Lake Seminole Watershed
Reasonable Assurance Plan

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Purpose of Document

Lake Seminole is currently listed by the Florida Department of Environmental Protection (DEP) as an impaired waterbody pursuant to Section 303(d) of the federal Clean Water Act. The primary pollutants associated with this impairment are nutrients, which have resulted in hyper-eutrophic conditions and associated water quality violations (e.g., dissolved oxygen) in the lake.

In 2004, the Pinellas County Board of County Commissioners adopted the Lake Seminole Watershed Management Plan (Plan). The Plan assimilated substantial diagnostic and feasibility analyses, and specifies four major projects aimed at reducing nutrient concentrations in the lake and improving water quality conditions. These projects include: 1) retrofitting stormwater outflows from the five highest nutrient loading sub basins with alum treatment systems; 2) alum treatment and redirection of a portion of flows in the Lake Seminole Bypass Canal into Lake Seminole; 3) removal of organic muck sediments and 4) lake level fluctuation. Using a WASP model developed specifically for Lake Seminole, it was predicted that the trophic state index (TSI) of the lake using the method derived by Huber et al. (1982) could feasibly be reduced from greater than 80 currently to approximately 60 through the implementation of the four major water quality improvement projects.

Since 1994 more than $32 million has been spent and/or allocated for Lake Seminole diagnostic feasibility studies, watershed management planning, engineering design, and construction of habitat restoration projects. Pinellas County has been responsible for over $10 million of these expenditures, while additional cost sharing has been provided by the Southwest Florida Water Management District (SWFWMD), the Florida Fish and Wildlife Conservation Commission (FWCC), the Florida Department of Environmental Protection (FDEP), and the Cities of Largo and Seminole. Moving forward, Pinellas County has dedicated substantial funds in their 2007-2012 Capital Improvement Plan, and has secured funding agreements with other agencies, as necessary to ensure the full implementation of the four major water quality improvement projects, as well as other associated infrastructure improvements. Specifically, $4.9 million has been allocated for the design and construction of the alum stormwater and bypass canal diversion treatment facilities designed to reduce external nutrient loads to Lake Seminole, and $8 million has been allocated to remove organic sediments from the lake to reduce external nutrient recycling. The County is moving forward with construction on these projects with the alum and bypass canal construction beginning in 2007, and as of April 2007 a contractor has been selected for the sediment removal project, anticipated to begin construction in 2008.

Furthermore, it should be noted that the commitments made by Pinellas County with regard to the implementation of the aforementioned water quality improvement projects are fully enforceable through their existing State of Florida Municipal Separate Storm Sewer System (MS4) Permit, issued under the National Pollutant Discharge Elimination System (NPDES) program. In addition, continued operation and maintenance of the alum stormwater and bypass canal diversion treatment facilities is guaranteed under a cooperative funding agreement between Pinellas County and SWFWMD. **Appendix A** contains copies of the Pinellas County MS4 permit and the cooperative funding agreement between the County and SWFWMD. Also, Pinellas County has received the appropriate approved Environmental Resource Permit (ERP) and Army Corps Of Engineers (ACOE) permits for the alum projects. Finally, a federal dredge and fill (CWA Section 404/10) permit from the U.S. Army Corps of Engineers, and a State of Florida Environmental Resource Permit (for delegated Water Quality Certification), will be required for the sediment removal project. This permit will likely specify monitoring and reporting requirements for the project, thus establishing additional federal and state enforcement provisions.

This document provides “reasonable assurance” that implementation of the Plan will be sufficient to attain compliance with water quality standards and eliminate the necessity of a TMDL. A comprehensive discussion of all restoration plans implemented or proposed for Lake Seminole are detailed in the reasonable assurance document. Several of the large scale restoration plans were proposed by the Plan, therefore, a majority of the content contained within this document was taken from the Plan.

The Clean Water Act regulations recognize that alternative pollution control requirements may obviate the need for a TMDL. Specifically, waterbody segments that would otherwise be listed as “impaired” are not required to be included on the Section 303(d) list if other pollution control measures required by local, State or Federal authorities are demonstrated to be stringent enough to result in compliance with water quality standards within a reasonable period of time (see 40 CFR 130.7(b)(1)). These alternatives to TMDLs are referred to as Category 4b waters. This reasonable assurance documentation is prepared for formal Category 4b Demonstration for Lake Seminole, to be coordinated with the U.S. Environmental Protection Agency (EPA). The EPA guidance on Category 4b demonstrations requires that the following elements be addressed:

1. Identification of segment and statement of problems causing the impairment.

2. Description of pollution controls and how they will achieve water quality standards.

3. An estimate or projection of the time when water quality standards will be met.

4. Schedule for implementing pollution controls.

5. Monitoring plan to track effectiveness of pollution controls.

6. Commitment to revise pollution controls as necessary.

In addition to addressing the elements listed above, adequate reasonable assurance documentation will establish that: 1) implementation of the major water quality projects set forth in the Plan are sufficient to meet the established TSI goal of 60; and 2) that the TSI goal of 60 is appropriate for Lake Seminole in light of unnatural origins of the lake, as well as the significant hydrologic and biological alterations that have taken place since the lake was first impounded.

The recommended structure for category 4B demonstrations was followed for the construction of the Reasonable Assurance Plan for Lake Seminole in Florida.

History of Lake Seminole

Physical Modifications

Lake Seminole, located in west central Pinellas County, Florida, was created in the mid-1940s by the impoundment of an arm of Long Bayou, a brackish water segment of Boca Ciega Bay (**Figure 1-1; Figure 1-2**). On July 3, 1945, the Pinellas County Board of County Commissioners passed a resolution to create a freshwater lake in conjunction with the planned construction of Park Boulevard and a causeway across Long Bayou by the State Public Roads Administration (**Table 1-1)**. A secondary purpose for the creation of a freshwater lake was to provide a source of irrigation water for nearby citrus groves as well as to augment potable water supplies provided by the Pinellas County Water System (SWFWMD, 1992). Fresh water was contained in the lake through the construction of a fixed crest weir with an elevation of 6-feet NGVD at the south end of the lake. The constructed lake was created through flooding both mangrove and salt marsh systems. Prior to inundation, the existing peat and sediment was not removed.

Since the single fixed crest weir located at the south end of the lake had the potential to cause significant tailwater flooding upstream of the lake, a second weir was constructed at the north end of the lake in the late 1940s (SWFWMD, 1992). Water was then pumped from a dredged basin at the southern end of Long Creek (the original tributary which flowed to Long Bayou) over the north weir and into the lake via three lift pumps. This modification allowed the water level in Lake Seminole to be permanently maintained at elevation 6-feet NGVD. Between 1957 and 1965, Long Creek was channelized upstream of Lake Seminole to improve drainage conveyance in a rapidly urbanizing portion of Pinellas County.

In 1963, Lake Seminole was designated a State Fish Management Area for the cooperative management of freshwater fishes with the local community. Subsequently, the Lake Seminole Park was constructed in 1967. Additionally, a small 18-inch diameter outfall pipe with an invert elevation of 3.5-feet NGVD was constructed from the lake through a series of three interconnected ponds in the park. Water flows from the lake through this series of interconnected ponds and eventually discharges into the Seminole Bypass Canal over a weir slightly below elevation 5-feet NGVD. The purpose of this outfall was to provide relatively constant flow through the ponds to prevent stagnation and water quality problems. In the late 1960s, the northern weir was replaced with a fixed curvilinear weir that exists today. The fixed elevation of the existing weir is 5-feet NGVD.

In the late 1960's, the Florida Fish and Wildlife Conservation Commission (FWCC) recommended preventative measures to reduce the decline in water quality in Lake Seminole. The water quality and fishery were declining and the abundance of nuisance vegetation was increasing. Point sources for nutrient pollution were targeted for evaluation and termination. In 1971, the City of Largo closed a secondary, high rate, filtration plant. The plant had been discharging into a drainage ditch which flowed into the north end of the lake. Not long after the termination of the wastewater treatment plant, Lake Seminole was classified as eutrophic by the USEPA based on samples collected and analyzed during a "National Eutrophication Survey" (Camp, Dresser, and McKee, 1990).

In 1976, the Seminole Bypass Canal was constructed in response to flooding in the upper Long Creek basin, as well as a perceived decrease in lake water quality thought to be caused by the pumping of Long Creek flows into the lake (SWFWMD, 1992). The construction of the Seminole Bypass Canal diverted runoff from approximately eleven square miles of the historic Long Creek basin, around Lake Seminole to the east and directly into Long Bayou. Subsequently, a fixed crest weir with an elevation of 3-feet NGVD was constructed at the southern terminus of the Seminole Bypass Canal. Although this modification successfully reduced flooding potential in the upper Long Creek watershed, it essentially resulted in the hydrologic isolation of Lake Seminole, and substantially increased the residence time of the lake. Prior to this modification, the lake was discharging at or slightly above the 5-foot NGVD weir crest elevation a majority of the time. However, after the construction of the Seminole Bypass Canal and the dismantling of the pumps, discharge over the weir has been infrequent and of short duration (SWFWMD, 1992).

The ecological conditions worsened in the 1980's due to the isolation of Lake Seminole which resulted in an increase in residence time, accumulation of organic sediments, a decline in water quality (algal blooms) and fisheries and an increase in nuisance aquatic vegetation (hyrdilla). The FWCC stocked the lake with triploid grass carp in 1987 as an attempt to control the hydrilla infestation. Additionally grass carp were stocked in 1988, 1989, and 1991. The grass carp successfully eliminated the majority of nuisance SAV from the lake and even today a few grass carp are present in the lake. In turn, the Pinellas County Board of County Commissioners passed a resolution in January 1989 (Resolution 89-13) urging the joint development of an effective long term lake management program through the cooperative efforts of the public, lake users, and state and local agencies with responsibilities on the lake. These agencies included Pinellas County, the Southwest Florida Water Management District (SWFWMD), the Florida Department of Natural Resources (FDNR), the Florida Department of Environmental Protection (FDEP), the Florida Fish and Wildlife Conservation Commission (FWCC), and the Cities of Largo and Seminole. Representatives from these agencies as well as affected homeowner and business interests, were subsequently assembled as the Lake Seminole Advisory Committee (LSAC).

In 1992, the Pinellas-Anclote Basin Board authorized a $10 million cooperative funding agreement with Pinellas County to restore the water quality in Lake Seminole. As a result of this agreement, SWFWMD funded a diagnostic feasibility study of Lake Seminole in 1992. The Lake Seminole Diagnostic Feasibility Study (SWFWMD, 1992) estimated potential pollutant loadings from the watershed, as well as the lake's ability to assimilate these pollutant loads. In support of this work a preliminary lake/watershed model was developed (Dames and Moore, 1992). This model was termed the Lake Seminole Management Model (LSMM). Other components of the diagnostic feasibility study included an assessment of plant and animal communities in the lake and watershed, as well as a characterization of lake water quality and sediments. This work was used as the basis for various lake and watershed management actions initiated by the County and other resource management agencies; however, a comprehensive lake and watershed management plan was never developed.

Since the completion of the diagnostic feasibility study, Pinellas County, with financial support from SWFWMD through the cooperative agreement, initiated several projects aimed at reducing external nutrient loads to Lake Seminole, and improving in-lake habitats. These included the Dog Leg Pond and the Pond-6 Stormwater Rehabilitation

Projects, and the construction of an improved outfall control structure to allow for greater lake level fluctuation. In addition, the County continued to sponsor periodic meetings of the LSAC to obtain input from represented local governments, regulatory and resource management agencies, and affected citizens and businesses regarding better management of the lake. The primary functions of the LSAC included: the identification of priority lake management issues and problems; the development of management goals and strategies; and, the provision of a general forum for the sharing of information and the discussion of ongoing and emerging lake management issues.

As part of the County's on-going work to develop comprehensive watershed management plans for all significant basins within their jurisdiction, and to provide a focus for the activities of the LSAC, the County selected PBS&J in 1997 to assist in the preparation of the Lake Seminole Watershed Management Plan (Plan). The Plan represents the culmination of a decade of diagnostic feasibility and resource planning activities undertaken by numerous governmental agencies and consulting scientists and engineers (PBS&J, 2001). In support of the Plan development, PBS&J completed a task deliverable document entitled *Lake Seminole Sediment Removal Feasibility Study* in 1999 (PBS&J, 1999). This task report addressed the feasibility of removing accumulated sediments from Lake Seminole with these objectives in mind. However, since the completion of that document, and the adoption of the Plan by the Pinellas County Board of County Commissioners in 2004, some of the assumptions and conditions leading to the recommendations contained in Plan have changed (e.g., availability of publicly owned parcels for spoil dewatering). Additionally, in 2004 the City of St. Petersburg initiated a sediment removal project as part of the overall restoration plan for Lake Maggiore, and much relevant information is now available from that project. In 2006, an updated and revised deliverable document, *Lake Seminole Sediment Removal Feasibility Study*, was submitted to Pinellas County by PBS&J (PBS&J, 2006).

In addition to Pinellas County's effort to rehabilitate Lake Seminole, the FWCC released juvenile largemouth bass to the lake on two occasions (mid-1990's and November 2006) to supplement the fishery population and restore the fishery. The initial stocking was unsuccessful but 3 months after the 2006 stocking event a healthy largemouth bass population was reported in the lake. In an attempt to improve the fisheries habitat and water quality in the lake, the FWCC initiated the first phase of a habitat enhancement project in 2002 which involved sediment removal and vegetation planting. Sections of the lake were isolated using bladder dams, dewatered, and scraped down using traditional mechanical equipment. This resulted in the removal of over 31,000 cubic yards of organic material from critical sport fish spawning areas and resulted in the establishment of native submerged and emergent vegetation. In 2006, phase II of the habitat restoration project began in collaboration with the Pinellas County Department of Environmental Management (PCDEM). However, the water level of the entire lake was drawn down. An extensive lake clean-up was completed involving nuisance vegetation removal, replanting, and drainage improvements. Over 460 volunteers throughout the community participated in three lake clean up events resulting in the removal of over 27 tons of trash and debris (**Photo 1-1**). Approximately 100,000 cubic yards of organic material were removed from the lake. While the water levels were low, a USGS water level and discharge recorder was installed at the southern weir of the lake.

Photo 1-1. Local Volunteer Lake Clean-Up in 2006 during lake level draw down.

Since the adoption of the Plan, Pinellas County has implemented several other restoration components in order to address water quality concerns and improve the ecological health of the lake. The alum treatment system and pump required to divert water from the Seminole Bypass Canal to the lake and three of five lake alum treatment facilities are at 100% design and will begin construction in 2007. In early 2007, Pinellas County selected Hayes-Bosworth, Inc in coordination with PBS&J, to dredge Lake Seminole. Finally, the lake level modification structure has been completed and was used to draw down the lake water level for the habitat enhancement projects. Pinellas County anticipates the completion of all proposed projects by 2012. To date Pinellas County has spent over $10 million on restoration projects in Lake Seminole. The Cities of Largo and Seminole have contributed over $156,107 toward the restoration of the Lake. Additionally, the FWCC, SWFWMD and SWIM have spent $336,623, $6,371,284 and $231,871, respectively. A total of over $19.2 million local and state funding has been allocated and/or spent toward the improvement of water quality in Lake Seminole since 1994.

Land Use

Since the construction of the Park Boulevard causeway and the impoundment of Long Bayou, land uses in the Lake Seminole watershed have changed from predominantly low density rural residential and agriculture (e.g., improved pasture and citrus) to high density urban residential and commercial. A review of historic aerial photography indicates that urbanization in the basin began in the 1950s, and was first evident along the western side of the lake where numerous waterfront residential developments were initiated. Many of these developments involved major dredge and fill activities to create canals and bulkheads.

From the early 1950s through the mid-1960s, urbanization continued to occur predominantly in the western portion of the watershed, along the Seminole Boulevard corridor. In the mid-1960s, land use changes in the eastern portion of the watershed began to occur. In 1967, Lake Seminole Park was constructed, and the park was subsequently expanded in 1976. Rapid infilling of urban land uses occurred throughout the watershed during the 1970s and 1980s; however, no new major dredge and fill activities in the lake were permitted during this time period. In the mid-1990s the 102nd Avenue Bridge was constructed over the central 'narrows' portion of Lake Seminole. **Figure 1-3** shows the boundaries of the Lake Seminole watershed and existing (2004) land use in the basin.

Causes of Current Problems

It should be emphasized that many of the problems facing Lake Seminole today were essentially predetermined by the physical origins of the lake, as well as the subsequent hydrologic modifications and land use changes that later occurred in the watershed. Long Bayou was historically a shallow tidal embayment which likely had been accumulating fine organic muck sediments in the poorly flushed backwaters for several centuries. When the lake was created by impounding Long Bayou, these sediments along with the riparian mangrove swamps were flooded by detained freshwater discharges from Long Creek. Today, these deposits of organic sediments constitute a lake management problem that now, more than ever, needs to be addressed. Increased nutrient input to Lake Seminole contributed to the decline in water quality. Additionally, wastewater from a treatment facility in Largo was discharging nutrient laden water into Lake Seminole until direct discharges ended in 1971. Subsequently, Long Creek flows were isolated from the lake via the construction of the Lake Seminole Bypass Canal substantially reduced lake circulation and flushing and increased the residence time of nutrients entering the lake. Combined with rapid urbanization with little or no stormwater treatment in the surrounding watershed, this hydrologic modification has likely significantly contributed to the persistent algae blooms and cultural eutrophication observed in Lake Seminole.

A stair-step decline in water quality was observed in 1999 and continued through 2005 which can not be attributed to changes in anthropogenic sources (**Figure 1-2**). In 1999, drought conditions contributed to the lowering of the lake level which further increased the residence time (**Figure 1-4**). During this period a persistent decrease in secchi depth was recorded which could have been due to the resuspension of sediment during and after the lake level was drawn down (**Figure 1-5**). The conditions were further exacerbated in 2006 by a scheduled lake level drawdown for a habitat enhancement sediment removal project. The lake level remained low for an extended period of time due to minimal precipitation and rapid evaporation. Lake water quality has not recovered back to pre-1999 conditions and it is hypothesized that the observed step-change has been maintained by increased residence time and internal nutrient recycling as well as an increasing dominance of nitrogen-fixing blue-green algae.

When the original decision was made by the Pinellas County Board of County Commissioners to create Lake Seminole, these problems could scarcely have been anticipated. However, with the commitment to create the lake comes the obligation to manage the lake and its watershed in a manner consistent with the goals, objectives, and policies of the Pinellas County Comprehensive Plan. The Lake Seminole Watershed Management Plan provides the framework for remediating the historic problems described above, as well as for creating a new future for Lake Seminole.

1. Description of the Impaired Water Body

Lake Seminole is a 684-acre freshwater lake located in west central Pinellas County, Florida (**Figure 1-1**). It was created by the impoundment of an arm of Long Bayou, an estuarine waterbody, in the 1940s. The Lake Seminole watershed encompasses approximately 3,500 acres, of which almost 90 percent is developed as urban land uses. Drainage from much of the historical watershed of the lake has been diverted to the Seminole Bypass Canal, which intercepts surface runoff and conveys it east of the lake to Long Bayou. The lake currently supports intense recreational use including boating, skiing, and fishing. In recent years; however, the sport fishery (primarily largemouth bass and bluegill) and water quality have declined. Prior to creation, Lake Seminole was comprised of a low energy mangrove and salt marsh system. Due to the estuarine marsh environment, a substantial amount of organic silt sediments were present during the impoundment of Long Bayou to create Lake Seminole. These sediments were not removed and have continued to accumulate since the 1940’s. The accumulation of organic silts in lakes is often associated with declining water quality and undesirable changes in aquatic invertebrate and fish communities. The available data indicate a trend of increasing eutrophication and harmful algal blooms in Lake Seminole. The primary concern with regard to water quality in Lake Seminole is excessive cultural (human-induced) eutrophication. Other types of water quality problems can occur in lakes, such as high concentrations of toxics (e.g., heavy metals, pesticides, etc.) and pathogens (e.g., coliform bacteria), but these types of public health problems have not been observed in Lake Seminole to any significant degree. Rather, the major water quality concerns are: 1) the control of excessive nutrients entering the lake; and 2) the fate of the nutrients that do reach the lake (e.g., internal nutrient recycling).

1.a Name of the Water Listed on the Verified List

This document addresses Lake Seminole WBID 1618 located in Pinellas County, Florida.

1.b Location of the Water Body and Watershed

Lake Seminole is located in west central Pinellas County (**Figure 1-1**). The lake is located in the Long Bayou Watershed.

1.c Watershed/8-digit Cataloging Unit Code (HUC)

The USGS Watershed/ 8-digit Cataloging Unit Code for Lake Seminole is 03100207. Lake Seminole is located within the Crystal River to St. Petersburg Watershed.

1.d NHD Identifier

Both Medium and High resolution data are available from the National Hydrography Dataset (NHD) for Lake Seminole. The Com_ID for the High resolution data is 120024097 and Medium Resolution is 16933868 (http://nhd.usgs.gov/). The Reach Number for the High and Medium Resolution polygon is 031002070160475 and 03100207003126, respectively.

1.e Water Body Type

Lake.

1.f Water Use Classification

The impaired waterbody, Lake Seminole, is classified as Class III-Freshwater. This classification designates Lake Seminole for recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife (FDEP, 1996).

1.g Designated Use Not Being Attained

Class III-Freshwater- recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife.

As of July 27, 2006, Lake Seminole was listed on the Group 5 Draft Verified List of Impaired Waters due to high nutrient concentrations (or TSI). Between 1999 and 2004, the annual average TSI value for Lake Seminole was greater than 60 all six years. The median Total Nitrogen value for 445 samples was 3.28 mg/l. The median Total Phosphorus value for 448 samples was 0.12 mg/l. The median Biological Oxygen Demand for 342 samples was 7.0 mg/l. (http://www.dep.state.fl.us/water/tmdl/verified_gp5.htm). This document addresses the eutrophication of Lake Seminole and the management strategies that can be implemented to address impairments listed for the lake from the 303(d) Impaired Waters List.

Due to the decline in water quality, use of the lake by residents, fisherman and tourists has diminished. The increase in nutrients and sediments has decreased the quality of the fishery habitat resulting in a reduction in quantity and quality of target fishes (i.e. largemouth bass, crappie, etc.).

1.h Length of Impaired Area

Lake Seminole is approximately 684 acres in size, and it is the second largest lake in Pinellas County. The lake is approximately 3.3 miles long by 0.43 miles wide.

1.i Pollutants of Concern

An elevated Trophic State Index (TSI) value has been identified as the water quality parameter of concern for Lake Seminole. Specifically, TSI values exceeded the IWR threshold of 60 in the years 1999 to 2004, which is the threshold value for lakes with levels of color in excess of 40 platinum-cobalt units (IWR 2004). Between 1991 and 1998, Lake Seminole's annual average chlorophyll-a values exceeded 24 µg / liter, which is the median value for mesotrophic lakes in Florida (FDEP 1996). However, it was not until 1999 that levels of chlorophyll-a exceeded 78 µg / liter, which is the median value for eutrophic lakes in Florida (FDEP 1996). Between 1991 and 2006, levels of TP in Lake Seminole have been higher than the median value (0.07 mg / liter) for mesotrophic lakes, but mostly lower than the median value (0.13 mg / liter) for eutrophic lakes in Florida (FDEP 1996). Since at least 1993, levels of TN in Lake Seminole have exceeded the median value (1.36 mg / liter) for mesotrophic lakes in Florida (FDEP 1996), while TN values have exceeded the median value for eutrophic lakes (2.4 mg / liter) since1999.

1.j Suspected or Documented Sources of the Pollutants of Concern

The documented sources of excessive nutrients in Lake Seminole is based on data collected by the extensive water quality monitoring plan implemented by PCDEM. The suspected or documented sources of nutrient enrichment in Lake Seminole water quality are discussed in terms of: 1) trophic state; 2) water and nutrient budgets; and 3) pollutant loads. The data analysis includes all data collected by PCDEM between collected between 1991-2006.

Trophic State

The term *trophic state* can be loosely defined as the nutritional status of a lake (Huber et al, 1982). Like other plants, microscopic, single-celled algae (also referred to as phytoplankton) require nitrogen and phosphorus and other primary nutrients to grow and reproduce. However, if nutrients are available in the water column of lakes in concentrations that are too high, nuisance algae blooms can occur. If these conditions persist for a prolonged period of time, many ecological changes begin to take place in the lake. First, the excessive algae concentrations increase turbidity in the water column and shade out the light that supports rooted plants, eventually resulting in the die-off of submerged aquatic vegetation. Second, the bacterial breakdown of the excessive amount of dead algal cells raining down on the lake bottom results in a depletion of oxygen in the water column which can result in fish kills. Third, when algae becomes the dominant source of primary production (photosynthesis) in the lake, this can result in a shift in the fish population structure from a predominance of carnivorous sport fish (e.g., largemouth bass) to a predominance of herbivorous rough fish (e.g., gizzard shad). This process is called *eutrophication*.

Lake eutrophication is a natural process resulting from the gradual accumulation of nutrients, increased productivity, and a slow filling in of the basin with accumulated sediments, silt and organic matter from the watershed. The classical lake succession sequence is usually depicted as a unidirectional progression through the following series of phases or trophic states including:

Oligotrophy - nutrient-poor, biologically unproductive, low turbidity;

Mesotrophy - intermediate nutrients and biological productivity, moderate turbidity;

Eutrophy - nutrient-rich, high biological productivity, high turbidity;

Hypereutrophy - pea soup conditions, the extreme end of the trophic continuum.

Although natural eutrophication could take tens of thousands of years to occur, a lake's lifespan can be drastically shortened by human-induced cultural eutrophication. Activities in the watershed such as forest clearing, road building, agricultural cultivation, residential and commercial development, stormwater runoff and wastewater discharges can all result in substantial increases in the discharge of nutrients, organic matter and sediments to the lake. **Figure 1-6** illustrates the differences between natural and cultural, or human-induced, eutrophication.

The primary measure of the degree of eutrophication in a lake is the concentration of chlorophyll-a in the water column. Chlorophyll-a is an estimate of algal cell biomass, and may be directly related to the trophic state of the lake. In addition, the primary nutrients of concern with respect to controlling eutrophication are total nitrogen (TN) and total phosphorus (TP). Finally, the most commonly used measure of water transparency is the Secchi disk depth, or the maximum depth at which a disk suspended on a weighted line can be visually detected below the water surface.

The following summaries of the status and trends in water quality and pollutant loading sources focus on the parameters related to the trophic state of the lake, including chlorophyll-a, TN, TP, and Secchi disk depth. With respect to indicators of eutrophication, water quality in Lake Seminole has generally declined over the past decade. Below are plots of annual averages of seasonal water quality data collected in Lake Seminole from the period of record, 1991 through 2006 (**Figures 1-4, 1-5 and 1-7 through 1-10**). Due to limitations in detection limits and other analytical problems, all data prior to 1995 should be investigated with caution.

Chlorophyll-a is the most commonly used measure of lake trophic state. **Figure 1-2** provides a timeline of major events in relation to Lake Seminole and chlorophyll a. A water sample was collected in Lake Seminole by the FWCC for each year from 1969-1972. The chlorophyll-a values ranged from 21.4-69.5 µg/l. In 1973, six water quality samples were collected by the EPA. This data provides a historical "snap-shot" of the water quality in Lake Seminole based on the quantity of samples, the average chlorophyll a was 102 µg/l. **Figure 1-7** shows trends in annual average chlorophyll-a concentrations from 1991-2006. Chlorophyll-a concentrations in Lake Seminole were the lowest on record and generally stable from 1991 through 1998, but increased substantially in 1999. The mean annual chlorophyll-a concentration from 1991 through 1998 was 65 *µ*g/l. However, in 1999 the mean monthly chlorophyll-a concentration increased to 120 *µ*g/l, almost double the mean annual concentration over the previous eight years. Based on annual rainfall to Tampa Bay, 1999 was the beginning of a multi-year drought that extended till 2001 (Morrison et al., 2006). Additionally, 1997-1998 were "El Nino" years with the associated above average rainfall. The increased rainfall in 1998 would have increased stormwater runoff and nutrient input into Lake Seminole. The following drought would have resulted in minimal freshwater input to the Lake. The water level in Lake Seminole dropped below 4.0 feet (NGVD) in 2000 (**Figure 1-4**). Since 1999, chlorophyll a values have fluctuated around 120 *µ*g/l. However, in 2006, values increased to 161 *µ*g/l. In 2006, chlorophyll a values were perhaps high due to lowering the lake from 5.0 ft NGVD to 2.5 ft NGVD for a habitat restoration project The lake level decreased further to below 2.0 ft NGVD due to an extended drought throughout the summer of 2006. The chlorophyll a values during this period are not indicative of the lake's normal condition. Further, no substantial changes in the lake or watershed that could significantly affect external pollutant loads or internal nutrient recycling are known to have occurred.

Figure 1-8 shows trends in annual average total nitrogen concentrations. Like chlorophyll-a, total nitrogen concentrations in Lake Seminole were relatively stable from 1992 through 1998, but increased substantially in 1999. The 1999 increase is potentially due to increased nutrient input in 1998 followed by decreased precipitation and increased evaporation in Lake Seminole. Similar to chlorophyll a, TN values increased in 2006, averaging 3.8 mg/l. In comparison, the average TN concentration in 1973 was 2.4 mg/l.

TP concentrations have decreased considerably from 1973 to 1992. The annual TP concentration in 1973 was 0.2 mg/l compared to 0.11 mg/l in 1992. As shown in **Figure 1-9**, total phosphorus concentrations decreased somewhat between 1993 and 1996. From 1997 to 2002, TP values increased from 0.11 mg/l to 0.14 mg/. In 2003, TP concentrations decreased substantially to 0.11 mg/l. Currently, concentrations have increased slightly but remain lower than 2002 values. The decrease in TP could be attributed to the organic sediment removal in Lake Seminole during 2002.

Figure 1-5 shows trends in the annual average Secchi depth. Secchi depth in Lake Seminole has generally decreased since 1991. In 2000, the mean monthly Secchi depth was 0.28 meters, the lowest during the previous six year reporting period. Secchi values remained low until 2002. An increase in secchi depth occurred from 2002 to 2004. In 2005, Secchi depth decreased substantially from 0.33m to 0.25m. The decrease in secchi depth could be due to the resuspension of sediment during and after the lake level was drawn down. As an indicator of water transparency, Secchi depth values are generally inversely related to chlorophyll-a concentrations. Secchi depth values less than about 0.5 meters generally represent conditions that are severely light limiting for aquatic macrophytes. Based on data collected by the EPA, the average secchi depth in 1973 was 0.7 m.

Figure 1-10 shows trends in annual rainfall totals in the Lake Seminole area (SWFWMD) for the period 1992-2005. As shown, 1995 and 1997 were wet years, with 1997 and 1998 being documented 'El-Nino' years during which most of the rainfall occurred during the winter months between 1997 and 1998. 2004 was also a wet year due to increased tropical storm and hurricane activity. Conversely, 1990 and 1999 were the driest years during this period. Additionally, water levels in Lake Seminole greatly declined in 1999 and 2000 presumably due to the lack of rainfall and increased evaporation. Given the lesser 1999 rainfall total, the observed increase in chlorophyll-a concentrations in 1999 cannot be readily explained in terms of increased external nutrient loads from stormwater runoff for that year. However, the increased nutrient load from 1998 could have contributed to a substantial storage of nutrients in the sediments and water column for 1999.

Although trophic state concepts have been in existence for some time, debate has existed over the terminology, the precise definition of various trophic state classes, and the development of an ecologically meaningful and widely accepted quantitative procedure for determining trophic state. There are several common indicators that are included in calculation of a lake's trophic state, chlorophyll a, total nitrogen and total phosphorus. Secchi depth was previously included in the calculation derived by Huber et al., (1982). The Florida lakes index is calculated differently for nitrogen limited, phosphorus limited, and nutrient balanced lakes, and involves the calculation of separate sub-indices for total nitrogen, total phosphorus, chlorophyll-a, and Secchi depth.

As discussed by Huber et al. (1982), three classes of lakes can be described pursuant to the total nitrogen to total phosphorus ratio. They are as follows:

Nitrogen-limited lakes	= TN/TP < 10
Nutrient-balanced lakes	= 10 < TN/TP < 30
Phosphorus-limited lakes	= TN/TP > 30

The sub-indices for the Huber et al., (1982) and FDEP approved TSI calculation are identical:

$\mathbf{CHLA_{TSI}}$=16.8 + [14.4 * LN (CHLA)]
$\mathbf{TN_{TSI}}$= 56+ [19.8 * LN (TN)]
$\mathbf{TN2_{TSI}}$= 10 * [5.96 + 2.15 * LN(TN + .0001)]
$\mathbf{TP_{TSI}}$= [18.6 * LN (TP * 1000)] – 18.4
$\mathbf{TP2_{TSI}}$= 10 * [2.36 * LN (TP * 1000) – 2.38]
$\mathbf{SD_{TSI}}$ = 10 [6.0 - (3.0 ln SD)]

*$CHLA_{TSI}$, TN_{TSI}, $TN2_{tsi}$, $TP_{TSI,}$ $TP2_{TSI}$, and SD_{TSI},] are sub-indices for chlorophyll-a, Total Nitrogen (nutrient-balanced lake), Total Nitrogen (nitrogen-limited lake), Total Phosphorus (nutrient-balanced lake), Total Phosphorus (phosphorus-limited lake) and Secchi depth, respectively.

The overall trophic state index (TSI) for a lake is determined by combining the appropriate sub-indices to obtain an average for the physical, chemical, and biological features of the trophic state. All TSI values included within the Lake Seminole Watershed Management Plan (Plan) were calculated using the Huber et al. (1982) formulas.

Limiting nutrient considerations for calculating TSI_{AVE*}:

If TN/TP > 30 then TSI_{AVE}=1/3 [$CHLA_{TSI}$ + SD_{TSI} + TP_{TSI}]
If TN/TP < 10 then TSI_{AVE} = 1/3 [$CHLA_{TSI}$ + SD_{TSI} + TN_{TSI}]
If 10< TN/TP<30 then TSI_{AVE} =1/3 [$CHLA_{TSI}$ + SD_{TSI} + 0.5[TP_{TSI} + TN_{TSI}]]

*It is important to note that this formula includes secchi depth.

The inclusion of secchi depth as an indicator for water quality in Florida lakes is controversial due to problems during the calculation of the TSI in dark-water lakes. Secchi depth readings can give an inaccurate representation of algal reduced light transparency due to the tannin-rich water. This complication is not a concern in Lake Seminole given the low levels of tannin colored waters in the lake. However, FDEP removed the secchi depth indicator from all calculations of TSI for Florida lakes. Currently, the Impaired Water Rule cites the "1996 Water-Quality Assessment for the State of Florida. Section 305(b) Main Report" as the accepted methodology for calculating the TSI (FDEP, 1996). Previously, in the Plan, it was recommended that the TSI calculation as derived by Huber et al. (1982), be used for all comparative TSI calculations for Lake Seminole. However, the use of modified versions of the above described trophic state index, or other indices altogether, will yield different calculated TSI values which may lead to confusion with regard to the establishment of defensible resource management and pollutant load reduction goals. Therefore, we amend our previous recommendation and suggest that the FDEP accepted TSI calculation be used for all future calculations of TSI in order to facilitate lake comparisons. The FDEP accepted TSI calculation for a nutrient balanced lake is:

Limiting nutrient considerations for calculating $NUTR_{TSI}$:

If TN/TP > 30 then $NUTR_{TSI}$ = $TP2_{TSI}$
If TN/TP < 10 then $NUTR_{TSI}$=$TN2_{TSI}$
If 10< TN/TP<30 then $NUTR_{TSI}$= (TP_{TSI} + TN_{TSI})/2

TSI= ($CHLA_{TSI}$ + $NUTR_{TSI}$)/2

For comparison, the TSI values for Lake Seminole were calculated using both formulas to demonstrate the complications that would arise without a standard formula. To determine the current trophic state of Lake Seminole, the most recent monitoring data available from Pinellas County, covering the period January through December 2005, were used. The mean seasonal concentrations of chlorophyll-a, TN, TP, and the mean seasonal Secchi depth, for this time period are as follows:

Chlorophyll-a (Chl-a)	= 129 µg/l
Total Nitrogen (TN)	= 3.42 mg/l
Total Phosphorus (TP)	= 0.111 mg/l
Secchi Depth (SD)	= 0.25 m

The Plan Calculation

Using the mean values shown above, the TN:TP ratio in Lake Seminole is **30.77**, making it a phosphorus limited lake, at least under current conditions.

TSI_{AVE}=1/3 [$CHLA_{TSI}$ + SD_{TSI} + TP_{TSI}]

These sub-indices are given and solved as follows:

$CHLA_{TSI}$ = 16.8 + [14.4 * LN (CHLA)] = **86.8**
$TP2_{TSI}$= 10 * [2.36 * LN (TP * 1000) – 2.38] = **87.4**
SD_{TSI} = 10 [6.0 - (3.0 ln SD)] = **101.6**

With the values of all sub-indices known, TSI_{AVE} for Lake Seminole can be solved as follows:

TSI_{AVE} = 1/3 [86.8 + 101.6 + 87.4] = **92**

Therefore, the calculated current trophic state index using the Huber et al. (1982) formula, which includes secchi depth, for Lake Seminole for the period January through December 2005 is **92**.

FDEP Calculation

Using the same mean values, the below formulas were used to calculate the TSI for a phosphorus limited lake.

$NUTR_{TSI}$= $TP2_{TSI}$
TSI= ($CHLA_{TSI}$ + $NUTR_{TSI}$)/2

These sub-indices are given and solved as follows:

$CHLA_{TSI}$ = 16.8 + [14.4 * LN (CHLA)] = **86.8**

$TP2_{TSI}$= 10 * [2.36 * LN (TP * 1000) – 2.38] = **87.4**

$NUTR_{TSI}$= $TP2_{TSI}$ = **87.4**

With the values of all sub-indices known, TSI for Lake Seminole can be solved as follows:

TSI= (86.8 + 87.4)/2 **=** **87**

Therefore, the calculated current trophic state index using the FDEP accepted TSI calculation for Lake Seminole for the period January through December 2005 is **87**.

TSI Comparison

The Plan TSI calculation computed a TSI of **92** compared to the FDEP formula which calculated **87** for the TSI of Lake Seminole for an approximately 5 point difference between the two formulas. The TSI calculations for both formulas from 1992 to 2006 are presented in **Figure 1-11**. From 1992-2004, the TSI calculation for a nutrient-balanced lake was used based on the TN:TP value. The Plan calculation is consistently 5-7 points greater than the FDEP method. A 5 point difference in TSI is equivalent to a 20 µg/l change in Chlorophyll a, a 0.04 mg/l change in TP and a 0.7 mg/l change in TN. The implications on water quality status and potential management decisions based on TSI values are substantial. One standard method for TSI calculation is necessary to successfully document and implement restoration plans to improve water quality in Lake Seminole.

Management Endpoint

A primary issue regarding the application of the TSI to the classification of Florida lakes for management purposes is the selection of a critical TSI value, or a value above which the lake is considered to have trophic related problems. Based upon a review of data from 573 Florida lakes, and the subsequent classification of each, Huber et al. (1982) determined the TSI value of 60 to be a generally applicable critical value defining eutrophic conditions. In response to the results reported by Huber et al. (1982), the FDEP established a classification criteria for lakes, estuaries and streams in Florida **(Table 1-2)**. A lake is classified as “good” with a TSI value < 59, “fair” with a TSI of 60-69, and “poor” with a TSI value >69 (FDEP, 1996). The Plan presented a TSI goal of 65 (using secchi depth) based on the predicted modeled results and realistic understanding of the lake’s urban setting. The aforementioned TSI comparison clearly shows that the Plans recommended target TSI of 65 is equivalent to the FDEP’s criteria of a TSI of 60. Therefore, both the FDEP and the Plan agree upon a target management endpoint of a TSI value of 60 (based on FDEP’s methodology). We present this TSI target based on the continued eutrophication of the lake and the unique formation and history of Lake Seminole, as described below.

Lake Seminole, was created in the 1940s by the construction of a causeway along Park Boulevard, thus isolating the upper reaches of Long Bayou from its historical tidal influences. Therefore, Lake Seminole can more properly be described as an artificial reservoir, than a true, natural lake. In addition to its artificial nature, the now freshwater

Lake Seminole was initially created out of a brackish to estuarine portion of a tributary to Tampa Bay's Boca Ciega Bay. Previous monitoring data from Lake Seminole indicated that the lake has been consistently eutrophic, and has exhibited numerous trophic related problems. In 1973, the annual TSI value calculated using the above described criteria was 81. In comparison, the current TSI is 87. Lake Seminole is now classified as severely hypereutrophic. In the absence of pre-1970 water quality data, lakes such as Lake Seminole are often assessed for indications of their historic water quality conditions through the use of paleolimnological indicators. Using this technique, the past water quality conditions are ascertained via the detection of changes in the diatom and/or dinaflagellate species composition of the lake in past years, as illuminated via examining different depths of sediments, and tying these depths back to specific dates via various sediment aging techniques (i.e., lead-210 decay). In 1990, the University of Florida in coordination with SWFWMD collected core samples from three locations in Lake Seminole for paleolimnological analysis (SWFWMD, 1992). Due to high concentrations of ^{210}Pb throughout the core, they were unable to successfully date the sections. Therefore, the results of the diatom analysis were unable to be correlated with the sediment age. Due to the well-mixed sediments and since Lake Seminole was not previously a freshwater lake, this technique is not likely to be useful. Instead, this Reasonable Assurance Plan outlines a complex and holistic lake restoration strategy, with which successful implementation might be expected to produce a greatly enhanced water quality with a target TSI value of 60. This target would not only be an improvement over current conditions, but apparently an improvement over conditions that existed in the early 1970's.

Water and Nutrient Budgets

The first step in determining the pollutant loads to any lake is the establishment of a water budget. Flows carry pollutants into and out of lakes, and a meaningful analysis of lake eutrophication and most other water quality problems cannot be conducted without a quantitative understanding of lake hydrology. The basic water balance equation considers the following terms, typically expressed in units of acre-feet per year:

INFLOW + PRECIPITATION = OUTFLOW + EVAPORATION + Δ STORAGE

For Lake Seminole, a storage volume of 3,420 acre-feet was calculated using an average depth of 5.0 feet and a surface area of 684 acres. Because the lake water level is currently managed within a relatively narrow range, this volume was assumed to be static for the purposes of this water budget analysis. Because the annual change in storage volume is considered to be zero, the water budget equation must be solved as follows:

INFLOWS + PRECIPITATION = OUTFLOWS + EVAPORATION

Figure 1-12 graphically illustrates the water budget concept. The water budget calculated for Lake Seminole using 1997 data is summarized in **Table 1-3**.

Using the information developed in the water budget, lake nutrient budgets provide the cornerstone for evaluating lake eutrophication problems. The following terms are evaluated and are typically expressed in terms of tons or kilograms per year:

INFLOW LOADINGS = OUTFLOW LOADING + NET SEDIMENTATION + ΔSTORAGE

Nutrient budgets can be prepared for both nitrogen and phosphorus, although there are differences in some of the minor terms of the equation. The major components of inflow and outflow nutrient loads are essentially determined by multiplying appropriate nutrient concentration data with the respective inflow and outflow water volumes determined in the lake water budget.

The **net sedimentation** term defines the amount of nitrogen and phosphorus accumulated or retained in lake bottom sediments and/or the macrophyte standing crop. It reflects the net result of all physical, chemical, and biological processes causing vertical transfer of nutrients between the water column and the lake bottom.

For a given loading, lake water quality will generally improve as the magnitude of sedimentation increases because higher sedimentation leaves less available nutrients behind in the water column to stimulate algal growth. Because several complex processes are involved that vary spatially and seasonally within a given lake, it is generally infeasible to measure net sedimentation directly. Accordingly, this term is usually calculated by obtaining the difference from the other terms, or estimated using empirical models; however, site specific data have been collected in Lake Seminole to enable a more direct estimate of net sedimentation of TN and TP (SWFWMD, 1992; PBS&J, 1999).

The **change in storage** term accounts for changes in the total mass of nitrogen and phosphorus stored in the lake water column between the beginning and end of the study period. Such changes would reflect changes in lake volume, average nutrient concentrations, or both.

As discussed above, there is no significant change in the volume of Lake Seminole on an annual average basis, and water quality monitoring has indicated relatively stable nutrient concentrations prior to 1999. Therefore, for the purposes of this analysis, the change in nutrient storage is considered to be close to zero allowing that the equation be solved as follows:

INFLOW LOADINGS = OUTFLOW LOADINGS + NET SEDIMENTATION

Figure 1-13 graphically illustrates the nutrient budget concept with respect to phosphorus. The nutrient budgets calculated for Lake Seminole using 1997 data are summarized in **Tables 1-4 and 1-5** for total nitrogen and total phosphorus, respectively.

Based on the water and nutrient budgets summarized in **Tables 1-3 through 1-5**, the following conclusions can be made regarding the inflow and outflow of both water and the nutrients TN and TP in Lake Seminole.

- Direct runoff from the watershed land surface accounts for about 65.4% of the total annual hydrologic inflows. Direct precipitation on the lake water surface accounts for about 33.9% of the total annual hydrologic inflows. Groundwater seepage from the surficial aquifer accounts for the remaining 0.7%.

- Hydrologic discharges from the Lake Seminole weir structure and diversion pipe in the south lobe of the lake account for about 81.4% of the total annual hydrologic outflows. Evapotranspiration accounts for about 17.8% of the total annual hydrologic outflows. Storage loss due to sedimentation accounts for the remaining 0.8%.

- Direct runoff from the watershed land surface and direct precipitation on the lake water surface account for about 36.8% and 5.3% of the total annual TN inputs, respectively. Groundwater seepage from the surficial aquifer only accounts for about 0.2% of the total annual TN inputs.

- Approximately 57.7% of the total annual TN inputs are derived from undetermined sources. Internal nutrient recycling processes (e.g., sediment fluxes) could account for a substantial fraction of this TN mass. In addition, analyses of Lake Seminole phytoplankton populations conducted during the summer and fall of 2000 have revealed high concentrations of the nitrogen fixing blue-green alga *Cylindrospermopsis cuspis* (PCDEM, 2000). The observed dominance of nitrogen-fixing cyanobacteria indicates that the biological fixation of atmospheric nitrogen may be a major source of TN inputs to Lake Seminole.

- Other potential undetermined sources of nitrogen inflows could include illicit discharges to lake surface waters, the municipal stormwater system and sanitary sewer overflows or leaks. However, to date, no direct evidence of such nitrogen sources has been discovered in Lake Seminole.

- Hydrologic discharges from the Lake Seminole weir structure and diversion pipe in the south lobe of the lake account for about 66.0% of the total annual TN losses. Sedimentation accounts for the remaining 34.0% of the total annual TN loss.

- Direct runoff from the watershed land surface accounts for about 96.2% of the total annual TP input. Direct precipitation on the lake water surface accounts for about 3.7% of the total annual TP input. Groundwater seepage from the surficial aquifer accounts for the remaining 0.1%.

- Hydrologic discharges from the Lake Seminole weir structure and diversion pipe in the south lobe of the lake account for about 39.6% of the total annual TP outflows. Sedimentation accounts for the remaining 60.4% of the total annual TP outflows.

Pollutant Loads

It should be noted that there are no permitted point source discharges in the basin, and the entire Lake Seminole watershed is served by central sanitary sewer facilities. Therefore, the water and nutrient budgets presented above underscore two very important points with respect to potential pollutant load reduction strategies for Lake Seminole:

- **stormwater runoff** represents the single most important source of external phosphorus loads to Lake Seminole; and

- **internal nutrient recycling** - including nitrogen fixation by blue-green algae and sediment fluxes - constitutes a substantial cumulative nitrogen and phosphorus source to Lake Seminole surface waters.

Stormwater Runoff

As part of the planning process, modeling of stormwater runoff using EPA's Surface Water Management Model (SWMM) was conducted to determine those major sub-basins contributing the highest nonpoint source pollutant loads. The location of the major sub-basins in the Lake Seminole watershed are shown in **Figure 1-14**, whereas the modeled annual nonpoint source loads of TN, TP and total suspended solids (TSS) for each of the major sub-basins are summarized in **Figure 1-15**.

Using a ranking procedure which integrates modeled TN, TP, and TSS loads, the five priority major sub-basins, or those with the highest integrated nonpoint source pollutant loads, are listed in **Table 1-6** in order of decreasing priority.

Because high density urban land uses in the Lake Seminole basin are relatively ubiquitous, there are not significant differences in the unit area loads generated from each of the major sub-basins. Although there are minor differences in the age of the urban land uses in the various sub-basins, and whether or not on-site stormwater treatment is provided, these differences are generally not significant. Consequently, the major sub-basins with greatest contributing drainage area were generally the ones that ranked highest in terms of nonpoint source pollutant loads, as they deliver the greatest hydrologic and pollutant loads per unit rainfall.

Internal Nutrient Recycling

As shown in **Table 1-4**, it is estimated that undetermined sources accounted for approximately 24.40 tons, or about 57.7%, of the annual TN inputs to Lake Seminole in 1997. However, it should be noted that the *undetermined sources* term was not measured but rather derived as the balancing term after accounting for modeled and measured inflows and outflows, and after accounting for an estimated sedimentation rate based on a measured sediment N:P ratio of 7.09. The estimated 24.40 tons of nitrogen from undetermined sources in Lake Seminole during 1997 equates to a rate of approximately 7.9 g N/m^2/yr. Under nitrogen limiting conditions, certain blue-green algae species (cyanobacteria) are capable of fixing atmospheric nitrogen to support their growth and reproduction. Measured nitrogen fixation rates in other hypereutrophic Florida lakes have ranged as high as 5.7 g N/m^2/yr, accounting for about 44% of the annual TN inputs, in Lake Tohopekaliga (Dierberg and Scheinkman, 1987). Therefore, based on the fact cyanobacteria with the potential ability to fix atmospheric nitrogen are the dominant alga in Lake Seminole (SWFWMD, 1992; PCDEM, 2000), it is reasonable to assume that nitrogen fixation accounts for the majority of the undetermined sources of nitrogen inflows to Lake Seminole.

It is possible that some portion of the internally derived mass of nitrogen revealed in the lake nitrogen budget may actually represent an undocumented point source discharge to Lake Seminole. Such a discharge could include sanitary sewer leaks or overflows, or an illicit discharge(s) to lake surface waters or municipal storm sewer systems. However, it should be noted that no direct evidence of an undocumented or illicit point source discharge has been discovered to date, and the presence of such an external pollutant source is not needed to explain the observed conditions and nutrient budgets. Nonetheless, Pinellas County will continue to investigate the possible existence of an undocumented point source discharge to Lake Seminole.

Upon a closer inspection of **Tables 1-4 and 1-5** it can be seen that the TN:TP ratio of the measured and modeled inflows to Lake Seminole (excluding the calculated *undetermined sources* term in the nitrogen budget) is 5.32, whereas the TN:TP ratio for the measured outflows is 20.98. These findings indicate that the nutrient inflows should establish nitrogen limiting conditions; however, the outflows reflect nutrient balanced conditions. Since very little dissolved inorganic nitrogen (ammonia and nitrate/nitrite) or phosphorus (orthophosphate) is present in Lake Seminole surface waters, the measured TN:TP ratio in lake outflows represents that which has been assimilated in phytoplankton biomass. Therefore, the additional nitrogen assimilated by lake phytoplankton must be derived from internal sources which likely include both nitrogen fixation and sediment nitrogen fluxes.

A stable isotope analysis ($\delta^{15}N$ and $\delta^{13}C$) was completed by PCDEM in 2000 to identify the various sources of nutrients within sediment, water or algal samples (Levy, 2000). The PCDEM collected Lake Seminole sediment, algae and wastewater from a nearby pump station. The results of this analysis supported the production of nitrogen within Lake Seminole due to cyanobacteria. The $\delta^{15}N$ signature of the algal samples was most comparable with cyanobacteria (N_2-fixers), the dominant algal species in the lake is *Cylindrospermospsis sp*. which is capable of nitrogen fixation. The $\delta^{15}N$ of the sediment samples was heavier and indicated that the nitrogen source in the sediment was comprised of a variety of types of organic matter (aquatic vegetation, phytoplankton, zooplankton, invertebrates and detritus). The analysis of the wastewater revealed that it could be a contributing factor to the nitrogen and carbon found in the sediments. The nitrogen budget in combination with the stable isotope analysis suggests that a majority of the biologically available nitrogen in Lake Seminole is produced by nitrogen fixing cyanobacteria.

As previously discussed, a significant increase in TN was observed in 1999 following the severe “El Nino” event of 1997 to 1998. We believe that 1999 signifies the “downturn” in water quality at Lake Seminole. The average annual nutrient concentration was compared to the flow-weighted average of nutrients input by direct runoff. The TN and TP load from direct runoff calculated in 2001 were divided by the hydrologic load to the lake, also due to direct runoff, to derive a flow-weighted average for both TN and TP. Over the entire period of record, TP concentrations are consistently lower than the flow-weighted average **(Figure 1-9)**. This signifies that TP is being stored in the lake sediments. This conclusion is supported by the TP budget calculated in 1997 which determined that 60% of the phosphorus ‘outflows’ from the lake were due to sedimentation (Table 1-5; PBSJ, 2001). In contrast, TN concentrations consistently exceed the flow-weighted average input by direct runoff **(Figure 1-8)**. This suggests the production of additional nitrogen due to internal processes. There is substantial documentation of cyanobacteria in the lake which are capable of converting atmospheric nitrogen to biologically available forms. The TN budget calculated in 1997 supports the conclusion of a substantial input of internally produced nitrogen citing “undetermined sources” producing 58% of the TN input to the lake (Table 1-4; PBSJ, 2001). Preliminary results from a mesocosm experiment in Lake Hancock, in Polk County, indicate a potential phenomenon that could also be occurring in Lake Seminole. Lake Hancock is a highly eutrophic lake with a dominant cyanobacteria algal population. The phosphorus laden sediments in combination with an “unlimited” nitrogen supply due to the nitrogen-fixers provide an environment for the overproduction of phytoplankton. The most effective approach to improving water quality and reducing the dominance of cyanobacteria involves management actions that drive the lake towards phosphorus limitation and away from nitrogen limitation. Examples of such management actions include reduction of external phosphorus loads (e.g., enhanced stormwater treatment), and the removal or inactivation of sediment phosphorus stores (e.g., lake dredging and whole lake alum treatment). Other effective means of reducing the dominance of cyanobacteria include improving circulation and reducing the residence time of lake surface waters.

2. Description of Water-Quality Goals

2.a Description of the Water Quality-Based Targets (both Interim and Final) Established for the Pollutant(s) of Concern

The keystone of any planning process is the establishment of goals. For each established goal, there must also be defined target criteria by which degree of attainment of that goal can be measured. Targets are therefore defined as specific units of measure that define progress towards a particular management goal. Below describes a summary of the final lake and watershed management goal adopted by the Lake Seminole Advisory Committee for water quality.

The lake and its watershed shall be managed such that good water quality, according to Class-III State standards, is achieved and maintained in the lake.

The following six water-quality based targets have been developed in order achieve the adopted Water Quality management goal. The rationale for each proposed monitoring objective is discussed below.

Target 1: **Attain a mean annual chlorophyll-a concentration of 30** μg/l **or less.**

Objective 1: Continue to measure in-lake chlorophyll-a concentrations.

Rationale: The amount of phytoplankton biomass, measured as chlorophyll-a, serves as an integrator and indicator of lake trophic conditions. High mean annual chlorophyll-a concentrations usually indicate excessive algal growth. With regard to available and comparable water quality data, the best continuous record exists for the parameter of chlorophyll-a. Furthermore, the collection and measurement of chlorophyll-a samples are already programmed into the existing PCDEM monitoring program.

Target 2: **Attain a mean annual multi-parametric TSI value of 6**0 **or less.**

Objective 2A: Continue to measure in-lake TN and TP concentrations.

Rationale: Nitrogen (N) and phosphorus (P) are the primary nutrients required by plants for growth and reproduction. In excessive concentrations, N and P can cause nuisance algae blooms. The measure of all chemical forms of these nutrients (total N and P, or TN and TP) in the water column is a measure of the algal growth potential, and thus is an important indicator of trophic state. TN and TP concentrations are two of three parameters used to calculate a multi-parametric TSI value, with chlorophyll-a being the other. The collection and measurement of TN and TP samples are programmed into the existing monitoring program.

Objective 2B: Continue to measure in-lake Secchi disk depths.

Rationale: Secchi disk depth serves as a simple measure of lake water clarity. The degree of water transparency is one of the most important attributes of water. Water transparency allows the penetration of light, which supports life through the photosynthetic process. The degree of water transparency has a direct impact on the growth and distribution of submerged aquatic vegetation. Water transparency also allows organisms with visual organs to see in order to search for food and shelter. Water transparency can be affected by suspended organic (e.g., algae) and inorganic (e.g., silt) matter in the water column, as well as tannins and dissolved substances. The measurement of secchi depth is incorporated into the existing monitoring program.

Target 3: Reduce current annual TP loads from external sources by 50%.

Objective 3A: Estimate mean annual nonpoint source TP loads to Lake Seminole from priority sub-basins.

Rationale: It is possible to estimate external TP loads from nonpoint source runoff through direct measurement at points of discharge to the lake. Since nonpoint source runoff represents approximately 96% of the total annual external TP load, and since this load is both measurable and manageable to a large extent, long term trends in these loading sources have been monitored to evaluate the effectiveness of load reduction strategies. TN loads were estimated to allow for the development of annual nutrient budgets. As part of the Alum system design for Lake Seminole, PCDEM completed this objective.

Objective 3B: Estimate mean annual loads of TP to Lake Seminole from groundwater seepage.

Rationale: Few site-specific data exist regarding the magnitude and timing of groundwater inputs to Lake Seminole. Using limited groundwater quality data collected by SWFWMD along the western perimeter of the lake, modeling techniques were applied to estimate groundwater loadings to the lake during wet and dry seasons. The results indicate that groundwater seepage contributes less than 1% of the total annual TP load to the lake. This estimate will be confirmed by direct field measurements using seepage meters or similar methods. TN loads will also be estimated to allow for the development of annual nutrient budgets. The SWFWMD wells will also be monitored every two years, and similar modeling techniques will be applied using these data, to determine potential long-term trends in this loading source. Monitoring of groundwater seepage is warranted due to the fact that the recommended enhanced lake level fluctuation schedule has the potential to alter seepage rates by increasing the head difference between the lake level and the water table.

Objective 3C: Estimate mean monthly loads of TP to Lake Seminole from atmospheric deposition.

Rationale: It is possible to estimate external TP loads from atmospheric deposition through direct measurement. Based on measurements taken from sites in the Tampa Bay region, it is estimated that atmospheric deposition accounts for only about 3.7% of the total annual external TP loads to the lake. Wet and dryfall measurements from samples collected in the Lake Seminole basin are needed to better estimate local conditions and loading rates. TN loads will also be estimated to allow for the development of annual nutrient budgets. Although this loading source is not considered to be significant or directly manageable at this time, long term trends will be monitored to determine the relative importance of this source, as well as the effectiveness of regional air quality programs.

Target 4: Annually calculate current water and nutrient budgets for Lake Seminole.

Objective 4: Estimate the mean mass of TN, TP and water volume discharged from Lake Seminole.

Rationale: The estimation of mean annual TN, TP, and hydrologic loads discharged from the lake combined with estimates of mean annual loads entering the lake are needed to calculate lake water and nutrient budgets. Estimates of external loadings from nonpoint sources, atmospheric deposition and groundwater are measurable and are addressed in separate monitoring objectives above. To balance a water/nutrient budget, direct measurements of outflows from the lake are needed. Annual estimates of loads leaving the lake will enable the calculation of net loadings into the lake, loads which should be related to mean annual in-lake chlorophyll-a concentrations and TSI values. The Lake Seminole outfall structure provides a convenient location for measuring flow and collecting water samples. Instrumentation for accurately measuring stage and flow volumes has been installed to meet this monitoring objective.

Target 5: Maintain Class-III water quality standards for dissolved oxygen, pH, specific conductance and chlorides.

Objective 5A: Estimate the monthly frequency, duration, and magnitude of bottom dissolved oxygen concentrations in Lake Seminole that fall below regulatory minima of 5.0 mg/l.

Rationale: In addition to phytoplankton biomass, the concentration of dissolved oxygen in the deepest portions of the lake is often a good indicator of overall lake water quality. Any dissolved oxygen concentrations below 5 mg/l are in exceedance of Class-III State water quality standards, and may result in fish kills and other adverse impacts on biota. The measurement and monitoring of dissolved oxygen concentrations are programmed into the existing monitoring program.

Objective 5B: Estimate for Lake Seminole: 1) the monthly trend in pH; and 2) the frequency, duration, and magnitude that monthly pH varies by more than one unit above or below natural background levels.

Rationale: A rapid or large change in lake pH may have severe adverse effects on lake biota. Although Lake Seminole monitoring data indicate that the lake is fairly stable with respect to pH, it will be critical to maintain normal pH ranges in the lake to ensure the success of the proposed alum injection and whole lake alum applications. The measurement and monitoring of pH is programmed into the existing monitoring program.

Objective 5C: Estimate for Lake Seminole: 1) the monthly trend in chloride concentration; and 2) the frequency, duration, and magnitude that monthly chloride concentrations exceed background levels by 10% or more.

Rationale: A rise in mean chloride concentrations above existing and historical levels (between about 200-250 mg/l) may have adverse effects on lake biota. Although mean annual lake chloride levels have remained fairly constant, future increases of in-lake chloride concentrations are possible due to the proximity of the lake to saltwater and the proposed enhanced lake level fluctuation schedule. Increasing chlorides could potentially lead to substantial degradation of existing lake flora and fauna. The measurement and monitoring of chloride is programmed into the existing monitoring program.

Objective 5D: Estimate for Lake Seminole: 1) the monthly trend in specific conductance; and 2) the frequency, duration, and magnitude that monthly specific conductance exceeds 1,275 µmhos/cm.

Rationale: Increases in specific conductance, like chlorides and pH, may adversely affect in-lake biota. Measurements of specific conductance may be used as a correlate to chloride measurements, and may be potentially used to explain trends in both chlorides and pH. The measurement and monitoring of specific conductance is programmed into the existing monitoring program.

Target 6: Attain an 80% TSS load reduction for all permitted MSSW facilities within the Lake Seminole watershed.

Objective 6: Determine the number of permitted Management and Storage of Surface Water (MSSW) facilities in the Lake Seminole watershed attaining an 80% TSS load reduction.

Rationale: Site plans and design specifications should exist for all permitted MSSW facilities in the Lake Seminole watershed. Therefore, a detailed inventory of these facilities and an assessment of their compliance with the required performance standards could feasibly be completed over a period of time. Retroactive enforcement will be based on this information.

The goals, targets and monitoring objectives related to the Water Quality management issue are summarized in **Table 2-1**.

2.b Averaging Period for Numeric Water Quality Goals

The averaging period for numeric water quality goals are calculated based on the methodology implemented within the Florida Impaired Waters Rule (62-303.350). Based on this rule, "Trophic state indices (TSIs) and annual mean chlorophyll a values shall be the primary means for assessing whether water should be assessed for further nutrient impairment." Pinellas County uses a stratified random sampling design which includes nine sampling periods per calendar year. Four samples are collected during each of the nine time periods. Therefore, thirty-six water quality samples are currently collected annually throughout Lake Seminole. This sampling frequency will continue and the seasonal annual average TN, TP, chlorophyll a and TSI values will be analyzed to determine if the implemented water quality goals are being met. Annually, TP loading rates will be calculated in order to determine if the 50% reduction goal is being met. Annual water and nutrient budgets will be quantified based upon water quality samples collected throughout the year. Dissolved oxygen, pH, specific conductivity, and chlorides will continue to be monitored. Concentrations of each parameter will be collected during each sampling trip and evaluated. The PCDEM will continue to investigate the TSS load reduction efficiency of all permitted MSSW facilities within the Lake Seminole watershed. Samples for the analysis of the phytoplankton community will be collected. Additionally, extensive monitoring will be completed in concert with the operation of the alum stormwater treatment facility in sub basin one (**Appendix B**). Water, benthic and sediment quality will be monitored in order to evaluate the success of the treatment facility and the effectiveness of the settling area. The goal of this monitoring effort is to measure the efficiency of the facility based on its Event Mean Concentration (EMC) efficiency and Load Efficiency prior to the construction of the remaining alum stormwater treatment facilities.

2.c Discussion of How These Goals Will Result in the Restoration of the Water Body's Impaired Designated Uses

Six target goals were presented to provide reasonable assurance that water quality will improve in Lake Seminole dependent upon the implementation of the four restoration management plans. The underlying goal of the restoration projects is the reduction/removal of nutrients in Lake Seminole. The rationale for each goal is detailed below:

1. Annual chlorophyll-a concentration of 30 μg/l is based on the desired beneficial uses of the lake with respect to aquatic vegetation and fisheries, and is consistent with the attainment of a chlorophyll-a TSI target of 60. In addition, waterbody modeling conducted as part of the planning process predicts that this target is attainable if all major restoration projects are implemented.

2. The target mean annual multi-parametric TSI value of 60 (using FDEP methodology) is based on the desired beneficial uses of the lake with respect to aquatic vegetation and fisheries, and is consistent with the attainment of a mean annual chlorophyll-a target of 30 μg/l, TP concentration of 0.095 mg/l and TN concentration of 1.6mg/l **(Table 1-2)**.

3. An analysis of pollutant loading sources to the lake has indicated that it is feasible to reduce current annual TP loads from stormwater runoff by 55.7% through the construction of enhanced regional stormwater treatment facilities in the basin. This load reduction equates to about 53.7% of the current annual TP load from all external sources (the remaining external source being direct atmospheric deposition).

4. One of the lake manager's most important tools is an accurate water/nutrient budget. This inflow/outflow analysis of both the sources and sinks of water and nutrients provides information critical to making management decisions. And since a lake's hydrologic and chemical character can change over time in response to changes in the watershed, water and nutrient budgets will be updated annually so that management strategies can be properly adjusted, and management actions re-prioritized.

5. Maintenance of Class-III State water quality standards, as defined in 62-302 of the Florida Administrative Code, is technically required by law. Although toxics such as metals and organic compounds are not considered to be problems in Lake Seminole, compliance monitoring with respect to dissolved oxygen (DO), pH, specific conductance and chlorides is relevant due to various management concerns. Both DO and pH are closely related to the management of living resources, whereas specific conductance and chloride concentrations may be used as indicators of saltwater intrusion.

6. There is a rebuttable presumption that State design criteria for MSSW facilities achieve an 80% pollutant load reduction. Furthermore, because Lake Seminole is an Outstanding Florida Water, a 95% pollutant load reduction is technically required for those MSSW facilities discharging directly into the lake. Although the statutes do not specify which pollutants are targeted by the State design criteria, they are generally interpreted to address total suspended solids (TSS) and biological oxygen demand. Attainment of these performance standards is rarely verified or enforced due to the complexities in monitoring individual MSSW facilities; however, available data indicate that most MSSW facilities are substantially deficient if not properly maintained. State law allows for stringent enforcement of these performance standards where it can be demonstrated that State water quality standards are being violated. It can be reasonably argued that nonpoint source pollutant loads to Lake Seminole are violating the State water quality standard for nutrients (e.g., must not cause an ecological imbalance). Assuming that MSSW facilities meeting the 80% TSS load reduction standard also provide adequate nutrient removal, strict enforcement of this minimal performance standard throughout the watershed is justified.

2.d Schedule Indicating When Interim And Final Targets Are Expected To Be Met

All watershed basins within the state of Florida have been assigned to one of five "Basin Groups" established by the Watershed Management Basin Rotation Project. The FDEP evaluates each basin group byway of a rotating schedule. Therefore, each group is evaluated every five years. The evaluation process identifies each waterbody to be placed on the 303(d) Impaired Water Body List for submission to the USEPA. Lake Seminole is located in Basin Group 5 which is currently under evaluation (2007). All proposed restoration projects at Lake Seminole are scheduled to be completed by 2012.

This self-imposed deadline signifies the next scheduled impaired waters evaluation for Group 5 basins. An improvement of water quality is expected in approximately 5 years. However, a significant improvement of water quality is expected after the sediment removal is completed.

2.e Description Of Procedures To Determine Whether Additional Corrective Actions Are Needed

The three Phase implementation of all proposed restoration projects provides a unique opportunity to monitor the transition of Lake Seminole. PCDEM, City of Seminole, City of Largo, the District, the FWCC, FDEP and local stakeholders have established a comprehensive sampling regime to monitor the benthic and water quality of Lake Seminole. PCDEM is responsible for coordination and implementation of data collection. The water quality data is analyzed annually to determine if any significant improvements or declinations of water quality are observed in the lake. PCDEM will submit an annual report to the FDEP detailing the current water quality and status of Lake Seminole.

Adaptive Management

As is true with all watersheds, the Lake Seminole watershed and water quality is not static. Currently, all scheduled restoration projects are projected to be completed by 2012. The dredging of Lake Seminole is one of final restoration projects to be implemented prior to 2012. Sediment removal could potentially have a significant impact (positive or negative) on the water quality for approximately five years. Therefore, the basis for improvement of water quality in the lake due to the implemented restoration projects would not begin till 2017. At that time, an adaptive management approach similar to the method used by the Tampa Bay Estuary Program (TBEP) to track chlorophyll-a and light attenuation in Tampa Bay (Janicki Environmental, 2006) will be implemented. The current TSI classification for Florida lakes is 0-59 is good, 60-69 is fair, 70-100 is poor (**Table 1-2**; FDEP, 1996). Each year, the annual TSI of Lake Seminole will be compared to the targeted management endpoint of 60. If the TSI value is <= 60, the year will be qualified as "green" signifying that the lake has met the target outcome. However, if the annual TSI exceeds 60 the magnitude of the exceedance will be determined. A TSI value of 61-69, will be classified as "yellow", signifying an improvement in water quality but the lake has not met the target. An annual TSI of 70-100 will be classified as "red", signifying poor water quality. PCDEM will monitor the green, yellow and red classification for Lake Seminole. A reassessment of the restoration techniques implemented will be performed if the lake is classified "red" consecutively for three of five years. Additionally, if after ten years, PCDEM does not see a progression from red to green classification for the lake, a more detailed assessment of the water quality and potential modifications to the restoration plan will be completed. PCDEM has proposed a whole lake alum treatment if water quality continues to decline after successful completion of projects focused on sediment removal, enhanced stormwater treatment, input of water from the Seminole Bypass Canal and lake level modification.

3. Description of the Proposed Management to be Undertaken

3.a Names of the Responsible Participating Entities

Pinellas County
City of Seminole
City of Largo
Southwest Florida Water Management District
Surface Water Improvement and Management (SWIM)
Florida Department of Environmental Protection
Florida Fish and Wildlife Conservation Commission

3.b Summary and List of Existing and Proposed Management Activities Designed to Restore Water Quality

The Lake Seminole Watershed Management Plan outlined three proposed management activities to restore water quality in Lake Seminole:

- reduce external phosphorus loadings;
- reduce internal nutrient recycling; and
- reduce lake hydrologic residence time.

The Plan specifies four major projects aimed at reducing nutrient concentrations in the lake, decreasing residence time, and improving water quality conditions. These projects include: 1) retrofitting stormwater outflows from the five highest nutrient loading sub-basins with alum treatment systems; 2) alum treatment and diversion of a portion of flows in the Lake Seminole Bypass Canal into Lake Seminole; 3) removal of organic muck sediments; and 4) lake level fluctuation. Pinellas County has dedicated substantial funds in their 2007-2012 Capital Improvement Plan, and has secured funding agreements with other agencies, as necessary to ensure the full implementation of the four major water quality improvement projects, as well as other associated infrastructure improvements. Specifically, $4.9 million has been allocated for the design and construction of the alum stormwater and bypass canal diversion treatment facilities designed to reduce external nutrient loads to Lake Seminole, and $8 million has been allocated to remove organic sediments from the lake to reduce external nutrient recycling. The County is moving forward with construction on these projects, and as of April 2007 a contractor has been selected for sediment removal project, anticipated to begin construction in 2008.

Several of the below restoration techniques have been completed on Lakes throughout Florida to improve water quality. However, Lake Seminole is the only lake to combine and implement the magnitude and quantity of restoration projects listed below. The structural, management, legal, policy, enforcement and public education components identified exhaust all reasonable restoration actions to restore water quality:

Six structural:

1. Excavate organic peat sediments from shoreline areas

2. Restore priority wetland and upland habitats

3. Install stage and flow measurement instrumentation on the Lake Seminole Outfall Control Structure

4. Construct enhanced regional stormwater treatment facilities in priority sub-basins

5. Divert Seminole Bypass Canal flows to improve lake flushing and dilution

6. Dredge organic silt sediments from submerged areas

Five Management:

1. Mechanically harvest nuisance aquatic vegetations

2. Improve treatment efficiency of existing stormwater facilities

3. Biomanipulate sport fish populations

4. Implement an enhanced lake level fluctuation schedule

5. Inactivate phosphorus through whole lake alum applications (if warranted by monitoring results)

Two Legal:

1. Adopt a resolution designating the Lake Seminole Watershed as a "Nutrient Sensitive Watershed"

2. Strengthen and standardize local ordinances for regulating stormwater treatment for redevelopment in the Lake Seminole Watershed

One Policy:

1. Establish a Lake Seminole Watershed Management Area (WMA) through amendments to the Pinellas County, and cities of Largo and Seminole Comprehensive Plans

One Compliance and Enforcement:

1. Expand and enforce restricted speed zones on Lake Seminole

Two Public Education:

1. Develop and implement a comprehensive public involvement program for the Lake Seminole Watershed

2. Develop and implement a local citizens Lakewatch program for Lake Seminole

A detailed description of each component and status is discussed below.

Structural Components

1. Excavate Organic Peat Sediments From Shoreline Areas

In May 2002, the FWCC completed a habitat enhancement project removing 31,000 cubic yards of tussock and organic sediments from the lake bottom. In addition, the area was re-vegetated with native species to improve the fishery habitat. A continuation of this project, which was designed to excavate organic peat sediments from shoreline areas, was completed in 2006. Together, the Florida Fish and Wildlife Conservation Commission, SWFWMD, Pinellas County, and local volunteers, coordinated to remove approximately 100,000 cubic yards of organic peat sediments located along the periphery of the lake, removed 26 tons of garbage and debris, replanted native vegetation and improved drainage around the lake.

There are four major shoreline segments in Lake Seminole where large accumulations of organic peat sediments had become a problem, and the majority of the 130,000 cubic yards of fibrous decayed plant matter identified as problem sediments were contained in these four segments. The four major shoreline segments with problem sediments are shown on **Figure 3-1**, and described below.

> **Segment 1** - a 44-acre area along the east shoreline of the lake, from the Lake Seminole County Park boat ramp northward to the 102nd Avenue bridge;
>
> **Segment 2** - a 13-acre area along the west shoreline of the lake, from 94th Place northward to the 102nd Avenue bridge;
>
> **Segment 3** - a 12-acre area east shoreline of the lake, from the 102nd Avenue bridge northward along Lake Seminole Drive; and
>
> **Segment 4** - a 16-acre area along the northeast shoreline of the lake, from Harborside Circle northward to the north end of the lake.

The organic shoreline sediments were excavated down to the underlying sand base to create open littoral areas more conducive to sport fish spawning activities. Some of the restored shoreline areas were allowed to recruit naturally with littoral vegetation. Additionally, pilot planting projects were implemented to establish a seed source for desirable aquatic vegetation. Desirable species composition and appropriate plant densities in the restored littoral vegetation communities are maintained with followup chemical treatments and mechanical harvesting.

The objective of this management action is the improvement of water quality, aquatic vegetation communities and fishery habitat, and improved shoreline recreational and aesthetic attributes. According to fishery biologists from the Florida Fish and Wildlife Conservation Commission, sport fish spawning habitat is limited in Lake Seminole. This management action would directly increase the shallow littoral bottom area available to sport fish for spawning.

Implementation Status (May 2007)

The removal of organic sediment in segment 1 and 4 were completed in 2006 (**Photo 3-1**). The remaining segments are scheduled to be completed in the future.

Photo 3-1. Organic sediment removal for shoreline restoration in Lake Seminole.

2. Restore Priority Wetland and Upland Habitats

This management action involves the restoration and/or creation of diverse, native aquatic vegetation communities in, and around the perimeter of, Lake Seminole. In addition, this action includes the restoration of priority remnant upland vegetative communities in the watershed. As part of the watershed planning process, habitat distribution and disturbance patterns were evaluated to determine the potential for special habitat management sites or habitats suitable for enhancement or restoration. The general findings from this evaluation were that the urbanized nature of the watershed does not provide justifiable opportunities for the creation or re-establishment of wildlife corridors or dispersal areas. The remnant habitats in the lake and watershed are small and fragmented to the point where an opportunity for a unifying ecological corridor is no longer viable. However, opportunities do exist for recreational corridor connections between Lake Seminole County Park and the Pinellas Trail that extends north-south along the western watershed boundary.

Of the approximately 120 habitat units evaluated within the lake and watershed, a high percentage exhibit nuisance and/or exotic species invasion in varying degrees. Therefore, nuisance species removal coupled with the enhancement and restoration of diverse, native vegetation communities and habitats in both the lake and the watershed is a critical component. It should be noted that the habitat coverage by the exotic upland species Brazilian pepper (*Schinus terebinthifolius*) and air potato (*Dioscorea bulbifera*) is very high throughout the watershed. Because these species displace both native upland and wetland species, they will be controlled or removed so that habitats can ultimately be restored to their natural condition. In addition, the native aquatics cattails (*Typha spp*.) and carolina willow (*Salix caroliniana*) have become nuisance species in Lake Seminole largely because of the static water levels that have been maintained for decades. Like Brazilian pepper, these species tend to grow as thick monocultures that exclude the establishment of other native species that may provide better fish and wildlife habitat. Cattails, in particular, occur so densely in Lake Seminole that the excessive growth and decomposition has resulted in the buildup of a layer of highly organic fibrous sediments around the perimeter littoral zone of the lake. These fibrous organic shoreline sediments further preclude spawning by desirable sport fish species.

Seven specific restoration sites were selected in conjunction with Pinellas County staff based on the restoration needs stated above as well as the size, ownership and proximity of the sites to one another and to Lake Seminole. In addition, watershed-wide and lake-wide habitat restoration and nuisance species controls are specified. **Table 3-1** lists the sites and their respective existing habitat and restoration/enhancement projects, while **Figure 3-2** identifies the location of each site.

The specific restoration sites that border Lake Seminole have incorporated a littoral shelf planting program that is designed to provide improved diversity, cover and forage for fish and wildlife. In their Annual Performance Report for Lake Seminole, 1990-91, the FWCC referenced the significant loss of littoral and submerged fish habitat due to the density of cattails along the eastern side of the lake and a reduction in the acreage of *hydrilla*. This loss in aquatic habitat has contributed significantly to the decline of the sport fisheries in Lake Seminole.

Implementation Status (May 2007)

Habitat restoration was completed at the Park Blvd site in 2006. The management of Brazillian Pepper has been ongoing for the past 4 years in the Lake Seminole Park property (**Photo 3-2**). The removal of nuisance species and habitat restoration in the Northeast parcel will be completed in 2008.

Photo 3-2. Removal of Brazilian Pepper along the boundary of Lake Seminole.

3. Install stage and flow measurement instrumentation on the Lake Seminole Outfall Control Structure

This management action involved the installation of instrumentation for accurately measuring lake stage and flow volumes at the Lake Seminole outfall control structure. In addition, this action involved the proper acquisition, storage, reduction and reporting of lake stage and flow volume data using accepted data management protocols.

The Lake Seminole outfall control structure provides a convenient location for measuring flow and collecting water samples; however, instrumentation for accurately measuring and recording stage and flow volumes was not in place. Installation of state-of-the-art instrumentation was needed to address the defined monitoring objective of calculating annual water and nutrient budgets for Lake Seminole. Estimates of external loadings from nonpoint sources, atmospheric deposition and groundwater can be measured or modeled, and are addressed in separate monitoring objectives. To balance a water/nutrient budget, the direct measurements of outflows from the lake are needed and can be related to mean annual chlorophyll-a concentrations and TSI values. Annual estimates of loads leaving the lake will enable the calculation of loadings to Long Bayou, and allow for a demonstration of downstream load reduction following full implementation of the Plan.

Implementation Status (May 2007)

The stage and flow measurement instrumentation was installed in 2006. All data is available from the USGS website (www.usgs.gov). The station ID is USGS 02308889.

4. Construct enhanced regional stormwater treatment facilities in priority sub-basins

The SWMM model pollutant loading estimates identified five priority sub-basins that would benefit from enhanced stormwater treatment facilities. The subbasins, listed in order of decreasing pollutant load are: 3, 1, 7, 6, and 2. The location of the sub-basins in the Lake Seminole watershed is shown in **Figure 3-3**.

Given the virtual lack of available vacant lands for wet detention pond construction and/or expansion, and the potentially very high cost of purchasing and converting existing land uses for this purpose, the use of enhanced treatment systems such as alum injection represents a far more cost-effective approach per unit land area. Alum treatment systems are capable of achieving substantially greater treatment efficiencies than wet detention ponds, on the order of 40% removal for TN and 90% removal for TP and TSS (ERD, 1994). Alum injection with off-line floc settling basins is the approach most commonly applied. This approach is typically preferred by regulatory agencies in that the floc buildup is confined to isolated ponds or basins which can be periodically maintenance dredged to restore the settling volume capacity. In addition, the potentially toxic effects of alum floc buildup can be isolated to these smaller man-made ponds. Although the alum injection infrastructure requires very little land area (e.g., typically less than 0.25 acres), additional land area on the order of a few acres is typically required for floc settling ponds.

A less land-intensive, and thus more cost effective, alternative to this approach is alum injection with in-lake floc settling. While this alternative eliminates the need for additional land area for floc settling ponds, floc buildup in the lake and subsequent resuspension may constitute future water quality problems. In addition, the potential toxicity of alum floc to benthic invertebrates has also been raised as a concern (WAR, 1999). However, these problems could at least be partially mitigated by the dredging of deeper floc settling basins in the lake bottom at the outfall point for each alum injection facility. The creation of in-lake settling basins would at least partially isolate the floc buildup into a smaller bottom area, and would allow removal of floc material via periodic maintenance dredging.

BMP locations within each of the priority sub-basins were evaluated with respect to location in the basin (e.g., upstream or downstream), proximity to vacant lands and existing hydrologic features (e.g., existing ponds, canals and wetlands), and engineering design issues (e.g., re-routing of the drainage network, utility impacts, etc.). The projects are described for each of the five priority sub-basins below.

Sub-Basin 3

- Alternative 3A - Alum injection with floc settling in an existing wet detention pond and/or an existing ditch/canal. This BMP alternative will involve the construction of an alum injection facility between 102nd Avenue N. and 104th Avenue N. immediately east of Seminole Boulevard. Alum will be injected into flows at this point, and the floc will settle in two existing wet detention ponds that will be modified for this purpose. Alternatively, the alum floc could be allowed to settle in an existing drainage ditch/canal that outfalls to Lake Seminole. This ditch/canal will likely need to be deepened to provide the necessary floc settling storage capacity.

Sub-Basin 1

- Alternative 1A - Alum injection with floc settling in an existing ditch/canal. This BMP alternative will involve the construction of an alum injection facility at 101st Street N., along the existing ditch/canal that outfalls to the north end of Lake Seminole. Alum will be injected into the flows at this point, and the floc will settle in the existing drainage ditch/canal. This ditch/canal will likely need to be deepened to provide the necessary floc settling storage capacity. This alternative would treat runoff from 376 acres, or about 80% of the sub-basin land area.

Sub-Basin 7

- Alternative 7A - Alum injection with floc settling in an existing ditch/canal. This BMP alternative will involve the construction of an alum injection facility east of Seminole Boulevard and north of Skipper Drive, at the outfall of the box culvert draining Sub-Basin 7. Alum will be injected into the flows at this point, and the floc will settle in an existing drainage ditch/canal that outfalls to Lake Seminole. This ditch/canal will likely need to be deepened to provide the necessary floc settling storage capacity. This alternative would treat runoff from 495 acres, or about 90% of the sub-basin land area.

Sub-Basin 6

It should be noted that three stormwater rehabilitation projects have been completed in Sub-Basin 6. These include:

- St. Petersburg Junior College MSSW facility. This facility treats runoff from both the St. Petersburg Junior College Campus site as well as offsite runoff from some upstream areas. This facility meets SWFWMD design standards for wet detention, and treats runoff from approximately 85 acres, or about 22% of the sub-basin land area

- Pinellas County Dog Leg Pond project. This project is primarily a habitat restoration project for an existing regional treatment pond; however, the treatment capacity of the pond has been enhanced by the modifications. The Dog Leg Pond facility treats runoff from approximately 33 acres, or about 8% of the sub-basin land area.

- Pinellas County Pond 6 project. This project was designed to provide both stormwater treatment and habitat restoration benefits. This facility exceeds SWFWMD design standards for wet detention, and provides 14-day residence time treatment for drainage inflows. In addition, environmental education facilities are planned for this location. The Pond 6 facility treats approximately 67 acres, or about 17% of the sub-basin land area.

Both the St. Petersburg Junior College MSSW facility and the Pinellas County Dog Leg Pond project are BMPs that are located fairly high in the basin. Therefore, the percentage of the annual flows from Sub-Basin 6 treated by these projects is relatively small. In addition, although the Pond 6 project is located low in the basin, it will treat runoff from only about 17% of the sub-basin land area due to the segregated routing of the drainage network in this basin. In addition to these three existing projects, another BMP alternative is schedule for construction as discussed below.

- Alternative 6B - Re-routing of drainage to Pond 6 site with combined alum and wetland treatment. This BMP alternative will involve re-routing the drainage network such that all flows discharging from Sub-Basin 6 will be treated on the Pond 6 site. This will require the re-construction of the drainage network along Seminole Boulevard whereby the flows discharging from the north box culvert discussed above will be re-routed to the south. This has required permitting coordination with FDOT. On the Pond 6 site, the combined basin flows will be treated either with the planned wet detention approach, or with some combination of alum injection and wetland treatment. Given the land area available on the Pond 6 site, it may be feasible to accommodate an alum injection facility with a small floc settling pond that would discharge treated stormwater into a wetland habitat restoration area for water quality polishing prior to discharge to Lake Seminole. This alternative will treat runoff from approximately 365 acres, or about 93% of the sub-basin land area.

Sub-Basin 2

- Alternative 2A - Alum injection with floc settling in an existing ditch/canal. This BMP alternative will involve the construction of an alum injection facility on the Orange Lake Civic Center property, located at the eastern terminus of 118th Avenue N. The facility will be located near the headwall of a box culvert that discharges flows from Sub-Basin 2 into an existing ditch/canal that outfalls to Lake Seminole. Alum will be injected into the flows at this point, and the floc will settle in the existing drainage ditch/canal. This ditch/canal will likely need to be deepened to provide the necessary floc settling storage capacity. This alternative would treat runoff 420 acres, or about 88% of the basin land area.

The above described potential and planned BMP projects are summarized in **Table 3-2.**

Implementation Status (May 2007)

Currently, three of the five stormwater projects are at 100% design and will begin construction in 2007. The enhanced stormwater treatment facilities will be implemented in two Phases. In Phase I, the stormwater treatment projects in Sub-basins 1, 3, 6 will be addressed. Extensive benthic and water quality monitoring will be performed to evaluate the treatment facility at sub-basin 1 prior to the initiation of Phase 2. Pinellas County has received the appropriate permits required to initiate and complete Phase I. In Phase 2, sub-basin 2 and 7 will be implemented. The projected completion date for Phase 1 is 2009 and Phase 2 is 2012.

5. Divert and Treat Seminole Bypass Canal flows to improve lake flushing and dilution

This management action will involve the diversion of some portion of the baseflows and/or high flows from the Seminole Bypass Canal into the northern end of Lake Seminole. Because there is a 2-foot elevational difference between Lake Seminole (e.g., weir elevation of 5.0 feet NGVD) and the Seminole Bypass Canal (e.g., weir elevation of 3.0 feet NGVD) the transfer of water from the canal to the lake would need to be facilitated using pumps. The effect of this diversion will be to reduce lake residence time, improve flushing and circulation, and potentially provide for some dilution of the nutrient mass in the lake water column. Water quality monitoring conducted by Pinellas County in the Seminole Bypass Canal indicates that canal water quality typically has much lower levels of TN, but higher levels of TP than that of Lake Seminole, especially during high flow periods. The effectiveness of this management action will be substantially enhanced by treating the diverted flows prior to discharge into the lake. The diversion of flows from the Seminole Bypass Canal includes the construction of an alum injection facility in association with the pump station such that diverted water will be treated prior to being discharged into Lake Seminole. Due to the alum injection, an in-lake settling basin will be dredged at the point of discharge to contain the accumulated alum floc. Depending on the diverted volumes, this enhancement should provide for significant dilution of in-lake nutrient concentrations.

Implementation Status (May 2007)

Pinellas County has completed the design and received the appropriate permitting required to begin construction of the Bypass Canal diversion structure with an enhanced treatment plant. Construction will begin in 2007.

6. Dredge organic silt sediments from submerged areas

In 2006, The Lake Seminole Sediment Removal Feasibility Plan was completed and provides a comprehensive updated investigation on sediment removal in Lake Seminole (PBSJ, 2006). The new report addresses two objectives: 1) update the 1999 sediment removal feasibility study based on current conditions and new information; and 2) conduct additional technical analyses and due diligence. The findings of that report identify the most cost-effective, permittable, and publicly acceptable approach to completing the sediment removal project. The information from the 2006 study on sediment removal from Lake Seminole is included in the reasonable assurance plan.

In conducting this evaluation of alternatives the following critical project planning design criteria for the Lake Seminole sediment removal project were identified:

- Project duration of two years or less;
- Selective removal of organics;
- Lake water availability for hydraulic dredging;
- Clean water return back to the lake;
- Dewatering process relatively unaffected by climatic variability;
- Minimal on-shore land area requirements for dewatering;
- Minimal volume of dewatered solids for disposal;
- Minimal truck traffic for solids disposal
- Minimal disturbance to water quality, wetlands, and listed species;
- Minimal disturbance to recreation and aesthetics; and
- Proven, cost-effective technology.

For sediment removal projects such as the Lake Seminole project, where on-shore processing space is severely limited, and for which sediment disposal trucking must be minimized, the only logical and reasonable alternatives involve an on-shore dewatering system that can produce the minimum feasible dewatered sediment volumes on the smallest space possible, and return clean water back to lake Seminole at a rate equal to the dredge flow rate. Nine sediment removal alternatives were evaluated and compared based on the following criteria:

- Project duration;
- Permittability;
- Public acceptance;
- Biddability and constructability; and
- Estimated project costs.

Table 3-3 gives a side by side comparison of all nine project alternatives.

Based on an objective and balanced consideration of the above factors, Alternative 6A, high gravity centrifuge dewatering with a dredge pumping rate of 800 gpm, is the only alternative investigated that satisfies all of the identified project criteria and standards completely. Therefore, Pinellas County concluded that Alternative 6A would be the recommended alternative for Lake Seminole sediment removal project.

Figure 3-4 shows a conceptual diagram of the process dewatering facility addressed in the preferred alternative. The actual on-shore dewatering process equipment area - excluding boundary set-backs from adjacent properties, piping to and from the lake, roads, administration support buildings and the like – would be 140' by 100'. Compared to all of the other alternatives investigated, this alternative best satisfies the extremely limited space-available criterion while meeting the other criteria.

All of the process operating equipment elements and the process configuration itself are well-known and have been proven nationally and internationally. Furthermore, the principal dewatering equipment elements would be "closed" and would not be susceptible to the sort of inclement weather conditions that might shut down "open" dewatering equipment elements such as lagoons.

The preferred alternative would return 93 percent of the water pumped out of the lake back to the lake. Therefore, there would be no undesirable lake drawdown effects. The water returned to the lake would contain about 0.36% solids. These solids would be the organic/inorganic residual remaining from the on-shore dewatering process, which does not pass through any other material (i.e. polymer) used in the process.

Finally, the preferred alternative would result in minimal impacts to wetlands and listed species, lake recreation and aesthetics, and neighborhood integrity. For these reasons, as well as the overall lake restoration objective of the project, it is anticipated that the preferred alternative would garner strong public acceptance and support.

Implementation Status (May 2007)

Hayes-Bosworth, Inc was selected as the highest ranked firm for the whole lake dredging project in February 2007. Hayes-Bosworth, Inc will proceed with design and construction plans to begin lake dredging (**Photo 3-3**). The projected completion date is December 2011.

Photo 3-3. Sediment resuspension in Lake Seminole.

Management Components

1. Mechanically Harvest Nuisance Aquatic Vegetations

This management action involves the permanent dedication of one mechanical harvester and transport barge, and a full-time operating crew, to Lake Seminole for the harvesting of cattails on a continual basis. When *Hydrilla* again becomes a component of the Lake Seminole flora, as it will when grass carp are removed and water transparency is improved, the program will be refocused to control this species as a means of controlling both the proliferation of this aggressive exotic as well as nutrient enrichment. The Pinellas County Highway Department (PCHD - Mosquito Control) will be responsible for the operation and maintenance of the harvester units. Drying and processing of the harvested plant matter would take place on publicly-owned property such as the Lake Seminole County Park. Elements of this management action include the following:

- Pinellas County will develop and implement a Lake Seminole Aquatic Weed Management Plan every two years. The plan will be cooperatively developed by the LSAC and technical representatives from Pinellas County Department of Public Works (PCDPW), PCDEM, SWFWMD, FDEP, FWCC, and PCHD. The purpose of this plan will be to clearly articulate the two year aquatic weed management goals and priority areas, each agency's responsibilities in meeting the goals, and a two year schedule for aquatic plant management activities on the lake. This plan will be based on the technical information generated from biannual submergent and emergent vegetative surveys.

- A target annual harvest goal for cattails of 10 acres/year was adopted. Cattails will be harvested from priority areas identified in the biannual Lake Seminole Aquatic Weed Management Plan.

- A target annual harvest goal for *Hydrilla* of 35 acres/year (inclusive of chemically treated senescent tissue) will be adopted. *Hydrilla* will be harvested opportunistically from areas of heavy concentration on a continual basis. The highest priority use of the harvester will be to remove senescent and decomposing *Hydrilla* mats following effective chemical treatment of infested areas. In this manner, mechanical harvesting of an annual biomass target would complement existing chemical treatment programs in controlling the coverage of nuisance aquatics while also resulting in the removal of a mass of stored nutrients thus reducing the potential for nutrient recycling.

- FDEP and SWFWMD have the primary responsibility for the management of submergent and floating nuisance aquatics in Lake Seminole under the existing Cooperative Aquatic Plant Control Program. A stable and adequate long-term funding source will be pursued so that interruption in maintenance activities is avoided in the future. Consideration will be given to the use of Pinellas-Anclote Basin Board funds for this purpose. Pinellas County will assume primary control of emergent nuisance aquatics.

- A maximum chemical treatment area limitation of 100 acres per year will be established for *Hydrilla* control. Chemical treatment of *Hydrilla* will be performed on a more frequent and regular basis to maintain the coverage within the proposed target range and to avoid the need for major treatment events on large coverage areas.

- Assisted revegetation of the cattail harvest areas with desirable endemic species will be performed at a target rate of approximately 5 acres/year. It is anticipated that the proposed increased range in the lake level fluctuation schedule will stimulate the natural recruitment and proliferation of a more diverse assemblage of desirable emergent species. Assisted revegetation, either implemented through publicly funded habitat restoration projects or required as conditions of permits, will be limited to commonly available, desirable endemic species.

This management action should not be considered contradictory with existing FDEP and SWFWMD policy which essentially states that *Hydrilla* and other exotic nuisance aquatic plants should be managed at their lowest feasible levels. Rather, mechanical harvesting of an annual biomass target would complement existing chemical treatment programs in controlling the coverage of nuisance aquatics while also resulting in the removal of a mass of stored nutrients thus reducing the potential for nutrient recycling. This is especially true with regard to the harvesting of senescing plant tissue following chemical treatment, which will be the primary objective of the harvesting program.

Implementation Status (May 2007)

Pinellas County contracted an aquatic weed-harvestor to remove nuisance aquatic vegetation (primrose willow and cattails) from 45 acres of the lake during the water level draw down in 2006 (**Photo 3-4**). The County will continue nuisance vegetation maintenance.

Photo 3-4. Nuisance vegetation along the shoreline of Lake Seminole.

2. Improve treatment efficiency of existing stormwater facilities

This management action involves the development and implementation of a comprehensive local program to improve compliance monitoring and enforcement of permitted surface water management (MSSW) facilities in the basin. This program will essentially be an enhanced version of the Adopt-a-Pond program implemented in several local governments in Florida, including Hillsborough County. This action would involve the following steps:

- Perform an inventory of all existing permitted MSSW facilities in the basin, as permitted by SWFWMD since 1985. Identify target MSSW facilities for inspection and potential monitoring. Monitoring candidates will be targeted based on the size of the service area and whether significant changes in contributing land uses have occurred since the facility was permitted. Develop a priority list of MSSW facilities to be inspected.

- Inspect and monitor the priority MSSW facilities identified in Step 1 above. The facility will be inspected for compliance with the permitted design. In addition, stormwater entering and discharging from the facility following a storm event will be sampled for TSS, TN and TP.

- If the facility is determined to be out of compliance with permitted design or water quality standards, the owner will be informed of the problems and the need to correct them. Florida Statutes require an 80% pollutant (TSS) removal efficiency and the attainment of Class-III water quality standards at the end of the discharge pipe.

- Working cooperatively with the owners, develop a site-specific improvement plan for each target MSSW facility. The improvement plans could include such modifications as changing the water level control elevations or planting a littoral shelf. In addition, facility improvement plans will incorporate habitat improvement elements wherever feasible.

- Provide financial assistance and technical guidance to owners, as appropriate, to implement the facility improvement plans.

Although facilities constructed prior to 1985 are legally vested from meeting water quality standards, the second level of priority under this program would be these older stormwater ponds. An attempt will be made to get owners of pre-1985 facilities to voluntarily participate in the program through financial incentives and/or assistance.

There is a rebuttable presumption that State design criteria for Management and Storage of Surface Water (MSSW) facilities achieve an 80% pollutant load reduction. Furthermore, because Lake Seminole is an Outstanding Florida Water, a 95% pollutant load reduction is technically required for those MSSW facilities discharging directly into the lake. Although the statutes do not specify which pollutants are targeted by the State design criteria, they are generally interpreted to address total suspended solids (TSS) and biological oxygen demand (BOD). Attainment of these performance standards is rarely verified or enforced due to the complexities in monitoring individual MSSW facilities; however, available data indicate that most MSSW facilities are substantially deficient if not properly maintained.

State law allows for stringent enforcement of these performance standards where it can be demonstrated that State water quality standards are being violated. It can be reasonably argued that nonpoint source pollutant loads to Lake Seminole are violating the State water quality standard for nutrients (e.g., must not cause an ecological imbalance). Assuming that MSSW facilities meeting the 80% TSS load reduction standard also provide adequate nutrient removal, strict enforcement of this minimal performance standard throughout the watershed is justified.

The intense level of existing urban development in the Lake Seminole basin limits the potential effectiveness of implementing more stringent regulations for new development. Many stormwater facilities exist within the watershed but may not be functioning at their intended level-of-service. Therefore, measures to bring these facilities into compliance with current or basin-specific performance standards are likely to be cost-effective management actions, especially in those major basins where regional treatment facilities are not being proposed.

There is currently a rebuttable presumption in the law that existing surface water management facilities that meet State design criteria also comply with State water quality standards. This rebuttable presumption can be, and has been, legally challenged where the need for strict compliance can be clearly demonstrated. Since Lake Seminole is an Outstanding Florida Water (OFW) the applicable water quality standard for nutrients is concentrations which cause degradation of water quality downstream of the discharge. Therefore, under existing regulations, it is possible to develop and enforce a higher basin-specific performance standard for existing stormwater management systems.

Implementation Status (May 2007)

Several systems within the priority sub basins were evaluated during the alum system design. PCDEM completed a system evaluation of the sub basin 6 creation in 2005.

3. Biomanipulate Sport Fish Populations

While there are a wide variety of ecological control mechanisms that generally fall under the category of 'biomanipulation', this management action will primarily involve manipulation of the lake fisheries to improve water quality conditions and modify the fish population structure such that sport fish species become dominant. This primarily involves the selected harvesting of herbivorous rough fish from Lake Seminole, including grass carp and gizzard shad. In addition, this action would include stocking of sport fish species, and the adoption and aggressive enforcement of a catch and release rule for select sport fish species in Lake Seminole.

It is anticipated that these activities will be phased to coincide with habitat and water quality improvements associated with other components of the Plan. Initial activities will involve removal of the grass carp via electrofishing and haul seines. The removal of grass carp is considered critical to habitat restoration efforts aimed at increasing the coverage of submerged aquatic vegetation in the lake. Phase I activities would also include haul seine removal of gizzard and threadfin shad as a means of removing phosphorus from the lake and reducing zooplankton predation, which in turn is expected to reduce chlorophyll-a concentrations.

Other activities will involve continued shad harvesting as well as stocking the lake with young carnivorous sport fish, including largemouth bass and bluegill. Phase III activities will involve continued stocking of sport fish as deemed necessary, as well as the adoption and strict enforcement of a 100% catch and release rule for largemouth bass. The catch and release rule could be relaxed after several years if monitoring data indicate the establishment of a healthy sustained sport fish population.

Implementation Status (May 2007)

The remaining grass carp in the lake should have no impact on the current vegetation in the lake due to their age and low density (personal communication, Tom Champeau). An unsuccessful attempt to stock the lake with largemouth bass was completed in the mid-1990's. In November 2006, over 12,000 largemouth bass were released into the lake and ongoing monitoring indicates that the stocking was a success. The FWCC will continue to monitor the largemouth bass population every 6 months to document fish population.

4. Implement an Enhanced Lake Level Fluctuation Schedule

This management action involves establishing an operational schedule for the proposed new Lake Seminole outfall control structure so as to provide for greater intra-annual lake level fluctuation and inter-annual variability. Since Long Bayou was severed to create Lake Seminole, static lake levels have been maintained at the approximate elevation of 5.0 feet NGVD. A lake level fluctuation schedule has never been formally adopted or implemented on Lake Seminole, and the maintenance of static levels has adversely affected both the aquatic vegetation communities and water quality by reducing plant diversity and increasing lake residence time.

The recommended enhanced lake level fluctuation schedule is shown in **Figure 3-5**. The enhanced schedule reestablishes a more natural pattern of seasonal and inter-annual variation in lake levels which are to be repeated every four years. The recommended four-year cycle is composed of three different annual lake level fluctuation schedules - A, B, and C. All three schedules have a high elevation of 5.0 feet NGVD. Schedule A has the greatest range with a low of 3.2 feet NGVD. Schedule B has a more moderate range with a low of 3.4 feet NGVD. Schedule C is the most conservative with a low of 3.8 feet NGVD. The four-year cycle involves a repeating pattern of the three schedules as follows: A, C, B, C, A, C . . . etc. **Table 3-4** provides a tabular summary of the target monthly lake level elevations for proposed Schedules A, B and C.

Schedules A, B, and C all call for both spring and fall low lake levels. The spring low lake level under Schedule A is more exaggerated than that for Schedule B, whereas the fall low lake level in Schedule B is more pronounced than that for schedule A. Schedules A and B are repeated every four years, whereas Schedule C is repeated every two years. Theoretically, the spring discharge should result in the flushing and dilution of accumulated in-lake nutrient concentrations prior to the summer growing season, whereas the fall discharge is intended to flush nutrient-rich runoff accumulated from the summer rainy season. All three schedules call for high lake levels of 5.0 feet NGVD during both the winter and summer months. These lake level highs are intended to flood littoral vegetation and control the expansion and proliferation of nuisance species, predominantly cattails and willows.

The recommended four-year enhanced lake level fluctuation schedule is intended to better simulate the natural hydrologic regime while still maintaining consistency with the operational range established by Pinellas County for flood control. However, it should be noted that the recommended four-year enhanced lake level fluctuation schedule is not meant to be implemented rigidly, but rather it is to serve as a guideline for improved lake management. For example, the recommended low water elevation of 3.2 feet NGVD called for in Schedule A should clearly not be attained if extended drought and exceptionally low water table conditions exist.

Water level manipulation is one of the most common lake management techniques, used not only for the control of nuisance aquatic vegetation but also for water quality management via flushing and dilution (EPA, 1990). The design and capabilities of the proposed new Lake Seminole outfall control structure will allow for maximum flexibility in the management of lake levels. Unfortunately, the existing outfall structure was conservatively constructed solely for the purpose of flood control, and did not allow for any controlled water level fluctuation. The built-in flexibility of the proposed new structure will be properly utilized and applied in the achievement of other lake management goals including aquatic plant management and water quality improvement.

A cursory inventory of nearshore areas and residential canals performed as part of the planning effort indicated that, with the exception of the “narrows” between the north and south lobes of the lake, no significant adverse impacts on recreational navigation or riparian access would be caused by the recommended low lake levels of 3.2, 3.4 and 3.8 feet NGVD that periodically occur naturally during drought conditions. Water depths in the “narrows” segment are limited by the accumulation of organic silt sediments, and navigable access between the north and south lobes of the lake are constrained during low lake levels. For this reason, implementation of the recommended enhanced lake level fluctuation schedule will not be initiated until the organic silt sediments are removed from the “narrows” segment, as discussed above.

Implementation Status (May 2007)

The lake level fluctuation schedule will be implemented after sediment removal (**Photo 3-5**).

Photo 3-5. Photograph of outfall structure under construction.

5. Inactivate phosphorus through whole lake alum applications (if warranted by monitoring results)

This management action involves whole lake applications of aluminum sulfate (alum) to the surface waters of Lake Seminole. Good candidate lakes for this procedure are typically those that have had nutrient diversion and have been shown through diagnostic-feasibility studies to have a high internal phosphorus release. The release of phosphorus stored in lake sediments can be so extensive in some lakes and reservoirs that algal blooms persist even after incoming phosphorus has been significantly lowered (EPA, 1990). Treatments of lakes with low doses of alum may effectively remove phosphorus (called phosphorus precipitation) but may be inadequate to provide long-term control of phosphorus release from lake sediments (phosphorus inactivation). Phosphorus precipitation removes phosphorus from the water column. Phosphorus inactivation, on the other hand, is a technique to achieve long-term control of phosphorus release from lake sediments by adding as much aluminum sulfate to the lake as possible within the limits dictated by environmental safety.

Iron, calcium, and aluminum have salts that can combine with (or sorb) inorganic phosphorus or remove phosphorus-containing particulate matter from the water column as part of a floc. Of these elements, aluminum is most often chosen because phosphorus binds tightly to its salts over a wide range of ecological conditions, including low or zero dissolved oxygen. In practice, aluminum sulfate (alum) or sodium aluminate is added to the water, and pin-point, colloidal aggregates of aluminum hydroxide are formed. These aggregates rapidly grow into a visible, brownish floc, a precipitate that settles to the sediments in a few hours or days, carrying phosphorus sorbed to its surface and bits of organic and inorganic particulate matter in the floc (EPA, 1990).

After the floc settles to the sediment surface, the water will be very clear. If enough alum is added, a layer of 1 to 2 inches of aluminum hydroxide will cover the sediments and significantly retard the release of phosphorus into the water column as an internal load. In many lakes, assuming sufficient diversion of external nutrient loading, this will mean that algal cells will become starved for this essential nutrient. In contrast, some untreated lakes, even with adequate diversion of nutrients, will continue to have algal blooms that are sustained by sediment nutrient release (EPA, 1990).

Due to the shallowness of Lake Seminole, and the presence of flocculent sediments that are subject to frequent resuspension, phosphorus inactivation via whole lake alum applications is not recommended until a significant portion of the flocculent sediments have been removed from the lake. The long-term effectiveness of whole lake alum applications for phosphorus inactivation is significantly reduced in lakes where the reactive sediment surface is frequently reworked by turbulent resuspension or other forces (EPA, 1990). Therefore, it is recommended that this management action only be pursued as warranted following the removal of the flocculent deep sediments.

Both empirically derived nutrient budgets and waterbody modeling using WASP5 indicate that internal nutrient recycling in Lake Seminole may be a very significant source of water column phosphorus. In addition, Lake Seminole is dominated by blue-green algal species which have the capability of fixing nitrogen in nitrogen limiting conditions. This management action would strongly drive the lake towards phosphorus limitation, thus reducing the dominance and impact of the persistent blue-green algae blooms that periodically plague Lake Seminole.

Implementation Status (May 2007)

The whole lake alum application will only be utilized if significant water quality improvements are not measured in result of the combination of all other restoration projects.

Legal Components

1. Adopt a Resolution designating the Lake Seminole Watershed as a "Nutrient Sensitive Watershed"

This management action will involve the adoption of a resolution by the Pinellas County Board of County Commissioners and the Cities of Largo and Seminole designating the Lake Seminole basin as a 'Nutrient Sensitive Watershed'. The resolution would reference the Lake Seminole Watershed Management Plan as the controlling planning document, and would identify the need for, and public commitment to, developing specific voluntary guidelines for the following:

- regular street sweeping within the basin;
- proper disposal of lawn cuttings and brush clippings to prevent the dumping of organic debris into the lake;
- proper removal of pet droppings along public and private shoreline areas of the lake to prevent pet waste runoff into the lake;
- fertilizer application rates for both residential and commercial land uses (e.g., number of pounds per acre per month) to prevent over application and excessive runoff and seepage to the lake;
- reclaimed wastewater effluent application rates for both residential and commercial land uses (e.g., limited number of inches per acre per day) to prevent over application and excessive runoff and seepage to the lake; and
- optional control measures for reclaimed wastewater effluent application within the basin (e.g., automatic rain shut-off valves) to prevent runoff during storm events.

Long-term monitoring data indicate that Lake Seminole has been eutrophic virtually since its creation in the mid-1940s. More recent data from the 1990s indicate that the rate of eutrophication is increasing rapidly. Since there are no point source discharges to the lake, and external sources of nutrients to the lake are generally diffuse in nature (e.g., stormwater runoff), the problem of reducing external nutrient loads to the lake must be attacked on many fronts. The predominantly residential and commercial land uses within the basin probably contribute a cumulatively substantial portion of the total nutrient load to the lake through sheetflow runoff, the dumping of lawn cuttings into the lake, pet waste runoff, and seepage of excessive applications of lawn fertilizers and reclaimed irrigation water. This may be especially true for golf courses and heavily landscaped residential areas within the basin. Formal legal recognition of the nutrient sensitivity of the Lake Seminole watershed, as well as measures to reduce these diffuse loads, are needed as part of the overall management strategy.

Implementation Status (May 2007)

Lake Seminole has been identified as a “Nutrient Sensitive” Waterbody. Pinellas County has installed signs throughout the watershed informing the public of the water quality concerns. The County has organized several meetings and presentations designed to inform the local stakeholders of approved methods to improve water quality.

A proposed rule introduced by the Florida Division of Agricultural Environmental Science to reduce phosphorus additions through fertilizer additions on urban lawns or turf (5E-1.003) is scheduled to be discussed March 29, 2007. The proposed rule states “Fertilizers labels as starter fertilizers shall have directions for use for a maximum application rate no greater than 1.0 lb of P2O5/1000 ft2 and that subsequent applications shall be either Low or No Phosphate fertilizer”. This rule would reduce the amount of phosphorus allowed for starter lawns and eliminate phosphorus application for established lawns.

2. Strengthen and Standardize Local Ordinances For Regulating Stormwater Treatment for redevelopment in the Lake Seminole Watershed

This management action involves the cooperative development and adoption of a consistent ordinance, between Pinellas County and the Cities of Largo and Seminole, defining special thresholds, rules, and conditions for stormwater rehabilitation through redevelopment within the Lake Seminole watershed. The ordinance will address the retrofitting of pre-1985 stormwater treatment and/or flood attenuation systems with systems that meet current standards for Outstanding Florida Waters. It is recommended that the ordinance establish the following criteria for redevelopment activities specifically within the Lake Seminole watershed.

- All residential, commercial, and industrial parcels undergoing redevelopment shall meet current State stormwater treatment standards for Outstanding Florida Waters (e.g., treat the first 1.5 inches of runoff) for the entire parcel area.

- Redevelopment shall be defined as any demolition and reconstruction or repaving activity that affects 1,500 square feet or more of area, or 10% or more of the total parcel area, whichever is less. Single family residential lots shall be exempted from this provision.

- Payment in lieu of constructing stormwater treatment facilities shall be an allowable relief mechanism for all parcels falling under the above provisions. The fee shall be based on the estimated costs associated with the construction of said stormwater treatment facilities.

- Fees collected from payments made in lieu of constructing stormwater treatment facilities shall be placed in the Lake Seminole Watershed Management Trust Fund, and shall be used exclusively for the construction, operation and maintenance of regional stormwater treatment facilities constructed pursuant to the Lake Seminole Watershed Management Plan. All fees collected under this ordinance shall be expended within the governmental jurisdiction from which they were collected.

As described above, the recommended ordinance will establish a Lake Seminole Watershed Management Trust Fund for fees collected from payments made in lieu of constructing stormwater treatment facilities on constrained parcels. The trust fund would be managed by Pinellas County, and would be used exclusively to finance ongoing operation and maintenance of the regional enhanced stormwater treatment facilities.

The recommended ordinance will clearly acknowledge the fact that no net gain in water quality within the watershed can be achieved if redevelopment projects do not make some provisions for improved stormwater management and treatment. This is especially true in the Lake Seminole watershed where the majority of the basin was developed with numerous high density residential and commercial projects prior to the State's adoption of Chapter 17-25 F.A.C. These older developments typically have no stormwater treatment systems incorporated into the original design. Because of the age of the developments in the Lake Seminole watershed, redevelopment is expected to occur at an increasing pace over the next decade. It is imperative for the restoration of the lake that some gains are made with respect to improving the level of stormwater treatment on older developed parcels in the watershed, especially those located directly on the lake.

Implementation Status (May 2007)

The Pinellas County Comprehensive Plan is being amended with more stringent environmental requirements.

Policy Component

1. Establish a Lake Seminole Watershed Management Area (WMA) Through Amendments to the Pinellas County, and Cities of Largo and Seminole Comprehensive Plans

This management action involves the establishment of a Lake Seminole Watershed Management Area (WMA), via amendments to the Pinellas County, and Cities of Largo and Seminole Comprehensive Plans. The WMA will formally establish a special planning and management district for the Lake Seminole watershed within the growth management framework.

The purpose of the WMA designation will be to focus the adopted goals of the Lake Seminole Advisory Committee within a defined tri-jurisdictional geographic area, and to better coordinate and consolidate the decision making processes for regulatory and management activities conducted by Pinellas County and the Cities of Largo and Seminole within the Lake Seminole watershed. The WMA in concept would be a 'planning' district, rather than a taxing district, that would cover the entire Lake Seminole watershed and place specific policy provisions in place for certain activities and land uses in both the unincorporated and incorporated areas of the basin.

As part of this action, Pinellas County and the Cities of Largo and Seminole would also adopt specific goals, objectives and policies for the Lake Seminole Watershed Management Area. At a minimum, the goals adopted by the Lake Seminole Advisory Committee will be embodied in the Comprehensive Plans of the County and the Cities. In addition, existing goals, objectives and policies as well as basin-specific level-of-service targets (e.g., stormwater treatment and O&M commitments) found elsewhere in the Pinellas County and City Comprehensive Plans will be consolidated under the Lake Seminole Watershed Management Area sections. Examples of such policies include:

- The requirement of OFW-level of stormwater treatment for all new development in the Lake Seminole WMA.

- The consistent application of local stormwater treatment requirements for redevelopment within the Lake Seminole WMA that exceeds the requirements of SWFWMD.

- Payment in lieu of stormwater treatment for exempted parcels.

- The consistent application of land development codes and regulations, as well as voluntary guidelines for management activities such as fertilizer and wastewater reuse application rates, within Lake Seminole WMA.

Numerous policy inconsistencies exist between the Pinellas County and Cities of Largo and Seminole Comprehensive Plans regarding issues that affect the Lake Seminole Watershed Management Plan. The designation of the Lake Seminole Watershed Management Area, and the adoption of a consistent set of policy guidelines and level-of-service targets between both local government Comprehensive Plans will facilitate a common approach to resource management of the Lake Seminole watershed.

Implementation Status (May 2007)

The Pinellas County Comprehensive Plan is being amended with more stringent environmental requirements.

<u>Compliance and Enforcement Component</u>

1. Expand and Enforce Restricted Speed Zones on Lake Seminole

This management action involved the adoption of an ordinance formally establishing new restricted speed zones in Lake Seminole, as well as the installation and maintenance of buoy markers that clearly define the established “no wake” areas. Recently, the perimeter restricted speed zone was extended out to 200 feet from the shoreline around the entire perimeter of the lake, and restricted speed zones were established for ‘Enhanced Fishing Zones’.

This action also improved the means of communicating to the public the limits, purpose, and intended benefits (e.g., erosion control, noise abatement, segregation of incompatible recreational uses) of the restricted speed zones, as well as allowable activities and speeds within these zones. Improved signage and instructional information is located at all public boat ramp kiosks clarifying the appropriate speeds allowed within restricted speed zone (e.g., clear definitions of no wake, idle speed, slow speed, etc.). Excessive watercraft speed and turbulence in the shallow ‘narrows’ and perimeter portions of the lake contributes to sediment resuspension and associated turbidity and water quality problems.

Implementation Status (May 2007)

Pinellas County has completed the expansion of the restricted speed zones and is drafting a speed zone ordinance.

Public Education Components

1. Develop and Implement a Comprehensive Public Involvement Program for the Lake Seminole Watershed

This management action involves the development and implementation of a comprehensive public involvement program for the Lake Seminole watershed. The program includes a number of elements including the following:

- Preparation of a semi-annual newsletter (e.g., twice per year) to be mailed to residents and businesses in the basin informing the public of the various components of the Plan as well as findings, trends, and upcoming activities.
- Production and airing of a government access television presentation on Lake Seminole, with updates to the program to be made on an annual basis. A video tape of this presentation will be made available to citizens upon request.
- Update and improve the 'Help Save Lake Seminole' brochure. The improved brochure will be distributed to all residents and businesses in the watershed.
- Establish a speakers bureau for homeowners association meetings and other public functions. Members of the Lake Seminole Management Committee will be recruited for this purpose.
- Establish an information clearinghouse for technical reports, monitoring data, and other information related to Lake Seminole.
- Implement Lake Seminole Day as an annual function. Sponsorship for this event will be actively solicited from local businesses.
- Installation of "Dump No Waste - Drains to Lake" plaques on storm drains throughout the watershed.
- Installation of additional roadway signs indicating the boundaries of the Lake Seminole Watershed Management Area.

Public apathy regarding lake and watershed management is a common pattern until obvious problems such as nuisance algae blooms and aquatic weed infestations become apparent. The public response to such problems is typically quite negative and unproductive. Improved public understanding of the causes of lake management problems, and the role that individuals can play in managing and improving the quality of the lake and watershed will contribute significantly to furthering the goals of the Plan. In addition, increased public involvement as stakeholders in the ownership and implementation of the Plan should reduce unproductive and excessive public criticism of the responsible governmental agencies, and improve the overall lake and watershed management effort.

Implementation Status (May 2007)

Pinellas County has established an extensive network for public outreach to all stakeholders of Lake Seminole. The County holds regular public meetings to discuss the status of the Lake, update past projects and inform of future projects. A website has been established discussing the history, management plan and ongoing projects (http://www.pinellascounty.org/Environment/pagesHTML/waterResources/wr3200.html).

A User group of individuals surrounding the lake are updated by email providing relevant information on the Lake status. Additionally, bilingual signs have been installed on 197 storm drains throughout the watershed stating "Dump No Waste-Drains to Lake" (**Figure 3-6**). A fine of $10,000 can be implemented if violated.

Listed below are the public events held since 2005 to inform local stakeholders in the Lake Seminole watershed:

Community Meetings
Four Seasons Mobile Home Park
Point West Mobile Home Park
Willow Point Condominiums Homeowners Association
Town Homes of Lake Seminole Homeowners Association
Lake Shore Homeowners Association
Lake Park Homeowners Association
Lake Seminole Square
Orange Lake Village Homeowners Association
Public Meeting May 25, 2005 over 400 in attendance
Lake Clean up Event February 2006 over 460 volunteers (**Photo 3-6**)

Photo 3-6. Volunteer participation in "Lake Clean-Up" Event in 2006.

Park Blvd replanting: February 2007 Eagle Scout project: install 30 live oaks along the southern shoreline (**Photo 3-7**)

Photo 3-7. Installation of 30 live oaks along Park Blvd by Eagle Scouts.

April 2007 Eagle Scout project to install aquatic plants over 2500 linear feet of shoreline (scheduled)

May 2007 Lake Clean up event (scheduled)

2. Develop and Implement a Local Citizens Lakewatch Program for Lake Seminole

This management action involves the recruitment of interested local citizens to participate in the collection of supplemental monitoring data from Lake Seminole and its watershed. Local citizen involvement in monitoring activities is implemented through a coordinated network of lakefront homeowners and other interested citizens. The recruitment and training of interested citizens follows the protocols established by the Florida LakeWatch program, which has implemented similar programs on numerous central Florida lakes.

The implementation of a citizen based sampling program allows for the collection of data needs that have been identified and which are currently not being address by Pinellas County or other agencies. Interested citizens will be recruited to assist in the collection of such data wherever feasible. Local citizen LakeWatch programs have been very successful in central Florida, where numerous lake associations are actively involved in monitoring and data collection on their lakes. This type of public 'ownership' in the resource could greatly improve public interest and involvement in the restoration and management of Lake Seminole.

Implementation Status (May 2007)

The citizen based Florida LakeWatch program currently collects samples from Lake Seminole. As of 2003, a total of 12 samples have been collected to measure water quality.

3.c Geographic Scope of any Proposed Management Activity

The geographic scope of the Lake Seminole Management Plan extends throughout the watershed. The management of the lake depends on both external (point source, runoff, etc.) and internal (sediment removal, lake level fluctuation, etc) modifications.

3.d Documentation of the Estimated Pollutant Load Reduction and Other Benefits Anticipated from Implementation of Individual Management Actions

The anticipated benefit of each component of the proposed restoration management plan for Lake Seminole is discussed below. Additionally, the estimated pollutant load reduction is discussed based on a comprehensive modeling effort which includes the four major restoration projects.

<u>Structural Components</u>

Excavate Organic Peat Sediments From Shoreline Areas

The expected benefits of this management action are improved sport fish reproductive success, increased biodiversity in the littoral plant communities and improvement in water quality of Lake Seminole. Combined with the proposed enhanced lake level fluctuation schedule, this action is expected to result in substantially improved shoreline habitat quality. The enhancement of the vegetative community along the littoral zone should increase nutrient uptake thereby reducing the nutrient concentrations. Additionally, the removal of organic materials will directly remove a source of decaying material which ultimately will release nutrients to the lake.

Restore Priority Wetland and Upland Habitats

A healthy and diverse community of native aquatic vegetation is an important component of all lake ecosystems. Emergent and submerged aquatic vegetation provides numerous ecological functions in lake systems including:

- food and shelter for fish and wildlife;
- stabilization of unconsolidated sediments; and
- nutrient uptake and stabilization of water quality.

It has been noted in Florida lakes that an inverse relationship generally exists between aquatic macrophyte coverage and algal biomass, as measured by chlorophyll-a concentrations (Huber et al., 1982). That is, lakes tend to either be macrophyte or algal dominated with respect to primary productivity. One of the net benefits derived from the above listed functions is improved water clarity. The improved water clarity and enhanced habitat complexity provided by aquatic macrophytes generally lead to improved sport fisheries and more satisfying recreational experiences and aesthetics.

Install Stage And Flow Measurement Instrumentation On The Lake Seminole Outfall Control Structure

The expected benefits of this management action include the acquisition of previously unavailable data essential to the support of various recommended management actions and monitoring programs. This data will be vital for the accurate calculation of the annual water and nutrient budgets.

Construct Enhanced Regional Stormwater Treatment Facilities In Priority Sub-Basins

The five priority sub-basins cumulatively generate approximately 72.30% of the total annual TN, 72.68% of the total annual TP, and 76.03% of the total annual TSS loads to the lake from stormwater runoff. Furthermore, stormwater runoff accounts for about 96.2% of the total external phosphorus inflows to the lake. Assuming a maximum effectiveness of 40% TN removal and 90% TP and TSS removal for enhanced stormwater treatment technology such as alum injection with floc settling basins, the construction of alum injection facilities at the outfall point of the five priority sub-basins could potentially result in the removal of approximately 1.82 tons of phosphorus annually, or about 55.66% of the total annual phosphorus inflows from stormwater runoff. This accounts for about 53.69% of the total external phosphorus load. Although this estimate likely represents a maximum effectiveness, enhanced stormwater treatment facilities strategically implemented in a small watershed like that of Lake Seminole could be very effective at reducing external pollutant loads, particularly for TP and TSS. The calculated mean pollutant removal efficiencies determined during laboratory testing based on a 10mg Al/liter application to raw stormwater can be found in **Table 3.5** (ERD, 2005). Based on this data, an expected 32% removal of TN, 82% removal of TP and 79% removal of TSS can be expected on average from the stormwater treatment facilities. In a lake that is at least periodically nitrogen limited with respect to inorganic N and P, this management action could be very effective at driving Lake Seminole more towards the desired state of phosphorus limitation.

Divert Seminole Bypass Canal Flows To Improve Lake Flushing And Dilution

Flushing and dilution is a well-documented lake management technique that involves increasing the rate at which the nutrient mass is flushed from the lake combined with the use of higher quality dilution water to reduce in-lake concentrations of nutrients and algae (NYSDEC, 1990). Flushing and dilution serve to reduce the concentration of nutrients, and the period of time that aquatic vegetation is exposed to these nutrients. The reduced nutrient concentrations and residence time should lead to reduced algal biomass and increased water column transparency due to lower algal cell concentrations and, to a lesser extent, the addition of more transparent water to the lake volume. Increased transparency, in turn, should lead to the proliferation of desirable rooted aquatic plants.

Algal cell concentrations may be reduced by flushing alone (e.g., the discharge of lake water). Increasing the water inflow will decrease the retention time and increase the flushing rate. If the flushing rate is greater than the algae growth rate, algal cells may be washed out of the lake system. Effective control of algae blooms can be achieved by a flushing rate of approximately 10-15% of the lake volume per day (NYSDEC, 1990). If flushing alone can be used to decrease algae concentration through washout, then lower quality water can be used, provided that the increases in the algal growth rate resulting from the higher nutrient concentrations are not sufficient to exceed the increased flushing rate. However, dilution water with nutrient concentrations significantly higher than those in the lake may exacerbate existing water quality problems.

If higher inflow nutrient concentrations result in algal growth rates that exceed the increased flushing rate, then algal concentrations in the lake could actually increase. For these reasons, it is imperative that a comparable or better quality source of dilution water be used in Lake Seminole. Fortunately, given the available external supply of dilution water provided by the Seminole Bypass Canal, flushing rates approaching 10-15% (342 to 513 acre feet) per day may be achievable during the wet season. In addition, water quality improvements expected to result from the regional stormwater treatment facility should ensure that suitable conditions exist to make this action viable. Based on removal efficiencies calculated on collected stormwater samples, it is estimated that alum treatment (10 mg Al/liter) will result in 19% removal of TN, 88% removal of TP and 65% removal of TSS (**Table 3.5**; ERD, 2005)**.**

Theoretically, the combined effects of dilution of water column nutrient concentrations, and reduced lake residence times, should produce substantial improvements in lake water quality on a seasonal and annual average basis. Simulations of this management action conducted using the WASP5 model indicate that it could reduce in-lake chlorophyll-a concentration by as much as 14%. Water quality improvements will, in turn, lead to improved conditions for aquatic vegetation and fisheries.

In addition to the water quality benefits, the availability of a dependable source of replacement water for lake water discharged during the implementation of an enhanced lake level fluctuation schedule provides a mechanism for restoring and maintaining target lake levels in the case of drought. Without a dependable source of replacement water, there is some risk that drought following a lake level drawdown will result in an extended period of low lake levels which may adversely impact recreational uses of the lake. This management action provides some insurance against that risk and allows for greater control over lake levels during drought conditions.

Dredge Organic Silt Sediments From Submerged Areas

The removal of up to 1 million cubic yards of unconsolidated flocculent sediments from Lake Seminole would result in direct improvements to waterborne recreation, submerged aquatic vegetation, sport fisheries, and water quality through the physical deepening of the lake. Waterbody modeling using WASP5 has indicated that the removal of the deep organic flocculent sediments could result in significant water quality improvements, with a predicted chlorophyll-a reduction of as much as 24.4%. This is the single most effective management action considered in the waterbody modeling work. The modes of water quality improvement would include: 1) increased lake depth to reduce sediment resuspension; 2) increased lake volume to dilute nutrient concentrations and limit algae growth; and 3) decreased sediment nutrient fluxes to the overlying water column.

In addition, similar sediment removal projects have been completed throughout the State of Florida. At Banana Lake, located in Polk County, Fl, it was estimated that approximately 90% of the nutrient loads to Banana Lake were eliminated by the diversion of the wastewater treatment plant discharge and the dredging of organic lake sediments. An in-lake sediment removal mesocosm experiment in Lake Hancock measured nutrient reductions rates between 20-30% due to sediment removal. These results are based on one season of sampling during the winter. Removal rates during the summer will be measured in May 2007. A comprehensive discussion of each completed and in-progress sediment removal projects is available as Case Study #1.

Management Components

Mechanically Harvest Nuisance Aquatic Vegetations

This management action not only addresses the control of nuisance aquatic vegetation, but it also addresses water quality problems related to eutrophication as well. Macrophytes are widely employed for nutrient removal in wastewater treatment facilities. Reddy and DeBusk (1987) present a summary of the application of aquatic plants to the treatment of wastewater. The assimilation of nutrients into macrophyte biomass is used to fix water column nutrients and provide a means for their eventual removal from the aquatic system. Physical removal (i.e., harvesting) of the plant biomass is required to prevent the return of the assimilated nutrients to the water column or sediments as the plants senesce and decompose. However, until relatively recently, experience with the use of macrophytes to remove nutrients from eutrophic surface waters has been limited in both the extent and scope. The principles of nutrient assimilation are the same in treating natural surface waters as in treating wastewater streams, but the relative concentrations of nutrients in the water column are much lower. The same species that have been employed in wastewater treatment, especially water hyacinth (*Eichhornia crassipes*), have been used in removing nutrients from surface waters (Reddy and DeBusk, 1987). There have been several reports published on the successful application of mechanical harvesting of rooted aquatic plants to the mitigation of eutrophication (Souza, et. al., 1988).

Using cattail tissue analysis data from Lake Tarpon (Dames & Moore, 1992), the harvesting of 10 acres per year of cattails would result in the removal of approximately 170 tons of dry weight organic matter, and 0.3 tons of TP, from the system. Based on available harvesting data from Lake Okeechobee (Gremillion et al., 1988), it is estimated that the controlled harvest of approximately 35 acres of *Hydrilla* in Lake Seminole could result in the annual removal of approximately 4.0 tons of TN and 0.5 tons of TP per year. If this mass of plant tissue were to senesce and decompose simultaneously, as would be the case after a large scale chemical treatment, the harvesting of this material would result in a very substantial internal load reduction.

Improve Treatment Efficiency Of Existing Stormwater Facilities

The pollutant load reduction associated with improving the performance of existing stormwater treatment systems is potentially significant given the level of development in the study area, especially in the western portions of the watershed. It is not possible to accurately quantify this potential load reduction; however, until an inventory of existing facilities is completed.

Biomanipulate Sport Fish Populations

The expected benefits of this management action would be a shift in the fish population structure and an improved sport fishery. In addition, the removal of rough fish would also result in an ancillary improvement in water quality conditions.

Implement an Enhanced Lake Level Fluctuation Schedule

The greater range of water level fluctuation will effectively create a more conducive environment for the expansion of a variety of desirable native emergent and submergent species such as bulrush and Eel grass, and will reduce the competitive advantage of cattails. The lowering of lake levels for short periods of time (e.g., weeks to months) almost always elicits a positive vegetation response whereby desirable submerged species such as Eel grass extend their coverage into deeper areas that are more exposed to light. This has the beneficial effect of oxidizing sediment organic matter and binding lake sediments. In addition, raising the water level elevation to, or slightly above, 5.0 NGVD for short periods of time will reduce the competitive advantage of nuisance littoral species such as cattails. Combined with site-specific revegetation projects, the primary benefit of this management action will be substantial improvements in the diversity of the littoral plant community in Lake Seminole, and an overall increase in macrophyte biomass.

A more varied water level fluctuation schedule will also improve sport fishing through the provision of better spawning habitat. Given the low cost of implementation, this component will likely be very cost-effective when compared to large scale habitat restoration projects. Finally, this component will create the opportunity for shoreline residents to remove exposed trash, debris and undesirable vegetation during low lake level periods. Combined with public education, this component should contribute to improved visual aesthetics along the lake shoreline.

It is difficult to quantify the water quality benefits of periodic lake flushing because of the complex biological, hydrogeological and chemical interactions. Using mean annual TN and TP concentrations from 1999 in-lake water quality data, it is estimated that the discharge of 1.0 foot of water from Lake Seminole (e.g., from elevation 5.0 to 4.0 NGVD) would result in a nutrient mass discharge of 5,598 lbs. of TN and 233 lbs. of TP. Although most of this nutrient mass will be replaced by inflowing precipitation, runoff and groundwater, effective dilution would occur if the cumulative nutrient concentrations in the inflow waters were even slightly lower than in-lake concentrations. Following the implementation of the proposed watershed management actions to reduce external nutrient loads to the lake, greater nutrient dilution can be expected. In addition, the diversion of water from the Seminole Bypass Canal through Lake Seminole, will provide for both increased flushing and dilution and reduced residence time, and will potentially constitute a reserve source of water to maintain target lake levels during periods of drought.

Waterbody modeling using the WASP5 model has indicated that the implementation of the recommended enhanced lake level fluctuation schedule alone will result in a slight increase in mean annual chlorophyll-a concentration of 1.9 μg/l or 3%. The interpretation of these model predictions is that the lesser lake volume during the early summer creates conditions more favorable for algal growth. When combined with other management actions (e.g., diversion of Seminole Bypass Canal flows), this effect is essentially negated. Despite the predicted slight degradation in water quality, this management action is strongly recommended for the other benefits to living resource that it will produce.

Inactivate Phosphorus Through Whole Lake Alum Applications (If Warranted By Monitoring Results)

Phosphorus inactivation has been highly effective and long-lasting in deeper, thermally stratified lakes, especially where an adequate dose has been given to the sediments and where sufficient attenuation of external nutrient loads has occurred. The effectiveness of this phosphorus inactivation has been less impressive in shallow lakes where sediment resuspension is a problem, or where high flows may wash the floc out or quickly cover it with another layer of nutrient-rich silt. Treatment longevity has extended beyond 10 years in some cases and to 5 years in many (EPA, 1990). Shallow, non-stratified lakes appear to have shorter periods of treatment effectiveness than stratified lakes. In those cases where the treatment effectiveness has been short-lived, the phosphorus-sorbing floc layer has usually become covered with new, phosphorus-rich sediments (EPA, 1990). Typical lake responses to alum treatment include:

- sharply lowered phosphorus concentrations;
- greatly increased transparency resulting in improved conditions for desirable aquatic vegetation; and
- algal blooms of much reduced intensity and duration.

It should also be noted that the addition of aluminum salts to lakes has the potential for serious negative impacts, and care must therefore be exercised with regard to dosage. The potential for toxicity problems is directly related to the alkalinity and pH of the lake water. The seasonal ranges of pH and alkalinity must be determined by monitoring before conducting alum treatments. When alum is added, aluminum hydroxide is readily formed in water at pH 6 to 8. This compound is the visible precipitate or floc described earlier. However, pH and alkalinity of the water will fall during alum addition at a rate dictated by the initial alkalinity or buffering capacity of the water. In soft water, only very small doses of alum can be added before alkalinity is exhausted and the pH level falls below 6. At pH 6 and below, $Al(OH)_2$ and dissolved elemental aluminum (Al^{+3}) become the dominant forms. Both can be toxic to aquatic animal species. Well-buffered, hard water lakes are therefore good candidates for this type of lake treatment because a large dose can be given to the lake without fear of creating toxic forms of aluminum. Soft water lakes must be buffered, either with sodium aluminate or carbonate-type salts, to prevent the undesirable pH shift and to generate enough $Al(OH)_3$ to control phosphorus release. Therefore, dosage is very lake-specific (EPA, 1990). Lake Seminole is classified as a “hard” water lake, based on an average Hardness value of 155mg/l in 2002.

Legal Components

Adopt a Resolution designating the Lake Seminole Watershed as a Nutrient Sensitive Watershed

The expected benefits from this management action include the reduction of diffuse nutrient loads from residential and commercial land uses within the basin. This management action, combined with improved public education, is aimed at addressing the more diffuse yet cumulatively substantial nutrient loads associated with typical urban landscape management practices.

Strengthen and Standardize Local Ordinances For Regulating Stormwater Treatment for redevelopment in the Lake Seminole Watershed

The expected benefits from this management action would include reduced nonpoint source pollutant loadings to Lake Seminole as the watershed undergoes redevelopment. The percent load reduction cannot be quantitatively predicted, as it will be totally dependent on the level of redevelopment that ultimately occurs.

Policy Component

Establish a Lake Seminole Watershed Management Area (WMA) Through Amendments to the Pinellas County, and Cities of Largo and Seminole Comprehensive Plans

The primary expected benefit of this management action is improved intergovernmental coordination between Pinellas County and Cities of Largo and Seminole with regard to watershed management issues in the basin.

Compliance and Enforcement Component

Expand and Enforce Restricted Speed Zones on Lake Seminole

The primary benefits of this action would be improved public safety and enjoyment of the lake, as well as reduced user conflicts. In addition, water quality may be improved through reduced wake and wave turbulence in shallow portions of the lake susceptible to sediment resuspension.

Public Education Components

Develop and Implement a Comprehensive Public Involvement Program for the Lake Seminole Watershed

The expected benefits of the management action include improved public understanding of lake management problems and solutions, and increased pubic involvement and participation in the Plan implementation process.

Develop and Implement a Local Citizens Lakewatch Program for Lake Seminole

The expected benefits include improved public interest and involvement in the lake and watershed management process, and assistance in the collection of supplemental monitoring data.

Modeling Results

WASP5 Model Results

The Plan included a comprehensive section that provides a summary of predictive watershed and waterbody modeling conducted to evaluate the efficacy of key potential management actions proposed to address priority management issues for Lake Seminole and its watershed. Priority lake and watershed management issues include:

- water quality degradation and eutrophication (Issue 1 - Water Quality);
- loss of desirable aquatic vegetation (Issue 2 - Aquatic Vegetation); and
- sport fishery decline (Issue 3 - Fisheries).

Because these three lake management issues are very much interrelated, the proposed management actions addressed herein were developed and evaluated in a holistic manner which considers their individual and cumulative impact on the trophic state of the lake. While other identified lake management issues (e.g., watershed habitat restoration, recreational user conflicts, etc.) are addressed in the Plan, predictive modeling was only conducted on those management actions aimed at addressing the priority issues listed above. A detailed description of the model components and calibration simulation is available in **Appendix C.**

Management Action Simulations

Management Action #1 - Regional Stormwater Treatment Facilities (BMPs)

Basins within the Lake Seminole watershed were ranked according to SWMM pollutant loading estimates. These rankings were used to develop locations for potential stormwater treatment facilities within sub-basins 1, 2, 3 and 7. Because several stormwater rehabilitation projects are currently under design or construction in sub-basin 6, and these projects were included in the future land use baseline simulation, no additional facilities were modeled for this sub-basin. The proposed management actions and alternatives for Lake Seminole were evaluated using the Linked Watershed-Waterbody Model (LWWM) developed for the Southwest Florida Water Management District by AscI, Inc. This water quality model provides a post-processing linkage between the watershed model SWMM, a public domain software program also developed by EPA, and the waterbody model WASP5. An external hydrodynamic file was also required for LWWM simulations which contained model segment flows, and was developed using an Excel spreadsheet and a Fortran routine.

Limited potential exists within the Lake Seminole watershed for stormwater retrofit using conventional wet detention treatment systems due to the lack of vacant land. All regional stormwater treatment facilities modeled for Management Action #1 were therefore assumed to be alum injection systems, with the corresponding alum treatment efficiencies shown in **Table 3-6** applied to pollutant loads passing through the facilities.

It should also be noted that due to the high pollutant removal efficiency and minimal land area requirements, the cost per pound of nutrients removed is substantially lower than a wet detention system. Based on current information provided by SWFWMD (Mike Holtkamp-SWFWMD, personal communication), typical costs per pound of TN removed by wet detention systems ranges between $3,846 and $1,108; whereas typical costs per pound of TN removed by alum treatment systems ranges between $338 and $120. Because they provide pollutant removal efficiencies per dollar that are an order of magnitude better than wet detention systems and due to limited land availability were selected as the design alternative of choice for Lake Seminole.

Separate non-point source input files were prepared for all possible combinations of potential alum injection treatment facilities within the watershed. Fifteen (15) separate simulations were performed using the various non-point source input files to evaluate the effect of reduced non-point source loads on average annual chlorophyll-a levels. All stormwater best management practice (BMP) management simulations used the same WASP input file (BMP.inp) and hydrodynamic file (98F.hyd). Only the non-point source file was changed for different combinations of potential watershed BMPs.

A summary of these results for all possible stormwater treatment project combinations is provided in **Table 3-7** along with the effective reduction in total non-point source load. The numeric designations for BMP combinations in **Table 3-7** refer to the sub-basins in which enhanced regional stormwater treatment facilities were simulated in the model runs. LWWM predictions for nutrient and chlorophyll-a concentrations within Lake Seminole resulting from implementation of all proposed watershed BMP facilities are provided in **Figure 3-7.**

These results indicate that the most effective alternative of regional stormwater treatment facilities is the combination of facilities located in sub-basins 1, 2, 3, and 7. The implementation of four regional alum treatment facilities at the outfall of these sub-basins is predicted to reduced in-lake chlorophyll-a concentrations by 4.4 μg/l, or about a 7% from baseline future land use conditions using 1998 rainfall. These results are not expected since external pollutant load reduction from regional stormwater treatment facilities should yield cumulative benefits determined by the percentage of the inflows being treated.

Management Action #2 - Lake Level Fluctuation

A variable lake level fluctuation schedule was proposed primarily for littoral habitat improvement within Lake Seminole. Both inter-annual and intra-annual variations are achieved with the proposed monthly lake level fluctuation schedule. In order to assess the potential impact of this management action on in-lake nutrient and chlorophyll-a levels, the hydrodynamic file for 1998 rainfall and future land use conditions was modified to account for monthly variable weir crest elevations. Schedule A was used for management simulations, which provides the greatest range of fluctuation in the 4-year repeating schedule. Only the hydrodynamic file reference in the WASP input file was changed from the 1998 future land use conditions simulation, and the same baseline non-point source file (98F.nps) was used for the weir management action simulation.

LWWM predictions for nutrient and chlorophyll-a concentrations within Lake Seminole resulting from implementation of the weir fluctuation schedule is provided in Figure 3-8. The simulation results for this management action actually show a slight increase in chlorophyll-a-a concentrations of 1.9 mg/m3 (3.03% increase over baseline conditions). This predicted increase is most likely due to a decreased in-lake volume during the early and mid-summer, the period when algal productivity is greatest. It is interesting to note that Greening and Doyon (1990) cite several case histories where lake drawdowns have led to a slight temporary degradation of water quality, which they attribute to a phosphorus release from decaying macrophytes exposed to oxidation. Although this management action apparently has the potential to cause a slight degradation in water quality, the beneficial effects of enhanced lake level fluctuation on aquatic vegetation and fisheries habitat probably justify its implementation.

Management Action #3 - Canal Diversion

An important factor affecting receiving water quality is the amount of time is takes to completely exchange in-lake volume, often referred to as residence time. Potential Management Action #3 is designed to reduce residence time within Lake Seminole by pumping water from the adjacent Seminole Bypass Canal into the northern lobe of the lake. Four separate simulations were performed to evaluate the lake response to various pumping rates and treatment alternatives for canal diversion water. Canal baseflow and stormwater volume and nutrient concentration estimates were based on hydrological evaluations of the Starkey Basin performed by ERD, and summarized in a December 15, 1998 SWFWMD letter to PBS&J.

Alternative 3A was simulated by creating a hydrodynamic file containing a constant pumping rate of 10.42 cfs from the bypass canal into the northern lobe of Lake Seminole (3A.hyd). This flow represents a diversion of 80% of the annual baseflow within the canal. Nutrient loads were adjusted in the WASP5 input data file to account for TN, TP and BOD loads contained within the diverted canal water.

Alternative 3A1 used the same hydrodynamic file as above which accounted for an 80% diversion of canal baseflow into the northern lobe of Lake Seminole (3A.hyd). Alum treatment of this constant 10.42 cfs canal diversion flow was simulated prior to discharge into Lake Seminole for this alternative. Nutrient loads calculated in Alternative 3A were reduced by the alum treatment efficiencies contained in **Table 3-6** prior to entry into the WASP5 input data file.

Alternative 3B was simulated by creating a hydrodynamic file (3B.hyd) containing higher pumping rates for canal diversion flow during July (11.40 cfs), August (11.60 cfs) and September (11.39 cfs). These increased pumping rates represent an 80% diversion of stormwater runoff flows expected during these months, in addition to the constant 10.42 cfs baseflow pumping rate. Stormwater flows routed during July, August and September would contain greater nutrient concentrations than a baseflow diversion only. Nutrient loads were therefore adjusted in the WASP5 input data file to account for these increased pollutant loads contained within the diverted stormwater flow in addition to baseflow.

Alternative 3B1 used the same hydrodynamic file as above (3B.hyd), but considered alum treatment of diverted canal baseflow and stormwater flow. Nutrient loads calculated in Alternative 3B were reduced by the alum treatment efficiencies contained in **Table 3-6** prior to entry into the WASP5 input data file for this alternative. The same baseline non-point source file (98F.nps) was used for all canal diversion management action simulations described above.

LWWM predictions for nutrient and chlorophyll-a concentrations within Lake Seminole resulting from implementation of canal diversion Alternative 3A1 are provided in **Figure 3-9**. **Table 3-8** contains a summary of input files used for the evaluation of Management Action #3 and resulting predicted chlorophyll-a concentration reductions.

The results of these LWWM simulations indicate that the greatest reduction in chlorophyll-a concentrations in Lake Seminole can be expected from a constant diversion of treated canal baseflow only (Alternative 3A1). This alternative yields a substantial predicted decrease in chlorophyll-a concentrations of 9.6 μg/l or about a 15% reduction over baseline conditions. Diversion of treated stormwater flows (Alternative 3B1) does not appear to be as effective, as the increased pollutant loads contained in this runoff effectively negate any reductions in chlorophyll-a concentrations achieved through a decrease in residence time.

Management Action #4 - Sediment Removal

Sediment removal as a lake management action is expected to result in improved water quality through two primary modes of action: 1) increased lake water volume; and 2) reduced sediment nutrient flux rates. The increase in lake water volume resulting from sediment removal can easily be quantified, being approximately equal to the wet volume of sediments removed. However, reductions in sediment nutrient fluxes resulting from sediment removal cannot be accurately quantified with the existing information from Lake Seminole. Many variables affect sediment nutrient exchange rates, and empirical data from Lake Seminole are currently not available.

During the calibration simulations, sediment nutrient fluxes were included in the variables which were manipulated to obtain the best fit of predicted parameter concentrations to recorded values. Initial sediment fluxes for N and P were set at rates with the same order of magnitude as those determined empirically for Lake Seminole sediments by Schelske et al. (1991; in SWFWMD, 1992). These calibrated flux rates were reduced incrementally in the dredging simulations described below to gain an understanding of the sensitivity of LWWM simulations to manipulation of this parameter.

Initial lake water volumes contained in the WASP5 input data file were increased to reflect the removal of 1 million cubic yards of sediment from the lake bottom, or about 100% of the estimated volume of unconsolidated organic sediments in the lake. In the simulations 36% of the increased lake water volume was applied to the northern lobe, while the remaining 64% was applied to the southern lobe. An updated hydrodynamic file was also created to reflect these increased volumes.

Table 3-9 contains a summary of input files used for the evaluation of Management Action #4, and the resulting predicted reductions in chlorophyll-a concentrations associated with a 20% (Alternative 4A), 35% (Alternative 4B), and 50% (Alternative 4C) reduction in sediment nutrient fluxes. It should be noted that all three simulations included 100% removal of the unconsolidated organic sediment mass, but applied different sediment nutrient flux rates resulting from the sediment mass removal. LWWM predictions for nutrient and chlorophyll-a concentrations in Lake Seminole resulting from implementation of dredging Alternative 4C are provided in **Figure 3-10**.

The simulation results for the sediment removal alternatives indicate that the model is extremely sensitive to the reduction of sediment nutrient fluxes. With a 50% reduction in sediment nutrient flux rates (Alternative 4C), the model predicts a very substantial reduction in chlorophyll-a concentrations of 15.3 μg/l, or about 24% below baseline conditions.

The proposed removal of approximately 1 million cubic yards of unconsolidated organic sediments from Lake Seminole, including both the fibrous shoreline sediments and the flocculent deep sediments, is expected to reduce sediment nutrient flux rates significantly based on the sediment characterization study. Unfortunately, an accurate estimate of the percent reduction in nutrient flux rates resulting from sediment removal cannot be made with the information currently available. However, it seems reasonable to assume that complete removal of the unconsolidated organic sediments in Lake Seminole could lead to a 50% reduction in sediment nutrient flux rates. With this conservative 50% reduction, significant water quality improvements in Lake Seminole are predicted.

Management Action Combinations

Model simulations were performed for all possible combinations of each of the four selected management action alternatives described above. In many cases, new WASP5 input data files were developed in order to combine all modifications made in the individual management scenario alternatives described above. In addition, updated hydrodynamic files were created for these simulations where required.

Figure 3-11 shows in-lake chlorophyll-a, DO, BOD, and nutrient concentrations resulting from a combination of all modeled management scenarios combined. **Table 3-10** contains a summary of input files used for the 15 LWWM simulations required for this optimization analysis, and predicted reductions in chlorophyll-a concentrations.

Simulation results for the various combinations of management action alternatives presented in **Table 3-10** above indicate that the most effective combination of alternatives includes the following:

- regional stormwater treatment facilities located in priority sub-basins 1, 2, 3, and 7;
- diversion of treated baseflows from the Seminole Bypass Canal into the lake; and
- removal of 1 million cubic yards of unconsolidated organic sediments.

The predicted reduction in chlorophyll-a concentration resulting from the implementation of this suite of management alternatives is 28.5 μg/l, or about a 45% reduction from baseline conditions. The second most effective combination of alternatives includes the three listed above plus the implementation of an enhanced lake level fluctuation schedule (Management Action #2). The proposed enhanced lake level fluctuation schedule is predicted to result in a slight increase in chlorophyll-a concentrations. However, the habitat benefits to be derived from this management action probably justify its inclusion in the recommended Plan.

Based on the above described model predictions, implementation of the most comprehensive suite of management action alternatives (Management Action Combination 1+2+3+4 from **Table 3-10** above) will yield the greatest overall improvement in both water quality and habitat conditions. Using the predicted reductions in chlorophyll-a associated with this suite of management action alternatives, it appears feasible to make very substantial improvements in the water quality and trophic state of Lake Seminole. The predicted 27.4 μg/l reduction in chlorophyll-a concentrations (44% reduction of modeled baseline conditions) associated with this suite of management action alternatives indicates that a mean annual chlorophyll-a concentration target of 30 μg/l is both technically feasible and justifiable with respect to the adopted lake and watershed management goals. This target equates to a chlorophyll-a TSI value of 65.

The model predictions summarized in **Table 3-10** also indicate that simultaneous implementation of the selected management action alternatives in many cases results in synergistic improvements in water quality and trophic state. An independent review of the LWWM model construct and calibration simulations was conducted by Dr. James Martin, one of the original authors of the WASP5 model code. This review is provided in **Appendix D** of this document.

3.e Copies of Written Agreements Committing Participants to the Management Actions

Pinellas County has received commitments from the City of Largo, City of Seminole, and the Florida Department of Transportation byway of a legal document entitled" INTERLOCAL AGREEMENT PROVIDING JOINT CONTROL OF POLLUTANTS WITHIN PINELLAS COUNTY" **(Appendix E)**. The interlocal agreement defines the responsibilities and authority for each entity in order to regulate the National Pollutant Discharge Elimination System developed by the USEPA.

3.f Discussion On How Future Growth And New Sources Will Be Addressed

Future land use conditions were modeled to predict non-point source pollutant loads (*.nps) in the Lake Seminole watershed under a projected ultimate build-out land use scenario. Although some differences in land use are anticipated under future land use conditions, the watershed is currently nearly 100% built out, resulting in little predicted difference in pollutant loads for future land use SWMM simulations. These simulations accounted for three stormwater projects which were recently constructed within the watershed:

- the St. Petersburg Junior College site stormwater master plan;
- the Pinellas County Dog Leg Pond; and
- the Pinellas County Pond 6.

A continuous simulation was performed using 1998 rainfall to create a non-point source input file (98F.nps) which was used for the baseline future land use condition simulations. An external hydrodynamic file for future land use conditions using 1998 rainfall (98F.hyd) was also prepared using these SWMM calculated inflows to Lake Seminole by applying the spreadsheet and Fortran routines described above. A WASP5 simulation for future land use conditions using 1998 rainfall was then performed, which used the hydrodynamic and non-point source input files described above. These simulation results were used as a baseline condition for the evaluation of potential management alternatives. Results were similar to the existing conditions 1998 calibration simulation results, and are provided as a baseline for comparison purposes in **Figures 3-7 through 3-11**.

3.g Confirmed Sources of Funding

Multiple sources of funded are confirmed for the restoration of Lake Seminole (Table 3-11). The SWFWMD, City of Largo, City of Seminole, Pinellas County, FWCC and DEP have allocated over $32 million toward the improvement of water quality through restoration projects and monitoring in Lake Seminole since 1994. To date Pinellas County has spent over $10 million on restoration projects in Lake Seminole. The Cities of Largo and Seminole have contributed over $156,107 toward the restoration of the Lake. The FWCC, and SWFWMD have spent $336,623 and $6,603,155, respectively. Pinellas County included the alum injection projects for funding in fiscal years 2007-2012, therefore; approximately $4.9 million has been designated for the design and construction of the alum stormwater treatment facilities designed to improve water quality in Lake Seminole (**Figure 3-12**). Additionally, a traditional sediment removal project was projected to cost the county over $20 million. However, Hayes-Bosworth, Inc. presented a proposal which could only cost the county $1 million. Hayes-Bosworth proposed to turn the sediment removal project into a business venture which would allow the company to absorb the remaining cost of sediment removal. The ingenuity and agreement between the public and private sector has allowed for multi-million dollar cost savings for the county.

3.h Implementation Schedule (Including interim milestones, and the date by which designated uses will be restored)

The following schedule outlines the timeline for implementation of the restoration projects proposed for Lake Seminole.

Phasing of Plan Components

It should be emphasized that the various components of the restoration projects are not all independent management actions that can be implemented without regard for the others. The implementation of other management actions are based on the measured effectiveness of preceding management actions. For example, it is recommended that the removal of the flocculent deep sediments in the lake not be initiated until the effectiveness of external phosphorus removal has been evaluated through water quality monitoring. If monitoring indicates that expected progress towards meeting the defined water quality targets is not being met through the reduction of external phosphorus loads, then the implementation of the full dredging project would be justified. Similarly, sediment phosphorus inactivation through whole lake alum applications should not be initiated until the flocculent sediments have been removed and monitoring results still indicate insufficient progress towards meeting water quality targets. In recognition of these dependencies, as well as potential financial constraints, it is recommended that the Plan be implemented in three phases, as described below.

- **Phase I** - The first phase would focus initially on the design and permitting of the major structural components for which land acquisition, engineering design and regulatory permit approvals will be required. These activities in support of the major structural components of the Plan may require up to two years to complete and therefore will be initiated immediately. The establishment of several legal and policy related components will also be implemented. Phase I activities are projected to require a minimum of two years to complete, including construction.

- **Phase II** - The primary focus of Phase I will be on watershed management activities that result in the reduction of external phosphorus loads to the lake (e.g., construction of enhanced regional stormwater treatment facilities) and in-lake restoration activities that build upon the watershed management projects completed under Phase I. These would include implementation of in-lake habitat restoration projects, as well as the removal of the flocculent deep sediments. Implementation of the enhanced lake level fluctuation schedule would occur during Phase II following the removal of accumulated sediments in the narrows to ensure navigability throughout the lake. Assuming that all land acquisition, design and permitting activities have been completed for the major structural components in Phase I, it is anticipated that the Phase II construction projects, and other non-structural components of the Plan, could be completed in two years.

- **Phase III** - The third phase of the Plan would focus primarily on following-up on in-lake restoration activities that build upon, or are dependent upon, the implementation of Phase I and Phase II projects. For example, assuming that adequate water quality improvement to support the proliferation of aquatic macrophytes in the lake has resulted from the implementation of the Phase I and II components, the aquatic weed harvesting program would be initiated during Phase III. Conversely, if the defined water quality targets have not been attained following implementation of the Phase I and II components, then sediment phosphorus inactivation would be implemented in Phase III. It should be noted that the majority of the Phase III projects are management or maintenance activities that will likely be conducted indefinitely on an ongoing basis.

Table 3-12 summarizes implementation schedule for the restoration of Lake Seminole. This table embodies the logical sequencing and dependencies of the various components discussed above. In addition to the these components, the recommended monitoring and success evaluation program already presented was implemented in Phase I to document existing baseline conditions, and to track progress throughout project implementation.

3.i Enforcement Programs or Local Ordinances (If management strategy is not voluntary)

The Pinellas County Board of County Commissions adopted the Lake Seminole Watershed Management Plan by resolution in 2001. This resolution articulates a commitment on the part of the County to directly fund, and secure additional grants and cooperative funding agreements, as needed to fully implement the Plan. While the watershed planning and lake restoration efforts undertaken by Pinellas County have been voluntary to date – that is, not required as part of a regulatory process – many of the commitments made with regard to specific projects are in fact enforceable through project-specific permit approvals and inter-local agreements. For example, the construction and monitoring of the alum stormwater and bypass canal diversion treatment facilities are embodied in the State of Florida Municipal Separate Storm Sewer System (MS4) Permit, issued to Pinellas County under the National Pollutant Discharge Elimination System (NPDES) program. In addition, continued operation and maintenance of these facilities is guaranteed under a cooperative funding agreement between Pinellas County and SWFWMD. **Appendix A** contains copies of the Pinellas County MS4 permit and the cooperative funding agreement between the County and SWFWMD. Finally, a federal dredge and fill (CWA Section 404/10) permit from the U.S.

Army Corps of Engineers, and a State of Florida Environmental Resource Permit (for delegated Water Quality Certification), will be required for the sediment removal project. This permit will likely specify monitoring and reporting requirements for the project, thus establishing additional federal and state enforcement provisions.

It should also be noted that Pinellas County has implemented a storm drain education program throughout the Lake Seminole Watershed. Over 2067 stormdrain labels stating, “Dump No Waste-Drains to Lake” have been distributed in an effort to inform the public of the consequences associated with improper disposal of materials down a stormdrain (**Figure 3-6**). 197 of these labels are within the Lake Seminole watershed. The County has the ability to fine anyone identified for improper disposal a maximum fine of $10,000 (Pinellas County, Florida, Chpt. 58-236-58-246).

4. Procedures for Monitoring and Reporting Results

4.a Description of Procedures for Monitoring and Reporting

The implementation of a water quality monitoring program is important to demonstrate reasonable progress based on the management activities proposed to improve Lake Seminoles water quality. Pinellas County contracted Janicki Environmental in 2003 to complete a document which details a comprehensive monitoring plan for Pinellas County. The document is entitled “A design of a surface water quality monitoring program for Pinellas County, FL” and has been included in **Appendix F**. From this point further, this document will be referred to as the “Monitoring Plan”.

Pinellas County utilizes stratified randomized design for the selection of all sampling stations, dates and time of day. Nine equal time periods have been determined for the calendar year. Four samples are collected once within each time period established by the county, for a total of 36 samples each calendar year. Each year the statistical program is rerun to determine that years sampling sites, dates and time of day. The sampling dates and times for 2007 are detailed in **Table 4-1**. The 2007 sampling stations are listed in **Table 4-2**. A suite of water quality and explanatory parameters are analyzed for each sampling site (Table 4-3). **Appendix G** includes the “Ambient Monitoring Program Annual Report: 2003-2005” for Pinellas County. This provides more detailed information on the sampling and statistical methodology as well as the format used for reporting. The PCDEM will continue to investigate the TSS load reduction efficiency of all permitted MSSW facilities within the Lake Seminole watershed. Samples for the analysis of the phytoplankton community will be collected. Additionally, extensive monitoring will be completed in concert with the operation of the alum stormwater treatment facility in sub basin one (**Appendix B**). Water, benthic and sediment quality will be monitored in order to evaluate the success of the treatment facility and the effectiveness of the settling area. The goal of this monitoring effort is to measure the efficiency of the facility based on its Event Mean Concentration (EMC) efficiency and Load Efficiency prior to the construction of the remaining alum stormwater treatment facilities. All data are statistically analyzed and reported annually by the PCDEM. These data are used to determine the water quality status of Lake Seminole.

4.b Quality Assurance/Quality Control Elements that Demonstrate the Monitoring will Comply with Chapter 62-160, F.A.C.

All field data will be collected in accordance of the Chapter 62-160, F.A.C. regulations. All water samples are delivered to the Pinellas County Utilities Department the same day and usually within six hours of sample collection at any given site. The Pinellas County Utilities Department Laboratory, a National Environmental Laboratory Accreditation Conference (NELAC) certified lab, performed most sample analyses. E-lab, a NELAC certified laboratory, also provided analysis services for this program. The Pinellas County Utilities Department laboratory uses Standard Methods and EPA Methods for in order to analyze ambient water samples collected by PCDEM (Table 4-4):

Methods for Chemical Analysis of Water and Wastes. EPA 600/4-79-020. Revised March 1983.

Standard Methods for the Examination of Water and Wastewater, 19th Edition. APHA, WEF,AWWA, 1998.

Appendix G includes additional information on the sampling protocol used by Pinellas County. **Appendix H** includes the standard checklist required prior to each sampling event and the protocol used for the special samples and additional data collected at Lake Seminole.

4.c Procedures for Entering all appropriate Data into STORET

The Data Manager, designated by the PCDEM, uploads all water quality data collected for monitoring of Lake Seminole to the Florida STORET database. The Florida STORET database automatically uploads all data to the Federal EPA STORET database. All data uploads will be documented and reported to the FDEP in Tallahassee.

4.d Responsible Monitoring and Reporting Entity

The PCDEM is the responsible monitoring entity for all waterbodies within Pinellas County. The PCDEM has a designated Data Manager who serves as the point of contact for coordinating the collection, management and reporting of all monitoring data associated with Lake Seminole. Furthermore, PCDEM serves as a depository of all monitoring data associated with the restoration of Lake Seminole.

4.e Frequency and Format for Reporting Results

Section 6.0, “Data Reporting Methods” of the Monitoring Plan, details the frequency and format for reporting results **(Appendix F)**. Currently, PCDEM provides periodic data reporting, annual reporting and an annual review of the monitoring program (**Appendix G**). The tasks required within the periodic data reporting are completed based on quarters of a calendar year. During the first quarter of each calendar year, PCDEM compiles the annual report for the previous sampling period. The report contains all of the water quality status information. After five years of data collection, the annual reports will also include status and trends information. During the second quarter of each calendar year, the annual monitoring program will be reviewed based on the previous years’ of monitoring data. The results of the annual review will be published during the third quarter. Based on the recommendations of the annual review, the random selection of the next year's sampling stations, dates and time of day will the selected.

The annual reporting of water quality results is concentrated on the analysis, presentation and submission of the results collected from the previous sampling year. The below criteria will be included within each annual report (Monitoring Report, Section 6.0):

- A summary section with descriptive answers to the important questions identified for the ambient monitoring program.
- Spatial reporting units consist of the individual geographic populations of interest
- Temporal reporting units consist of each calendar year. Using every two years of sampling results, wet and dry season statistics will be reported.
- The results for all measured parameters will be reported in each annual report.
- The EMAP-based statistical analyses will be conducted to produce frequency distributions of the area of each spatial reporting unit for each water quality parameter. Results will be presented in tabular and graphical format.
- The stratified-random analyses will be conducted to compute the annual mean and standard error for each spatial reporting unit and parameter measured.
- The FDEP Impaired Water Rule criteria will be applied to classify each coastal Water Body (WBID) using data from this monitoring program and any other applicable monitoring activities.
- Potential water quality problem areas will be identified, prioritized and discussed in each annual report.
- The targeted spatial and temporal populations of interest will be compiled through review of the exclusionary criteria applied during the previous year.

In addition the following information will be posted to a project website:

- A summary of the monitoring program, and the important questions it addresses.
- A high level summary of the most recently reported results for the ambient monitoring program.
- Program contact information
- A description of the annual reporting cycle and an updated status of the items in the reporting cycle,
- A library of PDF documents of past annual reports.
- A library of PDF document of past annual monitoring program review reports.

4.f Frequency and Format for Reporting on the Implementation of all Proposed Management Activities

The PCDEM will publish an annual State-of-the-Lake report which summarizes all of the monitoring data collected during the previous calendar year. In addition to monitoring data summaries, the annual report will include the status for all proposed management activities. Additionally, all stakeholders, which includes the FDEP, will be updated at the stakeholder meetings which are held regularly.

4.g Methods for Evaluating Progress Towards Goals

The PCDEM will evaluate all data collected and compare them to the goals established in section 2.a. A trend analysis of the annual TSI and mean chlorophyll values will be completed. The collection of 36 samples per year should result in a ±15% confidence interval (Monitoring Plan, 2003).

5. A Description of Proposed Corrective Actions

5.a Description of Proposed Corrective Actions that will be undertaken if water quality does not improve after implementation of the management actions or if management actions are not completed on schedule

The comprehensive monitoring program in Lake Seminole under the coordination of the PCDEM is instrumental for quantifying water quality improvements. The current implementation schedule for water quality improvements occur over three phase components. Upon completion of each phase the water quality of the Lake will be investigated to determine if improvements have been accomplished. The third phase component, Inactivate phosphorus through whole lake alum applications, will be implemented only if previous restoration projects were not successful in improving water quality. It is anticipated that the sediment removal will temporarily cause a declination in water quality due to the manipulation and resuspension of sediments. However, it is expected that an improvement in water quality will be recorded within 10 years of sediment removal. After all proposed restoration projects have been exhausted, Lake Seminole will be re-evaluated and new management techniques will be considered to improve water quality conditions if necessary.

5.b Process for Notifying the Department that these corrective actions are being implement

The PCDEM will complete an annual report (section 4.f) detailing the current water quality and provide an update on all current and future restoration projects on Lake Seminole. All state, federal, local and private agencies involved in the Lake Seminole restoration will be provided a copy of this final report. The FDEP in Tallahassee will be sent an annual report. In addition, The FDEP is a stakeholder within Lake Seminole, therefore, they will be notified of all corrective actions at the stakeholder meetings held regularly.

Case Study #1 - Sediment Removal

From PBSJ 2006, Lake Seminole Sediment Removal Feasibility Study.

This case study presents a brief summary of four lake sediment removal projects and a mesocosm experiment conducted in the west central Florida area during the past 15 years. The purpose of this summary is to develop an understanding of the real-world problems that have been encountered, and the lessons that have been learned, on projects similar to sediment removal project proposed for Lake Seminole. The projects summarized below include:

Banana Lake – Polk County
Lake Hollingsworth – Polk County
Lake Panasoffkee – Sumter County
Lake Maggiore – Pinellas County.
Lake Hancock-Polk County

For each project summary the following subjects are addressed: 1) project history 2) sediment removal methods considered and selected; 3) environmental monitoring data – including sediment quality data, discharge water quality, and pre- and post-dredge water quality data – where available; and 4) problems encountered – including engineering, environmental, and/or construction related issues - and corrective measures implemented. Various sources of information were used in developing these summaries including personal communication with project managers and both published and unpublished data.

Banana Lake

Banana Lake is a 342 acre lake located in Polk County. The lake exhibited very poor water quality for many years as reflected in high chlorophyll-a and low dissolved oxygen values. The hyper-eutrophic conditions were attributed to stormwater runoff from agricultural areas and the direct discharge of wastewater from the City of Lakeland municipal wastewater treatment plant. The wastewater treatment plant stopped discharging in 1986; however, water quality problems persisted. In the mid to late 1980s, Banana Lake was clearly a phytoplankton dominated lake characterized by year-round blooms of green algae and cyanobacteria. As a result, aquatic macrophyte communities were essentially eliminated and the lake sport fishery (e.g., largemouth bass) was replaced by a fish community dominated by planktivorous species (e.g., gizzard shad).

Because lake water quality did not improve significantly following the elimination of the wastewater treatment plant discharge, it was hypothesized by lake managers that the organic sediments that had accumulated on the lake bottom constituted a substantial nutrient reservoir sufficient to maintain high phytoplankton concentrations. Dredging was initiated 1989 and completed in 1990. A hydraulic dredge was used, and dredged spoil material was discharged in upland pits constructed on adjacent agricultural land. The upland drying pits were designed to contain the entire volume of dredged spoil material, and no return water was permitted back to the lake. The total in-lake volume of sediments removed, and the total area of drying pits, was approximately 1 million cubic yards and 400 acres, respectively.

It was subsequently estimated that approximately 90% of the nutrient loads to Banana Lake were eliminated by the diversion of the wastewater treatment plant discharge and the dredging of organic lake sediments. Although trophic state and water quality in Banana Lake improved following the dredging project (see **Figures CS1-1 and CS1-2**), the observed improvements have generally been less than anticipated. In addition to water quality improvements, the fish community balance also shifted to a more sport fish (e.g., carnivorous vs. planktivorous) dominated population. Beginning in 1998, Banana Lake began inadvertently receiving a portion of the nutrient laden decant water from the Lake Hollingsworth project, a problem that was later corrected. It is likely that the high ambient phosphorus concentrations in the soils of the Banana Lake watershed are sufficient to maintain high algal productivity.

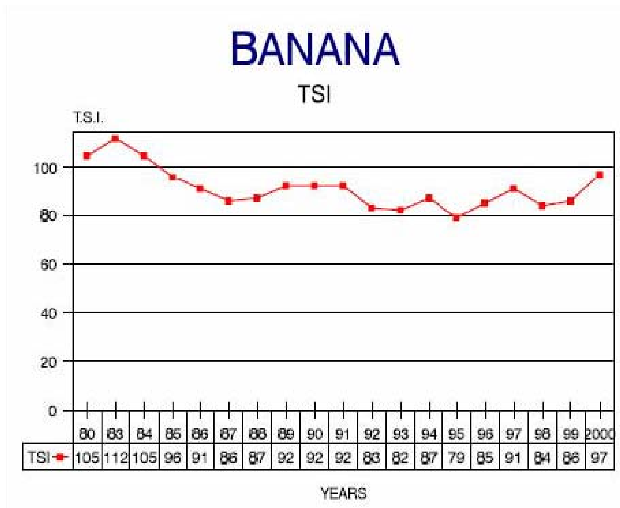

Figure CS1-1. Trophic Stat Index at Banana Lake

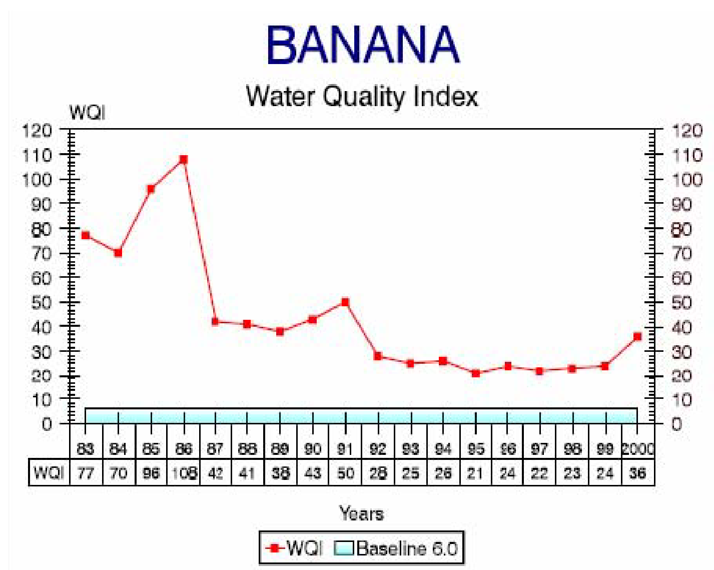

Figure CS1-2. Water Quality Index at Banana Lake

Lake Hollingsworth

Lake Hollingsworth is a 356 acre lake located within the City of Lakeland, Polk County. Lake water quality had been generally poor for many decades, with persistent algae blooms and low dissolved oxygen levels being the primary concern. Following implementation of several stormwater treatment projects water quality did not improve significantly, so the City of Lakeland contracted with BCI Engineers & Scientists to conduct a sediment removal feasibility study under the assumption that accumulated organic sediments in the lake were serving as a reservoir of nutrients and contributing to water quality problems. The BCI study was completed in 1995 and recommended hydraulic dredging of low density organic sediments combined with process treatment of the dredged slurry to separate the suspended solids. In 1996 project permitting was initiated, and a lake-side pilot test of the process treatment system was conducted.

In February of 1997 dredging was initiated with the dredge spoil being pumped to an adjacent site on which a temporary process treatment plant was constructed. The original design of the process treatment plant was modified several times as it failed to dewater the dredged material to an adequate percent solids to meet contractual requirements for trucking and disposal. Engineering problems with the process treatment plant included inefficient polymer dosing and mixing, and inadequate physical treatment of flocculated organics. In 2000, the plant was retrofitted with an earthen pit to be used as a clarifier for polymer dosing and mixing, combined with a system of evaporation/percolation lagoons comprising approximately 70-acres. This approach also failed primarily because the lagoons flooded prematurely due to inadequate percolation. In 2002, the treatment plant approach was scrapped, and the dredged spoil material was then pumped to the Holloway mine pits located on vacant lands approximately four miles from the plant site.

In March of 2001 the project was terminated due to low water levels in Lake Hollingsworth. Low water levels were attributed to both previous drought conditions and the limited amount of return water diverted back into the lake. The City of Lakeland estimated that at the time of termination the project was approximately 80 percent complete, with 2.96 million cubic yards of muck removed and 842,000 cubic yards remaining, and that a total of $12 million had been spent. This expenditure equates to a unit cost of $4.14/c.y. However, it should be noted that the engineering approach to this sediment removal project evolved from a sophisticated mechanical spoil dewatering system to a lagoon disposal alternative. Therefore, it is difficult to evaluate the overall cost-effectiveness of the project.

In 2003 the City of Lakeland conducted a whole lake alum treatment of Lake Hollingsworth with the objective of chemically sequestering remaining phosphorus reserves in lake sediments. In addition, the City implemented several stormwater treatment projects to reduce nutrient inflows. Upon refilling of the lake by average or greater annual rainfall depths, water quality improvements (e.g., Secchi disk depth and chlorophyll-a) have been observed; however, the lake trophic state index remains in the eutrophic to hyper-eutrophic range. Additional data collected by the City indicate that water quality and ecological conditions have improved significantly in response to lake dredging and alum treatment. Summary pre- and post-dredging data collected by the City of Lakeland in Lake Hollingsworth is detailed below. In addition to water quality, the City has reported a 10 percent increase in desirable aquatic vegetation as well as increases in both the abundance and diversity of benthic invertebrates (e.g., Shannon-Weaver Diversity Index increased from 1.04 to 1.60).

In summary, it is difficult to directly quantify the benefits associated with sediment removal in Lake Hollingsworth due to the multiple confounding effects of the dredging, stormwater treatment, and alum application projects, as well as recent climate change (e.g., increasing rainfall). Nonetheless, the net effect of these factors has clearly resulted in improved conditions in Lake Hollingsworth (**Figures CS1-3-14**).

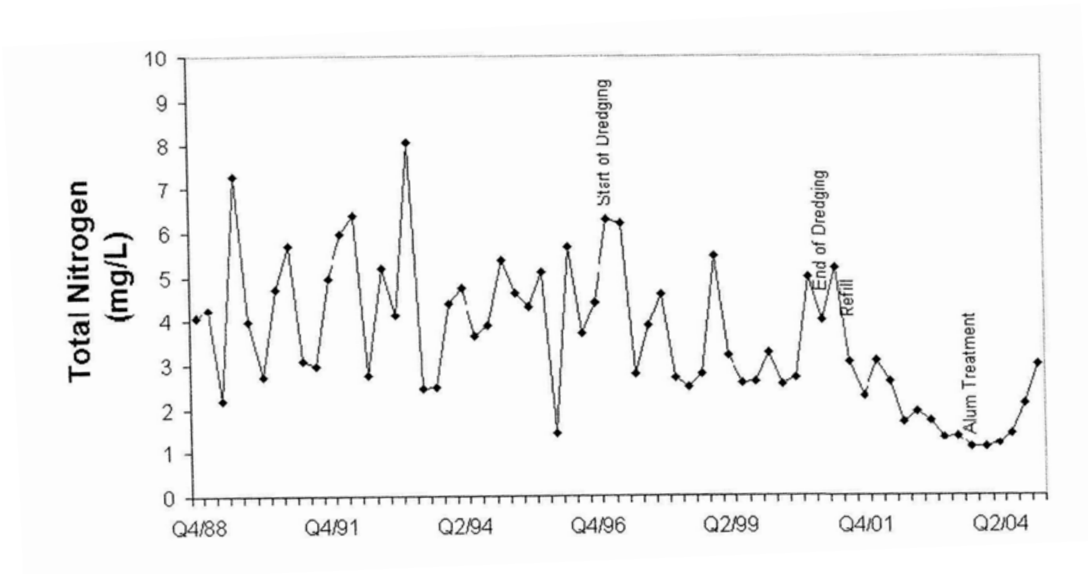

Figure CS1-3. Total Nitrogen at Lake Hollingsworth

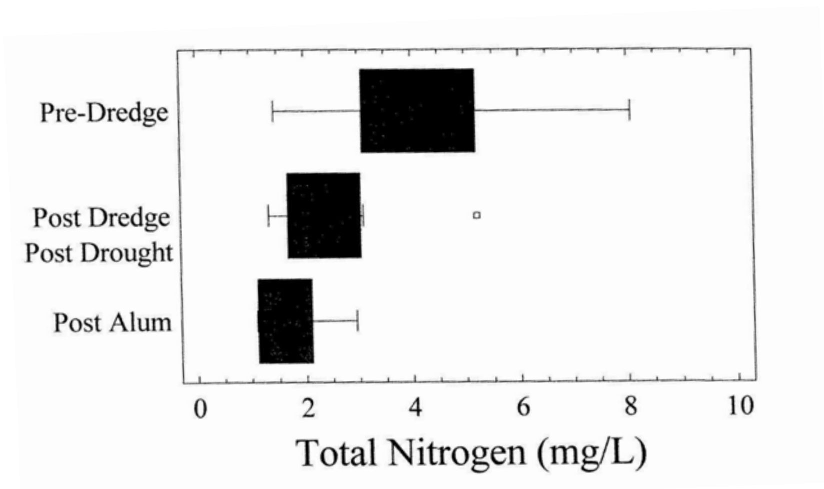

Figure CS1-4. Total Nitrogen concentration compared by restoration project at Lake Hollingsworth

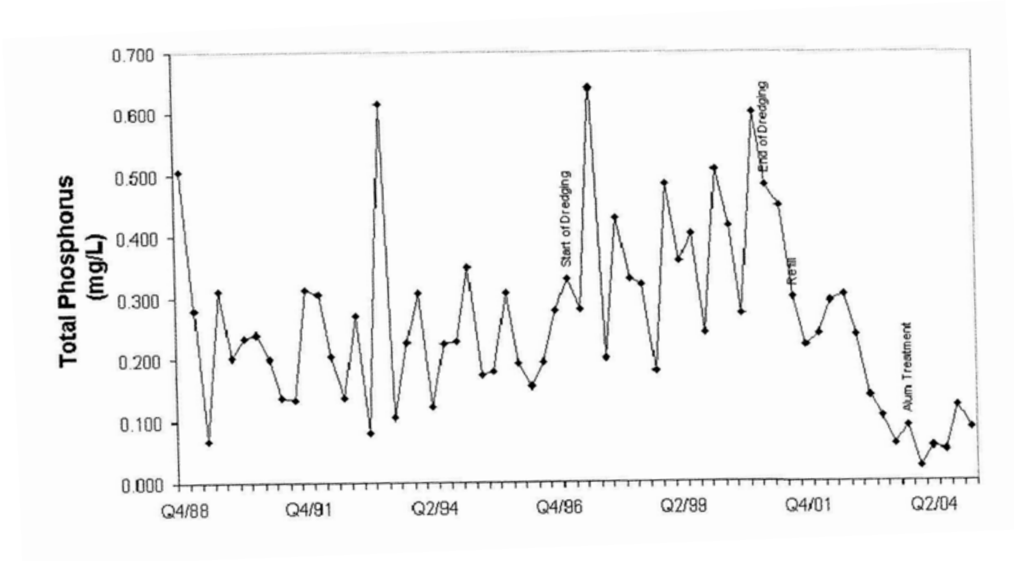

Figure CS1-5. Total Phosphorus at Lake Hollingsworth

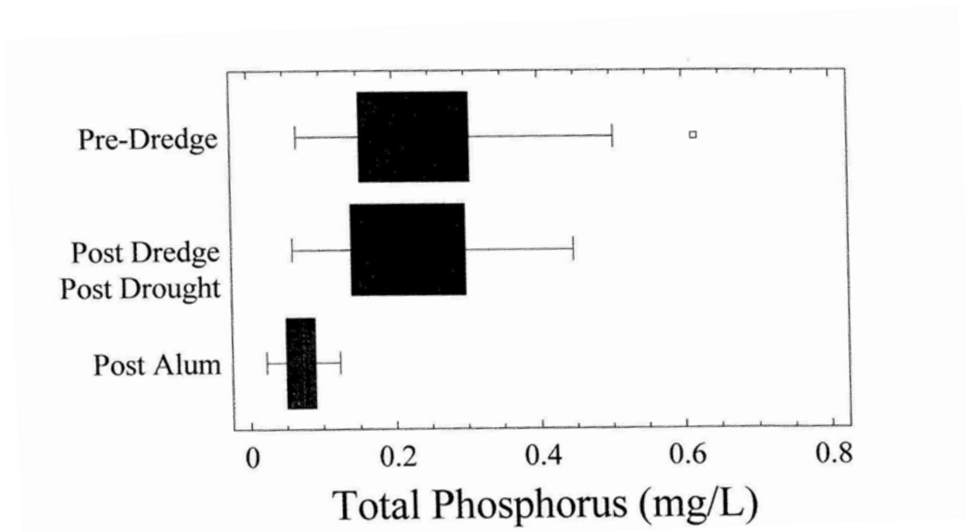

Figure CS1-6. Total Phosphorus Concentration Compared By Restoration Project At Lake Hollingsworth

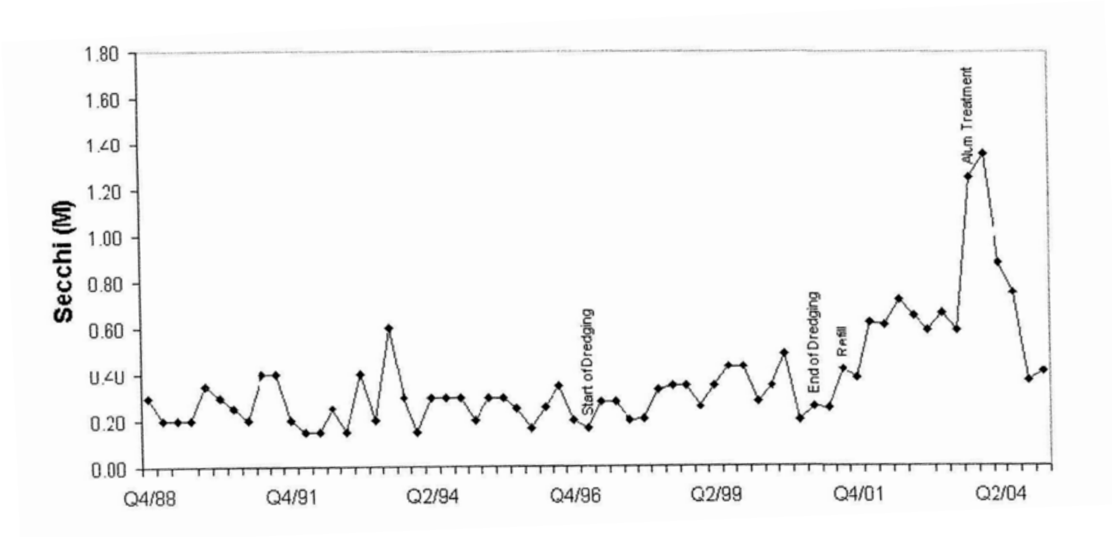

Figure CS1-7. Water Clarity at Lake Hollingsworth

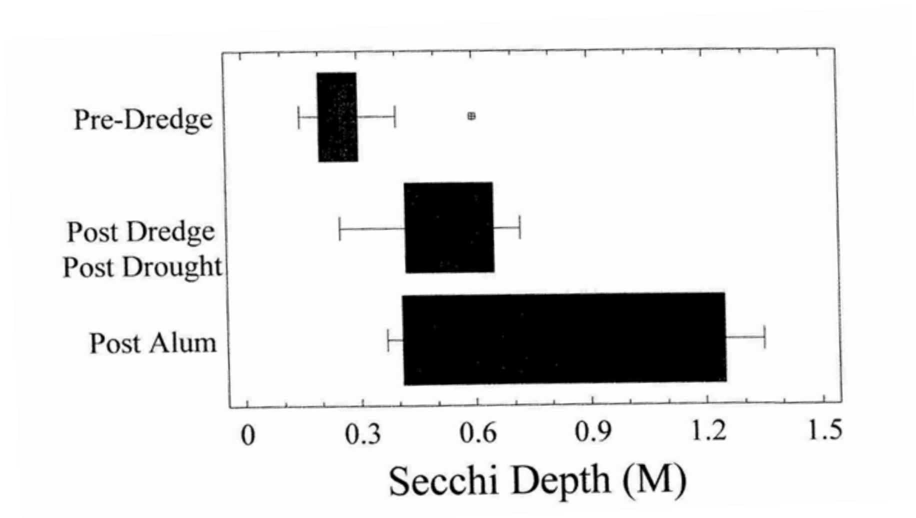

Figure CS1-8. Water Clarity Compared By Restoration Project At Lake Hollingsworth

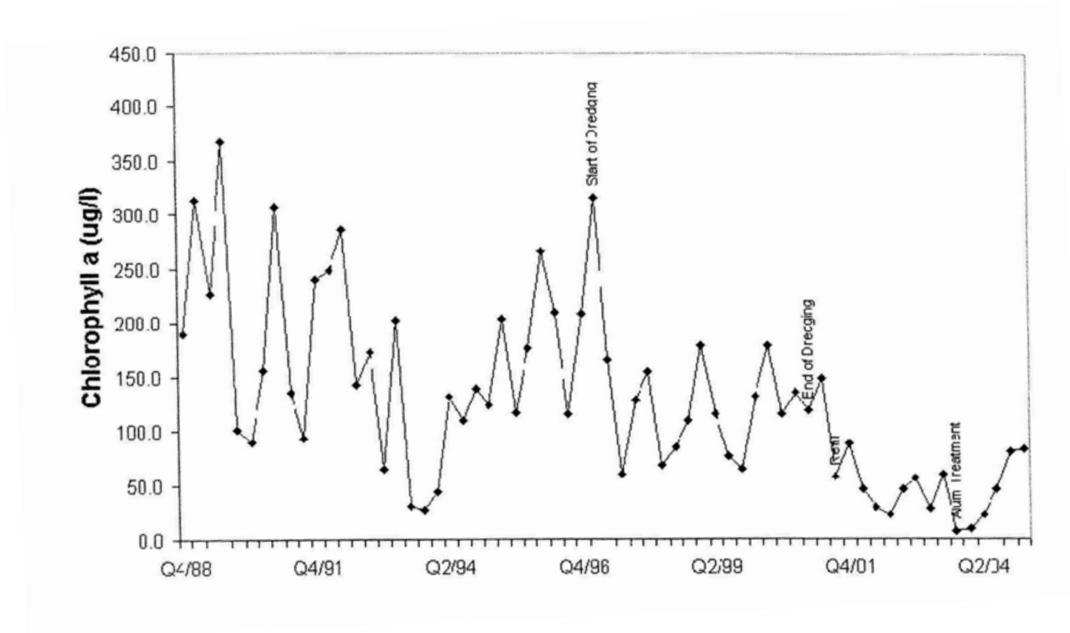

Figure CS1-9. Chlorophyll a at Lake Hollingsworth

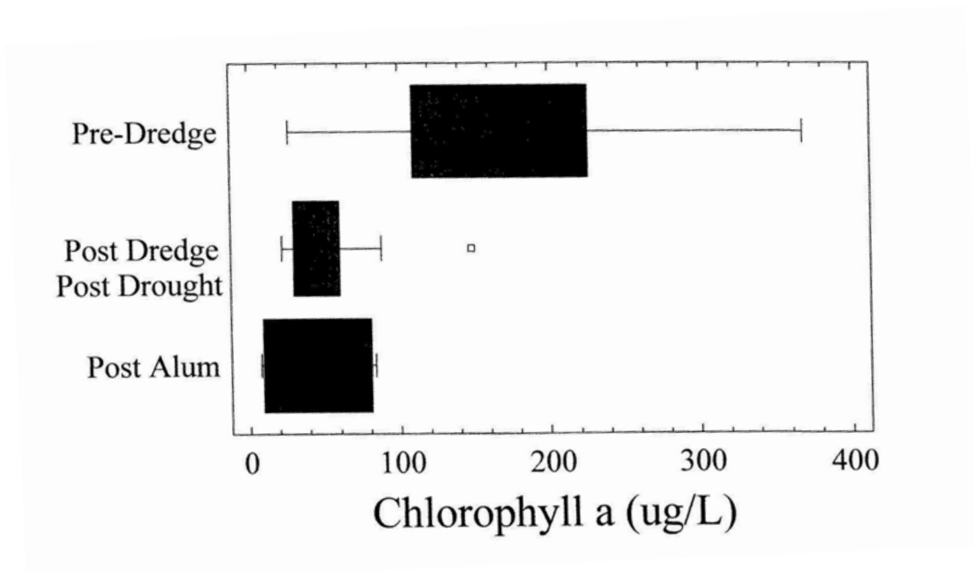

Figure CS1-10. Chlorophyll a concentration compared by restoration project at Lake Hollingsworth

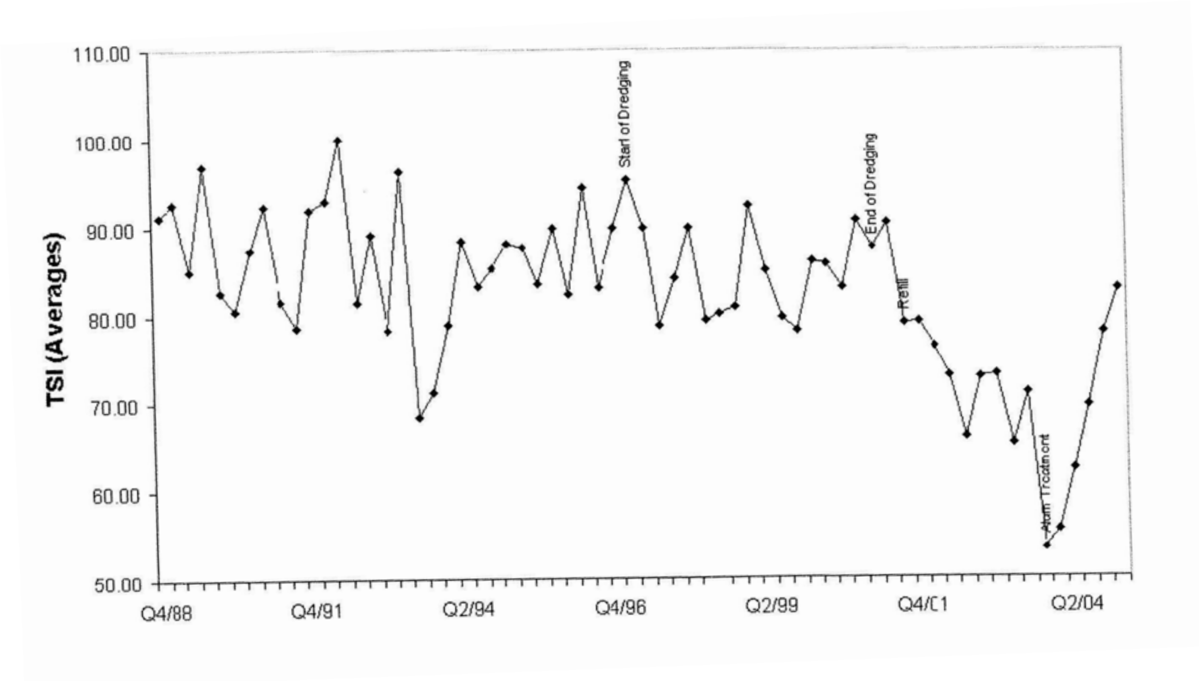

Figure CS1-11. Trophic State Index at Lake Hollingsworth

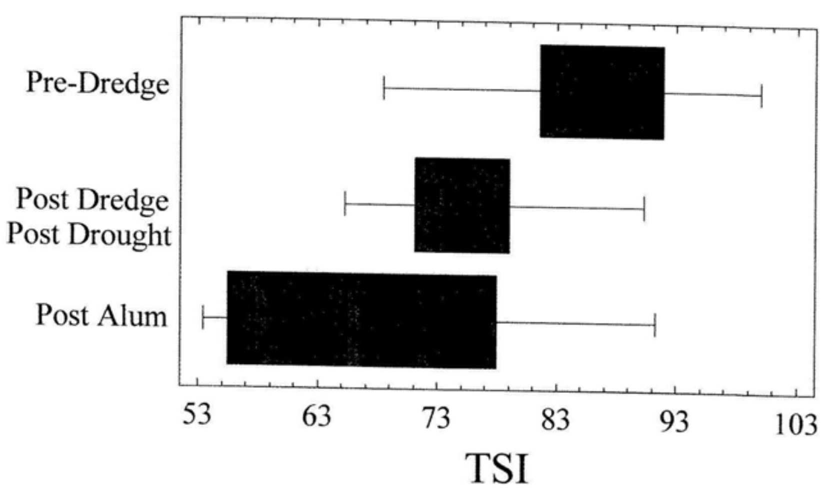

Figure CS1-12. Trophic State Index Compared By Restoration Project At Lake Hollingsworth

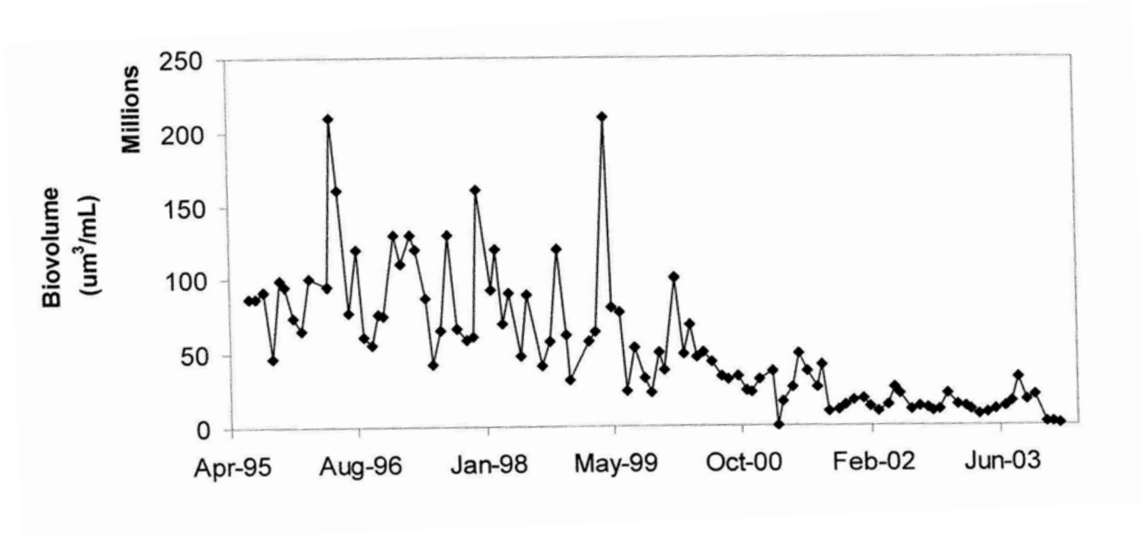

Figure CS1-13. Phytoplankton Biovolume at Lake Hollingsworth

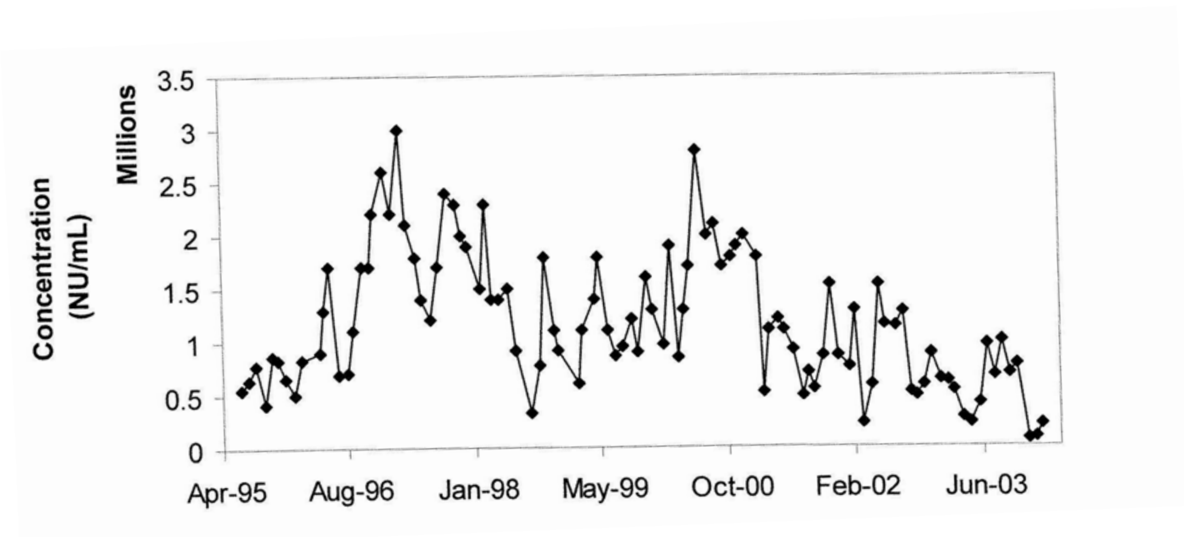

Figure CS1-14. Phytoplankton Concentration Compared By Restoration Project At Lake Hollingsworth

Lake Panasoffkee

Lake Panasoffkee is a very large (4,820-acres) lake located in rural Sumter County. Unlike many threatened Florida lakes, water quality in Lake Panasoffkee is generally very good, which is attributable to the substantial groundwater inflows into the lake from the Floridan aquifer. The threat to Lake Panasoffkee is the loss of desirable aquatic habitats for lake sport fish species. Since the 1940s, almost 800 acres, or 22 percent of the lake's area, has been lost due to sedimentation. Ironically, the groundwater inflow which keeps the lake's water quality high is also the major contributor to the sediment which is filling the lake. The groundwater carries large amounts of dissolved calcium carbonate. When the groundwater mixes with the lake water, the calcium carbonate solidifies, producing sediments which settle on the lake bottom covering fish-spawning areas. The apparent rate of sediment accumulation in Lake Panasoffkee has increased during the past two decades, possibly due to the impoundment of the hydrologic connection with the Withlacoochee River. These factors have combined to negatively impact the lake's fishery, promoting expanding shoreline vegetation and tussock formations, which in turn adversely impacts recreation and navigation. Unlike the other lakes discussed in this section, the calcium carbonate sediments in Lake Panasoffkee are very low in organic matter, with about 85 percent of the mass of unconsolidated sediments being inorganic material.

Due to concerns regarding sport fishery habitat loss, and recreational and navigational impacts, the Southwest Florida Water Management District (SWFWMD) initiated the design and permitting of a sediment removal project in 2000. The volume of sediment material to be removed from the lake was substantial (over 8 million cubic yards); however, upland disposal without any chemical treatment was always contemplated given the availability of large areas of vacant land adjacent to the lake and the low percent of organics and clay in the lake sediments. Because SWFWMD was the applicant, the Florida Department of Environmental Protection (FDEP) was responsible for State permitting of the project. In pre-application meetings, SWFWMD argued to the FDEP that the project was a habitat restoration project in the best interest of the public and the environment, and therefore should be permitted as a Notice General Permit (NGP). Even though the project was anticipated to involve the dredging of approximately 27 acres of submerged aquatic vegetation, the FDEP subsequently agreed with this assertion but required the SWFWMD to provide reasonable assurances that the project would not violate water quality standards, as Lake Panasoffkee is an Outstanding Florida Water. Such reasonable assurance would be required under a full Environmental Resource Permit; however, the time to process a NGP was significantly reduced over that likely required for an ERP. Since no flocculating chemicals were needed, return water back to the lake was permitted with a mixing zone. In addition, the U.S. Army Corps of Engineers also agreed with the classification of the project as habitat restoration, and issued their permit approval via a Nationwide 27 Permit. Had a full 404 Permit been required, consultation with other federal agencies and the public notice process would likely have extended the permitting timeframe significantly. All project permits were obtained within approximately one year.

The project design included hydraulic dredging of unconsolidated sediments, with spoil discharge directly to 450 acres of diked upland disposal areas composed of two primary drying cells and several smaller polishing cells. The project permits allow for treated return water back to the lake. The construction contract was awarded at an approximate cost of $2.76 per cubic yard of *in-situ* sediment removed, including the cost of all upland disposal area creation and maintenance. Approximately 8.2 million cubic yards of sediment are targeted for removal, and the total project budget is approximately $22.6 million. Construction of the upland disposal sites was initiated in 2002, and dredging was initiated in late 2003.

Lake Maggiore

Lake Maggiore is a 380 acre lake located in the City of St. Petersburg, Pinellas County. The lake has exhibited poor water quality and hyper-eutrophic conditions for at least the past two decades. Diagnostic feasibility studies conducted in the early 1990s identified accumulated organic sediments as a significant source of nutrients impacting water quality. In addition, the lake had accumulated so much silt that historic recreational uses had been effectively curtailed due to shallow water depths. As part of a multi-faceted restoration program, the City of St. Petersburg, in cooperation with SWFWMD, initiated the design and permitting of a sediment removal project in 1995. BCI Engineers & Scientists were hired to conduct a sediment removal feasibility study and to develop a conceptual design. BCI determined that approximately 2.3 million cubic yards of low density organic sediments should be removed from the lake.

Many project alternatives were considered; however, the recommended approach involved the filling of 34 acres of lake bottom and riparian wetlands with sand tailings generated from dredging, followed by the construction of upland drying pits on the 34 acres of created uplands. Hydraulic dredge spoil would then be pumped through a cyclone unit to remove sands, mixed with flocculating polymers, and then pumped into the pits where dewatering would occur via settling, evaporation and percolation. Upon settling, decant water would be pumped off and the settled solids would be physically removed from the pits, loaded into trucks and then disposed in the Toytown landfill and on the Sod Farm site. Upon completion of the project, the 34-acre drying pit area would then be restored to create an upland public park and recreational area for the City.

Regulatory permitting of the recommended alternative proved to be a challenge. The primary issue raised by both the U.S. Army Corps of Engineers and the FDEP was the proposed filling of 34 acres of lake bottom, which were determined by FDEP to be sovereign lands, and the eventual conversion of this area to an upland City park. In response to agency review comments the City and their consultants developed several modifications to the project as proposed in the original permit applications. The primary issue of concern was the restoration of the 34 acre drying pit area as functional riparian wetlands rather than an upland City park. In 1999 and 2000, respectively, the federal 404 Permit and the State Environmental Resource Permit were approved, requiring the drying pits to be restored back to wetlands.

The engineer's cost estimate for the project was $7-$8 million; however, when the project was let out to bid in 1999, the low bid for both dredging/treatment and disposal was $12.5 million. The City did not award the bid due to the cost discrepancy, and pursued additional funding from SWFWMD. In addition, based on discussions with bidders it was determined that project costs could be reduced if a process treatment system was incorporated into the bid package, and if disposal was pulled out as a separate bid item. Furthermore, it was recommended that the total volume of sediment to be removed be reduced to lower costs. The project was re-bid in August of 2001 with dredging and disposal as separate bid items. The low bid for dredging and treatment was $7.7 million, while the low bid for disposal via trucking was $4.8 million. The City awarded the bid for dredging to the low bidder with the requirement that they be responsible for obtaining any necessary permit modifications. In addition, the City determined that it would be more cost effective if disposal was performed using City trucks and personnel. The contractual requirement for the volume of sediments to be removed was reduced from 2.3 to 1.54 million cubic yards, and the permits were modified by the contractor to address minor wetland impacts and decant water discharges associated with the proposed process treatment plant.

The on-site process treatment plant was completed in June of 2004 and dredging began in September of 2004. The plant is essentially composed of three primary components:

1) a screening and cyclone unit to separate large debris, sand and other high density material; 2) a clarifier unit where polymer is mixed with the dredge spoil to flocculate low density organics; and 3) a series belt filter presses to compress and dewater the flocculated organics. Decant water from the belt filter presses is discharged into a polishing pond, which overflows into an existing 3-acre hardwood swamp along the lake shoreline. To date the plant has been operating fairly successfully at an average rate of about 2,000 cubic yards of dewatered muck per day. The dewatered muck, referred to as sludge or "cake", has been averaging approximately 25 percent solids. However, current data indicate that the cake contains a much higher fraction of sand than was anticipated, estimated at about 40 percent by weight. As of December 2005 the project was estimated to be approximately 50 percent complete, and the expected completion date was December of 2006. It should be noted that this project is the first lake sediment removal project in West Central Florida to demonstrate that a mechanical dewatering system can be successfully permitted and deployed.

In summary, the project summaries provided above indicate that organic sediment removal as a lake management tool represents many challenges, and project logistics and results are not always predictable. Nonetheless, the removal of nutrient laden organic sediments has been demonstrated to be a potentially powerful strategy in reducing lake eutrophication and related water quality problems, as well as improving lake aesthetics and recreational opportunities.

Lake Hancock

From PBSJ 2007, Preliminary Results from Sediment Removal Study at Lake Hancock.

Lake Hancock, with a surface area of approximately 4,550 acres, is the third largest lake in Polk County (ERD, 1999). The contributing watershed is approximately 131 square miles in size, for a watershed to open water ratio of 18:1. The major tributaries to Lake Hancock are the Banana Creek sub-basin (13,578 acres), the Lake Lena Run sub-basin (11,754 acres) and the North Saddle Creek sub-basin (49,034 acres). Lake Hancock has been characterized as having "poor" water quality, using the State of Florida's Trophic State Index (TSI), since at least 1970 (Polk County, 2005), and concerns over poor water quality in the lake have existed as far back as the 1950s (ERD, 1999). More recently, Lake Hancock's water quality was verified as impaired for nutrients using data collected between January 1997 and June 2004 (EPA, 2005). Levels of total nitrogen, total phosphorus and biological oxygen demand all exceeded the State of Florida's threshold screening values, all by considerable amounts (EPA, 2005). The poor water quality in Lake Hancock has resulted in a number of reports focusing on strategies to improve its condition.

Polk County and FDEP contracted PBS&J to complete an in-lake mesocosm experiment simulating sediment removal to assess the impact on water quality. An experimental design similar to that which was used to assess the value of sediment removal strategies for Lake Maggiore (in St. Petersburg) was conducted. In this approach, three pairs of 2 meter diameter aluminum rings were driven down through the water column, though the lake's organic sediments, and into the lake's underlying sand layer. A frame was extended from the bottom ring to above the lake's water level, and reinforced plastic was sewn into a hollow cylinder, and attached to the aluminum ring on the lake bottom, and also to a frame at the water surface. Of these pairs, one had its underlying layer of muck removed via a small suction dredge, with the other of the pair left as is. As in Lake

Maggiore, water from outside the tube was allowed to equilibrate with the water column within the tube, after excavation.

After removal of the muck layer, and equilibration of the overlying water columns, the water within these tubes was compared to each other, and to adjacent water undisturbed by these activities, to determine potential changes in water chemistry due to the lack of an underlying muck layer. To replicate the potential impacts of suspension of bottom sediments by wind action, both tubes were "mixed" with similar mixing actions (using a stirring paddle such as those used previously by the District for mixing water for sample splitting) until the tube with its muck layer still intact shows evidence of substantial resuspension of bottom sediments. Water samples were collected to determine differences in TN, TP, chlorophyll, etc. that were expected to occur for water masses with underlying muck sediments, as opposed to those where such sediments had been removed. This study will be conducted twice (wet season and dry season) at three locations throughout the lake. The dry season experiment was completed in December 2006, the wet season sampling is scheduled for May 2007.

Results from the first sampling period indicate a significant reduction in multiple water quality parameters under both mixed and not-mixed conditions (Table CS1-1). Chlorophyll a, TN, and TP decreased by 20-30% under not-mixed conditions.

Table CS1-1. Percent Change between Dredged and Undredged cylinders for both not-mixed and mixed conditions.

	Not-Mixed	Mixed
Chlorophyll a	-21	-31
N:P*	27	102
TKN	-20	-53
TN	-20	-53
SRP	-3	-20
TP	-37	-77
TSS	-34	-72
TSI	-3	-12
Turbidity	-40	-75
BOD	-12	-13

REFERENCES

The following technical references and information sources are cited in the above sections of this document.

Camp, Dresser and McKee, Inc. 1990. Proposal for Lake Seminole Modeling Study for SWFWMD. RFP 11-90.

Dames & Moore, Inc. 1992. Lake Tarpon aquatic weed harvesting and revegetation project. Final report submitted to the Southwest Florida Water Management District, Tampa, Florida.

Dieberg, F. and Scheinkman, MM. 1987. Contribution from nitrogen fixation (acetylene reduction) to the nitrogen budget of Lake Tohepekaliga (Florida). Hydrobiologia 154: 61-73.

Environmental Research & Design (ERD). 1994. Lake Maggiore restoration stormwater pre-treatment ponds/ alum treatment systems. Final report submitted to the City of St. Petersburg and the Southwest Florida Water Management District.

Environmental Research & Design (ERD). 1999. Lake Hancock water and nutrient budget and water quality improvement project . Prepared for SWFWMD.

Environmental Research & Design (ERD). 2005. Lake Seminole Regional Stormwater Treatment Facilities. Prepared forPinellas County Board of County Commissioners and Southwest Florida Water Management District.

FDEP. 1996. 1996 Water-Quality Assessment for the State of Florida. Section 305(b). Main Report. Florida Department of Environmental Protection.

Greening, H. and S. Doyon. 1990. Environmental and ecological effects of drawdown and enhanced fluctuation for Lake Apopka, Florida. Final report prepared for the St. Johns River Water Management District. Dames & Moore, Inc.

Gremillion, P.T., C.E. Mericas and H.S. Greening. 1988. Lake Okeechobee aquatic weed harvesting demonstration project. Final report prepared for the South Florida Water Management District, West Palm Beach, Florida.

Huber, W.C., P.L. Brezonik, J.P. Heany, R.E. Dickinson, S.D. Preston, D.S. Dwornik, and M.A. DeMaio. 1982. A classification of Florida lakes. University of Florida Water Resources Research Center. Publication No. 72. Gainesville, Florida.

Janicki Environmental (Monitoring Plan). 2003. A Design of A Surface Water Quality Monitoring Program for Pinellas County, Florida. Submitted to Pinellas County Environmental Resource Management Division.

Janicki Environmental, Inc., 2006. Tracking Chlorophyll-a and Light Attenuation in Tampa Bay: Application to 2005 Data: Final Report. Tampa Bay Estuary Program Technical Publication #02-06.

Levy, K. 2000. Isotope Studies. Pinellas County Department of Environmental Management.

PBS&J. 2006. Lake Seminole Sediment Removal Feasibility Study. Final task report submitted to the Pinellas County Board of County Commissioners.

PBS&J. 2001. Lake Seminole Watershed Management Plan. Final comprehensive report submitted to the Pinellas County Board of County Commissioners.

PBS&J, 1999. Lake Seminole Sediment Removal Feasibility Study. Final task report submitted to the Pinellas County Board of County Commissioners.

PCDEM. 2000. Ambient Surface Water Monitoring Report, Data Year 1991-1997.

Morrison, G., Sherwood, E., Boler, R., and J. Barron. 2006. Variations in Water Clarity and Chlorphyll a in Tampa Bay, Florida, in Response to Annual Rainfall, 1985-2004. Estuaries and Coast 28:926-931.

New York State Department of Environmental Conservation (NYSDEC). 1990. Diet for a small lake - a New Yorker's guide to lake management. Albany, NY.

Reddy, K.R. and T.A. DeBusk. 1987. State-of-the-art utilization of aquatic plants in water pollution control. Wat. Sci. Tech. 19(10): 61-79.

Schelske, C.L., M. Brenner, and T.J. Whitmore. 1991. Lake Seminole Sediment Characterization and Analysis. Final report prepared for the Southwest Florida Water Management District. University of Florida Department of Fisheries and Aquaculture. Gainesville, Fl.

Southwest Florida Water Management District. 1992. Lake Seminole Diagnostic Feasibility Study. Final report prepared for the Pinellas-Anclote River Basin Board. Brooksville, Fl.

Souza, S.J., J.D. Koppen, and R. Conner. 1988. Aquatic weed harvesting: a cost-effective means of improving the recreational, aesthetic and water quality conditions of Lake Hopatcong. Lake and Reservoir Management Vol. IV, North American Lake Management Society, Washington, D.C.

U.S. Environmental Protection Agency (EPA). 1990. Lake and Reservoir Guidance Manual. Second Edition 440/5-88-002. Washington, D.C.

Water & Air Research (WAR), Inc. 1999. Investigation of Biological Effects of Alum Treatment. Final report prepared for the St. Johns River Water Management District. Gainesville, Fl.

Table 1-1. Timeline of Events within Lake Seminole.

Year	Event
1945	Resolution to create freshwater lake
1956	Impoundment of an arm of Long Bayou
Late 1940's	weir constructed at north end of the lake
1957-1965	Long Creek was channelized
1963	Designated State Fish Management Area
1967	Construction of Lake Seminole Park
	18-inch diameter outfall pipe installed to connect three interconnected ponds.
Late 1960's	Fixed crest weir (6-ft NGVD) replaced with fixed curvilinear weir (5-ft NGVD)
1971	City of Largo Wastewater Treatment Plant closed
Mid-Late 1970's-	Lake Seminole classified as "Eutrophic" by USEPA
	Fixed crest weir construction at southern terminus of the Seminole Bypass Canal (3 ft NGVD)
1976	Lake Seminole Park expanded Construction of Seminole Bypass Canal
1987	Triploid Grass carp introduces
1989	Resolution 89-13: long term lake management program
1990's	Funding for Lake Seminole Diagnostic Feasibility Study
1992	$10 million cooperative agreement between SWFWMD and PCDEM Pinellas County begins water quality monitoring
Mid 1991-s	102nd Ave Bridge constructed over the central "narrows" portion of the Lake.
Mid-1990's	FFWCC stocks lake with Largemouth Bass-died
1999	Lake Seminole Sediment Removal Feasibility Plan
2001	Lake Seminole Watershed Management Plan completed
2002	Phase I- Habitat enhancement project by FFWCC (Organic sediment removal)
2003	Pinellas County adopts and implements Monitoring Plan by Janicki Environmental
2005	Pinellas County, the Southwest Florida Water Management District, and the Florida Fish and Wildlife Conservation Commission hosted the Lake Seminole Restoration and Recovery Public Meeting
2006	Lake Seminole Sediment Removal Feasibility Plan (updated)
	Lake level drawdown
	Phase II- FFWCC Habitat enhancement project. (organic sediment removed)
	Lake Clean-up (vegetation removal, replanting, drainage improvements, no wake zones implemented within 100ft of shoreline to restore native vegetation)
	FFWCC release 12,000 large mouth bass-successful
	Dog Leg Pond, St. Petersburg Junior College Pond and Pinellas County Pond 6 stormwater treatment facilities constructed and operational
2007-2009	Construction of enhanced stormwater treatment facilities
2009-2011	Sediment Removal

Table 1-2. Trophic State Index (TSI) for lakes and estuaries (from FDEP, 1996).

For lakes: 0-59 is good, 60-69 is fair, 70-100 is poor.
For estuaries: 0-49 is good, 50-59 is fair, 60-100 is poor.

Trophic State Index	Chlorophyll CHLA/ micrograms per liter (µg/1)	Total Phosphorus TP/ milligrams of phosphorus per liter (mgP/1)	Total Nitrogen TN/ milligrams of nitrogen per liter (mgN/1)
0	0.3	0.003	0.06
10	0.6	0.005	0.10
20	1.3	0.009	0.16
30	2.5	0.01	0.27
40	5.0	0.02	0.45
50	10.0	0.04	0.70
60	20.0	0.07	1.2
70	40	0.12	2.0
80	80	0.20	3.4
90	160	0.34	5.6
100	320	0.58	9.3

Table 1-3. Water budget for Lake Seminole calculated using 1997 data.

Inflows	cf	cfs	m^3	%
Direct Runoff (SWMM)	323,610,000	10.26	9,164,635	65.4%
Precipitation	168,013,404	5.33	4,758,140	33.9%
Surficial Aquifer	3,560,758	0.11	100,841	0.7%
TOTALS	**495,184,161**	**15.70**	**14,023,615**	**100.0%**
Outflows	**cf**	**cfs**	**m3**	**%**
Weir & Pipe Outflows	403,315,200	12.79	11,421,886	81.4%
Evapotranspiration	88,106,568	2.79	2,495,178	17.8%
Storage Loss	3,762,393	0.12	106,551	0.8%
TOTALS	**495,184,161**	**15.70**	**14,023,615**	**100%**
Lake Residence Time = 72 days				

Table 1-4. Total nitrogen (TN) budget for Lake Seminole calculated using 1997 data.

Inflows	lbs.	tons	kg	%
Direct Runoff (SWMM)	31,168	15.58	14,135	36.8%
Precipitation	4,487	2.24	2,035	5.3%
Surficial Aquifer	131	0.07	60	0.2%
Undetermined Sources*	48,805	24.40	22,138	57.7%
TOTALS	**84,591**	**42.30**	**38,366**	**100.0%**
Outflows	**lbs.**	**tons**	**kg**	**%**
Weir & Pipe Outflows	55,820	27.91	25,315	66.0%
Sedimentation**	28,772	14.39	13,051	34.0%
TOTALS	**84,591**	**42.30**	**38,366**	**100.0%**

* Calculated undetermined N sources = (sum of N outflows) - (sum of N inflows from direct runoff, precipitation and surficial aquifer).

** Calculated N sedimentation = [(sum of P inflows) - (sum of P outflows)] x (measured sediment TN:TP ratio of 7.09).

Table 1-5. Total phosphorus (TP) budget for Lake Seminole calculated using 1997 data.

Inflows	**lbs.**	**tons**	**kg**	**%**
Direct Runoff (SWMM)	6,467	3.23	2,933	96.2%
Precipitation	248	0.12	112	3.7%
Surficial Aquifer	9	0.00	4	0.1%
TOTALS	**6,724**	**3.36**	**3,049**	**100.0%**
Outflows	**lbs.**	**tons**	**kg**	**%**
Weir & Pipe Outflows	2,666	1.33	1,209	39.6%
Sedimentation*	4,058	2.03	1,840	60.4%
TOTALS	**6,724**	**3.36**	**3,049**	**100%**

* Calculated P sedimentation = (sum of the P inflows) - (weir & pipe P outflows).

Table 1-6. Major sub-basins with the highest integrated nonpoint source pollutant loads listed in order of decreasing priority.

Major Sub-basin	Drainage Area	%Total NPS Load	Priority Rank
3	654 acres	15%	1st
1	461 acres	14%	2nd
7	548 acres	12%	3rd
6	391 acres	12%	4th
2	478 acres	11%	5th

Table 2-1. Goals, targets and monitoring objectives for the Water Quality issue.

Goal(s)	Target(s)	Monitoring Objective(s)
The lake and its watershed shall be managed such that good water quality, according to Class-III State standards, is achieved and maintained in the lake	1. Attain a mean annual chlorophyll-a concentration of 30 ug/l or less.	1. Measure in-lake chlorophyll-a concentrations.
	2. Attain a mean annual multi-parametric TSI value of 65 or less.	2A. Measure in-lake TN and TP concentrations. 2B. Measure in-lake Secchi disk depths.
	3. Reduce current annual TP loads from external sources by 50%.	3A. Estimate mean annual loads of TP to Lake Seminole from priority sub-basins. 3B. Estimate mean annual loads of TP to Lake Seminole from groundwater seepage. 3C. Estimate mean annual loads of TP to Lake Seminole from atmospheric deposition.
	4. Annually calculate current water and nutrient budgets for Lake Seminole.	4. Estimate the mean mass of TN, TP, and water volume discharged from Lake Seminole.
	5. Maintain Class-III water quality standards for dissolved oxygen, pH, specific conductance and chlorides.	5A. Estimate the monthly frequency, duration, and magnitude of bottom dissolved oxygen concentrations in Lake Seminole that fall below the regulatory minima of 5.0 mg/l. 5B. Estimate for Lake Seminole: 1) the monthly trend in pH units; and 2) the frequency, duration, and magnitude that monthly pH varies by more than one unit above or below natural background levels. 5C. Estimate for Lake Seminole: 1) the monthly chloride concentration; and 2) the frequency, duration, and magnitude that monthly chloride concentrations exceed the background level by 10% or more. 5D. Estimate for Lake Seminole: 1) the monthly trends in specific conductance; and 2) the frequency, duration, and magnitude that monthly specific conductance exceeds 1,275 µmhos/cm.
	6. Attain an 80% TSS load reduction for all permitted MSSW facilities within the Lake Seminole watershed.	6. Determine the number of permitted MSSW facilities in the Lake Seminole watershed attaining an 80%TSS load reduction.

Table 3-1. Summary of recommended habitat restorations sites and projects in Lake Seminole and its watershed.

Site	Existing Habitat	Restoration/Enhancement Projects
Park Boulevard Site*	Oak and willow fringe with Brazilian pepper between the road and Lake Seminole	Remove Brazilian pepper, improve views to lake, extend existing shoreline and create a 6 to 1 littoral shelf, vegetate shoreline and littoral habitat in the lake.
Cross Bayou Little League Tract	Brazilian pepper fringe	Remove Brazilian pepper fringe, replant with appropriate vegetation.
Northern County-Owned Tract*	Brazilian pepper dominated areas, disturbed areas with castor bean and elderberry dominant cover, willow marsh along old creek	Remove Brazilian pepper and plant appropriate vegetation, clear and plant pines in central area, clear cattails and willows along creek and plant aquatic vegetation in littoral area. Controlled burn of pine flatwoods area.
Pinellas County Sheriff's Complex	Brazilian pepper dominated areas, drainage pond, and mature pine flatwoods	Remove Brazilian pepper and fill material, plant appropriate vegetation, improve pond to provide for treatment of stormwater, controlled burn in pine flatwoods.
102nd Avenue Bridge Area*	Willow dominant wetland area with jacaranda and Brazilian pepper	Remove exotic species and diversify the habitat with mixed hardwood plantings.
Lake Seminole County Park Pine Flatwoods Restoration	Air potato and grape vine within pine flatwoods	Develop and implement emergency control program in response to prolific growth of these two species in recent years.
Eagles' Nest Tract	Pine flatwoods	Recommend a controlled burn to revitalize pine flatwoods ecosystem and removal of Brazilian pepper from south property line.
Watershed-wide	Brazilian pepper	A cooperative program to remove Brazilian pepper from public and private property throughout the watershed.
Lake-wide*	Cattails and carolina willow	An ongoing cooperative program to establish more diverse, native aquatic vegetation communities in the lake littoral zone.

*In-lake habitat restoration projects.

Table 3-2. Potential stormwater BMP locations in the priority sub-basins.

Sub-Basin No.	Sub-Basin Area	Potential BMP Projects	Comments
3	654 acres	Alternative 3A - Alum injection with floc settling in an existing wet detention pond and/or an existing ditch/canal	Would treat 95% of basin land area; off-line or in-lake floc settling basins.
7	548 acres	Alternative 7A - Alum injection with floc settling in an existing ditch/canal.	Would treat 90% of basin land area; in-lake floc settling basin.
1	461 acres	Alternative 1A - Alum injection with floc settling in an existing ditch/canal	Would treat 80% of basin land area; in-lake floc settling basin.
2	478 acres	Alternative 2A - Alum injection with floc settling in an existing ditch/canal	Would treat 88% of basin land area; in-lake floc settling basin.
6	391 acres	St. Petersburg Junior College MSSW facility	Recently completed; treats about 22% of basin land area.
		Pinellas County Dog Leg Pond project	Recently completed; primarily a habitat restoration project.
		Pinellas County Pond 6 project	Design complete; will treat only 17% of basin land area; includes habitat restoration component.
		Alternative 6B - Re-routing of drainage to Pond 6 site with combined alum and wetland treatment	Would treat 93% of basin land area; potentially costly modifications to drainage network; FDOT permit coordination required.

Table 3-3. Summary Comparison of Project Alternatives.

Alternative	Project Duration	Permit-ability	Public Acceptance	Construct-ability	Estimated Cost	Conclusions
1	14 years	Very Low	Very Low	Very Low	$50.7 million	Not feasible due to logistical problems
2A	4 years	Very Low	Very Low	Very Low	$35.4 million	Not feasible due to permitting constraints
2B	4 years	Very Low	Very Low	Very Low	$38.7 million	Not feasible due to permitting constraints
3A	4 years	Moderate	Low	Low	$37.6 million	Not feasible due to lack of available land
3B	4 years	Moderate	Low	Low	$40.8 million	Not feasible due to lack of available land
4	2 years	High	High	Moderate	$10.1 million	Not feasible due to infrastructure limitations
5	2 years	Moderate	Moderate	Moderate	$27.6 million	Feasible but not cost-effective
6A	2 years	High	High	High	$13.9 million	Feasible – the preferred alternative
6B	2 years	High	High	High	$19.1 million	Feasible but cost savings not proven

Table 3-4. Tabular summary of target monthly lake levels under the recommended enhanced lake level fluctuation schedule.

Month	Target Lake Levels		
	Schedule A	Schedule B	Schedule C
January	4.8	4.8	4.8
February	5.0	5.0	5.0
March	5.0	5.0	5.0
April	5.0	5.0	5.0
May	4.4	4.4	4.4
June	3.2	3.4	3.8
July	4.4	4.4	4.4
August	4.8	4.8	4.8
September	5.0	5.0	5.0
October	5.0	5.0	5.0
November	4.8	4.8	4.8
December	4.4	4.2	4.6

Notes:

1. All elevations are given in feet NGVD.
2. Target lake level indicates the recommended water elevation to be attained on the first day of each month.
3. The proposed modified four-year lake level fluctuation schedule involves the sequential implementation of Schedules A,C,B,C... on a repeating four-year cycle.
4. Shaded rows indicate the months during which the three schedules differ.

Table 3-5. Mean Pollutant Efficiencies Achieved during Laboratory Jar Tests conducted on Stormwater Samples Collected in Lake Seminole watershed during November 2003-March 2004 (ERD 2005).

Sub-Basin	Parameter	10mg Al/liter
1	Total N	51
	Total P	91
	TSS	94
	BOD	0
2	Total N	33
	Total P	88
	TSS	83
	BOD	44
3	Total N	23
	Total P	67
	TSS	63
	BOD	34
6	Total N	22
	Total P	73
	TSS	73
	BOD	15
7	Total N	32
	Total P	90
	TSS	82
	BOD	64
Bypass Canal	Total N	19
	Total P	88
	TSS	65
	BOD	10

Table 3-6. Pollutant removal efficiencies for alum treatment systems (from Harper and Livingston, 1999).

Pollutant	Estimated Removal Efficiency
Total Nitrogen (TN)	50%
Total Phosphorus (TP)	90%
Biological Oxygen Demand (BOD)	75%

Table 3-7. LWWM simulation results for Management Action #1 - Regional Stormwater Treatment Facilities (BMPs).

BMP Combination (Sub-Basins)	NPS-TN Load Reduction (%)	NPS-TP Load Reduction (%)	NPS-BOD Load Reduction (%)	LWWM Modeled Chl A Reduction (mg/m^3)	LWWM Modeled Chl A Reduction (%)
1	5.65	11.97	6.19	0.9	1.43
2	3.93	8.96	4.33	0.6	1.00
3	7.04	17.32	8.54	1.6	2.52
7	2.43	7.19	3.35	0.4	0.58
1+2	9.57	20.93	10.53	2.0	3.17
1+3	12.69	29.29	14.73	2.8	4.44
1+7	8.08	19.17	9.54	1.8	2.81
2+3	10.97	26.27	12.88	2.4	3.87
2+7	6.36	16.15	7.68	1.4	2.28
3+7	9.47	24.51	11.89	2.3	3.58
1+2+3	16.61	38.25	19.07	3.8	6.06
1+2+7	12.01	28.13	13.88	2.7	4.29
1+3+7	15.12	36.48	18.08	3.5	5.58
2+3+7	13.40	33.47	16.23	3.2	5.02
1+2+3+7	19.05	45.44	22.42	4.4	7.04

Table 3-8. LWWM simulation components and results for Management Action #3 - Canal Diversion.

Management Action #3 Alternative	WASP Input File	Hydro-dynamic File	Non-point Source File	LWWM Modeled Chl A Reduction (mg/m^3)	LWWM Modeled Chl A Reduction (%)
3A	CanalA.inp	CanalA.hyd	98F.nps	4.7	7.44
3A1	CanalA1.inp	CanalA.hyd	98F.nps	9.6	15.2
3B	CanalB.inp	CanalB.hyd	98F.nps	0.3	0.46
3B1	CanalB1.inp	CanalB.hyd	98F.nps	8.8	13.98

Table 3-9. LWWM simulation components and results for Management Action #4 - Sediment Removal.

Management Action #4 Alternative	WASP Input File	Hydro-dynamic File	Non-point Source File	LWWM Modeled Chl A Reduction (mg/m^3)	LWWM Modeled Chl A Reduction (%)
4A	DredgeA.inp	Dredge.hyd	98F.nps	1.0	1.57
4B	DredgeB.inp	Dredge.hyd	98F.nps	8.2	13.01
4C	DredgeC.inp	Dredge.hyd	98F.nps	15.3	24.40

Table 3-10. LWWM simulation components and results for Management Action combinations.

Management Action Combination	WASP Input File	Hydro-dynamic File	Non-point Source File	LWWM Modeled Chl A Reduction (mg/m^3)	LWWM Modeled Chl A Reduction (%)
1	BMP1237.inp	98F.hyd	BMP1237.nps	4.4	7.04
2	Weir.inp	Weir.hyd	98F.nps	-1.9	-3.03
3	CanalA1.inp	CanalA.hyd	98F.nps	9.6	15.26
4	DredgeC.inp	Dredge.hyd	98F.nps	15.3	24.40
1+2	Mgt12.inp	Weir.hyd	BMP1237.nps	2.7	4.24
1+3	Mgt13.inp	CanalA.hyd	BMP1237.nps	12.7	20.19
1+4	Mgt14.inp	Dredge.hyd	BMP1237.nps	19.1	30.38
2+3	Mgt23.inp	Mgt23.hyd	98F.nps	7.6	12.08
2+4	Mgt24.inp	Mgt24.hyd	98F.nps	19.4	30.83
3+4	Mgt34.inp	Mgt34.hyd	98F.nps	25.3	40.22
1+2+3	Mgt123.inp	Mgt23.hyd	BMP1237.nps	10.7	17.01
1+2+4	Mgt124.inp	Mgt24.hyd	BMP1237.nps	23.7	37.75
1+3+4	Mgt134.inp	Mgt34.hyd	BMP1237.nps	28.5	45.31
2+3+4	Mgt234.inp	Mgt234.hyd	98F.nps	24.2	38.47
1+2+3+4	Mgt1234.inp	Mgt234.hyd	BMP1237.nps	27.4	43.56

Table 3-11 Confirmed Sources of Funding for Lake Seminole Restoration Projects

Contract Information		Funding Allocation by Source								
Contract #	**Contract Date**	**Total Project Cost**	**District**	**SWIM**	**City of Largo**	**City of Seminole**	**Pinellas Co**		**FFWCC**	**DEP 319(h)**
Weir Project #95CON00007 (P267)	12/20/1994	$315,312.72	$300,000.00				$15,312.72			
Creation Pond #95CON00008 (P267)	12/20/1994	$433,072.63	$433,072.63							
Barnett Property Purchase		$1,920,000.00					$1,920,000.00			
Creation Pond #95CON00008 – 3rd Amendment (P267)	1/1/2002	$75,353.00	$75,353.00							
Watershed Management Plan #95CON000040 (P267)	5/20/1996	$376,583.40	$301,266.72		$28,243.76	$47,072.93				
Dog Leg Pond #95CON000046 (P267)	2/7/1995	$263,950.84	$211,160.67			$52,790.17				
SPJC Pond #98CON000091 (P267)	2/14/2000	$711,937.21	$711,937.21							
Lake Seminole Aquatic Habitat Restoration 2 #05CON000033 (P109)	4/25/2005	$274,269.00	$137,134.50						$137,134.50	
Lake Seminole Aquatic Habitat Restoration 2 Post Drawdown Harvesting #05CON000033 (P109 phase 2)	Bd.Bk 02/2007	$140,000.00	$60,000.00				$80,000.00			
Lake Seminole Phase I Subbasin-1,3,6 Watershed Stormwater Pollution Reduction #02CON000072 (P902)	6/30/2002 8/30/2004	$2,900,000.00	$2,320,000.00				$80,000.00			$500,000 319H
Lake Seminole Phase II Subbasin-2&7 Watershed Stormwater Pollution Reduction #02CON000072 (P902)	Second Amendment not final	$1,780,000.00	$890,000.00				$890,000.00			$890,000.00 TMDL and Fed Appropriation
Lake Seminole Aquatic Habitat Restoration Excavate Organic Peat Sediment(P903)	9/30/2003	$398,977.32	$199,488.66						$199,488.66	
Long Bayou/Lake Seminole Bypass Canal Structural Comp. 2 #06OCS0000040 (W267)	8/10/2005 1/00/2007?	$1,113,742.00	$231,871.00	$231,871.00			$6,729,660.00	1		$650,000.00 319H
Park Blvd. Shoreline Restoration	Co. Complete 2006	$188,000.00				$28,000.00	$160,000.00			
Sediment Removal in Canals	Co. Complete 2006	$68,000.00					$68,000.00			
Lake Seminole Dredging Design and Permitting	Co. Request FY2008	$1,000,000.00	$500,000.00				$500,000.00	2		
Structural Component 6 Install Stage/flow Devices at Outfall Structure	Co. Complete 2006	$17,000.00					$17,000.00			
Property Purchase for Subbasin 3 Alum Treatment Facility Co. – Two Properties	Co. Purchased one Parcel Jan 2007 for $266,750 - 2nd in litigation	$533,500.00					$533,500.00	3		
	Project Totals	**$12,509,698.12**	$6,371,284.39	$231,871.00	$28,243.76	$127,863.10	$10,103,472.72	-	$336,623.16	$2,040,000

c Actual Expenses

Est Estimated Expenses

1 Estimated Operation Maintenance cost over 20 years

2 Proposed in FY2008 Coop. Fund Initiative

3 $266,750 actual purchase for 1st Property-2nd Property estimated cost

Table 3-12. Implementation schedule.

Phase I Components Pre-2007	Phase II Components 2007-2009	Phase III Components 2009-
Structural Component - Install Stage and Flow Measurement Instrumentation on the Lake Seminole Outfall Control Structure	*Structural Component* - Dredge Organic Silt Sediments from Submerged Areas	*Structural Component* - Excavate Organic Peat Sediments from Shoreline Areas
Legal Component - Adopt a Resolution Designating the Lake Seminole Watershed as a "Nutrient Sensitive Watershed"	*Structural Component* - Construct Enhanced Regional Stormwater Treatment Facilities in Priority Sub-Basins	*Structural Component* - Restore Priority Upland and Wetland Habitats (In-Lake Habitat Restoration and Enhancement)
Policy Component - Establish a Lake Seminole Watershed Management Area (WMA) through Amendments to the Pinellas County, and Cities of Largo and Seminole Comprehensive Plans	*Structural Component* - Divert Seminole Bypass Canal Flows to Improve Lake Flushing and Dilution	*Structural Component* - Restore Priority Upland and Wetland Habitats (Upland Habitat Restoration and Enhancement)
Public Education Component - Develop and Implement a Local Citizens LakeWatch Program for Lake Seminole	*Management Component* - Implement an Enhanced Lake Level Fluctuation Schedule	*Management Component* - Inactivate Phosphorus through Whole Lake Alum Applications (if warranted by monitoring results)
Compliance and Enforcement Component 1 - Expand and Enforce Restricted Speed Zones on Lake Seminole	*Management Component* - Improve Treatment Efficiency of Existing Stormwater Facilities	*Management Component* - Mechanically Harvest Nuisance Aquatic Vegetation
Structural Component - Install Stage and Flow Measurement Instrumentation on the Lake Seminole Outfall Control Structure	*Legal Component* - Strengthen and Standardize Local Ordinances for Regulating Stormwater Treatment for Redevelopment in the Lake Seminole Watershed	*Management Component4* - Biomanipulate Sport Fish Populations - Phase III (Enforce Catch & Release)
Public Education Component - Develop and Implement a Comprehensive Public Involvement Program for the Lake Seminole Watershed		
Management Component - Biomanipulate Sport Fish Populations - Phase I (Rough Fish Removal)		
Management Component - Biomanipulate Sport Fish Populations - Phase II (Sport Fish Stocking)		
Dark shaded cells indicate completed projects	Lightly shaded cells indicate current projects	

Table 4-1. Pinellas County Water Quality Monitoring Schedule 2007 (prepared Dec 11, 2006)

Sampling Period	Sampling Date	Western Crew Destination	Western Start Time
1	1/17/2007	SB and SA	Afternoon
2	2/20/2007	SB and SA	Afternoon
3	4/9/2007	SB and SA	Afternoon
4	5/23/2007	SB and SA	Morning
5	6/13/2007	SA and SB	Afternoon
6	8/7/2007	SA and SB	Morning
7	9/12/2007	SA and SB	Morning
8	10/25/2007	SB and SA	Morning
9	12/4/2007	SB and SA	Afternoon

Table 4-2. 2007 Lake Seminole Sampling Stations.

STRATA	LATITUTDE	LONGITUDE	SITEID	SITENAME	STRATA	LATITUDE	LONGITUDE	SITEID
SA	27.872644	-82.777619	SA -A-7-1	1A	SB	27.864164	-82.779380	SB -A-7-1
SA	27.873566	-82.776812	SA -B-7-1	1B	SB	27.840180	-82.779801	SB -B-7-1
SA	27.877137	-82.776281	SA -A-7-2	2A	SB	27.843598	-82.782720	SB -A-7-2
SA	27.875199	-82.777488	SA -B-7-2	2B	SB	27.852381	-82.779106	SB -B-7-2
SA	27.881385	-82.775812	SA -A-7-3	3A	SB	27.859810	-82.779756	SB -A-7-3
SA	27.886813	-82.776906	SA -B-7-3	3B	SB	27.846320	-82.778845	SB -B-7-3
SA	27.885740	-82.774746	SA -A-7-4	4A	SB	27.844376	-82.779097	SB -A-7-4
SA	27.879567	-82.776148	SA -B-7-4	4B	SB	27.841498	-82.783234	SB -B-7-4
SA	27.881941	-82.775395	SA -A-7-5	5A	SB	27.858452	-82.780739	SB -A-7-5
SA	27.881360	-82.777020	SA -B-7-5	5B	SB	27.851090	-82.779837	SB -B-7-5
SA	27.872552	-82.778451	SA -A-7-6	6A	SB	27.845241	-82.781345	SB -A-7-6
SA	27.877012	-82.772714	SA -B-7-6	6B	SB	27.863634	-82.781331	SB -B-7-6
SA	27.877813	-82.774992	SA -A-7-7	7A	SB	27.852095	-82.778218	SB -A-7-7
SA	27.878686	-82.776581	SA -B-7-7	7B	SB	27.843893	-82.782948	SB -B-7-7
SA	27.878431	-82.773895	SA -A-7-8	8A	SB	27.861073	-82.779766	SB -A-7-8
SA	27.884931	-82.773747	SA -B-7-8	8B	SB	27.854582	-82.779244	SB -B-7-8
SA	27.878862	-82.776888	SA -A-7-9	9A	SB	27.852124	-82.782230	SB -A-7-9
SA	27.882574	-82.775994	SA -B-7-9	9B	SB	27.861147	-82.782387	SB -B-7-9

Table 4-3. Indicators collected at each sampling site (From Monitoring Plan, 2003).

Water Quality Indicators	Explanatory Indicators
Water Temperature	Water Depth
Conductivity	Tide Stage (perhaps at a nearby location)
Dissolved Oxygen Concentration	Streamflow (of nearby hydrologic inputs)
Chlorophyll-*a* Concentration	Time of Sample Collection
Ammonia	Date of Sample Collection
Nitrite-Nitrate	Insolation
Total Kjeldahl Nitrogen	Cloud Cover
Total Phosphorous	Bottom Type Classification
Orthophosphate	Wind Direction and Speed
Secchi Disk Depth	Wave Height
Photosynthetically Active Radiation (PAR)	
PAR Attenuation	
Turbidity	
Total Suspended Solids	
Color (for lakes only)	
PH	

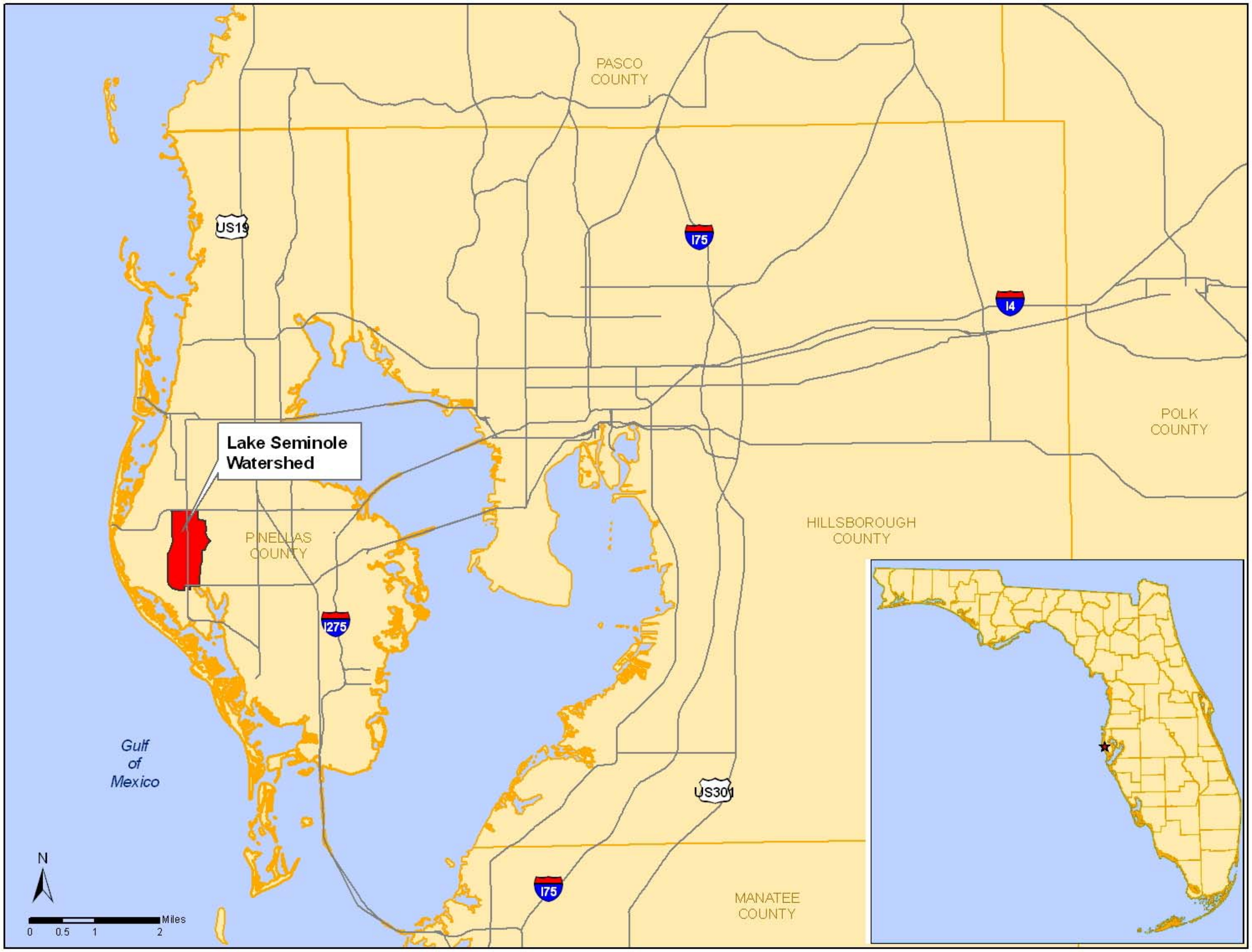

Figure 1-1. Location of Lake Seminole Watershed.

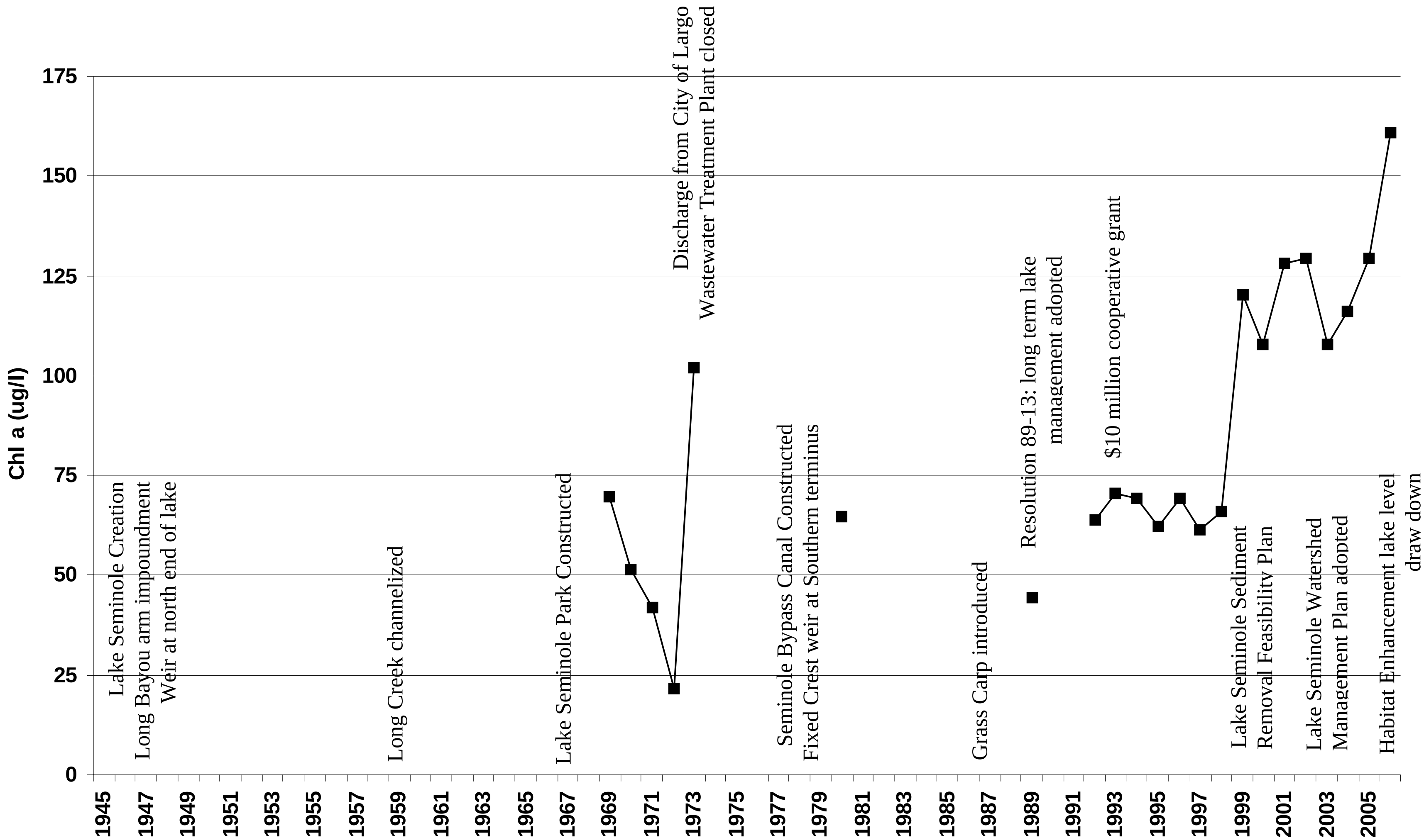

Figure 1-2. Timeline of Major Events in Lake Seminole and annual chlorophyll-a values.

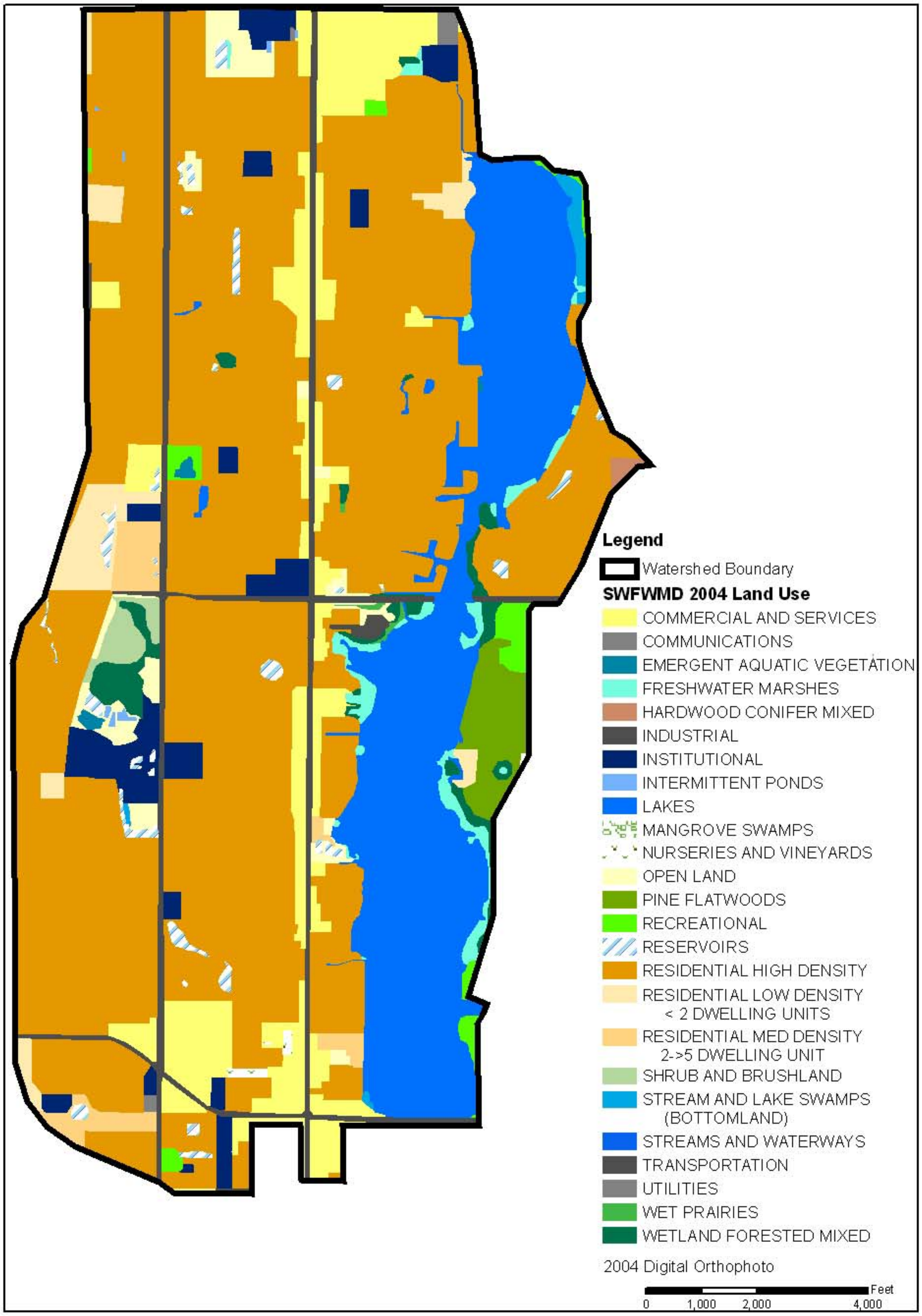

Figure 1-3. Current (2004) land use in the Lake Seminole Watershed.

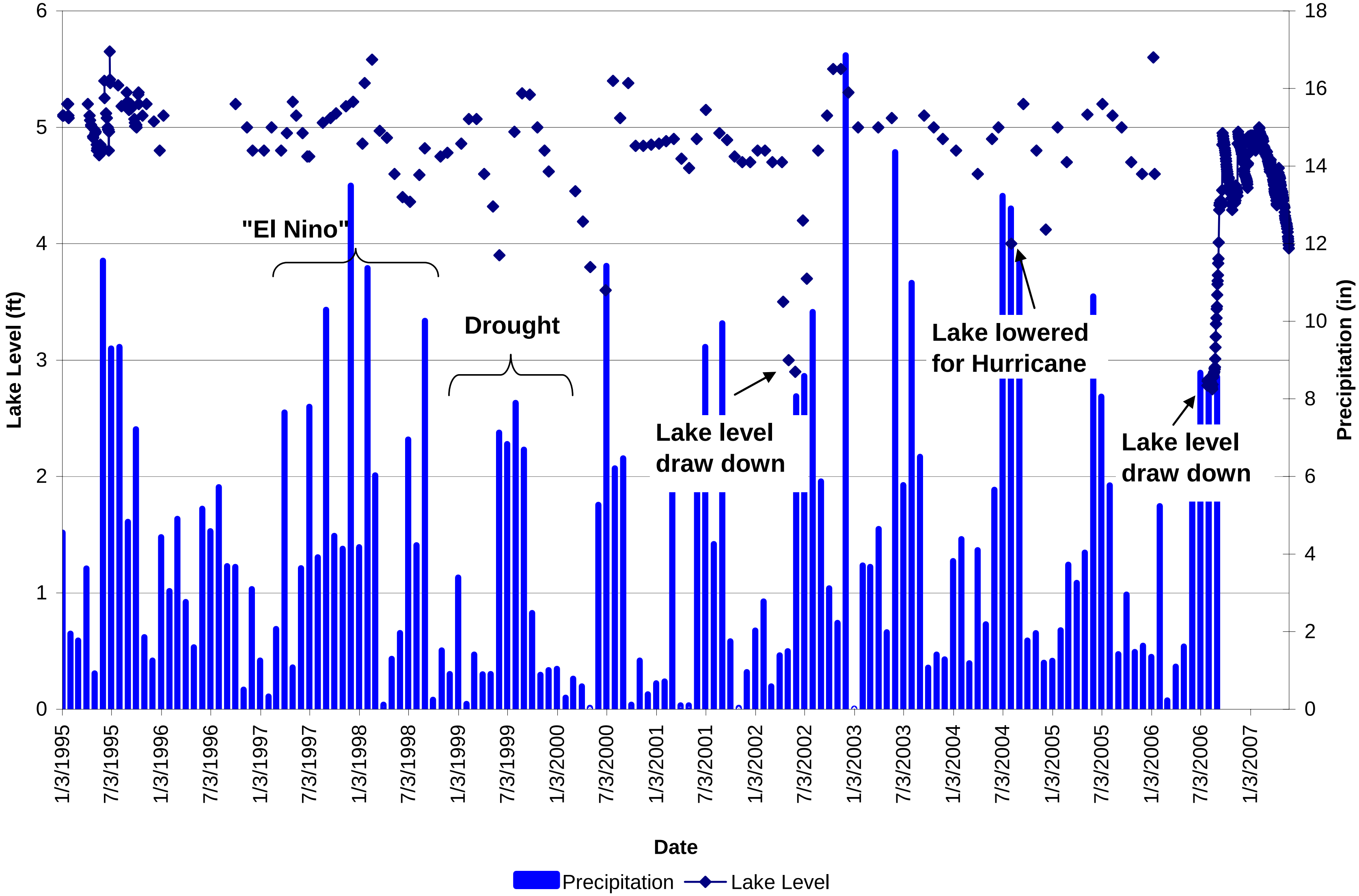

Figure 1-4. Lake Seminole Water Level from January 1995 to May 2007 and monthly Precipitation (SWFWMD).

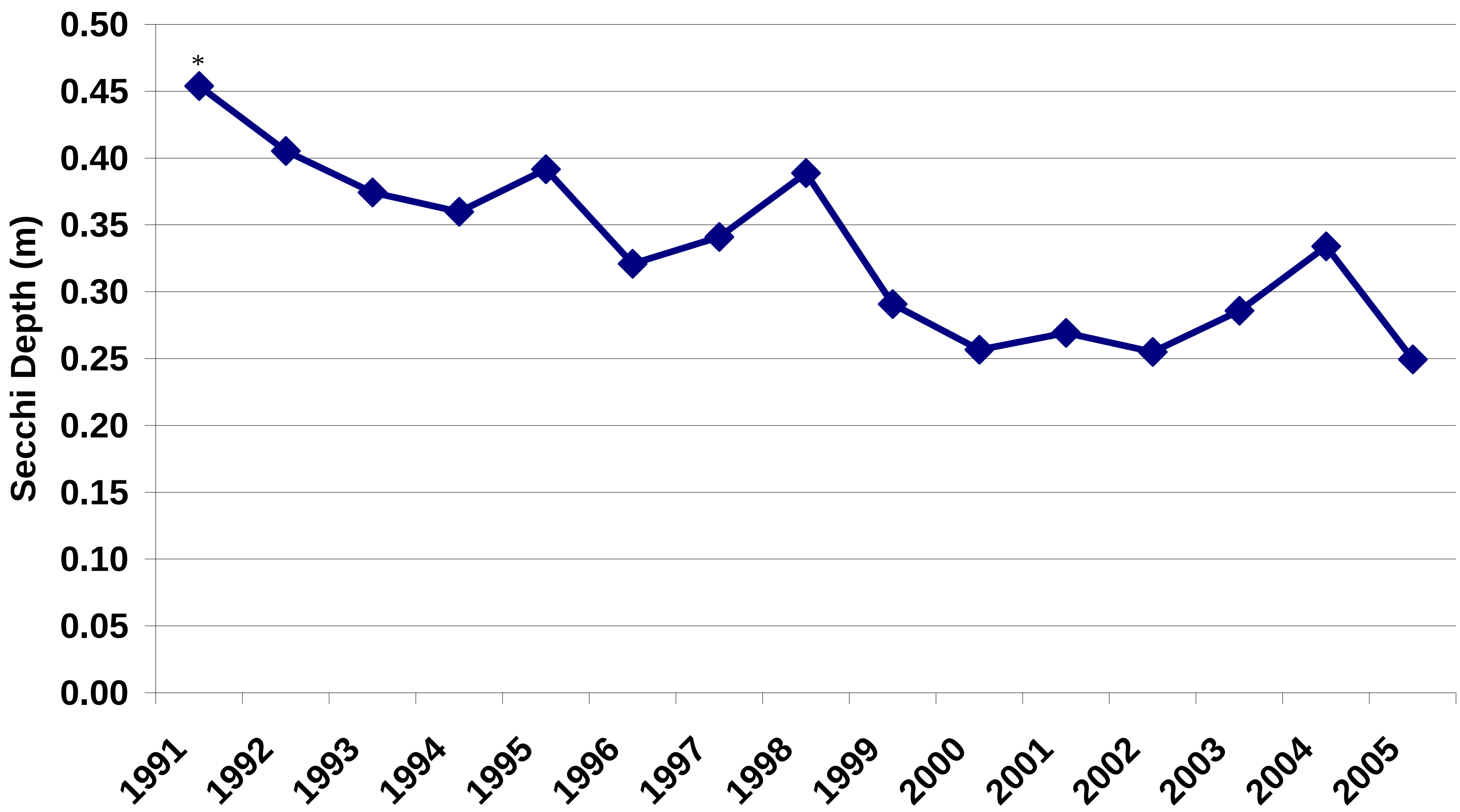

Figure 1-5. Trend in Lake Seminole annual average Secchi disk depths (*missing data for some seasons).

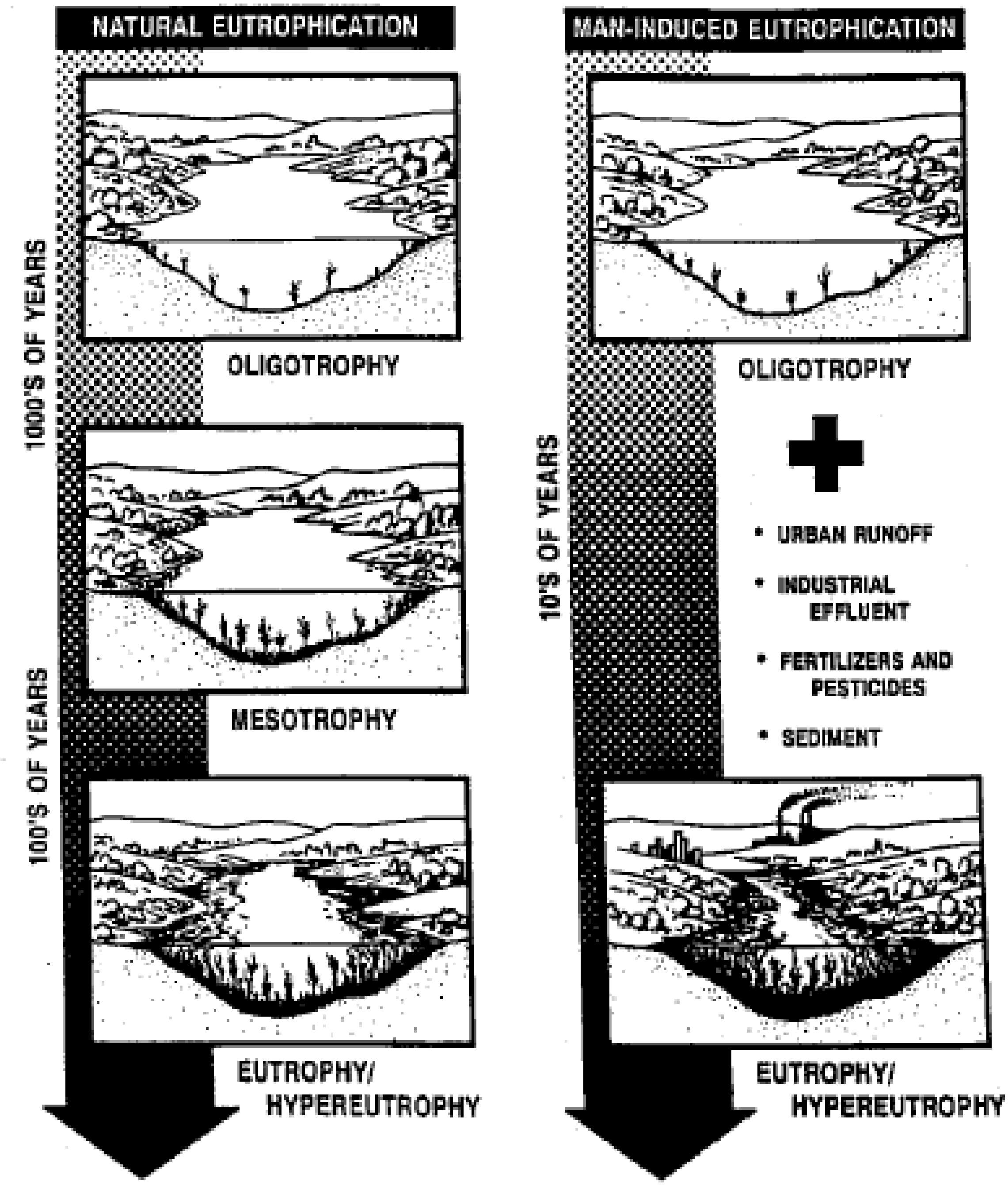

Figure 1-6. Natural vs. cultural (human-induced) eutrophication.

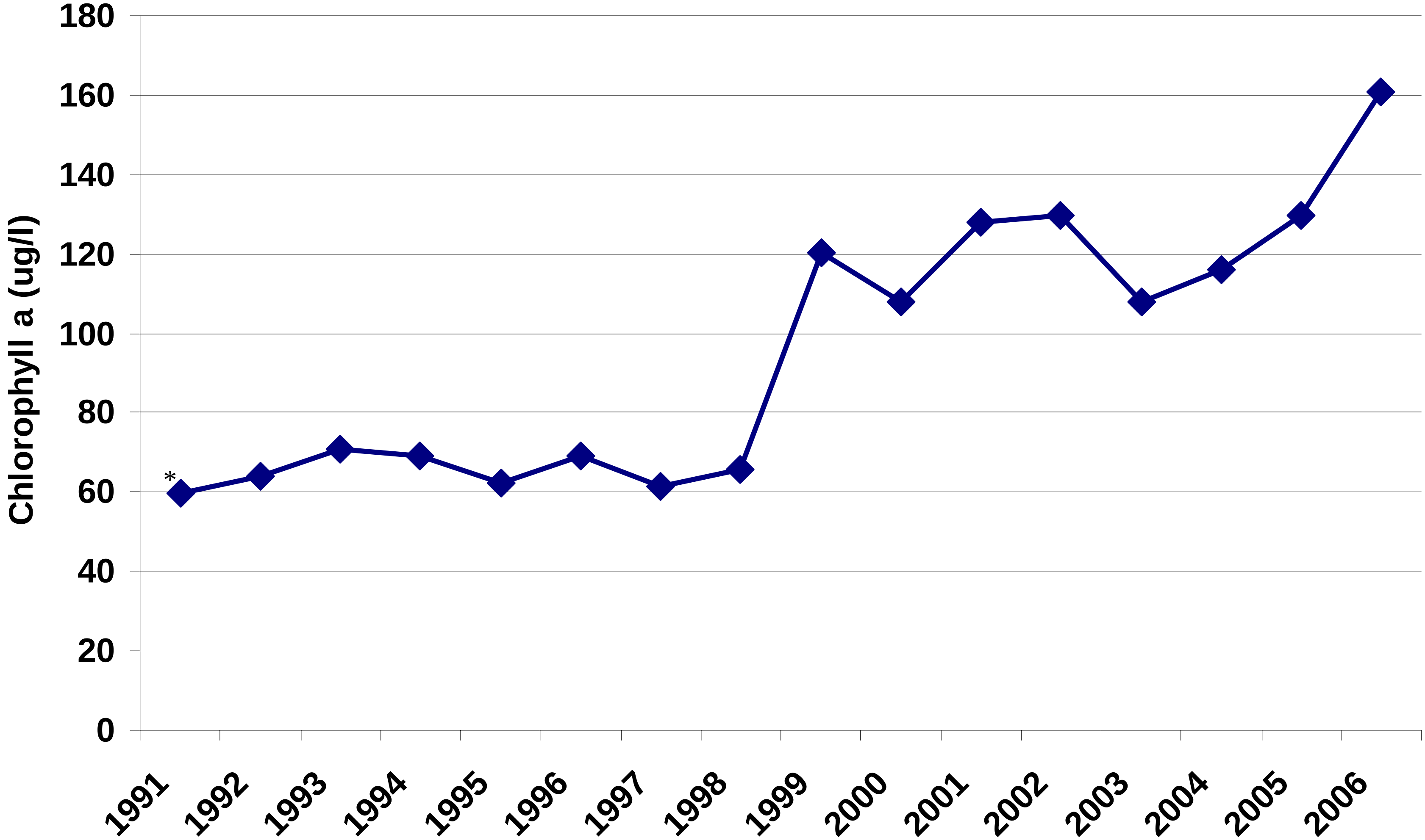

Figure 1-7. Trend in Lake Seminole annual average chlorophyll-a concentrations (*missing data for some seasons).

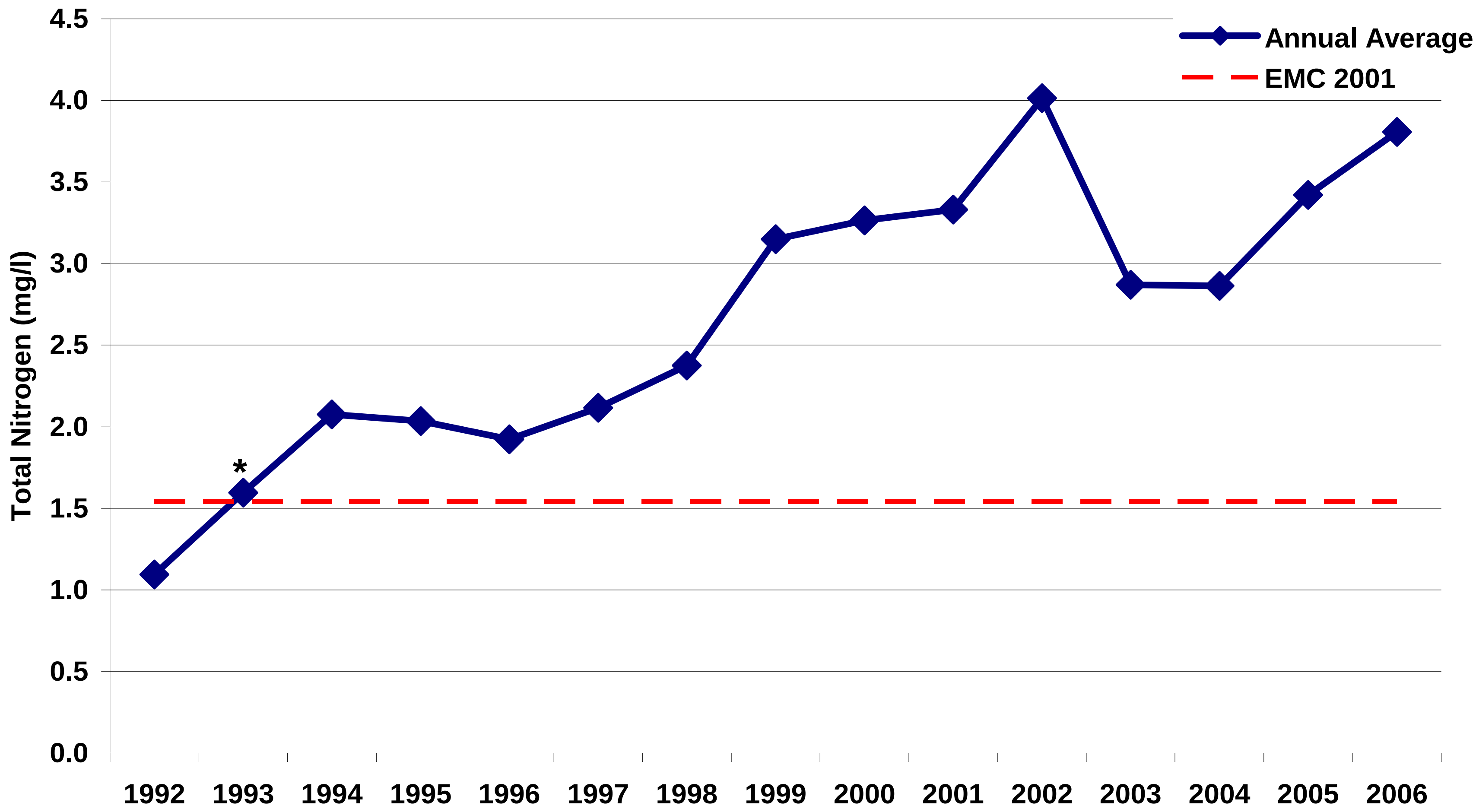

Figure 1-8. Annual Average Total Nitrogen in Lake Seminole and flow-weighted direct runoff calculated in 2001. (*missing data for some seasons).

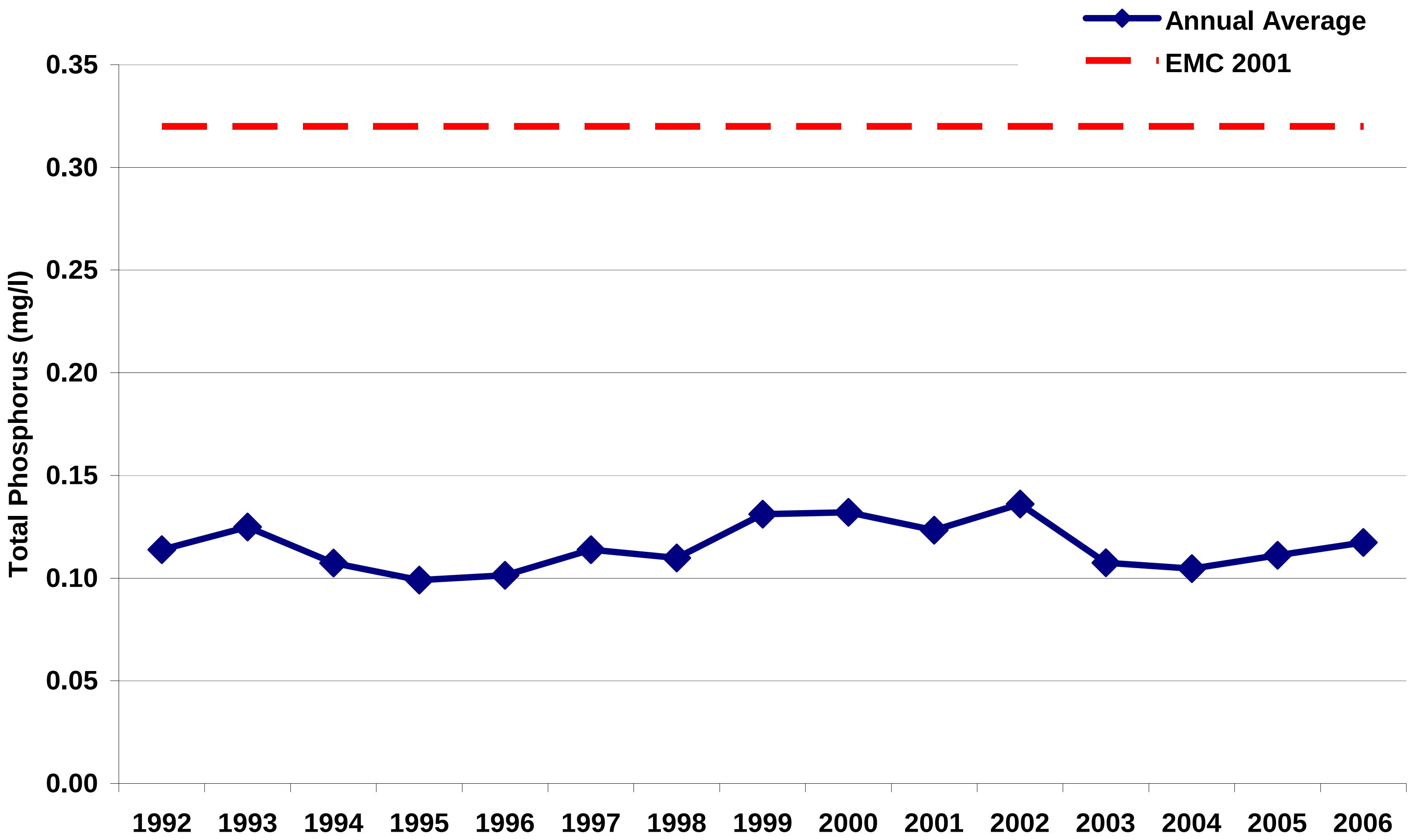

Figure 1-9. Annual Average Total Phosphorus in Lake Seminole and the flow-weighted direct runoff calculated in 2001.

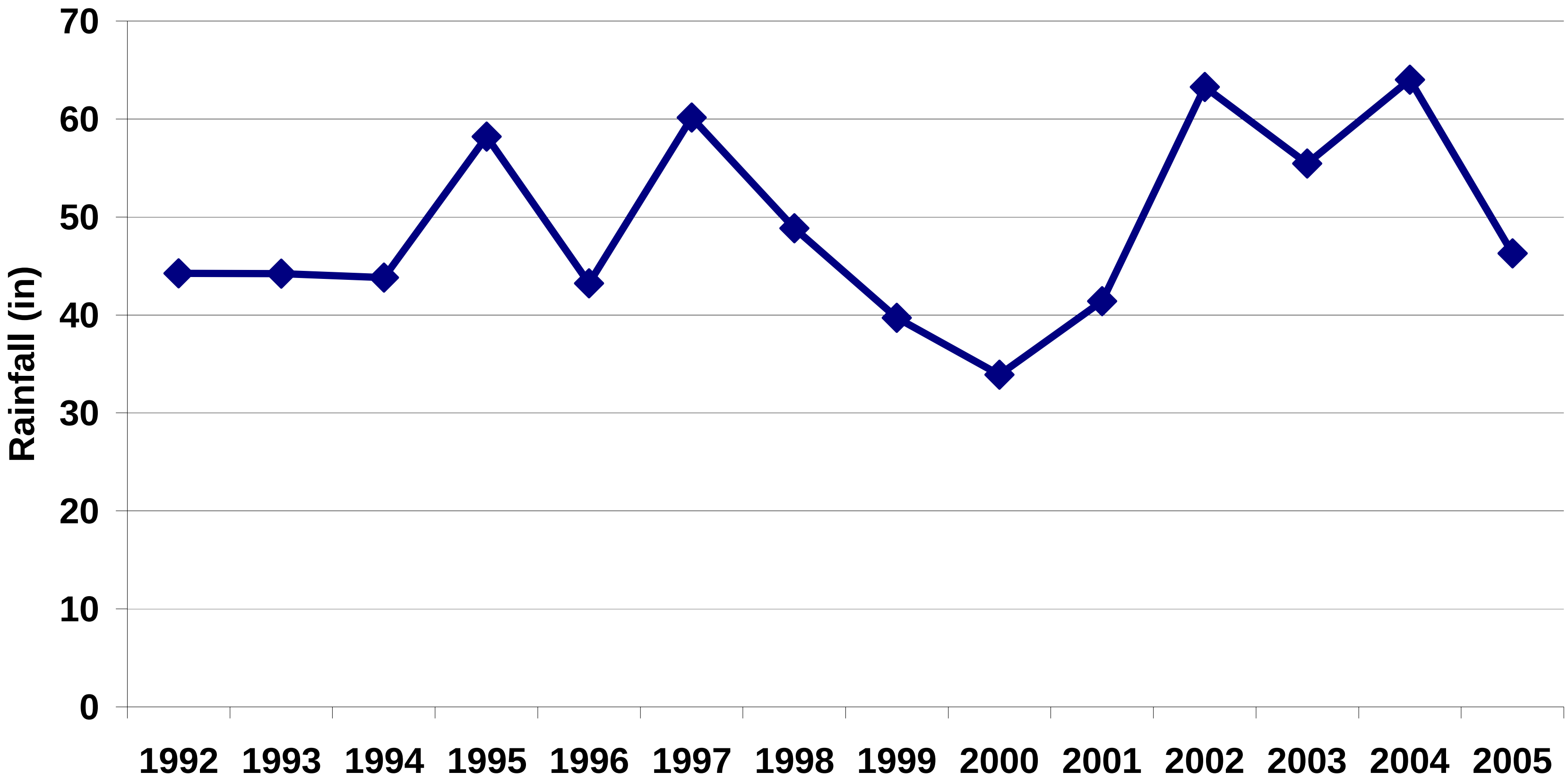

Figure 1-10. Trend in annual rainfall totals in the Lake Seminole watershed (SWFWMD).

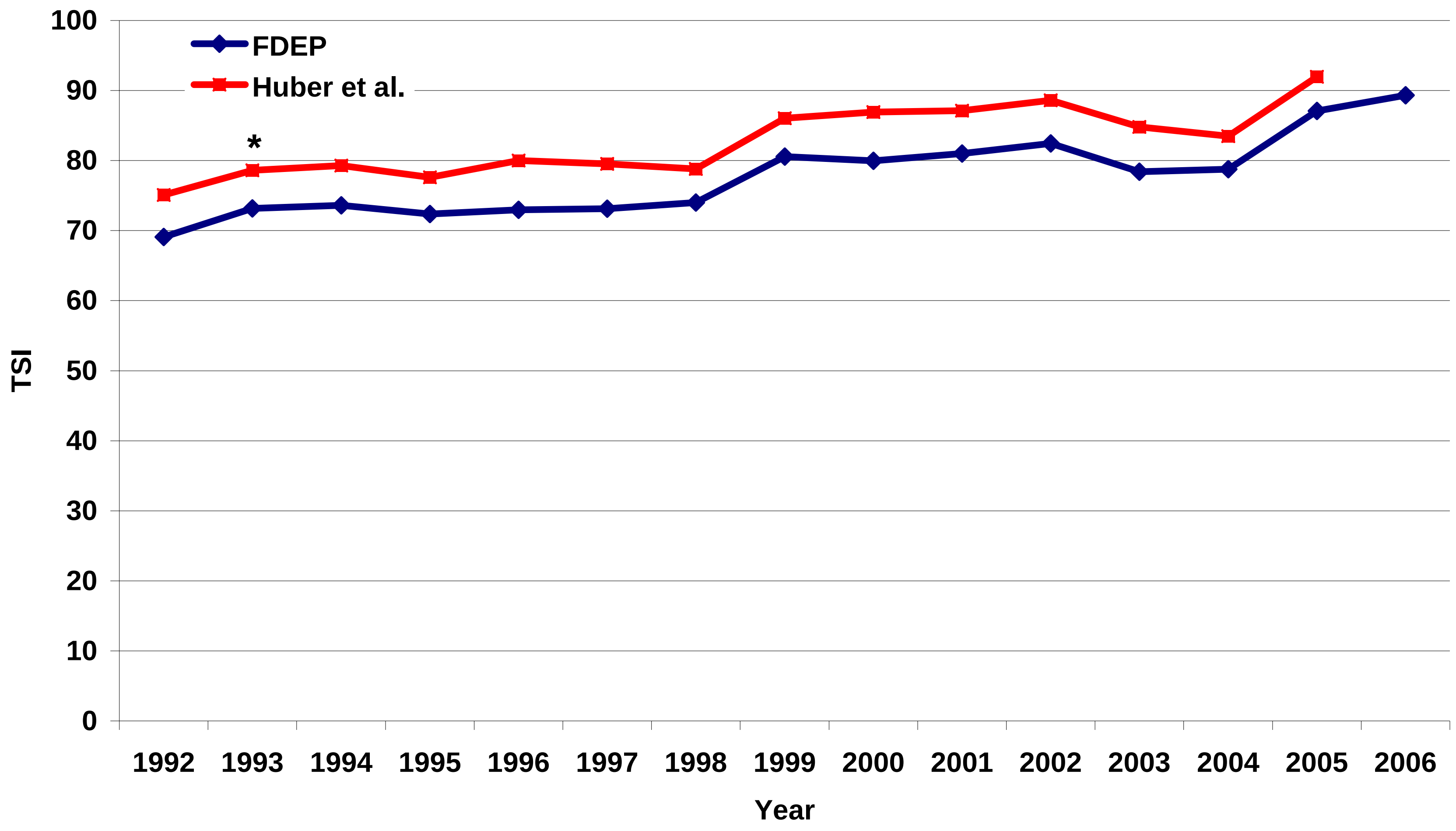

Figure 1-11. Comparison of TSI calculation methods for Lake Seminole (*-missing TN data for some seasons).

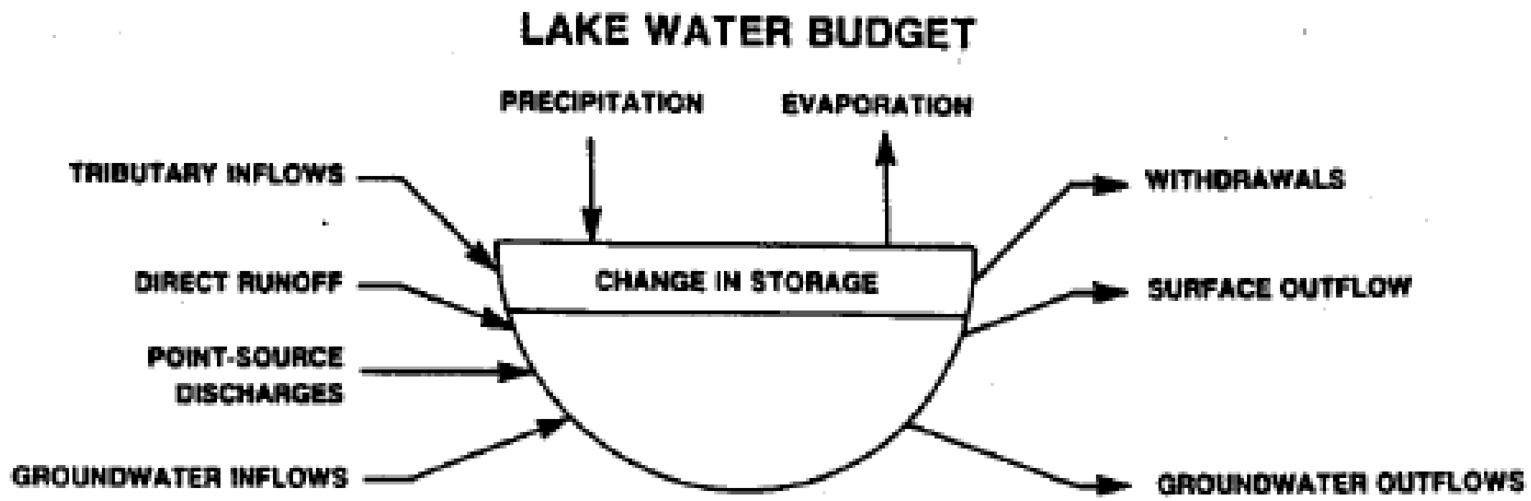

Figure 1-12. Graphical depiction of the lake water budget.

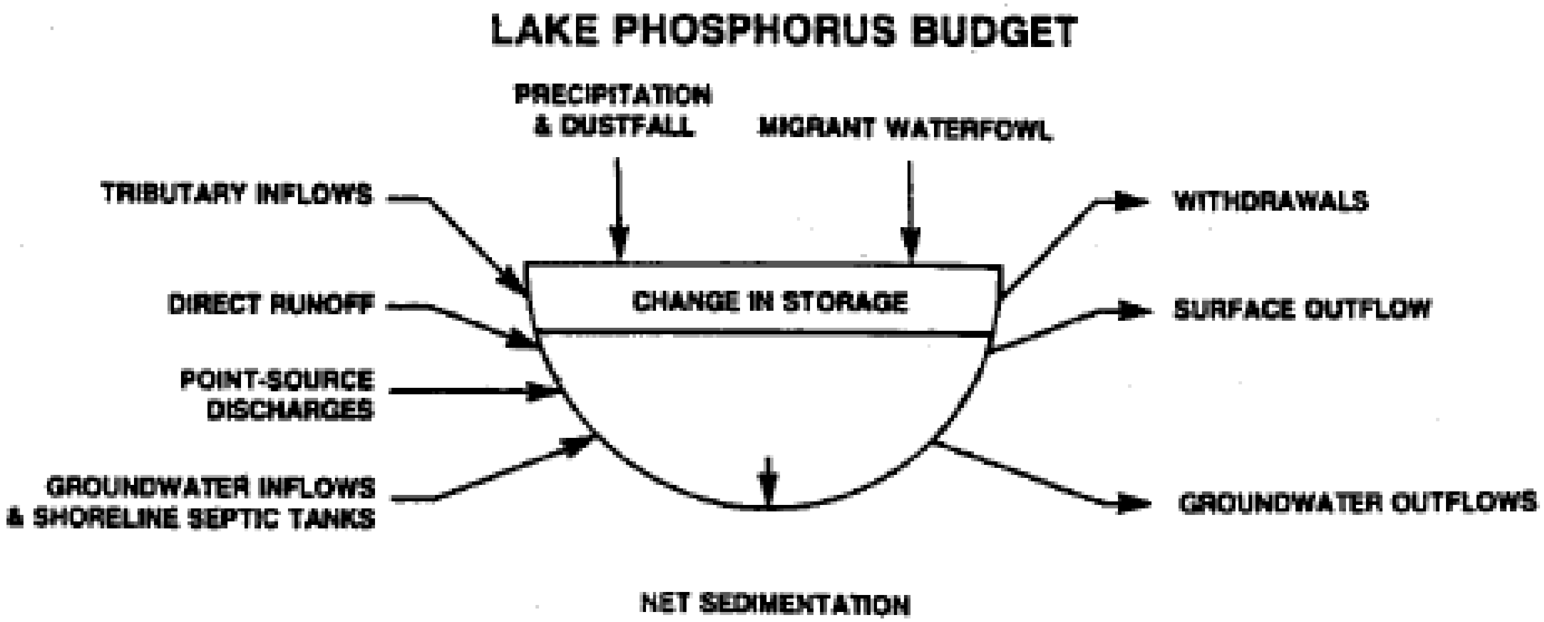

Figure 1-13. Graphical depiction of the lake phosphorus budget.

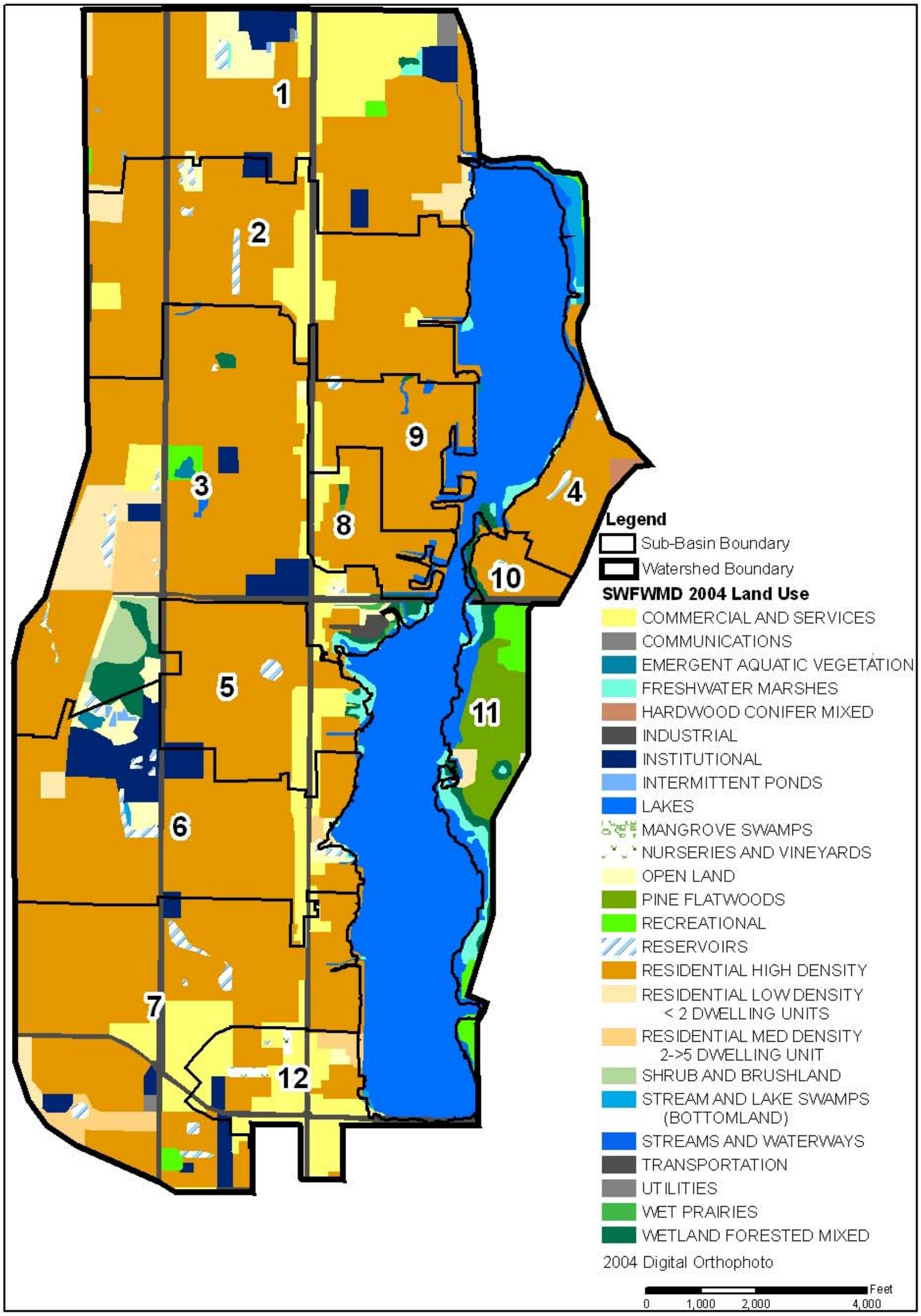

Figure 1-14. Major sub-basins delineation in the Lake Seminole watershed.

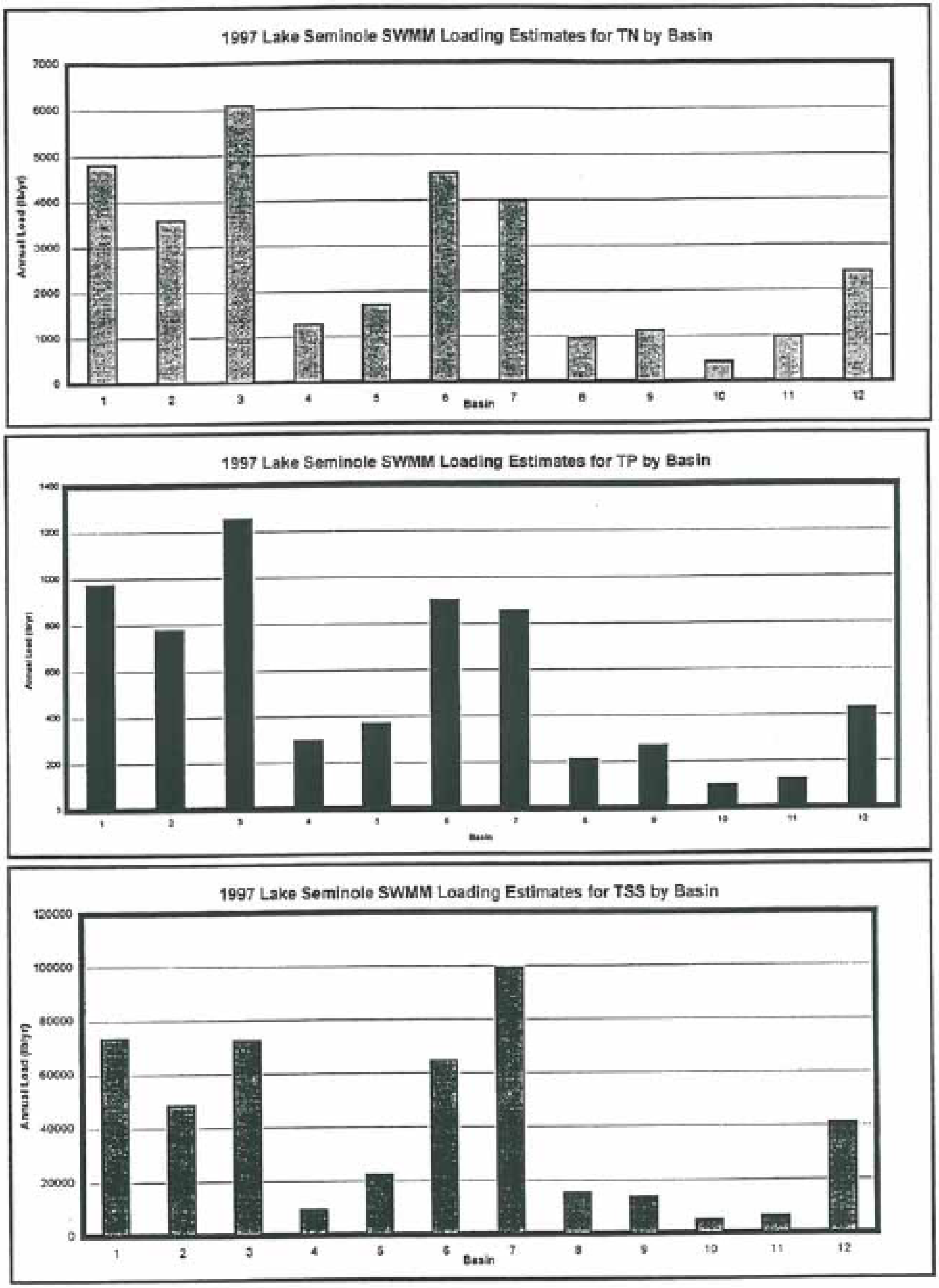

Figure 1-15. Pollutant load rankings of the major sub-basins.

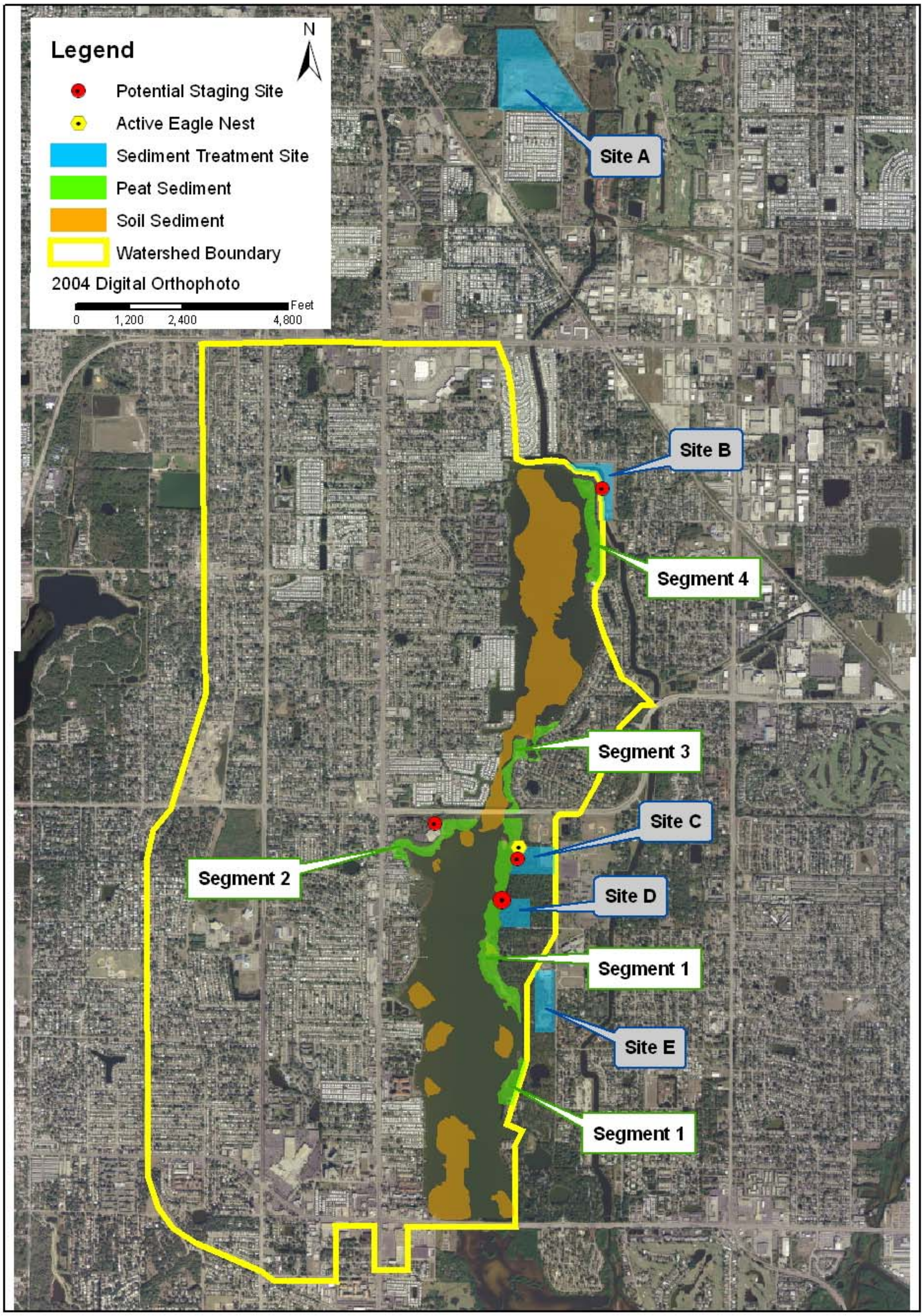

Figure 3-1. Potential publicly-owned staging and sediment treatment sites in the Lake Seminole vicinity.

Figure 3-2. Location of recommended habitat restoration sites in Lake Seminole and its watershed.

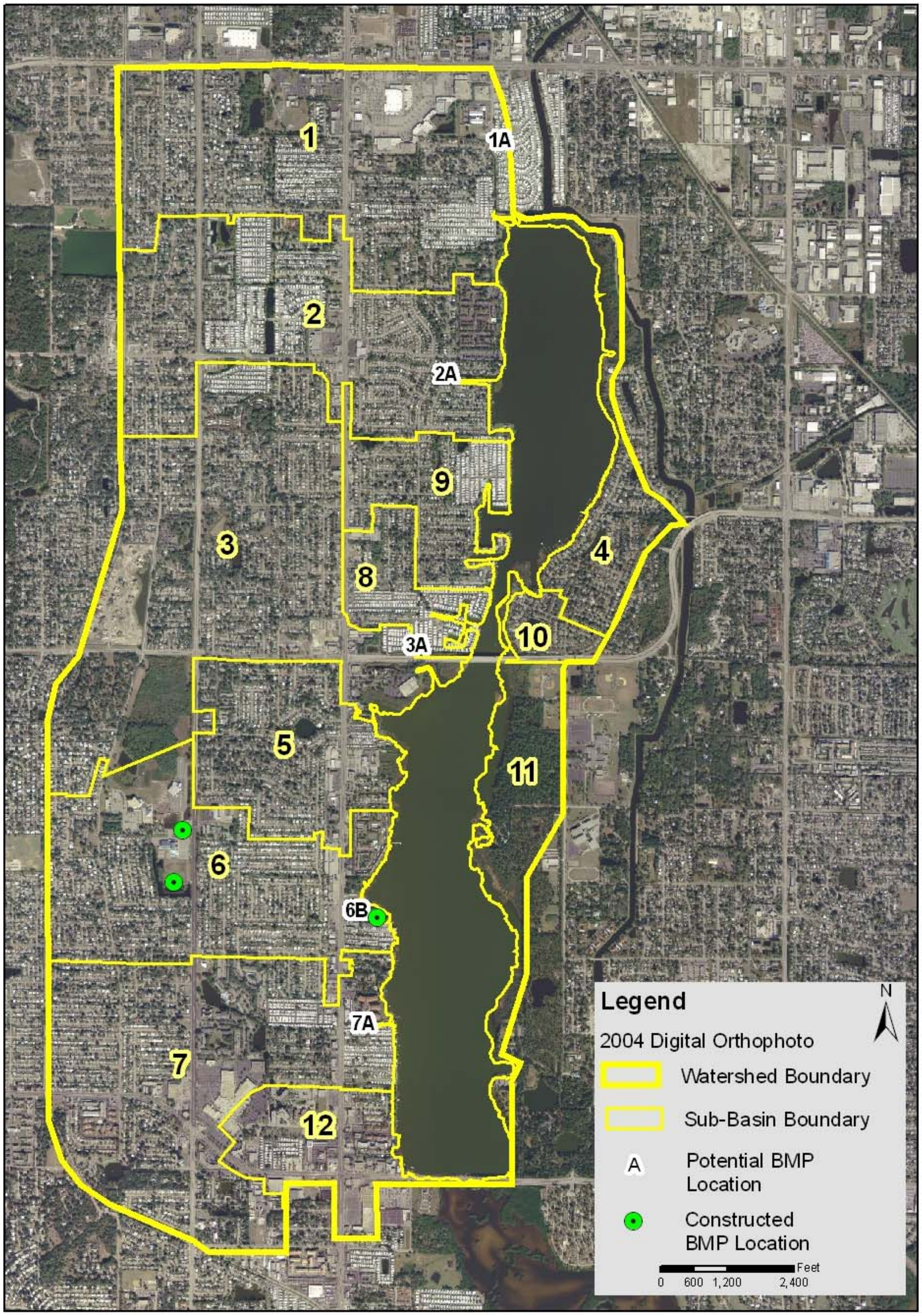

Figure 3-3. Location of recommended enhanced regional stormwater treatment facilities

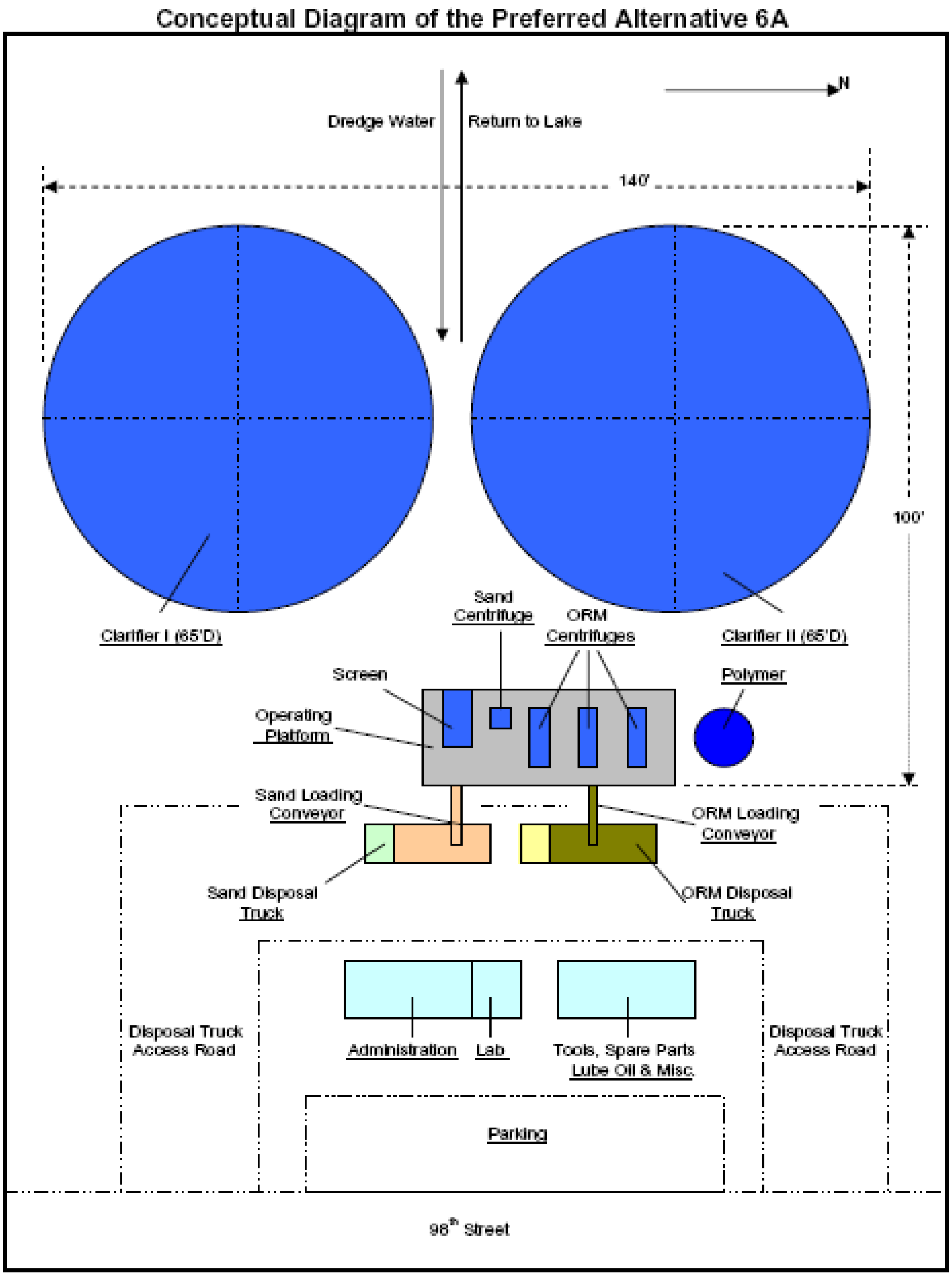

Figure 3-4. Conceptual Diagram of the Preferred Alternative 6A

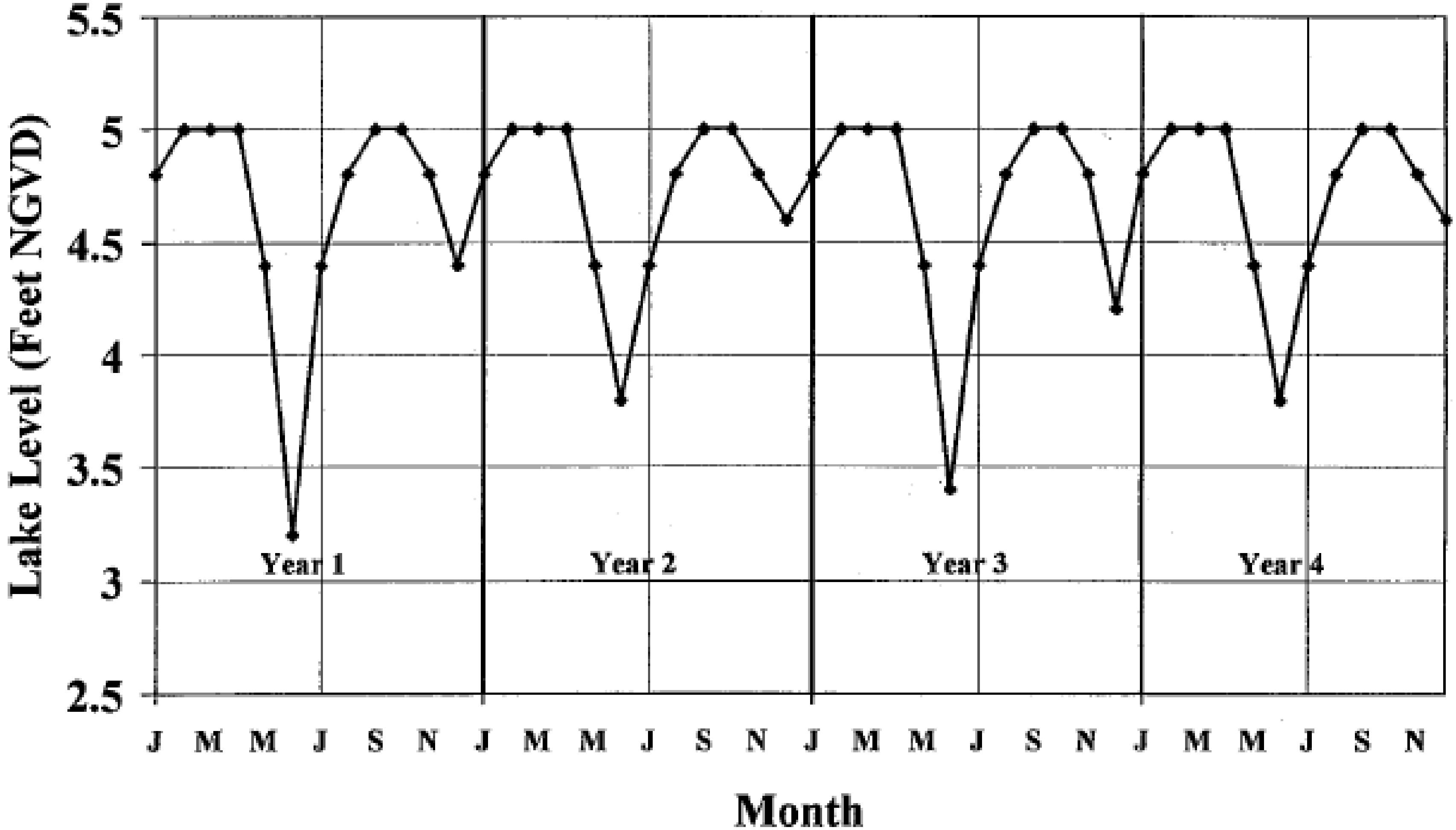

Figure 3-5. Recommended enhanced lake level fluctuation schedule

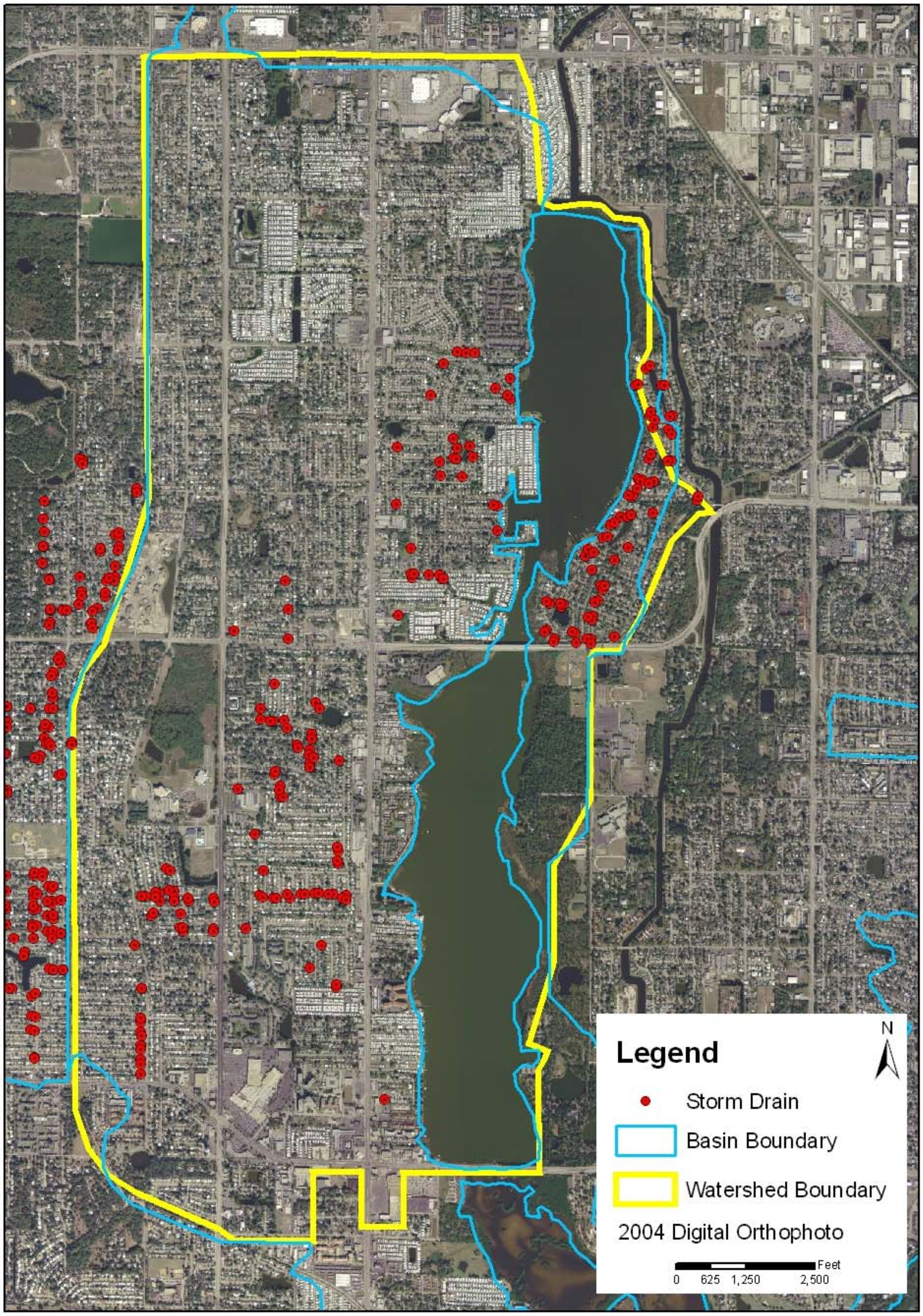

Figure 3-6. Storm Drain Labels within the Lake Seminole Watershed.

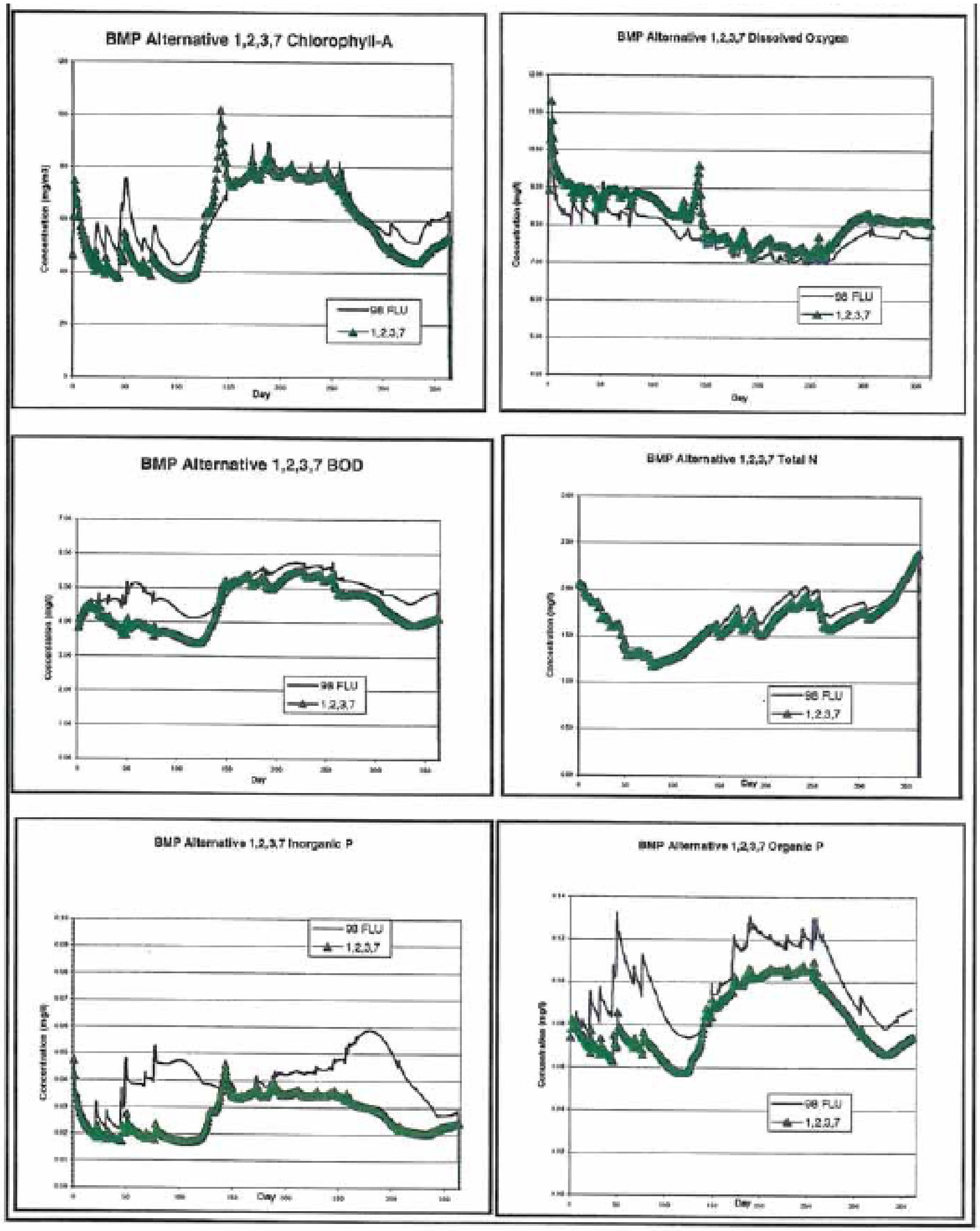

Figure 3-7. BMP Alternative #1237 simulation results vs. 1998 future land use baseline conditions. (Model plot)

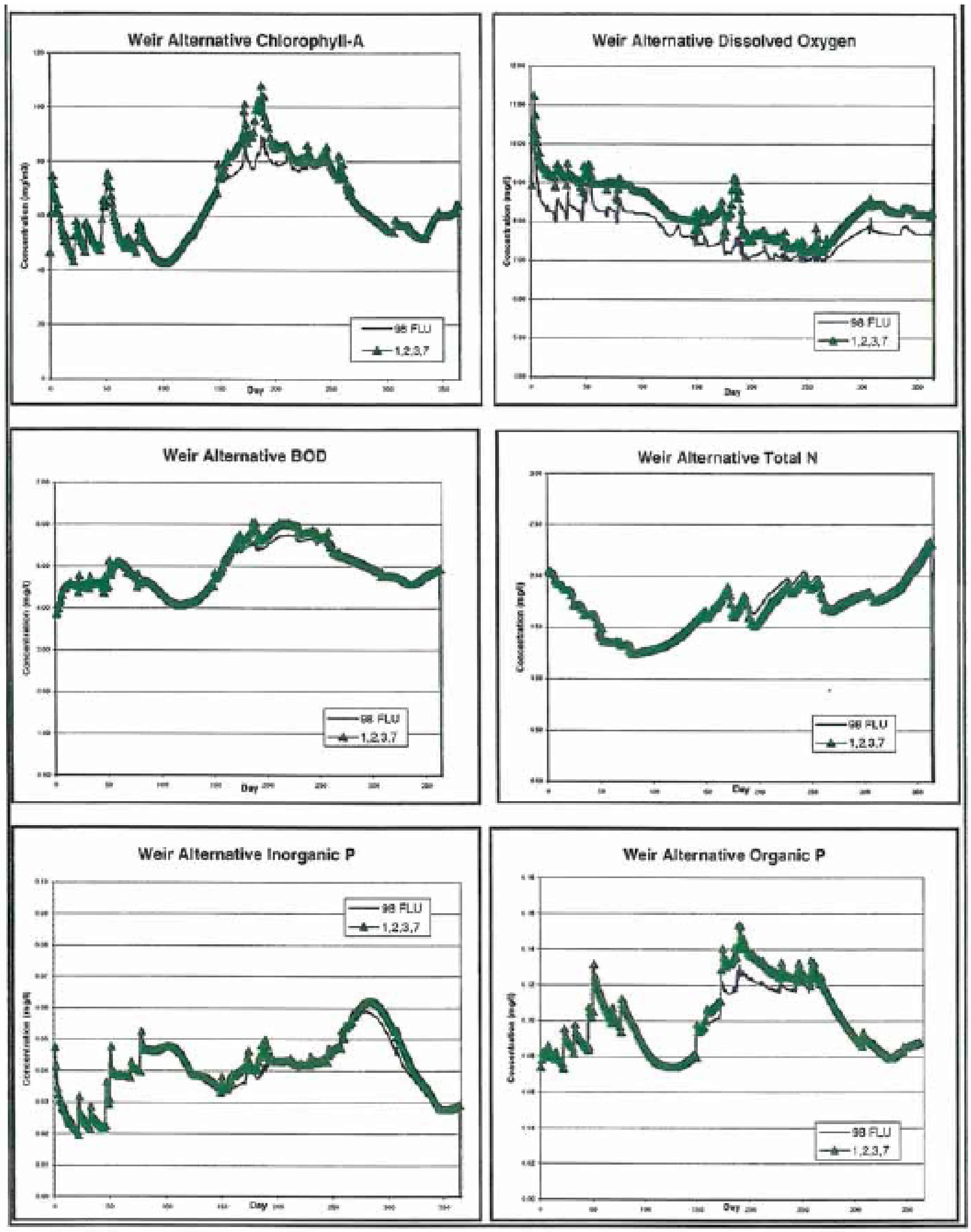

Figure 3-8. Weir Alternative simulation results vs. 1998 future land use baseline conditions. (Model plot)

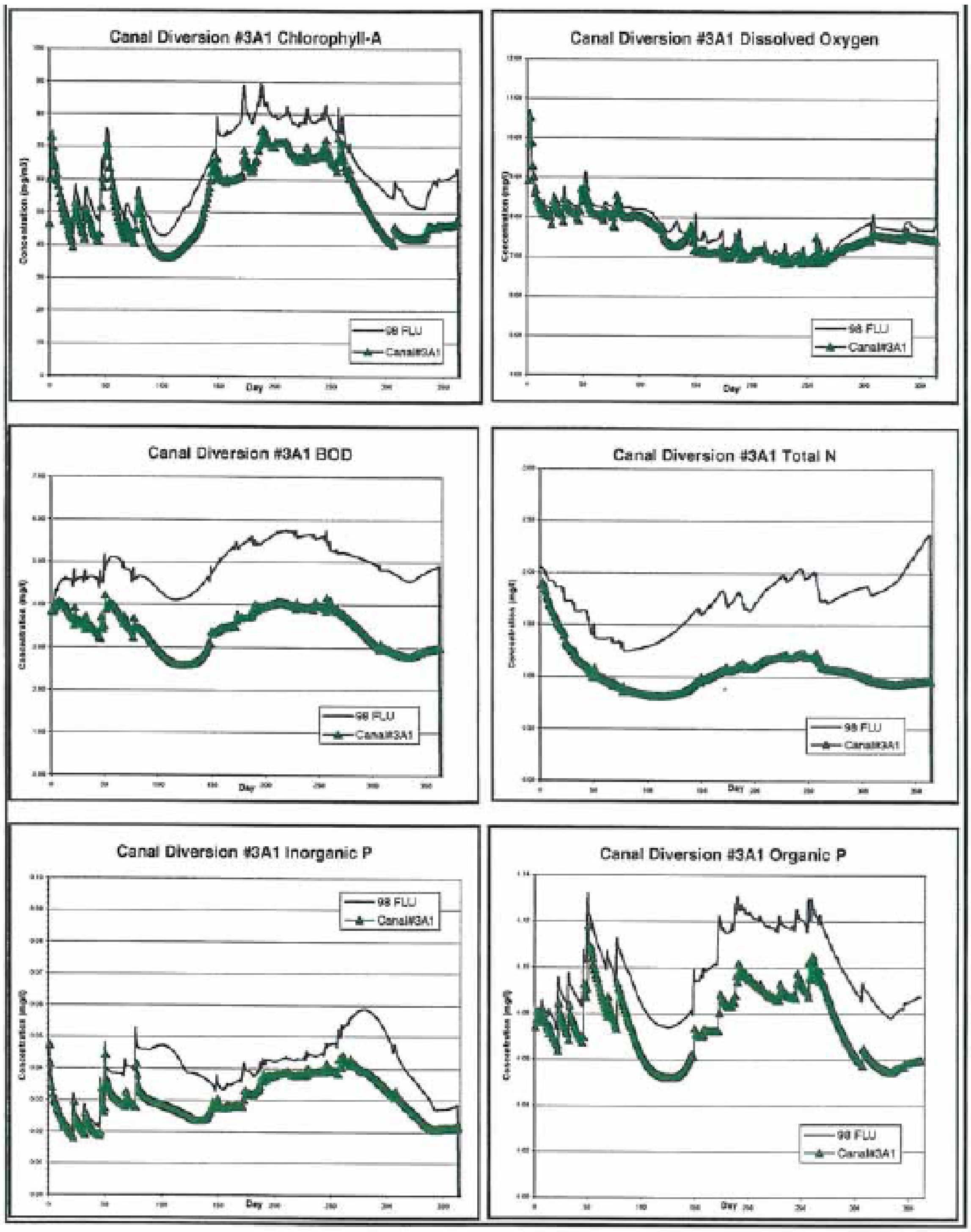

Figure 3-9. Canal Diversion Alternative #3A1 simulation results vs. 1998 future land use baseline conditions. (Model plot)

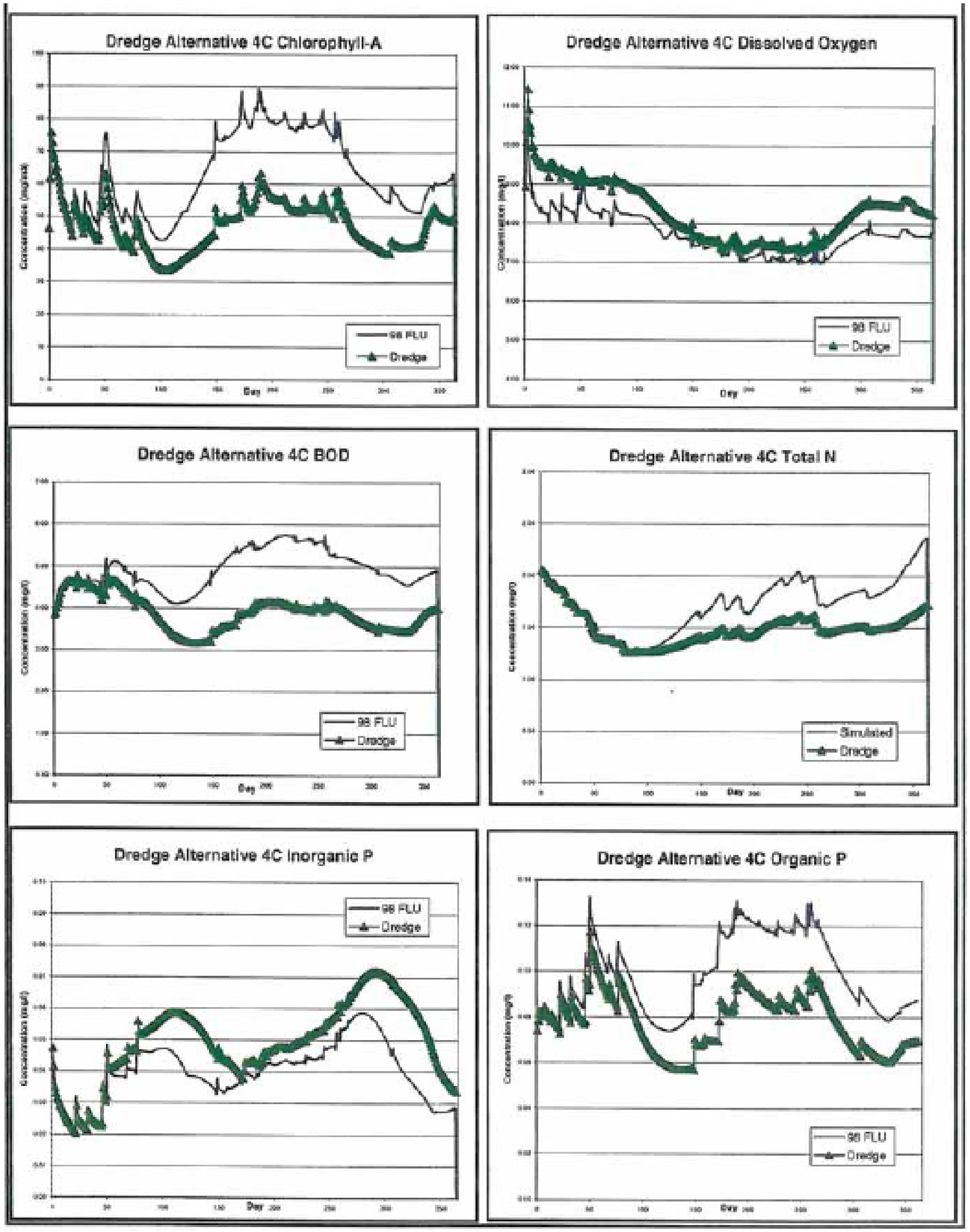

Figure 3-10. Dredging Alternative #4C simulation results vs. 1998 future land use baseline conditions. (Model plot)

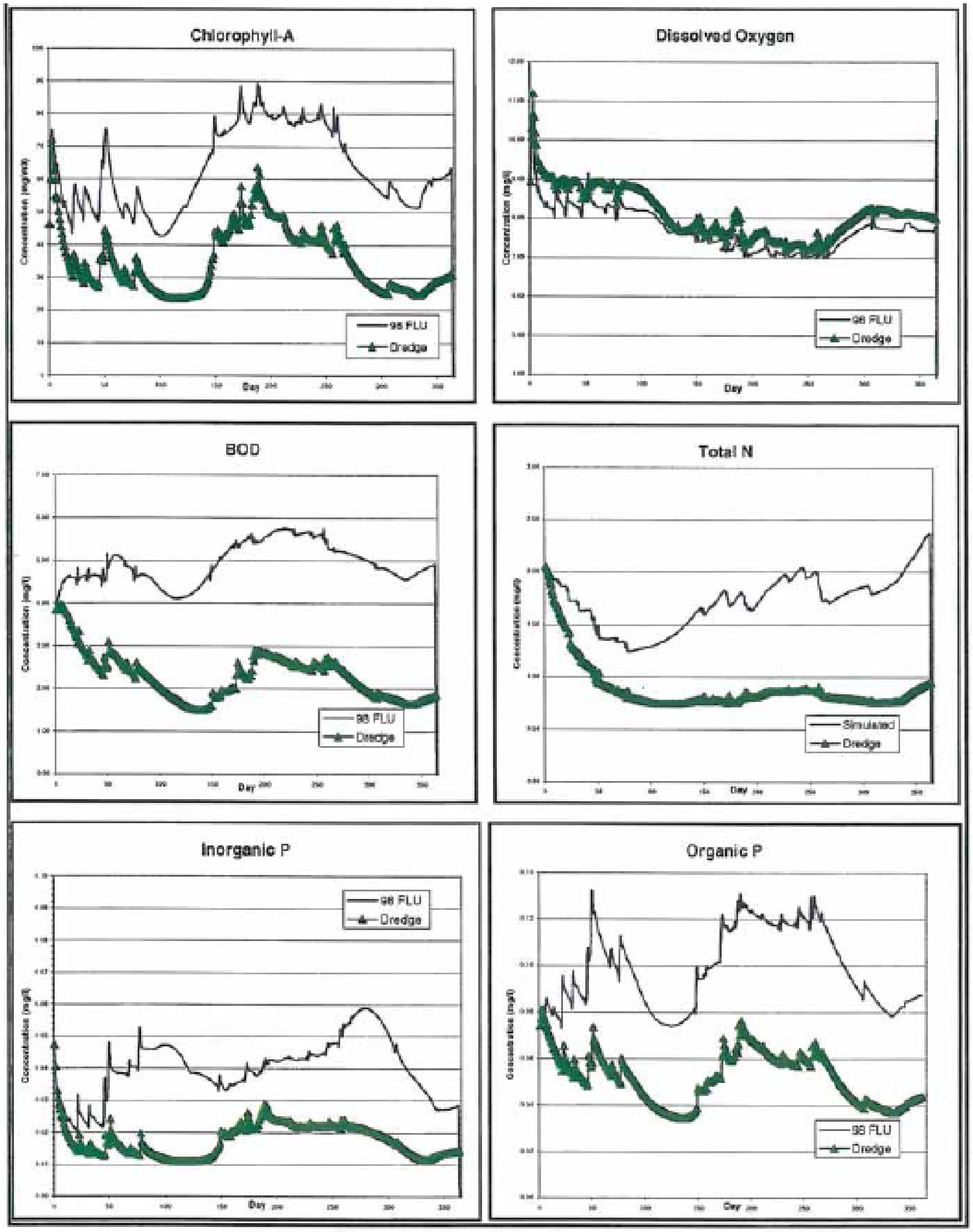

Figure 3-11. Combination of all Management Actions simulation results vs. 1998 future land use baseline conditions. (Model plot)

Category : Surface Water Quality

Project No: 829 **Title: Lake Seminole Alum Injection**
Cost Center: 8382600 Department: Environmental Management Primary Fund: 0401 CIE: Yes
Sub-cost Center: 8382611 Organization: CO ADMIN Secondary Fund: CIE Element: Drainage Element

	FY2007	FY2008	FY2009	FY2010	FY2011	FY2012	TOTAL
COSTS:							
Professional Svcs	105,000	47,500	47,500	0	0	0	200,000
Construction	2,060,000	1,138,410	1,523,600	0	0	0	4,722,010
Testing	0	30,970	35,900	0	0	0	66,870
TOTAL COSTS:	2,165,000	1,216,880	1,607,000	0	0	0	4,988,880
RESOURCES:							
Penny for Pinellas	1,141,000	23,750	23,750	0	0	0	1,188,500
Grant-Federal	0	287,560	493,040	0	0	0	780,600
Grant-Federal-PCEF	0	200,000	0	0	0	0	200,000
Grant-Local-SWFWMD	724,000	505,570	390,000	0	0	0	1,619,570
Grant-State-DEP	300,000	200,000	700,210	0	0	0	1,200,210
TOTAL RESOURCES:	2,165,000	1,216,880	1,607,000	0	0	0	4,988,880

Description: Design and construction of treatment systems with " Alum-Injection equipment" at discharge locations in Lake Seminole for the purpose of improving the lake's water quality.

Figure 3-12. Allocated Funding for Pinellas County Capital Improvement Projects.