Alabama Department of Environmental Management

Tennessee River Basin

Rivers and Reservoirs Monitoring Program

Limestone Creek Embayment
Wheeler Reservoir
Intensive Basin Survey 2018 & 2021

WHEL-5: Limestone Creek approx. 1 mile upstream of confluence with TN River (Limestone Co 34.59333/-86.89028)

BACKGROUND

The Alabama Department of Environmental Management (ADEM) began monitoring lake water quality statewide in 1985, followed by a second statewide survey in 1989. In 1990, the Reservoir Water Quality Monitoring Program [now known as the Rivers and Reservoirs Monitoring Program (RRMP)] was initiated by ADEM.

The current objectives of this program are to provide data that can be used to assess current water quality conditions, to identify trends in water quality conditions, and to develop Total Maximum Daily Loads (TMDLs) and water quality criteria. Descriptions of all RRMP monitoring activities are available in ADEM's 2017 Monitoring Strategy (ADEM 2017).

In 2018 and 2021, ADEM monitored the Limestone Creek (Wheeler Lake) tributary embayment as part of the intensive basin assessment of the Tennessee River under the RRMP (Figure 1). This site was selected using historical data and previous assessments. The purpose of this report is to summarize data collected in the Limestone Creek (Wheeler Lake) embayment (WHEL-5) during the 2018 and 2021 growing seasons (Apr-Oct). These are the fifth and sixth intensive basin assessments of the Tennessee River since ADEM began sampling on a basin rotation. Monthly and/or mean concentrations of nutrients [total nitrogen (TN); total phosphorus (TP)], algal biomass/productivity [chlorophyll *a* (chl *a*); algal growth potential testing (AGPT)], sediment [total suspended solids (TSS)], and trophic state [Carlson's trophic state index (TSI)] were compared to ADEM's historical data and established criteria.

A fish consumption advisory for mercury was issued by the Alabama Department of Public Health (ADPH) in 2010 based on fish tissue data collected by ADEM at station WHEL-5. Therefore, as an indicator of an impaired use, Limestone Creek (Wheeler Lake) from its confluence with the Tennessee River (Wheeler Lake) to the end of the embayment was listed on ADEM's 2012 §303(d) list of impaired waterbodies. In 2024, Limestone Creek (Wheeler Lake) was also added to ADEM's 2024 §303(d) list for impairment by nutrient enrichment.

Figure 1. Limestone Creek (Wheeler Lake) at WHEL-5.

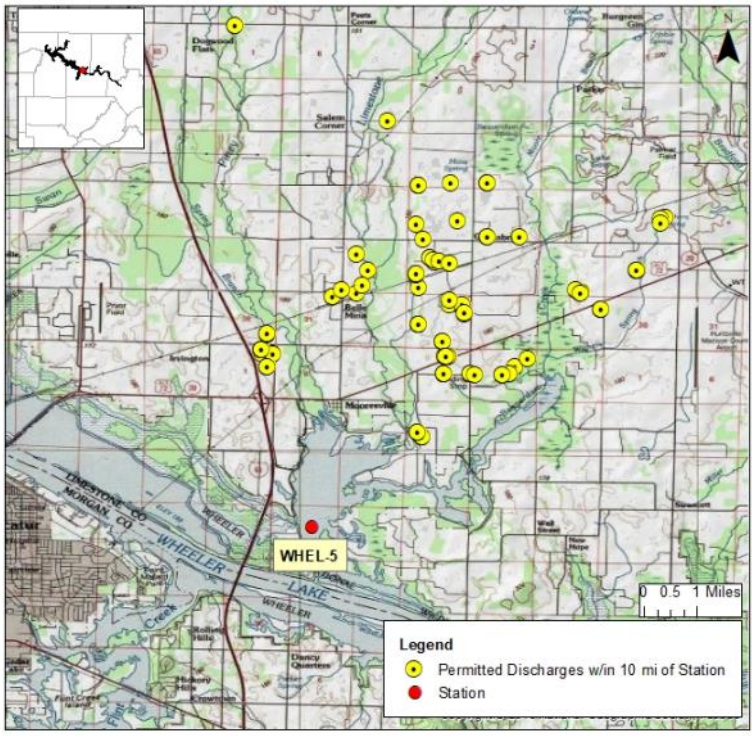


Figure 2. Map of the Limestone Creek (Wheeler Lake) embayment. Though additional discharges may occur in the watershed (Table 1), only permitted discharges within 10 miles of the station are displayed on the map.

WATERSHED CHARACTERISTICS

Watershed land uses are summarized in Table 1. Limestone Creek (Wheeler Lake) embayment is classified *Swimming/Fish & Wildlife (S/F&W)* and located in the Eastern Highland Rim ecoregion (71g). Based on the 2021 National Land Cover Dataset, land use within the 287 mi^2 watershed is predominantly pasture and cropland (Figure 3). As of February 13, 2024, ADEM has issued a total of 103 NPDES permits within the watershed (Figure 2).

Table 1. Summary of Watershed		**WHEL-5**
Basin		Tennessee R
Assessment Unit		AL06030002-0906-600
Drainage Area (mi^2)		287
Ecoregion[a]		71g
% Landuse		
Open Water		1%
Developed	Open Space	7%
	Low Intensity	5%
	Medium Intensity	3%
	High Intensity	<1%
Barren Land		<1%
Forest	Deciduous Forest	11%
	Evergreen Forest	2%
	Mixed Forest	2%
Shrub/Scrub		1%
Herbaceous		1%
Hay/Pasture		29%
Cultivated Crops		30%
Wetlands	Woody	7%
	Emergent Herb.	<1%
# NPDES outfalls[b]	TOTAL	103
Mining		11
Industrial General		76
Industrial Individual		2
Municipal		9
State Indirect Discharge		5

a. Eastern Highland Rim
b. #NPDES outfalls downloaded from ADEM's NPDES Management System database, Feb 13, 2024.

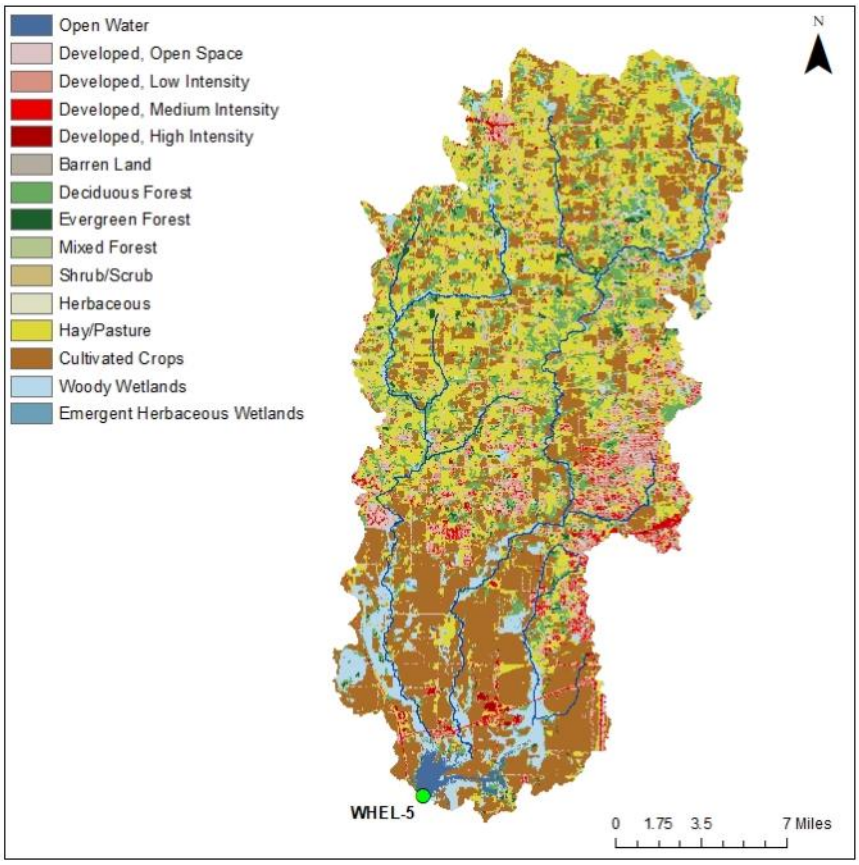


Figure 3. Land use within the Limestone Creek (Wheeler Lake) watershed at WHEL-5.

SITE DESCRIPTION

The Limestone Creek (Wheeler Lake) embayment at WHEL-5 is a very large embayment fed by Piney, Limestone, and Beaverdam Creeks. The mean bottom depth at the sample location was 3.2m in 2018 and 2.8m in 2021 (Table 2). It is located on the north side of the Tennessee River just east of I-65 and south of I-565. There are numerous islands and grass flats in the bay, though the main channel is clear of aquatic vegetation.

METHODS

Water quality samples were conducted at monthly intervals, April-October in 2018 and 2021. All samples were collected, preserved, stored, and transported according to procedures in the ADEM Field Operations Division Standard Operating Procedures (ADEM 2021), Surface Water Quality Assurance Project Plan (ADEM 2018a), and Quality Management Plan (ADEM 2018b).

Mean growing season TN, TP, chl *a*, and TSS were calculated to evaluate water quality conditions. Monthly concentrations of these parameters were graphed with discharge data, if available, and ADEM's previously collected data to help interpret the 2018 and 20201results. Carlson's TSI was calculated from the corrected chl *a* concentrations (Carlson 1977).

RESULTS

The following discussion of results is limited to those parameters which directly affect trophic status or parameters which have established criteria. A summary of all water chemistry analyses are presented in Table 2. The axis ranges of the graphs in Figures 4 -7 were set to maximum values reservoir-wide so that all embayment reports on the same reservoir could be compared.

Mean growing season TN values increased 2003 to 2013, but they seem to have stabilized since then (Figure 4). Monthly TN concentrations were highest in July in 2018 and in May in 2021 (Figure 5).

Table 2. Summary of water quality data collected April-October, 2018 and 2021. Minimum (Min) and maximum (Max) values calculated using minimum detection limits. Median (Med), Mean, and standard deviations (SD) values were calculated by multiplying the MDL by 0.5 when results were less than this value.

WHEL-5 2018	N		Min	Max	Med	Avg	SD
Physical							
Turbidity (NTU)	7		11.4	20.4	14.0	15.4	3.9
Total Dissolved Solids (mg/L)	7		54.0	98.0	88.0	82.9	15.0
Total Suspended Solids (mg/L)	7		12.0	30.0	17.0	18.9	6.0
Hardness (mg/L)	4		53.7	63.4	61.5	60.0	4.6
Alkalinity (mg/L)[J]	7		20.9	63.5	59.7	53.2	14.9
Photic Zone (m)	7		1.42	2.11	1.82	1.78	0.25
Secchi (m)	7		0.62	0.83	0.79	0.76	0.07
Bottom Depth (m)	7		2.4	3.8	3.1	3.2	0.5
Chemical							
Ammonia Nitrogen (mg/L)	7	<	0.015	0.068	0.008	0.016	0.023
Nitrate+Nitrite Nitrogen (mg/L)	7	<	0.007	0.494	0.078	0.188	0.200
Total Kjeldahl Nitrogen (mg/L)	7		0.362	1.190	0.737	0.760	0.289
Total Nitrogen (mg/L)	7	<	1.096	3.870	0.962	0.948	0.327
Dis Reactive Phosphorus (mg/L)[J]	7	<	0.004	0.040	0.004	0.009	0.014
Total Phosphorus (mg/L)	7		0.016	0.114	0.025	0.040	0.034
CBOD-5 (mg/L)	7	<	2.0	3.0	1.0	1.3	0.8
Chlorides (mg/L)[J]	7		2.5	5.4	4.4	4.1	1.2
Biological							
Chlorophyll a (mg/m³)	7		2.14	60.90	23.50	28.53	19.37
E. coli (MPN/DL)[J]	4	<	1	18	2	6	9
WHEL-5 2021	**N**		**Min**	**Max**	**Med**	**Avg**	**SD**
Physical							
Turbidity (NTU)	7		10.9	19.2	16.7	15.9	3.1
Total Dissolved Solids (mg/L)[J]	7		54.0	80.0	66.0	65.4	7.1
Total Suspended Solids (mg/L)[J]	7		13.0	19.0	15.0	16.0	2.4
Hardness (mg/L)	4	<	0.4	55.7	47.7	37.8	25.4
Alkalinity (mg/L)	7		42.3	49.6	45.9	45.7	2.8
Photic Zone (m)	7		1.55	2.99	2.40	2.26	0.52
Secchi (m)	7		0.48	0.85	0.60	0.64	0.14
Bottom Depth (m)	7		2.0	3.0	2.9	2.8	0.3
Chemical							
Ammonia Nitrogen (mg/L)	7	<	0.016	0.076	0.023	0.033	0.024
Nitrate+Nitrite Nitrogen (mg/L)	7		0.069	0.841	0.428	0.425	0.307
Total Kjeldahl Nitrogen (mg/L)[J]	7	<	0.324	1.140	0.348	0.437	0.354
Total Nitrogen (mg/L)[J]	7	<	1.251	4.803	0.734	0.862	0.384
Dis Reactive Phosphorus (mg/L)[J]	7	<	0.004	0.006	0.004	0.004	0.002
Total Phosphorus (mg/L)	7		0.026	0.112	0.058	0.054	0.030
CBOD-5 (mg/L)[J]	7	<	2.0	2.8	2.3	2.0	0.7
Chlorides (mg/L)	7		3.5	5.1	4.5	4.3	0.6
Biological							
Chlorophyll a (mg/m³)	7		24.90	47.40	33.10	35.00	8.14
E. coli (MPN/DL)[J]	4		1	10	1	3	4

J= one or more of the values is an estimate; N= # samples.

RESULTS (con't)

Mean growing season TP concentrations decreased 2003 to 2013 but increased 2015 to 2021 (Figure 4). In 2018, the highest monthly TP value was observed in April (Figure 5). In 2021 the highest monthly TP value was observed in June.

Mean growing season chl *a* concentrations increased 2015 to 2021, with the 2021 mean being the highest observed overall (Figure 4). In 2018, monthly chl *a* concentrations were highest in June, reaching a value of 60.90 (Figure 5). September was the highest monthly concentration recorded in 2021.

According to mean annual TSI, the productivity of the Limestone Creek (Wheeler Lake) embayment has been eutrophic in every sampling year (Figure 4). In 2018, monthly TSI calculations indicated eutrophic conditions in all months sampled except April, which was oligtotrophic, and June, which was hypereutrophic (Figure 5). In 2021, the site was eutrophic throughout the growing season from April to October.

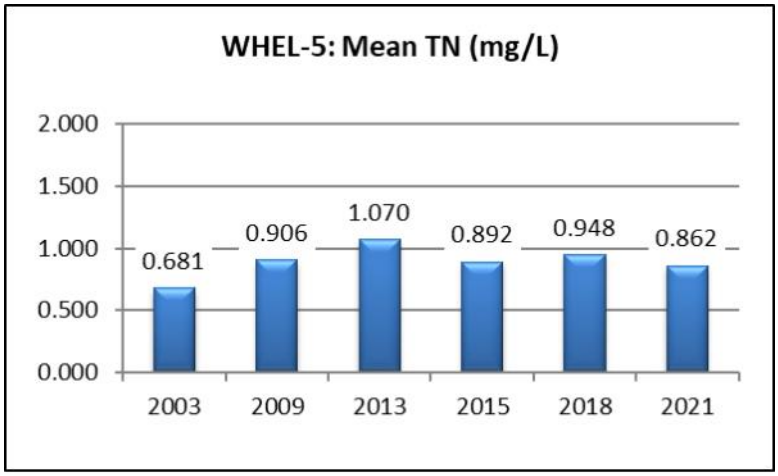
Mean growing season TSS concentrations increased 2009 to 2018 but decreased slightly in 2021 (Figure 4). Monthly TSS concentrations were highest in October of 2018 (Figure 6). In 2021, there was very little fluctuation in the monthly samples with concentrations ranging from 13 to 19 mg/L.

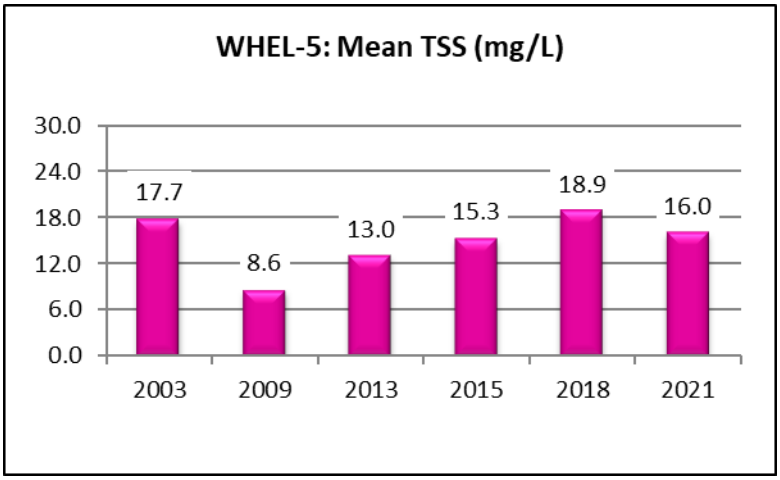
AGPT results show that Limestone Creek (Wheeler Lake) was phosphorus-limited in 2003 and 2013 and nitrogen-limited in 2009 (Table 3). The 2009 sample was below the maximum standing crop (MSC) value of 5.0 mg/L that Raschke and Schultz (1987) found protective of reservoir and lake systems. While the 2003 and 2013 samples were >5.0 mg/L, they were below 20.0 mg/L MSC, which Raschke and Schultz define as protective of flowing stream and river systems.

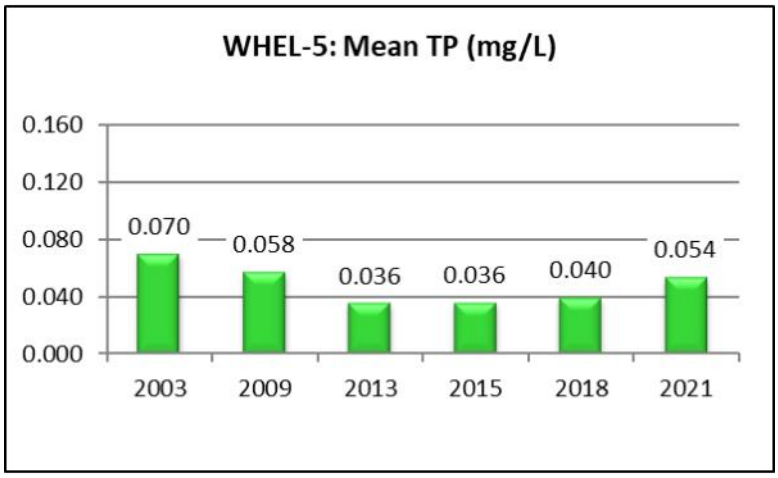
While dissolved oxygen (DO) concentrations at WHEL-5 were above the ADEM minimum criteria limit of 5.0 mg/L at 5.0 ft (1.5 m) in all months sampled during both 2018 and 2021 (ADEM Admin. Code R. 335-6-10-.09), some monthly readings in 2021 showed super-saturated DO conditions with concentrations >12.0 mg/L (Figure 7). DO was above 12.0 mg/L in September 2021, which is also the month when the highest monthly chl *a* concentration was measured.

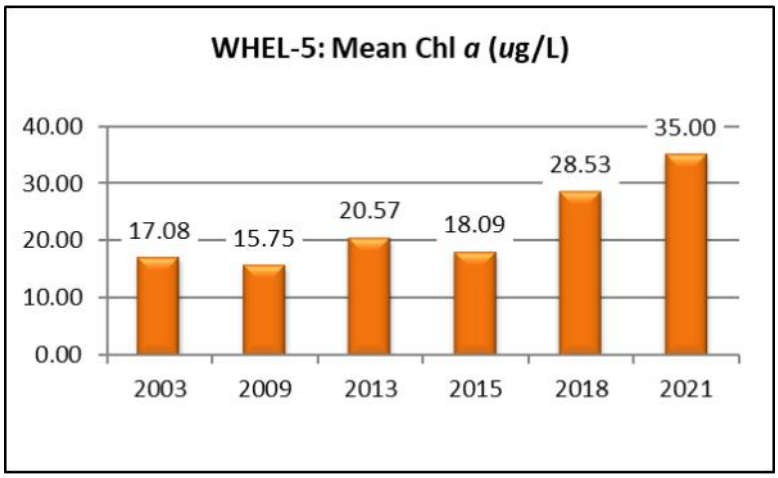
Table 3. Algal growth potential test results (expressed as mean maximum standing crop (MSC) dry weights of *Selenastrum capricornutum* in mg/L) and limiting nutrient status. MSC values below 5 mg/L are considered to be protective in reservoirs and lakes (Raschke and Schultz 1987).

Year	Mean MSC	Limiting Nutrient
2003	7.04	Phosphorus
2009	4.13	Nitrogen
2013	12.3	Phosphorus









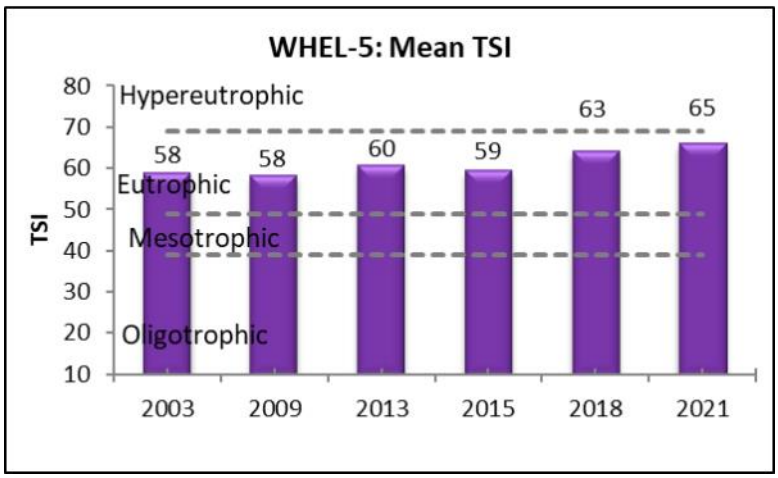
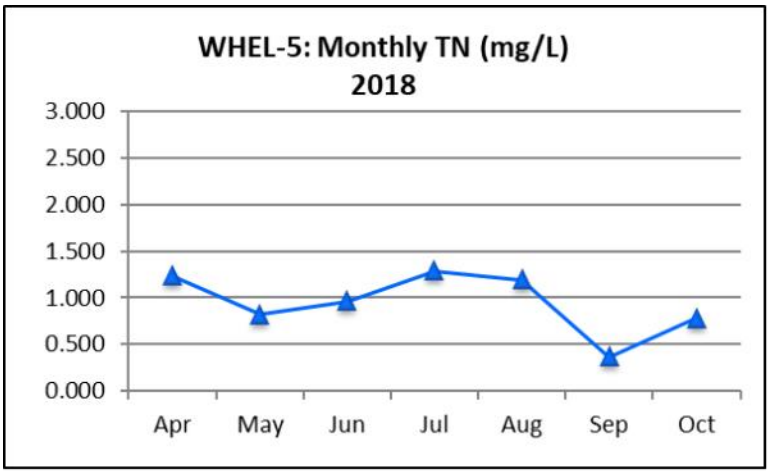
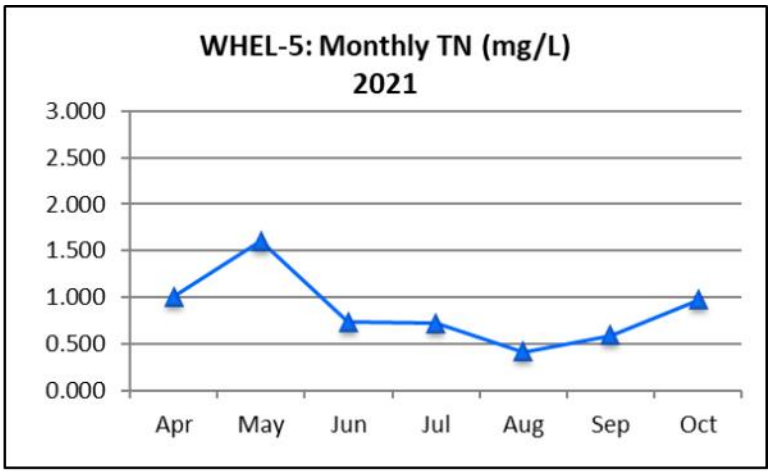
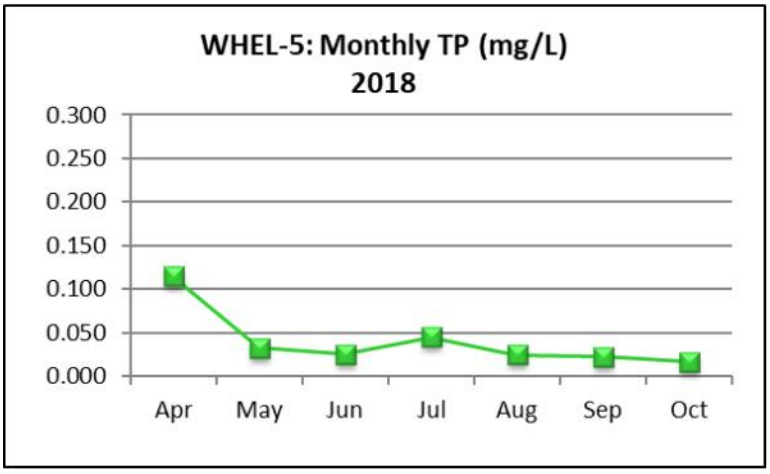
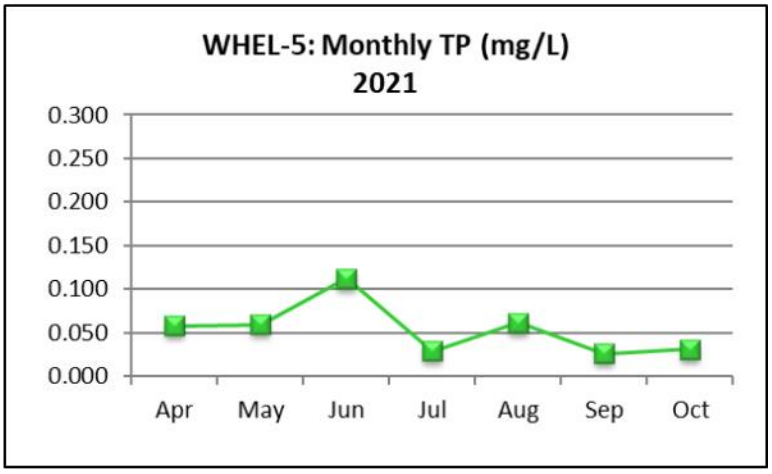


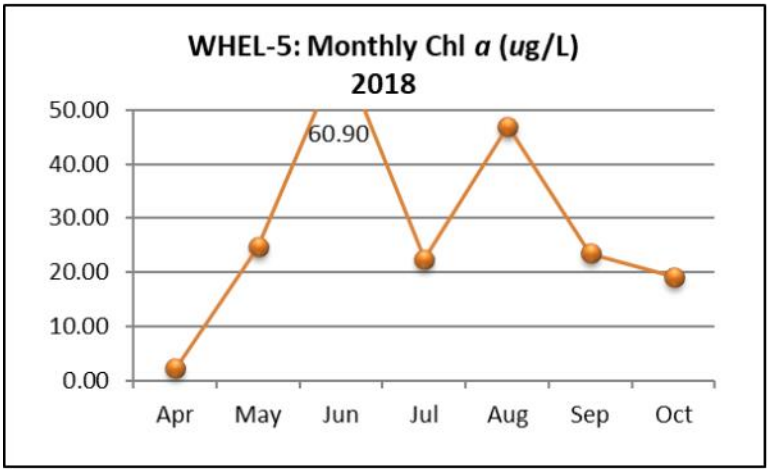
Figure 4. Mean growing season (2003-2021). TN, TP, chl *a,* and TSI measured in the Limestone Creek (Wheeler Lake) embayment (WHEL-5)**.** Vertical axis ranges are set to maximum values reservoir-wide for comparability between embayment reports within the same reservoir.

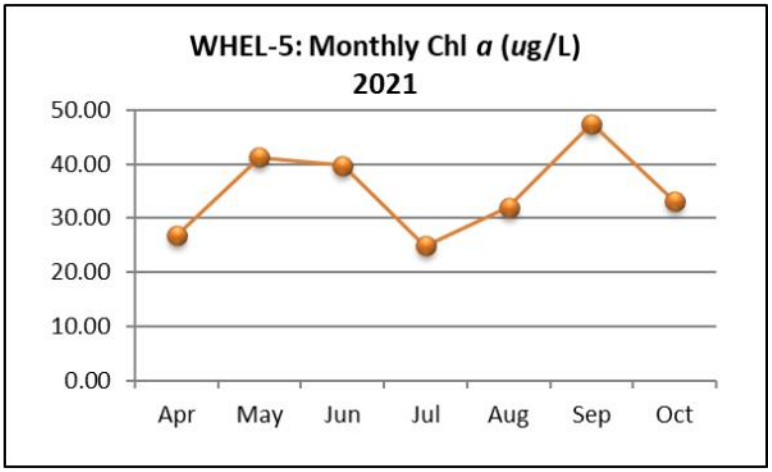


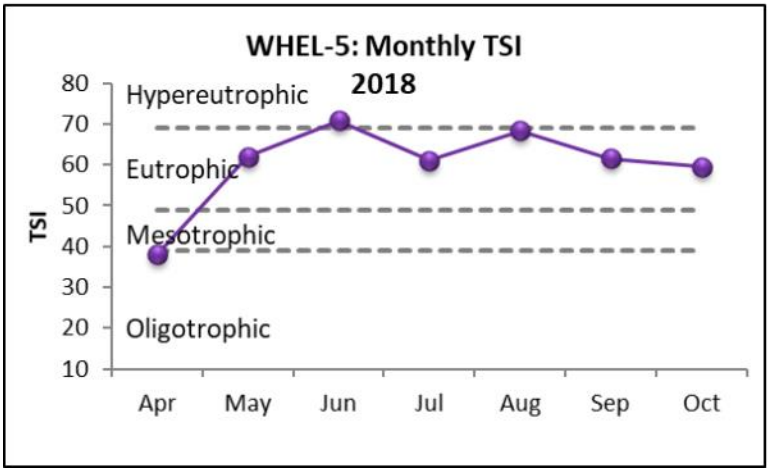












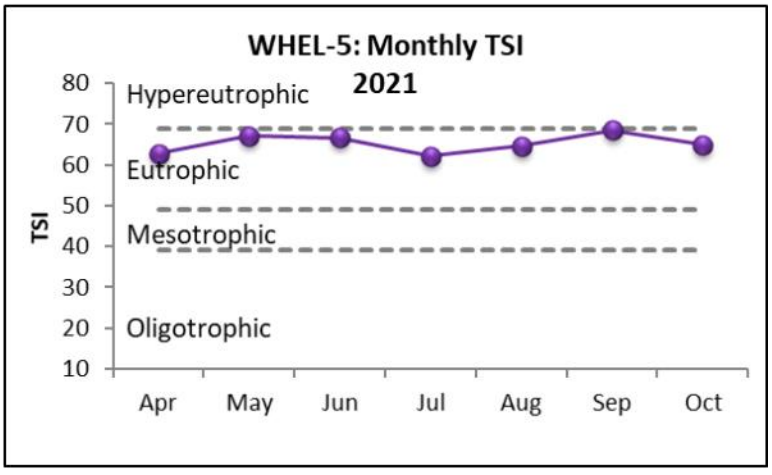


Figure 5. Monthly (April-October, 2018 & 2021) TN, TP, chl *a,* and TSI measured in the Limestone Creek (Wheeler Lake) embayment (WHEL-5)**.** Vertical axis ranges are set to maximum values reservoir-wide for comparability between embayment reports within the same reservoir.

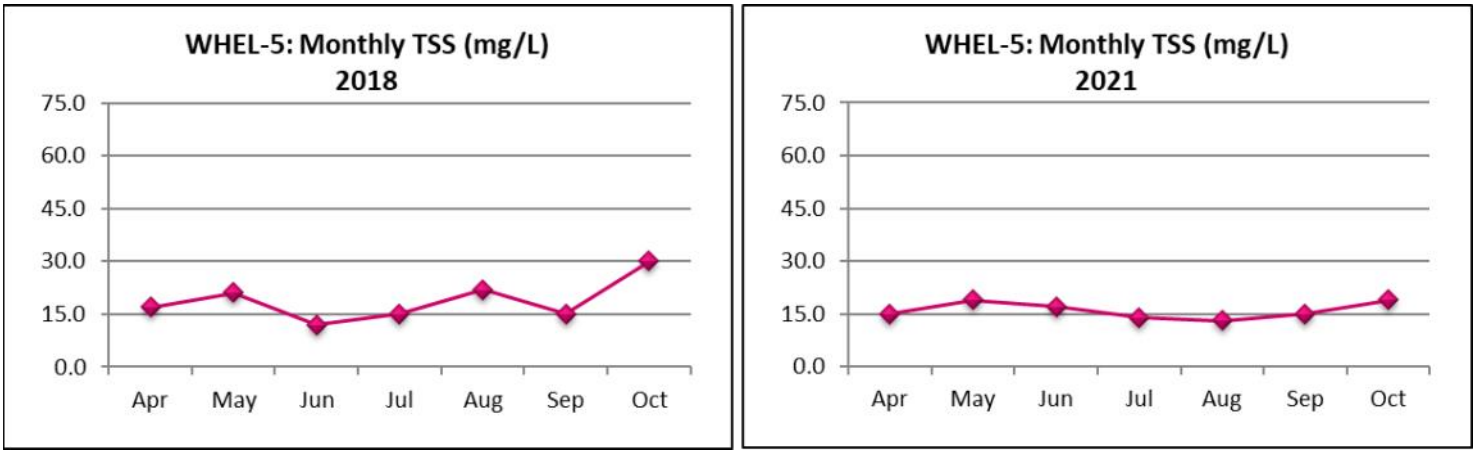


Figure 6. Monthly TSS measured in the Limestone Creek (Wheeler Lake) embayment (WHEL-5) in 2018 and 2021.

Figure 7. Monthly DO concentrations at 1.5 m (5 ft) for Limestone Creek (Wheeler Lake) embayment (WHEL-5) collected April-October 2018 and 2021. ADEM Water Quality Criteria pertaining to reservoir waters require a minimum DO concentration of 5.0 mg/L at this depth.

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