

Characterization of the Hydrology, Water Quality, and Aquatic Communities of Selected Springs in the St. Johns River Water Management District, Florida

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As the population of Florida grows, the demand for water for public supply and other uses continues to increase. Ground water traditionally has been the main source of water supply. Projections by water managers of the St. Johns River Water Management District (SJRWMD) and ground-water flow models developed by the SJRWMD and the U.S. Geological Survey (USGS) indicate that increased pumping of ground water is likely to result in decreased discharge from most of Florida's many springs. Recent droughts have exacerbated the situation and will continue to do so in the future; in 2000, many springs had record low discharge. Springs support fragile aquatic ecosystems that are vulnerable to hydrologic change. Some spring ecosystems have been studied at various levels of detail. Many others remain unstudied, yet water managers are required by State law to set minimum flows and levels (MFLs) for all first, second and third magnitude springs. A better understanding of the hydrologic and ecologic conditions of springs is needed — but springs can differ greatly in such attributes as channel length and area of adjacent wetlands, effects of backwater from other streams, water chemistry, and land use in the springshed, so monitoring a standard set of criteria is not feasible. As a result, this study was initiated to (1) create a baseline snapshot of the aquatic ecosystems of selected springs in the SJRWMD, (2) establish a list of key measurable indicators of ecosystem health for possible use in determining MFLs for each spring studied, and (3) investigate possible correlations between composition/abundance of the aquatic communities and associated water chemistry.

Four springs were selected by the SJRWMD during 2004, based on the need for data to establish appropriate MFLs: the Silver Springs group (average discharge 798 cubic feet per second, ft³/s), DeLeon Spring (formerly Ponce de Leon; 30 ft³/s), Gemini Springs (7 ft³/s), and Green Spring (1 ft³/s). Water-chemistry sampling at each spring was tailored to supplement sampling by the SJRWMD and the Florida Department of Environmental Protection (FDEP). Each spring was sampled three times for major constituents, nutrients, color, turbidity, biochemical oxygen demand BOD, total organic carbon TOC, and chlorophyll-*a* and -*b* and twice for pesticides, wastewater constituents, dissolved gases, sulfur hexafluoride, and the nitrogen and oxygen isotopes of nitrate. Samples from the spring runs also were collected and analyzed for major ions, nutrients, color, turbidity, BOD, TOC and chlorophyll-*a* and -*b*. Benthic invertebrate samples were collected during three sampling events using FDEP protocols; vegetation and fish population surveys, and passive sampling of benthic algae were done once.

Nitrate concentrations ranged from about 1 milligram per liter (mg/L) in each of the Silver Springs group and in both bores of Gemini Springs to about 0.7 mg/L at DeLeon Spring to less than the detection limit of 0.02 mg/L at Green Spring. Delta N-15 values ranged from 5.6 per mil at the Abyss Spring of the Silver Springs group (indicating inorganic nitrogen sources) to 10.6 per mil at De Leon Spring (indicating organic sources). The ratios at the other springs are indicative of mixed sources of nitrogen. No analyses could be made for Green Spring because nitrate concentrations were below detection limits. The phosphate concentration of spring water was about 0.03 mg/L in the Silver Springs group, about 0.05 mg/L at DeLeon Spring, and about 0.07 mg/L in Green Spring and Gemini Springs.

Results of sampling for a group of 54 pesticide compounds indicated that atrazine and 2-chloro-4-isopropylamino-6-amino-s-triazine (CIAT) were present in water from Silver Springs and Gemini Springs

during both sampling events. No pesticides were detected in Green or DeLeon Springs. Water samples also were analyzed for 63 organic compounds commonly found in wastewater. During the first sampling of Silver Springs, phenol was found in a low but quantifiable concentration. Also detected, but at levels too low to quantify, were tetrachloroethene, benzophenone, N,N-diethyl-*meta*-toluamide (DEET), camphor, indole, and p-Cresol. During the second sampling at Silver Springs, bisphenol-a, tetrachloroethene, DEET, para-Cresol, and diethoxyoctylphenol, a known endocrine disruptor, were detected. At DeLeon Spring, the first sampling resulted in detection of 3-methyl-1(H)-indole (skatol), indole, and para-Cresol. During the second sampling, ethoxyoctylphenol, a detergent metabolite and endocrine disruptor, was detected. At Green Spring, 1-methylnaphthalene, 2-methylnaphthalene, naphthalene, benzophenone, bisphenol-a, methyl salicylate, DEET, para-Cresol, and para-nonylphenol (total) were detected in the first sampling. Phenol and DEET were detected at Green Spring during the second sampling. At Gemini Springs, 2-methyl-naphthalene, naphthalene, benzophenone, methyl salicylate, DEET, and triphenyl phosphate were detected during the first sampling. Phenol and DEET were detected at Gemini Springs during the second sampling.

The fish surveys indicated that Green Spring was depauperate with the exception of a dense population of mosquitofish and possibly other poeciliids. At DeLeon Spring, multiple individuals of a nonindigenous armored catfish (Callichthyidae, *Hoplosternum littorale*) not previously reported from this system were observed. Although usually associated with wetlands, this recently introduced species is rapidly colonizing the St. Johns drainage and other areas of the Florida peninsula. In Gemini Springs, large numbers of another non-native catfish (Loricariidae, *Pterygoplichthys disjunctivus*) were observed; this species also has rapidly expanded its range, and is especially prevalent in springs in the St. Johns River. Common carp (*Cyprinus carpio*) were observed in Gemini Spring; this is a species that is not known to be established in the St. Johns drainage. The ecology of these exotics in springs is unknown, but the armored catfish are of particular concern because of possible interactions with native species and alteration of habitats.

Passive periphyton sampling devices were installed at Gemini and DeLeon Springs to better understand the abundance and composition of benthic algae. Grab samples also were collected at the time the samplers were deployed. In DeLeon Spring, the dominant periphyton was *Lyngbya wollei*, a nitrogen-fixing Cyanobacterium that can produce saxitoxins. At Gemini Springs, the dominant periphyton was *Rhizoclonium* sp., a green alga with no known toxin-producing capabilities. The samplers showed evidence of substantial growth of algal mats which may have affected the experiment by preventing phytoplankton from becoming attached to the filters on the sampling devices.

Results of sampling for benthic invertebrates indicated that the overall diversity and abundance appeared to be moderately high (compared with unperturbed oligotrophic springs) and, combined with sample composition, may provide some insight into relative eutrophication (especially at Gemini Springs). At Gemini Springs, one troglomorphic amphipod was collected, probably *Crangonyx hobbsi* (a cave species primarily distributed through the Florida panhandle, Suwannee drainage, and Biscayne aquifer, but with few records from the St. Johns drainage). At Gemini Springs, a gerreid (water strider), *Halobates* sp., was collected; this species is found primarily in marine habitats. At DeLeon Spring, a single specimen of a dragonfly (Libellulidae, *Erythemis plebeja*, pin-tailed pondhawk), considered rare by FDEP, was collected.; this species has not previously been reported from Volusia County. Most samples were dominated by amphipods (*Hyalella azteca* and *Gammarus fasciatus*) that appeared to fluctuated seasonally in relative abundance.