Contamination of the Floridan Aquifer

Aquifers are natural freshwater reservoirs that serve as filtration systems vital to the groundwater used globally. Aquifers have multiple layers, most of which are confined by non-water bearing rocks. The upper level of the aquifer is not confined and is closely tied to the water table. Aquifers are made of water bearing materials such as fractured or permeable rock and loose materials (gravel, sand, or silt). Composition of an aquifer depends on the region. The Floridan aquifer is mainly karstified limestone. The bottom of the Floridan aquifer can be down to 2,500ft deep or more then 4,500ft deep, depending on the area.[1] Aquifers are crucial groundwater sources for a variety of uses. In Florida, as of the 2015 water withdrawal study by the USGS, public usage accounted for 53% of groundwater usage in Florida and agriculture accounted for 28%.[2] The question this paper aims to answer is such: To what extent are the Florida aquifers being contaminated, how are those contaminants being mitigated, and what effect are the contaminants having?

Florida has long struggled with water issues, despite the amount of surface water in the state and the large aquifer under most of the state. The Floridan aquifer is one of the most productive aquifers around the world, supplying water to more than 10 million people daily. Before the year 2000 Miami particularly had drilled deep injection wells for sewage disposal, with the intent that the sewage would purify within the aquifer before eventually making its way back to accessible depths. Instead, scientists

[1]Williams and Kuniansky, "Revised Hydrogeologic Framework of the Floridan Aquifer System in Florida and Parts of Georgia, Alabama, and South Carolina."
[2] Richard L. "Water Withdrawals, Uses, and Trends in Florida, 2015."

who now had the access and funding to research these new discoveries quickly realized that the water was cycling much faster than anticipated.

More recently in 2016, there was construction of a new well that goes down 10,000ft in the Miami-Dade area.[3] Miami has had multiple sewage leakage issues from deep injection wells in the past. Another source of contamination the Miami area has been dealing with is saltwater infiltration where saltwater is infiltrating into the freshwater of the aquifer. Specifically, at the Florida Power & Light's (FPL) Turkey Point nuclear power plant there was a large salt plume contaminating the aquifer from the plant's cooling canals. Cleanup of this plume began in 2016, and according to the FPL's remedial action report from 2021 they are on track for the 10 year monitoring plan with one exception.[4] That exception being the lower two to three layers of the aquifer which will take further extraction to decontaminate.

There is a known issue with saline infiltration in coastal aquifers, especially when there are storm surges and flooding. The biggest causation of saline infiltration is overdrawing of the aquifers, pulling the salt water in due to hydraulic equilibrium.[5] Due to years of channeling, diverting, and disruption of the natural flow of the region in South Florida, there was a significant increase in saline infiltrating and overtaking parts of the Everglades. This led to the approval of the Comprehensive Everglades Restoration Plan (CERP) by Congress in 2000. The project is intended to span multiple decades with the main goal of ecosystem rehabilitation of South Florida's wetlands.[6] This has been a

[3] Smiley, "10,000-Foot Injection Well Could Change How Miami Flushes | Miami ...,"

[4] FPL "FPL Remedial Action Annual Status Report 2021"
[5] Basack et al. "Saltwater Intrusion into Coastal Aquifers and Associated Risk Management"
[6] *Progress toward restoring the Everglades the Ninth Biennial Review - 2022*

slow process over the years but due to a more than 2x increase in federal funding, as of the 2022 CERP report, construction of mitigation infrastructures has been accelerated. So far, 2 of their projects have been completed, with many waiting for approval before continuing or are currently in progress. There has been a noticeable improvement from these projects, though more work still needs to be done.

Due to delayed recharge times, both natural and human caused, overuse of the aquifers can lead to this saline infiltration as well as sinkholes. Sinkholes are a phenomena caused by the slow or rapid shifting of soils into cavities in aquifers that has a ripple effect to the overlying rock and soils. Sinkholes are connected to local hydrogeologic conditions and weather patterns. Florida, especially East-Central Florida, experiences sinkholes in seasonal patterns due to the changes in rainfall and groundwater levels.[7] An example of this is the significant water drawdowns that can occur during the dry winter months to sustain certain crops (oranges, strawberries) through the winter freezes. Rapid localized impacts from the irrigation drawdowns to protect crops during winter freezes is a well known cause of winter sinkholes in the karst-driven region of east central Florida.[8]

In the past decade, there has been a noticeable decline in recharge rate of the Floridan aquifer. This is due to a variety of reasons, most notably increase in competition for groundwater from the agricultural and urban sectors as well as reduced areas for recharge resulting from development.[7] Urban areas with high amounts of

[7] Xiao et al. “Investigation of the Impacts of Local-Scale Hydrogeologic Condition….”
[8] Marriott, Xe, and Jennifer Marriott, PWS. Personal Communication with Florida Trained Ecologist.

impermeable surfaces (eg. concrete, asphalt, buildings, etc) severely restrict the recharge ability of native soils, thus decreasing the aquifer recharge rate.

Changes in land cover is another major contributor to contamination, specifically of the upper Floridan aquifer because it is unconfined, leaving the aquifer more vulnerable to outside influence.[9] Things like overuse of fertilizer (leading to fertilizer runoff) from both agricultural and urban settings can more readily contaminate the aquifer, particularly since large areas of Florida are dominated by sandy soils that allow for a more rapid infiltration rate compared to denser soils, such as silt, loam, or clay-based soils. Changes in land cover often also are the result of conversions from agriculture to urban areas, since rarely do agricultural or urban areas change back to native vegetation except as part of some mitigation/restoration effort, which exacerbates the impacts of the associated land use to the underlying aquifer.

Florida springs are fed by groundwater and aquifers. In the past decade there has been a noticeable increase in nitrate-nitrogen levels in both Florida springs and municipal supplies. While in most places these do not exceed the maximum levels determined by the EPA (capped at 10 mg/L) they go over the expected standard of 0.35 mg/L in more than a few areas.[10]

In 2007, a Bayesian-based aquifer vulnerability assessment (FAVA) was made and applied in Florida as a way to put numbers to the contamination issue scientists were observing in the Floridan aquifer.[11] While this does not directly attempt to solve the issue at hand, FAVA presented the key to identifying the issue within the scientific

[9] Bawa and Dwivedi. "Impact of Land Cover on Groundwater Quality…"
[10] Hobara. "Analyzing Nitrates in North Florida's Drinking Water."
[11] Jonathan et al. "Development and Implementation of a Bayesian-Based…"

purview. Vulnerability assessments like this are key however to guide drafting and implementation of new regulations as they provide the science necessary to explain the importance of these issues to politicians in charge and the people voting. Without the appropriate regulations in place it is difficult to push for improved environmental protections or address environmental impacts when they occur. These assessments also provide the frameworks in how a topic is discussed, as well as helping to solidify a base level of knowledge for a subject.

As more information comes out, the EPA does their best to update regulations. The Ground Water Rule was established by the EPA in 2000. However the compliance deadline for following the rule was 9 years later, December 1st, 2009.[12] The focus of the groundwater rule is on the prevention of bacteria borne diseases, such as E. Coli and not pollutants broadly. The EPA does still have maximum amounts for some contaminants such as Nitrate-Nitrogen.[7]

In Southern Florida there have been attempts to decrease dependence on groundwater through the construction of desalination plants. As of 2023 there were 40 desalination plants in the area, of which 38 were brackish water plants and 2 of which were saltwater plants.[13] This can lead to other issues as a result of the desalination process, specifically the creation of a hypersaline solution as a byproduct, which is generally dumped into water bodies nearby to be diluted by the water. HOwever, the water body receiving the hypersaline solution may not be able to dilute the solution to the extent anticipated. This byproduct and management of it is not heavily regulated.

[12] Water, Office of. “Ground Water Rule Factsheet: General Rule Requirements”
[13] SFWMD. “Facilities Using Brackish Groundwater and Seawater in South Florida.”

Effects of this can be seen in Tampa Bay as they are struggling with ocean acidification tied to the new saltwater desalination plant in the area. Other than desalination plants, Florida has been working for the past approximately 30 years now to reuse non-potable water (typically grey water repurposed for irrigation or industrial purposes) as another way to reduce groundwater dependence. The population of Florida has increased by more than 10x over the past 50 years and keeping up with water demands is a challenge for many Florida municipalities.[14]

A major local movement is the Florida Right to Clean Water (FL RTCW) that is pushing for an amendment to Florida's legislation in order to get further legal protections for all of Florida's waters. The FL RTCW was established in 2022, representatives have given lectures across the state raising awareness for their cause as well as attempting to get people to sign their petition.[15] With this improvement in legal protections, the FL RTCW is intending to sue cities and companies when they perform or are seeking to perform actions that would cause harm to hydraulic environments.

The Floridan aquifer is being negatively affected by a variety of sources from both urban and agricultural areas. Some of the impacts to aquifers include agricultural runoff, particularly excess nitrogen, impervious land cover on normally permeable areas reducing natural recharge of aquifers, municipal sewage injections, and most notably saline infiltration from overuse of these aquifers. While there have been some attempts to rectify the contamination issues within the Floridan aquifer it is almost always in

[14] Florida DEP. "Alternative Water Supply."
[15] FL RTCW "Florida Right to Clean Water."

direct response to something going wrong instead of an attempt to fix the slow burning issues. Mitigation attempts are almost always responsive instead of predicated and never given the attention or funding necessary to make a change.

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