KINGS BAY SPRINGSWATCH MONITORING SUMMARY

June 2023– December 2023

PREPARED FOR

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

DIVISION OF PARKS AND RECREATION

Howard T. Odum FLORIDA SPRINGS INSTITUTE

Photo by John Moran

Volunteer and Staff Acknowledgments

This report was prepared by the Howard T. Odum Florida Springs Institute (FSI). Florida SpringsWatch volunteers and FSI staff conducted ecological monitoring in 2023 under the Florida Department of Environmental Protection (FDEP) Division of Recreation and Parks Research/Collection Permit Number 07012340. Florida SpringsWatch volunteers and FSI staff conducted ecological monitoring in 2023. We are grateful to the management of the Port Hotel & Marina in Crystal River for granting our volunteers free launch access to Kings Bay each month.

Our Kings Bay SpringsWatch program would not be possible without the hard work of our group leader, Peter Wottowa, and his dedicated team of volunteers: Beth Rucker, Dana Hamiliton, Jaennine Grabb, Judy Lathrop, Rick Irvine, Betty Irvine, Jill Lingard, and Pam Shemet. Together they put in 120 volunteer hours over nine monitoring sessions in 2023. We also acknowledge the data entry efforts from our diligent science interns. 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

Crystal River/Kings Bay is located in Citrus County, approximately 60 miles north of Tampa, Florida. In 1983, Crystal River was established as a National Wildlife Refuge (NWR) with the primary purpose of protecting the, then endangered and currently threatened, Florida Manatee. Kings Bay is located within the Crystal River NWR and falls under the state's designation as an Outstanding Florida Water. The first-magnitude spring system that forms the 600-acre Kings Bay embayment includes more than 70 springs and is one of Florida's largest spring systems as measured by discharge. Historic average spring flows were nearly 600 million gallons per day (MGD) and accounted for approximately 99 percent of the freshwater exiting Kings Bay through Crystal River.

Since the 1970's, Kings Bay has faced increasing impacts from a variety of anthropogenic stressors. Real estate development and the resulting excavation of numerous canals within the bay have drastically impacted the water quality of the system. Nitrates from urban lawns and golf course fertilizers, municipal water effluent, agriculture, and improperly managed septic tanks have contributed to the nutrient enrichment of the bay. Additionally, increased groundwater pumping in southwest Florida has reduced the discharge coming from the Kings Bay springs. Declining spring flows and elevated nutrients have contributed to the loss of native vegetation, the proliferation of undesirable planktonic and benthic algae, and a marked increase in salinity from the springs.

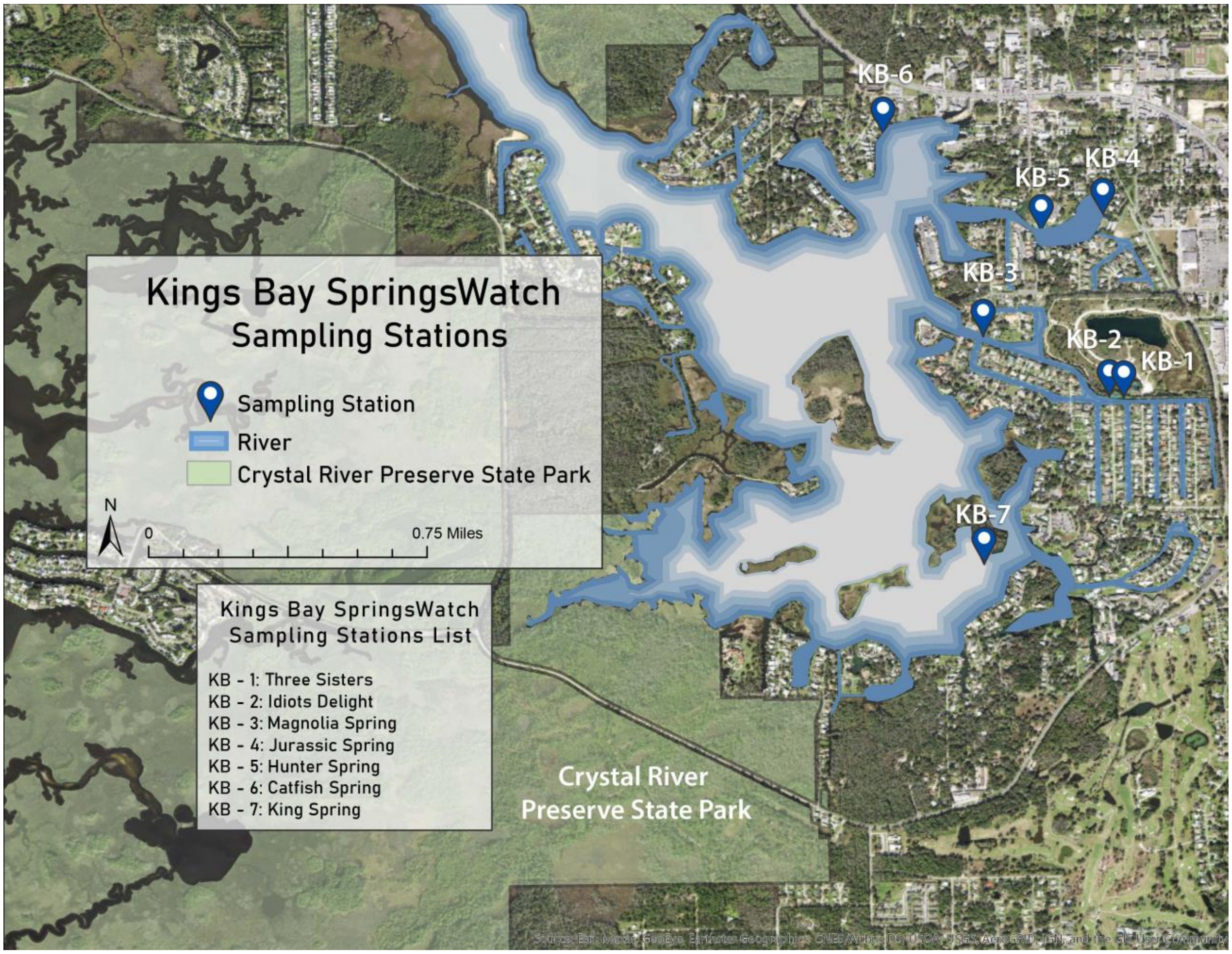
FSI's SpringsWatch volunteer citizen science program has provided enhanced monitoring of springs across Florida. The resulting data are provided in annual reports and via the SpringsWatch website (floridaspringsinstitute.org/springswatch) to inform the state's environmental agencies and educate the public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

This report focuses on ecological monitoring in the Kings Bay system conducted by SpringsWatch volunteers in 2023.

1.1 Monitoring Stations

Figure 1 identifies the seven stations monitored by SpringsWatch volunteers from June through December 2023. The monitoring stations cover ecologically important springs within the system.

Figure 1. Stations within the Kings Bay SpringsWatch study.



Section 2.0 Methods

SpringsWatch volunteers conducted ecological monitoring at Kings Bay from January through November 2023. Cold temperatures and springs closures during manatee season prevented some sampling efforts. Data collection included water quality field parameters, light attenuation measurements, aquatic vegetation surveys, and fish and bird counts.

2.1 Sampling Events

Table 1 summarizes the seven sampling events conducted in Kings Bay in 2023 by volunteers trained on SpringsWatch procedures.

Kings Bay monitoring events included the following:

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

Table 1. Summary of sampling events at Kings Bay during 2023.

Date	Temperature	Dissolved Oxygen	Specific Conductance	PAR	Secchi	Nitrate+Nitrite	Vegetation	Birds	Fish
1/24/2023	X	X		X			X	X	
2/26/2023	X	X		X			X	X	
3/5/2023	X	X	X	X	X	X	X	X	X
4/21/2023	X	X	X	X	X		X	X	X
5/30/2023	X	X	X	X	X		X	X	
6/28/2023	X	X	X	X			X	X	
7/6/2023	X	X	X	X	X		X	X	X
10/24/2023	X	X		X	X		X	X	
11/20/2023	X	X	X	X	X		X	X	X

2.2 Water Quality

SpringsWatch volunteers used handheld YSI meters at each of the seven Kings Bay monitoring stations to collect dissolved oxygen, temperature, and specific conductance measurements. The team leader maintained the meters according to factory instructions and calibrated them prior to and after each sampling event.

2.2.1 Nitrate-Nitrite (NOx-N)

FSI staff collected Nitrate-nitrite (NOx-N) samples at the Fish Bowl (station HOM-1) during the April 2023 sampling session. 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 (H_2SO_4) 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 nitrate-nitrite (NOx-N) analysis. All analyses were conducted within a standard holding time of 28 days from sample collection.

2.3 Light Measurements

Photosynthetically Active Radiation (PAR) underwater light transmission and attenuation coefficients were measured monthly at the seven 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 3 provides an image of the LI-COR PAR light sensor.

Figure 2. LI-COR PAR light sensor

2.4 Secchi Disk Visibility

SpringsWatch volunteers took periodic horizontal Secchi disk measurements at stations 1, 4, 5, and 7 throughout the sampling period. Cold temperatures and springs closures during manatee season prevented a consistent sampling effort.

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. The longer the Secchi depth, the clearer the water is. As Florida springs are often clearer than they are deep, we measure Secchi horizontally. 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.

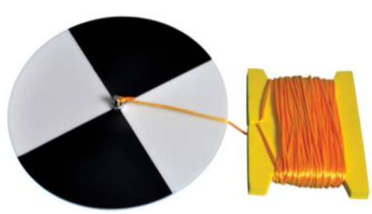


Figure 3. Secchi disk.

2.5 Vegetation

Volunteers photographed submerged aquatic vegetation (SAV) monthly at all seven stations (Figure 1). They took two photographs at each station in two different locations, which they sent to FSI to be analyzed for vegetation identification.

Understanding the distribution, abundance, and dynamics of SAV in springs is essential for understanding the overall health of these ecosystems and identifying any potential problems or issues that may need to be addressed. SAV provides shelter and breeding grounds for fish, amphibians, and invertebrates, and it is an important source of food for waterfowl and other animals. SAV also helps to stabilize sediments and improve water quality by absorbing excess nutrients and reducing erosion. In addition, SAV can have a positive effect on the surrounding environment by increasing oxygen levels and providing shade, which can help to regulate water temperature. Overall, the presence of SAV in Florida Springs is essential for the health and functioning of these ecosystems, and its protection and conservation is crucial for the long-term sustainability of these natural resources. SAV also has economic value, as it plays important role in the recreational and tourism industries in Florida. People visit Florida springs from all over the world to enjoy activities such as swimming, boating, and fishing in the clear, pristine waters, and the presence of SAV adds to the beauty and enjoyment of these activities.

2.6 Wildlife Surveys

SpringsWatch volunteers conducted visual fish counts monthly at Jurassic (KB-4) and King (KB-7) Springs. They also recorded bird observations throughout each of their monitoring sessions.

Section 3.0 Results

This section summarizes field measurements collected by Kings Bay SpringsWatch volunteers from January through November 2023.

3.1 Water Quality

3.1.1 Dissolved Oxygen, Temperature, Nitrate-Nitrite, and Specific Conductance

Groundwater typically differs in DO concentration and saturation depending on the duration of time the water has spent underground before emerging from a spring vent. At the KB-7 station, the DO saturation is lower than the averages of the other stations. This could be because the water emerging from the ground could be younger at the latter spring. As surface water interacts with photosynthesizing SAV and the atmosphere, more free oxygen is absorbed into the water. The higher DO levels often exhibited at stations further away from spring vents reflect atmospheric diffusion of oxygen into the low-oxygen water as well as the release of oxygen by the photosynthetic submerged aquatic plant community. Figures 5 through 11 present field parameter results collected from the 7 stations along Kings Bay as part of the Florida SpringsWatch program.

Figures 4 presents dissolved oxygen (DO) results measured in milligrams per liter (mg/L), or parts per million (ppm). Figures 5 show average DO results measured in percent saturation (%).

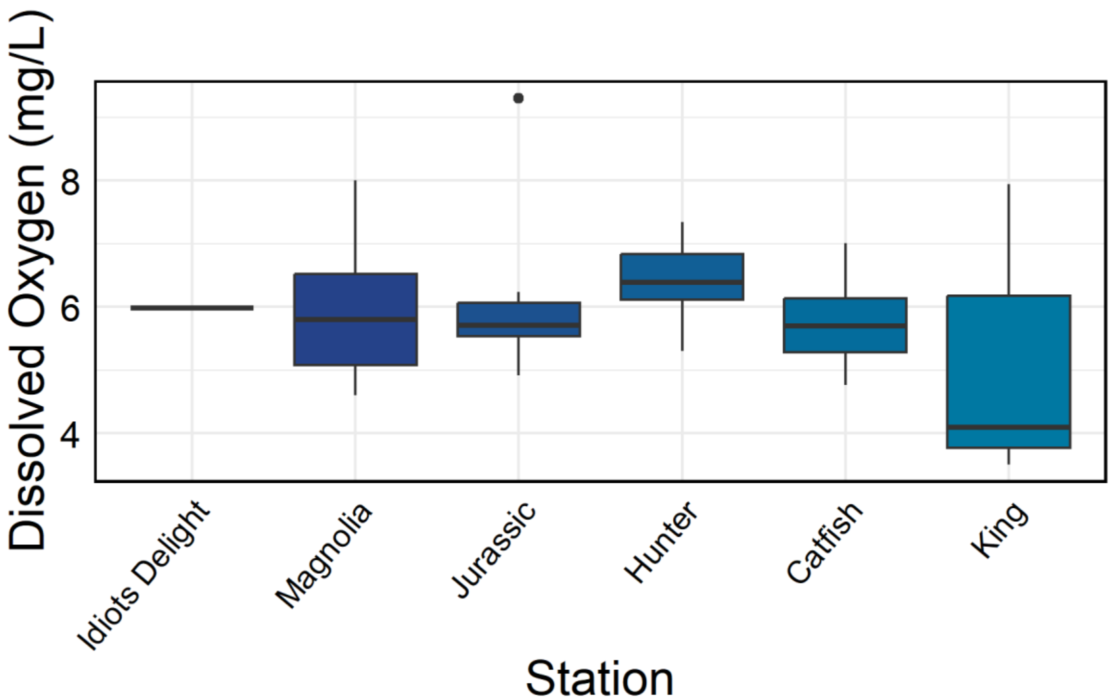


Figure 4. Dissolved oxygen (mg/L) measurements at Kings Bay station (January – November 2023)

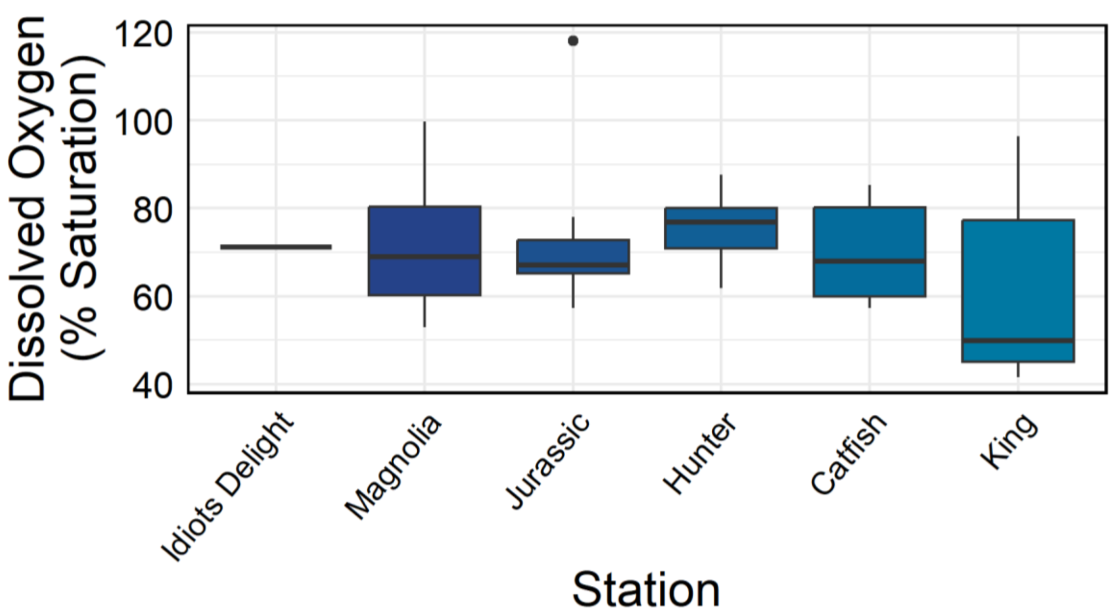


Figure 5. Dissolved oxygen measurements (DO%) at Kings Bay stations (January – November 2023).

Figure 6 present data for water temperature (°C) field measurements. Temperature in the Kings Bay remains relatively constant year-round since it is primarily fed by spring water (typically 22°C). Outliers were taken in hotter months, June-August.

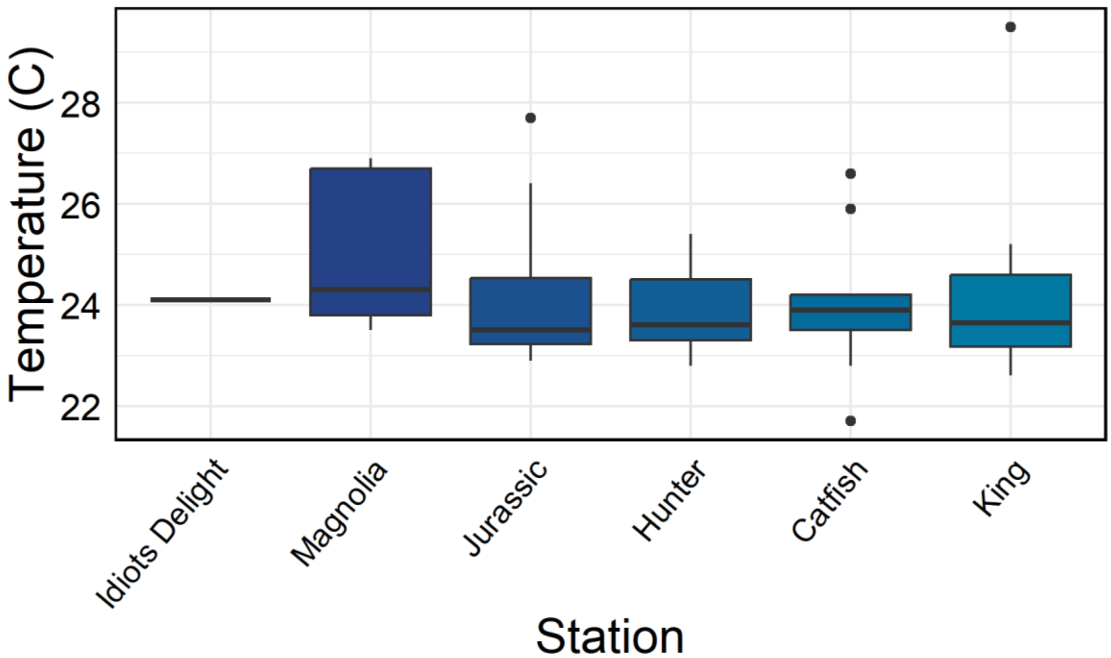


Figure 6. Average water temperature (°C) measurements at Kings Bay stations (January – November 2023).

Figures 7 present the results for specific conductance (uS/cm) field measurements. 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, phosphorous, saltwater, and other compounds. Higher specific conductance values suggest a higher concentration of these ions in the water. The results presented in Figure 7 show varying levels of specific conductance. This could suggest variable levels of nitrate/nitrite or differences in the age of the water exiting the vents. It is also important to note that Kings Bay is tidally influenced. This saltwater intrusion is likely the confound leading to the variation between dates at certain sites (specifically KB-7 and KB-5; Figure 7).

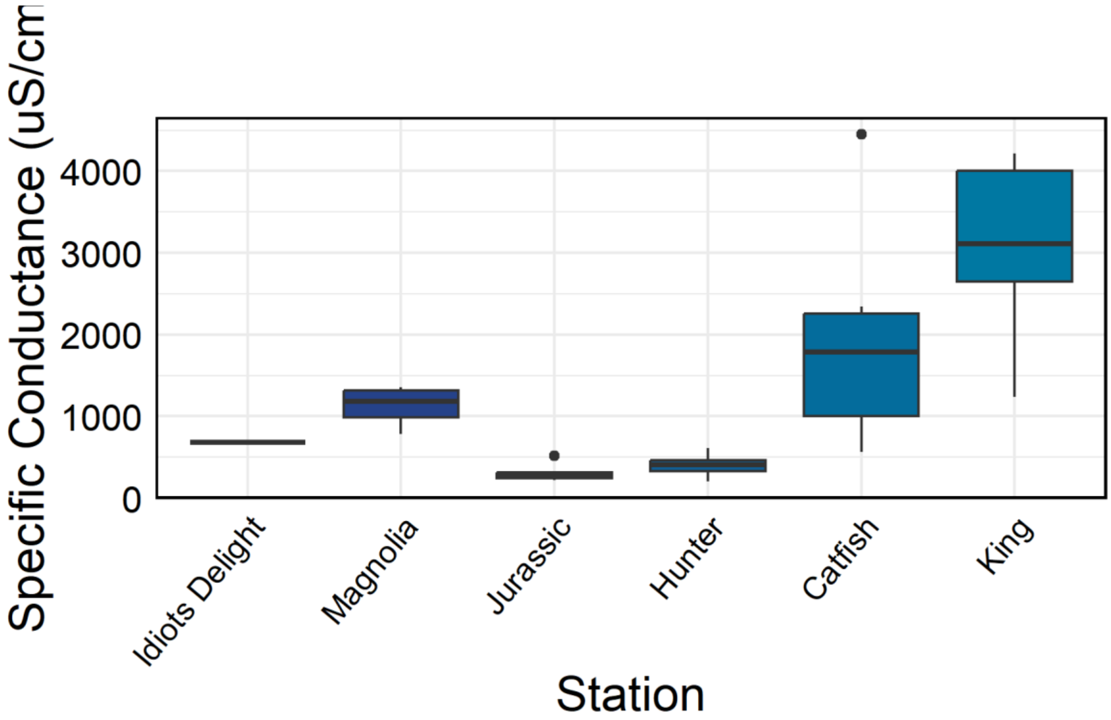


Figure 7. Specific conductance (uS/cm) measurements at Kings Bay stations (January – November 2023).

FSI staff collected Nitrate-nitrite (NOx-N) samples during the March 2023 sampling session at Three Sisters Spring (KB-1), Jurassic Spring (KB-4), and King Spring (KB-7). Kings Bay NOx-N measured at 0.0935 mg/L which is relatively quite low but still higher than the historic 0.05 mg/L concentration. Three Sisters NOx-N measured at 0.328 mg/L which is just 0.02 mg/L below the DEP springs impairment level of 0.35 mg/L. Jurassic springs NOx-N measured at 0.2865 mg/L not far behind the impairment level. The average NOx-N measurement from all three sites was 0.236 (Figure 8).

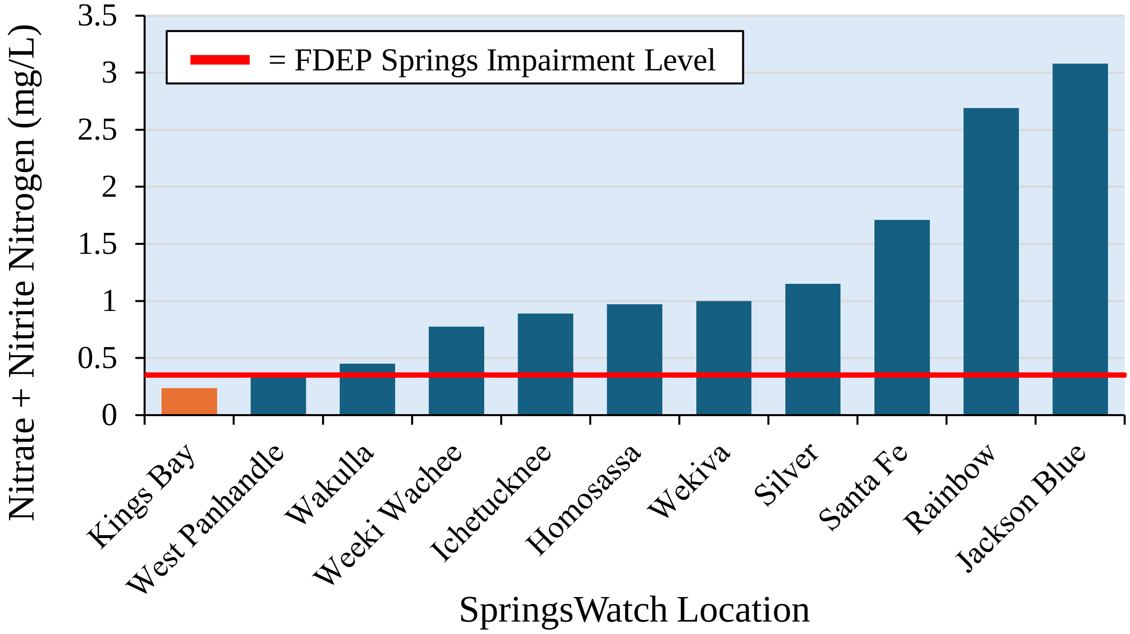


Figure 8. Nitrate-nitrite (NOx-N levels at SpringsWatch samples sites in 2023. Kingsbay is denoted by the orange bar.

3.2 Light and Clarity Measurements

Figure 9 displays the diffuse attenuation coefficient (k) estimates collected by Kings Bay SpringsWatch volunteers from January through November 2023. Figure 9 present the percent transmittance estimates for this period.

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. The diffuse attenuation coefficient (k) is 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.

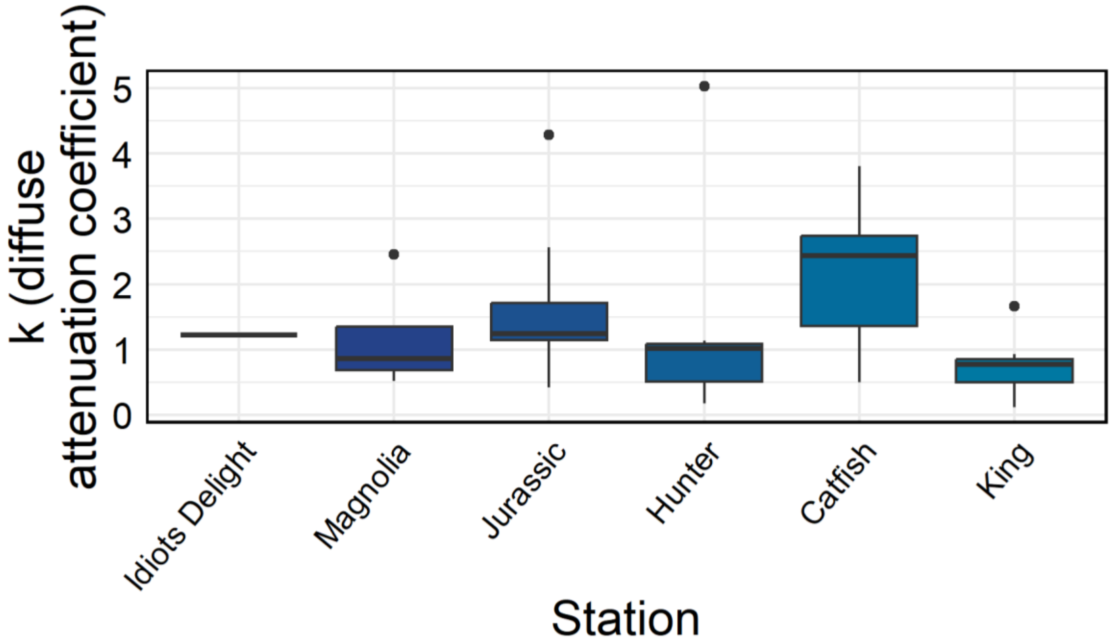


Figure 9. Average diffuse attenuation coefficient (k) measurements at all Kings Bay stations (January – November 2023).

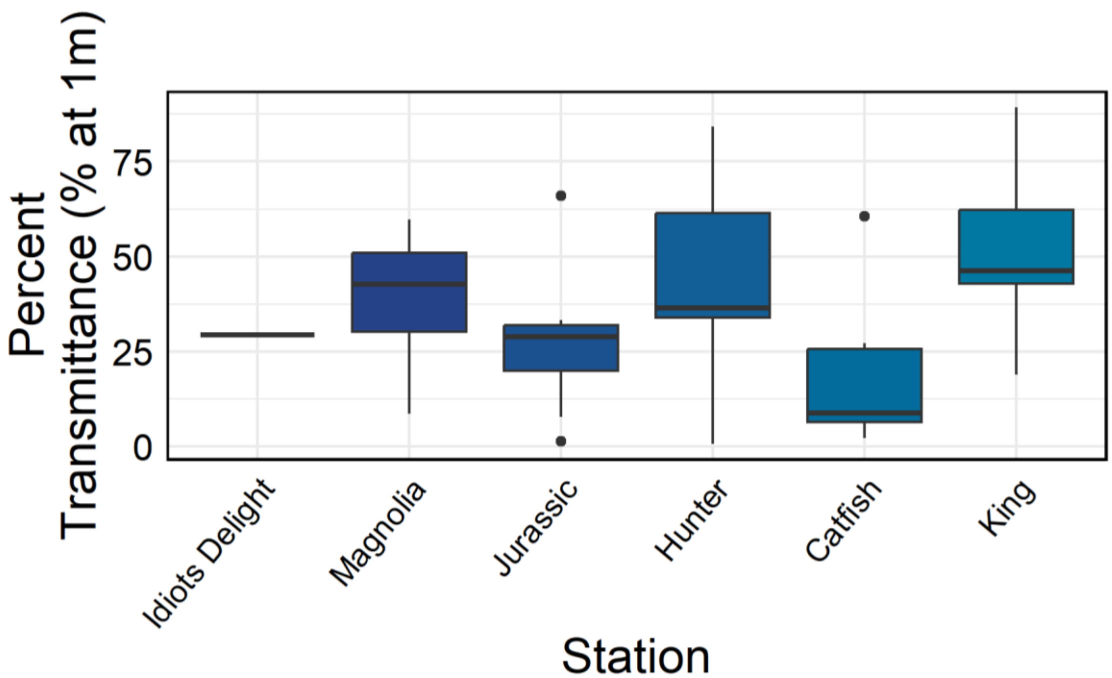


Figure 10. Percent transmittance data at one meter at Kings Bay stations (January to November 2023).

Figure 11 displays the horizontal Secchi measurements (in meters) collected by Kings Bay SpringsWatch from January through November 2023.

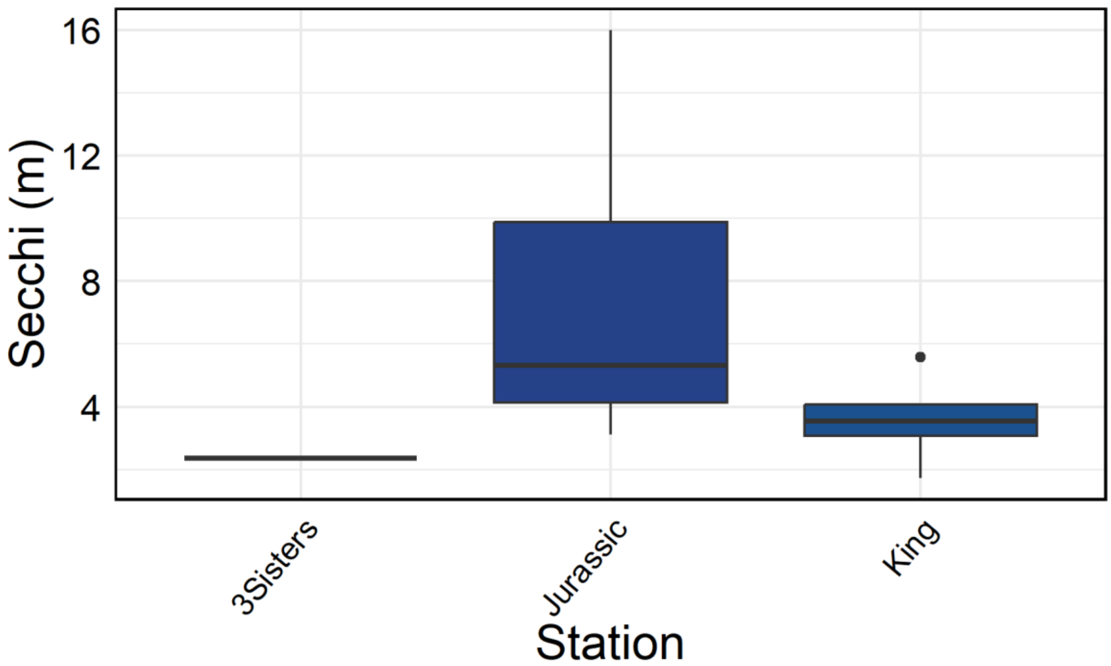


Figure 11. Horizontal Secchi (m) measurements at 4 Kings Bay stations (January – November 2023).

The Kings Bay system is mainly influenced by clear spring water and more murky water from the Gulf of Mexico. Regular Secchi measurements allow us to monitor changes in water clarity over time and detect trends or changes that may indicate a problem in the ecosystem. A sudden decrease in Secchi length could be a sign of an algal bloom or increased pollution.

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.

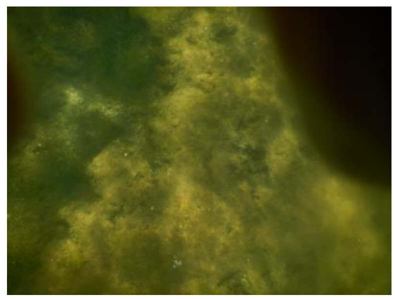
Pictured below are river bottom photos taken by Kings Bay SpringsWatch volunteers in 2023 which feature the SAV of the seven springs stations. Volunteers were unsuccessful in taking photos at stations KB-1 and KB-3 either due to spring closure for manatee season or low visibility.

KB-2

KB-4

KB-5

KB-6



KB-7

3.4 Fish Survey

Between January and November 2023, four fish counts occurred within Kings Bay. Table 2 shows the average number of each observed during fish counts in 2023.

Table 2. Summary of fish encountered during fish surveys at Kings Bay

Common Name	Scientific Name	Average # Counted per Survey
Bass	*Micropterus* sp.	6
Longnose Gar	*Lepisosteus osseus*	1
Mangrove Snapper	*Lutjanus griseus*	79
Mullet	*Mugil cephalus*	27
Sheepshead	*Archosargus probatocephalus*	13
Snook	*Centropomus undecimalis*	4
Striped Bass	*Morone saxatilis*	4
Sunfish sp.	*Lepomis* sp.	16
Minnow sp.	*Notropis* sp.	30

Pictured below are some of the fish most frequently observed by SpringsWatch volunteers during their monthly outings from January to November 2023. By average, the majority of fish counted were mangrove snapper, followed by minnow sp. and then mullet.

Mangrove Snapper

Stripped Mullet

Redear Sunfish

Sheepshead

Bass

Common Snook

3.5 Bird Survey

Between January and November 2023, nine bird counts occurred within Kings Bay. Table 3 shows the average number of each species observed during bird counts in 2023. Overall, 31 species were observed. American Coots were the most commonly observed bird.

Table 3. A table of bird species recorded by Kings Bay SpringsWatch over 2023 and the average number counted per survey.

Common Name	Scientific Name	Average # Counted Per Survey
American Coot	*Fulica americana*	29
Anhinga	*Anhinga anhinga*	16
Belted Kingfisher	*Megaceryle alcyon*	2
Black Vulture	*Coragyps atratus*	13
Blue Winged Teal	*Spatula discors*	2
Boat Tailed Grackle	*Quiscalus major*	2
Brown Pelican	*Pelecanus occidentalis*	16
Common Moorhen	*Gallinula chloropus*	9
Crow	*Corvus* sp.	44
Domestic Duck	*Anas platyrhynchos*	3
Double Crested Cormorant	*Phalacrocorax auritus*	27
Duck sp.	N/A	7
Great Blue Heron	*Ardea herodias*	2
Great Egret	*Ardea alba*	2
Green Heron	*Butorides virenscens*	2
Gull sp.	*Larus* sp.	4
Herring Gull	*Larus argentatus*	15
Laughing Gull	*Leucophaeus atricilla*	24
Lesser Scaup	*Aythya affinis*	10
Little Blue Heron	*Egretta caerulea*	2
Mallard	*Anas platyrhynchos*	6
Northern Cardinal	*Cardinalis cardinalis*	1
Osprey	*Pandion haliaetus*	2
Pied Billed Grebe	*Podilymbus podiceps*	2
Purple Gallinule	*Porphyrio martinicus*	1
Red Bellied Woodpecker	*Melanerpes carolinus*	3
Red Shouldered Hawk	*Buteo lineatus*	1
Redwing Blackbird	*Agelaius phoeniceus*	1
Snowy Egret	*Egretta thula*	1
Turkey Vulture	*Cathartes aura*	9
White Ibis	*Eudocimus albus*	12
Wood Duck	*Aix sponsa*	28
Wood Stork	*Mycteria americana*	1
Yellow-Crowned Night Heron	*Nyctanassa violacea*	1

4.0 Executive Summary

Florida springs are a vital and unique natural resource that deserve strong protection and study. These springs provide numerous ecosystem services, including supporting diverse and rare species of plants and animals, maintaining water quality, and serving as a source of drinking water for local communities. Florida springs are also important recreational sites, attracting millions of visitors each year who enjoy swimming, snorkeling, paddling, and other activities. Protecting Florida springs is not only important for the conservation of these natural resources, but also for the economic well-being of the state. The tourism and recreation industry in Florida generates billions of dollars in revenue each year, and a significant portion of this comes from visitors to springs. By studying Florida Springs, we can ensure that these resources are preserved for future generations to enjoy, and that their ecological and economic values are fully understood.

SpringsWatch volunteers collected data on water temperature, dissolved oxygen, specific conductance, and water clarity which are all important parameters to consider when evaluating the health and quality of Florida Springs. Water temperature can affect the metabolism and behavior of aquatic organisms, as well as the solubility and availability of nutrients. Dissolved oxygen is necessary for the survival and well-being of most aquatic organisms, and low levels can indicate poor water quality. Specific conductance is a measure of the ability of water to conduct electricity and is related to the concentration of ions in the water. High specific conductance can indicate the presence of pollutants or other contaminants. Water clarity is an important indicator of the overall health of an aquatic ecosystem, as it is related to the concentration of particles suspended in the water, such as algae, silt, and pollution. By monitoring these parameters, scientists and resource managers can gain a better understanding of the conditions in Florida Springs and identify potential problems to address. At Kings Bay, nitrate was below the FDEP spring impairment level of 0.35 mg/L but still significantly higher than historic levels.

Section 4.0 References

Florida Springs Institute (FSI). (2015), *Florida Springs Baseline Ecological Assessment: Standard Operating Procedures.* Howard T. Odum Florida Springs Institute, High Springs, Florida. Unpublished manuscript.

Wetzel, R. G. (2001). *Limnology: Lake and River Ecosystems. Third Edition.* San Diego, CA, CA: Academic Press.

Section 5.0 Appendix

Table A.1 Data collected during Kings Bay SpringsWatch monitoring sessions

Station Name	Parameter Name	Average	Number of Samples	Maximum	Minimum	Standard Deviation
KB-1	Secchi (meters)	2.4	1	2.4	2.4	NA
	Nitrate+Nitrite (mg/L)	0.3	1	0.3	0.3	NA
KB-2	k (diffuse attenuation coefficient)	1.2	1	1.2	1.2	NA
	Temperature (°C)	24.1	1	24.1	24.1	NA
	Dissolved Oxygen (%)	71.2	1	71.2	71.2	NA
	Dissolved Oxygen (mg/L)	6.0	1	6.0	6.0	NA
	Specific Conductance (µS/cm)	685.0	1	685.0	685.0	NA
	Percent Transmittance (% at 1 meter)	29.3	1	29.3	29.3	NA
KB-3	k (diffuse attenuation coefficient)	1.2	4	2.5	0.5	0.9
	Temperature (°C)	25.0	5	26.9	23.5	1.6
	Dissolved Oxygen (%)	72.4	5	99.7	53.0	18.3
	Dissolved Oxygen (mg/L)	6.0	5	8.0	4.6	1.3
	Specific Conductance (µS/cm)	1125.3	4	1356.0	785.0	261.9
	Percent Transmittance (% at 1 meter)	38.4	4	59.7	8.5	21.9
KB-4	k (diffuse attenuation coefficient)	1.7	8	4.3	0.4	1.2
	Temperature (°C)	24.3	8	27.7	22.9	1.8
	Dissolved Oxygen (%)	73.3	8	118.1	57.3	19.2
	Dissolved Oxygen (mg/L)	6.1	8	9.3	4.9	1.4
	Specific Conductance (µS/cm)	313.5	6	519.0	222.1	108.0
	Secchi (meters)	7.5	6	16.0	3.1	5.1
	Nitrate+Nitrite (mg/L)	0.3	1	0.3	0.3	NA
	Percent Transmittance (% at 1 meter)	27.7	8	66.0	1.4	19.4
KB-5	k (diffuse attenuation coefficient)	1.3	7	5.0	0.2	1.7
	Temperature (°C)	23.8	9	25.4	22.8	0.9
	Dissolved Oxygen (%)	75.3	9	87.7	61.8	9.3
	Dissolved Oxygen (mg/L)	6.4	9	7.3	5.3	0.7
	Specific Conductance (µS/cm)	405.0	6	615.0	203.7	141.1
	Percent Transmittance (% at 1 meter)	44.6	7	84.2	0.6	27.8
KB-6	k (diffuse attenuation coefficient)	2.2	9	3.8	0.5	1.1
	Temperature (°C)	24.0	9	26.6	21.7	1.5
	Dissolved Oxygen (%)	69.6	9	85.3	57.3	10.4
	Dissolved Oxygen (mg/L)	5.7	9	7.0	4.8	0.7
	Specific Conductance (µS/cm)	1957.3	6	4450.0	565.0	1397.3
	Percent Transmittance (% at 1 meter)	17.8	9	60.6	2.2	18.5
KB-7	k (diffuse attenuation coefficient)	0.7	7	1.7	0.1	0.5
	Temperature (°C)	24.4	8	29.5	22.6	2.2
	Dissolved Oxygen (%)	61.2	8	96.3	41.6	22.0
	Dissolved Oxygen (mg/L)	5.0	8	7.9	3.5	1.7
	Specific Conductance (µS/cm)	3043.2	5	4215.0	1240.0	1193.7
	Secchi (meters)	3.6	4	5.6	1.7	1.6
	Nitrate+Nitrite (mg/L)	0.1	1	0.1	0.1	NA
	Percent Transmittance (% at 1 meter)	52.1	7	89.3	19.0	23.2