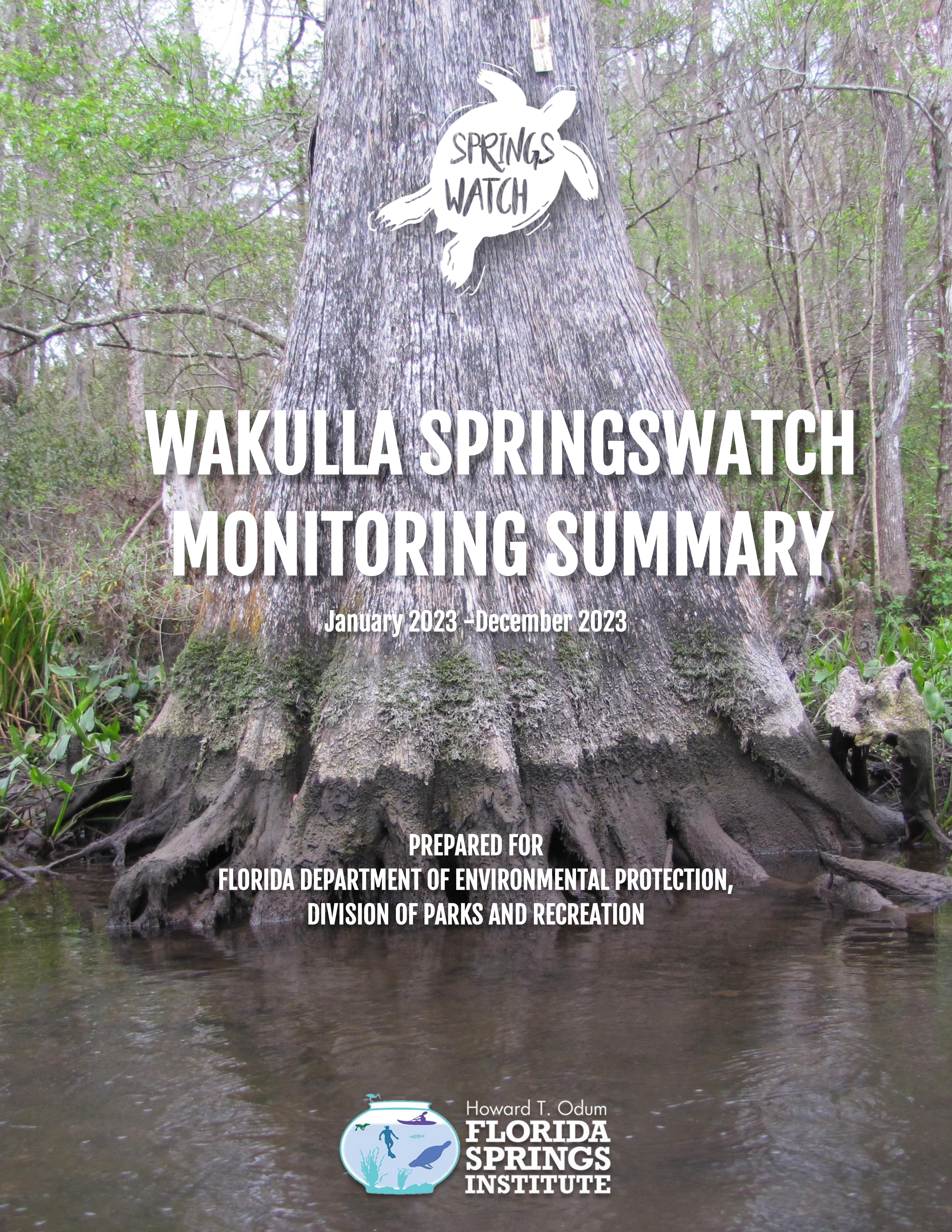


SPRINGS WATCH

WAKULLA SPRINGSWATCH MONITORING SUMMARY

January 2023 -December 2023

PREPARED FOR
FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION,
DIVISION OF PARKS AND RECREATION

Howard T. Odum
FLORIDA SPRINGS INSTITUTE

Volunteer and Staff Acknowledgments

This report was prepared by the Howard T. Odum Florida Springs Institute (FSI). Ecological monitoring was conducted by Florida SpringsWatch volunteers and FSI staff under the Florida Department of Environmental Protection Division of Recreation and Parks Research/Collection Permit Number 07012340.

Our Wakulla SpringsWatch program would not be possible without the hard work of our team leader, Sean McGlynn, Edward Ball Wakulla Springs State Park boat captains, and a dedicated team of volunteers: Brian Lupiani, Julia McGlynn, Cal Jamison, David Shepard, Miranda Capps, Brandon Monram, and Kaden Gould. Together they put in 188 volunteer hours over 12 monitoring sessions in 2023. We would like to thank Isaac Szabo for his underwater fish photography utilized in this report.

We would like to thank FSI's SpringsWatch Coordinators, Emanuela Torres-Marquis, Shannon Letcher, and Jill Lingard, Environmental Scientist Bill Hawthorne, and Associate Director, Haley Moody for their contributions to this report; all who worked under the guidance of Executive Director, Dr. Emily Taylor. We also acknowledge the ongoing guidance from former Executive Director Dr. Robert Knight.




Section 1.0 Introduction

Located 16 miles south of Tallahassee, Wakulla Spring is one of the largest first-magnitude artesian springs in Florida and the United States. Wakulla Spring lies within the Edward Ball Wakulla Springs State Park, which is listed on the Natural Register of Historic Places and is designated a National Natural Landmark. Wakulla Spring forms the headwaters of the Wakulla River, which flows for nearly 11 miles before merging with the St. Marks River in the town of St. Marks. Wakulla Springs is renowned for its natural beauty and has been a favorite recreational site, as well as potable water source, for residents of Leon, Wakulla, and surrounding counties. However, the river and springs have not been immune to human impacts, demonstrating reductions/reversals in flow, elevated nitrate nitrogen, increased dark-water days, and increased growth of invasive hydrilla and filamentous algae.

FSI's SpringsWatch volunteer citizen-science program has provided enhanced monitoring of the Wakulla River and springs ecological health since 2019. The resulting data are provided in annual reports and via the SpringsWatch website (floridaspringsinstitute.org/springswatch) to inform the state's environmental agencies and educate the public about the springs and river health.

This report was prepared by the Howard T. Odum Florida Springs Institute and is focused on 2023 ecological monitoring along the Wakulla River and springs conducted by SpringsWatch volunteers.

Section 2.0 Methods

SpringsWatch volunteers conducted ecological monitoring on the Wakulla River from January to December 2023. Data collection included water quality field parameters, light attenuation measurements, aquatic vegetation and wildlife surveys.

2.1 Monitoring Stations

Figure 1 shows the nine SpringsWatch monitoring stations along the Wakulla River. WAK-HS represents the head spring; WAK-1 through WAK-8 denote river stations. For the first half of 2023, SpringsWatch volunteers conducted monthly sampling sessions at six stations: WAK-HS, WAK-1, WAK-2, WAK-3, WAK-4, and WAK-7. The state park's pontoon boat couldn't access stations WAK-5, WAK-6, and WAK-8 during lower water levels.

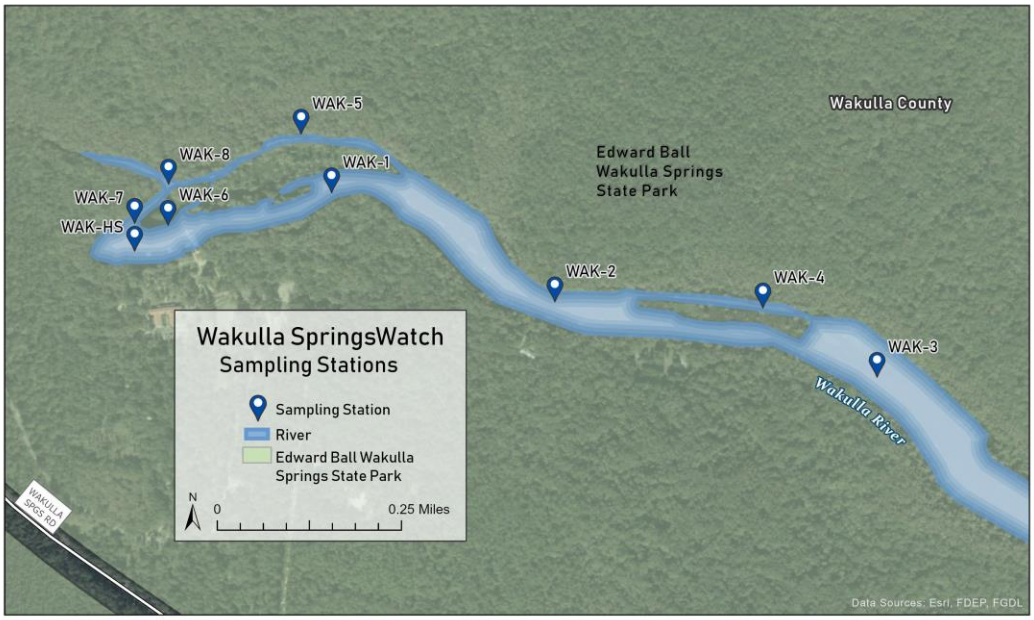


Figure 1. Wakulla SpringsWatch monitoring stations.

2.2 Sampling Events

Table 1 summarizes the 12 sampling events that occurred in 2023 along the Wakulla River. Monitoring was conducted by SpringsWatch volunteers with assistance from FSI staff.

Wakulla monitoring events include the following:

- Water quality field parameters (temperature, dissolved oxygen, dissolved nitrate-nitrite, and specific conductivity)
- Vertical light attenuation
- Vertical Secchi disk measurements of water clarity
- Aquatic vegetation survey
- Visual bird counts
- Visual fish counts

Table 1. 2023 Sampling Events for Wakulla SpringsWatch

Date	Temperature	Dissolved Oxygen	Specific Conductance	PAR	Secchi	Nitrate+Nitrite	Vegetation	Birds	Fish
1/26/2023	X	X	X	X	X		X	X	X
3/2/2023	X	X	X	X	X		X	X	X
3/30/2023	X	X	X	X	X		X	X	X
4/27/2023	X	X	X	X	X		X	X	X
5/25/2023	X	X	X	X	X		X	X	
6/21/2023	X	X	X	X	X		X	X	X
7/27/2023	X	X	X	X	X		X	X	X
8/24/2023	X	X	X	X	X		X	X	X
8/29/2023						X			
9/28/2023	X	X	X	X	X		X	X	X
10/26/2023	X	X	X	X	X		X	X	X
12/28/2023	X	X	X	X	X		X	X	

2.3 Water Quality

SpringsWatch volunteers used handheld YSI ProODO and EcoSense EC300A meters at each of the six Wakulla River monitoring stations to collect dissolved oxygen, temperature, and specific conductance measurements. Volunteers maintained the meters according to factory instructions and calibrated them before and after each sampling event.

2.3.1 Nitrate-Nitrite

Nitrate-nitrite samples were taken in August 2023 by FSI staff at station WAK-HS. Water samples were sent to a state-accredited laboratory (McGlynn Laboratories Inc.) for nitrogen as nitrate-nitrite (NOx-N) analysis. Preparation, storage, and analysis all followed FDEP Standard Operating Procedures. Samples were hand collected from approximately 0.1m depth. Sample bottles were re-capped and sealed before being acidified with approximately 0.25mL of 50% sulfuric acid (H2SO4) and then stored on ice prior to transport. Water sampled were held in a refrigerator for <21days before being sent to a state-accredited laboratory (McGlynn Laboratories Inc.) for NOx-N analysis. All analyses were conducted within a standard holding time of 28 days from sample collection.

2.4 Light Measurements

Photosynthetically Active Radiation (PAR) underwater light transmission and attenuation coefficients were measured monthly at the 15 monitoring sites. Volunteers used a LI-COR brand LI-250A underwater quantum photometer to measure PAR energy reaching the water surface and at depth intervals of one foot and two feet. Figure 2 provides an image of the LI-COR photometer.

Figure 2. LI-COR LI-250A Photometer

2.4 Secchi Disk Visibility

SpringsWatch volunteers took monthly vertical Secchi disk measurements at Wakulla head spring, station WAK-HS, throughout the sampling period.

The Secchi disk (Figure 3) is a tool for measuring water clarity in aquatic ecosystems. It is a disk with alternating black and white quadrants that is lowered into the water until it is no longer visible. The depth at which the disk disappears is known as the Secchi depth and is used as an indicator of water quality. Secchi length can be used to monitor changes in water clarity over time and can be used to identify problems such as algal blooms or pollution.

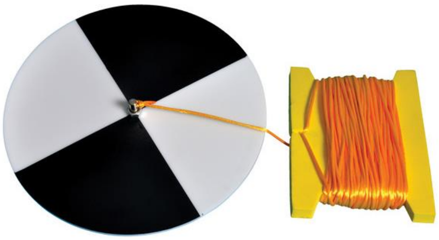


Figure 3. Secchi disk.

2.5 Vegetation

Submerged aquatic vegetation (SAV) was monitored monthly at each station. SpringsWatch volunteers took two photographs at each station in two different locations, which they sent to FSI for analysis and vegetation identification.

2.6 Bird Surveys

Between January and December 2023, eleven bird counts occurred within Wakulla by SpringsWatch volunteers. Wakulla SpringsWatch volunteer recorded visual observations of birds during the entire sampling session (Figure 1).

2.7 Fish Surveys

Between January and December 2023, nine fish counts occurred within Wakulla by SpringsWatch volunteers. Volunteers recorded visual observations of fish at each sampling station (Figure 1).

Section 3.0 Results

This section summarizes field data along the Wakulla River and springs collected from January to December 2023 by SpringsWatch volunteers.

3.1 Water Quality

3.1.1. Dissolved Oxygen, Water Temperature, and Specific Conductance

Figure 4 through Figure 9 present water quality results collected from Wakulla SpringsWatch stations from January to December 2023. Figures 4 shows dissolved oxygen results measured in percent saturation (DO%). Figure 5 presents DO data measured in milligrams per liter (mg/L), or parts per million (ppm).

DO levels fluctuated between spring and river stations primarily due to groundwater vs. surface water influence. Spring stations tend to exhibit lower DO values than river stations since emerging groundwater typically contains less free oxygen depending on the duration of time the water has been underground before reaching a spring vent.

Stations WAK-HS and WAK-7 are closest to the Wakulla Spring vent (Figure 1) and exhibited the lowest DO concentrations. As water moves downstream, its potential to receive oxygen from atmospheric diffusion and from photosynthesizing SAV and algae increases, resulting in higher DO concentrations.

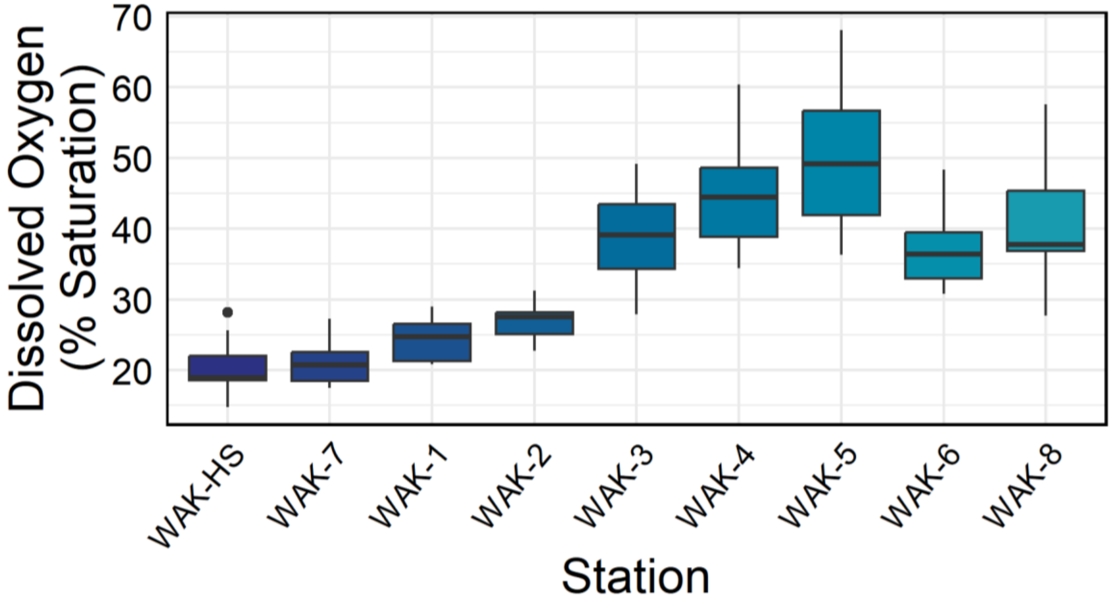


Figure 4. Dissolved oxygen percent saturation (DO%) by Wakulla SpringsWatch station (January-December 2023).

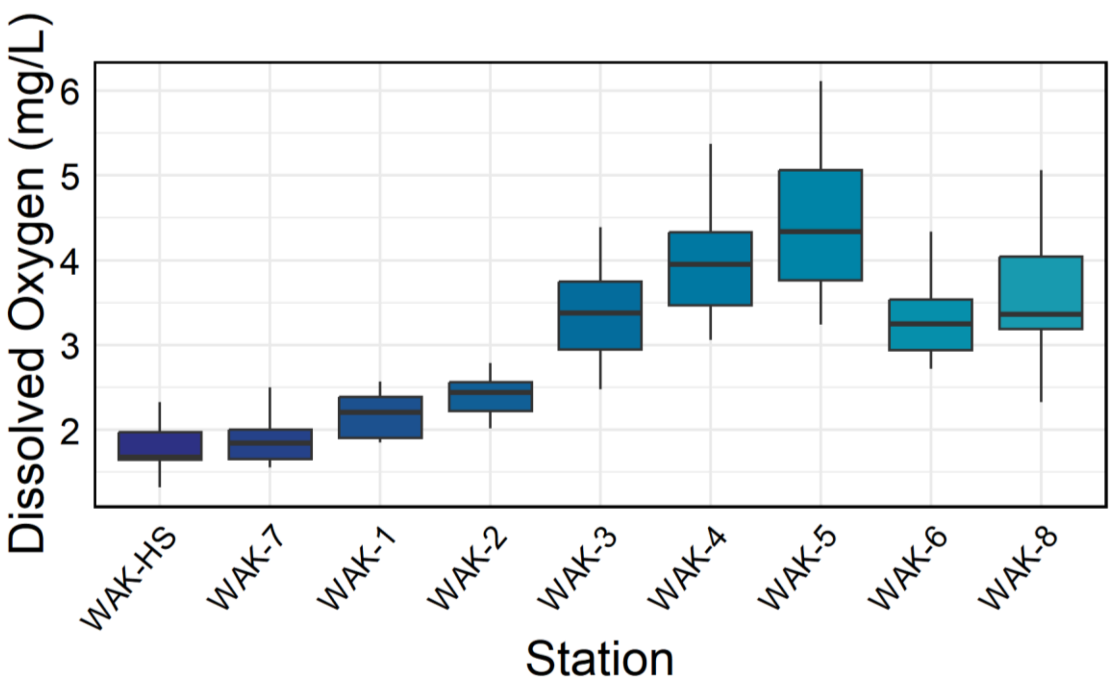


Figure 5. Dissolved oxygen percent saturation (DO mg/L) by Wakulla SpringsWatch station (January-December 2023).

Figure 6 presents data for water temperature (°C) field measurements by station and by month. Water temperature in the Wakulla Headspring, WAK-HS, ranged from 19.7-21.3°C with an average of 20.9 °C remaining relatively constant throughout the year due to its groundwater sources (typically 22°C).

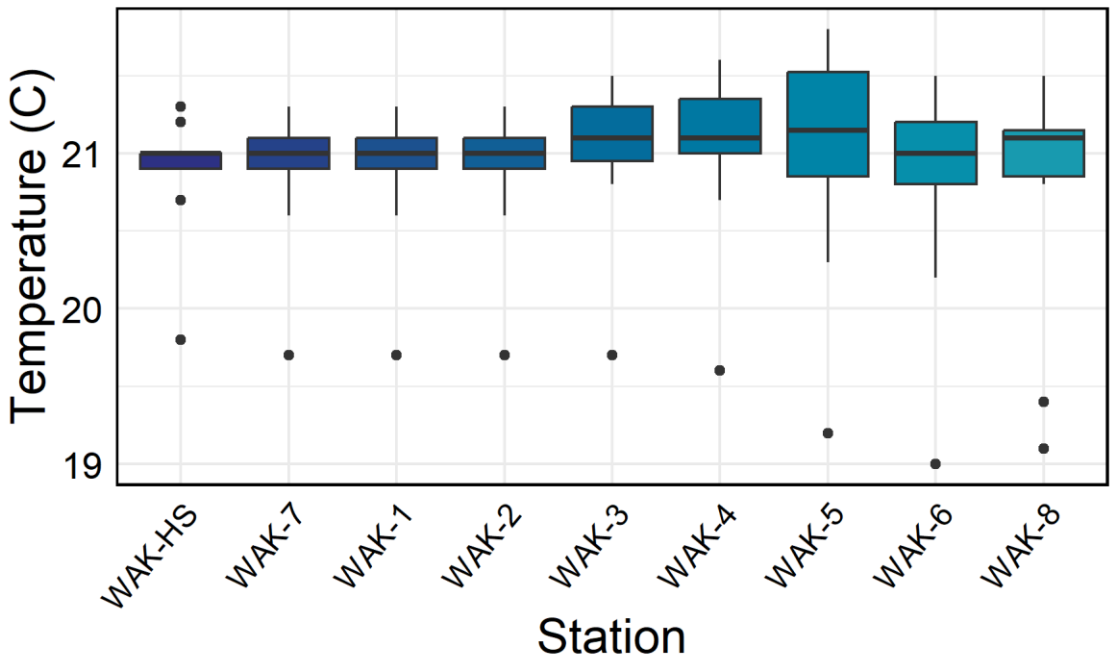


Figure 6. Water temperature (°C) by Wakulla River station (January-December 2023).

Figure 7 and Figure 8 show the results for specific conductance (uS/cm) field measurements by river station.

Specific conductance levels can be influenced by naturally occurring ions present in spring water but also from ions present due to higher levels of nitrate/nitrite, saltwater, and other compounds. Higher specific conductance values suggest a higher concentration of these ions in the water.

All of the Wakulla stations exhibited periodic elevated specific conductance readings. These readings may be due to backflow of saltwater inland from Springs Creek Springs (Davis and Verdi, 2014). Lower concentrations of specific conductance are a possible indicator of swallet inlets on the edge of the Apalachicola National Forest feeding surface water with elevated tannic color to Wakulla Springs. Evidence for these phenomena is provided in FSI's Wakulla Springs Restoration Plan (FSI 2012).

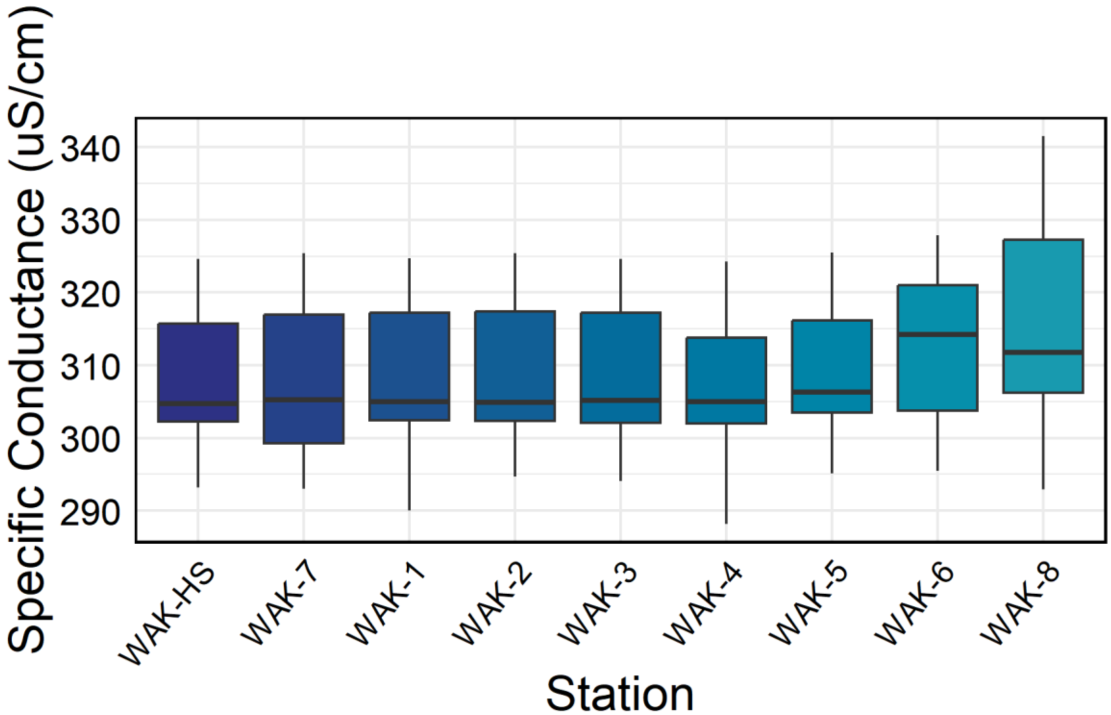


Figure 7. Specific conductance (uS/cm) by Wakulla SpringsWatch station (February-December 2023).

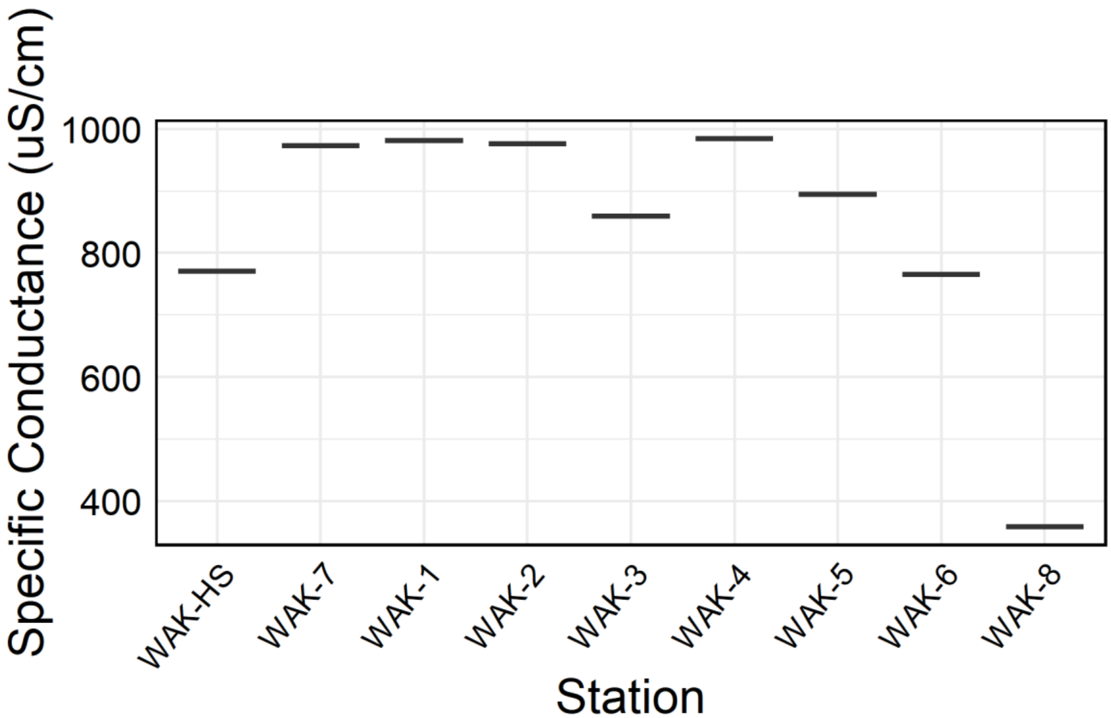


Figure 8. Specific conductance (uS/cm) by Wakulla SpringsWatch station (January 2023).

SpringsWatch volunteers collected Nitrate-nitrite (NOx-N) samples at Wakulla head spring in August 2023. The springs impairment level set by the Florida Department of Environmental Protection is 0.35mg/L. NOx-N at station WW-HS was 0.45 mg/L, which is greater than the FDEP threshold.

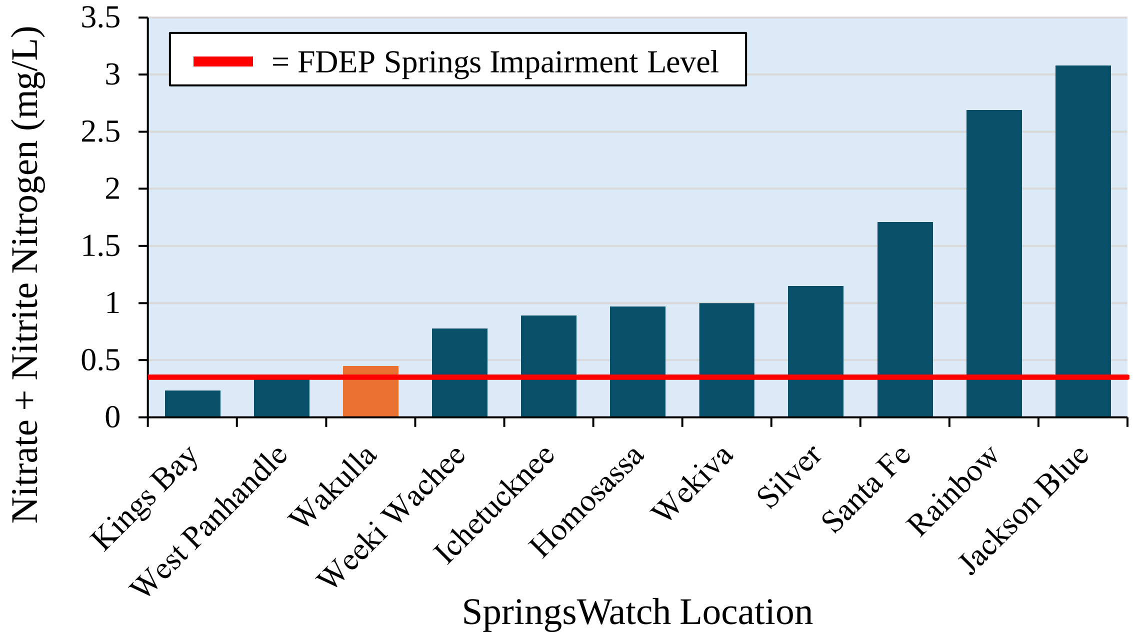


Figure 9. Nitrate-nitrite (NOx-N levels at SpringsWatch samples sites in 2023. Taken in August 2023, Wakulla is denoted by the orange bar.

3.2 Clarity and Light Measurements

3.2.1 Secchi Disk Visibility

Figure 10 presents vertical Secchi disk measurements in meters at the Wakulla headspring (station WAK-HS) during the sampling period. Secchi data provides additional information concerning water clarity and the light attenuation properties of the spring. Secchi distances ranged from 3.3 meters to 18.0 meters throughout 2023, with an average of 11.1 meters. Lower Secchi measurements indicate reduced water clarity, possibly due to recreational activity and resuspension of algae growing attached to surfaces in the stream channel.

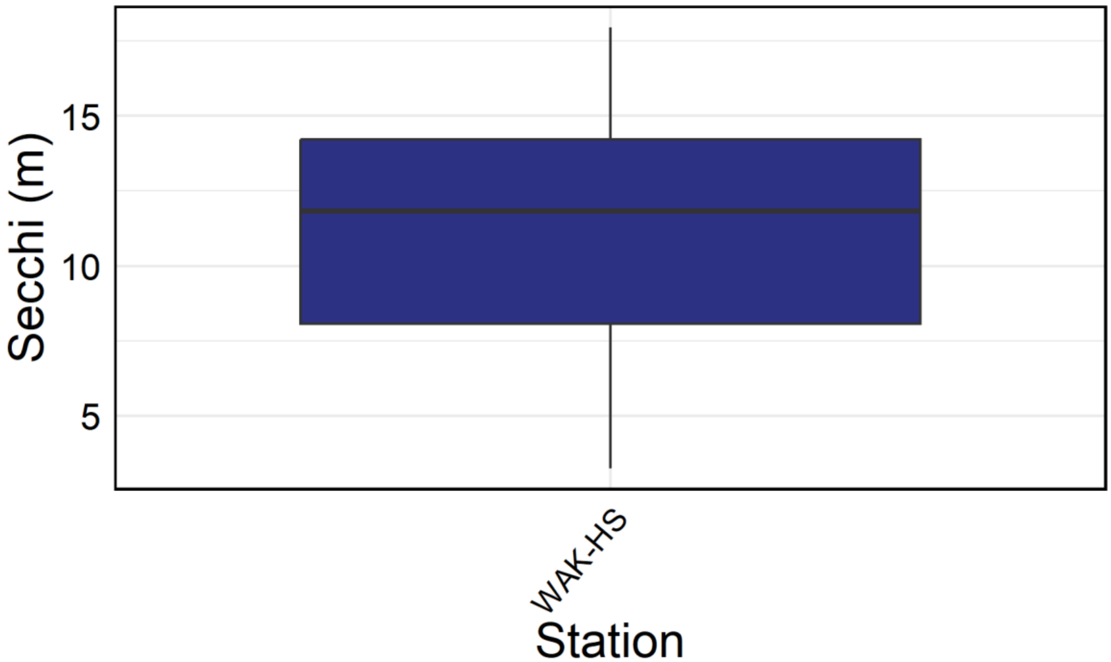


Figure 10. Vertical Secchi disk measurements (m) at Wakulla Spring (Station WAK-HS) (January-December 2023)

3.2.2 Light Measurements

Table 2 and Figure 11 present the percent transmittance estimates collected by Wakulla SpringsWatch volunteers from January through December 2023.

Percent transmittance refers to the amount of light that is able to pass through the water column to a depth of 1 meter below the surface. Figure 12 presents the k (diffuse light attenuation) calculated average per Santa SpringsWatch monitoring session (January to November 2023). The diffuse attenuation coefficient (k) is the calculated via the Lambert-Beer equation (Wetzel 2001) to measure how readily light dissipates throughout the water column. Higher attenuation values correspond to less water clarity. Higher values of percent transmittance tend to correspond with lower values of coefficient k. Higher k values, or lower percent transmittance values, can indicate poor water clarity since light cannot pass as easily through the water column, often due to increases in dissolved substances such as tannins (color) and suspended solids (turbidity) in the water.

In aquatic ecosystems, the diffusion attenuation coefficient can have a significant impact on the biota that inhabit the water. For example, in shallow, clear water with a low diffusion attenuation coefficient and high percent transmittance, light can easily reach the bottom of the water column, enabling the growth of aquatic plants and phytoplankton. This, in turn, can support the entire food web, from primary producers to top predators. On the other hand, in deep, turbid water with a high diffusion attenuation coefficient and low percent transmittance, light is unable to penetrate as far, limiting the growth of aquatic plants and phytoplankton. This can have cascading effects on the entire ecosystem, potentially reducing the population size and diversity of biota that depend on these primary producers. Thus, the diffusion attenuation coefficient is an important factor to consider when evaluating the health and productivity of aquatic ecosystems.

All of the stations had average percent transmittance between about 24-60%. Combined with the Secchi depth data described above, the continuing impairment of water clarity in Wakulla Spring is confirmed. As described in FSI (2012), reduced aquifer pressures in Leon and Wakulla counties due to large groundwater extractions by Tallahassee and in south Georgia have altered the historic movement of groundwaters in the Floridan Aquifer. Wakulla Spring is receiving an increased share of tannic groundwaters from the Apalachicola National Forest that in the past flowed south to Springs Creek. Increased tannic water is presumed to be the cause of reduced water clarity in Wakulla Spring.

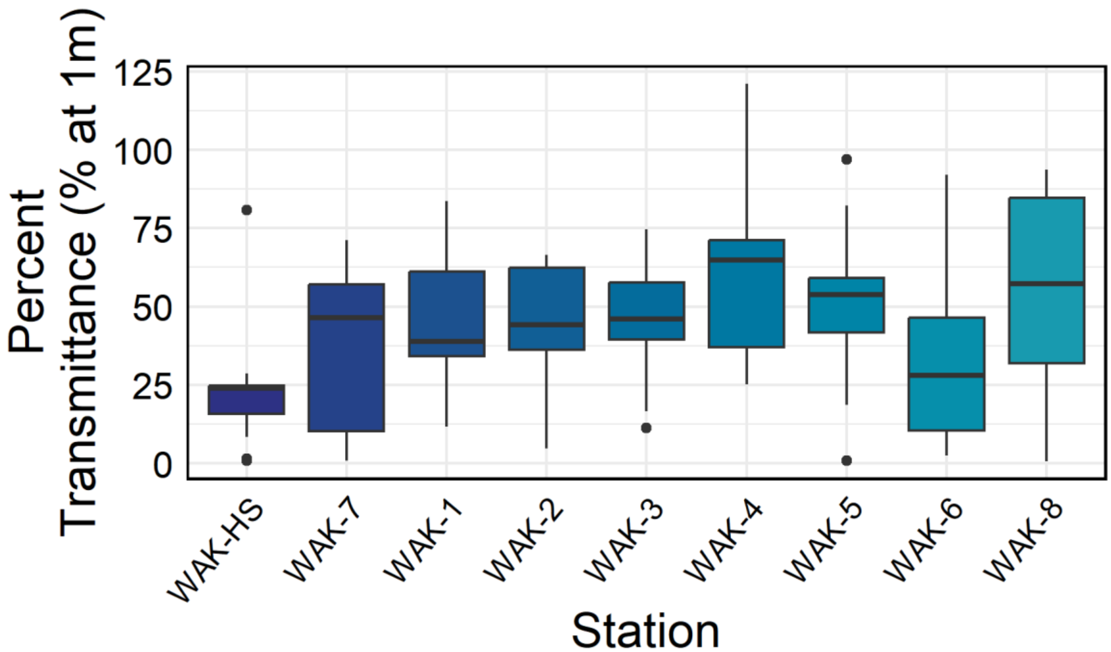


Figure 11. Percent transmittance (@ 1m) for Wakulla SpringsWatch (January–December 2023).

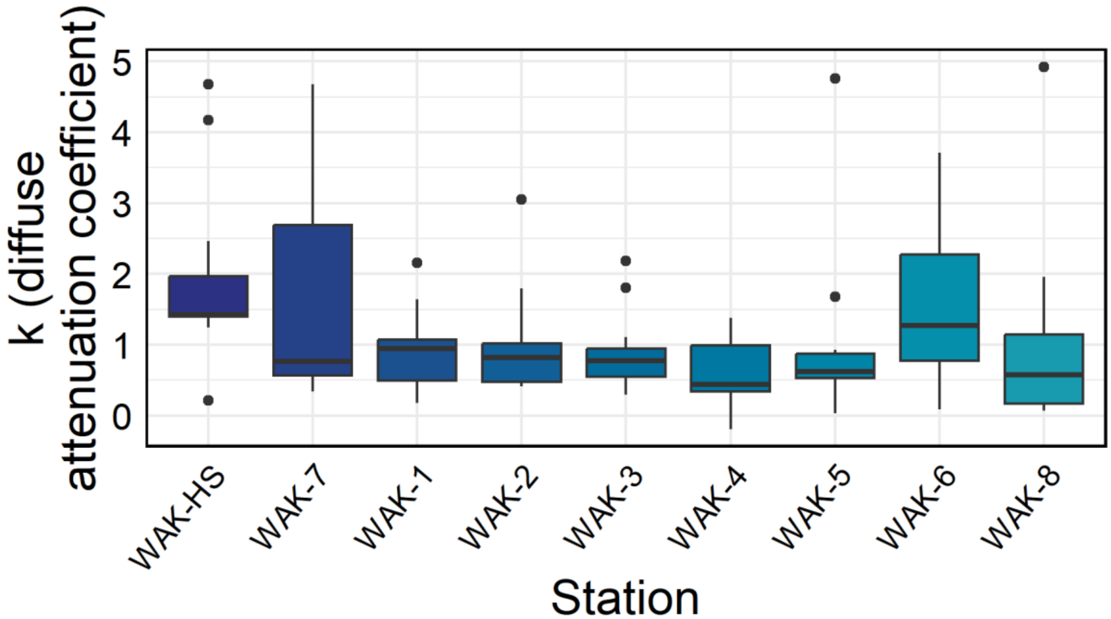
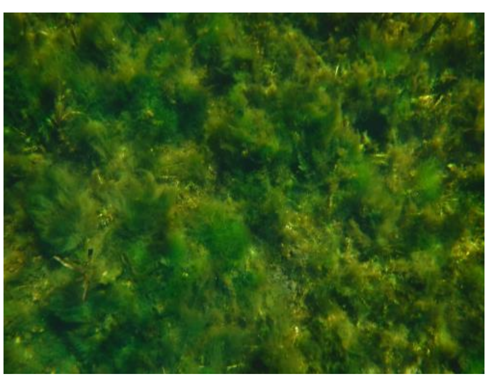


Figure 12. k (diffuse attenuation coefficient) by Wakulla SpringsWatch station (January - December 2023)

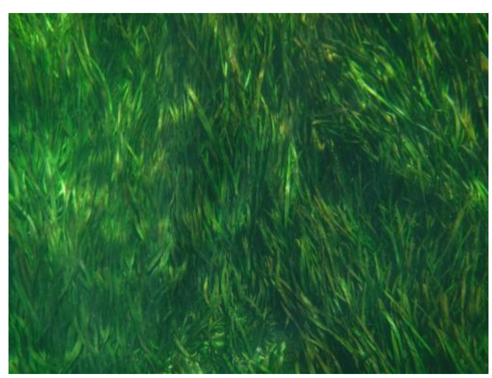
3.3 Aquatic Vegetation Survey

Submerged aquatic vegetation plays an important ecological role within a springs system. It provides habitat and food for fish and other wildlife, increases water clarity, affects nutrient cycles, and stabilizes shorelines and sediments. This data presents an ongoing record of conditions in the river and spring and will be useful for comparison to future evaluations of the ecological health the Wakulla system.

Pictured below are river bottom photos taken by SpringsWatch volunteers in 2023 which feature the SAV of the Wakulla River and springs.

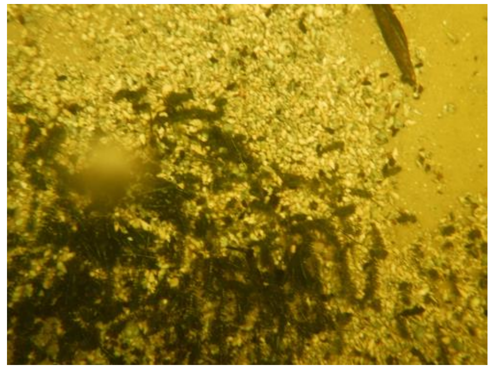


Hydrilla and algae



Vallisneria

Vallisneria and algae



Hydrilla and sand

3.4 Bird Survey

Wakulla SpringsWatch volunteers recorded visual monthly observations of birds between stations all stations (Figure 2). Table 2 presents a summary of birds observed during monthly outings. In total, 24 species were observed. Hooded Mergansers were the most commonly observed species.

Table 2. Average birds observed during Wakulla SpringsWatch monitoring sessions (January - December 2023)

Common Name	Scientific Name	Average # Counted Per Survey
American Coot	*Fulica americana*	4
Anhinga	*Anhinga anhinga*	10
Belted Kingfisher	*Megaceryle alcyon*	1
Black Crowned Night Heron	*Nycticorax nycticorax*	4
Black Vulture	*Coragyps atratus*	11
Cattle Egret	*Bubulcus ibis*	13
Common Moorhen	*Gallinula chloropus*	31
Double Crested Cormorant	*Phalacrocorax auritus*	16
Great Blue Heron	*Ardea herodias*	2
Great Egret	*Ardea alba*	3
Green Heron	*Butorides virenscens*	2
Hooded Merganser	*Lophodytes Cucullatus*	65
Least Bittern	*Ixobrychus exilis*	1
Little Blue Heron	*Egretta caerulea*	3
Osprey	*Pandion haliaetus*	1
Pied Billed Grebe	*Podilymbus podiceps*	7
Red Shouldered Hawk	*Buteo lineatus*	2
Red-Tailed Hawk	*Buteo jamaicensis*	3
Tricolored Heron	*Egretta tricolo*	2
Turkey Vulture	*Cathartes aura*	41
White Ibis	*Eudocimus albus*	36
White Pelican	*Pelecanus erythrorhynchos*	13
Yellow-Crowned Night Heron	*Nyctanassa violacea*	6
Yellow-Rumped Warbler	*Setophaga coronata*	1

3.5 Fish Survey

SpringsWatch volunteers conducted visual fish counts monthly at each station (Figure 1). **Error! Reference source not found.** presents a summary of fish observed on monthly outings. A minimum of 7 species were observed. Mullet were the most commonly observed fish.

Table 3. Average fish observed during Wakulla SpringsWatch monitoring sessions (January – December 2023)

Common Name	Scientific Name	Average # Counted per Survey
Bass	*Micropterus* sp.	22
Bluegill	*Lepomis macrochirus*	44
Bowfin	*Amia calva*	1
Catfish sp.	*Ictalurus* sp.	4
Florida Bass	*Micropterus floridanus*	3
Gar sp.	*Lepisosteus sp.*	4
Longnose Gar	*Lepisosteus osseus*	5
Mullet	*Mugil cephalus*	73
Sheepshead	*Archosargus probatocephalus*	2
Sunfish sp.	*Lepomis* sp.	7
White Mullet	*Mugil curema*	2
Minnow sp.	*Notropis* sp.	173

Pictured below are some of the fish species frequently observed by SpringsWatch volunteers during their monthly outings from January to November 2023.

Mullet

Blue gill

Longnose gar

Bowfin

Sheepshead

Section 4.0 References

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Section 5.0 Appendix

Table A.1. Data collected at Wakulla SpringsWatch sessions (January to December 2023)

Station Name	Parameter Name	Average	Number of Samples	Maximum	Minimum	Standard Deviation
WAK-HS	k (diffuse attenuation coefficient)	1.9	11	4.7	0.2	1.3
	Temperature (°C)	20.9	11	21.3	19.8	0.4
	Dissolved Oxygen (%)	20.4	11	28.2	14.8	3.9
	Dissolved Oxygen (mg/L)	1.8	11	2.3	1.3	0.3
	Specific Conductance (µS/cm)	349.6	11	770.0	293.2	139.8
	Secchi (meters)	11.1	11	18.0	3.3	4.6
	Nitrate+Nitrite (mg/L)	0.5	1	0.5	0.5	NA
	Percent Transmittance (% at 1 meter)	24.0	11	80.9	0.9	21.3
WAK-1	k (diffuse attenuation coefficient)	0.9	11	2.2	0.2	0.6
	Temperature (°C)	20.9	11	21.3	19.7	0.4
	Dissolved Oxygen (%)	24.3	11	29.0	20.8	3.1
	Dissolved Oxygen (mg/L)	2.2	11	2.6	1.9	0.3
	Specific Conductance (µS/cm)	369.1	11	981.0	290.0	203.2
	Percent Transmittance (% at 1 meter)	45.2	11	83.7	11.6	21.3
WAK-2	k (diffuse attenuation coefficient)	1.1	9	3.1	0.4	0.9
	Temperature (°C)	20.9	11	21.3	19.7	0.4
	Dissolved Oxygen (%)	26.8	11	31.2	22.7	2.5
	Dissolved Oxygen (mg/L)	2.4	11	2.8	2.0	0.2
	Specific Conductance (µS/cm)	369.2	11	976.0	294.7	201.5
	Percent Transmittance (% at 1 meter)	42.1	9	66.5	4.7	21.5
WAK-3	k (diffuse attenuation coefficient)	0.9	11	2.2	0.3	0.6
	Temperature (°C)	21.0	11	21.5	19.7	0.5
	Dissolved Oxygen (%)	38.6	11	49.2	27.9	6.9
	Dissolved Oxygen (mg/L)	3.4	11	4.4	2.5	0.6
	Specific Conductance (µS/cm)	358.3	11	859.0	294.1	166.4
	Percent Transmittance (% at 1 meter)	46.6	11	74.6	11.3	20.1
WAK-4	k (diffuse attenuation coefficient)	0.6	10	1.4	-0.2	0.5
	Temperature (°C)	21.0	11	21.6	19.6	0.5
	Dissolved Oxygen (%)	45.2	11	60.4	34.4	8.2
	Dissolved Oxygen (mg/L)	4.0	11	5.4	3.1	0.7
	Specific Conductance (µS/cm)	368.4	11	984.0	288.2	204.5
	Percent Transmittance (% at 1 meter)	59.3	10	121.1	25.2	28.6

Table A.1 Continued

Station Name	Parameter Name	Average	Number of Samples	Maximum	Minimum	Standard Deviation
WAK-5	k (diffuse attenuation coefficient)	1.1	10	4.8	0.0	1.4
	Temperature (°C)	21.0	10	21.8	19.2	0.8
	Dissolved Oxygen (%)	50.1	10	68.1	36.3	10.1
	Dissolved Oxygen (mg/L)	4.5	10	6.1	3.2	0.9
	Specific Conductance (µS/cm)	367.6	10	894.0	295.1	185.3
	Percent Transmittance (% at 1 meter)	51.1	10	97.0	0.9	27.7
WAK-6	k (diffuse attenuation coefficient)	1.5	10	3.7	0.1	1.1
	Temperature (°C)	20.8	11	21.5	19.0	0.7
	Dissolved Oxygen (%)	37.2	11	48.4	30.8	5.6
	Dissolved Oxygen (mg/L)	3.3	11	4.3	2.7	0.5
	Specific Conductance (µS/cm)	353.8	11	765.0	295.5	136.8
	Percent Transmittance (% at 1 meter)	33.7	10	92.1	2.5	29.6
WAK-7	k (diffuse attenuation coefficient)	1.7	11	4.7	0.3	1.6
	Temperature (°C)	20.9	11	21.3	19.7	0.4
	Dissolved Oxygen (%)	21.0	11	27.3	17.5	3.1
	Dissolved Oxygen (mg/L)	1.9	11	2.5	1.6	0.3
	Specific Conductance (µS/cm)	368.2	11	973.0	293.0	200.9
	Percent Transmittance (% at 1 meter)	37.3	11	71.3	0.9	26.3
WAK-8	k (diffuse attenuation coefficient)	1.1	10	4.9	0.1	1.5
	Temperature (°C)	20.8	11	21.5	19.1	0.8
	Dissolved Oxygen (%)	41.2	11	57.6	27.7	9.1
	Dissolved Oxygen (mg/L)	3.6	11	5.1	2.3	0.8
	Specific Conductance (µS/cm)	319.2	11	359.0	292.9	19.9
	Percent Transmittance (% at 1 meter)	54.8	10	93.6	0.7	34.0