RAINBOW RIVER MONITORING SUMMARY

January 2019 - December 2019

PREPARED FOR

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION,

DIVISION OF RECREATION AND PARKS

Howard T. Odum FLORIDA SPRINGS INSTITUTE

SPRINGS WATCH

Photo By Sandra Marraffino

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Our Rainbow River SPRINGSWATCH program would not be possible without the hard work of our volunteer team leader, Bill Vibbert. We would also like to acknowledge the contributions and dedication of our other volunteers: boat captain Ray Blasingame, Martha Henwood, Brooks Martin, Gretchen Martin, Sandra Marraffino, and Paul Marrafino.

Section 1.0 Introduction

Rainbow Springs consists of twelve named vents that discharge groundwater from the Floridan Aquifer System at a combined historic average discharge of more than 485 million gallons per day (MGD), making it one of the largest first magnitude spring systems in Florida. Rainbow Springs forms the headwaters of the Rainbow River, which is nearly 6 miles long and merges with the Withlacoochee River at Dunnellon, Marion County.

The entire Rainbow River is a Registered National Landmark listed in 1972, an Aquatic Preserve listed in 1986, and an Outstanding Florida Waterway listed in 1987. The state purchased the original area that was the Rainbow Springs Attraction in 1990 and officially opened Rainbow Springs State Park in March 1995 managed by the Florida Department of Environmental Protection's Division of Recreation and Parks.

Through citizen science conducted via the SPRINGSWATCH volunteer program, FSI is able to enhance monitoring of the Rainbow River and springs and use the resulting data to more accurately assess springs and river health to further educate the public.

This report was prepared by the Howard T. Odum Florida Springs Institute (FSI) and is focused on ecological monitoring currently being conducted by SPRINGSWATCH volunteers along the Rainbow River.

1.1 Monitoring Stations

Figure 1 identifies the ten stations monitored monthly from January 2019 through December 2019 by the Florida SPRINGWATCH volunteers for the following ecological metrics:

- Water quality field parameters (temperature, dissolved oxygen, and conductivity)
- Vegetation cover estimates
- Vertical light attenuation
- Horizontal Secchi disk measurements
- Bird survey

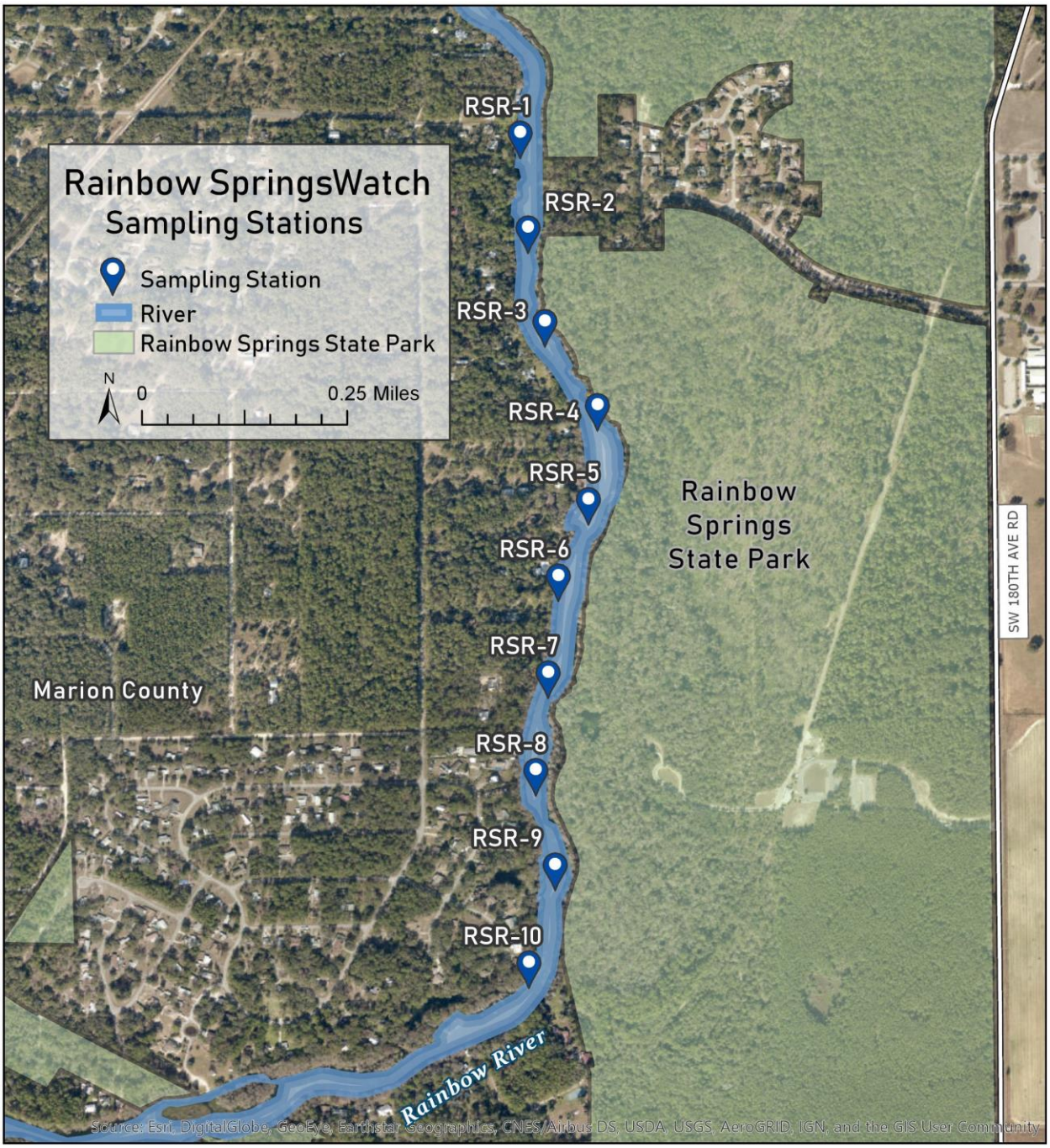

Figure 1. Florida SPRINGSWATCH Rainbow River - Monitoring Stations

Section 2.0 Methods

Ecological monitoring was conducted on the Rainbow River from January 2019 to December 2019 by the Rainbow SPRINGSWATCH program. Data collection included water quality field parameters, light measurements, bird surveys, and aquatic vegetation surveys.

2.1 Sampling Events

Field measurements were collected from a one-mile segment of the Rainbow River monthly during 2019. Sampling was conducted by volunteers of the Florida SPRINGWATCH Program. The monitoring events are summarized below (Table 1).

Table 1. Rainbow River sampling events (January 2019 - December 2019)

Date	Water Quality	Light Attenuation	Bird Survey	Vegetation	Horizontal Secchi
1/23/2019	X	X	X	X	
2/20/2019	X	X	X	X	X
3/29/2019	X	X	X	X	X
4/24/2019	X	X	X	X	X
5/22/2019	X	X	X	X	X
6/14/2019	X	X	X	X	X
8/14/2019	X	X	X	X	X
9/20/2019	X	X	X	X	X
10/31/2019	X	X	X	X	X
11/21/2019	X	X	X	X	
12/11/2019	X	X	X	X	

2.2 Water Quality

Surface water data were collected monthly at each station along the Rainbow River with YSI water quality meters. Handheld YSI ProODO and YSI EcoSense EC300A meters were used at each of the 10 monitoring stations along the Rainbow River to collect measurements of temperature/dissolved oxygen, and specific conductance respectively. Horizontal Secchi disk readings were also taken monthly at each station to measure water clarity. Calibration and maintenance of water quality meters was conducted according to factory instructions. Instruments were calibrated before and after each sampling event.

2.3 Light Measurements

Photosynthetically Active Radiation (PAR) underwater light transmission and attenuation coefficients were measured monthly at the 10 monitoring sites during comprehensive ecological assessments. Data were collected using an Apogee MQ-200 quantum meter with an underwater photosynthetically active radiation (PAR) sensor to measure vertical light attenuation in the water column and PAR energy transmittance at 1-foot intervals from the surface to a depth of 2 feet. This sensor measures light in the 400-700 nm wavelength range which is the visible portion of the spectrum that supports plant photosynthesis. Figure 2 provides a typical light senor installation. Light extinction (attenuation) coefficients were calculated from these data using the Lambert-Beer equation (Wetzel, 2001):

$I_z = I_o (e - k_z)$

Where:

I_z = PAR at depth z

I_o = PAR at the water surface

k = diffuse attenuation coefficient, m^{-1}

z = water depth, m

Figure 2. Image of Apogee MQ-200

2.4 Vegetation

Submerged Aquatic Vegetation (SAV) was monitored at all 10 stations (Figure 1) during each sampling event. Two photographs were taken at each station in two different locations which were sent to FSI for vegetation identification and percent coverage estimations. The average between the two photographs was used to provide the overall average percent plant coverage of each station.

Section 3.0 Results

This section summarizes field data collected as part of the ecosystem monitoring conducted along the Rainbow River from January 2019 to December 2019. Data collected by FSI and the Florida SPRINGSWATCH volunteers included water quality field parameters, horizontal Secchi disk measurements, light measurements, and aquatic vegetation assessments. These data provide a quantitative record of existing conditions in the river and springs and will be useful for comparison to future evaluations of the ecological health of the Rainbow River/Springs system.

3.1 Water Quality

3.1.1 Florida SPRINGSWATCH Rainbow River Water Quality

Figure 3 through Figure 6 presents field parameter results collected from the 10 stations along the Rainbow River as part of the Florida SPRINGSWATCH program from January 2019 to December 2019. Figure 3 presents dissolved oxygen (DO) data measured in percent saturation (%), and Figure 4 presents DO results measured in milligrams per liter (mg/L), or parts per million (ppm). Groundwater emerging from a spring vent tends to exhibit lower DO, however the extensive coverage of photosynthesizing SAV in the Rainbow River increases the amount of free oxygen in the water resulting in the higher DO concentrations demonstrated in Figures 3 and 4. Figure 5 presents data for temperature (°C) field measurements. Temperature in the Rainbow River remains relatively constant year-round since it is primarily fed by spring water (typically ~22°C). Figure 6 demonstrates the results for Specific Conductance field measurements, which also remained relatively consistent between stations. Specific conductance levels can be influenced by naturally occurring ions present in spring water but also from ions present due higher levels of nitrate/nitrite, phosphorous, and other compounds. Higher specific conductance values suggest a higher concentration of these ions in the water.

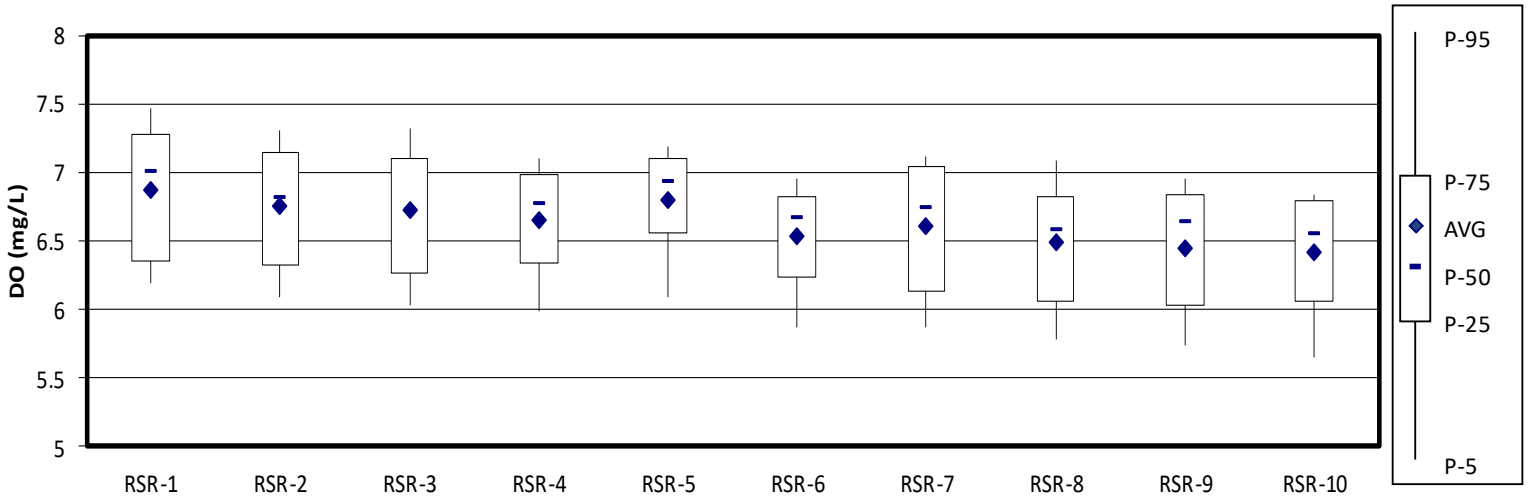

Figure 3. Florida SPRINGSWATCH Program Rainbow River Dissolved Oxygen Measurements (mg/L) (January 2019 - December 2019)

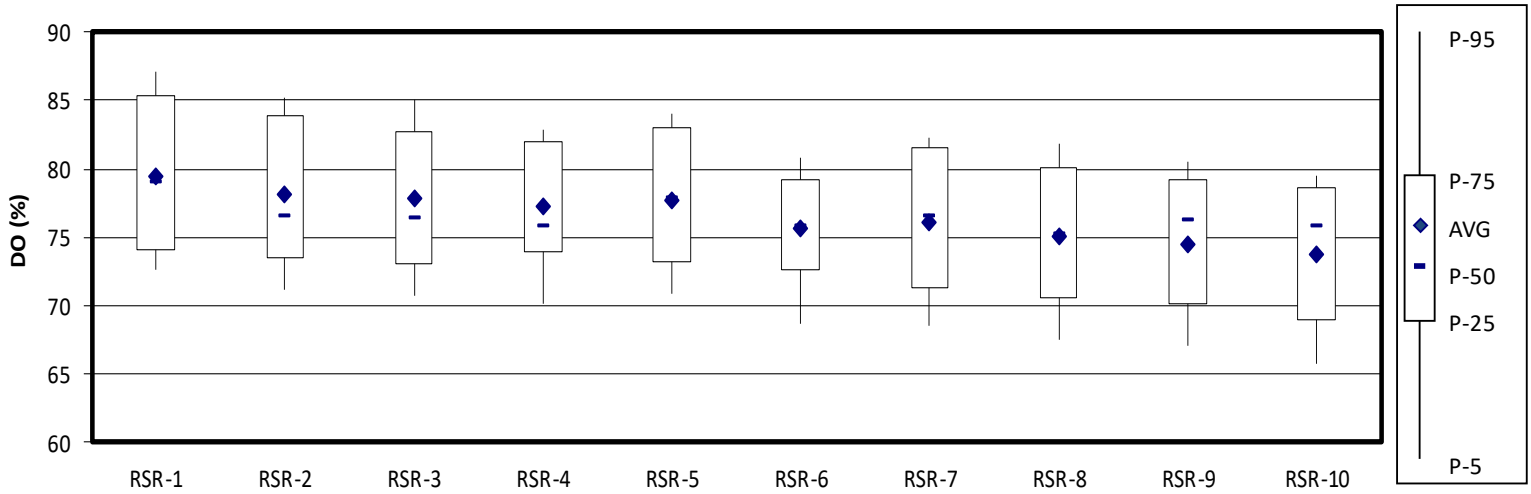

Figure 4. Florida SPRINGSWATCH Program Rainbow River Dissolved Oxygen Percent Saturation (%) Measurements (January 2019 - December 2019)

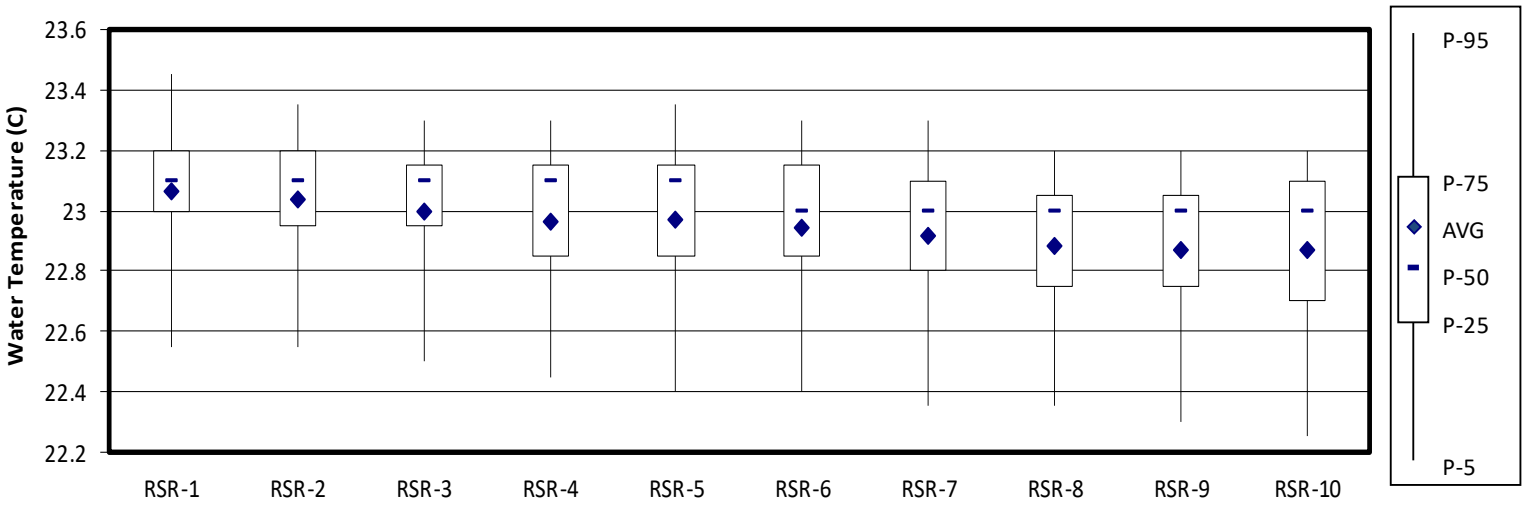

Figure 5. Florida SPRINGSWATCH Program Rainbow River Temperature (°C) Measurements (January 2019 - December 2019)

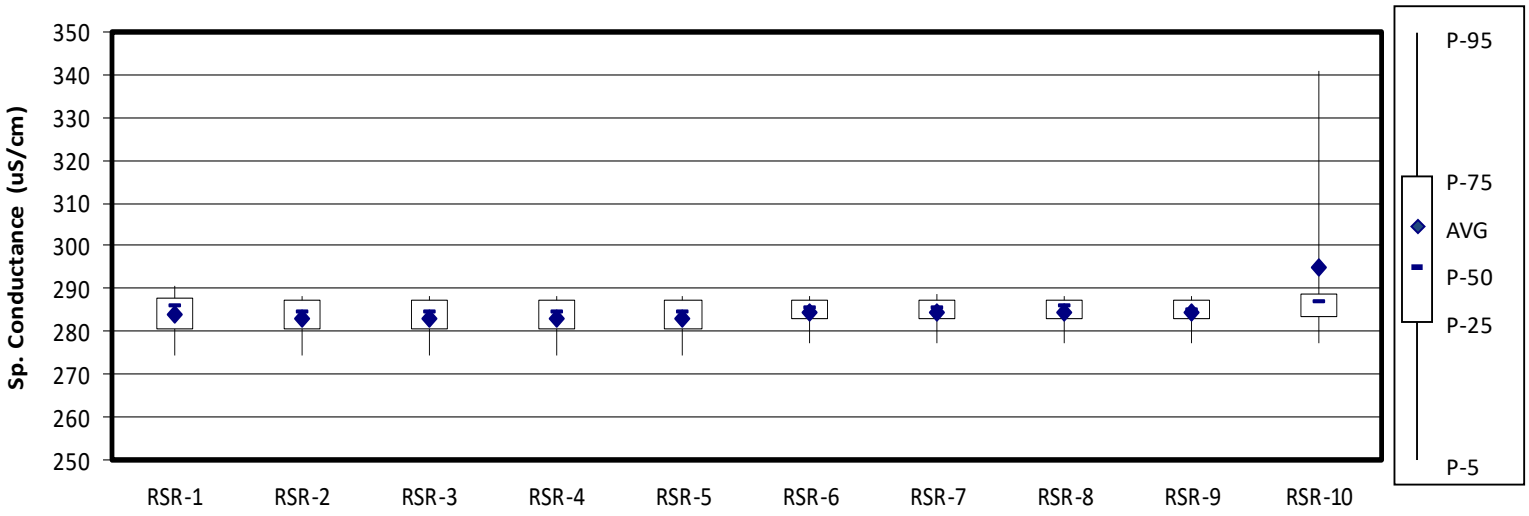

Figure 6. Florida SPRINGSWATCH Program Rainbow River Specific Conductance (uS/cm) Measurements (January 2019 - December 2019)

3.1.2 Horizontal Secchi Disk Visibility

Horizontal Secchi disk visibility measurements were collected by SPRINGSWATCH volunteers monthly at two river stations RSR-1 and RSR-10 (Table 2, Figure 7). These measurements provide additional information concerning water clarity and the light attenuation properties of the spring run. Higher Secchi values indicate a higher degree of water clarity.

Table 2. Horizontal Secchi disk (m) measurements in the Rainbow River

Date	RSR-1	RSR-10
2/20/2019	17.88	14.33
3/29/2019	17.07	10.67
4/24/2019	15.54	10.67
5/22/2019	14.94	9.14
6/14/2019	15.24	11.2
8/14/2019	13.11	10.36
9/20/2019	16.45	11.27
10/31/2019	22.55	12.19
Average	**16.6**	**11.2**

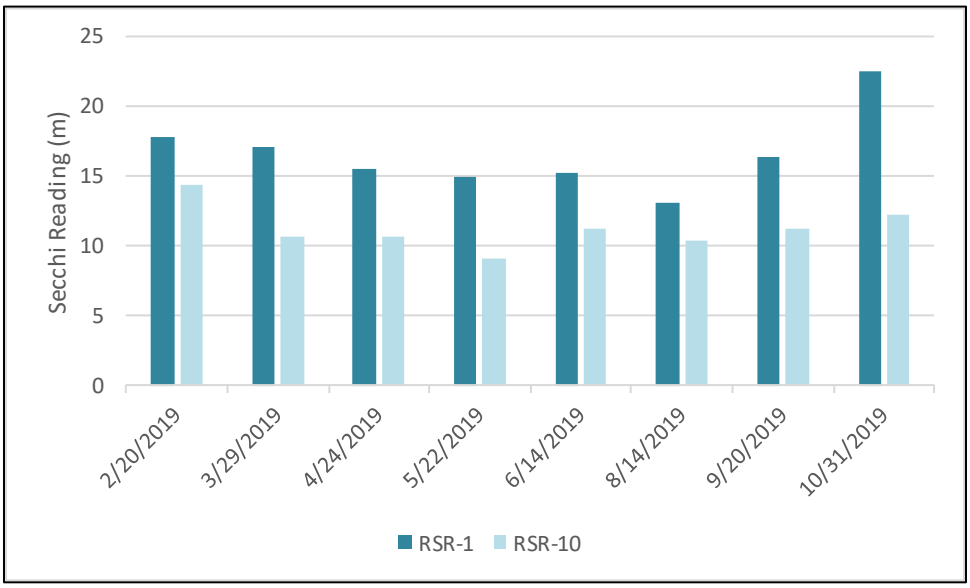

Figure 7. Florida SPRINGSWATCH program Rainbow River Secchi Disk (m) Measurements (January 2019-December 2019)

3.2 Light Measurements

Figure 8 displays the diffuse attenuation coefficient (k) and percent transmittance estimates collected by the Florida SPRINGSWATCH program along the Rainbow River from January 2019 to December 2019. Percent transmittance refers to the amount of light that is able to pass through the water column. 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 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 an increase in suspended solids (turbidity) in the water.

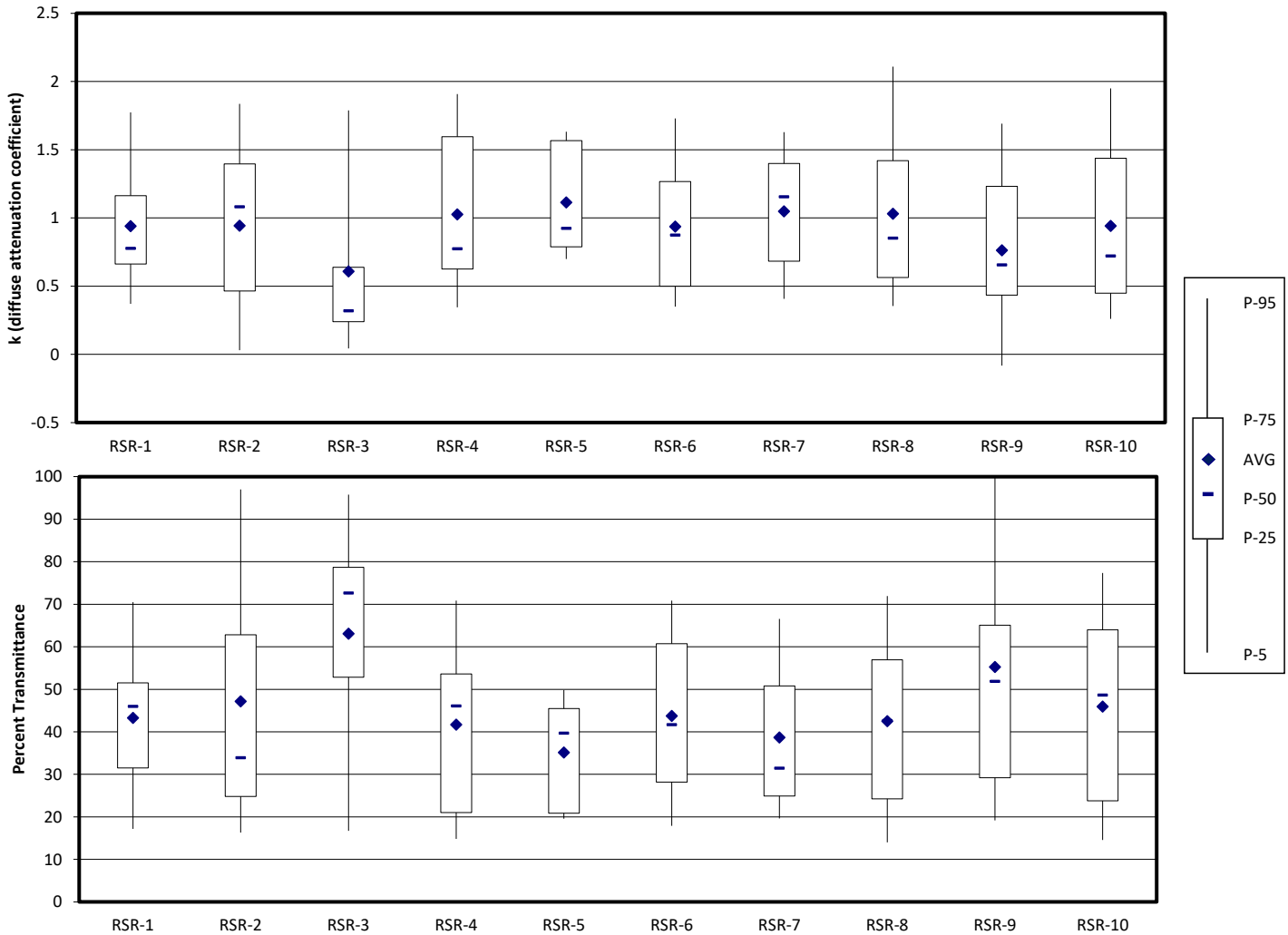

Figure 8. Rainbow River Diffuse Attenuation Coefficient (k) and Percent Transmittance Estimates (January 2019 - December 2019)

3.3 Aquatic Vegetation Survey

Submerged aquatic vegetation (SAV) cover was estimated at the Florida SPRINGSWATCH Rainbow River stations monthly during 2019 using underwater photographs taken at each station (Table 3). Table 3 presents the average percent cover of SAV, bare ground, algae, and detritus at each station over the period of study. Algae estimations include both filamentous algae and Muskgrass (*Chara Sp.)*.

Table 3. Average Percent Cover of SAV, bare ground, algae, and detritus at Florida SPRINGSWATCH Rainbow River Stations (January 2019 - December 2019)

Station	Algae	Coontail (Ceratophyllum demersum)	Strap-leaf sagittaria (Sagittaria kurziana)	Eelgrass (Vallisneria americana)	Waterthyme (Hydrilla verticillata)	Southern Naiad (Najas guadalupensis)	Average of SAV Total (non-Algae)	Bare Ground
RSR-1	13%	0%	81%	2%	0%	0%	82%	5%
RSR-2	5%	3%	59%	0%	5%	0%	66%	29%
RSR-3	9%	0%	63%	0%	1%	0%	64%	27%
RSR-4	9%	0%	74%	0%	0%	1%	75%	14%
RSR-5	17%	2%	83%	0%	0%	0%	85%	0%
RSR-6	11%	0%	74%	0%	1%	0%	75%	16%
RSR-7	10%	0%	66%	0%	0%	0%	66%	25%
RSR-8	13%	0%	63%	13%	0%	0%	76%	13%
RSR-9	11%	0%	80%	4%	0%	0%	84%	3%
RSR-10	18%	0%	44%	5%	0%	0%	49%	28%

3.4 Bird Surveys

SPRINGSWATCH volunteers who were experienced birders recorded their observations during each sampling trip. Species were identified to the lowest taxonomic group possible and quantities were recorded in listed in detail the species and quantities observed seasonally (Table 4).

Table 4. Bird survey results summary (January 2019 – December 2019)

Common Name	Scientific Name	Spring 2019	Summer 2019	Fall 2019	Winter 2019
American coot	*Fulica americana*	1	0	0	0
Anhinga	*Anhinga anhinga*	28	17	40	43
Barred owl	*Strix varia*	0	0	0	1
Belted kingfisher	*Megaceryle alcyon*	3	0	6	7
Black vulture	*Coragyps atratus*	7	1	5	11
Blue jay	*Cyanocitta cristata*	0	1	2	0
Carolina wren	*Thryothorus ludovicianus*	26	6	11	7
Cattle egret	*Bubulcus ibis*	46	27	0	0
Crow	*Corvus sp*	5	12	25	14
Double Crested cormorant	*Phalacrocorax auritus*	26	12	21	19
Eastern phoebe	*Sayornis phoebe*	0	0	6	0
Gallinule/Moorhen	*Gallinula galeata*	2	1	12	2
Great Blue heron	*Ardea herodias*	3	3	2	5
Great Crested flycatcher	*Myiarchus crinitus*	7	0	0	0
Great egret	*Ardea alba*	4	2	3	3
Green heron	*Butorides virenscens*	1	3	2	0
Limpkin	*Aramus guarauna*	6	1	3	0
Little Blue heron	*Egretta caerulea*	2	0	3	3
Northern cardinal	*Cardinalis cardinalis*	27	6	0	9
Northern flicker	*Colaptes auratus*	0	0	1	0
Osprey	*Pandion haliaetus*	1	0	0	0
Parula	*Setophaga americana*	0	0	0	1
Pekin duck	*Anas platyrhynchos domesticus*	1	0	0	0
Pied Billed grebe	*Podilymbus podiceps*	0	0	3	7
Pileated woodpecker	*Dryocopus pileatus*	2	2	3	4
Prothonotary warbler	*Protonotaria citrea*	2	0	0	0
Red bellied woodpecker	*Melanerpes carolinus*	4	4	5	5
Red Shouldered hawk	*Buteo lineatus*	6	7	10	2
Red-eye vireo	*Vireo olivaceus*	2	0	0	0
Redwing blackbird	*Agelaius phoeniceus*	0	0	30	0
Robin	*Turdus migratorius*	0	0	0	1
Sandhill crane	*Grus canadensis*	0	0	0	5
Snowy egret	*Egretta thula*	1	0	0	1
Spotted sandpiper	*Actitis macularius*	0	1	0	0
Swallow tailed Kite	*Elanoides forficatus*	3	1	0	0
Tricolored heron	*Egretta tricolo*	4	1	0	0
Tufted titmouse	*Baeolophus bicolor*	7	1	4	10
Turkey vulture	*Cathartes aura*	17	2	9	12
White ibis	*Eudocimus albus*	39	34	14	28
Wood duck	*Aix sponsa*	68	40	20	13
Yellow-rumped warbler	*Setophaga coronata*	0	0	0	7
Yellow-throated vireo	*Vireo flavifrons*	1	0	0	0

Section 4.0 References

Florida Department of Environmental Protection (FDEP) Bureau of Operational Services. (2017), [Daily Park Visitor Data]. Unpublished raw data.

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

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