Proceedings of the 12th Annual North American Lake Management Society Southeastern Lakes Management

Conference Theme:
Integrating Science and Technology Into Successful Lake Management

Hosted by the

Florida Lake Management Society

June 2-5, 2003

Orlando-Kissimmee Hyatt
Orlando, Florida

Harvey H. Harper and Sharon H. Darling, Editors

12th Annual North American Lake Management Society Southeast Lakes Conference

Program & Proceedings

Hyatt Orlando-Kissimmee
Orlando, Florida
June 2 – 5, 2003

Hosted by the Florida Lake Management Society

Welcome to the 12th Annual Southeast Lakes Conference of the North American Lake Management Society

June 2 – 5, 2003

Hyatt Orlando-Kissimmee, Orlando, Florida

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Requests for additional copies of this program and information about the society may be sent to the following address: Florida Lake Management Society, Attn: Lucee Price, P.O. Box 950701, Lake Mary, Florida 32795-0701 or online at http://www.nalms.org/flms/publications.html.

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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.

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

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 know activist on behalf of Lake Okeechobee and a member of the steering committee that founded the FLMS at the time of his death

The Aquatic Resource Management Award - is given to a professional who has worked to restore, protect and/or advance our understanding of Florida's aquatic resources.

The Marjory 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.

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.

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.

The FLMS Board of Directors solicits nominations for awards to be presented by the Society at the 2003 annual meeting. In your nomination, please include the name of the award; your name, address, telephone number, and email address; the name of your nominee; and the justification for your nomination. Submit nominations to FLMS, P.O. Box 950701, Lake Mary, Florida 32795-0701

Exhibitors

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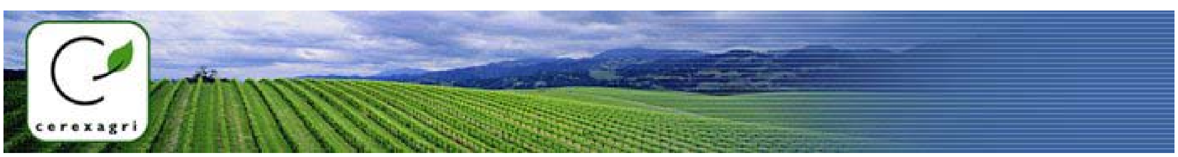

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The **Florida Center for Community Design and Research** is a Type II State University System (SUS) research center located in the School of Architecture and Community Design (SACD) at the University of South Florida (USF). The mission of the Florida Center is to assist the citizens of Florida in the creation of more livable and sustainable communities.
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Florida Center for Community Design and Research
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Dir. of Environmental Services & Products
3325 Bayshore Blvd F-25, Tampa, Florida 33629
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tbryan@genchemcorp.com

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Stevens Water Monitoring Systems, Inc. is a manufacture and marketer of integrated hydrological, meteorological and oceanographic monitoring instrumentation, accessories and information systems that help optimize water resource management and enhance forecasting. Stevens first understands the customers' objectives and then provides an applicable system that consists of electronic sensors, data logging and process control instruments, communication equipment and necessary software for data presentation to help the customer understand environmental conditions and efficiently execute decisions.

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12th ANNUAL SOUTHEASTERN
LAKES MANAGEMENT CONFERENCE

Conference Theme:
Integrating Science and Technology
Into Successful Lake Management

Orlando-Kissimmee Hyatt Hotel; Orlando, FL
June 2-5, 2003

FINAL PROGRAM

MONDAY - JUNE 2, 2003

7:00 am-7:00 pm	Exhibitor Set-Up *(Location: Florida Hall – West)*
8:00 am-5:00 pm	Check-In and Registration *(Location: Florida Hall – Foyer)*
8:30-12:00 noon	**Workshop 1A:** Lake and Pond Watershed Management, Part 1: Developing a Lake and Pond Watershed Management Plan (Coordinator: Dr. Harvey H. Harper, P.E.) *(Location: Paradise Room D)*
8:30-12:00 noon	**Workshop 2A:** Lake and Pond Restoration, Part 1 (Coordinators: Julia Palaschak and Jim Griffin) *(Location: Paradise Room E)*
8:30-12:00 noon	**Workshop 3:** Biological Monitoring - Aquatic Plant Identification (Coordinator: Kathy Burks) *(Location: Paradise Room F)*
10:00-10:30 am	MORNING REFRESHMENT BREAK *(Location: Garden Foyer)*
12:00-1:30 pm	LUNCH (on your own) OR YSI Lunch Demonstration (Pre-registration needed) *(Location: Pelican Room D)*
1:30-5:00 pm	**Workshop 1B:** Lake and Pond Watershed Management, Part 2: Developing and Implementing Best Management Practices (Coordinator: Dr. Harvey H. Harper, P.E.) *(Location: Paradise Room D)*
1:30-5:00 pm	**Workshop 2B:** Lake and Pond Restoration, Part 2 (Coordinator: Julia Palaschak) *(Location: Paradise Room E)*
1:30-5:00 pm	**Workshop 4:** Cyanobacteria (Blue-Green Algae) Identification (Coordinator: Andrew Chapman) *(Location: Paradise Room F)*
3:00-3:30 pm	AFTERNOON REFRESHMENT BREAK *(Location: Garden Foyer)*
8:00 pm-Midnight	**HOSPITALITY SUITE** (Sponsored by Eureka Environmental)

TUESDAY MORNING - JUNE 3, 2003

8:00 am-4:00 pm	Check-In and Registration *(Florida Hall – Foyer)*
8:45-9:30 am	Opening Remarks: *(Paradise Room 2)* — Rick Baird – FLMS President; Jeff Schloss – NALMS President
	Plenary Speaker – Dr. Dan Canfield, Jr. **"When Science is Not Enough: Challenges for the 21st Century"**
9:30-10:00 am	MORNING BREAK *(Exhibit Hall, Florida Hall - West)*

Session 1A: Aeration/Mixing Studies *(Location: Paradise Rooms D & E)*
Moderator: Clell Ford

10:05-10:30 am	**Richard B. Russell Oxygen Diffuser System Replacement** - Mark H. Mobley, J. Stephens Adams, John Hains, and James Sykes
10:30-10:55 am	**Stratification Intensity Increases as Latitude Decreases** - Robert W. Kortmann
10:55-11:20 am	**Layer Aeration: An 18-Year Review of Principles and Practice** - Robert W. Kortmann
11:20-11:45 am	**Explaining Improved Water Quality in Lake Apopka, FL: Reduced Phosphorus Loading vs. Wind Velocity** - Erich Marzolf

Session 1B: Wetland Issues *(Location: Paradise Room 3)*
Moderator: Mike Coveney

10:05-10:30 am	**An Evaluation of Techniques for Rejuvenating the Nutrient Removal Capacity of Treatment Wetland Communities** - Terence Auter, Thomas A. DeBusk, Forrest E. Dierberg, and Mark Sees
10:30-10:55 am	**Orlando Easterly Wetlands Reclamation Project: Operational Techniques used to Maintain Phosphorus Removal Performance** - Mark D. Sees, John White, and Thomas A. DeBusk
10:55-11:20	**Importance of Floodplain Wetlands to Restoration of the Kissimmee River Fishery** - Lawrence Glenn
11:20-11:45 am	**Establishment of a Wetlands Mitigation Bank in the Sand Hill Lakes Region of Northwest Florida** - Robert F. Lide

11:45 am-1:15 pm	LUNCH *(provided in Florida Hall - West)*

TUESDAY AFTERNOON - JUNE 3, 2003

Session 2A: Restoration Issues and Studies *(Location: Paradise Rooms D & E)*
Moderator: David L. Evans

1:15-1:40 pm	**Restoration of the Upper Saddle Creek Watershed** - Walter R. Reigner and Cornelius Winkler and William H. "Bud" Cates
1:40-2:05 pm	**Lake Persimmon Restoration: Progress But Not Completion** - Clell Ford and Jennifer Brunty
2:05-2:30 pm	**Restoring the Kissimmee River: Early Ecological Responses** - Brad Jones
2:30-2:55 pm	**Restoring Lake Okeechobee's Torry, Kreamer, and Ritta Islands: A Multi-Entity, Multi-Dimensional Approach** - Kim M. O'Dell, Bruce Sharfstein, Steve Gornak, and Ken Robinson

Session 2B: Sediment Removal and Reduction *(Location: Paradise Room 3)*
Moderator: Shailesh K. Patel

1:15-1:40 pm	**Field and Laboratory Assessments for Sediment Reduction and Nutrient Control in Restoring Mullet Lake (Central Florida)** - Forrest E. Dierberg, Janelle Potts, and Tom Workman
1:40-2:05 pm	**The Use of Portable Dams to Restore and Enhance Aquatic Habitat in Lake Seminole, Pinellas County, Florida** - Kelli Hammer Levy, Edwin Roman, Jeff Willitizer, Tom Champeau, and Jim Griffin
2:05-2:30 pm	**The Effects of Hydraulic Dredging on Water Quality in a Hypereutrophic Urban Lake in Central Florida** - Gene Medley
2:30-2:55 pm	**The Florida Department of Environmental Protection Perspective on Maintenance vs. Restoration Dredging** - Shailesh K. Patel and Tamy Dabu

2:55-3:15 pm	AFTERNOON BREAK *(Exhibit Hall, Florida Hall - West)*

Session 3A: Biological Issues *(Location: Paradise Rooms D & E)*
Moderator: Rick Baird

3:15-3:40 pm	**Blue-Green Algae, Toxins, and the Silver Bullet: PAK™27 Algaecide** - James Morgan
3:40-4:05 pm	**A Survey of Benthic Communities in Orange County Lakes** - Marcia Anderson and Julie Bortles
4:05-4:30 pm	***Daphnia lumholtzi* - Will It Be An Environmental Menace?** - John A. Osborne
4:30-4:55 pm	**Use of Geographic Information Systems to Determine Best Potential Littoral Zone Habitat Development - Lake Griffin, Florida** - Christine Schluter and Walt Godwin

TUESDAY AFTERNOON - JUNE 3, 2003 (Continued)

Session 3B: Public Outreach and Partnering *(Location: Paradise Room 3)*
Moderator: Mike Perry

3:15-3:40 pm **Can Ecotourism Development in Florida Help Save Our Precious Water Resources: Perspectives of Tourism Professionals and Government Decision Makers** - Taylor V. Stein, Julie K. Clark, and Jason L. Rickards

3:40-4:05 pm **Public Outreach - What They Know , What They Don't Know, and How to Tell Them** - Jennifer Brunty

4:05-4:30 pm **Lake County: An Integrated Approach to Stormwater Management** - John Kiefer, Tim Kelly, Walt Reigner, and David Hansen

4:30-4:55 pm **Fishing for Success** - Stephen Caton, Daniel E. Canfield, Jr., Chuck E. Cichra, and Sharon Fitz-Coy

5:00-7:00 pm **EXHIBITOR'S SOCIAL / POSTER SESSION** *(Exhibit Hall, Fla. Hall-West)*

Poster Session:

1. **Is Your Lake Ecosystem in ... JEOPARDY? -** Robert W. Kortmann and C.D. Mayne

2. **Manipulation of Fish Stocks for Lake Restoration** – Walt Godwin and Christine Schluter

3. **Pesticide Residue Issues in Floodplains, Wetland Restoration, and Surface Runoff Management** - William A. Tucker, Ann B. Shortelle, and Eric Arenberg

4. **In-lake Methods You Haven't Heard About** – Robert W. Kortmann

5. **Arsenic Levels in Native Florida Soils and Alum Residual Used in Wetland Restoration Projects** – Elizabeth Mace, Vickie Hoge, Erich Marzolf, and Sandra Fox

7:00-8:00 pm **FLMS Chapter Meeting** *(Paradise Room D)*

8:00 pm-Midnight **HOSPITALITY SUITE** (Sponsored by ERD)

WEDNESDAY MORNING - JUNE 4, 2003

8:00 am-3:00 pm	Check-In and Registration *(Florida Hall – Foyer)*
8:00-9:00 am	Continental Breakfast *(Florida Hall – West)*

Session 4A: Use of Alum for Water Quality Improvement *(Location: Paradise Rooms D & E)*
Moderator: Jim Griffin

9:00-9:25 am	**Alum Chemistry, Storage, and Handling in Lake Treatment Applications** - Christopher B. Lind
9:25-9:50 am	**The Use of Liquid Alum and Alum Residual for Nutrient Control Within Wetland Restoration Projects** - Victoria R. Hoge
9:50-10:15 am	**Lake Seminole Watershed Stormwater Pollution Removal Employing Alum: We Need All the Tools in the Toolbox** -Jim Griffin

Session 4B: Aquatic Vegetation *(Location: Paradise Room 3)*
Moderator: Keshav Setaram

9:00-9:25 am	**Spatial Analysis of Submerged Aquatic Vegetation Bed Structure in the Lower St. Johns River, Florida: Water Quality Effects** - Dean Dobberfuhl and Nadine Trahan
9:25-9:50 am	**A Comparison of Three Different Methods to Collect Submerged Aquatic Vegetation (SAV) Biomass in a Shallow Lake** - Andrew J. Rodusky, Bruce Sharfstein, Therese L. East, Ryan P. Maki, and Wilfredo A. Matamoros
9:50-10:15 am	**The Effects of Shading on *Chara zeylanica* Klein *ex.* Wild. and Its Epiphytes** - H.J. Grimshaw, K. Havens, B. Sharfstein, T. East, and A. Rodusky

10:15-10:45 am	MORNING BREAK *(Exhibit Hall, Florida Hall - West)*

Session 5A: Chemical and Biological Impacts of Alum Use *(Location: Paradise Rooms D & E)*
Moderator: Jim Griffin

10:45-11:10 am	**Phosphorus Inactivation and Interception in Animal Waste Lagoons and Growing Facilities** - Christopher B. Lind
11:10-11:35 am	**A Preliminary Biological Assessment of Soils Treated with Alum Residual in the Lake Apopka North Shore Restoration Area** - David L. Evans and Roxanne Conrow
11:35-12:00 noon	**Chemical and Ecological Impacts of Alum Coagulation** - Harvey H. Harper

Session 5B: Fisheries and Wildlife - Part 1 *(Location: Paradise Room 3)*
Moderator: Michael Hill

10:45-11:10 am	**Relationships Between Electrofishing Catch Rates and Harvestable Sportfish Population Densities in Florida Lakes** - Mark W. Rogers, Micheal S. Allen, Daniel E. Canfield, Jr., and Mark V. Hoyer
11:10-11:35 am	**Effects of Hydrological Variables on Year-Class Strength of Sportfish in Eight Florida Waterbodies** - Timothy F. Bonvechio and Micheal S. Allen
11:35-12:00 noon	**Assessment of Fish Kill Complaints in Pinellas County Lakes and Ponds** - Scott M. Deitche and Donald Hicks

12:00-1:30 pm	BANQUET LUNCH / PROGRAM *(Florida Hall – West)*

WEDNESDAY AFTERNOON - JUNE 4, 2003

Session 6A: Fisheries and Wildlife - Part 2 *(Location: Paradise Room 3)*
Moderator: Chuck Hanlon

1:30-1:55 pm	**Vegetative Characteristics of Three Low-Lying Coastal Rivers in Relationship to Flow, Light, Salinity, and Nutrients** – Sky Notestein, Mark V. Hoyer, and Tom Frasier
1:55-2:20 pm	**Bird Density and Species Richness on Five Florida Coastal Rivers with Comparison to Florida Freshwater Lakes** – Mark V. Hoyer, Sky Notestein, Tom Frasier, and Daniel Canfield, Jr.
2:20-2:45 pm	**Managing Fisheries with Size Limits: Conditions for Success** - Michael S. Allen
2:45-3:10 pm	**Factors Related to Occurrence and Abundance of Gizzard Shad, Threadfin Shad, and Black Crappie in Florida Lakes** - Michael S. Allen, Mark V. Hoyer, and Daniel E. Canfield, Jr.

Session 6B: Sediment and Erosion Control - Part 1 *(Location: Paradise Rooms D & E)*
Moderator: Patricia Hardy

1:30-3:10 pm **Overview of Sediment and Erosion Control Practices**

This session will present highlights from the Florida Stormwater, Erosion, and Sedimentation Control Inspector's Certification Program. Participants will have the opportunity to obtain a basic foundation of knowledge regarding processes and principles of erosion and sedimentation including a basic understanding of soils, definitions and purposes of stormwater management systems, proper use of specific BMPs for effective erosion and sediment control during construction, proper use of vegetation for erosion control, and defining the elements of and preparing an erosion and sediment control plan.

3:10-3:30 pm AFTERNOON BREAK *(Exhibit Hall, Florida Hall – West)*

Session 7A: Ocklawaha Basin Restoration Issues *(Location: Paradise Room 3)*
Moderator: Larry Battoe

3:30-3:55 pm	**The Impact of Gizzard Shad Removal on Phosphorus Recycling in Lake Griffin, Florida, USA** - Lawrence E. Battoe, Edgar F. Lowe, Walter Godwin, and Michael F. Coveney
3:55-4:20 pm	**River Floodplain Restoration in the Upper Ocklawaha River Basin** - Rolland S. Fulton
4:20-4:55 pm	**Restoration of Lake Apopka's North Shore - Pesticides and Progress** - Roxanne Conrow, Michael Coveney, Ed Lowe, Erich Marzolf, and James Peterson

Session 7B: Sediment and Erosion Control - Part 2 *(Location: Paradise Rooms D & E)*
Moderator: Patricia Hardy

3:30-4:55 pm	**Overview of Sediment and Erosion Control Practices (continued)**

5:30-6:30 pm	**POOLSIDE HOSPITALITY** *(Pool 2 – Hibiscus Court)*
8:00 pm-Midnight	**HOSPITALITY SUITE** (Sponsored by ERD)

THURSDAY MORNING - JUNE 5, 2003

8:00-8:45 am	Continental Breakfast (Florida Hall – West)

Session 8A: Lake Assessment and Water Quality Issues – Part 1 *(Location: Paradise Rooms D & E)*
Moderator: Don Hicks

8:20-8:45 am	**A Regional Lake Screening Procedure as a Guide for Implementing Pro-active Lake Management Strategies** - Keith Kolasa and Patricia Dooris
8:45-9:10 am	**Predicting the Frequencies of Algal Blooms in Florida Lakes** - Roger W. Bachmann, Mark V. Hoyer, and Daniel E. Canfield, Jr.
9:10-9:35 am	**Using Historic Bathymetry and Radiometrically Dated Cores to Estimate Lake-Wide Sedimentation** – Troy A. Keller and Maria Martinez
9:35-10:00 am	**Motorized Boating on Lakes: What Are the Environmental Impacts?** - Jeffrey Schloss

Session 8B: Lake Okeechobee *(Location: Paradise Room 3)*
Moderator: Bruce Sharfstein

8:20-8:45 am	**A Long-Term Periphyton Monitoring Program in Lake Okeechobee** - Andrew J. Rodusky
8:45-9:10 am	**Temporal Changes in Lake Okeechobee's Marsh Landscape - A Dynamic Marsh** - Mark Brady and Chuck Hanlon
9:10-9:35 am	**Recovery of Submerged Aquatic Vegetation from High Water Stress in Lake Okeechobee, Florida** - Bruce Sharfstein
9:35-10:00 am	**Factors Controlling Phytoplankton Dynamics in Lake Okeechobee, Florida** - B. Sharfstein, T.L. East, and R.P. Maki

10:00-10:20 am	MORNING BREAK *(Exhibit Hall, Florida Hall – West)*
10:30 am-12 noon	Exhibitor Break-Down *(Florida Hall – West)*

Session 9A: Lake Assessment and Water Quality Issues - Part 2 *(Location: Paradise Rooms D & E)*
Moderator: Jeff Schloss

10:20-10:45 am	**Lake Talquin and the Ochlockonee River: Interactions of an Impaired Alluvial Riverine System with Several Florida Lakes -** Sean E. McGlynn
10:45-11:10 am	**Landscape Variability of Total Phosphorus Concentration in the Kissimmee Upper Basin -** Nellie Morales
11:10-11:35 am	**What is Killing the "Waters of Death"? - An Update on Water Quality and Lake Management for Lake Istokpoga** – Clell Ford and Jennifer Brunty
11:35-12:00 noon	**Renovate – A New, Unique Selective Systemic Aquatic Herbicide** – Mark S. Mongin

Session 9B: South Florida Lakes *(Location: Paradise Room 3)*
Moderator: Carlos Fernandes

10:20-10:45 am	**Palm Beach County's Chain-of-Lakes: Past, Present, and Future – Part I** – Janet J. Phipps and Harvey H. Harper
10:45-11:10 am	**Palm Beach County's Chain-of-Lakes: Past, Present, and Future – Part II** – Harvey H. Harper and Janet J. Phipps
11:10-11:35 am	**Evaluation of Environmental Impacts on an Urban Lake in Central Florida** – Carlos A. Fernandes and Margaret S. Hopson-Fernandes
11:35-12:00 noon	**Disposal Alternative for Vegetative Materials Harvested from Lakes** – Martin Montalvo
12:00 noon	CONFERENCE ADJOURNED

1:00-5:00 pm **POST-CONFERENCE TOURS**

"Innovative Urban Stormwater Treatment Technologies"
(Sponsored by the City of Orlando)

or

"Lake Apopka North Shore Areas"
(Sponsored by the St. Johns River Water Management District")

SESSION 1A:

AERATION / MIXING STUDIES

RICHARD B. RUSSELL OXYGEN DIFFUSER SYSTEM REPLACEMENT

Mark H. Mobley, Mobley Engineering, Inc.; Norris, TN

J. Stephens Adams, Tennessee Valley Authority; Norris, TN

John Hains, USACE Trotter's Shoals Limnological Research Facility, USACE ERDC; Calhoun Falls, SC

James Sykes, USACE Richard B. Russell Operations; Elberton, GA

Since 1985, the Richard B Russell hydro project on the Savannah River near Calhoun Falls, South Carolina has used pure oxygen distributed in the reservoir to meet water quality requirements in the hydropower releases. The project uses up to $1M worth of oxygen each year to maintain dissolved oxygen levels. The original oxygen diffuser system included diffuser lines immediately upstream of the dam to operate with turbine use and 2,000 feet of diffuser approximately one mile upstream of the dam to operate continuously. All of these diffusers were originally equipped with ceramic diffuser heads that required chemical cleaning, and frequent maintenance. Over the years, the use of the diffusers immediately upstream of the dam was discontinued. About one half of the ceramic diffuser heads on the continuous diffuser were replaced with membrane diffusers to reduce clogging. Nevertheless, leaks and uneven oxygen distribution continued to be a problem.

In 2001, the original continuous diffuser was replaced with a porous hose line diffuser design that has ten lines, each 4,000 feet long extending along the old river channel upstream of the Richard B. Russell dam. The oxygen is distributed along the full length of each of these lines during operation, thus spreading the oxygen over a large area to achieve high oxygen transfer efficiencies to reduce oxygen expenditures. This presentation will provide a description of the oxygenation system, its design and installation and results of system operation.

Individual supply lines to each diffuser were installed in a ½ mile trench from the existing oxygen supply facility along a peninsula near the diffuser locations. The diffuser installation in the reservoir was conducted from the surface without divers. The diffusers were assembled from a temporarily closed boat ramp and floated into final position in the reservoir in sections. Floating over a mile of diffuser piping at a time across a popular reservoir required seven workboats, deep anchor points, long rope spans and a patrol boat to warn public boaters. The workboats and anchor points were used to maintain the diffuser location despite changing wind conditions. Once the diffuser was satisfactorily floating above the final location, a buoyancy pipe chamber was pumped full of water to sink the diffuser in a controlled manner to the bottom. This process can be reversed to retrieve the diffuser for maintenance or repositioning.

The diffuser installation was completed with some preliminary testing in September 2001. Results indicated some disparity in the individual diffuser line flows and difficulty in obtaining full system design flow during test conditions that included temporary piping and flow control.

During 2002, the existing liquid oxygen supply facility was modified to reliably achieve the maximum design flow capacity, a new oxygen flow control system was installed, and several diffuser lines were modified to provide better flow capacity. The WaterView® performance monitoring system was installed to monitor operation of the oxygen system, provide annunciation of system alarms, and provide remote control from the powerhouse of the valves that control individual line flows. Startup testing was completed in August 2002 including operation of the system at over 200 tons of oxygen per day. The oxygen system was operated successfully for the remainder of the 2002 season to maintain release DO levels.

The new diffuser system at Richard B Russell offers tremendous flexibility with individual control of each diffuser line, but this system places oxygen differently in the reservoir from what the operators are accustomed to and continued monitoring will be required to optimize the operation. Compared to the old continuous system, the line diffuser places oxygen much lower in the reservoir due to the low energy bubble plume and high oxygen transfer efficiency of its design. The oxygen input is also spread over almost a mile in the forebay instead of a single cross-section point. Thus, the operation characteristics of the new diffuser system will require new approaches to optimize the timing and rate of the oxygen placement to meet release DO requirements. The WaterView® performance monitoring system will provide valuable control and monitoring functions as the diffuser operations are adjusted to match turbine operation, total water flow and seasonal oxygen demands in the reservoir. Flexibility in oxygen placement, monitoring and control will be even more important in meeting the more complicated demands of maintaining downstream DO requirements with the re-initiation of pumped storage operations at Richard B Russell.

NOTES:

STRATIFICATION INTENSITY
INCREASES AS LATITUDE DECREASES

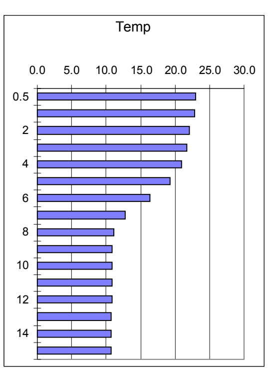
Robert W. Kortmann, Ph.D.
Ecosystem Consulting Service, Inc.
Coventry, CT

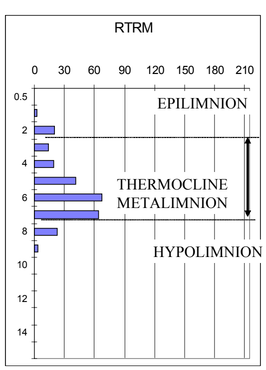
RTRM was first developed by Birge and Juday during the early 1900's. It was then "reintroduced" by Jack Valentyne. In the third issue of *LakeLine* (way back in the days when G.D. Cooke and Tom Gordon were NALMS' President and President-elect, respectively), RTRM was introduced to the applied "lake management community". Still, after nearly 100 years, most lake managers still diagnose stratification solely by observing temperature. Temperature alone can be very misleading when it comes to thermal structure (which is perhaps the most critical physical attribute of a lake ecosystem).

Density change as a function of temperature is non-linear. The further temperature deviates (in either direction) from 4^o C, the larger the density difference per degree. The difference in density between 29^o and 30^o C is forty times that of water between 4^o and 5^o. Use of RTRM at lakes across the globe has resulted in some interesting, and surprising, conclusions:

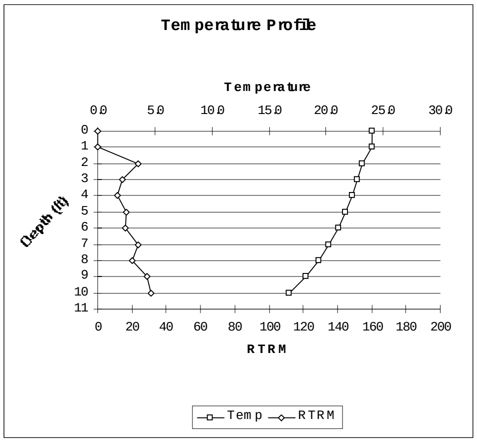
- Thermal stratification intensity and stability tends to increase as latitude decreases (warm monomictic lakes exhibit stronger stratification than the "typical" temperate dimictic lake portrayed in many textbooks).
- RTRM is additive, the depth interval is unimportant (1 m, 1 ft, 2 m, etc.)
- Ice floats. (No surprise there, but consider what the world might be like if the solid state of water behaved like almost every other substance on Earth, and *sank*.)
- Tropical lakes often exhibit multiple stratification seasons; stratification becomes unstable during the peak of summer (equinox) because of evaporative cooling.
- Shallow lakes often exhibit frequent stratification episodes, or even diurnal stratification periodicity, despite only several ^{o}C differential. Sometimes these cycles overwhelm the expected "light-dark" dissolved oxygen relationship to photosynthetic oxidation of water (to O_2), with anoxia developing in the *afternoon* instead of during the early morning hours. That can set up a "daily pump" for internal nutrient loading, shifts in respiration pathways, etc.

Several Examples of RTRM:

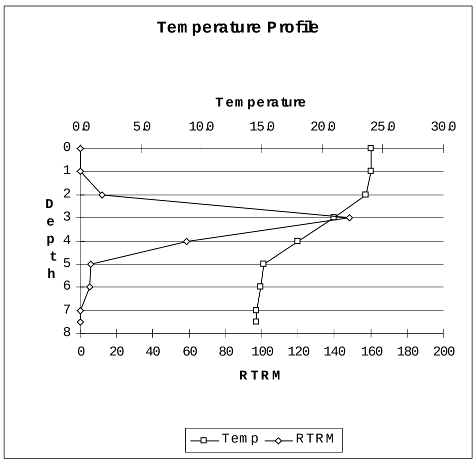




RTRM>20 generally identifies the upper and lower metalimnion boundaries. RTRM maximum identifies position and strength of the thermocline. However, you will rarely find this "classic example" in nature!

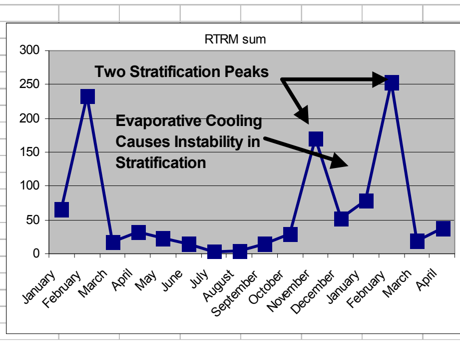


Stratification is *not* a function of depth. Stratification is a function of density change due to temperature differences. If the density gradients are strong enough to resist the mixing action of wind the water body will stratify (whether it is 20 meters deep or 20 inches!). To the left is a profile from a 10 ft deep lake. Total RTRM was 186 units. That's 186 RTRM units in 3 m of water – as much stratification as found in some deep dimictic lakes. Actually, this lake exhibits a metalimnion that extends from near the surface to the bottom (not at all unusual for soft-water humic stained lakes).



This is a supply reservoir near the North Carolina border. It is usually (most years) monomictic. Only during very occasional winters does the entire waterbody lose enough heat to reach 4°C, allowing for the possibility for ice formation. Note how intense the stratification structure is in relatively shallow water. These data were collected while the "hypolimnion" was being aerated (to prevent iron problems in water treatment). Before the waters below 4 m received hypolimnetic aeration (that's right below 13 ft in this lake) the metalimnion extended from 2 m to the bottom. *There was no hypolimnion* (although all waters deeper than 3 m became anoxic.

	RTRM sum
January	65
February	233
March	17
April	32
May	23
June	15
July	3
August	5
September	15
October	29
November	171
December	53
January	79
February	253
March	19
April	38



In several reservoirs lying on the Tropic of Capricorn, two primary stratification seasons were observed (along with two anoxia and P-release seasons). In December, when the sun is directly overhead, evaporative cooling causes instability in stratification. In warm lakes it takes very little temperature decrease to cause a large density change.

The point is that examining temperature profiles is a poor way to diagnose stratification structure and function. RTRM is simple to use and yields more useful information. A procedural handout, and Excel^{tm} program for its computation, are provided.

NOTES:

LAYER AERATION: AN 18-YEAR REVIEW OF PRINCIPLES AND PRACTICE

Robert W. Kortmann, Ph.D.
Ecosystem Consulting Service, Inc.
Coventry, CT

Layer aeration is a depth-discrete artificial circulation technique. The method "redistributes" water temperature (heat) and oxygen at middle depths of the water column. A "layer" is created which is bounded above and below by thermoclines. Layer aeration has been used to reduce epilimnetic nutrient loading from the hypolimnion, to restore cool water habitat suitable for cold water fisheries and as zooplankton refuge, and for managing water supply sources.

Lake Shenipsit covers 212 ha (523 acres) to mean and maximum depths of 9.9 m (32 ft) and 20.7 m (68 ft), respectively. Lake Shenipsit exhibits a limited littoral zone where rooted aquatic vegetation can establish. Only 8% of lake area is less than two meters deep. The volume:sediment contact area ratio between 6 and 12 meters is disproportionately large (metalimnetic depth range). During the early 1980s, Lake Shenipsit regularly exhibited bluegreen algae blooms including *Anabaena sp.* and *Aphanizomenon sp.* which resulted in taste and odor episodes, increased disinfectant demand (and DBPs), and shortened GAC substrate longevity. Layer Aeration was developed to manage aerobic respiration capacity of a lake or reservoir, and related water quality relationships. Layer Aeration uses biological oxygen sources in addition to compressed air gas phase transfer.

Aeration Process. The layer aeration depth range was selected based on iterative computer simulation modeling of heat and available dissolved oxygen mass, volume-sediment contact area ratios, thermal resistance to mixing as a function of temperature, and supply intake depth ranges. The following were the main objectives and design criteria:

1. Facilitate selection of the supply intake depth to avoid buoyancy controlled Cyanobacteria.
2. Use of neutrally buoyant aerator return flow.
3. Use of photosynthetic oxygen production and downward diffusional transport as oxygen sources.
4. Maintenance of cold layer temperatures and strong thermal resistance to mixing at the top and bottom of the layer.
5. Hypolimnetic aerators were installed to divert excess airflow (when not needed in the layer) to the now smaller hypolimnion for "anaerobic aeration" (operating the bottom in the nitrogen cycle to prevent P release, despite anoxia).
6. Layer temperature and oxygen criteria were established in relation to brown trout and *Daphnia sp.* habitat suitability requirements.

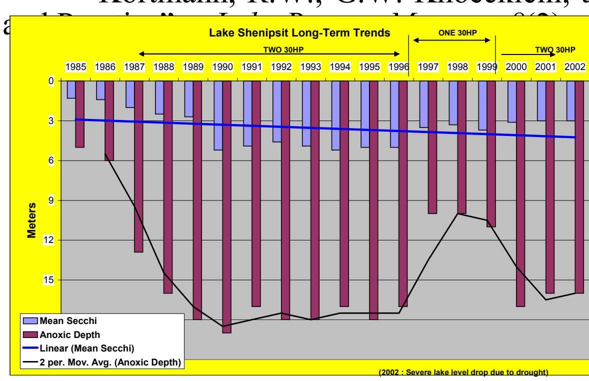
Physical Response. Layer aeration at Lake Shenipsit resulted in immediate deepening of the aerobic-anaerobic interface. That descent of anoxia exposed a disproportionately large sediment area to oxygen for a longer duration. The anoxic factor (Nurnberg, 1987) decreased from 40 before layer aeration, to less than 8 during the first years of layer aeration. Anoxia never ascended above the lower metalimnetic boundary (RTRM20) during aeration. Anoxia, light penetration, and compensation depth continued to deepen during subsequent years. Since 1990, Lake Shenipsit has exhibited a minimum of 2.5 x 10^6 m^3 (2000 acre-ft) of water which meets brown trout habitat criteria (Raleigh et al., 1986), and an additional 1.6 x 10^6 m^3 (1300 acre-ft) of metalimnetic water immediately below it which exceeds 1.5 mg/*l* DO. Large-bodied (>0.8 mm) *Daphnia sp.* became the dominant zooplankton species in 1990, and has persisted since. Hence, improved metalimnetic habitat (refugia) and the zooplankton community shift to *Daphnia sp.* contributed to the abrupt transparency increase in 1990. A strong thermocline persisted above the design layer (RTRMmax = 150 at 4 m), while a second functional thermocline developed below the aerated layer (RTRM = 31 at 10 m). Layer aeration has not weakened thermal stratification, but has focused resistance to mixing immediately above and below the aerated layer. Spring total phosphorous concentration decreased by about 25%. Summer TP revealed similar, or greater decreases. A sharp decrease in NH_4-N concentrations occurred following layer aeration, presumably due to enhanced nitrification and subsequent denitrification.

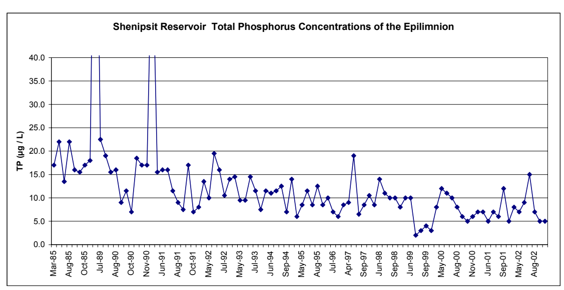
Biological Response. An immediate decrease in summer Cyanobacteria abundance was observed. Blooms of buoyant Cyanobacteria (*Anabaena sp., Aphanizomenon sp.*), decreased from > 17,000 cells/ml pre-aeration to < 500 cells/ml following two layer aeration seasons. Numbers of zooplankton increased following layer aeration. In 1989-1990 Cladocera comprised 60% of the zooplankton community (animals/liter^{-1}).

Water Supply. Significant decreases in the iron content, turbidity, and color of withdrawn raw water were observed at the treatment plant. Surface intake turbidity declined sharply. Pre-chlorination was eliminated, which is particularly advantageous prior to GAC filtration due to selective adsorption-desorption of chlorinated organics by GAC media, and potential disinfection byproduct and taste-odor effects (Voudrias et al., 1986). GAC media has recently been changed every 18-24 months, doubling its longevity.

<u>Reference</u>

Kortmann, R.W.; G.W. Knoecklein; and C.H. Bonnell. (1994). "Aeration of Stratified Lakes: Theory a[illegible] 99-120.





EXPLAINING IMPROVED WATER QUALITY IN LAKE APOPKA, FL: REDUCED PHOSPHORUS LOADING VS. WIND VELOCITY

Erich R. Marzolf
St. Johns River Water Management District; Palatka, FL

Lake Apopka is a shallow, 125 km^2, hypereutrophic lake northwest of Orlando Florida. The St. Johns River Water Management District (SJRWMD) in partnership with governmental entities developed and began implementing a multi-part restoration and management plan for Lake Apopka that includes external phosphorus (P) load reduction. The resulting improvements in water quality (~30%) since 1995 and reappearance of native submersed vegetation have been attributed to the plan's implementation (SJRWMD) or, alternatively, to a decline in wind velocity measured at Orlando, 32 km away (Bachmann et al. 2000). This wind hypothesis suggested that improvements resulted from reduced sediment resuspension following reduced wind stress.

A recent prolonged, record drought has provided an opportunity to examine the influence of water depth and wind stress on water quality within this large shallow lake. Regression analyses of water depth against both total suspended solids (TSS) and TP indicated no significant relationships. In contrast and as an indication of evaporative concentration, the chloride level was significantly ($p<0.0001$) negatively correlated with water elevation which explained approximately 60% of the variation in Cl. Regression analyses of wind velocity vs. various water quality measures, blocked by both water level and the time periods before and after water quality improvements, have provided several insights into the role of wind in affecting water quality. The strongest relationships between wind and water quality were found between mean daily wind velocity, not maximum daily velocity. The strongest relationship was found for wind and water quality measurements made on the same day. There was a significant correlation between wind velocity and TSS over all time periods; however, the relationship explained only 9% of the variation in TSS. When the two time periods were analyzed separately, the pre-water quality improvement period had both a steeper regression slope and larger R^2 than the post-improvement period. An analysis of co-variance indicated that the two slopes were significantly different from one another. During the drought of the post-improvement period, the slope of the relationships between wind and TSS increased as the lake became shallower. However, the variance explained was always less than 14% of the amount explained during the pre-improvement period. A similar pattern was observed for the response of TP to wind velocity during the various time and water level periods.

Thus, even during the drought when low lake levels might make the lake most vulnerable to the effects of wind, the actual effect was less than the pre-improvement period. The difference between time periods suggests that the role of wind in driving internal loading has declined as external P loading has declined. The ability to detect a drop in internal loading provides an indication that the lag between reduced external and internal P loading is on the order of a few years. The overall weak and declining effect of wind on water quality suggests that wind resuspension will not prevent the restoration of the lake. The lake has responded positively to partial implementation of plans to reduce external nutrient loading. Continued improvement is anticipated as additional components of the restoration plan are implemented. The results are consistent with multiple stable states theory for shallow lakes and indicate Lake Apopka is highly sensitive to phosphorus load reduction, a necessary first step toward restoration.

Reference

Bachmann, R.W.; M.V. Hoyer; and D.E. Canfield, Jr. 2000. “The Potential for Wave Disturbance in Shallow Florida Lakes. *Lake and Reservoir Management 16*(4):281-291.

NOTES:

SESSION 1B:

WETLAND ISSUES

AN EVALUATION OF TECHNIQUES FOR REJUVENATING THE NUTRIENT REMOVAL CAPACITY OF TREATMENT WETLAND COMMUNITIES

Terrence Auter, Thomas A. DeBusk, and Forrest E. Dierberg
DB Environmental, Inc.; Rockledge, FL

Mark Sees
City of Orlando; Christmas, FL

The Orlando Easterly Wetland (OEW) is a 486-hectare treatment wetland in Orange County, Florida, that has provided effective polishing of domestic wastewater effluent for over 15 years. Sediments gradually have accumulated at the wetland inflow region over time, resulting in a decrease in the available water column depth and a decline in the phosphorus (P) assimilation capacity. In this study, we used *in situ* enclosures (1.1 m^2) to test various sediment and vegetation management techniques (muck [sediment] removal; sediment chemical amendments; vegetation burning; vegetation tilling) for enhancing the P removal effectiveness of the inflow region communities.

A marked initial release of soluble reactive P (SRP) and total P (TP) occurred within the enclosures in which vegetation was either burned or tilled. These P concentrations decreased to background levels after one month. The enclosures treated with liquid alum, a solid alum residual, or vegetation burning mobilized more ammonium (NH_4^+) and total Kjeldahl nitrogen (TKN) during the first month than the control (untreated) enclosures. After 8 weeks with twice-monthly exchanges of water in each enclosure with ambient site water, SRP, TP, NH_4^+, and nitrite+nitrate (NO_x) concentrations in all treatments were at or below the levels within the control enclosures. TKN concentrations were higher in the tilled and alum residual amended treatments than the control enclosures over the same period.

Based on the first 4 months of field sampling, the three most effective techniques for rejuvenating the wetland P removal capabilities were muck removal and surficial application of either liquid alum or alum residual. Time-weighted water column TP concentrations in these respective treatments were 51, 52 and 64 µg/L, while the control enclosures exhibited TP concentrations of 106 µg/L. Average SRP concentrations for muck removal, liquid alum, alum residual and control treatments were 19, 14, 18 and 57 µg/L, respectively.

Based on these short-term findings, application of the alum compounds appears to be the most cost-effective sediment management technique for restoring wetland P removal effectiveness. While muck removal is a more expensive rejuvenation technique, it may provide additional benefits by improving system hydraulics. These data demonstrate that various cost-effective management options are available to restore the nutrient removal capacity of “aging” treatment wetland communities.

NOTES:

ORLANDO EASTERLY WETLANDS RECLAMATION PROJECT: OPERATIONAL TECHNIQUES USED TO MAINTAIN PHOSPHORUS REMOVAL PERFORMANCE

Mark D. Sees, City of Orlando; Christmas, FL

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After 15 years of effectively removing nutrients from reclaimed water, the 486 hectare Orlando Easterly Wetlands (OEW) system has shown signs of reduced performance. A principal reason for the reduced nutrient removal performance has been the deposition of organic rich sediments in the treatment cells, which has been responsible for considerable hydraulic short-circuiting, particularly near the inflow region of the wetland. In an effort to mitigate this short-circuiting and lower phosphorus (P) concentrations in the water column, the City of Orlando has explored two full-scale management options in several of the wetland cells. The first is periodic burning of emergent vegetation, and the second is physical removal of the accumulated sediments.

The OEW system receives tertiary-treated wastewater effluent from the City of Orlando Iron Bridge treatment facility. The wetland serves to further polish the effluent, primarily through nitrogen and P removal, and also serves as a wetland park, providing wildlife habitat and recreational activities (e.g., bird-watching, hiking) for the public. The OEW is comprised of multiple cells, or compartments, situated along three different flow paths. This multi-cell, multi-path configuration has enabled us to take selected cells off-line for management purposes, while still maintaining wetland operations.

For several years, we have utilized controlled fires in wetland cells to reduce standing dead biomass before deposition on the soil surface as detritus. We have evaluated the success of burning in several 12 hectare wetland cells, containing either cattails (*Typha* spp.) or giant bulrush *(Scirpus californicus*). Burns performed in the fall season effectively reduce the biomass of standing dead material, and the emergent plant foliage exhibits rapid re-growth. Our water quality measurements demonstrate that prescribed burning, however, results in an initial release of both soluble reactive P (SRP) and total P for several weeks followed the burn. Water is held in the wetland cell during this period to reduce impacts to downstream water quality. Following this initial P release, the burned area appears to exhibit a greater uptake of P vs. the control cell for several months following the fire. This enhanced P removal is thought to be due to uptake by the re-growing cattail vegetation, as well as by the biological activity of submerged plants (i.e., algae, submerged macrophytes) in the water column, which are now exposed to greater light levels than prior to the burn.

As a longer-term sediment management approach, we recently removed recently accreted high P organic sediments from five of the treatment cells in the inflow region of the wetland. To date, we have removed 260,000 cubic meters of sediment and organic debris from 46 hectares of wetlands. Sediment removal restored the wetland's water storage capacity and has allowed us to correct hydraulic short-circuits which have developed in some of the cells over time. Small-scale experiments also demonstrate that sediment removal rejuvenates the P removal capacity of the system and prevents the re-release of sediment P back into the water column. We will monitor the effectiveness of our sediment removal efforts on P removal at an operational-scale during the coming years.

NOTES:

IMPORTANCE OF FLOODPLAIN WETLANDS TO RESTORATION OF THE KISSIMMEE RIVER FISHERY

Lawrence Glenn
South Florida Water Management District
West Palm Beach, FL

The Kissimmee River restoration project is world's largest river restoration initiative (Melvin 2001). Approximately 104 km^2 of river/floodplain ecosystem is to be restored by the continuous backfilling of over 35 km of flood control canal (C-38) and reestablishment of historic hydrologic patterns, including a predictable seasonal flood pulse. During periods of high discharge and out of bank flow, approximately 11,000 ha of floodplain wetlands will potentially be inundated. A comprehensive restoration evaluation program has been established to quantify physical, chemical, and biological changes associated with ecosystem restoration, provide data for adaptive management of the restored system, and determine restoration success. Fish were identified as a critical component of the evaluation program because they are excellent indicators of ecosystem health or integrity (Karr 1981). In this presentation, changes in floodplain fish assemblage structure subsequent to channelization are used to identify loss of natural system functions and to illustrate the importance of floodplain wetlands to restoration of the Kissimmee River fishery.

Fish assemblages of three existing floodplain habitats were studied prior to restoration construction. Broadleaf marsh was sampled because it was the dominant habitat on the floodplain of the historic system and historic (reference) data were available for comparison. Pasture and woody shrub habitats were sampled because they are prevalent in the channelized system and are expected to revert to broadleaf marsh following restoration. Study sites for each habitat type were established in control (not affected by restoration) and impact areas (affected by restoration) within the river-floodplain system. Floodplain fishes were sampled monthly between August 1996 and January 1999 with a 1 m^3 aluminum throw trap (Kushlan 1981). Throw trap sampling provides accurate estimates of density, size structure, and relative abundance of fish populations within heavily vegetated habitats (Jordan et al. 1997). Ten replicates were collected from randomly selected locations within each habitat on each sampling date.

Metrics used to evaluate floodplain fish assemblages were chosen based on their sensitivity to natural system functions and their ability to illustrate disturbance related change. These metrics included species richness, species composition, relative abundance, diversity, and density. Metrics were compared among treatments (control vs. impact) for each habitats type and relative to pre-channelization conditions.

Ten species were collected within channelized floodplain habitats, indicating a 42% decrease in species richness (n = 24) from pre-channelized conditions. The relative abundance of fishes within the channelized floodplain is dominated by small-bodied fishes (i.e., Poeciliids and Elassomatids), which are indicative of shallow, densely vegetated habitats. A single large-bodied centrarchid was collected. Historically, 38% of the floodplain fish fauna were juvenile centrarchids, indicating the importance of historic floodplain wetlands as nursery areas. Diversity was low in all floodplain habitats (range: 0.06 – 0.77). Density of fishes was greatest in woody shrub and lowest in pasture (range: 0.22 – 5.35 m^2).

Re-establishment of historic hydrologic characteristics will be the system function driving restoration of floodplain fish assemblages. Increases in floodplain use will result from reproduction and population expansion by resident fishes, lateral migrations of small and large-bodied riverine fishes during periods of overbank flow (flood pulse), and from increased areal coverage of both temporary and permanently inundated floodplain habitat. Concurrent increases in primary and secondary production within floodplain habitats will provide the necessary food base to support increased fish populations and densities. Post-construction fish communities are expected to comprise approximately 50% small-bodied species (i.e., atherinids, small-bodied centrarchids, cyprinids, cyprinidontids, elassomatids, fundulids, percids, and poeciliids), 30% young-of-the-year or juvenile centrarchids, and >2% juvenile esocids, ictalurids, catostomids. Mean annual density of floodplain fishes is expected to be greater than 18 fish/m^2.

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NOTES:

ESTABLISHMENT OF A WETLANDS MITIGATION BANK IN THE SAND HILL LAKES REGION OF NORTHWEST FLORIDA

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The Northwest Florida Water Management District (NWFWMD) is establishing a wetlands mitigation bank in the Florida Panhandle north of Panama City that will be known as the Sand Hill Lakes Mitigation Bank. This presentation describes current and historic conditions of the proposed bank, planned mitigation activities, and the anticipated use of mitigation credits generated by the bank.

A wetlands mitigation bank generates "credits," as determined by an appropriate wetlands functional assessment method, by preserving high quality wetlands and enhancing or restoring degraded wetlands. Once released by permitting authorities, these credits may then be used to offset impacts caused by projects requiring compensatory mitigation. Advantages of mitigation banking over other forms of mitigation include ensured success in that credits are created in advance of project impacts, elimination of temporal loss of wetland functions, and economy of scale by grouping smaller mitigation needs together at one location and creating a larger, more sustainable mitigation site. Mitigation banks are particularly well-suited to addressing impacts associated with linear projects such as road construction.

The proposed Bank is in Washington County in the Sand Hill Lakes karst region straddling the boundary between the Choctawhatchee and St. Andrew Bay watersheds. This area is characterized by thick surficial sands, rolling hills, and numerous sinkholes and solution ponds with associated wetlands. The historic longleaf pine / wiregrass community, once dominant in the region, has been largely extirpated, being replaced with slash and sand pine plantation and secondary-growth scrub oak community. Undeveloped lakes with associated emergent and fringe wetlands are increasingly uncommon. Rapid development, associated with proximity to a burgeoning Panama City, is accelerating habitat loss and degradation of wetlands. In October, 2002 the NWFWMD purchased 2,155.3 acres, including ~1,000 wetland acres, to establish the Bank.

Wetlands at the proposed Sand Hill Lakes Mitigation Bank include ~420 acres of almost-pure stands of high-quality cypress swamp, ~130 acres of bayhead community, ~280 acres of solution lakes and sinkholes with associated emergent wetlands, and ~180 acres of degraded seepage slope and hydric pine flatwood. Disturbances to wetlands include exclusion of fire from hydric pine flatwoods, siltation from an extensive network of dirt roads, and alteration of hydrologic regime from extensive ditching, dams and redirection of natural flow paths. Upland buffers are xeric sand hills that, formerly covered by longleaf pine / wiregrass habitat, now host sand and slash pine plantation and scrub oak communities. The earliest ditching was associated with a small grain mill that operated from 1873 until the 1940s. Further ditching and alteration of natural flows occurred in the 1950s when the site was converted to a fish camp.

Preliminary assessments using the Wetland Rapid Assessment Method (WRAP) indicate that 300+ mitigation credits will be generated by the Bank. Credits will be created by preservation and ecological management of ~830 acres of high-quality wetlands coupled with enhancement and restoration of ~180 acres of degraded wetlands. Restoration activities will include introduction of prescribed fire, stabilization of eroding areas, removal of fill and sediment plumes from wetlands, and reestablishment of natural flow paths. Upland buffer activities will include restoration of longleaf pine / wiregrass community and closure of selected dirt roads. Projects requiring compensatory mitigation that occur within the mitigation service area (MSA), anticipated to cover approximately 2,000 square miles within portions of the Choctawhatchee and St. Andrew Bay watersheds, may, as authorized by permitting agencies, use available credits from the Bank.

When permitted, the Sand Hill Lakes Mitigation Bank will be one of two wetlands mitigation banks operating in the Florida Panhandle. The initial use of the Bank will be to provide compensation for wetland impacts caused by Florida Department of Transportation (FDOT) road projects. As appropriate, wetland credits may also be made available to other public and/or private entities requiring mitigation. Establishing the Bank will preserve and restore wetlands in a rapidly developing area and provide compensatory wetlands mitigation for FDOT and other entities.

NOTES:

SESSION 2A:

RESTORATION ISSUES AND STUDIES

RESTORATION OF THE UPPER SADDLE CREEK WATERSHED

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William H. "Bud" Cates
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The Upper Saddle Creek is part of a larger project planning area that encompasses the entire Upper Peace River watershed. It is the sub-basin most affected by phosphate mining in the watershed, lying between the Green Swamp Area of Critical State Concern (north of Interstate Highway 4) and the remaining bottomland forest along Saddle Creek. This bottomland forest currently represents northernmost extent of the Peace River habitat system that reaches southward to Charlotte Harbor and formerly extended through the planning area into Green Swamp. The core project area known as the Tenoroc Fish Management Area (TFMA) is a 6,430-acre parcel owned by the State of Florida, and operated by the Florida Fish and Wildlife Conservation Commission (FFWCC).

During the 1980's, numerous reclamation projects were completed on a program by program basis within the mined areas of the TFMA and several of the adjoining properties in the Upper Saddle Creek watershed. Since that time, several large-scale residential/commercial developments have been planned for these formerly mined areas. Construction of the Polk Parkway and proximity to the fast-developing Orlando/Disney World area has accelerated development opportunities within this area. Coordinating this development has and will continue to provide an opportunity to restore the areas ecologic and hydrologic function.

Significant efforts by the agencies resulted in developing a Memorandum of Understanding (MOU) that was signed on November 28, 1995. The MOU was agreed to by the U.S. Army Corps of Engineers, FDEP, FDOT, FGFWFC (later renamed the FFWCC) and the Southwest Florida Water Management District (SWFWMD). The MOU created a framework to facilitate restoration of ecological and hydrological function in the Upper Saddle Creek watershed. This restoration project is funded primarily by two sources: the Nonmandatory Land Reclamation (NLR) Trust Fund and FDOT's wetland mitigation funding for the Polk County Parkway. The total funding for nonmandatory reclamation is $4,593,896. The FDOT contributed $3,500,000 for wetland and surface water impacts resulting from construction of the Polk Parkway in the Peace River and Green Swamp watersheds. In addition, impacts to wetlands and surface waters in the Alafia River basin resulted in an additional contribution of $1,800,000, and $105,420; bringing the total FDOT contribution to $5,494,308.

The goals and objectives of the Upper Saddle Creek watershed restoration project were developed and refined through a succession of meetings, interviews and document review. Participants include the USACOE, FDEP, FFWCC, and SWFWMD, Upper Peace River Ecosystem Planning Committee (UPREPC), Polk County, FDOT, FIPR, and USF. Other actively interested parties include several adjoining property owners, and representatives of community environmental organizations such as the local chapter of the Sierra Club, and the Lake Region Audubon Society.

Numerous reclamation, mitigation and restoration goals have been developed by the various participating agencies, environmental organizations and private landowners that have an interest in the Upper Saddle Creek Restoration Project. Some of these goals include: Creation/restoration of wetland impacts in the Peace River basin, reclamation of five non-mandatory program areas, improve quantity and quality of flow to Saddle Creek, reduce flooding in Saddle Creek, restore the ecological connection between the Peace River and the Green Swamp, enhance regional opportunities for various outdoor recreation and educational activities, demonstrate successful wetland restoration on reclaimed clay settling areas, and showcase a new paradigm of cooperation between federal, state, regional, and local government agencies using public funds to achieve regional watershed restoration.

During a series of meetings and discussions conducted in 2002, the Project Team developed a set of four restoration alternatives, each of which were designed to achieve the project goals and objectives. Each of the alternatives was designed in sufficient detail to allow the project team to quantify such key factors as surface water routing and wetland acreage to be created. A series of specific evaluation criteria were developed to determine which alternative best meets the project goals. The evaluation criteria are as follows:

1. Provide for the replacement of required wetland acreages

2. Constructible within the allotted budget with funding allocated in a manner such that expenditures outside the non-mandatory reclamation area program boundaries do not exceed FDOT's funding limit

3. Provide wetland treatment of off-site inflows prior to their introduction into the Tenoroc FMA lakes and for provide wetland treatment prior to discharge to Saddle Creek

4. Increase base flow to Saddle Creek without increasing large event peak flows

5. Maximize the number of Tenoroc lakes that are configured as flow-through systems

6. Restore the ecological/hydrological connections provided by the historical headwater system of Saddle Creek

7. Preserve the existing desirable habitat as practical

Based on these factors, the project team recommended Alternative 2 as the preferred restoration alternative. Plans are now underway to complete the design and permitting of the preferred restoration alternative in a phased basin by basin approach.

NOTES:

LAKE PERSIMMON RESTORATION: PROGRESS BUT NOT COMPLETION

Clell Ford, *Jennifer Brunty*
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Sebring, FL

Lake Persimmon, a 13.4 ha Transition Region (Griffin et al. 1997) lake located approximately 5 miles north of Lake Placid in Highlands County, has been investigated for several years regarding persistently poor water quality. As part of the Lake Persimmon Water Quality Improvement Project, cooperatively funded by the Southwest Florida Water Management District (SWFWMD) and the Highlands County Board of County Commissioners, surface water, groundwater and seepage monitoring is being conducted. Lake Persimmon has previously been extensively investigated by SWFWMD, Highlands County and the University of Florida. Water quality in Lake Persimmon routinely scored FTSI values in the 80s. This was attributed to continuous algae blooms (primarily *Lyngbia*), persistent anoxic conditions, median Secchi transparency values of 0.3m., ammonia levels in deep waters that climbed as high as 4 mg/L, and canal nitrate levels ranging from 2 to 18 mg/L, earning SWFWMD's worst ranking of all Highlands County lakes.

Poor water quality conditions began to appear in the 1970s, and were persistent by the 1980s. A paleolimnology study conducted by the University of Florida (Whitmore and Brenner 1999) indicated that the lake tropic state has not changed since development, but recorded a distinct change in the $\delta^{15}N$ of organic matter in the sediments, from an average of less than +4 per mil in sediment sections dated prior to 1967, to +8.62 per mil in sediment deposited over the last 10 years. This indicates that the source of nitrogen to the lake has changed to one that includes possible organic human waste. Analysis of a series of historic aerial photographs, maintained by the Highlands County Natural Resources Department, shows that this time period corresponds with residential and agricultural development in the lake (87 ha) watershed.

This is corroborated by a change in the source of nitrogen to the lake beginning when development was completed around the lake. This $\delta^{15}N$ change , which show co since , is manifested by continuous algae blooms (primarily *Lyngbia*), persistent anoxic conditions, high ammonia-nitrogen values in bottom waters (median 1,028 μg/L) and high nitrate + nitrite – nitrogen values in canal bottom waters (median 11,900 μg/L).

In an on-going effort to improve water quality in Lake Persimmon, a whole-lake aeration system was installed in the fall of 2002. The immediate result of this aeration system on deep portions of the lake (> 2 m) was an increase in dissolved oxygen (to 7 mg/L) and a drop in ammonia nitrogen (to 708 μg/L); no appreciable change was seen in total nutrients, water transparency, chlorophyll-a levels or major ion chemistry. Water clarity did not improve until January 2003, when the Secchi transparencies increased to 1.2 m, likely due to cold temperatures (surface waters 15.3˚C) and continuous aeration. The root nutrient problem in lake Persimmon has not been corrected, though seepage is thought to be the culprit. Investigation to pursue further remediation continues. Meanwhile, residents are happier with water quality in Lake Persimmon than they have been in many years.

NOTES:

RESTORING THE KISSIMMEE RIVER: EARLY ECOLOGICAL RESPONSES

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Channelization and regulation of the Kissimmee River destroyed wetland habitat, disrupted the natural hydrologic regime, produced hypoxic conditions in the river channel, and facilitated higher phosphorus loading to Lake Okeechobee. Excavation of the central drainage canal (C-38) destroyed portions of the natural river channel and isolated remnants, which became non-flowing pools. Aquatic vegetation formerly confined to the edge of the channel expanded in width, and coverage of floating and mat-forming species increased. Extensive beds of floating exotic species often spanned these channels completely, requiring herbicide applications to maintain navigation. Accumulation of organic material over the river's natural sandy substrate altered the community structure of benthic invertebrates, which became dominated by species characteristic of lentic environments and low oxygen levels. Hypoxia was common due to oxygen demand and lack of reaeration and mixing. Channelization and maintenance of stable water levels resulted in the loss of about 14,000 ha of broadleaf marsh, wet prairie, and wetland shrub, and altered hydrologic characteristics of the remaining wetlands. Much of these wetlands was covered with dredged spoil or converted to pasture. Fish and avian populations were impacted by elimination of the seasonal flood pulse, which linked the river channel with the floodplain and maintained a mosaic of wetland habitats.

The goal of restoration is to establish an ecosystem capable of supporting a balanced, integrated, and adaptive community of organisms with species composition, diversity and functional organization comparable to natural habitat of the region. Restoring the river's ecological integrity depends primarily on establishing former flow, inundation, and geomorphic characteristics of the river and floodplain. This requires maintaining continuous, seasonally fluctuating discharges from the river's headwater, degrading spoil areas and backfilling 36 km of canal, removing two water control structures, reconnecting remnant river runs and creating 15 km of new river channel to replace portions destroyed by canal dredging, and filling lateral ditches. Once the hydrologic and geomorphic characteristics of the system are restored, the various components of the former ecosystem are expected to recover without the need for extensive maintenance or manipulations of the system. Coverage of wetland vegetation is expected to increase from 33% to 77% of the restored floodplain area. Restoration is also expected to reestablish the former aquatic invertebrate community, provide spawning, nursery, and foraging grounds for fish species, and create larger habitat for 24 species of amphibians and reptiles.

The first phase of restoration began in June 1999 and was completed in February 2001. This phase backfilled 11 km of canal and reconnected 22 km of river channel. Although the desired hydrologic regime has not been achieved yet due to land acquisition and canal improvements still required around the headwater lakes, an interim stage-discharge schedule has been established that has succeeded in providing continuous flow to the channel and intermittent inundation of the floodplain. Continuous flow within the intended velocity range has resulted in the positive response of several ecosystem components being evaluated as indicators of restoration success. Diversion of flow to remnant runs has flushed organic deposits, exposed sand substrate, widened channels, reduced vegetation coverage, increased the presence of stream-dwelling invertebrates, and raised dissolved oxygen concentrations to > 3 ppm. Nine species of shorebirds, absent before restoration, now forage on newly formed sandbars. Expectations associated with floodplain restoration have not progressed as far, due to only intermittent flooding. Nevertheless, large areas of wetlands have become established and the floodplain is being used extensively by wading birds and waterfowl.

The restoration project also will benefit efforts to control the eutrophication of Lake Okeechobee. The Kissimmee River is the lake's largest inflow and contributes about 30% of phosphorus entering the lake. Restoration of sloughs and marshes along the river is expected to increase retention of P inputs from upland watersheds and headwater inflow. Filling of lateral ditches and removal of cattle from the floodplain also will help to lower P loads from tributaries. Phosphorus loads leaving the restored area are expected to decline by as much as 60 percent.

Two years after completion of the first restoration phase, total phosphorus (TP) concentrations at the downstream end of the restored area are still near the baseline average of 50 ppb. Lower concentrations (~20 ppb) are not expected until natural floodplain hydroperiod and wetland vegetation become better established. This expectation also depends on the assumption that future TP concentrations at the headwater will not rise above the historic (1974-1995) average of 43 ppb. Increased loading from higher P concentrations in the late 1990s prompted concern that urban development south of Orlando might be accelerating eutrophication of the Kissimmee Chain of Lakes, which drain to the river through Lake Kissimmee. But evidence from water quality monitoring reveals that these higher concentrations originated at the south end of Lake Kissimmee rather than from general lake enrichment. Possible sources of additional phosphorus may have included local tributary inputs of phosphorus near the lake’s outlet, release and resuspension of benthic P following artificial drawdown and hydrilla control, or disturbance from channel dredging and removal of muck and tussocks. The most recent data show that concentrations at the lake's outlet have declined, but occasional spikes in TP continue to point toward nearby influences.

NOTES:

RESTORING LAKE OKEECHOBEE'S TORRY, KREAMER, AND RITTA ISLANDS: A MULTI-ENTITY, MULTI-DIMENSIONAL APPROACH

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Steve Gornak
Florida Freshwater Fish and Wildlife Conservation Commission; Okeechobee, FL

Ken Robinson
City of Belle Glade; Belle Glade, FL

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 Okeechobee gourd is a vine that was once commonly found in the extensive pond apple forest surrounding Lake Okeechobee in Palm Beach County, and in the Everglades, but was almost completely destroyed as early as 1930 (USFWS, 1999). It was present on Ritta, Torry and Kreamer islands, but the conversion of local swamps and marshes to agricultural practices resulted in the decline in these annual high-climbing gourd plants. The plant is now on the Florida and Federal endangered species lists.

The 1993 Lake Okeechobee Surface Water Improvement and Management (SWIM) Plan Update, the Restoration, Coordination, and Verification (RECOVER) component of the Comprehensive Everglades Restoration Plan (CERP), and the U.S. Fish and Wildlife Service's (USFWS), South Florida Multi-Species Recovery Plan have all identified one or more of these islands as potential restoration locations with specific goals of reestablishing natural hydrologic connections between the islands' wetland habitats and the lake. In the case of Torry and Kreamer islands, goals include 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 (FFWCC) and the South Florida Water Management District (SFWMD) are undertaking a habitat enhancement project on the three islands, the objectives of which are the removal of those remaining man-made features that impede the natural hydrology, and the removal of exotic vegetation, particularly from levees and berms. Concomitant with these efforts, the City of Belle Glade, with support from the SFWMD, is in the process of planting a 100 acre pond apple forest on Torry Island. Planting of other native species is also occurring.

The objectives of this project are four-fold:

(1) Remove some of the man-made features existing on Torry, Kreamer and Ritta islands (levees, ditches, control structures), that impede the natural hydrology. The levees will be degraded to the level of normal topography at lake bottom. The adjacent ditches will be backfilled with this material.

(2) Remove exotic plants, particularly from levees and berms on these islands.

(3) Plant an approximate 100 acre pond apple forest on Torry Island, as well as planting other native species to establish a typical array of native wetland vegetation.

(4) Protect higher elevation sites on the islands for continued proliferation of the Okeechobee gourd.

The Torry and Kreamer Island components of this project have strong potential to interface with an environmental education center that is being developed by the City of Belle Glade with support from the SFWMD, the FFWCC, Florida Department of Environmental Protection (FDEP), the Marshall Foundation and a number of other government and non-government agencies. The nature center encompasses a man-made lake, the surrounding wetlands on Torry Island, and a series of existing levees that will serve as walkways around the interior and exterior of the wetlands. Extensions to the existing walkways around the man-made lake are proposed, as well as observation towers, and biking, canoeing and hiking trails. Currently, the City of Belle Glade is in the process of physically removing exotics adjacent to, and along the walkways, in an effort to provide both access and a clear view of the wetlands of Torry Island. Herbicide application to kill exotic plants on both Torry and Kreamer may be initiated by the FDEP, with the City providing subsequent annual treatments. There will be several hiking trails and a multi-use trail, leading from the nature center to various parts of Torry Island.

NOTES:

SESSION 2B:

SEDIMENT REMOVAL AND REDUCTION

FIELD AND LABORATORY ASSESSMENTS FOR SEDIMENT REDUCTION AND NUTRIENT CONTROL IN RESTORING MULLET LAKE (CENTRAL FLORIDA)

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DB Environmental; Rockledge, FL

Tom Workman
St. Johns River Water Management District; Palatka, FL

Mullet Lake, a shallow (<2.0 m), 60-acre lake in central Florida, is targeted for restoration as part of a mitigation plan. Baseline data collected on the surface water and sediment indicate that this lake is eutrophic to hypereutrophic (chlorophyll *a* = 31-85 μg/L) and contains flocculent, unconsolidated sediments that are > 0.7 m thick over most of the lake bottom. The surficial sediments contain high total and exchangeable nitrogen (total = 1.57-2.02%; exchangeable = 67.5-227 μg N/g) and phosphorus concentrations (total = 1490-2000 μg P/g; exchangeable = 1.79-26.0 μg P/g), and an elevated oxygen demand (0.386-0.516 mg/g/h), indicating a significant potential for internal loading to the overlying shallow water from the frequently resuspended sediments. Because nonpoint source pollution from the watershed has been eliminated, the primary focus of Mullet Lake restoration is on the removal or reduction of lake sediments without incurring significant nutrient or oxygen demand releases to downstream waters.

We performed a laboratory study to examine the effects that sediment dry-out and reflooding would have on nutrient release and oxygen demand under oxic and anoxic incubation conditions. Sediments were composited from four stations in Mullet Lake, and air-dried in the lab to attain moisture losses of 29-34% and 62-65%. After drying, filtered Mullet Lake water was used to re-flood the sediments. A 10-day incubation was performed in the dark and at room temperature (21-23 ºC). Subsamples from the overlying water in the treatment and control vessels were collected 0, 1, 3, 5, 7 and 10 days after initiation of the incubation, and analyzed for soluble reactive phosphorus (SRP), ammonium, nitrite + nitrate, and pH. Water samples for biochemical oxygen demand (BOD), total Kjeldahl nitrogen, dissolved iron, and total phosphorus were analyzed at the beginning and end of the incubation.

Reflooding of upper layer (0 – 10 cm) sediments that had been dried to obtain moisture losses between 29 and 65% yielded negligible SRP releases under both oxic and anoxic conditions. By contrast, we observed significant releases from bottom (30-40 cm) sediments, especially under anoxic conditions. This SRP release was accompanied by dissolved iron concentrations that were 218±118 μg/L, compared to dissolved iron levels of only 15±0μg/L and 35±22 μg/L for the oxic-treated bottom sediment and the anoxic-treated upper sediment, respectively. Sediment desiccation followed by reflooding resulted in a marked increase in aqueous ammonium concentrations under oxic and anoxic conditions, whereas nitrite plus nitrate concentrations decreased relative to the water-only control. Soluble BOD decreased during both oxic and anoxic incubations relative to the initial values, with a greater BOD decrease observed under oxic conditions. These findings indicate that certain sediment reduction and removal techniques (e.g., drawdown and excavation; dredging) are likely to release nutrients either within the water column of Mullet Lake or at the sediment disposal site.

NOTES:

THE USE OF PORTABLE DAMS TO RESTORE AND ENHANCE AQUATIC HABITAT IN LAKE SEMINOLE, PINELLAS COUNTY, FLORIDA

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Lake Seminole, located in west central Pinellas County, Florida, was created in the late 1940s by the impoundment of an arm of Long Bayou, an estuarine embayment of Boca Ciega Bay. The fixed weir that segregated the lake from the tidal influences of the bay reduced flushing and kept water levels relatively stable. As a result of over fifty years of stabilized water levels, nuisance plants and associated muck deposits formed on the littoral shelf areas reducing beneficial habitat and degrading water quality. According to the Lake Seminole Watershed Management Plan (2001), approximately 130,000 yd^3 of organic peat sediments are located along the periphery of the lake. These sediments will need to be excavated to create beneficial fisheries habitat, improve shoreline recreational uses and improve aesthetics. Due to the highly urbanized watershed surrounding the lake, an alternative to lake drawdown is necessary to accomplish this component of the lake restoration.

The aquatic habitat enhancement project utilized water-filled bladder dams to isolate nearly 17 acres of cattail and willow tussocks. The project site was divided into two work areas, a northern segment encompassing approximately 9.9 acres and a southern segment that measured about 7 acres. The lake was lowered from 4.5 ft NGVD to 3.5 ft. NGVD to accommodate the height of the dams. The dams were then floated into place and filled with lake water until a tight seal was made with the lake bottom. Once erected around the project area, water was pumped from the work site into the lake. The sediments were allowed to dry for several days before windrowing with conventional earth-moving equipment (bulldozers). Approximately 31,000 yd^3 of muck sediments and tussock material were removed from the two work sites during this project at a cost of \$13.00/yd^3. The total cost of the project was \$403,770. The Southwest Florida Water Management District contributed \$200,000 in a cost share agreement with the Aquatic Resources Enhancement Section of the Florida Fish and Wildlife Conservation Commission to complete the project. One year later, natural recruitment is evident. Pickerel Weed (*Pontederia cordata*), Bulrush (*Scirpus sp.)*, Pondweed (*Potamogeton sp.)* and Eelgrass (*Vallisneria Americana*) are prominent in the restored area with plans to plant knotgrass (*Paspalum sp.)* in Spring 2003. The use of portable dams to isolate Lake Seminole shorelines for restoration was a highly successful management tool and will likely be used again to continue improving and enhancing lake conditions.

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NOTES:

THE EFFECTS OF HYDRAULIC DREDGING ON WATER QUALITY IN A HYPEREUTROPHIC URBAN LAKE IN CENTRAL FLORIDA

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In 1997, the City of Lakeland began a four year sediment removal project on Lake Hollingsworth in Lakeland, Florida. A hydraulic dredge was used to remove approximately 3 million cubic yards of sediments before dredging was suspended due to a drought and related low water levels in the lake. The lake contained an estimated 4.0 million cubic yards of organic sediments.

Lake Hollingsworth is a 364-acre urban lake located in the phosphorus rich Bone Valley Member of the Peace River Formation geographic region (White, 1970). Lakes in this region have been identified as having the highest phosphorus concentrations in the state of Florida (Griffin, et al., 1997). A paleolimnological investigation of core samples taken from the lake inferred that the lake had phosphorus concentrations sufficient for supporting eutrophic conditions prior to any anthropogenic disturbances in the watershed (Schelske, Brenner and Whitmore, 1994)

Lake Hollingsworth is a shallow, solution basin that contained extensive deposits of organic sediments. Prior to dredging, mean water depth was 4 feet, and maximum depth was 6 feet. Organic sediments covered approximately 75% of the bottom. The mean and maximum depths of organic sediments were 6.3 feet and 25 feet, respectively. Following the dredging, the mean water depth of the lake has increased to 7 feet with a maximum depth of 22 feet.

A diagnostic study of the lake was published in 1994 (City of Lakeland, 1994). An associated one-year monthly sampling program was conducted in 1991-1992 to evaluate existing conditions. Water quality in the lake was characterized as poor. Lake trophic indicators were among the highest reported for lakes in Florida. Mean concentrations of total nitrogen, total phosphorus and chlorophyll were 5.21 mg/L, 221 ug/L, and 205 ug/L, respectively. A mean trophic state index of 95 was reported for the one year sampling period. Secchi transparency ranged from 0.1 to 0.4 meters throughout the sampling period. The lake was phytoplankton dominated (Cyanophyta > 95% by volume) with less than 3% of the lake covered by macrophytes. In addition to the problems associated with nutrient over enrichment, coliform bacteria and lead concentrations routinely exceeded state water quality standards.

One year prior to the commencement of dredging, a monthly water quality monitoring program was initiated. In addition, monthly phytoplankton and quarterly benthic macroinvertebrate samples were collected.

Following the suspension of dredging in March 2000 and the return of normal water levels in June 2002, statistically significant changes in several water quality measures have been observed. Reductions in nitrogen and chlorophyll concentrations have resulted in a reduction in the trophic state index and an increase water clarity. Pre and post dredging water quality data is presented in Table 1.

Table 1. Lake Hollingsworth pre vs. post dredging water quality

	Pre Dredging (1990 – 1996)**	Post Dredging (2002-2003)**
Trophic State Index*	86	69
Chlorophyll a (ug/L)*	162	34
Total Phosphorus (ug/L)	246	253
Total Nitrogen (mg/L)*	4.48	1.83
Secchi Transparency (M)*	0.27	0.65

* Statistically significant difference between means
** Data calculated from quarterly means of all stations

As noted above, the dredging operation was suspended due to a record drought that exposed one-third of the lake bottom for eighteen months. The observed improvements in water quality may be associated with the removal of organic sediments, the two year period of low water, or some combination of these and other factors including stormwater treatment. The longevity of the improvements is uncertain, however, it should be noted that the changes are consistent with predictive results (for sediment removal) of eutrophication modeling preformed as part of the diagnostic study. Analysis of trends in phytoplankton and benthic macroinvertebrate community structure are currently underway, and monitoring of water quality and biota will continue into the future.

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NOTES:

SESSION 3A:

BIOLOGICAL ISSUES

BLUE-GREEN ALGAE, TOXINS, AND THE SILVER BULLET: PAK™27 ALGAECIDE

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The Ecology: Blue-green algae, more properly cyanobacteria, are prokaryotic, plant- like organisms that have been around for three to four billion years. Prokaryotes, like bacteria, do not possess a membrane-bound nuclei or specialized organelles and are incapable of sexual reproduction. However, like eukaryotes (true algae and vascular plants) they utilize chlorophyll *a* pigment and in the presence of sunlight convert inorganic carbon into organic compounds (their food) and simultaneously liberate oxygen. Cyanobacteria were perhaps the first oxygenators of the planet. Certainly they played a paramount role. We dislike cyanobacteria because: 1) They make our lakes look bad. "Pea soup" green cyanobacteria blooms are ugly. 2) They are a poor base for aquatic food chains. 3) They are relatively poor oxygenators. 4) Many species produce odorous metabolites that impart undesirable tastes and odors. 5) Many species produce toxic compounds.

The Bloom: Where do we find cyanobacteria? They are in our reservoirs, our lakes, and our ponds. It is well known that cyanobacteria dominate the phytoplankton communities when 1) there is a stable water column with residence time, 2) warm water temperatures (15-30^{o}C) are present, 3) high nutrient levels exist, especially when there is a low N:P ratio, 4) there is high light intensity. Cyanobacteria possess some unique physiological, morphological, and ecological adaptation that result in their population blooms when the conditions are favorable. Different species have developed special bloom strategies. Epilimnetic and metalimnetic bloom-forming species are largely successful by regulating buoyancy, moving vertically through the water column, providing access to maximum light, heat, and inorganic carbon. In sufficient concentration they then dominate the euphotic zone of eutrophic lakes. Surface blooms may be the result of mass recruitment of buoyant cells and/or colonies attracted to the upper most layer of the water column. It is widely accepted that while surface blooms are a natural occurrence, anthropogenic eutrophication is resulting in increased occurrence and severity, both in magnitude and duration, of these blooms.

The Toxins: The most noteworthy cyanobacteria toxins fall into one of two types – neurotoxins, affecting the nervous system, and hepatotoxins, affecting the liver and may be accumulative. Some cyanobacterial toxins are more benign causing respiratory discomfort and/or dermatological rashes. It is credibly accepted that all of the identified toxins, by looking at the chemical structures, are oxidizable. That is, they can chemically be broken down and presumably detoxified. The problem with saying this is that there are no efficacy studies to my knowledge to verify the oxidation and detoxification observation. Studies are forthcoming. However, it is my understanding that the toxin Microcystin LR is the only commercially certified toxin available for testing. It may be some time before we can prove the presumption.

PAK™27 Algaecide: The best way to minimize cyanobacteria, their blooms, and therefore the toxins is to use an algaecide as an algaestat and "prune the bloom." With early prevention one can limit the toxins, the odors, off-flavors and unacceptable surface appearance. PAK™27 is a granular addition compound of sodium carbonate (Na_2CO_3) and hydrogen peroxide (H_2O_2). This environmentally sound compound is not persistent and is nontoxic to the ecosystem. PAK™27 selectively removes cyanobacteria, leaving green algae, diatoms, and other desirable algal forms intact. It initially adds oxygen to the system and beneficial chlorophyll *a* oxygenators are retained in the water column providing oxygen to support fish and obligate aquatic organisms. The case study was done at the Bill Evers Reservoir, Bradenton, Florida. Bill Evers Reservoir, which is fed by the Braden River, has a surface area of 330 acres and a capacity of 1.5 billion gallons of water. The case study shows that as little as 6.5 pounds per acre-foot is effective as an algaestat for cyanobacteria species like *Anabaena* and *Planktothrix* (*Oscillatoria)*. The City of Bradenton has been successfully controlling cyanobacterial blooms with PAK™27 for the past five years. The "bloom" season can start as early as February and continue until late fall. PAK™27 is the ideal, environmentally sound, cost effective cyanobacteria algaecide. PAK™27 is 1) selective for cyanobacteria at recommended application rates, 2) nontoxic to the ecosystem, and 3) not bioaccumulative. PAK™27 is the Silver Bullet!

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NOTES:

A SURVEY OF BENTHIC COMMUNITIES IN ORANGE COUNTY LAKES

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Benthic macroinvertebrates are bottom dwelling organisms that are essential in aquatic food chains. They are excellent indicators of water quality because they have sensitive life stages that respond to environmental stress. Therefore, bioassessments, along with physical and chemical parameters, are extremely useful in determining any impairments on a system. Orange County EPD has been collecting macroinvertebrate data since the mid 1970's to the present. A qualitative comparison will be made between historical and current data on selected oligotrophic lakes. Metrics for analysis will include taxa richness, the Shannon-Weaver Diversity Index, the Hulbert Index, the Biotic Index, percentage of dominant species and functional feeding groups.

Methods for collecting and counting benthic macroinvertebrates have changed over the years. In the seventies, one grab was collected from the geographic middle of the lake. At the lab, the entire sample was picked through and all organisms were counted and recorded. The method today consists of collecting 12 dredge grabs for every 1000 acres of lake, in 2-4 m depths from the shoreline. In the lab a composite sample of the all the grabs is mixed in a pan. From this pan, 8 random sections are taken from 24 grids and placed in a second pan. From the second pan, one grid is picked over for organisms. This process is repeated until a minimum of at least 100 organisms are collected.

Human disturbance and other environmental stressors on a system can be measured by the changes in the macroinvertebrate metrics. The number of taxa, diversity index, Hulbert index, % suspension feeders, % shredders, ETO (Ephemeroptera, Trichoptera, Odonata) taxa and % pollution intolerant species will reduce in response to stress; while an increase in the % contribution of dominant taxa and % pollution tolerant taxa may be observed.

Four of the oligotrophic lakes selected in this survey were Lakes Butler, Down, Tibet-Butler and Waseon Bay. These lakes are part of an Outstanding Florida Waterbody (OFW) known as the Butler Chain, in which are lakes are connected by canals. These four lakes have seen shifts in their benthic communities over the past 20 years.

Lake Butler is a lake over 1000 acres and 24 grabs were taken. Butler has seen a large decrease in taxa, diversity index, and Hulbert index in just the past few years. Organisms with a Biotic index value of 5 have decreased from 66% to 12%. While organisms with a Biotic index value of 3 have increased from 22%-62%, and organisms with a Biotic index of 2, have increased from 11% -52%. The increase in the more tolerant organisms may be due to the change in methodology. Historically, it seems that collectors/gatherers have been the dominant functional feeding group, but in the second section of the lake, the percentage of shredders present are dominant functional feeding group instead.

Lake Down has seen a decrease over time in diversity, but recent results seem to show that it may be on the incline. The same pattern is seen with the Hulbert index as well. There has been an decrease in the BI=5 organisms (96% to 62%) and an increase in the BI=2 organisms (0-9%). Organisms with a Biotic index value of 3 have increased from 9% to 45%, and then has decreased to a current value of 28%.

Lake Tibet-Butler has had high values for diversity and the Hulbert index in the past, but began to sharply decline. In the year 2000, the Hulbert-Index has decrease by half its value in 1984 (14-7) and the diversity index has just started to increase. The dominant functional feeding group has shifted from predators to collectors/gatherers. The biotic index values for this lake have fluctuated over the years. The organisms with a BI = 5 have gone from 54% to 86% and then decreased to 55%. BI = 3 organisms have decreased from 33% to 7%, and then increased to 20%, while the BI = 2 organisms have decreased from 9.5% to 7%, and increased to 25%.

Waseon Bay is the only lake that has had a diversity index that seems to be increasing slightly over the years, despite its decline in water quality. However, the Hulbert Index has dropped significantly in the year 2000 and has started to recover. The dominant functional feeding group of collectors/gatherers has not changed, but the percentage of predators and shredders have decreased since 2000. Organisms with a biotic index of 5 have decreased over time from 72% to 58%, while the more intolerant species have seen a slight increase.

NOTES:

Daphnia lumholtzi – WILL IT BE AN ENVIRONMENTAL MENACE?

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Purpose, Scope and Objectives: Of the four species of *Daphnia* found in Florida, two are native (*Daphnia ambigua* and *D. laevis*) and two are exotic (*Daphnia magna* and *D. lumholtzi*). *Daphnia lumholtzi* is a native of Australia, Asia and Africa. G.O Sars first described it in 1885 from ephippi hatched from mud from Gracemere Lagoon, Australia (Sorensen and Sterner, 1992). *Daphnia lumholtzi* is a recent introduction into Florida, being first reported in Lake Parker, Polk County, in the early 1990's, about the same time that it was first discovered in several lakes in Missouri and Texas (Havel and Hebert, 1993; Sorensen and Sterner, 1992). It was found in July, 1993 in Lake Okeechobee by East, et al. (1998). Besides Florida, it has been reported in the states of Kansas, Missouri, Illinois, Kentucky, Ohio, Tennessee, North and South Carolina, Texas, Arkansas, Louisiana, Mississippi, and Alabama. The apparent mechanism for dispersion is by recreational boats and fishing boat live wells (Havel and Hebert, 1993) and by waterfowl (Proctor, 1964), flooding, and rivers (Stoeckel et al., 1996). In 1999, the author sampled three lakes in Polk County (Lakes Haines, Rochelle and Conine) to study *Daphnia lumholtzi* in the Central Florida environment. Additional, populations of *Daphnia ambigua* (Lake Claire) and *Daphnia laevis* (UCF experimental pond) were sampled simultaneously to make comparisons.

The purpose of this paper is to present the data on seasonal distribution and abundance of *Daphnia lumholtzi* in Central Florida and to discuss the potential spread of this species throughout the State. It is a concern of the author that this species may impact the bottom up ecological balance of the native fauna in Florida's freshwater lakes.

Methods: Vertical tow net hauls were taken with a #20 mesh nylon plankton net to sample *Daphnia* species in 1999-2003 from the study lakes located in Polk, Orange, Seminole and Brevard counties. *Daphnia spp*. were counted from within sample aliquots of 4 ml. that were obtained with a Hensen-Stempel automatic pipette after samples were adjusted to 100 ml. The strip-count method was achieved at magnifications of 100x and 200x using either a compound microscope or stereomicroscope. After enumeration, abundance was expressed as the number of individuals/liter.

Results and Discussion: The trend for seasonal abundance of *Daphnia ambigua* and *D. laevis* in the UCF campus lake and pond during 1999 followed the typical trend for most *Daphnia* species; that being, absent in autumn, then becoming present in early winter, increasing in abundance until mid-summer (June-July), the ungoing a population crash to disappear until early winter. This spring-summer high abundance with an late summer crash is not what has been reported for *D. lumholtzi*. In Missouri lakes, it was usually most abundant in late summer and autumn (Johnson and Havel, 2001). In Lake Springfield, Illinois, *D. lumholtzi* appeared in low numbers in June, with peak density two months after the peak density of native *Daphnia* sp. and when water temperatures were highest (Kolar, et al., 1997). East, et al., (1999) reported that

D. lumholtzi was more abundant in June-August and *D. ambigua* was more abundant in January-April, 1995, in Lake Okeechobee. In several Kissimmee lakes, north of Lake Okeechobee, *D. ambigua* was most abundant between December and April, while the peak for *D. lumholtzi* was in late spring, summer and autumn (Havens, et al., 2000). These results differ from what was observed by the author for the Polk County lakes, Lake Haines, Rochelle, and Conine. Trends for *D. lumholtzi* in those lakes were similar to that for *D. ambigua*, peaking in April and disappearing by May. Since the offset of the seasonal peaks for these two species has been given as a possible reason for non-competition , it would appear that in some lakes, such as those I studied, that direct competition may, indeed, be a major concern. It was interesting to note that in my study, no *D. ambigua* were found in lakes from which I collected *D. lumholtzi*.

Conclusions and Summary: *Daphnia lumholtzi* is a recent invader to Florida's freshwater lakes and rivers. It is rapidly being found in more and more Florida water bodies as it spreads out of the south-central area of the State. While some authors speculate that it is a potential environmental menace (Johnson and Havel, 2001), others suggest that it may actually be of benefit, by being utilized as an additional food source for late young-of-the-year fishes (Lemke, Stoeckel and Pegg, 2003). Only time will tell what the impact of this species will be on the aquatic ecology of the State of Florida and the Nation.

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USE OF GEOGRAPHIC INFORMATION SYSTEMS TO DETERMINE BEST POTENTIAL LITTORAL ZONE HABITAT DEVELOPMENT - LAKE GRIFFIN, FLORIDA

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Lake Griffin is one of the major lakes within the Harris Chain of Lakes system, covering nearly 9,800 Acres. Within the last 50 years farming and development surrounding the lake have caused significant degradation, until recent restorations efforts had taken place. The first stage in the restoration plan for Lake Griffin has been improving water quality and clarity. Measures taken to decrease external nutrient loading as well as internal nutrient re-suspension and cycling have resulted in dramatic improvements in both water quality and water clarity within the lake. This study involves exploring best options for the second phase of lake restoration which involves the redevelopment of potential littoral zone habitat.

A Geographic Information System (GIS) model was used to determine which areas of the lake could potentially support sufficient vegetation for fish habitat. There were three factors considered for the model. First the elevation at lake bottom must be shallow enough so that it could potentially receive sufficient ambient light to support vegetation. Secondly, the volume of soft organic sediment present within these areas was considered. Areas with little or no sediment present were given preference because this would minimize the amount of mechanical removal required. Finally, wave disturbance within these areas was considered, as it must be low enough to minimize re-suspension of sediment.

Existing bathymetric and sediment data sets (Danek, 1991) were used to create a three-dimensional model of the lake hard bottom. Licor data collected by the District was then used to determine how deep sufficient light would penetrate, assuming no sediment layer. The sediment layer was then added to the model to help narrow down areas by eliminating those where sediment was thickest. Areas with over three feet of sediment were eliminated. Finally, sediment re-suspension was considered. Wave disturbance data (Bachmann, 2000) was used to create a GIS layer, which could be overlain to show the percentage of time a particular area would be subject to re-suspension. Areas determined subject to re-suspension greater than 50% of the time were eliminated. The remaining areas were then classified, dependent on the amount of sediment present; areas with no sediment present were given the highest rating, “ideal”.

Lake Griffin’s internal structure is characterized by a flat, shallow interior basin with steep slopes around the near-shore areas of the lake. Areas classified to have potential littoral zone habitat were concentrated within narrow bands near the lake perimeter. The model estimated that 43 acres of the lake would be able to support littoral zone habitat at present conditions. It also predicted that an additional 243 acres could be made suitable for habitat with the removal of organic sediment.

This study is part of the preliminary phases in the littoral zone habitat creation plan. Its main purpose was to identify areas of best suitability. The model has some restrictions due to the age and accuracy of the data sets. Additional fieldwork classifying sediment and soils must be done in order to confirm predicted results. Lake Griffin was selected as a priority for this project because of its current water quality, water clarity and size. If successful this project could lead to similar endeavors on other lakes within the Harris Chain.

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NOTES:

SESSION 3B:

PUBLIC OUTREACH AND PARTNERING

CAN ECTOURISM DEVELOPMENT IN FLORIDA HELP SAVE OUR PRECIOUS WATER RESOURCES: PERSPECTIVES OF TOURISM PROFESSIONALS AND GOVERNMENT DECISION MAKERS

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As in many areas throughout the world, nature-based tourism and recreation is becoming a more important part in the development and management of rural communities and water resources throughout Florida. The Ecotourism Society described ecotourism as an approach to creating nature-based tourism opportunities that encourage responsible travel to natural areas to conserve and protect those areas, and improve the welfare of local people (Western, 1993). Using this definition, ecotourism is more of a philosophy or concept than a specific industry. Ecotourism provides opportunities for ecological, economic, and social benefits, but, at the same time, demands more from planners and managers than traditional nature-based tourism and recreation.

This project reports the results of a survey of county tourism professionals and a Delphi study of public land management agency decision-makers in Florida. This research was designed to identify how these two groups perceive the role of natural areas as a tourism resource in Florida and how these perceptions can result in a framework to help local tourism professionals and land management agencies develop a visionary platform for effective ecotourism planning in Florida. Results show that tourism professionals and public land management agency decision-makers perceive different priorities and visions of ecotourism in Florida. In general, tourism professionals believe nature-based recreation will help provide direct and indirect economic benefits throughout their counties. Ecological benefits and resource management issues were the primary concerns of public land management agency decision-makers.

The 1997 Ecotourism/Heritage Tourism Plan for Florida called for tourism professionals from all related professions to form regional committees to discuss ecotourism development projects. However, this Plan never articulated how these different groups would benefit by working together. As shown in this study, tourism professionals and agency decision-makers desire contrasting, and potentially conflicting, benefits of nature-based tourism. However, this research also showed areas of agreement and potential collaboration. One aspect of collaboration could be joint marketing programs. For example, public natural areas need maps to orient visitors traveling through the areas. Working collaboratively with local tourism businesses, public land management agencies could fund more detailed maps that include recreation opportunities within the public lands and tourism facilities and services outside the public lands. Private businesses would likely pay to be included in the map – reducing the costs of the maps, which the management agency would have to produce anyway.

Rarely do public agencies and local tourism businesses jointly plan to efficiently provide facilities and services. Agency decision-makers do not have the motivation to provide these facilities, and they are concerned with funding this infrastructure. By simply communicating with local tourism professionals, appropriate and motivated landowners could be identified to provide important and expensive tourism facilities at no cost to the public agency. Therefore, by moving tourism infrastructure to adjacent private lands will not only lower financial costs to public land management agencies, but it will also decrease ecological costs, as well. The intense impacts associated with infrastructure development would be moved away from the sensitive lands purchased by the government agency and transferred to the private lands, which are likely to be able to support the infrastructure.

Thus, the challenge is to identify how to best integrate public and private sectors into tourism planning. For example, research could examine the economic factors related to formal public to private partnerships. A feasibility analysis of a Public to Private Venture (PPV) in the Ocala National Forest shows that the private sector is likely to provide an economically sustainable operation on public lands given the U.S. Forest Service expands how they work with private businesses (Denny and Stein 2001). Economic feasibility research, like this, that moves beyond traditional lease or concession agreements will help expand the opportunities of private operators working with public agencies, while helping to protect the natural resources.

Although economics might be the primary motivation for developing private-public partnerships, this study's results show non-economic benefits could also be produced through effective partnerships. Working to sustain ecosystems and community quality of life presents a unique and valuable opportunity for collaboration between the two groups. Traditionally, people considered it up to the government to provide environmental benefits while private landowners focused on sustaining their businesses through profit maximization. However, results show that tourism professionals believe private landowners are able to provide these environmental benefits through a strong stewardship of their lands. If this is true, private ecotourism businesses, which are working with the government agencies, would not only give agencies a feeling of more control of their lands, but they would also help sustain the environmental resources within the area. Since these businesses are either owned or managed by local residents, their connection to the community is strong and likely to be reflected in the spin-off economic benefits generated from that nature-based tourism business.

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NOTES:

PUBLIC OUTREACH - WHAT THEY KNOW, WHAT THEY DON'T KNOW, AND HOW TO TELL THEM

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Bridging the gap between the information understood by lake professionals and the information understood by the average citizen can be accomplished in numerous ways with varying degrees of difficulty and expense. The principle barrier in conveying our message to the public is a lack of appreciation of just how very rudimentary the knowledge of the average citizen is concerning scientific principles that those who work in lake management consider second nature. Few members of the average audience have spent several years in college studying science, and even fewer, if any, have studied limnology, which has its own vocabulary and fundamental principles. Even an expert in groundwater quality may not recognize or know the purpose of a Secchi disc. The purpose of this presentation is to highlight some things that lake scientists can do to make information more accessible and comprehensible for the general public without losing the essence of the message.

The first thing to remember when speaking to the public about a lake study is that you do not need to convey every bit of information that will be included in your final report, nor do you need to use the type of graphs and tables that will be included in a scientific report. Whether using slides or overheads, if you are going to apologize that a slide is too complicated or the print is too small to read, do not use the slide. Given that you will spend approximately one minute on each slide, use summarizing tables and graphs and make the more complicated and complete data available in a report for those who are interested. Adding colorful clip-art to slides keeps the audience's eye attracted to the screen. Furthermore, when making slides, use a font without the fancy little seraphs like used with Times New Roman font. Arial or Comic Sans fonts can easily be read from the back of a room. And font sizes less than 20 points are generally too small, so consolidate information before reducing font size.

Relatively few members of the public are accustomed to reading graphs, other than pie charts and simple bar graphs, and therefore presentation of complicated information must be done in a clear and concise manner to prevent the audience from tuning out. Bar graphs are the friendliest to the public's eye, though line graphs can work well too if they are not excessively busy. Mixing your data lines with too many gridlines and perhaps two y-axes will turn most people off, even if you intend to spend several minutes on the slide. Many people are just interested in the bottom line when it comes to topics outside of their field, and busy people tend to resent presentations that last more than 20 to 30 minutes, not including questions. Also, here are a few of the terms that the general public is unfamiliar with: watershed, micrograms per liter, Secchi disc, nutrients, algae, periphyton, littoral zone, benthic, pelagic, chlorophyll (they know what it is but not the significance of it), or most of the other terms in Lakewatch's "A Beginner's Guide to Water Management - the ABC's." If you are going to discuss Secchi depths, bring a disc to show. If you say 'bacteria,' make it clear that there are also many natural and beneficial bacteria in lakes. Most people do not distinguish between algae and plants, or algae and hydrilla, or hydrilla and tussock, and so on....

Now, where and how do you go about spreading your message? There are many routes, many of them low or no cost, except for time. The following are some approaches taken by the Highlands County Natural Resource Department.

A Master Conservationist Program has been developed to teach citizens about environmental issues in general, and particularly about those issues related to our county and our lakes. The course was developed in-house based on information available in textbooks and on the internet. Students are expected to perform 24 hours of environmentally related volunteer work in exchange for 24 hours of course instruction. They receive handouts of information developed in-house, supplemented with brochures available for free from various government agencies. The students also view videos related to each course topic, videos that are generally available for free or at little cost. We also developed our own video, "Watersheds - What are they? And how you can protect yours," with grant money. The course is also supplemented with free field trips - there are many agencies, companies, and farmers who are willing to share what they do.

There are literally hundreds of publications, posters, brochures, coloring books, bookmarks, stickers, etc. available free for the asking, and many can be ordered on the internet at government web sites. The phosphate industry and agricultural groups also have publications available, suitable for all age groups. The Florida Department of Environmental Protection, the US EPA, the Water Management Districts, the Florida Fish and Wildlife Conservation Commission, and the USDA Natural Resource Conservation Service are good places to start. These publications can be distributed by the hundreds by setting up tables at local environmental or other community events.

Finally, even greater outreach has been achieved by our office through a weekly newspaper column titled "News from the Watershed." The column presents very basic information, one that a lake manager can easily write without gathering information - informing readers about such things as the need to pump septic tanks and the fact that storm drains empty directly into lakes, or describing ongoing lake projects, or highlighting a specific lake. These are just a few of the public outreach routes available - a little creativity goes a long way!

NOTES:

LAKE COUNTY: AN INTEGRATED APPROACH TO STORMWATER MANAGEMENT

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Lake County encompasses numerous open waterbodies including some of the largest and most beautiful lakes in the State of Florida. Water quality is variable as some are designated Outstanding Florida Waters while others are on the highest priority TMDL impairment lists. One of the most polluted lakes in the State, Lake Apopka, is the headwater of the Upper Ocklawaha Chain and exports heavy nutrient loads to downstream lakes such as Beauclair and Dora. Sources of impairment vary from lake to lake, but typically include agriculture and urbanization. The County's lakes, rolling topography, and proximity to Orlando are big draws and population grew by 38% from 1990 to 2000. During much of this growth surge, which is still occurring, County leaders and staff recognized that aging stormwater infrastructure was failing and based mainly on flood control, that their responses to constituents were "complaint driven", that funds were in short supply, and that the water quality of some of their best lakes was deteriorating.

Restoring the impaired lakes and keeping the rest healthy would require a different approach. Where to begin? The first step was to produce comprehensive GIS maps of the waters, inventory and classify important infrastructure, and establish a system for priority rankings of the basins. Once the magnitude of the problem was understood, the County was able to establish a carefully targeted *ad valorem* tax dedicated to Stormwater Management. Now viewed as a serious and pro-active force for water quality improvement, the County could join forces with other stakeholders including the Lake County Water Authority (LCWA), St. John's River Water Management District (SJRWMD), Florida Department of Environmental Protection (FDEP), Department of Community Affairs (DCA), municipalities, and others to improve and protect water quality.

An integrated watershed approach was taken to eliminate redundancies and maximize the use of funds and services from various public stakeholders. The County established inter-agency and public citizen Technical Working Groups and Steering Committees to formalize this process. WAV coordinators played a significant role in public education. The interaction among the various stakeholders frequently led to improved watershed projects through better use of available funds or through identifying additional sources of funds.

Planning is important, but County leaders felt that it was high time to begin fixing problems and wanted rapid migration to implementation. Therefore, a proactive culture evolved whereby engineers and scientists now conduct technical reviews with an eye toward identifying tasks for sudden implementation. These efforts recognize the priorities established early in the process and provide for incremental progress toward meeting overall watershed objectives. Failing infrastructure is viewed as an opportunity for retrofit improvements. With a well-educated public and obvious signs of progress, access rights to property have been easier to obtain. The County has been quite successful in obtaining voluntary easements in lieu of purchase. The Stormwater Division is now proactively solving problems and is largely out of the reactive mode of a few years ago.

Lake County is now implementing projects in 34 basins. The SJRWMD is spending millions of dollars on the Upper Ocklawaha Chain. The LCWA has funded and facilitated several important projects. Municipalities within the County also are spearheading improvements. The vast majority of these projects are planned to avoid redundancy and accomplish coordinated watershed objectives. Cost savings are realized, progress is steady, but challenges remain.

For example, the City of Leesburg collaborated with the LCWA, SJRWMD, and DCA to turn a standard retrofit project into a "stormwater park" complete with a boardwalk, educational placards, and picnic areas. Taking a watershed approach, the LCWA and Florida Fish and Wildlife Conservation Commission (FWC) working on Lake Beauclair recently identified potential cost-sharing and increased project benefits that could be attained by coordinating efforts with SJRWMD projects planned for Lake Apopka, the Apopka-Beauclair Canal, and the Apopka flow-way marsh system.

FDEP recently announced TMDL's for the highest priority waterbodies in the County, establishing a new and significant set of regulatory challenges. Stakeholders in Lake County are poised to handle this well, as they are already experienced in the mechanisms and benefits of partnering to fix and protect water quality on a watershed basis.

NOTES:

FISHING FOR SUCCESS

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This presentation will describe the Fishing For Success (FFS) program at the University of Florida's Department of Fisheries and Aquatic Sciences (FAS). FFS is a multi-faceted program that introduces children of all ages to Florida's freshwater environments. Created in 1998, FFS was initially designed as a mentoring program for underprivileged youth. However, based on a growing demand for environmental education opportunities in Alachua and surrounding counties, it has evolved into much more. Using fishing as the "hook", FFS is an effective way to reach youth. Through a combination of hands-on educational activities and the challenge of fishing, kids of all ages are introduced to a myriad of freshwater aquatic organisms and their related ecology. Kids who experience FFS have a better chance to develop early bonds to their surrounding environment that could last a lifetime. These bonds will help to insure quality fisheries in our future through fishing license dollars and a commitment to the conservation or natural resources.

Visiting school groups, 4-H, YMCA, Girls and Boys Clubs, scout groups, and other youth groups participate in activities specifically tailored to the age and interest of each group. Participants represent a wide range of ages and backgrounds, including the economically disadvantaged and individuals with learning and /or physical disabilities. The FFS curriculum provides students with an opportunity to learn about the history and biology of the threatened Gulf of Mexico sturgeon, as well as the culture of other sturgeon species. In addition to the sturgeon, FFS participants learn about freshwater sport fish, aquatic plants and invertebrates of Florida. Instead of simply being lectured about these creatures, they are encouraged to collect their own specimens from FAS ponds using dipnets. As an added reward, students are given an opportunity to fish FAS ponds stocked with channel catfish, sunshine bass, bluegill, and largemouth bass. For many, this constitutes a first experience with the aquatic environment. Aside from the obvious rewards of catching fish (i.e., confidence building, enhanced self-esteem, etc.), such activities have also been shown to provide valuable physical, therapeutic, and behavioral rehabilitation for participants.

In 2002, FFS conducted 130 programs for 3,484 school children at FAS in Gainesville. Off-site programs are also available, with 33 programs for over 5,000 youth around the Gainesville area being administered in the same year. If a group is unable to arrange a field trip, FFS takes its program to them. Aquatic plant and animal displays, educational presentations, interactive exhibits, and other hands-on activities were provided at various schools and community events throughout the year.

In February 2001, a new dimension was added to the FFS program. With water levels in local waters at an all-time low, families in Alachua and surrounding counties were having difficulty finding accessible places to enjoy fishing together. To address this need, FFS began hosting monthly Family Fishing Days at the FAS ponds in Gainesville. These events are free and open to the public, with FAS supplying bait and tackle to those who require equipment. FFS volunteers are on hand to assist with the fishing and fielding of any questions from the general public. These volunteers include UF graduate students and faculty, Florida Fish and Wildlife Conservation Commission biologists, as well as volunteers from the Gainesville community. Educational displays are also on hand at these open events. These events have proven to be a tremendous success with as many as 1,200 participants at a singe event.

Over 13,000 youth and their parents participated in FFS programs last year, with this year’s numbers projected to top 15,000. This growing program requires additional funding to expand beyond these numbers of participants and potentially statewide.

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SESSION 4A:

USE OF ALUM FOR WATER QUALITY IMPROVEMENT

ALUM CHEMISTRY, STORAGE AND HANDLING IN LAKE TREATMENT APPLICATIONS

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Aluminum sulfate (alum) is the single most widely used coagulant/precipitant chemical for water and wastewater treatment in the world. It is used in a number of industrial, pharmaceutical, and agricultural applications as well. Since 1968, alum has been used for precipitation of phosphorus in natural lake and reservoir systems to improve the trophic state of the water. Other coagulants and precipitants such as sodium aluminate, polyaluminum chloride, ferric sulfate, ferric chloride, aluminum chloride, lime, gypsum, and calcium nitrate have been used alone or in conjunction with an alum program. Aluminum, iron, and calcium chemistry, product characteristics, solubility, storage, and handling will be reviewed with special emphasis on safety and efficacy.

Storage and Handling: All of the products used to precipitate phosphorus from wastewater and natural waters are corrosive and present safety hazards. The users must familiarize themselves with the safety equipment required for safe use. Eye, face, hand, head and skin protection are advised for all materials.

Aluminum Sulfate: Alum is manufactured by digesting bauxite or aluminum trihydrate in sulfuric acid and water. After filtration and adjustment to commercial strength, alum will have a pH around 2.3-2.6. Some manufacturers will have a more dilute finished product with a higher pH. Acid alum products are also available with pH values less than 1. Alum is a corrosive material. It should not be stored in steel, aluminum, zinc or other metal tanks except 316 stainless steel. Alum can be stored in polyethylene tanks and fiberglass tanks provided the tank is designed to withstand a product with specific gravity of 1.4 or more. Piping and valves should be either 316 stainless steel, schedule 80 PVC, polyethylene, or other suitable acid resistant material. Do not use copper, galvanized, iron, steel, or aluminum piping, valves or fittings.

Ferric Sulfate: Ferric sulfate is manufactured from sulfuric acid and an iron source. The purest grade use hematite and magnetite. By-product material from steel and pigment manufacturing is available, but may contain levels of contamination unsuitable for lake treatment. Ferric sulfate is more corrosive than aluminum sulfate and should not be stored in or fed through any metal piping or tanks other than stainless steel or other acid resistant metal. Polyethylene and fiberglass tanks are suitable for storing ferric sulfate provided they are capable of handling material of specific gravity 1.5 or greater.

Ferric Chloride: Ferric chloride is the most aggressive and corrosive water treatment chemical used for P removal. It is almost exclusively an industrial by-product and may contain levels of contamination that preclude its use. It should not be stored in or fed through any metal **including** stainless steel, unless verified by the manufacturer that the metal is chloride and acid resistant. Plastic and fiberglass tanks should be specified for ferric chloride service and be rated for specific gravity 1.5 or greater.

Sodium Aluminate: Sodium aluminate is often used in conjunction with alum to provide a source of aluminum and some buffering action. Typical rates are two gallons of alum and one gallon of sodium aluminate fed simultaneously as possible. They cannot and should not be mixed together, but can be sprayed into the water in close proximity. Sodium aluminate is the produced by digesting an aluminum source with sodium hydroxide. Sodium aluminate can be stored in fiberglass, steel and plastic tanks. Tanks should be rated for materials with a specific gravity of 1.5 or greater. It is corrosive to copper, galvanized and aluminum. Sodium aluminate freezes at fairly high temperatures and must be kept above 70°F.

Aluminum Chloride and Polyaluminum Chloride Products: These materials are very popular in potable water treatment application. Polyaluminum products especially show excellent turbidity removal at lower metal doses than tradition iron and aluminum products, with less alkalinity depletion. Aluminum chlorohydrate is the most concentrated. These products are made by reacting aluminum or aluminum trihydrate with hydrochloric acid. Dozens of formulations, permutations, and concentrations are available. Consult the manufacturer for storage and handling specifics for their products.

NOTES:

THE USE OF LIQUID ALUM AND ALUM RESIDUAL FOR NUTRIENT CONTROL WITHIN WETLAND RESTORATION PROJECTS

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Water quality and wetland habitats within the Harris Chain of Lakes basin declined dramatically over the last century. As part of SJRWMD restoration programs, approximately 28,000 acres of muck farmland are being restored to marsh habitat to reduce external phosphorus (P) loading to the Lake Apopka and Harris Chain of Lakes. Based on previous studies of these organic soils, high P release is expected to occur during initial reflooding. Although chemical treatment has been successful in lake restoration programs, large-scale soil amendment application in wetlands for P immobilization has not been accomplished. If successful, the P loading from muck farms will be further reduced.

Therefore, the St. Johns River Water Management District evaluated various chemical compounds and water treatment residuals (WTRs) for their ability to reduce P flux from the sediments. Following an extensive series of field and laboratory experiments, alum residual was selected as the most economical soil amendment to use on a land-based application system. The alum residual was a by-product of the Lake Washington Water Treatment Plant in Melbourne, which utilized alum, $Al_2(SO_4)_3 \cdot 14H_2O$, as the primary coagulant in the potable water treatment process. Other materials added during the treatment process that became part of the WTR included powdered, activated carbon (PAC), quicklime (CaO), and acrylamide and sodium acrylate copolymers. To assist the polymers in dewatering the floc material, a belt filter press produced residual with approximately 20 percent total solids.

Within the Lake Apopka basin, alum residual was spread at a rate of 6.5 wet tons per acre on 2,000 acres at the former A. Duda & Sons Jem Farm and 10 wet tons per acre within 650 acres of the Marsh Flow-Way Phase I. Only a small portion of the treated area has recently been reflooded at this time and water quality results are preliminary. Approximately 57,000 tons of alum residual have been stockpiled for future use at the North Shore Restoration Area.

Environmental Research & Design, Inc. (ERD) was awarded contracts to design application plans and apply liquid alum at three sites in the Emeralda Marsh Conservation Area in already inundated fields. A comprehensive evaluation of proposed amendments, determination of sediment phosphorus inactivation requirements, and impacts of coagulant addition on surface water were conducted (ERD 2001) at the Lake Griffin Flow-Way by ERD. Previous sediment characterization work by Reddy et al. (1997) supplemented the effort. Liquid alum was selected as the treatment of choice in water-based applications with calcium hydroxide as a buffering agent to maintain appropriate pH conditions within the water column at sites with low alkalinity. To allow access for the application equipment in dense vegetation, pathways were cut by a "cookie cutter" (barge/cutting system) perpendicular to the direction of flow at 100' intervals. The alum was dispensed by a spray nozzle from a floating barge up to a distance of 50'. The barge was pulled by a pontoon boat in deeper areas (>2.5') and Marsh Master in shallow areas. A total of 110,700 gallons of liquid alum and 16,431 kg of lime slurry ($Ca(OH)_2$) were applied between November 26, 2001 and March 28, 2002. A significant reduction (55%-89%) in dissolved orthophosphorus in all cells was documented. The total phosphorus decrease ranged from 45%-67%. The final expense of the application was $87,210.

The former Lowrie Brown Farm contained approximately 125 acres of shallow vegetated marsh and 410 acres of shallow (3 ft), open water. The objective of this project was to treat the nutrient concentration in the water column and sediments prior to dewatering for a planned construction project. The target water quality goal was 30 μg TP/L. Following water quality and sediment monitoring, a dosage of 10 mg/L in the northeast and northwest cells, and 15 mg/L in the south cell was recommended by ERD. Due to low water levels, approximately 25 acres were treated with 6.5 wet tons/acre of alum residual. The rest of the shallow vegetated area was spread by airboat. The deeper area was spread by a boat/barge system which injected alum at a controlled rate into a continuously pumping stream of water from the surface water source in a ratio of 1 part alum to 10 parts water prior to spraying on the water surface (ERD 2002a). A total of 99,000 gallons of alum were applied at a cost of $90,755. Prior to the alum residual and liquid alum application, the average TP value was 310 μg TP/L. TP dropped to 64 μg TP/L following treatment.

Long Farm was purchased in 1992 and reflooded in 1993. Since that time, water quality has remained poor with Secchi readings of less than 0.5 m. Dissolved orthophosphorus comprised 95% of the TP with a mean concentration of 4,800 μg/L (ERD 2002b). Little submersed vegetation exists in the site. To reconnect the Long property hydrologically and ecologically to other areas within the EMCA, nutrient levels must be reduced. In addition, reduced color would improve aquatic and wetland plant establishment for fish and wildlife habitat. Following the application of 220,500 gallons of liquid alum and 50,000 gallons of lime slurry, the dissolved orthophosphorus concentrations were approximately 177 μg/L. The total expense of the application was $224,500.

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NOTES:

LAKE SEMINOLE WATERSHED STORMWATER POLLUTION REMOVAL EMPLOYING ALUM: WE NEED ALL THE TOOLS IN THE TOOLBOX

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Lake Seminole is a 684-acre lake with a 3,480 acre highly urbanized contributing watershed (Figure 1). The lake was created in the late 1940's by the impoundment of Long Bayou and the construction of Park Avenue[1]. The original water was brackish; however, in time, the impounded waters were converted to a freshwater lake, which in the early 1960's supported an excellent bass fishery. The lake was never pristine; however, in recent years the water quality has move from a eutrophic to a hypereutrophic system with many of the resulting problems of such a change. In 1992 the Southwest Florida Water Management District (District) conducted lake assessment that highlighted the growing nitrification problems in the lake and made numerous recommendations for lake restoration[2]. Based on this study and other concerns the District and Pinellas County developed a cooperatively funded plan to restore the lake.

The first major effort in this process was the development of a Lake Watershed Management Plan[3] (Plan). This plan was published, in its final form, September 2001. The Plan lists the following objectives:[4]

- Reduce pollution and nutrient loading from external and internal sources;
- Improve lake water quality (reduce TSI and meet state water quality standards);
- Improve watershed and in-lake habitat quality and diversity;
- Control nuisance and exotic aquatic vegetation;
- Sustain or enhance a balanced assemblage of endemic sport fisheries and wildlife;
- Provide for public flood protection;
- Maintain or enhance the aesthetic and recreational attributes of the lake; and,
- Maximize and balance recreational opportunities for all user groups.

The first and primary goal of the Plan was to reduce pollution and nutrient loading from external and internal sources. The methods of achieving this goal are the focus of this paper. In discussing this goal and how it will be achieved, I will also discuss one of the major problems facing environmental scientists and engineers who are tasked with urban lake restoration, the limitations imposed by land availability and/or cost of land in urban areas. More precisely, that land issues drive the project decisions and ultimately the types of best managements practices (BMPs) used in urban lake restoration projects. A corollary to this is that land issues require that a lake restoration project manager use every available tool in his or her toolbox.

Lake Seminole, with a mean color of 38 platinum cobalt units (pcu) has a trophic state index (TSI) in excess of 86. The current Florida rule for establishing impaired lakes is based on the mean color and TSI. Lake with a mean color of less than 40 pcu must not exceed a TSI value of 40 and lakes with a mean color greater than or equal 40 pcu must not exceed a TSI of 60. Additionally, a lake is considered nutrient enriched if the TSI increases over the 10-year period of record or if TSI measurements were 10 units higher than historic values. Those lakes that do not meet these color and TSI based limits will be placed on the State's impaired water planning list[5]. Clearly, by these criteria, Lake Seminole is an impaired water body and will be listed when the group five watersheds are evaluated. Even without these criteria and the pending state and federal actions that they imply, it was obvious early in the evaluation process that Lake Seminole was in need of major restoration. The primary problem was how to accomplish this restoration in such an urban area.

The answer was a multi-faceted approach to address the watershed and in-lake water quality and pollution load issues.[6] The first problem that arose in addressing the watershed issues was the lack of available land for traditional (wet detention) treatment. One of the early actions of the joint Southwest Florida Water Management District (SWFWMD), Pinellas County and Florida Game and Freshwater Fish Commission (FGFWFC) effort was to purchase land for wet detention. The only available tract was a parcel adjacent to the west shore of the lake containing 5 acres of upland property. The cost of this parcel in 1994 was $1,920,000 and the cost of the wet detention pond creation project was estimated at $600,000. The pond system will treat about 80% of the 64.7 acre contributing watershed. The cost per treated acre was $48,837. The Plan required the treatment of an additional 2,467 acres. Based on the above calculation the cost of wet detention treatment could be in excess of one hundred and twenty million dollars. The Plan quickly became cost prohibitive.

Other approaches were explored. These included lake level fluctuation, shoreline muck removal, dredging, and the use of alum for both watershed and in-lake pollution removal. All of these approaches (tools in the toolbox) were evaluated and many have either been integrated as restoration approaches or are being evaluated. The Plan employed a combination of models to assist the decision makers and has resulted in a solid approach to urban lake restoration. A key element in the Plan approach is the use of alum in the mix of tools. Without this tool, the Plan approach, and the restoration of the lake would not have been feasible. For example, the estimated cost for the watershed stormwater treatment discussed above when alum is put into the mix was reduced by about 95%.[7] Additionally, when alum is put in the mix for in-lake phosphorus control, the cost can be reduced by between 25 and 75 %.

There are problems that must be evaluated and managed with the use of alum. Fortunately, with the large volume of data collected from numerous similar projects in Florida and other states, the data collection needs for effective evaluation and management decisions related to alum use are well known.[8,9,10,11,12] Many challenges remain, however, the Plan for Lake Seminole is solid and through the use of all the tools in our toolbox, this cooperative venture has a good chance of success.

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2. Ibid, p VIII-34.
3. Pinellas County, 2001, The Lake Seminole Watershed Management Plan.
4. Ibid p 1-2.
5. Impaired Surface Water Rule (Section 62-303, Florida Administrative Code.
6. The Plan also recommended projects to address habitat, fisheries, education, recreation and flooding issues; however, these will not be discussed.
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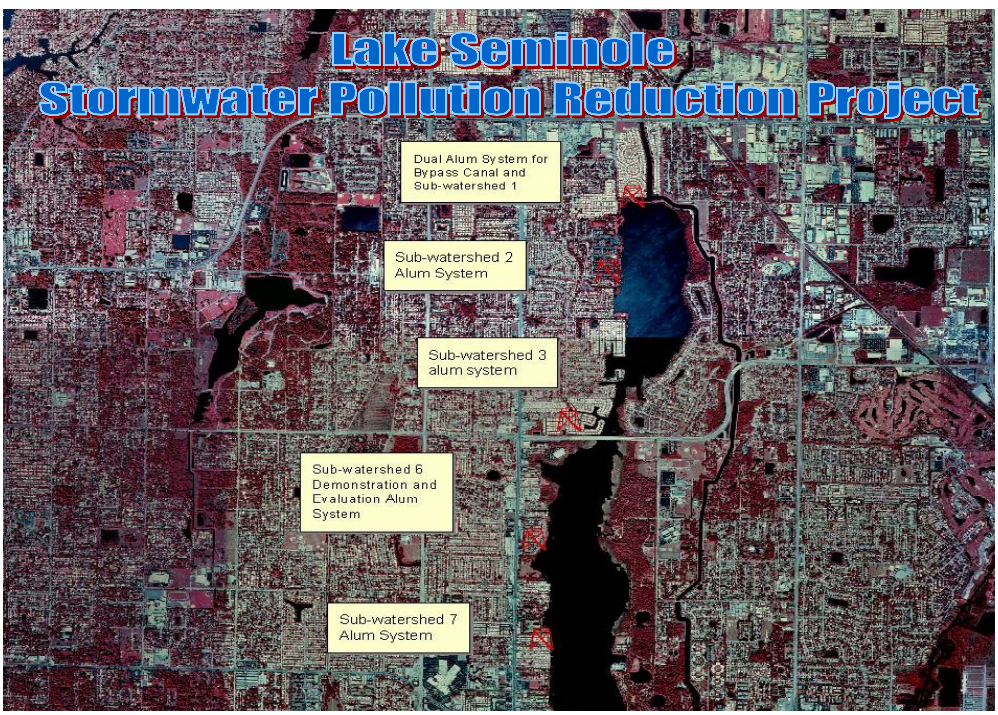

Figure 1. Lake Seminole Watershed and the Proposed Sub-watershed Regional Alum Facility Sites.

SESSION 4B:

AQUATIC VEGETATION

SPATIAL ANALYSIS OF SUBMERGED AQUATIC VEGETATION BED STRUCTURE IN THE LOWER ST. JOHNS RIVER, FLORIDA: WATER QUALITY EFFECTS

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In preparation for establishing a SAV restoration target for the lower St. Johns River, relationships between relevant water quality parameters, light, and vegetation response are being examined. Coarse measurements of grassbeds (e.g., percent cover or occurrence) do not appear to be sufficiently sensitive to reflect water quality or light changes in this system. Field-based qualitative assessments often suggest degradation while quantitative measurements do not. Largely this is the result of two deficiencies in the percent cover and occurrence measurements. First, a given level of cover can be achieved either through several large patches or through many smaller patches. While both scenarios may yield the same cover measurements they may actually represent much different levels of grassbed health. Second, SAV patches may decrease in proportion to the overall grassbed. In this situation, actual areal losses may be incurred without any change in measured percent cover. Because of these and other characteristics of cover measurements, SAV data have not agreed with observed changes in the SAV community. More importantly, cover measurements do not appear to be reflecting the effects of water quality changes presumably driving the changes seen in the grassbeds. To ameliorate these deficiencies alternatives are being explored that may more precisely quantify changes in the SAV community.

Geostatistical analysis (GA) is an approach currently being explored to characterize grassbed structure and dynamics. GA has the inherent strengths of evaluating spatial relationships of variables and quantifying spatial parameters like patch size and heterogeneity. For this study, data was used from two SAV monitoring sites in the Lower Basin of the St. Johns River, Florida (LSJRB). At each site SAV was measured monthly using 0.25-m quadrats at one-meter intervals along each of five transects. Within each quadrat SAV density was estimated using a scale of 0-3 and later converted to median percent cover classes. Water quality samples were also taken biweekly at each site. For this exploratory analysis 16 months (September 2001-September 2002) of SAV data were used. Variograms were created for each site each month from which the following geospatial parameters were extracted: nugget, partial sill, sill, major and minor range. The data were then used to perform ordinary kriging using second order polynomial trend removal and enabling anisotropy to produce interpolated surfaces. Geospatial parameters were then regressed against water quality data to assess relationships betwixt patch structure and water quality. Additionally, an ANOVA was performed to examine grassbed structural differences between sites.

Parameters derived from semivariograms of SAV data were strongly related to both nutrient concentrations and light attenuation, although these relationships appeared to be site-specific. At Rice Creek the heterogeneity, or patchiness, of the grassbeds was negatively related to DIN and light attenuation and positively related to phosphorus concentrations, though these effects were somewhat contradictory when classified by spatial and non-spatial components. Patch Size was positively affected by NH_4 and negatively affected by K_d. At Buckman Bridge patchiness was positively related to PO_4 and negatively related to NO_X and K_d. Patch Size was positively related to PO_4 and water temperature. The two sites were significantly or marginally significantly different with respect to patch size along shore, non-spatial patchiness, and total patchiness.

Given the limited temporal and spatial scope of the SAV data, it would appear that using GA to quantify grassbed changes may be a more precise technique than simple percent cover or occurrence measurements. Geospatial parameters were strongly related to water quality parameters. More importantly, both the geospatial parameters and the interpolated images demonstrated excellent qualitative agreement with field observations of grassbed condition. Going forward it will be necessary to check the validity of these conclusions with a more comprehensive data set. However, GA shows strong promise as a tool to investigate normal SAV variability and separate that variability from anthropogenic effects. Ultimately, this analysis will aid efforts to establish SAV restoration targets in the LSJRB.

NOTES:

A COMPARISON OF THREE DIFFERENT METHODS TO COLLECT SUBMERGED AQUATIC VEGETATION (SAV) BIOMASS IN A SHALLOW LAKE

Andrew J. Rodusky, Bruce Sharfstein,
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Two boat-based and one in-water sampling method have been used to collect submerged aquatic vegetation (SAV) as part of a long-term monitoring program in Lake Okeechobee, Florida, USA. The boat-based methods consisted of collecting SAV with a ponar dredge and an oyster tongs-like rake apparatus. The in-water method involved use of a 0.5 m^2 PVC quadrat frame deployed by a diver. During summer 2002, SAV biomass samples were collected using both methods at various sites in the lake to compare between-methods sampling efficiency. Sites used for these comparisons were selected based on plant type, plant density and sediment type. Statistical comparisons between the biomass data indicated that there were significant ($p \leq 0.003$) mean biomass differences in only one of 15 possible pairwise comparisons between sampling methods. All relationships between SAV biomass collected by the rake, quadrat and/or the ponar dredge were statistically significant, linear, and explained between 57% and 78% of the mean biomass variability. The slope of these relationships suggested that the rake apparatus somewhat under-sampled biomass, primarily at low to moderate biomass, relative to the other methods, although the amount of this under-sampling was small. Because 14 of the 15 comparisons did not yield significantly different biomass values and these differences were consistently small across a range of plant species, plant densities, and two sediment types, the boat-based rake method appears to be a suitable replacement for the ponar dredge and quadrat methods.

NOTES:

THE EFFECTS OF SHADING ON *Chara zeylanica Klein ex. Wild.* AND ITS EPIPHYTES

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The effect of shading, on the growth of Chara zeylanica Klein ex Wild., and its epiphytes, mainly Rhizoclonium africanum Kutz., was investigated in a large outdoor tank using water, sediment, and plants from Lake Okeechobee, Florida. Plants were grown in peat sediment and lake water, under ambient temperature (27-30 °C) and photoperiod (12L : 12D).

Treatments were established by differentially shading plants with varying numbers of layers of fiberglass screen. Photon flux density (PFD) ranged from 8 to 153 μmole photons m^{-2} s^{-1}, or 1.1 to 21.6 % of average incident photosynthetically active solar radiation (PAR), based on percent transmittance and continuous daytime measurements from a mid-lake PAR sensor.

Parameters examined included the ash-free dry mass (AFDM) and growth rate of C. zeylanica and of its epiphytes, mainly R. africanum. The AFDM of both C. zeylanica and its epiphytes, but not their AFDM ratio, decreased linearly with decreasing PAR, were strongly correlated, and had statistically significant treatment effects.

The apparent photosynthetic PFD for no net growth (NNG) of heavily epiphytized C. zeylanica, measured approximately a quarter meter above the sediment surface was estimated to average 4 μmole photons m^{-2} s^{-1}, or 0.5 % of mean incident PAR, with an upper 95% confidence limit of 21 μmole photons m^{-2} s^{-1}, or 3 % of mean incident PAR). The estimated apparent NNG photosynthetic PFD mean of the epiphytic community did not differ statistically from zero, and had an upper 95% confidence limit of 10 μmole photons m^{-2} s^{-1}, or 1.4% of mean incident PAR. These results suggest that C. zeylanica and its epiphytic community can grow in very low light, which may be an important adaptation, given the poor light climate typical of this and many other culturally eutrophic waterbodies.

NOTES:

SESSION 5A:

CHEMICAL AND BIOLOGICAL IMPACTS OF ALUM USE

PHOSPHORUS INACTIVATION AND INTERCEPTION **IN ANIMAL WASTE LAGOONS AND GROWING FACILITIES**

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Nutrient Inactivation, specifically Phosphorus Inactivation is the interception and chemical precipitation of phosphorus from the soluble reactive form into an insoluble un-bioavailable form. The algae responsible for eutrophication of surface waters need their nutrients soluble—they have no roots to chemically solubilize and absorb nutrients. Precipitation of phosphorus with aluminum and iron compounds has been an integral part of lake restoration since 1968. Over 200 lakes have been treated to eliminate P as a nutrient. Iron and aluminum compound in municipal wastewater treatment for P removal has been a recognized technology for decades. Using the same chemistry animal wastes can be treated to precipitate P prior to final disposal, or better reuse. Inactivation of the phosphorus allows the manure and waste to be utilized for their valuable nitrogen, carbon, and trace nutrient content while reducing the impact of non-point runoff. Ferric iron sulfate has the added benefit of precipitating the odiferous, toxic, and corrosive hydrogen sulfide (H_2S) from sludges and liquid streams. Hydrogen sulfide can also be effectively controlled by sodium nitrite. The use of alum or iron in waste streams will also control struvite. In widespread use in broiler chicken litter management since 1995, these chemicals, their applications specifically in poultry, egg production, dairy, and swine waste treatment will be presented in an overview case study format.

A 1997 USDA-NRCS study provided data that there was 128.2 billion pounds of manure produced by livestock. That 128.2 billion pounds contained 1437 million pounds of phosphorus. Phosphorus in manure has a large soluble and labile fraction that makes it especially potent in contributing to eutrophication. Cattle manure contains approximately 0.12% total P while broiler chicken and turkey manure contain an order of magnitude more, 1.2% P. The use of manure for its nitrogen value (0.1%-2.5%) provides more P than crops need, and the result is runoff of bioavailable P. The US EPA Impaired Water Inventory has over 1100 waters impaired or threatened, many by manure P.

Many alternative waste handling technologies are either expensive and/or involve far too much of an operator's attention and maintenance to survive long in a farm setting. Composting is less complex but increases the soluble P fraction while volatilizing a significant portion of the N as NH_3. Thus the P is still in the watershed in a form that can contribute to the P problem.

Treatment of the manure in the animal growing facility with alum or aluminum chloride precipitates the soluble P into a form that is not bioavailable to non rooted plants, and is stable in the environment under normal ranges of pH (>3->9). Further the aluminum compound will reduce the pH inhibiting the evolution of ammonia gas, reduce litter/manure pH thereby inhibiting pathogens, improve the animals growth rates, improve the growing environment to satisfy animal welfare rules, and improve runoff quality of land applied manure.

The use of ferric sulfate can bind phosphorus as well. Under anaerobic conditions ferric chloride and ferric sulfate bound P can be released as a soluble salts as iron is reduced from Fe^{+3} to Fe^{+2}. Ferric sulfate does function effectively in precipitating H_2S odors from sewage, animal wastes, industrial waste and sludge. Theoretically 10 pounds of 50% ferric sulfate (typical commercial strength liquid product) will "consume" 0.915 pounds of H_2S. Ferrous sulfate and ferrous chloride are also used in sewage system odor control, but the strength of these products are low and around five times more volume will be needed. Ferrous salts will release sulfides at pH < 6.5 whereas ferric salts do not.

Sodium nitrite/nitrate liquors are gaining popularity in odor control applications. They are not as corrosive as ferric or ferrous salts and do not increase the solids load to a facility by forming a precipitate. Rather they function as oxidizers and an alternative source of oxygen. Bacteria will utilize the oxygen from nitrite and nitrite first after dissolved oxygen is depleted. It provides a preferred metabolic pathway so the bacteria do not need to use the oxygen from sulfate. In turn, H_2S is not produced as a by-product. Theoretically 11.7 pounds of nitrite/nitrate liquor will be needed per ppm of sulfide.

NOTES:

A PRELIMINARY BIOLOGICAL ASSESSMENT OF SOILS TREATED WITH ALUM RESIDUAL IN THE LAKE APOPKA NORTH SHORE RESTORATION AREA

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Lake Apopka is considered to be among the most polluted lakes in Florida. The North Shore Restoration Area (NSRA) of Lake Apopka was historically drained and converted to muck farmland. In an effort to improve ecological function of Lake Apopka, portions of these muck farms were re-flooded and allowed to return to marsh habitat in 2002. Based on previous studies, high phosphorus release from these organic sediments was expected upon initial re-flooding. Treatment of soils with alum was shown to reduce the release of dissolved reactive phosphorus (Ann 1996). In spring of 1999, prior to re-flooding, alum residual was applied to soils in portions of the NSRA in an effort to inhibit the release of phosphorus.

Although alum may effectively sequester phosphorus in the sediments, its use also may lead to conditions that inhibit production and diversity of the benthic invertebrate fauna (Smeltzer 1990, Water and Air Research 1999). In an effort to address questions regarding possible effects of soil treatment on aquatic invertebrate communities, throw trap samples and sediment core samples were collected in alum-treated areas and control (non-treated) areas of the NSRA in November 2002. Three sites within the treated area and three sites within the control area were established for comparison. Three replicate square-meter throw trap samples were collected at each site using a 3-mm mesh bar seine. Four replicate three-inch diameter core samples were collected at each sampling site.

Relative abundance of major taxonomic groups of invertebrates collected in throw trap samples were: beetles (49 percent), snails (33 percent), dipterans (7 percent), true bugs (7 percent), dragonflies and damselflies (3 percent), and crayfish (1 percent).

Relative abundance of major taxonomic groups of invertebrates collected in core samples were: naidid worms (51 percent), chironomid larvae (28 percent), lumbriculid worms (8 percent), beetles (4 percent), other dipterans (4 percent), snails (2 percent), amphipods (1 percent), dragonflies (1 percent), and flat worms (1 percent). All of these taxonomic groups are known to rapidly colonize newly constructed wetlands (Evans 1996).

Abundance of major taxonomic groups, total abundance, and total number of taxa collected in throw trap samples were similar in the treated and control areas. Total number of taxa and the abundance of most major taxonomic groups occurring in core samples were similar in the treated and control areas. Total invertebrate abundance in core samples was higher in the control area due to moderately high densities of small naidid worms (> 2,500 m^{-2}). Conversely, lumbriculid worms were significantly more abundant in the treated sediments. Reasons for the observed differences in annelid worm distribution are not known, but influencing factors may include sediment grain size and food availability. Under optimal conditions naidid worms can undergo rapid asexual reproduction.

Results of this preliminary work indicate that treatment of soils with alum residual had no adverse effect on benthic invertebrate colonization during the first three months of flooding.

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NOTES:

CHEMICAL AND ECOLOGICAL
IMPACTS OF ALUM COAGULATION

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The BMP of treating stormwater runoff with alum originated in 1986 in a lake restoration project at Lake Ella in Tallahassee, Florida. This system provides treatment of stormwater runoff entering the lake by injecting liquid alum into major stormsewer lines on a flow-weighted basis during rain events. When added to runoff, alum forms non-toxic precipitates of $AlOH_3$ and $AlPO_4$ which combine with phosphorus, suspended solids and heavy metals, causing them to be deposited into the sediments of the lake in a stable, inactive state. The alum stormwater treatment system for Lake Ella resulted in immediate and substantial improvements in water quality which has led to implementation of additional systems on other urban lakes and receiving waterbodies. There are currently 30 operational alum stormwater treatment systems in existence, with 28 located in the State of Florida, An additional eight alum stormwater treatment systems are under construction in Florida, with six treatment systems under design or permitting.

The existing alum stormwater treatment systems have been designed with dosage rates ranging from 5-10 mg Al per liter. Based on hundreds of laboratory tests performed over the last 15 years, alum treatment of stormwater runoff has consistently achieved a 85-95% reduction in total phosphorus, 90-95% reduction in orthophosphorus, 60-70% reduction in total nitrogen, 50-90% reduction in heavy metals, 95-99% reduction in turbidity and TSS, 60% reduction in BOD, and >99% reduction in fecal coliform bacteria compared with raw stormwater characteristics. Ultimate water quality improvements in the receiving waterbodies have been closely related to the proportion of total inputs treated by each alum system. Measured concentrations of dissolved aluminum in lake systems receiving alum treatment of stormwater inputs have been typically low in value, with mean concentrations ranging from 50-100 µg/l.

Sediment core samples collected in receiving waterbodies for alum treatment systems suggest that the alum floc becomes incorporated into the sediment material over time rather than accumulating on the sediment surface as a distinct layer. The primary mechanisms for this mixing process are thought to be a combination of wind action and benthic activity. As alum floc ages in the sediment, it is transformed into a long chain crystalline structure which is extremely stable and inert. Heavy metals such as cadmium, copper, chromium, lead, nickel and zinc, which are bound into the crystalline formation, exhibit virtually no potential for re-release in the sediment pH range of 5.0-7.0 and at redox conditions ranging from highly reduced to highly oxidized. Sediment samples collected in lake systems prior to receiving alum treatment have indicated a large potential for re-release, particularly under reduced environments. Introduction of alum floc into lake sediments has been shown to substantially reduce pore water concentrations of total phosphorus, total aluminum, and heavy metals.

Long-term benthic monitoring data indicates a general trend of improved benthic populations in lake systems following introduction of alum treatment. In virtually all lakes receiving alum treatment, benthic organism density decreases initially following introduction of alum treatment, which closely follows the reduction in system productivity and nutrient concentrations within the lake. Often, there is a dramatic shift from detritivores to carnivores, with no deformities noted in post-treatment organisms compared with numerous deformities observed in pre-alum treatment samples. After 2-3 years, no significant differences are observed in benthic populations, taxa richness, sample diversity, or sample evenness in pre- and post-treatment monitoring events.

In general, alum treatment of stormwater runoff is substantially less expensive than traditional treatment methods, and often requires no additional land purchase. Construction costs for existing alum stormwater treatment facilities have ranged from \$135,000-\$400,000, depending upon the number of outfall locations treated. The capital construction costs of alum stormwater treatment systems is independent of watershed size and depends primarily on the number of outfall locations treated. Estimated annual O&M costs for chemicals and routine inspections range from approximately \$6,500-\$25,000 per year. In general, alum stormwater treatment systems provide removal efficiencies for common stormwater constituents which are similar to those achieved by dry retention systems and substantially greater than removal efficiencies achieved by wet detention, dry detention, and detention with filtration systems.

Current alum treatment system designs emphasize floc removal prior to reaching the receiving waterbody. Several innovative floc collection systems are currently being evaluated which utilize small settling basins or filter fabric for floc collection and retention. Automatic floc disposal systems are currently used which pump settled floc from sump areas into the sanitary sewer system or adjacent upland drying beds. Recent system improvements include the use of fiber optic cables for lightening-sensitive components, and system simplifications to further reduce the number of components and capital construction costs.

NOTES:

SESSION 5B:

FISHERIES AND WILDLIFE - PART 1

RELATIONSHIPS BETWEEN ELECTROFISHING CATCH RATES AND HARVESTABLE SPORTFISH POPULATION DENSITIES IN FLORIDA LAKES

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Electrofishing is a valuable and commonly used tool to assess sportfish population abundance in Florida lakes, but the relationship between electrofishing catch per effort and population densities has not been evaluated in Florida lakes. Three possible relationships between catch rates and population density are possible: proportional, hyperstability, and hyperdepletion. Proportional relationships occur when catch per effort and population densities increase linearly and catchability (the portion of the population collected with one unit of effort) is constant. Hyperstable relationships occur when population density changes at a faster rate than catch per effort and can give the appearance that the population is stable when the population density is changing. Hyperdepletion occurs when catch rates change at a faster rate than population density, but hyperdepletion is rare in assessment fisheries. Fisheries managers often assume a linear relationship between electrofishing catch rates and density, but the linearity of the relationship should be tested in order to manage populations correctly.

Quantifying the relationship between electrofishing catch rates and population density requires a correction due to errors in variables. Catch rates and population density are both measured with error, thus the relationship may be biased when estimated by ordinary least squares regression. Ordinary least squares regression may be used when variables are measured without error or when errors in the y variable are much greater than errors in the x variable. When the x variable is measured with error, ordinary least squares regression estimates are negatively biased. In order to understand the true relationship between catch rates and population density, errors in variables should be accounted for.

Evaluating the relationship between catch rates and population density in Florida's lakes may allow fisheries managers to use electrofishing catch rates to estimate population density rather than using more costly and time consuming methods (e.g., mark-recapture). We modeled the relationship between electrofishing catch rates and population densities of harvestable sportfish in Florida lakes.

We evaluated the relationships between electrofishing catch rates (number/minute) and population densities (number/hectare) for largemouth bass *Micropterus salmoides* (≥ 250 mm), bluegill *Lepomis macrochirus* (≥150 mm), and redear sunfish *Lepomis microlophus* (≥150 mm) to determine the efficiency of electrofishing catch rates to index fish populations. Population densities and electrofishing catch rates were obtained from Florida LAKEWATCH data collected during 1986-1989. Population densities were estimated using mark recapture methods and electrofishing catch rates were estimated from electrofishing catches during the marking period. We used nonlinear models to test the linearity of the relationship. We corrected for negative bias in the regression estimates, due to sampling errors, using simulation methods.

Results indicated highly variable relationships between electrofishing catch rates and population densities of largemouth bass, bluegill, and redear sunfish. Electrofishing catch rates were linearly related to largemouth bass population densities, indicating density independent catchability. Electrofishing CPE was nonlinearly related to population density leading to hyperstable relationships for bluegill and redear sunfish. The hyperstable relationship indicated density dependent catchability, where handling times likely limited catch rates at high population densities.

We concluded that the linear relationship between electrofishing catch rates and population densities for largemouth bass indicated that electrofishing catch rates may be used to index population abundance. The hyperstable relationships between catch rates and population densities for bluegill and redear sunfish may limit the use of catch rates to index population abundance. The variability in the relationships for largemouth bass, bluegill, and redear sunfish suggests that caution should be used when using catch rates to index population abundances in Florida lakes depending on the magnitude of population changes fisheries managers want to detect. Conclusions about the use of catch rates as abundance indices, based on catch rate and population density comparisons, should acknowledge the potential for biases in mark-recapture estimates that may mask the true relationship.

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NOTES:

EFFECTS OF HYDROLOGICAL VARIABLES ON YEAR-CLASS STRENGTH OF SPORTFISH IN EIGHT FLORIDA WATERBODIES

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Purpose

Hydrological variables, such as water level and flow rate, have influenced recruitment of sportfishes in lakes, reservoirs and rivers. We evaluated how annual and seasonal water levels influenced year-class strength of selected sportfishes across four lentic and four lotic systems in Florida. Species investigated included black crappie *Pomoxis nigromaculatus*, bluegill *Lepomis macrochirus*, largemouth bass *Micropterus salmoides*, redbreast sunfish *Lepomis auritus*, redear sunfish, *Lepomis microlophus*, and Suwannee bass *Micropterus notius*.

Methods

Hydrological data for lotic systems was obtained from U.S. Geological Survey gauging stations. Hydrological data for the lentic systems was obtained from the St. Johns River Water Management District and the Southwest Florida Water Management Districts.

Boat electrofishing equipment was used for fish collecting. Catch-per-effort (CPUE) for electrofishing was estimated in 20 minute transects at each system. All sampling took place in the fall (September-December) and spring (January-March) due to potential sampling biases in the summer.

The residuals from catch-curve regressions were used to assess relationships between hydrological variables and year-class strength of sportfish. Correlation analysis was used to assess the relationship between residuals and hydrological variables such as stream flow rate and water level measured by discharge (m^3/sec), and stage level (m) on a seasonal or annual basis. The seasonal environmental variables were separated into: 1) winter, January through March; 2) spring, April through June; 3) summer, July through September; and 4) fall, October through December. All statistical analyses were conducted with SAS (1997) and statistical tests were considered significant when $P \leq 0.10$.

Results

In three of the four lentic systems, largemouth bass year-class strength was positively related to water levels ($\underline{P} \leq 0.10$). Conversely, in two of three lotic systems, largemouth bass year-class strength was negatively related to flow rates ($\underline{P} \leq 0.10$). Similar to largemouth bass in lotic systems, year-class strength of Suwannee bass was negatively related to flow rates in one lentic system ($P \leq 10$). In two of three lotic systems, year-class strength of redbreast sunfish was positively related to flow rates ($P \leq 10$). In one of two lotic systems, year-class strength of bluegill was positively related to flow rates ($P \leq 10$). In four lentic systems, no correlations were found to be related to water levels ($P \leq 10$). In one lentic system, no correlations were found between black crappie and water levels ($P \leq 10$).

Conclusions

Management implications of this work included regulation changes pertaining to minimum flows and levels (MFL's) for lakes and rivers. Residuals from catch curves are being verified with the subsequent year of data collection, to determine if these relationships exist.

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NOTES:

ASSESSMENT OF FISH KILL COMPLAINTS IN PINELLAS COUNTY LAKES AND PONDS

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The Pinellas County Department of Environmental Management's Water Resources Management Section is charged with responding to citizen water quality complaints. From January of 1999 through December of 2002, County staff responded to 722 complaints. Of those, approximately 15% were fish kills. An overwhelming majority of the reported kills occurred in freshwater systems. The visible nature of fish kills requires an immediate response to both assess the situation and to provide the citizens of Pinellas county with timely service. Although the County does not usually clean up the dead fish, our information regarding causes has enabled many homeowners, associations, municipalities, and the County itself to modify lakes and ponds to minimize the likelihood of these events occurring again.

Water Resources staff developed an integrated Access database to catalog and analyze citizen complaint data, in response to the ever-increasing numbers of citizen water quality issues. The database has been an effective tool for analyzing complaint data. The parameters examined in this paper include temporal and spatial trends from 1999-2002.

In 2003, WRMS began entering historic complaint data (pre-1998) into the Access database. The historic complaint project is still ongoing and additional fish kills will become part of the complaint database in the future. The historic data provides an additional layer of information for temporal and spatial assessments of fish kill trends in Pinellas County.

Species breakdowns are an essential aspect of assessment. Initial assessment places tilapia as the most prevalent species represented in freshwater fish kills. Bass, bluegill, threadfin shad, gizzard shad, and grass carp are also represented.

The primary cause of fish kills in Pinellas County was low dissolved oxygen. Factors contributing to low dissolved oxygen were highly variable and included algae blooms, sedimentation, aeration system failure and groundwater pumping. Data will be examined for additional factors such as natural versus man-made waterbodies.

NOTES:

SESSION 6A:

FISHERIES AND WILDLIFE - PART 2

SESSIONS 6B & 7B:

SEDIMENT AND EROSION CONTROL - PARTS 1 & 2

OVERVIEW OF SEDIMENT AND EROSION CONTROL PRACTICES

This session will present highlights from the Florida Stormwater, Erosion, and Sedimentation Control Inspector's Certification Program. Participants will have the opportunity to obtain a basic foundation of knowledge regarding processes and principles of erosion and sedimentation including a basic understanding of soils, definitions and purposes of stormwater management systems, proper use of specific BMPs for effective erosion and sediment control during construction, proper use of vegetation for erosion control, and defining the elements of and preparing an erosion and sediment control plan.

SESSION 7A:

OCKLAWAHA BASIN RESTORATION ISSUES

THE IMPACT OF GIZZARD SHAD REMOVAL ON PHOSPHORUS RECYCLING IN LAKE GRIFFIN, FLORIDA, USA

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Lake Griffin is a large 38 km^2 (9,400 acres) lake near Leesburg, Florida that has exhibited hypereutrophic conditions as a result of large nutrient loading from farms developed on former littoral marshes. The former farmlands are now in public ownership, nutrient loads are now declining, and the properties are being restored to wetlands. In order to accelerate the recovery of Lake Griffin, several other restoration methods are being applied to the lake. These include projects to increase the range of water level fluctuation, harvest gizzard shad (GS) (*Dorosoma cepedianum*), and work with local governments to treat storm water runoff.

Removal of planktivorous/benthivorous fish is a form of biomanipulation, a technique that has been successfully applied to many lakes world-wide to improve water quality with an average success rate of 60% (Hansson et al., 1998; Drenner & Hambright, 1999). “More than 10 detailed reviews of biomanipulation have been published since 1990… None of these reviews leaves a doubt that biomanipulation can be an effective and powerful tool for water quality improvement” (Mehner et al., 2000). There also have been two international conferences on biomanipulation in 1989 and in 2000.

Originally, biomanipulation meant “the deliberate reduction of planktivory, which is followed by an increase in size of zooplankton… That definition has been broadened to include other effects including nutrient recycling by fish” (Mehner et al., 2000). In Florida, with its paucity of large-bodied zooplankton (Bays and Crisman, 1983), impacts of GS harvest are most likely a result of bottom-up effects (nutrient recycling), rather than top-down effects (planktivory). “A commonly observed scenario in lakes following a reduction in the abundance of planktivorous/benthivorous fish is a decrease in phosphorus (P) concentration in the water (Henriksson et al., 1980; Wright and Shapiro, 1984; Sondergaard et al., 1990)” (Persson, 1997). Results from GS harvest in Lake Griffin and other Florida lakes strongly indicate similar benefits from shad removal.

As part of a comprehensive restoration program (Fulton, 1995), in the winter and spring of 2002, the St. Johns River Water Management District removed 445 metric tons of GS from Lake Griffin. We used literature values for GS excretion of SRP to estimate the impact of the GS harvest on internal cycling of phosphorus in Lake Griffin. The estimated impact is a reduction of 13 to 23 metric tons of soluble reactive phosphorus recycling to the lake water annually (0.34 to 0.61 $g \cdot m^{-2}$). This value exceeds the recent range of external phosphorus loading to Lake Griffin.

To further analyze the impact of GS harvest on Florida lakes specifically, an interagency scientific taskforce (the Shad Group) will focus on examining three specific areas with respect to shad harvest in order to compare information on Florida GS with literature values measured elsewhere. These focus areas are: 1) Shad diet, to ascertain what Florida GS are eating (plankton or detritus) through gizzard contents analysis and stable isotope ratio analysis; 2) Population effects of GS harvest – what is the impact of GS harvest on the GS population characteristics and recruitment; and 3) Excretion and bioturbation effects of GS – how does GS function at an ecosystem level with respect to recycling nutrients from the sediments.

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RIVER FLOODPLAIN RESTORATION IN THE UPPER OCKLAWAHA RIVER BASIN

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In 1988, the St. Johns River Water Management District (SJRWMD) purchased Sunnyhill Farm, a 4,000 acre former muck farm and dairy operation. To improve navigation and drain the floodplain wetlands in this area, the Ocklawaha River had been diverted from its natural course to the C-231 Canal in the 1920's. The old river channel was abandoned and more than 3,000 acres of wetlands were drained and converted to farmland. In the 1970's, the canal and adjacent levee and were enlarged as part of the Four River Basins Project by the U.S. Army Corps of Engineers.

Since purchase of the property, the SJRWMD has managed water levels to encourage development of wetland systems. In 1992, the SJRWMD initiated restoration of the historic Ocklawaha River by clearing willows and other vegetation that had overgrown about six miles of the abandoned river channel. However, full restoration of the historic river and floodplain wetland system is still prevented by ditches and levees built for farm operations and by muck sediments that have accumulated in the river channel during the period of farm operations.

SJRWMD's primary goal for the Sunnyhill Restoration Area is restoration of the historic river and floodplain wetland system. The C-231 Canal will be maintained to serve its functions of navigation and flood control, but some of the flow will be diverted through the historic wetland system. Other goals for the project include restoration of wildlife habitat, improvement of water quality, expansion of flood storage opportunities, and development of recreational opportunities.

The plans for the full-scale restoration are to remove accumulated sediments in the river channel, recontour the river channel to restore water flows similar to natural historic patterns, and remove ditches and levees to restore uninterrupted floodplain wetlands. When the project is completed, there will be an inlet structure at the south end of the property to divert water from the C-231 Canal. From there, water will flow through more than nine miles of the restored river channel and more than 2,800 acres of riparian wetlands. A water level control structure will be located at the north end of the property; after passing this structure water will flow through a rim ditch along the C-231 Canal and re-enter the canal further downstream.

A key issue that was addressed in developing restoration plans was defining and restoring historic hydrological functions, to the extent feasible under existing conditions. Information sources used in developing hydrological objectives included historic surveys, existing soils and topography, habitat requirements of wetland vegetation and wildlife, and hydrological modeling of historic and existing systems.

Because of limited quantitative information on the hydrology prior to the 1920s, we relied heavily on hydrological modeling to determine historic patterns of floodplain inundation and river current velocities. From early survey information, we developed a model of historic flows using HEC-2. The model results and soil distributions indicated that key features of Sunnyhill historic hydrology included:

- Extensive wetlands at the southern (upstream) end of the property had prolonged inundation of the floodplain wetlands, even at low-water flows; current velocities in river channel were relatively low

- In the northern (downstream) part of the property, floodplain inundation was intermittent; water was confined to the river channel at low flows; current velocities in river channel were relatively high

Although limited information is available on historic water levels, there probably has been substantial oxidation and subsidence of the wetland soils during the decades of farming, so restoring historic water levels would result in water that is too deep for wetland habitat development. So information on habitat requirements of wetland plants and existing topography on the site was used to develop objectives for water levels. A hydrological model of the existing system was then used to determine flow rates, structure design, and modifications to the river channel required to meet the hydrological objectives. Because of limited available flow, the hydrological objectives for restoration of the historic riparian wetland system are expected to be only partially met.

The Sunnyhill Restoration project is expected to be constructed through the U.S. Army Corps of Engineers' Section 1135 Program, which is used for environmental enhancement of existing Corps water resources projects. Additional funding will come from the Natural Resources Conservation Service Wetland Reserve Program. Construction is expected to begin in 2004. SJRWMD will have continuing management responsibility for the site after completion of construction.

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RESTORATION OF LAKE APOPKA'S NORTH SHORE – PESTICIDES AND PROGRESS

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The restoration of Lake Apopka, a 125-km^2 hypereutrophic lake in central Florida, has been a priority of the St. Johns River Water Management District (SJRWMD) since the mid-1980s. SJRWMD, in partnership with the U.S. Department of Agriculture's Wetland Reserve Program, purchased about 8,000 ha (20,000 acres) of farmlands bordering the north shore of Lake Apopka in order to reduce discharge of phosphorus-enriched irrigation water and to restore the former floodplain. Following temporary flooding of some of the fields, an unprecedented number of waterfowl, shorebirds, marsh birds, and thicket species began using the site, and the 1998 Audubon Christmas Bird Count was 174 species, a record for inland sites in North America. The birding bonanza was quickly followed by unusual mortality of primarily American white pelicans and other fish-eating birds, including the endangered wood stork. Over 675 dead birds were found onsite. Offsite bird mortality also occurred during the same time period, but exact numbers and linkage to the north shore could not be determined. The north shore area was dewatered by the end of Feb 1999, and efforts to restore the historic floodplain have been postponed while the investigation of the mortality event proceeds.

The initial investigation of the bird mortality focused on soil, necropsy and analytical results of tissue samples. Accumulating evidence indicated a strong likelihood that historic organochlorine pesticide (OCP) use by the farmers may have been largely responsible for the bird deaths. Toxaphene concentrations in bird brains collected on-site were typically higher than other OCPs and ranged from 0.05 mg/kg wet wt to 288 mg/kg. No diagnostic threshold for death exists for toxaphene in bird brains. However, 80 percent of the dead American white pelicans analyzed exceeded a mammalian (swine) lethal threshold of 4 mg/kg in brain tissue. Up to 21 percent of the dead birds analyzed exceeded a brain diagnostic threshold of 5 mg/kg for dieldrin. Although very few birds had brain levels indicative of death from DDT (and metabolites), sublethal effects of total DDT, such as eggshell thinning, elevate DDT to a high level of concern for future restoration of the north shore.

Because two risk assessments conducted prior to flooding failed to predict acute mortality from OCP concentrations in soil/sediments or in fish (ATRA Inc. 1998), better quantification of the rate of bioaccumulation of OCPs from soil through the food chain to fish and then to birds is necessary. A three-part collaborative study ("Bioaccumulation Study") between SJRWMD and Dr. Timothy S. Gross and his colleagues from the University of Florida and the U.S. Geological Survey (USGS) was initiated in 2001. Each part of the study is based on exposure to actual pesticide residues in soils from the Lake Apopka restoration area. Furthermore, the high total organic carbon (TOC) content of these soils is a key factor in regulating OCP availability.

In the first part of the bioaccumulation study, soils from the north shore representing a matrix of OCP and TOC were placed into 120-cm (4 ft) diameter microcosm tanks and flooded with pond water containing 1 L of zooplankton inocula. Following equilibration, each of the 39 tanks was stocked with crayfish and mosquitofish, and the organisms were subsampled periodically for 16 weeks and analyzed for OCPs. Levels of OCPs in mosquitofish expressed on a lipid basis were roughly 3 to 10 times higher than in crayfish.

The second component of the bioaccumulation study is a bird feeding experiment designed to determine bioaccumulation rates of the primary OCPs for a fish-eating bird exposed to a diet of fish naturally exposed to high OCPs at the north shore. In May 2002, fish were stocked into screen-enclosed ponds constructed on the north shore at a site known to have high levels of OCPs. Nestling great egrets were collected from south Florida and acclimated to enclosure pens at the USGS facility in Gainesville. The birds were fed a diet containing approximately 30 percent contaminated fish harvested from the ponds. After 56 days, OCP levels were measured in the feathers, brain, blood, liver and fat of half of the birds and, after 74 days, in the second half of the birds. Although toxaphene levels were elevated in fat tissues (avg. 61 mg/kg wet wt), brain levels (avg. 0.3 mg/kg) were well below the 4 mg/kg diagnostic threshold. The other OCPs showed similar patterns of tissue partitioning as did the toxaphene. In the on-going Phase 2 of the feeding experiment, great egrets will be fed a diet containing a larger percentage of contaminated fish, for a longer period of time, and tissue OCP levels will be measured at intervals. At the end of the experiment, food will be restricted in a subset of birds to test whether OCPs in the fat are remobilized to the brain and other tissues.

In the third part of the bioaccumulation study, three screen-enclosed 0.6 ha (1/4 acre) ponds were prepared at three sites on the north shore. The sites were chosen to represent typical low, medium, and high soil OCP levels found in the former farm fields. The ponds were stocked with a variety of fish in Dec. 2002. Organisms will be sub-sampled periodically to help us evaluate accumulation of OCPs in a developing ecosystem that will provide high eco-relevance to the eventual north shore restoration.

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SESSION 8A:

LAKE ASSESSMENT AND WATER QUALITY ISSUES – PART 1

A REGIONAL LAKE SCREENING PROCEDURE AS A GUIDE FOR IMPLEMENTING PRO-ACTIVE LAKE MANAGEMENT STRATEGIES

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Introduction: Approximately 130 lakes lie along the 90-mile Lake Wales Ridge, which extends from the cities of Davenport and Haines City in the northern ridge to Sebring and Lake Placid to the south. A high number of deep sinkhole basin lakes makes this region uniquely different from other lake regions in the District, as well as throughout the state. As focal points of outdoor recreation many of these lakes have become closely linked to the economies and quality of life of the local communities in this region.

Project Purpose: The lakes along the Lake Wales Ridge are threatened by a variety of urban and agricultural related water quality impacts. New urban development is quickly replacing the former agriculture land and remaining open land around these lakes. Subsequently, some lakes are reaching maximum urbanization with upwards of 80 to 90 percent urban land uses within their watersheds. Based on the current rate of urbanization and the continual impacts from historical development, there are more lakes in need of protection or restoration than the District and local governments can possibly address. Because of the limited funds available for lake projects, a screening procedure was developed by the District in order to set priorities for financing future lake management projects. This document will describe the screening methodology, screening results, and finally, the management priorities and strategies derived from the screening results.

Screening Methodology: The screening process was developed on the basis of three major components : 1) a water quality summary index, 2) the hydrologic importance as determined by lake size and its connectivity with other lakes and streams, and 3) an evaluation of lake habitat quality. During the screening procedure a score of 1 to 4 was assigned to each of these three screening components with a score of 4 representing best conditions. The sum of these three assigned scores resulted in the final lake screening value for the 106 lakes evaluated, ranging from 3 to 12.

The water quality summary index was performed by compiling all available water quality from the District and Polk County and calculating the Florida Trophic State Index (FTSI). Lakes receiving a low FTSI, meaning those with overall good water quality received a higher screening value. The hydrologic importance was determined by reviewing District aerial maps and District lake level files to identify connections to other lakes and streams. Large connected lakes were assigned the highest screening value. The evaluation of lake habitat quality was the most field intensive part of the process and involved collecting new data through a field assessment of shoreline habitat and surrounding impacts, as well as a GIS land use assessment of each lake watershed. Criteria for the field assessment of shoreline habitat quality included: quality of shoreline bottom sediments, diversity of shoreline vegetation, coverage or density of shoreline vegetation, coverage of invasive exotic plants, and the number of direct stormwater discharges. The GIS land use assessment was used to determine the percent urban development for each lake watershed to serve as an indicator of the potential impacts from urban stormwater runoff. Once all the individual habitat and land use criteria were scored, scores were converted to a final habitat screening value ranging between 1 and 4.

Results: Lake screening results were separated into three major groupings. The first grouping includes lakes receiving high screening values ranging between 10 and 12. Since these lakes have overall good water quality and habitat, they were categorized as **preservation** lakes. Lakes in this grouping would benefit from pro-active measures to protect the current water quality and habitat. The second screening grouping is for lakes receiving low screening numbers ranging between 3 and 7. These lakes were lumped under an improvement or **restoration** category. Since some of these lakes have an overall poor condition, substantial restoration measures should be anticipated to improve water quality. The third grouping is for lakes receiving intermediate screening values ranging between 7.1 and 9.9. Lakes in this category may benefit from a **combination** of both preservation and restoration actions to prevent further degradation. Lakes and their corresponding value were color coded for GIS mapping purposes with: blue designated for high screening lakes, red for low screening lakes, and green for intermediate.

Application of Results: The final goal of the lake screening assessment was to develop management strategies specific to the three lake groupings and to determine a priority order for guiding future lake management projects. Lakes falling within the high screening values or blue designation would benefit from activities that focus on **preservation**. Preservation of the overall good condition of these lakes will require preventive management involving a "hold the line" type approach. Since these lakes have both good water quality and high habitat quality, it is essential that programs that will offset future growth be in place. Although current regulations require new developments to provide stormwater treatment, these regulations do not address all pollution impacts. For example, stormwater systems are only required to treat runoff generated from up to the first one inch of rainfall per storm event. Additionally, stormwater regulations do not address ground water pollution derived from application of fertilizers, insecticides, and herbicides to lawns, and from septic system effluent. Degradation of natural habitat is also anticipated as development expands around these lakes. Although rules are in place to limit removal of shoreline plants, the tendency over time is for natural shoreline vegetation to be removed as lakefront property owners clear private beaches. As a result, much of the natural shoreline and adjacent upland providing natural buffers are replaced with high maintenance lawns.

One measure for water quality preservation may be achieved through the development of density requirements and increased setbacks and for septic systems on waterfront properties (Terrene Institute 1995). For both water quality and habitat protection, another pro-active measure would include development of ordinances by local governments requiring natural vegetated buffer zones (Terrene Institute 1995). For example, the town of Dundee located in the Ridge region has successfully created buffers of passive recreation lands around each of the lakes located in their municipality, and by doing so, has achieved both recreation and water quality benefits.

Perhaps the most comprehensive form of habitat and water quality protection could be achieved through a land preservation program that focuses on natural lands adjacent to lakes. Several lakes in the Lake Wales Ridge are bordered by substantial areas of natural uplands and wetlands. Preservation of these lands would provide multiple benefits including water quality protection, aquifer recharge, and protection of adjacent upland scrub and cutthroat seep wetlands. This land preservation program should be coordinated with other acquisition programs to identify parcels that may also fill gaps between other acquired public lands. Public education programs which target pollution prevention and protection of existing high quality habitat would also be crucial for maintaining conditions within the preservation lakes. For example, brochures on the importance of aquatic plants and shoreline enhancement through aquascaping could be distributed to lakefront homeowners on preservation lakes.

The final pro-active program to be applied involves increased coordination among regulatory agencies. Information collected during this screening effort would be useful during the regulatory review process of permitted activities. For example, watershed boundaries that were completed for this project would help regulatory staff identify receiving water bodies associated with new developments under review. Additionally, information regarding the hydraulic connectivity within each lake watershed may also help assess regional impacts associated with new permitted activities. Specific water quality data such as the ratio of the primary nutrients, nitrogen to phosphorus would also be helpful. During this assessment it was found that some lakes were either highly phosphorus limited or highly nitrogen limited. Providing a list of these nutrient limited lakes to regulatory staff would help identify lakes which need more specific regulatory review due their increased potential for water quality degradation.

The low screening grouping (red coded) was for lakes receiving low screening numbers ranging between 3 and 7 and was categorized as **restoration** lakes. These lakes are likely to require significant restoration measures in order to improve water quality and/or habitat quality. Obtaining measurable improvements in water quality within these lakes may be difficult and expensive.

In-lake restoration activities typically focus on reducing internal sources of nutrients, primarily the build-up of flocculent organic sediments. Activities anticipated for some of these lakes may include sediment dredging, lake drawdown, drawdown combined with mechanical sediment removal, whole lake alum injection, or perhaps long term aeration. Other alternatives such as experimental techniques using harvesting of floating plants for in-lake nutrient uptake may also be applied. In addition to in-lake restoration, addressing untreated stormwater within the watershed of these lakes will also be needed to enhance water quality over the long term. It is preferable to begin with restoration projects that target the less complex stormwater problems first, such as correcting erosion problems. Erosion channels have formed on several of the lakes along the Ridge where urban stormwater runoff discharges down steep sandy slopes washing sediment into the lakes. Projects that stabilize erosion problems are anticipated to be relatively short term projects, providing immediate benefits to the receiving lakes by reducing sediment transport. The lakes in the restoration category are also likely to require longer term stormwater projects addressing broad scale urban runoff. Solutions to providing stormwater treatment will require conventional processes through the completion of stormwater master plans, establishment of stormwater utilities, and construction of stormwater retrofits.

Many of the lakes within the restoration category would benefit from projects that create or enhance shoreline habitat. Re-planting littoral zones could be accomplished through cooperative programs with other state and local agencies. In order to stimulate public involvement and perhaps initiate volunteer based replanting projects, public education on enhancement of shoreline habitat should target local homeowner associations on these impaired lakes.

The last screening grouping was for lakes receiving intermediate screening values (green designated lakes). Lakes falling in this category may benefit from a **combination** of both preservation and restoration programs in order to prevent further degradation. For water quality it is anticipated that projects will focus on stormwater remediation in the watersheds of these lakes. Similar to lakes in the restoration grouping, stormwater remediation would occur by completing stormwater master plans, establishing of stormwater utilities, and constructing stormwater treatment projects.

The lakes in this grouping are also likely to require habitat enhancement projects such as littoral zone re-plantings. For lakes that contain adequate habitat, preventive measures should be applied to protect the existing system. These would be similar to recommended measures for the lakes in the preservation grouping and include land preservation programs, and the development of local ordinances for the creation of natural vegetated buffer zones. In addition, public education programs which target pollution prevention and protection of existing high quality habitat would also be crucial for maintaining existing conditions. Restoration of hydraulically altered wetlands connected to lakes would also offer habitat and water quality enhancement opportunities. As a starting point to develop future restoration projects, existing public lands near lakes should be evaluated to identify regions that have undergone alteration of natural wetland hydraulic features, such as the channelization of historic streambeds and connected wetlands.

Conclusion - Setting Management Priority: The management priority proposed as part of the completion of this screening procedure is somewhat unique. Instead of placing priority on restoration of lakes of poor condition, the District proposes to place emphasis on protective lake management strategies first to attempt to prevent further degradation of lakes with an overall good condition. The highest priority for future lake management projects is placed on intermediate grouping lakes (green designation), while high grouping lakes receive second priority, and low grouping lakes receive last priority.

The basis for this prioritization was the greater potential for loss of habitat and water quality, preventative timing, and cost benefit. Pro-active or protective management strategies planned include: stormwater treatment opportunities which would offset increases in pollutants from expanding urban developments, increased coordination with regulatory agencies, land preservation, education, and working with local governments to develop ordinances for shoreline buffer zones. As a result of the high number and high cumulative cost of the potential future projects, it will be critical for the District to continue to develop partnerships with federal, state, and local agencies to successfully manage these lakes.

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PREDICTING THE FREQUENCIES OF ALGAL BLOOMS IN FLORIDA LAKES

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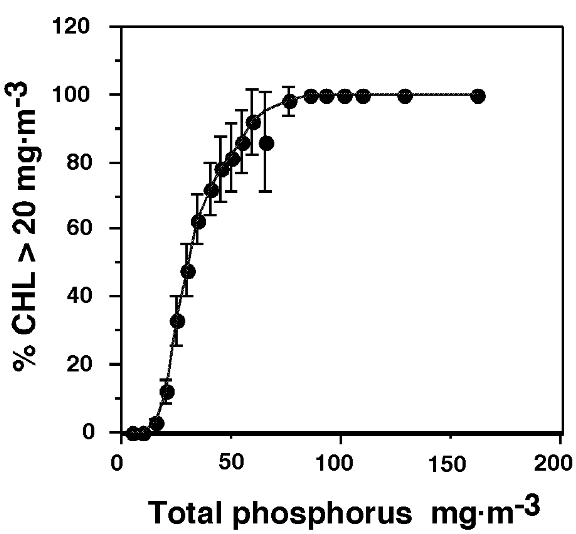
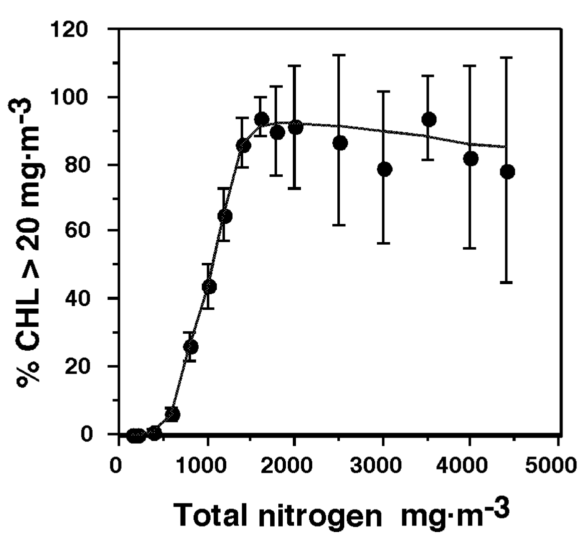
Many lake management plans designed to control the abundance of phytoplankton set goals using the average chlorophyll *a* concentration during the warm season of the year. An alternative approach that has been advocated by Walker (1985) is to focus on the frequency that the chlorophyll *a* concentration exceeds a specific concentration. The rationale is that while the average chlorophyll *a* concentration may be acceptable to lake users, fluctuations in chlorophyll *a* concentrations about the mean may lead to chlorophyll *a* concentrations high enough to be objectionable. The objective of our study was to find relationships for Florida lakes between the average annual concentrations of total phosphorus (TP), total nitrogen (TN) and chlorophyll *a* and the frequencies that chlorophyll *a* concentrations exceeded various levels that might be defined as objectionable.

We analyzed 1473 lake-years of data on 438 Florida lakes that had been collected by citizen volunteers participating in Florida LAKEWATCH. For each lake we had monthly measurements of TP, TN and chlorophyll *a* concentrations that we used to find the annual frequencies that phytoplankton chlorophylls exceeded concentrations of 10, 20, 30, 40, 50, and 60 $mg{\cdot}m^{-3}$ based on the annual average concentrations of chlorophyll, total phosphorus, or total nitrogen. Because previous studies showed that TN/TP ratios were important, we first grouped the data by TN/TP ratios of >17, <17 but >10, and <10.

The following curves are a sample of our results for Florida lakes. The percents of the annual samples with chlorophyll *a* concentrations greater than 20 $mg{\cdot}m^{-3}$ are plotted against TP and TN concentrations. These lakes have TN/TP ratios greater than 17 by weight and the error bars represent 95% confidence limits about the means.





Similar S-shaped curves were found when different chlorophyll levels were used as a bloom criterion or when different TN/TP ratios were used. All of our results have been summarized (Bachmann et al. 2003) in a series of tables that should be applicable for an estimation of the frequency that chlorophyll concentrations will exceed an established level (an algal bloom) from a knowledge of annual average concentrations of chlorophyll, TP, or TN in Florida lakes. The tables of algal bloom frequencies might also be useful for managers of north-temperate lakes because nutrient-chlorophyll relationships are similar for Florida lakes and north-temperate lakes (Brown et al. 2000). However, we caution that the tables using TP and TN might not be applicable to lakes where there may be some other limiting environmental factor (e.g., light) rather than these limiting nutrients. For example, some Florida lakes with high concentrations of dissolved organic materials (colored lakes) are known to have low algal chlorophylls (Bachmann et al. 2002), and lakes with large amounts of inorganic suspended materials like the pelagic areas of Lake Okeechobee can have lower algal bloom frequencies than might be predicted from our tables (Walker and Havens 1995).

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USING HISTORIC BATHYMETRY AND RADIOMETRICALLY DATED CORES TO ESTIMATE LAKE-WIDE SEDIMENTATION

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Sedimentation rates can be calculated by measuring mass accumulation from sediment cores dated using radiometric analysis. The number and distribution of radiometrically dated cores limit the spatial accuracy of lake-wide estimates of sedimentation. Lake sediment accumulation can vary spatially, creating additional uncertainty to estimates of sedimentation (Whitmore et al. 1996). Lake Jesup (43 km^2 surface area) is a hypereutrophic lake with an average soft sediment accumulation of 1.8 m and an average depth less than 1 m. This shallow lake has a spatially heterogeneous sediment distribution (Cable et al. 1997). Cable et al. (1997) estimated sedimentation using 8 radiometrically dated cores and 41 additional long cores sampled using an equal area grid. To improve the spatial accuracy of sediment accrual estimates, we calculated sediment using bathymetric surveys conducted in 1939 and 1996. The objective of this study was to determine how improved estimates of sediment accrual affect lake-wide estimations of the sedimentation rate.

We estimated sediment thickness accrual by subtracting grids created from points collected in hydrographic surveys from 1939 (NOS) and 1996 (Arc Surveying and Mapping, 1996) using ArcGIS™. These values were then intersected with Thiessen polygons developed from all 49 core locations. We converted thickness (cm) to mass accumulation (g dry mass/cm^2) for all cells contained in each Thiessen polygon using power equations fitted from raw data contained in Cable et al. (1997). Finally, we calculated area weighted estimates of sediment mass, total phosphorus (TP), total nitrogen (TN), non-apatite inorganic phosphorus (NAIP), total carbon (TC) accumulation rates for each Thiessen polygon.

Lake Jesup has a thick layer of soft sediment covering most of the lake bottom. The thickest accumulations are found along the southern and western portions of the lake (Fig. 1). Areas showing the thickest accumulation (and the highest mass accumulation rates (> 100 $mg/cm^2/yr$) over the period 1939 to 1996 were observed in the northern central part of the lake. The areal weighted average mass sedimentation rate for Lake Jesup was estimated at 55 $mg/cm^2/yr$. There was a significant positive relationship between mass

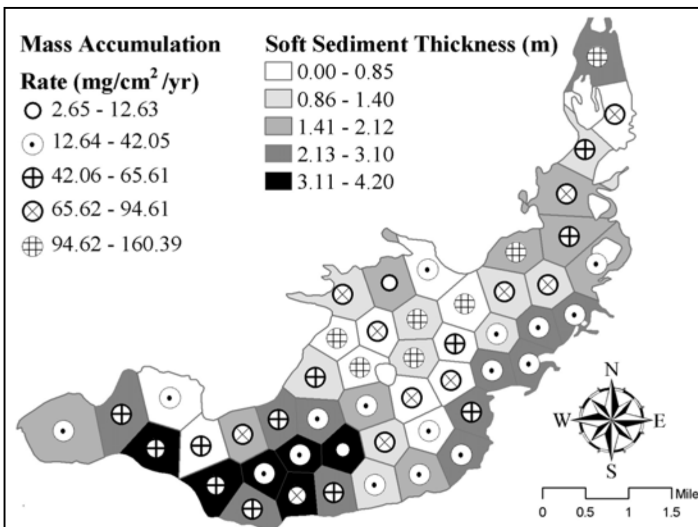

Fig1. Mass Sedimentation Rate and Soft Sediment Thickness in Lake Jesup

accumulation and sediment thickness (correlation, r = 0.67). However, there was no correlation between measured sediment thickness (cm) and the percentage of mass loss on ignition (correlation, r = 0.2). Sedimentation rates for TP, TN, NIAP, and TC show similar generalized spatial patterns.

In Lake Jesup, this approach showed that mass sediment accumulation rates between 1939 and 1996 are not spatially coincident with the thickest soft sediments, suggesting that thick layers of sediment were deposited prior to 1939. Using sediment cores and historic bathymetric surveys agencies and researchers can obtain valuable, cost effective and spatially explicit estimates of sedimentation avoiding the problem of finding stratigraphic features to relate dated cores to undated cores.

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MOTORIZED BOATING ON LAKES: WHAT ARE THE ENVIRONMENTAL IMPACTS?

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Introduction-What determines a motorboat's environmental impact on a lake? Two recent publications (LaBounty and Asplund 2003, Korth and Dudiak 2002) distributed by the North American Lake Management Society (www.nalms.org) provide an excellent overview of many of the complex physical, chemical, biological AND sociological factors that come to play. These as well as an earlier review by Wagner (1991) and the results of our own studies conducted on specific New Hampshire lakes, with the assistance of volunteer monitors in our NH Lakes Lay Monitoring Program (NH LLMP). form the basis of this overview.

Potential Impacts-Motorized watercraft have the potential to impact on water quality and related resources through direct and indirect ways. Fuel from motor exhaust can directly add hydrocarbons, metals and even phosphorus into the water. Older (pre-1979) two-cycle outboards, can discharge as much as one third to one half of the fuel used unburned directly into the water. This is in addition to the pollutants from the combusted fuel and oil mixture. Inboard and larger outboard engines, however, are four-cycle in design and thus operate much cleaner. In addition, recent advances in outboards include new four-cycle models and two-cycle engines with solid state ignition and fuel injection which are more efficient and burn cleaner than older models. Fuel and oil in water can also result from spills and leaks during maintenance and fueling. Generally, studies have shown fuel and related pollution problems tend to be significant only when boats are in dense concentrations on the water or in and around large marinas. However the pollution of surface and groundwater supplies with the carcinogen MTBE, a gasoline additive currently required for federal clean air regulations, has been on the rise. While leaking underground tanks and spills at fueling sites are the major culprits, spills from individual watercraft and uncombusted fuels can also play a part.

Additional impacts from boating are related to the generation of a wake and the extent of the turbulence caused by the propeller or water jet. The extent of these disturbances are dependent on the hull design, engine power and speed of the craft. A speeding bass boat planing at 30 knots can produce less of a wake than a bow-rider traveling at 10 knots. A 50 hp to 150hp outboard can produce turbulence down below 4.6meters Beachler and Hill (in LaBounty and Aplund). Jet watercraft create less turbulence downward but cause more concentrated horizontal turbulence. This advantage may be negated though by the fact that these "jet-skis" are often observed speeding around and around in very shallow waters.

These processes have the potential to fragment aquatic plants, re-suspend bottom material and erode shallows and shoreline areas. Fragmenting plants can spread their range into new areas since most plants can regenerate from fragments. Re-suspending the lake sediment and eroding the shoreline can create turbid water conditions. Nutrients are generally attached to or associated with re-suspended particles resulting in increased phosphorus levels in the upper waters. These conditions can favor nuisance algae blooms while suppressing native aquatic plant growth in deeper waters. Re-suspension of toxic ammonia compounds can be common in shallow, productive lakes. Erosion or burial of habitat areas and physical damage to eggs and young are additional concerns related to aquatic and riparian organisms as are conditions conducive to causing stress or abandonment of bird and fish nesting areas.

Other researchers have argued that wakes and turbulence from boats may have less impact than wind induced turbulence. However, personal observations on windy days suggest that wind causes more of a lapping pattern against the shoreline while the wake of a motorcraft often rides into shore as a larger wave that has higher erosion potential. Wind impacts are also more dependent on the "fetch" of a lake (the distance over water that the wind can blow with no obstructions) while boat impacts can occur on virtually any lake. Anthony and Downing (in LaBounty and Aplund) found that boat traffic was highly correlated to turbidity while wind speed alone was not and a greater surface area of their lake was impacted from boat traffic than wind alone.

NH Boat Impact Studies-Consistent with the reviewed literature, highly variable results have been documented for boat impact studies for lakes in New Hampshire dependent on the number of boats operating and differing lake characteristics. An 80 hp boat towing a skier around Beaver Lake in Derry caused a 2.3 meter decrease in water clarity within 5 minutes. After two hours with no activity, the lake still had not fully recovered. At Squaw Cove in Squam Lake, transparency during the circling of a boat decreased only by 0.3 meters and almost immediately recovered. At another deeper cove on the same lake, transparency decreased by almost three feet. Differences in these cases relate to the bottom material and shoreline character of the test areas. Squaw cove has a very sandy bottom and has a well vegetated (protected from erosion) shoreline. The other Squam cove has a less protected shoreline and more fine bottom materials while Beaver Lake has a predominately muddy bottom with a very unprotected shoreline.

Nutrient impacts were also dependent on these same characteristics. The nutrient levels at both Squam sites increased by only two to three units (from 2 to 5 parts per billion total phosphorus) with no corresponding algae response. In contrast, nutrients increased over tenfold (from 8 to 88 parts per billion) after a busy boating day at Conway Lake. This resulted in a doubling of the algae levels the following day. Conway Lake has a very organic (mucky) bottom with two deep basins and substantial shallows. Some shoreline is protected but a greater amount is cleared. Another observation from our monitoring involving boat impacts is the re-suspension of nuisance algae from mats growing on shallow lake bottoms, from layers that often concentrate at the middle depths of deeper lakes, and from species growing within underwater weed beds (the "clouds" of algae we sometimes see floating around).

Final Considerations-Thus, motor craft impacts may differ due to lake area, bottom sediment composition, weed bed extent, shallowness, shoreline development and shoreline condition (slope, soils, and vegetative cover) as well as the characteristics of the watercraft. This confounds any research based management approach. Issues of user conflicts (canoes or sailcraft versus motorboats; anglers versus water-skiers), and aesthetics are important components that are not directly related to the resource impacts. They do, however, often incite emotional responses. Some lakes in our state have addressed these sorts of conflicts by limiting access completely,

creating no-wake zones at specified depths or distances from shore, using “activity zones” that restrict areas where certain types of boating can take place or by maintaining time restrictions for various boating activities. In the end, we may never come to full resolution of these issues. However, understanding the potential negative impacts for a given lake’s characteristics and resources could lead to an acceptable compromise.

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NOTES:

SESSION 8B:

LAKE OKEECHOBEE

A LONG-TERM PERIPHYTON MONITORING PROGRAM IN LAKE OKEECHOBEE

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Past investigations have suggested that periphyton may serve two important functions in Lake Okeechobee, a large, shallow, eutrophic lake in south-central Florida. First, periphyton may act as a nutrient "sink" by sequestering phosphorus and nitrogen from the water column, thereby reducing nutrient availability for phytoplankton. Second, periphyton may act as an important food source for higher trophic-level organisms such as invertebrates and fish. The potential of periphyton as a nutrient sink and its role as a food source are poorly understood in Lake Okeechobee, due to temporal and spatial biomass variability. A long-term program to monitor periphyton biomass and nutrient concentrations (CNP) was implemented to assess the importance of these roles. Monitoring of periphyton biomass commenced with *in situ* incubations of acrylic rod periphytometers. After a significant lake level decline and subsequent reappearance of submerged and emergent macrophyte taxa in areas of the pelagic/littoral interface region, the periphytometer incubations were replaced with direct measurements obtained from periphyton collected by harvesting submerged and emergent macrophyte taxa. Preliminary data from the long-term monitoring program indicate that mean epiphyte biomass (mg/g dry weight per host plant) was highest on *Hydrilla* (621 mg/g) and lowest on *Scirpus* (1 mg/g). Only a limited number of macrophyte samples yielded enough periphyton biomass to determine periphyton nutrient concentration. Of those that did, the epiphytes on *Potamogeton* had the highest mean TP and TN concentrations, while epipelon had the highest mean TC concentration.

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RECOVERY OF SUBMERGED AQUATIC VEGETATION FROM HIGH WATER STRESS IN LAKE OKEECHOBEE, FLORIDA

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In May 2001, a lake stage recession followed by a major drought reduced water levels in Lake Okeechobee by more than 2 meters triggering a widespread recovery of the Lake's submerged aquatic vegetation (SAV) community. A systematic survey along 15 transects conducted on 22 occasions over three years (1 year pre and 2 years post recession) along with three lake wide SAV mapping efforts performed at the peak of the growing season in late summer 2000, 2001 and 2002 were used to characterize the responses of the SAV community. Initially, there was no response to the recession, however 2 months post recession *Chara* began to expand rapidly and had colonized in excess of 34,000 acres of lake bottom by the end of summer. Vascular plants, including *Potamogeton, Vallisneria, Hydrilla, Najas and Ceratophyllum* were slower to recover, but had become dominant, as a group, as measured by acres of coverage, by late summer 2002. Nevertheless, *Chara* continued to occupy in excess of 21,000 acres; mostly in the southern peat sediment zone of the lake. As recovery continued, overall species diversity increased from an average of 3 to 4 species in summer 1999 to 7 species in summer of 2002. Coincident with the increase in overall species diversity was an increase in the percentage of transect sites characterized by beds containing 2 or more species of SAV.

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FACTORS CONTROLLING PHYTOPLANKTON DYNAMICS IN LAKE OKEECHOBEE, FLORIDA.

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Nutrient and light limitation bioassays and photosynthesis-irradiance curves are routinely performed using natural phytoplankton assemblages in Lake Okeechobee to identify the specific factors that influence phytoplankton dynamics. Phytoplankton biomass was dominated by blue-greens (43%), diatoms (36%), and green algae (10%). Light limitation accounted for 59% of all bioassay outcomes, while phosphorus was never found to be limiting. The occurrence of light limitation could be predicted by examining the secchi depth:total depth ratio, chlorophyll a, and dissolved inorganic nitrogen concentrations. Photosynthetic parameters were similar at all sites during the period of high lake stage prior to the drought of 2000 and differed thereafter. Further analysis is underway to determine if lake stage and related environmental variables help explain this change.

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SESSION 9A:

LAKE ASSESSMENT AND WATER QUALITY ISSUES – PART 2

MCGLYNN – PAGE 1

LANDSCAPE VARIABILITY OF TOTAL PHOSPHORUS CONCENTRATION IN THE KISSIMMEE UPPER BASIN

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Most studies related to total phosphorus in water bodies of the Kissimmee Upper Basin (KUB) have focused on temporal variations, nutrient budgets, and trophic classification (e.g., Morales, 2001a & 2001b; Glen et al., 2000; O'Dell, 1994; Moyer, 1991; Jones et al., 1983; Huffstutler, et al., 1958). The current study presents the first attempt to identify total phosphorus concentration background levels in the KUB. Landscape variability of total phosphorus concentration was studied in the KUB to identify baseline concentrations, potential sources and priority management areas in the basin.

Ten-years (1990-1999) of monthly total phosphorus concentration data from the South Florida Water Management District and the University of Florida Lake Watch Program were analyzed for KUB lakes. Identification of total phosphorus concentration patterns was attempted using classification schemes based on sub-basins, land uses, lake regions, and north-south and east-west gradients. Among these classifications, the lake region-based scheme provided the most plausible basis for explaining total phosphorus concentration distribution in the KUB.

Landscape patterns of total phosphorus concentrations were correlated with lake elevation within the watershed lake regions. Lakes located on KUB ridges (above 90-ft) have lower background total phosphorus concentrations than lakes located in lowland regions (below 60-ft) (i.e., 0.007-0.014 mg/l and 0.020-0.030 mg/l, respectively) (Table 1). This could be due, at least in part, to less surface runoff from higher permeability soils in the ridges. Within a particular lake region, lakes exhibiting higher total phosphorus concentrations ostensibly indicate the presence of phosphorus sources from adjacent land uses. Potential impacts from stormwater runoff were identified in Lakes Clear and Holden (in the Orlando Ridge near metropolitan Orlando), Bay Lake (in the Osceola Slope near Disney World), Lake Center (in the Osceola Slope) and the Kissimmee Chain-of-Lakes (in the Kissimmee/Okeechobee Lowland).

Total phosphorus concentrations in the Kissimmee Upper Basin could be reduced to baseline levels with aggressive stormwater best management practices, as well as by establishing buffer zones around water bodies, increasing the range and temporal dynamics of water level fluctuations and optimizing the maximum extent and duration of low/high stages.

Table 1. Total phosphorus background concentration distribution in Florida lake regions within the Kissimmee Upper Basin.

Lake Region (mg/l)	Elevation (ft)	Median TP Concentration Range	
		Glenn, et al. (2000)	Current Study
Dr. Phillip Ridge	100-170	0.007-0.014	0.007-0.014
Orlando Ridge	75-120	0.030-0.049*	0.010-0.014
Lake Wales Ridge Transition	70-130	0.015-0.019	0.015-0.019
Osceola Slope	60-90	0.015-0.019	0.015-0.019
Kissimmee/Okeechobee Lowland	< 60	0.030-0.049*	0.020-0.029

*Several lakes within the lake region with higher total phosphorus concentrations than expected.

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NOTES:

RENOVATE* - A NEW, UNIQUE SELECTIVE SYSTEMIC AQUATIC HERBICIDE

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Aquatic tolerances for triclopyr in fresh water were granted and posted in the federal registry in August 2002. This action cleared the way for a federal registration for aquatic label triclopyr by the EPA in November 2002. Now with a federal label in hand, SePRO will introduce Renovate, the first aquatic herbicide to receive registration since 1988.

Renovate is a highly selective broadleaf herbicide that can be used to control a variety of nuisance and exotic aquatic plant species. In addition to controlling unwanted exotics, Renovate allows many native monocots and less susceptible dicots to thrive following treatment. Therefore, this product can be used selectively to restore aquatic wetlands and for ecosystem management.

This unique, new herbicide enters the plant through foliar or cut surface applications and provides fast-acting results. Renovate is suitable for selective control of floating, emergent and submersed aquatic plants in partial or whole lake treatments. Renovate translocates systemically in the plant when applied to the leaves and shoots. It is absorbed by leaves, and is readily translocated downward through the shoots and into the root system.

Renovate is an effective solution to a wide range of nuisance and exotic aquatic plant problems. Most importantly Renovate is an excellent tool to be used with integrated pest management programs to control and stop the spread of plants such as, Eurasian watermilfoil, loosestrife, Alligatorweed and Water hyacinth. In particular Eurasian watermilfoil and Purple Loostrife are non-indigenous and extremely detrimental to our nations fresh waterways.

Purple Loosetrife, *Lythrum salicaria* L., is a perennial plant that grows up to 8 feet in height. Purple loosestrife was introduced to the United States from Europe in the early 1800's in ship ballast and as an ornamental plant. The magenta flowers are the plants characteristic features. The distribution of purple loosestrife rapidly spread from 1940 to 1980 with the plant now growing wild in at least 42 of the 50 states. Its greatest concentration is in New England, Mid-Atlantic, and Great Lakes states. Wetlands infested with purple loosestrife often lose 50% of native plant biomass. Many wetlands become 100% infested with a dense coverage that significantly changes the native environment. Impacts to food and cover for wildlife habitat and decreasing sunlight and nutrients for native plants are the most significant threats to endangered or declining plant and animal species.

Eurasian watermilfoil, *Myriophyllum spicatum*, introduced from Europe and Asia, has spread throughout the United States since it was first observed in Washington D.C. in 1942. Watermilfoil invades lakes, ponds and reservoirs and is especially troublesome in nutrient rich waters. Due to its unique growth habits, Eurasian watermilfoil competes aggressively with native aquatic plants. As a winter annual, watermilfoil begins growth well before native species initiate growth. Later in the season, watermilfoil forms a dense canopy that covers and shades out existing vegetation. The plant's ability to grow in eutrophic conditions and over a broad temperature range also contributes to its competitive edge over native plants.

As a food source for waterfowl, both Eurasian watermilfoil and purple loosestrife have less nutrient value than the native plant species they replace. Their aggressive growth forms a dense structure that supports a lower abundance of invertebrates or insects that intern diminish the habitat for fish or waterfowl. In addition waterways filled with these exotics have less capacity to be of value for flood control. A review of SePRO's field data, documenting three years of our Experimental Use Permit (EUP) trials that will be reviewed and the efficacy of Renovate to selectively manage wildlife habitat will be discussed.

* Trademark of Dow Agrosciences manufacturer for SePRO Corporation

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SESSION 9B:

SOUTH FLORIDA LAKES

PALM BEACH COUNTY'S CHAIN-OF-LAKES: PAST, PRESENT, AND FUTURE

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The Palm Beach County Chain-of-Lakes consists of five interconnected lake systems, covering a linear distance of approximately 30 miles. Historically, the chain-of-lakes was part of an extensive wetlands system which was modified by channelization and dredging activities during the early 1990s. Lake surface areas range in size from approximately 34.8 acres to 378 acres, with mean depths ranging from 6.8 ft to 11.5 ft. Each of the five lakes exhibits primarily eutrophic water quality characteristics based upon calculated Trophic State Index (TSI) values.

In general, sediments within the chain-of-lakes consist of surficial layers of both consolidated and unconsolidated organic muck, extending to a depth of 0-8 inches, underlain by parent material consisting of brown to gray fine sand. Sediment phosphorus concentrations are somewhat elevated. However, extensive accumulations of organic muck are present in the south lobe of Lake Osborne, with muck accumulations ranging from a few inches to more than 10-15 ft in isolated pockets within the lake. The organic muck layers are frequently disturbed and resuspended into the water column by both wind action and boating activities which results in significant degradation of water quality characteristics in the southern lobe.

A qualitative survey of macrophyte species within the chain-of-lakes was performed during June 2002. Aquatic vegetation within the chain-of-lakes is limited primarily to shallow shoreline areas, and consists of a combination of native and non-native vegetative species. Thick areas of hydrilla are also present in portions of the chain-of-lakes, particularly in Pine Lake, Lake Osborne, and Lake Ida.

The existing hydrologic regime of the chain-of-lakes is quite complex and is regulated by a number of man-made canals and water structures. The chain-of-lakes are located along northern, central, and southern portions of the E-4 Canal system, with patterns and magnitudes of water movement regulated to a large extent by operational schedules of existing water control structures. Depending on the operation of the various control structures, water can move either from north-to-south or north-to-south. The dominant inputs into the chain-of-lakes consist of the E-4 and C-51 Canals. Residence times within the lakes are extremely short, ranging from 3-15 days in 4 of the 5 lakes.

Based on the extremely short residence times for each of the lakes, the water quality characteristics in each of the lakes is regulated primarily by the quality of the tributary inflow. As a result, significant improvement in water quality characteristics within the chain-of-lakes can only be achieved by improving water quality within the E-4 and C-51 Canal systems. Additional improvements in water quality characteristics can be obtained by removing or inactivating areas of nutrient-rich lake bottom sediments, particularly in South Lake Osborne.

Development of water treatment alternatives for the tributary inflow system is complicated by the large volumes of water that must be treated, combined with the fact that flow can rapidly switch directions, depending upon operation of water control structures. Since the E-4 Canal system feeds into the chain-of-lakes from both the north and south, separate treatment systems must be constructed on both the northern and southern ends of the system to provide treatment regardless of the flow direction. Due to soil limitations and other constraints, the most feasible treatment systems for improving water quality in the tributary inflows is a wet detention system or an off-line chemical treatment system. Based on a projected 20-year project life, the present worth costs for the wet detention treatment option is approximately \$74,016,140, with a present worth cost of \$38,576,550 for the chemical inflow treatment option. These present worth costs include capital construction costs as well as annual operation and maintenance costs for each of the two systems.

At the present time, large portions of the chain-of-lakes are virtually void of native emergent or submergent vegetation. Lake bottom vegetation, especially submergent vegetation, can be extremely effective in removing nitrogen and phosphorus from the water column and improving visual water quality by reducing phytoplankton concentrations. Based upon current water depths and available light penetration in the lakes, approximately 50-70% of the area of each of the five lakes could be planted with either emergent or submergent vegetation.

Sediment removal is recommended in South Lake Osborne to provide a deeper water column for improvement of navigation and safety, reduce nutrient recycling within the lake, reduce the incidence of shallow water macrophytes, and to provide a less toxic environment for organisms within the lake. The most feasible dredging method for South Lake Osborne appears to be hydraulic dredging. A containment pond would need to be constructed to provide disposal for the dredged material. The estimated cost of removing the existing 495,000 yd^3 of organic muck sediments from South Lake Osborne is approximately \$4,950,000.

A management plan for the chain-of-lakes was developed and the following recommendations are made for improvement of water quality in the chain-of-lakes:

1. The SFWMD is planning significant capital projects for the C-51 Canal, which should reduce water discharges and pollutant loads to the Palm Beach County Chain-of-Lakes. Therefore, construction of the tributary water treatment alternatives for the C-51 Canal, L-30 Canal, and E-4 Canal are not recommended at this time.

2. Revegetation of aquatic macrophytes in the chain-of-lakes is recommended due to the relatively low cost, compared to the other alternatives, and potential for improving water quality throughout the chain-of-lakes. The recommended revegetation plan can be completed for a capital cost of approximately \$4,428,000, with an annual operation and maintenance cost of approximately \$369,000.

3. Lake bottom sediment dredging of South Lake Osborne is also recommended to remove approximately 500,000 yd^3 of organic muck which is frequently resuspended from wind action and boating activities, contributing to degraded water quality and navigational safety issues. The estimated capital cost to perform sediment dredging in South Lake Osborne is $4,950,000.

4. Source controls are also recommended in the chain-of-lakes watersheds to minimize the quantity of stormwater runoff and pollutant loads which reach laterals, canals, and the lakes themselves. The source control project should include construction sediment erosion and control programs, improved operation and maintenance procedures, and regulations requiring source control implementation.

5. A public education program should be established by Palm Beach County to inform residents about the relationship between stormwater runoff and lake water quality.

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EVALUATION OF ENVIRONMENTAL IMPACTS ON AN URBAN LAKE IN CENTRAL FLORIDA

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Little Lake Wilson is a small urban lake (s.a. 7 acres, mean depth 7 feet, maximum depth 16 feet) located in Hillsborough County, FL. Major land use includes cropland, pastureland, commercial and services. In addition, Dale Mabry Highway (SR 597), one of the most important North-South connectors in the County, is located in the watershed. The relatively small watershed (immediate watershed ± 100 acres during small rainfall events i.e. a 10 year event with < 6”) renders the lake highly susceptible to environmental perturbation. Water quality data, collected on a regular basis since 1998, reflects the increase in development in the area specifically the impact of the widening of SR 597. One consequence of this project was the installation of a 36” stormwater pipe that discharges directly into the lake. The abundant flow of nutrients is accelerating eutrophication resulting in an environmental imbalance in the lake. The eutrophication process in this lake has manifested in an overgrowth of *Salvinia minima* (waterfern). An analysis of the drainage and topography of the area west of Dale Mabry that drains into Little Lake Wilson yields two major points of interest: the size of the drainage area relative to the lake and the diversity of land use. Historically, drainage water from this area reached the lake through sheet flow. Highway expansion along with area development has modified the flow rate of the runoff generated across Dale Mabry. The reduction of permeable surfaces has also resulted in a decrease in percolation causing a significant increase in the concentration of water column nutrients. We feel that this increase in nutrient availability is probably a significant cause of the outbreak of waterfern in Little Lake Wilson.

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DISPOSAL ALTERNATIVE FOR VEGETATIVE MATERIALS HARVESTED FROM LAKES

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The issue of disposal is becoming one of the most difficult subjects to deal with when planning any project involving vegetation or sediment removal. Careful forethought must be given to both the regulatory and financial concerns regarding this material. The Hillsborough County Public Works Department recently undertook an endeavor to remove over five acres of nuisance vegetation that was proving to be an impediment to proper flow as well as storage capacity for Lake Magdalene within the Sweetwater Creek Watershed. The lake outfall if formed by this small 10.3 acre pond which becomes the primary outfall for over 4000 acres of upstream watershed. The project scope was to harvest approximately five acres of floating or submerged nuisance vegetation, such as Primrose willow, Cattails and Punk trees. After exploring various clearing methods the decision was made to use mechanical removal. It would serve to perform a physical nutrient uptake, rather than allowing the plants to fallow within the water column. Disposal of the material was one of the chief considerations within the project design. Outright disposal of the material alone within a land fill would have cost in excess of $21,000. A system was devised in which we could compost the material on sight within the containment cell and then apply the material on carefully selected areas for soil enrichment. Through this process we were able to dispose of over 600 cubic yards of compost for under $5000.

NOTES:

[1] Southwest Florida Water Management District, 1992, Lake Seminole Diagnostic Feasibility Study Part 1, p vi.
[2] Ibid, p VIII-34.
[3] Pinellas County, 2001, The Lake Seminole Watershed Management Plan,
[4] Ibid p 1-2.
[5] Impaired Surface Water Rule (Section 62-303, Florida Administrative Code
[6] The Plan also recommended projects to address habitat, fisheries, education, recreation and flooding issues; however, these will not be discussed.
[7] Based on a 20 year cost for alum injection and the construction of 6 alum injection systems.

POSTER SESSION

IS YOUR LAKE ECOSYSTEM IN ...*Jeopardy?*

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An "Ecosystem" is nature's unit of organization in which all living organisms collectively interact with the physical and chemical environment as one physical system. NALMS is an organization of individuals and groups with a very diverse set of perspectives, which interact for the protection and restoration of aquatic ecosystems. Much is involved for ecosystem management to be successful - much more than just good science. Lake managers must have an extensive knowledge in various disciplines to successfully ameliorate problematic lake conditions.

This poster presentation is the second in a series of audience-interactive presentations in a "game show format". Competition categories include:

Jeopardy:

Acronyms in Lake Management
Applied Limnology
In-Lake Management Techniques
Terminology & Jargon
Reservoirs & Lakes
People & Places

Double Jeopardy:

Trophic Dynamics
Biology
Properties of Water
Watershed Management

Final Jeopardy:

Ecosystem Ecology

Test your knowledge; compete with your colleagues.
Answers in the form of a question, please!

PESTICIDE RESIDUE ISSUES IN FLOODPLAINS, WETLAND RESTORATION, AND SURFACE RUNOFF MANAGEMENT

William A. Tucker, Ann B. Shortelle, and Eric Arenberg
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An emerging concern for Florida's Water Management Districts, FDEP, and local governments who are acquiring former agricultural land for preservation and recreational uses is residual contamination due to past land practices. General procedures for assessing acquisitions and planning restoration will be presented, as well as a case study involving a parcel in the Lake Monroe (Seminole County, SJWMD) floodplain that will be used for wetland restoration, surface water retention, recreation, and other park-like amenities.

As the prime contract supporting a comprehensive program of assessment and remediation of sites operated by The University of Florida's Institute for Food and Agricultural Sciences (IFAS) at 28 research facilities throughout the state of Florida, a variety of lessons learned concerning pesticide residue issues at such sites have been developed. For example:

- At most sites unacceptable pesticide and herbicide contamination is not associated with pesticide application practices.
- Unacceptable concentrations in soil and/or groundwater are frequently limited to well-defined source areas such as mix/rinse areas, pesticide storage and waste disposal locations.
- Cattle dip vats where arsenical pesticides were used for tick eradication represent important localized sources of arsenic in soil.
    - Arsenic levels in soil remains a sensitive issue because risk-based screening levels for residential and recreational use have recently been lowered and are currently near natural background concentrations.
    - A rapid soil arsenic field test has been developed that can identify these low levels quickly to guide definitive sampling and delineation.
- Several sites have been or may be closed and the land re-used residentially or for various public purposes including recreation, water management, or wetland mitigation. Appropriate risk management alternatives for reuse of the land has raised new and challenging questions.

Key Terms: agriculture; pesticides; assessment remediation; arsenic; field screening method

IN-LAKE METHODS YOU'VE NEVER HEARD ABOUT

Robert W. Kortmann, Ph.D.
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Lake ecosystems, like organisms, can be more autotrophic ("driven by internal primary productivity"-autochthonous organics) or more heterotrophic ("driven by inputs of allochthonous organics" - *photosynthesis happens in the watershed too!).* Most lake assessment (and many lake management) methods focus on the autotrophic nature of lake ecosystems. For example, trophic state indices (TSI) often use chlorophyll-a, Secchi disk transparency, and total phosphorus concentration (TP) to characterize the trophic state of a lake. These parameters relate most directly to pelagic phytoplanktonic autotrophy and do not account for littoral or allochthonous organic inputs (remember "trophy" refers to the rate of supply and production of organic matter). Assessment methods which use whole ecosystem respiration measures account for allochthonous sources of organic carbon as well. Anoxic factor, AHOD, Dissolved Inorganic Carbon Increments, Respiratory Quotients and similar methods measure respiration of the "ecosystem organism" (both aquatic and terrestrial productivity influences - *Is detritus productive?).*

By viewing lakes as "land-water ecosystem organisms", often with unique chemical, physical, and biological attributes, several potentially useful management strategies emerge, some of which are quite inexpensive and "naturalistic". Several in-lake methods that you've (probably) not heard of (few have) are discussed, including:

- Flow Routing / Depth-Selective Outflow: This is a gravity/hydrology driven approach which manipulates depth-discrete flushing rates in a thermally stratified system. It is particularly attractive for aquatic systems which exhibit a large watershed to lake area ratio (healthy water budget), and where the anoxic water volume is small relative to the area which it covers (management design criteria deal with volume exchanges - internal phosphorus loading is related to areal P release).
- Winter Thermal Treatment: The land-locked alewife *(Alosa pseudharengus)* has been intentionally and unintentionally introduced into many lake ecosystems. After establishing a substantial population (over about 10-15 years) lakes tend to express a more eutrophic character. Zooplankton grazers such as *Daphnia sp.* become very rare, algal biomass accumulates, and many additional indirect impacts occur. Winter thermal treatment is a simple, inexpensive, physical method to substantially reduce alewife populations and to augment biomanipulation via piscivorous fish stocking.
- Iron Cycle Manipulation and Enhancement: The iron cycle (ferric-ferrous couple) plays very important roles at the bottom of lakes (especially in relatively low alkalinity, softwater systems). It is a primary participant in respiration as an alternate terminal electron acceptor (ATEA), and it is the primary agent for the binding of phosphorus in sediments. In some (perhaps many) lakes which have experienced a eutrophic level of areal productivity for many years the iron cycle has been depleted (aka "iron deficiency" or "anemic lakes"). The iron cycle can be restored in such lakes by relatively low cost sediment amendment treatments- restoring a phosphorus removal

mechanism that is driven by the natural respiratory pathways functioning at the bottom of the lake. In lakes which exhibit high ferrous iron in hypolimnetic waters, the lake-generated iron can be used to precipitate phosphorus after altering the redox state

- Alum Surrogates: The use of alum has gained popularity in recent years. Toxicity related to pH shift and aluminum has been "designed around" by methods which maintain pH> 6.0. However, little attention has been given to the potential long-term impacts of the large sulfur loads which accompany alum treatment. Might this shift the redox system from iron to sulfide generation (with very obvious consequences). Might the added sulfur lead to ferrous sulfide deposition and iron deficiency? Might it be better to use an alum surrogate like aluminum nitrate, where the nitrate would leave the system as nitrogen gas (via dissimilatory nitrate reduction - an anaerobic process which occurs at a redox potential above iron reduction and sediment-phosphorus liberation). Perhaps there are analogous ways to precipitate phosphorus and seal sediments which don't load a system with sulfur and which maintain *ambient* pH.
- Layer Aeration Strategies: Layer aeration is a process which creates a cool aerobic layer(s), bounded by "functional thermoclines" (note: resistance to mixing due to density differences as a function of temperature are additive- thermal structure can be manipulated without eliminating stratification). The process takes advantage of photosynthetic oxygen production above the compensation depth to offset respiratory demand in deeper waters. In a sense, layer aeration is a depth-discrete artificial circulation approach. It manipulates *how* a lake stratifies without *preventing* stratification. Hence, it is useful for management of water supply quality (at specific intake depths), for creating layers which meet cold water fish habitat suitability requirements, for maintaining zooplankton refugia, and for isolation of deep waters with accumulated P due to sediment release. The method is also useful for maintaining cool/cold aerobic layers while allowing the deepest hypolimnion to become anaerobic and perform denitrification (dissimilatory nitrate reduction is an anaerobic process performed by facultative anaerobes - *not all anaerobiosis is "bad').*
- Alternative Algaecides: In some places around the world algaecides other that copper sulfate are being used with some success. Low dose oxidants tend to provide adequate control, particularly against nitrogen-fixing Cyanobacteria (which have a high cellular iron requirement, and nitrogenase is "turned off'). Low dose oxidants (e.g. hydrogen peroxide, permanganate) can provide algaecidal and algaestatic properties, as well as removing micronutrients (eg. Iron removal from surface waters can inhibit Cyanobacteria).

Many effective lake management methods remain to be explored and discovered. As we learn more about the operation of lake ecosystems, we will learn more about how to effectively manage them. "Kapieren and Kopieren"- "First understand nature, then imitate it".

Well, had you ever heard of these in-lake approaches?

ARSENIC LEVELS IN NATIVE FLORIDA SOILS AND ALUM RESIDUAL USED IN WETLAND RESTORATION PROJECTS

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Arsenic is the 20" most abundant element in the Earth's crust. Arsenic is ubiquitous, occurring naturally in rocks and soil, water, air, plants and animals. It is released into the environment through natural activities such as volcanic action, erosion of rocks, and forest fires, or through human actions. Approximately 90% of industrial arsenic in the U.S. is currently used as a wood preservative, but arsenic is also used in paints, dyes, metals, drugs, soaps, and semiconductors. Agricultural applications, mining, and smelting also contribute to arsenic release to the environment.

Studies have linked long-term exposure to arsenic in drinking water to cancer of the bladder, lungs, skin, kidney, nasal passages, liver, and prostate. Non-cancer related effects of ingesting arsenic include cardiovascular, pulmonary, immunological, neurological, and endocrine (e.g., diabetes) effects.

Arsenic concentrations are generally higher in organic soils and aquatic systems. Chen, et al. (2002) surveyed the arsenic background concentration of Florida soils and determined that Histosols (organic soils) contained the greatest concentrations of arsenic (0.15-11.7 mg/kg). Extensive soil sampling on the North Shore Restoration Area of Lake Apopka indicated a mean arsenic concentration of 3.36 mg/kg within the top foot of the muck (organic) soils.

Alum residual is a by-product of the drinking water treatment process and is currently being used by the St. Johns River Water Management District (SJRWMD) to reduce phosphorus (P) flux from soils to flood water in the recently purchased North Shore Restoration Area properties and Phase I of the Lake Apopka Marsh Flow-Way. The alum residual binds free P in the soil and helps reduce P loading to Lake Apopka.

The alum residual used at Lake Apopka is a by-product generated by the Lake Washington Water Treatment Plant (LWWTP) in Melbourne. Surface waters naturally contain suspended materials such as sand, microscopic organisms, clay, and organic particles that can cause color, taste, odor, and turbidity. The LWWTP utilizes aluminum sulfate (alum) to coagulate these particles from the lake water. Granulated activated carbon and quick lime are also added to assist in particle removal. Polymers are used to facilitate dewatering the alum residual. The alum residual retains a high binding capacity for P (60 mg P/g) and it is this property which makes it useful at Lake Apopka. The average arsenic concentration in LWWTP alum residual is approximately 4.8 mg/kg.

WTP residuals are not generally considered hazardous wastes. As part of the RCRA Subtitle C regulations, the U.S. Environmental Protection Agency (EPA) defines hazardous wastes as ignitable, corrosive, reactive, or toxic. According to EPA, the greatest concern for WTP residuals is toxicity, as determined by the Toxicity Characteristic Leaching Procedure

(TCLP). A waste is deemed hazardous if the arsenic concentration in the TCLP leachate exceeds 5 mg/L. The LWWTP residual was evaluated for safety through TCLP leachate and bioassay tests. Arsenic concentrations were not detectable within the TCLP leachate, and the residual therefore would not be classified as hazardous waste. The LWWTP alum residual has also been evaluated using the Florida Department of Environmental Protection Synthetic Precipitation Leaching Procedure (SPLP). The arsenic concentrations from the SPLP process were also nondetectable. Bioassay tests performed on the alum residual indicated no toxicity to aquatic organisms.

The LWWTP residual has been thoroughly tested for phosphorus removal effectiveness from bench top to field scale studies. Approximately 75,000 wet tons (3,250 truck loads) of alum residual were hauled from the Lake Washington WTP. This represented approximately 25 years of stockpiled material covering 18 acres adjacent to the plant. In 1999, approximately 2,000 acres were treated at a rate of 6.5 wet tons per acre at the former Duda Jem Farm (totaling approximately 13,000 wet tons of residual). This application rate increases the average arsenic concentration in the top foot of soil by less than 0.2%. Future plans include alum residual application to approximately 9,000 acres in the North Shore Restoration Area and eventually reflooding the entire area.

For future use of alum residual it is important to note that on February 22, 2002, a new EPA standard for arsenic in drinking water at 10 ppb became effective, replacing the old standard of SO ppb. The date by which drinking water systems must comply with the new 10 ppb standard is January 23, 2006. The potentially increased arsenic concentrations within WTP residuals will need to be reviewed as plants begin retrofitting their coagulation processes to remove more arsenic from the source water.

References

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