White Lake Springs: Flow Rates Variable

What studies have been done of the springs?

Frey (1949):

Dr. Frey examined springs areas in 1947 and found the centers to be about 8" lower than the edges, with hard sand bottoms, with no detectible chemical evidence of any volume of water entering the lake through these depressions, although he noted that "at a time of higher lake level and more favorable ground water conditions there might be visible evidence of inflowing water". He also noted that rainfall on the lake surface and watershed was the primary source of water to the lake.

NC DNRCD (1982):

Newly installed groundwater wells provided "evidence of a semi-confined groundwater aquifer which is probably the source for the springs that have been reported near the northeastern shore in the lake"; this report goes on to state: "the exact relationship between rainfall, groundwater levels, and the lake level should become more clear as monitoring continues" (which did not, as there was no funding). The US Geological Survey definition of a water table, or unconfined aquifer is "an aquifer whose upper water surface (water table) is at atmospheric pressure, and thus is able to rise and fall. Water-table aquifers are usually closer to the Earth's surface than confined aquifers are, and as such are impacted by drought conditions sooner than confined aquifers" (https://www.usgs.gov).

USGS (2010):

Hydrogeological mapping based on nearby well data shows that the surficial aquifer in this region includes a shallow layer of groundwater bisected by a shallow "hardpan" clay layer.

NC DEQ (2017):

Groundwater level monitoring noted the association between levels in a shallow onshore well and a shallow in-lake well. A deeper in-lake well installed by DEQ at a springs site had the same pH and nutrient levels as the lake water.

Shank and Zamora (2019)*:*

- Groundwater inputs to the lake are low, because the groundwater capture zone feeding the lake is relatively small. Inflow comes primarily from the north and east, with outward groundwater flow along the west and southwestern edge of the lake.
- There was no evidence (from an isotope study) that springs from deeper confined aquifers are contributing water to the lake.
- High-volume rainfall (as was seen during Hurricane Florence) and infiltration could create flow through "preferential groundwater flow paths" such as fractures in the hardpan clay layer that produce freshwater springs, with the chemical characteristics of the surficial aquifer groundwater.
- Monitoring of groundwater levels (both above and below the clay layer) in late 2018 demonstrated the direct relationship between rainfall and groundwater levels.
- Lake water loss to groundwater was determined to be 5 times greater than the amount of groundwater flowing into the lake.
- Annual groundwater flow into the lake was variable, ranging from near zero to 6% of lake volume, with higher flow related to higher groundwater levels.
- There was no evidence found that blueberry farm pond pumping is affecting groundwater flow into White Lake. Most of these ponds are in areas where groundwater flow is naturally away from the lake (so they are outside the groundwater capture zone for the lake).

The following three figures are from Shank and Zamora's 2019 report:

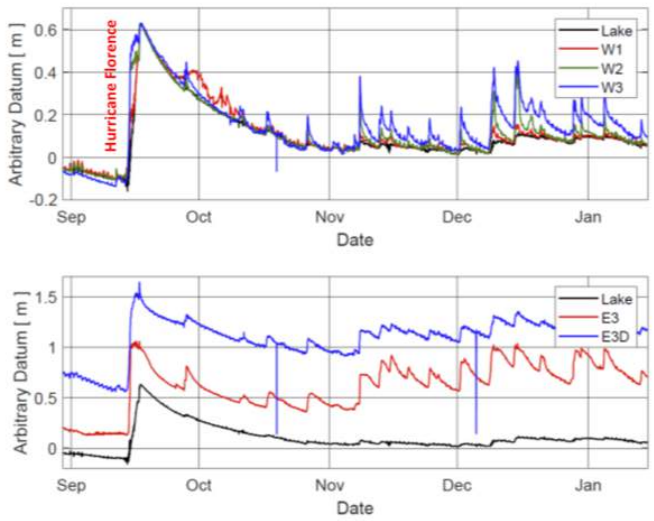


Figure 16. Time-series water level plots from east (E) and west (W) well transects. W1 is closest and W3 is furthest from lake. E3 is shallow and E3D is a deep well. White Lake water level was monitored at end of lake pier near west well transect.

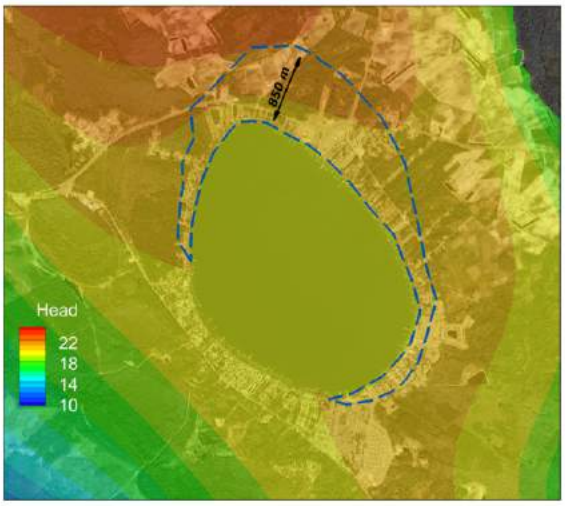


Figure 23. Groundwater contributing zone for White Lake showing the widest section in the northeastern sector.

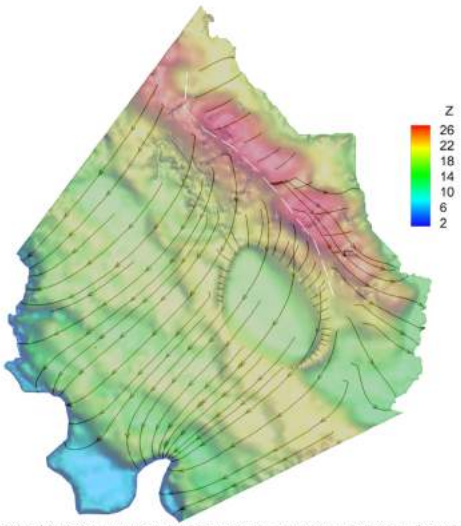
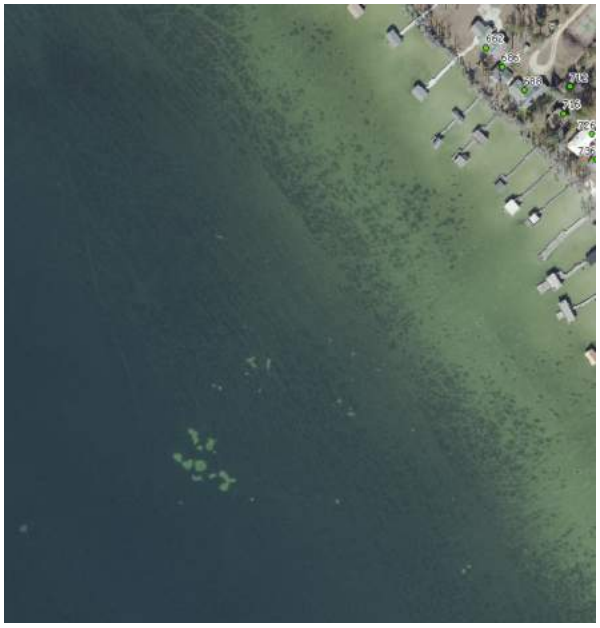


Figure 20. Plan view of 3-D numerical simulation showing groundwater flow lines. Dashed white line marks the flow divide: groundwater on the left side generally flows towards the Cape Fear River and groundwater on the right side generally flows towards Colly Creek. All flow lines begin at the terrain surface.

Shown below is a cropped image from aerial photography of White Lake taken in 2013, with the springs visible as white sand areas. The springs are generally clustered along the seven-foot depth contour along the eastern shoreline.



Steve Bunn and Bill Stafford Springs Sampling

Seepage meters were constructed, based on the design in Lee (1977), allowing for the direct measurement of springs flow rates. The simple devices seal off a 3-square foot area of lake bottom, and a bag is attached to a valve to capture water flow for a timed period.

The first sampling was done in July 2018, with divers placing a seepage meter in a 30' diameter spring (#1); the flow rate was measured at 0.26 gallons/hr (1 liter/hr), and the seepage meter was removed after the measurement was made. Rainfall was above average in the early summer 2018, with June rain totaling 10 inches, but no lake level measurements were available.

On September 15, 2021, divers installed a seepage meter in a 15-foot diameter spring (#2); the flow rate was 0.63 gallons/hr (2.4 liters/hr), or an estimated 35 gallons/hr total flow for the 15-ft. spring. Several other springs were tested, and no flow was detected. September rainfall was 3.2 inches, and lake level was 64.35 feet NAVD 88.

A second sampling trip was done October 8, 2021; there was no measurable flow from meter #2, while a newly installed meter in the 30'spring sampled in 2018 (#1) had a flow rate of 0.079 gallons/hr (0.3 liters/hr). October rainfall was 0.7 inches, with a lake level of 64.1 feet NAVD 88. This was over a foot below the lake level high found in February. Normal lake level variation ranges from 12 to 18 inches over an annual cycle.

Frequently Asked Questions:

Q: Do low lake levels mean the springs are not working?

A: No, the hydrology of the lake is influenced by rainfall, so lake levels and groundwater levels (and therefore groundwater flow rates) fluctuate naturally. Groundwater flow is highest when the water table is high, which happens when it rains a lot. Rainfall amounts can vary quite a bit from year to year. Lake water can also flow from the lake into the groundwater as well as exiting from the Turtle Cove outlet.

Q: Does the higher pH of the lake mean the springs are not working?

A: No. The pH of the lake is dictated by rainfall pH, as every inch of rainfall is equivalent to a volume of 29 million gallons of water added to the lake. The pH of rainfall had been around 4.5 (= "acid rain") and is now averages around 5.8. Atmospheric pollutants that created acid rain have been substantially reduced over the same time as the pH of the lake changed.

Q: Was springs flow much higher long ago?

A: The recent work by Bunn and Stafford to measure springs flow are the first direct measurements that have been done. There is no way of knowing what the historical flow rates might have been because they were not measured, although the earliest observations (by David Frey) indicate that springs flow was variable then as it is now and is directly related to water table levels.

References

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Frey, D.G. 1949. Morphometry and hydrography of some natural lakes in the North Carolina Coastal Plain. The Bay Lake as a morphologic type. Journal of the Elisha Mitchell Scientific Society 65(1): 1-37.

Lee, D.R. 1977. A device for measuring seepage flux in lakes and estuaries. Limnology and Oceanography 22(1): 140-147.

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