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DEVELOPMENT OF A FUNCTIONAL, BEST MANAGEMENT PRACTICE PROGRAM IN THE TRI-COUNTY AGRICULTURAL AREA OF NORTHEAST FLORIDA

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DEVELOPMENT OF A FUNCTIONAL, BEST MANAGEMENT PRACTICE PROGRAM IN THE TRI-COUNTY AGRICULTURAL AREA OF NORTHEAST FLORIDA

by

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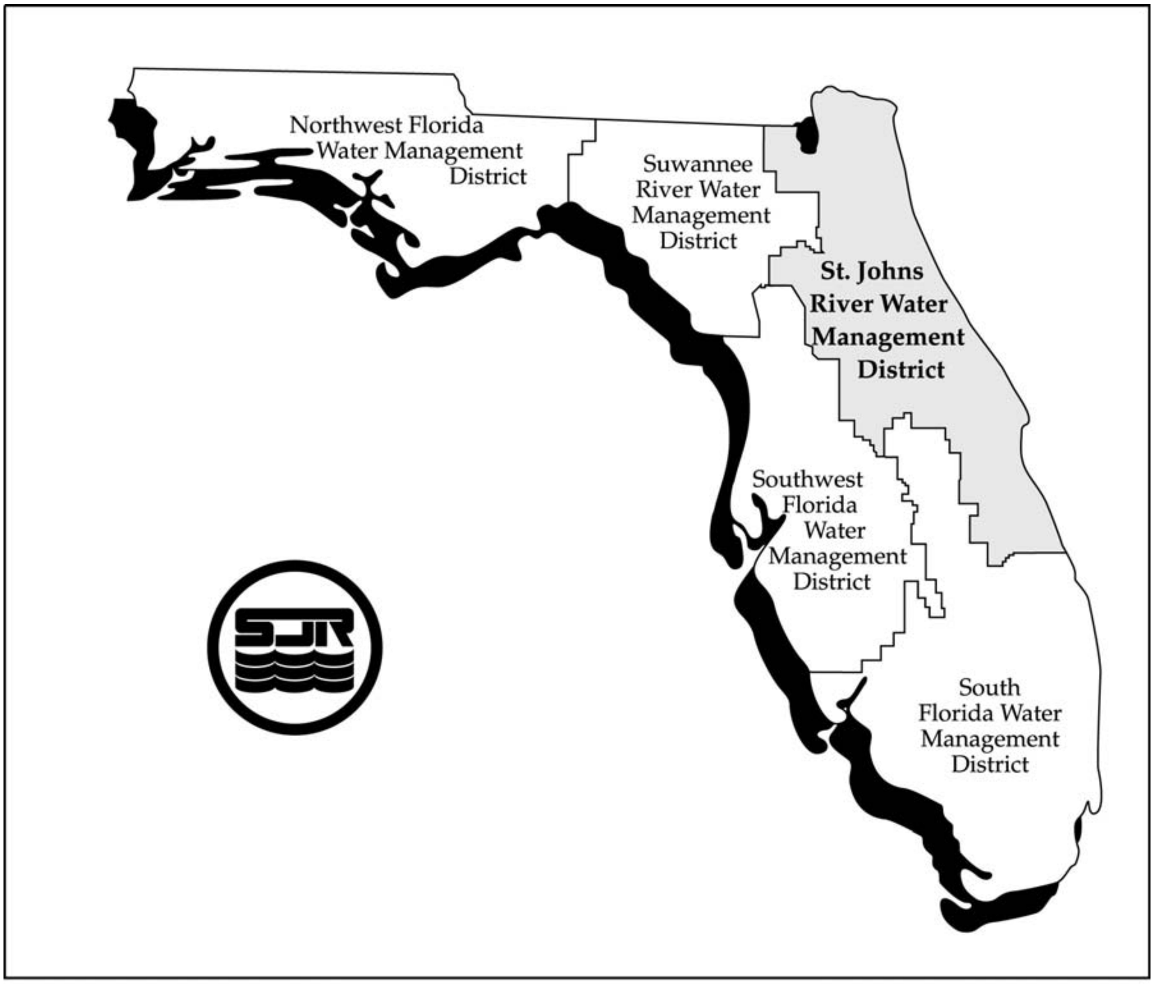

The St. Johns River Water Management District (SJRWMD) was created by the Florida Legislature in 1972 to be one of five water management districts in Florida. It includes all or part of 18 counties in northeast Florida. The mission of SJRWMD is to ensure the sustainable use and protection of water resources for the benefit of the people of the District and the state of Florida. SJRWMD accomplishes its mission through regulation; applied research; assistance to federal, state, and local governments; operation and maintenance of water control works; and land acquisition and management.

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INTRODUCTION

Recognizing that the waters of the state of Florida are among its basic resources, the Florida Legislature enacted the Florida Water Resources Act of 1972, which created the state's five water management districts including the St. Johns River Water Management District (SJRWMD). The districts were established along watershed boundaries to protect and manage Florida's precious water resources. SJRWMD is responsible for managing groundwater and surface water supplies in all or part of 18 counties in northeast and east-central Florida.

The St. Johns River is the largest river system located entirely within the state of Florida. The lower St. Johns River begins at the confluence of the Ocklawaha River (river kilometer 163) and flows north to the inlet at the Atlantic Ocean in Mayport, Florida (Figure 1). Twelve major tributary watersheds drain into the lower St. Johns River and cover approximately 7,192 square kilometers. These watersheds consist of primarily rural, agricultural, and undeveloped lands to the south and urbanized lands to the north including the greater Jacksonville metropolitan area.

The lower St. Johns River can be divided into three ecological zones based on flow patterns, salinity regime, and morphological characteristics: (1) a freshwater tidal zone that extends from the city of Welaka north to the city of Green Cove Springs; (2) a predominantly oligohaline zone that extends from Green Cove Springs northward to the Fuller Warren Bridge in Jacksonville; and (3) a poly-mesohaline zone that reaches from the Fuller Warren Bridge to the mouth of the river (Figure 2). The area from Palatka to south of Orange Park along the eastern shoreline contains approximately 11,330 hectares of agricultural cropland and is commonly known as the tri-county agricultural area (TCAA). The area generates large quantities of sediment and nutrient-enriched agricultural runoff that drains from a network system of ditches and canals into receiving surface waters of the St. Johns River.

Algal blooms can be particularly severe within the freshwater lacustrine zone of the lower St. Johns River and typically peak during the spring and summer with the onset of increased water temperatures and photoperiod. Algal organic matter is then transported downstream, where the decline, death, and decomposition of these blooms dramatically lowers oxygen levels in the Jacksonville reach of the river (Hendrickson and Konwinski 1998). These blooms can lead to the degradation of submerged aquatic vegetation as light becomes blocked within the photic zone.

Annual agricultural production in the TCAA is concurrent with the advent of the freshwater algal blooms. Early spring production of irrigated vegetables that are grown on flat and poorly drained soils, with standard agricultural management

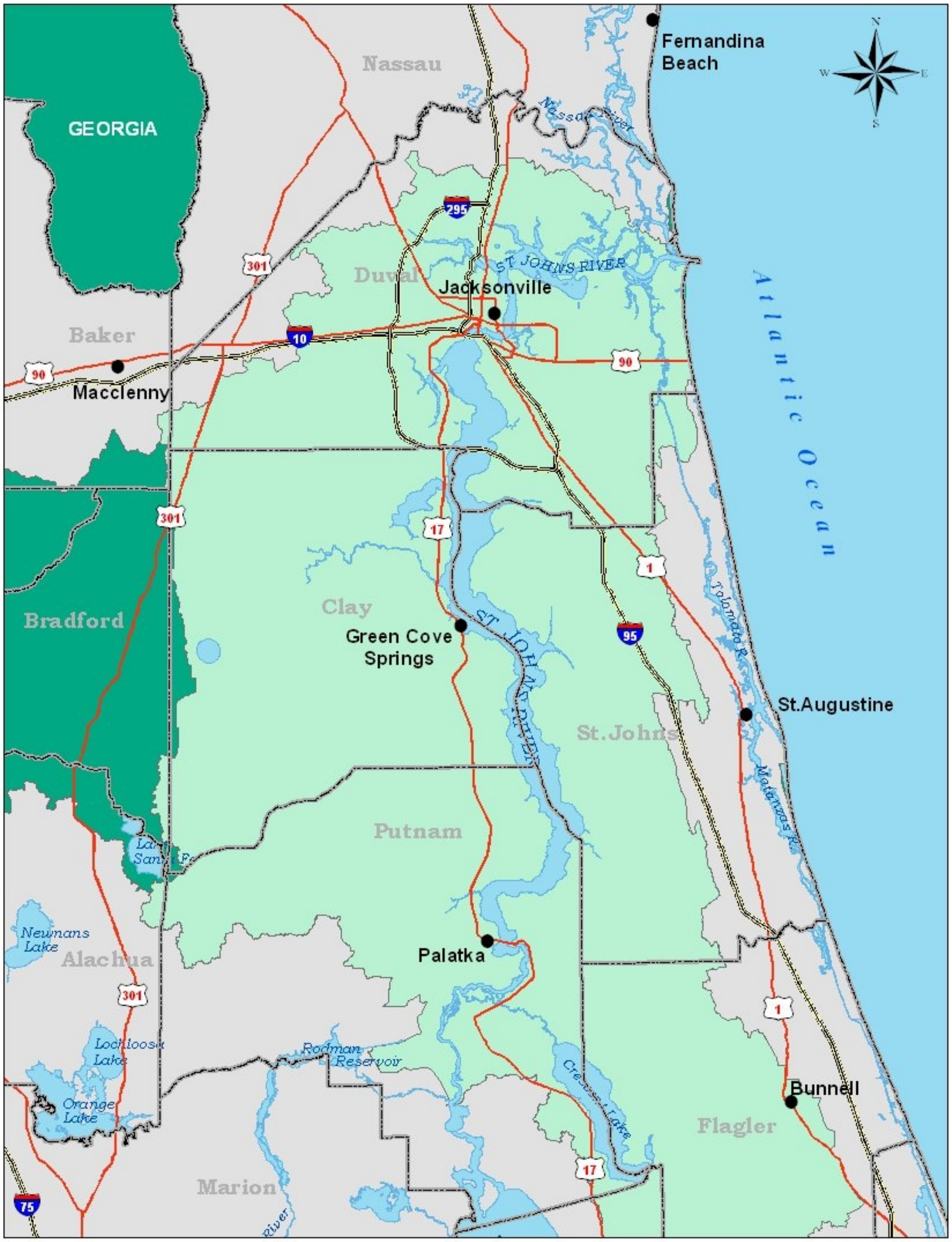

Figure 1. The lower St. Johns River begins at the confluence of the Ocklawaha River and flows north to the inlet at the Atlantic Ocean in Mayport, Florida

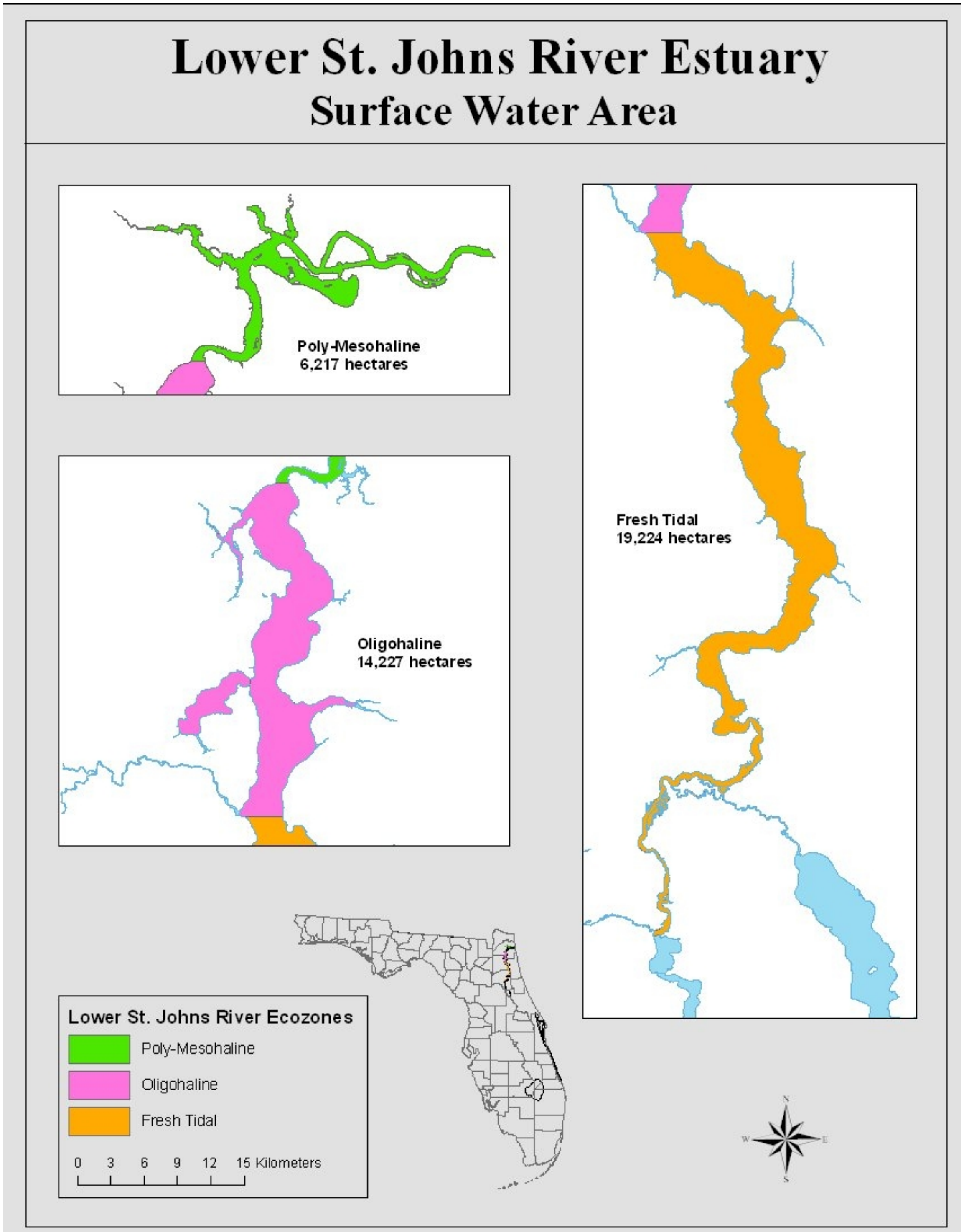

Figure 2. The three ecological zones of the lower St. Johns River

practices of fertilization, irrigation, and drainage, can effectively convey nutrient-rich storm water to the freshwater zone of the river. In addition, recent findings have indicated that agricultural production is the major anthropogenic source of pollution, contributing approximately 50% of the bioavailable phosphorus and 39% of the bioavailable, nitrogen-augmented, nonpoint source load to the freshwater lacustrine zone of the lower St. Johns River (Hendrickson et al. 2006).

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PROJECT AREA

The tri-county agricultural area (TCAA) extends from Palatka to south of Orange Park along the eastern shoreline of the St. Johns River and contains approximately 11,330 hectares of agricultural cropland. The TCAA (Figure 3) is positioned in the

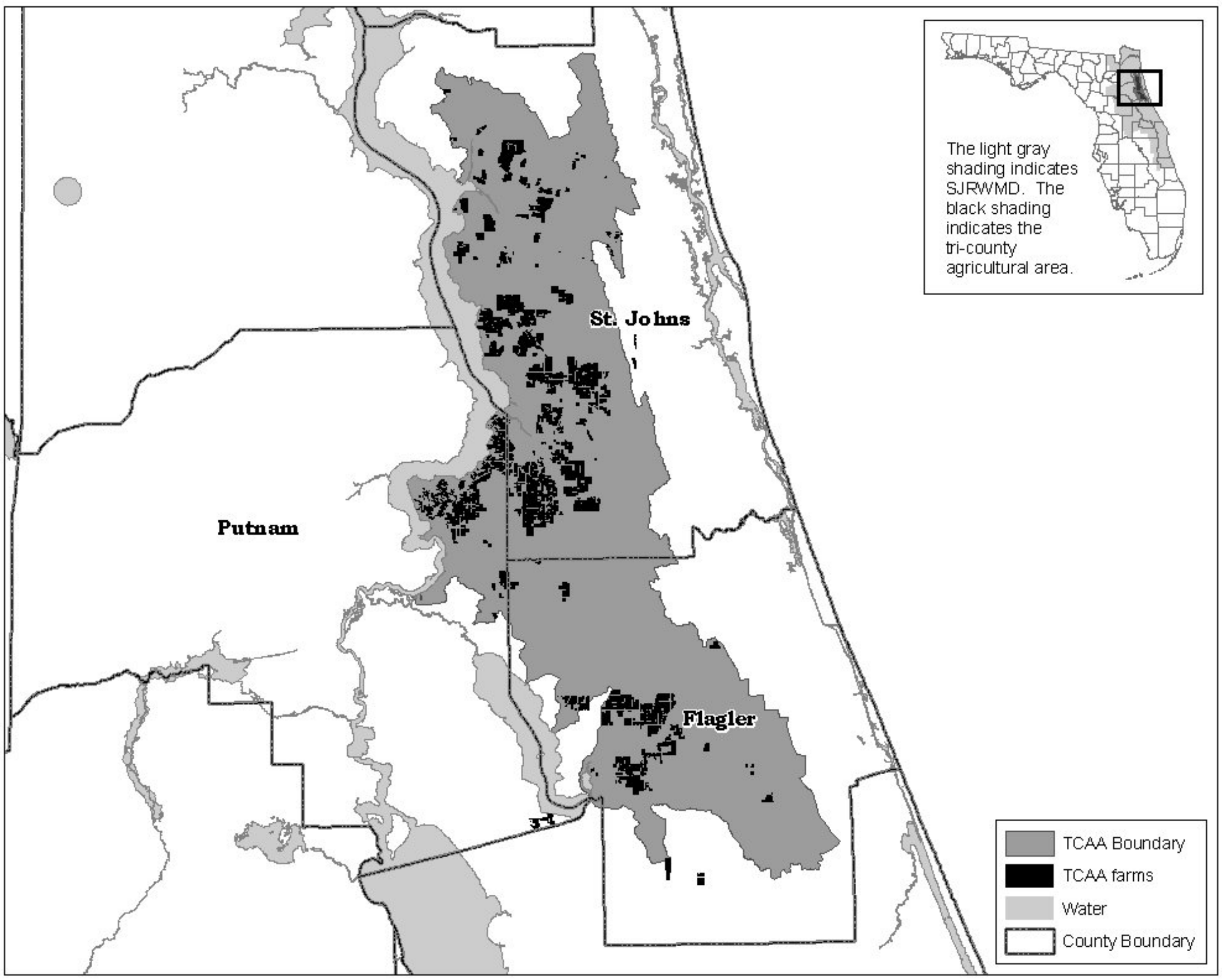

Figure 3. The tri-county agricultural area (TCAA) project area locator map

coastal plain ecoregion of Florida and is dominated by nearly level flatwoods soils. These poorly drained, sandy, and loamy soils typically contain an underlying impermeable layer within approximately 0.3–0.5 meters of the soil surface. Flatwoods are scattered throughout the area, with obscure drainage patterns and depressional areas that are ponded for long periods of time. Agricultural row-crop fields are situated primarily on low, broad flats and around floodplains. Networks of man-made drainage canals are used to maintain water tables and convey runoff from agricultural production areas. The Flagler Estates, Hastings, and Elkton water control districts have been established to maintain ditches, and clear weeds and sediment obstructions.

The potato-growing season generally starts in late December or early January and continues through late May or early June. Growing seasons will vary slightly depending on the geographical location of the field and its proximity to the river. Sorghum-Sudan grass, a cover crop, is generally planted after harvest, to control wind and water erosion in the field. Potatoes are grown in soils having a high water table, with subirrigation and controlled drainage. A naturally high water table (impermeable layer) allows for the development of a temporary water table at a desired depth below the root zone.

Wells supply groundwater to water furrows via a header pipe. Water furrows that are spaced 18.3 meters apart with 16 rows between each water furrow supply irrigation water (Figure 4). Rows are bedded and range in height from 0.2–0.36 meters. Typically, the fields have been laser-leveled to facilitate even distribution of gravity-drained irrigation water and water table control. The current practice of tailwater recovery, employed by most farmers, uses a weir or a dam-like structure to hold the water back in ditches and canals along the edges of the fields. Surface water runoff generated by agricultural activities is then conveyed by gravity flow to receiving waters through drainage canals.

Water tables generally remain relatively high in the soil profile during the growing season, consequently limiting available storage for rainfall. To keep water from damaging the crop, the drainage system must lower the water table to a desired level within 24 hours after a rainfall event. It is a standard practice within the TCAA to begin lowering the water table prior to an anticipated storm event, to ensure that crop damage is minimized. The grower’s judgment determines when and to what degree the water table is lowered prior to a storm and when it is raised following a storm event. This judgment is critical in considering that if the water table is not adjusted in a timely manner, the crop may sustain water damage. If the water table is lowered too far, the grower must irrigate to bring the water table back to the desired level. As growers consider the high value of the potato crop and the relatively low cost of pumping irrigation water, there is an economic incentive for the grower to err on the side of lowering the water table too far, to avoid the risk of crop damage.

Figure 4. Water furrows supply irrigation water

Increased production, historically, has been the primary concern of producers and educational institutions. Crop production on flat and poorly drained soils, combined with standard farm management practices of fertilization, irrigation, and drainage, all too effectively conveys nutrient-laden storm water to the St. Johns River. Traditionally, these standard farm management practices have been documented in conservation plans that address irrigation efficiency and soil erosion, with little attention given to reducing nutrient loads resulting from agricultural activities.

AGRICULTURAL NONPOINT SOURCE (NPS) DIAGNOSTIC ASSESSMENT

An agricultural nonpoint source (NPS) diagnostic monitoring study conducted at 10 farm sites from 1991 through 1993 revealed that nutrient loading was primarily associated with the growing season (January–June) and storm events. The study also showed that NPS-loading rates associated with agricultural row-crop land use are four to five times greater than those of other land use activities. A mass balance analysis of nutrient inputs and outputs, using four intensively sampled farms, showed that 97%–99% of the primary nitrogen (N) and phosphorus (P) input to the farm system was from fertilizer. Seventy percent of the accountable N exported off the farm system was through biomass removal, and 22% was lost through surface water runoff (Livingston Way 2001). These results suggest that fertilizer application rate, biomass removal, and surface water runoff are the critical components that most affect the nutrient budget of a farming system in the TCAA.

The general conclusion of the preliminary diagnostic study suggests that no one factor controls the losses of the nutrients and sediment in runoff water. Variables including crop productivity, fertilizer application rate, weather, crop variety, cover crop, soil properties, irrigation management, and planting and harvest dates, play a role in transport processes that determine how much, and when, nutrients and sediment leave the fields. These factors must be considered when designing effective management plans for nutrient reduction.

BEST MANAGEMENT PRACTICE (BMP) ASSESSMENT

Subsequently, a 4-year best management practice (BMP) assessment study (1994–1997) was conducted, using U.S. Environmental Protection Agency (EPA)-319 funds, to identify and evaluate BMPs that would reduce nutrient loading rates. A BMP is defined as an economically feasible, on-farm management practice designed to minimize pollutants in drainage waters. The primary goal of the 4-year BMP assessment study was to develop and implement economical, alternative BMPs on four demonstration fields and evaluate their abilities to produce measurable reductions in nutrient and sediment loadings from agricultural operations while also sustaining profitable crop yields.

Representatives from all TCAA stakeholders were invited to participate in the project, to provide their perspectives and expertise. Additionally, a private consulting firm, Soil and Water Engineering Technology, Inc. (SWET Inc.), with expertise in agricultural engineering and modeling was hired to participate. With total stakeholder representation, a partnership called the technical task force team (TTFT) was formed to identify potential solutions and conduct the assessment. Each group or agency was responsible for various tasks associated with the project.

The four fields/farms selected were based on previous grower cooperation during the pre-BMP diagnostic study, field acreage and physical characteristics, farm management practices, and existing data (Table 1). The results of this study concluded that the BMPs evaluated were effective in reducing nutrient loading from area farms in the TCAA without adversely affecting yields.

Table 1. Best management practice (BMP) assessment study design

Farms	County	Hectares	Nutrient BMP	Water Table BMP	Sediment BMP	Integrated Pest Management
C	St. Johns	11	X			X
G	St. Johns	14.3		X		X
I	Putnam	15.6	X	X	X	X
J	Flagler	14.6	X	X	X	X

Note: hectare = a metric unit area of 100 ares (2.471 acres, or 10,000 square miles)

The high water table model (HWTMOD), a field-scale model, was used by SWET Inc. to evaluate the data collected during the BMP assessment study and to provide a quantitative comparison and analysis of BMP effects on nutrient and sediment loads in the tailwater discharged from the four area farms. The model was used to account for the annual variability associated with climatic conditions and farming practices. The model demonstrated, with relative confidence, its ability to reproduce the measured data and consequently the comparative effects of the various BMP conditions.

Modeling results concluded that the nutrient and water table management BMPs were more effective at reducing nitrogen and phosphorus loading from agricultural discharges than standard farm management practices. The nutrient and water table management BMPs combined the effects of the recommended reduced nutrient rates and improved water management. Ostensibly, reduced nutrient rates and split applications enhanced the crop’s nutrient efficiency and reduced the luxury amount available for runoff. Improved water management also reduced the potential for runoff associated with loading. The results showed that the combined effects were greater than what could be expected from the nutrient and water table BMPs independently.

The results also demonstrated that the nutrient management BMP had an immediate effect on nitrogen loads, whereas reductions of phosphorus loads occur over time with the continued practice of zero-phosphorus applications. Nitrogen loads showed a fairly significant reduction (30%) at all farms each year, whereas the phosphorus loads showed only a slight reduction (11%) over the 7-year, simulated period. The results of the long-term modeling of the nutrient management BMP showed a substantial decrease in phosphorus loads (30%) over a 20-year period.

TOTAL MAXIMUM DAILY LOAD (TMDL)

The Florida Department of Environmental Protection (FDEP) and SJRWMD have worked together to establish total maximum daily loads (TMDLs), as mandated by the EPA Clean Water Act (Title 3, section 303-d) of the (U.S.) *Code of Federal Regulations*, for those Florida water bodies that the FDEP has listed as impaired waters and by the 1999 Consent Decree, which stipulated that the EPA develop TMDLs by Sept. 30, 2003. The EPA approved the proposed TMDL in March 2004. The approved TMDL will require an initial 90% BMP implementation on row-crop lands in the TCAA to establish a "fair playing field" between NPS and point sources. In addition to the 90% BMP implementation, a 30% reduction of the current total nitrogen and phosphorus loads contributed from the TCAA will be required in order to meet the TMDL.

WATER QUALITY PROTECTION BMP PROGRAM

In order to meet the TMDL, the Water Quality Protection Cost-Share Program (WQPP) was established to promote BMP implementation. The TCAA WQPP is a voluntary cost-share program designed to reduce nutrient loading to the river from agricultural sources. The WQPP was initiated in 2000, and implementation started in 2001.

PARTICIPATING ORGANIZATIONS

Numerous agencies and organizations are working together to support and promote the WQPP, including:

- Florida Farm Bureau
- Florida Fruit and Vegetable Association
- Florida Department of Agriculture and Consumer Services
- Florida Department of Environmental Protection
- North Florida Growers Exchange
- Flagler, Putnam, and St. Johns counties' Soil and Water Conservation districts
- St. Johns River Water Management District (SJRWMD)
- University of Florida–Institute of Food and Agricultural Sciences (UF-IFAS)
- USDA–Natural Resources Conservation Service

The project's objective is to encourage voluntary implementation of nutrient management and water management BMPs on 11,330 hectares of row-crop agriculture in the TCAA. This program provides an economic incentive to growers who voluntarily implement verified nitrogen and phosphorus BMPs, thus offsetting any potential increase in production cost and/or risk while the grower adapts to the new BMP technology. The program provides cost-share funds for agricultural practices that have potential water conservation, runoff, and water quality benefits and which also sustain profitable crop yields (Table 2).

WATER QUALITY COST-SHARE PROGRAM (WQPP) CONDITIONS

- The WQPP is available to any vegetable grower in the TCAA currently growing potatoes and/or cabbage, provided that program guidelines are met.
- Cost-share funds are available on a first-come, first-served basis.
- The WQPP requires a 5-year contract period for implementation of the BMPs.

- BMPs must be implemented each year of the 5-year contract period.
- Request of funds should be submitted within 6 months after each growing season along with program records, fertilizer receipts, and soil test results.
- There is no limit on the number of fields that can be enrolled in the program.

Table 2. Eligible best management practices (BMPs) and available cost-share funds

Irrigation and Water Table Management BMPs	Cost-Share Rate/Unit (in U.S. dollars)
Observation wells	$30.00
Structure for water control	$1,200.00
Irrigation water management and sediment control	$50.00
Nutrient Management BMPs Reduced Rates	
175–200 lbs N/acre	$30.00
201–225 lbs N/acre	$20.00
226–250 lbs N/acre	$10.00
30 lb P/acre or soil test recommendation	$30.00
Reduced rate w/ nitrogen sap meters	Reimbursed
Soil testing/field	$13.00
Conservation crop rotation	$30.00
Shutoff valve	Reimbursed

Note: lbs N = pounds of nitrogen
lbs P = pounds of phosphorus

CURRENT STATUS OF THE WQPP

Since SJRWMD initiated the TCAA WQPP during fiscal year 2000, approximately 60 farms have been identified as potential participants in the cost-share program. It is estimated that if all 60 farms were enrolled in the BMP cost-share program, a 26% and 18% reduction in dissolved nitrogen and phosphorus loading, respectively, from the TCAA could be expected. (SWET Inc. et al. 1998).

Currently, 21 growers participate in the WQPP. Growers implement either all or some components of the nutrient management and water table management BMPs on 5,868 hectares (Figure 5). WQPP participants have implemented BMPs on 47% of all row-crop lands. The 21 grower contracts include support for construction of permanent water control structures and observation water table wells that are installed concurrently with implementation of the water table management BMP. Nutrient management BMPs provide a sliding scale for nitrogen fertilization, while the phosphorus BMP employs the recommended reduced BMP rate or the UF-IFAS laboratory soil test recommendation. For growers to receive maximum cost-share dollars and realize the maximum nutrient load reduction, BMP practices must be implemented concurrently.

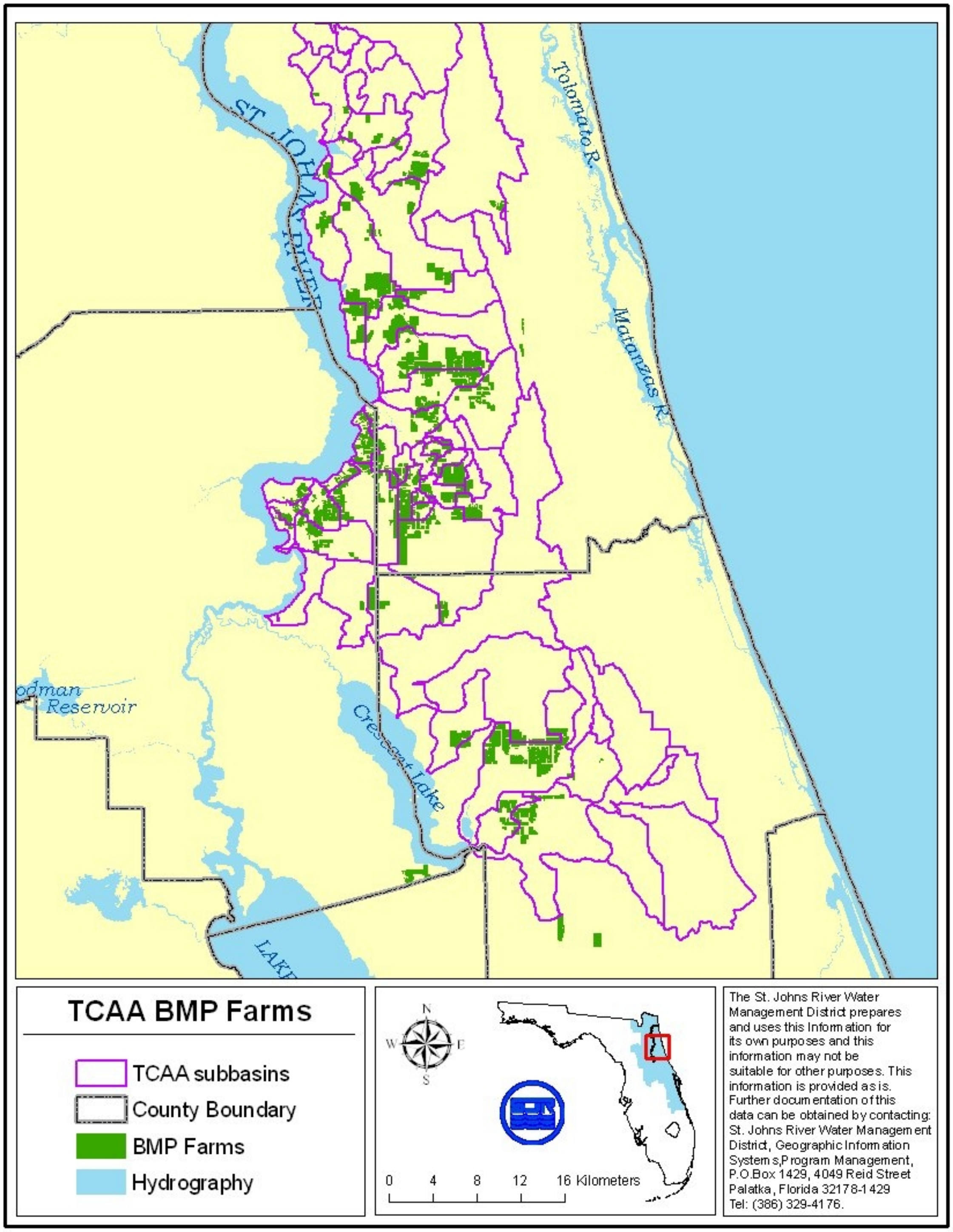

Figure 5. 2005 tri-county agricultural area (TCAA), with best management practice (BMP) farms

DEVELOPING NEW BMP TECHNOLOGY TO ACHIEVE THE 30% TMDL NUTRIENT REDUCTION—CONTROLLED-RELEASE FERTILIZER (CRF)

Since January 2000, SJRWMD has worked with University of Florida—Institute of Food and Agricultural Sciences (UF-IFAS) to conduct field plot experiments at the Hastings Research and Education Center's Yelvington Farm, to determine the effectiveness of controlled-release fertilizers (CRFs) in production agriculture operations as a potential new best management practice in the TCAA. Over a 4-year period, approximately 80 product and treatment combinations have been examined at the research farm. To date, the results of the field plot experiments are encouraging and have demonstrated that CRFs could be used effectively for potato production in the TCAA.

The initial results over the 4 years have shown no loss in potato yield or quality and that nitrogen fertilization rates could be reduced from the standard BMP rate of 224 kilograms of nitrogen (kg N) per hectare to 196 kg N/hectare (Hutchinson 2005). This would result in a nitrogen savings of approximately 227,000 kg N/year in the TCAA. This number may increase as more efficient CRFs are developed. Improved CRF technology could overcome the concerns of both growers and regulatory agencies by supplying ample nutrients to the crop to sustain crop yields while reducing the potential for off-site movement of nutrients.

As a result of the preliminary field plot experiments, SJRWMD and UF-IFAS collaborated in 2005 on a field demonstration study conducted on three individual farms to assess production yields and water quality benefits associated with applications of CRFs, as compared to conventional soluble fertilizers.

At each farm, a field was designated for the grower's standard treatment (control). In this treatment, the grower produced potatoes according to his standard practice. A field was also designated for the alternative fertilizer program. The alternative program was the controlled-release fertilizer program (treatment). Two CRF programs were applied in the study. The first program consisted of 196 kg N/hectare based on planted hectares. Of the total, 168 kg N/hectare was supplied by a 38-0-0 polymer-coated urea. The remaining 28 kg N/hectare was supplied by urea. This program was applied to Farms A and C (Table 3).

The second program was a blend of three polymer-coated urea products totaling 196 kg N/hectare (44.5-0-0, 25%; 44.0-0-0, 50%; 43.5-0-0, 25%). The program was applied at Farm B. All other production practices for each farm followed the grower's standard program.

Table 3. Controlled-release fertilizer (CRF) field demonstration study details

Farm	Treatment	Hectares	Nitrogen (kg/ha)	Controlled-Release Fertilizer (CRF) (kg/ha)	Potato Variety	Yield (cwt/ha)
A	Treat	9.42	196	28 Urea 168 38-0-0	Atlantic	279
	Control	13.4	*269	NA	Atlantic	246
B	Treat	4.7	*230	43-0-0,44-0-0 and 44.5-0-0 (25,50, 25%N)	Atlantic	364
	Control	11.3	*280	NA	Atlantic	416
C	Treat	7.6	*230	28 Urea 168 38-0-0	1867	437
	Control	15.1	*302	NA	1867	418

*Includes a supplemental leaching rainfall application (3 inches of rain in 3 days or 4 inches of rain in 7 days)
cwt/ha = hundredweight per hectare
kg/ha = kilograms per hectare

The runoff from each field drained into a separate ditch. Automated water quality monitoring equipment was located at each tailwater ditch and programmed to collect water quality samples as flow from the field increased in the ditch. Both flow [cubic feet per second (cfs)] and rain [inches (in)] were measured at all field sites. Data were downloaded on a weekly basis during the growing season and biweekly during the fallow season concurrent with the collection of the water quality samples.

Event mean concentrations (EMC) were calculated for individual storm events, collected from each farm for total nitrogen. (Data are shown in Table 4.)

Table 4. Event mean concentrations for individual storm events collected at Farms A, B, and C, for total nitrogen

Parameter	Treatment	Farm A April 7, 2005	Farm B April 2, 2005	Farm C March 25, 2005
TN EMC (mg/L)	CRF Treat	3.33 (-36% red)	20.4 (-48% red)	6.58 (-88% red)
	Grower Control	5.23	38.93	53.28

Note: mg/L = milligrams per liter

The total nitrogen EMC for all farms indicates a considerable reduction of nitrogen concentration in the runoff from the CRF treatment fields, as compared to the grower control fields for the individual storm events (notated above).

More recent water quality data collected over the duration of the growing season, representing three storm events for each Farm A, B, and C, indicate an 80%, 24%, and 68% average total nitrogen load reduction, respectively, for CRF treatment fields compared to grower control fields (data not shown).

The data presented strongly support the continued research and effort to investigate CRF as a new nitrogen BMP in the TCAA as a means to assist area growers and water resource managers in overcoming concerns for agricultural production and nutrient reduction.

CONCLUSIONS

What is presented here represents just a small snapshot of the collective work of many dedicated people, spanning 15 years from 1990 to 2005. The following notable lessons have been learned during the project period on the development of BMPs:

- Evaluate and define the water quality issue(s) prior to implementing BMP strategies.
- Involve all stakeholders that could potentially be impacted by the results of the work.
- Ensure that BMPs are flexible, economical, and realistic, if they are to be accepted by the community.
- Continue to work with stakeholders to accelerate BMP technology and implementation.

Each of these steps is equally important to the development and success of an effective BMP program that addresses the concerns of all stakeholders.

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