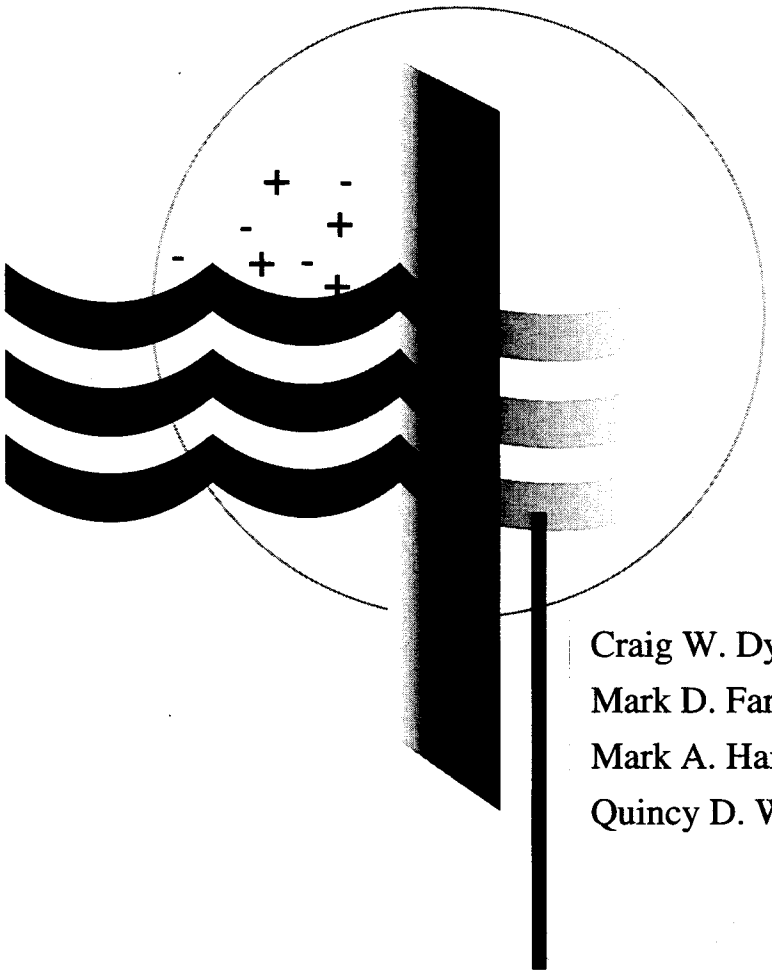
SEAWATER DESALINATION

An Investigation of Concentrate Disposal By Means of a Coastal Ocean Outfall



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Southwest Florida
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ACKNOWLEDGMENTS

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INTRODUCTION

In response to a mounting concern for increased water demands in the face of regional environmental degradation from over-drafting the hydrologic system, the Southwest Florida Water Management District (District) initiated a very aggressive program to evaluate and take action to address the various water management concerns. As the process evolved, the investigations pointed toward many problems that would have to be resolved to meet District rules and Florida Statutes as they pertain specifically to adverse environmental impacts. The future needs for water in the Tampa Bay area will steadily increase with time and environmentally compatible solutions must be found to meet the needs for sustainable growth. The expedited development of alternative water supplies is critical to solving the water supply issues in Tampa Bay. When all issues are given full consideration, it is the District's position that seawater desalination holds great potential to meet the current and future needs for Tampa Bay.

The November 23, 1993, edition of Kiplinger's Florida Newsletter stated: "...Florida will run out of inexpensive water as population grows... ...means sweeping changes in the way water is regulated lie ahead... ...will affect all users.... ...it will be a monumental struggle." This prognostication has been most apparent in the Tampa Bay area as growing coastal communities are seeking additional water with cost being the dominating factor in the decision-making process. The lack of available water in coastal areas due to saltwater intrusion has forced these growing communities to seek water from inland counties that have not as yet experienced the demands of growth. Some coastal communities would seek additional water from ground or surface water sources in geographic areas outside their political borders and would transfer this supply through an extensive pipeline system. This method of water management, used most extensively in California in a program known as the State Water Project, has been severely criticized as inequitable, accentuated in times of drought. The water management implications of such a strategy in Florida would be enormous, not to mention the political and legal confrontations that would have to play out before such a plan could be implemented.

The rationale for considering seawater desalination is obvious when you observe the location of Tampa Bay which has abundant access to seawater from the Gulf of Mexico or Tampa Bay. Desalination is utilized extensively throughout Florida which has the most such facilities of any state in the U.S. Currently Florida has 176 desalination plants, all brackish water except for a seawater facility in Key West.

The implementation of effective conservation and reclaimed water is not sufficient to supply Tampa Bay in the short- or long-term. New water supplies must be generated to replace sources which are causing severe environmental damage, as well as water needed for growth. The District views seawater desalination as a long-term water supply option that can expeditiously provide an enormous amount of safe, dependable and affordable water to the Tampa Bay area to assist in the resolution of the water supply problem.

The District initiated an effort to address the two major obstacles associated with seawater desalination; cost and disposal of the waste concentrate. This investigation dealt solely with the issue of concentrate discharge. Joining forces with agencies which had a common interest or

regulatory oversight seemed the appropriate way to expedite possible solutions and make the best use of District resources.

WORK WITH ELECTRIC POWER RESEARCH INSTITUTE

In 1992, the District joined the Electric Power Research Institute (EPRI) to elicit support for promoting desalination on a national level. EPRI conducts research for the electric power utility industry including research in the water and wastewater industry. EPRI's Desalination and Water Reuse Committee (Table 1), co-chaired by Mark D. Farrell from the District, is responsible for oversight of the research efforts including several desalination research efforts co-funded by the District.

EPRI had recently completed a desalination study to determine the technical and economic feasibility of converting existing coastal power plants to dual purpose electric power and desalination. The results of the study indicated there are economic benefits to having a dual purpose facility; however, disposal of the concentrate was still one of the major obstacles. Therefore, EPRI recommended that a subsequent study be conducted to evaluate potential concentrate disposal options. Initial investigation suggested that ocean disposal would be the most practical option for large seawater desalination facilities.

A subsequent desalination study was initiated to investigate off-shore and near-shore ocean disposal, and inland disposal. An objective of the study was to develop and make available computer codes that predict dispersion of the concentrate to the ocean under common coastal conditions. Additionally, the study was to provide guidelines for ocean discharge of different desalination plant sizes, outfall configurations, and concentrations to the Atlantic and Pacific oceans, and the Gulf of Mexico. Several existing models, used for fresh water discharges, were evaluated and the Cormix code from the United States Environmental Protection Agency (EPA) Environmental Research Laboratory in Athens, Georgia was selected and modified to B-Cormix to be able to handle concentrate discharges into seawater.

In 1993, several workshops were held to demonstrate the use of the B-Cormix concentrate discharge model. One was held in California while another workshop was held at the District's Tampa office and included staff from the Florida Department of Environmental Protection (FDEP) and EPA. The workshops provided an opportunity for regulatory agencies, water utilities, and consultants to discuss the problems facing seawater desalination such as the disposal of the concentrate. Based on the success of the workshops, EPRI initiated a third study to verify and calibrate the model using literature and observed data.

DISCUSSIONS WITH REGULATORY AGENCIES

In 1994, the District initiated discussions with the regulatory agencies involved in the permitting of concentrate discharges to determine how concentrate disposal could be managed in an environmentally acceptable manner.

Meetings were held with EPA at Region IV headquarters in Atlanta to explain Florida's water supply problems and to gain their assistance in resolving the problems. The EPA and FDEP agreed to assist in determining the permittability of a concentrate discharge at a facility with an existing permitted discharge, such as a power plant. The parties agreed that due to the pending delegation of the National Pollutant Discharge Elimination System (NPDES) to the FDEP that all coordination on matters related to the permitting of a concentrate discharge should be handled at the state level by the FDEP. A meeting with FDEP in Tallahassee identified key permitting issues to be considered for a discharge to the Gulf of Mexico. The permitting issues include the state's Antidegradation Policy, Water Quality Based Effluent Limitations (WQBEL), establishment of mixing zones, and a Waters of the State determination.

The Antidegradation Policy is contained in FDEP rules 62-302.300 and 62-4.242, Florida Administrative Code (F.A.C.). The basis of the policy is that new or expanded discharges pass the public interest test in addition to meeting all other FDEP rules. The discharge is not allowed to degrade the quality of the receiving waters below the state standards. Passing the public interest test would require that other alternative disposal methods are not economically and technologically reasonable. Providing a safe and reliable public drinking water source is a positive factor in making a public interest demonstration.

A discussion of the WQBEL process is contained in FDEP rules 62-650 F.A.C. The WQBEL is set for parameters in a discharge to protect the receiving waters. FDEP's experience with discharges from brackish water reverse osmosis plants indicates that specific parameters should be investigated. Seawater desalination issues are considered separate from brackish ground water desalination because seawater is withdrawn, a portion of fresh water is removed with virtually nothing added, and the concentrate discharged back into the source from where it was withdrawn. It was determined that a characterization of the concentrate and receiving waters, including acute and chronic toxicity tests, would need to be conducted.

Mixing zone policy is contained in FDEP Rule 62-4.244, F.A.C., and allows for the establishment of mixing zones for discharges under certain conditions. An essential condition is that the discharge cannot be acutely toxic. Mixing zones have limitations depending on the quality and quantity of the effluent as well as the quality of the receiving water.

The FDEP's criteria for determining if a discharge is acutely toxic is through laboratory testing of selected organisms whereby a 96-hour LC50 concentration is calculated. The 96-hour LC50 is the concentration of effluent lethal to 50 percent of the test organisms during a 96-hour bioassay. If the 96-hour LC50 is greater than or equal to 300 percent, then a discharge is not considered acutely toxic and a discharge could be permitted. If the 96-hour LC50 is between 100 and 300 percent, then a mixing zone or dilution of the effluent prior to discharge would be required. If the LC50 is less than 100 percent, then the discharge would not be permitted without prior dilution or an exemption. Additionally, chronic toxicity would need to be investigated to assess long-term exposure with respect to survival, growth, and reproductivity of organisms in the receiving waters.

PLAN OF STUDY

The FDEP and the District developed a Plan of Study (Appendix A) to characterize the seawater concentrate water quality and to assess the biological effects the concentrate may have on receiving waters, namely the Gulf of Mexico. The Florida Progress Corporation (FPC) agreed to use their Anclote River Power Plant as a test site for collecting seawater samples. Acute and chronic toxicity tests were performed on an invertebrate species, *Mysidopsis bahia* (mysid shrimp), and a fish species, *Menidia beryllina* (Gulf silverside minnow), using concentrate produced from a small portable seawater reverse osmosis (RO) unit.

METHODS

The University of South Florida (USF) was contracted to assist in the production of the concentrate. For this study, USF purchased a PUR Powersurvivor™ 35 Reverse Osmosis unit which is typically used for marine applications. The unit consists of an intake line, cartridge prefilter, a patented pump, pressure vessel and membrane, and discharge lines for the product water and concentrate. The membrane is a FilmTec, spiral wound, high rejection, polyamid thin film composite seawater membrane, comparable to commercial seawater desalination membranes manufactured by FilmTec.

The RO unit is rated for 15 U.S. gallons per hour of seawater and will produce 1.4 U.S. gallons per hour of product water operating at approximately 10 percent recovery. The unit operates within a temperature range of 36 to 113 degrees Fahrenheit (2 to 45 degrees centigrade) with a 98 percent minimum salt rejection. The production specifications are for water at 25 degrees centigrade, with 32,000 parts per million (ppm) sodium chloride and a pH of 4 to 10.

USF analyzed the seawater and determined that a 40 percent recovery could be expected. The RO unit was operated in a manner to simulate the operation of a full scale plant with a 40 percent recovery. For example, starting with 10 gallons of seawater, the unit was operated until 4 gallons of product water was removed leaving 6 gallons of concentrate.

Seawater samples for toxicity testing were collected for eight test events from October 17, 1994 through March 6, 1995. A range of low salinity, 6 parts per thousand (ppt), to high salinity (30 ppt) source water was used based on the expected salinity range of the seawater at the Anclote facility. Worst case scenarios included potential ionic imbalance (FDEP, 1994) and high salinity concentrate effluent. The source water for all events was collected at or near the mouth of the Anclote River. Water was collected via boat using five-gallon carboys and thirty-gallon barrels and was then transferred to the District where the concentrate was produced. A 40 percent recovery of fresh water (60 percent concentrate) was generally obtained when running the RO unit. For each event, subsamples of the concentrate and source water were submitted to the District lab for chemical analyses. Additionally, for the first two events, samples were taken to Savannah Laboratories in Tampa for the analyses of hydrogen sulfide, combined radium 226 and 228, and gross alpha. The remaining concentrate, and source water to be used as diluent in the bioassays, was delivered to the CH2M HILL and/or Environmental Science and Engineering (ESE) laboratories in Gainesville.

CH2M HILL and ESE performed acute and chronic toxicity bioassays following procedures outlined by EPA (1993) and EPA (1988) respectively. These tests were conducted on two organisms recommended by the FDEP and EPA: an invertebrate, *Mysidopsis bahia* (mysid shrimp), and a fish, *Menidia beryllina* (Gulf silverside minnow).

Acute Bioassays

The acute toxicity tests were conducted for 96 hours on the organisms noted above and employed two replicates per treatment. A treatment is considered a control (e.g., 100 percent seawater) or a specific dilution (e.g., 50 percent effluent). The first test conducted was an acute screening bioassay of the proposed diluent taken from the Anclote River. This test, which consisted of a seawater control and 100% Anclote River water (the proposed diluent for the definitive tests), revealed that the diluent was not toxic to the test organisms. The acute definitive bioassays consisted of a seawater control, 100 percent effluent (i.e., concentrate discharge), 50, 25, 12.5, 6.25 and 3.125 percent effluent concentrations or, in later tests, a seawater control, 100 percent effluent, 97, 94, 87.5, 75, and 50 percent effluent concentrations. For the February 15, 1995 event, the source water was diluted with water collected from a well near the Anclote River to obtain a low salinity sample (6 ppt). The low salinity test was necessary because any effects attributable to ionic imbalances were considered to be most extreme at this salinity. Upon completion of the tests, the contractor(s) calculated 96-hour LC50 concentrations (Table 2).

Chronic Bioassays

All chronic bioassays were conducted for seven days using the mysid shrimp and silverside minnow noted above. The bioassays consisted of a seawater control, 100 percent Anclote River water, 100 percent concentrate effluent, 50, 25, 12.5, 6.25, and 3.125 percent effluent concentrations. Four replicates of each treatment were employed with the silverside minnow and eight replicates of each treatment were employed with the mysid shrimp. Upon completion of the tests, the contractor(s) calculated the No Observable Effect Concentrations or NOEC (NOEC is the highest percent concentration of concentrate that has no observable effect on survival, growth, and fecundity) for both species (Table 3).

RESULTS AND DISCUSSION

The Savannah Lab analyses of hydrogen sulfide, combined radium 226 and 228, and gross alpha revealed there were no unacceptable levels of any of these constituents in the source water or concentrate effluent. Comparing the results of the chemical analyses performed by the District lab with values in the F.A.C. Chapter 62-302.560 Criteria: Class III Waters (i.e., Recreation-Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife) indicated that chloride exceeded state standards. That chloride values for all test events exceeded the state standards (i.e., not greater than 10 percent above background, in this case the source water) was not surprising since seawater was the source water.

All the acute bioassays resulted in LC50 values greater than 100%. As can be seen in Table 3, there was some degree of toxicity in the chronic tests, however, 68 percent of the values were at 100 percent NOEC for the concentrate and only one value was below 50 percent NOEC. The levels of chronic toxicity noted in the bioassay tests should be eliminated by the available dilution in the

Anclote facility discharge canal, prior to mixing with the Gulf of Mexico waters which are waters of the state. The available dilution in the discharge canal is such that the discharge complies with the FDEP's rules governing toxicity without the need for a toxicity mixing zone in the Gulf waters, which are considered waters of the state.

CONCLUSIONS

This cooperative effort has demonstrated that seawater desalination can be a safe, dependable, and environmentally-compatible water supply source. Specifically, the analyses show that the chemistry of the raw seawater and concentrate indicates no problem contaminants. Additionally, the acute and chronic toxicity test results show that state standards can be met at the Anclote site, and applied elsewhere, for a seawater desalination concentrate discharge through predischarge dilution or an acceptable mixing zone.

There do not appear to be any acute toxicity effects related to ionic imbalance or to the high salinity concentrate effluent, since all 96-hour LC50 values for the acute bioassays were greater than 100%. Though some toxic effects were noted in the chronic tests, of the higher salinity concentrate, mixing and dilution of the concentrate effluent with the receiving water should eliminate any potential effects in the Gulf of Mexico. Furthermore, the test indicator species, which are very sensitive organisms, showed a high degree of tolerance and adaptability to the higher concentration of salinity.

As indicated in FDEP's letter dated April 12, 1995 (Appendix A), "In conclusion, based on the information and analysis provided by the Southwest Florida Water Management District in conformance with the agreed-upon Plan of Study, the Department agrees the results indicate that a seawater concentrate discharge can be managed to meet the Department's water quality standards and is manageable and permittable with appropriate conditions under current DEP point source discharge criteria."

TABLE 1. EPRI DESALINATION AND WATER REUSE COMMITTEE

EPRI Desalination and Water Reuse Committee	
Bureau of Energy Conservation	National Water Research Institute
California Department of Water Resources	Separation Consultants, Inc.
Central Basin Municipal Water District	South Florida Water Management District
Central Contra Costa Sanitary District	Southwest Florida Water Management District
General Atomics	Tampa Electric Company
Honolulu Board of Water Supply	Washington University
Los Angeles Department of Water and Power	West Coast Regional Water Supply Authority
Metropolitan Water District of Southern California	

TABLE 2. RESULTS FOR THE 96-HOUR ACUTE TOXICITY TESTS FOR *MYSIDOPSIS BAHIA* (MYSID SHRIMP) AND *MENIDIA BERYLLINA* (GULF SILVERSIDE MINNOW).

DATE	LAB	LC50 VALUES (%)		SALINITY OF SOURCE WATER (ppt)	SALINITY of Concentrate (ppt)
		MYSID	MENIDIA		
12-21-94[A]	ESE	>300	>300	26	43
		135	>300	26	43 thermal concentrate
	CH2M HILL	>300	>300	26	43
01-03-95[A]	ESE	>100	>300	25.5	44
01-18-95[B]	ESE	265	>300	25	45
	CH2M HILL	167	103	25	45
01-27-95[B]	ESE	268	172	20.5	45
	CH2M HILL	124	113	20.5	45
02-15-95[C]	ESE	188	>300	6[1]	12
	CH2M HILL	>300	>300	6[1]	12
03-01-95[A]	ESE	108	201	30	53
	CH2M HILL	102	133	30	53

[1]River water (28 ppt) was diluted with well water to obtain the 6 ppt source water.
[A]Serial dilutions for this event ranged from 100% to 3% concentrate and were not adjusted up to original concentrate concentration.
[B]Serial dilutions for this event ranged from 50% to 100% concentrate and were not adjusted up to original concentrate concentration.
[C]Serial dilutions for this event ranged from 50% to 100% concentrate and were adjusted up to original concentrate concentration.

TABLE 3. RESULTS FOR THE SEVEN DAY CHRONIC TOXICITY TESTS FOR *MYSIDOPSIS BAHIA* (MYSID SHRIMP) AND *MENIDIA BERYLLINA* (GULF SILVERSIDE MINNOW). SERIAL DILUTIONS FROM 100% CONCENTRATE TO 3% CONCENTRATE (NOT ADJUSTED) WERE PERFORMED FOR EACH TEST EVENT. VALUES ARE THE PERCENT OF *NO OBSERVABLE EFFECT CONCENTRATION* (NOEC) CONCENTRATE.

DATE	LAB	SPECIES	SURVIVAL NOEC	GROWTH NOEC	FECUNDITY NOEC	SALINITY OF Concentrate
02-15-95	ESE	MENIDIA	100	100	NA	12 ppt
		MYSID	100	100	NA	
	CH2M HILL	MENIDIA	100	25	NA	
		MYSID	100	100	100	
03-01-95	ESE	MENIDIA	100	100	NA	53 ppt
		MYSID	50	50	NA	
	CH2M HILL	MENIDIA	100	100	NA	
		MYSID	50	50	50	
03-08-95	ESE	MENIDIA	100	100	NA	45 ppt
		MYSID	100	<100	100	
	CH2M HILL	MENIDIA	100	100	NA	
		MYSID	100	50	50	

LITERATURE CITED

Guidance Document for Membrane Technology and Ion Exchange By-product Water Permitting. Draft document, 9pp. Florida Department of Environmental Protection, 1994.

Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms. EPA/600/4-90-027F. U.S. Environmental Protection Agency, 1993.

Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Marine and Estuarine Organisms. EPA/600/4087/028. U.S. Environmental Protection Agency, 1988.

APPENDIX A

Department of Environmental Protection

Lawton Chiles
Governor

Twin Towers Office Building
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Virginia B. Wetherell
Secretary

April 12, 1995

Mr. Mark D. Farrell, P.E.
Assistant Executive Director
Southwest Florida Water Management District
2379 Broad Street
Brooksville, Florida 34609-6899

Dear Mr. Farrell:

Your agency approached the Department of Environmental Protection in August 1994 to seek our involvement in the determination of an acceptable desalination-generated brine discharge to the Gulf of Mexico. As a result of that meeting and the pending delegation of the National Pollutant Discharge Elimination System (NPDES) program to the State of Florida, it was agreed by all parties (including EPA) that the State would work with the District to address the brine issue.

Subsequently, the Department and the District agreed upon a plan of study titled "Characterization of Chemical Quality and Potential Toxicity of Seawater Desalination Discharge Brine" (see enclosure). The objectives of the study were as follows:

1. To determine the chemical quality of a simulated brine discharge from a RO seawater desalination process;

2. To determine the potential toxicity of a simulated brine discharge from an RO seawater desalination process with varying salinity; and

3. To determine the dilution characteristics of the potential receiving waters at the Anclote River Power Plant.

The plan of study concentrated on the potential for discharge toxicity to marine life. The results from the study, although conducted on the Anclote River source waters and not the thermal discharge as projected in the proposal, can serve as the basis for determining the applicability of such a process at the Anclote River site and the potential of such a discharge statewide. The results of the tests, conducted at varying salinity and concentrations, indicate the following:

- The water chemistry of the sampled raw water and brine indicated no problem contaminants.

- As the salinity of the raw water and consequently the salinity of the brine increases, the potential for acute and chronic toxicity increase.

- Any toxicity observed in the tests performed appear to be directly related to the high salinities of the brine (i.e., greater than 45 ppt).
- Although the indicator species used in the test are very sensitive test organisms, they showed a high degree of tolerance and adaptability to higher concentrations of salinity.
- The acute and chronic toxicity test results favorably show that standards can be met at the Anclote site for a seawater desalination brine discharge through predischarge dilution or an acceptable mixing zone, as defined in Chapter 62-4.244, Florida Administrative Code.

In conclusion, based on the information and analysis provided by the Southwest Florida Water Management District in conformance with the agreed upon plan of study, the Department agrees the results indicate that a seawater brine discharge can be managed to meet the Department's water quality standards and is manageable and permittable with appropriate conditions under current DEP point source discharge criteria. It should be understood that any permit approvals are site specific and other conditions may apply.

The Department appreciates the cooperative effort put forth by the District to resolve this significant environmental issue and provide the citizens of Florida with information to support the use of this potential option for a safe, dependable, and environmentally-compatible water supply source. If we can be of further assistance in the matter, please advise.

Sincerely,

Richard D. Drew, Chief
Bureau of Water Facilities
Planning and Regulation

RDD/ds

Enclosure

CC: Richard Garrity
Richard Harvey
Mark Latch

PLAN OF STUDY

CHARACTERIZATION OF CHEMICAL QUALITY AND POTENTIAL TOXICITY OF SEAWATER DESALINATION DISCHARGE CONCENTRATE ANCLOTE RIVER POWER PLANT

INTRODUCTION

To alleviate the serious potable water supply problems currently being experienced within the Southwest Florida Water Management District (District), alternative sources of supply (in addition to groundwater) are under investigation to determine their technical and financial feasibility. Among the methods under consideration are desalination of brackish water and seawater, supplies of which are plentiful within the District. Although the technology for desalinating brackish and seawater is well established (i.e. reverse osmosis or RO), questions remain concerning the proper discharge of the concentrated concentrate which is a by-product of the RO process. Of particular concern is the potential toxicity of the concentrate discharge to indigenous organisms (particularly invertebrates and specifically the mysid shrimp) in a receiving water body. Although the mechanism of acute toxicity is unclear at present, it is suspected that an ionic imbalance in the concentrate discharge may be responsible (FDEP 1994). To date, this problem has been reported only in discharges from brackish water RO operations where the ionic quality of the influent water is often substantially different from that of seawater, especially in the calcium concentrations. However, since the ionic ratios in seawater are relatively constant, the concentrate discharge from a seawater desal operation may not exhibit the toxicity properties of a discharge from a brackish water plant. The purpose of this study, therefore, is to characterize the chemical quality and potential toxicity (if it exists) of the concentrate discharge from a seawater desalination operation.

The objects of the following Plan of Study, prepared by the District, are threefold:

1. To determine the chemical quality of a simulated concentrate discharge from an RO seawater desalination process;

2. To determine the potential toxicity of a simulated concentrate discharge from an RO seawater desalination process; and

3. To determine the dilution characteristics of the potential receiving waters at the Anclote River Power Plant.

CHEMICAL QUALITY

The following chemical parameters will be tested to characterize the quality of the inflow (dilution) water to the power plant from the Anclote River as well as to characterize the simulated concentrate discharge from the RO desalination operation:

Dissolved oxygen
pH
Conductivity
Nitrogen (nitrite/nitrate, ammonia, TKN, total N)
Phosphorus (ortho P, total P)
Fluoride
Aluminum
Copper
Turbidity
Alkalinity
Hardness
Silica
Sodium
Potassium
Calcium
Magnesium
Total Cations
Bicarbonate
Carbonate
Hydroxide
Chloride
Sulfate
Total Anions

These analyses will be performed by the District laboratory on samples collected from the inflow to the Anclote River Power Plant and from a sample of concentrate produced from a PUR® Powersurvivor 35 reverse osmosis unit. The water used to produce the concentrate will be collected at the entrance to the inflow canal to the power plant cooling towers.

The following analyses will be performed by a contract laboratory (Savannah Laboratories) on some of the samples of water and concentrate noted above:

Hydrogen sulfide
Combined radium 226 and 228
Gross alpha

All analyses will be performed using the appropriate analytical techniques recommended in Standard Methods or by the U.S. Environmental Protection Agency (EPA). Additionally, both laboratories have FDEP-approved Laboratory Quality Assurance Plans.

TOXICITY TESTING

To characterize any potential toxicity the contract laboratories, Environmental Science and Engineering (ESE) and CH2M HILL, will perform acute and chronic toxicity bioassays following procedures outlined by EPA (1993) and EPA (1988) respectively. The tests will be conducted on

two standard test organisms recommended by the FDEP and EPA: an invertebrate, *Mysidopsis bahia* (mysid shrimp) and a fish, *Menidia beryllina* (Gulf silverside). The ESE and CH2M HILL bioassay laboratories also have FDEP-approved Quality Assurance Plans.

The purpose of the bioassay tests will be to simulate the worst case conditions, 1) ionic imbalance, and 2) high salinity concentrate effluent. After consultation with Steve Wolfe of FDEP's Bioassay Program, the lowest salinity that might be expected at the inflow point should be addressed since any effects attributed to ionic imbalances should be most extreme at this salinity.

A review of all salinity data available at the District (Fig. 1) and through the U.S. Geological Survey (Fernandez 1990) suggests that a salinity of approximately 6.0 ppt would be the lowest instantaneous value that might be expected at the mouth of the Anclote River near the power plant intake (lowest daily mean salinity is closer to 17.0 ppt - Fig. 2). Therefore bioassay tests will be conducted using 6.0 ppt water as a diluent. The diluent will be collected from the Anclote River and, depending on the salinity of the sample at the time of collection, this water will be salinity-adjusted (up or down), if necessary, by the addition of sea salts or well water respectively. Other bioassay tests will be conducted using unadjusted river water to determine potential toxicity of high salinity concentrate (40-50 ppt) to receiving waters.

The first test that must be conducted will be an acute screening bioassay of the proposed dilutent taken from the Anclote River. This test is designed to eliminate the diluent as a possible toxicant. Since the Anclote River drains an area of approximately 112 square miles (Fernandez 1990), much of which has been urbanized or developed in some way, there is a possibility that the diluent itself might be toxic as a result of overland runoff. If the results of this test suggest that the river water may be toxic, the remaining bioassays will be conducted using artificial seawater as a diluent.

All acute bioassays will be conducted for 96 hours using the two test organisms noted above and employing two replicates of each treatment. The acute screening bioassay will consist of a seawater control and 100% Anclote River water (the proposed diluent for the definitive tests). The acute definitive bioassays will consist of a seawater control, 100% effluent (i.e. concentrate discharge), 50%, 25%, 12.5%, 6.25% and 3.125% effluent concentrations or, a seawater control, 100% effluent, 97%, 94%, 87.5%, 75%, and 50% effluent concentrations. Upon completion of the tests, the contractor will calculate LC50 concentrations (that concentration of effluent lethal to 50% of the organisms tested) and produce a report of the test procedures and results.

All chronic bioassays will be conducted for seven days using the mysid shrimp and silverside minnow noted above. Four replicates of each treatment will be employed with the silverside minnow and eight replicates of each treatment will be employed with the mysid shrimp. The bioassay tests will consist of a seawater control, a 100% Anclote River control, 100% concentrate effluent, 50%, 25%, 12.5%, 6.25%, and 3.125% effluent concentrations. Upon completion of the tests, the contractor will calculate the No Observable Effect Concentrations or NOEC (NOEC is highest percent of concentrate that has no observable effect on survival, growth, and fecundity) for both species and produce a report of the test procedures and results.

DILUTION CALCULATIONS

Based on the flow data provided by Florida Power Corporation for the Anclote plant and the LC50 concentrations calculated from the bioassay results, various concentrate production and dilution scenarios can be constructed. Dilution curves based on this information will be produced to allow the calculation of optimum desal production and concentrate discharge rates for a variety of salinity and flow conditions. Additionally, the mixing characteristics of the discharge channel and potential concentrate discharge mechanism will be discussed.

LITERATURE CITED

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Figure 1. Minimum salinity at mouth of Anclote River vs. mean daily discharge.

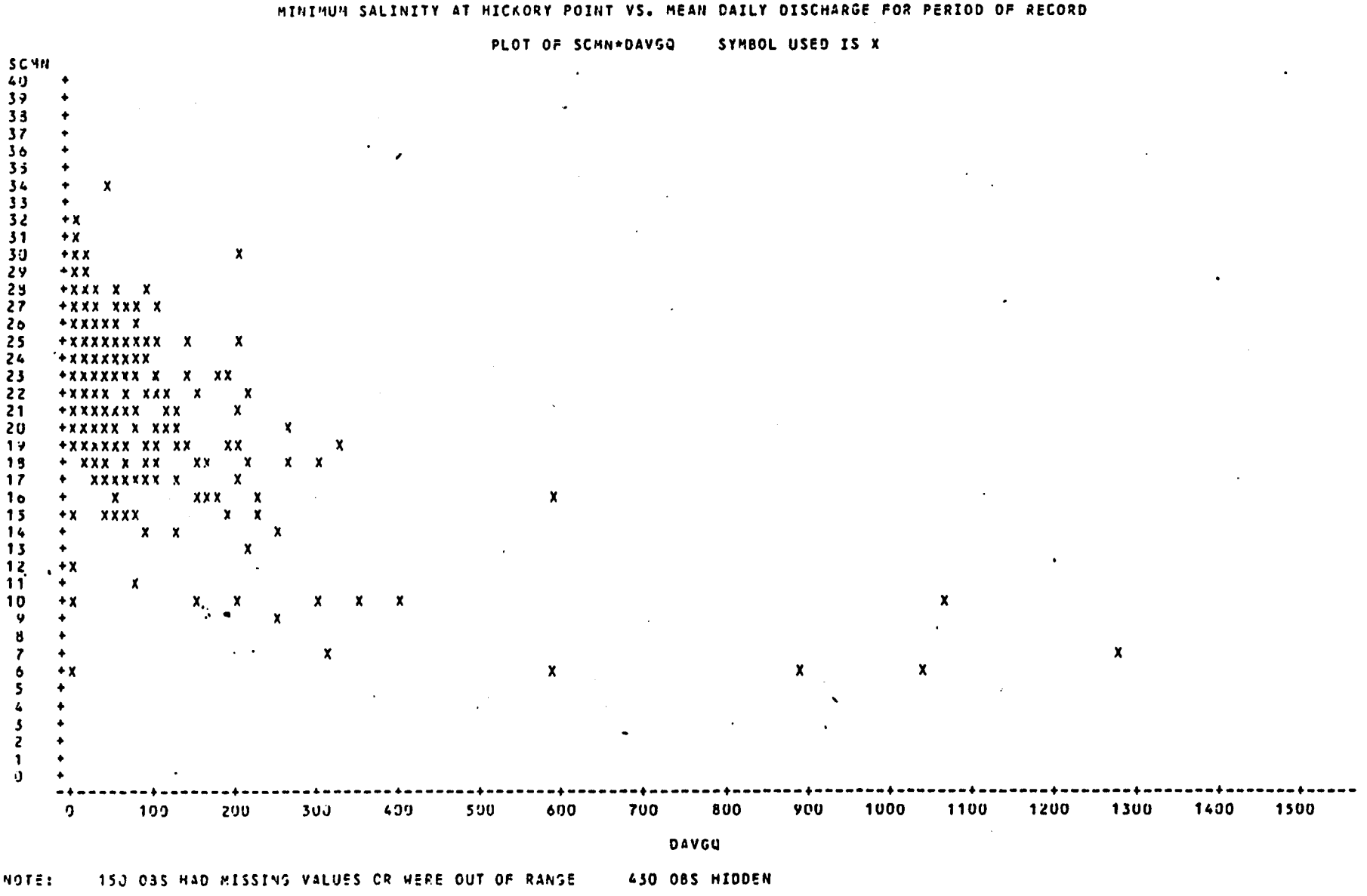

Figure 2. Mean salinity at mouth of Anclote River vs. mean daily discharge.