Audubon
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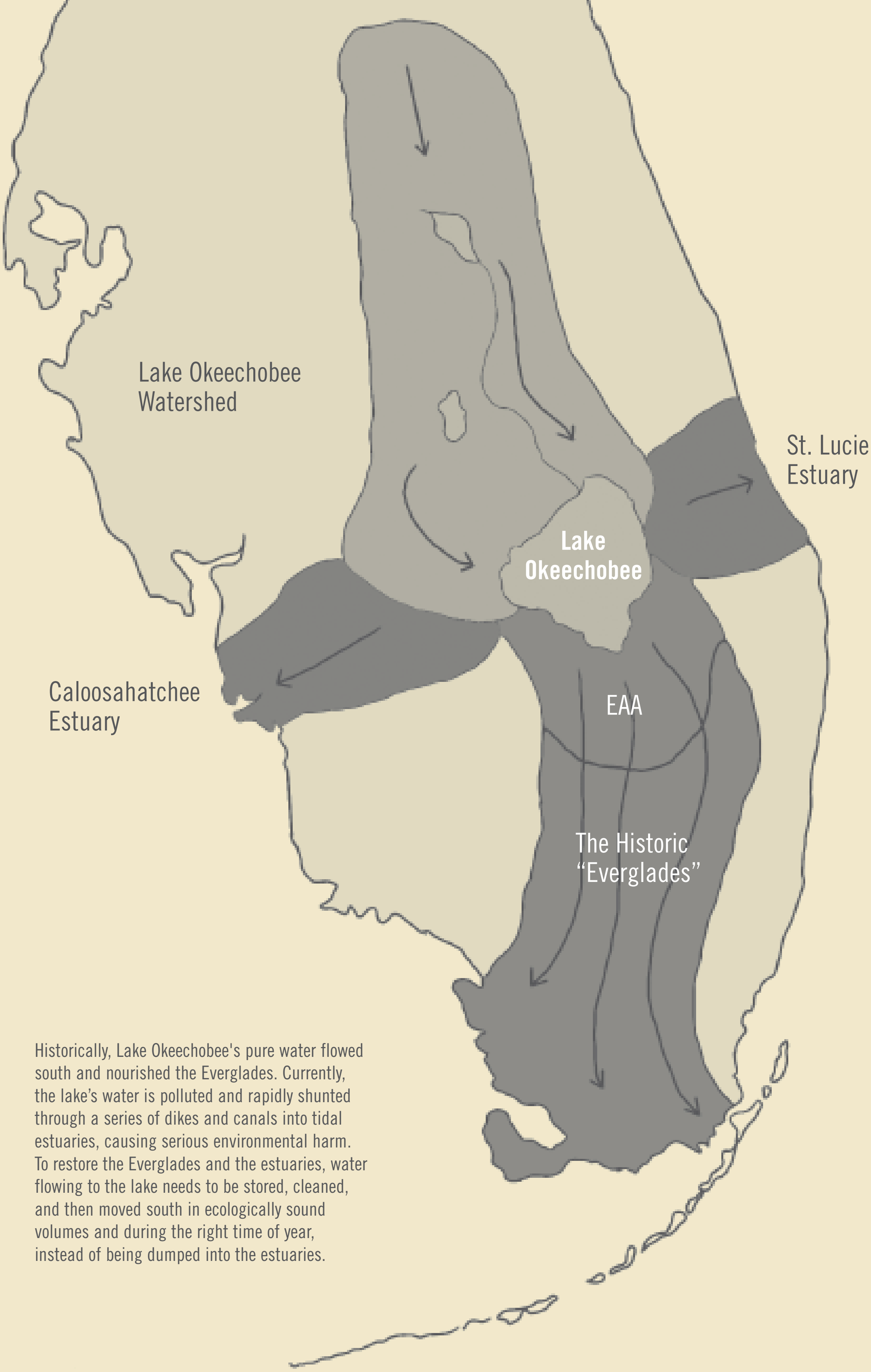
Etching of snail kite by John Costin

Lake Okeechobee

everything in harmony | restoration needs



Historically, Lake Okeechobee's pure water flowed south and nourished the Everglades. Currently, the lake's water is polluted and rapidly shunted through a series of dikes and canals into tidal estuaries, causing serious environmental harm. To restore the Everglades and the estuaries, water flowing to the lake needs to be stored, cleaned, and then moved south in ecologically sound volumes and during the right time of year, instead of being dumped into the estuaries.

Lake Okeechobee Restoration:

Watershed, weather, and strategies toward achieving goals

Lake Okeechobee is a vital component of the Greater Everglades Ecosystem, and a critical link between the lakes and rivers that flow from the north, the St. Lucie and Caloosahatchee estuaries on the east and west, and the Everglades wetlands and bays to the south. With its great size, Okeechobee is an invaluable habitat in itself. Lake management impacts water supply, flood protection, and the health of natural systems throughout South Florida, making it a critical issue for all. The restoration of Lake Okeechobee is an important endeavor that will benefit people, natural areas, and South Florida's phenomenal array of wildlife, including 69 threatened and endangered species such as the Everglades Snail Kite and endemic Okeechobee Gourd.

Throughout South Florida, drainage and development have seriously disrupted natural flows of water in the major rivers, lakes, estuaries, and other habitats of the Greater Everglades Ecosystem. Lands developed for urban and agricultural uses quickly drain polluted water into the remaining natural areas rather than retain and cleanse this water as they did in a more natural condition. The cumulative effect of accelerated drainage of developed lands amplifies flooding of remaining natural areas during the wet season, and often leaves too-little water to meet human or ecosystem needs during the long dry season. Replacing the lost capacity to store and clean water throughout the system is one of the primary challenges facing Everglades restoration and, once met, will be a major step in achieving a sustainable South Florida.

A new understanding of several issues important to the management and restoration of Lake Okeechobee has emerged in recent years. It is now realized that to restore water quality in the lake and help protect downstream systems from polluted lake water, phosphorus loads entering the lake must be reduced much more than Everglades restoration plans envisioned in 1999. Additionally, much more water must be stored in Lake Okeechobee's upstream watershed and downstream in the Everglades Agricultural Area to maintain healthy water levels in the lake and downstream systems, facilitate treatment of water as it moves through the system, prevent ecologically damaging releases to the estuaries, and protect the Herbert Hoover Dike. Since the challenges facing the system surpass original estimates, it is necessary to re-examine restoration strategies to determine how much can be expected from current efforts and how much additional effort will be required to restore critical functions within the lake's watershed.[1]

[1] This paper focuses primarily on Lake Okeechobee's watershed because although restoring Lake Okeechobee and its watershed are recognized as integral to restoring the entire system, Okeechobee's upstream watershed has received too-little attention considering it is roughly as large as the Everglades proper.

table of contents

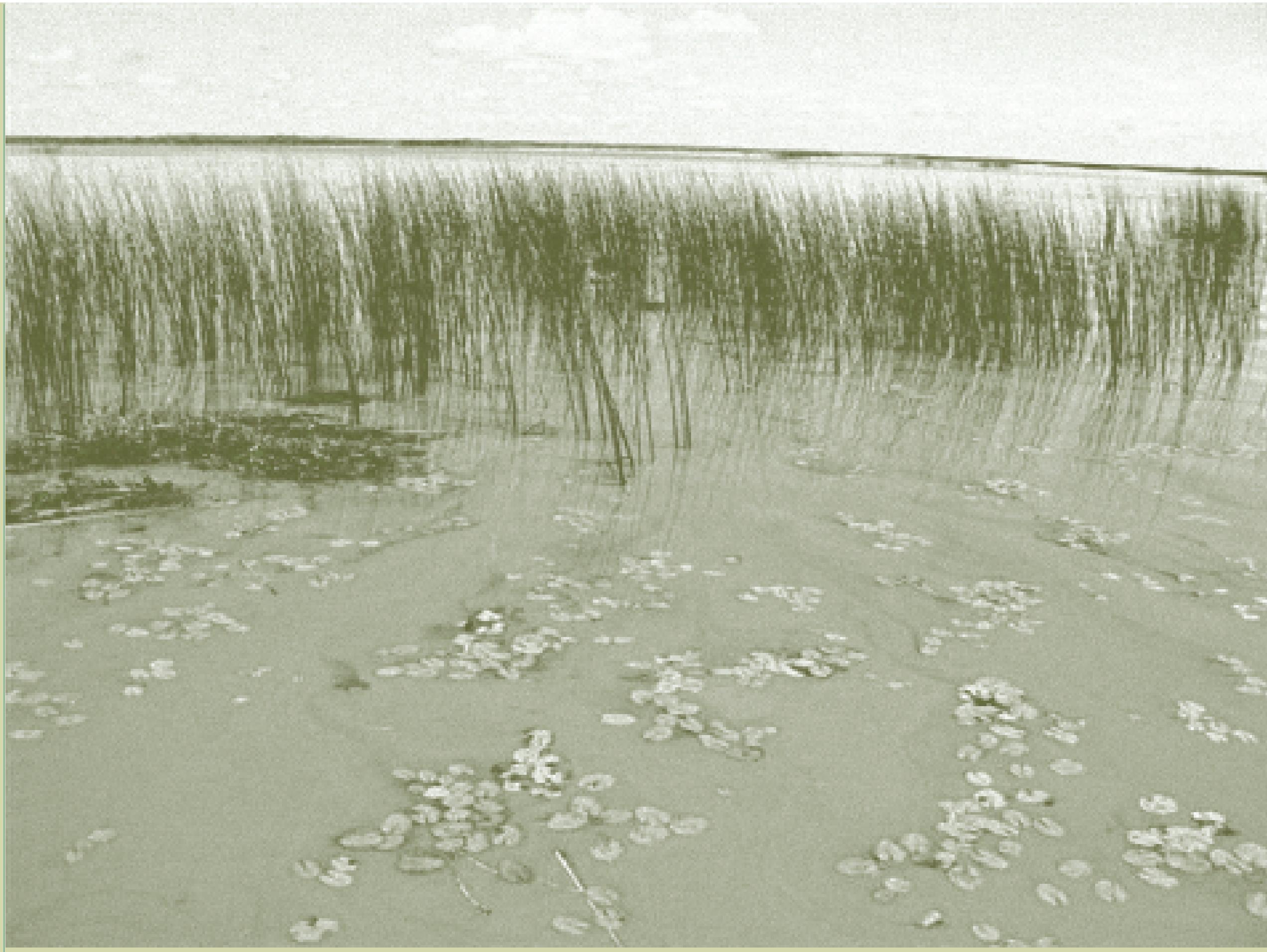


photo by Don Fox, Florida Wildlife Commission (FWC)

Confronting challenges

There are three main challenges

There are three main challenges to restoring the lake and estuaries that must be dealt with as restoration plans proceed: Weather patterns that produce runoff, which significantly exceeds previous estimates;; more stringent phosphorus goals due to improved understanding of phosphorus dynamics; and, the escalation of land prices in South Florida.

Weather and water: Weather patterns are remarkably difficult to predict, especially over the long term. However, recent improvements in understanding South Florida's climate, including a weather pattern called the Atlantic Multi-decadal Oscillation (AMO), suggests that restoration will require much more storage around Lake Okeechobee than originally anticipated. During past "warm" phases of the AMO pattern, summers in south Florida were wetter and Lake Okeechobee received almost twice as much summer inflow than during the cool (drier) phase (Fig. 1). Although, the increase in rainfall amounts seemingly were not great (roughly a 10% increase), the net inflows into Lake Okeechobee were much larger (roughly double). A recent peer review (http://www.sfwmd.gov/site/index.php?id=830) of the SFWMD's efforts to address climate variability recommended the SFWMD develop a better understanding of the rainfall-runoff relationships in the lake's watershed basins during different phases of the AMO phenomenon, particularly in view of today's heavily-drained and highly managed conditions, which may further increase runoff.

The inflows modeled in current restoration plans (1965-2000) include a period of years, in which about 70% are from the drier pattern, which skews predictions toward drier forecasts. Though fewer in numbers, historical data shows that the "drier" period also contains years that are extremely wet. Similarly, the "wetter phase" also includes severe drought years, such as in 2000-01. Thus, for either the wet or dry phase of the AMO cycle, significant amounts of lost storage capacity around the lake must be restored to prevent rapid rises in lake level during wet periods, buffer rapid drops in water levels during droughts (and water rationing), reduce harmful discharges to the estuaries, and protect the Hoover Dike from failure.

Water quality and pollution: When the Comprehensive Everglades Restoration Plan (CERP) was designed, the goal for phosphorus entering the lake was an average of 361 metric tons per year. In 2000, the Total Maximum Daily Load (TMDL) for the lake was set at 140 metric tons. The significant lowering of the goal occurred

The restoration of Lake Okeechobee is an important endeavor that will benefit people, natural areas, and South Florida's phenomenal array of wildlife, including 69 threatened and endangered species such as the Everglades Snail Kite and endemic Okeechobee Gourd.

in light of new data, and updates to the model used in calculations. Wetter periods in the climate cycle send more water, and hence more phosphorus, into Lake Okeechobee (even if concentrations remain the same), making it more difficult to achieve the new phosphorus standard. Eight of the highest phosphorus loads to the lake on record occurred since the wet phase of the AMO pattern returned in 1995 (Fig. 2). In light of more water moving through the system, carrying more nutrients, achieving the lake's new phosphorus loading standard will require restoring more of the watershed's lost storage and treatment capability than originally planned.

Escalating land prices: Many restoration projects will require public land acquisition. Land prices have escalated dramatically in recent years as speculation and competition for development has increased. It is now more costly to conserve habitat in the watershed and implement projects to restore lost water storage and treatment capabilities. The longer it takes to implement restoration projects the more expensive they will become. Further complicating matters, there is no robust estimate of the land needed to achieve restoration. This makes budgeting and planning more difficult, and decreases the likelihood that the needs of restoration will be incorporated into land use decisions.

Figure 1. Average net inflows to Lake Okeechobee during the warm and cold phases of the AMO cycle. Inflows during both periods are quite variable among years, but the warm phase years average almost twice the inflow as cold phase years (source, SFWMD news release 9-7-05). Although myriad weather and solar phenomena interact to influence Florida's climate, AMO influences are so great (an average of an extra "million acre-feet" of water to manage in the summer) they should be carefully evaluated. Original CERP plans were based on the period of record from 1965-1995, which is composed almost entirely of the lower inflow years, creating a significant disparity between projected needs and present realities.

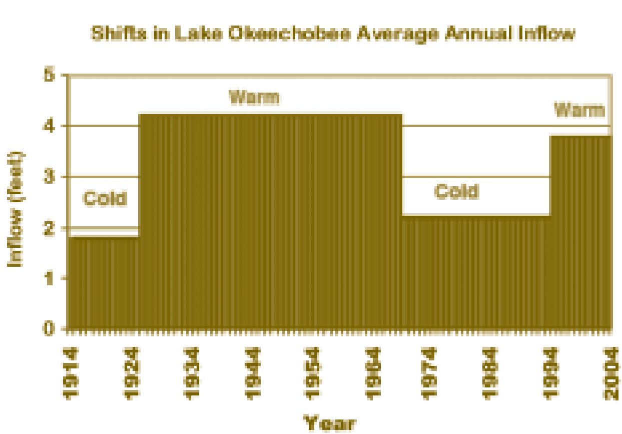
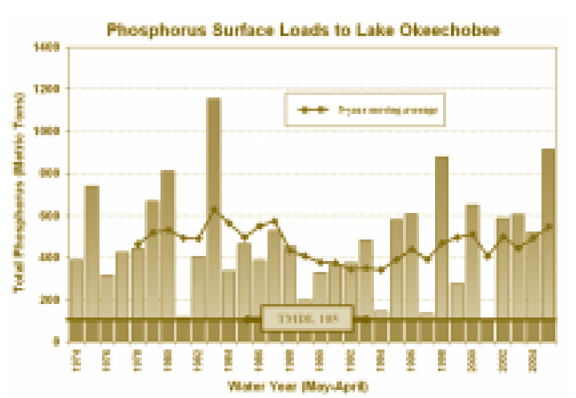


Figure 2. Very high annual loads of phosphorus have been entering Lake Okeechobee since the return of the wet AMO pattern in about 1995 (source, November 30, 2005 SFWMD presentation to Lake Okeechobee WRAC). Actual phosphorus concentrations in inflows have not risen recently; the increased load is a result of larger volumes of water.

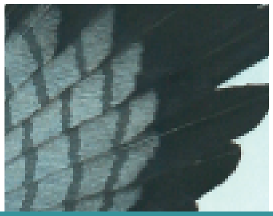


Replacing the lost capacity to store and clean water throughout the system is one of the primary challenges facing Everglades restoration and, once met, will be a major step in achieving a sustainable South Florida.

courtesy of the South Florida Water Management District

Restoring healthy water levels in Lake Okeechobee

Modifications to the lake's regulation schedule (called the Water Supply and Environment schedule, or WSE) can only achieve minor improvements in the timing of water releases and cannot result in significant improvements until more storage and treatment is restored within the system.



Improving water level management in Lake Okeechobee

Presently, Lake Okeechobee's water levels tend to rise abruptly during wet periods, and drop abruptly during dry periods. High water levels in the lake lead to long-term in-lake damage, harmful estuary releases, and concern about Hoover Dike's integrity, and low levels create water shortages. Modifications to the lake's regulation schedule (called the Water Supply and Environment schedule, or WSE) can only achieve minor improvements in the timing of water releases and cannot result in significant improvements until more storage and treatment is restored within the system.

The Everglades are widely known as a "River of Grass," that filled during the summer and very slowly moved water southward for months after summer rains ended. The large storage capacity, and slow discharge characteristic, created relatively smooth and continuous outflows into Florida Bay during both wet and dry seasons. What appears under-appreciated is that the watershed upstream of Lake Okeechobee also is quite flat, and functioned much like the River of Grass, catching and holding vast amounts of water during the wet season and slowly discharging it to Lake Okeechobee throughout the dry season. That watershed is now severely drained and the vast amounts of water that fall upstream of the lake are moved to it quickly in the wet season, creating un-naturally rapid water level rises and the cascade of problems associated with them. During the ensuing dry season virtually no inflow remains, which combined with human water supply withdrawals, contributes to accelerated water level declines and frequent water shortages for natural systems and humans.

Even a single high water year in Lake Okeechobee requires years of recovery. Experience in the late 1990s and again in 2004 show that once the 40,000-acre submerged plant zone is lost, regrowth cannot start until the lake drops down to about 12 feet, and is unlikely to be successful unless it remains that low for about 3 months.[2] It may be several years before the lake attains these conditions, and once it does, it takes a second favorable year to fully reestablish plants. Fish populations decline greatly with the decline in plants, and take perhaps an additional 2 years to recover after the plants do, making total recovery time for these lake communities at least 5 years. The estuaries also require multiple years to recover from the damage caused by large releases during wet years; it is critically important to ensure that such events are extremely rare occurrences. Conversely, very low lake levels can permanently destroy organic soils and create extreme depletions of aquatic organisms that also can take multiple years from which to recover.

[2] An excellent summary paper on high-water impacts and plant recovery needs in Lake Okeechobee is: Havens, K. E. 2005. Lake Okeechobee: hurricanes and fisheries. Lakeline Fall: 25-28.

The restoration of lost storage capacity upstream of the lake is critical to reduce the problems caused by large and rapid inflows during the wet season, and lack of inflow during the dry season. The same storage features that can help reduce rapid water level rise in wet periods, can help meet water supply needs during drought, and help prevent harmfully low levels in the lake. Additionally, restoring storage south of the lake, and adequate conveyance to those storage areas, are needed to help lower the lake more quickly and safely, when needed

Upstream storage challenges

Although there is much variability, during the warm phase of the AMO cycle[3], a net inflow of about 4 feet of water (in terms of lake depth) enters Lake Okeechobee annually. Human water use of this inflow averages about 1 foot a year and the remaining "3 feet" of net inflow must be dumped, somewhere downstream. Averages obviously are composed of higher and lower numbers, and the management challenges are greater than merely addressing "4 feet" of inflow, as exemplified by the facts that a net of about 6 feet of water entered the lake in 2004 and 2005, only a few years after one of the greatest droughts on record. Similarly, even during the cool, drier phase of the AMO, net inflows greater than 5 feet have occurred. Thus, the management system must be built to handle events significantly more extreme than average inflows indicate.

Within the CERP, the Lake Okeechobee Watershed (LOW) project includes the most storage of any project upstream of the lake. The tentatively selected plan has not been finalized as of October 2006, but it appears the project will provide a maximum static storage capacity of 300,000 acre-feet of water, or the equivalent of about 8 inches of water in the lake. Perhaps 80-90% of the storage capacity is in reservoirs, with the remainder in stormwater treatment areas and a small amount of wetland restoration. The ongoing Kissimmee River Restoration project will provide an increase of approximately 100,000 acre-feet of storage capacity in the Kissimmee Lakes region. In total, these projects are expected to provide approximately 400,000 acre-feet of storage in upstream of Lake Okeechobee (about 10 inches in the lake).

If major projects upstream of the lake only provide approximately 1 foot of storage, lake levels will remain vulnerable to rapid and unacceptable rises during wet periods. Especially in this wetter phase of the AMO cycle with average inflows of about 4 feet, extremely harmful years for the lake and downstream systems will be very common. Restoration of lost water and storage treatment capabilities presently are not of sufficient scale to significantly reduce the number of years the lake experiences harmfully high water levels and associated nutrient loads.

Downstream storage challenges

The majority of storage planned downstream of the lake is provided by the Everglades Agricultural Area (EAA) Reservoirs and Lake Okeechobee Aquifer Storage and Recovery (ASR) projects of the CERP. The EAA Reservoirs are planned to provide 360,000 acre-feet of storage that will accept local (i.e., EAA) runoff, and deliveries from the lake. Storage projects also are planned along the C-43 and C-44 canals, but these are designed mostly to capture local runoff and will have little capacity available to accept deliveries from the lake during wet periods.[4] Original projections that the EAA STAs could handle about 6 inches of lake water each year was revised to as little as 2 inches[5] in 2006 due to poor water quality in the lake; it is not certain how much additional water the STAs will be able to handle in the future. Given the large volumes of water involved, the reservoirs and STAs clearly are insufficient to store and clean both local runoff and significant discharges from the lake, and will only be able to accept minimal deliveries from the lake and estuaries when water levels are at their highest.

The Lake Okeechobee ASR project has the potential to provide some storage downstream of the lake, though there is much uncertainty around the effectiveness of this project and the timing of when it might be completed. Although final designs could change this, we include ASR with "downstream storage" because most wells were envisioned to pump water from the lake itself, or downstream, thus will not help reduce inflows. When the ASR project was conceived, there were fewer than a dozen small ASR wells operating in Florida. The idea of a water storage technology that required very little land was appealing and resulted in the incorporation of 330 large (5 million gallon per day) ASR wells into the design of the CERP. However, the technology has many uncertainties relating to storage efficiency, water quality, impact on receiving aquifers, and costs for operation and maintenance. Even if ASR proves feasible at some level, it is important to realize this technology stores water slowly and will not prevent harm to the lake due to large inflows. Water levels in the lake will still rise quickly and remain high for some time, damaging the lake and estuaries until the ASR system can pump the water underground. Other proven methods of restoring storage and treatment, like wetland restoration, STAs, and reservoirs, should be prioritized around the lake given the significant uncertainties and limited benefits of ASR. Such technologies also provide certain habitat values, unlike ASR.

[3] Net inflow is total annual rain and inflow minus annual evaporation, therefore reflects the amount of water volume increase that must be dealt with each year.

[4] For an explanation of expected average storage rates in these features, see Steinman, A. D., K. E. Havens, H. J. Carrick, and R. VanZee. 2002. The past, present, and future hydrology and ecology of Lake Okeechobee and its watersheds. Pages 19-37 in The Everglades, Florida Bay, and Coral Reefs of the Florida Keys: An ecosystem sourcebook. J. W. Porter and K. G. Porter, eds. CRC Press, Boca Raton, FL.

[5] Source: Draft Supplemental Environmental Impact Statement: Lake Okeechobee Regulation Schedule Study, U.S. Army Corps of Engineers. August 2006.

Water storage goals to achieve restoration

Given the large volumes of water that the watershed is capable of quickly delivering to Lake Okeechobee, Audubon estimates that at least 1.2 million acre-feet of storage capacity need to be restored upstream of the lake (equal to about 2.5 feet in the lake) to gain reasonable control of water level rise and capture significant inflows for adequate treatment. In a 2.5 million acre watershed, this reflects a volume of water almost 6 inches deep across the watershed. Detailed study of rain events indicates storing 1.2 million acre-feet will not prevent all harmful high water events, but likely can prevent most. Although achieving this amount of storage will be difficult, it is unrealistic to expect significant lessening in extreme high stage events in Lake Okeechobee without this level of effort.

In addition to upstream storage, at least 1 million acre-feet of storage are needed downstream of the lake[6] in order to complete reasonable restoration of Lake Okeechobee, the estuaries, and the Greater Everglades Ecosystem. This amount of storage is needed to help retain water during high lake levels in summer, prevent large declines and water shortages during dry periods, and allow adequate water quality treatment – all without requiring large amounts of water to be discharged to other natural systems that would suffer as a result. Being able to convey water to and from storage areas is critical to their function, and both upstream and downstream storage will need to be planned with adequate conveyance.

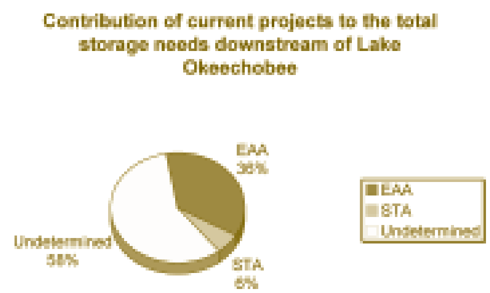
Restoration plans appeared somewhat undersized to begin with, and now the disparity is even greater given our improved understanding of probable future weather patterns. Figures 3 and 4 below show estimates of the storage provided by current projects and the shortfall compared to Audubon's estimates of storage required to achieve restoration. The Lake Okeechobee ASR project is not included in these figures. The storage shortfall we present should be included in planning efforts (like the ASR Contingency Plan) until the ASR Regional Study is complete and there is an idea of how ASR implementation might proceed given the uncertainties stated earlier.

Upstream of Lake Okeechobee

Project	Storage estimate (ac-ft)
CERP/LOER	300,000
Kissimmee River Restoration (KRR)	100,000
Kissimmee Lakes Long-Term Plan	not determined
Best Management Practices	0*
Total planned	400,000
Needed	1,200,000
Shortfall	800,000

Figure 3. Contribution of current restoration projects toward Audubon's estimated storage need of 1.2 million acre-feet upstream of Lake Okeechobee.

*BMPs presently have no numeric or formula-based water storage requirement and need revision to include one.



> The restoration of lost storage capacity upstream of the lake is critical to reduce the problems caused by large and rapid inflows during the wet season, and lack of inflow during the dry season. The same storage features that can help reduce rapid water level rise in wet periods, can help meet water supply needs during drought, and help prevent harmfully low levels in the lake. Additionally, restoring storage south of the lake, and adequate conveyance to those storage areas, are needed to help lower the lake more quickly and safely, when needed.

[6] For a more detailed analysis of the problems facing Lake Okeechobee and the large-scale solutions required to achieve restoration, we refer you to Audubon's paper, "Lake Okeechobee: A synthesis of information and recommendations for its restoration" available at fl.audubon.org. For information on downstream storage, see our EAA paper at http://www.audubonofflorida.org/PDFs/pubs_policydocs-EAA_Sustainability0405.pdf.

Downstream of Lake Okeechobee

Project	Storage estimate (ac-ft)
EAA Reservoirs	360,000
STAs	63,000
CERP ASR:	unknown**
Total planned	423,000
Needed	1,000,000
Shortfall	577,000

Given the large volumes of water that the watershed is capable of quickly delivering to Lake Okeechobee, Audubon estimates that at least 1.2 million acre-feet of storage capacity need to be restored upstream of the lake (equal to about 2.5 feet in the lake) to gain reasonable control of water level rise and capture significant inflows for adequate treatment.

In addition to upstream storage, at least 1 million acre-feet of storage are needed downstream of the lake in order to complete reasonable restoration of Lake Okeechobee, the estuaries, and the Greater Everglades Ecosystem.

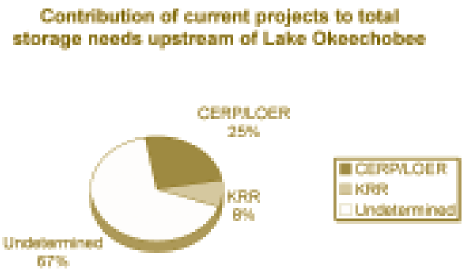
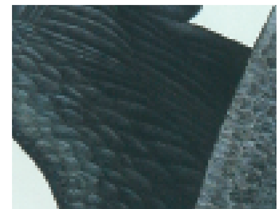


Figure 4. Contribution of current projects toward Audubon's estimated storage need of one million acre-feet of storage downstream of Lake Okeechobee.

**ASR wells are considered downstream features because current plans require water to enter the lake before it is pumped into the ASR system.

Restoring water quality in Lake Okeechobee

Ongoing imports of phosphorus continue to increase the phosphorus problem in Lake Okeechobee's watershed. The average annual net import of phosphorus, from cities and farms, to the lake's upstream watershed is estimated at more than 5,000 metric tons.



Current efforts to reduce nutrient pollution in Lake Okeechobee

As noted earlier, the current phosphorus goal for Lake Okeechobee is a 5-year average of 140 metric tons per year. Of this amount, about 35 metric tons are predicted to enter in rain and dust, leaving 105 metric tons that can arrive in inflows. Recent annual inflows have averaged 500-600 metric tons (Fig. 2). About 900 metric tons entered the lake in 2005; a reminder of how much water and phosphorus can move through a system that is heavily influenced by tropical weather activity. These large inflows occurred in spite of decades of research and programs to control the phosphorus pollution of Lake Okeechobee, including the 1976 Final Report on the Special Project to prevent the Eutrophication of Lake Okeechobee, Rural Clean Water Program, Surface Water Improvement and Management Act, and Dairy Buy-out Program. Although these plans had merit, and achieved some successes, they were too limited to protect Lake Okeechobee. The result has been little change in total phosphorus loading and continuing declines in in-lake water quality (Figure 5).

Two major new efforts for phosphorus control are underway. The Lake Okeechobee Protection Plan (LOPP) was presented in 2004 and is the over-arching road map to reaching the lake's phosphorus goal by the year 2015. That plan accounted for CERP projects, assumes Best Management Practices for phosphorus control around the lake, and accounts for other control measures needed to reach the goal. The CERP LOW project was expected to install reservoirs and filter marshes that can clean an estimated 50-100 metric tons of phosphorus per year, depending on which design alternative is selected. The Lake Okeechobee and Estuary Recovery plan (LOER), announced by the Governor in 2005 includes these plans and adds some additional projects. Unfortunately, these plans have not considered the entire scope of rainfall and inflow volumes the system may receive and now, like previous programs, appear too limited to meet the phosphorus goal by the 2015 deadline.

Figure 6 presents an example of how current plans would fare when the annual phosphorus inflow from the watershed is 600 metric tons, as has occurred frequently since 1995 (Fig. 2). An estimated 300 metric tons would reach the lake in such a year, 195 metric tons above the TMDL. Since the TMDL is based on a 5-year average, the other 4 years would have to average only 55 metric tons per year to satisfy the TMDL. Considering that Lake Istokpoga's phosphorus outflow alone, representing less than 15% of the lake's watershed, contributes an average of 59 metric tons, having Lake Okeechobee's four-year inflow average reach 55 tons is virtually impossible.

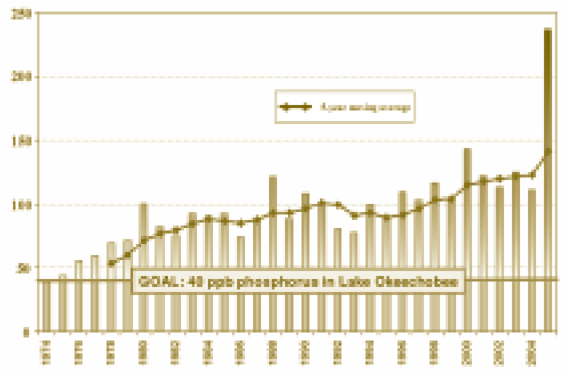
The role of storage in water treatment

If the LOW project of the CERP is likely to store 1 foot or less of lake water, and considering average summer net inputs to the lake are about 4 feet, it is clear that much of the water will bypass CERP features and flow into the lake untreated. Water flowing towards the lake must be captured long enough to

There are two facets to meeting Lake Okeechobee's water quality goals: working on individual properties (urban and agricultural) to reduce outflows at their source, and public works projects to treat water before it enters the lake.

provide sufficient treatment to meet the TMDL. The ability to capture about 1.2 million acre-feet of water upstream of the lake, as recommended in the previous section, is critical in achieving a reasonable ability to clean water before it enters the lake.

Figure 5. Water quality in Lake Okeechobee has continued to decline despite decades of research and programs to control nutrient pollution entering the lake (source: November 30, 2005 SFWMD presentation to Lake Okeechobee WRAC).



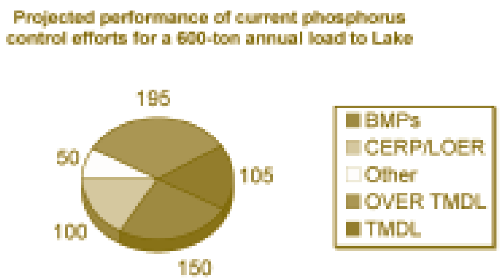


Figure 6. AA simplified example of how present programs might work in a year with 600 tons of phosphorus flowing toward Lake Okeechobee. Best Management Practices (BMPs) are projected to reduce phosphorus by 25%, the CERP/LOER projects can be projected to remove another 100 tons, and small non-CERP projects might catch another 50 tons (total uncertain). The phosphorus goal allows for 105 tons from inflows. This would result in additional loading of 195 tons of phosphorus over the goal.

Phosphorus is still being added to the system

Ongoing imports of phosphorus continue to increase the phosphorus problem in Lake Okeechobee's watershed. The average annual net import of phosphorus, from cities and farms, to the lake's upstream watershed is estimated at more than 5,000 metric tons.[7] Continued phosphorus additions lead to saturation of soils and waterbodies followed by increased phosphorus outflows. For example, studies on four of the major lakes in the Kissimmee Chain, and on Lake Istokpoga, estimate that at current loading rates, these lakes may become phosphorus saturated in as little as 10-15 years.[8] Once saturated, these lakes will have a diminished ability to capture phosphorus, and will shed much greater phosphorus loads in their outflows, increasing the loading to the Kissimmee River and Lake Okeechobee. The phosphorus concentrations flowing from Lakes Istokpoga and Kissimmee roughly doubled in the 1990s,[9] indicating the effects of saturation may already be showing. The same saturation process occurs on all properties where phosphorus additions continue, and as long as phosphorus additions are allowed phosphorus levels will continue to increase over the long-term.

Water quality goals to achieve restoration

There are two facets to meeting Lake Okeechobee's water quality goals: working on individual properties (urban and agricultural) to reduce outflows at their source, and public works projects to treat water before it enters the lake. Best Management Practices on properties must require either a halt to continued addition of phosphorus to properties, or water quality treatment on those properties to protect waterways. There also is a large amount of phosphorus remaining in the soils of the watershed due to decades of over-fertilizing (this remnant phosphorus is termed "legacy" phosphorus). For example, the Buck Island Ranch stopped using phosphorus fertilizer 20 years ago and still has outflow concentrations in the 300-700 ppb range,[10] about ten times as high as Lake Okeechobee's goal of 40 ppb. Water treatment capabilities must be restored within the watershed to prevent this legacy phosphorus from continuing to harm the lake. Landowners will provide a significant portion of this restored treatment capability through on-site programs (Buck Island is implementing further BMPs to help reduce their outflow numbers), but public projects such as wetland restoration and STAs are a necessary addition.

Although this document focuses on Lake Okeechobee, lake water quality improvement also is critical to the proper function of downstream CERP features and water supply to the Everglades. As has been recently demonstrated, only limited volumes of water can be treated through the STAs and sent to the Everglades when Lake Okeechobee's water is extremely polluted. Better water quality in Lake Okeechobee discharges will pay dividends in less water treatment and higher quality water delivered to the Greater Everglades, and other systems receiving lake water.

[7] see: Mock-Roos & Associates, Inc. 2002. Phosphorus budget update for the northern Lake Okeechobee watershed. Final report. South Florida Water Management District Contract No. C-11683. and Mock-Roos & Associates. 2003. Lake Istokpoga and Upper Chain of Lakes phosphorus source control: Task 4 final report. South Florida Water Management District Contract No. C-13413. West Palm Beach.

[8] See: White, J., M. Belmont, K. R. Reddy, and C. Martin. 2003. Phosphorus sediment water interactions in Lakes Istokpoga, Kissimmee, Tohopekaliga, Cypress and Hatchinehaw. Presentation to Interagency Committee, Dec.

[9] South Florida Water Management District. 2002. Surface Water Improvement and Management (SWIM) Plan—update for Lake Okeechobee. SFWMD, West Palm Beach.

[10] Bohlen, P. Archbold Biological Station, personal communication.

Solutions: An approach for achieving meaningful restoration

Experience has shown that water can flow into the lake much faster than it can be released, making harmfully deep levels unpreventable, even during average rainfall years. High inflows also contribute to unacceptable pollution loads, causing significant harm to the lake and downstream systems. These problems can only be addressed by restoring lost water storage and treatment capacity in the watershed.

In spite of the unprecedented and necessary projects currently underway for the system (namely the CERP/LOER, Kissimmee River Restoration, and the LOPP), like previous efforts, these projects appear much too small. At the same time, the expensive real estate market and competition for land makes land-based solutions to these challenges extremely expensive. It is clear that an expanded effort must be mounted, and that this work must begin immediately to minimize costs and increase the chance for success.

Three Steps to Success

1. Re-examine the scope of challenges to restoration: The first step toward achieving full restoration of Lake Okeechobee and its watershed, so critical to bringing the Greater Everglades Ecosystem back to health, is to establish a multi-disciplinary technical group to conduct a formal review of the most recent findings regarding climate conditions, land and watershed development and land use, and current and legacy nutrient phosphorus in the system. This public process may be best conducted under the auspices of the South Florida Restoration Task Force, established by Congress in 1996 to coordinate and advise restoration initiatives, through its Science Coordination Group.

2. Produce a comprehensive estimate of restoration needs: Based upon the assessment of restoration challenges, this technical group should conduct a comprehensive and rigorous estimate of restoration needs. This includes estimates of the total water storage, water treatment, and conveyance infrastructure, needed both upstream of and downstream from Lake Okeechobee to achieve ecological goals and objectives throughout the system. This estimate should aim, in part, at quantifying the total storage needed to achieve natural timing of water movement through the system and prevent discharge of polluted water to any natural area.

3. Develop a plan to implement storage and treatment solutions: Once an adequate estimate of restoration needs is developed, it will be the task of agencies, the federal, state and local governments, and their partners, to determine a course of action for meeting any needs not met by ongoing restoration projects and initiatives. This effort must include identification of the land, infrastructure, configuration, and conveyance needed to achieve restoration goals. Finally, funding and timetables to achieve the goals must be determined.

Build a firm foundation for the future

1. Maximize the benefits of current restoration projects: Storage and treatment should be maximized in all on-going restoration efforts including the Kissimmee River Restoration project, LOW/LOER, other CERP projects (especially in the EAA), and the LOPP.

- The 2007 revision of the Lake Okeechobee Protection Plan (LOPP) is an excellent opportunity for state and federal agencies to ensure compliance with Lake Okeechobee's phosphorus goal by the 2015 deadline. Many actions should be considered to help meet this goal, including:
- Adjusting plans to compensate for the increased inflows expected within the system (especially by developing a synthetic data set that could sufficiently analyze "wet pattern" AMO years only).
- Halting the continued net import of phosphorus. If certain land uses (urban or agricultural) cannot stop importing phosphorus, then treatment on the properties must be installed to protect waterways.
- Basing goals for Best Management Practices on meeting numeric water quality standards, rather than irrelevant "percent-reduction" goals.

Lake Okeechobee's problems can only be addressed by restoring lost water storage and treatment capacity in the watershed. In spite of the unprecedented and necessary projects currently underway for the system (namely the CERP/LOER, Kissimmee River Restoration, and the LOPP), like previous efforts, these projects appear much too small. At the same time, the expensive real estate market and competition for land makes land-based solutions to these challenges extremely expensive. It is clear that an expanded effort must be mounted, and that this work must begin immediately to minimize costs and increase the chance for success.

- Aggressively pursuing Managed Aquatic Plant technologies as complimentary or stand-alone projects.
- Ensuring water quality in the Kissimmee Chain of Lakes and Lake Istokpoga watersheds will prevent additional lakes from becoming phosphorus saturated.
- Ensuring the Kissimmee Chain of Lakes and Lake Istokpoga achieve storage capacity proportional to their flow contributions.
- Prohibiting imports of sludge and septage to the watershed and ensure sludge and septage generated in the watershed is not used in ways that cause phosphorus or nitrogen imbalances.
- Implementing phosphorus goals (Total Maximum Daily Loads) within Lake Okeechobee's watershed so that they are compatible with the goal for Lake Okeechobee (i.e., do not set TMDLs in the watershed that, even when met, can produce violations of the lake's TMDL).
- Complete testing on ASR technology and if it proves feasible at some level, consider implementation opportunities upstream of Lake Okeechobee where it could help address inflow and nutrient movement issues.

2. Implement creative private land initiatives: Federal and state agencies have many private land initiatives that could make important contributions to reaching restoration goals. These include:

- Best Management Practices and Environmental Resource Permits should have reasonable but stringent requirements for water detention (i.e., storing water until it evaporates or percolates). A preliminary goal (pending investigation) would be to achieve a pre-drainage volume of runoff from each property. Because of the large acreages involved, this effort has the potential to restore very large amounts of storage.
- Traditional tools that can help restore water storage, such as easements, cooperation with state and federal farm programs, and/or wetland restoration on properties.
- Considerations for programs that provide extra water storage, such as:
- World Wildlife Fund's Florida Ranchlands Environmental Services Project, where landowners might be paid for storage and treatment of water, and
- "Hanlon's Recyclable Water Concept" where adjacent landowners build and manage cooperative water management features, reducing dependence on the regional system and giving them better control over their own water resources.

Storage projects on private lands would help create an agile water management system because they could be used during times of greatest necessity and revert to other uses when not needed.

Final Consideration: Regional Initiatives for a Healthier Watershed

The greener the Lake Okeechobee watershed, the healthier all the lakes, rivers and streams will be in this region and the healthier Florida's water supply will be. To keep the watershed green and as part of the overall water storage and quality efforts, local, state and federal agencies should develop Regional Restoration Projects to restore or conserve ecosystem values in key areas of the watershed. Regional initiatives also improve recreation benefits.

Potential focal projects could include:

- Restoring riverine corridors including Arbuckle Creek, Reedy Creek, the Kissimmee River, upper Fisheating Creek, and/or others;
- Restoring regions such as the Istokpoga Marsh, parts of Indian Prairie (possibly removing part of the Hoover Dike), Nicodemus Slough, Paradise Run, the upland borders of the Kissimmee River floodplain, and others.

Funding for such projects could come from traditional conservation funding, Rural Land Stewardship-type initiatives (significant storage might be attained if local governments used this approach to setting aside "green-space" when permitting development, as part of their comprehensive plans), or other avenues. These projects range in size from small to very large, but in total, would make a significant contribution to the future environmental health of south Florida.

solutions exist.

GLOSSARY OF TERMS, ACRONYMS, AND ABBREVIATIONS

Acre: a square of land with sides of 209 feet and totaling 43,560 square feet (English measure). Abbreviated “ac”

Acre-foot: the amount of water that would cover one acre (43,560 square feet) one foot deep. It equals 326,000 gallons of water. Abbreviated “ac-ft”

AMO: “Atlantic multi-decadal oscillation” a pattern of alternate warming and cooling of the Atlantic Ocean that recently has lasted 2-4 decades for each condition and that tends to increase rain and runoff into Lake Okeechobee during the warm phase and decrease them during the cool.

ASR: “Aquifer Storage and Recovery” a well where surface water is injected into deep aquifers during high water periods and recovered during dry periods.

BMP: “Best Management Practices,” typically thought of for agricultural operations but also applicable to urban areas. BMPs are a series of activities that are recommended to improve efficiency, environmental protection and also protect profitability.

CERP: “Comprehensive Everglades Restoration Plan”.

EAA: “Everglades Agricultural Area” about 700,000 acres (280,000 ha) of farmland south of Lake Okeechobee and north of the Water Conservation Areas.

EPA: “Environmental Protection Agency” a federal agency that is a counterpart to the State’s DEP.

Eutrophic: nutrient rich, in limnology, usually refers to water bodies with phosphorus concentrations above 20 parts per billion

FDACS: “Florida Department of Agriculture and Consumer Services”

FDEP: “Florida Department of Environmental Protection”

LOPA: “Lake Okeechobee Protection Act” (HB 991), legislation passed in 2000 designed to help restore Okeechobee and its watershed.

LOPP: “Lake Okeechobee Protection Plan” The plan to meet Lake Okeechobee’s phosphorus goal by 2015, which was developed by mandate from the Lake Okeechobee Protection Act.

LOW project: “Lake Okeechobee Watershed Project” the Lake Okeechobee watershed component of CERP.

MFL: “Minimum Flows and Levels” For lakes, this is the water level below which withdrawing more water would cause harm lasting several years.

P: “phosphorus” in this document P refers to total phosphorus, often written elsewhere as “TP”

ppb: parts per billion, also known as micrograms per liter

Regulation Schedule: a plan for water level management in water bodies. Usually expressed as a graph with dates across the bottom and water levels on the side

SFWMD: “South Florida Water Management District”

SSM: “supply-side management” For Okeechobee, this is the water management plan during drought conditions, otherwise known as a water rationing plan for the Lake’s water.

STA: “stormwater treatment area” otherwise known as “filter marshes,” these constructed areas use aquatic vegetation to filter nutrients from the water.

TMDL: “Total Maximum Daily Load” the amount of a pollutant that can enter a waterway per year without causing undue harm.

Ton: an English ton is 2000 pounds while a metric ton is 2200 pounds, or 10% larger (actually, a metric ton is 1000 kilograms and at 2.2 pounds per kilogram, equals 2200 pounds).

USACE: “United States Army Corps of Engineers”

WSE: “Water Supply and Environment” the water level management plan for Lake Okeechobee which tends to keep water from exceeding 17 feet and allows it to drop as low as 13.5, during normal periods.

everything in harmony

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