators (Monthly)

Specific Conductivity*	Iron
Color	Nickel
Turbidity	Selenium
Chloride	Chromium
Sulfate	Arsenic
Dissolved Organic Carbon	Beryllium
Total Dissolved Solids	Mercury
Total Suspended Solids	Lead

Monitored During Aquifer Analysis

pH	Dissolved Oxygen
Redox Potential	Temperature
Specific Conductivity*	

Extended Water Quality Indicators (Quarterly)

The key indicators listed above plus:

Aluminum	Cobalt
Barium	Gross Alpha†
Calcium	Vanadium
Magnesium	Molybdenum
Sodium	

*Monitored in all wells during aquifer analysis; monthly water quality program monitors specific conductivity in only four wells.

†If Gross Alpha $\geq$ 15 pic/l, the following elements will be analyzed:

Radium 226
Uranium
Thorium

PHASE III: ZONE OF DISCHARGE ANALYSIS

The results of Phase I and Phase II will be analyzed in this phase through groundwater quality modeling in order to simulate leachate transport through the aquifer zone of discharge.

PHASE IV: DEMONSTRATION CELLS

One or more test cells designed to minimize leachate production will be constructed at the ash landfill site, using representative ash. Seepage through the cell will be monitored in adjacent wells constructed especially for this purpose.

PHASE V: GEOPHYSICAL SURVEY

Resistivity analysis will provide information on the presence of solution cavities within the landfill.

PHASE VI: DESIGN AND CONSTRUCTION OF LANDFILL

Preceding phases having provided the site- and material-specific information necessary, an ash landfill will be designed and constructed which will enable adequate leachate attenuation.

6.2.4 ARCHAEOLOGY

During construction activities, normal archaeological monitoring and safeguards will be followed to protect possible discoveries. The state historic preservation officer will be notified if a potential historical site or find is discovered. Work will be stopped in the immediate area and will not be resumed until the approval of the Florida Division of Archives, History, and Records Management is received.

Chapter 7 Economic and Social Effects of Plant Construction and Operation

CHAPTER 7

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7.0 ECONOMIC AND SOCIAL EFFECTS OF PLANT CONSTRUCTION AND OPERATION

7.1 INTRODUCTION

Formal cost-benefit analysis procedures were originally developed as a means of evaluating alternative public projects. Benefits to the public were expressed in monetary terms so that the ratio of benefits to expenditures for a given project could serve as a general index of project favorability. The cost-benefit ratio thus provided a common measure for evaluating dissimilar uses of public funds. Recently, cost-benefit analysis has also become widely accepted for project justification in the private sector and joint public/private ventures.

The proposed construction and operation of Crystal River Units 4 and 5 have elements of both a public and private enterprise because of Florida Power's status as a publicly-regulated utility and the public's critical need for electric power. The application of cost-benefit analysis in this case is complicated by the large number of different population groups and organizations that will experience benefits and costs as a result of the project. A partial listing of these groups is as follows:

Florida Power, its employees, and stockholders
Local government units and taxpayers
Residents and businesses in the Florida Power economic impact area
Workers in the Florida Power labor market area
Employers in the Florida Power labor market area
Existing and prospective customers of Florida Power
State government of Florida
Competing fuel users in the United States and elsewhere

Due to the number of groups and interrelationships involved, the full economic impacts of the project could not be expressed adequately in a single cost-benefit comparison or ratio. Two other problems affecting the analysis are the following. First, most of the dollar flows generated by the proposed project will be payments for goods or services

rendered, so that the actual net benefit created in each case will not equal the amount of the transaction per se. The net benefit will consist either of a portion of the payment, or a "surplus" quantity which is not actually paid (see below). Second, there are a large number of unknown factors which make the forecasting of future costs and benefits difficult.

This chapter will focus first upon the cost-benefit status of the project for Florida Power itself, and for the individuals and organizations that purchase electricity from Florida Power. Other economic and social impacts of the project will be listed and discussed individually, without attempting to determine whether the sum of benefits will exceed the sum of costs for specific population groups or organizations. Even in the two cases just mentioned, it will be possible only to state whether or not there is a net benefit under various alternative assumptions.

NOTE: The Draft Environmental Impact Statement was prepared in 1977 and 1978. Since that time, a number of changes have occurred, such as the dramatic increase in the price of energy and in discount rates. Although updated economics data would reflect different statistics, the conclusions presented in this chapter would not be changed, since the analysis performed in 1977 and 1978 compared costs/benefits on the same relative (present worth) basis.

7.2 COSTS AND BENEFITS OF THE PROJECT TO POWER USERS AND TO FLORIDA POWER CORPORATION

7.2.1 COSTS ATTRIBUTABLE TO PROPOSED CRYSTAL RIVER UNITS 4 AND 5

The cost-benefit analysis of the proposed project utilizes cost information that was originally developed to evaluate the choice between low-sulfur and high-sulfur coal (see Chapter 8). The annual costs of capital, fuel, and operation/maintenance have been determined for Crystal River Units 4 and 5 in each year of operation. The cost estimates assume the use of saltwater cooling towers. The present worth of these power generation costs for each unit has been determined by discounting back to April 1, 1978, using the estimated cost of capital to Florida Power (11.1 percent). The figures for the low-sulfur coal option, which is the only relevant case here, are shown in the upper portion of Table 7.2-1.

The assumptions underlying the estimated power generation costs are discussed in Chapter 8. Two especially significant quantities are the rates of escalation in fuel costs and operation/maintenance costs. The delivered cost of coal is assumed to rise by 10 percent per year between 1977 and 1980, and by 5 percent per year after 1980. Operation/maintenance costs are assumed to escalate indefinitely at a rate of 6 percent per year. Thus, the estimated power generation costs assume continued inflation in the U.S. economy. This point becomes important when placing a dollar value on the electricity produced.

The total costs attributable to the construction and operation of Crystal River Units 4 and 5 include a number of elements other than power generation expenditures. It is necessary to account for the costs of transmitting and distributing the electricity generated, plus the general administrative expenses and tax payments incurred by Florida Power. In addition, the proposed power generation units must contribute to the net income available for dividend payments to Florida Power stockholders. The information utilized to estimate these additional costs is presented in Table 7.2-2.

Table 7.2-1. Summary of Incremental Costs Associated with Crystal River Units 4 and 5

	Present Worth of Expenditures in Millions of April 1978 Dollars		
	Unit 4	Unit 5	Total
POWER GENERATION COSTS			
Capital	292.8	191.6	484.4
Fuel	700.5	644.0	1,344.5
Operation/Maintenance***	54.8	51.0	105.8
SUBTOTAL	(1,048.1)	(886.6)	(1,934.7)
SHARES OF OTHER COSTS ATTRIBUTABLE TO UNITS 4 AND 5			
Transmission, Distribution, and Administration*	87.8	80.8	168.6
Capital Costs Other than Power Generation Facilities †	20.4	13.4	33.8
Taxes Payable Currently**	129.4	119.1	248.5
Dividend Payments ††	110.3	101.5	211.8
SUBTOTAL	(347.9)	(314.8)	(662.7)
TOTAL PRESENT WORTH	1,396.0	1,201.4	2,597.4

* Assumed equal to 11.63 percent of fuel plus O/M costs.
† Assumed equal to 7 percent of capital costs for power generation.
** Assumed equal to 17.13 percent of fuel plus O/M costs.
†† Assumed equal to 14.60 percent of fuel plus O/M costs.
*** Operation/maintenance costs do not include contingencies associated with the operation of saltwater cooling towers; only normal costs are included.

Sources: Florida Power Corporation, 1978.
Environmental Science and Engineering, Inc., 1978.

Table 7.2-2. Recent Revenue and Expenses of Florida Power Corporation (x $1,000.00)

	1977	1976
SUMMARY OF REVENUES AND EXPENSES		
Production and maintenance expenses	317,218	305,329
Transmission, distribution, administration	38,789	33,635
Taxes payable currently	79,876	27,730
Deferred income taxes and investment tax credit (net)*	41,045	53,895
Depreciation*	54,440	41,440
Operating income	124,770	89,410
(Dividend payments)	(46,830)	(44,117)
(Net interest payments)	(49,093)	(42,722)
(Retained earnings)*	(28,847)	(2,571)
TOTAL OPERATING REVENUE	656,138	551,439
SELECTED EXPENSES AS PERCENTAGES OF PRODUCTION AND MAINTENANCE COST		
Transmission, distribution, administration	12.23%	11.02%
Taxes payable currently	25.18%	9.08%
Dividend payments	14.76%	14.45%
TOTAL	52.17%	34.55%

* These items constitute sources of funds used for construction. The figures for retained earnings do not include income other than operating revenues.

Source: Ten Year Statistical Report, 1976-1977; Florida Power Corporation.
Environmental Science and Engineering, Inc., 1978.

Table 7.2-2 presents a summary of revenue and expense statistics for Florida Power in 1977 and 1976. The portions of operating income devoted to dividend payments, net interest payments, and retained earnings are indicated by the figures in parentheses. The procedure used in assigning non-production costs to the proposed Crystal River units is to express the actual costs for 1977 and 1976 as percentages of production and maintenance costs, and then to apply the percentages to the future production costs for the proposed units. For example, the total cost of power transmission, distribution, and administration was equal to 12.23 percent of production and maintenance cost in 1977, and 11.02 percent in 1976 (see the lower portion of Table 7.2-2). The average of these two figures, 11.625 percent, can be applied to the sum of fuel and operation/maintenance costs for the proposed units to estimate the share of future transmission, distribution, and administrative costs attributable to these units. The present worth of each of these additional cost elements is listed in the lower portion of Table 7.2-1.

The additional cost elements shown in the lower portion of Table 7.2-1 do not include interest payments or funds used for new construction (indicated by asterisks in Table 7.2-2), since these items are already covered by the capital costs listed elsewhere in Table 7.2-1. However, estimates are included for capital costs other than power generation facilities. The shares of these costs attributable to the proposed Crystal River Units 4 and 5 are assumed to equal 7 percent of the capital costs for power generation.

The outcome of these computations is that the total present worth of expenditures associated with construction and operation of the proposed units is estimated at $2,597 million in April 1978 dollars (shown in the bottom line of Table 7-2.1). The present worth of Unit 4, at approximately $1.4 billion, is substantially above the worth of $1.2 billion assigned to Unit 5. The difference is due to sharing of facilities with Unit 4 and to the fact that costs occur later for Unit 5 than for Unit 4. These present worth values are intended to cover all costs

attributable to the proposed Crystal River Units 4 and 5, including the normal profits required to keep a private corporation such as Florida Power in operation.

7.2.2 BENEFITS OF THE PROJECT TO FLORIDA POWER CORPORATION

The sale of electricity produces benefits for both Florida Power and its customers. Benefits to Florida Power can be estimated in a more straightforward fashion than benefits to consumers and thus are considered first. A major complicating factor is the difficulty of forecasting accurately forecasting the future price of electricity. All computations of future benefits are very sensitive to the price assumed (referring to the weighted average charge per kilowatt-hour for all classes of power users). Therefore, it is necessary to consider several different price escalation rates in the analysis.

The benefits of the proposed project to Florida Power consist simply of the revenues yielded by sale of electricity from Crystal River Units 4 and 5. Table 7.2-3 presents operating statistics for Florida Power which have been used to compute the average price of electricity in 1977. Total operating revenues in that year were equal to 4.12 cents per kilowatt-hour of electricity sold, but only 3.83 cents per kilowatt-hour generated, purchased, or interchanged (the difference due to company use and losses of energy). The latter type of figure is appropriate for valuing the net output of a new generating facility.

Regarding the escalation of electricity prices over time, four separate cases have been considered as shown in Table 7.2-4. The first three cases involve constant escalation rates of 4 percent, 4.5 percent, and 5 percent, respectively, for all years subsequent to 1977. The fourth case involves an escalation rate of 6.7 percent until July 1, 1980, and 4 percent thereafter. The fourth case is intended to be consistent with recent trends in electric rates, and with the assumed escalation in fuel cost. Between 1975 and 1977, the average price of electricity sold by Florida Power increased at a rate of 6.7 percent per year. The cost analysis has assumed that the delivered cost of coal to Florida Power will increase by 10 percent per year until 1980. Thus, a continuation of the 6.7 percent rate of increase in electricity prices during 1977 to

Table 7.2-3. Selected Operating Statistics for Florida Power Corporation

Total energy generated, purchased, and interchanged	17,133.8 Gwh
Company use and losses	1,198.8 Gwh
Total energy sold	15,935.0 Gwh
Total operating revenues	$656,138,000
Revenue per kwh sold	$0.0412
Revenue per kwh generated, purchased, and interchanged	$0.0383

Source: Ten Year Statistical Report, 1976-1977; Florida Power Corporation.

Table 7.2-4. Assumed Escalation Rates of Quantities Used in the Cost-Benefit Computations

Average Price of Electricity:	
Case I	4%
Case II	4.5%
Case III	5%
Case IV	6.7% before 1980 4% after 1980
Operation and Maintenance	6%
Fuel	10% before 1980 5% after 1980

Source: Environmental Science and Engineering, Inc., 1978.

1980 would imply that not all of the fuel cost increment will be passed on to Florida Power consumers.

Each of the proposed units is expected to generate an average of 3,300 Gwh of electricity per year over its 30-year active life. (Utilization of the full 640-Mw net capacity would imply power generation at a rate of 5,610 Gwh per year.) Using each of the four escalation rates listed in Table 7.2-4, the average price of electric power has been determined for every year between 1982 and 2013, based on a 1977 price of $0.0383 per kwh generated. These future prices have been multipled by 3,300 Gwh, discounted back to April 1, 1978 (using the cost of capital as the discount rate), and summed to yield a present value of electricity sales in millions of dollars. The resulting figures for each power generation unit, given each rate of price escalation, are presented in the first two columns of Table 7.2-5.

The total present worth of electricity sales in each case is presented in the third column of Table 7.2-5. The fourth column gives the present worth of project cost (from Table 7.2-1), which is the same for all four cases. The ratio of sales to cost is presented in the last column of Table 7.2-5. This ratio indicates the benefit-cost status of the project to Florida Power as a corporate entity (but not necessarily to its employees, customers, stockholders, etc.). A ratio of unity would mean that all project costs would be covered by revenues over the long run, including a reasonable return to investors. If Florida Power were a typical profit-making enterprise, a ratio greater than unity would mean that the project could be expected to yield excess profits. However, given that the company is a regulated public utility (and that any future electricity prices will be regulated prices), a value greater than unity probably indicates that the proposed project would be subsidizing other, less efficient power generation units.

The last column of Table 7.2-5 shows that the benefit-cost ratio of the project for Florida Power will be almost exactly unity in two different scenarios: (1) if electricity prices escalate at a uniform rate of 4.5

Table 7.2-5. Present Worth of Electricity Sales and Florida Power Corporation Expenditures Attributable to Crystal River Units 4 and 5

		Present Worth of Sales, in Millions of April, 1978 Dollars			Present Worth of Expenditures (Millions of Dollars) April, 1978	Sales/ Expenditures Ratio
		Unit 4	Unit 5	Total		
Assumed Rate of Escalation in the Average Sale Price of Electricity per kwh						
Case I:	4% per year	$1,262.1	$1,143.1	$2,405.2	$2,597.4	0.93
Case II:	4.5% per year	$1,361.0	$1,241.6	$2,602.6	$2,597.4	1.00
Case III:	5% per year	$1,469.7	$1,350.4	$2,820.1	$2,597.4	1.09
Case IV:	6.7% until 1980 4% after 1980	$1,362.3	$1,233.8	$2,596.1	$2,597.4	1.00

Source: Environmental Science and Engineering, Inc, 1978.

percent per year; or (2) if the price escalation rate is 6.7 percent until 1980 and 4 percent per year thereafter. A price escalation rate of 5 percent will yield a benefit-cost ratio of 1.086, whereas the ratio will be only 0.926 if electricity prices escalate at 4 percent per year.

According to these figures, it will not be necessary for Florida Power to pass on the full increases in fuel cost and operation/maintenance cost to consumers in order to break even on the proposed units. The two scenarios with benefit-cost ratios near unity would involve less rapid escalation in electricity prices than in fuel and operation/maintenance costs (except that the operation/maintenance escalation rate would be exceeded slightly during 1977-1980 in Case IV). On one hand, this means that the gain in average productive efficiency resulting from the introduction of Crystal River Units 4 and 5 could enable Florida Power to absorb certain cost increases internally. On the other hand, if the escalation in electricity prices is greater than the rates assumed in Cases II and IV, the analysis indicates that Crystal River Units 4 and 5 will be generating net revenue in excess of normal profits. Because of the status of Florida Power as a publicly regulated utility, this revenue must ultimately benefit the public. For example, it could be applied to upgrading or pollution control measures at other facilities in the system.

7.2.3 NET BENEFITS TO ELECTRICITY CONSUMERS

The benefits of the proposed Crystal River Units 4 and 5 to Florida Power customers will involve the influence of the project on the average price of electricity and the availability of electric power. The second factor relates to the ability of Florida Power to meet peak power demands without costly interruptions in service. The manner in which these factors determine consumer benefit is illustrated below in a brief supply-demand analysis. The analysis is complicated somewhat by special circumstances involving electric power production (namely, the importance of peak versus average demands, the existence of regulated prices and non-price rationing, and the costs of service interruption). However, it is possible to represent the essential elements.

Figure 7.2-1 depicts three hypothetical cases of supply-demand equilibrium for electric power. Considering Case I, in the upper diagram, the demand curve is denoted DD and the supply curve is denoted SS. (Ignore for the moment the dashed-line extension of the supply curve.) Since Florida Power is a regulated public utility, the supply curve is equivalent to an average cost curve. That is, the analysis assumes that at any level of production, the average price charged for electricity will never exceed the level necessary to cover all costs (including a normal return to investors). The downward slope of the curve at low levels of production reflects the influence of fixed costs; the upward slope in the high output range reflects the need to utilize relatively inefficient equipment when production approaches capacity. (The supply curve shown pertains to an intermediate time horizon. In the very short run, the supply function would be horizontal since electric rates would be fixed. In the long run, the supply function would also be nearly horizontal, since the company could adjust its productive capacity to any level that was optimal in terms of demand.)

The intersection of the supply and demand curves for electric power in Case I occurs at point "A." The equilibrium output is thus the quantity Q_1 (in Kwh). The total expenditures for electricity by all classes

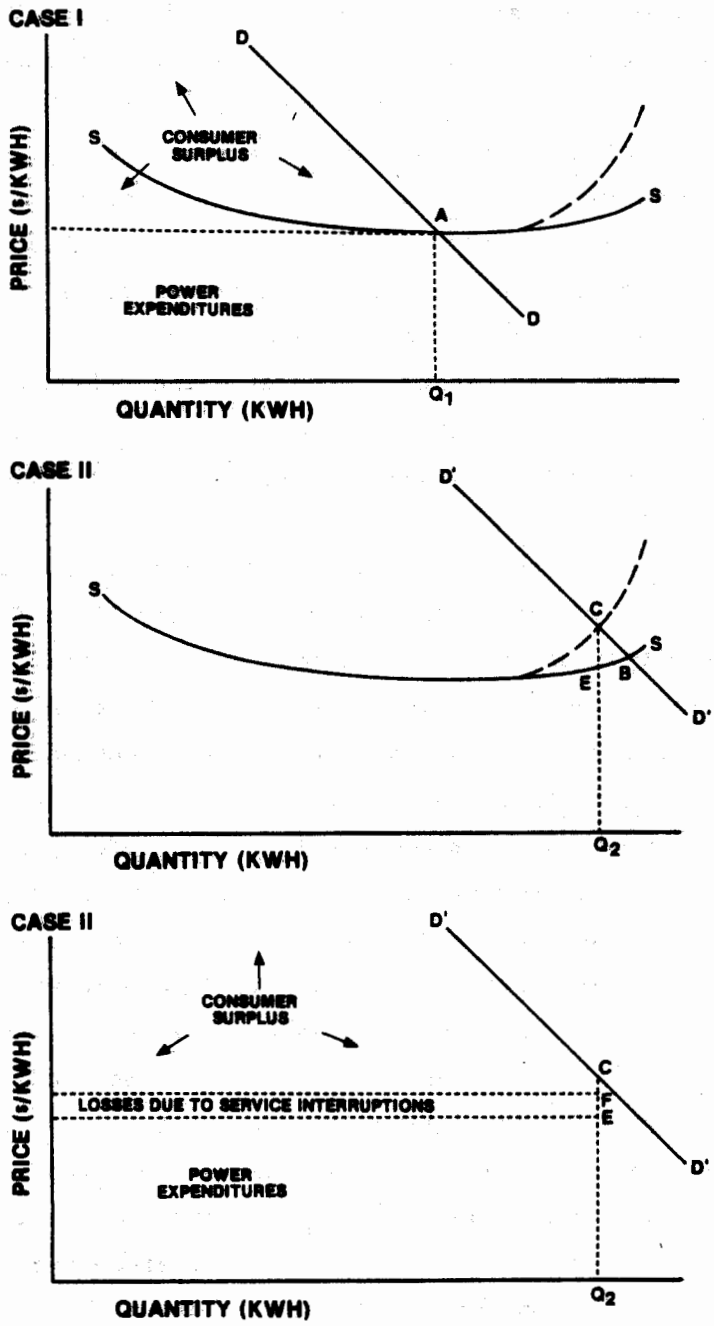

Figure 7.2-1
GENERALIZED SUPPLY-DEMAND EQUILIBRIUM FOR ELECTRIC POWER

SOURCE: ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1978

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PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

of users are represented by the rectangular area below and to the left of "A," namely the area enclosed by dotted lines. The net benefits accruing to customers as a result of electricity purchases can be measured in terms of the "consumer surplus." This quantity is the sum of all additional amounts that consumers would be willing to pay if each unit of electricity were sold individually at the maximum price that the market would bear. The consumer surplus is equal to the area above the horizontal dotted line but below the demand curve (not all of which is shown in the diagram). Since consumer surplus is the best measure of net benefits to electricity purchasers, the relevant question when considering a new facility is whether or not the facility will cause an increase in consumer surplus relative to the no-project alternative.

Before discussing the impact of the proposed units, it is necessary to describe another set of circumstances. Case II in Figure 7.2-1 depicts a future situation in which the demand for electric power has increased, so that the demand curve is now the line denoted D'D'. If this demand function referred to constant rather than fluctuating energy requirements, the equilibrium would occur at point B. However, it is assumed in this example that the average level of production implied by point B would involve short-term peak energy consumption exceeding the productive capacity of the power company. Thus, the average or long-term production of electricity is constrained to a lower quantity, denoted Q_2. In order to represent this as an equilibrium situation, another "supply curve" has been drawn in the figure as a dashed line. This function expresses the limited ability of the power company to fulfill short-term peak demands. The equilibrium solution is shown to occur at point C, where the dashed line crosses the demand curve. The dashed line is not a true supply curve, however, since the price paid by power customers is that indicated by point E rather than point C. (This is a case of non-price rationing which results because the producer is restricted to the average cost curve when setting prices, rather than charging what the market will bear.)

The lower portion of Figure 7.2-1 depicts the net benefit to consumers associated with the situation just described. Payments to the power company are equal to the area below the horizontal dotted line through

point E. Consumer surplus would equal the area above this line. However, the present example assumes that power customers suffer economic losses as a result of the capacity constraint on peak energy usage (e.g., monetary costs associated with power failures). These losses are represented in the diagram as a subtraction from consumer surplus. The magnitude of the subtraction is equal to Q_2 times the distance between points F and E. (The placement of point F is not related to the other curves; F could be either above or below point C.) Case II is very important in the present context since capacity constraints could well affect future sales by Florida Power if the proposed facilities are not constructed.

Figure 7.2-2 deals with the effect on consumer surplus of an increase in power generating capacity. In both of the cases depicted, the supply curve without new facilities is denoted SS, whereas the supply function with the addition of new capacity is denoted S'S'. The two cases illustrate the conditions under which consumer surplus is increased by the expansion of generation capacity. In case A, the supply-demand equilibrium without new facilities occurs below the level at which capacity is constraining upon electricity sales. (The equilibrium point G lies to the left of the dashed line.) Thus, the special circumstances involving capacity constraints do not apply either before or after the addition of new facilities. In this case, it is obvious that consumer surplus will increase only if the new facilities reduce the average price of electricity. That is, since the demand curve is unchanged, the area between the horizontal price line and the demand curve can only increase if the price line is lowered. This situation is shown to occur in case A, where the supply-demand equilibrium shifts from point G to point H.

Case B in Figure 7.2-2 is a situation in which capacity constraints are binding before the addition of new facilities. The demand curve and the points C, E, and F are all at the same locations as in Case II of Figure 7.2-1. As before, point F refers to the "price" of power when losses due to service interruptions are added to the actual payments for electricity. This case is assumed to be a situation in which the new production facilities are somewhat less efficient than the existing

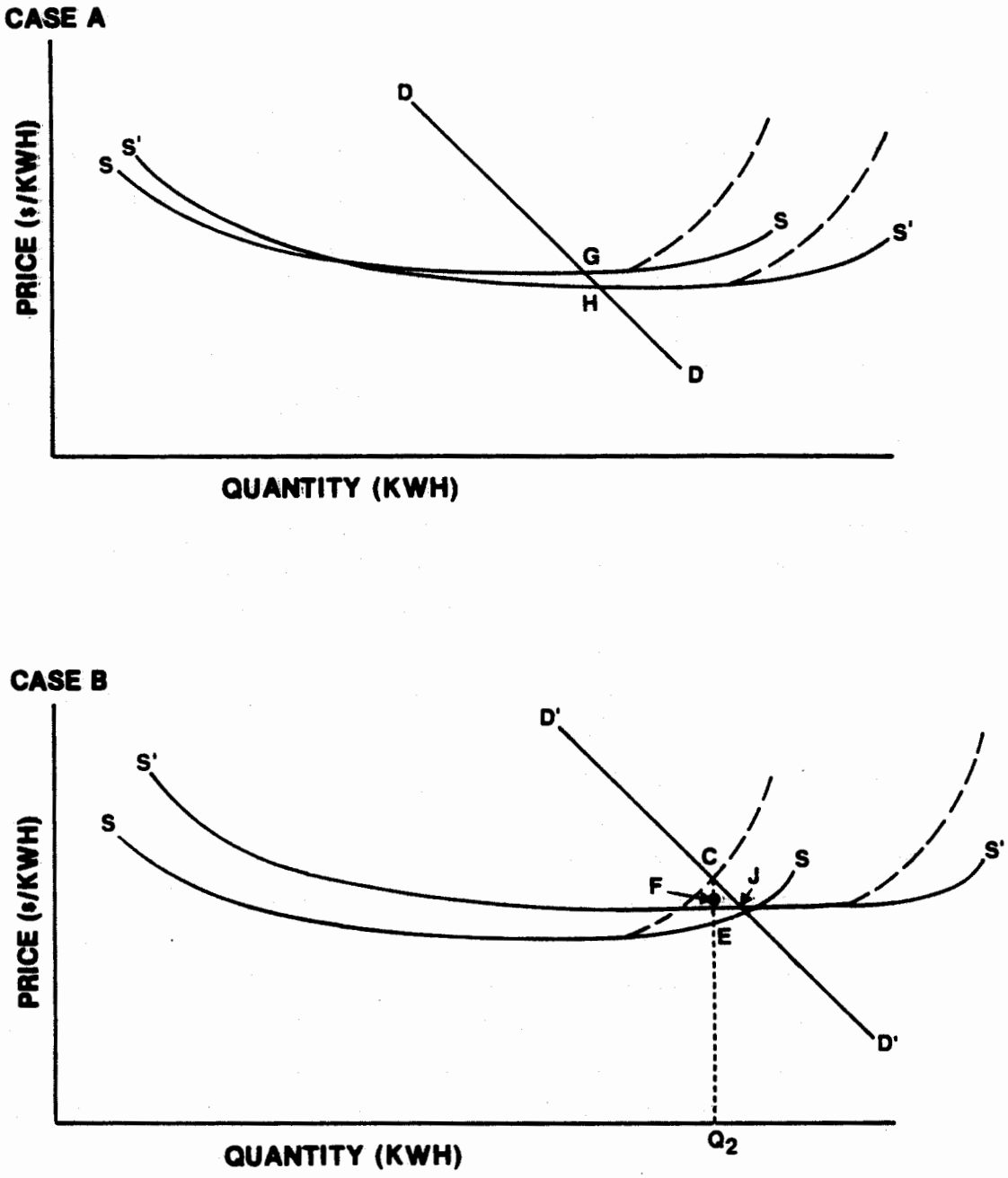

Figure 7.2-2
HYPOTHETICAL EFFECTS OF INCREASES IN PRODUCTIVE CAPACITY

SOURCE: ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1978

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CITRUS COUNTY, FLORIDA

facilities. Thus, the new supply curve S'S' lies above the old supply curve SS throughout the relevant range. The new supply-demand equilibrium is at point J, which involves an increase in direct payments for electricity (relative to point E). Nevertheless, there is an increase in consumer surplus as presently defined, for the reason that losses due to service interruptions are eliminated. The two important considerations are that there is no capacity constraint at point J, and that the new supply curve S'S' lies below point F. The increase in consumer surplus is equal to Q_2 times the ordinate of F minus the ordinate of J, plus the small triangular area to the right of F. This example demonstrates that electric power consumers can benefit from new productive capacity when there is no change, or even a moderate decline, in the overall efficiency of production.

Now referring specifically to Florida Power, it is difficult to establish with certainty that the proposed Crystal River Units 4 and 5 will increase the overall productive efficiency of the system. Such an increase appears very likely, in view of the previously-discussed assumption that Florida Power will not have to pass on to consumers the full escalation in fuel and operation/maintenance costs in order to break even on these new units. In any case, the examples just cited show that consumers can benefit significantly even if there is not an increase in efficiency that translates into lower prices. The magnitude of the net benefit will depend upon the extent to which there would be a capacity constraint without the proposed units, and upon the monetary losses that would result from service interruptions.

In the absence of Crystal River Units 4 and 5, the loss of load probability (LOLP) for the Florida Power system would increase very significantly after 1982. As discussed in Chapter 1, the LOLP would rise from 2.9 days per year in 1982 (including dependency upon interruptible loads and interconnections) to 9.0 days per year in 1983, and 13.8 days in 1985. The likelihood of blackouts and/or brownouts within the Florida Power service area thus would increase significantly. It is not possible at present to place a dollar value on the losses resulting from such

power outages, but the experience of other areas in the United States suggests that these costs to power users and to society at large can be very considerable.

The overall conclusion of the cost-benefit analysis for Florida Power customers is that there is almost certain to be a positive net benefit, perhaps a very large benefit, associated with construction of the proposed power generating units.

7.2.4 EXTERNAL SOCIAL AND ECONOMIC BENEFITS

In addition to the net benefits of the proposed project to Florida Power and consumers of electricity, there will be a variety of other social and economic impacts involving local residents, businesses, and governmental units.

The government of Citrus County will receive an average of approximately $2,900,000 in annual net property taxes from Unit 4 during its first five years of operation, beginning in fiscal year 1983. Unit 5 will pay an estimated average of $2,280,000 in annual net property taxes beginning in 1985. (These are taxes based on the total value of land and improvements. Appreciation in land value will not have a major effect on tax yield prior to the completion of each facility.) The county will experience major net benefits because the proposed facilities will create relatively few demands for public services. Florida Power will pay for the construction and maintenance of any additional transportation facilities required by the new units (including water, rail, and roadway facilities) and will be self-sufficient in terms of potable water supply and sewage disposal. In addition to county taxes, Florida Power will pay approximately $40,000 in required fees to state and federal governments for permits and licensing.

The construction of the proposed power generating units will require an average of 528 workers during the 7-year construction period. The construction manpower requirement for both units combined will exceed 700 persons for more than three years and will peak at 1,275 workers in early 1982. The total payroll for the construction project will be approximately $150 million in 1978 dollars.

Based on Florida Power observations from the previous three units (without an actual survey), the construction labor force is likely to be drawn from the following areas, in terms of distance from the plant site:

25% from within a 32 kilometer (20 mile) radius
25% from within the next 32 kilometers (20 miles)
25% from within the next 32 kilometers (20 miles)
25% from within the next 32 kilometers (20 miles)

It is possible that transient labor will, in the short run, place a strain on the community. Some construction labor will utilize community facilities such as roads without paying individual property taxes. Since taxes on Units 4 and 5 will not be paid until each unit goes into operation, the community may experience a period during which the proposed project has a net negative impact on local government finance. The initial tax payments on Unit 4 should more than adequately compensate for any stresses created during this period.

Contract labor and other specialized labor services for plant maintenance are expected to cost approximately $500,000 in 1983 and $250,000 in 1984 (expressed in present dollars). With the start-up of Unit 5, the figure will total approximately $300,000 in 1985 and each year thereafter (with the exception of every fifth year throughout the lives of the plants, when the total will reach about $500,000). The higher costs every fifth year will involve activities such as warranty checks and turbine engine rebuilding. Since these costs will involve highly specialized labor, not all of the payments will contribute to the local economy. The intent is, however, to utilize the local labor market whenever possible.

It is anticipated that various construction materials, such as concrete, fill material, and lumber will be purchased from local suppliers on a competitive basis. Other local purchases could include tools, office supplies, automotive parts, hardware, first aid and safety supplies, fuels, and lubricants. When available in the area, construction equipment and vehicles will probably be rented from local sources by contractors. Purchases of consumer goods by construction workers, both resident and transient, have contributed importantly to the local economy during previous projects, and are expected to have a similar impact during the construction of Units 4 and 5.

After start-up, the operation and maintenance of Unit 4 are expected to create 112 jobs at a labor cost of approximately $3,024,000 per annum. Since a portion of Unit 4 personnel could be used for the operation of both plants, it will be necessary to hire only an additional 20 persons

when Unit 5 is brought on line in 1984. This will increase the cost of labor by $420,000 to a total of $3,444,000 per year starting in 1985.

It is expected that the local labor market will be able to supply some of the skills necessary to operate the plants. Florida Power intends to utilize the local labor market to the maximum extent possible. Thus, a sizable fraction of the above mentioned payroll should go to existing Citrus County residents. In addition, most of the other workers hired will become residents of the county, and the multiplier effects of local spending by these employees will have a broad influence on the local economy.

7.3 EXTERNAL SOCIAL AND ECONOMIC COSTS

The following discussion deals with the potentially negative social and economic effects of Crystal River Units 4 and 5. Four categories of impact are considered: labor force, housing, land use, and other costs. These would be largely non-monetary costs in that dollar outlays would not be involved. The effects on labor force and housing conditions would be short-term in nature, whereas the land use and other effects would be long-term.

7.3.1 LABOR FORCE

The proposed project's positive effects on employment and payrolls in Citrus County have already been noted. The negative effects would include the possibilities of creating labor shortages during the construction project and unemployment afterward. It is worthwhile in this regard to examine the effects of the Crystal River Unit 3 construction project, although the historical data are somewhat difficult to interpret due to other trends in the county.

Labor force and employment statistics for Citrus County in the years 1970 through 1976 are presented in Table 7.3-1. Construction employment at Unit 3 reached a peak of 1,700 workers in 1973. (Construction employment appears in Table 7.3-1 as a separate category under Nonagricultural Wage and Salary Employment, and also constitutes a substantial part of the total for "All Other Nonagricultural Employment"). The power plant construction peak coincided with a high level of homebuilding and real estate activity. As a result, the number of jobs in Citrus County climbed to 9,760 in 1973, an increase of 120 percent over 1970. The number of employed Citrus County residents also more than doubled over this period, reaching 11,520 workers in 1973.

The decline in construction employment at Crystal River in 1974 was followed closely by a major slump in real estate activity. There was a loss of nearly 50 percent in construction employment and more than 60 percent in finance and real estate employment between 1973 and 1975. However, the size of the civilian labor force continued to increase. The consequence was a jump in the unemployment rate from 3.4 percent in 1973 to 13.4 percent in 1975, and 14.5 percent in 1976. The Crystal River Unit 3 project was not the only factor responsible for this gain in unemployment, and probably was not the major factor since this gain also corresponds with the general economic recession in the mid-1970's. However, some portion of the unemployed persons present in 1975 and 1976 were probably construction workers who had been attracted to the area by the Crystal River project.

Table 7.3-1. Trends in Labor Force and Employment by Major Industry in Citrus County, Florida: 1970-1976

	March 1970	March 1971	March 1972	March 1973	March 1974	March 1975	March 1976*	Change 1970-1976 Number	Change 1970-1976 Percent
LABOR FORCE SERIES †									
Civilian Labor Force	5,620	6,580	8,280	11,920	11,900	12,400	13,200	7,580	134.9
Total Unemployment	140	200	320	400	700	1,700	1,900	1,760	1,257.1
- Unemployment Rate	2.5	3.1	4.0	3.4	5.9	13.4	14.5	---	---
Total Employment	5,480	6,380	7,960	11,520	11,200	10,700	11,300	5,820	106.2
ESTABLISHMENT SERIES**									
Nonagricultural Wage and Salary Employment	2,740	3,300	4,180	6,300	6,200	5,700	5,900	3,160	115.3
- Manufacturing	140	140	200	260	320	400	300	160	114.3
- Construction	300	420	560	1,380	840	700	600	300	100.0
- Transportation, Communications, and Utilities	180	220	260	300	360	500	500	320	177.8
- Wholesale & Retail Trade	620	720	980	1,220	1,300	1,400	1,600		
- Finance, Insurance, Real Estate	160	300	420	800	780	300	300	980	158.1
- Services and Miscellaneous	700	820	940	1,160	1,120	1,000	1,100	400	57.1
- Government	640	680	820	1,180	1,480	1,400	1,500	860	134.4
All Other Nonagricultural Employment	1,500	1,860	2,340	3,280	3,060	NA	NA	---	---
Agricultural Employment	180	180	180	180	180	200	200	20	11.1
Total Employment	4,420	5,340	6,700	9,760	9,440	---	---	---	---

NA = Not available.
† Estimates in labor force series are based on place of residence.
** Estimates in establishment series are based on place of work.
* Preliminary.

SOURCE: State of Florida Department of Commerce, Division of Employment Security, Office of Research and Statistics, Basic Labor Market Information, May 1976 and May 1977.

A second type of labor force impact would involve labor shortages and upward pressure on wages during the peak construction period. Construction projects generally pay higher wages than do other activities employing blue-collar labor, and thus can draw workers away from other sectors. In addition to causing labor shortages, this situation could possibly involve a general escalation in wage rates which would be a burden to other employers. There is little indication that these problems actually occurred during the construction of Unit 3, however. Even at the peak of construction activity, Citrus County remained a labor-exporting area, with nearly 2,000 more employed residents than jobs within the County.

The construction of Units 4 and 5 would be expected to cause substantially less disruption in the local labor market than Unit 3, for two reasons: (1) the scale of the local economy has increased substantially in the intervening years; and (2) the period of intensive construction activity will be spread out over time to a substantially greater extent for Units 4 and 5 than for Unit 3. The construction of Unit 3 at one point accounted for more than 15 percent of all jobs in Citrus County, whereas the proposed project is not likely to exceed 10 percent of the at-place employment in the county. During the declining phase of the proposed project (from early 1982 to 1984), there will be a reduction of 1,125 jobs at Crystal River, or 563 jobs per year. However, Citrus County has a long-term growth rate of 600 to 1,000 jobs per year (see Table 7.3-1). Thus, it is likely that construction workers remaining in the area after the proposed project will be able to find alternative employment. The overall conclusion is that the proposed project will not have major negative impacts on the local labor market, and certainly will have no effects sufficient to offset the positive influence of construction payrolls on the local economy.

7.3.2 HOUSING

The influx of construction workers to Citrus County could potentially create stress on the local housing market. The experience of the Unit 3 construction period suggests that an overall housing shortage is unlikely, although it is possible that a shortage was prevented in 1972 and 1973 by the ongoing boom in housing construction. The demand for dwelling units as a result of Units 4 and 5 should be less than the demand due to construction of Unit 3.

The major housing impact to be expected will be inflation in the price of rental housing. Earlier experience suggests that local landlords will respond to the strong demand for short-term housing by raising the rental rates for virtually all available units. This phenomenon may involve a temporary hardship for local residents who will be forced to pay inflated rates throughout approximately the duration of the construction project. A similar phenomenon may occur with regard to the sale prices of less expensive owner-occupied units. However, as in the case of upward pressure on wage rates, these housing impacts would represent money transfers from one group to another rather than net costs to society as a whole.

7.3.3 LAND USE

The proposed Crystal River power generating Units 4 and 5 would clearly be consistent with existing land use patterns. The site is already the location of three generating units and is bordered on all sides by undeveloped land and pine plantations. At present there are only six occupied dwelling units within 6 kilometers (4 miles) of the plant site (as measured from the proposed stack location for Units 4 and 5). Most land within 6 kilometers (4 miles) of the site, and virtually all land within 5 kilometers (3 miles), is zoned for mining and industrial use. Maps of present land use and zoning are presented elsewhere in this report (Figures 2.2-2 and 2.2-3). On the other hand, there are a number of existing dwellings and large areas of residentially-zoned land located between 6 and 8 kilometers (4 and 5 miles) from the site. The existing development is concentrated in the communities of Yankeetown and Inglis and along the south bank of the Withlacoochee River, whereas a large proportion of the vacant residentially-zoned land is found in the Crystal Manor subdivision to the east of U.S. Highway 19-98. Crystal Manor was tracted and sold in roughly 1-acre lots through interstate land sales, but presently contains only ten dwellings and no signs of additional construction activities.

The issue of land use compatibility relates primarily to future growth. Over the past decade, Citrus County has been one of the fastest-growing counties per capita in the nation. The population of the county more than doubled between 1960 and 1970, and doubled again between 1970 and 1977. The emergence of Citrus County as a retirement community was overwhelmingly responsible for these population gains. As of early 1978, it is estimated that retired persons account for over 40 percent of the Citrus County population. Rapid growth is expected to continue in the future. The Bureau of Economic and Business Research (BEBR), University of Florida, has forecasted that the Citrus County population will increase from its estimated 1977 level of 38,591 persons to a total of 82,200 inhabitants in the year 2000 (medium projection). Thus, there will be a gain of roughly 43,600 persons, or 78 persons per square mile of land area in the county.

When interpreting these trends, it should be noted that the high percentage rates of growth have been due in part to the small initial population base in Citrus County. The population increases remain fairly small-scale compared with many urban areas. For example, according to the BEBR, there will be 19 other counties in Florida for which the gains in population density between 1977 and the year 2000 will exceed the 78 persons per square mile increase predicted for Citrus County. The overall Citrus County density of 147 persons per square mile in the year 2000 will be below the present population density of the state of Florida as a whole.

It is clear that the future population growth projected for Citrus County can potentially be attained without substantial land development near the Crystal River power plant site. Recent development has been heavily concentrated in the central portion of the county and in the immediate vicinity of Crystal River 11 kilometers (7 miles) from the proposed power generating units. The population gains expected between 1977 and the year 2000 could be accommodated on only 1 to 2 percent of the land area in the county, assuming an average dwelling unit density of 3 to 5 units per acre. Thus, land shortages will not be a factor in shifting new development toward the power plant site. Some housing construction is likely to occur at Crystal Manor, however, when the remainder of the land purchasers take title for lots in that subdivision. Development at Crystal Manor and in the residentially-zoned areas along the Withlacoochee River and northwest of Crystal River would constitute a very mild land use conflict with the proposed power generating facilities given the approximately 6 to 10 kilometer (4 to 6 mile) distance of these areas from the power plant site. It is not considered appropriate to assign a negative land use impact to the proposed project on this account since the new power generating facilities are expected to be in place before the development in question occurs.

7.3.4 OTHER SOCIAL AND ECONOMIC COSTS

There are a variety of other potential impacts of the proposed project on social and economic conditions. These possible effects involve public facilities, aesthetics, recreation, cultural resources, and natural resource production. Most are expected to be minor in significance.

U.S. Highway 19-98 is the only major road leading to the project site. Recently this highway was completely four-laned north and south of the plant site; it can now accommodate up to 22,500 cars a day. Projections of highway usage developed by the Withlacoochee Regional Planning Council, which take into account the construction and operation of Units 4 and 5, show that U.S. 19-98 will reach capacity south of Crystal River in the year 1987, north of Crystal River in 2010, and in the vicinity of Red Level in 2056. Several minor roads in the area also have recently been improved. Therefore, highway conditions in the area are generally better than the conditions prevailing when the first three units were constructed at the Crystal River site.

Units 4 and 5 will place no direct burdens on public water and sewer systems, as noted earlier. Of course, the increases in population in the area caused by the construction and operation of the units will add to demands for these and other public services. It is anticipated, however, that the additional demands can be readily met by existing facilities in the county. Local schools, hospitals, and other public facilities were adequate to serve the influx of population during the construction of Unit 3. According to the Superintendent of Citrus County Schools, a new primary school is planned to open in 1979. The existing high schools and middle schools in the area have adequate capacity to absorb additional students.

Noise created by construction is not expected to cause any disturbance to the populace, due to the rural nature of the surrounding area. The negative aesthetic effects of construction will be minimal, because the proposed site is located within an existing power generation complex.

The scenic value of the site area will be altered slightly by the addition of the proposed power generating units, stacks, and cooling towers to the existing complex. The stacks will be clearly visible from the coastline north and south of the plant, and from a few points on U.S. Highway 19-98 to the east. Whether the group of four stacks will represent a significantly greater visual impact than the two existing stacks is a purely subjective matter. There will be a plume emanating from each of the new stacks which will be visible only in the immediate vicinity of the stack (due to dispersion). The effluent will be light in color but nevertheless will represent a negative visual impact. The cooling tower drift may be visible under some meteorological conditions, but should not represent a significant aesthetic impact.

As previously discussed, the land to be occupied by the proposed facilities (as distinguished from the Florida Power property as a whole) is without notable scenic, recreational, historic, cultural, or archaeological value. The lack of value for recreation is related to the absence of attractive beaches and convenient water access. Since the shallow waters off the Gulf Coast in the Crystal River vicinity impose a natural barrier, commercial fishing has never become a major industry in the area. However, shrimpers and mullet boats frequently harvest the coastal waters. Sport fishing is a popular recreational activity in this vicinity, especially near the existing discharge channel during winter months. Units 4 and 5 will have little tendency to enhance or retard these sport fishing activities. Because of the consistency of the proposed project with existing land use and zoning, the two new power generation units are expected to have little impact on nearby property values. No persons will be displaced by the project.

A small cost can be assigned to the loss of potential forest products as a result of the proposed project. The land to be occupied by the power generating units and supporting facilities has not been managed in recent years for purposes of timber production; but the loss of this use could, nevertheless, be considered an opportunity cost. The total stumpage value of timber harvested in Florida in 1974, the last year for which data are available, was $74.7 million (State of Florida, Division

of Forestry, 1974). The total land area of tree farms in the state was 2.67 million hectares (6.6 million acres) (American Forest Institute, 1975). Thus, the average dollar value of stumpage was $28 per hectare per year, or roughly $35 per hectare in present dollars ($11.32 per acre and $14.14 per acre, respectively). The potential value of forest products from the 138 hectares (320 acres) involved in the proposed project would thus amount to roughly $5,000 per year. On a capitalized basis, this value stream represents a land value increment of somewhat less than $50,000.

Chapter 8 Alternate Energy Sources and Sites

CHAPTER 8

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8.0 ALTERNATIVE ENERGY SOURCES AND SITES

8.1 MANAGEMENT ALTERNATIVES

8.1.1 CONSTRAINT IDENTIFICATION

Florida Power Corporation has forecast that the total net energy use by its customers will increase from 17,540 Gigawatt hours (Gwh) in 1977 to 26,320 Gwh in 1987, and 33,418 Gwh in 1997. These forecasts represent a compound annual percent increase of 3.26 percent over the 20-year period. Even though these forecasts indicate substantial increases in energy demands in the future, the forecasts also represent substantially lower growth rates than prevailed in the immediate past. By comparison, between 1968 and 1977, the net energy use increased at a compound annual rate of 9.69 percent. The forecasted reductions in growth rates are due primarily to the anticipated slowdown in population growth, the saturation of residential customers with appliances, and the reduction in sales to Seminole Electric Cooperative, Inc. The computer modeling studies and assumptions used to derive these forecasts are described in detail in Chapter 1.0.

Based on its demand forecasts and its present system capacity, Florida Power has determined the need for additional generating capacity to meet its forecasted demands and to maintain the reliability of its electric generation system. Generation capacity planning studies conducted by Florida Power indicate that a rapid reduction in reserve capacity would occur after 1982 without major additions to its system's generating capacity (see Chapter 1).

For capacity planning purposes, Florida Power has developed a generation expansion plan to meet its needs for additional capacity. The generation expansion plan is described in Chapter 1.0. The plan is comprised

of a mixture of base load coal generation, mid-range (combined cycle) generation, simple cycle combustion turbine generation, and capacity purchases from other utilities. In developing the plan, the management alternatives open to Florida Power include the following: (1) not to generate or purchase additional power; (2) to purchase the required energy from other sources; (3) to uprate and continue operation of older units or to reactivate retired plants; (4) to enter into a joint project for providing new generating capacity; (5) to construct smaller units than the facilities proposed; and (6) to construct the proposed power generating facilities.

These management alternatives are discussed and evaluated in the following sections.

8.1.2 OMISSION OF PROPOSED PROJECT WITHOUT SUBSTITUTE ENERGY SOURCES

In order to assess the reliability of the electric generation system, computations of loss of load probability (LOLP) under various alternatives are used. The LOLP assessment uses statistical models that relate the uncertainty of load and generating capacity availability to yield a measured index of the reliability of supply. The LOLP is calculated from a forecast of weekly peak demand and variances, and the projected forced outage rates and scheduled outages for each generating unit. A LOLP value of one day in 10 years has been generally accepted throughout the electric utility industry as a reasonable design goal. For purposes of generating capacity planning, it has been determined that a criterion of 2.5 days per year dependency upon interruptible loads and interconnections is equivalent to one day in ten years LOLP for firm loads.

The projected system dependency in terms of loss of load probability is presented for the alternatives with and without the proposed units in Table 8.1-1. As shown in the upper portion of the table, the addition of 640 Mw units in 1982 and 1984, as proposed, would bring the LOLP close to the desired value of 2.5 days per year by 1983, and would lower it below this criterion in the two subsequent years. However, if the 1982 unit were omitted, the LOLP would be between 8 and 18 in the years beginning with 1983. Omission of the 1984 unit as well as the 1982 unit would create a situation of negative reserves in 1985 and 1986, with LOLP values exceeding 30. These projections of LOLP include the other planned additions to the Florida Power generating capacity as described in the generation expansion plan in Section 1.3.

Omission of the proposed power generating facilities, with no substitution of alternative power sources, would thus result in a system having greatly increased loss of load probability values. The omission would jeopardize the reliability of the electrical supply in Florida Power's service area and act as a detriment to the interconnected systems of the State of Florida. Unlike distribution-initiated service interruptions which affect only a small number of individual customers, blackouts or

Table 8.1-1. Projected Florida Power System Dependency With and Without Proposed Units

	Capacity in Mw	Winter Peak Demand, Mw*	Reserves Mw	Reserves %	LOLP Days/Year
With Both Proposed Units Included					
1978†	4,554	4,150	404	9.7	12.2
1979	5,055	4,450	605	13.6	4.6
1980	5,275	4,750	525	11.1	3.1
1981	5,530	5,050	480	9.5	3.1
1982	5,985	5,360	625	11.7	2.3
1983	6,485	5,660	825	14.6	2.8
1984	6,235	5,760	475	8.2	1.7
1985	6,845	6,050	795	13.1	1.5
1986	7,441	6,140	1,301	21.2	0.7
1987	7,374	6,310	1,064	16.9	1.3
With 1982 Unit Excluded					
1982	5,985	5,360	625	11.7	2.9
1983	5,845	5,660	185	3.3	9.0
1984	5,595	5,760	-165	-2.8	5.6
1985	6,205	6,050	155	-2.5	5.3
1986	6,801	6,140	661	10.8	2.9
1987	6,734	6,310	424	6.7	4.7
With Both Proposed Units Excluded					
1984	5,595	5,760	-165	-2.9	12.2
1985	5,565	6,050	-485	-8.0	13.8
1986	6,161	6,140	21	0.3	9.1
1987	6,094	6,310	-216	-3.4	14.1

*Winter peak is assumed to occur in January of each year.
†Figures for 1978 represent actual calculations.

Source: Florida Power Corporation, 1978.

brownouts due to lack of overall system capacity impact large segments of the service area simultaneously. Such outages create situations which are not only expensive and inconvenient to customers but endanger the health and safety of the community. Therefore, in order to maintain acceptable levels of LOLP, the Florida Power system will require the additional capacity provided by the proposed project or by firm substitute energy sources of equivalent capacity.

8.1.3 PURCHASES OF REQUIRED ENERGY FROM OTHER SOURCES

Since the mid-1960's, Florida Power has maintained a policy of participating in mutually advantageous firm power exchanges with other electric utilities, such as Tampa Electric Company and Southern Company Services, Inc. These exchanges allow the selling utility to take advantage of economies of scale, while enabling the buyer to defer capital investment and obtain efficient peak generating capacity. Florida Power is currently negotiating or has firm purchase contracts with four municipal utilities--City of Tallahassee Electric Department, City of Lakeland Department of Electric and Water Utilities, Gainesville-Alachua County Regional Utilities Electric, Water, and Sewer Board, and Orlando Utilities Commission. The importance of these purchases to the Florida Power system is shown by the fact that in the winter of 1981-82 Florida Power has planned a reserve capacity of 9.8 percent which is equivalent to the capacity purchases from other utilities. However, it is very unlikely that additional purchases of the magnitude necessary to eliminate the proposed generating facilities would be feasible within the time frame required. The excess capacity in nearby utility service areas is limited, and by 1981 the reserves for the State of Florida as a whole will be approaching the 20 percent level which is commonly considered minimal for maintenance of reliable service.

8.1.4 REACTIVATION AND/OR UPRATING OF OLDER PLANTS

A program of uprating older plants or reactivating retired units would have only limited benefits, for the following reasons. Existing turbines and generators can be uprated by only modest amounts. Sufficient generation to decrease LOLP would not be possible from reactivation of Florida Power units. If the original equipment is replaced, so that essentially a new unit is constructed, the unit would be subject to recent legislation requiring offstream cooling and stack emission controls. Such steps might require more additional land for cooling facilities and solid waste storage areas than is available at the site. In addition, older equipment is relatively inefficient and unreliable, so that such facilities generally cannot be utilized for baseload generation, as opposed to peaking capacity. Therefore, uprating and reactivation of older plants is clearly not a feasible means of fulfilling a major proportion of the capacity needs demonstrated by Florida Power.

8.1.5 JOINT PROJECTS

Florida Power has engaged in joint projects on a limited basis in the past. For example, 10 percent of the recently-completed nuclear generating capacity at Crystal River is owned by four other utilities. It is unlikely under any circumstances that further joint projects could have accounted for a large proportion of the capacity increment required by 1983. However, there may have been some additional opportunities for joint projects which could have proven favorable if investigated several years ago. These might have involved any or all of the three smaller utilities which have service areas abutting the Florida Power service area and which are each proceeding with the development of new generating capacity. Florida Power will participate in these projects indirectly through power exchanges, but could not join with these companies in fulfilling capacity requirements at the present time. There is some possibility of a future joint project between Florida Power and Seminole Electric Cooperative, but such an arrangement cannot fulfill Florida Power's additional capacity needs in the 1982 to 1984 period.

8.1.6 CONSTRUCTION OF SMALLER UNITS THAN THE PROPOSED FACILITIES

The demand forecasts demonstrate that major new generating capacity is needed for the Florida Power service area by 1984. A small portion of this additional capacity will be provided by combined cycle and simple cycle combustion turbine-type generation; however, for system efficiency the majority of additional capacity should be provided by larger base-load generation units. Three potential unit sizes have been considered by Florida Power on the assumption that the most efficient means of obtaining the needed capacity would be the construction of two units. These sizes were 550 Mw, 600 Mw, and 640 Mw. The 600 Mw size was developed from a conceptual viewpoint, whereas the other two unit sizes represent standard turbines presently available to the industry. Studies by Florida Power have indicated that the incremental savings in variable costs associated with the 640 Mw size would outweigh the incremental fixed costs of the larger unit. The 640 Mw size was therefore selected as the most economical system alternative.

The possibility of siting the two 640 Mw power generating units at different locations was considered in some detail. The use of different sites would present some opportunities for minimizing transmission distances. On the other hand, a number of the facilities needed to serve the two units would have to be duplicated if the units were sited apart. These facilities would include access roads, solid waste disposal areas, coal handling systems, water treatment facilities, and power transmission corridors. In addition to the economic advantages of pooling these facilities, there would be fewer environmental impacts, all else being equal, than if two separate sites were utilized. Therefore, the site selection process has assumed (subject to later review) that the most viable option in economic and environmental terms would be to construct two 640 Mw generating units at the same location.

8.1.7 CONSTRUCTION OF THE FACILITIES AS PROPOSED

The construction of two linked 640 Mw units, to be completed respectively in late 1982 and early 1984, was judged the best feasible management alternative in terms of system reliability, capacity, and cost. The units would come on-line at the appropriate times to meet the growing demands for energy in the Florida Power service area and to provide adequate system reserves.

8.2 ALTERNATIVE ENERGY SOURCES

8.2.1 CONSTRAINT IDENTIFICATION

The possible means of power generation include nuclear, coal, oil, gas, hydroelectric, solar, and geothermal. The primary constraints which apply to Florida Power Corporation regardless of present plans and customer needs are: (1) the physiography of the siting region; (2) the current state of technology; (3) government policies regarding conservation of scarce resources; and (4) fuel availability. The topography and geology of Florida rule out the development of hydroelectric power and/or the use of pumped storage. Solar, geothermal, and other new-line power generation alternatives have not been developed to the point at which they could feasibly be utilized for large-scale power generation in Florida. The use of oil for electric power generation is being curtailed by government regulation. Finally, the availability of natural gas is doubtful. The recoverable reserves of natural gas may be much larger than is commonly believed, so that the present shortage situation might be alleviated in the future; however, this possibility cannot be counted on in planning long-term commitments. The alternative energy sources which can feasibly be considered by Florida Power are therefore limited to coal and nuclear power.

8.2.2 NUCLEAR

The lead time required for licensing, design, and construction of a nuclear power generating facility is presently close to 10 years. Based on previous analysis of the need for power in Chapter 1.0, Florida Power must have the two proposed units on-line by 1982 and 1984. In addition, there are numerous regulatory and financial uncertainties surrounding construction of nuclear units and disposition of used nuclear fuel. Florida Power has experienced some of these potential difficulties in the licensing, construction, and operation and maintenance of Crystal River Unit 3. Thus, nuclear power has not been considered a feasible alternative for the facilities under discussion.

8.2.3 COAL

Coal, the only remaining energy alternative, can be obtained for the proposed power generating units from either the eastern or western states. An economic analysis has been conducted by Florida Power to establish the relative favorability of low-sulfur versus high-sulfur coal. The computations were based upon two 640-Mw units at the Crystal River site with freshwater cooling towers. However, the cost elements considered would be common to most of the feasible cost/plant/site options. The issue addressed was the trade-off between higher fuel costs with low-sulfur coal, versus higher capital and operating costs with high-sulfur coal due to the use of scrubbers for sulfur removal. Low-sulfur coal was defined as a product which yields 0.6 pounds of sulfur or less per million Btu (MBtu) when burned. The prospective coal supplies discussed below range from 0.40 to 0.59 pounds of sulfur per MBtu. The assumptions involved in the cost analysis were the following:

1. Cost of capital equals 11.1 percent.
2. Operation and maintenance cost for low-sulfur coal units will be 1.8 mills per kilowatt-hour in 1982 and will escalate at 6 percent per year over the life of the unit, based on past industry experience with similar units.
3. Operation and maintenance cost for a high-sulfur coal unit will be twice that of a low-sulfur coal unit. The cost difference is related to the need for approximately 50 additional employees to operate and maintain flue gas desulfurization equipment, and the need for 540,000 metric tons (600,000 tons) of limestone per year. (See also the differences in heat rate and plant size noted in Item 6 below).
4. Fuel costs for the year beginning October 1, 1978, will be $1.74 per MBtu for high-sulfur coal and $1.94 per MBtu for low-sulfur coal.
5. Fuel prices will escalate at 10 percent per year through 1980 and 5 percent per year thereafter. The escalation over the

next two years is expected to reflect the impacts of the recent United Mine Workers of America contract settlement, the Federal Surface Mining Control and Reclamation Act of 1977, and the Black Lung Benefits Revenue Act of 1977. A leveling off in escalation rates is expected after 1980 based on the belief that the effects of recent regulations will have been largely realized and that the coal industry will have stabilized beyond its current level of activity.

6. The heat rate for a high-sulfur coal unit will be 9,800 Btu per kilowatt-hour, versus 9,400 Btu per kilowatt-hour for a low-sulfur unit. The reason is that an energy increment of between 28 and 32 Mw will be required in the high-sulfur coal unit for operation of the larger induced draft fans and the slurry pumps entailed by the desulfurization process and for reheating stack gases.
7. A high-sulfur coal unit must be 5 percent larger than a low-sulfur coal unit in order to achieve the same net output because of the internal power requirements just mentioned.
8. Plant life will be 30 years.

The computed total costs, expressed as the present worth of operations commencing in October 1982 and April 1984, are presented in Table 8.2-1. In the case of proposed Unit 4, it is found that the low-sulfur coal option would involve a present-worth saving of approximately $63 million in 1978 dollars relative to the high-sulfur coal plant. Although the absolute magnitude of the saving is dependent upon the assumed discount rate (equal to the cost of capital), the relative saving is not sensitive to this assumption since the annual cost of the high-sulfur coal option remains in roughly the same proportion to the low-sulfur coal option over all years of operation. (The former exceeds the latter by 4.5 percent to 7 percent.) In the case of Unit 5, the low-sulfur coal option is credited with a present-worth saving of $45 million in 1978 dollars.

An important issue to be considered, however, is the future availability and relative cost of low-sulfur coal. The figures in Table 8.2-1 involve an implicit assumption that the delivered price of low-sulfur coal consistently will be 11.1 percent higher per Btu than the delivered cost of high-sulfur coal. Two other independent computations have indicated that low-sulfur coal units will be economically preferable to high-sulfur coal units if:

1. The differential in delivered price between low-sulfur and high-sulfur coal does not exceed 22.6 percent at any time, or
2. The price differential does not exceed 13.75 percent in 1978 and does not escalate to more than 25.25 percent over a 20-year period.

Florida Power has identified six specific low-sulfur coal supplies, with recoverable reserves exceeding 820,000,000 metric tons (900,000,000 tons), for which the principals have agreed to discuss firm offerings of production, sale of reserves, or joint participation in mining. These supplies are located in Appalachia, Colorado, central Utah, and the Powder River basin in Wyoming. The evaluations of reserves have included detailed study of mining costs, investment costs, preparation costs, and transportation costs. Although firm price quotations have not been requested as yet, it is possible to anticipate the bid prices with considerable accuracy. The available information suggests that the delivered price of low-sulfur coal will not deviate from high-sulfur coal by more than the margins suggested above, due in part to the following considerations:

1. Transportation costs for coal delivered into Florida are a substantial portion of the delivered cost and will in some cases exceed the cost of the coal itself. Therefore, the future cost of fuel will be as dependent on rates of escalation in transportation, applicable to both high- and low-sulfur coals, as to the mined cost of the coal itself.
2. Mining and land reclamation costs will escalate at uniform rates regardless of the sulfur content of the coal produced.

Table 8.2-1. Hypothetical Cost Comparison of Power Generation Units Utilizing Low-Sulfur and High-Sulfur Coal

Unit 4	Present Worth in Millions of October 1982 Dollars		Present Worth in Millions of April 1978 Dollars	
	Low-Sulfur Coal	High-Sulfur Coal	Low-Sulfur Coal	High-Sulfur Coal
Capital	469.3	556.0	292.2	346.2
Fuel	1,124.9	1,051.6	700.5	654.8
Operation and Maintenance	88.0	176.0	54.8	109.6
Total Present Worth	1,682.2	1,783.6	1,047.5	1,110.6

Unit 5	Present Worth in Millions of April 1984 Dollars		Present Worth in Millions of April 1978 Dollars	
	Low-Sulfur Coal	High-Sulfur Coal	Low-Sulfur Coal	High-Sulfur Coal
Capital	359.3	427.9	191.1	227.5
Fuel	1,211.2	1,131.8	644.0	601.8
Operation and Maintenance	95.9	191.9	51.0	102.1
Total Present Worth	1,666.4	1,751.6	886.1	931.4

Sources: Florida Power Corporation, 1978.
Environmental Science and Engineering, Inc., 1978.

3. Although coal of less than 0.6 pounds sulfur per MBtu is presently in scarce supply relative to all other coals, it is anticipated that the 1977 Clean Air Act amendments will reduce the demand for compliance quality coals. There is now evidence that the availability of low-sulfur coals from the west is exceeding demand, a trend which should moderate future price increases.

Therefore, the choice of low-sulfur coal units by Florida Power appears to be an economically justifiable decision.

8.3 ASSESSMENT OF ALTERNATIVE SITES

8.3.1 INTRODUCTION

This section presents an evaluation of alternative sites for the two 640 Mw fossil-fueled power generating units proposed by Florida Power Corporation. In order not to preclude any possible sites in the initial selection process, the region considered for potential site locations included the entire state of Florida north of 27°00' North latitude and east of 85°30' West longitude, although the Florida Power service area constitutes only a portion of this region.

As part of their ongoing expansion planning process, Florida Power has conducted a large number of site selection studies, which have included aerial and field surveys, geologic studies, ecological investigations, water resource studies, and a detailed site analysis utilizing a computer model. The most extensive study, which concerned the siting of a major nuclear unit, initially considered 185 sites. On the basis of map analysis, the list was later reduced to 50 sites. Since nuclear and fossil-fuel plants have many of the same requirements, the list of 185 sites analyzed in the nuclear study was taken as a starting point in evaluating possible sites for the facilities discussed here. Several new sites were added, and a considerable number were deleted due to changes in land use, environmental conditions, or public policies since the time of the nuclear study. The resulting list of approximately 30 sites has been analyzed intensively with respect to the criteria described below.

Rather than reviewing the entire site selection process, only 11 potential sites are discussed here. This list has been obtained by eliminating all sites that were found in the course of the selection process to be either: (1) infeasible, or (2) clearly inferior to another site

in the same geographic area. The resulting group of 11 sites include all those which can be described in retrospect as serious possibilities for the proposed power plant development. The locations of the 11 sites which were evaluated in detail are shown in Figure 8.3-1. The following section describes the criteria used in evaluating potential sites, the characteristics of the 11 sites chosen for discussion, the relative favorable characteristics of the sites in terms of cost and environmental impact, and the manner in which the preferred alternative was selected.

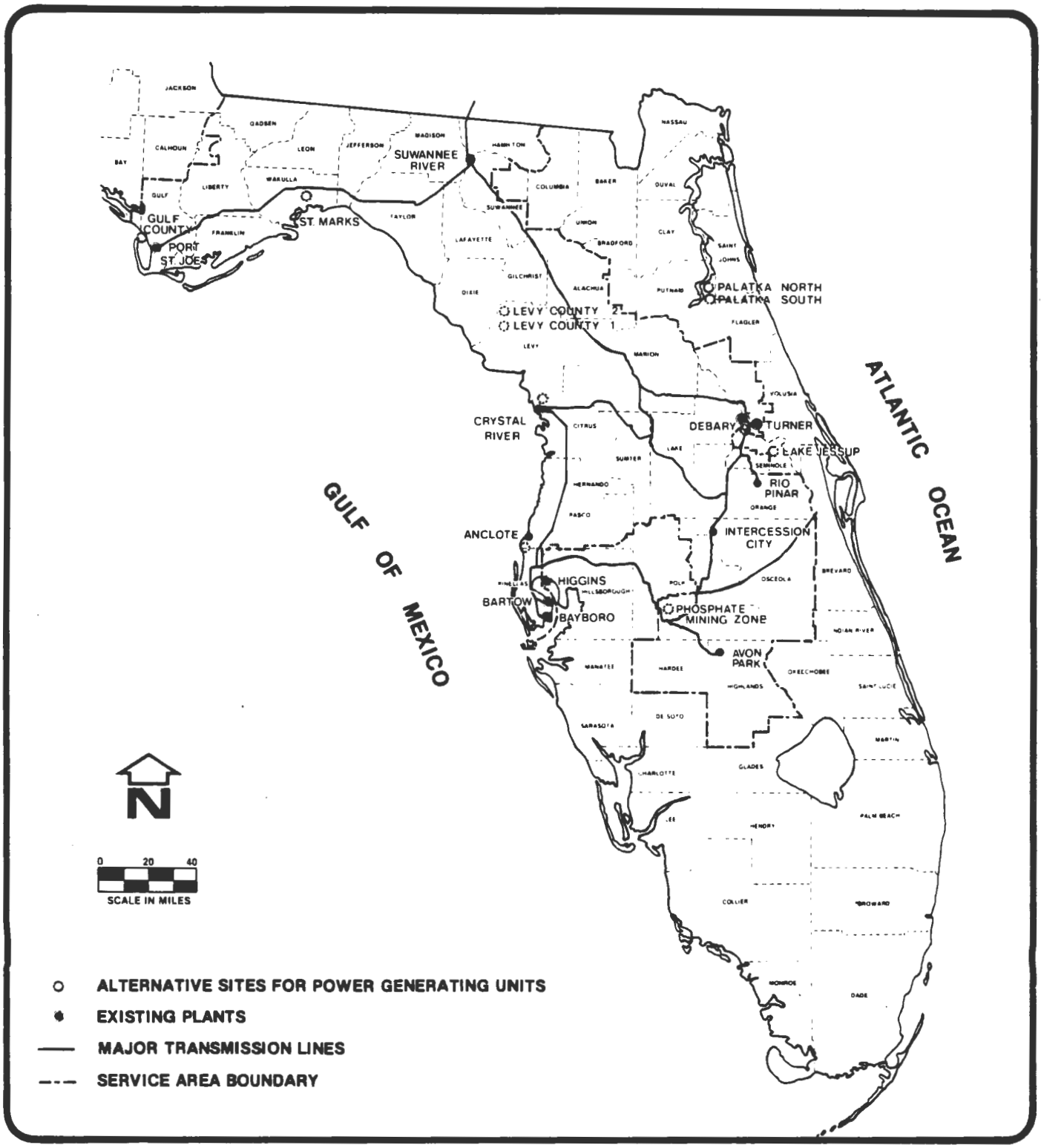

Figure 8.3-1
ALTERNATIVE SITES FOR POWER GENERATING UNITS

SOURCE: FLORIDA POWER CORPORATION, 1972
ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1978

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8.3.2 GENERAL SITING CRITERIA

INTRODUCTION

In the initial screening process, relatively few factors were considered as absolute constraints upon the inclusion of candidate sites. A site was required to contain an adequate acreage of dry land for placement of the proposed facilities and could not involve gross conflicts with existing land use or social/cultural values. The site had to be potentially accessible by rail and highway, and preferably also by barge. The other initial evaluation criterion was that potential sources of cooling system makeup water and service water had to be available at or near the site.

Since many land parcels within the siting region possess these basic qualifications, the studies conducted by Florida Power have considered nearly 200 individual sites. However, as the description of alternatives will indicate, there are few highly favorable sites for power generation in Florida, due to environmental constraints which include air quality, water supply, aquatic ecology, wildlife habitat, and existing patterns of land and water use considerations.

The specific criteria used to evaluate candidate sites are grouped here for purposes of discussion into three categories: general siting criteria, engineering criteria, and environmental criteria. The first category generally refers to land suitability and access to transportation and transmission facilities.

LAND ACREAGE AND OWNERSHIP

The area of land required for the proposed power generating units is calculated as follows:

	Hectares	Acres
Generating plant	12	30
Access, parking, and construction laydown	53	130
Coal storage and handling	40	100
Cooling towers	5	12
Cooling ponds, up to	607	1,500
Fly and bottom ash storage	101	250
Total, with cooling towers	211	522
Total, with cooling ponds	818	2,022

These computations indicate that about 200 hectares (500 acres) are needed if the proposed facilities utilize cooling towers, whereas the power generating units with cooling ponds would require approximately 800 hectares (2,000 acres). Even if cooling towers are assumed, the land requirements are somewhat indefinite because of possible variations in ash-sludge storage. More than 100 hectares (250 acres) could be required if no user is found for residual ash.

Land acquisition costs have been considered as a criterion but are generally not a major source of cost differentials among alternative sites. More important is the possibility of land acquisition problems due to multiple ownership of the site area and/or existing residents at the site. The most-preferred situation is one in which the site consists of few individual parcels; the least-preferred situation would be one in which land condemnation proceedings are necessary.

TOPOGRAPHY AND GEOLOGY

Topography presents few obstacles to power plant development in Florida due to the generally level terrain. However, wet areas should be avoided for engineering as well as environmental reasons. Areas which are subject to flooding by storm runoff or ocean surges are obviously unfavorable. Avoidance of areas with known seismic activity is not a highly relevant criterion in Florida.

Geologic criteria relate to the ability of soils to support power plant structures, and the suitability of the site for construction of ponds and material storage areas. The critical variables in the former case are the depth to competent bedrock and the existence of solution activity, which is widespread throughout Florida. With regard to ponds and storage areas, there should preferably be impervious soils available for use as linings. The site should permit construction of ponds and storage areas in such a fashion that there will be no threats to public safety, surface water quality, or ground water quality.

TRANSPORTATION AND POWER TRANSMISSION FACILITIES

Highway access to a site is required for transportation of materials and personnel. The proximity of a site to supplies of construction labor is also potentially important. Rail access, preferably involving direct linkage to a major carrier, is required for purposes of fuel delivery. Water access has not been considered an absolute necessity for potential sites. The possibility of obtaining fuel by barge has been treated as an important positive factor in site comparisons, although it was not possible to express this factor in monetary terms.

A lack of adequate highway or rail access to a potential site was considered negative in terms of both project cost and environmental impact. The possibility of environmental impact would relate to the ecosystem disruption required for the creation of new transportation corridors. Perhaps the most important cost consideration, in general, is the influence of transportation facilities and site location on delivered fuel. Given the projected coal consumption of the proposed facilities, a $1 per ton difference in the delivered cost of coal would amount to a differential of $4,000,000 or more in annual operating costs.

The candidate sites included in the selection process were not limited to locations near the Florida Power's existing transmission lines.

However, any new transmission corridors required as part of site alternatives have been treated as elements of project cost and environmental impact in the same fashion as transportation corridors. At least two 230 kv lines, or one 500 kv line, would be required for the proposed facilities. Possible problems of right-of-way acquisition have also been considered. The line transmission losses which would be involved in serving the Florida Power's customers from the various sites were an important source of cost differentials. For the more remote sites considered, the losses would amount to significant percentages of total generating capacity.

8.3.3 ENGINEERING SITING CRITERIA

The two 640 Mw power generating units are proposed to be on-line in October 1982 and April 1984. The following basic engineering design criteria would apply at any of the alternative sites:

1. Unit life: 30 years;
2. Average annual load factor: 66 percent;
3. Net unit heat rate: 9,400 Btu/kwh (assuming low-sulfur coal);
4. Fuel consumption: roughly 3,600,000 metric tons (4,000,000 tons) per year of low-sulfur coal;
5. Cooling system: fresh-water cooling towers (cooling ponds and once-through cooling with salt water were considered as options in some cases).

Each 640-Mw unit would produce about 5.2 billion Btu per hour, of which a large proportion would be waste heat that must be dissipated by the cooling system. If cooling towers were utilized, heat dissipation for both 640-Mw units would require evaporation of 41,640 lpm (11,000 gpm) when the units were operating near capacity with a small additional amount lost in drift. The amount of cooling system makeup water required under these conditions would depend upon the water quality of the source utilized (which would determine the allowable cycles of concentration). The prevailing relationship is diagrammed in Figure 8.3-2. Under the conservative assumption that somewhat less than five cycles of concentration could be maintained, the cooling tower makeup requirement would equal 53,700 lpm (14,200 gpm), or about 76 million liters (20 million gallons) per day.

In addition to cooling system makeup water, service water would be required for drinking, cooling of bearings, and other uses. Cycle makeup water would be required for conversion to steam. Withdrawals for these uses would average about 3 mld (0.8 mgd) and would reach a maximum of approximately 5.7 mld (1.5 mgd). In addition, if scrubber systems were used to control stack emissions, an additional 5.7 mld (1.5 mgd)

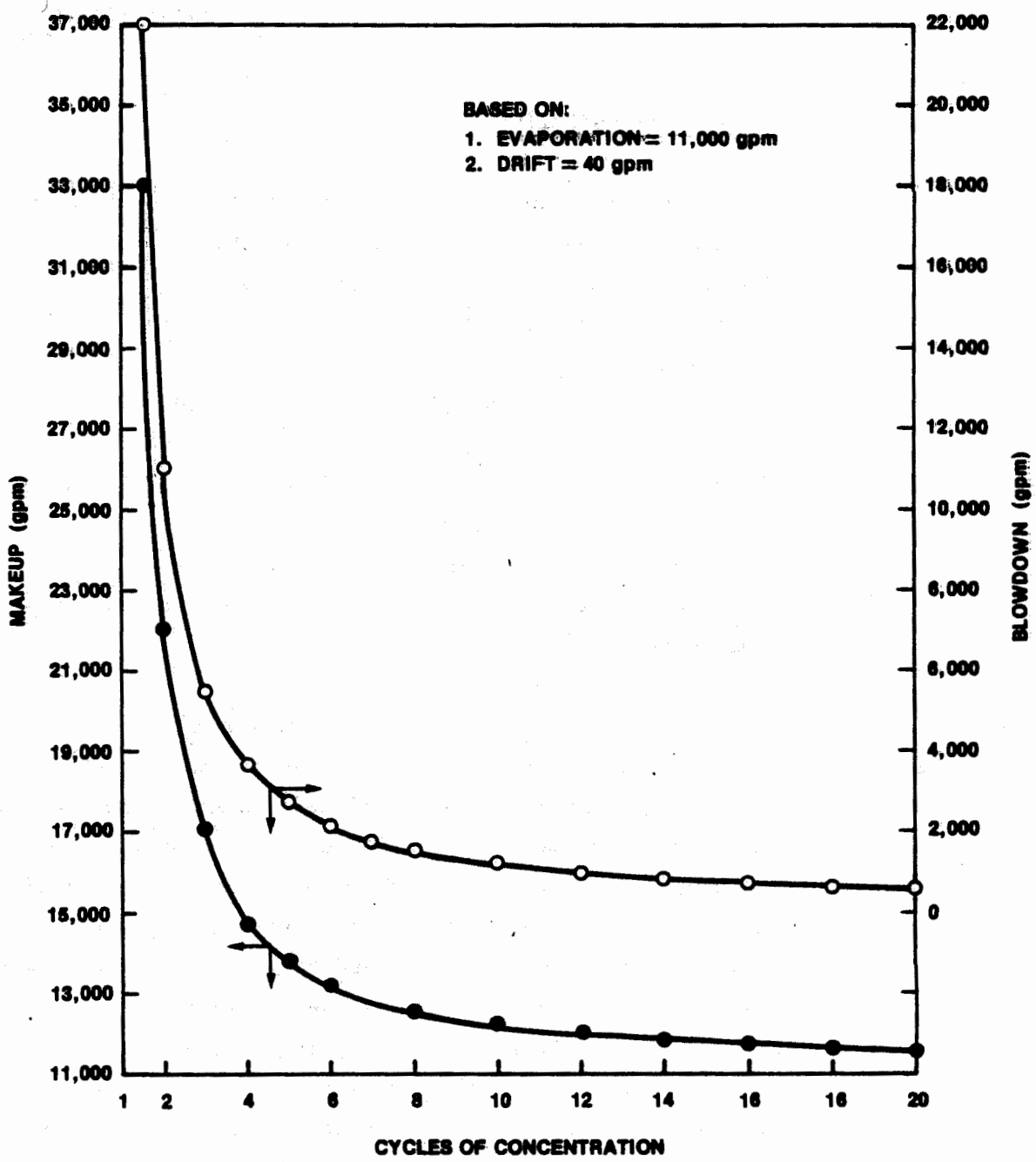

Figure 8.3-2
MAXIMUM MAKEUP AND BLOWDOWN VS. CYCLES OF CONCENTRATION IN CIRCULATING WATER FOR PROPOSED POWER GENERATING UNITS

SOURCE: FLORIDA POWER CORPORATION, 1978

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would be needed. All of these water uses would require various levels of treatment.

A maximum freshwater withdrawal rate of 87 mld (23 mgd), obtained by summing the figures just cited, has been utilized in the site evaluation process (cooling ponds could involve somewhat smaller withdrawals if losses due to percolation are low). The impacts most commonly associated with withdrawals of this magnitude from surface waters are alterations of hydroperiod (with possible salinity effects) and entrainment of aquatic organisms. A guideline utilized in Florida is that maximum withdrawal rates from surface water bodies should not exceed 5 percent of the minimum observed 30-day flow, or the estimated 100-year minimum monthly flow. On the other hand, reliance upon groundwater supplies could affect adversely the yields of nearby wells, and could possibly risk saltwater intrusion in coastal areas. The quantity and quality of available water supplies have thus been highly important in site selection.

The wastewaters yielded by power generation include cooling system blowdown water, boiler wash, backwash, plant runoff, and runoff from storage and waste disposal areas. These wastewaters must be disposed without damage to aquatic ecosystems or surface and groundwater resources. The design of wastewater disposal systems would be expected to vary considerably among site alternatives. Such systems could include deep-well injection, percolation/evaporation, or surface water discharge, with varying levels of treatment. The evaluation of site alternatives with regard to wastewater has focused upon the feasibility and expense of disposing residuals in such a manner as to comply with all applicable water quality standards. The water quality characteristics of primary concern for discharges from steam electric generating plants are dissolved solids concentrations and temperature, although other constituents such as biocides and corrosion inhibitors can be important.

8.3.4 ENVIRONMENTAL SITING CRITERIA

The environmental criteria employed in the site selection process included air quality, water resources, aquatic and terrestrial ecology, population and land use, historical and archaeological sites, recreational resources, other socioeconomic considerations, and public safety. The most detailed criteria were those pertaining to air and water resources, since these involved specific quantitative standards established by federal and state agencies.

AIR QUALITY AND EMISSIONS

Both the federal and state governments have promulgated regulations relating to the quality of ambient air. These regulations are a major factor in obtaining approval of a site for a fossil-fueled power plant. The federal and state air quality criteria which were considered in the evaluation of alternatives are presented in the following discussion.

Federal air quality limitations which can significantly affect power plant siting are the National Ambient Air Quality Standards (NAAQS) and the Prevention of Significant Deterioration (PSD) regulations. The NAAQS were promulgated by the U.S. Environmental Protection Agency (EPA) on April 30, 1971 (40 CFR Part 50). Prevention of Significant Deterioration regulations were also promulgated by the EPA (40 CFR Part 52). More recently, however, the Congress of the United States has passed amendments to the Clean Air Act which include new provisions for PSD. The President signed into law the Clean Air Act Amendments (PL 95-95) on August 7, 1977.

The NAAQS were established to protect the health and welfare of the citizens of the United States. A distinction was established between protection of public health only, and protection of public health and welfare. The former objective would be addressed by "primary" standards, whereas the latter would be addressed by "secondary" standards. Thus, secondary NAAQS have been designed to prevent occurrences such as

impairment of visibility, corrosion and damage to plants as well as public health impacts. Table 8.3-1 presents the NAAQS for total suspended particulate matter, sulfur dioxide, and nitrogen dioxide. These are the major air pollutants emitted from a fossil fuel steam electric power plant.

A new fossil-fueled power plant (exceeding 250 mm Btu/hr) must meet the emission limitation standards known as New Source Performance Standards (promulgated by the U.S. EPA in 40 CFR Part 60). Meeting these standards does not guarantee that NAAQS will not be violated, although the New Source Performance Standards make it highly unlikely that a new fossil- fueled power plant will violate NAAQS due entirely to its own emissions. NAAQS violations could occur primarily through source interaction and contribution to an existing air quality problem. Since a new source cannot cause or contribute to a violation of the NAAQS (except under provisions allowed in nonattainment areas, PL 95-95, Section 129), compliance with NAAQS must be evaluated in the site selection process.

The 1977 amendments to the Clean Air Act have significantly modified PSD requirements previously established by the EPA. The major air quality limiting features of Section 127 are the maximum allowable increases in concentrations of TSP and sulfur dioxide. A new fossil fuel power plant cannot result in any increases relative to baseline conditions which exceed the allowable increments for that area (or for a nearby area, in the case of Class I). All areas of the country are classified as either Class I, II, or III with the exception of national parks (exceeding 2,430 hectares or 6,000 acres), national wilderness areas (exceeding 4,050 hectares or 10,000 acres), and other federally designated lands (discussed in Sections 162 and 164, PL 95-95). Initially, for Florida, all areas of the state have been designated as Class II with the exception of the St. Marks, Bradwell Bay, Okefenokee, Cedar Keys, and Chassahowitza National Wilderness Areas and the Everglades National Park, which have been designated Class I. Table 8.3-2 presents the allowable air quality increments for Class I and II areas.

Table 8.3-1. National and State of Florida Ambient Air Ouality Standards (ug/m^3)

Air Pollutant	Standard	Averaging Time		
		Annual Average	24-Hour*	3-Hour*
Total Suspended Particulate Matter (TSP)	National Primary	75†	260	---
	National Secondary	60†	150	---
	State of Florida	60†	150	---
Sulfur Dioxide (SO_2)	National Primary	80	365	---
	National Secondary	---	---	1,300
	State of Florida	60	260	1,300
Nitrogen Dioxide (NO_2)	National Primary	100	---	---
	National Secondary	100	---	---
	State of Florida	100	---	---

* Not to be exceeded more than once per year.
† Annual geometric mean.

Source: Florida Administrative Code, 1977.

Table 8.3-2. Prevention of Significant Deterioration Increments (PL 95-95 Section 127)

Classification	Air Pollutant	Maximum Allowable Increases Over Baseline* (ug/m^3) Averaging Time		
		Annual Average	24-Hour†	3-Hour†
Class I	TSP	5**	10	---
	SO_2	2	5	25
Class II	TSP	19**	37	---
	SO_2	20	91	512

*Baseline refers to concentrations existing at time of first application, and sources which have commenced construction prior to January 6, 1975.
†Not to be exceeded more than once per year.
**Annual geometric mean.

Source: Public Law 95-95, 95th Congress, 1977.

Similar to the federal requirements, the State of Florida (Department of Environmental Regulation) has promulgated ambient air quality standards (AAQS) and a limitation on significant degradation. The AAQS established by the state are numerically equal to the federal secondary NAAQS (except for the annual and 24-hour sulfur dioxide standard). Since these standards are slightly more restrictive than the federal NAAQS, the state standards take precedence in evaluating compliance.

The DER recently promulgated a PSD regulation similar to the federal PSD regulation. The allowable increments in the state regulation are identical to those promulgated by PL 95-95. Therefore, no additional analysis beyond the federal level is required in evaluating sites. In order to evaluate alternative power plant sites with respect to these regulations, existing emission sources and air quality data were considered. Since Florida has generally favorable atmospheric dispersion conditions, existing air quality and sources will be the major determinants of compliance with air quality regulations. Consequently, alternative sites were evaluated primarily on these two factors.

The selection study also considered the potential effects of cooling tower fogging and drift on agriculture, local terrestrial habitats, and transportation. While there are no quantitative limiting standards for such effects, they must be evaluated on a case-by-case basis. Drift is ordinarily not a significant problem if proper safeguards are taken.

AQUATIC ECOLOGY

Impacts of power-generating facilities on water resources can also involve effects on aquatic organisms. Entrapment of organisms by intake structures is a potential impact. Certain types of water resource effects, such as thermal discharges, can possibly be beneficial to some aquatic communities; but there is usually at least an initial presumption that changes relative to baseline conditions will be negative.

Quantitative criteria generally do not exist for evaluating the impacts of alternative power plant sites on aquatic ecosystems. The procedure utilized in the selection studies, where possible, has been to review available baseline information, assess the probable magnitude of effects, and evaluate the overall importance of these impacts. The major factors considered in establishing importance are the existence of rare, endangered, or diminishing aquatic species, and the relationship of aquatic ecology to water uses, especially recreation and commercial fisheries.

TERRESTRIAL ECOLOGY

Terrestrial habitats, altered by the construction of power plant facilities, are often subject to further impact by aspects of permanent operations such as noise, air quality degradation, and cooling tower drift. Destruction of habitats is frequently the most significant environmental impact produced by construction of transmission and transportation corridors. The key factors that are considered when evaluating alternative power plant sites are: (1) the sensitivity of habitats to impact (e.g., the need to maintain a minimum habitat size); (2) the existence of species which are endangered or otherwise given protected status; and (3) the relative uniqueness of the habitats in question. The preferred site would be one in which the existing terrestrial ecosystems are not notably diverse, interesting, or valued for hunting, and are widely represented in the surrounding area.

POPULATION AND LAND USE

Fossil-fueled power plants should be sited, if possible, in areas of low population density in their immediate adjacent areas, to minimize nuisances to the public involving noise, air quality impact, transportation system usage, and other factors. Sites should not be located near sensitive areas that are incompatible with power plant construction and operation, such as parks, wilderness areas, wildlife refuges, national parks, wild and scenic rivers, and locations that may

be candidates for future recognition as scenic or recreation areas. Preferably, power plant developments should avoid areas of high natural productivity (i.e., marshes and coastal zones), and should not occupy prime agricultural land. Consistency with existing zoning and land use plans is an important criterion in areas where such expressions of public preference exist.

HISTORICAL AND ARCHAEOLOGICAL SITES

The existence of significant historical or archaeological resources at a site would not necessarily disqualify the site as a power plant location but would constitute a negative factor. At the least, monetary costs and delays could result from the need for site exploration and excavation.

RECREATION

Protection of scarce recreational resources is a high priority objective in power plant siting and in environmental impact assessment. To a considerable extent, impacts on recreation are covered by the previously mentioned criteria for air quality, water quality, and ecology. The explicit recognition of recreational value primarily involves placing an especially heavy emphasis upon protection of land areas and water bodies used for this purpose. Under no circumstances should a power-generating facility displace an appreciable share of the recreational resources in an area.

OTHER SOCIOECONOMIC IMPACTS

Some of the social and economic factors which are potentially important for power plant siting are the following: (1) employment and income created by facility construction and operation; (2) social impacts of imported construction labor; (3) increase in local tax revenues due to the power generating facility, versus the impact of the facility on the total cost of providing public services; (4) effects of the power plant

construction project upon local labor force conditions and wage rates; and (5) desirable and undesirable influences of the project upon regional growth and land use. No absolute criteria exist for evaluating power plant sites in terms of these factors, but they can support or detract from a specific site to a considerable extent.

WATER RESOURCES CRITERIA

The State of Florida has initiated a Comprehensive Planning Process to guide and implement orderly, long-range, economic, social and physical development (Chapter 23, Florida Statutes). The Water Element of the Comprehensive Plan proposes goals, objectives, and policies designed for optimal management of water resources in Florida (Executive Order 76-29).

The criteria set forth in the Water Element of the proposed Comprehensive Plan were used to evaluate alternative sites for Florida Power Corporation's new generating facilities. These general policy criteria are designed to:

1. Encourage all reasonable beneficial uses of water;
2. Protect water quality;
3. Protect floodplains and other wetlands;
4. Protect soil fertility and prevent erosion;
5. Maximize the production of agricultural and natural plant communities;
6. Maintain the natural hydroperiod as much as practical;
7. Prevent flood damages;
8. Prevent saltwater intrusion;
9. Provide for growth and development in areas inherently suited for such activities; and
10. Protect the functional integrity of coastal ecosystems.

The federal government and the State of Florida have promulgated extensive rules and regulations relating to the management of water resources in Florida. These regulations provide a means of enforcing the general

policy criteria set forth in the proposed Water Element of the Comprehensive Plan. The major legislation which relates to these rules and regulations is presented in the following list:

Federal Legislation

PL 89-90, Water Resources Planning Act

PL 92-500, Federal Water Pollution Control Act Amendments of 1972

PL 85-624, Fish and Wildlife Coordination Act

PL 92-583, Coastal Zone Management Act of 1972

PL 89-298, Title II--Flood Control Section

PL 90-542, Wild and Scenic Rivers Act

PL 90-454, Estuarine Areas Protection and Restoration Act

PL 90-448, Housing and Urban Development Act of 1968, Title XIII--National Flood Insurance Act of 1968

PL 93-523, Safe Drinking Water Act

PL 93-234, Flood Disaster Protection Act of 1973

PL 85-500, Title III--Water Supply Act of 1958

PL 91-190, National Environmental Policy Act of 1969

State Legislation

Chapter 373, Florida Statutes (Water Managment Policy)

Chapter 403, Florida Statutes, Florida Air and Water Pollution Control Act

Section 252.44, Florida Statutes (Disaster Preparedness)

Chapter 298, Florida Statutes (Policy for Water Management Districts)

Section 298.74, Florida Statutes (Drainage of Lakes)

Chapter 380, Florida Statutes, the Florida Environmental Land and Water Management Act of 1972

Chapter 160, Florida Statutes (Advisory Role of Regional Planning Councils)

Chapter 370, Florida Statutes (Coordinating Role of Department of Natural Resources, Division of Resource Management)

Chapter 582, Florida Statutes (Policies for Prevention of Soil Erosion, Floodwater, and Sediment Damages)

Section 258.36, Florida Statutes, the Land Conservation Act of 1972

Chapter 23, Florida Statutes (Development of a State Comprehensive Plan)

Executive Order 76-29 (Inclusion of a Water Resources Element Within the State Comprehensive Plan)

Chapter 163, Florida Statutes, Local Government Comprehensive Planning Act

The water quality criteria established by the State of Florida (F.A.C. Chapter 17-3) and the federal government (P.L. 92-500, Section 304) are described in Table 8.3-3. Thermal criteria established by F.A.C. Chapter 17-3.05 are listed as follows (where T refers to ambient water temperature):

Zone	Streams	Lakes	Coastal		Open
			Summer	Winter	
North	90° F Max T + 5° F	90° F Max T + 3° F	92° F Max T + 2° F	90° F Max T + 4° F	97° F Max T + 17° F
Peninsula	92° F Max T + 5° F	92° F Max T + 3° F	92° F Max T + 2° F	90° F Max T + 4° F	97° F Max T + 17° F

In evaluating alternative sites for Florida Power's proposed units, the doctrine of "reasonable beneficial use" as established in Chapter 373, Florida Statutes was used to provide general criteria for consumptive use of waters at alternative sites. Withdrawals from surface waters were tested against a guideline of 5 percent of minimum observed 30 day flow. Proposed groundwater withdrawals were evaluated on the basis of whether or not significant effects on the potentiometric surface would occur.

Table 8.3-3. Numerical Water Quality Criteria

Parameter	Fresh Water	Saline Water
Dissolved Oxygen		
minimum	4 mg/l	4 mg/l
24-hour mean	5 mg/l	5 mg/l
Ammonia Nitrogen	0.02 mg/l*	0.4 mg/l*
Total Kjeldahl Nitrogen	0.90 mg/l †	
Nitrate Nitrogen	0.30 mg/l †	0.30 mg/l**
Nitrite Nitrogen	0.20 mg/l †	0.20 mg/l**
Phosphorus	0.06 mg/l †	0.06 mg/l**
Suspended Sediment	25 mg/l*	25 mg/l*
Pesticides/Herbicides	†	†
pH	6-8.5	6-8.5
Arsenic	50 ug/l	50 ug/l
Cadmium	0.4-3 ug/l*	5 ug/l*
Chromium	300 ug/l*	300 ug/l*
Copper	500 ug/l	500 ug/l
Iron	300 ug/l	300 ug/l
Lead	50 ug/l	50 ug/l
Manganese		100 ug/l
Mercury	0.05 ug/l*	0.1 ug/l*
Nickel	100 ug/l*	100 ug/l*
Zinc	1 mg/l	1 mg/l
Silver	†	†
Chlorine	10 ug/l*	10 ug/l*
Cyanide	None detectable	None detectable
Polychlorinated Biphenyls	0.001 ug/l*	0.00 ug/l*
Phthalate Esters	3 ug/l*	
Hydrogen Sulfide	2 ug/l*	2 ug/l*
Selenium	†	†
Total Dissolved Solids		
monthly average	500 mg/l	
maximum	1000 mg/l	
Alkalinity	20 mg/l*	20 mg/l*
Aluminum,		1.5 mg/l*
Detergents	0.5 mg/l	0.5 mg/l
Fluoride	10 mg/l	10 mg/l
Oil and Grease	15 mg/l	15 mg/l
Phenol	1 ug/l	1 ug/l
Gross Beta	1000 pCi/l	1000 pCi/l
Specific conductivity	500 umhs/cm	
Turbidity	50 JTU	50 JTU
Chloride	250 mg/l	

Table 8.3-3. Numerical Water Quality Criteria (Continued, Page 2 of 2)

Parameter	Fresh Water	Saline Water
Fecal Coliforms		
monthly geometric mean	200/100 ml	200/100 ml
10% of samples	400/100 ml	400/100 ml
any one day	800/100 ml	800/100 ml
Total Coliforms		
monthly geometric mean	1000/100 ml	1000/100 ml
20% of samples	1000/100 ml	1000/100 ml
any one day	2400/100 ml	2400/100 ml

* EPA recommended criteria (1975).
† EPA recommended criteria (1975) defined in terms of LC_{50}.
** DER--Planning Appendix to the Water Quality Management Plans.

Source: Florida Department of Environmental Regulation, 1978.

8.3.5 EVALUATION OF CANDIDATE SITES

DESCRIPTION OF CANDIDATE SITES

The general locations of the following candidate sites are shown in Figure 8.3-1.

Gulf County Site

Several sites near Port St. Joe, Gulf County (in the Florida panhandle), have received consideration in site selection studies by Florida Power. The locations have included sites along the coast at Palm Point, between Port St. Joe and Beacon Hill, and 1.6 kilometers (1 mile) northwest of Mexico Beach. The most favorable potential site, and the one considered here, is on the south side of the Gulf County Canal near its confluence with the Intracoastal Waterway.

A once-through cooling system, drawing water from the Intracoastal Waterway and discharging into the Gulf County Canal, has been proposed for the Gulf County site. Off-stream cooling could utilize the same water source. Another possibility would be fresh water from wells. The ground water is the softest and least mineralized in the state, and a high rainfall and an aquifer of unconsolidated quartz sand and gravel make a good supply of ground water probable.

Road access to the site is favorable, as Routes 71 and 382 run near the eastern boundary. Dredging of a short access canal and turning basin would allow coal barges to reach the site via the Gulf County Canal. The geographic location of the site is favorable for receiving coal barged down the Mississippi River. There is rail access at Port St. Joe, which might possibly be extended to the site by a 4-kilometer (2.5-mile) spur at little or no cost to Florida Power. As discussed later, the existing railroad service and freight cost structure in Florida for coal delivery cause this site to be considerably more expensive to serve by rail than any of the other sites considered.

A 230-kv power line extending east from Port St. Joe is presently under construction. Location of the proposed power generating units at the Gulf County site would require extensive additional improvements to the transmission system. Due to the great distance of this site from the load centers served by Florida Power, the line transmission losses would amount to a significant proportion of the total power generated.

The site seems to offer no major difficulties of topography or geology. Surficial quarternary rock is underlain by blue-grey clay, then shoal river formation, and, at about 120 meters (400 feet), chipola limestone. No earthquakes have been reported along the west coast of Florida. The area is subject to relatively frequent storms, which bring both high winds and flooding of low-lying areas. On the average, tropical storms (winds exceeding 34 knots) occur every 1.4 years, and hurricanes occur every 3.8 years.

The Intracoastal Waterway is considerably altered from natural conditions, and the Gulf County Canal is completely artificial. No data which describe the water quality and flow regime of these waterways have been located. The effects of withdrawals from the Intracoastal Waterway on currents and aquatic systems cannot be accurately predicted at present. However, a power plant at the site under discussion could clearly have adverse impacts upon St. Joseph Bay, which receives flow from the Gulf County Canal. The bay is about 24 kilometers (15 miles) long and 8 kilometers (5 miles) wide, with a surface area of 17,732 hectares (43,782 acres). The single opening to the Gulf of Mexico is about 3.2 kilometers (2 miles) wide, and tidal range averages about 0.5 meters (1.4 feet). Most of the bay has been classified by the State of Florida Department of Environmental Regulation as suitable for shellfish propagation and harvesting. Some sludge deposits and oxygen depression presently occur within a 1.6- to 2.4-kilometer (1- to 1.5-mile) radius of the canal outlet because of paper mill waste discharges. Heated water discharged into the canal would flow 8 kilometers (5 miles) and would cool considerably before entering St. Joseph Bay. However, supersaline water would not be diluted. The effects of thermal and saline

additions to the bay could be serious, since there is considerable doubt whether the flushing rates for the bay would be adequate to dissipate these effluents.

The site is wholly owned by the St. Joe Paper Company. It is about two-thirds covered by planted pine, with the remainder consisting of fresh-water marsh. Both these habitats are widely represented in the area. Population density in the region is low, and there are no buildings on the site, which is presently used for tree farming. The nearest population center is Port St. Joe (population 4,246 in 1977), located 3.2 kilometers (2 miles) to the southwest. There is some industrial development on the Gulf County Canal to the north of Port St. Joe. The only known place of historic or archaeological interest in the area is the town of Port St. Joe, which was the site of the first State Constitutional Convention in 1878. The Pig Island Wildlife Reserve and the T.H. Stone State Park are located in the general vicinity of the site.

With regard to air quality, there are presently major sources of particulates (TSP) near the proposed Gulf County site, the most significant being the St. Joe Paper Company pulp mill in Port St. Joe. A new steam electric power plant could comply readily with NAAQS and PSD requirements pertaining to sulfur dioxide concentrations; but the concentrations of particulates would have to be investigated closely. In addition, this site has lower dispersion potential than sites further east and south in Florida.

St. Marks

The St. Marks site is located in Wakulla County about 1.2 kilometers (0.7 miles) southeast of Newport, 0.8 kilometers (0.5 mile) east of St. Marks River, and 3.2 kilometers (2 miles) northeast of St. Marks. The site lies in the river floodplain at an average elevation of about 5.2 meters (17 feet) which is an undesirable feature for a power plant site. The only sources of water are wells and the St. Marks River. The quality of ground and surface waters is not known, but ground water

apparently contains sulfur. The average flow of the St. Marks River (1956-1973) 18,860 lps (666 cfs) at a point about 10 kilometers (6 miles) upstream from the site and the minimum of record is 8,778 lps (310 cfs). The proposed power generating facilities would require about one-tenth of the minimum flow for cooling water make-up, so that alteration of hydroperiod could be a major problem. Other uses of this water are not known.

Road access is good; State Road 59 runs along the eastern boundary of the site. The Seaboard Coastline Railroad serves St. Marks, and access could be provided to the site by constructing about 4 kilometers (2.5 miles) of new track. Barge access to the site would require extensive dredging. There is an existing 230 kw transmission line nearby, but the site is quite distant from the major areas of power need, so that transmission losses (i.e., voltage drops) would be considerable.

The geologic foundation at the site is sandy, chalky limestone. Although the cooling requirements of the proposed facilties would amount to 5 percent of the average flow of the St. Marks River, the effects on the estuary to the south would be moderated by the fact that the St. Marks joins with the larger Wakulla River about 6 kilometers (4 miles) downstream from the site. The estuary and a great deal of the neighboring coast is within St. Marks National Wildlife Refuge. Although the plant would not necessarily have major negative impacts on the estuary, the sensitivity of the area would mandate a careful demonstration of no-effect.

County maps show no buildings on the site. Marsh hammocks and saw palmetto-pine cover the site. Both habitats are extensive in the area. The site, which is located within the Aucilla Wildlife Management Area, is 0.8 kilometers (0.5 miles) from the border of the St. Marks National Wildlife Refuge. Population density in the region is generally low, but the site is only 0.8 kilometers (0.5 miles) from the community of Newport, and only 3.2 kilometers (2 miles) from St. Marks (population

293 in 1977). The archaeological and historical resources of the site are unknown.

Air quality in the vicinity of the St. Marks site is affected by some sources of TSP and sulfur dioxide, which include the 151 Mw oil-fired power plant operated by the City of Tallahassee just south of the proposed site. More important, the nearby St. Marks Wilderness Area has been designated a Class I air management area by virtue of the recent Clean Air Act Amendments. This fact could severely constrain future power plant development.

Levy County (2 Sites)

The southern Levy County site lies on the east bank of the Suwannee River, about 13 kilometers (8 miles) west of Chiefland (population 2,036 in 1977), and 2.4 kilometers (1.5 miles) south of Manatee State Park. Road access is provided by paved County Road 347 along the eastern boundary. Barges could reach the site via the Suwannee River; but the increase in river traffic caused by barging coal to the site might constitute a significant impact. Rail service by the Seaboard Coastline Railroad through Chiefland would require at least 32 kilometers (20 miles) of new track.

A second potential site in this area is located about 10 kilometers (6 miles) to the north. This site also occupies the east bank of the Suwannee River and lies between the town of Suwannee River (population 225 in 1977) and Manatee Springs State Park. Road and rail access would be from the U.S. 19 corridor about 4 kilometers (2.5 miles) away.

The nearest 230 kw transmission line is located in western Alachua County, about 40 kilometers (25 miles) away from either site. A 69 kv line extends into Chiefland from the east. Cooling water for either site would be available from the Suwannee River. The average annual flow at Wilcox (immediately north of the town of Suwannee River) is 250,000 lps (8,800 cfs). The minimum daily flow for 17 years of record

is 92,590 lps (3,270 cfs). The proposed power generating facilities would require less than 1 percent of this minimum flow.

Both potential sites are located on the Chiefland limestone plain, a flat rolling surface formed by erosion of Eocene limestone and leveled by deposition of fine argillaceous sand. The southern site includes several small intermittent ponds, suggesting sink holes; but the northern site lacks such features.

Aquatic vertebrates of special concern which have been reported in the Suwannee River are the following:

Endangered:	Florida manatee
	River redhorse
	American alligator
Rare:	Suwannee bass
Depleted:	Atlantic sturgeon.

The effects of the proposed power generating facilities on river and estuarine ecosystems would be limited by the fact that water withdrawals would average only about 0.35 percent of total river flow.

Construction of power plant facilities at the southern site might entail destruction of some freshwater marsh (6 percent of the site), cypress dome communities (14 percent of the site), and cypress-sweet gum-tupelo (13 percent of the site). Freshwater marsh is extensive throughout the surrounding area. The remainder of the southern site is covered by planted pine (43 percent of the site) and mesophytic hardwoods (22 percent of the site). The northern site lacks aquatic habitats and is covered by forest (of unknown composition) with some open fields. According to one siting report, the vicinity of the two Levy County sites could not be considered a typical wilderness habitat. Within the area there is hunting for white-tailed deer, grey and fox squirrels, wild hog, and rabbits. Levy County is included within the range of Florida panther (an endangered species), but this animal is not considered likely to occur at either site. No endangered species of birds

are among the 99 known to occupy Manatee Springs State Park. However, two permanent residents, the American osprey and white ibis, are listed as "status-undetermined" species.

Old Town, site of one of the largest early Indian villages in Florida, lies on the west bank of the river about 5.6 kilometers (3.5 miles) northwest of the northern site. This is the nearest point of known historic or archaeological interest. Both sites are very close to Manatee Springs State Park which comprises 730 hectares (1,800 acres). The southern site borders Lower Clay Landing, a cluster of eight homes, and lies 2.4 kilometers to 3.2 kilometers (1.5 to 2 miles) north of Fowler Bluff, a concentration of about 50 buildings, most of them seasonal dwellings. There are several houses on the opposite bank.

The Suwannee River is used for sport fishing, commercial catfishing, and a dwindling sturgeon fishery industry. The river is also used for power boating and water skiing, and has been proposed both as a state canoe trail and as a federal Wild and Scenic River. On the whole, the sites on the Suwannee River would be among the most sensitive in terms of possible public and governmental reaction.

There are presently no major sources of air pollutants in the vicinity of the proposed sites, and the area is classified as Class II. Therefore, construction of new generating facilities should not cause a violation of NAAQS and should meet PSD increments under current conditions. However, if the area became a Wild and Scenic River and thus was shifted to a Class I area, the proposed facility might have to be limited in total capacity.

Crystal River

This site is located in Citrus County on the north shore of the Crystal River estuary about 110 kilometers (70 miles) north of St. Petersburg. The property is owned by Florida Power, which operates three existing power plants at the site: a 383 Mw oil unit, a 498 Mw coal unit, and an

825 Mw nuclear unit. The present oil unit (Crystal River Unit 1) is scheduled for conversion to coal in March of 1979. Unit 2 was converted to coal in December of 1976. All three existing units use once-through cooling with salt water. For the proposed new power generating facility, there are several theoretically possible sources of makeup water for cooling towers or ponds, which are described in the following paragraphs.

First, for freshwater makeup, wells could be drilled along the present power line rights-of-way. This alternative would require a water pipeline of about 9 kilometers (5.6 miles) in length.

Second, surface water could be withdrawn from the Crystal River or Lake Rousseau. Because Lake Rousseau appears preferable in terms of water quality, discharge, and avoidance of environmental impact, only Lake Rousseau has been considered in the latter stages of facility planning. Lake Rousseau was created by the construction of Inglis Dam across the Withlacoochee River in 1909. More recently, the lake was intended to be part of the Cross Florida Barge Canal. The section of the Canal between Lake Rousseau and the Gulf was constructed before the project was discontinued. The Canal cuts across the Withlacoochee River below Inglis Dam and reaches Lake Rousseau about 2.4 kilometers (1.5 miles) above the dam. Most of the flow of the Withlacoochee River is shunted through the lock. This arrangement leaves both the western area of Lake Rousseau behind Inglis Dam, and the section of the Withlacoochee River downstream from the dam, separated from the principal through-flow. Water withdrawals from behind the dam to serve the proposed new power generating facilities would increase flow substantially through the western arm of the lake, but would amount to less than 1 percent of the total flow of the Withlacoochee River.

Third, sea water could be used for once-through cooling, as in the present units. This step would require modification of existing intake and discharge canals.

Fourth, sea water could be used for off-stream cooling, such as cooling towers.

Fifth, the Barge Canal section below the Withlacoochee River could be utilized as a water source and possibly as a cooling pond. Using this source might involve construction of a salinity barrier and a gate to admit high flows from the Withlacoochee.

The Crystal River site is underlaid by a thin veneer of Pleistocene and Recent sediments over Inglis and Avon Park limestone. The groundwater table is at 3 meters (10 feet), and bedrock is encountered at 6 meters (20 feet). An existing network of vertical solution channels probably does not compromise the soundness of the rock. The site at which the proposed facilities would be located, to the northeast of the existing power generating units, presently consists of pine forest. There are some wet areas which should be avoided. It is considered unlikely that faunal species of special concern occur at the site, because of the highly altered state of the habitats present. However, bald eagles and ospreys are among birds observed on the site.

Facilities for barge delivery of coal are already present at the site. Without further maintenance dredging, the barge access arrangements would be somewhat limiting on the barge loads that could be handled. However, unloading capacity per se is more than adequate. The Crystal River site is presently served by both 230 kv and 500 kv transmission lines that extend east and south to the major urban centers of central Florida. These lines could easily accommodate the additional power loads generated by the proposed facilities. Crystal River is fairly well located relative to the load centers of Florida Power system.

The Crystal River site is favorable in terms of land use. Beyond the boundaries of Florida Power's holdings (which exceed 1,600 hectares or 4,000 acres) there are few sensitive land uses within several miles in any direction. The area consists primarily of wetlands, scrub, pasturage, planted pine, and some industrial land uses. The Crystal River site is considered especially favorable in terms of public acceptance of new power generation facilities.

There are two important considerations regarding air quality impact at the Crystal River site. First, the existing fossil-fuel plants at Crystal River predate the New Source Performance Standards and thus exceed the allowable sulfur dioxide emissions under these standards by a factor of five. Second, the Chassahowitzka Wilderness Area, located 21 kilometers (13 miles) south of the site, is now a Class I area with regard to air quality. These two factors may make it difficult for a new power generating facility to meet NAAQS and PSD requirements, unless the baseline air concentrations at Chassahowitzka are reduced (e.g., by substituting some low-sulfur fuel for high-sulfur fuel at the existing plants).

Anclote

The Anclote site is located in the extreme southwest portion of Pasco County on the north shore of the Anclote River estuary, 2 miles north of Tarpon Springs (population 11,951 in 1977). Five kilometers (3 miles) directly offshore are the Anclote Keys which include an undeveloped state park and a national wildlife refuge. Florida Power presently operates a 1,030-Mw facility at this site. Both of these facilities are oil-fired and utilize salt water for once-through cooling. Fuel is delivered to the site via pipeline.

The geology of the site involves 0 to 6 meters (0 to 20 feet) of unconsolidated sand overlying weathered limestone, with well-developed organic sediments occurring in scattered wet areas. Solution-collapse features are common. The site contains longleaf and slash pines and a xeric hardwood scrub. There are also limited areas of freshwater marsh and more mesic hardwoods. Saltwater marshes and mangroves are found along the coast. The area is heavily influenced by man and is considered unlikely to contain rare or endangered faunal species. However, bald eagles are among the birds seen near the site. Raccoons are much in evidence and may, perhaps, prevent the establishment of viable rookeries.

The principal advantages of the Anclote site for power generation are its proximity to the Pinellas County load center and its position within the existing transmission system. Its disadvantages involve water supply, land availability, and the presence of nearby urban development. Relatively little land would be available at the site without extensive condemnation proceedings. This fact, along with the existing stress upon freshwater resources in the vicinity of the site, would limit the available cooling options to saltwater cooling towers or once-through cooling. The latter would appear to be ruled out by the limited ability of the shallow waters in Anclote Anchorage to absorb additional heat loads, as well as by government policies.

Coal could potentially be brought to the site by either barge or rail. However, since barge docking and unloading facilities presently do not exist at the site, dredging would be required. The impacts of dredging and barge transportation on aquatic ecosystems could be significant.

The existing power generation facilities at Anclote are subject to New Source Performance Standards, so that the construction of a new facility would probably not cause a violation of either NAAQS or PSD air increments in the general vicinity of the plant. However, since the Anclote site is close to urban areas that are already subject to air quality stress (i.e., Pinellas County has been designated as a nonattainment area for sulfur dioxide), a new source could worsen existing air quality problems.

Phosphate Mining Site

The phosphate mine site under consideration is the 4,500 hectare (11,000-acre) International Minerals Corporation property located directly west of Homeland and approximately 8 kilometers (5 miles) southwest of Bartow (population 13,975 in 1977) in Polk County, Florida. The site has been selected in order to take advantage of land that has already been disrupted due to mining operations, for which the development of power generating facilities would, in fact, result in

reclamation of the existing land. A power generating facility at this site would utilize sanitary wastewater from the City of Tampa's sewage disposal plant as cooling tower makeup water. A 64-kilometer (40-mile) pipeline costing roughly twenty million in current dollars would be required. Construction of this pipeline undoubtedly would involve some environmental impacts. On the other hand, the wastewater from Tampa would benefit water quality in the bay area as well as conserve freshwater resources inland.

The topography of the general area around the phosphate mining site is characterized by numerous depressions that are solution-related. However, geologic studies indicate that the underlying rock materials would be competent for support of heavy structures. The site has been highly altered by phosphate strip mining and agriculture so that almost no natural habitat remains. Of the total site area, 52.9 percent is pasture and cleared land of low natural fertility; 37.5 percent consists of abandoned mining areas with associated ponds and slime pits; 8.9 percent supports mesophytic hardwood growth, and 0.6 percent is citrus grove. The site formerly had been covered by pine flatwoods. The only game mammals known to occur on the site are marsh and cottontail rabbits. Game birds are limited to ducks, bobwhite quail, and mourning doves. Despite the large areas of pond and marsh habitat, the site is not an area of concentration for either doves or waterfowl (Florida Department of Natural Resources, 1971). The bald eagle, Florida grasshopper sparrow, and Florida burrowing owl are known to occur in the general vicinity of the site, but are considered unlikely to nest in such a highly disturbed area.

The phosphate mining site has very good highway and rail access, although there is no water access. A transportation alternative which might prove favorable is the barging of coal to Tampa, and rail shipment for the last 64 kilometers (40 miles). A backhaul arrangement could possibly be established involving outbound shipment of phosphate products. The location of the site is highly favorable with regard to

the anticipated pattern of demand for power, and moderately favorable in terms of proximity to existing transmission corridors. There are no historic, scenic, cultural, or natural landmarks within the vicinity of the site, although the Peace River to the south has been designated as a Canoe Trail by the state. The site is rated highly in terms of: (1) the value of the land in question for alternative uses, which is low; (2) the nature of surrounding land uses; and (3) the overall degree of ecological impact that would be produced by power plant development.

Air quality would be a problem at the phosphate mining site because the area contains major industrial sources of TSP and SO_2, resulting in elevated ambient concentrations. Violations of NAAQS for TSP have been observed. The vicinity of the site has been designated an Air Ouality Maintenance Area for TSP and SO_2 by the Florida Department of Environmental Regulation, so that special review is required for new sources. Although the exact situation cannot be known without detailed study, it appears that the proposed facility might cause or contribute to NAAQS violations unless extra controls were implemented. Also, the air quality increment for Class II might not be available for the facility.

Lake Jessup

The Lake Jessup site is located in Seminole County on the southeastern shore of Lake Jessup, about 4 kilometers (2.5 miles) north of Oviedo and 19 kilometers (12 miles) northeast of Orlando. This site has been included here due to the desirability of an alternative in the Orlando area which would utilize municipal wastewater for cooling system makeup. Relatively little information is available for the Lake Jessup site, or for the possibility of utilizing municipal wastewater in this case. The City of Orlando operates two 30 mld (8 mgd) sewage treatment plants whose combined flow would fall somewhat short of the cooling water makeup requirements of the proposed facilities (although the shortfall might be small by 1984). Orlando wastewater might, therefore, have to be supplemented by water from other municipal treatment plants, from

Lake Jessup, or from other sources. The costs and environmental impacts associated with piping Orlando wastewater to the Lake Jessup site are uncertain at the present time.

The Lake Jessup site under consideration is composed of land parcels owned by as many as 40 different individuals. The site contains orange groves and truck farms, along with limited areas of marsh and scrub forest. There are a small number of existing residences. The area surrounding the site is generally rural in character, but has a moderately high population density. Most of the site itself is well drained and contains dark soils of high organic content. Unlithified sediments of the Fort Preston Formation are exposed on the site, and there are peat deposits of unknown thickness. Structural contours on geologic maps indicate that Eocene limestones lie at 23 to 30 meters (75 to 100 feet) beneath the surface. Deep foundations would probably be required for construction of the proposed power generating facilities.

An existing bituminous road runs along the southern edge of the property. Railroad service is presently available only at Ovido, about 4 kilometers (2.5 miles) to the south, but a dismantled spur right-of-way reaches the southern edge of the site. It appears unlikely that barging of coal to the site via Lake Jessup would be feasible, due to limited depth and other constraints.

The probable impacts of the proposed project at Lake Jessup upon water, land, and air resources are relatively unknown. The project, if sited carefully, should have only limited effects upon terrestrial fauna and flora because most of the land has been altered from natural conditions for agricultural use. The loss of prime agricultural land would be a significant impact in itself, however. Water quality in Lake Jessup would be a serious concern; and extensive hydrological studies would be required to prevent either alteration of hydroperiod or contamination of ground water. The site is only 2.4 kilometers (1.5 miles) from the Econolockhatchee River, which has been designated as a State Canoe

trail. However, the site is not within the surface drainage basin of this water body. Regarding air quality, the Lake Jessup site is perhaps as favorable as any of the other alternatives discussed here, because of the absence of industrial emissions or Class I areas in the immediate vicinity.

DeBary

The DeBary site is located on the east bank of the St. Johns River in Volusia County near the town of DeBary. Other nearby communities are Orange City, Deltona, and Deland. Since 1976, Florida Power has operated a 336 Mw combustion turbine plant at the site, and more than 1,250 Mw of additional generating capacity is located in the vicinity. The land area at the site consists of sandy hills and some freshwater marsh underlain by limestone. Secondary and remnant channels of the St. Johns River dissect the eastern portion of the site, and there are some surface depressions due to solution activity. The area immediately surrounding the 810 hectare (2,000 acre) site consists of sandy hills and stands of slash pine, with very little developed land.

The primary vegetative associations at the DeBary site, in order of importance, are sand pine scrub, brush flatwoods, brush swamp, prairie, mesophytic hardwoods, and freshwater marsh. The existing fauna in the vicinity of the site are known to include more than 41 species of mammals, 192 species of birds, 33 species of amphibians, and 58 species of reptiles. The presence of rare or endangered species has not been determined. A 1973 study by the State of Florida found no significant archaeological or cultural resources at the site proper, although two potentially important sites were identified at the south end of Pine Island which would require further examination. The Wekiva River, a state Canoe Trail, enters the St. Johns River 1.6 kilometer (1 mile) below the site; and Huntoon Island State Park is 3.2 kilometers (2 miles) downstream.

The DeBary site is potentially favorable in terms of transportation, since a rail line crosses the property. Barge access is possible via the St. Johns River, although construction of barge terminal facilities would require substantial dredging. The barge traffic generated by the proposed power generating plant might also create navigational problems on the river due to the volume of existing traffic. A significant disadvantage of the site is that a substantial area is subject to flooding under extreme conditions.

The DeBary site is well-situated relative to the anticipated future power needs within Florida Power's service area. No new transmission corridors would be required. The size of the site would permit the use of either cooling towers or cooling ponds. On the other hand, the site is questionable in terms of water supply, wastewater disposal, and air quality degradation. Water quantity and quality have become serious issues in the St. Johns River basin. The long-term average discharge of the St. Johns is 85,000 lps (3,000 cfs), and the average for the driest month (May) is 51,000 lps (1,800 cfs). However, the lowest monthly flow of record is only 1,980 lps (70 cfs). Withdrawals by the proposed facilities for cooling water makeup could therefore approach one-third of discharge on rare occasions.

Disposal of wastewater from the power plant operations into the St. Johns could be unacceptable because of the recreational use of the river in this vicinity. Evaporation/percolation ponds could pose a threat to groundwater supplies, due to the permeability of the limestone substrate and the fact that recharge to the Floridan aquifer occurs at the site. Finally, ambient air quality near the site is likely to be degraded due to the existing power plants in the area.

Palatka North and Palatka South

Two sites in Putnam County near the City of Palatka (population 9,271 in 1977) are discussed here, one about 8 kilometers (5 miles) northeast of

Palatka and one approximately 5.6 kilometers (3.5 miles) southeast of the city. Both sites front on the St. Johns River. These sites are outside Florida Power's service district, but are less distant from the primary areas to be served than several of the other alternatives under consideration. The major advantages of these sites are that direct barge access to East Coast ports would be possible via the St. Johns River (control depth 4 meters or 13 feet), and that rail delivery from points outside Florida would be less costly than for any of the other alternatives.

The Palatka North site consists primarily of a large dairy farm. The adjacent land is pine woods with a large cypress dome directly to the west. Some cypress occurs on the site, but only in a few low areas. A significant land use problem is the fact that the riverfront near the site is lined with upper-income homes. The Palatka South site is primarily forested with some open fields and marshy areas. Nine houses and a boat ramp at Stokes Landing presently exist on the site. Deep foundations would probably be required for construction of the proposed facilities at the Palatka South site. Undifferentiated Pleistocene and recent deposits overlie older deposits, and Eocene limestones begin at about the 60 meter (200 foot) depth.

Both the Palatka North and Palatka South sites would be served by the Seaboard Coastline Railroad, with 3.2 to 4.8 kilometer (2 to 3 mile) rail spurs required in each case. A significant factor in terms of cost and environmental impact is that a transmission corridor exceeding 64 kilometers (40 miles) in length, and probably another shorter corridor, would be required in order to link either site to Florida Power's existing transmission system. The flows in the St. Johns River are probably adequate for its use as a source of cooling system makeup water, although salinity and entrainment of aquatic life might pose problems. The possibility of water quality and thermal impacts as a result of power plant operation would have to be studied carefully.

The only existing major source of air emissions near the Palatka North site is the Hudson Pulp and Paper Company facility west of Palatka. However, the Seminole Electric Cooperative plans a 600 Mw coal-fired power plant at a location near Bostwick. This expansion may consume PSD increments that otherwise would be available for the Florida Power facilities. In addition, there might be a possibility of NAAQS violations. With regard to the Palatka South site, the Hudson and Seminole emissions would be more distant, but air quality would be affected by a 580 Mw combined cycle facility operated by Florida Power and Light Company at a nearby location. Thus, NAAOS would also have to be examined closely in this case.

COST COMPARISON OF ALTERNATIVE SITES

The total cost of providing electrical service is no longer the only criterion considered in power plant siting and design. Government regulations and policies aimed at minimizing environmental impacts, along with growing awareness of these concerns on the part of the public and the industry, have created a situation in which many factors can override cost considerations. However, close attention must obviously be paid to cost in order to establish site feasibility.

Table 8.3-4 presents a summary cost comparison of all the sites discussed above, with the Crystal River site as a base. All costs are presented as increments relative to the corresponding cost for the Crystal River site (with negative increments written in parentheses). Three major categories of cost are considered, on an annualized basis: power transmission, fuel delivery, and cooling. Most of the omitted elements, such as site acquisition and site development costs, would not affect significantly the outcome of the comparison. However, an excluded element which could have a major bearing on the comparison is the existence of cost differentials due to different air emission control requirements at the various sites. (This factor is discussed later). The data are necessarily quite rough because a large number of uncertainties are involved.

Table 8.3-4. Comparative Costs for Power Plant Site Alternatives: Increment Costs Relative to Crystal River Site (Millions of Dollars)

	Transmission	Fuel Delivery	Cooling	Total
Gulf County	26	8-10	(10)	24-26
St. Marks	11-14	4-5	0	15-19
Levy County (2 sites)	7-9	0	0	7-9
Crystal River	0	0	0	0
Anclote	2	3-4	0	5-6
Phosphate Mining Zone	(3)	4-5	4	5-6
Lake Jessup	2	0	3-4	5-6
DeBary	0	0	0	0
Palatka North	9-10	(1-2)	0	7-9
Palatka South	8-9	(1)	0	7-9

Note: Numbers in parentheses are negative quantities.

Sources: Florida Power Corporation, 1977.
Environmental Science and Engineering, Inc., 1977.

The transmission cost element covers both the required investment in new transmission facilities, on an annualized basis, and the anticipated line transmission losses. An average cost of $550,000 per mile of new transmission corridor is assumed; but actual costs obviously could deviate from this figure depending upon the conditions encountered. The valuations placed on the transmission losses are based upon estimates of future demand for power in each of the five major regions served by Florida Power.

Fuel delivery is potentially a very important cost element and is perhaps the factor that involves the greatest degree of uncertainty. The findings of fuel supply studies have indicated that it is adequate to conduct cost comparisons of alternative sites using the assumption that all coal shipments, amounting to 4,000,000 tons (3,600,000 metric tons) per year, will be by rail. The availability of water transportation thus is not reflected in the cost comparisons shown in Table 8.3-4. However, water access is treated qualitatively as a "plus" for the following sites:

<u>Full Water Access Advantage</u>

Gulf County
Crystal River
Palatka (North and South)

<u>Partial Water Access Advantage</u>

St. Marks
Levy County (2 sites)
Anclote
Phosphate zone
DeBary

The sites listed as having a partial advantage are cases in which reliance upon barge transportation could be problematic, due to: dredging requirements (St. Marks, Anclote, and DeBary); the existing

volume of barge traffic (DeBary); or other anticipated impacts. The phosphate zone site is also included because of its potential for barge/rail shipments involving deep-draft barges to Tampa.

Regarding rail transportation, the prevailing rate structure is such that all shipments to Florida are charged as if they pass through Jacksonville, whether or not this is actually the case. Three representative rates for coal shipments from Eastern Kentucky are the following:

to Crystal River: $17.37/ton
to Bartow (phosphate zone): $18.53/ton
to Port St. Joe: $21.98/ton

The cost comparisons in Table 8.3-4 assume that cooling towers would be utilized at all of the alternative sites except Gulf County, in which case there would be once-through cooling. Cooling tower makeup water would necessarily be fresh water except possibly at the Gulf County, Crystal River, and Anclote sites. Cooling ponds could potentially be substituted for towers at several of the sites; but this might produce only limited savings, due to the precautions which would be required in constructing and operating the ponds. The only nonzero cost increments for cooling other than at the Gulf County site are for the two cases in which municipal wastewater effluent would be the primary source of cooling tower makeup water. The use of treatment plant effluent would involve an increment of approximately one million dollars in operating costs, in addition to the costs associated with pipeline construction.

The total increments shown in the last column of Table 8.3-4 indicate that the Crystal River and DeBary sites are most favorable in terms of cost, and that the Gulf County and St. Marks sites are by far the least favorable because of their distance from major load centers served by Florida Power and the existing power transmission system. The overall cost comparisons presented in Table 8.3-4 suggest a categorization of the sites into the following four groups:

SITE RATINGS ACCORDING TO COST*

Unacceptable

Gulf County

St. Marks

Marginal

Levy County (2 sites)

Palatka North

Palatka South

Moderately Favorable

Anclote

Phosphate zone

Lake Jessup

Highly Favorable

Crystal River

DeBary

*Excluding differential costs due to air emission controls.

The group containing Gulf County and St. Marks has been termed "unacceptable" because the cost increments for these sites relative to Crystal River would amount to more than 10 percent of the total annual project costs at the latter location. Sites in the "marginal" category remained eligible for consideration if they were especially favorable in other respects. As for sites in the "moderately favorable" and "highly favorable" cost categories, the differences between these in terms of cost have been considered less important than distinctions involving environmental impact and social acceptance.

AIR QUALITY COMPARISON OF ALTERNATIVE SITES

The factors affecting the degree of air emission control required at the alternative sites have already been discussed on an individual basis. These factors could not be included in the cost comparisons without detailed studies to determine the emission controls required in each case. However, Table 8.3-5 presents a summary evaluation of the sites in terms of the probability that the proposed power generating facilities

Table 8.3-5. Air Quality Constraints for Alternative Sites

Probability of Approval Without Additional Cost	Site	Probable Magnitude of Additional Cost Required To Meet NAAQS and PSD
80% or Better	Levy County (2 sites) Lake Jessup	None
50% - 65%	Gulf County Palatka South DeBary	None
0% - 20%	Anclote Palatka North	Small
0%	St. Marks (Wakulla Co.) Crystal River Phosphate Zone (Polk Co.)	Small to Large

Source: Environmental Science and Engineering, Inc., 1977.

could be approved at a given site without additional expenditures beyond the level required to comply with New Source Performance Standards and Latest Reasonable Available Control Technology. These judgments are necessarily subjective, but are based on all available information regarding air quality and applicable standards.

Table 8.3-5 shows that air emission control requirements could reduce or negate some of the cost differences noted earlier, in particular the cost advantage of the Crystal River site and the disadvantages of the "marginal" sites (the Levy County and Palatka alternatives). The extent of these offsetting effects is relatively uncertain, however.

FURTHER SCREENING OF SITE ALTERNATIVES

The two most remote site locations, relative to Florida Power's service area, were eliminated from further consideration on the basis of cost differentials. The group of sites ranking next in terms of remoteness and comparative cost, namely the locations in Levy County and the sites near Palatka, also lacked sufficient compensating factors to warrant further consideration. A major disadvantage in terms of environmental impact is that new transmission corridors would be required for all four of these sites, with the total length possibly exceeding 97 kilometers (60 miles) for the Palatka alternatives.

The Palatka North site would tend to involve land use conflicts and site acquisition problems. Site development could pose difficulties at South Palatka. Surface water quality would be a serious issue in both cases due to the recreational use of the St. Johns River and the commercial fisheries operating in the area. With regard to Levy County, the sites on the Suwannee River would be generally unfavorable given the strong local sentiment in support of preserving natural amenity and water quality, and the resulting controversy that would be generated by any new major power plant project.

The Anclote site was judged to be inferior to other alternatives with comparable cost characteristics, despite its favorable location within Florida Power's service area, because of the limitations of the site land, the proximity of urban development, and the lack of satisfactory cooling arrangements.

Regarding the Lake Jessup site, the possibility of a power generating facility near Orlando which utilizes municipal wastewater for cooling system makeup could be favorable in terms of both water conservation and efficient coverage of Florida Power's service area. However, this alternative has been considered less desirable, on balance, than the phosphate zone alternative, which would also utilize municipal wastewater. Population density in the area surrounding the Lake Jessup site is moderately high, and there are some residents at the site itself. Unlike the phosphate mining site, land acquisition could be difficult since the land involved is parceled among as many as 40 owners. Conversion of the Lake Jessup site to power generation use would displace valuable existing uses (citrus groves and truck farming). Although neither the Lake Jessup site nor the phosphate mining site would have barge access, the barge/rail arrangements possible for the phosphate mining site would be considered a plus. The Lake Jessup site is better than the phosphate mining site in terms of air quality. The extra emission controls required in the latter case could create an appreciable difference in total project costs. On the other hand, the availability of an adequate volume of cooling water could be questionable for Lake Jessup. Overall, the phosphate mining site has been considered preferable to Lake Jessup because of greater public acceptability and land use compatibility.

FINAL SITE SELECTION

The three most favorable site alternatives for new generating facilities are Crystal River, DeBary, and the phosphate mining property. These sites differ in a number of fundamental respects, so that the outcome of any comparison is dependent upon the relative importance assigned to

specific factors. As indicated earlier, the cost differentials for these sites are not critical; the greatest weight should instead be given to environmental impact and resource conservation issues. In order to summarize these issues, Table 8.3-6 shows in very simple outline the most serious liabilities associated with each site. The four categories of environmental impact considered are water supply, wastewater discharge, ambient air quality, and terrestrial ecology. It is not necessary at this point to consider impacts which are essentially similar for the three sites, or which are of secondary importance (for example, the effects of a facility at DeBary on navigation in the St. Johns River).

The issue of water supply for cooling system makeup is considered critically important. Consequently, the option of utilizing saltwater cooling towers at Crystal River is considered as a separate alternative in Table 8.3-6, since this option has major implications for water supply impact.

Water supply would not constitute a liability for the phosphate zone site or for the Crystal River site with off-stream saltwater cooling. Power generating facilities at the phosphate zone site would utilize municipal wastewaters that otherwise would have zero or negative ecological value (when discharged into Hillsborough Bay). The use of salt water at Crystal River would not represent consumption of a limited resource. Also, the location of the intake in the existing discharge canal for Crystal River Units 1, 2, and 3 would limit entrainment/impingement problems. On the other hand, water supply would represent a very serious liability at DeBary, and could be serious at Crystal River with freshwater cooling. Numerous public agencies and water management districts in Florida have questioned the wisdom of utilizing the state's limited freshwater resources for power plant cooling purposes, given the potential availability of salt water. Water supply and water quality are particularly critical issues in the St. Johns River basin where the DeBary site is located.

Table 8.3-6. Summary of Liabilities Associated with the Three Most Favorable Sites

Facility Site	Water Supply	Wastewater Supply	Ambient Air Quality	Terrestrial Ecology
DeBary	X	X		
Phosphate zone		X	X	(X)
Crystal River (with fresh-water cooling)	X		X	
Crystal River (with salt-water cooling)			X	

Source: Environmental Science and Engineering, Inc., 1978.

Disposal of cooling system blowdown water and other wastewaters from power plant operation would present for fewer problems at Crystal River than at the other two sites, because of the direct discharge to the Gulf of Mexico and the very high degree of dilution received in the Crystal River discharge canal. Wastewaters discharged at DeBary and at the phosphate zone site could affect extensive river systems (St. Johns River and the Peace River, respectively). The contaminants introduced by the use of municipal wastewater could present special problems at the phosphate zone site, whereas discharges at the DeBary site could be opposed due to the intensive recreational use of the St. Johns River. Groundwater contamination would be a possibility in either case if evaporation/percolation ponds were utilized.

None of the three sites is highly favorable in terms of air quality impacts, but the DeBary site is clearly best in this regard. The addition of new facilities at Crystal River would require special measures to meet NAAQS and PSD requirements, given the proximity of the site to the Chassowitzka Wilderness Area. At the phosphate mining site, the existing air quality degradation in the vicinity could make the licensing of new power generating facilities questionable. (The air quality increment for Class II might not be available.) This site could well be the worst in terms of air quality.

In a general sense, the regions surrounding the Crystal River and the Polk County phosphate mine plant site alternatives contain the same floral and faunal assemblages. One hundred and sixteen plant species have been identified on the Crystal River site (ESE, 1977), while a similar study in the region of the phosphate mine site found 144 species (CF Development Corporation 1976). Table 8.3-7 shows the number of animal species expected to be found near each site. It can be seen that both regions have similar faunal diversities and that both have similar numbers of rare or endangered species.

Table 8.3-7. Number of Faunal Species Found in Polk and Citrus Counties

	Polk County	Citrus County
Mammals	42 (8)*	47 (10)
Birds	306 (32)	274 (24)
Reptiles	57 (7)	69 (5)
Amphibians	24 (1)	36 (3)

* Numbers in parentheses refer to number of species on the list of the Florida Committee on Rare and Endangered Plants and Animals (1977).

Sources: Archbold Biological Station, 1977.
Environmental Science and Engineering, Inc., 1977.

Of the 426 animal species which may be found on the Crystal River site, 107 were sighted during a three-day survey in August 1977 (ESE, 1977). Such a large species diversity is not unusual, considering the interspersion of several habitat types on this site. The community types on this site include pine flatwoods, evergreen oak scrub, freshwater marsh, ruderal transmission corridors, pine plantation, mesic hammock, hydric hammock, coastal hydric hammock, coastal hammock, and salt marsh. The ruderal and flatwoods areas here are in early succession states and consequently are not unique or of great value. The hammock areas, on the other hand, do contain large old-age trees, and represent mature complex systems. This is especially true of the coastal hydric hammock.

According to the Florida Power 1978 Ten-Year Site Plan, about one-third of the mine site consists of mined lands. About one-half of the area is pasture and cleared land, about 10 percent in hardwoods, and 1 percent in citrus. Due to its low diversity of habitat, its cleared expanses, and its industrial activity, this site would be expected to contain a much lower diversity of wildlife than is present. Some adaptive species such as quail, mourning dove, and eastern cottontail rabbit are abundant. Isolated or perched freshwater marshes, which usually constitute about 20 to 30 percent of the natural flatwoods in the region, are found on the site. Their precise extent would depend on how much of the pasture constitutes relaimed land. In any event, the wildlife value of the marshes would probably be considered relatively low because of the altered nature and the depression of the water table in the region.

Reclaimed areas do, however, have high potential as wildlife habitat, especially around the old mine pit lakes (Archbold Biological Station, 1977). Rare or endangered species which are found here include the Florida sandhill crane, Audubon's caracara, and many wading birds. The area would have less potential for rare and endangered reptiles and amphibians.

The phosphate mine is within two miles of the Peace River. Drainage from the site historically went to this river through two creeks which have since been altered by mining. Drainage from the western portion of the site at one time went to Hookers Prairie and the South Prong of the Alafia River, but adjacent mining has altered this as well. The only significant hardwoods on the site are remnants of a creek bottom mixed swamp or bayhead which has since been largely isolated.

The alternative site in Polk County would probably present a lesser impact on wildlife and mature or unique natural ecosystems than would the Crystal River site. However, off-site impacts might counteract this advantage to some extent. Such impacts could result from effects of seepage, spills, or air emissions on the Peace River and its floodplain vegetation, construction of pipelines to bring water to the site from as far away as Tampa, and construction of new transmission systems to tie in with existing lines as far away as Lakeland. Pipeline and transmission corridors could thus alter more habitat than the site itself. Proper alignment of such corridors could, however, result in minimal habitat disruption by crossing primarily pasture and rangeland areas.

The construction of power generating facilities would involve roughly similar on-site impacts at Crystal River and DeBary. As indicated above, the phosphate mining site would be preferable in this regard given the presently disrupted condition of the land. However, the most critical element in the comparison of sites is the existence of off-site impacts. In contrast to the Crystal River and DeBary sites, which would not require new corridors for water or power transmission, the phosphate zone alternative would involve construction of a 64-kilometer (40-mile) pipeline and a new power transmission corridor exceeding 8 kilometers (5 miles) in length. Since the routing of these facilities is unknown, their terrestrial impacts are uncertain, but the extent of ecosystem disruption could be very substantial.

The conclusion from the site evaluation is that the Crystal River site with saltwater cooling towers is the most favorable alternative. The fact that fewer air quality problems are expected at DeBary is more than offset by the avoidance at Crystal River of serious environmental problems involving water supply and wastewater disposal. Relative to the phosphate mining site, the Crystal River site with saltwater cooling is clearly advantageous in terms of wastewater disposal, ecosystem preservation, and the saving of five million dollars or more per year. However, the phosphate zone site will be considered as a potential location for power generating facilities in the future.

Chapter 9 Plant Design Alternatives

CHAPTER 9

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9.0 PLANT DESIGN ALTERNATIVES

9.1 INTRODUCTION

This chapter presents plant design alternatives in the following categories:

- Plant location and layout
- Coal handling systems
- Water source and intake alternatives
- Cooling alternatives
- Atmospheric pollution control alternatives
- Wastewater discharge alternatives
- Solid waste disposal alternatives
- Transmission facilities

Discussion is in order according to energy and materials flow through a generalized power generating facility. The categories are grouped as either Input or Output Systems as shown conceptually in Figure 9.1-1. Input systems are those which bring essential materials and energy to the power plant proper, and output systems are those which handle the electrical power output and other by-products of power generation such as waste heat, waste water, and solid waste. The input and output systems discussed here are essential, but auxiliary, to the actual power generating structure. The design of the electrical generating system of the plant is not included as a design alternative.

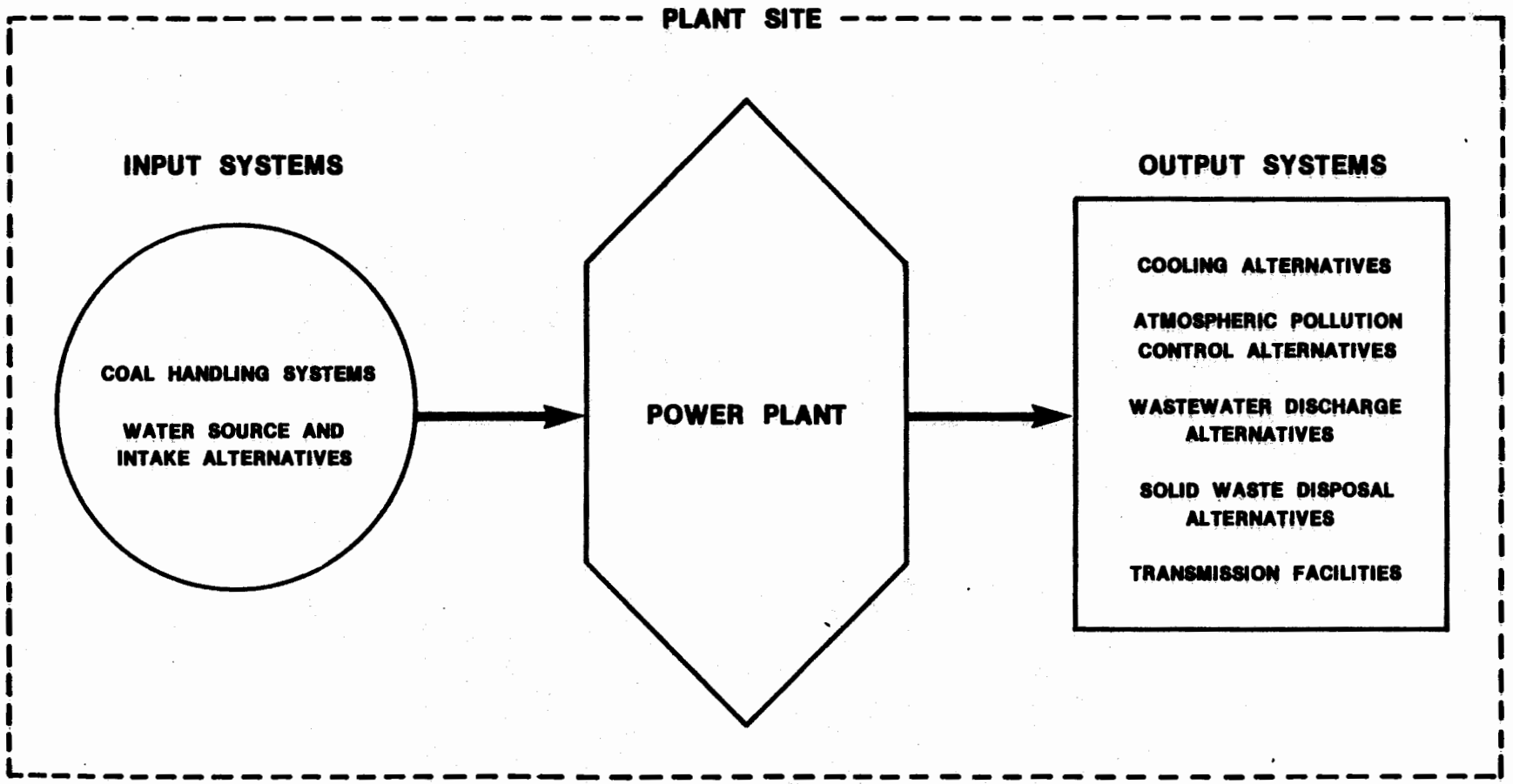

Figure 9.1-1
CONCEPTUAL DIAGRAM OF ALTERNATIVE SYSTEMS

SOURCE: ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1978

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

9.1.1 GENERAL OBJECTIVES

The purpose of this section is to summarize design alternatives for auxiliary systems of proposed power generating units 4 and 5 at Crystal River, Florida. Alternatives considered in each of the auxiliary systems categories are those in operation at power plants throughout the country, or those which exist at the forefront of technology, but might be shown to be feasible in the future.

Several standards and criteria serve to reduce the number of alternatives initially addressed to the final number of alternatives considered: state and federal standards for all air and water quality impacts, public policies, engineering, social and ecological values, and economics of public service.

A comparative analysis of economic, technical, and environmental considerations is offered at the end of each systems category as a basis for guiding decisions as to which alternatives are preferred. This effort does not select a final alternative in any category but serves to provide the decisionmaker with the necessary information to make the final choices.

9.1.2 EVALUATION CRITERIA FOR ALTERNATIVE SYSTEMS

ECONOMIC CRITERIA

Economic evaluations were developed for a single generating unit (Unit 4). Evaluations for a second generating unit (Unit 5) can be developed by appropriate adjustment of the Unit 4 criteria. Commercial operation of Unit 4 is scheduled for October, 1982. The evaluation period for Unit 4 will be 30 years beginning in October, 1982, and ending in September, 2012.

Estimates of capital costs for Unit 4 were developed in constant (1977 or 1976) dollars as noted without considering the effects of inflation. Costs for alternative flue gas scrubbers and associated equipment, cooling towers, and common facilities which could be prorated to a second unit, if constructed, will be shown separately in all estimates. The annual fixed charge rate on the plant investment is 17.0 percent for 1976 studies and 14.0 percent for 1977 studies. The present worth discount rate is 12.0 percent for 1976 and 11.0 for 1977 studies.

Construction overhead, including interest during construction, financing, and administrative costs was estimated to be 25 percent. Escalation rates for price inflation are 7 percent per year compounded monthly to the anticipated date of delivery for equipment and materials, and 7 percent per year compounded monthly to the midpoint of the anticipated construction period for field construction. When capital costs for specific items are expected to deviate significantly in escalation from the above average, the escalation factors will be adjusted accordingly, with a notation about the cause made in the estimate.

Escalation was calculated only for the project estimate and will be separately stated as an adjustment to the constant dollar base costs of equipment and construction. Escalation will not be calculated for system studies except as required for annual cost analyses.

Load Model--New Units

The load model for purposes of siting studies is shown on Table 9.1-1.

Load Model--Existing Units

The load model of the existing coal-fired units (Crystal River Units 1 and 2) is shown on Table 9.1-2. The load model will be utilized for site related studies involving facilities common to a four unit plant (cooling water, coal delivery and storage, ash and rejects generation, etc.).

Fuel Costs

The fuel costs of coal are projected as shown on Table 9.1-3 for the first 7 years of operation. Fuel costs after 1988 are assumed to escalate at the rate of 5.0 percent per year (annually compounded) for the remaining plant life.

Capacity Cost

The capacity costs for 1982 commercial operation has been established at $450 per kw for 1976 studies and $480 per kw for 1977 studies (System Basis Average) and $300 per kw (Incremental Basis). System basis capacity costs are assumed to escalate at the rate of 7.0 percent per year (annually compounded) for the new plant, base load generation additions.

Energy Cost

The energy costs consist of a portion for fuel costs and a portion for operating and maintenance costs. The projected energy cost for the 30-year evaluation period is shown on Table 9.1-4.

Table 9.1-1 Load Model for Each Proposed Unit, Crystal River Units 4 and 5

Net Plant Output (Mw)	Hours of Operation				
	1982-1986	1987-1991	1992-1996	1997-2001	2002-2012
660-600	1,300	1,300	1,100	800	600
600-540	4,000	4,000	3,700	3,400	3,000
540-480	700	700	600	600	600
480-420	300	300	200	200	200
420-360	200	200	200	200	200
360-300	100	100	200	200	200
300-120	600	600	800	800	700
Total Hours On-Line	7,200	7,200	6,800	6,200	5,500
Average Output While On-Line	0.88	0.88	0.85	0.84	0.84
Annual Capacity Factor*	0.72	0.72	0.66	0.59	0.52
Average Output While On-Line Over Operating Lifetime*				0.855	
Average Annual Capacity Factor Over Operating Lifetime*				0.624	

*Capacity Factor and Output based on 660 Mw net expected capability.

Source: Black and Veatch, 1976.

Table 9.1-2 Combined Load Model for Existing Crystal River Units 1 and 2

Percent Capacity	Net Plant Output		Hours of Operation/Year				
	Unit 1	Unit 2	1977-1981	1982-1986	1987-1991	1992-1997	1997-2001
	Mw	Mw					
100	379	491	800	700	300	200	200
100-90	379-341	491-442	3,900	3,300	2,100	1,300	1,300
90-80	341-303	442-393	1,000	1,100	2,000	2,200	2,200
80-70	303-265	393-344	700	700	1,000	1,400	1,400
70-60	265-227	344-295	400	600	700	800	800
60-50	227-189	295-246	400	500	500	600	600
Total Hours On-line			7,200	6,900	6,600	6,500	6,500
Average Output While On-line			.88	.86	.83	.80	.80
Annual Capacity Factor			.72	.68	.63	.59	.59
Average Output While On-line Over Operating Lifetime						0.84	
Average Annual Capacity Factor Over Operating Lifetime						0.65	

Source: Black and Veatch, 1976.

Table 9.1-3 Fuel Costs of Coal

Year	Fuel Costs ($/M Btu)
1982	2.20
1983	2.31
1984	2.43
1985	2.55
1986	2.67
1987	2.81
1988	2.95

Source: Black and Veatch, 1976.

Table 9.1-4 Energy Costs

Year	Present Worth Factor*	Energy Charges			Present Worth of Energy Costs ($/kwh)
		Fuel † ($/kwh)	Operating** ($/kwh)	Total ($/kwh)	
1982	0.8929	0.02046	0.00138	0.02184	0.01950
1983	0.7972	0.02148	0.00149	0.02297	0.01831
1984	0.7118	0.02256	0.00160	0.02416	0.01720
1985	0.6355	0.02368	0.00174	0.02542	0.01615
1986	0.5674	0.02487	0.00188	0.02675	0.01518
1987	0.5066	0.02611	0.00203	0.02814	0.01426
1988	0.4523	0.02742	0.00219	0.02961	0.01339
1989	0.4039	0.02879	0.00237	0.03116	0.01259
1990	0.3606	0.03023	0.00256	0.03279	0.01182
1991	0.3220	0.03174	0.00276	0.03450	0.01111
1992	0.2875	0.03333	0.00298	0.03631	0.01044
1993	0.2567	0.03499	0.00322	0.03821	0.00981
1994	0.2292	0.03674	0.00348	0.04022	0.00922
1995	0.2046	0.03858	0.00376	0.04234	0.00866
1996	0.1827	0.04051	0.00406	0.04457	0.00814
1997	0.1631	0.04253	0.00439	0.04692	0.00765
1998	0.1456	0.04466	0.00474	0.04940	0.00719
1999	0.1300	0.04689	0.00511	0.05200	0.00676
2000	0.1161	0.04924	0.00552	0.05476	0.00636
2001	0.1037	0.05170	0.00597	0.05767	0.00598

Table 9.1-4 Energy Costs (Continued, page 2 of 2)

Year	Present Worth Factor*	Energy Charges			Present Worth of Energy Costs ($/kwh)
		Fuel † ($/kwh)	Operating** ($/kwh)	Total ($/kwh)	
2002	0.0926	0.05429	0.00644	0.06073	0.00562
2003	0.0826	0.05700	0.00696	0.06396	0.00528
2004	0.0738	0.05985	0.00752	0.06737	0.00497
2005	0.0659	0.06284	0.00812	0.07096	0.00468
2006	0.0588	0.06599	0.00877	0.07476	0.00440
2007	0.0525	0.06928	0.00947	0.07875	0.00413
2008	0.0469	0.0725	0.01022	0.08297	0.00389
2009	0.0419	0.07639	0.01104	0.08743	0.00366
2010	0.0374	0.08021	0.01193	0.09214	0.00345
2011	0.0334	0.08422	0.01288	0.09710	0.00324
2012	0.0298	0.08843	0.01391	0.10234	0.00305

Present Worth Factors = 8.0850

* Present worth discount rate of 12.00 percent per year.
† Fuel costs shown are based on a projected net plant heat rate of 9,700 Btu/kwh.
** Operating and maintenance costs escalated at 8 percent per year--compounded.

Source: Black and Veatch, 1976.

Temperature Data

Wet bulb and dry bulb air temperature data and ambient inlet water temperature data used in development of cost estimates are presented in Tables 9.1-5 and 9.1-6, respectively.

Table 9.1-5 Average Monthly Temperatures

Month	Dry Bulb* (°F)	Wet Bulb † (°F)
January	61.4	55
February	63.3	58
March	63.7	62
April	69.8	66
May	76.2	71
June	78.9	74
July	79.3	75
August	79.0	75
September	76.8	74
October	73.0	69
November	63.7	63
December	56.8	57
Annual	69.0	67

Note: The above data on dry bulb and wet bulb temperatures are for different years and cannot be compared directly. However, these data are not used simultaneously in this study and are considered representative for the uses made of the data.

* Source: Crystal River Site, 1975 Meteorological Data.
† Source: Black & Veatch Report to Florida Power Corporation entitled Cooling Channel for Crystal River Plant, dated October 1, 1971.

Table 9.1-6 Mean Inlet Water Temperatures

Month	Mean Temperature °F
January	57
February	62
March	65
April	75
May	79
June	84
July	85
August	85
September	83
October	75
November	66
December	60

Source: Crystal River Unit 3 Environmental Report.

9.2 PLANT SITING, LOCATION, AND LAYOUT ALTERNATIVES

9.2.1 OBJECTIVES

Alternatives were considered in this subsection at three levels: plant siting, location on the site, and layout of the facility. For purposes of this discussion, "location" refers to the placement of the facility within a specific area on FPC property at Crystal River. "Layout" refers to the arrangement of the various components (cooling towers, turbine buildings, roads, etc.) within a particular "location." "Siting" refers to the placement of the facility within a larger geographical area and is discussed more thoroughly in Chapter 8 of this document.

9.2.2 EVALUATION CRITERIA

SITING CRITERIA

Siting of the proposed power plant at or near the existing Crystal River site was considered among other potential sites within Florida Power's powershed under the following criteria:

1. Adequate supplies of cooling water,
2. Nearness of fuel transportation routes,
3. Distance to Florida Power's load center and transmission system,
4. Available land resources, and
5. Potential environmental, economic, and social impact.

For a complete summary of alternative sites, see Chapter 8 of this document.

ON-SITE LOCATION CRITERIA

Location criteria for proposed units on the Crystal River site were as follows (Black and Veatch, 1976):

1. The plant location shall be compatible with applicable laws, regulations, and environmental standards.
2. The plant shall be located to be accessible to fuel supply, water supply, and electrical transmission lines.
3. The plant shall be located to take advantage of the existing substations, roads, railroad trackage, cooling water system, and coal-handling facilities.
4. The plant shall be located to provide sufficient area for construction laydown.
5. The plant shall be located so that it does not interfere with the operation of the existing units during plant construction.
6. The plant shall be located and plant facilities arranged such that plant operations will not affect the safety and security of the nuclear plant (Crystal River Unit 3).

LAYOUT CRITERIA

Layout requirements included physical space requirements and arrangements needed for each of the following major plant functional systems (Black and Veatch, 1976):

1. Two 600 Mw (net capacity) coal-fired steam generating units including office, maintenance, warehousing, and personnel facilities.
2. Flue gas emissions control systems including electrostatic precipitators and a separate chimney for each unit. Site planning included provisions for future SO_2 scrubbers.
3. Space allocation for closed cycle cooling systems incorporating round natural draft towers and associated underground piping systems for condenser cooling and cooling tower makeup and blowdown water.
4. Coal delivery and handling systems including facilities for both rail and ocean-barge delivery of coal, and for storing, processing, and conveying coal to the steam-generating units.
5. Electrical transmission system to the existing plant substation complex. Site planning included allocation of space for transformers and for transmission lines to both the existing 500 kv and 230 kv substations.
6. Plant water treatment and storage systems including facilities for pretreatment, demineralization, and storage of plant systems makeup water and underground piping corridors for supply pipelines from an offsite well field.
7. Ash handling systems including facilities for collecting and holding ash prior to transport offsite or to onsite disposal areas.
8. Space for future installation of SO_2 scrubber additive receiving, storage, and preparation systems as well as facilities to collect and prepare the process sludge for disposal.

9. Ash disposal area suitable for disposal of ash and rejects material produced by a four-unit station (two new units and existing Crystal River Units 1 and 2) for the life of the plant.
10. Wastewater systems including facilities for storage and treatment of plant system wastes.
11. Construction areas including materials laydown and subassembly work spaces, shop and personnel buildings, warehousing, and access roads.
12. Railroad trackage from the existing plant entrance track to serve construction areas and the coal train unloading facility.

Note: Criterion #9 not achieved by final site ash disposal alternative. Ash disposal area for Units 4 and 5 limited to 95 acres.

9.2.3 ALTERNATIVES CONSIDERED

SITE ALTERNATIVES

The Crystal River site was favored as the site closest to satisfying the siting criteria with the greatest potential for minimizing impacts (see Chapter 8). Figure 9.2-1 shows the Crystal River site, general property boundaries, and surrounding area.

LOCATION ALTERNATIVES

On the basis of location criteria, three locations on Florida Power Corporation's Crystal River property were selected as feasible (Figure 9.2-2):

Location 1. Location 1 would be located to the north and west of the present ash disposal pond for existing Crystal River Units 1 and 2 (Figure 9.2-2). The generation facilities would be located approximately 600 meters (2,000 feet) northwest of existing Units 1 and 2, and the borrow pit/ash disposal area would be located to the north of the existing transmission lines. Additional coal storage facilities would be located immediately west of the existing coal storage facility.

Concern over coastal wetlands and additional cost analysis lead to the evaluation of three additional variations of location 1. These three variations are as follows:

1. Variation 1a. Relocation of generation facilities about 73 meters (240 feet) east of the initial location 1 in order to move all facilities out of the coastal salt marsh.
2. Variation 1b. Relocation of generation facilities about 400 meters (1,300 feet) northeast of location 1 so that all facilities would be out of the salt marsh and impacts on the coastal wetland forest would be reduced.
3. Variation 1c. Relocation of generation facilities about 850 meters (2,800 feet) northeast of location 1 so that all

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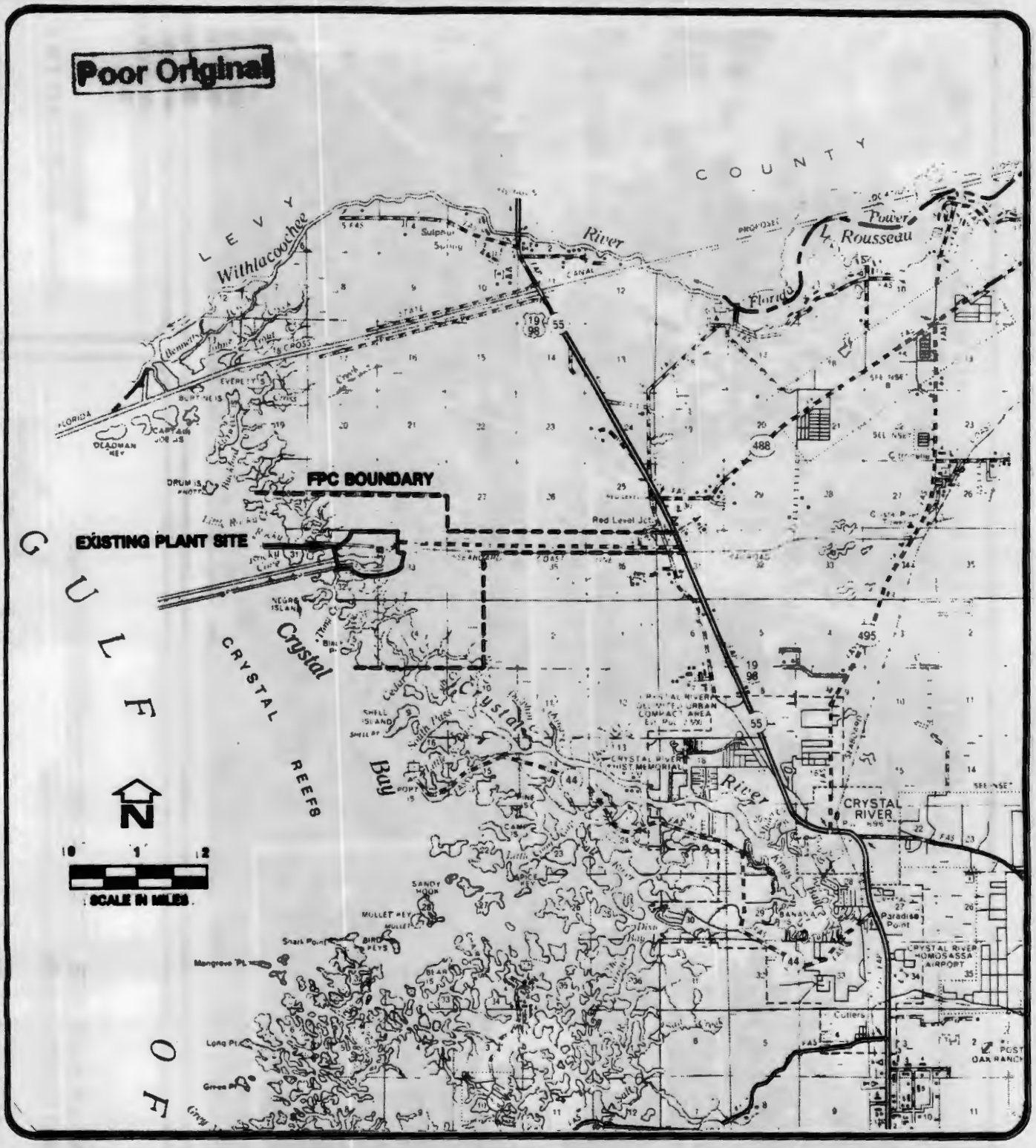

Figure 9.2-1
FLORIDA POWER CORPORATION CRYSTAL RIVER SITE

SOURCE: ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1977

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

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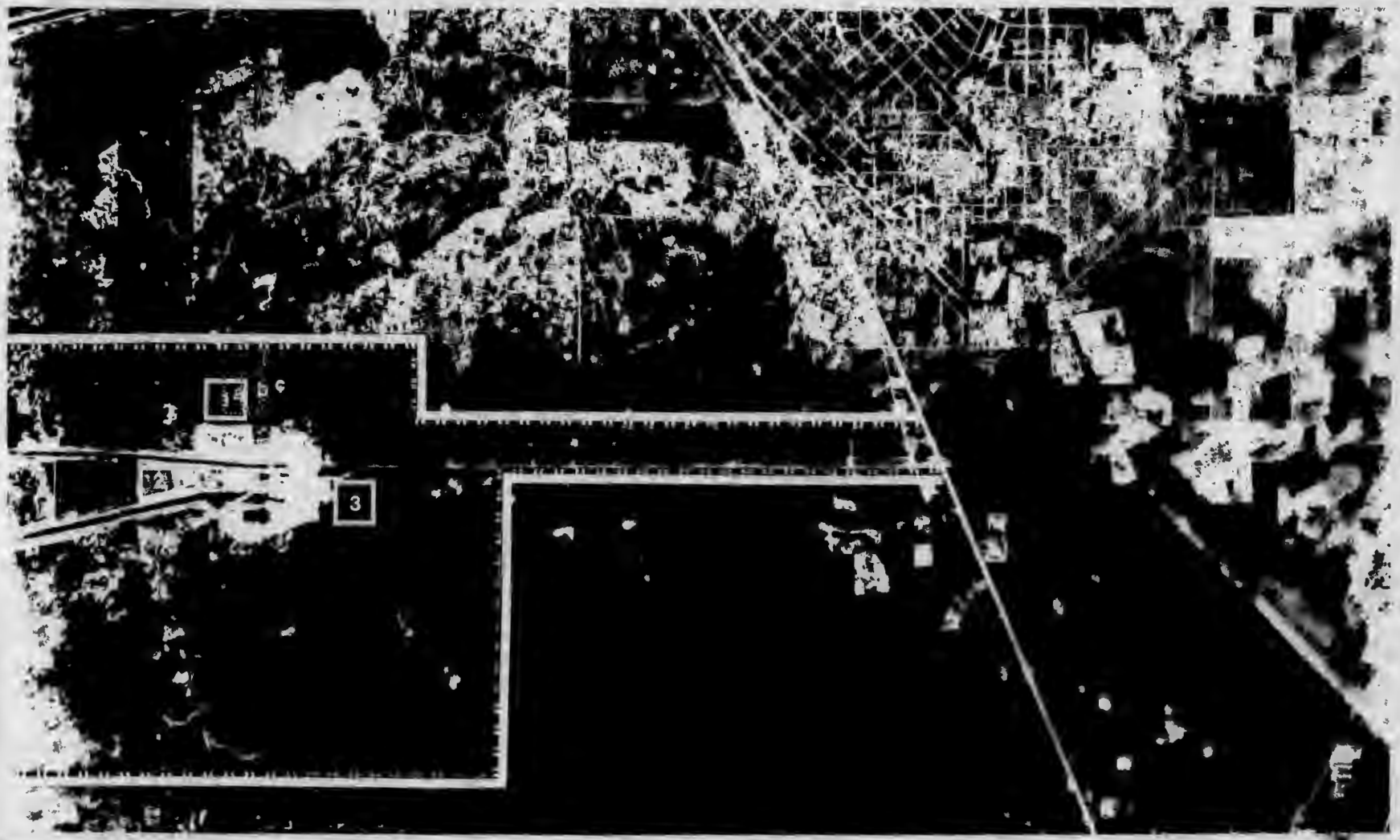

Figure 9.2-2

GENERAL AREA OF PLANT SITE, FLORIDA POWER PROPERTY BOUNDARY, AND PROPOSED PLANT LOCATION ALTERNATIVES

SOURCE: Environmental Science and Engineering, Inc., 1978

N

0 ½ 1
SCALE IN MILES

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

Poor Original

Poor Original

facilities would be out of the coastal salt marsh and coastal wetland forest.

:ation 2. The generation facilities would be located between the isting intake and outfall canals approximately 820 meters (2,700 feet) the west of Unit 2 (Figure 9.2-2). A portion of the area has been ed for experimental mariculture and the remainder is salt marsh. The al handling and storage facilities would be located identically to the :ation 1 arrangement, and the ash disposal area would be located in proximately the same location.

:ation 3. Generation facilities for location 3 would be located proximately 450 meters (1,500 feet) southeast of existing Crystal ver Unit 3 (Figure 9.2-2). Coal handling and storage facilities are entical to those of the location 1 arrangement, but the ash disposal ea is located in the southeast portion of the property.

YOUT ALTERNATIVES

tails of layout alternatives depend upon final selection of the plant sign and auxiliary systems. The following layouts present feasible rangements of the facility at locations 1, 2, 3, or 1c with three oling water alternatives. Figures 9.2-3, 9.2-4, 9.2-5, and 9.2-6 pict locations 1, 1c, 2, and 3 with natural draft towers. Possible youts using mechanical draft towers are presented for locations 1, 2, d 3 in Figures 9.2-7, 9.2-8, and 9.2-9. Figures 9.2-10, 9.2-11, and 2-12 present layouts for locations 1, 2, and 3 if once-through cooling used.

a large extent the final layout of the plant is determined by deci- ons on alternatives selected for major plant components like cooling, al handling, water sources, waste discharges, and air pollution ntrol equipment. In the following section alternative locations and youts are discussed.

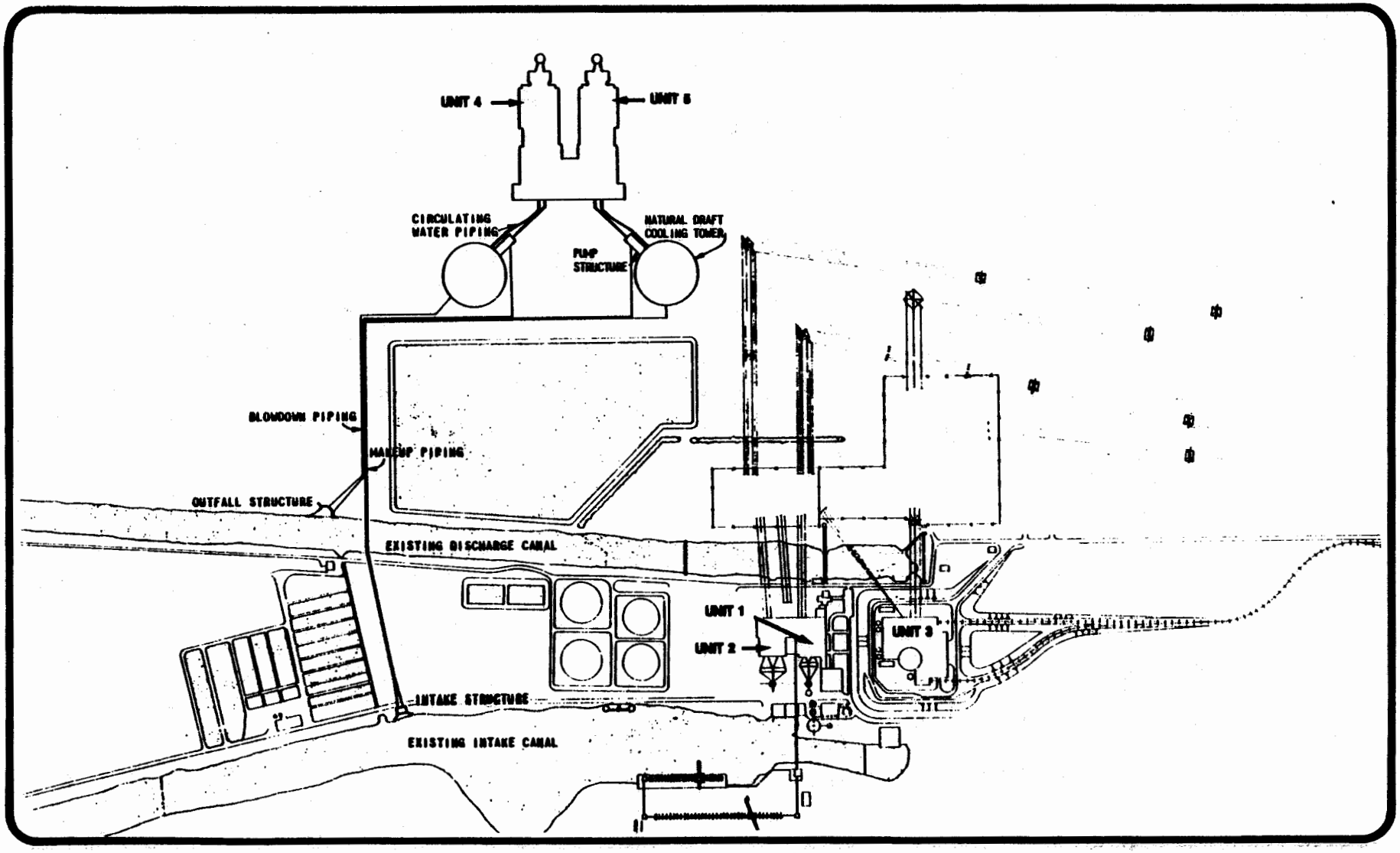

Figure 9.2-3
PROPOSED ALTERNATIVE LOCATION 1 WITH NATURAL DRAFT COOLING TOWERS

SOURCE: BLACK AND VEATCH, 1976

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

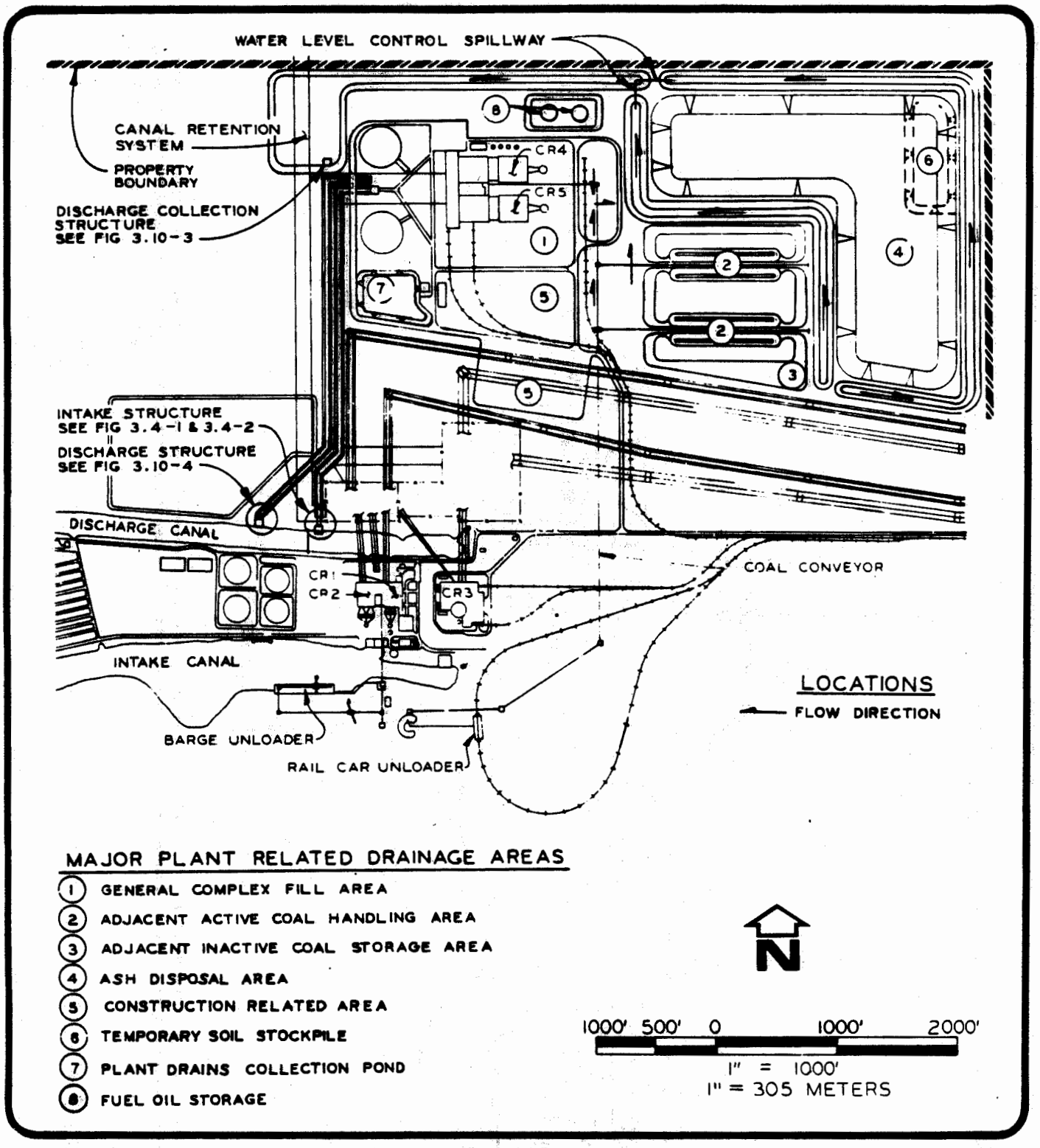

Figure 9.2-4

PROPOSED ALTERNATIVE LAYOUT OF VARIATION 1c WITH NATURAL DRAFT COOLING TOWERS

Black and Veatch, 1980

FLORIDA POWER CORPORATION

PROPOSED CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

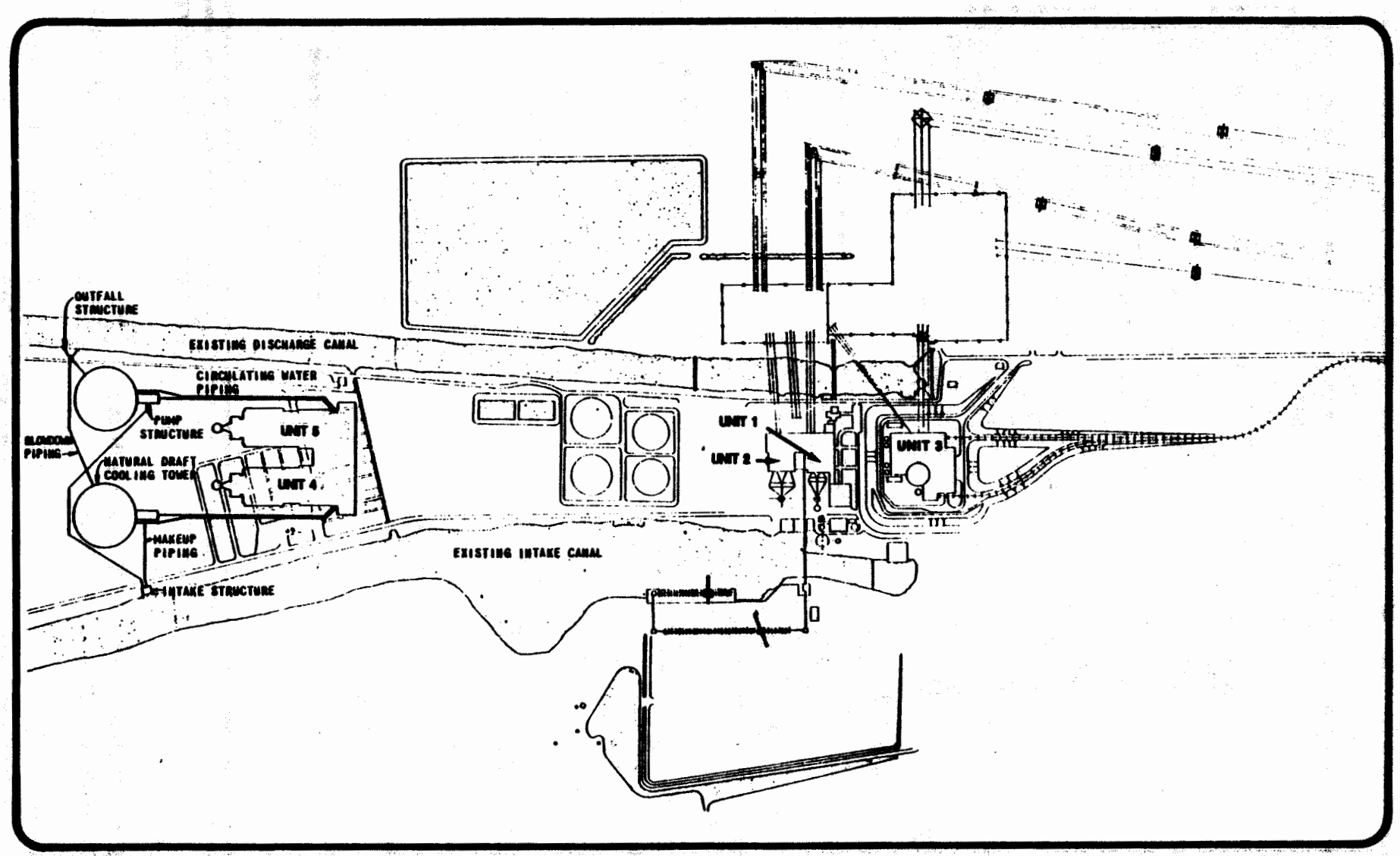

Figure 9.2-5

PROPOSED ALTERNATIVE LOCATION 2 WITH NATURAL DRAFT COOLING TOWER

SOURCE: Black and Veatch, 1976

N

0 200 400 800

SCALE IN FEET

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

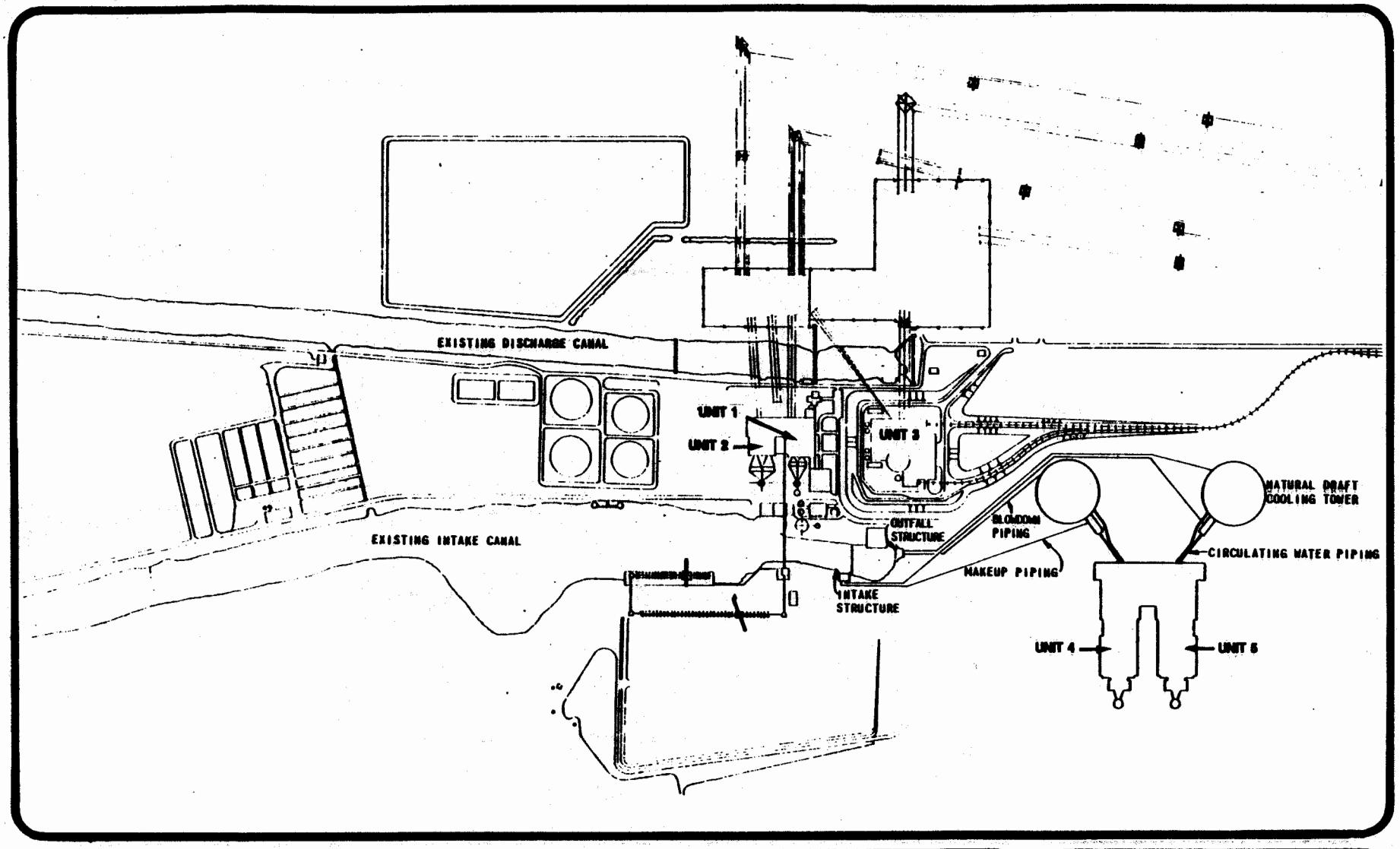

Figure 9.2-6

PROPOSED ALTERNATIVE LOCATION 3 WITH NATURAL DRAFT COOLING TOWERS

SOURCE: Black and Veatch, 1976

N

0 200 400 800

SCALE IN FEET

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

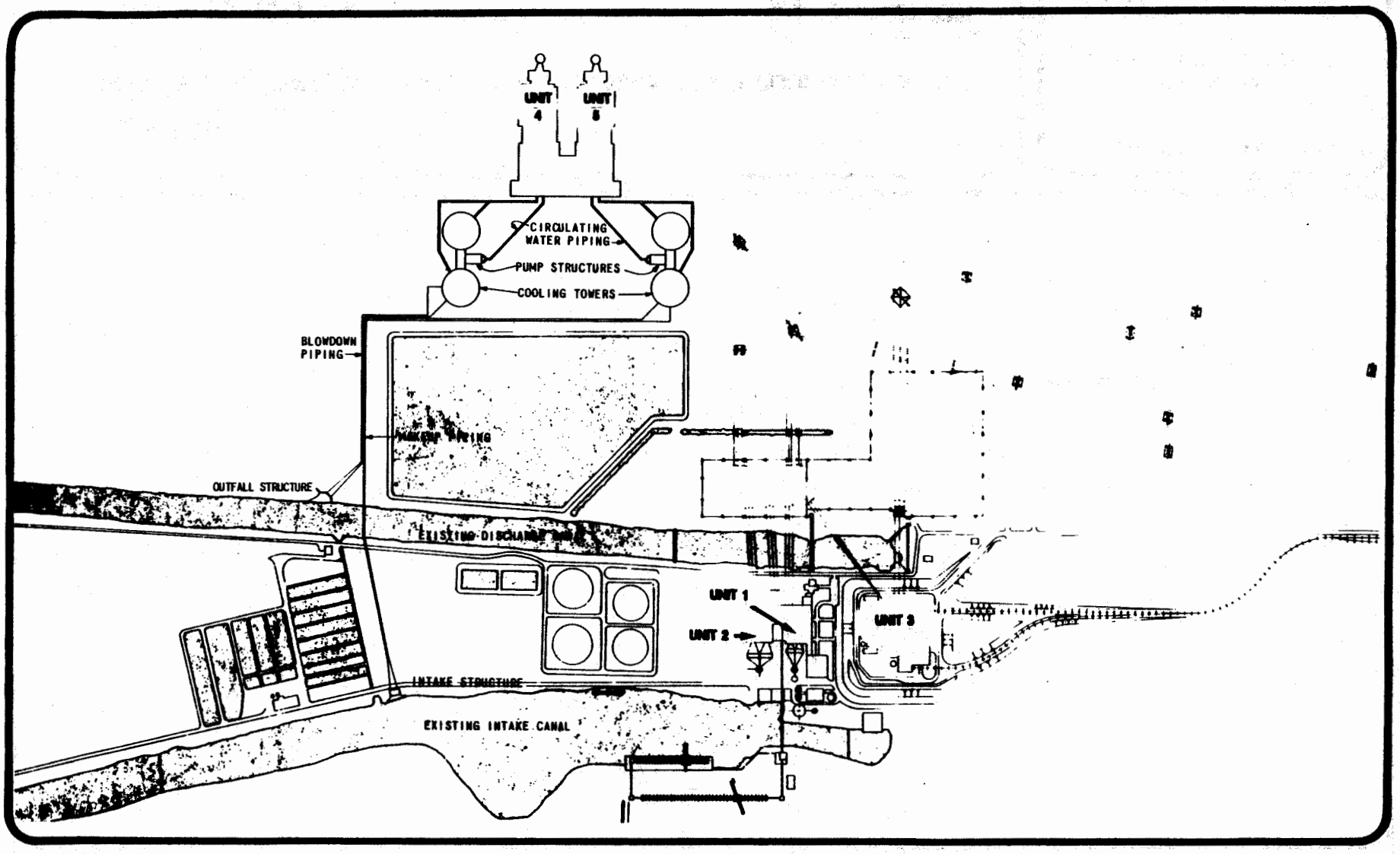

Figure 9.2-7

PROPOSED ALTERNATIVE LOCATION 1 WITH MECHANICAL DRAFT COOLING TOWERS

SOURCE: Black and Veatch, 1978

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

Poor Original

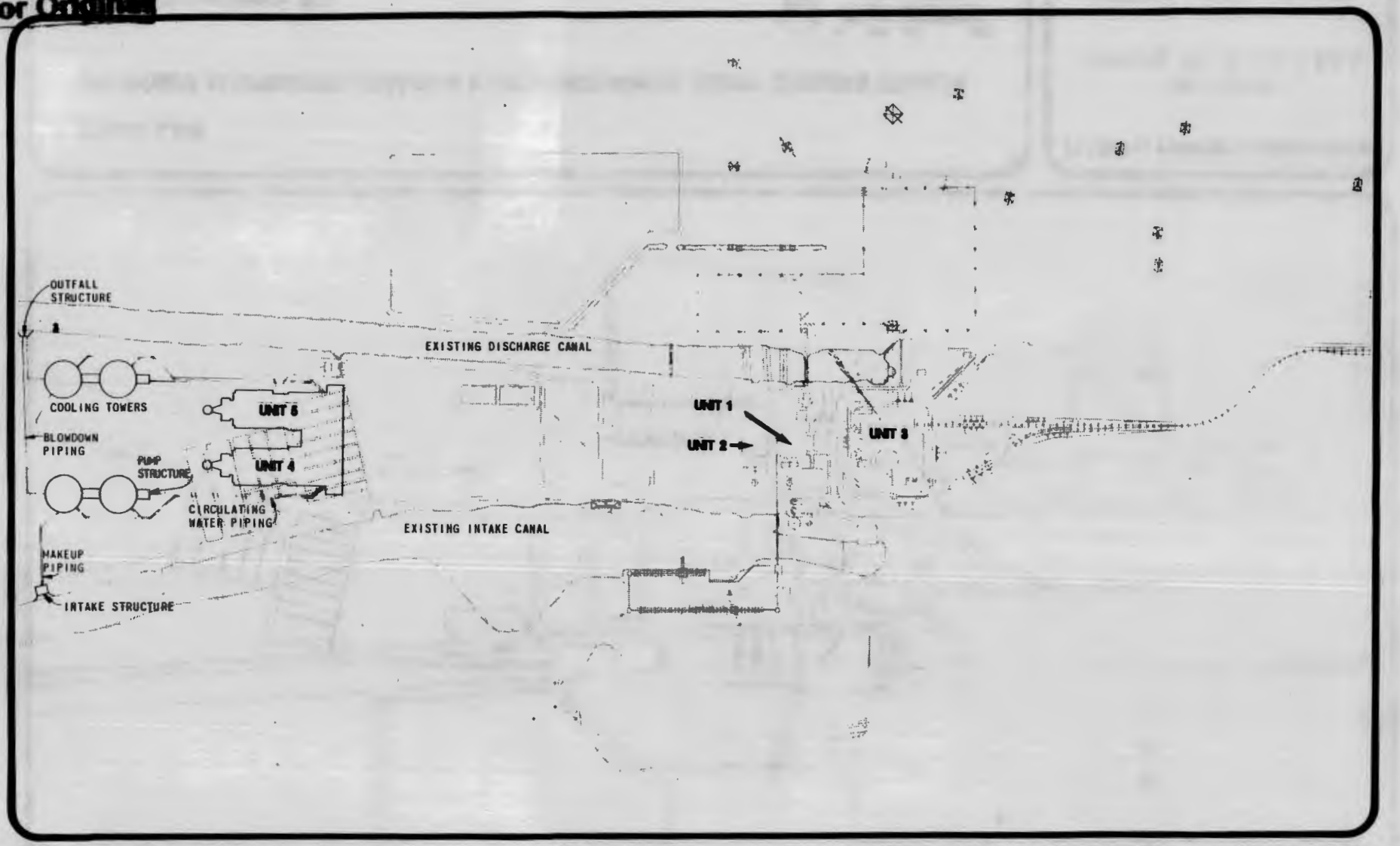

Figure 9.2-8

PROPOSED ALTERNATIVE LOCATION 2 WITH MECHANICAL DRAFT COOLING TOWERS

SOURCE: Black and Veatch, 1978

N

0 200 400 800

SCALE IN FEET

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

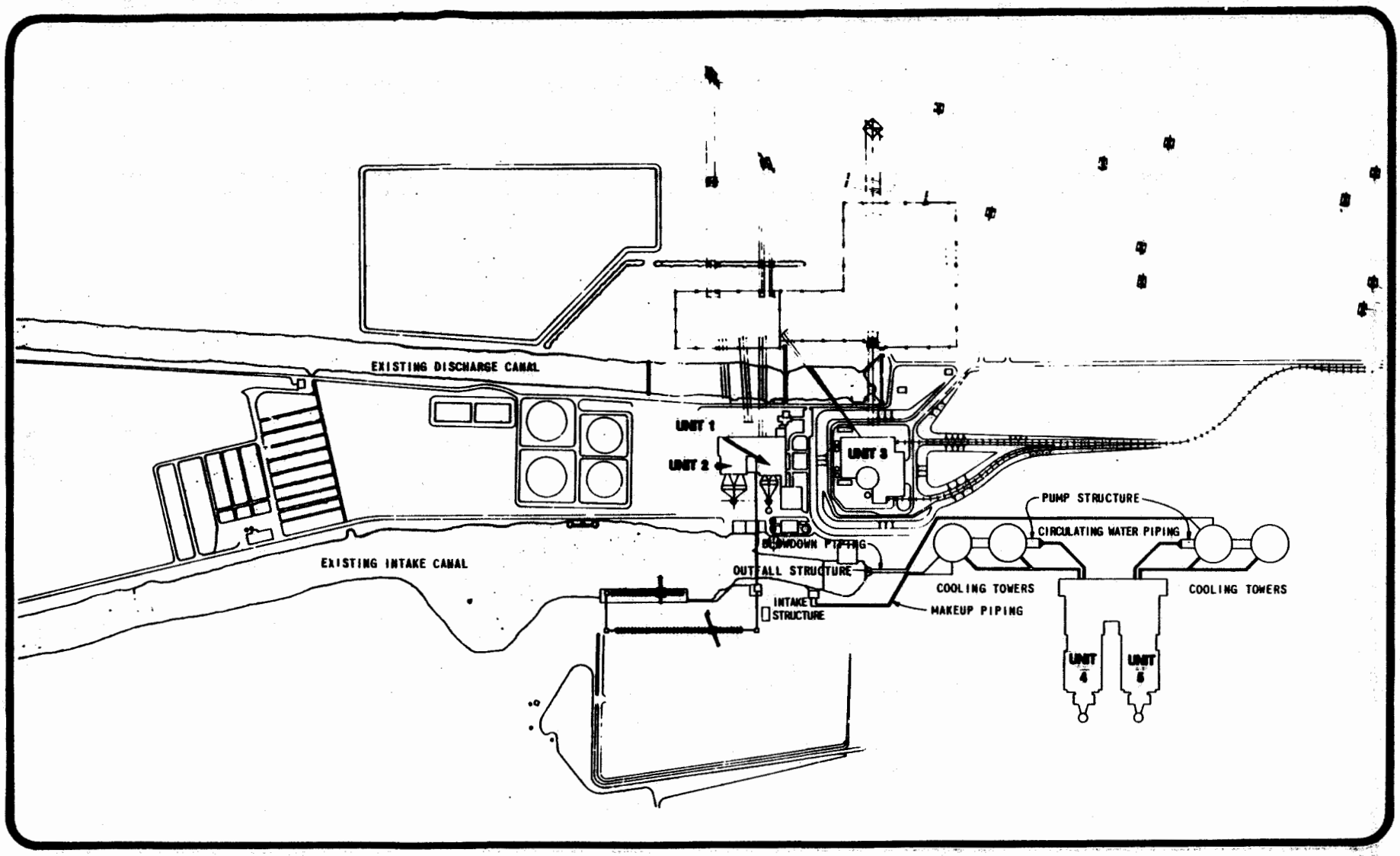

Figure 9.2-9

PROPOSED ALTERNATIVE LOCATION 3 WITH MECHANICAL DRAFT COOLING TOWERS

SOURCE: Black and Veatch, 1976

N

0 200 400 800
SCALE IN FEET

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

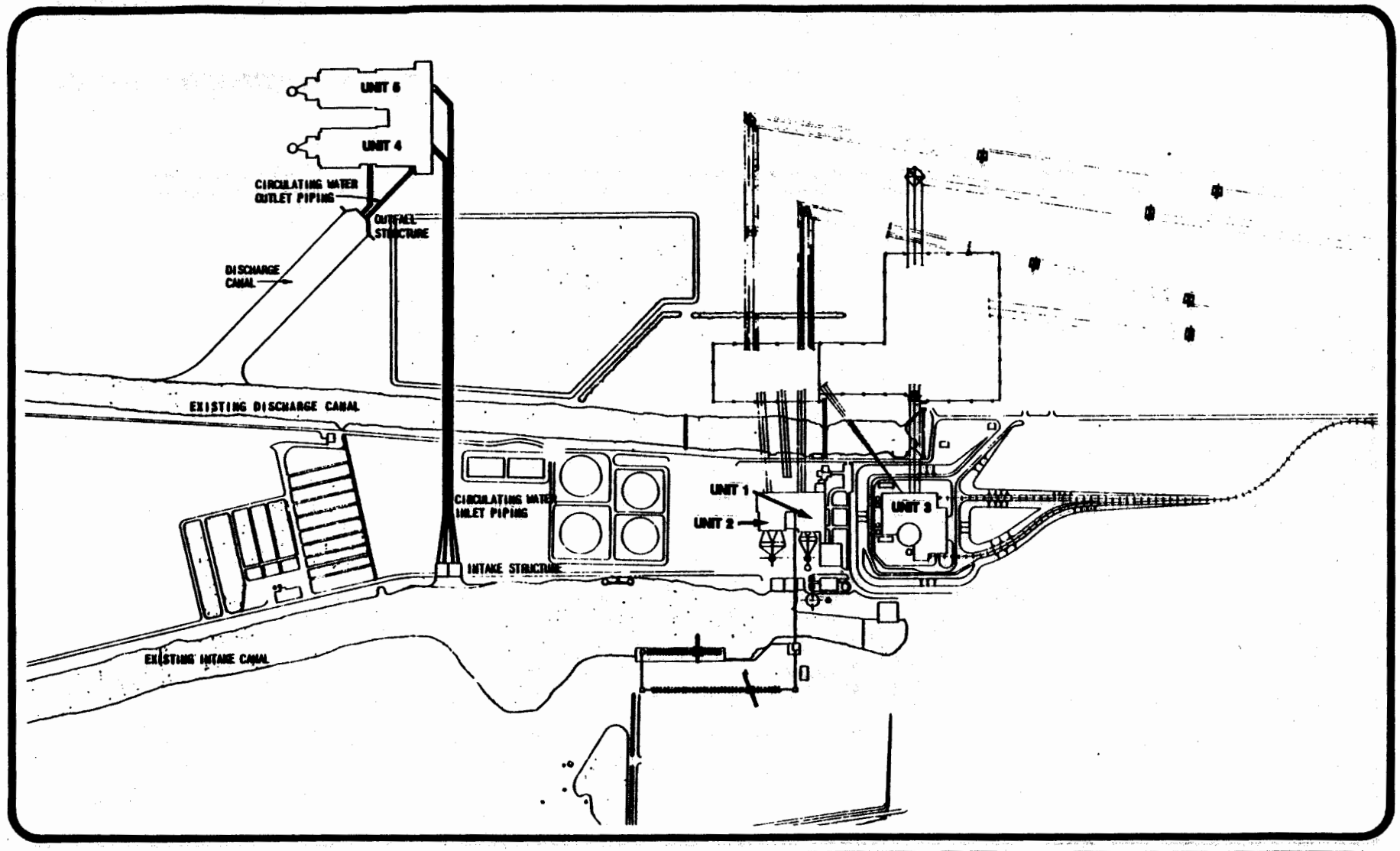

Figure 9.2-10

PROPOSED ALTERNATIVE LOCATION 1 WITH ONCE-THROUGH COOLING

SOURCE: Black and Veatch, 1980

N

0 200 400 800

SCALE IN FEET

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

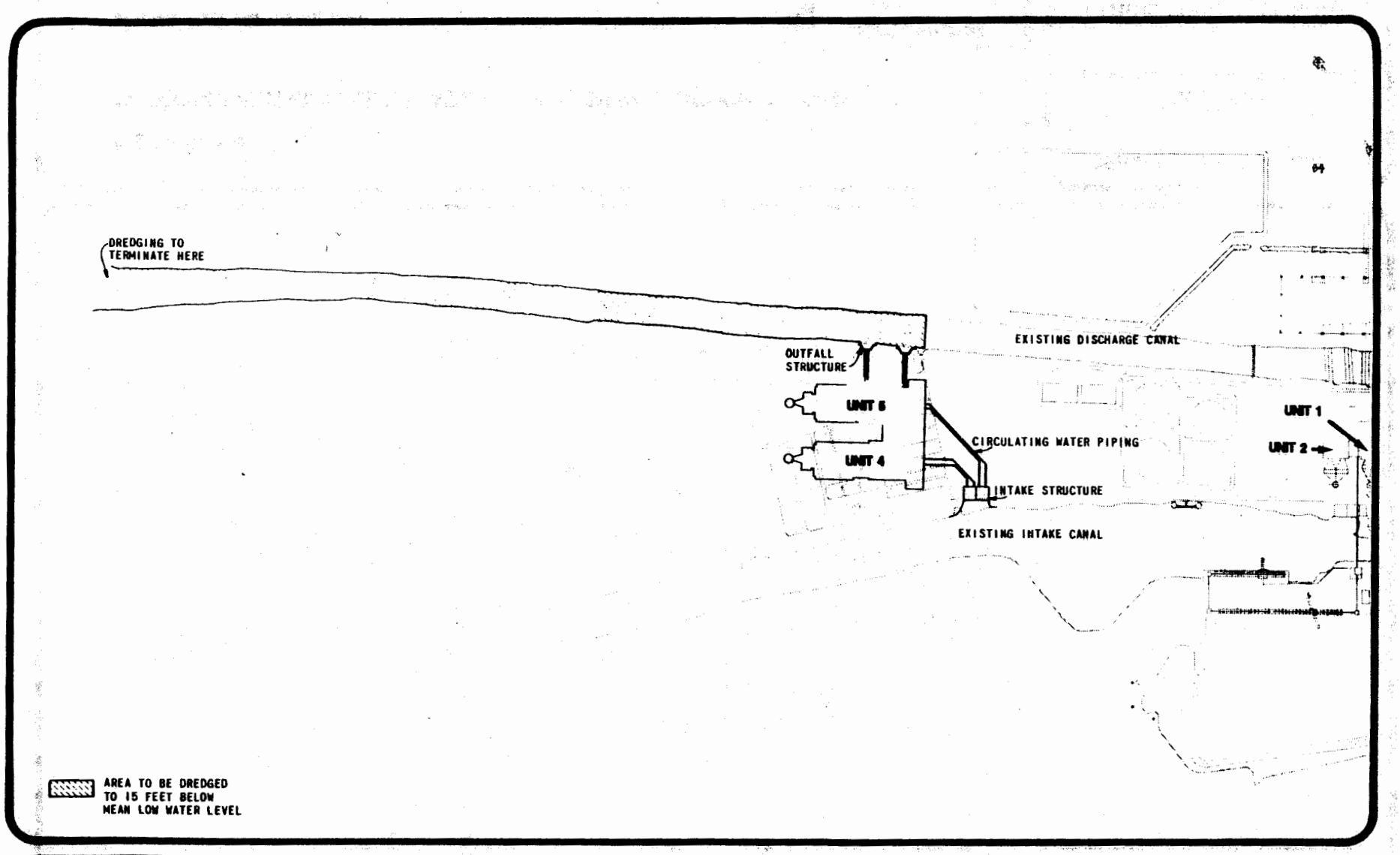

Figure 9.2-11

PROPOSED ALTERNATIVE LOCATION 2 WITH ONCE-THROUGH COOLING

SOURCE: Black and Veatch, 1976

N

0 200 400 800
SCALE IN FEET

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

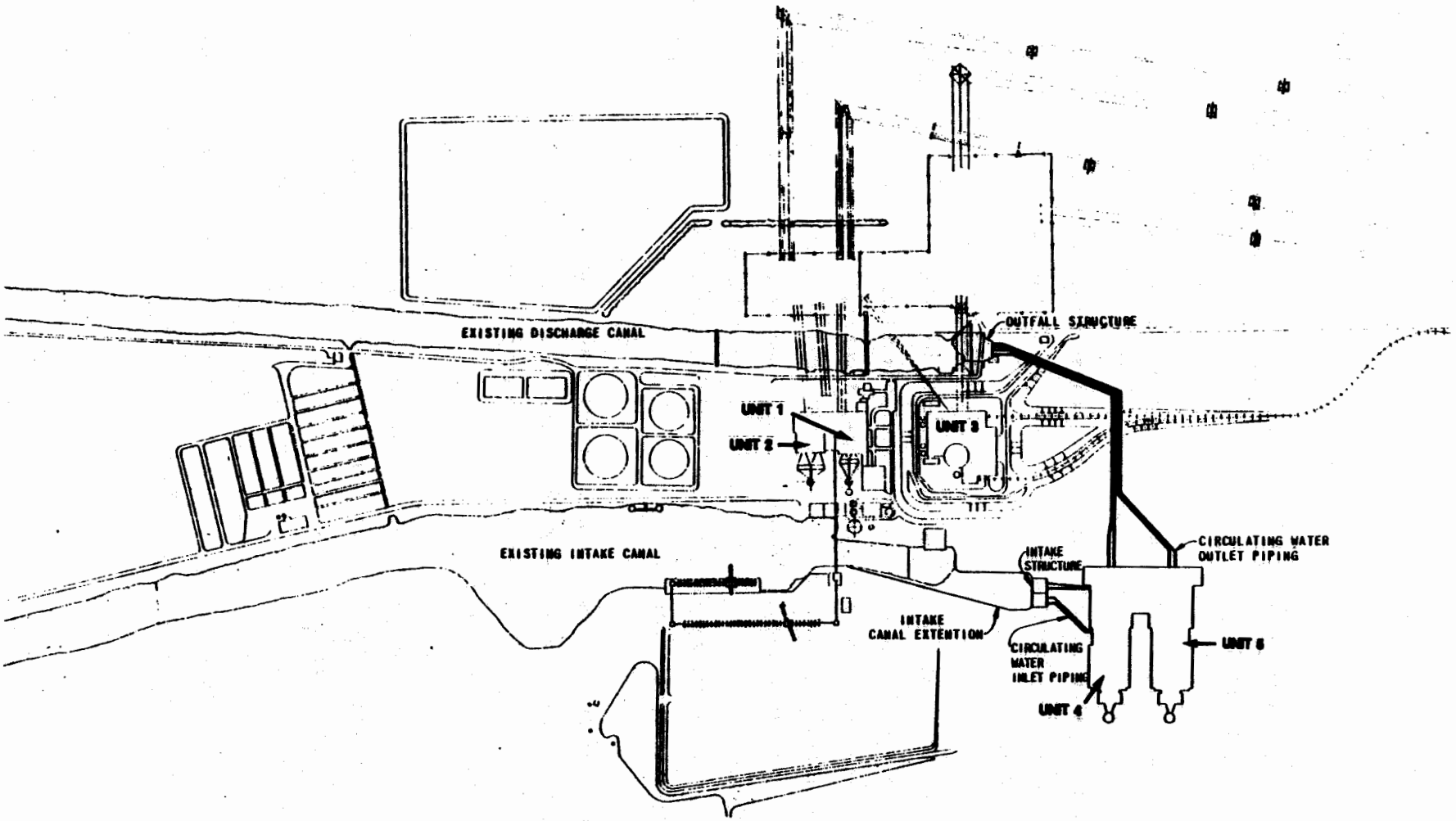

Figure 9.2-12

PROPOSED ALTERNATIVE LOCATION 3 WITH ONCE-THROUGH COOLING

SOURCE: Black and Veatch, 1978

N

0 200 400 800

SCALE IN FEET

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

9.2.4 COMPARATIVE ANALYSIS OF LOCATION AND LAYOUT ALTERNATIVES

LOCATION ALTERNATIVES

The major advantages of location 1 are that it is most isolated from the existing Crystal River plant facilities. The site minimizes interferences with existing plant operations, access, and security of the existing units. Accessibility of roads, railroads, and transmission tie lines is also good.

The major disadvantages of location 1 are that the general facilities, cooling towers, plant runoff pond, and construction areas would be located within coastal marsh and forested wetlands. Using salt water from the existing intake canal would require the pipeline to cross the existing discharge canal, presenting increased exposure for accidental line rupture and may require specialized operating procedures. However, location 1 or a variation could successfully use makeup water from the existing discharge canal.

The installation of tower structures for transmission tie lines within the existing ash disposal pond would create a need for pond management and reclamation, if this disposal area were to remain in service after construction of the new units.

Location 1c represents a relocation of location 1 so that all facilities would be located outside of the coastal marsh and forest wetlands. The generation facilities would be located about 850 meters (2,800 feet) northeast of location 1. New coal storage and handling facilities would be located between the generation facilities and the ash area. The ash storage area would be in approximately the same place as for location 1, but would be reduced from about 81 to 43 hectares (200 acres to 105 acres).

As the generation facilities of location 1 and alternative plans are moved east from the wetlands, a consequent reduction in available space occurs. The advantages of this location include the fact that no coastal marshes or coastal wetland forests will be displaced, and all facilities will be located as far away as possible on the property from the coastal wetlands. Transmission tie line, railroad, and road routings will be minimized. Interference with operation and security of all existing units will be minimized during construction and operations. Access and suitability for construction are excellent.

The major disadvantages of this location include the fact that it does not meet the space requirements for the ash storage area. Thus, a second ash storage offsite will be needed in the future to contain the ash generated by the facility if the planned sale of ash does not materialize. Because the site fabrication and storage-laydown yard areas available for construction are limited, the west end of the ash storage area will have to be used as a construction storage-laydown area. Two separate coal handling and storage areas will be required, thus increasing handling costs and personnel required. Space for the plant and coal runoff canal retention system is limited.

The advantages of location 2 are the short routing distances that are required for makeup discharge pipelines, coal handling conveyors, and transmission tie lines to the existing substations. There would be less displacement of natural vegetation and communities than for locations 1 or 3.

The major disadvantage of location 2 would be that the between-canals location makes access to the plant difficult. All construction materials must cross over the discharge canal from the storage and work areas, with resultant potential for scheduling problems and inefficiency.

Future operations would be adversely impacted because of restricted access, increased distance to ash and sludge disposal areas, and more complicated ash-sludge handling and materials delivery operation. Plant security would be more complex because of the canals splitting the site into three units.

Movement of materials over the discharge canal would increase the potential for accidental release of contaminating substances into the canal.

One advantage of location 3 is the fact that access to this location is excellent. Interference with access and operations of the existing coal-fired units is minimized. The facility is in proximity to the coal storage and ash disposal areas.

The disadvantages of this location include the displacement of extensive amounts of coastal marsh and wetland forest. Transmission tie lines that cross coal-handling yards to the 230 kv substation present potential safety hazards and interference with plant operations. Construction activity would create some disruptions in operation and security of the existing nuclear plant.

Environmental considerations dictate that location 1c be the preferred site. It is the only location which is mainly outside of the coastal wetland areas (Saltwater Marsh and Coastal Hydric Hammock forest--see Vegetation Map, Section 2.7). Secondary effects upon the estuary due to increased runoff and erosion, loss of biological filtration, and accidental spillage are reduced. This location permits retention of the buffer strip or barrier afforded by the coastal forest, thus retaining its value as a hurricane surge buffer and an aesthetic visual screen. Possibilities of water quality impacts due to accidental spillage and dredge and fill activities would be highest for locations 1 and 2, and lowest for location 1c. Location 1c is underlain by some "non-coastal"

wetlands, but these are considered to be of less regional importance than the coastal wetlands.

Locations 1, 2, and 3 all cause significant displacement of coastal wetlands. Each of these sites also has a higher potential for release of contaminants and pollutants into the estuarine system. Runoff potential is higher due to proximity to the shore and removal of the coastal wetland forest buffer zone. Location 2 has a potential for accidental spillage of materials into the discharge canal during movement across the canal. Location 1 adversely affects aesthetic appeal because of its high visibility from the Gulf of Mexico.

Location of the ash storage area location north of the access road would lessen the potential of a seepage of pollutants to the estuary because of the greater distance involved. Splitting of the coal storage facilities may increase the difficulty of controlling seepage and runoff problems. However, a smaller area of coastal wetlands would be displaced.

Displacement of a natural system through relocation of railroad spurs and access roads would be minor, although the recommended new access road would affect the narrow visual barrier to the north of the existing transmission lines. It would also cross some small swamp and marsh systems.

LAYOUT ALTERNATIVES

Layout alternatives have not been detailed for all categories of facilities design at this time. Layout design depends on final selection of the auxiliary input and output alternatives such as cooling system and water source.

Coal Handling and Storage Facilities

For location 1, supply would be from the east, with the active storage and stacker-reclaimer about 240 meters (800 feet) east of Unit 5. This

alternative was recommended because of lower capital costs and increased active storage area. The space available for ash and sludge storage is reduced, however. An alternative supply would be from the east with active storage, stacker-reclaimer, and inactive storage area all located within the coal yard railroad track loop south of the existing access road.

With the supply from the west, all facilities would remain near the existing coal facilities, with coal conveyed to the west side of the plant around the existing facilities. Increased costs and interference with existing units are disadvantages.

Access Roads

The existing access road could be upgraded and used for both construction and operations traffic. The advantages are the maximum use of existing facilities and minimum of environmental disturbance. The disadvantages are interference with operation and access to existing facilities. A separate access road for Units 4 and 5 would be constructed along the property boundary to the north of the existing transmission lines. While this alternative would result in less interference with the existing units, there would be increased impacts from construction.

Railroad Intersections

Plan A

Elevate U.S. Highway 19-98 to cross over the rail spur to the plants. The existing access road would be simultaneously upgraded for divided access to the highway. Estimated direct capital costs would be $1,385,000. Highway vehicular traffic would be disrupted during construction, but rail traffic would be largely unhindered. This plan may be linked to the access road alternative of upgrading the existing access road.

Plan B

Elevate the plant rail spur to cross Highway 19, and move existing road intersection 91 meters (300 feet) north of its existing location. Direct capital costs are estimated at $1,175,000. Plan B offers less disruption to vehicular traffic, but more for rail traffic.

Plan C

Leave the intersection of U.S. 19-98 and the rail spur at grade and employ unit trains (special trains that are dedicated to Florida Power Coal delivery). With this alternative, trains would take approximately two minutes per direction to cross U.S. 19-98. Four one-way trips per day would be scheduled. (Discussion of railroads is finalized in this subsection.)

Ash and Sludge Storage Areas

Currently, only a 43-hectare (105-acre) storage area east of the plants is proposed. Additional alternative sites to contain the majority of the potential ash and sludge generated have not been identified at this time. Since there is probably insufficient upland area remaining on the property, additional sites presumably would be located in upland areas outside of the property.

Retention and Percolation Basins

At the time of this analysis, specific locations for percolation and retention basins have not been described. They will be located generally to the south and west of the new units.

SUMMARY

Location

Tables 9.2-1 and 9.2-2 summarize advantages and disadvantages of alternative on-site locations.

Alternatives Overview

Figure 9.2-13 is a summary diagram of feasible alternatives for plant siting, location, and layout considered in this section.

Table 9.2-1 Alternative On-Site Locations Summary Matrix

Location	Costs (1,000's)	Location and Development		Environment	
		Advantages	Disadvantages	Advantages	Disadvantages
1	424,635	1. Near to ash disposal area. 2. Isolated from neighbor lands. 3. Room for four-unit expansion. 4. Second nuclear unit possible.	1. Transmission tie towers in existing ash pond—pond management problems. 2. Adjacent to neighboring lands.		1. Location in coastal wetlands. 2. Higher runoff potential. 3. Elimination of storm buffer zone. 4. Aesthetic impact on Gulf side.
1C	422,427	1. Minimal routing for roads, transmission tie lines, and railroad. 2. Excellent constructability.	1. Proximity to neighboring lands. 2. Not enough ash storage space. 3. Reduced space for retention ponds. 4. Limited construction laydown area.	1. No disruption of coastal wetlands. 2. Least total wetlands disruption. 3. Retains visual buffer to Gulf. 4. Retains storm buffer zone.	1. Additional ash storage displaced from site. Impacts may occur at another site.
2	427,575	1. Short routing for makeup discharge pipe, coal conveyors, and transmission tie lines. 2. Isolated from neighbor lands.	1. Construction materials must cross discharge canal—delays and accidents.	1. Reduced displacement of natural systems.	1. Ash pond located in coastal wetlands. 2. High runoff potential. 3. Potential accidental release of contaminants to discharge canal.
3	420,490	1. Proximity to coal and ash disposal areas. 2. Isolated from neighbor lands.	1. Precludes second nuclear unit.		1. Location in coastal wetlands. 2. Aesthetic impact on Gulf side. 3. Runoff potential.

Source: Environmental Science and Engineering, Inc., 1978.

Table 9.2-2. Alternative Locations Summary Matrix

Location	Costs (1,000's)	Access and Interference		Security and Safety	
		Advantages	Disadvantages	Advantages	Disadvantages
1	424,635	1. Most distant from existing plants. 2. Minimal interference to existing plants. 3. Excellent access to roads, railroad, transmission tie lines, and discharge canal.		1. Will not be potential fire/explosion hazard to nuclear unit. 2. Allows rapid employee exit from property. 3. Will not disrupt security of existing units.	
1C	422,427	1. Minimal interference with existing units. 2. Excellent access.		1. Minimal interference with existing security. 2. Excellent employee exit.	
2	427,575		1. Access during construction difficult. 2. Access for delivery of operational materials difficult.		1. Increased difficulty of security on three-part site. 2. Poor employee exit from property.
3	420,490	1. Excellent access. 2. Minimal operational interference with existing units.	1. Some interference with existing units during construction.		1. Transmission tie lines must cross coal handling facility. 2. Disruption of CR3 security during construction.

Source: Environmental Science and Engineering, Inc., 1978.

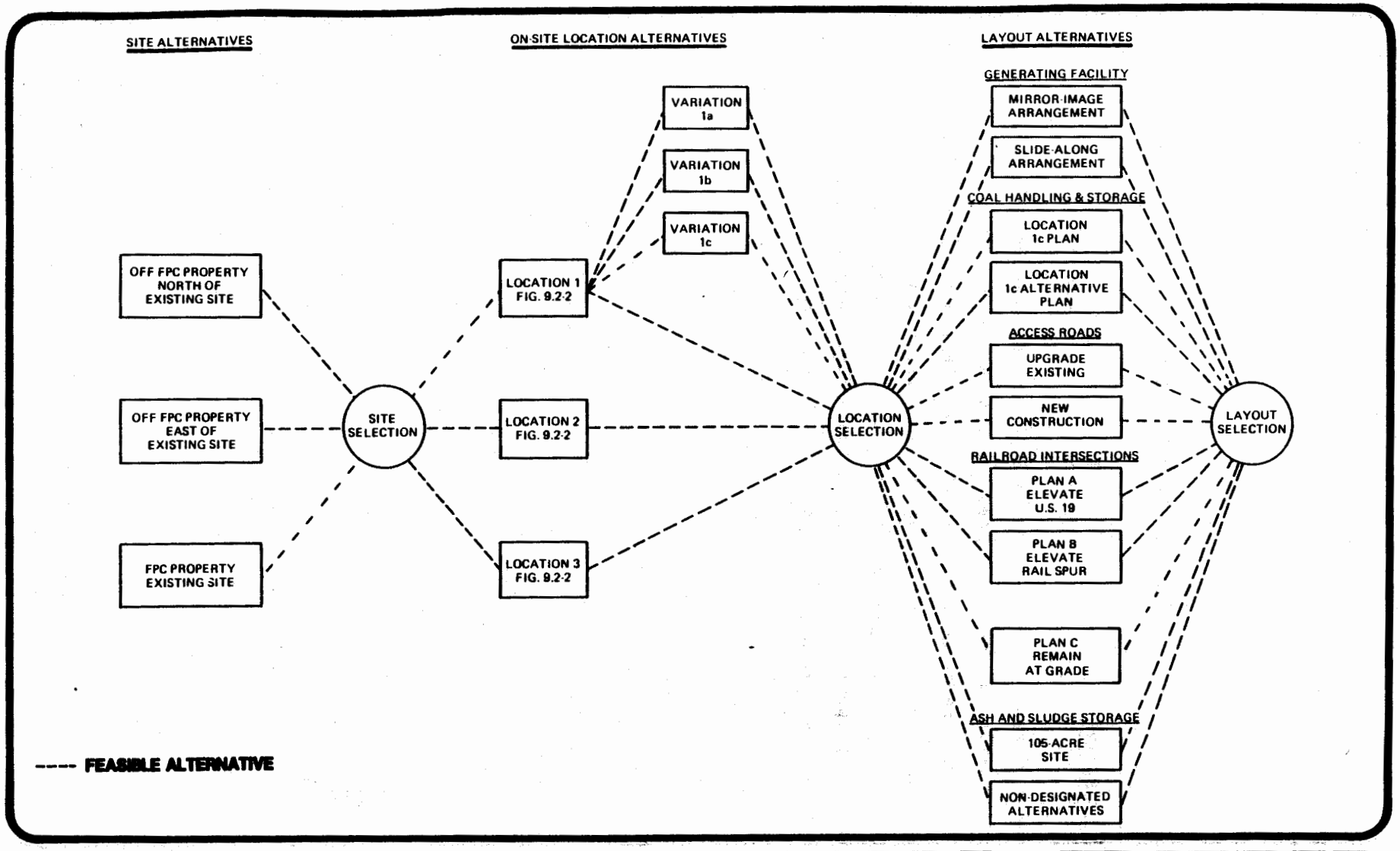

Figure 9.2-13

FEASIBLE ALTERNATIVES—PLANT SITING, LOCATION AND LAYOUT SUMMARY DIAGRAM

SOURCE: Environmental Science and Engineering, Inc., 1978

FLORIDA POWER CORPORATION

PROPOSED CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

9.3 COAL HANDLING SYSTEMS

9.3.1 OBJECTIVES

The major elements which must be included in any coal handling system for the existing and proposed fossil steam generating facilities at Crystal River are barge and rail delivery, barge and rail unloading, primary stock out, reserve and active storage, crusher system and plant supply system. The objective of this subsection is to provide an understanding of proposed and existing alternatives considered for major elements of the coal handling system outlined above.

9.3.2 EVALUATION CRITERIA

The following criteria were used as a basis for developing coal handling alternatives:

1. Site arrangement should be designed to accommodate a broad range of both high- and low-sulfur content coals from mine source areas in the eastern and western United States.
2. Combined facility for serving two existing and two proposed coal-fired plants should be designed to handle 6,536,160 metric tons (7,203,115 tons) per year, with a reserve of 1,634,040 metric tons (1,800,780 tons).
3. Reception facilities should be able to handle deliveries of 571,900 to 599,200 metric tons (630,260 to 660,340 tons) per month.
4. Coal terminal facilities should be designed for deliveries by unit trains, oceangoing barges, or both trains and barges.
5. Coal supplies intended for the existing power generation units must necessarily be segregated from supplies for the new units (consisting of low-sulfur coal). Allowing for this factor and for mobile equipment access, the total land requirements for reserve storage would amount to about 15 hectares (37 acres).
6. The volume of active storage should equal a 3-day supply of coal for both the new and existing units. Separate storage and reclaim facilities for the two sets of units would be appropriate. For operation at 90 percent of capacity, utilizing the worst coals, the 3-day fuel requirements would be about 24,500 metric tons (27,000 tons) for the existing units and 49,000 metric tons (54,000 tons) for the new units.
7. The procedure utilized in developing and evaluating alternatives has been to assume that both the barge unloading facilities and the rail facilities should be sufficient to meet the full needs of the plant. Given this assumption, the effective production rating of both the barge terminal and the rail terminal should be on the order of 1,360 metric tons (1,500 tons)

per hour; and the capacity of conveyor systems, feeders, reclaimers, etc., should be 2,700 to 3,200 metric tons (3,000 to 3,500 tons) per hour.

8. The coal handling arrangements should involve an integrated system with the ability to stock-out from either unit train or barge unloading facilities to the active storage area or segregated reserve storage area serving each pair of units.
9. Coal storage areas should if possible be located away from coastal marsh and coastal wetland forest areas.

SITING OF COAL HANDLING FACILITIES

The selection and siting of coal handling facilities must obviously be coordinated with the siting of the power generating units and related facilities such as ash storage ponds. Table 9.3-1 summarizes the key characteristics of eleven alternative coal handling plans which have been considered in the design process. Each plan involves one of the four plant sites (see Section 9.2), one of the rail unloading options, and a specific arrangement of rail lines and coal storage areas. The last four columns describe the locations of the major land-extensive facilities relative to the existing reserve storage area (which is just south of the existing active storage area and barge unloading dock).

Table 9.3-1 Characteristics of Alternative Coal Handling Plans

	Type of Coal Unloading Facility	Type of Rail Access	Location of Facilities Relative to Existing Reserve Storage Area			
			Unloading Facility	Rail Lines	New Active Storage	New Reserve Storage
Plans Serving Locations 1 or 2						
I	Trestle Dump	Loop	South	South, Southwest	South	South
II	"Rotoside" Rotary Dumper	Ladder	South	South, Southwest	South	South and East
III	Trestle Dump	Loop	East	East, Southeast	South	South and East
IV	Conventional Rotary Dumper or Bottom Dump Hopper	Loop	South	South, Southwest	West	West
VII	Bottom Dump	Loop	East	East	West	West
IX	Bottom Dump	Loop	East	East	South	Southeast

Table 9.3-1 Characteristics of Alternative Coal Handling Plans (Continued, page 2 of 2)

	Type of Coal Unloading Facility	Type of Rail Access	Location of Facilities Relative to Existing Reserve Storage Area			
			Unloading Facility	Rail Lines	New Active Storage	New Reserve Storage
Plans Serving Location 3						
V	Trestle Dump	Loop	South	South, Southwest	Southeast	South
VI	"Rotoside" Rotary Dumper	Ladder	South	South, Southwest	South	South and East
VIII	Bottom Dump Hopper	Loop	South	South, Southwest	South	South and East
Plans Serving Location Variation 1c						
X	Bottom Dump Hopper	Loop	East	East	South or East	East
XI	Bottom Dump Hopper	Loop	East	East	Northeast	East

Source: Black and Veatch, 1976.

9.3.3 ALTERNATIVES CONSIDERED

Coal is unloaded from barges and/or unit trains and is either delivered directly to the generating units or stocked out to active storage or reserve storage. Active storage is required to provide for short-term variations between coal usage and supply, particularly during periods when car or barge unloading and yard operations might be curtailed. Long-term storage is needed to level variations between coal purchase contractual commitments and station usage. The primary stockout and reclaim systems, serving active storage, must be designated so that coal is available for automatic reclaiming without resorting to coal dozers or other mobile reclaim equipment. The emergency stockout system, serving reserve storage, will allow barge or train deliveries to continue in the event that the primary stockout systems are unavailable. Other major coal handling facilities are the emergency reclaim hoppers, the crusher system, the coal sample system, and the interconnected network of conveyors, surge bins, and feeders.

The requirement for new coal handling facilities were considered in light of existing and contracted facilities for serving Units 1 and 2, requirements for proposed units, and siting of the overall facility.

The location of facilities is critical since nearly all the land to the west and south of the existing reserve storage area is presently either coastal marsh or coastal wetland forest. Encroachment upon these areas would constitute a serious environmental impact, as discussed elsewhere. Table 9.3-1 serves to indicate that it is rather difficult to provide adequate coal storage and rail access at the Crystal River site without utilizing wetland areas. However, the alternative ultimately selected does accomplish this objective.

Many of the alternatives listed in Table 9.3-1 were ruled out when the fuel subsidiary company decided to proceed with construction of a rail loop and bottom dump unloading facility east of the present reserve

storage area. Only Plans VII thorugh XI remained viable, barring major alteration or replacement of the facilities now under construction. Next, the overall site evaluation process described earlier yielded the conclusion that location 1c would be the best location for the new power generating units.

The remaining choice was between coal handling Plans X and XI, which differed only with regard to the location of the active storage area for the new units. It was found that insufficient land was available for this facility near the rail unloading area, if adequate reserve storage was to be provided without encroaching significantly upon wetlands. Therefore, the new active storage area has been sited north of the access road and transmission corridor, near the new generating units, even though this has cut into the land available for ash storage and construction laydown. It is apparent from Table 9.3-1 that this chosen alternative (Plan XI) is preferable to all other alternatives in terms of ecosystem protection.

EXISTING AND COMMITTED FACILITIES

Coal supplies for Crystal River Units 1 and 2 have in the past been received by barge. The existing facilities are designed for the unloading of oceangoing barges with net capacities of up to 13,600 metric tons (15,000 tons) and loaded drafts of up to 4.3 meters (14 feet). There is a barge and tug mooring dock, a clamshell type barge unloader, a stacker-reclaimer, and a belt conveyor system connecting the barge unloader and stacker-reclaimer. The rated capacity of the unloading and stockout systems is 1,360 metric tons (1,500 tons) per hour, and the capacity of the reclaiming and coal preparation systems is 540 metric tons (600 tons) per hour. Active storage for the existing units is located adjacent to the barge dock, and a reserve storage area of roughly 6.5 hectares (16 acres) is located further south.

The fuels contractor for the plant (Electric Fuels Corporation) has recently contracted for the installation of a railcar unloading facility to serve the existing units, which went into service in 1978. As presently designed, this installation includes the following components:

1. A railroad loop track for coal delivery and unit train turn-around. The track branches to the south from the existing Crystal River Unit 3 plant spur, rises about 9 meters (30 feet) to the unloading point, and then descends to grade at the original turnout point. The unloading loop includes approximately 1,500 meters (4,800 feet) of new track.
2. An elevated structure for bottom dumping of railcars having power operated hopper doors. The dump structure is about 30 meters (100 feet) long and includes multiple hoppers served by a single collecting conveyor.
3. A belt conveyor linking the dump structure with the existing coal handling system at the tailpoint of the barge dock belt.

NEW FACILITIES FOR PROPOSED UNITS

Barge Unloading Facilities

The peak barge unloading capability with the existing clamshell type unloader and associated conveyors is about 15,400 metric tons (17,000 tons) per day under optimum conditions. The unloader is probably adequate for sustained delivery rates to about 295,000 metric tons (325,000 tons) per month without seriously jeopardizing machine design or maintenance procedures. Thus, depending upon the proportions of annual coal requirements to be delivered by barge, the existing facilities may be marginal for the demands of the four coal-fired units. Two alternative methods of upgrading the terminal unloading operations have been proposed.

Plan 1

Add a second barge unloader and extend the existing dock approximately 27 meters (88 feet) to the east to accommodate longer barges, compensate for the decreased travel of the dual machines, and provide space for machine erection while maintaining unloading operations for the existing units. The second machine would be similar in design and unloading capabilities to the existing unloader. The paired machines, operating in separate holds of a barge, would raise the effective production rating of the terminal to an average of about 1,540 metric tons (1,700 tons) per hour.

Plan 2

Replace the existing barge unloader with a high capacity, continuous ladder type barge unloader rated at 2,700 metric tons (3,000 tons) per hour (free digging capacity). The existing dock would be extended approximately 40 meters (132 feet) to the east to provide erection space accommodating the trailing surge-bin and yard conveyor loadout structure required by this type of unloader.

Improvements to the existing unloading facilities under either plan would include the installation of a second conveyor system paralleling the existing conveyor. The discharge point of the new conveyor would be designed to feed either the existing stacker-reclaimer yard belt or a new 2,700-metric ton (3,000-ton) per hour conveyor extending to the active storage and stockout systems provided for the new units. If retained under Plan 1, the existing unloader would be modified somewhat, but still might limit barge unloading operations involving coals dedicated to the existing power generation units. The relative advantages of Plan 1 would involve operation flexibility, redundancy, and the ability to use existing dock trackage without modification. The advantages of the ladder type unloader would include better control of fugitive

dust, greater efficiency in free digging and cleanup modes, and more exact maintenance costs.

A cost comparison of the two barge unloading alternatives has indicated that Plan 2 would be higher in terms of capital cost ($8,150,000 versus $4,810,000 for Plan 1) but lower in terms of other annualized costs ($573,000 versus $1,016,000 for Plan 1). The total annualized cost of Plan 2 would be $2,517,000, and the annual cost of Plan 1 would be $2,163,000. Thus, the addition of a second clamshell type barge unloader (Plan 1) is the most economical alternative if increased barge unloading capability is required for future terminal operations.

Other Coal Handling Facilities

The present discussion has focused primarily upon facilities that would constitute major points of difference among alternatives. Some of the other facilities deserving mention are the stacker-reclaimer unit, the crushers, the emergency stockout system, and the conveyors. All of the alternatives have assumed the use of a slewing type stacker-reclaimer at the new active storage area rather than a trench type, due to the need for a longer track and power control system in the latter case to achieve comparable storage capability. The use of silos for active coal storage was determined to be economically unfeasible, although attractive in many respects. A similar decision was made with regard to groundlevel storage with gravity feed to underground conveyors.

A crusher structure with two 730-metric ton (800-ton) per hour crushers would be included in the coal handling system, and would contain chutes, crusher surge bin, feeders to regulate flow to the crushers, and bypass chutework to divert coal directly to the plant supply system. The conveyors associated with unit train unloading facilities should match the unloading systems in capability. A 3,200-metric ton (3,500-ton) per hour rate will be required when the unloading system that is presently under construction is modified for expansion to serve the new generating

units. [A 1,590-metric ton (1,750-ton) per hour conveying rate would have been adequate for the trestle dump unloading system.] The emergency stockout system will include a fixed boom cantilevered conveyor and telescopic dust chute capable of building a conical coal pile of about 13,600 metric tons (15,000 tons).

9.3.4 COMPARATIVE ANALYSIS OF ALTERNATIVES CONSIDERED

Figure 9.3-1 summarizes siting and major element alternatives of coal handling facilities. Location variation 1c was the preferred plant location at the Crystal River site (see Section 9.2, Plant Location and Layout Alternatives). Plan XI, which is outlined in Table 9.3-1, was the preferred layout plan. This alternative is the most workable plan of the two possibilities for location 1c (see Table 9.3-1) and results in less impact to coastal wetlands.

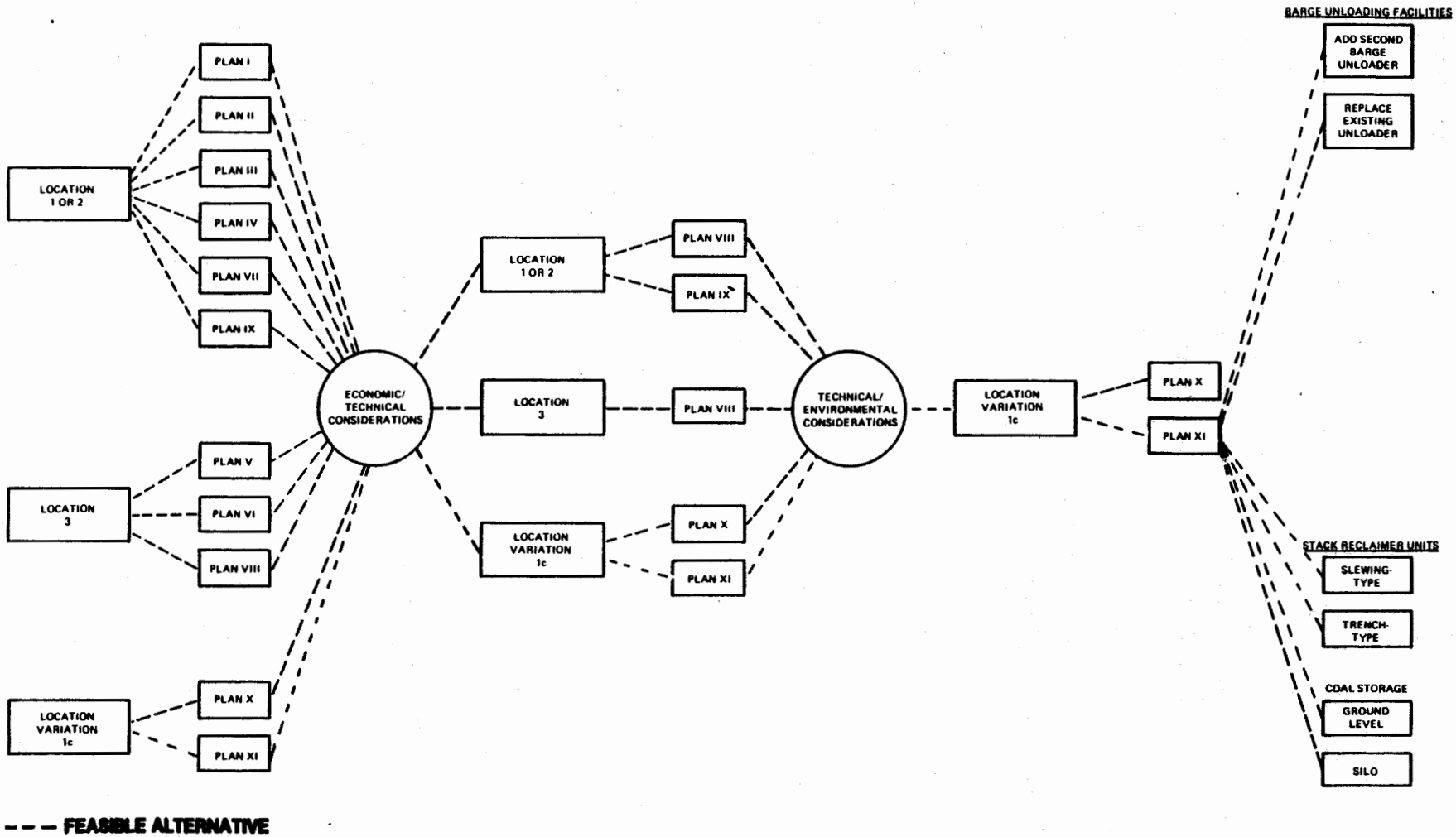

Figure 9.3-1

COAL HANDLING FACILITIES SITING AND MAJOR ELEMENTS ALTERNATIVES DIAGRAM (see Table 9.3-1 for outline of Plans I-XI)

SOURCE: Environmental Science and Engineering, Inc., 1978

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9.4 WATER SOURCE AND INTAKE ALTERNATIVES

9.4.1 OBJECTIVES

The objectives of this section are to present possible alternative water sources and associated intake designs for the proposed electric generating facility. Clearly, both the water source and intake design are related to the cooling system design ultimately selected. If a large volume of water is required by the selection of once-through cooling or power spray modules, some water sources will not be able to provide the required water. If cooling towers are used, several other water sources become viable alternatives because they can reasonably provide the smaller water volumes which are needed by cooling tower systems.

The alternative designs for cooling water systems are presented in Section 9.5 of this document. In this section, as water sources and intakes are discussed, the cooling system compatible with each source will be identified.

9.4.2 EVALUATION CRITERIA

WATER QUANTITY

Cooling water is required for the generating unit main condenser and the auxiliary cooling system. The alternative cooling systems are described in Section 9.5. Water requirements for condenser cooling vary depending upon water source and cooling system design.

High purity water is required for makeup to the steam generator. The steam flow at rated load is estimated to be 2.23×10^6 kilograms (4.91×10^6 pounds) per hour per unit. One percent of this value is assumed to be required for replacement of leakage. An additional quantity is required to replace steam lost during each soot blowing cycle. A total of approximately 1 cubic meter (250 gallons) per minute as an average daily flow is required per unit for steam supply makeup.

Bottom ash will be transported to a dewatering bin in a water slurry. This water will be delivered from the service water system and will be recycled. Fly ash will be transported dry to silos.

Potable water is required for sanitary services, cafeteria, drinking, washrooms, and showers. General plant use includes wash water and fire service.

The estimated service water demands for Units 4 and 5 are tabulated in detail in Chapter 3 of this report.

WATER QUALITY

Guidelines used for recirculating water quality limitations are given in Table 9.4-1.

Table 9.4-1 Recirculating Water Quality Limitations

Characteristic	Limitation	Comment
pH and Hardness	Langelier Saturation Index = 1.0	Langelier Saturation Index = pH-pHs where
pH and Hardness with addition of proprietory chemicals for deposit control	Langelier Saturation Index = 2.5	pH = measured pH pHs = pH at saturation with $CaCO_3$ See Sisson for nomagraph solution.
Sulfate and Calcium	$(C_{SO_4}) \times (C_{Ca}) = 500{,}000$	C_{SO_4} = concentration of SO_4 in mg/l C_{Ca} = concentration of Ca in mg/l as $CaCO_3$
Silica	$C_{SiO_2} = 150$	C_{SiO_2} = concentration of SiO_2 in mg/l
Magnesium and Silica	$(C_{Mg}) \times (C_{SiO_2}) = 35{,}000$	C_{Mg} = concentration of Mg in mg/l as $CaCO_3$

Source: U.S. EPA, 1973.

9.4.3 WATER SOURCE ALTERNATIVES CONSIDERED

Water source alternatives considered ranged from salt water to brackish water to fresh water. For purposes of discussion, water sources were categorized as fresh water or salt water. The following sources were considered:

Fresh Water	Salt Water
Crystal River	Gulf of Mexico
Withlacoochee River	Withlacoochee Reach of Barge Canal
Lake Rousseau	Saline Aquifer (deep wells)
Freshwater Aquifer (shallow wells)	

FRESHWATER ALTERNATIVES

Freshwater sources include the Crystal River, 4.8 kilometers (3 miles) to the south, and the Withlacoochee River and Lake Rousseau, 6.4 and 5.8 kilometers (4 and 3.6 miles) to the north and northwest, respectively, and a well field 9.2 kilometers (5.7 miles) to the east of the plant site (Figure 9.4-1). In each case, 76.2-centimeter (30-inch) diameter reinforced concrete pipe would be used to convey the raw water to the plant site. Only closed-cycle cooling would be possible using fresh water.

Crystal River

Crystal River as a source of cooling water was considered with an intake structure at a site approximately 4 kilometers (2.5 miles) downstream (west) of the town of Crystal River. The Crystal River runs from several head springs at Kings Bay, westward to the Gulf of Mexico. The maximum flow during normal tides is about 112 cubic meters (4,000 cubic feet) per second, 9,780,000 cubic meters (2,584 million gallons) per day. Interactions of wind and tidal forces result in complex mixing processes between fresh spring water and estuarine water causing large salinity

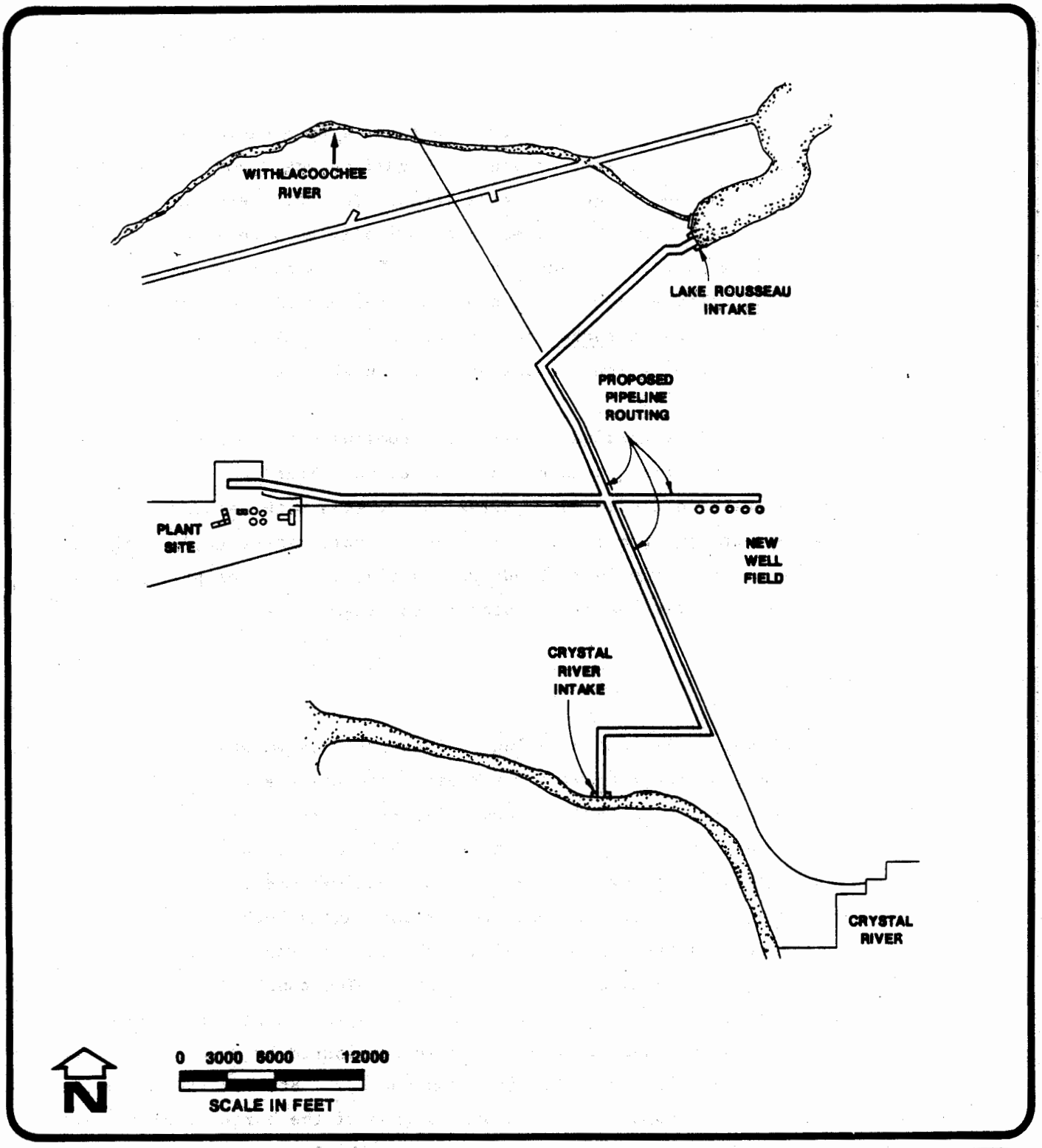

Figure 9.4-1

FRESHWATER SOURCE LOCATIONS

SOURCE: BLACK AND VEATCH, 1969
ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1980.

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variations (ESE, 1977). The river contains many aquatic weeds including Hydrilla. A wide variety of aquatic organisms are found in the river including freshwater and estuarine forms. The endangered manatee is common in the river. The river acts typically as a home for many planktonic eggs, larvae, and juveniles of many estuarine species. Preliminary studies suggest that at some seasons of the year, young, entrainable forms of Anchoa sp. (anchovies) and Callinectes sapidus (blue crabs) are present at the proposed intake site.

The Crystal River pumping facility for cooling water makeup would consist of an intake structure housing either three vertical traveling screens or three double entry traveling screens with three 50 percent capacity vertical pumps, each rated at 28 cubic meters (7,500 gallons) per minute. Approximately 16,500 meters (54,000 feet) of piping would be required to convey the river water to the plant site.

Lake Rousseau

Lake Rousseau (also known as Inglis Reservoir) is an artificial impoundment of the Withlacoochee River which was created by Florida Power Corporation in 1909 for hydroelectric power generation. During the 1960's, the lake became part of the U.S. Army Corps of Engineers Cross Florida Barge Canal project. The lake was modified for the barge canal project with the construction of the Inglis Lock, the Withlacoochee River Bypass Canal and the Gulf of Mexico reach of the barge canal (which lies west of the lake). The construction of the present structures at the Inglis Lock and bypass canal were completed in 1969. The barge canal project has been terminated by President Carter due to environmental and political controversy. Studies and discussions are in progress to decide final disposition of the barge canal project including those structures on or abutting Lake Rousseau.

An area of the lake east of the Inglis Dam has been chosen by Florida Power as the general location of a proposed cooling water intake structure. This area extends from the dam upstream about 2.4 kilometers

(1.5 miles) and has been the site of detailed multidisciplinary studies by ESE (1978).

The lake is part of a system modified by the construction of the Withlacoochee Reach of the Cross Florida Barge Canal. Opening of the canal and a northern bypass for the Withlacoochee River has considerably reduced the flow of water through the southwestern arm of the lake where an intake is presently proposed. Drawing the water volume estimated by Black and Veatch (1977) for cooling would increase the flow in this arm of the lake. This would perhaps resuspend sediments currently stored on the lake bed but ultimately may cause hydrodynamic conditions in the lake to be more like those before the Inglis Bypass was opened.

The bathymetry of Lake Rousseau is shown as a drowned river valley. Depth contours are widely spaced from the shoreline to the old river channel. At the river channel the isobaths are closely spaced indicating a V-shaped channel. The old river channel meanders tortuously through Lake Rousseau indicating a complete lack of structural and bedrock control. Several meander "necks" and "cutoffs" (as defined by Thornbury, 1954) indicate that the Withlacoochee was developing a valley flat prior to its flooding.

By planimetry the volume of Lake Rousseau [at 8.2 meters (27 feet) mean sea level] was found to be in excess of 3.1×10^7 cubic meters (25,000 acre-feet). The surface area of the lake, excluding marshy areas, is approximately 1,200 hectares (3,000 acres). Compared to the annual excess flow through the lake of 9.0×10^8 cubic meters per year (730,000 acre-feet/year, Geraghty and Miller, 1977), the storage volume is small. This fact is critical in assessing the availability of water in the lake for consumptive use (ESE, 1978).

Sufficient water appears to be available from Lake Rousseau for cooling purposes. Based on USGS figures, the proposed project would require a maximum consumptive use of 76,000 cubic meters (20 million gallons) per

day; and according to USGS figures, this is 3.3 percent of the Withlacoochee River 100-year low flow (ESE, 1977).

Shallow Well Fields

Well fields were discussed as an alternative in a report prepared by Geraghty and Miller, Inc. (1977), consulting groundwater geologists and hydrologists.

The well field would be located 8.7 kilometers (5.4 miles) east of the plant site to minimize the potential for horizontal saltwater intrusion. The characteristics of the aquifer in the area, as estimated by Geraghty and Miller from a flow net analysis, should be adequate to support the proposed withdrawal.

An aquifer test performed by Geraghty and Miller (1978) obtained much lower transmissivity values suggesting that groundwater flow to Crystal River may occur through solution channels or local zones of high permeability.

If high transmissivity zones were encountered in the well field, the field could require as few as five wells. However, in the absence of verification of this transmissivity data and based upon aquifer coefficients from the aquifer test, the conceptual well field would require a linear arrangement of 139 wells spaced 152 meters (500 feet) apart in order to produce the desired yield of 76 million liters per day (20 million gallons per day) and comply with Southwest Florida Water Management District Rules and Regulations. Each well would produce 380 liters per minute (100 gallons per minute). The transmission line would amount to approximately 21 kilometers (13 miles) of pipe in the well field itself and another 8 kilometers (5 miles) of pipe to convey the water to the plant site.

Withlacoochee River

The Withlacoochee River is 6.4 kilometers (4 miles) to the north of the Crystal River plant site. It drains an area of approximately 518,000 hectares (1,280,000 acres) in its 256-kilometer (159-mile) course. Average discharge is about 1,938 cubic meters (512,000 gallons) per minute. Most of this flow goes into Lake Rousseau which has inundated a stretch of the old river channel. The majority of the inflow to Lake Rousseau goes into the barge canal and is then diverted above the Inglis Lock into the Withlacoochee Bypass Canal and is discharged back into the existing river channel downstream from Lake Rousseau. About 723 cubic meters (191,000 gallons) per minute below the Inglis Dam is diverted back into the barge canal.

Although no pumping facilities design is available at this time, it is assumed that it would be similar to the one proposed for the Crystal River pumping facility.

SALTWATER ALTERNATIVES

Sources of saltwater or brackish water cooling are (1) the Gulf of Mexico, (2) the Withlacoochee Reach of the Cross Florida Barge Canal, and (3) the saline aquifer (deep wells).

Gulf of Mexico

The Gulf serves as a cooling source for existing units 1, 2, and 3 through a once-through cooling system. In this area, the Gulf ranges in salinity from about 18 ppt to 27 ppt and in temperature from 14 to 30°C (57 to 86°F)(Grimes, 1971).

The mean tidal range for the area is about 1 meter (3 feet). The bottom is gradually sloping in a manner typical of the drowned limestone plateau of west-central Florida. In-shore shallow flats are often exposed

at low tide. These areas are bottom dominated by dense summer growths of marine grasses. More seaward, the depth drops to about 2 meters (6.6 feet) and phytoplankton of drifting green plants take over more of a role in primary production. Coastal marshes are extensive and dominated by Juncus (McKellar, 1974).

The Gulf of Mexico can provide the necessary quantities of water for once-through cooling, cooling tower makeup water, or for the use of power spray modules with dilution. Water may be obtained either from the existing intake or existing discharge canal.

Withlacoochee Reach of Cross Florida Barge Canal

The Withlacoochee Reach of the Cross Florida Barge Canal was created by the Corps of Engineers as part of the initial construction of the Gulf Reach of the Cross Florida Barge Canal. Fresh water enters this section of the canal by infiltration from the surficial aquifer, by seepage through the Inglis Dam and the Inglis Lock, and by discharge of high river flow over the Inglis Dam spillway. Saline water from the open Gulf is exchanged with fresh water as a result of the tidal and wind forces.

It is not known at this time what effect withdrawing sufficient quantities of cooling water from the canal would have on Gulf and freshwater inflows into the canal. However, because the canal is open-ended on the Gulf, the canal can provide the necessary quantities of water.

Deep Aquifer

Underlying the freshwater aquifer is water of higher salinity. The potential yield and quality of water are largely unknown. However, if suitable freshwater sources could not be made available, and entrainment and impingement impacts of drawing open Gulf water were considered significant as additional units were proposed to come on line, then this

source could be considered feasible. More testing and investigation needs to be done before specific consideration and design parameters could be given for this source.

9.4.4 INTAKE STRUCTURE ALTERNATIVES CONSIDERED

Consideration of required intake designs falls into two general classes. These classes are: (1) large-volume intakes, and (2) lower volume intakes. Large volume intakes would be required if once-through or power spray modules were used for condenser cooling. Such systems would be realistic only if makeup water were taken from the Gulf of Mexico or the Withlacoochee Reach of the Cross Florida Barge Canal, where the large volumes of water needed would be available. Lower volume intakes would be required for cooling tower makeup water from either fresh or saltwater sources. The amounts of water required for cooling tower makeup are considerably less than the amounts required for once-through cooling or power spray modules. At this point in the analysis, the full list of water sources discussed in the preceeding section will be considered feasible sources for the quantities of water which would be needed for cooling tower makeup.

Intake structures are not required for groundwater makeup sources such as shallow or deep saline aquifer well fields. Alternative intake design for these sources is not discussed further.

LARGE-VOLUME INTAKES

Many designs for intake structures which might mitigate environmental impacts are prohibitively expensive for cooling systems which require large amounts of water. Such systems include once-through cooling and power spray modules with dilution. For these cooling systems the existing intake canal is indicated as the technically feasible source water (Black and Veatch, 1976). Other methods of obtaining water would require rather large alterations, including additional dredging. Such possibilities would include new canals, lengthy pipe systems, and modification of the Withlacoochee Reach.

Depth placement of the intake structure in the intake canal does not appear to be useful in limiting entrainment. Zooplankton populations were not found to be vertically stratified at Crystal River (Maturo, et al., 1974). Designs should be concerned mainly with limiting impingement.

An inlet flush with the side of the canal would be superior to an inlet placed at the end of an open channel. The flow in the intake canal would help direct finfish and shellfish past the screens instead of into them. With additional intake structures on the bank of the intake canal, it does seem possible that impingement could increase at Units 1, 2, and 3. Organisms tired or injured by the intake of Units 4 and 5 would be more easily carried into the screens of the existing units.

Designs such as inclined or horizontal traveling screens or perforated pipe intakes would also serve to reduce impingement. These methods would be expensive but would allow moving organisms some alternate route away from the screens.

If vertical screens are to be used, the impacts can be minimized by operating the screens continuously and providing a path for gentle and rapid return of impinged creatures to the water. Vertical screens could also be placed at an angle to the flow and lead fish into a bypass system.

LOWER VOLUME INTAKES

Water requirements for cooling tower makeup are considerably less than for once-through or power spray modules with dilution. Crystal River, Lake Rousseau, the Withlacoochee River, the Gulf of Mexico, and the Withlacoochee Reach of the Cross Florida Barge Canal will, at this point in the analysis, be considered feasible sources for cooling tower makeup.

Crystal River

The Crystal River intake system will be supplemented by two 5.7 cubic meters (1,500 gallons) per minute wells that would supply potable water to the plant site. Eleven years of record show the river minimum level to be about 0.9 meters (3 feet) below mean sea level and maximum level to be about 1.8 meters (6 feet) above mean sea level.

One alternative design for a Crystal River intake is conventional vertical traveling screens. The vertical traveling screen intake structure would consist of three 1.5-meter (5-foot) wide screens at an approach water depth of 2.4 meters (8 feet). Each screen would be placed in approximately a 1.7-meter (5-foot, 6-inch) wide pump bay.

The overall structure would be approximately 6.1 meters wide by 7.6 meters long by 6.1 meters high (20 feet wide by 25 feet long by 20 feet) high. The remaining components of the vertical traveling screen intake would be the same as for Lake Rousseau except for the material used for the components. The brackish water of Crystal River would require the use of corrosion-resistant material for the screens and framing.

A double entry vertical traveling screen for Crystal River would be located in a conventional concrete structure. The overall arrangement is similar to the double entry vertical traveling screen for Lake Rousseau. The only difference would be the corrosion-resistant materials and coatings of the components for the Crystal River intake.

The perforated pipe intake system for Crystal River will be the same for Lake Rousseau. A perforated pipe intake system operates more efficiently in a river because the current carries the backwashed debris away, thereby reducing the number and length of backwashes.

One difference from Lake Rousseau would be the orientation of the perforated pipes. In Crystal River, the perforated pipes would be oriented parallel with the current and offset so that a water craft could only damage one perforated pipe.

Lake Rousseau

Lake Rousseau is expected to have a severe weed problem. Both floating seasonal weeds and a submerged type of vegetation must be controlled at the intake site. Eleven years of record show the lake minimum level to be about 6.7 meters (22 feet) above mean sea level and maximum level to be about 8.5 meters (28 feet) above mean sea level.

A vertical traveling screen intake structure in Lake Rousseau would require three 0.9-meter (3-foot) wide screens at an approach water depth of 3.6 meters (12 feet). Each screen would be placed in approximately a 1.7-meter (5-foot, 6-inch) wide pump bay.

The overall intake structure would be approximately 6.1 meters wide by 7.6 meters long by 6.1 meters high (20 feet wide by 25 feet long by 20 feet high). The structure would also house the trash racks and mechanical rake to protect the screens from heavy debris, as well as contain the stop logs.

A differential controller would control the operation of the screens. The controller would start the screen drive and the spray pump at a predetermined headloss across the screens.

The entire intake system is remotely operated except for the mechanical trash rake and debris disposal. When trash removal is required, an operator must operate the mechanical rake and dispose of the trash and the accumulated screened debris.

Open water type double entry vertical traveling screens in Lake Rousseau would be mounted on a platform. The platform would be about 7.6 meters by 11 meters (25 feet by 35 feet) and would be located over approximately 4.6 meters (15 feet) of water. The platform would support the three 30 cubic meters (8,000 gallons) per minute pumps and three 0.9-meter (3-foot) wide screens, each directly connected to a pump.

A perforated pipe intake system would require two perforated pipes approximately 110 centimeters (42 inches) in diameter. The pipes would be located in approximately 2.4 to 4.6 meters (8 to 15 feet) of water, approximately 0.6 meters (2 feet) from the bottom and pin jointed to the main feeder pipes that supply water to the pump structure. The feeder pipes would be approximately 91 centimeters (36 inches) in diameter and about 61 meters (200 feet) long.

Backwash for the perforated pipes would be done by a valving arrangement that would allow two of the pumps to backwash one of the perforated pipes at a time. A differential head controller would be used to determine when backwashing of the perforated pipes is required. The pump structure would be located on shore and would support the three 30-cubic meter (8,000-gallons) per minute pumps.

Withlacoochee River

Specific designs for intake structures in the Withlacoochee River are not available. Vertical traveling screens, double entry vertical traveling screens, and perforated pipe designs similar to those suggested for Crystal River would be possible.

Gulf of Mexico

Gulf of Mexico waters could be taken in by an intake structure located on the existing intake or discharge canals. Locating the intake on the existing discharge canal would have environmental advantages since the

water entrained would have already passed through the cooling systems of Units 1, 2, and 3. Units 4 and 5, therefore, would not impact additional water over that already impacted by Units 1, 2, and 3. Such an intake would be closer to Units 4 and 5 and thus would reduce the cost of piping; but, because the water is also hotter, the plant would be subjected to engineering penalties.

Three alternative methods of locating the intake structure are available, either on the existing intake canal or on the discharge canal. The inlet could be flush with the canal shoreline; the inlet could be set off the canal shoreline in open water; or the inlet could be set back from the existing canal at the end of a new channel.

An intake structure on the existing discharge canal would provide makeup water for saltwater cooling towers. Required volumes would be about 68,000 gallons per minute. The structure would be about 50 feet in width and would be divided into three cells. Given the amount of water required, it should be possible to keep maximum velocities below 0.5 feet per second.

Withlacoochee Reach of Cross Florida Barge Canal

Specific designs for intake structures are not available for this water source. Intake for cooling tower makeup water would be similar to those suggested for Crystal River.

9.4.5 COMPARATIVE ANALYSIS OF ALTERNATIVES CONSIDERED

ECONOMIC CONSIDERATIONS

Comparative capital and annual costs of alternative freshwater supply sources are given in Table 9.4-2 and 9.4-3. Data were not available for the Withlacoochee River as a source.

The Crystal River source has the highest capital cost of the three freshwater water supply sources considered, as well as the highest total annual cost. The primary reason for the higher costs is Crystal River alone would not provide proper quality of raw water, and use of freshwater wells for stream cycle makeup water would have to be provided. Costs for development of the Withlacoochee River would probably be between the costs for use of Crystal River and Lake Rousseau; depending, of course, on detailed analysis of quantity available (possible well field subsidy as required for Crystal River) and additional piping requirements.

Cost data for saltwater sources specific to the proposed site are available only for the Gulf of Mexico. These data can be extracted from the section on alternative cooling systems, Tables 9.5-3 through 9.5-11. Major costs would be for the intake system and canal work to modify existing canals. Total capital costs for Gulf of Mexico source drawn through the existing canal system are generally less than $10,000,000 for any of the proposed cooling alternatives. Annual maintenance costs range from $40,000 to $100,000 per year depending on the cooling alternative. Site specific cost data were not available for the following additional saltwater source alternatives: Withlacoochee Reach of the Barge Canal or deep wells (saline aquifer). Undoubtedly, all of these later alternative sources will be more expensive than the Gulf source. Mixing of fresh and salt water in the Cross Florida Barge Canal would result in changing water quality. Distance from the power plant and the need for acquiring rights-of-way, and future uncertainties as to the

Table 9.4-2 Comparative Capital Costs--Alternative Water Supply Sources--Crystal River Units 4 and 5

Requirement	Water Source		
	Crystal River	Lake Rousseau	Well Field
Piping from Wells	$1,685,000	$ 0	$4,275,000
Piping from Intake	5,405,000	4,800,000	0
Intake Structure	531,000	525,000	0
Wells	154,000	0	604,000
Subtotal	7,775,000	5,325,000	4,879,000
Differential	2,896,000	446,000	Base
Escalation (23 percent)	660,000	103,000	Base
Subtotal	3,556,000	549,000	Base
Interest During Construction (15 per cent)	534,000	82,000	Base
Indirect Costs (8.7 per cent)	309,000	48,000	Base
Total	4,339,000	579,000	Base

Source: Black and Veatch, 1977.

Table 9.4-3 Comparative Annual Costs--Alternative Water Supply Sources--Crystal River Units 4 and 5

Requirement	Water Source		
	Crystal River	Lake Rousseau	Well Field
Operating Costs			
Energy	$ 75,000	$ 21,000	Base
Chemical	88,000	Base	$146,000
Demand Charges	7,000	2,000	Base
Fixed Charges at 14 percent	616,000	95,000	Base
Total	786,000	118,000	146,000
Differential	668,000	Base	28,000

Source: Black and Veatch, 1977.

dispensation of the canal could add to the cost of this alternative. Costs for deep wells would be similar to those for the shallow (freshwater) field, only higher, due to increased drilling and piping costs, and varying quality of the source.

Without site-specific cost data for each alternative source considered, a strict ranking relative to cost can be offered only as a "best guess." However, site specific estimates for the most apparent cost-effective source alternatives were included. A relative ranking of alternatives according to lowest estimated cost (or in cited cases, speculated cost) is:

Gulf of Mexico
Lake Rousseau
Shallow wells (freshwater)
Withlacoochee Reach Cross Florida Barge Canal
Crystal River
Withlacoochee River
Deep Wells (saline water)

Cost data for alternative intake structures are given in Tables 9.4-4, 9.4-5, and 9.4-6. Perforated pipe rank lowest in cost with vertical traveling screens and double-entry vertical traveling screens second and third, respectively. Cost data were not available for inclined and horizontal traveling screens.

TECHNICAL CONSIDERATIONS

Technical considerations are primarily centered on water quality characteristics of each alternative water source and upon a comparison of power plant water needs and present water use in the area.

Projected consumptive use requirements for competing users of all fresh water in Citrus County are listed in Table 9.4-7 (Corps of Engineers, 1977). The total projected nonpowerplant requirements for ground water

Table 9.4-4 Capital Cost Summary Alternative Intake and Discharge Systems—Crystal River

Item	Vertical Traveling Screens ($)	Perforated Pipe ($)	Double Entry ($)
Well system*	Base	Base	Base
Structure	103,000	Base	95,000
Screening device	52,000	Base	61,000
Pumping system	Base	Base	Base
Subtotal	155,000	Base	156,000
Escalation at 7.2%	11,000	Base	11,000
Indirect costs at 8.7%	14,000	Base	15,000
Interest during construction at 51%	85,000	Base	85,000
Total	265,000	Base	267,000
Differential	265,000	Base	267,000

*The cost of the two 5.7 cubic meters (1,500 gallons) per minute wells and their associated piping is included in the cost for all alternatives for Crystal River.

Source: Black and Veatch, 1978.

Table 9.4-5 Capital Cost Summary Alternative Intake and Discharge Systems—Lake Rousseau

Item	Vertical Traveling Screens ($)	Perforated Pipe ($)	Double Entry ($)	Double Open Water ($)
Structure	103,000	Base	95,000	—
Platform	—	—	—	350,000
Screening device	Base	21,000	9,000	29,000
Pumping system	Base	Base	Base	Base
Subtotal	103,000	21,000	104,000	379,000
Escalation at 7.2%	7,000	2,000	7,000	27,000
Indirect costs at 8.7%	10,000	2,000	10,000	35,000
Interest during construction at 51%	56,000	11,000	57,000	207,000
Total	176,000	36,000	178,000	648,000
Differential	140,000	Base	142,000	612,000

Source: Black and Veatch, 1978.

Table 9.4-6 Annual Cost Summary Alternative Intake and Discharge Systems

Item	Vertical Traveling Screens ($)	Perforated Pipe ($)	Double Entry* ($)	Double Open Water* ($)
Lake Rousseau				
Energy	4,000	Base	4,000	4,000
Demand Charges	1,000	Base	1,000	1,000
Fixed Charges	20,000	Base	20,000	86,000
Differential Annual Cost	25,000	Base	25,000	91,000
Crystal River				
Energy**	4,000	Base	4,000	—
Demand Charges	1,000	Base	1,000	—
Fixed Charges	37,000	Base	37,000	—
Differential Annual Cost	42,000	Base	42,000	

*The energy costs include operating the screen drive and spray pumps.
**The energy costs associated with operating the two 5.7 cubic meters (1,500 gallons) per minute wells is included in all alternatives for Crystal River.

Source: Black and Veatch, 1978.

Table 9.4-7 Present and Projected Future Freshwater Demands in Citrus County, in Cubic Meters per Day (Million Gallons per Day)

	Groundwater Demand 1976		Projected Water Demand 1985		Projected Water Demand 2035	
	cmd x10^3	mgd	cmd x10^3	mgd	cmd x10^3	mgd
Municipal	14.8	(3.9)	26	6.8	87.4	23.1
Industrial*	31	(8.2)	29	7.7	7.6	2.0
Agricultural	42	(11.1)	45	12.0	101	26.7
TOTAL	87.8	(23.2)	100	26.5	196.0	51.8

*Excludes power plant demands.

Source: Geraghty and Miller, 1977.

and surface water to the year 2035 is 196,000 cubic meters per day (51.8 million gallons per day). Projected cooling tower makeup needs for the proposed project will increase consumptive use requirements in Citrus County to 272,000 cubic meters per day (71.8 million gallons per day). Consequently, power plant usage represents approximately 28 percent of the total surface and groundwater demand. Agricultural and municipal consumptive use will account for 69 percent of demand.

Crystal River

Water samples were collected by Florida Power Corporation at three points at low, flood, high, and ebb tide conditions on Crystal River. The water quality data listed in Table 9.4-8 are from the sample point nearest the proposed intake structure location. Comparison of the listed concentration values indicates the tidal influence. The daily variations in water quality and the poor quality of the water makes this an undesirable source of cooling tower makeup and an unsatisfactory source for service water. With Crystal River as the source, control of cooling water quality would be difficult. Total dissolved solids concentrations, as well as chloride and sulfate concentrations, make the water unsuitable as a potable water supply.

With Crystal River as the source of makeup, a maximum of five cycles of concentration can be maintained in the cooling water system. The estimated maximum and average station water requirements for Crystal River source are presented in Table 9.4-9.

Extensive pretreatment of the river water source would be required prior to use as service water. Clarification, lime softening, and filtration would not provide a water suitable for potable use or for supply to the ion exchange system. To produce suitable water, an additional step such as reverse osmosis would be required. The variable river water quality would make control of process equipment difficult.

Table 9.4-8 Crystal River Water Analyses

Constituent	Low	Flood	High	Ebb
Calcium*	163	130	200	140
Magnesium*	312	300	353	345
Sodium*	1,838	1,806	4,289	2,092
Potassium*	47	42	83	52
M-alkalinity*	127	133	183	134
Sulfate*	212	215	464	246
Chloride*	2,021	1,930	4,323	2,249
Silica†	6.4	6.4	6.0	6.2
Specific Conductance, umhos	3,817	3,846	6,061	4,464
pH	8.1	8.1	8.1	8.1

*mg/l as $CaCO_3$
†mg/l as SiO_2

Source: Black and Veatch, 1977.

Table 9.4-9 Estimated Station Water Requirements Crystal River Units 4 and 5

	Water Source					
	Crystal River gpm		Lake Rousseau gpm		Well Field gpm	
Requirement	Avg.	Max.	Avg.	Max.	Avg.	Max.
Cooling Tower Makeup	9,200	13,750	8,300	12,400	8,850	13,200
Service Water	400	1,000	400	1,000	400	1,000
Raw Water	100	300	100	300	100	300
Total	9,700	15,050	8,800	13,700	9,350	14,500

Source: Black and Veatch, 1977.

Crystal River does not have a water supply sufficient for use in power spray module cooling. The 1,000 gpm (1,440 mgd) described by Black and Veatch (1976) amounts to about 64 cubic meters (2,300 cubic feet) per second (1,486 mgd). A maximum water supply of about 100 cubic meters (4,000 cubic feet) per second (2,584 mgd) is available at Crystal River (ESE, 1977).

Cooling towers with Crystal River makeup water would not require as large a volume of water as cooling with estuarine waters [.037 cubic meters per minute/53 cubic meters per day (9,700 gallons per minute/ 14 million gallons per day) average, 83 cubic meters per day/.058 cubic meters per day (15,000 gpm/22 mgd) maximum] (Black and Veatch, 1977). However, salinity fluctuations require a larger volume of makeup water from Crystal River than would be needed from either Lake Rousseau or the well fields.

Lake Rousseau

Water quality data for Lake Rousseau are presented in Table 9.4-10. These data were taken from analysis of the samples collected by Florida Power Corporation and from data compiled by the USGS during 1975. The minimum and maximum concentrations found in these data are tabulated, along with the analysis of a typical sample. The lake water is of acceptable quality to serve requirements, with pretreatment of the service water supply.

An average of nine cycles of concentration can be maintained in the cooling water system when using Lake Rousseau as the makeup water source. The estimated maximum and average station water requirements from the Lake Rousseau source are presented in Table 9.4-9.

The concentrations of dissolved solids in Lake Rousseau are lower than either Crystal River or well fields (Black and Veatch, 1977; ESE, 1977). As mentioned before, this factor partially determines the amount of

Table 9.4-10 Lake Rousseau Water Analyses

Constituent	Minimum	Maximum	Typical
Calcium*	97.5	115	106
Magnesium*	19.3	21.8	21
Sodium*	6.5	7.6	7.4
Potassium*	0	0.3	0.2
M-alkalinity*	97	121	108
Sulfate*	16.6	22.9	19
Chloride*	4.5	10.4	7
Silica†	-	-	1.0
Nitrate	5	7.3	6.3
Specific Conductance, umhos	235	330	266
pH	7.2	8.4	7.8

*mg/l as $CaCO_3$
†mg/l as SiO_2

Source: Black and Veatch, 1977.

water needed. Black and Veatch indicate that less water would be needed from Lake Rousseau [.034 cubic meters per minute/49 cubic meters per day (8,800 gallons per minute/13 million gallons per day) average and .053 cubic meters per minute/76 cubic meters per day (13,700 gallons per minute/20 million gallons per day) maximum] than from well fields [.037 cubic meters per minute/53 cubic meters per day (9.350 gallons per minute/14 million gallons per day) average and .056 cubic meters per minute/17 cubic meters per day (14,500 gallons per minute/21 million gallons per day) maximum].

It would appear that Lake Rousseau waters with lower levels of dissolved solids would need a lower amount of antiscaling chemical treatment.

The chemical characteristics of Lake Rousseau, as listed in USGS data from 1966 through 1975 and as represented by the water sample, are quite consistent. The service water supply would require pretreatment through use of lime softening, clarification, and filtration. Possible organic contamination must be removed by pretreatment before use as potable water and as supply to the demineralization system. Although Lake Rousseau is an acceptable service water source, the possible organic content makes it less suitable than well water.

Shallow Well Field

Well water chemical characteristics based on data provided by Florida Power Corporation are tabulated on Table 9.4-11. These data were derived from analyses of samples from three existing wells. The wells are the present source of fresh water supply to the Crystal River plant.

These analyses indicate some variations in water quality between wells, in addition to some variations for each well. Use of the raw well water as the makeup to the cooling water system would allow up to six cycles of concentration to be maintained. The estimated maximum and average

Table 9.4-11 Well Water Analyses

	Well 3	Well 4		Well 5	
	4/13/76	4/13/76	11/30/76	4/13/75	8/18/75
Calcium*	147	173	160	167	153
Magnesium*	70	74	82	74	82
Sodium*	10	9	9	10	10
M-alkalinity*	208	237	234	232	226
Sulfate*	5	5	5	5	5
Chloride*	13	13	11	13	13
Nitrate	-	-	-	-	-
Silica†	414	-	4.4	4.3	3.9
Specific Conductance umhos	435	485	430	475	440
pH	7.8	7.6	7.8	7.6	7.7

*mg/l as $CaCO_3$
†mg/l as SiO_2

Source: Black and Veatch, 1977.

station water requirements from the well source are presented in Table 9.4-9.

Operation of the existing pretreatment system on the present well water supply demonstrates the expected success of providing a suitable service water by lime softening and filtration. The water supply has been satisfactory as supply to the existing demineralization system and potable water systems. The service water system for the new generating units would require a similar pretreatment process if well water is used in conjunction with Crystal River water.

Withlacoochee River

Chemical characteristics of Withlacoochee River water are presented in Table 9.4-12. Lower levels of dissolved solids are present than in either well water or the waters of Lake Rousseau, although specific conductance is higher in the river, based upon these data. Given the uncertain plans for this area of the Withlacoochee and the relatively low flows available through the Inglis lock, this source does not appear dependable enough as a source for cooling tower makeup.

Withlacoochee Reach of Cross Florida Barge Canal

Chemical characteristics of the Withlacoochee Reach of the Cross Florida Barge Canal are presented in Table 9.4-13.

Gulf of Mexico

The use of saline estuarine water in cooling tower makeup would require larger volumes of estuarine water than if fresh water were used. Black and Veatch (1976) estimate that some .17 cubic meters per minute/ 245 cubic meters per day [45,000 gallons per minute (64.8 million gallons per day)] would be required for a natural draft tower using estuarine water, while less than .04 cubic meters per minute/54.5 cubic

Table 9.4-12 Withlacoochee River Water Analysis, Bypass Channel Below Structure

Constituent	Concentrations	
	High Flow	Low Flow
Calcium, mg/l	41	36
Magnesium, mg/l	5.7	4.0
Bicarbonate, mg/l as HCO_3	131	—
Carbonate, mg/l as CO_3	0	—
Alkalinity, mg/l as $CaCO_3$	108	—
Chloride, mg/l	16	6.1
Specific Conductance, umhos	352	229
pH	7.7	7.8
Suspended sediment, mg/l	9.7	—

Source: Environmental Science and Engineering, Inc., 1977 (based on USGS, 1976).

Table 9.4-13 Cross Florida Barge Canal Water Analysis at Inglis Lock

Constituent	Concentrations Sept/Oct/Nov/Dec	May
Calcium, mg	140	200
Magnesium, mg/l	310	650
Bicarbonate, mg/l as HCO_3	169	—
Carbonate, mg/l as CO_3	0	—
Alkalinity, mg/l as $CaCo_3$	139	—
Chloride, mg/l	6,800	12,060
Specific conductance, umhos	15,025	25,200
pH	7.7	7.5
Suspended sediment, mg/l	6.7	—

Source: Environmental Science and Engineering, Inc., 1977 (based on USGS, 1976).

meters per day [10,000 gallons per minute (14.4 million gallons per day)] would be needed for fresh water from Crystal River, Lake Rousseau, or well fields (Black and Veatch, 1977). This is because estuarine water contains larger quantities of dissolved solids and can be cycled through the tower fewer times before "blowdown" or discharge. Chemical characteristics of Gulf of Mexico water in the present intake canal are presented in Table 9.4-14.

Deep Aquifer

The chemical makeup and availability of water from deep aquifers is not available.

ENVIRONMENTAL CONSIDERATIONS

All the water sources considered would exhibit some impacts if drawn upon by the power plant. Impacts are, of course, intimately connected to the type of cooling system used and the intake design using the best available technology. There will, as a result, be some overlap between this section and other sections concerning water sources impacts. The major criteria which were considered in the development of this section are entrainment, impingement, water availability, water quality, and circulation. The impacts on the ecology of these waters would include impingement of larger organisms on the screens and entrainment of smaller organisms into the power plant condenser and other structures. Water availability in each source as compared to the need of Florida Power Corporation must also be considered. Another aspect to be discussed is the possible disruption of existing patterns of water quality and circulation in the source body of water.

Cooling towers would require much less water to be entrained while once-through cooling and power spray modules would require considerably more water (Black and Veatch, 1977). Generally, the more water taken in by the cooling system, the more organisms entrained. Entrainment would be

Table 9.4-14 Water Quality Crystal River Plant Station D, Intake Canal, Gulf of Mexico

Date	Salinity 0/00	PO_4-P Parts per 10 million	NO_3-N Parts per 10 million	NH_3-N Parts per 10 million	SiO_2-Si pp ppm	NO_2-N ppb	Organic C ppm
11/6/73	28.117	0.19	0.103	<0.05	0.591	1.0	3.7
11/20/73	29.25	0.08	0.021	0.46	0.367	0.5	6.4
12/3/73	27.627	0.24	0.106	0.36	0.736	7.9	3.15
12/18/73	25.587	0.34	0.066	0.03	0.509	0.8	3.41
1/3/74	22.158	0.18	0.044	0.52	0.295	1.4	4.39
1/14/74	23.873	0.10	0.012	0.05	0.563	0.3	2.87
1/28/74	23.207	0.482	0.008	0.26	0.737	0.2	5.63
2/12/74	23.418	0.14	0.029	0.37	0.755	0.3	6.6
2/27/74	20.563	0.023	No data	0.19	0.377	1.0	6.9
3/13/74	26.484	0.113	0.057	0.56	0.280	0.3	No data
3/26/74	20.075	0.09	0.004	0.68	0.850	No data	6.3
4/9/74	23.121	0.14	0.012	0.44	1.012	0.9	7.6
4/24/74	24.040	0.28	<0.001	0.38	0.805	0.8	12.3
5/7/74	26.046	0.14	0.006	0.43	0.757	0.4	4.9
5/22/74	26.060	0.18	0.022	0.36	1.01	0.3	7.3
6/4/74	25.189	0.21	0.037	0.53	0.966	0.1	6.9
6/21/74	27.627	0.33	0.046	0.35	1.283	0.7	5.9
7/3/74	20.342	<0.01	0.662	1.94	1.252	<0.1	6.3
7/19/74	24.60	<0.01	0.478	0.25	1.522	<0.1	4.9
7/31/74	21.0	12.02	0.630	0.90	0.659	<0.1	8.0
8/16/74	23.8	5.12	0.482	0.51	1.145	<0.1	7.1
8/28/74	25.6	1.71	0.11	0.34	0.410	<1	5.7
9/13/74	25.8	0.18	0.08	0.22	0.184	<1	5.1

Source: Environmental Science and Engineering, Inc., 1977 (based on Florida Power Corporation, 1976).

less for cooling towers. Impingement could be substantially reduced if cooling towers are used, since the required volume of water can be provided with lower intake velocities (EPA, 1976; Boreman, 1977). Circulation, water quality, and water availability impacts are generally directly proportional to the volume of water that will be withdrawn for consumptive use.

Impacts which could take place with groundwater use include horizontal salinity intrusion, vertical upwelling of highly mineralized water through confining zones, consumptive use of freshwater, lowering of surfical water table and interference with surface water flows. Questions of entrainment and impingement of organisms as associated with use of surface water do not apply to groundwater since the organisms are simply not present. Geraghty and Miller estimate that in 1976, groundwater withdrawals in Citrus County for industrial, agricultural, and municipal purposes totaled 87,800 cubic meters (23.2 million gallons) per day (see Table 9.4-7). Withdrawals are not concentrated in any one area.

Potential impacts resulting from well water cooling would be dependent upon the following information:

1. Aquifer characteristics:
    a. Transmissivity;
    b. Storage coefficient;
    c. Thickness, composition, and extent of clay layers between pumping zone and surface waters;
    d. Aquifer leakance values.
2. Wellfield design:
    a. Pumping rates;
    b. Number of wells;
    c. Spacing of wells;
    d. Penetration of aquifer;
    e. Proximity of wells to surface waters; and
    f. Duration of pumping at each well.

Many impacts depend upon information from test pumping. See Section 9.4.3, Shallow Well Fields.

Saline groundwater has also been suggested for cooling tower makeup. This would not amount to a consumptive use of freshwater. High concentrations of minerals present in such water would allow fewer cycles through cooling towers and technical problems may result from corrosion. There are no known power plants which presently employ this source of cooling water.

Use of the existing Withlacoochee Reach of the Cross Florida Barge Canal would result in entrainment as would using Gulf of Mexico water through the present intake canal. Future modifications to the canal reach could reduce this factor, but plans for the disposition of the area are uncertain. The availability of water in this source depends upon technical decisions yet to be made by the state and federal governments concerning the Barge Canal property.

An intake structure at the presently proposed site on Crystal River would have an impact on an area of freshwater marsh. This area is populated by sawgrass and cattails and provides habitats for a number of freshwater fish including the sailfin molly and the mosquito fish (ESE, 1977). The other water source alternatives would not require construction through existing wetlands.

Lake Rousseau impacts would be mainly entrainment of planktonic forms if impingement is considerably reduced, as expected, by proper intake design. Studies are underway to estimate the numbers and types of organisms which would be entrained and any disruption of present circulation patterns in the lake which might result (ESE, 1977).

The life habits of the expected species of freshwater fish in Lake Rousseau are such that few drifting eggs, larvae, and entrainable juveniles

would be present in the deeper sections of the lake presently proposed as an intake site (ESE, 1977).

If a best available technology intake is designed, entrainment may be considerably reduced. Organisms entrained could be limited to forms which occupy many important positions in the lake food web, but are not considered commercially or recreationally valuable in themselves (ESE, 1977a; ESE, 1977b). The intake could be placed in deep offshore waters of low biological productivity (ESE, 1977).

The asiatic clam, Corbicula, may cause technical problems if Lake Rousseau is used for cooling tower makeup water. Corbicula is known to occur in the lake (ESE, 1977). Corbicula fluminea is an opportunistic species recently introduced into U.S. waters. It is a species with high reproductive capacity and fast growth which has the ability to colonize power plant condensers. The clam reduces water flow through condenser tubes and prevents laminar flow. The organism is resistant to biocides and can withstand chlorination far above the limits allowed by EPA. Young clams can attach in flows up to 2.2 meters (7.2 feet) per second. Problems may result in discharge waters when many of the clams die at once. The Savannah Nuclear Plant must be shut down periodically for maintenance due to infestations of Corbicula.

Both EPA (EPA, 1976) and U.S. Fish and Wildlife Service (F&WS, 1977) emphasize that the best way to minimize power plant impacts on important aquatic resources is by locating the plant near water where such resources are scarce. These agencies suggest that the best available knowledge of the source water be used by the planner to properly place the intake vertically and horizontally and to arrive at the design which will least affect the aquatic system. In addition, both agencies would like to see designs which limited intake velocities to about 15 centimeters (0.5 feet) per second. This is generally considered to be a flow velocity which most species of fish can resist and avoid impingement.

Placement and design of the intake structure should be fitted to the water needs of the cooling system and the source body of water.

Water volumes required for cooling tower makeup are considerably less than that required for the systems described above (Black and Veatch, 1976). The perforated pipe intake design for Lake Rousseau could be modified for use in any of the alternative source waters. This design allows low approach velocities as recommended and allows organisms to avoid the intake by swimming in any direction except directly into the inlet holes. Problems may be encountered with this design due to slime, algae, or weed fouling. Proposed backwash will help overcome this problem.

This design could greatly mitigate entrainment if the intake pipes are placed at the depth of the least productive waters. Studies are currently underway to identify the waters of lowest biological value in Lake Rousseau for this purpose.

If a pump platform is used with the perforated pipe intake, care should be taken to withdraw water from a point away from the base of the platform. The platform itself would act as habitat and protection for eggs and larvae of freshwater fish. If the intake is away from the platform, these organisms can be avoided.

Whatever the surface source, many commercially, recreationally, and ecologically important planktonic forms may be entrained and subjected to thermal and mechanical stress within the power plant (Florida Power Corporation, n.d.; Maturo, et al., 1974). Present technology could not prevent this entrainment in any manner which would be economically feasible. Table 9.4-15 gives a summary assessment of alternative water sources. Figure 9.4-2 summarizes the source and intake alternatives considered in this section. An intake placed on the existing discharge canal would reduce the impacts of cooling water withdrawal. Near the

Table 9.4-15 Environmental Assessment of Alternative Water Sources

Water Source	Advantages	Disadvantages
Gulf of Mexico through existing canals	1. Lower costs 2. No consumptive use of fresh water 3. If water is withdrawn from existing discharge canal no "new" water would be entrained.	1. Entrainment of important species 2. Impingement of important species (for once-through or PSM) 3. If cooling towers are used salinity contributes to technical problems and larger volume of water needed than fresh sources
Withlacoochee Reach of Cross Florida Barge Canal	1. Systems altered would be of lower value 2. No consumptive use of fresh water	1. Uncertainty of future plans for the area 2. If cooling towers are used a lower volume of water will be needed than for freshwater sources but technical problems may arise
Crystal River	1. Water of lower salinity than above sources	1. Consumptive use of fresh water 2. Entrainment of important species 3. Requires alteration of wetlands 4. Percentage of water to be used is higher than for Lake Rousseau
Lake Rousseau	1. Entrainment may be reduced by placing intake in waters of low biological productivity 2. Percentage of water used is lower than at Crystal River 3. May improve circulation in southwestern arm of the lake 4. Dissolved solids lower than for Crystal River or well fields would mean less water required for cooling towers	1. Consumptive use of fresh water 2. Potential for fouling problems from Asiatic Clam, Corbicula.
Well Fields	1. No entrainment or impingement	1. Potential for saltwater intrusion not clear 2. Water availability not clear

Source: Environmental Science and Engineering, Inc., 1978.

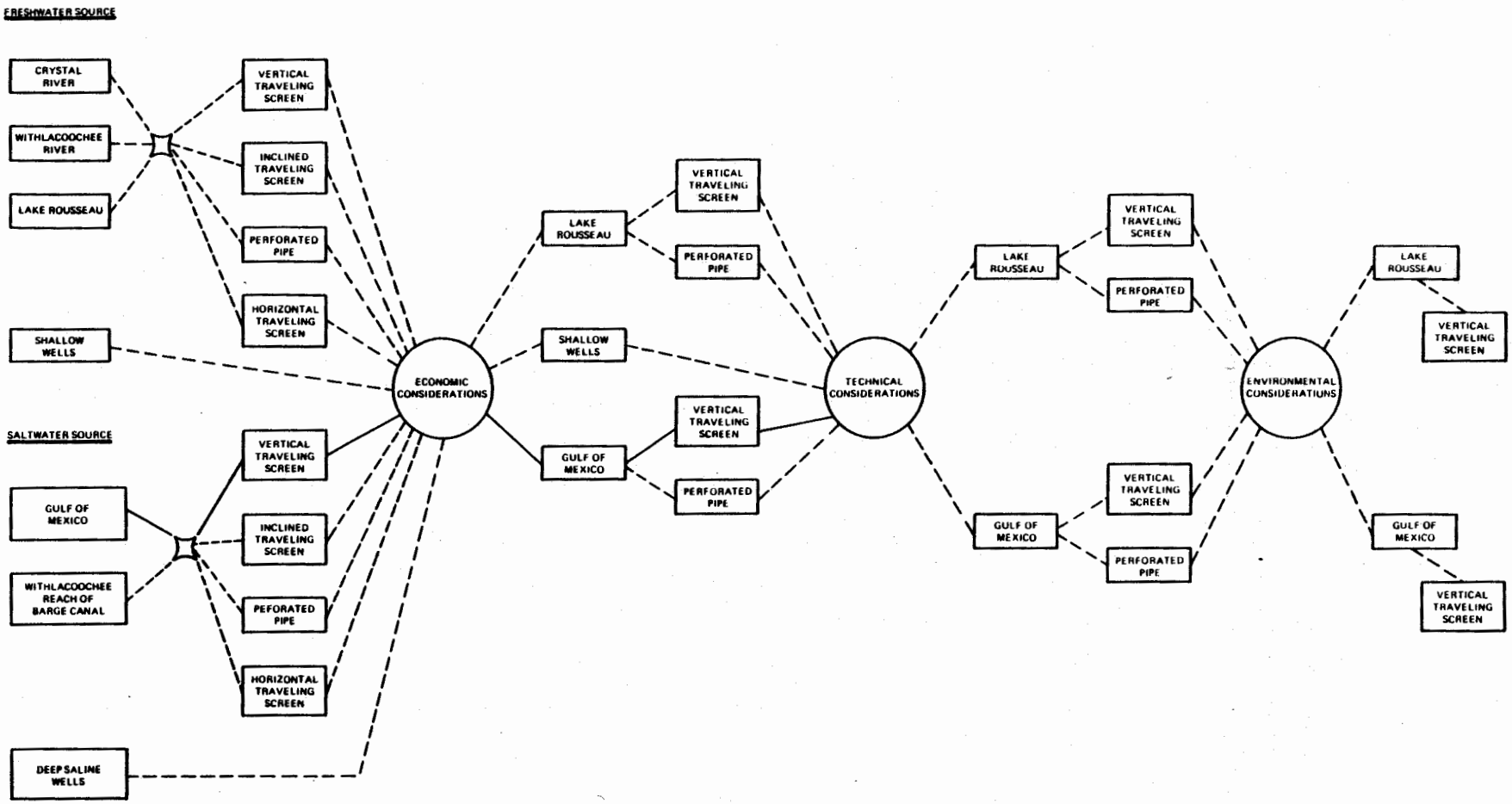

Figure 9.4-2

SUMMARY DIAGRAM OF WATER SOURCE AND INTAKE ALTERNATIVES

SOURCE: Environmental Science and Engineering, Inc., 1978

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

discharge of Units 1, 2, and 3, most planktonic organisms in the water have already been entrained. If this water were withdrawn, fewer new organisms would be entrained. In addition, existing currents in the canal could be used to sweep the intake screens and reduce impingement.

9.5 COOLING SYSTEM ALTERNATIVES

9.5.1 OBJECTIVES

The general objective of this section is to examine alternative systems for removing waste heat from steam-generating electrical power plants. It is not possible to use all the heat energy transferred from the fuel source to steam in the generation of electrical energy, and it becomes necessary to remove this excess heat energy from the plant site on a continuous and operational basis. Waste heat is rejected from a plant site via cooling water from which it can be dissipated through circulation and evaporation. Several different circulation and evaporation systems for dissipating waste heat are in operation at power plants throughout the country. The specific objective of this section is to provide a basis for comparison of cooling system alternatives for the proposed new units of the Crystal River site. The bases for comparison are technical, economic, and environmental criteria.

9.5.2 EVALUATION CRITERIA

The following criteria were used for evaluation of heat dissipation systems:

1. The heat rejection system should be able to reject waste heat from two coal-fired generating units of 600 to 660 Mw net capacity. At peak loading rates, heat rejection would be approximately 8.316×10^8 kilocalories ($3,300 \times 10^6$ Btu) per hour.
2. The heat rejection system should allow operation of the units at maximum design capacity for 99 percent of the observed summer ambient conditions.
3. The heat rejection system should comply with Federal and State regulations.

9.5.3 ALTERNATIVES CONSIDERED

Analysis of alternative cooling systems was conducted on the basis of technical, economic, and environmental considerations. General acceptance of the technology by the utility industry in the United States and Florida was also a consideration. Cooling systems considered were:

1. Once-through cooling;
2. Mechanical draft wet cooling towers;
3. Natural draft wet cooling towers;
4. Power spray modules; and
5. Dry and wet-dry cooling towers.

ONCE-THROUGH COOLING SYSTEMS

Once-through cooling was considered for the proposed facility because this method is used predominately by Florida utilities and is used presently by the existing units at the proposed site.

Once-through cooling systems circulate water from a source through the plant to remove waste heat and then discharge the heated water back to the source. The existing once-through system at the Crystal River site serves three existing power generating units with total combined capacities of 1,752 Mw (Kemp, 1977). Table 9.5-1 lists the Crystal River site among power plants in the United States utilizing cooling water canals. Other types of once-through cooling systems such as man-made ponds or lakes were considered.

Cooling ponds continuously circulate power plant cooling water through a large lake or pond. The proposed facilities would require a cooling pond of at least 98 hectares (1,300 acres). This estimate is derived from the requirement of approximately .4 hectares (1 acre) cooling pond area per megawatt. As a consequence, large areas of natural habitat could be destroyed. Florida Power Corporation does not control sufficient land area suitable for the pond.

Table 9.5-1 Some Major Coastal and Estuarine Power Plants in the United States Utilizing Cooling Water Canal Systems (from Kemp, 1977)

Name of Plant	Location	Cooling Water Flow m^3/min	Length of Canals, km	
			Intake	Discharge
Pilgrim[c]	Cape Cod Bay, Ma.	1,223	---	0.4
Brayton Point[c]	Naragansett Bay, Ma.	2,297	---	0.4
Millsonte[d]	Niantic Bay, Conn.	3,545	---	0.5
Conn. Yankee[e]	Conn. R., Conn.	1,505	---	1.9
Oyster Creek[c]	Barnegat Bay, N.J.	1,632	1.1(2.4)[a]	1.0(2.4)[a]
Indian River[c]	Indian R., Del.	570	0.2	3.0
Peach Bottom[f]	Susquehanna R., Pa.	5,690	---	1.4
Chalk Point[c]	Patuxet R., Md.	1,894	0.5	2.4
Morgantown[g]	Potomac R., Md.	4,250[b]	---	0.6
Douglas Pt.[g]	Potomac R., Md.	2,400[b]	0.3	---
Yorktown[h]	York R., Va.	2,700[b]	0.3	0.5
Surry[c]	James R., Va.	6,360	3.2	0.8
Chesterfield[i]	James R., Va.	2,776	---	0.5(6.0)[a]
Cape Fear[c]	Cape Fear, N.C.	1,017	---	---

Table 9.5-1 Some Major Coastal and Estuarine Power Plants in the United States Utilizing Cooling Water Canal Systems (from Kemp, 1977) (Continued, page 2 of 2)

Name of Plant	Location	Cooling Water Flow m^3/min	Length of Canals, km	
			Intake	Discharge
Brunswick[j]	Cape Fear, N.C.	6,800	5.2	9.7
Turkey Point[k]	Biscayne Bay, Fla.	2,176	0.5	6.6
Anclote[l]	Tarpon Springs, Fla.	2,720	1.0	1.2
Crystal River[m]	Crystal River, Fla.	2,414	5.0	2.0
Bartow[n]	St. Petersburg, Fla.	1,476	0.3	0.3
P.H. Robinson[c]	Galveston Bay, Tex.	4,226[b]	2.5	2.5
Cedar Bayou[o]	Galveston Bay, Tex.	2,550[b]	---	9.8

[a]Numbers in parentheses indicate tidal creeks which are serving as canals.
[b]Estimates based on megawatt rating and condenser temperature rise.
[c]Clark and Brownell (1973); [d]AEC (1973b); [e]AEC (1973a); [f]AEC (1972c); [g]W. Boynton (personal comm.); [h]White, et al. (1976); [i]Koss, et al. (1974); [j]AEC (1974); [k]Nugent (1970), prior to the construction of Unit 3; [l]Kemp (1976); [m]this study; [n]Blake, et al. (1976); [o]Gilmore, et al. (1975).

The Southwest Florida Water Management District (SWFWMD) has suggested that power plants examine once-through cooling with estuarine water coupled with a desalinization process. This option would allow power plants to produce fresh water rather than consume it (SWFWMD, 1977). Such an option would require further study before economic and technical implications could be evaluated. Table 9.5-2 presents data (Kemp, 1977) for existing desalinization plants throughout the world which provide some information regarding the energetics of present systems.

Once-through cooling alternatives for the proposed units would utilize the existing intake and discharge canals to the greatest extent possible. However, the existing canal cross sectional area must be modified to handle the greater flow volumes. Each new power unit will require 1,820 cubic meters (480,000 gallons) per minute. The main condenser system requires 1,740 cubic meters (460,000 gallons) per minute, and the auxiliary cooling system requires 76 cubic meters (20,000 gallons) per minute. Consequently, the existing flow of 5,220 cubic meters (1,380,000 gallons) per minute will be increased to 8,680 cubic meters (2,294,000 gallons) per minute. Deepening of the intake canal to 5.5 meters (18 feet) below mean low water and of the discharge canal to 4.6 meters (15 feet) below mean low water would be required. These modifications will maintain the existing hydraulic characteristics of Units 1, 2, and 3. Intake canal flow velocities would be increased from 0.40 to 0.49 meters (1.3 to 1.6 feet) per second on the ebb tide. Flood tide velocities would be higher. To reduce intake velocities would be costly. Velocities in the discharge canal would be 0.76 meters (2.5 feet) per second on the ebb tide.

The Units 4 and 5 will have a temperature rise of 8.1°C (14.5°F) at an intake ambient temperature of 30.6°C (87°F). This temperature rise is the same as the combined discharge of Units 1, 2, and 3. However, with Units 4 and 5 operating at maximum power, the volume of water and the amount of heat discharged would be increased by 70 percent. This larger

Table 9.5-2 Summary of Desalinization Data for Selected, Cost-Effective Plants (from Kemp, 1977)

Plant Location	Method[a]	Capacity m^3/day	Annual Cost Minus Direct Energy[b] $/$m^3$	Annual Cost Minus Direct Energy[b] kcal CE/m^3	Electric and Fuel Costs[c] kcal CE/m^3	Salinity, ppm[d] In	Salinity, ppm[d] Out	Free Energy[e] Delta G kcal/m^3	Ratio, Annual Cost/ Free Energy
Aruba[f]	ST	9,000	.56	13,300	12,260	35,000	5	5,374	4.8
Isreal[f]	VF	908	.43	9,630	9,410	41,500	500	3,142	6.1
Iran[f]	MFD	1,390	.51	9,080	11,170	35,000	25	4,395	4.6
Kuwait[f]	ST	4,500	.43	8,340	9,410	45,000	50	5,302	3.3
Kuwait[f]	MFD	9,000	.43	8,170	9,410	45,000	50	5,302	3.3
#44-49,20-24[g]	MFD	1,045	.29	4,960	6,350	35,000	50	3,971	2.8
Saudi Arabia[h]	MFD	38,000	.14	2,180	3,060	35,000	50	3,971	1.3
Israel[i]	MFD-DP	400,000	.13	2,080	2,850	35,000	50	3,971	1.2
Key West[j]	MFD	10,300	.22	5,680	4,820	35,000	50	3,971	2.6
Tijuana[k]	MFD-DP	28,400	.17	3,890	3,720	35,000	50	3,971	1.9
Cuba	MFD	4,740	.28	7,220	6,130	33,600	50	3,919	3.4
Virgin Is.[m]	MFD	8,500	.20	4,060	4,380	35,000	50	3,971	2.1
Mean			.32	6,549	6,914			4,271	3.1

Table 9.5-2 Summary of Desalinization Data for Selected, Cost-Effective Plants (from Kemp, 1977) (Continued, page 2 of 2)

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[a]Abbreviations for methods are: ST=submerged tube distillation; VF=vacuum freeze; MFD=multi-flash distillation; MFD-DP=multi-flash distillation combined with steam electric power plant in dual purpose unit.

[b]Annual costs are given in U.S. dollars of year reported (1959-1969), and energy costs are given in coal equivalents for the given year, estimated using kcal/$ ratios for particular country as reported by Darmstadter, et al. (1971) and Kylstra (1974).

[c]Electricity and fuel costs taken at 6 percent and 7 percent of total cost, respectively (United Nations, 1964). Coal equivalent energy per unit price taken from Zucchetto (1975a).

[d]Salinity values for most plants tabulated were reported in the literature. However, some are estimated based on knowledge that feedwater is ocean quality and on typical performance reported for particular method.

[e]Free energy of chemical potential is calculated from $=nRT \ln (C_1/C_2)M_s$, where n=moles salt, R=gas constant, T=absolute temperature, M_s=mass of removed, C_1=input salinity, C_2=output salinity.

[f]United Nations (1964) $G = (\frac{mole}{35\ g})(1.99\times10^{-3}\ kcal/deg\cdot mole)(305°)(10^6\ g/m^3)(\frac{C1}{1,000(C_1-C_2)})\ \ln(C_1/C_2)$

[g]Location of plants not given (United Nations, 1969). A composite energy/$ ratio is used assuming all are located in Caribbean and Near East.

[h]Siefert, et al. (1973).

[i]Clawson, et al. (1969).

[j]Wright (1969).

[k]Steinbruchel and Beagle (1968).

[l]Jebens and Dykstra (1965).

[m]Foster (1969).

Source: Kemp, 1977.

discharge will increase the possibility that heated water will be recirculated into the station condensers under certain environmental conditions. It was conservatively assumed that a .56°C (1°F) rise at the station inlet would occur on an annual average. The cost analysis demonstrated that it is not economically feasible to build a dike to prevent circulation. The annual fuel costs due to a delta .56°C (1°F) temperature at the station intake is $265,000. The annualized construction cost of a diversion dike to prevent recirculation is $2,176,000 (Black and Veatch, 1976).

The optimum system parameters for a once-through cooling system based on technical and economical considerations were determined as presented in Table 9.5-3.

Consideration of once-through cooling as an alternative required examination of three alternative intake and discharge canal layouts; one for each of the three possible plant locations discussed in Section 9.2.

The layout for Location 1 is shown in Figure 9.2-10 (Black and Veatch, 1976). An intake canal depth of 5.5 meters (18 feet) below mean low water is required to maintain a flow velocity of 0.5 meters (1.6 feet) per second. This flow will be accomplished after deepening the existing canal for deeper draft.

The existing discharge canal would have to be dredged an additional 1.5 meters (5 feet) to a depth of 4.6 meters (15 feet) below mean low water level. Dredging would start at the point of discharge of Units 4 and 5 circulating water and proceed westward approximately 1,280 meters (4,200 feet). In addition, a spur to the existing canal would be extended northeast approximately 381 meters (1,250 feet), terminating at the new plant. The discharge canal velocity would be 0.76 meters (2.5 feet) per second at ebb tide with all units in operation.

Table 9.5-3 Circulating Water System Parameter Values Used for Once-Through System Evaluation

Item	Parameter Value	
Flow Rate	1,741 m^3/minute	460 gpm
	2,506,000 m^3/day	662 mgd
Condenser Surface Area	28,000 m^2	300,000 sq. ft.
Peak Condenser Pressure	7.24 cm	2.85 in Hg, absolute
Condenser		
Tube length	12.2 meters	40 feet
Tube diameter	2.54 centimeters	1.0 inch
Tube material		90-10 copper-nickel
Tube gauge		18
Water velocity	2.44 meters/second	8.0 feet/second
Piping		
Material		Fiberglass reinforced plastic
Diameter	244 to 305 centimeters	96 to 120 inches
Number		2
Water velocity	2.44 to 3.05 meters/second	8 to 10 feet/second
Intake System		
Pump type		Vertical
Capacity, percentage each		25
Number		4
Screen type		Traveling

Source: Black & Veatch, 1976.

The intake structure would be located flush with the north bank of the existing intake canal. Units 4 and 5 would require 900 meters (3,000 feet) and 1,100 meters (3,600 feet), respectively, of 108-inch fiberglass reinforced pipe. Piping to each unit would be placed in a common trench at a depth of 0.9 to 1.5 meters (3 to 5 feet) below grade. Auxiliary cooling system heat exchangers would be supplied via the circulating water system. Estimated flow is 76 cubic meters (20,000 gallons) per minute. Auxiliary cooling water would be discharged into the main cooling system discharge canal.

The once-through cooling system for Location 2 (Figure 9.2-11) is identical in concept to the once-through system at existing Units 1, 2, and 3. Some features are unique to Location 2 and differ significantly from Location 1. The point at which the heated circulating water enters the discharge canal is about 240 meters (800 feet) east of Location 1. Therefore, an additional 240 meters (800 feet) of dredging for a total of 1,500 meters (5,000 feet) would be required. The intake canal will require dredging to 5.5 meters (18 feet) below mean low water. The circulating water piping to and from the unit condenser would consist of two 108-inch fiberglass reinforced plastic pipes. Each pipe would be approximately 70 meters (1,200 feet) in length.

The once-through cooling system for Location 3, shown in Figure 9.2-12, is identical in concept to the once-through system at Location 1. The point at which the heated circulating water enters is at the extreme east end of the existing discharge canal, which will necessitate dredging the entire discharge canal to 4.6 meters (15 feet) below mean low water level. The dredging would result in an increase in dredging of 980 meters (3,200 feet) as compared to dredging in Location 1. The total dredging required will be 2,300 meters (7,400 feet). The circulating water piping to and from the unit condensers would consist of two 108-inch fiberglass reinforced plastic pipes. Each pipe would be approximately 600 meters (2,000 feet) in length for Unit 1 and 850 meters (2,800 feet) in length for Unit 2.

NATURAL DRAFT COOLING TOWERS

Natural draft cooling towers use evaporative cooling. The air flow through a natural draft cooling tower is provided by the density difference between atmospheric air and the air inside the tower, which has been warmed by the hot water from the plant condensers. In order to maximize this buoyancy differential, natural draft cooling towers presently are designed to be hyperbolic in shape and to have high exhaust heights.

Natural draft cooling towers are gaining acceptance rapidly in the power industries in areas of high humidity, primarily because they offer an economic advantage over other alternatives which have substantial energy costs, such as mechanical draft cooling towers. At the present time there are no natural draft cooling towers in operation in Florida.

One natural draft cooling tower per unit would be used. The tower would be designed to dissipate 8.316×10^8 kilocalories (3.3×10^9 Btu) per hour with a range of 12°C (22°F), assuming 26°C (79°F) wet bulb and an approach of 8°C (15°F). Under these design conditions, the water which is supplied to the unit condensers would be 34°C (94°F). The cooling tower would be approximately 120 meters (400 feet) high and 100 meters (325 feet) in diameter at the base.

A wet, natural draft cooling tower incorporates direct contact between the cooling medium (air) and the circulating water. Heat is transferred primarily through evaporation of the circulating water. The draft through a natural-draft tower depends upon three parameters: (1) the density difference between the ambient air and the warm, moist air in the tower; (2) the pressure difference due to the chimney height; and (3) the induced draft due to the wind velocity. Two types of flow, crossflow and counterflow, are utilized in natural-draft towers. A

crossflow tower incorporates a horizontal air flow through the fill and the falling water, while the counterflow tower incorporates a vertical air flow through the fill. The saltwater system would be operated at between 2.0 and 1.3 cycles of concentration, while the freshwater system would be operated at about 6 cycles of concentration. Water treatment measures for the control of corrosion, scale, and biological fouling have not been specified at this time.

The major components of a natural draft cooling tower system include the turbine generator, the condenser, the natural draft cooling tower, sources of intake water, intake structure, circulatory water piping, and an auxiliary cooling system. The information presented is for one unit unless otherwise noted.

A study was performed to determine the optimum condenser size for a saltwater makeup system. The results, based upon current project economic criteria, determined that the optimum condenser is a two-pass arrangement with a surface area of approximately 120,000 square meters (400,000 square feet). With this alternative, the temperature rise would be 12°C (22°F) and the pressure would be 8.99 centimeters (3.54 inches) Hg absolute under peak loading conditions. A 90-10 copper-nickel tubing is expected to perform satisfactorily with salt water at approximately 50,000 ppm salt of concentration or fresh water. The circulatory water flow rate would be approximately 1.150 cubic meters (304,000 gallons) per minute.

The circulating water flow rate for the natural draft cooling tower heat dissipation system would be 1,150 cubic meters (304,000 gallons) per minute requiring one supply pipe and one return pipe, each consisting of a 108-inch fiberglass reinforced plastic pipe. Each pipe would be placed in a trench at a depth of 1 to 1.5 meters (3 to 5 feet) below grade.

The cooling tower makeup piping for salt water would be approximately 120 centimeters (48 inches) in diameter to transport 45 to 95 cubic meters (12,000 to 25,000 gallons) per minute from a new intake structure on the existing discharge canal to the cooling tower basin. The blowdown piping would be approximately 137 centimeters (54 inches) in diameter and would transport approximately 23 to 76 cubic meters (6,000 to 20,000 gallons) per minute from the tower basin to the discharge canal. The cooling tower piping system for fresh water would be similar to that for the saltwater alternative, but because freshwater needs are less, the piping could be somewhat smaller.

An auxiliary once-through cooling system or closed cycle system would be used for auxiliary equipment cooling. The once-through alternative, which would be used to supplement one saltwater cooling tower alternative, would use water from the existing intake canal and discharge into the cooling tower. For either a freshwater and saltwater tower, the auxiliary cooling water system could be a part of the closed-cycle cooling system. The estimated flow for auxiliary cooling would be approximately 76 cubic meters (20,000 gallons) per minute.

The natural draft cooling tower heat dissipation system would require approximately 5 to 12 cubic meters (12,000 to 25,000 gallons) per minute of saltwater makeup per unit to replace water lost in the system due to evaporation and blowdown. The freshwater towers would require approximately 50 cubic meters (13,700 gallons) per minute for makeup and auxiliary cooling for both units.

Conceptual studies were conducted in 1976 to assess alternative locations for expanding generation facilities at the Crystal River site using natural draft cooling towers. See Figures 9.2-3, 9.2-4, 9.2-5, and 9.2-6 for presentation of these layouts.

MECHANICAL DRAFT WET COOLING TOWERS

Mechanical draft wet cooling tower systems utilize evaporative cooling to provide the necessary condenser cooling for the steam generator. In these towers, fans provide the air flow for the interaction of the air and water. As far as cooling tower systems are concerned, mechanical draft towers have been the major method for providing closed-cycle cooling in the utility industry. In Florida, mechanical draft cooling tower systems have mainly been utilized on smaller facilities (30-150 Mw). At the present time, one mechanical draft cooling tower of approximately the same size as the proposed units is in operation in Florida. For Units 4 and 5, it is assumed that the condenser size, circulating water flow rate, and tower approach will be the same as the natural draft selection. The only difference would be the tower design and circulating water piping.

Two mechanical draft cooling towers per unit would be necessary. The towers would be designed to dissipate 8.316×10^8 kilocalories (3.3×10^9 Btu) per hour per unit with a range of 12°C (21°F), 26°C (79°F) wet bulb, and an approach of 8°C (15°F). Under the above conditions, the temperature of the water to the condensers would be 34°C (94°F). The saltwater tower would operate at between 2.0 and 1.3 cycles of concentration with a makeup rate to offset evaporation and blowdown of between 45 and 95 cubic meters (25,000 gallons) per minute respectively. A freshwater tower would operate with six cycles of concentration and 440 liters per second (6,900 gallons per minute) makeup per tower. Each tower would be approximately 68.6 meters (225 feet) in diameter and 18 meters (60 feet) high.

The mechanisms (evaporation and convection) whereby heat exchange takes place in a mechanical draft cooling tower are identical to a natural draft tower. The mechanical-draft cooling tower incorporates the use of fans to provide the flow through the cooling tower and to eliminate the need for the great height of the natural-draft towers. The air flow

rate is controlled to satisfy the cooling tower design requirements. Present mechanical-draft units are typically 15 to 30 meters (49 to 98 feet) high. Future towers will be built to greater heights. The mechanical systems available are forced-draft and induced-draft counter/crossflow types.

Multifan freshwater mechanical draft cooling towers have been used extensively throughout the United States for power plant heat dissipation systems. There are two primary types of mechanical draft tower arrangements; the in-line fan and the clustered fan arrangement.

The in-line fan arrangement is commonly referred to as a conventional cooling tower and has been used in numerous applications. However, the clustered fan arrangement offers distinct advantages over the conventional cooling tower. These advantages are as follows:

1. A consolidated plume which minimizes the effects of fog and drift. This could be important at Crystal River if the tower were to operate with saltwater and if drift is considered troublesome.
2. Improvement in site arrangement which results in reduction in circulating water piping lengths and system head losses.
3. A more predictable performance because the effects of recirculation are greatly reduced.

The clustered fan arrangement generally is about 20 to 30 percent higher in initial capital cost than in-line arrangement. However, savings in piping length (because the towers can be located closer to the central plant complex and closer together) make the total system cost about equal. Therefore, because of its inherent advantages for the Crystal River site, only the clustered fan arrangement will be considered in this analysis.

The basic components of mechanical draft cooling towers are similar to the previously discussed natural draft towers. Two exceptions are the tower framework and the fans.

The tower framework in a mechanical draft cooling tower consists of columns, diagonal braces, and a system of longitudinal and transverse ties. The fans, which provide air movement in mechanical towers, can be located at either the top or bottom of the tower. Fan diameter in large modern towers may be 26 meters (86 feet). The blades are made of resin-coated fiberglass or coated aluminum to provide a lightweight corrosion-resistant mechanism.

Layouts for mechanical draft cooling towers are presented in Figures 9.2-7, 9.2-8, and 9.2-9 for locations 1, 2, and 3.

DRY AND WET-DRY COOLING TOWERS

The dry systems are based upon indirect contact between the air and the hot water, and heat transfer takes place through convection and conduction. Dry (non-evaporative) cooling towers are installed to circumvent problems of vapor plumes associated with mechanical draft wet cooling towers or to avoid high water consumption associated with large natural draft hyperbolic cooling towers. However, the impairment of condenser pressure for summer ambient conditions results in year-round penalties in plant performance, which makes dry cooling systems economically difficult to justify (Klanian and Noyes, 1973). Dry type cooling tower systems not only are significantly higher than wet tower systems in capital costs, but their incremental generation cost is higher because of heat rate and replacement capability penalties associated with high condenser pressure.

Wet/dry tower systems make use of both direct and indirect contact between the air and the water, and the heat transfer takes place through evaporation, convection, and conduction. A wet/dry system can utilize a

combination wet/dry mechanical draft cooling tower, or it can employ a conventional wet tower and a separate, conventional dry tower. In systems employing separate wet and dry towers, the dry tower operates year-round and does its greatest work in winter, while the wet tower operates only during warmer periods.

Wet/dry cooling tower systems are designed to achieve one of the following objectives:

1. Diminish visible water-vapor plumes,
2. Obtain colder fluid temperature which approaches ambient wet bulb, or
3. Conserve makeup water, as compared to a 100 percent wet tower.

Wet/dry systems are generally more expensive than wet systems due to high capital and operating costs. Incremental generation costs for wet/dry systems are usually intermediate between lower-cost wet systems and higher-cost dry systems. No dry or wet/dry cooling systems are being used by electric utilities in Florida at this time.

POWER SPRAY MODULES

Heat dissipation by spray cooling is an alternative that may be used in cases where sufficient land is not available for cooling ponds, or where increased heat dissipation through existing ponds or canals is desired. The power spray module system considered for the proposed Crystal River site consisted of installing power spray modules in the discharge canal of the existing once-through cooling system. Increased cooling is achieved by positioning power spray modules (PSM) in the discharge canal to cool the water before it reaches the Gulf. Prior to reaching the point of discharge (POD), sufficient dilution water is added to reduce the discharge temperature in order to meet Florida effluent standards.

The PSM discussed in this section is manufactured by Ceramic Cooling Tower Company and is in operation at several installations including the

Commonwealth Edison Company Quad-Cities Nuclear Station. Thermal performance tests conducted during the summer of 1975 show the system to be operating at 100 percent performance.

Spray module systems similar to the PSM system are also in operation at various installations. However, for purposes of this study, the PSM is considered to be representative of the various systems presently being utilized.

It is not economically feasible to provide sufficient cooling with a PSM system alone to meet the State of Florida thermal effluent standards; i.e., 1.1°C (2.0°F) in the summer and 2.2°C (4.0°F) in the winter. It would require 7,300 meters (24,000 feet) of canal to accomplish this degree of cooling. The temperature of the discharge water can be reduced to within 3.3°C (6.0°F) of summer ambient with sprays, and dilution water can be added to accomplish another 1.1°C (2.0°F) of cooling. Thus the discharge temperature would be reduced to within 2.2°C (4.0°F) and 4.4°C (8.0°F) of ambient in the summer and winter, respectively. These temperatures exceed the State of Florida effluent standards; however, to achieve any further cooling would require substantial additional investment and operating costs which would make this arrangement so costly that it would not be feasible to consider.

To use power spray modules at Location 1 (see Section 9.2), the existing inlet canal would be required to accommodate a dilution flow rate of one million gpm. Therefore, it would be necessary to widen the existing intake canal approximately 23 meters (75 feet) in order to maintain a canal velocity of .49 meters (1.6 feet) per second based on 5.5 meters (18 feet) of depth. Another approach would be to construct a canal running parallel on the north side of the existing intake canal. This method would produce unpredictable dilution temperatures because of the potential of recirculating heated discharge water. Therefore, only

widening of the existing intake is given consideration for cost analysis.

The discharge canal would be required to accommodate the four pass PSM system and would have to be widened to at least 49 meters (160 feet) and extended 1,040 meters (3,400 feet) into the Gulf. In order to reduce the temperature of the effluent from the new units to within 2.2°C (4°F) and 4.4°C (8°F) of ambient in the summer and winter, respectively, 176 PSM units are required. If the modules are placed four abreast, a channel length of 2,150 meters (7,040 feet) will be utilized by the spray system [the entire discharge canal length plus an addition 1,040 meters (3,400 feet)]. Each module would have a 56-kilowatt (75-horsepower) electric motor for a total energy requirement of 9,840 kilowatts (13,200 horsepower).

A dilution canal, running north from the existing intake canal to the discharge canal and having dimensions of 38 meters (125 feet) wide, 3 meters (10 feet) deep, and 1,010 meters (3,300 feet) long would be required. The canal would supply dilution water to three dilution pumps which would be located on the south bank of the discharge canal. Each dilution pump would be rated at 1,260 cubic meters (334,000 gallons) per minute.

The PSM system at Location 1 would consist of a series of self-contained spray modules spanning the width and length of the channel. Each unit would be made up of a circulating pump and a group of four, deflector-type spray nozzles spaced 12 meters (40 feet) on centers. The entire unit would be supported by a series of floats and moored in place in the channel. Each module would operate independently and would require a 56-kilowatt (75-horsepower) motor drive. The modules are placed side-by-side in the channel. For Crystal River, the modules would be placed four abreast in the channel (four-pass).

For Location 2, the sprays would begin about 240 meters (800 feet) further east and the dilution canal will likewise be placed 240 meters (800 feet) to the east. All other features remain essentially unchanged.

At Location 3, it would be desirable to start the sprays as far east in the discharge canal as possible. However, in order to prevent the drift from reaching the substation, it would be necessary to begin the sprays 120 meters (400 feet) west of the substation. As a result, the spray system would start 670 meters (2,200 feet) farther east than was possible for location 1. Hence, a significant amount of dredging would be saved as compared to Location 1.

9.5.4 COMPARATIVE ANALYSIS OF ALTERNATIVE COOLING SYSTEMS

ECONOMIC CONSIDERATIONS

Cost comparisons were made for all alternatives considered. General incremental cost data (Figure 9.5-1) for wet towers, wet/dry towers, and dry towers indicated capital costs for dry and wet/dry towers to be significantly higher than those for wet towers. Because of these significant differences, wet/dry and dry towers costs were not pursued further. Site-specific costs were developed for all other alternatives considered.

Cost comparisons were developed for saltwater cooling at Alternative Site Locations 1, 2, and 3 in 1976 (Black and Veatch). In 1977, as conceptual planning for the facility progressed, freshwater and saltwater cost comparisons were developed for Location 1c (Black and Veatch). In this document other costs figures are also presented for comparison. These costs are from Kemp (1977) and U.S. EPA (1973).

Capital and annual cost summaries developed by design engineers in 1976 for four types of cooling alternatives are given in Tables 9.5-4 through 9.5-9 for Site Locations 1, 2, and 3 and in Tables 9.5-10 and 9.5-11 for Location 1c. These costs are per unit for each of the proposed Units 4 and 5. Maintenance costs are summarized in Table 9.5-12. Fuel costs for the natural draft and mechanical cooling towers are based on increases of unit heat rates by 5.3 kcal/kwh (21 Btu/kwh) and 7.6 kcal/kwh (30 Btu/kwh), respectively, over the saltwater systems.

The 1976 study showed similar costs for locations and alternatives. Rank according to capital and annual costs was the same for Locations 1, 2, and 3. The alternative of lowest cost was once-through cooling, while power spray modules were the most expensive. Saltwater towers were intermediate in costs. Maintenance costs were not included in these cost comparisons.

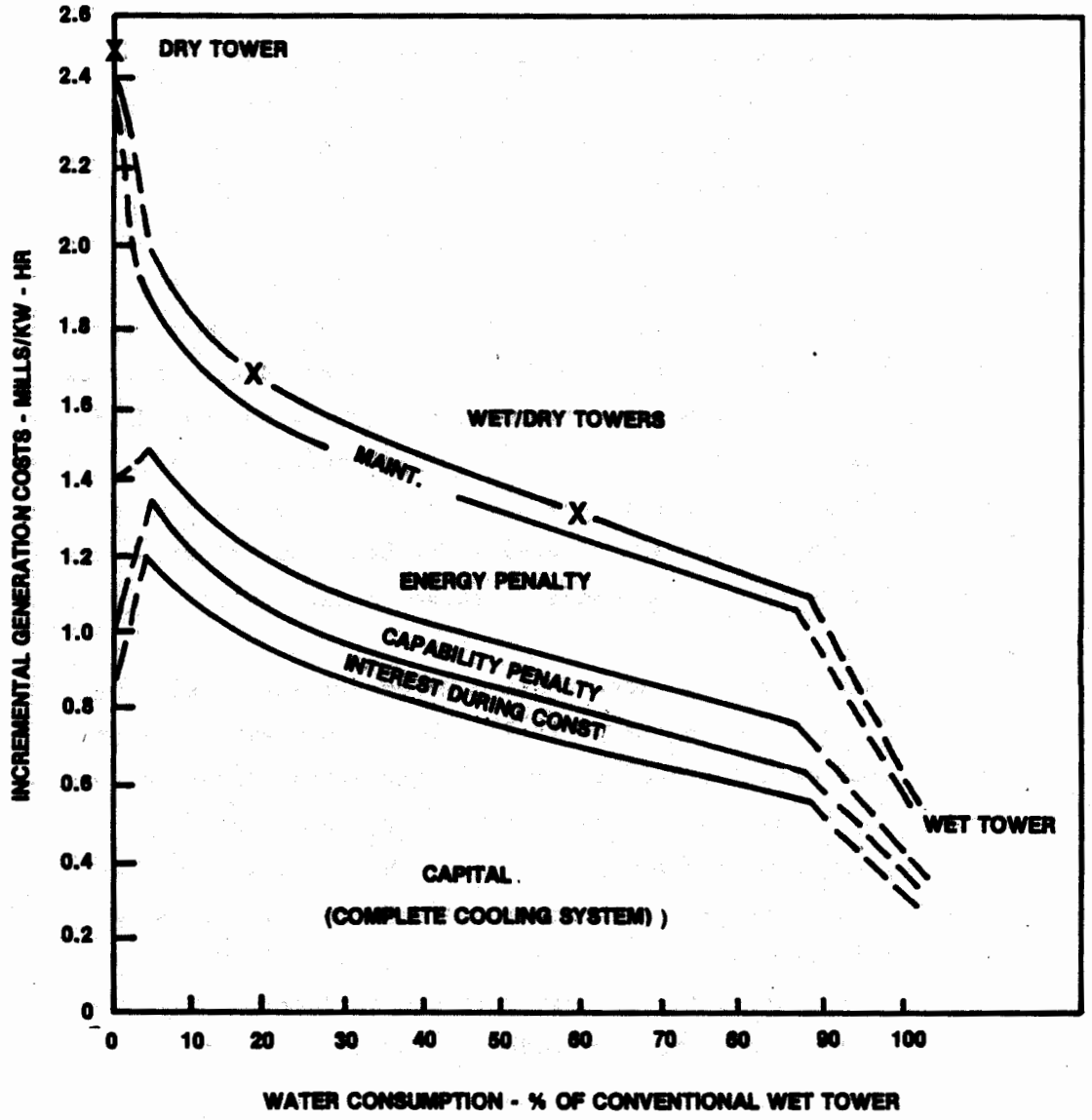

Figure 9.5-1

POWER INDUSTRY BASED ON INCREMENTAL COSTS OF VARIOUS TYPES OF COOLING TOWERS

SOURCE: Klanian and Noyes, 1973

FLORIDA POWER CORPORATION

PROPOSED CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

Capital and annual cost summaries developed by design engineers in 1977 for cooling alternatives at proposed site Location 1c are given in Tables 9.5-10 and 9.5-11. These tables present costs for both freshwater and saltwater cooling tower systems as well as data for once-through and spray/dilution saltwater systems. Costs presented are per unit for proposed Units 4 and 5. In both capital and annual costs at Location 1c, once-through cooling was lowest and power spray modules were highest. Cooling tower options were intermediate in costs. Natural draft towers were more expensive than mechanical draft towers in terms of capital costs, but the mechanical towers were more expensive in annual costs. Saltwater towers were cheaper than freshwater towers, whether mechanical or natural draft (for both capital and annual costs). Maintenance costs were included in these comparisons.

Cost estimates for saltwater cooling alternatives at existing Units 1, 2, and 3 were listed by Kemp (1977). These cost estimates presented in Table 9.5-13 were for back-fitting cooling alternatives to existing Units 1, 2, and 3 and used existing once-through cooling as base. Back-fitting costs are generally two to three times optimized costs for fitting cooling systems to new plants (U.S. EPA, 1973), so higher costs reflected in Kemp's values as compared to Black and Veatch's values for proposed units are probably primarily due to retrofitting. Operation and maintenance costs were included in these cost estimates.

It is not the absolute magnitudes of the costs which are of primary interest, however (since estimates are not in constant dollars), it is the order of comparison when ranked according to lowest cost. Table 9.5-14 compares capital cost data by Black and Veatch and Kemp with another set of data by U.S. EPA (1973). The EPA data is offered as a basis of comparison of capital cost data for proposed power plants with typical values for new plants.

Table 9.5-4 Capital Cost Summary*
Alternative Cooling Systems, Location 1 (Per Unit)

Item	Mechanical Draft Tower	Natural Draft Tower	Spray/ Dilution System	Once-Through Cooling
Condenser	$ 4,000	$ 4,000	$ 3,000	$ 3,000
Intake System	936	936	4,000	2,000
Piping System	1,416	1,151	2,173	2,173
Cooling Tower	5,319	7,000	—	--
Pumping System	1,220	1,220	1,564	1,164
Spray System	—	—	3,960	--
Canal Work	--	--	3,862	968
Total Direct Costs	12,891	14,307	18,559	9,305
Differential Costs	3,586	5,002	9,254	Base

*All values presented in thousands of dollars (1977).

Source: Black and Veatch, 1976.

Table 9.5-5 Capital Cost Summary*
Alternative Cooling Systems, Location 2 (Per Unit)

Item	Mechanical Draft Tower	Natural Draft Tower	Spray/ Dilution System	Once-Through Cooling
Condenser	$ 4,000	$ 4,000	$ 3,000	$ 3,000
Intake System	936	936	4,000	2,000
Piping System	1,201	1,006	504	504
Cooling Tower	5,319	7,000	—	—
Pumping System	1,220	1,220	1,564	1,164
Spray System	—	—	3,906	—
Canal Work	—	—	3,463	442
Total Direct Costs	12,676	14,162	16,437	7,110
Differential Costs	5,566	7,052	9,327	Base

*All values presented in thousands of dollars.

Source: Black and Veatch, 1976.

Table 9.5-6 Capital Cost Summary*
Alternative Cooling Systems, Location 3 (Per Unit)

Item	Mechanical Draft Tower	Natural Draft Tower	Spray/ Dilution System	Once-Through Cooling
Condenser	$ 4,000	$ 4,000	$ 3,000	$3,000
Intake System	936	936	4,000	2,000
Piping System	983	698	1,436	1,436
Cooling Tower	5,319	7,000	—	—
Pumping System	1,220	1,220	1,564	1,164
Spray System	—	—	3,960	—
Canal Work	—	—	3,888	1,076
Total Direct Costs	12,458	13,854	17,848	8,676
Differential Costs	3,782	5,178	9,172	Base

*All values presented in thousands of dollars.

Source: Black and Veatch, 1976.

Table 9.5-7 Annual Cost Summary*
Alternative Cooling Systems, Location 1 (Per Unit)

Item	Mechanical Draft Tower	Natural Draft Tower	Spray/ Dilution System	Once-Through Cooling
Fuel†	$ 470	$ 326	Base	Base
Energy**	1,939	1,405	2,142	718
Demand Charges	404	313	444	149
Fixed Charges††	3,616	4,013	5,206	2,610
Total Annual Cost	6,429	6,057	7,792	3,477
Differential Annual Costs	2,952	2,580	4,315	Base

*All values presented in thousands of dollars.
†Represents lost efficiency in steam cycle.
**Represents energy required to operate cooling system.
††Fixed charges are based on capital costs that are escalated to 1981 and include indirect costs. These costs are as follows:

Total Direct Costs (from Table 9.5-3)	12,891	14,307	18,559	9,305
Escalation and Indirect Costs	8,379	9,300	12,063	6,048
Total Capital Costs	21,270	23,607	30,622	15,353

Source: Black and Veatch, 1976.

Table 9.5-8 Annual Cost Summary*
Alternative Cooling Systems, Location 2 (Per Unit)

Item	Mechanical Draft Tower	Natural Draft Tower	Spray/ Dilution System	Once-Through Cooling
Fuel†	$ 470	$ 326	Base	Base
Energy**	1,939	1,405	2,142	718
Demand Charges	404	313	444	149
Fixed Charges††	3,556	3,972	4,626	1,994
Total Annual Cost	6,369	6,016	7,212	2,861
Differential Annual Costs	3,508	3,155	4,351	Base

*All values presented in thousands of dollars.
†Represents lost efficiency in steam cycle.
**Represents energy required to operate cooling system.
††Fixed charges are based on capital costs that are escalated to 1981 and include indirect costs. These costs are as follows:

Total Direct Costs (from Table 9.5-4)	12,676	14,162	16,437	7,110
Escalation and Indirect Costs	8,239	9,205	10,719	4,622
Total Capital Costs	20,915	23,367	27,156	11,732

Source: Black and Veatch, 1976.

Table 9.5-9 Annual Cost Summary*
Alternative Cooling Systems, Location 3 (Per Unit)

Item	Mechanical Draft Tower	Natural Draft Tower	Spray/ Dilution System	Once-Through Cooling
Fuel†	$ 470	$ 326	Base	Base
Energy**	1,939	1,510	2,142	718
Demand Charges	404	313	444	149
Fixed Charges††	3,495	3,886	5,006	2,434
Total Annual Cost	6,308	6,035	7,592	3,301
Differential Annual Costs	3,007	2,734	4,291	Base

*All values presented in thousands of dollars.
†Represents lost efficiency in steam cycle.
**Represents energy required to operate cooling system.
††Fixed charges are based on capital costs that are escalated to 1981 and include indirect costs. These costs are as follows:

Total Direct Costs (from Table 9.5-5)	12,458	13,854	17,848	8,676
Escalation and Indirect Costs	8,098	9,005	11,601	5,639
Total Capital Costs	20,556	22,859	29,449	14,315

Source: Black and Veatch, 1976.

Table 9.5-10 Capital Cost Summary*
Alternative Cooling Systems, Site 1C (Per Unit)

Item	Mechanical Draft Tower (Saltwater)	Mechanical Draft Tower (Freshwater)	Natural Draft Tower (Saltwater)	Natural Draft Tower (Freshwater)	Spray/ Dilution System	Once-Through Cooling
Condenser	$5,000	$4,500	$ 5,000	$ 4,500	$3,300	$ 3,300
Auxiliary Cooling	--	1,374	--	1,374	Base	Base
Intake System	1,030	--	1,030	--	3,116	1,558
Piping System	928	928	760	684	7,498	7,498
Cooling Tower	6,300	6,000	8,400	7,560	--	--
Pumping System	1,800	1,620	1,800	1,620	2,457	1,638
Spray System	--	--	--	--	4,350	--
Canal and Outfall	--	--	--	--	1,730	403
Well Field Pipeline	1,040	2,498	1,040	2,498	1,040	1,040
Comparative Direct Costs	16,098	16,920	18,030	18,236	23,491	15,437
Differential Costs	661	1,483	2,593	2,799	8,054	Base

*All values presented in thousands of dollars (1977).

Source: Black and Veatch, 1977.

Table 9.5-11 Annual Costs*
Alternative Cooling Systems, Site 1C (Per Unit)

Item	Mechanical Draft Tower (Saltwater)	Mechanical Draft Tower (Freshwater)	Natural Draft Tower (Saltwater)	Natural Draft Tower (Freshwater)	Spray/ Dilution System	Once-Through Cooling
Fuel†	$ 726	$ 726	$ 455	$ 455	Base	Base
Energy**	2,803	2,803	2,087	2,046	3,288	1,754
Demand Charge	1,302	1,302	1,141	1,121	835	417
Fixed Charges††	3,654	3,879	4,133	4,181	5,385	3,539
Operation and Maintenance Costs	240	271	226	254	642	308
Total Annual Cost	8,725	8,981	8,042	8,057	10,150	6,018

*All values presented in thousands of dollars (1977)
†Represents lost efficiency in steam cycle.
**Represents energy required to operate cooling system.
††Fixed charges are based on capital costs that are escalated to 1981 and include indirect cost. These costs are as follows:

Total Direct Cost	16,098	16,920	18,030	18,236	23,491	15,437
Escalation and Indirect Cost	10,263	10,786	11,494	11,625	14,976	9,841
Total Capital Cost	26,360	27,706	29,524	29,861	38,467	25,278

Source: Black and Veatch, 1977.

Table 9.5-12 Cooling System Maintenance Cost, Crystal River Unit 4 Preliminary Estimates*

	Mechanical Draft Cooling Tower Saltwater	Natural Draft Cooling Tower Saltwater	Pump Spray Modules and Dilation Pumps	Once Through Saltwater Cooling System
Chemical Injection Cost--Circulating Water †	--	--	--	--
Chlorination	23,200	23,200	46,500	46,500
Wellfield Maintenance	1,200	1,200	1,200	1,200
Towers--Fans, Motors	29,700	--	--	--
Towers--Interior Painting	4,700	28,000	--	--
Towers--Deterioration	19,000	26,000	--	--
Towers--Cleaning	13,900	13,900	--	--
Intake Structure	16,250	16,250	97,500	65,000
Traveling Screens	8,550	8,550	39,400	39,400
Seaweed and Grass	27,600	27,600	60,000	60,000
Circulating Pumps	15,600	15,600	54,600	31,200
Pump/Spray Modules	--	--	274,000	--
Substation Cleaning	67,500	52,600	47,800	47,800
Operator Inspections	12,600	12,600	21,000	16,800
Total Annual Maintenance	239,800	225,500	642,000	307,900

Table 9.5-12 Cooling System Maintenance Cost, Crystal River Unit 4 Preliminary Estimates (Continued, page 2 of 3)

	Natural Draft Cooling Tower Fresh Water Wellfield	Mechanical Draft Cooling Tower Fresh Water Wellfield	Natural Draft Cooling Tower Fresh Water Lake Rousseau	Mechanical Draft Cooling Tower Fresh Water Lake Rousseau
Chemical Injection Cost--Circulating Water †	146,000	146,000	--	--
Chlorination	4,900	4,900	7,300	7,300
Wellfield Maintenance	3,500	3,500	--	--
Towers--Fans, Motors	--	21,200	--	21,200
Towers--Interior Painting	--	--	--	--
Towers--Deterioration	18,600	14,300	18,600	14,300
Towers--Cleaning	9,100	9,100	10,300	10,300
Intake Structure	--	--	7,100	7,100
Traveling Screens	--	--	4,600	4,600
Seaweed and Grass	--	--	18,400	18,400
Circulating Pumps	11,600	11,600	11,600	11,600
Pump/Spray Modules	--	--	--	--
Substation Cleaning	47,800	47,800	47,800	47,800
Operator Inspections	12,600	12,600	37,800	37,800
Total Annual Maintenance	254,100	271,000	163,500	180,400

Table 9.5-12 Cooling System Maintenance Cost, Crystal River Unit 4
Preliminary Estimates (Continued, page 3 of 3)

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*This cost is necessary to allow a higher number of cycles of concentration for the wellfield alternative. A high number of cycles of concentration may also be used with water from Lake Rousseau without treatment because of its superior quality. All saltwater cooling tower alternatives have a lower number of cycles of concentration and use more makeup water.

The estimates presented show only predictable maintenance costs for work usually done during planned outages.

Source: Florida Power Corporation, 1978.

Table 9.5-13 Summary of Cost Estimates for Cooling Water Management Alternatives at Crystal River Power Plant*

Cost Item	Power Plant Units Covered	Closed Circuit Alternatives (10^6)				
		Multi-Cell Mech. Draft	Circular Mech. Draft	Natural Draft	Fan-Asstd. Nat. Draft	Modular Spray Units †
Capital Investment, Equipment and Installation**	#3	32.8	37.2	53.6	39.2	36.5
Present Worth 1978 U.S. Dollars	#3	59.0	64.1	76.3	64.7	53.5
Annual Costs Capital Amortization Operation and Maintenance	#3	9.2	10.1	12.4	10.2	8.7
Capital Investment, Equipment and Installation	#1, 2, 3	61.5	63.7	83.9	72.4	64.1
Present Worth, 1978 U.S. Dollars	#1, 2, 3	118.4	125.0	136.0	126.4	102.9
Annual Costs, Capital Amortization Operation and Maintenance	#1, 2, 3	17.9	18.9	21.2	19.4	16.1

*Table was adapted from Gilbert Associates (1974). Assumptions include: plant life = 30 yrs; load factor = 0.70 for Units 1-3, 0.75 for Unit 3; cost of capital = 11.25%; fixed charge rate = 17.3%; fuel = $0.020/kwh; capacity = $250/kw; 1% of yr hot enough to impose turbine penalty; once-through cooling system used as base cost.

Table 9.5-13 Summary of Cost Estimates for Cooling Water Management Alternatives at Crystal River Power Plant* (Continued, page 2 of 2)

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†Estimated on the basis of average cost ratios for Unit 3/Units 1-3 for other cooling alternatives.

**Tower design factors are: T (range), T (wet bulb), T (approach), °F = 15.1, 79, 12, respectively, except Nat. Draft and Spray Modules for which T (approach) = 14, 16, respectively.

Source: Kemp, 1977.

Table 9.5-14 Capital Cost Data Comparison

Cooling System	Black and Veatch, 1977, Proposed Crystal River Units 4 & 5, Per Unit Cost (10^3\$)/mw (1977 Dollars)	Rank	Kemp, 1977, Existing Crystal River Units 1, 2 & 3 Combined Cost (10^3\$)/mw (1974 Dollars)*	Rank	U.S. EPA, 1973, General for Nuclear Plant Cooling Systems Cost (10^3\$)/mw (1973 Dollars)	Rank
Once-Through Cooling	24.5	1	Base	1	3-5	1
Mechanical Draft Cooling Tower	25.5-26.9	2	35.1-36.4	2	8-11	3
Natural Draft Tower	28.6-28.9	3	41.3-47.9	4	9-13	4
Modular Spray Units	37.3	4	36.6	3	7-10	2

*These costs reflect costs of retrofit for existing units at Crystal River and would thus be higher than costs for new units.

Source: Environmental Science and Engineering, Inc., 1978.

TECHNICAL CONSIDERATIONS

All of the cooling systems considered are technically feasible. Technical considerations are reflected to a great extent in the economic rankings presented in the previous section. Once-through cooling is the system most widely used by Florida utilities. A ranking of cooling systems considered according to number in use throughout the United States most probably would reveal the following ranking:

1. Once-through cooling,
2. Mechanical draft cooling,
3. Natural draft cooling,
4. Dry and wet/dry cooling, and
5. Power spray modules.

Reliability of each of these systems is high enough to make all of them technically available for cooling consideration for the proposed units. Significant differences in operation and maintenance could emerge once a source of cooling water is selected. For example, few saltwater cooling towers are in operation at this time due to lower heat transfer, less evaporative heat loss, and higher corrosion properties of saltwater.

Comparison of Freshwater Versus Saltwater Cooling Systems

As previously discussed, the design and performance analyses of cooling systems are based upon thermodynamic principles and atmospheric conditions. The same major components are required for freshwater and saltwater systems. In the case of saltwater cooling systems, it is necessary to consider the incremental effects of salt concentration upon the design and performance characteristics. The major influences of salt water on the performance of cooling towers are:

1. A reduction in evaporative heat loss, since the vapor pressure of salt water is lower than that of fresh water;
2. Lower heat transfer in the condenser due to the lower specific heat, lower thermal conductivity, higher viscosity, and higher density of salt water than fresh water; and
3. Increased corrosion.

The design specifications for any saltwater system must be modified to maintain performance and counteract corrosion. There are several strategies for developing a satisfactory design for saltwater cooling towers. However, the net result is an incremental increase in the capital and operating costs of saltwater towers relative to those of freshwater towers. The specific problems that the design engineer must overcome in developing a saltwater cooling system are discussed in the following paragraphs.

Make-Up Water Requirements

A saltwater system would operate at a maximum of 1.3 to 2.0 cycles of concentration and would require between 45 and 95 cubic meters (12,000 and 25,000 gallons) per minute per unit saltwater makeup. A freshwater system operating under the same thermal load requirements would operate at much greater cycles of concentration and would require only 6,944 gallons per minute of make-up water per unit.

Blowdown Volume and Quality

The volume of blowdown water from a saltwater cooling tower will be three to four times as great as from a freshwater cooling tower. The salinity of saltwater blowdown would be approximately 50,000 milligrams per liter. Total dissolved solids in the blowdown of a freshwater tower would be an order of magnitude less.

Scale Treatment

Calcium, magnesium, and silica dissolved in cooling water are responsible for the formation of scale on heat transfer surfaces. The primary cause of scale formation is the decrease in solubility of the scale-forming salts ($CaCO_3$, $MgCO_3 \cdot 3H_2O$, $Mg(OH)_2$, and $CaSO_4$) with an increase in temperature. However, the solubility of these salts is increased by the presence of other ions in solution (the "salt effect").

Sulfuric acid treatment is a common practice to prevent scale formation in freshwater cooling systems. However, the "salt effect" in saltwater systems may make acid treatment unnecessary. The decision whether or not to use acid treatment must be made on an individual basis once operating characteristics are developed.

Corrosion Treatment

Corrosion treatment is very critical to the long-term operation of a cooling system. Freshwater cooling systems are generally protected with non-chromate inhibitors in a wide variety of proprietary formulations. The high chloride concentrations in saltwater systems accelerate corrosion and inhibit the formation of protective coatings by chemical inhibitors. Corrosion treatment for saltwater systems is much more complicated and expensive than for freshwater systems. The potential for discharge of concentrations of environmentally undesirable chemicals is also higher in a saltwater system.

Fouling Treatment

Fouling is the deposition of suspended material from the recirculating water. Fouling leads to reduced heat transfer, increased resistance to water flow, and severe localized corrosion. Sources of fouling are: (1) silt and other suspended materials in the makeup waters; (2) airborne particulate matter deposited into the tower via incoming air; (3) leakages and spills from the operating plant; (4) suspended materials resulting from deterioration of the cooling tower timber; and (5) biological growths. Biological fouling, the most serious fouling problem, will be discussed in a later subsection.

When estuarine water is used, the amount of suspended materials is often high. This high level of suspended materials causes increased fouling problems, especially in basins where the flow rate is low. Screening of entraining waters may not be sufficient to control fouling, and chemical

treatment may be necessary. Airborne particulate matter may include a variety of materials, depending upon the location, and industrial and agricultural activities in the vicinity of the tower. Since these particles cannot be controlled externally, chemical treatment of the water is necessary. If wood is used, fouling due to deterioration should be controlled by chemical treatment.

If ground waters are used for freshwater makeup, fouling should be minimal due to the expected low concentrations of suspended organic material. Studies are being initiated to determine the suspended solids characteristics of potential surface water sources.

Biological Fouling

Sunlight, increases in temperature, and concentrations of bacteria, food, and airborne contaminants in a cooling tower environment result in the growth of algae, fungi, and bacteria. Algae will primarily be limited to those areas of the cooling tower exposed to sunlight. Slime is composed of bacteria, fungi, yeast, and in some cases, protozoa. Slime is found in the darker areas since the slime constituents do not synthesize their own food (like algae), but get it from the cooling waters. Slime deposits can retard heat transfer and cause serious pitting on metal surfaces.

Seawater fouling organisms are generally larger than those in fresh water. Some of these organisms are seaweeds, sea-acorns, mussels, and other testaceans. These marine organisms can reach sizes big enough to cause blockage of pumps, cooling water channels, and pipes. Where, as here, the asiatic clam Corbicula is present, significant fouling can occur in freshwater systems as well.

A variety of organic compounds and inorganic chemicals such as chlorine and bromine are employed to control biological growth in the recirculating cooling water. These biocides are supposed to kill or inhibit the

growth of undesirable organisms. Many of these compounds kill bacteria at high concentrations and inhibit their growth in lower concentrations; however, in extremely diluted concentrations bacteria growth may be stimulated. Proper concentrations of chlorinated phenols, acrolins, and quaternary ammonium compounds are efficient biocides; however, chlorine is the most economical method of treatment and is thus the most widely used. Chlorine concentrations should be kept below 0.5 ppm to prevent cooling tower wood deterioration and adverse environmental effects on aquatic life at the discharge. If chlorination in low concentrations in unsuccessful in reducing or eliminating bacteriological fouling, a combination of chlorination and other biocide treatment may be employed.

Chlorination can be applied constantly in low concentrations or intermittently in higher concentrations (shock treatment). A continuous low degree of chlorination of 0.1 ppm is preferred to an intermittent supply of several ppm. Intermittent chlorination application may allow organisms such as mussels and barnacles to close themselves under adverse water conditions (high chlorination levels) and open up when conditions improve (chlorine concentration drops). Survival of these organisms may cause clogging problems.

Salinity in high concentrations has been proved to be toxic to many estuarine organisms. The high salinity in the basin may serve as a biocide to such organisms. Mussels and barnacles will probably close their shells, thus escaping injury. Some micro-organisms may tolerate salt concentrations, but for other organisms salt concentrations may be detrimental.

Turbine Generator--Condenser Design

Specific heat and thermal conductivity decrease with increasing salinity, whereas viscosity increases with salinity; thus condensers must be larger and circulating water flows greater in order to maintain a given heat removal rate when salt water rather than fresh water is used. The

cooling tower and pump capacity must be increased in size to accommodate the larger flow rates. Pump horsepower must be increased to circulate larger volumes of denser, more viscous salt water. Construction materials must be selected which are resistant to corrosive attack.

Cooling Tower Design

Vapor pressure of water decreases as salinity increases; therefore, saltwater cooling towers have a larger tower volume and/or an increased air flow rate than do freshwater towers of the same water flow rate and inlet and outlet temperatures. Air flow rate is generally increased to attain equivalent performance.

Natural draft towers in the United States have used fresh water almost exclusively. At present, there are two large saltwater natural draft towers in this country. These towers have accumulated about 5 unit-years of operation time. This operating experience is not sufficient to assess the nature and amount of corrosion which will occur over the life of the facility. As a result, nonpredictable maintenance problems could occur which may influence the reliability of the proposed facility.

ENVIRONMENTAL CONSIDERATIONS

Once-Through Cooling System Alternatives

The once-through cooling system proposed for Crystal River Units 4 and 5 would use the existing intake and discharge canals with some modifications. Dredging would be necessary to deepen the intake canal to 5.5 meters (18 feet) and the discharge canal to 4.6 meters (15 feet) and provide the volumes of water needed for once-through cooling design and to accommodate coal barges. Velocities in both the intake and discharge canal would be increased.

Studies associated with the existing three units of the proposed site have determined a number of impacts associated with once-through

cooling. Generally speaking, the major environmental effects of once-through cooling fall into three groups:

1. Impingement, or the impacts associated with the screens which strain larger organisms from the incoming water;
2. Entrainment, or the impacts associated with passage through the power plant of smaller organisms than those affected by impingement; and
3. Impacts associated with organisms which are exposed to the heated plume from the plant.

Other alterations in the environment include alterations brought about by changes in existing circulation patterns and biocide treatments. Recent studies indicate that potentially toxic bromates may be produced by a sunlight-induced reaction in chlorinated sea water (Macalady, et al., 1977).

Screenwash sampling was conducted at Crystal River by the Florida Department of Natural Resources in 1969. These data are summarized by Grimes (1971). During 1973-1974, researchers from Florida Universities conducted a number of studies aimed at assessing the effects of once-through cooling at Units 1 and 2. Nuclear Unit 3 was under construction at that time. More recently, studies of impingement at Units 1, 2, and 3 were conducted to meet the requirements of NRC Environmental Technical specifications (NUS, 1978). Further studies are also underway with regard to intake modifications since the studies of 1973-1974.

Mean daily impingement of finfish and invertebrates from the NUS 1978 study and from Snedaker's 1973-1974 study are presented in Tables 9.5-15 and 9.5-16. Also presented are comparable data from the Anclote Power Station near Tarpon Springs, Florida (Texas Instruments, 1977) and from Big Bend Power Station near Tampa, Florida (Conservation Consultants, 1977). Flow rates at Anclote and at Big Bend are much lower than those of Units 1, 2, and 3 at Crystal River. Impingement is therefore considerably high at the Crystal River site.

Table 9.5-15 Mean 24-Hour Impingement Rates of Finfish at CRPS Units 1, 2, and 3 (1977-1978), CRPS Unit 2 (1972-1973), Anclote Power Station (1976), and TECO-Big Bend Power Station (1976-1977). (Biomass data in kg)

Month	Crystal River Units 1, 2, 3 1977-1978 (1,318,000 gpm)		Unit 2 1972-1973* (328,000 gpm)		Anclote 1976† (723,000 gpm)		TECO-Big Bend 1976-1977** (723,000 gpm)	
	Number	Biomass	Number	Biomass	Number	Biomass	Number	Biomass
January	29,662	291.4	472	24.3	113	5.3		
February	20,187	96.0	1,728	50.6	111	5.8	52 (1976)	--
March	2,966	82.1	932	28.1	85	1.2	787 (1977)	--
April	2,734	32.2	333	11.9	80	1.9		
May	737	8.8	190,571	824.6	145	1.6	191	--
June	684	43.6	438	12.6	745	8.0		
July	1,071	36.2	2,384	12.6	118	2.5		
August	891	21.5	92	5.4	89	1.6	417	--
September	387	11.5	92	2.6	17	0.6		
October	568	15.3	298	5.8	72	2.6		
November	2,544	41.2	282	15.8	218	12.6	265	--
December	25,286	218.5	666	36.4	304	13.0		
MEAN	7,310	74.9	16,524	85.9	175	4.7	323	--

*Calculated from Snedaker (1974).
†Calculated from Texas Instruments (1977), Figures VII-4 and VII-5.
**From Conservation Consultants (1977), Table 7.2.

Source: NUS, 1978.

Table 9.5-16 Mean 24-Hour Impingement Rates of Invertebrates at CRPS Units 1, 2, and 3 (1977-1978), CRPS Unit 2 (1972-1973), Anclote Power Station (1976), and TECO-Big Bend Power Station (1976-1977). (Biomass data in kg)

Month	Crystal River Units 1, 2, 3 1977-1978 (1,318,000 gpm)		Unit 2 1972-1973* (328,000 gpm)		Anclote 1976† (723,000 gpm)		TECO-Big Bend 1976-1977** (723,000 gpm)	
	Number	Biomass	Number	Biomass	Number	Biomass	Number	Biomass
January	5,179	31.3	298	2.0	143	0.2		
February	2,961	13.2	220	2.0	168	0.4	409 (1976)	--
March	2,771	24.2	131	1.0	490	2.3	408 (1977)	--
April	1,015	32.2	180	18.8	489	29.0		
May	345	26.7	89	7.0	350	14.2	152	--
June	567	6.2	316	3.2	1,525	7.4		
July	2,943	16.8	789	2.6	336	5.5		
August	2,749	17.4	59	0.4	636	3.8	422	--
September	1,557	39.3	84	0.6	145	8.9		
October	651	13.2	699	1.1	131	29.8		
November	1,852	28.5	84	0.5	139	29.8	185	--
December	1,047	21.6	508	2.4	150	6.6		
MEAN	1,970	22.6	288	3.5	392	11.5	292	--

*Calculated from Snedaker (1974).
†Calculated from Texas Instruments (1977), Figures VII-4 and VII-5.
**From Conservation Consultants (1977), Table 7.2.

Source: NUS, 1978.

Grimes' 1969 collections (summarized in 1971) contained 59 species of finfish and 15 species of macroinvertebrates. Both number of species and numbers of individuals were low in summer and high in March and in fall. Snedaker's collections in 1972, 1973, and 1974 included 152 species of fish and 34 species of invertebrates with 10 species contributing over 95 percent of the total impinged biomass. Most common species were the polka-dot batfish, and striped burrfish, and blue crab, and squid (Snedaker, 1974). Slightly less than 8 percent of the impinged biomass was composed of species of economic importance. The NUS study was conducted in 1977 and 1978, at which time 106 species of finfish and 45 species of invertebrates were collected. Eleven species of finfish accounted for 94 percent of the total number of fish individuals captured. Table 9-5.17 presents ranking (highest to lowest) of species of biomass collected during the two impingement studies conducted at Crystal River. NUS estimated that impingement at all three existing units amounted to about 0.5 percent of the number of blue crabs taken commercially in the Citrus-Pasco County area in 1976. Impingement of pink shrimp was estimated to be about 1 percent of the number caught commercially in the Citrus-Pasco County area.

If once-through cooling is employed for Units 4 and 5, total numbers and weights of impinged organisms would undoubtedly increase since both flow rate and water volume used by the power complex would increase under present designs. Increased flow rate may increase the incidence of impingement for some organisms which currently may be able to avoid the screens. Increased volumes may be expected to increase the total number of species impinged.

Maturo, et al. (1974) estimated that between 900 and 2,300 kilograms (2,000 and 5,100 pounds) per day of biomass were entrained by Units 1 and 2, and that about twice these figures would be entrained by Units 1, 2, and 3 operating together. Assuming that Units 4 and 5 might entrain about as much as Units 1 and 2, the total entrainment for all five units using once-through cooling might be as high as 2,700 to 6,950 kilograms (6,000 to 15,300 pounds) per day. Mortality of entrained individuals

Table 9.5-17 Ranking (Highest to Lowest) of Species by Biomass Impinged at CRPS (1977-1978, 1972-1973) and at Anclote Power Station (1976)

Crystal River (1977-1978)	Crystal River (1972-1973)	Anclote (1976)
Scaled sardine	Atlantic threadfin	Horseshoe crab
Polka-dot batfish	Polka-dot batfish	Blue crab
Blue crab	Striped burrfish	Striped burrfish
Pink shrimp	Blue crab	Pink shrimp
Sea catfish	Scrawled cowfish	Atlantic stingray
Silver perch	Tunicates	Spotted eagle ray
Pinfish	Pinfish	Scrawled cowfish
Atlantic thread herring	Squid	Southern puffer
Scrawled cowfish	Silver perch	Spot
Bay anchovy	Pink shrimp	Spider crab

Source: NUS, 1978.

varies with species, age, sex, and other factors (Alden, 1976). A study of juvenile fish entrained by Units 1 and 2 (Florida Power Corporation, N.D.) provided an estimate that 2.4×10^8 individuals could be entrained in the worst case. Juvenile fish entrained by five units would be about three times this number. The biomass of the individuals killed or injured by the plant is not lost to the estuarine consumers. The consumer species may change to those more likely to receive sinking, non-moving prey (Alden, 1976). Maturo, et al. (1974) found in statistical analyses of zooplankton populations that increased flow rates were associated with negative effects on planktonic juveniles of fish and macroinvertebrates. Re-entrainment of discharge water, as predicted by Black and Veatch (1976), would multiply entrainment mortalities since weakened organisms may pass through more than once. Re-entrainment would also increase the temperature of the thermal plume. Generally, estuarine organisms are well-equipped by evolutionary processes to withstand thermal stress; however, the effects of higher temperatures are related in a complex manner to the length of exposure time, seasonality, and other environmental factors. While an organism may be tolerant to one temperature if not subjected for a long period of time, it may be killed if exposed for a longer period.

The extent of the thermal plume for Units 1 and 2 has been studied by Palmer and Carder (1975). Others have studied the effects of the plume upon organisms. Van Tine (1974) found that the biomass of algae and seagrasses was higher in the intake estuary than in the discharge estuary during most of the year. On an annual basis, the standing crop was about 43 percent higher on the intake side. Evink and Green (1974) reported the results of benthic sampling in the intake and discharge estuaries by means of 297 dropnet collections. The mean yearly invertebrate biomass for the discharge and intake was 2.46 g/m^2 and 9.62 g/m^2, respectively. Fish biomass was 6.1 g/m^2 in the intake and 5.16 g/m^2 in the discharge. These studies were conducted with Units 1 and 2 in operation. A larger plume resulting from all five units with once-through cooling would increase this area of impact.

Dredging operations required by the design for once-through cooling proposed by Black and Veatch (1976) would also have adverse environmental effects. Communities of bottom-dwelling organisms would be covered by spoil disposal. Despite efforts toward containment as a result of dredging, increased waterborne sediments would be dispersed to settle on other communities.

While specific studies of impingement, entrainment, and plume extent identified the community effects of once-through cooling, Odum, et al. (1975) examined the estuary at Crystal River from a systems standpoint. Energy cost-benefit analyses by this group indicated that when all energies contributed by man and nature are considered, energy flow associated with once-through cooling is about 1 percent of those required for cooling towers. Units 1, 2, and 3 were considered in that group of studies (see also Kemp, 1977).

Odum's conclusions were based on the fact that resources must be mined and processed elsewhere to produce cooling towers. These activities consume energy and produce various types of pollution elsewhere. When the entire process is considered, the total pollution produced versus the benefits derived were thought to be less beneficial to the entire system when the cooling towers are used.

The impacts of once-through cooling do not appear to be easily reduced since these impacts are connected with the large volume of flow required. The Gulf of Mexico is the only body of water in the site vicinity large enough to be used either as a source or a receiving body. Taking water from the Withlacoochee Reach of the Cross Florida Barge Canal has been suggested. Without detailed studies, it is not clear by what degree impingement and entrainment could be reduced under this plan. The destiny of the water body is uncertain as a part of the decision regarding disposition of the Barge Canal. It is not known whether the modifications thus far suggested will even be implemented in the Withlacoochee Reach or if they would be completed in time to meet the needs of the applicant.

Systems which somehow divert organisms away from the screens by noise, bubblers, etc., have not proven very effective (EPA, 1976). Sloped or horizontal screens with some bypass system to reduce impingement could be used. It does not seem economically feasible to reduce intake velocities to the recommended 15 centimeters per second (0.5 feet per second) for the volume of water required.

With the present system proposed by Black and Veatch (1976), the five units in operation on the same intake canal may increase total impingement by a factor greater than the proportion of increased flow. Fish and macroinvertebrates tired or injured by the intakes at Units 4 and 5 could be more easily impinged by the other three units.

A number of suggestions have been advanced to alter the present configuration of the canals. These all revolve around drawing water further offshore or discharging water further from shore. These measures will not necessarily lessen impacts since other populations would be affected. These populations would require study before any conclusions about relative impacts could be reached. Many estuarine organisms found inshore are more tolerant to thermal stress than closely-related offshore species. Furthermore, inshore systems have already adjusted to the stress, and changing the placement of the plume would require a new adjustment process.

Considering all factors, once-through cooling for Crystal River Units 4 and 5 would not appear to be the best available technology. It is highly unlikely that Units 4 and 5 would be licensed without extensive environmental studies. The status of Units 1, 2, and 3 is still undetermined. The Southwest Florida Water Management District has suggested that the once-through cooling system for power plants could be combined with a desalinization process (SWFWMD, 1977). This would allow power plants to produce rather than consume fresh water.

Cooling Towers

In general the effects of cooling towers on the environment include the following factors:

1. Fogging;
2. Icing caused by cold weather fogging;
3. Deposition of chemically-laden drift particles, especially when saltwater makeup water is used;
4. Consumptive use of water;
5. Climate modification due to the atmospheric discharge of heat and water vapor;
6. Effects on receiving water as a result of blowdown discharge;
7. Acid rainout due to mingling of cooling towers and stack gas plumes; and
8. Noise.

These factors are those summarized by EPA researchers (Shirazi, et al., 1977).

Factor 6 will be discussed in a later section which deals with the discharge of cooling water for the proposed site. Factor 2 is not a realistic concern for the climate of the Crystal River area. Factor 4 is discussed in Section 9.4.

Fogging problems were found to be related to climatic conditions which are conducive to natural fog formation. Shirazi, et al. (1977) reported the work of EG&G, Inc., 1971, which related the potential for fogging and climate modifications in the United States.

The proposed site is in an area which has a low potenital for fogging and climatic modifications based on a number of meteorological criteria. This conclusion is based on typical cooling tower designs and is general in nature, but does assign a low probability of such problems to the area of Florida near the proposed site.

Acid rainout (Factor 7) is not considered to be likely at the proposed site if cooling towers are used. The plant stacks are planned to be much higher than the air exits for either mechanical or natural draft towers. Since low sulfur coals are planned as fuel and scrubbers will probably not be used, the gases leaving the stacks will be about 150°C (270°F). The spatial differences in discharge points, temperature and velocity differences, and the meteorology of the site suggest that acid rains are not likely. This aspect is discussed in more detail in Chapter 5.

Noise from cooling towers can be a problem in some areas. Several methods for the estimation of sound emissions can be found in Teplitzky (1977). Since the nearest residences are more than 3.2 kilometers (2 miles) from the proposed site, it does not appear likely that noise will be an important impact for either natural or mechanical draft towers (see Section 2.2.3 for nearby residences).

Salt or brackish water from the Gulf of Mexico or Crystal River would bring forth some concerns connected with deposition of salt on the surrounding area (Factor 3).

Salt Drift

A drift deposition estimate was performed for various cooling tower alternatives using the procedure developed by C.L. Hosler, Pennsylvania State University. The analysis considered site meteorological data including wind speed and direction. Drift rate values for saltwater cooling towers with new drift eliminator designs are estimated to be within the range of 0.002 to 0.005 percent of the total circulating water.

It was assumed that the towers would be equipped with high efficiency drift eliminators which would reduce the drift rate to 0.0005 percent of the circulating water flow rate. This level of drift is lower than that used in previous Crystal River studies by a factor of 10. Drift

measurements at the Atlantic City Electric B.L. England Station have verified this assumption.

Drift analysis results for the three proposed plant site locations are plotted as isopleths on Figures 9.5-2, 9.5-3, and 9.5-4. Drift analysis results are not available for Location Variation 1c, however, the results may be similar to Location 1 with the pattern shifted to the east. Isopleths of 67 kilograms per hectare (60 pounds per acre) per year and 7 kilograms per hectare (6 pounds per acre) per year are shown. A value of 30 is equivalent to the natural background level. This means that the area at the 67 kilogram per hectare (60 pound per acre) per year isopleth will receive a deposition rate of 67 kilograms per hectare (60 pounds per acre) per year above ambient for a total deposition of 100 kilograms per hectare (90 pounds per acre) per year. At the substation, the deposition rate will be increased by about 7 kilograms per hectare (6 pounds per acre) per year for site alternatives 1 and 3, which is small in comparison to ambient levels. Although stations on the Atlantic Coast are experiencing background levels of 67 kilograms per hectare (60 pounds per acre) per year on the substation with no apparent operational problems (Black and Veatch, 1977), it has been stated that additional salt drift levels of 30 pounds per acre above ambient background would cause operational problems at this facility (Black and Veatch, 1980).

It is expected that a natural draft saltwater cooling operation at Crystal River will present only minor substation operational difficulties and that location of towers as shown for location 3 could affect other existing facilities.

Natural Versus Mechanical Draft Towers

The differences between natural and mechanical draft cooling towers with regard to environmental impact primarily involve the factors of noise, salt drift, and power consumption.

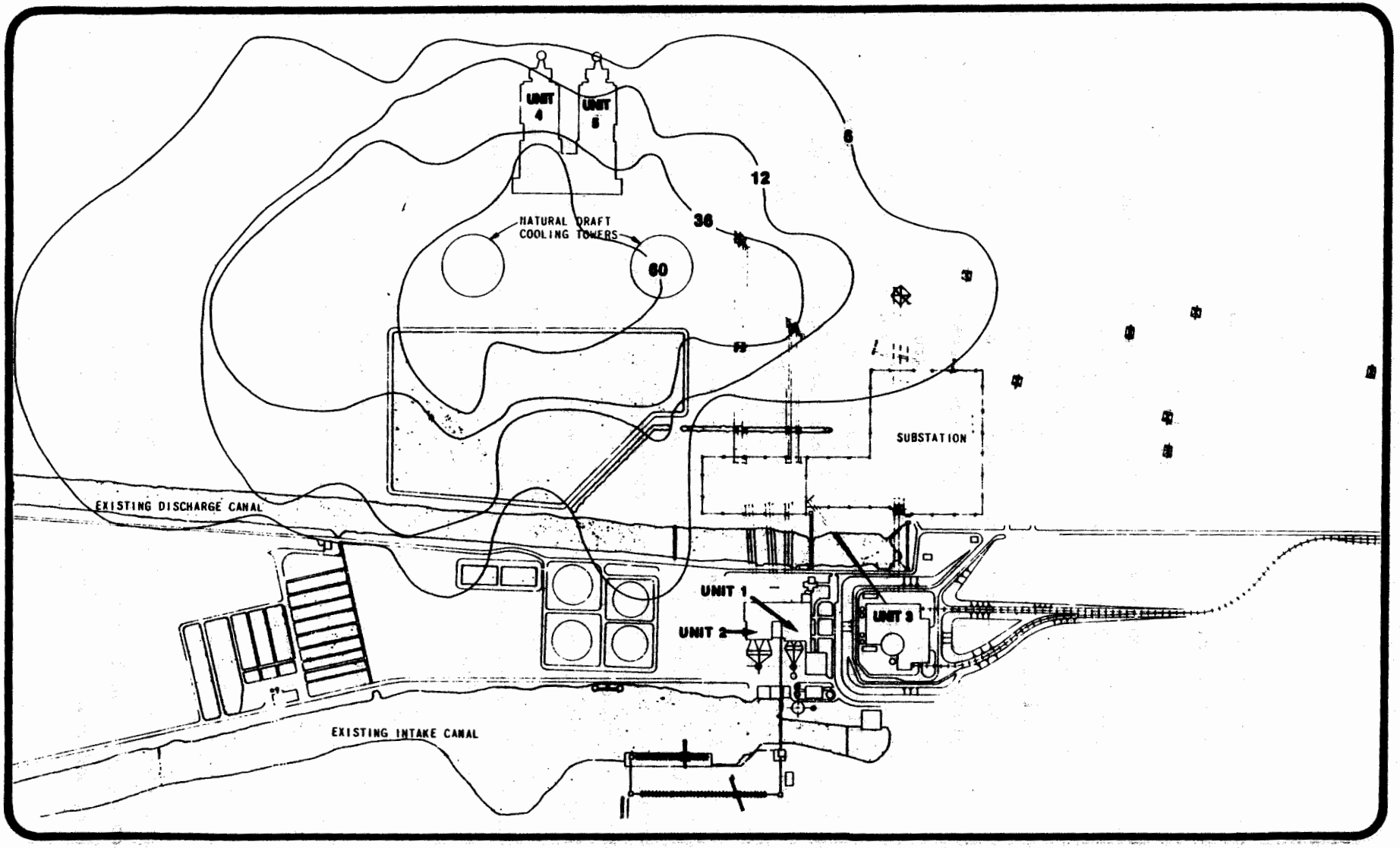

Figure 9.5-2

SALT DEPOSITION RATES - NATURAL DRAFT COOLING TOWERS, LOCATION 1
POUNDS/ACRE/YEAR

SOURCE: Black and Veatch, 1978

N

0 200 400 800
SCALE IN FEET

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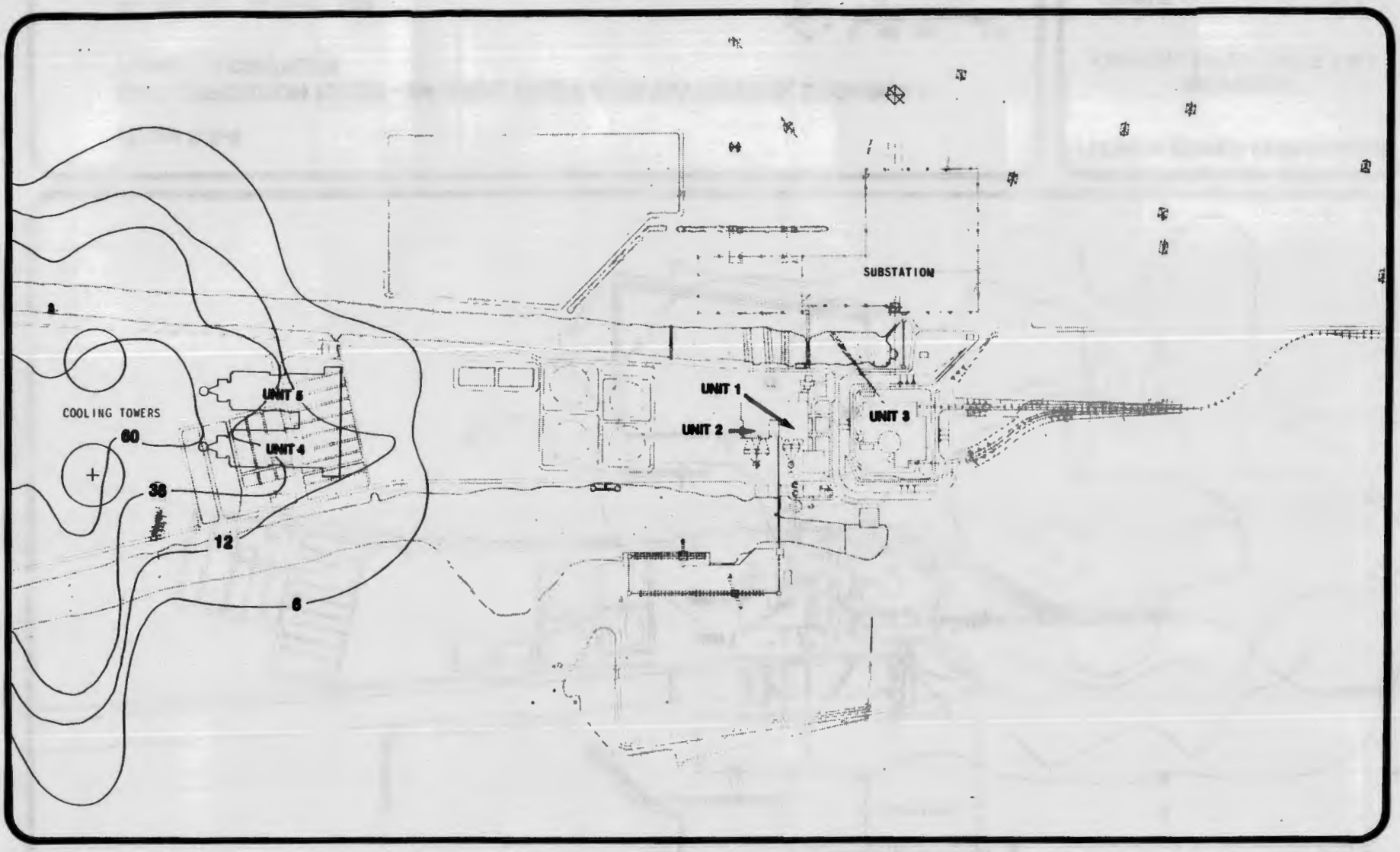

Figure 9.5-3

SALT DEPOSITION RATES - NATURAL DRAFT COOLING TOWERS, LOCATION 2 POUNDS/ACRE/YEAR

SOURCE: Black and Veatch, 1978

N

0 200 400 800

SCALE IN FEET

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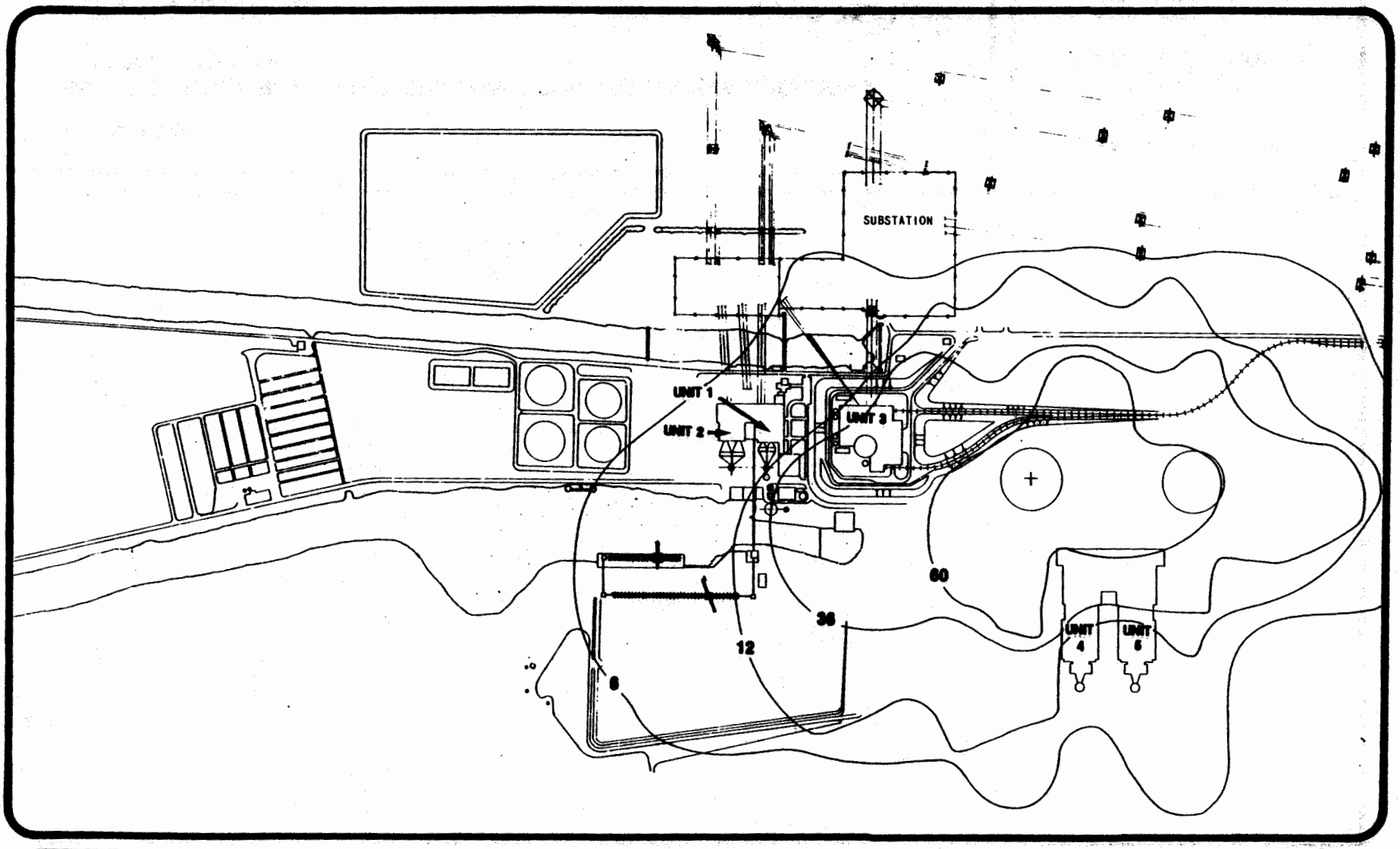

Figure 9.5-4

SALT DEPOSITION RATES - NATURAL DRAFT COOLING TOWERS, LOCATION 3 POUNDS/ACRE/YEAR

SOURCE: Black and Veatch, 1978

N

0 200 400 800
SCALE IN FEET

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Noise from a mechanical draft tower should be greater than from a natural draft since fan sounds would be present in the mechanical draft tower. Even so, for the proposed secluded site it does not seem likely that noise would be of critical concern. Future development around the site during the plant's time of operation could change this (see other sections of this document). This noise is not thought to have adverse effects on wildlife (Edmonds, et al., 1975), because the noise is steady and is related to sounds of falling water.

Salt drift for mechanical draft towers in operation has not been studied in depth. EPA's test facility at Turkey Point studies the mechanical draft type (Shirazi, et al., 1977; Henderson and Dowdell, 1975). Salt deposition was not found to be significant with this experimental tower (Hindawi, et al., 1976). Black and Veatch (1976) estimates indicate that salt drift quantities may be higher for the mechanical draft tower than for the natural draft tower. As is the case with the natural draft cooling tower, use of fresh makeup water would eliminate concerns with salt drift.

Greater power consumption associated with mechanical draft towers would have an environmental impact. If more power is used in the cooling process, this power is lost to human use while contributing to air and water impacts.

Power Spray Modules

This cooling system would require additional dredging to accommodate a dilution flow rate of 63,100 liters per second (1 million gpm) (Black and Veatch, 1977). Both the existing intake and discharge canals would require widening under the design outlined by Black and Veatch. Dredging would result in the destruction of some terrestrial habitat, and the resulting turbidity changes and siltation in the open Gulf would have adverse impacts on estuarine organisms already under thermal stress from Units 1, 2, and 3. Salt drift from the PSM system would result in effects similar to either natural or mechanical draft cooling towers.

Concentrations of the drift would occur near the discharge canal and would be low. With the amounts of water necessary, it is not feasible to use fresh water in a PSM system to mitigate any salt drift problems.

9.5.5 SUMMARY

Because different types of cooling systems impact different components of the environment, it is often difficult to compare the environmental costs of the proposed systems. Systems ecologists working at Crystal River attempted to make such a comparison on the basis of total productivity lost.

Table 9.5-18 is an estimate of the total productivity lost as a result of thermal discharges from existing Units 1 and 2 once-through cooling; 803×10^3 kilocalories (coal equivalent calories)/ year per Mw of electricity generated (Kemp, 1977).

Data from Table 9.5-18 can be compared with the once-through impact data. Table 9.5-19 is an estimate of productivity loss due to effects of salt spray deposition as a result of cooling towers for existing Units 1, 2, and 3. Total loss due to salt deposition is $3,270 \times 10^6$ kilocalories (coal equivalent calories)/year. This is a loss of 1.866×10^6 kilocalories/year per Mw. Based on these data, Kemp (1977) concluded that environmental impacts in terms of loss of ecosystem primary production are twice that for cooling towers than for once-through cooling. It is recognized that this data cannot be directly extrapolated for proposed Units 4 and 5 due to possible synergistic effects of adding additional units to the site; however, it is relevant in a general sense in selecting a cooling alternative.

Table 9.5-20 lists advantages and disadvantages of various cooling alternatives considered.

Table 9.5-18 Estimates of the Energetic Impact of Discharges from Crystal River Power Plant Units 1 and 2 on the Surrounding Ecosystems, as Indicated by Changes in Community Gross Primary Productivity (Kemp, 1977)

Ecological Subsystem	$(PG._M \cdot r_M)$* Changes in Gross Productivity (kcal CE/m^2·yr)	(A) Affected Area ($m^2 x 10^6$)	(E_M) Energy Value Loss (kcal CE$x10^6$/yr)
Inner Bay †			
Control	673		
Discharge	386		
Change	287	0.93	267
Outer Bay**			
Control	509		
Discharge	476		
Change	33	1.81	60
Salt Marsh ††			
Juncus			
Control	1,570		
Discharge	985		
Change	585	0.76	445
Spartina			
Control	1,165		
Discharge	1,004		
Change	161	0.19	31
TOTAL CHANGE		3.69	803

*Abbreviations in column heading refer to Eq(34), Methods Section. Energy quality ratio, r_M, for gross productivity is from Odum, *et al*. (1975).
†Smith (1976).
**McKellar (1975).
††Productivity data from Young (1974b). Areas estimated from Klausewitz, *et al*. (1974), assuming 20 percent *Spartina* and 80 percent *Juncus* (Young, personal communication).

Source: Kemp, 1977.

Table 9.5-19 Effects of Salt Spray Deposition on Terrestrial Ecosystems for Alternative Cooling Water Management Schemes for Crystal River Power Plant Units 1, 2, and 3

Salt Deposition Rate $g/m^2 \cdot yr$	Calculations Parameters	Footnote	Multi-Cell Mechanical Draft	Circular Mechanical Draft	Natural Draft Tower	Fan-Asstd. Natural Draft
44-88	Area affected, $m^2 x 10^6$	*	1.40			
	Productivity, kcal $CE/m^2 \cdot yr$	†	992			
	Fractional reduction	**	0.40			
	Total Prod. Lost, kcal $CE x 10^9/yr$		0.56			
2	Area affected, $m^2 x 10^6$	*	5.99	2.43		
	Productivity, kcal $CE/m^2 \cdot yr$	†	1073	1073		
	Fractional reduction	**	0.20	0.20		
	Total Prod. Lost, kcal $CE x 10^9/yr$		1.29	0.52		
9-11	Area affected, $10^6 m^2$	*	12.67	28.87	5.95	1.03
	Productivity, kcal $CE/m^2 \cdot yr$	†	1117	1117	992	992
	Fractional reduction	**	0.10	0.10	0.10	0.10
	Total Prod. Lost, kcal $CE x 10^9/yr$		1.42	3.74	0.59	0.10
Total effect, kcal $CE x 10^9/yr$			3.27	3.74	0.59	0.10

*Areas affected by given level of salt deposition for given cooling alternative are estimated from isopleths of salt spray deposits calculated by Gilbert Associates (1974). Areas are prorated for higher possible salinity of spray (34 ppt).

†Vegetation maps of Dames and Moore (1974) show which ecosystems are affected by which levels of deposition. Weighted mean productivity for entire area is calculated assuming that the productivities (kcal $CE/m^2 \cdot yr$) for community types affected are: salt marsh=1385; pine flatwoods=595; planted pine=600; mesic hammock=830.

**Fractional reduction of production estimated from Mulchi and Armbruster (1975) data on corn for different salt loading rates.

Source: Kemp, 1977.

Table 9.5-20 Analysis of Alternative Cooling Systems: Environmental Considerations

	Advantages	Disadvantages
Once-through Cooling (estuarine water)	1. Low costs 2. No fresh water consumption* 3. Possibility of desalinization process	1. New dredging required 2. Impingement of large numbers of finfish and shellfish 3. Entrainment of large amounts of planktonic forms 4. Increased size of area swept by present thermal plume 5. Biocide additions
Natural Draft Cooling Towers with Freshwater Makeup	1. No salt drift 2. Area is rated low for fogging potential 3. Reduced volume of water means fewer organisms will be entrained if surface fresh waters are used	1. Consumptive use of fresh water 2. If groundwater is used, potential for salt water intrusion exists 3. Noise 4. Biocide and antiscaling chemical additions (fewer biocides if groundwater is used)
Natural Draft Cooling Towers with Saltwater Makeup	1. No consumption of fresh water* 2. Area rated low for fogging potentials	1. Potential for salt drift 2. Noise 3. Potential for increased technical problems due to corrosion 4. Biocide and chemical additions 5. Somewhat more flow required than if freshwater used. Increased entrainment of saltwater organisms

Table 9.5-20 Analysis of Alternative Cooling Systems: Environmental Considerations (Continued, page 2 of 2)

	Advantages	Disadvantages
Mechanical Draft Cooling Towers with Freshwater Makeup	1. No salt drift 2. Area rated low for fogging potential 3. Reduced volume of water flow than if saltwater is used. Fewer organisms would be entrained if surface fresh waters are used	1. Increased noise over natural draft tower 2. Higher initial and operating costs than natural draft tower 3. Consumes more power than natural draft tower. The power produced contributes to air pollution and discharge impact
Mechanical Draft Cooling Towers with Saltwater Makeup	1. No consumption of fresh water* 2. Area rated low for fogging potential	1. Increased noise over natural draft 2. Potential for salt drift greater than natural draft 3. Higher initial and operating costs than natural draft 4. Consumes more power than natural draft. Power produced contributes to higher air and water emissions 5. More water would be needed than if freshwaters are used. Leads to larger entrainment
Power Spray Modules (saltwater only)		1. Salt drift near canal 2. High costs 3. Large volumes of water needed. Leads to large impingement and entrainment 4. New dredging required

*Fresh water would still be required for boiler makeup and service water.

Source: Environmental Science and Engineering, Inc.

9.6 ATMOSPHERIC POLLUTION CONTROL SYSTEM ALTERNATIVES

9.6.1 OBJECTIVES

The immediate increased use of coal in conventionally-fired boilers is an integral part of any national energy scenario through the year 2000. There can be a substantial impact upon the public health and welfare due to as much as a six-fold increase in coal-fired generation (Balzhiser, 1977). Therefore, the increased use of coal-fired boilers will necessitate improvement of emission control technology.

As of the present time, New Source Performance Standards (NSPS) have been promulgated for emissions of sulfur dioxide, nitrogen oxides, and particulates emanating from coal-fired power generation units. Values of the NSPS in effect, as well as tighter standards, are being considered for the future. Interest in fine particulate matter, sulfates, trace elements, and polycyclics is increasing.

The constraints presented by the energy crisis and the NSPS have encouraged the development of advanced energy generation systems and novel pollution control methods. Some of the more progressive energy schemes employ simultaneous pollutant removal techniques.

Most alternative energy production and emission control methods are now in various stages of research and development. All are characterized by uncertainties in capital requirements, operating costs, and performance. The Electric Power Research Institute (EPRI) has performed comparative analyses for energy and pollutant control options for which design data are available (Balzhiser, 1977).

Of interest in this study is the category of direct-fuel utilization. Low-sulfur coal is considered to be the option which offers the lowest combined costs and presents the fewest uncertainties in the present stage of technical development and performance. For this reason, utility companies choose to burn low-sulfur coal in conventionally fired boilers when that alternative is available.

Low-sulfur coal can be obtained by the exploitation of naturally-occurring coal deposits in the Eastern and Western United States. It can also be obtained by the beneficiation and refinement of higher sulfur coals.

Low-sulfur eastern and western coals which, when burned, emit less than .54 kilogram (1.2 pounds) of sulfur dioxide per million Btu's of heat input, meet new plant emission standards and most State Implementation Plan (SIP) limits [Commerce Technical Advisory Board (CTAB), 1975)].

In the East, certain low-sulfur coals are generally reserved for the domestic steel industry or for exporting. However, seams of low-sulfur coal considered to have limited metallurgical value are available at premium prices.

In the West, development of low-sulfur coal is inhibited by limited water resources, transportation problems, and the environmental effects of strip mining.

Most of the western reserves underlie federally-owned lands. Plans to lease government-owned areas to mining companies have been frustrated by opposition on the grounds that the National Environmental Policy Act (NEPA) requirements for an Environmental Impact Statement (EIS) have not been fulfilled (Balzhiser, 1977).

The prospects are encouraging for obtaining low-sulfur coal if it is mined (U.S. Department of the Interior, Bureau of Mines, 1975). Much of

the western coal, however, is sub-bituminous grade, has lower heat content, and contains a higher ash than eastern coals.

9.6.2 SULFUR DIOXIDE CONTROL ALTERNATIVES

Sulfur dioxide control alternatives may be categorized as follows:

1. Burning of low-sulfur coal, whether naturally occurring or upgraded.
2. Removal of sulfur dioxide from the flue gas. Flue gas desulfurization can be accomplished through non-resource recovery methods or by regenerative processes.
3. Removal of sulfur dioxide at the combustion stage.

Roughly half of the recoverable coal from Montana and Wyoming can meet the present NSPS without desulfurization of any kind. Of the portion which would cause emissions greater than allowed by the NSPS, most would require treatment levels between 1 percent and 40 percent (Figure 9.6-1). If the stringent standards in Balzhiser (1977) are adopted, over 75 percent of all Montana and Wyoming coal will require desulfurization.

The above analysis discusses mainly western coal. Eastern coal will be discussed in a subsequent section. Undoubtedly, what happens to western coal mining will affect the eastern price structure and electric utility decision making.

COAL BENEFICIATION

When low-sulfur coal is not available, a significant amount of high-sulfur coal can be beneficiated in order to meet the NSPS requirements. The only widely used method for treating coal to reduce its sulfur content is known as the sink-float method. This alternative is feasible when a large portion of the sulfur is present as iron pyrite.

Where organic sulfur is high (such as in northern West Virginia and western Pennslyvania coals), the float-sink method does not reduce sulfur sufficiently to meet NSPS requirements.

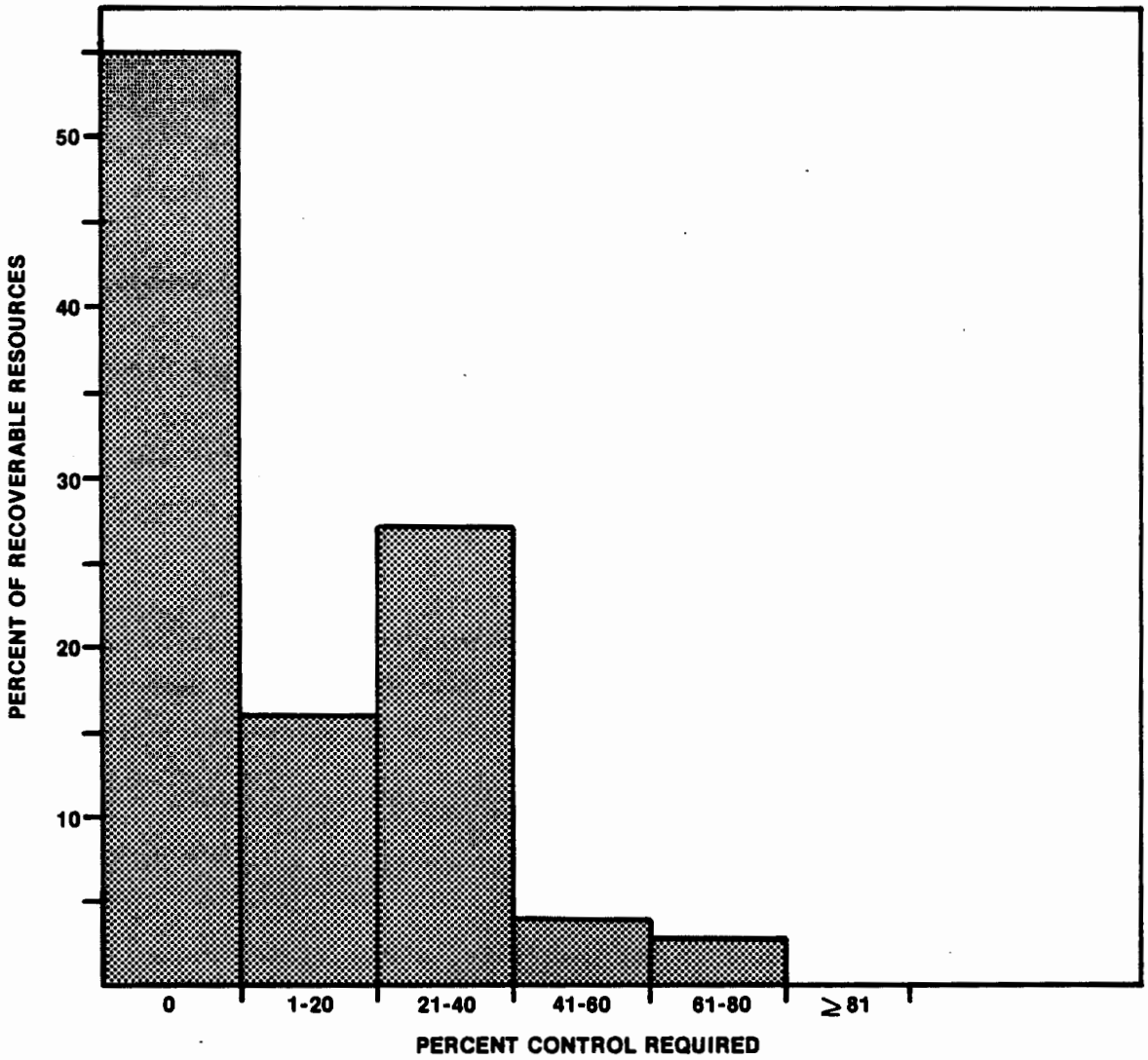

Figure 9.6-1
STATISTICAL DISTRIBUTION OF PERCENT CONTROLS REQUIRED FOR ALL RECOVERABLE RESOURCES IN MONTANA AND WYOMING

SOURCE: RENNE, 1976

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If applicable, beneficiation is the least costly sulfur dioxide control. It requires the lowest investment by a utility and displaces a substantial portion of the ash at the utility site to the mine site as refuse (CTAB, 1975).

According to the CTAB report, coal beneficiaton in conjunction with FGD is the "most economical best all around choice" for meeting the NSPS requirements quickly. In the report named above, it was assumed that lime/limestone flue gas desulfurization (FGD) is reliable and available.

Assumptions in the foregoing discussion were that regenerative processes were not available for immediate use on a large scale and that advanced power generating systems will not be available in the immediate future.

An estimated 13 percent of the United States coal reserves can meet the present NSPS. With coal beneficiation, approximately 28 percent of the coal reserves can meet the pollution criteria, and with chemical cleaning, 48 percent of the coal reserves become available without further treatment (Balzhiser, 1977).

SOLVENT REFINED COAL

Solvent refining is a method of chemically cleaning coal in order to remove the organic sulfur constituent. The most advanced process is one which includes a hydrogenation step. This generates a product of 8,900 kilocalories per kilogram (16,000 Btus per pound) from coal ranging between 4,400 to 6,700 kilocalories per kilogram (8,000 and 12,000 Btu's per pound) (Balzhiser, 1977). The material produced is chemically and physically different from coal, but preliminary combustion tests indicate that it will be a suitable boiler fuel and meet the current NSPS requirements. Although claims are made that the economics look favorable, in-depth analysis needs to be made regarding hydrogenation costs and hidden energy costs.

TRW, Batelle, and Atlantic Richfield companies are all developing chemical coal cleaning processes in which inorganic solvents are utilized. The Electric Power Research Institute (EPRI) is preparing to fund a project to combine organic and inorganic sulfur removal.

DYNAMIC EMISSION CONTROLS

Dynamic Emission Controls (DEC) are not built-in control methods, but rely upon the use of meteorological as well as ambient pollutant data as decision-making tools. Fuel and load switching are used to keep ambient emission standards from being violated. The economics of DEC are very appealing, but it might be difficult to enforce their use. DEC is not now available to FPC as an alternative.

Similarly, the use of tall stacks will effect significant reductions in ambient sulfur dioxide concentrations (Smith and Frankenberg, 1975). Tall stacks for control of pollutants do not provide for compliance with the NSPS. Also, limitations regarding stack height with respect to building height rule out this alternative.

HIGH SULFUR COAL--FLUE GAS DESULFURIZATION

Flue gas desulfurization (FGD) involves the removal of sulfur dioxide from the combustion gases by a positive control device. FGD processes are broken down into two major categories. They are:

1. Throwaway processes, where resource recovery is not practiced; and
2. Regenerative processes, where the removal media is regenerated and the sulfur recovered.

There are cases where recovery is an economically marginal consideration in one location, but is very favorable somewhere else.

Throwaway Processes

Throwaway processes are characterized by the use of either lime or limestone to remove sulfur at various points within the process. Several methods can be used. They are:

1. Use of lime or limestone slurry in a scrubber;
2. Use of lime to causticize an alkaline scrubbing solution while removing sulfur;
3. Injection of lime or limestone directly into the furnace; and
4. Fluidized Bed Combustion (FBC), which is in the developmental stage.

Several other methods can be used, including use of Nahcolite ore and bag filters (Genco, et al., 1975), but are at the pilot plant stage.

Wet Lime/Limestone Scrubbing

Lime and limestone FGD processes can chemically remove as much as 90 percent of the sulfur oxides from power plant flue gases by reaction with a slurry of lime or limestone in a scrubber. Heavy concentration of industries and the market for gypsum have resulted in a large number of successful commercial applications in Japan. The U.S. EPA in 1971 felt that FGD processes, particularly lime and limestone scrubbing, were commercially feasible in the United States. Table 9.6-1 is a summary of the operational and planned installations employing FGD. There are more units which use wet lime/limestone scrubbing than any other technique.

In the United States, wet lime/limestone scrubbing is a throwaway process, producing a sulfite/sulfate sludge which must be disposed. In Japan a further oxidation step is employed, and quality gypsum is produced.

Table 9.6-1 Number and Total Mw of Flue Gas Desulfurization (FGD) Systems in the United States

Status	No. of Units	Mw
Operational		
Active	23	4,693
Inactive	5	605
Under construction	18	6,171
Planning		
Contract awarded	10	3,761
Letter of intent	8	2,325
Requesting/evaluating bids	5	2,577
Considering FGD systems	46	24,007
Total	115	44,139

The results of commercial applications in the United States are mixed. Lime scrubbing is practiced at Duquesne Light Company's Elrama and Phillips Power Stations. According to Pernick and Knight (1976), problems have included:

1. Deposit accumulation in spray nozzles;
2. Corrosion/erosion problems with recycle pumps;
3. Deposits in scrubber vessel in venturi throat dampers, lower cone and elsewhere;
4. Unacceptable reliability; and
5. Duct deterioration.

The company is now using magnesium oxide modified lime in order to improve performance, thus adding to costs and to sludge disposal problems.

An alternative scrubbing process developed by Atomics International Division, Rockwell International Corporation, and Whellabrator-Frye, Inc., employs dry lime scrubbing in the absorption of SO_2 and a fabric filter to collect the resulting particulate matter. Pilot tests were performed in June, 1977, at Basin Electric Power Cooperative's Leland Olds Station in Stanton, North Dakota. Favorable tests resulted in a demonstration project at a planned 410 Mw coal-fired Coyote station (Focker, et al., 1978).

With the problems which can occur, many utilities still consider lime/limestone FDG to be in the development stage.

Because the U.S. EPA approves of FGD, and because FGD has demonstrated success outside the United States, utilities have searched thoroughly for ways to make FGD work. According to Beychock (1974), these include:

1. Having redundant units on hand as "spares" to avoid outages;
2. Liberal use of standby pumps, centrifuges, and other rotating machinery;
3. Employment of experienced chemical staff to operate what are essentially chemical processes; and

4. Planning and staffing for aggressive corrective maintenance during the startup of a major new unit.

In the previously mentioned study by the CTAB (1975), lime/limestone FGD was considered to be commercially available. Capital costs are substantial, and operating costs are close to those from use of low-sulfur coal. Total annual cost (which includes cost of capital) would be greater for lime/limestone FGD than for low-sulfur coal. The lead time is longer than for low sulfur coal.

In order to meet the immediate needs of sulfur dioxide control on a national scale, the CTAB recommended a combination of coal beneficiation coupled with lime/limestone FGD.

Double Alkali Scrubbing

The double alkali process, which has several variations, involves scrubbing flue gas with a soluble alkali such as sodium hydroxide, ammonia, or sodium sulfite, and regenerating the absorbent with an insoluble alkali such as lime. The double alkali process has the potential advantage of soluble alkali scrubbing with limited scaling, plugging, and erosion problems (Marten, 1977).

As in the case of lime/limestone scrubbing, most of the proven experience lies with Japanese installations. Nippon Kokan K.K., Showa Denko, and Kureha Chemical successfully demonstrated on a commercial scale before 1974 that double alkali scrubbing worked (Beychok, 1974).

In the United States, the process is at the research and development stage. Utah Power and Light's 100 Mw Unit 3 (Gadsby Station) was fitted with a pilot scale sodium hydroxide/lime process in 1971. A 20 Mw prototype double alkali system was operated between February, 1975, and July, 1976, at Gulf Power's Scholz Number 1 plant in Chattahoochee, Florida (Marten, 1977).

Government funded research is being conducted by the Bechtel Corporation at TVA's Shawnee Power Station, Paducah, Kentucky. Test results on parallel venturi scrubber/turbulent contact absorber installations (10 Mw each) are promising. Lime and limestone are being used for the second step (EPA, 1976).

Limestone Addition

The injection of limestone into the furnace as a sulfur removal method was practiced at Kansas City Power and Light's Hawthorne and Lawrence Stations. The method was advocated by Combustion Engineering. Many problems, including sulfur dioxide removal efficiencies between 20 and 35 percent, have caused this method to be abandoned.

Fluidized Bed Combustion

FBC is a modern outgrowth of limestone addition. Sulfur is captured by the limestone, and calcium sulfate is formed in a bed which is maintained at temperatures between 870°C and 900°C (1,600 and 1,650°F) (Balzhiser, 1977). DOE, EPA, and EPRI are supporting research and development in Atmospheric Fluidized Bed Combustion (AFBC). Scale-up of a modular unit to 100 to 200 Mw is expected in the early 1980's by DOE in Morgantown, West Virginia.

Regenerative Processes

Regenerative processes are characterized by regeneration of the removal medium and by recovery of the sulfur. Lime/limestone scrubbing falls under this category when gypsum is produced. When chemicals or methods besides lime and limestone are used, economic considerations always dictate regeneration/recovery.

The regenerative processes offer several advantages over the throwaway methods. These include (Murthy, et al., 1976):

1. There is no sludge or filter cake to dispose of;
2. Pure sulfur dioxide, sulfur, or sulfuric acid is produced; and
3. There are significantly reduced quantities of secondary waste streams.

The disadvantages are due to:

1. Up to 5 percent increased energy input for supplying reducing gases; and
2. Higher investment and operating costs.

Most types of these flue gas desulfurization processes are in the developmental stage.

One of the major problems plaguing many regenerative processes is the need for reducing agents such as hydrogen sulfide, hydrogen, carbon monoxide, and coal. Those FGD processes that require a reducing gas or solid are listed in Table 9.6-2.

A status summary of regenerative processes is presented in Table 9.6-3. The list is by no means exhaustive, considering Japanese experience. The only feasible alternatives for FPC are:

1. Magnesium oxide scrubbing,
2. Catalytic oxidation,
3. Sodium sulfite scrubbing, and
4. Sulfuric acid scrubbing.

Regenerative processes hold some future promise for Florida. The electric power industry can conceivably sell recovered sulfur, sulfur dioxide, or sulfuric acid to the phosphate industry, which in turn can use the product to acidulate phosphate rock for the production of fertilizer. The quantity of sulfur which electric companies can produce is on the order of magnitude of requirements of the phosphate industry.

Table 9.6-2 Flue Gas Desulfurization (FGD) Processes Which Require a Reducing Gas or Solid

Gas or Solid	Type of FGD Process
1. Hydrogen Sulfide for direct use in process	a. Citrate b. Stauffer c. Catalytic--IFP D. Westvaco
2. Hydrogen	a. Shell (SFGD) b. Alakalized alumina
3. Carbon Monoxide	a. Consol-aqueous potassium salts
4. Hydrogen Sulfide for Claus Plant[a]	a. Wellman-Lord b. Stone and Webster/Ionics c. Ammonia Scrubbing d. Bergbau-Forschung (if RESOX is not used) e. Shell
5. Coal (coke)	a. Foster Wheeler's RESOX process in FW-BF b. Al-ACP c. $MgSO_4$ regeneration (MgO process)

a. Note that concentrated SO_2 from processes 4(a) through 4(e) can be converted to sulfur by the RESOX process or the ASARCO-Phelps Dodge direct sulfur process.

Source: Murthy, 1976.

Table 9.6-3 Brief Status Summary on Regenerative Processes*

Process Name	Year, Installation Site, Vendor, Size, and Type of Boiler	Status
MgO scrubbing	1972, Mystic, Boston Edison, Chemico, 150 Mw, oil	Shut down since June, 1974
	1974, Dickerson, Potomac Electric, Chemico, 100 Mw, coal	Shut down since July, 1975
	1975?, Eddystone, Philadelphia Electric, UEC, 120 Mw, coal	Shut down for modification
Wellman-Lord	1975?, D.H. Mitchell, NIPSCO, Davy Powergas/ Allied Chemical, 115 Mw, coal	Under construction
Cat-Ox	1972, Wood River, Illinois Power Company, Monsanto, 110 Mw, coal	Shut down since 1974
Chiyoda CT-101	1975, Scholz power plant, Gulf Power Company, Chiyoda, 23 Mw, coal	Operating since June, 1975
Citrate †	1973, Pfizer's Vigo Chemical Complex, McKee/Peabody, 1 Mw slipstream coal	Shut down September, 1974, after data collection
Phosphate	1974, Norwalk Harbor Station, Connecticut Power and Light Company, Stauffer, 0.1 Mw, oil	Shut down June, 1974, after data collection

Table 9.6-3 Brief Status Summary on Regenerative Processes* (Continued, page 2 of 3)

Process Name	Year, Installation Site, Vendor, Size, and Type of Boiler	Status
Catalytic-IFP	No data in open literature	No data in open literature
Consol-potassium salts	1972, Cromby, Philadelphia Electric Company, Consol/Bechtel, 10 Mw, coal	Shut down since 1972 after data collection (a smaller plant, 1000 acfm was operated until 1975)
Al-ACP	1971, Mohave, So. California Edison, Al, 0.5 Mw, oil	Shut down 1972 after data collection on open-loop system
FW-BF	1975, Scholz power plant, Gulf Power Company, Foster Wheeler, 20 Mw, coal	Started commissioning January, 1975, many problems

Table 9.6-3 Brief Status Summary on Regenerative Processes* (Continued, page 3 of 3)

Process Name	Year, Installation Site, Vendor, Size, and Type of Boiler	Status
Westvaco	1970, Westvaco Research Center, Westvaco, 0.2 Mw, oil	Shut down 1974 after data collection
SFGD	1974, Big Bend Station, Tampa Electric, Shell, 0.6 Mw, slipstream, coal	Tests are in progress

*Only installations in the United States are discussed in this table.
†Extensive pilot plant studies on a lead smelter gas are being conducted by USBM Salt Lake City Metallurgy Research Center.

Source: Murthy, 1976.

Magnesium Oxide Scrubbing

This process was the first commercially demonstrated sulfur removal-regeneration process. It operates similarly to lime scrubbing with the exception that a slurry of magnesium oxide was used instead.

Spent magnesium sulfite/sulfate from the Boston Edison Mystic Station was transported to a regeneration plant in Rumford, Rhode Island. Sulfuric acid was produced and magnesium oxide was regenerated. The unit at Boston Edison was shut down in 1974 after the closing of the regeneration plant. Adoption of magnesium oxide scrubbing in Florida would require a central regenerating plant.

Catalytic Oxidation

Catalytic oxidation employs a vanadium pentoxide catalyst which converts sulfur dioxide to sulfur trioxide. A solution of sulfuric acid is the ultimate product. The process was demonstrated on a 110 Mw coal-fired unit at Illinois Power Company. At the time, more effort was required to make the process work than was realized, and the result was that installation, though theoretically quite feasible, was shut down. It could probably work if sufficient interest and funds exist (Murthy, 1976).

Sulfuric Acid Scrubbing

The Chiyoda CT-101 process employs dilute sulfuric acid scrubbing. Liming follows the scrubbing step and an oxidation step. The process has been employed successsfuly in many Japanese plants, including a 250 Mw unit. High quality gypsum is produced; therefore, the Japanese are very satisfied.

Gulf Power Company in Florida has installed this system at the Scholz Power Plant on a 23 Mw unit. Results have not been analyzed yet.

Sodium Sulfite Scrubbing

The Wellman-Lord process employs a sodium sulfite scrubbing solution. The resulting bisulfite liquor is thermally regenerated in an evaporator-crystallizer to yield sulfur dioxide and recycled sodium sulfite.

The process was demonstrated by MKK, Japan, before 1974 (Beychok, 1974). The sulfur product was concentrated sulfur dioxide.

The first demonstration in the United States is at the Northern Indiana Public Service Company (NIPSCO) on a 115 Mw coal-fired unit. The 85 percent sulfur dioxide from the Wellman-Lord generator feeds an Allied Chemical reduction process which yields greater than 99.5 percent pure sulfur. Tests performed in August and September, 1977, determined sulfur dioxide removal efficiency of greater than 90 percent with particulate emissions achieving NSPS (Gaur, 1978).

ECONOMIC CONSIDERATIONS

Capital and operating costs for sulfur dioxide control technology considered to be commercially available are presented in Tables 9.6-4 and 9.6-5. Table 9.6-6 presents Busbar costs of coal-fired technologies. The desirability of using either naturally-occurring low-sulfur coal or beneficiated coal when possible is clearly indicated.

Section 8.2.3 of Chapter 8 presents an economic analysis of low-sulfur coal versus high-sulfur coal for the proposed units. As indicated, the results were similar to those presented in Table 9.6-4 and 9.6-5. Capital costs of FGD for the proposed units were estimated at $73 per kw (Florida Power Corporation, 1977). This cost, combined with an annual operating cost of $10 per kw (not including energy costs and replacement energy costs), does not make FGD economically attractive.

Table 9.6-4 Capital Costs for Commercially Available Continuous SO_x Control Technologies ($/kw)*

Control Technology	To the Utility		To the Coal Producer
Lime/limestone FGD	FGD Units	$54-69	
	Sludge Disposal	$10-50†	
	Total	$64-119	
Lime/limestone FGD with high coal beneficiation	FGD Units	$36-49	
	Sludge Disposal	$ 3-14†	$16-23
	Total	$39-63	
Lime/limestone FGD with moderate coal beneficiation	FGD Units	$42-54	
	Sludge Disposal	$ 4-20†	$7-11
	Total	$46-74	
Low sulfur coal**		$ 5-15	No increment for low- over high-sulfur coal
Coal beneficiation		Nil	$7-23

*Based on a new 1000 Mw plant using 3 percent sulfur Northern Appalachian Coal, meeting New Source Performance Standards.

†The utility may in some instances contract for sludge disposal, lowering its capital investment, while generally raising the operating cost.

**Coal meeting new source performance standards, i.e., 0.54 kilograms (1.2 pounds) SO_x per million Btu.

Source: Commerce Technical Advisory Board, 1975.

Table 9.6-5 Potential Capacities and Operating Costs of Commercially Available Continuous SO_x Controls.

Control Technology	Lead Time (Years)	Potential Capacity by 1980	Increase In Generating Costs (Mills/kwh)
Low sulfur coal*	3-6	20,000-40,000 Mw	4-7
Coal benefication	3-4	200-300 million tons coal per year†	0.5-2
Lime/limestone FGD	4-7	45,000-55,000 Mw	4-6**
-OR-			-OR-
Lime/limestone FGD With Lower Sulfur Coal	4-7	Somewhat more than 45,000-55,000 Mw for FGD alone	3-5††

*Coal meeting New Source Performance Standards, i.e., .54 kilogram (1.2 pounds) SO_x per million Btu.
†Only a minor fraction of the product meets SO_x emission standards.
**Based on a new 1,000 Mw plant using 3 percent sulfur Northern Appalachian Coal and meeting New Source Performance Standards.
††Use of the combined strategy instead of FGD alone reduces the sludge disposal and FGD capacities needed, thus increasing the capacity available by 1980.

Source: Commerce Technical Advisory Board, 1975.

Table 9.6-6 Busbar Costs for Coal-Fuel Technologies

Control Scenario	Busbar Power Costs, Mills/kwh
Direct Utilization	
Low-sulfur coal	25-28
Alkali scrubbing	28-34
Regenerative scrubbing	30-41
Fluidized bed combustion	27-42
Liquefaction	
Solvent refined coal	36-43
Petroleum-type fuel	41-48
Gasification	
Low-Btu gas (moving bed)	43-49
Medium-Btu gas (slagging moving bed)	35-41
Low-Btu gas (entrained)	32-37
Medium-Btu gas (entrained)	28-34

Source: Balzhiser, 1977.

Capital and operating costs of regenerative processes are also economically unattractive. The Chiyoda CT-101 (sulfuric acid scrubbing) process has an estimated investment cost between $80 and $100 per kw (Murthy, 1976). The Wellman-Lord process, which employs sodium sulfite scrubbing, has capital costs of between $63 kw and $117 kw. Operating costs are estimated at between 3 mills per kw and 6.3 mills per kw, including credit for the sulfur (Murthy, 1976; Gaur, 1978). While these processes are viable for Florida, they are not economically attractive.

9.6.3 PARTICULATE CONTROL ALTERNATIVES

Particulate control can be effected by the use of the following methods:

1. Wet scrubbers,
2. Fabric filters,
3. Mechanical separators, and
4. Electrostatic precipitators.

Process controls such as the use of excess oxygen and the use of low ash coal can reduce particulate emissions, but not to the levels required by NSPS. Very often, as discussed previously, specification of low sulfur coal results in high ash coal (western coals). Increased oxygen for more complete combustion will increase nitrogen oxides and sulfur trioxide conversion. It should not be required in a modern installation.

WET SCRUBBERS

Wet scrubbers remove dust by impaction and interception of particles onto fine water droplets. Their use has been limited in the past because of excessive energy consumption, large water volumes, required water treatment, and sludge disposal.

When used in conjunction with gas absorption and chemical reaction, scrubbers can be feasible particulate control devices. Tests conducted by Environmental Science and Engineering, Inc. (1973) on the magnesium oxide venturi scrubber at Boston Edison's Mystic Station indicated that 90 percent particulate removal can be accomplished during simultaneous sulfur dioxide removal. Tests conducted by EPA (Statnick, 1975), however, indicate that for fine particles, the efficiencies can actually be negative. A collection efficiency of 92.5 percent was achieved on particles in the 3.1 micron range. However, in the 0.30 micron particle range, a collection efficiency of minus 100 percent was experienced. The probable reason given for the poor performance was failure of the mist eliminator.

Better results were obtained at TVA's Shawnee Wet Limestone Scrubbing Test Facility. Good total collection efficiencies were observed on the venturi scrubber (greater than 90 percent); however, the efficiency dropped markedly in the submicron range. In a Turbulent Contact Absorber (TCA), overall efficiencies of greater than 99 percent were observed. The collection efficiency of submicron particles was greater than 90 percent at a pressure of 25.4 centimeters (10 inches) of water.

Unless coupled with sulfur dioxide collection, scrubbers are not economic solutions to particulate control. Even with sulfur dioxide control, mist must be controlled to insure good performance.

FABRIC FILTERS

Fabric filter media, such as baghouses, operate on the principles of impaction, interception, and diffusion of particles onto a filter cake. Baghouses have demonstrated higher collection efficiencies than electrostatic precipitators, particularly in the submicron range (Balzhiser, 1977), but suffer from the following disadvantages:

1. High maintenance costs, and
2. Large spatial requirements.

At efficiencies of less than 99 percent, fabric filters are not competitive with electrostatic precipitators. However, since efficiencies above 99 percent can be achieved with fabric filters, applications in congested areas may increase (Babcock and Wilcox, 1972).

MECHANICAL SEPARATORS

Mechanical separators such as cyclones depend upon centrifugal separation, and subsequent impaction, of particles from a gas stream. Particles of less than 10 microns are collected with efficiencies of less than 90 percent (Babcock and Wilcox, 1972). The use of mechanical collectors is possible only in conjunction with more sophisticated controls.

ELECTROSTATIC PRECIPITATORS

Electrostatic precipitators produce an electric charge on the particles to be collected, and then propel the charged particles by electrostatic forces to the collecting electrodes. The precipitator operation involves four basic steps (Babcock and Wilcox, 1972):

1. An intense, discharging field is maintained between the discharge electrode and the collecting electrodes.
2. The carrier gases are ionized by the intense, discharging field. These gas ions, in turn, charge the entrained particles.
3. The negatively charged particles, still in the presence of an electrostatic field, are attracted to the positively (grounded) charged collecting electrodes.
4. The collected dust is discharged by trapping into storage hoppers.

The collection efficiency of the electrostatic precipitator is related to the time of particle exposure to the electrostatic field, the strength of the field, and the resistivity of the dust particle. An efficiency of 99 percent is obtained at a cost generally favorable in comparison with other types of equipment. A very high percentage of particulate-removal units installed in commercial boiler plants since 1970 are electrostatic precipitators. Because of their inherent advantages in handling large volumes of flue gases with low pressure drop, efforts at EPRI and elsewhere are underway to improve their performance in the fine particulate range (Balzhiser, 1977).

9.6.4 NITROGEN OXIDES CONTROL ALTERNATIVES

Nitrogen oxides (NO_x) are formed by the oxidation of nitrogen compounds in the fuel, or by conditions of high temperature, pressure, and oxygen concentrations during combustion.

The extent to which power plants contribute to total NO_x emissions can be discerned from Table 9.6-7. Coal-, oil-, and gas-fired units account for over half of the NO_x emission from stationary combustion sources, and over one-third of the NO_x emissions from all sources.

Control of nitrogen oxides from coal-fired units at the present time is accomplished by use of low nitrogen fuel or by modified combustion techniques. The status of current control technology is summarized in Table 9.6-8. Flue gas recirculation is considered to be ineffective as an NO_x control method when applied at coal-fired units. Reduced combustion-air preheating and steam or water injection are considered to be noncompetitive in comparison with the other alternatives presented. The other control alternatives can be used separately or in combination to effect compliance with present day NO_x standards. These alternatives present no great problems from a technical point of view. In fact, Combustion Engineering guarantees that its equipment can meet the 0.6 pound NO_x per million Btu's that was expected in the summer of 1977 (Ricci, 1977). These units are almost identical to their older design furnaces, except the new units are larger, and have over-fire air.

In summary, no difficult decisions need to be made for NO_x control by the utility. Guarantees from manufacturers should suffice to insure that NO_x standards are met at the present time.

Table 9.6-7 Major Industrial Sources of NO_x Emissions

Rank	Source	Mass NO_x (metric ton/yr)	% Emissions, Stationary Sources	% Emissions, All Sources
1.	Coal-fired steam utility generators	3,495,000	30.8	15.6
2.	Fuel-burning reciprocating engines	2,132,000	18.8	9.54
3.	Oil-fired industrial/commercial boilers	1,245,000	11.0	5.57
4.	Oil-fired steam utility generators	1,114,000	9.80	4.98
5.	Gas-fired steam utility generators	835,100	7.35	3.74
6.	Coal-fired industrial/commercial boilers	734,600	6.45	3.29
7.	Gas-fired industrial/commercial boilers	491,400	4.32	2.20
8.	Fuel-burning turbine engines	253,300	2.23	1.13
9.	Cement manufacture	91,310	0.803	0.408
10.	Industrial/commercial space heating	80,560	0.709	0.360
11.	Crude distillation of petroleum	69,640	0.613	0.312
12.	Glass manufacture	68,160	0.600	0.305
13.	Catalytic cracking of petroleum	60,730	0.534	0.272
14.	Coal refuse piles (and abandoned mines)	30,590	0.269	0.137
15.	Nitric acid manufacture	27,050	0.238	0.121
16.	Vacuum distillation of petroleum	25,100	0.221	0.112
17.	Ethylene manufacture	24,020	0.211	0.107
18.	Wood-waste incineration	23,960	0.211	0.107
19.	High-density polyethylene manufacture	13,930	0.123	0.0623
20.	Propylene manufacture	12,600	0.111	0.0563
21.	Benzene manufacture	10,770	0.0947	0.0482
22.	C_4 hydrocarbons manufacture	10,450	0.0919	.0467
23.	Brick kilns and dryers	8,680	0.0764	0.0388
24.	Mineral-wool manufacture	8,061	0.0709	0.0361
	Others	503,989	4.43	2.25
	TOTAL	11,370,000	100.17*	50.85

*Because of rounding.

SOURCE: Monsanto Research Corporation--Dayton Laboratory, 1976.

Table 9.6-8 Summary of Current NO_x Control Methods

Method	NO_x Reduction		
	Gas	Oil	Coal
Flue-gas recirculation	60%	20%	Not effective
Reduced combustion-air preheat	50%	40%	Not effective
Steam or water injection	60%	40%	Not effective
Staged combustion	55%	40%	40%
Low excess air	20%	20%	20%
Reduced heat-release rate	20%	20%	20%
Combined staging, low excess air, and reduced heat release	50%	35%	40%
Change to fuel with lower % N	Not effective	40%	20%

Source: EPA report No. 650/2-74-066
U.S. Environmental Protection Agency, 1974.

9.6.5 SUMMARY

Table 9.6-9 is a summary of the advantages and disadvantages of the air pollution control alternatives. The preferred alternatives discussed in detail in Chapter 3 are:

1. Low-sulfur for sulfur dioxide emissions control,
2. Electrostatic precipitators for particulate emissions control, and
3. Boiler design for nitrogen oxide emissions control.

These alternatives discussed in the preceding section are the most reliable and cost-effective alternatives now known.

Table 9.6-9 Summary of Atmospheric Pollution Control System Alternatives

Pollutant	Control Scenario	Advantages	Disadvantages
Sulfur Dioxide	Low Sulfur Coal (compliance coal)	Meets NSPS without additional controls Lower cost than other alternatives No waste products (other than fly and bottom ash)	Availability questionable Lower sulfur dioxide content in flue gases affects ESP performance
	Coal Beneficiation (mechanical washing, magnetic separation, and chemical separation)	Least cost of control alternatives Meets NSPS without additional controls, in some cases Reduces amount of waste when additional controls are used	Water utilization at mine Magnetic and chemical separation in laboratory stages Most coals that were beneficiated would still not meet NSPS
	Solvent Refined Coal	Low ash and sulfur product Higher Btu/lb fuel; therefore, lower transportation costs Can meet NSPS without additional controls	Processes still in development stage More expensive than all other alternatives

Table 9.6-9 Summary of Atmospheric Pollution Control System Alternatives (Continued, page 2 of 6)

Pollutant	Control Scenario	Advantages	Disadvantages
Sulfur Dioxide (continued)	Dynamic Emissions Controls	Can comply with AAQS and PSD increments	Prohibited by Federal regulation
		Very low cost alternative	Will not meet NSPS
			Effectiveness uncertain
	FGD Throwaway Processes		
	1. Wet Lime/Limestone Scrubbing	Can remove up to 90 percent of sulfur dioxide	Produces large quantities of sludge that require large disposal area
		Considered commercially available	Potential for operation and maintenance problems
		Least expensive and most demonstrated of FGD processes	Potential for unit failure due to scrubber alone
			Lower plume exit temperatures resulting in greater ground level impact

Table 9.6-9 Summary of Atmospheric Pollution Control System Alternatives (Continued, page 3 of 6)

Pollutant	Control Scenario	Advantages	Disadvantages
Sulfur Dioxide (continued)	2. Double Alkali Scrubbing	Limited scaling, plugging, and erosion problems Proven successful in Japan on industrial boilers	Sludge produced has potential for water pollution Process is in research and development stages in the United States Loss of reactant (sodium hydroxide, ammonia or sodium sulfite) increases costs
	3. Limestone Addition	No semi-liquid sludge produced from process	Low sulfur dioxide removal efficiency does not allow NSPS to be achieved
	4. Fluidized Bed Combustion	Sulfur dioxide is removed in furnace and produces calcium sulfate (a dry waste) Heat transfer properties favorable	Not demonstrated on full-scale power plant Economics uncertain
	5. Dry Lime/Limestone Scrubbing	Dry waste product produced Potential for operation and maintenance minimized	Not demonstrated on full-scale power plant Rates of reaction must be adequately controlled

Table 9.6-9 Summary of Atmospheric Pollution Control System Alternatives (Continued, page 4 of 6)

Pollutant	Control Scenario	Advantages	Disadvantages
Sulfur Dioxide (continued)	FGD--Regenerative Processes		
	1. Magnesium Oxide Scrubbing	Small amounts of waste produced Potentially marketable by-product Reactant is recycled	Regeneration of reactant necessary More costly than wet limestone scrubbing Quantity of by-product may be too large to market
	2. Catalytic Oxidation	Small amounts of waste produced Potentially marketable by-product Reactant is recycled	More costly than wet limestone scrubbing Catalyst employed, contamination possible Quantity of by-product may be too large to market Corrosion problems in acid portion of facility

Table 9.6-9 Summary of Atmospheric Pollution Control System Alternatives (Continued, page 5 of 6)

Pollutant	Control Scenario	Advantages	Disadvantages
Sulfur Dioxide (continued)	3. Sulfuric Acid Scrubbing	Small amounts of waste produced Potentially marketable by-product produced Demonstrated in Japan	More costly than wet limestone scrubbing The high-quality gypsum may not be as economically attractive in the United States as in Japan Lower plume temperature can result in greater ground-level impact
	4. Sodium Sulfite Scrubbing	Small amount of waste produced Reactant is recycled Potentially marketable by-product	More costly than wet limestone scrubbing Lower plume temperature can result in greater ground-level impact
Particulate	Electrostatic Precipitation	Handles large quantities of flue gas at low pressure drop Removal efficiencies of 99.5 percent achievable Low maintenance costs Cost/Benefit more favorable than other control equipment	Highly dependent on coal utilized in boiler

Table 9.6-9 Summary of Atmospheric Pollution Control System Alternatives (Continued, page 6 of 6)

Pollutant	Control Scenario	Advantages	Disadvantages
Particulate (continued)	Fabric Filters	Potential for greater overall efficiency (especially in sub-micron range) Can be utilized in dry lime/ limestone scrubbing applications	Larger space requirements than ESP's Limited design requirements Higher maintenance costs than ESP
	Wet Scrubbers	Can be combined with sulfur dioxide removal processes	Large volumes of water necessary Waste sludge produced with resultant disposal problems Lower plume temperature resulting in greater ground-level impact Excessive energy requirement
	Mechanical Separators	Very low capital, maintenance, and operating costs	Achievement of NSPS not possible

Note: Nitrogen dioxide control alternatives not summarized since the boiler can be designed to limit emissions.

Source: Environmental Science and Engineering, Inc., 1978.

9.7 WASTEWATER DISCHARGE SYSTEM ALTERNATIVES

9.7.1 OBJECTIVES

The objective of this analysis is to categorize the various wastewaters produced by the operation of the plant and to discuss methods for their disposal.

9.7.2 EVALUATION CRITERIA

The requirements are that all waters discharged from the plant site will be of a quality that complies with existing regulatory requirements, and that reuse of water will be incorporated to the greatest extent practical.

9.7.3 ALTERNATIVES CONSIDERED

SOURCES OF WASTEWATER DISCHARGES

The sources of wastewaters include circulating water, ash and sludge handling, rainwater runoff, and low volume wastewaters which consist of water pretreatment, ion exchange regeneration, metal cleaning, plant drains, sanitary waste, and boiler blowdown.

CIRCULATING WATER

Salt Water

If seawater is used as circulating water for condenser cooling on a once-through basis or as makeup to a cooling tower system, it will either evaporate, be lost to the atmosphere as drift, or be returned to the sea. In each case, shock chlorination would be required for control of biofouling of the condenser and cooling tower.

Cooling tower makeup would be at a constant rate regardless of generating unit load. The cycles of concentration of the circulating

water will therefore vary between 1.1 and 1.2 depending on the cooling tower evaporation rate. The expected peak and normal cooling tower makeup requirement is approximately 4,289 dm^3/s (68,000 gpm, 97.9 mgd), based on such constant rate makeup pumpage.

Chemical analyses of makeup water, obtained from the existing intake and discharge canals, are shown in Table 9.7-1.

In the cooling tower scenario, blowdown flow at normal plant load (66 percent) for Units 4 and 5 would be 61,142 gallons (231.5 cubic meters) per minute. At peak load (100 percent), blowdown would be 57,727 gallons (219 cubic meters) per minute. The difference in blowdown flows results from greater evaporation at peak generating load.

With cooling towers, consumptive use from evaporation and drift at peak conditions will be 712 dm^3/s (11,280 gpm, 16.2 mgd), and 0.8 dm^3/s (13 gpm, 18,720 gpd) respectively, and 433 dm^3/s (6,870 gpm, 9.9 mgd), and 0.5 dm^3/s (8 gpm, 11,520 gpd), for normal conditions.

Blowdown temperature is expected to range from a minimum of 30°C (86°F) in January and February to a maximum 2-hour average of 35.6°C (96°F) in June, July, and August. Relevant chemical constituents of blowdown are expected to be as shown in Table 9.7-2.

Fresh Water

Quantity and Quality

At maximum evaporation of 41 cubic meters per minute (59,800 cubic meters per day) [11,000 gallons per minute (15.8 million gallons per day)], maximum drift of 0.15 cubic meters per minute (220 cubic meters per day) [40 gallons per minute (0.06 million gallons per day)], and operating at six cycles of concentration, the required blowdown from both units will be 8.18 cubic meters per minute (11,700 cubic meters per

Table 9.7-1 Gulf Coastal Salt Water Quality Data

Parameter	Range (mg/l)
Total Dissolved Solids	15,008 - 36,080
Vol. Dissolved Solids	2,348 - 7,884
Chloride as Cl	7,990 - 17,090
Calcium Hardness	610 - 1,000
BOD_5	0 - 15
COD	0 - 328
Total Iron	0 - 4.6
Total Copper	0 - 0.59
Total Zinc	0 - 0.15
Total Boron	0 - 5.9
Total Chromium	0 - 0.11
Total Lead	0 - 0.42
Total Arsenic	0 - trace
Total Mercury	0 - 0.8
Turbidity	0 - 80
pH	7.5 - 8.2
Conductivity (umhos/cm)	23,100 - 49,500

Source: Florida Power Corporation, 1977.

Table 9.7-2 Expected Quality of Saltwater Cooling Tower Blowdown for Crystal River Plant Units 4 and 5

Constituent	Cooling Tower Blowdown
Ca, mg/l as $CaCO_3$	1,300
Mg, mg/l as $CaCO_3$	5,330
Na, mg/l as $CaCO_3$	24,024
M Alk, mg/l as $CaCO_3$	157
SO_4, mg/l as $CaCO_3$	2,909
Cl, mg/l as $CaCO_3$	27,587
NO_3, mg/l as $CaCO_3$	1
SiO_2, mg/l as such	1
TSS, mg/l as such	30
Cl_2, mg/l as such	0.2 average 0.5 maximum
T-PO_4, mg/l as P	10
pH	8.0 to 8.5
Maximum 2-hour Average Temperature, C°	35.6°C

Source: Black and Veatch, 1978.

day) [2,160 gallons per minute (3.1 million gallons per day)]. Over the lifetime of the units, assuming 66 percent average annual load factor and average atmospheric conditions, the required blowdown will average 2.5 cubic meters per minute (3,600 cubic meters per day) [655 gallons per minute (0.9 million gallons per day)] per unit. The expected quality of freshwater tower blowdown is presented in Table 9.7-3.

Cooling water is continuously treated as necessary to adjust pH in order to limit scale formation. Organic phosphates are also added to inhibit scale formation. It has been common practice to add metals to prevent corrosion, but this is not planned.

In order to control bacterial, fungal, and algal growth, and to prevent fouling by invertebrates, biocides are added to the cooling water. This is discussed in the next section.

Biocide Treatment

Shock chlorination will be used in the circulating water systems for control of bacterial slimes and algae. The chlorination system will be controlled to limit free available chlorine to an average concentration of less than 0.2 mg/l and a maximum concentration of less than 0.5 mg/l in the blowdown discharged to meet the limits set by the EPA. In addition, the chlorination system will be controlled so that neither free nor total residual chlorine is discharged from any one of the units for more than two hours in any one day.

Blowdown to be discharged to the existing discharge canal will be taken from the cold side of the circulating water system as required by EPA regulations.

There will be a phosphate residual in the blowdown as a result of using an organic phosphate material for scale control.

Table 9.7-3 Expected Quality of Freshwater Tower Blowdown for Crystal River Plant Units 4 and 5

Constituent	Cooling Tower Blowdown
Calcium, mg/l as $CaCO_3$	1,000
Magnesium, mg/l as $CaCo_3$	443
Sodium, mg/l as $CaCO_3$	60
M-alkalinity, mg/l as $CaCO_3$*	200
Sulfate, mg/l as $CaCO_3$	1,219
Chloride, mg/l as $CaCO_3$	78
Nitrate, mg/l as $CaCO_3$	6
Silica, mg/l as SiO_2	26

*Based on feeding H_2SO_4 to control alkalinity to 200 mg/l, and utilizing an organic phosphate scale inhibitor.

Source: Black & Veatch, 1976.

Treatment and Disposal

Alternative disposal methods of cooling tower blowdown include injection wells and complete reuse and recycling. Neither of these alternatives were considered to be economically viable or necessary.

OTHER WASTEWATERS

Chemical Wastes

Quantity and Quality

Acidic and caustic chemical wastes will result from regeneration of ion exchange resins and from chemical cleaning operations (metal cleaning wastes).

It is estimated that the wastewaters from the makeup demineralizer will average 0.04 cubic meters (10 gallons) per minute, based on an average demineralized water demand of 0.66 cubic meters (173 gallons) per minute. The condensate polishing system wastewaters, assuming 50 regenerations of each resin bed per year, are estimated to average 0.008 cubic meters (2 gallons) per minute. The preoperational chemical cleaning wastes are estimated to be 4,500 cubic meters (1,200,000 gallons) in volume, with subsequent gallons of wastewater for each cleaning operation. Besides pH, potential causes of pollution are oil and grease, TSS, iron, copper and other metals, phosphates, organic compounds, and BOD from organic emulsifiers.

An acid wash is done every 3 to 5 years to remove scale and corrosion products from the boiler. The composition of this fouling depends upon boiler water composition and additives, boiler tube materials and leaked contaminants. The effluent is analyzed before each treatment is selected. Contents of the approximately 1,360 cubic meters (360,000 gallons) of cleaning water cannot be known ahead of time, but materials commonly

found include calcium carbonate, calcium sulfate, $Ca_x(PO_4)$ silicates $Mg(OH_2)$, iron and copper oxides, zinc, nickel, aluminum, oil, and suspended solids.

Treatment and Disposal

A neutralization basin of approximately 378 cubic meters (100,000 gallons) capacity will be produced for treatment of chemical wastes prior to their ultimate disposal. A basin of this capacity would be sufficient to accommodate the wastewaters produced during regeneration of the ion exchange systems, and would handle the largest volume of chemical cleaning solution wastes at any one time.

The neutralization basin would be a reinforced concrete basin lined with chemical resistant membrane, brick, and mortar. A chemical waste mixer, mounted on the walkway spanning the open-topped basin, would be provided to hasten neutralization of the chemical wastes. Sulfuric acid and sodium hydroxide, as required for neutralization, would be available from the demineralization system regeneration equipment.

The neutralized chemical wastewaters would be conveyed to the Plant Drains Collection Pond for ultimate disposal. Pumping may be needed due to the distance. The Plant Drains Collection Pond would not normally overflow, as the exfiltration rate from the pond is expected to substantially exceed influent flows. During high rainfall events, the Plant Drains Collection Pond could overflow into the cooling tower blowdown conduit. The large quantities of rainfall runoff are expected to make any contributions from the neutralized chemical wastes insignificant. Alternatively, the Plant Drains Collection Pond could be sized for an eventuality exceeding the 10-year, 24-hour design storm and, relying solely on evaporation, exfiltration, and flow to the ash disposal area for dust suppression, would not include provision for surface discharge.

Water Pretreatment Waste

Quantity and Quality

A sludge consisting mainly of calcium carbonate produced in the solids contact unit, and backwash water from the gravity filters, will require disposal. Using the well water analysis presented in the Water Supply and Treatment System Analysis, 1.3 kilograms (2.9 pounds) of precipitate, predominantly calcium carbonate, will be formed per 3,785 liters (1,000 gallon) throughput. Assuming a 5 percent solids concentration in the sludge, a waste flow of about 0.015 cubic meters (2 gallons) per minute will result at the annual average service water demand condition of 0.98 cubic meters (259 gallons) per minute.

Assuming the gravity filters are backwashed weekly for 10 minutes at a rate of 0.06 cubic meters (15 gallons) per minute per square foot of filter area, the annual backwash waste flow is estimated at 0.02 cubic meters (6 gallons) per minute.

Treatment and Disposal

A desirable disposal point for the pretreatment system wastewater is the bottom ash system. The solid portion of the sludge, after dewatering, will be disposed with the bottom ash to the landfill. An estimated 500 kilograms (1,100 pounds) per day of pretreatment system solids will be disposed of in this manner. The pretreatment wastewater may need to be pumped from the pretreatment sludge sump to the ash system because of the elevations and distance.

Ash Handling

Quantity and Quality

Makeup water will be required for the ash water recirculation system to replace evaporation losses and the water entrained in the ash. At the annual average load condition, the estimated water losses from the

bottom ash handling systems are as follows:

Evaporation losses	0.17	cubic meters (45 gallons) per minute
Entrained water in ash	0.068	cubic meters (18 gallons) per minute
Total makeup required	0.238	cubic meters (63 gallons) per minute

Wastewater from the water pretreatment system will be utilized as a source of makeup water. A small amount of service water will be required for the crusher seals and other services.

Treatment and Disposal

A dewatering operation will take place prior to transporting the ash to ultimate disposal. The decanted water will be recirculated and reused. None of the systems considered will involve direct discharge of ash handling water. Since the ash disposal area will be relatively flat, a perimeter ditch and dike system will be constructed to contain rainfall runoff which comes from the active ash disposal area.

The only wastewater from the ash systems that will require disposal will be rainfall runoff from the active ash storage area. The rainfall inside the active ash storage will be contained within the ditch and the dike and will be allowed to evaporate and exfiltrate within the area. The area within the dike will be about 8.1 hectares (20 acres) in size. The annual average rate of wastewater runoff generated by precipitation within the active ash storage area will be about 0.22 cubic meters (57 gallons) per minute.

The maximum 10-year, 24-hour rainfall event of 213 millimeters (8.37 inches) will result in approximately 12 cubic meters (3,160 gallons) per minute of runoff which will be contained within the active ash storage area ditch and dike. A rainfall event of greater than 213 millimeters (8.37 inches) in a 24-hour period will overflow the active ash storage ditch and dike entering the general site drainage system.

Miscellaneous Plant Drains

Quantity and Quality

Miscellaneous plant drains include wastewater from the roof and floor drain system and various equipment drains. Wastewater from the floor drain system results from plant cleaning and maintenance activities and from miscellaneous sources including equipment or pipe leakage, boiler blowdown, and relief valve drains.

Annual average flow rates of the contributors to the miscellaneous plant drains are 0.19 cubic meters (50 gallons) per minute.

Treatment and Disposal

Oil separation traps will be installed in all drains subject to contamination by oil or grease. The traps will be emptied by scavenging equipment for off-site disposal. The miscellaneous plant drainage system will be pumped to the Plant Drains Collection Pond. Normally, exfiltration from this pond is expected to exceed the input. Size of the Plant Drains Collection Pond will be adequate to handle a 10-year, 24-hour rainfall event in order to meet EPA requirements for runoff limitations.

The sources and quantities of plant wastewater directed to the pond at the annual average conditions are as follows:

Misc. Plant Drains	0.19	cubic meters (50 gallons) per min.
Neutralization Basin Effl.	.079	cubic meters (21 gallons) per min.
Pond Precipitation	.068	cubic meters (18 gallons) per min.
Total	0.337	cubic meters (89 gallons) per min.

Based on the 10-year, 24-hour rainfall event of 8.37 inches, the following are the maximum inflowing amounts to the Plant Drains Collection Pond.

Misc. Plant Drains	0.19 cubic meters (50 gallons)	per min.
Neutralization Basin Effl.	0.11 cubic meters (28 gallons)	per min.
Pond Precipitation	3.88 cubic meters (1,025 gallons)	per min.
Total	4.18 cubic meters (1,103 gallons)	per min.

The Plant Drains Collection Pond will be about 2.6 hectares (6.5 acres) in area to provide the necessary exfiltration. A minimum effective depth of about 0.91 meters (3 feet) is required to give a 24-hour retention time maximum flows. The pond will have a discharge and monitoring structure designed to prevent discharge of floating material. Discharge will be directed to the cooling tower blowdown conduit and then to the existing discharge canal. The structure will have provision either for grab sampling or for continuous monitoring as required by the EPA or Florida Department of Environmental Regulation.

Coal Storage Area Runoff

Quantity and Quality

Rainfall runoff from the coal storage areas on an average annual basis is as follows:

New Coal Storage Area 1 .30 cubic meters (80 gallons) per minute
New Coal Storage Area 2 .16 cubic meters (43 gallons) per minute

Using the 10-year, 24-hour rainfall event of 213 millimeters (8.37 inches) as a basis, the maximum runoff from the coal storage areas can be estimated as follows:

New Coal Storage Area 1 22 cubic meters (5,930 gallons) per min.
New Coal Storage Area 2 11.9 cubic meters (3,140 gallons) per min.

There is expected to be some pickup of suspended and dissolved solids in the wastewater from the coal, especially in the initial runoff water.

Treatment and Disposal

All coal storage area runoff will be directed to a perimeter ditch sized to contain a 10-year, 24-hour rainfall event to meet EPA discharge regulations for coal pile runoff.

It is expected that the exfiltration from the coal area rainfall runoff perimeter ditch will exceed the input in all but very heavy rainfall situations. The ditch will be equipped with overflows which discharge into the general site area drainage when rainfall runoff exceeds the holding capacity of the ditch.

General Site Area Runoff

Quantity and Quality

Rainfall runoff from the general site areas on an average annual basis is estimated at 0.4 cubic meters (85 gallons) per minute. Using the 10-year, 24-hour rainfall event of 213 millimeters (8.37 inches) as a basis, the maximum runoff from the general site areas can be estimated at 22.4 cubic meters (5,930 gallons) per minute. The runoff water may pick up some dissolved and suspended solids, especially in areas disturbed by construction.

Treatment and Disposal

General site area runoff will be directed to perimeter ditches. The ditches will be sized to contain a 10-year, 24-hour rainfall event.

Sanitary Wastes

Quantity and Quality

The maximum loading from Units 4 and 5 will occur with Unit 4 operating and Unit 5 under construction. Under these conditions, the estimated maximum hydraulic loading figures will be as follows:

100 permanent personnel (35 gpd*)	13.00	cmd†	(3,500 gpd*)
50 temporary personnel (25 gpd*)	4.73	cmd†	(1,250 gpd*)
40 visitors (25 gpd*)	3.8	cmd†	(1,000 gpd*)
1,000 construction personnel (20 gpd*)	76.00	cmd†	(20,000 gpd*)
Total	97.53	cmd†	

* gallons per day

† cubic meters per day

Biological loading will be approximately 0.034 kilograms (0.075 pounds) of BOD_5 per day for permanent personnel and approximately .020 kilograms (0.045 pounds) of BOD_5 per day for temporary personnel, visitors, and construction personnel, or a total of approximately 26 kilograms (57 pounds) of BOD_5 per day.

During commercial operation, the sewage treatment plant will process approximately 26 cubic meters (8,640 gallons) of sewage per day, containing approximately 8 kilograms (18 pounds) of BOD_5.

Treatment and Disposal

Consideration will be given to constructing a new sewage treatment plant for Units 4 and 5, or alternatively, transporting sewage to the existing sewage treatment plant.

New Sewage Treatment Plant--Plan I

Under this plan, a new sewage treatment plant (STP) would be installed to serve Units 4 and 5 only. The facility would be designed to achieve 90 percent reduction of BOD_5 and suspended solids, in accordance with the requirements of the DER. Chlorination would be provided to disinfect the plant effluent. The plant would be a 114 cubic meters (30,000-gallons) per day packaged, activate sludge unit which employs the extended aeration process method of treatment. Figure 9.7-1 (Black and Veatch, 1977) shows a possible location of this new sewage treatment plant. Effluent from the STP would be routed to a dedicated percolation

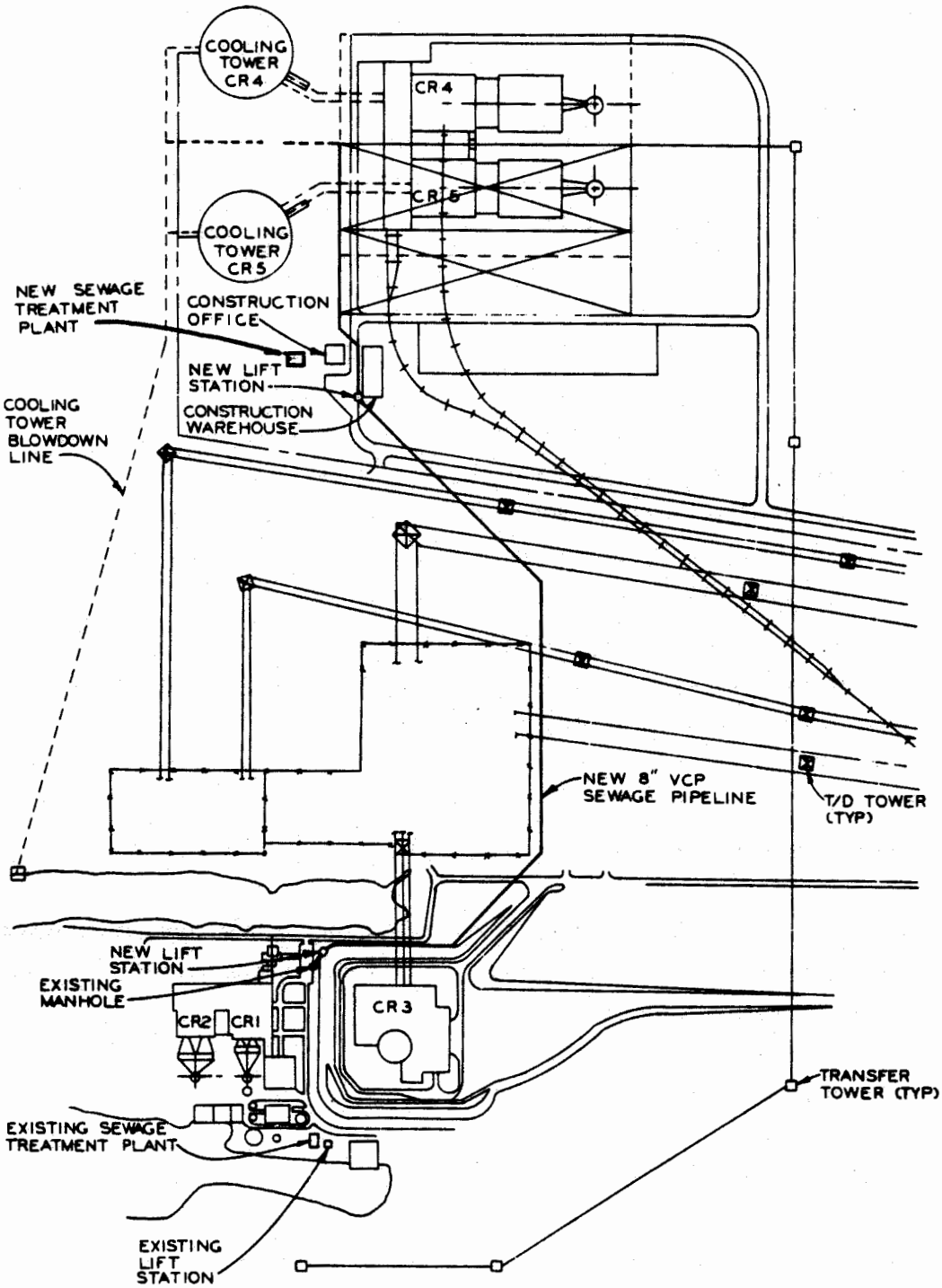

Figure 9.7-1
SEWAGE TREATMENT AND TRANSPORTATION

N

0 200 400 800
SCALE IN FEET

SOURCE: BLACK AND VEATCH, 1969

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

pond for ultimate disposal. Sewage sludge either will be disposed of onsite in the ash landfill or will be removed by a commercial sludge disposal service.

Transporting Sewage to Existing Sewage Treatment Plant--Plan II

The existing facility has a capacity of 114 cubic meters (30,000 gallons) per day. The current average hydraulic load from Units 1, 2, and 3 is about 30 cubic meters (8,000 gallons) per day with reported maximum flows of 42 cubic meters (11,000 gallons) per day. The existing plant is capable of handling the additional wastes from Units 4 and 5 under most situations. However, with the maximum loading from operation of Units 1, 2, 3, and 4, and construction of Unit 5, the existing sewage treatment could be overloaded by several thousand gallons per day.

Transporting the sewage to the existing facility would require 820 meters (2,700 feet) more of 8-inch vitrified clay pipe than would a new sewage treatment plant. It is estimated that at least 12 additional manholes and 2 lift stations would be required to transport the sewage. Figure 9.7-1 shows the possible routing of this sewage piping. No significant additional operator attention and cleanup facilities would be required if the existing facility were utilized.

Capital costs for these plans are shown in Table 9.7-4. The operating costs and the comparative annual costs for the two plans are shown in Table 9.7-5. A new sewage treatment plant could be located in the cooling tower area, and the plant effluent could be routed to a dedicated percolation pond. Following completion of construction, the average sewage flow expected from Units 4 and 5 will be about 0.02 cubic meters (6 gallons) per minute.

Table 9.7-4 Comparative Capital Costs—Alternative Sanitary Waste Treatment Systems

Item	Plan I New Sewage Treatment Plant	Plan II Transporting Sewage to Existing Sewage Treatment Plant
Sewage	$ 50,000	$ 0
Operator's Wash Station	5,000	0
Sewage Piping and Manholes	Base	101,000
Lift Stations	Base	30,000
Subtotal	55,000	131,000
Interest During Construction at 42 per cent	23,000	55,000
Indirect Costs at 8.7 per cent	5,000	11,000
Total	83,000	197,000
Differential	Base	114,000

Source: Black and Veatch, 1977.

Table 9.7-5 Comparative Annual Costs--Alternative Sanitary Waste Treatment Systems

Item	Plan I New Sewage Treatment Plant	Plan II Transporting Sewage to Existing Sewage Treatment Plant
Operating Costs		
Energy	$ 1,500	$ 500
Operating Personnel	10,000	Base
Subtotal	11,500	500
Differential Operating Costs	11,000	Base
Demand Charge	800	300
Fixed Charge at 14 per cent	Base	16,000
Total	11,800	16,300
Differential	Base	4,500

Source: Black and Veatch, 1977.

DISCHARGE STRUCTURES

If saltwater is used for condenser circulation, the discharge structure requirements will be as discussed in Cooling System Alternatives, Section 9.5 of this document. If fresh water is used, the cooling tower blowdown discharge will also be located at the existing circulating water discharge canal. The maximum blowdown rate would be 10.4 cubic meters (2,750 gallons) per minute if water from Crystal River is utilized, and about half this magnitude if Lake Rousseau water is used.

If Lake Rousseau water is used for cooling tower makeup, one pipe approximately 10 inches in diameter will be required for blowdown. A 12-inch diameter pipe will be required if Crystal River water is utilized. The location of the discharge at the existing discharge canal will be such that the cooling tower blowdown can gravity feed into the canal.

9.7.4 COMPARATIVE ANALYSIS OF ALTERNATIVES CONSIDERED

INTEGRATED WASTEWATER MANAGEMENT

Suitable reuse and handling of wastewaters can reduce costs and minimize potentially harmful effluents. Table 9.7-6 summarizes sources of wastewater and their flow rates, characteristics, and possible reuses. Table 9.7-7 summarizes three alternative wastewater flow patterns which are schematicized in Figures 9.7-2, 9.7-3, and 9.7-4.

Each of the three wastewater flow schemes offers advantages as well as disadvantages. In Alternative 1, for example, boiler blowdown may be recycled either to demineralization or to pretreatment for reuse, rather than simply being bled off as waste as in Alternatives 2 and 3. On the other hand, Alternatives 2 and 3 handle stormwater runoff with efficient runoff retention collection systems rather than relying solely on grading and seepage through ground cover. A retention system may provide a measure of treatment through sedimentation and limited, naturally-occurring biological stabilization of the critical first flush of pollutant-containing runoff. Alternative 3 offers a distinct advantage over Alternatives 1 and 2, however, by virtue of the ash landfill in place of an ash pond for ultimate ash disposal. Land filling will enable disposal with the least adverse environmental impact by minimizing contact between ash and water, thereby minimizing both leachate production and the potential for surface discharge of pollutants.

ENVIRONMENTAL CONSIDERATIONS

Characterization and Volume of Wastewaters

There are two potential sources of fresh water for cooling, and sea water is a third possibility. Fresh water would be evaporated to a calcium concentration of about 1,000 ppm, allowing five or more cycles of concentration. The rate of blowdown would be 11,000 cubic meters (3 million gallons) per day or less. Sea water would probably go through less than 1.3 cycles of concentration. This would produce a

Table 9.7-6 Sources of Wastewater: Their Flow Rates, Characteristics, and Possible Reuses

Source	Volume	Content	Possible Reuses
Cooling blowdown, fresh water	3,400-11,000 cmd* (0.9-3 mgd)	pH 6-7, TDS, low level organic phosphates and chlorine	Ash transport
Cooling blowdown, salt water maximum	333,310 cmd* (88 mgd)	Salts 31 ppt, phosphates, chlorine	?
Demineralizer, condensate polisher	0.079 cmpm † (21 gpm)	H_2SO_4, N_2OH, concentrated minerals from freshwater inflow	Neutralizing, ash transport
Boiler cycle losses	.31 cmpm † (81 gpm)	High pH but low poise, still rather pure water	Recycle to demineralizer or for cooling tower makeup
Plant floor and equipment drains, all miscellaneous cleaning, etc.	0.19 cmpm † (50 gpm)	Oils, grease, pH, metals, no PCB's, phosphates, TSS	Ash transport
Roof drains	Average 0.08 cmpm † (Average 20 gpm)	TSS, rather clean	Most uses
Ash handling if 20 acres, 680 GPM exfiltrate, net rain gain 12.4 GPM	0.07 cmpm † 18 gpm entrained in ash	TSS, pH, metals, oil and grease	Recycle from pond for ash transport, entrained is lost
Coal runoff--Area 1	Average 0.3 cmpm † (Average 80 gpm)**	TSS, pH, metals, oil and grease	Neutralizing, ash handling
--Area 2	Average 0.16 cmpm † (Average 43 gpm)**		

Table 9.7-6 Sources of Wastewater: Their Flow Rates, Characteristics, and Possible Reuses (Continued, Page 2 of 2)

Source	Volume	Content	Possible Reuses
Sewage	Average <0.05 cmpm (Average <13 gpm)**	Nutrients, BOD, TSS	Irrigation of grounds, ash handling
Metal cleaning	1,200,000 gallons at start up 360,000 gallons every 3-5 years	pH, TSS, oil and grease, metals	Neutralizing, ash handling

*cubic meters per day = cmd
†cubic meters per minute = cmpm
**gallons per minute = gpm

Source: Black and Veatch, 1976.

Table 9.7-7 Wastewater Flow Alternatives

	Cooling Water	Service Water	Steam Cycle Water	Plant Drains Collection Pond	Wastewater Associated With Ash Disposal	Runoff Collection Retention System	Coal Storage
Alternate 1	From seawater Alternate addition from Lake Rousseau and pretreatment Blowdown discharge to Gulf via Long Channel	From wells Sewage effluent to cooling tower blowdown channel or groundcover irrigation Plant drains discharge to ash pond	From demineralizer Boiler recycle to demineralizer or pretreatment Condensate polishing utilized Waste effluent to ash pond No neutralization basin	Not included in this alternative	Ash Pond: Receives flow from plant drains system, cooling tower blowdown, rainfall, pretreatment, filtering condensate polishing Outflow to exfiltration, evaporation, overflow to cooling tower blowdown channel Ash storage: Incident rainfall overflow to cooling tower blowdown channel	Runoff controlled by grading and groundcover inflow from roof drains and grounds Outflow to evaporation, exfiltration, cooling tower blowdown channel	(In conjunction with coal runoff pond) Receives rainfall Outflow to cooling tower blowdown channel, evaporation, exfiltration
Alternate 2	From seawater Alternate addition from pretreatment Blowdown discharge to Gulf via Long Channel	From wells Sewage effluent to cooling tower blowdown channel Plant drains discharge to plant drains collection pond	From demineralizer Boiler cleaning wastes, condensate polisher blowdown to neutralization basin	Receives flow from plant drains, neutralization pond, rainfall Outflow to ash pond, evaporation, exfiltration Overflow to cooling tower blowdown channel	Ash pond: Receives from plant drains collection pond, water pretreatment and filtering, cooling tower blowdown, rain Outflow to evaporation, exfiltration, ash storage Ash storage: incident rainfall overflow to cooling tower blowdown channel	Receives flow from ash pond, ash storage, coal storage, grounds, rainfall Outflow to evaporation, exfiltration, cooling tower blowdown channel	Receives rainfall Outflow to runoff collection system, evaporation, exfiltration

Table 9.7-7 Wastewater Flow Alternatives (Continued, page 2 of 2)

	Cooling Water	Service Water	Steam Cycle Water	Plant Drains Collection Pond	Wastewater Associated With Ash Disposal	Runoff Collection Retention System	Coal Storage
Alternate 3	From seawater Blowdown discharge to Gulf via Long Channel	From wells Sewage effluent to dedicated percolation pond Plant drains discharged to plant drains collection pond	From demineralizer Boiler cleaning wastes, condensate polisher blowdown to neutralization basin	Receives flow from plant drains, neutralization basin, boiler blowdown, rainfall Outflow to ash landfill for dust suppression, evaporation, exfiltration No overflow structure	Ash landfill: Receives flow from plant drains collection pond, ash and rejects handling, rainfall Outflow to exfiltration, evaporation, overflow to retention collection system	Receives direct rainfall, roof drainings, overflow from coal storage and ash landfill Overflow to discharge canal, evaporation, exfiltration	Receives rainfall Overflow to runoff collection system, evaporation, exfiltration

Source: Environmental Science and Engineering, Inc., 1980.

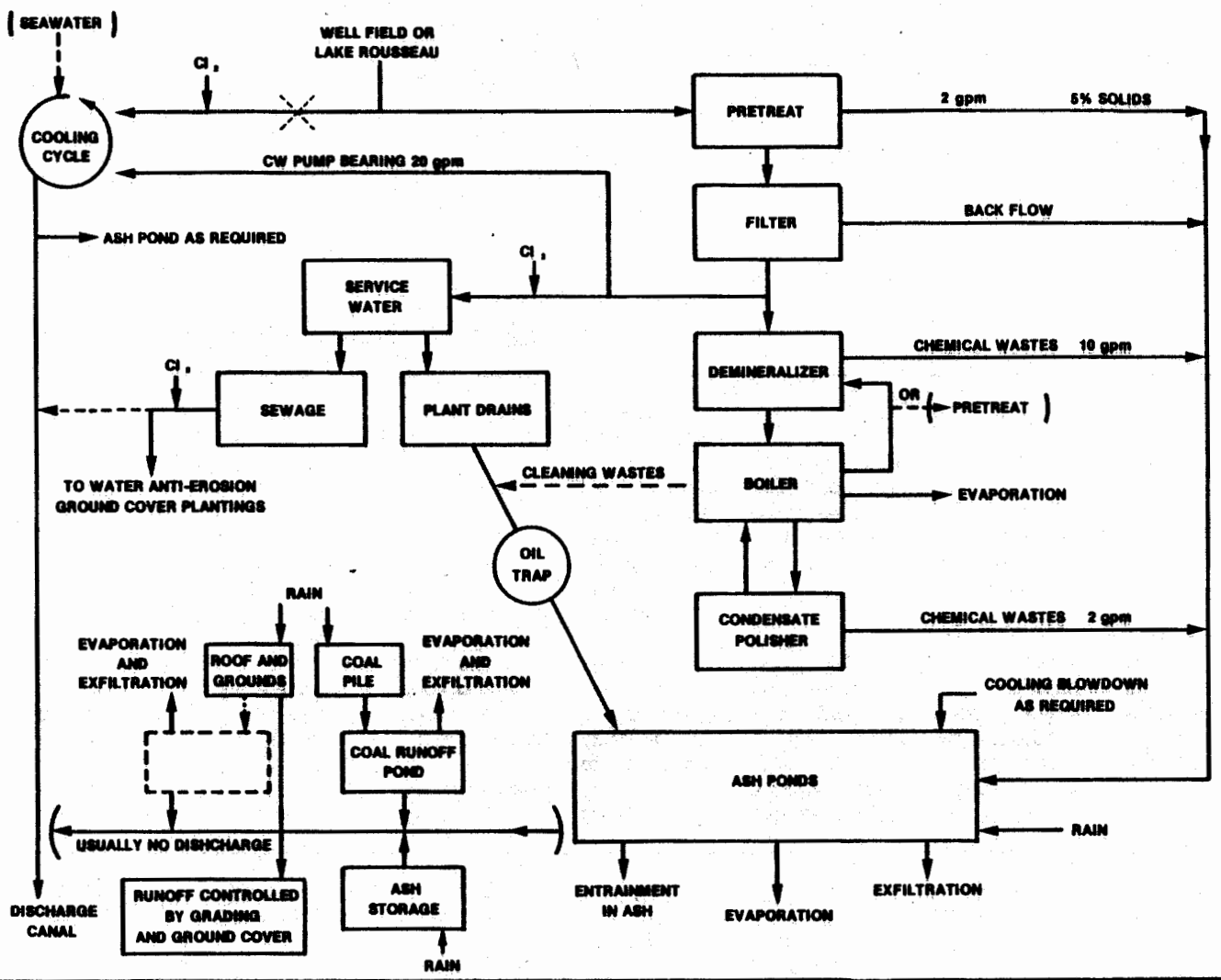

Figure 9.7-2
WASTEWATER FLOWS, ALTERNATE 1

SOURCE: ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1980.

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

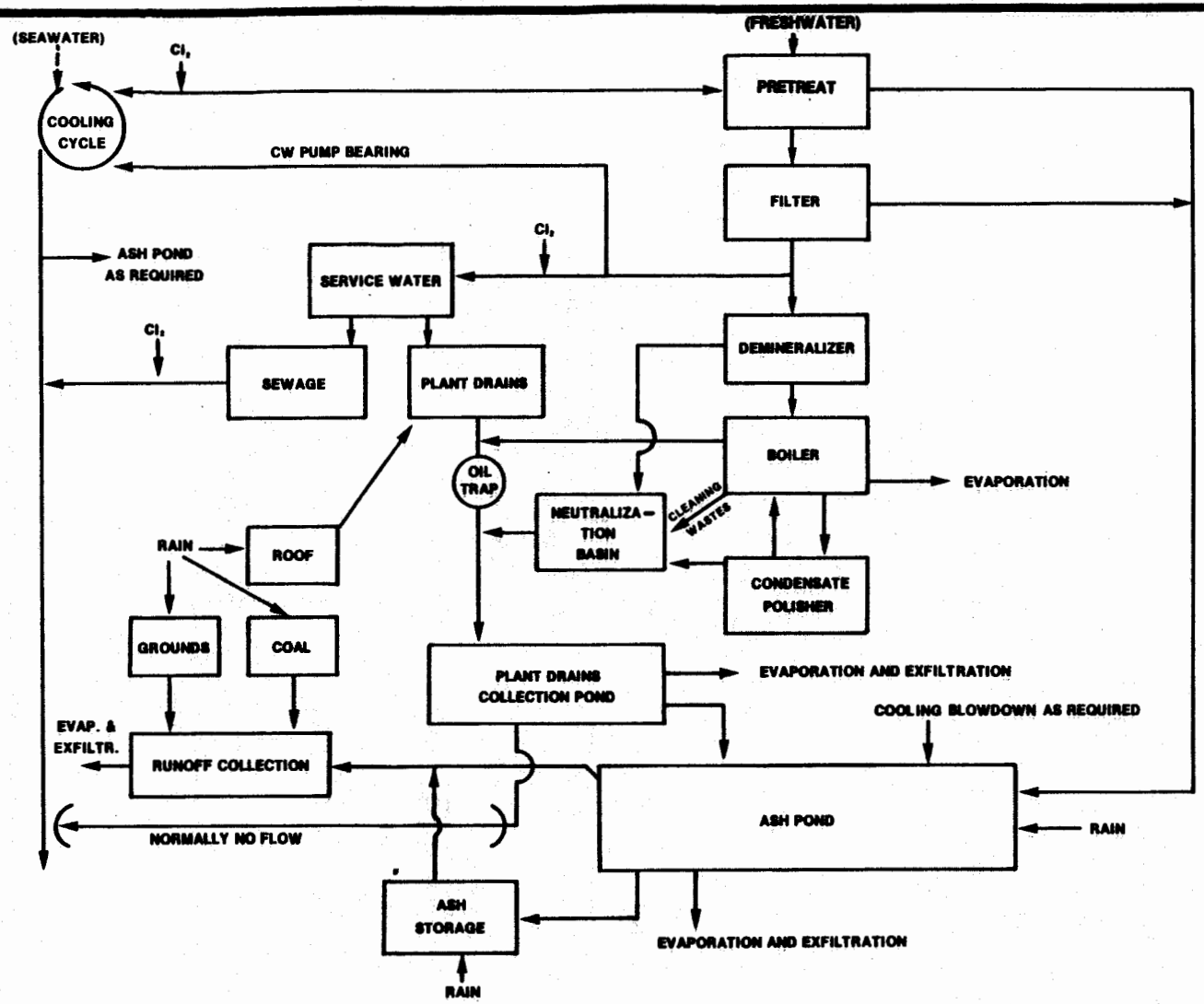

Figure 9.7-3
WASTEWATER FLOWS, ALTERNATE 2

SOURCE: ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1980.

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

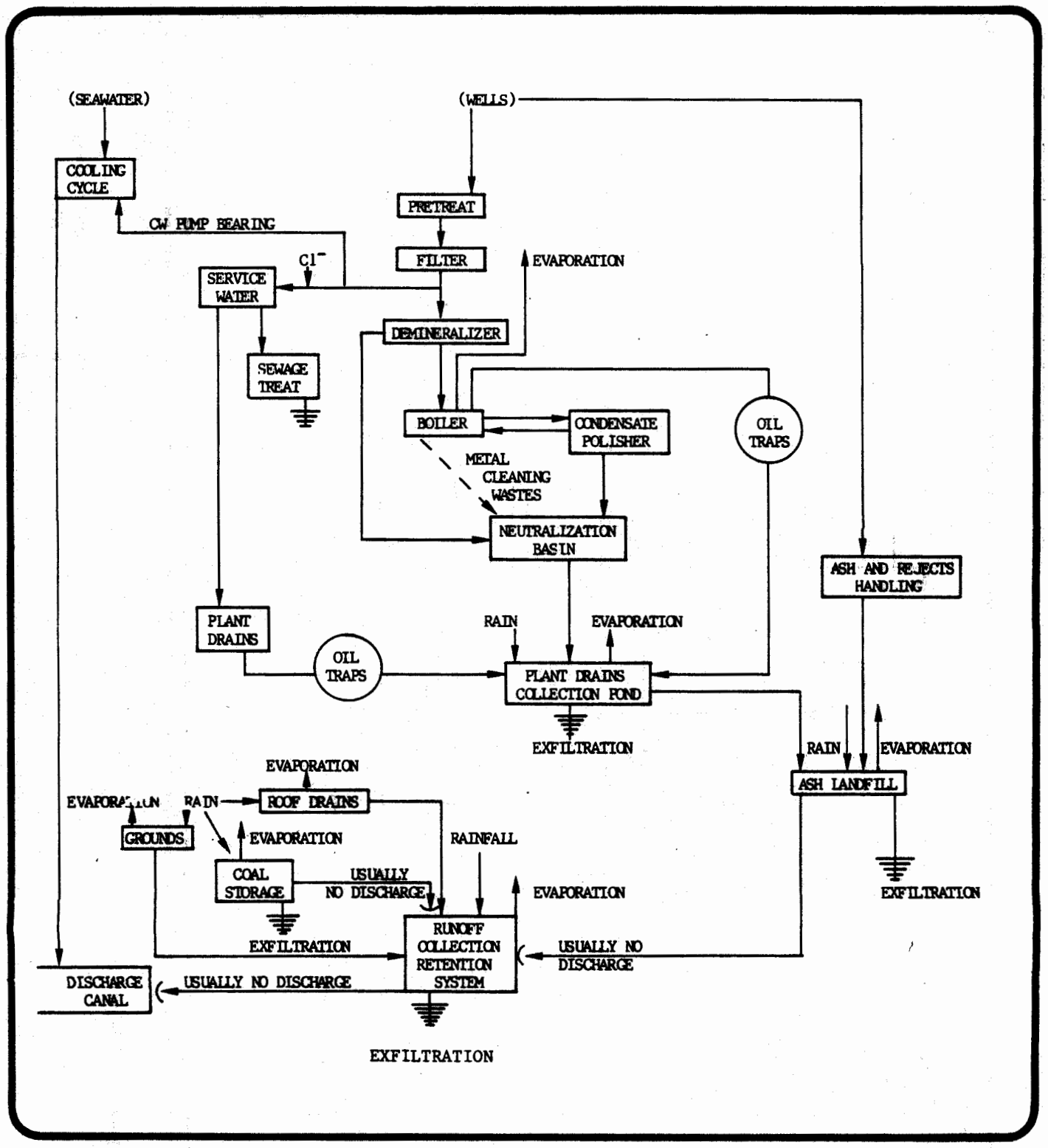

Figure 9.7-4

WASTE WATER FLOWS ALTERNATE 3

SOURCE: ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1980

FLORIDA POWER CORPORATION

PROPOSED CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

maximum of about 333,000 cubic meters (88 million gallons) per day of water at 31 ppt (intake=24 ppt). For either source, the evaporation rate is about 61,500 cubic meters (16 million gallons) per day maximum.

Cooling water is continuously treated as necessary to adjust pH in order to limit scale formation. Organic phosphates are also added to inhibit scale. It has been common practice to add higher phosphates and metals to prevent corrosion, but this is not planned because EPA does not allow any discharge of corrosion inhibitors. In order to control bacterial, fungal, and algal growth, and to prevent fouling by invertebrates, biocides are added to the cooling water.

Biocide Treatment Systems

The usual biocide for prevention of fouling is chlorine gas or hypochlorite. Shock treatment has been in common use and is now required by EPA in preference to continuous treatment. Discharge limit is an average of 0.2 ppm for no more than 2 hours per day (40 CFR 423.15 i and j).

Chlorine is highly toxic, but a summary of all available data suggests that 0.2 ppm is generally safe (Becker and Thatcher, 1973). As with all toxins, some species are much more sensitive to chlorine and are killed by considerably lower concentrations. Carpenter, et al. (1972) found that chlorine added at 0.1 ppm to cooling water intake with undetectable concentrations (<0.05 ppm) at discharge, reduced phytoplankton productivity in the discharge by 79 percent. There is some suggestion that this result is just a temporary lag in growth (Hirayama and Hirano, 1970); still, concentrations should be kept as low as possible. More recently, Toetz, et al. (1977) found that even at the very low initial concentration of 0.028 ppm (and actual exposure therefore less), chlorine depressed by 50 percent the nitrate uptake by phytoplankton.

However, these demonstrations are all of short-term effects. From laboratory experiment models of chlorination effects on marine phytoplankton, Goldman and Davidson (1977) concluded that chlorine toxicity is a function of biomass and that "...phytoplankton not killed by chlorination are capable of renewed growth once recovered, with no apparent permanent effects on growth rates." (species was Phaeodactylum tricornutum). Probably the most serious potential effect of chlorination arises from the still unknown fate and toxicity of organochlorine compounds.

Adding chlorine during the day might minimize effects, because ultraviolet speeds chlorine breakdown in sea water (Hostgaard-Jensen, et al., 1977). The effects of these bromine compounds and the effects generally of chlorination on marine ecosystems are almost completely unknown. The best available guide for residual chlorine remains the data of Brungs (1973—fresh water) and Becker and Thatcher (1973), cited above.

Chlorine can be chemically reduced by adding sodium bisulfate or sulfur dioxide, but the additions must be carefully gauged to avoid overcompensation and a new pollution problem. Such treatment is seldom performed, both because of the expense and because chlorine concentrations are usually low enough to be presumed safe and meet EPA requirements.

Ozone has been used in place of chlorine for disinfection and sterilization, but there is little experience with it in this country. It is a powerful oxident sometimes used as sewage biocide. Even with the high organic content of sewage, 3.5 ppm ozone for 20 minutes gives essentially complete kill (Bollyky and Siegel, 1977). Presumably the only byproduct is dissolved oxygen. The O_3 can be electrically generated as needed, so that the hazards of transport are less than with chlorine. However, ozone treatment may be more expensive than chlorine treatment. The concentrations used by Bollyky and Siegel (1977) were lower than previously thought effective, but cost data were not given. If the cost differential is small and if there are no detrimental side effects, ozone treatment should receive serious consideration.

Other methods of fighting fouling include osmotic shock, heating and drying of tubes, continuously running sponge rubber balls through the tubes, and antifouling paints. All of these have been tried, but are usually less effective than chlorination. However, some plants in the United States have found that the sponge rubber balls alone provide adequate cleaning. Environmentally, this would be the preferred cleaning method, because no biocides would be used. There is also an advantage in that balls with abrasive bands can be used to scrape scale from condenser tubes. However, the initial costs are relatively high, and the U.S. EPA estimates that the investment is not repaid unless other methods cannot achieve 80 percent cleanliness of tubes. Usually, other methods can maintain 95 percent cleanliness. If Lake Rousseau water were used for cooling, such a physical cleaning method might be justified by the potential of Corbicula fouling.

Toxins such as acrolein have been suggested as a slimicide. Normal dosage is approximately 0.2 to 1.0 ppm, but shock treatments of 3.0 to 5.0 ppm are sometimes used. Acrolein is highly flammable and quite toxic to mammals. Thiocyanates are effective against many microorganisms, and methylene-bis-thiocyanate is especially attractive because it supposedly is rendered harmless after 1 hour at pH 8. It would be an especially well-suited possibility in this situation with fresh water emptied into sea water.

Another potent biocide, 2,2-dibromo-3-nitrolo propionamide (DBNPA), would also hydrolyze rapidly in sea water. Its half-life is only two hours at pH 8, and rapidly decreases to only 2.5 seconds at pH 11.

Other biocides sometimes used include mixtures of chlorinated phenols. Toxicities of these compounds vary widely not only because of species differences, but also because of antagonistic and synergistic interactions with other substances. Even well below toxic levels, these phenols will give a disagreeable taste to the flesh of fish.

In summary, the best antifouling treatments from an environmental standpoint are the sponge rubber balls, which involve no biocides, and ozone, which leaves only dissolved oxygen. Unfortunately, the physical method is rather expensive and not always adequate by itself. Ozone has been used in some sewage plants, but apparently never by power plants. It is thought to be rather expensive, but no cost data are available.

Chlorine is effective, inexpensive, and very widely used. During long use, no obvious great environmental detriment has become apparent, although some recent research finds major effects from very low concentrations. Residual chlorine could be reduced with SO_2 or sodium bisulfate before discharge, although there is a danger of over-treatment and a new pollutant. Chlorine would seem to be the favored treatment, unless ozone becomes financially feasible.

Of the other biocides, DBNPA and methylene-bis-thiocyanate seem most promising for use at Crystal River because they are rapidly inactivated at the pH of sea water. However, no data are presently available on breakdown products or their effects.

Discharge to Sea

Blowdown from cooling towers could be discharged into the existing canal carrying once-through sea water from the three power plants presently on the site. This 2.4 kilometer (1.5-mile) long discharge canal carries 7,521 cubic meters (1,987 million gallons) per day. Added materials therefore would be diluted and mixed well before reaching open coastal waters. Cooling towers using salt water, which produce the maximum increase in salt load, would add a maximum of about 333,000 cubic meters (88 million gallons) per day of concentrated sea water to the canal. Thus a salinity increase of 0.54 percent from about 24 ppt to 24.13 ppt would result. This is substantially below the limits of any detectable

salinity effect on ecosystems. Blowdown would be drawn from the cool side of the cooling tower, so that there would be no temperature increase relative to the present discharge.

Discharge Via Injection Wells

This alternative is expensive compared to surface discharge, and there is no reason to dispose of water resources in this way when other discharge methods appear acceptable. According to the EPA Administrator's Decision Statement 110.5, before using injection wells all alternatives must be explored and found less satisfactory with regard to environmental protection. This is not the case here, for discharge of blowdown to the sea appears to offer little potential for harm. Furthermore, new state laws in response to Section C of the Safe Drinking Water Act (PL 93-523) should be pending.

Zero Discharge

Techniques are available whereby part of the circulating water is continually desalinated and recirculated. All water received is evaporated off, with only salts to dispose of. Costs run approximately $1.00 per 3.8 cubic meters (1,000 gallons) for electrodialysis or reverse osmosis, totalling at least $328,000 per year for freshwater sources [3,400 cubic meters (0.9 million gallons) per day desalinated].

The volume of water saved would be extremely small compared to freshwater resources of the region, and would not justify the expense of zero discharge. Environmental effects of discharge can be minimal, and zero discharge appears not to be cost-effective.

Alternatively, the blowdown could be recirculated to other uses where water quality is not very critical. However, such use is limited to sluice water for ash transport, involving only 260 cubic meters (0.07 million gallons) per day.

Conclusions

The best method of disposal appears to be via the existing seawater discharge canal. Salinity increments after dilution would be less than 0.2 ppt. The only other additions would be chlorine, a low level of organic phosphate (scale retardant) and a pH lower than sea water. The levels of these will be low so that they will constitute very small increments to existing discharge.

Zero discharge significantly increases costs without noticeable savings to either the coastal ecosystem or regional water resources. It is thus not cost-effective. Local surface and ground water resources are large and currently little used. Some of the blowdown probably will be used in ash handling, but this would be a small portion of total discharge.

9.8 SOLID WASTE DISPOSAL SYSTEM ALTERNATIVES

9.8.1 OBJECTIVES

Coal-burning power plants produce large quantities of solid wastes. With increased use of coal in the future, impacts on solid waste production will also increase. The primary sources of solid wastes from coal-fired power plants are:

1. Bottom ash from furnace;
2. Fly ash from flue gas dust control equipment;
3. Sludge disposal from non-regenerative sulfur dioxide removal systems; and
4. Coal pulverizer rejects.

Typical wastes quantities from coal fired plants are given in Table 9.8-1. Values are for 3 percent sulfur coal. Florida Power Corporation expects about half of the ash for the "No Control" situation (Table 9-8.1) for Units 4 and 5.

If beneficiated coal is used, a large portion of the waste disposal can be accomplished before the coal is received by mine disposal. The major point made in the table is that if only high-sulfur coal is available at the mine, then coal beneficiation will provide the best option from a waste disposal point of view. If a substantial portion of the sulfur is of an organic nature, then moderate beneficiation followed by flue gas desulfurization (FGD) will provide the second best option. The worst situation is no beneficiation, large scale FGD, and no regeneration. If gypsum can be produced as a by-product, then the disposal requirements are similar to the "No Control" case.

Disposal of coal ash has been accomplished throughout the years by ponding or landfilling. Now, however, there is concern about leaching,

Table 9.8-1 Gross Surface Wastes for Commercially Continuous SO_x Emission Control Technologies*

	Limestone Requirements (tons/year)	Gross Wastes (tons/year) at the Utility		Gross Wastes (tons/year) at the Mine
		Ash	Sludge	Coal Refuse
No Controls † for comparison)		600,000		
Coal Beneficiation † (highest level for comparison)		165,000		720,000
Lime FGD (alone)	230,000	600,000	500,000	
Lime FGD (with moderate coal beneficiation)	100,000	220,000	240,000	500,000
Lime FGD (with high level coal beneficiation)	66,000	165,000	155,000	720,000

*Based on a new 1000 Mw plant using 3 percent sulfur Northern Appalachian coal, meeting New Source Performance Standards.
†Does not meet New Source Performance Standards.

SOURCE: Commerce Technical Advisory Board (CTAB), 1975.

and the advent of soluble FGD wastes causes even more concern. Therefore, disposal methods must be selected which protect the integrity of streams, ground water, and other aquatic systems.

9.8.2 ASH DISPOSAL

BOTTOM ASH

Bottom ash here is considered to be furnace slag. The material is relatively insoluble and usually poses no disposal problems. Slag can be disposed of as landfill or sold as road base material, granular material for roofing, aggregate for use in concrete blocks and preformed concrete, asphalt mix material, insulation, and grit for sandblasting (Babcock and Wilcox, 1977).

FLY ASH

The possibility of selling fly ash exists. Fly ash can also be landfilled. Alternatives can be designed to prevent dispersal of the fly ash in transport to the disposal site. Dustless unloaders and wetting methods can be used to alleviate fly ash dispersal.

ASH DISPOSAL ALTERNATIVES

Two ash disposal alternatives were considered for the proposed Units 4 and 5. The alternatives were disposal using: (1) a conveyor system and (2) a truck disposal system (Black and Veatch, 1976).

Conveyor System

In this alternative bottom ash and fly ash would discharge onto a belt conveyor and be transported to the disposal site.

The bottom ash, in a slurry form, would be transported to the dewatering operation. From the dewatering operations,the ash would be discharged onto the conveyors by means of vibrating feeders or chain-type conveyors for control of ash discharge onto the belt. Truck unloading capability would also be necessary for periods of conveyor maintenance.

The fly ash storage silo transfer system would incorporate dustless unloaders for discharge of fly ash onto the belt. Dustless unloaders, which discharge fly ash at a controlled rate along with water, will allow transportation of fly ash without generating dust. The fly ash silo transfer system would also require truck unloading facilities for use during conveyor maintenance periods or for offsite commercial sales.

A disadvantage of the conveyor system is controlling fly ash dust in loading and unloading operations and in blowout during conveyor travel. The dustless unloaders will be effective in reducing re-entrained fly ash. However, fly ash from western coals has a tendency to solidfy when mixed with water. This characteristic could cause operation and maintenance problems if major quantities of western coals are used, or if the design blend coal exhibits fly ash characteristics similar to western coals.

The conveyor system would utilize a 61-centimeter (24-inch) belt and be designed for 376 metric tons (415 tons) per hour. This conveying rate would be sufficient to transport the ash to the disposal site.

The conveyor system would include a permanent transfer house at the disposal site. From this transfer house to the more removed areas of the disposal site, the conveyor system would be constructed of 12-meter (40-foot) light frame sections mounted on skids. Three 30-meter (100-foot) portable conveyors would be used at the end of the conveyor for final direction of the ash. Conveyor sections would be moved and removed as ash is disposed.

Truck System

In this alternative, dewatered bottom ash and dry fly ash would be transported to the disposal site in off-highway rear dump trucks. Off-highway rear dump trucks would be used due to the large volumes of materials to be hauled, the relatively short haul distances, and the requirements for rapid loading and unloading of vehicles.

The off-highway dump trucks, which would be tandem drive axle type as commonly seen on construction and mining sites, are available from a number of manufacturers in sizes from 9 to 45 cubic meters (12 to 60 cubic yards). The trucks would be provided with an automatic latching, top hinged, swing tailgate with extra seals to ensure dust tightness. Advantages of these trucks are wide availability and salability, the high maneuverability inherent in short wheelbase design, and rapid loading and unloading capability.

Based on operation with the design blend coal, it is assumed that open top trucks would be used for both the bottom ash and fly ash transporting operations. The use of open trucks would have similar dust entrainment problems as the conveyor system. Similar to the conveyor system, the most effective method for dust suppression is the use of rotary dustless unloaders at the storage silo. With these unloaders, the fly ash would be wetted down in order to permit transportation to the disposal site in the open top trucks.

In the event cementation problems are experienced with the design blend coals, the trucks would be purchased with a design suitable for the use with removable top covers. With enclosed dump trucks, fly ash could be loaded in a dry state into the trucks. Silo telescopic spouts would be designed to fit tightly over the truck-loading aperture. A pressure relief opening in the truck would be vented into the fly ash storage silo. Dust emission during unloading would be minimized by the operation of the dump or tailgate. Dust suppression would be provided by water fogging.

The number of vehicles required to satisfy these parameters will be a function of vehicle capacity and haul distance. Based on an estimated round-trip time (load, loaded truck to disposal site, unload, return empty truck to loading area) of 20 minutes, five 22-cubic meter (30-cubic yard) trucks would be required for both Units 4 and 5.

Ash Disposal Operations

Ash landfill operations of the initial disposal site would be essentially the same for both the conveyor and truck systems. A perimeter dike approximately 0.9 meter (3 foot) high would be constructed to contain rainfall. Ash disposal would be initiated at the southern end of the disposal area and expanded to the north. This method of development would allow the western portion of the ash disposal area to be initially used for construction lay down purposes.

Rainfall runoff from the active disposal area would be collected in a drainage ditch system and retained within the disposal area. The landfill procedures would consist of (1) removing and stockpiling all soil materials within a given area, (2) deposition of the ash, and (3) covering with topsoil and seeding grass as each section is completed to the specified height.

The ash would be spread into lifts of 15 to 25 centimeters (6 to 10 inches) in thickness and rolled for optimum compaction density. Water fogging or sprays would be used in compaction and control of the ash dust. The following equipment would be used in landfill operations:

1. Compactors. A self-propelled dozer pulling a tapered shoe roller. A spreader blade would also be mounted on the front of the dozer.
2. Water Trucks. Water storage tank mounted on tandem axle truck. The truck would include an engine-driven pump, mounted boom, and portable hand-hose spray units.
3. Reclamation Equipment. Earth-moving equipment as required for "cut and cover" type procedures in the covering of ash. The type of equipment will be variable depending upon the intensity and nature of the reclamation operations at a given point in the disposal area life. It is projected that equipment would include a medium capacity bulldozer with "U" type blade supplemented periodically by a pan scrapper.

Disposal Area Alternatives

There are two design alternatives for the construction of the ash disposal area: (1) lining, or (2) not lining the ash disposal area. A discussion of the economic and environmental considerations of these alternatives follows:

Economic

Lining of ash disposal area would have an incremental cost over not lining the area. The costs would vary depending upon the type of liner. Lining could be accomplished by either a 30-centimeter (12-inch) impermeable clay layer or a PVC liner overlain with a 30-centimeter (12-inch) earth cover. The costs would be $958,320 for the clay liner and $1,742,400 for PVC liners.

Environmental

As both of the proposed liners would accomplish the same purpose, discussion will be limited to lining versus not lining the ash disposal area. The estimated environmental impact in either case is speculative due to uncertainties about ash leachate and runoff impacts.

No Lining--Potential impacts from not lining the landfill would consist of: (1) leachate getting into the groundwater and (2) rainfall runoff. According to some workers, leachate formed by the percolation of water through an active ash disposal area, will probably contain significant concentrations of Fe, SO_4^{-2} and other contaminants (Coutant, et al., 1978). These concentrations were attributed to oxidation and reduction reactions taking place in the ash. The effluent (leachate) was determined to have a biological impact. The same study also concluded that the direct effluent from ash slurry water generally showed little potential for significant environmental impact. This slurry water would not be unlike direct rainfall runoff from the ash area.

The probable impacts of this alternative will be mitigated by the design and operation of the ash disposal system. Since fly ash will be handled dry and the bottom ash will be dewatered, the available rainfall storage in the ash pond will be considerable. Frequent composting and covering of each ash lift will mitigate the possibility of leachate. The rainfall runoff will be diverted to the canal retention system.

Lining--With lining of the ash disposal area, the potential for direct leachate from the ash will be lessened. However, the potential for leaching from other areas or direct discharge will be present.

It is estimated that 0.15 cubic meters (55 gallons) per minute from rainfall would exfiltrate from an unlined ash disposal area. By lining the area, this water would have to be either exfiltrated into the drainage system or discharged directly. If this water were to remain in contact with the ash long enough to allow oxidation/reduction to take place, the resulting effluent could have a significant impact. As with the no-lining alternative, the design and operation of the landfill operations can mitigate these impacts.

A study is presently underway at the Units 4 and 5 which will monitor and test the leachate from the Ash Disposal Area. This study will establish lining needs in light of the geohydrology and geology of the Crystal River site. The monitoring study is discussed more fully in Section 6.2.3 of this report.

9.8.3 SCRUBBER WASTE SOLIDS DISPOSAL

If a FGD system is used, there is a potential for the generation of tremendous quantities of solid waste. With the use of limestone or lime scrubbing, the alternatives are sludge treatment followed by disposal or byproduct generation. The Commerce Technical Advisory Board (1975) has stated: "Options relating to sludge disposal entail large trade-offs in capital vs. operating costs. The broad range of capital required depends on the variability in the price and location of land for disposal, on the disposal method chosen, and on whether the utility chooses to contract with an outside organization for sludge disposal."

Alternative methods for byproduct generation have existed for years and more are being developed. Market conditions are important considerations before decisions can be made to manufacture gypsum from sludge. So far it has proven attractive only in Japan, where there is little disposal space and a high demand for gypsum.

Extensive research is being conducted to determine the ramifications of FGD waste treatment methods (Jones, 1977). Overall, the alternatives are:

1. Pond disposal;
2. Landfill disposal;
3. Mine disposal;
4. Ocean disposal;
5. Gypsum production.

POND DISPOSAL

The material in FGD sludge does not settle easily and is high in soluble compounds and COD. Ponding is possible if an impervious liner of clay or synthetic material is used to separate the sludge from ground water.

The problem with pond disposal is that ultimately the area must be reclaimed. Pond settling of untreated FGD sludge typically results in a

concentrated slurry of less than 50 percent solids (Princiotta, 1975) which exhibits highly liquid behavior. Further dewatering to about 65-70 percent solids is required before physical stability is attained, and optimum compaction is achieved at about 80 percent solids (Rossoff, et al., 1974).

The wastes are very difficult to pump when there are more than 50 percent solids (Rossoff and Rossi, 1974). Since the pond is used as the primary dewatering mechanism, only those approaches that would greatly improve settling properties of the solids are applicable. Examples include: process modifications to increase the size of the sulfite crystals, oxidation to produce gypsum, and chemical treatment (Jones, 1977).

The Aerospace Corporation (Rossoff, et al., 1974) has established ponding costs varying from $5.50 and $10.00 per metric ton of dry solids, excluding pond reclamation costs.

LANDFILL DISPOSAL

The procedures for landfill disposal are similar to those for pond reclamation. Therefore, the sludge must be of a consistency that settles and thickens easily. The Duquesne Light Company has experimented with a fixing agent followed by a thickening operation. The final product is excellent for landfilling, according to Pernick (1977). Many other candidate fixing agents are being studied (EPA, 1976).

The problems are lessened somewhat if low-sulfur Western coal is used, because more of the sludge is in the sulfate (gypsum) form (Jones, 1977).

MINE DISPOSAL

Mine disposal of FGD wastes is logical in that coal cars leave empty from power plants after coal delivery. The major problems arise because

of possible leaching of these wastes from the mine site. Certain types of mines in various locations do hold promise and are being investigated for their suitability in handling sludge by the Radian Corporation (U.S. Bureau of Mines Contract S0144135) and Arthur D. Little, Inc. (EPA Contract 68-03-2334).

OCEAN DISPOSAL

While ocean disposal is a possibility, many problems are indicated (Jones, 1977):

1. Ocean floor sedimentation;
2. Suspended solids;
3. Sulfate rich, high COD wastes;
4. Trace contaminants.

The following options are open which appear promising:

1. Dispersed disposal of sulfate-rich FGD wastes on the Continental Shelf,
2. Concentrated disposal of treated, brick-like FGD wastes on the Continental Shelf,
3. Dispersed disposal of sulfate-rich FGD wastes in the deep ocean,
4. Concentrated disposal of both sulfate-rich and treated FGD wastes in the deep ocean (Jones, 1974).

No doubt permits would be required, as well as environmental impact statements, before this alternative could be considered viable.

GYPSUM PRODUCTION

The prevailing attitude in the United States automatically ties FGD, by lime and limestone scrubbing, to sludge formation with insurmountable disposal problems. In Japan, a simple oxidation step makes it possible to produce dry gypsum, which is sold as a byproduct (Beychok, 1974). As of 1974, processes developed by Chiyoda, Mitsubishi, Nippon K.K.,

Show Dneko, and Kureha Chemical were in use for gypsum production in Japan.

In the sludge disposal problems discussed previously, the solutions were very often based upon the use of fixing agents, thickening, and even oxidation, to produce calcium sulfate. Probably by the time all costs are considered, including fixing and pond reclamation in the disposal alternatives, the revenues from gypsum production can offset the added cost of its production. Thus, in the long run, it might be the best all-around solution for the disposal of FGD slurry.

Gulf Power Corporation has employed a dilute sulfuric acid scrubbing process [Chujoda (T-101)] at its Scholz Generation Station in Chattahochee, Florida. Gypsum is produced as a by-product. Their costs should be analyzed as well as the marketability of the gypsum produced.

Gypsum production is a feasible alternative which has not been greatly promoted so far. The economics have not yet made it appear attractive. However, new attention given to the environmental problems of sludge disposal, and the costs of fixing agents and thickening, may give this alternative a higher priority.

9.9 TRANSMISSION FACILITIES ALTERNATIVES

9.9.1 EXISTING FACILITIES

The Crystal River site presently is served by two 500 kv transmission lines and four 230 kv transmission lines, all of which enter the site from the east. There is one 500 kv substation and one 230 kv substation.

The 500 kv substation is a three position ring bus arrangement with one transmission line exiting north (Crystal River, Central Florida), one transmission line exiting east, and one nuclear generation tie exiting south. The 230 kv substation consists of a four bay breaker and one-half arrangement with four transmission lines exiting north (double circuit Curlew Line, and double circuit Central Florida Line), two fossil-fuel generation ties exiting south, and two reserve auxiliary ties exiting south (one to fossil-fuel generation—Crystal River Units 1 and 2, and one to nuclear generation—Crystal River Unit 3). The substations are located so that all of the tie lines to existing power generation units are 180 meters (600 feet) in length or less.

9.9.2 FUTURE REQUIREMENTS

The proposed addition of two 640 Mw units at the Crystal River site will not require construction of any new transmission corridors, substations, or transmission lines other than ties to the existing substation which will require additional circuit breakers. Transmission planning has been based on the assumption that the first of the new generation units would be connected to the 230 kv substation and the second unit to the 500 kv substation. There would be one 230 kv reserve auxiliary transformer for the two new coal-fired units. The addition of these units would require the tie lines and some expansion of the existing substation facilities.

9.9.3 ALTERNATIVE TRANSMISSION SYSTEMS

The relevant criteria when evaluating alternative transmission systems in this case were that the length of the lines should be minimized, environmentally sensitive areas should be avoided, and transmission line crossings should be minimized for reasons of safety. Four transmission alternatives have been considered, corresponding to the four potential sitings of the power generating units.

Under the first alternative, serving location 1 with cooling tower, the tie lines would extend south from the power generation units, then would part and head east to the two substations (refer to Section 9.2). Both would exceed 910 meters (3,000 feet) in length. The line to the 500 kv substation would necessarily cross all four of the existing 230 kv lines serving the Crystal River complex. Both of the tie lines would cross wetland areas due to the location of the power generating units within the present coastal marsh.

The second alternative, involving location 2 with cooling towers, would require a 455-meter (1,500-foot) tie extending east and northeast to the 230 kv substation, and a line approximately 1.6 kilometers (1 mile) long to the 500 kv substation. The latter would cross the existing 230 kv lines and would extend across a fragile wetland area.

The third alternative would serve location 3, located southeast of the existing power generation units, and would require tie lines of 760 meters and 1,160 meters (2,500 and 3,800 feet), respectively. No power line crossings would be required in this case, and environmentally-sensitive areas would not be affected.

The fourth alternative would involve location 1c, in which the power generation units would be located directly north of the 500 kv substation. The tie lines in this case would extend west and south and would have total lengths of 1,000 and 1,300 meters (3,300 and 4,300 feet). No major effects to the coastal forest will result; however, the line to

the 500 kv substation would again have to cross the existing 230 kv lines.

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Attachment 1. Program Review and Statistical Evaluation Synopsis;
Attachment 2. Water Quality Summary;
Attachment 4. Example of Physical Plant Data Format. Data is stored on computer tape;
Attachment 5. Synopsis of Research Publications of the Hydrographic Study;
Attachment 6. Thesis of Mr. Ronald Klausewitz containing Thermal Plume Model Verification;
Attachment 7. Source of Cooling Water Study;
Attachment 8. Summary of Phytoplankton Data;
Attachment 9. "Evaluations of Interactions between a Power Generation Facility and a Contiguous Estuarine Ecosystem." Samuel C. Snedaker and staff;
Attachment 10. Map of Approximate Macrophyte Standing Crop. Martin vanTine;
Attachment 11. Juvenile Fish Entrapment Study;
Attachment 12. Intake Velocity Measurements Taken at the Travelling Screens of Units 1 and 2;
Attachment 13. A Review and Annotated Bibliography of the Problem of Fish Entrapment at Power Generating Facilities.

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