environmental status report

As a matter of responsible citizenship and good business, Florida Power Corporation, as a prime corporate policy and goal, is taking every meaningful step to protect the environment from any adverse effects that might result from the production, transmission and distribution of electricity. Sound planning of each new facility coupled with complete operational surveillance programs and timely evaluations of each potential pollution source will provide the necessary information for attaining our stated goal.

Ongoing research programs, education of Company personnel and working knowledge of existing techniques and control equipment will always remain at a level consistent with the desired upward trend in Company environmental competence.

A. P. Perez

A. P. Perez
President

florida power corporation

QUARTERLY
ENVIRONMENTAL STATUS
REPORT

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GENERAL

The publication of this quarterly issue of the **Environmental Status Report** records the development of Florida Power Corporation's environmental activities during April, May, and June, 1971. This report emphasizes those programs investigating the environs of the Crystal River Nuclear Plant now under construction. In addition, a progress report of the environmental efforts at the Anclote fossil-fired generating site is included in Appendix G. The locations of the Crystal River and Anclote sites are shown in Figure 1 (page 6).

Since the last issue of this report, the Company's Power Plant Engineering and Construction responsibility has been elevated with the promotion of Mr. Joel T. Rodgers to Assistant Vice President-Generation Engineering and Construction. In addition, the Generation Engineering and Construction effort is now organized into five Departments:

Department	Head	Title
Generation Engineering	W.A. (Walt) Szelistowski	Director
Generation Construction	H.L. (Hal) Bennett	Director
Generation Quality & Standards	M.H. (Mike) Kleinman	Manager
Generation Services	R.B. (Bob) McKnight	Manager
Generation Environmental & Regulatory Affairs	J.A. (John) Hancock	Manager

The Generation Environmental and Regulatory Affairs Department is the principal group involved with this report and associated activities. One of the primary functions of this Department is to provide a contemporary service to the overall Generation Engineering and Construction effort by developing an understanding of environmental processes, from regulatory and ecological perspectives, and interpreting the interaction these influences have with respect to the engineering, construction and production of electric power. The meeting of future electric generating needs with minimal environmental impact at a reasonable cost **in the public interest** can only be accomplished if the decision makers can be brought a complete perspective on such issues. The Company is optimistic that this organization can do just that.

Research program development continued through the quarter as preparations were made for contract renewals in some programs. The productivity of the first year's activities has been exemplary, not only in terms of the dedication and response of the investigators to the challenges of their specialties, but more importantly as a basis for further growth toward a systematic, cooperative alliance between academic and industrial interests seeking solutions to common problems. An example of this cooperative, problem-solving application is the development and initiation of the "Technical Report." In response to requests by Florida Power Corporation for the examination of specific areas of environmental concern, the Marine Science Institute of the University of South Florida developed the "Tech Report." The utility and significance of this problem-oriented tool lie with the ability of the mechanism to present short-term evaluations within a contextual framework of long term study. This then allows interim conclusions to be drawn and projections made which lend credible guidance toward developing "environmentally compatible" engineering decisions. This technique has been received quite enthusiastically by the researchers and should continue to provide a major environmental contribution. Two "Tech Reports" received this quarter have been included in Appendix G with the quarterly progress report of the Marine Science Institute.

The "Southern Conference on Environmental Radiation Protection from Nuclear Power Plants" was held in St. Petersburg Beach, Florida on April 21-22, 1971. The purpose of the conference was to promote the interchange of technical information relating to the radiological impact of nuclear power plants on the environment and man. The objectives of the conference were:

1. To provide updated information on in-plant sources of radioactivity and waste management practices included in the operation of modern nuclear power plants.

2. To evaluate techniques used for in-plant and environmental monitoring at nuclear power stations.

3. To inform participants of the Region IV Office of the U. S. Environmental Protection Agency plan for collection of environmental data for assessment of population exposure.

4. To discuss the United States Atomic Energy Commission amendments to 10 CFR, Parts 20 and 50, relative to discharges of radioactivity to the environment at the lowest practical levels.

One hundred three representatives of industry, university faculties, and Federal, State and Local governments attended this conference. The conference was sponsored by the Region IV Radiation Office of the U. S. Environmental Protection Agency (Atlanta, Georgia) and the Florida Division of Health. The Florida Power Corporation hosted the conference. Dr. Joseph A. Lieberman, Deputy Assistant Administrator for Radiation Programs, Radiation Office, Environmental Protection Agency, keynoted the conference. The dinner session was fortunate in having Dr. Ernest B. Tremmel, Director, Division of Industrial Participation, United States Atomic Energy Commission, present "What the Future Holds for Nuclear Power." The various discussions held throughout the conference resulted in the healthy interchange of various viewpoints.

As noted in the previous issue of the **Environmental Status Report,** a "Memorandum of Agreement Regarding Emergency Radiological Assistance for the Crystal River Site of the Florida Power Corporation" has been initiated by the Florida Division of Health pursuant to satisfying Florida Power Corporation's responsibilities for offsite emergencies. Since that time an "in-house" review of the memorandum has been accomplished and interchange made with Florida Power and Light Company due to the potential applicability of the memorandum to all operational nuclear plants in the State. A meeting to further discuss this effort was planned for July 29, 1971 at the State Division of Health facilities in Jacksonville and for attendance by representatives of the Occupational and Radiological Health Section of the Florida Division of Health, Florida Power Corporation and Florida Power and Light Company.

Florida Power, and in particular the Generation Environmental and Regulatory Affairs Department, has been privileged to have the assistance of Dr. Richard W. Englehart and Mr. Gregory T. Gibson during the summer months. Dr. Englehart, an Assistant Professor of Nuclear Engineering at the University of Florida, is providing invaluable assistance, not only through his nuclear background, but also through his enthusiastic involvement with the environmental aspects of electric power production. His unique awareness may be attributable, at least in part, to his previous experience with the Florida Power sponsored program "Environmental Surveillance for Radioactivity in the Vicinity of the Crystal River Nuclear Power Plant: An Ecological Approach," foregoing at the University of Florida.

Mr. Gibson, a senior in nuclear physics at Georgia Tech, is also enhancing the productivity and general development of the department with his background in the nuclear sciences and his interests in industrial-environmental management.

II SITE METEOROLOGY PROGRAM (CRYSTAL RIVER)

Data acquisition of site meteorological conditions continues to be an important aspect of our environmental monitoring. The information received is pertinent to the various research programs as well as to the effective development of the operative procedures for the nuclear plant. The results of the meteorology program have experienced little fluctuation from those obtained and presented in the previous issue. For the results of the previous quarter, reference is given to the January, February, March, 1971 **Environmental Status Report,** pages 10-22.

III MARINE ECOLOGY PROGRAM (CRYSTAL RIVER)

The efforts of the Florida Department of Natural Resources have been directed toward the production of manuscripts presenting the results of data analyses from samples collected during 1969 and 1970. Publication is expected in the near future.

It has been announced by Mr. Robert M. Ingle, Chief, Marine Science and Technology, that the research activities at the Crystal River plant site will be terminated following completion of the July sampling. A brief report of the quarterly progress is included in Appendix A.

MARINE THERMAL PLUME PROGRAM

The University of South Florida, Marine Science Institute, has continued to document the thermal plume characteristics under spring and summer conditions. The computer model of the plume activity in the estuary has been programmed and is presently being "debugged." The Oceanographic Data Acquisition System began monitoring thermal plume temperature characteristics at an average of ten locations in the discharge area this quarter. It was not operational during the latter part of the quarter due to broken sensor cables and malfunction of the tone receivers which control buoy interrogation. The problems have been resolved. During the next quarter, the system will be retrofitted by Electronic Communications Inc. to improve data collection reliability. A fourth progress report has been received and is included in Appendix B.

PRE-OPERATIONAL RADIOLOGICAL SURVEY

A. Florida Department of Health and Rehabilitative Services

The Department of Health and Rehabilitative Services continued their radiological surveillance around the Crystal River Site during the second quarter. During this period, one hundred samples were analyzed. The analyses and comparisons, in addition to recapitulation of data relating to vegetation, are presented in Appendix E.

B. University of Florida Department of Environmental Engineering

The Department of Environmental Engineering continued to sample the marine and marshlands during this quarter. The freshwater sampling network was expanded to include the Crystal River and Withlacoochee River.

In addition, the first set of data has been received from the TLD sampling network. The results of the first data set compare favorably with expected levels at sea level.

VI CHLORINATION STUDY

In a recently initiated program, the University of Florida Department of Environmental Engineering began a study of the effects of power plant chlorination on the marine microbiota at the Crystal River Site.

The desirability of the chlorination of cooling water lies in the control of fouling organisms within the condenser tubes. The attached organisms reduce efficiency by reduction of heat transfer and cause pitting of the stainless steel tubing. The previously used method of "condenser tube shooting" has proved to be of only limited effectiveness.

To document the environmental effects of the chlorination, the Department of Environmental Engineering has received two objectives for their studies: to measure residual chlorine in the discharge area under various ambient conditions; and to study direct and indirect effects of chlorinated cooling water on the quality of the receiving water.

This quarter, two baseline studies were conducted before chlorination was initiated. These studies will aid in separating thermal effects from changes induced by chlorine additions. The results of the two baseline studies are given in Appendix C.

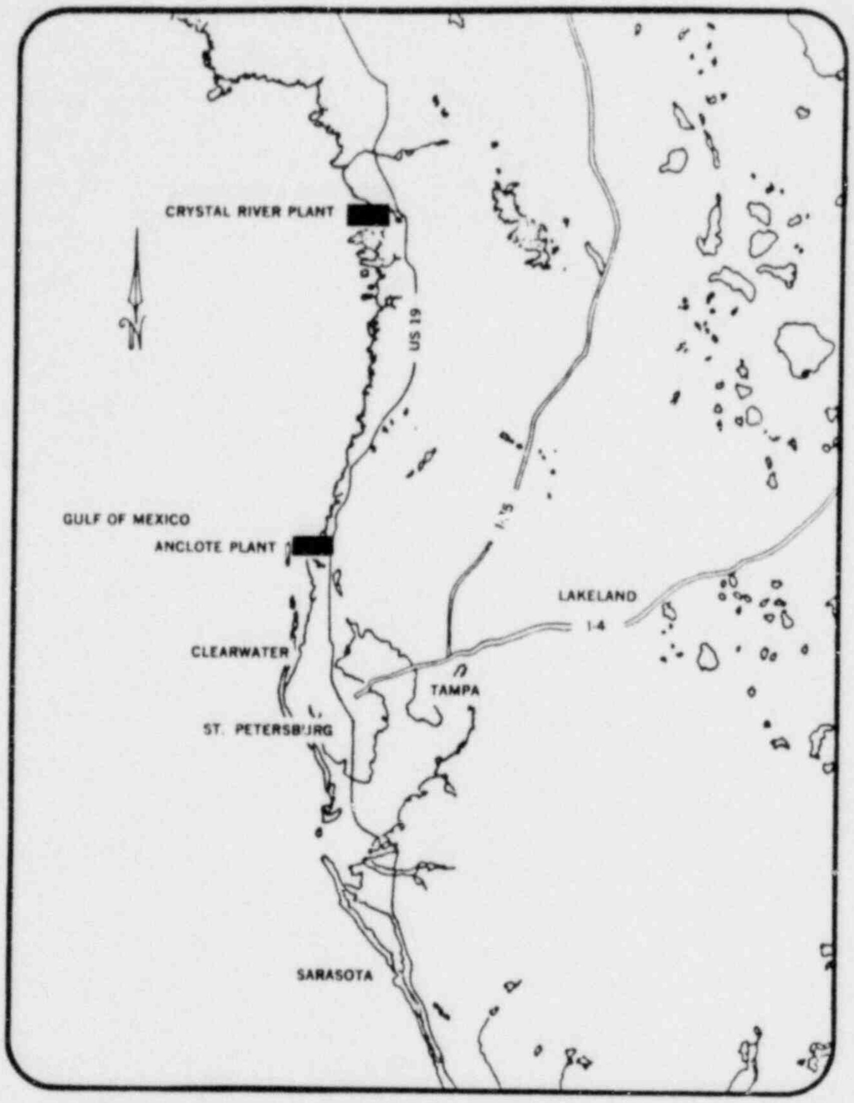

Figure 1. Location of FPC Power Plant Sites on the Gulf of Mexico

VII | appendices

appendix a

THERMAL ADDITION reports

CRYSTAL RIVER PLANT SITE

FLORIDA DEPARTMENT OF NATURAL RESOURCES

MARINE RESEARCH LABORATORY

Director

Robert M. Ingle

Supervisor

Edwin A. Joyce, Jr.

Staff

Churchill B. Grimes

William G. Lyons

Stanley W. Morey

Joe Mountain

QUARTERLY REPORT TO THE FLORIDA POWER CORPORATION APRIL, MAY AND JUNE 1971

All Marine Research Laboratory efforts in Thermal Effects studies during this quarter have primarily directed toward completion of analyses and writing of manuscripts for publication.

CRYSTAL RIVER FIELD LABORATORY

The first publication on the fish data collected during 1969 (Professional Paper Series #11) was received from the printer early in this quarter. The manuscript of the results of 1970 fish sampling was completed during the last of June and is being readied for the printer. It will be published as a Technical Series of the Marine Laboratory. All regular sampling was continued, although late June samples were delayed to July in order to complete the manuscripts.

Following the completion of sampling in July, the Field Laboratory staff and equipment will return to St. Petersburg where Mr. Joe Mountain will begin the analysis of the 1971 samples. The temporary termination of the field laboratory results from further delay in the initiation of operation of the nuclear power plant (now estimated to begin in early 1974). Data gathered thus far will provide a good baseline of information and the continual collection of additional data is not presently necessary nor economically warranted. The field laboratory will probably be re-established in early 1973 prior to initiation of nuclear generation. In the meantime, Thermal Effects research at the St. Petersburg facilities will be increased.

ST. PETERSBURG LABORATORY

As in the field laboratory, most effort during this quarter has been directed toward analysis and publication of 1969 and 1970 data. These manuscripts are currently at the printers and include analysis of 1969 invertebrate collected at Crystal River (Professional Paper Series #14); analysis of 1969 and 1970 benthic marine algae (Professional Paper Series #16) and a symposium on the thermal effects studies conducted at the St. Petersburg facilities (Professional Paper Series #15). These publications will total almost 400 pages when published and will be a major contribution to our understanding of the thermal effects problem.

With the temporary closing of the Crystal River Field Laboratory and the completion of publications on earlier studies, the St. Petersburg laboratory is presently preparing for new and more detailed thermal tolerance studies. These will be designed to delimit significant areas of concern as indicated by our earlier studies.

Robert M. Ingle

ROBERT M. INGLE
Chief, Marine Science & Technology
21 July 1971

appendix b

data report

NO. 004

ON INDEPENDENT ENVIRONMENTAL STUDY OF THERMAL EFFECTS OF POWER PLANT DISCHARGE

University of South Florida

Marine Science Institute

Principal Investigator

Dr. Kendall L. Carder

Graduate Assistants

Ronald H. Klausewitz

Frederick C. Schlemmer II

Student Assistant

Bruce A. Rodgers

INTRODUCTION

During the period covered by this report, spring and summer plume characteristics were documented. These data were collected for input into a thermal plume model as well as to provide a historic record of a certain environmental parameter.

Discharge basin bathymetry, dye dispersion, water turbidity, and STD (salinity-temperature-depth) investigations are reported below, as well as the results of a preliminary run of a numerical circulation model. This run was designed primarily to "debug" the program and does not include various dynamic boundary conditions.

BATHYMETRIC SURVEY

Date: March 13, 1971
Time: 11:32–14:08
Tide: 08:54 +0.1
14:54 +3.0

The path of transport of water in any basin is highly dependent on the relative depth of one area compared to another. It was quite important, therefore, that the basin to be modeled at Crystal River be accurately charted for depth. A Sonarmarine Depth-finder was used to record the depths along five east-west transects of the outfall basin. The absolute depths ranged from 19.5 feet just west of the English Bars to less than one foot over the oyster bars in the mid-section of the basin. The boat was run at a nearly uniform speed of six miles per hour.

The recorded depths were then corrected for tidal height using the tidal record from the plant recorder. A mean sea level depth was arrived at from the recorded tidal history, and the depths were adjusted to the mean. From this data a contour of the basin was drawn, appearing as Figure 1.[1] Of interest are the holes predominantly in the south and southwest portion of the basin. These could be scour holes associated with high current flow, which is not unlikely based on the results of the hydraulic model (see Figures 17 and 18), or sinkholes in the limestone base. The rectilinear pattern of the oyster bars is of interest and may represent a pattern of resistant limestone substrate. The westernmost bars (the English Bars) are almost completely dead as is the westmost bar of the middle string. This may indicate a more complete blockage of the brackish water by the growing inner bars. It will be of particular interest to investigate the base material of the middle string of bars since these are the most influential factors in the drainage of the immediate discharge area.

BAR CONFIGURATION AND COMPOSITION

On 1 May, 1971, a bathymetric investigation was begun of the oyster and shell bars in the discharge area. These bars have a marked effect on the flow of water inside the discharge area as has been shown in dye dispersion studies and STD runs.[2] The depth of the bars and their composition must be determined as input to the hydraulic model. The depth determines the amount of flow over the bar, and the composition determines the friction factor for the material on the surface of the bar.

The results of the investigation (depths are listed in Table 1 and stations shown in Figure 2) show a very congested bar area north of Elbow Pass with almost total blockage of circulation except in the area south of Station 15. South of Elbow Pass the best east-west drainage is provided for the discharge area by the bathymetry at Stations 1 through 5. This evidence is supported by the implied circulation patterns provided by the contours of previous STD reports[2] as well as in the ebb tide STD contours prepared for this report (see especially Figure 8).

Some previously uncharted bars were discovered to be east of Station 21. These bars are not shown on any USCGS charts nor are they apparent in the aerial photographs used to establish the Marine Science Institute baseline chart.[2] They apparently are of fairly recent origin.

Since it is planned to exercise the hydraulic model with various bathymetric changes in the discharge basin it is essential to establish all of

[1]Figures and tables are shown on pp. 21 through 33.
[2]See reference 3.

the obstructions present. Only in this manner can it be established which factors or physical features are the most important in the rate of dispersion of the heated water. On-going study areas will be those east and west of the bar line investigated here.

CRYSTAL RIVER STD SURVEY NO. 7

At 1200 hours on 12 June, 1971, a twenty-eight station STD (salinity-temperature-depth) survey of the discharge basin commenced during a flood tide. Salinities and temperatures were measured at the surface and at depths of three feet. Tidal and meteorological data are summarized in Table 2. The survey was completed at 1720 hours.

Figures 3, 4, 5, and 6 show the surface and three foot contours of temperature and salinity respectively. The salinity contours indicate a strong southerly flow of fresh Withlacoochee River water from the Cross Florida Barge Canal. This water apparently is displaced by heavier Gulf water moving up the Barge Canal during flood tide. Since the bathymetry in the discharge basin is shallower and contains more obstacles to flow than does that of the Barge Canal, a tidal phase lag occurs in the discharge basin as compared to an identical longitude in the Barge Canal. This allows the basin to fill with Barge Canal water from the north as well as Gulf water from the west.

The temperature contours (Figures 3 and 4) indicate that thermal plume water fills into the area east of the strong southerly (Barge Canal source) flow and north of the discharge canal. Solar heating in the shallows may be distorting the size of the thermal plume to make it appear somewhat larger. Thermal buoy data should provide the basis for a better understanding of the non-conservative diurnal effects. It will be discussed in the next technical report.

CRYSTAL RIVER STD SURVEY NO. 8

A STD survey of the discharge basin under ebb tidal conditions commenced at 0927 hours on 1 July, 1971. Light scattering measurements were also taken but will be discussed in a later section. Measurements were taken at the surface as well as at a depth of three feet. Tidal and meteorological data are summarized in Table 3. The survey was completed at 1457 hours.

Figures 7, 8, 9, and 10 are surface and three foot contours of temperature and salinity respectively. Since these data were collected later in the ebb cycle than measurements reported previously, the contours extend farther westward. The effect of the gaps in the oyster bars is readily apparent when surface and three foot contours are compared. The water column also appears to be better mixed during ebb tide than during flood due to the higher turbulent velocities expected during ebb.

DYE DROP #1 March 10, 1971

The dye was dispersed as the tide turned from flood to ebb. The point of insertion was just east of biological marker #3 near the end of the north bank of the discharge canal. The dye spread quickly north and west in a large almost concentric ring. As the ebb tide current became stronger, the northern section, which had been heading for the grass flats, stalled, and the westward movement accelerated with the increasing ebb tide. When diffusion made the dye invisible to the naked eye, it was detected by means of a fluorometer (Turner, Model 111) which can detect dye levels down to one-tenth of a part per billion. In the west portion of the channel the dye diffused rapidly to 5 to 10 ppb within about three hours and spread over an area with a mile long periphery. After four hours the dye had reached the western tip of the discharge canal spoil bank. It had traveled 1.1 n.m. west and .25 n.m. north. Along the north rim the dye was still visible, stalled in the shallows.

Figure 11 shows the path of the dye. The arrows represent velocity "streamlines" or places where the concentration of the dye remained the strongest in comparison with the surrounding waters.

Table 4 provides tidal and meteorological data as well as the time and dye concentration at the stations listed on Figure 11.

Conclusions:
As the effluent reached the end of the northern spoil and emptied into the larger body of water several important effects are noted. The velocity of the water dropped rapidly here (see Figure 16, channel current run), and the plume water took two different paths depending on the tidal condition. Since the dump was made just before the turn of the tide, the water first headed into the flats north of the discharge canal. STD runs made in the past[3] support the conclusion that on flood conditions the plume heads north into the shallows (see Figure 3, Flood STD). As the ebbing tidal current increased, the dyed water close to the channel was drawn back into the channel, diffusing out to form a wide, invisible front which flowed rapidly along the discharge canal spoil bank. Although this water was rapidly flushed toward the Gulf, the water that had been dispersed into the shallows before the tidal current changed was not flushed out, even though observed through a period of maximum ebb current. The residence time for these salt marshes will be the subject of future investigation. Their resistance to flushing may have been the effect of the strong southerly wind.

DYE DROP #2

Dye was dropped as the tide turned from ebb to flood on 13 June, 1971. The drop zone was located at Biological Station #5, at the west tip of the discharge spoil bank.

The dye moved slowly westward as a large concentrated mass, being conveyed by the plant discharge. As the flood tidal currents became effective, the mass of dye stalled, turned northward, and divided into two masses approximately equal in size (see Figure 12). The dye moved slowly toward the bars until the bars were nearly submerged. At that time the dye divided into three concentrations: two turned northward flowing through Finger Pass, and the third turned eastward and moved through the first break in the bars north of the discharge canal.

When diffusion had rendered the dye impossible to trace visually, it was detected by means of a fluorometer (see Dye Drop #1). The dye dispersed to the northwest, turned east, and slowed in velocity. The velocity did not increase again until 1515 hours at which time it had reached the next group of bars shoreward.

At the second set of bars the flow of the dyed water was quite similar to the first set. The velocity increased when the tops of the bars began to submerge. The flow through these bars was concentrated in the second, third, and fourth breaks north of the discharge canal. After the dye had passed through these bars it became undetectable on the fluorometer.

Figure 12 shows the paths of the dye. The arrows represent velocity "streamlines" or places where the concentration of the dye remained the strongest in comparison with the surrounding waters.

Table 5 gives the station numbers which correspond to the numbers on Figure 12 as well as the time and concentration at each station.

Conclusions:
As flood tide waters approached the discharge canal several effects were noted. First, the total area filled with water one basin at a time. Each had its own definite boundaries. The boundaries for the first area are the bars on the east and west edges of Figure 12. The boundaries for the second area are the bars on the east of Figure 12 and the shore, even further to the east. The southern boundary has been determined.

The basin by basin flooding of these areas was supported by the stalling of the dye progression until the water level reached the top of the bars, at which time the dye and water surged through the breaks in the bars. During the time of this surge it was also possible to see a difference in the water level itself.

Secondly, as flood tide waters approached the discharge canal the plume water was forced to turn northward and fill the first basin, between the bars. As the tidal currents increased they caused plume water moving west in the canal to slow in velocity and turn northward to fill the second basin (between the east bars and the shoreline). This conclusion is supported by previous flood tide STD runs,[3] in which the plume

[3]See reference 3.

has been found to move to the northwest and concentrate in the areas described here as the first and second basins. Future dye studies and investigations will give an even greater understanding of the rates and patterns of flooding and flushing in the total basin.

TRANSMISSOMETER SURVEYS

On June 26 and 27, 1971, transmissometer surveys of the Crystal River plant discharge basin and a comparison run including both the input and discharge basins were run respectively. The transmissometer was a Model 412 from Hydro Products with a one meter light path. Figure 13 shows the results of the discharge basin run of June 26, and Figure 14 shows the results of the comparison run on the two channels. The results for both runs are tabulated in Tables 6 and 7, respectively.

The discharge basin exhibited very high turbidities, with transmissivity ranging from 0% in the areas just west of the discharge spoil bank and west of the English Bars, to 12% in a small area just north of the intake spoil bank (station 36). The southerly wind of 7 mph although not exceptionally strong was quite sustained and apparently had been so for some time since seas on the westernmost legs were rough and running at about three feet. This undoubtedly contributed to some of the turbidity in the area west of the English Bars. Lack of fetch was a likely contributing factor to the relative clarity of the water just north of the intake spoil but remoteness with respect to proximity to the barge canal was quite important, also. The transmissometer was towed from the barge (see earlier reports for a description)[4] about two feet below the surface of the water. It is interesting to note the similarity of the 3% contour with past ebb STD plume patterns even though flood tide was firmly into the basin at the time of measurement.

There was no marked difference in water clarity between the discharge plume water and that of the rest of the basin. In fact, the water in the discharge canal was less turbid than some of the water farther out in the basin. The discharge channel showed consistently higher readings than the intake channel.

The comparison run between the intake and discharge canals was performed under very similar conditions on the next day. The method of towing the instrument as well as towing speed were similar to those of the previous day.

A comparison between Stations 19-22 and Stations 46-49 taken at approximately the same locations but after the effects of three hours of wind bears out the conviction that a large portion of the turbidity in the outer basin was caused by wind waves. The marked turbidity differences between similar areas on either side of the intake spoil can probably be attributed to differences in depth, sediment type, and proximity to the Cross Florida Barge Canal.

The high turbidity in the area of Station 19 is not so easily explained. Its source may have been the Cross Florida Barge Canal. It should be noted that in both runs the northern areas were relatively high in turbidity. It will be the object of the next run to investigate the vicinity of the barge canal and its spoil banks to assess its contribution to the total turbidity of the discharge basin.

Due to low resolution resulting from near zero readings through the one meter light path, it is desirable in the future to operate with a unit more adapted to the higher, inshore type turbidity values. The Model 612 transmissometer with a one-tenth meter (ten centimeter) path will be used in future surveys at Crystal River. This unit will be borrowed from the Anclote River research project when available.

LIGHT SCATTERING

On 1 July, 1971, a series of 35 turbidity stations was made using a Brice-Phoenix light scattering photometer. This instrument has been described in detail by Spilhaus (1965) and Pak (1970). Carder (1970) and Beardsley *et al.* (1970) have shown that the light scattered at an angle of 45° from the direction of propagation of the incident light beam was proportional to the total cross-sectional area of the suspended particles for

[4]See reference 3.

several oceanic samples. Thus, light scattering values can be quantitatively related to particle concentration.

Figure 15 is a contour plot of the volume scattering function $\beta(\theta)$ for $\theta = 45°$ (relative portion of light scattered at 45°) during ebb tide. The data indicate that the turbidity in the discharge canal is about one-half that in the Cross Florida Barge Canal with local sources (resuspended bottom sediments) contributing heavily to the turbidity pattern during strong tidal flow. This is especially true in regions constricting the flow as discussed in the previous section. The turbidity in the region as a whole is between 30 and 100 times that of the clearest open ocean water, and between 10 and 20 times that of typical surface water from the Gulf of Mexico (unpublished data by the author).

The principle source of turbidity is the Withlacoochee River – Cross Florida Barge Canal network. The salinity patterns during flood tide (Figure 5) indicate a strong southerly flow from the Barge Canal along the western edge of the marshlands. During slack water a certain amount of deposition occurs, especially in the grassy areas. These regions then provide a ready course of fine sediments for resuspension when turbulent water velocities become great enough at peak ebb tide or during periods of strong winds.

VELOCITIES ON THE DISCHARGE CHANNEL

On 6 March, 1971, a current vane study of the discharge canal was performed. The intent was to determine what head the plant flow produced along the canal for entry into the hydraulic model. The times of measurement were chosen for a tide at practically a "stand" condition, for March 6 tidal range was 0.3 feet over a four hour and thirty-two minute period. Thus the tidal impact on the velocities were at a minimum. The measurements were made approximately in the center of that time. The biological stations were used as measuring points to provide a stable reference.

The results show the highest velocity was at Biological Station #1 as anticipated. It is interesting to note that the lowest velocity was at Biological Station #3. This is the point at which the effluent actually diverges into the discharge basin or embayment. A "delta" effect is evident here as occurs at the mouth of natural rivers entering larger bodies of water. This point usually is accompanied by a marked decrease in the rate of flow and a consequent dropping of the heavier sediments. The bathymetric study of the discharge canal (Carder 1970-B) shows no evidence of this type of delta building leading to the possibility that the suspended sediments are fine enough to be carried in suspension even at the reduced velocity.

Point X (see Figure 16) is the location where the temperature is one-half the difference between ambient and maximum effluent temperature or that location where the water has lost 50% of the gained heat. The time required for this is equal to 5.2 hours under slack water tidal conditions.

HYDRAULIC MODEL RESULTS

The first run of the hydraulic model yielded results for a complete tidal cycle. These results are being analyzed to determine the sequence of flooding and ebbing flow throughout the basin. This is the first successful run of the model. Water sources and sinks in the discharge basin have not been included yet except for tidal input along the western open boundary. The bars are being treated as shallow areas and will be incorporated into a weir scheme in a later version.

The grid interval on this run was 467.713 feet and the tidal period was 12.0 hours. The forcing function was a simple sinusoid 1.6 feet in amplitude. This value was arrived at after studying tidal record data for the Gulf of Mexico (Coast and Geodetic Survey, 1962). The time increment consistent with stability requirements was 12 seconds. The program ran for 49 minutes simulating 12 hours of real time.

Conclusions:

The ebb tide results (Figure 17) show flow quite consistent with the STD results for ebb tide (see Figure 8). The effluent after leaving the discharge spoil bank heads to the southwest and empties through two major gaps in the southern set of bars.

The flood tide results (Figure 18) show a fairly complete reversal of this process with the flood waters approaching the tip of the discharge spoil on a northeasterly course. This movement would logically produce the northern displacement of the plume during flood conditions that we have seen during flood STD runs (see Figure 3). This northern area is quite well contained between the shoreline, the middle set of bars, and the flooding waters. It would become an area on flood tide much like a basin, containing the plume water and the river water. This would make it an area of high sedimentation and stratification, which is consistent with observed field data.

Respectfully submitted,

Kendall L. Carder

Kendall L. Carder
Principal Investigator

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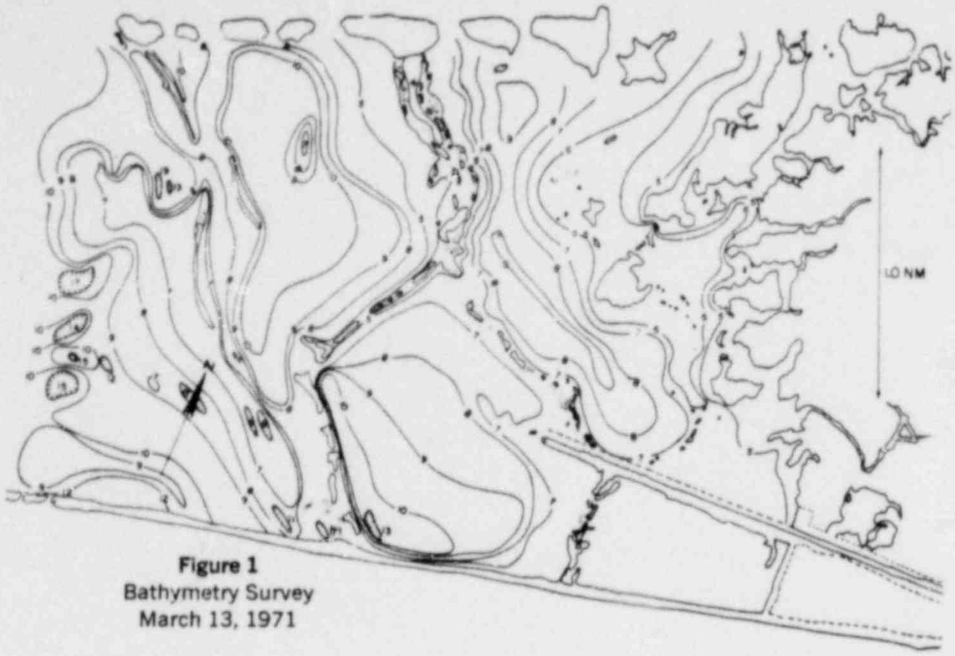

Figure 1
Bathymetry Survey
March 13, 1971

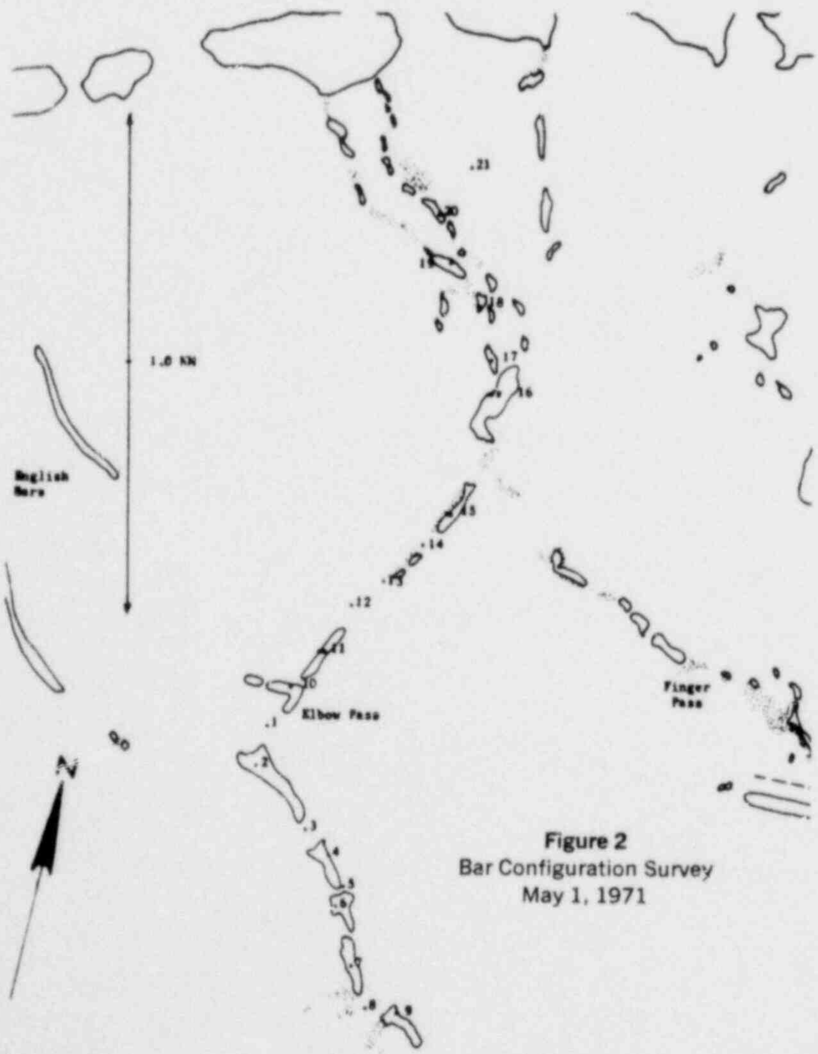

Figure 2
Bar Configuration Survey
May 1, 1971

Figure 3
Flood Tide Surface Temperatures
June 12, 1971
Contour Interval 0.5°C

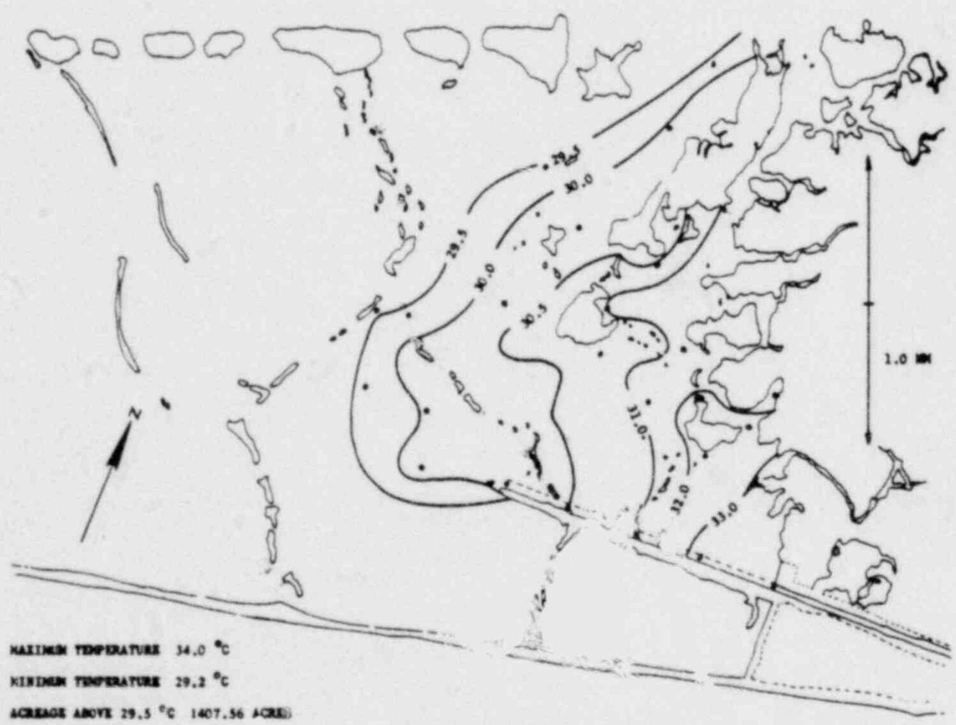

Figure 4
Flood Tide Three Foot Temperatures
June 12, 1971
Contour Interval 0.5°C

Figure 5
Flood Tide Surface Salinity
June 12, 1971
Contour Interval 0.5 ‰

Figure 6
Flood Tide Three Foot Salinity
June 12, 1971
Contour Interval 0.5 ‰

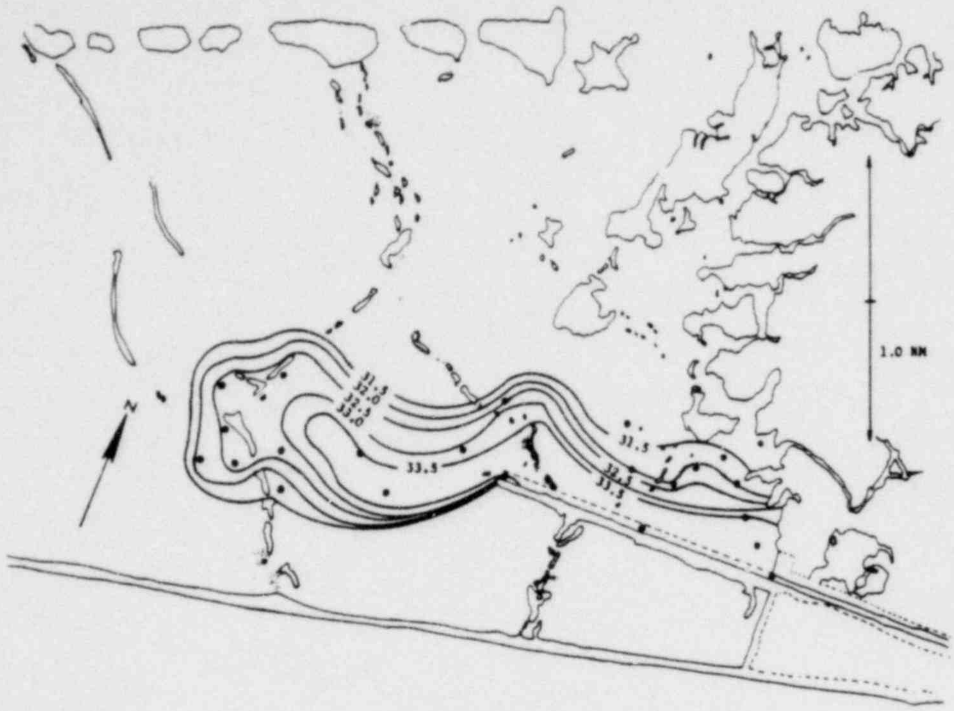

Figure 7
Ebb Tide Surface Temperatures
July 1, 1971
Contour interval 0.5°C

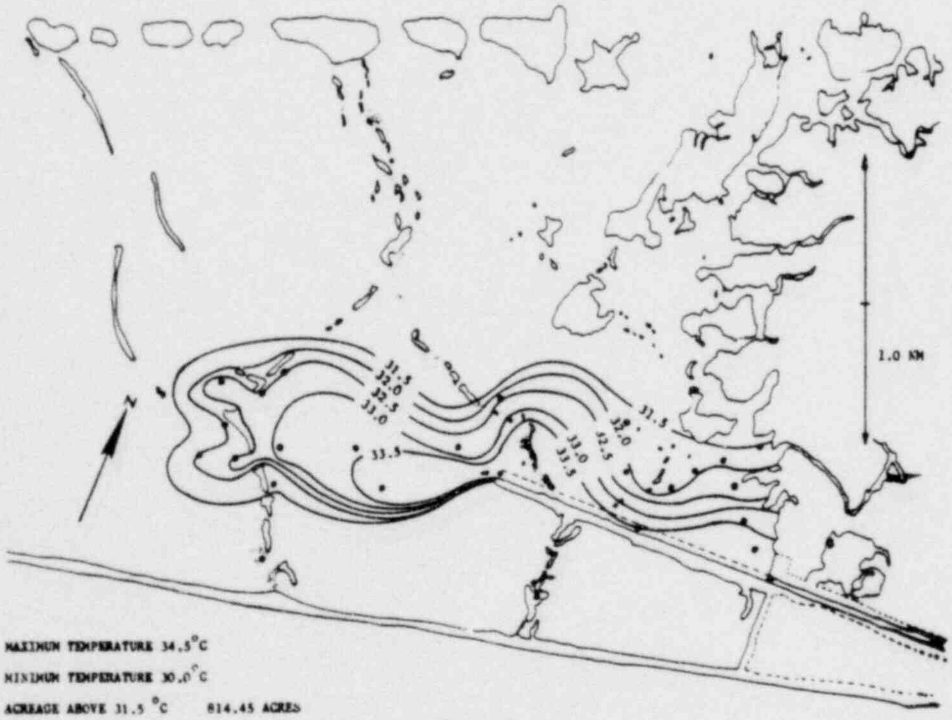

Figure 8
Ebb Tide Three Foot Temperature
July 1, 1971
Contour Interval 0.5°C

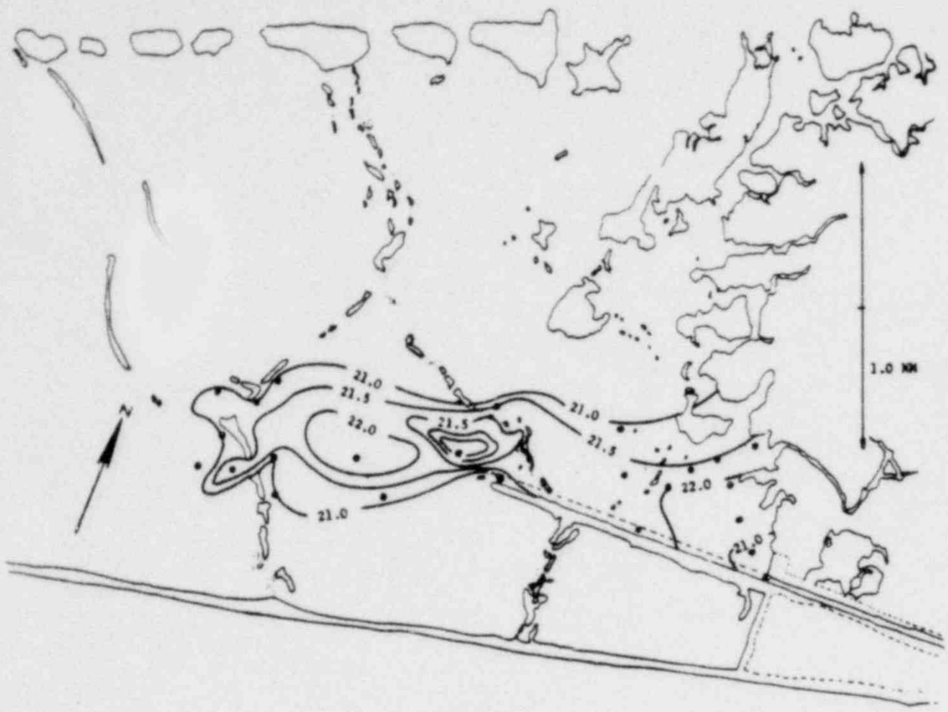

Figure 9
Ebb Tide Surface Salinity
July 1, 1971
Contour Interval 0.5 ‰

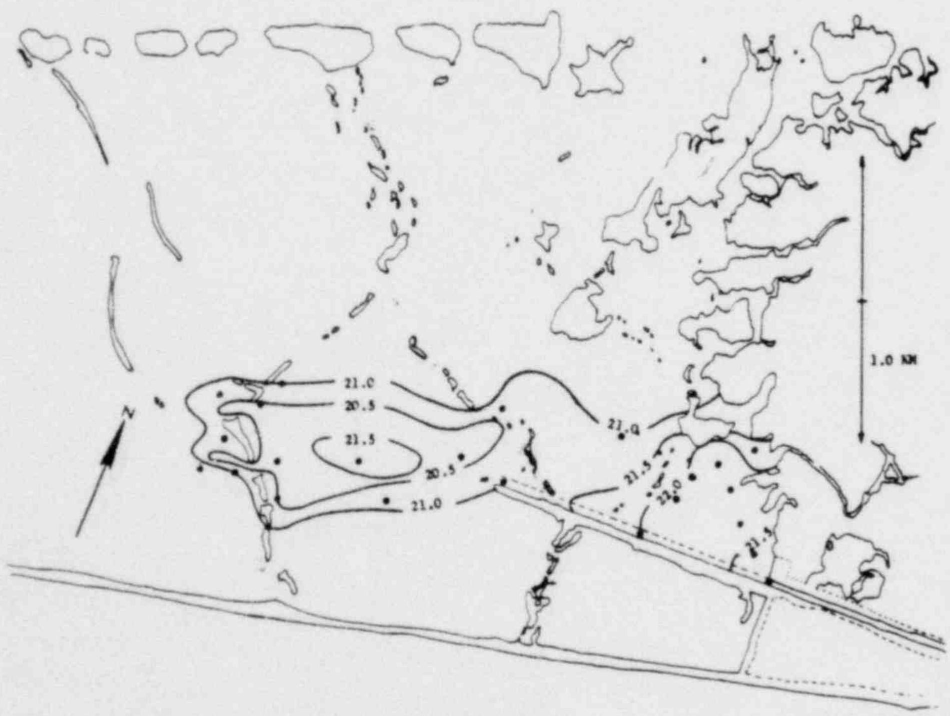

Figure 10
Ebb Tide Three Foot Salinity
July 1, 1971
Contour Interval 0.5 ‰

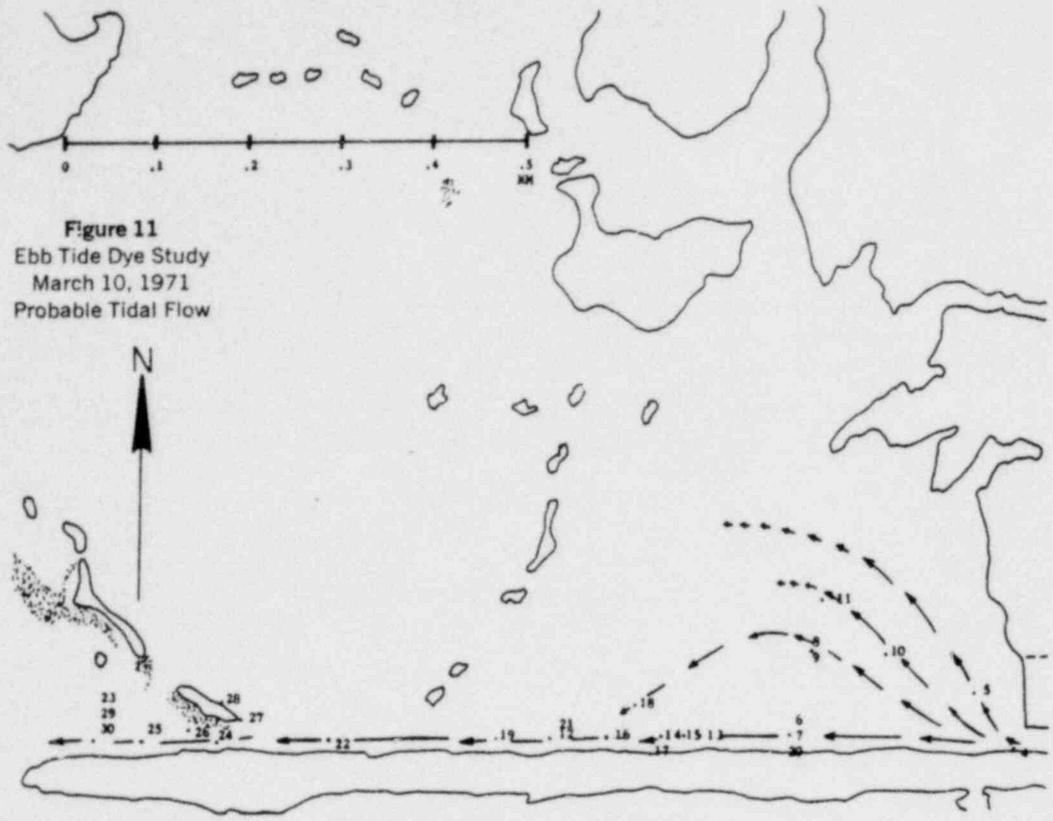

Figure 11
Ebb Tide Dye Study
March 10, 1971
Probable Tidal Flow

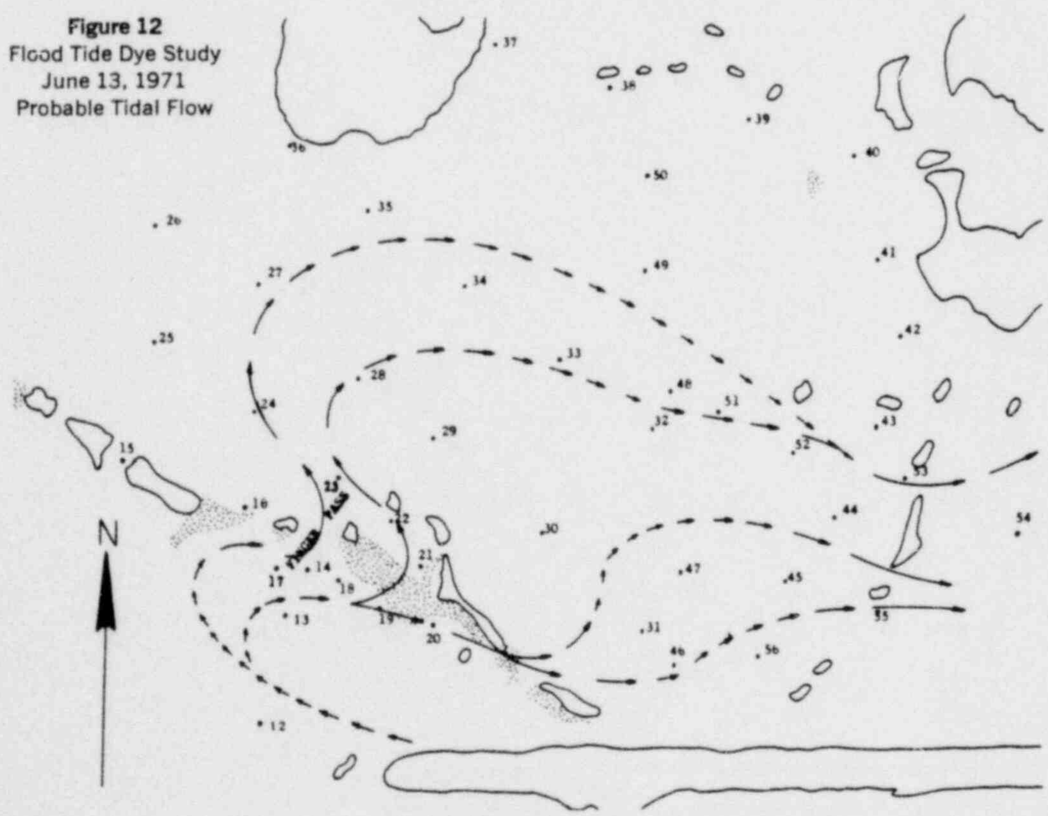

Figure 12
Flood Tide Dye Study
June 13, 1971
Probable Tidal Flow

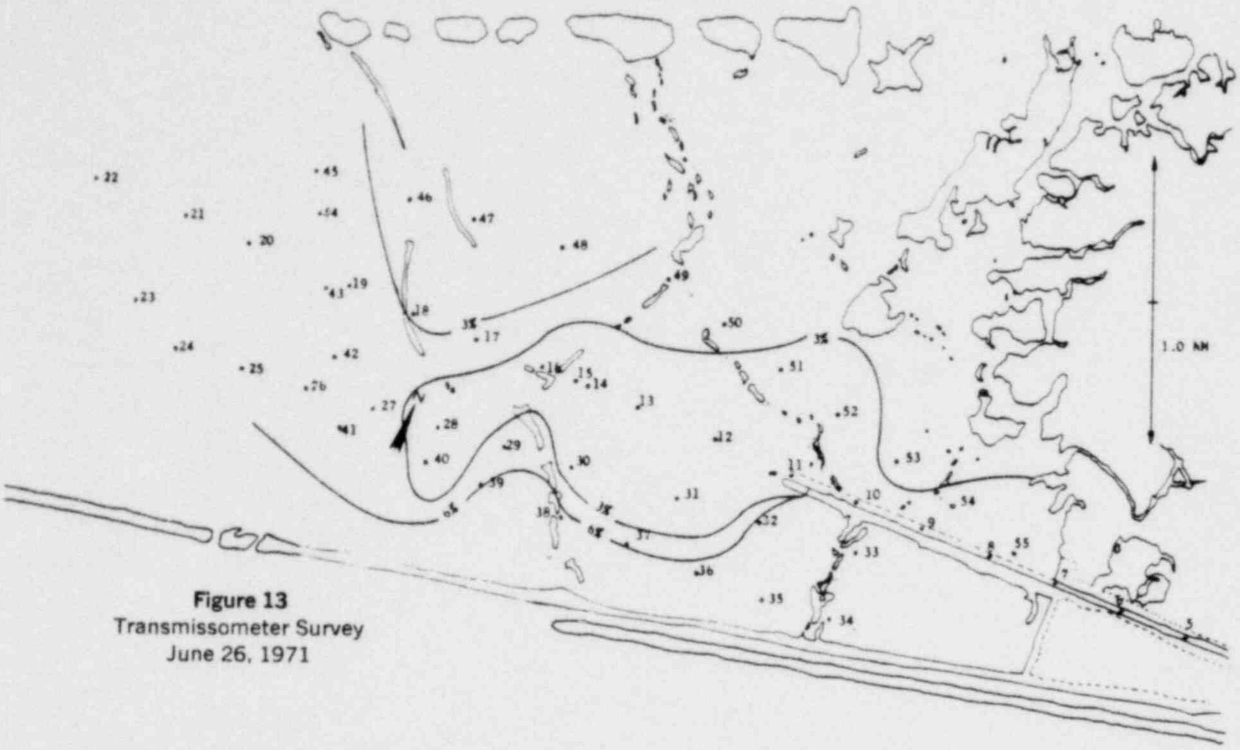

Figure 13
Transmissometer Survey
June 26, 1971

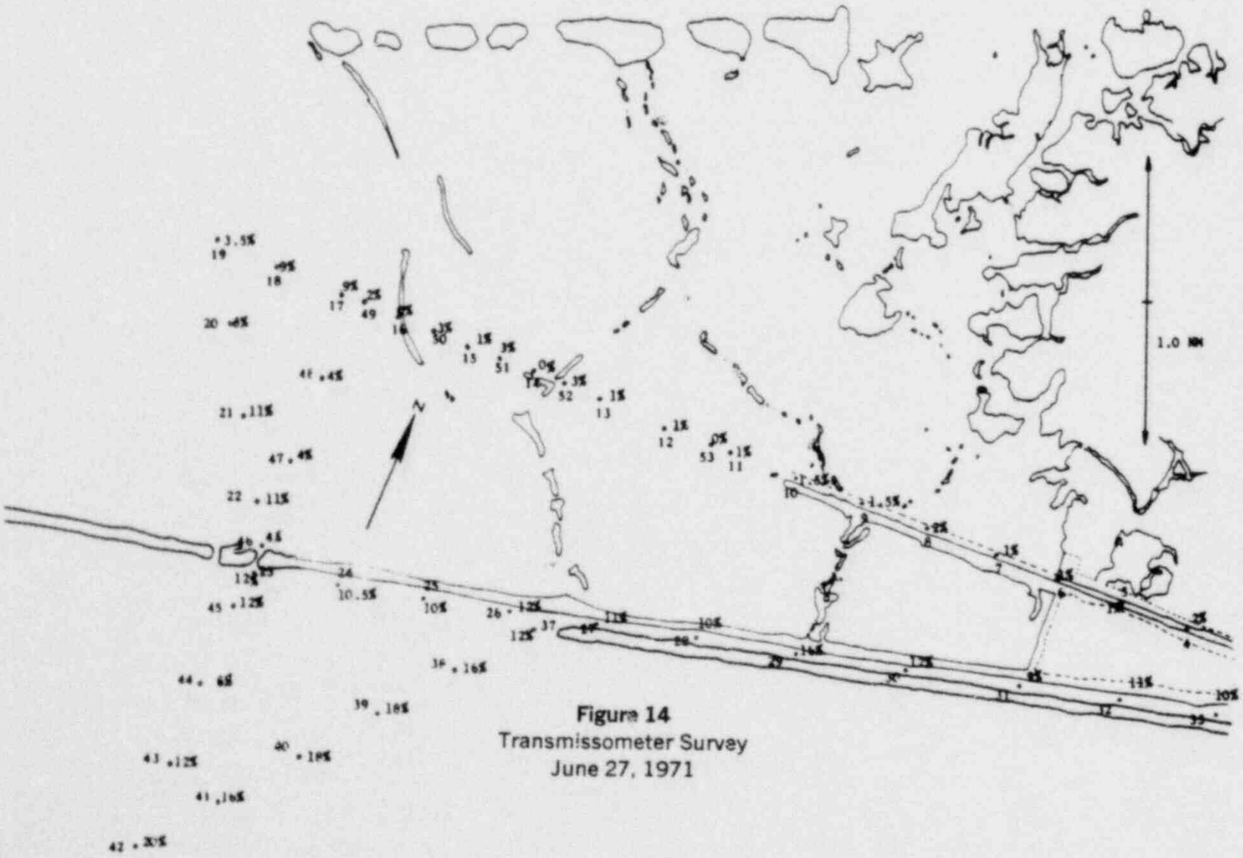

Figure 14
Transmissometer Survey
June 27, 1971

Figure 15
Light Scattering
July 1, 1971

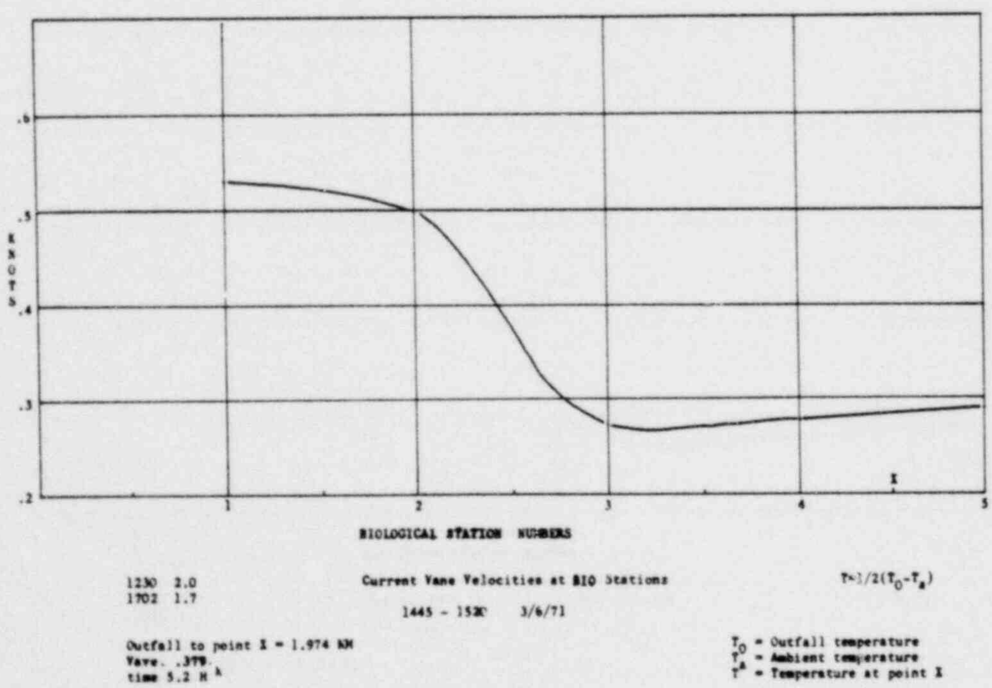

Figure 16

Figure 17
Hydraulic Model Program
Ebb Tide Results
July 12, 1971

Figure 18
Hydraulic Model Program
Flood Tide Results
July 19, 1971

TABLE 1

DATE: May 1, 1971

CONDITIONS: Clear
Wind 5 knots from 205°

TIDE: 1156 +1.8
1730 +2.9

TIME	STATION NO.	CORRECTED DEPTH (TO MEAN WATER)	CHARACTERISTICS
1415	1	—2.6	old shells (pass)
1430	2	— .5	old shells (bar)
1435	3	—2.5	old shells (pass)
1440	4	—1.0	live oysters (bar)
1445	5	—3.4	old shells (pass)
1450	6	—1.9	live oysters (bar)
1500	7	—1.9	live oysters (bar)
1505	8	—3.8	shells (pass)
1530	9	—1.7	live oysters (bar)
1540	10	+2.2	live oysters (bar)
1550	11	—3.2	live oysters (bar)
1556	12	—2.2	live oysters (bar)
1600	13	— .7	live oysters (bar)
1605	14	—2.2	live oysters (bar)
1610	15	— .2	live oysters (bar)
1615	16	+1.4	live oysters (bar)
	17	+1.3	live oysters (bar)
	18	+1.1	live oysters (bar)
	19	+1.4	live oysters (bar)
	20	+1.2	live oysters (bar)
	21	—4.2	mucky bottom, sticky & grey

TABLE 2

DATE: June 12, 1971

TIME: 1245 to 1720 (EDT)

TIDE:	Time (EDT)	HT (FT)
	1054	+2.0
	1642	+3.9

SKY: Clear

TIME (EDT)	WIND (SPD. (MPH/DIR)	AIR TEMP (°F)	HUMIDITY (%)
1300	8-10/290	83	76
1400	11/295	82	11
1500	7/300	84	69
1600	8/295	86	70
1700	7/300	83	76

TABLE 3

DATE: July 1, 1971

TIME: 927 to 1457 (EDT)

TIDE:

Time (EDT)	HT (FT)
0748	+3.3
1454	+1.0
2124	+2.6

SKY: Clear

TIME (EDT)	WIND (SPD. (MPH/DIR)	AIR TEMP (°F)	HUMIDITY (%)
1000	0-2/260	85	66
1100	3/270	85	66
1200	5-7/265	86	70
1300	4/265	85	69
1400	4/265	84	69

TABLE 4

DATE: March 10, 1971

TIDE: 1336 +2.6
1914 +0.2

Conditions:
Partly Cloudy
Wind 13 knots
from 183

DROP TIME 1315

STATION NUMBER	TIME	RHODAMINE DYE IN PPB
4	1405	169.0
5	1415	227.8
6	1423	0.0
7	1430	92.6
8	1441	0.735
9	1449	10.44
10	1450	16.2
11	1453	3.97
12	1506	0.147
13	1508	3.09
14	1511	0.44
15	1513	1.03
16	1519	0.74
17	1524	1.91
18	1533	0.88
19	1537	1.32
20	1547	0.0
21	1551	0.74
22	1600	1.03
23	1607	0.0
24	1616	0.74
25	1620	0.0
26	1623	0.0
27	1627	0.74
28	1631	0.0
29	1638	0.147
30	1640	0.74

TABLE 5

DATE: June 13, 1971

TIDE: 0630 +3.1
1706 +3.8
1208 +1.9

CONDITIONS:
Wind from 300° N. increasing from 0 m.p.h. at 1135 to 18 m.p.h. at 1440.

DROP TIME: 1135

STATION NUMBERS	TIME	RHODAMINE DYE IN PPM
12	1303	.873
12	1308	.7275
13	1315	.582
14	1318	4.947
15	1321	.582
16	1324	.582
17	1327	.582
18	1330	1.746
19	1334	3.201
20	1337	9.312
21	1339	2.4735
22	1342	13.386
23	1345	16.005
24	1348	5.529
25	1350	.7275
26	1353	.528
27	1356	.528
28	1400	2.328
29	1403	.4365
30	1406	.528
31	1410	.528
32	1413	.528
33	1416	.528
34	1419	1.3095
35	1422	.7275
36	1425	.528
37	1428	.528
38	1430	.528
39	1432	.528
40	1435	.528
41	1438	.7275
42	1440	.528
43	1443	.528
44	1445	.528
45	1450	.873
46	1501	1.455
47	1505	1.164
48	1508	.7275
49	1512	.7275
50	1515	.7275
51	1520	1.164
52	1522	1.164
53	1525	.873
54	1527	.582
55	1530	1.3095
56	1532	1.0185

TABLE 6

Date: June 26, 1971

Conditions: Clear skies with 7 m.p.h. wind from the south at 1410 and increasing to 16 m.p.h. at 1530.

STATION NUMBERS	TIME	% TRANSMISSIVITY
5	1423	2%
6	1426	2%
7	1431	3%
8	1436	0%
9	1440	2%
10	1445	0%
11	1450	0%
12	1456	0%
13	1502	2%
14	1506	2%
15	1507	2%
16	1510	2%
17	1515	5%
18	1520	2.5%
19	1525	5%
20	1533	1%
21	1538	0%
22	1545	1%
23	1555	1%
24	1600	1%
25	1605	1%
26	1610	1%
27	1615	4%
28	1620	2%
29	1625	4%
30	1630	2%
31	1638	0%
32	1644	10%
33	1650	8%
34	1655	1%
35	1700	6%
36	1705	12%
37	1710	8%
38	1715	8%
39	1721	7%
40	1725	3%
41	1745	5%
42	1750	5%
43	1755	1%
44	1800	2%
45	1803	3%
46	1810	1%
47	1815	1%
48	1822	1%
49	1830	3%
50	1835	3%
51	1840	1%
52	1845	1%
53	1850	5%
54	1855	2%
55	1900	2%

TABLE 7

Date: June 27, 1971

Conditions: Clear skies with 5 m.p.h. wind from the southwest at 0855 and increasing to 18 m.p.h. at 1105.

STATION NUMBERS	TIME	% TRANSMISSIVITY
4	0905	2%
5	0908	1%
6	0912	1%
7	0915	1%
8	0919	2%
9	0923	1.5%
10	0926	1.5%
11	0930	1%
12	0935	1%
13	0940	[illegible]%
14	0945	0%
15	0950	1%
16	0955	0%
17	1000	9%
18	1055	9%
19	1104	3.5%
20	1110	8%
21	1115	11%
22	1120	11%
23	1125	12%
24	1130	10.5%
25	1135	10%
26	1140	12%
27	1150	11%
28	1155	10%
29	1200	16%
30	1205	12%
31	1210	9%
32	1215	11%
33	1220	10%
37	1320	12%
38	1325	16%
39	1331	18%
40	1335	18%
41	1340	16%
42	1345	20%
43	1350	12%
44	1355	6%
45	1400	12%
46	1405	4%
47	1410	4%
48	1415	4%
49	1421	2%
50	1426	3%
51	1430	3%
52	1435	3%
53	1445	0%

appendix C

EFFECTS OF POWER PLANT chlorination ON MARINE MICROBIOTA CRYSTAL RIVER SITE

University of Florida

Department of Environmental Engineering

Principal Investigator

Dr. Jackson L. Fox

Graduate Student

M. S. Moyer

INTRODUCTION

The Florida Power Corporation steam-electric generating plant near Crystal River, Florida uses approximately 650,000 gallons per minute of Gulf of Mexico water for condenser cooling. The continuous passage of productive estuarine water through the condenser tubes causes fouling of both the copper-nickel and the stainless steel tubes. The attached organisms, which have not been positively identified, cause two major problems: reduction in heat transfer efficiency and pitting. Pitting effects are most apparent on the stainless steel tubing. Both effects have obvious and serious economic implications.

In order to remove the fouling organisms from the tubes, a technique known as "condenser tube shooting" has been used. Solid plugs of various materials, such as plastic or rubber, are forced through the tubes using air pressure. While this procedure is temporarily effective, the organisms adhering tightly to the tube walls are probably not removed and act as seed for regrowth. Furthermore, this procedure does little to stop pitting.

To successfully remove the organisms, they must be killed. For this reason, chlorine, a powerful disinfectant, is added to the cooling water before it enters the condenser tubes. In most cases, chlorine is added as sodium hypochlorite. Such a system of control, combined with "condenser shooting," has been shown to effectively control the growth of marine organisms in condenser tubes. Such a system is presently in use at the Crystal River installation.

The toxicity of chlorine to a wide variety of organisms is well known. The environmental implications of large amounts of chlorine on marine and freshwater ecosystems, however, is not well-known. For this reason, the Florida Department of Pollution Control has justifiably placed a number of constraints upon the Florida Power Corporation's use of chlorine. The objective of this study is to meet two of the requirements for chlorination as set forth by the FDPC. These are: (1) to measure residual chlorine in the discharge area under various ambient conditions and (2) to study the direct and indirect effects of chlorinated cooling water on the quality of the receiving waters.

This report covers the results of two baseline studies conducted before chlorination was initiated. These were necessary in order to separate thermal effects from changes due to chlorine addition.

LITERATURE REVIEW

Past and present studies conducted to evaluate the total impact of cooling water discharges from power plants have been of two main types: laboratory evaluations and field studies. Field studies have been made to assess the effects of heat and the combined effects of heat and chlorine. The following summary of research on heated effluents will include only field work. A more extensive review of the literature will be submitted as part of the final report.

In one of the earliest studies conducted on a number of power stations in England, Markowski (1959) concluded that passage through the condensers of these stations, which were both coastal and freshwater, had "no detrimental effect on the organisms found."

Warriner and Brehmer (1966), from their field investigations made at the Virginia Electric and Power Company at Yorktown, Virginia, found that the primary production of the natural phytoplankton communities of the York River is enhanced by the artificial increase in water temperature during the winter months. However, if the temperature of the river water was above 15°C, they found that a temperature rise of 5.5°C always depressed primary production significantly.

In a study done at a power plant located at Chalk Point, on the Patuxent River estuary, Maryland, Morgan and Stross (1969) found that algae passing through the cooling system of the power plant were inhibited by an 8°C rise if the natural water was 23°C or warmer. Algae were stimulated, however, by the same input of heat if the ambient water temperature was 16°C or cooler. Another study at Chalk Point by Hamilton *et al.* (1970) showed that the primary production of cooling water may be reduced by as much as 91 per cent by chlorination. They also found that bacterial densities and concentrations of chlorophyll were reduced. In the absence of chlorination, they found that productivity was sometimes stimulated. Merriman (1970) is presently participating in a long-term study which is designed to determine the biological consequences of the heated effluent of the Connecticut Yankee Atomic Power Company into the Connecticut River. After five years of study, Merriman has concluded that "industrial heating in a major river of the northeastern U.S. has so far had no drastic biological consequences." He also feels that the levels of heating being experienced may even have beneficial long-range results.

Because of the overall importance of temperature to aquatic ecology and because of the projected need of electrical power by the beginning of the 21st century, more long-term studies are needed to predict more precisely the varied effects of heat and chlorine on marine and freshwater environments.

MATERIALS AND METHODS

The majority of past workers have examined phytoplankton at the influent and at the discharge in order to determine the "shock" effect of the increased temperature upon the organisms as they pass through the condenser tubes. Unfortunately, it is difficult to determine the viability of the organisms visually. For this reason, we have included a wide variety of parameters in an effort to determine, both directly and indirectly, the viability of the organisms and any changes in their metabolic rate and biomass.

Sampling stations were chosen in an effort to determine the immediate effects of the addition of the chlorine on the organisms and the changes which may occur as the organisms are flowing down the canal.

Figure 1[1] shows the sampling stations. Station 1 is in the center of the intake canal just south of the cyclone screen. Station 2 is in the center of the discharge canal and slightly west of the Unit 1 discharge. This station was chosen as being representative of the thoroughly mixed discharge water from both units. Stations 3, 4, and 5 are located at ½ mile intervals down the discharge canal. Station 5 is located adjacent to the boat ramp, on the frame used by the Florida Department of Natural Resources. Station 6 is located ½ mile to the north of the navigational light on the end of the south bank of the discharge canal. This station was chosen as being representative of shallow, estuarine water. Also, the flow of heated water has been shown to travel in a northerly direction after leaving the discharge canal.

1. Figure and Tables are shown on pp. 42 through 57.

The first baseline study was performed on April 28, 1971. Since only Unit 1 was in operation at that time, it was necessary to repeat the study at a time when both units were in operation. The second baseline was run on June 4, 1971. The table below shows the number of "sample runs" made during the two baseline studies and the total time taken to sample all stations. A run consisted of sampling Stations 1 through 6. In order to make more than one run in a day, some time overlap was necessary.

	Sample Runs	Time
April 28	A	9:00 A.M. – 12:15 P.M.
	B	1:30 P.M. – 3:15 P.M.
	C	4:55 P.M. – 6:40 P.M.
June 4	A	8:25 A.M. – 11:20 P.M.
	B	12:30 P.M. – 5:05 P.M.

Analyses were performed at three locations: (1) on board the sampling vessel (2) in the trailer-laboratory (3) in the Department of Environmental Engineering laboratories at Gainesville. In the following section, the collection methods and analytical techniques for the parameters used are described. When necessary, the purpose for choosing a parameter is also explained.

The baseline parameters are as follows:

1. **Temperature and dissolved oxygen:** These were measured on board the vessel using an instrument (YSI) equipped with an electronic oxygen probe and a thermistor thermometer. Temperatures were taken at a depth of 1 foot. Occasionally, deeper recordings were taken to see if wide variations occurred with depth. They did not. Since oxygen is less soluble at higher

temperatures, measurements were made to ascertain whether or not dissolved oxygen was sufficient to support marine life.

2. **Total bacterial populations:** A 75 ml sterilized screw-top test tube was used to collect about 35 ml of water just below the water surface. A sterile glove was used to avoid contamination from the hand. In the trailer laboratory, the sample was serially diluted and millipore filtered. The filter was placed on a pad soaked with a medium consisting of Bacto gelatin, BBL phytone, yeast extract, and ½ strength artificial sea water.[2] The composition of artificial sea water was as follows:

$NaCl$ — 1.2%
KCl — 0.035%
$MgCl_2 \cdot 6H_2O$ — 0.265%
$MgSO_4 \cdot 7H_2O$ — 0.35%

The filters were returned to Gainesville, incubated at room temperature, and counted at 48 and 96 hours. Spread plates were also made using the same medium described plus agar for solidification. Incubation times and temperature were identical. Bacterial counts were determined because it was felt that these organisms would be among the most sensitive to chlorine additions.

3. **Chlorophyll a:** Chlorophyll **a** is the green pigment common to almost all photosynthetic plants, including algae. Chlorophyll measurements are used to estimate biomass and also gives an indication of the relative viability of phytoplankton populations. For the analysis of chlorophyll, 750 ml of sea water was collected in a 1 liter plastic bottle and returned to the trailer laboratory. There, 750 ml were millipore filtered. The filters were placed in a dessicator and returned to Gainesville, where the chlorophyll was extracted with 90 per cent acetone. Spectrophotometric readings were made at 665, 630, and 645 millimicrons. The formulae of Parsons and Strickland (1963) were used to calculate the amount of chlorophyll **a**.

4. **Primary productivity:** This procedure measures the rate of photosynthesis (net and gross) of planktonic populations. The carbon-14 method of Strickland and Parsons (1960) was used.[3] Basically, this method consists of adding 5 microcuries of C-14 labeled sodium bicarbonate to 300 ml of sea water. Two bottles were used: one clear and one taped to exclude sunlight. The two bottles were filled, injected with C-14 and suspended on buoyed polyvinyl rods at each station for approximately 3½ hours. During photosynthesis in the light bottle, algae take up labeled bicarbonate. In the dark bottle, organisms other than algae may do the same. Algae do not photosynthesize in the dark. After incubation, the bottles were returned to the trailer laboratory, where 50 ml from each were millipore filtered and placed in a dessicator. Upon their return to Gainesville, the filters were gamma counted on a Geiger-Meuller counter and the counts converted to milligrams carbon fixed per cubic meter of water per hour. Dark bottle counts were subtracted from light bottle counts to correct for non-algal carbon fixation.

5. **Weights:** One liter of surface water was collected in a plastic bottle and returned to Gainesville. There, total solids were determined by evaporation of 50 ml and suspended solids by filtration of 500 ml with a Reeve Angel glass fiber filter (Grade 934AH).

6. **Adenosine triphosphate (ATP):** ATP is an energy yielding compound present in living organisms. It dissipates rapidly upon death. Since microscopic counts fail to accurately reflect the state of the total "health" of the community, ATP is used as both an indicator of viability and biomass. Samples of water were collected from each station and brought back to the trailer laboratory where 750 ml were filtered through a millipore filter (pore size of 0.8 microns). The filters were then immediately immersed in boiling tris-buffer for ten minutes. This procedure kills the organisms present and extracts the ATP quantitatively. The solutions were then frozen. Upon returning to Gainesville, the bottles were brought up to a volume of 10 ml with tris-buffer. After

2. All bacteriological media preparations are according to the advice of Dr. M. Tyler, Chairman of the Department of Microbiology, University of Florida.

3. Total alkalinity and pH, necessary supporting parameters for the determination of primary production, were also performed according to the methodology of Strickland and Parsons (1960).

thorough mixing, aliquots were centrifuged to bring down cell debris and the supernatant poured into a test tube.

A liquid scintillation spectrometer (Packard Tri-Carb Model 2002) was used to measure light emission caused by the addition of a mixture of luciferin-luciferace to our unknown quantity of ATP. Photon emissions were converted to micrograms ATP per liter using previously prepared standard curves.

7. **Secchi Disc:** The secchi disc is a flat, circular piece of metal or weighted wood attached to a metered line. The surface is divided into black and white quadrants. To read, the disc is lowered until it disappears from view. A measurement is made at this point. It is then raised until it becomes visible. The reading made at this point is averaged with the previous reading for a final value. Secchi disc readings give a rough estimate of turbidity.

8. **Phytoplankton and zooplankton:** These data are not yet available and will be presented shortly as a separate report.

RESULTS AND DISCUSSION

In order to avoid confusion, the results are presented in two sections. The sections and the subjects covered under each have been designated as follows:

- A. Physical
  1. Temperature
  2. Dissolved Oxygen
  3. Total Solids
  4. Suspended Solids
  5. Secchi Disc Readings
- B. Biological
  1. Primary Productivity
  2. Chlorophyll **a**
  3. Bacteria
  4. ATP

PHYSICAL RESULTS

Temperatures and dissolved oxygen values for both baseline studies are shown in Figures 2 and 3. In April (Figure 2), the temperature of the intake water (Station 1) was 24.3, 27, and 27°C for the three runs. Temperature rise through the condensers, as reflected by Station 2 results were 6.7, 5, and 6°C for runs A, B, and C. Temperature changes were insignificant down the canal (Stations 3–5). At Station 6, the temperature approximated those recorded at Station 1 earlier in the day. The greatest difference between temperatures at 1 and 6 was 2.7°C during run A. This is due to normal diurnal fluctuations, for Station 1 was sampled at 9:00 A.M. and Station 6 at 12:15 P.M. If one looks at run B, it can be seen that the intake water temperature reached 27°C by 1:30 P.M., exactly the same temperature as recorded at Station 6 during run A.

During June, the same general trends were observed. As expected, intake water temperatures were higher than in April. At 8:25 A.M., the water at Station 1 was 27°C and at 12:30 P.M. had risen to 27.5°C. April temperatures taken at about the same time at Station 1 were 24.3 and 27°C. Temperature rises through the condensers in June were 5.5 and 6.5°C for runs A and B. These figures are not significantly different from those found in April. Again, temperature changes throughout the canal were insignificant, with the greatest difference between Stations 2 and 5 being 1.5°C. The maximum temperature reached during June was 34.5°C (94.1°F) at Station 5 during run B. Station 6 temperatures never returned to levels recorded at Station 1.

As expected, dissolved oxygen changes were inversely proportional to temperature fluctuations. Values never reached dangerously low levels, with the minimum value recorded being 6.3 ppm on June 4 at Station B–5. In April, values were always higher than 7.7 ppm. Surprisingly, D.O. did not consistently drop from Station 1 to 2.

In most cases, the change in D.O. from Station 1 to 2 was slight, except during the C run on April 28, when a decrease of .8 ppm was recorded. The turbulence caused by the force of the effluent probably causes enough re-aeration to offset the decrease in oxygen solubility due to increased temperatures.

The results of the weight determinations and the Secchi disc readings are shown in Table 1.

Total solids and suspended solids exhibited extreme variability with no obvious trends. Furthermore, no correlation could be found between these two parameters or between these parameters and other results. The rationale for choosing solids determinations as parameters was based on the supposition that dying and dead organisms, killed as a result of heat shock, would settle to the bottom and thus diminish the solids content of the water. The occurrence of such a phenomenon is not supported by our findings. The only conclusion that can be drawn from this data is that heat does not radically affect either the total or suspended solids. Perhaps when chlorination is underway, more obvious changes will be found.

During four of the five runs, a drop in Secchi disc readings was noted between Stations 1 and 2. Due to the subjectivity of this parameter and the lack of correlation between it and the solids results, no concrete conclusions can be drawn from these rather insignificant changes.

BIOLOGICAL RESULTS

Baseline primary productivity values are shown in Figures 4 and 5. As other studies have suggested, the amount of change in the activity of photosynthetic forms due to a temperature increase caused by passage through condensers is dependent upon the intake water temperature. Our results strengthen this hypothesis. As the figures show, there was a decrease in productivity from Stations 1 to 2 when the intake temperature was 27°C or greater. The percentage decrease varied from 13.8–48.1. This occurred during four of the five sampling runs. The only instance of an increase in primary productivity from Station 1 to 2 was in the morning run on April 28th when the intake temperature was 24.3°C. This was an 8.2 per cent increase. The productivity values at all remaining stations during this morning run remained higher than the intake value. At no station was a temperature higher than 31.5°C recorded. The value at Station 5 represented a 42.7 per cent increase over the primary production value at Station 1.

During all other runs, primary production values were lower at Station 2 than at Station 1. Furthermore, these values remained as low as or lower than Station 2 values until the water temperature reached 32°C or lower. Apparently, there were two critical temperatures influencing primary production during our studies. To summarize: If the intake temperature is 27°C, or above, there is a loss in primary production by a temperature increase of as little as 5°C. As long as the temperature remains above 32°C, primary production values will continue to drop.

The results of the chlorophyll **a** studies are shown in Figures 6 and 7. Increased temperature had a varying effect on the amount of chlorophyll present in the samples. This effect seemed to depend upon the time of day. In the morning runs of April 28th and June 4th, Chlorophyll **a** decreased by 5.55 and 21.5 per cent from Stations 1 to 2. In all three afternoon runs, chlorophyll **a** increased from Stations 1 to 2. There seems to be no apparent reason for this observed phenomenon. Studies designed to determine whether or not the observed changes are statistically significant are currently underway.

During four of the five runs, ATP values (shown in Figures 8 and 9) increased from Stations 1 to 2. The exception occurred during run B on June 4. At that time, the drop observed was slight, but continued down the canal. During this sampling run, the intake temperature was the highest recorded (27.5°C) and the canal temperatures were also the highest recorded for any run. It was during this run that the maximum temperature of 34.5°C was measured at Station 5.

ATP, as measured at Station 1, showed a definite diurnal fluctuation, with values rising as the day progressed. While ATP varied considerably down the canal, most Station 5 values approximated Station 1 levels, indicating no long-lasting effects of heat on ATP values. Run C (April 28) was an exception in that ATP at Station 5 was considerably below the Station 1 value. This same phenomenon was also noted in the bacterial populations.

The largest response due to an increase in temperature is evident in the bacterial populations. In the following discussion, the figures cited will be the results of the millipore filter method following a 48-hour incubation. This method was chosen because of the greater chance of contamination in the spread plate procedure. The range of bacterial counts at the stations varied from 69–3100 organisms per ml. Figures 10 through 14 show these changes. Figures 15 through 19 are the spread plate results and are included as supplementary information. In all cases except the late afternoon run of April 28th, when bacterial populations declined throughout the canal, condenser tube passage stimulated bacterial growth. The percentage increases from Stations 1 to 2 varied from 45.5 to 550 per cent. The greatest increase was noted when temperature changes from Stations 1 to 2 were the lowest (+5.0 and +5.5°C). A temperature increment of 6.5°C and over did not appear to have as great a stimulatory effect. In general, the bacterial populations experienced continued growth as they passed down the canal.

SUMMARY

The results of these two baseline studies indicate tnat micro-organisms are affected by passage through the condenser tubes. There were both stimulating and inhibiting effects noted. In general, the parameters measured at the end of the canal (Station 5) did not differ significantly from values measured at the intake canal.

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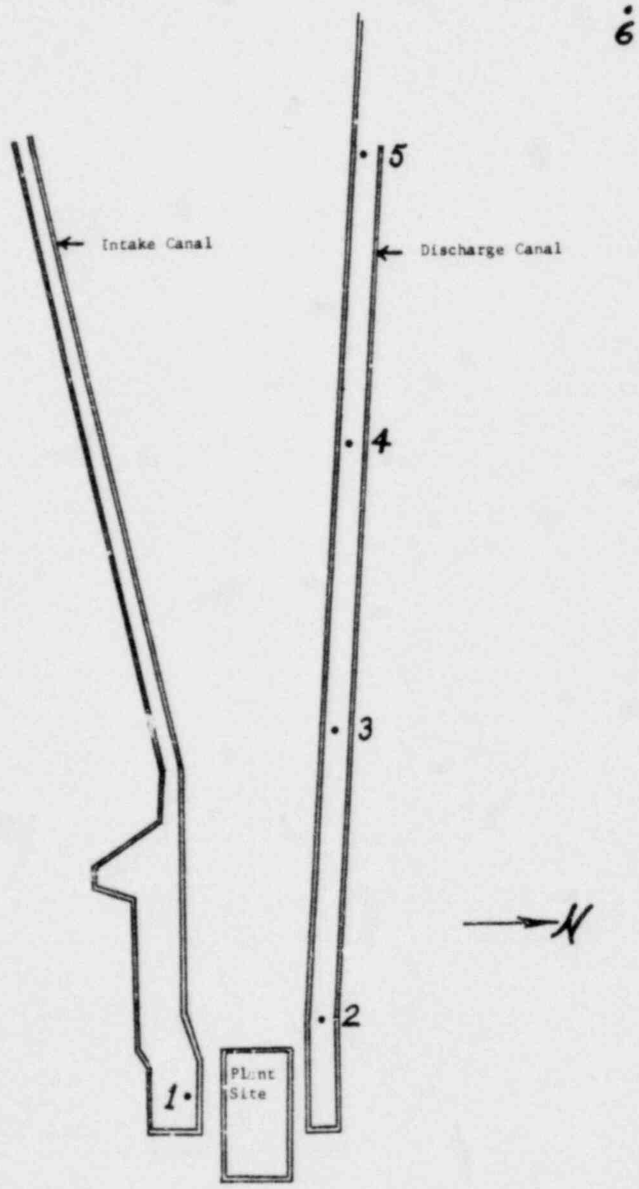

Figure 1. Station Locations

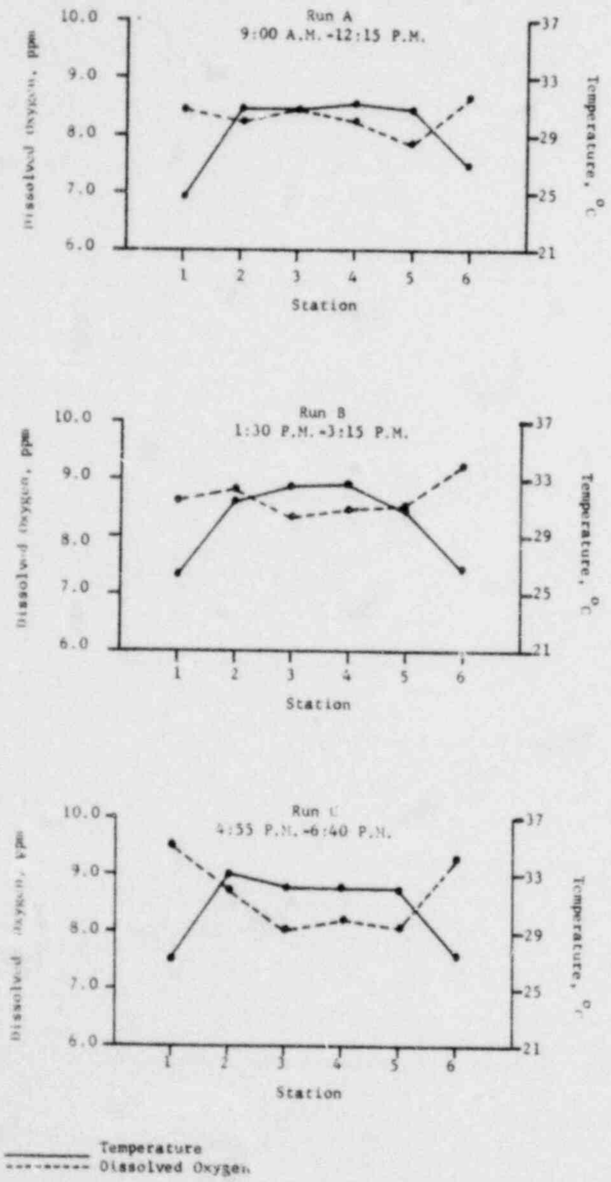

Figure 2
Temperature and Dissolved Oxygen Values, April 28, 1971

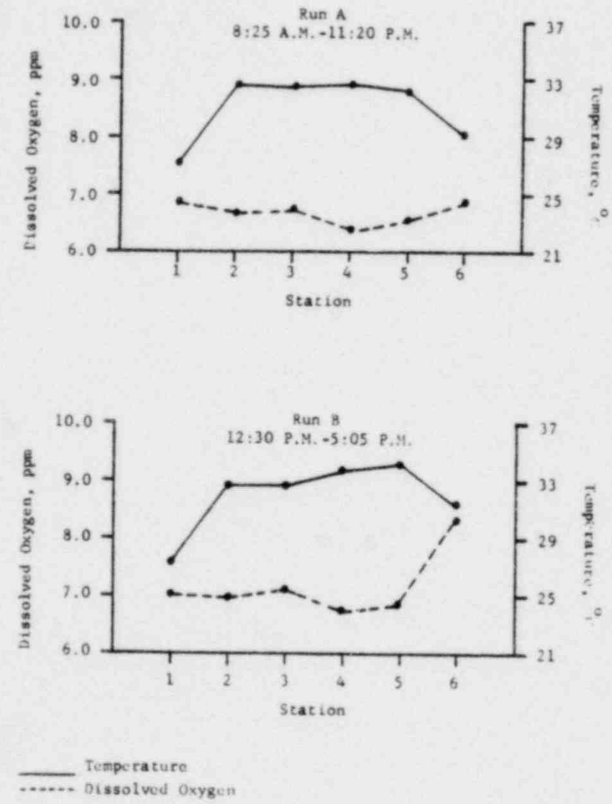

Figure 3
Temperature and Dissolved Oxygen Values, June 4, 1971

Table 1. Baseline variations in total solids, suspended solids, and secchi disc readings.

	APRIL 28, 1971			JUNE 4, 1971		
Station	Total Solids (mg/1)	Suspended Solids (mg/1)	Secchi Disc (meters)	Total Solids (mg/1)	Suspended Solids (mg/1)	Secchi Disc (meters)
A–1	22,914	4.2	1.5	25,080	10.0	1.1
A–2	23,158	6.8	1.0	25,126	13.2	.9
A–3	25,966	8.2	1.0	24,878	9.4	1.0
A–4	23,742	7.0	1.0	25,342	13.2	1.0
A–5	21,678	4.6	1.1	25,302	7.6	.9
A–6	20,842	9.6	1.0	23,404	7.6	1.2
B–1	21,460	11.0	1.0	25,130	5.4	1.5
B–2	21,554	10.8	1.0	25,160	10.2	.9
B–3	21,636	12.0	1.1	25,258	8.2	.9
B–4	22,530	12.6	1.0	25,152	10.0	.9
B–5	22,694	13.0	1.0	25,374	9.0	.9
B–6	23,422	16.6	.8	21,808	11.0	1.2
C–1	21,248	14.0	1.3			
C–2	21,400	11.8	1.1			
C–3	21,982	10.2	1.0			
C–4	21,814	12.0	1.0			
C–5	21,616	16.0	1.0			
C–6	20,484	10.2	1.0			

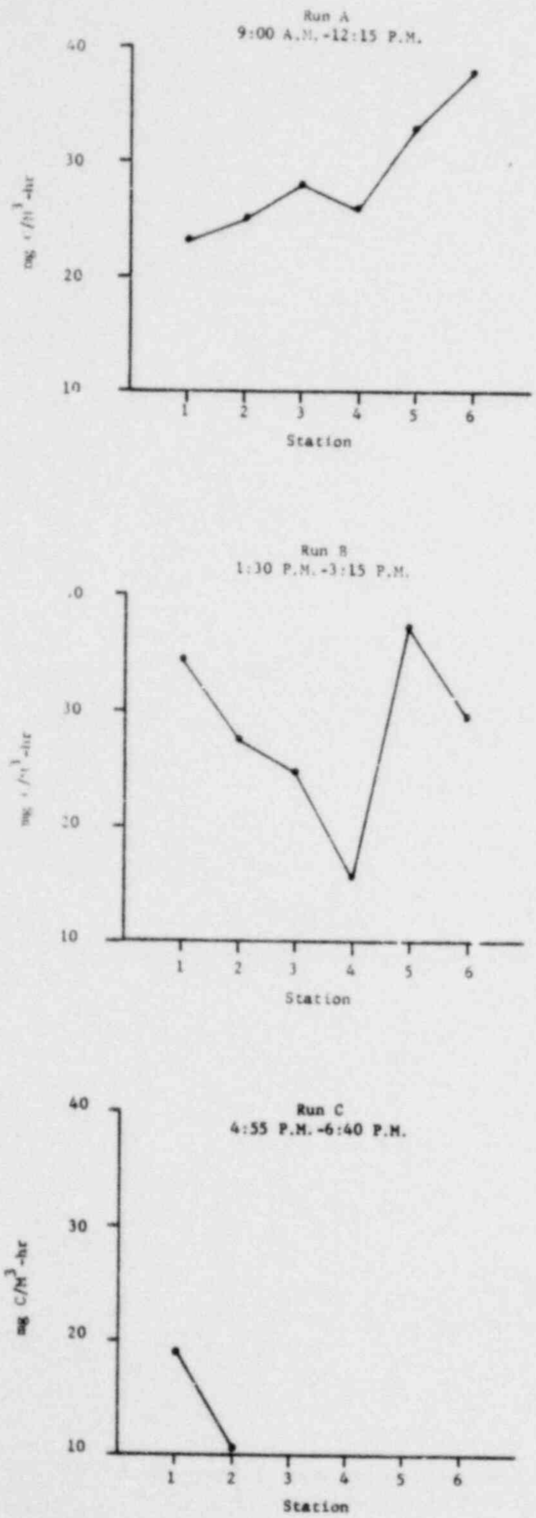

Figure 4. Primary Productivity Values, April 28, 1971

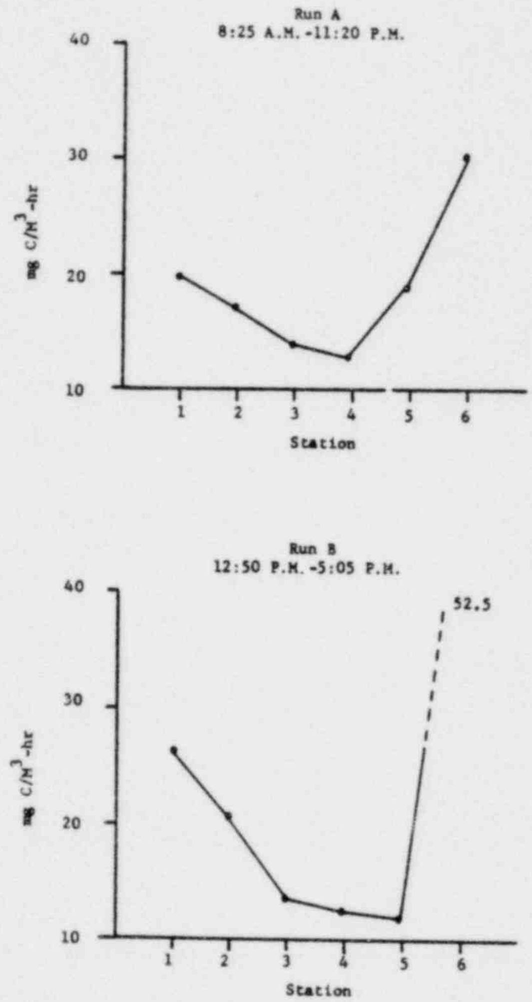

Figure 5. Primary Productivity Values, June 4, 1971

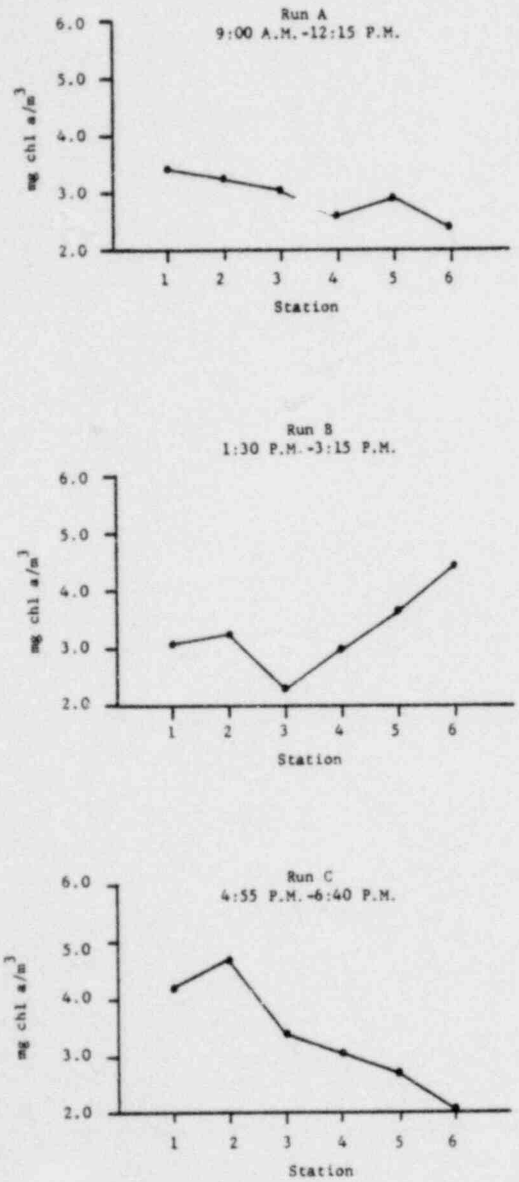

Figure 6. Chlorophyll a Values, April 28, 1971

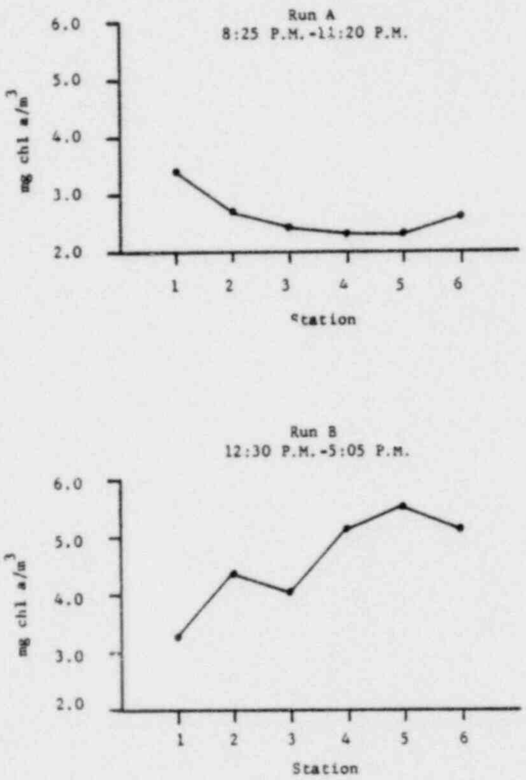

Figure 7. Chlorophyll a Values, June 4, 1971

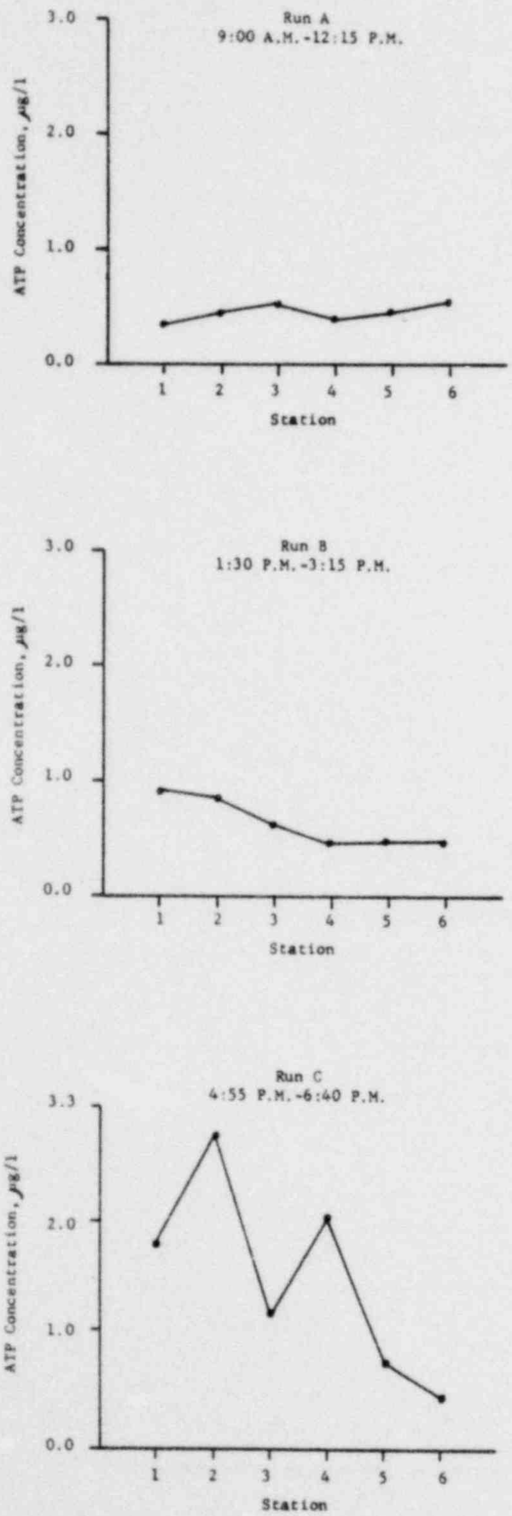

Figure 8. ATP Values, April 28, 1971

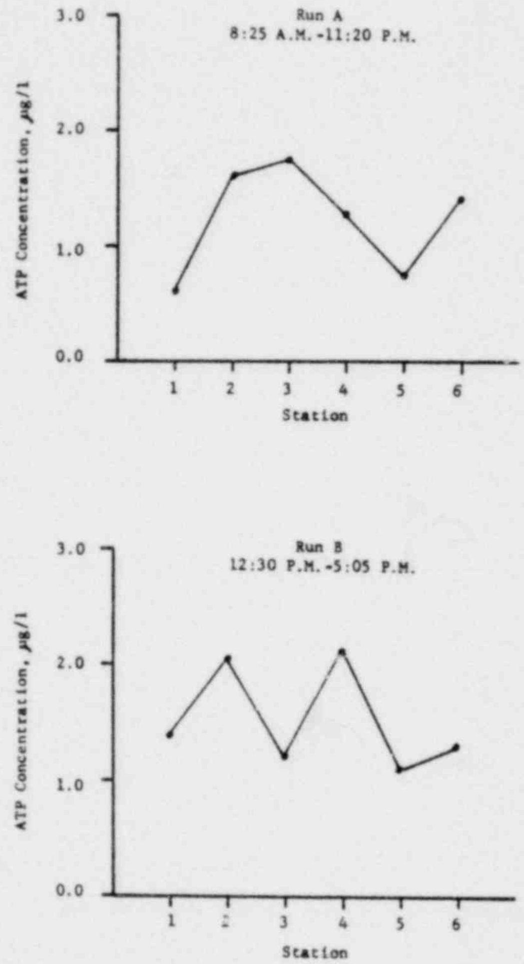

Figure 9. ATP Values, June 4, 1971

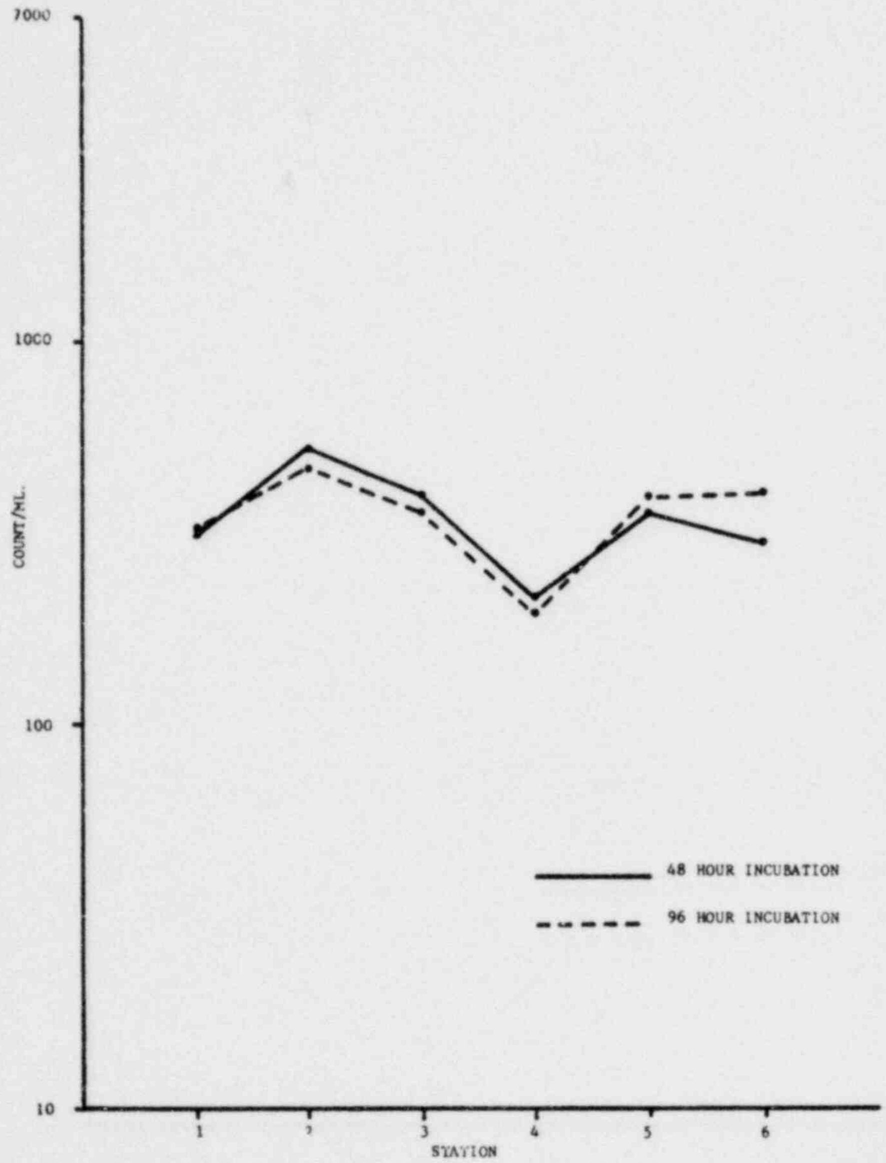

Figure 10. Total Bacterial Counts. Millipore Filter Method. April 28, 1971. 9:00 A.M.

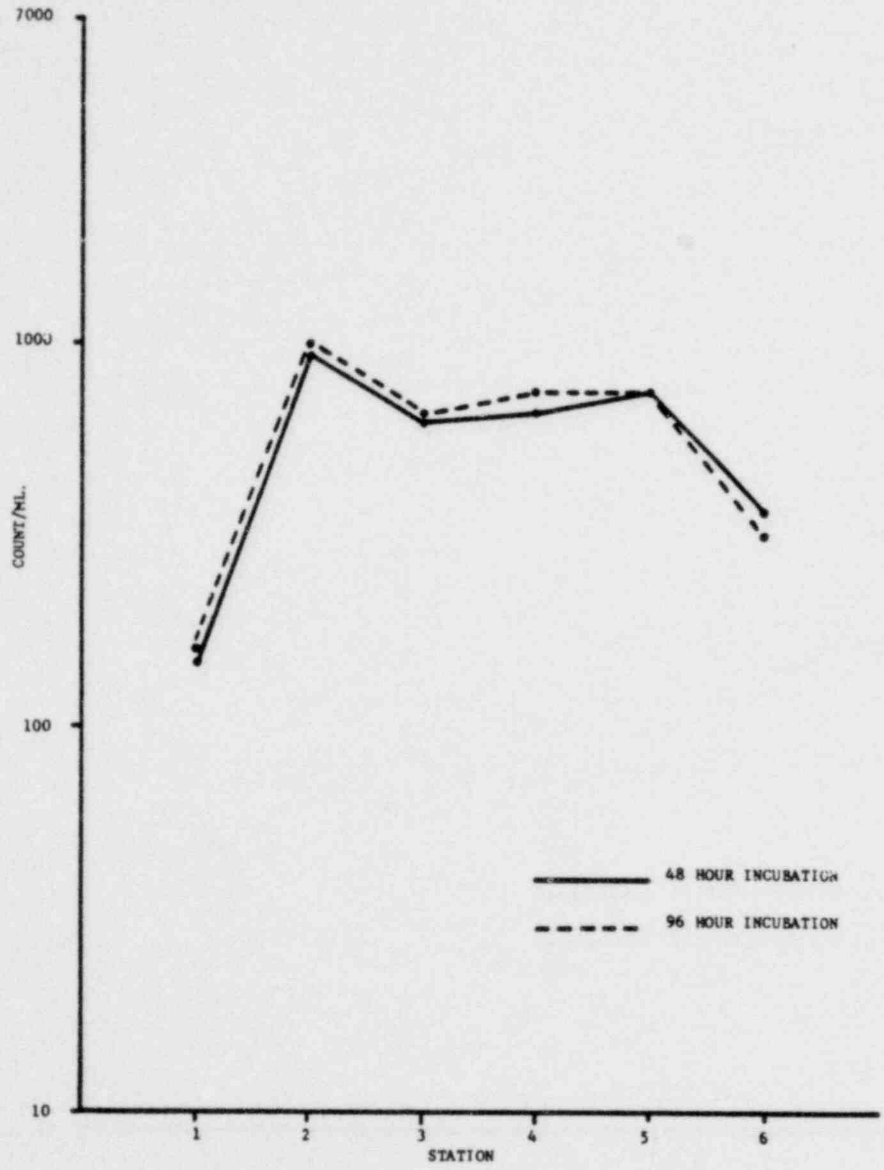

Figure 11. Total Bacterial Counts. Millipore Filter Method. April 28, 1971. 1:00 P.M.

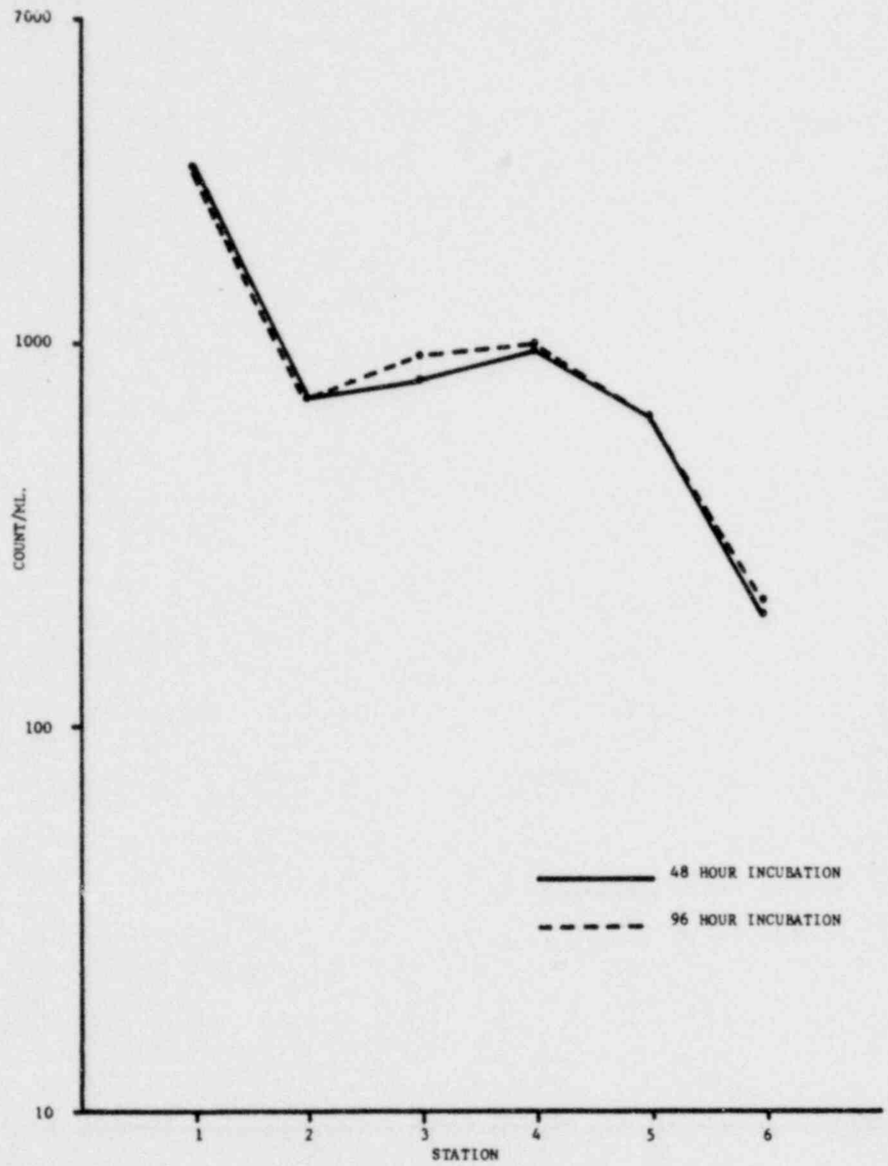

Figure 12. Total Bacterial Counts. Millipore Filter Method. April 28, 1971. 5:00 P.M.

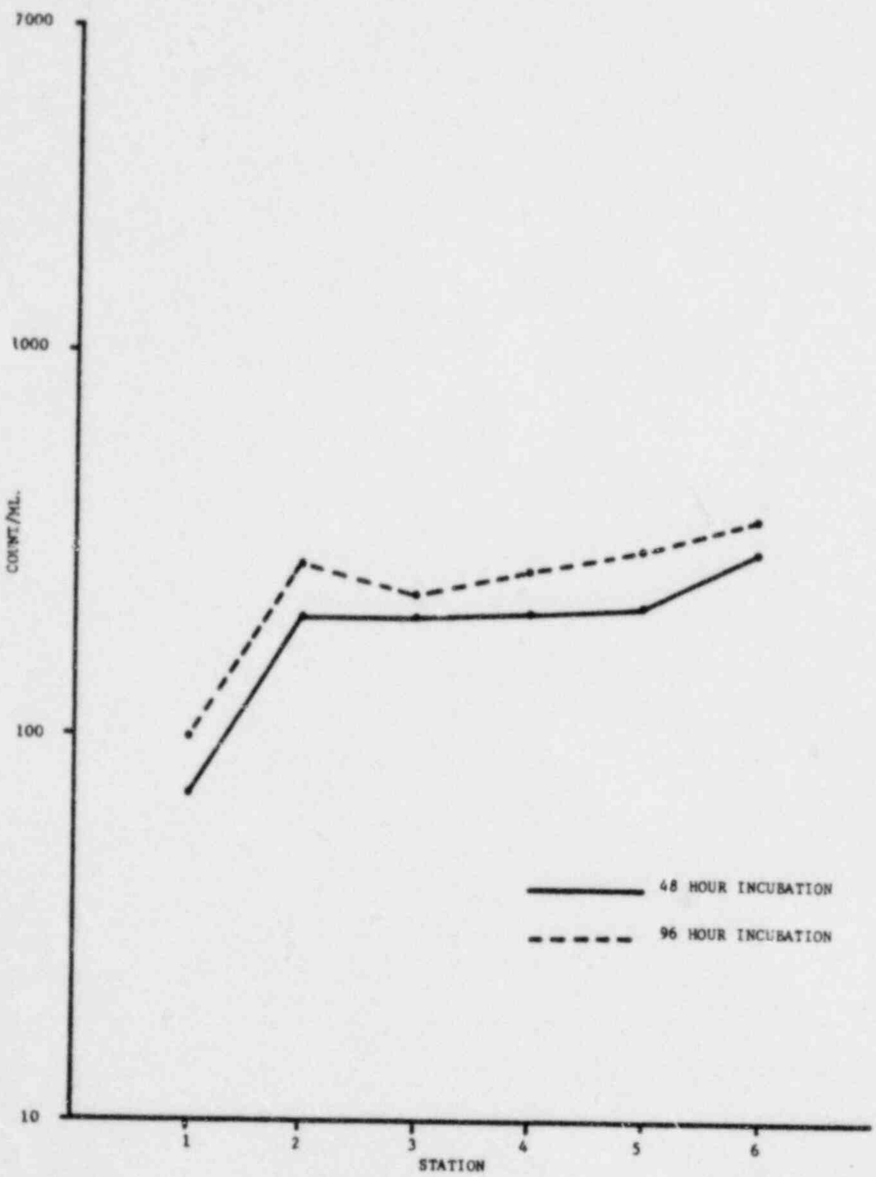

Figure 13. Total Bacterial Counts. Millipore Filter Method. June 4, 1971. 8:25 A.M.

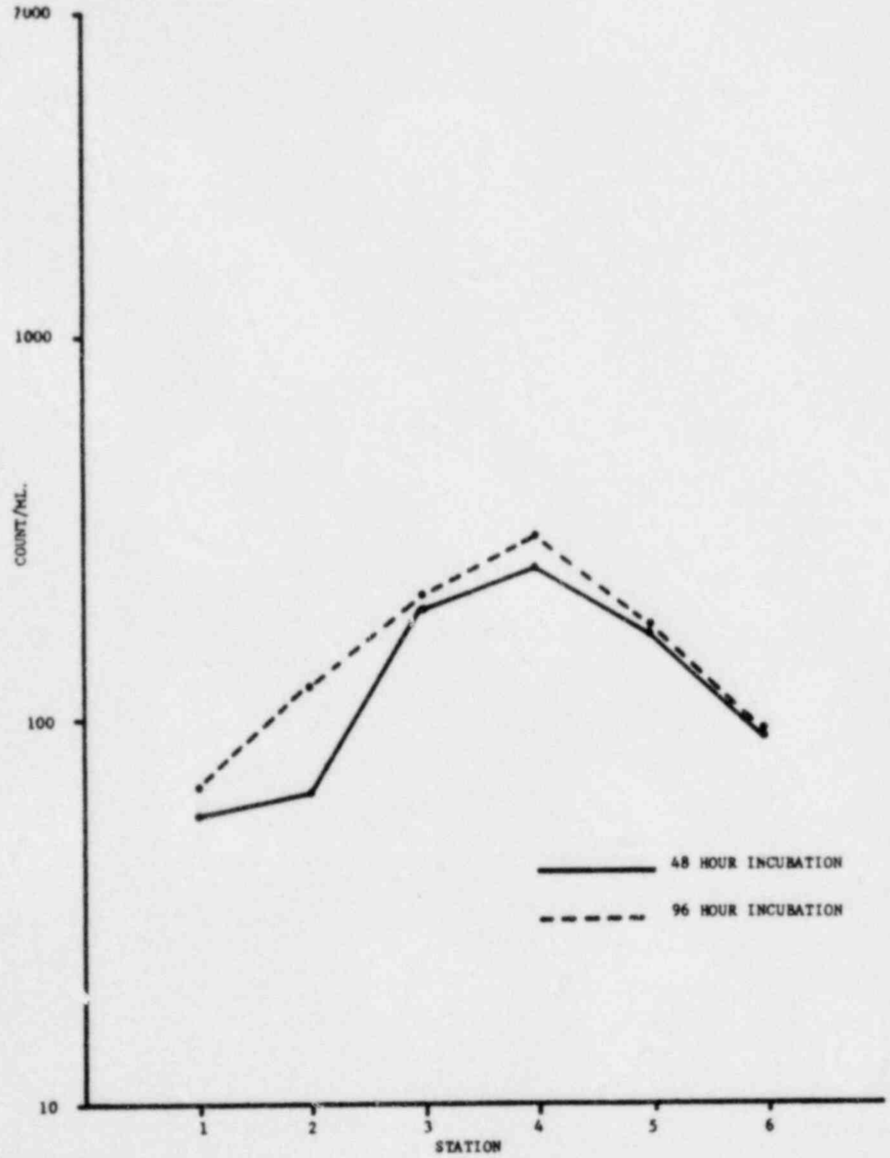

Figure 14. Total Bacterial Counts. Millipore Filter Method. June 4, 1971. 12:30 P.M.

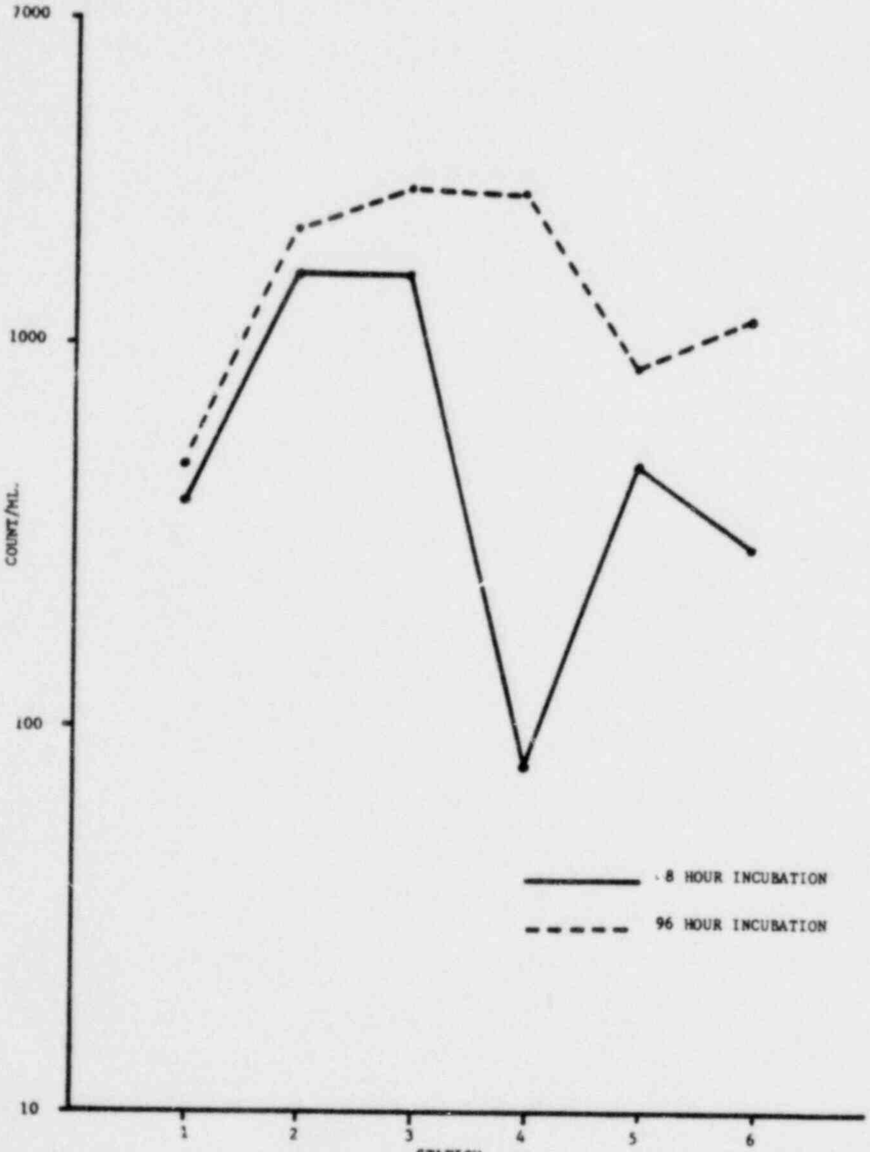

Figure 15. Total Bacterial Counts. Spread Plate Method. April 28, 1971. 9:00 A.M.

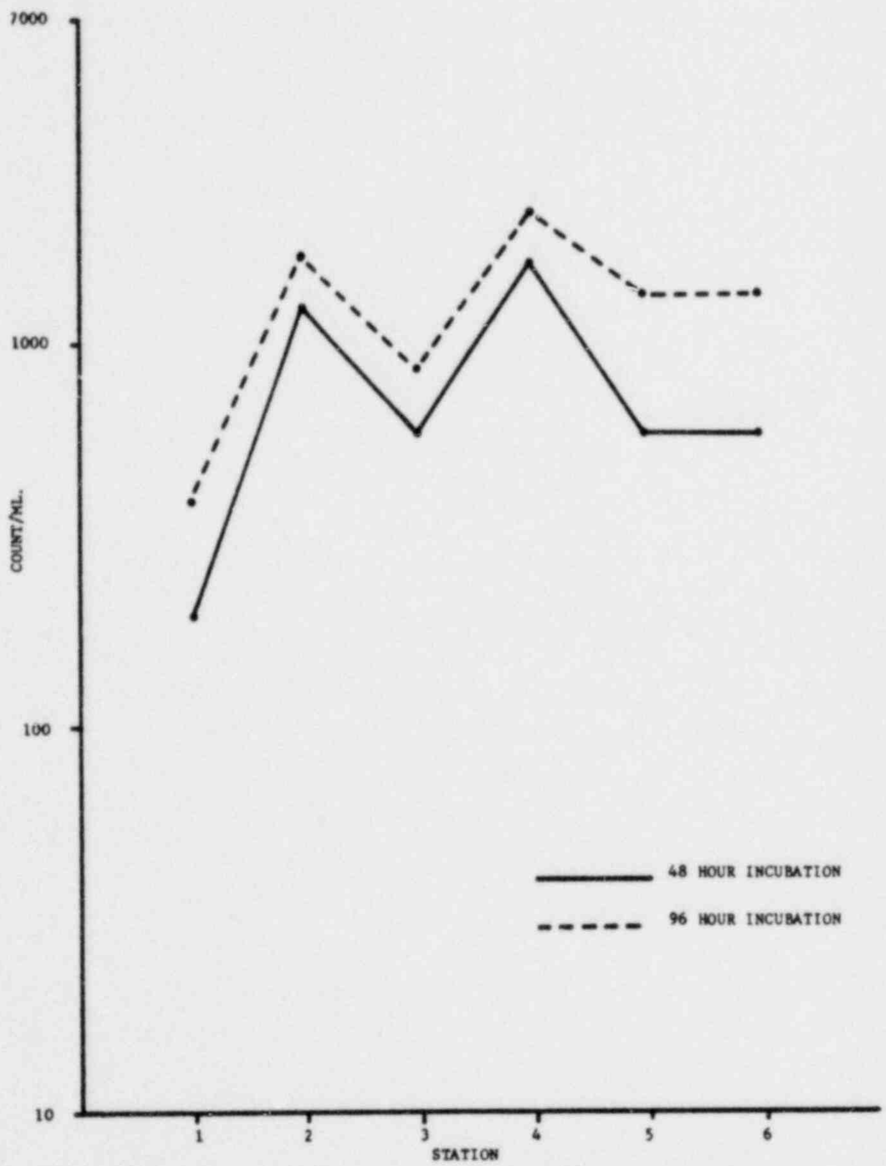

Figure 16. Total Bacterial Counts. Spread Plate Method. April 28, 1971. 1:00 P.M.

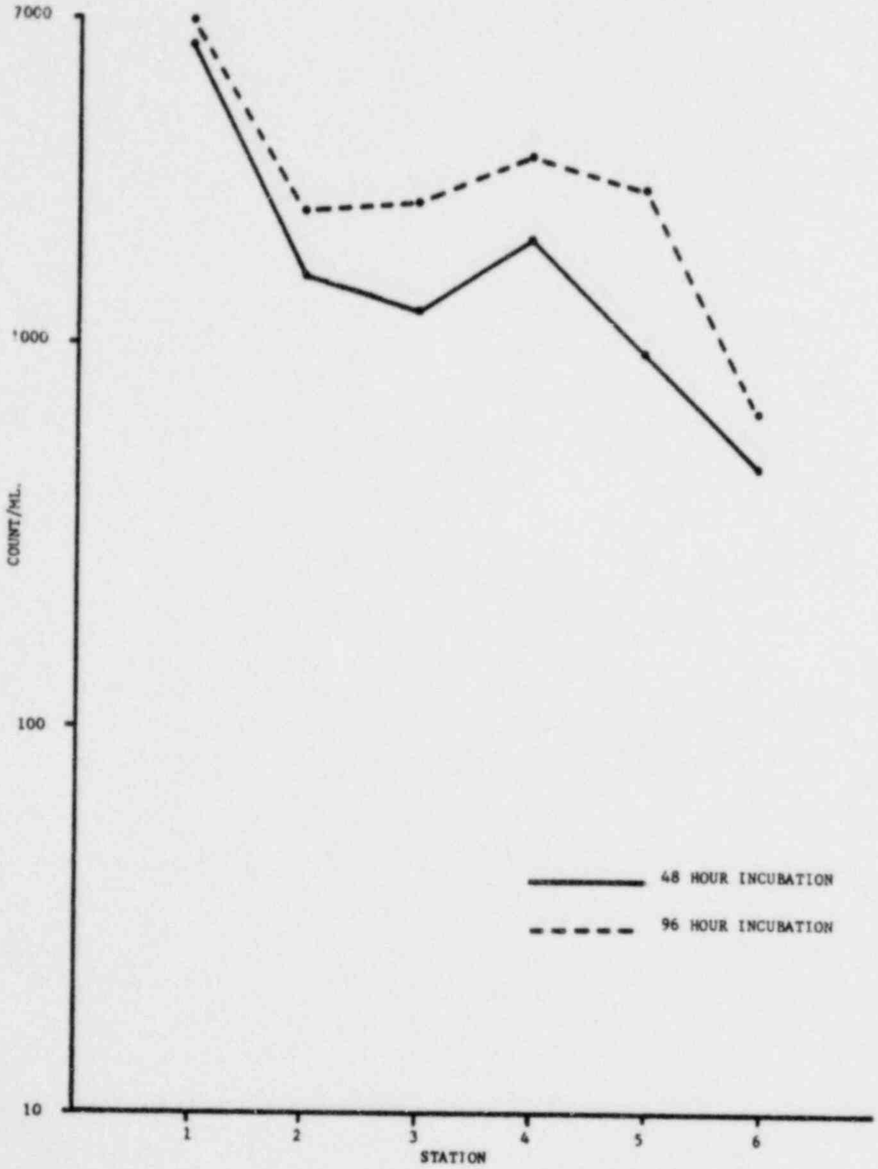

Figure 17. Total Bacterial Counts. Spread Plate Method. April 28, 1971. 5:00 P.M.

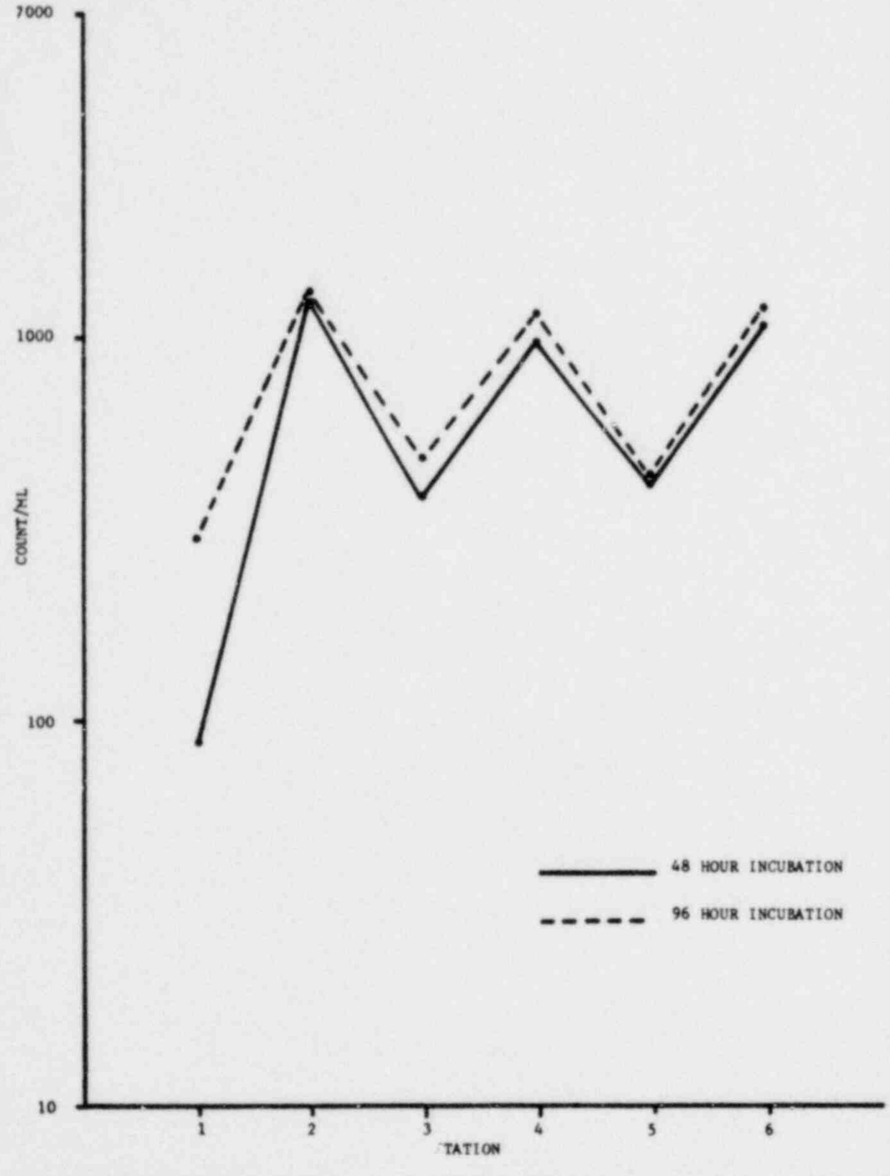

Figure 18. Total Bacterial Counts. Spread Plate Method. June 4, 1971. 8:25 A.M.

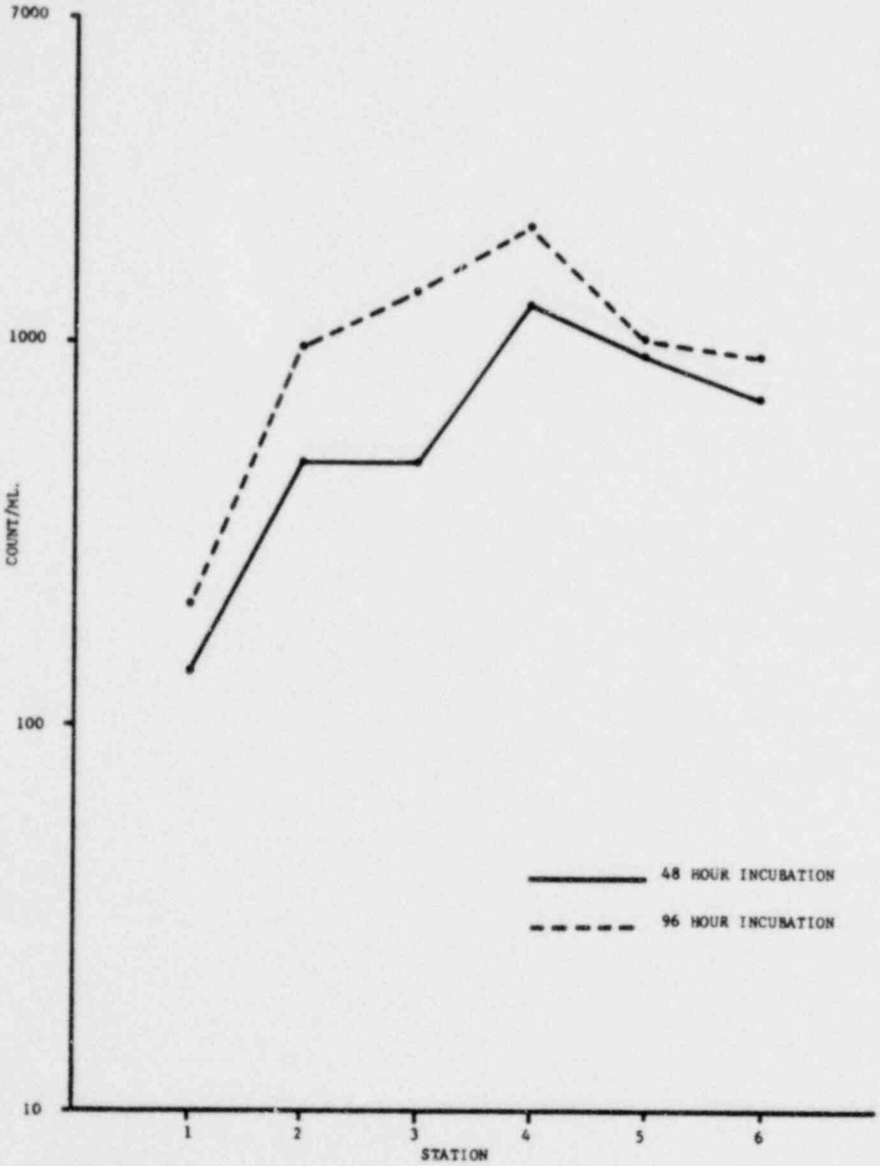

Figure 19. Total Bacterial Counts. Spread Plate Method. June 4, 1971. 12:30 P.M.

appendix d

environmental

SURVEILLANCE FOR RADIOACTIVITY IN THE VICINITY OF THE CRYSTAL RIVER NUCLEAR POWER PLANT: AN ECOLOGICAL APPROACH

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PROGRESS REPORT

Marine and Marshland Sampling

Sampling areas were the same as those established and shown in the **Environmental Status Report:** January, February, March, 1971. The data for these collections are given in Table 1.* Refer to the section "Gamma Analysis of Samples from Marine Reconnaissance Trips" in the January–March, 1971 **Environmental Status Report** for a detailed description of the format and symbols.

Inventory of Marine Fishes

A literature search has been made and a tentative checklist compiled of marine fishes thought to be found in the area from Cedar Key to Crystal River. The list will be updated as more information becomes available.

Marshland and Terrestrial Sampling

Table 4 (Status Table of Marshland and Terrestrial Sampling) previously published in the January-March, 1971 **Environmental Status Report** lists 49 samples, 15 of which had been submitted for gamma scans. Table 2 of this report summarizes these 15 analyses. The results as presented are preliminary, since the laboratory routine had not been systemized at the time of receipt of the samples. The raw data has been received and updated for resubmission to the computer. The six radionuclides in the preliminary matrix were ^{40}K, ^{226}Ra, ^{232}Th, ^{137}Co, ^{95}Zr, and ^{106}Ru.

Freshwater Sampling

During the winter quarter 1970–71, the sampling network was expanded to include the Crystal River and the Withlacoochee River. (See **Environmental Status Report,** January–March, 1971.) The results presented in Table 3, herein, combine samples taken during the initial reconnaissance trip and the first sampling expedition.

Thermoluminescent Dosimetry

TLD-100, (⅛" x ⅛" x 0.035") high sensitivity, LiF dosimeters have been used to monitor the gamma air dose in the area. At each location, 4 dosimeters were encased in a lucite, build-up casket and suspended 3 feet above ground. Exposures will be for a period of one month. The reader system will be a Harshaw 2000 TLD system with a high sensitivity photomultiplier tube and stainless steel planchets flushed with dry nitrogen.

Fifteen sampling sites have been established. Figure 3 (page 56) in the **Environmental Status Report:** January–March, 1971, illustrates their deployment in the area of the power plant site. The first set of data is listed in Table 4, herein, and covers the period February 23, 1971 through March 23, 1971.

The data from all sites, except number 10, range between 4·0 mR and 11·4 mR, normalized to a 30-day period. This corresponds to a yearly range of from 48 to 136 mR and compares favorably with levels that might be expected at sea level.

Site number 10 is located at the northeast corner of the Crystal River Units 1 and 2 transmission line switching yard (north side of the discharge canal). This dosimeter has recorded radiation levels some two to six times higher than the other dosimeters. Investigations are underway to determine if this reading is valid and if there is some material present causing this phenomena.

Tritium Network

Subsequent to the publishing of first quarter progress in the January–March, 1971, **Environmental Status Report,** a letter was received from the Analytical Quality Control Service, Environmental Protection Agency, Winchester, Massachusetts, which pointed out an error in the activity of the tritium standard received from that service. The corrected values for the tritium concentrations in samples taken October 13, 1970 and reported in Table 6 of the previous quarterly report are presented in Table 5 herein. The letter also noted the latest estimate for the half life of tritium as 12·262 years rather than the earlier 12·24 years.

*Tables are shown on pp. 62 through 68.

TABLE 1. GAMMA ANALYSIS OF MARINE SAMPLES, WINTER QUARTER 1970–71

(Table continues through page 65)

Lab. Number	Date Collected	Location	Description	Size (kg)	K(K-40) (g/kg)	Ra-226 pCi/kg	Th-232 pCi/kg	Cs-137 pCi/kg	Others pCi/kg	Comments
277L	12/6/70	Area A – Offshore	Water	3.59	0.23± 0.14					K-40 only radionuclide identifiable
278L	12/6/70	Area B – Offshore	Water	3.45	0.44± 0.14					K-40 only radionuclide identifiable
280L	12/6/70	Area C – Offshore	Water	3.46	0.21± 0.14					K-40 only radionuclide identifiable
282L	12/6/70	Area A – Offshore	Sediment	3.78	0.24± 0.20	5600± 370	62± 26		Zr-95 16± 4 Ru-106 320± 70 Ce-144 560± 180 Mn-54 14± 12	Dry weight basis
311A	12/15/70	Area B – Offshore	Sediment	3.18	1.07± 0.23	5300± 410	155± 32	37± 34	Zr-95 39± 5 Ru-106 570± 86 I-131 36± 26 Ce-144 920± 210	Dry weight basis; 44% moisture
310A	12/15/70	Area C – Offshore	Sediment	3.65	0.58± 0.18	2700± 310	100± 25	42± 26	Zr-95 27± 4 Ru-106 360± 67 I-131 52± 20 Ce-144 1100± 160	Dry weight basis; 39% moisture
316A	12/15/70	Area A – Offshore	Plankton		43± 35			470[illegible] 46[illegible]	Zn-65 99± 86	Dry weight basis; 99% moisture
285L	12/6/70	Area A – Offshore	Algae	0.238	35± 2.6		650± 320			Dry weight basis
302L	12/16/70	Area B – Offshore	Algae	0.248	17± 2.1			800± 240	I-131 350± 190 Ce-144 3700± 1500	Dry weight basis; 83% moisture; Ce-144 quantity questionable
286L	12/6/70	Area C – Offshore	Algae	0.230	44± 2.9	8600± 3900	870± 340	330± 320	Zr-95 120± 92	Dry weight basis

Lab. Number	Date Collected	Location	Description	Size (kg)	K(K-40) (g/kg)	Ra-226 pCi/kg	Th-232 pCi/kg	Cs-137 pCi/kg	Others pCi/kg	Comments
312A	12/15/70	Area A – Offshore	Grass	0.154	25± 3.6					Dry weight basis; 86% moisture
306L	12/15/70	Area B – Offshore	Grass							Dry weight basis; 72% moisture; output missing
287L	12/6/70	Area C – Offshore	Grass	0.087	18± 6.0	[illegible]2,000± 10,000		1200± 780		Dry weight basis
290L	12/6/70	Area A – Offshore	Oysters, total sample	2.21		1600± 450				Note absence of potassium
307A	12/15/70	Area B – Offshore	Oysters, total sample	2.05	0.45± 0.24	670± 410	41± 34			
289L	12/6/70	Area C – Offshore	Oysters, total sample	2.28	0.51± 0.22		63± 31	39± 29		
295L	12/6/70	Area A – Offshore	Crabs	1.02	1.8± 0.53	2400± 850	140± 71			
304L	12/6/70	Area B – Offshore	Crabs — 5 (6")	1.05	2.4± 0.53	1900± 860				
315A	12/15/70	Area C – Offshore	Blue Crabs, large sample	1.58	1.3± 0.35	1300± 570	91± 47	51± 45	I-131 46± 35 Zn-65 100± 60	
293L	12/6/70	Area A – Offshore	Pinfish — 3	0.529	4.0± 1.0		230± 140			
296L	12/6/70	Area B – Offshore	Pinfish	1.80	2.5± 0.32	1400± 480				
317A	12/15/70	Area C – Offshore	Pinfish	1.08	3.2± 0.51			78± 61	Zn-65 113± 83	
321A	12/15/70	Area A – Offshore	Mullet	1.48	2.7± 0.39	790± 600	190± 52	73± 48	Zr-95 13± 8	
319A	12/15/70	Area B – Offshore	Mullet	1.02	2.9± 0.53	1100± 850	90± 70			
320A	12/15/70	Area A – Offshore	Mullet	1.68	2.5± 0.33			180± 40		
322A	[illegible]/70	Area A – Offshore	Spotted Seatrout	0.94	3.7± 0.56					K-40 only radionuclide identifiable
303L	12/6/70	Area B – Offshore	Spotted Seatrout — 3 (6"–17")	1.10	4.0± 0.52	1300± 800				
335B	1/30/71	Area C – Offshore	Spotted Seatrout	0.293	4.9± 1.7	3700± 2800				
298L	12/6/70	Area B – Offshore	Redfish — 1	1.08	3.0± 0.51			96± 62		
327A	1/8/71	Area B – Offshore	Redfish	0.401	5.1± 1.3	6800± 2100				

Lab. Number	Date Collected	Location	Description	Size (kg)	K(K-40) (g/kg)	Ra-226 pCi/kg	Th-232 pCi/kg	Cs-137 pCi/kg	Others pCi/kg	Comments
328A	1/2/71	Area B – Offshore	Redfish	0.493	2.9± 1.2	22,000± 2200				
297L	12/6/70	Area B – Offshore	Croaker — 4	0.640	2.9± 0.83	1700± 1300				
325A	1/2/71	Area B – Offshore	Croaker	1.09	3.3± 0.49			59± 58		
294L	12/6/70	Area B – Offshore	Pigfish	3.17	1.3± 0.18	390± 260				
324A	1/2/71	Area B – Offshore	Silver Perch	2.69	0.80± 0.19	320± 300				
334B	1/30/71	Area C – Offshore	Silver Perch	2.08	2.8± 0.28			38± 32		
329A	1/18/71	Area B – Offshore	Spot	1.59	2.8± 0.37	1400± 570		91± 45	Zn-65 63± 61	
333A	1/23/71	Area B – Offshore	Sand Seatrout	0.753	3.5± 0.71	1900± 1100				
336B	1/30/71	Area C – Offshore	Sand Seatrout	0.135						Computer error
330A	1/18/71	Area A – Offshore	Black Sea Bass	0.396	3.6± 1.3			180± 160		
332A	1/18/71	Area B – Offshore	Whitings	1.15	3.7± 0.48			110± 56	I-131 57± 43	
275L	12/6/70	Area A – Marshland	Water	3.51	0.30± 0.14					K-40 only radionuclide identifiable
276L	12/6/70	Area B – Marshland	Water	3.45	0.17± 0.14	340± 230				
280L	12/6/70	Area C – Offshore	Water	3.46	0.21± 0.14					K-40 only radionuclide identifiable
283L	12/6/70	Area A – Marshland	Sediment	3.35	0.67± 0.20	2800± 340	130± 27	30± 28	Zr-95 23± 4 Ru-106 360± 74 I-131 41± 21 Ce-144 890± 170 Mn-54 24± 13	Dry weight basis
281L	12/6/70	Area B – Marshland	Sediment	4.94	0.45± 0.14	2300± 240	140± 20		Ru-106 190± 52 I-131 26± 15 Ce-144 800± 120	Dry weight basis

Lab. Number	Date Collected	Location	Description	Size (kg)	K(K-40) (g/kg)	Ra-226 pCi/kg	Th-232 pCi/kg	Cs-137 pCi/kg	Others pCi/kg	Comments
284L	12/6/70	Area C – Marshland	Sediment	1.17	3.4± 0.60	10,000± 1000	550± 84	280± 86	Zr-95 41± 13 Ru-106 710± 220 I-131 75± 65 Ce-144 660± 520	Dry weight basis
291L	12/6/70	Area A – Marshland	Oysters, total sample	2.18		4300± 510				Note absence of potassium
292L	12/6/70	Area B – Marshland	Oysters, total sample	2.14	0.17	830	38	11		Net count recorded; no statistical comparison by computer
288L	12/6/70	Area C – Marshland	Oysters, total sample	1.41		4900± 730	90± 54	84± 57		Note absence of potassium
299L	12/6/70	Area C – Marshland	Meat only of oysters from sample 288L	0.194		8600± 4400			Zn-65 1200± 460	Configuration error; results questionable in quantity
300L	12/6/70	Area C – Marshland	Shells only of oysters from sample 288L	0.958	0.75± 0.56	2200± 970	150± 75	120± 76		
314A	12/15/70	Area A – Marshland	Blue Crabs	1.34	2.1± 0.44	2700± 710	170± 59			
301L	12/6/70	Area B – Marshland	Blue Crabs	1.23	2.4± 0.46	840± 730	180± 60			
309A	12/15/70	Area C – Marshland	Blue Crabs	0.391	5.8± 1.4					K-40 only radionuclide identifiable
305L	12/6/70	Area B – Marshland	Mullet	0.548	2.3± 0.95	1700± 1600				
318A	12/15/70	Area B – Marshland	Killifish	0.345	3.6± 1.5					K-40 only radionuclide identifiable
323A	12/15/70	Area A – Marshland	Menidia — Silversides							Computer error
313A	12/15/70	Area B – Marshland	Menidia — Silversides	0.249	5.1± 2.0				Ru-106 2300± 720	Ru-106 quantity questionable
308A	12/15/70	Area B – Marshland	Spotfish	0.517	4.3± 0.99		150± 130			
326A	1/2/71	Area A – Marshland	Ladyfish							Weight lost
331A	1/18/71	Area A – Marshland	Drumfish	0.403	4.2± 1.3			220± 160	Zn-65 220± 210	

TABLE 2. GAMMA ANALYSIS OF TERRESTRIAL SAMPLES, FALL AND WINTER 1970–71

Lab. Number	Date Collected	Location	Description	Size (kg)	K(K-40) (g/kg)	Ra-226 pCi/kg	Th-232 pCi/kg	Cs-137 pCi/kg	Others pCi/kg	Comments
509B	1/10/71	5 mile radius of plant site	5 female Hooded Mergansers, ducks	2.57	2.9± 0.24	400± 320		94± 29		6 nuclide matrix
510B	1/10/71	5 mile radius of plant site	Red Breasted Duck, Mergansers	3.49	2.3± 0.18					6 nuclide matrix
511B	12/17/70	5 mile radius of plant site	Basking Shark	0.700	11± 0.87	2000± 1100				6 nuclide matrix
512B	12/17/70	5 mile radius of plant site	**Juncus** (no. 507A, dried)	0.290	4.4± 1.8	7000± 3000	380± 240		Ru-106 650± 650	6 nuclide matrix
513B	1/19/71	5 mile radius of plant site	Spartina (no. 506A, dried)	0.271						Computer error
514B	2/7/71	5 mile radius of plant site	Armadillo	3.73	1.8± 0.17	690± 230		430± 24		6 nuclide matrix
500K	11/9/70	5 mile radius of plant site	Spartina, snails	3.03	0.79± 0.18	560± 280	28± 24		Zr-95 8± 4 Ru-106 130± 60 I-131 21± 17	
501K	11/6/70	5 mile radius of plant site	Pokeberries							Data missing
502K	11/6/70	5 mile radius of plant site	Crawfish	0.188						Configuration error in computer
503L	12/15/70	5 mile radius of plant site	Salt water mussels, meat only	1.35						Configuration error in computer
504L	12/19/70	Negro Island	Sabal Palm Berries	1.934	10± 0.41	900± 440		120± 38	Zn-65 67± 56	
505A	12/19/70	Negro Island	Raccoon Scat	2.18	2.8± 0.32	4600± 490		150± 40	Zr-95 18± 6 Ru-106 140± 100	
506A	12/19/70	5 mile radius of plant site	Spartina	0.685		1700± 1200		120± 97	Zr-95 41± 16	Note absence of potassiur
507A	12/19/70	5 mile radius of plant site	**Juncus,** Black Rush	0.721		3200± 1200	120± 98	160± 96	Zr-95 31± 15	Note absence of potassiur
508B	1/19/71	5 mile radius of plant site	Prickly Pear Cactus	3.54	1.7± 0.16	310± 230		47± 19		

TABLE 3. GAMMA ANALYSIS OF FRESHWATER SAMPLES, WINTER QUARTER 1970–71

Lab. Number	Date Collected	Location	Description	Size (kg)	K(K-40) (g/kg)	Ra-226 pCi/kg	Th-232 pCi/kg	Cs-137 pCi/kg	Others pCi/kg	Comments
010B	2/20/71	Withlacoochee River at Yankeetown	Water	3.967 3.24		260± 210				
009B	2/20/71	Withlacoochee River at Yankeetown	Sediment	1.34		14,000± 990	520± 76	810± 86	Zr-95 28± 12 Ru-106 630± 200 I-131 71± 63	
017B	2/20/71	Withlacoochee River at Yankeetown	Centrarchids	3.28	0.20± 0.15	270± 240		27± 19		
018B	2/20/71	Withlacoochee River at Yankeetown	Algae — Mougeotia	0.146	8.8± 3.5	12,000± 5500		2700± 500	Zr-95 900± 90	Dry weight basis; 96% moisture
008L	12/17/70	Crystal River, Marker 25	Water	3.51						No radionuclide identifiable
006L	12/17/70	Crystal River, Marker 25	Sediment	2.20	0.92± 0.31	5300± 550	300± 45	73± 45	Zr-95 25± 6.4 Ru-106 190± 110	Dry weight basis
001L	12/17/70	Crystal River, Marker 25	Benthic algae	0.365	8.5± 1.6	5000± 2500			Zr-95 40± 30	Dry weight basis
003L	12/17/70	Crystal River, Marker 25	Weeds	0.096	84± 6.9	28,000± 10,000		1000± 810	Zr-95 180± 130	Dry weight basis; 93.5% moisture
016B	2/20/71	Crystal River, Marker 25	Blue Crabs	3.72	0.46± 0.14	530± 230	42± 19			
007L	12/17/70	Crystal River, Christmas Island	Water	3.63		280± 220				
005L	12/17/70	Crystal River, Christmas Island	Sediment	2.49	0.37± 0.22	580± 480	67± 30			Dry weight basis
002L	12/17/70	Crystal River, Christmas Island	Eichornia — water hyacinth	0.085	18± 6.9	57,000± 12,000		1100± 930		Dry weight basis; 93.5% moisture
004L	12/17/70	Crystal River, Christmas Island	Hydrilla	0.063	36± 8.7			1300± 1100		Dry weight basis; 94% moisture
011B	2/20/71	Crystal River, Main Boil	Killifish	3.52	1.6± 0.17	1100± 260				
012B	2/20/71	Crystal River, Main Boil	Blue Crabs	1.53	1.5± 0.38	4100± 640	160± 52			
013B	2/20/71	Crystal River, Main Boil	Centrarchid, fresh water	3.34	0.40± 0.15	250± 240				
014B	2/20/71	Crystal River, Main Boil	Freshwater Bass	3.39	0.38± 0.15	370± 240				
015B	2/20/71	Crystal River, Main Boil	Freshwater Needlefish	3.34	1.17± 0.17	1200± 270		32± 21		

TABLE 4
THERMOLUMINESCENT DOSIMETRY
FEBRUARY 23, 1971 TO MARCH 23, 1971

Station Number	Mean Dose, mR	2 Standard Deviations	Normalized Dose mR/30 Days
1	8.6	±1.8	9.2
2	5.7	±1.3	6.1
3	10.6	±0.4	11.4
4	5.7	±1.4	6.1
5	5.6	±1.1	6.0
6	7.3	±1.6	7.9
7	6.9	±0.5	7.4
8	6.5	±1.1	7.0
9	6.1	±2.6	6.6
10	24.7	±2.4	26.5
11	3.7	±2.1	4.0
12	5.8	±1.6	6.2
13	4.9	±2.0	5.3
14	4.3	±0.5	4.6
15	6.8	±2.8	7.3

TABLE 5
CORRECTED RESULTS OF THE TRITIUM
NETWORK SAMPLING
OCTOBER 13, 1970

Site No.	Tritium Concentration pCi/ml
1	0.84
2	1.55
3	0.72
4	1.61
5	0.16
6	0.30
7	0.60
8	0.33
9	void
10	0.88

appendix e

pre-operational

SURVEILLANCE OF THE NUCLEAR POWER PLANT SITE OF THE F! ORIDA POWER CORPORATION, CRYSTAL RIVER SITE

STATE OF FLORIDA

Department of Health and Rehabilitative Services

Emmett Roberts, Secretary

Department of Health and Rehabilitative Services

Dr. Chester L. Navfield, Administrator

Radiological and Occupational Health Section

Staff

Wallace B. Johnson

Benjamin P. Prewitt

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M. Melinda Geda

Lois F. Godwin

This report covers the period April 1–June 30, 1971. During this period the following samples were collected:

Vector	Number of Sites Sampled	Number of Samples
Vegetation	10	30
Food Crop	0	0
Silt	5	5
Milk	0	0
Biota	6	6
Seawater	5	5
Surface Water	4	4
Drinking Water	6	6
TLD	5	15
Air Particulates	5	29
TOTAL		100

Recapitulation of data relating to vegetation is included herewith as Table 1 and Table 2.

A review of data for 1969, 1970 and 1971 is included in Table 3, on the following page. A plot of the data relating to gross beta activity in vegetation is included as Figure 1. A preliminary analysis of the data indicates that a well established seasonal trend is seen in gross beta activity in vegetation with an annual peak level being reached in June or July. Analysis of potassium 40 in vegetation does not show a similar trend. We will continue to investigate the levels of cesium 137 and other radionuclides, when present, to determine which portion of this total activity is responsible for this seasonal trend. It is important that this apparent trend be well documented, since increasing levels of gross beta activity over the first half of the year might well be interpreted as resulting from operation of the nuclear unit following start-up.

TABLE 1
COMPARISON OF MONTHLY MEANS ALL STATIONS FOR VARIOUS RADIONUCLIDES
pCi/kg Wet Weight

	Jan.	Feb.	Mar.	Apr.	May	June
Gross Beta	4435	5250	4672	6479	6350	6521
Gross Alpha	474	561	525	917	903	794
Cesium 137	649	404	374	708	1504	1138
Potassium 40	4133	4750	3850	4960	4740	3820
Zirconium 95	136	232	268	718	602	661

TABLE 2
COMPARISON OF QUARTERLY MEANS OF INDIVIDUAL SAMPLING LOCATIONS
1st Quarter and 2nd Quarter — 1971

Sampling Location	Gross Beta		Gross Alpha		Cesium 137	
	Qtr. 1	Qtr. 2	Qtr. 1	Qtr. 2	Qtr. 1	Qtr. 2
C01	4305	6194	455	769	126	347
C02	4394	6368	659	949	70	2900
C03	4642	6423	552	847	306	440
C04	4953	5884	360	853	1873	613
C05	4048	4848	489	728	1500	1533
C06	4618	7826	420	1269	340	4540
C08	5132	6228	564	690	85	127
C09	5211	7560	553	950	75	123
C11	4868	6375	559	877	143	473
C12	5688	6795	675	783	96	237
GRAND MEAN	4786	6450	529	871	461	1133

TABLE 3
COMPARISON OF MONTHLY MEANS OF ALL SAMPLING LOCATIONS FOR CERTAIN RADIONUCLIDES

	Gross Beta pCi/g Ash			Cesium 137 pCi/kg Wet Weight		Potassium 40 pCi/kg Wet Weight	
Month	1969	1970	1971	1970	1971	1970	1971
January		184	157	342	649	4730	4133
February		184	198	368	404	5070	4750
March		169	169	220	374	4070	3850
April		196	217	190	708	4552	4960
May	178	207	233	277	1504	5390	4740
June	211	227	244	367	1188	5180	3820
July	224	209		411		4740	
August	198	112		707		5637	
September	195	119		735		5587	
October	172	115		771		4611	
November	182	120		835		4760	
December	178	123		940		4830	

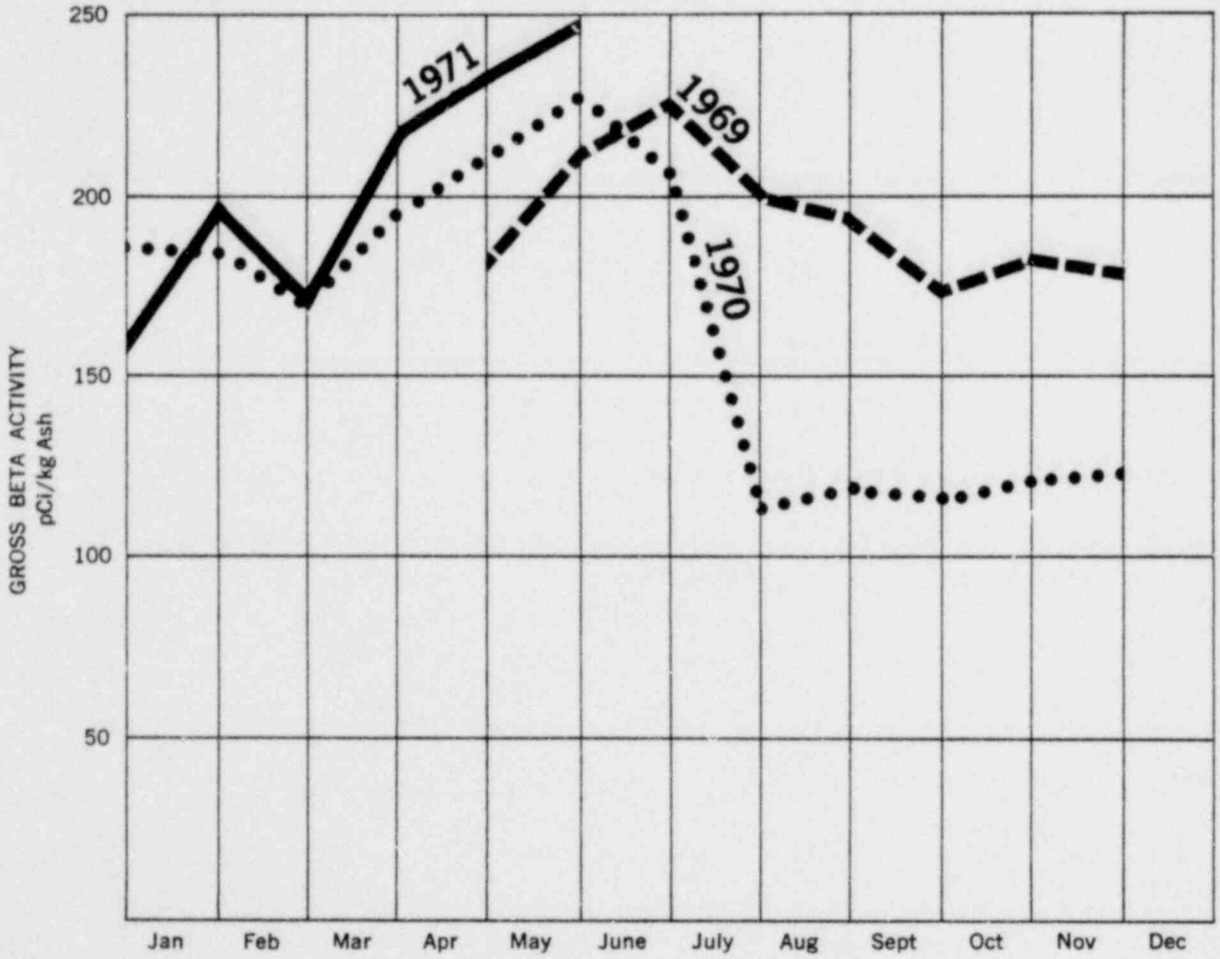
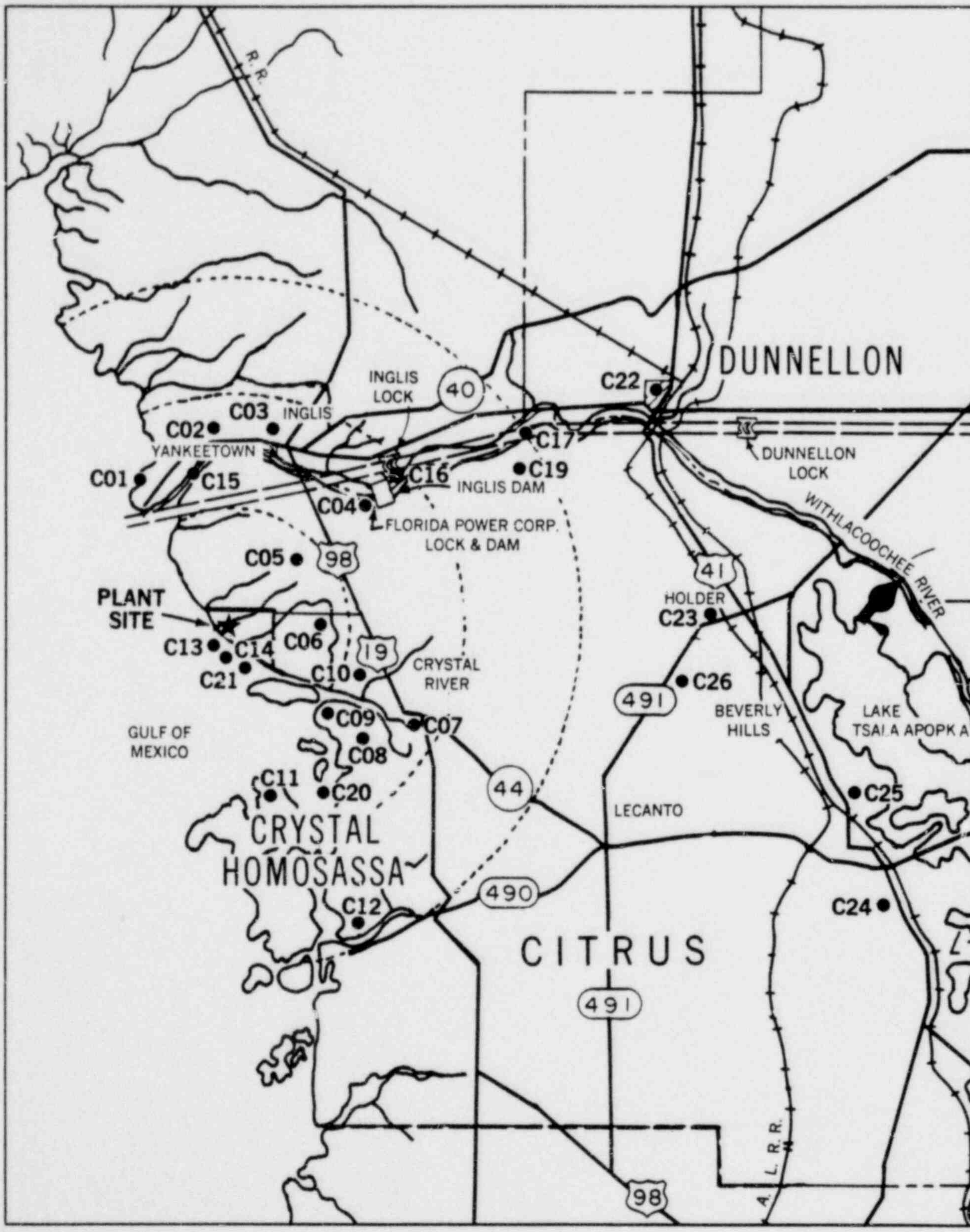


Figure 1
Comparison of monthly means of all Sampling Locations
for Gross Beta Activity in Vegetation



FLORIDA DIVISION OF HEALTH
RADIOLOGICAL SAMPLING SITES — CRYSTAL RIVER

GAMMA BACKGROUND
THERMOLUMINESCENT DOSIMETER
CaF: Mn.

Sampling Location	5-12-71 m rem/hr	6-10-71 m rem/hr	7-14-71 m rem/hr	Mean
C04	.027	.022	.020	.023
C07	.020	.025	.020	.022
C08	.020	.031	.020	.024
C18	.024	.019	.023	.022
C26	.036	.025	.035	.032
MEAN	.025	.024	.024	

PARTICULATES IN AIR
(Sampling Period in Hours) ND = < 1 pCi/m³

Sampling Location	4-14-71	4-29-71	5-10-71
C04	ND(576)	ND(354)	ND(263)
C07	ND(572)	ND(359)	ND(266)
C08	ND(573)		ND(286)
C18	ND(578)	ND(356)	ND(262)
C26	ND(571)	ND(359)	ND(290)
	5-25-71	6-9-71	6-22-71
C04	ND(358)	ND(357)	ND(310)
C07	ND(357)	ND(316)	ND(360)
C08	ND(338)	ND(699)	ND(304)
C18	ND(358)	ND(359)	ND(318)
C26	ND(332)	ND(359)	ND(320)

VEGETATION — GROSS BETA — pCi/kg Wet Weight

Sampling Location	Apr. 14	May 10	June 9	Mean
C01	6195	6752	5635	6194
C02	7511	5646	5947	6368
C03	7721	4921	6626	6423
C04	5482	6545	5624	5884
C05	5425	4320	4798	4848
C06	7530	9215	6733	7826
C08	6517	5656	6510	6228
C09	8071	6556	8054	7560
C11	3346	7632	8147	6375
C12	6995	6257	7132	6795
MEAN	6479	6350	6521	

VEGETATION — GROSS ALPHA — pCi/kg Wet Weight

Sampling Location	Apr. 14	May 10	June 9	Mean
C01	589	943	774	769
C02	1089	964	793	949
C03	947	651	944	847
C04	898	894	766	853
C05	1039	681	464	728
C06	1039	1573	1195	1269
C08	788	643	640	690
C09	1087	825	939	950
C11	671	1113	847	877
C12	1024	741	583	783
MEAN	917	903	794	

VEGETATION — POTASSIUM 40 pCi/kg Wet Weight

Sampling Location	Apr. 14	May 10	June 9	Mean
C01	4800	4600	3700	4367
C02	6200	3100	3200	4167
C03	8300	4900	2300	5167
C04	3200	5700	2900	3933
C05	2200	2500	2800	2500
C06	4900	2700	1800	3133
C08	6500	5700	6000	6067
C09	7200	6500	4000	5900
C11	1100	6800	5600	4500
C12	5200	4900	5900	5333
MEAN	4960	4740	3820	

VEGETATION — CESIUM 137 — pCi/kg Wet Weight

Sampling Location	April	May	June	Mean
C01	490	210	340	347
C02	1700	4100	2900	2900
C03	330	260	730	440
C04	440	730	670	613
C05	2100	1200	1300	1533
C06	320	8000	5300	4540
C08	150	90	140	127
C09	90	80	200	123
C11	1200	100	120	473
C12	260	270	180	237
MEAN	703	1504	1188	

VEGETATION — ZIRCONIUM 95 — pCi/kg Wet Weight

Sampling Location	April	May	June	Mean
C01	750	940	720	803
C02	760	560	680	667
C03	300	280	900	493
C04	840	520	700	687
C05	740	580	560	627
C06	970	960	960	963
C08	400	240	310	317
C09	860	420	810	697
C11	740	860	610	737
C12	820	660	360	613
MEAN	718	602	661	

VEGETATION — RUTHENIUM 106 — pCi/kg Wet Weight

Sampling Location	April	May	June	Mean
C01	760	610	400	
C02	ND	ND	ND	
C03	ND	ND	ND	
C04	560*	ND	340	
C05	630	ND	ND	
C06	520**	ND	ND	
C08	320	ND	ND	
C09	530	ND	ND†	
C11	320	400	ND	
C12	650***	350	ND	
MEAN‡	536	453	370	

*Cerium 144 760 pCi/kg wet weight
**Cerium 144 880 pCi/kg wet weight
***Cerium 144 640 pCi/kg wet weight
†Cerium 144 380 pCi/kg wet weight
‡of detectable observations only

SILT — pCi/kg

Gross beta, gross alpha, and other radionuclides analyzed were non-detectable for all sampling locations except for those shown.

CERIUM 144

Sampling Location	April	May	June
C01		400	
C09		690	
C13		340	
C14		290*	

*Zirconium 95 160 pCi/kg
Gross Alpha 7534 pCi/kg

MARINE BIOTA — OYSTERS pCi/kg Wet Weight

Sampling Location	April	May	June
Gross Beta			
C20		1486	
Gross Alpha			
C20		109	
Potassium 40			
C20		1100	

MARINE BIOTA — BLUE CRAB — pCi/kg Wet Weight

Sampling Location	April	May	June
Gross Beta			
C09		4134	
C12		3563	
C21		2798	
Gross Alpha			
C09		ND	
C12		1158	
C21		1137	
Potassium 40			
C09		2200	
C12		1200	
C21		1700	

MARINE BIOTA — MULLET pCi/kg Wet Weight

Sampling Location	April	May	June
	Gross Beta		
C08		3074	
	Gross Alpha		
C08		804	
	Potassium 40		
C08		2000	

MARINE BIOTA — HARD TAIL JACK pCi/kg Wet Weight

Sampling Location	April	May	June
	Gross Beta		
C13		4500	
	Gross Alpha		
C13		445	
	Potassium 40		
C13		2600	

DRINKING WATER

Location	April	May	June
C07		No detectable activity	
C10		Gross Beta	
C18		Gross Alpha	
C22		Gamma Scan	
C23		Tritium < 200 pCi/1	
C24			

SURFACE WATER

Location	April	May	June
C12		No detectable activity	
C15		Gross Beta	
C16		Gross Alpha	
C17		Gamma Scan	
		Tritium < 200 pCi/1	

SEA WATER

Location	April	May	June
	Gross Beta pCi/1		
C08		51	
C09		108	
C11		287	
C13		329	
C14		284	
	Gross Alpha pCi/1		
C08		ND	
C09		ND	
C11		ND	
C13		ND	
C14		ND	
	Potassium 40 pCi/1		
C08		ND	
C09		ND	
C11		ND	
C13		220	
C14		220	
	Tritium pCi/1		
C08		< 200	
C09		< 200	
C11		< 200	
C13		< 200	
C14		< 200	

appendix f

radiation

SURVEILLANCE REPORT

PINELLAS COUNTY HEALTH DEPARTMENT

George R. McCall

Staff

Mrs. Russell Hobbs

The following data are a summary of air monitoring results and rainfall collections taken in St. Petersburg, Florida, for the second quarter of 1971. The approximate air volume on which the determinations are based was 2100 cubic meters for the 48-hour sampling periods and 3100 cubic meters for 72-hour periods. The counting equipment consists of a thin end window (2 mg/ cm^2) Geiger-Mueller tube coupled with a Packard Mod. 410A scaler-timer system. On each occasion, the instrument is standardized against a 32,000 pci Strontium-90 calibration source of dimensions identical to the air filters.

PINELLAS COUNTY HEALTH DEPARTMENT

RADIATION SURVEILLANCE QUARTERLY REPORT

Apr. 1 — June 30, 1971

DATE (1971)	AIR Gross Beta Activity (pCi/m^3)	RAINFALL (mm)	REMARKS
4/2	0.575	0	
4/5	0.5975	23.22	
4/7	0.464	8.50	
4/9	0.402	0	
4/12	0.6	0	
4/14	0.796	0	
4/16	0.80	0	
4/19	0.805	0	
4/21	0.835	0	
4/23	0.748	0	
4/26	0.55	0.58	
4/28	0.281	0	
4/30	0.342	0	
5/3	0.454	0	
5/7	1.22	0	
5/10	1.06	0	
5/12	0.525	0	Air flow rate recalibrated
5/14	0.437	4.60	
5/17	0.229	51.80	
5/19	0.487	0	
5/21	0.711	0	
5/24	0.784	0	
5/26	0.808	2.06	
5/28	0.799	0	
5/31	0.793	0	
6/2	0.44	0	
6/4	0.60	0	
6/7	0.597	27.5	
6/9	0.238	0	
6/11	0.236	0	
6/14	0.393	10.95	
6/16	0.578	0	
6/18	0.464	0	
6/21	0.27	1.13	
6/23	0.333	0	
6/25	0.299	10.92	
6/28	0.229	0	
6/30	0.287	53.3	

George R. McCall

Public Health Physicist, Division of Radiological and Occupational Health

June 30, 1971
/rh

appendix g

environmental

INVESTIGATION AT THE ANCLOTE POWER PLANT SITE

University of South Florida, Marine Science Institute

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M. Proctor
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INTRODUCTION

Research for the Anclote environmental project since the last interim report has been primarily a continuation of previously outlined work (See Environmental Status Report, January-March 1971). Of particular interest is the initiation of an expanded program in turbidity and sedimentation analysis. In addition the mathematical model for the hydrology of the Anclote area is nearing completion and the first computer runs have been completed.

The technical report concept initiated during the last interim period has proved to be a successful means of providing specific data for particular problems. Six reports have been submitted to date.

SUB-DISCIPLINE PROGRESS REPORTS

I. Physical

The numerical model of the Anclote River estuary has been modified to include spatially variable friction coefficients representing sand, silt, or grass bottom type. The circulation model has been run successfully for present and projected bottom and power plant configurations including the following physical changes:

- Intake canal excavation
- Discharge canal excavation
- Barge canal addition
- 2,000,000 gal/min condenser pumping capacity

A technical report on both physical and numerical circulation models is under preparation.

STD (salinity, temperature, depth) and current measurements have become part of the standard data obtained by the sedimentation team this summer. Their report contains a more detailed description of that program.

In addition a study of flood tidal currents near the proposed outfall was completed and results appear in Technical Report #5 which is an addendum to this report.

II. Water Quality — Plankton

The water quality program continues to involve thirty-three stations which are sampled on a monthly basis. Fourteen of these stations are sampled for plankton. Analyses of principle inorganic nutrients, dissolved organic carbon, dissolved oxygen and measurements of primary productivity are made from samples at each station.

III. Sea grasses, algae, and bacteriology

Research has continued on sea grasses and algae as outlined in the last interim report. In particular a detailed analysis of sea grass species, density, and distribution was included in a general benthic community survey along the axis of the proposed discharge canal. (See Section IV "Benthic Invertebrates" below.)

Monitoring of coliform and luminescent bacteria in the lower Anclote River, Anchorage and adjacent Gulf is continuing. Increases in the number of luminescent bacteria with increasing water temperature have been observed.

IV. Benthic invertebrates

Procedures and objectives, formalized and listed during the last interim reporting period, are now functioning as a regular systematic sampling program.

A major short-term study entitled "The benthic community along the proposed discharge canal for the Anclote River power plant" was completed and submitted to Florida Power Corporation as Technical Report #6. The study, which considered the distributions and densities of both sea grasses and benthic invertebrates is included as an addendum to this report of progress.

V. Fishes

Sampling of fishes in the Anclote area has continued using primarily trawls, trammel nets, and the Fyke net. A permanent Fyke net station has been established at the mouth of the small bayou on the Florida Power property adjacent to the MSI laboratory facility. This will enable investigators to obtain a complete quantitative sample of the fishes entering this area over a tidal cycle.

Beach seine collections on Anclote Key have been added to the fish sampling program. Results of a survey on juvenile fishes inhabiting grass beds adjacent to and on a transect including the proposed outfall appear in Report #6.

VI. Geology

A. Suspended Sediments

The turbidity measuring program continued but was hampered by equipment malfunctions and long delays in delivery of new instruments. Due to unforeseen production holdups, the new Hydro Products Model 612 transmissometer still had not arrived in time for field deployment and use in the preparation of this report. All surveys were consequently made utilizing the older Model 412 (1 meter path) unit on loan from the Geology Department, and thus values are compatible with those described in the 1970 Annual Report.

Figures 1A through 1F (pages 89-92) are contoured areal plots of surface water turbidity values (per cent transmissivity per meter: % T/m) obtained between February 12 and June 25, 1971. Due to variations in transect lines and field procedures, the runs cannot be compared in great detail. The primary purpose at this stage was to work out various logistical problems and at the same time acquire background data for more regular runs to commence upon procurement of the new 10cm path transmissometer. Only a brief analysis of these data will be included in this report.

The contour intervals listed below are uniformly designated on Figures 1A through 1F (if encountered on that particular run).

< 5%	15-20%	40-50%	
5-10%	20-30%	50-60%	T/m
10-15%	30-40%	> 60%	

Figs. 1A and 1B — 12 February 1971. These lines were run in two sessions to determine the magnitude of change that might take place in a single area over varying tidal conditions.

The earlier run, (Fig. 1A), was made with moderate flood current prevailing while the later transect (Fig. 1B) was made during slack water and early ebb conditions.

Transmissivity ranged from 0% T/m to 56% T/m, with generally higher values observed during the second run. This observation can be attributed to the more optically transparent water mass from north Anclote Anchorage and Sand Bay moving southward with the ebbing tide. (Net movement was approximately 0.3 mile during the two hour time span between observations).

Surface water samples were also collected along these lines and the total suspended load varied from a high of 18 mg/1 to a low of 2 mg/1. These corresponded to transmissivity readings of 2% T/m and 54% T/m respectively.

Fig. 1C — 16 April 1971. The lines plotted for this date illustrate to some degree the problems encountered during attempts to survey a relatively large area under varying tidal conditions.

The morning run was made in the area south of the line designated AM-PM. Dead calm wind and sea conditions were encountered throughout most of the run. Tidal condition ranged from slack water to early flood.

The afternoon lines in the northern sector were made during maximum flood tide with the sea state turning into a two foot chop with winds from the west at 10-15 m.p.h.

Transmissivity values ranged from 5-35% T/m, with the lower values generally associated with shoal areas and the natural tidal pass south of Anclote Key. Surprisingly, the Anclote River showed some of the highest values recorded during the morning run (> 30% T/m). There was some indication of a turbid "plume" extending from Bird Key to Marker "7x" parallel to and south of the ship channel. This was apparently due in part to heavy boat traffic in the area.

The high turbidity found in the natural pass south of Anclote Key (lowest readings of the day — 5% T/m), were due also in some part to the heavy boat traffic in the area, but probably primarily the result of tidal scouring on the adjacent shoal areas.

The northern lines also showed a similar relationship between turbidity and topography but in general the values were lower due to the more turbulent state of the water and thus related poorly to turbidity distributions noted six or seven hours earlier.

Fig. 1D — 17 April 1971. These lines covered areas north and south of the main channel but contrary to the procedure on April 16, Fig. 1C, the lines were made in reverse order with the northern area covered in the A.M. and the southern portion in the P.M.

Calm wind and sea state conditions prevailed in the morning but picked up to a 1-2 foot chop and higher westerly winds in the afternoon.

Transmissivity values ranged from 18% T/m to 68% T/m — the latter being the highest value observed to date in the Anclote area.

Again, a relationship to bottom topography was observed with lower turbidity characteristic of deeper water areas.

A comparison of Figs. 1C to 1D, which were run on consecutive days, illustrates the importance of acquiring transmissivity data in the shortest time possible in light of the extreme conditions which can prevail within a relatively short time span.

Fig. 1E — 24 May 1971. This series of lines illustrates conditions after several consecutive days of moderate westerly winds. Winds on the day of the run varied from 10-15 mph and a 2-foot chop was present in the Anchorage.

Due to engine problems and the small size of the boat used; the runs were incomplete and confined to the more sheltered area north of the main channel.

Transmissivity ranged from 2% to 52% T/m. Most notable in these transects is the high turbidity along the western shoal areas (on the east side of the Keys) and higher than usual turbidity in the Anchorage. In contrast, the thickly grassed shoals running parallel to the shore line in the eastern portion of the Anchorage exhibited very low turbidity. This would appear to be a verification of the stabilizing influence of these grasses on unconsolidated bottom types under certain conditions.

Fig. 1F — 25 June 1971. The survey depicted on Fig. 1F was made under calm sea state conditions with west to southwesterly winds averaging below 8 mph. Flood and slack water prevailed through most of the lines.

Except for the grass beds along Bailey's Bluff, the shoal areas are almost defined by transmissivity values lower than 10% T/m. In general, all values were low with the highest observation approaching 25% T/m found well outside Anclote Key and north of Anclote Anchorage. The lowest values were observed north of the main channel and in the natural pass south of the Key.

Turbidity in the Anchorage was uniformly high and decreased northward.

B. Transmissometer — Temperature Survey: Anclote River

Fig. 2 — 26 April 1971. Fig. 2 (page 92) shows the results of a transmissometer survey run on the Anclote River to help define natural turbidity levels inherent to this source. Vertical profiles were recorded at fourteen stations between three and thirteen miles above the mouth. Stations are located on the map view of the river and, in addition, data and the bottom profiles of the river are also included on the same figure.

The survey commenced at slack water and continued through early ebb. Consequently conditions were almost ideal and values were spot checked for reproductivity during the return run with good results. The river itself was probably at an almost zero net flow state due to lack of precipitation for a number of months preceding the survey. Data is not yet available for April 1971 from the USGS gauging station at Elfers so the estimated flow cannot be verified.

Transmissivity ranged from 0-29% T/m. Minimum values of 0-2% were found between stations 3 and 8 which is a section four to nine miles above the river mouth. The water character changed rapidly above station 13 and this area (11-12 miles above the mouth) is probably the maximum extent of strong tidal influence. From the high T/m% values obtained above this point it is believed that the river contributes negligible sediment to the system under low flow conditions. Apparently the most important source of sediments is the area of maximum tidal effect due to scouring and resuspension between four and nine miles above the mouth. Bottom sediments from this region should be collected and studied to determine their significance to the total sediment budget of the area.

Future surveys of this type will be made with the more sensitive 10cm path transmissometer along with STD and a current meter to further characterize this portion of the river under varying net flow conditions.

C. Aerial Photography

Two sets of uncontrolled, oblique aerial photographs of the Anclote area have recently been obtained. On May 11, 1971 a small plane was rented for one hour and a hand-held camera was used to test the usefulness of infrared Ektachrome ("false color IR") film in delineating bottom morphology and grass beds in the Anclote area. Despite difficulties imposed by time limitations and the uncertainty of exposure settings to be used with this film, the first test was successful on both counts. The photos also revealed interesting features of Anclote Key such as vegetation patterns related to recent northward extension of the island.

A second set of aerial photographs was obtained May 27, 1971 using two cameras loaded with infrared Ektachrome and Ektachrome film. These exposures were employed to map sea grasses and to guide field work during the preparation of Technical Report #6 (Zimmerman *et al.*, 1971). Infrared Ektachrome proved superior to Ektachrome in revealing details of bottom features during this single, limited comparison.

During the past months we have made contact with the U. S. Geological Survey (USGS) to determine past coverage of the area by NASA/USGS remote sensing overflights. We have also initiated a joint proposal for further high altitude overflights preparatory to NASA's SKYLAB program.

We have been copying the NASA/USGS exposures showing the Anclote area and have added these to our collection of aerial photographs. This collection now includes data from NASA/USGS, U.S. Coast & Geodetic Survey, U.S. Department of Agriculture, Pinellas County, Florida Power Corporation, and the Marine Science Institute.

D. Reports and Data Summaries

Several students have taken advantage of the Anclote Environmental Project's facilities and supporting data to conduct independent research projects in this area. Copies of the following reports are on file at the Marine Science Institute:

1. "The Sedimentation Process: Information and Recommendations for Future Studies at Anclote Anchorage and Crystal River" by R. M. Fruland;
2. "Distribution of Dyed Sand at the Southern End of Anclote Key" by J. Dyer, R. Klausewitz and V. Maynard;
3. "A Preliminary Investigation of Sediment Processes in the North Anclote Key Area" by D. Eggimann;
4. "A Study of the Relationships between the Inorganic/Organic Fractions of the Water Column and Underlying Sediments at Marker #3, Anclote Anchorage, Florida" by R. V. Cano.
5. "Bottom Sediments of Anclote Anchorage: Comparison of Sample Preparation Techniques for Nitrogen Analyses" by W. R. Gunn and V. R. Maynard.

The following additional background data has been obtained or compiled:

1. Published streamflow and water quality records of Anclote River from late 1964 to September 1968, "in press" data for October 1968 to September 1970, and provisional data from October 1970 to March 1971.
2. Rainfall and air temperature data from the cooperative weather observer in Tarpon Springs. These data have been plotted on a common time base with the streamflow data and are available for use of all disciplines.
3. Tidal current data from the U.S. Coast & Geodetic Survey. Half-hourly measurements of current speed and direction for a 3-day period in 1951. Apparent basis for published Tidal Current Tables.
4. Foundation core borings from Florida Power Corporation contractor used to prepare cross-sectional fence diagram to be correlated with offshore work.

E. Progress to Date

The new Hydro Products Model 612 transmissometer was received the first week in July and

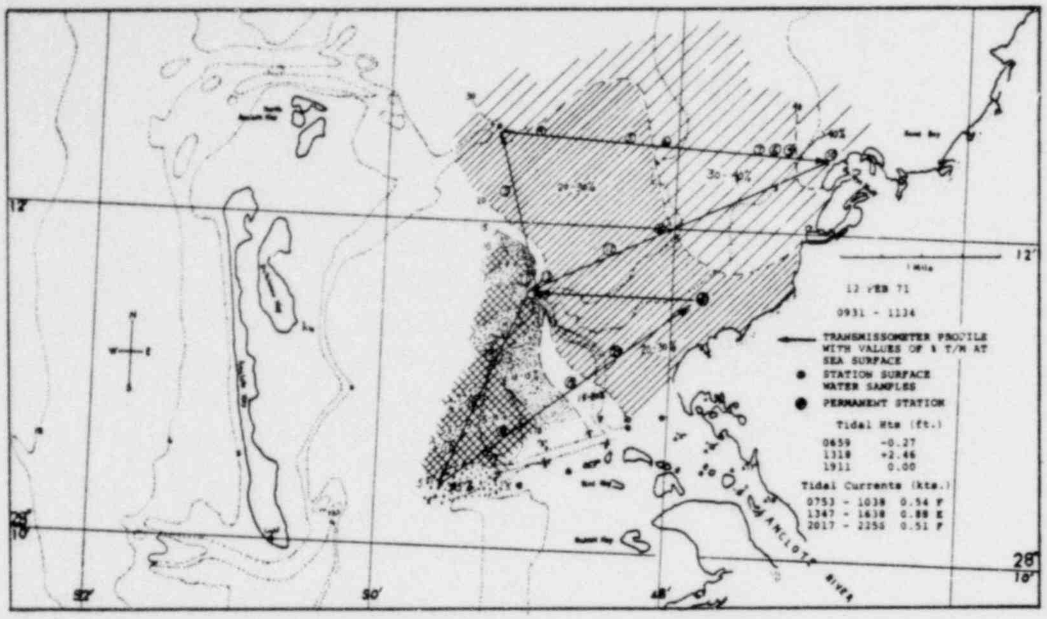


Figure 1A

intensive surveys will be conducted during the summer months with this unit. Initial field trials indicate that transects will be made almost exclusively with the 10cm path length. Hopefully, this will allow more sensitive measurements to be made.

Calibration experiments are now being carried out in the laboratory to determine the effects of known concentrations of natural materials on light transmission under controlled conditions.

To facilitate coverage of the large area involved in this study, regular weekly surveys will be made through the summer utilizing two Model 612 transmissometers operating concurrently from two boats. This will help eliminate, to some degree, the discrepancies noted earlier in attempting to portray conditions over a large area under rapidly changing tide and wind conditions.

In addition, more supplementary physical data will be obtained at approximately twenty standard stations while making traverses. The additional parameters will be salinity, temperature, and transmissivity in vertical profiles along with surface current and wind velocities.

These parameters, especially the latter two, should allow a greater degree of insight into the natural distribution of turbidity and water movement in the area.

While Dr. George Griffin is with us for the summer and an additional boat, transmissometer and STD are available, we are conducting once a week two boat, 6-8 man surveys of transmissivity and hydrographic parameters. A second day each week we are measuring Anclote Key beach profiles, offshore echo sounder profiles, wind and wave parameters, and longshore currents. In addition we have begun a program of coring in very shallow water using PVC pipe pushed into the sediment by hand. The grab sampling program has also been started this month.

Miss P. C. Jones has joined the project and commenced sedimentological and geochemical studies. She will be responsible for laboratory analyses of sediment textures, organic content, heavy minerals, etc. and will assist in the field program.

Thirty buoys have been constructed and will be "permanently" deployed as station markers for all disciplines to supplement regular navigation aids in the Anclote area.

The group has completed design of a station location grid system that will serve as a basis for common reference and computer retrieval of data obtained by all disciplines. The base map for this grid is now being drafted and will be distributed to all personnel for use in both field and the laboratory.

RECOMMENDATION

Our thus far limited application of aerial photography indicates that it is very useful in the Anclote area and that its use should be continued by contracting for overflights on a seasonal basis. Color and IR color photography should be conducted in conjunction with IR scanning in order to monitor seasonal variations in sea grass distribution and sea surface temperatures prior to constuction of the Anclote generating complex.

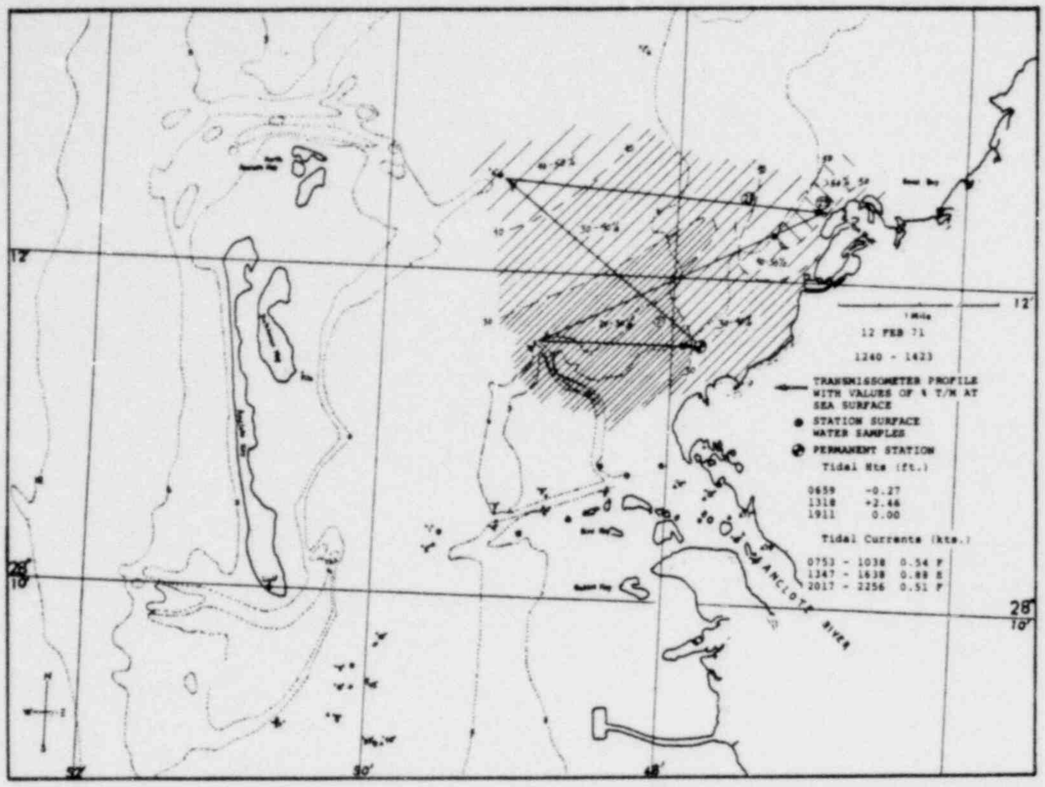


Figure 1B

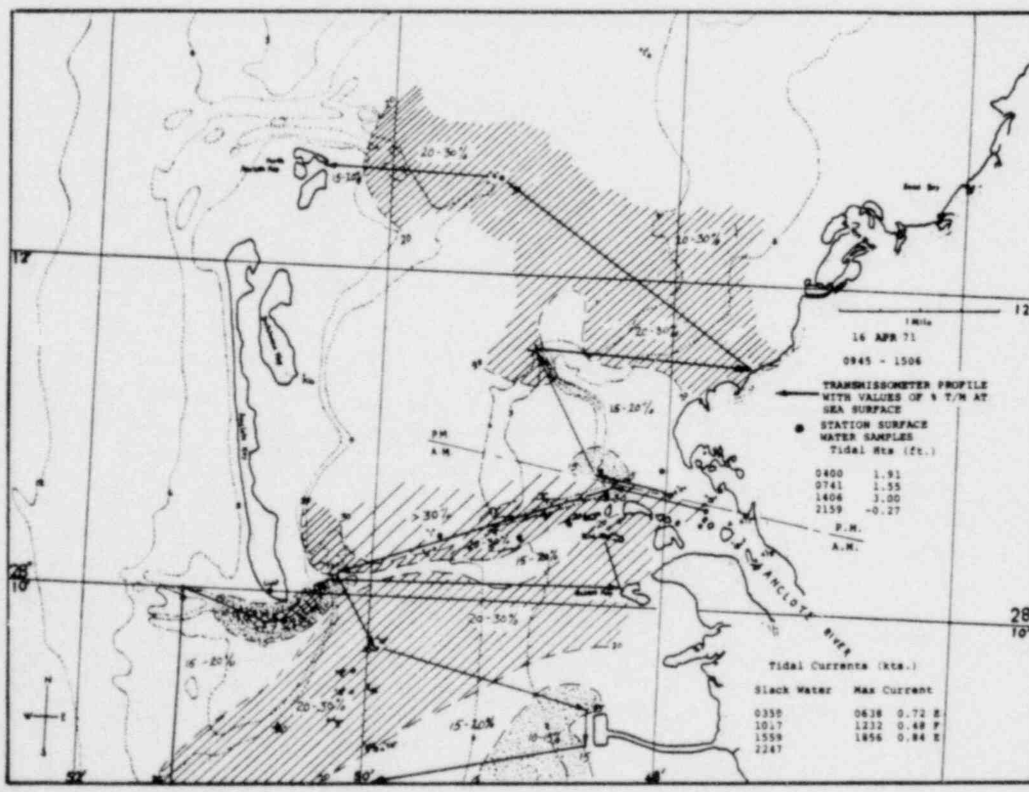


Figure 1C

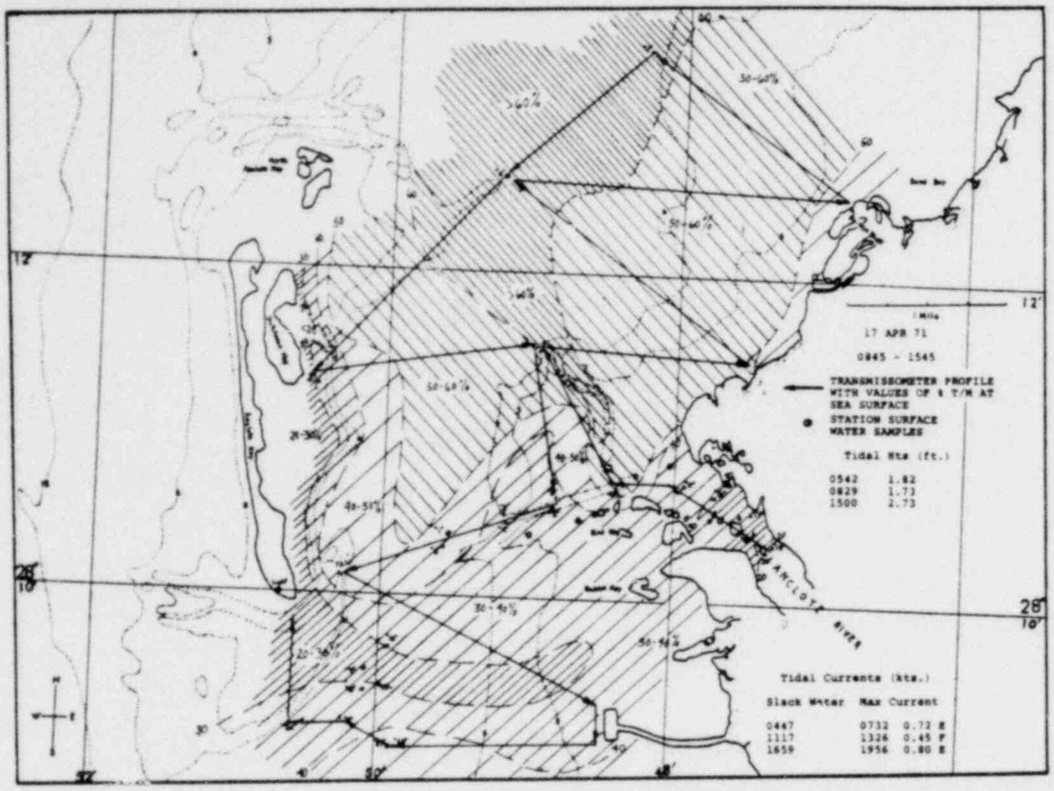


Figure 1D

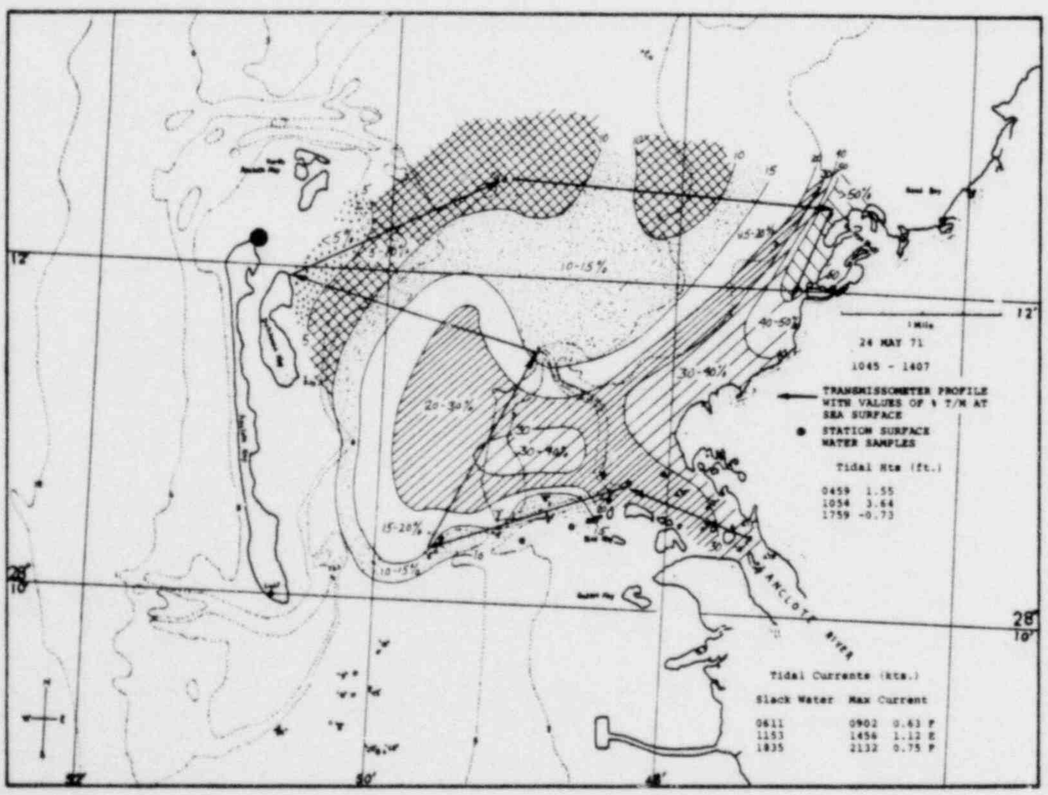


Figure 1E

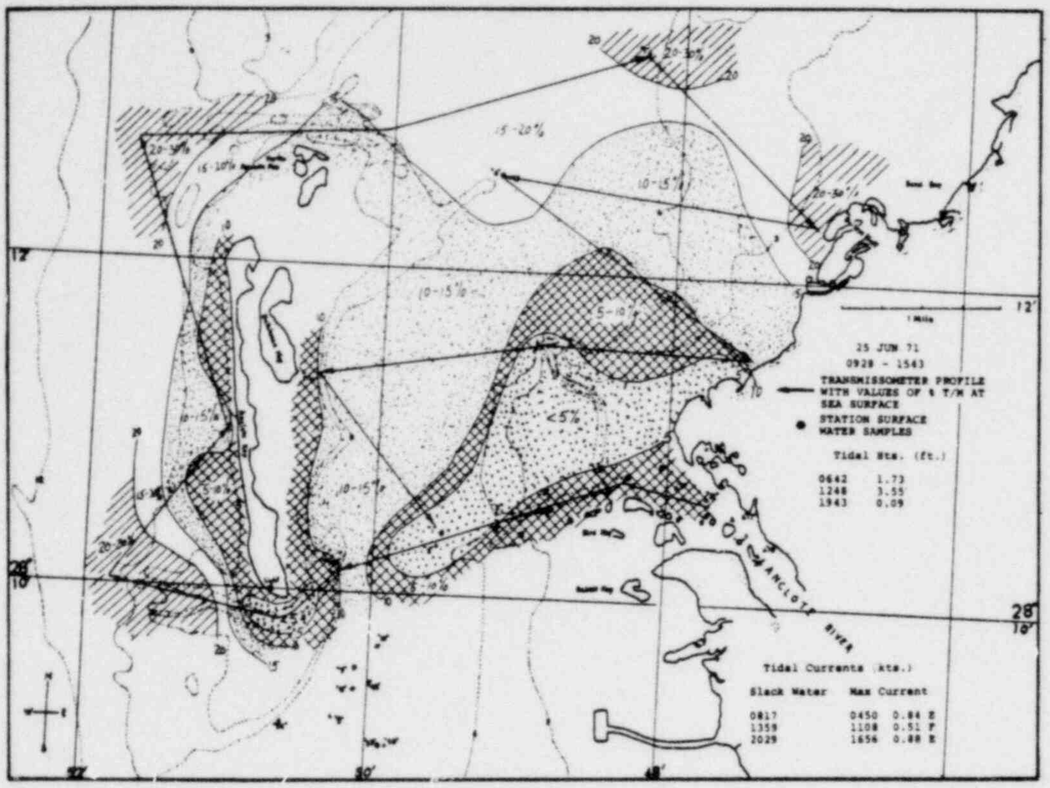
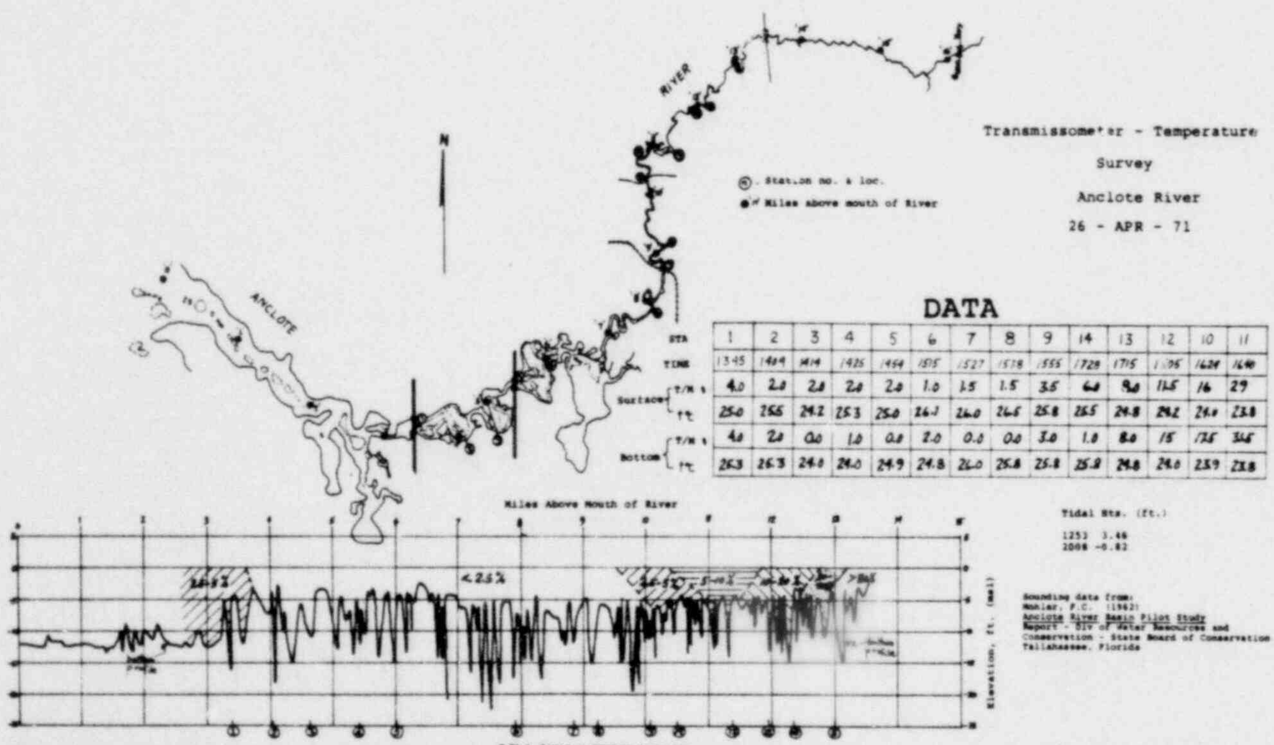


Figure 1F



DATA

STA		1	2	3	4	5	6	7	8	9	14	13	12	10	11
TIME		1345	1409	1414	1425	1454	1515	1527	1538	1555	1728	1715	[illegible]	1624	1640
Surface	T/M %	4.0	2.0	2.0	2.0	2.0	1.0	1.5	1.5	3.5	6.0	9.0	11.5	16	29
	t°c	25.0	25.5	24.2	25.3	25.0	26.1	26.0	26.5	25.8	25.5	24.8	24.2	24.0	23.8
Bottom	T/M %	4.0	2.0	0.0	1.0	0.0	2.0	0.0	0.0	3.0	1.0	8.0	15	13.5	34.5
	t°c	26.3	26.3	24.0	24.0	24.9	24.8	26.0	25.8	25.8	25.8	24.8	24.0	23.9	23.8

Sounding data from:
Mehlar, F.C. (1962)
Anclote River Basin Pilot Study
Report - Div of Water Resources and Conservation - State Board of Conservation
Tallahassee, Florida

Figure 2
Transmissometer — Temperature Survey
Anclote River 26 April 71

ANCLOTE ENVIRONMENTAL PROJECT

Technical Report #5

FLOOD TIDAL CURRENTS NEAR PROPOSED OUTFALL

by

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May 1971

On April 22, 1971, twelve stations were sampled three times for current information over the periods of maximum flood current and of slack water before and after maximum flood current. The station numbers and locations were approximately the same as those used in the ebb current study reported in Technical Report #3. They are as indicated on Figure 1 (page 94). Table I lists tidal data.

Run #1 (0639-0850) bracketed the maximum flooding current (0644). Currents found at maximum flood current were as expected from Humm *et. al.*, (1971). Stations 1, 8, and 9 in deep water had the highest current speeds and were moving in a generally northeasterly direction. Flow decreased shoreward with the decreasing depth. There was flow at all stations except 4 and 12 where the shallowest depths occurred. There was a 0.11 knot current to the ENE at Station 5, the other shoremost station. At Station 11, near the small channel leading north from the Anclote River, the flow was shifting to the north. This could be attributed to a northward deflection of some of the Anclote River flow by the flooding tidal current.

Run #2 (0905-1024) bracketed the slack water (0947) after the maximum flooding current. This run found zero or negligible flow at all stations except 8, 9, and 10. Stations 8 and 9 were both deep water stations and showed 0.17 knot and 0.29 knot currents to the northeast and north respectively. Station 10, in the grass flats west of the north channel leading from the Anclote River, had a current of 0.17 knots to the northeast. These three stations were taken in descending order and were the only deep water stations taken before slack water. This accounts for their values being somewhat larger than those of the other stations of Run #2.

Run #3 (1525-1710) bracketed the slack water (1623) before the second maximum flooding current of the day. The flow found during this run was in good general agreement with that reported by Humm *et. al.*, (1971). There was relatively substantial flow to the north and northeast in all deeper water stations. There was a decrease in current speed with decreasing depth on all transects except between Stations 7 and 8 where a small increase was noted. Flow direction was generally to the north except at Stations 6 and 7 where it was northeasterly. This too would agree with that reported by Humm et. *al.* (1971). A surprisingly strong current was found at Station 9 where the speed was in excess of 0.53 knots to the north. Zero flow was found at all of the shallower stations (3, 4, 5, and 12) with negligible flow (0.09 knots) at Station 2.

The range of the predicted tidal heights was substantial and representative of the larger ranges expected in Anclote Anchorage. The predicted tidal currents were representative of the stronger tidal currents experienced in Anclote Anchorage. The winds were 10-15 knots from the south during the first half hour of Run #1, then dropped to almost a calm for the rest of the day.

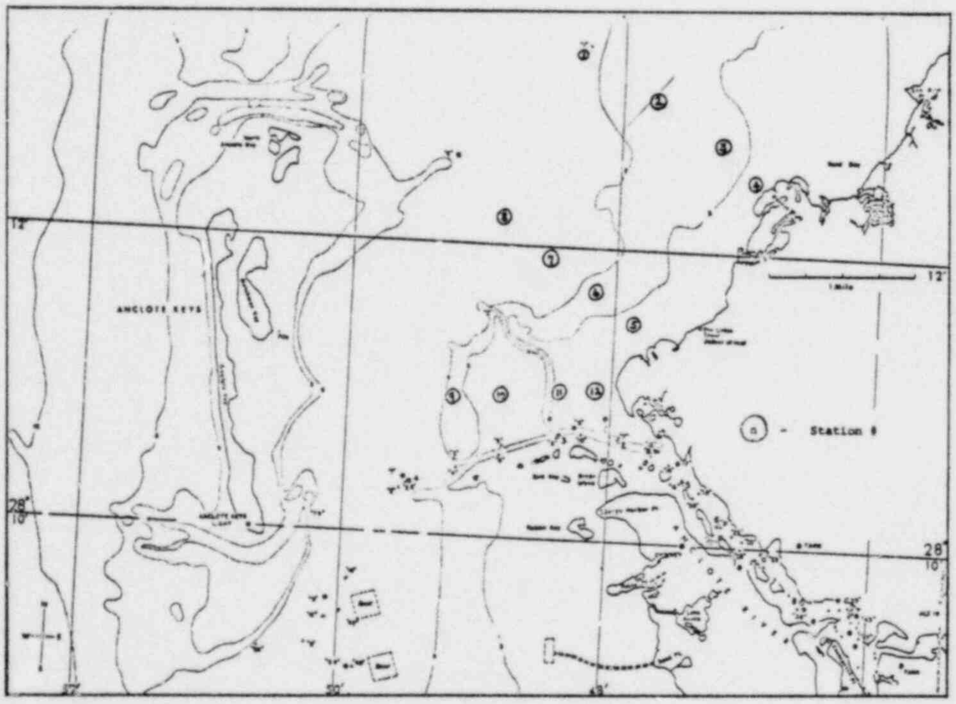

Figure 1
Current Survey 4/22/71
Causey - Schlemmer

TABLE 1
Tide and Current Data for April 22, 1971 at
Anclote Anchorage

Predicted Tidal Currents

Slack water Time	Maximum Current Time	Velocity
0353	0644	0.63 FLOOD
0947	1250	1.04 EBB
1623	1920	0.72 FLOOD

Predicted Tidal Heights

Time	Height
0335	0.18
0954	2.91
1605	0.00
2230	2.91

Current Data — Run #1

Station #1	Time	Velocity (KT)	Direction (°T)
1	0817	.29	030
2	0828	.13	035
3	0843	.11	040
4	0850	0	—
5	0726	.11	060
6	0737	.17	050
7	0747	.25	065
8	0800	.42	060
9	0712	.46	010
10	0701	.26	080
11	0651	.18	055
12	0639	0	—

Current Data — Run #2

Station #1	Time	Velocity (KT)	Direction (°T)
1	1024	0	—
2	1018	0	—
3	1012	.05	040
4	1007	0	—
5	0952	0	—
6	0947	0	—
7	0941	0	—
8	0935	.17	040
9	0922	.29	010
10	0916	.17	040
11	0910	0	—
12	0905	0	—

Current Data — Run #3

Station #1	Time	Velocity (KT)	Direction (°T)
1	1525	.14	330
2	1535	.09	000
3	1544	0	—
4	1553	0	—
5	1610	0	—
6	1621	.22	050
7	1629	.46	055
8	1637	.35	025
9	1651	> .53	010
10	1700	.25	000
11	1717	0	—
12	1710	0	—

ANCLOTE ENVIRONMENTAL PROJECT

Technical Report #6

THE BENTHIC COMMUNITY ALONG THE PROPOSED DISCHARGE CANAL FOR THE ANCLOTE RIVER POWER PLANT

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Submitted: June 30, 1971

This report is based upon a study of the benthic community and includes distribution and densities of sea grasses and benthic invertebrates along the axis of the proposed discharge canal.

METHODS

On May 29, June 3, 9 and 17, 1971, bottom samples were taken on a transect positioned along the proposed discharge canal. Stations were selected on the transect and sampled for densities of benthic plants and animals. Bottom plugs (20 x 20 cm) were obtained with a specially designed square corer resembling a post hole digger. Each sample was sieved (in the field) through a 0.5 mm square mesh sieve. Plant material was removed from the remaining fauna and sediment. For each sample taken, sea grass densities were determined by counting the emergent branches per unit area. The longest, living leaf was measured for each branch and average lengths reported. All living plant material including stems, leaves and rhizomes were retained, rinsed with distilled water, blotted and dried at 75°C for three to four days. Dry weights are given and include epiphytic algae. (Table I)[1]

At the margin of the grass bed, densities were obtained by counting the emergent stems within a metal meter square frame. No blade lengths are reported for this station, #9. Average lengths may be slightly low as some branches were unavoidably cut in sampling. Macroscopic algae growing in the grass bed were collected by hand. These species are reported.

Animals in the sieved material from each sample were relaxed with propylene phenoxythol, stained with Rose Bengal and fixed in 10% formalin (in the field). Organisms from samples at stations 1, 2, 3 and 4 were sorted in the laboratory, identified and counted. Species diversity was determined (Table II) and the densities listed. (Table III)

Epibenthic trawl samples were taken at two stations, 5 and 10. The trawl was one meter wide and one-half meter high at the opening. A .35 cm mesh bag was attached. The trawl was taken

1. Tables and Figures are shown on pp. 99 through 108.

over a distance of 15 meters. Relative abundance of fauna are reported in Table IV.

TRANSECT DESCRIPTION

The transect was begun at the high water line and extended Gulfward (Figures 1 & 2) along the proposed discharge canal. Terrestrial vegetation above the high water line had previously been removed by bulldozing. Red mangroves, *Rhizophora mangle*, and black mangroves, *Avicennia germinans*, along with typical sand strand vegetation were missing from the disturbed area. This vegetation was present, however, in undisturbed areas immediately to the north and south.

STATION 1:
At the high water line, there was a narrow band of *Spartina*. (Figures 3, 4 and Table I). The dominant animal here was the snail, *Littorina irrorata* (Table IIIa). Beyond the *Spartina*, a sand zone extended 28 meters offshore. This area was bare of grasses and attached algae, however twenty-two invertebrate species were recorded. (Table I and IIIa).

STATION 2:
Shoal grass, *Diplanthera wrightii*, dominated this shallow water zone (Figures 3, 4 and Table I). The grass was less dense toward shore and more Gulfward (Table I). Faunistically, this zone was similar to the preceding sand zone (Table I and IIIb).

STATION 3:
At 108 meters offshore, turtle grass *(Thalassia testudinum)* appears and is mixed with *Diplanthera* (Figures 3, 4 and Table I). This region was considered the lower littoral zone, with a mean water depth of just under one meter. Animal diversity and density were comparatively low in the sample from this area (Table II and Table IIIc). However, there is reason to believe that part of the sample was lost and thus does not truly represent the faunal diversity of this station.

STATION 4:
At the sublittoral fringe, in water averaging just over one meter in depth, *Thalassia* was found in a pure stand (Figures 3, 4 and Table I). Animal diversity and density increased slightly from previous stations (Table II). The gastropod *Modulus modulus* was abundant along with two caecidae, *Caecum pulchellum* and *Meisceras nitida*.

Crabs were common at this station and included the mud crab *(Neopanope texana)*, hermit crabs *(Pagurus bonairensis, Pagurus longicarpus)*, the spider crab *(Libinia emarginata)* and the blue crab *(Callinectes sapidus)*.

STATION 5:
An epibenthic trawl was taken at this station and revealed a high diversity of polychaetes and molluscs (Table Va). The most abundant crustacean was the shrimp, *Hippolyte pleuracantha*. Densities of this shrimp approached sixty individuals per square meter. Others present were the grass shrimp *Palaemonetes intermedius, Palaemonetes pugio, Palaemon floridanus* and the stick shrimp *Tozeuma carolinensis*. The pink shrimp *Penaeus duorarum* was present, but probably not sampled representatively. The trawls were taken at mid-day when most of the *Penaeus* population are burrowed into the sand bottom.

This station also represents the nearest shoreward appearance of manatee grass, *Syringodium filiforme*.

Mean water depth was slightly greater than one meter. The dominant aspect of the trawl sample was the high density of the pinfish. *(Lagodon rhomboides)*. Density was greater than ten per square meter (Table Va), indicating the high productivity of these sea grass beds.

STATION 6:
Both manatee grass and turtle grass were present in dense beds (Figures 3, 4 and Table I). The greatest density for *Syringodium* (100 emergent stems per square meter) was found at this station and average leaf lengths for both *Syringodium* and *Thalassia* were longer than at other transect stations. (Table I) Mean water depth was 1.5 meters. Invertebrate diversity was high,

with 41 species found in the sample (Table II). Molluscs were the most diverse group and nearly as abundant as polychaetes (Table II). Among the more abundant molluscs were the snails *Meioceras nitidium*, *Bulla striata*, and *Marginella eburneola*. Syllids, lumbrinerids and a species of *Prionospio* were the most abundant polychaetes (Table IIIe).

STATIONS 7 and 8:

Sea grass beds at stations 7 and 8 were dense but variable in composition. In this rather large region, pure stand of *Thalassia*, *Syringodium* and *Diplanthera* were found along with mixed patches. Pure stands of one grass were frequently found adjacent to pure or mixed stands of other grasses. The sea grass *Halophila baillones* also occurred in the area but was not collected in bottom plugs. Paired samples within a few feet of each other at stations 7 and 8 reflected variability in grass density and species composition (Table I). This variability was also evident in invertebrate species composition and densities (Table II, Table IIIf and IIIg). Molluscan and polychaete diversity and abundance were variable but generally high. Prominent among polychaetes were syllids, sabellariids, *Scoloplos*, *Fabricia*, *Clymenella*, *Capitella* and *Spirorbis*. Abundant gastropods (snails) were *Rissoina catesbyana*, *Modulus modulus*, *Crepidula maculosa*, *Crepidula fornicata*, *Bulla striata* and *Marginella eburneola*. Common pelecypods (clams) were *Chione cancellata*, *Lucina* sp.,*Tellina* sp., *Brachiodontes exustus* and *Tellina tampaensis*. One interesting and potentially valuable feature of these grass beds was the abundance of the edible scallop, *Argopecten irrandians concentricus*. Thirty minutes collecting effort by three persons yielded approximately five dozen large scallops. This figure becomes impressive, considering that these animals are living among dense grass blades and are relatively hard to see.

Aerial photographs in Figure 6 show the extent of the grass bed. It can be seen that grasses cover most of the bottom with only occasional bare patches several meters in size interspersed. The patchiness becomes more evident and extensive toward the outer margin.

STATION 9:

This station was essentially on the outer margin of the grass bed (Figure 3 and 4). The dominant vegetation was shoal grass *(Diplanthera)* which was sparse and small at the margin but larger and denser toward shore. Approximately 25 meters within the marginal beds,*Diplanthera* was mixed with sparse *Thalassia* and *Syringodium* and very sparse growths of *Halophila*. Mean water depth was just under two meters. Invertebrate densities and diversity were comparatively low (Table II and Table IIIh).

STATION 10:

Bottom fauna here was representative of types found in the sand, mud and shell bottom community of deeper waters beyond the grass beds (Figures 3, 4 and 6 & Table I). Invertebrates were insediment fauna, mainly polychaete worms and pelecypods (clams). (Table IIIi) *Cirriformia filigera* was the most abundant polychaete, while *Nucluana concentrica* was the most abundant pelecypod. Other wormlike invertebrates included sipunculoids, echiuroids, chaetegnaths and rynchocoels. Mean water depth was slightly greater than two meters.

SUMMARY

1. Seagrass beds are present over most of the area proposed for the Anclote Power Plant discharge channel. Composition of the beds varies between pure and mixed stands of shoal grass *Diplanthera wrightii)*, and turtle grass *(Thalassia testudinum)* and manatee grass *(Syringodium filiforme)*. These beds exhibit their more dense and luxuriant growth at average water depths between 0.7 and 1.75 meters.

2. The species diversity and densities of benthic invertebrates were greatest at stations with greatest grass densities.

3. A total of 145 benthic invertebrate species were obtained from sampling. Molluscs (61 species) and polychaetes (48 species) constituted the major portion of the benthic fauna sampled.

TABLE I
DENSITIES AND BIOMASS OF SEA GRASSES AT
STATIONS ALONG THE PROPOSED OUTFALL CHANNEL

Station	Distance from shore (meters)	Depth (meters)	SPARTINA density (M^2)	SPARTINA av. length (cm)	THALASSIA density (M^2)	THALASSIA av. length (cm)	DIPLANTHERA density (M^2)	DIPLANTHERA av. length (cm)	SYRINGODIUM density (M^2)	SYRINGODIUM av. length (cm)	Total dry wgt. (g/M^2)
1	0	.5	175	29.9	0	—	0	—	0	—	—
2 (a)	30	.6	0	—	0	—	1550	9.5	0	—	36.50
(b)	60	.8	0	—	0	—	3600	6.1	0	—	137.25
3	108	.9	0	—	400	18.3	1675	8.6	0	—	390.50
4	140	.9	0	—	625	23.0	0	—	0	—	1156.50
6	262	1.06	0	—	150	36.0	0	—	1000	32.4	439.00
7 (a)			0	—	0	—	1775	23.5	925	20.3	253.88
(b)	411	1.22	0	—	225	33.9	425	29.2	800	21.8	458.50
8 (a)			0	—	0	—	750	21.1	800	17.4	128.38
(b)	580	1.52	0	—	125	14.5	500	10.6	700	11.7	208.38
9	980	1.83	0	—	very sparse	—	0 to >100	—	very sparse	—	—
10	1038	2.13	0	—	0	—	0	—	0	—	0

TABLE II*
SPECIES DIVERSITY AT STATIONS ALONG THE PROPOSED OUTFALL CHANNEL
(from 20 x 20 cm Bottom Plug)

Group:	Stations:	1	2	3	4	6	7	8	9	10
POLYCHAETES	Species	4	4	3	4	12	13	16	5	10
	Individuals	9	10	7	10	102	397	42	19	21
MOLLUSCS	Species	13	12	6	15	23	14	23	10	8
	Individuals	46	18	14	36	91	27	72	36	17
CRUSTACEANS	Species	3	2	2	6	4	5	4	1	3
	Individuals	6	5	4	12	43	12	11	1	5
OTHERS	Species	2	4	1	2	2	0	0	3	4
	Individuals	3	4	1	4	10	0	0	5	4
TOTALS	Species	22	22	12	27	41	32	43	19	25
	Individuals	64	37	26	62	246	436	125	61	47

*Compiled from Table III

TABLE IIIa
Station 1
BENTHIC INVERTEBRATE DENSITIES
ON THE PROPOSED OUTFALL CHANNEL

Group:		Numbers/ 20 x 20 cm Plug
POLYCHAETES		
1.	*Onuphis emerita oculata*	5
2.	*Clymenella mucosa*	2
3.	*Laeonereis* sp.	1
4.	*Pectinaria gouldii*	1
	Total	9
MOLLUSCS		
1.	*Littorina irrorata*	13
2.	*Batellaria minima*	4
3.	*Melampus bidentatus*	1
4.	*Nassarius vibex*	1
5.	*Prunum apicinum*	1
6.	*Cerithium muscarum*	1
7.	*Olivella mutica*	1
8.	*Anomalocardia cuneimeris*	9
9.	*Tellina tampaensis*	7
10.	*Ensis minor*	3
11.	*Tagelus divisus*	2
12.	*Brachiodontes exustus*	2
13.	*Nucluana concentrica*	1
	Total	46
CRUSTACEANS		
1.	*Pagurus longicarpus*	2
2.	*Uca pugilator*	2
3.	*Amphipods*	2
	Total	6
MEROSTOMATA		
1.	*Limulus polyphemus*	1
SIPUNCULOIDEA		
1.	Unidentified species	2

TABLE IIIb
Station 2
BENTHIC INVERTEBRATE DENSITIES
ON THE PROPOSED OUTFALL CHANNEL

Group:		Numbers/ 20 x 20 cm Plug
POLYCHAETES		
1.	*Clymenella mucosa*	4
2.	*Onuphis emerita oculata*	4
3.	*Nereis succinea*	1
4.	*Diopatra cuprea*	1
	Total	10
MOLLUSCS		
1.	*Nassarius vibex*	2
2.	*Terebra protexta*	2
3.	*Modulus modulus*	2
4.	*Prunum apicinum*	1
5.	*Bulla striata*	1
6.	*Cerithium muscarum*	1
7.	*Crepidula maculosa*	1
8.	*Conus jaspideus*	1
9.	*Marginella* sp.	1
10.	*Anomalocardia cunimerus*	2
11.	*Cardita floridana*	2
12.	*Tellina tampaensis*	2
	Total	18
CRUSTACEAN		
1.	*Pagurus longicarpus*	1
2.	*Amphipods*	4
	Total	5
ECHINODERMS		
1.	*Ophioderma brevispinum*	1
2.	*Ophiophragmus filograneus*	1
	Total	2
TUNICATE		
1.	*Stylea plicata*	1
SIPUNCULOIDEA		
	Unidentified species	1

TABLE IIIc
Station 3
BENTHIC INVERTEBRATE DENSITIES
ON THE PROPOSED OUTFALL CHANNEL

Group:		Numbers/ 20 x 20 cm Plug
POLYCHAETES		
1. *Diopatra cuprea*		2
2. *Clymenella mucosa*		1
3. Unidentified		4
	Total	7
MOLLUSCS		
1. *Nassarius vibex*		4
2. *Bulla striata*		2
3. *Cerithium muscarum*		2
4. *Modulus modulus*		2
5. *Cardita floridana*		3
6. *Anomalocardia cuneimeris*		1
	Total	14
CRUSTACEAN		
1. *Amphipods*		2
2. *Cythura polita*		2
	Total	4
SIPUNCULOIDEA		
Unidentified species		1

TABLE IIId
Station 4
BENTHIC INVERTEBRATE DENSITIES
ON THE PROPOSED OUTFALL CHANNEL

Group:		Numbers/ 20 x 20 cm Plug
POLYCHAETES		
1. *Scoloplos* sp.		2
2. *Clymenella mucosa*		1
3. *Nereis succinea*		1
4. Unidentified		6
	Total	10
MOLLUSCS		
1. *Modulus modulus*		7
2. *Caecum pulchellum*		5
3. *Meioceras nitida*		4
4. *Nassarius vibex*		3
5. *Cerithium muscarum*		3
6. *Bulla striata*		3
7. *Crepidula maculosa*		2
8. *Terebra protexta*		2
9. *Conus jaspideus*		1
10. *Prunum apicnum*		1
11. *Tellina tampaensis*		1
12. *Brachiodontes exustus*		1
13. *Anadara transversa*		1
14. *Lioberus castaneus*		1
15. *Cardita floridana*		1
	Total	36
CRUSTACEANS		
1. *Neopanope texana*		4
2. *Pagurus bonairensis*		4
3. *Alpheus heterochaelis*		1
4. *Pagurus longicarpus*		1
5. *Libinia emarginata*		1
6. *Callinectes sapidus*		1
	Total	12
ECHINODERMS		
1. *Ophioderma brevispinum*		1
SIPUNCULOIDEA		
Unidentified species		3

TABLE IIIe
Station 6
BENTHIC INVERTEBRATE DENSITIES
ON THE PROPOSED OUTFALL CHANNEL

Group:		Numbers/ 20 x 20 cm Plug
POLYCHAETES		
1.	Syllidae	47
2.	*Prionospio* sp.	14
3.	Lumbrineridae	11
4.	*Fabricia* sp.	8
5.	*Paraprionospio pinata*	7
6.	*Capitella capitata*	4
7.	*Eupomatus* sp.	3
8.	Spionidae	2
9.	*Scoloplos rubra*	2
10.	Magelonidae	2
11.	*Spirorbis spirillum*	1
12.	*Scoloplos* sp.	1
	Total	102
MOLLUSCS		
1.	*Meioceras nitidum*	23
2.	*Bulla striata*	14
3.	*Marginella eburneola*	10
4.	*Turbonilla dalli*	4
5.	*Crepidula maculosa*	4
6.	*Mitrella lunata*	3
7.	*Prunum apicinum*	3
8.	*Marginella* sp.	2
9.	*Retusa sulcata*	2
10.	*Terebra protexta*	1
11.	*Anachis obesa*	1
12.	*Olivella mutica*	1
13.	*Chione cancellata*	6
14.	*Phacoides nuttalli*	6
15.	*Tellina* sp.	3
16.	*Cardita floridana*	1
17.	*Laevicardium mortoni*	1
18.	*Musculus lateralis*	1
19.	*Argopecten irradians concentricus*	1
20.	*Lucina amiantus*	1
21.	*Lucina* sp.	1
22.	*Ensis minor*	1
23.	*Macoma* sp.	1
	Total	91
CRUSTACEANS		
1.	Amphipods	33
2.	*Eurypanopeus depressus*	4
3.	*Pagurus bonairensis*	4
4.	*Hippolyte pleuracantha*	2
	Total	43
ECHINODERMS		
1.	*Ophiophragmus filograneus*	1
SIPUNCULOIDEA		
	Unidentified species	9

TABLE IIIf
Station 7
BENTHIC INVERTEBRATE DENSITIES
ON THE PROPOSED OUTFALL CHANNEL

Group:		Numbers/ 20 x 20 cm Plug
POLYCHAETES		
1.	Syllidae	315
2.	*Fabricia* sp.	57
3.	*Scoloplos rubra*	4
4.	*Capitella capitata*	4
5.	*Spirorbis spirillum*	4
6.	*Spiophanes bombyx*	3
7.	*Eupomastus* sp.	3
8.	*Nereis succinea*	2
9.	*Exogone dispar*	1
10.	*Typosyllis* sp.	1
11.	*Brania* sp.	1
12.	*Sphrosyllis* sp.	1
13.	*Scoloplos* sp.	1
	Total	397
MOLLUSCS		
1.	*Crepidula fornicata*	5
2.	*Mitrella lunata*	3
3.	*Bulla striata*	3
4.	*Marginella eburneola*	3
5.	*Prunum apicinum*	2
6.	*Bittium varium*	1
7.	*Turbonilla dalli*	1
8.	*Rissoina catesbyana*	1
9.	*Mitrella lunata*	1
10.	*Musculus lateralis*	2
11.	*Cardita floridana*	2
12.	*Chione cancellata*	1
13.	*Laevicardium mortoni*	1
14.	*Ischnochiton papillosa*	1
	Total	27
CRUSTACEANS		
1.	*Pagurus bonairensis*	5
2.	Amphipods	4
3.	*Hippolyte pleuracantha*	1
4.	*Pitho* sp.	1
	Total	11

TABLE IIIg
Station 8
BENTHIC INVERTEBRATE DENSITIES
ON THE PROPOSED OUTFALL CHANNEL

Group:		Numbers/ 20 x 20 cm Plug
POLYCHAETES		
1.	Sabellariidae	8
2.	*Scoloplos rubra*	7
3.	*Clymenella mucosa*	6
4.	*Hypsicomus* sp.	3
5.	*Exogone dispar*	3
6.	Spionidae	2
7.	*Nereis succinea*	2
8.	*Spirorbis spirillum*	2
9.	*Onuphis magna*	2
10.	*Glycera americana*	1
11.	*Pectinaria gouldii*	1
12.	*Eupomatus* sp.	1
13.	*Prionospio* sp.	1
14.	*Diopatra cuprea*	1
15.	Terebellidae	1
16.	*Notomastus latericeus*	1
	Total	42
MOLLUSCS		
1.	*Rissoina catesbyana*	27
2.	*Modulus modulus*	8
3.	*Crepidula maculosa*	3
4.	*Bittium varium*	2
5.	*Anachis semiplicata*	1
6.	*Crepidula plana*	1
7.	*Maringella aureocinta*	1
8.	*Turbonilla dalli*	1
9.	*Eupleura sulfcidentata*	1
10.	*Chione cancellata*	5
11.	*Lucina* sp.	4
12.	*Tellina* sp.	4
13.	*Brachiodontes exustus*	3
14.	*Tellina tampaensis*	2
15.	*Musculus lateralis*	1
16.	*Lioberus* :*astaneus*	1
17.	*Lima pell*ı*cida*	1
18.	*Argepecten irradians concentricus*	1
19.	*Laevicarc ium mortoni*	1
20.	*Phacoid*ı*s nassula*	1
21.	*Ischnor*ı*iton papillosa*	1
22.	*Acant*ᐟ*oehiton* sp.	1
23.	*Der*.*aliurn laqueatum*	1
	Total	72
CRUSTACEANS		
1.	*Pagurus bonairensis*	4
2.	Amphipods	3
3.	*Hippolyte pleuracantha*	2
4.	Isopods	2
	Total	11

TABLE IIIh
Station 9
BENTHIC INVERTEBRATE DENSITIES
ON THE PROPOSED OUTFALL CHANNEL

Group:		Numbers/ 20 x 20 cm Plug
POLYCHAETES		
1.	*Spiophanes bombyx*	14
2.	*Clymenella mucosa*	2
3.	Sabellidae	1
4.	Terebellidae	1
5.	*Laeonereis* sp.	1
	Total	19
MOLLUSCS		
1.	*Rissoina catesbyana*	2
2.	*Marginella eburneola*	1
3.	*Anachis obesa*	1
4.	*Lucina* sp.	19
5.	*Lucina amiantus*	4
6.	*Nuculana concentrica*	3
7.	*Chione cancellata*	3
8.	*Ensis minor*	1
9.	*Tellina* sp.	1
10.	*Tellidora cristata*	1
	Total	36
CRUSTACEANS		
1.	Amphipod	1
BRACHIOPOD		
1.	*Glottidia* sp.	1
ECHIUROID		
1.	Unidentified species	3
PHORONID		
1.	*Phoronis architecta*	1

TABLE IIIi
Station 10
BENTHIC INVERTEBRATE DENSITIES
ON THE PROPOSED OUTFALL CHANNEL

Group:		Numbers/ 20 x 20 cm Plug
POLYCHAETES		
1.	*Cirriformia filigera*	9
2.	*Glycera americana*	2
3.	*Spionidae*	2
4.	*Clymenella mucosa*	2
5.	Capitellidae	1
6.	*Onuphis eremita oculata*	1
7.	*Notomastus* sp.	1
8.	*Spiophanes bombyx*	1
9.	*Prionospio* sp.	1
10.	Syllidae	1
	Total	21
MOLLUSCS		
1.	*Turbonilla dalli*	3
2.	*Tectonatica pusilla*	2
3.	*Anachis obesa*	1
4.	*Nucluana concentrica*	5
5.	*Lucina* sp.	2
6.	*Tellina* sp.	2
7.	*Laevicardium mortoni*	1
8.	*Dentalium laquaetum*	1
	Total	17
CRUSTACEANS		
1.	Amphipoda	3
2.	Isopoda	1
3.	Caridean shrimp (juveniles)	1
	Total	5
SIPUNCULOIDEA		
	Unidentified species	1
ECHIUROID		
	Unidentified species	1
CHAETEGNATHA		
	Unidentified species	1
RYNCHOCOELA		
	Unidentified species	1

TABLE IV
MACROSCOPIC ALGAE IN GRASS BED
ALONG PROPOSED OUTFALL CHANNEL

Group:	Relative Abundance
CHLOROPHYTA	
Halimeda incrassata	Common
Caulerpa ashmeadii	Common
Caulerpa prolifera	
Penicillus capitatus	Common
Penicillus lamourouxii	
Anadyomene stellata	
Acetabularia crenulata	
Udotea conglutinata	
PHAEOPHYTA	
Sargassum pteropleuron	
RHODOPHYTA	
Laurencia poitei	Very common, sometimes completely covering large areas of grass.
Spyridia filamentosa	
Chondria collinsiana	
Digenia simplex	Very common with *Laurencia potei*
Hypnea musciformis	
Polysiphonia echinata	Common, usually as an epiphyte. Larger plants probably break off.
CYANOPHYTA	
Lyngbya semiplena	In turfs in shallow water *Diplanthera* beds.

TABLE Va

FAUNA STATION 5 FROM A 15 METER TRAWL ALONG THE PROPOSED OUTFALL CHANNEL

Group:	Relative Abundance
POLYCHAETES	
Nereis succinea	Abundant
Syllidae	Abundant
Fabricia	Abundant
Spirorbis spirillum	Abundant
Sabella microphthalma	Common
Polydora sp.	Common
Lumbrineris sp.	Common
MOLLUSCS	
Modulus modulus	Abundant
Mitrella lunata	Abundant
Rissoina catesbyana	Abundant
Caecum pulchellum	Abundant
Meioceras nitidum	Abundant
Nassarius vibex	Common
Anachis semiplicata	Common
Cerithium muscarum	Common
Terebra protexta	Common
Marginella aureocincta	Common
Bittium varium	Common
Marginella eburneola	Common
Cerithiopsis bicolor	Common
Prunum apicinum	Common
Turbonilla sp.	Present
Certhiopsis greeni	Present
Cardita floridana	Abundant
Chione cancellata	Common
Laevicardium mortoni	Common
Tellina sp.	Common
Lioberus castaneus	Present
CRUSTACEANS	
Hippolyte pleuracantha	Abundant
Penaeus duorarum	Present
Palaemonetes intermedius	Present
Palaemonetes pugio	Present
Palaemon floridanus	Present
Tozeuma carolinensis	Present
Amphipods	Present
Eurypanopeus depressus	Abundant
ECHIURUID	
Unidentified species	Common
ECHINODERMS	
Lytechinus variegatus	Common
FISH (juveniles)	
Lagodon rhomboides	117
Gobiosoma robustum	17
Syngnathus scovelli	2
Chasmodes saburrae	1
Hippocampus sp.	1

TABLE Vb

FAUNA STATION 9 FROM A 15 METER TRAWL ALONG THE PROPOSED OUTFALL CHANNEL

Group:	Relative Abundance
POLYCHAETES	
Glycera americana	Abundant
Pectinaria gouldii	Abundant
Lumbrineris sp.	Abundant
Nereis succinea	Common
Owenia fusiformis	Common
Pista palmata	Common
Clymenella mucosa	Common
Laeonereis culveri	Common
Nereiphylla paretti	Common
Sabellariidae	Present
Scoloplos fragilis	Present
Glycera dibranchiata	Present
Onuphis eremita oculata	Present
Scoloplos rubra	Present
Naineris sp.	Present
Nereidae	Present
Sigalionidae	Present
Orbiniidae	Present
Phyllodocidae	Present
Eteone sp.	Present
MOLLUSCS	
Tectonatica pusilla	Abundant
Prunum apicinum	Abundant
Mitrella lunata	Abundant
Bittium varium	Common
Crepidula plana	Common
Crepidula maculosa	Common
Haminoea succinea	Common
Lucina sp.	Abundant
Nucluana concentrica	Abundant
Musculus lateralis	Common
Lima pellucida	Common
Tellina sp.	Common
Chione cancellata	Common
Trachycardium egmontianum	Common
Lyonsia hyalina floridana	Common
Laevicardium mortoni	Common
Dinocardium robustum	Uncommon
Cuspidaria gemma	Uncommon
Dentalium laqueatum	Common
CRUSTACEANS	
Tozeuma carolinensis	Abundant
Hippolyte pleuracantha	Abundant
Periclemenes longicaudatus	Abundant
Lareutes fucorum	Common
Trachypenaeus constrictus	Common
Palaemonetes intermedius	Present
Processa sp.	Present
Mysids	Present
Amphipods	Present
Isopods	Present
Persephona punctata	Present
Osachila tuberosa	Present
Eurypanopeus depressus	Present
FISH (juveniles)	
Bairdiella chrysura	14
Cynoscion nebulosus	4
Syngnathus floridae	3
Prionotus tribulus crassiceps	1

TABLE VI
SPECIES LISTING OF INVERTEBRATES FOUND ALONG THE PROPOSED OUTFALL CHANNEL

POLYCHAETES
- *Brania* sp.
- *Capitella capitata*
- Capitellidae
- *Cirriformia filigera*
- *Clymenella mucosa*
- *Diopatra cuprea*
- *Eteone* sp.
- *Euzomatus* sp.
- *Exogone dispar*
- *Fabricia* sp.
- *Glycera americana*
- *Glycera dibranchiata*
- *Hypsicomus* sp.
- *Laeonereis* sp.
- *Laeonereis culveri*
- Lumbrineridae
- *Lumbrineris* sp.
- Magelonidae
- *Naineris* sp.
- *Nereidae* sp.
- *Nerei phylla paretti*
- *Nereis succinea*
- *Notomastus* sp.
- *Notomastus latericeus*
- *Onuphis eremita oculata*
- *Onuphis magna*
- Orbiniidae
- *Owenia fusiformis*
- *Paraprionospio pinnata*
- *Pectinaria gouldii*
- Phyllodocidae
- *Pista palmata*
- *Polydora* sp.
- *Prionospio* sp.
- Sabellidae
- *Sabella microphthalma*
- Sabellariidae
- *Scoloplos* sp.
- *Scoloplos fragilis*
- *Scoloplos rubra*
- Sigalionidae
- Spionidae
- *Sphrosyllis* sp.
- *Spiophanes bombyx*
- *Spirorbis spirillum*
- Syllidae
- Terebellidae
- *Typosyllis*

MOLLUSCS
- *Anachis obesa*
- *Anachis semiplicata*
- *Battilaria minima*
- *Bittium varium*
- *Bulla striata*
- *Cerithiopsis bicolor*
- *Cerithiopsis greeni*
- *Cerithium muscarum*
- *Conus jaspideus*
- *Crepidula fornicata*
- *Crepidula maculosa*
- *Crepidula plana*
- *Eupleura sulcidentata*
- *Haminoea succinea*
- *Littorina irrorata*
- *Magelia biplicata*
- *Marginella* sp.
- *Marginella aureocincta*
- *Marginella eburneola*
- *Meioceras nitidium*
- *Melampus bidentatus*
- *Mitrella lunata*
- *Monoilispira leucocyma*
- *Nassarius vibex*
- *Olivella mutica*
- *Prunum apicinum*
- *Pyramidella crenulata*
- *Retusa sulcata*
- *Rissoina catesbyana*
- *Tectonatica pusilla*
- *Terebra protexta*
- *Turbonilla dalli*
- *Anadara transversa*
- *Anomalocardia cuneimeris*
- *Argopecten irradians concentricus*
- *Brachiodontes exustus*
- *Cardiomya* sp.
- *Cardita floridana*
- *Chione cancellata*
- *Cuspidaria gemma*
- *Dinocardium robustum*
- *Dosinia discus*
- *Ensis minor*
- *Laevicardium mortoni*
- *Lima pellucida*
- *Lioberus castaneus*
- *Lucina amiantus*
- *Lucina* sp.
- *Macoma* sp.
- *Musculus lateralis*
- *Nucluana concentrica*
- *Phacoides nassula*
- *Phacoides nuttalli*
- *Tagelus divisus*
- *Tellidora cristata*
- *Tellina* sp.
- *Tellina tampaensis*
- *Trachycardium egmontianum*

- *Dentalium laqueatum*

- *Acanthochitona* sp.
- *Ischnochitin papillosus*

CRUSTACEANS
- *Alpheus heterochaelis*
- Amphipoda
- Caridean shrimp (juveniles unidentified)
- *Clibanarius vittatus*
- *Cyathura polita*
- *Eurypanopeus depressus*
- *Hippolyte pleurocantha*
- Isopoda
- *Latreutes fucorum*
- *Libinia emarginata*
- Mysids (for Mysidea or Mysidacea)
- *Neopanope texana*
- Ostracoda
- *Paguristes hummi*
- *Pagurus bonairensis*
- *Pagurus floridanus*
- *Palaemonetes intermedius*
- *Palaemonetes pugio*
- *Penaeus duorarum*
- *Periclimenes longicaudatus*
- *Pitho* sp.
- *Processa* sp.
- *Tozeuma carolinense*
- *Trachypeneus constrictus*
- *Trachypeneus similis*
- *Uca pugilator*

MEROSTOMATA
- *Limulus polyphemus*

BRACHIOPODA
- *Glottidia* sp.

ECHIURIDA
- Unidentified species

PHORONIDA
- *Phoronis architecta*

SIPUNCULOIDEA
- Unidentified species

CHAETOGNATHA
- Unidentified species

RHYNCHOCOELA
- Unidentified species

ECHINODERMS
- *Lytechinus variegatus*
- *Ophioderma brevispinum*
- *Ophiophragmus filograneus*

ASCIDIAN
- *Styela plicata*

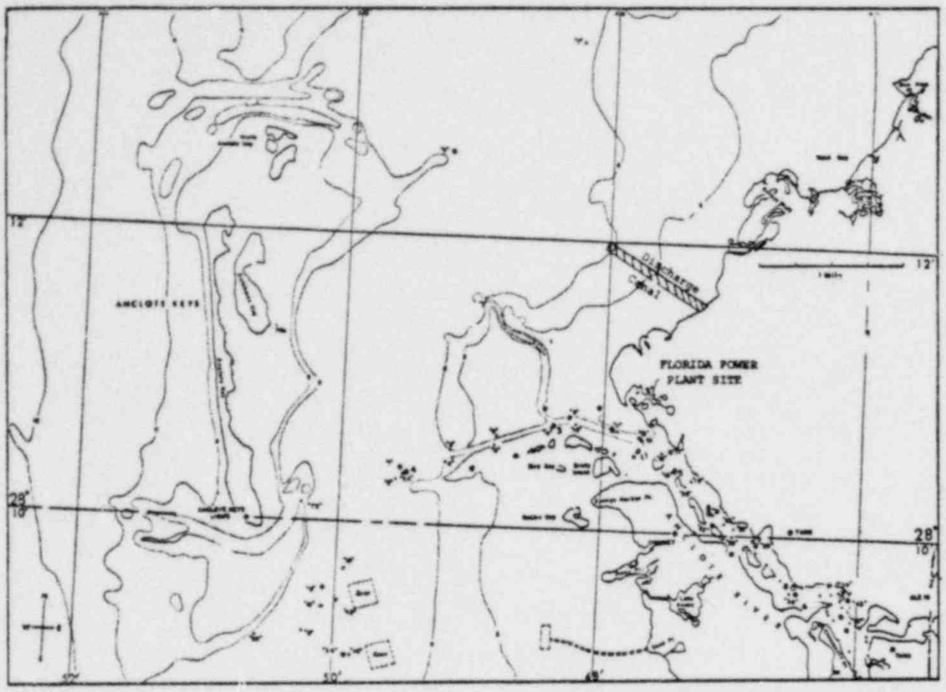

Figure 1
Anclote Anchorage and location of the proposed discharge canal for the Florida Power Anclote River Generating Plant.

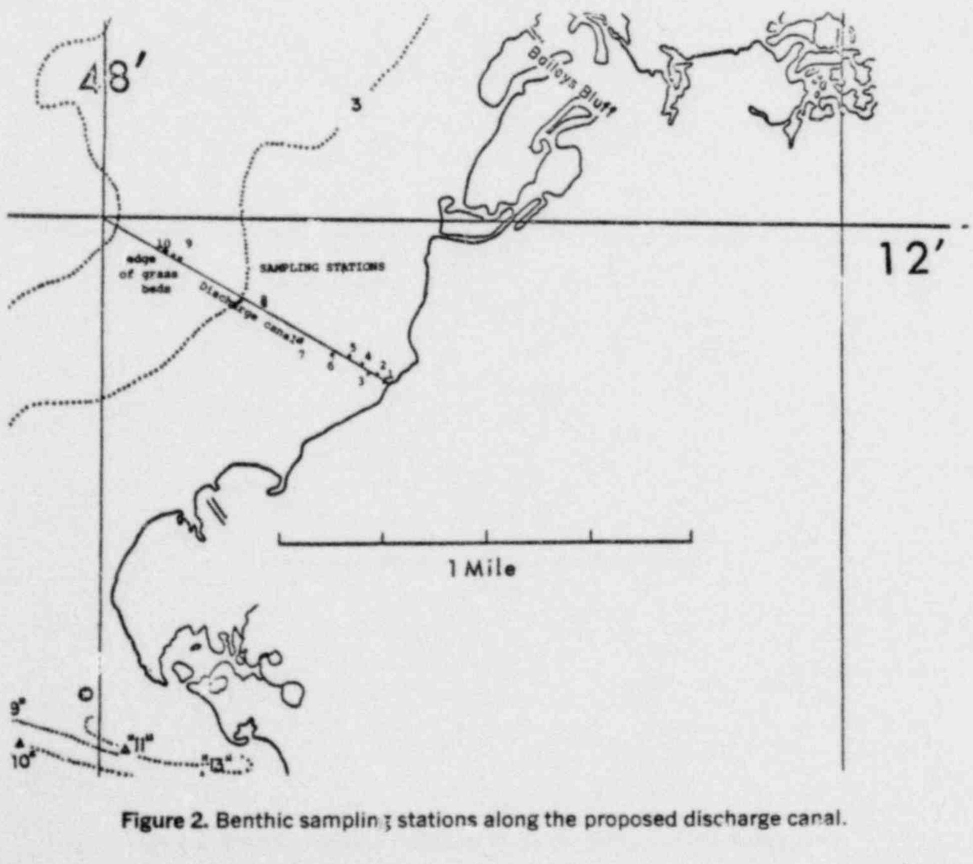

Figure 2. Benthic sampling stations along the proposed discharge canal.

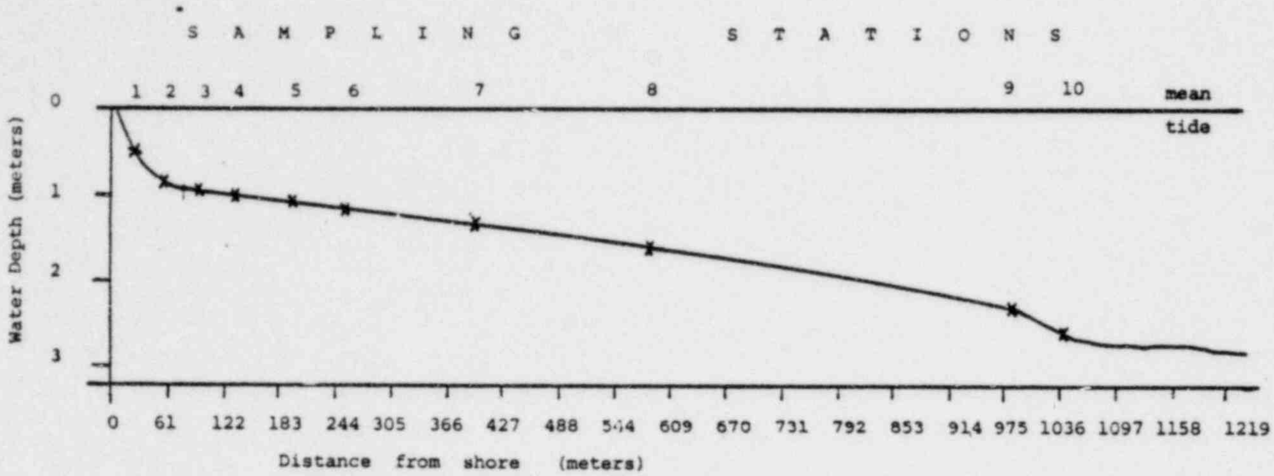

Figure 3. Sampling stations and bottom profile along the proposed discharge canal.

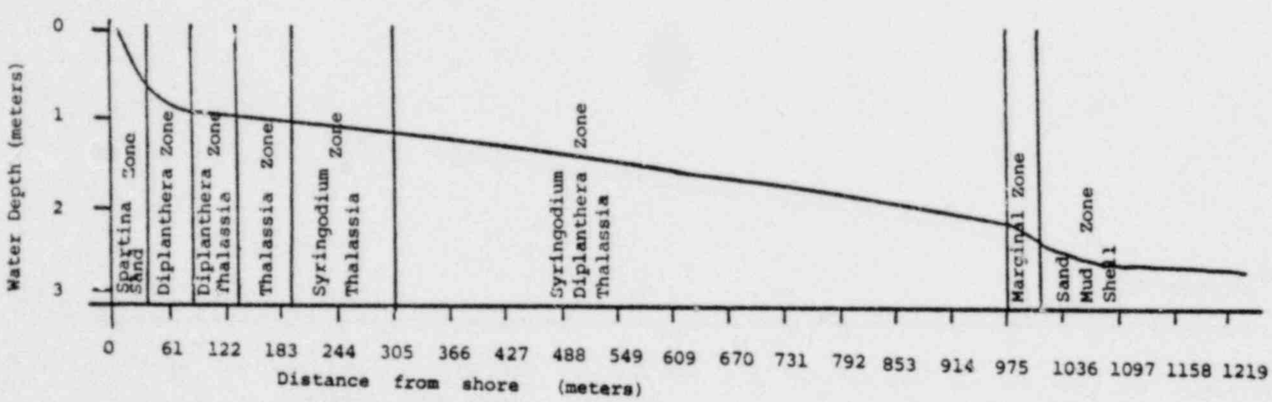

Figure 4. Major biological zones as they occur along the proposed discharge canal.

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