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AWARDS

The Florida Lake Management Society presents the following annual awards:

The Marjorie Carr Award is the Society's highest award and is given for lifetime work on behalf of Florida's aquatic resources. This award is named in honor of Marjorie Carr who, among other things, organized citizens and brought to an end the proposed Cross-Florida Barge Canal.

> Past recipients include: Hal Scott (1990), Vince Williams (1991), Cassie and David Gluckman (1993), Johnny Jones (1994), Richard Coleman (1995), Nat Reed (2000), Mike Kasha (2001), Everett Kelly (2002), Joe E. Hill (2003), and Jake Stowers (2004).

The Edward Deevey, Jr. Award is given to an individual for contributing to our scientific understanding of Florida's waterbodies. Edward Deevey was an internationally recognized limnologist and was affiliated with the State Museum of Florida at the time of his death.

> Past recipients include: William Beck (1990), Jim Hulbert (1991), Howard T. Odum (1993), Tom Crisman (1994), Marty Wanielista (1995), Karl Havens (1999), Claire Schelske (2000), and Betty Rushton (2003).

The Scott Driver Award is given to an "activist" who has promoted the restoration, protection, and/or appreciation of Florida's aquatic resources. Scott was a well known activist on behalf of Lake Okeechobee and was a member of the steering committee that founded FLMS at the time of his death.

> Past recipients include: Helen Spivey (1990), Jim Hawley (1991), Wayne Nelson (1993), Jim Thomas (1994), Tom Reese (1995), Judith Hancock (1999), Carroll Head (2000), Mary Carter (2001), Al Cheatum (2002), Thomas E. Fortson (2003), and Beverly Sidenstick (2004).

The Richard Coleman Aquatic Resources Award is given to a professional who has worked to restore, protect, and/or advance our understanding of Florida's aquatic resources. This award is named in honor of Richard Coleman who was a founder and first president of FLMA and, prior to his death, worked tirelessly to protect and restore aquatic resources throughout the State of Florida.

> Past recipients include: Eric Livingston (1990), William Wegener (1991), Paul Shaffland (1993), Jeff Spence (1994), Sandy Fisher (1995), Kim Schildt (2000), Jess Van Dyke (2001), Patrick J. Lehman (2002), Lothian Ager (2003), and Dr. Marty Kelly (2004).

The Marjorie Stoneman Douglas Award is given to individuals in the media who report on aquatic resource issues. This award is named in honor of Marjorie Stoneman Douglas who authored the book, "Everglades River of Grass", founded the Friends of the Everglades, and who has been environmentally active in South Florida.

> Past recipients include: John Morgan (2000), Georgia Davis (2001), Victor Hull (2002), Dave McDaniel (2003), and Bob Hite (2004).

The Bob Graham Award is given to persons elected to office who demonstrate a commitment to lake and aquatic resource conservation. Bob Graham is remembered for his support of many environmental initiatives, including the purchase for preservation of thousands of acres of Gulf Coast wetlands.

> Past recipients include: Robert B. Rackleff and Debbie Lightsey (2001), Shannon Staub (2002), and Cliff Barnes (2003).

The President's Award is given by the President of the Society to an individual for outstanding support of the work of the Society during the past year.

> Past recipients include: Nancy Page (1999), Julie McCrystal (2000), Erich Marzolf (2001), and Chuck Hanlon (2002).

EXHIBITORS

FINAL PROGRAM

16th ANNUAL CONFERENCE OF THE FLORIDA LAKE MANAGEMENT SOCIETY

Conference Theme: We're Back!!

Hawk's Cay Resort – Duck Key – Florida Keys
June 6-9, 2005

FINAL PROGRAM

MONDAY - JUNE 6, 2005

7:00 am-7:00 pm	Exhibitor Set-Up
8:00 am-5:00 pm	Check-In and Registration
8:00-11:45 am	**Workshop 1: Lake and Pond Watershed Management – A Primer** (Coordinators: Don Moores and Julia Palaschak – Berryman & Henigar)
8:00-11:45 am	**Workshop 2: Managing a Sediment Removal Project** (Coordinators: Shailesh Patel and Collins K. McCay – Dredging & Marine Consultants)
8:00-11:45 am	**Workshop 3: Aquatic Plant Identification and Monitoring** (Coordinator: Ken Langeland – UF Center for Aquatic and Invasive Plants)
8:00-11:45 am	**Workshop 4**: **Data Management and Exploratory Analyses with Excel** (Coordinators: Erich Marzolf and Elizabeth Mace – St. Johns River Water Management District)
9:45-10:00 am	MORNING REFRESHMENT BREAK
12:00-1:00 pm	LUNCH (provided with Workshop registration)
1:15-5:00 pm	**Workshop 5: Lake and Pond Restoration** (Coordinator: Kelli Levy – Pinellas County Environmental Management/Water Resources Management Section)
1:15-5:00 pm	**Workshop 6: Lake and Watershed Planning Using GIS** (Coordinators: Jim Griffin – Southwest Florida Water Management District and Kimberly Jackson – Florida Department of Environmental Regulation)
1:15-5:00 pm	**Workshop 7: Cyanobacteria Identification** (Coordinators: John Burns – PBS&J and Andy Chapman – Green Water Laboratories)
1:15-5:00 pm	**Workshop 8**: **Nutrient Management Methods** (Coordinator: Harvey H. Harper – Environmental Research & Design, Inc.)
3:00-3:15 pm	AFTERNOON REFRESHMENT BREAK

TUESDAY - JUNE 7, 2005

8:00 am-4:00 pm	Check-In and Registration	
9:00-9:15 am	Opening Remarks:	Chuck Hanlon – FLMS President Gene Medley – NALMS President Jeff Herr – Conference Chairman

Session 1: Stormwater Management and Load Reduction
Moderator: John Burns

9:15-9:35 am — **Stormwater Use for Irrigation: Volume and Nutrient Control** – Martin Wanielista and Ewoud Hulstein

9:35-9:55 am — **Lake Thonotosassa Restoration and Management: Restoration of a Rural Lake After Point Source Removal** – Jim Griffin and Amy Remley

9:55-10:15 am — **Stormwater and Lakes Management Planning in the City of Maitland** – S. Duarte, J. Abbott, A.B. Shortelle, W. Tucker, and D. Sample

10:15-10:35 am — MORNING BREAK *(Exhibit Hall)*

Session 2: Evaluating Watershed Impacts
Moderator: Clell Ford

10:35-10:55 am — **Shell Creek and Prairie Creek Watersheds Management Plan: Reasonable Assurance Documentation to Address TMDL Issues within the Watersheds** – Eric DeHaven, Roberta Starks, David Brown, and Steven Minnis

10:55-11:15 am — **Istokpoga and its Watershed- On Washing the Car from the Top and Fixing the Plumbing –** Clell Ford

11:15-11:35 am — **The External Phosphorus Budget for Lake Apopka, 1995-2002 –** V.R. Hoge, E. Marzolf, M.F. Coveney, and I. Bjuak

11:35-11:55 noon — **Back-pumping of Agricultural Runoff into a Large Shallow Lake: Concurrent Changes in the Macroinvertebrate Assemblage** – Andrew J. Rodusky, Bruce Sharfstein, and Ryan P. Maki

12:00-1:15 pm — LUNCH *(provided)*

Session 3: Hurricane Impacts
Moderator: Erich Marzolf

1:15-1:35 pm	**The Effects of Hurricane Charley on Eelgrass (*Vallisneria americana*) Populations in Lake Conway** – Ronald Novy
1:35-1:55 pm	**Effects of 2004 Hurricanes on Water Quality in Orlando Lakes –** Kevin McCann and Ronnie Long
1:55-2:15 pm	**Hurricane Effects on Lake Okeechobee: A Case Study in Alternate Steady-State Shifts** – Bruce Sharfstein and Therese L. East
2:15-2:35 pm	**Hurricanes and Lake Apopka: Past, Present, and Future** – E. Marzolf, M. Coveney, R. Conrow, L. Battoe, and E. Lowe
2:35-3:00 pm	AFTERNOON BREAK *(Exhibit Hall)*

Session 4: Ecological Issues and Studies
Moderator: Gene Medley

3:00-3:20 pm	**Assessment of the Seed Bank and Torpedograss Seed Viability at Selected Marsh Sites in Lake Okeechobee –** Dwilette McFarland, Dian Smith, Michael Smart, and Chuck Hanlon
3:20-3:40 pm	**Vegetation Mapping in Lake Okeechobee, Florida Using Multiscaled Non-Temporally Coincident Color Infrared Photography** – Mark Brady, Gary Florence, Richard Eastlake, and Marty Goodwin
3:40-4:00 pm	**A Conceptual Ecosystem Model for Lake Istokpoga, Central Florida** – Nellie E. Morales
4:00-4:20 pm	**Re-Establishing Ecological Integrity: Proposed Hydrologic Performance Measures for Lake Istokpoga, Central Florida** – Nellie E. Morales and Paul Gray
4:20-4:40 pm	**Restoration of Former Agricultural Land to Wetlands on Lake Okeechobee's Ritta Island** – Kim M. O'Dell, Steve Gornak, and Bruce Sharfstein
4:40-5:00 pm	**Seed Germination in Wild Celery (*Vallisneria americana* Michx.) from Lake Okeechobee, Florida, U.S.A.** – H.J. Grimshaw, W.A. Matamoros, and B. Sharfstein
5:00-7:00 pm	**EXHIBITOR'S SOCIAL / POSTER SESSION** *(Exhibit Hall)*

Posters:

1. **Does Alum Floc Distribution Affect Success of Phosphorus Control in a Shallow Impoundment? –** V.R. Hoge, W. Godwin, J. Ryan, and A.B. Shortelle
2. **Spatial and Temporal Differences in Water Quality and Water Clarity in Kings Bay (Citrus County), Florida – Preliminary Results**– Amy H. Remley

WEDNESDAY - JUNE 8, 2005

8:00 am-3:00 pm	Check-In and Registration
8:00-8:20 am	Continental Breakfast

Session 5: Diagnostic Studies
Moderator: Rick Baird

8:30-8:50 am	**Feasibility of Pesticide Remediation During Restoration of Wetlands Along the North Shore of Lake Apopka, Orange and Lake Counties, Florida** – T. Bartol, A.B. Shortelle, M.L. Jones, E.M. Kellar, W.A. Tucker, and M.C. Diblin
8:50-9:10 am	**The Use of Heterotrophic Bacteria in an Urban Central Florida Lake** – Richard Baird, Julie Bortles, and Lillian Pierson
9:10-9:30 am	**Seasonal and Diurnal Variability in Lake Hancock, an Ultra-Hypereutrophic Lake –** Harvey H. Harper
9:30-9:50 am	**Assessing Water Quality Improvements in the Upper Ocklawaha River Basin** – Michael F. Coveney, Rolland S. Fulton, Walter F. Godwin, Erich R. Marzolf, Lawrence E. Battoe, Edgar F. Lowe, and Roxanne Conrow
9:50-10:10 am	**Effects of Increased Phosphorus Loading on Dissolved Oxygen in a Subtropical Wetland, the Florida Everglades** – Paul V. McCormick and James A. Laing
10:10-10:40 am	MORNING BREAK *(Exhibit Hall)*

Session 6: Use of Coagulants for Water Quality Improvement and Lake Management
Moderator: Jim Griffin

10:40-11:00 am	**Monitored Performance Efficiency of an Off-Line Alum Stormwater Treatment System in Largo, Florida -** Jeffrey L. Herr
11:00-11:20 am	**Field Evaluation of Alternative Nutrient Control Treatments within the Upper Ocklawaha River Basin** –Vickie Hoge, Walt Godwin, Ann B. Shortelle, Maria L. Jones, and Joy Ryan
11:20-11:40 am	**Evaluation of Dose Requirements for Alum Sediment Inactivation** – Harvey H. Harper
11:40-12:00 noon	**Phosphorus Sequestration Using Aluminum-Containing Amendments in Organic Soils from a Municipal Wastewater Treatment Wetland** – Lynette M. Malecki and John R. White
12:00-12:20 pm	**Properties of Iron Humate and Its Use in Phosphorus Removal from Water** – Bobby E. Rehberg
12:30-1:50 pm	BANQUET LUNCH / PROGRAM

Session 7: St. Johns River
Moderator: Mike Coveney

1:50-2:10 pm	**Temporal and Spatial Patterns of Carbon, Nitrogen, and Phosphorus Content of Submerged Aquatic Vegetation in the Lower St. Johns River –** Michele Lockwood and Dean R. Dobberfuhl
2:10-2:30 pm	**Littoral Sediment Characteristics and Submerged Aquatic Vegetation Interactions in the Lower St. Johns River, Florida –** Dean Dobberfuhl
2:30-2:50 pm	**Assessment of Shallow Groundwater Nutrient Loadings into the Lower St. Johns River –** Ying Ouyang
2:50-3:10 pm	AFTERNOON BREAK *(Exhibit Hall)*

Session 8: Critters – The Good, the Bad, and the Ugly
Moderator: David Evans

3:10-3:30 pm	**Channeled Apple Snails: Causing an Environmental Problem in Central Florida's Lake Brantley – and Beyond** – Dana R. Denson
3:30-3:50 pm	**Seminole County's Action Plan: Addressing the Channeled Apple Snail Infestation in Lake Brantley** – Gloria M. Eby and John A. Osborne
3:50-4:10 pm	**The Correlation of Various Aquatic Macroinvertebrate Measures Between Qualitative Shore Zone Samples and Quantitative Sublittoral Zone Samples in South Florida Lakes** – Robert P. Rutter
4:10-4:30 pm	**Macroinvertebrate Assessments / Lake Condition Index as a Tool for Determining the Condition of Lakes Beauclair and Dora in the Lake County Upper Ocklawaha River Basin** – Sandi Hanlon-Breuer and Dana R. Denson

Session 9: Cyanobacteria
Moderator: Mike Perry

4:30-4:50 pm	**Cyanobacteria Research on the Harris Chain of Lakes: Where We Are and Where We Need to Go** – Lance M. Lumbard and Andrew D. Chapman
4:50-5:10 pm	***Cylindrospermopsis Raciborskii* (Cyanobacteria) Morphological Variation in the Harris Chain of Lakes, Florida** – Andrew D. Chapman, Peter D'Aiuto, Chris Williams, and Lance Lumbard
5:10-5:30 pm	**Phytoplankton Blooms and Associated Cyanobacterial Toxins in Lake Okeechobee** – Therese L. East

THURSDAY MORNING - JUNE 9, 2005

8:00-9:00 am Continental Breakfast

Session 10: Water Quality
Moderator: Andy Rodusky

9:00-9:20 am **Lake Level and Trophic State Variables Among a Population of Shallow Florida Lakes and within Individual Lakes** – Mark V. Hoyer, Christine A. Horsburgh, Daniel E. Canfield, Jr., and Roger W. Bachmann

9:20-9:40 am **Protecting Water Quality in Wakulla Springs with Nutrient Criteria and the Total Maximum Daily Load Process** – Joe Hand

9:40-10:00 am **STORET Made Easy: The Seminole Watershed Atlas Water Quality Data Management System** – Kyle Campbell, Ron Chandler, Shawn Landry, Kim Ornberg, and Gloria Eby

10:00-10:20 am **Treatment Effectiveness of a Floating Wetland Deployed in an Urban Lake** – Tom DeBusk, David Haselow, Tom Goffinet, and Rick Baird

10:20-10:45 am MORNING BREAK *(Exhibit Hall)*

Session 11: Water Storage and Sediment Removal
Moderator: Shailesh Patel

10:45-11:05 am **Freeboard Analysis of the C-43 West Storage Reservoi**r – Jing-Yea Yang and David W. Grounds

11:05-11:25 am **Using "MIKESHE" to Simulate and Evaluate Alternative Designs of the C-43 West Storage Reservoir –** Peter deGolian, Jing-Yea Yang, and Clyde Dabbs

11:25-11:45 am **New Technology for Size-Selective Removal and Monitoring of Sediments** – Dave Braatz and Randall Tucker

10:30 am-12 noon EXHIBITOR BREAK-DOWN

12 noon CONFERENCE ADJOURNED

POSTERS

DOES ALUM FLOC DISTRIBUTION AFFECT SUCCESS OF PHOSPHORUS CONTROL IN A SHALLOW IMPOUNDMENT?

V.R. Hoge and W. Godwin
St. Johns River Water Management District
Palatka, FL

J. Ryan and A.B. Shortelle
MACTEC, Inc.
Newberry, FL

To date >3,000 acres of District properties have been treated with a liquid alum application to reduce nutrient concentrations and improve water clarity. Generally, applications have been initially successful. However, one important question is the length of effectiveness at sites where sediments are specifically targeted for treatment. Possible reasons for short duration of treatment benefits are insufficient dosage, subsequent external loading, and incomplete initial sediment coverage or an actual loss or relocation of the "alum blanket".

We are currently testing the distribution and movement of alum floc as factors important to nutrient control in a shallow impoundment. S.N. Knight North, approximately 240 acres, was treated with liquid alum (18 mg Al/L) in December, 2004. This application reduced the total phosphorus (TP) concentration of the site to 50 µg TP/L (February 2005). The site is expected to be reconnected with Lake Griffin during 2005.

Welch and Cooke (1999) examined shallow lakes and found that internal phosphorus (P) loading was decreased by an average of 67% for six successful cases and lasted an average of eight years. Unsuccessful efforts to control internal P loading were blamed on macrophyte interference, rough fish, high pH and low dissolved oxygen (DO) at the sediment-water interface, and wind mixing.

Monitoring is currently underway at S.N. Knight North to:

- Quantify initial floc distribution and movement,
- Evaluate fish and benthic invertebrate communities pre and post alum application,
- Quantify DO, pH, and SRP values at depths throughout the water profile and at the sediment-water interface.

The results, to date, of the monitoring will be presented.

SPATIAL AND TEMPORAL DIFFERENCES IN WATER QUALITY AND WATER CLARITY IN KINGS BAY (CITRUS COUNTY), FLORIDA – PRELIMINARY RESULTS

<u>*Amy H.. Remley*</u>
Surface Water Improvement and Management (SWIM) Program
Southwest Florida Water Management District
Tampa, FL

Located in Citrus County, Florida, Kings Bay is a first magnitude spring system that forms a 600-acre embayment and headwater of Crystal River. Tidally influenced, the shallow bay functions as an inland estuary supporting numerous listed and unlisted wildlife species and economically important recreational activities. Declining water clarity and displacement of native aquatic vegetation, by nuisance exotic plant species, are current management issues in Kings Bay. Work completed by the University of Florida for the Southwest Florida Water Management District (District) in 1997 indicated an inverse relationship between the abundance of submerged aquatic vegetation (SAV) and chlorophyll concentrations (proxy measure of phytoplankton abundance) in the bay. Therefore, periods of reduced SAV abundance may indirectly affect water clarity through the correlative increase in clarity-reducing phytoplankton. Additional factors suspected of affecting water clarity in Kings Bay include color and suspended solids; volatile and non-volatile. To determine which factors affect water clarity spatially and temporally, the District initiated a bi-monthly (every other month) comprehensive monitoring program in October, 2003. Every other month, District staff measure water clarity with a horizontal Secchi disc (developed for measuring water clarity in shallow rivers/streams) and record in situ water quality information at twelve fixed stations. At each station, grab samples are collected to measure chlorophyll, color, nutrients, suspended solids, and turbidity. Preliminary results regarding the spatial and temporal changes in water clarity and the relationships between water clarity and significant water quality parameters in Kings Bay will be presented.

District staff, with field support from the Florida Department of Environmental Protection's St. Martin's Marsh/Big Bend Seagrass Aquatic Preserve, records water clarity and water quality information at twelve fixed stations in Kings Bay. Locations of the twelve stations were determined partly on sites established by previous studies on sediments, vegetation and water quality completed by the Florida Institute of Technology, University of Florida (UF) and UF/Lakewatch, respectively. This correlation of sites will help evaluate interactions between the bay's sediments, aquatic plants, water quality and water clarity. Additionally, sites were selected to represent the unique physical and hydrologic differences found throughout the bay. At each site, water clarity was measured twice by two observers with a horizontal Secchi disc. An average of the four resultant readings was subsequently used in all statistical analyses. In-situ water quality, including depth, dissolved oxygen, pH, specific conductance (proxy measure of salinity) and temperature, was measured with a YSI 600XL data sonde and recorded in the field. Grab samples for chlorophyll, color, nutrients, total suspended solids, and turbidity were collected at each site and sent for analysis by the District's laboratory. Statistical analyses were preceded by tests of normal distribution. A Kruskal-Wallis test (p-value of 0.05) was used to compare the medians of non-parametric data. A multiple regression analysis (p-value of 0.01) on log-transformed data was used to determine the relationships of chlorophyll, color and suspended solids with water clarity. Temporal changes in bay-wide water quality and water clarity were assessed graphically with the means of the grouped inter-site data.

Results indicated significant spatial differences in water quality and water clarity; often with notable differences between sites affected by spring discharge and those located outside the influence of ground water. Similarly, seasonal changes in water quality and water clarity were indicated. Approximately 61% of the variation in log-transformed water clarity data was explained collectively by the log-transformed concentrations of chlorophyll a and total suspended solids. To improve water clarity, the District will focus on implementing projects with resource management partners that support or enhance existing stands of SAV and reduce concentrations of suspended solids in Kings Bay.

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Belanger, T., H. Heck, M. Sohn, P. Sweets, M. Morris, and N. Julien (1993). Sediment Mapping and Analysis in Crystal River/Kings Bay and Lake Panasoffkee. Final Report Submitted to the Southwest Florida Water Management District. Florida Institute of Technology. Melbourne, Florida.

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Hoyer, M. V., L. K. Mataraza, A. B. Munson and D. R. Canfield, Jr. (1997). Water Clarity in Kings Bay/Crystal River. Final Report Submitted to Southwest Florida Water Management District. University of Florida, IFAS. Gainesville, Florida.

PRESENTATIONS

SESSION 1

STORMWATER MANAGEMENT AND LOAD REDUCTION

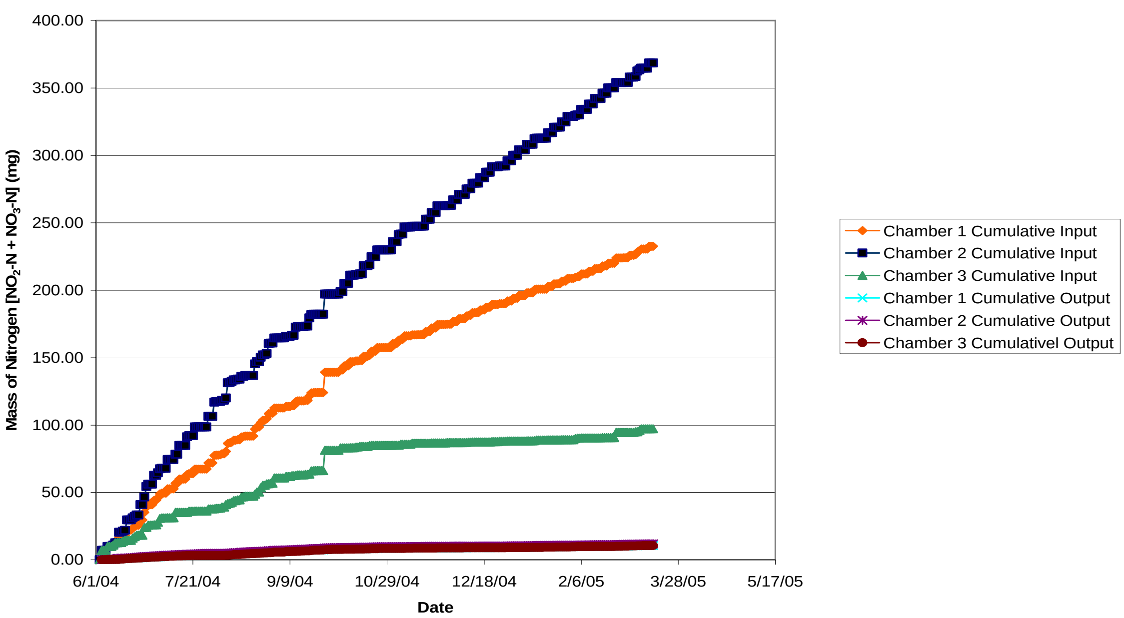
STORMWATER USE FOR IRRIGATION: VOLUME AND NUTRIENT CONTROL

Martin Wanielista, *and Ewoud Hulstein*
University of Central Florida - Stormwater Management Academy
Orlando, FL

In the field of watershed management, a change in surface conditions of the watershed can have measured effects on the volume of water discharged as well as the pollutant loadings in the discharged water. One example for the management of excess stormwater is the use of detained stormwater to reduce off-site effects.

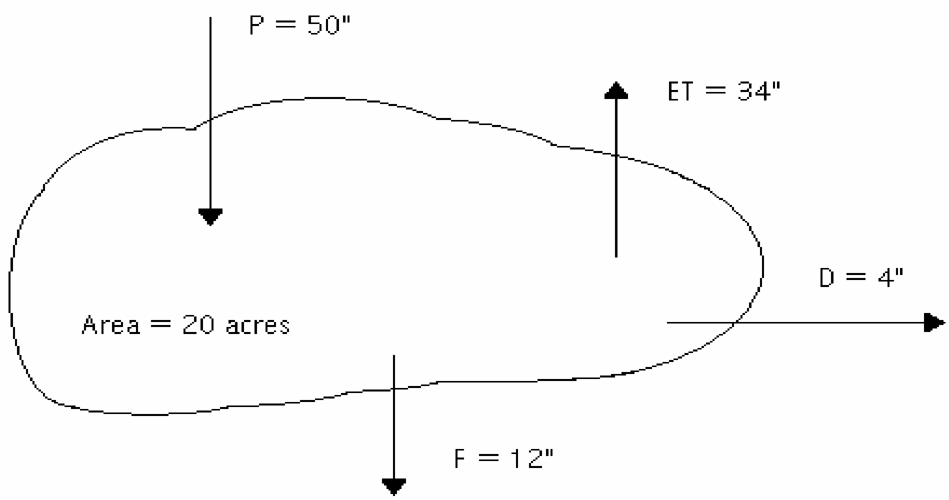
The feasibility and potential benefits of using the detained stormwater as a source for irrigation was investigated. A field experiment was set up in an outdoor location on the UCF main campus and has been in operation since June, 2004. The experiment consists of three chambers, each four feet deep with a surface area of four square feet, filled with compacted soil and covered with turfgrass. The turfgrass was irrigated twice a week with stormwater following an irrigation schedule common to turfgrass in Florida. Mass balance data were collected to construct a nitrate balance and a water balance.

From data collected over a period of nine months, it is concluded that the use of stormwater with nitrate concentrations up to 2 mg/L as a source for irrigation water has a negligible impact on the nitrate concentration in the groundwater. The upper three lines in the graph below represent mass in and the lower one is the mass out (4 ft below).



A total nitrogen analysis of the groundwater, precipitation, and irrigation water, indicated that all nitrogen species are converted to ammonium as water passes through four feet of soil and groundwater. The nitrate removal results are valid for a fluctuating groundwater table, since the water table of the experimental soil chambers fluctuated from 4 ft to 0.5 ft below the grass surface. A mass balance around the soil chambers indicated that nearly all of the nitrogen present in the groundwater was caused by soil leaching.

An example problem based on data collected from the described field experiment in Central Florida shows the calculations for a volume and nitrate balance. The pre condition was pasture land. The pre condition mass balance is shown below. The post condition was a single family residential area that has a 40 percent equivalent impervious area at rainfall events of 3 inches. Estimation methods for the variables of a yearly mass balance (some variables shown in the schematic below) are explained.



INPUT - OUTPUT = dS
P - D - F - ET = 0
50(20) - 4(20) - 12(20) - 34 (20) = 0

From the field monitoring, the modified Blaney-Criddle Equation was shown to be accurate for estimating actual ET for the conditions in the described experiment, which led to a calculated actual ET of 42.3 inches for St. Augustine grass in Central Florida (based on a high rainfall year).

Post-development vs. pre-development volume balance is achievable through irrigation of detained stormwater. Moreover, if stormwater is retained and used as a source for irrigation, a reduction of a watershed’s nitrate mass load emissions can be achieved.

NOTES:

LAKE THONOTOSASSA RESTORATION AND MANAGEMENT: RESTORATION OF A RURAL LAKE AFTER POINT SOURCE REMOVAL

Jim Griffin *and Amy Remley*
Southwest Florida Water Management District
Brooksville, FL

Lake Thonotosassa is the largest lake in Hillsborough County (819 acres) and one of the two meandered lakes in the County. As this 1934 Tampa Tribune excerpt indicates, the lake was the historic home to aboriginal peoples long before the arrival of European settlers:

"The name Thonotosassa is derived from the Indian name, Tenotosassa meaning "lake of flints." There for untold centuries before the whiteman (sic) came to make his home in the wilderness, the Seminole tribe gathered from all southwest Florida for its annual "free corn dance," when marriages were celebrated with feasting, and the tribal chiefs and the older men held high court in settling disputes among members of the tribe and meted out punishment to offenders." © 1934 Tampa Tribune

More recently, the lake's history, as recorded in its sediment, has been one of a water body deteriorating through post-aboriginal human use of the watershed. This sediment history, based on diatom assemblages at various sediment depths, indicates the lake was eutrophic (TSI = 60) prior to modern development in the watershed and became hypereutrophic (TSI>70) during the past century (Whitmore and Brenner 1995). Based, in part, on these findings a TSI goal of 60 was established for the lake.

The Surface Water Improvement and SWIM plan goals for the lake include: (1) reduction in chlorophyll-a concentration to 20 μg/L, (2) reduction in total phosphorus to 70 μg/L, (3) reduction in total nitrogen to 1.20 mg/L and (4) increase in Secchi depth to 1.0 m. The total phosphorus concentration, based on Hillsborough County Environmental Protection samples collected at a mid-lake station, has been reduced, but remains above the TP goal (Figure 1). These data indicate that the lake is not yet responding to the point and non-point BMPs implemented in the watershed.

This paper presents the results of seventeen years of SWIM management of Lake Thonotosassa's surface water resources and discusses the near term and long term management goals for the lake. Management strategies recommended by the Lake Thonotosassa SWIM plan have been implemented; however, the lake remains a hypereutrophic system. Additional best management practices are necessary to meet the goals established by the original diagnostic study and subsequent SWIM plans. However, before these projects can be specified, it will be necessary to re-evaluate the lake and watershed.

A diagnostic assessment completed in 1992 (Dynamac Corp. 1992) provided evidence that a TSI goal of 60 could be achieved by controlling the phosphorous load to the lake. By 1997 all point sources were removed from the Pemberton/Baker Creek system, the only surface water inflow to Lake Thonotosassa, resulting in significant reduction of the nutrient loads entering the lake. Between 1996 and 2004 three major BMPs were constructed to control non-point source loads and additional reductions in nutrient load were observed.

Figure 1 shows the observed and predicted (based on Lake Thonotosassa EUTROMOD model) total phosphorus (TP) concentrations in the lake from 1977 to 2004 and the TP goal of 0.070 mg/L. The reductions in TP are significant but remain above the goal. By 2003 the in-lake conditions as measured by the chlorophyll TSI indicate that the lake was not responding as was predicted by our original model and nutrient balance study.

In addition to the implementation of point and non-point sources of pollution to the lake, significant changes in land use have occurred since the diagnostic assessment and nutrient balance were completed in 1992. Accordingly, the FY 2003 SWIM plan recommended an update of the existing nutrient budget. This paper will outline key elements that remain in restoration of Lake Thonotosassa to include (1) an update to the 1992 nutrient budget and lake and watershed evaluation; (2) re-activation of the Lake Thonotosassa Technical Advisory Group, and (3) potential non-point source BMPs that will be evaluated.

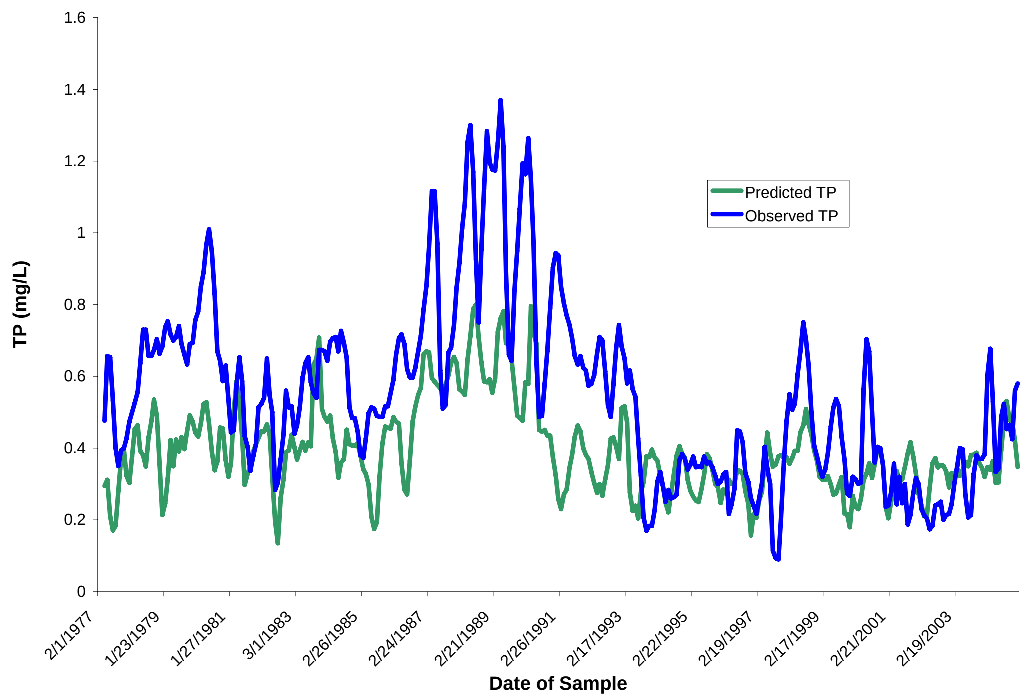


Figure 1. TP predicted by EUTROMOD and observed for Lake Thonotosassa (moving average).

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STORMWATER AND LAKES MANAGEMENT PLANNING IN THE CITY OF MAITLAND

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The numerous lakes in Maitland are an integral part of the fabric of community life, and contribute substantially to the value and well being of the community. The City of Maitland is currently updating its Stormwater and Lakes Management Plan (SLMP) originally developed in the mid 1990's. The updates include incorporating newly annexed areas, new Best Management Practices (BMPs), development of a GIS system to aid in lake management, water quality modeling and statistical evaluations of 10 years of lake data, and other related tasks.

This study also provides information necessary to determine if the capacity of the city's major drainage systems is adequate to convey the stormwater associated with the 10-year/24-hour, 25-year/24-hour, and 100-year/24-hour design storms. Characteristics of the basins within and draining to the City of Maitland, along with information derived from previous studies, were used to determine the hydrologic and hydraulic modeling parameters used in this report. The main lake basin parameters include drainage area, imperviousness, slope, hydraulic width, lake stage elevation, and geometry of lakes. The main pipe parameters include length, Manning's roughness coefficient, geometry, and upstream/downstream invert elevations. The U.S. Environmental Protection Agency's (EPA) Storm Water Management Model (SWMM) Version 5.0.001 software was used to model the hydrology and hydraulics of each basin within the city.

Loading rates of Total Suspended Solids (TSS), Total Nitrogen (TN), Total Phosphorus (TP), Biochemical Oxygen Demand (BOD) were estimated using land use characteristics of each basin and pollutant loading rates per acre appropriate for central Florida provided by Harper (1994). ARC-GIS was used to estimate land use coverage for each sub-basin. In-place BMPs were identified using multiple sources of information including aerial photo interpretation, information from City of Maitland staff, development dates and plans, and with reference to the 1996 SLMP. The effect of these BMPs was estimated using BMP treatment efficiencies were then estimated using ArcGIS.

The City's water quality data base is comprehensive and represents a valuable resource for assessing water quality conditions and trends. The water quality data itself represents a superior resource for assessing lake quality than could be achieved using models that are simplistic representations of complex lake processes. The primary results used to support this SLMP were the trends in TSI for the various lakes, leading to a relatively reliable estimate of present day lake quality and permitting the prioritization of some lakes as potentially degraded or degrading and requiring prioritization for City action to maintain or restore their water quality.

Water quality in Maitland's lakes has not deteriorated as severely as was anticipated by the 1996 SLMP. In part, the maintenance of fair to good water quality conditions has been the result of retrofit BMPs installed by the City. Water quality is better than expected, however, even in lakes that the City has not funded major BMP retrofits, indicating that the 1996 SLMP may have overestimated loadings or used water quality models that were too conservative. In addition, assimilative capacity of water bodies can give a false sense of "security". Nutrient loadings (both external, and eventually internal) to lakes lead inevitably to increased productivity and decline in water quality. Current good water quality must not be allowed to develop a sense of compliancy. Nutrient loadings must continue to be aggressively reduced to maintain lake water quality.

BMPs for controlling stormwater loading to and in-lake options for City lakes are being re-evaluated and updated with the understanding that some BMPS have limited application to City lakes due to land constraints. Potential technologies for reducing pollutant loading via stormwater runoff as BMPs were reviewed and characterized with respect to effectiveness and cost in the 1996 SLMP. But since then, additional research has become available that is useful in characterizing both effectiveness and cost of these options.

The modeling and project selection for each lake watershed area are being updated to meet the current water quality objectives for each lake. Projects are being prioritized primarily by cost-benefit analysis to protect the city's lakes resource. Among lakes, project prioritization considers community benefit, and include prioritization of projects providing greater overall community impact or benefit. Funding options to support lake restorations and stormwater BMP projects are also evaluated.

Water quality modeling is being conducted to evaluate stormwater BMPs, the potential for TMDLs, and to predict lake water quality. The updated modeling makes use of the newly developed GIS system for evaluation of loading to City lakes, along with the monthly lake water quality data now available for most of the City of Maitland lakes.

This paper includes the results of the analyses for the updated SLMP. These analyses show where the City's efforts to arrest declines in lake water quality have been successful, where improvements are evident, and where additional resources are best focused in the future.

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SESSION 2

EVALUATING WATERSHED IMPACTS

SHELL CREEK AND PRAIRIE CREEK WATERSHEDS MANAGEMENT PLAN: REASONABLE ASSURANCE DOCUMENTATION TO ADDRESS TMDL ISSUES WITHIN THE WATERSHEDS

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The Shell Creek reservoir, located in the southern region of the Peace River Basin, provides potable water to the City of Punta Gorda, Florida (City). The reservoir is sustained by two Class I waters - Shell and Prairie Creeks. In 2000, the City reported degradation of water quality in the reservoir. It was also observed that stream flows in Prairie and Shell Creeks were generally above historical median daily discharge rates throughout the drought of 1999 - 2000.

Land use in the Prairie and Shell Creek watersheds is predominantly agriculture comprised of citrus and row crops. It has been identified that runoff or direct leaching from the irrigation of agricultural lands is affecting the City's potable water supply. These irrigation waters are derived from mineralized ground-water wells.

In 2003, the Florida Department of Environmental Protection (FDEP) placed Shell and Prairie Creeks on the total maximum daily load (TMDL) list of verified impaired waters. The impaired parameters include chloride, specific conductance, and total dissolved solids (TDS). A stakeholders group, supervised by the Southwest Florida Water Management District (District), was established to address the TMDL listings. This group consists of 18 different state and local governments as well as private agricultural interests and other association and commodity groups.

The *Shell Creek and Prairie Creek Watersheds Management Plan* (SPCWMP) was submitted to the FDEP and the Environmental Protection Agency (EPA) in December 2004. The goal of the stakeholders group is to provide reasonable assurance that resource management actions initiated through the SPCWMP will improve surface water quality within the Shell and Prairie Creek watersheds to consistently meet Class I standards for chloride and TDS by the year 2014. The SPCWMP defines water quality monitoring networks, resource management actions, and cost-share reimbursement initiatives that will be used in the Shell and Prairie Creek watersheds to reduce or eliminate runoff of mineralized ground water. The monitoring networks include water-quality sample collection from numerous wells and surface-water bodies, as well as continuous/hourly in-situ monitoring of specific conductance and temperature in streams and canals throughout the watersheds. The proposed resource management strategies include the following action items: Well Back-Plugging Program, District Resource Regulation Well Construction and Water Use Permitting, Facilitating Agricultural Resource Management Systems (FARMS), Environmental Quality Incentives Program, Best Management Practices for Peace River Area Citrus Groves, Southern Water Use Caution Area Plans/Recovery Strategy, Quality of Water Improvement Program, Land Acquisition, Mobile Irrigation Lab, Education and Outreach, and Research Efforts.

To date, measurable improvements have been made in both the ground and surface waters of the Shell and Prairie Creek watersheds. Back-plugging has proven to be an immediate remediation technique for poor water-quality wells. Thirty-six wells throughout the Shell and Prairie Creek watersheds have been back-plugged over the past two years. Post back-plugging monitoring results in the Prairie Creek watershed have shown a 44 – 80 percent reduction in chloride and TDS in agricultural irrigation wells. Cost-share reimbursement on agricultural properties through the development of alternative irrigation sources such as tail-water recovery have resulted in the reduction of ground water withdrawals and subsequent water quality improvement in surface waters throughout the area. Eight FARMS projects are either completed, under construction, or in the contract phase.

District staff conducted a briefing at the FDEP office in Tallahassee in September 2004, and again at the EPA office in Atlanta in January 2005. Subsequent to the briefings, the District has received letters from both the EPA and FDEP indicating strong support for the SPCWMP and its intent of providing reasonable assurance. Formal approval of the SPCWMP will occur once the FDEP and EPA approve the Group 3 Basin Master list, which includes Shell and Prairie Creeks. This is expected in the next two months.

NOTES

**ISTOKPOGA AND ITS WATERSHED –
ON WASHING THE CAR FROM THE TOP
AND FIXING THE PLUMBING**

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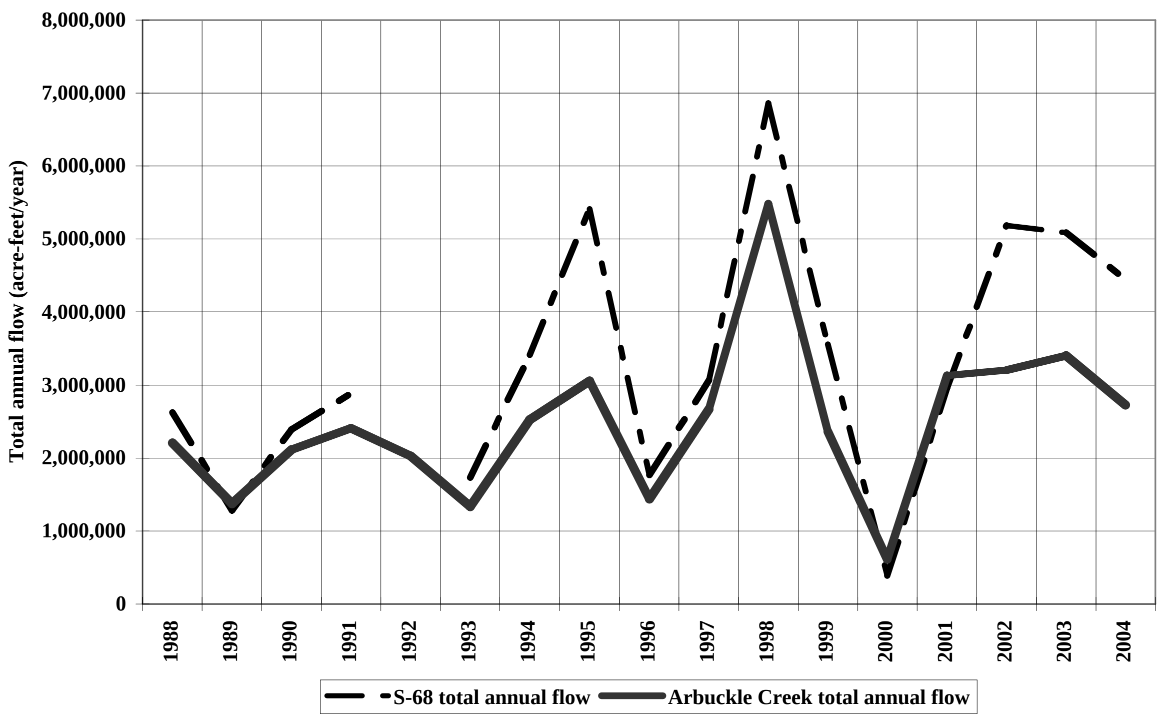
Lake Istokpoga, Florida's 5th largest lake at 27,609 acres and with a drainage basin that represents one-sixth of the Okeechobee watershed, is at the center of what is quickly becoming one of the most contentious ecosystem "discussions" in Florida. Since 1963, the Lake has been effectively managed as a flood control and water supply reservoir. Nationwide, ecosystem restoration focuses on where problems are expressed, not where they originate; the Everglades, Lake Okeechobee and Lake Istokopga are no exception.

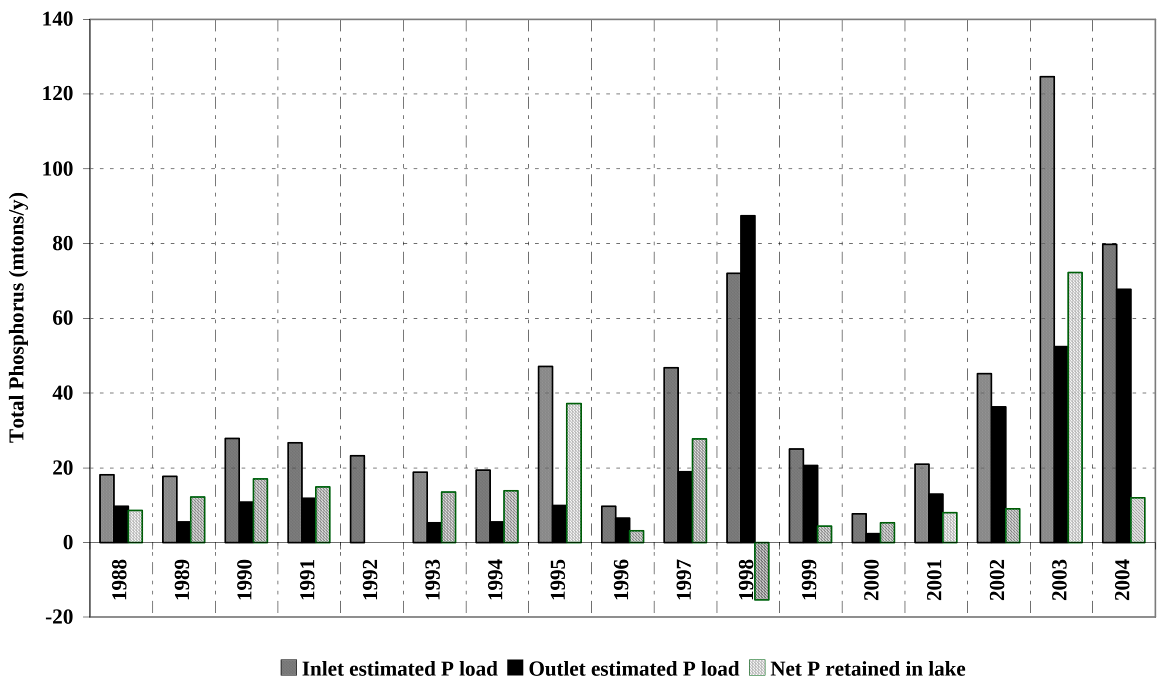
Average water discharge from Istokpoga was 3.3 million acre-feet per year between 1988 and 2004 (Figure 1). Istokpoga has become the #1 source of permitted surface water supply in the Kissimmee Valley, with a total consumptive use permitted at 183,000 acre-feet in 1995. This value is projected to double by 2020 (Kissimmee Valley Water Supply Plan, 2000).

Figure 1. Total annual flowinto (Arbuckle Creek) and out of (S-68) Lake Istokpoga (SFWMD data)



Istokpoga has been described by the South Florida Water Management District as an uncontrolled source of phosphorus to Okeechobee, based on an almost linear increase in phosphorus export loading between 1990 and 1999; Walker and Havens (2000) cited rainfall as the primary driving factor for the increase. However, since 2000 the increase in phosphorus loading to the lake from Arbuckle creek, which drains 2/3rds of the Istokpoga watershed, has increased from an estimated 72 metric tons during the 1998 El Niño, to 124 metric tons in 2003; in-lake retention of phosphorus (based on simple mass-balance calculations) jumped to 72 mtons in 2003 – equal to the load in 1998. Export of phosphorus has increased every year since the 2000-2001 drought, independent of discharge volume. Since 1996, in-lake nutrient concentrations have averaged 17 μg/L higher on the north end (73 μg/L) than the south (56 μg/L). Median total phosphorus and total nitrogen values were the highest on record for the lake in 2004. Lake sediments continue to absorb some of the load (see Figure 2) but the lake appears to be well on its way to becoming saturated with phosphorus. The lake and its watershed are going in the wrong direction. Reducing nutrient loading to the lake from the Arbuckle Creek watershed is the only way to meet restoration goals of a 23% reduction in phosphorus exports to Lake Okeechobee. Providing incentives and implementing BMPs for all residents of the watershed must be a high priority for future work. Wetland restoration for small tracts of Arbuckle Creek would provide a tremendous lift for the whole of the Okeechobee watershed downstream, helping to "wash the car from the top".

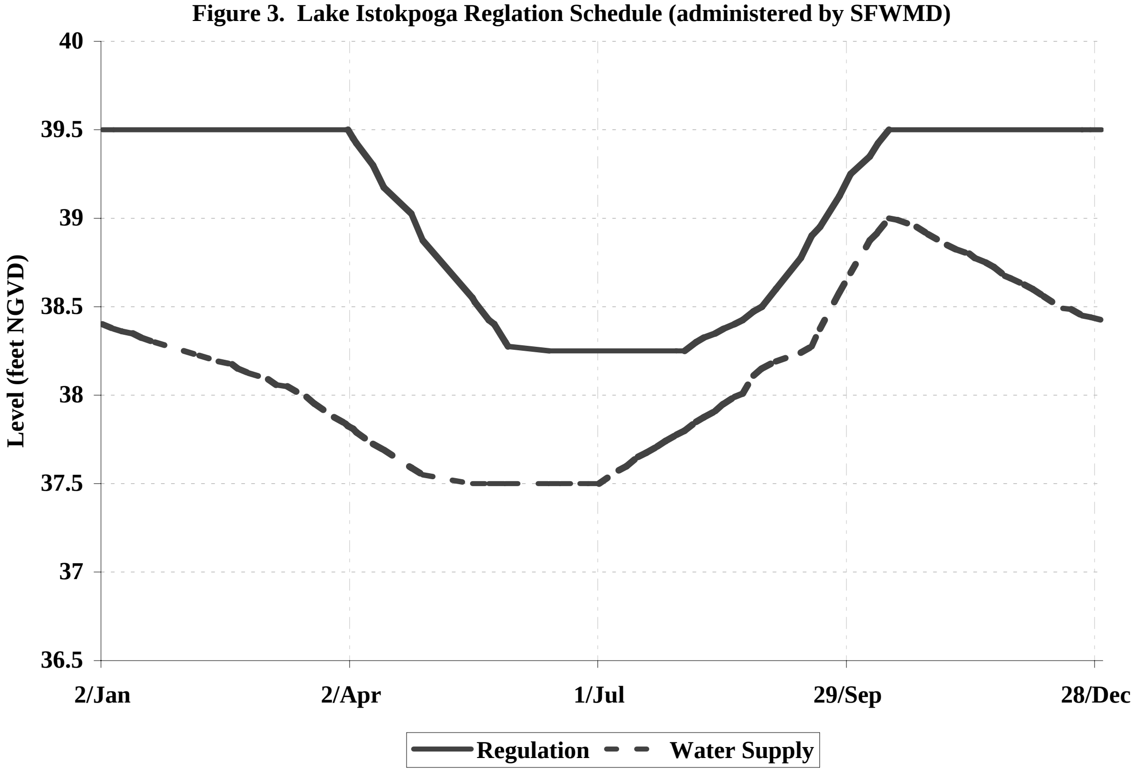
Figure 2. Istokpoga inlet (Arbuckle Creek), in-lake storage and Istokpoga outlet (S-68) annual Phosphorus loads (SFWMD data)



Water level stabilization, as illustrated by the water regulation schedule in Figure 3, has resulted in reduced wetland habitat, reduced natural wetland function, accumulation of muck and detritus along shorelines and in residential canals, along with promotion of invasive exotic aquatic plants; lake habitat dynamics play an enormous role in the lake's nutrient budget, with the potential to store up to 50% of the nutrients loaded to the lake annually, as well as filling a critical place in the life cycle of all the fauna that depend on the lake. Restoring at least a semblance of the natural fluctuation of the lake is critical to making Istokpoga a sustainable ecosystem.

Several projects, including restoring residential canal depths, building storage reservoirs and revising the water regulation schedule must be implemented to "fix the plumbing" for this lake. Without a concerted effort, the window of opportunity for making the Istokpoga ecosystem sustainable and meeting the nutrient loading reduction goals set for the Lake Okeechobee restoration projects will be lost.

Figure 3. Lake Istokpoga Reglation Schedule (administered by SFWMD)



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THE EXTERNAL PHOSPHORUS BUDGET FOR LAKE APOPKA, 1995-2002

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Lake Apopka is a shallow 125 km^2 eutrophic lake which is one of the headwaters for the Ocklawaha Chain of Lakes. Historical heavy phosphorus (P) loadings from farms, industries, and wastewater treatment are generally held responsible for the degradation of water quality. In 1985, the Florida legislature directed the St. Johns River Water Management District (SJRWMD) to develop an external nutrient budget as part of a comprehensive restoration effort. A 1989-1994 draft P budget was published in 1997 (Stites et al., 1997). This report extends the calculation of P budgets through 2002.

The 1995 - 2002 P budget reflects significant changes in land use within the basin. Between 1997 and 2002, over 6,000 hectares of farmland on the lake's north shore were purchased utilizing SJRWMD, state, and federal funding and taken out of agricultural production. Largely due to a reduction in farm discharge and effects from a drought, the total annual net loadings of P to Lake Apopka were reduced by over half from an average of 53 metric tons (1989-1994) to 23 metric tons (1995-2002).

Larger reductions would have been possible, however an event occurred which temporarily increased the District's discharges from the former farmlands. During late 1998, significant numbers of birds died from residual pesticides during temporary flooding of the former farmlands. To reduce the area's attractiveness to wetland wildlife, the majority of the area has remained drained while research on safe approaches to further wetland restoration is conducted. This has necessitated increased pumping, however all current discharges from the former Unit 1 and Units 2 of the Zellwood Drainage and Water Control District are currently treated with liquid alum to reduce effective P loading to Lake Apopka. Any P trapped in alum floc that is discharged is calculated as P loading. These sites are currently being redesigned to retain floc. As additional properties are flooded and restored to marsh, discharges should continue to decrease.

The second largest source of P to the lake was rainfall, which contributed an average of 5.6 metric tons of P annually. Basin runoff and Apopka Spring contributed approximately 1.2 and 0.8 tons annually, respectively. All other sources (Winter Garden Sewage Pollution Control Facility, Scotts Hyponex Peat Mine, Johns Lake tributary, and seepage into the lake) contributed 1.1 tons P/year combined.

Losses of P from the lake, primarily through the Apopka-Beauclair Canal, accounted for only 33% of the inputs. Net storage declined similarly to the decline in annual loading. Depending on the year, between 5.4 and 42.0 tons of the annual external P remained in the lake each year. The lowest net annual storage of 5.4 tons occurred in 2003. The average net storage over the eight years was 22.8 tons. In contrast, the average net annual storage from 1989-1994 was 51.4 tons.

Water quality results indicate that P and chlorophyll levels in Lake Apopka are responding to decreased external P loading, a primary component of the comprehensive restoration plan. In 1995, P concentrations began to fluctuate around a new, lower level. In fact, the November 2003 value (58 µg TP/L) was the lowest monthly average measured in nearly two decades of SJRWMD monitoring. Further improvements are expected as more components of the restoration plan are executed such as wetland and littoral zone restoration, rough fish harvesting, operation of the Marsh Flow-Way and additional flooding of former farms.

The external P budget will assist in the evaluation of the effects of present and future land use. External loading data will also provide a basis to evaluate recent and future effects of P reductions in the lake and track the success of reaching restoration goals.

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NOTES

BACK-PUMPING OF AGRICULTURAL RUNOFF INTO A LARGE SHALLOW LAKE: CONCURRENT CHANGES IN THE MACROINVERTEBRATE ASSEMBLAGE

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The macroinvertebrate community in the southern portion of Lake Okeechobee was monitored at four sites (two "impact" and two "reference") in the vicinity of two water conveyance structures used to back-pump agricultural runoff for water supply into the lake during June – September, 2001. Monitoring was conducted prior to back-pumping (May), during back-pumping events (June-September) and during the following year (May-September, 2002, impact sites only), to assess the existing community structure, document any changes that occurred during the back-pumping and document any post back-pumping community recovery. Initial nonparametric multi-dimensional scaling (MDS) ordination and analysis of similarity (ANOSIM) analyses indicated that the pre-backpumping macroinvertebrate assemblages were not significantly different among the two reference sites and the western impact site, while the assemblage at the eastern impact site was significantly different from all the other sites. During the months of back-pumping, the macroinvertebrate assemblages were very similar among both reference sites and among both impact sites, but were significantly different between each reference site and its respective impact site (a changed situation for the western impact:reference pair but not for the eastern pair). During summer 2002, the macroinvertebrate assemblage at the eastern impact site appeared to be similar to that during all months of 2001 except for June and July, suggesting that a small taxonomic shift occurred during backpumping, followed by a return to an assemblage very similar to that prior to back-pumping. At the other impact site, the assemblages appeared to be different among both years suggesting that this community was in a progressive state of change. Principal components analysis (PCA) generated environmental variable ordination patterns were then compared to the macroinvertebrate ordination patterns and suggested that assemblage changes between the paired reference and impact sites was influenced most strongly by changes in specific conductance, pH and dissolved oxygen concentrations which may have been attributable to the back-pumping.

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SESSION 3

HURRICANE IMPACTS

THE EFFECTS OF HURRICANE CHARLEY ON EELGRASS (*Vallisneria americana*) POPULATIONS IN LAKE CONWAY

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It is well known that lake systems can undergo significant stress associated with dramatic impacts. During the summer of 2004, Central Florida experienced such a dramatic impact in the form of three major hurricanes events. One such hurricane that resulted in the greatest influence to the area was Hurricane Charley. On August 13, 2004, the eye of Hurricane Charley passed within a few miles of Lake Conway unleashing winds of up to 105 mph. Shortly after the passing of the natural event, one of its impacts to the lake was evident in the observation of massive amounts of the submersed aquatic species, Vallisneria americana, pilled along its shorelines.

Lake Conway's submersed aquatic vegetation has undergone annual vegetation monitoring since 1977 and has always exhibited a desirable diversity of beneficial native species. Shortly after the passing of Hurricane Charley, uprooted biomass samples were collected from the shoreline of Lake Conway for examination. It was determined that Vallisneria americana made up 99% of the uprooted biomass. Based on field observations, approximately 35,350 linear feet of Lake Conway's shoreline contained the uprooted biomass at a density of 42.2 pounds (wet wt.) per linear foot. As a result, it was estimated that over 750 tons (wet wt.) of Vallisneria americana was uprooted because of the intense wave action generated from the hurricanes winds. It was also determined that a greater net loss of submersed vegetation occurred within the lobes of the lake having a larger fetch.

A regularly annual submersed biomass survey was conducted in October of 2004. The results of this survey indicated that the Vallisneria americana population was reduced by over 1000 tons (wet wt.) since the previous year. However, the spatial distribution of remaining rooted Vallisneria remained consistent with the distributions from the previous year. This concluded that although a large amount of the submersed species was destroyed, there was no catastrophic loss of the species from any one area. Additionally, other submersed species were found to be less susceptible to the wave induced uprooting action.

With the sudden loss of submersed biomass, one of the largest concerns was the release of nutrients associated with the decaying plant material. Since the aftermath of the hurricane, water quality samples have not shown any increase in nutrients, clarity or algal populations. This may be in part the result of the removal of the windrowed biomass by the lakefront residents or the lakes natural ability to assimilate the available nutrients by the lakes remaining submersed species.

NOTES

EFFECTS OF 2004 HURRICANES ON WATER QUALITY IN ORLANDO LAKES

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Introduction

On August 13, 2004 the eye wall of Hurricane Charley passed over Orlando Florida. The National Weather Service reported sustained winds of 85 mph and gust of greater than 100 mph. Following Hurricane Charley, Orlando experienced hurricane conditions again with sustained winds > 74 mph on September 4, 2004 from Hurricane Francis and again on September 25, 2004 from Hurricane Jeanne. Since a direct hit from a hurricane, and multiple occurrences of hurricane conditions during one season, in the City limits of Orlando had not been previously recorded, the potential impact on lake water quality was unknown. The purpose of this research was to determine the effects the hurricanes had on the water quality in City lakes. The potential of negative impacts from sediment re-suspension caused from wind waves is well-documented concern (Carper and Bachmann 1984, Hanlon 1999). Central Florida lakes tend to be shallow productive lakes with flocculent sediments that would have only been subjected to the wave energy experienced during the 2004 hurricanes. Significant uprooting of submerged and emergent macrophytes was also observed following the hurricanes. Another concern was organic loading to lakes associated with leaves and debris. Hurricane Charley resulted in catastrophic damage to the areas abundant oak trees, which in association with torrential rains, resulted in tremendous quantities of leaf and other organic material entering lakes via stormwater conveyance systems. Pollutant loading from major sewage spills was widespread due to lift station failure brought on by prolonged power outages and infiltration of rainfall that overwhelmed the hydraulic capacity of the sanitary sewer system. Sediment loading to area lakes was high due to severe erosion in watersheds and along shorelines. The Orlando area lakes also received unusually large quantities of inflow during this time period with rainfall totals of 16.3 inches in August 2004 and 15.0 inches in September.

Methods

Data collected from 81 lakes during the September thru October time frame in 2004 was compared to the same lake dataset and time period in 2003. Since the samples were collected as part of our ambient monitoring program, samples were not collected any less than 5 days following the occurrence of hurricane conditions and the majority of data was collected greater than 10 days following a hurricane. Comparisons of mean values for the entire dataset during these two same time frames were used to determine hurricane effects. Historical data collected on City lakes during normal years indicate some fluctuations in water chemistry for individual lakes, but very little variance in overall annual mean values for the entire City of Orlando lake dataset. Since annual mean data for the entire dataset showed only small variations from year to year, it was assumed that data collected during the same two month time periods in 2003 and

2004 would normally be very similar and observed differences could be attributed to the hurricane conditions experienced during 2004. Differences between the 2004 and 2003 datasets were evaluated using paired t –test at a 90% confidence interval (McCann *et al* 2004). Rainfall data was collected using the City's automated tipping bucket weather stations.

Results

Significant difference in water chemistry following the 2004 hurricanes was observed for surface dissolved oxygen, surface water temperature, total phosphorus and nitrate. Despite heavy organic loading, dissolved oxygen concentrations, measured at 0.5 m below the surface, increased from 7.1 mg/l (91.2 % saturation) in 2003 to 7.7 mg/l (97 % saturation) in 2004. Since no fish kills were observed or reported, City lakes appeared to maintain normal oxygen levels through the storm events. Some of the increase in dissolved oxygen was due to a significant decrease in surface temperatures, which decreased from 28.4^o C in 2003 to 27.1^o C in 2004. Total phosphorus concentrations increased significantly from 0.042 mg/l in 2003 to 0.055 mg/l in 2004. There was also a slight increase in ortho phosphate, from 0.005 mg/l to 0.008 mg/l. Total nitrogen, ammonia, and nitrite showed very slight variations in concentrations between the two years but nitrate levels increase significantly from 0.035 mg/l in 2003 to 0.063 mg/l in 2004. Alkalinity, pH and specific conductivity also had very small and insignificant variations between 2003 and 2004. Despite experiencing conditions during the hurricanes that would have greatly increase solids in city lakes, this effect was apparently short lived. Total suspended solids were 6.3 mg/l in 2003 and 6.2 in 2004 while volatile suspended solids decreased from 6.2 in 2003 to 5.5 in 2004. Total dissolved solids also decreased slightly from 121 mg/l in 2003 to 117 mg/l in 2004. There was a slight decrease in chlorophyll-a following the hurricanes with concentrations of 18.0 μg/l in 2003 and 17.2 μg/l in 2004. Even though many Orlando lakes were confirmed to have highly elevated fecal coliform bacteria levels immediately following the hurricanes, levels quickly returned to background levels. Samples collected a minimum of 5 days following hurricanes in 2004, averaged 114 cfu's, which was very similar to a level of 101 cfu's in 2003 (McCann *et al* 2004).

Conclusions

Data collected following hurricane conditions indicated City of Orlando lakes returned to near back ground conditions in a 5-10 day time period. Potential negative impacts from external and internal pollutant loading may have been offset by the beneficial effect of high flushing rates due to the rainfall associated with the three hurricanes. The Rainfall total for August and September was 31.3 inches in 2004, which is more than half the normal yearly total of 48 inches for this area. Lakes will be monitored during 2005 to determine if the hurricanes will have any long term effects that may have been somewhat masked in the short term due to high flushing rates.

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NOTES

HURRICANE EFFECTS ON LAKE OKEECHOBEE: A CASE STUDY IN ALTERNATE STEADY-STATE SHIFTS

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In September 2004, two hurricanes, Frances and Jeanne, passed just to the north east of Lake Okeechobee within 21 days of each other. Peak wind velocities over the lake surface reached 80 mph during Hurricane Frances and 78 mph during Hurricane Jeanne. During both of these hurricanes the strong wind velocities caused a seiche along the north-south axis of the lake resulting in minimum and maximum water level ranges of about 10 ft. to18 ft. In addition, lake levels increased by approximately 6 ft. as a result of rain on the lake and runoff from the watershed.

Significant physical, chemical, and biological changes have been detected since the hurricanes, most notably in the shallower, near shore regions. Total Phosphorus concentrations more than doubled in the month following the storms' passage and increased to 3 to 5 times typical values by December. Secchi depth transparencies declined from their pre-storm values of 0.6 –1.0 meter or more to 0.1 - 0.2 meters and turbidity, which typically is less than 10 mg L^{-1} in the littoral zone increased to 40-50 mg L^{-1} in October as the result of the resuspension of sediments from the lake bottom.

Post-hurricane plant community surveys indicate that submergent biomass has declined substantially. In July 2004, the last month in which a survey was done prior to the hurricanes, average biomass for all stations sampled was 35.5 g dry wt. m^{-2}. In October 2004, almost immediately post storms, biomass had dropped to 4.65 g dry wt. m^{-2}. In April 2004, average biomass had declined still further to 0.04 g dry wt. m^{-2}; as compared to an average biomass of 37.5 g dry wt. m^{-2} the preceding April. Results from nutrient bioassays, phytoplankton photosynthesis-irradiance curves, and chlorophyll-*a* concentrations suggest that phytoplankton biomass and productivity were at a 10 year low in the three months following the storm; although they had rebounded to near normal winter time levels by January 2005.

Eight months after the passage of the hurricanes, turbidities in Lake Okeechobee remain high, secchi disk readings remain low, TP concentrations continue to be twice as high as usual (with an average TN:TP ratio of 8.7), and while phytoplankton biomass and productivity appear to have reverted to typical levels there is no evidence of renewed submerged aquatic vegetation growth. While it is difficult to completely separate the effects of hurricanes Frances and Jeanne from the normal seasonal effects of windy winter weather on current Lake conditions, speculation exists that if these conditions persist, the littoral zone of Lake Okeechobee could switch from a clear-water macrophyte-dominated state to a turbid, phytoplankton-dominated state.

NOTES

HURRICANES AND LAKE APOPKA: PAST, PRESENT, AND FUTURE

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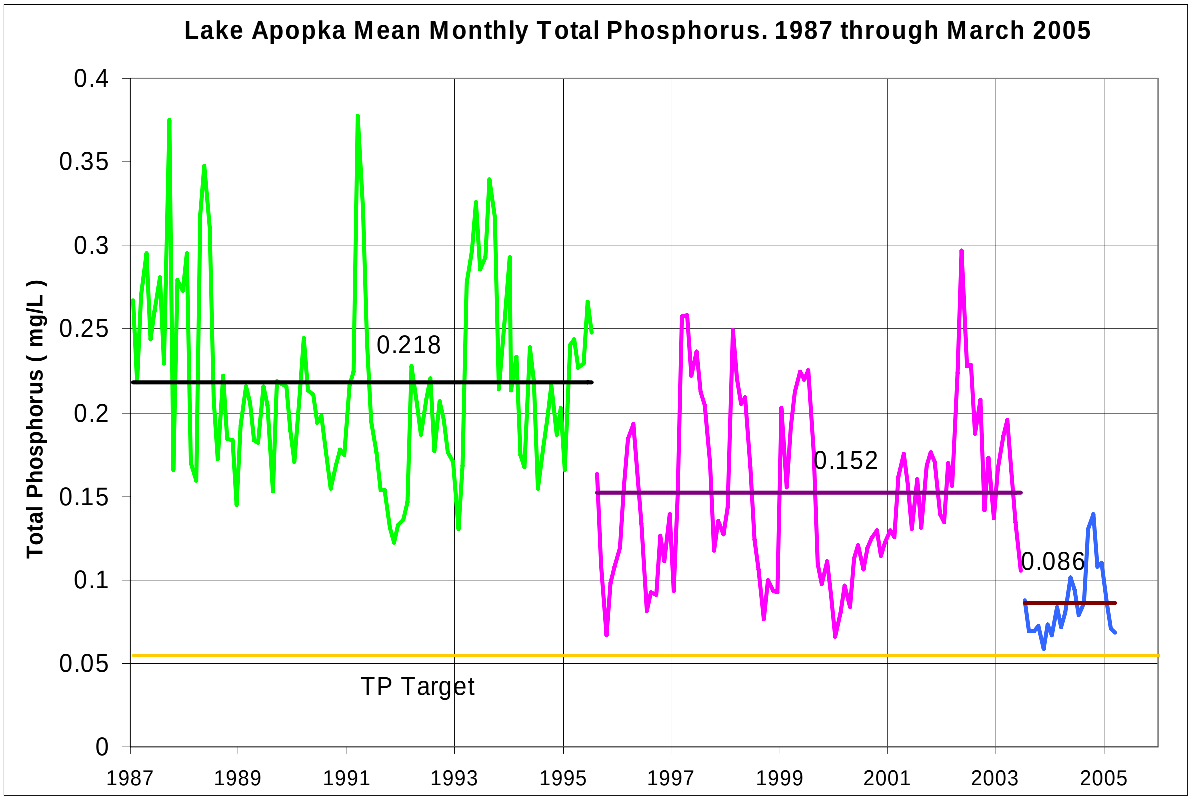
Lake Apopka is a shallow, 125-km^2 eutrophic lake northwest of Orlando Florida. The purported roles of hurricanes and wind on Lake Apopka, Florida, include: a 1947 hurricane uprooted submersed vegetation (SAV) and converted the lake from a clear water system to the current state of continuous algal blooms (Conrow et al. 1989, Bachmann et al. 1999, 2001), a decline in wind velocity has reduced sediment resuspension and is thereby responsible for improvements in water quality during the mid-1990s (Bachmann et al. 2000), and wind-induced sediment resuspension is sufficient to prevent significant return of SAV in the lake (Bachmann et al. 2001). In contrast, assessments by the St. Johns River Water Management District (SJRWMD) concluded anthropogenic phosphorus (P) loading has played the dominant role in determining the lake's state (Lowe et al. 2001, Hoge et al. 2003). Storms may have accelerated the loss of macrophytes *after* the increase in P loading, but many strong storms apparently failed to reduce macrophyte abundance and failed to elicit the turbid state *before* the increase in P loading. The SJRWMD in partnership with governmental entities developed and is implementing a multi-part restoration and management plan for Lake Apopka that includes external P load reduction and removal of in-lake phosphorus. External P load reduction is being accomplished first by regulation of farm discharges and ultimately by farm acquisition and restoration of former wetlands which were converted to muck farms during the 1940s. Finally, since 2003 a legislative rule restricts P runoff from new development within the watershed. Removal of in-lake P is being accomplished by a large scale removal of rough fish (primarily gizzard shad) and operation of a 683 acre recirculating filter marsh (Marsh Flow-Way) designed to remove suspended solids, algae and their associated nutrients from the lake water. Rough fish removal began in 1993 and the Marsh Flow-Way began operation in 2003. Since 1995, improvements in total P, chlorophyll and secchi transparency have been 36%, 32% and 33%, respectively.

The hurricanes of 2004 provided an opportunity to examine the role hurricanes might play in the ongoing recovery of the lake. During August and September three hurricanes, Charley, Frances and Jeanne, crossed central Florida near Lake Apopka. The latter two created daily mean wind velocities of approximately 35 mph and maximum hourly velocities of approximately 80 mph at the center of the lake. Immediately following these storms total P roughly doubled in the lake with smaller changes in chlorophyll and Secchi transparency. These changes are presumed to be the result of resuspension of material from the lake bottom. By December chlorophyll and Secchi transparency had returned to pre-storm levels. Phosphorus levels returned slightly slower, likely due to required pumping of P-rich water (alum treated refractory-P) from unflooded portions of the District-owned former farms. Comparisons of daily wind velocity and important water quality parameters fail to demonstrate that typical winds over the lake cause long-term changes in water quality sufficient to alter the ongoing improvements within the lake. These data suggest in-lake wind resuspension of sediments and P are short-lived events (days to months) that do not prevent the ongoing improvements in water quality.

Since early 2003 when water levels returned to normal following the record drought of the previous years, water quality in the lake may have taken another step improvement (see figure) beyond that which began in 1995. Other indications that the reduction of external P loading and P removal have altered fundamental features of the lake include an increasing trend in NO_x during the past year at the southern water quality site nearest Apopka Spring, which discharges NO_x at approximately 4 mg/L. This may indicate that the southern portion of the lake has become P-limited. A second recent change is the dramatic increase in the need for hydrilla treatment and the colonization of native SAV within the lake. This indicates that more light is now reaching portions of the lake's bottom and is sufficient for SAV to recolonize. These results indicate Lake Apopka is sensitive to phosphorus load reductions and is approaching the 0.055 mg/L goal set for the lake. Long-term achievement of this goal is expected to promote reestablishment of SAV. Once SAV has recolonized the lake, the macrophyte-dominated state should be resilient to hurricane disruption, as it was for millennia prior to the effects of excessive nutrient loading.



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NOTES

SESSION 4

ECOLOGICAL ISSUES AND STUDIES

ASSESSMENT OF THE SEED BANK AND TORPEDOGRASS SEED VIABILITY AT SELECTED MARSH SITES IN LAKE OKEECHOBEE

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Torpedograss (*Panicum repens* L.) is a highly invasive, exotic perennial grass that has become established in more than 70% of Florida's public lakes and rivers. Although viable seeds have been reported in Mexico and Portugal, torpedograss is believed to primarily spread asexually by stem fragments and rhizomes in the United States. The largest infestation of torpedograss occurs in Lake Okeechobee where it has degraded fish and wildlife habitat by displacing more than nine thousand hectares of native vegetation.

As part of the South Florida Water Management District's comprehensive vegetative management program, the viability of torpedograss seeds and species composition of the seed bank were evaluated. Substrate samples (5 cm deep) were collected from six sites representing upper and mid marsh locations where torpedograss was established. The substrates were placed in a growth chamber and examined for seedling emergence for eight weeks under 14-hr photoperiod and alternating temperature. During the evaluation period, 14 native plant species including *Eleocharis cellulosa* (spikerush), *Nymphaea odorata* (fragrant waterlily), *Rhynchospora tracyi* (beakrush), and *Sagittaria lancifolia* (arrowhead) emerged. Collectively, the upper elevation sites accounted for 63% of the total number of seedlings (n=266), while the lower elevation sites showed greater species diversity. Except for one floating-leaved species, all seedlings were emergent species; no submersed species or any torpedograss seedlings were present. The lack of torpedograss seedlings was verified in further laboratory studies in which torpedograss seeds (n=1,000) from Lake Okeechobee showed only trace (0.3 percent) germination. These results suggest that, in Lake Okeechobee, torpedograss is spread mostly by vegetative means not by seed. Additionally, if vegetation management efforts can effectively reduce torpedograss coverage, native plant communities may reestablish from the existing seed bank in the upper and mid regions of the marsh.

NOTES

VEGETATION MAPPING IN LAKE OKECHOBEE, FLORIDA USING MULTISCALED NON-TEMPORALLY COINCIDENT COLOR INFRARED PHOTOGRAPHY

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Lake Okeechobee is a 730 mi^2 lake located in south central Florida and is the central component of the Kissimmee River/Lake Okeechobee/ Everglades ecosystem. Within the lake's boundary there are almost 100,000 acres of freshwater marsh which is critical habitat for wading birds and an important spawning area for the lake's multi-million dollar fishing industry. Because of its importance, the marsh is periodically mapped to determine the spatial extent, distribution, and species composition of the emergent plant community. Typically this has been done based on traditional color infrared photography using a stereoscope and light table. The color infrared transparencies are placed on the light table and viewed in stereo pairs. Vegetation delineation is done by hand with pen and ink and then converted to a digital format. The proposed new mapping approach is to do the entire delineation and classification of vegetation digitally using a process called "softcopy photogrammetry". With this method the photographs are scanned into a digital format and subsequent delineation and classification of vegetation takes place directly into a georeferenced GIS layer. The photographs to be used were taken at three different scales and at three different times, via airborne camera incidental to other projects. The three sets of photographs will be merged into a seamless, georeferenced GIS coverage of the entire marsh allowing GIS analysis of species composition and distribution of vegetation within the marsh.

NOTES

A CONCEPTUAL ECOSYSTEM MODEL FOR LAKE ISTOKPOGA, CENTRAL FLORIDA.

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Lake Istokpoga is the fifth largest lake (112 km^2) in Florida and is situated approximately 40 km northwest of Lake Okeechobee (27° 23'N, 81° 17'W). It supports a vast variety of fish and wildlife resources and is a source of water supply to the Indian Prairie basin. Boating, fishing, hunting, and general enjoyment of the lake are the primary recreational activities. Deterioration of the lake's health in recent years prompted the development of restoration efforts in the lake, including the surrounding watershed (Champeau et al. 1999).

A conceptual ecosystem model was developed for Lake Istokpoga's restoration planning purposes as part of the Comprehensive Everglades Restoration Plan: Lake Okeechobee Watershed Project and the Lake Okeechobee Protection Plan: Lake Istokpoga Watershed. Conceptual ecosystem models (CEMs) are used as planning tools to convert policy-level goals into measurable indicators of the "health" of natural and human systems (Ogden, 2003). In addition, CEMs are used to develop a suite of working hypotheses that explain the cause and effect linkages among ecosystem stressors and attributes, as a basis for identifying restoration and research priorities.

Lake Istokpoga's CEM is comprised of a top-to-bottom hierarchy of cultural drivers, stressors, ecosystem effects, attributes, and performance measures (Figure 1). The major known ecological drivers in the lake have been caused by changes in landuse practices, the introduction of invasive species, and drainage and water management practices. The stressors resulting from these "drivers" include excessive nitrogen and phosphorus inputs (excess nutrients), invasive species (including some exotics), and altered water level fluctuations (hydropatterns). The ecological effects from these stressors are specified in the conceptual ecosystem model of this lake.

The effects of restoration efforts on ecosystem attributes will be evaluated using a suite of ecological performance measures. For each performance measure, either a quantitative or a qualitative target (desired endpoint of local/regional restoration efforts) and a suite of monitoring parameters are proposed. These targets will guide the development of an adaptive assessment strategy for reaching long-term management restoration goals for the Lake.

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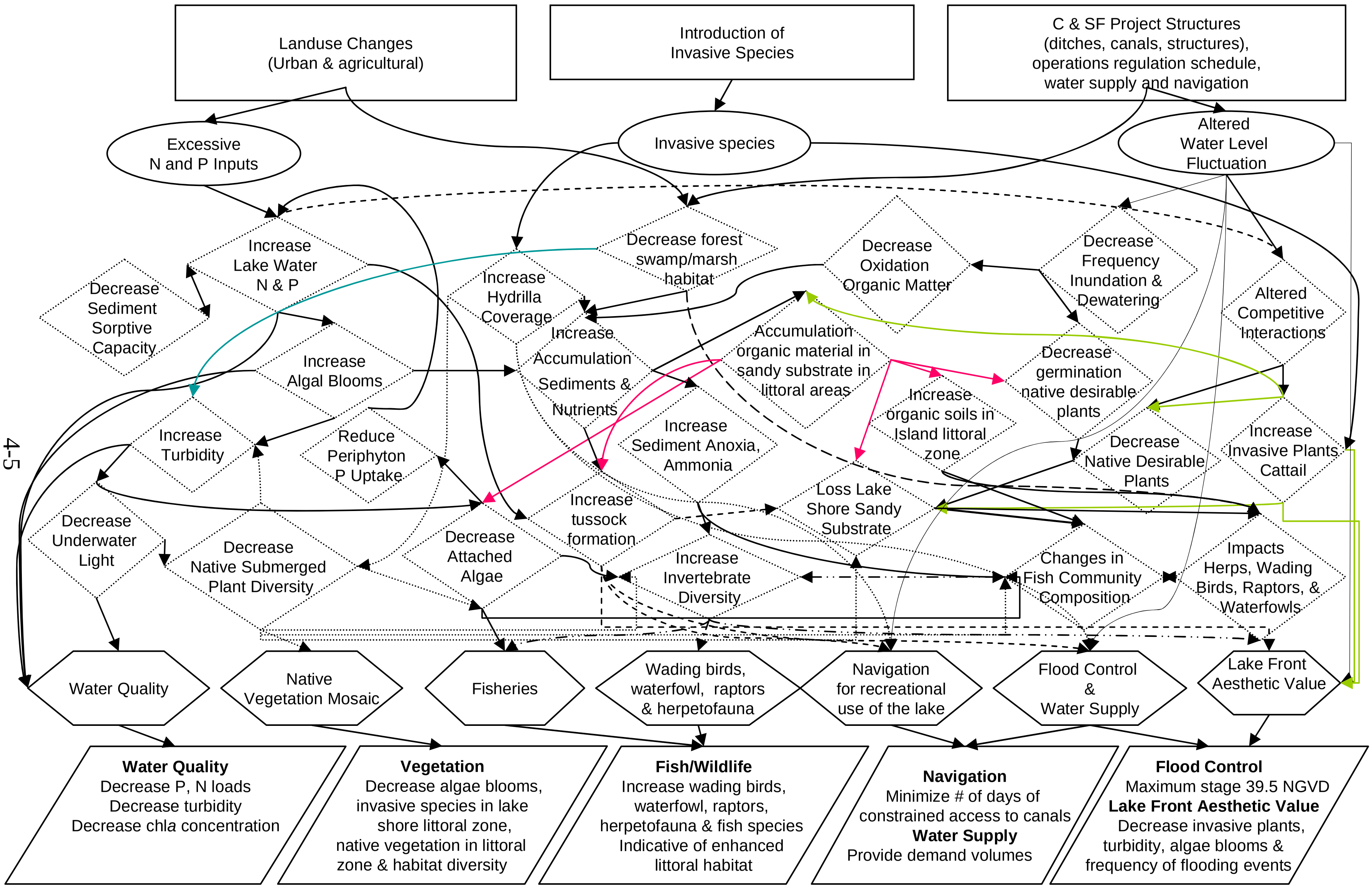

Figure 1. Lake Istokpoga's Conceptual Ecosystem Model.

RE-ESTABLISHING ECOLOGICAL INTEGRITY: PROPOSED HYDROLOGIC PERFORMANCE MEASURES FOR LAKE ISTOKPOGA, CENTRAL FLORIDA

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Installation and operation of the water control structure S-68 in 1962, and modification of the regulation schedule in 1990 compressed Lake Istokpoga's water level fluctuation range from seven feet (36 to 43 ft NGVD) to 1.5 feet (38.0 to 39.5 ft NGVD) (Figure 1). The upper stage limit of 39.5 ft NGVD was set to prevent flooding of houses surrounding the Lake. The lower stage limit was raised to 38.0 ft NGVD to maintain access to the lake from private canals and docks. The reduced fluctuation in water levels has contributed to an array of environmental changes, including loss of diverse wetland plant communities, increased detritus, tussocks and floating vegetation, proliferation of invasive species, and impacts to cypress trees around the Lake's shoreline (Champeau et al. 1999).

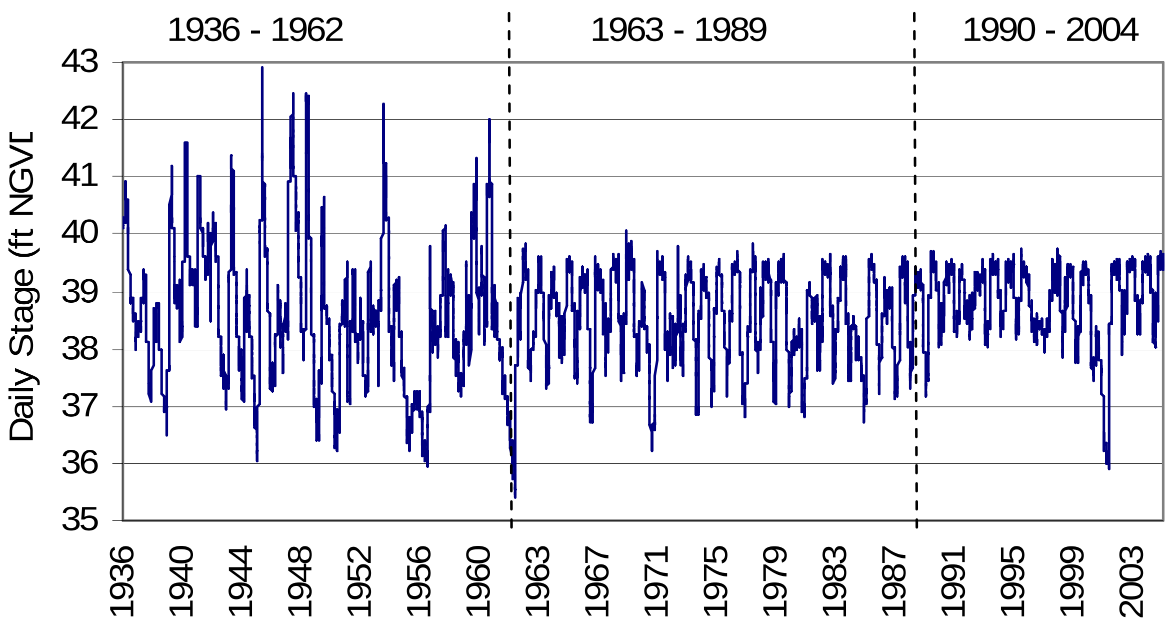

Figure 1. Daily stage lake water level fluctuations for Lake Istokpoga from 1936 to 2004.

At the request of the Comprehensive Everglades Restoration Plan - Lake Okeechobee Watershed Project (CERP-LOWP), a team of experts from government and non-government agencies proposed a variety of ecologically desirable lake level fluctuation (EDLLF) strategies (Figure 2) to improve the ecological conditions of the Lake. The process to develop EDLLF involved a series of meetings and development of a conceptual ecosystem model. EDLLF was based upon published research which suggested that greater stage variation in lakes and reservoirs, both within and among years, will promote a more diverse plant community (Keddy and Fraser, 2000). It also considered lake attributes including: 1) ecological integrity for fish and wildlife species; 2) navigational access for recreational purposes; 3) flood protection; and 4) water supply.

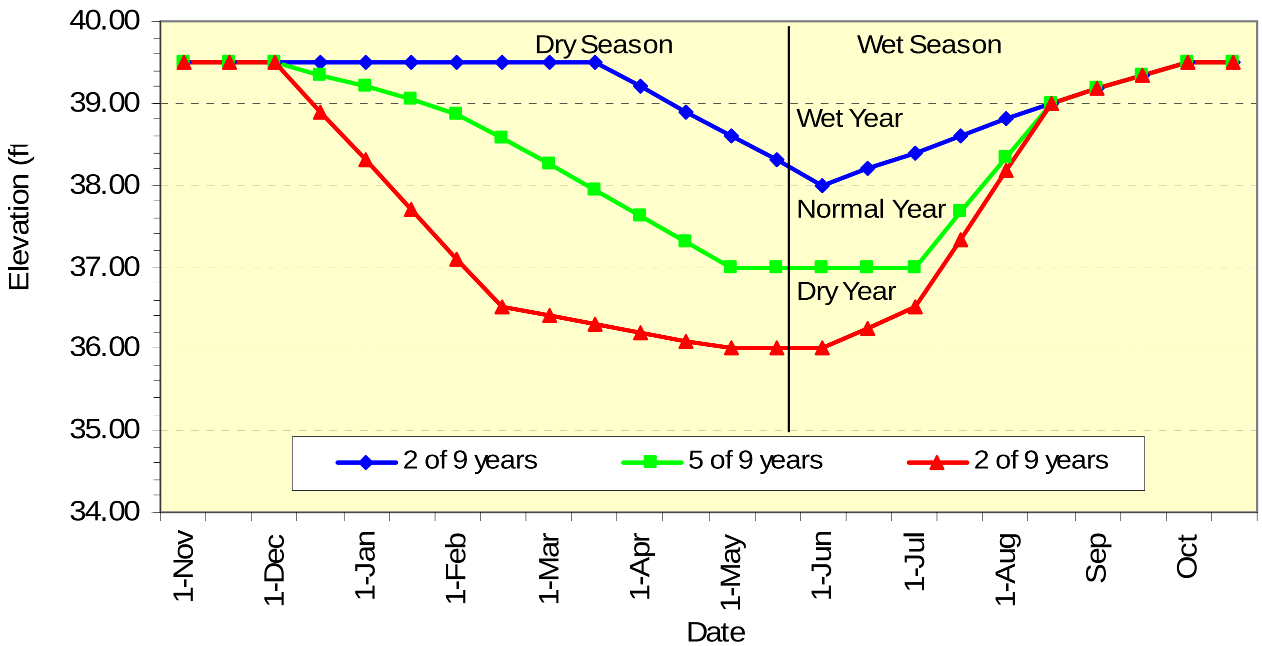

Figure 2. Ecologically desirable water level fluctuations for Lake Istokpoga within modern constraints.

A set of hydrologic performance measures (HPMs) was derived from the ecologically desirable lake level fluctuations: 1) maximum stage; 2) minimum stage; 3) winter-spring recession; and 4) stage fluctuation maximization. These HPMs were used to select a preferred operational schedule from several alternatives and will be used to assess its future performance. They also will serve as testable hypotheses toward adaptively improving water level management in the future.

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NOTES

RESTORATION OF FORMER AGRICULTURAL LAND TO WETLANDS ON LAKE OKEECHOBEE'S RITTA ISLAND

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Approximately 7000 acres at the southern end of Lake Okeechobee are occupied by three low lying islands named Torry, Kreamer and Ritta. Anecdotal information suggests that prior to settlement, Torry and Kreamer were covered by dense stands of pond apple (*Anona glabra)*, and the endangered Okeechobee gourd (*Cucurbita okeechobeensis*). All three islands were settled in the early 1900s and were cleared, ditched and bermed to produce cropland. By the mid-1970's all farming operations had been abandoned.

The 1993 Lake Okeechobee Surface Water Improvement and Management (SWIM) Plan Update, the RECOVER (**Re**storation, **Co**ordination and **Ve**rification) component of the Comprehensive Everglades Restoration Plan (CERP), and the U.S. Fish and Wildlife Service, South Florida Multi-Species Recovery Plan have all identified one or more of these islands as potential restoration targets with specific goals of reestablishing natural hydrologic connections between the islands' wetland habitats and the Lake; and in the case of Torry and Kreamer islands, preserving Okeechobee Gourd habitat and increasing the spatial extent of willow and/or pond apple to benefit wading bird populations.

The Florida Fish and Wildlife Conservation Commission and the South Florida Water Management District (SFWMD) recently completed a habitat enhancement project on Ritta Island, through the removal of perimeter levees and ditches (8 km), as well as the abandoned concrete water control structures associated with these features that impeded the natural hydrology of the islands. This was accomplished by backfilling the adjacent ditches with the degraded levee material and the removal of exotic vegetation, from dikes and berms. A total of 132,730 m^3 of material was pushed back into the lakeside and island-side channels from where it was originally dredged. The levee degradation caused the lakeside channel to lose approximately 1 ft in depth, resulting in a depth of approximately 5 ft at 14 ft mean sea level with no resulting navigational hazards.

Funding for this effort was provided from the state-appropriated Lake Okeechobee Protection Program, through a cooperative agreement between the FFWCC and the SFWMD, and carried out by a third party contractor. Project oversight was provided by the FFWCC. Concomitant with these efforts, the two agencies are in the process of re-establishing pond apple (2.8 ha) and cypress forests (0.64 ha) along the shoreline of the island.

Hurricanes Frances and Jeanne in the Fall of 2004 enhanced the results generated by the removal of the island levees. Each hurricane provided for flooding and sheet flow of water across the island. These hydrologic conditions generated more suitable ecological conditions across the island, flushed invasive plants species from the interior canals, and began to remove arrowroot *(Thalia geniculata)* from the northwest corner of the island. Since completion of the restoration project a variety of wading birds have been sighted on the northern portion of the island and the removal of arrowroot is expected to allow for colonization by eelgrass *(Vallisneris americana)* and peppergrass *(Potamogeton illinoensis)*. Anticipated improvements in water quality and depth should attract wading birds to nest in the existing stands of willow *(Salix spp.)*.

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NOTES

SEED GERMINATION IN WILD CELERY (*Vallisneria americana* Michx.) FROM LAKE OKEECHOBEE, FLORIDA, U.S.A.

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The necessity of light and cues from the sediment for seed germination in the rooted, submersed aquatic plant *Vallisneria americana* were investigated in our laboratory using fruits harvested 21 November 2002 from Lake Okeechobee, Florida. Under darkness, seeds were removed from these fruits, mixed, and introduced into plastic buckets containing sterilized lake water and sterilized lake sediments. Incubations of covered (dark) and uncovered (light) buckets were conducted in a Revco® environmental chamber, set at 28 - 31°C on a 13L : 11D h photoperiod with a mean photosynthetic photon flux density of 96 ± 20 µmole photons m^{-2} s^{-1} (mean ± SE; n = 40), while germination was monitored near-weekly as seedling recruitment.

In the first approximately 10 wk experiment, which began 18 April 2003 and approximately 149 days post seed harvest, out of 122 total germinations, 121 or 99.2 % occurred in the light, while only one or 0.8 % occurred in the dark. Upon subsequent exposure to light, seeds previously held in the dark in the initial experiment, began germinating after approximately 60 days, indicating secondary dormancy.

During this 26 wk follow-up experiment which began 27 June 2003, the germination rate was only 1.0 per day, compared to 1.7 germinations per day in the original experiment. These observations suggest involvement of the phytochrome system in seed germination of *V. americana*, and have implications concerning the seed bank in turbid portions of Lake Okeechobee.

In a third, approximately 21 wk sediment-free light-dark experiment that began 3 July 2003 using sterilized lake water, 100% (25) of the light exposed seeds germinated while none of the seeds held in the dark did. This indicates that light is required for seed germination in *V. americana*, but that environmental cues from the sediments apparently are not.

These results have implications concerning the timing of drawdown in a lake or surface water reservoir; in particular, those with the objective of encouraging the re-establishment of submersed aquatic plants, such as *V. americana*, in turbid waterbodies.

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SESSION 5

DIAGNOSTIC STUDIES

FEASIBILITY OF PESTICIDE REMEDIATION DURING RESTORATION OF WETLANDS ALONG THE NORTH SHORE OF LAKE APOPKA, ORANGE AND LAKE COUNTIES, FLORIDA

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MACTEC Engineering and Consulting, Inc. (MACTEC) was contracted by the St. Johns River Water Management District (District) to complete a Feasibility Study (FS) for a portion of the Lake Apopka North Shore Restoration Area (NSRA). The District has acquired ~20,000 acres of former agricultural lands that had once been wetlands, but were drained for agricultural use between 1941 and 1985. The purpose of the FS was to summarize the nature and extent of contamination and risks posed by organochlorine pesticides (OCPs) in soil within the NSRA, and evaluate remedial alternatives under a range of potential remediation target levels that would permit planned restoration of 10,000 acres that have not been reflooded. The soils contaminated by pesticides were associated with the death of piscivorous birds in the NSRA during winter 1998-1999.

The FS was performed using procedures adapted from US Environmental Protection Agency (USEPA) guidance for performing FSs for contaminated sites under the Superfund program (USEPA, 1988). The NSRA is not a superfund site, however, the Superfund FS process provides a useful framework that is relevant to the problem at hand and specific modifications were made to the USEPA FS process to fit this project.

The OCPs of greatest potential concern at the site are toxaphene; DDE; the sum of DDD, DDE, and DDT, known as DDTx; dieldrin, and total chlordane (sum of alpha- and gamma-chlordane and heptachlor epoxide). These chemicals were identified as chemicals of potential concern (COPCs) based on their frequency of occurrence in NSRA soils, their toxicity, and levels of these constituents that were observed in carcasses of birds that died in the vicinity of the NSRA during winter 1998-1999.

The distribution of contaminants and the behavior of the critical receptors indicate that farm fields (typically 160 acres each) represent an appropriate exposure unit. Where food is plentiful birds feed over a relatively small area, as represented conceptually by the farm field. For each of the 70 fields in the study, a best estimate and a conservative estimate of the carbon-normalized concentrations of each of the COPCs was calculated. A set of Remedial Action Objectives (RAO) was provided by the District. These RAOs were derived by back calculation from fish tissue risk trigger levels. Following a review of these RAOs, and other data, a best estimate target level (BETL) and a conservative target level (CTL) were established for each of the COPCs. Values between these two limits are considered a reasonable range of potential remedial action objectives that may result from ongoing research or discussions with stakeholders. A comparison of the best estimate soil concentrations to the BETLs showed that 17 fields containing 2,200 acres of the 9,900 acres exceeded the BETLs with 787 acres requiring at least 50% reduction. Approximately 1,420 acres exceed the BETLs by less than 20%. Alternately for the worst case scenario; it is possible that 6,900 acres in 46 fields exceeded the CTLs, with 3,774 acres requiring at least 50% reduction to reach CTLs.

A list of 23 potential technologies were developed and reduced to 12 alternatives best able to reduce exposure under site conditions. The 12 retained alternatives were evaluated against predefined criteria. These 12 alternatives were evaluated against the remediation target levels (BETL and CTL) on a field by field basis and expected flood levels were overlayed. A sequence of actions, including pilot testing and phased restoration, emerged that would allow the District to proceed with wetland re-establishment with a known set of remediation approaches, costs and expectations. There remains considerable uncertainty regarding the ultimate cost of restoration. On-going research and pilot testing will improve final cost projections.

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NOTES

THE USE OF HETEROTROPHIC BACTERIA IN AN URBAN CENTRAL FLORIDA LAKE

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Urban Central Florida lakes that do not meet one or more of their Class III water quality standards may become identified as "impaired" under the State's Impaired Water Rule (IWR) and may be subject to Total Maximum Daily Load (TMDL) allocations. The use of aeration, alum, dredging, aquashade, grass carp, herbicides are all methods that have their place in a comprehensive lake management/restoration program. They all have their advantages and disadvantages, which can include cost and impact on the natural lake environment (Holdren, et. al., 2001). Lake managers are always looking to reduce costs for water quality improvements while maintaining quality habitats. Heterotrophic bacteria have been used to degrade petroleum contamination in groundwater and surface water (Suthersan, 1999 and USEPA, 2004). Anecdotal reports of the use of heterotrophic bacteria to improve water quality in sewage lagoons and golf course retention ponds (Nesbitt 1995, King 1996) and other areas with very high nutrient enrichment are wide spread. An Internet search on Google produced over 300,000 hits from or about companies using some form of bacteria to reduce algae and/or muck.

Duvall, et. al. (2001) completed a study comparing the effects of various commercially available bacterial products and chemical algaecides (copper sulfate and diquat) on phytoplankton, macrophytes, zooplankton and sediment bacteria. These studies were conducted in 100 liter enclosures within a 61,000 liter pond in California during the fall of 1998 and spring of 1999. They found that the bacterial formulations did not significantly reduce the planktonic algae growth and that "increases in bacterial numbers do not necessarily result in increased bacterial competition with phytoplankton for nutrients".

In the present study, heterotrophic bacteria were used evaluate the efficacy of a bioremediation protocol in a typical urban lake. Lake June, a 1.82-hectare (4.5 acre) lake in unincorporated Orange County, Florida, was selected. Lake June is within a 92-acre drainage basin. The watershed is immediately adjacent and identical to the Clear Lake watershed as described by Harper (1995), a mixture of residential and light commercial, all on septic tank/drain field systems. The lake contains 36 acre-ft or 44.3 million liters of water and is controlled by a drainwell on the north end of the lake. Lake June was divided into five sampling locations and sampled at surface and bottom locations four times before the first bacteria applications were made. The sampling location in the center of the lake was sampled monthly for a year prior to event. In November, 2004 four (4) batches of heterotrophic bacteria were prepared and added, over a one-week period, to Lake June according to a protocol developed by and at the direction of Bioremediate.com. Based on previous applications of these bacteria in similar settings, expected results included increased clarity of the water column, reduction of chlorophyll a concentrations and reduction of fecal coliform counts.

Heterotrophic bacteria were hydrated and grown to counts of approximately 5-9 billion cells/mL. The first batch was applied to the surface of Lake June, after water quality samples were collected on 11/17/04, a dose of nitrifying bacteria was added on 11/21/04 and two more doses of heterotrophic bacteria were added on 11/29/04 and 12/1/04. The final two additions were applied in the south half of Lake June. Samples were collected and analyzed for fecal coliform bacteria using the membrane filter method. Chlorophyll a and other selected water quality parameters, including but not limited to; ammonia, total nitrogen, total phosphorus and ortho-phosphorus were collected and analyzed as described in APHA Standards Methods (1998).

Subsequent to the addition of the bacteria, chlorophyll a concentrations decreased by 43% at two of the sampling sites from their peak measurements. Fecal coliform bacteria appeared to increase during the application events. Total phosphorus and total nitrogen did not improve significantly after the addition of the heterotrophic bacteria. Other water quality parameters were measured and compared to pre and post heterotrophic bacteria addition. The overall results of this study were consistent with Duvall (2001) in that the addition of heterotrophic bacteria did not out compete planktonic algae for available nutrients. However, trends in selected parameters warrant continued sampling.

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NOTES

SEASONAL AND DIURNAL VARIABILITY IN LAKE HANCOCK, AN ULTRA-HYPEREUTROPHIC LAKE

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Lake Hancock is a large, shallow (mean depth ~ 1.5 m), hypereutrophic lake located southeast of the City of Lakeland and north of the City of Bartow in Polk County, Florida. With a surface area of approximately 4550 acres, Lake Hancock is the third largest lake in Polk County and the fourth largest lake in Florida. The drainage basin entering the lake covers 131 square miles and includes drainage from Lakeland and Auburndale. Lake Hancock is characterized by persistent blue-green algal blooms, high nutrient concentrations, and widely fluctuating levels of dissolved oxygen and pH and has often been recognized as having some of the poorest water quality within the State. The lake contains approximately 18 million cubic yards of nutrient-rich flocculent bottom sediments which frequently resuspend into the overlying water column as a result of wind action (ERD, 1999). The lake is dominated by fish, vegetation, and wildlife populations which are indicative of hypereutrophic conditions. Discharges from Lake Hancock enter the Peace River which outfalls into Charlotte Harbor. Flow from Lake Hancock is thought to be one of the most significant sources of nitrogen loadings to Charlotte Harbor.

During 2003, the Southwest Florida Water Management District funded a study titled "Lake Hancock Outfall Treatment System Evaluation" to evaluate alternatives for treatment of discharges leaving Lake Hancock. As part of this project, a surface water quality monitoring program was conducted from March 2004-February 2005 to provide a more thorough understanding of the physical and chemical characteristics of the surface water in Lake Hancock, including both seasonal and diurnal variability, and to provide input for selection of a cost-effective treatment system for the Lake Hancock outfall. This monitoring program included monthly surface water monitoring at three potential treatment system intake sites, quarterly diurnal water quality monitoring, and quarterly particle fractionation studies to characterize physical and chemical characteristics of particulate matter in Lake Hancock water.

Due to the shallow water depth, thermal stratification was rarely observed in Lake Hancock. However, field measured surface pH values within the lake were found to be highly variable, ranging from greater than 10 s.u. to less than 7 s.u. Relatively isograde pH conditions were observed during approximately half of the monthly monitoring events, with sharp decreases in pH observed with increasing water depth during the remaining events. During several events, water column pH values ranged from 10 s.u. near the water surface to less than 7 s.u. near the water-sediment interface in a water depth of approximately 1.25 m. A similar pattern was observed for specific conductivity measurements. On approximately half of the monitoring dates, specific conductivity exhibited a relatively isograde pattern from surface to bottom. However, during the remaining dates, large increases in specific conductivity, with increases frequently exceeding more than 100%, were observed near the water-sediment interface, suggesting significant internal recycling on these dates. Field measurements of dissolved oxygen in Lake Hancock were also highly variable, with surface measurements ranging from super-saturated conditions to less than 4 mg/l. A general trend of rapidly decreasing dissolved oxygen with increasing water depth was observed during most monitoring events (ERD, 2005). In general, Lake Hancock appears to be a harsh aquatic environment, with rapidly fluctuating levels of pH, dissolved oxygen, and conductivity.

Diurnal monitoring was conducted on a quarterly basis at two separate locations within Lake Hancock. Diurnal variability in temperature at a given depth was typically observed to be approximately 1-2^{o}C, although temperature differences as high as 5^{o}C were observed at a given depth on several occasions. Measured diurnal fluctuations in pH ranged from approximately 2-3 units at a given depth during most events. Dissolved oxygen concentrations were highly variable within the water column, with fluctuations ranging from approximately 14 mg/l (late afternoon) to 2 mg/l (sunrise) at the surface during one diurnal event, and values ranging from greater than 20 mg/l to 10 mg/l at a given depth during another event. Substantial variability in conductivity measurements were also observed during the diurnal monitoring, particularly in lower portions of the water column.

Measured total nitrogen concentrations in Lake Hancock ranged from approximately 1400-7100 µg/l during the 12-month monitoring program, with total phosphorus concentrations ranging from approximately 100-715 µg/l, and chlorophyll-a concentrations ranging from approximately 60-800 mg/m^3. Approximately 60-75% of the total nitrogen and total phosphorus in Lake Hancock is comprised of particulate matter which is predominantly less than 11 microns in size. This material is primarily organic in nature, suggesting it is comprised primarily of algal cells. A significant removal of both nitrogen and phosphorus can be achieved by removal of the algal particles from the water column.

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NOTES

ASSESSING WATER QUALITY IMPROVEMENTS IN THE UPPER OCKLAWAHA RIVER BASIN

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The St. Johns River Water Management District has been working to restore water quality and aquatic habitat in the Upper Ocklawaha River Basin (Lake Apopka and the Harris Chain of Lakes) since the late 1980s. A keystone in the District's restoration program is reduction in anthropogenic phosphorus loading to the lakes. Much of the excess P loading was from farms developed on peat soils in the original floodplains.

Phosphorus loading is being reduced through acquisition of the farms, reflooding to restore aquatic habitat, and management of restoration areas to minimize P losses. Most of the farms were located at Lake Apopka and Lake Griffin, and P loading to these lakes has declined as a direct benefit of watershed restoration. Loading to other lakes has declined due to reduced P discharge from Lake Apopka. P levels in the lakes have declined, and other indicators of eutrophication (chlorophyll a, and Secchi transparency) have improved, without extended delays due to internal P recycling. We will describe the process of recovery of the lakes. We will examine relationships between P loading and P concentrations and sedimentation coefficients for P, as well as relationships between P and other trophic variables.

NOTES

EFFECTS OF INCREASED PHOSPHORUS LOADING ON DISSOLVED OXYGEN IN A SUBTROPICAL WETLAND, THE FLORIDA EVERGLADES

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The Florida Everglades is a network of phosphorus (P)-limited oligotrophic marshes that is experiencing eutrophication as a result of P-enriched agricultural runoff. Effects of P enrichment on diel dissolved oxygen (DO) profiles were measured along nutrient gradients produced by runoff into two Everglades marshes and in field enclosures (mesocosms) subjected to experimental P enrichment. Strong diel DO fluctuations and aerobic conditions characterized nutrient-poor areas of the marshes, whereas dampened diel fluctuations and prolonged periods of anoxia were common in enriched areas. Oxygen concentrations in P-enriched mesocosms declined progressively with time and were significantly lower than in unenriched mesocosms after 3 years. In both the marsh and the mesocosms, reductions in water-column DO with enrichment were associated with a decline in periphyton and submerged macrophytes and an increase in sediment oxygen demand. Increases in floating and emergent macrophyte cover caused by enrichment may have contributed to lower DO through shading, which inhibited submerged productivity, and the production of nutrient-rich detritus, which increased oxygen demand. While oxygen concentrations in wetlands generally are lower than in lakes and rivers, declines in water-column DO can be ecologically significant and result in adverse biological impacts. The use of these diel DO investigations in the marshes of lake littoral zones may provide valuable information for the evaluation of lake health.

NOTES

SESSION 6

USE OF COAGULANTS FOR WATER QUALITY IMPROVEMENT AND LAKE MANAGEMENT

MONITORED PERFORMANCE EFFICIENCY OF AN OFF-LINE ALUM STORMWATER TREATMENT SYSTEM IN LARGO, FLORIDA

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The Largo Regional Stormwater Treatment Facility is located on a 76-acre parcel of land on the west coast of Florida near Tampa. The facility provides chemical (alum) treatment for both stormwater and baseflow discharging through a drainage canal, known as the Main Channel, which receives drainage from an 1159-acre urbanized watershed. The Main Channel ultimately discharges to Boca Ciega Bay, a tributary of Tampa Bay. Tampa Bay is an estuary of national significance included in the National Estuary Program and is the Southwest Florida Water Management District's (SWFWMD) Surface Water Improvement and Management (SWIM) Program's number one priority waterbody for protection, preservation, and restoration. The primary objective of the Largo Regional Stormwater Treatment Facility is to reduce non-point source pollutant loadings of primarily total nitrogen and total suspended solids to Boca Ciega Bay. Secondary project objectives include upland enhancement, wetland restoration, wetland creation, public education, and passive recreation.

In 2001, ERD completed final design and permitting for the construction of an off-line alum stormwater treatment facility, upland and wetland enhancement, and educational and recreational facilities. The alum stormwater treatment facility was designed to treat all stormwater and baseflow discharges through the Main Channel up to the peak discharge for a 1.25-inch, 4-hour design storm. Channel discharges up to 75 ft^3/sec are diverted off-line through a 4-ft x 8-ft concrete box culvert and into an existing 3-acre wet borrow pit. Water flow rate is continuously measured in the box culvert and alum is added on a flow-proportionate basis at a dose of 7.5 mg/l as aluminum. Alum floc settles in the wet pond and is automatically pumped into a sanitary sewer system. Construction of the Largo Regional Stormwater Treatment Facility was completed in June 2002.

During August 2002, ERD installed stormwater collection and flow monitoring equipment at the treatment system inflow and outflow locations. Twenty-four flow composite water samples were collected at the inflow and outflow monitoring locations from September 2002-February 2003. Samples were collected approximately once each week throughout the monitoring period, returned to the ERD Laboratory, and analyzed for a variety of parameters. Water flow rate through the treatment system was monitored continuously during the monitoring period.

Initial system operation and training was performed by ERD during August-October 2002. System operation since November 1, 2002 has been performed by the City of Largo. The alum system was temporarily out of alum and turned off on September 11-12, October 4-8, and October 16-17, 2002. The alum system was also turned off from December 15, 2002 through February 5, 2003 due to lack of budgeted funds for alum purchase. The system was restarted on February 5, 2003 and operated continuously through the end of the monitoring period.

Under on-line conditions, the stormwater treatment system achieved approximately 37% removal of total nitrogen, 85% removal of total phosphorus, 88% removal of TSS, and 26% removal of BOD. Under off-line conditions, the stormwater treatment system achieved an 8% reduction in total nitrogen, 46% reduction in total phosphorus, 91% reduction in TSS, and 42% increase in BOD.

NOTES

FIELD EVALUATION OF ALTERNATIVE NUTRIENT CONTROL TREATMENTS WITHIN THE UPPER OCKLAWAHA RIVER BASIN

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Water quality and riparian wetland habitat within the Upper Ocklawaha River Basin in North Central Florida declined dramatically over the last century. To reduce nutrient loading to adjacent water bodies within the UORB, over 13,750 hectares of former agricultural area have been purchased by the St. Johns River Water Management District (SJRWMD) for restoration to aquatic and wetland habitat. High water column phosphorus levels (> 1 mg TP/L) have been common as these properties are reflooded. Five former farm fields with open water habitat have been successfully treated with liquid alum to reduce phosphorus concentrations within the water column and reduce phosphorus flux from the sediments. However, in a more densely vegetated system, an application from an airboat and a Marshmaster™ caused significant disturbance resulting in appreciable capture of treatment chemical by the emergent vegetation.

Nutrient control projects are planned in the future at Sunnyhill Farms (780 ha) and Ocklawaha Prairie (>1,000 ha). Both sites are densely vegetated eliminating the use of barges. Aerial application may be economically feasible in large vegetated sites, but new materials need to be investigated. Promising candidates are Baraclear™ tablets, granular alum, alum residual, and ferric residual. These materials are readily available, and when spread aerially should penetrate vegetation.

In order to develop the application rates for a field trial, a laboratory study using various concentrations of the four candidate materials was conducted. Treatment substrate was placed into appropriate beakers and overlying sitewater was added to each vessel. The testing was conducted without sample stirring to more readily simulate field conditions. Following treatment, total phosphorus (TP), alkalinity and pH were evaluated on day 0, 1, 2, 5 and 12. At the conclusion of the test, samples were analyzed for dissolved orthophosphorus (PO_4-D). Granular alum was the most effective compound for reducing TP concentrations during the bench tests, followed by the high dose Baraclear™ treatment.

Based on the results of the laboratory study and results of treatments at other SJRWMD properties, a replicated field trial was conducted at Ocklawaha Prairie. Fifteen (four treatments plus control in triplicate) circular mesocosm enclosures, approximately 3 meters in diameter, were field-constructed using rolled Plexiglas-type material (Kimlite Industries) supported by wood stakes and inserted into the sediment. Treatments were hand broadcast into field enclosures arranged in a randomized block design on August 4, 2004.

Water samples were collected on days 0, 2, 5, 8, 15, 29, 57, 127, 163, 236, and 266 and were analyzed by PPB Laboratories (Gainesville, FL) and the SJRWMD Laboratory (Palatka, FL). *In situ* water quality measurements, including pH, dissolved oxygen, temperature and conductivity were recorded during each site visit. Field conditions, water depths, vegetative changes, weather observations, and opportunistic wildlife observations were also recorded.

Application of treatment material was successful, although some material was temporarily captured by the vegetation. TP levels were significantly reduced by alum residual, Baraclear^{TM}, and granular alum. Treatment effects on PO_4-D were dramatic as reductions occurred immediately and in all treatments. Dissolved aluminum significantly increased with Baraclear^{TM} and granular alum treatments (through day 29). However, by day 60, aluminum levels had started to decline toward pretest conditions. Mesocosms treated with Baraclear^{TM} and granular alum were overdosed, as indicated by a substantial depression in pH and damaged vegetation.

Overall, granular alum and Baraclear^{TM} appear to be most effective at decreasing levels of total phosphorus and orthophosphorus, while avoiding increases in dissolved aluminum. However, granular alum is significantly less expensive than Baraclear^{TM}.

NOTES

PHOSPHORUS SEQUESTRATION USING ALUMINUM-CONTAINING AMENDMENTS IN ORGANIC SOILS FROM A MUNICIPAL WASTEWATER TREATMENT WETLAND

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Constructed wastewater treatment wetlands are a relatively low-cost alternative increasingly being used in developing countries to provide primary wastewater treatment, while in industrial nations of Europe and North America, treatment wetlands are being used for tertiary treatment of nutrients prior to discharge into surface waters. Over time, the phosphorus (P) removal capacity of these constructed treatment wetlands may decline as P is released from the accrued organic soils. The Orlando Easterly Wetland (OEW) Reclamation Project is one of the oldest and largest constructed treatment wetlands in the United States, located east of Orlando in Christmas, FL. The 1220 acre wetland was designed in 1986 for the City of Orlando's Iron Bridge Regional Water Pollution Control Facility (WPCF) which needed an alternative discharge point for its wastewater effluent. The main goal in designing the system was to use macrophytes to facilitate additional nutrient removal for an average daily flow of up to 35 mgd of effluent from the Iron Bridge WPCF before discharging it to the St. Johns River.

The OEW has consistently reduced nutrient concentrations to meet discharge permit requirements. In recent years, however, P concentrations have increased during the winter months resulting in concern over the P binding capacity of the soil. Little research has been done on methods to restore the treatment capacity of older constructed wetlands since most of the treatment wetlands in use today are relatively young. One method to increase the P binding capacity of the wetland soil is to add amendments containing aluminum (Al). The use of amendments such as alum for nutrient inactivation has several advantages over other restoration methods including ease of application, relatively low cost, and it has been used in lake systems for over three decades. However, its effectiveness in wetlands to inactivate P, its longevity, and the effect of alum on the microbial activity, and in turn the nutrient cycling are yet unknown.

An intact core incubation study was performed to determine the effectiveness and dosages of alum and three other Al-containing alternatives (alum residual, polyaluminum chloride (PAC), and partially-neutralized aluminum chloride (PNAS)) in immobilizing P in organic soils under anaerobic conditions. Seventy-eight cores were collected; six replicates for each of the four chemical amendments, at three dosage rates, and six controls. The dosages were 35.97 g Al m^{-2}, 17.99 g Al m^{-2}, and 8.99 g Al m^{-2} for each amendment. The pH, soluble Al, and dissolved reactive P (DRP) were measured over a two-week time period in the water column. Upon completion the cores were sectioned into 0-5 cm and 5-10 cm intervals for soil characterization including total P, organic matter content, pH, microbial biomass P (MBP), sediment oxygen demand (SOD), and potentially mineralizable phosphorus (PMP).

Soil analysis found there to be no significant differences in total P and organic matter content between treated cores in either the surface or subsurface layer. There was also no significant difference in soil pH between treatments or dosage rates. Because the soil acidity remained unaffected, there were also no significant differences in the microbial biomass between treatments or dosages, however, there was a clear trend of increased microbial biomass with a decrease in aluminum dosage rate in the surface layer. This trend was also evident in the PMP results which serve as a measure of the microbial activity. Overall, the alum residual (173 mg m^{-2} d^{-1}) and PNAS (148 mg m^{-2} d^{-1}) treated cores had significantly greater SOD values in the surface layer than the alum (98.0 mg m^{-2} d^{-1}) and PAC (90.7 mg m^{-2} d^{-1}) treated cores indicating decreased microbial activity in the alum and PAC cores.

The water column pH of the cores treated with alum were significantly lower than all other treatments averaging 3.65 ± 1.12, while the cores treated with PAC (4.85 ± 0.96) and PNAS (4.21 ± 0.93) had pH values significantly lower than the alum residual and controls averaging 6.12 ± 0.19 and 6.09 ± 0.25, respectively. For all treatments, the cores receiving the highest dosage had significantly lower water column pH values than the mid and low-level dosages. Inversely related to pH, the alum (12.6 mg L^{-1}) and PNAS (9.32 mg L^{-1}) treated cores had significantly higher soluble Al concentrations than the PAC, alum residual, and control cores. The magnitude of the DRP uptake rates of all treatments (-60.41 mg m^{-2} d^{-1} to -2.11 mg m^{-2} d^{-1}) were equal or greater than the release rates of the controls (averaging 2.27 mg m^{-2} d^{-1}) suggesting any application rate might provide effective treatment of soil-released P in the short term. There were no significant differences in P flux rates between dosage levels for any of the treatments, however, at all dosage rates the alum, PAC, and PNAS were more effective at binding P than the alum residual. This research suggests that a one-time application of an Al-containing chemical amendment might prevent release of P from the soil back into the water column, however long term studies are needed to verify efficacy over time.

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NOTES

PROPERTIES OF IRON HUMATE AND ITS USE IN PHOSPHORUS REMOVAL FROM WATER

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Iron humate is a co-product of the treatment of surface waters for potable water production. A ferric sulfate solution is prepared from magnetite ore which is free of heavy metal contamination. There are only a few ore bodies in the world that are able to meet the stringent specifications necessary for potable water production. The ore is treated with virgin sulfuric acid and oxygen and filtered to produce the solution that is added to surface water for the precipitation of organic materials. The dosing amount varies by the amount of organics in the water, but typically ranges from 100 to 300 ppm. The iron humate slurry is pumped off the bottom of large cone bottom tanks and concentrated from about 2% solids to about 20% solids by filter presses. The supernatant returns back to the head of the water plant for recycle.

Iron humate is then solar dried in fields and manipulated several times to obtain a dry product of 70% plus solids content that can be used in potting soils, agricultural applications or for removal of phosphorus in water.

The original experiments at the University of Florida by Dr. J. B. Sartain and his graduate student, Eric Brown, demonstrated that iron humate mixed with a greens grade sand at 2.5% could remove most or all phosphorus supplied to a golf green, yet the P was still available for plant growth even though it was removed from the water. These were lysimeter studies with sand/ humate as a filter with leaching over many weeks.

Other experiments with SFWMD sponsorship have been conducted with similar sand/humate filters and results of these studies will be covered. Phosphorus has been absorbed from streams flowing through cattle ranches with 85 to 100% removal rates.

NOTES

SESSION 7

ST. JOHNS RIVER

TEMPORAL AND SPATIAL PATTERNS OF CARBON, NITROGEN, AND PHOSPHORUS CONTENT OF SUBMERGED AQUATIC VEGETATION IN THE LOWER ST. JOHNS RIVER

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The St. Johns River is one of the largest rivers in Florida at approx. 300 miles in length, and unique in that it flows northward. The lower St. Johns River (LSJR) basin is slow flowing, and tidally influenced over the entire 100 mile journey it makes to the Atlantic Ocean near Jacksonville. "The LSJR is classified as a sixth-order, darkwater river estuary that exhibits characteristics associated with riverine, lacustrine, and estuarine aquatic environments" (DEP, 2002). Submerged aquatic vegetation (SAV) is an important part of the LSJR ecosystem. It helps to support critical fisheries habitat, as well as act as a food resource for herbivores, including the Florida Manatee. It is important to understand the factors affecting the distribution and health of the SAV community to properly manage and protect it (Boustany et al., 2002). The project was designed to measure carbon and nutrient contents, assess species compositional differences, and identify any regional differences between SAV along the LSJR.

SAV was sampled quarterly from four sites along the LSJR from November 2003 to January 2005. For the purposes of this study, sites were divided between the freshwater lacustrine and oligohaline lacustrine zones. Samples were collected from existing sites having long-term SAV, water quality, and invertebrate sampling histories. These sites include: Rice Creek (RIC), Scratch Ankle (SCA), Moccasin Slough (MOC), and Bolles School (BOL). Eight species of SAV were collected for this study: *Hydrilla verticillata (Hyd), Micranthemum sp. (Mic), Sagittaria subulata (Sag), Ruppia maritima (Rup), Najas guadalupensis (Naj), Vallisneria americana (Val), Ceratophyllum sp. (Cer), Chara sp. (Cha).* SAV was carefully removed from the sediment to keep the plant material intact. The plants were then placed in ziplock bags for transport. SAV was brought back to the lab, thoroughly rinsed, and sorted by species. Two of the species were further separated into root and shoot samples when sufficient biomass was available. The plant samples were dried, ground, and analyzed for total carbon (TC), total nitrogen (TN) and total phosphorous (TP) at a commercial laboratory.

The Kruskal-Wallis test was used since the data were non-normally distributed. Although not statistically significant, there did appear to be a relatively large difference in TN and TP among species. For example, there was a >2-Fold difference in TP among species. There were significant differences in TC among species (P=0.023) where Hyd=Mic>Sag>Rup>Naj>Val>Cer>Cha. Each site did not have the same species assemblages. *V. americana* was found at each of the four study sites and was used to examine site differences. However, no significant differences in TC, TN or TP between sites were found. Seasonal differences were found in root and shoot allocation of the river's dominant species, *Vallisneria americana*. *V.americana* shoots demonstrated significant change in TC (P=0.007) and TN (P=0.001). Root TC values were marginally significant (P=0.058). Root TN and TP significantly changed through time (p=0.053 and p=0.012, respectively). When comparing values among sites for *V.americana* shoots had no significant TC or TN differences. Significant differences were found in shoot TP (P=0.018) where MOC>BOL>SCR>RIC.

While suggestive of specific, regional, and temporal differences, more data will be needed to rigorously test these ideas. These results can ultimately be used to estimate the nutrient reservoir within SAV biomass, investigate trophic and food-quality interactions between invertebrate and vertebrate herbivores and SAV, and will be further used to parameterize an SAV production model for the lower St. Johns River.

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NOTES

LITTORAL SEDIMENT CHARACTERISTICS AND SUBMERGED AQUATIC VEGETATION INTERACTIONS IN THE LOWER ST. JOHNS RIVER, FLORIDA

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Submerged aquatic vegetation (SAV) exists as a mosaic of patches in the littoral areas of the lower St. Johns River basin (LSJRB). Pollution (Potter and Lovett-Doust 2001), disturbance (Doyle 2001), grazing (Hauxwell et al. 2004), salinity stress (Doering et al. 1999), and light limitation (Blanch et al. 1998) are some of the possible factors contributing to the presence or absence of vegetation at any given point. Another possible limiting factor may be sediment quality (Rogers et al. 1994). For example, the role of sulfide toxicity in salt marshes has been well documented (Carlson 1994). The purpose of this project was to conduct sediment sampling in the littoral areas of the LSJRB and attempt to (1) characterize littoral sediment characteristics, (2) compare littoral sediment characteristics to pelagic sediments, and (3) assess possible interactions between submerged aquatic vegetation (SAV) and important sediment characteristics. Hopefully, greater understanding of how sediment and SAV interact will yield better predictions regarding SAV coverage and distribution.

Sediment cores were collected in littoral areas of the lower St. Johns River during the summer of 2003 from 24 littoral sites exhibiting SAV cover ranging from bare to fully covered. Mainstem river sites accounted for 22 of the sites and offline lakes accounted for two of the sites. At each site, a core was collected from the shoreward edge, approximate middle, and the deep edge of the grassbed. Nine sites had duplicate cores taken at each location for QA/QC purposes and to better characterize those beds. The 10 x 20-cm cores were sectioned into two 10-cm intervals in the field, dried to constant weight, and analyzed at the University of Florida soil science laboratory. Parameters included grain size; bulk density; sediment oxygen demand; and organic, nutrient, and metals content. ANOVA was used to identify differences in sediment parameters within and among sites and non-linear regression was used to relate SAV and sediment measurements.

TP and N:P were generally lower in the lower sediment horizon although, the interaction between river zone and sediment horizon was significantly different for the upstream freshwater riverine reach. Sediments were more organic in the freshwater riverine reach and became progressively more mineral proceeding downstream. Crescent Lake was markedly different from the river and was an obvious outlier in most analyses. For example, loss on ignition and sediment oxygen demand represented the lowest values in the dataset while bulk density represented the highest. Soil organic and nutrient content were significantly lower in the littoral areas than in the river channel in the oligohaline-lacustrine (OL) and freshwater-lacustrine (FL) reaches, possibly indicating focusing in the deeper central river channel. Sediment/channel differences were much more pronounced in the OL than the FL reach. There was a significant negative exponential relationship between soil organic and nutrient content and SAV percent cover. Regression models showed that increased SAV cover was associated with lower soil organic and nutrient content at > 40% coverage.

Results from this study are important for a number of reasons. First, these data have shown how spatially heterogeneous sediment quality can be both within the littoral area and between the pelagic and littoral areas. It would appear that the accumulation and storage of organic material and nutrients is greater in the freshwater reach, particularly when comparing littoral areas between the two reaches. Second, these data suggest that there are important interactions between sediment quality and SAV success. These observational data suggest two alternative hypotheses: (1) highly organic sediments may preclude SAV, perhaps due to redox or toxic conditions, while more mineral sediments encourage SAV establishment, and (2) increasing colonization and coverage of SAV may increase oxygenation of the sediments and reduce organic sediment loads. Additional experimental work will be needed to determine which hypothesis, if not both, may be applicable. Third, regression models suggest a threshold response in terms of organic matter and nutrient accumulation in the sediments. Areas with SAV coverage exceeding ~ 40% generally had much lower organic material. This may have important management implications. Encouraging SAV growth and persistence at levels > 40% should have beneficial effects in terms of reduced organic matter accumulation and associated problems such as sediment resuspension and turbidity.

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NOTES

ASSESSMENT OF SHALLOW GROUNDWATER NUTRIENT LOADINGS INTO THE LOWER ST. JOHNS RIVER

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While storm water runoff and surface loading of nutrients into the lower St. Johns River (LSJR) have been explored in great details, the vadose zone leaching and groundwater discharge of nutrients into the river have not yet been thoroughly quantified. This study is designated to ascertain the extent and magnitude of shallow groundwater nutrient loadings into the adjacent LSJR near in the Manor Del Rio area, Duval County, using numerical models and field measurements. The three-dimensional finite difference models, namely *Visual MODFLOW* and *MT3DMS*, are used to simulate the transient groundwater flow and nutrient transport under averaged net surface recharge and river stage conditions. An area of 5.6 km x 4.4 km that encompasses the entire Manor Del Rio area and its vicinity is selected as the active modeled domain. The Manor Del Rio area is a residential area associate with septic tanks as a sewage disposal system. A simulation scenario is chosen to predict the shallow groundwater flow and nutrient transport in the Manor Del Rio area for a simulation period of 10 years and to estimate the travel time when the nutrient plumes reaches the adjacent LSJR. Comparison of the groundwater nutrient loading rates obtained from model predictions with those from indirect field measurements will also be presented.

NOTES

SESSION 8

CRITTERS – THE GOOD, THE BAD, AND THE UGLY

CHANNELED APPLE SNAILS: CAUSING AN ENVIRONMENTAL PROBLEM IN CENTRAL FLORIDA'S LAKE BRANTLEY – AND BEYOND

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A large population of the channeled apple snail (*Pomacea canaliculata*) was encountered by FDEP and Seminole County biologists at Lake Brantley in Longwood, Seminole County, in late June 2004. Prior to this time, these very large snails had been reported from Hillsborough, Pinellas, Palm Beach, and Leon counties, but had not been seen in central Florida. A second central Florida population was reported and verified at Lake Tohopekaliga in Osceola County in late November 2004. Since that time, reports have been received from Volusia, Hendry, Citrus, Hernando, Sumter, Indian River, Collier, Pasco, and Orange counties.

The snails are very active herbivores which readily consume large amounts of many types of aquatic macrophytes. Brief experiments indicated that they readily feed on virtually any aquatic plant offered. (Unfortunately, they seem to be least fond of *Hydrilla verticillata*.) In Lake Brantley, a decrease in aquatic plant biomass has been observed in some locations, and there is concern that the presence of these snails may lead to deterioration in water quality. A biological assessment of the health of Lake Brantley performed on October 21, 2004 using FDEP's Lake Condition Index, however, suggests that – at least to date - water quality has remained good.

In addition to their voracious appetite, channeled apple snails have very high fecundity. Numerous clutches of 100 to 1000 small bright pink eggs are repeatedly laid on hard surfaces above the water line (as do native apple snails). Egg-laying has been observed year-round in Lake Brantley, though the rate of reproduction slows somewhat during the winter. These eggs hatch in a couple of weeks, and the 2 mm juveniles grow quickly, under ideal conditions reaching sexual maturity in 2 to 3 months.

Channeled apple snails are very adaptable, possessing both a lung and a gill, and being able to tolerate relatively cold temperatures and very low-oxygen conditions. They can tolerate desiccation for long periods of time, and, although they prefer aquatic macrophytes, they will readily consume a variety of other items, such as algae, dead animals, and detritus.

As with many invasive species, eradication of channeled apple snails is probably impossible. Some predators, notably limpkins, snail kites, and some other birds, have been observed feeding on the snails. Alligators and turtles probably prey on them to a degree, as well. Molluscicides are not a feasible alternative due to both cost and environmental considerations. Physical removal of adults and eggs by lakeside property owners is helpful, but of limited effectiveness. The most effective strategy to limit their spread is public education.

There is concern in central Florida that the snails will infest the Wekiva River (an Outstanding Florida Waterway), which is connected via canals and a small stream named Sweetwater Creek, to Lake Brantley. Considerable local media attention, including television and newspaper interviews) has been focused on this issue. Numerous talks have been given to both school groups and government agency personnel regarding this pest species, in hopes of slowing their spread throughout the state.

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Ferriter, A. (2005). "Exotic South American snail occurs in Florida waters." Wildland Weeds, Florida Exotic Pest Plant Council, p. 7.

Howells, R. (2003). "*Pomacea canaliculata*: Channeled apple snail." *Aquatic Nuisance Species Digest, Vol. 5*, No. 1, p. 1.

Internet Resources:

Fact sheet, Lake Brantley infestation and other information:
http://www.dep.state.fl.us/central/Home/Watershed/Snails.htm

The Apple Snail Website: http://www.applesnail.net/

Fact sheet, Gulf States Marine Fisheries Commission:
http://nis.gsmfc.org/nis_factsheet.php?toc_id=154

IFAS *Featured Creatures* series (all Florida *Pomacea* spp.):
http://creatures.ifas.ufl.edu/misc/gastro/apple_snails.htm

Seminole County snail cleanup information:
http://www.seminole.wateratlas.usf.edu/news/default.asp?announce=archived

Global Invasive Species Database: http://www.issg.org/database/species/ecology

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SEMINOLE COUNTY'S ACTION PLAN: ADDRESSING THE CHANNELED APPLE SNAIL INFESTATION IN LAKE BRANTLEY

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With the recent infestation (June 2004) of the channeled apple snail (*Pomacea canaliculata*) occurring in Lake Brantley and with direct connection to the Big Wekiva River system, community outreach became priority for both FDEP and Seminole County. Lake Brantley, located in Seminole County, Central Florida, is 285 acres in size and is classified as an oligotrophic lake with an historic TSI average of 36. Upon literature review and conducting various experiments by Dr. John A. Osborne at the University of Central Florida (UCF), mechanical control of these exotic apple snails seemingly became Lake Brantley's only choice in population control and water quality protection.

Chemical Control

In conjunction with Dr. John Osborne (UCF Biology Department) chelated copper sulfate (K-Tea), known to be an effective molluscicide, was used to determine [LD_{50}] of *Pomacea canaliculata* as an option for population control. Five equally sized snails were utilized in each of six, 10 gallon, aquaria containing water from Lake Brantley. The initial concentration of chelated copper sulfate ($CuSO_4$) ranged from 0 ppm (control) to 1 ppm. After 48 hours of exposure, the LD_{50} value was 0. A second trial was conducted using fresh snails in each aquarium with $CuSO_4$ concentrations ranging from 1 to 5 ppm of $CuSO_4$ increasing each aquarium by 1 ppm. After 48 hours of exposure, the LD_{50} value was 0. A third trial was conducted using a range from 5 ppm to 10 ppm. After 48 hours of exposure, 20 snails were presumed dead. The snails appeared dead in aquaria containing 6 ppm to 10 ppm $CuSO_4$ and were left in the treated aquaria for an additional 24 hours until the aquaria were cleaned. As the aquaria were broken down for cleaning, the 20 dead snails were placed into fresh lake water. Once transferred, all 20 snails revived thus indicating that after 72 hours of exposure at 10 ppm of CuSO4 the LD_{50} value was 0 for the experiment. It was concluded that copper sulfate would not be effective as a method to eradicate the *Pomacea canaliculata* population.

Mechanical Control

Much of the literature review conducted concludes that "collecting by hand and destroying both the snails and their eggs, although labour-intensive, is the most effective non-chemical way to reduce snail numbers" (Cowie 2002). Armed with this knowledge and proven ineffectiveness of chemical applications, Seminole County took a proactive role on community outreach by raising lakefront homeowner awareness and holding public educational events. Such efforts included media coverage, mass mailings of educational brochures, and actions lake residents can take. Volunteering opportunities were made available where residents were encouraged to collect adult snails and egg clutches at Seminole County Snail day held on September 16, 2004.

Analyzing Ecological Impacts

Water quality data provided by Seminole County's Surface Water Quality Monitoring Program has indicated a decreasing trend in Secchi transparency (r=0.502) after the invasion of the exotic apple snail as well as reduction in aquatic macrophyte biomass. Further consumption of the diverse aquatic macrophyte in Lake Brantley would cause the degradation of Lake Brantley's water quality. Currently Seminole County is using FDEP Lake Condition Index (LCI) methodologies to monitoring these changes using macroinvertebrate diversity and abundance as an early indicator of changes within this trophic level. As of October 16, 2004, Lake Brantley scored 'Very Good' on the FDEP LCI scale.

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THE CORRELATION OF VARIOUS AQUATIC MACROINVERTEBRATE MEASURES BETWEEN QUALITATIVE SHORE ZONE SAMPLES AND QUANTITATIVE SUBLITTORAL ZONE SAMPLES IN SOUTH FLORIDA LAKES

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A biological integrity Lake Condition Index (LCI) has been developed by the Florida Department of Environmental Protection (FDEP) to aid in assessing impairment due to nonpoint source (stormwater) pollution (Gerritsen et al. 2000). The multi-metric index is derived from several measures of the benthic macroinvertebrate community inhabiting sediments in the sublittoral zone, defined as a depth of 2-4m. The metrics are: total taxa, EOT taxa (Ephemeroptera/Odonata/Trichoptera), % EOT, % Diptera, Hulbert Index indicator taxa, and Shannon-Weaver Diversity. Other indices that have been used to assess impairment based on the sublittoral community include Shannon-Weaver diversity (Washington 1984), the Hulbert Index (Hulbert 1990), and the Florida Index of Lake Integrity (FDEP 1994).

The LCI is a quantitative method. In lakes of 1000 acres or less, twelve ponar grabs are collected approximately equidistant around the lake and composited as a single sample, from which a subsample of 100+ organisms is obtained for calculating the various metrics. In addition to the quantitative ponar sampling, biologists from the FDEP South District also conducted qualitative dipnet sampling in the shore zone (defined as the water/land interface to a depth of 1m), a method requiring considerably less gear and collecting/processing time. Two experienced biologists sampled a 20m stretch concurrently for 30 minutes. Net contents were field-picked in shallow white pans to collect all species present. The objectives were to determine (1) habitat utilization by aquatic macroinvertebrates in this zone, and (2) how well shore zone taxa measures correlated with sublittoral zone taxa and index measures.

Three qualitative shore zone taxa measures (total taxa, EOT taxa, and Hulbert Index indicator taxa) were correlated with their quantitative sublittoral counterparts, as well as the various indices. Correlations differed depending on season (winter *vs*. summer), and overall were low to moderate, precluding the use of shore zone sampling as an indicator of conditions in the sublittoral zone. The strongest correlations ($r = 0.36$-0.63) were obtained with Hulbert Index indicator taxa.

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NOTES

MACROINVERTEBRATE ASSESSMENTS / LAKE CONDITION INDEX AS A TOOL FOR DETERMINING THE CONDITION OF LAKES BEAUCLAIR AND DORA IN THE LAKE COUNTY UPPER OCKLAWAHA RIVER BASIN

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The Lake Condition Index (LCI) is a macroinvertebrate/biological tool that was developed by the Florida Department of Environmental Protection to identify impairment and determine the condition of Florida lakes. Macroinvertebrates function as continual natural monitors of ecosystem health, reacting to the effects of both periodic and cumulative pollution and habitat alteration. Traditional water quality measures, especially chlorophyll, are less sensitive than the benthic macroinvertebrates for detecting early changes due to nutrient enrichment in clear lakes.

Lake Beauclair, located in the central portion of Lake County, was verified as impaired for nutrients and included on the verified list of impaired waters for the Ocklawaha Basin. Discharge from Lake Apopka via the Apopka-Beauclair Canal currently represents approximately 93 percent of the annual load of phosphorus to Lake Beauclair. The discharge of Lake Beauclair into Lake Dora contributes approximately 91 percent of the total annual phosphorus load for Lake Dora.

The LCI scores for Beauclair East and West sides were both very poor. LCI score rankings ranged from very poor in the Lake Dora East lobe to poor in Center and West lobes. However, there was an improvement in diversity (total taxa) with an increase in distance from the Lake Beauclair discharge point into Lake Dora. Lake Dora West was the only site with a pollution-intolerant lake macroinvertebrate species present (based on the Hulbert Index).

In order to restore water resources and address the total maximum daily loads (TMDL) requirements for Lake Beauclair, the Lake County Water Authority has on off-line alum system or NuRF (Nutrient Reduction Facility) project planned that would significantly reduce the total phosphorus concentration in Lake Beauclair by as much as 81%. This could have a significant positive impact on water quality in Lake Dora as well. The LCI will continue to be an invaluable tool in assessing the impacts that the planned improvements have on the ecosystem in the Ocklawaha Basin.

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SESSION 9

CYANOBACTERIA

CYANOBACTERIA RESEARCH ON THE HARRIS CHAIN OF LAKES: WHERE WE ARE AND WHERE WE NEED TO GO

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Cyanobacteria, also called blue-green algae, have baffled scientists, beguiled the media and angered the general public for decades. Commonly known for their ability to cause unsightly algal blooms, they are often associated with nutrient-rich water such as the Harris Chain of Lakes in Lake County, Florida. Under certain conditions, some cyanobacteria can pose a threat to wildlife, livestock and public health. For this reason, the Lake County Water Authority Board of Trustees recently initiated an unprecedented effort to determine the abundance of cyanobacteria and their associated toxins within lakes Apopka, Harris, Beauclair, Dora, Eustis, Yale and Griffin.

Between September 2001 and October 2003, each of the seven lakes were sampled bi-weekly and analyses were performed to identify cyanobacteria species type, unit count, and potentially toxic versus non-toxic percentages. Periodically, these samples were analyzed for cyanotoxins including microcystin, anatoxin-a and cylindrospermopsin. Bloom conditions were occasionally sampled and analyzed for microcystin. The study continued through October 2004 with the elimination of Lake Apopka and the addition of cell count and biovolume analyses for the remaining six lakes.

Throughout the study period, all the lakes within the Harris Chain were consistently dominated by at least one type of cyanobacteria species. For the years it was studied, Lake Apopka maintained the highest mean abundance of cyanobacteria (1.3×10^6 units/ml) while Lake Yale maintained the lowest for all three years (9.8×10^4 units/ml). Potentially toxigenic cyanobacteria comprised 0.5% of the total cyanobacteria in Lake Apopka, 15.2% of the total cyanobacteria in Lake Beauclair and 38.6% of the cyanobacteria in Lake Harris. For year three, all six lakes exceeded the World Health Organization (WHO) Guideline I for 20,000 toxigenic cyanobacteria cells/ml fifty percent of the time or more (Chorus and Bartram 1999).

Microcystin was generally detectable at low levels throughout the Harris Chain for the duration of the study period (< 1.0 µg/l). The highest concentration of microcystin obtained from normal sampling was 9.39 µg/l. Periodic bloom events during the final year of the study resulted in concentrations up to 7,550 µg/l. Cylindrospermopsin was not detected during the first year of the study, three times during the second year of the study and sixteen times during the third year of the study. The highest reported concentration of cylindrospermopsin (0.20 µg/l) was only slightly above the minimum detectable limit of 0.05 µg/l. Anatoxin-a was present near the minimum detectable limit (0.05 µg/l) twenty times during the first year of the study, seven times during year two and none was detected during the third year of the study. The highest concentration of anatoxin-a was 7.0 µg/l.

This study indicates that dominance of cyanobacteria is widespread throughout the chain but the abundance of particular cyanobacteria species within lakes varies. Low concentrations of at least one form of cyanotoxin are generally present in all of the Harris Chain of Lakes, however, bloom conditions can lead to localized areas of highly concentrated cyanotoxins. The health effects of cyanotoxins are outside the scope of this study, but various agencies have expressed a desire to use this information in epidemiological studies. It is important to note that the public health department has never received a report of human illness attributed to cyanobacteria in Lake County (Melling 2005). In addition to assisting the medical community, this data will also provide information with which to gauge the success of the Lake County Water Authority's Nutrient Reduction Facility as well as several other major projects planed for the Harris Chain of Lakes.

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NOTES

CYLINDROSPERMOPSIS RACIBORSKII (CYANOBACTERIA) MORPHOLOGICAL VARIATION IN THE HARRIS CHAIN OF LAKES, FLORIDA

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Two morphological forms (morphs) of the filamentous cyanobacteria *Cylindrospermopsis raciborskii* occur in the Harris Chain of Lakes in central Florida: straight and coiled. It is not well understood what environmental conditions favor one morphotype over the other. *C. raciborskii* populations from 7 lakes over a three-year period (Sept. 2001 to Oct. 2004) were analyzed and patterns in relative abundance of the two morphs between lakes and within lakes over time were examined. In all lakes both straight and coiled morphs were found at least some time during the study period. In Lakes Eustis, Griffin, Harris and Yale straight trichomes were dominant in over 90% of samples with *C. raciborskii* present. In Lake Dora straight trichomes were only dominant in 56% of samples and in Lakes Apopka and Beauclair the coiled morph was more often the dominant form (58% and 71% respectively). In Lakes Beauclair and Dora morphological dominance switched from the straight morph in Year 1 of the study to the coiled morph by Year 3. In general, at times when both morphs were present changes in abundance of the two forms tracked one another. Coiled trichomes were less common in Lakes Yale (<5% of samples), Harris (20%), Griffin (45%) and Apopka (53%) compared to Lakes Eustis (96% of samples), Beauclair (100%) and Dora (100%). Lakes Dora and Beauclair had some of both morphs in all or almost all samples collected. Possible relationships between water quality and distribution and abundance of the two morphotypes of *C. raciborskii* will be discussed.

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PHYTOPLANKTON BLOOMS AND ASSOCIATED CYANOBACTERIAL TOXINS IN LAKE OKEECHOBEE

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The phytoplankton in Lake Okeechobee is strongly dominated by cyanobacteria, including taxa such as *Anabaena*, *Aphanizomenon*, *Microcystis*, and *Cylindrospermopsis* which are known to produce toxins in other lakes. Since July 2003, biomass and taxonomic composition of bloom-forming cyanobacteria in Lake Okeechobee have been monitored on a monthly basis at 10 shoreline sites where blooms historically have been known to occur. Concurrently, water chlorophyll-*a*, total nitrogen and total phosphorus concentrations have also been monitored. In May of 2004, cyanobacterial toxin analysis was initiated as an additional component of this routine monitoring project. Water samples from 5 of the 10 shoreline stations were analyzed for the presence of cyanotoxins (microcystin, cylindrospermopsin, and anatoxin-a). During this study, average chlorophyll-*a* concentrations were highest at the sites along the western shore and lowest at the southern near shore sites and peak chlorophyll-*a* concentrations occurred during the summer months of June and July. Preliminary cyanotoxin results indicate that the most commonly observed toxin was microcystin, which is produced by the blue-green alga *Microcystis*, a genus that has been common in the lake since the 1980s. The temporal pattern for cyanotoxin concentrations closely mimicked the temporal pattern for chlorophyll-*a* and cyanotoxin concentrations were highest at the western shore sites. The results also indicate that while there presently may not be a serious problem with cyanotoxins in Lake Okeechobee, they do occur, along with the algae known to produce them.

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SESSION 10

WATER QUALITY

LAKE LEVEL AND TROPHIC STATE VARIABLES AMONG A POPULATION OF SHALLOW FLORIDA LAKES AND WITHIN INDIVIDUAL LAKES

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Monthly total phosphorus, total nitrogen, chlorophyll, Secchi depth and lake water level data for 84 Florida lakes were used to examine relations between trophic state variables and water level fluctuation. The lakes averaged 566 ha and ranged in size from 4.0 ha to 5,609 ha with the period of record for individual lakes averaging 57 months and ranging from 7 months to 175 months. The range of lake level fluctuation for individual lakes averaged 1.3 m and ranged from 0.1 m to 3.5 m. The lakes also ranged from oligotrophic to hypereutrophic with average chlorophyll values for individual lakes ranging from 1 $\mu g \cdot L^{-1}$ to 97 $\mu g \cdot L^{-1}$. No overall relation between trophic state variables and lake level fluctuation could be found among the population of lakes. However, individual lakes showed direct, inverse, and/or no significant relations between lake trophic state variables and water level fluctuation, regardless of the magnitude of water level fluctuation. Examining two individual mechanisms impacting trophic state variables that are related to water level fluctuation showed that sediment resuspension (estimated with the dynamic ratio which is the square root of lake surface are divided by lake mean depth) and potential percent area covered with aquatic plants (assuming light is the limiting factor for aquatic plant abundance) can increase or decrease as water level increases or decreases depending on the individual lake's morphology. These data suggest that predicting how water level fluctuations will impact trophic state variables among a population of lakes will be difficult if not impossible and that any accurate predictions will have to be made after first examining several mechanisms within individual lake systems.

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PROTECTING WATER QUALITY IN WAKULLA SPRINGS WITH NUTRIENT CRITERIA AND THE TOTAL MAXIMUM DAILY LOAD PROCESS

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The recent degradation of water quality in Edward Ball Wakulla Springs State Park has been documented by the park biologist and other researchers. A dramatic rise in nitrates and elevated phosphorus is suspected to be contributing to the degradation. “Safe” levels of 0.40 milligrams per liter (mg/L) of nitrate and 0.025 mg/L of phosphorus have been proposed, based on the well-documented relationship of chlorophyll to nitrogen and phosphorus in Florida lakes. Sewage processes in the city of Tallahassee wastewater treatment plant (land spreading of residuals, spraying of sewage effluent, and fertilizing crops in the sprayfield) make up 80 percent of the total nitrate budget to the springs. Nitrate concentrations in the springs have paralleled nitrate concentrations in ground water below the sprayfield over the last 25 years. The total maximum daily load (TMDL) process scheduled for 2007 will need to address all sources of nitrates to Wakulla Springs.

This presentation focuses on the following three issues surrounding Wakulla Springs: documenting the degradation of the aquatic health of the springs, establishing “safe” nutrient concentrations that will protect the springs, and identifying current nutrient loads to the springs and reducing those loads to maintain “safe” levels of nitrogen and phosphorus.

Supporting data for the study come from a number of different sources. Park personnel have collected data on bird populations with monthly surveys over the last 12 years, plus numbers of down days for the glass-bottomed boats. The author collects information semiannually on apple snail, hydrilla, and algal mat densities in the park using visual surveys (i.e., the Healthy Aquatic Plant Index, or HAPI). STORET is the source of information on nitrogen and phosphorus trends in the springs. The Northwest Florida Water Management District has estimated nutrient loads to the springs through a Wakulla River nutrient study (Chelette and Pratt, 2002). Finally, a study of nutrients and algal mats in springs was used to come up with “safe” and “problem” phosphorus levels (Stevenson et al., June 10, 2004).

The aquatic health of Wakulla Springs has been documented in a number of ways. Water clarity has been reduced (i.e., glass-bottomed boats run only 30 percent of the time, versus 50 percent of the time 10 to 20 years ago). Algal mats have covered 10 to 50 percent of the spring run in the last 4 years, while hydrilla covers 60 percent of the spring run (this is more than any of 26 springs studied and twice the coverage of the next most dense spring). About $100,000 was spent to harvest hydrilla in 2001; herbicide is now used once or twice a year as a control. In addition, bird counts at the springs have been halved over last 6 years, limpkins disappeared from the system in 2000, the numbers of anhinga have been dramatically reduced, apple snails have disappeared, and the health index for aquatic bugs is “poor” to “severely degraded.”

A number of conclusions and recommendations have been developed from the data. First, springs with natural forest in the springshed have low nitrate concentrations, while springs with center pivot sprayfields and agriculture have high nitrate concentrations. In most Florida wells, the level of nitrate is about .02 mg/L. Land use is the major cause of elevated nitrate; atmospheric deposition is not a factor in high nitrate levels.

Nitrogen loading in Wakulla Springs is caused by land use in the local springshed (100 pounds/day), Tallahassee urban ground water runoff (about 400 pounds/day), and Tallahassee sewage operations (about 1,100 pounds/day). Eighty-two percent of Wakulla's nitrate comes from sewage (effluent, 56 percent; residuals, 22 percent; and fertilizer, 6 percent). Nitrogen loading of 1,600 pounds/day from Wakulla Springs needs to be reduced by 40 percent to 1,000 pounds/day to reach a "safe" level. This "safe" level of nitrate in Wakulla Springs can be achieved by reducing the Tallahassee sewage load from 1,100 to 500 pounds/day.

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NOTES

STORET MADE EASY: THE SEMINOLE WATERSHED ATLAS WATER QUALITY DATA MANAGEMENT SYSTEM

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The acquisition of surface water quality data in Florida is a collective effort performed by many governmental agencies and citizen volunteer programs. In order to compile Florida's water quality data at the state and federal level, the Florida Department of Environmental Protection and US EPA use a database known as STORET (STORage and RETrieval database). The STORET database stores data collected from multiple jurisdictions and municipalities so that statewide and federal trends concerning water quality can be analyzed. However, many of the entities responsible for sampling surface water have consistently found that meeting requirements for uploading their data to STORET to be difficult and costly. The reasons for this difficulty include: differences in data management system capabilities and data formats, variability in data parameters and units, and documentation requirements that go beyond typical water quality data management systems.

The University of South Florida and Seminole County recently developed a Water Quality Data Management System (WQDMS) with funding from US EPA to serve as a model of data transfer between a local government and STORET. The WQDMS is integrated with the Seminole County Watershed Atlas (http://www.seminole.wateratlas.org/) and allows for the electronic transfer of water quality data directly from an analytical laboratory to a quality control module and ultimately to the Water Atlas and STORET.

The methods for developing the WQDMS involved reviewing and documenting the data collection, data transfer, and quality control procedures in place at Seminole County. In addition, requirements were developed in conjunction with the analytical lab (Harbor Branch) to standardize the format of the data provided back to the County and ensure that the data, units and parameters that were included in the electronic file met Florida's IWR related STORET requirements.

The WQDMS changed four critical steps in the data flow process. In the first step, County staff ensured the spatial integrity of sampling locations and developed standardized station naming that would be compatible with STORET. In the second step, standardized electronic data are sent from the lab and are directly imported into the Atlas database. In the third step, these data are reviewed and approved by Seminole County staff through a secure web-based interface. The tool performs a cross-check against the data to ensure that the resultant file will be compatible with Florida's IWR related STORET requirements. Once quality control is complete, the fourth and final step is to generate a Florida SIM file which meets all required STORET standards and which can be uploaded into STORET at predetermined intervals. The data can also be simultaneously published to the Water Atlas for citizens and other professionals to access.

The advantages of this system for Seminole County include: a significant reduction in the amount of information that must be keyed into the system for meeting Florida's IWR related STORET requirements, improvement in quality control by removing any potential data entry errors, and a significant reduction in staff time spent managing data for multiple uses (internal use, the public, and STORET). The improvement of data quality and regularity of routine data uploads to STORET is also imperative in the Florida Department of Environmental Protection's (FDEP) Total Maximum Daily Load (TMDL) process. The system is currently being adapted for use in other Florida counties and upgraded to be compatible with STORET 2.0 that is soon to be implemented by FDEP.

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NOTES

TREATMENT EFFECTIVENESS OF A FLOATING WETLAND DEPLOYED IN AN URBAN LAKE

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We performed a one-year study to evaluate the water treatment effectiveness of a floating wetland, deployed near the center of a 1.6 hectare, hypereutrophic urban lake. The wetland vegetation was contained within a floating boom 18 meters in diameter, which was equipped with a flexible fabric skirt that extended from the waters surface to the sediments. This effectively isolated the parcel of water beneath the vegetation from the lake's water column (Figure 1). A solar-powered pump was deployed to provide a semi-continuous water exchange from the lake's water column into the compartment at a rate of 75 – 150 m^3/day.

Figure 1.

The floating wetland deployed in Lake June.

The floating wetland effectively shaded phytoplankton, providing chlorophyll *a* and turbidity reductions (system inflow vs. outflow) of 75% and 60%, respectively (Table 1). Total nitrogen levels were reduced by 47% during passage through the wetland. Because of internal cycling of phosphorus (P) within the wetland compartment, we assumed little net P removal would be achieved by the wetland under steady-state conditions. We therefore injected alum once monthly into the system to stabilize P in the accumulating wetland sediments. Phosphorus reduction by the wetland from November 2003 through August 2004 averaged approximately 50% (Table 1). In contrast to the observed effective reduction in chemical constituents, concentrations of microbiological constituents (total and fecal coliforms) increased during passage through the wetland. Birds utilized the wetland extensively for perching and feeding, and this likely caused the observed increase in coliform levels within the system. Bird use may also have impacted nutrient removal effectiveness of the wetland.

Table 1. Summary of the water quality treatment performance of the Lake June floating wetland. Total P and soluble reactive P were collected approximately every week for one year. Other constituents were measured every 4 – 6 weeks for six months. Values (in mg/L, unless otherwise noted) represent means (and ranges) for each constituent.

Parameter	**Wetland Inflow (Lake)**		**Wetland Outflow**	
total phosphorus	0.168	(0.084 – 0.379)	0.084	(0.054 – 0.130)
Soluble reactive phosphorus	0.006	(<0.002 – 0.027)	0.008	(<0.002 – 0.029)
total nitrogen	1.80	(1.36 – 2.17)	1.08	(0.76 – 1.25)
chlorophyll *a* (mg/m^3)	0.078	(0.034 – 0.123)	0.026	(0.015 – 0.035)
total suspended solids	17	(6 – 26)	6	(2 – 10)
turbidity (NTU)	12	(8 – 18)	6	(4 – 11)
total aluminum	0.161	(0.057 – 0.260)	0.142	(0.060 – 0.260)
Sulfate	18.1	(10 – 21)	20.9	(12 – 44)
dissolved oxygen	9.6	(6.3 – 15)	1.2	(0.17 – 3.6)
total coliform (CFU)	339	(100 – 840)	3057	(400 – 6800)
fecal coliform (CFU)	193	(20 – 550)	1051	(280 – 1800)

Sediment cores collected from the lake and within the wetland enclosure suggested a large, historical accumulation of organic material. The depth of unconsolidated and consolidated floc varied widely both within and outside of the wetland enclosure, ranging from 0.2 to 0.4 m. No evidence of an alum floc was found in any of the cores collected from within the enclosure after one year of operation. Similarly, pore water aluminum concentrations were comparable between lake and wetland sediments (0.33 vs. 0.36 mg/L). However, laboratory incubations confirmed a reduction in SRP release from wetland sediments relative to those collected from the lake.

Our prior experience with this floating wetland concept suggested that a system sized at approximately 2% of the area of the overall water body could significantly reduce the mass of key pollutants that contribute to impaired water quality. In the present study, the floating wetland comprised 1.6% of Lake June's surface area. Based on an average estimated flow rate of $100m^3$/day through the wetland, the Lake June floating wetland removed a total mass of 25.6 kg N and 2.81 kg P/yr from the lake water column.

NOTES

SESSION 11

WATER STORAGE
AND SEDIMENT REMOVAL

FREEBOARD ANALYSIS OF
THE C-43 WEST STORAGE RESERVOIR

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The C-43 Reservoir will ultimately provide 160,000 acre-feet of storage for the entire Caloosahatchee River Basin as part of the Comprehensive Everglades Restoration Plan. The objective in selection of design freeboard is to assure that failure of the reservoir's dam will not result from wind set-up and wave action, in combination with the most critical pool elevation.

Over the years, many laboratory tests and field investigations have been conducted for freeboard estimates. These estimates were primarily determined by the empirical methods with a different form of models or figures and tables. The Zuider Zee formula is a frequently used equation to determine the wind set-up of a reservoir and is supported in USACE manual EM 1110-2-1420. The wind set-up estimated from this formula is a function of the wind velocity, fetch length, and the average depth of the reservoir along the fetch. Wind set-up is larger for higher wind speed, longer fetch distance, and in shallow reservoirs with rough bottoms.

The Shore Protection/Coastal Engineering Manuals provide a wave run-up analysis that is performed for the interior slopes of the reservoir to assure that overtopping of a dam does not occur. The guidelines and procedures presented in these manuals have received general acceptance and were selected for use in estimating freeboard requirements for C-43 West Storage Reservoir. The freeboard is defined as the vertical distance between the crest of a dam and some specified pool level, usually the normal operating level or the maximum flood level. Therefore, the freeboard of the C-43 West Storage Reservoir was determined under two scenarios: (1) using a probable maximum wind condition with the reference elevation as the normal operating level, and (2) using slower than the probable maximum wind conditions with the maximum reservoir level.

The key parameters, including water fetch length, wind velocity, average water depth, slope angle, and slope roughness, were used in establishing the freeboard allowance and in determining the final dam height. Only the key parameters of two potential reservoir alternatives, A of two cells and B of three cells of constant water surface and varied top of bank elevation, will be presented in the following.

Water Fetch Length: The reservoir's fetch lengths are geometrically constrained by land availability. EM 1110-2-1414 recommends a fetch calculated based on the average fetch within a 24° radius from the origin. Therefore, the fetch length was estimated as the radial average of path lengths over an arc of 24° , drawn at 3° intervals, centered on the longest path to the opposite dam. The length of each path was given equal weight in the calculated average. The fetch length for reservoir Alternative A was estimated to be about 3.55 miles. The fetch length for cell 1, 2 and 3 of reservoir Alternative B was calculated to be 3.55, 3.53 and 2.11 miles, respectively.

Wind Velocity: The 3-second gust wind speed of about 120 mph was estimated at the project site based on the South Florida Building Code. The freeboard analysis for Scenario 1 was performed using a 120 mph maximum design wind speed near the project site, as the wind velocity over water is higher than that over land surfaces (EM 1110-2-1420). The adjusted maximum wind velocity (146-153 mph) used in the freeboard analysis for Scenario 1 under both alternatives is similar to that of recent major hurricanes.

Water Depth: The height of the dam is derived from the reservoir water depth plus the minimum required freeboard. The average water depth was estimated based on the elevations of the bottom of the reservoir and the volume requirements. The bottom elevation of the reservoir ranges from about 15 to 27 feet. The average water depth ranges from 14.2' in reservoir Alternative B to 17.6' in reservoir Alternative A for various reservoir configurations. The average water depth of cell 1 and 2 in reservoir alternative A was estimated to be about 19.1' and 15.7', respectively.

Dam Slope: The average earthwork quantities estimated for 4H: 1V was about 1.8 millions cubic yards more than that for 3H: 1V. Therefore, the dam slope of 3H: 1V was used in estimating the freeboards.

Slope Roughness: Multiple layers of compacted soil-cement are selected for the dam slope protection to dissipate the energy in the waves and reduce the height of the wave run-up. It consists of a series of 16" thick by 8' wide horizontal layers of soil cement with a 3H: 1V slope to the exposed stair-step face and with random fill adjacent to the 1H: 1V slope of the central clays/clayey sands impervious core in the dam. A 16" thick flat plate of soil cement was proposed to be installed below the normal reservoir pool level.

Results and Conclusions

Freeboard calculation for the C-43 West Storage Reservoir was based on a rational method for estimating wind set-up and wave run-up on the dam. For Scenario 1, the estimated freeboard heights for the C-43 West Storage Reservoir are 9.7' and 10' for reservoir cell 1 and 2 of reservoir Alternative A, respectively. The freeboard heights of 9.9', 10.3' and 7.3' were estimated for cell 1, 2, and 3 in reservoir Alternative B, respectively. The results indicate that the reservoir Alternative A is more economic than reservoir Alternative B for the constant water surface condition based on the estimated earthwork quantities.

References

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USING "*MIKESHE*" TO SIMULATE AND EVALUATE ALTERNATIVE DESIGNS OF THE C-43 WEST STORAGE RESERVOIR

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Introduction

The C-43 West Storage Reservoir is one of the "Acceler8" project defined in the Comprehensive Everglades Restoration Project. The goal of the project is to provide water to meet increasing demands in the area around the reservoir, and to contribute to the long-term ecological improvement of the Caloosahatchee River Estuary. This goal will be accomplished by storing excess storm water during the wet season and releasing to the estuary during the dry season. Releases will be regulated to meet specific discharge requirements of the estuary.

Model Selection

The integrated surface water/ground water model, MikeSHE, was selected to evaluate multiple design alternatives. The model was selected for its wide range of capabilities. The program allows the user to define logical operands to optimize control structure operations, to evaluate seepage from the reservoir, to calculate changes in water quality, to determine the potential impact of a dam break, and to predict sedimentation rates within the reservoir.

Design Alternatives

The proposed reservoir will have a storage capacity of approximately 160,000 acre-feet. The current reservoir design has a foot print approximately eight (8) miles long and three (3) miles wide. The current design calls for an average, full pool, water depth of approximately 15 feet. A boundary canal will surround the reservoir to capture seepage through the bed of the reservoir.

During this project, two different alternatives were evaluated. "Alternative 1" calls for a 3-cell, 1-pump configuration. The single inflow pump is located in the northwest corner of the reservoir and draw water from the Townsend Canal near the confluence with the C-43 Canal. Outflow gates are located in each cell. The operational strategy of the outflow gates is to first release water from the gate located furthest from the pump. This would achieve maximum residence time in the reservoir and provide an ancillary water quality benefit. Water would be release from the other gates as needed to meet flow requirements in the estuary.

"Alternative 2" calls for a 3-cell, 2-pump design. One inflow pump is located in the northwest corner of the reservoir on the Townsend Canal near the confluence with the C-43 Canal. The second pump is located on the southeast corner of the reservoir on the Roberts Canal. This pump captures flows from citrus operations on the south side of the reservoir. In both alternatives, additional structures are included in the design to maintain water levels in the seepage canal and to manage flows into several small tributaries near the reservoir. An additional pump was also included in the design to return excess seepage to the reservoir.

Model Results

Multiple optimization runs were completed for each alternative in order to determine the optimum pump and gate sizes. Figure 1 shows a comparison of the predicted monthly mean flow from the final optimization run for each alternative to the target monthly mean flow at S-79. The modeling results indicate this reservoir makes a significant contribution, but cannot meet the specified discharge requirements to the estuary alone.

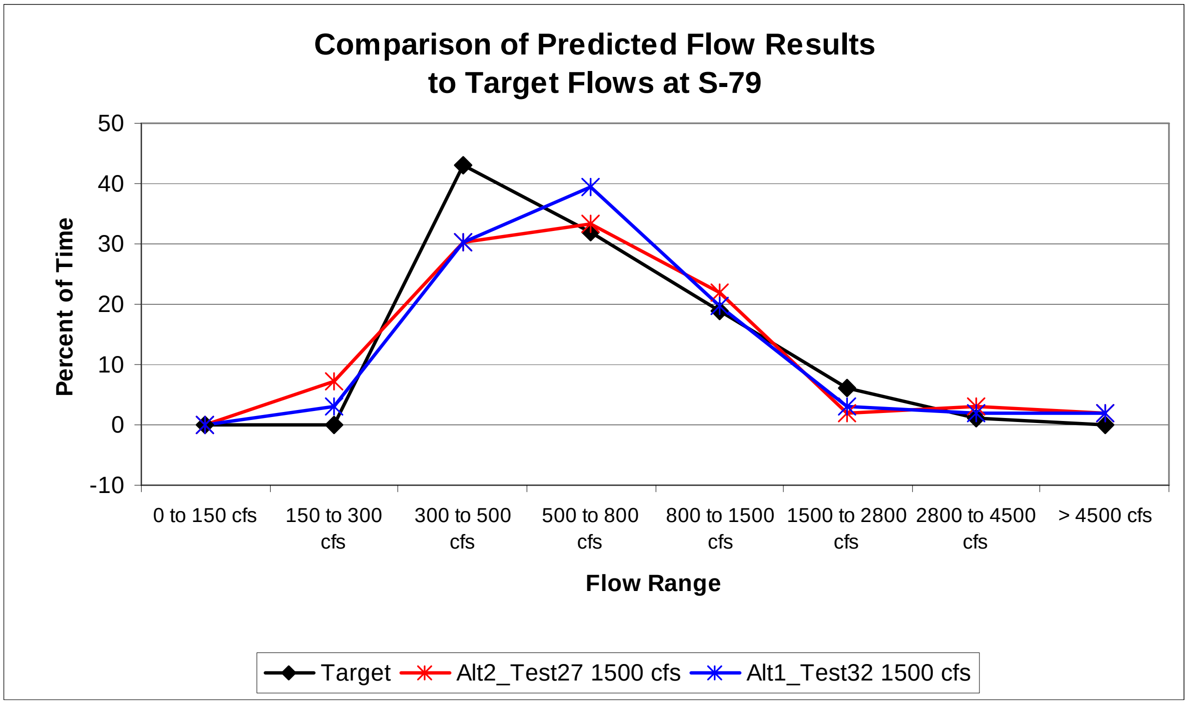

Figure 1: Monthly Mean Flow Comparison at S-79.

The results also indicate that modeled reservoir operations will meet water demands in the area around the reservoir, reduce peak flows in nearby streams where flooding has been reported, and provide water quality improvements by reducing nutrient concentrations within the reservoir itself.

NOTES

NEW TECHNOLOGY FOR SIZE-SELECTIVE REMOVAL AND MONITORING OF SEDIMENTS

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Sedimentation remains a major impairment to surface waters. Streamside Systems was formed to research, design, and market equipment to address sediment impacts: to prevent downstream migration of impacting sediments; to selectively remove harmful bedload or contaminated sediments; to actively flush harmful or contaminated fine sediments from the substrate; and to restore sediment-impacted aquatic habitats. Streamside Systems is unique in offering products that selectively remove the harmful particle sizes. Streamside Systems offers complementary series of active and passive equipment, both of which are effective in size-selective removal of targeted particle sizes. The passive systems capture sediments as they move downstream, while the active systems remove targeted sizes of sediments at a given location.

The active Sand Wand Series is manually operated, and involves a combination of variable water jet and suction to selectively remove fine sediments from the substrate, including subsurface interstitial areas. The "Sand Wand", a two-inch hand-held unit, was tested for effectiveness in restoring salmonid habitat in the Little Manistee River, Michigan, where a dam break had covered the riffle gravel and filled pools with sand. Pebble counts showed 64% sand and 36% gravel at the start, and ZERO SAND and 100% gravel after the test; the median particle size (D50) was 0.2 mm in impacted riffles, and 16 mm after restoration. On a larger scale, a restoration project on Boyden Creek, Michigan, used a 3-inch Magnum Sand Wand to selectively remove fine silts and sands after a dam failure, to effectively clean the substrate, and to restore the native gravel and cobble streambed. This restoration method is scalable to any size stream, and has widespread application to sediment impacts in many surface waters across the country.

The passive series of sediment collectors was designed to remove targeted sizes of sediments (generally sand and finer) as they move downstream as bedload. The passive Collectors are scalable to any size of stream, and involve a ramped Collector on the stream bottom, which selectively removes fine sediments as they move over the screened hopper. The collected material may be pumped out, or in some areas may be removed with a continuous siphon system, while organic matter (leaf litter, fish eggs, invertebrates, etc) and any sediment coarser than the screen (e.g., gravel and cobble) passes over the Collector and remains in the stream. As a new, best available technology (BAT) alternative to dredging, the passive Streamside Collectors can **avoid** the common adverse impacts of dredging. The Streamside Systems passive sediment collectors are effective with any sediment dense enough to settle and move along the stream bottom. A 10-foot wide precast concrete Collector is currently in use by the Central Arizona Project (CAP) on a water diversion canal in south Phoenix. A 4-foot wide stainless steel siphon Collector is being used to restore brook trout habitat and prevent downstream sediment impacts in Purlear Creek, Rendezvous Mountain State Educational Forest, North Carolina. Streamside collectors were successful in removing even the finest and lowest density sediments tested to date, iron floc. Koski and Herricks (2004) state: "The approach using the Streamside Systems Collector worked well in collecting the iron floc and pumping it to the dewatering bags". Multiple Collectors were used in Snow Creek (Stokes Co, NC) to remove fine bed sediments mobilized by an instream construction project. There are numerous potential applications for this equipment, such as reducing reservoir sedimentation; preventing downstream sediment impacts below dam-removal, construction, logging, or agricultural disturbances; sand mining; municipal stormwater and culvert installations to capture sediment; providing washed and sorted sand for beach nourishment; assessment and remediation of sediment-impacted habitats; maintaining navigation depths; and concentration and removal of fine-sediment-associated contaminants.

Since sediment is such a widespread problem, data on sediment sources and rates of transport are also of critical value. Streamside Systems offers a variety of bedload monitoring collectors to sample targeted sizes of bedload sediment. Prototypes of portable units have been tested for continuous operation (3 to 5-month periods) for sand to medium gravel. The Streamside collectors sample true bedload, and largely avoid the collection of suspended sediment and organic matter. The collectors can operate unattended, and can stockpile bedload material for later sieve analyses. For medium and large gravel, cobble, and even boulders, Streamside bedload collectors utilize removable hopper assemblies downstream from the suction hopper for fines; this is a clear design advantage over pit traps, in that the fine sediments are removed on a continuous basis and will not fill the collector basin(s) intended for coarser material. Streamside Systems bedload collectors are more accurate, by operating for longer periods of time, at up to complete cross-section widths, to reduce sample variability. Applications for such data include development of watershed sediment budgets (Braatz and Tucker 2005); validation of sediment transport models; development of sediment TMDL's for fine bed sediments; localization of sediment sources; and assessment of stormwater impacts.

Independent Performance Testing on a small (2-foot wide) Streamside Collector has been completed by the Hydraulics Laboratory at the Engineering Research Center of Colorado State University. A variety of substrate compositions, depths, and water velocities was utilized, and efficiency of bed sediment capture by the Collector ran as high as 99%. The final report from this study will be available in the near future at www.streamsidesystems.com. Additional independent assessment studies are underway by North Carolina State University.

References

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Koski, K.V. and Herricks, E.E. 2004. Evaluation of a Method for Removing Iron Floc to Restore Anadromous Fish Habitat in Duck Creek, Alaska. National Fish and Wildlife Foundation Project - Final Report, Project No 1999-0239-000.

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