Proceedings of the
Florida Lake Management Society
2000 Annual Conference

FLMS
Florida Lake Management Society

Hawk's Cay Resort
Duck Key, Florida
May 22-25, 2000

FLMS

FLORIDA LAKE MANAGEMENT SOCIETY

2000 ANNUAL MEETING

Hawk's Cay Resort
Duck Key, FL

May 22-25, 2000

FINAL PROGRAM

SUNDAY - MAY 21, 2000

4:00-6:00 pm	Check-In and Registration

MONDAY - MAY 22, 2000

9:00 am-5:00 pm	Check-In and Registration
10:00 am-1:00 pm	Workshop A: Environmental Statistics (Coordinator: Dr. Harvey H. Harper, P.E.)
1:00-2:00 pm	Lunch (on your own)
2:00-5:00 pm	Workshop B: Selection of Stormwater BMPs (Coordinator: Dr. Harvey H. Harper, P.E.)
5:00-5:30 pm	Resort and Activities Orientation

TUESDAY - MAY 23, 2000

8:00 am-3:40 pm	Check-In and Registration
8:00-8:45 am	Continental Breakfast
8:45-9:00 am	Opening Remarks

Session 1: Habitat Studies and Impacts
Moderator: Nancy Page

9:00-9:20 am	**Persistence and Enlargement of Boat-Grounding Scars on Seagrass Beds in South Florida -** William F. Precht
9:20-9:40 am	**Pond Apple Habitat Restoration Project -** Janet J. Phipps and Carman N. Vare
9:40-10:00 am	**A Comparative Biological Assessment of Cape Coral's Proposed Reverse Osmosis Concentrate Mixing Zone -** Chuck Kelso
10:00-10:20 am	**Cyanotoxic Algal Blooms in Florida's Lakes, Rivers, and Tidal River Estuaries -** Chris Williams, Andrew Chapman, Wayne Carmichael, Marek Pawlowicz, and John Burns
10:20-10:40 am	MORNING BREAK (Exhibit Hall)

Session 2: Restoration Studies and Issues
Moderator: Donald C. Hicks

10:40-11:00 am	**Natural Drawdown and Restoration of Lake Jackson, Leon County, Florida** -Tyler L. Macmillan
11:00-11:20 am	**Restoration of Lake Jackson, Leon County, Florida and Future Funding Opportunities by FWC -** Michael J. Hill
11:20-11:40 am	**Newburgh Lake Restoration Case Study -** Larry Danek, Doyle Cottrell and John O'Meara
11:40-12:00 noon	**Establishing a Phosphorus Loading Goal for the Restoration of a Large Urban/Suburban Lake -** Dean R. Dobberfuhl and Lawrence Keenan
12:00 noon-1:00 pm	LUNCH

Session 3: Lake Apopka
Moderator: Erich R. Marzolf

1:20-1:40 pm	**Investigation into the Deaths of Fish-Eating Birds at Lake Apopka: Preliminary Wildlife Results -** Roxanne Conrow, Elizabeth Mace, and Steven Richter
1:40-2:00 pm	**Investigation into the Deaths of Fish-Eating Birds on Former Muck Farms at Lake Apopka: Preliminary Soil Results -** Erich Marzolf, Michael Coveney, Dawne Wilson, Edgar Lowe, and Robert Sorvillo
2:00-2:20 pm	**Inferring Historic Phytoplankton Shifts in Lake Apopka Using Sedimentary Algal Pigments -** Matthew N. Waters and Claire L. Schelske
2:20-2:40 pm	AFTERNOON BREAK (Exhibit Hall)
2:40-3:00 pm	**What Will Lake Apopka Be Like in 50 Years? -** Roger W. Bachmann, Mark V. Hoyer, and Daniel E. Canfield, Jr.
3:00-3:20 pm	**Update on Improvements in Water Quality in Lake Apopka -** Erich Marzolf, Michael Coveney, Roxanne Conrow, James Peterson, and Edgar Lowe
3:20-3:40 pm	Panel Discussion
3:45-4:15 pm	**FLMS BUSINESS MEETING**
5:30-7:00 pm	EXHIBITOR'S SOCIAL (Exhibit Hall)

Poster Session: Progressive Public Education and Volunteer Programs: An Integrated Approach to Addressing Water Quality - Sandi Hanlon and Kim Ornberg

WEDNESDAY - MAY 24, 2000

8:00 am-3:00 pm	Check-In and Registration
8:00-9:00 am	Continental Breakfast

Session 4: Diagnostic Studies
Moderator: Pamela Leasure

8:40-9:00 am	**A Preliminary Investigation of Potential Effects of Alum Treatment on Benthic Macroinvertebrate Communities -** David L. Evans, Simon A. Cordery, Charles R. Fellows, Eric D. Flagg, and Christine S. Hartless
9:00-9:20 am	**Beyond Total Nutrients: Watershed Activities and Limiting Factors for Algal Growth in Lake Wales Ridge Transition Lakes -** Clell J. Ford
9:20-9:40 am	**Phosphorus Relationships and Issues Between Lake Istokpoga, Tributaries and Outflows -** Jennifer L. Brunty
9:40-10:00 am	**Finding the Smoking Gun to Identify Pollution from On-Site Sewage Treatment Disposal Systems -** C. Joe King
10:00-10:20 am	**Impacts of Alum Sediment Inactivation on Internal Recycling and Groundwater Seepage in the Winter Park Chain-of-Lakes** -Harvey H. Harper
10:20-10:40 am	MORNING BREAK (Exhibit Hall)

Session 5: Water Quality Issues
Moderator: Douglas A. Leeper

10:40-11:00 am	**Water Quality Changes in Lake Adair Following Removal of Roosting Cormorants -** Kevin D. McCann, Lee D. Olson, and Patricia G. Hardy
11:00-11:20 am	**Results of the Seagull Dispersal Plan to Reduce Fecal Coliform Contamination in Lake Fairview -** Richard A. Baird, Kevin D. McCann, and Linda M. Jennings
11:20-11:40 am	**Eutrophication Reduction in Stormwater Treatment Systems by User-Based Acceptance of Defined Fertilization Program -** Joseph L. Gilio
11:40-12:00 noon	**The Problem of Achieving Clean Stormwater Runoff in a Residential "Waterfront Wonderland" -** Connie S. Jarvis
12:00-12:20 pm	**Modeling the Performance Efficiency of Florida Stormwater Treatment Systems -** Jeffrey L. Herr
12:20-1:20 pm	LUNCH

<u>Session 6: Issues for the Restoration of Lake Okeechobee</u>
Moderator: Chuck Hanlon

1:40-2:00 pm	**Effects of a Habitat Enhancement Project on Age-0 Largemouth Bass Abundance, Growth, and Habitat Quality at Lake Kissimmee, Florida -** Mike Allen and K.I. Tugend
2:00-2:20 pm	**Using Remote Sensing and GIS to Evaluate Long-Term Patterns of Change in Vegetation Cover in Lake Okeechobee, Florida -** Chuck Hanlon
2:20-2:40 pm	**Using GIS to Develop a Cartographic Model of Vegetation Distributions in the Littoral Zone of Lake Okeechobee -** Mark A. Brady and Charles Hanlon
2:40-3:00 pm	**Habitat Use of the American Alligator in the Everglades -** Cory R. Morea, Kenneth G. Rice, H. Franklin Percival, and Stanley R. Howarter
3:00-3:20 pm	AFTERNOON BREAK (Exhibit Hall)

<u>Session 7: Everglades and Florida Bay</u>
Moderator: Frank E. Marshall, III

3:20-3:40 pm	**The Everglades Nutrient Removal Project Test Cells: The Use of Experimental Wetlands to Optimize Performance of Stormwater Treatment Areas - Status of Research -** Jana Newman and Tammy Lynch
3:40-4:00 pm	**Decomposition of Cellulose in Relation to Nutrient and Water Loading Rates in a Subtropical Constructed Wetland -** Tammy Lynch and Jana Newman
4:00-4:20 pm	**Florida Bay Salinity Transfer Function Analysis -** Frank E. Marshall, III
4:20-4:40 pm	**Florida Bay Watch: Results of Four Years of Nearshore Water Quality Monitoring in the Florida Keys -** Brian D. Keller, Arthur Itkin, and David R. Bryan
5:00-7:00 pm	VOLLEYBALL TOURNAMENT (teams selected at random from list of interested persons) TUG-OF-WAR (Engineers vs. Biologists)
7:00-8:00 pm	COCKTAIL HOUR
8:00-9:30 pm	BANQUET AND ANNUAL AWARDS

THURSDAY - MAY 25, 2000

8:00-10:00 am	Check-In and Registration
8:00-9:00 am	Continental Breakfast

Session 8: Stormwater/Watershed Issues
Moderator: Ernesto Lasso de la Vega

8:40-9:00 am	**The Application of BASINS to Comprehensive Watershed Management -** Craig Dye, Jim Griffin, and John Rickerson
9:00-9:20 am	**The Importance of Local Hydrology and Particle Size Distribution in BMP Design for Suspended Solids Removal -** G. Bryant
9:20-9:40 am	**An Evaluation of Seasonal Water Level Fluctuations in Artificial Ponds in Coastal Southwest Florida** - John Cassani and Ernesto Lasso de la Vega
9:40-10:00 am	**Treatment of Stormwater Runoff from an Agricultural Basin by a Wet-Detention Pond in Ruskin, Florida -** Betty T. Rushton, Benjamin M. Bahk, and Melissa Musicaro
10:00-10:20 am	**Using Information Technology and the Internet to Improve Watershed Management -** Kyle N. Campbell, Shawn M. Landry, and Tim Foret
10:20-10:40 am	MORNING BREAK (Exhibit Hall)

Session 9: Water Quality and Management Issues
Moderator: Shailesh K. Patel

10:40-11:00 am	**Developing a Lake Management Plan for the Tsala Apopka Chain-of-Lakes Using a Modified Team Approach -** Mark Hoyer, Christine A. Horsburgh, and Daniel E. Canfield, Jr.
11:00-11:20 am	**Dredged Sediments - A Recovered Resource -** Shailesh K. Patel, Wayne A. Ericson, Martin S. Smithson, Joel S. Steward, and Tom L. Price
11:20-11:40 am	**Lake Persimmon Water Quality Investigation and Water Quality Restoration Plan -** Keith V. Kolasa, Craig W. Dye, Thomas J. Whitmore, and Clell J. Ford
11:40-12:00 noon	**Environmental Implications of High Radium-226 Activities in Florida Lakes** -Mark Brenner, Joseph M. Smoak, William Kenney, Thomas J. Whitmore, Micheal S. Allen, Claire L. Schelske, and Douglas A. Leeper
12:00 noon-1:20 pm	LUNCH (Volunteer Monitoring Network Members Only)

<u>Session 10-A: Lake Level Issues</u>
Moderator: Seán E. McGlynn

1:20-1:40 pm	**Okeeheepkee, Disappearing Waters, and the Karst Lakes of Leon County -** Seán E. McGlynn
1:40-2:00 pm	**The Rehabilitation Program for Alligator Lake, Columbia County, Florida -** Robert A. Mattson
2:00-2:20 pm	**Establishing Minimum Lake Levels in the Southwest Florida Water Management District: An Update of Current Approaches -** Douglas A. Leeper and Martin H. Kelly
2:20-2:40 pm	**Hydraulic Seepage Within an Astatic Karst Lake, North Central Florida -** James D. Hirsch and Anthony F. Randazzo

<u>Session 10-B: Volunteer and Citizen Monitoring Programs</u>
Moderator: Jim Griffin

1:20-1:40 pm	**The Hillsborough County Volunteer Monitor Experience - How Do We Measure Success in Environmental Education Programs? -** Carlos A. Fernandes and Julia Palaschak
1:40-2:00 pm	**Frog Listening Network -** Laura Maniscalco Delise and Dianne McCommons Beck
2:00-2:20 pm	**Watershed Action Volunteer (WAV) Program - St. Johns River Water Management District -** Patricia G. Hardy and William Watkins

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SESSION 1

HABITAT STUDIES AND IMPACTS

Tuesday – May 23, 2000
9:00 – 10:40 a.m.

POND APPLE HABITAT RESTORATION PROJECT

Janet J. Phipps, Ph.D. and Carman N. Vare
Palm Beach County Department of Environmental Resources Management
West Palm Beach, Florida

Palm Beach County, especially the eastern portion of the county, has undergone extensive alterations due to development. The freshwater lakes are remnants of a once-natural freshwater system of open water and wetlands located along the western slope of the coastal ridge. This system has been dredged, filled in, and channelized to accommodate urban development. In addition, the extensive drainage canal systems which crisscross south Florida drain urban, industrial, and agricultural pollutants to the lakes. All the lakes are interconnected by the E4 canal and ultimately discharge into the Lake Worth Lagoon; thus, they are essentially flow through systems. As such, they are less eutrophic than would be expected considering they represent significantly less that one percent of their drainage basins. As part of the enhancement programs= effort to replace the lost wetlands associated with the freshwater lake system, 32 shoreline restoration projects encompassing 8.5 miles of shoreline within publicly-owned lands are outlined in the *State of the Lakes* management and enhancement plan adopted by the Palm Beach County Board of County Commissioners January 1998. Pond Apple Habitat is the first such project completed in Lake Osborne.

Pond Apple Habitat is located on a finger canal connecting to the E4 canal which enters the north lobe of Lake Osborne. This restoration project is unique in that an approximate 0.3 acre stand of mature pond apple trees (*Annona glabra*) survived on the shoreline despite extensive exotic species invasion. These pond apple trees are one of the few remaining such resources within the entire county. Enhancing and creating additional wetlands around the pond apple trees was the goal of the project. An additional 2.5 acres of vegetated wetlands were created around the existing trees, incorporating them into an herbaceous/hardwood wetland. After removing over 200 large exotic trees, approximately 10,000 cubic yards of fill were removed essentially doubling the width of the canal and adding shallow-water habitat to an area where it previously did not exist. An additional 240 trees, including cypress (*Taxodium distichum*) and pond apples, were added. Red maple (*Acer rubrum*), red bay (*Persea borbonia*), and dahoon holly (*Ilex cassine*) were added to the higher elevations. Additionally, open areas were planted with over 16,000 herbaceous plants to accommodate an open water view for the public. Herbaceous plants included fire flag (*Thalia geniculata*), leather fern (*Acrostichum* spp.), canna (*Canna flacida*), swamp lily (*Crinum americanum*), pickerelweed (*Pontederia cordata*), to name a few. Although it is planned to add tape grass (*Vallsineria americana*) to open littoral areas, this species was not included in the construction contract due to the uncertainty of success with this species. Volunteer events with college students are planned to relocate tape grass plugs from existing sources within Lake Osborne to the project site upon receipt of the appropriate permits from the state.

The project design enhanced the existing hardwood component of the wetlands in anticipation of a heronry developing. This spring a limpkin (*Aramus guarauna*) nest is present and tricolored herons (*Egretta tricolor*) have already nested in the existing pond apples.

Numerous wading birds, including the endangered wood stork (*Mycteria americana*) are already feeding in the created littoral zone. An osprey platform was installed on an inactive utility pole that was present and was retained for that purpose. Ospreys are already using the platform for resting and feeding.

This project is located partially on land owned by the state for Palm Beach Community College and on County-owned parks property. The college has been a partner in this project in not only providing exotic vegetation removal funds but closely working with our Department so that the environmental sciences classes and students have first-hand experience in environmental restoration. The students have and are providing the biological monitoring before and after construction and are the volunteer force to plant additional plants as well as assist in the control of exotic plant species and cleanups. This close-working relationship with the college faculty and students for the long-term care of this enhancement project is unique and emphasizes the importance of environmental education associated with such enhancement project.

Funding for this project was provided by the Florida Fish and Wildlife Conservation Commission’s Lake Restoration Program, Palm Beach Community College, Palm Beach County’s Vessel Registration Fund, and the Department of Environmental Resources Management.

A COMPARATIVE BIOLOGICAL ASSESSMENT OF CAPE CORAL'S PROPOSED REVERSE OSMOSIS CONCENTRATE MIXING ZONE

Chuck Kelso
City of Cape Coral
Cape Coral, Florida

Introduction

The City of Cape Coral's Reverse Osmosis (R.O.) Water Treatment Facility provides potable water to approximately 70,000 Cape Coral residents. This R.O. facility converts the saline Lower Hawthorn aquifer into a reliable potable water supply. Water extracted from the Lower Hawthorn aquifer also protects the Middle Hawthorn and surficial aquifers from excessive withdrawals.

The saline water of the Lower Hawthorn is made potable by the pressurized reverse osmosis process. This process extracts potable (product) water from the non-potable (raw) water of the Lower Hawthorn aquifer. The saline raw water is pre-treated upon entering the R.O. facility. After pre-treatment the raw water is separated into potable product water and concentrate (reject). The product water is distributed to Cape Coral's residents and the concentrate is released to the City's tidal saltwater canal system. Prior to release, this concentrate is oxygenated and treated to achieve Class III water quality standards. The concentrate is released from a manifold in Lake Finisterre. This lake is part of a 100-mile canal network connected to the tidal Caloosahatchee River. The Lake Finisterre concentrate discharge manifold is currently considered a point source industrial discharge because of the concentrate's flow volume and treatment processes. The industrial discharge status of the concentrate flow requires stringent discharge compliance monitoring. Regulatory compliance is currently achieved with Federal and State permits (U.S. Environmental Protection Agency NPDES permit # FL004008 and a Florida Department of Environmental Protection Temporary Discharge Permit). Prior to this bioassessment, the discharge permits required the concentrate to be regularly sampled within five feet of the manifold discharge ports. The City was offered a mixing zone exemption pursuant to the provisions of Rule 62-4.244(1)(c). This exemption expanded the mixing zone throughout the Lake Finisterre canal system. The goal of expanding the mixing is to achieve Florida Class III marine water quality standards while effectively increasing the dilution factor of the concentrate stream. The Florida Department of Environmental Protection (FDEP) requested a biological assessment of the proposed mixing zone as a condition of approval for this exemption. This biological assessment is a comparative inventory of the near-shore habitats, benthic infauna and phytoplankton communities near the Lake Finisterre concentrate manifold. The biological parameters of the proposed mixing zone are compared to a similar, but hydrologically separate canal in south Cape Coral. This comparison is designed to evaluate the biological impact of the concentrate within the mixing zone.

Results and Discussion

Surface Water Quality.

Surface water quality parameters at all three sample sites (R.O. 1, R.O. 2 and Bimini) were predominantly within FDEP-endorsed water quality standards. Dissolved oxygen concentrations were slightly depressed (3.22-3.85 ppm) in the bottom waters of all sample sites. The water column of all three sites also displayed moderate salinity stratification.

Habitat Quality and Characterization.

All sample sites were man-made waterways. Shoreline vegetation was minimal (<10% mature *Rhizophora mangle* and *Laguncularia racemosa*). Bulkheads and rip-rap provided substrate for encrusting oyster communities. Attached filamentous algae were also common on these substrates. Deeper substrates (>1m) were primarily siliceous sand mixed with organic detritus and small shell material. The sediment samples at all three sites appeared light-colored and oxygenated. Hydrogen sulfide odors were not detected in any of the sampled sediments. Fish and periphyton were abundant at all three sites. The Marine Benthic Habitat Assessment Score (FDEP) was 44 at all sample sites. This identical score is caused by the identical design criteria of Cape Coral's man-made waterways.

Benthic Macroinvertebrates.

Mean taxon counts for the sites were 16.33 at R.O.1, 18.33 at R.O.2 and 11.00 at Bimini. These differences, however were not significant ($p>0.05$). Station R.O.2's mean Shannon-Weaver Diversity Index of 3.10 was significantly higher ($p<0.05$) than both R.O.1 and Bimini (1.80 and 1.25, respectively). Station R.O.2's proximity to the aerated concentrate discharge and higher flow could influence the elevated diversity at R.O.2. Stations R.O.1 and Bimini showed no significant difference in benthic macroinvertebrate diversity.

Phytoplankton Diversity and Taxonomic Richness.

Shannon Weaver Diversity of three phytoplankton tows was similar (R.O.1: 1.32, R.O.2: 1.94 and Bimini: 1.16, see Table 3). Taxonomic richness was also similar in the phytoplankton samples (R.O.1: 5, R.O.2: 6 and Bimini: 6). Chrysophycea (diatoms) occupied 95% of the proposed mixing zone samples (R.O.1 and R.O.2) while *Anabaena*, a cyanobacterium dominated 80% of the Bimini phytoplankton sample.

Conclusion

The results of this study indicate that Cape Coral's reverse osmosis concentrate discharge has no adverse effects on the benthic infauna near the discharge manifold. The benthic infauna diversity and taxa richness near the discharge were equal to, or higher than, the values measured at the reference site. Phytoplankton diversity and taxa richness were also similar among all sample sites. These results also indicate that the concentrate discharge has no adverse effect on the phytoplankton community near the discharge manifold.

References

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CYANOTOXIC ALGAL BLOOMS IN FLORIDA'S LAKES, RIVERS, AND TIDAL RIVER ESTUARIES

Chris Williams[1,4], Andrew Chapman[1],
Wayne Carmichael[3], Marek Pawlowicz[4],
and John Burns[1]

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Harmful algal blooms (HABs) are significant proliferations of algal cells beyond background levels that exert negative impacts on the environment, economy, and human health. The state of Florida has an extended history of HAB events in many of its largest and most utilized water systems. In 1998, the Florida Harmful Algal Bloom Task Force was established by the Florida Department of Environmental Protection to develop a plan of action for use in the event of a HAB outbreak. One of the first objectives of the Task Force was to determine what types of HABs are the most prevalent in Florida and which of these are of the greatest concern in regards to both the ecology of Florida's waterways and human health. In March of 1999, the Task Force identified cyanobacteria (blue-green algae) as one of the top research priorities for further investigation (Steidinger et al., 1999), due to their inherent abilities to produce toxic compounds and act as tumorigenic agents. In June of 1999, the St. Johns River Water Management District (SJRWMD) initiated a collaborative study with the Florida Marine Research Institute, the Florida Department of Health, and Wright State University to determine the geographical distribution of toxigenic cyanobacteria and their associated toxins in Florida's surface waters.

In conjunction with other federal, state, and county agencies, the SJRWMD developed a biomonitoring program to determine the prevalence of toxigenic cyanobacteria throughout the state of Florida. Each representative water body was prioritized for sampling by trophic level, history of cyanobacterial blooms, size, relative recreational use, special federal and/or state designations, and utilization or potential utilization as a drinking water resource. Water samples were analyzed for plankton composition, with identification to the lowest taxonomic level possible, and estimates of biomass and relative dominance were reported by genera/species. Those samples that contained high biomasses of any cyanobacterial species previously documented to produce algal toxins were analyzed further for toxin composition and toxicity. Toxin composition analyses consisted of enzyme-linked immunosorbent assays, protein phosphatase inhibition assays, anticholinesterase activity assays, and high performance liquid chromatography. Toxicity analyses were performed using mouse bioassays. The types of analyses performed on individual water samples depended on the algal species identified in the samples. Mouse bioassays were not performed on all samples collected.

A total of 167 water samples were collected throughout the state of Florida between June 10 and November 4, 1999. *Microcystis*, *Cylindrospermopsis*, and *Anabaena* species were the most frequently observed toxigenic cyanobacteria. *Microcystis aeruginosa*, *Cylindrospermopsis raciborskii*, and *Anabaena circinalis* were the most prevalent species reported. Species of *Planktothrix*/*Oscillatoria*, *Coelosphaerium*, *Lyngbya*, and *Aphanizomenon* also were observed but much less frequently. A total of 88 samples, representing 75 individual water bodies from throughout the state of Florida, contained significant levels of toxigenic cyanobacteria. Co-occurrence of toxigenic species was common. Of the known cyanotoxins, microcystins and cylindrospermopsin were positively identified in 77 and 34 water bodies, respectively. Anatoxins were not found in any of the samples. Cylindrospermopsin was positively identified in all assayed samples that contained *Cylindrospermopsis raciborskii*. Mouse bioassays showed that 78% of the samples with measurable levels of microcystins and cylindrospermopsin were lethally toxic, while protein phosphatase inhibition assays demonstrated that 80% of the samples that contained microcystins exhibited potentially tumorigenic properties.

The three major types of toxigenic cyanobacteria identified in this study all warrant great concern. *Microcystis* species are problematic in that they are the toxic algae most often observed in samples from Florida waters. *Cylindrospermopsis raciborskii* is a relatively unstudied algal species that is being reported more frequently in Florida as biologists become more familiar with its identification. This species exhibits several disturbing characteristics, such as its distribution throughout the water column and its abilities to maintain high levels of biomass year-round, fix atmospheric nitrogen, and grow under low phosphorous levels. *Cylindrospermopsis*, *Anabaena* and *Microcystis* all have been positively associated with animal and human sickness and mortality (Sivonen and Jones, 1999; Kuiper-Goodman et al., 1999). The high prevalence and widespread distributions of cyanotoxins in Florida's surface waters, the demonstrated toxicity of these compounds, and the identification of these cyanobacteria in current or future drinking water resource sites attest to the potential risks of cyanobacterial blooms to both surface water ecology and to public health. As eutrophication causes blooms to last longer, extend farther, and reach higher concentration levels, the potential for damages is likely to escalate.

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SESSION 2

RESTORATION STUDIES AND ISSUES

Tuesday – May 23, 2000
10:40 a.m. – 12 noon

NATURAL DRAWDOWN AND RESTORATION OF LAKE JACKSON, LEON COUNTY, FLORIDA

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Havana, Florida

Lake Jackson, located immediately north of the City of Tallahassee (Leon County, Florida), has a drainage area of 43.2 square miles and a surface area of approximately 4,000 acres. The Lake Jackson watershed is a closed basin; it has no water loss through surface water runoff; evaporation and leakage through sinkholes in the bottom of the lake account for all water losses from the system. During periods of extended drought, lake levels decline, and at times, large portions of the lakebed can become dry when sinkholes capture the remaining water. Similar sinkhole lake draining "events" are documented to have occurred in 1907, 1909, 1932, 1935, 1936, 1957, and 1982. The most recent event occurred in 1999.

The southernmost portions of Lake Jackson have been heavily impacted by stormwater runoff from urban development, primarily in the Meginniss and Fords arm drainage basins and the portion of the lake adjacent to the arms. A Surface Water Improvement and Management (SWIM) watershed management program has been underway since 1988 and a number of stormwater retrofits and lake restoration projects have been implemented. However, all research has indicated that nutrient enriched sediments in the southern portion of the lake would need to be removed or otherwise neutralized for the restoration to be successful.

In the early 1990s hydraulic dredging was utilized to remove 112,000 cubic yards of deep sediment deposits in the southernmost portion of Meginniss Arm, but cost and land requirements for dewatering, and a number of other factors precluded the use of this technique for other areas of the lake. The lake management team agreed that use of earthmoving equipment during the next natural lake drawdown would be the best technique for removing the enriched sediment in the southern portion of the lake.

The 1999 natural drawdown actually began in 1998 when the lake level began to decline due to below normal rainfall conditions. In March 1998 the lake level was at elevation 86.2 (feet NGVD) and has been gradually declining since then. At the beginning of the next typical spring dry season (April 1999) the level reached the "normal low" threshold of 82 feet. At this point, lake managers decided that the current level, combined with a predicted dry summer, could cause the lake to dewater in the late fall of 1999. This theory was consistent with the conclusions of a study of the 1982 dewatering event (Wagner 1984).

In anticipation of a natural dewatering, preparations began in April 1999 for a major sediment removal restoration project. A working committee called the "Drawdown Interagency Restoration Team" (DIRT) was formed and weekly meetings were held to coordinate development of the information necessary for the project implementation. This included surveys of the work areas, analysis of sediment chemistry and depth, development of permit applications, identification of access points and disposal areas, public information, estimation of funding needs, and various other logistical tasks. Dedicated funding had not been identified for the project, but the word got out quickly and funding commitments started coming in. To get the project started, the Leon County Board of County Commissioners committed $2 million to the project and Florida Fish and Wildlife Conservation Commission (FWC) committed $150,000.

Since the target areas within and immediately adjacent to Meginniss and Fords Arms are at slightly higher elevations than the adjacent areas of the lake, it was determined that these areas would be dry enough for the first phase of the work to be performed under low water conditions. Plans and permits for Phase I were complete by September 1999 and in early September, Leon County crews began clearing vegetation on Meginniss Arm. On September 15, a track hoe excavator moved onto the lake bottom to begin digging channels to dewater the muck to prepare it for removal. Contractors under the supervision of the FWC moved into Fords Arm in late September. Work has been nonstop since then.

Dry conditions caused the lake level to continue its decline through the summer of 1999, with the lake dividing into separate pools as ridges on the lake bottom became exposed. On September 16, 1999, a large pool connected to Porter Hole sink drained through the sink, leaving most of the lake bottom exposed. Dry conditions have continued and many of the remaining pools have dried. Most recently, Lime Sink slowly drained the largest remaining pool, with completion of the draining on May 6, 2000.

After the start of the restoration work, additional funding was secured to expand into Phase II. Leon County has added $2.46 million, the FWC added approximately $250,000, the Northwest Florida Water Management District (NWFWMD) put in $500,000 (in addition to over $150,000 spent on planning, design, permitting, coordination and sediment analysis etc.), and the Department of Environmental Protection contributed $250,000. The state budget from the 2000 Florida Legislative session includes an additional $2.65 million for the project. If dry conditions continue, the restoration work should be completed in the summer of 2000.

References

Wagner, J.R. (1984). "Hydrogeological Assessment of the October 1982 Draining of Lake Jackson, Leon County, Florida." Northwest Florida Water Management District, Water Resources Special Report #84-1.

RESTORATION OF LAKE JACKSON, LEON COUNTY FLORIDA AND FUTURE FUNDING OPPORTUNITIES BY FWC

Michael J. Hill
Florida Fish and Wildlife Conservation Commission (FWC)
Tallahassee, Florida

Lake Jackson is a 4,004 acre lake located north of Tallahassee in Leon County, Florida. During the 1970s, Lake Jackson was internationally known for its largemouth bass fishery. Also known as a Adisappearing lake≅, Lake Jackson was formed over karst features such as sinkholes and has benefited from natural water level fluctuations. Large portions of the lake have drained through sinkholes roughly every 25 years, notably in 1907, 1932, 1957, 1982 and in 1999. The 1982 event lasted only 4 months, but the 1957 event extended to over 30 months. Due to the uncertainty of the duration of this natural drawdown, the FWC, working closely with the multi-agency task force, prepared to mobilize an experienced muck removal contractor to excavate in Fords Arm of Lake Jackson. The task force determined that the southernmost portion of the lake was the most impacted by stormwater runoff from urban development. The FWC removed approximately 192,000 cubic yards of muck from Fords Arm in 60 days.

Muck is the resulting accumulation of organic material on the lake bottom, primarily from aquatic plants. When excessive nutrients, carried by stormwater runoff, empties into a lake, increased plant production increases the rate of muck deposition. Accumulated muck in aquatic systems has a deleterious affect on the aquatic habitat. The high organic content of muck reduces dissolved oxygen levels during decomposition. Muck also increases turbidity, promotes excessive growth of aquatic plants (sometimes invasive, exotic plants), fosters tussock formation, and hinders bed construction for the successful spawning of native sunfish species. Muck removal provides for improved benthic habitat, improved water quality, and improved fisheries habitat. Through drawdowns, natural or man-induced, the drying, oxidation, compaction or removal of the muck is desirable to enhance the aquatic habitat. Additionally, muck removal during drawdowns can be achieved without turbidity concerns.

With the establishment of 403.813 (2)(r) F.S., muck removal projects have been successfully used by the FWC under an aquatic plant removal permit, rather than a permit for dredge and fill. A few examples include Lake Kissimmee, Lake Tohopekaliga, Piney Z Lake, and Lake Jackson. Ideally, benefits to the aquatic habitat would occur by extracting the muck completely from the lake and depositing it on approved upland disposal sites. Where possible, the FWC has implemented that strategy, such as in Lake Jackson. However, in some cases we have found that construction of earthen fishing fingers and wildlife islands with scraped material is desirable.

The work is bid out on a price per cubic yard basis. The quantity of muck to be removed can be calculated by setting up a grid over the lake bottom and using a probe to determine the muck depth. An average muck depth is calculated and used to determine payment to the contractor. Another technique to determine the quantity of material removed is to count trucks.

This technique can be useful in some special, smaller circumstances, but does require additional manpower.

A typical muck removal project usually begins when a wide-tracked bull dozer first pushes muck into Awindrows≅ perpendicular to the shoreline. After a 2-3 windrows are created, a tracked excavator (backhoe) perches atop the first windrow, which now has had time to dry sufficiently for hauling. The excavator deposits muck into a six-wheel drive articulating dump truck (end-dump). These end-dumps are perfectly suited for moving material in very wet areas and avoids the need to construct roads on the lake bottom. As the excavator removes the last created windrow, a few more are pushed up. The process is repeated throughout the work site. This gives us some control if unexpected heavy rains refills the lake. It is more desirable to have to remove a small quantity of muck than to have the entire work site covered with flooded windrows that would be difficult or impossible to remove. After the required quantity of muck has been removed, the entire area will be back-bladed with a dozer to remove equipment tracks and to restore the original bottom contour.

Disposal sites need to be near-by or directly adjacent to the work site if off-road dump trucks are used. Considerable expense is associated with hauling to distant disposal sites. Due to the seed bank present in muck, one can expect quick re-vegetation on the fill material. Giant smartweed, dog fennel, ragweed and pickerelweed often grow thickly and may require herbicide treatments for control. Chemical analysis or leachate tests of the spoil material may be required for some disposal sites.

Within the FWC, the Aquatic Resources Enhancement Section (ARES) of the Division of Fresh Water Fisheries, Bureau of Fish Management has been working on public lakes to improve the aquatic habitat. The ARES funds are derived from the 1989 increase in the fresh water fishing license fee. This increase has generated about $1.5 million annually for implementation of aquatic resource enhancement projects in Florida waters. Project lakes have required two criteria: lakes must have public access and fishing potential. The 1999 Legislature, through Florida Forever, granted the FWC an additional $5 million annually over nine years for lake restoration projects.

ARES programs are not limited to muck removal projects. Other programs include: aquatic plant re-vegetation, tussock (floating island) removal, stormwater retrofit projects, providing bank fishing access, construction of fish spawning sites, and construction of fishing piers. The FWC will consider qualifying proposals for suitable aquatic resources enhancement projects.

NOTES

NEWBURGH LAKE
RESTORATION CASE STUDY

Larry J. Danek, Ph.D.; Doyle E. Cottrell, P.E.; John M. O'Meara
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In October of 1998, a major milestone occurred in the history of Newburgh Lake - the 105-acre lake and surrounding park area was opened to the public after almost 2 years of restoration work.

Newburgh Lake is an urban impoundment built in the early 1930s by Henry Ford as part of his village industries. Since that time the lake was used as a recreational resource for boating, fishing, and passive activities. However, the quality of Newburgh Lake had deteriorated over the years. It had experienced years of sediment accumulation; some of which had been contaminated with PCBs from an upstream source, which degraded the benthic community, water quality, and allowed for bioaccumulation of the PCBs in the food chain. This last concern resulted in potential human health hazard and a fish consumption advisory for fish caught from the Lake. In addition to these concerns, shallow depths resulted from the sediment accumulation and the water became nutrient-rich, resulting in excessive growth of aquatic plants. All of these concerns led to very limited use of Newburgh Lake.

Beginning in 1993, a series of studies were conducted on Newburgh Lake to define and evaluate the extent of the problems, and to develop a basis of design for the restoration of the Lake. Some of the results included:

- The mean depth of the lake was 3.9 feet.
- Lowering the lake level 3 feet reduced the surface area by 50%.
- A large portion of the western part of the lake was 1 foot or less.
- Highest PCB concentrations were at the western end of the lake, just below the surface sediments.
- All PCB levels were below TSCA trigger levels.
- Sediment thickness ranged from 0.5 to 7 feet.
- The low-level outlet structure on the dam had not been used in over 30 years and was inoperable.
- There was a large, active interceptor sewer that had been laid on the lake bottom during the 1930s and was now partially buried.
- Fish were contaminated with PCBs.

As a result of the studies a remediation and restoration plan was developed that outlined objectives to meet the needs of the public. The objectives were formulated as follows:

- Restoration of the water quality in Newburgh Lake.
- Reduction of the human health risk.

- Restoration of habitat.
- Increased recreational use.
- Increased public perception of Newburgh Lake as a valuable resource for both recreation and education.

Restoration of Newburgh Lake began in the winter of 1997 with the construction of a cofferdam at the dam face to remove and replace the old outlet structure so that the water level could be controlled. The following construction activities were then implemented to remediate the lake:

- The lake level was initially lowered to allow access for sediment removal, but left a 3-acre pool at the outlet to aid in sedimentation control.
- Detailed sediment sampling to better define the PCB distribution and to provide for disposal classifications was completed.
- Sediment removal began using a variety of techniques: earthmoving equipment, draglines, hydraulic dredges, and a swamp buggy excavator.
- An initial fish kill to remove the contaminated fish in the lake and the upstream river system was completed.
- Sediment removal was completed.
- Shoal and aquatic plant areas were built and the lake bottom was contoured.
- Fish habitats were built.
- Parkland areas were upgraded.
- The lake was refilled and the fish restocked.
- Monitoring program was initiated.

The construction was originally estimated to be approximately $8.0 million - the low bidder was $7.65 million and the project came in at $7.4 million. When the disposal costs, engineering, fish kills, and construction management are added in, the project cost $11.8 million to complete.

The Newburgh Lake Restoration project set out to reduce the health risk associated with lake use to restore this urban lake to a beneficial resource. This was accomplished, as the project repaired the level controls on the dam structure; removed approximately 558,000 tons of sediment, of which 350,000 tons contained PCBs; disposed of all sediment in a Type II landfill; deepened the lake to a minimum of 8 feet, except were shoals were constructed; established 10 acres of aquatic vegetation shoals; eradicated, removed, and disposed of approximately 30,000 pounds of contaminated fish; created structural and spawning bed fish habitat; restocked the lake with game fish; resurfaced over 2 miles of roads; built a new boat ramp and new docks; and cleaned additional area in the park for recreation use.

ESTABLISHING A PHOSPHORUS LOADING GOAL FOR THE RESTORATION OF A LARGE URBAN/SUBURBAN LAKE

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St. Johns River Water Management District
Palatka, Florida

Lake Jesup is a large (48.7 km^2) hypereutrophic lake lying northeast of Orlando in Seminole County, Florida. The watershed (404 km^2) has been subjected to a number of activities resulting in increased lake eutrophication. The main channel of the St. Johns River, once had a broad connection to the lake. This connection has been greatly restricted due to the combined effects of a bypass canal diverting river flow and construction of the SR 46 causeway. In addition, until 1983 seven secondary wastewater treatment plants were discharging directly into tributaries of Lake Jesup. Another stressor has been the conversion of large areas of floodplain around the lake to agricultural use. Finally, past and ongoing residential development in the watershed has resulted in increased nutrient loading rates. The Florida legislature passed the Lake Jesup Act of 1994 creating the Friends of Lake Jesup Basin Management Team (Friends). The Friends were tasked with addressing the aforementioned problems and developing a restoration and management plan for Lake Jesup. In cooperation with this team, the St. Johns River Water Management District is providing the technical expertise to develop nutrient goals for Lake Jesup. This paper presents one rationale and method for establishing a phosphorus-loading goal for Lake Jesup.

The primary use on Lake Jesup is recreational and commercial fishing. Historical accounts indicate that the lake was less turbid, had widespread submerged aquatic vegetation (SAV), and possessed a more productive fishery. Therefore, the District feels that any nutrient loading goals should promote quality fisheries and provide water quality conditions that enable SAV to develop. Consultation with the Florida Game and Freshwater Fish Commission indicated that 25% areal coverage of SAV would foster fisheries production in Lake Jesup. Currently, the greatest barrier to SAV establishment is reduced light penetration due to turbid conditions. Occasionally, small transient areas of *Hydrilla*, and even *Vallisneria*, have been found in the lake, indicating that some areas in the lake can support rooted macrophytes. The District's goal, and the topic of this presentation, is to establish a nutrient-loading goal that will reduce chlorophyll concentration and turbidity to the point where light penetration is sufficient to support SAV.

Assuming a 0.92 m MSL ordinary high water level, 25% areal coverage corresponds to the 0.13 m MSL depth contour, or 0.785 m deep. *Vallisneria americana*, our target species, requires at least 10% surface PAR (Rogers et al. 1994). Therefore, if we calculate 10% light penetration to a 0.785 m depth we get a light extinction coefficient of 2.93. Based on the empirical relationship $Secchi = 1.72/k$ we require a mean Secchi depth of 0.59 m. The Secchi-chlorophyll regression for Lake Jesup indicates that a mean chlorophyll a level of 43 $\mu g\ liter^{-1}$ is required. An additional chlorophyll-TP regression was used to calculate that a TP level of 0.08 mg $liter^{-1}$ is required to maintain the necessary light regimen and enable SAV colonization and maintenance. To augment these static calculations, we employed a Monte Carlo simulation, based on a logistic regression, to estimate risk of algal blooms under current wet-season conditions. Bloom frequency is predicted to be 96-98% under current conditions, suggesting that more conservative loading limit than that based on a static estimate of 0.08 mg P liter^{-1} may be needed.

Based on the dominant use of Lake Jesup, we feel that maximizing fisheries production is a suitable management goal. The chain of reasoning and calculation elucidated above suggests that mean chlorophyll a concentrations should be reduced to 43 μg liter^{-1}, or a 43% reduction from the current mean of 72 μg liter^{-1}. To achieve this chlorophyll reduction, mean TP in the lake should be reduced to 0.08 mg liter^{-1}, representing a 50% reduction from present levels. However, these are static values and may not accurately estimate conditions needed for SAV in the lake. For example, plants existing near the metabolic compensation point (e.g., P=R) would probably not persist if algal bloom frequency was high or of long duration. Conversely, infrequent and short duration blooms may not have a lasting effect. Therefore, loading limits may be changed from static estimates based on frequency, duration, and recovery time of SAV.

References

Rogers, S.J., D.G. McFarland, and J.W. Barko. (1994). “Evaluation of the Growth of *Vallisneria americana* Michx. in Relation to Sediment Nutrient Availability. *Lake and Reserv. Manage. 11*: 57-66.

SESSION 3

LAKE APOPKA

Tuesday – May 23, 2000
1:20 – 3:40 p.m.

INVESTIGATION INTO THE DEATHS OF FISH-EATING BIRDS AT LAKE APOPKA: PRELIMINARY WILDLIFE RESULTS

Roxanne Conrow, Elizabeth Mace, Steven Richter
St. Johns River Water Management District; Palatka, Florida

John Schell
BBL Sciences; Tallahassee, Florida

and David Stites
CH2M Hill; Gainesville, Florida

Lake Apopka is a 125 km^2 lake in central Florida about 10 miles northwest of the Orlando metropolitan area. By the end of 1998, the St. Johns River Water Management District (SJRWMD), at the direction of the Florida Legislature, and with partial funding from the Federal Wetlands Reserve Program, completed purchase agreements for 3,600 ha of farmland along the north shore of Lake Apopka. Historically, the farmland was a large, primarily sawgrass marsh, and the acquisition was aimed towards reducing phosphorus loading to the lake and restoring wetland habitat. Environmental audits were performed on all of the properties resulting in remediation that included the removal of over 20,000 tons of soil and 3,000 gallons of ground water. An environmental risk assessment of the residual pesticide levels indicated that some concern was warranted about long-term, sublethal effects on growth or reproduction of fish-eating birds, and SJRWMD planned a several-year monitoring program to assess potential problems.

As farming activities ended in summer 1998, parcels were left shallowly flooded by the farmers, a typical end-of-season practice for erosion and nematode control. However, unlike in past years, water levels continued to rise over time due to rainfall and seepage and by September water depths in the various fields typically ranged from 5 to 75 cm. These variations in water conditions resulted in usage by large numbers and many species of wetland birds, including the migratory American white pelican. Numbers of white pelicans fluctuated, reaching 1,350 on November 25, 1998 then declining to less than 100 in mid-December. Pelican numbers increased again to reach 3,550 on December 28 and a high count of 4,370 on January 29, 1999. Reports of dead or dying birds, primarily white pelicans but also other fish-eating birds, began in December 1998. SJRWMD began dewatering the area for management purposes in December and by mid-February the fields were dry. However large numbers of birds continued to utilize the area, concentrating in the remaining pools of water, and along the drainage ditches. Deaths increased through January, peaked in the beginning of February and ceased by the end of March 1999. Ultimately, from on-site and off-site tallies, over 800 white pelicans and 50 wood storks died, as well as lesser numbers of other fish-eating species. A presentation at the 1999 Florida Lake Management Society Meeting provided an overview of those events along with the laboratory results from several specimens, indicating organochlorine poisoning was a probable cause of death. However, because the samples were analyzed by a number of different laboratories, with some labs consistently reporting much higher values, interpretation of results was difficult. In the ensuing year, we have conducted a new investigation to obtain a data set of soil, sediment, water, and animal tissue analyses performed by one laboratory, En Chem, Inc. of Madison, WI. En Chem was chosen for their expertise in analyzing pesticides, especially toxaphene. SJRWMD has been assisted by local, state and federal agencies, and a citizen's advocacy group participating in a Technical Advisory Group (TAG) for the investigation of the bird deaths.

A total of 158 tissues from 34 birds were analyzed by En Chem. Six species were represented but most of the specimens were American white pelican and great blue heron (23 and 4 birds, respectively). All of the birds were delivered to the Laboratory of Wildlife Disease Research at the University of Florida for full (fresh birds) or partial (frozen birds) necropsies. Of the pelicans examined, 60% were classified as juvenile or subadult.

Out of 11 fresh bird carcasses examined:

- 1 was found beneath a powerline and exhibited trauma sufficient to kill it;
- 1 exhibited a very heavy growth of avian cholera from its liver culture;
- 1 died from severe hemorrhage associated with a catfish spine perforating the esophagus;
- 5 had positive titers to Newcastle disease virus.

Additional, specialized testing for Newcastle disease in other, frozen tissues is in progress. Based on these findings, it is likely that not all of the deaths occurring in the Lake Apopka "mortality event" are the direct result of organochlorine pesticide poisoning. However, a number of organochlorine pesticides (primarily DDD, DDE, dieldrin, and toxaphene) were found in a majority of the tissues, sometimes at high levels. In particular, high levels of toxaphene were identified in many of the birds. In addition to the birds, over 40 fish (6 species) and 5 rodents were collected from the area and analyzed at En Chem for pesticides.

All existing data - tissues, soil, sediment, water - are currently being examined by Exponent, a firm with expertise in environmental risk assessments. Exponent's report, including results of the avian mortality analysis, with evaluation of causality associated with pesticides and other factors, as well as exposure pathways from sediment to birds, is expected in draft form by August 2000. SJRWMD will discuss their findings and management recommendations with the TAG and a group of university researchers nationally recognized for their expertise in biogeochemical, avian and environmental toxicology.

INVESTIGATION INTO THE DEATHS OF FISH-EATING BIRDS ON FORMER MUCK FARMS AT LAKE APOPKA: PRELIMINARY SOIL RESULTS

Erich Marzolf, Michael Coveney, Dawne Wilson, Edgar Lowe
Department of Water Resources,
St. Johns River Water Management District; Palatka, Florida

and Robert Sorvillo
BEM Systems, Inc.; Orlando, Florida

Lake Apopka is a 125 km^2 lake in central Florida about 10 miles northwest of the Orlando metropolitan area. Historically, Lake Apopka was the second largest lake in the state. However, in the 1940s the northern third, mostly sawgrass marsh, was isolated by levees from the remainder of the water body. The marsh was drained, and agriculture in the peat soil initiated. The St. Johns River Water Management District (SJRWMD) in partnership with local, state, and Federal governments developed a five-part restoration and management plan for Lake Apopka that included reduction of phosphorus loading from external sources, primarily agriculture (acquisition and restoration of 52.6 km^2 floodplain farms). Environmental Site Assessments performed as part of the land acquisition process resulted in remediation that included the removal of 20,343 tons of soil and 3,230 gallons of groundwater. Some 400 soil samples were analyzed for pesticide residues in the environmental assessments and in follow-up sampling. An environmental risk assessment indicated that some concern was warranted about long-term, sublethal effects on growth or reproduction of fish-eating birds, and SJRWMD planned a several-year monitoring program to assess these potential problems. The strategy recommended in the risk assessment to deal with the background levels of pesticides was to shallowly flood the site to promote dense emergent vegetation. This approach combined the beneficial effects of: (1) a halt to further application of pesticides, and (2) natural attenuation resulting from the accelerated microbial breakdown in a nutrient-rich, anaerobic soil environment, and burial and dilution of the pesticide residues with new organic matter. Individual parcels were shallowly flooded during summer 1998 as farming activities terminated. This flooding was initially comparable to the shallow flooding done on these farms on an annual basis to control nematodes and to limit soil subsidence. However, flooding by the District extended over a greater area and more seasons and was deeper in some areas than earlier agricultural flooding. Birds using the site began to die in large numbers during the fall of 1998 and winter of 1999, apparently due to factors associated with feeding. Most of the species affected were fish-eating birds, and the species most affected was the American white pelican. Initial tests led U.S. Fish and Wildlife Service to conclude in February 1999 that organochlorine pesticide poisoning was likely the cause of the bird deaths. Since the possibility of acute toxicity from field background pesticide levels in the soils was not predicted by the environmental risk assessment, further detailed sediment and soil sampling was conducted. A stratified random sampling approach was agreed upon by a technical advisory group consisting of university, local, state and federal agency representatives and non-profit organizations. In addition, the

Environmental Site Assessments conducted during acquisition have been independently reevaluated to examine whether they were performed properly.

The soil sampling plan blocked the entire area into 10 acre blocks within which a randomly located point was selected for sampling. In addition, samples were collected in drainage canals, the banks of drainage canals and field ends and in deeper cores throughout the area. The coordinates for all sampling locations were mapped in the District's GIS and supplied to the sampling contractor, BEM Systems Inc. BEM Systems returned corrected differential GPS coordinates for each sampling site. Agreement between target and actual sampling locations was excellent, usually within 50 cm. En Chem, Inc., a laboratory in Madison WI was selected to analyze all samples following a detailed investigation into laboratories with experience in the analysis of pesticides, especially toxaphene. To date soil, sediment or water have been sampled at over 1,000 locations, and > 40,000 analyses have been completed.

A wide range of organochlorine pesticides (i.e. Aldrin, Chlordane, DDT, DDD, DDE, Dieldrin, Toxaphene) were found in a majority of the soil samples at low concentrations. There were significant differences in concentration between compounds and throughout areas of the North Shore Restoration Area (NSRA). These differences are likely the result of varying amounts of pesticide used by the multiple farm operations and the date individual pesticides were last applied to an area. Pesticide concentrations in the canal sediments and banks were generally lower than in adjacent fields. Pesticide concentrations in canal water were much lower than in the sediment or soil. Pesticide concentrations were highest in the top foot and declined with depth into the soil. In addition to the general patterns, an area of intense contamination was discovered in a field adjacent to an airstrip historically used by crop dusters. Additional samples were collected to confirm and delineate the extent of this "hotspot" contamination. The District has contacted the previous owner and is conducting discussions concerning the cleanup of the area. In addition, this finding prompted additional sampling of all airstrips (10) in the NSRA.

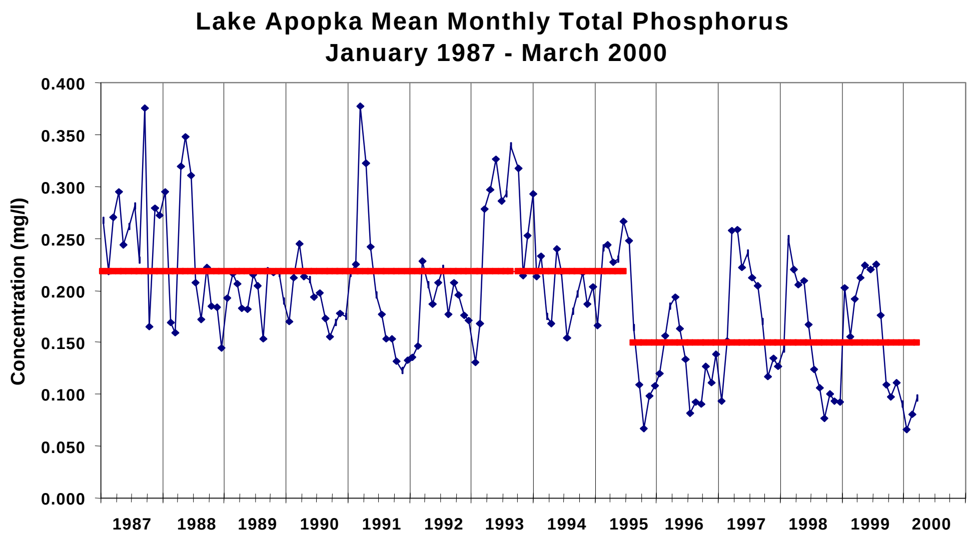
These data in addition to data on bird, fish and rodent tissues has been supplied to Exponent, a firm with expertise in assessing environmental risks associated with organochlorine pesticides. They will be making recommendations to the District concerning the role of pesticides in the bird deaths and the need to address the pesticides remaining in the soil. The presentation will provide a status update on this work.

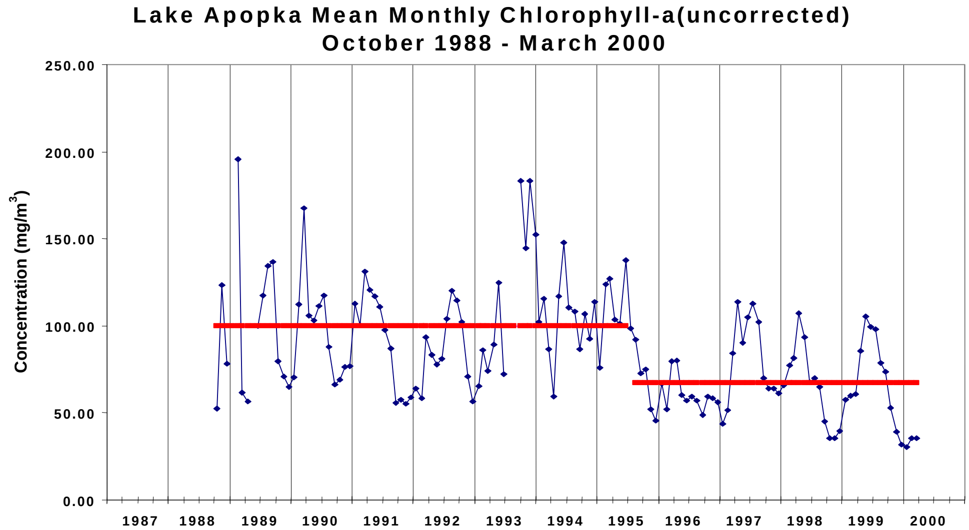
UPDATE ON IMPROVEMENTS IN WATER QUALITY IN LAKE APOPKA

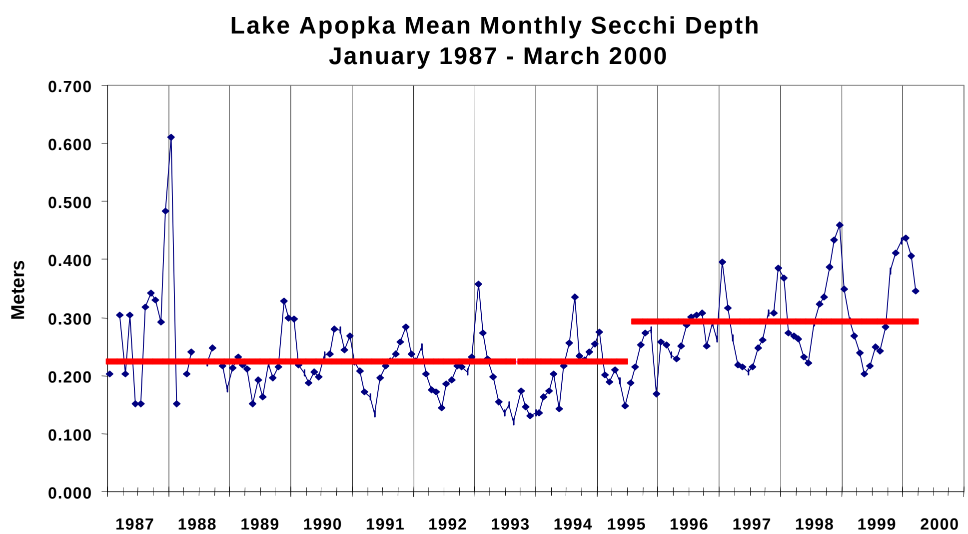
Erich Marzolf, Michael Coveney,
Roxanne Conrow, James Peterson, and Edgar Lowe
Department of Water Resources,
St. Johns River Water Management District
Palatka, Florida

The presentation originally planned for this period was canceled. In its place, we will provide an update on water quality improvements and the volunteer establishment of submersed vegetation in Lake Apopka. Lake Apopka is a 125 km^2 lake in central Florida about 10 miles northwest of the Orlando metropolitan area. The St. Johns River Water Management District (SJRWMD) in partnership with local, state, and Federal governments developed a five-part restoration and management plan for Lake Apopka that includes reduction of phosphorus loading from external sources, primarily agriculture (acquisition and restoration of floodplain farms). Beginning in 1993, our consent orders with the farms resulted in modest reductions in P loading. Also, we began our mass harvest of gizzard shad. We saw the combined effects of these two efforts starting in 1995, when the total phosphorus (TP) concentration began to fluctuate around a new, lower level. We do not expect further decline in average TP in the lake until we can flood the former farms and reduce drainage pumping. Chlorophyll also declined in mid-1995 and has been on a continuing downward trajectory. In fact, the January 2000 value was the lowest monthly average that we have measured in our decade of monitoring. Secchi depth increased over the same period of time, with a significant increasing trend. These changes occurred during a period when average wind speeds measured at Lake Apopka were constant. We cannot say yet whether chlorophyll and Secchi depth have reached equilibrium with the new, lower average TP concentration or if chlorophyll and Secchi depth will improve further without additional P loading reductions. This summer the Marsh Flow-Way, a treatment marsh west of the Apopka-Beauclair Canal will begin operation. By removing seston and associated TP, the Marsh Flow-Way will accelerate the rate at which the lake responds to P load reductions. Also since 1995, *Vallisneria americana* (eelgrass) has increased markedly in the lake. This spring, more than 70 patches with a combined area over 6 acres were mapped. We believe that this spontaneous return of submersed macrophytes is a response to improved underwater light conditions. In addition to providing valuable habitat, submersed macrophytes will hasten the recovery of the lake through several positive feedback mechanisms.

In each figure below, two horizontal lines show the average values 1) from the start of District monitoring until mid-1995, and 2) from mid-1995 until the present. These means are significantly different ($p < 0.002$).


Lake Apopka Mean Monthly Total Phosphorus
January 1987 - March 2000
Concentration (mg/l)
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000


Lake Apopka Mean Monthly Chlorophyll-a(uncorrected)
October 1988 - March 2000
Concentration (mg/m3)
250.00
200.00
150.00
100.00
50.00
0.00
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000


Lake Apopka Mean Monthly Secchi Depth
January 1987 - March 2000
Meters
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000

SESSION 4

DIAGNOSTIC STUDIES

Wednesday – May 24, 2000
8:40 – 10:40 a.m.

A PRELIMINARY INVESTIGATION OF POTENTIAL EFFECTS OF ALUM TREATMENT ON BENTHIC MACROINVERTEBRATE COMMUNITIES

David L. Evans, Simon A. Cordery, Charles R. Fellows,
Eric D. Flagg, and Christine S. Hartless
Water and Air Research, Inc.
Gainesville, Florida

Aluminum sulfate (alum) has been used successfully to improve the quality of surface waters by removing phosphorus and suspended particulates. Alum stormwater treatment systems have been installed in more than a dozen Florida urban lakes to reduce trophic state and increase water clarity. Although use of alum may produce the intended results, treatment also introduces the potential for deleterious effects on aquatic biota. Flocculent sediments that accumulate as a result of alum treatment (Harper 1990) may interfere with respiratory function of benthic organisms (Barbiero et al. 1988). Furthermore, as the rate that analytes are "stripped" from the water column increases, the concentration of sediment metals and other sediment contaminants may increase to levels that are sufficient to cause toxic effects (Barbiero et al. 1988, Gensemer and Playle 1998).

A preliminary investigation was conducted to quantify the potential effects of small, continuous doses of alum on benthic invertebrate communities in four Florida urban lakes. A benthic invertebrate sampling plan was designed to document differences between pre- and post-treatment benthic invertebrate communities in lakes that have received continuous alum treatment over a long time period. Benthic communities occurring in alum-treated lakes and in untreated reference lakes also were compared.

The sampling effort, conducted December 1998 and June 1999, was designed to supplement existing pre-treatment data by using untreated reference lakes to represent pre-treatment conditions in the selected alum-treated lakes. Prior to treatment, alum-treated lakes were typically eutrophic lakes with urbanized watersheds; therefore the selected reference lakes had similar characteristics. Based on a review of historical water quality data, watershed land use, and lake management practices the following treatment and reference lakes were selected:

Treatment Lake	*Reference Lake*
Lake Ella, Tallahassee	AJ Henry Park, Tallahassee
Lake Dot, Orlando	Lake Lurna, Orlando
Lake Osceola, Winter Haven	Lake Ivanhoe, Orlando
Lake Lucerne, Orlando	Lake Olive, Orlando

During summer, all lakes were numerically dominated by organisms tolerant of hypoxia, including *Limnodrilus hoffmeisteri*, Hirudinea, *Chironomus* spp., and *Chaoborus* spp. Less tolerant taxa including *Procladius*, *Labrundinia*, *Polypedilum halterale* group, *Ablabesmyia*, and *Clinotanypus*, were more abundant in some of the lakes in winter, when dissolved oxygen concentrations were highest.

There was no significant difference between organism densities recorded in the treated lakes and reference lakes. In summer, the average number of taxa per sample was significantly lower ($p=0.044$) in treated lakes (2.4 taxa) than in the reference lakes (4.6 taxa). Although the average number of taxa in winter also was lower in treated lakes (4.1 taxa) than reference lakes (5.6 taxa), the difference was not significant ($p=0.234$). In the alum-treated lakes, mean Shannon-Weiner diversity values declined or remained low (0.41 – 1.48) following treatment, despite the anticipated improvement in water quality. Mean diversity in alum-treated lakes was 1.23 in winter and 0.74 in summer, significantly lower than diversity values recorded for untreated reference lakes, where winter and summer means were 1.83 and 1.43, respectively ($p=0.01$ in winter; $p=0.05$ in summer). There was no significant difference between the average densities of various invertebrate feeding guilds recorded in treated and reference lakes.

A high percent occurrence of morphological deformities in *Chironomus* spp. was recorded in Lake Dot and Lake Lucerne (17 % and 44 %, respectively). In Lake Dot, deformities occurred most frequently near the alum injection system point of discharge. Other investigations have demonstrated a significant positive relationship between the frequency of deformities and sediment metal concentrations, with significantly lower growth rates occurring in deformed larvae (Janssens de Bisthoven, Timmermans and Ollevier 1992). *Clinotanypus*, a chironomid of common and widespread distribution known to be sensitive to sediment metals, was absent from the treated lakes and observed in three of the reference lakes, but not in the treated lakes. Although sediment contaminants were not quantified, results suggest alum treatment may accelerate accumulation of sediment contaminants, increasing the potential for toxic effects.

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PHOSPHORUS RELATIONSHIPS AND ISSUES BETWEEN LAKE ISTOKPOGA, TRIBUTARIES AND OUTFLOWS

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Highlands County Soil and Water Conservation District
Sebring, Florida

Lake Istokpoga, the state's fifth largest lake at 11,207 hectares, is located in Highlands County and is a primary source of water flowing into Lake Okeechobee, located 48 km to the southeast. The lake is shallow, with an average depth of only 1.1 m. Arbuckle and Josephine Creeks are the primary surface inflows to Lake Istokpoga, while water leaves the lake through the Istokpoga and C-41A canals. Arbuckle Creek is the most influential contributor, while almost all surface water leaving the lake flows out at a regulated rate through the S-68 structure into the C-41A canal. Inflow water has been very high in nutrients, particularly in Arbuckle Creek, which have contributed to the growth of over 800 hectares of tussock islands (Florida Fish and Wildlife Conservation Commission estimate). Arbuckle Creek flows from Lake Arbuckle in Polk County, through range and improved pastureland and past the Spring Lake Improvement District (SLID) before reaching Lake Istokpoga. Recent Total Maximum Daily Load (TMDL) regulations will drastically reduce allowable phosphorus levels in tributaries of Lake Okeechobee, including the canals flowing from Lake Istokpoga, which are directly impacted by the quality of water flowing into the lake.

South Florida Water Management District (SFWMD) water samples were collected intensively between 1988 and 1994 and sampling continues in some locations (SFWMD data from DBHYDRO database, 1988-1999). Sampling locations were at both creek inlets, both canal outlets and at a variety of locations in both the north (4 locations) and south (3 locations) regions of the lake. Additional samples were taken at runoff/outfall locations from dairies, ranches, groves and at an outfall from the SLID. These outfalls upstream of Lake Istokpoga contributed significant amounts of P to Arbuckle Creek. These data indicate that Lake Istokpoga received an average of 2.0×10^4 kg yr^{-1} of TPO_4-P between 1988 and 1994 from Arbuckle and Josephine Creeks. Outfall phosphorus (not including the SLID) concentrations ranged from 5 to 11,360 mg L^{-1} TPO_4-P and the average outfall concentration declined from a high of 2690 μg L^{-1} TPO_4-P in February of 1990 to 260 μg L^{-1} TPO_4-P in March, 1999. Phosphorus levels in Arbuckle Creek were consistently lower than P levels in water flowing into the creek at point sources.

Outflow of TPO_4-P through the S-68 structure, and towards Lake Okeechobee, averaged 0.8×10^4 kg yr^{-1} during this period. Much of the remaining 1.2×10^4 kg yr^{-1} contributes to the growth of tussock islands in the lake. Some phosphorus is lost to the Kissimmee River through the Istokpoga canal, where concentrations are high, averaging 80 μg L^{-1} but flows may be relatively small.

Arbuckle Creek is the primary surface water contributor (91%) of phosphorus to Lake Istokpoga. Phosphorus concentrations ranged from 30 μg L^{-1} to 41 μg L^{-1} between 1988 and

1999, though values were generally lower in more recent years. Average phosphorus concentrations were higher ($p < 0.05$) in Arbuckle Creek compared to Josephine Creek (100 and 50 ❍g TPO_4-P L^{-1}, respectively). Concentrations were also higher ($p < 0.05$) in tributaries compared to outflows (80 and 60 ❍g TPO_4-P L^{-1}, respectively). Lake phosphorus concentrations were higher ($p < 0.05$) near inflows on the north and west shores compared to near outflows on the east and south shores (60 and 40 ❍g TPO_4-P kg^{-1}, respectively). Sources of phosphorus to Lake Istokpoga must be addressed to protect surface water quality downstream. Florida Lakewatch data (LAKEWATCH, University of Florida, 1996-1999) support SFWMD findings with regard to phosphorus concentrations in the north versus south sections of the lake. Lakewatch data indicate that total P averaged 65 and 49 ❍g L^{-1} in the north and south ends of the lake, respectively.

Future management of Lake Istokpoga is focused on the removal of the tussock islands to maintain the lake's water quality, recreational, navigational, flood control, fish and wildlife habitat and water supply functions. The effect of tussock removal on nutrient dynamics in the lake is currently unknown. New plant growth may rapidly remove nutrients entering through Arbuckle and Josephine Creeks. Alternately, the nutrient problem at lake outflows may worsen when there is not sufficient plant growth to remove nutrients to reduce concentrations between inflows and outflows, as is currently the case. Sources of nutrients to the creek must be considered and Best Management Practices should be implemented whenever appropriate to alleviate the pressure on Lake Istokpoga to serve as a kidney for the Kissimmee Basin watershed.

FINDING THE SMOKING GUN TO IDENTIFY POLLUTION FROM ON-SITE SEWAGE TREATMENT DISPOSAL SYSTEMS

C. Joe King
Polk County Natural Resources
Water Resources Section
Bartow, Florida

The largest contributors of pollution in Florida's surface and groundwater today are non-point sources (NPS). These include agriculture, urban and stormwater runoff, and on-site sewage treatment disposal systems (OSTDS). Therefore, correctly identifying the source(s) of pollutants is an important task for environmental scientists and engineers. The function of the "Smoking Gun" approach is to identify human septage, particularly OSTDS's, as a potential contributor to the degradation of surface and groundwater.

It has been estimated that there are more than 1.8 million OSTDS in use in the state of Florida day. OSTDS are often installed in areas that are not conducive to the hydrogeology of the area. My experience has shown that some are not maintained properly or old and no longer efficiently treating the wastes. A recent study has shown that the optimal setback for OSTDS in west central Florida should be a minimum of 900 feet from surface waters. The Smoking Gun Model was designed to positively identify potential OSTDS contamination using established chemistry and biological test procedures. This mulitimethod approach uses three parameters that were selected based on the ability to identify human septage in surficial groundwater. Independently each may not have the power to positively qualify human septage, but together they provide the evidence for the Smoking Gun strategy. Parameters selected were, nitrogen isotopes= delta $^{15/14}$ ratios, the enterococci bacteria, and caffeine. The three are metaphorically referred to as: the gun, the smoke, and the bullet.

Nitrogen Isotopes, N^{14} and N^{15}

The two stable forms of nitrogen isotopes are N^{14} and N^{15}. In Florida, background groundwater nitrate concentrations are usually less than 1 mg/L. There is no naturally existing mineral source for nitrate in Florida. Therefore, elevated levels of nitrate are associated with human activities. Anthropogenic sources can include organic nitrogen (OSTDS) and inorganic nitrogen (fertilizers), to identify only two. Typically, the lighter N^{15} represents inorganic sources and, conversely, N^{14} represents human/animal wastes. The delta ratios of N^{15} to N^{14} can provide a scale or signature that can be used to qualify the source(s) of the nitrate nitrogen. Higher ratios, delta N^{15} greater than ten, would indicate organic nitrate. Lower delta ratios, less than two, would be the signature for inorganic nitrate.

Enterococci Bacteria

The enterococci bacteria are a subgroup of the Streptococci bacteria. Two species, *S. faecium* and *S. faecalis*, are primarily from human sources. The enterococci have been statistically shown to positively correlated with the increase occurrence of human gastrointestinal diseases.   The commonly used fecal coliform bacteria have not been shown to correlate with human diseases. In 1988, the USEPA, based on human disease studies, issued guidance criteria of no more than 35 col./100 ml for enterococci bacterial counts for body submergence in freshwater. (33 col./ml in saltwater).

Caffeine

Except isolated incidences, the major source for caffeine in groundwater is human urine. Caffeine once excreted from the body breaks down rapidly and is a good indicator for a local source of input. Additionally, caffeine has been found, using several studies nationwide, to implicate OSTDS as the source of contamination.

Study Area

Groundwater surficial wells were installed in the Lake Marianna watershed, Polk County, Fl. This watershed is one of the headwaters to the Peace River. Well development was accomplished using a soil auger and installation of 2" PVC pipe with a 0.02 slotted pipe point. Average well depth was 10 feet and each well rested just above a confining clay layer. Sample collections were made following a DOH approved Polk County Water Resources Laboratory CompQAP.

Results

Will be reported at the FLMS Conference to be held May 22-25, 2000

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IMPACTS OF ALUM SEDIMENT INACTIVATION ON INTERNAL RECYCLING AND GROUNDWATER SEEPAGE IN THE WINTER PARK CHAIN-OF-LAKES

Harvey H. Harper, Ph.D., P.E.
Environmental Research & Design, Inc.
Orlando, Florida

The Winter Park Chain-of-Lakes, located in Winter Park, Florida, consists of four interconnected urban lakes (Lakes Virginia, Mizell, Osceola and Maitland) with a combined surface area of 914 acres. Each of the lakes is relatively deep with maximum depths ranging from 21-30 ft (6-9 m). The lakes receive stormwater runoff from a combined drainage area of 3104 acres consisting of commercial, institutional and residential land uses. Annual areal loadings of total nitrogen and total phosphorus to the four lakes are relatively similar. Water quality varies seasonally but is typically in the mesotrophic/eutrophic range. Sediment characteristics in the four lakes are also relatively similar and consist of unconsolidated organic muck of varying thickness overlying a firm sand bottom. The lakes are typically polymictic, with extended anoxic conditions developing in deeper areas during the summer months.

During 1997-1998, Lake Mizell received multiple alum surface treatments for sediment inactivation. The alum inactivation dose was calculated using an innovative new methodology based on available sediment phosphorus. The speciation procedure of Chang and Jackson was used to speciate sediment phosphorus into saloid (soluble plus easily exchangeable), iron-bound, and aluminum-bound fractions. The saloid and iron-bound fractions are considered to be available for release from the sediments, while the aluminum-bound fractions are considered to be inert. A 4:1 aluminum/phosphorus molar ratio was used to estimate the required aluminum addition. A total of 49,500 gallons of liquid alum were added to Lake Mizell during three separate treatments, equivalent to a total water column dose of 12.5 mg Al/liter or 41 g Al/m^2. Post-treatment sediment samples indicated that the inactivation treatment reduced available phosphorus in the top 0-10 cm of the sediments by 60-70%. The majority of this reduction was achieved by conversion of iron-bound phosphorus to aluminum-bound phosphorus.

Direct measurements of seepage inflow were performed in the four lakes during 1998-1999 using 30 groundwater seepage meters. Seepage inflow was measured on approximately a biweekly basis from September 1998 to March 1999, covering both wet and dry season conditions. Seepage samples were analyzed for soluble species of both nitrogen and phosphorus. Seepage influx isopleths were developed for each lake to estimate seepage contributions under wet and dry season conditions. Estimates of nutrient flux resulting from internal recycling were performed by laboratory incubation of large diameter sediment core samples collected from shallow, mid-depth, and deep areas in each lake. A total of 16 sediment cores (10-cm diameter) were collected from the four lakes and incubated in the laboratory for 60 days under oxic and anoxic conditions. Each of the sediment core samples was collected with a 1-meter deep layer of the overlying water column. Small volume sub-samples were collected from each core tube on a daily basis and analyzed for alkalinity, nutrients, color, and sulfate. Periodic measurements of pH, dissolved oxygen and redox potential were also performed. Annual sediment release of nitrogen and phosphorus was estimated for each lake based on the results of the alum experiments and historical dissolved oxygen data indicating the extent and duration of oxic and anoxic conditions in each lake.

Concentrations of phosphorus in groundwater seepage were lower in areas which had received alum inactivation than in areas with no inactivation. Differences were most apparent when comparing seepage collected from deep areas in the lakes. No significant differences were observed in release rates for total nitrogen. Sediment phosphorus release in the incubation experiments was similar in both treated and untreated sediments under oxic conditions, but was substantially lower under anoxic conditions in alum treated sediment cores from Lake Mizell compared with release rates in the other lakes. Alum sediment treatment appears to be effective in reducing phosphorus loadings from both internal recycling and groundwater seepage. The longevity of the sediment inactivation process was estimated to be approximately 1.5 years based on nutrient inactivation requirements and seepage loading rates.

SESSION 5

WATER QUALITY ISSUES

Wednesday – May 24, 2000
10:40 a.m. – 12:20 p.m.

WATER QUALITY CHANGES IN LAKE ADAIR FOLLOWING REMOVAL OF ROOSTING CORMORANTS.

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City of Orlando, Stormwater Utility Bureau
Orlando, Florida

Lake Adair is a shallow 10 hectare lake located near downtown Orlando Florida, with a mean depth of 2.6 m. The trophic state could be described as hypereutrophic with mean total phosphorus and nitrogen concentrations of 173 ug/L and 1.45 mg/L respectively based on 1995 and 1996 data. The mean chlorophyll- a concentration was 77 mg/m^3 with a maximum value of 345 mg/m^3. Due to a trend of increasing nutrient levels and frequent springtime blooms of blue-green algae, a diagnostic study was implemented to quantify nutrient inputs to the lake. In conjunction with the nutrient budget, a hydrologic analysis was done to allow the use of phosphorus models to predict effects of reductions in nutrient inputs to the lake. Nutrient and hydrologic inputs to the lake which were evaluated included stormwater runoff, groundwater baseflow through stormwater conveyance systems, discharge water from an upstream lake and groundwater seepage through the lake bottom. In addition, the nutrient input from the droppings of Double-crested Cormorants, *Phalacrocorax auritus*, was evaluated.

In order to determine nutrient loading from several hundred migratory cormorants, which roost on the lake, pan experiments were done to determine the quantity and nutrient content of the droppings. From those results a mass loading rate of phosphorus and nitrogen from the roost was determined. Analysis of cormorant droppings revealed high concentrations of phosphorus and nitrogen. The phosphorus concentration from 7 sampling events averaged 7.7 % on a dry weight basis. Nitrogen concentrations had a mean value of 13.4% on a dry weight basis. The loading rate of phosphorus from the Cormorants was estimated to be 614 kg $year^{-1}$ or 73% of the total loading. Nitrogen loading to Lake Adair was estimated to be 3182 kg $year^{-1}$ with the Cormorants contributing 1148 kg $year^{-1}$ or 36.1% of the loading.

Prediction of in-lake lake phosphorus concentrations was done using the general Vollenweider model (Vollenwieder 1975) with a modified phosphorus sedimentation coefficient proposed by Canfield and Bachman (1981). Using data collected during the Adair study for input, this model predicted an in lake phosphorus concentration of 166 ug/L which agreed well with empirical phosphorus data of 173 ug/l. The modified Vollenweider model predicted a phosphorus concentration of 80 ug/l by removing the 614 kg $year^{-1}$ phosphorus loading associated with the Cormorants. Even though Lake Adair would still be considered eutrophic without the birds, the water quality was predicted to improve and the frequency of severe algae blooms should decrease. A phosphorus concentration of 157 ug/L was the predicted result of removing the 93 kg $year^{-1}$ phosphorus loading associated with stormwater runoff. This option would be very expensive and result in minimal changes in water quality.

The cormorants were dispersed from Lake Adair in the spring of 1997 using pyrotechnic (fireworks) devices. Relocation of the birds resulted in decreased nutrient levels and the elimination of severe springtime algae blooms. Changes in water quality were determined by comparing two years of data before (n=35) and after (n=25) relocation of the cormorants. The two time periods compared were 1995 - 1996 and 1998 - 1999. As predicted by modeling, removal of the cormorants resulted in dramatic decreases in phosphorus concentrations. Mean phosphorus declined 63% from 173 ug/l to 63 ug/l. Mean total nitrogen also declined with a 39% reduction from 1.45 mg/l to 0.89 mg/l. Decreases in nutrient levels resulted in a decline of 49% in chlorophyll-a concentrations from 77 mg/m^3 to 39 mg/m^3. The most beneficial aspect of the bird removal was elimination of severe spring algae blooms. Prior to the bird dispersal chlorophyll-a concentrations exceeded 200 mg/m^3 each spring since 1992 with a maximum value of 345 mg/m^3 in May of 1996. Following the bird dispersal the maximum concentration of chlorophyll-a was 71.7 mg/m^3. Despite the reductions in chlorophyll-a concentrations, mean Secchi depths have only increased 17 percent from a mean value of 0.70 m to 0.82 m.

There appears to be a general lack of data on nutrient loading to water bodies from cormorants or other large piscivorous birds. Nutrient loading estimates for the cormorants at Lake Adair was much higher than the vast majority of loading rate estimates for birds found in the literature. Gere and Andrikovics (1992) estimated that a nesting colony of 1500 pairs of Cormorants and their fledglings took up 12.5 tons of nitrogen and 3.1 tons of phosphorus on an annual basis in Hungary's Lake Balaton. These estimates were the only literature values found which were similar to the Lake Adair study. Much of the data on nutrient loading from birds is also suspect because very few studies involve collection of empirical data, instead electing to make estimates based on variables such as metabolic and food consumption rates.

Relocation of cormorants from Lake Adair was relatively easy using pyrotechnic devices and was effective at improving water quality. Lake Adair may not be typical because it is a small urban lake that had a disproportional population of cormorants. Results from this study indicate that nutrient loading from birds should not be overlooked when performing diagnostic studies on lakes.

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THE PROBLEM OF ACHIEVING CLEAN STORMWATER RUNOFF IN A RESIDENTIAL "WATERFRONT WONDERLAND"

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Cape Coral contains approximately 400 miles of navigable waterways within its 116 square miles. Three hundred miles are landlocked and one hundred miles are tidally influenced. Built in the 1960's, Cape Coral was promoted as Southwest Florida's "Waterfront Wonderland". This bedroom community is currently at 33% of the final projected population. There is little industry and 85% of the City is zoned residential.

Cape Coral's canal system provides many services to the residents. These services include waterfront living, flood control, irrigation water supply (supplemental to Cape Coral's reuse system), recreational opportunities and wildlife habitat. However, there are several problems associated with residential canal systems. Both canal design and the lack of interconnects restrict circulation. This can lead to stratification and low dissolved oxygen levels. Residential debris accumulation also impacts both aquatic organisms and aesthetic appeal of the waterways.

Non-point source (NPS) pollution is the biggest problem affecting water quality within Cape Coral's canals. The combination of canal design and residential development creates a variety of surface water management challenges. Stormwater flows deposit sediments, home care byproducts and road residues into canals. The typical canal/shoreline interface is a vertical concrete bulkhead. The absence of a vegetated littoral zone prevents the removal of nutrients and pollutants from stormwater runoff.

The City implemented a stormwater utility fee in 1991 to fund the current stormwater program. Dredge and stormwater crews work to maintain canals, swales, stormwater pipes and catch basins. Construction/erosion inspectors participate in canal management by enforcing turbidity controls at development sites and checking onsite retention plans during the pre-construction review process. Other ideas discussed to reduce NPS pollution include backyard swales, slopes, terraces and littoral zone plantings. Currently none of these options are mandatory.

The inherent vulnerability and immense size of the canal system requires efforts from the entire community. Public education is achieved through television, speaking engagements, informational brochures and the City's website.

An extensive water quality monitoring program is used to track the effectiveness of Cape Coral's NPS pollution control efforts. Water samples are taken monthly from 33 sites located in the City's canal system. Water quality data from Water Years 1992-1999 show increasing trends in biological oxygen demand, total phosphorous, total nitrogen, turbidity and total suspended solids. These trends indicate that Cape Coral's population growth has had an impact on surface water quality. Water quality within the City's canals may decline with population growth unless stricter measures are implemented.

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MODELING THE PERFORMANCE EFFICIENCY OF FLORIDA STORMWATER TREATMENT SYSTEMS

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State of Florida Water Policy is provided in Chapter 62-40 of the Florida Administrative Code (FAC). Chapter 62-40.420 FAC states that the Florida Department of Environmental Protection (FDEP) and the water management districts shall adopt rules that specify design or performance criteria for new stormwater management systems which achieve certain average annual pollutant load reductions. In the early 1980s, it was generally believed that all types of stormwater management systems provided good pollutant removal efficiencies, and providing treatment for the first 0.5 inches of runoff would provide annual pollutant removal efficiencies of 80-90% for typical stormwater constituents. Significant stormwater treatment research has been conducted since that time, and it is now well understood that various stormwater treatment technologies provide highly variable pollutant removal efficiencies.

Environmental Research & Design, Inc. (ERD) has developed a procedure for estimating the actual performance efficiency of Florida stormwater treatment systems. Generally, the procedure includes evaluating historic rainfall records, calculating annual runoff volumes, calculating mass pollutant loads utilizing annual runoff volumes and pollutant concentrations, and calculating annual mass pollutant load reductions for specific stormwater treatment systems.

Rainfall events are typically divided into 10-20 rainfall event ranges from 0.00-0.05 inches to greater than 9.00 inches. Based on available historic hourly rainfall data, a probability distribution is developed to determine the number of annual rain events within each rainfall event range for the project area. Specific hydrologic parameters such as percent imperviousness, percent directly connected imperviousness, curve number for non-directly connected impervious areas, and time of concentration are developed for each sub-basin in the project area. A hydrologic model, such as the Santa Barbara Urban Hydrograph Model, is then used to calculate the runoff volume for the rainfall event representing each rainfall event range. The individual runoff volumes for each rainfall event range are multiplied times the number of events to determine the annual runoff volume for each rainfall event range. The annual runoff volumes from all rainfall ranges are summed to determine the overall annual runoff volume for each sub-basin.

Typical pollutant concentrations are then developed for each land use in each sub-basin area. Ideally, pollutant concentrations for the constituents of concern are determined based on field monitoring and laboratory analyses. In many cases, literature values are used to represent mean annual pollutant concentration. Many engineers in the State of Florida utilize the information contained in "Stormwater Loading Rate Parameters for Central and South Florida" (Harper, 1994). This document provides concentration-based and areal loading rates for 12 different land uses for total nitrogen, orthophosphorus, total phosphorus, BOD, TSS, total zinc, and total lead. The annual mass pollutant loadings generated within each sub-basin area is calculated by multiplying the annual runoff volume times each pollutant concentration.

The required percent reduction for each pollutant of concern is then calculated based on project pollutant load reduction goals. Some cities and counties in Florida are currently developing more stringent stormwater treatment regulations so that pollutant loadings following development are equal to or less than pollutant loadings from undeveloped land. In this manner, development does not increase pollutant loadings to receiving waters, and water quality should not degrade further. The actual mass pollutant removal efficiencies are then calculated for each stormwater treatment system alternative based on rainfall depth, rainfall pollutant load, treatment volume depth, and treatment system efficiency for each rainfall event range using a spreadsheet model. The removal efficiencies are summed for each rainfall event range to estimate the average annual mass pollutant removal efficiency for each stormwater treatment alternative. The stormwater treatment alternatives can then be selected which achieve desired pollutant load reduction goals.

Based on several analyses performed by ERD, only dry retention, or combinations of off-line retention and dry detention or wet detention are required to achieve at least an 80% reduction in total nitrogen, total phosphorus, BOD, and TSS mass loadings on an annual basis. For post-development pollutant loadings to match pre-development pollutant loadings, dry retention must be provided for the runoff from a 3- to 4-inch rain event. Excellent removals can also be achieved by providing off-line retention of the runoff from 1.25-1.5 inches of rainfall, followed by dry detention of the runoff from 3 inches of rainfall or wet detention with a 14-day wet season residence time.

SESSION 6

ISSUES FOR THE RESTORATION OF LAKE OKEECHOBEE

Wednesday – May 24, 2000
1:40 – 3:20 p.m.

HABITAT USE OF THE AMERICAN ALLIGATOR IN THE EVERGLADES

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Beyond the fact that alligators are known to show a high affinity for holes and other open water patches in the Everglades, little is known of how alligators use marsh and canal habitats. In Water Conservation Area 3A North (WCA) and Everglades National Park (ENP), adult alligators were surgically implanted with radio-transmitters. Several weeklong intensive sampling efforts from 7 November 1997 to 31 July 1998 were used to examine habitat use.

Radio-tagged marsh alligators located in WCA used cattail, water lily, mixed marsh potholes, and holes more than their availability would suggest. Sawgrass was used less than its availability would suggest. WCA alligators were located in sawgrass 36 % of the locations, mixed marsh potholes 28 %, cattail depressions 16 %, water lily potholes 10 %, holes 7 %, and open water 1 %.

ENP slough alligators used spike rush, holes, and shrub more than their availability would suggest. Sawgrass was used less than its availability would suggest. ENP alligators were located in holes 37 % of the locations, spike rush 27 %, sawgrass 24 %, and in shrub islands 10%. The remaining time was spent in low mixed marsh and cattail habitat types.

Canal alligators used canal and hole habitats more than their availability would suggest. Canal alligators were located in canals during 83 % of the locations. On occasion, canal alligators, particularly females, moved from the canal and into the surrounding marsh. Canal alligators spent nearly 10 % of their time in marsh holes.

SESSION 7

EVERGLADES AND
FLORIDA BAY

Wednesday – May 24, 2000
3:20 – 4:40 p.m.

THE EVERGLADES NUTRIENT REMOVAL PROJECT TEST CELLS: THE USE OF EXPERIMENTAL WETLANDS TO OPTIMIZE PERFORMANCE OF STORMWATER TREATMENT AREAS – STATUS OF RESEARCH

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The Everglades is an oligotrophic ecosystem that is being negatively impacted by hydrologic changes and nutrient-rich runoff generated from urban and agricultural sources (Light, and Dineen, 1997). The Everglades Forever Act (EFA) requires the South Florida Water Management District (District) to construct a series of large treatment wetlands (ca. 16,000 ha) called Stormwater Treatment Areas (STAs) to reduce nutrient levels in runoff before it reaches the Everglades (Chimney and Moustafa, 1999). The EFA also requires the District to conduct research to optimize nutrient removal performance by the STAs. One part of the District's STA Optimization Research and Monitoring Program involves conducting research in the Everglades Nutrient Removal Project (ENRP) test cells. The test cells are shallow, fully lined wetlands, about 0.2 ha in size, located within the boundaries of the ENRP, a prototype STA built and operated by the District (Chimney et al., 2000). Thirty test cells are arranged into two groups of 15 cells each; one group is located at the northern end of the ENRP and the other at the southern end. Inflows to each set of test cells come from within the ENRP itself.

Experiments conducted in the test cells have focused on wetland performance in response to extremes in operating conditions. One series of experiments was designed to determine the maximum and minimum nutrient removal efficiency that the test cells can achieve by sequentially decreasing and increasing the hydraulic loading rate (HLR), keeping depth constant, and thereby altering the hydraulic retention time (HRT). At the north site, over a 30-week period, the HLR was sequentially increased from a mean control HLR of 2.6 cm/d (Control-N) to a mean of 10.7 cm/d (High-N) in two test cells, and simultaneously decreased in two test cells to a mean HLR of 0.74 cm/d (Low-N). At the south site, over a 15-week period, the HLR was increased to a mean HLR of 4.8 cm/d (High-S) in one test cell, and decreased to about 1.27 cm/d (Low-S) in another. Water depth in all test cells was maintained at 0.6 m. Grab and composite water quality samples were collected either biweekly or weekly, depending on the parameter, at the inflow water source and the outflow of all test cells. Water samples were analyzed for total phosphorus (TP), total dissolved phosphorus (TDP) and soluble reactive phosphorus (SRP). All field collection and laboratory analyses have been conducted in accordance with South Florida Water Management District Comprehensive Quality Assurance Plan (SFWMD, 1998), which mandates the use of either Environmental Protection Agency (USEPA, 1983) or American Public Health Association (APHA, 1989) approved analytical methods.

The mean influent TP concentration was 89.3 ppb at the north site, and 29.4 ppb at the south site. Mean influent dissolved inorganic phosphorus, measured as SRP, comprised about

33% of the TP inflow at the north and 20% at the south site, however, about 36% of SRP analyses at the south site inflow were less than the minimum detection limit (MDL) of 4 ppb. At the north site, mean outflow TP concentrations never exceeded 50 ppb and were 32.0 ppb, 41.0 ppb, and 48.4 ppb for Low-N, Control-N, and High-N, respectively. The dissolved organic P faction (TP – SRP) decreased to 13%, 14%, and 17% for High-N, Control-N, and Low-N, respectively. At the south site, the mean outflow TP concentrations were equal to or slightly higher than the influent concentration, while the outflow SRP was not affected by HLR and remained at about 20% of influent TP. More than half the effluent SRP values at both the north and south sites were less than the MDL. Mean percent concentration TP reduction for High-N and Low-N were 46% and 64%, respectively, and were significantly different from the mean percent reduction for the control cells of 54%. However, at the south site, mean TP reductions were –6%, 0.34%, and 3.7% for the high, low and control HLRs, respectively.

At the north test cells preliminary indications were that mean reductions in TP concentrations were inversely proportional to changes in HLR. However, even at mean HLRs of 10 cm/d mean outflow TP concentrations were less than 50 ppb. Additionally, SRP uptake was unaffected by changes in hydraulic loading. At the south test cells influent TP concentrations were a third of the mean influent values at the north, and mean TP percent reductions were not affected by changes in HLR. For these emergent wetland systems, HLRs affected TP reduction only at the higher influent concentrations.

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DECOMPOSITION OF CELLULOSE IN RELATION TO NUTRIENT AND WATER LOADING RATES IN A SUBTROPICAL CONSTRUCTED WETLAND

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Decomposition of plant cellulose is an important component of nutrient cycling in wetlands and can be a significant nutrient source to the system (Harrison et al., 1988). Factors affecting the rates at which plant material is broken down include temperature, pH, dissolved oxygen, and nutrient availability. Cotton strip assays have been shown to be a good indicator of natural cellulose decomposition rates (Maltby, 1985). Cotton strip assays were used to determine the effects of nutrient concentration and hydraulic loading rate (HLR) on cellulose mineralization within a subtropical constructed wetland. The South Florida Water Management District has built thirty fully lined, rectangular-shaped, 0.2 ha wetlands (test cells), within a larger 1,545 ha constructed wetland known as Everglades Nutrient Removal Project (ENRP) (Chimney et al., 2000). The test cells are vegetated with *Typha* spp. and/or submerged aquatic vegetation (SAV) communities, and are arranged into two groups of fifteen cells each, with mean total phosphorus (TP) concentration of 89 and 29 µg P/L at the north (high TP) and south sites (low TP), respectively. Experiments being conducted in the test cells will manipulate HLR (ranging from 0.74 to 10.70 cm/day) to maximize nutrient removal efficiencies.

Cotton strip assays were performed in the test cells using a technique similar to Maltby (1985) and Newman et al. (in prep). A stainless steel frame, with three 12 by 30-cm strips attached was inserted into the soil to a depth of 15 cm for one week (i.e., 15 cm of the cotton strip was within the sediment and 15 cm was in the water column). Four replicated cotton strips were placed within emergent and submergent vegetation at the inflow and outflow regions. Upon removal, the strips were cut into 2-cm increments, 10-cm above the soil surface and 10-cm below the soil surface. The strips were frayed by hand until a single thread could be removed intact along the length of the cut edge. Each strip was soaked in water and blotted dry to remove excess water and simulate 100% humidity. Tensile strength was tested by inserting the strip into a Chatillon TCD-200 tensiometer equipped with a digital force gauge (DFIS 200, Chatillon, Greensboro, NC) and applying force to the strip until it was torn. All tensile strengths were adjusted to correct for the loss in tensile strength of a field control strip. The data were linearized and are expressed as annual cotton rotting rates (CRR) over time (Newman et al. in prep), which was calculated as:

$$\text{CR (rottenness)} = \sqrt[3]{(y_o - y)/y}$$

$$\text{CRR} = (\text{CR}/t)*365$$

where y_0 = mean tensile strength of control strip; y = mean tensile strength of the test strip at a given depth; and t = duration of burial.

Cotton strip assays were used to compare sediment and water column cellulose decay rates over various HLRs, nutrient regimes, and vegetation types. Varying HLR at higher nutrient loads (north test cells) appeared to have greater influence on CRR (107.2, 86.3, and 47.4 yr^{-1} for high, control, and low HLR designated cells, respectively) then at lower nutrient loads (south test cells) (32.6, 33.8, and 37.3 yr^{-1} for high, control, and low HLR cells, respectively). This suggests that decomposition rates increased as phosphorus loads increased, where as at lower nutrient loads, decomposition rates were not affected. No differences were observed between HLR treatments for pH and dissolved oxygen, which may affect decomposition rates. Additionally, decomposition rates within *Typha* spp. communities (41.3 yr^{-1}) were similar to those found within SAV communities (30.6 yr^{-1}). Preliminary results indicate that at high TP, CRR was responsive to HLR but at low TP, CRR was not responsive to HLR also differences in CRR could not be detected between vegetation types for either high or low TP levels.

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FLORIDA BAY SALINITY
TRANSFER FUNCTION ANALYSIS

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This study was commissioned to evaluate the existing linear regression models that are being used as hydrologic transfer functions to simulate salinity conditions in Florida Bay. The general study area for this project is the Everglades National Park and the adjacent upland areas of Dade County, Florida that are served by the South Florida Water Management District C-111 Canal. The Florida Bay water bodies included in this study are:

1. Joe Bay
2. Little Madeira Bay
3. Terrapin Bay, and
4. Garfield Bight

The current transfer functions relate salinity to a regional indicator of hydrologic condition (water level in Shark River Slough at Lp33). It is thought that local hydrological conditions and the C-111 Canal water management system operations may also affect the salinity of these water bodies, particularly Joe Bay. Because of this, this study also included an evaluation of new models using other independent variables that are representative of the operation of the water control and diversion structures of the C-111 Canal.

A linear regression model has certain features that are assumed when the model is constructed. After a model has been constructed from existing data, the features of the model must be tested for deviations from these assumptions, in addition to examining the value of the coefficient of determination. Residuals analysis through the use of residual plots (as was done in this study) can be useful for testing the basic model assumptions.

In general, residuals analysis shows that none of the four existing hydrologic transfer function models show signs of being nonlinear. The error variance is not steadily increasing or decreasing systematically and reasonably simulates a normal error distribution. Even so, two problems are seen in the residual plots for all of the four regression equations:

1. There are a number of potential outliers, and
2. There appears to be seasonality in the data and in the errors

Outliers and seasonality can have a relatively severe effect on the estimated parameters of the regression model. Outliers should be tested and removed if appropriate. The seasonality of the data can usually be handled by using a different type of model that is more robust to seasonal data variability. There are also signs in the residual plots that indicate that other important independent variables that may need to be included in the each of the salinity models, particularly the Joe Bay model.

To evaluate the impact of operational activities on the regression equations, several separate analyses were performed. The model residuals were plotted against each of the independent variables to see if they are related in any way. Simple linear regression equations were also developed using each independent variable and the subject salinity values, and the coefficients of determination compared. The results show that Joe Bay salinity is related to the most operational independent variables, and the Garfield Bight salinity model the least. The pattern of variation of the residual values for some of the cases indicate that the effect of C-111 Canal system operations may be complex, and may be systematic.

It is clear from the correlation matrix that there is cross-correlation between most of the independent variables. The salinity in all of the water bodies is correlated rather highly with the salinity in all of the other water bodies. The C-111 Canal structure flows are also highly correlated. The cross-correlation that is seen can be troublesome for multi-variable linear regression relationships.

Independent variables that are conspicuous by their absence are unlagged values of some of the structure flows and all of the rainfall stations. When lagged values were evaluated, it was found that lagged values of flow and rainfall were strongly related to salinity in all of the water bodies. In Joe Bay the delay in the effect of water management operations is pronounced and in Little Madeira Bay it is also noticeable. It appears that the variability in the salinity of these water bodies of Florida Bay is related to both short term and longer term factors, the effect of some being delayed in time.

Using a double mass curve analysis, it was determined that the existing Joe Bay linear regression transfer function model was significantly affected by water management system operations, at the 95% confidence level. The Joe Bay transfer function was statistically different for the periods of water management system operation, compared to the periods when no operational activities were taking place.

Taking all of the factors into account, it appears that some of the models, particularly the Joe Bay salinity model and perhaps the Little Madeira Bay salinity model, may be able to be improved by including the effects of water management operations and rainfall using lagged values in the transfer function. The other two transfer functions may be adequate in the updated forms. However, because there is seasonality, serial correlation, and cross-correlation, time series models which can include moving average and autoregressive effects may be better suited for Florida Bay salinity transfer functions.

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FLORIDA BAY WATCH: RESULTS OF FOUR YEARS OF NEARSHORE WATER QUALITY MONITORING IN THE FLORIDA KEYS

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Florida Bay Watch is a program of The Nature Conservancy in which trained volunteers collect seawater samples and environmental data using standard scientific methods. It is designed to augment and assist scientific studies conducted by universities, agencies, and other institutions. In particular, nearshore water quality data reported here complement offshore water quality monitoring program conducted in Florida Bay and along the Keys by Florida International University (FIU).

Approach. Frozen seawater samples and data forms are collected monthly from volunteers and the samples are sent to an analytical laboratory at FIU. Total nitrogen, total phosphorus, and chlorophyll-*a* concentrations are determined using standard methods. The monitoring period reported here was November 1994-October 1998; November marks the beginning of the dry season and October marks the end of the wet season.

The nearshore sampling stations had various start-dates and durations as volunteers entered and left the program. To examine possible patterns through time in concentrations of the three water-quality parameters, four stations with full four-year data sets for the period Nov. 1994 - Oct. 1998 were used. Two of the stations were in the upper Keys and the other two were in the middle Keys. Two stations were at developed shorelines and the other two were at natural shorelines; all four were bayside of the Keys. Monthly station means were averaged for each year, defined as Nov.-Oct. to include a full dry season and wet season.

Station types were assigned using three criteria: (1) region of the Keys, (2) developed vs. natural shorelines, and (3) oceanside vs. bayside of the Keys. Developed shorelines included various kinds of canals (e.g., dead-end, open-ended, aerated) and boat basins. Natural shorelines often included a dock from which samples were collected. One-year periods between November 1994 and October 1998 were used to compare water-quality parameters between station types; no 12-month period included at least one station in all 12 possible categories. Therefore, annual averages of monthly station means were examined factor by factor because two- and three-factor arrays were not complete.

Results. The concentration of chlorophyll-*a* decreased steadily between Nov. 1994/Oct. 1995 (1.34 μg/L) and 1996/97 (1.03 μg/L), then increased substantially in 1997/98 (2.00 μg/L). This initial decrease paralleled observations of declining microalgal blooms over the same period in parts of Florida Bay. Both total phosphorus and total nitrogen increased over the four years (0.51 to 0.92 μM and 41.30 to 47.00 μM, respectively); increasing total phosphorus was also measured offshore by FIU in the Florida Keys National Marine Sanctuary, but no significant change was measured in offshore waters of Florida Bay.

The concentration of chlorophyll-*a* did not vary in a consistent manner from year to year among the regions of the Keys. Values consistently were 1.5 to 3 times greater along developed shorelines (1.14 to 1.55 μg/L) than along natural shorelines (0.41 to 0.99 μg/L). Bayside concentrations (1.08 to 1.53 μg/L) were generally about two times greater than oceanside concentrations (0.34 to 0.69 μg/L). The concentration of total phosphorus (TP) also did not vary consistently among regions of the Keys. Developed shorelines (0.45 to 0.58 μM) had somewhat higher TP values than natural shorelines (0.40 to 0.45 μM) except during 1997/98 (0.42 vs. 0.97 μM). As with chlorophyll-*a*, bayside TP concentrations (0.44 to 0.73 μM) consistently were greater than oceanside concentrations (0.28 to 0.41 μM). Unlike chlorophyll-*a*, total nitrogen concentrations (TN) did not differ consistently between developed (36.5 to 45.8 μM) and natural shorelines (39.0 to 40.2 μM). Bayside concentrations (41.8 to 44.2 M) consistently exceeded oceanside concentrations (24.0 to 41.7 μM). In general, TN concentrations in the upper and lower Keys (33.4 to 50.7 μM) exceeded those in the middle Keys (27.0 to 35.7 μM).

Conclusions. We compared upper Keys, bayside stations with offshore FIU Florida Bay stations for the period 1996/97. Nutrient concentrations were elevated at the nearshore stations (TP: 0.31 μM; TN: 52.3 μM) compared to offshore levels (TP: 0.17 μM; TN: 39.4 μM); the concentration of chlorophyll-*a* at developed stations (0.86 μg/L) was more than twice the offshore value (0.33 μg/L). These patterns are consistent with nearshore nutrient loading, possibly from septic systems.

SESSION 8

STORMWATER/
WATERSHED ISSUES

Thursday – May 25, 2000
8:40 – 10:40 a.m.

THE APPLICATION OF BASINS TO COMPREHENSIVE WATERSHED MANAGEMENT

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This paper provides an evaluation of the United States Environmental Protection Agency (USEPA) BASINS software as a watershed and water quality analysis tool. BASINS is an acronym for Better Assessment Science Integrating Point and Nonpoint Sources. It is a geographic information system (GIS) based ArcView® application with integrated water quality analysis and modeling tools. USEPA developed BASINS to facilitate watershed level examination of environmental information and environmental systems and to provide a management tool for investigating watershed management alternatives. The tools included in BASINS allow analysis on several levels making it a particularly valuable device for water resource managers. The study was limited to the BASINS program, existing data supplied with BASINS, available local water quality data, land use data and locally delineated watersheds. In the study we applied tools resident in BASINS to model and visualize existing water quality conditions in watersheds where comprehensive watershed management (CWM) plans were being developed. We also applied BASINS in efforts to model future conditions and to evaluate watershed management strategies.

Comprehensive Watershed Management (CWM) is a methodology developed by the Southwest Florida Water Management District (SWFWMD) to conduct water resource assessment and planning on a watershed basis. This approach is designed to allow SWFWMD to carefully assess the regional status of water resources for the eleven watersheds within its geographic area of responsibility. The approach is interdisciplinary in that it brings together scientists, planners and stakeholders to evaluate the condition of the watershed's water quality, natural systems, flood protection and water supply.

The primary objectives of the study were to (1) determine the application of BASINS to the CWM process; (2) evaluate the various tools and models contained within BASINS; and (3) determine the feasibility of using BASINS to examine CWM management alternatives. To meet these goals, we developed a study approach that employed BASINS as the primary tool for evaluating the current water quality conditions and investigating various CWM strategies related to water quality maintenance and/or restoration.

The BASINS program is composed of six primary components that are linked to make a highly effective ArcView application. These components include (1) an extensive set of USEPA devised, national databases with integrated data extraction tools and customized ArcView project builders; (2) specialized assessment tools for multi-watershed level (TARGET), watershed level (ASSESS) and station level (Data Mining) application; (3) utilities for data organization, evaluation and management (watershed delineation, specialized theme import functions, land-use reclassification, DEM reclassification, and look up tables); (4) watershed characterization reports

® ArcView is developed by Environmental Systems Research Institute (ESRI) Inc.

which allow the ordering and display of the USEPA nation database elements; (5) stream models which allow the transport of selected pollutants in streams and rivers (TOXIROUTE) and a point plus non-point source data receiving body water quality model (QUAL2E); and (6) a nonpoint source model and postprocessor watershed loading and transport model (NPSM). The study demonstrated the value of this integrated watershed tool approach.

The study found that BASINS is a valuable CWM tool. That its basic assessment tools and watershed characteristic report functions were of significant value to CWM planning and water quality evaluation. We found the most significant value of BASINS was that it gave the CWM water quality team the ability to conduct complicated evaluations in a short time period (2 to 5 minutes) on a personal computer. BASINS is well documented and has a relatively thorough user's manual[1]. The USEPA also maintains a list-server[2] and web page to assist BASINS users[3]. Although, true mastery of BASINS requires significant ArcView knowledge, BASINS specific training and many dedicated hours of use and experimentation, we found that many of the functions could be employed with only limited self-education.

We found several limitations to the use of BASINS. Most of these were either related to computer hardware and software requirements or database issues. BASINS requires a fast (200 MHz Pentium or higher), computer with significant available hard disk (620 mb or more) and RAM (64 mb plus 64 mb virtual). ArcView 3.0a or 3.1 software is also required. Additionally, the QUAL2E implementation in BASINS limits its use to non-NT machines. The second major problem found in BASINS was the difficulty in converting local data for use in BASINS and the limited nature of existing BASINS databases. BASINS has features for conversion of local data; however, we found that most of the converted data could not be used with the various BASINS tools. This lead us to the conclusion that full implementation of BASINS would require assistance by USEPA to develop local BASINS databases.

BASINS is an excellent tool for water quality analysis on a watershed scale. It does require significant training and practice to use effectively. The major requirement for true implementation of BASINS in CWM planning is the development of better tools to allow local development of databases.

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2. Paul Cocca, cocca.paul@epa.gov, (202) 260-8618.

3. http://www.epa.gov/ost/basins

THE IMPORTANCE OF LOCAL HYDROLOGY AND PARTICLE SIZE DISTRIBUTION IN BMP DESIGN FOR SUSPENDED SOLIDS REMOVAL

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There are numerous verification programs being established to evaluate the performance claims of proprietary manufactured stormwater quality devices. Generally, these programs all involve requirements for field monitoring data from one or more sites which forms the basis of the evaluation.

A criticism of these verification programs is that they do not recognize that every site is different and that no procedures are provided to normalize field monitoring for site specific factors such as particle size distribution, local hydrology, drainage layout, and device sizing that will undoubtedly affect the field monitoring results. Instead, most programs rely on establishing a certain level of performance which perpetuates the belief that stormwater quality controls provide consistent performance. Stormwater quality controls will vary in effectiveness from storm to storm depending on antecedent conditions (inter-event time, average daily traffic, atmospheric loading) and storm characteristics (intensity, duration).

A continuous simulation model has been developed that accounts for factors (particle size distribution, storm characteristics, inter-event times, device sizing) that affect performance. Results from the model show good agreement with actual field monitoring results. In addition to providing long term TSS removal estimates, one of the key benefits of the model is the ability to alter the design parameters to match actual field conditions. The ability to input actual field parameters provides insight to the sensitivity of TSS removal performance to design parameters and helps to explain the variability in field monitoring results between different sites based on site specific conditions.

The agreement between model results and field monitoring indicates the importance of normalizing the data for important parameters such as BMP sizing, local hydrology and site particle size distribution for stabilized urban sites. This normalization is critical to the evaluation of BMPs and to the comparison of performance between BMPs.

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AN EVALUATION OF SEASONAL WATER LEVEL FLUCTUATIONS IN ARTIFICIAL PONDS IN COASTAL SOUTHWEST FLORIDA

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Seasonal pond level variations are being examined in Lee County, Florida to develop improved management strategies and pond construction recommendations. The vast majority of ponds in coastal southwest Florida are artificial and have been constructed for a variety of purposes, including "fill" excavation, stormwater management, and sources of irrigation, among others. Extreme variations in pond levels have created various management problems relating to littoral zone plant communities and wildlife habitat, water quality, irrigation limitations, and aesthetics. Staff gages installed at 11 sites are used to measure monthly water levels. Each site was monitored for at least one year. Seasonal variations in pond level will be evaluated with respect to local precipitation, pond slope, surface to volume ratio, maximum depth, surficial aquifer characteristics, and consumptive use. Other qualitative assessments associated with the specific basin's watershed will be analyzed with respect to fluctuating water levels.

TREATMENT OF STORMWATER RUNOFF FROM AN AGRICULTURAL BASIN BY A WET-DETENTION POND IN RUSKIN, FLORIDA

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The use of wet-detention ponds to attenuate stormwater flow and pollutant loads has been demonstrated in many studies, but most of these have been conducted in urban or residential developments. Few studies have documented the use of wet-detention ponds to treat flow from an agricultural basin dominated by row crop farming. This project near Ruskin, Florida was designed to characterize an agricultural stormwater treatment system by: (1) Measuring the reduction (or increase) of pollutants in storm runoff treated by a wet-detention pond, (2) Determining water quality concentrations in a pre-treatment ditch and water table wells, (3) Comparing sediment samples for two different years, and (4) Analyzing processes taking place in the stormwater system.

The efficiency of the wet-detention pond to remove pollutants was affected by the unseasonable amount of rainfall induced by the El Niño phenomenon. During the two years of study (48 rain events), over 70 percent of all the pollutant loads for potentially toxic metals entered the pond during five El Niño storms, and, since higher pollutant loads are often more easily reduced these conditions contributed to the much better metal pollution removal during 1998. Another process which may have enhanced constituent reduction was the newly excavated sediments. Clean sediments provide more attachment sites for constituent removal. Yearly data show pollutant load reductions for 1998 were greater than 90 percent for most metals, but for 1999 reduction of metals only ranged from 60 to 90 percent. In contrast, inorganic nutrient removal was better in 1999 (> 80 percent) than during 1998 (50 to 70 percent). Organic nitrogen had the poorest removal efficiency for both years (20 to 40 percent). The total suspended solids removal rate was 98 percent for 1998 but a negative 43 percent for 1999. Ten pesticides were detected at the inflow during El Niño while only five (usually with lower concentrations) were detected at the outflow. Bacteria exhibited widely fluctuating concentrations and there was no consistent pattern between the inflow and outflow. The discharge of fecal coliform may be a problem since samples appear to exceed the standards established to protect the propagation and harvesting of shellfish.

A ditch treated pollutants before water entered the pond and reduced median concentrations by an average of 52 percent after the ditch was cleaned out, indicating that maintenance should be an important part of storm water management. But, phosphorus levels increased in the ditch and they were also measured at high concentrations in the pond, often exceeding 3 mg/L with average concentrations greater than 1 mg/L. Although not strictly relevant since the pond discharges to a mixing zone, the average outflow water quality values for copper and iron were in non-compliance of Class II marine standards for both years and the sediment samples in the marsh also exceeded the probably toxic level for copper in 1999. The sewage lagoon adjacent to the pond may be contributing pollution by migration in groundwater. The ammonia concentrations in a water table well between the pond and the sewage lagoon show

levels of 14 mg/L indicating a groundwater connection. Also higher phosphorus concentrations in the wells closest to the fields show P may also be migrating in groundwater.

Conclusions

Considerable differences in performance were noted between years with extremely high concentrations flushed through the system during the El Niño storms.

1. Annual averages of copper and iron exceeded Class II marine water standards in the pond at the outflow during both years.

2. Phosphorus concentrations at the inflow and outflow were over twice as high as concentrations measured in other urban and agricultural studies conducted in the region.

3. Total suspended solids, total organic nitrogen, and iron concentrations increased from the inflow to the outflow during the dry second year.

4. Pesticides in stormwater were detected, and more were found at the inflow (10) than at the outflow (5). Two appear to exceed standards (Endosulfan at the inflow and outflow and Chlordane at the inflow). Pesticides were also detected in ambient water quality samples collected in the roadside pre-treatment ditch (50 percent of samples for endosulfan, 14 percent, for chlordane, 7 percent, for Bromacil and 14 percent, for Diazinon).

5. Both fecal coliform and total coliform bacteria appear to exceed levels considered safe for the propagation and harvesting of shellfish at the outflow. This has implications since the pond water discharges to an estuary that has been a prime shellfish harvesting area.

6. High concentrations of metals were measured in the sediments where fresh water was discharged into the brackish marsh. Some concentrations were possibly toxic, but since this is a mixing zone the standards do not apply to this area.

7. Phosphorus concentrations in the ditch were all between 2 and 6 mg/L when dissolved oxygen levels were below 1 mg/L. All P samples were below 2 mg/L when D.O. was above 2 mg/L.

8. Concentrations in the sediments usually showed an increase from 1997 to 1998 for most metals demonstrating that the sediments in this newly constructed pond increased from undetectable amounts in 1997 to much higher concentrations in 1998. This may account for the good removal (about 90%) in 1998 compared to 1999 (about 60%) as attachment sites on sediment particles are occupied.

9. Ditch maintenance with polluted sediments removed from the site reduced concentrations in the water in the ditch by an average of 50 percent and emphasizes the importance of periodic maintenance for roadside ditches.

10. Large events flush out the system and often contribute the majority of pollutant loads measured for the entire year.

11. Maintenance guidelines for stormwater systems need to be developed.

12. Low dissolved oxygen and high pH in eutrophic stormwater systems affect their ability to reduce pollutant loads.

13. More information is needed about treatment efficiency as ponds age. This study indicates that recently constructed ponds are much better at pollution removal.

14. Phytoplankton growth in eutrophic systems may actually increase total suspended solids and organic nitrogen in a stormwater system.

15. Rainfall can be a significant hydrologic and constituent input to stormwater ponds. Twenty-five percent of the water entering the pond entered as rainfall on the pond and 50 percent of all the ammonia loads entered the system directly in rainfall.

An interim report which includes all the data is available.

USING INFORMATION TECHNOLOGY AND THE INTERNET TO IMPROVE WATERSHED MANAGEMENT

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The purpose of this presentation is to provide an overview of effective information technology (IT) strategies for assisting watershed management efforts and the benefits that can be realized from this technology. We have completed and deployed a web-based system for lake management data in Hillsborough County, FL, and are in the process of designing systems for managing and serving comprehensive water resources data in two additional Florida municipalities. From these activities, we would like to present our preliminary findings of how strategically planned information management solutions and web applications can improve watershed management activities.

Several factors are critical to the success of an Internet-based solution for the management of watershed data. Similar to the planning efforts themselves, we have found the design of an information management system requires the inclusion of a broad range of stakeholders that guide the systems design and functionality. Literally, the system should provide a depository or "data warehouse" function for a wide variety of data types at different spatial scales from different jurisdictions to serve watershed management purposes (Voinov and Costanza 1999). These data should include agency-collected data, volunteer monitoring data, and quality-assured data from private engineering firms and academic studies. The system should ensure that data collected in studies are deposited into the warehouse and can be extracted in raw format for "colleague to colleague" interaction, or displayed on the Internet with ample educational material in a summarized format for a "colleague to citizen" application. An important aspect of providing this functionality is specifying both data and metadata standards for any "new" studies that are contracted (i.e. standardized accuracy and precision of geographic data). Another important consideration in the overall design is updating and maintenance. In Seminole County, FL we are designing procedures to automatically import data from host agencies in a native export format and automate quality control. The Seminole County Watershed Atlas will be an Internet application that allows users to access online GIS maps and query all known scientific data by waterbody. The system will store these data in a SQL-based Water Resources Atlas Database or W-RAD and subsequently link those data at multiple spatial scales through ESRI's Spatial Database Engine (SDE). This configuration allows acceptable performance for querying large datasets and can serve the data in a user-friendly Internet mapping application. An added benefit to this design is greatly reducing the costs of maintenance and providing the flexibility of adding and continuously updating data sets as needed.

In the system we have implemented in Hillsborough County Florida (http://www.lakeatlas.usf.edu/), which has been in operation for approximately one year, we have observed the following effects on overall water resources management. The first noticeable improvement is quality assured data are now easily accessible by all stakeholders and this has reduced the amount of time agency staff are required to devote fielding questions from local citizens, realtors, and other people researching water resources. The second effect we have observed is an increase in communication among stakeholders and additional requests from citizens to fill identified "data gaps". E-mail discussion groups have facilitated, albeit on a limited scale, the discussion of water resource management. Third, the project has guaranteed institutional memory and data stewardship for both scientific and social data. The oral history component of this application has cataloged and stored more than 2,000 images and narratives from local citizens and scientists that may have otherwise been lost and unavailable to individuals conducting water resource research. Finally, the amount of educational material distributed to individuals has greatly increased. Since inception in March of 1999, the site has received 517,000 hits from 32,673 users and may prove to be a cost effective means of distributing educational materials over the long term.

In conclusion, we envision the watershed management plan of the future as a continually updated resource in contrast to a static document. Consistent with other researchers, we recommend that municipalities undertaking research activities to support watershed management planning have an information management plan in place (Michener et. al 1998). Second, the process of design should be inclusive with local stakeholders to ensure the system will serve a wide variety of needs. Third, the system should be flexible in its design and ensure a wide variety of data types and structures are included. Finally, the system should include stored procedures that facilitate maintenance and real-time updating of spatial and non-spatial data.

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SESSION 9

WATER QUALITY AND MANAGEMENT ISSUES

Thursday – May 25, 2000
10:40 a.m. – 12:00 noon

DREDGED SEDIMENTS –
A RECOVERED RESOURCE

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Crane Creek, a tributary to the Indian River Lagoon estuary, located in Melbourne, Florida, was dredged to remove sediment that contained a fine-grained/organic bearing fraction generally referred to as "muck". Sediment was removed from the creek using a hydraulic dredge and pumped into upland disposal sites abutting the creek. The St. Johns River Water Management District, wanted to evaluate the chemical and physical characteristics of the hydraulically segregated sediment fractions, and its potential uses and environmental impacts. Therefore, in December 1998, such a study was initiated seven months after the dredging was completed. In the disposal site the sediment segregated into two distinct fractions: a coarse fraction (sand/shell) that immediately settled out near the discharge pipe and a fine-grained/organic fraction that migrated farther away and deposited near the site's out-fall structures. The *in-situ* solids content of the coarse fraction ranged between 70% to 90% with less than 3% organic content whereas the solids content of the fine-grained/organic fraction ranged from 20 to 50% with 10% to 40% organic matter. In general, an increase in concentration of polycyclic aromatic hydrocarbons, nutrients, and metals was observed as the fine-grained/organic fraction of the sediment increased. Thus, prudence would suggest analysis of the dominantly fine grained, organic bearing fraction prior to placement or use as a soil amendment. However, a horticultural study using the muck sediment revealed no detrimental effects from muck on St. Augustine grass, Bahia grass, or Mexican Heather. These results, along with results from a previous horticultural study of muck, strongly suggest that muck can be used as a topsoil amendment for grass cover establishment in a variety of projects (e.g., landscaping, erosion control, golf courses, and sod establishment on roadway shoulder and medians). The sand/shell fraction of the dredged material has beneficial properties as construction fill material,

embankment material for building roads, highways and bridges, and meets the grain size requirements for the production of concrete or asphalt pavements. It is important to realize that much of the muck in the dredged material is largely eroded upland soils being carried away by stormwater runoff from developed areas in the basin. This study supports previous and on-going work that demonstrates the utility of uncontaminated sediments dredged from Florida's estuaries, especially the Indian River Lagoon and its tributaries. Such dredged material should be regarded as a resource, not as waste or spoil.

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LAKE PERSIMMON WATER QUALITY INVESTIGATION AND WATER QUALITY RESTORATION PLAN

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Lake Persimmon is a small, shallow, hypereutrophic seepage lake located in southern Highlands County. Based on a comparison to 76 lakes monitored in Highlands County by the District, Lake Persimmon has one of the top two highest Florida Trophic Index's (median 79.2) in the County. In 1997, a study to investigate the lake's poor condition was started as a cooperative effort between the Peace River Basin Board and the Highlands County Board of County Commissioners. Lake Persimmon displayed numerous characteristics indicative of hypereutrophic lakes. Monthly data collected during the study indicated continually high chlorophyll-*a* concentrations (median 82.9 *u*g/L - trichromatic) and poor water clarity (median Secchi 0.29 m). Depth profile data revealed this shallow lake (maximum depth 3.5 m) undergoes moderate anoxia from spring to fall, with severe anoxia and thermal stratification occurring during the height of the summer. During periods of severe anoxia, low dissolved oxygen concentrations (below 2 mg/L) were measured near the surface (1 m). Additionally, in the bottom 1 meter strata, ammonium concentrations peaked between 5 and 7 mg/L, while an increase in bottom phosphorus concentrations was also observed.

No historical change in trophic state was reported in the paleolimnological analyses completed by Thomas J. Whitmore and Mark Brenner (University of Florida, Institute of Food and Agricultural Sciences, Department of Fisheries and Aquatic Sciences). This finding is contrary to the historical trend of many other hypereutrophic lakes studied in Florida. In fact, diatom assemblages indicated that P concentrations have actually declined slightly over time in Lake Persimmon. These results seem to indicate that the historic phosphorus availability of Lake Persimmon may be primarily related to the surrounding and underlying soils found in the Lake Wales Ridge Transition Region. High phosphorus concentrations found in other nearby lakes in this region, such as lakes Huckleberry and Wolf , provides evidence for soil phosphorus availability in this region. $\delta^{15}N$ analyses conducted by the University of Florida indicated that there has been a notable change in the nitrate supply to the lake in recent decades. Furthermore, they reported that the source change may be related to new sources in the watershed such as leaching from residential septic systems and application of synthetic fertilizers.

The results of the paleolimnological analyses support the findings of the recent water quality analysis which found substantial nitrate enrichment in Lake Persimmon. Concentrations near or above 1 mg/L are common in the lake, while concentrations as high as 17 mg/L (median 4.5 mg/L) were measured in the main canal located along the southeast side of the lake. A significant correlation was observed between nitrate concentrations in the canal and nitrate in the lake (Spearman correlation rho=0.650, n=12), suggesting similarity between ground water inflows for the canal and the lake.

In addition to the water quality assessment of the lake, basic ground water analyses were conducted to help identify the primary anthropogenic source(s) of the ground water nitrate contamination in the Lake Persimmon watershed, and to determine relationships between ground water and water chemistry cycles in the lake. Water quality data obtained from the Florida Department of Environmental Protection (FDEP) for the residential potable supply wells in the Lake Persimmon watershed, revealed that numerous residential wells contained high concentrations of nitrate. Residential drinking wells in this region are generally shallow and range between 60 and 100 feet deep. Nine of the thirty-five residential wells in the watershed were found to contain nitrate concentrations in excess of state standards (10 mg/L), some of which contained concentrations near 30 mg/L. Another 7 wells located just outside of the western watershed boundary were also found to contain concentrations above the state standard. Contaminated wells were primarily located to the east, south, and west of the lake. The south and east regions of the watershed were determined as areas of predominant ground water inflow based on the downward topographic slope and water table elevations measured in piezometers. Wells located to the north and northwest of the lake contained low concentrations of nitrate. Ground water movement is generally directed away from the lake in this region. In addition to water quality data for residential potable supply wells, water quality data were also collected for four shallow ground water monitoring wells (8-16ft) installed during the study. Only one of these wells contained elevated nitrate concentrations. This well was located in the southern portion of the watershed in a region of predominant ground water inflow. The finding of nitrate contaminated wells in regions of predominant ground water inflow suggests that nitrate contaminated ground water enters the lake and canal through lateral seepage. It should also be noted, that well contamination may be related to land use. Contaminated wells were primarily located down gradient of citrus groves. On the north side of the lake, where well nitrate concentrations were low, land use is comprised of residential land and forests.

To help quantify land applied nitrogen loads in the Lake Persimmon watershed, estimates of loading rates for each of the anthropogenic sources were obtained from literature and then applied to the respective land use areas in the watershed. The estimated annual total nitrogen load for all fertilizer users was approximately 10 to 15 times greater than the estimated load for septic effluent in the watershed. The estimated load from annual rainfall (48.5 inches from July 1998 - July 1999) was insignificant in comparison to anthropogenic sources. The annual land applied nitrogen loads were also estimated separately for fertilizer application in citrus groves, residential areas, and nurseries. Based on the literature application rates, fertilizer applied in citrus groves provides approximately twice the annual load of total nitrogen, ammonium, and nitrate than fertilizer applied in the residential areas. The estimated nitrogen load derived from nursery fertilizer was rather insignificant in comparison to citrus groves applications. Indications that fertilizer application are the primary source of nitrogen in the watershed were supported by nitrogen isotope tests performed for a single residential potable supply well tested during the study. $\delta^{15}N$ signature indicated that the origin or source of nitrate in this residential drinking well is associated with synthetic fertilizers.

Based on the findings of the study, a short term improvement may be provided to the lake through artificial aeration and possibly, through whole lake alum treatment. Long term nutrient load reduction projects should focus on BMP's which target reduction of fertilizer application in the watershed. A detailed discussion of planned remedial actions for Lake Persimmon are provided in the Lake Persimmon Assessment report (SWFWMD 2000).

ENVIRONMENTAL IMPLICATIONS OF HIGH RADIUM-226 ACTIVITIES IN FLORIDA LAKES

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We use paleolimnological methods to evaluate past environmental changes in Florida lakes (Brenner et al. 1988, 1993, 1995, 1996, 1997, 1999a, 1999b, 1999c; Deevey et al. 1986; Whitmore 1989, 1991; Whitmore et al. 1996). Sediment chronology (i.e. age-depth relation) for the last ~100 years is established by 210Pb dating (Schelske et al. 1994). Gamma spectroscopy enables simultaneous measurement of activities of naturally-occurring radionuclides total 210Pb and 226Ra (supported 210Pb). In many Florida lake cores, 226Ra activities are high and variable in sediments deposited during the last century (Brenner et al. 1994, 1995, 1997). Stratigraphic changes in radium activity are often correlated with total phosphorus (TP) concentrations, suggesting a common delivery mechanism for the radionuclide and nutrient (Brenner et al. 1994, 1997). After ~1900, radium and TP were probably transported to Florida lakes at higher rates because human activities disturbed nutrient- and uranium-rich riparian soils. Paleolimnological study of groundwater-augmented Round Lake, Hillsborough County, indicated that pumped groundwater is also a source of 226Ra to Florida lakes (Brenner et al. 2000). Radium-226 activity in pumped aquifer water (6.2 dpm L-1) is about twice the in-lake value (3.4 dpm L-1). Lakewater activities are below the drinking water standard, but high activities were measured in recent sediments, aquatic plants, mollusc shells and soft tissues, and fish bones. Unionid mussels bioaccumulate 226Ra, and display values between 220 and 455 dpm g-1 dry in soft tissues. Various human activities that accelerate soil erosion, including residential development, road and railroad construction, agriculture, and phosphate mining, as well as groundwater pumping for irrigation, residential and industrial use, promote delivery of 226Ra to Florida's aquatic ecosystems. Uptake and biological accumulation of radium by freshwater pelecypods may be an important pathway for 226Ra transfer to higher trophic levels of aquatic and terrestrial food webs. High 226Ra activities in topmost lake sediments and biota can also pose potential health risks for humans.

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SESSION 10-A

LAKE LEVEL ISSUES

Thursday – May 25, 2000
1:20 – 2:40 p.m.

OKEEHEEPKEE, DISAPPEARING WATERS, AND THE KARST LAKES OF LEON COUNTY

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An extended period of drought in North Florida has given us a unique opportunity to study karst. More than 3,300 karst features have been identified within Leon County, Florida, such as sinkholes, closed depressions, springs and large lake basins containing known sinkholes (Benoit et al., 1992). On the average, 2.5% of the land in Florida lies over some sort of cave, though cave porosity can be as high as 16%. The average cave is an elliptical tube, 5 ft high by 10 ft wide (Wilson, 2000). Larger caves are less stable. The numerous caves that honeycomb the limestone beneath Leon County contain a large underground subsurface flow called the Floridan Aquifer. Younger sediments, such as Miocene-age Hawthorn/Miccosukee Formations overlie the Floridan Aquifer. Erosion, subsidence, or collapse into solution cavities in the underlying limestone can breach these sediments and surface waters can flow directly into (sinks) or out of (springs) the Floridan Aquifer.

Most of Leon County's Lakes were once tributaries of either the St. Marks or the Ochlockonee Rivers. They evolved from tributaries, to solution basins and finally into sinks and ceased flowing into surficial rivers and began to flow directly into the underground river, the Floridan Aquifer. These caves may be called "Sinkholes", "Swallowholes", "Go-Away Holes" or just "Sinks", but they are really "short circuits to the Aquifer". While these lakes no longer routinely flow into a river, the river can spill over into the lake during times of high water. The presence of Tritium in the Upper Floridan Aquifer at depths greater than 100 meters indicates recharge within the last 40 years (Katz et al., 1997). Additional evidence of recharge within the Floridan Aquifer is the presence of three distinct plumes of Perchloroethylene (PCE, a highly mobile dry cleaning solvent) that has contaminated seven City of Tallahassee supply wells (Watts et al., 1991). This contamination is the result of improper dumping of PCE by more than 70 dry cleaning facilities that were in operation in Tallahassee since the late 1940s. The interchange of river, lake and ground water is truly dynamic in North Florida and puts special emphasis on improving our water quality.

Lake Lafayette was the first lake to drain in August 1999. It is a 300-acre lake located in the Gulf Coastal Lowlands. The rate of flow into the sink was measured at 96 cfs. Exploration of the caverns of the sink by divers has exposed a complex cavern system. Lake Miccosukee, a 6000-acre lake also in the Coastal Lowlands, emptied on approximately ten-year intervals before a control structure was built around the sink to control water levels. In October, the gates were opened and the lake drained into the sink. An acceptance rate of 60 cfs was measured. Lake Jackson, a 3000-acre Outstanding Florida Waterbody and an Aquatic Preserve, is located in the Northern Uplands portion of the County. The south-central portion of the lake vanished into Porter's Hole Sink on September 16, 1999. Then on May 7, 2000, Lime Sink drained the northern half of the lake. The acceptance rate of Porter Hole was measured at 12 cfs; Lime Sink was draining at a rate of less than 3 cfs. Lake Iamonia is another Upland lake located in the

Highlands. The sink on its northern shore has a control structure that has been open, and yet the lake remained full and only began to drop within the last six months. Continued doubt that the sink was not taking water and that declining lake levels were due to evapotranspiration led to a closing of the gates. The water level in the Sink Basin rapidly declined, evidence that the sink was actively taking water. The acceptance rate of the sink was measured at 6 cfs.

In fall 1999, it was so dry that a 3 foot rise in water levels was observed within the karst features of the County. This correlated with winter dormancy and the cessation of a transpirational pull by the forest. A corresponding water level drop in the spring occurred when the sap began to rising. This is a vivid illustration that these karst features represent the potentiometric surface of the upper Floridan Aquifer at low water levels. In times of drought less water enters the lake and the water levels decline. The rate at which the lake drains is a function of the volume of water in the lake and the rate at which that water drains into the sinkhole, or Acceptance Rate. This is controlled by the smallest constriction in the caverns through which the waters must traverse to get to the aquifer. The periodic draining and refilling of this lake may be the mechanism that produces the trophy bass that Lake Jackson is associated with. Periodic drawdowns inhibit aquatic plants and facilitate the oxidation of accumulated bottom sediments enhancing sandy clear water habitats that favor the proliferation of large mouthed bass. There is also evidence that species competing with the bass do not recover as rapidly. The flow from the major sinkhole lakes in Leon County totals approximately 177 cfs. The flow from the springs south of the County, representing part of the Floridan Aquifer emerging from beneath the ground, is in excess of 3418 cfs. Thus, sinkhole lake water may represent as much as 5% of the flow of the Upper Floridan Aquifer from Leon County under optimal conditions. This may overestimate the contribution of karst recharge because many of the marine springs emerging within the Gulf have not been measured for flow, but does illustrate the significant contribution these lakes make to the groundwater.

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ESTABLISHING MINIMUM LAKE LEVELS IN THE SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT: AN UPDATE OF CURRENT APPROACHES

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In response to a 1996 mandate from the Florida Legislature, the Southwest Florida Water Management District has developed methods for establishing minimum levels for lakes within its jurisdiction. In accordance with state law, the methods and the minimum levels derived through their implementation are intended to prevent Asignificant harm≅ to lakes (and other water resources) which may be expected to occur as a result of water withdrawals.

Methods for establishing minimum levels for District lakes with intact, cypress-dominated wetlands have been developed and codified. Implementation of the methods involves evaluation of historic high and low water levels, as determined through analyses of lake stage data, review of on-site hydrologic indicators of past water levels, identification of structural alterations to lake outlets, and use of lake-stage fluctuation data from nearby lakes for the development of surrogate water level fluctuation statistics for systems lacking lake-stage data (SWFWMD 1999a). The approach encompasses a wetland protection perspective, and was developed to ensure persistence of lake-fringing cypress wetlands and thereby protect other ecological and cultural lake values. An independent review of the methods deemed the approach to be scientifically reasonable and defensible, although it was recommended that a program of additional data collection be implemented to refine the methodology (Stephenson et al. 1999). This recommendation is currently being addressed through the development of the Northern Tampa Bay Phase II Scope of Work (SWFWMD 1999a).

The District has also developed methods for establishing minimum levels for lakes lacking cypress-dominated fringing wetlands. Protection of lake area suitable for colonization and persistence of herbaceous wetland vegetation in these systems is viewed as a reasonable and defensible approach for minimum levels development. Proposed methods incorporates information on the depth-distribution of common wetland plants in District lakes and lake bathymetry. In addition to providing a means for evaluating changes in ecological values (*e.g.*, coverage of wetland vegetation) associated with changes in lake water levels, bathymetric maps can also be used to evaluate changes in cultural values (*e.g.*, lake area suitable for boating activity) associated with water level change.

The Southwest Florida Water Management District is developing innovative approaches for establishing minimum lake levels. Input from District staff, representatives of local governments and utilities, other State agencies, interested citizens, and independent consultants is contributing to the establishment of minimum levels which will protect and help preserve the natural and cultural values of District lakes.

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HYDRAULIC SEEPAGE WITHIN AN ASTATIC KARST LAKE, NORTH CENTRAL FLORIDA

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Characterizing groundwater seepage within an astatic karst lake is challenging because seepage patterns and magnitude are often controlled by subsidence features that breach confining units separating the lake and upper aquifers from deep sub-lake aquifers. Lakes that are underlain by leaking and/or breached confining units are susceptible to dramatic variations in seepage magnitude and patterns over short horizontal distances and time periods.

This study was undertaken to test the hypothesis that the seepage meter method is an effective method to characterize seepage magnitude and distribution in astatic karst lake environments. Two special excavation seepage meters were installed in an area underlain by a large subsidence feature shown (SJRWMD, 1992) to breach the confining unit underlying the lake to test how fine grained muck material at the sediment water interface affects seepage. To test this hypothesis seepage meter and excavated seepage meter measurements were recorded within Brooklyn Lake. This lake experiences extreme and dynamic changes in lake stage elevations that reduced its area in half in less than five years. Previous non-empirical investigations have determined that the main factors causing low lake stages were lack of rainfall, regional declines of water levels in the Floridan aquifer, and lake bottom leakage (i.e., seepage outflow from the lake). The seepage method utilizes a bottomless cylinder (i.e., cut off end of a 55-gallon steel drum) that is inserted open end down into lake bottom sediments. The top closed end of the drum is fitted with a plastic bag assembly that is filled with a known volume of water. Water enters or exits the drum and plastic bag assembly as a result of seepage flow. Excavation seepage meters utilize longer drum wall lengths and removable watertight lids. These modifications enable excavation seepage meters to be driven deeper into lake bottom sediment and allow the removal of sediments within the base of the seepage meter.

Seepage measurements were made in littoral and non-littoral parts of Brooklyn Lake and at locations where the underlying confining layer was determined to be breached or to be intact. Lake bottom core samples also were collected and analyzed to estimate the vertical permeability and grain size distribution of material near the water/sediment interface (i.e., upper 60 to 76 centimeters (cm) of sediment).

In general, seepage out of the lake and/or no seepage was recorded at all seepage meter locations except one. The magnitude and occurrence of seepage outflow varied throughout the lake. The highest naturally occurring seepage outflow values were recorded at seepage meters located within shallow littoral sections of the lake. In comparison, low and no seepage outflows were recorded in deep areas of the lake underlain by subsidence features. The highest outflow values measured during the entire study were recorded at the two excavation seepage meters after muck sediments were excavated to a depth of approximately 76 cm below the lake bottom. Average seepage flux values recorded for excavation seepage meters were -137.58 L x m^{-2} x day^{-1} and –1,014.49 L x m^{-2} x day^{-1}. Annual seepage outflow estimates using average and weighted average calculations for the lake were 248.2 cm/year (yr) and 211.8 cm/yr, respectively.

No empirical seepage measurements have been reported for the lake prior to this investigation. Seepage meter results reveal that a much larger percent of outflow occurs within the permeable littoral areas of Brooklyn Lake compared to deeper non-littoral sections. Excavation seepage meter results and laboratory permeameter and grain size analyses determined seepage variation is largely controlled by differences in the permeability of material at the water/sediment interface within Brooklyn Lake. Results of this study indicate the seepage meter method is an effective means by which to measure the magnitude and distribution of hydraulic seepage within Brooklyn Lake. Results of this study can be used to model surface water and groundwater interactions within the lake. This information will also aid scientists and regulatory agencies in determining the feasibility of augmenting the stage level of Brooklyn Lake by increasing inflow and/or decreasing seepage outflow.

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SESSION 10-B

VOLUNTEER AND CITIZEN MONITORING PROGRAMS

Thursday – May 25, 2000
1:20 – 2:20 p.m.

THE HILLSBOROUGH COUNTY VOLUNTEER MONITOR EXPERIENCE – HOW DO WE MEASURE SUCCESS IN ENVIRONMENTAL EDUCATION PROGRAMS?

Carlos A. Fernandes, Ph.D. – Lake and Stream Programs Coordinator
Julia Palaschak – Adopt-a-Pond Coordinator
Hillsborough County Public Works Department
Stormwater Management Section
Tampa, Florida

The County of Hillsborough (FL) historically has focused its attention with regards to water resources on the Tampa Bay National Estuary. In the last three years the County has expanded this effort to include lakes and streams. The County has 17 distinct watersheds. Some are lake-centered and others are stream-dominated systems.

Three different volunteer monitoring programs comprise the monitoring and management plan for the County's freshwater bodies. The programs are Lake Management/Monitoring Program (LaMP), Stream WATERWATCH and Adopt-a-Pond.

LaMP and Stream WATERWATCH collectively employ 124 volunteers who sample 92 lakes and 32 streams. Volunteers collect and drop water samples at designated drop-off points where the samples are picked up and taken to the laboratory for analysis, help with clean-up activities, do some "little" pond restoration and get involved in environmental education events. Volunteers are recruited and are committed to collect at least 12 sets of samples.

Adopt-a-Pond has 132 pond-groups. Adopt-A-Pond volunteers primarily monitor the physical aspects of their man-made stormwater ponds, planting native aquatic vegetation, cleaning up trash, and conducting group work-days at the ponds. Adopt-A-Pond volunteers can receive *Hach* and *Chemetric* kits upon request to conduct monthly water quality testing on stormwater ponds.

Why monitor? There are numerous reasons to monitor a watershed. Monitoring helps us understand what is going on in our watershed; it builds public awareness and support for watershed programs and activities; monitoring tells us whether our interventions (applicable solutions) are actually making a difference in the ecosystem. Perhaps the most compelling reason for monitoring is that: *if you are not monitoring, how do you know that your watershed work is succeeding?*

What standard(s) should be used to measure the success of an environmental education volunteer program? Is it the number of volunteers recruited and maintained or the number of sites sampled (area covered)? Is it the accuracy of the data produced from the samples or the observed overall status of the bodies of water after the program(s) are initiated? Or is it a combination of all of the above?

Standards for success should be based upon the goals of the program, which should be established before the program is initiated. We would like to propose that the following "general" components can also be considered standards for evaluating an environmental education program:

a) an identifying logo for the program
b) frequent and consistent training sessions for the volunteers
c) an adequate supply of equipment for field work
d) clearly identified objectives and requirements for data quality
e) review and enforcement of QA/QC standards
f) a Quality Assurance Project Plan (QAPP), when required
g) partnerships with volunteers, neighborhood groups, similar programs, & local agencies
h) public events to demonstrate appreciation for volunteers and attract new participants
i) educational tools such as newsletters, workbooks, brochures, and monthly meetings
j) program evaluations and comments from volunteers, citizens, peers

The Hillsborough County Public Works Department/Stormwater Management Section considers its volunteer monitoring programs to be successful because they satisfy the public's expectation of regular maintenance/monitoring and up-to-date information. The programs receive reimbursement via cooperative agreements from various funding agencies that also consider the programs successful and worthy of continued support. For example, the Southwest Florida Water Management District considers the programs successful because of the number of educational public events sponsored by the programs, the number of ponds "adopted", and the number of active volunteers in the lake and stream monitoring programs. The citizens consider the programs successful because they receive the technical support that they feel the county should provide.

More today than ever before, public involvement in crafting local watershed management plans is another important aspect of any volunteer water-monitoring program since these plans define the basic requirements/restrictions for the different water bodies in each area.

The goal of this presentation is to share the success stories as well as program setbacks, to share experiences in overcoming program setbacks, and to share views on how to obtain continued growth and sustain success in environmental education programs. Ideas on Watershed Management Plan integration will also be presented.

FROG LISTENING NETWORK

Laura Maniscalco Delise
Hillsborough River Greenways Task Force
Tampa, Florida

Dianne McCommons Beck
Florida Department of Environmental Protection
Tampa, Florida

The Frog Listening Network is a volunteer research project initiated in 1998 by the Hillsborough River Greenways Task Force (HRGTF). The purpose of the project is to teach interested citizens to monitor the environmental health of the Hillsborough River basin's lakes, ponds and streams, and West Central Florida, through identifying the calls of the 21 species of frogs and toads (including exotics) found in the watershed.

Frogs are a key link in aquatic and terrestrial habitats, having a life history that spans both. They are excellent barometers of general ecosystem and habitat health due to their sensitivity to even minor changes within their habitat environment, including changes in hydrology, water and air quality, and landscape changes on a local scale. Species composition and change is also monitored and can signify deleterious effects of suburban sprawl and urbanization of watersheds and rural landscapes.

Information is acquired through the monitoring network of citizens trained to identify frog vocalizations. Participants are trained to identify frog species by their calls, using mnemonics and other information such as habitat requirements and breeding seasons. Data sheets have been developed and distributed to volunteers, and are sent in to the repository at the Florida Fish and Wildlife Conservation Commission (FFWCC) where the data are entered, analyzed and mapped. Data generated and mapped is used in addition to other data collected within a given habitat to determine its general health. A second volume Frog Listening Network tape and compact disk have been developed for training and identification purposes, as well as photo identification cards.

After one complete year (1998-99) of data collection, the HRGTF has produced a base map from which all subsequent data collection years will be compared. Data has been received and recorded from volunteers from the Green Swamp and Cypress Creek in Pasco County to downtown Tampa in Hillsborough County and Brooker Creek in Pinellas County. Late data is still being entered and analyzed. All 21 species have been reported, with the exception of the bronze frog, probably due to its rarity and limited monitoring on Southwest Florida Water Management District lands. Data show increasing trends in the presence of and an expansion of range of the Cuban tree frog into the New Tampa area, a rapidly urbanizing area. Other trends include a decrease in the presence of both the pinewoods tree frog and the barking tree frog, as well as a spread of spring peepers into southern Pasco County.

Currently, over 250 volunteer citizens have been officially trained in the Frog Listening Network while an additional 2000 volunteers have taken part in introductory Frog Listening Network presentation. Volunteers include school children, general public and scientists, among others. The Frog Listening Network is a valid way to collect environmental information on the health of lakes, ponds, streams and within watersheds, and should be continued locally and initiated statewide. This volunteer monitoring program is easily transferable through slight adjustment of specific species found in any Florida watershed. This is exhibited by the program's expansion into the Englewood areas of Charlotte and Sarasota Counties, with sponsorship by the Lemon Bay Conservancy.

WATERSHED ACTION VOLUNTEER (WAV PROGRAM – ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

Patricia Hardy
WAV Coordinator for Alachua County, Florida

William Watkins
St. Johns River Water Management District
Palatka, Florida

The Watershed Action Volunteer (WAV) program began in Duval, St. Johns and Flagler county in 1994. The St Johns River Water Management District sponsors it. The WAV program enlists volunteers who participate in local watershed monitoring and protection programs and projects. There are now more than 800 citizens in 11 different counties participating in a variety of activities and projects that support water resource management goals of the District.

The goals of the program include:

- enhancing the public's understanding of watersheds and watershed concepts
- increasing District productivity
- building public support for restoration and protection of water resources
- facilitating formation of public/private partnerships

The WAV program educates citizens about watershed concepts through presentations, training programs, and hands-on opportunities. Many volunteers are trained to perform tasks related to improving watersheds in their communities. WAVs may find themselves participating in water quality monitoring, biological monitoring or assessments, submerged aquatic vegetation assessments, aquatic habitat restoration, educational presentations, guided ecotours, shoreline cleanups, office assistance and special projects (i.e.- Northeast Florida Yards and Neighborhoods and Ponds). The data are assembled into a database and provided to District project managers and are available through both internal and external database systems, including EPA's STORET system. The ambient water quality monitoring program has a state-approved Quality Assurance plan as well as a training/reference manual. A qualified monitoring program coordinator provides database management and training for volunteers.

The structure of the WAV program consists of:

- District Program Coordinator
- Monitoring Program Coordinator
- Education Coordinator
- County Coordinators
- Special Projects Coordinators

WAVs often provide direct support to District staff. Sometimes they work on projects of high priority to local governments. They WAV program is successful in part because of partnerships with local governments and other agencies that support county WAV coordinators who, in turn provide a local identity and presence for the program. The volunteers provide services that help support local governmental programs for water resource and land management. Counties buy into the program because it results in more useful data, enhanced public image, cost savings, new partnerships and more. Grants are also sought from regional, state and federal sources to support special projects and assist with program expansion.

FLMS 2000 - ANNUAL CONFERENCE

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