PROCEEDINGS OF THE SEVENTH ANNUAL SOUTHEAST LAKES MANAGEMENT CONFERENCE

"Integrating Water Resources and Growth into the 21st Century"

April 15-18,1998
Radisson Plaza Hotel
Orlando, Florida

Conference Chairman:
Carey Cordell

Technical Sessions Chairman:
Harvey H. Harper

1998 Proceedings Editors:
Sharon H. Darling
Harvey H. Harper

The 7th Annual Southeast Lakes
Management Conference was organized by:
Florida Lake Management Society (FLMS)
North American Lake Management Society (NALMS)
Florida Department of Environmental Protection (FDEP)
Environmental Research & Design, Inc. (ERD)

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FLORIDA LAKE MANAGEMENT SOCIETY

1998 Officers and Directors

OUR MISSION

The mission of the Florida Lake Management Society is to: promote protection, enhancement, conservation, restoration, and management of Florida's aquatic resources; provide a forum for education and information exchange; and advocate environmentally sound and economically feasible lake and aquatic resources management for the citizens of Florida.

SEVENTH ANNUAL SOUTHEAST
LAKES MANAGEMENT CONFERENCE

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9:00-10:00 am	Registration/Check In	
10:00 11:30 a.m.	OPENING PLENARY SESSION Welcome: Welcome to Orlando: Welcome: Introduction of Keynote Speaker: Key Note Address:	 Gene Medley President of FLMS Commissioner Bill Bagley – City of Orlando Barbara Wiggins NALMS Southeast Region Director Carey Cordell, Conference Chairman Jack R. Vallentyne "Faustian Behavior and Demotechnic Traps"
11:30 a.m. 1:00 p.m.	Lunch on Your Own	

	Session 1: Lake Okeechobee Moderator: Tom James Summerlin	Session 2: Watershed Protection and Growth Management Moderator: Jim Hulbert Princeton	Session 3: Apalachicola-Chattahoochee-Flint River Basin Moderator: Mary Paulic Adair
1:00-1:20 p.m.	A Sediment Phosphorus Model of Lake Okeechobee - Michael J. Erickson, Victor J. Bierman, Jr., Scott C. Hinz, K. Ramesh Reddy, and R. Thomas James	Land Development Provisions to Protect Georgia Water Quality - David B. Nichols, Bruce K. Ferguson, Scott S. Weinberg, and Mary-Anne Albanza Akers	Overview of the ACF Basin - from Courtroom to Interstate Compact: How Much Water Does the Apalachicola System Need? - John Abendroth
1:20-1:40 p.m.	Phosphorus Kinetics of Planktonic and Benthic Assemblages In Lake Okeechobee - Alan D. Steinman, Soon-Jin Hwang, and Karl E. Havens	Strategy for Assessing and Prioritizing Lakes in Highlands County - Clell J. Ford	ACF System Operation for Management of Water Resources - Memphis Vaughan
1:40-2:00 p.m.	Periphyton Responses to Nitrogen and Phosphorus Additions in the Littoral Zone of Lake Okeechobee, Florida - Karl E. Havens, Therese L. East, Andrew J. Rodusky, and Bruce Sharfstein	Integrating Watershed Protection with Growth Management In the Lake Wiley Watershed, Charlotte, North Carolina - Wei-Ning Xiang	Fishery Management Issues - Matt Thomas
2:00-2:20 p.m.	Daphnia Lumhohlzi vs. Daphnia Ambigua: Will the Exotic Replace the Native In Lake Okeechobee, Florida? - Therese L. East, Karl E. Havens, A.J. Rodusky, and M.A. Brady	Protecting the Water Quality of Ichetucknee Springs: A Watershed Working Group Process - James A. Stevenson	An Overview of the Water Resource Demands Management and Other Issues In the Apalachicola River and Bay Systems - Grady L.(Lee) Marchman and Steve Leitman
2:20-2:40 p.m.	BREAK	BREAK	BREAK

Wednesday, April 15, 1998 – Continued			
	Session 4: Nutrient Interactions and Processes In Lakes Moderator: Garth Redfield Summerlin	Session 5: Statewide Basin Planning and Assessment I Moderator: Tom Singleton Princeton	Session 6: Interstate Watershed Issues Moderator: Mary Paulic Adair
2:40-3:00 p.m.	The Experimental Lakes Area of Northwestern Ontario - Jack Vallentyne	The Florida Bioassessment Program: A Venture In Problems and Solutions - James L. Hulbert	The Suwannee Basin Interagency Alliance -Kirk B. Webster
3:00-3:20 p.m.	Factors Influencing the Variability of Chlorophyll Concentrations in Florida Lakes: An Evaluation of Nutrient-Chlorophyll Models for Florida - Claude D. Brown, Daniel E. Canfield, Jr., Roger W. Bachmann, and Mark V Hoyer	Bioassessment Results for the St. Marks River Watershed In Leon, Jefferson, and Wakulla Counties, Florida - Russel Frydenborg	Georgia River Basin Management Planning -Phillip R. White
3:20-3:40 p.m.	Effect of Sampling Frequency and Wind Velocity on Estimates of Total Phosphorus Concentrations In a Shallow, Subtropical Lake - Charles Hanlon	Correlation of the Chemical and Biological Data and the Use of eBase In the St. Marks River Watershed - Joe Hand	Integrated Resource Management in the Tennessee Valley - Donald W. Anderson
3:404:00 p.m.	Quantifying Atmospheric Deposition of Phosphorus to Florida Lakes - Garth W. Redfield	Spatial Models of Nonpoint Source Pollutant Loading: A Tool for Watershed Management and Decision Making - Neal Parker, Jr. and Mark Brown	Findings from the National Water Quality Assessment Program: Georgia-Florida Coastal Plain, 1992-1996 - Marian P. Berndt
4:00-4:20 p.m.	BREAK	BREAK	BREAK

	Session 7: Funding and Educational Opportunities Moderator: Drew Kendall Summerlin	Session 8: Statewide Basin Planning and Assessment II Moderator: Tom Singleton Princeton	Session 9: NALMS Chapter Concerns Moderators/Speakers: Adair Barbara Wiggins Bill Jones Chris Holdren
4:204:40 p.m.	Section 319 Funding for Nonpoint Source Pollution - Betty Barton	A Spatial Model of Nitrate Loading from Residential Septic Tanks - Alan C. Foley and Mark Brown	
4:40-5:00 p.m.	Florida Stormwater, Erosion and Sediment Control Training and Certification Program -Daniel R. DeWiest and Eric H. Livingston	Spatial Models of Development Intensity:Emergy-Based Watershed Management and Decision Making - M.T. Brown and J. Dudas	
5:00-5:20 p.m.	State Revolving Loan Fund - Funding for Nonpoint Source Pollution - Sheryl R. Parsons	A Model for Implementing Basin Planning and Management: St. Marks River Watershed Pilot Project - Thomas L. Singleton	
5:30 p.m.	FLMS ANNUAL BUSINESS MEETING - SUMMERLIN ROOM		
6:00-7:30 p.m.	EXHIBITOR'S SOCIAL - EXHIBIT HALL		
	Session 10: Bridging the Gap Between Professionals and Citizens		
7:30-9:00 p.m.	Moderator: Sandy Fisher Adair		
9:00-12:00 midnight	HOSPITALITY SUITE -ROOM 1110		

Thursday, April 16, 1998			
7:30-8:20 a.m.	Thursday, April 16, 19981999 Southeastern Conference Planning Meeting (Breakfast Buffet Available) - Butler Room		
	Session 11: Nonpoint Source Management Moderator: Kevin McCann Summerlin	Session 12: Southeast Fisheries Moderator: Mike Allen Princeton	Session 13: Volunteer Efforts In the Southeast Moderator: Sidney Post Concord
8:20-8:40 a.m.	Stormwater Pollution Control Using Baffle Boxes and Inlet Devices - Gordon England	Effects of Trophic Level, Larval Shad Abundance and Spawning Times on Largemouth Bass Recruitment Potential in Alabama Impoundments - Micheal S. Allen, James C. Greene, Frederick J. Snow, Michael J. Maceina, and Dennis R. DeVries	Cape Fear River Keeper - Bouty Baldridge
8:40-9:00 a.m.	Packed Bed Filter - Troy R. Attaway, Sherry L. Burroughs, Timothy J. Egan and Carla N. Palmer	Relations Between Reservoir Hydrology and Crappie Recruitment In Alabama - Michael J. Maceina	Hands-On Watersheds - Jennifer Mott
9:00-9:20 a.m.	Evaluation of Treatment Alternatives for a Regional Stormwater Retrofit Facility In Largo, Florida - Jeffrey L. Herr and Harvey H. Harper	Use of Artificial Habitats by Juvenile Largemouth Bass: Can We Enhance Nursery Areas Through Habitat Manipulation? – James R. Jackson, Richard L. Noble and Elise R. Irwin	Volunteers In Orange County, Florida – Richard A. Baird
9:20-9:40 a.m.	Maintenance of Stormwater Retrofit Projects -Gordon England	Labyrinth Weir for Dissolved Oxygen Improvement - A. Scott Hendricks	Public Outlook for Volunteers - Sidney Post
9:40-10:00 a.m.	Characterization of Stormwater Contaminated Sediment and Debris for Determining Proper Disposal Methods - John H. Cox	The Index of Biotic Integrity: A Test Using Limnological and Fish Data from 60 Florida Lakes - Eric J. Schulz, Mark V. Hoyer, and Daniel E. Canfield, Jr.	
10:00-10:20 a.m.	BREAK	BREAK	BREAK

	Session 14: Use of Ponds and Wetlands for Stormwater Treatment Moderator: Eric Livingston Summerlin	Session 15: Fish Population Dynamics and Trophic State Interactions Moderator: David Evans Princeton
10:20-10:40 a.m.	Pollution Sources and Sinks In Stormwater Management Systems – Betty Rushton	Influence of Gizzard Shad on Plankton Community Interactions – David L. Watson, David R. Bayne, and Dennis R. DeVries
10:40-11:00 a.m.	A Description of the Sediments Found In an Isolated Natural Marsh Used for Stormwater Treatment - David W. Carr	Mercury Content In Florida Bass - C.W. "Mickey" Sheffield
11:00-11:20 a.m.	Stormwater Treatment of Runoff from an Agricultural Basin by a Wet Detention Pond In Cockroach Bay, Florida - Benjamin Bahk	Feeding Rate of Triploid Grass Carp as Determined by Size and Water Temperature - John A. Osborne
11:20-11:40 a.m.	Pollutant Removal Efficiencies of the Greenwood Urban Wetland Stormwater Treatment System - Kevin McCann and Lee Olson	Triploid Grass Carp Removal by the Use of Sound Attraction - Daniel J. Willis, Daniel E. Canfield, Jr., and Mark V. Hoyer
11:45 a.m.-1:00 p.m.	LUNCH - CONCORD/CHEROKEE ROOM	

Thursday, April 16, 1998		
1:00 p.m.	Tour Groups leave from Hotel Lobby	
	Session 16: Restoration of a Large Urban Lake in Orlando - Lake Jesup Moderator: Erich Marzolf Summerlin	Session 17: Public Education and Awareness Moderator: Eric Livingston Princeton
1:00-1:20 p.m.	The Lake Jesup Restoration Program - History and Status – Regina Lovings	Florida Yards and Neighborhoods: A Public Education Program for Nonpoint Source Pollution Reduction - Douglas H. Kutz
1:20-1:40 p.m.	Water Quality Conditions in Lake Jesup: Past and Current - Erich R. Marzolf	Orlando Lakes/Stormwater Public Awareness Program - Bruce D. Fallon
1:40-2:00 p.m.	Use of the Environmental Fluid Dynamics Code (EFCD) Model to Analyze Circulation Patterns in Lake Jesup - Hector Herrera and Chou Fang	The Development of Effective Algal Control Strategy for Oradell Reservoir, New Jersey - Fred S. Lubnow, Stephen J. Souza, Louis Brigandand Steve Wacker
2:00-2:20 p.m.	Evaluating Recent Historical Nutrient Deposition and Storage within Lake Jesup, Florida - C.L. Schelske, J.E. Cable, E.R. Marzolf, T.J. Whitmore, W.F. Kenney, and P.S. Hansen	CAPS (Community Advisory Panels): Head Protection and a Pro-Active Tool for Managing Florida Waters - Amy Richard
2:20-2:40 p.m.	Invertebrate Populations and Water Sediments Physico-Chemical Conditions of Lake Jesup at the Confluence with the St. Johns River, Central Florida - Richard J. Lobinske, Julie L. Bortles and Arshad Ali	Pontoon Classroom Project - B. Eric Bennett
2:40-3: 10 p.m.	BREAK	BREAK

	Session 18: Lake Apopka Issues Moderator: Mark Hoyer Summerlin	Session 19: Involving Citizens in Lakes and Watershed Monitoring Moderator: Patti Sanzone Princeton	Session 20: Lake Management Activities - NALMS SE Chapters Moderator: Chris Holdren Adair
3:10-3:30 p.m.	The Restoration of Lake Apopka, Florida -Michael F. Coveney, David L. Stites, Edgar F. Lowe, and Lawrence E. Battoe	The Adopt-A-Pond Program - Julia E. Palaschak	Florida Lake Management Society (FLMS) -Gene Medley
3:30-3:50 p.m.	Historic Nutrient Enrichment of Lake Apopka: Evidence from Paleolimnological Investigations - C.L. Schelske, W.F. Kenney J.A. Cable, and P.S. Hansen	Florida Lakewatch: A Teamwork Approach -Sandy Fisher	Georgia Lake Management Society (GLMS) -Marty Williams
3:50-4:10 p.m.	Trends In the Fish Population of Lake Apopka - William E. Johnson, Joseph E. Crumpton, and Walter F. Godwin	Hillsborough Lake Atlas Project - James C. Griffin, Kyle N. Campbell, and Shawn M. Landry	North Carolina Lake Management Society (NCLMS) - Mike Struve

Thursday, April 16, 1998 - Continued			
4:10-4:30 p.m.	Fluid Mud, The Marsh Flow-Way and the Restoration of Lake Apopka - Roger W. Bachmann, Mark V. Hoyer, and Daniel E. Canfield, Jr.	Hillsborough Stream-Watch: A Community-Based Approach to Watershed Monitoring -James C. Griffin	Lake and Watershed Association of South Carolina (LWASC) - B. Eric Bennett
4:30-4:50 p.m.	Interpreting Historic Lake Conditions from Biogenic Materials and Bioavaliable Phosphorus In Lake Apopka Sediments - William F. Kenney	The Florida Homestead Assessment System -Susan W. Williams and Arthur G. Hornsby	
4:50-5:10 p.m.	Muck Farm Restoration at Lake Apopka: Management of Potential Risks from Pesticide Residues - David Stites, Donna Cline, and Roxanne Conrow	The Allen's Creek Wildlife Monitoring Project at Lakeview Road and Hercules Avenue -Mariben Espiritu Andersen	
7:00-9:00 p.m.	BANQUET - SUMMERLIN AND PRINCETON ROOMS		
9:00-12:00 midnight	HOSPITALITY SUITE - ROOM 1110		

	FRIDAY, April 17, 1998	
	Session 21: Volunteers -Worth Their Welaht. In Gold Moderator: Sandy Fisher Summerlin	Session 22: Nitrate in Florida's West Coast Rivers - Sources and Sinks Moderator: Tom Frazer Princeton
8:20-8:40 a.m.	What Is -'CHEVWQMN" (Charlotte Harbor Estuaries Volunteer Water Quality Monitoring Network)? - Judith A. Ott	Increasing Nitrate Levels in the Major Coastal Springs in Citrus and Hernando Counties, FL - Gregg W. Jones and Sam B. Upchurch
8:40-9:00 a.m.	Freshwater Lakes - TBA	Biogeochemical Indicators of Trophic Status In a Relatively Undisturbed Shallow Water Estuary - L. Kellie Dixon and Ernest D. Estevez
9:00-9:20 a.m.	Volunteer Water Quality Monitoring in Western North Carolina -Marilyn Westphal, Richard P. Maas, and Steven C. Patch	Nitrate-Nitrogen In the Suwannee River - H. David Hornsby
9:20-9:40 a.m.	Pond Watch and Florida Yards and Neighborhood Mutual Collaboration Program - Ernesto Lasso de la Vega	Phytoplankton Community Structure and Dynamics in the Suwannee River Estuary - Erin L. Bledsoe and Edward J. Phlips
9:40-10:00 a.m.	BREAK	BREAK

Friday, April 17, 1998 – Continued		
	Session 23: Algae Benthos and Alligators Moderator: Michael Hein Summerlin	Session 24: Lake Management and Restoration Issues Moderator: Dan DeWiest Princeton
10:00-10:20 a.m.	Public Education Programs Integrating the Lake Community Stakeholders Into Restoration and Management Initiatives - Stephen J Souza and Kathleen Hale	The Decline of Hypereutrophic Newnans Lake, Florida: Management and Restoration Implications - Margaret A. Lasi and John R. Shuman
10:20-10:40 a.m.	Periphyton Water Garden In a Public Park, Orlando, Florida – Kyle Jensen and Erich R. Marzolf	Water Chemistry Trends in Florida Lakes and Reservoirs - Julia D. Terrell, David L. Watson, Mark V. Hoyer, and Daniel E. Canfield, Jr.
10:40-11:00 a.m.	American Alligator Population Densities and Their Relations to Trophic Status, Fish Biomass, and Human Development on Florida Lakes – Jason D. Evert, Allan R. Woodward, Mark V. Hoyer, and Christine Horsburgh	The Use of Alum to Restore Class III Water Quality Standards in Highly Urbanized Lakes - Richard A. Baird and B. Jackson
11:00-11:20 a.m.	Lake Apopka Revisited: An Evaluation of Environmental Contaminants and Associated Reproductive Anomalies In Alligators Timothy S. Gross, Damien Giroux, H. Franklin Percival, and Denise A. Gross	Technical and Non-Technical Issues Related to Dredging Projects -Shailesh K. Patel, Wayne A. Ericson, and Joel S. Steward
11:20-11:40 a.m.	Apple Snail Survival and Recruitment Following an Extreme Draw Down of Lake Kissimmee - Philip C. Darby, Patricia Valentine-Darby, and H. Franklin Percival	Benthic Macroinvertebrate and Trophic State Assessments of Selected Lakes In the Butler Chain: Past and Present Conditions and Future Projections - Forrest E. Dierberg, Moris -Cabezas and Pam Thomas
11:40 a.m.-1:00 p.m.	LUNCH - CONCORD/CHEROKEE ROOM	

	Session 25: Lake Restoration Projects - Case Studies Moderator: Mike Scheinkman Summerlin	Session 26: Estuaries, Rivers and Lakes Moderator: Dave Worley Princeton
1:00-1:20 p.m.	Newburgh Lake Restoration: A Case Study In Urban Lake Restoration -John O'Meara, Doyle Cottrell, and Michael Tomlinson	To Dredge or Not and Then What? A Management Perspective on the Indian River Lagoon, Florida - Joel Steward and Shailesh K. Patel
1:20-1:40 p.m.	Cockroach Bay Restoration Project, A Multi-Agency Nonpoint Source Management Success Story? - Jack Merriam	Cleaning Up the Neuse River - Annette Lucas
1:40-2:00 p.m.	Newburgh Lake Restoration: Fish Eradication Case Study - John H. Wiese, Michael Tomlinson, and John O'Meara	Vertical Leakage from Karst Lakes in Florida - Louis H. Motz
2:00-2:20 p.m.	Multiple Benefits of Lake Level Fluctuation In Lake Tarpon, Florida -Douglas E. Robison and Pamela S. Leasure	How to Solve Tough Water Quality Problems with Community Involvement - Richard W. Alleman
2:20-2-40 p.m.	Nonpoint Source Management for a North Florida Lake: The Retrofit and Restoration of Lake Jackson - Tyler L. Macmillan	The Condition of Estuarine Resources in the Southeast Region – Kevin Summers
2:40-3:00 p.m.	BREAK	BREAK

Friday, April 17, 1998 – Continued		
	Session 27: Rodman Reservoir Moderator: Gene Medley Summerlin	Session 28: Buffer Protection and Best Management Practices to Control Nonpoint Source Pollution Moderator: Patti Lodge Princeton
3:00-3:20 p.m.	The Rodman Reservoir Controversy: Important Issues and a Review of the Existing Evidence - Mark V. Hoyer, Daniel E. Canfield, Jr., and Eric J. Schulz	Buffers - An Important Best Management Practice for Controlling Nonpoint Source Pollution - Lin Xu
3:20-3:40 p.m.	Ecological Aspects of the Proposed Ocklawaha River Restoration -Constance Bersok	Implementing Buffer Protection In the Neuse River Basin - Annette Lucas
3:40-4:00 p.m.	Mike Mertha	Silviculture Best Management Practices: Monitoring for Effectiveness -Jeffrey L. Vowell
4:00-4:20 p.m.	The Case for Restoring the Ocklawaha - Bob Simons and Gary Appleson	Nutrient Balance for a Dairy Waste Management System - A.B. (Del) Boucher and Nigel B. Pickering
4:20-4:40 p.m.	Panel Discussion/Questions	Control of Stormwater Pollution Surrounding Lakes, Rivers, Streams and Other Waterways - John J. Medico, Jr.

Saturday, April 18, 1998 -- Workshops		
NUMBER	TIME	TITLE DESCRIPTION
1	8:30 a.m.to12 noon	Phosphorus Inactivation and Removal Moderator: Harvey H. Harper Summerlin Room The workshop will discuss methods and effectiveness of reducing phosphorus concentrations in stormwater runoff utilizing common and innovative stormwater management techniques. Special emphasis will be placed on the use of chemical coagulants for phosphorus removal. Phosphorus inactivation techniques will also be discussed to reduce internal phosphorus loading in lakes, including dose determination, longevity, impacts and costs.
11	9:00 a.m.to5:00 p.m.	Overview of Linmology Moderator: Marty Kelly Adair Room This workshop will be divided into separate morning and afternoon sessions. The morning session will address Basic Limnology and cover topics such as heat, light, nutrients, algae, and biological communities. This session is intended for persons with little or no formal training in limnology. The afternoon session will address Applied Limnology and will include topics such as watershed evaluations, development of hydrologic and nutrient budgets, and take restoration. The results of case studies will be presented.
III	1:00 p.m. to3:00 p.m.	Protecting Surface Water Resources within the Lake Jesup Watershed - How Everyone Can Help Moderator: Erich Marzolf Summerlin Room This workshop will include:- An overview of Lake Jesup Program status for the public- Perspectives of a member of the public on the role of a citizen's advisory group- What you can do to protect water resources- Questions/Panel Discussion

ABSTRACTS

OF THE SEVENTH

ANNUAL SOUTHEAST LAKES

MANAGEMENT CONFERENCE

A SEDIMENT PHOSPHORUS MODEL OF LAKE OKEECHOBEE

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Lake Okeechobee, a large (1730 km^2 shallow (mean depth 2.7 in) lake in central south Florida, has received excessive external nutrient loads over the past two decades, resulting in accelerated eutrophication (Havens et al., 1997). The concern over this accelerated eutrophication led to efforts to improve understanding and management of this lake Aumen and Wetzel, 1995). These efforts included construction of a water quality model to estimate the phosphorus (P) load reduction required to reach goals of reduced algal blooms and lower water column P concentrations. This model, the Lake Okeechobee Water Quality Model (LOWQM), is a deterministic, mass balance model that simulates the nitrogen, phosphorus, oxygen cycles, and phytoplankton dynamics (James and Bierman, 1995).

Prior modeling and experimental work estimated that bio-available (dissolved), lake-bed sediment P loads into the water column are 2-6 times greater than external loads (James et al., 1997; Reddy, 1991). Because these sediment P loads are significant, long-term model simulations require adequate representation of sediment P dynamics for Lake Okeechobee. However, the present form of LOWQM does not adequately represent processes which transform sediment organic P to dissolved inorganic P. We addressed this limitation by developing a stand-alone sediment P model that includes these processes and incorporating it into LOWQM.

The stand-alone model serves two purposes: (1) to investigate the importance of various factors controlling sediment P processes in Lake Okeechobee; and (2) to calibrate model coefficients for use within a multi-segment application of LOWQM (representing the

sediment regions of the lake). The latter purpose is important because calibration of sediment type-specific processes can be done quickly, without the computational burden of running LOWQM, and without the problem of mixing among the water column segments, which confounds the calibration in LOWQM. The mixing problem is eliminated by running separate simulations of the stand-alone model using LOWQM predicted long-term average organic P loads for each individual segment, and adjusting process parameters for each sediment type.

Both models simulate mineralization of readily and moderately degradable particulate organic P (POP) to inorganic P (IP). Refractory POP is represented as a non-degradable form. These models also describe redox-dependent IP sorption to sediment solids; dissolved IP (DIP) diffusion; sorbed IP and POP settling, resuspension, and mixing between sediment layers; and burial of all forms of P. The response of sediment P release due to onset of anoxic conditions is represented by reducing the surficial layer partitioning coefficient to equal the deeper, anoxic layer coefficient. Under reduced conditions, the resulting enhanced P release represents the dissolution of IP sorbed to metal hydroxides formed under aerobic conditions in the surface layer, and the disappearance of the aerobic sorption barrier to DIP diffusing upward from deeper, anaerobic sediments.

Predicted sediment DIP fluxes into the water column under aerobic conditions are approximately 0.04 mg m^{-2} d^{-1} for sand sediments, 0.43 mg m^{-2} d^{-1} for mud sediments, 0.70 mg m^{-2} d^{-1} for peat sediments, and 1.56 mg m^{-2} d^{-1} for littoral sediments. Under anaerobic conditions, predicted fluxes were 2-3 times higher. Predicted DIP fluxes are in general agreement with measured fluxes under aerobic (0.02-0.80 mg m-2 d-1 and anaerobic (2.5-5.3 mg m^{-2} d^{-1} conditions.

The stand-alone model was used to estimate the 90% response time to reductions in sediment P depositional fluxes. The results suggest that it will take 5-10 years for steady-state P fluxes to develop between the sediments and the water column following a reduction of P loads to the sediments.

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NOTES

PHOSPHORUS KINETICS OF PLANKTONIC AND BENTHIC ASSEMBLAGES IN LAKE OKEECHOBEE

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Phosphorus cycling in shallow lake ecosystems may be regulated to a large extent by interactions between benthic and pelagic assemblages. These interactions may control phosphorus availability in the water column, taxonomic composition and abundance of the plankton, and food web structure (Lodge et al., 1988). Reports of an inverse relationship between phytoplankton and periphyton in Lake Okeechobee suggest that these communities may be in competition with each other (Phlips et al., 1993; Steinman et al., 1997). This study examined the phosphorus uptake dynamics and kinetics in the littoral marsh and along the littoral-pelagic ecotone in Lake Okeechobee to gain a better mechanistic understanding of phosphorus dynamics between the periphyton and plankton.

Phosphate uptake kinetics and uptake rates were calculated for planktonic (phytoplankton and bacterioplankton) and benthic (epiphyton and epipelon) assemblages on a bimonthly basis over one year at three different sites. Two of the sites, located along the littoral-pelagic ecotone, had low underwater irradiances and high total phosphorus concentrations (annual mean total phosphorus: 112 ug/L). The third site, located in the littoral marsh zone, had high underwater irradiances and low total phosphorus concentrations (annual mean total phosphorus: 7 ug/L).

Based on $^{32}P\text{-}PO_4$ turnover times, phosphorus-limitation was observed only during summer (July and September) at the ecotone sites, when phosphorus concentrations were lowest. At the marsh site, phosphorus-limitation was observed throughout the year. The half saturation constant (Ks values of plankton (annual mean: 0.78 ug/L) and periphyton (annual mean: 0.47 ug/L) were usually lowest at the marsh site, and lower during the phosphorus-limited period compared to other times at the ecotone sites. The plankton maximum uptake rate (V.,) increased by over 15 times during the phosphorus-limited period at the ecotone sites. The specific uptake rates of plankton were significantly greater than those of periphyton at all sites, suggesting that the plankton were more efficient than periphyton at taking up phosphate.

The marsh site was capable of sustaining high periphyton biomass, presumably because of high nutrient recycling abilities and unlimited light availability. The high biomass of periphyton at the marsh site compensated for its low specific uptake rates; the relative amount of phosphorus taken up by periphyton was twice as great at the marsh site than at the ecotone sites. Our results support the notion that periphyton assemblages play an increasingly important role in phosphorus dynamics of lakes and wetlands as more light reaches the sediment surface (Sand-Jensen and Borum, 1991; Axler and Reuter, 1996). Although periphyton do not take up phosphate as quickly as phytoplankton or bacterioplankton, the marsh area in Lake Okeechobee appeared to contain the characteristics that allow periphyton to compete successfully with plankton. This periphyton community can reduce ambient phosphorus concentrations in the water column via uptake or adsorption, as is the case in both Lake Okeechobee and undisturbed regions of the Everglades (McCormick and O'Dell, 1996). However, these communities appear to be sensitive to nutrient levels, as excessive concentrations will result in taxonomic shifts, which may influence the structure and function of higher trophic levels in the aquatic food web.

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NOTES

PERIPHYTON RESPONSES TO NITROGEN AND PHOSPHORUS ADDITIONS IN THE LITTORAL ZONE OF LAKE OKEECHOBEE, FLORIDA

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Lake Okeechobee, the largest (1,730 km^2) lake in the southeastern United States, is characterized by a large region of turbid, relatively shallow (2-5 m depth) open water, and an expansive (>400 km2) littoral marsh with a diverse vascular plant community. The pelagic region is eutrophic, with total phosphorus concentrations in excess of 90 ug/L due to a history of excessive phosphorus inputs from the watershed and currently high internal loading from sediments (Havens et al., 1996). The littoral region is oligotrophic, with interior waters typically displaying total phosphorus concentrations below 10 ug/L This reflects the fact that under most conditions, the two lake regions are hydrologically uncoupled (Richardson and Hamouda, 1995). However, when water levels in the lake are high, large quantities of water and phosphorus may be transported into the littoral zone. Because the pristine littoral zone supports a valuable fishery and wildlife habitat, there are concerns about possible eutrophication effects. Our objective was to experimentally assess the impacts of increased phosphorus (and nitrogen) concentrations on the littoral periphyton community of Lake Okeechobee.

Portions of the littoral community in a region dominated by spike-rush *(Eleocharis cellulosa*) and bladderwort (Utricularia spp.) were enclosed inside 1.2 m diameter transparent plastic cylinders, and subjected to four treatments: (1) untreated controls; (2) nitrogen – additions of KN03 to increase nitrogen by 5,000 ug/L; (3) phosphorus - additions of KH2PO4 to increase phosphorus by 100 ug/L; and (4) nitrogen + phosphorus - combined additions of nitrogen and phosphorus. The treatment phosphorus and nitrogen concentrations approximated those observed in the pelagic zone, and the additions were done three times weekly for 28 days. Initial and final conditions in the mesocosms and three open reference sites were sampled for periphyton and phytoplankton chlorophyll-a, periphyton tissue phosphorus and nitrogen content, phytoplankton productivity, and whole-community oxygen metabolism.

Mesocosms dosed with phosphorus (cumulative amount = 1,000 ug/L; displayed rapid uptake of the added nutrient, with <35 ug/L; total phosphorus and <5 ug/L; soluble phosphorus remaining in the water column at the end of the experiment. There were significant increases in periphyton tissue phosphorus in this treatment, especially in surface algal mats. There were no significant changes in any of the other response variables.

Mesocosms dosed with nitrogen (cumulative amount = 55,000 ug/L; accumulated relatively high concentrations of total nitrogen (up to 20,000 ug/L; and soluble nitrogen (up to 19,000 ug/L; in the water column, and did not display significant changes in periphyton tissue nitrogen. In this treatment, there were significant increases in the chlorophyll-a content of epiphyton associated with submerged *Eleocharis* stems, indicating nitrogen limitation of that community.

Mesocosms dosed with both nitrogen and phosphorus responded in a similar manner to other treatments, in terms of phosphorus removal from the water column and incorporation into periphyton tissue. There also were significant increases in whole-community oxygen production rate, chlorophyll-a associated with artificial plastic substrata, and the chlorophyll-a content of surface algal mats and epiphyton on Utricularia fronds. Phytoplankton chlorophyll-a and net primary productivity also significantly increased.

As we observed in a previous experiment where only a combined nitrogen + phosphorus treatment was considered (Havens et al., 1998), the littoral periphyton of Lake Okeechobee can sequester large amounts of phosphorus from the water column. This appears to be a general property of lake and wetland periphyton communities (Wetzel, 1996). We expected to find that the littoral periphyton was strongly phosphorus-limited on the basis of observed low phosphorus concentrations in the water column, and results from recent studies of phosphorus uptake kinetics (Hwang et al., 1998). However, the results of the experiment did not support that hypothesis. Instead, the current status of this community appears to be nitrogen + phosphorus co-limitation. This conclusion is based on the fact that many response variables were not affected by nitrogen or phosphorus when added alone, but they increased significantly when the nutrients were added together. This opens up the possibility that the seemingly pristine littoral zone has already suffered effects of phosphorus inputs from the pelagic region. This issue should be investigated further in future research.

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NOTES

DAPHNIA LUMHOLTZI vs. DAPHNIA AMBIGUA: **WELL THE EXOTIC REPLACE THE NATIVE IN LAKE OKEECHOBEE, FLORIDA?**

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Daphnia lumholtzi, a large cladoceran native to Africa, Asia, and Australia (Green, 1971; Gophen, 1979), has been detected recently in reservoirs and lakes throughout the United States. Sorensen and Sterner (1992) were the first to discover the presence of this species in a Texas reservoir in 1990. Specimens were collected subsequently from lakes and reservoirs in Missouri, Oklahoma, Illinois, and Louisiana (Havel and Hebert, 1993; Work and Gophen, 1995; Kolar et al., 1996; Stoeckel et al., 1996; Davidson and Kelso, 1997). In July 1993, D. *lumholtzi* was discovered at low densities in the macro-zooplankton assemblage in Lake Okeechobee.

There are several identifying characteristics that make it easy to distinguish D. *lumholtzi* from other *Daphnia* species. The most prominent distinguishing features are the long headspine and tailspine which are longer than those produced by any native species. The helmet also has distinctive sharp lateral fornices. Finally, there are approximately 10 prominent spines along the ventral carapace margin. The only other *Daphnia* species present in Lake Okeechobee is *D. ambigua*, which is similar in form but lacks the long helmet spine and fornices and has very weak carapace spines.

Given D. *lumholtzi's* large size relative to the native *Daphnia ambigua* and possible rapid invasion potential, there are concerns related to displacement of native taxa, as well as alteration of plankton community structure and function, and possible deleterious impacts on higher trophic levels. The objectives of this study were to assess the extent of invasion of this exotic species in Lake Okeechobee by identifying the seasonal and spatial distribution and abundance of *D lumholtzi*, and to explore the changing relationships between *D. lumholizi* and the resident *Daphnia* species.

During 1995 and 1996, bimonthly quantitative macro-zooplankton samples were collected, using a 153 um 30.5 cm diameter Wisconsin net. Limnological parameters were measured from 42 pelagic sampling sites. The sampling sites were chosen using a systematic aligned sampling method developed in ARC/INFO, and located using a Trimble Pathfinder Global Positioning System (GPS), which allowed for navigation to within 30 in (nominally) of each site. Population densities of both *Daphnia* species were classified into 16 categories, and maps representing their seasonal abundances and spatial distribution were created with ARCVIEW 2.0.

Analysis of the quantitative macro-zooplankton samples indicated that the exotic D. *lumholtzi was* most abundant in the summer and fall months, while the native *D ambigua was* most abundant in the spring and winter months. D *lumholtzi* was mostly concentrated in the extreme north and south ends of the lake, but it also was present in lower densities in the central region during the fall. *D. ambigua* displayed a more ubiquitous distribution throughout the entire lake during the spring and winter, but was concentrated in the central region during the summer. Pearson's analysis indicated an inverse correlation in abundance of the two species. *D. lumholtzi* was most abundant when *D. ambigua* abundances were low. In addition, D. *lumholtzi* was positively correlated to temperature, Secchi depth, and phytoplankton biomass and negatively correlated to dissolved oxygen and total depth, while *D. ambigua was* inversely correlated to those same parameters. With respect to the total daphnid population densities, *D lumholtzi* represented up to 70% of the population in the summer but less than I% in the spring and winter.

This research suggests that the potential exists for D lumholtzi to establish a successful resident population in Lake Okeechobee although this species may simply be filling a "vacant' seasonal or spatial niche due to unfavorable conditions for *D. ambigua.* However, continued observations are needed to document the persistence and expansion of *D lumholtzi* in Lake Okeechobee. Additional experimental research also is needed to elucidate what factors affect the abundance and distribution of *D lumholtzi* and to determine what possible impacts an invasion by this species might have on the pelagic food web.

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NOTES

LAND DEVELOPMENT PROVISIONS- TO PROTECT GEORGIA WATER QUALITY

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The quality of urban streams reflects the quality of land management activities within the watershed. In Georgia, the Department of Natural Resources (DNR) has been assigned the responsibility to protect and manage the water resources of the State by the state legislature and constitution. However, authority for land use management is the responsibility of local governments across the State. As a result, the DNR has no authority to regulate land use activities within the watersheds of streams.

In Georgia, as in many other states, local governments have often adopted zoning codes and land development ordinances of other communities without considering the impacts those regulations may have upon the environment or upon the quality of life of their citizens. The result is that the land development regulations of many municipalities unintentionally contribute to urban sprawl. The quantity of impervious surfaces dictated by these land development ordinances is a major contributor to the nonpoint source pollutant loads of urban streams. As a result, streams in urban and urbanizing areas are the most disturbed and degraded within the State.

In an effort to address the conflict between the management of the streams and the management of the land, the Department's Environmental Protection Division contracted with an outside consultant through a Section 319(h) Grant. The consultant's task was to develop a series of recommended provisions that local governments could incorporate within their own ordinances that would help protect streams from the normally harmful impacts of land development.

The consultant assembled a task force of citizens from across the State who represented various interest groups. Through a series of meetings, the task force refined the consultant's recommendations into a set of provisions that all groups could support. The resulting provisions were not intended to be adopted in their entirety. Rather, they were intended to serve as a "menu" from which local governments could choose specific provisions and adapt them to fit local conditions. Each provision was supported by published research from national authorities in the field.

The resulting provisions go beyond reducing the impacts of land development upon stream water quality. They can also serve to reduce some of the costs associated with typical land development. Several of the provisions also serve to improve the safety of the community's residents, as well as to improve their quality of life. The provisions were intended to address new development only, not the retrofit of existing development.

As part of tile contract, the consultant produced a booklet for the use of local government officials. The booklet lists each of the provisions, explains each provision's role in runoff quality, and discusses their impacts upon cost and safety. A number of illustrations and examples of both good and bad development practices are included in the booklet. The booklet is available from the Nonpoint Source Program of the Georgia Environmental Protection Division at (404) 656-4887.

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NOTES

STRATEGY FOR ASSESSING AND PRIORITIZING LAKES IN HIGHLANDS COUNTY

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Purpose An assessment of public access lakes in Highlands County, conducted by the Highlands Soil and Water Conservation District, was performed to provide objective criteria for determining the condition of each lake, both relative to standard water quality criteria and to other comparable lakes. Because of the diversity of lakes in the County, ranking by a single parameter was abandoned in favor of sorting lakes by several criteria in order to make comparisons among fundamentally similar lakes.

Scope Highlands County, located in south central Florida, is home to 40 public access lakes containing approximately 46,283 acres of surface water. Because it includes both the southern end of the Lake Wales Ridge and the Kissimmee Valley lowlands, Highlands County boasts a wider spectrum of lakes than almost any other county in Florida. Of these 40 lakes, 20 are classified in the Southern Lake Wales Ridge (SLWR) Region, 19 in the Lake Wales Ridge Transition (Transition) Region, and one (Lake Istokpoga) in the Kissimmee/Okeechobee Lowland Region (Griffith et al., 1997).

Objectives The objectives for this assessment are as follows: (1) refine the criteria used relative to how each describes, sorts or assesses a given lake; (2) summarize the current condition of public access lakes using descriptive assessment criteria; (3) compare condition of public access lakes within Florida Lake Regions, drainage basins and throughout the County; and (4) Prioritize public access lakes in terms of those most in need of resources or attention.

Approach Information was gathered for each public access lake. Descriptive factors included size, basin type, shape, access type, water level variation [Southwest Florida Water Management District (SWFWMD) and South Florida Water Management District (SFWMD)], and water chemistry (Florida LAKEWATCH, 1997; SFWMD unpublished data, 1994). Sorting factors included drainage basin (SCS, 1994), land use in the watershed, watershed soil types (SCS, 1989), and Florida Lake Region (Griffith et al., 1997). Assessment factors included watershed drainage modifications, stressed lake status, Florida Trophic State Index (FTSI) (Hand and Paulic, 1992) and Bioassessment results (Rutter, 1997).

Results Lakes and lake issues sort out cleanly along Florida Lake Region lines, which encompass watershed soil types and lake shape. The 20 SLWR Region lakes, typically clear with low algal biomass and low nutrients in sandy well drained soils, were also those most likely to suffer from chronically low water levels; of the 15 lakes in the County classified by SWFWMD as stressed, 13 of them were SLWR Region lakes. Conversely, none of these lakes were considered to have degraded water quality or biota assemblages based on FTSI or bioassessment results; FTSI values ranged between 18-45 units. However, two did have high total nitrogen values, with one reaching 2.8 mg/L. SLWR Region lakes tend to be sensitive to runoff from roadways and nutrient inflows from the watershed.

Nineteen lakes in the County are in the Transition Region; these lakes are characterized as being darker in color, -with higher nutrients in more poorly-drained soils relative to the SLWR Region. Transition lakes were rarely classified as having chronically low water levels. Though nutrient levels in Transition lakes were higher than in the SLWR Region, water quality in most of these lakes was still classified as moderate to good (FTSI less than 50). However, the six lakes considered to have the most degraded water quality (FTSI > 65) in the County are located in this Region. Lakes with degraded water quality and highly impaired biotic assemblages included lakes with highly developed watersheds and those that received extensive storm water runoff. Improving water quality and biotic integrity for these lakes may be aided by restoration of more natural water level fluctuations, as well as storm water abatement and application of best management practices in the watershed. Though 39 of the County's 40 public access lakes are in the Lake Istokpoga/ Kissimmee River watershed, Istokpoga itself is considered separately due to its size, extremely managed water levels, and impressive environmental degradation. Istokpoga has been designated as a Fish Management Area by the Florida Game and Freshwater Fish Commission, and will be the subject of an ecosystem-wide restoration effort.

Conclusions and Recommendations. A strategy for lakes assessment in a given watershed must account for the fundamental variations among lake types. Highlands County is establishing a lakes management program to provide a balanced and comprehensive approach to lake resources in the County. A central part of this program is development of a strategy for assessing and prioritizing the County's lakes. The ultimate goal is establishment of a County-wide lakes management program consisting of watershed management plans for each lake. This assessment and prioritization strategy is applicable to a wide spectrum of lakes, providing objective criteria for assessment and prioritization of water resources, critical tools for protecting and improving the environmental and economic heart of Florida.

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NOTES

INTEGRATING WATERSHED PROTECTION WITH GR0WTH MANAGEMENT IN THE LAKE WILEY WATERSHED, CHARLOTTE, NORTH CAROLINA

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This presentation reports a case study in the Lake Wiley watershed, Charlotte, North Carolina. Generally considered as being "quiet and sleeping" with the lowest land development rates in the fast-growing Charlotte/Mecklenburg region, the area is characterized by, among others: (1) low-density residential and industrial land uses; (2) restrictive watershed regulations; and (3) lack of municipal water and sewer services. On the other hand, however, the on-going development of Interstate 485 which is to be complete by the year 2002, and the proposed expansion of the nearby Charlotte-Douglas International Airport, have promised significant economic impacts on the area. The study, conducted through a project team at the University of North Carolina at Charlotte led by the author, explored future land development scenarios for the watershed area for the year 2015.

Using a geographic information system (GIS), the study first performed a land suitability assessment based on a thorough survey of the area's physical, ecological, social-economical, and land use conditions. It then generated three groups of alternative land development scenarios that took into account both the projected demands for land development and the suitability of land resources. More specifically:

1 .The development accommodation group addressed the following issues:

A. What are the *demands* for residential, commercial, office, and industrial development ?

B. Given the land suitability assessment results, what are the best ways to accommodate these demands ?

2.The ideal land development group addressed the following issue:

A. Given the land suitability assessment, which takes into account the existing conditions including the airport expansion, what are the ideal or optimum land use patterns in the area ?

3.The build-out group investigated the following issue:

A. What is the build-out scenario as defined by the existing/revised district plan and the land use ratio ?

The study then identified, by comparisons, discrepancies and similarities among the scenarios. Maps and charts were produced to document these findings.

The results of the project provided the local planners, general public, and elected officials with an informative basis for better decision making, one that balances the concerns over watershed protection and growth accommodations.

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PROTECTING THE WATER QUALITY OF ICHETUCKNEE SPRINGS: A WATERSHED WORKING GROUP PROCESS

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The Ichetucknee Springs and River is probably the most pristine spring and river system remaining in Florida. The Ichetucknee is a National Natural Landmark and an Outstanding Florida Water. It is one of the crown jewels of the Florida State Park system and is the premier tubing river in the United States. Nearly 200,000 visitors a year enjoy the springs and river, generating an estimated $1.7 million a year for the local economy. Many old timers were baptized in the springs, and several local families continue to have their family reunions there. All of these natural, recreational, economic, and social values depend upon the clear, clean waters that flow from the seven springs in the park.

In 1995, concern about the future quality of the spring water led to formation of the Ichetucknee Springs Water Quality Working Group. The Working Group is composed of all federal, state, regional, and local agencies that have responsibilities in, or knowledge about, the Ichetucknee Basin. Other member stakeholders include local citizens, private landowners, educators, businesses, and environmental organizations. The Working Group has been gathering information about the basin from past studies, new research, and interviews with old timers to help discover the origin of the spring waters and the threats to water quality.

Dye tracing studies in the Ichetucknee Basin have proven that Rose Sink, located six miles north of the park, is connected to the springs at Ichetucknee. The I 0-mile-long Rose Creek flows into Rose Sink and its water reappears in the springs. The Working Group believes that the waters of Alligator Lake, Cannon Creek and Clayhole Creek, which drain into sinkholes, also flow through a cave system that connects with the Ichetucknee. These creeks receive contaminated stormwater runoff from urban and agricultural areas in the basin.

Monitoring of water, sediments and fish tissue from the springs and sinkholes in the basin indicates that the waters in the springs are still in relatively good condition. However, contaminants are already showing up, including nitrates in the spring water, pesticides in the fish in the river, hydrocarbons in the sediments in sinkholes, and coliform bacteria in the creeks.

The Working Group is using all the tools in the ecosystem management tool box - education, research, monitoring, land acquisition, agricultural incentives, land use planning, regulations, and enforcement. Emphasis has been on educating local officials and residents of the Ichetucknee Basin through slide programs, public meetings, field trips, news articles and a nationally televised program.

Protection activities for the Ichetucknee include:

0 building stormwater retention ponds,
0 establishing vegetative buffers along streams,
0 protecting sinkholes from refuse dumping,
0 reducing the use of pesticides and fertilizers,
0 reducing septic tank impacts along the Ichetucknee Trace,
0 eliminating leaking gasoline tanks,
0 removing trash from the creeks,
0 purchasing sensitive lands for water quality protection,
0 monitoring water quality, and
0 conducting research to better understand the source of spring water.

NOTES

OVERVIEW OF THE ACF BASIN -FROM COURTROOM TO INTERSTATE COMPACT: HOW MUCH WATER DOES THE APALACHICOLA SYSTEM NEED?

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This presentation documents the transition from contentious litigation to interstate cooperation, in the form of an Interstate Compact, in the relationship between the States of Alabama, Florida, and Georgia and the Federal Government over the water resources of the Apalachicola-Chattahoochee-Flint (ACF) River Basin in the southeastern United States.

The Apalachicola-Chattahoochee-Flint (ACF) River system extends 385 miles from northeast Georgia to the Gulf of Mexico and drains an area of 19,600 square miles within portions of Alabama, Florida, and Georgia. The ACF River Basin is a dynamic hydrologic system containing interactions between aquifers, streams, reservoirs, floodplains, and estuaries.

While there has generally been adequate water in the ACF Basin to meet the needs of most users, there have been periods of low water flows and drought dating back to the 1920s. With increased growth and development, recent droughts in the 1980s created greater competition among users for limited water resources than had been experienced before.

As early as 1982, the Army Corps of Engineers had received requests from Georgia interests for new and expanded water supply withdrawals from existing Corps reservoirs in the ACF and adjacent Alabarna-Coosa-Tallapoosa (ACT) River Basins. In response to these requests, the Corps initiated preparation of water supply reallocation reports to address actions toward the proposed reallocation of existing storage in these reservoirs from hydropower.

On June 28, 1990, the State of Alabama filed litigation in the United States District Court for the Northern District of Alabama against the Corps. This lawsuit challenged the adequacy of the National Environmental Policy Act (NEPA) process and documentation addressing the proposed reallocations. It also alleged that the Corps violated their duty to operate these reservoirs in a neutral and objective manner consistent with Congressional authorizations. The States of Florida and Georgia also petitioned to become parties to the lawsuit.

Shortly after the litigation was filed, representatives from the four parties began discussions to resolve the conflicts. There was general agreement among the parties that litigation was the least desirable option for resolving the water resource conflicts.

On January 3, 1992, the Governors of the States of Alabama, Florida, and Georgia and the Assistant Secretary of the Army for Civil Works signed a Memorandum of Agreement (MOA) committing to work together as partners through a Comprehensive Study process to seek resolution of water resource issues. As a result of this agreement, the Court placed the litigation on an inactive docket pending completion of the Comprehensive Study.

The goal of the Comprehensive Study has been to develop relevant technical information, strategies, and plans, and recommend a formal coordination mechanism for the long-term, basinwide management and use of the water resources to meet the environmental, public health, and economic needs of the ACF and ACT Basin's.

In August 1996, the Study Partners came to an agreement that the type of coordination mechanism that seemed to best fit the management needs of the Partners was an Interstate Compact. Through such a Compact, the States would be able to allocate water within the basin to meet, to the extent possible, the water needs of the basin. The Legislatures of the States of Georgia, Alabama, and Florida approved identical Compacts in early 1997 and the Compacts were approved by Congress and signed into law by the President on November 20, 1997.

The ACF Interstate Compact provides for the establishment of an ACF Interstate Commission, comprised of voting representatives from the States of Alabama, Florida, and Georgia, to manage the water resources of the Basin. The primary responsibility of the Commission is to develop a water allocation formula for the distribution of water within the Basin. The Compact requires that the three states unanimously agree to an allocation formula by December 31, 1998. Upon approval by the three states, the allocation formula must receive a concurrence opinion from the Federal Government within an additional 210 days.

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NOTES

AN OVERVIEW OF WATER RESOURCE DEMANDS MANAGEMENT AND OTHER ISSUES IN THE APALACHICOLA RIVER AND BAY SYSTEMS

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The Apalachicola River system is a 20,000 square mile drainage basin located in northern Florida, Georgia, and Alabama. The system includes two Georgia-located major river systems, the Chattahoochee and the Flint. These rivers join at the Georgia/Florida state line, at Lake Seminole, to form the Apalachicola River, which drains into the Gulf of Mexico at Apalachicola Bay. The bay is responsible for approximately ninety percent of Florida's oyster harvest and a significant portion of the blue crab and shrimp harvests. It also provides nursery areas for finfish, crabs, and shrimp. The bay has been designated an Outstanding Florida Waterway (as has the River), a State Aquatic Preserve, and an International Biosphere Reserve. Maintaining the flow regime of the river is important to preserving the ecological productivity of Apalachicola River and Bay. In 1997, a compact commission was established by the three states to manage the water resources of the basin from a system-wide context. Establishment of the Commission represented the culmination of five years of study and negotiation with the other states in the basin and the federal government. The legislation establishing this Commission calls for the three states to adopt a formula for allocating water in the basin. The nature of this "formula" will be decided by ongoing negotiations among the three states and is to be finalized by the end of this year.

River Flows. Although there are fifteen reservoirs in the basin, only four of these are operated as storage reservoirs for managing downstream flows: Lake Lanier, West Point Lake, Lake W.F. George, and Lake Seminole. The reservoir system in the basin has a low storage-to river flow ratio in the downstream portion of the basin and, therefore, the capabilities to augment flow are limited. These potential capabilities are further reduced because the reservoir that contains about two-thirds of the total storage, Lake Lanier, is located in the headwaters of the basin and the ability to refill this reservoir is constrained by a relatively small drainage basin to contribute flows. The ability of this reservoir to augment flows in the lower basin is further constrained because homeowners and recreational users of the reservoir are opposed to altering lake levels to any significant degree. The water resources of the basin are also consumed for a variety of reasons, which include municipal demands (including the City of Atlanta), industrial demands, thermal power, and agriculture. During the five years of its development, the Comprehensive Study has indicated that even average demands in the basin consume a considerable portion of the river base flow. It has also demonstrated that the largest consumer of water during the low flow season is agriculture, and that the majority of agricultural consumption is in the Flint Basin. When peak flows are examined with an approach to increasing demands, it can be demonstrated that it is possible for demands to exceed availability. Therefore, even in the largest river in the state, it will be necessary to manage water consumption if the natural productivity of the river, bay, and associated wetland habitats are to be sustained.

Bay Salinity Freshwater needs in the Apalachicola Bay estuary have been under critical study in preparation for the on-going negotiations. With river flows into the bay varying, both chronologically and seasonally, from less than five-thousand to nearly two-hundred thousand cubic feet per second, the Bay salinity can approach either pure saline or pure fresh, and can vary widely in a short period of time. In order to provide a key to evaluate this variance on the biota of the system, the Northwest Florida Water Management District has developed a three-dimensional hydrodynamic model of the bay, which can predict salinity at any point in the bay system. This model will be particularly helpful in evaluating impacts to the oyster population so critical to the area's economy. River flows are generated from river and reservoir simulation models such as HEC5 or STELLA. The hydrodynamic model correlates freshwater inputs from these flows and saline water inputs from the Gulf, as well as factors such as rain, wind and currents, and predicts salinity at chosen points in the Bay, both spatially and at chosen depths.

Stormwater. Nonpoint source pollution from urban areas represents one of the most serious threats to water quality in Apalachicola Bay, and may be far more devastating than more distant or regional sources of pollution originating upstream in the riverine watershed. This threat is increasing, as the area is becoming the focus of growing development interests. As part of an overall management strategy for Apalachicola Bay, the District has closely examined the impacts of urban stormwater runoff on the bay by monitoring and characterizing the quality and quantity of runoff from the communities located along the bay. Central to this project was the incorporation of improved stormwater management practices as an integral component of the ongoing comprehensive effort to protect and restore the environmental and economic resources associated with Apalachicola Bay. Most stormwater outfalls discharge untreated stormwater directly into the bay. These conditions have resulted in degraded water quality and increased flood hazard potential, which will only increase in severity as time progresses and the system continues to degrade. Deteriorating neighborhoods and crumbling infrastructure all contribute to the stormwater contamination problem. Percentage of impervious surface, lack of ground covers, omission of erosion controls during and after construction, and inappropriate land uses all contribute to the annual pollution load. A computer model was developed to simulate stormwater quantity and pollutant loading for the "downtown" area of Apalachicola, corresponding to approximately seventeen percent of the entire City study area. Based on the results from the model and from storm event monitoring, this area of the city contributes a substantial amount of contaminants to the estuary. According to projections and calculations, on an annual average this relatively small area discharges 2458 pounds of suspended solids, 6.6 pounds of ammonia nitrogen, 56.6 pounds of Kjeldahl nitrogen, 13.5 pounds of nitrate/nitrite, 13.2 pounds of phosphorous, and 5.5 pounds of orthophosphate.

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FACTORS INFLUENCING THE VARIABILITY OF CHLOROPHYLL CONCENTRATIONS IN FLORIDA LAKES: AN EVALUATION OF NUTRIENT-CHLOROPHYLL MODELS FOR FLORIDA

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Annual data selected from the Florida LAKEWATCH (FLW) database were used to reconstruct nutrient-chlorophyll relationships for Florida lakes to evaluate: (1) univariate and multivariate nutrient-chlorophyll regression models, specifically to rest for the effect of using TN and TN/TP on the predictive abilities of the basic TP-chlorophyll model; (2) how models created from annual Florida chlorophyll data compare with published models based on seasonal data from temperate regions and from Florida; and (3) if observed chlorophyll:TP ratios are different for north-temperate and Florida lakes.

Data (FLW) were randomly sorted into two, equal-sized subsets. The first data subset (model development subset) was used to develop four new nutrient-chlorophyll regression models using TP, TN, TP + TN/TP, and TP + TN as variables in the models. The second data subset (model confirmation. subset) was used to evaluate the predictive abilities of the four new developed models and 10 published nutrient-chlorophyll models. Four measures of precision (correlation coefficients, confidence limits, average errors and percent errors) were calculated for each new and published model and compared. TP-chlorophyll models developed from Florida annual and seasonal (July-August) averages were contrasted with one developed from north-temperate lake seasonal means. Slope coefficients, intercepts, data scatter, Pearson correlation coefficients, and goodness of fit (R2) were used to evaluate the significance of differences between models. Florida seasonal log10-transformed TP concentrations were used in a north-temperate equation to evaluate differences between predicted and observed chlorophyll concentrations. Florida LAKEWATCH data and three additional datasets were divided into two sub-groups, lakes with annual TP concentrations > 100 ug/L and lakes with annual TP concentrations < 100 ug/L and mean chlorophyll:TP ratios and ranges were determined and contrasted.

Statistical analyses indicated that new Florida models had smaller 95% confidence intervals, and smaller average errors and percent errors than previously published TP-chlorophyll models developed from north-temperate lake data. The Florida linear regression model with the smallest 95% confidence interval (38-268%) and average error (8%) was:

$$\log(\text{chl}) = -0.76 + 0.97 \log(\text{TP}) + 0.172 \log(\text{TN})$$

where chl is chlorophyll concentration (ug/L), TP is total phosphorus concentration (ug/L) and TN is total nitrogen concentration (ug/L). A simplified TP-chlorophyll model developed from the Florida lakes database was only slightly less precise (95 % confidence interval 37-281 %) than the multivariate (TP+TN) model. The north-temperate equation under-estimated chlorophyll concentrations in Florida lakes at extremely low TP concentrations. and over-estimated chlorophyll concentrations at extremely high TP concentrations. Reasonable estimates of

chlorophyll, however, were obtained for the majority (±3 ug/L for 45%; ±7 (ug/L) for 65%; and ±10 ug/L for 73%) of Florida lakes. Florida lakes with annual mean chlorophyll concentrations less than 100 ug/L of TP tend, as a population, to have more measured algal chlorophyll per measured TP concentration than north-temperature lakes. Regional differences, however, are probably inconsequential, as the TP-chlorophyll relationship was similar for both north-temperate and Florida lakes.

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NOTES

EFFECT OF SAMPLING FREQUENCY AND WIND VELOCITY ON ESTIMATES OF TOTAL PHOSPHORUS CONCENTRATIONS IN A SHALLOW, SUBTROPICAL LAKE

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Collecting samples at a frequency that will allow water quality conditions to be accurately estimated is an important consideration when designing a monitoring program. Although some effort has been made to statistically determine a sampling frequency that effectively characterizes ambient water quality, few studies have considered biases associated with episodic events (Brewin et al., 1996). For example, in shallow lakes, bottom sediments frequently are resuspended during wind events, causing the chemical, physical, and biological characteristics of the water body to change (Bengtsson and Hellstrom, 1992; Phlips et al., 1995). Hamilton and Mitchell (1997) reported that total phosphorus (TP) concentrations more than doubled in several shallow New Zealand lakes once wind velocity exceeded a critical velocity.

Monitoring data often are used to characterize water chemistry as mean values even though sampling frequencies may be less than optimal for detecting all episodic changes. These parameter means are assumed to integrate chronic and episodic conditions, however, the influence of sampling frequency still is uncertain. During this investigation, the effect of wind velocity and sampling frequency on estimates of TP were evaluated. Wind velocity and vector direction were continuously monitored for one year at two pelagic locations in Lake Okeechobee, a shallow polymitic lake. The threshold wind velocity was estimated using the model described by Carper and Bachmann (1984). Water samples were collected using automatic samplers and TP concentrations were determined daily during a 12-month period. The data set was sub-divided to simulate four different sampling frequencies, including daily, weekly, bi-monthly, and monthly.

Sampling frequency had little discernable effect on estimates of annual average TP concentrations, which varied by less than 5 percent. However, estimates of monthly average TP derived from daily, bi-monthly, and monthly frequencies often differed by more than 20 percent and sometimes by more than 40 percent. Daily and weekly frequency estimates of monthly average TP generally were similar and never differed by more than 16 percent.

Total P concentrations were positively associated with wind velocity. Regression analysis revealed that, overall, the strongest relationship between these variables was generally found when TP was regressed with the average 24-hour antecedent wind velocity. During the windy season (November-April), winds exceeded the 17.5-21 km h-1 threshold velocity during 40-50 percent of the sampling events. As a result, about 50-70 percent of the variation in TP was explained by wind velocity. In contrast, during the calm season (May-October), monthly average wind velocity was reduced, and the threshold velocity was only exceeded during 7-16 percent of the sampling events; wind velocity explained only 5-22 percent of the variability in TP.

Sampling frequency also affected observed maximum and minimum values. Monthly maximum values observed at the daily frequency were generally 50-250 ug L-1 greater than maximum values observed at other sampling frequencies. Minimum TP concentrations observed at the daily frequency were always' less than minimum bi-monthly and monthly values and sometimes differed by more than 100 ug L-1

Because episodic events are more likely to go undetected at low sampling frequencies, it may be beneficial to conduct short-term, high and low frequency sampling studies in shallow polymitic systems when designing a monitoring program to determine: (1) the frequency at which wind-driven mixing events occur; (2) how water quality constituents are affected by mixing events; and (3) how estimates of physical, chemical, and biological parameters are affected by sampling frequency.

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QUANTIFYING ATMOSPHERIC DEPOSITION OF PHOSPHORUS TO FLORIDA LAKES

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This presentation describes concepts underlying the atmospheric input of phosphorus (P) to ecosystems, summarizes published rates of P deposition and outlines improvements for estimating rates of P deposition. Attempts to evaluate atmospheric contributions of P to ecosystems have proven problematic due to limitations of particle sampling methods, lack of a means for validating total P deposition rates, and persistent sample contamination. Airborne P is transported to lakes and their watersheds by particles derived from soil, dust, pollen, insects, bird excrement, fertilizers, ashes, some pesticides, and aerosols from the ocean. Particles conveying P from the atmosphere are primarily greater than 2 ~= in diameter and increase greatly in abundance with land disturbances associated with urbanization and agriculture. Coarse particles (>10 gm) can be an important agent in moving P in spirals of retention and transport across the landscape, and represent the greatest measurement challenge due to high settling velocities. Larger particulate debris up to I mm in diameter can be a very important source of P to small lakes surrounded by woodlands. The P content of particles can be expected to range from 0.14.2%; higher P levels are associated with areas of P mining and fertile peat soils. Plant canopies can alter P deposition rates greatly across landscapes through retention and release or generation of P-bearing particles. Both canopy geometry and surface structure cause variation in deposition rates from the atmosphere. As particles move across large expanses of water, deposition rates will decline as particles settle to the water surface. Conversely, periods of moderate winds have been associated with injection of aerosols into the air from bubbles breaking in the P-rich surface film.

Atmospheric P concentrations set the context for summarizing deposition rates. Phosphorus concentrations in the atmosphere over cities average about 150 ng P/m , while values in coastal environments tend to range from 10-20 ng P/m^3 . Very low concentrations, sometimes below 1 nghn3, are found in the open marine environment and in remote continental areas. To convert concentrations into deposition rates, multiply a deposition velocity matching the average particle size. Typical deposition velocity values are 0.5 cm/sec for particles less than 1 um in diameter, 5 cm/sec for intermediate sized particles (1 - 10 um), and 10 cm/sec or more for larger particles.

The vast majority of published rates of P deposition are estimates from "bulk" measurements in which the sampler is left exposed to both wet and dry deposition for extended periods, usually 1-2 weeks. Such data are often influenced to varying degrees by local contamination due to extended periods of exposure, and contain some unknown fraction of dry deposition due to the geometry and aerodynamics of the collector. While the drawbacks of bulk collections are undeniable, the simplicity of the method and a general lack of practical alternatives encourage investigators to continue publishing bulk deposition data. Therefore, until more definitive estimates of P deposition are published routinely, we must continue to rely on historical bulk deposition data to assess atmospheric inputs of phosphorus for environmental management.

Published annual rates of P deposition range from about 5 mg $P/m^2/yr$, to well over 100 mg $P/m^2/yr$, although most values fall between 20-80 mg $P/m^2/yr$. Rates below 30 mg $P/m^2/yr$ are found in remote areas and near coastlines; immediate rates of 30-50 mg $p/m^2/yr$ are associated with forests or mixed land uses; and rates greater than. 50 mg $P/m^2/yr$ are recorded from urban or agricultural settings. Florida lakes surrounded by open fields with fertile peat soils, or in mining areas with high P content in soils, will probably receive airborne P inputs above 100 mg $P/m^2/yr$.

The rate of wet deposition of P from the atmosphere can be quantified using common bucket collectors with careful attention to sample processing and site selection to minimize contamination. For dry P deposition, a review of available methods revealed that a monitoring program should estimate inputs for the size classes of particles carrying airborne P and use an inferential approach measuring atmospheric concentrations and deposition velocities. Inferential rates should be applicable to the landscape level to account for canopy effects and gradients in particle concentrations across an aquatic environment. Separating natural organic inputs of P from sample contamination will continue to be challenging. Calibrated surface accumulation methods will be required to sample intermediate and coarse-sized particles to provide direct measurements of total particle flux by size class. Atmospheric P concentrations can be obtained with high-volume (ca., 1.1 m^3/min) particulate matter samplers. Sampling stations should be located for upwind/downwind gradients to allow in situ estimation of differences in concentration and net deposition velocities. Improved statistical tools and methods for detecting biological contamination are needed for data screening.

A publication on this study is available upon request.

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**THE FLORIDA BIOASSESSMENT PROGRAM:
A VENTURE IN PROBLEMS AND SOLUTIONS**

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Assessing the cumulative environmental effects of multiple pollution sources presents many new and complex challenges. This is especially true for nonpoint sources, which, unlike typical point sources, are intermittent, creating temporally and spatially variable shock loadings to surface waters. Consequently, traditional assessment methods relying solely upon sampling and characterization of the water column are ineffective for determining the environmental effects of nonpoint source discharges. Therefore, in 1989, in an effort to help the states address these challenges and comply with the biological portion of the Clean Water Act, the Environmental Protection Agency (EPA) developed the first of a series of bioassessment protocols-the "Rapid Bioassessment Protocols for Use in Streams and Rivers" (Plafkin et al., 1989). In 1991, the Florida Department of Environmental Protection (DEP) established a Bioassessment/Biocriteria Committee to oversee and coordinate the development of bioassessment protocols patterned after those of EPA. The committee's mission, "Using biological indicators to assess ecosystem health, identify problems, and offer solutions," even though current, had its roots in 1948 when a predecessor agency chose to use aquatic macroinvertebrates as tools for monitoring and evaluating water quality. Thus, Florida realized early that "resident biota in a watershed function as continual natural monitors of environmental quality, responding to the effects of both episodic as well as cumulative pollution and habitat alteration" (Barbour et al., 1996).

Florida work was to be conducted on a regional framework, be multimetric and cost-effective, and include habitat evaluation. Efforts have culminated in more ecologically-based determinations of cumulative environmental effects of nonpoint source pollution. A Stream Condition Index (SCI) was completed in 1996 as a tool for assessing problems associated with nonpoint source pollution in Florida streams. The SCI consists of the integration of seven metrics-"characteristics of the biota that change in some predictable way with increased human influence." The metrics include number of taxa; number of mayfly, caddisfly, and stonefly taxa (EPT); number of Chironomid taxa; % dominant taxon; % Diptera; the Florida Index (a tolerance rating); and % filterers.

The SCI was developed within the context of ecoregions-areas of relative homogeneity based on natural water chemistry, soils, physiography, vegetation, and land use. For streams, 13 ecoregions were delineated and macroinvertebrate communities in reference streams within the ecoregions were evaluated and compared with anthropogenically affected streams. From analysis of the macroinvertebrate communities, biologically the 13 ecoregions culled down to three bioregions. "Bioregions identify and partition the natural variability in the freshwater macroinvertebrate assemblage (Barbour et al., 1996) in the Panhandle, Peninsula, and Northeast portions of the state" (McCarron et al., 1997).

A similar tool, the Lake Condition Index (LCI), is being developed for lakes. Maps delineating 47 lake regions/ecoregions have been completed; as with the stream ecoregions, however, they appear to group biologically into three bioregions. The LCI is calculated using eight metrics: richness measures (number of taxa; number of mayfly, caddisfly, and dragonfly/damselfly taxa); composition measures (Shannon-Wiener Index; % dominant taxon; % mayflies, caddisflies and dragonflies/damselflies); a tolerance measure (Hulbert's Lake Condition Index); and trophic measures (% collector-gatherers; % collector-filterers).

Likewise, a bioassessment screening tool for streams, the Bioreconnaissance (BioRecon), was designed. The BioRecon is performed more rapidly (about three hours) than the SCI (about 20 hours) using only three metrics with very little laboratory time involved. This increases spatial coverage of streams, thus allowing resources to be concentrated in the problem areas.

Four other items have been found to be essential: frequently scheduled training; regularly planned meetings of the biologists performing the work, along with managers; adequate *funding* sources; and frequent, easy to understand, simple reporting.

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NOTES

BIOASSESSMENT RESULTS FOR THE ST. MARKS RIVER WATERSHED IN LEON, JEFFERSON, AND WAKULLA COUNTIES, FLORIDA

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A basinwide study, consisting of 30 stations, was performed on the St. Marks River watershed in Leon, Jefferson, and Wakulla Counties, Florida. The purpose of the investigation was to determine potential human effects on water quality, habitat, and biological communities.

Habitat factors were important in explaining poor biological community health at Munson Slough at Springhill Road (an urban ditch), Lafayette Creek at US 90 (an urban ditch), Ward Creek (a sluggish, intermittent marsh stream), Sweetwater Creek (where erosion from a dirt road caused habitat smothering), Sally Ward Swamp (a sluggish, intermittent swamp stream), and Boggy Branch (a low velocity, channelized system). Dissolved oxygen was less than the Class III water quality standard at Ward Creek, Bream Fountain, the St. Marks River below Horn Spring, and the Spring Creek estuary. Low dissolved oxygen at Ward Creek was attributed to the sluggish, marshy conditions there, while the low values seen at the remaining sites appeared to be due to Floridan Aquifer spring inputs. Turbidity measurements at Sweetwater Branch (6.2 NTU) and English Branch (13 NTU) were higher than the values found in 75% and 90%, respectively, of other Florida streams.

Nitrate-nitrite enrichment (levels higher than those found in 80% of other Florida streams or estuaries) was observed at McBride Slough (0.52 mg/L), Boggy Branch (8.7 mg/L), Sally Ward Swamp (0.35 mg/L), the Wakulla River above US 98 (0.42 mg/L), the Wakulla River below Boggy Branch (0.4 mg/L), the Spring Creek estuary (0.22 mg/L), and the St. Marks River at Indian Point (0. 13 mg/L). Nitrate-nitrite enrichment at the majority of the sites appeared to be caused by discharges from Floridan Aquifer springs. The springs apparently receive nonpoint sources of nitrogen in their respective recharge areas. The enrichment at Boggy Branch was associated with an industrial facility (Primex).

Fecal coliforms at Munson Slough at Springhill Road (880 organisms/100 mL) and at Sweetwater Branch (830 organisms/100 mL) violated the Class III water quality standard (which allows a maximum of 800 organisms/100 mL) (Rule 62-302.530(6) FAC). Similarly, total coliforms at Munson Slough at Springhill Road (52,000 organisms/100 mL) and at Sweetwater Branch (3,200 organisms/100 mL) violated the Class III water quality standard of 2,400 organisms/100 mL (Rule 62-302.530(7) FAC). All other sites in the St. Marks Basin complied with both bacterial standards.

Based on the Strewn Condition Index (SCI) scores, Sally Ward Swamp and Ward Creek were ranked in the "very poor" category. SCI scores at Black Creek, Munson Slough at Springhill Road, Lafayette Creek at US 90, English Branch, Sweetwater Creek, and Boggy

Branch placed these sites in the "poor" category. Alford Arm Creek, Moore Branch, Munson Slough at Oak Ridge Road, Fisher Creek, and the Wakulla River above US 98 had SCI scores in the good range, while Lafayette Creek at Weems Road and Lloyd Creek were classified as "excellent."

The stress observed in the macroinvertebrate communities at several sites may be explained. Ward Creek is a sluggish, marshy system which intermittently has periods of no flow and low dissolved oxygen. Black Creek at Baum Road is another site which occasionally goes dry. Munson Slough at Springhill Road and Lafayette Creek at US 90 are both urban ditches, with extensive habitat degradation. The benthic biota at these two sites are probably suffering from a combination of factors, including poor habitat, periodic abrasive effects from flooding, and sporadically poor water quality. English Branch is a small, first-order, and probably intermittent stream. Based on the turbidity measurement, this stream is apparently also subject to runoff containing suspended solids.

Sweetwater Branch was subject to habitat smothering from significant amounts of soil erosion associated with an unpaved county road (Cody Road) that crosses the stream. Sally Ward Swamp, not being a typical, perennially flowing stream system, probably scored poorly because of the sluggish or intermittent nature of flow through this hardwood swamp. The SCI was developed for flowing streams, and it is not an appropriate measure for wetland systems. Habitat was a limiting factor at Boggy Branch, with respect to low water velocity, habitat smothering, and artificial channelization. This site also was subject to considerable nitrate-nitrite enrichment, which could directly affect algal and macrophyte communities, and indirectly, the benthic populations. A more intensive biological assessment (a "5th Year Study") of the effects of the Primex discharge was carried out in December 1997.

Salinity appeared to be the dominant factor affecting the estuarine biota in this study. Taxa richness at all estuarine sites was better than average for a Florida estuary. The Apalachee Bay taxa. richness score was higher than those found in 95% of other Florida estuaries. Compared with other Florida estuaries, three sites had Shannon-Weaver diversifies somewhat less than the average value, including the St. Marks at Indian Point, the Spring Creek estuary, and the St. Marks River near Posey's. Low or fluctuating salinity was a factor common to all three of these sites. Low dissolved oxygen (caused by spring inputs) was an additional stressor at the Spring Creek estuary. Urban stormwater inputs may potentially have affected the St. Marks River near Posey's, although low salinity was probably the overriding factor.

NOTES

CORRELATION OF THE CHEMICAL AND BIOLOGICAL DATA AND THE USE OF eBASE IN THE ST. MARKS RIVER WATERSHED

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STORET data collected over the last 15 years and new biology data are used to assess water quality in the St. Marks River Basin and identify water resources issues. Biological water quality results are compared to the chemical results and a new GIS mapping tool for data assessment (eBASE) is also presented. Ecosystem Management Database, or eBASE, is not a database in the traditional sense of a database. eBASE is an information management tool for visualizing, cataloging, and communicating a diverse array of data, including raw and interpreted data; natural (chemical, physical, and biological) and cultural (social and economic) data; traditional GIS data layers; and non-traditional multimedia spatial information, including photographs, videoclips, and sound tracks. It is designed to enhance the ability of resource managers to interpret water quality data in the context of place, i.e., the natural and human induced conditions that uniquely define the behavior of water within a watershed. eBASE is based on a GIS platform that utilizes ArcView and ArcView Internet Map Server software to deliver maps to the Intra/Internet. It is currently being served through the DEP Intranet on server tlhdwf2 and on the Internet at address 199.87.88.01

One of the problems with most existing water quality data is that it has been collected for specific projects and purposes. Because of the expense and work involved, water quality samples are only collected and analyzed when there is some reason to do so. In some years, many samples are collected and analyzed for a wide assortment of parameters. In other years, few or no samples are collected. Some locations, because of permitting requirements or because they were a special point of interest to a particular research project, will have many pieces of data. Other locations may have none. Quality control may also vary on the data that does exist. And this data may be physically contained in different locations and formats, according to who paid for the data to be generated in the first place. The following account summarizes the steps used to assess this mismatched and discontinuous data.

Biological and chemical data were rated "good" , "fair" or "poor" based on their index values at the 30 sites. At 70% of the stations, chemical and biological data correlated, although there was quite a bit of variation within each category. Some of the stations that did not compare with each other were due to the use of the biological technique in an area where it was not appropriate. eBASE proved to be a very interesting way to view water quality data. The data could be shown on a general, water quality index level, or one could "drill down" through the data to view specific water quality parameters. The ease of data viewing in a mapping environment facilitated assessment of the information.

NOTES

SPATIAL MODELS OF NONPOINT SOURCE POLLUTANT LOADING: A TOOL FOR WATERSHED MANAGEMENT AND DECISION MAKING

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Introduction. Development of landscapes leads to changes in land cover, surface water runoff, and regional energy flows, among other things. Each of these changes is related to the intensity of activity. Development intensity may be related to load on the environment, where the higher the intensity of development, the greater the environmental load. Quantitative indices of development intensity correlated to environmental load could be used to organize water quality sampling design, predict problem areas and model changes in water quality based on changes in development intensity.

This research uses a spatial model of pollutant loading and several Landscape Development Intensity (LDI) indices to test relationships between water quality and intensity of development Using a Geographical Information System (GIS) framework, total phosphorus load was modeled in sub-basins of the St. Marks Watershed of north Florida The model provides for spatial influences of distance on phosphorus load to a waterbody, and is capable of determining cumulative pollutant load along any drainage path to the receiving water. Model results were validated and correlations were made with the spatial distribution of the various LDI indices. In addition the model was used to evaluate the effect of wetland stormwater treatment systems within sub-basins (Tilley and Brown, 1998).

Methods. A spatial pollutant load model was developed in a GIS environment that accounts for the mitigating effect of distance and determines cumulative pollutant load for all raster cells within a watershed as well as total load. Model results were validated using averaged annual total phosphorus data from EPA's STORET database for known sampling points in the St. Marks Watershed.

Indices of landscape development intensity (LDI) based on total energy flow expressed as emergy were generated for sub-basins of the St. Marks Watershed The LDI indices included: total emergy flow, empower density, transformity, and environmental loading ratio. In addition, physical indices of development intensity including: percent imperviousness, road density, weighted land use, and building structure were also generated for sub-basins. The LDI and physical indices were correlated with observed and models phosphorus loads.

Emergy is a measure of the work required to generate a product or service, and accounts for both environmental and economic inputs to a system. Emergy is expressed in units of the same form of energy, most often solar emergy (units are solar emjoules, abbreviated sej). Transformity is a measure of energy quality and is the ratio of emergy required to make something to its energy content (units are sej/J), empower density is emergy per area per time (sej/m2*yr-1) and the environmental loading ratio is the ratio of nonrenewable to free, renewable inputs upon a system, and therefore a possible indicator of environmental impact (Brown and Ulgiati, 1997; Ulgiati et al., 1996).

Results and Discussion. Spatially simulated total phosphorus loadings were compared with STORET data in sub-basins of the St. Marks Watershed that ranged from mostly forested (low LDI indices) to highly developed portions of Tallahassee (high LDI indices). Correlations of predicted versus observed annual phosphorus load were used to validate the model. Total phosphorus loads ranged from 0.45 kg/ha*yr-I for undeveloped basins to 1.48 kg/ha*yr-I for highly developed sub-basins of Tallahassee. Indices of LDI were calculated for varying spatial areas surrounding each water quality monitoring location and for entire sub-basins. Indices were correlated with model output and STORET dam

Simulated decreases in total phosphorus load of between 40% and 60% were achieved in sub-basins of the St. Marks when wetland stormwater treatment areas that ranged from 4% to nearly 15% of total basin area were included in sub-basins. The ecologically engineered wetland systems represented historical wetland areas that had been eliminated by development.

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NOTES

THE SUWANNEE BASIN INTERAGENCY ALLIANCE

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The Suwannee River Basin covers almost 10,000 square miles and is shared by Georgia (57 percent) and Florida (43 percent). Major management issues within the basin include water quality protection and the interbasin transfer of water. Traditionally, there has been little direct communication between the states on water management and other natural resource issues within the basin.

Over 30 years ago, a federal study commission found that, "the problems of the [Suwannee] basin communities are not all alike, but they are of common interest. There is now no common forum for analyzing... problems and for deciding upon a unified program. Such a forum is needed." The Suwannee Basin Interagency Alliance (SBIA) helps fill that ongoing need.

The SBIA was created to coordinate interstate natural resource management activities within the Suwannee Basin. Georgia's River Basin Management Planning program and Florida's Ecosystem Management and Surface Water Improvement and Management (SWIM) programs all emphasize integrated holistic watershed management and provide common ground for interstate cooperation.

The SBIA is co-chaired by Florida and Georgia and has an array of federal, state, and regional agencies as participants. The SBIA is also reaching out to basin stakeholders for participation and support. The first formal meeting the SBIA was held on September 20, 1995, in Cordele, Georgia.

The goals of the SBIA include:

- The development of an interstate management plan based upon the principle of voluntary cooperation among agencies within the Suwannee Basin.

- Improved communication and coordination among agencies and the public.

- More efficient use of funds and human resources through interagency cooperation.

- Improved communication with stakeholders in the basin.

The public participation for the Georgia portion of the basin plan began in January 1998. The Georgia plan will be completed in 2001. The Georgia plan will be used in combination with SWIM plans and the Suwannee Ecosystem Management Plan to provide a voluntary framework for cooperative management efforts.

Important to the planning process are SBIA coordinated special projects. This includes a 1998 comprehensive assessment of surface water quality in the basin. The primary cooperating agencies in the water quality assessment are the Georgia Department of Natural Resources, Environmental Protection Division; the United States Fish and Wildlife Service; the Suwannee River Water management District; and the Florida Department of Environmental Protection.

Common indicator parameters have been agreed upon and field sampling will be conducted within common time frames STORET will be used as the common database for water quality data. A report on water quality for the entire basin will be cooperatively produced in 1999.

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GEORGIA RIVER BASIN MANAGEMENT PLANNING

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Abstract In response to a 1992 state law, The Georgia Environmental Protection Division (EPD) adopted a River Basin Management Planning (RBMP) approach to watershed protection. The RBMP approach uses the watershed as the focus instead of the state-wide regulatory and nonregulatory approaches used in the past. RBMP will be used to develop fourteen river basin plans and provide opportunities for stakeholder involvement to identify priority issues in the watershed. Each river basin plan will use a planning cycle that includes a 12-step process organized into five stages. Those stages include basin planning organization, data collection, assessment/prioritization, basin plan development, and implementation. Each plan is developed over a five-year period starting with the Chattahoochee, Flint, Coosa, and Oconee plans.

Introduction. In 1992, the Georgia General Assembly passed a law (O.C.G.A. 12-5-520) which gave the Georgia Environmental Protection Division (EPD) the responsibility of developing river basin management plans for Georgia's major river basins. In response to the law, EPD adopted a River Basin Management Planning (RBMP) approach or watershed protection approach in an effort to facilitate the protection and enhancement of water resources throughout the state. The RBMP approach is a holistic method to water resource management using the watershed as the focus, rather than the state-wide approaches used in the past.

The river basins used in RBMP planning include the Altamaha, Chattahoochee, Coosa, Flint, Ochlockonee, Ocmulgee, Oconee, Ogeechee, Saint Marys, Satilla, Savannah, Suwannee, Tallapoosa, and Tennessee. A management plan will be prepared for each one of the river basins to include a description of the basin or watershed, identification of local governments in each basin, land use inventories, and a description of the plan goals. A description of the strategies and measures necessary to accomplish the goals is also a part of each plan. The Chattahoochee, Flint, Coosa, and Oconee Rivers are the first basins to be addressed according to the law passed at the General Assembly. The law also requires the establishment of a local advisory committee to be appointed by the EPD Director for each basin. The advisory committee will provide advice and counsel to EPD during the plan development.

Key Features of RBMP Program. The RBMP program has several key features that represent either improvements in the implementation of existing regulatory and non-regulatory programs or provide new methods for accomplishing water resources management goals. First, the program management features include focusing on watersheds, stakeholder involvement, and identifying issues. By focusing on watershed protection, EPD will improve the efficiency of state water resource programs by consolidating activities such as monitoring programs, modeling studies, permit public notices, and public meetings.

Another important feature of the program is public participation or stakeholder involvement. Stakeholder involvement includes using cooperative forums such as basin teams, local advisory committees and public meetings designed to bring together various groups to promote the awareness of water related-issues. It also encourages stakeholders responses on a variety of related issues. The program places monitoring and assessment at the forefront of the management process as a way to guide and better identify the top priority issues concerning watershed protection.

Conclusion Under the River Basin Management Planning approach, EPD has five years to complete each river basin plan. To date, the Chattahoochee and Flint plans have been completed. These plans were approved by the Board of the Georgia Department of Natural Resources in February 1998. After an initial implementation period, EPD and other designated groups will enter into the next five-year cycle designed to revise the plans as appropriate.

The Coosa, Oconee, and Tallapoosa, plans are currently underway and are scheduled for completion in late 1998. Other plans that are presently underway include the Savannah, Ogeechee, Ochlockonee, Suwannee, Satilla, and Saint Marys. The Savannah and Ogeechee plans are scheduled to be completed in 2000. The Ochlockonee, Suwannee, Satilla, and Saint Marys plans are scheduled to be completed in 2001. The Ocmulgee, Altamaha, and Oconee plans are scheduled to be completed in 2002. The Tennessee plan is scheduled for completion in 2004.

NOTES

INTEGRATED RESOURCE MANAGEMENT
IN THE TENNESSEE VALLEY

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Integrated Resource Management was the guiding principle under which the Tennessee River system was developed and is currently operated. The purpose of this presentation is to describe the successful application of this principle and to relate it to today's renewed emphasis on watershed management. In many respects, the terms "watershed approach!' and "integrated resource management" are synonymous. Both reflect an understanding that issues are interrelated in complex ways, both place a high value on flexibility, and both recognize the need to set priorities which are broadly supported by those who must bear the cost of achieving them.

The Tennessee Valley encompasses an area of about 41,000 square miles and extends across seven southeastern states. In 1933, Congress created the Tennessee Valley Authority (TVA) and directed it "to improve the navigability and to provide for the flood control of the Tennessee River; to provide for reforestation and the proper use of marginal lands in the Tennessee Valley; and to provide for the agricultural and industrial development of said valley." These ambitious goals have been achieved because of the realization of their interconnectedness. Storage of water in tributary reservoirs controlled floods and provided flow augmentation for maintaining a navigation system; reforestation reduced peak flows, conserved soil, and increased the design life of the reservoir system. Reduction of floods encouraged economic development. Economic development created a demand for more electricity and low cost electricity encouraged more economic development. Reservoirs created for flood control supported recreation; recreation use demanded protection of water quality. The 54 dams of the Tennessee River watershed were designed to work together as a single unit and today they are still operated with this fundamental philosophy termed Integrated Resource Management. The same dams, designed and operated individually or on the basis of political jurisdictions, could not possibly achieve the level of benefits provided by an integrated system.

While the planners and designers of the Tennessee River system were far-sighted, they could not anticipate all future developments. By the 1980s, increased demand on the system and the public's growing concern for environmental quality required a re-evaluation of operational policies. As a result, TVA modified the way it operated the system. Minimum flows and water quality improvements were implemented at many of its dams. Tributary lake levels were stabilized to improve recreational opportunities, economic development, and scenic views. Implementation of these improvements at a reasonable cost and with minimal impact on flood control, navigation, and hydroelectric power production was made possible by the operational flexibility inherent in a fully integrated system.

TVA is also applying the Integrated Resource Management principle to more localized issues. Beginning in 1992, TVA expanded its efforts to improve water quality in tributary streams. River Action Teams have now been formed throughout the Valley to help communities identify problems and develop partnerships to address them. These Teams take with them a recognition that water issues cannot be separated from land, economic, cultural, and political issues. This is particularly true as the Nation turns its attention to the control of polluted runoff. Correcting these problems will require the broadest possible participation and the ability to balance multiple objectives and interests. The term commonly used for this process is "watershed approach.")

In February 1998, EPA Administrator Carol Browner and Secretary of Agriculture Dan Glickman released a report titled, "Clean Water Action Plan: Restoring and Protecting America's Waters." This Plan sets a direction for water quality management which will emphasize a watershed approach. Based on TVA's 60-year experience with integrated resource management, the move toward a watershed approach is likely to produce significant water quality gains.

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NOTES

FINDINGS FROM THE NATIONAL WATER QUALITY ASSESSMENT PROGRAM: GEORGIA-FLORIDA COASTAL PLAIN, 1992-1996

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The water quality in the Georgia-Florida Coastal Plain was evaluated from 1992-1996 as part of the National Water Quality Assessment (NAWQA) program of the U.S. Geological Survey. NAWQA began in 1991 to assess the status and trends in the Nation's water quality and to determine the effects of human actions and natural factors on water quality. The Georgia-Florida Coastal Plain study area, one of the first of the areas studied, encompasses nearly 62,000 square miles and contains several major rivers, including the Suwannee River in Georgia and Florida and the Altamaha River in Georgia. About 80 percent of the 9 million people residing in the study area obtain drinking water from ground water.

Evaluation of the quality survey of water was done through a background water quality survey and through studies of land-use impacts. Land-use study areas for ground water included a row-crop agricultural area in the upper Suwannee River basin and two urban areas (Ocala and Tampa, Florida). Ground water/surface water interaction was studied in a karst area in the lower Suwannee River basin. Streams were sampled regularly at nine fixed sites distributed among major land uses and were sampled for three years, in time periods ranging from weekly to quarterly. Stream synoptic studies, short-term investigations focusing on specific hydrologic conditions and land uses, supplemented the fixed site information. Constituents analyzed in ground and surface water samples included nutrients, pesticides, and major ions; streambed samples were analyzed for pesticides, trace elements, and major ions. Stream ecological assessments, which integrated physical, chemical, and biological factors, were done at eight of the stream sampling sites.

Nitrate concentrations (as nitrogen) exceeded the U.S. Environmental Protection Agency (US EPA) drinking water standard of 10 milligrams per liter (mg/L) in more than 20 percent of ground water samples from surficial aquifers in agricultural areas. In the 23 ground water samples from the row-crop agricultural area in the upper Suwannee River Basin, 33 percent exceeded the drinking water standard. These samples were from aquifers that overlie the Upper Floridan Aquifer, the major source of drinking water for the study area. Nitrate concentrations in streams did not exceed drinking water standards or guidelines, but were higher in stream draining basins with agricultural and mixed land uses. Phosphorus concentrations in nearly 30 percent of stream samples were greater than 0. 1 mg/L, the US EPA guideline for the prevention of nuisance algal growth.

Nitrate concentrations (as nitrogen) in the lower Suwannee River are affected by a cycle of water exchange between the river and the adjoining aquifer. During low flow in the river, ground water containing nitrate enters the river, increasing river nitrate concentrations. During high flow, river water enters the aquifer, resulting in a decrease in nitrate concentrations in the aquifer adjacent to the river. The dynamics and extent of the ground water/surface water interaction along the river is dependent on ground water levels in the aquifer and surface water levels in the river.

Of 85 pesticides and degradation products analyzed, 21 were detected in ground water and 32 were detected in streams. Pesticide concentrations did not exceed any US EPA drinking water standards, but criteria for protection of aquatic life were exceeded in some streams. Diazinon concentrations exceeded the aquatic-life criteria of 0.08 micrograms per liter in 20 percent of samples from an urban stream. The most frequently detected pesticides in ground water and streams were three herbicides: attrazine, metolachlor, and prometon. No insecticides were detected in ground water. The kinds and frequency of pesticides detected differed in agricultural and urban areas.

Concentrations of organochlorine pesticides in 22 percent of streambed-sediment samples exceeded aquatic-life criteria. Most exceedances were for chlordane and DDT and their degradation products, which were also the organochlorine pesticides most frequently detected in streambed sediments. Polychlorinated biphenyls (PCBs) were detected at only one site (in an urban basin) at a concentration below the aquatic-life criterion.

Findings from this 1992-1996 sampling, plus data collected during the less intensive sampling period (1996-2000) and data collected by other agencies in the Georgia-Florida Coastal Plain, will be used to determine the sampling frequencies and locations when intensive studies resume in the year 2002.

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FLORIDA STORMWATER, EROSION, AND SEDIMENT CONTROL TRAINING AND CERTIFICATION PROGRAM

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The Florida Stormwater, Erosion, and Sediment Control Training and Certification Program is a multi-media educational program consisting of a reference manual, a set of instructional video tapes, and a "live" review session with an instructor. The course has been developed by the Stormwater/NPS Management Section at the Florida Department of Environmental Protection using Section 319 grant funds from the U.S. Environmental Protection Agency. The objective of the program is to increase compliance with state and federal stormwater permitting requirements and to assure that erosion, sediment, and stormwater controls achieve their intended benefits. The course will facilitate training of new inspectors, assure that existing inspectors have a uniform level of expertise, and promote compliance with stormwater regulations through training rather than fines.

The curriculum consists of eight chapters. The first three chapters cover the fundamentals of erosion, soils, and stormwater/runoff estimation. The next three chapters provide a "toolbox" of essential information about the design, construction, inspection, and maintenance of the numerous structural and nonstructural Best Management Practices (BMPs) used to prevent erosion, control sediment, and manage stormwater. Chapter 7 pulls the basic knowledge and the "toolbox" together in the form of the erosion control plan. The final chapter discusses inspection practices and procedures.

The training program has been evolving over the past three years. The initial draft of the manual was distributed for peer review and revised. The second draft was evaluated during a three-day trial class with over 40 participants from around the state. Comments were received for several months, in addition to a thorough in-house review. This resulted in the final draft, which has been substantially complete for several months. The training video is now roughly three-quarters through the production process. The anticipated completion date is February 1998, with classes beginning during Spring 1998.

Once the videos are ready, a train the trainers class will be held at which perspective training coordinators will take the course, become certified, and review various alternatives for presenting the class around the state at the local level. It is anticipated that staff from the DEP, water management districts, local governments, and private sector will become training coordinators. Hopefully, classes will be available in each county in Florida. Possible class delivery mechanisms will include viewing on cable TV, public access stations, community college TV stations, weekly classes, and even home study.

NOTES

STATE REVOLVING LOAN FUND:
FUNDING FOR NONPOINT -SOURCE POLLUTION

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To help address growing needs for water pollution control funding, Congress created the Clean Water State Revolving Fund (CWSRF) as part of the Clean Water Act Amendments of 1987. The CWSRF succeeded the Construction Grants Program, a direct grant program for funding of waste water treatment projects. Since 1987, Congress has appropriated funds for the implementation of State Revolving Loan Fund programs in the 50 states and Puerto Rico. These funds may be used to fund Section 212 (Publicly Owned Wastewater Treatment Plants), for Section 319 (nonpoint source) and Section 320 (estuary) projects.

Over one-third of the pollution problems faced in the United States today are the result of nonpoint source pollution, yet there is generally a small amount of funding available through nonpoint source programs. The CWSRF can finance nonpoint source pollution control activities as well as the development and implementation of Comprehensive Conservation and Management Plans associated with the National Estuary Program. With close to $3 billion in new project funds available in FY 1998, and a long-term capitalization goal of $2 billion a year, the CWSRF has enormous potential as a funding source for nonpoint source and estuary projects. Due to its flexibility, the CWSRF has the potential to be the primary financing source for comprehensive watershed management efforts. By the end of FY 1997, the CWSRF had funded a total of more than $650 million in nonpoint source and estuary projects around the country.

In FY 1998, more than $153 million in capitalization grants are available to Region 4 states (Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina and Tennessee) alone. There are a number of ways the CWSRF can be used to fund nonpoint source or estuary projects. Some of the success stories to date are:

- Washington State using CWSRF funds to purchase, reconstruct, and enhance badly degraded wetlands areas (Section 320 project)

- Missouri using CWSRF funds for the purchase of animal waste collection equipment and the construction of waste storage facilities by farmers (Section 319 project)

- Alaska using CWSRF funds to plan and construct landfills to protect ground water.

In conclusion, the CWSRF can be a significant funding source to address the problem of nonpoint source pollution. It provides flexible funding for eligible projects, and potentially frees Section 319 funding up for demonstration projects. If these projects are successful, projects like them could be funded with CWSRF monies.

NOTES

A SPATIAL MODEL OF
NITRATE LOADING FROM
RESIDENTIAL SEPTIC TANKS

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A spatial model was developed to simulate residential septic tank nitrate-nitrogen ($N0_3^-$) loading and subsequent movement within the surficial aquifer in a rapidly developing section of Wakulla County. The population of Wakulla County is estimated to increase by almost 50% to 20,000 people in 2005. The surficial aquifer in Wakulla County is a layer of unconsolidated sand and sediments that overlies the limestone St. Marks formation - the uppermost layer of the Floridan Aquifer in this area. It is estimated that about 70% of Wakulla County's current wastewater treatment is performed by on-site sewage disposal systems (OSDS) (Ayres and Associates, 1987). Septic tanks are the most common form of residential on-site sewage disposal system (Kirkner and Associates, 1987). Potential for groundwater contamination increases as the areal density of septic tanks increases (Yates, 1985). To date the modeled parameters include groundwater flow, $N0_3^-$ inputs from residential on-site sewage disposal systems, and the removal of $N0_3$ through the process of denitrification.

Due to the complexity of nitrogen biogeochemistry, several assumptions were made to facilitate modeling: (1) Based on information presented in Walker et al. (1973), all nitrogen in on-site sewage disposal system effluent was assumed to be in the form of $N0_3$.; (2) The $N0_3$ was spatially modeled in the surficial aquifer assuming unretarded movement within the groundwater and no chemical transformation; and (3) The only mechanisms for removal of $N0_3$ were hydraulic transport beyond the study area boundaries or denitrification. Nitrogen removal as a result of denitrification can be significant. Under these assumptions, the resultant $N0_3$ loading from on-site sewage disposal systems was modeled as a worst-case scenario.

Required spatial data included a digital elevation map (DEM), a soils coverage, and a land use coverage. The simulations were conducted in a raster-based GIS environment to manipulate the data layers. The digital elevation map was used to generate the phreatic surface and thus water flow direction - in the surficial. aquifer. The land use data were used as nitrate load coverages. Total nitrogen loading from a, land use type was calculated assuming the attainable density of houses (based on the Wakulla County Planning Department's Comprehensive Plan). An average household of four people was used with an average nitrogen loading of 33 kg/yr (US EPA, 1980). A hydraulic conductivity coverage was created from Soil Conservation Service soil maps using an average hydraulic conductivity for each soil type. The above coverages were combined to spatially simulate maximum nitrogen loading.

Denitrification was spatially modeled using relationships developed by Tsai (1989). The main factors required for denitrification are temperature above 60" F, anaerobic conditions, a source of carbon (organic matter), and $N0_3$. At the landscape scale Groffinan and Tiedje (1997) found that 86% of the variability in denitrification rates could be accounted for by soil texture and soil moisture. Additional data layers necessary to account for these factors included average water depths for wet and dry season conditions and soil carbon content. These parameters were derived from SCS data.

Minimization of load reduction and maximization of initial load results in a conservative estimate of $N0_3$loading to the surficial aquifer. The model indicates that $N0_3$ loading could increase by over 200% if residential densities increase to the maximum allowed by the comprehensive plan. Most of the increased load was a result of increased urbanization around the town of Crawfordville. This increase in $N0_3$ loading - equivalent to agricultural fertilization in some areas - could have negative impacts on water quality and may cause undesirable changes within ecosystems.

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NOTES

A MODEL FOR IMPLEMENTING BASIN PLANNING AND MANAGEMENT: ST. MARKS RIVER WATERSHED PILOT PROJECT

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Florida's river basins are composed of many parts - lakes, ponds, streams, sink holes, springs, ditches, human structures, ecological communities, and the geological formations that shape them - meshed together to form a comprehensive whole: a system. Traditionally, resources within watersheds have been managed on the basis of political boundaries - state, county, city, neighborhood - with resource management further divided according to environmental media such as ground water, surface water, and air. The political and organizational structures that resource managers typically work within tend to preclude effective resource protection and management. The challenge this pilot project undertook was to inaugurate a change from program-oriented to place-based planning and management.

The Florida Department of Environmental Protection (FDEP) has embraced an ecosystem management strategy for resource preservation and protection. Ecosystem management is a form of place-based management, which provides a basic philosophy of cooperation between the scientific community, political leaders, and the public, based on the boundaries of natural systems.

We must first understand how drainage basins work before we can hope to plan for their protection and management. Place-based basin management requires an understanding of the mechanics and function of drainage systems, and the affect of human activities on natural basin function. The St. Marks River Watershed Pilot Project was launched to test the implementation of the ecosystem management approach on a Florida drainage basin. The Pilot Project serves to:

1. Develop a method for conducting a basin assessment using existing information; and

2. Demonstrate how information collected in a basin assessment can be used to enhance resource planning and management decisions.

In developing the methodology for conducting a basin assessment, it was necessary to inventory and evaluate existing information. Extensive and detailed information is available from many programs at FDEP, from other state, local, regional and federal agencies, and from many other sources. Although there are gaps and inconsistencies in the available information, it is possible to use existing data to evaluate overall ecosystem health and to identify environmental problems within a basin. Evaluation of existing data also pointed out the strong need for coordinated, integrated monitoring networks. The methodology developed in the St. Marks River Pilot Project included the creation of a tool, the Ecosystem Management Database (eBASE). eBASE is not a database in the traditional sense of a database. eBASE is an information tool for visualizing, cataloging, and communicating a diverse array of data, including raw and interpreted data; natural (chemical, physical, and biological) and cultural (social and economic) data; traditional GIS data layers; and non-traditional multimedia spatial information, including photographs, videoclips, and sound tracks. It is designed to enhance the ability of resource managers to interpret water quality data in the context of place - the natural and human induced conditions that uniquely define a watershed. eBASE is based on a GIS platform that utilizes ArcView and ArcView Internet Map Server software to deliver maps to the Intra/Internet.

Basin assessment information provides the foundation for basin planning, while providing feedback on the effectiveness of basin management efforts. Information provided by a basin assessment allows for examination of the system as a whole and for development of a plan for the management of the system. Many local problems are better understood when examined from a basin or ecosystem perspective. For example, stormwater problems in the City of Tallahassee are related to a variety of land use and cultural issues, overlaid on the varied vulnerability of water resources across the basin. The problems created by urban stormwater affect surface and ground water quality, habitat quality, and resource usefulness. These issues are typically managed by separate, uncoordinated programs. Often, basin planning and basin management are carried out as independent activities. A basic level of planning, supported by assessment information, can allow us to look at a whole system and then select the appropriate management options.

Some of the issues examined in the St. Marks River Pilot Project include: the use of biological water quality indicators; a comparison of biological and chemical measures of water quality; the use of spatial pollutant load models to evaluate the fate and movement of nutrients, to estimate nitrate loading from residential septic tanks, and to test stormwater management alternatives; and the use of spatial models of development intensity to predict water quality in Florida watersheds.

NOTES

STORMWATER POLLUTION CONTROL USING BAFFLE BOXES AND INLET DEVICES

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Abstract While retention ponds are the traditional method used for treating stormwater, they are not often feasible for retrofit projects due to available land constraints. This paper will present several new types of treatment methods utilizing existing inlets and pipes.

Baffle Boxes. Baffle Boxes are concrete or fiberglass sediment boxes constructed in line, or at the end of, existing storm drain pipes. The are typically 10- 15 feet long, 2 feet wider than the pipe, and 6-8 feet high. The box is divided into two or three chambers, with weirs set at the same level as the pipe invert in order to minimize hydraulic losses. There are trash screens or skimmers to trap floating trash and yard debris. Manholes are set over each chamber to allow access for cleaning with vacuum trucks.

Scale model testing by Dr. Ashok Pandit at Florida Tech. has shown that baffle boxes have a removal efficiency of 90% for "baseball" sand or sandy clay at entrance velocities up to 6 feet/sec. For fly ash, typical in size for clays and silts, the removal efficiency is 20-28% at velocities up to 6 feet/sec.

Grate Inlet Skimmer The grate inlet skimmer basket is a fiberglass box resembling a trash can that is placed inside a grate inlet. The unit has several 4-inch diameter weep holes at different elevations in the box which are covered with stainless steel filter screen. The filter screens allow low to medium flows to pass through while trapping sediment and floating debris. An insert in the top of the box serves as a skimmer to prevent floatables, such as leaves and trash, from leaving the box though the overflow holes located around the top of the container.

Curb Inlet Baskets. The third configuration of sediment control device tested is the curb inlet basket, a fiberglass form that fits inside curb inlets. It attaches to and extends the inlet 14 inches into the inlet while dropping 5 inches vertically. At the end of the fiberglass throat is a 4 inch high weir with a notch that funnels incoming water into a basket hanging on the backside of the weir. The trash basket catches floating trash, grass clippings, and yard debris, and is located under the manhole cover where it can be easily removed and emptied, without human entry into confined spaces.

Conclusion. There are no universal fixes for stormwater pollution control. Each outfall and drainage basin must be analyzed to determine types of pollutant loadings, size of drainage basin, type of conveyance system, and pollutants targeted for removal. The appropriate BMP or series of BMPs should then be selected.

Baffle boxes are effective BMPs for sediment removal in small to medium size drainage basins. They are easily installed in line with existing pipes, requiring minimal easements and utility relocations.

For small flows and drainage basins, grate inlet baskets and curb inlet baskets are affordable alternatives for providing stormwater treatment. Installation into existing inlets and manholes avoids disruptive and expensive construction. Inlet devices trap small amounts of sediment and larger volumes of yard debris and trash. Research is being continued to quantify nutrient loading rates from grass clippings captured by these units. Table I shows the results of several years of clean-out records and associated costs.

The tradeoff for these low-cost treatment methods is the perpetual maintenance expense. It is important to note that if the devices are not going to be frequently maintained they will not be effective. A dedicated source of manpower and equipment is needed to remove pollutants from these BMPs.

Table 1.

TYPE OF BMP	NUMBER INSTALLED	AVERAGE WEIGHT CLEANED (lbs)	AVERAGE COST PER CLEANING	AVERAGE COST/LB. SEDIMENT REMOVAL	AVERAGE COST/LB. TP REMOVAL	AVERAGE COST/LB. TN REMOVAL
Baffle Box	31	4244	$450	$0.11		
CIB	50	10.2	$3.50		$8.54	$3.33
GIB	39	36	$45	$1.25		

Appendix. Dr. Ashok Pandit, 1996

NOTES

PACKED BED FILTER

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Clear Like, a 360-acre lake within the City of Orlando, has a basin area of nearly 2,000 acres. Much of this basin is extensively developed in commercial and industrial land uses. The basin also includes the Citrus Bowl, additional development of which would require stormwater treatment. Due to two decades of continued water quality degradation in Clear Lake, the City of Orlando proposed the use of vegetated, rock-filled filters to treat stormwater. Because of the need to treat stormwater runoff from the Citrus Bowl, and the infeasibility of accomplishing this on-site, a unique approach of treating compensatory areas was proposed. In addition, the potential to use recycled concrete in lieu of granite was an important objective. Beds were proposed to be planted in single species, dual species and unplanted (control beds) to best determine removal efficiencies. Three different flow rates were selected to determine impact to removal efficiencies.

Ten packed beds were utilized to study the pollutant removal rates from differing rock media (crushed concrete and granite), wetland vegetation types and flow rates. In order to accurately determine the pollutant removal rates of the packed bed filters, automated, flow proportional composite samplers were installed at the inlet and outlet of the total bed system. One sampler was placed at the storage facility with the intake tube fitted inside the pump wet well. The sampler was connected to the pump controller to obtain flow-proportional samples by determining the total pump run time for a specified time period. A second sampler was placed directly downstream of the confluence of all individual bed outfalls in order to provide data on the overall bed system outflow.

Throughout the sampling period of April 26 to August 9, fifteen simulated storm events were sampled at various flow rates (low-30 gpm, mid-60 gpm, and high 120 gpm). The samples were analyzed in accordance with Standard Methods for the Examination of Water and Water (17' Edition) for the following parameters: cadmium, chromium, copper, lead, zinc, total dissolved solids, total suspended solids, total Kjeldahl nitrogen, total nitrogen, total phosphorus and orthophosphate. Grab samples were taken for the same fifteen events from a spigot on the pump discharge line and from the system outfalls and analyzed for fecal coliform and total organic carbon. To assess the pollutant removal rates from varying individual packed beds, water quality samples were taken at the inflow and outflow of each bed.

Cadmium, total phosphorus, total suspended solids and volatile suspended solids were removed by the overall packed bed system at a rate of 80 percent. The beds were most effective in removing total and volatile suspended solids, with average removal rates of 91 and 89 percent, respectively. Analysis of the individual bed data indicated that within the concrete-filled beds, the vegetated beds had no removal advantage over the control bed. Within the granite-filled beds, the vegetated beds exhibited significantly better removal than the control bed.

The concrete media control bed was consistently better at pollutant removal than the granite media control. A possible explanation for this is that the differences in pH (7.5 in concrete vs. 6.9 in granite beds) influenced biological and chemical reactions within the beds. Another possibility is that the different textures of the media affected the amount and/or type of epilithic algae that was able to grow.

Within the concrete media beds, the vegetated beds exhibited no advantage over the control bed in the removal of any of the pollutants studied. The control bed exhibited consistently high removals for all parameters. Non-vegetated, concrete media beds exhibited statistically higher removal rates than the control. This may be due to the fact that concrete media acts as a favorable substrate for epilithic algae and/or bacteria. The rock itself also provides a large treatment surface and essentially mimics the effect of dense plant stems (in regard to slowing flows, providing contact surfaces and creating substrate for microbial agents) found within a traditional marsh.

In contrast to the concrete beds, the vegetated granite media beds were consistently better at removing pollutants than the granite control bed. It is possible that the granite is an inferior substrate for algae and bacteria, increasing the importance of removal by the plants. The lower pH within the granite beds could also affect the chemical and biological reactions related to pollutant uptake.

Analysis of three different flow rates (low-30 gpm, mid-60 gpm, and high-120 gpm) indicated that the high flow rate was the best operating rate for the system. This rate was recommended for future operation. Other recommendations included modifications to the inflow system to prevent clogging by silt and long term monitoring to complement and refine the results of this study.

NOTES

EVALUATION OF TREATMENT ALTERNATIVES FOR A REGIONAL STORMWATER RETROFIT FACILITY IN LARGO, FLORIDA

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From February 1997 through August 1997, a study was conducted for the Southwest Florida Water Management District (SWFWMD) SWIM Department and the City of Largo to evaluate and prepare a preliminary design for a regional stormwater treatment facility to be constructed on a 31 ha (76 ac) parcel of land. A drainage canal, known as the Main Channel, traverses the entire length of the site and flows from northwest to southeast. The Main Channel drains approximately 469 ha (1159 ac) of urban areas upstream of the project site. The water discharging through the Main Channel flows south to Boca Ciega Bay. Most of the upland areas on the project site were used for sanitary landfilling activities during the 1960s and 1970s. A substantial portion of the remaining site area is considered jurisdictional wetlands, including a 6 ha (15 ac) palustrine wetland hardwood system located at the southern end of the project site. Computer hydrologic modeling was conducted to simulate the response of the watershed under various rainfall conditions using CHAN for Windows Version 2. Common rain event simulations were used as the basis for estimates of annual runoff volumes, while design storm event simulations defined the hydraulic performance of the existing canals under extreme rainfall conditions.

The project site has three primary constraints which affect the feasibility of stormwater retrofit alternatives. First, the site is relatively low, with a wet season groundwater table being at or above the land surface in most areas. In those areas with higher ground surface elevations, a majority of the land has been previously used as a sanitary landfill. Due to the high groundwater table conditions, retention systems are not applicable for this site. Therefore, wet detention and alum treatment were initially evaluated as stormwater treatment alternatives. Due to the extensive existing hardwood wetland located in the southern portion of the site, wetland treatment was added as a potential stormwater treatment alternative. Site-specific testing was conducted using alum treatment and wetlands treatment to determine the anticipated pollutant removal efficiencies for these alternatives. Laboratory jar testing was conducted using liquid aluminum sulfate on composite stormwater runoff and dry weather baseflow samples collected at this site. Alum treatment of stormwater runoff in the Main Channel resulted in removal efficiencies of 40% for total nitrogen, 90% for total phosphorus, and 85% for total suspended solids. Alum treatment of dry weather baseflow in the Main Channel resulted in removal efficiencies of 30% for total nitrogen, 90% for total phosphorus, and 75% for total suspended solids. To characterize the wetland soil and evaluate soil-water column exchange, studies were undertaken using a series of isolation experiments. Based on the experimental results, there appears to be little benefit from a water quality standpoint of discharging raw stormwater runoff or dry weather baseflow from the Main Channel into the wetland system.

Following the initial testing, two stormwater retrofit alternatives were selected for more complete evaluation. These included construction of a wet detention facility and construction of an alum injection system with floc settling and disposal to treat the stormwater runoff and baseflow discharging through the Main Channel. Both alternatives involve constructing a diversion weir across the Main Channel. Stormwater runoff from common rain events and dry weather baseflow would be diverted into a wet detention pond with a 14-day wet season residence time, or treated with alum allowing the floc to settle out in an existing borrow pit pond. For both alternatives, the treated water would discharge into the Country Club Outfall Canal, immediately east of the project site. The wet detention alternative had a present worth cost of $2,760,175, including both capital cost and 20 years of O&M costs. The chemical injection alternative had a present worth cost of $1,758,208. Both alternatives provide estimated annual mass load reductions of 50% for total phosphorus, 20% for total nitrogen, and 60% for total suspended solids.

For several reasons, the chemical injection treatment alternative was selected for implementation. This alternative provides equivalent total nitrogen and total phosphorus mass load reduction; however, the construction cost is only about 25 % of the cost of the wet detention alternative, and the present worth cost is only about 63 % of the wet detention alternative. The other reason for selecting the chemical treatment alternative was the concern over constructing a wet detention pond in an area which had previously been used as a sanitary landfill. Unknowns discovered during construction could significantly increase the construction cost, could cause long delays in construction, and could even prohibit construction if any unusual materials were discovered.

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NOTES

MAINTENANCE OF STORMWATER RETROFIT PROJECTS

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Abstract The last few years have seen the development of new BMPs to address the needs of stormwater retrofitting for treatment purposes. An often overlooked aspect of these BMPs is the long-term maintenance costs required to ensure that treatment efficiency does not decline with time. This paper addresses the types of maintenance required and associated costs for a number of types of BMPs.

Ponds Ponds are the most effective method commonly used for treating stormwater. Where they can be used, they trade off large construction costs for low maintenance costs. Maintenance for wet ponds includes mowing, cleaning outfall and inlet structures, dredging, and cattail control. Mowing will cost $100-500 each time, depending on the size of the pond. Deep ponds have a life of 10- 15 or more years before dredging is required. Dry ponds and swales will require mowing, sediment removal from the bottoms, cleaning outfall and inlet structures, and repairing ditch blocks. If retention swales are less than 18 inches deep, they will often fill up in 34 years. Citizen concerns will cause mowing intervals to be frequent in high visibility areas.

Wetlands. While wetland treatment was in vogue a few years ago, it has proven difficult to provide long-term survivability of wetland species. Most systems are not designed to realistically mimic the hydroperiods and soil and nutrient conditions needed for plant survival. In addition, the natural erosion process will require periodic dredging to maintain conveyance capabilities and then you have a problem with the agencies, dredging wetlands, and replanting at $10,000 an acre for wetland plants.

Exfiltration Pipes. Proper design of exfiltration systems will provide skimmers and sumps. These skimmers and sumps require frequent cleaning to keep material out of the pipes and extend their useful lives. Eventually, they will need jetting to remove accumulations in the pipes, so make the skimmers removable. Jetting intervals will be 24 years.

Baffle Boxes. Baffle boxes will need to be within 15 feet of a stabilized road for a vacuum truck to service them. Manholes should be centered over each chamber for ease of cleaning. The clean-out frequency varies with each location due to variable loadings. A typical schedule is every other month during wet season and every 3-4 months during dry season.

Inlet Devices. Inlet devices placed in manholes and inlets have low up-front costs but will need frequent maintenance to be effective since they have small capacities for trash accumulations. Once again, the loading rates vary widely with lawn care practices. These are usually put on a monthly clean-out schedule during wet season and every 2-3 months in dry season.

Sediment Traps. Sediment traps are typically sumps in inlets or manholes which trap dirt and trash. Sometimes these are grated inlets constructed with no outfall pipes. When installed along dirt roads, they may fill after every rain. Other installations are surnps in inlets upstream of culverts or exfiltration pipes. A vacuum truck is used to clean them and the maintenance schedule is entirely location-dependent.

Results. Table I shows the types and numbers of devices currently installed and a summary of average debris removal. Baffle boxes, inlet weirs, and sediment traps principally trap dirt while the other devices trap trash, grass, and leaves. The different devices target different pollutants.

Table 1.

TYPE	NUMBER	AVERAGE WEIGHT CLEANED (kg)	AVERAGE COST PER CLEANING ($)
Baffle Box	24	1925	450
Inlet Weir	40	2.76	3.50
Grate Inlet Basket	30	16.3	45
Curb Inlet Basket	68	4.6	3.50
Sediment Traps	13	101.6	6

Conclusion. In order for stormwater retrofit projects to successfully remove pollutants on a long-term basis, the type of maintenance needs should be considered in the design and construction. If adequate personnel, equipment, and funding are not allocated, the projects will be useless. Retrofit projects need maintenance just as roads and wastewater plants need maintenance.

NOTES

CHARACTERIZATION OF STORMWATER CONTAMINATED SEDIMENT AND DEBRIS FOR DETERMINING PROPER DISPOSAL METHODS

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Scope and Objectives. Increasing attention to maintenance and, consequently, how to properly use or dispose of the expanding volume of stormwater sediment, is an emerging issue in Florida. This paper presents the results of an evaluation of the contaminants contained in this material. The study was a cooperative effort between FDEP and the Florida Association of Stormwater Utilities. Fourteen cities and counties participated. Work began in October 1996. We completed the final report in August 1997. The major objective was to gain a better understanding of the need to test stormwater sediments and the level of precaution associated with disposal or reuse of these residuals.

Methods Each municipality determined the type of residuals they wished to examine. In total, participants sampled 87 sites representing common land uses and stormwater best management practices (BMPs). For comparison, soil samples collected at 15 open land area sites provided background contaminant levels. We used concentration limits associated with regulations that often affect the disposal or use of stormwater sediment to rank each land use and BMP category in terms of the potential to be problematic for disposal.

The assessment addressed both in-place sediment and stock piled material. At each site, participants collected a composite sample formulated from 3-7 individual aliquots. To promote consistency, the Department prepared and distributed a sampling methodology guidance document to each participant. The FDEP Central Laboratory in Tallahassee provided sample bottles and containers for shipping. The lab also paid the cost of shipping and conducted the analyses. The Department tested for a total of one-hundred-twenty-eight (128) pollutants that included metals (7); pesticides and PCBs (26); volatile organics (34); semi-volatile PAHs, phthalates and phenols (60); and total recoverable petroleum hydrocarbons. We also examined half of the stormwater sediment samples using TCLP procedures for comparison with forty (40) RCRA Hazardous Waste parameters.

Results As a rule, background sites contained lower levels and substantially fewer contaminants than found in stormwater sediments. We identified fifty-three (53) pollutants present in concentrations exceeding minimum detection limits (MDLs). The traffic-related metals, Cr, Pb, and Zn, occurred at virtually all sites. As expected, most exceedances of screening levels involve detectable levels of arsenic above soil cleanup criteria. However, a majority of the sediments tested also contained low to moderate levels of lead. At one industrial site, TCLP test results exceeded the hazardous waste limit for this constituent by a factor of two.

In addition to metals, nearly all samples of BMP sediment contained organic contaminants. Total recoverable petroleum hydrocarbon (TRPH) levels exceeded MDLs at 90% of the test sites. Eighty-two percent (82%) of the samples also included the pesticide Chlordane. None of the samples contained organic pollutants in excess of hazardous waste limits. However, traffic-related PAHs exceeded the screening level criteria more often than previous studies have shown.

<u>Conclusions and Recommendations.</u> The question as to whether these materials warrant extreme concern is close to being answered. In most cases these residuals are not "hazardous waste". However, contamination with a wide array of inorganic and organic pollutants extends well beyond the levels associated with the raw stormwater itself. We offer the following recommendations relative to the disposal and testing of stormwater generated residuals:

1. For safe disposal, take stormwater sediments to a permitted lined landfill. Utilize the material as daily landfill cover. This disposal option should only require infrequent characterization.

2. To minimize environmental and health risks, we do not recommend disposal of stormwater sediments in unlined landfills or pits nor reuse via land application. For these options, test to ensure compliance with the Clean Soil Criteria specified in Chapter 62-770, FAC. Concentrations of arsenic and several PAHs will exceed the Clean Soil Residential Criteria in about 50 percent of the samples.

3.The performance of catch basins and street sweeping appears to be better than we would have projected. Low frequency in cleaning has resulted in past poor performance.

4. There currently are no State rules and programs that pertain directly to the disposal of stormwater residuals. There is a need for specific criteria relative to stormwater sediments.

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NOTES

EFFECTS OF TROPHIC LEVEL, LARVAL SHAD ABUNDANCE AND SPAWNING TIMES ON LARGEMOUTH BASS RECRUITMENT POTENTIAL IN ALABAMA IMPOUNDMENTS

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Largemouth bass, *Micropterus salmoides,* support important recreational fisheries, particularly in the southeastern United States, where, in 1991, about 50% of all freshwater anglers sought black basses, *Micropterus spp. (U.* S. Department of the Interior, 1996). Accordingly, a vast amount of research has focused on largemouth bass populations, with a recent emphasis on mechanisms affecting recruitment success (Isely, 1981; Gutreuter and Anderson, 1985; Goodgame and Miranda, 1993; Mimda and Hubbard, 1994a, b; Miranda and Pugh, 1997; Ludsin and DeVries, 1997). Indeed, largemouth bass recruitment dynamics may vary across impoundments, where factors such as climate, habitat availability, trophic state, larval shad abundance, timing of largemouth bass and prey-fish spawning, and availability of. food resources may differ greatly. Therefore, we evaluated the factors related to age-0 largemouth bass density and growth rate during their first summer across nine impoundments in Alabama.

We sampled larval gizzard shad, *Dorosoma cepedianum,* and threadfin shad, D. *petenense,* once every two weeks from each reservoir using a bow-mounted pushnet (0.75-m diameter, 500 um mesh) in 1993 and 1994. Sampling began in mid-March and extended until larval shad were no longer collected at each reservoir (late-June to early-July). In conjunction with larval fish collections, we measured Secchi disk transparency and collected water samples for analysis of planktonic chlorophyll-a concentrations at each reservoir/site. We collected age-0 largemouth bass using the shoreline rotenone technique of Timmons et al. (1978) during late-June to late-July 1993 and 1994. All age-0 largemouth bass were placed in 95% ethanol and returned to the laboratory. At the laboratory, largemouth bass were measured for length (nearest I mm TL) and weight (nearest 1 g), and otoliths removed to determine hatching date and growth rates (mm/d) using the methods of Miller and Storck (1982).

Reservoir chlorophyll-a values ranged from oligotrophic (< 3 mg/&) to eutrophic (7-40 mg/m3) according to the classification scheme of Forsberg and Ryding (1980). Abundance of larval threadfin shad, larval gizzard shad and age-0 largemouth bass increased with trophic conditions. For larval threadfin shad, mean annual density increased with chlorophyll-a concentration among reservoirs ($r=0.76$, $P < 0.001$). Similarly, mean annual density of larval gizzard shad increased with chlorophyll-a ($r=0.74$, $P< 0.001$). Mean largemouth bass density and growth rates were positively correlated with larval threadfin shad and gizzard shad densities (all $P < 0.01$). Reservoirs/sites with high larval shad abundance typically had higher densities and more rapid growth rates of age-0 largemouth bass than reservoirs/sites with low larval shad abundance.

Initiation of spawning was not related to trophic conditions across reservoirs/sites. The first day of larval shad collection did not differ between threadfin shad and gizzard shad (t-test - $F_{19,20}$,= 1.32, P = 0.1). Additionally, the first day of larval shad collection was not correlated with chlorophyll-a. Likewise, mean largemouth bass swim-up date was not related to chlorophyll-a. Thus, initiation of spawning for larval shad and mean swim-up date for largemouth bass were not related to trophic state.

However, duration of larval occurrence was related to trophic conditions for both shad species. Total days of larval shad occurrence increased with chlorophyll-a for both threadfin shad (r=0.55, P < 0.01) and gizzard shad (r=0.63, P < 0.01), suggesting that larval shad were present later in summer in reservoirs/sites with high chlorophyll-a than in lakes with low chlorophyll-a. For example, at reservoirs/sites with chlorophyll-a :5 5 mg/L, larval shad of both species were not collected in June (with one exception), whereas in lakes with chlorophyll--a >_ 8 mg/L, larval shad of both species were present past June 15th.

We found generally higher densities and more rapid growth of age-0 largemouth bass in reservoirs with high larval gizzard shad and threadfin shad densities than in reservoirs with low larval shad densities. DeVries et al. (199 1) and DeVries and Stein (1992) found that larval threadfin shad and gizzard shad may reduce zooplankton abundance, possibly reducing recruitment of sportfishes. Timing of occurrence of larval threadfin shad and larval gizzard shad may have affected potential for piscivory of age-0 largemouth bass. We found prolonged occurrence of larvae of both shad species in lakes with high chlorophyll-a compared to lakes with low chlorophyll-a Occurrence of larval shad in late June and July may have allowed age-0 largemouth bass to feed on larval threadfin shad and larval gizzard shad during their first summer in eutrophic reservoirs, whereas larval threadfin shad and larval gizzard shad were likely not available as prey in oligo-mesotrophic reservoirs. Results from this study are correlative and do not demonstrate that larval shad actually contributed to rapid growth and high density of age-0 largemouth bass. Nevertheless, in contrast to predictions based on models of competition, eutrophic impoundments with high larval shad densities may provide the highest growth and density of age-0 largemouth bass, and possibly higher recruitment than oligo-mesotrophic impoundments with lower larval shad densities. Thus, high densities of larval shad may have been beneficial rather than detrimental to recruitment of age-0 largemouth bass across the reservoirs we examined.

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NOTES

USE OF ARTIFICIAL HABITATS BY JUVENILE LARGEMOUTH BASS: CAN WE ENHANCE NURSERY AREAS THROUGH HABITAT MANIPULATION?

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Recruitment of juvenile largemouth bass to adult sizes can be influenced by the availability of nursery habitats that provide both foraging opportunities and refuge from predation. While the importance of littoral vegetation to juvenile fish has received much attention, analogous critical habitats in unvegetated systems remain poorly understood. Studies in Jordan Lake, North Carolina, an unvegetated flood control reservoir, have shown preferential use of gravel substrates on moderate slopes by juvenile largemouth bass (Irwin et al., 1997). Persistent spatial differences in juvenile bass abundance both within and among embayments of Jordan Lake have been demonstrated, and areas that traditionally hold higher densities of juvenile bass tend to be those that are characterized by higher availability of preferred habitats (Irwin et al., 1997; Phillips et al., 1997). It is likely that habitat availability influences the carrying capacity of nursery habitats, and that habitat enhancement may offer a management option in recruitment-limited systems.

We created eight artificial habitat patches in an embayment of Jordan Lake by spreading crushed rock along shoreline areas that previously lacked preferred habitat and supported relatively low bass densities. The experimental design included four sites enhanced by a continuous patch of gravel 18 m long to a depth of 1 m, and four sites enhanced by three intermittent 6.6 m patches of gravel with equivalent open intervals between patches. Habitats were further partitioned among shallow and relatively steep sloping shoreline areas, with two habitats of each treatment type applied in each slope type. Enhanced habitats and adjacent control areas were sampled monthly during the growing season in 1995 and 1997 by electrofishing, and catch rates of juvenile bass in each area were recorded.

Sampling of the artificial habitats and adjacent controls revealed preferential use of the enhanced areas. While juvenile bass catch rates were highly variable among sites and sample dates, average catches across the entire growing season were higher in treatment than control areas in all but the continuous treatment on shallow slope in 1995, and higher in treatment areas for all treatments in 1997. Treatment response was most dramatic in the intermittent treatments, with catches in those areas more than double those from associated controls. Comparisons with long term data demonstrated that treated areas held higher relative densities of juvenile bass than in the years prior to enhancement.

Our results, while preliminary, suggest that juvenile largemouth bass respond to habitat enhancement, and that local densities of juvenile bass might be enhanced by increasing the availability of quality nursery habitat. For recruitment-limited largemouth bass stocks, habitat enhancement may increase juvenile carrying capacity.

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NOTES

LABYRINTH WEIR FOR DISSOLVED OXYGEN IMPROVEMENT

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The Lloyd Shoals Project dam (FERC No. 2336) forms Jackson Lake, a 1,923 ha impoundment located in the central Georgia piedmont approximately 80 kilometers southeast of Atlanta, Georgia. Discharge from the dam enters the Ocmulgee River, which supports a warm water stream fishery, consisting mainly of sunfish, minnows, suckers, catfish, and perch. The current usage classification for the Ocmulgee River downstream of Lloyd Shoals Dam is "fishing", which requires daily average dissolved oxygen (DO) of 5.0 mg/l, and instantaneous DO not less than 4.0 mg/1

Jackson Lake is eutrophic and exhibits strong thermal stratification during the summer months typical of southeastern monomictic reservoirs. Dissolved oxygen near the surface is usually at or near saturation, but the hypolimnion generally contains reduced DO or may be anoxic. Jackson Lake is about 28 meters deep at the dam, and water is withdrawn from the middle depths between 5-11 meters. Consequently, discharge in the summer is oxygen deficient, often containing less than 2.0 mg/l.

During the late 1980s, Georgia Power Company (GPC) investigated several alternatives to enhance DO content of the discharge, including reservoir destratification, hypolimnion pumps, forebay gas injection, draft tube aeration, surface aerators, tailrace diffusers, and tailrace weirs. Weirs are generally low-cost, low-maintenance, passive structures that can provide benefits comparable to more costly technologies. Consequently, a labyrinth reaeration weir was selected as the most cost-beneficial alternative for the Lloyd Shoals Project.

During the summer of 1996, GPC evaluated the effect of the weir on water quality in the Ocmulgee River. Hydrolab Recorder submersible data logging units were used to monitor DO concentrations in the Ocmulgee River upstream and downstream of the weir at 30-minute intervals throughout the summer. In addition to the Ocmulgee River monitoring data, Jackson Lake water quality profile data was collected weekly to document current reservoir stratification and potential effects on Ocmulgee River water quality.

Jackson Lake profile data collected during 1996 was very similar to summer profile data collected during the late 1980s. Jackson Lake exhibited stratification throughout the summer, and strong temperature and DO gradients were evident as early as May 1996. Temperatures at the surface exceeded 30-C during June and July, and bottom temperatures remained near or below I 0oC. During July and August, DO was often less than 2.0 mg/l at -6 meters depth.

The monitoring data indicated that the construction of the weir resulted in immediate and significant dissolved oxygen improvement in the Ocrnulgee River. A total of 6,683 paired upstream and downstream DO measurements were collected from May through September 1996. Mean DO concentration for the study period was 3.01 mg/I upstream from the weir and 5.43 mg/I downstream of the weir, indicating the weir improved DO in the Ocmulgee River an average of 2.42 mg/I throughout the 1996 study. Dissolved oxygen was significantly higher (paired t-test, $P < 0.01$) downstream of the weir during each month of the study.

From May through September 1996, only 32% of the 30-minute DO values were above 4.0 mg/l upstream of the weir, but 94% were greater than 4.0 mg/I downstream of the weir. Dissolved oxygen upstream of the weir was below 4.0 mg/I for the entire month of July. However, 90% of the values recorded downstream of the weir during July exceeded 4.0 mg/l, which documented a substantial increase in DO concentrations and the quality of aquatic habitat.

Continuous monitoring showed that the weir recovered an average 50 percent of the daily mean oxygen deficit (difference between observed DO and saturation) exhibited in the Lloyd Shoals Project discharge. This aeration was similar to the 55-60 percent recovery documented at TVA's South Holston labyrinth weir.

Data collected prior to the construction of the weir documented DO concentrations were often less than 2.0 mg/I as far as 1.6 Ian downstream from the dam during the summer months. The current study showed Georgia standards for DO were generally met less than I Ian downstream from the weir, even though DO values upstream from the weir were similar to available historical data. In addition, the Ocmulgee River downstream of the Lloyd Shoals Project was listed for the first time in many years as fully supporting its designated use classification. This improvement must be attributed to the presence of the weir because DO profile data from Jackson Lake and data collected upstream from the weir were very similar to historical data.

The Ocmulgee River downstream of Jackson Lake has a high potential to support a quality recreational fishery. Largemouth bass, redeye bass, and shoal bass are among the many sport species present in the River. It is likely that the documented improvement in water quality has contributed to a wider distribution and greater abundance of many fish species. Anecdotal evidence indicates that fishing in the Ocmulgee River near the dam has improved greatly since the construction of the weir, particularly for shoal bass. Two fishery surveys of the Ocmulgee River were conducted prior to the construction of the weir, and GPC is considering another survey of this fishery. The objectives of this new survey will be to document changes that may have occurred in the abundance, distribution, and diversity of fish species after water quality improvement.

NOTES

THE INDEX OF BIOTIC INTEGRITY: A TEST USING LIMNOLOGICAL AND FISH DATA FROM 60 FLORIDA LAKES

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An index of biotic integrity (IBI), using fish assemblage metrics and two fish classification schemes, was tested using data from fish assemblages collected in 60 Florida lakes between 1986 and 1990. The lakes ranged in trophic status from oligotrophic to hypereutrophic and had aquatic macrophyte abundances (PVI-percent volume infested) ranging from <1% to 100% of lake volume. Forty-six fish species were collected from the study lakes. Fish species were classified by trophic feeding guild and tolerance to increases in turbidity or warming and decreases in dissolved oxygen concentration using fish classification schemes proposed by the U.S. Environmental Protection Agency (USEPA) and the North Carolina (NC) Department of Environment, Health, and Natural Resources. Fish assemblage metrics tested included total number of fish species (TFS), total number of native fish species (NFS), percent piscivorous species (%PIS) percent omnivorous species (%OMN) and percent species generally intolerant to increases in turbidity or warming and decreases in dissolved oxygen concentration (%GI) Values calculated for the fish assemblage metrics were compared within lake size classes (<I 00 ha and >_ 100 ha) and used to assign IBI scores for the fish assemblage metrics for each of the 60 lakes.

None of the 46 fish species tested in this study were recognized as generally intolerant species using the USEPA-IBI fish classification scheme. Total USEPA-IBI scores were calculated using TFS, NFS, %PIS and %OMN and ranged from 1.0 to 4.0. The NC-IBI fish classification scheme used all five fish assemblage metrics and total NC-IBI scores ranged from 0.0 to 5.0. Total IBI scores were used to assign lake acceptability ratings and tested for their ability to predict the estimated degree of anthropogenic impact (low, moderate, or high) as determined by chloride concentrations and expert limnological opinion. Correlation coefficients were calculated for the values of the five fish assemblage metrics against lake surface area (LSA), adjusted total chlorophyll concentration (ATChl), and PVI.

Correlations were significant (p<_ 0.05) and positive for TFS, NFS, %PIS-EPA, %PIS-NC, and %GI-NC against LSA and for TFS, NFS, %PIS-EPA, %PIS-NC, and %GI-NC against ATChI. Use of total IBI scores did not predict the degree of anthropogenic impact for the 60 Florida lakes tested in this study. The average of the total USEPA-IBI scores calculated for high anthropogenic impact lakes was lower than, but not significantly different from, the averages of the total USEPA-IBI scores calculated for low or moderate anthropogenic impact lakes. The average of the total NC-IBI scores calculated for high anthropogenic impact lakes was significantly lower (p<_ 0.05) than the averages of the total NC-IBI scores calculated for low or moderate anthropogenic impact lakes. A lower IBI score is supposed to indicate a lower degree of anthropogenic impact to a lake.

The IBI approach, tested using fish assemblage metrics, did not accurately predict the degree of anthropogenic impact for this set of 60 Florida lakes. Because lake surface area and lake trophic status have a dominant effect on the fish assemblage metrics tested for this study, the IBI approach may be of limited utility for predicting anthropogenic impact in lake data sets that have wide ranges of surface areas and trophic status classifications.

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NOTES

POLLUTION SOURCES AND SINKS IN STORMWATER MANAGEMENT SYSTEMS

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Several types of stormwater treatment systems located at the Florida Aquarium in Tampa provide an opportunity to investigate individual cause and effect relationships that help explain pollution concentrations. The purpose of this presentation is to identify some processes taking place by using water quality data collected: (1) directly in rainfall; (2) in untreated runoff from a parking lot; and (3) from the outfall of three types of wet ponds built to treat stormwater. The three ponds on-site include: a modified wet detention pond (BUILD), a detention with effluent filtration system (man-made underdrains)(STREET), and a system that uses a whole-basin approach for storm water management (PK LOT). The ponds are named for the type of runoff each treats. BUILD treats runoff from the aquarium roof, STREET treats runoff from the streets in front of the aquarium, and PK LOT is the final treatment after a series of swales, and strands draining the aquarium parking lot.

Methods. Water quality in rainfall and the untreated parking lot runoff were measured using automated equipment programmed to collect flow-weighted samples during storm events. Also, the underdrain samples from the effluent filtration system were composite samples taken for three days at a time. Water quality at the wet ponds was usually collected after rain events to compare the water near the discharge point in the three ponds.

Results. The water quality sampling results generally show much higher concentrations in the untreated runoff measured from the Parking Lot than at any of the other stations (Table 1).

Table 1. Average and median concentrations of constituents measured at stations on-site.

Constituent	LOD (lab limit of detect.)	Units	Rain			Untreated Parking Lot Runoff			Pond Outflow BUILD			Pond Outflow STREET			Pond Outflow PK LOT		
			n	AVG	MED	n	AVG	MED	n	AVG	MED	n	AVG	MED	n	AVG	MED
Ammonia-N	0.031	mg/l	46	0.22	0.17	47	0.17	0.12	35	0.07	0.05	35	0.03	0.02	33	0.06	0.05
Nitrate-N	0.01	mg/l	46	0.28	0.20	47	0.33	0.20	35	0.10	0.09	35	0.04	0.03	33	0.04	0.01
Organic-N	0.06	mg/l	45	0.17	0.14	47	0.43	0.61	35	0.63	0.60	35	0.65	0.66	33	1.45	1.41
Ortho-Phos.	0.01	mg/l	46	0.02	0.03	47	0.05	0.05	35	0.08	0.08	35	0.06	0.04	33	0.19	0.12
Total Ph os.	0.01	mg/1	46	0.02	0.01	47	0.10	0.08	35	0.13	0.12	35	0.12	0.09	33	0.35	0.31
Copper	1.0	ug/l	40	4.69	1.90	45	23.18	18.20	35	53.50	25.90	35	9.70	7.70	33	18.40	10.00
Lead	2.0	ug/1	40	1.34	1.00	45	5.72	4.05	35	2.04	1.30	35	2.00	1.50	33	1.37	1.00
Zinc	30.0	ug/l	39	24.87	15.00	45	80.20	66.00	35	48.70	48.40	35	18.90	15.00	33	16.60	15.00
Iron	30.0	ug/l	40	40.2	26.0	45	425.0	299.0	35	114.9	80.0	35	121.3	98.0	33	146.1	94.0
Sulfate	0.052	mg/l	34	2.69	2.47	41	4.09	3.44	35	149.0	103.0	35	26.00	22.00	34	286.0	215.0
T. Susp. Solids	0.05	mg/l	ND	ND	ND	39	18.37	11.80	34	3.39	2.88	34	9.84	4.84	32	11.21	3.37
Hardness	0.02	mg/l	31	0.84	0.74	41	22.65	20.60	35	338.0	247.0	35	92.00	76.00	33	457.0	335.0

The difference between the average and the median values indicate the skewed distribution of the data. Other trends to notice in Table I are the lower levels of lead and zinc discharged from the ponds compared with untreated runoff in the parking lot. Copper would also be lower except chemical treatment has been used to control weeds and algae colonizing the building and parking lot ponds. Also, both ammonia and nitrate are highest in rainfall and much lower in the ponds, but organic nitrogen concentrations are higher in the ponds showing the transformation from inorganic to organic nitrogen. Phosphorus is also much higher in the parking lot pond that seldom discharged and became stagnant Reduced flow is an advantage for the receiving waters but creates a problem for wet detention ponds in the landscape. Both the building pond and the parking lot pond have received inputs of salt water. Therefore, they have higher hardness and sulfate concentrations.

Some strong correlations existed in untreated stormwater: Compared to concentrations in rainfall- Nitrate in rainfall vs runoff (R^2=0.82), ammonia in rainfall vs runoff (R^2=0.63); Metals also were closely related -- iron in runoff vs copper in runoff (R^2=0.70), iron in runoff vs lead in runoff (R^2=0.75), iron in runoff vs zinc in runoff (R^2=0.68), copper in runoff vs zinc in runoff (R^2=0.94); Hours since the last rainfall - copper vs inter-event dry period (R^2=0.67), zinc vs interevent dry period (0.67); Other constituents also varied together- iron in runoff vs total phosphorus (R^2=0.58), suspended solids in runoff vs lead (R^2=0.88), suspended solids in runoff vs iron (R^2=0.63), and suspended solids in runoff vs zinc (R^2=0.93).

Table 2. Concentration in STREET underdrain compared to STREET pond (n=10).

Constituent	LOD*	Units	Drain	Pond
Ammonia-N	0.031	mg/1	0.57	0.02
Nitrate-N	0.01	mg/1	0.19	0.01
Organic-N	0.06	mg/1	0.31	0.71
Ortho-Phos.	0.01	mg/l	0.20	0.05
Total Phos.	0.01	mg/1	0.25	0.12
Copper	1.0	ug/1	1.44	7.94
Lead	2.0	ug/1	1.00	1.77
Zinc	30.0	ug/1	12.11	18.00
Iron	30.0	ug/1	65.6	96.8
Sulfate	0.052	mg/1	ND	ND
T. Susp. Solids	0.05	mg/1	1.33	5.18
Hardness	0.02	mg/l	231.116	0.74

* LOD Lab detection limit

The nutrients measured in the underdrain pipe in the STREET pond are much higher than in the pond itself (Table 2). It should be noted that the underdrain system discharged all the time while the STREET pond only discharged during large (>0.50 inch) rain events. Therefore, the highest mass loading of nutrients from any of the sites occurred through the underdrain pipes.

Conclusions. (1) The whole-basin approach for the parking lot was an excellent design alternative and significantly reduced discharge off-site. (2) Ponds with low dissolved oxygen need solutions other than chemical treatment. Low dissolved oxygen increased metals and phosphorus in the water column.

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NOTES

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

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Purpose, Scope and Objectives. The Cockroach Bay Restoration Project in Ruskin, Florida is an effort to reclaim over 650 acres of natural habitat in a landscape historically used for row crop agriculture. As a part of the larger reclamation landscape, a wet-detention pond was constructed to receive runoff from 210 acres of active row crop farmland. The monitoring of the wet-detention pond (named The Cockroach Bay Stormwater Project) is jointly funded by the Southwest Florida Water Management District, Florida Department of Environmental Protection, and the Environmental Protection Agency through a Section 319(h) grant. The primary objective of this project is the determination of stormwater treatment by the wet-detention pond. Monitored constituents include nutrients, metals, total suspended solids (TSS), pesticides, and bacteria.

Methods. Automated ISCOtm refrigerator samplers are used at the inflow and outflow of the detention pond to collect samples. At the inflow, samples are collected based on rainfall. A minimum rainfall intensity of 0.25 inches per 45 minutes triggers the sampler to collect timed samples. After the first sample, additional samples are collected every 10 minutes for four hours for a total of 24 samples. At the outflow, flow-weighted samples are collected every 10,000 cubic feet. Composite samples at the inflow and outflow are analyzed for nutrients, metals, ions, TSS, and pesticides. Grab samples for bacteria analysis are taken at the beginning of each month. All samples are collected and transported for analyses according to the project quality assurance plan.

Results. The results in this paper are a summary of four storm events collected in 1998. Since January 1998, sampling at the inflow has been based on rainfall intensity due to problems with the flow meter. As a result, samples taken in 1998 represent storm flow better than prior samples taken during 1997. The following summarizes the treatment efficiency between the inflow and outflow of the detention pond for nutrients, metals, bacteria, and pesticides.

Mass loading (ML) calculation of nutrients from four storms in 1998 indicate that the detention pond serves as a sink (Table 1). Mass loading data represent the summation of calculations performed for each storm event based on inflow and outflow volumes. Inflow volume was estimated using a model as a result of the flow meter problems mentioned before, and the outflow volume was measured by a bubbler flow meter. The decreases from the inflow to the outflow (based on ML) indicate that the pond is a sink for nutrients. The transformation from inorganic to organic forms contribute to the reduction and retention of nitrogen and phosphorous. The large algae blooms present in the littoral zone support this conjecture.

Analyses of metals from the inflow samples (Table 2) indicate violations of the Class II water quality standards (shaded boxes indicate standard violations). The source of the metals is unclear, however they seem to be correlated with high total suspended solid (TSS) values (average value of 833 mg/L). The average TSS value at the outflow is 10 mg/L and the metal concentrations are much lower. The high concentrations of metals may be associated with the high amount of silt visible in the inflow samples collected. Silt was not visibly present in the outflow samples.

Table 1

Nutrient	Ave. Inflow Conc. (mg/L)	Ave Outflow Conc. (mg/L)	Inflow Mass Loading (kg)	Outflow Mass Loading (kg)	% Change (based on ML)
Ammonia	0.168	0.064	21.5	4.0	-81.4
Nitrate	0.818	0.330	114.8	22.5	-80.4
Total N	1.490	0.903	176.2	69.2	-60.7
Ortho P	1.938	0.727	157.8	47.7	-69.8
Total P	5.403	0.890	598.9	59.1	-90.1

Table 2

Metals	Units	Class II Standard	Inflow				Outflow			
			Jan 16	Jan 24	Feb 17	Feb 20	Jan 16	Jan 24	Feb 17	Feb 20
Aluminum	ug/L	1500	8610	8340	21800	30000	345	234	753	1120
Cadmium	ug/L	9.3	3.03	3.01	8	13.3	<.3	<.3	<.3	<.3
Copper	ug/L	2.9	168	291	712	1100	7.23	27.4	19.2	27.1
Iron	ug/L	300	3710	5850	14200	21500	134	244	700	610
Lead	ug/L	5.6	9.23	36	128	178	<2	<2	<2	<2
Nickel	ug/L	8.3	8.47	13.5	24.6	33.1	<4.3	<4.3	<4.3	<4.3
Silver	ug/L	0.05	0.859	1.15	3	4.5	<.1	<.1	<.1	<.1
Zinc	ug/L	86	164	232	570	820	<30	<30	<30	<30

Grab samples for bacteria collected monthly at the inflow and outflow do not indicate alarming levels of fecal and total coliform. bacteria. Values from November 1997 to February 1998 do not indicate levels that violate Class III standard. Monitoring of bacteria levels continue. Preliminary results from pesticide analysis indicate that during storm flow on January 24, 1998, the following pesticides and their residues were detected: DDE-p,p', endosulfan II, and endosulfan sulfate. These and other pesticides were not detected in storm samples collected at the outflow. The detention pond may attenuate pesticides entering at the inflow by dilution or breakdown processes. We await results from other sampling collections. Monitoring of pesticides and long-term trends continue.

Conclusions and Recommendations. Data presented here represent only four storm events from 1998. Monitoring and data collection continue. In addition to the continuation of the abovementioned analyses, additional sampling of sediments, groundwater, and fish are in progress to obtain a more holistic insight into the stormwater treatment of agricultural runoff by a wet detention pond.

NOTES

INFLUENCE OF GIZZARD SHAD ON PLANKTON COMMUNITY INTERACTIONS

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Gizzard shad, a common forage fish in Southeastern water bodies, can reduce the energy transfer from primary producers to sport fish by regulating plankton communities in water bodies. Larval shad feed as particulate feeders on zooplankton and shift to filter feeding omnivory (on zooplankton, phytoplankton and detritus) as adults. Also, due to high fecundity paired with rapid growth rates, larval shad are able to outgrow larval predators and, therefore, have a narrow window of vulnerability to predation. The objectives of this study were to evaluate the direct and indirect effects of gizzard shad on the zooplankton community, the phytoplankton community, and nutrient concentrations [phosphorus (P) and nitrogen (N)].

In an effort to accomplish the above objectives, we conducted an enclosure/exclosure experiment using a 2x2 factorial design. Mesocosms were placed in a pond, with and without juvenile gizzard shad, and with low and high densities of zooplankton. The experiment was replicated using four complete randomized blocks. We conducted our experiment from July 6 through August 9, 1 T3. Sixteen enclosures were constructed of polyethylene bags (1.4-m diameter, 1.5-m deep, 2.36-m volume), sealed at the bottom, and suspended from four floating frames in the limnetic zone of one of the shad treatment ponds described earlier. Each frame held four bags and treatments were randomly assigned to bags so that each frame received a full compliment of treatments. On July 6, low zooplankton (LZP) treatment bags were filled with pond water filtered through a 54-um mesh net, while high zooplankton (HZP) treatment bags were filled with unfiltered pond water. Because zooplankton density was low in the source pond, HZP treatment bags were supplemented with zooplankton collected from another pond on July 9. Gizzard shad were collected by electrofishing from the pond containing the bags on July 12. Five juvenile gizzard shad were introduced into one HZP and one LZP bag per block yielding a density of 2.12 fish m3 for the gizzard shad (GS) treatment similar to densities seen in the field. The remaining two bags per frame received no fish and constituted the two no gizzard shad (NGS) treatments (one with HZP and one with LZP). Survival was monitored (87.5%) and five dead fish were replaced on July 13. Mean length of a subsample, of stocked fish was 92.7 ± 7.4 mm. TL (mean ± I SD, n=26).

Zooplankton density ($p<0.01$), large sized phytoplankton (> 70,um in greatest linear axial diameter), density ($p=0.01$), and N:P ratios ($p=0.04$) were reduced with shad. Primary productivity ($p<0.01$), chlorophyll-a ($p<0.01$), productivity to biomass ratio (assimilation number)($P=0.02$), and total phosphorus (p--0.01) all increased with shad presence.

Our data suggest that gizzard shad directly influenced zooplankton, phytoplankton and water chemistry dynamics. Similarly, previous work in Mesocosms has found shad effects on zooplankton (DeVries and Stein, 1992; Lazzaro et al., 1992; and Drenner et al., 1986), on phytoplankton dynamics (Lazzaro et al., 1992 ; and Drenner et al., 1986), and on nutrient concentrations (Lazzaro et al., 1992). Assimilation number was higher in the presence of shad due to a reduction of largesized (less efficient primary producing) phytoplankton in the shad treatment, causing larger changes in primary productivity than chlorophyll-a. This suggest that in larger systems containing shad, management decisions based entirely on chlorophyll-a changes may not adequately address trophic changes in that system.

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NOTES

FEEDING RATE OF TRIEPLOID GRASS CARP AS DETERMINED BY SIZE AND WATER TEMPERATURE

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Purpose The native range of the grass carp White amur) are the rivers of China, Siberia and Manchuria which flow into the Pacific Ocean between latitudes 50*N to 23*N (Cross, 1969). It was introduced into the United States in 1963 at the Bureau of Sport Fishery and Wildlife experimental station in Stuttgart, Arkansas. Due to its potential for reproduction outside its native range and its ability to consume large amounts of native vegetation (Stanley, 1976), it created controversy throughout the 1960s and 1970s (Burkhalter, 1975). However, with knowledge of reproduction (Huisman, 1978), hybridization (Marian and Krasznai, 1978), and triploidy of hybrids (Vasil'ev, et al., 1975), soon the hybrid grass carp (Lynch, 1979) and finally the triploid grass carp (Malone, 1984) were developed. Soon after, a method to certify its triploidy (Wattendorf, 1986), and thus certify its sterility, lead to the permitting of the triploid (3N) grass carp in Florida for aquatic weed control. While much is known about the fish as a weed control agent (Cassani, 1996), feeding and growth rates of the fish as a function of water temperature and fish size are not well documented. The purpose of this presentation is to describe these relationships.

Methods and Materials. Feeding trials of triploid grass carp were conducted between February 1994 and December 1995 utilizing hydrilla. The trials were carried out in 4 m3 vinylcoated wire mesh cages suspended in an experimental pond on the campus of the University of Central Florida. The feeding experiments were conducted over a seven-day incubation. Four fish per cage were used for small fish (less than 6 kg), while one fish per cage was used for larger fish (greater than 6 kg). Pre- and post -weight of the fish and plants were recorded to determine the growth rate, feeding rate, and feeding efficiency of the triploid grass carp. The size of fish ranged from 0.2-9.1 kg and water temperatures ranged from 17-29*C. Water temperature was recorded as the mean temperature in the pond throughout the incubation period. Of the 60 cage trials that were conducted, only 30 were utilized. Trials were discarded if water temperature varied more than 2*C within the seven-day trial, fish appeared stressed or injured, the vegetation became coated with algae or died, and/or fish mortality occurred.

Results. While relative feeding rates declined with increase in the size of fish, absolute feeding rates tended to level out for fish weighing more than I kg. Fish smaller than I kg tended to consume their body weight per day. Triploid grass carp between 1-6 kg consumed nearly 50% of their body weight per day; those larger than 6 kg tended to consume nearly 10% of their body weight. Feeding efficiency was 3-4% for fish less than 2 kg. Weight gain, relative and absolute feeding rates, and feeding efficiency was found to increase with increasing water temperature. Relative and absolute feeding rates for 0.2-0.4 kg fish at 17*C were approximately 25% of that for similar sized fish at 27C. Above 25*C, these fish tended to consume their body weight per day of hydrilla. The optimal temperature for feeding, growth, and food conversion was determined to be 25'C.

Conclusions Triploid grass carp stocked into waters of 17*C or greater will respond with substantial feeding and growth rates. Thus, winter stocking of the fish can be of benefit for controlling hydrilla, since feeding and growth continues at winter temperatures (I 5-20*C). Large triploid grass carp (6-10 kg) consume nearly the same absolute amount of hydrilla as small fish (0.5-1 kg), and consequently are just as effective as weed control agents. This explains how lakes containing large triploid grass carp tend to remain weed free. Small triploid grass carp (utilized in initial stocking), say at a weight of 300 gm, can be expected to double their weight in 150 days at 17'C or double their weight in 25 days at 25*C. Fish stocked in waterbodies with ample vegetation can quickly reach sizes beyond that which results in heavy bass predation, especially if the fish are stocked in summer.

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NOTES

TRIEPLOID GRASS CARP
***(Cienopharyngodon idella)* REMOVAL**
BY THE USE OF SOUND ATTRACTION

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Grass carp *(Ctenopharyngodon idella),* a native of China, was introduced into Florida in the early 1970s for the purpose of controlling hydrilla and other aquatic vegetation. Grass carp quickly proved to be successful at removing hydrilla and other submersed aquatic plants. Grass carp were only used in a few instances to control aquatic plants prior to 1984, primarily as a consequence of their possible reproduction and dispersal in Florida waters. Currently, sterile grass carp (a triploid), which have the same aquatic weed control capabilities as the diploid grass carp, are being used for aquatic plant removal in Florida. A problem associated with the use of triploid grass carp is when they are stocked in high numbers they can consume all the submersed aquatic vegetation and they are difficult, if not impossible, to remove from the lake. Several methods of triploid grass carp removal have been investigated, such as herding, angling, netting, and toxic fish baits, all with limited success.

We are presently training triploid grass carp to advance to a specific area by coupling pure-tone low frequency sound with a food reward. The fish are being trained using an intermittent reinforcement schedule to strengthen the association of the behavioral response (orientation to the sound). If the triploid grass carp continue to return to the designated area when the sound is presented without reinforcement, it may be possible to place the triploid grass carp in lakes with nuisance aquatic plants, allow them to consume the plants, and then attract them to a removal device.

The pilot study began outdoors in 6-ft diameter tanks with 30 inches of water. Water clarity quickly became a problem because of algae growth in the tanks. This made it difficult to view the fishes' reactions to the sound. Two air blowers that were extremely loud were added to the building next to the tanks. The noise from the blowers was possibly competing with the low frequency sound transmission. The grass carp were frightened in many of the trials due to the presence of the feeder. These problems from the pilot study lead to a new design of the methods for the second trial.

The tanks were brought indoors, and they were plumbed with clear water (algae-free). Tarps were constructed to keep the fish from seeing the feeder during the trials. Feeding tubes were also placed in the tanks so the fish would not relate the presence of the feeder with the food. This provided a more controlled study environment.

Data from the second trial suggest that it is possible to train the grass carp to respond to low frequency sound. The second trial shows that triploid grass carp can be trained in approximately 28 days to come to low frequency sound. The carp in the 1000 hz and 600 hz tanks responded to the sound by coming to the feeding square before the food reward was delivered 92% and 92% of the time, respectively. During the 800 hz trials, the fish responded to the feeding square 80% of the time.

The fishes trained to the 1000 hz sound showed no difference in their response (time in seconds) in coming to the feeding squares throughout the training session. It would take the grass carp approximately 4 seconds to come to the square for food before they were trained and approximately 4 seconds to come to the food after they were trained. The grass carp in the 800 hz tank came to the feeding square in 12 seconds before they were trained and 5 seconds after they were trained. The grass carp in the 600 hz tank came to the feeding square in 7 seconds before they were trained and 3 seconds after they were trained. These data suggest that grass carp can be trained to respond to sound, which may lead to an effective means of removing grass carp from a lake after they have controlled a desired amount of aquatic vegetation.

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NOTES

WATER QUALITY CONDITIONS IN LAKE JESUP: PAST AND CURRENT

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Lake Jesup, a 16,000-acre lake in Seminole County Florida, has been hypereutrophic since water quality monitoring began in the 1970s. As a result of the Florida Legislature's Lake Jesup Act of 1994, the St. Johns River Water Management District and the Friends of Lake Jesup Restoration and Basin Management Team began studies to evaluate the condition of the lake and watershed with the goal of developing and implementing a restoration plan for the lake. One component of the initial work was water quality sampling on Lake Jesup and its tributaries. The lake's poor water quality problems are the result of several different causes, including increased external nutrient loading, reduced hydrologic exchange with the St. Johns River due to bridge and canal construction, and conversion of floodplain wetlands. Increased nutrient loading is the result of accelerating population growth within the watershed, which includes portions of the cities of Orlando, Winter Park, Winter Springs, Oviedo, and Sanford. The combined population of Seminole and Orange Counties will have nearly quadrupled between 1960 and 2000, to an estimated population of nearly 1.25 million people. Hydrologic modifications to the confluence of Lake Jesup and the St. Johns River began around the turn of the century, and have eliminated riverine flows from the St. Johns River into, and out of, Lake Jesup. Currently, there is a single channel connecting the lake and river. A portion of Lake Jesup's floodplain was leveed off from the lake and pumped dry for agriculture, primarily pasture. The combined affects of these changes have increased both nutrient concentrations and hydraulic residence times, leading to excessive algal growth and intermittent fish kills. Increased algal primary production has led to large organic sediment accumulations, reaching several meters deep in places. The poor water transparency and extensive muck deposits have contributed to the nearly complete lack of submersed vegetation within the lake.

Several water quality parameters, including phosphorus and chlorophyll, show a high degree of both spatial and temporal variability. Presumed causes for the variability include large changes in hydrodynamic conditions within the lake (residence times), variable nutrient loading from the lake's tributaries, and lake elevation. Flow reversals in the channel connecting the lake and river are common and can cause significant changes to the water chemistry within portions of the lake. When the river flows into Lake Jesup, the eastern end of the lake near the river has reduced nutrient and chlorophyll concentrations, while at the western end of the lake where the District's preliminary hydrodynamic modeling suggests water stagnation is the greatest, nutrient and chlorophyll concentrations may increase. On one date, the lake had a dense algal bloom on the west end (chlorophyll-a = 427 ug/L), while at the east end the chlorophyll-a concentration was less than 50 ug/L. One month later, the hydrodynamic conditions had changed and chlorophyll-a concentrations were less than 50 ug/L at both locations. Mean chlorophyll-a concentration during 1995-1997 for the lake is 59 ug/L. but varied between 2-427 ug/L.

Slow and slight improvements in water quality parameters have occurred since 1983 when the last sewage treatment plants stopped discharging secondary effluent into the lake's tributaries. While nutrient concentrations in the tributaries have declined, the combined loading from the tributaries, sediments, and groundwater are sufficient to maintain in-lake concentrations resulting in hypereutrophic status for the lake. Elevated nutrient concentrations correlate with low water elevations, suggesting internal loading as a significant source of water column nutrients. The slight improvement in water quality since effluent diversion may, in part, be responsible for the appearance of hydrilla in the lake during 1996.

Restoration plans being developed focus on the three problems above. A reduction of tributary inflows of nutrients is being addressed by a variety of methods. One important aspect is education of the watershed residents and how they can improve water quality around their homes. In addition, potential sites for stormwater parks to treat the first-flush of water following rain events are under evaluation along several tributaries. To reduce in-lake nutrient concentrations, several different marsh flow-way designs are under evaluation. The possibility of limited muck sediment dredging to reduce internal loading is also under investigation. Hydrologic restoration of riverine flows through Lake Jesup are under investigation by the District, the Florida Department of Transportation and the U.S. Army Corps of Engineers. There are ongoing efforts to remove remaining levees from the lake's floodplain and return these areas to natural inundation cycles.

Long-term restoration goals for the lake are to restore and maintain the lake's natural hydrology to the extent desirable and practicable, protect and enhance water quality, restore and protect aquatic and wetland communities and their habitats, rehabilitate and maintain fisheries, and to enhance appropriate resource-based recreational values.

NOTES

USE OF THE ENVIRONMENTAL FLUID DYNAMICS CODE (EFDC) MODEL TO ANALYZE CIRCULATION PATTERNS IN LAKE JESUP

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Lake Jesup is a 16,000-acre lake located in the center of Seminole County. Historically, the St. Johns River flowed through Lake Jesup at the north end of the lake. The construction of a channel, known as Government Cut, and the improvement of SR 46 disrupted that historic flow so that the river now bypasses Lake Jesup entirely. In an effort to improve the water quality of Lake Jesup, the Friends of Lake Jesup and the District have worked together to create a hydrodynamic model to analyze the circulation patterns of Lake Jesup and the effects to those circulation patterns due to the re-introduction of flows from the St. Johns River.

The model used for this project was the Environmental Fluid Dynamics Code (EFDC) model authored by John M. Hamrick at the Virginia Institute of Marine Science. It is currently being used for a wide range of environmental studies in the Chesapeake Bay area (Hamrick, 1991 and 1992) and the Indian River Lagoon in Florida (Moustafa. and Hamrick, 1994; Moustafa et. al., 1995). The EFDC model requires a considerable amount of data to perform its hydrodynamic calculations. Data gathering efforts by the District include construction of two stage (water elevation) stations, installation of a full weather station that collects rainfall, wind speed and direction, pan evaporation, air temperature and humidity, solar radiation and atmospheric pressure. Data supplied by other agencies include bathymetry of the St. Johns River (FDOT) and bidirectional flow measurements and stage at the mouth of Lake Jesup (FGFWFC and USGS). The District contracted for bathymetry of Lake Jesup and Acoustic Doppler Current Profile (ADCP) measurements. Data used to run the Lake Jesup hydrodynamic model was collected from January 1, 1997 to November 16, 1997. The District has also done extensive hydrologic modeling of tributaries within the Lake Jesup watershed to estimate the tributary flows into the lake.

Two separate reconnection alternatives were simulated in order to assess the impacts to the internal circulation patterns of Lake Jesup. The most aggressive reconnection alternative involves the complete removal of the SR 46 causeway, closure of Government Cut with the reestablishment of the historic St. Johns River channel, and the creation of a hydraulic connection at the easternmost end of the existing SR 46 causeway with a dredged channel approximately two miles long on the eastern shore of Lake Jesup.

Modeling results have shown that significant changes to the internal circulation of Lake Jesup can be accomplished under the most aggressive reconnection alternative at lower lake stages. This is primarily a result of the flows being contained within the boundary of the proposed dredged channel which allows the flows to reach farther into the Lake Jesup. Modeling results during higher stages show that flows from the St. Johns River into Lake Jesup leave the proposed dredged channel boundary and are diverted out the existing mouth of the lake. During higher stages, the proposed absence of the causeway provides for a substantial increase in flow velocities in the northern portion of Lake Jesup.

The least aggressive reconnection alternative involves the closure of Government Cut with the re-establishment of the historic St. Johns River channel and no additional openings in the SR 46 causeway. Modeling results for the least aggressive reconnection alternative show a marginal increase in flow velocities in the northern portion of Lake Jesup but insignificant changes to the internal circulation pattern of Lake Jesup.

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NOTES

EVALUATING RECENT HISTORICAL NUTRIENT DEPOSITION AND STORAGE WITHIN LAKE JESUP, FLORIDA (USA)

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Paleolimnological assessments may be made using several sedimentary parameters, including nutrient deposition and storage, diatom assemblages, and ^{21O}Pb dating. Lake Jesup is a 75 km^2 hypereutrophic lake located in central Florida north of Orlando. Current land uses within the region are devoted to urban areas (48%), agriculture and rangeland (12%), wetlands (18%), transportation (6%), forests (9%), and water (7%). During the 1900s, four time intervals were identified when anthropogenic changes in the lake and watershed may have affected its trophic state: (1) 1900 to 1920, the time interval when channel diversions and steamboat shipping along the St. Johns River occurred; (2) 1920 to 1950, the time frame when large-scale hydrologic manipulation between the river and lake took place and also when several bridges were constructed over the lake; (3) 1950 to 1985, the period when the lake received the largest constant input of wastewater effluent discharge; and (4) 1985 to 1996, the period when effluent discharge was halted and steps were begun to restore water quality. Magnitude and variations in sediment and nutrient storage were estimated for Lake Jesup to assess historical trophic state changes during the 20th Century. Accumulation rates of sediment and nutrients were estimated as well for the 1900s.

We collected and analyzed 49 sediment cores within an equal area grid across Lake Jesup in March 1996 to assess the recent environmental history of the lake and watershed. Sediments consist of clays and carbonates underlying black-brown muck. Within the muck, the largest fraction of sediment is usually inorganic material, such as sand and shell fragments. Sample analyses included nutrients (N,P,C) for all samples, ^{210}Pb dating and bulk sediment accumulation calculations of eight sediment cores, biogenic silica measurements on six cores, and diatom assemblage counts on three cores collected within the lake basin. Isotopic activities were determined by gamma spectrometry, which permitted simultaneous measurements of ^{210}Pb, ^{226}Ra, and ^{117}CS . The Constant Rate of Supply model was used to determine the age/depth relationships and sediment mass accumulation rates. Recent rates of accumulation for organic matter (OM), total nitrogen (TN), total carbon (TC), total phosphorus (TP), non-apatite inorganic phosphorus (NAIP), and individual silica fractions (mineral, diatom, sponge spicule, biogenic, and, total) were calculated using the sediment ages from the dated cores.

Lake Jesup's shape and position along the St. Johns River contribute to its uneven sediment distribution. The lake is a slightly U-shaped ellipse with only a narrow channel connecting it to the St. Johns River. Circulation and dilution are limited to a few small streams entering the lake and this narrow connection to the river. The western end of the lake does not mix well with the central and northern regions of the lake due to its shape and prevailing wind. The hydrologic residence time of Lake Jesup ranges from 3 months to I year, but the residence time within the western embayment may be much longer due to the poor circulation and mixing.

Nutrient deposition in Lake Jesup has varied throughout the 20th century. Sediment within the central basin of the lake and in the narrow northern channel have consistently shown an increasing trend in OM content, TP, NAIP, and TN accumulation since the early 1900s. The greatest accumulation of organic matter and nutrients occurred early in this century in several regions of the lake, especially the areas on opposite ends of the central lake circulation gyre. The western embayment has consistently reflected the highest accumulation of organic matter and nutrients (> 50% of 20th Century deposition) during the 1950-1985 time interval when wastewater effluent discharge was greatest. Total nitrogen, TP, and NAIP each showed 4.5-fold, 12.5-fold, and 9.7-fold increases, respectively, in the northern channel. The outlying depositional areas of the lake basin (western embayment and northern channel) represent the best historical records of nutrients and sediment. The transitional areas found in the central lake are largely affected by water circulation and contain lower accumulations of sediments and nutrients.

A reliable ^{210}Pb geochronology was obtained from seven of the eight original historic cores collected in Lake Jesup and provided a measurement of mass accumulation rates. Diatom and nutrient data from Lake Jesup sediments indicate that the lake has been at least eutrophic since the turn of the century. Nutrient storage has been high since 1900 when settlement of Florida was begun in earnest. A big pulse in nutrient storage coincides with a 1950s population boom and the discharge of wastewater effluent to Lake Jesup. Diatom abundance counts indicate that the lake became hypereutrophic in the 1950s and 1960s, based on a marked shift in the assemblage diversity of three sediment cores. The lake has demonstrated some recovery from the high nutrient loading that occurred during the 1950-1985 time interval. However, this recovery is slow and probably will continue to be, because circulation within the lake tends to exclude the western embayment and exchange is restricted by a narrow entrance/exit at the confluence with the St. Johns River.

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NOTES

INVERTEBRATE POPULATIONS AND WATER AND SEDIMENTS PHYSICO-CHEMICAL CONDITIONS OF LAKE JESUP AT THE CONFLUENCE WITH THE ST. JOHNS RIVER, CENTRAL FLORIDA

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One goal of the Lake Jesup Restoration Program is to evaluate the possibility of restoring historic water-flow paths between the lake and the St. Johns River. The present altered flow paths have contributed to the accumulation of soft sediments throughout the lake, most likely resulting in altered benthic communities more suited to these conditions. The northeast section of the lake, near the confluence with the St. Johns River, is the most likely area to be affected by changes in the water-flow paths between lake and river. Specifically, the soft sediments may be resuspended and scoured by new currents and exported downstream. Physical changes in the sediments will likely result in secondary impacts on other physico-chemical and biological parameters within the lake and, perhaps, would result in benthic communities adapted to firmer substrates.

The present investigation elucidated the density and distribution of benthic invertebrates in the northeast section of Lake Jesup on a monthly basis from December 1996 to December 1997. Concurrently, data were collected on selected water and sediments physico-chemical parameters. This information was analyzed spatially and temporally to characterize the benthic environment in this section of the lake.

Fifteen permanent stations between 28' 45'N (Davis Point) and 28’ 47'N (State Road 46 bridge) were sampled monthly from December 1996 to December 1997. Navigation to the stations utilized a Global Positioning System receiver. One benthic sample was collected at each station with a 15 cm x 15 cm x 15 cm Ekman dredge; while at one randomly selected station, three benthic samples were collected each month. At each station, water depth was measured with a graduated pole and Secchi disk transparency was measured with a 20 cm Secchi disk. Water temperature, dissolved oxygen and specific conductivity were measured at the air-water interface, at the middle of water column, and at the sediment-water interface. Water samples were collected at the middle of the water column with a 2.2 L horizontal alpha bottle to determine water pH, turbidity, chlorophyll-a, chlorophyll-b, total chlorophyll, soluble reactive phosphorus, total phosphorus, and total Kjeldahl nitrogen. Triplicate samples were taken at one randomly selected station each month for all water parameters. Soft sediment depth was measured monthly at each station with a graduated pole. On a seasonal basis, three 5 cm deep sediment cores were collected from five stations and composited; sediment pH, percent dry matter, extractable soluble reactive phosphorus, total organic carbon, total phosphorus and total Kjeldahl nitrogen were determined.

In the laboratory, each dredge sample was subjectively rated for sediment components (muck, sand, detritus), presence of snail shells and noticeable odors. All benthic samples were washed through a 350 um pore net and collected material examined in a gridded white tray. Invertebrates were identified, enumerated and dried at 60'C for 24 hours to determine dry biomass. Crustacea (primarily Ostracoda) were numerically dominant, followed by Oligochaeta, the gastropod *Tryonia aequicostata*, Chironomidae (predominantly *Glyptotendipes paripes)*, Chaoboridae and Hirudinea. Significant differences in densities were noted between stations for various taxa (especially Station 15, which had significantly higher densities of several taxa), but little or no significant differences were noted between months. Chlorophyll-a concentrations ranged from 31.3-122.2 mg/m3, indicating eutrophic conditions. Water physico-chemical parameters primarily fluctuated with mean water depth, with a positive correlation between water depth and Secchi disk transparency, and inverse correlations with water pH and turbidity. Total chlorophyll was positively correlated with turbidity and negatively correlated with Secchi transparency. Mean dissolved oxygen was negatively correlated with water temperature. Monthly differences were significant between many parameters. Significant station differences were also noted, with Stations 14 and 15 having significantly lower turbidity and higher Secchi transparency, while Station 7 had significantly lower dissolved oxygen. Various significant correlations were noted between benthic invertebrates and water depth, water temperature, mean conductivity, water pH, and dissolved oxygen. Fourteen of the 15 stations had muck or muck/detritus sediments ranging in mean depths of 0.3-0.9 m, with total organic carbon and total phosphorus ranging from 6.8-15.9% and 1.03-3.15 mg/g, respectively, while Station 15 had a sand bottom. This station had significantly lower soluble reactive phosphorus and total organic carbon, and significantly higher dry weight percent. Station 15 also supported the greatest faunal diversity and total benthic biomass.

The dramatically higher density and diversity of benthic invertebrates at sand-bottomed Station 15 is consistent with the hypothesis that firmer substrates in the lake would support a more robust and diverse benthic community. This change in benthos would probably have positive effects on higher trophic levels in the lake. Further study would be needed to determine rates and extent of soft sediment scouring that would occur if historical water flow is restored.

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NOTES

FLORIDA YARDS AND NEIGHBORHOODS: A PUBLIC EDUCATION PROGRAM FOR NONPOINT SOURCE POLLUTION REDUCTION

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The objective of the program was to educate homeowners on ways to reduce fertilizer and pesticide pollutants going into the Indian River Lagoon (IRL), while creating a beautiful landscape that is attractive to wildlife and people. The Florida Yards and Neighborhoods (FYN) Program was completed using grant funds from the Florida Department of Environmental Protection, the "Clean Water Act", Section 319. University of Florida County Extension Agencies in six eastern Central Florida Counties (Volusia, Indian River, Brevard, Martin, St. Lucie and Palm Beach) worked on this program from about July 1995 until August 1997.

Sea grass beds provide habitat for multitudes of creatures that depend of the IRL for some part or all of their life cycles. Hence, the National Estuary Program is involved in this program since reduced pollutants in the IRL will curtail algae blooms that indirectly kill sea grass beds. This program meets part of the educational attributes of the Comprehensive Conservation and Management Plan for the IRL. The FYN program has a positive affect on freshwater lakes and rivers located within the six-county area as well. Examples of fresh water systems in Brevard County are the St. Johns River and Lake Poinsett, and the Sebastian River.

The methods used to dissenfinate and acquire information in all six counties included:

- developing educational materials and teaching environmentally sound landscape management techniques to homeowners.
- FYN handbooks - "A Guide to Environmentally Friendly Landscaping" were provided to all of our clients completing the pre-surveys.
- About 83 0 public workshops were conducted for over 10,000 persons.
- Thirteen demonstration landscapes were designed and installed to highlight the key principles and practices.
- Educational displays were used to educate the public at community activities.

On-site evaluations of properties were used to identify yards that had successfully incorporated these principles into their design. After the evaluation, approved yards were designated as "Certified Florida Yards" and each participant received an 8-inch x 12-inch aluminum yard sign. Florida Yard Advisor Volunteers spent 500 hours performing yard certifications after receiving additional training through the Master Gardener program.

Pre- and post-evaluations for 404 respondents revealed that participants increased adoption of efficient watering, fertilizing and the overall FYN landscape practices, such as Integrated Pest Management (IPM). IPM is the method of scouting and recording beneficial and harmful insects in the garden based on indicator plants, then judging the necessity of spraying based on population dynamics. IPM also encourages the use of biorational sprays (earth-friendly) first, then submits to the use of more harsh chemicals when nothing else will control the problem.

Findings indicated that more than 25% of the homeowners surveyed used some type of commercial lawn service. Many homeowners reflected that they asked for professional advice from the commercial maintenance personnel. This indicates that we have a large portion of our targeted audience that will only make practice changes in their landscape, based on the advice and practices of the commercial lawnservice personnel maintaining their yards.

The results demonstrated FYN practices can reduce nonpoint source pollution from residential property owners. Quantifying amounts of fertilizer and pesticide reduction is difficult, one reason is because some participants were already using minor amounts of pollutant-producing products before the education program began. Concluding remarks from participants indicate this program costs no more to practice than conventional landscaping.

This is the homeowner's opportunity to do something to help the environment and receive recognition when a "Florida Certified Yard" sign is placed in their landscape. The sign makes their neighbors cognizant of good landscaping examples, and encourages them to become participants. Participants are enticed to create a micro environment in their landscapes that attracts wild life. This cumulative approach to building wildlife habitat is needed in urban areas where large uninterrupted tracts of wild lands are scarce.

Recently, the University of Florida has hired a state-wide coordinator to continue the education of homeowners across the State. A new grant-funded education program began on December 15, 1997 along the six counties adjoining the IRL. This next phase of the program will teach the commercial land care professionals methods to reduce pollutants through their professional practices.

NOTES

ORLANDO LAKES/ STORMWATER PUBLIC AWARENESS PROGRAM

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The City of Orlando includes public awareness as an environmental function of the Stormwater Utility Bureau. Though just recently required by N.P.D.E.S., public awareness has been routine for Orlando for several years. The public can be willing to play a role in reducing the pollution entering the lakes. Environmental education of the citizens can be an integral part of stormwater and lake management. Several methods of public awareness have been developed for students, citizens, neighborhood associations, and Civic Clubs.

The major efforts include residential and business brochures and storm drain signs. Two to three brochures are developed each year and are included in the almost 90,000 electric and water customer bills. Business-specific brochures can be mailed on an individual basis or grouped together using standard industry codes. Over 3,000 storm drain signs have been installed by volunteers, with thousands more to come. These signs read "No Dumping! Drains To Lake!".

Other beneficial methods include exhibits/displays at events, speaker presentations and newsletter articles. The Stormwater Utility displays related information at over 50 events per year. These events include community fairs, district picnics, and Earth Day. Several qualified staff make presentations to classes, neighborhood association meetings, and civic club meetings. "Canned" newsletter articles are given to groups and associations.

In most cases, the message is about what individuals can do to help reduce the amount of pollution entering the stormsewers and lakes. Good housekeeping "Do's and Don'ts" are pointed out, and the public is asked to change their habits to be more environmentally friendly.

NOTES

CAPS (COMMUNITY ADVISORY PANELS): HEAD PROTECTION AND A PRO-ACTIVE TOOL FOR MANAGING FLORIDA WATERS

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Aside from representing objects worn on one's head for protection against the elements, the term "CAP" is also an acronym for *Community Advisory Panel.* A Community Advisory Panel is a group of people, consisting of representatives from the community in the broadest sense, that meets on a regular basis to review and discuss issues that panel members deem important. Such groups include individuals from a full spectrum of constituencies, interests, cultures, genders, socioeconomic groups, businesses, etc.

During my 17 years spent in the great state of Texas, I was fortunate to have had the opportunity to serve on CAPs for two separate petro-chemical companies -- Union Carbide in the tiny coastal fishing village of Seadriik Texas and DuPont in Victoria, Texas.

Now I'm back in my home state and serving as an information specialist for the Florida LAKEWATCH program. And although I've been reintroduced to Florida's water management challenges for only a brief time, I cant help but think that Community Advisory Panels could help enormously in bridging the gap between water managers and communities. (It didnt take long to see that citizen involvement in managing our aquatic resources often amounts to complaints at public hearings and/or to the media after a management plan has been formulated and adopted by resource managers.)

With continued population growth and development in Florida involving a broad spectrum of cultural influences, demands on our resources, and widely differing public opinion, the need for more CAPs becomes increasingly apparent.

The purpose of this abstract is to introduce and/or reinforce the concept of CAPs to those in charge of managing Florida's aquatic resources, to provide first-hand anecdotal information earned from serving on CAPs (the successes and the pitfalls), to describe the anatomy of a CAP, and to make recommendations to those interested in organizing CAPs.

While this paper is not the more traditional scientific abstract, I have made note of my methods and approach to preparing this presentation and they include:

- sitting in a comfortable armchair and reflecting on personal experiences and lessons learned while serving on CAPs;
- identifying parallels between CAPs in the petro-chemical industry and Florida's water management industry;
- digging out my CAPs file to search for clues on how to compose this presentation; and
- picking up the phone to speak with a few experts.

These efforts resulted in the following summarization of observations and ideas:

- The anatomy of a CAP consists of four basic elements: CAP participants/members, a neutral facilitator to run the meetings, water management and/or regulatory representatives, and by-laws composed by panel members.

- CAPs are an excellent way of initiating dialogue between regulatory agencies and the public.
- CAPs can bring even the most adversarial positions to the table for discussion.
- aCAPs can provide management with public concerns/questions they never would have dreamed of on the
- CAPs can be effective tools for communicating with the media/general public.
- CAPs can help to ease tensions that have resulted from recent public demands for increased accountability by industry, governmental and regulatory agencies.
- There are a few common sense strategies that were found to be effective for organizing and conducting CAP meetings.
- CAPs exist in Florida's water management arena and have proven to be effective.

Based on this research, the following recommendations can be made to individuals interested in organizing a CAP:

- Study examples of other CAPs. How they work under specific conditions.
- Ask yourself "who is my neighbor?" Create a map of constituencies.
- Ask yourself "how can I organize these groups in a meaningful way?"
- Ask yourself "how do I put something together that will build support?"
- Do an inventory of any legislative parameters/roadblocks to the process.
- Take a good hard took at your nominees for the CAP. Did you choose representatives from the broadest scope possible? Did you leave someone or some group out of your panel? Why? (Take a truth potion before you answer these questions.)

We know that Florida's aquatic resources carry different values for different people. A reminder of this every now and then can certainly help the communications process; CAPs can provide the opportunity. Based on first-hand experience, I am an enthusiastic fan of Community Advisory Panels. I have seen how effective they can be at bringing folks from all walks of life together to discuss and develop management strategies that embrace the interests of many.

Such a process allows everyone to buy into solutions to problems as well as bask in the glow of success.

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Kathy Hunt - Community Affairs; Union Carbide Seadrift; Seadrift, TX
Francis Lynn - University of North Carolina; Chapel Hill, NC
Harold Suire - Education Research Institute (ERI); Baton Rouge, LA
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NOTES

PONTOON CLASSROOM PROJECT

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Purpose, Scope and Objective . Many people grow up taking a plentiful supply of clean and safe water for granted. The Pontoon Classroom is a project designed to increase awareness of water resources, water treatment, conservation, public health and environmental stewardship among students at local schools. This day long field trip allows students to leave the traditional classroom behind and visit a watershed, reservoir, treatment plant and laboratory. It affords them the opportunity to interact with water professionals in each of these areas, and to learn first hand how such conditions or actions as pollution, land management, and recreation may positively or negatively impact the quality of drinking water in their community. Hands-on activities are structured so that learning takes place in a fun and exciting atmosphere.

Approach. Spartanburg Water System (SWS) approached the school districts of Spartanburg County with the idea in 1995. Each school district was asked if there was interest in such a program, and to provide ideas and expectations. which each would like to see incorporated. Spartanburg Water System compiled this input and, applying the filter of physical and economic practicality, devised the framework of the program.

Students are divided into small groups and placed on pontoon boats with teachers and Spartanburg Water System personnel for a guided tour of one of Spartanburg's reservoirs, a recreational lake, and the accessible portions of its watershed. SWS personnel point out significant landmarks and examples of activities that may have either a positive or negative impact on source water quality. Students are exposed to information on a variety of subjects including water safety, water quality, source water protection, and reservoir management practices. They are allowed to participate in field sampling and testing for several basic water quality parameters, and the significance of each is explained.

Students are then taken on a tour of one of Spartanburg Water System's dams, the main water treatment plant and the water quality laboratory. SWS personnel give a guided tour of the water treatment plant, describe the processes used and the reasons for them, and perform demonstrations of various water treatment processes. The students are led and encouraged to explore, through questions and answers, the connections between what they have learned about reservoir management practices and the treatment process.

In the laboratory, students see some of the many analyses that are required to assure that they, as customers, receive clean and safe drinking water. They have the opportunity to examine some of the many organisms that inhabit the reservoir lakes, and to learn how each is handled during treatment. Students are taught how regulations come about and why compliance is important, and they are encouraged to examine their own roles in assuring a continuing supply of safe drinking water.

Findings and Results. The Pontoon Classroom program takes students from the traditional classroom setting, places them in a beautiful outdoor environment, and provides them with vital information about a precious natural resource by disguising learning as fun Students learn something of the interconnection between their everyday activities, economic development, natural resource management, science, public health, and other factors. The relaxed setting and hands-on participation seem to stimulate genuine interest. The Pontoon Classroom is both well attended and well received by students and teachers.

NOTES

THE RESTORATION OF LAKE APOPKA, FLORIDA

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Lake Apopka is a large (125 km^2), shallow (mean depth = 1.6 m) lake in central Florida made hypereutrophic by 50 years of agricultural stormwater discharges from farms on over 70 km? of drained littoral marshes. Lake Apopka was originally dominated by submersed macrophytes, with attendant clear water and abundant gamefish. Since the late 1940s, the lake has been characterized by high nutrient levels, high turbidity caused by algae and resuspended sediments, and almost no remaining submersed or emergent macrophytic vegetation. Mean values for water quality indicator variables for the period 1987-1997 include TP 0.203 mg P l^{-1}, TN 5.12 mg N l^{-1}, chlorophyll a 0.092 mg l^{-1}, TSS 79 mg l^{-1}, and Secchi depth 0.23 m.

The restoration program at Lake Apopka includes: (1) drastic reduction in P loading from the watershed; (2) removal of nutrients and resuspended sediments in a 1375-ha treatment wetland; (3) mass removal of gizzard shad to remove nutrients and to improve food web structure (biomanipulation); and (4) restoration of littoral zone habitat through planting. This restoration plan was developed through numerous diagnostic and feasibility studies conducted by the SJRWMD and collaborators. Furthermore, this plan is supported by work in Europe and elsewhere which describes the existence of multiple stable and quasi-stable states in shallow, eutrophic lakes.

According to Scheffer (1990) and others, shallow lakes may exist in three conditions determined by nutrient loading: (1) Low P loading gives a stable, macrophyte-dominated, clearwater condition; (2) High P loading results in a stable, phytoplankton-dominated, turbid condition; and (3) Intermediate P loading results in a condition with two alternate quasi-stable states. In this third condition, the lake may be dominated by either macrophytes or algae, and the state may shift in response to climactic or biological disturbance. A change in state from a stable, phytoplankton-dominated, turbid condition to a stable, macrophyte-dominated, clear condition requires a decline in P loading to below the level where both states are possible. Furthermore, fish biomanipulation or re-establishment of desirable plants may aid the restoration process.

Case studies show that an improvement in lake trophic condition often is obtained when a significant reduction in P loading is Affected. This is true even in shallow lakes with P-rich sediments, although internal loading may slow the initial response of shallow lakes (Sas, 1989).

Reduction in P loading to Lake Apopka is the cornerstone of the restoration program. Reduced P availability will lower algal biomass and decrease the rate of accumulation of new flocculent sediments derived from algae. Underwater light conditions will improve due to lower levels of both algae and resuspended sediments. More light will allow submersed and floating-leafed plants to recolonize shallow areas. Macrophyte growth will close an important positive feedback loop; aquatic plants will compete with algae for nutrients and will dampen wind-driven resuspension of sediments. Further improvement in light conditions will allow plant colonization to greater depths.

Phosphorus loading to Lake Apopka (ca. 0.6 g P m^{-2} yr^{-1}) during at least the last 40 years has been elevated five to seven-fold compared to historic levels. The target TP concentration established for Lake Apopka is 0.055 mg l^{-1} which will require a decrease in P loading to 0. 13 g P m^{-2} yr^{-1}. Phosphorus loading will be reduced to this goal through the on-going purchase of almost 73 km^2 riparian farms and restoration of these areas to aquatic habitat. Any remaining agriculture will have to meet strict loading limits. Biogeochemical processes in the sediments of Lake Apopka will limit internal P loading when external loading has been controlled. Despite the high loading of dissolved P to Lake Apopka for decades, about 80% of the P in surficial sediments already is found in mineral or resistant organic forms (Reddy and Graetz, 1991).

Light absorption in Lake Apopka is due to both algae and resuspended sediments derived from algae. Extinction coefficient data (Schelske et al., 1995) can be used to predict the effect on underwater light of a decline in algal chlorophyll to the restoration target (0.025-0.030 mg l^{-1}). The area of lake bottom where light levels should support plant growth will increase from only about 3% at present to 30-80%, depending on assumptions about the compensation point for particular plant taxa.

In summer 1995, trophic indicators (TP, TN, TSS, Secchi depth, Chl) in Lake Apopka significantly improved based on a I 10-year data set. These changes were consistent with modest reductions in P loading achieved since 1993 through regulatory actions. Recently, patches of submersed vegetation (e.g., *Vallisneria, Chara)* have re-established naturally at more than 20 sites around the lake. This improvement in water quality likely will not be permanent, since higher farm loading typically will occur until final discharge limits are met. However, the improved condition demonstrates that the lakewater concentration of P will fall following load reduction. With lower P levels, beneficial biological changes such as lowered algal biomass and increased growth of macrophytes will occur.

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NOTES

HISTORIC NUTRIENT ENRICHMENT OF LAKE APOPKA: EVIDENCE FROM PALEOLIMNOLOGICAL INVESTIGATIONS

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Lake Apopka, a 125-km^2 hypereutrophic lake, is of limnological interest because the primary producer community shifted abruptly in 1947 from a macrophyte-dominated system to a phytoplankton-dominated system. As a result of this shift, it was hypothesized that recent sediments produced during the phytoplankton phase are more flocculent than the underlying sediments produced during the macrophyte phase. Sediment studies were undertaken in 1996 under contract with the St. Johns River Water Management District with four major objectives: (1) to characterize and determine the origins of flocculent and consolidated sediment layers; (2) to quantify lake-basin storage of sediments and phosphorus during the planktonic phase; (3) to investigate causes for the abrupt shift in the primary producer community; and (4) to estimate lake-basin deposition of dry mass, organic matter, and total phosphorus.

Methods. More than 50 sediment cores were collected, sectioned, and analyzed. Eight cores were ^{21O}Pb-dated to establish the chronology of nutrient and sediment deposition. An additional 46 cores were collected on an equal area grid to determine spatial variability and to equally weight data used to calculate sediment and nutrient deposition. Dry mass, organic matter (OM), total phosphorus (TP), and non-apatite inorganic phosphorus (NAIP) sedimentation rates were calculated for the lake basin from data collected. In addition, data on fraction dry weight, total carbon (TC), total nitrogen JN), and the TC/TN ratio were obtained for all cores and data on biogenic silica (BSi), and diatom microfossils were obtained for some cores.

Characterizing Sediments. Several stratigraphic markers were used to infer the change from macrophyte to phytoplankton dominance. The ratio of TC/TN, fraction dry weight, and TP concentration provided stratigraphic evidence that flocculent sediments were by-products of autotrophic metabolism during the recent 50-year period of phytoplankton dominance. These variables were used to establish the thickness of flocculent sediments. Thickness varied greatly and ranged from 1-136 cm along the 46 survey cores. That highly organic flocculent sediments were produced from planktonic production was verified with additional analyses, including chemical measurement of BSi and analysis of diatom microfossils in ^{210}Pb-dated cores.

Calculating Sediment Storage. Inventories (storage) of mass, organic matter, TP, and NAIP at each survey station were calculated based on flocculent sediment thickness. Storage of sediment mass and TP varied markedly among stations. This variability can be illustrated by noting that <5% of the total storage of TP was found in flocculent sediments at the 10 stations with the lowest storage, and that 63% of the TP storage was found at 15 stations with the highest storage. Variability in sediment deposition over the lake basin is attributed to the dynamics of sedimentation that resuspend and focus sediments at high sedimentation sites. Such stations are characterized as depositional sites which preserve the paleolimnological record and can be used to infer historical conditions in the lake. Stations with low sedimentation were in the central part of the lake where effects of win action on sediment dynamics are greatest.

Establishing Environmental Causes. Increased phytoplankton production is expected as a consequence of increased historic phosphorus loading. In the last 50 years, dry mass and TP sedimentation rates approximately tripled and quadrupled, respectively. Several other independent indicators point to historic nutrient enrichment of Lake Apopka. An increase in TP concentration in cores and a concomitant increase in polyphosphate stored in algal cells (Kenney this session) indicate that phosphorus loading has increased at a rate greater than that required to support the present high standing crop of phytoplankton. Changes in species composition of diatom microfossils and planktonic/benthic (P/B) ratios of diatom microfossils also were used to infer increased TP loading, increasing phytoplankton standing crops, and decreased water transparency (Schelske et al., in press). All of these indicators are consistent with the hypothesis that Lake Apopka became hypereutrophic in the 1940s as the result of increased phosphorus loading.

Estimating Lake Basin Sedimentation. The whole-basin inventory of dry mass in flocculent sediments was 2.21 x 10^9 kg (2,210,000 metric tons). These sediments are highly organic, averaging 63% organic matter measured as loss on ignition (LOI); therefore, sediment storage is determined largely by organic matter. Because sediments are highly organic, a 2.1-fold increase in dry mass sedimentation since approximately 1947 can be attributed to an increase in organic matter produced by phytoplankton. The whole-basin inventory of TP in flocculent sediments was 2.55 x 10^6 kg (2,250 metric tons). This inventory, which accumulated in approximately 50 years, is 54 times larger than the present inventory of TP in the water column. Average TP storage for the 50-year period of phytoplankton dominance was 45,000 kg yr^{-1}. These data indicate that residence time of phosphorus in the water column is short, on the order of one year. An average rate of TP storage under-estimates recent rates of TP sedimentation which have increased historically. Rates of deposition were 61.6% larger than the average in the most recent 10 years and about 50% smaller during the first 10 years of phytoplankton dominance if the annual rate of TP accumulation increased 4-fold during the 50-year period of phytoplankton dominance. These data show that the sediments are a significant sink for the phosphorus.

Conclusions. Sediments have been a significant sink for anthropogenic phosphorus loading since 1947 when phytoplankton became the dominant primary producer. Sedimentation is highly variable over the lake basin, with more than 60% of the TP storage in 33% of the basin.

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NOTES

TRENDS IN THE FISH POPULATION OF LAKE APOPKA

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The environmental degradation of Lake Apopka (12,400 ha) is well known. The impact of this degradation, in causing declines in the sport fishery of Lake Apopka, has also been documented. Principal point sources of nutrient loading to the lake were eliminated between 1977 and 1980, and agricultural discharges from farming operations have been reduced since 1992. The St. Johns River Water Management District, under the S.W.I.M. program, has begun management efforts to correct the problems in Lake Apopka. Previous studies by the Florida Game and Fresh Water Fish Commission documented fish population trends and provided baseline data prior to the commencement of most management activities; however, a need existed to update the status of the fish population of Lake Apopka to provide the most current data.

In 1997, the St. Johns River Water Management District provided funding to the Florida Game and Fresh Water Fish Commission to assess the fish population of Lake Apopka. Littoral fish populations were evaluated by 0.1 -hectare blocknet samples (N = 16), and data were proportioned by major habitat types (open/brush shoreline, 44%; cattails (*Typha spp*.), 38%; bulrush (*Scirpus californicus*), 5%; and grasses (*Paspalum sp*. and *Panicum spp*.), 3%). Littoral sport fish species were also evaluated by bimonthly electrofishing samples (N = 30 per sample month). Fall trawl samples were taken (N = 50) to assess limnetic black crappie (*Pomoxis nigromaculatus*) and catfish populations, and experimental gill nets (N = 30) were fished January, March and M4y 997 to evaluate limnetic gizzard shad (*Dorosoma cepedianum*) populations.

Blocknet samples taken in the littoral zone of Lake Apopka in 1997 resulted in a mean fish biomass of 113.6 kg/ha (data were proportioned by habitat type). Six species composed 78% of the fish biomass: bluegill (*Lepomis macrochirus*) (27.7%), black crappie (22.4%), redear sunfish (*Lepomis microlophus*) (8.9%), warmouth (*Lepomis gulosus*) (7.3%), Florida gar (*Lepisosteus platyrhincus*) (5.7%), and blue tilapia (*Tilapia aurea*) (5.5%). The proportioned mean biomass of the 1989-1991 sample period was 226.7 kg/ha. A decrease in blue tilapia mean biomass from 61.3 kg/ha (27%) in 1989-1991 to 6.2 kg/ha in 1997 contributed the largest proportion of the change. The mean biomass of dominant sport fish collected in 1997 was 37% less for black crappie (25.4 kg/ha) when compared to 1989-1991 (40.2 kg/ha), while no difference was found for bluegill and redear sunfish.

Small bluegill and threadfin shad dominated fish numbers in the littoral samples. Numbers of harvestable-size sport fish in littoral samples were dominated by black crappie (53/ha≥24 cm total length (TL)), bluegill (52/ha ≥ 16 cm TL), and redear sunfish (20/ha 2≥16 cm. TL). Numbers of these harvestable-size species were at least 49% lower when compared to values from 1989-1991 for black crappie (12 1 / ha), bluegill (I 24/ha), and redear sunfish (76/ha). The number of bluegill and redear sunfish less than 16 cm TL was greater in 1997.

Largemouth bass *(Micropterus salmoides)* composed 16.5 kg/ha (7.3%) of the proportioned mean littoral biomass in 1989-1991 blocknet samples and 6.2 kg/ha (5.4%) in 1997 samples, a 62% reduction. Mean numbers of largemouth bass, proportioned by habitat type, in 1997 were: 12/ha for total bass, 2/ha for young-of-the-year bass, 9/ha for bass $\geq$ 26 cm TL, and 1/ha for bass $\geq$ 36 cm TL. These values were lower compared to 1989-1991 data of 20/ha for total largemouth bass, 6/ha for young-of the-year bass, 15/ha for bass $\geq$ 26 cm TL, and 9/ha for bass $\geq$36 cm TL. The average electrofishing catch rate for largemouth bass 24 cm TL in 1997 (0.2/5 min) was also substantially lower compared to annual average values from 1989-1992 (range = 0.4-0.5/5 min).

Large differences were noted when littoral blocknet data were compared by habitat type. Total fish biomass in 1997 averaged 65.6 kg/ha in sites devoid of all vegetation, 132.3 kg/ha in cattails, 327.2 kg/ha in bulrush, and 676.8 kg/ha in grass sites. Biomass of sport fish followed a similar trend among habitats. Black crappie ranged from an average biomass of 14.9 kg/ha in open areas to 202.5 kg/ha in grass sites; largemouth bass ranged from 1.0 kg/ha in open areas to 56.0 kg/ha in grass sites; bluegill ranged from 15.6 kg/ha in open areas to 224.6 kg/ha in grass sites; and redear sunfish ranged from 6.8 kg/ha in open areas to 27.5 kg/ha in grass sites.

Trawl catches in the limnetic area of Lake Apopka were dominated by black crappie, white catfish *(Ameiurus catus)*, bluegill, and brown bullhead catfish *(Ameiurus nebulosus)*. Catch per trawl for total black crappie (14.5/trawl) in 1997 was the lowest compared to samples taken in 1992 (22.9/trawl) and 1993 (28.4/trawl), while the 1997 average value for black crappie $\geq$ 24 cm TL (0.5/trawl) was intermediate among years. Low catch rates for total black crappie were attributed to a weak 1997 year class (crappie <15 cm TL). White catfish catch increased from 1.9/trawl in 1992, to 6.4/trawl in 1993, to 12.0/trawl in 1997; surpassing values for brown bullhead catfish (7.7/trawl). Although 99% of the bluegill were less than 16 cm TL (modal TL = 10 cm), catch rates increased from 0.5/trawl in 1992, to 2.6/trawl in 1993, to I 1.0/trawl in 1997.

Experimental gill nets samples taken in 1997 produced catches of gizzard shad which composed 94% by number and 90% by weight of the total catch. The average catch rate of gizzard shad (25/hr) in 1997 was lower than any year sampled from 1989-1992 (range = 42-67/br). The modal size of 28 cm TL was 3 cm smaller than any year from 1989-1992 (modal range = 31-38 cm TL). Low catch rates and reduced size of gizzard shad collected in experimental gill nets suggested a substantial impact has occurred on the population from commercial gizzard shad harvest in Lake Apopka.

When compared to blocknet samples taken from 1989-1991, average total biomass and numbers of harvestable-size sport fish were lower or unchanged in 1997 samples. All parameters used to measure the largemouth bass population were lower in 1997. Although bluegill and redear sunfish populations were dominated by small size classes (as in the past), total numbers were increased in samples taken in both littoral blocknets and limnetic areas. A weak year class of black crappie was produced in 1997 which contributed to lower average total numbers sampled by blocknet and trawl. The average number of black crappie $\geq$ 24 cm TL collected in trawl samples was similar to past data. Although rooted aquatic vegetation constitutes less than I% of the surface area of Lake Apopka, data collected from blocknet samples indicated that expansion of this type of habitat is vital to the sport fish population and to the ultimate goal of restoring the sport fishery of Lake Apopka.

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FLUID MUD, THE MARSH FLOW-WAY
AND THE RESTORATION OF LAKE APOPKA

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The key to the water quality problems in Lake Apopka lies not with excess phosphorus but with a layer of fluid mud (Figure 1) that currently covers 90% of the lake bed to an average depth of 45 cm (18 inches) . Because the lake is so shallow, these particles are regularly resuspended by the daily winds and are a major contributor to the poor water transparency. Unlike the usual lake sediments, this highly organic material lacks structure and has the physical properties of a dense suspension, so it does not provide support for rooted aquatic plants.

The current restoration plan for Lake Apopka is based on principles developed in deep lakes and emphasizes reducing phosphorus inputs. The basic assumptions are that: (1) the water transparency is determined by plankton algae; (2) the algal populations are controlled by phosphorus concentrations; and (3) reducing phosphorus inputs will reduce the total phosphorus concentration in the lake. We found that these assumptions could not be supported in Lake Apopka. The living algae make up only about 10% of the weight of total suspended solids in the water column, so the Secchi disk transparency is less than it would be in other Florida lakes with the same amount of algal chlorophyll (Figure 2). We also found that algal populations are currently not controlled by phosphorus levels based on relationships between chlorophyll and phosphorus developed for other Florida lakes (Figure 3). Phosphorus levels would have to drop by 61 % before phosphorus would become limiting. Like many shallow lakes with phosphorus-rich sediments, phosphorus concentrations are not likely to respond to changes in external inputs of this element. From 1989 to 1993, phosphorus inputs to Lake Apopka dropped by 80%, yet there was no corresponding change in total phosphorus concentration in the lake water (Figure 4). This is undoubtedly a reflection of the phosphorus exchange capacity of the sediment particles. Lastly, even if the proposed nutrient reductions could drop the total phosphorus concentration by 80%, the calculated Secchi disk depth would only increase from the present average of 23 cm (9 inches) to 29 cm (11 inches).

The proposed marsh flow-way will not solve the fluid mud problem. It will remove only about 0.5 % of the TSS each day, an amount far less than can be resuspended by the daily winds, thus there will be no improvement in TSS until the flocculent sediments have been completely removed. Calculations based on the historic rates of sediment accumulation and the projections for the marsh flow-way indicate that it will take over 300 years to remove the fluid mud, and the lake will remain turbid during that time period. The conclusion is that something more than phosphorus controls and the marsh flow-way will be needed to clear the waters, restore the macrophytes, and bring back the largemouth bass in Lake Apopka.

We suggest that the restoration of Lake Apopka should be guided by the experiences of European limnologists who have developed an understanding of how shallow lakes function and have devised a series of techniques for their restoration (Moss et al., 1996).

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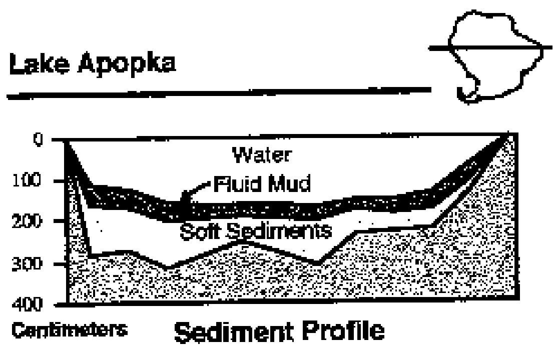

Fig. 1. An east-west section of Lake Apopka showing the fluid mud layer based on measurements made in 1987.

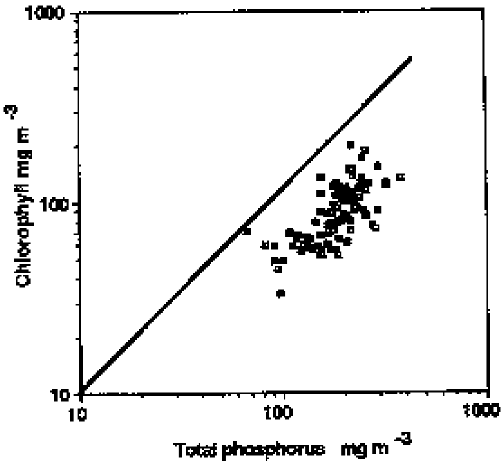

Fig. 2 Monthly measurements of chlorophyll and total phosphorus concentrations in Lake Apopka in 1988 through 1997. Line represents the best-fit regression line for 208 Florida lakes from the Florida Lakewatch program.

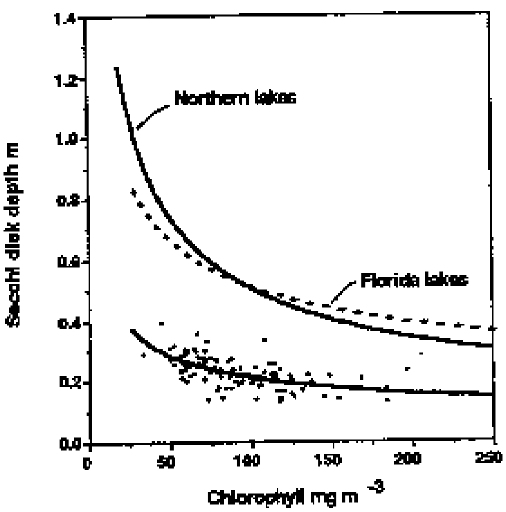

Fig. 3. Secchi disk depths in Lake Apopka at different chlorophyll concentrations in 1988 through 1997. The upper line represents the best fit line for a broad group of lakes from the literature, and the broken line represents the best fit line for Florida lakes with a color value of 34 mg L-1 Pt. The bottom line represents the best fit regression for the Lake Apopka data and has the equation Log SD = 0.152 -0.417Log Chl.

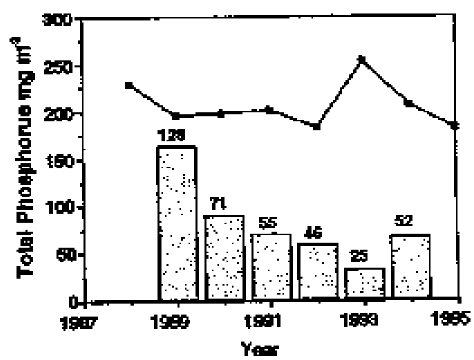

Fig. 4 Average annual total phosphorus concentrations in Lake Apopka. The bars represent the annual total external phosphorus loading in megagrams.

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INTERPRETING HISTORIC LAKE CONDITIONS FROM BIOGENIC MATERIALS AND BIOAVAILABLE PHOSPHORUS IN LAKE APOPKA SEDIMENTS

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Introduction. Lake Apopka is a polymictic, hypereutrophic lake. By 1950, algae replaced macrophytes, creating an open water system with increased wave action. Phosphorus (P) loading has increased significantly since the 1940s, creating a surplus of available P relative to available nitrogen. The sediments of Lake Apopka form two layers which represent the period of macrophyte dominance and the period of open water, algal dominance. I studied a sediment core from Lake Apopka to determine the origins of sediments and to evaluate the changes in P processing associated with increased total P TP loading.

Methods. I collected a sediment/water interface core at a high sedimentation site in Lake Apopka during September 1997. The core was collected at a location with an established sediment chronology. I analyzed 20 samples at 5-cm. intervals from the upper 1 00-cm. of this core for biogenic silica (BSi) and several P fractions. BSi present in diatom valves or sponge spicules was determined through a time course extraction with 1% sodium carbonate. P and Si02 were measured from chemically assayed fractions using autoanalyzers with electronic data acquisition. Solutions used in chemical equilibrations included 18 mega-ohm water (H20-P), nitrilo triacetic acid (NTA-P), and sodium hydroxide (NaOH-P). After measuring H_20-P, samples were autoclaved to determine heat extractable phosphate or polyphosphate (HE-P). TP in sediments was measured after autoclaving samples in sulfinic acid and potassium persulfate. Biologically available P (BAP) was measured by comparing the growth responses of P-limited algal cultures. Cultures were spiked either with one of a series of P standards (orthophosphate, 0 to 40 ppb) or with a sediment sample as the P source. BAP was measured directly through bioassay on six subsamples. A linear model predicting BAP from H20-P ($R^2 = 0.91$, $n = 6$) was applied to the remaining 14 samples from the core to complete the BAP profile. For both biological assay and chemical assays, the maximum allowable relative standard difference (RSD) was 20%, in most cases the RSD was -10%.

Results. The interface between sediment layers was at 60 cm, with 12 samples from the recent sediment layer and eight samples from the older sediment layer. BSi was 3% of dry mass in the older sediments and averaged 5% of dry mass in the recent sediments (range 4-7%). In the older sediment layer, more than 75% of BSi was from the sponge component. Freshwater sponges require substrate (macrophytes) and indicate the relative availability of surface habitat in the water column. In the recent sediment layer, more than 75% of BSi was from the diatom component Although some diatoms require substrate, many do not. An increase in %BSi as diatoms in the recent sediment layer relative to the older sediment layer indicates a decrease in the relative availability of surface habitat and an increase of open water habitat. The accumulation rate for diatom BSi increased 45-fold in the algal sediment layer, comparing pre- 1900 (70 cm) and post- 1975 (40 cm) rates. Since-1975 (40 cm), P accumulating in the sediment decreased from 25% BAP to <1 0% BAP. The decrease in BAP storage is coupled with an increase in HE-P storage from < 0% to 20% of TP The accumulation rate for HE-P (polyphosphate) increased 28-fold in the algal sediment layer, comparing pre- 1900 (70 cm) and post-1975 (40 cm) rates. Comparing the same periods, BAP accumulation increased 4-fold, while TP accumulation increased 15-fold. Therefore, biogenic materials and BAP indicated that two distinct changes have occurred in Lake Apopka: (1) by 1950 (60 cm) the source of sediment material shifted from macrophyte production to algal production; and (2) after 1975 (40 cm) the processing of TP changed as a smaller percentage of TP accumulated as BAP and a larger percentage accumulated as polyphosphate.

Discussion. The second finding indicates that classic geochernical models for sediment/water P interactions do not accurately describe the Lake Apopka system. Intact algae in the sediment effectively sequester P as intracellular reserves. These reserves are available to the cell, but are apparently geochernically inert and are not BAR Classically, organic matter decomposes in the sediment. Subsequently, mineralized P is precipitated with cations or sorbed on charged surfaces until conditions allow return to the water column via diffusion from sediments. These concepts were applied to chemical assays and depending on prevailing chemical conditions, either NaOH-P or NTA-P has been used as a proxy for BAP (Williams et al., 1980; Golterman et al., 1977). If organic matter in the sediment is not decomposed under normal sediment conditions, NaOH can release organic-bound and biogenic P which is not BAR In Lake Apopka, algal cells maintain cellular integrity in the sediment. HE-P in the sedimented algae was not measured as BAP by bioassays, but was measured by the NaOH-P extraction. The role of polyphosphates (HE-P) sequestered in sedimented algae may have important implications for lake management. In shallow lakes, high nutrient loading dictates a shift from macrophyte dominance to algal dominance (Scheffer et al., 1993). Returning nutrient-enriched shallow lakes to stable macrophyte dominance is a possible management goal. Algal polyphosphate synthesis can rapidly sequester BAP from the water column. If these algae are sedimented and remain intact, BAP is removed from the system indefinitely. Algal polyphosphate synthesis and subsequent burial of intact algae is a natural process of sequestering P that minimizes internal cycling of P.

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NOTES

MUCK FARM RESTORATION AT LAKE APOPKA: MANAGEMENT OF POTENTIAL RISKS FROM PESTICIDE RESIDUES

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Which scenario really is best for the Lake Apopka ecosystem - fanning the muck soils of the north side of the lake or restoring the area to wetlands? This question may be obscured by concern about the potential for the pesticide residues contained in those soils to negatively affect the wetland ecosystem that will develop there after the lands are reflooded. The St. Johns River Water Management District (SJRWMD) is taking an appropriate and prudent path for the management of the natural resources of the Lake Apopka ecosystem by evaluating and managing potential risks to the environment while restoring the muck farms to wetlands .

Farmed soils throughout the world carry the residues of the last half-century of chemical management of agricultural pests. The soils of the muck farms on the north side of Lake Apopka are no different than most in this regard. What is different about these soils is that they are being returned to their original status as wetland sediments. This fact has attracted considerable attention, concern, and fear. Soils that are considered clean enough to grow table vegetables for a considerable portion of the American population, soils that are considered safe enough to be worked daily by farmers, soils that when flooded by the farmers as part of their pest management procedures are considered safe for migratory shorebirds; and soils that are farmed without concern in a rapidly growing metropolitan area, are now the focus of intense scrutiny concerning their worthiness as sediments in a restored wetland.

The farmland conditions described above will no longer exist after wetlands are recreated on the site. Humans will no longer be directly exposed to the soils. No additional pesticides will be added to them or the surrounding environment. The contaminated soils will become sediments, and environmental conditions most favorable to the breakdown of pesticide residues will develop within the sediments. As aquatic vegetation grows in the wetland and falls to the sediment surface, these new and uncontaminated materials will bury and dilute the old. Slowly, the pesticide residues will degrade, and will be buried deeper and deeper in new sediments. Finally, they will be removed from the soil surface zone, no longer in contact with the life above.

In 1997, the United States Department of Agriculture (USDA) requested that the SJRWMD undertake an Environmental Risk Assessment to evaluate the potential for risk to the wetlands that are envisioned east of the Apopka-Beauclair Canal. Risk Assessments are usually performed for a contaminated site within a larger ecosystem at risk from the site in question.

Contaminants have most often been dumped, either accidentally or illegally. At Lake Apopka, by contrast, the pesticide residues are the result of the legal application of pesticides as part of appropriate fanning practices. The Risk Assessment performed at Lake Apopka was unique in being prospective as the wetlands of the north shore were eliminated almost one-half century ago.

The Risk Assessment found that only one set of chemical residues, DDT and its breakdown products, was present in sufficient concentrations to potentially create risk. That potential risk was to top predators (the blue heron was the example organism) if the predator were eating only the largest and most contaminated fish. "Natural Attenuation" was recommended as the appropriate method to eliminate the pesticide residues. In essence, this means allowing a marsh to develop, and monitoring the system to ensure that the conditions in the marsh and marsh sediments will protect the biological community from the potential harm, and over time eliminate the potential risk.

The St. Johns River Water Management District (SJRWMD) has been aware of these chemical soil constituents and has been concerned over their potential since the first discussions of farm purchases for the development of the Marsh Flow-Way Demonstration Project began in 1988. The SJRWMD has confirmed the fact that pesticide residues are not transported in the water. We have tested the new sediments that developed in the flow-way test cell and found them free of pesticide residues. We have tested the fish found after almost seven years of demonstration project operation, and found that the constituents of most concern, DDT and DDT breakdown products, were present at only the lowest levels in fish flesh.

The District will continue to refer to the services of environmental toxicologists during the restoration. A group of environmental toxicologists and related specialists will recommend monitoring procedures for the site. Environmental toxicologists will analyze and interpret monitoring data for SJRWMD.

Restoring Lake Apopka is a prodigious undertaking and, like most ambitious projects, is not without risk. We have assessed, and continue to assess, those risks and are taking the necessary steps to reduce them. If we find problems, we will identify and implement the best solution or solutions. We are concerned - concerned that we rebuild a healthy functioning ecosystem. That has been, and will continue to be, our goal. Returning the Lake Apopka muck farms to wetlands is part of the program to reach that goal.

NOTES

THE ADOPT-A-POND PROGRAM

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The purpose of the Adopt-A-Pond Program is to reduce nonpoint source pollution and improve the water quality treatment function of urban stormwater ponds using public-private partnerships between Hillsborough County and residents who live on or near stormwater ponds. This presentation will discuss the basic tenets of the Adopt-A-Pond Program as it exists in Hillsborough County today, as well as future applications of the program.

The scope of the Adopt-A-Pond Program is the urban stormwater pond drainage basin, focusing on improving the conditions of ponds through stormwater pollution prevention and neighborhood-based pond maintenance. To be eligible for the program, ponds must be part of the County's municipal separate stormwater sewer system. The objectives of the program are to:

1. Facilitate the formation of neighborhood "pond groups".
2. Provide a one-time clean-up of eligible ponds, including nuisance vegetation and muck removal.
3. Hold educational meetings in pond groups' neighborhoods to discuss: their drainage basin and its outfall; stormwater pollution prevention practices; pond issues such as ownership and easements; and preparation for pond planting days.
4. Provide native aquatic plants which pond groups install during their pond planting events.
5. Distribute quarterly newsletter "On Our Pond".
6. Recognize pond group efforts and successes.
7. Provide water quality testing kits and training to pond groups.
8. Provide pond groups with guidance and information on continued pond maintenance and stormwater pollution prevention practices such as environmentally friendly landscape maintenance.
9. Host an annual pond seminar featuring panel discussions and exhibits.

The Adopt-A-Pond Program is funded through a cooperative funding agreement between Hillsborough County and the Southwest Florida Water Management District (SWFWMD) Basin Boards, and is implemented by the Hillsborough County Stormwater Management Section. Citizens learn about the program through newspaper articles, cable television public access programming, brochures, and newsletters. Citizens interested in the program must complete an application which is reviewed by SWFWMD, the Environmental Protection Commission of Hillsborough County (EPC), and the Hillsborough County Roadway Maintenance Division. Eligible pond groups sign a three-year agreement to care for their pond.

Most groups are interested in the program's one-time free clean-up because their pond is overgrown with nuisance vegetation. Very few of those groups know who owns the pond, where drainage easements exist, what permits exist or who they were issued to, and whether homeowners association by-laws specify pond maintenance responsibilities. The majority of the ponds in the program are privately owned, with easement access dedicated to the County. However, most groups contacting the program believe the County either owns the pond or is responsible for cleaning the pond. Clarifying ownership, easement, and maintenance responsibilities is an important task of the program, and is important to a pond group's on-going pond maintenance. Other information groups learn includes the path of stormwater runoff through neighborhoods; many citizens do not know that storm drains connect to ponds, and that ponds connect to wetlands and other natural areas in their neighborhoods. This information helps groups focus on the "stormwater treatment facility" aspect of the pond, and the importance of their maintenance methods.

Historically, the Adopt-A-Pond Program has successfully partnered with the Roadway Maintenance Division to achieve pond clean-ups. They were already performing that task on County-owned ponds and on some private ponds. The Adopt-A-Pond Program leverages their work by preparing a neighborhood pond group to take over after the initial work is done.

Willingness to work in the pond and self-motivation are key to a pond group's success. It has been difficult to incorporate these elements as part of the eligibility criteria. The telephone interview, through which the pond group requests an application, is extremely important to "weeding out" poor candidates. It is important to downplay the free clean-up at this point, to emphasize the role of the group as pond caretakers, to define the program in terms of pollution prevention, and to talk about the pond as a stormwater treatment facility. The application itself requires signatures to demonstrate "full participation", and defines participation.

The pond group representative is typically the person who initiates contact with the program, and they may be somewhat surprised, even intimidated, to find themselves in a leadership role. There are many ways to support that person's efforts, such providing fliers for work days, encouraging them to delegate tasks to others in the group, helping them define work days goals, and giving out lots of praise.

Inspections of ponds in the program show the majority of groups continue caring for their pond once the clean-up and planting is completed. The program has recently incorporated volunteer water quality testing to measure changes and target problems in the drainage basin. The program newsletter "On Our Pond" receives many compliments, and is available on the Internet. The most recent pond seminar attracted over 450 people. The program has 86 pond groups in various stages of "adoption", and receives applications all year from interested groups. Program development includes hiring a contractor for pond clean-ups, and procuring funding to purchase equipment dedicated to the program for pond clean-ups. These steps are necessary to keep up with citizen demand for the program.

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HILLSBOROUGH LAKE ATLAS PROJECT

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A major problem encountered by a county or city government, in attempting to assist its citizens in lake management, is the paucity of data available for small private lakes. This problem is being solved in Hillsborough County Florida through a program called the Hillsborough Lake Atlas Project. The Project is an innovative approach to the archiving of parametric, geological, historic, oral, and photographic data on an area, s lake resources. The Project incorporates parametric data into Arc/Info and ArcView Geographic Information Systems (GIS) databases. These databases will then be available to all interested users through a userfriendly dedicated Web site and on CD-ROM.

The Lake Atlas is being designed primarily for use by citizens interested in the condition of Hillsborough County lakes. For this reason, a significant effort is being made to incorporate citizen-generated data (volunteer monitor data) and to make the data understandable and relevant to the lay person. In addition, the Atlas will incorporate the level of detail necessary for more technical applications.

The first phase of the project focused on gathering existing data and continued collection of additional data not presently available in established databases. Existing data on Hillsborough County Lakes is collected and maintained by more than seven agencies and institutions. Most of this information is currently inaccessible to the public and difficult for professionals involved in lake management to access. Therefore, the first step in making this data accessible through the Lake Atlas Program was to develop a catalog of available data. This catalog, referred to as a meta-data database, provides vital information on data formats, periods of collection, geographic projections, sampling protocols, and method of acquisition. Once cataloged, data sets can be prioritized for incorporation into the Lake Atlas.

Additional lake data is being collected through lake surveys, which were initiated during this phase for those lakes where no data or only partial data exists. A Differential Global Positioning System (DGPS), capable of sub-meter accuracy, and a survey-quality recording depth finder was used to establish limnological characteristics. The lake surveys include the determination of the abundance of aquatic macrophyte in the emergent, floating-leafed, and submersed zones of the lake and water quality sampling and measurements. All lakes selected for vegetation surveys have active LAKEWATCH volunteer monitoring activities. The data generated by volunteer monitors is used to maintain the water quality database for the lake. Volunteers are also asked to provide "Oral Histories". The Oral History Database will provide important observations to supplement parametric and physical data on lakes.

The second phase of the project, currently in progress, is the integration of data through design and development of a GIS database. Geographic data in Hillsborough County is currently held in different projections and GIS platforms that are incompatible. The project is converting all geographic data into an Arc/Info coverage for use in ArcView. Geographic data sets such as infrared aerial photography, parcel-based land-use, and roads will provide a base-map for the Atlas. Non-geographic data will be incorporated into the Atlas Program converted from agency proprietary databases.

Once the base-data is completed, the Atlas will be published in HTML for use on the Internet and on a CD-ROM. The format will be a multimedia interactive Atlas that will allow users to browse the data in many different formats. Functions will include a Lake Navigator, Guided Tours, Water Quality, Lake History, and Watershed Characteristics. In addition, the Atlas will focus on citizen education in complex topics such as watershed management and lake maintenance.. A mock-up of the Lake Atlas has been developed as part of the project I s second phase. This mock-up will be used throughout the project to refine the database design and evaluate the human factors involved in database use.

The Lake Atlas Project is scheduled for completion in March 1999. A functional database on Hillsborough County Lakes will exist for use on interactive CD-ROM and through a dedicated Web-site at that time. Beta versions of the Atlas will be available for evaluation in December. Data collection and database update and activities are planned to continue for a minimum of four years after the Atlas goes on-line.

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NOTES

HILLSBOROUGH STREAM-WATCH: A COMMUNITY-BASED APPROACH TO WATERSHED MONITORING

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Community-based monitoring partners citizens with government entities to correct a shared problem. The Hillsborough County Stormwater Management Section manages two programs that have elements of community-based monitoring. They are the Adopt-A-Pond Program and the Hillsborough Lake Management Program. This presentation describes a planned extension of these programs to streams and other surface water conveyances and receiving bodies. The project is named Hillsborough Stream-Watch.

The presentation will describe an approach to water and habitat monitoring (community based watershed monitoring) that has been used successfully in many parts of the United States and is now being applied to the Hillsborough River and its tributaries, and some additional selected streams in Hillsborough County. The presentation will introduce the concepts of community-based monitoring and discuss the application of these concepts to multi-parameter data collection by citizen volunteers.

Community-based monitoring is an expansion of traditional volunteer monitoring which had its roots in the original efforts of the Izaac Walton League. The Isaac Walton League was formed in 1922 to "save outdoor America for future generations". One of the League's first activities was the organization of the nation's first national water pollution inventory in 1927. This and other early League activities essentially launched the volunteer monitoring effort in the United States. From this early beginning, volunteer programs have been established in every state and volunteers can be found monitoring water quality in all the nation's major streams and a large number of its other water bodies. The term "community-based monitoring" is recognition of the important role of volunteer citizen groups in support of existing agency monitoring activities. The term is used in the context of the Hillsborough Stream-Watch Project to emphasize the partnership being formed by the County and its citizens to preserve the Hillsborough River Basin. Because a Florida Game and Fresh Water Fish Commission's Environmental Education Grants Program grant funds the project, the partnership also extends to the State of Florida.

A major goal of the program is to demonstrate the efficacy of community-based monitoring and to produce a model program that can be exported to other communities. A key element of the project is the establishment of a regional environmental training center (RETC). The RETC will recruit, train, and assist citizen volunteers in adopting and monitoring stream and watershed segments. The RETC model will allow communities to establish Stream-Watch programs with a minimum of development cost and will allow the standardization of stream monitoring programs throughout Florida. This approach is similar to the successful State of Georgia Adopt-A-Stream program, which has a small college base for this statewide monitoring program.

The project will also demonstrate the proper application of community-based monitoring and watershed restoration methodology to the management of nonpoint source (NPS) pollution problems in a watershed. In accomplishing this, the project will test the thesis that volunteer monitors, properly trained and supported, can play a key role in the collection of physical, chemical, and biological water quality data and that volunteer monitors can be an asset to agencies engaged in water quality data collection.

The Hillsborough Stream-Watch will be administered as a two-level education and citizen volunteer monitoring activity. Level I will involve volunteer training in overall ecosystem monitoring, water quality (turbidity) testing, stream segment adoption, and stream-segment cleanup procedures. A field-training phase will be included to familiarize the volunteer with the stream and the procedures for conducting a habitat survey and turbidity measurement. Level I volunteer activities will involve monthly visits to the adopted stream-segment to conduct habitat surveys and turbidity testing. Level I volunteers will conduct a stream-segment clean-up once during the initial Level I activities period. Level II extends the Level I activities to biological and chemical monitoring of the adopted stream segment. Additionally, Level II volunteers will participate in a stream habitat enhancement project and learn about various methods of stream enhancement.

The project is planned to last 18 months. The final project activity will be a proof of concept demonstration conducted in conjunction with the Hillsborough River Day. During this activity, Stream-Watch volunteers will conduct water quality and stream habitat restoration projects that will be evaluated by field professionals recruited from participating agencies. The proof of concept demonstration is intended to prove the efficacy of community-based watershed monitoring by monitoring a large watershed over a short period of time and producing useful data on the water quality of the total system.

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NOTES

THE FLORIDA HOMESTEAD ASSESSMENT SYSTEM

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The purpose of the Florida Homestead Assessment System (Home-A-Syst) is to give nonfarm rural and suburban residents who have wells and/or septic systems a way to identify potential pollution risks to the groundwater that supplies the wells. Home-A-Syst, which is voluntary and free, also offers information on how to correct identified risks. According to the 1990 U.S. Census, 1,967,481 of Florida's 12,937,926 residents lived in rural areas. Of these 1,920,045 (98 percent) residents more than likely get their drinking water from their own wells and have septic systems to treat wastewater. While these rural residents individually may not contribute significantly to groundwater contamination, collectively their sheer numbers may pose significant pollutant loading to groundwater. This may be especially true when the density of houses in an area exceeds one per five acres. Soil and shallow water tables in some parts of the state are such that septic systems may contribute to nitrate contamination of ground and surface waters. Casual disposal of household wastes such as used motor oil, cleaning solvents, surplus paints and pesticides can also pose risks to drinking-water supplies.

The objectives of Florida Home-A-Syst were to develop educational materials that provide rural non-farm residents with: (1) self-assessments to identify pollution risks associated with homestead activities and products; and (2) information on corrective actions that can reduce these risks. The Florida and the National Fann-A-Syst/Home-A-Syst Office's "generic" Home-A-Syst book was adapted to prepare materials relevant to Florida. Florida Cooperative Extension Service agents, who are the primary disseminators of Home-A-Syst statewide, received training, the Home-A-Syst books, educational videos, training storyboards, evaluation tools and promotional materials such as news releases and camera-ready brochures in summer 1997.

Volunteer UF/IFAS extension agents and specialists revised the 11 Home-A-Syst chapters. Experts performed technical reviews of the chapters. Relevant text and graphics from the UF/IFAS Florida Yards and Neighborhoods Handbook were incorporated in the chapters. Program evaluation experts assisted with preparation of the pre-assessment, follow-up and general surveys. The latter appears in the Home-A-Syst book; the former two are for extension-agent use with the target audience.

Florida Home-A-Syst has proven to be immensely popular among extension agents and well received by the target audience. Last fall we printed 5,000 more books because we ran out of the first 5,000 that our Section 319 grant funded. The reasons for the program's popularity may be related to the fact that water quality is a hot topic in Florida, many residents moved here from other states are very interested in learning more about their adopted state, and the materials fit nicely with the Master Gardener, Florida Yards and Neighborhood, Environmental Landscape Management, LAKEWATCH and Master Wildlife Conservationist extension programs. Five anonymous surveys have been returned. Of these, two respondents said they made changes and five said they would recommend the program to other nonfarm suburban and rural residents. Because the materials were distributed to county extension offices last summer and fall and some counties are just beginning to promote the program, it is too soon for users to be completing the Horne-A-Syst self-assessments and returning the surveys.

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NOTES

THE ALLEN'S CREEK WILDLIFE MONITORING PROJECT AT LAKEVIEW ROAD AND HERCULES AVENUE

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The project was designed to collect data on mammals, amphibians, reptiles, fish, birds and plants that use the project site before and after restoration of an environmentally and hydrologically disturbed system in a section of Allen's Creek. Site disturbances include encroaching urbanization, borrow pits from past peat mining activities, and high water flows causing flooding and excessive erosion. The Allen's Creek watershed is approximately 4800 acres and is located in urban central Pinellas County. The 25-acre project site is surrounded by residential development and two public schools.

Small mammal utilization is monitored twice a year (April and June) using six sand tracking stations. Three of the sand track stations are monitored by Plumb Elementary students during the rest of the school year. Reptile and amphibian use are monitored three times a year (April, June and October) by County staff using drift fences at two stations. Plumb Elementary students monitor one drift fence during the other months of the year. One drift fence is not monitored by elementary students for safety reasons. During the month of March, Clearwater Audubon Society members and County staff survey the project site for birds. Fish species are monitored annually using seines. The project site is also surveyed annually for plant diversity.

Results of this monitoring project, relative to other Allen's Creek habitats, indicate depauperate diversities of mammals, amphibians, reptiles, birds and fish. The existing vegetation is dominated by nuisance and invasive species including Brazilian pepper, primrose willow and air potato. The project site supports urban wildlife with the dominance of opportunistic species including raccoons, opossums, brown anoles, black racers, northern cardinals and Tilapia sp. Other species using the site include river otters, rabbits, read ear turtles, southern leopard frogs, garter snakes, hawks, herons, and bass.

Monitoring results will be used to assess restoration success by evaluating the number and types of animals using the restored habitat. Monitoring activities incorporate public involvement by teaching participants about restoration goals and objectives, ongoing activities, urban wildlife, and the environment. Public participants also help the County protect and maintain the sampling stations. The project is also fulfilling County goals for the Allen's Creek Watershed Management Plan by providing an effective mechanism for environmental education to the public through direct involvement of local citizens.

It is hoped that public participation and public involvement will enhance the project's success in the areas of public acceptance and support, environmental education, publicity, and effectiveness. Involved students are already learning about urban wildlife, their habitat needs, and behavior. Students are also learning about environmentally harmful and beneficial plants and are incorporating what they have learned into class curricula (e.g., writing, reading, referencing, math, language, arts, science, etc.). Local residents have already shown a sense of ownership in the project by supporting and facilitating student field trips and by keeping a watchful eye on the site. This strong community involvement should help ensure the long-term success of the Maple Swamp Restoration Project.

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NOTES

WHAT IS "CHEVWQMN"
(Charlotte Harbor Estuaries Volunteer
Water Quality Monitoring Network)?

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What is the Charlotte Harbor Estuaries Volunteer Water Quality Monitoring Network? It is a network of volunteer monitoring groups throughout the estuaries in the Charlotte Harbor, Florida area who collect water quality data on a regular, technically sound basis. The estuaries within the volunteer monitoring network include: Charlotte Harbor, Gasparilla Sound, Cape Haze, Lemon Bay, Pine Island Sound, Matlacha Pass, and Estero Bay. All of these estuaries are designated Florida Aquatic Preserves. Volunteers live in Charlotte and Lee Counties.

The monitoring network is a collaborative project of the Florida Department of Environmental Protection (FDEP), Charlotte Harbor Aquatic and Buffer Preserves Office, Charlotte Harbor Environmental Center (CHEC) and FDEP South District Branch Laboratory, with assistance from a Florida Gulf Coast University (FGCU) intern.

The purpose of the volunteer monitoring network is to provide baseline and long-term synoptic, widely distributed water quality information about these six interconnected estuaries. The data will supplement agency information to assess the current health of the estuaries, as well as longterm trends. The information will be used to identify resource management needs and specific problem areas which need further scientific, management or enforcement investigation and actions. Through the volunteer monitoring network, volunteers, elected officials, and the general public will also learn the values of the estuaries and the technical processes used to evaluate estuarine health.

The methodology used by the volunteer monitoring network includes field sampling and analysis of 14 physical and chemical parameters at 40 sites synoptically once each month. The sampling occurs on the first Monday of each month within one hour of sunrise. The sites are distributed throughout the estuaries, primarily near tributary mouths. In addition to the field analyses, samples for an additional five chemical and biological parameters for laboratory analysis will be collected by the volunteers at each site to be transported to the Florida Department of Environmental Protection South District Branch Laboratory for analysis, starting in June 1998.

The 14 parameters analyzed in the field include: weather, wind, precipitation and water surface conditions, air temperature, tide stage, salinity, water color, water depth, Secchi depth, water temperature, dissolved oxygen, and pH. The five parameters to be analyzed by the Laboratory include: chlorophyll-a, fecal coliform bacteria, total phosphorus, total Kjeldahl nitrogen, and NO2NO3- Salinity is measured using a hydrometer, water color is measured using a Hach Color test kit, and dissolved oxygen and pH are measured using LaMotte test kits. The details of the methods are included in "Standard Field Procedures Manual" and "Comprehensive Quality Assurance Plan" for the monitoring network.

How Did the CHEVWQMN Get This Far? In 1992, Lemon Bay Conservancy organized the Three Creeks Watch of volunteers to regularly monitor water quality in the tributaries to Lemon Bay. Starting in 1996, the Charlotte Harbor Environmental Center (CHEC) volunteers began monitoring northern Charlotte Harbor with a grant from the Southwest Florida Water Management District (SWFWMD). In 1997, FDEP volunteers began monitoring Pine Island Sound, Matlacha Pass, and Estero Bay with a grant from the Charlotte Harbor National Estuary Program. Beginning in spring 1998, additional FDEP volunteers will begin monitoring additional sites near the barrier islands of Pine Island Sound and Matlacha. Pass. The methods currently used throughout the monitoring network evolved from the design initiated by the Three Creeks Watch volunteers, modified to include the synoptic monthly sampling time and tide, water color, chlorophyll, coliform bacteria, and nutrient sampling.

What Has The CHEVWQMN Accomplished So Far? Comprehensive Quality Assurance Plan has been prepared for the monitoring network and approved by FDEP, CHNEP, and EPA. A "Standard Field Procedures Manual" has been prepared and is used by monitors each month. All volunteers receive regular classroom and field training. Quality assurance sampling sessions are held approximately every six months, with corresponding corrective actions. The data base is established and data entered to date. Twenty-nine stations are being sampled regularly and I stations are pending. A display of the 1997 northern Charlotte Harbor volunteers and data has been prepared and the annual report is drafted.

What's Next For The CHEVWQMN? By summer 1998, the 1997 Northern Charlotte Harbor annual report will be completed; 11 additional stations will be established, coordination and training will occur with the Three Creek Watch volunteers; volunteer training for collection of samples to be analyzed in the laboratory will occur; and collection and analysis of chlorophyll, coliform bacteria, and nutrient samples will begin.

What Have We Learned So Far From The CHEVWQMN? (1) Identify the objectives of the monitoring program before sampling begins. (2) Seek support funding for the monitoring program, especially incidentals like awards, T-shirts, food and gas before sampling begins. (3) Establish the data base and data management system before sampling begins. (4) Complete and get approval for a quality assurance plan before sampling begins. (5) Estimate how much time is needed to complete and get approval for the quality assurance plan, then multiply the estimate by eight to be realistic. (6) Estimate how much time is needed to administer the program and train volunteers, then multiply the estimate by four to be realistic. (7) Up front, give volunteers the background information needed to show how their sampling fits into a "bigger picture". (8) Train, Train, Train. (9) QA, QA, QA. (10) Data Check, Data Check, Data Check. (11) Avoid sites which require volunteers to use boats in open water if at all possible. (12) In estuaries, include the parameters of salinity, tide stage, and water color. (13) Share the data regularly with volunteers and the public. (14) Invite the press to training sessions and annual workshops. (15) Be flexible and willing to learn from the volunteers. (16) Before you start a volunteer monitoring program, determine if you have the right skills to manage the program, including teaching, scientific, sales and organizing skills, etc.

NOTES

VOLUNTEER WATER QUALITY MONITORING IN WESTERN NORTH CAROLINA

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As the population of Western North Carolina and the entire United States continues to grow, increasing pressure is being placed on local rivers and streams. Domestic and industrial supply, agriculture, waste treatment and recreation all depend upon water resources. As greater demand is placed on these water resources, the need for information on how to use them wisely becomes increasingly important. The last two decades have seen many changes and improvements in water quality management; however, many questions remain unanswered. Without additional detailed information, watershed managers and decision-makers do not have the necessary resources for the development of sound policies for the management of rivers, streams, and lakes.

An accurate and on-going water quality database, as provided by the Volunteer Water Information Network (VWIN), is essential for good environmental planning. Volunteers sample from designated sites once a month. This provides an increasingly accurate picture of water quality conditions and changes in these conditions over time. With this information, communities are able to identify streams of high water quality which need to be preserved, as well as streams which cannot support further development without significant water quality degradation. In addition, the information allows planners to assess the impacts of increased development as well as the impact of measures that have been implemented to control pollution. Thus, this program provides the water quality data for evaluation of current management efforts and can help guide decisions affecting future management actions. The VWIN program also encourages the involvement of citizens within the region and promotes awareness, ownership and protection of their water resources.

The VWIN program was first organized through the efforts of a few concerned citizens of Buncombe County in the mountains of Western North Carolina. It was quickly realized that three ingredients were necessary to establish a successful monitoring program. First, to keep costs affordable, volunteers would be needed to collect the samples. Sample collection is often one of the greatest costs of any monitoring effort. With volunteers, not only would the costs be cut drastically, but many citizens would become personally involved in preserving water quality. Interestingly, volunteer recruitment has continued to be one of the easiest tasks, particularly as the program has grown larger and become more well known in the area. An ever-increasing number of citizens have become aware of water quality issues and over 100 volunteers are currently donating their time and efforts to maintaining this valuable resource. Second, an inexpensive, quality laboratory facility would be needed to analyze the samples. The University of North Carolina-Asheville, with its extensive laboratory and large Environmental Studies Program, was recruited for this purpose. This arrangement not only benefited the program by providing low cost analysis at a state certified laboratory facility, but benefited the university as well by providing extensive research potential and laboratory experience to many students in the Pollution Control track of the Environmental Studies

Program. Third, reliable sources of funding were needed to finance the program. Fortunately, several local governments realized the importance of tracking water quality in this fast developing region. Where local governments have been hesitant, local environmental groups have stepped in to help find funding.

The program began in February, 1990 with only 27 sites in one county and has since grown to 130 sites on 80 streams and rivers in seven Western North Carolina counties. Parameters selected for analysis include orthophosphate, total phosphorus, ammonia nitrogen, nitrate-nitrogen, turbidity, suspended solids, pH, alkalinity, conductivity, and heavy metals (copper, lead, and zinc). The parameters were selected based on the range of useful information they could provide and the affordability of analysis. Sample sites were chosen to adequately cover as many watershed drainage areas as possible within each county. Some sites were chosen to cover potential future water supplies. Several sites were also selected as control sites to provide comparison between undeveloped and developed watersheds. In recent years the program has expanded to cover lakes as well. One of the most beautiful lakes in Western North Carolina is suffering degradation from sedimentation and has joined the program to help locate the sources of this problem and its effects on the lake's water quality. Recently, areas that are geographically removed from Western North Carolina have joined the program because of its reputation as a low-cost but very high quality program. Samples are submitted by overnight delivery, adding only minimal additional cost to the program

A data summary of the results is sent to each county every month and an annual report is prepared for each county by the Environmental Quality Institute of the University of North CarolinaAsheville at the end of each monitoring year. This report contains detailed statistical analysis by parameter and by site, and provides valuable information on changing water quality through trend analysis by time, season, and flow rate. The reports are sent to the funding agency, to state and local government agencies that are concerned with water quality, to environmental groups involved in the program, and to other concerned citizens. As the program has grown, it has gained enormous recognition and respect. Virtually all of the area newspapers publish summaries of the results from the annual report along with favorable commentary about the program. Recognition of the program has spread to many other areas as well. The formula for success has been shared with groups in states as diverse and distant as California, Michigan, and Wisconsin. But it should never be forgotten that the major reason for the success of any program such as this is the dedicated volunteers who are willing to give so much time and effort to preserving the quality of our waters.

NOTES

**POND WATCH AND FLORIDA
YARDS AND NEIGHBORHOOD
MUTUAL COLLABORATION PROGRAM.**

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Pond Watch is a volunteer monitoring program implemented by the Lee County Hyacinth Control District (LCHCD) for the last five years. The volunteers are citizens of Lee County who have lakes or ponds (retention ponds) on their property and need assistance in managing them.

The volunteers acquire valuable information that helps them understand pond processes. The information also helps the District manage the pond. Once a month they record the ponds turbidity with a Secchi disk, water levels, and the monthly precipitation. They also collect a water sample for chemical analysis at the Districts laboratory for total phosphorus, orthophosphorus, nitrites, nitrates, ammonia, and chlorophyll-a. In addition, they report the species and relative quantity of aquatic weed cover. The program saves the District valuable time by reducing inspections and conserves the use of chemicals for weed control.

An annual meeting is organized by the District to evaluate the condition of the ponds and exchange experiences among the volunteers. It is also a forum for education on new practices or techniques applied to the ponds.

For the last four years, the majority of our reports have shown that most problems in ponds, specifically the aquatic weed proliferation, are triggered by excessive nutrients. These nutrients tend to concentrate in the pond when the rainy season starts. Nutrients are carried by the water that washes the roads and lawns that may have an excess amount of chemical fertilizer.

In our effort to minimize the aquatic weed proliferation and the effect that the effluent of the retention pond might have on the environment, the District has encouraged adoption of the Florida Yard and Neighborhood Program (FYN) by citizen volunteers. This program was established by the University of Florida, Institute of Food and Agricultural Science four years ago in Hillsborough, Manatee, Sarasota and Charlotte Counties. At present, it has not been implemented in Lee County. The objectives of the FYN program is to reduce the pollution originated at the homeowners level. This is accomplished by applying the best management practices recommended for the landscape activities, thus helping and improving the environment.

We are proposing a mutual collaboration project to address a common concern of FYN and LCHCD. Similar projects have already been implemented in the State of Florida and have demonstrated effectiveness. We hope that by collaborating, the community will find additional assistance in dealing with subjects ranging from water restrictions, non point source pollution, fish kills, and aquatic weed management.

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NOTES

INCREASING NITRATE LEVELS IN THE MAJOR COASTAL SPRINGS IN CITRUS AND HERNANDO COUNTIES, FLORIDA

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Nitrate concentrations have been rapidly increasing in a number of major springs in southwest-central Florida. Jones and Upchurch (1993) showed rapidly increasing, elevated nitrate concentrations (2.0-3.0 mg/l) in Lithia and Buckhorn Springs in Hillsborough County resulting from the long-term operation of dairy farms and the cultivation of citrus. Jones et al. (1996) showed similar trends with somewhat lower nitrate concentrations (1.0 mg/l) in Rainbow Springs in Marion County resulting from the fertilization of thousands of acres of pasture. Similar increasing trends are evident in the Homosassa, Chassahowitzka, and Weeki Wachee Spring complexes in Citrus and Hernando Counties.

The mean concentration of nitrate in Floridan aquifer ground water, as determined from the analysis of samples collected from over 700 monitor wells across Florida between 1985 and 1992, was 0.01 mg/l (Upchurch, 1993). The mean concentration of nitrate in ground water discharging from 16 springs in the Homosassa, Chassahowitzka, and Weeki Wachee Spring complexes, sampled quarterly between 1994 and 1996, ranges from 0. 18 to 0. 62 mg/l. (Jones et al., 1997). Comparison of these concentrations indicates that the nitrate concentrations in the springs are significantly elevated above 0.01 mg/l the probable background level of nitrate in the Floridan aquifer.

Although the nitrate concentrations in the coastal springs of Citrus and Hernando Counties are considerably lower than those of Lithia, Buckhorn, and Rainbow Springs, they are still of great concern. This is because even at these low concentrations, water discharging at the rate of approximately 500 mgd from the main springs and smaller surrounding springs contains an annual nitrate load of over 360 tons. This nitrate is rapidly delivered by the coastal rivers to the extensive estuaries along the Gulf Coast. The effect of this quantity of a limiting nutrient on the aquatic vegetation in the estuaries has not been quantified.

The recharge area for the coastal springs in Citrus and Hernando Counties encompasses approximately 1000 square miles. One-hundred-twenty three (123) wells open to the upper 250 feet of the Floridan aquifer were sampled in the recharge area for a number of chemical analytes including total nitrogen, ammonium, TKN, nitrite, and nitrate. These data were used to characterize the chemical quality of the ground water flow system and to delineate areas of elevated nitrate concentrations.

Fourteen sources of nitrate in the recharge area were investigated to determine which were responsible for the increasing levels. These included: (1) naturally occurring from organic decay; (2) rainfall; (3) fertilization of golf course turf; (4) fertilization of residential turf/landscape; (5) sewage-system effluent disposal; (6) land disposal of sewage sludge; (7) effluent from septic tanks; (8) land disposal of septage sludge; (9) row crop fertilization; (10) citrus fertilization; (11) pasture fertilization; (12) poultry farms; (13) dairies; and (14) cattle.

Nitrogen isotopic data from samples obtained from 23 wells and seven springs suggested that the dominant source of nitrate in ground water in the recharge area and ground water discharging from the springs was inorganic. Residential and golf course turf/landscape fertilization was identified as the principal source of nitrate in the springs. Supporting data included: (1) the inorganic nature of the source; (2) the close proximity of the source to the springs; (3) nitrogen loading calculations; and (4) the rapid increase in nitrate concentrations in the springs that began in the late 1960s shortly after the development of the large, coastal, residential subdivisions.

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NOTES

BIOGEOCHEMICAL INDICATORS OF TROPHIC STATUS IN A RELATIVELY UNDISTURBED SHALLOW WATER ESTUARY

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The study area consists of the near-coastal waters of Chassahowitzka National Wildlife Refuge, outside the mouths of the Chassahowitzka and Homosassa Rivers, in west central Florida. Randomized stations within 30 polygons were sampled for submerged aquatic vegetation (SAV). Cover and abundance of submerged aquatic vegetation were measured using a rapid-survey technique (Braun-Blanquet, 1932), assigning a cover-abundance value by taxon for each of four 0.25 m2 quadrats per station. Water quality samplings consisted of early morning and late afternoon measurements of physical parameters at 30 stations, with nutrients, chlorophyll, and phytoplankton collected at 20 near-shore stations. Additional locations were sampled within the Chassahowitzka River. Sampling and analyses were performed under Mote Marine Laboratory's Comprehensive Quality Assurance Plan. Research was sponsored by the U.S. Fish and Wildlife Service -Air Quality Branch.

Numerous vents comprise the Chassahowitzka, headsprings and individual vents vary widely in conductivity. Floating mats of senescent vegetation, *Typha sp.*, *Potomageton pectinatus*, and *Lyngbya* sp. were at the most upstream stations, but the mainstem was clear and fast-moving. Tidal changes in water elevation, but no reversing flows, were observed at the headspring. At the eastern boundary of the Refuge, floating algae mats, *Myriophyllum spicatum*, and *Hydrilla verticillata* were very dense and reversing tidal flows were observed. Downstream, *Cladium jamaicensis* fined the river, while *Juncus* dominated the higher marsh. At the mouth, *Potomageton* growth was luxuriant. Remaining coastal stations were within and offshore of a dense archipelago of *Juncus* islands, with relatively shallow, clear waters.

Coastal and riverine waters were well mixed with minimal stratification. Based on conductivity, spring discharge quality varies with tide stage. Conductivities in the southern portion of the study area are comparable with areas influenced directly by the Homosassa, and Chassahowitzka, Rivers, implying substantive freshwater discharges in addition to the named rivers Dissolved oxygen values exhibited diurnal swings ranging from 4.8 mg/L (64% saturation) to 8.9 mg/L (128% saturation) between early morning and late afternoon. Some dissolved oxygen values were below instantaneous criterion of 4.0 mg/L during the morning sampling.

Nutrient concentrations in the coastal region were generally low. Nitrate-nitrite-nitrogen was notable both in the main spring and within 0. 1 Ian (near 0.400 mg/L N02+3-N) but was rapidly assimilated. Water column nitrogen is halved over a distance of 3.0 Ian (downstream) to approximately 0.2 mg/L, and is almost all in the organic form. Nitrogen subsequently increases further downstream, with increasing conductivity. This spatial pattern may represent some combination of nitrogen fixation and export of organic nitrogen from the extensive marshes. The highest ammonium-nitrogen concentrations (0.027 mg/L) were observed in the upper 3 Ian of the river but ammonium-nitrogen was not detected in discharge from the main spring. All but one total phosphorus value were below detection limits (<0.05 mg/L). For orthophosphorus, 13 of the 20 coastal stations were below detection limits (<0.005 mg/L). Inorganic nitrogen to inorganic phosphorus ratios (IN:IP, mg:mg), were generally less than 7, indicating nitrogen-limitation. For riverine and coastal stations, dinoflagellates formed a relatively constant proportion of the phytoplankton population. Trophic state indices (TSI) (Hand et al., 1988) were calculated from limiting nutrients and chlorophyll. TSI values at all stations were less than 50, therefore considered "Good". Spatial patterns of TSI, however, indicate higher values (40-49) in the northern Mason Creek-Homosassa Bay area, despite comparable conductivity values. The higher TSI in the northern region imply higher nutrient loadings or terrestrial influences.

Of the 30 polygons identified for sampling, vegetation was found at all but one of the primary sites. Drift algal species were observed in almost half of all quadrats. The most frequently observed attached species are listed below.

Species	**Frequency**	**Abundance**	**Density**
	%	**(B-B)**	**(B-B)**
Caulerpa paspaloides	38	4.00	1.50
Acetabularia crenulata	31	1.72	0.53
Halodule wrightii	18	3.82	0.70
Thalassia testudinum	18	3.16	0.58
Batophora oerstedi	18	0.68	0.13
Caulerpa prolifera	13	2.63	0.33

During May 1996, the Chassahowitzka was a well mixed and relatively oligotrophic estuary with trophic state calculations indicating that water quality was in the "Good" range. In all, the Chassahowitzka region can be termed very clean. Inorganic nitrogen supplied to the head of the river by the main spring is quickly removed by the extensive biomass in the river. Algal growth in most of the coastal area appears slightly nitrogen-limited. Distribution of phytoplankton between dinoflagellate and non-dinoflagellate species was relatively uniform across the study area.

Geographic patterns of trophic state indices indicate that the northern portion of the study area, near the Homosassa, River, received higher nutrient loadings but comparable amounts of freshwater.

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NOTES

NITRATE-NITROGEN IN THE SUWANNEE RIVER

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The Suwannee River is the second largest river in the State of Florida with a mean annual discharge of 10,470 cubic feet per second or 6.7 billion gallons per day. The Suwannee River Basin covers 9,950 square miles. Forty-three percent of the basin is in Florida and fifty-seven percent of the basin is in Georgia. The predominant developed land use in the Florida portion of the Basin is agriculture, including forestry, pasture, row crops, and intensive animal husbandry.

The Suwannee River Water Management District (SRWMD) maintains a surface water quality-monitoring network comprised of 100 stations (56 stations in the Suwannee River Basin). This network has been operational since 1989 and is funded by the Surface Water Improvement and Management (SWIM) Trust Fund. Using data from this network, a statistically significant (95 percent confidence level) increasing trend in nitrate-nitrogen concentration has been identified. There is an inverse relationship between nitrate-nitrogen concentrations and flow at Branford, Florida. The nitrate-nitrogen is transported into the river via ground water in Florida. The SRWMD's groundwater monitoring network, as well as other studies, show elevated concentrations of nitrate-nitrogen in the upper Floridan Aquifer system. At low flow conditions, the base flow of the Suwannee River is made up of ground water from the upper Floridan Aquifer system.

The total load of nitrate-nitrogen for the Suwannee River Basin for water year 1997 was 5,461 tons. Of the total load, the Santa Fe River Basin accounts for 1,082 tons (20 percent) and the middle Suwannee River Basin accounts for 1,650 tons (30 percent). The Santa Fe River Basin is 1,390 square miles (14 percent) of the Suwannee River Basin area; while the Middle Suwannee River Basin is 862 square miles (8.7 percent) of the Suwannee River Basin Area.

NOTES

PHYTOPLANKTON COMMUNITY STRUCTURE AND DYNAMICS IN THE SUWANNEE RIVER ESTUARY

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Suwannee River is a relatively "pristine ecosystem" that, up to the past decade, has seen minimal land development and point source pollution throughout the watershed. However, building pressures, development, and modified land usage in the Suwannee River drainage basin may alter the character of the Suwannee River estuary. Presently, the Suwannee River estuary is one of northwest Florida's most productive and diverse aquatic habitats. The productivity of Suwannee Sound near Cedar Key, Florida is undoubtedly impacted by the quality and quantity of discharge from the Suwannee River. Alterations in the character and amount of riverine discharge can illicit profound biological responses in phytoplankton communities.

In 1996, we began initial efforts to establish baseline data for key water quality parameters and the structure, distribution, and variability of phytoplankton in the Suwannee River and the coastal environment most directly impacted by the outflow of the river. Beyond describing the structure of this community, we are concerned with determining the factors that control productivity and biomass.

Physical Parameters Light transparency salinity, and water color were measured at two-mile intervals along the central transect from the: Suwannee River to the Gulf of Mexico. The penetration of light through the water column is influenced by color, tripton, and phytoplankton abundance, and measured by Secchi depth or light extinction coefficients (Kt). Light transparency in the river was low. One of the major contributors to light attenuation in the river and nearshore stations was color, which reached levels greater than 200 Pt-Co units. Water transparency increased along the transect into the Gulf of Mexico as indicated by higher Secchi depths and lower Kt values.

Chemical Parameters Water samples collected at these same stations were analyzed for nitrate + nitrite, total nitrogen, soluble reactive phosphorus, total phosphorus, and silica. Nutrient levels observed within the Suwannee River estuary were highest in riverine samples. Moving offshore, away from the river, nutrient concentrations decreased substantially.

Biological Components. The phytoplankton community along the transect consisted of diatoms, green algae, blue-greens, and dinoflagellates. A narrow region within the transect exhibited elevated levels of phytoplankton standing crops. This algal community was biovolumetrically dominated by diatoms throughout the sampling period, while small celled (1 -2 um blue-greens and green algae (2-4 gm) were numerically important., Additionally, dinoflagellates were observed in high numbers (190,000 cells/L) in the offshore stations during the spring sampling regime.

Nutrient Limitation Bioassays Primary production in aquatic ecosystems is directly dependent on the availability of essential growth-limiting factors, principally nutrients and light. The character and quantity of nutrient and light supplies also impact the structure and dynamics of the primary producer communities. Nutrient addition bioassays were conducted with samples from riverine, estuarine, and marine stations to evaluate the nutrient limiting status of the region. Nitrogen, phosphorus, silica, and trace metals were added to whole-water samples and phytoplankton growth was measured fluorometrically. The riverine samples were not nutrient-limited for the dates sampled. Nitrogen limitation occurred within the estuary during periods of high riverine discharge. The marine stations displayed N and P co-limitation throughout the four sampling periods.

Conclusions. The results of this research provide a preliminary view of spatial and temporal patterns in basic water quality parameters and the structure of primary producer communities. This type of information forms the basis for establishing the characteristics of the aquatic environment that sustain other biological resources of the Suwannee River estuary, including shellfish and fish populations.

Along the transect from the Suwannee River to the Gulf of Mexico, lies a narrow region of elevated levels of phytoplankton standing crop. As nutrients are transported from the river into the Gulf of Mexico, there is an area of sufficient light and nutrient availability for phytoplankton to bloom. The location of this peak is dependent upon river flow, wind, and tidal mixing, as well as N and P limitation offshore.

NOTES

PERIEPHYTON WATER GARDEN IN A PUBLIC PARK, ORLANDO, FLORIDA

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The ability of periphyton filtration to reduce nutrient and metal pollutants in urban lakes is being investigated. Utilitarian systems have been built and their high performance encouraged deployment of a periphyton culture system in an urban park setting, as a multi-function amenity. This demonstration project on Lake Wade in Orlando was constructed during the fall of 1997 and will be operated for at least one year. Lake Wade is an urban lake of almost 5 acres which receives runoff from the surrounding 188-acre watershed which is 30% urban and 70% residential. The lake has total phosphorus concentrations in excess of 100 ug/L and roughly a 30-day hydraulic residence time. These conditions have promoted planktonic algae concentrations between 16-110 ug/L in the lake. Based upon prior work, the size of this periphyton filter is adequate to remove 100-200 pounds of phosphorus per year. The lake presently receives an estimated 150-200 pounds per year. The target for the system is to reduce in-lake total phosphorus concentrations by half, to about 60 ug/L.

The Lake Wade Periphyton Water Garden is approximately 15 feet wide by 300 feet long and has a harvestable surface area of approximately 0.1 acre. Lake water is pumped from the center of the lake through an inlet one meter above the bottom to the uphill portion of the garden and allowed to run down over a shallow substrate covered with periphyton before it returns to the lake. These conditions promote rapid periphyton photosynthesis and nutrient uptake along with the growth of a thick periphyton mat. In addition, the mat physically filters and collects suspended particulate matter from the lake water. Another benefit includes the addition of dissolved oxygen due to increased reaeration during all hours and photosynthesis during the day. The periphyton mat is harvested every week to remove nutrients in the form of periphyton biomass and trapped particulate matter from the system. Biomass is scraped into sumps which are, in turn, pumped out into a trailer-mounted tank. This harvested material is being evaluated for a variety of purposes, including wet application as a soil amendment and as a fibrous feed stock for package manufacturing in a molded pulp process. These uses of the periphyton remove the nutrients from the lake and potentially from the watershed, while allowing the incorporation of this recycled packaging material into the soil at the destination.

The Lake Wade Periphyton Water Garden is located in a park between a playground and school, so it was designed to accommodate both public access and education, as well as to aesthetically contribute to the park setting.

This talk will present summarized results from past projects, preliminary results from this system and the success in achieving the following goals for this system:

1 Measure Environmental Enhancement

a. Measure the removal of nutrients and metals from water and their accumulation in harvested periphyton.
b. Measure response of lake to nutrient removal.
c. Evaluate possible uses/disposal solutions for the harvested periphyton.
d. Evaluate techniques to optimize the system's nutrient removal efficiency.
e. Evaluate the effort and costs associated with the system and provide insights into the construction of larger systems.

2. Measure Acceptability to the Public

a. Design a system to capture the interest of the general public.
b. Ascertain whether the public thinks such systems are an asset to the park.
c. Is the system's operation compatible with the public and its use of the park?

3. Measure Education and Community Involvement

a. Design a system so that its basic function can be effectively communicated to the public and students.
b. Does the system help to educate the public on how lakes become polluted and what they can do to prevent and reduce pollution?
c. Can the adjacent schools use the system to educate students about the biological processes inherent with the system's operation?

NOTES

AMERICAN ALLIGATOR POPULATION DENSITIES AND THEIR RELATIONS TO TROPHIC STATUS, FISH BIOMASS, AND HUMAN DEVELOPMENT ON FLORIDA LAKES

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The numerical responses of phytoplankton, zooplankton, and fishes, to nutrient levels in lakes are well-researched (see Jones and Bachmann, 1976; Bays and Crisman, 1983; Hanson and Leggett, 1982; and Hoyer and Canfield, 1994). However, very few studies address the relationship of crocodilians to ambient aquatic nutrients. Gorzula et al. (1986) found correlations between certain limnological parameters, namely pH, conductivity, and water hardness, and certain sympatric crocodilian species *(Paleosuchus trigonatus, Caiman crocodilus,* and C *crocodilus* - Llanos subsp.) in Venezuela. They concluded that these characteristics may influence habitat suitability. Furthermore, Wood et al. (1985) found that the number of observed alligators generally increases with water column total nitrogen ($r^2 = 0.49$, $P < 0.05$), but of the small number of Florida lakes surveyed ($n = 23$), only three could be considered oligotrophic (according to the standards of Forsberg and Ryding, 1980). In addition, few small lakes (i.e., less than 250 ha) were surveyed. Therefore, their findings may not be truly representative of Florida lake communities with alligator populations.

Aside from the possible "bottom-up" effects of nutrient concentrations, alligator population densities are probably correlated with many other factors related to habitat and/or prey resources (see Wood et al., 1985; Newsom, 1987; and Herron, 1994). Among these factors are lake morphology, phytoplankton production, amount of plant coverage, fish biomass, and human development. Therefore, in order to (1) ascertain the relative importance of nutrients in explaining the variation found in alligator densities among lakes, and (2) build a predictive model for alligator abundance, a field study was undertaken to see if and how the abundance of *Alligator mississippiensis* varies among Florida lakes according to their respective physical, chemical, and biological characteristics.

Data from 60 Florida lakes were analyzed by simple and multiple linear regression techniques (standard least squares procedure) using JM? software (SAS Institute). Most data used in analyses were obtained from the Florida LAKEWATCH program (University of Florida / Institute of Food and Agricultural -Sciences) and the Florida Game and Fresh Water Fish Commission (GFC). Additional data were obtained through independent observations on lakes using a standard GFC sampling technique to estimate relative alligator densities (i.e., night counts of alligators by a single observer using a spot light as transects are run by power boat). Information regarding the percentage of human-developed shoreline was taken from U.S. Geological Survey 7.5-minute series topographic maps through the use of a cartometer.

Analyses revealed that alligator Population densities were positively correlated ($P < 0.002$) with total phosphorus ($r^2 = 0.55$), total nitrogen ($r^2 = 0.53$), chlorophyll-a ($r^2 = 0.53$), lake color ($r^2 = 0.37$), percentage of lake area covered by macrophytes (PAC) ($r^2 = 0.28$), and fish biomass (r2 = 0.45). However, alligator density was inversely related ($P < 0.0005$) to water transparency ($r^2 = 0.46$), mean lake depth ($r^2 = 0.49$) and percentage of human-developed shoreline ($r^2 = 0.38$, $P < 0.0001$). Finally, in our study, shoreline development (a measure of the regularity of the shoreline) was not associated with number of observed alligators ($P = 0.1433$), although Wood et al. (1985) found a significant correlation.

Finally, while only as much as 55% of the variation in alligator population densities among lakes was accounted for by any single predictor (total phosphorus), a multiple linear regression model using three parameters (plant coverage, water transparency, and fish biomass) account for 78% of the variation in abundance ($P < 0.0001$; $n = 24$). Another useful model incorporated mean lake depth and chlorophyll-a concentration, yielding a model r^2 of 0.74 $P < 0.0001$, $n = 24$).

These findings and models are important because of their potential use in determining ranges of natural population density values associated with this top predator. Any assessment of suspected anthropogenic impacts on populations should be made only after careful consideration of the array of environmental parameters which may affect alligator abundance in Florida's lentic habitats.

This brief piece benefited from the comments of L. Nico, J Wilson, and A. Hester.

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NOTES

LAKE APOPKA REVISITED: AN EVALUATION OF ENVIRONMENTAL CONTAMINANTS AND ASSOCIATED REPRODUCTIVE ANOMALIES IN ALLIGATORS

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Populations of the American Alligator (*Alligator mississippiensis*) have increased throughout the Southeastern United States since they were first listed on the endangered species list in the early 1970s. On Lake Apopka, however, the population of juvenile alligators declined sharply in the early 1980s and has yet to fully recover (Masson, 1994; Rice, 1996). Environmental contaminants have been hypothesized as a primary contributing factor in this decline as well as in the associated reported reproductive anomalies (Guillette et al., 1994; Gross et al., 1994). Contaminants and nutrients have entered Lake Apopka from a variety of sources: extensive agricultural activities, sewage treatment facilities, and a major pesticide spill from the former Tower Chemical Company in 198 1. The chemical spill from Tower Chemical Co. was primarily a mixture of dicofol (a DDTmodified product) and sulfuric acid, resulting in the site's designation as a Superfund Site. Preliminary studies of Lake Apopka alligators suggested altered and/or depressed reproduction. Plasma sex steroids were decreased for juvenile alligators and patterns abnormal for hatchlings (Guillette et al., 1994; Gross et al., 1994). Indeed, histological examinations of alligator gonads indicated significant anomlies for neonates and juveniles from Lake Apopka. Additionally, alligator eggs from Lake Apopka had greatly reduced hatchabilities and increased neonatal mortalities, as compared to other Central Florida lakes. These results suggested DDT and its derivatives (i.e., DDE) as potential causes of these reproductive anomalies. The current study was designed to examine DDT and its derivatives (i.e., DDE) as potential causes of reproductive and neonatal anomalies in Lake Apopka alligators.

Adult female nesting, alligators from Lakes Apopka (n=29) and Woodruff (n=10) were trapped during the reproductive season from 1994 through 1996. Fat biopsies and plasma were collected from each female and the eggs collected from each of their respective nests. Fat samples were utilized for contaminant analysis. Eggs were returned to the laboratory for incubation. Two eggs from each clutch were utilized to stage development and for contaminant analyses. Contaminant analyses focused on quantization of DDT and DDE. Egg clutches were monitored for: total egg numbers, nested egg numbers, hatched egg numbers, percent of total eggs nested, viability rate (percent of total eggs that hatched), hatch rate (percent of nested eggs that hatched), neonatal mortality, survival rate (percent of total hatched eggs that survived), and production rate (percent of total eggs that produced surviving offspring). These clutch parameters were then correlated to DDT and DDE residue levels for maternal fat samples and eggs. Additionally, Lake Apopka clutches were designated as to geographical collection area: North (north of Buffalo Point to Muck Farm marsh areas) and South (Gourd-Neck Springs area). Geographical areas were then similarly compared and correlated to DDT and DDE concentrations.

Concentrations of DDE were higher for maternal fat and eggs from Lake Apopka alligators as compared to Woodruff, whereas DDT concentrations did not differ between lakes. Total egg numbers did not differ between lakes; however, numbers of nested eggs were decreased for Apopka, as were the number of hatched eggs, neonatal survival numbers, nest rate, viability rate, hatch rate, production rate and survival rate. Although a positive correlation existed between female fat tissue and egg concentrations of DDE, there was not any significant correlation between the nest/clutch characteristics and DDT nor DDE concentrations in fat or egg. Simply, females or eggs with high DDT or DDE concentrations represented clutches with high and low clutch characteristics. Indeed, analyses of both lakes, together or individually, failed to show any significant correlations between **DDE or DDT and** clutch parameters. However, when clutches and females from Lake Apopka were separated into two geographical populations, North and South, significant differences were observed in clutch characteristics. Clutches from South Lake: Apopka had higher nested egg numbers, hatched egg numbers, neonatal survivor numbers, viability rate, hatch rate and production rate than clutches from North lake Apopka. These results indicate two potentially distinct populations and effects for Lake Apopka; however, few differences were, detected between sites for DDT or DDE concentrations in maternal fat or eggs. Indeed, clutch parameters for Lake Apopka sites did not correlate to DDT nor DDE concentrations in fat or eggs.

Results from this study do not support the earlier hypotheses (Guillette et al., 1994; Gross et al., 1994) which linked DDT or DDE to Lake Apopka alligator clutch anomalies. Other reproductive anomalies, such as altered neonatal sex steroids and gonadal histology, were not examined in this study and may be related to DDT and/or DDE effects. These results indicate two distinct populations and effects for Lake Apopka alligators. Results also indicated significant immuno-toxicological effects for Lake Apopka neonates. Results, however, do not support earlier hypotheses which linked DDT or DDE to clutch anomalies. Additional studies are needed to examine other contaminant types and distinct Apopka populations.

NOTES

APPLE SNAIL SURVIVAL AND RECRUITMIENT FOLLOWING AN EXTREME DRAW DOWN OF LAKE KISSIMMEE

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The Florida Game and Fresh Water Fish Commission (GFC) initiated a program in 1971 to improve lake habitats to support fish and wildlife. The restoration technique involves dropping lake levels to dry down the littoral zone in order to promote desirable aquatic plant communities. More intensive measures include muck removal, burning, and discing following the draw down. Surveys of fish and aquatic macroinvertebrates suggest that extreme draw downs benefit these lake inhabitants. However, little information exists on the impacts of extreme draw downs on the Florida Apple Snail (Pomaceapaludosa). The apple snail is a critical component of Florida lake food webs, including providing the nearly exclusive source of food for the Florida Snail Kite (Rostrhamus sociabilis) whose range includes the Kissimmee Chain-of-Lakes in Central Florida. The GFC, in cooperation with the South Florida Water Management District, conducted an extreme draw down of Lake Kissimmee during the period December 1995 through June 1996. The Kissimmee draw down provided, in effect, a large-scale experimental system to investigate the impacts on apple snail populations derived from lake restoration activities.

We used miniature transmitters to monitor the movements and survival of 31 snails as water levels receded. We also assessed pre-draw down snail abundance in eight sites throughout the littoral zone of the lake (Fall 1995). We followed up with snail abundance assessments for two consecutive years (Fall of 1996 and 1997) following re-establishment of lake water levels. Snail abundance was evaluated by the use of trap arrays, a method which we validated using I -in' throw traps.

Snails did not exhibit a tendency to move along a depth gradient either as a function of nine 2-week time intervals ($F_{I,7}$ =0.86, p=0.38), nor as a function of the depth of the snails' locations ($F_{1,3}$=3.07, p=O. 14). Fifteen of the 22 snails (70%) released in greater than 20 cm of water became stranded. The mean (± SD) survival time for stranded snails was 3.9 ± 3.1 weeks. The majority of deaths during the telemetry study were a result of predation.

No snails were found in three unconsolidated muck sites using either the trap arrays or 1-m^2 throw trap. The difference between snail density in the clean sand substrate sites and the predominantly sand substrate with a thin flocculent organic layer suggests that flocculent organic debris accumulation may negatively impact apple snail populations.

In September - October 1996, we returned to the same sites of 1995 to assess the population following the Spring 1996 draw down and restoration. The total catch for the 1996 survey (83 snails) was 20% of the total catch for 1995 (400 snails). Snail numbers increased, marginally, in a few of the sites where organic material was removed. No snails were found in sites which contained the highest numbers of snails in 1995. The absence of snails in these sites in Fall 1996 resulted from heavy predation of stranded snails and from deaths due to dry down intolerance during the dry down. The dry down also suppressed recruitment, since the dry down occurred over the typical peak breeding season for apple snails.

We returned in the Fall of 1997 and found that the snail population had not grown beyond 1996 levels. We believe that the severity of the dry down and the limited reproductive rates of apple snails precludes a rapid recovery to pre-draw down population levels. It may require three or more years for the population to recover, which is consistent with the observed return of snail kites to periodically dry marshes and lakes. The impacts of conducting lake dry downs during the peak period of apple snail reproduction may have as great an impact on snail populations as the direct mortalities attributable to the dry down conditions.

NOTES

TBE DECLINE OF HYPEREUTROPE11C NEWNANS LAKE, FLORIDA: MANAGEMENT AND RESTORATION IMPLICATIONS

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Newnans Lake is a large (2,750 ha), shallow (z = 1.5 m), hypereutrophic lake located in north-central Florida. Although the lake is considered to be naturally eutrophic (Brezonik and Shannon, 1971; Canfield and Hoyer, 1988), recent monitoring efforts indicate that water quality in the lake has declined noticeably over the last decade. Chlorophyll-a concentrations in Newnans Lake average 225 [ug/l (1994-1996), about four times higher than the 1957-1980 average of 54 ug/l (Huber et al., 1982). Ongoing investigations by the St. Johns River Water Management District reveal that this high algal biomass is associated with a persistent bloom (up to 98% relative biovolume) of the exotic blue-green *Cylindrospermopsis raciborskii*. Exactly when C *raciborskii* first appeared in the lake is not known, but it was not reported in the 1960s and 1970s (Shannon and Brezonik, 1972; Nordlie, 1976), nor was it detected in 1965 and 1966 samples recently analyzed by Chapman and Schelske (1997). This species is now also present and prevalent in other hypereutrophic lakes in northern and central Florida (Chapman and Schelske, 1997). The prevalence and dominance of C. *raciborskii* in Florida lakes may represent an unprecedented challenge to lake managers and limnologists. Not only does this blue-green species have the potential of altering the trophic structure of a lake (by displacing other dominant algal species and increasing lake primary productivity) but it may represent a possible environmental health problem given past reports of its toxicity (Chapman and Schelske, 1997).

Total nutrient concentrations in Newnans Lake reflect the lake's high algal biomass (TP = 0. 13 mg/l, TN = 4.29 mg/l). The trophic state index (TSI) for Newnans Lake (Carlson, 1977; as modified by Huber et al., 1982) is 91, the highest value recorded for lakes in the St. Johns River Water Management District. By comparison, TSI values for Newnans Lake during the 1960s and 1970s were around 70 (FDEP 305-b reports), typical of a moderately eutrophic condition.

Newnans Lake is additionally characterized by having a thick accumulation of organic sediments which in some areas of the lake can be over 5 m deep. Although the lake's traditional sportfishery (largemouth bass and black crappie) is greatly reduced, it now provides a locally popular stocked sunshine bass fishery.

Causes for the recent deterioration of Newnans Lake water quality remain unclear. Past research shows that a dam placed at the lake's outlet in 1967 increased in-lake sediment nutrient concentrations, but results regarding sediment accumulation rates were inconclusive. Paleolinmological investigations are currently underway to further describe historical nutrient and sediment accumulation rates in the lake and to reconstruct past epilimnetic total phosphorus concentrations.

Recent land-use changes in the watershed are suspected of causing increased nutrient loading to the lake, as evidenced by high total phosphorus concentrations in some urban tributaries (averaging 0.22 to 0.32 mg/l). Sediment resuspension in this shallow lake may play a significant role in nutrient dynamics. The St. Johns River Water Management District is undertaking diagnostic research to quantify the lake's major external and internal nutrients sources and to further characterize the trophic structure of the lake. Research results will then be used to identify the cause(s) of degraded water quality and to develop methods for restoring the lake. At this stage, it appears that restoration of Newnans Lake may involve a combination of watershed management, sediment remediation, and permanent outlet darn removal.

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NOTES

WATER CHEMISTRY TRENDS IN FLORIDA LAKES AND RESERVOIRS

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Introduction. The Clean Water Act of 1987 established the framework for accelerated efforts to control nonpoint source (NPS) pollution. Since that time, management agencies have attempted to control nonpoint source to improve and prevent further degradation of water quality in lakes (US EPA, 1990). In Florida, the Florida Department of Environmental Protection (1996) concluded that the pressures of population growth and development were serious threats to the State's water resources and that nonpoint source pollution accounted for most of the water quality problems in the State. Our objective was to determine if water chemistry, specifically total phosphorus, total nitrogen, and chlorophyll concentrations as well as water clarity (Secchi disk measurements), changed significantly across the State of Florida over the past 30 years.

Methods. Water chemistry data were compiled from various sources and separated into three time periods (early, middle, and present). The earliest data consisted of data collected on 10 1 lakes between 1967-1973 (Holcomb, 1968 and 1969; and Holcomb and Starling, 1973). The middle time period consisted of data collected on 165 lakes between September 1979 and August 1980. (Canfield, 1981). The most recent water quality data were compiled from data collected by Florida LAKEWATCH (1997 and 1998) and Griffith et al. (1997). Statistical comparisons between the early and middle time periods, the middle and present time periods, and the early and present time periods were done using a paired t-test. Lakes that had point source removal occur were deleted from all statistical tests.

Results. Comparing total phosphorus (TP), total nitrogen (TN), chlorophyll (CHL), and water clarity (SECCHI) between the early and middle time periods shows only TN ($p \leq 0.05$) was significantly different (early TN = 1130 ug/L and middle TN = 920 ug/L). Between the middle and present time periods, only TN ($p \leq 0.05$) and CHL ($p \leq 0.05$) were significantly different (middle TN = 821 and present TN = 910; middle CHL = 20 and present CHL = 23). Between the early and present time periods, only TP ($p \leq 0.05$) and CHL ($p \leq 0.05$) were significantly different (early TP = 197 and present TP = 49; early CHL = 16 and present CHL = 28).

Discussion. No significant increases in nutrient concentrations over thirty years suggest that nonpoint source pollution may not be significantly affecting the TP and TN concentrations in lakes across the state. Water clarity has also not changed over the last thirty years. Chlorophyll concentrations have shown slight increases but these increases may not be larger than natural long-term variability, which has been reported as plus or minus 31 % of the mean (Knowlton et al., 1984). These changes may also be related to other factors such as water level fluctuations or plant control programs (grass carp or herbicides). Thus, nonpoint source pollution is probably having a minimal effect on the water chemistry of Florida lakes. Lake managers should consider this information prior to expending monies for nonpoint source pollution control, which may not yield the desired management objectives (lower TP, lower TN, lower CHL, and increased water clarity).

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NOTES

THE USE OF ALUM TO RESTORE CLASS III WATER QUALITY STANDARDS IN HIGHLY URBANIZED LAKES

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Alum has been used in several Florida lakes to improve certain water quality parameters. One of the most successful, Lake Ella in Tallahassee, remains an excellent example of its use. The present investigation evaluates the water quality of three Central Florida lakes. The expressed intent and goal of the use of alum is to improve or prevent the further decline of the Class III water quality standards and, thus, the aesthetics, fishing, boating, and other forms of recreational contact activity. The lakes in the present study are Lake Osceola and Lake Mizell of the Howell Branch Creek basin, and Lake Holden in the Boggy Creek basin. According to data collected by the Environmental Protection Department (EPD), these three lakes have had Trophic State Index (TSI) values at or above 60 in the past few years. The study evaluates water quality trends before and after the construction and initiation of the alum system. The lakes selected represent two methods of alum application, direct in-lake injection and whole-lake application for sediment phosphorus inactivation.

The study reviews water quality data from the selected lakes for several years prior to the application of alum and through the present time at historical EPD locations and Water Management District permit stations (in the case of Lake Holden). The study uses data collected and analyzed by the Environmental Protection Department Laboratory, a fully certified environmental laboratory by the DHRS and FDEP. The report evaluates phosphorus, nitrogen, chlorophyll, and other parameters; calculates statistical significance of before and after alum treatments for each parameter; and describes, in detail, the physiometrics of each lake system. Preliminary review of the data indicates that six months after the whole-lake treatment in Lake Mizell, the Secchi disk remains improved over 300% as compared to the pre-application condition. In Lake Holden and Lake Osceola, where only a portion of the basin receives alum during storm events, there appears to be little improvement in Secchi disk depth.

Lake Holden in Orange County, Florida receives stormwater runoff from a variety of land uses. The most intense is some 40 acres of industrial land use in the City of Orlando. It has been estimated that about 50% of the phosphorus loading enters Lake Holden in the north lobe. Engineering studies demonstrated that there was no room for traditional retention ponds. Therefore, an in-line alum treatment system was designed and built. The plan was formulated upon the premise that alum would remove phosphorus from the stormwater as it entered the lake. Phosphorus in the water column would be reduced and, thus, not be available for the growth of planktonic algae, thereby allowing the growth of planted macrophytes. Subsequent increases in clarity would stimulate natural growth of submerged aquatic plants, thus establishing a balanced ecosystem for both flora and fauna, as defined in F.A.C. 62-302.530, Class III water quality standards. After about a year and a half of data collection, chlorophyll, phosphorus, and Secchi disk values remain unchanged. However, this is extremely short-term and rainfall rates have been well above normal. This has resulted in several instances of the alum system not having sufficient product to cover rain events, sediment resuspension during the storms, and overtopping of the existing stormwater abatement systems in the industrial area.

Lake Mizell is a 62-acre lake surrounded primarily by residential land uses. It received a surface treatment of alum in the spring of 1997. After almost a year of well above normal rainfall chlorophyll, Secchi disk, and phosphorus remain improved over pre-alum application. Statistical evaluations will be available at the time of the FLMS/SE NALMS conference.

Lake Osceola is a 157-acre lake, with a very substantial flow from upstream lakes. Land uses contributing to Lake Osceola include residential, commercial, and light industrial. The alum injection system treats stormwater from mostly downtown Winter Park, Florida. This system has been in operation since 1994 and is expanding in outfalls treated. There has been a slight downward trend in the total phosphorus concentrations since 1994. However, early in 1998, the total phosphorus increased, perhaps in response to the increased rainfall and lake levels. Increased lake levels can affect septic tanks, fertilizers from yard maintenance, and kill vegetation by inundating it.

NOTES

TECHNICAL AND NONTECHNICAL ISSUES RELATED TO DREDGING PROJECTS

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Removal or dredging of muck (organic and fine-grained) sediments from any water body requires consideration of various technical as well as non-technical issues. The purpose of this presentation is to share knowledge gained in various dredging projects conducted mostly in urbanized areas within the State of Florida.

For the most part, the "pump and dump" approach to muck removal is not feasible from both a physical as well as regulatory standpoint. This is particularly true in highly urbanized areas such as major cities or municipalities that have experienced extensive development over the past 20 years. As expected, the availability of land to simply dispose of sediments is either limited or, if available, the cost is prohibitive. Generally speaking, municipalities do not set aside areas to accommodate future sediment removal projects. However, if lakes and other open water bodies are considered a valuable community benefit, this way of thinking must change.

Therefore, technical considerations such as sediment characterization, depth of dredging, impacts on existing structures, management technologies to improve material recovery and return water quality, and final disposition, particularly the beneficial uses of muck, are critical. A feasibility study to determine sediment characteristics and disposal option(s) is the first step in a dredging project with specific objectives. The most common reasons for considering the need for dredging are the impacts of sediments and their removal on the water quality or navigation or the benthic environment or a combination of these aspects. Regardless of the reason to dredge, one of the first steps is to determine the characteristics of the sediment. Sediment characteristics of interest include chemical, physical, and biological; but for the most part, the chemical and physical characteristics are what determine the project's feasibility. The first hurdle to overcome is to determine the chemistry of the sediments. This involves determining if the sediment is of concern either during the dredging process via impact on the water quality (in system) or at the disposal site (leachate and return water qualities). Equally important is the sediment's physical characterization to provide vital information on the in situ variation and distribution of sediments. Tests conducted also provide insight into the settling behavior of the sediments as they are dredged, transported, and deposited in a disposal area. The settlement behavior is critical because it dictates the disposal area requirements.

Volume estimates and sediment behavior determine the disposal approach to be used. Recently, the use of chemical polymers to assist with enhancing dewatering has been used. The approach is to create flocs of the slurried material and expedite sediment dewatering by self weight consolidation or facilitate water solids separation via a screening process. This results in reduced solids disposal volume requirements. One advantage gained from the use of chemical polymers is clarity in the water column above the flocculated sediments. The impacts from the use of chemical polymers are assessed through completion of toxicity tests using aquatic animal species.

Another approach commonly used to separate water and solids is a hydrocyclone. Generally, two flow streams result from using a hydrocyclone: overflow and underflow. The underflow is generally comprised of a dense sandy material. The overflow consists of fine grained and/or organic material slurry. The underflow sand could be available for use as construction fill or for beach renourishment. The fine-grained/organic overflow material would be used in a beneficial way such as topsoil, additives in potting media, or for the horticulture/golf course industry.

Depending on the size of a disposal area and sediment physical characteristics, one or a combination of approaches may be used.

In addition, non-technical issues such as bid document preparation, contractor prequalification, and bidding are just as important to successfully complete dredging projects. It is important to develop a detailed schedule and define critical dates such as bid document completion, project advertisement, completion of the disposal site, preparation of commencement and duration dredging, and project completion.

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BENTHIC MACROINVERTEBRATE AND TROPHIC STATE ASSESSMENT OF SELECTED LAKES IN THE BUTLER CHAIN: PAST AND PRESENT CONDITIONS AND FUTURE PROJECTIONS

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The Butler Chain of Lakes in Orange County, Florida, contribute to the high recreational, real estate, and sporting values of the area. As the basin undergoes more development, regulatory agencies and lake associations are becoming more concerned with potential degradation of the water quality. In response to these concerns, a study was initiated to assess the past and present biological and water quality conditions of the lake, and after appropriate modeling, to project future changes of the lakes' water quality and biota.

The macroinvertebrate assemblages in four lakes (Butler, Sheen, Tibet, and Wauseon Bay) of the Butler Chain were species rich, diverse, and composed of taxa representative of unpolluted water according to five core metrics (total number of taxa; Shannon-Wiener diversity index; total number of Ephemeroptera, Trichoptera, and Odonata taxa; pollution sensitive species of the Hulbert LCI; and the percent filterers) that are sensitive for discriminating lake impairment. For management purposes, the five core metrics were integrated into a benthic macroinvertebrate index (BMI) and ordinal rankings of very poor, poor, good, and very good assigned to the numerical BMI (Florida Department of Environmental Protection, 1996).

Based on macroinvertebrate communities in the 1990s, Lakes Tibet and Sheen contained *very good* assemblages according to the BMI composited from the above five core metrics; benthic macroinvertebrates from Lake Butler and Wauseon Bay represented *good* assemblages. Data to discern temporal trends were available for only Lake Butler, where the BMI decreased between the 1970s and 1990s.

All four lakes have a low trophic state index (TSI), indicating low nutrient and high clarity surface waters. Recent total phosphorus and chlorophyll-a concentrations indicate the lakes may be beginning a gradual shift toward nutrient enrichment and increased biological productivity, but the absolute magnitude of the elevations are small thus far, and do not influence the trophic state of these lakes.

According to the most recently established trophic state limits for total phosphorus, Secchi disk transparency, and chlorophyll-a (Ndrnberg, 1996), an anticipated 50% increase in the total inorganic phosphorus and chlorophyll-a concentrations (based on water quality modeling simulations of future land usage) will result in a shift from oligotrophy to mesotrophy in all four lakes. A perceptible decrease in water clarity in the lakes will probably be the most significant single impact to the lakes in response to the projected increases in nutrients and chlorophyll-a.

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NOTES

NEWBURGH LAKE RESTORATION:
A CASE STUDY IN URBAN LAKE RESTORATION

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Urban storm water runoff and accumulation of contaminated sediment over 60 years has rendered the 105-acre Newburgh Lake, an impoundment of the Rouge River in Wayne County, Michigan, virtually useless as a recreational resource. Shallow water and nutrient-rich sediments have led to excessive growth of aquatic plants precluding most boating activities. Moreover, some sediments contain PCBs which present a potential health hazard associated with fish consumption. The Newburgh Restoration Project has formulated the following objectives to address the causes of the lake's problems and assess the needs and goals of the public, Wayne County, Michigan Departments of Environmental Quality and Natural Resources, and local municipal governments:

- Restoration of lake water quality through removal of sediment (total of 625,000 yd3) and use of vegetative filters at outfalls to reduce pollutant loads to the lake.

- Elimination of fish advisory for PCBs, thereby reducing human health risks through fish removal, removal of contaminated sediments, and lake restocking.

- Increase amount and diversity of aquatic life and recreational use by recontouring the lake bottom and planting indigenous plants to enhance fish and waterfowl habitat and improve recreational activities, specifically boating and fishing.

This presentation provides a project overview of the various restoration phases including data collection and development of the Basis of Design, dam rehabilitation, fish removal, sediment removal and disposal, bottom recontouring, and habitat enhancement. The fact that Newburgh Lake is a river impoundment, contains heterogeneous sediments, has an urban park setting, is subject to sudden lake level fluctuations resulting from storm events, and has a large sewer buried under the lake bottom has presented numerous challenges to the restoration team.

To address the lake's problems, studies were conducted to obtain the required background information to solve these problems. An initial sediment study was conducted to determine the distribution and concentrations of potential contaminants and to estimate the volume of sediment that had accumulated. A bathymetric study was conducted to determine current water depths and establish the lake's morphology. A geotechnical study was conducted to provide the engineering data necessary for sediment removal. The results of these investigations indicated that: (1) the lake was very shallow, with a mean depth of 3.9 feet; (2) more than half of the lake's surface (west end of the lake) was 2 feet deep or less; (3) the sediments in the shallow western end were contaminated with PCBs; (4) the lake had highly variable geotechnical conditions; and (5) the control structure on the dam required repair.

During the design process another interesting fact was discovered in that an old sanitary sewer had been built on the original lake bottom and extended under the length of the lake.

Construction activities began in the winter of 1997 with the erection of a coffer dam at the dam face to repair the outlet structure. Once the inoperable outlet structure of the dam was removed, stop logs in the coffer dam were removed slowly to drain the lake at a rate of 3 feet every 3 days. This prevented the lake bank from becoming unstable. The lake was lowered until only a 3-acre pool remained. This pool was used for sedimentation control. Next, additional sediment sampling was conducted to verify the concentrations and more precisely define the distribution of the PCBs. This sampling also was required for disposal reasons, since different concentrations involved different disposal costs or uses.

The restoration contractor began sediment removal operations in April 1997. The contractor spent the first few months mobilizing and establishing their learning curve for meeting the many challenges of restoring Newburgh Lake. Because Newburgh Lake is an impoundment of an urban river system, storm events have a direct and immediate effect on the lake level, thus requiring the contractor to adapt to, and work with, rapidly fluctuating lake levels.

Removal of the sediment has been accomplished using a variety of techniques including mechanical dredging with a dragline, hydraulic dredging with a cutterhead, and earth moving equipment. Each technique has been used in different areas of the lake because of the differing conditions encountered. Earth moving equipment, however, has been the most productive and has been used for the majority of the lake. Being an urban lake, we also have had to deal with considerable amounts of debris during the course of the excavation. Often this debris interfered with the operation of the dredges. During sediment removal, the river channel was excavated deeper than the final project depth to aid in flow control and dewatering of the sediments. The contractor constructed a network of haul roads on the lake surface and holding/loading cells in order to process the material. Currently, most of the contaminated sediment has been removed and disposed of in a municipal landfill. There is no TSCA material at this project.

A fish kill was conducted in June 1997 to remove all of the contaminated fish from the lake and the preceding 2-mile upstream reach. A total of 22,240 pounds of fish were removed from the lake; 78 percent of this weight was represented by carp, goldfish, and their hybrids. The fish kill will be discussed in greater detail in another presentation at this conference.

One other complication occurred during July 1997, when a facility that discharges its storm water to a storm sewer that enters the lake had an oil spill. Cleanup of this spill and sediment removal had to be conducted concurrently without either operation interfering with the other.

To date, the project has removed approximately 350,000 tons of sediment and is approximately 60 percent complete. Current estimated completion is October 1998 with the full park opening next spring. Newburgh Lake has been a challenging project to date. We have been presented with many challenges, some anticipated and some unanticipated. We hope that our experiences with the Newburgh Lake Restoration Program will provide some guidance to those who are anticipating their own restoration projects.

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COCKROACH BAY RESTORATION PROJECT: A MULTI-AGENCY NONPOINT SOURCE MANAGEMENT SUCCESS STORY?

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The Hillsborough County Environmental Lands Acquisition and Protection Program (ELAPP) purchased 650 acres of disturbed land adjacent to Cockroach Bay, in southwestern Hillsborough County. Land use in southern Hillsborough County is predominantly agriculture and Cockroach Bay has historically received untreated agricultural stormwater runoff. Stormwater sampling of agricultural stormwater discharge was conducted in 1993 along Cockroach Bay Road just upstream of the site. The results of that sampling showed the highest nutrient concentrations of any land use sampled, 2.97 mg/l total nitrogen and 2.35 mg/1 total phosphorus. The Cockroach Bay Restoration project is aimed at restoring the ELAPP site, which had been altered for agricultural use and borrow pits, to productive upland and wetland habitats. It also includes construction of a stormwater treatment pond-marsh system to treat the agricultural runoff from the ditch along Cockroach Bay Road.

This project has been overseen from the start by a 17-member organization called the Cockroach Bay Restoration Alliance (COBRA). Members of this organization represent federal, state, and local agencies and also a citizens group, and decisions were usually made on a consensus basis. Funding for the project came from a number of sources. The land was purchased by the Hillsborough County Environmental Land Acquisition and Protection Program. Construction funds were from the following agencies: the United States Environmental Protection Agency (US EPA), 319 funding through the Florida Department of Environmental Protection (FDEP); the US EPA Coastal America program through the Tampa Bay National Estuary Program (administered by the Tampa Bay Regional Planning Council); the FDEP Pollution Recovery Trust Fund; and the Southwest Florida Water Management District SWIM funds. Additional funding assistance came as in-kind services from the Hillsborough County Roads and Streets Department and thousands of volunteers for planting projects.

The number of funding sources, along with the flow path of the money, resulted in delays in obtaining contract approvals and/or changes. Each funding contract had different contractual requirements, time frames, and funding provisions. For instance, the FDEP Pollution Recovery Trust Fund Contract was for two years, but in October of the first year, we were informed that the money would disappear that December. Therefore, we had to expend and invoice $200,000 worth of work in less than three months, whereas we thought we had 15 months remaining. The contracts for this project were particularly difficult because we had to work with the project manager for the contract, but also had to deal with attorneys, contracts staff, and fiscal staff for each agency in the funding chain.

To date the project has created 14 acres of stormwater treatment ponds and 18.5 acres of intertidal wetlands, with transitional and upland habitats. The objective of this portion of the project is to treat stormwater pollutants from the 21 0-acre watershed which is predominantly in agricultural land use. Another portion of the project which is completed is part of Phase I -A which involves the partial filling, reshaping , and planting of a borrow pit, and opening it to tidal flow. The balance of Phase I -A, the filling and reshaping of another borrow pit, and creation of upland habitats remains, as well as Phase- 1 C which is a future phase if we are able to locate a source of fill for a large borrow pit. SWFWMD is currently negotiating with the U. S. Army Corps of Engineers to obtain spoil from a dredging project for this future phase.

Was the project a success? It was certainly an extremely successful demonstration of interagency cooperation. Many of the COBRA members consistently attended monthly meetings of COBRA and/or its subcommittees. Agency personnel helped ensure that design and construction would yield a healthy, functioning ecosystem which would help protect and restore Tampa Bay. The numerous funding agencies demonstrated a willingness to make necessary changes to funding plans and schedules to accommodate a variety of delays and shifts in phasing. This was the largest environmental restoration project ever undertaken in Hillsborough County and the entire Tampa Bay Region and the project was completed ahead of schedule without any major problems, at a cost of $1,184, 142 less than the original cost estimate.

What about from a technical standpoint? According to *Charting the Course, the Comprehensive Conservation and Management Plan for Tampa Bay* "Despite progress in bay cleanup, nitrogen continues to be a key focus of concern for Tampa Bay". It further notes that agricultural land uses contribute 19% of the total nitrogen loading to Tampa Bay (65% of the load from Hillsborough County). Thus, the actual nitrogen load reduction due to this project, calculated to be 0.39 tons/year, as well as the value of the demonstration of the effectiveness of wetland treatment systems in treating agricultural runoff, are both extremely important to the efforts of the Tampa Bay National Estuary Program to protect and restore Tampa Bay.

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NONPOINT SOURCE MANAGEMENT FOR A NORTH FLORIDA LAKE: THE RETROFIT AND RESTORATION OF LAKE JACKSON

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Lake Jackson (Leon County, Florida) has been adversely affected by nonpoint source pollution resulting from residential, commercial, and highway development in its watershed. Various restoration and stormwater retrofit projects have been implemented to address problems from the past, and while these efforts may have slowed the rate of decline, much remains to be done.

Located immediately north of the City of Tallahassee, Lake Jackson is a solution basin lake with a drainage area of 43.2 square miles and a surface area of approximately 4,000 acres. The lake is long and irregular in width, ranging from one-half to two miles, and has two extensions in the southern part of the lake, Megginnis and Fords Arms. The surrounding hills are at elevations of 220-230 feet and the watershed is a closed basin - it has no water loss through surface water discharge points. Average depths of the lake are 8-12 feet with greater depths (20- feet) in two small steep-sided sinkhole depressions in the central part of the lake. The lake level is subject to wide fluctuation, from 76-97 feet NGVD, with the "normal" lake levels falling between 82-87 feet NGVD.

Lake Jackson's natural chemistry and ecological characteristics are typical of many lakes found in the Tallahassee Hills physiographic region and throughout north and central Florida. In a less culturally altered condition, Lake Jackson's water would be neutral, clear, soft, and have moderate nutrient values. The lake naturally had extensive macrophyte coverage and an excellent standing stock of gamefish; it is renowned throughout the southeast as a trophy bass fishery.

One of the unique features of Lake Jackson is its tendency to "disappear". In response to long-term climatological and hydrologic conditions, Lake Jackson naturally "dewaters" about every 25 years. The dewatering events are typically preceded by extended periods of below average rainfall during which water is lost from the lake due to surface evaporation and leakage to ground water. As drought conditions continue, the sinkhole(s) appear to drain the lake at a high rate, "swallowing" the remaining water in as little as two days.

In the early 1970s, urban and suburban growth began to spread northward from the City of Tallahassee into the Lake Jackson watershed. Runoff from two large shopping malls, extensive commercial strip development, residential development, and an interstate highway (I-10) began to impact the southern portions of the lake. The topographic relief of the southern watershed, combined with highly erodable soils, resulted in significant sediment loss from construction sites and regular discharges of highly turbid runoff into the relatively clear waters of the Lake Jackson.

During the early and mid- I 970s, a number of studies of Lake Jackson were performed by researchers from nearby state agencies and universities, all of which revealed extensive water quality and habitat impacts in the southern end of the lake. Most reports included warnings of impending problems and recommended the implementation of strict land use (zoning) controls and land development regulations to prevent the loss of pollutants from construction sites and developed areas. The studies documented increased nutrient levels, turbidity, and sediment deposition in the southern portion of the lake, along with depressed dissolved oxygen levels and degradation of aquatic habitat as the result of excessive macrophyte and algae growth.

Little was done to mitigate or prevent impacts until the early 1980s, when a large stormwater retrofit facility was installed by the Northwest Florida Water Management District (NWFWMD) and the Florida Department of Environmental Regulation in the Megginnis Aim basin. In the late 1980s, the NWFWMD developed a watershed plan for Lake Jackson under the State's new Surface Water Improvement and Management (SWIM) program. This planning effort has led to a higher level of coordination between local, regional, state, and federal agencies in their efforts to improve the condition of the lake. Also in the late 1980s and early 1990s, local governments (Leon County and the City of Tallahassee) implemented stringent watershed land use controls (density and intensity restrictions) and ordinances that require the installation of pollution controls to control runoff during and after site development.

Over the past ten years, a number of restoration and stormwater retrofit projects have been implemented in the Lake Jackson watershed. These include expansion and improvement of the Megginnis Arm stormwater treatment facility and installation of four other public regional stormwater treatment facilities; complete stormwater retrofit of a large shopping mall as part of an expansion project; removal (hydraulic dredging) of polluted sediment from Megginnis Arm; and revegetation of the Arm with native emergent species. Plans have been developed to install four additional stormwater retrofit facilities in the southern portion of the watershed and the pollution contribution from septic tanks in the watershed is currently being examined. All of the recommended stormwater retrofits for the 2,230-acre Megginnis Arm drainage area have been completed and efforts are currently underway to fully assess the effectiveness of the combined subbasin stormwater retrofit and restoration projects.

Preliminary data indicate that the quality of stormwater runoff entering Megginnis Arm has improved in recent years, but much work remains to complete all of the planned watershed stormwater retrofits and restore this and other impacted areas of the lake. Plans are being prepared to scrape polluted sediments from the lake bottom during the next natural dewatering event, and another upcoming project will involve the development of an ecological model of the lake to help with the establishment of Pollutant Load Reduction Goals. In summary, efforts to improve water quality and habitat are slowly being implemented, but the lake system is still quite stressed, especially in the southern end. Stay tuned for regular updates ......

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NOTES

TO DREDGE OR NOT ... AND THEN WHAT?
A MANAGEMENT PERSPECTIVE ON
THE INDIAN RIVER LAGOON., FLORIDA

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The 156-mile long Indian River Lagoon (IRL) estuary in east central Florida contains one of the most diverse fisheries in North America (Gilmore, 1987). One of several reasons for this large diversity is the distribution and abundance of seagrasses in the IRL. Unfortunately, there has been a general decline in seagrass coverage since the 1940s (Woodward-Clyde, 1994; SJRWMD seagrass maps of 1986-1994). The decline is most likely a result of a long-term increase in the water column attenuation of sunlight reaching the plants. This problem is most apparent in the hydrodynamically restricted central IRL (Merritt Island to Sebastian) where increasingly large inputs of nutrients, organic materials, and soils are the trend. Also, concomitant with the loss of seagrasses, the central IRL is rapidly accreting, fine-grained, organic-enriched sediment or muck.

Muck sediment is viewed as both a symptom and contributing source of this eutrophication.

- Muck can easily be resuspended, increasing turbidity in the water and blocking light to seagrasses. During the wet months (August - October), it is fairly typical to observe a two-fold increase in light attenuation in the central IRL compared to the north IRL (SJRWMD, unpublished data).

- Muck can flux appreciable loads of N into the water column, contributing to algae growth and exacerbating turbidity levels. For example, the annual flux rate of ammonia N from muck in the mouth of Turkey Creek (a large tributary in central IRL) is 2 metric tons. This is equivalent to one third of the annual surface runoff load of ammonia N from the creek's 100 sq mi basin (Trefry et al., 1992).

- Muck has a high oxygen demand, contributing to oxygen depletion in the water column (Trefry et al., 1992; SJRWMD unpublished data).

If there is any good news, it is the fact that muck blankets only -10% of the Lagoon bottom (from northern Mosquito Lagoon to just north of St. Lucie R. estuary, including the mouths of several major creek tributaries). However, over 65% of the muck is deposited in the central IRL, which is only 27% of the total length of the IRL and only 28% of the total IRL bottom area. The concentration of muck in the central IRL is linked to the high rate of development in south Brevard County, one of the highest rates among coastal counties. Muck is a result of this development because over 70% of muck sediment is eroded upland soils and organic material from wastewater treatment plants and vegetation. Furthermore, the age of the deepest layers of the muck is only about 40 years (Trefry et al., 1990), dating back to the onset of aggressive development in the basin.

The central IRL is the focal point for restoration activities including muck management. The strategy for removal and control of muck consists of a sequence of actions that traces the general path of muck from source to sink. A substantial amount of muck material, thousands of metric tons every year, are conveyed through creek tributaries of the central IRL. For decades, the lower reaches of these creeks have served as traps, retaining a large amount of muck and saving the IRL from the full burden. The muck that escapes to the IRL eventually settles in deep areas like the Intracoastal Waterway and other depressions. The creek traps are now quickly filling in (e.g., muck depths exceed 10 ft in Crane Creek and 15 ft in Turkey Creek) and muck migration rates to the IRL may increase. The first series of management actions involve cleaning out the traps, restoring the creeks' storage capacities, and implementing source controls in the watersheds to impede muck deposition in the creeks and the Lagoon. The next consideration would be dredging major deposits in the Lagoon where water quality and seagrasses are impacted by muck resuspension and dispersion.

But, following muck removal, the real challenge begins -- disposal. Fortunately, nearly all the muck deposits surveyed are not considered highly contaminated or hazardous. In fact, considering its general upland sources, muck should be regarded as a beneficial resource to be used not as landfill spoil. An investigation has shown a positive response of bermudagrass and other horticultural species grown in IRL muck. Because of its physical and chemical properties, muck has potential as a topsoil amendment for nurseries, golf courses, roadway medians, and other green spaces.

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NOTES

CLEANING UP THE NEUSE RIVER

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Since late 1995, the North Carolina Division of Water Quality has been developing an historic initiative to achieve a 30 percent reduction in the nitrogen loading reaching the Neuse River estuary. This plan, called the Neuse Nutrient Sensitive Waters (NSW) Management Strategy, requires that this reduction be achieved within five years of its implementation date (expected August 1998).

One of the principles of the Neuse NSW Strategy is that each source of nitrogen to the Neuse River must do its share to meet the 30 percent reduction. Therefore, the NSW Strategy includes requirements for all the major recognized and controllable sources of nitrogen. The following is a summary of these requirements:

1. Point sources, such as wastewater treatment and industrial plants, discharging more than 0.5 million gallons of wastewater per day will have to optimize their facilities for nitrogen removal and then meet a "mass-based" nitrogen limit in terms of pounds per year. The mass-based load will be determined using each plant's permitted flow in 1995. Dischargers will have the option of meeting the mass-based load collectively through a coalition of dischargers or paying offset fees to fund nonpoint source nitrogen controls.

2. Owners and operators of agricultural lands will have two options -- either become part of a collective local strategy for implementing best management practices on their land, or implement standard best management practices as specified by the rule. Local farming strategies implemented under the collective option will be coordinated by a multi-agency Basin Oversight Committee. The Committee will be responsible for assisting in targeting reductions so they can be achieved in the most cost-effective manner while quantifying and reporting reductions.

3. The basin's most populated and rapidly growing cities, towns, and counties will be required to develop and implement local stormwater management programs. These local stormwater programs will have to address nitrogen control on new developments and include components such as public education and protection of existing riparian areas.

4. A nutrient management program will be implemented for individuals who apply nutrients to 50 or more acres of residential, agricultural, commercial, recreational, industrial, or right-of-way land per year. These people will be required to successfully complete nutrient training administered by state agencies or develop nutrient management plans for the lands where fertilizer is applied.

5. All landowners are required to protect 50-foot riparian areas with existing forest vegetation. These areas include 30 feet of undisturbed forest vegetation plus 20 feet of either grass, trees or other vegetation.

One of the biggest challenges in implementing this strategy will be to account for nitrogen reductions. The accounting process will be refined as the Division increases its knowledge about the dynamics of nitrogen movement in the environment and the effectiveness of best management practices.

NOTES

VERTICAL LEAKAGE FROM KARST LAKES IN FLORIDA

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Vertical Leakage. In the karst lake district in peninsular Florida, as many as 70 percent of the lakes lack surface outlets, and groundwater outflow is an important part of the water budgets of these seepage lakes. Even in drainage lakes, from which losses also occur by surface water outflow, the groundwater outflow component can be relatively large, and some drainage lakes lose nearly as much water via groundwater outflow as they do via surface water outflow. In a lake that interacts with the groundwater system, the principal inflows are precipitation, surface water inflow, direct runoff (i.e., overland flow) into the lake, and groundwater inflow from the surficial aquifer, and the principal outflows are evaporation, surface water outflow, and groundwater outflow. In a lake groundwater system that is typical of many lakes in Florida, a large part of the groundwater outflow occurs by means of vertical leakage from the lake through the surficial aquifer and an underlying confining unit to the deeper, highly transmissive upper Floridan Aquifer. In a water budget for this type of lake, the change in storage dS/dt is balanced by the sum of the inflows and outflows expressed as:

$$dS/dt = P + Is + R + Ig - E - 0s - 0g - L \qquad (1)$$

where dS/dt is the change in lake storage with respect to time, P is precipitation, 4 is surface water inflow, R is direct runoff, Ig is surficial aquifer inflow, E is evaporation, 0s is surface water outflow, 0g is surficial-aquifer outflow, and L is the vertical leakage from the lake to the underlying upper Floridan Aquifer. The vertical leakage can be described in terms of Darcy's equation written for vertical flow (Motz, 1998) or:

$$L=(Kv/b)\ \Delta h \qquad (2)$$

where Kv/b is the vertically-averaged vertical conductance of the units between the bottom of a lake and the upper Floridan Aquifer, and Δh is the difference between the water-surface elevation (or stage) of a lake and the hydraulic head in the upper Floridan Aquifer. The Kv/b value for a lake includes the influence of all the units between the bottom of the lake and the top of the upper Floridan Aquifer. If the leakance (K'/b') of the confining unit is significantly less than the conductances of other units that may be present, then Kv/b = K'/b'.

Water Budgets for Four Lakes. Water budgets for August 1994 to July 1995 have been determined for four lakes (Lowry, Magnolia, Brooklyn, and Geneva) in the Upper Etonia Creek Basin (UECB) in north-central Florida (Annable et al., 1996). In the UECB, lake levels and groundwater levels in the surficial aquifer generally are higher than the hydraulic heads in the upper Floridan Aquifer, and the UECB is a major recharge area for the upper Floridan Aquifer. The water budget components for each of the lakes were determined from monthly water level measurements at 35 shallow wells, calculation of surficial aquifer inflows and outflows from Darcy's equation, rainfall measurements, pan evaporation measurements and pan coefficients, direct measurements and estimates of stream flow, estimates for direct runoff, and stage-area and stage-volume relations for the lakes. Leakage from each lake to the upper Floridan Aquifer was calculated as a residual in the water budget equation (Equation 1). Values for K, /b for each lake were calculated using lake-stage elevations, hydraulic heads for the upper Floridan Aquifer, and Equation 2.

Results and Conclusions Values for vertical leakage ranged from 0.19 m/yr at Lake Geneva to 1.99 m/yr at Lake Brooklyn. These values range from 5.7-19.7 percent relative to the other terms in the water budgets (Equation 1) for these two lakes. Values for Kv/b range from 0.064 yr^{-1} at Lake Geneva to 0.3 51 yr^{-1} for Lake Brooklyn. If Kv/b is determined for a lake, then vertical leakage can be estimated for other conditions of lake stage and hydraulic head in the upper Floridan Aquifer, using Kv/b for the lake and Darcy's equation written for vertical flow (Equation 2). The impact that changes in vertical leakage can have on other components in the water budget, such as lake storage and stage, could be investigated using Equation 1. Also, if Kv/b is determined for a lake, then pumping from the upper Floridan Aquifer to augment lake levels could be evaluated using Equations 1 and 2.

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NOTES

HOW TO SOLVE TOUGH WATER QUALITY PROBLEMS WITH COMMUNITY INVOLVEMENT

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Urban nonpoint source pollution is often very difficult to resolve. Even the best-laid plans sometimes do not seem to be effective. This stems from the diverse nature of the sources, jurisdictions and scope. An approach that will produce effective solutions includes coupling highly managed and systematic community action planning with project management techniques. Community members include groups that have a stake in the outcome, such as residents or business owners within a watershed, and government agencies that have jurisdiction and responsibilities for regulation and inf1rastructure. Bringing the community together to work for specific, common objectives is a powerful force.

Estuaries located downstream from intensely urbanized watersheds are commonly degraded by nonpoint sources. The potential sources are well known. They include untreated stormwater runoff poorly treated wastewater, poor housekeeping, and illegal waste disposal. Often, the nature of the contamination has been documented through water quality monitoring programs. It is not unusual for a situation like this to be described in some detail with a call for action in some type of plan. Obvious problems call for obvious solutions. Yet, while people agree that something must be done, years go by with no effective solutions. In some cases, people grow impatient with studies and planners. They want action. A carefully managed process that involves community members, clearly defines the root causes of the problems, obtains commitments and follows through with specific actions can be effective.

In twenty years experience, the author has observed six reasons why plans fail to fix water pollution problems in urban areas. The geographic scope may be too large and encompass too many problems with a large cumulative price tag. Trying to fix every problem in a watershed dilutes the effort. Even if effective work is being accomplished, the results are undetectable. Secondly, the causes of pollution are not defined specifically enough or are unknown. For example, a plan may identify stormwater runoff as a problem, without indicating which particular outfall needs to be retrofitted. Therefore, no one is obligated to fix it. Thirdly, the plans often omit specific water quality success criteria, or where they do, there is no mechanism to track and report results on a regular basis. This lets everyone off the hook- Unfortunately, sometimes completion of the "plan" document itself is considered the primary goal. A true plan is a commitment to accomplish something. Fourth, experts are not utilized effectively or their time is wasted. Serious plans normally establish some combination of citizen or interagency group that steers the work. It is essential, however, that the work be accomplished by experts. Unless experts are brought into the process and utilized in an efficient manner, the group may never understand how to make the solutions feasible and waste much time on the wrong track. An expert's time is valuable and should be used wisely, otherwise it may not be available when truly needed. Fifth, while it may not be difficult to obtain consensus on what should be done, it is a different matter to get firm commitments from government agencies or private groups to take action. A process that does not press for firm commitments in terms of participation, funding, and time lines is useless. Lastly, more often than not, plans are static documents. Many planning documents are gathering dust in the archives of government agencies. Plans should be updated on a regular basis to adapt to new information and redirect effort to priority problems.

An effective community action plan to improve water quality in a tributary will include several essential elements. Working with a group that has been given the responsibility to oversee restoration of a water body, a manager will need to: (1) prioritize drainage basins based upon water quality degradation; (2) select and delineate a basin, subbasin, or an area small enough that is manageable; (3) identify and characterize the problems; (4) assemble project teams and project plans for each area of responsibility; and (5) track and report progress. Steps I and 2 are the easiest to accomplish. Even if no actual water quality data exists, results from surveying knowledgeable people can be substituted. The focus needs to be on a geographic area small enough to manage, but with the worst problems. It is essential that resources be focused into one place. Step 3 will require intensive information gathering and synthesis, but identifying and interviewing the right expert can save time. An example of this might be a city engineer who has been on the job many years and can describe precisely what is fundamentally wrong with a stormwater system. The group must not be content with general descriptions, but should press for very specific information, so that the root causes of water quality degradation are accurately characterized. This may include a chain of dependencies. Step 4 will require identifying the proper experts for each team based on the identified issues. The project team will craft a complete project plan to implement a necessary fix. A team leader must be designated that will report progress back to the steering committee. For example, a small team of local government engineers would create a project plan to design and build improvements to a specific stormwater system based on criteria provided. This plan would be approved by the steering committee and incorporated into the overall water quality improvement plan. Since the engineers crafted the project, it should be technically correct, feasible, and the team will have ownership. Success is highly likely and the engineer's time is not wasted by including them in planning outside their field of expertise. Finally, the steering committee must adopt success criteria. A project team may be used to accomplish this. While it is ideal to link improvements to some biological target such as expanded seagrass beds, the science and expense of doing this is often not practical. In its simplest form, success criteria can be numeric water quality concentration targets that, based on professional opinion, are protective of biological communities. A low cost monitoring program should be designed and implemented. The results should be posted against the targets at each meeting and perhaps on the Internet. Tracking progress keeps the work focused on the correct goal and serves to document achievement.

The community holds the power to fix tough water quality problems in urban areas. The tools are available. What is needed is a leader with a clear vision and stamina to guide them. When people are involved in a planning process that is not ambiguous, and they can clearly see progress, enthusiasm results. This leads not only to a sense of pride of accomplishment, but facilitates funding and partnership. Since all urban estuaries suffer from essentially the same kinds of water quality degradation, this process can be adapted to any of them. The process works. It requires the commitment of someone willing to lead the way.

NOTES

THE RODMAN RESERVOIR CONTROVERSY: IMPORTANT ISSUES AND A REVIEW OF THE EXISTING EVIDENCE

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Rodman Reservoir, a 9000-acre impoundment created as part of the Cross Florida Barge Canal Project, has become a controversial subject between citizens who want to preserve the reservoir for recreational and wildlife purposes and those who want a restored Oklawaha River and its associated benefits. This presentation addresses some important issues concerning the Rodman Reservoir controversy and examines evidence supporting or refuting those issues. For over 20 years, each side has invoked the name of science to add credibility to their arguments. However, misrepresentation of the facts to influence not only the value judgments of individuals, but also Florida's policy makers, has been documented in the published literature.

A large amount of ecological data has been collected on Rodman Reservoir and the Oklawaha River over the past 20 years. We have reevaluated most of the existing information in preparing this paper. What becomes obvious is that most of the studies conducted had problems in design and data interpretation that are directly attributable to the philosophy of the individuals conducting the studies. Many of the studies did not have well-defined, testable hypotheses and did not attempt to determine if there were alternative explanations. A number of reports had conclusions that were not supported by the author's own data.

For example, proponents of restoration claim that the fish population in Rodman Reservoir is declining and that rough fish have replaced sportfish. However, based on recent biomass estimates provided by the St. Johns River Water Management District, over 60% of Rodman Reservoir's fish population is sportfish. Restoration proponents also claim that the Oklawaha River supports more fish species than Rodman Reservoir; however, routine sampling from 1992 to 1994 collected 38 species from Rodman Reservoir and 35 species from the Oklawaha River. Claims that fishing in a restored Oklawaha River will be as good as in Rodman Reservoir are not supported by the evidence. The Florida Game and Fresh Water Fish Commission documented the sport-fishing use of Rodman Reservoir (281,611 person-hours) was 4.5 times greater than the use of the Oklawaha River (62,209 person-hours) and that angler catch, harvest, and success was better in Rodman Reservoir.

We, as scientists, cannot let this stand because it hurts the scientific process. We believe that science and scientists should inform the public and policy-makers of the facts and what the consequences of individual management actions might be. Consequently, in this paper we attempted, to the best of our abilities, to fairly evaluate the facts as they exist.

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NOTES

ECOLOGICAL ASPECTS OF THE PROPOSED OCKLAWAHA RIVER RESTORATION

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Historically, the Ocklawaha River flowed from its headwaters in Lake Griffin to its confluence with the St. Johns River. During the construction of the Cross Florida Barge Canal, two dams were constructed along the lower reaches of the river. Only one of the dams was ever closed and this dam created the Rodman Reservoir in 1968.

The impounded area between Eureka and Rodman dams is classified into three major types of systems: the riverine portion immediately downstream of Eureka, followed by the transitional area, and the open water lacustrine system that is most commonly referred to as the reservoir area. The riverine and transitional areas are still predominantly forested by floodplain swamp species and the historic river channel is the main conduit for navigation. The lacustrine portion is predominantly open water, with a submerged river channel, and vegetated primarily by submergent and emergent herbaceous vegetation; freshwater swamps are limited to the shoreline, with hydric hammock communities along the upland edge.

The Department of Environmental Protection proposes to restore the Ocklawaha River in the area between Eureka and Rodman dams. The 1994 St. Johns River Water Management District study on alternative management plans for the Rodman Reservoir recommended "partial restoration", meaning restoring river hydrology and floodplain functions through breaching of the dam with only limited earthwork and removal of other structures. The Florida Legislature then directed the Department to design and permit this restoration alternative. The resulting plan, which incorporates the current restoration body of knowledge with both existing conditions and the restoration recommendation, is currently undergoing permit application review.

The restoration proposal is based on three drawdown phases. Each phase is designed to be accomplished within a year, allowing for a three-month drawdown period between October and December. The first phase will draw down the water level from normal elevation of 18 ft. NGVD to 12 ft NGVD, which is one foot lower than the past maintenance level drawdowns. The second drawdown will reduce the water level to approximately 6 ft. NGVD. The final drawdown will equalize the water level of the reservoir with that of the natural river channel downstream, about 4 ft. NGVD. Prior to each drawdown, unconsolidated sediments upstream of the dam will be removed by a suction dredge and deposited in an upland disposal site, to minimize sediment resuspension and to provide a sealing area for additional sedimentation during each future drawdown. During each drawdown phase, there will be limited construction of channel stabilization and erosion control structures, along with planting of native species of trees to provide for erosion control, at multiple locations. The dredged Cross Florida Barge Canal will be backfilled where it intersects with the historic river channels of the Ocklawaha, Deep Creek and Sweetwater Creek, in order to restore the flow in those channels. The channel and floodplain of Camp Branch will also be restored by backfilling the Cross Florida Barge Canal west of Buckman Lock. The removal of the spillway structure and 2,000 linear feet of the earthen dam will be one of the last physical steps in the restoration plan.

The phased approach provides maximum control over water quality, erosion, and nuisance vegetation control. Re-establishment of native plant communities over time is also enhanced by exposing additional areas of historic floodplain each year rather than exposing all of the floodplain at one time.

The proposed restoration of nearly 7,200 acres of currently inundated floodplain will restore the natural hydroperiod and, over time, will enhance wildlife habitat. Riverine floodplains are unique in their high species diversity, density, and productivity. Ecological functions provided by floodplains, such as those areas upstream and downstream of the Rodman Reservoir, also include attenuation and gradual release of floodwaters, organic carbon production, periodic pulses of particulate nutrients, and structural habitat diversity. During and immediately after the final drawdown, the dominant vegetation on the newly exposed floodplain will be herbaceous. Areas that are not re-vegetating naturally will be seeded with native herbaceous species to control erosion; certain critical areas will be planted with woody species for channel stabilization. Within 25 years, those trees planted to control erosion will have matured and contributed to the seedbank of the floodplain. In addition, other trees and shrubs will become established through seed contribution of upstream and nearby forested communities. As the tree species mature and shade-out the herbaceous community, the floodplain swamp will eventually resemble that community in the portions of the Ocklawaha River upstream and downstream of the site.

Restoring the natural floodplain structure of the Ocklawaha River will have a positive effect on a wide range of native wildlife species. Benthic invertebrate populations in the reservoir are relatively stable, whereas both diversity and abundance are expected to increase after restoration. The fish population would shift from the relatively few species of lacustrine zone to a more diverse assemblage characteristic of riverine systems; in addition, migratory species such as American eel and striped bass would also be expected to increase. Bird species utilizing the area would be expected to shift as habitat is provided for terrestrial species and tree-nesting species, such as the wood duck; in addition, riverine and swamp habitat will be increased for limpkins. The removal of the reservoir/dam and the restoration of the riverine forest has the potential to benefit two aquatic mammals - the river otter and West Indian manatee.

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THE CASE FOR RESTORING
THE OCKLAWAHA RIVER

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In the mid 1960s, the Rodman Dam was built as part of a failed attempt to construct a Cross Florida Barge Canal. This act crippled one of the great rivers of Florida, severely damaging many species of fish and wildlife, as well as the recreational resource that had supported ecotourism on the St. Johns, Ocklawaha, and Silver Rivers for more than 100 years.

A number of studies have been done, and all of them support restoration and conclude that the river can be restored. The issue at hand, then, is whether to maintain the river and Rodman Reservoir as they are now at considerable expense to both the tax payer and the environment, or whether to restore the river and its floodplain forest at considerable expense in terms of both money and the time that it will take for restoration to occur.

How do these two alternatives compare in terms of wildlife, endangered species, water conservation, other environmental considerations, economics, and recreational potential? We have time to discuss only the wildlife and endangered species issues.

Wildlife The reservoir provides more habitat than the river did for bass, bream, gizzard shad, greater siren, pig frog, leopard frog, Florida softshell turtle, banded water snake, ribbon snake, alligator, bald eagle, osprey, anhinga, great blue heron, tri-color heron, great egret, snowy egret, lesser scaup, ring-necked duck, pied-billed grebe, double-crested cormorant coot, common moorhen, ring-billed gull, tree swallow, red-winged blackbird, common grackle, boat-tailed grackle, fish crow, and round-tailed muskrat.

The river and river floodplain provided more habitat for stripped bass, channel catfish, American eel, bluenosed shiner, southern tessellated darter, southern toad, squirrel tree frog, pine woods tree frog, Florida box turtle, green anole, ground skink, broadheaded skink, brown water snake, rainbow snake, yellow rat snake, Acadian flycatcher, great-crested flycatcher, barred owl, redshouldered hawk, swallow-tailed kite, wild turkey, yellow-billed cuckoo, downy woodpecker, yellow-bellied sapsucker, red-bellied woodpecker, pileated woodpecker, Carolina chickadee, tufted titmouse, Carolina wren, house wren, ruby-crowned kinglet, blue-gray gnatcatcher, American robin, hermit thrush, veery, solitary vireo, red-eyed vireo, parula warbler, yellow-throated warbler, black-and-white warbler, prothonotary warbler, summer tanager, cardinal, white-tailed deer, black bear, wild hog, gray squirrel, flying squirrel, raccoon, opossum, southeastern myotis, red bat, Seminole bat, and evening bat.

There are many species, such as river otter and limpkin, which occur in both situations to such an extent that it is impossible to say for sure which is better. There are also species, such as the stripped bass and channel catfish, which are prevented from occurring in areas upstream from the Rodman Reservoir area. The natural movements and migrations of many species have been interrupted by the dam and reservoir.

Overall, it is clear that wildlife has been hurt far more than it has been helped by maintaining the dam and reservoir.

Endangered Species. The only species clearly affected either way that are listed as endangered are the manatee, which has been disastrously impacted by the lock and dam (at least nine have been killed by the lock or dam), and several plant species that occurred along deep creek and may have been eliminated from part of their former range. Several threatened species are impacted, but to a lesser extent. The bald eagle is benefited to a slight degree by the reservoir, but this is not significant for the species according to the U.S. Fish and Wildlife Service and the Florida Game and Fresh Water Fish Commission, because there is an abundance of unused and under-used eagle habitat within easy flying distance. Black bears are also listed as threatened, and they lost both habitat and a safe travel corridor when the reservoir was created. Alligators are benefited by the reservoir, whereas indigo snakes are hurt (both are listed as threatened).

On balance, the impact of the dam and reservoir on listed species has been very bad, with the worst impacts affecting the most highly endangered species.

Whether or not the Rodman Reservoir can be managed to produce large bass is irrelevant to whether or not we should restore the river system. North Florida has an abundance of lakes and very few, if any, river floodplain systems like the Ocklawaha. Throughout North Florida, a major effort at restoring natural systems and restoring native wildlife habitats is underway. Maintaining the Rodman Reservoir is inconsistent with these land protection and restoration efforts, and with the policies and objectives of the State of Florida. A number of studies of the issue have been done by various state and federal agencies, and none have recommended keeping the dam or asserted that managing the fishery is worth the environmental costs.

NOTES

BUFFERS - AN IMPORTANT BEST MANAGEMENT PRACTICE FOR CONTROLLING NONPOINT SOURCE POLLUTION

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Even though nitrogen is an essential nutrient, too much of it in surface waters can cause "overfertilization" of plants that then deplete oxygen in the waters. When oxygen levels in the waters get too low, they can kill fish and other animals and plants. Restoring the health of impaired waters is crucial to the environmental and economic health of the State of North Carolina. In North Carolina, numerous well-known scientists have been documenting the effectiveness of vegetated riparian areas ("buffers") in removing nitrogen from waters.

A "riparian area" simply means the land directly adjacent to a stream, river, lake, or estuary. Riparian areas that contain a dense cover of trees and other plants are highly effective at removing nitrogen before it reaches the water. The reason is most nitrogen travels just below the ground's surface. The extensive roots from trees and other plants and high denitrification potential remove a very high percentage, scientists estimate up to 80 percent, of dissolved nitrogen before it reaches the water. Buffers can also help stabilize streambanks and provide aquatic and wildlife habitat. Research has shown that a corridor of vegetation can be effective for buffering valuable aquatic resources from the potential negative impacts of adjacent land.

Riparian buffers are composed of forest, herbaceous vegetation, or both. In buffer design, width is considered the most important controllable variable in determining the effectiveness of buffers in reducing pollutants and protecting stream health. Buffers that are too narrow may not be sustainable or effective to filter nitrogen and protect streambanks. On the other hand, buffers that are wider than necessary are unpopular with landowners. Factors influencing optimal buffer width include topography, hydrology, geology, and land use. Additional factors, such as the value of the water resource and adjacent land, must be considered when determining widths.

One of the most widely recognized buffer planning models is the three-zone concept that has been implemented in the Chesapeake Bay Program. Zone 1, a permanent forest buffer immediately adjacent to the streambank which provides detritus to the stream, helps maintain lower water temperature vital to fish habitat and provides streambank stability. Zone 2, a managed forest immediately upslope from Zone 1, is the primary area for the removal of nutrients and sediments carried in surface runoff and shallow groundwater. Zone 3, a herbaceous or grass filter strip upslope from Zone 2, helps to convert concentrated flows into dispersed flows and trap sediments.

Currently proposed buffer requirements in North Carolina use a two-zone design: forested vegetation near the stream, and a combination of herbaceous and woody vegetation away from the stream. The proposed buffer width in North Carolina is 50 feet: 30 feet of zone 1 (forest vegetation) and 20 feet of zone 2 (herbaceous and woody vegetation). The design also depends on the stream order and land area that drains to the riparian areas. The larger the drainage area, the wider the buffer width. It is also very important to protect the small streams with buffers, since most nonpoint source pollution enters the river system through small streams.

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IMPLEMENTING BUFFER PROTECTION IN THE NEUSE RIVER BASIN

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On December 11, the Environmental Management Commission (EMC) approved an historic initiative -- the Neuse Nutrient Sensitive Waters (NSW) Strategy. This Strategy consists of nine separate rules that, together, are designed to achieve a 30 percent reduction in the nitrogen reaching the Neuse River. Even though nitrogen is an essential nutrient, too much of it in the Neuse is causing "overfertilization" of plants that are depleting the water of oxygen. When oxygen levels in the waters get too low, fish, animals, and plants can be destroyed. Restoring the health of the Neuse River is crucial to the environmental and economic health of our state.

The rule for protection and maintenance of riparian areas is one of the most important parts of the Neuse River nutrient management strategy. A 'riparian area" simply means the land directly adjacent to a stream, lake, or estuary. Riparian areas that contain a dense cover of trees and other plants are highly effective at removing nitrogen before it reaches the water. The reason - most nitrogen travels just below the ground's surface. The extensive roots from trees and other plants remove a very high percentage -- scientists estimate up to 80 percent - of dissolved nitrogen before it reaches the water.

Although most of the rules that are part of the Neuse Strategy are scheduled to become effective in August 1998, the EMC believes that the riparian area rule deserves immediate action. Therefore, the Commission adopted minor clarifications to the existing rule requiring protection and management of riparian areas right away. These clarifications will become effective on January 22.

The riparian area rule deems it illegal to remove existing "forest vegetation" in the first 30 feet of land directly adjacent to a storm or other waterbody (known as "Zone 1 ") except in certain situations. "Forest vegetation" means not only trees, but also shrubs, saplings, and herbaceous plants such as vines and grasses. Some situations where forest vegetation in Zone 1 may be disturbed include removing individual diseased trees or particular trees in danger of damaging dwellings or the streambank. A very limited amount of harvesting is allowed in the outer 20 feet of Zone 1.

Zone 2 consists of an additional 20 feet on either side of the stream which is required to have a dense plant cover. For both zones of the riparian area, the landowner or caretaker is required to keep the trees and plants healthy and to promptly repair any eroded channels. Eroded channels short-circuit the riparian area's capability to remove nitrogen.

The rule for Protection and Maintenance of Riparian Areas with Existing Forest Vegetation species activities that are allowed in the two zone. In Zone 1, minimal harvesting of trees is allowed. In both Zones 1 and 2, certain public uses such as road crossings, bridges, and airport facilities are allowed if there is no practical alternative and the structures minimize impacts to water quality. Activities that are now allowed in either zone include new development and fertilizer use. Periodic mowing is allowed only in Zone 2 as long as water quality is not compromised.

The Division of Water Quality will cooperate with other state agencies and local governments to implement this riparian area rule, such as the state programs for Sediment and Erosion Control and the Forestry and Coastal Protection.

NOTES

SILVICULTURE BEST MANAGEMENT PRACTICES: MONITORING FOR EFFECTIVENESS

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Florida's Silviculture Best Management Practices (BMP) Program was established in the mid-1970s as a result of the 1972 Federal Clean Water Act. Under delegation by the Florida Department of Environmental Protection, the Florida Division of Forestry has responsibility for BMP development, implementation, and monitoring. This statewide program was originally designed for the purpose of controlling non-point source water pollution associated with forestry operations, through the use of BMPs. Florida's first Silviculture BMP Manual was published in 1979 and served as the basis for the program until revised in 1993.

The BMP revision process was conducted by a Technical Advisory Committee composed of representatives from state and federal government, forest industry, private non-industrial landowners, environmental groups, and academia. Florida's new Silviculture BMP Manual now addresses 14 categories of forest operations, six of which were not included in the original BMP Manual. In addition, new criteria for "Special Management Zones" were developed, along with Wetland BMPs, to provide protection for overall ecosystem integrity and wildlife habitat, as well as water quality.

The Division of Forestry (DOF) is also responsible for BMP implementation, which is essentially an educational/training exercise to transfer BMP technology to forestry practitioners. Implementation, primarily through BMP workshops, is an on-going part of the BMP program and is carried out on a request basis, or when specific needs are identified through monitoring.

Since 1981, the DOF has monitored forestry operations for compliance with BMPs by conducting biennial Compliance Surveys. The purpose of these "Surveys" is to determine statewide compliance with Silviculture BMPs by evaluating a random sample of forestry operations. For the period of record through 1995, the DOF has evaluated over 1, 100 individual forestry operations and recorded statewide compliance ranging from 84% (1985), to 96% (1995). The cumulative, statewide average for compliance with Silviculture BMPs is 91%.

While the Compliance Survey serves the purpose of measuring implementation success, there is also the question of BMP effectiveness. To address this question quantitatively, the DOF developed a BMP *Effectiveness* Study which was initiated in September 1995. The study involved 17 cooperating agencies, organizations, and forestry companies, and had the purpose of evaluating the effectiveness of BMPs to protect aquatic (stream) ecosystems associated with intensive silviculture operations.

Four sites were selected in major ecological sub-regions of Florida, and included conditions of steep topography and moderate to highly erodible soils. Each site was associated with a small order stream immediately adjacent to an area scheduled for silviculture treatments, and each stream was sampled before and after treatments, and at points above and below the treated area. The treatments at each site consisted of clearcut harvesting followed by intensive mechanical site preparation and machine planting. Sampling consisted of a biological assessment to measure water quality and overall stream health.

In February 1996, a bioassessment was conducted on all four sites prior to the silviculture treatments. Sampling for the bioassessment at each site was conducted at several points along each stream, both above and below the treatment area, to account for natural in-stream variation. In addition, each site was given a stream habitat assessment and a Stream Condition Index (SCI) value. Silviculture treatments were completed in the spring and summer of 1996, and all four sites were planted in the winter of 1996. All applicable BMPs were implemented during the silviculture treatments, and included those BMPs associated with roads, stream crossings, site preparation, timber harvesting, and tree planting. According to the BMP Manual, three of the sites required a 35 ft Special Management Zone (SMZ), and one site required a 200 ft SMZ.

In February 1997, the four study sites were re-sampled and the data was analyzed by the Florida Department of Environmental Protection. Comparing the SCI before the silviculture treatments with the SCI after treatments showed no statistically significant difference for all four sites. Based on the SCI, three of the sites rated "excellent" before and after the forestry operations, and one site rated "good" before and after treatments. Likewise, the aquatic habitat assessments showed no major habitat changes attributable to the forestry operations.

In conclusion, this study shows that BMPs associated with the silviculture operations performed were effective in protecting and maintaining the water quality, aquatic habitat, and overall stream health of these sites. In addition, because these sites were selected to represent a variety of common, high-pollution-potential conditions, there is reason to expect these BMPs to perform equally as well on other sites. Hence, the study supports the hypothesis that proper application of BMPs, even on "high risk" sites with intensive silviculture, provides adequate protection to adjacent stream systems.

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NUTRIENT BALANCE FOR A DAIRY WASTE MANAGEMENT SYSTEM

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Current and proposed environmental regulations in Florida are encouraging better dairy design by forcing dairies to improve handling of their animal wastes. The primary objective of a modem dairy waste management system is to manage the waste in a way that minimizes surface or ground water contamination while maintaining the economic vitality of the farm. This is usually done by maximizing the beneficial use of the nutrients in the waste. To achieve this goal, it has become necessary to better understand the nutrient balances throughout the farm where nutrients from manure could potentially move to either surface or ground waters. These areas are typically where the manure/waste is applied to the land, such as in the pastures, sprayfields, and solids application areas. A nutrient balance is needed to ensure that the soil and plant system will uptake, bind, and volatilize sufficient nutrients to minimize nutrient transport during stormwater events. The two primary nutrients of concern in animal waste are nitrogen N and phosphorus (P) because of their relatively high content in dairy manure and potentially adverse impacts on receiving waters. To gain a better understanding of the effectiveness of various components of dairy management systems for controlling nitrogen and phosphorus losses to surface and ground water, a one-year study was conducted at a typical North Florida dairy (Bottcher, 1995).

Project Objectives. The long-term objective of this project is to prevent water quality problems from dairy waste management systems while optimizing the use of waste for profitability. The approach for achieving this objective is to gain a better understanding of spatial and temporal manure deposition patterns and how the N and P are deposited, transformed, and transported through the various components of a dairy waste management system. Knowledge of the N and P dynamics, within the various waste system components specifically, will allow for the assessment of the relative efficiency of each component to collect, transport and/or transform the nutrients, as well as overall system performance. The following specific tasks were completed to provide the information necessary to evaluate one Florida dairy's waste management system's performance with regard to nutrient management:

1. The amount of N and P in manure generated by the lactating herd on a dairy was estimated.

2. The amounts of raw manure deposited in all areas accessible to the lactating cows were estimated by tracking cows and counting their defecations and urinations.

3. The amount of N and P entering the waste management system from the manure collection areas was measured and compared to deposited manure amounts to evaluate the relative losses in the collection.

4. The amounts of N and P contained in the solids being removed from the solids separator were measured by subsampling.

5. The amounts of N and P contained in the effluent being pumped from the waste lagoon to a sprayfield were measured and compared to amounts entering the lagoon.

6. The atmospheric losses of land-applied waste effluent for a period of 30 days after application were measured using replicated soil-matrix volatilization (SMV) pans.

7. The atmospheric losses of land-applied raw manure in a pasture/holding area for a period of 30 days after application were measured using SMV pans.

8. A final N and P balance, including removal and transport efficiencies, for the various components of the waste management system was developed.

The project determined by physical observation where the manure (urine and feces) was being deposited. The nitrogen and phosphorus flows through the waste management system were measured at the milk parlor, leaving the waste lagoon, and on the surface of the sprayfield. Measurements were taken over a 24-hour period four times during the year. The nutrient losses of urine and feces within the various components (i.e., sprayfield, pastures, dirt holding lots, and concrete floors) were determined using replicated SMV pans -study where nutrient levels were tracked over 30 days. These studies were done four times during the year to evaluate seasonal effects. Overall, a mass balance of feed inputs and milk and animal exports determined nutrient input and outputs to the dairy.

Results. The study found that cows urinate and defecate about 9 and 12 times, respectively, fairly uniformly throughout the day. Therefore, for design purposes, the study verified that time spent in an area could be assumed proportional to the waste deposited there. The SMV tests showed that about a 50% loss of nitrogen due to volatilization will occur for fresh manure deposited in a field and for manure going through a waste management system using a sprayfield.

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NOTES

CONTROL OF STORMWATER
POLLUTION SURROUNDING LAKES, RIVERS,
STREAMS, AND OTHER WATERWAYS

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Purpose Stormwater runoff from impervious roads, such as asphalt and concrete, is a major pollution source to lakes, rivers, streams, and other waterways. In lakes surrounded by asphalt roads, the first-flush of rainfall contains the greatest pollution elements, such as hydrocarbons, heavy and light metals, and sulfur. The heavy and light metal pollutants are well documented and the sulfur content affects the acid level of lake waters.

This pollution is an on-going malady, since asphalt roads are composed of hydrocarbons that continuously rise to the surface. Asphalt, being a thermoplastic materials, is softened with the heat of the sun and tire pressure of moving vehicles. Furthermore, pollution volatiles within the asphalt continue to rise to the surface by the evaporative process, characteristic of this material. Therefore, during a rain event, the first-Rush is washed into the lakes through storm sewer systems containing elements as inlets, catch basin, headwalls, flumes, and other drainage structures. The purpose of this presentation is to show how this pollution can be minimized.

Scope. The first series of slides shows the effects of stormwater runoff pollution along beaches, lakes, rivers, and other bodies of water. The second series of slides shows the various stormwater systems, such as retention and detention ponds.

Objective. The third series of slides covers the development of porous concrete pavement, the description of porous concrete road sections, and pavement procedures. The final series of slides includes Environmental Porous Pavement, a new patent-pending development that involves the recycling of existing asphalt roads and converting them into non-polluting porous roads with virtually zero runoff.

Conclusions and Recommendations. This technology is particularly applicable to the recycling of asphalt roads that contribute to the pollution to nearby lakes, rivers, streams, bays, and other waterways. Conventional road construction equipment is modified to accommodate the new patent applications, involving the recycling of impervious roads into environmental and safe porous roads, thereby eliminating runoff. It is expected that this equipment will be in operation in less than six months.

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