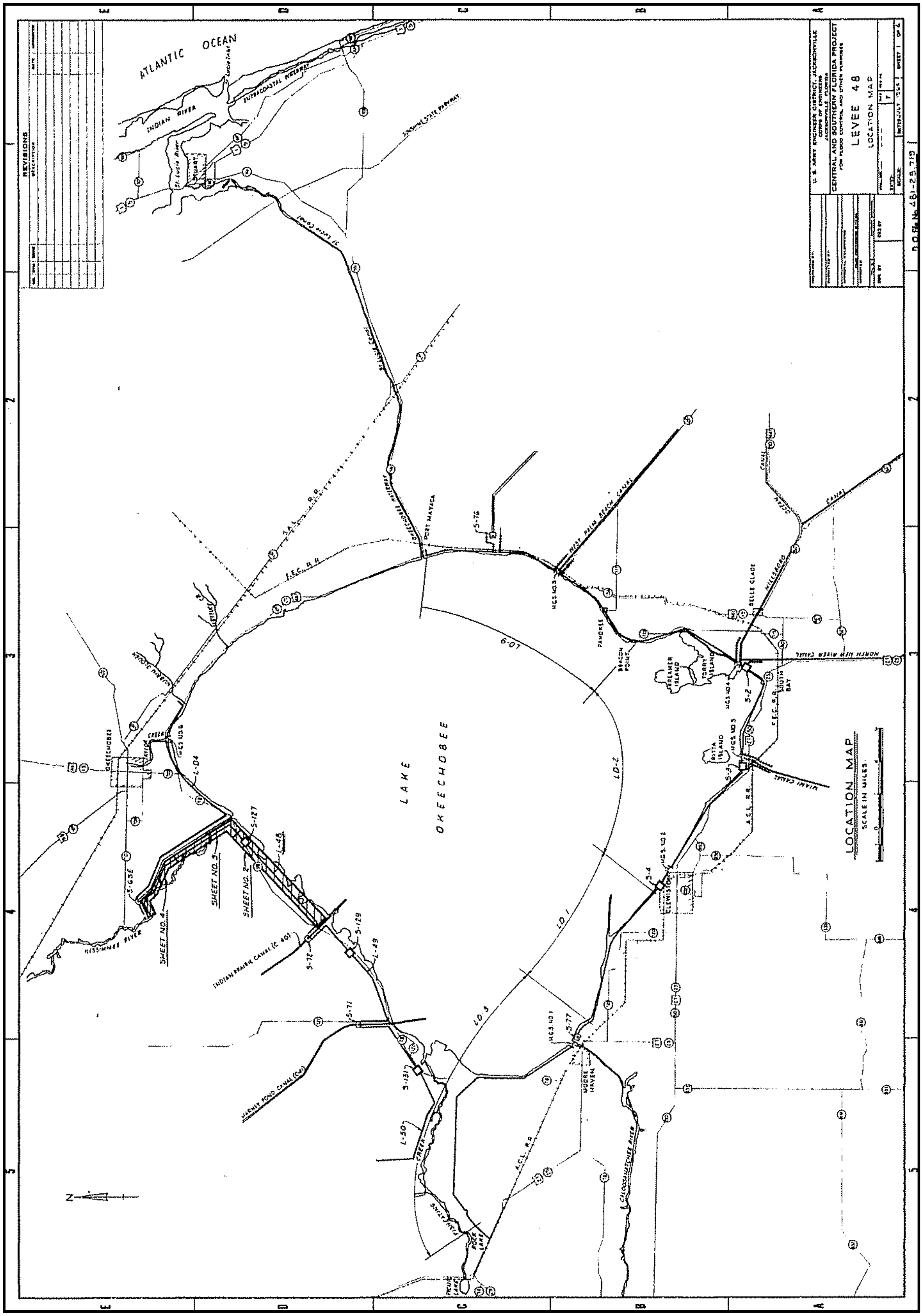
CHAPTER NINE
Lake Okeechobee II: Science in a Race with Politics and Nature

Throughout the 1980s, two other problems, inextricably tied to the Kissimmee, simmered in Florida: how to improve the water quality of Lake Okeechobee and how to regulate the lake's stage in order to protect its littoral zone. Although studies were conducted and recommendations made about the littoral zone, most of the focus in the time period was on water quality. In December 1981, for example, the SFWMD adopted a management strategy for protecting water quality in Lake Okeechobee, a natural outgrowth of the SFWMD's institutional transformation nine years earlier when the flood control district became a water management district. Historically, the district had two primary goals in managing the waters of Lake Okeechobee: to control flooding in time of heavy rainfall, and to supply water for agriculture and the urban centers in South Florida in time of drought. Now the SFWMD recognized "a third major goal of equal importance . . . namely, to maintain and improve the quality of the water resources within the District."[1] But this bland pronouncement understated the extent that the ground was shifting under the SFWMD. If flood control and drainage were public works that abetted economic growth, water quality fundamentally involved the imposition of economic restraints. In the past, when the district was primarily concerned with water supply, it was able to treat water as a raw resource to be exploited for economic gain. Now that the district was responsible for water quality, it had to treat water as commons, not property. Neither the people within the institution nor the SFWMD's many partners in government and the private sector were prepared for such a fundamental shift in thinking.[2]

Yet, still, as discussed in previous chapters, it was really state and not federal initiatives in the 1980s that drove water management in South Florida, including the work on Lake Okeechobee. The Corps continued to operate the C&SF Project for flood protection and water supply (both to urban areas and to the Everglades), but these efforts were largely overshadowed by state promotion of the preservation of the South Florida ecosystem, in large part against the effects of the C&SF Project. Just as Kissimmee River restoration was one piece of the state plan to "Save Our Everglades," the SFWMD's concern with Lake Okeechobee water quality and regulation levels served as an essential part of the program.

In order to get a firm grip on the problems with water quality in Lake Okeechobee, scientists used a systems ecology approach, especially focusing on mathematical and computer models to determine nutrient loading in the lake. At the same time, advances in chemistry and other forms of scientific measurement that had been ongoing in the post-World War II era enabled scientists to measure smaller and smaller particles, allowing for better analyses of problems in waterbodies such as Lake Okeechobee. Scientists were thus able to use the techniques of physics, chemistry, geology, geochemistry, meteorology, and hydrology "to measure ecosystem parameters at increasingly sophisticated levels and to analyze large data bases."[3]



Lake Okeechobee. (Source: U.S. Army Corps of Engineers, Jacksonville District.)

In using these methods to scrutinize Lake Okeechobee, scientists focused on two separate but related problems to the waterbody's eutrophication: how to get a better scientific understanding of what was causing the lake's eutrophication, and how to distribute the burden of economic restraints that would accompany control measures. It was evident that the SFWMD must find a way to reduce nutrient loading of the immense lake, but farmers and environmentalists disagreed strongly about where the control measures should fall and who should pay for them. Indeed, agricultural interests were divided among themselves. Opinion differed as to whether dairy farms north of the lake or sugar cane fields south of the lake were the main polluters. Opinion differed, too, on how fast eutrophication was occurring – an unknown that made it exceedingly difficult for the SFWMD to weigh management options on a cost-benefit scale.

One divisive issue was Lake Okeechobee's regulation schedule, which dictated lake "stages," or the quantity of water held in the lake from month to month. In 1978, the Corps of Engineers and the SFWMD implemented a new regulation schedule that raised the maximum lake stage level from 15.5 feet to 17.5 feet above sea level. While this increased the water supply, it had deleterious effects on water quality. High water affected marsh vegetation around the shoreline – the shallow lake's extensive "littoral zone," which accounted for more than one-fifth of the lake's surface. Continuous inundation of much of Lake Okeechobee's marsh area reduced the diversity of plant species, thereby affecting wading birds, waterfowl, reptiles, and fishes. In 1984, for example, the SFWMD published a study detailing the effects of high lake stages on wading bird utilization of Lake Okeechobee's littoral zone. The study concluded that "successful feeding conditions" for wading birds required a receding lake stage below 15.0 feet above mean sea level (msl), while successful nesting required "that the ground beneath the colony during the nesting period be flooded" from March to July.[4] Other examinations verified the damage that high lake levels caused to vegetation. Three years after the Corps had elevated the regulation schedule to 15.5-17.5 feet msl, scientists reported that "substantial changes" had occurred "in the composition and distribution of plant communities" in the littoral zone. These included the destruction of spikerush (*Eleocharis cellulose*), the proliferation of cattails, and the domination of torpedo grass (*Panicum repens*) in the mixed grass zone.[5]

The problem was that the Corps of Engineers and the SFWMD had to develop a regulation schedule for Lake Okeechobee that also took into account the water storage needs of urban and agricultural areas. Before 1974, the schedule had kept lake levels from exceeding 15.5 feet msl, while also allowing recessions down to 13.5 feet msl. This changed in the 1970s when the Corps elevated the schedule to between 14.5-16.0 feet msl in 1974 and then increased it to 15.5-17.5 feet msl in 1978 as explained above. The changes created less than optimal conditions for flora and fauna inhabiting the littoral zone, although scientists still needed more time to analyze how severe the effects really were.[6]

The same battle had been waged in the 1970s over the regulation schedules of the water conservation areas. Environmentalists deplored the Corps' drastic drawdowns of water levels in the areas, mainly because of the damage it caused to flora and fauna, and they also wanted better regulation in order to mitigate the effects of high water on deer populations. However, although the Corps reexamined its conservation area regulation schedules in the late 1970s, its final report – issued in October 1980 – concluded that no reason existed for modifying the schedules.[7]

Lake Okeechobee marsh area. (Source: South Florida Water Management District.)

Environmentalists and sportsmen hoped for more success with Lake Okeechobee regulation. Yet sugar growers remained staunch advocates of the new regulation schedule since it protected them from drought. Thus, the schedule highlighted conflicts between the needs of water quality and water quantity, and the gulf in thinking about water as commodity or commons.[8]

At the same time, changes in marsh vegetation in turn affected the lake's ability to assimilate nitrogen and phosphorus inputs, inextricably tying protection of the littoral zone to Lake Okeechobee water quality issues. One source of contention that aggravated the SFWMD's efforts to approach water quality evenhandedly and dispassionately was backpumping. Environmentalists focused on backpumping in part because of their animosity toward the sugar industry. But they had pragmatic reasons as well: it was easy to locate where the effluent was coming from (in contrast to "nonpoint source pollution"), and they could request public officials to stop it. Moreover, it was completely unnatural. By the flip of a switch, the SFWMD and the Corps of Engineers could activate the large S-2 and S-3 pumping stations on the south shore of Lake Okeechobee and reverse the flow of water through the three main canals braiding the 188,000-acre EAA, siphoning nutrient-laden water out of the sugar cane fields back into the lake. Environmentalists were appalled that the state would continue this practice in the face of mounting evidence that it was harming the lake. They were unmoved by arguments that backpumping was necessary during drought conditions to protect the water supply of South Florida. Although this activity was not the primary cause of nutrient loading of Lake Okeechobee, the S-2 and S-3 pump stations were obvious sources of agricultural pollution that the state controlled and could seemingly shut off at will. Therefore, environmentalists targeted backpumping as an evil, pressured the SFWMD to stop it, and attacked the sugar growers by extension.[9]

The controversy over backpumping formed the immediate background to the SFWMD's formulation of a water quality management strategy. Environmentalists argued that the state should not allow the operation of the S-2 and S-3 pumps without a permit. In 1977, the Florida Department of Environmental Regulation issued a Temporary Operating Permit to the SFWMD to continue backpumping, pending the completion of the district's scientific investigation on the eutrophication of Lake Okeechobee. In 1979, the Florida Wildlife Federation and other environmental organizations brought suit against the Department of Environmental Regulation and the SFWMD, alleging that the backpumping of polluted water from the EAA into Lake Okeechobee violated state water quality standards. The Florida Sugar Cane League, Inc., and Dairy Farmers, Inc., intervened as interested parties in the lawsuit. The threat of litigation prompted the department to order the SFWMD to develop a water quality plan for Lake Okeechobee.[10] This was the political underpinning of the SFWMD's announcement in December 1981 of a new water quality management strategy. It was a necessary requirement to hold onto its Temporary Operating Permit.[11]

The SFWMD based the water quality management strategy on its newly completed scientific study of the lake. This study produced a conceptual model of Lake Okeechobee using extensive data on the lake's chemical and biological properties. The purpose of the model was to predict ecological change, test outcomes based on different inputs, and inform management guidelines – all with the goal of preventing catastrophic eutrophication of Lake Okeechobee.[12] Although overly simplistic by later standards, the model represented a sophisticated advance in water management and a first step on the path toward Everglades restoration.

S-2 pumping station on the south end of Lake Okeechobee. (Source: South Florida Water Management District.)

As helpful as the conceptual model might be in selecting the appropriate management options for the protection of Lake Okeechobee, the model did not exist in a political vacuum, nor did it insulate management decisions from politics in the coming decade. Although the state successfully averted litigation over backpumping in the early 1980s, management of Lake Okeechobee continued to provoke considerable controversy. In 1985, Governor Graham established the Lake Okeechobee Technical Advisory Committee, made up of scientists from government, academia, and the private sector, to provide technical advice to the SFWMD in defining management options for Lake Okeechobee. Two years later, in 1987, the Florida legislature enacted the Surface Water Improvement and Management (SWIM) Act, requiring the SFWMD to develop a plan for Lake Okeechobee and other water bodies in South Florida.[13] Ultimately the same water pollution problems that were involved in the protection of Lake Okeechobee would form the basis for a federal lawsuit against the state of Florida in 1988, even though that suit would focus on waters entering Loxahatchee National Wildlife Refuge and Everglades National Park. Throughout the 1980s, the SFWMD put forward its conceptual model of Lake Okeechobee in part to keep the district on an even keel as it navigated these roiling political waters.

The use of a model to represent Lake Okeechobee's chemical and biological properties derived from a growing worldwide science on eutrophication of lakes and reservoirs. If the Kissimmee-Okeechobee-Everglades ecosystem was biologically unique, the accelerated eutrophication of Lake Okeechobee was not unusual at all. The same phenomenon had overtaken Lake Apopka in North Florida and was occurring in numerous water bodies all over the world. A by-product of human population growth, agricultural expansion, and increased use of fertilizers in crop production, "cultural eutrophication" was found to result when unnaturally large quantities of plant nutrients, mainly nitrogen and phosphorus, were loaded into lakes, thereby stimulating production of algae and other macrophytes and starting a train of other biological and chemical effects that could ultimately kill the lake. In the 1960s, scientists began to develop simple models using algorithms to approximate the real-world conditions of lakes that were undergoing accelerated eutrophication. The algorithms correlated such lake characteristics as water depth and surface area, water residence time (or flushing rate), and volume of nutrient loading. The use of models as a management tool for controlling eutrophication required the accumulation of empirical and statistical data over several years, and the selection of an appropriate model for the lake. By the mid-1970s, there were a handful of tried and tested models available to water managers, and the use of models had become an integral part of recommended management practice for controlling eutrophication.[14]

The SFWMD initiated a study of the biology and chemistry of Lake Okeechobee in 1973 aimed at developing the necessary data for modeling the lake. The study included four components: collection of lake water samples to obtain water chemistry data for trend analysis; development of a "material budget" (the measurement of the amount of water, phosphorus, nitrogen, and chloride coming into and leaving the lake at various points around the lakeshore); collection of data on the physical, biological, and chemical properties of the lake in spatial relationship; and finally, a trophic state assessment (to determine if the lake was oligotrophic, mesotrophic, or eutrophic). This major study continued through March 1980, yielding seven years of data for the SFWMD's initial modeling effort. In total, over 5,500 water samples were collected and analyzed for nitrogen species, phosphorus species, sodium, potassium, calcium, magnesium, chloride, alkalinity, color, turbidity, temperature, dissolved oxygen and specific conductivity, providing over 115,000 data points.[15]

Four scientists with the SFWMD – Anthony C. Federico, Kevin G. Dickson, Charles R. Kratzer, and Frederick E. Davis – analyzed the data and produced a detailed report, "Lake Okeechobee Water Quality Studies and Eutrophication Assessment," in May 1981. One of the authors' findings was that the chemical and biological properties of Lake Okeechobee varied widely across its large expanse. The highest concentration of phosphorus occurred at the outlet of Taylor Creek/Nubbin Slough at S-191 downstream from the dairy farms. The highest nitrogen levels were found at the pump stations S-2 and S-3 at the head of the North New River and Hillsboro canals and the Miami Canal, respectively, where irrigation water from the EAA was backpumped into the lake. Thus, at the northern location there was an excess of phosphorus

Lake Okeechobee and C&SF Project structures. (Source: U.S. Army Corps of Engineers, Jacksonville District.)

relative to what plants could absorb, while at the southern location there was more nitrogen than plants needed.[16] Since a major strategy in the control of eutrophication was to identify the limiting nutrient and reduce its input into the water body, this circumstance complicated the lake's management. Neither phosphorus nor nitrogen could be conclusively identified as the limiting nutrient, so both would have to be addressed.

Another result of the study was an improved understanding of the residence time of water in the lake. There were two elements to this: the average time that water took to move through the lake (excluding evaporation) and the average elapsed time for water coming into the lake to replenish water going out of the lake (excluding rainfall). For this large, shallow lake, the average water residence time was a sluggish 3.47 years, the hydraulic loading rate a somewhat brisker 1.57 years. During the period 1973 to 1979, direct rainfall and the Kissimmee River amounted to approximately 70 percent of the water coming into the lake, while evaporation accounted for almost 66 percent of the water leaving the lake. These characteristics were important to understand in order to determine the impact that water from different sources had on Lake Okeechobee's phosphorous levels. The authors found that the longer it took water to move through the lake the more phosphorus and nitrogen was retained.[17]

Federico, Dickson, Kratzer, and Davis tested eight nutrient loading models for their applicability to Lake Okeechobee, and selected a modified Vollenweider model, published in 1976. R. A. Vollenweider was a prominent limnologist of Canada. As the authors noted, Vollenweider's first model, published in 1968, was based on a mathematical relationship between water depth and various measures of water quality.[18] A limitation of the model was that the measures of water quality were largely subjective. Subsequent models in the early 1970s refined Vollenweider's equation by factoring in trophic state indices, or quantitative indices used in categorizing lakes according to their place on a continuum from oligotrophic (nutrient-poor) to eutrophic (nutrient-rich). The EPA had developed one such index, as had a number of limnologists in the early to mid 1970s. Kratzer, one of the authors of the SFWMD report, had developed a trophic state indice specific to nitrogen levels in Florida lakes. Federico, Dickson, Kratzer, and Davis found that the indices were useful as far as they went, but the early indice-based models did not take into account water residence time and hydraulic loading rate – critical factors recognized by Vollenweider in his model of 1976.[19] The latter Vollenweider model discriminated among trophic states based on annual phosphorus loading and mean depth divided by hydraulic residence time.[20] It took form as the following mathematical expression:

$$TP = (L_p/q_s)\,(1 + \surd\, t_w)$$

where: TP = average annual in-lake total phosphorus concentration
L_p = annual areal phosphorus loading
q_s = annual areal water loading
t_w = hydraulic residence time, and
$\surd$ = mean depth[21]

However, one problem remained with this Vollenweider model: it was oriented to lakes in northern temperate zones. Florida lakes, it appeared, could withstand higher total phosphorus concentrations before reaching the same level of production. Based on Kratzer's trophic state indice for Florida lakes, the authors modified the Vollenweider model to allow higher loading rates. The final result was a plot curve showing "permissible" and "excessive" phosphorus inputs into Lake Okeechobee. As water residence time increased, so too did the permissible phosphorus load. The report included a similar plot curve for the permissible nitrogen load.[22]

Using the modified Vollenweider model, Federico, Dickson, Kratzer, and Davis concluded that Lake Okeechobee had a 78 percent probability of being eutrophic if phosphorus was the limiting nutrient, and a 79 percent probability if nitrogen was the limiting nutrient. The model further indicated that the phosphorus and nitrogen loads were 40 and 34 percent, respectively, above the excessive loading rate. Since the authors could not conclusively state that phosphorus or nitrogen was the limiting nutrient, they recommended that both phosphorus and nitrogen inputs be reduced to the permissible levels predicted by the modified Vollenweider model.[23]

The report by Federico, Dickson, Kratzer, and Davis provided the technical foundation for the water quality management strategy that the SFWMD adopted seven months later. In the latter document, which was approved by the district's governing board on 11 December 1981, SFWMD leadership accepted the finding that both nitrogen and phosphorus loading must be reduced, and it evaluated alternatives according to cost-effectiveness. Describing the control of eutrophication of Lake Okeechobee as "a very ambitious endeavor," it proposed a phased approach over a number of years. Phase I, of unspecified duration, would comprise five major activities. First, the SFWMD would continue the Interim Action Plan, with its provision for limited backpumping into the lake for five years. Second, the district would initiate development of a water retention facility within the EAA on the state-owned Holey Land tract. Third, it would accelerate use of Best Management Practices (BMPs) for dairy farms in the Taylor Creek/Nubbin Slough basin. Fourth, it would implement an expanded regulatory program with more stringent controls on any new construction of drainage systems within the lake's watershed. Finally, the district would coordinate with the Corps of Engineers in ensuring completion of the Kissimmee River Survey Review.[24]

The most controversial part of the strategy involved the Interim Action Plan. The SFWMD developed the plan as its initial response to the threat of litigation over its Temporary Operating Permit, issued to the district by the Department of Environmental Regulation so that the district could continue limited backpumping into the lake through pump stations S-2 and S-3. The plan promised to reduce the nutrient load on Lake Okeechobee by directing water from the sugar cane fields southward to the water conservation areas rather than northward back into the lake.[25] However, it also allowed for a resumption of backpumping in periods of drought in order to take advantage of Lake Okeechobee's water storage capacity. Just such drought conditions prevailed during the summer of 1981, and as the S-2 and S-3 pumps went into action, quantities of nitrogen far in excess of the permissible level were dumped into the lake. In a 12-month period during 1981-1982, water gauges recorded 14,250 tons of nitrogen pouring into the lake – nearly five times the recommended maximum.[26] To avoid a repetition of this event, district staff revised the Interim Action Plan to allow for backpumping in low volumes whenever the lake level fell below historical average.[27]

Reactions to the SFWMD's Lake Okeechobee water quality management strategy were mixed. The Department of Environmental Regulation commented favorably on the overall conceptual plan. However, it added a number of stipulations to the Temporary Operating Permit;

for example, it required the SFWMD to report in detail on the implementation of BMPs in the Taylor Creek/Nubbin Slough basin.[28] The Florida Game and Fresh Water Fish Commission responded chiefly to the proposal to develop a water storage facility on the state-owned Holey Land tract. It had opposed this option in the past, partly because of the impact it would have on the local deer herd, but primarily because the facility would adversely affect Everglades wildlife habitat in Conservation Area No. 3 downstream from the site. It responded more favorably to this proposal because the plan incorporated the adjoining Rotenberger tract into the project, essentially designating one area for water storage and the other area for wildlife.[29]

Environmental groups attacked the SFWMD's plan as both overdue and inadequate. Johnny Jones, executive director of the Florida Wildlife Federation, expressed outrage over the proposed use of the Holey Land area for water storage. "As we read the Management Strategy, it is nothing more than a smoke screen for the South Florida Water Management District's real agenda," he wrote. "That is a further state and federal subsidy for the agricultural interests of the EAA." The sugar growers, Jones insisted, should be forced to retain water on their own lands.[30] Paul C. Parks, commenting on behalf of the Florida Chapter of the Sierra Club, also objected to the use of state land "to take the pollution from farms," and declared, "this plan for the EAA is not going to be acceptable to the public." He was even more skeptical about the district's plan to implement BMPs among the dairy farmers in the Taylor Creek/Nubbin Slough basin. The district was naïve to expect significant results through volunteerism. "These dairies are not 'farms' in the usual sense," Parks wrote. "They are milk factories and their pollution ought to be regulated by the Department [of Environmental Regulation] like that of any other industry."[31]

The Rotenberger Tract. (Source: South Florida Water Management District.)

Parks also voiced skepticism about the district's use of the modified Vollenweider model. He maintained that the model provided reasonable guidance for getting started on nutrient load reductions, but the Department of Environmental Regulation should require a continuing research program to assess whether the target amounts predicted by the model were adequate. The development of this model, he argued, was symptomatic of an unfortunate tendency to separate technical issues from policy issues. "The technical question is, can this be done; the policy question is, will this be done?"[32]

A month later, Parks wrote to the Department of Environmental Regulation again about the SFWMD's water quality management plan, arguing that it failed to justify an extension of the Temporary Operating Permit "because it is unlikely to result in nutrient loading rate reductions which are sufficient to meet the criteria established by the modified Vollenweider equation," that is, a 40 percent reduction of phosphorus loading and a 34 percent reduction of nitrogen loading. It was all very well for the SFWMD to establish targets for nutrient load reductions, Parks argued, but it also needed to demonstrate convincingly how it would achieve those levels.[33]

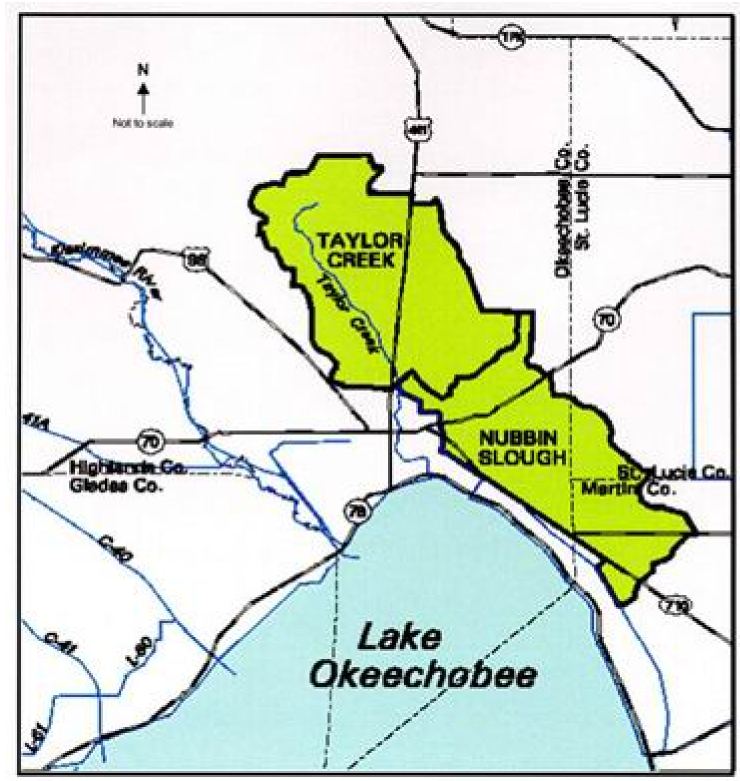
Initially, dairy farmers and sugar growers had little to say about the SFWMD's water quality management strategy. They gave it their tacit approval, a reasonable position considering some of the management options advocated by environmentalists that would have been more costly to them. Later, as drought conditions brought about a resumption of backpumping and public debate about Lake Okeechobee in the mid-1980s, the sugar growers would raise some objections. They criticized the SFWMD's strategy insofar as it did not pinpoint phosphorus as the chemical agent requiring the most stringent controls despite mounting evidence that phosphorus, not nitrogen, was the limiting nutrient in the eutrophication of Lake Okeechobee. Sugar growers also voiced skepticism about developing the Holey Land for water storage, as they eyed this area for future annexation to the EAA. Certainly they found this proposal preferable to taking land out of sugar cane production for water storage, however, so they muted their criticism.[34] As for the dairy farmers, their action in implementing BMPs spoke most directly to their attitudes about the SFWMD's strategy.

There were 24 separate dairy operations in the Taylor Creek/Nubbin Slough basin in the mid-1980s, as well as an additional 12 dairy operations in the Lower Kissimmee Valley plus some beef cattle operations. In keeping with industry trends nationwide, these were large livestock operations that involved concentrated animal feeding stations as well as pasturing of cows. The average dairy farm in the region had about 1,000 cows. The cows were fed a phosphorus supplement to enhance milk production, which the cows were unable to absorb fully, excreting the unabsorbed portion in their manure. Treating and disposing of this animal waste was a challenge. Although some dairy farms employed state-of-the-art livestock waste management techniques, more stringent and systematic controls were needed.[35]

The SFWMD recommended a number of BMPs to the dairy farmers. These included better rotation of cows between pastures, feedlots, and barns to distribute manure more widely; fencing and other measures to keep cows away from watercourses; and various types of "biological nutrient removal," or use of aquatic plants to take up phosphorus that was already in the water. Such aquatic plants were called "scrubbers" or "polishers" since they had the effect of cleansing the water. In particular, there was a need to collect barn wash and direct this phosphorus-laden water through "oxidation/polishing lagoons" for treatment before it was released as effluent to

Lake Okeechobee. The SFWMD even proposed converting animal waste to methane gas for local energy use.[36]

Beginning in 1981, many dairy farmers in the Taylor Creek/Nubbin Slough basin began upgrading their barns to improve treatment of barn wash (water used to rinse out dairy barns). They were aided by a federal grant under the federal Rural Clean Waters Project. For each barn, the federal government supplied 75 percent of the cost in a cost-share arrangement with the dairy farmer, up to a limit of $50,000 per barn. The SFWMD estimated the average cost at $100,000 per barn. Despite this funding shortfall, the dairy farmers were highly motivated to get their barns renovated. By 1987, all but three barns in the Taylor Creek/Nubbin Slough basin had undergone modification under the Rural Clean Waters program, with work in progress on the remaining three. In the Lower Kissimmee Valley, meanwhile, where the state contributed funds to a similar cost-share program initiated in 1986, all 19 livestock operators had signed up for renovation of their barns at a cost per barn of $170,000 by 1987.[37]



Taylor Creek/Nubbin Slough area. (Source: U.S. Army Corps of Engineers, Jacksonville District.)

Despite early skepticism, the state got surprisingly good cooperation from the dairy farmers in implementing the BMPs. State officials favored this approach as a low-cost management option that treated the problem at the source, and the farmers recognized the program's necessity. Although agriculturists benefited from federal and state funding supports, the program rested fundamentally on the farmers' voluntary efforts, which they made largely at their own expense.[38]

BMPs were only a starting point, however. The SFWMD's water quality management strategy called for additional control measures to reduce nutrient loading. District staff maintained that the results of BMPs had to be evaluated before pressing ahead with other, more expensive, engineering solutions such as the Holey Land reservoir. Such a systematic, fiscally conservative approach was standard practice in watershed management, but it carried the risk of doing too little too late. Indeed, the amount of nutrients pouring into Lake Okeechobee continued to exceed target levels in the mid-1980s and water quality monitoring showed that phosphorus concentrations were approaching the highest levels ever recorded. No one knew, of course, how long the excessive nutrient loading could persist before the ecological consequences became severe. Environmentalists argued that water managers, in the face of such uncertainty, must err on the side of caution, particularly since Lake Okeechobee was so large and central to South Florida's ecosystem.[39]

There were other signs that time was running out. Fishing guides and commercial fishermen reported extensive growths of filamentous blue-green algae on the lake surface. South shore residents complained that their drinking water had acquired a bad odor and taste.[40] Biologists studying the nesting success of wading birds in Lake Okeechobee's marshes found the birds' numbers declining because of damage to the littoral zone. When drought threatened in June 1985, causing the SFWMD to resume backpumping, the Florida Wildlife Federation again threatened to sue.[41] Amid heightening public concern, Governor Graham called for a comprehensive review. He asked the head of the Department of Environmental Regulation, Victoria Tschinkel, to put together a committee. Eager to bridge conflicts surrounding the lake's management, the governor wanted the review to "include consideration of the interests of federal, state and appropriate local government, agricultural and other users, environmentalists and sportsmen and other interests as may be appropriate."[42]

An algae bloom on Lake Okeechobee. (Source: South Florida Water Management District.)

The Lake Okeechobee Technical Advisory Committee (LOTAC), as it became known, made a hurried study and issued preliminary findings in August 1986. LOTAC generally endorsed the SFWMD's approach, including the district's emphasis on BMPs, although it shortened the list of BMPs to just three in order to gain maximum compliance. These included a reiteration of the SFWMD's goal of fencing all animals away from watercourses, noting that about 75 percent of the appropriate land area in the Taylor Creek/Nubbin Slough basin had been so fenced by 1987, much of it under the Rural Clean Waters Project; a prohibition of all direct discharge of barn wash into surface waters – a goal that was already practically attained in the Taylor Creek/Nubbin Slough basin and within reach for the dairy operators in the Lower Kissimmee Valley; and the implementation of measures to control storm water runoff from high intensity use areas. Ultimately, LOTAC declared, it might prove necessary for all dairy farms in the region to become "confinement dairies," where all runoff from the milking barns would be collected in a reservoir for treatment.[43]

In addition to its discussion of BMPs, LOTAC accepted the modified Vollenweider model as the best available mathematical model for predicting permissible nutrient loading rates. It also affirmed the district's goal of reducing phosphorus loading by 40 percent. LOTAC went further than the SFWMD's water quality management plan, however, in identifying phosphorus as the limiting nutrient. Based on data accumulated since 1980, this conclusion was inescapable. While the amount of nitrogen had leveled off, the amount of phosphorus in the lake had doubled over the period 1973-1984. LOTAC theorized that the lake was losing its capacity to assimilate phosphorus because bottom sediments could no longer bind the mineral. Adjoining watersheds such as the Taylor Creek/Nubbin Slough basin were similarly unable to hold any more phosphorus. One scientist likened the situation to water dripping on a sponge: the sponge absorbed each drip until it became saturated, at which point the water passed right through.[44] It appeared that with background levels in the environment already high, phosphorus increases could soon accelerate. LOTAC recommended an intensified plan of research focusing on phosphorus loading, BMPs, effects of lake levels on biological communities, and downstream impacts of proposed diversions.[45]

Governor Graham turned LOTAC's recommendations into an executive order, promulgated on 23 August 1986. The order outlined more than a dozen action items – mostly research and monitoring – for the Department of Environmental Regulation, SFWMD, and four other state agencies, and it requested the Corps of Engineers and U.S. Department of Agriculture to participate in cost sharing and research efforts. The Department of Environmental Regulation was responsible for overall program coordination, and the agencies were to execute a memorandum of understanding and prepare a comprehensive plan by 1 November 1986. The governor's executive order contained one specific engineering requirement: it directed the SFWMD to coordinate with the Corps of Engineers on completion of a preliminary design for a diversion of waters from the Taylor Creek/Nubbin Slough basin.[46]

The Taylor Creek/Nubbin Slough diversion was not a new proposal; the Corps had recommended it to Congress in 1968, and the governing board of the SFWMD had requested that the Corps develop plans for it in 1979. The general plan was to divert waters from the basin to the St. Lucie Canal, which flowed east to the St. Lucie Estuary. Although the plan held some attraction to citrus growers in St. Lucie County because it would provide an alternative source of irrigation water during drought, it also raised concerns that the polluted water from the dairy farms would degrade the St. Lucie Estuary. After public review of seven alternatives, the Taylor Creek/Nubbin Slough diversion plan had been shelved in 1980. Now that the need to protect Lake Okeechobee appeared urgent, the SFWMD asked the Corps to give the plan further consideration. The project would be costly, primarily because it would involve the acquisition of a lot of private land, but it appeared to offer one of the fastest and most effective means of reducing phosphorus loading.[47]

At the same time, the SFWMD prepared cost estimates and fact sheets for the whole panoply of Lake Okeechobee protection options. The total cost, if all options were implemented, could run as high as $200 million, it suggested. But the SFWMD's current budget for Lake Okeechobee was a mere $4.4 million, and LOTAC-recommended projects for the current year would require an additional $5.2 million. Given the significance of Lake Okeechobee as a state resource, the district sought additional monies from the state's general fund. State legislators were sympathetic. In January 1987, the Senate Natural Resources Committee proposed a "Save Our Lakes" bill that would provide funding for protection and restoration through a documentary stamp tax. The House Natural Resources Committee considered a similar proposal. The SFWMD's Patricia A. Bidol, executive program director, presented the district's plans and cost estimates to the House committee at the end of January.[48]

Meanwhile, at the beginning of January 1987, there was a change of governors. Bob Graham went to the U.S. Senate and Robert "Bob" Martinez replaced him in the Florida statehouse. Governor Martinez, a Republican and former mayor of Tampa, promised to continue his Democratic predecessor's popular environmental programs, including Save Our Everglades and the Lake Okeechobee protection plan. He indicated his support of the proposed legislation to protect and restore surface waters. However, soon after taking office the governor halted progress by the Department of Environmental Regulation and SFWMD in appointing a Lake Okeechobee Science Review Panel as recommended by LOTAC. Apparently, Martinez was responding to concerns by the sugar growers that the people making up the panel were all from out of state. Following the governor's lead, Dale Twachtmann, the newly appointed secretary of the Department of Environmental Regulation, placed a three-month hold on all LOTAC-directed activities by his department. On 11 April, Martinez and Twachtmann, accompanied by Estus Whitfield (who remained in his position as the governor's environmental advisor despite the change in governors) and three other staff, met with the sugar growers in Belle Glade.[49]

Governor Bob Martinez. (Source: The Florida Memory Project, State Library and Archives of Florida.)

Participating on behalf of sugar in this two-and-a-half hour meeting was the industry's Environmental Quality Committee, composed of the six most prominent men in the business – Alex Fanjul, Nelson Fairbanks, Jose Alvarez, John Hundley, George H. Wedgworth, and Joe Marlin Hilliard. Accompanying them were four staff and four consultants. The sugar growers told the governor that they had a history of involvement in environmental issues. Their Environmental Quality Committee, formed in 1963, had addressed the problem of air pollution in the 1960s and 1970s as the industry came under attack for its open-field burning of cane fields. The committee helped to develop regulations to limit open-field burning, and it oversaw technological improvements in the sugar mills so that they met Clean Air Act standards. In 1974, it initiated research on the eutrophication of Lake Okeechobee, and by 1987, it had completed more than a score of studies through contracts with environmental science and engineering firms. Many of the recommendations contained in these contracted studies, the agriculturists claimed, had appeared in the recommendations by LOTAC.[50]

The Environmental Quality Committee gave the LOTAC recommendations a strong endorsement. It agreed with LOTAC's selection of phosphorus as the limiting nutrient in the eutrophication of Lake Okeechobee. It supported the use of the modified Vollenweider model as a management tool. Finally, the committee approved of three project recommendations by LOTAC: the diversion of water from the S-4 basin on the west side of Lake Okeechobee to the Caloosahatchee River (similar to the Taylor Creek/Nubbin Slough diversion but much smaller), the Holey Land Reservoir project, and a pilot project to investigate the feasibility of Aquifer Storage Recovery. The agriculturalists favored these projects because they saw the necessity of increasing water supply for the EAA in place of backpumping and water storage in Lake Okeechobee.[51]

The sugar growers tried to demonstrate their willingness to compromise, but they also shared some concerns about the SFWMD with the governor. "We are concerned that the District has utilized a fast track approach recently on the Lake Okeechobee matter," their written presentation stated. It seemed that the district's leadership had decided that throwing enough money at these problems would solve them. Perhaps this could be attributed to a desire to put programs into effect before the new governor changed the makeup of the governing board. Most disturbing to the agriculturists, John R. "Woody" Wodraska, who had become chairman of the governing board, continued to make divisive public statements concerning the need to control nitrogen, despite LOTAC's finding that phosphorus was the limiting nutrient.[52]

Although "Big Sugar" was greatly vilified in the public's eye, Governor Martinez decided to go to Belle Glade, a town largely populated by sugar growers and Haitian cane cutters, to consult on environmental policy for Lake Okeechobee. Perhaps because of this trip, Martinez was soon beset by charges that he would not support the pending legislation to protect Lake Okeechobee. On 4 May, the governor felt compelled to issue a statement aimed at correcting the "misunderstanding." Reiterating his support for the initiative to save Florida's imperiled lakes (now titled the Surface Water Improvement and Management bill, or SWIM), he explained that he merely opposed two features of the bill: the establishment of advisory councils to guide each lake's protection program – "new, unnecessary layers of bureaucracy" – and the use of state tax revenues to pay for the program.[53] Both of these features remained in the bill, however, when the state legislature passed the measure and Martinez signed it into law.

The Surface Water Improvement and Management Act marked a turning point after nearly two decades of plodding efforts to prevent the catastrophic eutrophication of Lake Okeechobee. The SWIM Act declared that "the declining quality of the state's surface waters has been detrimental to the public's right to enjoy these surface waters and it is the duty of the state, through the state's public agencies and subdivisions, to enhance the environmental and scenic value of surface waters."[54] The act mandated the establishment of a priority list of water bodies of regional and statewide significance, a list that began with Lake Okeechobee, Lake Apopka, Tampa Bay, Biscayne Bay, Indian River Lagoon, and Lower St. Johns River, and would grow to include 23 other water bodies by 1997.[55] For each listed water body, the law required the appropriate water management district to design and implement a surface water and improvement (SWIM) plan. It also created an advisory council (in the case of Lake Okeechobee, this was the second incarnation of LOTAC, known as LOTAC II), and it established a SWIM trust fund to provide financial support for planning and implementation efforts mandated under the law.

Scientific understanding of the eutrophication of Lake Okeechobee had progressed from the first study by the U.S. Geological Survey in 1969 to a myriad of studies by federal and state agencies, universities, and consultants in the 1970s and 1980s. The SFWMD had drawn water samples on a regular basis since 1973, and it had expanded its lake monitoring program in 1986 to encompass more than 50 sites in an effort to improve understanding of areal differences in water quality and the influence of the littoral zone and localized inflows. It had also begun to assess the effects of such lake reclamation activities as aquatic weed control and bottom sediment removal. Meanwhile, continuous gauging of phosphorus and nitrogen loading at all major surface water inflow structures around Lake Okeechobee enabled managers to determine the relative effects of different protection options such as the Taylor Creek/Nubbin Slough diversion. By 1987, managers had the requisite science to evaluate an array of potential engineering projects in various combinations, each project bearing an estimated cost, time of completion, and amount of phosphorus that would be subtracted from the total load going into Lake Okeechobee. The SWIM plan that emerged in 1989 included some phosphorus reductions from biological and chemical treatments, as well as implementation of further BMPs, but by and large it involved engineering solutions.[56]

Even before the development of the SWIM plan, scientific investigation had pointed the way to two critical decisions by water managers. The first was their acceptance of the modified Vollenweider model to establish maximum loadings of nitrogen and phosphorus that could be safely discharged into the lake. Modeling results called for reductions of nutrient loadings by 34 percent for nitrogen and 40 percent for phosphorus. When district managers were unable to achieve these reductions, it lent urgency to their request for state and federal support of the effort. Indeed, while nitrogen levels fell, concentrations of phosphorus more than doubled from the mid 1970s to the late 1980s.[57] The second important science-based decision by water managers was to adopt phosphorus control as the primary lake management strategy. Without that direction, water managers might have been faced with a standoff between the nitrogen-producing sugar growers on the south shore of the lake and the phosphorus-producing dairy farmers on the north shore.

But the SWIM plan did not only address water quality; it also recognized the need for action to protect Lake Okeechobee's littoral zone. According to the plan, "the most practical means" to ensure the propagation of littoral zone vegetation and wildlife was the "development of an appropriate regulation schedule." Yet the plan admitted that "the needs of natural systems in the Lake, especially the littoral zone plan communities have not yet been defined." It therefore called for the creation of a "special technical committee" to "define water level requirements of the littoral zone communities." Accordingly, in 1988, the Lake Okeechobee Littoral Zone Technical Group, composed of representatives from the SFWMD, the FWS, the Florida Game and Freshwater Fish Commission, Everglades National Park, the Florida Department of Natural Resources, the Florida Department of Environmental Regulation, and different universities, worked to develop a sense of how much water was needed to protect the littoral zone.[58]

Throughout the 1980s, then, the SFWMD wrestled with important water quality and littoral zone issues pertaining to Lake Okeechobee, using science as a major guide. Especially important in the time period was the realization that phosphorous was the limiting nutrient in Lake Okeechobee, and that concentration levels of the mineral were reaching dangerous proportions. In many ways, this reliance on science and the solutions that were ultimately proposed foreshadowed efforts in the 1990s to restore the South Florida ecosystem. At the same time, some actions taken to prevent the eutrophication of Lake Okeechobee had effects that proponents did not fully consider – another example of the law of unintended consequences. The curtailment of backpumping under the Interim Action Plan, for example, probably saved Lake Okeechobee from hypereutrophication, but it merely moved the problem to the water conservation areas. The gradual spread of cattails and an exotic plant called melaleuca soon began to tell a story of creeping eutrophication of the Everglades, just as algae blooms had alerted people to eutrophication of Lake Okeechobee a decade earlier. As water quality problems worsened in the Everglades, Florida officials proposed a new solution: the purchase of environmentally threatened lands.

Chapter Nine Endnotes

[1] South Florida Water Management District, "Executive Summary, Water Quality Management Strategy for Lake Okeechobee," 11 December 1981, Folder 16, Box 3, Marshall Papers.

[2] Matthew Alan Cahn, *Environmental Deceptions: The Tension Between Liberalism and Environmental Policymaking in the United States* (Albany: State University of New York Press, 1995), 65-80.

[3] McIntosh, *The Background of Ecology*, 203.

[4] Quotation in Michael Zaffke, *Wading Bird Utilization of Lake Okeechobee Marshes, 1977-1981*, Technical Publication 84-9 (West Palm Beach, Fla.: South Florida Water Management District, Environmental Sciences Division, Resource Planning Department, 1984), 17; see also James F. Milleson, *Vegetation Changes in the Lake Okeechobee Littoral Zone, 1972 to 1982*, Technical Publication 87-3 (West Palm Beach, Fla.: South Florida Water Management District, Environmental Sciences Division, Resource Planning Department, 1987), i.

[5] Paul J. Trimble and Jorge A. Marban, "A Proposed Modification to Regulation of Lake Okeechobee," *Water Resources Bulletin* 25 (December 1989): 1250.

[6] Zaffke, *Wading Bird Utilization of Lake Okeechobee Marshes, 1977-1981*, 4.

[7] Department of the Army, Jacksonville District, Corps of Engineers, "Review of the Regulation Schedule for Water Conservation Area No. 3A, Central and Southern Florida, October 1980," File Conservation Areas 1, 2, 3, 1970-86, Box 02193, SFWMDAR; James W. R. Adams, Colonel, Corps of Engineers, District Engineer, to Honorable Bob Graham, Governor of Florida, 31 October 1980, ibid.

[8] "Summary of Florida Sugar Industry's Presentation to Governor Bob Martinez and FDER Secretary Dale Twachtmann, Belle Glade, Florida," 11 April 1987, 19, File LOTAC I/LOTAC II, Box 18060, SFWMDAR.

[8] *The Palm Beach Post*, 29 July 1985.

[9] Joseph D. Carroll, Jr., Director, Vero Beach Field Office, U.S. Fish and Wildlife Service to Field Supervisor, 23 June 1982, File NWR Fisheries Studies, Conservation Area 1 Loxahatchee, CE-SE Central and Southern Florida FCP, FWSVBAR; John C. Jones, Executive Director, Florida Wildlife Federation to Victoria Tschinkel, Secretary, FDER, 16 April 1982, Folder 16, Box 3, Marshall Papers.

[10] State of Florida, Division of Administrative Hearings, "Recommended Order" in *Florida Wildlife Federation et al. v. State of Florida et al.*, 8 November 1979; *The Palm Beach Post*, 29 July 1985.

[11] Paul C. Parks, Ph.D., Florida Chapter of the Sierra Club, to William Buzick, Deputy Director, Division of Permitting, Florida Department of Environmental Regulation, 1 June 1982, Folder 15, Box 3, Marshall Papers.

[12] Thomas James, telephone communication with Theodore Catton, 1 April 2005.

[13] South Florida Water Management District, "Draft Interim Surface Water Improvement and Management (SWIM) Plan for Lake Okeechobee," 10 October 1988, 1-2, File Okeechobee SWIM Plan (SFWMD) 1988, Box 1, S1497, Department of Agriculture and Consumer Services, Surface Water Improvement and Management Plan Files, FSA.

[14] Sven-Olof Ryding and Walter Rast, eds., *The Control of Eutrophication of Lakes and Reservoirs* (Park Ridge, N.J.: Parthenon Publishing Group, 1989), 85-94. The leading institution in the development of eutrophication control strategies was the Organization for Economic Cooperation and Development (OECD). Another source of support was UNESCO's Man and the Biosphere Program. The United Nations designated the 1980s the "Water Decade." Within the United States, EPA and the Clean Water Act Amendments of 1972 provided guidance for water managers at the regional level.

[15] Anthony C. Federico, et al., *Lake Okeechobee Water Quality Studies and Eutrophication Assessment*, Technical Publication 81-2 (West Palm Beach, Fla.: South Florida Water Management District, Resource Planning Department, 1981), 3-8.

[16] Federico et al., *Lake Okeechobee Water Quality Studies and Eutrophication Assessment*, 21.

Chapter Nine Endnotes (continued)

[17] Federico et al., *Lake Okeechobee Water Quality Studies and Eutrophication Assessment*, 22-23.

[18] Federico et al., *Lake Okeechobee Water Quality Studies and Eutrophication Assessment*, 215-216.

[19] Federico et al., *Lake Okeechobee Water Quality Studies and Eutrophication Assessment*, 202-205, 219.

[20] United Nations Environmental Programme, Division of Technology, Industry, and Economics, International Environmental Technology Centre, "Planning and Management of Lakes and Reservoirs: An Integrated Approach to Eutrophication" <http://www.unep.or.jp/publications/techpublications/techpub-11/1-4-2.asp> (5 April 2005).

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[25] "Summary of Florida Sugar Industry's Presentation to Governor Bob Martinez and FDER Secretary Dale Twachtmann, Belle Glade, Florida," 11 April 1987, 19, File LOTAC I/LOTAC II, Box 18060, SFWMDAR.

[26] *The Palm Beach Post*, 29 July 1985.

[27] South Florida Water Management District, "Executive Summary, Water Quality Management Strategy for Lake Okeechobee," 11 December 1981, 12, Folder 16, Box 3, Marshall Papers.

[28] Terry Cole, Assistant Secretary, FDER, to John R. Maloy, Executive Director, SFWMD, 15 June 1982, Folder 16, Box 3, Marshall Papers.

[29] Colonel Robert M. Brantly, Executive Director, FGFWFC, to Victoria Tschinkel, Secretary, FDER, 18 May 1982, Folder 32, Box 2, Marshall Papers.

[30] John C. Jones, Executive Director, Florida Wildlife Federation, to Victoria Tschinkel, Secretary, FDER, 16 April 1982, Folder 16, Box 3, Marshall Papers.

[31] Paul C. Parks, Ph.D., Florida Chapter of the Sierra Club, to William Buzick, Deputy Director, Division of Permitting, FDER, 2 May 1982, Folder 16, Box 3, Marshall Papers.

[32] Parks to Buzick, 2 May 1982.

[33] Parks to Buzick, 1 June 1982, Folder 15, Box 3, Marshall Papers.

[34] "Summary of Florida Sugar Industry's Presentation to Governor Bob Martinez and FDER Secretary Dale Twachtmann, Belle Glade, Florida," 11 April 1987, 19.

[34] *The Palm Beach Post*, 29 July 1985.

[35] Paul C. Parks, Ph.D., Florida Defenders of the Environment, to Nancy Roen, General Development Corp., 5 August 1987, File LO Major Programs – Correspondence, Background, LOSAC, Box 18060, SFWMDAR; William F. Ritter and Adel Schirmohammadi, eds., *Agricultural Nonpoint Source Pollution: Watershed Management and Hydrology* (Boca Raton, Fla.: Lewis Publishers, 2001), 136.

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[37] John R. Wodraska, Executive Director, SFWMD, to Jim Smith, Chief of Staff, Office of the Governor, 4 May 1987, File LO Programs – Correspondence, Background, LOSAC, Box 18060, SFWMDAR.

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implementation of Best Management Practices (BMPs). . . . Although cost-share incentives and some regulations are used, current nonpoint pollution abatement programs rely mostly on voluntary implementation of management practices." Ritter and Shirmohammadi, eds., *Agricultural Nonpoint Source Pollution*, 259.

[39] Bob Graham to Victoria J. Tschinkel, Secretary, 26 August 1985, File Lake Okeechobee File #1, Box 06591, SFWMDAR; Paul C. Parks, Ph.D., Florida Defenders of the Environment, Inc., to Nathaniel P. Reed, 3 February 1986, ibid.

[40] See Table 1, Major Algal Bloom Events on Lake Okeechobee, 1970-1988, in South Florida Water Management District, "Draft Interim Surface Water Improvement and Management (SWIM) Plan for Lake Okeechobee, 10 October 1988, File Okeechobee S.W.I.M. Plan (SFWMD) – 1988, Box 1, S1497, Department of Agriculture and Consumer Services, Surface Water Improvement and Management Plan Files, FSA.

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[43] Patricia A. Bidol, Ph.D., Executive Program Director, SFWMD, "Lake Okeechobee: Proposed Solutions and Associated Costs," Presentation to the Florida House Committee on Natural Resources, 21 January 1987, File Lake Okeechobee, Box 06591, SFMWDAR; South Florida Water Management District, "Summary Sheets: Lake Okeechobee Protection Options," February 1987, ibid.

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[45] South Florida Ecosystem Restoration Task Force, Science Subgroup, "South Florida Ecosystem Restoration: Scientific Information Needs," 1996, 147, available at <http://everglades.fiu.edu/taskforce/scineeds/sub2.pdf> (30 July 2004.)

[46] Executive Order 86-150, 23 August 1986, File Lake Okeechobee #2, Box 06591, SFWMDAR. Estus Whitfield, the governor's lead advisor on the environment, crafted the executive order with input from environmental groups and state agencies. See letters in this file.

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[49] "Summary of Florida Sugar Industry's Presentation to Governor Bob Martinez and FDER Secretary Dale Twachtmann, Belle Glade, Florida," 11 April 1987; Patricia A. Bidol to George H. Wedgeworth, Sugar Cane Growers Coop, 6 March 1987, File LOTAC I/LOTAC II, Box 18060, SFWMDAR.

[50] "Summary of Florida Sugar Industry's Presentation to Governor Bob Martinez and FDER Secretary Dale Twachtmann, Belle Glade, Florida," 11 April 1987, 1-5, 51.

[51] "Summary of Florida Sugar Industry's Presentation to Governor Bob Martinez and FDER Secretary Dale Twachtmann, Belle Glade, Florida," 11 April 1987, 17-23, 38.

[52] "Summary of Florida Sugar Industry's Presentation to Governor Bob Martinez and FDER Secretary Dale Twachtmann," 43.

[53] Quotations in "Statement by Governor Bob Martinez Concerning SWIM Bill," 4 May 1987, File SWIM Bill 5/4/87, Box 1, S1401, Executive Office of the Governor Subject Files, 1987-1988, FSA; see also Alec Wilkinson, *Big Sugar: Seasons in the Cane Fields of Florida* (New York: Alfred A. Knopf, 1989), 239.

[54] Quoted in South Florida Water Management District, "Draft Interim Surface Water Improvement and Management (SWIM) Plan for Lake Okeechobee, 10 October 1988, File Okeechobee S.W.I.M. Plan (SFWMD) – 1988, Box 1, S1497, Department of Agriculture and Consumer Services, Surface Water Improvement and Management Plan Files, FSA.

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[56] South Florida Water Management District, "Draft Interim Surface Water Improvement and Management (SWIM) Plan for Lake Okeechobee, 10 October 1988, 18-19, File Okeechobee SWIM. Plan (SFWMD) – 1988, Box 1, S1497, Department of Agriculture and Consumer Services, Surface Water Improvement and Management Plan Files, FSA. See also Daniel E. Canfield, Jr., and Mark V. Hoyer, "The Eutrophication of Lake Okeechobee," *Lake and Reservoir Management* 4 (No. 2 1988): 91-99.

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[58] South Florida Water Management District, "Draft Interim Surface Water Improvement and Management (SWIM) Plan for Lake Okeechobee," Executive Summary 1-3.