LAKE OKEECHOBEE TMDL – TECHNOLOGIES & RESEARCH: LESSONS LEARNED

John C. Folks, CFEA, REPA, ASAE Member, Environmental Administrator, Florida Department of Agriculture, Office of Agriculture Water Policy, 1203 Governors Square Blvd., Suite 200, Tallahassee, FL 32301. folksj@doacs.state,fl,us

Written for presentation at the
CSREES 2005 State of Science of Animal Manure and Waste Management Symposium
Sponsored by the National Center for Animal & Waste Management
Marriott San Antonio Rivercenter
San Antonio, Texas USA
January 5-7, 2005

ABSTRACT. The Lake Okeechobee Restoration Program is a state-mandated and funded program to assure compliance of Lake Okeechobee contributing water sources with its established Total Maximum Daily Load (TMDL) for phosphorous. The lake watershed's dominating land use is production agriculture, with cow/calf operations accounting for 47% of the basin's land area. Thus the majority of the sources of phosphorous loading to the lake are nonpoint. The nature of nonpoint source surface water pollution requires a change in thought and actions by government agencies and researchers. Technological costs can no longer be offset by government taxing authorities, or through service fee increases, as has been characteristic of point source remediation. Nonpoint sources very spatially in nature and extent and are typically privately owned and operated. Private companies and individuals that depend on their natural resources and lands' productive capacity operate in a market that does not allow increases in product pricing to offset environmental costs. The traditional measure of feasibility used for point sources and the technologies developed for them are generally not applicable to nonpoint sources. The Lake Okeechobee Restoration Program has implemented potentially promising technologies, on a sub-regional and regional scale, and is using the annual cost per pound of phosphorous removed as the performance measure for these projects.. To deal with spatially extensive applications of a technology on private lands requires a unique set of measures. These measures consider not only the capital costs but the operation and maintenance costs, along with impacts of the nonpoint source technology on the producers' bottom line.

Keywords. Best management practices, chemical treatment, nutrients, reservoirs, manure, surface drainage, economic evaluation

INTRODUCTION

Lake Okeechobee is a large, shallow, eutrophic lake located in south central Florida. The Lake is the largest body of freshwater in the southeastern United States and covers a surface area of 730 square miles, with an average depth of 8.6 feet. It is encircled by a man-made embankment, constructed over a seven year period from 1930-37, that is approximately 140 miles long with crest elevations ranging from 32 to 46 feet (URS, 2002). Lake Okeechobee functions as the central part of a large interconnected aquatic ecosystem in south Florida and as the major surface water body of the Central and Southern Florida Flood Control Project. The Lake provides a number of values to society and nature including water supply for agriculture, urban areas, and the environment; flood protection; a multi-million dollar sport and commercial fishery; and habitat for wading birds and migratory waterfowl. These values have been threatened in recent decades by excessive phosphorus loading, harmful high and low water levels, and rapid expansion of exotic plants. Total phosphorus concentrations in the Lake have more than doubled since the early 1970's, now averaging more than 120 parts per billion (ppb). The high phosphorus loading rate to the Lake is derived from the watershed (external loads) and the phosphorous laden sediments already in the Lake (internal loads). In 2002, the annual load to Lake Okeechobee was 543 metric tons (Mtons). The five-year average phosphorus load from 1998 to 2002 was 554 Mtons and exceeded the Lake Okeechobee TMDL by 414 Mtons (Table 1). This five-year average included the smallest measured historical load (169 Mtons in 2000), due to the worst drought in recent history; and the largest measured load in the past decade (780 Mtons in 1998), due to an above average wet year. Such load extremes are the reason the Lake Okeechobee TMDL is based on a five-year average, to account for variations in water flow and concentrations.

Nutrient Management/Best Management Practices Planning

The implementation of agricultural Best Management Practices (BMPs) to immediately reduce the watershed's phosphorus loading to the Lake is the corner stone of the State-mandated restoration effort.

The coordinating agencies(the Florida Department of Environmental Protection (FDEP), Florida Department of Agriculture and Consumer Services (FDACS) and the South Florida Water management District (SFWMD)) agreed that the first step to successfully control phosphorus was to develop a tool, called an Agricultural Nutrient Management Plan (AgNMP), to determine specific on-farm current and future phosphorus sources and delineate best management practices (BMPs) necessary to obtain whole-farm nutrient balance and an edge-of-farm phosphorus discharge concentration of 150 ppb. AgNMPs were completed for all active dairies in the Lake Okeechobee watershed (S-191, S-154, S-65D, and S-65E), representing over 31,000 acres (Figure 2). The AgNMPs indicated that it would cost a total of $105 million to achieve whole-farm nutrient balance and an edge of farm surface water discharge concentration of 150ppb for all dairies in the watershed.

On other agricultural lands; conservation plans meeting United States Department of Agriculture (USDA), Natural Resources and Conservation Service (NRCS) standards have been completed on 27,476 acres, with an additional 61,391 acres in the planning process. Cow/calf production is the largest agricultural land use in the Lake Okeechobee watershed, it is anticipated that the implementation of BMPs identified by Conservation Plans will substantially improve water quality in the watershed. FDACS and the NRCS in a cooperative effort, obtained a $500,000 federal appropriation to further advance Conservation Planning in the Lake Okeechobee watershed. These funds have been used to identify and to train additional Technical Service Providers (TSPs) and Conservation Planners to develop Conservation Plans for cow/calf operations. FDACS has contracted with Environmental Management Solutions (EMS), a certified TSP for services related to the expedited Conservation Planning effort. This has resulted in an additional 94,907 acres of Conservation Plans under development in the four basins immediately north of the lake with another 46,033 acres awaiting planning. Collectively, these activities cover 267,507 acres or 94 percent of the agricultural acreage in the four basins immediately north of the lake (Figure 1). An additional 84,200 acres of agriculture operations outside the four basins have also agreed to participate in the process.

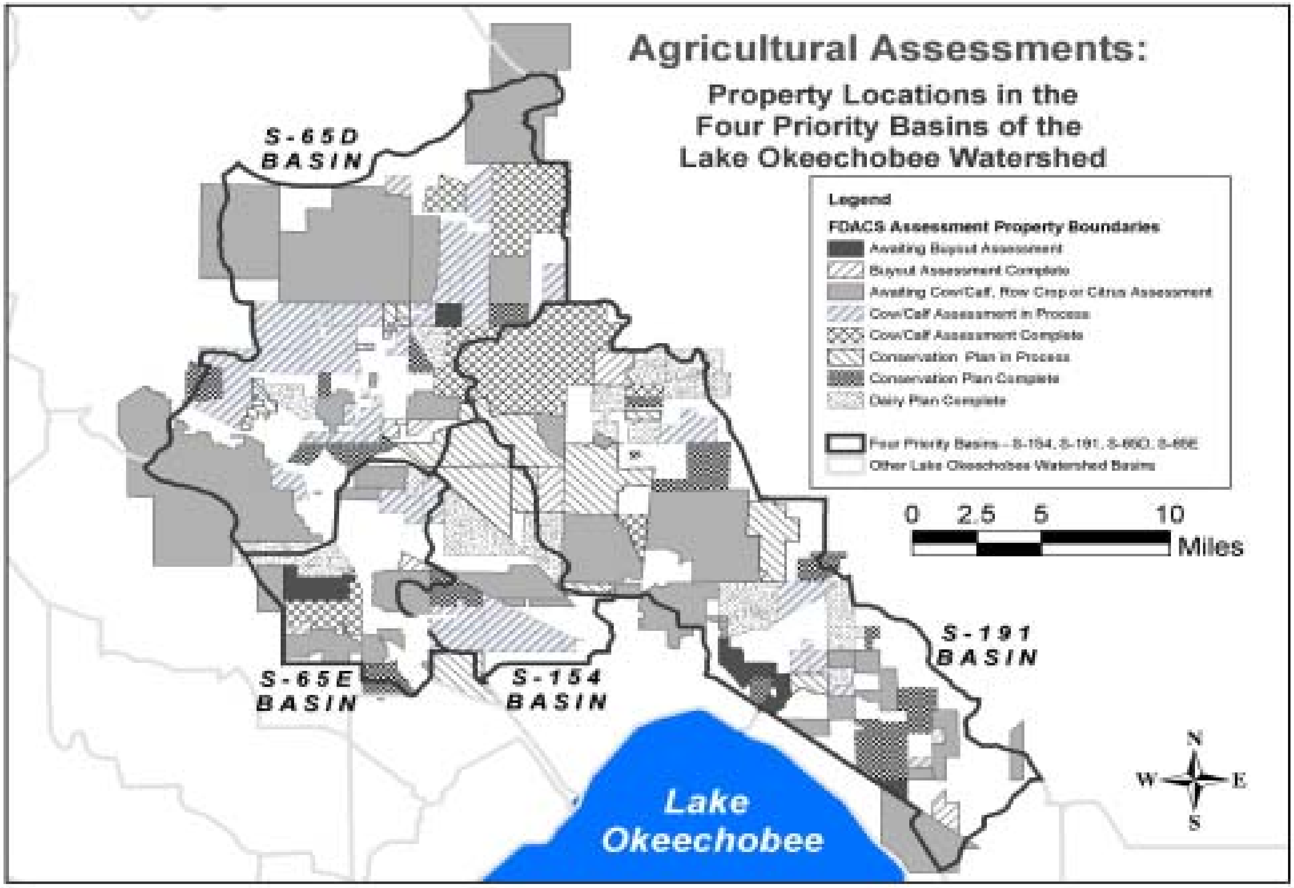

Figure 1. Area of Landowner Participation in the Four Basins Immediately North of the Lake .

Diversified Technology Implementation

A chemical, Edge-of-farm stormwater treatment Best Available Technology (BAT)was selected for implementation on three dairy properties in the Lake Okeechobee watershed (Figure 2). These projects consist of stormwater retention areas that capture runoff (especially from all of the high nutrient pasture areas); reuse the runoff on-site in current operations if possible; and chemically treat only stormwater that has to be discharged offsite. The three BAT project sites are currently operational but the lack of rain, has resulted in insufficient flow to evaluate for their use. Since Phosphorus load is being monitored at these sites, the performance of this technology will be accurately determined. Project performance is being evaluated for various total phosphorus discharge concentration goals ranging from 150 ppb to 40 ppb. Annual phosphorus load reductions are expected to range from 80 to 90 percent.

The Lake Okeechobee Isolated Wetland Restoration Program (LOIWRP) along with the USDA's Conservation Reserve Enhancement Program (CREP)are being used to restore the amount and timing of stormwater runoff to wetlands, which will reduce the amount of phosphorus discharged from parcels to Lake Okeechobee. Historically, isolated wetlands covered a significant percent of land area in the four priority basins, capturing stormwater runoff and helping to retain phosphorus in the watershed. However, many of these wetlands have been drained to maximize agricultural production, allowing more phosphorus to reach Lake Okeechobee. There are currently about 45,000 acres of restorable wetlands in the four basins immediately north of the lake. It is estimated that approximately 1,600 acres of wetlands will be restored through these programs, with an equivalent drainage/treatment area of 4,000 acres.

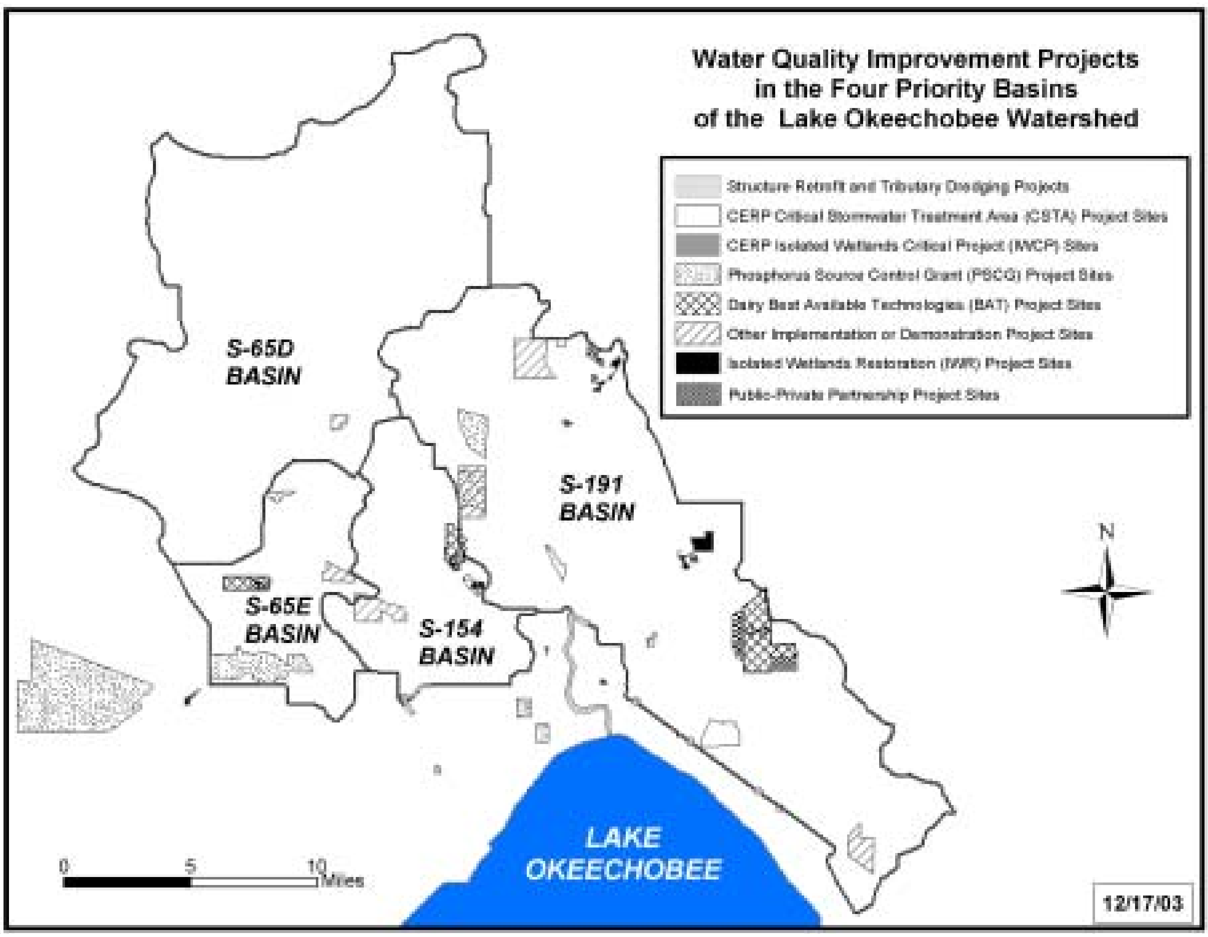

Figure 2. Water Quality Improvement Projects in the Four Priority Basins of the Lake Okeechobee Watershed

In 1989, a Dairy Buy-Out Program was established at the request of the dairy industry for farmers who were unwilling or unable to comply with the FDEP Lake Okeechobee Dairy Rule, which required the implementation of mandated BMPs. The Dairy Buy-Out Program did not purchase the property or cows, but simply facilitated removal of the animals. Of the 49 original dairies that existed in the Lower Kissimmee River and the S-191 (Taylor Creek/Nubbin Slough) basins before implementation of the Dairy Rule, 18 participated in the Dairy Buy-Out Program. A total of 14,039 milking cows were relocated or were removed from the watershed under this Program. These former dairies have a high amount of residual phosphorus in the soil and can not be used for concentrated animal operations.

Lagoon remediation, stormwater runoff detention/retention, and wetland enhancement are the primary activities being implemented on these sites. The goal of this remediation is to implement practices and technologies, based on information presented in their AgNMPs, that will reduce the phosphorus load associated with surface water discharge to 150 ppb or less from the former dairies.

Table 2 delineates all of the projects being pursued in addressing water quality in the Lake Okeechobee watershed. These projects consist of diversified technologies applied on different areas of land and phosphorous sources. A sample listing of technologies include: soil amendments (Al) to address residual phosphorous in soils, algae scrubbers to capture phosphorous from surface waters, waste treatment systems and edge-of-farm chemical treatment systems for dairies, re-hydrating wetlands and constructing large stormwater treatment systems in association with stormwater reservoirs.

General Project Category	Specific Project Name	Project Description
Phosphorus Source [illegible]	Tampa Farms Composting Facility	Composting chicken manure exported from watershed

Control Grant Program	Milking "R" Chemical Treatment	Optimizing dairy stormwater treatment system
	Solid Waste Authority	Tri-county biosolids pelletization
	QED--McArthur Farms 3	Dairy farm wastewater treatment system
	Candler Ranch	Runoff treatment - iron humate filter
	Davie-Dairy Cooling Pond	Concrete cooling ponds
	Evans Properties--Bassett Grove	Citrus grove stormwater system retrofit
	Okeechobee Utility Authority – Ousley Estates	Gravity sewer system replacing septic and package plants
	Lofton Ranch	Wetland restoration
	Smith Okeechobee Farms	Stormwater retention and wetland restoration
	Lazy S Ranch	Runoff treatment - iron humate filter
Dairy Best Available Technology	Dry Lake 1	Edge of farm stormwater retention/detention with chemical treatment
	Butler Oaks	
	Davie Dairy 1 & 2	
Silica Soil Amendment Evaluation Project	Larson Dairy 6	Soil amendment application to bind residual phosphorus
	Milking R	
Isolated Wetland Restoration Program	Kirton Ranch	Wetland restoration on agricultural properties
	Hazellief	
	McArthur Farms	
	Williams Ranch	
4th St. Boat Ramp Project	Residential and commercial area around 4th Street in Okeechobee	Urban stormwater retrofit including baffle box and swales
Former Dairy Remediation	Lamb Island Dairy Remediation	Remediation of properties that were previously dairy farms utilizing stormwater detention, wetland treatment, lagoon remediation, and soil amendments
	Lamb Island Dairy Tributary Stormwater Treatment Project	
	Five former dairy sites	
Regional Public-Private Partnership	QED	Dairy waste separation and treatment facilities
	Davie Dairy 1 & 2	Chemical treatment of 800 acres of off-site runoff
Other Projects*	Hydromentia	Aquatic Plant Based Water Treatment System Pilot Project – water hyacinths and algal turf scrubber
	Tributary Dredging & Structure Retrofits	Sediment removal and modification of water control structures for water quality improvement
	AquaFlorida	Conceptual design of a regional stormwater treatment area

Table 1: Water Quality Projects in the Lake Okeechobee Basin

Research Projects

After having implemented a number of technologies (Table 1) it was obvious that opportunities still existed with other potential approaches. Thus an extensive research program was implemented to ascertain the applicability of other selected technologies. Table 2 (below) lists the technologies chosen for consideration. Most of the research associated with these technologies will last several years to assure the performance of these technologies is evaluated over typical wet and dry seasons in south Florida.

Regional Technologies
1. Regional Processing of Sewage Sludge and/or Animal Solid Waste Residuals
2. Aquaculture and/or Algal-Based Water Treatment Systems
3. Reservoir-Assisted Stormwater Treatment Areas (RASTAs)
4. Terminal Large Scale Water Treatment Facility Using Chemical Treatment and Solids Separation (CTSS)
5. Canal and Tributary Maintenance Program
6. Tributary Sediment Traps
7. Modify Design and Operation of Regional Water Control Structures
On-Farm Technologies
8. Isolated Wetlands Restoration and Creation
9. Improved Dairy Farm Waste Processing Technologies
10. Stormwater Retention, Reuse and Chemical Treatment at Edge of Properties
11. Wetlands Treatment of Runoff at Edge of Properties
12. Non-Structural Management at the Land Parcel Level
13. Phytoremediation
14. Phosphorus Absorption, Binding, and Filtration Technologies
15. Additional Farm Level Best Management Practices
16. On-Farm Composting of Animal Solid Waste

Table 2. List of Alternate Nutrient Reduction Technologies being research

Economic and Environmental Reality – A Lesson Learned

The Lake Okeechobee Restoration Program is driven by the TMDL for phosphorous in Lake Okeechobee. With few point sources, it is the nonpoint sources that account for the majority of the phosphorous load. Though many technologies have been used to address point sources, few are transferable to nonpoint sources. Therefore, we find our selves in an operational “discovery” mode. Within the Lake Okeechobee watershed the State has brought to bare its best professional judgment of technologies intended to address phosphorous loading generated by nonpoint sources. The Lake Okeechobee Protection Act (LOPA, Chapters 00-130, Laws of Florida) was passed by the 2000 Legislature. This Program committed the State of Florida to restore and protect Lake Okeechobee. This will be accomplished by achieving and maintaining compliance with water quality standards in Lake Okeechobee and its tributary waters, through a watershed-based, phased, comprehensive, and innovative protection program designed to reduce phosphorus loads and implement long-term solutions, based upon the Lake’s Total Maximum Daily Load (TMDL). The Program sets forth a series of activities and deliverables for the coordinating agencies: the South Florida Water Management District (hereafter, District); the Florida Department of Environmental Protection (hereafter, FDEP); and the Florida Department of Agriculture and Consumer Services (hereafter, FDACS).

	1: Average Annual Reduction in P Load Entering Lake		2: P Concentration at Edge f Field/Site After Implementation		3: PV Cost Per Pound of Phosphorus Removed From Lake		
Technology Description	Pounds per Year	Confidence Level (a)	Parts per Billion	Confidence Level (a)	$ Per Lb. of P Removed	$ per CWT of Milk	Confidence Level (a)
1. Chemical Treatment of Runoff at Edge of Property	216,000	High	123	High	$53	$.65	High
2. Wetlands Treatment of Runoff at Edge of Property	148,000	High	297	High	$87	$.48	High
3. Non-Structural Management at the Land Parcel Level	270,000	Moderate	221	Moderate	$50		Moderate
4. . Enhanced Cow-Calf BMPs	197,000	Moderate	208	Moderate	$88		Moderate
5 Reservoir Assisted Stormwater Treatment Areas (RASTAs)	94,000	High	40	High	$104		High
6. Taylor Creek / Nubbin Slough RASTA with Lake Okeechobee Supplemental Water Source	72,000	High	40	High	$90		High

7. Tributary Sediment Removal	29,000	Moderate	212	Moderate	$6	Moderate
19. Terminal Large Scale Water Treatment Facilities	229,000	High	10	High	$212	High

Table 3 Summary of Costs for Phosphorous Control Technologies

The effectiveness of these technologies is being measured by their load reduction capability and cost per pound of phosphorous removed (Table 3). A technology may effectively reduce phosphorous loading when judged on the best of cost per pound of phosphorous removed but this approach, while applicable to public agencies can be miss leading if used in the private sector. Most nonpoint sources technologies are privately owned and therefore must be financially feasible in order for the private sector to implement and operate. They must also be within that particular landowner's level of expertise and management skills. The construction, operation and maintenance costs may be considerable and thus could have a major impact on the private sector's profitability. These "reality" measures are only now being applied to phosphorous technologies in the Okeechobee watershed (Table 3) and its associated research.

Technologies 1 & 2 in Table 3 have been applied to dairies with the resulting impact of $.65 and $.48 per hundred weight (CWT) of milk produced. This amount may seem to be a small cost but the average net operating margin for dairies in Florida is $1.30. These technologies, if implemented, represent a further reduction in this margin by 37-50%. These technologies are not all encompassing, in that the dairyman must also implement additional BMPs, whose construction and maintenance costs, may consume the remainder of his margin.

CONCLUSION

The nature of nonpoint sources of surface water pollutants requires a change in thought and actions by government agencies and researchers. Technological costs can no longer be offset by government taxing authority, or through service fee increases, as has been characteristic of point source remediation (waste water & potable water utilities). Nonpoint sources are unique because they are usually privately owned and operated for profit. Private companies and individuals that depend on their land and resources' productive capacity operate in a market place that does not allow increases in product pricing to offset environmental costs. When considering any technology for nonpoint sources these questions must be addressed:

1. Will the technology supply acceptable environmental compliance?
2. Will it provide a realistic revenue stream to offset the costs of compliance?
3. Will it be simple enough for an agricultural operator to manage, or will it require a specialized operator?
4. If a specialized operator is required, do they exist in sufficient numbers for competitive pricing?

To achieve long-term sustainable environmental protection from nonpoint sources, technologies must, at a minimum, pay for themselves, but preferably be profitable.

REFERENCES

Published Paper

Florida Department of Environmental Protection (FDEP). 2001. Total Maximum Daily Load for Total Phosphorus, Lake Okeechobee, FL. Tallahassee, FL.

South Florida Water Management District (SFWMD). 2002. Surface Water Improvement and Management (SWIM) Plan Update for Lake Okeechobee. West Palm Beach, FL.

URS. 2002. Value Engineering Study, Herbert Hoover Dike Rehabilitation and Repair, Reach 1. Prepared by URS Group, Inc. for the Jacksonville District of the United States Army Corps of Engineers.