STATE OF FLORIDA

DEPARTMENT OF ENVIRONMENTAL REGULATION

IN RE:)

Florida Power & Light Company)
St. Lucie Power Plant Unit No. 2;)
Modification of Terms and Condi-)
tions of Certification No.)
PA-74-02, St. Lucie County,)
Florida,)

Petitioner.)

PETITION FOR MODIFICATION OF CONDITIONS OF CERTIFICATION

Petitioner, FLORIDA POWER & LIGHT COMPANY, hereby petitions for modification of the conditions of certification for the St. Lucie Power Plant Unit No. 2 pursuant to Section 403.516(1), Florida Statutes, and Section 10 of the General Conditions of Certification and states:

I. INTRODUCTION

1. Petitioner is an electric utility company which is constructing a two-unit nuclear power plant, on Hutchinson Island, approximately midway between the cities of Fort Pierce and Stuart, Florida, in St. Lucie County (the "St. Lucie Power Plant"). St. Lucie Unit No. 1 ("Unit No. 1") is fully constructed and began operation in 1976. St. Lucie Unit No. 2 ("Unit No. 2") is near completion and is anticipated to begin operation in late 1982 or 1983. Certain facilities at the St. Lucie Power Plant will be utilized by both Unit No. 1 and Unit No. 2 (see Exhibit A). Two such common facilities, associated with the circulating cooling water system, are pertinent to this petition:

a. the intake canal into which water from the Atlantic Ocean is pumped via two buried conduits which extend approximately 1200 feet offshore; and

b. the discharge canal from which the heated water is discharged back into the ocean via two discharge structures, the existing Unit No. 1 Y-port discharge structure and the new Unit No. 2 multiport diffuser.

2. Unit No. 1 was licensed and its construction began prior to the effective date of the Florida Power Plant Siting Act (Sections 403.501 - 403.517, Florida Statutes), while Unit No. 2 was certified pursuant to the Florida Power Plant Siting Act. On May 18, 1976, the Governor and Cabinet (the "Board") issued the site certification for Unit No. 2, subject to Special Conditions of Certification ("Conditions"). By order dated April 7, 1980, the Board approved a modification to the Conditions which authorized a redesign of the cooling water discharge multiport diffuser.

3. Petitioner is now seeking modifications of the Conditions relating to:

a. the thermal limitations and monitoring program;

b. the method of measuring for compliance purposes the seventeen degree (17°) isotherm that extends from the discharge ports of the multiport diffuser;

c. the biological monitoring program; and

d. the chemical limitations and monitoring programs.

These modifications are intended to remove inconsistencies between the permit conditions of Units No. 1 and No. 2 in those areas where the two units have common facilities, to accommodate differences between anticipated performance characteristics based on theoretical design models and actual operating characteristics experienced since Unit No. 1 began operation, to reflect the modified design of the circulating cooling water system's multiport diffuser, and to delete obsolete conditions.

II. PROPOSED MODIFICATION TO THERMAL LIMITATIONS (SPECIAL CONDITION II.A.1)

4. Projected demands on Petitioner's system will require the utilization of the full generating capacity of both Units No. 1 and No. 2. It is for this reason that Petitioner requested and was granted permission by the United States Environmental Protection Agency ("EPA") to increase the maximum allowable discharge water temperature for Unit No. 1. Petitioner is herein seeking an identical increase . St. Lucie Unit No. 2 from the DER.

5. Both Units No. 1 and No. 2 were originally permitted to discharge water at temperatures up to 24°F. above ambient. This limit was imposed upon Unit No. 1 in its National Pollutant Discharge Elimination System (NPDES) permit issued by EPA. It was imposed on Unit No. 2 in the site certification issued by the Board on May 18, 1976. The 24°F. value was derived from the theoretical engineering design criteria for the plant condensers.

6. Based on more than five years of operational experience with Unit No. 1, Petitioner has determined that the influence of naturally occurring phenomena will alter the theoretical operating conditions of the plant to a greater extent than anticipated, thereby causing a reduction in cooling water flow. These naturally occurring phenomena are:

a. Biological fouling that partially occludes the intake pipes; and

b. Tidally caused increases in the level of water in the discharge canal that cause an increase in head pressure between the discharge canal and the ocean.

Tidally influenced increases in head pressure in the discharge canal cannot be avoided. The biological fouling of the cooling water intake pipes can be mitigated by cleaning, but such would entail frequent and costly plant shut-downs.

Cleaning of the cooling water intake pipes, therefore, is not a cost-effective or practical solution to the biological fouling problem.

7. The operational impacts of reduced flows will be intensified by virtue of the Appendix A Technical Specifications imposed by the United States Nuclear Regulatory Commission. Those Specifications have the effect of restricting the intake canal level to a minimum of 10.5 feet elevation below mean low water to assure the maintenance of a minimum submergence level for the cooling water pumps (§ 3.7.5.1).

8. Reductions in flow will cause the cooling water to remain in contact with the heated surface of the condensers for a longer period of time than under normal flow conditions. Assuming a constant megawatt output under reduced flow conditions, the same heat load would be absorbed by less water, resulting in higher temperature discharges. At maximum plant load, the presently allowable 24°F. above ambient temperature limit would be exceeded by several degrees.

9. Because of the desire to avoid losing some of the useful, low-cost generating capacity of Unit No. 2, Petitioner seeks permission to increase the discharge water temperature in lieu of reducing the output of the plant.

10. There is also a need to establish identical thermal limits for Units No. 1 and No. 2 because they share a common cooling water discharge canal, making it impractical to have two different discharge water thermal limitations. This can be accomplished by raising the discharge temperature limitations in the Unit No. 2 certification to the limit now allowed by EPA for Unit No. 1. Petitioner is separately seeking an amendment of the Unit No. 1 NPDES permit to include Unit No. 2 with identical thermal limitations for both units. However, the certification modification sought herein is a legal prerequisite to the NPDES permit modification. (See 33 U.S.C. § 1341.)

11. Petitioner proposes that Section II.A.1 of the Conditions be modified as follows:

II. Effluent Standards and Limitations

. . . .

A. Thermal

1. Discharge

At the point of discharge heated water temperature from the multiport diffuser will not exceed ~~24°~~ 30°F. above ambient at anytime except that the maximum discharge temperature shall be limited to 32°F. above ambient during condenser and/or circulating water pump maintenance, throttling circulating water pumps to minimize use of chlorine, and fouling of circulating water system. This temperature may be measured at a point within the discharge canal. (In determining the temperature differential the time of travel thru the plant may be considered.)

12. As shown in a study performed by Applied Biology, Inc. (see Exhibit B), operation of Unit No. 2 at the proposed temperature levels will be environmentally acceptable.

III. PROPOSED MODIFICATION TO THE MEASUREMENT FOR COMPLIANCE WITH THE TWELVE-FOOT MIXING ZONE (SPECIAL CONDITION II.A.2)

13. Petitioner proposes that the description of the measurement method for determination of compliance with the 12-foot mixing zone (see Section II.A.2 of the Conditions) be modified to reflect the originally contemplated measurement direction while also accommodating the modified design of the multiport (offshore angled) diffuser approved by the Board by order dated April 7, 1980. The proposed modification is needed because a literal reading of the current 12-foot mixing zone limitation would artificially restrict the zone of influence of the heated discharge water to a smaller volume than that contemplated in the initial site certification.

14. The original alternating diffuser design for the Unit No. 2 discharge structure consisted of a 12-foot diameter (inside diameter) partially buried concrete conduit that was to extend into the Atlantic Ocean approximately 2,800 feet from the shoreline. The last 1,060 feet of the pipe was to be a multiport diffuser with 48 alternating 18-inch ports spaced 22.5 feet between centers and oriented to discharge normal (perpendicular) to the centerline of the diffuser. (See Exhibit C.)

15. The modified offshore angled diffuser, approved by the Board by order dated April 7, 1980, consists of a 16-foot diameter (inside diameter) buried concrete conduit that extends into the Atlantic Ocean approximately 3,050 to 3,070 feet from the shoreline. The last 1,380 to 1,400 feet of the pipe is mounted with 58 four-foot diameter riser pipes spaced 24 feet between centers that extend above the ocean bottom and have 16-inch ports oriented to discharge at a 25° angle from the centerline of the diffuser, directed offshore. (See Exhibits D and E.)

16. The original (and current) 12-foot mixing zone limitation requires that the heated discharge water not exceed 17°F. above ambient at 12 feet from the point of discharge "as measured along the axis of the discharge plumes from each port." Because the original discharge plumes were oriented normal to the centerline of the diffuser, the measurement along the axis of the discharge plumes for compliance with the 12-foot mixing zone required a measurement normal to the centerline of the diffuser. If the 12-foot mixing zone dimension is measured in the same direction as originally contemplated (normal to the centerline of the diffuser), detailed calculations have shown that the original 12-foot mixing zone limitation can be met by the modified offshore angled diffuser, even with the increased thermal limitation of 30°F. proposed in Section II of this petition. (See Table 1.) However, if the literal language of the

current limitation were enforced and the 12-foot mixing zone were measured along the axis of the 25° offshore angled discharge plumes, the allowable mixing zone volume would be significantly reduced. Therefore, compliance with the literal language of the current 17°F. limit would require an environmentally unnecessary substantial reduction in the generating capacity of Unit No. 2.

17. The original 12-foot mixing zone limitation, if measured normal to the centerline of the diffuser, can be met under a wide range of discharge cooling water flows and ocean currents. (See Table 1.) The four representative discharge flows used in Table 1 were derived by taking the high and low Unit No. 2 discharge flows during combined Unit No. 1 and Unit No. 2 operation under normal 8-pump operation (pumping the cooling water through the diffuser) and under 7-pump operation. (See Table 2.) The various "friction factors" used in Table 2 take into account various levels of biological fouling of the Unit No. 1 and Unit No. 2 discharge pipes. As biological fouling increases in one discharge pipe, the more discharge flow (cfs) will be realized in the other discharge pipe. Therefore, it is expected that the discharge flow from Unit No. 2 will be at its greatest when both units are in operation and the Unit No. 1 discharge pipe is heavily fouled (friction factor of 0.045). Even under "worst case" conditions, the original 12-foot mixing zone limitation will be met if measured normal to the centerline of the diffuser. (See Table 1.) In addition to the above, the total cross-sectional volume of water contained within the 17°F. isotherm envelope will be less with the new design. (See Exhibit F.)

18 For the reasons stated above, Petitioner proposes that Section II.A.2 of the St. Lucie Unit No. 2 Special Conditions of Certification be modified as follows:

II. Effluent Standards and Limitations

. . . .

A. Thermal

. . . .

2. 12-Ft. Zone

At 12 feet from the point of discharge, as measured ~~along~~ normal to the axis of the discharge ~~plumes from-each-port~~ diffuser manifold, the heated water will not exceed 17°F above ambient.

19. The proposed modification will allow Unit No. 2 to operate at full generating capacity and will not result in any impacts to the environment or the public additional to those previously considered in the certification proceedings.

IV. PROPOSED MODIFICATION TO THE THERMAL MONITORING PROGRAM (SPECIAL CONDITION III.A.2.a)

20. Petitioner proposes that the requirement of Section III.A.2.a of the Conditions that a recording thermograph to be placed at the ocean surface "at a point of maximum surface temperature of a discharge from Unit No. 2," be deleted.

21. Petitioner has monitored the thermal discharge for Unit No. 1 for over three years and, based on that experience, determined that:

a. Florida's maximum allowable temperature (97°F. at the surface) was never exceeded by the discharge from the Unit No. 1 Y-port discharge structure. The multiport diffuser of Unit No. 2 will disperse heated discharge water even more efficiently than the Unit No. 1 Y-port discharge structure. Thus the discharge water temperature from the multiport diffuser will also comply with Florida's maximum allowable temperature.

b. Monitoring tempe. e levels in the ocean by means of a recording thermograph is costly, ineffective and difficult to accomplish because of

vandalism (theft of thermographs) and accidental damage to thermographs by boaters.

22. For the reasons stated above, EPA and the United States Nuclear Regulatory Commission have concurred that it is unnecessary to maintain a monitoring station in the ocean and have deleted this requirement from the Unit No. 1 NPDES Permit and Environmental Technical Specifications. It is anticipated that this requirement will also be omitted from the combined NPDES permit for Units No. 1 and No. 2.

23. Deletion of Section III.A.2.a from the Conditions will result in an estimated savings to Petitioner of approximately $20,000.00 annually, but will not result in increased adverse impacts to the public or the environment.

V. PROPOSED MODIFICATION TO THE BIOLOGICAL MONITORING PROGRAM (SPECIAL CONDITION III.B)

24. Petitioner is separately required by EPA and the Florida Department of Environmental Regulation to establish a biological monitoring program for both Units No. 1 and No. 2.

25. A combined plant-wide biological monitoring program would eliminate needless duplication in the monitoring of biological effects of the thermal discharges of Units No. 1 and No. 2.

26. Petitioner proposes that the current text of Section III.B of the Conditions be deleted and that the Proposed St. Lucie Plant Preoperational and Operational Biological Monitoring Program of August 1981 (the "Proposed Biological Monitoring Program," see Exhibit G), be substituted as the St. Lucie Unit No. 2 Biological Monitoring Program.

27. The Proposed Biological Monitoring Program reflects the knowledge gained by Petitioner during the last six years in the preoperational and operational monitoring programs for Unit No. 1 and will more accurately monitor the effects of the thermal discharge of Unit No. 2 than the

.sting biological monitoring program without adverse impact on the public or the environment.

VI. PROPOSED MODIFICATION OF THE CHEMICAL LIMITATIONS AND MONITORING PROGRAMS (SPECIAL CONDITIONS II.B.2, 4 and 6, and III.A.1)

28. Petitioner proposes that the monitoring requirement for TDS and the limitations and monitoring requirements for the discharge of oil and grease, copper and cyclohexylamine be eliminated from the Conditions Sections II.B.2, 4 and 6, and Section III.A.1, for the following factual reasons, respectively:

a. TDS -- The TDS concentration at the end of the canal will remain essentially constant and will reflect the intake seawater value. Any discharges from sources within the plant should have a negligible effect on the natural TDS levels contained in the once-through cooling water stream. Exhibits H-J contain the salinity levels measured in the discharge canal during two prior years of operation of Unit No. 1. Because there is a direct correlation between TDS concentration and salinity levels, from these data it is apparent that further monitoring of TDS concentrations is unnecessary.

b. Oil and grease -- All discharges to the once-through cooling water discharge system which are regulated under 40 CFR 423 for oil and grease are already required to be monitored for oil and grease by the Unit No. 1 federal NPDES permit. Petitioner anticipates that the same regulations will be imposed on Unit No. 2 when the Unit No. 1 NPDES permit is modified to include Unit No. 2. The process of heat rejection to the circulating cooling water does not present a possibility of contaminating the water with oil and grease.

c. Copper -- Petitioner will be installing condenser tubes fabricated from titanium rather than

from copper/nickel alloys. Therefore, the condenser tubes will not add copper to the cooling water discharge.

d. Cyclohexylamine -- Petitioner will not discharge any cyclohexylamine to the once-through cooling water system.

29. Petitioner further proposes deletion of the monitoring requirements for pH and dissolved oxygen contained in Section III.A.1 of the Conditions. Petitioner monitored the chemical levels in the intake and discharge canals of the St. Lucie Plant cooling water system for several years pursuant to the federal permit requirements for Unit No. 1 (see Exhibits H-K). The collected data show that the heat rejection process to the circulating cooling water does not have a measurable impact on pH or dissolved oxygen levels and, therefore, that it is unnecessary to monitor the cooling water pH and dissolved oxygen levels. The United States Nuclear Regulatory Commission agrees with this conclusion and has deleted this monitoring requirement from the Environmental Technical Specifications for St. Lucie Unit No. 1 (see Exhibit L at 6-8).

30. Petitioner proposes that the following modifications be made to Sections II.B and III.A.1 of the Conditions:

II. Effluent Standards and Limitations

. . . .

B. Chemical

Liquid wastes discharges shall not contain concentrations of pollutants at the point of discharge which may be measured in the discharge canal in excess of the following limitations:

1. Chlorine (Free Available chlorine): 0.2 mg/l average, 0.5 mg/l maximum

~~2. Oil and Grease: 15 mg/l~~

~~3~~2. Polychlorinated biphenyls: or other polycyclic Halogenated compounds — None

~~4. Copper: 20 ppb~~

~~5~~3. Boron: 4 mg/l (net)

~~6. Cyclohexylamines: 0.5 mg/l~~

III. Water Monitoring Program

A monitoring program shall be undertaken by Florida Power & Light Company on the receiving waters and area waters as generally described as follows:

A. Chemical and Physical Monitoring Program

1. Chemical - The following parameters shall be monitored in the intake and/or discharge and reported to the Department quarterly.

Parameter	Sampling Location	Type of Sample	Frequency of Sampling
Flow	**Intake	Pump logs	hourly
Temperature	**Intake/POD	--	hourly
~~pH~~	~~*POD~~	~~Grab~~	~~Weekly~~
~~TDS~~	~~*POD~~	~~Grab~~	~~Monthly~~
~~Oil and Grease~~	~~*POD~~	~~8-hour composite~~	~~Monthly~~
~~Dissolved Oxygen~~	~~*POD~~	~~Grab~~	~~Weekly~~
Free and Total Chlorine Residual	*POD	Grab	Weekly during chlorination
Boron	*POD	Grab	When batch discharges are required***
~~Copper~~	~~*POD~~	~~Grab~~	~~Monthly~~

*May be monitored in discharge canal at the location specified in III.A.2.b.
**May be monitored in intake canal (Plant intake Structure).
***From the refueling water storage tank and nonaerated waste hold up tanks (4).

31. The above proposed modifications to the chemical limitations and monitoring programs will relieve Petitioner of the requirement of instituting needless monitoring programs and will not result in any increased impact on the public or the environment.

VII. REQUEST FOR RELIEF

32. None of the proposed modifications will result in significant environmental impacts or effects to the public that were not previously considered in the certification proceedings.

33. WHEREFORE, Petitioner respectfully requests:

(a) the DER to give notice and opportunity for hearing in accordance with Chapter 403 and Chapter

120, Florida Statutes;

(b) the Secretary of DER to approve the modifications herein described; and

(c) the Secretary of DER to grant such other relief as may be appropriate.

Respectfully submitted,

STEEL HECTOR & DAVIS
Southeast First National
Bank Building
Miami, Florida 33131

and

HOPPING BOYD GREEN & SAMS

By [signature]
Wade L. Hopping
William H. Green
Attorneys for Petitioner
Post Office Box 6526
Tallahass' !, Florida 32301
(904) 222-7500

CERTIFICATE OF SERVICE

IT IS HEREBY CERTIFIED that copies of the foregoing have been furnished by U. S. Mail to all parties listed on the attached Service Schedule this 1st day of September, 1981.

[signature]
Attorney

SERVICE SCHEDULE

Ms. Victoria J. Tschinkel, Secretary
Department of Environmental Regulation
2600 Blair Stone Road
Twin Towers Office Building
Tallahassee, Florida 32301

Mr. Hamilton S. Oven
Administrator of Power Plant Siting
Department of Environmental Regulation
2600 Blair Stone Road
Twin Towers Office Building
Tallahassee, Florida 32301

Lou Hubener, Esq.
Department of Environmental Regulation
2600 Blair Stone Road
Twin Towers Office Building
Tallahassee, Florida 32301

Arthur Canaday, Esq.
General Counsel
Florida Public Service Commission
Room 207, Fletcher Building
Tallahassee, Florida 32301

Joan M. Heggen, Secretary
Department of Community Affairs
2571 Executive Center Circle East
Tallahassee, Florida 32301

Mr. James Dean
Associate Planner, Power Plant Siting Program
Bureau of Land and Water Management
Department of Community Affairs
204 Carlton Building
Tallahassee, Florida 32301

Conservation Alliance of St. Lucie County
c/o Mrs. Marjorie Silver Alder
304 St. Andrews Lane
Fort Pierce, Florida 33450

Martin County Conservation Alliance
Martin Harold Hodder, Esq.
1131 N. E. 86th Street
Miami, Florida 33138

League of Women Voters of
St. Lucie County
c/o Mrs. Judith James
Route 3, Box 423
Fort Pierce, Florida 33450

Mr. Estes Whitfield
Senior Governmental Analyst
Office of Planning and Budgeting
Office of the Governor
The Capitol
Tallahassee, Florida 32304

Citizens United Against
Radioactive Environment
c/o Harry H. Alder
304 St. Andrews Lane
Fort Pierce, Florida 33450

The Honorable Bob Graham
Governor
The Capitol
Tallahassee, Florida 32304

The Honorable George Firestone
Secretary of State
The Capitol
Tallahassee, Florida 32304

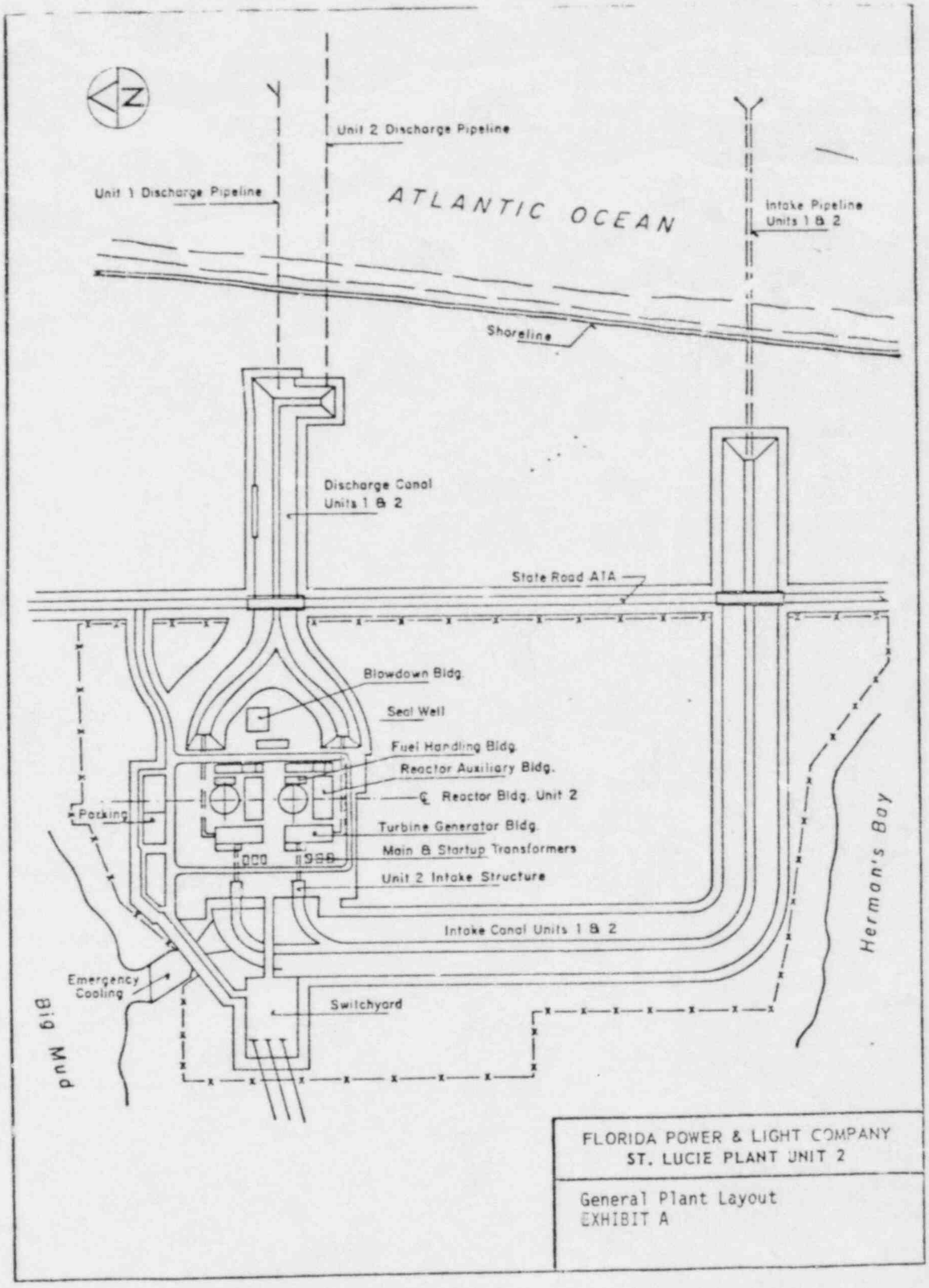
The Honorable Jim Smith
Attorney General
The Capitol
Tallahassee, Florida 32304

The Honorable Gerald Lewis
Comptroller
The Capitol
Tallahassee, Florida 32304

The Honorable William Gunter
Treasurer
The Capitol
Tallahassee, Florida 32304

The Honorable Ralph D. Turlington
Commissioner of Education
The Capitol
Tallahassee, Florida 32304

The Honorable Doyle E. Conner
Commissioner of Agriculture
The Capitol
Tallahassee, Florida 32304



FLORIDA POWER & LIGHT COMPANY
ST. LUCIE PLANT UNIT 2

General Plant Layout
EXHIBIT A

AB-261

FLORIDA POWER & LIGHT COMPANY

ST. LUCIE PLANT

EFFECTS OF INCREASED WATER TEMPERATURE ON THE MARINE BIOTA OF THE ST. LUCIE PLANT AREA

JULY 1980

APPLIED BIOLOGY, INC.

ATLANTA, GEORGIA

EXHIBIT B

TABLE OF CONTENTS

TABLE OF CONTENTS
(continued)

EXECUTIVE SUMMARY

The St. Lucie Nuclear Plant Units 1 and 2 have potential operating modes that alter the temperature and/or volume of the discharge water during certain periods of the year. These operating conditions consist of reduced water flow through the plant resulting from:

1. High tides that limit the flow of discharge water through the discharge pipe;
2. Marine fouling that partially occludes the discharge pipe;
3. Condenser tubes that may be plugged or fouled by marine organisms.

The reduced water flow leads to increased discharge temperatures when the plant is operating at full power. Florida Power & Light Company (FPL) ... considered reducing the megawatt output of the plant to remain within present environmental regulations; however, the need to maintain the generating capacity of the St. Lucie Plant makes the alternative of increasing the discharge water temperatures more desirable than reducing the output of the plant.

To assess the potential environmental impact of increased temperatures associated with reduced flows, FPL has asked Applied Biology, Inc. (ABI), to evaluate the ecological implications of several possible temperatures and flow regimes. These potential operating modes are:

1. Full-pumping flow (1150 cfs per unit) with a condenser ΔT of 28°F;
2. Reduced flow (1075 cfs per unit) with a condenser ΔT of 30°F;

3. Reduced flow (1000 cfs per unit) with a condenser ΔT of 32°F.

In evaluating the impact associated with each of these operating modes, ABI considered a "worst-case" situation of discharging the warmer water during September, the hottest month of the year, which coincides with the highest animal abundance in the aquatic habitat near St. Lucie. Both flow through the plant and temperature rise are variables to consider. Flow was evaluated in relation to plant-entrained organisms while temperature was considered in relation to the amount of offshore water entrained into the discharge plume and heated above the tolerance level of the organisms under consideration. The projected impact of the higher thermal discharge was considered in relation to a reasonable portion of the receiving body of water under oceanic conditions, with and without a current flow lateral to the shoreline. Concurrently, ABI evaluated the potentially higher temperatures in relation to the operation of either Unit 1 or Unit 2 and the two units combined.

WATER MASSES

The offshore waters adjacent to the St. Lucie Plant are primarily derived from the continental shelf, the Indian River, and the Florida Current. The waters influenced by the plant are primarily continental shelf water with some small contributions by Indian River waters discharging from the St. Lucie Inlet or the Ft. Pierce Inlet. The Florida Current rarely sweeps closer than 12 miles off the Hutchinson Island shoreline. It is unlikely that Florida Current waters have a direct influence in translocating near-shore waters.

Extensive studies for Unit 1 on entrapment of fishes into the intake canal and impingement of fishes on the traveling screens have indicated that loss of fishes due to the operation of the intake structure is negligible.

FISH

Assuming the intake of fishes is proportional to the amount of intake water, the additional intake of cooling water by Unit 2 will increase the number of fishes drawn into the intake canal. However, the reduction of flow per unit associated with a thermal increase would reduce this effect slightly.

Fishes are highly motile and will avoid unfavorable thermal regimes near the discharge. Increased water temperatures from Unit 1 due to increased ΔTs would enlarge the area which fish would avoid. The maximum zone of exclusion for fishes would be about 23.1 acre-feet in September. Because of the effectiveness of its diffuser pipe, the thermal additions of Unit 2 would increase this zone of exclusion by less than 2 acre-feet.

ICHTHYOPLANKTON

Ichthyoplankton mortality will increase when Unit 2 is operational due to increased intake of water. At reduced pumping rates for either unit, the impact associated with plant entrainment would decrease, while higher discharge temperatures would increase the impact of plume entrainment. Using both units operating under normal conditions as a basis of comparison, the increase in impact due to alteration of the

operating mode does not exceed 2 percent of the organisms in the region of potential impact. It is anticipated that impacts of higher temperatures for either unit would be offset by reduced impacts associated with lower flows.

MARINE TURTLES

Adult marine turtles are mobile and will avoid unfavorable thermal regimes. Loggerhead turtle hatchlings have demonstrated reduced swimming speeds at water temperatures over 86°F and a cessation of response to light stimuli at 92°F. Based on studies of swimming speed of hatchlings in response to thermal increases, it is anticipated that the few turtles that might encounter these higher water temperatures would resume normal swimming after leaving the exposure area. No effects on distribution, nesting, egg development, or survival are expected.

BENTHIC MACROINVERTEBRATES

The only area where the discharge water influences the benthic community is in the immediate scour area at the point of discharge of Unit 1. Changes in pumping mode or discharge temperature would not appreciably influence the size of the area. Accordingly, no impact on the benthic macroinvertebrate community from discharge temperature changes is anticipated.

The planktonic larvae of many benthic invertebrates, however, could be impacted. Because of the limited periods of production of these larvae, a loss of this segment of the ecosystem could have broad ramifications on the benthic community.

WORM REEFS

The adult polychaete worms that construct the reefs from their sand tubes could be influenced by the units' combined thermal plume during periods with an onshore current. No significant impact on the adult worms is anticipated. The larval stage of development of these worms are sensitive to temperatures above 85°F. The degree of impact would be related to population distribution, water currents, plume configuration, intake volumes, and duration of exposure. Effects on the worm reef, either directly from higher temperature or indirectly through effects on the larvae, would be potentially offset by high recruitment during the cooler months.

ZOOPLANKTON

Zooplankton mortality will increase with the increased intake of water by Unit 2. As with the ichthyoplankton, mortality would increase at higher temperatures but would be largely offset by a decreased mortality related to lower volumes of water pumped through the plant. The maximum effect would increase the impact by less than 2 percent of the number of zooplankters in the region of potential impact.

PHYTOPLANKTON

Phytoplankton losses due to Unit 2 becoming operational and to changes in plant operating modes are estimated to increase by less than 2 percent of the total phytoplankton in the region of potential impact. Rapid turnover rates in the community would compensate for this reduction.

MACROPHYTES

Onshore currents coul. shift the thermal plume inshore and increase the temperature on the macrophyte assemblage on the worm reefs. While these plants are present in low numbers, they might experience a temporary die-back. Revegetation would be expected to occur rapidly after temperatures decreased.

CONCLUSIONS

1. The impact of the St. Lucie Plant is associated with entrainment of organisms both through the plant and into the discharge plume.

2. An incremental increase in impact is expected when Unit 2 is operational. This increase will primarily be associated with the larger volume of water passing through the plant.

3. The diffuser type discharge pipe for Unit 2 will enable rapid mixing of the discharge with ambient waters. This rapid mixing will result in a very small thermal plume being produced. Accordingly, the Unit 2 discharge plume will have a negligible zone of thermal exclusion for motile forms.

4. A potential operating mode raising the ΔT 2°F would only slightly increase the impact in the area of potential impact.

5. Larger increases in ΔT would occur concomitant with decreases in water flow through the plant. This reduction in flow would offset the increased impact associated with the higher temperatures.

6. An increased mortality of less than 2 percent of organisms in the area of potential impact would be associated with the worst-case situation of mean maximum ambient water occurring in September.

7. Lesser impacts would be expected during the remainder of the year.

A. INTRODUCTION

Florida Power & Light (FPL) Company's St. Lucie Plant Unit No. 1 is an 850-MW electric generating facility which uses ocean waters for once-through cooling. Unit 2, now under construction, is similar and is expected to be operational in 1983. After exiting from the plant's condensers, heated water is discharged offshore where it is diluted by ambient waters. This heated water forms a thermal plume having temperatures higher than those of the ambient waters in the vicinity of the discharge structure. The size and temperature of the plume are both of concern to FPL in determining what effects, if any, the plume might have on the aquatic ecosystem off Hutchinson Island.

The purpose of this document is to outline the predicted impact on biological systems that would result from both units under alternative operating modes. The following paragraphs discuss the factors which may necessitate the use of alternative operating conditions. Subsequent sections discuss the potential impact of these changes on biological systems of concern in the St. Lucie area.

TEMPERATURE DISCHARGE LIMITATIONS FOR ST. LUCIE UNIT NO. 1

Operating limitations established by Operating License No. DPR-67 Environmental Technical Specifications currently limit temperature rise (ΔT) across the condensers to 26°F under normal full-power operation. These specifications limit the maximum ocean surface temperature or "hot spot" for the discharged water to 5.5°F above ambient with a 93°F instan-

taneous maximum at any point. Under the Federal Water Pollution Control Act, the establishment of limitations and monitoring requirements for non-radiological liquid effluents is within the jurisdiction of the U.S. Environmental Protection Agency (EPA). A memorandum of understanding betwen EPA and the U.S. Nuclear Regulatory Commission (NRC) gives recognition to this responsibility. A revised National Pollutant Discharge Elimination System (NPDES) permit, issued by EPA on 18 January 1980 provides for a ΔT of 30°F with an allowance for an increase to 32°F under certain operating conditions. No limitation on the offshore temperature increase above ambient was established for the discharged water, and the instaneous maximum for the ambient ocean surface temperature was increased to 97°F. A request to delete the current environmental technical specification thermal limitations in favor of those contained in the NPDES permit is pending before the NRC and is expected to be issued shortly. Thermal limitations for Unit 2 have been established only in the state of Florida. Conditions of certification are 24°F above ambient at the point of discharge from the multiport diffuser with a maximum ocean surface temperature of 97°F but not more than 2°F above ambient during June, July, August, and September, or 4°F above ambient during the remainder of the year.

CIRCULATING WATER SYSTEM

Water for the once-through cooling system of both units enters a submerged intake structure located about 1200 ft offshore. From the intake structure, the water passes through submerged pipes under the beach and dunes and enters a 5000-ft long intake canal. This open canal

transports the cooling water for both units to the plant and through the condensers. After receiving heat from the condensers, the water for both units is discharged into a common open canal, flows underneath the dunes and beach, through buried pipelines, and exits through the respective discharge structures.

Unit 1 Discharge

The Unit 1 discharge structure is located approximately 2400 ft north of the intake and a minimum of 1200 ft offshore. Heated discharge water leaves the discharge structure through a Y-shaped nozzle or Y-port at a design velocity of 13 ft/sec. This high-momentum-type jet serves to entrain cooler ambient water which dilutes the heat. The ocean depth in the area of the discharge is about 18 ft. The discharge pipe and nozzle have been buried in a short trench excavated in the substrate to 36 ft below mean sea level (FPL, 1973). From the point of discharge, the warmer water rises to the surface and forms a surface plume of heated water. Under normal full-load conditions, the maximum increase in surface water temperature seldom exceeds 5°F above ambient. The plume then spreads out on the surface of the ocean under the influence of wind and currents and returns to ambient temperature by heat dissipation to the atmosphere.

Unit 2 Discharge

The Unit 2 discharge pipeline extends about 1959 ft from the discharge canal headwall to the ocean and terminates in the discharge section. The Unit 2 discharge is a multiport diffuser designed with 58

jet ports, each sized to issue a jet about 16 inches in diameter. The length of the diffuser is 1416 ft and the port spacing is 24 ft. The diffuser manifold is optimized with ports alternately oriented north and south at an angle of 25 degrees from the manifold. The distribution of smaller amounts of heated water over a wide area will enable a more rapid and efficient mixing with ambient waters. Maximum surface water temperatures are expected to be 2.0°F less than those near the Unit 1 discharge.

Both the Y-port and multiport discharge will be used when both units are in operation. When only one unit is on-line, the Y-port discharge will be closed.

<u>FACTORS NECESSITATING AN INCREASED PLUME TEMPERATURE</u>

FPL has taken into consideration naturally occurring events which may alter normal operating conditions and thereby alter the temperature or volume of the discharge water. These natural events, which will ultimately cause higher water discharge temperature, are:

1. High tides that limit the flow of discharge water through the discharge pipe;
2. Marine fouling that partially occludes the discharge pipe;
3. Condenser tubes that may be plugged or fouled.

In order to preclude an overflow of the discharge canal under the first and second conditions, the plant may have to reduce the circulating water flow through the system, while the third condition naturally limits circulating water flow. The following two alternatives are available to FPL under reduced flow conditions:

1. Reduce the megawatt output to maintain the temperatures within their normal limits, or,

2. Allow the water discharge temperature to increase to some point above normal.

Because of the need for maintaining the generating capacity at St. Lucie, FPL considers the alternative of increasing the discharge water temperature to be more desirable than reducing the output of the plant. At some point as temperature increases, however, the circulating water flow through the plant must be reduced to avoid inefficient plant operation resulting from excessive condenser back pressure.

To examine the ramifications of an increased thermal discharge on the aquatic ecosystem, FPL hypothesized several operating modes of flow and temperatures which could have potential impacts on the aquatic ecosystem offshore of the St. Lucie Plant. These operating modes assume that generating output is maintained at 100 percent. The present normal operating mode is full-pumping flow (1150 cfs) with a condenser ΔT of 26°F. Under high tide or marine fouling conditions, the flow rates and temperature increases under consideration are:

1. Full-pumping flow (1150 cfs per unit) with a condenser ΔT of 28°F,

2. Reduced flow (1075 cfs per unit) with a condenser ΔT of 30°F,

3. Reduced flow (1000 cfs per unit) with a condenser ΔT of 32°F.

FPL retained Applied Biology, Inc. (ABI), to evaluate potential biological effects on the marine aquatic biota under these different flow rates and temperature conditions.

To evaluate the impact associated with an increase in thermal discharge and the addition of Unit 2, ABI has considered each of the potential operating modes in relation to the various components of the ecosystem that might be affected. This report presents the results of that evaluation and summarizes the plant operating conditions that could be maintained without causing significant environmental impacts.

SOURCES OF THERMAL AND BIOLOGICAL DATA FOR THIS STUDY

To evaluate various operating modes to determine which are environmentally acceptable, ABI used data on discharge rates, dilution rates, thermal increases, and plume sizes from Envirosphere (1978) and FPL (1980). These data are summarized in Table A-1.

Most temperature data have been given in degrees Fahrenheit and have been rounded to the nearest whole degree for ease of presentation. While rounding of numbers results in slight arithmetic discrepancies, the differences have only minor ecological significance. Data presented in the literature in degrees Celsius were cited as such.

An accurate assessment of potential environmental impacts from thermal discharge necessitated that an evaluation be made during the time of year when ambient water temperatures were normally highest. Discharging warm water at this time would produce the most severe or "worst-case" impact. If a worst-case evaluation predicts an impact that is judged to be environmentally acceptable, all lesser impacts would also presumably be acceptable. Therefore, biological data taken in September were chosen

TABLE A-1

PREDICTED DISCHARGE, DILUTION AND THERMAL DATA
ST. LUCIE PLANT

Parameter	ΔT = 26°F	ΔT = 28°F	ΔT = 30°F	ΔT = 32°F
Ambient offshore water temperature (°F)	85	85	85	85
Discharge temperature (°F) (in discharge canal)	111	113	115	117
Plant discharge volume rate (amount of water per unit time pumped by power plant)	cfs ($m^3 \times 10^6$/day)			
	1150 (2.81)	1150 (2.81)	1075 (2.63)	1000 (2.45)
Ocean dilution volume rate for each unit (amount of water per unit/time required to cool plume from one isotherm to the next lower isotherm)				
from discharge to 105°F isotherm	2225 (5.44)	2484 (6.08)	2565 (6.28)	2612 (6.39)
from 105°F to 100°F isotherm	1125 (2.75)	1212 (2.97)	1213 (2.97)	1204 (2.95)
from 100°F to 95°F isotherm	2249 (5.50)	2423 (5.93)	2427 (5.94)	2407 (5.89)
from 95°F to 90°F isotherm	5523 (13.51)	5947 (14.55)	5956 (14.50)	5911 (14.46)
Plant discharge volume rate plus ocean dilution volume rate for each unit (combined amount of water per unit time required to reduce temperature from discharge to isotherms)				
from discharge to 105°F isotherm	3375 (8.26)	3634 (8.89)	3640 (8.90)	3612 (8.84)
from discharge to 100°F isotherm	4500 (11.01)	4846 (11.86)	4853 (11.87)	4816 (11.78)
from discharge to 95°F isotherm	6749 (16.[illegible]1)	7269 (17.79)	7280 (17.81)	7223 (17.67)
from discharge to 90°F isotherm	12272 (30.03)	13216 (32.34)	13230 (32.37)	13134 (32.14)

NOTE: ΔT refers to the temperature rise across the condensers as a result of passage of ambient cooling water through the plant.

for analysis because of the concurrent high animal abundance and high ambient temperatures recorded for the St. Lucie Plant area (ABI, 1977, 1978, 1979, 1980).

For this report, the mean high temperature for September (85°F) was used as ambient rather than the maximum high temperature (87°F). The selection of 85°F enables an evaluation of real and repetitive ecological conditions and consequences rather than an evaluation of isolated uncommon instances. This temperature was calculated from U.S. Geological Survey records of the mean maximum temperatures at Canova Beach, Florida, 1950-1962.

To relate the impact of the thermal discharge to a reasonable portion of the receiving body of water, it was necessary to establish a region of potential impact. Because the amount of oceanic current flowing past the plant strongly influenced the size of the region of potential impact, two conditions representing different offshore current regimes were defined and used in the impact analysis. Conditions without and with a current flow were respectively termed "static" and "dynamic".

Static conditions would cause the heated discharge to accumulate near the point of discharge and would create the worst-case maximum surface temperature. The region of potential impact under static conditions was defined by ABI as that volume of water located between shore and the ABI biological sampling stations (Figure A-1). This area is 15.6 x $10^6 m^3$ (17.0 x 10^6 yd^3) with an average depth of 9.2 m (30.2 ft) for a calculated volume of 14.4 x $10^6 m^3$ (15.7 x 10^6 yd^3).

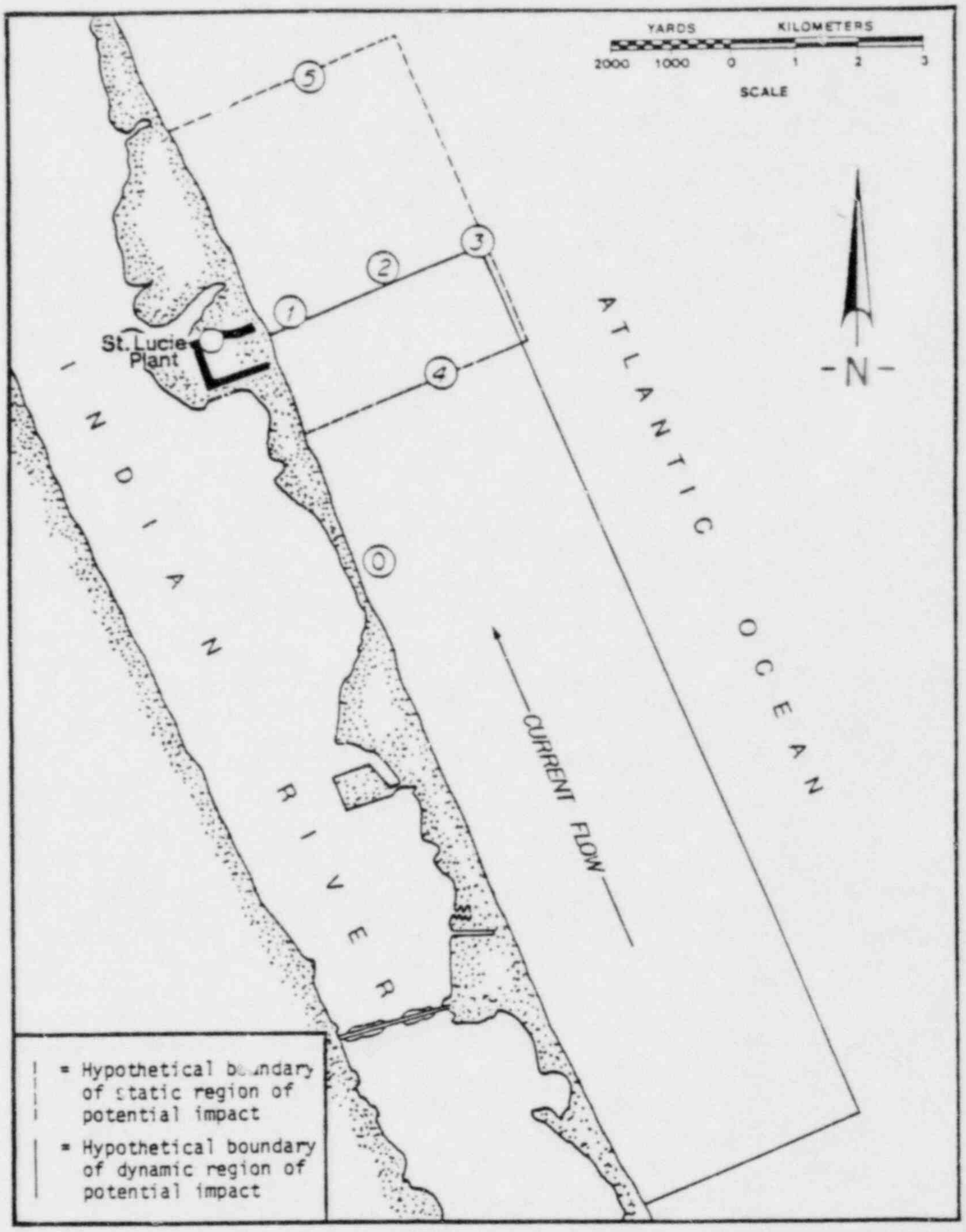


Figure A-1. Schematic illustration of approximate location of hypothetical static and dynamic regions of potential impact in relation to current sampling station locations. St. Lucie Plant.

Analysis under dynamic conditions required ABI to select a conservative current speed of 17.0 cm/sec (.56 ft/sec) for a predominantly northerly lateral current, based on available current velocity measurements (Envirosphere, 1976; Worth and Hollinger, 1977; ABI, 1978). Assuming this velocity, the region of potential impact defined by ABI is that volume of water which is calculated by multiplying the cross-sectional area between shore and Station 3 by 14,688 m (16,068 yd) (Figure A-1). This figure (14,688 m; 16,068 yd) is the distance a parcel of water might flow in 24 hours at a rate of 17.0 cm/sec. The calculated volume is 47.1 x $10^6 m^3$ (61.6 x 10^6 yd^3) or approximately 3.3 times the static condition volume.

Biological assessments presented in the following sections are based on ABI calculations using September ambient conditions observed at St. Lucie over a four-year period (ABI, 1977, 1978, 1979, 1980). Predictions based on these data are limited to the month of September and do not necessarily represent annual variations in the populations found during other months of the year.

For aquatic organisms, mortality caused by exposure to high temperatures is a function of both the amount of thermal increase and the duration of exposure to the higher temperature. The exposure time function was disregarded for this report and death was considered to occur with instantaneous exposure to lethal temperatures (i.e., it was assumed that 100 percent of all organisms passing through the plant would die). This assumption provided a worst-case evaluation. Because the time of

passage through lethal temperature zones would be extremely rapid for some organisms, the actual mortality would be considerably lower than stated.

PREDICTED DISCHARGE DATA

The proposed operating conditions described by FPL represent two changes in mode of operation. One mode requires an increase in temperature of the discharge water with no change in discharge flow rate. The other combines a water temperature increase with a reduction in flow through the condensers.

The implications of varying discharge rates, dilution rates, and water temperature increases for both units have been presented in Table A-1. The discharge water temperatures range from 111°F (associated with a condenser ΔT of 26°F and an ambient water temperature of 85°F) to 117°F (associated with a condenser ΔT of 32°F). An increase in condenser temperature from 26° to 28°F would increase the dilution volume rates. For each unit to achieve a discharge temperature decrease from 100°F to 95°F in the ocean, a volume of 2249 cfs of ambient water would be required for dilution if the original discharge temperature was 26°F over ambient (111°F). A volume of 2423 cfs would be required for dilution if the discharge was 28°F over ambient (113°F). Because the potential ΔTs of 30° and 32°F over ambient (115 and 117°F, respectively) are associated with a reduced flow through the plant, the dilution volume rates would not change appreciably from 2423 cfs, and a lower, although hotter, volume of water would be discharged. The volumes of dilution water

involved are the same for both units because the amount of heat rejected by each unit is the same.

POTENTIAL IMPACT ON AQUATIC BIOTA

Under normal operating conditions with a condenser ΔT of 26°F, mortality of aquatic biota due to plant operation is primarily caused by mechanical, thermal, and chemical damage to organisms entrained through the plant condensers. Weakly swimming plankton are the principal organisms carried into the thermal plume with the dilution water. The extent of impacts to these aquatic biota is generally proportional to the volumes of water, the densities of organisms, and the thermal tolerance of the particular group of organisms under consideration.

The conditions hypothesized by FPL, that is, a constant flow of 1150 cfs per unit and a condenser ΔT of 28°F, would produce increased impacts only because a greater number of organisms would be carried into dilution water which might be heated above a species' thermal tolerance level. Because the flow through the plant would be constant, no change in impact would occur due to direct entrainment through the plant.

The operating conditions of reduced flow and thermal increases of 30° and 32°F would have an associated increased mortality proportional to the increased volume of dilution water needed to reduce temperatures below lethal levels. The total impact, however, would be mitigated by the reduction in the intake volume of water and the reduction in associated organisms that would be directly entrained through the plant.

Because highly motile forms such as fishes and adult sea turtles avoid regions with thermal regimes outside their tolerance or preferred limits, the impact of the thermal plume would be to exclude them from a limited area. An increase in plume size would increase the area they avoid.

The extent of impact to sedentary organisms would be in proportion to the amount of temperature increase to which they would be exposed. Most of these are benthic forms that are exposed to the thermal plume only in shallow waters and near the immediate point of discharge of Unit 1. The larvae of these organisms may be impacted as plankton.

SUMMARY

This report describes hypothetical plant operating modes that would increase the temperature of the discharge water from the St. Lucie Plant. Consideration is given to the ecological implications of this thermal increase occurring during the month in which there are high biological populations concomitant with high ambient temperatures. An evaluation has been made of the changes in environmental impact between normal operating conditions and potential conditions as well as for the addition of St. Lucie Plant Unit 2.

LITERATURE CITED

ABI. 1977. Ecological monitoring at the Florida Power & Light Co. St. Lucie Plant, annual report 1976. Vol. 1. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga.

ABI. 1978. Ecological monitoring at the Florida Power & Light Co., St. Lucie Plant, annual report 1977. Vol. 1. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga.

ABI. 1979. Florida Power & Light Company, St. Lucie Plant annual non-radiological environmental monitoring report, 1978, biotic monitoring. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga.

ABI. 1980. Florida Power & Light Company, St. Lucie Plant annual non-radiological environmental monitoring report, 1979, biotic monitoring. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga.

Envirosphere Company. 1976. St. Lucie Plant site ocean current analysis for Florida Power & Light Company. Ebasco Services, Inc., New York.

Envirosphere Company. 1978. Predicted thermal plumes for elevated discharge temperatures. St. Lucie Unit 1. Envirosphere Co., New York, N.Y.

FPL. 1973. Hutchinson Island Plant environmental report. Vol. 1. Florida Power & Light Company, Miami, Fla.

FPL. 1980. Environmental report - operating license. St. Lucie Plant Unit 2. 2 Vol. Florida Power & Light Co., Miami, Fla.

Worth, D.F., and M.L. Hollinger. 1977. Nearshore marine ecology at Hutchinson Island, Florida 1971-1974: III. Physical and Chemical Environment. Fla. Mar. Res. Publ. No. 23:25-85.

B. WATER MASSES IN THE HUTCHINSON ISLAND AREA

INTRODUCTION

The marine environment in the vicinity of the St. Lucie Plant is comprised of three distinctly different water masses. These are the Indian River, the continental shelf, and the Florida Current.

Indian River (Estuarine) Water Mass

The Indian River water mass is a uniformly shallow (<13 ft deep) lagoonal estuary stretching approximately 100 mi from the St. Lucie inlet to just north of Titusville. It is bounded on the west by the Florida mainland and on the east by Atlantic barrier islands.

The Ft. Pierce and St. Lucie Inlets provide free interchange between the Indian River and the Atlantic Ocean shelf waters. Ft. Pierce is the larger of the two inlets and has been variously reported to discharge a maximum flow of 1400 m^3 (1831 yds^3)/sec (von Zweck et al., 1974) and 1926 m^3 (2519 yds^3)/sec (Walton, 1974a, 1974b). Maximum ebb tide flow rates in the St. Lucie Inlet have been estimated at 1133 m^3 (1482 yds^3)/sec (Walton, 1974a, 1974b).

Continental Shelf Water Mass

The continental shelf water mass can be divided into inner and outer shelf components. The inner shelf extends from the beach to the 120-ft isobath approximately 12 mi east of the St. Lucie Plant. The outer shelf extends from the 120-ft contour approximately 8 mi to the 600-ft isobath.

The outer boundary of the shelf water mass lies approximately 20 mi seaward of the St. Lucie Plant site and fluctuates in response to a variety of geostrophic (deflective forces related to rotation of the earth) and meteorological forces.

Florida Current Water Mass

The Florida Current, a major component of the Gulf Stream system, flows rapidly northward (4 to 6 ft/sec) in a narrow channel between the Bahamian-Caribbean archipelago on the east and the continental United States on the west. Waters originating in the Caribbean flow through the Yucatan Strait into the eastern Gulf of Mexico and then into the Straits of Florida. Maul (1977) has shown that penetration by the Gulf Loop Current into the eastern Gulf of Mexico coincides with the historical annual cycle of current speeds and transports of the Gulf Stream. Penetration by the Gulf Loop occurs coincidentally with increased velocity of the Gulf Stream in spring and summer.

Wennekens (1959) reported that a water mass, termed "continental edge," becomes differentiated from the Gulf Loop Current in the eastern Gulf of Mexico. The contine... edge is identified by sai...ity and temperature characteristics and can be found along the entire western edge of the Florida Current throughout the length of the Florida Straits. The eastern boundary of continental edge water is 10 to 15 mi seaward of Miami, Florida.

HYDROGRAPHY OF THE ST. LUCIE AREA

To study marine systems, it is convenient to compartmentalize water masses (e.g., estuarine, continental shelf, and oceanic). However, this implies a simplicity that is nonexistent because the marine environment is neither static nor independent. All of its components--biological, physical, chemical, and geological--are interrelated. The physical component, in turn, is a dynamic meshing of tidal, geostrophic, and wind-driven currents.

Differences in water temperature and salinity are used in conjunction with ocean current data to determine the origin, position, and interaction of each body of water. Historically, physical oceanographers have relied on averages from a collection of individual observations widely separated in space and time. The patterns that emerge can be misleading because they depict situations rarely found in natural systems (Iselin, 1955). More recently, understanding of these patterns has been aided by the use of remote sensing satellites. These satellites provide time-series photographs that can be analyzed to plot the source, location, movement, and thermal structure of large water mass systems.

Indian River (Estuarine) Hydrography

The Indian River system is characterized by wide temporal and regional variations in temperature and salinity. Generally, during summer months (May through September), warmer waters are found at the surface and temperatures increase in proportion to distance from the moderating effects of inlets. Conversely, cooler waters are found on the

bottom and temperatures decrease in proportion to distance from the inlets (von Zweck et al., 1974). The reverse situation exists during cooler winter months. In addition to seasonal changes in estuarine thermal structure, short-term variations occur that are related to local weather conditions. Because the water is shallow, dramatic changes in water temperatures have been observed within 24 hours of cold front passages (Gallagher, 1971). Briel (1974) reported that temperatures in the south portion of the Indian River (Ft. Pierce to Stuart) ranged from 57.2° to 87.8°F. Because this range is so wide, water temperatures within the Indian River are somewhat less indicative of water movements than is the more stable parameter of salinity.

Salinity values vary seasonally with precipitation rates and daily, especially near inlets, with the tidal cycle. Von Zweck et al. (1974) found that in the Indian River salinity ranges at the surface and at a depth of 3 to 4 m (10 to 13 ft) correlated well with the precipitation minus evaporation rates: "Larger vertical salinity gradients were generally encountered at periods of high precipitation, with the gradients generally larger in the vicinity of Vero Beach than at Fort Pierce."

Waters from various sources, including Taylor Creek, converge during ebb tide and remain poorly mixed at Ft. Pierce Inlet, resulting in large horizontal salinity ranges. During early flood tide, water remaining in the inlet plus some water that has reached the ocean is returned to the river systems, thus producing low salinity values. During late flood

tide, high salinity shelf waters pass into the system. Thus, the overall effect of a tidal cycle is to increase the salinity range near these inlets. Because rainfall is seasonal, the influence of Taylor Creek and St. Lucie River waters near the inlets will be greater during wet summer months and wider salinity ranges will result. Salinity at Ft. Pierce Inlet was reported to range from 15 to 35 ppt while at St. Lucie Inlet the range was from <1 to 35 ppt (Briel, 1974). Lowest values were recorded during wet summer months and they reflect the influence of Taylor Creek and the St. Lucie River systems on the localized salinity structure of the Indian River.

Although the Indian River system exhibits wide temporal and regional ranges in water temperature and salinity, it probably influences the physical characteristics of only a small area of Atlantic continental shelf waters.

Continental Shelf Hydrography

Very little is known about the hydrography of continental shelf waters adjacent to Florida's central east coast. Anderson et al. (1956-1960) presented temperature data collected during the Theodore N. Gill cruises, and Worth and Hollinger (1977) reported on three years of data collected on the inner shelf adjacent to the St. Lucie Plant.

Shelf water adjacent to Hutchinson Island originates north of Cape Canaveral, especially during the winter. An additional contribution is derived locally from the Indian River and Florida Current systems. For

convenience, the northern water mass contribution is here designated "Carolinian." It is composed of the Florida Current and river effluents with a small input of Virginia coastal water (slope water and river effluents; Stefansson et al., 1971). This Carolinian water mass flows southward as a wind-driven coastal counter-current, diminishing in volume as it is absorbed into the northward flowing Florida Current (Day, 1961). Shelf waters to the south of Cape Canaveral are probably composed increasingly of Florida Current and, to a lesser extent, Indian River waters as the Carolinian shelf water contribution diminishes.

Evidence suggests that Cape Canaveral acts as a barrier to southward flowing Carolinian water and that very little reaches as far south as Jupiter Inlet some 30 mi to the south of the St. Lucie Plant site (Day, 1961). High rainfall, with its associated river-runoff rates, and northerly winds during winter tend to increase the size of the shelf water mass to the south of Cape Canaveral by extending its eastern and southern boundaries.

Worth and Hollinger (1977) reported salinities of 33 to 38 ppt for inner shelf Hutchinson Island waters less than 10 m (33 ft) deep. Salinity ranges were consistent with seasonal water mass circulation. Highest salinities generally occurred during summer when southeasterly winds tended to minimize the Carolinian shelf water contribution. The reverse of this situation was found during winter, when northerly winds drove large volumes of lower salinity water to the south and east of Cape Canveral.

Because the continental shelf is relatively shallow, its waters respond rapidly to seasonal and daily temperature changes in the air temperature cycle. The water temperature range is greatest near shore and diminishes with increasing water depth to the shelf break. Stefansson et al. (1971) reported an annual temperature range of 15° to 18°C (27° to 32.4°F) for nearshore North Carolina waters and an 8° to 9°C (14.4° to 16.2°F) range at the shelf break. The annual temperature range of nearshore Hutchinson Island waters was reported to be 11°C (19.8°F) with a January low of 19°C (66.2°F) and a September maximum of 30°C (86.0°F; Worth and Hollinger, 1977). Anderson et al. (1956-1960) reported that the shelf waters off Hutchinson Island ranged from a winter low of 20° to 23°C (68.0° to 73.4°F) to a summer high of 26° to 29°C (78.8° to 84.2°F).

Temperature data taken from various approximate east and west transects at the latitude of the St. Lucie Plant (Table B-1) indicated that lowest surface water temperatures were always recorded landward of the 60-ft isobath. Highest surface water temperatures were usually found at the 600-ft contour near the western wall of the Florida Current (Gulf Stream). With the exception of isolated instances of isothermal conditions, the surface temperatures increased in a seaward direction. The nearshore temperatures ranged from a winter low of less than 17°C (62.6°F; three weeks after the January 1977 record freeze) to a high of approximately 28°C (82.4°F) during late summer. The gradients normal to the coast were steepest during winter and seaward of the 60-ft isobath (Figure B-1). These data were consistent with the findings of Stefansson et al. (1971) for North Carolina shelf waters. Instances of large

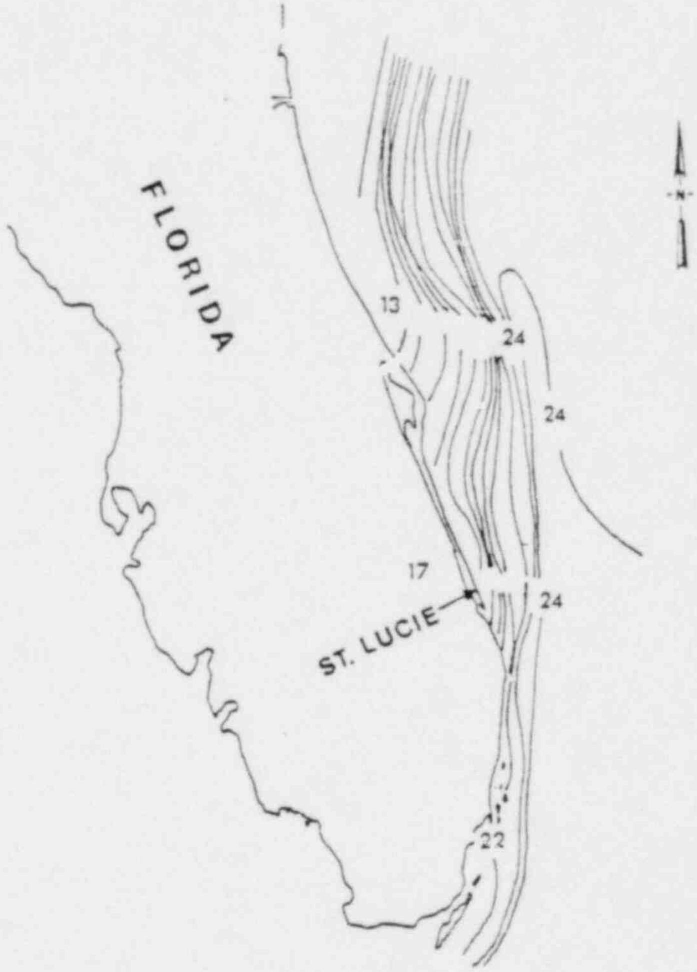


Figure B-1. Surface isotherms (°C) on 9 February 1977. (Data obtained from Department of Transportation, U.S. Coast Guard Oceanographic Unit, Airborne Radiation thermometer programs.)

seaward temperature gradients during summer (e.g., August 1975; Table B-1) are attributed to cold-water intrusion and will be discussed in the following section.

Vertical Temperature Structure

Shallow inner shelf waters like those at Hutchinson Island are expected to be well-mixed. This mixing is attributable largely to turbulence fields (Bowden, 1970) and to the proximity of different water masses, local wind patterns, local currents, and tidal interactions. In addition to these factors, the Florida Current has a major, but possibly seasonal, effect on shelf waters off Hutchinson Island.

The vertical temperature structure of inner shelf waters adjacent to Hutchinson Island is generally isothermal (less than 1°F) during late summer to early winter and again during spring following the cessation of cold front activity (Worth and Hollinger, 1977). Larger differences in vertical temperature structure (ΔT of surface minus bottom temperatures: ΔT_{S-B}) were noted during winter and especially summer. Large ΔT_{S-B} during winter were attributed to localized cooling of surface waters or to southward intrusions of cool Carolinian shelf water. Relatively large ΔT_{S-B} reported during late spring and summer reflect bottom intrusion of cold shelf or slope water. Worth and Hollinger (1977) reported ΔT_{S-B} that ranged from 5.0° to 7.3°C (9.0° to 13.1°F) during late spring and summer of 1972 and 1973. Evidence was seen of cold water intrusion during May 1976 (Table B-1).

TABLE B-1

SURFACE WATER TEMPERATURES
FROM BEACH TO FLORIDA CURRENT
IN THE VICINITY OF HUTCHINSON ISLAND[a]

	Surface water temperature (°C)					
				Florida Current		
Date	Beach	60 ft depth	600 ft depth	West wall	Maximum	Distance of west wall from beach (mi)
Feb 1974	<19	19	22	23	24	23
Mar	21	21	22	23	24	24
Apr	23	23	24	23	25	19
May	<24	24	25	25	25	26
Jun	27	27	27	27	27	-
Aug	<28	<28	28	N/A	29	-
Sep	<28	28	28	28	28	25
Jun 1975	<27	<27	28	28	28	21
Jul	<26	26	28	28	29	22
Aug	<27	27	29	29	29	24
Sep	<28	<28	29	29	29	20
Oct	<26	26	26	26	26	9
Nov	<23	23	24	24	25	17
Dec	<20	<21	23	23	24	20
Jan 1976	<17	18	22	21	24	17
Feb	<18	18	21	22	23	26
Mar	<23	22	24	24	25	26
Apr	<24	23	24	24	24	14
May	23	24	26	25	26	14

TABLE B-1
(continued)
SURFACE WATER TEMPERATURES
FROM BEACH TO FLORIDA CURRENT
IN THE VICINITY OF HUTCHINSON ISLAND[a]

	Surface water temperature (°C)					
				Florida Current		
Date	Beach	60 ft depth	600 ft depth	West wall	Maximum	Distance of west wall from beach (mi)
Jun	26	26	26	27	27	28
Jul	28	28	29	28	29	19
Aug	28	28	28	28	29	18
Sep 1976	<28	28	28	28	28	21
Oct	<23	<23	25	25	26	30
Nov	<23	23	25	25	26	24
Dec	<20	21	25	25	25	27
Jan 1977	21	21	24	24	25	21
Feb	<17	18	22	23	24	24
Mar	<24	<24	26	26	26	21

[a]Data collected by Geostationary Orbital Earth Satellite (GOES) and obtained from the Satellite Environmental Field Services Station, Miami.

The intrusion of cold saline bottom water along Florida's central east coast was termed upwelling by Taylor and Stewart (1959). Little is known of the mechanism by which cold water penetrates the usually unstratified waters of the inner shelf off Hutchinson Island. Lateral current shear, meandering, or spin-off eddies of the Florida Current may be responsible for the presence of cold water (Lee, 1971). Given the homogeneity of inner shelf waters and the southeasterly direction of the prevailing summer winds, Ekman transport (a type of lateral water movement) seems unlikely as the causative mechanism for these intrusions. However, Worth and Hollinger (1977) reported a total of six periods during late spring and summer 1972-1973 when bottom and, in some instances, surface water temperatures were depressed below seasonal norms. Each period was preceded by sust[illegible] winds from the southeast to south (130° to 180°) sector, which tends to support the theory of the upwelling resulting from Ekman transport as defined by Smith (1968).

From preliminary data collected during stratified summer condit[illegible] on the middle shelf (≤130 ft) off North Carolina, Blanton (1971) r[illegible]ported that onshore flow of Gulf Stream waters at the bottom was compensated b[illegible] offshore flow of shelf water at the surface. A schematic model in[illegible] that vertical mixing between shelf water and Gulf St[illegible]am [illegible] weakened portions of the pycnocline could account for th[illegible] cool dense bottom water often observed in the midshelf region (approximately 30 mi seaward of the beach) off North Carolina.

Florida Current Hydrography

Wennekens (1959) reported that water temperatures in the western portion of the Florida Current ranged from a winter low of 26°C to 30°C (78.8° to 86.0°F) during summer. Niiler and Richardson (1973) reported a seasonal range of 24° to 27°C (75.2° to 80.6°F). Salinity in the Florida Current has been reported to range between 36.1 and 36.0 ppt (Wennekens, 1959).

During spring and summer, several important climatic and hydrographic changes occur that can cause significant compositional changes in shelf waters off Hutchinson Island:

1. Area weather comes increasingly under the influence of the Azores-Bermuda high pressure system with its associated southeasterly winds (Stommel, 1965);
2. Greater insolation of the Gulf Stream produces stratifications and formation of thermoclines which periodically break down (Leming, 1971);
3. There is an observed increased flow of the Gulf Stream system (Niiler and Richardson, 1973), especially the western wall of the Florida Current (Lee, 1971).

The predominance of southeasterly winds during summer tends to prevent the intrusion of low salinity Carolinian shelf water into the southern shelf area. Thus, the shelf water mass south of Cape Canaveral diminishes in size and is replaced by water of high salinity (Worth and Hollinger, 1977). Lee and Mayer (1976) showed that lateral current shear, Florida Current meandering, and spin-off eddies frequently occur along the southeast coast of Florida. An average of four eddies per week was recorded during a 10-month period at Pompano Beach, Florida. Passage

of these eddies brought warm waters of the Florida Current onto the very narrow (<? mi) shelf for periods that averaged one week. It is unknown at the present time whether spin-off eddies intrude onto the shallow inner shelf off Hutchinson Island. Lee and Mayer (1976) found that frictional effects of shallow water (<10 m or 33 ft) tended to minimize these Florida Current spawned events off Miami.

Rarely has oceanic water been observed on the inner shelf off Hutchinson Island during winter (personal observation, R. Gallagher). The winter predominance of low-salinity shelf water and a relatively steep temperature gradient in a seaward direction indicate that a density differential may be of sufficient magnitude to prevent shoreward intrusions of the Florida Current beyond the outer shelf.

Table B-2 shows the thermal structure of the shelf waters from the beach to the western wall of the Florida Current between February 1976 and March 1977. Average distance of the western wall seaward of the St. Lucie Plant was approximately 24 mi (Figure B-2). The western wall of the Florida Current was usually near the 600-ft isobath some 20 mi seaward of the St. Lucie Plant. Variations in the locations of the Florida Current are not sufficient to bring the western wall of the Current onto the inner continental shelf at Hutchinson Island.

TABLE B-2

SURFACE ISOTHERMS WHICH DELINEATE APPROXIMATE DISTANCE OF THE FLORDIA CURRENT FROM THE ST. LUCIE PLANT[a]

Date	Surface isotherm delineation in °C (°F)	Approximate distance from plant in km (mi)	Plant area water temperature in °C (°F)
10 Feb 1976	23.0 (73.4)	43 (27)	18 (64.4)
26 Mar	25.0 (77.0)	45 (28)	23 (73.4)
20 Apr	24.0 (75.2)	19 (12)	23 (73.4)
18 May	26.0 (78.8)	19 (12)	25 (77.0)
8 Jun	27.0 (80.6)	50 (31)	26 (78.8)
20 Jul	29.0 (84.2)	34 (21)	27 (80.6)
17 Aug	29.0 (84.2)	34 (21)	28 (82.4)
14 Sep	28.0 (82.4)	34 (20)	27 (80.6)
30 Oct	25.5 (77.9)	50 (31)	23 (73.4)
16 Nov	25.0 (77.0)	39 (24)	22 (71.6)
10 Dec	25.0 (77.0)	39 (24)	20 (68.0)
11 Jan 1977	24.5 (76.1)	39 (24)	22 (71.6)
8 Feb	23.0 (73.4)	40 (25)	17 (62.6)
18 Mar	26.0 (78.8)	34 (21)	23 (73.4)

[a]Data obtained from Department of Transportation, U.S. Coast Guard Oceanographic Unit, Airborne Radiation thermometer programs.

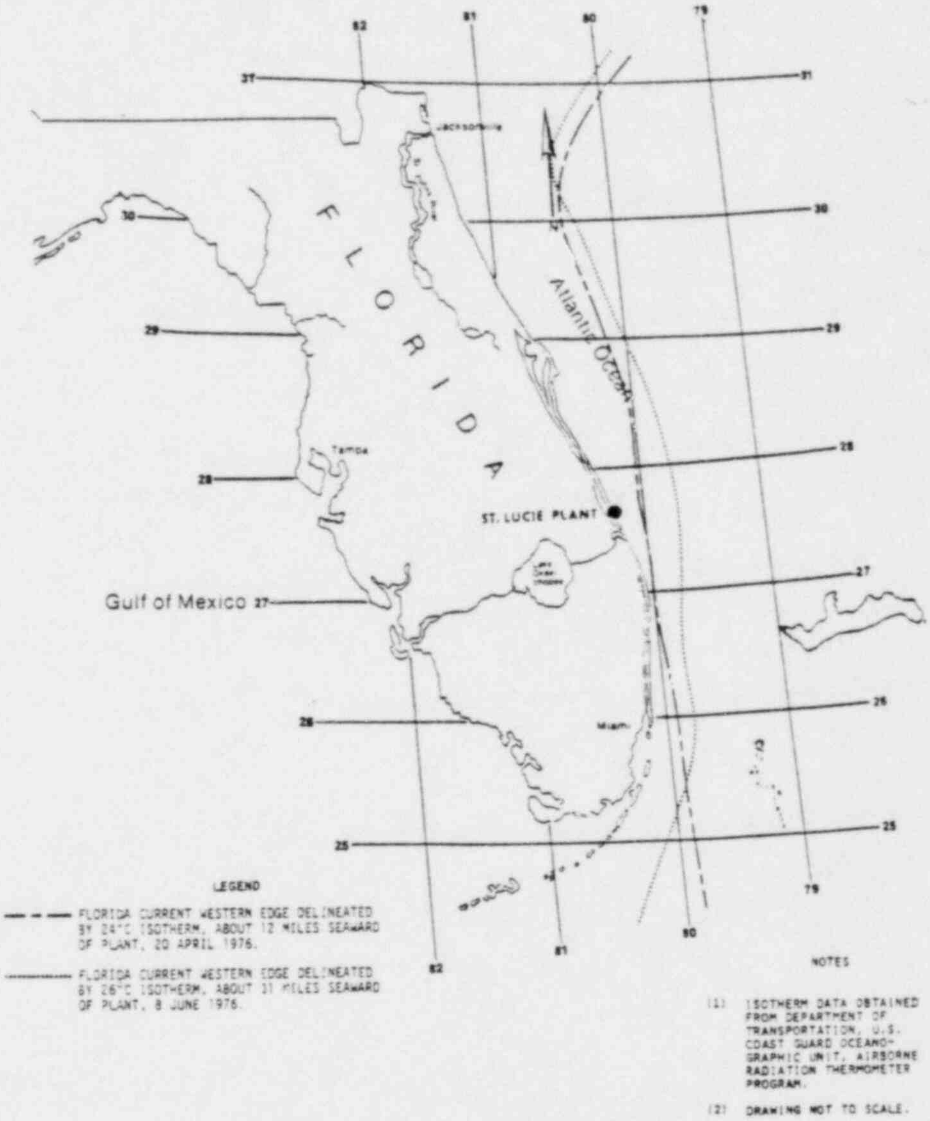


Figure B-2. Maximum and minimum distance of the western edge of the Florida Current from the St. Lucie Plant.

SUMMARY

The offshore waters adjacent to the St. Lucie Plant are derived from three sources: the Indian River, the continental shelf, and the Florida Current. These are distinct bodies of water, each with characteristic temperatures and salinities. The continental shelf waters provide most of the water used by the plant. The Indian River system has little effect in moderating physical characteristics of the shelf water near the plant.

The Florida Current rarely sweeps within 12 mi of the shoreline at St. Lucie, and the yearly average distance of the current's western edge is about 24 mi offshore.

LITERATURE CITED

Anderson, W.W., J.W. Gehringer, and E. Cohen. 1956-1960. Physical oceanographic, biological and chemical data - South Atlantic coast of the United States, M/V Theodore N. Gill cruises 1-9. USFWS Spec. Sci. Rep. Fish. No. 380. 206 pp.

Blanton, J. 1971. Exchange of Gulf Stream water with North Carolina shelf water in Onslow Bay during stratified conditions. Deep-Sea Res. 18:167-178.

Bowden, K.F. 1970. Turbulence II. Pages 11-32 in H. Barnes, ed. Oceanographic marine biological manual review: Vol. 8. Hafner Publishing Co., N.Y.

Briel, L.I. 1974. Water quality studies of the Indian River. Pages 56-109 in Indian River study, annual report 1973-1974. Vol. 1. Harbor Branch Consortium, Ft. Pierce, Fla.

Day, G.G. 1961. A literature survey of the hydrography, bathymetry and fisheries of the Atlantic Ocean under the Atlantic Missile Range with an appendix on the Mona Island regions. U.S. Atomic Energy Commission. Publ. No. TID-14437. 114 pp.

Gallagher, R.W. 1971. Preliminary report on the hydrography of the Pensacola Bay Estuary, Florida. Florida Department of Nat. Res. Mar. Res. Spec. Sci. Rep. No. 29.

Iselin, O.D. 1955. Recent advances in our understanding of the circulation problem and their implications. Journ. Mar. Res. 14(4):315-322.

Lee, T.N. 1971. Oceanographic features of nearshore waters on a narrow continental shelf. Pages 105-170 in Limitations and effects of waste disposal on an ocean shelf. 16070 EFG. U.S. EPA. Water Pollution Control Res. Ser.

Lee, T.N., and D.A. Mayer. 1976. Low frequency spin-off eddies on the shelf off southeast Florida. J. Mar. Res. 35(1):193-220.

Leming, T.D. 1971. Oceanography: central Florida's Atlantic continental shelf. NOAA Trop. Atl. Lab. Inf. Rep. No. 18. 13 pp.

Maul, G.A. 1977. The annual cycle of the Gulf Loop Current, Part I: Observations during a one-year time series. J. Mar. Res. 35(1):29-47.

Niiler, P.P., and W.S. Richardson. 1973. Seasonal variability of the Florida Current. J. Mar. Res. 31(3):144-167.

Smith, R.L. 1968. Upwelling. Pages 11-46 in G. Allen, ed. Oceanographic marine biological annual review. Vol. 6. Hafner Publishing Co., N.Y.

LITERATURE CITED (continued)

Stefanasson, O., L.P. Atkinson, and D.F. Bumpus. 1971. Hydrographic properties and circulation of the North Carolina shelf and slope waters. Deep Sea Res. Oceanogr. Abstr. 18(4):383-420.

Stommel, H. 1965. The Gulf Stream. Univ. Calif. Press, Berkeley, Calif. 248 pp.

Taylor, C.B., and H.B. Stewart, Jr. 1959. Summer upwelling along the east coast of Florida. J. Geophys. Res. 64:33-40.

von Zweck, O., D. Richardson, N. Szuchy, and G. Adragna. 1974. Physical oceanographic studies of the Indian River Region. Pages 36-51 in Indian River study, annual report 1973-1974. Vol. 1. Harbor Branch Consortium, Ft. Pierce, Fla.

Walton, T.L. 1974a. St. Lucie Inlet. Glossary of inlets. Report No. 1. Fla. Sea Grant Program. 48 pp.

Walton, T.L. 1974b. Fort Pierce Inlet glossary report No. 2. Fla. Sea Grant Program. 39 pp.

Wennekens, M.P. 1959. Water mass properties of the Strait of Florida and related waters. Bull. of Mar. Sci. of the Gulf and Caribbean 9(1):1-52.

Worth, D.F., and M.L. Hollinger. 1977. Nearshore marine ecology at Hutchinson Island, Florida. 1971-1974. III. Physical and chemical environment. Fla. Dept. Nat. Res. Mar. Res. Lab. No. 23. pp. 25-85.

Personal Observation

Gallagher, R. Applied Biology, Inc., Field Station Manager, Jensen Beach, Fla.

C. FISH

INTRODUCTION

The adult fish community found offshore of the St. Lucie Plant may be affec*ed by plant intake or discharge operations. The plant intake operation affects fishes by entrapment into the intake canal. Some fishes may be impinged on the traveling screens from the intake canal; others take up residence in the canal itself or fall prey to those already there. In either event, they are lost to the offshore ecosystem. Effects of the plant discharge are primarily associated with the thermal alteration of a portion of the offshore habitat.

EFFECT OF INTAKE ON FISHES

The density and distribution of fishes are related to such factors as season, time of day, habitat preference, migration, spawning, tidal cycle, and weather conditions. Accordingly, the degree of impact resu 'ng from intake of fishes is related to the density and distribution of fishes in the immediate vicinity of the intake structure (Sharma, 1978). While some individual species have a high sensitivity to and avoid the horizontal currents associated with a velocity cap intake structure, other species are likely to be drawn into the intake structure. Presumably, the number of fishes entrapped would be proportional to the volume and/or velocity of plant flow.

Monitoring of the fish community from 1976 through mid-1980 indicated no large accumulation of fishes entrapped in the intake canal.

Although impingement rates probably do not represent the number of fishes in the canal at any point in time, they do reflect the general abundance of fishes taken into the system during a long period of evaluation. Impingement studies conducted from early 1976 through 1978, while Unit 1 was in normal operation, showed a calculated mean annual impingement of 81,931 fishes weighing 628 kg (1384 lbs). This was not considered to be a large number of fishes or biomass removed from the ecosystem (ABI 1979).

The normal plant flow for Unit 1 (as listed under Plant Discharge Volume Rate in Table A-1) is 1150 cfs (2.81×10^6 m^3 per day) at condenser ΔTs of 26° and 28°F. At condenser ΔTs of 30° and 32°F, Unit 1 flow is 1075 cfs (2.63×10^6 m^3 per day) and 1000 cfs (2.45×10^6 m^3 per day), respectively. The degree of impact resulting from intake effects is thus expected to be lower at condenser ΔTs of 30° and 32°F than at 26° or 28°F because total Unit 1 flow will be reduced when the plant is operating at the higher condenser temperatures. The addition of Unit 2 will double the water intake for each of these operating modes and accordingly, could potentially increase the impact.

EFFECT OF DISCHARGE ON FISHES

The effect of the discharge on adult fishes is associated with the volume of water discharged offshore that has temperatures high enough to exclude or limit fishes from the area. The adult fishes offshore of the St. Lucie Plant are highly motile and will actively avoid areas that are too hot.

Wurtz and Renn (1965) stated that waters whose temperatures regularly exceed 95°F would not be expected to support a large or diverse fish population. Bush et al. (1974) gave a general upper temperature limit for all bony fishes of about 100°F, and 86°F for the sharks and rays. Tropical organisms live within 18° to 27°F of their lethal thermal limits (Mayer, 1914); they seldom live in waters above 88° or 90°F (de Sylva, 1969). In summarizing data assembled from the literature on upper lethal limits obtained for laboratory specimens of larval, juvenile, and adult marine fishes, de Sylva (1969) showed that most marine fishes do not survive water temperatures higher than 95°F.

In studies on Galveston Bay, Texas, Gallaway and Strawn (1974, 1975) found that all indices of species diversity declined when mean surface temperatures exceeded 95°F, although most species were abundant in waters with temperatures as high as 91° to 95°F. Species found at temperatures higher than 95°F were the sea catfish and Atlantic croaker, found at temperatures of up to 99°F, and the striped mullet, found in water of up to 104°F. The Galveston Bay studies showed that gulf mennaden and bay anchovy (species common in the St. Lucie area) avoided temperatures of 86° and 91°F, respectively. Occasionally, sea catfish and gulf menhaden did not avoid the heated area and were killed. These exceptions to the avoidance behavior pattern were unusual and involved relatively few individuals.

Although temperatures near 95°F will no doubt exclude or limit most fishes found in the St. Lucie area, exclusion from a thermally influenced

area does not imply mortalities. The most probable effect of thermal increase in an open system would be directive, that is, resulting in avoidance. The size of the zone from which fish are excluded will vary with the discharge temperature and volume and the size of the corresponding plume. Total exclusion will probably occur from the point of discharge at the diffuser to the 95°F isotherm. The volumes of water enveloped by the exclusion zone for Unit 1 (95°F or higher) range from about 0.3 acre-feet at a condenser ΔT of 26°F to 0.5 acre-feet at a condenser ΔT of 32°F. For Unit 2, the volumes of water enveloped by the exclusion zone is about 0.2 acre-feet for ΔTs ranging from 28°F to 32°F (FPL, 1980).

Within the plume, a zone varying from exclusion to nonexclusion of fishes would be temperature-, time-, and species-specific. This transition zone is considered to occur at temperatures from 90° to 95°F. The volumes of water enveloped by the 90°F isotherm for Unit 1 range from about 10.9 acre-feet at a condenser ΔT of 28°F to 23.1 acre-feet at a condenser ΔT of 32°F. The discharge from Unit 2 would create an exclusion zone inside the 90°F isotherm of less than 20 acre-feet regardless of temperature (FPL, 1980). During two-unit operation, the diffuser pipe will be used preferentially when only one unit is on-line. In this situation, increased efficiency of heat dispersion by the diffuser will reduce the plume associated with Unit 1.

A zone of nonexclusion, or nonavoidance by fishes, will probably occur within the plume where temperatures are less than 90°F.

Coutant (1974) noted that it is the proportion of the potentially suitable habitat modified by the thermally influenced water volume, rather than the specific volume, that is especially important. For Unit 1, the total volume of water (i.e., the exclusion and transition zones combined) that may be limiting to adult fishes offshore of the St. Lucie Plant ranges from 10.9 to 23.1 acre-feet. Although the volume that may be limiting to fishes at a condenser ΔT of 32°F represents more than a two-fold increase over the volume at a condenser ΔT of 26°F, the volume of plume-affected water is still small in relation to available habitat. Ten and nine tenths (10.9) acre-feet and 23.1 acre-feet represent approximately 0.01 and 0.02 percent, respectively, of the volume of the static area of potential impact delineated in Section A, "Introduction", of this report. Additionally, these volumes are projected for a high ambient water temperature of 85°F in September; less of the study area would be affected during most of the year.

Motile adult fish would rarely be killed by heated water unless trapped. They will migrate from lethal conditions or congregate in areas with sublethal or near-optimal water temperatures (Sylvester, 1972). Bull (1936) demonstrated a precise temperature discrimination in a wide variey of species, obtaining responses with thermal increases as small as 0.05°F.

Numerous field studies at power plants have shown summer avoidance of thermal effluent by fishes. In Florida, avoidance of thermal effluent by fishes has been reported by Carr and Giesel (1975) at Jacksonville; by

Grimes (1971), Grimes and Mountain (1971), and Homer (1976) at Crystal River; and by Nugent (1970) at Turkey Point. A trend in the degree of thermal avoidance by fishes is indicated in previous studies. Fishes in the shallow waters of tidal creeks and salt marshes subjected to heated effluents (Nugent, 1970; Carr and Giesel, 1975; Homer, 1976) were affected to a greater extent than those inhabiting shallow bays (Adams, 1974). Fishes in deeper bay waters (Gallaway and Strawn, 1974) were even less affected. An extension of this trend, that is, less thermal effect with increasing size of the receiving body of water, could logically be applied at the St. Lucie Plant, where thermal effluent is discharged into an open oceanic area strongly influenced by weather, water currents, and tidal action. In addition, resistance to lethal temperatures is greater with slowly increasing temperatures than with an abrupt change in the higher temperature ranges (Sylvester, 1973). Fishes would slowly encounter increasing temperatures as they moved into the thermal plume discharged offshore of the St. Lucie Plant and effectively avoid water temperatures that were too hot.

SUMMARY

The plant intake can affect adult fishes by entrapment in the intake canal and potential impingement on the intake traveling screens. The degree of impact resulting from intake effects is expected to be lesser at condenser ΔTs of 30° and 32°F than at 26° or 28°F because plant flow will be reduced when the plant is operating at the higher condenser temperatures. The addition of Unit 2 will double the water intake, however, and could potentially increase the impact.

The plant discharge affects adult fishes by excluding or limiting them from an offshore area of increased temperatures. Within the thermal plume, total exclusion of adult fishes will probably occur inside the 95°F isotherm, partial exclusion from about 95° to 90°F, and nonexclusion at temperatures less than 90°F. The volumes of water from both units, which may limit adult fishes offshore of the St. Lucie Plant, is not expected to exceed a volume of 25 acre-feet over the temperature range of 26° to 32°F. Although the affected water volume increases more than two-fold over this range of condenser ΔTs, the highest volume (at a condenser ΔT of 32°F) is only 0.02 percent of the available habitat. Additionally, these volumes are projected for a high ambient water temperature of 85°F in September; less of the study area would be affected during most of the year.

LITERATURE CITED

Adams, C.A. 1974. Comparison of selected vertebrate populations in two estuaries adjacent to the Crystal River power generation facility, Crystal River Power Plant environmental considerations. Pages 1-105 in Final report to the Interagency Advisory Committee, Vol. II, Sec. F. Fla. Power Corporation, St. Petersburg, Fla. (Cited in Homer, 1976).

Bull, H.O. 1936. Studies on conditioned responses in fishes. VII. Temperature perception in teleosts. J. Mar. Biol. Assoc. U.K. 21:1-17. (Cited in Brett, 1956).

Bush, R.M., E.B. Welch, and B.W. Mar. 1974. Potential effects of thermal discharges on aquatic systems. Environ. Sci. Technol. 8(6): 561-568.

Carr, W.E.S., and J.T. Giesel. 1975. Impact of thermal effluent from a steam-electric station on a marshland nursery area during the hot season. Fish. Bull., U.S., 73:67-80.

Coutant, C.C. 1974. Temperature selection by fish - a factor in power plant impact assessments. Symposium on the physical and biological effects on the environment of cooling systems and thermal discharges at nuclear power stations, Oslo, 26-30 August 1974. IAEA SM-187/11. Int'l. Atomic Energy Agency. 25 pp.

de Sylva, D.P. 1969. Theoretical considerations of the effects of heated effluents on marine fishes. Pages 229-293 in P. A. Krenkel and F.L. Parker, eds. Biological aspects of thermal pollution. Vanderbilt Univ. Press. 407 pp.

Gallaway, B.J., and K. Strawn. 1974. Seasonal abundance and distribution of marine fishes at a hot-water discharge in Galveston Bay, Texas. Contrib. Mar. Sci. 18:71-137.

Gallaway, B.J., and K. Strawn. 1975. Seasonal and areal comparisons of fish diversity indices at a hot-water discharge in Galveston Bay, Texas. Contrib. Mar. Sci. 19:79-89.

Grimes, C.B. 1971. Thermal addition studies of the Crystal River steam electric station. Fla. Dept. Nat. Res. Mar. Res. Lab. Prof. Paper Series No. 11. 53 pp.

Grimes, C.B., and J.A. Mountain. 1971. Effects of thermal effluent upon marine fishes near the Crystal River steam electric station. Fla. Dept. Nat. Res. Mar. Res. Lab. Prof. Paper Series No. 17. 64 pp.

Homer, M. 1976. Seasonal abundance, biomass, diversity, and trophic structure of fish in a salt-marsh tidal creek affected by a coastal power plant. Pages 259-267 in G.W. Esch and R.W. McFarlane, eds. Thermal ecology II. NTIS No. CONF - 750425. Technical Information Center, Energy Research and Development Administration. 404 pp.

LITERATURE CITED (continued)

Mayer, A.G. 1914. The effects of temperature upon tropical marine animals. Pap. Tortugas Lab. 6(1):1-24. (Cited in de Sylva, 1969).

Nugent, R.S., Jr. 1970. The effects of thermal effluent on some of the macrofauna of a subtropical estuary. Sea Grant Tech. Bull. No. 1, Univ. of Miami, Fla. 198 pp.

Sharma, R.K. [illegible]. Perspectives on fish impingement. Pages 351-356 in L.D. Jensen, ed. Fourth national workshop on entrainment and impingement. Ecological Analysts, Inc., Mel[illegible]ille, N.Y. 424 pp.

Sylvester, J.R. 1972. Possible effects of thermal effluents on fish: a review. Environ. Pollut. 3:205-215.

Sylvester, J.R. 1973. A note on the upper lethal temperature of juvenile *Haemulon flavolineatum* from the Virgin Islands. J. Fish. Biol. 5:305-307.

Wurtz, C.B., and C.E. Renn. 1965. Water temperatures and aquatic life. The Johns Hopkins Univ. Cooling Water Studies for Edison Electric Inst. RT-49, Rept. No. 1. 99 pp. (Cited in Carr and Giesel, 1975).

D. ICHTHYOPLANKTON

INTRODUCTION

Ichthyoplankton consist of fish eggs and larvae that passively drift or lack sufficient mobility to maintain themselves in a current. Because most marine fish species are pelagic spawners, ichthyoplankton have a wide distribution and thus can be carried considerable distances by currents. The ichthyoplankton community off Hutchinson Island includes the developmental stages of important forage fishes such as anchovies, herrings, and mojarras and important economic fishes such as drums and pompanos. As these planktonic forms are carried to the vicinity of the St. Lucie Plant, they become susceptible to entrainment through the plant and into offshore thermal plume discharges.

Mortalities resulting from plant entrainment are caused by mechanical, chemical, and temperature-related stresses associated with passage through the cooling system (Marcy, 1975; Schubel et al., 1977). Because ichthyoplankton are primarily pelagic, the number of organisms entrained through the plant is directly related to the volume of water that passes through the plant. Regardless of the cause of mortality, it is assumed that no plant-entrained ichthyoplankton survive. However, ichthyoplankton can survive offshore plume entrainment when plume temperatures are not above a species' tolerance level.

The effects of entrainment on ichthyoplankton into thermally elevated waters depend on variables such as specific species tolerance and time-temperature relationships. For this report, however, it is assumed

that a temperature of 95°F exceeds the lethal limits for most species, regardless of exposure duration (Table D-1; de Sylva, 1969).

ICHTHYOPLANKTON AT ST. LUCIE

Fish eggs and larvae were collected near Hutchinson Island from 1976 through 1979 (ABI, 1977, 1978, 1979, 1980). The numbers of eggs and larvae per cubic meter were calculated for September, the month having the highest average ambient water temperatures. Mean numbers of eggs and larvae were 1.453 and 0.694 individuals/m^3 (1.111 and .530/yd^3), respectively. These values were calculated from replicate data obtained at offshore Stations 1 through 5. It should be noted that the average egg and larval densities obtained were based on surface samples only and thus may not accurately represent egg and larvae densities in the entire water column.

EFFECTS ON PLANT-ENTRAINED ICHTHYOPLANKTON

With the concurrent operation of Units 1 and 2 at a 26° or 28°F ΔT, the volume of water entrained through the plant would be approximately 2300 cfs or 5.62×10^6 m^3 per day. Potentially, under these operating conditions, 8.2×10^6 eggs and 3.9×10^6 larvae per day would be impacted. The potential operating modes that would increase the condenser ΔT to 30° or 32°F would have an associated decrease in flow rate through the plant resulting in a proportional reduction in ichthyoplankton mortalities (Table D-2). If the operating mode resulting in a condenser ΔT of 32°F is considered, a 12.8 percent reduction in flow volume would occur along with reduced ichthyoplankton mortalities of 1.1×10^6 eggs and 0.5×10^6 larvae per day.

TABLE D-1

EFFECTS OF TEMPERATURE ON ICHTHYOPLANKTON

Family	Common name	Principal reference	Stage	Temperature limits °C	Temperature limits (°F)	Criteria[a]	Occurrence at St. Lucie	Comments and/or secondary references
Albulidae	bonefish	Eldred (1967b)	larvae	28.0°	(82.4°)	OR		Breed in deep water (Bruger, 1974).
Antennariidae	frogfish	Rasquin (1958)	embryos, larvae	21.0-27.0°	(69.8-80.6°)	OR	x	Produce egg rafts (Mosher, 1954).
Atherinidae	silverside	Reynolds and Thomson (1974a, 1974b)	prejuveniles	8.0-35.0°	(46.4-95.0°)	TIR	x	More temperature tolerant than older fish.
		Huff and Westman (1966)	adults, gametes	temperature varied		AC	x	Johnson (1975), Middaugh and Lempesis (1976), Hubbs and Bryan (1974).
		Hildebrand (1924), Czechomski (1972)	embryos, larvae	28.0°	(82.4°)	ILT, AC, CTM	x	No temperature preferences before three weeks of age.
Belonidae	needlefish	Fonds et al. (1974)	embryos,	12.0-24.0	(53.6-75.2°)	TIR		Breder (1959), Foster (1973), Berry and Rivas (1962) for local species.
Blenniidae	blenny	Campbell and Davies (1975)	adults	4.0-26.0 35.1°	(39.2-78.8°) (95.2°)	OR ILT, AC		Embryos less tolerant (de Sylva, 1969).
	prickleback	Wourms and Evans (1974a, 1974b)	breeding adults			OR		
	blenny	Brett (1970)	adults	26.8° 14.8°	(90.2°) (58.6°)	ILT TIR		
		Shiogaki and Dotsu (1973)	embryos	15.7-18.2°	(60.3-64.8°)	OR		
Carangidae	jacks	Santerre (1976)	embryos, larvae	34.2°	(93.6°)	ILT		Larvae produced in warm months are close to ILT, of importance in the vicinity of power plant discharges. Ahlstrom and Ball (1954), Berry (1959).
		Hoff et al. (1972)	embryos,	28.0°	(82.4°)	OR	x	
			larvae					Aprieto (1974); Leak (1977).
Clupeidae	menhaden	Kendall and Reintjes (1975)	larvae	0.0-25.0°	(32.0-77.0°)	OR	x	Larvae tend to mid-range.
		Young (1974)	juveniles, adults	33.0°	(91.4°)	ILT	x	Oxygen consumption, temperature and weight (Hettler, 1976).
	sardine	Saksena et al. (1972)	larvae	26.0-33.5°	(78.8-92.3°)	TIR	x	Richards et al. (1974); Houde et al. (1974), Martinez and Houde (1975).

TABLE D-1
(continued)
EFFECTS OF TEMPERATURE ON ICHTHYOPLANKTON

Family	Common name	Principal reference	Stage	Temperature limits °C	(°F)	Criteria	Reference St. Lucie	Comments and/or secondary references
Cyprinodontidae	sheepshead minnow	Harrington and Harrington (1961)	juveniles	43.0°(?)	(109.4°)	OR	x	Not in plankton.
	pupfish	Lowe and Heath (1969)	adults	44.6°	(112.3°)	ILT		Inland western form.
	mummichog	Garside and Chin-Yuen-Kee (1972)	adults	36.3°	(97.4°)	ILT	x	Not in plankton.
		Jean and Garside (1974)	adults	37.5°	(99.5°)	ILT	x	Not in plankton.
Elopidae	tarpon	Eldred (1967a, 1972)	larvae	19.8-32.0°	(67.6-89.6°)	OR	x	Harrington (1958); Tagatz (1973); Tucker and Hodson (1976).
Engraulidae	bay anchovy	Springer and Woodburn (1960)	adults	8.1-32.5°	(46.6-90.5°)	OR	x	Other local species (Daly, 1970).
		Saksena et al. (1972)	larvae, embryos	27.8°	(82.0°)	ILT	x	de Sylva (1969).
	striped anchovy	de Sylva (1969)	embryos	21.0°	(69.8°)	ILT	x	
	northern anchovy	Brewer (1976)	embryos	11.5-27.0°	(52.7-80.6°)	TTR, AC, CTM		Blastodisk most sensitive stage.
			larvae	7.0-30.2°	(44.6-86.4°)	TTR, AC, CTM		Little acclimation potential.
			juveniles, adults	29.5°	(85.1°)	ILT, AC, CTM		ILT less than that of larvae.
Gobiesocidae	clingfish	Martin and Martin (1970)	embryos, fry, adults	23.9° 31.1°	(75.0°) (88.0°)	optimal ILT	x	Brett (1970).
Gobiidae	neon goby	Valenti (1972)	embryos	28.0°	(82.4°)	OR	x	Rearing study
	code goby	Springer and McErlean (1961)	embryos	15.5-31.0°	(59.9-87.8°)	OR	x	Field study.
							x	
	crested goby	Delmonte (1968)	breeding adults	27.0-28.0°	(80.6-82.4°)	OR	x	Panama population, rearing study.
	goby	de Vlaming (1971)	adults	39.7°	(103.5°)	CTM, AC		Pacific species.

TABLE D-1
(continued)
EFFECTS OF TEMPERATURE ON ICHTHYOPLANKTON

Family	Common name	Principal reference	Stage	Temperature limits °C	(°F)	Criteria[a]	Occurrence at St. Lucie	Comments and/or secondary references
Mugilidae	striped mullet	Sylvester and Nash (1975)	embryos, larvae	7.7-30.6°	(45.9-87.1°)	TTR, AC	x	Sylvester (1974); Hawaiian populations.
		de Sylva (1969)	larvae	32.0°	(89.6°)	ILT	x	Florida forms.
Ophichthidae	speckled worm eel	Eldred (1966)	larvae	18.0-24.0°	(64.4-75.2°)	OR	x	Mostly at surface, at night.
Pomadasyidae	French grunt	Sylvester (1973)	juveniles	36.0-38.0°	(96.8-100.4°)	CTM, AC	x	Related species described (Saksena and Richards, 1975).
Sciaenidae	spot	Hettler (1971)	postlarvae, juveniles	31.1°C	(88.0°)	CTM, AC	x	CTM unrealistic for power plant studies.
Sparidae	pinfish	Hettler (1971)	postlarvae, juveniles	31.0°	(87.8°)	CTM, AC	x	Wohlschlag and Cech (1970), Cardeilhac (1976).

[a] AC = Acclimation Study
CTM = Critical Thermal Maximum or Minimum
ILT = Incipient Upper Lethal Temperature
OR = Observed Range
TTZ = Thermal Tolerance Zone
TTR = Thermal Tolerance Range

TABLE D-2

NUMBER[a] OF ICHTHYOPLANKTON MORTALITIES ($\times 10^6$ PER DAY) RESULTING FROM ENTRAINMENT AT VARIOUS DISCHARGE TEMPERATURES (ΔT) IN SEPTEMBER

	Eggs					
	Plant entrained		Plume entrained[b]		Total entrained	
ΔT (°F)	Unit 1	Units 1 and 2	Unit 1	Units 1 and 2	Unit 1	Units 1 and 2
26	4.1	8.2	19.9	39.8	24.0	48.0
28	4.1	8.2	21.8	43.5	25.9	51.7
30	3.8	7.6	22.1	44.1	25.9	51.7
32	3.6	7.1	22.1	44.2	25.7	51.3

	Larvae					
	Plant entrained		Plume entrained[b]		Total entrained	
ΔT (°F)	Unit 1	Units 1 and 2	Unit 1	Units 1 and 2	Unit 1	Units 1 and 2
26	2.0	3.9	9.5	19.0	11.5	22.9
28	2.0	3.9	10.4	20.8	12.4	24.7
30	1.8	3.7	10.5	21.1	12.3	24.8
32	1.7	3.4	10.6	21.1	12.3	24.5

[a]Based on average density of 1.453 eggs/m^3 and 0.694 larvae/m^3.

[b]From the point of discharge at the diffuser to the 95°F isotherm.

EFFECTS ON PLUME-ENTRAINED ICHTHYOPLANKTON

As plant discharge water is diluted into offshore receiving waters, ichthyoplankters will become entrained into isotherms in excess of their thermal tolerances. The dilution rate required to reduce the discharge water from a temperature of 111°F (26°F above ambient) to the 95°F isotherm is 11[illegible].98 cfs or 27.38 x 10^6 m^3 per day (Table A-1).

Egg mortalities per day due to plume entrainment, as calculated from mean September values, would increase from 39.8 x 10^6 individuals at the present maximum discharge ΔT of 26°F to 44.2 x 10^6 individuals at a proposed condenser ΔT of 32°F (discharge temperature of 117°F; Table D-2). Larval mortalities per day would increase from 13.0 x 10^6 individuals at a condenser ΔT of 26°F to 21.1 x 10^6 individuals at the proposed condenser ΔT of 32°F. Dilution volume required to reduce the discharge temperature to tolerable levels increases with increasing condenser temperatures up to 32°F. Ichthyoplankton mortalities would also increase proportionally.

TOTAL ENTRAINMENT EFFECTS

Total entrainment refers to the number of ichthyoplankton lost in passage through the plant plus the mortality associated with the offshore dilution volume. Expressed as the number of ichthyoplankton mortalities per day, egg mortalities from both units would increase from 48.0 x 10^6 individuals at a condenser ΔT of 26°F to just over 51.3 x 10^6 individuals at condenser ΔTs of 28°, 30°F and 32°F. Larval mortalities would range from 22.9 x 10^6 individuals at a condenser ΔT of

26°F to just ove. 24.5 x 10^6 individuals at condenser ΔTs of 28°, 30°, and 32°F (Table D-2).

Assuming an even distribution of eggs and larvae in the water, the percentage of organisms in the region of potential impact that would be affected is the same as the percentage of water affected by the plant operation. Under static (worst-case) conditions, 23.0 percent of the volume of water in the region of potential impact at a condenser ΔT of 26°F, would be utilized for either plant cooling of both units or plume dilution to 95°F (Table D-3). Under dynamic conditions, only 7.0 percent of the volume of this same region is utilized at this ΔT. An increase in the condenser temperature to 28°F ΔT causes the percentage of the volume of the region potentially impacted to increase 1.7 percent and 0.6 percent under static and dynamic water conditions, respectively (Table D-3). Condenser ΔTs above 28°F have little effect on the percentage of the volume of the defined region utilized under either static or dynamic water conditions. Thus, the alternate modes of operation would affect less than 2 percent of the region of potential impact.

SUMMARY

Ichthyoplankton mortality may occur as a result of entrainment in 1) power plant condenser cooling waters and 2) thermally elevated plant discharge waters. A 100-percent mortality of ichthyoplankton passing through the plants is assumed. Thus, the number of individuals impacted would be directly proportional to the volume of water required to cool the condenser units at the various operating modes. Condenser ΔTs of 30°

TABLE D-3

TOTAL VOLUME[a] IMPACTED EXPRESSED AS PERCENTAGE OF THE VOLUME OF THE REGION POTENTIALLY IMPACTED

Condenser ΔT (°F)	Assuming static conditions		Assuming dynamic conditions	
	Unit 1	Unit 1 and 2	Unit 1	Unit 1 and 2
26	11.5	23.0	3.5	7.0
28	12.4	24.7	3.8	7.6
30	12.4	24.7	3.8	7.6
32	12.3	24.5	3.8	7.5

[a]Plant discharge volume plus ocean dilution volume (amount of water per unit/time required to cool discharge water at the specified condenser ΔT to 95°F).

or 32°F would have an associated decrease in flow rate through the plants and would result in a proportional reduction in egg and larvae mortality. However, as condenser temperatures increase, the dilution volumes required to reduce the discharge temperature to tolerable levels would also increase. Plume entrainment mortalities would therefore increase with condenser temperature.

When overall entrainment mortality is considered (total number of ichthyoplankton lost in passage through the plant as well as mortality associated with the offshore dilution volume) condenser ΔTs above 26°F results in an egg or larvae mortality increase of less than 2 percent.

LITERATURE CITED

ABI. 1977. Ecological monitoring at the Florida Power & Light Co. St. Lucie Plant, annual report 1976. Vol. 1. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga.

ABI. 1978. Ecological monitoring at the Florida Power & Light Co. St. Lucie Plant, annual report 1977. Vol. 1. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga.

ABI. 1979. Florida Power & Light Co., St. Lucie Plant, annual non-radiological environmental monitoring report, 1978. Biotic monitoring. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga.

ABI. 1980. Florida Power & Light Co., St. Lucie Plant, annual non-radiological environmental monitoring report, 1979. Biotic monitoring. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga.

Ahlstrom, E.H., and O.P. Ball. 1954. Description of eggs and larvae of jack mackerel (Trachurus symmetricus) and distribution and abundance of larvae in 1950 and 1951. Fish. Bull. Fish Wildlife Ser. 56:210-242.

Aprieto, V.L. 1974. Early development of five carangid fishes of the Gulf of Mexico and the south Atlantic coast of the United States. Fish. Bull. 72:415-443.

Berry, F.H. 1959. Young jack crevalles (Caranx species) off the southeastern Atlantic coast of the United States. Fish. Bull. Fish Wildl. Ser. 59:438-526.

Berry, F.H., and L.R. Rivas. 1962. Data on six species of needlefishes (Belonidae) from the western Atlantic. Copeia 1962:152-160.

Breder, C.M., Jr. 1959. Observations on the spawning behavior and egg development of Strongylura notata (Poey). Zoologica 44(4):141-148.

Brett, J.R. 1970. Temperature. Pages 515-560 in O. Kinne, ed. Marine ecology, Vol. 1, part 1. Wiley-Interscience, London.

Brewer, G.D. 1976. Thermal tolerance and resistance of the northern anchovy, Engraulis mordax. Fish. Bull. 74:433-445.

Bruger, G.E. 1974. Age, growth, food habits, and reproduction of bonefish, Albula vulpes, in south Florida waters. Fla. Mar. Res. Pub. No. 3. 20 pp.

Campbell, C.M., and P.S. Davies. 1975. Thermal acclimation in the toleost Blennius pholis. Comp. Biochem. Physiol. A. Comp. Physiol. 52(1):147-152

LITERATURE CITED (continued)

Cardeilhac, P.T. 1976. Induced maturation and development of pinfish eggs. Aquaculture 8:389-393.

Ciechomski, J.D.D. 1972. Embryonic and larval development of Austroatherina incisa. Anales de la Sociedad Cientifica Argentina 193(5-6):273-281.

Daly, R.J. 1970. Systematics of southern Florida anchovies (Pisces: Engraulidae). Bull. Mar. Sci. 20:70-104.

Delmonte, P.J. 1968. Laboratory rearing through metamorphosis of some Panamanian gobies. Copeia 1968:411-412.

de Sylva, D.P. 1969. Theoretical considerations of the effects of heated effluents on marine fishes. Pages 229-293 in P.A. Krenkel and F.L. Parker, ed. Biological aspects of thermal pollution. Vanderbilt University Press, Nashville, Tenn.

de Vlaming, V.L. 1971. Thermal selection behavior in the estuarine goby Gillichthys mirabilis. J. Fish. Biol. 3(3):277-286.

Eldred, B. 1966. The early development of the spotted worm eel, Myrophis punctatus Lutken (Ophichthidae). Fla. Bd. Conserv. Mar. Lab., Leaf. Ser. IV, Pt. 1, No. 1. 13 pp.

Eldred, B. 1967a. Larval tarpon, Megalops athlanticus Valenciennes, (Megalopidae) in Florida waters. Fla. Bd. Conserv. Mar. Lab., Leaf. Ser. IV, Pt. 1, No. 4. 9 pp.

Eldred, B. 1967b. Larval bonefish, Albula vulpes (Linnaeus, 1758?), (Albulidae) in Florida and adjacent waters. Fla. Bd. Conserv. Mar. Lab., Leaflet Ser. IV, Part 1, No. 3. 4 pp.

Eldred, B. 1972. Note on larval tarpon, Megalops atlanticus (Megalopidae), in the Florida Straits. Fla. Dept. Nat. Res. Mar. Res. Lab., Leaf. Ser. IV, Pt. 1, No. 22. 6 pp.

Fonds, M., H. Rosenthal, and D.F. Alderdice. 1974. Influence of temperature and salinity on embryonic development, larval growth and number of vertebrae of the garfish, Belone belone. Pages 509-525 in J.H.S. Blaxter, ed. The early life history of fish. Springer-Verlag, N.Y.

Foster, N.R. 1973. Behavior, development, and early life history of the Asian needlefish, Xenentodon cancila. Prod. Acad. Natur. Sci. Phil. 125-77-88

Garside, E.T., and Z.K. Chin-Yuen-kee. 1972. Influence of osmotic stress on upper lethal temperatures in the cyprinodontial fish Fundulus heteroclitus (L.) Can. J. Zool. 50:787-791.

LITERATURE CITED (continued)

Harrington, R.W., Jr. 1958. Morphometry and ecology of small tarpon, Megalops atlantica Valenciennes, from transitional stage through onset of scale formation. Copiea 1958:1-10.

Harrington, R.W., Jr., and E.S. Harrington. 1961. Food selection among fishes invading a high subtropical salt marsh from onset of flooding through the progress of a mosquito brood. Ecology 42:646-666.

Hettler, W.F., Jr. 1971. Effects of increased temperature on post-larval and juvenile estuarine fish. Proc. 25th Ann. Conf. S.E. Assoc. Game and Fish Commissioners. pp. 635-642.

Hettler, W.F., Jr. 1976. Influence of temperature and salinity on routine metabolic rate and growth of young Atlantic mennaden. J. Fish. Biol. 89:55-65.

Hildebrand, S.F. 1924. Notes on habits and development of eggs and larvae of the silversides Menidia menidia and Menidia beryllina. Bull. U.S. Bur. Fish. 38 (1921-1922):113-120.

Hoff, F., C. Rowell, and T. Pulver. 1972. Artificially induced spawning of the Florida pompano under controlled conditions. Proc. Third Annual Workshop World Mariculture Society. pp. 53-64.

Houde, E.D., W. J. Richards, and V.P. Saksena. 1974. Description of eggs and larvae of scaled sardine, Harengula jaguana. Fish. Bull. 72:1106-1122.

Hubbs, C., and C. Bryan. 1974. Effect of parental temperature experience on thermal tolerance of eggs of Menidia audens. Pages 431-435 in O.H.S. Blaxter, ed. The early life history of fish. Springer-Verlag, N.Y.

Huff, J.G., and J.R. Westman. 1966. The temperature tolerances of three species of marine fishes. J. Mar. Res. 24(2):131-140.

Jean, R., and E.T. Garside. 1974. Selective elevation of the upper lethal temperature of the mummichog Fundulua heteroclitus (L.) (Cyprinodontidae), with a statement of its application in fish culture. Can. J. Zool. 52:433-435.

Johnson, M.S. 1975. Comparative geographic variation in Menidia. Evolution 28:607-618.

Kendall, A.W., Jr., and J.W. Reintjes. 1975. Geographic and hydrographic distribution of Atlantic menhaden eggs and larvae along the middle Atlantic coast from RV Dolphin cruises, 1965-66. Fish. Bull. 73:317-335.

LITERATURE CITED (continued)

Leak, J.C. 1977. Distribution and abundance of Carangid larvae in the eastern Gulf of Mexico. Proc. 57th Ann. Mtg. Amer. Soc. Ichthy. Herpet., 19-25 June 1977. (Abstract).

Lowe, C.H., and W.G. Heath. 1969. Behavioral and physiological responses to temperature in the desert pupfish Cyprinodon macularius. Physiol. Zool. 42(1):53-59.

Marcy, B.C., Jr. 1975. Entrainment of organisms at power plants, with emphasis on fishes - an overview. Pages 89-108 in S.B. Saila, ed. Fisheries and energy production: a symposium. Lexington Books, Lexington Books, D.C. Heath and Co., Lexington, Mass. 300 pp.

Martin, R.A., and C.L. Martin. 1970. Reproduction of the clingfish, Gobiesox strumosus. Quart. Jour. Fla. Acad. Sci. 33:275-278.

Martinez, S., and E.D. Houde. 1975. Fecundity, sexual maturation, and spawning of scaled sardine (Harengula jaguana Poey). Bull. Mar. Sci. 25:35-45.

Middaugh, D.P., and P.W. Lempesis. 1976. Laboratory spawning and rearing of a marine fish, the silverside Menidia menidia Menidia. Mar. Biol. (BER.) 35(4):295-300.

Mosher, C. 1954. Observations on the spawning behavior and the early larval development of the sargassum fish, Histrio histrio (Linnaeus). Zoologica 39:141-152

Rasquin, P. 1958. Ovarian morphology and early embryology of the pediculate fishes Antennarius and Histrio. Bull. Amer. Mus. Nat. Hist. 114(4):327-372.

Reynolds, W.W., and D. A. Thomson. 1974a. Temperature and salinity tolerances of young Gulf of California grunion Leuresthes sardina (Atheriniformes, Atherinidae). J. Mar. Res. 32(1):37-45.

Reynolds, W.W., and D.A. Thomson. 1974b. Responses of young Gulf grunion Leuresthes sardina to gradients to temperature, light, turbulence and oxygen. Copeia 1974(3):747-758.

Richards, W.J., R.V. Miller, and E.D. Houde. 1974. Egg and larval development of the Atlantic thread herring, Opisthonema oglinum. Fish Bull. 72:1123-1136.

Saksena, V.P., and W.J. Richards. 1975. Description of eggs and larvae of laboratory-reared white grunt, Haemulon plumieri (Lacepede) (Pisces, Pomadasyidae). Bull. Mar. Sci. 24(4):523-536.

LITERATURE CITED (continued)

Saksena, V.P., C. Steinmetz, Jr., and E.D. Houde. 1972. Effects of temperature on growth and survival of laboratory-reared larvae of the scaled sardine, Harengula pensacolae Goode and Bean. Trans. Amer. Fish. Soc. 101(4):691-695.

Santerre, M.T. 1976. Effects of temperature and salinity on the eggs and early larvae of Caranx mate Pisces (Carangidae) in Hawaii. J. Exp. Mar. Biol. Ecol. 21(1):51-68.

Schubel, J.R., C.F. Smith and T.S. Y. Koo. 1977. Thermal effects of power plant entrainment on survival of larval fishes: a laboratory assessment. Chesapeake Sci. 18(3):290-298.

Shiogaki, M., and Y. Dotsu. 1973. The egg development and larva rearing of the tripterygiid blenny Tripterygion etheostoma. Jap. J. Ichthyol. 20(1):42-46.

Springer, V.G., and A.J. McErlean. 1961. Spawning seasons and growth of the code goby, Gobiosoma robustum (Pisces: Gobiidae), in the Tampa Bay Area. Tulane Stud. Zool. 9:87-98.

Springer, V.G., and K.D. Woodburn. 19J0. An ecological study of the fishes of the Tampa Bay Area. Fla. St. Bd. Conserv., Prof. Pap. Ser. No. 1. 104 pp.

Sylvester, J.R. 197?. A note on the upper lethal temperature of juvenile Haemulon flavonlineatum from the Virgin Islands. J. Fish. Biol. 5(3):305-307.

Sylvester, J.R. 1974. Thermal response of juvenile Hawaiian mullet Mugil caphalus (L.) to acclimation time and fluctuating low temperatures. J.Fish. Biol. 6:001-006.

Sylvester, J.R., and C.E. Nash. 1975. Thermal tolerance of eggs and larvae of Hawaiian striped mullet, Mugil cephalus L. Trans. Am. Fish. Cos. 104(1):144-147.

Tagatz, M.E. 1973. A larval tarpon, Megalops atlanticus, from Pensacola, Florida. Copeia 1973(1):140-141.

Tucker, J.W., Jr., and R.G. Hodson. 1976. Early and mid-metamorphic larvae of the tarpon, Megalops atlantica, from the Cape Fear River estuary, North Carolina, 1973-74. Chesapeake Sci. 17:123-125.

Valenti, R.J. 1972. The embryology of the neon goby, Gobiosoma oceanops. Copeia 1972:477-482.

Wohlschlag, D.E., and J.J. Cech, Jr. 1970. Size of pinfish in relation to thermal stress response. Contr. Mar. Sci. 15:21-31.

LITERATURE CITED (continued)

Wourms, J.P., and D. Evans. 1974a. The annual reproductive cycle of the black prickleback *Xiphister atropurpureus*, a Pacific coast blennioid fish. Can. J. Zool. 52(7):795-802.

Wourms, J.P., and D. Evans. 1974b. The embryonic development of the black prickleback *Xiphister atropurpureus*, a Pacific coast blennioid fish. Can. J. Zool. 52(7):879-887.

Young, J.S. 1974. Menhaden and power plants - a growing concern. Mar Fish Rev. 36:19-23 (MFR Paper 1094).

E. MARINE TURTLES

INTRODUCTION

Marine turtles, from egg to adult, are closely tied to their thermal environment. Each reptilian species has a characteristic preferred temperature range which is thought to be the range in which various physiological processes function optimally. Turtle response to temperature determines in part their distribution, behavior, and biology.

MARINE TURTLES AT THE ST. LUCIE PLANT

Three species of marine turtles are known to nest along Hutchinson Island, Florida, in the vicinity of the St. Lucie Power Plant: the Atlantic loggerhead, *Caretta caretta*; the Atlantic green, *Chelonia mydas*; and the leatherback, *Dermochelys coriacea* (Gallagher et al., 1972; Worth and Smith, 1976). The loggerhead turtle is the most abundant species with an estimated 2000 females producing about 4000 nests each year (ABI, 1980). Green turtles are uncommon (less than 25 nest per year) and nest primarily on the southern half of the island (Gallagher et al., 1972; Worth and Smith, 1976). Leatherback nesting is only occasional.

Predators, primarily raccoons, destroy up to 50 percent of yearly nest production efforts (ABI, 1978). Although the highest nest densities generally occur in the southern part of the island, predation is highest in the northern half of this island. Raccoon populations are apparently highest in the northern half of the island where undisturbed upland habitats are abundant.

The nesting season begins with the arrival of loggerhead turtles, generally during the first week of May, and continues through August. Nesting activity is typically highest during the tenth week of the season and declines steadily thereafter. While most turtles produce only one nest per season, other turtles may return to the beach to lay as many as five consecutive clutches of eggs with a lapse of about 14 days between nestings. On the average, about 120 eggs per nest incubate in the sand for 65 days. The hatchlings then dig out and crawl toward the sea.

TEMPERATURE CONTROL MECHANISMS OF MARINE TURTLES

Reptiles can exert some limited physiological control over their body temperatures by effecting changes in: 1) the radiative properties of the skin, 2) ventilation and evaporation, 3) blood flow, and 4) metabolic rate (Bartholomew and Tucker, 1963). Turtles are capable of altering blood flow to the periphery of the body in response to extreme temperature changes (Spray and May, 1972). For example, vasoconstriction occurs upon heating, resulting in a reduction of blood flow in the skin and carapace (Weathers and White, 1971).

Many reptiles control body temperature through behavioral thermoregulation (Cowles and Bogert, 1944; Colbert et al., 1946; Bogert, 1959; Dawson, 1960). [illegible]havioral thermoregulation mechanisms in sea turtles include habitat selection, basking, and dormancy.

EFFECTS OF TEMPERATURE ON MARINE TURTLES

The optimum body temperature range for marine turtles and the mechanism by which they maintain these temperatures is not completely understood. However, environmental temperature is known to affect many aspects of marine turtle physiology and behavior.

Physiology

In a variety of reptiles, temperatures between 30° and 40°C (86° and 104°F) produce high metabolic rates and allow greater activity than lower temperatures (Cloudsley-Thompson, 1971). Heartbeat rates and oxygen consumption increase with increasing temperature (Hutton et al, 1960). An increase of 10°C (18°F) in acclimated animals usually results in a doubling of metabolic rate and oxygen consumption. As body temperatures approach a critical maximum, the ability of blood hemoglobin to bind with oxygen decreases. The oxygen-carrying capacity of reptile blood may be reduced as much as 40 percent at the extremely high temperatures reptiles encounter (Pough, 1976).

Egg-Laying Behavior

Seawater temperatures may influence the timing of nesting in marine turtles (Worth and Smith, 1976). Unseasonably warm ocean temperatures at Hutchinson Island may have induced the 1975 nesting season to occur four weeks earlier than in previous years. The influence of early nesting on the population is unknown (ABI, 1978).

Unseasonably cool or warm ocean temperatures may also cause large variations in nest production and in the periodicity of the renesting behavior of adult female loggerheads (Caretta caretta). In South Africa, Hughes (1972) found that when ocean temperatures were unusually low (21.7°C, 71.1°F) fewer nests were produced per season than when ocean temperatures were higher (24.3°C, 75.7°F).

Egg Development

Temperature has a dramatic effect on reptilian embryogenesis and hatchlings. Embryonic metabolism increases with emperature, up to a point; embryos thus develop much faster in warm environments than in cool ones (Legler, 1960; Goode and Russell, 1968; Bustard and Greenham, 1968; Bustard, 1969, 1971). The temperature range for optimal development is relatively narrow. For Atlantic green turtles, Chelonia mydas, the highest percentage of eggs hatched between 27° and 32°C (Bustard and Greenham (1968). Embryos of tropical reptilian species, however, are less tolerant of variations from their thermal optimum than are temperate forms (Licht and Moberly, 1965; Bustard and Greenham, 1968).

There is no reason to suspect that the thermal plume would alter subsurface sand temperatures in the areas where turtle eggs are deposited.

Hatchling Behavior

Increased temperatures inhibit the nest emergence behavior of green turtle hatchlings (Bustard, 1967; Mrosovsky and Shettleworth, 1968; Mrosovsky, 1968). Phototaxis, essential to the sea-finding ability of all marine turtles, is also inhibited in green turtle hatchlings at temperatures between 28.5°C (83.3°F; Mrosovsky, 1968) and 33.0°C (91°F; Hendrickson, 1958). These are beneficial effects in that they promote nocturnal emergence which reduces hatchling predation. The thermal influences on hatchling behavior are therefore selective adaptations to the brief terrestrial phase of the life history of marine turtles.

Physiological studies with green turtle hatchlings show an increase in oxygen consumption rate as a function of temperature (McGinnis, 1968). Young turtles would thus need to surface for air more frequently as temperatures increase.

THERMAL MAXIMA OF MARINE TURTLES

Critical thermal maximum (CTM) is defined as the temperature at which locomotory activity becomes disorganized and the animal loses its ability to escape from conditions that will promptly lead to its death" (Cowles and Bogert, 1944). Lowest CTM's (39.0°C, 102.2°F) occur in aquatic species of turtles such as the soft-shelled turtles, *Trionyx ferox*, while highest CTM's (43.9°C, 111°F) occur in terrestrial forms such as the gopher turtle, *Gopherus polyphemus* (Hutchinson et al., 1966). These upper limits appear to conform to the geographical ranges of the species and the habitats in which they reside. Additionally, those

turtles with large body mass have somewhat lower tolerances to temperature extremes.

Thermal maxima in marine turtles (Cheloniidae and Dermochelyidae) may be somewhat lower than in other lower forms. Captive green and leatherback turtles raised at the Miami Seaquarium during the summer of 1975 exhibited abnormal behavior when tank temperatures approached 27°C (80.6°F). The turtles stopped eating and were found floating listlessly on the surface. All individuals died when tank temperatures exceeded 29°C (84.2°F; personal communication, Ross Witham). No information on the synergistic effects of temperature with other enviromental variables is available.

Temperature tolerance indicated that 50 percent of loggerhead turtle hatchlings cannot survive continuous exposure to temperatures in excess of 37.4°C (99.3°F; ABI, 1978). Swimming speed is reduced at temperatures higher than 30°C (86°F) and phototaxis is completely inhibited at temperatures higher than 33°C (92°F; O'Hara, 1980).

PLANT EFFECTS ON MARINE TURTLES

During plant operations that produce a 28°F ΔT, the combined area enclosed by the 2.0°F above ambient isotherm from discharges of both Units 1 and 2 is approximately 405 acres (FPL, 1980). This area would constitute a habitat where the thermal addition might influence the swimming speed of hatchlings. At ΔTs of 30° and 32°F, the area of influence would increase to no more than 644 acres. The reduction in

swimming speed through the plume area would be temporary because tested hatchlings resumed normal swimming after leaving the region of thermal elevation.

Hatchling phototaxis would be inhibited in the areas enclosed by a 92°F isotherm. This temperature would be produced only during the 30° and 32°F ΔT regimes associated with Unit 1. The rapid dissipation of heat from the Unit 2 discharge prevents surface temperature from reaching 92°F. For the St. Lucie Plant, the 92°F isotherm encloses less than 2 acres. Depending on the plume configuration, this area may be 200 to 400 ft wide. The number of turtle hatchlings that would encounter this band of water would be extremely small. Hatchling turtles entering this heated area would probably be carried out of the area by the discharge currents. In addition, hatchling turtles are positively buoyant and thus swim in surface waters where temperatures apparently do not reach 92°F.

SUMMARY

Naturally occurring, unseasonably warm ocean waters have been related to the initiation of marine turtle nesting four weeks earlier than normal. Although such an event is unlikely, warm water discharge from the St. Lucie Plant could possibly attract a few egg-laying females toward the beaches adjacent to the plant. The ramifications of this possibility for the well-being of these individuals and their nests are unknown.

Reduced swimming speed by hatchlings is expected when they encounter thermal regions over 30°C (86°F). Disorientation may occur in hatchlings that encounter waters heated to 33°C (92°F). At St. Lucie, the areas exposed to these temperatures is estimated at less than 2 acres during a worst-case (e.g., September operation of both units) situation.

The high mobility of adult turtles will enable them to avoid unfavorable temperatures. Hatchling turtles exposed to temperatures over 33°C (92°F) would be stressed but these hatchlings may be able to reorient after leaving the exposure area.

LITERATURE CITED

ABI. 1978. Ecological monitoring at the Florida Power & Light Co. St. Lucie Plant, annual report 1977, Vol. 1. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga.

ABI. 1980. Florida Power & Light Co., St. Lucie annual non-radiological environmental monitoring report, 1979, biotic monitoring. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga.

Bartholomew, G.A., and V.A. Tucker. 1963. Control of changes in body temperature, metabolism, and circulation by the agamid lizard, Amphibolurus barbatus. Physiol. Zool. 36:199-218.

Bogert, C.M. 1959. How reptiles regulate their body temperature. Sci. Amer. 200:105-120.

Bustard, H.R. 1967. The mechanism of nocturnal emergence from the nest in green turtle hatchlings. Nature 214:317.

Bustard, H.R. 1969. Tail abnormalities in reptiles resulting from high temperature egg incubation. British J. Herp. 4:121-123.

Bustard, H.R. 1971. Temperature and water tolerances of incubating sea turtle eggs. British J. Herp. 4:196-198.

Bustard, H.R., and P. Greenham. 1968. Physical and chemical factors affecting hatching in the green sea turtle, Chelonia mydas (L.) Ecology 49:269-76.

Cloudsley-Thompson, J.L. 1971. Temperature and water relations of reptiles. Morrow Publishing Co., Watford Herts, England. 148 pp.

Colbert, E.H., R.B. Cowles, and C.M. Bogert. 1946. Temperature tolerances in the American alligator and their bearing on the habits, evolution and extinction of the dinosaurs. Bull. Amer. Mus. Nat. Hist. 86:329-73.

Cowles, R.B., and C.M. Bogert. 1944. A preliminary study of thermal requirements of desert reptiles. Bull. Amer. Mus. Nat. Hist. 83:265-96.

Dawson, W.R. 1960. Physiological responses to temperature in lizard Eumeces obsoletus. Physiol. Zool. 33:87-103.

FPL. 1980. Environmental report - operating license. St. Lucie Plant Unit No. 2. 2 Vol. Florida Power Light Co., Miami, Fla.

Gallagher, R.M., M.L. Hollinger, R.M. Ingle, and C.R. Futch. 1972. Marine turtle nesting on Hutchinson Island, Florida, in 1971. Fla. Dept. Nat. Res. No. 37. 11 pp.

LITERATURE CITED (continued)

Goode, J., and J. Russell. 1968. Incubation of eggs of three species of chelid tortoises, and notes on their embryological development. Aust. J. Zool. 16:749-61.

Hendrickson, J.R. 1958. The green sea turtle, Chelonia mydas (Linn.) in Malaya and Sarawak. Proc. Zool. Soc. Lond. 130:455-535.

Hughes, G.R. 1972. The marine turtles of Tongaland, 7. The Lammergeyer 17:40-62.

Hutchinson, J.H., A. Vinegar, and R.J. Kosh. 1966. Critical thermal maxima in turtles. Herp. 22(1):32-41.

Hutton, D.E., D.R. Boyer, P.M. Campbell, and J.C. Williams. 1960. Effects of temperature and body size upon heart rate and oxygen consumption in turtles. J. Cell. Comp. Physiol. 55:87-94.

Legler, J.M. 1960. Natural history of the ornate box turtle, Terrapene ornata ornata Agassiz. Univ. of Kansas Publ. Mus. Nat. Hist. XX:527-669.

Licht, P., and W.R. Moberly. 1965. Thermal requirements for embryonic development in the tropical lizard Iguana iguana. Copeia 1965: 515-517.

McGinnis, S.M. 1968. Respiration rate and body temperature of the Pacific green turtle, Chelonia mydas agassizii. Am. Zool. 8:766.

Mrosovsky, N. 1968. Nocturnal emergence of hatchling sea turtles: control by thermal inhibition of activity. Nature 220 (5174):1338-1339.

Mrosovsky, N., and S.J. Shettleworth. 1968. Wavelength preferences and brightness cues in the water finding behavior of sea turtles. Behavior 32:211-257.

O'Hara, J. 1980. Thermal influences on the swimming speed of loggerhead turtle hatchlings. Copeia. In press.

Pough, H.F. 1976. The effect of temperature on the oxygen capacity of reptile blood. Physiol. Zool. 49(2):141-151.

Spray, D.C., and M.L. May. 1972. Heating and cooling rates in four species of turtles. Comp. Biochem. Physiol. 41(A):507-522.

Weathers, W.W., and F.N. White. 1971. Physiological thermoregulation in turtles. Am. J. Phyhsiol. 221:706-710.

Worth, D.R., and J.B. Smith. 1976. Marine turtle nesting on Hutchinson Island, Fla. in 1973. Fla. Dept. Nat. Res. Marine Res. Lab. 18:1-17.

LITERATURE CITED (continued)

Personel Communication

Witham, Ross. Florida Department of Natural Resources, Marine Research Laboratory.

F. BENTHIC MACROINVERTEBRATES

INTRODUCTION

The benthic macroinvertebrate community in the vicinity of the St. Lucie Plant has three components: the offshore benthic community where adult forms may be found, the offshore meroplanktonic invertebrate community where larval forms may be found (see Section H, "Zooplankton") and the unique worm reef community (see Section G, "Worm Reef") found inshore of the plant discharge. These components may be impacted by operation of the power plant units either by direct contact with the thermal plume or by entrainment of the pelagic larvae through the plant. It is anticipated that plume water temperatures are highest in September, thus impacts on organisms are expected to be greatest in that month.

Entrainment via intake waters generally does not affect adults of the offshore benthic community because the mouth of the intake structure takes in water from midwater areas while adult benthic organisms are closely associated with bottom sediments. Heated effluent is presently discharged from Unit 1 via an offshore Y-port discharge structure. Although the thermal plume rises quickly from this discharge, there is some direct contact with benthic macroinvertebrates in the scoured area near the structure.

Another discharge structure of the diffuser-type will be constructed to service the additional discharge water of Unit 2 No scouring is expected from this type of discharge and the heated water should rise quickly to the surface.

THERMAL EFFECTS ON BENTHIC MACROINVERTEBRATES

Various effects on benthic macroinvertebrate communities have been attributed to power plant thermal effluents. These effects include alterations in species diversity, biomass, species composition, density of individuals, and species richness. Kolehmainen et al. (1974) found that species composition and biomass in a Puerto Rican bay were unaffected by temperatures below 34°C (93.2°F), but at temperatures between 34° and 35°C (93.2° and 95.0°F) the number of species dropped abruptly. Virnstein (1972) suggested that temperatures of 32° to 33°C (89.6° to 91.4°F) were restrictive to the benthic fauna in an area of Tampa Bay, Florida. Bader and Roessler (1972) indicated an optimum temperature range of 26° to 28°C (78.8° to 82.4°F) for diversity of species and maximum number of benthic organisms in Biscayne Bay, Florida. They reported 50 percent exclusion of species at 30° to 34°C (86.0° to 93.2°) and stated that "temperatures above 32°C (89.6°F) are harmful to marine life, with few exceptions, if sustained over the natural tidal cycles." Although these studies were conducted in relatively confined waters of bays and estuaries, absolute temperatures of 32° to 34°C (89.6° to 93.2°F) should be considered limiting to marine benthic forms.

PLANT EFFECTS ON THE BENTHIC COMMUNITY AT ST. LUCIE

Applied Biology, Inc., has conducted a survey of the benthic macroinvertebrate community at the six offshore stations near the St. Lucie Plant since March 1976. Results indicate that the marine environment in the vicinity of the plant supports a rich and diverse assemblage of benthic invertebrates. Densities at the six stations ranged from 300

individuals/m^2 (392/yd^3) in June 1976 to 24,150/m^2 (31,588/yd^3) in September 1976. Shipek grab samples taken in September of other years occasionally demonstrated higher densities than those taken at other months of the year.

Monitoring conducted by ABI since March 1976 has indicated that operation of St. Lucie Unit 1, has had minimal impact upon the offshore benthic fauna (ABI, 1977, 1978, 1979, 1980). Although seasonal variation in community structure parameters was sometimes considerable, significant differences attributable to plant operation were not observed between test and control stations in any one year. Significant differences were not observed between years of baseline monitoring (1971-1973) or years of intermittent (1976) or full-time operation (1977-1979). The discharge temperature showed few correlations with any seasonal community parameter (variation in density, diversity, equitability, biomass, or community structure) at any one station (ABI, 1978, 1979, 1980).

Minimal impact is made possible by the limited exposure of the benthic community to the thermal plume of Unit 1. In general, the plume rises rapidly to the surface and affects only the immediate scour area near the discharge jets of the Y-port discharge. Only organisms in the immediate scour area are affected by the higher temperatures. Although the size of the plume will be increased with two units in operation, the diffuser-type discharge to be constructed for Unit 2 will not increase the scour area. The plume will rise rapidly to the surface where it will have little effect on the benthos. In the event that a reduction in cir-

culating water flow rate occurs and higher ΔTs increase the discharge temperature, the lack of direct contact of the plume and the benthic community will negate any potential effects of the warmer discharge.

Another factor that contributes to minimal impact is the physical location of the St. Lucie Plant. Hutchinson Island lies near the boundaries of the Carolinian and Caribbean zoogeographical provinces (Briggs, 1970). Although the invertebrate fauna can be considered primarily Carolinian, organisms with both temperate and tropical affinities inhabit the area during certain portions of the year. Warming temperatures during the late spring and summer months appear to enable organisms of tropical origin to settle and survive in the area, with maximum immigration occurring around September when water temperatures are highest. The immigration of tropical forms evidently surpasses the extinction of cold water species because the number of individuals, number of taxa, and diversity increase during this period. Biomass is low, however, because of the small size of the newly metamorphosed individuals. When temperatures begin to decline, many of the tropical species disappear, and a decrease in the number of taxa and density of organisms is observed. Individuals of the remaining temperate species increase in size after September and thus biomass increases.

<u>SUMMARY</u>

Under normal operating conditions, the Unit 1 impact on the benthic community is limited to the scour area where the heated jet of water comes in contact with the substrate. The addition of a second unit with

a diffuser discharge pipe will increase the volume of heated water but will not increase the size of the scour area of Unit 1. The benthic community near the Unit 2 discharge is not expected to be impacted. Should the temperature of the discharge be increased, the thermal plume will continue to rise quickly to the surface and will have minimal impact on the benthic community.

LITERATURE CITED

ABI. 1978. Ecological monitoring at the Florida Power & Light Co. St. Lucie Plant, annual report 1977. Vol. 1. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga.

ABI. 1979. Florida Power & Light Co. St. Lucie Plant annual non-radiological environmental monitoring report 1978. Vol. II. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga.

ABI. 1980. Florida Power & Light Co. St. Lucie Plant annual non-radiological environmental monitoring report 1979. Vol. II. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga.

Bader, R.G., and M.A. Roessler, eds. 1972. An ecological study of South Biscayne Bay and Card Sound. Progress report to U.S. Atomic Energy Commission (At (40-1) - 3801-4).

Briggs, J.C. 1970. A faunal history of the north Atlantic Ocean. Systematic Zoology 19(1):19-34.

Kolehmainen, S., T. Morgan, and R. Castro. 1974. Mangrove-root communities on a thermally altered area in Guayanilla Bay, Puerto Rico. Pages 371-390 in J.W. Gibbons and R.R. Sharitz, eds. Thermal ecology. NTIS No. CONF - 730505. Technical Information Center, U.S. Atomic Energy Commission, Oak Ridge, Tenn.

Virnstein, R.W. 1972. Effects of heated effluent on density and diversity of benthic infauna at Big Bend, Tampa Bay, Florida. M.A. Thesis, University of South Florida, Tampa, Fla. 60 pp.

G. WORM REEFS

INTRODUCTION

The sabellariid polychaete *Phragmatopoma lapidosa* is a colonial worm that lives primarily in the intertidal zone. Its colonies are composed of thousands of sand tubes, each constructed by an individual worm. The colonies expand to form extensive rock-like structures, which appear as small reefs lying roughly parallel to the shore.

P. lapidosa is a tropical marine species whose known geographic range is from Brazil to southern Florida (Hartman, 1944). Along the eastern shore of Florida, worm reefs usually occur in isolated patches from Biscayne Bay to Cape Canaveral (Kirtley, 1966). One worm reef, known as Walton Rocks, is located approximately 1 mi south of the St. Lucie Plant discharge. The nearest comparable reefs are located at Seminole Shores, about 12 mi south of the plant, and at Ft. Pierce Inlet, about 9 mi to the north.

Worm reefs support a unique community, providing food, substrate, and shelter for organisms that otherwise could not exist in the high-energy surf zone (Gore et al., 1978). A great variety of fish and macroinvertebrates have been found on the reefs (Gilmore, 1977; ABI, 1977a, 1979a). Among the macroinvertebrates were some decapod crustacean species that are apparently found almost exclusively in association with *P. lapidosa* reefs (Gore et al., 1978). Environmental factors may affect not only the worms of the reef but also the associated fauna of the reef community.

Worm reefs have been reported to help stabilize beaches by deflecting waves (Kirtley and Tanner, 1968; Courtenay et al., 1974). However, both the worm colony and accumulated sand are susceptible to damage by extreme wave action during storms. Although subject to such naturally occurring destructive forces, the communities generally appear to have long-term stability (Gore et al., 1978; ABI, 1979). Possible year-round recruitment of P. lapidosa larvae and of associated worm reef species (e.g., decapods) in addition to rapid reef repair by existing adult P. lapidosa allow the communities to persist (Kirtley and Tanner, 1968; Eckelbarger, 1976; Gore et al., 1978).

LIFE HISTORY OF PHRAGMATOPOMA LAPIDOSA

Larvae of P. lapidosa exist as members of the plankton community and are subject to movement by the ocean currents. A laboratory study of P. lapidosa indicated that, at 21° to 23°C (69.8° to 73.4°F), larval development from fertilization to metamorphosis takes 14 to 30 days (Eckelbarger, 1976). The worm larvae subsequently settle out of the water column and attach themselves to stable substrates such as peat, wharf pilings, rocks, or existing worm reefs. The colonies at Walton Rocks are attached to a shelf of coquinoid rocks that protrudes from the surf zone during extreme low tides. After settlement on a hard substrate, the worms develop to their adult form.

P. lapidosa apparently spawns several times during the year along Florida's east coast. Larvae of two sabellariid species, P. lapidosa and Sabellaria vulgaris, were abundant in the nearshore plankton off Ft.

Pierce in February, August, and October 1974 (Eckelbarger, 1976). Eckelbarger (1976) found sabellariid larvae at similar times of the year. Samples were not collected in other months in that area. Polychaete larvae (including pre-settling intermediate stages) have been found throughout the year in the plankton near the St. Lucie Plant (ABI, 1977b, 1978, 1979b, 1980). P. lapidosa larvae were not distinguished from other polychaete species in these studies; however, polychaete larvae were most abundant in March (1977), April (1978), August (1975 and 1976), and October/November (1976 and 1977).

Observations made at Walton Rocks indicated larval settlement of P. lapidosa occurred between October and January for three consecutive years (ABI, 1977, 1979). In another study, settlements were noted at Walton Rocks in March (Eckelbarger, 1976). Observations made during 28 months of study at Seminole Shores indicated larval settlement only in September, December, and May. It thus appears that P. lapidosa has at least three major spawning and settling periods on the east coast of Florida: a spring (February-April) spawn with settling in March/May, a late summer (August) spawn with settling in September, and an autumn spawn (October/November) with settling in the autumn or winter (i.e., December).

Because P. lapidosa and many of the invertebrates found in the worm reef community spend their larval lives in the plankton community, they are subject to movement by water currents. With predominant water movement to the north in the St. Lucie Plant area the larvae which settle at

Walton Rocks may be products of adults spawning south of Walton Rocks (Worth and Hollinger, 1977). Likewise, larvae produced by adults at Walton Rocks may be part of the recruitment for worm reef communities north of the St. Lucie Plant.

THERMAL TOLERANCES OF PHRAGMATOPOMA LAPIDOSA

In laboratory tests, Eckelbarger (1976) found that the optimum temperature range for development of P. lapidosa larvae from fertilization to 48 hours old is 24° to 26°C (75.2° to 78.8°F). At 29.5°C (85.1°F), only 50 percent of the larvae developed during the 48-hour test period. At 35°C (95°F), no embryonic development occurred. No information is available concerning thermal tolerances of the later larval stages, so for purposes of this report, 35°C (95°F) is considered to cause 100-percent mortality.

Although no information is available concerning thermal tolerances of adult P. lapidosa found in the worm rocks, Eckelbarger (1976) suggested that naturally elevated temperatures may have played a role in the temporary destruction of the worm reef at Walton Rocks in 1973. In July and August of 1974, prior to operation of the St. Lucie Plant, water temperatures of 30°C (86°F) or higher were recorded at Walton Rocks (Gore et al., 1978). If Eckelbarger's theory is substantiated, any thermal addition from the St. Lucie Plant would accentuate the impact of naturally destructive temperatures.

Potential thermal effects on meroplanktonic larvae of the associated worm reef fauna would be similar to those described in Section H, "Zooplankton," of this report. No information has been found concerning thermal effects on adults of species associated with worm reefs.

PLANT EFFECTS ON WORM REEFS

The worm reef community as a whole may be affected by plant related factors that affect P. lapidosa larvae, juveniles, and adults as well as the planktonic larvae, juveniles, and adults of associated reef fauna. The planktonic larval stages would be subject to entrainment through the power plant and entrainment into the offshore plume. Juveniles and adults of the reef community would be affected by onshore movement of the thermal plume. During entrainment through the plant, larvae would be subjected to thermal changes, mechanical damage, and chemical influences. However, because it is the most significant factor, this discussion focuses only on thermal effects of plant operation on P. lapidosa.

Thermal Effects on P. lapidosa Larvae

In determining plant effects, the worst-case result of 100-percent mortality would occur for P. lapidosa larvae exposed to water temperatures of 95°F or higher during plant passage or offshore plume entrainment. While there are no data on the distribution of P. lapidosa larvae in the water column, larvae are considered herein to be equally distributed in the water column. The percentage of the standing crop of P. lapidosa experiencing 100-percent mortality can be estimated by comparing the volume of water heated to 95°F or higher to the volume of the

cooler receiving water body in the area of potential impact. The volumes of water contai ed within the area of potential impact during static conditions and d ring 17 cm/sec (.56 ft/sec) flow (dynamic) over a 24-hr period have been calculated for Unit 1 or Unit 2, and Units 1 and 2 combined (Table G-1). For each of the potential operating modes, the thermal effects of entrainment are expressed as percentages based on relative water volumes for both static and dynamic conditions (Table G-2).

Assuming a mean maximum ambient water temperature of 85°F, all potential operating modes would result in 100-percent mortality of P. lapidosa larvae passing through the plant. These larvae represent approximately 2.0 percent of the standing crop of P. lapidosa larvae at a ΔT of 26°F under static water conditions for one unit alone (Table G-2). Only a small decrease in percentages for ΔTs of 30° and 32°F are noted because of the reduced flow across the condensers. Less than 1 percent would be affected under dynamic water conditions for all proposed ΔTs. For Units 1 and 2 combined, these percentages should be doubled at each particular temperature increase. Therefore, a maximum of 4 percent of the standing crop would be expected to be entrained through both units during static current conditions (ΔT of 26°F). A minimum of 1 percent should be observed during dynamic current conditions and reduced flow rates. It should be noted that increases in temperature across the condensers change the percentages only slightly while the current decreases the impact significantly.

TABLE G-1

VOLUMES OF WATER HEATED TO ≥95°F

ΔT across the condenser (°F)	Volume of water entrained through power plant (m^3/day)	Volume of offshore water required to dilute plant discharge to 95°F (m^3/day)	Total volume of water heated to temperatures ≥95°F (m^3/day)
Unit 1 or Unit 2			
26	2.8×10^6	13.7×10^6	16.5×10^6
28	2.8×10^6	15.0×10^6	17.8×10^6
30	2.6×10^6	15.2×10^6	17.8×10^6
32	2.5×10^6	15.2×10^6	17.7×10^6
Unit 1 and Unit 2 combined			
26	5.6×10^6	27.4×10^6	33.0×10^6
28	5.6×10^6	29.9×10^6	35.5×10^6
30	5.3×10^6	30.4×10^6	35.7×10^6
32	5.0×10^6	30.4×10^6	35.4×10^6

TABLE G-2

PERCENTAGE OF THE AREA OF IMPACT POTENTIALLY UNDER STATIC AND DYNAMIC CONDITIONS EXPOSED TO TEMPERATURES OF ≥95°F

ΔT across the condenser (°F)	Percentage by volume entrained through plant		Percentage by volume entrained into offshore plume		Total percentage by volume elevated to temperatures ≥95°F	
	Static	Dynamic	Static	Dynamic	Static	Dynamic
Unit 1 or Unit 2						
26	2.0	0.6	9.5	2.9	11.5	3.5
28	2.0	0.6	10.4	3.2	12.4	3.8
30	1.8	0.6	10.5	3.2	12.3	3.8
32	1.7	0.5	10.6	3.2	12.3	3.7
Unit 1 and Unit 2 Combined						
26	3.9	1.2	19.0	5.8	22.9	7.0
28	3.9	1.2	20.8	6.4	24.7	7.6
30	3.7	1.1	21.1	6.4	24.8	7.5
32	3.4	1.0	21.1	6.5	24.5	7.5

The volumes of offshore ambient water needed to dilute the plant discharge to various isotherms, from the discharge temperature down to 95°F, have been calculated for four condenser temperature increases (Table A-1). For each operating mode, the total daily offshore volume heated to temperatures of 95°F or higher is presented in Table G-1 for one unit and both units combined.

Considering one unit alone, during entrainment into the offshore thermal plume, the percentage of the larval P. lapidosa standing crop experiencing 100-percent mortality would increase only slightly from 9.5 percent at a condenser ΔT of 26°F to 10.6 percent at a condenser ΔT of 32°F under static conditions. Under dynamic conditions, the percentage affected would be lower, approximately 2.9 percent at a condenser ΔT of 26°F and 3.2 percent for all other ΔTs. For Units 1 and 2 combined, percentage of mortality should range from 5.8 percent at 26°F to approximately 21 percent at ΔTs of 30° and 32°F during static conditions.

The sum of percentages of larvae entrained through the units and entrained into the offshore plume gives the total percentage of the standing crop of P. lapidosa larvae which experience 100-percent mortality resulting from exposure to the heated water. The total percentage of mortality of P. lapidosa larvae calculated for one unit is a maximum of approximately 12.4 percent at ΔTs of 28° and 30°F under static conditions and 3.5 to 3.8 percent for all proposed condenser temperature increases under dynamic water conditions. For Units 1 and 2 combined, percentage of mortality ranges from 7.0 to 7.6 percent at all proposed

temperature increases during dynamic current conditions to nearly 25 percent during static conditions. For either static or dynamic conditions, these total percentages are approximately equal for condenser ΔTs of 26°, 28°, 30°, and 32°F.

A considerably smaller percentage of the standing crop of P. lapidosa larvae is affected under dynamic conditions than under static conditions. For either dynamic or static conditions, condenser temperature increase for both units from 28° to 30°F does not notably change the percentage of the larval standing crop affected by entrainment through the plants. Increasing the ΔT to 30° and 32°F only slightly decreases the percentage in each case. During entrainment into the offshore plume, a greater percentage of the standing crop of P. lapidosa larvae is affected as the temperature across the condenser is increased from 28° to 30°F. The summed percentages for plant entrainment and offshore plume entrainment are nearly equal for condenser ΔTs of 28°, 30°, and 32°F when one or both units are in operation.

Onshore Thermal Effects on the Worm Reef Community at Walton Rocks

Onshore surface currents of oceanic water have been shown to occur in the St. Lucie Plant-Walton Rocks area approximately 10 percent of the time (Envirosphere, 1976, 1978; Worth and Hollinger, 1977). Water from the discharge of Unit 1 is projected to be driven onshore and would reach the worm reefs during these periods. Under the given conditions (Table A-1), the maximum inshore temperature of water reaching Walton Rocks in September would range from 89° to 91°F under the proposed operating

modes. Unit 2 is projected to add no additional volume of water at or above 5°F over ambient to the surface plume; but it is projected to add a considerable volume of 2°F ΔT. This would increase the size of the plume but would not be expected to increase the impact on Walton Rocks.

If the September ambient temperature of 85°F is stressful (50-percent survival) to the worm reef community, any thermal addition can be detrimental. Increasing the temperature across the condenser could compound the deleterious temperature effects. Also, although onshore currents do not occur very frequently, they could have a deleterious effect should they occur when P. lapidosa larvae or other larval forms are settling onto the reef.

SUMMARY

Any environmental factors that affect the worm reef subsequently affect the reef community as a whole. Considering the predominantly northern currents in the St. Lucie Plant area (Worth and Hollinger, 1977; Envirosphere, 1978) adverse thermal effects on the Walton Rocks reef or on its meroplanktonic larvae might have some effect on reefs north of that area.

Thermal aspects of power plant operation can directly affect the worm reef community in three ways: 1) entrainment of planktonic larvae through the plant, 2) entrainment of planktonic larvae into the offshore plume, and 3) exposure of the reef to the thermal plume. In calculating plant and offshore plume entrainment effects for September, only 95°F or

higher temperatures (i.e., those causing 100-percent mortality of *Phragmatopoma lapidosa* larvae) were considered. Eckelbarger's (1976) tests showing that 50 percent of the *P. lapidosa* larvae did not develop at 85.1°F indicates that the actual percentages of the *P. lapidosa* larval standing crop affected could be greater.

Worm reef communities can usually survive naturally occurring destructive forces by means of rapid repair of the reef by surviving worms and by apparent year-round recruitment of reef fauna. Although one of the settlement periods for *P. lapidosa* occurs in September, adverse thermal effects on the worm reef occurring in that month might be offset by recruitment in subsequent months. Indeed, most of the larval settlements that have contributed significantly to the reef structure during the last four years (1976-1980) have occurred during winter months when ambient water temperatures are less than maximum (ABI, 1979a).

LITERATURE CITED

ABI. 1977a. Worm reef monitoring at the Florida Power & Light Co., St. Lucie Plant, April 1976 - April 1977. AB-60. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga. 26 pp.

ABI. 1977b. Ecological monitoring at the Florida Power & Light Co., St. Lucie Plant, annual report, 1976. 2 Vol. AB-44. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga.

ABI. 1978. Ecological monitoring at the Florida Power & Light Co., St. Lucie Plant, annual report, 1977. 2 Vol. AB-101. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga.

ABI. 1979a. Worm reef monitoring at the Florida Power & Light Co., St. Lucie Plant, July 1977-April 1979. AB-207. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga.

ABI. 1979b. Florida Power & Light Co., St. Lucie Plant. Annual non-radiological environmental monitoring report. 1978. 2 Vol. Biotic monitoring. AB-177. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga.

ABI. 1980. Florida Power & Light Co., St. Lucie Plant, annual non-radiological environmental monitoring report. 1978. 2 Vol. Biotic monitoring. AB-244. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga.

Courtenay, W.R., Jr., D.J. Herrema, M.P. Thompson, W.P. Azzinaro and J. van Montfrans. 1974. Ecological monitoring of beach erosion control projects, Broward County, Florida and adjacent areas. Prepared for U.S. Army Corps of Engineers, Coastal Engineering Research Center, Ft. Belvoir, Va. Technical Memorandum 41. 88 pp.

Eckelbarger, K.J. 1976. Larval development and populations aspects of the reef-building polychaete Phragmatopoma lapidosa from the east coast of Florida. Bull. Mar. Sci. 26(2):117-132.

Envirosphere Company. 1976. St. Lucie Plant site ocean current analysis for Florida Power Light Co. Envirosphere Company. Division of Ebasco Services Incorporated. New York, New York. 6 pp.

Envirosphere Company. 1978. Predicted thermal plumes for elevated discharge temperatures. St. Lucie Unit 1. Envirosphere Co., New York, N.Y.

FPL. 1980. Environmental report - operating license. St. Lucie Plant Unit No. 2. 2 Vol. Florida Power Light Co., Miami, Florida

Gilmore, R.G. 1977. Fishes of the Indian River lagoon and adjacent waters, Florida. Bulletin of the Florida State Museum Biological Sciences 22(3):101-148.

LITERATURE CITED (continued)

Gore, R.H., L.E. Scotto, and L.J. Becker. 1978. Community composition, stability and trophic partitioning in decapod crustaceans inhabiting some subtropical sabellariid worm reefs. Bull. Mar. Sci. 28(2):221-248.

Hartman, O. 1944. Larval development and population aspects of the reef-building polychaete Phragmatopoma lapidosa from the east coast of Florida. Bull. Mar. Sci. 26(2):117-132. (Cited in Eckelbarger, K.J. 1976).

Kirtley, D.W. 1966. Intertidal reefs of Sabellariidae (Annelida, Polychaeta) along the coasts of Florida. M.S. Thesis. Florida State Univ., Tallahassee, Fla.

Kirtley, D.W., and W.F. Tanner. 1968. Sabellariid worms: builders of a major reef type. J. Sed. Petrol. 38:73-78.

Worth, D.F., and M.L. Hollinger. 1977. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. III. Physical and chemical environment. Fla. Dept. Nat. Res. Mar. Res. Lab. No. 23. pp. 25-85.

H. ZOOPLANKTON

INTRODUCTION

Zooplankters are aquatic invertebrates that have limited mobility or passively drift with water currents. They serve as a major link in the aquatic food chain and are the principal organisms involved in biomass and energy transfer from the phytoplankton to higher organisms. Zooplankters which are only temporarily found in the water column are called meroplankters; these include larval stages in the life cycle of benthic macroinvertebrates. Because of their small size and limited swimming ability, zooplankters are easily entrained through intake structures of power plants and subjected to the effects of plant operation. These effects include exposure to rapid temperature elevations as well as mechanical and chemical stresses. This section examines the effect of elevated water temperature on the zooplankton communities at the St. Lucie Plant. Zooplankton entrainment both through the plant and as part of the dilution water entrained into the offshore thermal plume are considered in relation to the total region of potential impact.

THERMAL EFFECTS ON ZOOPLANKTON

Zooplankton mortality, as a result of power plant entrainment, appears to be site specific and dependent on the species and environmental conditions. However, studies indicate that 1) zooplankton mortality rapidly increases at temperatures higher than 95°F, 2) there is little or no acclimation of organisms at 98.6°F, and 3) 100-percent mortality of populations occurs at 104°F or higher (Polgar et al., 1976; Marcy et

al., 1978). For the purpose of evaluating impact, therefore, 104°F was designated as the lethal temperature for zooplankton, regardless of exposure duration.

PLANT EFFECTS ON ZOOPLANKTON

To evaluate the potential impact of the proposed increases in condenser temperature and the resultinc higher discharge temperatures, values in Table A-1 were used. Data to the 105°F isotherm were used for zooplankton because of its close approximation to the designated lethal temperature of 104°F. Values considered in addition to those presented in the over-all introduction to this report include:

1. Assumption of 100-percent mortality for zooplankters passing through the plant;
2. Average September density = 4534 zooplankters/m^3 (Table H-1);
3. Average zooplankton biomass = 17 mg/m^3.

September zooplankton densities generally represent a seasonal peak in the zooplankton populations following the gradual spring and summer increase from relatively low winter levels. Zooplankton biomass and density were determined by averaging values from surface and bottom collections made at offshore Stations 1 through 5 in the month of September for the years 1976 through 1979 (ABI, 1977, 1978, 1979, 1980). Although zooplankton exhibits spatial variations in the environment, it was assumed for the purposes of this study that the averaged values were representative of a homogeneous water column.

Effects on Plant-Entrained Zooplankton

The quantity of zooplankton subjected to lethal temperatures was calculated for each of the condenser temperatures by multiplying the average density and biomass of zooplankters by the volume of plant discharge water. This quantity was then expressed as a percentage of the total zooplankton available in the potential impact area under either static or dynamic conditions (Table H-1). The data discussed represent the cumulative impact of the simultaneous operation of Units 1 and 2.

At an ambient water temperature of 85°F, entrained zooplankters would be exposed to lethal temperatures of 104°F or higher during all plant operating modes. A condenser ΔT of 26° or 28°F would cause a 3.9 percent reduction of the calculated total zooplankton density and biomass in the region of potential impact under static conditions and a 1.2 percent reduction under dynamic conditions (Table H-1). There would be a slight decrease in the percentage of zooplankters killed at condenser ΔTs of 30° and 32°F because of their reduced plant entrainment associated with reduced flow.

Effects on Offshore Zooplankton

Exposure to lethal temperatures continues offshore through the 105°F isotherm. Because increases in condenser temperatures would require more offshore dilution to reduce the discharge temperature to tolerable levels, the extent of impact associated with the dilution water would increase with increased temperature (Tables A-1 and H-1).

TABLE H-1

PREDICTED PLANT DISCHARGE FLOW, OFFSHORE DILUTION VOLUME, AND PERCENTAGE REDUCTION OF ZOOPLANKTON DENSITY AND BIOMASS AT SELECTED CONDENSER TEMPERATURES FOR SEPTEMBER CONDITIONS AT AN AMBIENT DENSITY WATER TEMPERATURE OF 85°F AND CRITICAL ISOTHERM OF 105°F AT THE ST. LUCIE PLANT

Parameter	Units	ΔT (°F)	Plant entrainment: Unit 1	Plant entrainment: Units 1 and 2	Offshore plume entrainment[a]: Unit 1	Offshore plume entrainment[a]: Units 1 and 2	Total entrainment: Unit 1	Total entrainment: Units 1 and 2
Plant discharge flow[b] and offshore dilution volume rate	$m^3 \times 10^6$ per day	26	2.8	5.6	6.1	12.2	8.9	17.8
		28	2.8	5.6	6.1	12.2	8.9	17.8
		30	2.6	5.2	6.3	12.5	8.9	17.7
		32	2.4	4.9	6.4	12.8	8.8	17.7
Number[c] zooplankters killed	no. $\times 10^{10}$ per day	26	1.3	2.5	2.8	5.5	4.[illegible]	8.1
		28	1.3	2.5	2.8	5.5	4.0	8.1
		30	1.2	2.4	2.9	5.7	4.1	8.1
		32	1.1	2.2	2.9	5.8	4.0	8.0
Biomass[d] reduction	mg $\times 10^7$ per day	26	4.8	9.5	10.4	20.7	15.2	[illegible]0.2
		28	4.8	9.5	10.4	20.7	15.2	[illegible].2
		30	4.4	8.8	10.7	21.3	15.1	[illegible]0.1
		32	4.1	8.3	10.9	21.8	15.0	30.1
Percentage reduction of zooplankton density and biomass comparing entrained water to region of potential impact assuming[e]:		static condition						
		26	1.9	3.9	4.2	8.5	6.1	12.4
		28	1.9	3.9	4.2	8.5	6.1	12.4
		30	1.8	3.6	4.4	8.7	6.2	12.3
		32	1.7	3.4	4.4	8.9	6.1	12.3
		dynamic conditions						
		26	0.6	1.2	1.3	2.6	1.9	3.8
		28	0.6	1.2	1.3	2.6	1.9	3.8
		30	0.6	1.1	1.3	2.6	1.9	3.7
		32	0.5	1.0	1.4	2.7	1.9	3.7

[a] Discharge temperature to 105°F isotherm.

[b] Derived from volume rates listed in Table A-1.

[c] Based on average density of 4534 zooplankters/m^3.

[d] Based on average biomass of 17 mg/m^3.

[e] Based on proportion of impacted water to total water (1.44×10^8 m^3 static, 4.71×10^8 m^3 dynamic) available in region of potential impact.

The percentage of zooplankton killed by offshore plume entrainment increases with increased condenser temperature. At a condenser ΔT of 26° and 28°F, the mortality of zooplankton under static conditions in the area of potential impact would be 8.5 percent. At a ΔT of 32°F, the mortality would increase to 8.9 percent. Under dynamic conditions, the mortality at 26° to 28°F ΔT would be 2.6 percent increasing to 2.7 percent at a ΔT of 32°F. A condenser ΔT from 28° to 32°F would increase offshore zooplankton biomass loss from 20.7×10^7 mg/day to 21.8×10^7 mg/day, respectively (Table H-1).

Total Entrainment Effects

Plant entrainment and offshore plume entrainment values were combined both to assess total zooplankton mortality caused by the various projected plant operating modes and to evaluate their influence on the region of potential impact. During normal operation of both units at a condenser ΔT of 26° or 28°F, there would be a 12.4 percent reduction in the total zooplankton population in the area of potential impact under static conditions and a 3.8 percent reduction under dynamic conditions in 24 hours. The projected data (Table A-1) indicate that the total volume of water heated to approximately 105°F would increase slightly at condenser ΔTs of 28° and 30°F and decrease slightly at 32°F ΔT. Thus, the total number of zooplankters [illegible] to lethal temperatures would be approximately the same at condenser ΔTs of 26°, 28°, 30° and 32°F. For these four operating modes, there would be an average 12.4 percent reduction in the total zooplankton population under static conditions, a 3.8 percent reduction under dynamic conditions.

Ecological Impact

The total entrainment results indicate that the increased stress associated with the various operating modes proposed in Table A-1 would not increase the percentage of impacted zooplankton (Table H-1). Condenser temperature increases would generally be accompanied by reduced flow through the plant, maintaining a nearly constant total amount of discharge water plus dilution water heated above 105°F. Because of patchy distribution of zooplankton, however, assessments based on average density figures may misrepresent the potentially serious ecological implications of plant impact on specific components of the zooplankton.

An assessment of the effects of entrainment on zooplankton into thermally elevated plant discharge waters should evaluate the potential impact on the two major components comprising the zooplankton:

1. Holoplankters, which comprise the greatest portion of the zooplankton, spend their entire life cycles in the water column and reproduce within an average of 1 to 8 weeks;
2. Meroplankters, which comprise a much smaller portion of the zooplankton, are only temporarily found in the plankton community and predominantly represent the larval stages of benthic macroinvertebrates.

The effect of plant-related mortality on holoplankters such as copepods, appendicularians, and chaetognaths would probably be limited because depletion of the offshore population could be minimized by recruitment and repopulation by unaffected adults from offshore communities. However, the consequences of increased mortality of meroplankton could be more serious. Meroplankton larval stages include the larvae of decapod crustaceans (shrimp and crabs), molluscs, echino-

derms and polychaete larvae (possibly Phragmatopoma lapidosa, a sabellariid polychaete that makes up the worm reefs). Because a major portion of nearshore meroplankton results from the spawning of benthic organisms in the area, power plant entrainment of these larvae could result in a decrease in abundance of recruitable larvae in the waters adjacent to the power plant.

SUMMARY

This study considers three main points for evaluating thermal effects on zooplankton: 1) the passage of zooplankton through the plant, 2) the entrainment in the offshore discharge plume of planktonic forms that had not passed through the plant, and 3) the combination of the two sources of impact.

A 100-percent mortality was assumed for zooplankton passing through the plant. For condenser ΔTs of 28°, 30°, and 32°F, the number of zooplankters passing through the plant would be the same as or less than the number at 26°F ΔT. The difference of 0.5 percent or less mortality between different plant operating modes under static (worst-case) conditions is considered negligible (Table H-1).

Zooplankters in the vicinity of the offshore discharge could become entrained into the plume and subjected to temperatures elevated above ambient. Because the volume of water encompassed by the 105°F (lethal=104°F) offshore isotherm increases as the condenser temperature increases, the number of zooplankters killed would increase proportionately.

However, based on the total (plant plus offshore entrainment) volume of water elevated to lethal temperatures, zooplankton mortality at the potential condenser temperature increase would be essentially the same as that at the 26°F ΔT.

The predicted increase of less than 1 percent in zooplankton mortality should not significantly impact the holoplanktonic component because of recruitment of members from the open ocean. However, should a substantial number of the meroplankton of nearshore benthic invertebrates become affected, a portion of the potential recruitment to adult benthic populations may be lost in the immediate vicinity of the plant. Because of limited periods of larval production by many benthic species for replacement of these planktonic larval stages, the consequent loss to the ecosystem could have ramifications to other communities.

LITERATURE CITED

ABI. 1977. Ecological monitoring at the Florida Power & Light Co. St. Lucie Plant, annual report 1976. Vol. 1. AB-44. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga.

ABI. 1978. Ecological monitoring at the Florida Power & Light Co. St. Lucie Plant, annual report 1977. Vol. 1. AB-101. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga.

ABI. 1979. Florida Power & Light Co. St. Lucie Plant annual non-radiological environmental monitoring report 1978. Vol. 2 and 3. AB-177. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga.

ABI. 1980. Florida Power & Light Co. St. Lucie Plant annual non-radiological environmental monitoring report 1980. AB-244. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga.

Marcy, B.C., Jr., A.D. Beck, and R.E. Ulanowicz. 1978. Effects and impacts of physical stress on entrained organisms. Pages 136-165 in J.R. Schubel and B.C. March, Jr., eds. Power plant entrainment, a biological assessment. Academic Press, New York. 271 pp.

Polgar, T.T., L.H. Bongers, and G.M. Krainak. 1976. Assessment of power plant effects on zooplankton in the near field. Pages 358-367 in G.W. Esch and R.W. McFarlane, eds. Thermal ecology II. ERDA Symposium (CONF-750425). Augusta, Ga.

I. PHYTOPLANKTON

INTRODUCTION

Phytoplankton consists of weakly swimming or passively drifting microscopic plants. These unicellular or colonial primary producers, which directly or indirectly support all aquatic consumers, form the base of many food chain relationships. Phytoplankton populations are sensitive to elevated water temperatures. Populations subjected to increased water temperature during power plant entrainment or entrainment in thermal plumes may exhibit changes in density and species composition. Phytoplankton mortality occurs when the magnitude of the temperature increase results in elevating the water temperature beyond the upper maximum temperature limits of these organisms.

Because of their microscopic size and lack of motility, phytoplankters in the vicinity of the St. Lucie Plant are subject to entrainment through the power plant condenser cooling system where they are subjected to potentially lethal temperatures. Offshore, phytoplankters contained in dilution waters are entrained in the thermal plume and are killed when their upper temperature limits are exceeded. The number of phytoplankters entrained through the plant and into the offshore discharge plume is proportional to the volume of plant discharge flow and the volume of offshore dilution water. To assess the impact of power plant-induced mortalities on phytoplankton populations, the biomass and numbers of phytoplankton killed in entrained plant condenser cooling water plus entrained offshore dilution water must be considered in relation to the total phytoplankton available in the region of potential impact.

THERMAL EFFECTS ON PHYTOPLANKTON

'iving organisms have upper maximum temperature limits above which they cannot survive and reproduce. Water temperatures of 30° to 33°C (86° to 91.4°F) have been suggested as the range in which the upper thermal limits of many organisms should occur (Drost-Hansen, 1969). Representative marine diatoms and other algae subjected to elevated water temperatures have been observed to exhibit no growth at temperatures higher than 102°F (Ukeles, 1961); tests on 1' species of salt marsh epiphytic algae have shown that none were "able to survive and grow when chronically exposed to temperatures greater than 39°C (102.2°F)" (Saks and Lee, 1972). Survival of phytoplankton after exposure to potentially lethal high water temperatures (higher than 103°F) has been shown also to be related to the duration of exposure (Ukeles, 1961; Saks and Lee, 1972).

Phytoplankton species have previously been collected at St. Lucie in September (ABI, 1977a, 1978, 1979, 1980); those species for which temperature range information is known are listed in Table I-1. The upper lethal temperatures for these species range from 84.2° to 98.6°F. Some species observed in tropical areas exist at water temperatures close to their upper lethal temperature and may not survive at the extreme upper limit of naturally occurring water temperature ranges. Results of a preliminary study at the St. Lucie Plant indicated a 90 percent phytoplankton mortality after their passage through the plant at a water temperature of 98.6°F. This study, coupled with an extensive literature survey, enabled ABI to select 100°F as the most probable upper maximum temperature limit for St. Lucie phytoplankton.

TABLE I-1

TEMPERATURE REQUIREMENTS OF CERTAIN ALGAL PARAMETERS FOR SELECTED ST. LUCIE PHYTOPLANKTON SPECIES OCCURRING IN SEPTEMBER

Taxon	Parameter and temperature, °C (°F)						References
	Optimum productivity	Upper lethal	Optimum abundance	Growth: Optimum	Growth: Depressed	Accli-mation	
BACILLARIOPHYTA (diatoms)							
Chaetoceros laciniosus		29 (84.2)				15 (59.0)	Crippen, 1974
Nitzschia acicularis (8)		35 (95.0)		25 (77.0)	33 (91.4)		Saks et al., 1974
Nitzschia filiformis				26 (78.0)			Maylor, 1965
			31-35 (87.8-95.0)				Patrick, 1969
Nitzschia sigma				25 (≥77.0)			Admiraal, 1977
Rhizosolenia delicatula				13 (55.4)			Grall, 1972
Skeletonema costatum	20 (68.0)					20 (68)	Nielsen and Jorgensen, 1968
	8 (46.4)					8 (46.4)	Nielsen and Jorgensen, 1968
		37 (98.6)					Hirayama and Hirano, 1970
		34 (93.2)				20 (68.0)	Crippen, 1974
PYRRHOPHYTA (dinoflagellates)							
Gymnodinium simplex				23-28 (73.4-82.4)			Thomas et al., 1973
Prorocentrum micans				25 (77.0)			Thomas et al., 1973

PLANT EFFECTS ON PHYTOPLANKTON

Assumptions and Calculations

For the following discussion, some assumptions in addition to those discussed in the overall introduction to this report were necessary to evaluate plant effects on phytoplankton populations:

1. 100-percent mortality of phytoplankton entrained through the plant and into the offshore plume at 100°F or higher water temperature, regardless of duration of exposure;
2. Average cell density = 1.3×10^6 cells/liter based on September 1976 through 1979 data;
3. Average active chlorophyll-a = 1.86 mg/m^3 based on data derived as in item 2, above;
4. Chlorophyll-a constituting an average of 1.5 percent of the dry weight of organic matter (ash-free dry weight) of the algae (APHA, 1976), which calculated to an average biomass of 0.12462 g/m^3 for the data in item 3, above.

Equations 1 and 2 were used to calculate the total phytoplankton density (d) and biomass (e) available in the region of potential impact under static and dynamic conditions:

1. $a \times c = d$ (Equation 1)
2. $b \times c = e$ (Equation 2)

The parameters a, b, c, d, and e are defined in Table I-2:

TABLE I-2

Current conditions	Average phytoplankton (a) Density (cells/liter)	(b) Biomass (g/m^3)	Volume of water available in region of potential impact (c) (m^3/day)	Total phytoplankton in region of potential impact (d) Density (cells/day)	(e) Biomass (g/day)
static	$1.3x10^6$	0.12462	$1.44x10^8$	$1.9x10^{17}$	$1.8x10^7$
dynamic	$1.3x10^6$	0.12462	$4.71x10^8$	$6.1x10^{17}$	$5.9x10^7$

The number and biomass of phytoplankters that would be subjected to lethal temperatures were determined from average September density and biomass values multiplied by the volumes of plant-entrained water and offshore plume-entrained water. The flow data for various condenser temperature increases were considered for Unit 1 operation and for combined Units 1 and 2 operation (Table I-3).

Assessment of Potential Impact

The normal condenser ΔT of 26°F is associated with a calculated phytoplankton mortality of 7.7 percent of the total phytoplankton in the offshore region of potential impact under static conditions and 2.3 percent under dynamic conditions (Table I-2). For the combined operation of Units 1 and 2, all projected values would essentially double. Phytoplankton mortality during combined operation at a potential condenser ΔT of 28°F would increase to 17.0 percent under static

TABLE I-3

PREDICTED PLANT DISCHARGE FLOW, OFFSHORE DILUTION VOLUME, AND PERCENTAGE REDUCTION OF PHYTOPLANKTON DENSITY AND BIOMASS AT SELECTED CONDENSER ΔT FOR SEPTEMBER CONDITIONS AT AN AMBIENT OCEAN TEMPERATURE OF 85°F AND CRITICAL ISOTHERM OF 100°F AT THE ST. LUCIE PLANT

Parameter	Units	ΔT (°F)	Plant entrainment: Unit 1	Plant entrainment: Units 1 and 2	Offshore plume entrainment[a]: Unit 1	Offshore plume entrainment[a]: Units 1 and 2	Total entrainment: Unit 1	Total entrainment: Units 1 and 2
Plant discharge flow[b] and offshore dilution volume rate	$m^3 x 10^6$/day	26	2.8	5.6	8.2	16.4	11.0	22.0
		28	2.8	5.6	9.1	18.2	11.9	23.8
		30	2.6	5.2	9.3	[illegible]6	11.9	23.8
		32	2.5	5.0	9.3	18.6	11.8	23.6
Number phytoplankters killed[c]	number x 10^{15}/day	26	3.6	7.3	10.7	21.3	14.3	28.6
		28	3.6	7.3	11.8	23.7	15.5	30.9
		30	3.4	6.8	12.1	24.2	15.5	30.9
		32	3.3	6.5	12.1	24.2	15.3	30.7
Biomass lost[d]	g x 10^5/day	26	3.5	7.0	10.2	20.4	13.7	27.4
		28	3.5	7.0	11.3	22.7	14.8	29.7
		30	3.2	6.5	11.6	23.2	14.8	29.7
		32	3.1	6.2	11.6	23.2	14.7	29.4
Percentage reduction of phytoplankton density and biomass comparing entrained water to region of potential impact assuming[e]:								
	Static conditions							
		26	2.0	4.0	5.7	11.7	7.7	15.7
		28	2.0	4.0	6.3	13.0	8.3	17.0
		30	1.8	3.7	6.4	13.3	8.3	17.0
		32	1.7	3.6	6.5	13.3	8.2	16.9
	Dynamic conditions							
		26	0.6	1.2	1.7	3.5	2.3	4.7
		28	0.6	1.2	1.9	3.9	2.5	5.1
		30	0.6	1.1	2.0	4.0	2.5	5.1
		32	0.5	1.1	2.0	4.0	2.0	5.0

[a]Discharge temperature to 100°F isotherm; water temperatures >100°F assumed lethal.

[b]Derived from discharge and dilution water volumes (Table A-1).

[c]Based on average density of 2.3 x 10^6 cells/liter.

[d]Based on average biomass of 0.12462 g/m^3 derived from average active chlorophyll-a of 1.86 mg/m^3.

[e]Proportion of impacted water to total water [1.4 x 10^8 m^3/day (static); 4.7 x 10^8 m^3/day (dynamic)].

(worst-case) conditions and 5.1 percent under dynamic conditions. The total mortality under static and dynamic conditions at condenser ΔTs of 30° and 32°F is less than or equal to that at 28°F. The biomass, numbers, and percentage of phytoplankton killed at the potential increased condenser ΔTs of 28°, 30°, and 32°F would be higher than those at the condenser ΔT of 26°F. However, the increase in mortality associated with the increased ΔTs would be small (Table I-3).

Large quantities of offshore water are available for exchange and stabilization of the phytoplankton population at the St. Lucie Plant, and the turnover rates of these populations are rapid. Thus, the projected reductions of 17.0 percent of the total phytoplankton under static conditions and 5.1 percent under dynamic conditions at a condenser ΔT of 28°F would most likely result in only local phytoplankton depletion. Large-scale changes in phytoplankton community structure would be unlikely. Therefore, considering only lethal temperatures, condenser temperatures higher than 26°F ΔT for combined operation of Units 1 and 2 at the St. Lucie Plant should not substantially increase the thermal impact on offshore phytoplankton populations.

The discussion has addressed only lethal effects. However, conditions resulting in both enhanced phytoplankton growth and adverse sublethal impact may exist outside the critical 100°F isotherm. Possible growth enhancement has been observed in the area of the offshore discharge (ABI, 1977b). Although certain phytoplankton species may exhibit enhanced productivity and growth after exposure to elevated, but

sublethal, water temperatures, other species may exhibit reduced survival potential, impaired photosynthetic capability or atypical growth and reproduction after such exposure.

SUMMARY

Assumptions made in this section allow for worst-case conditions. Impact assessment calculations involving total heated water volumes and mean phytoplankton density data do not account for recruitment of phytoplankton from waters outside the area of potential impact. As described in the over-all introduction to this report, increased condenser temperatures produce moderate increases in the total volume of water heated to the assumed 100°F lethal temperature. Thermal impact on the phytoplankton community is proportional to the total volume of water heated above 100°F. The percentage reduction of phytoplankton at condenser ΔTs of 28°, 30°, and 32°F would reflect proportionately moderate increases above that calculated for the condenser ΔT of 26°F. The reduction in phytoplankton at the increased condenser temperatures would remain small in comparison to the total available offshore phytoplankton. Factors such as rapid turnover rates and the stabilizing influence of offshore mixing should prevent the occurrence of any long-term or widespread phytoplankton depletion.

For combined operation of Units 1 and 2 at a condenser ΔT of 26°F, the predicted reductions in total phytoplankton and total biomass available in the region of potential impact are 15.7 percent under static conditions and 4.7 percent under dynamic conditions. Under static

conditions, the maximum projected number of phytoplankton killed under any of the potential operating modes is only 1.3 percent greater than that at a ΔT of 26°F.

Local phytoplankton depletion could occur under static conditions; however, a maximum projected mortality of 5.1 percent of the total phytoplankton available in the region of potential impact under dynamic conditions should not cause large-scale changes in phytoplankton community structure in the offshore St. Lucie area. Structural continuity of the phytoplankton community would be maintained by rapid turnover rates and the availability of oceanic waters for exchange and subsequent stabilization of the community.

In general, the additional impact on the phytoplankton community resulting from increased condenser ΔTs of 28°, 30°, and 32°F would be small in relation to the projected impact at 26°F ΔT.

LITERATURE CITED

Admiraal, W. 1977. Influence of light and temperature on the rate of estuarine benthic diatoms in culture. Mar. Biol. 39:1-9.

APHA. 1976. Standard methods for examination of water and wastewater, 14th ed. American Public Health Association, Washington, D.C. 874 pp.

ABI. 1977a. Ecological monitoring at the Florida Power & Light Co., St Lucie Plant, annual report 1976. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga.

ABI. 1977b. Effects of increased water temperature on the marine biota of the St. Lucie Plant area: Literature review and special studies. AB-65. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga.

ABI. 1978. Ecological monitoring at the Florida Power & Light Co., St. Lucie Plant, annual report 1977. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga.

ABI. 1979. Florida Power & Light Co, St. Lucie Plant annual non-radiological environmental monitoring report 1978, biotic monitoring. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga.

ABI. 1980. Florida Power & Light Co., St. Lucie Plant annual non-radiological environmental monitoring report 1979, biotic monitoring. Prepared for Florida Power & Light Co. by Applied Biology, Inc., Atlanta, Ga.

Crippen, R.W. 1974. Some thermal effects on a simulated entrainment regime on marine plankton. Ph.D. Thesis, University of Maine. 113 pp. University microfilms, Ann Arbor, Michigan. (75-12,414).

Drost-Hansen, W. 1969. Allowable thermal pollution limits - a physico-chemical approach. Chesapeake Sci. 10:281-288.

Grall, J.R. 1972. Spring bloom of the diatom Rhizosolenia delicatula near Roscoff. Mar. Biol. 16:41-48.

Hirayama, K., and R. Hirano. 1970. Influences of high temperature and residual chlorine on marine phytoplankton. Mar. Biol. 7:205-213.

Naylor, E. 1965. Effects of heated effluents upon marine and estuarine organisms. Adv. Mar. Biol. 3:63-103.

Nielsen, E.S., and E.G. Jorgensen. 1968. The adaptation of plankton algae I. General part. Physiologia plantarum 21:401-413.

LITERATURE CITED (continued)

Patrick, R. 1969. Some effects of temperature on freshwater algae. Pages 161-185 in P.A. Krenkel and F.L. Parker, eds. Biological aspects of thermal pollution. Vanderbilt University press, Nashville, Tenn. 407 pp.

Saks, N.M., and J.J. Lee. 1972. The differential sensitivity of various species of salt marsh epiphytic algae to ionizing radiation and thermal stress. COO-3254-8; CONF-720708-1. Symp. on the Interaction of Radioactive Contaminants with the Constituents of the Marine Environment, Seattle, Wash. 8 pp.

Saks, N.M., J.J. Lee, W.A. Muller, and J.H. Tietjen. 1974. Growth of salt marsh microcosms subjected to thermal stress. Pages 391-398 in J.W. Gibbons and R.R. Sharitz, eds. Thermal ecology. NITS No. CONF-730505. Technical Information Center, U.S. Atomic Energy Commission, Oak Ridge, Tenn. 670 pp.

Thomas, W.H., A.N. Dodson, and C.A. Linden. 1973. Optimum light and temperature requirements for Gymnodinium splendens, a larval fish food organism. U.S. Natl. Mar. Fish. Serv. Fish Bull. 71(2):599-601.

Ukeles, R. 1961. The effect of temperature on the growth and survival of several marine algal species. Biol. Bull. 120(2):255-264.

J. MACROPHYTES

INTRODUCTION

Two marine vegetation communities are located in the St. Lucie Plant area. One of these, the offshore benthic macrophyte community, will not be discussed in this report because the thermal plume is not expected to reach the offshore benthic area. The other community of concern in the plant area is the diverse and well-developed seaweed assemblage found growing on the intertidal worm reefs (see Section G). These reefs, called Walton Rocks, lie parallel to the beach south of the plant site in the intertidal and sublittoral surf zone.

THERMAL EFFECTS ON AQUATIC PLANTS

Studies have shown that elevated water temperatures can adversely affect aquatic plants (ABI, 1977). All algal species have a temperature range in which they can survive and an even narrower range in which optimum growth occurs. High temperature affects plants indirectly by altering the environment and directly by interfering with cell metabolism. The temperature at which these effects occur depends upon the species, location, season, environmental factors, and physiological state of the plant.

Extensive mortalities of algae and seagrasses occurred in Biscayne Bay when temperatures near a thermal discharge reached 91.4°F and higher. Thermal tolerance limits between an upper limit range of 88° and 91°F were reported for the important green benthic macroalgae (Bader et al.,

1972); temperatures higher than 91°F were lethal to most of the algae and seagrasses in the area (Thorhaug, 1974). A temperature range of 79° to 82°F appeared optimum for maximum diversity and abundance (Roessler and Tabb, 1974). It is likely, therefore, that marine algae at Hutchinson Island would be killed at temperatures higher than 90°F.

PLANT EFFECTS ON WORM REEF VEGETATION

During periods of onshore currents, the plant discharge thermal plume may be carried over Walton Rocks. It is predicted that these currents will prevail approximately 10 percent of the time (Worth and Hollinger, 1977). With a condenser ΔT of 32°F, water temperatures at Walton Rocks could reach 91°F.

Elevated temperatures on the worm reef would probably result in a reduction in vegetation species diversity and an increase in blue-green algal species should the condition persist. Sustained high temperatures would probably eliminate the algal community on the worm reef; recolonization, however, would probably occur when temperatures decreased.

SUMMARY

Condenser ΔTs of 30° or 32°F could produce water temperatures of 90° or 91°F at Walton Rocks during periods of onshore currents. Temperatures higher than 90°F would probably cause a die-back of the vegetation growing on the worm reefs, but revegetation would occur once temperatures decreased.

LITERATURE CITED

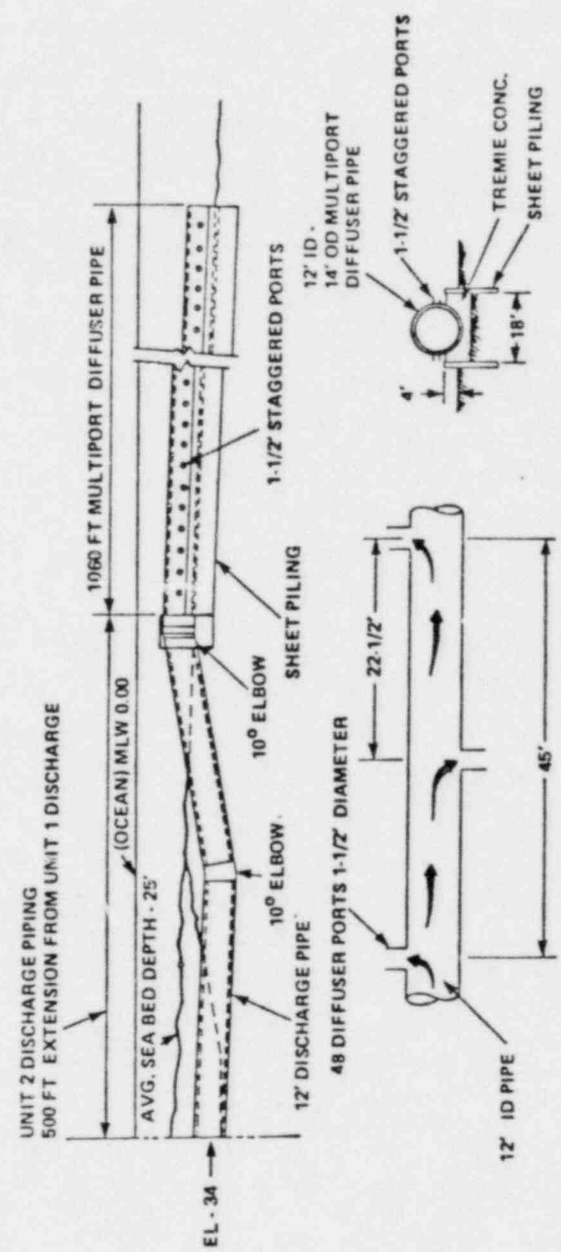
ABI. 1977. Effects of increased water temperature on the marine biota of the St. Lucie Plant area: Literature review and special studies. AB-65. Prepared for Florida Power & Light Co., Miami, Fla.

Bader, R.B., M.A. Roessler, and A. Thorhaug. 1972. Thermal pollution of a tropical marine estuary. Pages 425-428 in M. Ruivo, ed. Marine pollution and sea life. 625 pp.

Roessler, M.A., and D.C. Tabb. 1974. Studies of effects of thermal pollution in Biscayne Bay, Florida. EPA-660/3-74-014. U.S. Environmental Protection Agency. 145 pp.

Thorhaug, A. 1974. Effect of thermal effluents on the marine biology of southeastern Florida. Pages 518-531 in J.W. Gibbons and R.R. Sharitz, eds. Thermal ecology. NTIS No. CONF-730505. Technical Information Center, U.S. Atomic Energy Commission, Oak Ridge, Tenn.

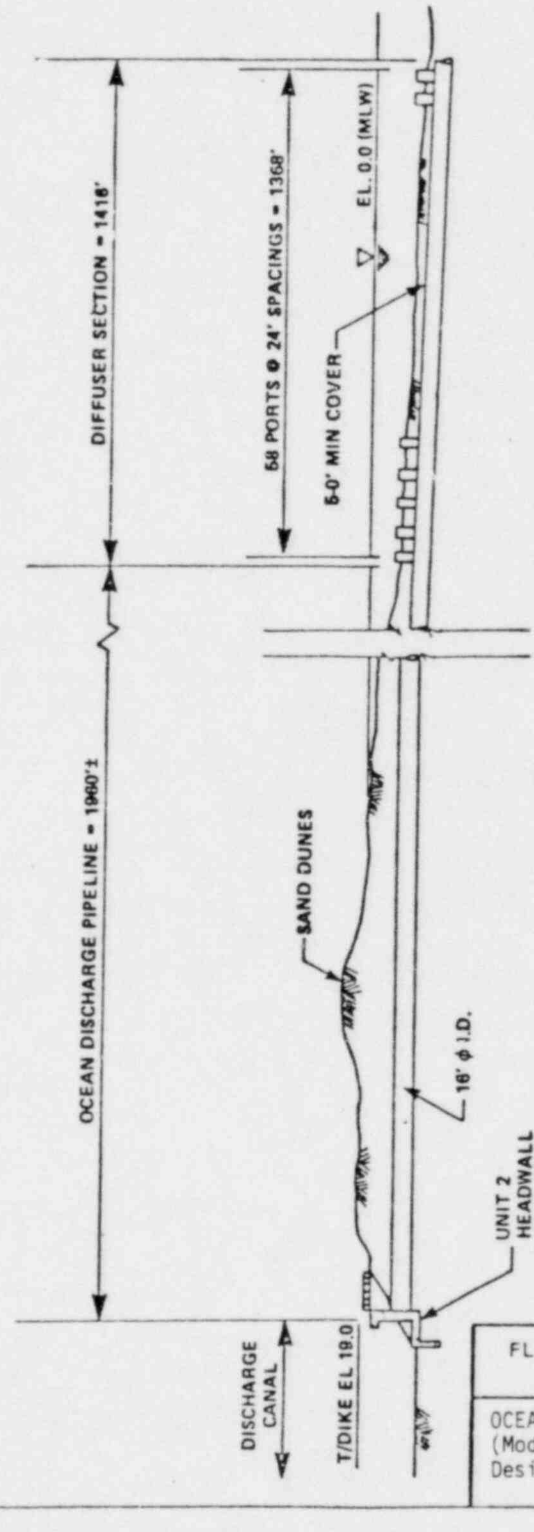
Worth, D.F., and M.L. Hollinger. 1977. Nearshore marine ecology at Hutchinson Island, Florida 1971-1974: III Physical and Chemical Environment. Fla. Dept. Nat. Res. Mar. Res. Lab. No. 23. pp. 25-85.



FLORIDA POWER & LIGHT COMPANY
ST. LUCIE PLANT UNIT 2

UNIT 2 OCEAN DISCHARGE STRUCTURE
(Original Alternating Diffuser Design)

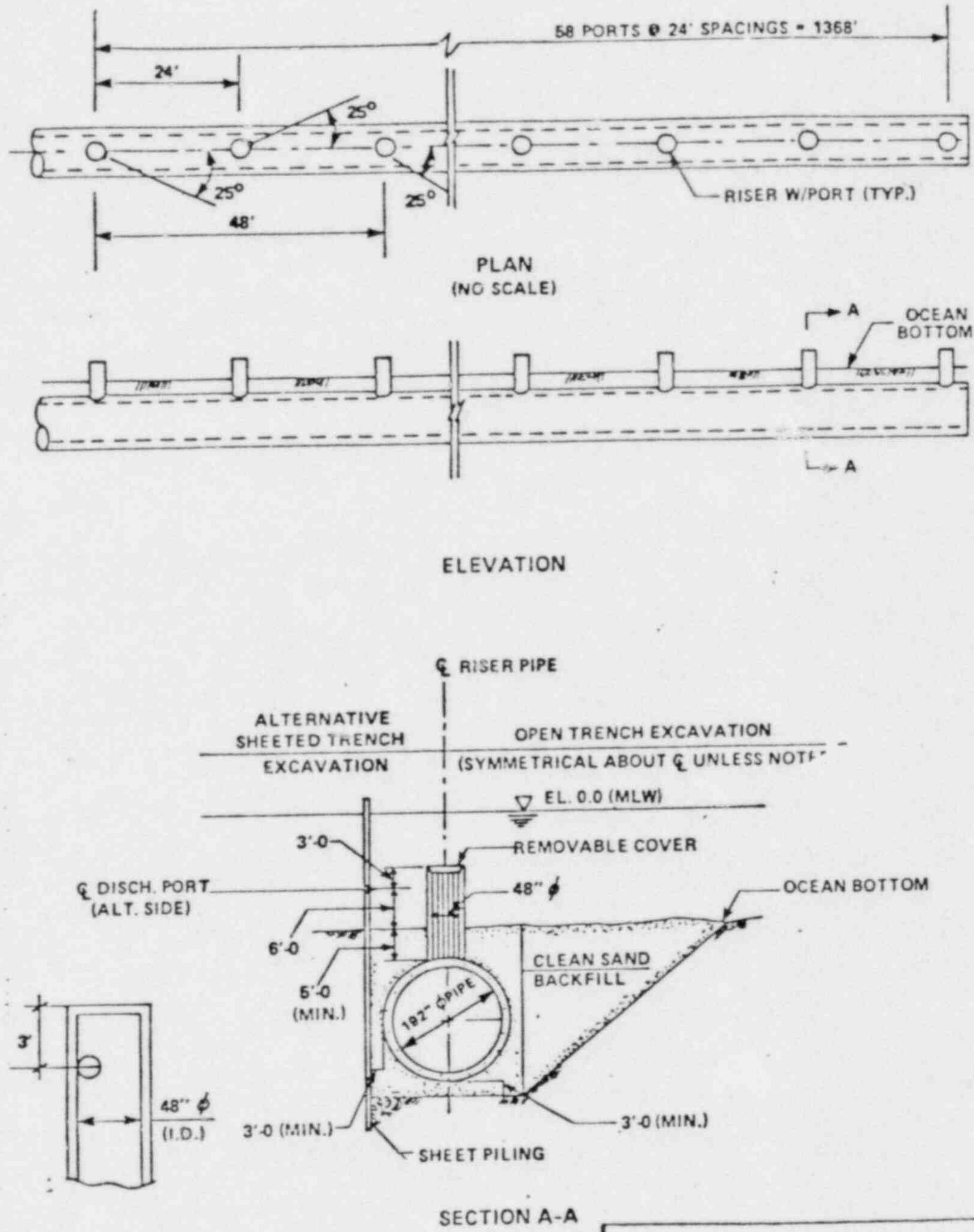
EXHIBIT C



FLORIDA POWER & LIGHT COMPANY
ST. LUCIE PLANT UNIT 2

OCEAN DISCHARGE PIPELINE
(Modified Offshore Angled Diffuser Design)

EXHIBIT D



FLORIDA POWER & LIGHT COMPANY
ST. LUCIE PLANT UNIT 2

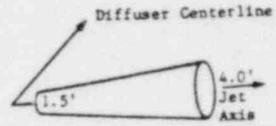
Details of the Multiple Diffuser (Modified Offshore Angled Diffuser Design

EXHIBIT E

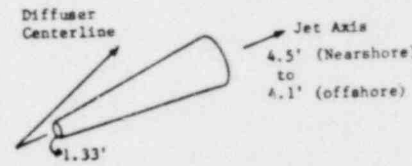
SUMMARY TABLE OF DIFFUSER CHARACTERISTICS

lume Characteristics	Original Alternating Diffuser	Modified Offshore Angled Diffuser
emperature Rise	24°F	30°F
ischarge Flow Rate	1145 cfs	880 to 1317 cfs

chematic of the
hermal discharge
et 17° F isotherm



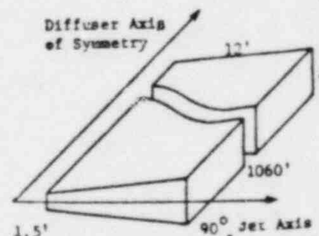
Diffuser Ports 90° to Centerline



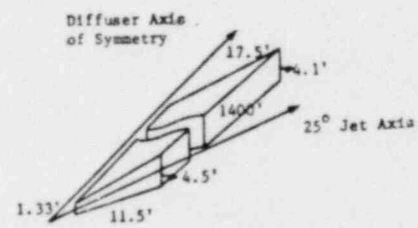
Diffuser Ports 25° to Centerline

ormal distance rom port to 17° F.*	12 ft (cone length 12 ft)	4.9 ft (nearshore port cone length 11.5ft) 7.4 ft(offshore port cone length 17.5ft)
olume contained ithin 17° F boundary	3700 ft³ for 48 ports	5700 ft³ for 58 ports

chematic of volume
ontained within the
7°F isotherm envelope



70,000 ft³



48,000 ft³

olume contained
ithin 17° F isotherm
nvelope of diffuser

Distance computed normal to centerline of discharge diffuser

Florida Power & Light Company
St. Lucie Plant Unit 2

Summary Table of
Diffuser Plume Characteristics

EXHIBIT F

AB-358
STLU1
MONITOR1-55

PROPOSED ST. LUCIE PLANT PREOPERATIONAL

AND OPERATIONAL BIOLOGICAL MONITORING PROGRAM

AUGUST 1981

EXHIBIT G

ATTACHMENT 1

PROPOSED ST. LUCIE PLANT PREOPERATIONAL AND OPERATIONAL BIOLOGICAL MONITORING PROGRAM

I. GENERAL

The ecological baseline study of Florida Power & Light Company's (FPL) St. Lucie Unit No. 1 was designed and implemented by the staff of the Florida Department of Natural Resources Marine Research Laboratory. Five offshore sampling stations were established (Figure 1) and sampling was conducted from July 1971 to August 1974. These results have been reported as St. Lucie Plant baseline data prepared by the Florida Department of Natural Resources (References 4-12). The last portions of the data analyses and report preparation for this baseline study are presently being completed. Following the sampling for the baseline study, the Environmental Technical Specifications (ETS) for the operational monitoring ogram, contained in the operating license for St. Lucie Unit No. 1 i sued by the Nuclear Regulatory Commission (NRC), were written. These s ecifications delineated the biotic communities to be studied and stated that sampling was to be conducted at the same five stations established for the baseline study. The objective of the operational monitoring study was to gather data for comparison with data obtained during the baseline study.

In March 1976, sampling for the operational monitoring program was begun by Applied Biology, Inc. (ABI). In addition to the five stations established for the baseline study, a nearshore site south of the plant was selected as a control station. This control station was located distant from the plant and therefore away from possible influence from warmwater discharges. In accordance with the ETS, collections were made

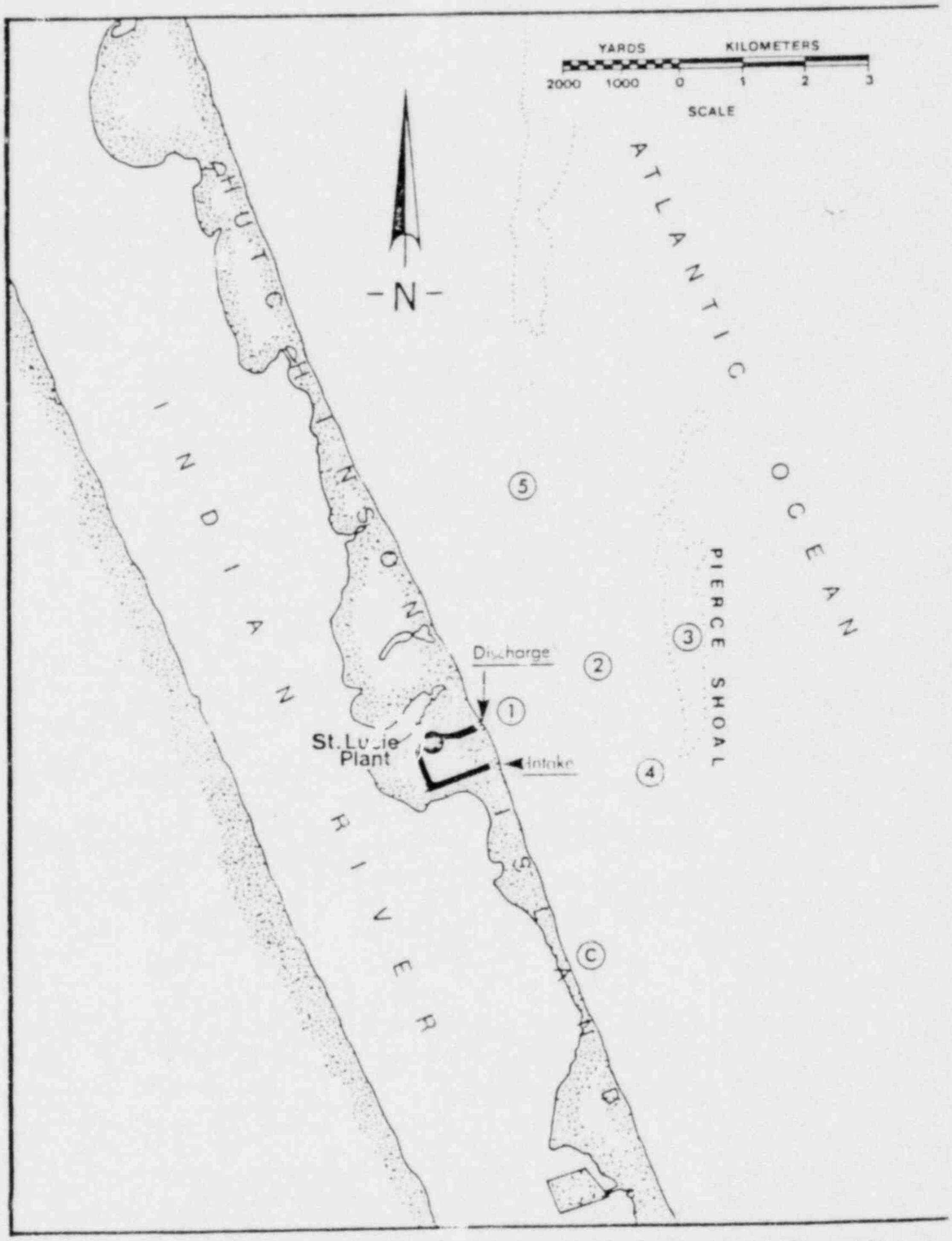


Figure 1. Location of the five offshore sampling stations (1-5) established for baseline study and the control (C) station designated for the operational monitoring study.

to assess benthic organisms, plankton, nekton, macrophytes, water quality and migratory sea turtles. The results and analyses of these collections have been reported annually (Ref. 1, 2, 3, 16).

The five offshore stations were established by the Florida Department of Natural Resources (FDNR) before a comprehensive evaluation of the offshore currents was available. More recently, water current data (Ref. 14) have been obtained that indicates that if the stations were relocated they could better evaluate the biological communities in areas of potential plume impact. As shown in Figure 2, the predominant surface currents, and subsequent plume orientation from the point of discharge (Station 1), are to the north. Based on water current evaluation and the results of the biological monitoring program to date, FPL believes that certain revisions to the program prescribed in the ETS and/or NPDES Permit are appropriate. The program described herein reflects these revisions and would be used by both St. Lucie Unit No. 1 (operational monitoring) and St. Lucie Unit No. 2 (preoperational and operational monitoring). It is proposed that the program continue for 2 years after St. Lucie Unit No. 2 is operational.

In the regulatory scheme established by the Federal Water Pollution Control Act of 1972 (FWPCA), 33 USCA § § 1251 et seq., the Environmental Protection Agency (EPA) was given jurisdiction over all water quality matters relating to non-radiological liquid effluents. In its Yellow Creek decision (ALAB-515), the NRC's Atomic Safety and Licensing Appeal Board held that the NRC may not specify water quality restrictions in

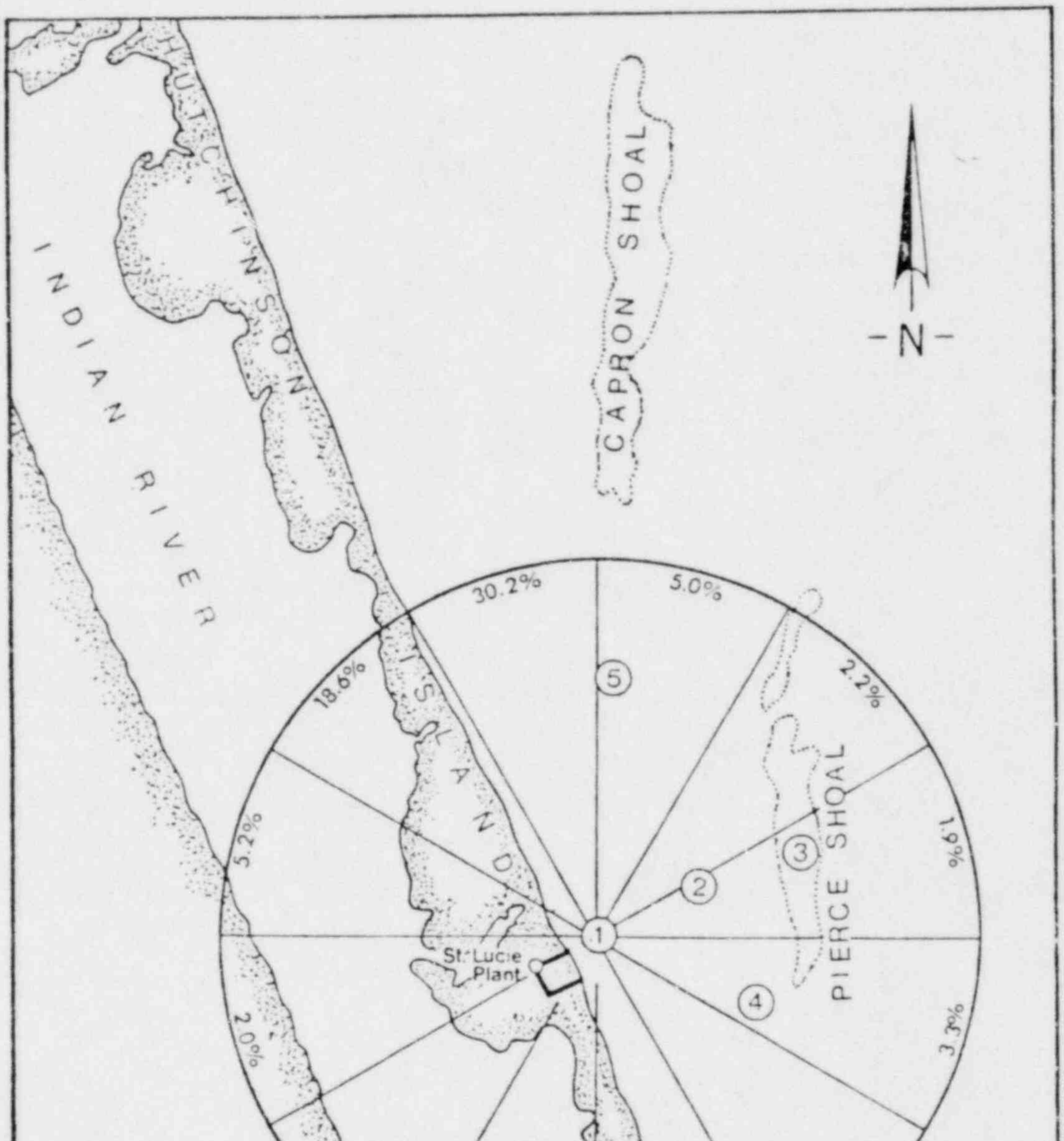


Figure 2. Frequency distribution of surface current direction in relation to operational monitoring sampling stations.

excess of those imposed by the EPA. On the basis of ALAB-515 and the water quality effluent limitations and monitoring requirements contained in the National Pollutant Discharge Elimination System (NPDES) permit issued by EPA pursuant to FWPCA for St. Lucie Unit No. 1, FPL has petitioned the NRC for the deletion of thermal and chemical monitoring requirements contained in the ETS for St. Lucie Unit 1. However, this request to the NRC did not address the aquatic biological monitoring requirements also contained in the St. Lucie Unit No. 1 ETS. To remove this state of implicit dual regulation, FPL proposes to incorporate appropriate aquatic biological monitoring requirements into the NPDES permit for St. Lucie Units 1 and 2 and to request their deletion from the Unit 1 ETS. (The NRC operating license and accompanying ETS for St. Lucie Unit No. 2 have not yet been issued.) The program described below is herewith submitted to the EPA for that purpose.

II. PROPOSED BIOLOGICAL MONITORING PROGRAM

Objective - To monitor the populations of sea turtles, nektonic and benthic organisms of the Atlantic Ocean near the plant to determine the extent that plant operations may be influencing the nearshore ecosystem.

Specification - The biological conditions shall be assessed 1) in terms of abundance and composition of the marine biotic community and 2) in terms of the relationship between physical properties of the waters and the abundance and composition of the biological community. Communities described below are to be evaluated to determine potential alterations due to plant operation.

A. Benthic Organisms

Benthic organisms will be collected quarterly and inventoried as to kind and abundance.

B. Nektonic Organisms

Samples will be collected by gill netting once per month during April through September and twice per month during October through March. Kind and abundance of organisms present will be determined.

C. Water Quality

Analysis will be made at the surface at the same time as the nekton sample collections and near the bottom at the same time as the benthic sample collections. Parameters measured will be temperature, salinity, dissolved oxygen and turbidity.

D. Migratory Sea Turtles

Sea turtle nesting surveys will be conducted biannually on the FPL shoreline property and along selected control beaches. Sea turtles entering the intake will be removed, tagged and released back into the ocean on a continual basis.

E. Reporting Requirements

Results of the aquatic biological monitoring program shall be reported in an Annual Non-Radiological Environmental Monitoring Report to be submitted to the EPA.

III. IMPLEMENTATION OF PROPOSED BIOLOGICAL MONITORING PROGRAM

A. Introduction

The monitoring program study design originated and was implemented in 1971 by the Florida Department of Natural Resources Marine Research Laboratory. The sampling regime was based on the ecological information available at the time. Sample locations were selected in relation to predicted plume direction, predicted plume areal extent (Ref. 4) and the major macrohabitats known to exist off Hutchinson Island. Stations 1, 2 and 3 were located in the predicted thermal plume area, while 4 and 5 were established as north and south controls located in the same macrohabitat as Station 2 (Ref. 5).

Since 1972, extensive data on the biological communities near the St. Lucie Plant have been obtained (Refs. 1-3, 6-12, 16). Additional physical data have been gathered on winds (Ref. 13), currents (Ref. 12) and the thermal plume (Ref. 15).

These biological and physical studies indicate that effects of the St. Lucie discharge are limited to surface areas near the point of discharge. The proposed study is therefore designed to evaluate the biological conditions in the near-field area of potential plume impact.

B. Benthic Organisms

To assess the potential that there are thermal effects on the benthic community, quarterly samples will be taken at control Station BC, Station B1, and at a station (B2) to be located just north of the thermal

plume's warmest spot (Figure 3). Four or more replicates will be taken. Station 2 of the current program will be retained as Station C1 to help integrate the modified program with the existing data. Station 5 of the current program will be retained as Station B3 for at least one or two years after Unit 2 goes on-line, to document the probability that there is no effect of combined Units 1 and 2 discharge at this location. Benthic sampling at other offshore stations (3 and 4) will be terminated.

C. Nekton

The sampling program will consist of nearshore gill netting. Two sampling stations will be established near the intake structure and three in the discharge area (Figure 4). The discharge station samples will provide data on near, intermediate and distant effects of the plume on fish distribution. Stations will be located in the thermal plume's warmest spot and approximately 200 meters and 450 meters from this warmest spot. These stations will be sampled as follows: once per month during April through September when the commercially important migratory species are generally not present offshore the St. Lucie Plant and twice per month during October through March when these species are present. Station 2 (C1) will be retained to help integrate the data from the modified program with the exisiting data.

D. Migratory Sea Turtles

Sea turtle nesting surveys will be conducted biannually during odd-numbered years to monitor species, numbers and nesting characteristics. The nesting surveys will be conducted during the summer nesting season on

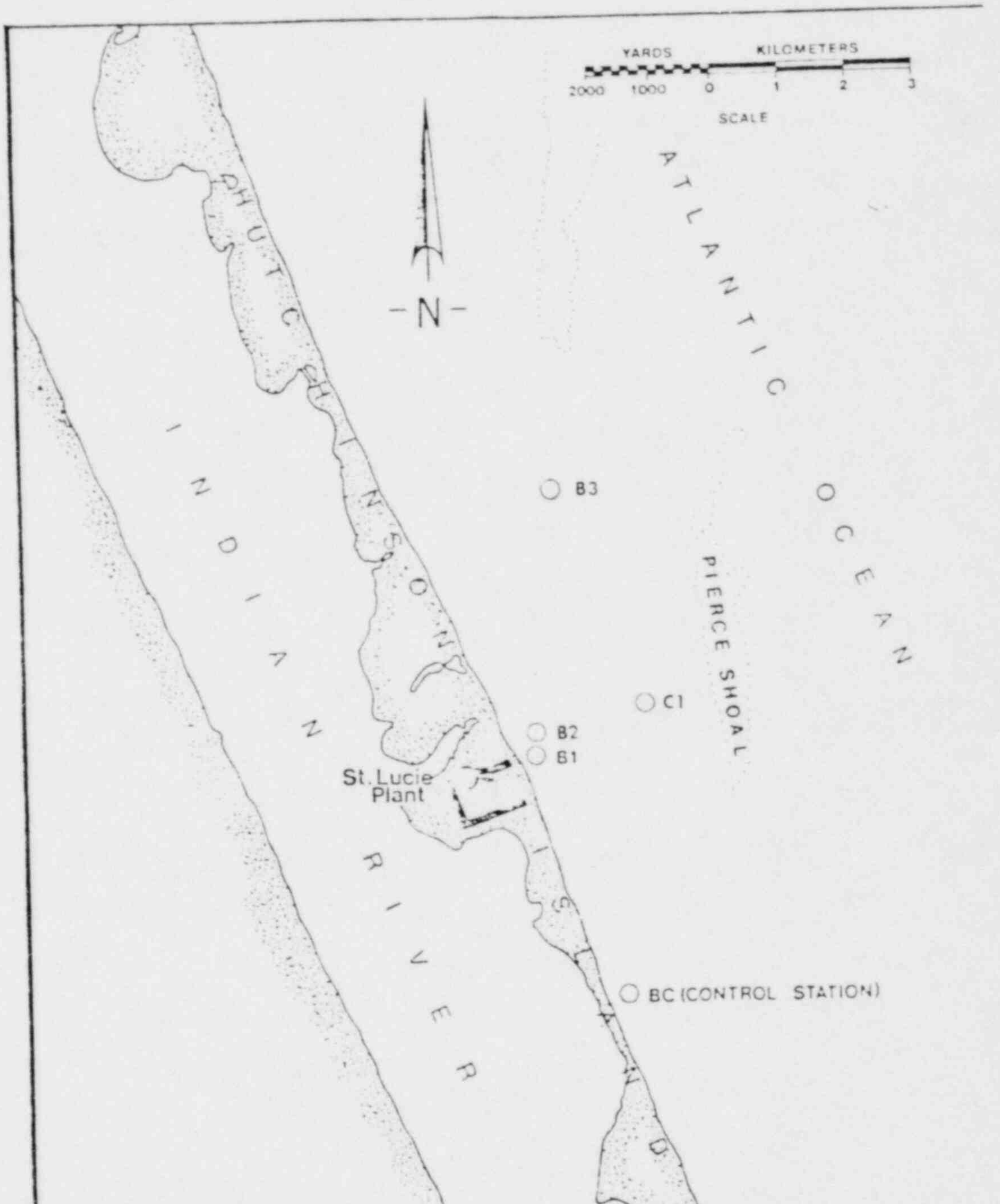


Figure 3. Location of benthic sampling stations.

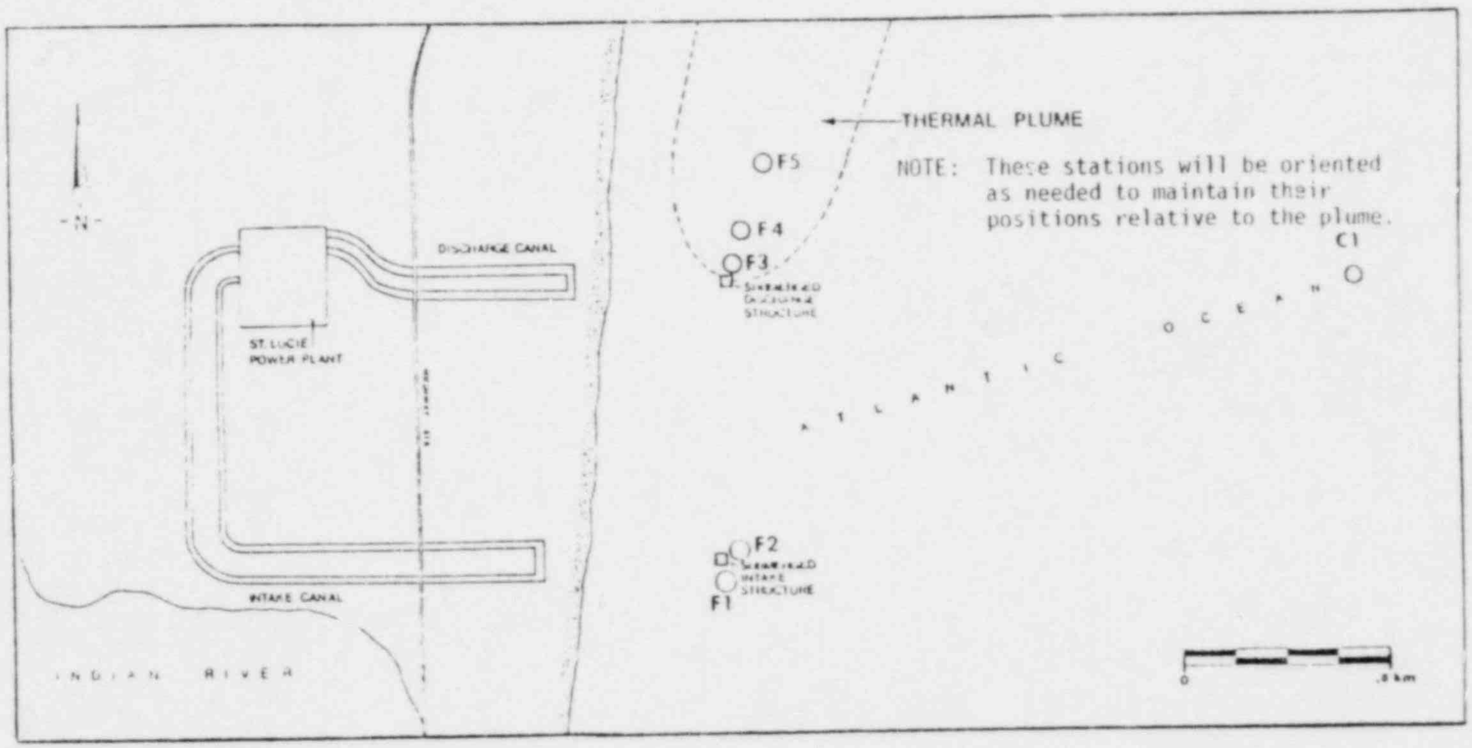


Figure 4. Location of gill net stations.

the FPL shoreline property and along selected control beaches. Specifics of the nesting surveys, such as sampling frequency and the amount of beach sampled, vary between study years and are established following input from the appropriate state and federal agencies.

Sea turtle removal from the intake canal is conducted on a continual basis. The turtles are removed with nets from the canal, measured and weighed, tagged and released back into the ocean. The utmost care is taken so as not to injure the animals.

E. Water Quality

Samples for water quality analysis will be collected concurrently with the biological samples.

IV. SIGNIFICANT CHANGES FROM THE ETS MONITORING PROGRAM

The ETS contain a provision for modification of the program based upon the data accumulated after two years of operation. The program proposed in Section II above differs significantly from that prescribed in the St. Lucie Unit No. 1 ETS in several respects. These changes and their bases are described below.

A. Plankton - The monthly collection of phytoplankton and zooplankton has been deleted.

Justification

Interstation comparisons have shown that concentrations of zooplankton, phytoplankton and chlorophyll a generally have been higher in the area of the Station 1 discharge than at the other stations, suggesting some enhancement of plankton concentrations due to the thermal input. It is unlikely that differences in plankton concentrations are significant in the high energy, nearshore location under consideration. Continued plankton monitoring does not appear to be justified.

B. Nektonic Organisms - Collecting of samples by trawling and seining has been deleted and gill net station locations have been revised.

Justification

The ETS allowed collection of samples by "trawling, seining, or other suitable method". Trawling and beach seining are sampling techniques that are highly selective for bottom dwelling and surf zone dwelling forms. During operational monitoring, neither of these communities appeared to be influenced by the thermal discharge (Ref. 3). Gill netting obtains samples in the water column and is an effective method for collecting sport and commercial fish species. The proposed schedule emphasizes collections during the period of the year when migratory species such as bluefish, Spanish mackerel and king mackerel are near the St. Lucie Plant. Stations moved to the immediate plume area will better assess the influence of the thermal discharge on the movements of fishes in the area.

C. Macrophytes - The quarterly collection of macroscopic aquatic vegetation has been deleted.

Justification

The highest diversity of algae, 88 species, was collected during the third year of the study. The number of species collected was lowest in early spring and highest in summer and early fall. This seasonal patter was typical for subtropical marine vegetation. Diversity was higher near shore because drift (unattached) algae were the predominate forms and these were carried inshore by the prevailing winds and currents (Ref. 3).

Vegetation distribution and growth at all nearshore stations surveyed seems to be limited by a lack of approp te substrate for vegetation attachment. Well-developed macrophyte communities may occur on isolated rock outcroppings, but the chances of the collecting dredge encountering one of these outcroppings is remote. Because the attached macrophyte community is so limited, it is not considered an important food source or habitat for organisms living in the St. Lucie area. Because of the above, the sampling provides little useful data and there is no need for further monitoring of macrophytes.

D. Water Quality - Collection of selected nutrients has been deleted.

Justification

Data from the control station, located distant from the St. Lucie Plant, were compared with results from station-specific water parameter analyses. Data from the literature for marine waters of nearshore coastal environments adjacent to the plant were also compared with the present study. Data comparisons (Ref. 3) indicated:

a. Nearly all parameters measured varied significantly during different months of the year; and

b. There were no significant differences in parameters among stations or at different depths.

These results show that the operation of the St. Lucie Plant has no significant effect on the selected nutrients in this study. Continued nutrient analyses does not appear warranted.

E. Migratory Sea Turtles - Various requirements relating to the effects of the discharge thermal plume and temperature stress, hatching and rearing factors for migratory sea turtles have been deleted.

Justification

The requirements of the ETS have been satisfied. A report was prepared (Ref. 2) and submitted to the NRC by FPL letter No. L-78-109, dated 30 March 1978, that described studies performed to determine the effects of the discharge thermal plume on turtle nesting patterns and turtle hatchling swimming. Additionally, control studies on temperature stress, hatching and rearing factors conducted using turtle eggs from displaced nests were reported. The results of the studies of turtle hatchlings

show no evidence that potential nearshore surface temperatures from the plant will cause permanent impairment or mortality (Ref. 2).

F. Entrainment of Aquatic Organisms (ETS 4.1) - Various requirements relating to assessment of the effects on planktonic organisms of passage through the plant condensers have been deleted.

Justification

The results of the ichthyoplankton and zooplankton sampling have been presented in the Annual Non-Radiological Environmental Monitoring Reports for 1976, 1977, 1978 and 1979 (Ref. 1, 2, 3, 16).

These studies show that the inshore ocean waters near the St. Lucie Plant are not typical of a productive fish nursery area. Physical characteristics needed in a nursery area are low or fluctuating salinities, silt-sand-mud bottom, and extensive beds of rooted aquatic vegetation. Chemically, the waters in the St. Lucie Plant area are homogeneous with little seasonal variations. Physically, the nearshore areas are characterized by the presence of relatively constant salinities, shell-hash sediments and the absence of significant macrophytic grassbeds.

Important migratory sport and commercial fishes were not found to be spawning in the area of the St. Lucie Plant. In general, low concentrations of fish eggs and larvae have been recorded in the intake canal, which confirms that entrainment is not significant. Zooplankton losses through entrainment are not significant.

Based on the above, the required Entrainment Studies need not be included in the operational monitoring program.

LITERATURE CITED

1. ABI. 1977. Ecological monitoring at the Florida Power & Light Company, St. Lucie Plant, annual report, 1976. Report to Florida Power & Light Company, Miami, Fla.

2. ___. 1978. Ecological monitoring at the Florida Power & Light Company, St. Lucie Plant, annual report, 1977. Report to Florida Power & Light Company, Miami, Fla.

3. ___. 1979. Florida Power & Light Company, St. Lucie Plant annual non-radiological environmental monitoring report, 1978. Vol. II and III. Biotic monitoring. Report to Florida Power & Light Company, Miami, Fla.

4. Florida Power & Light Co. 1971. Hutchinson Island plant unit No. 1 environmental report Docket No. 50-335. 20 May 1971. Florida Power & Light Company, Miami, Fla.

5. Florida Department of Natural Resources. 1972. Preliminary environmental studies of coastal waters near Hutchinson Island, Florida. Progress report to Florida Power & Light Company, Miami, Fla.

6. Gallagher, R.M. 1977a. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. I. Rationale and methods. Fla. Mar. Res. Publ. No. 23:1-5.

7. ________________. 1977b. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. II. Sediments. Fla. Mar. Res. Publ. No. 23:6-24.

8. Worth, D.F., and M.L. Hollinger. 1977. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. III. Physical and chemical environment. Fla. Mar. Res. Publ. No. 23:25-35.

9. Futch, C.R., and S.E. Dwinell. 1977. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. IV. Lancelets and fishes. Fla. Mar. Res. Publ. No. 24:1-23.

10. Camp, D.K., N.H. Whiting, and R.E. Martin. 1977. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. V. Arthropods. Fla. Mar. Res. Publ. No. 25:1-63.

11. Gallagher, R.M., M.L. Hollinger, R.M. Ingle, and C.R. Futch. 1972. Marine turtle nesting on Hutchinson Island in 1971. Fla. Dept. Nat. Resour., Mar. Res. Lab. Spec. Sci. Rept. No. 37:1-11.

12. Worth, D.F., and J.B. Smith. 1976. Marine turtle nesting on Hutchinson Island in 1973. Fla. Mar. Res. Publ. No. 18:1-17.

13. Dames & Moore. 1977. Graphical and tabular wind roses. St. Lucie, Hutchinson Island, Florida, 1973. Report to Florida Power & Light Company. Miami, Fla.

LITERATURE CITED (continued)

14. Envirosphere Co. 1976. St. Lucie Plant site ocean current analysis. Report to Florida Power & Light Company, Miami, Fla.

15. ________________. 1977. Thermal evaluation study. St. Lucie Unit 1 ocean diffuser. Report to Florida Power & Light Company, Miami, Fla.

16. ABI. 1980. Florida Power & Light Company, St. Lucie Plant annual non-radiological environmental monitoring report, 1979. Vol. II and III. Biotic monitoring. Report to Florida Power & Light Company, Miami, Fla.

ATTACHMENT II

ST. LUCIE UNIT NO. 2 BIOLOGICAL MONITORING PROGRAM - OPERATIONAL PHASE ADDITIONS

The following additions to the Biological Monitoring Program submitted to EPA on 3 April 1980 are recommended for the program to serve St. Lucie Unit No. 2 in the operational mode.

A. Benthic organisms. Specification - Two additional sampling stations will be added near the Unit No. 2 discharge. These stations will be in close proximity to the discharge pipe with one north and one south of the pipe. Stations will be sampled quarterly with four or more replicates collected to assess the taxonomic composition and abundanace.

Justification

The Unit No. 2 discharge pipe will extend 1875 feet further offshore than the Unit No. 1 pipe. There is a habitat and sediment change from beach terrace gray sand near shore (e.g. Unit 1 discharge area) to a shell hash substrate in the area of Unit 2 discharge. The ongoing monitoring program has shown these habitats to support somewhat different communities. These different communities may react differently to a heated discharge.

B. Nekton. Specification - Two additional offshore gill net stations will be established. One station will be in the middle of the Unit No. 2 thermal plume's warmest area and the other, the control, about 200 meters upcurrent from this warmest spot. The stations will be sampled once per month during April through

September when the commercially important migratory species are generally not present offshore the St. Lucie Plant and twice per month during October through March when these species are present.

Justification

The adult fish community in the discharge plume from Unit No. 2 should be examined to determine if attraction or exclusion is occurring. The St. Lucie No. 2 discharge pipe will extend about 1875 feet past the Unit No. 1 point of discharge and the discharged water may influence fish movement in the area.

C. Water Quality. Specification - Physical parameters will be measured at the same stations and frequency as the biological samples.

Justification

Water quality determinations are made to support the biological program and should be taken concurrently with biological sampling.

This program will enable an evaluation of the impact of the Unit No. 2 discharge to be made. The addition of these stations and sampling regimes takes into consideration the option of directing the plant discharge through the St. Lucie Unit No. 2 diffuser pipe if one unit is down.

FLORIDA POWER & LIGHT COMPANY

ST. LUCIE PLANT

UNIT NO. 1

FLORIDA POWER & LIGHT COMPANY

PEOPLE . . . SERVING PEOPLE

ANNUAL ENVIRONMENTAL REPORT NO. 2

FOR THE YEAR

1977

EXHIBIT H

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE 5

Month JANUARY

7

AY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]	SALINITY[2]	T.R.C.[3]	
1			8.20		35.0		
2			8.17		34.8		
3			8.20		34.9	.02	
4			8.20		35.0		
5	6.60		8.22	6.90	34.6		
6			8.20		34.8		
7			8.20		35.0		
8			8.21		35.0		
9			8.20		34.8		
0			8.2		35.6		
1			8.2		35.2		
2	7.1		8.15	7.1	35.5		
3			8.21		35.2		
4			8.15		35.1		
5			8.2		35.1		
6			8.2		35.1		
7			8.15		34.6	.02	
8			8.15		35.2		
9	7.2		8.1	7.2	35		
20			8.15		35		
21			8.1		35		
22			8.1		35		
23			8.15		35		
24			8.1		35.2	.02	
25			8.1		35.2		
26	7.3		8.1	7.2	35.1		
27			8.1		35.2		
28			8.15		35		
29			8.10		34.8		
30			8.05		34		
31			8.15		35	.02	

NOTES:

[1]Dissolved Oxygen in ppm.

[2]Salinity in ppt.

[3]Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE 5 (cont.)

1977 Month FEBRUARY

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]	SALINITY[2]	T.R.C.[3]	
1			8.10		35.0		
2	7.6		8.12	7.7	33.5		
3			8.12		35.0		
4			8.12		35.0		
5			8.10		34.5		
6			8.12		34.8		
7			8.10		35.0		
8			8.10		35.2	0.02	
9	7.3		8.12	7.2	35.0		
10			8.10		35.2		
11			8.12		35.1		
12			8.12		35.1		
13			8.10		[illegible]		
14			8.10		35.2		
15			8.11		35.1		Did Not Chlorinate
16	6.9		8.18	7.3	35.0		
17			8.20		35.0	0.02	
18			8.15		35.0		
19			8.14		34.9		
20			8.20		35.0		
21			8.10		35.0		
22			8.13		35.0	0.02	
23	6.6		8.14	6.6	35.1		
24			8.14		35.2		
25			8.13		35.3	0.02	
26			8.10		34.8		
27			8.11		34.8		
28			8.12		35.1		
29	-	-	-	-	-	-	
30	-	-	-	-	-	-	
31	-	-	-	-	-	-	

NOTES:
[1] Dissolved Oxygen in ppm.
[2] Salinity in ppt.
[3] Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE 5 (cont.)

1977

Month MARCH

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]	SALINITY[2]	T.R.C.[3]	
1			8.13		34.9	0.02	
2	6.7		8.10	6.45	35.1		
3			8.10		34.5		
4			8.12		33.5		
5			8.13		33.5		
6			8.17		34.0		
7			8.13		34.8		
8			[illegible].12		35.2		
9	6.4		8.10	6.0	34.8		
10			8.10		35.0	0.02	
11			8.10		35.5		
12			8.10		35.0		
13			8.10		35.5		
14			8.10		35.0		
15			8.10		35.3		
16	6.6		8.20	6.1	35.0	0.02	
17			8.11		35.0		
18			8.17		35.0		
19			8.13		34.8		
20			8.10		34.6		
21			8.15		35.2		
22			8.20		34.9	0.02	
23	6.5		8.18	6.2	35.2		
24			8.18		35.2		
25			8.21		35.4		
26			8.20		35.2		
27			8.20		35.1		
28			8.15		34.8		
29			8.18		35.0	0.05	
30	6.8		8.15	6.7	34.8	0.04	
31			8.18		35.0		

NOTES:

[1] Dissolved Oxygen in ppm.

[2] Salinity in ppt.

[3] Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE 5 (cont.)

1977 Month APRIL

DAY	INTAKE D.O.[1]		DISCHARGE pH	DISCHARGE D.O.[1]	DISCHARGE SALINITY[2]	DISCHARGE T.R.C.[3]	REMARKS
1			8.15		34.6		
2			8.21		34.8		
3			8.18		35.0		
4			8.17		34.9		
5			8.21		35.0	0.02	
6	7.3		8.19	7.3	35.0		
7			8.18		35.0		
8			8.18		35.1		
9			8.18		35.1		
10			8.20		35.0		
11			8.21		35.0		
12			8.19		35.0	0.015	
13	6.95		8.17	6.7	35.0		
14			8.10		35.0		
15			8.13		35.0		
16			8.11		34.8		
17			8.15		34.5		Did Not Chlorinate
18			8.20		34.9		↓
19			8.21		34.2		↓
20	6.3		8.17	6.95	34.5		↓
21			8.18		34.5		↓
22			8.18		34.2		↓
23			8.18		33.5		↓
24			8.18		33.8		
25			8.17		34.0		
26			8.20		34.1		
27	6.3		8.18	6.90	34.0		Did Not Chlorinate
28			8.20		34.0		
29			8.19		34.0	0.02	
30			8.20		34.5		
31	-	-	-	-	-	-	

NOTES: [1]Dissolved Oxygen in ppm.
[2]Salinity in ppt.
[3]Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE 5 (cont.)

Month MAY

1977

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]	SALINITY[2]	T.R.C.[3]	
1			8.15		34.0		
2			8.21		34.3		
3			8.15		34.5		
4	6.5		8.20	6.75	34.0	0.025	
5			8.14		34.8		
6			8.15		34.5		
7			8.12		34.1		
8			8.12		34.6		
9			8.12		34.7	0.03	
10			8.20		34.2		
11	6.5		8.22	6.9	33.7		
12			8.21		33.9		
13			8.20		33.5		
14			8.15		34.0		
15			8.20		33.5		
16			8.18		33.9		
17			8.15		33.3		
18	6.2		8.18	5.95	34.0	0.05	
19			8.18		34.2		
20			8.15		33.9		
21			8.18		34.0		
22			8.19		34.2		
23			8.12		34.8		
24			8.12		34.3	0.04	
25	6.05		8.11	5.90	34.0		
26			8.12		33.5		
27			8.15		33.8		
28			8.15		33.3		
29			8.17		33.5		
30			8.15		33.5		
31			8.15		33.5		

NOTES:
1 Dissolved Oxygen in ppm.
2 Salinity in ppt.
3 Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE 5 (cont.)

1977 Month JUNE

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]	SALINITY[2]	T.R.C.[3]	
1	6.35		8.19	7.28	34.0		
2			8.19		34.0	0.03	
3			8.20		34.3		
4			8.20		34.0		
5			8.20		34.2		
6			8.13		34.1		
7			8.18		34.9	0.04	
8	5.98		8.12	6.2	34.2		
9			8.17		34.5		
10			8.15		34.2		
11			8.15		34.3		
12			8.25		34.6		
13			8.15		34.9		
14			8.11		34.9	0.03	
15	6.00		8.13	6.2	35.0		
16			8.12		34.5		
17			8.19		34.7		
18			8.20		35.0		
19			8.15		35.0		
20			8.13		34.7		
21			8.13		34.6	0.03	
22	6.25		8.10	6.3	34.1		
23			8.12		34.4		
24			8.11		34.6		
25			8.12		33.9		
26			8.10		34.2		
27			8.12		34.2		
28			8.20		33.9	0.035	
29	6.10		8.21	6.95	34.1		
30			8.22		33.9		
31	-	-	-	-	-	-	

NOTES:
[1] Dissolved Oxygen in ppm.
[2] Salinity in ppt.
[3] Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE 5 (cont.)

Month JULY

1977

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]	SALINITY[2]	T.R.C.[3]	
1			8.21		33.8		
2			8.20		34.0		
3			8.22		33.5		
4			8.20		34.3		
5			8.23		33.9	0.03	
6	6.6		8.16	6.1	34.2		
7			8.13		33.8		
8			8.17		33.5		
9			8.14		33.7		
10			8.16		33.5		
11			8.16		34.4		
12			8.20		34.0	0.03	
13	6.1		8.18	5.9	31.0		
14			8.1[illegible]		31.8		
15			8.13		32.0		
16			8.12		33.0		
17			8.13		33.2		
18			8.23		31.5		
19			8.18		31.2	0.02	
20	6.0		8.20	5.9	33.1		
21			8.20		32.0	0.03	
22			8.20		31.2		
23			8.18		31.0		
24			8.20		31.5		
25			8.18		30.0		
26			8.18		32.0	0.04	
27	6.2		8.18	6.2	32.0		
28			8.14		31.5		
29			8.20		30.5		
30			8.20		31.1		
31			8.20		31.0		

NOTES:
[1] Dissolved Oxygen in ppm.
[2] Salinity in ppt.
[3] Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE 5 (cont.)

1977

Month AUGUST

DAY	INTAKE D.O.[1]		DISCHARGE pH	D.O.[1]	SALINITY[2]	T.R.C.[3]	REMARKS
1			8.17		29.6		
2			8.20		29.4	0.06	
3	7.95		8.12	7.65	30.3		
4			8.18		30.5		
5			8.18		29.5		
6			8.18		30.0		
7			8.20		31.5		
8			8.20		31.0		
9			8.20		31.0	0.02	
10	6.10		8.20	5.70	33.0		
11			8.20		33.6		
12			8.20		33.5		
13			8.15		33.3		
14			8.12		32.6		
15			8.17		32.4		
16			8.16		32.4	0.00	
17	6.30		8.20	5.90	33.5		
18			8.20		33.5		
19			8.18		33.7		
20			8.17		33.5		
21			8.18		33.5		
22			8.15		34.0		
23			8.18		33.7	0.02	
24	6.10		8.13	6.00	34.0		
25			8.12		33.6		
26			8.20		33.5		
27			8.18		31.8		
28			8.13		35.0		
29			8.18		33.5	0.01	
30			8.18		34.0		
31	6.10		8.18	6.00	34.0	0.02	

NOTES:
[1] Dissolved Oxygen in ppm.
[2] Salinity in ppt.
[3] Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE 5 (cont.)

1977 Month SEPTEMBER

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]	SALINITY[2]	T.R.C.[3]	
1			8.17		34.1		
2			8.18		33.6		
3			8.16		34.0		
4			8.17		34.2		
5			8.15		34.0		
6			8.15		34.0	0.04	
7	6.1		8.17	5.7	33.8		
8			8.17		33.8		
9			8.15		33.9		
10			8.17		34.0		
11			8.17		34.0		
12			8.17		33.8		
13			8.18		33.8	0.04	
14	6.3		8.16	6.0	33.7		
15			8.12		33.9		
16			8.15		33.9		
17			8.18		33.8		
18			8.18		33.8		
19			8.12		33.6		
20			8.12		33.4		
21	6.0		8.08	5.7	34.2	0.01	
22			8.10		34.1		
23			8.14		34.0		
24			8.10		34.0		
25			8.13		34.3		
26			8.20		34.0		
27			8.18		33.8		No Chlorination
28	6.8		8.16	6.2	33.9		
29			8.13		34.0		
30			8.15		34.0		
31	-	-	-	-	-	-	

NOTES:
[1]Dissolved Oxygen in ppm.

[2]Salinity in ppt.

[3]Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE 5 (cont.)

1977 Month OCTOBER

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]	SALINITY[2]	T.R.C.[3]	
1			8.14		34.2		
2			8.11		34.2		
3			8.15		33.4		
4			8.10		33.0		
5	6.6		8.20	8.2	34.0	0.02	
6			8.16		33.5		
7			8.20		33.2		
8			8.18		33.4		
9			8.18		33.5		
10			8.05		33.5		
11			8.14		33.0		
12	5.8		8.16	5.4	33.1	0.01	
13			8.15		33.2		
14			8.14		33.2		
15			8.15		33.2		
16			8.10		33.2		
17			8.08		33.1		
18	6.0		8.12	5.6	33.2		
19			8.12		33.2		
20			8.15		33.0	0.02	
21			8.16		33.0		
22			8.12		33.5		
23			8.18		33.2		
24			8.14		32.0		
25	6.4		8.15	5.9	32.3	0.01	
26			8.10		32.0		
27			8.20		32.5		
28			8.20		32.0		
29			8.18		32.1		
30			8.20		32.0		
31			8.12		32.0		

NOTES: [1] Dissolved Oxygen in ppm.

[2] Salinity in ppt.

[3] Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE 5 (cont.)

1977 Month NOVEMBER

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]	SALINITY[2]	T.R.C.[3]	
1	6.8		8.15	6.4	34.2		
2			8.12		34.3	0.03	
3			8.14		34.2		
4			8.12		34.4		
5			8.12		34.2		
6			8.15		34.2		
7			8.15		34.4		
8	6.6		8.13	6.2	34.2	0.01	
9			8.10		34.5		
10			8.10		34.0		
11			8.10		34.0		
12			8.10		34.0		
13			8.10		34.0		
14			8.10		33.8		
15	7.0		8.10	7.0	33.5		
16			8.15		35.0	0.04	
17			8.10		35.0		
18			8.14		35.2		
19			8.10		35.5		
20			8.12		35.1		
21			8.12		35.4		
22	6.6		8.12	6.25	35.5	0.02	
23			8.13		35.3		
24			8.12		35.2		
25			8.12		35.4		
26			8.10		34.8		
27			8.11		35.0		
28			8.10		33.8		
29	6.2		8.20	6.0	34.0	0.03	
30			8.15		34.5		
31	-	-	-	-	-	-	

NOTES:
[1] Dissolved Oxygen in ppm.
[2] Salinity in ppt.
[3] Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE 5

1977 | Month DECEMBER

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]	SALINITY[2]	T.R.C.[3]	
1			8.10		34.5		
2			8.05		34.0		
3			8.05		34.1		
4			8.10		34.1		
5			8.15		34.2		
6			8.18		34.0		
7	6.4		8.12	6.2	35.0	0.03	
8			8.16		35.0		
9			8.20		35.5		
10			8.19		35.0		
11			8.20		35.0		
12			8.25		35.5		
13	6.8		8.25	6.8	34.5	0.04	
14			8.20		34.5		
15			8.20		35.0		
16			8.20		35.0		
17			8.21		35.0		
18			8.20		35.2		
19			8.10		34.5		
20	6.8		8.18	7.0	35.0		
21			8.10		34.5	0.04	
22			8.25		34.0		
23			8.20		35.0		
24			8.20		34.8		
25			8.21		34.7		
26			8.20		34.5		
27			8.20		34.0	0.04	
28	6.7		8.20	7.0	35.0		
29			8.20		35.0		
30			8.20		35.0		
31			8.05		34.5		

NOTES:
[1]Dissolved Oxygen in ppm.
[2]Salinity in ppt.
[3]Total Residual Chlorine in ppm.

Florida Power & Light Company

ST. LUCIE PLANT

ANNUAL NON-RADIOLOGICAL MONITORING REPORT 1978

Volume 1

ABIOTIC MONITORING

EXHIBIT I

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE C-1

Month January 1978

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]	SALINITY[2]	T.R.C.[3]	
1			8.1		35.0		
2			8.1		35.1		
3			8.2		34.0		
4	7.0		8.2	6.6	34.5	0.04	
5			8.2		34.8		
6			8.2		34.5		
7			8.2		35.0		
8			8.2		35.2		
9			8.1		34.8		
10	7.0		8.2	6.8	34.5	0.04	
11			8.2		34.0		
12			8.2		35.0		
13			8.2		35.0		
14			8.2		34.5		
15			8.2		34.0		
16			8.2		35.0		
17	6.9		8.2	6.5	35.0	0.05	
18			8.2		34.5		
19			8.2		34.3		
20			8.2		34.2	0.05	
21			8.2		34.3		
22			8.2		34.2		
23			8.2		34.0		
24	7.3		8.2	7.0	35.0	0.03	
25			8.2		35.0		
26			8.2		35.1		
27			8.2		35.0		
28			8.2		35.2		
29			8.3		35.0		
20			8.2		34.9		
31	6.7		8.2	6.5	35.0	0.03	

NOTES:
[1]Dissolved Oxygen in ppm.
[2]Salinity in ppt.
[3]Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE C-1 (CONT.)

Month February 1978

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]	SALINITY[2]	T.R.C.[3]	
1			8.3		35.1		
2			8.3		34.9		
3			8.3		34.9		
4			8.3		35.0		
5			8.3		35.0		
6			8.3		34.3		
7	6.9		8.2	6.6	34.6	0.01	
8			8.2		34.0		
9			8.3		34.0		
10			8.2		35.0		
11			8.2		34.9		
12			8.2		34.8		
13			8.2		35.2		
14	6.8		8.2	6.6	34.8	0.01	
15			8.2		35.3		
16			8.2		35.0		
17			8.2		34.8		
18			8.2		35.0		
19			8.2		35.5		
20			8.2		34.8		
21	6.6		8.2	6.1	34.5	<0.01	
22			8.2		34.5		
23			8.2		34.3		
24			8.2		35.4		
25			8.2		35.5		
26			8.2		35.3		
27			8.2		35.2		
28	6.5		8.2	5.9	35.0	<0.01	
29							
30							
31							

NOTES: [1]Dissolved Oxygen in ppm.

[2]Salinity in ppt.

[3]Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE C-1 (CONT.)

Month March 1978

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]	SALINITY[2]	T.R.C.[3]	
1			8.2		35.0		
2			8.2		34.8		
3			8.2		35.1		
4			8.2		35.0		
5			8.2		35.1		
6			8.2		35.0		
7	7.2		8.2	6.8	34.9	<0.01	
8			8.3		35.2		
9			8.2		35.0		
10			8.2		34.5		
11			8.2		35.0		
12			8.2		34.6		
13			8.2		35.0		
14	6.6		8.2	6.5	35.0	<0.01	
15			8.2		34.5		
16			8.2		34.5		
17			8.2		35.2		
18			8.2		35.1		
19			8.2		35.0		
20			8.2		33.0		
21	6.8		8.2	6.8	34.9	<0.01	
22			8.3		35.0		
23			8.2		35.2		
24			8.2		35.0		
25			8.2		35.1		
26			8.2		35.0		
27			8.2		35.0		
28	6.9		8.2	6.8	35.1	<0.01	
29			8.3		34.0		
30			8.3		34.5		
31			8.3		34.5		

NOTES: [1] Dissolved Oxygen in ppm.

[2] Salinity in pp[illegible]

[3] Total Resi[illegible] [illegible]hlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE C-1 (CONT.)

Month April 1978

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]	SALINITY[2]	T.R.C.[3]	
1			8.3		35.0		unit off
2			8.3		34.8		line. No
3			8.2		35.0		circulating
4	6.4		8.3	6.8	34.8		water
5			8.3		35.0		pumps.
6			8.3		34.9		operating
7			8.2		35.0		
8			8.3		34.8		
9			8.3		35.0		
10			8.3		35.0		
11	7.0		8.3	7.4	35.1		
12			8.3		34.8		
13			8.3		35.0		
14			8.3		34.8		
15			8.3		35.0		
16			8.3		35.1		
17			8.3		35.0		
18	8.4		8.3	8.0	35.1		
19			8.3		35.3		
20			8.3		34.0		
21			8.3		34.2		
22			8.3		34.5		
23			8.2		34.1		
24			8.2		34.2		
25	8.4		8.2	8.4	34.3		
26			8.2		34.7		
27			8.2		34.8		
28			8.2		34.8		
29			8.2		34.7		
30			8.2		34.7		
31							

NOTES: [1]Dissolved Oxygen in ppm.

[2]Salinity in ppt.

[3]Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE C-1 (CONT.)

Month May 1978

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]	SALINITY[2]	T.R.C.[3]	
1			8.2		35.0		unit off
2	6.9		8.2	6.3	35.0		line. No
3			8.2		35.0		circulating
4			8.2		35.1		water
5			8.1		35.3		pumps
6			8.2		35.0		operating
7			8.1		35.2		
8			8.2		35.0		
9	7.2		8.2	6.5	35.1		
10			8.2		34.9		
11			8.2		35.0		
12			8.2		35.0		
13			8.2		35.0		
14			8.2		34.9		
15			8.2		34.9		
16	6.9		8.2	6.8	34.8		
17			8.2		34.9		
18			8.1		34.9		
19			8.2		34.9		
20			8.2		35.0		
21			8.2		34.9		
22			8.2		34.9		
23	7.6		8.2	7.5	35.0		
24			8.2		34.8		
25			8.2		34.8		
26			8.2		34.8		
27			8.2		34.9		
28			8.2		35.0		
29			8.2		35.1		
30	6.5		8.2	6.5	35.0		
31			8.2		35.[illegible]		

NOTES:
[1] Dissolved Oxygen in ppm.
[2] Salinity in ppt.
[3] Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE C-1 (CONT.)

Month June 1978

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]	SALINITY[2]	T.R.C.[3]	
1			8.2		34.9		
2			8.2		35.0		
3			8.2		35.4		
4			8.2		34.5		
5			8.2		34.5		
6	6.4		8.2	6.1	34.5	<0.01	
7			8.2		34.2		
8			8.2		34.1	<0.01	
9			8.2		34.0		
10			8.2		34.[illegible]		
11			8.2		34.1		
12			8.2		34.0		
13	6.2		8.2	5.6	34.0	0.01	
14			8.2		34.0		
15			8.2		34.1		
16			8.2		34.6		
17			8.2		34.7		
18			8.2		34.6		
19			8.2		34.2	0.01	
20	6.3		8.2	5.8	34.4		
21			8.2		34.4		
22			8.2		34.0		
23			8.2		34.8	<0.01	
24			8.2		34.9		
25			8.2		34.8		
26			8.3		34.8	0.02	
27	5.9		8.3	5.8	34.9		
28			8.3		34.9		
29			8.3		34.9		
30			8.2		34.8		
31							

NOTES:
[1]Dissolved Oxygen in ppm.
[2]Salinity in ppt.
[3]Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE C-1 (CONT.)

Month July 1978

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]	SALINITY[2]	T.R.C.[3]	
1			8.2		34.8		
2			8.2		34.8		
3			8.2		34.8	0.01	
4			8.2		34.9		
5	6.0		8.2	5.5	34.9		
6			8.2		35.0		
7			8.2		34.8	0.01	
8			8.2		34.8		
9			8.2		34.7		
10			8.2		35.0	0.01	
11			8.2		34.5		
12			8.2		34.6		
13	6.1		8.2	5.6	34.8		
14			8.2		34.8		
15			8.2		34.0		
16			8.2		35.0		
17			8.2		34.5	0.01	
18			8.2		34.8		
19	6.3		8.2	6.4	34.9		
20			8.2		35.1		
21			8.2		35.0		
22			8.2		33.8		
23			8.2		34.4		
24			8.2		34.8		
25			8.2		34.5	0.02	
26	6.7		8.2	6.4	34.6		
27			8.2		34.5		
28			8.2		34.7		
29			8.2		34.5		
30			8.2		34.9		
31			8.2		34.9	0.02	

NOTES:
[1] Dissolved Oxygen in ppm.
[2] Salinity in ppt.
[3] Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE C-1 (CONT.)

Month August 1978

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]	SALINITY[2]	T.R.C.[3]	
1	6.7		8.2	6.6	34.4		
2			8.2		34.6		
3			8.3		35.2		
4			8.2		35.0		
5			8.2		35.1		
6			8.2		35.0		
7			8.2		35.1		
8	6.5		8.2	6.4	35.0		
9			8.2		35.0	0.01	
10			8.2		35.0		
11			8.2		35.0		
12			8.2		34.9		
13			8.2		35.0		
14			8.2		34.8	0.01	
15	6.1		8.2	6.5	35.0		
16			8.2		35.0		
17			8.2		34.8		
18			8.2		34.8		
19			8.2		34.8		
20			8.2		35.0		
21			8.3		34.7		
22	6.0		8.2	6.3	34.8		
23			8.2		34.7		
24			8.1		34.8		
25			8.3		35.2	<0.01	
26			8.2		35.1		
27			8.2		35.0		
28			8.2		35.0		
29	6.1		8.2	7.0	34.8	0.02	
30			8.2		34.7		
31			8.1		34.2		

NOTES:
[1] Dissolved Oxygen in ppm.
[2] Salinity in ppt.
[3] Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE C-1 (CONT.)

Month September 1978

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]	SALINITY[2]	T.R.C.[3]	
1			8.3		34.9		
2			8.2		34.5		
3			8.3		35.0		
4			8.2	6.4	35.1		
5	6.0		8.3	6.4	34.2	0.01	
6			8.3		34.7		
7			8.3		34.9		
8			8.3		35.0		
9			8.3		34.5		
10			8.3		34.2		
11			8.3		34.0		
12	5.6		8.3	5.5	34.5	0.01	
13			8.4		35.0		
14			8.3		35.1		
15			8.3		35.0		
16			8.3		35.0		
17			8.3		35.2		
18			8.3		34.0		
19	8.8		8.3	6.2	35.0	<0.01	
20			8.3		35.2		
21			8.3		34.5		
22			8.2		34.2		
23			8.2		34.3		
24			8.2		34.5		
25			8.2		34.0		
26	8.9		8.3	8.2	34.0		
27			8.2		34.9	0.01	
28			8.2		34.2		
29			8.3		34.3		
30			8.2		34.9		
31							

NOTES: [1]Dissolved Oxygen in ppm.

[2]Salinity in ppt.

[3]Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE C-1 (CONT.)

Month October 1978

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]	SALINITY[2]	T.R.C.[3]	
1			8.3		35.0		
2			8.3		34.5		
3	8.2		8.3	8.0	34.2	0.01	
4			8.2		34.8		
5			8.3		35.0		
6			8.2		34.2		
7			8.3		34.5		
8			8.3		35.0		
9			8.2		34.5		
10	6.2		8.2	5.7	34.0		chlorinator
11			8.2		34.8		out of service
12			8.2		35.0		
13			8.2		35.0		
14			8.2		34.9		
15			8.2		34.9		
16			8.1		35.0		
17	5.8		8.1	5.5	34.5		chlorinator
18			8.2		34.5		out of service
19			8.2		34.2		
20			8.1		34.0		
21			8.2		34.0		
22			8.1		34.0		
23			8.1		34.8		
24	5.8		8.1	4.7	34.0		
25			8.2		34.0	0.01	
26			8.1		34.5		
27			8.2		34.8		
28			8.2		34.0		
29			8.1		34.2		
30			8.1		34.2		
31	5.5		8.2	5.5	34.5		

NOTES: [1]Dissolved Oxygen in ppm.
[2]Salinity in ppt.
[3]Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE C-1 (CONT.)

Month November

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]	SALINITY[2]	T.R.C.[3]	
1			8.2		34.7		
2			8.2		34.2		
3			8.1		34.8		
4			8.1		34.7		
5			8.2		34.9		
6			8.2		34.2		
7	5.5		8.2	5.4	34.5		Unit off line
8			8.2		34.7		
9			8.2		34.5		
10			8.2		34.6		
11			8.2		34.7		
12			8.2		35.0		
13			8.2		35.5		
14	6.6		8.1	5.9	35.0		
15			8.2		35.0	0.03	
16			8.2		35.0		
17			8.2		35.0		
18			8.2		34.8		
19			8.2		35.0		
20			8.2		34.5		
21	6.2		8.2	6.0	34.8	0.04	
22			8.2		35.0		
23			8.2		34.8		
24			8.2		34.8		
25			8.2		35.0		
26			8.2		32.5		
27			8.2		34.5		
28	5.8		8.2	5.6	35.0		
29			8.2		35.0	0.03	
30			8.2		34.8		
31							

NOTES:
[1]Dissolved Oxygen in ppm.
[2]Salinity in ppt.
[3]Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE C-1 (CONT.)

Month December 1978

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]	SALINITY[2]	T.R.C.[3]	
1			8.2		34.0		
2			8.2		34.5		
3			8.2		34.5		
4			8.2		34.3		
5			8.2		34.5		
6	6.0		8.2	6.4	35.5	0.01	
7			8.2		35.0		
8			8.2		35.2		
9			8.2		35.0		
10			8.2		35.0		
11			8.1		34.5		
12	6.0		8.2	5.7	35.5	0.02	
13			8.1		34.2		
14			8.1		34.2		
15			8.2		35.0	0.02	
16			8.2		34.8		
17			8.2		35.0		
18			8.2		34.2		
19	6.8		8.2	6.8	34.7		
20			8.2		34.0		
21			8.2		34.0		
22			8.2		33.8		
23			8.2		34.0	0.03	
24			8.2		33.9		
25			8.2		34.5		
26			8.2		34.0		
27	6.5		8.2	6.4	34.8	0.02	
28			8.2		34.0		
29			8.1		34.5		
30			8.2		34.4		
31			8.1		34.0		

NOTES:
[1]Dissolved Oxygen in ppm.
[2]Salinity in ppt.
[3]Total Residual Chlorine in ppm.

Florida Power & Light Company

ST. LUCIE PLANT

ANNUAL NON-RADIOLOGICAL MONITORING REPORT

1979

Volume 1

ABIOTIC MONITORING

EXHIBIT J

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE C-1

Month JANUARY 1979

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]	SALINITY[2]	T.R.C.[3]	
1			8.2		35.5		
2			8.2		34.2		
3	6.5		8.2	6.2	34.4	.01	
4			8.1		34.5		
5			8.1		34.5		
6			8.1		34.2		
7			8.1		34.1		
8			8.1		35.0		
9	6.6		8.1	6.3	35.2	.02	
10			8.1		33.8		
11			8.1		34.0		
12			8.1		33.9		
13			8.1		34.0		
14			8.2		34.0		
15			8.2		34.0		
16	6.9		8.2	6.7	33.7	.01	
17			8.2		33.8		
18			8.2		33.8		
19			8.2		33.7		
20			8.2		34.0		
21			8.2		34.0		
22			8.2		34.0		
23	6.5		8.2	7.5	35.0	0.1	
24			8.2				
25			8.2				
26			8.2				
27			8.2				
28			8.2				
29			8.2				
30	7.0		8.2	7.3			
31			8.2			.00	

NOTE:

[1] Dissolved Oxygen in ppm.

[2] Salinity in ppt. (Deleted from ETS effective January 24, 1979)

[3] Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE C-1 (Cont.)

Month FEBRUARY 1979

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]		T.R.C.[2]	
1			8.2				
2			8.2				
3			8.2				
4			8.2				
5			8.2				
6	6.7		8.2	6.5			
			8.2			<.01	
			8.2				
9			8.2				
10			8.2				
11			8.2				
12			8.2				
13	7.2		8.2	7.28		<.01	
14			8.2				
15			8.2				
16			8.2				
17			8.2				
18			8.2				
19			8.2				
20	7.18		8.2	7.30		<.01	
21			8.2				
22			8.2				
23			8.2				
24			8.2				
25			8.2				
26			8.2				
27	6.55		8.2	6.37		<.01	
28			8.2				
29							
30							
31							

NOTES: [1]Dissolved Oxygen ppm.
[2]Total Residual Ch ne in ppm

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE C-1 (Cont.)

Month MARCH 1979

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]		T.R.C.[2]	
1			8.2				
2			8.2				
3			8.2				
4			8.2				
5			8.2				
6	6.7		8.2	6.6			
7			8.2			<.01	
8			8.1				
9			8.2				
10			8.2				
11			8.2				
12			8.2				Did not chlorinate 3/12 - 3/16
13	6.6		8.2	6.4			
14			8.2				
15			8.2				
16			8.2				
17			8.2				
18			8.2				
19			8.1			<.01	
20			8.1				
21	6.7		8.2	6.6			
22			8.2				
23			8.1			.01	
24			8.2				
25			8.2				
26			8.2			0.015	
27	6.6		8.2	6.4			
28			8.2				
29			8.2			<.01	
30			8.1				
31			8.1				

NOTES:
1 Dissolved Oxygen in ppm.
2 Total Residual Chlorine in ppm

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE C-1 (Cont.)

Month APRIL 1979

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]		T.R.C.[2]	
1			8.2				Refueling -
2			8.7				No chlorination
3	6.4		8.[illegible]	6.4			
4			8.2				
5			8.2				
6			8.2				
7			8.2				
8			8.2				
9			8.2				
10			8.2				
11	9.0		8.3	9.0			
12			8.3				
13			8.3				
14			8.3				
15			8.3				
16			8.3				
17	6.4		8.3	6.4			
18			8.3				
19			8.3				
20			8.3				
21			8.3				
22			8.3				
23			8.3				
24	6.4		8.3	6.5			
25			8.3				
26			8.3				
27			8.3				
28			8.3				
29			8.3				
30			8.2				
31							

NOTES:
[1] Dissolved Oxygen in ppm.
[2] Total Residual Chlorine in ppm

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE C-1 (Cont.)

Month MAY 1979

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]		T.R.C.[2]	
1	6.5		8.2	6.5			Refueling -
2			8.2				No chlorination
3			8.3				
4			8.2				
5			8.2				
6			8.2				
7			8.2				
8	6.5		8.2	6.5			
9			8.2				
10			8.2				
11			8.2				
12			8.2				
13			8.2				
14			8.2				
15	6.6		8.2	6.6			
16			8.2				
17			8.2				
18			8.2				
19			8.2				
20			8.2				
21			8.2				
22			8.2				
23	6.2		8.3	6.2			
24			8.3				
25			8.3				
26			8.3				
27			8.3				
28			8.3				
29	6.4		8.3	6.4			
30			8.4				
31			8.3				

NOTES:
[1]Dissolved Oxygen in ppm.
[2]Total Residual Chlorine in ppm

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE C-1 (Cont.)

Month JUNE 1979

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]		T.R.C.[2]	
1			8.3				
2			8.4				
3			8.2				
4			8.2				
5			8.2				
6	6.4		8.2	6.49			Refueling
7			8.2				No chlorination
8			8.2				
9			8.2				
10			8.2				
11			8.2				
12			8.2			.03	
13	6.0		8.2	5.6			
14			8.2				
15			8.2				
16			8.2				
17	6.2		8.2				
18			8.2				
19			8.2	5.70			
20			8.3				
21			8.2			.03	
22			8.3				
23			8.2				
24			8.3				
25			8.2				
26	6.0		8.2	6.22			
27			8.3			.03	
28			8.2				
29			8.3				
30			8.2				
31			8.3				

NOTES:
[1]Dissolved Oxygen in ppm.
[2]Total Residual Chlorine in ppm

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE C-1 (Cont.)

Month JULY 1979

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]		T.R.C.[2]	
1			8.3				
2			8.2				
3	5.80		8.2	5.60			
4			8.2				
5			8.2			<.01	
6			8.2				
7			8.2				
8			8.2				
9			8.2				
10	6.20		8.2	5.70			
11			8.2			.03	
12			8.2				
13			8.2				
14			8.2				
15			8.2				
16			8.2				
17	5.80		8.2	5.50		.02	
18			8.2				
19			8.2				
20			8.2				
21			8.2				
22			8.2				
23			8.2				
24	7.20		8.1	6.30		.02	
25			8.2				
26			8.1				
27			8.2				
28			8.1				
29			8.1				
30			8.1				
31	7.20		8.2	6.70			

NOTES:
[1]Dissolved Oxygen in ppm.
[2]Total Residual Chlorine in ppm

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE C-1 (Cont.)

Month AUGUST 1979

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]		T.R.C.[2]	
1			8.2				
2			8.2			.01	
3			8.2				
4			8.2				
5			8.2				
6			8.2				
7	5.9		8.2	5.6		.02	
8			8.2				
9			8.2				
10			8.2				
11			8.2				
12			8.2				
13			8.2				
14	6.6		8.2	6.2			
15			8.2			.01	
16			8.2				
17			8.2				
18			8.2				
19			8.2				
20			8.2				
21	5.9		8.1	5.8			
22			8.2			0.02	
23			8.2				
24			8.2				
25			8.2				
26			8.2				
27			8.2				
28	5.8		8.2	5.2		0.01	
29			8.1				
30			8.2				
31			8.2				

NOTES:
[1]Dissolved Oxygen in ppm.
[2]Total Residual Chlorine in ppm

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE C-1 (Cont.)

Month SEPTEMBER 1979

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]		T.R.C.[2]	
1			8.2				
2			8.2				
3							
4			8.2				
5			8.2				
6	5.5		8.1	5.2		.01	
7			8.1				
8			8.1				
9			8.1				
10			8.1				
11	7.2		8.1	6.6			
12			8.1			.02	
13			8.1				
14			8.1				
15			8.1				
16			8.1				
17			8.1				
18	6.9		8.1	6.4		.01	
19			8.1			.01	
20			8.1				
21			8.1				
22			8.1				
23			8.1				
24			8.1				
25	6.8		8.2	6.9			Did not chlorinate
26			8.1				9/22-9/30
27			8.1				
28			8.1				
29			8.1				
30			8.1				
31							

NOTES:
[1]Dissolved Oxygen in ppm.
[2]Total Residual Chlorine in ppm

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE C-1 (Cont.)

Month OCTOBER 1979

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]		T.R.C.[2]	
1			8.1				
2			8.2				
3	5.9		8.2	5.9		.02	
4			8.2				
5			8.2				
6			8.2				
7			8.2				
8			8.2			.02	
9	6.0		8.2	6.0			
10			8.2				
11			8.2				
12			8.1				
13			8.1				
14			8.2				
15			8.1				Did not chlorinate
16	6.0		8.1	6.0			10/15-10/23
17			8.1				
18			8.1				
19			8.1				
20			8.1				
21			8.1				
22			8.1				
23	5.8		8.1	5.8			
24			8.1			.02	
25			8.1				
26			8.1				
27			8.1				
28			8.1				
29			8.1				
30	6.2		8.1	6.1		.03	
31			8.1				

NOTES:
[1] Dissolved Oxygen in ppm.
[2] Total Residual Chlorine in ppm

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE C-1 (Cont.)

Month NOVEMBER 1979

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]		T.R.C.[2]	
1			8.1				
2			8.2				
3			8.2				
4			8.2				
5			8.2				
6	6.6		8.2	6.6			
7			8.2			.02	
8			8.2				
9			8.2				
10			8.2				
11			8.2				
12			8.1				
13	6.2		8.2	6.2			
14			8.1				
15			8.1				
16			8.2			.01	
17			8.1				
18			8.2				
19			8.2				
20	6.4		8.1	6.3		.02	
21			8.1				
22			8.1				
23			8.1				
24			8.1				
25			8.1				
26			8.1				
27	6.7		8.1	6.6			
28			8.2			.02	
29			8.2				
30			8.2				
31							

NOTES: [1]Dissolved Oxygen in ppm.
[2]Total Residual Chlorine in ppm

ST. LUCIE PLANT UNIT NO. 1
CHEMICAL PARAMETERS
TABLE C-1 (Cont.)

Month DECEMBER 1979

DAY	INTAKE		DISCHARGE				REMARKS
	D.O.[1]		pH	D.O.[1]		T.R.C.[2]	
1			8.2				
2			8.2				
3			8.2				
4	5.8		8.2	6.0			
5			8.2			.02	
6			8.2				
7			8.2				
8			8.2				
9			8.2				
10			8.2				
11	5.7		8.2	5.6		.01	
12			8.1				
13			8.1				
14			8.1				
15			8.1				
16			8.1				
17			8.1				
18	6.1		8.1	5.9		.01	
19			8.1				
20			8.1				
21			8.1				
22			8.1				
23			8.1				
24			8.1				
25			8.1				
26	6.1		8.1	6.0		.02	
27			8.2				
28			8.2				
29			8.2				
30			8.2				
31			8.2				

NOTES:
[1]Dissolved Oxygen in ppm.
[2]Total Residual Chlorine in ppm

FLORIDA POWER & LIGHT COMPANY

ST. LUCIE PLANT

ANNUAL NON-RADIOLOGICAL

ENVIRONMENTAL MONITORING REPORT

1980

VOLUME 1

ABIOTIC MONITORING

EXHIBIT K

ST. LUCIE PLANT UNIT NO. 1
CIRCULATING WATER CHEMICAL PARAMETERS
TABLE C-1

Month & Year January 1980

DAY	INTAKE	DISCHARGE			REMARKS
	D.O.[1]	pH	D.O.[1]	T.R.C.[2]	
1		8.2			
2	6.7	8.1	5.7	0.01	
3		8.1			
4		8.1			
5		8.1			
6		8.1			
7		8.1			
8	6.8	8.2	7.3		
9		8.2		0.01	
10		8.2			
11		8.1			
12		8.1			
13		8.1			
14		8.1			
15	6.7	8.1	6.6		
16		8.2			
17		8.2			
18		8.2		0.01	
19		8.2			
20		8.2			
21		8.2			
22	6.8	8.2	6.4	0.02	
23		8.2			
24		8.2			
25		8.[illegible]			
26		8 2			
27		.2			
28		2			
29	6.6	[illegible]	6.3		
30		8.2			
31		8.2		0.02	

NOTES: [1]Dissolved Oxygen in ppm.

[2]Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CIRCULATING WATER CHEMICAL PARAMETERS
TABLE C-1
Month & Year February 1980

DAY	INTAKE	DISCHARGE			REMARKS
	D.O.[1]	pH	D.O.[1]	T.R.C.[2]	
1		8.2			
2		8.2			
3		8.2			
4		8.2			
5	7.5	8.1	7.1		
6		8.2			
7		8.2		0.01	
8		8.2			
9		8.2			
10		8.2			
11		8.2			
12	7.1	8.1	7.2	0.01	
13		8.1			
14		8.1			
15		8.1			
16		8.1			
17		8.1			
18		8.1			
19	7.2	8.1	7.2	0.01	
20		8.1			
21		8.1			
22		8.1			
23		8.1			
24		8.1			
25		8.1			
26	6.0	8.1	6.0	0.01	
27		8.1			
28		8.1			
29		8.1			
30					
31					

NOTES: [1] Dissolved Oxygen in ppm.

[2] Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CIRCULATING WATER CHEMICAL PARAMETERS
TABLE C-1
Month & Year March 1980

DAY	INTAKE	DISCHARGE			REMARKS
	D.O.[1]	pH	D.O.[1]	T.R.C.[2]	
1		8.1			
2		8.1			
3		8.1			
4	6.9	8.1	7.1	0.01	
5		8.1			
6		8.1			
7		8.1			
8		8.1			
9		8.1			
10		8.1			
11	6.2	8.1	5.6	0.01	
12		8.2			
13		8.2			
14		8.2			
15		8.1			
16		8.1			
17		8.1			PLANT SHUTDOWN-REFUELING
18	5.6	8.1	5.8		NO CHLORINATION
19		8.1			"
20		8.1			"
21		8.1			"
22		8.1			"
23		8.1			"
24		8.1			"
25	7.9	8.2	7.5		"
26		8.2			"
27		8.2			"
28		8.2			"
29		8.2			"
30		8.2			"
31		8.2			"

NOTES: [1]Dissolved Oxygen in ppm.
[2]Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CIRCULATING WATER CHEMICAL PARAMETERS
TABLE C-1

Month & Year April 1980

DAY	INTAKE	DISCHARGE			REMARKS
	D.O.[1]	pH	D.O.[1]	T.R.C.[2]	
1		8.2			PLANT SHUTDOWN-REFUELING
2	6.5	8.2	4.6		NO CHLORINATION
3		8.2			"
4		8.2			"
5		8.2			"
6		8.2			"
7		8.2			"
8	6.4	8.2	6.3		"
9		8.2			"
10		8.2			"
11		8.2			"
12		8.2			"
13		8.2			"
14		8.2			"
15	6.3	8.2	6.5		"
16		8.2			"
17		8.2			"
18		8.2			"
19		8.2			"
20		8.2			"
21		8.2			"
22	6.6	8.2	6.7		"
23		8.2			"
24		8.2			"
25		8.2			"
26		8.2			"
27		8.2			"
28		8.2			"
29	7.1	8.2	6.2		"
30		8.2			"
31					

NOTES:
[1]Dissolved Oxygen in ppm.
[2]Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CIRCULATING WATER CHEMICAL PARAMETERS
TABLE C-1
Month & Year May 1980

DAY	INTAKE	DISCHARGE			REMARKS
	D.O.[1]	pH	D.O.[1]	T.R.C.[2]	
1		8.2			PLANT SHUTDOWN-REFUELING
2		8.2			NO CHLORINATION
3		8.2			"
4		8.2			"
5		8.2			"
6	7.7	8.2	6.6		"
7		8.2			
8		8.2			
9		8.2			
10		8.2			
11		8.2			
12		8.2			
13	5.8	8.2	6.6		
14		8.2			
15		8.2			
16		8.2			
17		8.2			
18		8.2			
19		8.2			
20	5.7	8.2	5.3		
21		8.2		0.01	
22		8.2			
23		8.2			
24		8.1			
25		8.2			
26		8.2			
27	5.7	8.2	5.7		
28		8.1		0.01	
29		8.2			
30		8.2			
31		8.2			

NOTES:
[1] Dissolved Oxygen in ppm.
[2] Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CIRCULATING WATER CHEMICAL PARAMETERS
TABLE C-1

Month & Year June 1980

DAY	INTAKE	DISCHARGE			REMARKS
	D.O.[1]	pH	D.O.[1]	T.R.C.[2]	
1		8.2			
2		8.2			
3	5.4	8.2	5.4		
4		8.2		0.01	
5		8.2			
6		8.2			
7		8.2			
8		8.2			
9		8.2			
10	6.2	8.2	6.3		
11		8.2			
12		8.2			PLANT S/D: NO CHLORINATION
13		8.2			"
14		8.2			"
15		8.2			"
16		8.2			"
17	5.8	8.2	6.1		"
18		8.2			"
19		8.2			"
20		8.2			"
21		8.2			"
22		8.2			
23		8.2			"
24	6.0	8.2	6.0		"
25		8.3			"
26		8.3			"
27		8.3			"
28		8.3			"
29		8.3			"
30		8.2			"
31					

NOTES:
[1] Dissolved Oxygen in ppm.
[2] Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CIRCULATING WATER CHEMICAL PARAMETERS
TABLE C-1

Month & Year July 1980

DAY	INTAKE	DISCHARGE			REMARKS
	D.O.[1]	pH	D.O.[1]	T.R.C.[2]	
1	5.2	8.3	5.4		
2		8.2			
3		8.2		0.01	
4		8.3			
5		8.3			
6		8.2			
7		8.2		0.01	
8	6.0	8.3	6.2		
9		8.2			
10		8.2			
11		8.2			
12		8.2			
13		8.2			
14		8.2			
15	5.6	8.2	5.8	0.01	
16		8.2			
17		8.2			
18		8.2			
19		8.2			
20		8.3		0.01	
21		8.3			
22	6.0	8.2	6.4		
23		8.2			
24		8.2			
25		8.2			
26		8.2			
27		8.2		0.01	
28	6.4	8.2	6.6		
29		8.2			
30		8.2			
31		8.2			

NOTES:
[1]Dissolved Oxygen in ppm.
[2]Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CIRCULATING WATER CHEMICAL PARAMETERS
TABLE C-1
Month & Year August 1980

DAY	INTAKE	DISCHARGE			REMARKS
	D.O.[1]	pH	D.O.[1]	T.R.C.[2]	
1		8.3			
2		8.3			
3		8.3		0.01	
4	6.4	8.2	6.3		
5		8.3			
6		8.2			
7		8.2			
8		8.2			
9		8.2			
10		8.2			
11	6.7	8.2	6.8		
12		8.2		0.01	
13		8.2			
14		8.2			
15		8.2			
16		8.2			
17		8.2			
18		8.2			
19	8.0	8.2	8.5	0.01	
20		8.2			
21		8.3			
22		8.3			
23		8.3			
24		8.2			
25		8.2			
26	6.5	8.2	6.1	0.01	
27		8.2			
28		8.2			
29		8.2			
30		8.2			
31		8.2			

NOTES:
[1]Dissolved Oxygen in ppm.
[2]Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CIRCULATING WATER CHEMICAL PARAMETERS
TABLE C-1

Month & Year September 1980

DAY	INTAKE	DISCHARGE			REMARKS
	D.O.[1]	pH	D.O.[1]	T.R.C.[2]	
1		8.3			
2	6.2	8.3	6.4		
3		8.2		0.01	
4		8.2			
5		8.2			
6		8.2			
7		8.2			
8		8.2		0.01	
9	6.7	8.2	6.8		
10		8.2			
11		8.2			
12		8.2			
13		8.2			
14		8.2			
15		8.3		0.01	
16	4.7	8.3	5.2		
17		8.3			
18		8.3			
19		8.2			
20		8.2			
21		8.2			
22		8.2		0.01	
23	5.3	8.2	5.6		
24		8.2			
25		8.2			
26		8.2			
27		8.2			
28		8.2			
29		8.3		0.01	
30	5.4	8.2	5.4		
31					

NOTES:
[1]Dissolved Oxygen in ppm.
[2]Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CIRCULATING WATER CHEMICAL PARAMETERS
TABLE C-1

Month & Year October 1980

DAY	INTAKE	DISCHARGE			REMARKS
	D.O.[1]	pH	D.O.[1]	T.R.C.[2]	
1		8.2			
2		8.2			
3		8.2			
4		8.2			
5		8.2			
6		8.2			
7	6.2	8.2	5.5	0.01	
8		8.2			
9		8.2			
10		8.2			
11		8.2			
12		8.2			
13		8.2		0.01	
14	5.8	8.2	5.6		
15		8.2			
16		8.2			
17		8.2			
18		8.2			
19		8.2			
20		8.2		0.01	
21	5.9	8.3	5.7		
22		8.4			
23		8.3			
24		8.3			
25		8.2			
26		8.2			
27		8.3		0.01	
28	5.7	8.3	5.6		
29		8.3			
30		8.3			
31		8.3			

NOTES:
[1] Dissolved Oxygen in ppm.
[2] Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CIRCULATING WATER CHEMICAL PARAMETERS
TABLE C-1

Month & Year November 1980

DAY	INTAKE	DISCHARGE			REMARKS
	D.O.[1]	pH	D.O.[1]	T.R.C.[2]	
1		8.3			
2		8.3			
3		8.3		0.01	
4		8.3			
5	6.3	8.3	6.2		
6		8.3			
7		8.3			
8		8.3			
9		8.3			
10		8.3		0.01	
11		8.3			
12	6.1	8.3	6.4		
13		8.3			
14		8.3			
15		8.2			
16		8.2			
17		8.3			
18	6.1	8.3	6.1		
19		8.3		0.01	
20		8.3			
21		8.3			
22		8.3			
23		8.3			
24		8.2		0.01	
25	6.4	8.3	6.2		
26		8.3			
27		8.3			
28		8.3			
29		8.2			
30		8.2			
31					

NOTES: [1] Dissolved Oxygen in ppm.

[2] Total Residual Chlorine in ppm.

ST. LUCIE PLANT UNIT NO. 1
CIRCULATING WATER CHEMICAL PARAMETERS
TABLE C-1

Month & Year December 1980

DAY	INTAKE	DISCHARGE			REMARKS
	D.O.[1]	pH	D.O.[1]	T.R.C.[2]	
1		8.2			
2	6.2	8.2	6.2	<0.01	
3		8.2			
4		8.2			
5		8.2			
6		8.3			
7		8.2			
8		8.2		<0.01	
9	6.3	8.3	6.4		
10		8.3			
11		8.3			
12		8.2			
13		8.2			
14		8.2			
15	6.6	8.3	6.3	<0.01	
16		8.3			
17		8.3			
18		8.3			
19		8.3			
20		8.3			
21		8.3			
22		8.2		<0.01	
23	5.6	8.2	7.3		
24		8.2			
25		8.2			
26		8.1			
27		8.2			
28		8.2			
29		8.2		<0.01	
30	6.8	8.2	7.0		
31		8.2			

NOTES:
[1] Dissolved Oxygen in ppm.
[2] Total Residual Chlorine in ppm.

TERA
50-335
180

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

4/11/80

Docket No. 50-335

MEMORANDUM FOR: Robert Reid, Chief
Operating Reactors Branch 4, DOR

FROM: George Lear, Chief
Environmental Specialists Branch, DSE

SUBJECT: PROPOSED CHANGES TO ENVIRONMENTAL TECHNICAL SPECIFICATIONS (ETS) FOR ST. LUCIE (TAC 11614)

PLANT NAME: St. Lucie
RESPONSIBLE BRANCHES: ORB-4, ESB
PROJECT MANAGER: P. Erickson
REVIEW STATUS: Complete

On April 12, 1979, Florida Power and Light Company (FP&L) submitted a request to delete certain water quality requirements from the Appendix B Environmental Technical Specifications for St. Lucie Unit 1. The licensee's only justification for deleting those requirements is that they are contained in the NPDES permit.

On September 7, 1979, Region IV of the U.S. Environmental Protection Agency issued for comment changes to the St. Lucie NPDES permit proposed by FP&L and requested NRC review. These proposed permit changes involve the same parameters proposed to be deleted from the ETS. The proposed permit changes would result in less restrictive requirements. The licensee provided EPA with an extensive environmental assessment of making the proposed changes.

In responding to EPA's request, we have reviewed the assessment which FP&L sent to EPA. At the same time we reviewed the portions of the NPDES permit which contain restrictions similar to those in the ETS. We found that we had no objections to the proposed changes to the permit. We found that we could rely on the NPDES permit for limiting those parameters which the licensee requested to be deleted from the ETS. On December 4, 1979, we sent a letter to the Chief, Water Enforcement Branch of Region IV-EPA, informing him that we did not object to the permit modifications and that we intend to rely on the NPDES permit conditions for limiting those parameters to be deleted from our ETS. On February 18, 1980 the permit was modified in accordance with the utility's request.

EXHIBIT L

8004150 151

On March 4, 1980, we telephoned EPA-Region IV and they indicated that they had no objections to our relying on the NPDES permit. We, therefore, are deleting the water quality parameters as requested by the licensee. As we will be relying on the NPDES permit, we have added to Section 6, Special Conditions, a requirement for reporting of violations and changes to the permit. We have also added a requirement for the reporting of unusual events.

The licensee's amendment request did not address water quality monitoring programs. We note that the ETS aquatic monitoring requirements are referred to in the NPDES permit as the EPA required program. We plan to discuss aquatic monitoring with EPA and the licensee to coordinate the transfer of these monitoring requirements to the NPDES permit. When the requirement to rely on the ETS monitoring program is removed, we will then completely revise the ETS to rely on the NPDES permit for specifying aquatic monitoring.

Enclosure 1 contains an Environmental Impact Appraisal for the license amendment. Enclosure 2 contains the new pages of the ETS with marginal bars indicating the changes effected by this action.

George Lear, Chief
Environmental Specialists Branch
Division of Site Safety and
Environmental Analysis

Enclosures:
1. EIA
2. New pages of ETS

cc: M. Ernst
W. Gammill
P. Erickson
R. Samworth
T. Cain
B. Grimes
D. Crutchfield
S. Treby

[illegible] E 1

ENVIRONMENTAL IMPACT APPRAISAL

BY THE OFFICE OF NUCLEAR REACTOR REGULATION

SUPPORTING AMENDMENT NO.   TO FACILITY LICENSE NO. DPR-67

FLORIDA POWER AND LIGHT COMPANY

ST. LUCIE NUCLEAR POWER PLANT

DOCKET NO. 50-335

Description of Proposed Action

By letter dated April 12, 1979, supplemented by letter dated September 10, 1979, Florida Power and Light Company (the licensee) requested an amendment to the Appendix B Environmental Technical Specifications (ETS) for St. Lucie Nuclear Power Plant, Unit 1. The licensee proposes to delete certain water quality requirements from the ETS. The licensee's justification for deleting these requirements is that they are contained in the NPDES permit issued by the U.S. Environmental Protection Agency under the Clean Water Act and are not within the jurisdiction of the NRC.

On September 12, 1979, Region IV of the U.S. Environmental Protection Agency requested NRC review of changes to the St. Lucie NPDES permit proposed by FP&L. These proposed permit changes are for the same parameters proposed to be deleted from the ETS. The licensee provided EPA with an extensive environmental assessment of making the proposed changes.

In responding to EPA's request, the staff reviewed the assessment which FP&L sent to EPA. At the same time, we reviewed the portions of the NPDES permit which contain restrictions similar to those in the ETS. We found that we had no

objections to the proposed changes to the permit. We found that we could rely on the NPDES permit for limiting those parameters which the licensee requested to be deleted from the ETS. On December 4, 1979, we sent a letter to the Chief, Water Enforcement Branch of Region IV-EPA, informing him that we did not object to the permit modifications and that we could rely on the NPDES permit conditions for limiting those parameters to be deleted from our ETS. On March 4, 1980, EPA-Region IV informed us that our proposal to rely on the NPDES permit for regulation of the water quality parameters to be deleted from the ETS was acceptable.

Specifically, the licensee proposes to delete limiting conditions for operation in Sections 2.1.1 Maximum Discharge Temperature, 2.1.2 Maximum Condenser Temperature Rise, 2.2.1 Biocides, and 2.2.2 pH; Surveillance programs in Sections 3.1.A.1 Biocides, 3.1.A.2 Heavy Metals, 3.1.A.3 pH, 3.1.A.4 Dissolved Oxygen and 3.1.A.5 Temperature Usage. In addition, definitions in Section 1.0 associated with the sections to be removed would be deleted.

This appraisal reviews the results of, and provides a basis for, deleting the specifications described above and for relying on the NPDES permit for protection of the aquatic environment in the vicinity of the St. Lucie site.

Environmental Impacts of Proposed Action

[illegible]

Specification 2.1.1 requires that the maximum discharge temperature shall not exceed [illegible]°F in the discharge canal. The surface temperature within the zone of mixing is not to exceed a rise of 5.5°F nor a maximum temperature of 93°F

113°

97°F

as an instantaneous maximum at any point. In addition, thermal defouling of the intake is allowed subject to a maximum release temperature of 120°F, and conditions for circulating water system outage, which would result in higher discharge temperatures, are limited to 115°F.

Specification 2.1.2 limits the temperature rise across the condenser under full power operation to 26°F. When maintenance or outage of the circulating water system occurs, the temperature rise is limited to 35°F for no greater than a 72-hour period.

The FES for operation of Unit No. 1 (June 1973) summarized the projected impact related to the thermal discharge as follows (p. i):

> Planktonic organisms will be eventually killed by thermal shock as they pass through the condenser. However, there appears to be very little marine life in the vicinity of the intake, so the impact on the ecosystem is expected to be minor.
>
> The maximum ocean surface temperature rise at the Atlantic Ocean discharge will be about 6°F. The 3°F isotherm should cover about 35 acres and the 1°F isotherm about 2050 acres. These temperatures may have some unknown effects on the mating habits of turtles in the plume zone and on the activity of turtle hatchlings as they leave their beach nests. Effects on other marine life are expected to be minimal.

The thermal limitations in the permit, as modified on February 18, 1980, are: a maximum discharge temperature for normal operation of 113°F and 117°C during maintenance of the circulating water system (CWS); a maximum condenser temperature rise of 30°F except during maintenance of the CWS when the temperature can be 32°F; and, ambient ocean surface-temperature not to exceed an instantaneous maximum of 97°F.

The licensee's consultant provided an assessment to EPA of the impacts which might occur at the higher discharge limits allowed by the NPDES permit. This [illegible] comprehensive report considered the "worst case" situation of discharging the heated water during the month of September, which is the hottest month for ambient water temperatures and coincides with the highest animal densities in the site vicinity. The impact of the thermal discharge was evaluated with the receiving water under static and dynamic conditions. Thermal effects were evaluated on phytoplankton, zooplankton, ichthyoplankton, benthic invertebrates, fish and turtles.

Reduction in phytoplankton due to increased temperatures are estimated to be less than 2.5% of the total phytoplankton in the region of potential impact. Rapid turnover rates in the community would easily compensate for this reduction.

Zooplankton mortality will increase at the higher discharge temperatures but will largely be offset by a decreased mortality from lower volumes of water pumped through the plant. A maximum effect of a decrease of less than 1% in number of zooplankters was predicted.

Mortality of ichthyoplankton entrained through the plant would decrease at reduced pumping rates while higher discharge temperatures would increase the impact on organisms entrained into the plume. It was projected that impacts of higher temperatures would be offset by reduced impacts at lower flows.

Benthic invertebrates would not be directly influenced by the discharge water as it is directed towards the surface and does not impinge on the bottom near the discharge.

The adult fishes will be primarily affected by the thermal plume by being excluded from an offshore area where they would encounter increased temperatures. Within the thermal plume, total exclusion of adult fishes due to thermal avoidance will probably occur from the point of discharge to the [illegible]°F isotherm, and no exclusion from temperatures less than [illegible]°F. The total volume of water which may li[illegible] adult fishes offshore of the plant was calculated by the licensee to be about 65 acre-ft. This volume of heated water is less than 1% of that available as habitat for fishes in the site vicinity.

Marine turtles use the offshore for breeding and the beach for nesting. The adult turtles are mobile and can easily avoid the heated plume. According to the licensee, turtle hatchlings have demonstrated reduced swimming speeds at water temperatures over 86°F. If turtle hatchlings encounter heated areas, they would resume normal swimming after sinking below the heated areas. No adverse effects are anticipated.

In summary, the staff concludes that the impacts from deleting the current ETS thermal limits and relying on the thermal requirements of the NPDES permit are acceptable for the following reasons: (1) The St. Lucie FES conservatively assumed that all entrained organisms would be killed. (2) The thermal impact

of the entrainment of phytoplankton, zooplankton, and ichthyoplankton was not predicted to be significant. (3) In general, low concentrations of ichthyoplankton were recorded in the intake canal thereby confirming the FES prediction that small numbers would be entrained. (4) As discussed above, the increase in ΔT will permit less water to be drawn into the plant, and thereby fewer organisms would be exposed to the higher ΔT.

Biocides

Specification 2.2.1 limits the concentration of total residual chlorine at the end of the discharge canal to 0.1 mg/l. Chlorine is also not to be used for more than 2 hours per day. The NPDES permit requirements on the discharge of chlorine are identical to those in ETS 2.2.1. The staff concludes that no environmental impact will result from reliance on the NPDES permit values as the chlorine discharges allowed by the permit are the same as those allowed by the ETS.

pH

Specification 2.2.2 limits the pH of the cooling water in the discharge canal not to be less than 6.0 nor greater than 9.0 standard units. The NPDES permit restricts the pH of the neutralization basin discharge to the intake canal to not less than 6.0 standard units. No upper limit is provided. Monitoring in the discharge canal since 1976 has shown that the pH of the circulating water ranges from a low of 8.00 to a high of 8.4[2,3]. These data show that the pH is quite stable which is to be expected for a sea water system which is naturally well buffered. Normal sea water has a pH of approximately 8.0, but can range from 7.5 to 8.4. At a pH of 8.0, the vast amount of the CO_2 present in sea water occurs in bound forms, with most of it occurring as

bicarbonate ion. Sea water containing weak acids, such as carbonic acid and to a lesser extent boric acid, has a strong buffering action compared with pure water. Thus the addition of acid to the system:

$$CO_2 + H_2O \rightleftarrows H_2CO_3 \rightleftarrows H^+ + HCO_3^- \rightleftarrows H^+ + CO_3^{=}$$

shifts the equilibrium to the left and the resulting carbonic acid ionizes to a small extent so the pH remains relatively stable.

The staff concludes that Specification 2.2.2 limiting the pH of the cooling water in the discharge canal can be deleted, as acids or bases released into the CWS would be diluted many times by the flow of the CWS, and because the buffering action of the sea water will help to neutralize releases of acid or bases. The combination of dilution and the buffering action of sea water will assure that releases of acids or bases will not affect the biotic community in the site vicinity.

Environmental Surveillance

Specification 3.1.A.1 requires monitoring of total residual chlorine in the discharge canal on a weekly schedule. Section 2.2.2 required monitoring of TRC at the plant discharge, however, Specification 3.1.A.1 requires monitoring in the discharge canal to determine the decay of chlorine in the canal. The licensee has measured residual chlorine in the canal since March 1976[2,3]. Levels measured have ranged from 0.01 to 0.08 mg/l. All measurements have been below the 0.1 limit of Specification 3.1.A.1.

The NPDES permit requires monitoring of total residual chlorine in the discharge canal prior to discharge to the Atlantic Ocean. Compliance with the NPDES permit level of 0.1 mg/l and monitoring will assure that impacts to organisms from the discharge of chlorine are within those discussed in the St. Lucie FES.

Specification 3.1.A.2 requires monthly monitoring of the heavy metals, Mercury, Arsenic, Chromium, Copper, Iron, Lead, Nickel and Zinc, in the intake and discharge canals to detect any measurable increase in these metals. Sampling conducted by the licensee during 1977 and 1978 has shown levels at or below the level of detectability with no measurable increases due to plant operation[2,3]. The NPDES permit does not require routine monitoring for heavy metals. However, based on the results of the licensee's monitoring, the staff concludes that heavy metal monitoring is no longer necessary and can be deleted from the ETS.

Specification 3.1.A.3 requires monitoring for pH. This specification is redundant to that in Limiting Condition for Operation 2.2.2, pH, and is deleted on the basis of that provided for Section 2.2.2.

Specification 3.1.A.4 requires surveillance of the dissolved oxygen (DO) in the intake and discharge canals to determine whether the cooling water being returned to the ocean has been depleted of oxygen. Dissolved oxygen has been monitored since early 1976[2,3] and found to be normally within the range of 5.00 and 9.00 ppm. DO levels in the two canals have been found to be very similar throughout the year. The NPDES permit does not require DO monitoring. The staff finds, however, that the DO surveillance program can be deleted as plant operation has not significantly affected the concentrations in the intake canal.

Specification 3.1.A.6 requires temperature monitoring in the intake and discharge canals and in the offshore thermal plume by continuous self-contained thermographs. In addition, the licensee was to conduct a study using aerial infrared photography to demonstrate compliance with the temperature rise limitations outside the zone of mixing.

The licensee conducted the aerial infrared photography study in 1977. Four infrared flights were performed approximately three months apart to reflect seasonal conditions. Each quarter's flight was scheduled to occur during low and high tide conditions. The results of three of the quarters showed compliance with the ETS limit of 4°F temperature rise outside the 400 acre mixing zone. The flight during the summer months showed that the ETS limit of 1.5°F temperature rise outside the 400-acre mixing zone was complied with during the months June through September. The licensee's study satisfied the requirements of the overflight study and demonstrated that compliance with the limitations on temperature rise outside the mixing zone could be met. The staff concludes that this section of Specification 3.1.A.6 is complete and can be deleted.

The NPDES permit requires monitoring at the intake and discharge canals for compliance with the permit temperature limitations, but does not require continuous monitoring of the ocean surface temperature. The permit, however, contains a limit of 36.1°C for the instantaneous surface maximum at any point in the thermal plume. The permit does not indicate how compliance of the surface limitation can be met. The staff finds that the ETS requirements can

be deleted and the NPDES permit relied on for monitoring of the discharge temperature. However, for monitoring of the surface thermal plume, the staff considers that the aerial overflights have demonstrated compliance with the requirements of Specification 2.1.1, and may be deleted on that basis.

Minimum Effective Chlorine Usage

Specification 4.3 requires that the licensee study ways to minimize the amount of chlorine needed to maintain condenser cleanliness while avoiding unnecessary discharge of chlorine to the environment. Starting in 1977, the licensee began testing different injection rates of chlorine and generally has found that lower injection rates result in fouling in circulating water system parts other than the condenser. The fouling of components of the circulating water system have been found to be unacceptable and rates had to be returned to normal. Studies conducted during 1978 are incomplete in that results from other chlorine injection rates must wait until plant shutdown allows for inspection of the circulating water system. These results should be available in the annual report for 1979.

In the licensee's supplemental submittal of September 10, 1979, it was stated that Specification 4.3 could be deleted because the NPDES permit "...contains provisions dealing with this subject..." The NPDES permit states on page 2 of Part I that in the event that the station cannot be operated at or below the 0.1 mg/l, the licensee can submit a demonstration that discharge of higher levels of chlorine are consistent with requirements of the Florida Water Quality Standards. Evidently the NPDES permit does not require a chlorine

minimization study, but rather provides for studies for the use of higher chlorine concentrations. The staff finds that because the chlorine discharge concentration in the permit is the same as that in the ETS and that initial attempts by the licensee have not shown effective defouling of the CWS at lower injection rates, the chlorine minimization program can be deleted from the ETS. However, the staff has added to the ETS a requirement that when changes are proposed to be made to the NPDES permit, the NRC be notified and the supporting justification for the proposed limitations required by EPA be submitted to us. In this way, the staff can update the chlorine environmental impact analyses made in the St. Lucie FES.

Conclusion and Basis for Negative Declaration

On the basis of the foregoing analysis, it is concluded that there will be no environmental impact attributable to the proposed action other than has already been predicted and described in the Commission's FES or described in this analysis for St. Lucie Nuclear Power Station, Unit 1. Having made this conclusion, the Commission has further concluded that no environmental impact statement for the proposed action need be prepared and that a negative declaration to this effect is appropriate.

References

1. Effects of Increased Water Temperature on the Marine Biota of the St. Lucie Plant Area. Applied Biology, Inc. 106 pp. February 1979.

2. Annual Environmental Report No. 2 For The Year 1977. Florida Power and Light Company. St. Lucie Plant Unit No. 1.

3. Annual Non-Radiological Monitoring Report 1978. Volume 1 Abiotic Monitoring. Florida Power and Light Company.

SECTION 2

2.0 Limiting Conditions

2.1 Thermal

2.2 Chemical

None required.*

---

* In consideration of the provisions of the Clean Water Act (33 USC 1251, et seq.) and in the interest of avoiding duplication of effort, the conditions and monitoring requirements related to water quality and aquatic biota are specified in the National Pollution Discharge Elimination System (NPDES) Permit No. FL-0002208 issued by the U.S. Environmental Protection Agency for the St. Lucie Plant No. 1 to discharge into the Atlantic Ocean. The Nuclear Regulatory Commission will be relying on the NPDES permit limitations for the protection of the aquatic environment due to non-radiological effluents.

4.2 Exceptional Occurrences

4.1.1 Unusual or Important Environmental Events

Requirements

The licensee shall record any occurrence of unusual or important events that potentially could result in environmental impact causally related to station operation. The following are examples: excessive bird impaction events; onsite plant or animal disease outbreaks; unusual occurrence or mortality of any species protected by the Endangered Species Act of 1973; fish kills in the site vicinity; and unanticipated or emergency discharges of waste water or chemical substances.

Action

Should an unusual or important event occur, the licensee shall make a prompt report to the NRC in accordance with the provisions of Subsection 5.6.2.a

4.3 Exceeding Limit Permits

Requirements

The licensee shall notify the NRC of occurrences in which the limits specified in relevant permits and certificates issued by other Federal, State and local agencies are exceeded and which are reportable to the agency which issued the permit.

The licensee shall make a report to the NRC in accordance with the provisions of Subsection 5.4.2.a.2 in the event that a limit specified in a relevant permit or certificate issued by another Federal, State or local agency is exceeded (for example, the NPDES Permit and the 401 Certification are relevant).

4.4 Reporting of Changes in Permits and Certificates

Requirements

The licensee shall notify the NRC of changes and additions to required Federal, State, regional and local authority permits and certificates for the protection of the environment that pertain to the requirements of these ETS.

Action

The licensee shall make a report to the NRC within 30 days in the event that a change is made, or the licensee initiates, or becomes aware of request for changes to any of the water quality requirements, limits or values stipulated in a relevant permit or certificate issued by other Federal, State and local agencies.

If a permit or certification, in part or in its entirety, is appealed and stayed, NRC shall be notified as described above.

TABLE 1

ST. LUCIE UNIT 2
SUBSURFACE JET CHARACTERISTICS

Discharge Flow (cfs)	Discharge Temp. Rise (°F.)	Average Distance From Point of Discharge to Reach 17°F. Above Ambient (ft)*		
		Stagnant	Southward Current	Northward Current
1317	30	6.1	5.2	5.2
1007	30	6.1	5.2	5.2
1150	30	6.1	5.2	5.1
880	30	6.1	5.2	5.1

*Ambient ocean temperature = 87°F. Distance computed normal to centerline of discharge diffuser.

TABLE 2

FLORIDA POWER & LIGHT COMPANY
ST. LUCIE PLANT

OCEAN DISCHARGE PIPELINE FLOW DISTRIBUTION

Discharge Flow (cfs)	Discharge Temp Rise (°F)	Heat Discharge Rate (Btu/hr x 10^9)	Unit 1* Discharge Flow (cfs)	Velocity (fps)	Friction Factor	Unit 2** Discharge Flow (cfs)	Velocity (fps)	Friction Factor	Head++ (ft)	Flow ## Variation (percent)
2137	30	14	1000	11.31	0.015	1137	14.03	0.015	4.8	13.8 to 2.0
2137	30	14	894	10.11	0.030	1243	15.34	0.015	5.8	22.9 to 7.2
2137+	30	14	820	9.28	0.045	1317	16.26	0.015	6.6	29.3 to 13.5
2137	30	14	1077	12.18	0.015	1060	13.1	0.030	5.7	7.3 to 8.6
2137+	30	14	1130	12.78	0.015	1007	12.43	0.045	6.2	2.6 to 13.2
1870#	30	12.25	875	9.9	0.015	995	12.28	0.015	3.7	24.6 to 14.2
1870#	30	12.25	780	8.82	0.030	1090	13.45	0.015	4.5	32.8 to 6.0
1870#+	30	12.25	720	8.15	0.045	1150	14.2	0.015	5.0	38 to 0.9
1870#	30	12.25	940	10.63	0.015	930	11.48	0.030	4.3	19 to 19.8
1870#+	30	12.25	990	11.2	0.015	880	10.86	0.045	4.8	14.7 to 24.1

* 12' Diameter
**16' Diameter
\# Refers to 7-pump operation (one waterbox out of service).
\#\#With respect to a base flow of 1160 cfs per unit.
\+ Test cases for plume evaluation
\+\+Elevation difference between ocean and discharge canal.