AGRICULTURE AND GROUNDWATER QUALITY: THE FLORIDA EXPERIENCE

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Florida is well-known as the place to go for sunny beaches, Disney World and winter vacations. But the "sunshine state" is also a major agricultural state, ranking about tenth in the nation in gross sales from agriculture (Mulkey, et al., p. 2). Citrus, vegetables, livestock and ornamental nurseries lead the list of commodities produced in Florida.

Florida agriculture is also a major water using industry. Much of its citrus, vegetable and ornamentals production is irrigated even though Florida ranks about third in the nation in terms of average annual rainfall with about 55 inches per year. Florida soils are sandy in most places and have poor water holding capacity. This means water stored in the root zone is soon depleted by a growing crop. In addition, Florida's abundant rainfall tends to be seasonal and at times erratic. Growers cannot always count on rainfall for the regular applications of moisture needed in order to prevent stress on plants and drought damage to crops. Moreover, some of Florida's most intensive agricultural production occurs in areas that were once wetlands but have been developed for agricultural use by extensive water management systems of canals, levees and pump stations. In these areas, agricultural management and water management are inseparable.

Florida agriculture relies heavily on chemical fertilizers. Its sandy soils are not well endowed with plant nutrients. Florida agriculture also relies on chemical pesticides. Insects, nematodes and fungi thrive in its subtropical environment.

Groundwater contamination can occur when irrigation is used in conjunction with water soluble chemicals on deep sandy soils (Hornsby, pp. 9–12). Although Florida has had several highly publicized instances of well contamination by agriculture, studies show that, for most agrichemicals, significant contamination may be a much more localized event than initially expected (Vogel).

Muck, Dairies and the Lake

Disney World near Orlando is located about halfway down the Florida peninsula. It also happens to be located at the headwaters of the Kissimmee River basin. The Kissimmee River, which was channelized by the Corps of Engineers in the 1960s, flows southward from a series of lakes for about ninety miles, emptying into the north end of Lake Okeechobee.

The lake is an important hydrologic feature of south Florida, having a diameter of about thirty-five miles and an average depth of seven to ten feet. Historically, the lake would regularly overflow its low, ill-defined, southerly rim to feed a sheet flow of water across the sawgrass prairies comprising the Everglades on Florida's southern extremity, emptying finally into Florida Bay another hundred miles south of the lake.

With the population growth and agricultural development in south Florida, local drainage districts, the state of Florida and the Corps of Engineers developed and then expanded major public works to bring flood control and water management to the region. Levees were built around Lake Okeechobee and canals were developed from the lake through the upper reaches of the Everglades to the lower east coast. Pumping stations and strategically placed dams give water management officials the ability to control water levels in the lake and canals. During rainy periods water can be stored in the lake for release during dry periods. However, some reserve capacity must be retained for flood waters during heavy tropical rains for the protection of surrounding areas. Levels in the canals must be managed in order to prevent salt intrusion from the ocean. Below the lake, large areas of the original Everglades are surrounded by levees and used as "conservation areas." Water can be diverted into them for release later if necessary to supply water to the lower east coast canals.

With drainage of the Everglades area south of the lake, agricultural development was able to proceed without fear of catastrophic flooding. The Everglades Agricultural Area is the site of intensive winter vegetable and sugar cane production. The soil in the area is organic muck soil. It oxidizes when exposed to the air, causing soil subsidence with the passage of time. When the soil oxidizes it releases nitrogen that moves into the groundwater. The groundwater table is high in this region, normally within a few feet of the surface. Groundwater and surface water interrelate closely and agriculturalists manage the water table locally by pumping into and out of smaller ditches that link up with the large drainage canals.

The canals from Lake Okeechobee to the lower east coast of Florida traverse the areas of Palm Beach, Broward and Dade counties that are underlain by the Biscayne Aquifer. This aquifer is relatively shallow and is subject to direct recharge from local rainfall from the canals and conservation areas. The Biscayne is also the source of freshwater for the well fields supplying Miami, Fort Lauderdale and the other major lower east coast cities.

The complex interrelationships among surface water, ground water, agricultural practices and urban water supplies has engendered intense political debate about public policies and programs for water management in the region. The South Florida Water Management District struggles to pursue water management practices that serve multiple, often competing, objectives. Backpumping from the Everglades Agricultural Area into the lake has been an important part of district operations to manage stages in the canals and store water in the lake. But backpumping is viewed by environmentalists and others as contributing to the eutrophication of the lake and impending loss of the fishery. Agriculturalists in the area see the movement of water into and out of the lake as an essential method of protecting their crops from the alternate threats of drought and flood. The Florida Department of Environmental Regulation, with responsibility for water quality protection in the state, has in recent years been at odds with the district over the issue of backpumping.

Limnologists who have studied the lake argue that phosphorus, not nitrogen, is the critical nutrient posing real threats to the health of the lake. The phosphorus entering the lake does not come primarily from the Everglades Agricultural Area on the south rim of the lake. Rather, much of the phosphorus is traced to dairy operations in Okeechobee County north of the lake.

Rural Okeechobee County became home to several large dairy operations during the 1950s when south Florida dairymen relocated their herds from the rapidly urbanizing counties to the south. Geographic distance from urban centers seemed certain to insulate the dairy farms from the inevitable conflicts and pressures of urban encroachment. Unfortunately, no one realized that Okeechobee County's hydrologic relationship to the rest of south Florida would eventually nullify the insulating effects of its otherwise remote location.

A major portion of the dairy production area is in the drainage basins of Taylor Creek and Nubbins Slough that empty into Lake Okeechobee. Studies have shown that the area contributes a significant percentage of the phosphorus entering the lake (Baldwin). Phosphorus has been blamed for recent blue-green algae blooms that have covered substantial portions of the lake. The algal blooms increase the biological oxygen demand in the lake, reducing the dissolved oxygen levels in the water with adverse consequences for aquatic life including the fishery. Other effects are impaired tastes in drinking water drawn from the lake, toxicity to fish and unsightly floating algal mats.

The dairymen, with cost-share support from the South Florida Water Management District and other government agencies and technical assistance from the University of Florida's Institute of Food and Agricultural Sciences and the Soil Conservation Service of the United States Department of Agriculture, have implemented "best management practices" designed to reduce the amount of phosphorus that moves from the dairy lots into the region's watercourses (Baldwin). Apparently, however, these efforts are not sufficient.

The water quality issues in Lake Okeechobee are the focus of current study and debate. Apparently enforcement of regulations prohibiting the discharge of nutrients from agricultural lands into the surrounding waters would render agricultural operations economically infeasible, even if such nondegradation goals were possible to achieve.

A report of the Governor's Lake Okeechobee Technical Advisory Committee last year included a proposal to divert Taylor Creek and Nubbin Slough away from Lake Okeechobee into either a surface reservoir or into deep aquifer storage (Department of Environmental Regulation). Critics of this proposal express concern that the surface reservoir may be discharged to coastal estuaries with possible adverse effects on the estuarine environment. Dairymen have been required, by rule, to employ specified best management practices to reduce the movement of phosphorus into the watercourse. Some restrictions on backpumping into the south end of the lake have also been imposed. Beyond that, no definite measures have been adopted relative to the water quality effects of agriculture on the hydrologic system of which Lake Okeechobee is a part.

Pesticides, Deep Sands and Groundwater

Disney World is located amid the major citrus growing region of Florida. To the west, south and north citrus is grown on low sand hills known as the Florida Ridge. Soils here are deep and sandy and rainfall percolates rapidly downward to the water table in underlying aquifers. Along the Atlantic coast, from Indian River County south, citrus is grown in what is referred to as flatwoods areas—land that typically requires drainage and is characterized by high water tables.

About one hundred miles north of Disney World, in the vicinity of the town of Hastings, is a major potato growing area. Other vegetable crops are grown here as well. Throughout north Florida and out into the panhandle region, more traditional forms of row crop agriculture predominate.

In 1982, water samples drawn from a well near Hastings were found to contain the chemical aldicarb (McNeal). Aldicarb is widely used in citrus, potatoes and row crops as a control for nematodes and certain other pests. Aldicarb and its decomposition products are soluble in water and are not adsorbed by mineral soils, although they may be held by soils of high organic matter content, according to Chesters, et al. (Council for Agricultural Science and Technology, p.47).

Aldicarb is an acute poison (Shankland). However, it has not been shown to cause cancer, mutations or other chronic effects. It apparently is not accumulated in the body when ingested in asymptomatic doses.

Because of its toxic nature, its presence in well water created quite a stir within health, environmental and agricultural circles. Further sampling and testing revealed the presence of aldicarb in other Florida counties, especially in citrus production areas (McNeal). The chemical was found primarily in the shallower, surficial aquifers. It was never identified in samples drawn from the deeper Floridan aquifer, although traces were found in a part of the state where the limestone formations of the Floridan are near the surface (Kuhl).

The Florida Department of Environmental Regulation launched studies at seven separate sites around Florida to learn more about the behavior of aldicarb under various conditions of application and use (McNeal). Union Carbide, manufacturer of the chemical under the trade name of Temik, cooperated in the studies.

The Florida Department of Agriculture and Consumer Services, which has responsibility for pesticide registration and enforcement, used the new information about the behavior of aldicarb under Florida conditions to change the registration of aldicarb in a manner designed to eliminate threats to groundwater quality while retaining this useful chemical for agricultural applications. Specifically, the label rate of application was cut in half (Kuhl; McNeal). Applications of aldicarb are now permitted only during dry seasons of the year. Setbacks from potable water wells are now specified (within which the application of aldicarb is prohibited). Applicators are required to notify the Department of Agriculture and Consumer Services of their intent to apply aldicarb.

In July, 1983, the chemical ethylene dibromide was found in a sample of North Florida well water. Ethylene dibromide (EDB) was widely used as a fumigant for the control of nematodes in citrus, row crops and turf.

Subsequent sampling and testing of well water was conducted statewide through combined efforts of the Florida Department of Environmental Regulation, the Florida Department of Health and Rehabilitative Services and the Florida Department of Agriculture and Consumer Services with assistance from the Pesticide Research Laboratory at the University of Florida's Institute of Food and Agricultural Sciences (Aller; Kuhl). EDB was found in well water in twenty-two counties.

Under a program administered by the Florida Department of Agriculture and Consumer Services, EDB has been employed using four to five times the normal application over a twenty-year period in buffer strips around nematode-infested citrus groves and portions of groves, not only to kill the nematodes, but also to kill the citrus roots and prevent spread of the infestation. (Council for Agricultural Science and Technology; Kuhl). The nematodes move along the roots, but otherwise are essentially immobile. EDB was also used in some North Florida peanut producing counties.

EDB is described as a volatile liquid that is relatively soluble in water (Council for Agricultural Science and Technology). The solubility in water, the large quantities applied and the low retention by Florida soils help explain why this substance was found in groundwater under conditions favorable for downward movement despite its volatility.

Public health considerations prompted swift action against EDB. EDB is a chronic poison known to be carcinogenic and mutagenic (Shankland). The Commissioner of Agriculture ordered a halt to the sale and use of EDB in August, 1983 (Kuhl; Aller). The Florida registration of EDB was canceled, with minor exceptions. In October, 1983, the Environmental Protection Agency canceled federal registration of EDB.

The Florida Department of Environmental Regulation offered remedies to owners of contaminated wells (Aller). Depending on cost effectiveness, owners could either have a new well installed, activate charcoal filters fitted to existing water supplies or have their homes connected to existing, safe public water supply systems. Under this program very few new wells were drilled because the contaminants that ruined existing wells often persist in the surrounding aquifer, rendering local groundwater supplies unfit for unfiltered use. However, the program has installed hundreds of granulated activated charcoal filters statewide. Several hundred more homes have been connected to public water supply systems. One town replaced its municipal wells and several others fitted their treatment systems with charcoal filters. Funding for the remedial program has been provided by the state and also by the manufacturer listed as the registrant for EDB (Kuhl).

Public Policy For Water Quality Protection

Florida agriculture has received exceptional treatment, which is not to say favored treatment, in matters relating to water quality protection. To date, serious problems involving agricultural sources of water contamination have been handled through cooperative efforts of the industry with the relevant state agencies. However, the state has a water pollution control statute and a regulatory program in place to implement it.

Florida Statutes require construction and operating permits for "installations" that "will reasonably be expected to be a source of . . .

water pollution . . . " or for any "discharge into waters within the state (of) any waste which . . . reduces the quality of the receiving waters below the classification established . . . " (Florida Statutes, Chapter 403, Sections 403.087 and 403.088).

Florida has adopted numerical or descriptive standards that limit the amounts of pollutants allowed in state waters. These standards are based upon the quality of water believed to be necessary to support the designated use of the particular water bodies. In that context, all surface waters of the state have been classified according to five use categories, the most sensitive (for toxics) being Class I, Potable Water Supplies, and the least sensitive being Class V, Navigation, Utility and Industrial Use (Chapter 17–3.041, Florida Administrative Code). Technology based effluent limitations have also been adopted, as have certain minimum criteria "freefroms," stipulating substances that are banned outright.

Pursuant to authority granted by earlier safe drinking water legislation, the Department of Environmental Regulation (Florida's lead agency for pollution control) adopted administrative rules in 1982 classifying groundwater sources, with a "G-1" category designating current sources of public drinking water supply, high recharge areas, single source aquifers in limited areas, or aquifers set aside for future public water supply (*Florida's Environmental News*). The rule establishes minimum water quality criteria designed to prevent the introduction of dangerous toxic and carcinogenic materials to water supplies.

Studies showed some gaps in statutory authority or program funding to fully implement and enforce a comprehensive groundwater protection program. The state legislature responded by passing the Water Quality Assurance Act of 1983 (*Florida's Environmental News*). In summary, the act:

a) established a statewide groundwater monitoring network, and a data collection and repository program;

b) established a well-field contamination prevention program;

c) directed that all artesian free-flowing wells be plugged by 1995;

d) created a Pesticide Review Council, a multiagency advisory group reporting to the Commissioner of Agriculture on matters relating to pesticide registration and use within the state;

e) created a regulatory program for above- and below-ground storage tanks designed to eliminate the chronic threat to Florida's groundwater;

f) established a package plant inspection program, and provided $100 million for construction of sewage treatment plants;

g) created a program to promote proper disposal of small quantities of hazardous waste;

h) required a statewide assessment of hazardous wastes, and the siting of areas by each county where hazardous waste transfer stations could be located;

i) required the siting of a multi-purpose hazardous waste facility;

j) prohibited the disposal of hazardous waste into landfills or into underground formations;

k) required a permit for the closure of landfills (subject to performance standards);

l) provided $30 million over three years for cleanup of hazardous waste sites and pollutant spills.

Implementation of these programs is already underway. One area of emphasis has been the coordination of efforts between the Department of Environmental Regulation and the Department of Agriculture and Consumer Services in the area of pesticide use. Other needs relate to the analytical capability to analyze and interpret the large quantity of data on groundwater quality.

Florida is still learning about the relationship of agricultural practices to groundwater quality. Public policy so far has called for a multiagency preventative approach to managing agrichemicals (Vogel). This approach has included development of health-based standards, state pesticide registration requirements for data submission, product testing and field monitoring, education and preventive application restrictions to protect the resource as a whole. The multiagency approach has been dubbed effective in addressing the aldicarb and EDB detections and in implementing remedial measures in the EDB case. The same approach has carried over into more recent efforts to establish an improved state pesticide registration program.

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