

# Appendix J of Lake Monroe Watershed Management Plan Detailed HUC-12 Water Quality Analysis by Subwatershed

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# 1 Water Quality Analysis by Subwatershed (HUC12)

The Lake Monroe watershed consists of sixteen 12-digit Hydrologic Unit Code (HUC) subwatersheds. To better understand localized differences, data was analyzed according to these 12-digit HUC subwatersheds. Each subwatershed reflects a specific tributary drainages. Land uses, point and non-point watershed concern areas, and water quality sampling locations and results are discussed in detail below for each subwatershed based on the following information:

- Monthly Tributary Monitoring (2020-2021)
- Sampling Blitz “Snapshot” Monitoring Events (2020-2021)
- Brown County Regional Sewer District E. Coli Sampling (2020)
- Habitat Evaluation CQHEI Habitat Assessment (2020-2021)
- Land Cover Assessment
- Windshield Survey Visual Assessment (2020)
  - Riparian Buffer
  - Streambank Erosion
  - Livestock Access to Streams
- NPDES Point Source Location Data
- Historical Water Quality Data (where available)

As Lake Monroe straddles three 12-digit HUCs (Allen Creek, Moore Creek, Jacobs Creek), a separate section was added to analyze data collected within the lake.

- Lake Monroe Monitoring (2020-2021)
- Historical Lake Monroe Monitoring Data
  - USACE Annual Lake Monitoring
  - CBU Annual and Periodic Lake Monitoring
  - IDEM/IDNR Annual Beach Blue-Green Algae Monitoring
  - USFS Annual Beach E. Coli Monitoring
  - 1997 Jones Report (1992-1993 Lake Monitoring)

Figure 1-1 Lake Monroe Subwatersheds

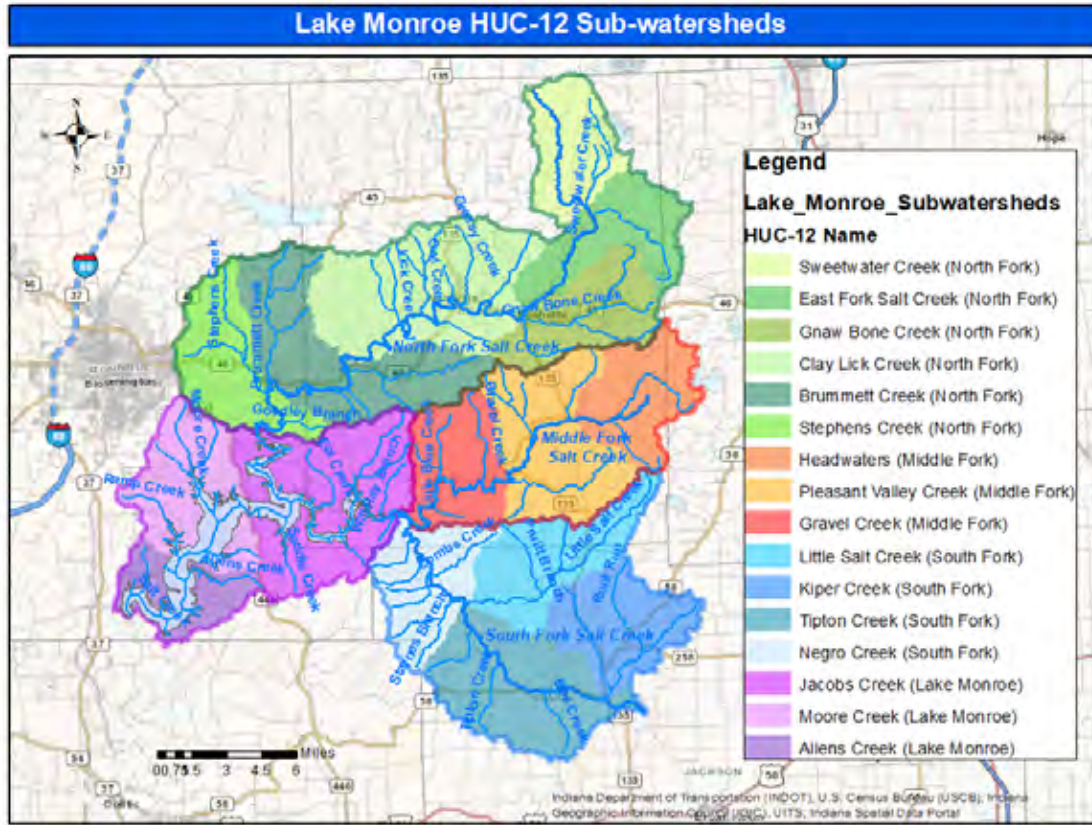


Table 1-1 Lake Monroe 12-Digit Hydrologic Unit Code Subwatersheds

12-Digit HUC	Name	10-Digit HUC Name	Acres	Percentage
051202080401	Kiper Creek (SF)	South Fork Salt Creek	14,531	5%
051202080402	Little Salt Creek (SF)	South Fork Salt Creek	15,681	6%
051202080403	Tipton Creek (SF)	South Fork Salt Creek	21,822	8%
051202080404	Negro Creek (SF)	South Fork Salt Creek	13,548	5%
051202080501	Headwaters Middle Fork (MF)	Middle Fork Salt Creek	13,206	5%
051202080502	Pleasant Valley Creek (MF)	Middle Fork Salt Creek	20,333	7%
051202080503	Gravel Creek (MF)	Middle Fork Salt Creek	13,237	5%
051202080601	Sweetwater Creek (NF)	North Fork Salt Creek	12,239	4%
051202080602	East Fork Salt Creek (NF)	North Fork Salt Creek	13,719	5%
051202080603	Gnaw Bone Creek (NF)	North Fork Salt Creek	13,598	5%
051202080604	Clay Lick Creek (NF)	North Fork Salt Creek	28,572	10%
051202080605	Brummett Creek (NF)	North Fork Salt Creek	23,857	9%
051202080606	Stephens Creek (NF)	North Fork Salt Creek	14,947	5%
051202080701	Jacobs Creek (LM)	Lake Monroe-Salt Creek	28,880	10%
051202080702	Moore Creek (LM)	Lake Monroe-Salt Creek	18,240	7%
051202080703	Allens Creek (LM)	Lake Monroe-Salt Creek	10,273	4%

## 1.1 Kiper Creek – South Fork (HUC 051202080401)

The Kiper Creek Subwatershed (HUC 12 – 051202080401) is located in the southeastern corner of the watershed as shown in Figure 4-2. The subwatershed encompasses approximately 14,531 acres and represents 5% of the overall watershed. The subwatershed is located entirely within Jackson County and contains Freetown. Kiper Creek, Little Salt (Kiper) Creek – not to be confused with Little Salt Creek in the Little Salt Creek subwatershed – and Runt Run all originate in the subwatershed and combine before discharging into South Fork Salt Creek at the downstream limit of the subwatershed. According to the IDEM 303(d) list, there are no impaired streams within the Kiper Creek Subwatershed.

### 1.1.1 Land Use

The Kiper Creek Subwatershed has the highest percentage of agricultural land (25%) of the sixteen Lake Monroe subwatersheds. Cropland is most concentrated along Runt Run, Little Salt Creek, and the downstream portion of Kiper Creek. Pasture is located along the headwaters of Little Salt Creek (Spraytown area), along Kiper Creek, and north of Freetown. Kiper Creek Subwatershed also has the highest percentage of developed land (5%) of all sixteen Lake Monroe subwatersheds primarily due to Freetown, a community of roughly 400 residents. (While Nashville in the Clay Lick subwatershed is much larger than Freetown, it makes up a smaller percentage of other overall subwatershed.) Several parcels of land in the northern third of the subwatershed are owned by the United States Forest Service.

### 1.1.2 Point Source Water Quality Issues

The Kiper Creek Subwatershed contains no confined feeding operations and two NPDES permitted facilities. Springhill Camps maintains a very small (0.0196 MGD) sewage treatment system under NPDES permit IN0044211 that discharges to an unnamed tributary of Little Salt Creek near Freetown. One self-reported violation occurred in July 2018 when sampling revealed E. coli levels above the permit threshold. No other violations were found.

Jackson County Regional Sewer District maintains a wastewater treatment plant under NPDES permit IN0052949 that discharges to Little Salt Creek near Freetown. The facility also has a separate permit for municipal sludge application under Land Application Permit No. INLA000470. The NPDES permit was most recently renewed in 2019. A self-reported violation in nitrogen concentration occurred in 2015 and self-reported violation in TSS occurred in 2016. No other violations were found. However, the plant does appear to be located within the 100-year floodplain of Little Salt Creek.

### 1.1.3 Non-Point Source Water Quality Issues

In early spring 2020, the watershed coordinator conducted a windshield survey which included 14 stream crossing sites within the Kiper Creek Subwatershed. Observations including streambank erosion, stream buffers, and livestock access were recorded for each site and the results are

summarized in Table 4-2 below. Streambank erosion was noted at 13 of the 14 observed sites and lack of sufficient riparian buffer was observed at 10 of the 14 observed sites. Livestock access was documented at 1 of 14 sites but is believed to be more prevalent due to the larger amount of pasture in the subwatershed.

Table 1-2 Kiper Creek Windshield Survey Summary

Parameter	Observations
Streambank Erosion	4/14 sites with erosion >3' 9/14 sites with erosion <3' 1/14 sites with no erosion
Stream Buffers	0/14 sites with no buffers 10/14 sites with buffers <20' 4/14 sites with sufficient buffer
Livestock Access to Streams	1/14 sites with livestock access

Figure 1-2 Kiper Creek (South Fork) Subwatershed

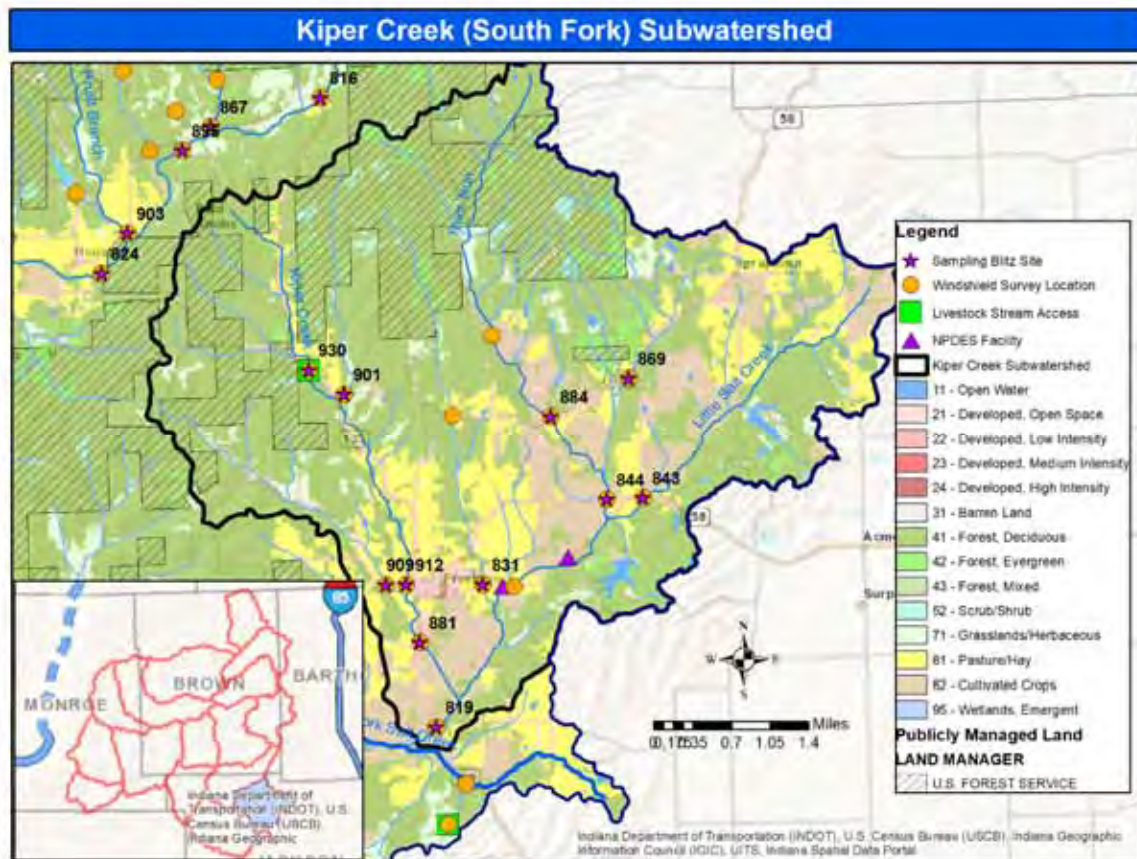




Figure 1-3 Site 881 on Kiper Creek (downstream)



Figure 1-4 Site 930 on Kiper Creek (upstream)



#### 1.1.4 Water Quality Assessment

Eleven stream sites were selected for the spring and fall watershed sampling blitz events. Samples were analyzed for a variety of chemical parameters and E. coli. Habitat was evaluated using CQHEI. Macroinvertebrates and the fish community have not been assessed in this subwatershed. No monthly sampling locations or stream gages are located in this subwatershed.

##### **Water Quality Information**

During the two blitz events, no exceedances were reported for total nitrogen, nitrate, or total suspended solids. One sample (of 11) exceeded the total phosphorus target of 0.02 mg/L in the fall and 5 of 11 exceeded the total phosphorus target in the spring. The only site with total phosphorus exceedances during both events was site 819 on Little Salt (Kiper) Creek at the downstream end of the subwatershed. Soluble reactive phosphorus concentrations exceeded the target stream concentration of 0.005 mg/L in 3 of 11 fall samples and 1 of 11 spring samples with very little correlation between elevated total phosphorus levels.

E. coli was measured above the state standard in 1 of 11 samples in each blitz event, at site 930 on Kiper Creek (upstream) in the fall and at site 881 on Kiper Creek (downstream) in the spring. Livestock with access to the stream were observed near site 930 and livestock fenced from the stream were observed at site 881 during the windshield survey.

An additional water sample was collected at site 881 (downstream Kiper Creek) on April 27, 2021 to send for source analysis. The source analysis indicated a 50.5% probability of a human source and a 49.5% probability of an animal source. The E. coli concentration was reported at 1,299.7 CFU/100 ml, significantly exceeding the target of 235 CFU/100 ml.

*Table 1-3 Kiper Creek Sampling Blitz Results - Nutrients*

Blitz ID	Creek Name	Fall TN (mg/L)	Spring TN (mg/L)	Fall NO3 (mg/L)	Spring NO3 (mg/L)	Fall TP (mg/L)	Spring TP (mg/L)	Fall SRP (mg/L)	Spring SRP (mg/L)
819	Little Salt Creek	0.228	0.488	0.008	0.416	0.021	0.024	0.005	0.004
831	Unnamed tributary of Little Salt (Kiper) Creek	0.100	0.194	0.020	0.138	0.003	0.016	0.006	0.003
843	Little Salt Creek	0.186	0.460	0.008	0.316	0.019	0.039	0.003	0.003
844	Runt Run	0.199	0.456	0.083	0.360	0.009	0.061	0.003	0.012
869	Unnamed tributary of Runt Run	0.183	0.177	0.008	0.073	0.018	0.018	0.003	0.002
881	Kiper Creek	0.287	0.336	0.193	0.254	0.012	0.022	0.009	0.002
884	Runt Run	0.100	0.130	0.008	0.043	0.010	0.033	0.002	0.002
901	Unnamed tributary of Kiper Creek	0.100	0.179	0.008	0.135	0.004	0.011	0.003	0.002
909	Unnamed tributary of Kiper Creek	0.502	0.233	0.506	0.160	0.007	0.010	0.011	0.002
912	Kiper Creek	0.101	0.347	0.008	0.296	0.010	0.010	0.002	0.002
930	Kiper Creek	0.100	0.232	0.014	0.131	0.002	0.005	0.005	0.002

Table 1-4 Kiper Creek Sampling Blitz Results - E. coli and Sediment

Blitz ID	Creek Name	Fall E. Coli (MPN/100 mL)	Spring E. coli (MPN/100mL)	Fall TSS (mg/L)	Spring TSS (mg/L)
819	Little Salt Creek	42	32	0.5	0.6
831	Unnamed tributary of Little Salt (Kiper) Creek	186	1	0.5	0.5
843	Little Salt Creek	5	99	0.5	1.2
844	Runt Run	39	5	0.5	0.5
869	Unnamed tributary of Runt Run	19	10	2.2	0.5
881	Kiper Creek	146	488	1	4.8
884	Runt Run	32	5	0.5	0.5
901	Unnamed tributary of Kiper Creek	137	27	0.5	0.5
909	Unnamed tributary of Kiper Creek	10	3	0.5	0.5
912	Kiper Creek	6	6	0.5	0.5
930	Kiper Creek	435	4	0.5	0.5

Table 1-5 Kiper Creek Fecal Contamination Source Analysis

BC_ID	LM_ID	Stream	4/27/21 E. Coli	Coliform (PFU/100ml)	% Human	% Animal
N/A	881	Kiper Creek (downstream)	1299.7	0.1	50.5	49.5

### 1.1.5 Habitat and Biological Assessment

#### Habitat/Biological Information

Volunteers completed the Citizen Qualitative Habitat Evaluation Index (CQHEI) habitat assessment at all 11 sites during the spring and fall sampling blitz events. Although a comparison scale for the CQHEI has not yet been developed, Hoosier Riverwatch indicates that scores greater than 60 rate as habitat conducive to supporting warm-water biota (IDNR, 2004). CQHEI scores ranged from 45 to 61 during the fall blitz and 45 to 77 during the spring blitz. Only 9% of sites scored above 60 during the fall blitz and only 45% of sites scored above 60 during the spring blitz, indicating poor stream habitat throughout the subwatershed. The lowest scores were in the smallest streams (unnamed tributaries) and in Kiper Creek. In most subwatersheds, CQHEI scores were generally higher in the spring due to higher flow levels. It is unclear why many CQHEI scores were lower in the spring in the Kiper Creek subwatershed and could be due to a difference in volunteers between events.

Table 1-6 Kiper Creek Sampling Blitz Results - Habitat Evaluation (CQHEI)

Blitz ID	Stream Name	Fall 2020 CQHEI	Spring 2021 CQHEI
819	Little Salt (Kiper) Creek	53	62.5
831	Unnamed tributary of Little Salt (Kiper) Creek	59.5	54
843	Little Salt (Kiper) Creek	50	72
844	Runt Run	45	77
869	Unnamed tributary of Runt Run	48	59
881	Kiper Creek	52	47
884	Runt Run	60	67
901	Unnamed tributary of Kiper Creek	56	50.3
909	Unnamed tributary of Kiper Creek	59	56
912	Kiper Creek	54	69
930	Kiper Creek	61	45
Average CQHEI			
		54.3	59.9
% of Sites >60			
		9%	45%

Table 1-7 Kiper Creek 2017 - 2019 USFS Houston South 3-Year Average of Fish Survey Results

Blitz ID	Stream	Station	# Species	Fish IBI	IBI Rating	QHEI	QHEI Rating
930	Kiper Creek	SR 135	8	27.3	Poor	50.3	Fair

No stream sections in the subwatershed were evaluated using macroinvertebrate Index of Biotic Integrity (mIBI). The USFS sampled fish in Kiper Creek at site 930 from 2017 through 2019 and reported an average fish-based Index of Biotic Integrity (IBI) of 27.3, indicating a poor rating.

The USFS also evaluated habitat using the Qualitative Habitat Evaluation Index (QHEI) at site 930 and reported an average QHEI score indicating fair habitat. This corresponds well with the fall CQHEI score of 61 (generally healthy) but not the spring CQHEI score of 45.

#### 1.1.6 Kiper Creek Subwatershed Summary

The Kiper Creek subwatershed contains the highest concentration of agricultural land in the watershed. Water chemistry data from the Kiper Creek subwatershed suggest that total phosphorus, soluble reactive phosphorus, and E. coli are potential contaminants of concern.

Streambank erosion and insufficient riparian buffer were observed throughout the watershed which may contribute to the poor habitat scores. Kiper Creek appears to be the primary stream of concern due to its E. coli exceedances and low habitat scores compared to the other named streams.

## 1.2 Little Salt Creek – South Fork (HUC 051202080402)

The Little Salt Creek Subwatershed (HUC 12 – 051202080402) straddles the border between Brown and Jackson Counties as shown in Figure 4-5. The subwatershed encompasses approximately 15,681 acres and represents 6% of the overall watershed. Little Salt Creek (GNIS 00451161) runs through the subwatershed, combining with its tributaries Cross Branch and Pruitt Branch before discharging into South Fork Salt Creek at the downstream limit of the subwatershed. According to the IDEM 303(d) list, Little Salt Creek (GNIS 00451161) is impaired for E. coli, which includes several of its tributaries. This impairment designation is based on samples collected by IDEM in 2013 where Little Salt Creek crosses under Buffalo Pike, corresponding with site 824.

### 1.2.1 Land Use

The Little Salt Creek Subwatershed has the fifth highest percentage of agricultural land (8%) of the sixteen Lake Monroe subwatersheds. Pasture is primarily located along the northern stretch of State Road 135 and around the community of Houston in the western half of the subwatershed. Cropland is concentrated along the downstream stretch of Little Salt Creek near Houston. Population is sparse and generally located along the main roads (State Road 135, Houston Road, Buffalo Pike). About half the land in the watershed is owned by the United States Forest Service.

### 1.2.2 Point Source Water Quality Issues

The Little Salt Creek Subwatershed contains no confined feeding operations and no NPDES permitted facilities.

### 1.2.3 Non-Point Source Water Quality Issues

In early spring 2020, the watershed coordinator conducted a windshield survey which included 18 stream crossing sites within the Little Salt Creek Subwatershed. Observations including streambank erosion, stream buffers, and livestock access were recorded for each site and the results are summarized in Table 4-8 below. Streambank erosion was observed at 14 of 18 sites, nearly all less than three feet in height. Insufficient riparian buffers were observed at 7 of 18 sites. Livestock with free access to streams was noted at 2 of 18 sites.

*Table 1-8 Little Salt Creek Windshield Survey Summary*

Parameter	Observations
Streambank Erosion	1/18 sites with erosion >3' 13/18 sites with erosion <3' 4/18 sites with no erosion
Stream Buffers	5/18 sites with no buffers 2/18 sites with buffers <20' 11/18 sites with buffers >20'
Livestock Access to Streams	2/18 sites with livestock access

Figure 1-5 Little Salt Creek (South Fork) Subwatershed

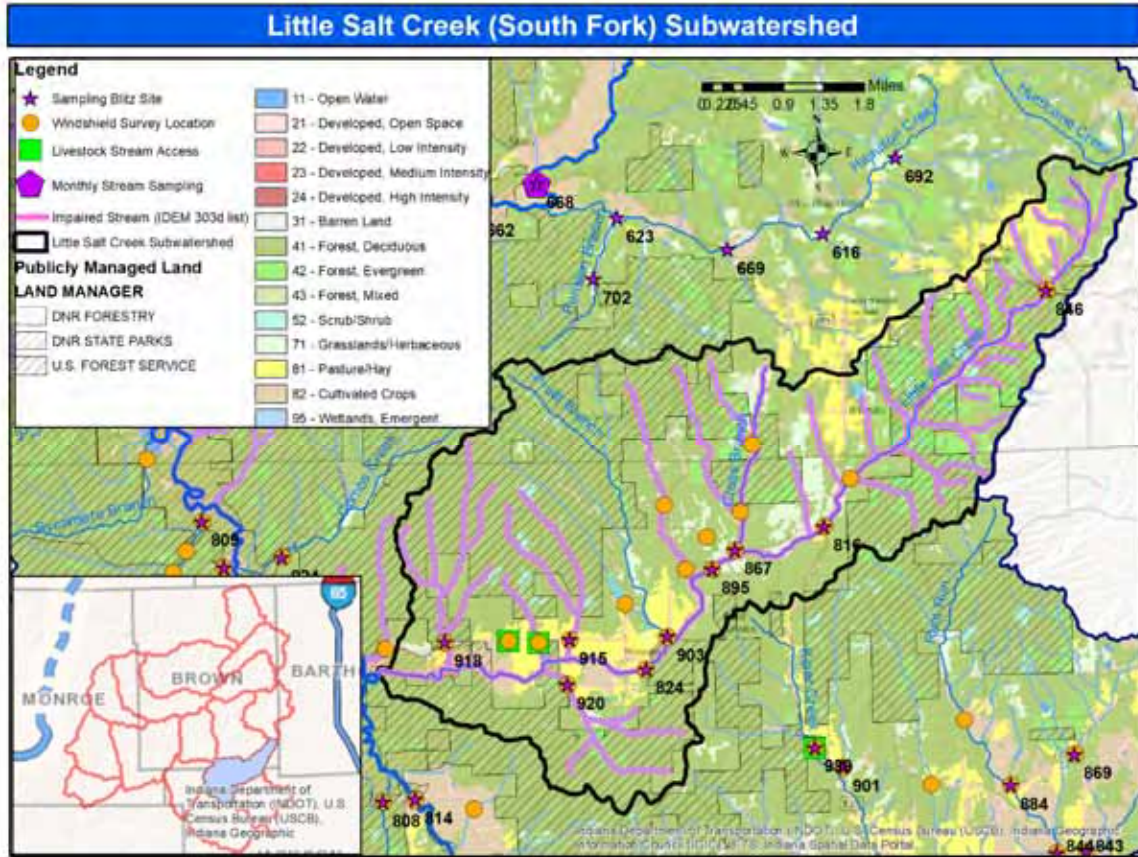


Figure 1-6 Site 903 on Pruitt Branch



*Figure 1-7 Site 915 on an unnamed tributary to Little Salt Creek*



*Figure 1-8 Site 816 on Little Salt Creek*



#### 1.2.4 Water Quality Assessment

Nine sites were selected for the spring and fall watershed sampling blitz events though one was dry during the fall blitz. Samples were analyzed for a variety of chemical parameters and *E. coli*. Habitat was evaluated using CQHEI. No monthly sampling locations or stream gages are located in this subwatershed. Historical fish community assessment data was reviewed.

##### **Water Quality Information**

Water chemistry data from the Little Salt Creek subwatershed suggest that nitrogen and phosphorus are potential contaminants of concern. Two sites exceeded both the total nitrogen target and the nitrate target during the fall blitz. Site 903 is located on Pruitt Branch just before it enters Little Salt Creek and site 915 is on a nearby unnamed tributary of Little Salt Creek. Both are bordered by cropland.

There was one exceedance of total phosphorus during the spring blitz at site 824 on Little Salt Creek (just downstream of Pruitt Branch) and one exceedance of soluble reactive phosphorus during the fall blitz at site 895 on Little Salt Creek (upstream of Pruitt Branch).

The E. coli target of 235 CFU/100 ml was exceeded in 2 of 8 samples during the fall blitz, at site 816 on Little Salt Creek and site 915 on an unnamed tributary of Little Salt Creek (which also had nitrogen and nitrate exceedances). Site 816 is located near the midpoint of Little Salt Creek. Samples collected further upstream (846) and downstream (895 and 924) had very low concentrations of E. coli, indicating a localized source that is then diluted further downstream.

BCRSD collected samples from site EF21 just upstream of site 816 on Little Salt Creek for five weeks in spring 2020. Though only one sample exceeded the target concentration of 235 CFU/100 ml and the geometric mean of the samples was well under the state geometric mean target of 125 CFU/100 ml, an additional water sample was collected on April 27, 2021 to send for source analysis. While the results of the source analysis at that site were inconclusive, the E. coli concentration was reported at 344.8 CFU/100 ml, exceeding the target of 235 CFU/100 ml.

*Table 1-9 Little Salt Creek Sampling Blitz Results - Nutrients*

Blitz ID	Creek Name	Fall TN (mg/L)	Spring TN (mg/L)	Fall NO3 (mg/L)	Spring NO3 (mg/L)	Fall TP (mg/L)	Spring TP (mg/L)	Fall SRP (mg/L)	Spring SRP (mg/L)
816	Little Salt Creek	0.219	0.100	0.018	0.039	0.004	0.016	0.002	0.002
824	Little Salt Creek	0.100	0.267	0.029	0.223	0.003	0.045	0.002	0.004
846	Little Salt Creek		0.100		0.028		0.011		0.005
867	Cross Branch	0.100	0.100	0.008	0.022	0.002	0.016	0.003	0.002
895	Little Salt Creek	0.100	0.129	0.008	0.052	0.002	0.015	0.006	0.002
903	Pruitt Branch	1.870	0.583	1.848	0.531	0.003	0.011	0.005	0.002
915	Unnamed tributary of Little Salt	1.172	0.311	0.981	0.261	0.015	0.009	0.004	0.002
918	Unnamed tributary of Little Salt	0.100	0.154	0.012	0.080	0.002	0.009	0.002	0.002
920	Unnamed tributary of Little Salt	0.100	0.100	0.008	0.008	0.002	0.004	0.002	0.002



Table 1-10 Little Salt Creek Sampling Blitz Results - E. coli and Sediment

Blitz ID	Creek Name	Fall E. Coli (MPN/ 100 mL)	Spring E. coli (MPN/ 100 mL)	Fall TSS (mg/L)	Spring TSS (mg/L)
816	Little Salt Creek	2,420	11	3.5	0.5
824	Little Salt Creek	23	1	1.3	0.5
846	Little Salt Creek		20		0.5
867	Cross Branch	29	6	0.5	0.5
895	Little Salt Creek	29	4	3	0.5
903	Pruitt Branch	63	3	0.5	5
915	Unnamed tributary of Little Salt	613	4	3.5	0.5
918	Unnamed tributary of Little Salt	3	3	0.5	0.5
920	Unnamed tributary of Little Salt	12	-	0.5	0.5

Table 1-11 Little Salt Creek BCRSD E. coli Sampling

BCRSD Site ID	Blitz Site ID	Stream	5/05/20 E. coli	5/12/20 E. coli	5/19/20 E. coli	5/26/20 E. coli	6/02/20 E. coli	Geo. Mean	> State Geomean (125)
EF21	near 816	Little Salt Creek	136	4	190	461	93	85	no

Table 1-12 Little Salt Creek Fecal Contamination Source Analysis

BC_ID	LM_ID	Stream	4/27/21 E. Coli	Coliform (PFU/100ml)	% Human	% Animal
N/A	816	Little Salt Creek	344.8	< 1	NA	NA

### 1.2.5 Habitat and Biological Assessment

#### Habitat/Biological Information

Volunteers completed the Citizen Qualitative Habitat Evaluation Index (CQHEI) habitat assessment at all 9 sites during the spring and fall sampling blitz events. Although a comparison scale for the CQHEI has not yet been developed, Hoosier Riverwatch indicates that scores greater than 60 rate as habitat conducive to supporting warm-water biota (IDNR, 2004). CQHEI scores ranged from 46.5 to 78 during the fall blitz and 61.5 to 93 during the spring blitz. While only 56% of sites scored above 60 during the fall blitz, 100% of sites scored above 60 during the spring blitz, indicating good habitat

throughout the subwatershed. CQHEI scores were generally higher in the spring due to increased streamflow levels (compared to the drought conditions in the fall).

*Table 1-13 Little Salt Creek Sampling Blitz Habitat Assessment (CQHEI)*

Blitz ID	Stream Name	Fall 2020 CQHEI	Spring 2021 CQHEI
816	Little Salt Creek	57	75
824	Little Salt Creek	74.5	86.5
846	Little Salt Creek	63	83
867	Cross Branch	60	79
895	Little Salt Creek	59	61.5
903	Pruitt Branch	61	68.5
915	Unnamed tributary of Little Salt	46.5	75.5
918	Unnamed tributary of Little Salt	78	93
920	Unnamed tributary of Little Salt	67	82
Average CQHEI			
		62.9	78.2
% of Sites >60			
		56%	100%

IDEM assessed the fish and macroinvertebrate communities in Little Salt Creek in 2013 as part of their nine-year rotation to monitor water quality in the East Fork White River basin. The United States Forest Service (USFS) conducted fish surveys and evaluated QHEI in Little Salt Creek and one of its tributaries 2017-2019. The Fish Index of Biotic Integrity (IBI) is based on fish community characteristics and can range from 0 (no fish) to 60 (excellent) with streams expected to score at least 36 (fair) to meet aquatic life use water quality standards.

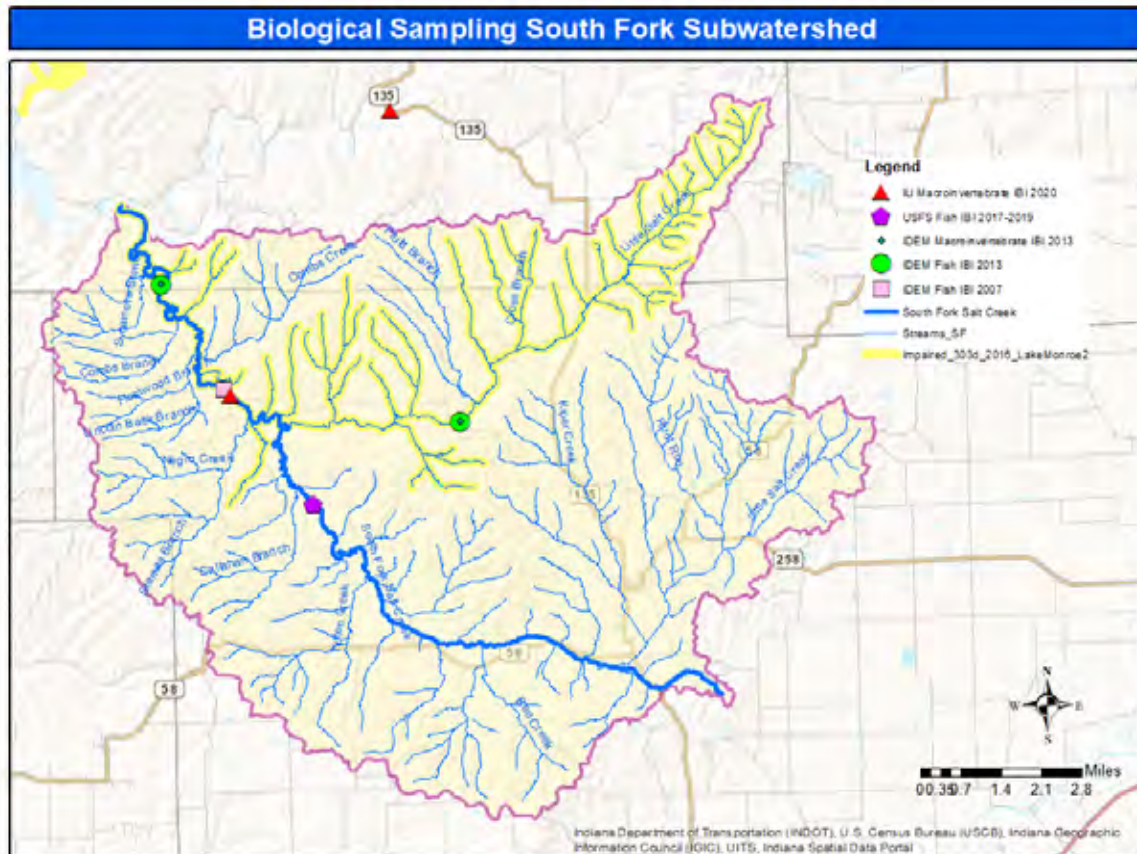
*Table 1-14 Little Salt Creek Historical Biological Sampling*

Sampler	Date	Site ID	Stream	Station	Fish IBI	Fish IBI Rating	mIBI	mIBI Rating	QHEI	QHEI Rating
IDEM	2013	824	Little Salt Creek	Buffalo Pike	36	Fair	34	Impaired (<36)	--	--
USFS	2017-2019 Average	824	Little Salt Creek	Buffalo Pike	41.3	Fair	--	--	69.5	Excellent
USFS	2017-2019 Average	Near 920	Unnamed tributary of Little Salt Creek	Thompson Cemetery	28	Poor	--	--	56.7	Good

Both surveys indicate that the fish Index of Biotic Integrity at site 824 is “fair” while the IDEM survey indicates that the macroinvertebrate Index of Biotic Integrity is “impaired” with a score of 34. The fish-based IBI for site 920 on an unnamed tributary of Little Salt Creek was “poor” which may be due in part to its small size.

The USFS habitat assessment (QHEI) indicates that habitat at site 824 is “excellent” at 69.5, which corresponds well with the high ratings from the blitz CQHEI assessments – 74.5 in the fall and 86.5 in the spring. The USFS QHEI assessment at site 920 is “good” at 56.7, which corresponds well with the blitz CQHEI assessments of 62.9 and 78.2.

Figure 1-9 Biological Sampling Locations in South Fork Salt Creek Subwatershed



### 1.2.6 Little Salt Creek Subwatershed Summary

Little Salt Creek and several of its tributaries are designated as impaired for E. coli according to the most recent 303(d) impaired streams list. However, only two E. coli exceedances were reported during the fall blitz and none during the spring blitz. Site 816 on Little Salt Creek had E. coli exceedances during the fall blitz, in one of five samples collected by BCRSD, and in the single sample collected for source analysis. Samples collected further downstream during the fall blitz had low E. coli levels, indicating that the E. coli is diluted to low levels further downstream. However, no samples were collected downstream from site 915 on an unnamed tributary to Little Salt Creek, a site which also had an E. coli exceedance during the fall blitz. The windshield survey also revealed

livestock with free access to streams at 4 of 20 stream crossings and there is no sewer system in the subwatershed.

There were a few exceedances for nitrogen and phosphorus, including total phosphorus and soluble reactive phosphorus exceedances in Little Salt Creek. Pruitt Branch (site 903) and an unnamed tributary to Little Salt (915) had exceptionally high nitrogen and nitrate levels. Habitat evaluation through CQHEI was generally good and historical fish surveys showed a “fair” fish biotic integrity in Little Salt Creek. Unstable streambanks and agricultural activity are likely sources of sediment and nutrients to the streams.

### 1.3 Tipton Creek – South Fork (HUC 051202080403)

The Tipton Creek Subwatershed (HUC 12 – 051202080403) is the southernmost subwatershed and is located in the northwest corner of Jackson County as shown in Figure 4-10. The subwatershed encompasses approximately 21,822 acres and represents 8% of the overall watershed. The headwaters of South Fork Salt Creek are located in this subwatershed along with Tipton Creek, Bee Creek, and Callahan Branch. USGS Stream Gage 03371600 is located in this watershed just north of the town of Kurtz (site 855). This stream gage was installed in January 2020 and the City of Bloomington Utilities Storm Team has collected samples here during storm events since July 2020.

According to the IDEM 303(d) list, there are no impaired streams within the Tipton Creek Subwatershed.

#### 1.3.1 Land Use

Landuse within the Tipton Creek Subwatershed consists primarily of forest but it has the second highest percentage of agricultural land (24%) of all the Lake Monroe subwatersheds. Cropland is most concentrated along South Fork Salt Creek and Tipton Creek. Pasture is located along smaller tributaries to South Fork as well as the ridges along the northern and southern edges of the watershed. Several parcels of land in the northern half of the subwatershed are owned by the United States Forest Service including most of the land around Callahan Branch and west of Tipton Creek.

#### 1.3.2 Point Source Water Quality Issues

The Tipton Creek Subwatershed contains no confined feeding operations and no NPDES permitted facilities.

#### 1.3.3 Non-Point Source Water Quality Issues

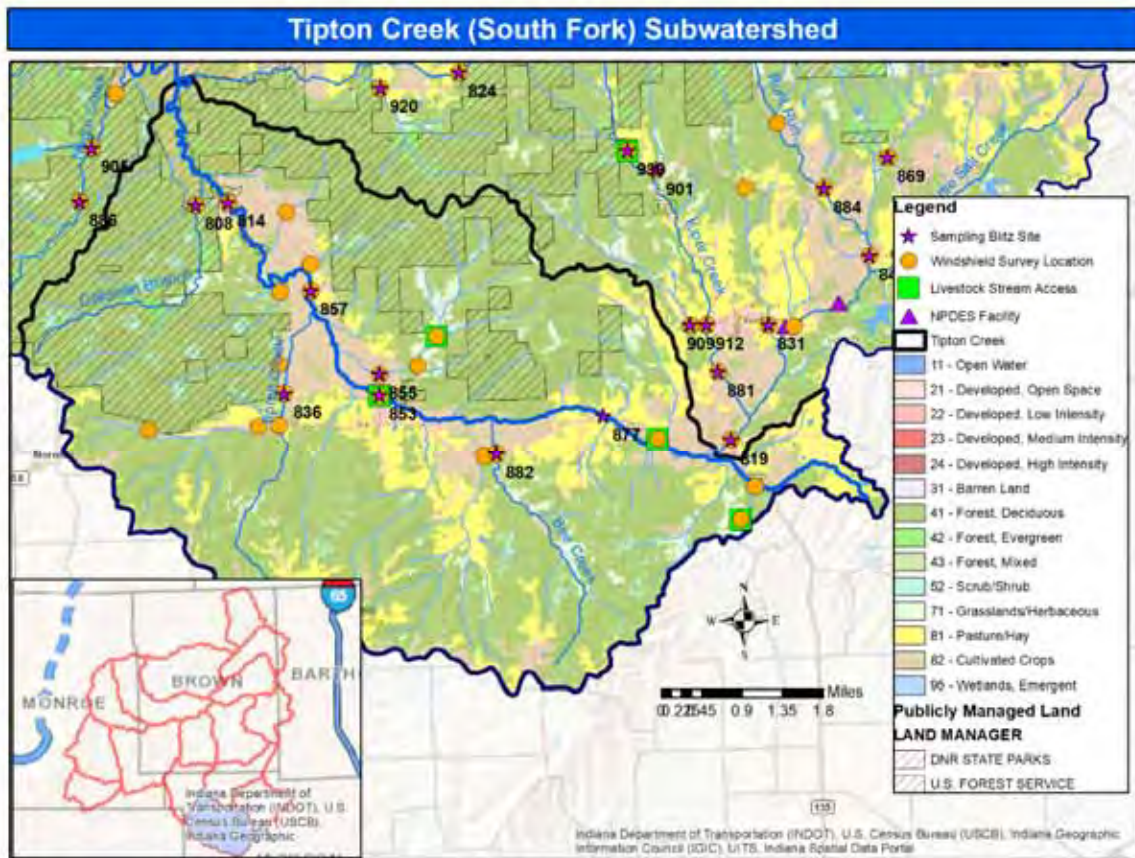
In early spring 2020, the watershed coordinator conducted a windshield survey which included 20 stream crossing sites within the Tipton Creek Subwatershed. Observations including streambank erosion, stream buffers, and livestock access were recorded for each site and the results are

summarized below. Streambank erosion was noted at all 20 observed sites and lack of sufficient riparian buffer was observed at 10 of the 20 observed sites. Livestock access was documented at 4 of 20 sites.

Table 1-15 Tipton Creek Windshield Survey Summary

Parameter	Observations
Streambank Erosion	9/20 sites with erosion >3' 11/20 sites with erosion <3' 0/20 sites with no erosion
Stream Buffers	1/20 sites with no buffers 9/20 sites with buffers <20' 10/20 sites with buffers >20'
Livestock Access to Streams	4/20 sites with livestock access

Figure 1-10 Tipton Creek (South Fork) Subwatershed



### 1.3.4 Water Quality Assessment

#### Water Quality Information

Eight sites were selected for the spring and fall watershed sampling blitz events though one was dry during the fall blitz. Results indicate that both nitrogen and phosphorus are constituents of concern. Total phosphorus concentrations exceeded the target concentration of 0.02 mg/L in 2 of 7 samples (29%) during the fall blitz and 6 of 8 samples (75%) during the spring blitz. Soluble reactive phosphorus concentrations exceeded the target stream concentration of 0.005 mg/L in 3 of 7 (43%) fall samples and 2 of 8 (25%) of spring samples. Interestingly, the SRP exceedances were at different sites for each event. The sites with the highest concentrations of total phosphorus were 853 on South Fork Salt Creek, 814 on South Fork Salt Creek, and 836 on Tipton Creek (spring only). Interestingly, the TP levels at 857 on South Fork Salt Creek between 853 (upstream) and 814 (downstream) were below target levels during both blitz events.

Total nitrogen and nitrate concentrations at site 855 on an unnamed tributary to South Fork Salt Creek were significantly higher than any other samples during both the spring and fall blitz events. The second highest total nitrogen and nitrate concentrations were in Tipton Creek at site 836 during the spring blitz. Both these streams enter South Fork Salt Creek between sites 853 (upstream South Fork Salt) and 857 (downstream South Fork Salt). Levels of total nitrogen and nitrates were notably higher at site 857 (downstream) during the spring blitz, likely due to these two tributaries.

The only E. coli exceedance during the blitz events was at site 855 on an unnamed tributary to South Fork Salt Creek during the fall blitz. This site is located downstream from a spot with observed livestock access to the stream.

*Table 1-16 Tipton Creek Sampling Blitz Results - Nutrients*

Blitz ID	Creek Name	Fall TN (mg/L)	Spring TN (mg/L)	Fall NO3 (mg/L)	Spring NO3 (mg/L)	Fall TP (mg/L)	Spring TP (mg/L)	Fall SRP (mg/L)	Spring SRP (mg/L)
808	Callahan Branch		0.155		0.141		0.017		0.004
814	South Fork Salt Creek	0.258	0.689	0.024	0.600	0.037	0.026	0.009	0.004
836	Tipton Creek	0.100	0.982	0.020	0.888	0.005	0.033	0.002	0.007
853	South Fork Salt Creek	0.268	0.632	0.008	0.510	0.030	0.047	0.004	0.018
855	Unnamed tributary of SF Salt	1.037	1.169	0.912	1.082	0.018	0.014	0.007	0.005
857	South Fork Salt Creek	0.271	0.719	0.023	0.607	0.016	0.022	0.002	0.002
877	South Fork Salt Creek	0.170	0.498	0.008	0.372	0.013	0.023	0.006	0.002
882	Bee Creek	0.111	0.384	0.016	0.311	0.009	0.021	0.005	0.002

Table 1-17 Tipton Creek Sampling Blitz Results - E. coli and Sediment

Blitz ID	Creek Name	Fall E. Coli (MPN/ 100 mL)	Spring E. coli (MPN/ 100 mL)	Fall TSS (mg/L)	Spring TSS (mg/L)
808	Callahan Branch		3		0.5
814	South Fork Salt Creek	157	15	5.5	3.6
836	Tipton Creek	29	5	0.7	1
853	South Fork Salt Creek	64	66	5.2	1.6
855	Unnamed tributary of SF Salt	>2,419	3	1.8	0.5
857	South Fork Salt Creek	21	36	1.5	2.2
877	South Fork Salt Creek	38	140	2.8	0.6
882	Bee Creek	144	2	0.5	0.5

### 1.3.5 Habitat and Biological Assessment

#### Habitat/Biological Information

Volunteers completed the Citizen Qualitative Habitat Evaluation Index (CQHEI) habitat assessment at all 8 sites during the spring and fall sampling blitz events. Although a comparison scale for the CQHEI has not yet been developed, Hoosier Riverwatch indicates that scores greater than 60 rate as habitat conducive to supporting warm-water biota (IDNR, 2004). CQHEI scores ranged from 44 to 89.5 during the fall blitz and 42.5 to 85 during the spring blitz. Only 38% of sites scored above 60 during the fall blitz and only 50% of sites scored above 60 during the spring blitz, indicating poor habitat throughout the subwatershed. Higher CQHEI scores in the spring may be partially due to increased streamflow levels (compared to the drought conditions in the fall) but could also be due to differing volunteer interpretation.

Table 1-18 Tipton Creek Sampling Blitz Results - Habitat Evaluation (CQHEI)

Blitz ID	Stream Name	Fall 2020 CQHEI	Spring 2021 CQHEI
808	Callahan Branch	53	70
814	South Fork Salt Creek	65	43
836	Tipton Creek	89.5	76.3
853	South Fork Salt Creek	57	55
855	Unnamed tributary of SF Salt	44	50
857	South Fork Salt Creek	47.3	42.5
877	South Fork Salt Creek	63	85
882	Bee Creek	55	67.5
	Average CQHEI	59.2	61.2
	% of Sites >60	38%	50%

No stream sections in the subwatershed were evaluated using the macroinvertebrate Index of Biotic Integrity (mIBI). Fish studies were conducted by USFS in 2017-2019 to evaluate the fish-based Index of Biotic Integrity (IBI) and habitats were evaluated using the Qualitative Habitat Evaluation Index (QHEI). IBI scores ranged from very poor to good, with the lowest scores appearing to correspond with the smallest streams. Sites 807 and 837 were not selected as sampling blitz sites due to their small size and site 808 was dry during the fall blitz due to its small size. The QHEI scores ranged from fair to good and roughly corresponded with CQHEI ratings. Len Kring of USFS (who conducted the evaluations) mentioned that portions of Tipton Creek appear to be channelized. He also has observed large flooding events in the Houston area that likely increase sediment and E. coli levels significantly in the short term.

*Table 1-19 Tipton Creek 2017 - 2019 USFS Houston South 3-Year Average of Fish Survey Results*

<b>Blitz ID</b>	<b>Stream</b>	<b>Station</b>	<b>Fish IBI</b>	<b>IBI Rating</b>	<b>QHEI</b>	<b>QHEI Rating</b>
808	Callahan Branch	CR 825 N / Pike	28.7	Poor	68.3	Good
836	Tipton Creek	CR 980 W	35.3	Fair	60.8	Good
814	S Fork Salt Creek	CR 825 N / Pike	46.7	Good	66.7	Good
807	Trib S F Salt Creek	CR 825 N / Pike	22.0	Poor	42.5	Fair
837	Trib Tipton Creek	CR 980 W	19.0	Very Poor	51.3	Fair

### 1.3.6 Tipton Creek Subwatershed Summary

The Tipton Creek subwatershed contains the second highest percentage of agricultural land. Water monitoring results indicate that phosphorus and nitrogen are both concerns in the subwatershed. Nitrogen was a concern primarily at site 855 on an unnamed tributary to South Fork Salt Creek and at site 836 on Tipton Creek. Phosphorus concerns were more widespread but the three sites with the highest total phosphorus levels were 853 on South Fork Salt Creek, 814 on South Fork Salt Creek, and 836 on Tipton Creek (spring only).

Only one E. coli exceedance was recorded though it was >2,419 CFU/100 ml at site 855 on an unnamed tributary to South Fork Salt Creek, which also had extremely high nitrogen levels. This site is surrounded by cropland and downstream from an area where livestock have direct access to streams.

Poor stream habitat, streambank erosion, and insufficient riparian buffer are prevalent in the subwatershed.



## 1.4 Negro Creek – South Fork (HUC 051202080404)

The Negro Subwatershed (HUC 12 – 051202080404) is located primarily in the northwest corner of Jackson County plus small portions of Brown, Lawrence, and Monroe Counties as shown in Figure 4-14. The subwatershed encompasses approximately 13,548 acres and represents 5% of the overall watershed. The subwatershed contains the downstream stretch of South Fork Salt Creek until it combines with Middle Fork Salt Creek as well as the tributaries Sycamore Branch, Combs Branch, Fleetwood Branch, Lincoln Branch, Maumee Branch, and Negro Creek. This watershed contains the sampling location used to collect samples monthly from South Fork Salt Creek from May 2020 to April 2021. This location was also used by IDEM in 2013 as part of their basin sampling.

According to the IDEM 303(d) list, the stretch of South Fork Salt Creek that runs through the Negro Creek Subwatershed is impaired for biological integrity.

### 1.4.1 Land Use

Land use within the Negro Creek Subwatershed consists primarily of forest and it has the second lowest percentage of agricultural land (2%) of all the Lake Monroe subwatersheds. Approximately 80% of the subwatershed is public land belonging either to the United States Forest Service or the Indiana DNR State Parks Division. Population is extremely sparse. According to the IDEM 303(d) list, the downstream stretch of South Fork Salt Creek is impaired for low dissolved oxygen and low biological integrity, including several of its unnamed tributaries.

### 1.4.2 Point Source Water Quality Issues

The Negro Creek Subwatershed contains no confined feeding operations and no NPDES permitted facilities.

### 1.4.3 Non-Point Source Water Quality Issues

In early spring 2020, the watershed coordinator conducted a windshield survey which included 12 stream crossing sites within the Negro Creek Subwatershed. Observations including streambank erosion, stream buffers, and livestock access were recorded for each site and the results are summarized below. Streambank erosion was noted at 9 of the 12 observed sites. No sites had insufficient riparian buffer and no sites had livestock access to streams.

*Table 1-20 Negro Creek Windshield Survey Summary*

Parameter	Observations
Streambank Erosion	4/12 sites with erosion >3' 5/12 sites with erosion <3'
Stream Buffers	0/12 sites with no buffers 0/12 sites with buffers <20'
Livestock Access to Streams	0/12 sites with livestock access

During the windshield survey, we also noted that the United States Forest Service has been replacing some stream crossings to improve both hydrologic flow and stream biology. The two newest crossings were designed so aquatic wildlife could move easily upstream and downstream. This entails leaving the streambed intact and building a bridge with a wide span to preserve the full channel width, rather than putting in a culvert that restricts flow and can cut off the downstream section during periods of low flow. Two other crossings were identified for potential future projects. One is a double culvert that has collected large amounts of sediment. The other is a perched culvert where the culvert itself is an inch above the streambed on the downstream side so that during periods of low flow the stream is disconnected across the culvert. The new crossings are also more resistant to flooding and less likely to become blocked with debris.

*Figure 1-11 Windshield Site 905 County Road 1200N at Negro Creek*

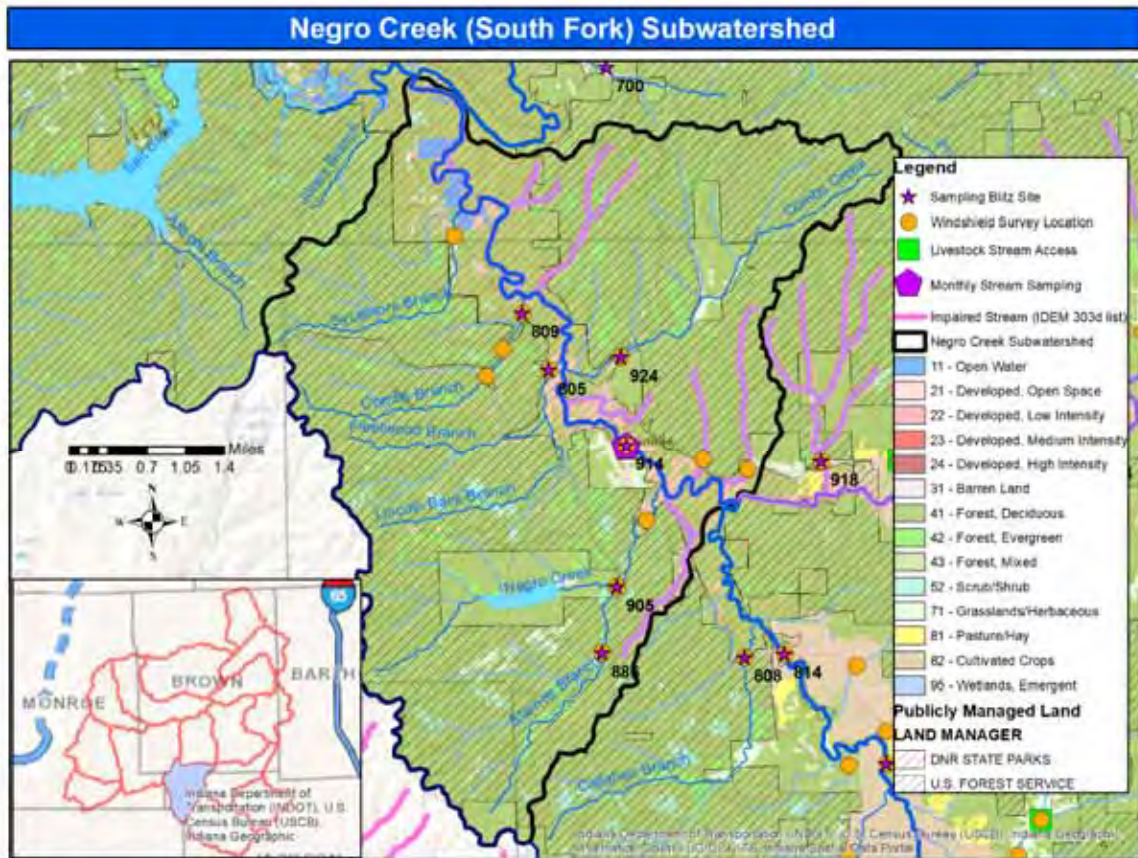


*Figure 1-12 Windshield Site 808 – County Road 825N over Callahan Branch. Double Culvert Slated for Replacement Due to Clogging*



*Figure 1-13 Windshield Site 936 - Tower Ridge Road at Combs Branch. Perched culvert.*

Figure 1-14 Negro Creek (South Fork) Subwatershed



#### 1.4.4 Water Quality Assessment

Six sites were selected for the spring and fall watershed sampling blitz events though four were dry during the fall blitz. Blitz samples were analyzed for a variety of chemical parameters and E. coli. Habitat was evaluated using CQHEI. The South Fork Salt Creek monthly sampling site (914) is also located within this watershed. Monthly samples were analyzed for a variety of chemical parameters and E. coli. The monthly sampling site was evaluated using the Qualitative Habitat Evaluation Index (QHEI) and macroinvertebrates were assessed. Historical fish assessments were reviewed. No stream gages are located in this subwatershed.

#### Water Quality Information

Water chemistry data from the blitz indicated good water quality in the Negro Creek subwatershed with the exception of two total phosphorus exceedances. One was at site 914 on South Fork Salt Creek during the fall blitz and the other was at site 805 on Lincoln Back Branch during the spring blitz.

However, monthly samples collected from South Fork Salt Creek at site 914 revealed regular total phosphorus exceedances (83%) and soluble reactive phosphorus exceedances (75%) as well as periodic exceedances for total nitrogen (33%), nitrates (17%), and E. coli (25%).

The sample collected on June had exceptionally high E. coli, total phosphorus, total nitrogen, soluble reactive phosphorus, and nitrate levels. The data point was reviewed to determine if it should be excluded from the data set as an outlier or mismeasurement. A review of flow data revealed that stream flows were elevated at the site in the three days preceding sampling, which could mean that the elevated levels were due to increased runoff from the watershed. Average daily stream flow measured in South Fork Salt Creek at Kurtz was 79.7 cubic feet per second (cfs) the day before sampling, dropping to 19.0 cfs the day of sampling. (Measured flow in North Fork at Nashville remained fairly constant during the same period, dropping from 9.6 to 8.7 cfs) Data collected from South Fork Salt Creek at Kurtz by the CBU Storm Team during flows between 20 cfs and 100 cfs was reviewed for comparison. This data indicated that the results from the June 24<sup>th</sup> sampling event conducted by the IU Limnology Lab were within the expected range for elevated flow conditions with the exception of total nitrogen, which was considerably higher than the CBU data range. Ultimately the data point was kept in the report and analysis.

*Table 1-21 Negro Creek Sampling Blitz Results - Nutrients*

Blitz ID	Creek Name	Fall TN (mg/L)	Spring TN (mg/L)	Fall NO3 (mg/L)	Spring NO3 (mg/L)	Fall TP (mg/L)	Spring TP (mg/L)	Fall SRP (mg/L)	Spring SRP (mg/L)
805	Lincoln Back Branch		0.140		0.064		0.026		0.005
809	Combs Branch		0.106		0.095		0.019		0.004
886	Starnes Branch		0.100		0.031		0.016		0.002
905	Negro Creek		0.170		0.085		0.012		0.002
914	South Fork Salt Creek	0.368	0.507	0.008	0.388	0.041	0.019	0.004	0.002
924	Combs Creek	0.100	0.100	0.008	0.043	0.002	0.003	0.005	0.002

*Table 1-22 Negro Creek Sampling Blitz Results - E. coli and Sediment*

Blitz ID	Creek Name	Fall E. Coli (MPN/ 100 mL)	Spring E. coli (MPN/ 100 mL)	Fall TSS (mg/L)	Spring TSS (mg/L)
805	Lincoln Back Branch		4		3.2
809	Combs Branch		-		0.5
886	Starnes Branch		-		0.5
905	Negro Creek		-		1
914	South Fork Salt Creek	48	21	3	5.6
924	Combs Creek	3	-	0.7	0.5

Table 1-23 South Fork Salt Creek Monthly Monitoring at Site 914 in Negro Creek Subwatershed

Sample Date	South Fork E. coli (cfu/100 ml)	South Fork TSS (mg/L)	South Fork TN (mg/L)	South Fork NO3 (mg/L)	South Fork TP (mg/L)	South Fork SRP (mg/L)
4/22/2020	70	5.2	0.319	0.185	0.037	0.012
5/27/2020	365	31.3	0.719	0.377	0.041	0.011
6/24/2020	1,414	16.8	3.379	2.115	0.116	0.036
7/21/2020	261	2.4	0.604	0.205	0.051	0.009
8/27/2020	41	2.3	0.411	0.092	0.042	0.009
9/24/2020	13	7.5	0.511	0.008	0.055	0.005
10/22/2020	26	9.5	0.513	0.011	0.050	0.008
11/19/2020	48	4.3	0.261	0.228	0.022	0.010
12/16/2020	26	1.75	0.596	0.501	0.017	0.005
1/25/2021	32	2.8	0.749	0.690	0.017	0.004
2/25/2021	141	25.3	0.865	0.550	0.035	0.013
3/18/2021	326	14.8	0.640	0.493	0.028	0.007

#### 1.4.5 Habitat and Biological Assessment

##### Habitat/Biological Information

Volunteers completed the Citizen Qualitative Habitat Evaluation Index (CQHEI) habitat assessment at all 11 sites during the spring and fall sampling blitz events. Although a comparison scale for the CQHEI has not yet been developed, Hoosier Riverwatch indicates that scores greater than 60 rate as habitat conducive to supporting warm-water biota (IDNR, 2004). CQHEI scores ranged from 50 to 63 during the fall blitz and 61 to 80 during the spring blitz. While only 17% of sites scored above 60 during the fall blitz, 100% of sites scored above 60 during the spring blitz, indicating good habitat throughout the subwatershed during periods of high flow. Higher CQHEI scores in the spring may be partially due to increased streamflow levels (compared to the drought conditions in the fall) but could also be due to differing volunteer interpretation.

Table 1-24 Negro Creek Sampling Blitz Results - Habitat Assessment (CQHEI)

Blitz ID	Stream Name	Fall 2020 CQHEI	Spring 2021 CQHEI
805	Lincoln Back Branch	63	61
809	Combs Branch	50	68
886	Starnes Branch	60	69
905	Negro Creek	54.5	72
914	South Fork Salt Creek	54.5	70.5
924	Combs Creek	53	80
	Average CQHEI	55.8	70.1
	% of Sites >60	17%	100%

The IU Limnology Lab evaluated site 914 on South Fork Salt Creek at the Maumee Bridge to determine the macroinvertebrate Index of Biotic Integrity (mIBI) and the Qualitative Habitat Evaluation Index (QHEI). The site scored 20 for mIBI, indicating an impaired macroinvertebrate community, and 34 on QHEI, indicating poor habitat. IDEM guidelines state that in streams with a QHEI score less than 51, “habitat is likely having a negative impact on aquatic communities.” The low QHEI score is due at least in part to the lack of riffles in this portion of the stream and a substrate that is only sand and silt with no exposed rocks.

IDEM evaluated biotic integrity further downstream in 2013. They calculated the fish-based Index of Biotic Integrity (IBI) to be 42, with a “fair” rating, and calculated mIBI to be 32, with an “impaired” rating.

USFS surveyed fish in 2017-2019 and gave an average IBI score in Negro Creek of 26, with a “poor” rating, and a QHEI score of 57.6 meaning a “good” rating. The low IBI score may be influenced by the relatively small size of Negro Creek.

*Table 1-25 Biological Sampling in Negro Creek Subwatershed (Current and Historical)*

Sampler and Date	Site ID	Stream	Station	Fish IBI	Fish IBI Rating	mIBI	mIBI Rating	QHEI	QHEI Rating
IU Limno Lab 2021	914	South Fork Salt	Maumee Bridge	--	--	20	Impaired (<36)	34	Poor
IDEM 2013	below 914	South Fork Salt	Young-Maumee	42	Fair	32	Impaired (<36)	--	--
USFS 2017-19 Average	811	Negro Creek	CR 1190 W	26	Poor	--	--	57.6	Good

#### 1.4.6 Negro Creek Subwatershed Summary

The Negro Creek subwatershed contains very little agricultural or developed land. Water quality results from the blitz events showed high water quality with the exception of two total phosphorus exceedances. Habitat scores were generally high. Riparian buffer was largely intact and less than half of observed stream crossings showed signs of severe erosion. However, the macroinvertebrate community in South Fork Salt Creek appears to be impaired.

Monthly sampling of South Fork Salt Creek at site 914 revealed regular total phosphorus exceedances (83%) and soluble reactive phosphorus exceedances (75%) as well as periodic exceedances for total nitrogen (33%), nitrates (17%), and E. coli (25%). Based on blitz data, these exceedances appear to be coming from areas of the watershed further upstream rather than the immediate Negro Creek subwatershed.

## 1.5 Headwaters Middle Fork – Middle Fork (HUC 51202080501)

The Headwaters Middle Fork Subwatershed (HUC 12 – 51202080501) straddles the Brown County Bartholomew County border as shown in Figure 4-15. The subwatershed encompasses approximately 13,206 acres and represents 5% of the overall watershed. The subwatershed contains the headwaters of Middle Fork Creek along with its tributaries South Branch Salt Creek and Hurricane Creek.

According to the IDEM 303(d) list, there are no impaired streams within the Headwaters Middle Fork Subwatershed.

### 1.5.1 Land Use

Land use within the Headwaters Middle Fork Subwatershed consists predominately of forestland and it is ranked 7/16 based on percentage of agricultural land (6%) of all the Lake Monroe subwatersheds. It also has the highest amount of herbaceous cover (7%), some of which may be utilized for pasture. Pasture is primarily located along South Branch Salt Creek while herbaceous land is located more along ridgetops. Cropland is located along South Branch Salt Creek, Middle Fork Salt Creek, and a few ridgetops. Population is sparse and generally located along the main roads (Bellsville Pike, Grandview Road). Density increases on the east end of Bellsville Pike near Grandview Lake (a lakefront residential community located outside the Lake Monroe watershed). All land in the subwatershed is privately owned.

### 1.5.2 Point Source Water Quality Issues

The Headwaters Middle Fork Subwatershed contains no confined feeding operations and no NPDES permitted facilities.

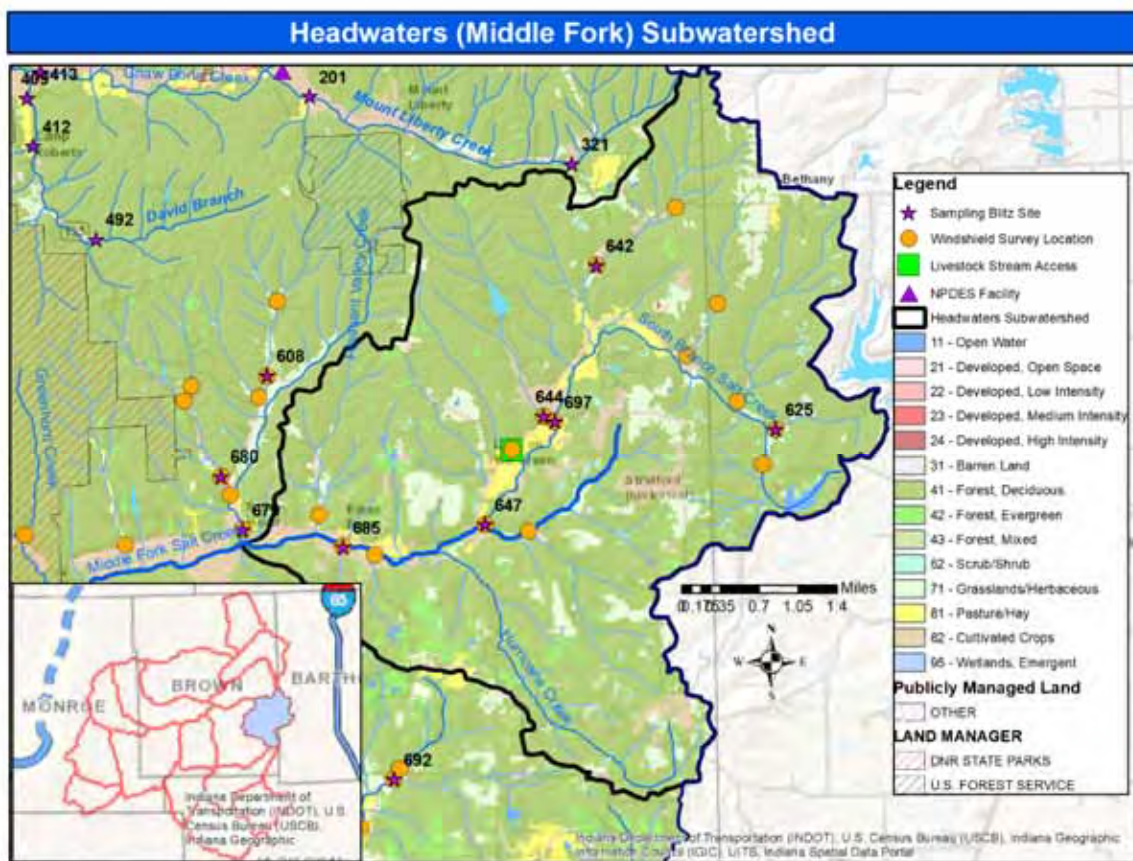
### 1.5.3 Non-Point Source Water Quality Issues

In early spring 2020, the watershed coordinator conducted a windshield survey which included 15 stream crossing sites within the Headwaters Middle Fork Subwatershed. Observations including streambank erosion, stream buffers, and livestock access were recorded for each site and the results are summarized below. Streambank erosion was noted at 14 of the 15 observed sites and lack of sufficient riparian buffer was observed at 9 of the 15 observed sites. Livestock access was documented at 1 of 15 sites.

Table 1-26 Headwaters Middle Fork Windshield Survey Summary

Parameter	Observations
Streambank Erosion	4/15 sites with erosion >3' 10/15 sites with erosion <3' 1/15 sites with no erosion
Stream Buffers	2/15 sites with no buffers 7/15 sites with buffers <20' 6/15 sites with buffers >20'
Livestock Access to Streams	1/15 sites with livestock access

Figure 1-15 Headwaters (Middle Fork) Subwatershed



#### 1.5.4 Water Quality Assessment

Six sites were selected for the spring and fall watershed sampling blitz although two were dry during the fall sampling event. Samples were analyzed for a variety of chemical parameters and E. coli. Habitat was evaluated using CQHEI. Macroinvertebrates and the fish community have not been assessed in this subwatershed. No monthly sampling locations or stream gages are located in this subwatershed.



### Water Quality Information

Water chemistry data from the Headwaters Middle Fork subwatershed suggest that phosphorus and E. coli are the two likely constituents of concern. The two sites of most interest are site 644 on an unnamed tributary of South Branch Salt Creek and 697 located immediately downstream on South Branch Salt Creek. Site 644 had exceedances for E. coli (fall) and total phosphorus (fall and spring) while site 697 had exceedances for E. coli (fall), total suspended solids (fall), total phosphorus (fall), and soluble reactive phosphorus (spring). The sites are in an area with both cropland and pasture though no livestock with direct access to streams were observed.

Fall blitz data suggests that E. coli is a concern in the Headwaters Middle Fork subwatershed, with 3 of 4 fall samples exceeding the water quality target. E. coli concentrations at site 644 on an unnamed tributary of South Branch Salt Creek and the immediately downstream site 697 on South Branch Salt Creek both exceeded 2,419 CFU/100 ml. A sample collected further downstream at site 647 on South Branch Salt Creek had E. coli levels well below the target, indicating that E. coli is diluted as water moves downstream. The other E. coli exceedance was from site 685 on Middle Fork Salt Creek near the downstream edge of the watershed. Site 613 on Middle Fork Salt Creek, located downstream in the next subwatershed (Pleasant Valley), had an E. coli level well below the target, indicating that E. coli is diluted as water moves downstream.

Brown County RSD collected five samples over five weeks at a site near site 685 on Middle Fork Salt Creek and three of the five exceeded the 235 CFU/100 ml, with the geometric mean well above the state geomean standard of 125 CFU/100 ml. Two samples were collected for source testing in April 2021, one from the BCRSD site near 685 on Middle Fork Salt Creek and the other from site 697 on South Branch Salt Creek. Neither had E. coli concentrations above the water quality target. The sample collected near site 685 had enough coliphage residue to generate source testing results, indicating that 50.5% of the identified coliphage were most likely from human sources and 49.5% of the identified coliphage were most likely from animal sources.

*Table 1-27 Headwaters Middle Fork Sampling Blitz Results - Nutrients*

Blitz ID	Creek Name	Fall TN (mg/L)	Spring TN (mg/L)	Fall NO3 (mg/L)	Spring NO3 (mg/L)	Fall TP (mg/L)	Spring TP (mg/L)	Fall SRP (mg/L)	Spring SRP (mg/L)
625	Unnamed trib of South Branch Salt		0.205		0.079		0.026		0.004
642	Unnamed tributary of South Branch Salt		0.150		0.103		0.019		0.004
644	Unnamed tributary of South Branch Salt	0.446	0.374	0.017	0.243	0.033	0.022	0.003	0.004
647	South Branch Salt Creek	0.100	0.322	0.008	0.252	0.010	0.018	0.002	0.003
685	Middle Fork Salt Creek	0.100	0.298	0.020	0.228	0.006	0.015	0.002	0.004
697	South Branch Salt Creek	0.100	0.276	0.012	0.218	0.026	0.009	0.002	0.006

Table 1-28 Headwaters Middle Fork Sampling Blitz Results - E. coli and Sediment

Blitz ID	Creek Name	Fall E. Coli (MPN/ 100 mL)	Spring E. coli (MPN/ 100 mL)	Fall TSS (mg/L)	Spring TSS (mg/L)
625	Unnamed trib of South Branch Salt		44		5
642	Unnamed tributary of South Branch Salt		6		0.575
644	Unnamed tributary of South Branch Salt	>2,4219	-	10	1.6
647	South Branch Salt Creek	21	5	5.2	1.2
685	Middle Fork Salt Creek	649	19	1.5	1
697	South Branch Salt Creek	>2,419	6	30.7	1.4

Table 1-29 Headwaters Middle Fork BCRSD E. coli Sampling May 2020

BCRSD Site ID	Blitz Site ID	Stream	5-May	12-May	19-May	26-May	2-Jun	Geometric Mean	> State Geomean (125)
EF18	near 685	Middle Fork Salt Creek	1,440	89	1,170	461	122	385	yes

Table 1-30 Headwaters Middle Fork Fecal Source Analysis April 2021

BC_ID	LM_ID	Stream	4/27/21 E. Coli	Coliform (PFU/100ml)	% Human	% Animal
EF18	near 685	Middle Fork Salt Creek	126.0	0.4	50.5	49.5
	697	South Branch Salt Creek	98.5	< 1	NA	NA

### 1.5.5 Habitat and Biological Assessment

#### Habitat/Biological Information

Volunteers completed the Citizen Qualitative Habitat Evaluation Index (CQHEI) habitat assessment at all 6 sites during the spring and fall sampling blitz events. Although a comparison scale for the CQHEI has not yet been developed, Hoosier Riverwatch indicates that scores greater than 60 rate as habitat conducive to supporting warm-water biota (IDNR, 2004). CQHEI scores ranged from 51 to 69.5 during the fall blitz and 72 to 85 during the spring blitz. 67% of sites scored above 60 during the fall blitz and 100% of sites scored above 60 during the spring blitz, indicating good habitat throughout the subwatershed. Higher CQHEI scores in the spring may be partially due to increased streamflow levels (compared to the drought conditions in the fall) but could also be due to differing volunteer interpretation.

Table 1-31 Headwaters Middle Fork Sampling Blitz Results - Habitat Assessment (CQHEI)

Blitz ID	Stream Name	Fall 2020 CQHEI	Spring 2021 CQHEI
625	Unnamed trib of South Branch Salt	60	77
642	Unnamed tributary of South Branch Salt	69	81
644	Unnamed tributary of South Branch Salt	51	72
647	South Branch Salt Creek	69.5	85
685	Middle Fork Salt Creek	61	74
697	South Branch Salt Creek	66.5	78
	Average CQHEI	62.8	77.8
	% of Sites >60	67%	100%

No stream sections in the subwatershed were evaluated using the Qualitative Habitat Evaluation Index (QHEI), the fish-based Index of Biotic Integrity (IBI), or the macroinvertebrate Index of Biotic Integrity (mIBI).

#### 1.5.6 Headwaters Middle Fork Subwatershed Summary

The Headwaters Middle Fork subwatershed contains the highest percentage of herbaceous land and moderate levels of agricultural land indicating potential impact from livestock. Water quality monitoring indicates that phosphorus and E. coli are the two constituents of concern. Habitat assessments were good and suggest healthy stream habitat throughout the subwatershed.

### 1.6 Pleasant Valley – Middle Fork (HUC 51202080502)

The Pleasant Valley Subwatershed (HUC 12 – 51202080502) is located in the southeast corner of Brown County as shown in Figure 4-16. The subwatershed encompasses approximately 20,333 acres and represents 7% of the overall watershed. The subwatershed contains the middle stretch of Middle Fork Salt Creek as well as the tributaries Hamilton Creek, Pleasant Valley Creek, Strahl Creek, Skinner Creek, and Pension Branch. Monthly samples from Middle Fork Salt Creek were collected at the downstream edge of this watershed, site 668.

According to the IDEM 303(d) list, there are no impaired streams in the Pleasant Valley Subwatershed.

### 1.6.1 Land Use

Land use within the Pleasant Valley Subwatershed consists primarily of forestland but is tied for the third highest percentage of agricultural land (9%) of all the Lake Monroe subwatersheds. Cropland is primarily located along Middle Fork Salt Creek and Hamilton. Pasture is primarily located on the southern edge of the watershed along the ridge separating Pleasant Valley subwatershed from Little Salt Creek subwatershed. About a quarter of the subwatershed is public land. The northwest portion is part of Brown County State Park and contains its horseman's camp while several parcels in the southwest corner are owned by the United States Forest Service.

### 1.6.2 Point Source Water Quality Issues

The Pleasant Valley Subwatershed contains no confined feeding operations and no NPDES permitted facilities.

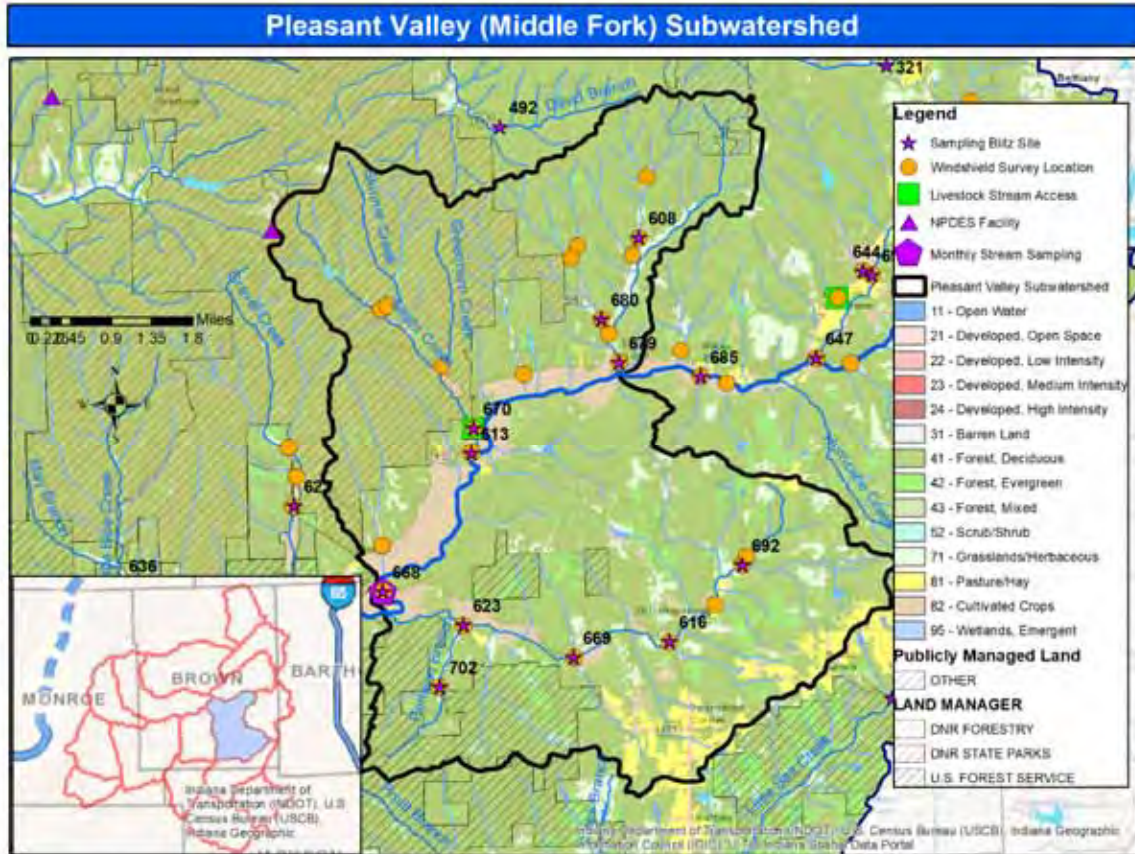
### 1.6.3 Non-Point Source Water Quality Issues

In early spring 2020, the watershed coordinator conducted a windshield survey which included 23 stream crossing sites within the Pleasant Valley Subwatershed. Observations including streambank erosion, stream buffers, and livestock access were recorded for each site and the results are summarized below. Stream bank erosion was noted at 19/23 observed sites and lack of sufficient riparian buffer was observed at 21 of 23 observed sites. Livestock access was documented at 1 of 23 sites.

*Table 1-32 Pleasant Valley Windshield Survey Summary*

<b>Parameter</b>	<b>Observations</b>
Streambank Erosion	7/23 sites with erosion >3' 12/23 sites with erosion <3' 4/23 sites with no erosion
Stream Buffers	8/23 sites with no buffers 13/23 sites with buffers <20' 2/23 sites with buffers >20'
Livestock Access to Streams	1/23 sites with livestock access

Figure 1-16 Pleasant Valley (Middle Fork) Subwatershed



#### 1.6.4 Water Quality Assessment

Eleven sites were selected for the spring and fall watershed sampling blitz events though four were dry during the fall blitz. Monthly samples were also collected from Middle Fork Salt Creek at site 668 at the downstream edge of the watershed. Samples were analyzed for a variety of chemical parameters and E. coli. Habitat was evaluated during the blitz events using CQHEI. Macroinvertebrates were surveyed and habitat was evaluated using QHEI once at the monthly sample site 668. The fish community has not been assessed and no stream gages are located in this subwatershed.

#### Water Quality Information

Water chemistry data from the Pleasant Valley subwatershed suggest that phosphorus and E. coli are the primary constituents of concern. While there was only one total phosphorus exceedance during the fall blitz, it was site 668 on Middle Fork Salt Creek which had exceedances in 7 of 12 monthly sampling events. During the spring blitz, 4 of 11 sites exceeded the total phosphorus target and 4 of 11 sites exceeded the soluble reactive phosphorus target. The two sites to have both TP and SRP exceedances in the spring were 608 on Pleasant Valley Creek and 702 on Pension

Branch. The other two sites to exceed the total phosphorus target were 613 on Middle Fork Salt Creek (near the middle of the watershed) and 616 on Hamilton Creek (near the stream’s midsection).

For each site with a TP exceedance in the spring, there was a corresponding site further downstream that had TP levels below the target. For site 608, it’s site 679. For site 702, it’s site 623. For site 613, it’s site 668. For site 616, it’s site 669. This appears to indicate that the phosphorus concentrations were diluted as they moved downstream.

One E. coli exceedance was reported during the fall blitz at site 692 on an unnamed tributary of Hamilton Creek. Other sites located further downstream on Hamilton Creek reveal a general decrease in E. coli concentrations moving downstream – 488 at site 692, 137 at site 616, and 20 at site 669.

Brown County Regional Sewer District collected five samples over five weeks at three sites. Furthest upstream was site 613 on Middle Fork Salt Creek near the entrance to the Brown County State Park Horseman’s Camp. Next was site 668 on Middle Fork Salt Creek located near the downstream edge of the watershed (and also used as the monthly sampling location). The third was site 623 on Hamilton Creek, which enters Middle Fork Salt Creek downstream from site 668. All three sites had E. coli exceedances in 3 of 5 sampling events and a geometric mean well above the state standard. Monthly samples collected at site 668 on Middle Fork Salt Creek also exceeded the E. coli target in 3 of 12 sampling events although levels were considerably lower than the BCRSD samples.

*Table 1-33 Pleasant Valley Sampling Blitz Results - Nutrients*

Blitz ID	Creek Name	Fall TN (mg/L)	Spring TN (mg/L)	Fall NO3 (mg/L)	Spring NO3 (mg/L)	Fall TP (mg/L)	Spring TP (mg/L)	Fall SRP (mg/L)	Spring SRP (mg/L)
608	Pleasant Valley Creek		0.240		0.117		0.025		0.006
613	Middle Fork Salt Creek	0.100	0.357	0.008	0.261	0.005	0.026	0.002	0.004
616	Hamilton Creek	0.100	0.283	0.008	0.229	0.019	0.021	0.002	0.003
623	Hamilton Creek	0.100	0.316	0.008	0.251	0.005	0.019	0.002	0.003
668	Middle Fork Salt Creek	0.323	0.343	0.012	0.295	0.029	0.015	0.003	0.003
669	Hamilton Creek	0.230	0.351	0.230	0.311	0.002	0.018	0.002	0.003
670	Strahl Creek		0.212		0.125		0.015		0.004
679	Pleasant Valley Creek		0.319		0.281		0.014		0.006
680	Unnamed tributary of Pleasant Valley Creek	0.100	0.162	0.090	0.107	0.002	0.019	0.003	0.017
692	Unnamed tributary of Hamilton Creek	0.111	0.309	0.138	0.236	0.002	0.013	0.005	0.005
702	Pension Branch		0.100		0.031		0.022		0.006

Table 1-34 Pleasant Valley Sampling Blitz Results - E. coli and Sediment

Blitz ID	Creek Name	Fall E. Coli (MPN/ 100 mL)	Spring E. coli (MPN/ 100 mL)	Fall TSS (mg/L)	Spring TSS (mg/L)
608	Pleasant Valley Creek		4		0.5
613	Middle Fork Salt Creek	20	10	0.5	2.4
616	Hamilton Creek	137	12	40	0.5
623	Hamilton Creek	23	15	1.2	1
668	Middle Fork Salt Creek	111	18	7	1.4
669	Hamilton Creek	20	12	1.2	0.6
670	Strahl Creek		-		0.5
679	Pleasant Valley Creek		8		4.6
680	Unnamed tributary of Pleasant Valley Creek	44	21	1	0.5
692	Unnamed tributary of Hamilton Creek	488	-	0.5	0.5
702	Pension Branch		6		0.5

Table 1-35 Pleasant Valley BCRSD Sampling Results May 2020

BCRSD Site ID	Blitz Site ID	Stream	5-May	12-May	19-May	26-May	2-Jun	Geo. Mean	> State Geomean (125)
EF17	613	Middle Fork Salt Creek (midstream)	755	31	755	861	192	310	yes
EF15	668	Middle Fork Salt Creek (downstream)	310	115	925	866	122	322	yes
EF16	623	Hamilton Creek (joins MF downstream from 668)	1,020	43	705	548	166	309	yes

Table 1-36 Pleasant Valley Fecal Contamination Source Analysis April 2021

BC_ID	LM_ID	Stream	4/27/21 E. Coli	Coliform (PFU/100ml)	% Human	% Animal
EF16	623	Hamilton Creek	22.3	0.3	NA	NA
EF15	668	Middle Fork Salt Creek	26.5	< 1	NA	NA
	692	unnamed tributary to Hamilton Creek	2.0	< 1	NA	NA

Table 1-37 Middle Fork Salt Creek Monthly Sampling at Site 668 in Pleasant Valley Subwatershed

Monthly Sampling Site 668	Middle Fork E. coli (cfu/100 ml)	Middle Fork TSS (mg/L)	Middle Fork TN (mg/L)	Middle Fork NO3 (mg/L)	Middle Fork TP (mg/L)	Middle Fork SRP (mg/L)
4/22/2020	50	3	0.231	0.157	0.013	0.003
5/27/2020	245	15.5	0.409	0.244	0.022	0.021
6/24/2020	158	3.4	0.444	0.173	0.040	0.006
7/21/2020	154	3.4	0.425	0.094	0.024	0.004
8/27/2020	82	2	0.340	0.133	0.025	0.005
9/24/2020	13	2.75	0.289	0.008	0.016	0.004
10/22/2020	131	5.65	0.451	0.008	0.045	0.004
11/19/2020	453	2.6	0.148	0.098	0.016	0.005
12/16/2020	32	1.1	0.561	0.496	0.010	0.004
1/25/2021	16	4.7	0.467	0.520	0.014	0.003
2/25/2021	56	26.2	0.780	0.623	0.027	0.009
3/18/2021	260	37.8	0.563	0.413	0.038	0.007

### 1.6.5 Habitat and Biological Assessment

#### Habitat/Biological Information

Volunteers completed the Citizen Qualitative Habitat Evaluation Index (CQHEI) habitat assessment at all 11 sites during the spring and fall sampling blitz events. Although a comparison scale for the CQHEI has not yet been developed, Hoosier Riverwatch indicates that scores greater than 60 rate as habitat conducive to supporting warm-water biota (IDNR, 2004). CQHEI scores ranged from 34 to 74 during the fall blitz and 56 to 85 during the spring blitz. Only 27% of sites scored above 60 during the fall blitz but 82% of sites scored above 60 during the spring blitz, indicating good stream habitat in much of the subwatershed. Higher CQHEI scores in the spring may be partially due to increased streamflow levels (compared to the drought conditions in the fall) but could also be due to differing volunteer interpretation.

Table 1-38 Pleasant Valley Sampling Blitz Results - Habitat Assessment (CQHEI)

Blitz ID	Stream Name	Fall 2020 CQHEI	Spring 2021 CQHEI
608	Pleasant Valley Creek	56	56
613	Middle Fork Salt Creek	49	74
616	Hamilton Creek	34	75
623	Hamilton Creek	74	73.5
668	Middle Fork Salt Creek	57	58
669	Hamilton Creek	53	61
670	Strahl Creek	53	62
679	Pleasant Valley Creek	46	61



680	Unnamed tributary of Pleasant Valley Creek	73	79
692	Unnamed tributary of Hamilton Creek	63	85
702	Pension Branch	56	65
	Average CQHEI	55.8	68.1
	% of Sites >60	27%	82%

*Table 1-39 Habitat and Biological Sampling in Pleasant Valley Subwatershed*

Sampler and Date	Site ID	Stream	Station	mIBI	mIBI Rating	QHEI	QHEI Rating
IU Limno Lab August 2020	668	Middle Fork Salt	SR-135	24	Impaired (<36)	40.5	Poor

No stream sections in the subwatershed were evaluated using fish-based Index of Biotic Integrity. The IU Limnology Lab evaluated habitat using the Qualitative Habitat Evaluation Index (QHEI) at the monthly sampling site 668 and gave it a score of 40.5, indicating poor habitat. CQHEI scores during the fall and spring blitz events were reported as 57 and 58, respectively, also indicating poor habitat. In August 2020, the IU Limnology Lab collected macroinvertebrates and gave it a mIBI score of 24, indicating impairment.

#### 1.6.6 Pleasant Valley Subwatershed Summary

The Pleasant Valley Subwatershed has significant agricultural land and 21 of 23 observed stream sites lack sufficient riparian buffer. Water quality data indicate that the two main constituents of concern are phosphorus and E. coli. However, there was a site with low phosphorus levels downstream from every phosphorus exceedance during the spring blitz, indicating that dilution is decreasing levels moving downstream. E. coli is more of a concern, particularly based on samples collected by BCRSD though the source sampling was inconclusive. Habitat scores as evaluated by CQHEI and QHEI were generally good. Macroinvertebrate community health in Middle Fork Salt Creek appears to be impaired.

## 1.7 Gravel Creek – Middle Fork (HUC 51202080503)

The Gravel Creek Subwatershed (HUC 12 – 51202080503) is located in southern Brown County as shown in Figure 4-17. The subwatershed encompasses approximately 13,237 acres and represents 5% of the overall watershed. The subwatershed contains the downstream stretch of Middle Fork Salt Creek until it combines with South Fork Salt Creek as well as the tributaries Gravel Creek, Little Blue Creek, May Creek, and Spanker Branch.

According to the IDEM 303(d) list, there are no impaired streams in the Gravel Creek subwatershed.

### 1.7.1 Land Use

Land use within the Gravel Creek Subwatershed consists predominately of forestland and the subwatershed ranks 13/16 for percentage of agricultural land (2%). Cropland is located along Gravel Creek and the eastern (upstream) half of Middle Fork Salt Creek. Herbaceous land was observed to be generally used as hay fields with no livestock present. The vast majority of the subwatershed is public land, split mainly between Brown County State Park and Hoosier National Forest. A small area along Middle Fork Salt Creek is part of the Lake Monroe property managed by the Indiana Department of Natural Resources. There are very few houses in the subwatershed and much of the USFS property is designated as a wilderness area. The subwatershed does contain the small tourist village of Story with a restaurant, hotel, and cabins.

### 1.7.2 Point Source Water Quality Issues

The Gravel Creek Subwatershed contains no confined feeding operations and no NPDES permitted facilities.

### 1.7.3 Non-Point Source Water Quality Issues

In early spring 2020, the watershed coordinator conducted a windshield survey which included 13 stream crossing sites within the Gravel Creek Subwatershed. Observations including streambank erosion, stream buffers, and livestock access were recorded for each site and the results are summarized below. Streambank erosion was noted at all sites and lack of sufficient riparian buffer was observed at only 3 of 13 sites. No livestock with access to streams was observed. Several wetland areas were observed, particularly in the western portion of the watershed. Signs of beaver were observed and the chorus of frogs in March was nearly deafening.

Table 1-40 Gravel Creek Windshield Survey Summary

Parameter	Observations
Streambank Erosion	6/13 sites with erosion >3' 7/13 sites with erosion <3' 0/13 sites with no erosion
Stream Buffers	1/13 sites with no buffers 2/13 sites with buffers <20' 10/13 sites with buffers >20'
Livestock Access to Streams	0/13 sites with livestock access

Figure 1-17 Gravel Creek (Middle Fork) Subwatershed

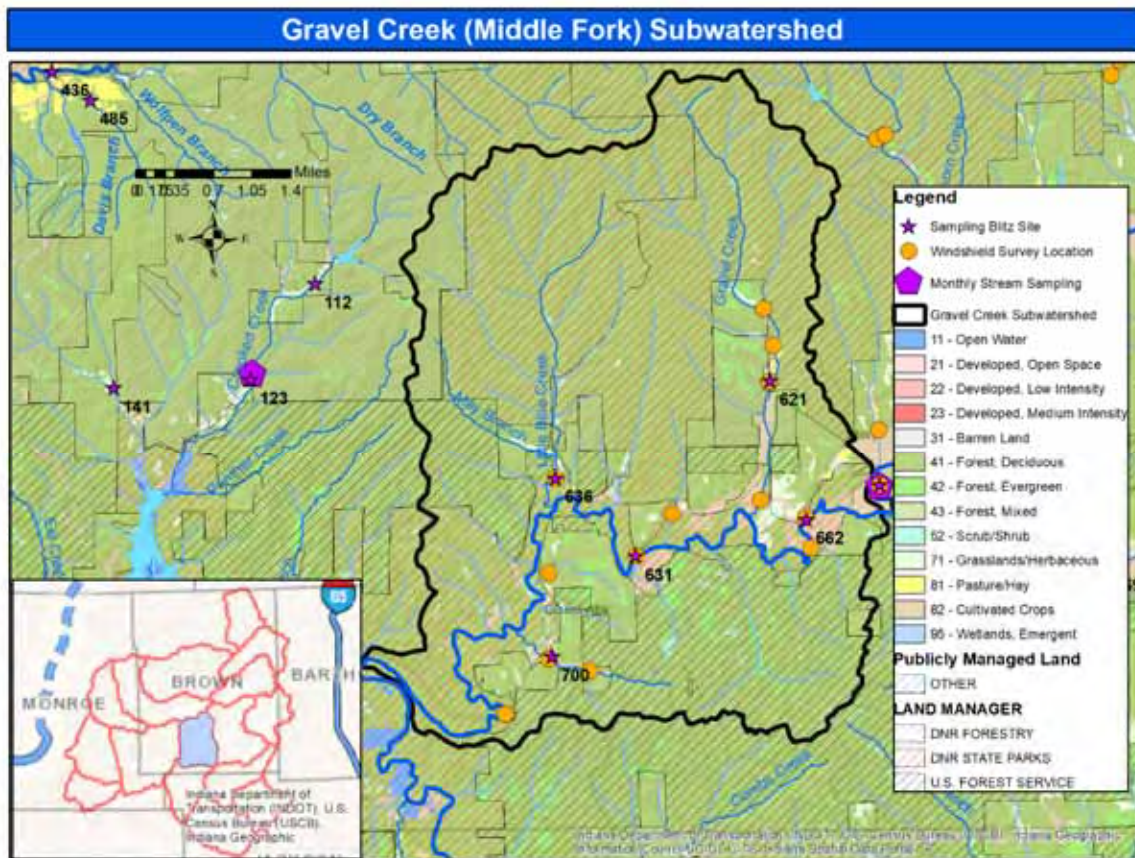


Figure 1-18 Forested wetland near site 636



#### 1.7.4 Water Quality Assessment

Five sites were selected for the spring and fall watershed sampling blitz events though one was dry during the fall blitz. Samples were analyzed for a variety of chemical parameters and *E. coli*. Habitat was evaluated using CQHEI. Macroinvertebrates and the fish community have not been assessed in this subwatershed. No monthly sampling locations or stream gages are located in this subwatershed.

##### **Water Quality Information**

*E. coli* sampling during the blitz events reported no exceedances. However, samples collected by Brown County Regional Sewer District in Middle Fork Salt Creek near site 662 revealed exceedances in 3 of 5 samples and a geometric mean well above the state standard.

Blitz data suggests total phosphorus may be a concern with 2 of 4 fall samples and 3 of 5 spring samples exceeding the water quality target. All but one of the total phosphorus exceedances ranged from 0.021 to 0.031 mg/L, not too far above the target of 0.020 mg/L. However, the highest reported concentration was 0.101 mg/L at site 662 on Middle Fork Salt Creek during the fall blitz, which is over five times the target concentration of 0.02 mg/L. The total nitrogen concentration at that site during the fall blitz was 1.208, nearly double the total nitrogen target of 0.69 mg/L. It is unclear if this sample is an outlier, particularly since no sample was collected from downstream site 631 on Middle Fork Salt Creek during the fall blitz. A sample collected upstream from site 668 on Middle Fork Salt Creek (in the Pleasant Valley subwatershed) had a total phosphorus concentration of 0.029 mg/L and a total nitrogen concentration of 0.343 mg/L. The samples from Hamilton Creek (which enters Middle Fork Salt Creek upstream from site 662) all had total phosphorus and total nitrogen levels below the water quality targets. This indicates that whatever caused the elevated nutrient levels at site 662 must have entered the stream between the upstream edge of the watershed and the site.

Table 1-41 Gravel Creek Sampling Blitz Results - Nutrients

Blitz ID	Creek Name	Fall TN (mg/L)	Spring TN (mg/L)	Fall NO3 (mg/L)	Spring NO3 (mg/L)	Fall TP (mg/L)	Spring TP (mg/L)	Fall SRP (mg/L)	Spring SRP (mg/L)
621	Gravel Creek	0.100	0.179	0.008	0.139	0.007	0.021	0.004	0.004
631	Middle Fork Salt Creek (midstream)		0.356		0.250		0.031		0.005
636	Little Blue Creek	0.100	0.125	0.008	0.095	0.002	0.019	0.003	0.004
662	Middle Fork Salt Creek (upstream)	1.208	0.361	0.008	0.247	0.101	0.022	0.005	0.003
700	Spanker Branch	0.169	0.202	0.008	0.081	0.022	0.025	0.004	0.007

Table 1-42 Gravel Creek Sampling Blitz Results - E. coli and Sediment

Blitz ID	Creek Name	Fall E. Coli (MPN/ 100 mL)	Spring E. coli (MPN/ 100 mL)	Fall TSS (mg/L)	Spring TSS (mg/L)
621	Gravel Creek	57	2	2.5	0.5
631	Middle Fork Salt Creek		23		3.4
636	Little Blue Creek	2	1	1.5	0.5
662	Middle Fork Salt Creek	1	14	28.5	1.8
700	Spanker Branch	6	-	16.5	0.8

Table 1-43 Gravel Creek BCRSD E. coli Sampling May 2020

BCRSD Site ID	Blitz Site ID	Stream	5-May	12-May	19-May	26-May	2-Jun	Geometric Mean	> State Geomean (125)
EF14	near 662	Middle Fork Salt Creek	705	63	1,220	548	144	336	yes

### 1.7.5 Habitat and Biological Assessment

#### Habitat/Biological Information

Volunteers completed the Citizen Qualitative Habitat Evaluation Index (CQHEI) habitat assessment at all 11 sites during the spring and fall sampling blitz events. Although a comparison scale for the CQHEI has not yet been developed, Hoosier Riverwatch indicates that scores greater than 60 rate as habitat conducive to supporting warm-water biota (IDNR, 2004). CQHEI scores ranged from 41 to 66 during the fall blitz and 39 to 69 during the spring blitz. Only 40% of sites scored above 60 during

the fall blitz and only 40% of sites scored above 60 during the spring blitz, indicating poor habitat in several streams, particularly Middle Fork Salt Creek (both sites scored below 60 during both blitz events).

*Table 1-44 Gravel Creek Sampling Blitz Results - Habitat Assessment (CQHEI)*

Blitz ID	Stream Name	Fall 2020 CQHEI	Spring 2021 CQHEI
621	Gravel Creek	62	69
631	Middle Fork Salt Creek (midstream)	57	51
636	Little Blue Creek	66	60
662	Middle Fork Salt Creek (upstream)	41	39
700	Spanker Branch	48.5	63
	Average CQHEI	54.9	56.4
	% of Sites >60	40%	40%

No stream sections in the subwatershed were evaluated using the Qualitative Habitat Evaluation Index (QHEI), the fish-based Index of Biotic Integrity (IBI), or the macroinvertebrate Index of Biotic Integrity (mIBI).

### 1.7.6 Gravel Creek Subwatershed Summary

The Gravel Creek subwatershed contains a high percentage of public land, is sparsely populated, and has minimal agricultural land. Streambank erosion was present at all observed sites but 10 of 13 had sufficient riparian buffer. The primary water quality issue appears to be phosphorus with exceedances in most blitz samples. The blitz data does not indicate an E. coli issue but the BCRSD data suggests that Middle Fork Salt Creek near site 662 has consistently elevated E. coli levels. Source analysis was not conducted at the site due to lack of livestock and septic systems in the subwatershed.

## 1.8 Sweetwater Creek - North Fork (HUC 051202080601)

The Sweetwater Creek Subwatershed (HUC 12 – 051202080601) is located in the northeast corner of the watershed and is contained primarily in Brown County with a small portion in Bartholomew County as shown in Figure 4-19. The subwatershed encompasses approximately 12,239 acres and represents 4% of the overall watershed. The headwaters of North Fork Salt Creek are located in this subwatershed as well as the Sweetwater Creek tributary and its reservoir, Sweetwater Lake.

According to the IDEM 303(d) list, there are no impaired streams within the Sweetwater Creek Subwatershed. However, a watershed management plan was developed for Sweetwater Lake in 2006.

### 1.8.1 Land Use

Landuse within the Sweetwater Creek Subwatershed consists primarily of forestland with 6% of land classified as agricultural and an additional 7% classified as herbaceous. Pasture is primarily located along North Fork Salt Creek and along Fox Ridge Road which runs parallel to North Fork Salt Creek between it and Sweetwater Lake. Cropland is located primarily along the southern sections of North Fork Salt Creek and Sweetwater Creek, near Gatesville. Herbaceous land is located primarily on ridgetops and some of it may be used as pasture. The northeast corner of the subwatershed features Sweetwater Lake, a highly dense residential development built around Sweetwater Lake and its twin Cordry Lake (though the latter lies outside the Lake Monroe watershed). Very little land in the subwatershed is publicly owned.

### 1.8.2 Point Source Water Quality Issues

The Sweetwater Creek Subwatershed contains no confined feeding operations and no NPDES permitted facilities.

### 1.8.3 Non-Point Source Water Quality Issues

In early spring 2020, the watershed coordinator conducted a windshield survey which included 17 stream crossing sites within the Sweetwater Creek Subwatershed. Observations including streambank erosion, stream buffers, and livestock access were recorded for each site and the results are summarized below. Streambank erosion was noted at 15 of 17 observed sites and lack of sufficient riparian buffer was observed at 9 of the 17 observed sites. Livestock access was documented at 1 of 17 sites.

*Table 1-45 Sweetwater Creek Windshield Survey Summary*

<b>Parameter</b>	<b>Observations</b>
Streambank Erosion	3/17 sites with erosion >3' 12/17 sites with erosion <3' 2/17 sites with no erosion
Stream Buffers	4/17 sites with no buffers 5/17 sites with buffers <20' 8/17 sites with buffers >20'
Animal Access to Streams	1/17 sites with animal access

Figure 1-19 Sweetwater Creek (North Fork) Subwatershed

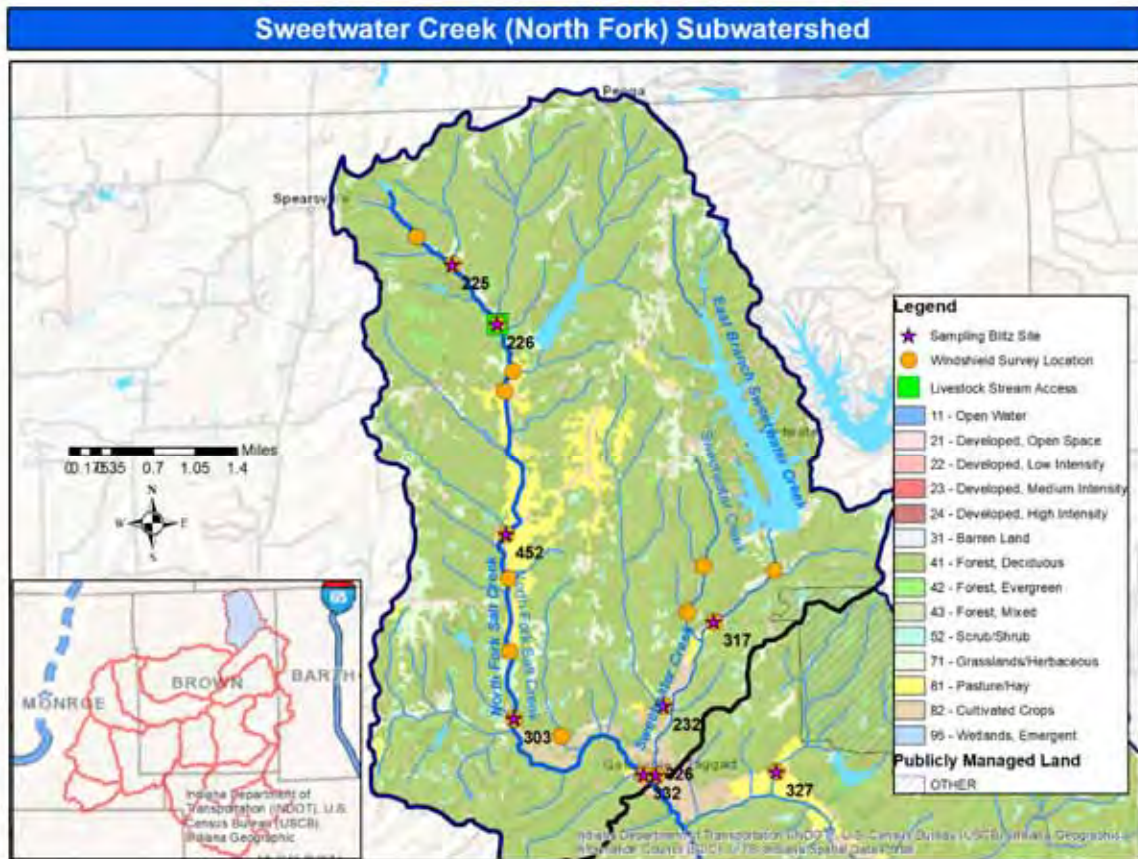


Figure 1-20 Site 232 on unnamed tributary of Sweetwater Creek





#### 1.8.4 Water Quality Assessment

Eight sites were selected for the spring and fall watershed sampling blitz events though two stream sites were dry at the time of the fall sampling blitz. Samples were analyzed for a variety of chemical parameters and E. coli. Habitat was evaluated using CQHEI. Macroinvertebrates and the fish community have not been assessed in this subwatershed. No monthly sampling locations or stream gages are located in this subwatershed. Historical chemistry and bacterial data was reviewed from the 2006 Watershed Management Plan for Sweetwater Lake.

#### Water Quality Information

Water chemistry data from the blitz events in the Sweetwater Creek subwatershed suggest phosphorus is a contaminant of concern. Total phosphorus levels exceeded the target concentration of 0.02 mg/L in 7 of 8 spring samples. Soluble reactive phosphorus levels exceeded the target concentration of 0.005 mg/L in 3 of 8 spring samples and 2 of 6 fall samples.

There was one E. coli exceedance during the fall blitz at site 317 on East Branch Sweetwater Creek (downstream from Sweetwater Lake) but the spring sample had very low levels of E. coli. Brown County Regional Sewer District also collected one sample from site 317 which was well below the target. BCRSD collected five samples over five weeks from sites 326 on Sweetwater Creek and 332 on North Fork Salt Creek which showed a few exceedances but the geometric mean was below the state standard geometric mean of 125 CFU/100 ml. An additional sample was collected from site 332 on North Fork Salt Creek in April 2021 for fecal coliform source analysis. The sample had very low E. coli levels and the source analysis was inconclusive.

*Table 1-46 Sweetwater Creek Sampling Blitz Results - Nutrients*

Blitz ID	Creek Name	Fall TN (mg/L)	Spring TN (mg/L)	Fall NO3 (mg/L)	Spring NO3 (mg/L)	Fall TP (mg/L)	Spring TP (mg/L)	Fall SRP (mg/L)	Spring SRP (mg/L)
225	North Fork Salt Creek		0.116		0.058		0.049		0.014
226	Unnamed tributary of NF Salt	0.100	0.121	0.046	0.057	0.002	0.014	0.008	0.004
232	Unnamed tributary of Sweetwater Creek	0.100	0.103	0.038	0.033	0.002	0.032	0.004	0.013
303	North Fork Salt Creek	0.100	0.350	0.008	0.291	0.009	0.028	0.006	0.007
317	East Branch Sweetwater Creek	0.136	0.198	0.075	0.059	0.002	0.024	0.004	0.003
326	Sweetwater Creek	0.100	0.280	0.036	0.197	0.002	0.021	0.003	0.002
332	North Fork Salt Creek	0.100	0.321	0.022	0.233	0.002	0.021	0.004	0.004
452	North Fork Salt Creek		0.347		0.248		0.026		0.003

Table 1-47 Sweetwater Creek Sampling Blitz Results - E. coli and Sediment

Blitz ID	Creek Name	Fall E. Coli (MPN/100 mL)	Spring E. coli (MPN/100mL)	Fall TSS (mg/L)	Spring TSS (mg/L)
225	North Fork Salt Creek		3		2
226	Unnamed tributary of NF Salt	4	10	0.5	0.5
232	Unnamed tributary of Sweetwater Creek	4	10	1.8	0.5
303	North Fork Salt Creek	3	3	0.7	0.5
317	East Branch Sweetwater Creek	921	17	2.3	1
326	Sweetwater Creek	10	2	0.5	0.5
332	North Fork Salt Creek	22	6	0.5	0.5
452	North Fork Salt Creek		8		0.6

Table 1-48 Sweetwater Creek BCRSD E. coli Sampling May 2020

BCRSD Site ID	Blitz Site ID	Stream	5-May	12-May	19-May	26-May	2-Jun	Geo. Mean	> State Geomean (125)
EF01	326	Sweetwater Creek	115	12	379	365	82	109	no
EF02	332	North Fork Salt Creek	338	9	219	61	77	80	no
EF03	near 317	Outlet Sweetwater Lake	75	--	--	--	--	--	no

Table 1-49 Sweetwater Creek Fecal Contamination Source Sampling April 2021

BC_ID	LM_ID	Stream	4/27/21 E. Coli	Coliform (PFU/100ml)	% Human	% Animal
EF02	332	North Fork Salt (above Sweetwater Creek)	10.9	0.1	NA	NA

Looking at historical data, water quality monitoring was conducted in 2005-2006 as part of developing a Watershed Management Plan for Sweetwater Creek based on concerns of the residents of Sweetwater Lake. Phosphorus and chlorophyll-a levels in Sweetwater Lake were well below state averages and in fact, among the lowest in the state. Likewise, no E. coli sample results exceeded the state water quality standards of 235 colonies per 100 mL despite the prevalence of septic systems around the lake. The planners concluded that although water quality was relatively healthy, the top four threats to local water quality were failing septic systems, erosion & sedimentation, geese, and lawn chemicals. The watershed management

plan recommended establishing mandatory septic system inspections, educating about erosion, encouraging lakeshore stabilization projects such as riprap or plantings, continuing efforts to discourage geese, and publishing a list of approved fertilizers and rates. These actions have all been carried out by the Sweetwater-Cordry Conservancy since the plan was published.

### 1.8.5 Habitat and Biological Assessment

#### Habitat/Biological Information

Volunteers completed the Citizen Qualitative Habitat Evaluation Index (CQHEI) habitat assessment at all 8 sites during the spring and fall sampling blitz events. Although a comparison scale for the CQHEI has not yet been developed, Hoosier Riverwatch indicates that scores greater than 60 rate as habitat conducive to supporting warm-water biota (IDNR, 2004). CQHEI scores ranged from 51 to 75.5 during the fall blitz and 60 to 94 during the spring blitz. While only 50% of sites scored above 60 during the fall blitz, 88% of sites scored above 60 during the spring blitz, indicating generally good stream habitat throughout the subwatershed. Higher CQHEI scores in the spring may be partially due to increased streamflow levels (compared to the drought conditions in the fall) but could also be due to differing volunteer interpretation. The one site with low CQHEI scores during both the spring and fall blitz events was site 232, an unnamed tributary of Sweetwater Creek located just north of Gatesville.

*Table 1-50 Sweetwater Creek Sampling Blitz Results - Habitat Assessment (CQHEI)*

Blitz ID	Stream Name	Fall 2020 CQHEI	Spring 2021 CQHEI
225	North Fork Salt Creek	74.5	82
226	Unnamed tributary of NF Salt	75.5	82.5
232	Unnamed tributary of Sweetwater Creek	54	60
303	North Fork Salt Creek	70	63
317	East Branch Sweetwater Creek	53	76.5
326	Sweetwater Creek	51	69
332	North Fork Salt Creek	54	79.5
452	North Fork Salt Creek	70	94
	Average CQHEI	62.8	75.8
	% of Sites >60	50%	88%

No stream sections in the subwatershed were evaluated using the Qualitative Habitat Evaluation Index (QHEI), the fish-based Index of Biotic Integrity (IBI), or the macroinvertebrate Index of Biotic Integrity (mIBI).

### 1.8.6 Sweetwater Creek Subwatershed Summary

The primary constituent of concern in the Sweetwater Creek subwatershed appears to be phosphorus, with 7 of 8 spring blitz samples exceeding the total phosphorus target. One E. coli exceedance was reported out of the 14 blitz samples and 3 E. coli exceedances were reported out of the 12 BCRSD samples. Site 326 on Sweetwater Creek was the only site with multiple E. coli exceedances, with 2 of 8 total samples exceeding the target value of 235 CFU/100 ml.

## 1.9 East Fork Salt Creek – North Fork (HUC 051202080602)

The East Fork Salt Creek Subwatershed (HUC 12 – 051202080602) is located primarily in Brown County with a portion extending east into Bartholomew County as shown in Figure 4-23. The subwatershed encompasses approximately 13,719 acres and represents 5% of the overall watershed. The headwaters of East Fork Salt Creek are located in this subwatershed as well as a portion of North Fork Salt Creek just below its headwaters.

According to the IDEM 303(d) list, there are no impaired streams within the East Fork Salt Creek Subwatershed.

### 1.9.1 Land Use

Landuse within the East Fork Salt Creek Subwatershed consists primarily of forestland with the 11<sup>th</sup> highest percentage of agricultural land at 5%. Cropland is generally located along North Fork Salt Creek and pasture is concentrated along East Fork Salt Creek. Population is sparse and generally located along the main roads (Salt Creek Road, Hoover Road, Georgetown Road). The majority of the subwatershed is private land although there are two state properties – Mountain Tea State Forest and Whippoorwill Nature Preserve.

### 1.9.2 Point Source Water Quality Issues

The East Fork Salt Creek Subwatershed contains no confined feeding operations and no NPDES permitted facilities.

### 1.9.3 Non-Point Source Water Quality Issues

In early spring 2020, the watershed coordinator conducted a windshield survey which included 12 stream crossing sites within the East Fork Salt Creek Subwatershed. Observations including streambank erosion, stream buffers, and livestock access were recorded for each site and the results are summarized below. Streambank erosion was noted at 9 of the 12 observed sites and a lack of sufficient riparian buffer was observed at 8 of the 12 observed sites. Livestock access was documented at 1 of 12 sites.

*Table 1-51 East Fork Salt Creek Windshield Survey Summary*

<b>Parameter</b>	<b>Observations</b>
Streambank Erosion	4/12 sites with erosion >3' 5/12 sites with erosion <3' 3/12 sites with no erosion
Stream Buffers	3/12 sites with no buffers 5/12 sites with buffers <20' 4/12 sites with buffers >20'
Livestock Access to Streams	1/12 sites with livestock access

*Figure 1-21 Site 488 on an unnamed tributary to North Fork Salt Creek*



*Figure 1-22 View from Site 419 on North Fork Salt Creek at Annie Smith Road*



Figure 1-23 East Fork Salt (North Fork) Subwatershed

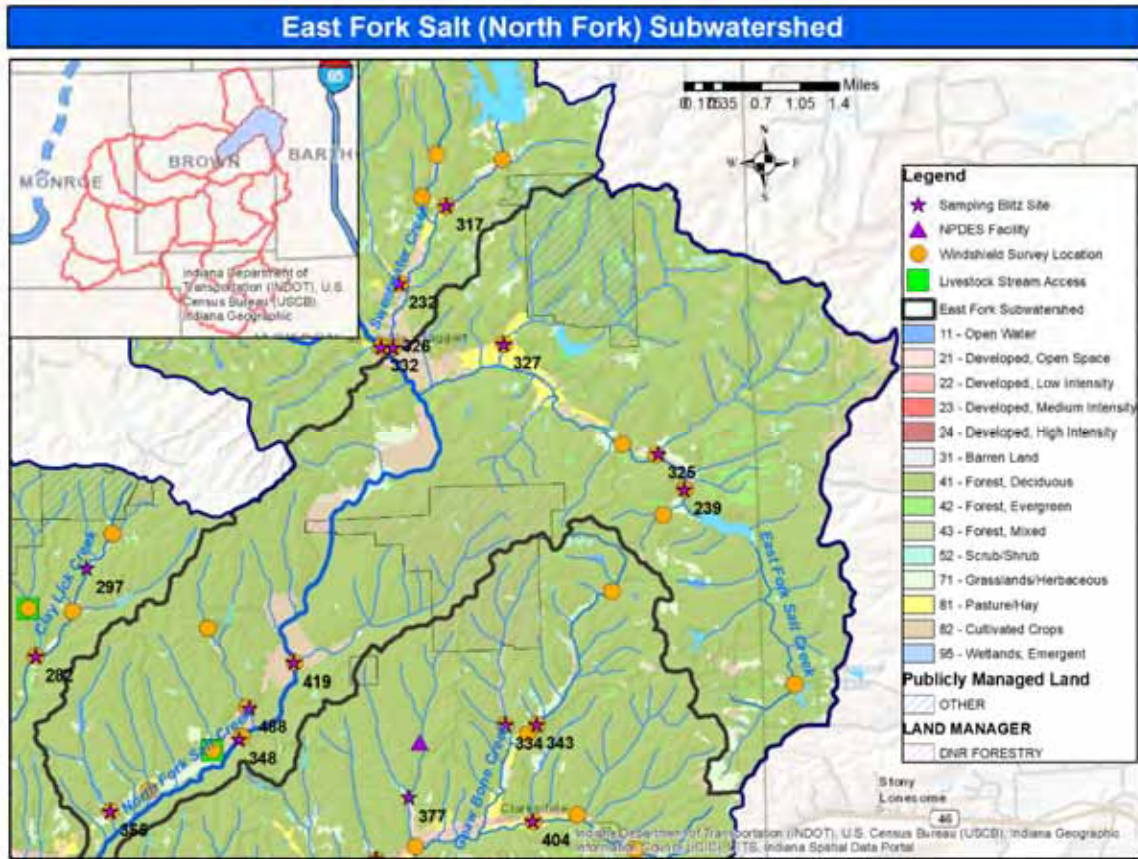


Figure 1-24 Site 355 Unnamed tributary to North Fork Salt Creek – lowest habitat scores

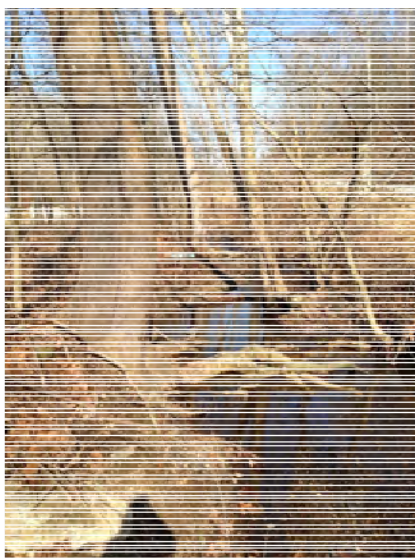


Figure 1-25 Site 488 on unnamed tributary to North Fork Salt Creek - most exceedances



#### 1.9.4 Water Quality Assessment

Seven sites were selected for the spring and fall watershed sampling blitz events though four were dry at the time of the fall sampling blitz. Samples were analyzed for a variety of chemical parameters and *E. coli*. Habitat was evaluated using CQHEI. Macroinvertebrates and the fish community have not been assessed in this subwatershed. No monthly sampling locations or stream gages are located in this subwatershed.

##### **Water Quality Information**

Water chemistry data from the blitz events in the East Fork Salt Creek subwatershed suggest that phosphorus is the primary contaminant of concern with nitrogen also a potential concern. During the spring blitz, all seven sites had total phosphorus concentrations above the water quality target and three of seven sites exceeded the soluble reactive phosphorus water quality target.

The site with the most (and highest) exceedances was 488 on an unnamed tributary to North Fork Salt Creek in the western (downstream) portion of the watershed. During the fall blitz, site 488 had significant exceedances for total suspended solids, total nitrogen, total phosphorus, and soluble reactive phosphorus. Nearby site 419 on North Fork Salt Creek greatly exceeded the water quality target for nitrates with a reported concentration of 1.074 mg/L during the fall blitz. However, that value exceeds the reported total nitrogen concentration of 0.145 mg/L, indicating a potential laboratory error. Sites 488 and 419 are both located adjacent to cropland.

Table 1-52 East Fork Salt Creek Sampling Blitz Results - Nutrients

Blitz ID	Creek Name	Fall TN (mg/L)	Spring TN (mg/L)	Fall NO3 (mg/L)	Spring NO3 (mg/L)	Fall TP (mg/L)	Spring TP (mg/L)	Fall SRP (mg/L)	Spring SRP (mg/L)
239	East Fork Salt Creek		0.315		0.126		0.038		0.006
325	Unnamed tributary of EF Salt		0.100		0.031		0.027		0.004
327	Unnamed tributary of EF Salt		0.238		0.127		0.027		0.002
348	North Fork Salt Creek	0.115	0.412	0.008	0.308	0.003	0.023	0.003	0.003
355	Unnamed tributary of NF Salt		0.254		0.072		0.038		0.010
419	North Fork Salt Creek	0.145	0.438	1.074	0.369	0.008	0.024	0.002	0.003
488	Unnamed tributary of NF Salt	2.154	0.152	0.008	0.069	0.235	0.031	0.014	0.014

Table 1-53 East Fork Salt Sampling Blitz - E. coli and Sediment

Blitz ID	Creek Name	Fall E. Coli (MPN/ 100 mL)	Spring E. coli (MPN/ 100 mL)	Fall TSS (mg/L)	Spring TSS (mg/L)
239	East Fork Salt Creek		3		4
325	Unnamed tributary of EF Salt		3		0.5
327	Unnamed tributary of EF Salt		1		3.6
348	North Fork Salt Creek	167	5	5.5	2.2
355	Unnamed tributary of NF Salt		3		0.6
419	North Fork Salt Creek	57	14	15	1.15
488	Unnamed tributary of NF Salt	181	3	639.2	0.5

### 1.9.5 Habitat and Biological Assessment

#### Habitat/Biological Information

Volunteers completed the Citizen Qualitative Habitat Evaluation Index (CQHEI) habitat assessment at all 11 sites during the spring and fall sampling blitz events. Although a comparison scale for the CQHEI has not yet been developed, Hoosier Riverwatch indicates that scores greater than 60 rate as habitat conducive to supporting warm-water biota (IDNR, 2004). CQHEI scores ranged from 45.5 to 71.3 during the fall blitz and 55 to 79 during the spring blitz. While only 29% of sites scored above 60 during the fall blitz, 86% of sites scored above 60 during the spring blitz, indicating good habitat in most streams. The one site with low rankings during both blitz events was 355 on an unnamed tributary of North Fork Salt Creek.



Table 1-54 East Fork Salt Creek Sampling Blitz Results - Habitat Assessment (CQHEI)

Blitz ID	Stream Name	Fall 2020 CQHEI	Spring 2021 CQHEI
239	East Fork Salt Creek	45.5	73
325	Unnamed tributary of EF Salt	53	79
327	Unnamed tributary of EF Salt	46	72
348	North Fork Salt Creek	63	65
355	Unnamed tributary of NF Salt	51.5	55
419	North Fork Salt Creek	71.3	62
488	Unnamed tributary of NF Salt	50	63
	Average CQHEI	54.3	67.0
	% of Sites >60	29%	86%

No stream sections in the subwatershed were evaluated using the Qualitative Habitat Evaluation Index (QHEI), the fish-based Index of Biotic Integrity (IBI), or the macroinvertebrate Index of Biotic Integrity (mIBI).

#### 1.9.6 East Fork Salt Creek Subwatershed Summary

Phosphorus appears to be the largest concern in the subwatershed with 7 of 7 spring blitz samples exceeding the total phosphorus target. Nitrogen and sediment may also be issues at site 488 on an unnamed tributary to North Fork Salt Creek which is directly adjacent to cropland. Erosion and lack of riparian buffers are prevalent throughout the subwatershed.

### 1.10 Gnaw Bone Creek – North Fork (HUC 051202080603)

The Gnaw Bone Creek Subwatershed (HUC 12 – 051202080603) is located in the eastern half of Brown County as shown in Figure 4-26. The subwatershed encompasses approximately 13,598 acres and represents 5% of the overall watershed. Gnaw Bone Creek, Henderson Creek, Mount Liberty Creek, and David Branch are located within this subwatershed as well as the town of Gnaw Bone. Gnaw Bone Creek discharges into North Fork Salt Creek at the downstream limit of the subwatershed.

According to the IDEM 303(d) list, there are no impaired streams within the Gnaw Bone Creek Subwatershed.

### 1.10.1 Land Use

Landuse within the Gnaw Bone Creek Subwatershed consists primarily of forestland with the fourth lowest percentage of agricultural land (4%) of the Lake Monroe subwatersheds. Cropland and pasture are both primarily located along Gnaw Bone Creek, Mount Liberty Creek, and the downstream section of Davis Branch. Population is sparse and generally located along the main roads (State Road 46 and State Road 135). The vast majority of the subwatershed is private land though the Laura Hare Nature Preserve is partially located in the subwatershed.

### 1.10.2 Point Source Water Quality Issues

The Gnaw Bone Creek Subwatershed contains no confined feeding operations and two NPDES permitted facilities. One is the Gnaw Bone Waste Water Treatment Plant and the other is the Camp Moneto Waste Water Treatment Plant. A review of the IDEM Virtual Filing Cabinet found no violations for Camp Moneto WWTP. The Gnaw Bone Regional Sewer District WWTP received a noncompliance letter in September 2020 due to multiple exceedances that were not properly reported. The facility exceeded ammonia-nitrogen limits four times in 2020, TSS twice in 2019, CBOD once in 2019, and E. coli five times in 2019-2020. IDEM expressed particular concern about the ammonia-nitrogen levels and frequency.

### 1.10.3 Non-Point Source Water Quality Issues

In early spring 2020, the watershed coordinator conducted a windshield survey which included 17 stream crossing sites within the Gnaw Bone Creek Subwatershed. Observations including streambank erosion, stream buffers, and livestock access were recorded for each site and the results are summarized below. Streambank erosion was noted at 8 of the 17 observed sites and lack of sufficient riparian buffer was observed at 14 of the 17 observed sites. Livestock access was not documented at any site.

*Table 1-55 Gnaw Bone Creek Windshield Survey Summary*

Parameter	Observations
Streambank Erosion	3/17 sites with erosion >3' 5/17 sites with erosion <3' 9/17 with no erosion
Stream Buffers	7/17 sites with no buffers 7/17 sites with buffers <20' 3/17 with buffers >20'
Livestock Access to Streams	0/17 sites with livestock access

Figure 1-26 Gnow Bone (North Fork) Subwatershed

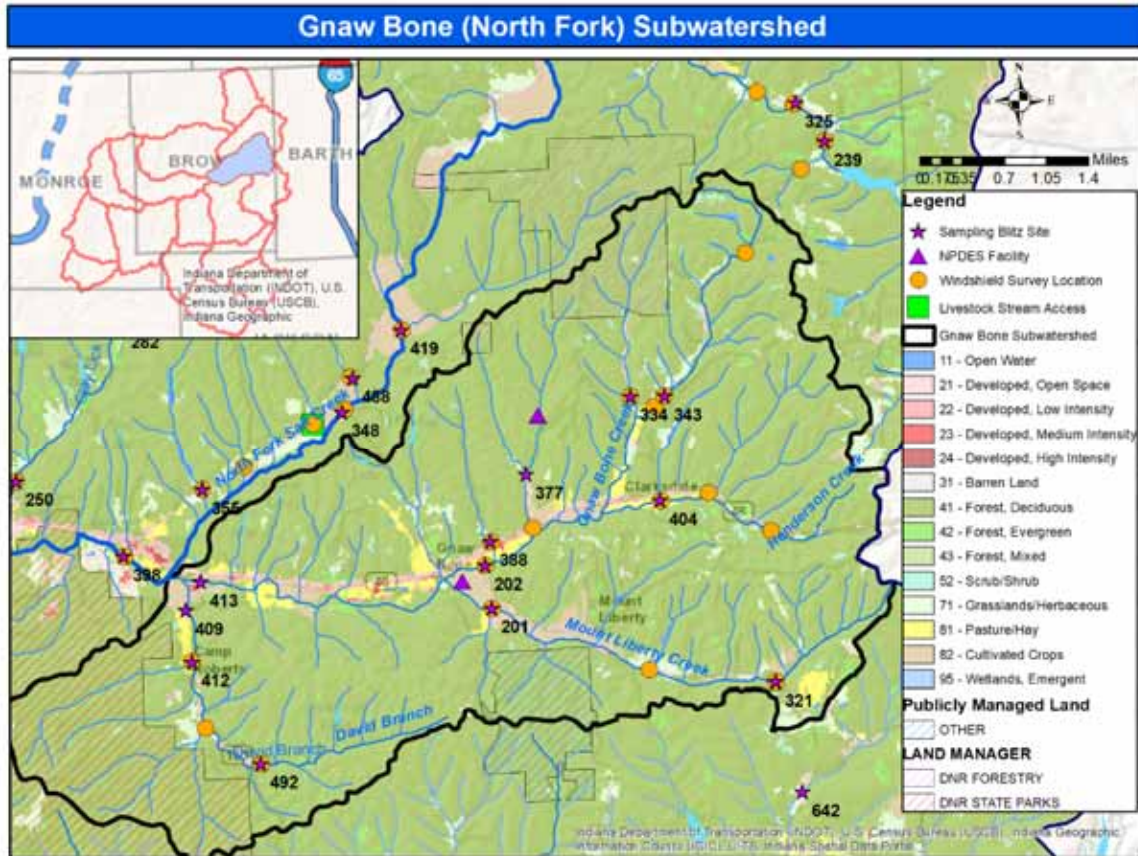


Figure 1-27 Site 388 - Unnamed tributary to Gnow Bone Creek



Figure 1-28 Site 202 - Gnaw Bone Creek



#### 1.10.4 Water Quality Assessment

Twelve sites were selected for the spring and fall watershed sampling blitz events though six were dry at the time of the fall sampling blitz. Samples were analyzed for a variety of chemical parameters and *E. coli*. Habitat was evaluated using CQHEI. Macroinvertebrates and the fish community have not been assessed in this subwatershed. No monthly sampling locations or stream gages are located in this subwatershed.

##### **Water Quality Information**

Only one blitz sample exceeded the *E. coli* water quality target – site 404 on Henderson Creek during the fall blitz. However, sampling conducted by the Brown County Regional Sewer District in spring 2020 suggest *E. coli* issues in two of the three sites sampled – site 413 on Gnaw Bone Creek and site 201 on Mount Liberty Creek.

Phosphorus also appears to be a concern with 12 of 12 spring samples exceeding the total phosphorus target and 6 of 12 spring samples exceeding the soluble reactive phosphorus target. Sites 388 (unnamed tributary of Gnaw Bone Creek) and the immediately downstream site 202 (Gnaw Bone Creek) had the highest concentrations of total phosphorus, both over three times the target concentration of 0.02 mg/L. One site, 492 on David Branch, exceeded the total phosphorus and soluble phosphorus targets during the spring blitz and also exceeded the soluble reactive phosphorus target during the fall blitz.

No exceedances were reported for total suspended solids, total nitrogen, or nitrates.

Table 1-56 Gnaw Bone Creek Sampling Blitz Results - Nutrients

Blitz ID	Creek Name	Fall TN (mg/L)	Spring TN (mg/L)	Fall NO3 (mg/L)	Spring NO3 (mg/L)	Fall TP (mg/L)	Spring TP (mg/L)	Fall SRP (mg/L)	Spring SRP (mg/L)
201	Mount Liberty Creek	0.100	0.483	0.010	0.414	0.002	0.025	0.003	0.002
202	Gnaw Bone Creek	0.100	0.263	0.029	0.198	0.002	0.098	0.003	0.011
321	Mount Liberty Creek		0.224		0.146		0.026		0.005
334	Unnamed tributary of Gnaw Bone		0.170		0.094		0.026		0.007
343	Gnaw Bone Creek		0.149		0.081		0.025		0.005
377	Unnamed tributary of Gnaw Bone		0.100		0.022		0.026		0.005
388	Unnamed tributary of Gnaw Bone		0.185		0.142		0.079		0.009
404	Henderson Creek	0.100	0.169	0.059	0.103	0.002	0.026	0.004	0.004
409	David Branch	0.118	0.218	0.014	0.151	0.002	0.029	0.004	0.013
412	Unnamed tributary of David Branch		0.150		0.113		0.021		0.004
413	Gnaw Bone Creek	0.100	0.298	0.011	0.258	0.002	0.028	0.003	0.006
492	David Branch	0.100	0.210	0.043	0.102	0.017	0.029	0.019	0.007

Table 1-57 Gnaw Bone Creek Sampling Blitz Results - E. coli and Sediment

Blitz ID	Creek Name	Fall E. Coli (MPN/ 100 mL)	Spring E. coli (MPN/ 100 mL)	Fall TSS (mg/L)	Spring TSS (mg/L)
201	Mount Liberty Creek	89	6	1.2	0.625
202	Gnaw Bone Creek	35	12	0.5	0.5
321	Mount Liberty Creek		6		0.5
334	Unnamed tributary of Gnaw Bone		-		0.5
343	Gnaw Bone Creek		2		0.5
377	Unnamed tributary of Gnaw Bone		9		0.5
388	Unnamed tributary of Gnaw Bone		9		0.5
404	Henderson Creek	727	14	0.5	0.5
409	David Branch	7	16	2.3	2.4
412	Unnamed tributary of David Branch		-		0.5
413	Gnaw Bone Creek	47	194	0.5	0.5
492	David Branch	15	71	1	0.5

Table 1-58 Gnaw Bone Creek BCRSD E. coli Sampling Results May 2020

BCRSD Site ID	Blitz Site ID	Stream	5-May	12-May	19-May	26-May	2-Jun	Geo. Mean	> State Geomean (125)
EF11	413	Gnaw Bone	449	78	620	186	141	224	yes
EF12	202	Gnaw Bone	338	21	276	172	84	122	no
EF13	201	Mount Liberty	401	61	449	228	118	197	yes

#### 1.10.5 Habitat and Biological Assessment

##### Habitat/Biological Information

Volunteers completed the Citizen Qualitative Habitat Evaluation Index (CQHEI) habitat assessment at all 12 sites during the spring and fall sampling blitz events. Although a comparison scale for the CQHEI has not yet been developed, Hoosier Riverwatch indicates that scores greater than 60 rate as habitat conducive to supporting warm-water biota (IDNR, 2004). CQHEI scores ranged from 41 to 74 during the fall blitz and 54 to 83.5 during the spring blitz. While only 33% of sites scored above 60 during the fall blitz, 83% of sites scored above 60 during the spring blitz, indicating good habitat in most streams. The two stream sections with low scores during both blitz events were site 343 on Gnaw Bone Creek and site 412 on an unnamed tributary of David Branch. Higher CQHEI scores in the spring may be partially due to increased streamflow levels (compared to the drought conditions in the fall) but could also be due to differing volunteer interpretation.

Table 1-59 Gnaw Bone Creek Sampling Blitz Results - Habitat Assessment (CQHEI)

Blitz ID	Stream Name	Fall 2020 CQHEI	Spring 2021 CQHEI
201	Mount Liberty Creek	54	62.5
202	Gnaw Bone Creek	47	60.5
321	Mount Liberty Creek	41	75.5
334	Unnamed tributary of Gnaw Bone	72.5	76.3
343	Gnaw Bone Creek	57.2	54
377	Unnamed tributary of Gnaw Bone	59.8	72.5
388	Unnamed tributary of Gnaw Bone	42	68
404	Henderson Creek	61	75.5
409	David Branch	54	83.5
412	Unnamed tributary of David Branch	51	59
413	Gnaw Bone Creek	74	61
492	David Branch	69	78

	Average CQHEI	56.9	68.9
	% of Sites >60	33%	83%

No stream sections in the subwatershed were evaluated using the Qualitative Habitat Evaluation Index (QHEI), the fish-based Index of Biotic Integrity (IBI), or the macroinvertebrate Index of Biotic Integrity (mIBI).

#### 1.10.6 Gnaw Bone Creek Subwatershed Summary

The Gnaw Bone Creek subwatershed has relatively little agricultural and developed land. The main constituents of concern appear to be phosphorus and E. coli. All twelve spring blitz samples had phosphorus levels above the target with sites 388 (unnamed tributary of Gnaw Bone Creek) and the immediately downstream site 202 (Gnaw Bone Creek) having the highest concentrations. While only one blitz sample exceeded the E. coli target, site 404 on Henderson Creek, two sites sampled by BCRSD exceeded the state geomean target, site 413 on Gnaw Bone Creek and site 201 on Mount Liberty Creek. Lack of riparian buffer was observed at 14 of 17 sites and erosion was noted at 8 of 17 sites though CQHEI scores were relatively high.

### 1.11 Clay Lick Creek – North Fork (HUC 051202080604)

The Clay Lick Creek Subwatershed (HUC 12 – 051202080604) is located in central Brown County as shown in Figure 4-34. The subwatershed is the second largest, encompassing approximately 28,572 acres and representing 10% of the overall watershed. The watershed contains a portion of North Fork Salt Creek as well as tributaries Clay Lick Creek, Greasy Creek, Owl Creek, Lick Creek, and Jackson Creek with its reservoir Yellowwood Lake. The subwatershed also contains the town of Nashville, the North Fork stream gage (near site 389 just south of Nashville), and the monthly North Fork sampling location (site 256 southeast of Yellowwood Lake).

According to the IDEM 303(d) list, there are no impaired streams within the Clay Lick Creek Subwatershed.

### 1.11.1 Land Use

Land use within the Clay Lick Creek Subwatershed consists primarily of forestland but it has the sixth highest percentage of agricultural land (5%) of all the Lake Monroe subwatersheds and the largest area of developed land, Nashville. Pasture and cultivated crops are located primarily along North Fork Salt Creek with some pasture and herbaceous land along smaller streams like Clay Lick, Greasy Creek, Owl Creek, and Lick Creek. Portions of the subwatershed have much higher population density than the other subwatersheds, particularly in Nashville and along the main roads (State Road 46, State Road 135, Greasy Creek Road, Clay Lick Road). The town of Nashville is located along the North Fork Salt Creek, has approximately 1,000 residents and is well known as an art colony and tourist destination. About a third of the subwatershed is public land. A portion of Brown County State Park is located in the southern half, a portion of Yellowwood State Forest in the western half, and a handful of smaller parcels managed by other organizations are located in the northeast corner.

### 1.11.2 Point Source Water Quality Issues

The Clay Lick Creek Subwatershed contains no confined feeding operations and one NPDES permitted facility, the largest in the watershed. The Town of Nashville maintains a 0.60 MGD wastewater treatment plant that discharges into North Fork Salt Creek just west of Nashville. This treatment plant is by far the largest in the area and has been dealing with significant violations. The plant has been operating under an agreed order since 2019. In October 2019, IDEM issued a notice of violation and proposed agreed order for the plant. The letter mentioned an overflow event on February 24, 2019 and alleged there had been additional unreported overflows to North Fork Salt Creek. The letter also mentioned the lack of a preventative maintenance program, insufficient removal of sludge/solids, inadequate staffing, and flooding of the salt stockpile causing salt to enter North Fork Salt Creek.

In response, the town hired a consulting firm to develop a wastewater treatment plant agreed order of response that would include all the necessary elements to bring the plant back into compliance. This plan was approved by IDEM in June 2020 and the town has been working to remedy all the issues. The town has also started work on a sanitary sewer utility master plan to determine how well the plant is currently functioning, investigate options for expansion or reconstruction, and exploring possibilities for expanding service outside town limits. (Brown County Democrat 12/04/19 – “Town Okays Major Study of Sewer Service”)

One of the challenges that the treatment plant faces is its location in the floodway of North Fork Salt Creek, meaning it is at high risk for flooding. It was built in the 1960's and expanded several times, most recently around 2010. Some concerns have been raised that the state might not permit expansion of the plant within the floodway and that a relocation could be required. There are also efforts currently underway to consider wastewater treatment at the county level and explore the possibility of a treatment plant that would serve multiple communities. A study was recently published evaluating the feasibility of a Helmsburg Regional



Sewer District and the Brown County Regional Sewer District is working on its own plan for all areas of the county that are not currently served by wastewater treatment plants.

### 1.11.3 Non-Point Source Water Quality Issues

In early spring 2020, the watershed coordinator conducted a windshield survey which included 26 stream crossing sites within the Clay Lick Creek Subwatershed. Observations including streambank erosion, stream buffers, and livestock access were recorded for each site and the results are summarized below. Streambank erosion was noted at 21 of the 26 observed sites and lack of sufficient riparian buffer was observed at 20 of the 26 observed sites. Many of the sites with no riparian buffer were residential properties where the surrounding area was mowed to the edge of the stream. While lawn is preferable to tilled land, mowed grass provides minimal filtration when stormwater flows into streams. Other sites had streams immediately adjacent to roads with no room for riparian planting. Livestock access was documented at 2 of the 26 observed sites.

*Table 1-60 Clay Lick Creek Windshield Survey Summary*

Parameter	Observations
Streambank Erosion	9/26 sites with erosion >3' 12/26 sites with erosion <3' 5/26 sites with no erosion
Stream Buffers	10/26 sites with no buffers 10/26 sites with buffers <20' 6/26 sites with buffers >20'
Livestock Access to Streams	2/26 sites with livestock access

*Figure 1-29 Site 482 Showing No Riparian Buffer on Residential Property*



*Figure 1-30 Stream Gage on North Fork Salt Creek – State Road 46 Bridge Near Site 389*



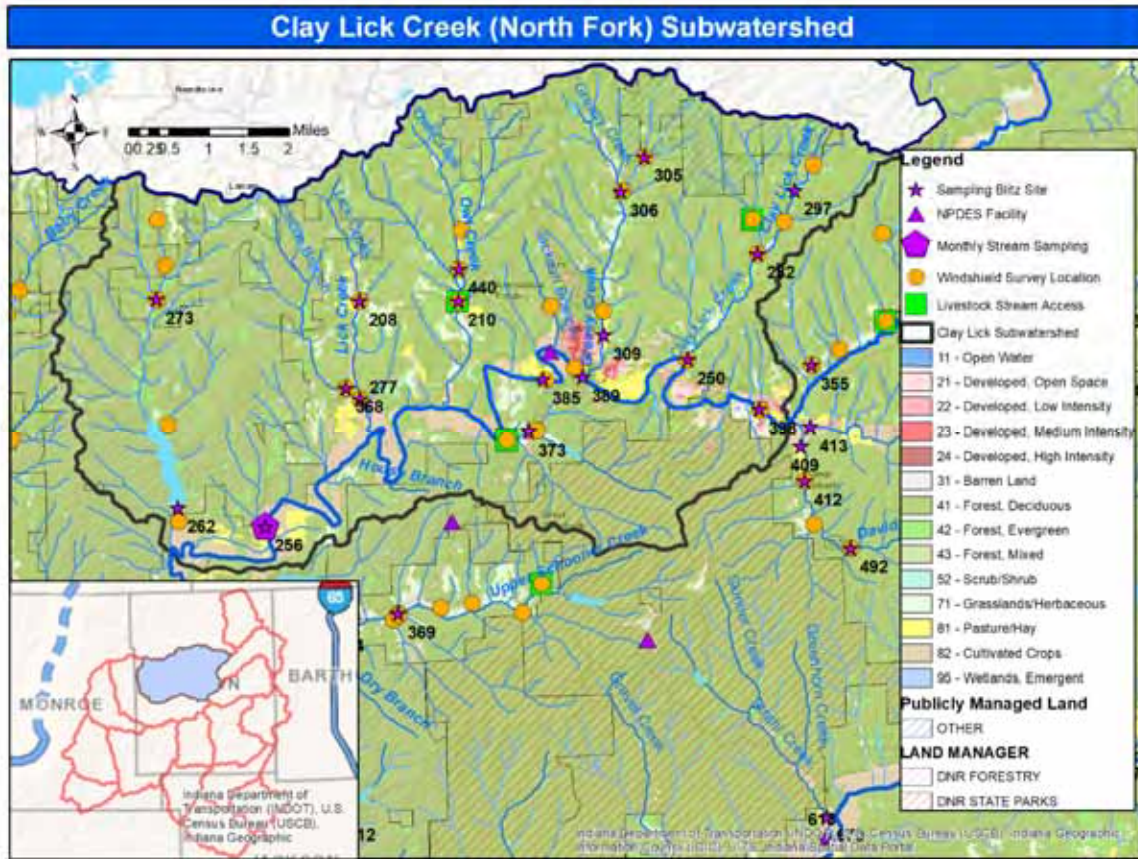
*Figure 1-31 Site 277 Showing Insufficient Riparian Buffer on Agricultural Property*



*Figure 1-32 Site 306 - Road Immediately Adjacent to Stream*

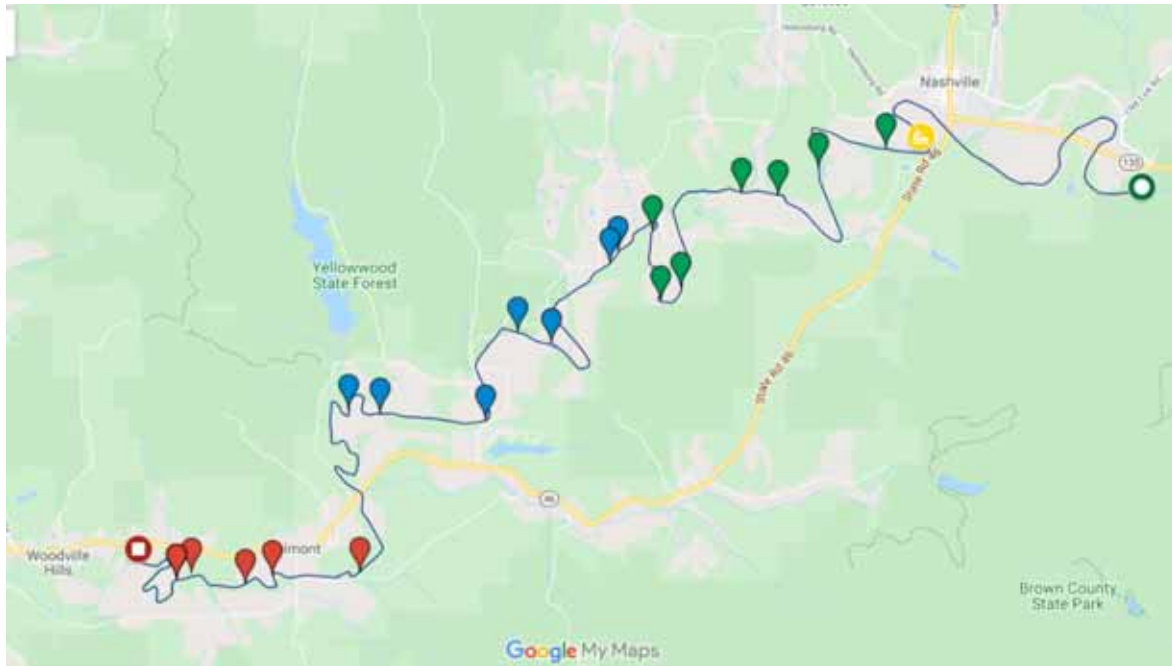


Figure 1-33 Clay Lick Creek (North Fork) Subwatershed



The Brown County Soil and Water District conducted a kayak survey of North Fork Salt Creek in June 2020 within the Clay Lick Creek and Brummett Creek subwatersheds. The stream was surveyed between Brown County State Park (east of Nashville) and the Monroe/Brown County line (about halfway between Bloomington and Nashville). Observations were recorded by section and included log jams, areas of significant erosion, agricultural crossings, invasive terrestrial plant species, and trash. Many of these concerns are not observable from the roads.

Figure 1-34 North Fork Salt Creek Kayak Survey (portions of Clay Lick and Brummetts Creek subwatersheds)



Section 1 (No Markers – Brown County State Park to Deer Run Park) contained no log jams and no notable obstacles to kayaking. Some erosion locations were identified, including a significant area behind the Brown County Music Center and another across from the Deer Run Park boat ramp (site 385).

Section 2 (Green Markers – Deer Run Park to Howard Farms) had a dense section of Japanese Knotweed, one of the newer invasive terrestrial plant species in this area. There were also a couple of very old trash dumps that have become overgrown. Two log jams were noted.

Section 3 (Blue Markers – Howard Farms to Sycamore Land Trust) had several large log jams and unpleasant odors were noted throughout the section.

Section 4 (Red Markers – Sycamore Land Trust to Monroe County Line) had many large log jams and several of the log jams had accumulated trash. This section of the creek (in the Brummett Creek subwatershed) also tended to have narrower and deeper banks.

General observations included several stream crossings for farm equipment that appeared heavily eroded and could benefit from improved management practices. Areas of large erosion tended to occur along agricultural fields and where trees had fallen. The last big logjam removal project was by Salt Creek Preservation Group in 2009.

#### 1.11.4 Water Quality Assessment

Eighteen sites were selected for the spring and fall watershed sampling blitz events though four were dry at the time of the fall sampling blitz and one site was missed during the spring sampling blitz. Additional monthly samples were collected from North Fork Salt Creek at site 256. Samples were analyzed for a variety of chemical parameters and E. coli. Habitat was evaluated during the blitz events using CQHEI. Habitat was evaluated once using QHEI at site 256 and macroinvertebrates were also assessed once at site 256. The fish community have not been assessed in this subwatershed. A stream gage is located on North Fork Salt Creek at site 389 just south of Nashville.

##### **Water Quality Information**

Water chemistry data from the blitz sites in the Clay Lick Creek subwatershed suggest E. coli concerns at three sites – 277 on Lick Creek, 398 on North Fork Salt Creek (upstream), and 299 on Owl Creek. Data from the Brown County Regional Sewer District suggest E. coli concerns at site 256 on North Fork Salt Creek (downstream), near site 389 on North Fork Salt Creek (midstream), near site 398 on North Fork Salt Creek (upstream) and near site 309 on Greasy Creek. E. coli was well below target levels in all 12 monthly samples collected at site 256 on North Fork Salt Creek.

Samples were collected for source analysis at five sites in April 2021. All five had levels of E. coli below the state standard. Two of the five samples had sufficient coliphage residue for source analysis. Site EF06/256 on North Fork Salt Creek at Yellowwood Road was reported as having 54% coliphage strains connected to human sources and 46% coliphage strains connected to animal sources. Site EF20 (near 309) on Greasy Creek at State Road 46 was reported as having 94% coliphage strains connected to human sources and 6% coliphage strains connected to animal sources. However, these percentages do not reflect the true source probability as there are species of coliphage that can not be traced to a particular source. The primary conclusion to be drawn from these results is that both human and animal fecal contamination were present in the five samples where results were obtained.

The primary chemical constituent of concern appears to be phosphorus, with 16 of 17 spring samples exceeding the total phosphorus target, six of which also exceeded the soluble reactive phosphorus target. The highest concentration (0.040 mg/L) was reported at site 262 in Jackson Creek at the outlet of Yellowwood Lake.

The only nitrogen and nitrate exceedances were both in the fall at the same site, 385 on North Fork Salt Creek, which had levels of total nitrogen and nitrates one hundred times the target levels. This site is located at the Deer Run Boat Ramp and is surrounded by cropland to the north as well as being located downstream from the Nashville wastewater treatment plant.

Monthly samples collected at site 389 on North Fork Salt Creek also reported multiple total phosphorus and soluble reactive phosphorus exceedances. Nitrogen and nitrate exceedances were minimal (1/12 and 2/12) and were only slightly above the target. The site did experience three total suspended solids exceedances. The two highest TSS levels were reported for 2/25/21 and 3/18/21 when average daily streamflow measured at the North Fork stream gage

was over 500 cfs. For comparison, the other ten sampling events were on days with streamflow less than 130 cfs and nine of them were less than 50 cfs.

*Table 1-61 Clay Lick Creek Sampling Blitz Results - Nutrients*

Blitz ID	Creek Name	Fall TN (mg/L)	Spring TN (mg/L)	Fall NO3 (mg/L)	Spring NO3 (mg/L)	Fall TP (mg/L)	Spring TP (mg/L)	Fall SRP (mg/L)	Spring SRP (mg/L)
208	Lick Creek		0.127		0.089		0.015		0.005
210	Owl Creek	0.108	0.255	0.008	0.177	0.002	0.027	0.002	0.011
250	Clay Lick Creek	0.100	0.101	0.008	0.046	0.002	0.024	0.003	0.004
256	North Fork Salt Creek	0.251		0.008		0.020		0.003	
262	Jackson (Yellowwood) Creek	0.105	0.349	0.008	0.150	0.014	0.040	0.002	0.004
273	Jackson (Yellowwood) Creek	0.100	0.100	0.013	0.017	0.017	0.103	0.003	0.027
277	Lick Creek	0.100	0.100	0.008	0.024	0.016	0.022	0.002	0.004
282	Clay Lick Creek	0.259	0.148	0.008	0.086	0.028	0.026	0.004	0.005
297	Clay Lick Creek		0.169		0.094		0.034		0.015
305	Unnamed tributary of Greasy Creek		0.100		0.011		0.022		0.003
306	Greasy Creek	0.100	0.197	0.028	0.100	0.002	0.023	0.006	0.005
309	Greasy Creek	0.163	0.202	0.008	0.099	0.003	0.028	0.003	0.005
368	Sciscoe Branch		0.100		0.010		0.027		0.009
373	Green Valley Creek	0.171	0.210	0.052	0.103	0.002	0.022	0.003	0.005
385	North Fork Salt Creek	6.792	0.406	6.605	0.307	0.002	0.026	0.005	0.006
389	North Fork Salt Creek	0.100	0.389	0.012	0.303	0.002	0.030	0.003	0.004
398	North Fork Salt Creek	0.109	0.350	0.008	0.278	0.002	0.026	0.003	0.004
440	Owl Creek	0.402	0.267	0.204	0.164	0.006	0.032	0.002	0.006

Table 1-62 Clay Lick Creek Sampling Blitz Results - E. coli and Sediment

Blitz ID	Creek Name	Fall E. Coli (MPN/ 100 mL)	Spring E. coli (MPN/ 100 mL)	Fall TSS (mg/L)	Spring TSS (mg/L)
208	Lick Creek		23		0.6
210	Owl Creek	1	4	1.7	0.5
250	Clay Lick Creek	9	11	2.7	0.5
256	North Fork Salt Creek	4		6.7	
262	Jackson (Yellowwood) Creek	4	-	1.2	3.4
273	Jackson (Yellowwood) Creek	1	1	2.2	0.6
277	Lick Creek	378	20	0.5	0.5
282	Clay Lick Creek	214	-	4.3	0.5
297	Clay Lick Creek		3		0.6
305	Unnamed tributary of Greasy Creek		5		0.5
306	Greasy Creek	23	50	0.5	0.5
309	Greasy Creek	73	21	5	0.5
368	Sciscoe Branch		33		0.5
373	Green Valley Creek	28	3	1.2	0.5
385	North Fork Salt Creek	10	27	2.8	1.6
389	North Fork Salt Creek	16	17	2.5	0.6
398	North Fork Salt Creek	1,986	15	5.2	1.2
440	Owl Creek	299	9	17.2	0.5

Table 1-63 Clay Lick Creek BCRSD E. coli Sampling Results May 2020

BCRSD Site ID	Blitz Site ID	Stream	5-May	12-May	19-May	26-May	2-Jun	Geo. Mean	> State Geomean (125)
EF05	near 262	Outlet Yellowwood Lake	87	33	87	461	13	69	no
EF06	256	North Fork Salt Creek	705	310	1,170	32	126	253	yes
EF07	277	Lick Creek	449	22	401	93	59	117	no
EF08	near 389	North Fork Salt Creek	1,440	58	811	1,990	122	439	yes
EF09	250	Clay Lick	85	36	171	187	25	76	no
EF10	near 398	North Fork Salt Creek	424	195	661	345	96	283	yes
EF20	near 309	Greasy Creek	755	83	276	365	228	270	yes

Table 1-64 Clay Lick Creek Fecal Contamination Source Analysis April 2021

BC_ID	LM_ID	Stream	4/27/21 E. Coli	Coliform (PFU/100ml)	% Human	% Animal
	440	Owl Creek (above West Branch Owl Creek)	48.7	< 1	NA	NA
EF06	256	North Fork Salt (Yellowwood Rd)	56.5	0.6	54	46
EF08	near 389	North Fork Salt (SR 46 below Salt Creek Trail)	167.0	< 1	NA	NA
EF20	near 309	Greasy Creek (downstream @ SR-46)	205.0	0.4	94	6
EF10	near 398	North Fork Salt (above Gnaw Bone Creek)	93.3	< 1	NA	NA

Table 1-65 North Fork Salt Creek Monthly Sampling at Site 256 in Clay Lick Creek Subwatershed

Site 256 Sample Date	North Fork E. coli (cfu/100 ml)	North Fork TSS (mg/L)	North Fork TN (mg/L)	North Fork NO3 (mg/L)	North Fork TP (mg/L)	North Fork SRP (mg/L)
4/22/2020	66	7.6	0.194	0.123	0.018	0.006
5/27/2020	210	30.8	0.396	0.268	0.022	0.008
6/24/2020	70	2.8	0.554	0.104	0.028	0.006
7/21/2020	184	0.5	0.422	0.117	0.037	0.005
8/27/2020	58	2.5	0.369	0.140	0.022	0.004
9/24/2020	15	5.5	0.256	0.008	0.019	0.003
10/22/2020	58	4.8	0.357	0.008	0.036	0.012
11/19/2020	23	1.8	0.331	0.450	0.021	0.01
12/16/2020	41	2	0.693	0.700	0.016	0.005
1/25/2021	15	1.6	0.603	0.645	0.015	0.003
2/25/2021	105	101.3	0.683	0.478	0.048	0.01
3/18/2021	185	148.6	0.533	0.249	0.040	0.009

A review of historical data revealed that sampling was conducted in 2005-2006 as part of developing a Watershed Management Plan for Yellowwood Lake. The lake was on the 2004 list of Impaired Waterbodies as a Category 5B impairment for mercury in Largemouth bass. However, Indiana guidance states that that developing conventional Total Maximum Daily Limits (TMDLs)



for mercury is not an appropriate approach as most mercury sources are airborne and therefore managing mercury was limited to education in the plan with no mercury sampling conducted. Water samples were analyzed for sediment, nutrients, and E. coli.

Sampling results indicated moderate levels of phosphorus in Yellowwood Lake with the majority of samples within Carlson's Trophic State Index (TSI) mesotrophic range. Nitrogen levels were relatively low suggesting that the lake is nitrogen limited. Stream sampling in the watershed using Hoosier Riverwatch procedures also suggested that the Yellowwood Lake watershed did not have any significant chemical water quality impairments.

A bathymetric study of Yellowwood Lake in 2006 showed significant sediment accumulation and loss of water depth throughout the lake but with the greatest accumulation concentrated in the north end of the lake and near inlets where up to 5.5 feet had accumulated since 1955. Total sediment accumulation was less than 1% of the 1955 lake basin volume over 65 years. However, the degree of accumulation in the north end of the lake has had a significant impact on aesthetic qualities and usability. The north end of Yellowwood Lake was subsequently dredged 2008-2010. Roughly 6 to 8 feet of sediment was removed from a 17-acre area, totaling 5.2 million cubic feet of sediment. During the project, an underwater ridge was constructed across the north end of the lake in the hopes of creating a sediment trap to keep incoming sediment in the very north end of the lake. Several fish structures were also installed.

E.coli measurements were taken as part of the watershed management plan for Yellowwood Lake in 2004-2006. E. coli sampling for Yellowwood Lake's tributaries was conducted roughly monthly in Jackson Creek and roughly quarterly in John Floyd Hollow between October 2004 and May 2006 by volunteers using the Coliscan Easygel method. Four additional samples were collected from Jackson Creek using a contracted (professional) service. The results from the contracted service were several orders of magnitude less than the volunteers' results, leading the watershed plan steering committee to question the validity of the volunteers' results. One of the four contracted samples had levels of E. coli slightly above the state standard of 235 colonies per 100 mL while fourteen of the seventeen volunteers' samples had E. coli levels above the state standard with six samples exceeding 1,000 colonies per 100 mL. The watershed management plan recommended additional monitoring, education about septic system maintenance, and education about equestrian manure management.

#### 1.11.5 Habitat and Biological Assessment

##### **Habitat/Biological Information**

Volunteers completed the Citizen Qualitative Habitat Evaluation Index (CQHEI) habitat assessment at all 18 sites during the fall blitz and 17 sites during the spring blitz. Although a comparison scale for the CQHEI has not yet been developed, Hoosier Riverwatch indicates that scores greater than 60 rate as habitat conducive to supporting warm-water biota (IDNR, 2004). CQHEI scores ranged from 40.5 to 70.7 during the fall blitz and 50 to 88 during the spring blitz. Only 28% of sites scored above

60 during the fall blitz and only 56% of sites scored above 60 during the spring blitz, indicating poor habitat in many streams. The stream sections with consistently low CQHEI scores were site 208 on Lick Creek, site 256 on North Fork Salt Creek (not evaluated in the spring), site 273 on Jackson Creek, site 305 on an unnamed tributary of Greasy Creek, site 368 on Siscoe Branch, site 398 on North Fork Salt Creek, and site 440 on Owl Creek. Most sites scored higher during the spring blitz (likely due to higher water flow) but site 385 on North Fork Salt Creek dropped from a score of 70 to a score of 50.

*Table 1-66 Clay Lick Creek Sampling Blitz Results - Habitat Assessment (CQHEI)*

Blitz ID	Stream Name	Fall 2020 CQHEI	Spring 2021 CQHEI
208	Lick Creek	57	55.5
210	Owl Creek	47	62
250	Clay Lick Creek	65.7	81.5
256	North Fork Salt Creek	48.8	
262	Jackson (Yellowwood) Creek	66.7	62
273	Jackson (Yellowwood) Creek	59.2	59.5
277	Lick Creek	51	61.5
282	Clay Lick Creek	70.7	88
297	Clay Lick Creek	49.2	82.5
305	Unnamed tributary of Greasy Creek	40.5	51
306	Greasy Creek	59	64
309	Greasy Creek	46	78
368	Sciscoe Branch	59	60
373	Green Valley Creek	58	76.2
385	North Fork Salt Creek	70	50
389	North Fork Salt Creek	67	77
398	North Fork Salt Creek	60	54
440	Owl Creek	50	51
	Average CQHEI	56.9	65.5
	% of Sites >60	28%	56%

*Table 1-67 Habitat and Biological Sampling in Clay Lick Subwatershed*

Sampler and Date	Site ID	Stream	Station	mIBI	mIBI Rating	QHEI	QHEI Rating
IU Limno Lab August 2020	256	North Fork Salt	Yellowwood Road Bridge	20	Impaired (<36)	60	Good

No stream sections in the subwatershed were evaluated using fish-based Index of Biotic Integrity. The IU Limnology Lab evaluated habitat using the Qualitative Habitat Evaluation Index (QHEI) at the

monthly sampling site 256 on North Fork Salt Creek and gave it a score of 60, indicating good habitat. This contrasts with the CQHEI score of 48.8 assigned during the fall blitz, indicating poor habitat, but the site was not re-evaluated during the spring blitz. In August 2020, the IU Limnology Lab collected macroinvertebrates and gave site 256 a mIBI score of 20, indicating impairment.

#### 1.11.6 Clay Lick Creek Subwatershed Summary

The Clay Lick Creek subwatershed is one of the largest and contains significant areas of both agricultural and developed land. Erosion and insufficient riparian buffer were observed throughout the watershed. Phosphorus and E. coli appear to be the main concerns. Sixteen of seventeen spring blitz samples exceeded the total phosphorus standards as did 8 of 12 monthly sampling events collected at site 256 on North Fork Salt Creek at Yellowwood Road. E. coli data collected by BCRSD indicate elevated levels in multiple sites on North Fork Salt Creek as well as Greasy Creek. Source sampling indicates both human and animal sources. Habitat scores evaluated using CQHEI were low at over half the sampling site locations though the QHEI score for site 256 on North Fork Salt Creek was good. Logjams were reported in several sections of North Fork Salt Creek.

## 1.12 Brummett Creek – North Fork (HUC 051202080605)

The Brummett Creek Subwatershed (HUC 12 – 051202080605) straddles the Monroe-Brown county line with about a third in Monroe County and two thirds in Brown County as shown in Figure 4-35. The subwatershed is the third largest, encompassing approximately 23,857 acres and representing 9% of the overall watershed. The subwatershed contains a lower portion of North Fork Salt Creek as well as its tributaries Brummett Creek, Schooner Creek and Wolfpen Branch.

According to the IDEM 303(d) list, there are no impaired streams within the Brummett Creek Subwatershed.

### 1.12.1 Land Use

Landuse within the Brummett Creek Subwatershed consists primarily of forestland with approximately 7% agricultural land. Cultivated crops are located primarily along Brummett Creek, North Fork Salt Creek, and the lower section of Schooner Creek. Pasture is primarily located along North Fork Salt Creek and the middle section of Brummett Creek. Additional land that was classified as herbaceous and field verified as pasture is located along upper Schooner Creek, Baby Creek, and the ridge between Brummett Creek and its largest tributary. Population density is low and generally located along the main roads (State Road 46, Upper Schooner Road, Brummetts Creek Road).

About half of the subwatershed is publicly owned. This includes portions of Brown County State Park (in the east), Yellowwood State Forest, Morgan-Monroe State Forest, T.C. Steele State Historic Site, and Lake Monroe State Park. The land managed as part of Lake Monroe State Recreational Area includes the floodplain of North Fork Salt Creek (between Kent Road and State Road 46) as well as the downstream portion of the Brummett Creek floodplain (along Brummetts Creek Road). Much of this land is cropland that the DNR leases to farmers.

### 1.12.2 Point Source Water Quality Issues

The Brummett Creek Subwatershed contains no confined feeding operations and three NPDES permitted facilities. A review of the IDEM Virtual Filing Cabinet found no violations for Unionville Elementary WWTP (northwest corner of the subwatershed) or Greg Rose Properties WWTP (which is located in the northeast corner of the subwatershed and is not yet operational as the proposed subdivision has not been constructed).

The Brown County State Park WWTP (eastern edge of the subwatershed) has received and responded to a series of compliance letters since 2015. Many of the issues were administrative in nature (late in permit renewal, used the wrong log sheets) but several significant issues were identified. An inspection in October 2015 revealed several areas of inflow/infiltration into the sewage system that the park has subsequently been working to identify and replace. The concern was repeated in March 2016, October 2016, and January 2017 compliance letters from IDEM. The January 2017 letter also referenced an exceedance in E. coli levels in June 2016, which according to the park's response was addressed by cleaning the ultraviolet chamber tank and subsequent readings were within limits. Another violation letter was issued in March 2020 which described a sewer overflow that may have reached North Fork Salt Creek. This concern was repeated in a June 2020 violation letter. The park responded both times that they have increased monitoring frequency and are also investigating if a pump repair or system upgrade may be needed to handle peak flows.

The Brown County State Park treatment plant only handles the central portion of the park (campgrounds, nature center, office) while the Abe Martin Lodge sends its wastewater to the Nashville treatment plant and the horseman's camp has an on-site septic system. As the Nashville treatment plant considers expansion, there has been discussion about closing the Brown County State Park treatment plant and sending wastewater from the central portion of the park to Nashville as well.

### 1.12.3 Non-Point Source Water Quality Issues

In early spring 2020, the watershed coordinator conducted a windshield survey which included 31 stream crossing sites within the Brummett Creek Subwatershed. Observations including streambank erosion, stream buffers, and livestock access were recorded for each site and the results are summarized below. Streambank erosion was noted at 27 of the 31 observed sites and lack of

sufficient riparian buffer was observed at 9 of the 31 observed sites. Livestock access was documented at 2 of 31 sites.

Table 1-68 Brummett Creek Windshield Survey Summary

Parameter	Observations
Streambank Erosion	3/31 sites with erosion >3' 24/31 sites with erosion <3' 4/31 sites with no erosion
Stream Buffers	4/31 sites with no buffers 5/31 sites with buffers <20' 22/31 sites with buffers >20'
Livestock Access to Streams	2/31 sites with livestock access

Figure 1-35 Brummett Creek (North Fork) Subwatershed

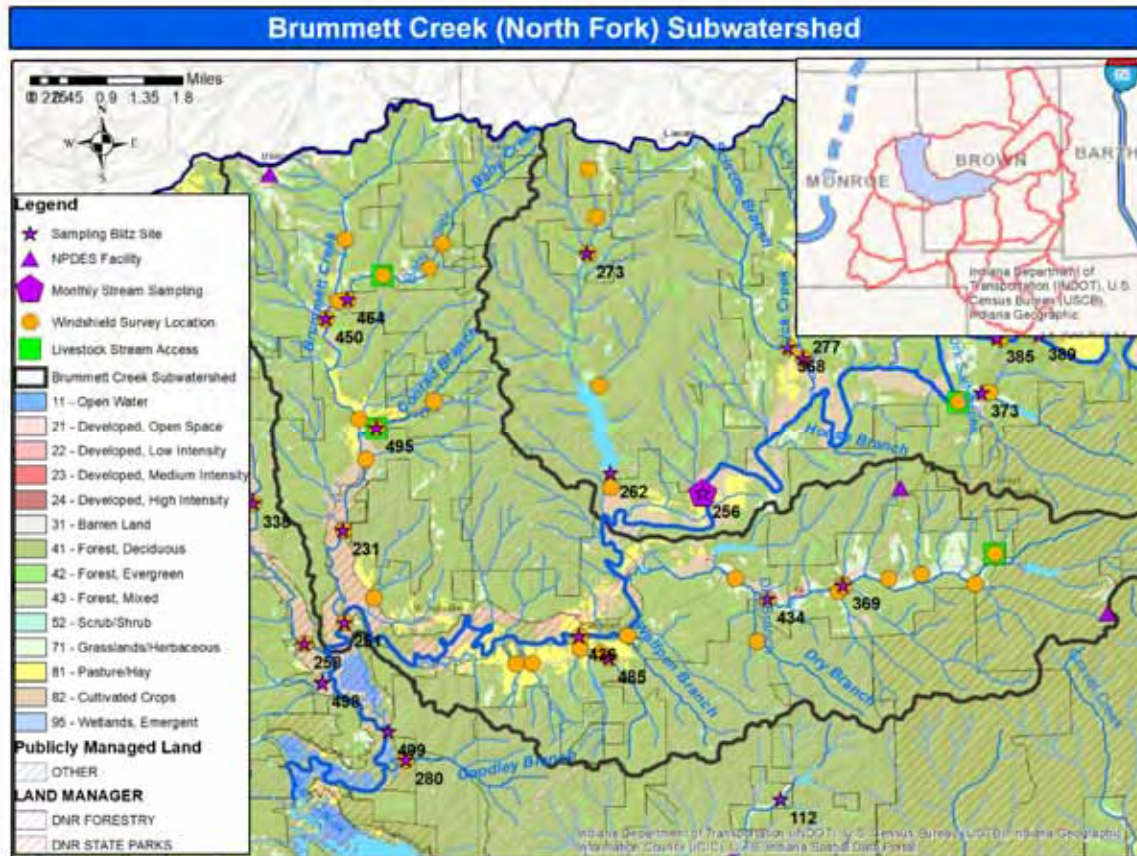


Figure 1-36 Site 467 - Livestock with Access to Baby Creek



#### 1.12.4 Water Quality Assessment

Nine sites were selected for the spring and fall watershed sampling blitz events though two were dry at the time of the fall sampling blitz and one was missed during the spring sampling blitz (site 436 on North Fork Salt Creek). Samples were analyzed for a variety of chemical parameters and *E. coli*. Habitat was evaluated using CQHEI. Macroinvertebrates and the fish community have not been assessed in this subwatershed. No monthly sampling locations or stream gages are located in this subwatershed.

##### **Water Quality Information**

Water chemistry data from the Brummett Creek subwatershed suggest that the primary constituent of concern is phosphorus, with 6 of 8 spring samples exceeding the total phosphorus target of 0.02 mg/L. 1 of 7 fall samples and 1 of 8 spring samples also exceeded the soluble reactive phosphorus target. There were no recorded exceedances for *E. coli*, total suspended solids, total nitrogen, or nitrates during the blitz events.

However, sampling conducted by the Brown County Regional Sewer District in spring 2020 at site 436 on North Fork Salt Creek at Belmont revealed 3 out of 5 exceedances and a geometric mean exceeding the state standard of 125 CFU/100 ml, indicating an *E. coli* concern in North Fork Salt Creek within the Brummett Creek subwatershed. BCRSD sampling also identified *E. coli* as a concern in North Fork Salt Creek upstream in the Clay Lick subwatershed. They did not sample further downstream as North Fork crosses into Monroe County less than two miles downstream from site 436.

Table 1-69 Brummett Creek Sampling Blitz Results - Nutrients

Blitz ID	Creek Name	Fall TN (mg/L)	Spring TN (mg/L)	Fall NO3 (mg/L)	Spring NO3 (mg/L)	Fall TP (mg/L)	Spring TP (mg/L)	Fall SRP (mg/L)	Spring SRP (mg/L)
231	Brummett Creek	0.135	0.359	0.010	0.192	0.002	0.023	0.002	0.003
251	North Fork Salt Creek	0.420	0.303	0.008	0.169	0.016	0.037	0.003	0.004
369	Upper Schooner Creek	0.109	0.224	0.116	0.138	0.002	0.028	0.006	0.009
434	Lower Schooner Creek	0.100	0.214	0.019	0.114	0.002	0.024	0.002	0.005
436	North Fork Salt Creek	0.174		0.008		0.008		0.002	
450	Brummett Creek	0.100	0.201	0.063	0.098	0.002	0.020	0.002	0.004
464	Baby Creek	0.100	0.114	0.011	0.055	0.002	0.023	0.002	0.008
485	Davis Branch		0.100		0.053		0.022		0.005
495	Conrad Branch		0.179		0.114		0.020		0.003

Table 1-70 Brummett Creek Sampling Blitz Results - E. coli and Sediment

Blitz ID	Creek Name	Fall E. Coli (MPN/ 100 mL)	Spring E. coli (MPN/ 100 mL)	Fall TSS (mg/L)	Spring TSS (mg/L)
231	Brummett Creek	18	6	2.5	2.2
251	North Fork Salt Creek	10	31	9	8
369	Upper Schooner Creek	161	3	0.7	0.5
434	Lower Schooner Creek	55	4	0.7	1
436	North Fork Salt Creek	21		14.5	
450	Brummett Creek	1	2	0.7	0.5
464	Baby Creek	57	8	0.5	0.5
485	Davis Branch		2		7.4
495	Conrad Branch		12		0.5

Table 1-71 Brummett Creek BCRSD E. coli Sampling May 2020

BCRSD Site ID	Blitz Site ID	Stream	5-May	12-May	19-May	26-May	2-Jun	Geo. Mean	> State Geomean (125)
EF04	436	North Fork Salt Creek	338	112	1,630	365	128	310	yes

### 1.12.5 Habitat and Biological Assessment

#### Habitat/Biological Information

Volunteers completed the Citizen Qualitative Habitat Evaluation Index (CQHEI) habitat assessment at all 11 sites during the spring and fall sampling blitz events. Although a comparison scale for the CQHEI has not yet been developed, Hoosier Riverwatch indicates that scores greater than 60 rate as habitat conducive to supporting warm-water biota (IDNR, 2004). CQHEI scores ranged from 37 to 67 during the fall blitz and 59 to 82 during the spring blitz. While only 33% of sites scored above 60 during the fall blitz, 66% of sites scored above 60 during the spring blitz, indicating good habitat in most streams. The three stream sections that scored poorly during both blitz events were site 251 on North Fork Salt Creek, site 436 on North Fork Salt Creek (not sampled in the spring), and site 485 on Davis Branch.

Blitz ID	Stream Name	Fall 2020 CQHEI	Spring 2021 CQHEI
231	Brummett Creek	52	73.5
251	North Fork Salt Creek	59.5	59
369	Upper Schooner Creek	57	82
434	Lower Schooner Creek	65	81
436	North Fork Salt Creek	44	
450	Brummett Creek	67	79
464	Baby Creek	37	65.5
485	Davis Branch	46	59
495	Conrad Branch	63	81
	Average CQHEI	54.5	72.5
	% of Sites >60	33%	66%

No stream sections in the subwatershed were evaluated using the Qualitative Habitat Evaluation Index (QHEI), the fish-based Index of Biotic Integrity (IBI), or the macroinvertebrate Index of Biotic Integrity (mIBI).

### 1.12.6 Brummett Creek Subwatershed Summary

Water quality in the Brummett Creek subwatershed as evaluated through the blitz events was generally good. Phosphorus appears to be the primary constituent of concern with 6 of 8 samples exceeding the total phosphorus targets in the spring. However, E. coli sampling done by the Brown County Regional Sewer District indicate that E. coli is a concern in North Fork Salt Creek at site 436 in Belmont. Habitat scores were also low at three sites during both the spring and fall blitz events, including sites 436 and 251 on North Fork Salt Creek and site 485 on Davis Branch. Streambank erosion was observed throughout the Brummett Creek subwatershed (27 of 31 observed sites) though few sites (3 of 31) had severe erosion (> 3 feet).



## 1.13 Stephens Creek – North Fork (HUC 051202080606)

The Stephens Creek Subwatershed (HUC 12 – 051202080606) is located primarily in the eastern half of Monroe County with the southeast corner located in Brown County as shown in Figure 4-37. The subwatershed encompasses approximately 14,947 acres and represents 5% of the overall watershed. Stephens Creek and its tributary Kerr Creek discharge into North Fork Salt Creek along with Goodley Branch shortly before North Fork Salt Creek enters Lake Monroe. The Kerr Creek portion of the subwatershed has been identified by the Monroe County Highway Department as a critical area due to periodic flash flooding of Kerr Creek Road, which is located directly beside Kerr Creek.

According to the IDEM 303(d) list, there are no impaired streams within the Stephens Creek Subwatershed.

### 1.13.1 Land Use

Land use within the Stephens Creek Subwatershed consists primarily of forestland with the fourth highest percentage of agricultural land of the subwatersheds at 7%. Cropland is primarily located along Stephens Creek. Pasture is located primarily on the ridge along the northwestern edge of the watershed (adjacent to State Road 45) and the southwestern edge of the watershed (State Road 446) though land classified as herbaceous is scattered across the watershed and may be in use as pasture or hay fields. Population density is higher than average for the watershed and there are especially dense areas along the western edge of the subwatershed which includes the eastern edge of Bloomington. About a quarter of the land is publicly owned with the largest portion located in the southeastern corner.

### 1.13.2 Point Source Water Quality Issues

The Stephens Creek Subwatershed contains no confined feeding operations and no NPDES permitted facilities.

### 1.13.3 Non-Point Source Water Quality Issues

In early spring 2020, the watershed coordinator conducted a windshield survey which included 8 stream crossing sites within the Stephens Creek Subwatershed. Two additional livestock access sites were identified by local citizens. Observations including streambank erosion, stream buffers, and livestock access were recorded for each site and the results are summarized below. Streambank erosion was noted at all 8 of the observed sites and lack of sufficient riparian buffer was observed at 3 of the 8 observed sites. Livestock access was documented at 2 sites identified by local citizens. Several other sites had livestock that were fenced from the stream, including site 338 on Stephens Creek (see photo below).

Table 1-72 Stephens Creek Windshield Survey Summary

Parameter	Observations
Streambank Erosion	3/8 sites with erosion >3' 5/8 sites with erosion <3' 0/8 sites with no erosion
Stream Buffers	0/8 sites with no buffers 3/8 sites with buffers <20' 5/8 sites with buffers >20'
Livestock Access to Streams	2/10 sites with livestock access

Figure 1-37 Stephens Creek (North Fork) Subwatershed

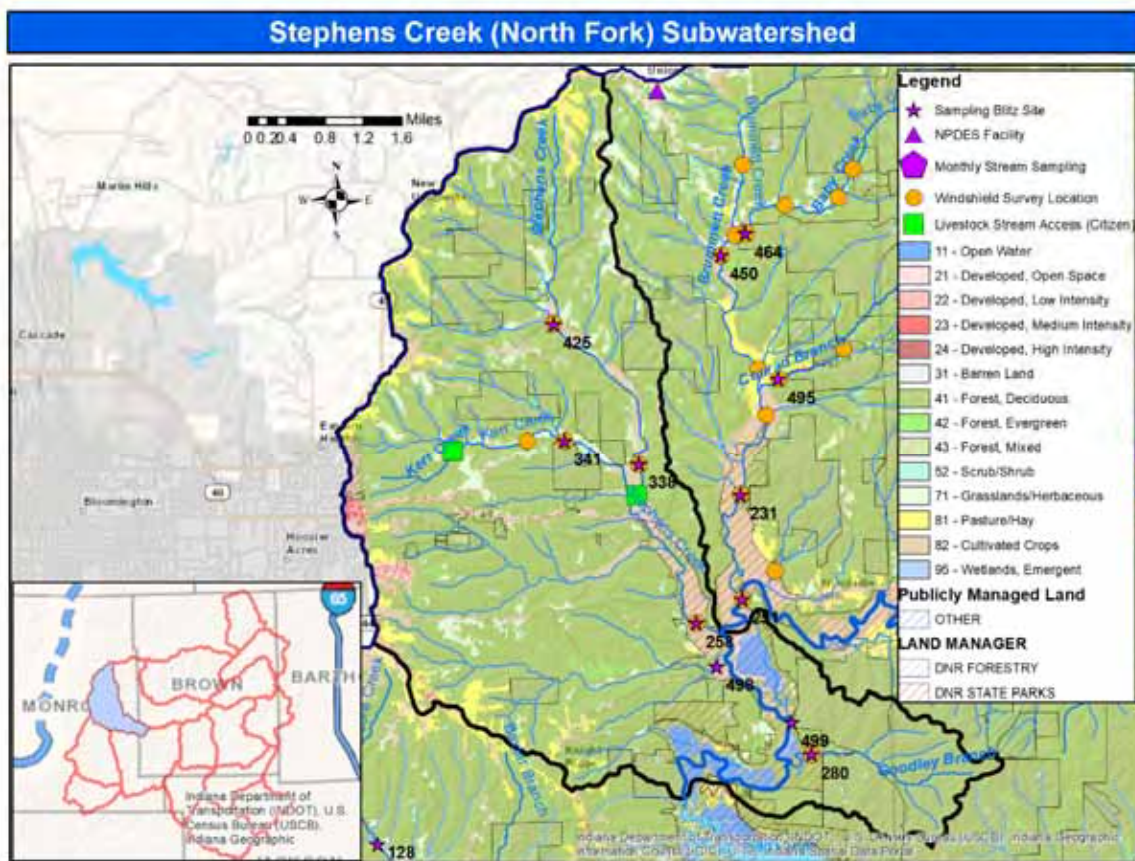


Figure 1-38 Site 338 on Stephens Creek (midstream)



#### 1.13.4 Water Quality Assessment

Seven sites were selected for the spring and fall watershed sampling blitz events. Samples were analyzed for a variety of chemical parameters and *E. coli*. Habitat was evaluated using CQHEI. Macroinvertebrates and the fish community have not been assessed in this subwatershed. No monthly sampling locations or stream gages are located in this subwatershed.

##### **Water Quality Information**

Water chemistry data from the Stephens Creek subwatershed suggest that *E. coli* is an issue in Kerr Creek (site 341) and the upstream portion of Stephens Creek (sites 425 and 338). *E. coli* levels were highest in the most upstream site (425), decreasing as the water moves downstream to the midstream site (338), and dropping below the target of 235 CFU/100 ml in lower Stephens Creek (site 258) as well as further downstream in North Fork Salt Creek (site 499) indicating that the bacteria is diluted as additional tributaries enter the stream. Two samples were submitted for source analysis but neither generated results.

*E. coli* and phosphorus appear to be the primary concerns though there were also two nitrogen exceedances. There was not a visible correlation between elevated *E. coli* counts and elevated nutrient levels – the two total phosphorus exceedances during the fall blitz were from sites that had low levels of *E. coli* and the three sites with *E. coli* exceedances during the fall blitz had low levels of total phosphorus.

There was one total nitrogen exceedance during the fall blitz, at site 499 on North Fork Salt Creek. The reported level of total nitrogen (2.420) was one of the highest recorded during the blitz, as was the reported level of total phosphorus (0.143). The reported soluble reactive phosphorus concentration (0.009) was also above the target. No exceedances were reported during the fall blitz at the upstream site 436 on North Fork Salt Creek (see section 4.12 Brummett Creek

subwatershed). Unfortunately, neither site was sampled during the spring blitz due to a volunteer cancellation.

The total nitrogen target was exceeded once during the spring blitz, at site 258 on lower Stephens Creek. This site also had levels of total phosphorus and soluble reactive phosphorus above water quality targets. The total phosphorus target was exceeded at five of six sites during the spring blitz and the soluble reactive phosphorus target was exceeded at three of six sites during the spring blitz.

Total suspended solids levels were below the target in all samples.

*Table 1-73 Stephens Creek Sampling Blitz Results - Nutrients*

Blitz ID	Creek Name	Fall TN (mg/L)	Spring TN (mg/L)	Fall NO3 (mg/L)	Spring NO3 (mg/L)	Fall TP (mg/L)	Spring TP (mg/L)	Fall SRP (mg/L)	Spring SRP (mg/L)
258	Stephens Creek (downstream)	0.162	0.829	0.008	0.279	0.024	0.027	0.002	0.006
280	Goodley Branch	0.380	0.100	0.008	0.012	0.028	0.020	0.003	0.004
338	Stephens Creek (midstream)	0.309	0.457	0.253	0.426	0.002	0.023	0.002	0.003
341	Kerr Creek	0.100	0.342	0.008	0.149	0.002	0.029	0.003	0.008
425	Stephens Creek (upstream)	0.269	0.271	0.221	0.199	0.002	0.032	0.007	0.005
498	Unnamed tributary of NF Salt	0.100	0.374	0.008	0.338	0.004	0.021	0.002	0.007
499	North Fork Salt Creek	2.420		0.008		0.143		0.009	

*Table 1-74 Stephens Creek Sampling Blitz Results - E. coli and Sediment*

Blitz ID	Creek Name	Fall E. Coli (MPN/ 100 mL)	Spring E. coli (MPN/ 100 mL)	Fall TSS (mg/L)	Spring TSS (mg/L)
258	Stephens Creek (downstream)	186	9	7.8	0.5
280	Goodley Branch	3	1	8.3	
338	Stephens Creek (midstream)	921	3	2.2	0.5
341	Kerr Creek	411	4	2	0.5
425	Stephens Creek (upstream)	1,986	5	3	0.5
498	Unnamed tributary of NF Salt	1	-	2.5	1.8
499	North Fork Salt Creek	1		22.7	0.5

Table 1-75 Stephens Creek Fecal Contamination Source Analysis April 2021

BC_ID	LM_ID	Subwatershed	Stream	4/27/21 E. Coli	Coliform (PFU/100ml)	% Human	% Animal
	425	Stephens (NF)	Stephens Creek	35.5	< 1	NA	NA
	341	Stephens (NF)	Kerr Creek	142.1	< 1	NA	NA

### 1.13.5 Habitat and Biological Assessment

#### Habitat/Biological Information

Volunteers completed the Citizen Qualitative Habitat Evaluation Index (CQHEI) habitat assessment at all 7 sites during the fall blitz and at 6 sites during the spring blitz. Although a comparison scale for the CQHEI has not yet been developed, Hoosier Riverwatch indicates that scores greater than 60 rate as habitat conducive to supporting warm-water biota (IDNR, 2004). CQHEI scores ranged from 37 to 74 during the fall blitz and 33.5 to 76 during the spring blitz. Only 57% of sites scored above 60 during the fall blitz and only 57% of sites scored above 60 during the spring blitz, indicating poor habitat in many streams. The three stream sites with low scores during both blitz events were site 258 on Stephens Creek (downstream), site 338 on Stephens Creek (midstream), and site 499 on North Fork Salt Creek (which was not evaluated in the spring). This indicates that larger and downstream stream sections tended to score worse on CQHEI.

Table 1-76 Stephens Creek Sampling Blitz Results - Habitat Assessment (CQHEI)

Blitz ID	Stream Name	Fall 2020 CQHEI	Spring 2021 CQHEI
258	Stephens Creek (downstream)	37	33.5
280	Goodley Branch	65.5	68
338	Stephens Creek (midstream)	58	51
341	Kerr Creek	72	73.5
425	Stephens Creek (upstream)	70	76
498	Unnamed tributary of NF Salt	74	65
499	North Fork Salt Creek	38.5	
	Average CQHEI	59.3	61.2
	% of Sites >60	57%	57%

No stream sections in the subwatershed were evaluated using the Qualitative Habitat Evaluation Index (QHEI), the fish-based Index of Biotic Integrity (IBI), or the macroinvertebrate Index of Biotic Integrity (mIBI).

### 1.13.6 Stephens Creek Subwatershed Summary

The Stephens Creek subwatershed appears to have E. coli issues that may be linked to livestock or to failing septic systems, as both livestock and houses on septic systems were observed in the subwatershed. Phosphorus also appears to be a concern with total phosphorus exceedances observed at all sites during at least one blitz event. Total phosphorus and total nitrogen were exceptionally high at site 499 on North Fork Salt Creek during the fall blitz and the site was not sampled during the spring blitz. Habitat scores were low in the middle and downstream sites on Stephens Creek as well as in North Fork Salt Creek (though it was only evaluated during the fall blitz).

## 1.14 Jacobs Creek – Lake Monroe (HUC 51202080701)

The Jacobs Creek Subwatershed (HUC 12 – 51202080701) straddles the Monroe/Brown County border as shown in Figure 4-40. It is the largest subwatershed, encompassing approximately 28,880 acres and representing 10% of the overall watershed. The subwatershed contains the upper basin of Lake Monroe (upstream/east of the State Road 446 causeway) as well as the tributaries Crooked Creek, Panther Creek, Will Hay Branch, Jones Branch, Axsom Branch, Saddle Creek, and Eel Creek.

According to the IDEM 303(d) list, Crooked Creek is impaired for E. coli, including several of its tributaries. Lake Monroe is also impaired for taste and odor, algal blooms, and mercury in fish.

### 1.14.1 Land Use

Landuse within the Jacobs Creek Subwatershed consists primarily of forestland with 15% as open water (Lake Monroe) and less than 1% agricultural land, the lowest percentage of the subwatersheds. Over 90% of the subwatershed is public land with the southern portion owned by the United States Forest Service, much of the central portion a part of Lake Monroe State Recreation Area, and the northern portion part of Yellowwood State Forest. The southern portion is designated as a wilderness area with few roads.

### 1.14.2 Point Source Water Quality Issues

The Jacobs Creek Subwatershed contains no confined feeding operations and one NPDES permitted facility, Salt Creek Services Waste Water Treatment Plant. A review of the IDEM virtual filing cabinet revealed no violations.

### 1.14.3 Non-Point Source Water Quality Issues

In early spring 2020, the watershed coordinator conducted a windshield survey which included 6 stream crossing sites within the Jacobs Creek Subwatershed. (There are relatively few stream crossings in the watershed due to the extensive amount of park land and open water.) Observations including streambank erosion, stream buffers, and livestock access were recorded for each site and the results are summarized below. Streambank erosion was noted at 3 of the 6 observed sites and lack of riparian buffer was noted at 4 of the 6 sites though all sites had at least some buffer. No sites with livestock access to streams were observed.

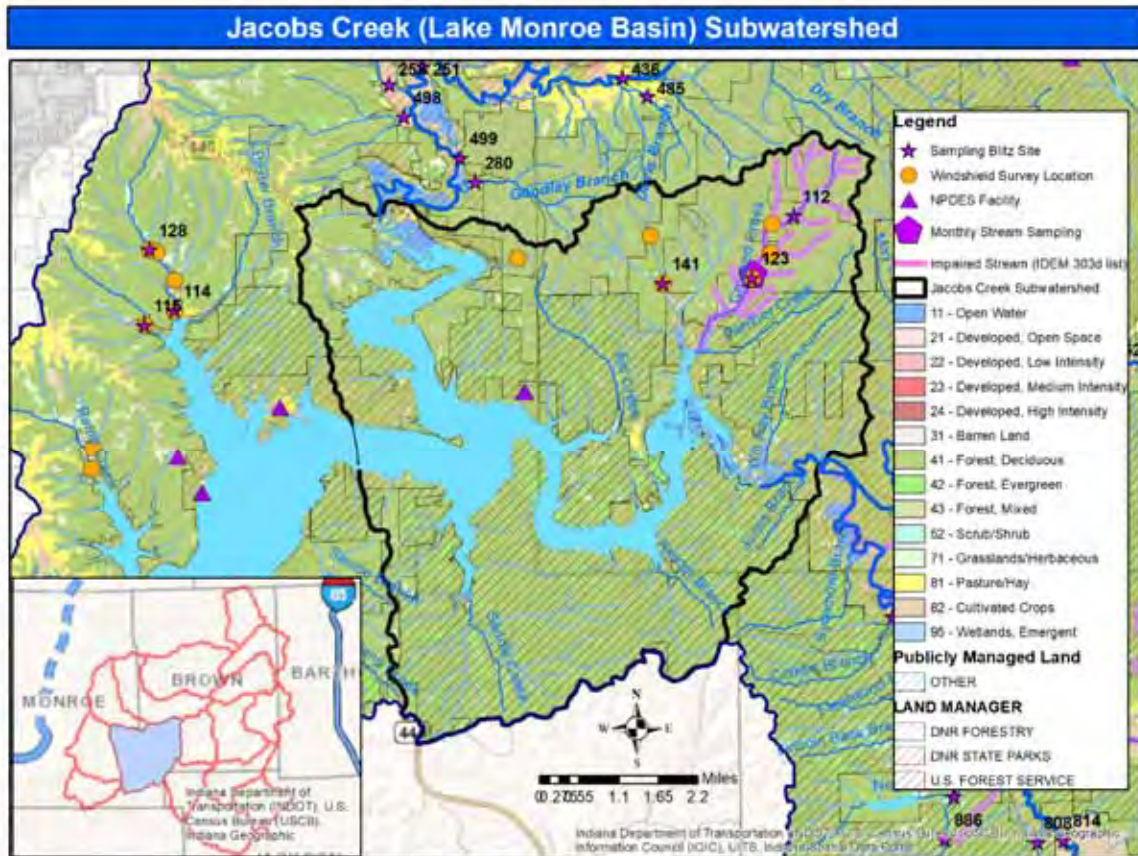
*Table 1-77 Jacobs Creek Windshield Survey Summary*

<b>Parameter</b>	<b>Observations</b>
Streambank Erosion	1/6 sites with erosion >3' 2/6 sites with erosion <3' 3/6 sites with no erosion
Stream Buffers	0/6 sites with no buffers 4/6 sites with buffers <20' 2/6 sites with buffers >20'
Livestock Access to Streams	0/6 sites with livestock access

*Figure 1-39 Site 121 Crooked Creek*



Figure 1-40 Jacobs Creek (Lake Monroe Basin) Subwatershed



#### 1.14.4 Water Quality Assessment

Three sites were selected for the spring and fall watershed sampling blitz events though all three were dry during the fall blitz. Samples were also collected monthly from Crooked Creek at site 123 though the creek was dry in September and October. Samples were analyzed for a variety of chemical parameters and E. coli. Habitat was evaluated using CQHEI. Macroinvertebrates were assessed in Crooked Creek during one of the monthly sampling events. No stream gages are located in this subwatershed. Lake sampling results are discussed in section 4.17.

#### Water Quality Information

Water chemistry data from the Jacobs Creek subwatershed suggest that the only constituent of concern is phosphorus. There were no exceedances for E. coli, total suspended solids, total nitrogen, or nitrates for the blitz samples or the monthly samples in Crooked Creek. However, all three spring blitz samples had total phosphorus levels above the target level of 0.02 mg/L and two of the three spring blitz samples had soluble reactive phosphorus levels above the target level of 0.005 mg/L. Of the ten monthly samples collected in Crooked Creek, the only exceedances were for soluble reactive phosphorus, which was above the target level of 0.005 mg/L in 3 of 10 samples.



Table 1-78 Jacobs Creek Sampling Blitz Results - Nutrients

Blitz ID	Creek Name	Fall TN (mg/L)	Spring TN (mg/L)	Fall NO3 (mg/L)	Spring NO3 (mg/L)	Fall TP (mg/L)	Spring TP (mg/L)	Fall SRP (mg/L)	Spring SRP (mg/L)
112	Crooked Creek		0.322		0.083		0.037		0.007
123	Crooked Creek		0.129		0.054		0.027		0.010
141	Unnamed tributary of Lake Monroe		0.100		0.057		0.027		0.004

Table 1-79 Jacobs Creek Sampling Blitz Results - E. coli and Sediment

Blitz ID	Creek Name	Fall E. Coli (MPN/ 100 mL)	Spring E. coli (MPN/ 100 mL)	Fall TSS (mg/L)	Spring TSS (mg/L)
112	Crooked Creek		2		2.6
123	Crooked Creek		1		0.5
141	Unnamed tributary of Lake Monroe		15		0.5

Table 1-80 Monthly Sampling of Crooked Creek at Site Site 123 in Jacobs Creek Subwatershed

Site 123	Crooked Creek E. coli (cfu/100 ml)	Crooked Creek TSS (mg/L)	Crooked Creek TN (mg/L)	Crooked Creek NO3 (mg/L)	Crooked Creek TP (mg/L)	Crooked Creek SRP (mg/L)
4/22/2020	6	1.3	0.100	0.067	0.010	0.002
5/27/2020	13	1.6	0.172	0.142	0.009	0.002
6/24/2020	60	1	0.328	0.200	0.014	0.007
7/21/2020	65	0.5	0.302	0.175	0.004	0.003
8/27/2020	157	0.7	0.252	0.136	0.005	0.005
9/24/2020	dry	dry	dry	dry	dry	dry
10/22/2020	dry	dry	dry	dry	dry	dry
11/19/2020	2	0.5	0.100	0.010	0.007	0.004
12/16/2020	1	0.5	0.100	0.043	0.005	0.004
1/25/2021	4	0.2	0.100	0.066	0.005	0.003
2/25/2021	7	3.2	0.407	0.241	0.016	0.008
3/18/2021	16	3.8	0.202	0.105	0.011	0.006

#### 1.14.5 Habitat and Biological Assessment

##### Habitat/Biological Information

Volunteers completed the Citizen Qualitative Habitat Evaluation Index (CQHEI) habitat assessment at all 3 sites during the spring and fall sampling blitz events. Although a comparison scale for the CQHEI has not yet been developed, Hoosier Riverwatch indicates that scores greater than 60 rate as habitat conducive to supporting warm-water biota (IDNR, 2004). CQHEI scores ranged from 56 to 64 during the fall blitz and 66 to 71 during the spring blitz. While 67% of sites scored above 60 during the fall blitz, 100% of sites scored above 60 during the spring blitz, indicating good habitat throughout the subwatershed. Higher CQHEI scores in the spring are likely due to increased streamflow levels.

*Table 1-81 Jacobs Creek Sampling Blitz Results - Habitat Assessment (CQHEI)*

Blitz ID	Stream Name	Fall 2020 CQHEI	Spring 2021 CQHEI
112	Crooked Creek	64	70
123	Crooked Creek	56	66
141	Unnamed tributary of Lake Monroe	61	71
	Average CQHEI	60.3	69.0
	% of Sites >60	67%	100%

*Table 1-82 Habitat and Biological Sampling in Jacobs Creek Subwatershed*

Sampler and Date	Site ID	Stream	Station	mIBI	mIBI Rating	QHEI	QHEI Rating
IU Limno Lab August 2020	123	Crooked Creek	Tecumseh Trail	28	Impaired (<36)	49	Fair

No stream sections in the subwatershed were evaluated using fish-based Index of Biotic Integrity. The IU Limnology Lab evaluated habitat using the Qualitative Habitat Evaluation Index (QHEI) at the monthly sampling site 123 and gave it a score of 49, indicating fair habitat for a small stream. CQHEI scores during the fall and spring blitz events were reported as 56 and 66, respectively, indicating poor habitat in the fall and good habitat in the spring (potentially due to dry conditions during the fall blitz). In August 2020, the IU Limnology Lab collected macroinvertebrates and gave it a mIBI score of 28, indicating biological impairment.

#### 1.14.6 Jacobs Creek Subwatershed Summary

Since Crooked Creek is listed on the IDEM 303(d) list as impaired for E. coli, elevated E. coli levels were anticipated in the stream. However, all 12 samples collected from Crooked Creek (11 at site 123 and 1 at upstream site 112) had E. coli concentrations well below the E. coli target of 235

Lake Monroe Watershed Management Plan Appendix J – Detailed HUC12 Subwatershed Analysis

CFU/100 ml, indicating that E. coli is not an issue. Several phosphorus exceedances were recorded (3 of 13 total phosphorus samples and 5 of 13 soluble reactive phosphorus samples) which may indicate a phosphorus concern. Habitat scores in the two evaluated streams were good. Although 4 of the 6 windshield survey sites had insufficient riparian buffer, they do not appear to be representative of the rest of the watershed, which is heavily forested and comprised mainly of public land.

## 1.15 Moore Creek – Lake Monroe Basin (HUC 51202080702)

The Moore Creek Subwatershed (HUC 12 – 51202080702) is located in southeastern Monroe County as shown in Figure 4-43. The subwatershed encompasses approximately 18,240 acres and represents 7% of the overall watershed. The subwatershed contains the central portion of Lake Monroe (west of the State Road 446 causeway and east of the Allens Creek State Recreation Area) as well as the tributaries Moore Creek, Butcher Branch, Baxter Branch, Ramp Creek, and Siscoe Branch.

According to the IDEM 303(d) list, Lake Monroe is impaired for taste and odor, algal blooms, and mercury in fish. No other impairments were identified in Moore Creek Subwatershed.

### 1.15.1 Land Use

Landuse within the Moore Creek Subwatershed is 67% forestland, 21% open water (Lake Monroe), and about 7% agriculture. Pasture and cropland are generally located on ridgetops, particularly along the edges of the Lake Monroe watershed and along Handy Ridge Road. Herbaceous land that is likely pasture is located along Moore Creek Road and Ramp Creek Road. Population is concentrated along the northern and western edges of the watershed. Several parcels of land in the eastern portion of the watershed are publicly owned as part of the Morgan Monroe State Forest, the Hoosier National Forest, and the Lake Monroe State Recreational Area.

### 1.15.2 Point Source Water Quality Issues

The Moore Creek Subwatershed contains no confined feeding operations. There are three NPDES permitted facilities identified in the subwatershed but one, NPDES Permit No. IN0050105 (South Central Regional Sewer District), is incorrectly mapped. The permit belongs to the Lake Monroe RSD Stinesville facility, which is located in Stinesville and discharges to Beanblossom Creek.

The two NPDES permitted facilities actually in the subwatershed are the Paynetown Waste Water Treatment Plant (Paynetown WWTP) and the Bloomington Utilities Monroe Drinking

Water Treatment Plant (Bloomington Water Plant). A review of the IDEM virtual filing cabinet revealed that the Bloomington Water Treatment Plant reported a minor incident in 2019 where a heavy rainfall caused the sludge settling basins to overflow but not reach the receiving waters. The 2018 inspection noted that the lower sludge handling pond was in urgent need of sludge removal. No other issues were found. The Paynetown WWTP received an inspection report in 2018 indicating potential issues with one of the effluent lines and a piece of laboratory equipment. These issues were not mentioned in later inspections.

### 1.15.3 Non-Point Source Water Quality Issues

In early spring 2020, the watershed coordinator conducted a windshield survey which included 8 stream crossing sites within the Moore Creek Subwatershed. (Most roads in this subwatershed run along ridgetops and do not cross streams.) Observations including streambank erosion, stream buffers, and livestock access were recorded for each site and the results are summarized below. Streambank erosion was noted at 3 of 8 sites and lack of sufficient riparian buffer was observed at 1 of 8 sites. No sites had livestock with access to streams.

*Table 1-83 Moore Creek Windshield Survey Summary*

Parameter	Observations
Streambank Erosion	1/8 sites with erosion >3' 2/8 sites with erosion <3' 5/8 sites with no erosion
Stream Buffers	0/8 sites with no buffers 1/8 sites with buffers <20' 7/8 sites with buffers >20'
Livestock Access to Streams	0/8 sites with livestock access

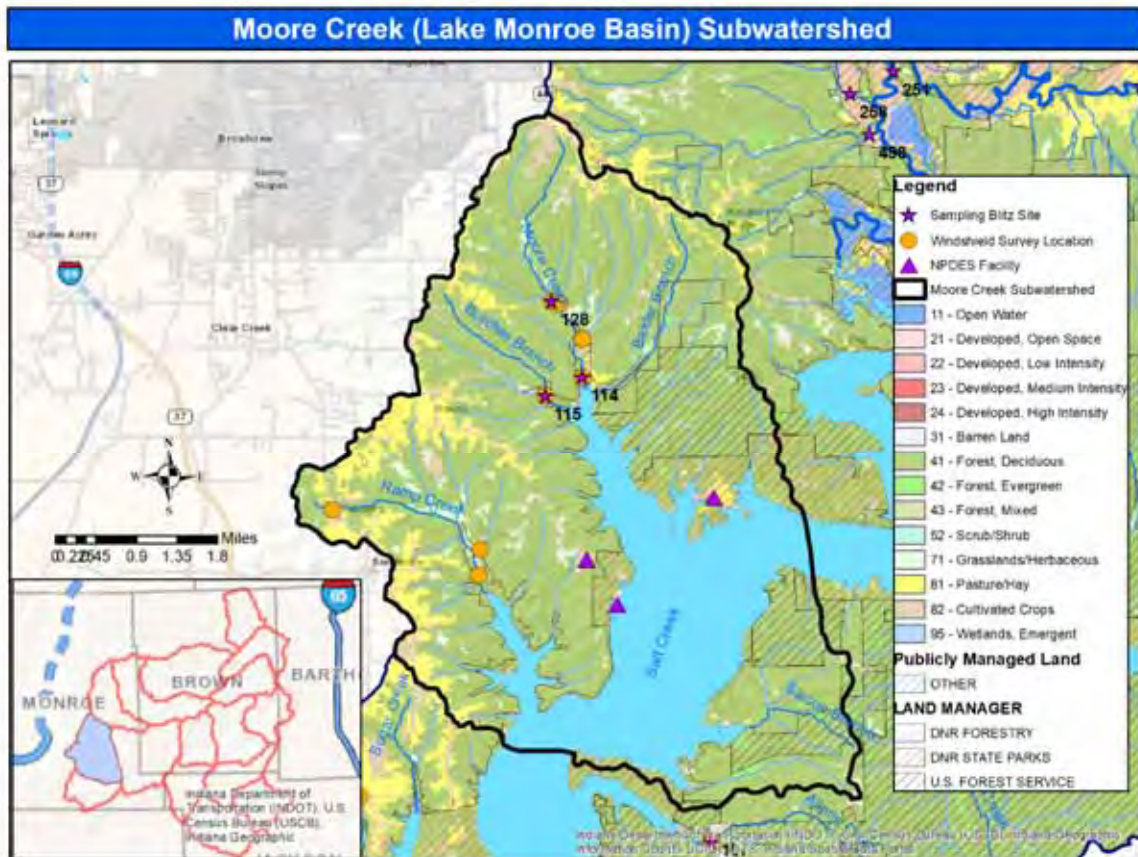
*Figure 1-41 Site 114 - Moore Creek entering Lake Monroe*



Figure 1-42 Site 115 - Butcher Branch



Figure 1-43 Moore Creek (Lake Monroe Basin) Subwatershed Map



#### 1.15.4 Water Quality Assessment

Three sites were selected for the spring and fall watershed sampling blitz events though two were dry during the fall blitz. Samples were analyzed for a variety of chemical parameters and E. coli. Habitat was evaluated using CQHEI. Macroinvertebrates and the fish community have not been

assessed in this subwatershed. No monthly sampling locations or stream gages are located in this subwatershed.

### Water Quality Information

Water chemistry data from the Moore Creek subwatershed suggest that phosphorus may be a concern in the subwatershed, with all three spring samples exceeded the total phosphorus target and one (site 114 on downstream Moore Creek) exceeding the soluble reactive phosphorus target. There was also one sediment exceedance at site 115 on Butcher Branch in the spring. Both sites 114 and 115 are located close enough to the lake that they are likely impacted by activities in Lake Monroe, such as elevated water levels and brackish conditions during flood events. This may increase the likelihood of elevated sediment and phosphorus levels.

Table 1-84 Moore Creek Sampling Blitz Results - Nutrients

Blitz ID	Creek Name	Fall TN (mg/L)	Spring TN (mg/L)	Fall NO3 (mg/L)	Spring NO3 (mg/L)	Fall TP (mg/L)	Spring TP (mg/L)	Fall SRP (mg/L)	Spring SRP (mg/L)
114	Moore Creek	0.123	0.342	0.008	0.195	0.011	0.048	0.002	0.013
115	Butcher Branch		0.305		0.246		0.026		0.005
128	Moore Creek		0.442		0.367		0.024		0.004

Table 1-85 Moore Creek Sampling Blitz Results - E. coli and Sediment

Blitz ID	Creek Name	Fall E. Coli (MPN/ 100 mL)	Spring E. coli (MPN/ 100 mL)	Fall TSS (mg/L)	Spring TSS (mg/L)
114	Moore Creek	2	5	7.5	4
115	Butcher Branch		19		53
128	Moore Creek		2		0.5

#### 1.15.5 Habitat and Biological Assessment

##### Habitat/Biological Information

Volunteers completed the Citizen Qualitative Habitat Evaluation Index (CQHEI) habitat assessment at all 3 sites during the spring and fall sampling blitz events. Although a comparison scale for the CQHEI has not yet been developed, Hoosier Riverwatch indicates that scores greater than 60 rate as habitat conducive to supporting warm-water biota (IDNR, 2004). CQHEI scores ranged from 45 to 65 during the fall blitz and 37 to 82 during the spring blitz. Two of the three sites scored above 60 during both blitz events while site 114 on downstream Moore Creek scored below 60 during both events, indicating poor habitat at that site. It should be noted that site 114 is located where Moore

Creek widens and enters Lake Monroe and experiences regular water level fluctuations due to changing water levels in the lake. The area around the creek is marshy and silty.

*Table 1-86 Moore Creek Sampling Blitz Results - Habitat Assessment (CQHEI)*

<b>Blitz ID</b>	<b>Stream Name</b>	<b>Fall 2020 CQHEI</b>	<b>Spring 2021 CQHEI</b>
114	Moore Creek	45	37
115	Butcher Branch	65	82
128	Moore's Creek	63	76
	Average CQHEI	57.7	65.0
	% of Sites >60	67%	67%

No stream sections in the subwatershed were evaluated using the Qualitative Habitat Evaluation Index (QHEI), the fish-based Index of Biotic Integrity (IBI), or the macroinvertebrate Index of Biotic Integrity (mIBI).

#### 1.15.6 Moore Creek Subwatershed Summary

The Moore Creek subwatershed appears to have some phosphorus concerns, with all three spring samples exceeding the total phosphorus target. One site (114 on Moore Creek) also exceeded the soluble reactive phosphorus target and another (115 on Butcher Branch) also exceeded the total suspended solids target. Both sites 114 and 115 are located very close to Lake Monroe and are likely impacted by water fluctuations in the lake.

### 1.16 Allens Creek – Lake Monroe Basin (HUC 51202080703)

The Allens Creek Subwatershed (HUC 12 – 51202080703) is located in southern Monroe County and extends just barely into Lawrence County as shown in Figure 4-44. The subwatershed encompasses approximately 10,273 acres and represents 4% of the overall watershed. The subwatershed contains the lower basin of Lake Monroe as well as the tributaries Sugar Creek and Allens Creek and the town of Smithville.

According to the IDEM 303(d) list, Lake Monroe is impaired for taste and odor, algal blooms, and mercury in fish. No other impairments were identified in Allens Creek Subwatershed.

### 1.16.1 Land Use

The Allens Creek Subwatershed has the third highest percentage of agricultural land (9%), mostly in the form of pasture, as well as the highest percentage of open water (32%) and the lowest percentage of forest (54%). Pasture is concentrated north and west of the lake with an additional concentration along Fairfax Road, east of Sugar Creek. Population is concentrated in the northern and western sections of the watershed and population density is much higher than most of the Lake Monroe watershed, with considerable residential development between Bloomington and the lake. This includes the town of Smithville and the Eagle Pointe Golf Resort. About a third of the subwatershed (excluding the lake) is public land, including the section between the two lobes of Lake Monroe that is part of the Lake Monroe State Recreational Area and the section immediately east of the lake that is part of the Hoosier National Forest.

### 1.16.2 Point Source Water Quality Issues

The Allens Creek Subwatershed contains no confined feeding operations and two NPDES permitted facilities. The United States Forest Service Hardin Ridge Wastewater Treatment Plant serves a recreational area. This facility had multiple exceedances in 2018 (TSS, Phosphorus, Nitrogen, E. coli) which led to an upgrade in equipment in May 2019. Phosphorus was mentioned as a constituent that is difficult to keep below permitted levels. The Hardin Monroe Wastewater Treatment Plant serves a residential community and was cited for discharging excessive solids and E. coli in June 2017 but it resolved the issue by the end of the year.

### 1.16.3 Non-Point Source Water Quality Issues

In early spring 2020, the watershed coordinator conducted a windshield survey which included 3 stream crossing sites within the Allens Creek Subwatershed. There are relatively few streams in the subwatershed and roads are generally located along ridgetops. Few roads are present south of the lake as the area is part of the USFS Charles C. Deam Wilderness Area. Observations including streambank erosion, stream buffers, and livestock access were recorded for each site and the results are summarized below. Streambank erosion was noted at 1 of 3 observed sites and lack of sufficient riparian buffer was noted at 1 of 3 observed sites. No sites had livestock with access to streams.

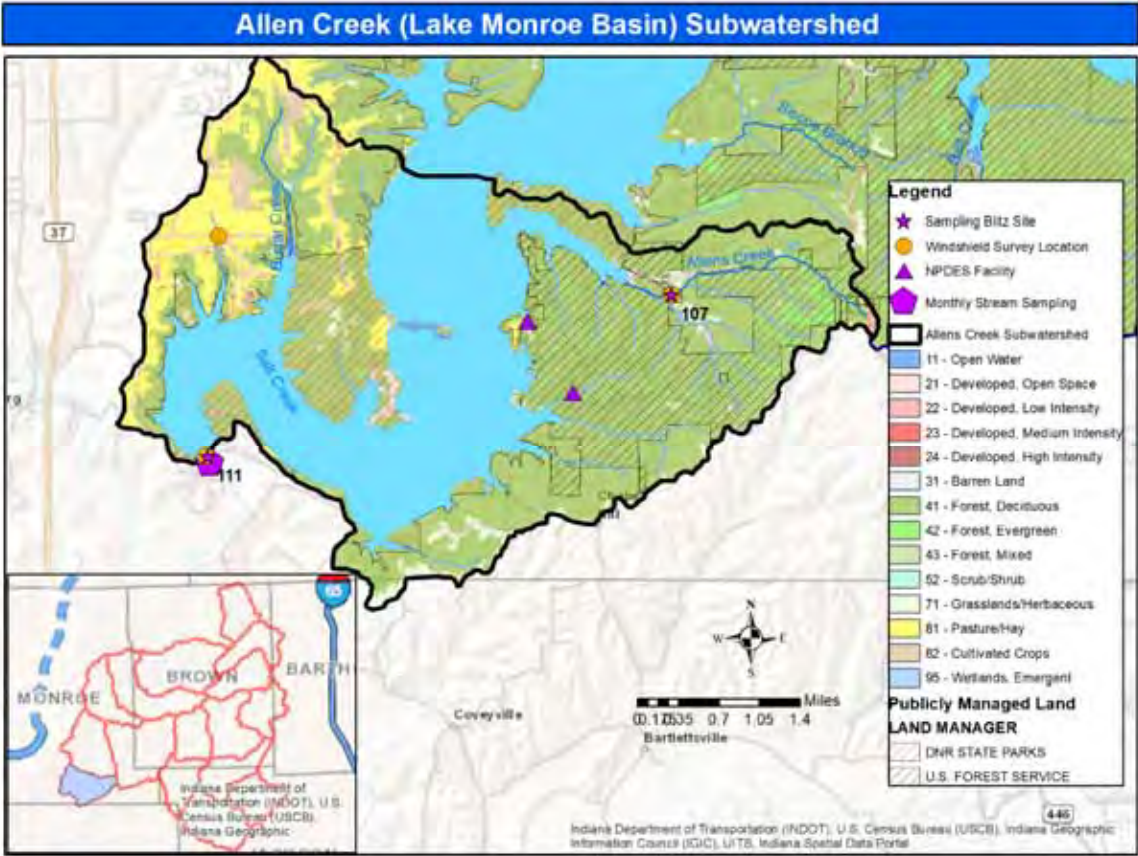
*Table 1-87 Allens Creek Windshield Survey Summary*

<b>Parameter</b>	<b>Observations</b>
Streambank Erosion	0/3 sites with erosion >3' 1/3 sites with erosion <3' 2/3 sites with no erosion
Stream Buffers	2/3 sites with no buffers 0/3 sites with buffers <20' 1/3 sites with buffers >20'



Livestock Access to Streams	0/3 sites with livestock access
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Figure 1-44 Allen Creek (Lake Monroe Basin) Subwatershed Map



1.16.4 Water Quality Assessment

Allens Creek subwatershed had few stream crossings and therefore few sampling locations. This was due largely to a lack of perennial streams and roads being located along ridgetops. Two sites were selected for the spring and fall watershed sampling blitz. Site 107 is located on Allens Creek, which was dry during the fall sampling blitz. Site 111 is located at the outlet of Lake Monroe and therefore is not really representative of the watershed as the water is leaving the lake rather than entering it.

Samples were analyzed for a variety of chemical parameters and E. coli. Habitat was evaluated using CQHEI. Site 111 (Lake Monroe outlet) was sampled monthly from April 2020 through March 2021 and the macroinvertebrate community was assessed once. The fish community has not been assessed in streams in this subwatershed. Flow through the dam is provided by the U.S Army Corps of Engineers.

### Water Quality Information

Water chemistry data from the sampling blitz events suggest no concerns in Allens Creek, the single sampling site in this subwatershed entering the lake.

Looking at site 111, the Lake Monroe outlet, total phosphorus and soluble reactive phosphorus appear to be constituents of concern. The spring and fall blitz samples exceeded both the total phosphorus and the soluble reactive phosphorus targets. Monthly sampling also indicated phosphorus concerns with over 58% of samples exceeding the total phosphorus target and 42% exceeding the soluble reactive phosphorus target. No other constituents had exceedances during the blitz or monthly sampling. Additional information about the Lake Monroe outlet is discussed in section 4.17 (Lake Monroe Water Quality Data).

*Table 1-88 Allens Creek Sampling Blitz Results - Nutrients*

Blitz ID	Creek Name	Fall TN (mg/L)	Spring TN (mg/L)	Fall NO3 (mg/L)	Spring NO3 (mg/L)	Fall TP (mg/L)	Spring TP (mg/L)	Fall SRP (mg/L)	Spring SRP (mg/L)
107	Allens Creek		0.100		0.021		0.012		0.004
111	Lake Monroe Outlet	0.308	0.369	0.008	0.209	0.026	0.026	0.014	0.008

*Table 1-89 Allens Creek Sampling Blitz Results - E. coli and Sediment*

Blitz ID	Creek Name	Fall E. Coli (MPN/ 100 mL)	Spring E. coli (MPN/ 100 mL)	Fall TSS (mg/L)	Spring TSS (mg/L)
107	Allens Creek		11		0.5
111	Lake Monroe Outlet	10	-	6.5	3

*Table 1-90 Monthly Sampling of Lake Monroe Outlet at Site 111 in Allens Creek Subwatershed*

Site 111 Sample Date	Lake Monroe Outlet E. coli (cfu/100 ml)	Lake Monroe Outlet TSS (mg/L)	Lake Monroe Outlet TN (mg/L)	Lake Monroe Outlet NO3 (mg/L)	Lake Monroe Outlet TP (mg/L)	Lake Monroe Outlet SRP (mg/L)
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4/22/2020	1	4.8	0.508	0.308	0.024	0.01
5/27/2020	6	4.4	0.429	0.201	0.016	0.004
6/24/2020	5	3.2	0.286	0.052	0.027	0.005
7/21/2020	5	6.8	0.326	0.008	0.037	0.011
8/27/2020	4	9.5	0.340	0.015	0.056	0.016
9/24/2020	4	10	0.498	0.010	0.036	0.01
10/22/2020	5	6.2	0.384	0.081	0.011	0.006
11/19/2020	2	11.0	0.181	0.087	0.015	0.004
12/16/2020	1	10.4	0.317	0.071	0.023	0.002
1/25/2021	4	6.0	0.300	0.071	0.018	0.003
2/25/2021	1	6.2	0.408	0.153	0.017	0.004
3/18/2021	55	6.5	0.489	0.175	0.024	0.003

#### 1.16.5 Habitat and Biological Assessment

##### Habitat/Biological Information

Volunteers completed the Citizen Qualitative Habitat Evaluation Index (CQHEI) habitat assessment at both sites during the spring and fall sampling blitz events. Although a comparison scale for the CQHEI has not yet been developed, Hoosier Riverwatch indicates that scores greater than 60 rate as habitat conducive to supporting warm-water biota (IDNR, 2004).

CQHEI scores at both sites scored above 60 during both blitz events, indicating good habitat. The results were somewhat surprising for site 111 at the Lake Monroe Outlet, as the site is highly modified and lined with riprap. The IU Limnology Lab evaluated QHEI at that site and gave it a score of 31, indicating poor habitat.

*Table 1-91 Allens Creek Sampling Blitz Results - Habitat Assessment (CQHEI)*

Blitz ID	Stream Name	Fall 2020 CQHEI	Spring 2021 CQHEI
107	Allens Creek	63	83
111	Lake Monroe Outlet	65	73
	Average CQHEI	64	78

	% of Sites >60	100%	100%
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*Table 1-92 Habitat and Biological Sampling in Allens Creek Subwatershed*

Sampler and Date	Site ID	Stream	Station	mIBI	mIBI Rating	QHEI	QHEI Rating
IU Limno Lab August 2020	111	Lake Monroe Outlet	Tailwaters	20	Impaired (<36)	31	Poor

No stream sections in the subwatershed were evaluated using fish-based Index of Biotic Integrity. The IU Limnology Lab evaluated habitat using the Qualitative Habitat Evaluation Index (QHEI) at the monthly sampling site 111 and gave it a score of 31, indicating poor habitat. CQHEI scores during the fall and spring blitz events were reported as 65 and 73, respectively, indicating good habitat. As the dam outlet is highly channelized and covered with riprap, habitat scores would typically be expected to be low. In August 2020, the IU Limnology Lab collected macroinvertebrates and gave it a mIBI score of 20, indicating biological impairment.

#### 1.16.6 Allens Creek Subwatershed Summary

The Allens Creek subwatershed had few data points due to the limited number of stream crossings and the small size of most streams in the watershed. Site 107 on Allens Creek had high CQHEI scores and no monitoring exceedances during the blitz events. Site 111, the Lake Monroe outlet, had levels of total phosphorus and soluble reactive phosphorus above target levels during both blitz events and several of the monthly monitoring events, indicating a phosphorus concern. However, since it is the outlet of the lake, this data is more representative of Lake Monroe than of streams in the watershed. Further discussion of Lake Monroe water quality data is presented below in Section 4.17.

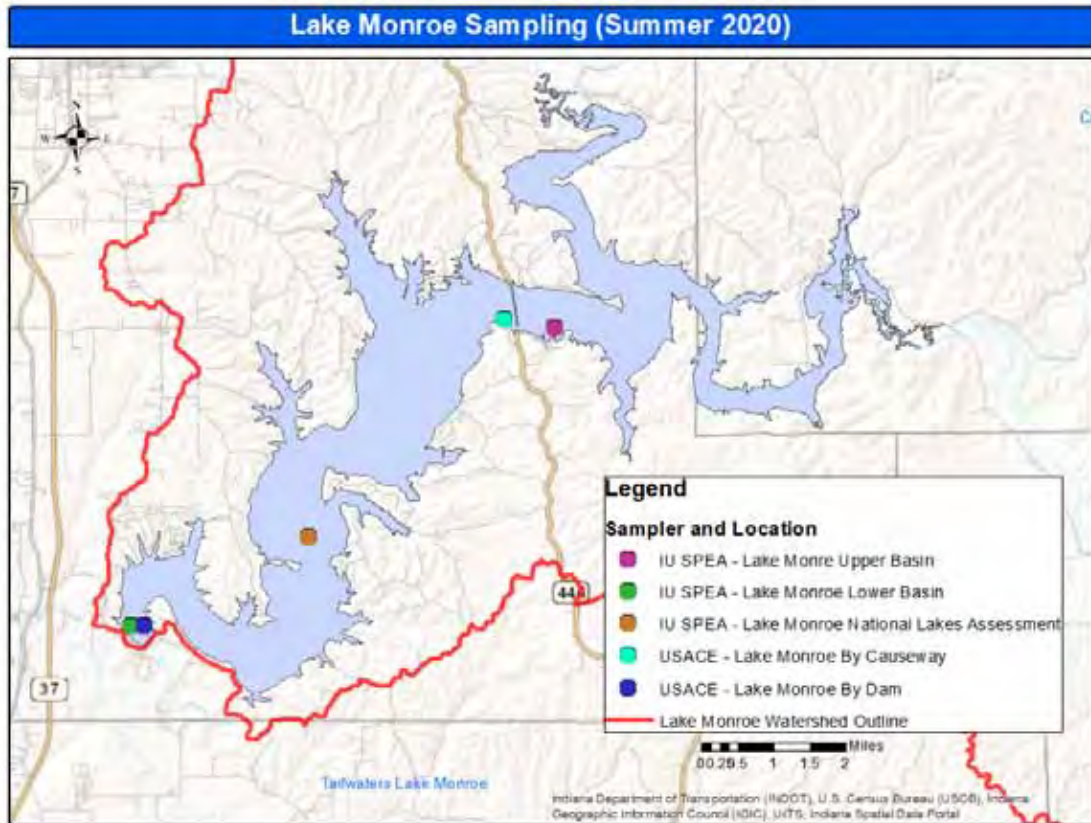
### 1.17 Lake Monroe Water Quality Data

Lake Monroe spans three HUC-12 subwatersheds – Jacobs, Moores, and Allens. Data was collected by the IU Limnology Lab from April through October 2020 at three different sampling locations, the upper basin, the center basin, and the lower basin. During periods of stratification (which differed between the basins), samples were collected from both the epilimnion and hypolimnion.

Samples have also been collected periodically by the U.S. Army Corps of Engineers, the Indiana Clean Lakes Program, and by City of Bloomington Utilities. Monthly sampling of the three lake

basins was conducted for twelve months as part of the Lake Monroe Diagnostics and Feasibility Study (Jones, 1997).

Figure 1-45 Lake Monroe Sampling Map



### 1.17.1 Water Quality Data – Nutrients and Sediment

As discussed in the Lake Monroe 2020 Monthly Monitoring section (3.4.6), samples collected from Lake Monroe regularly exceeded the water quality targets for total phosphorus, soluble reactive phosphorus, total nitrogen, and chlorophyll-a. Dissolved oxygen profiles show that the hypolimnion becomes anoxic during the summer months, particularly in the lower basin (which is the deepest section of the lake). According to the Redfield ratio of nitrogen to phosphorus, algal growth is phosphorus limited for most of the season but when the hypolimnion is anoxic, phosphorus is released from the bottom sediments and the hypolimnion becomes nitrogen limited. When the lake turns over, this phosphorus becomes accessible to algae in the epilimnion, encouraging further algal growth in the late summer and early fall.

Historical data indicate that phosphorus and organic matter have been at levels of concern for many years as summarized below.

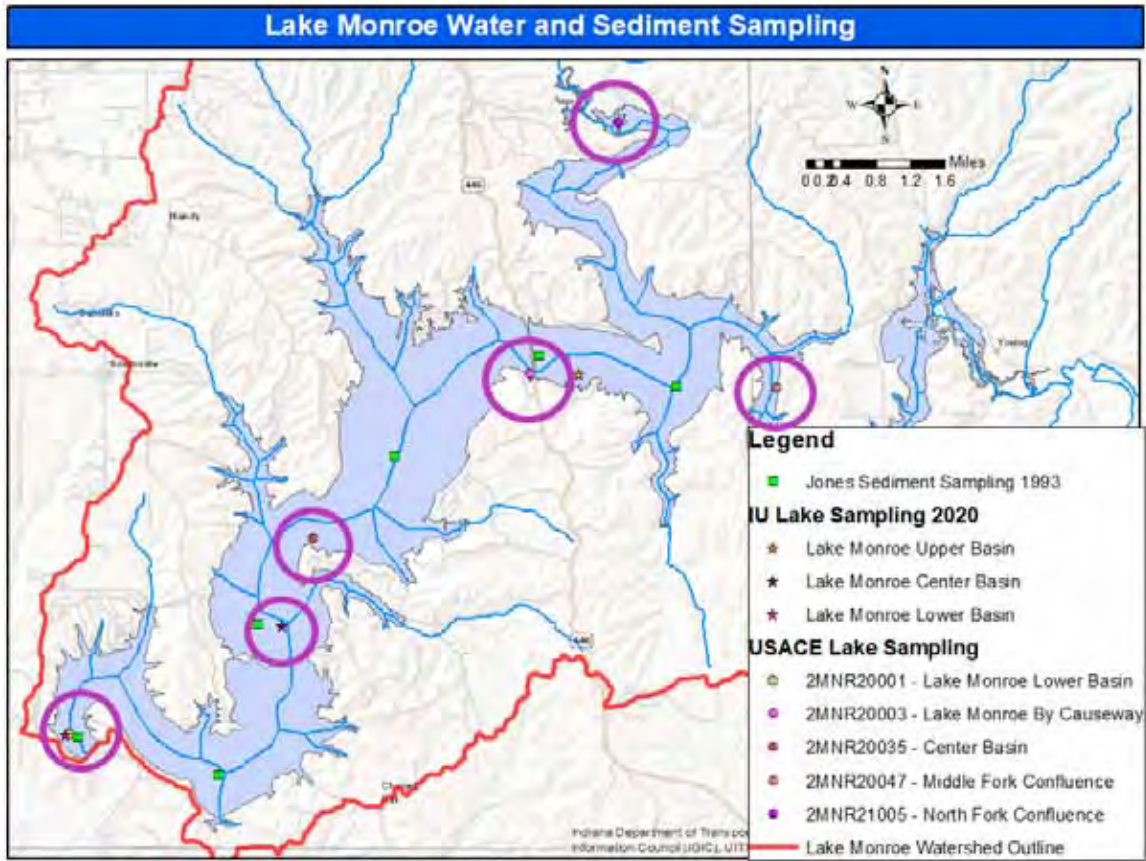
USACE Historic Sampling

A review of data collected annually from 2007-2020 by USACE shows regular total phosphorus exceedances in both the epilimnion and the hypolimnion of all three basins. Note that the sampling locations are slightly different, particularly in the upper basin. Samples were collected every July from the lower basin just above the dam (2MNR20001), the center basin near Allens Creek (2MNR20035), and adjacent to the upper basin just below the causeway (2MNR20003). Phosphorus concentrations were the highest in the lower basin hypolimnion followed by the center basin hypolimnion and the upper basin hypolimnion.

*Table 1-93 Historical Phosphorus Levels in Lake Monroe USACE 2007-2020*

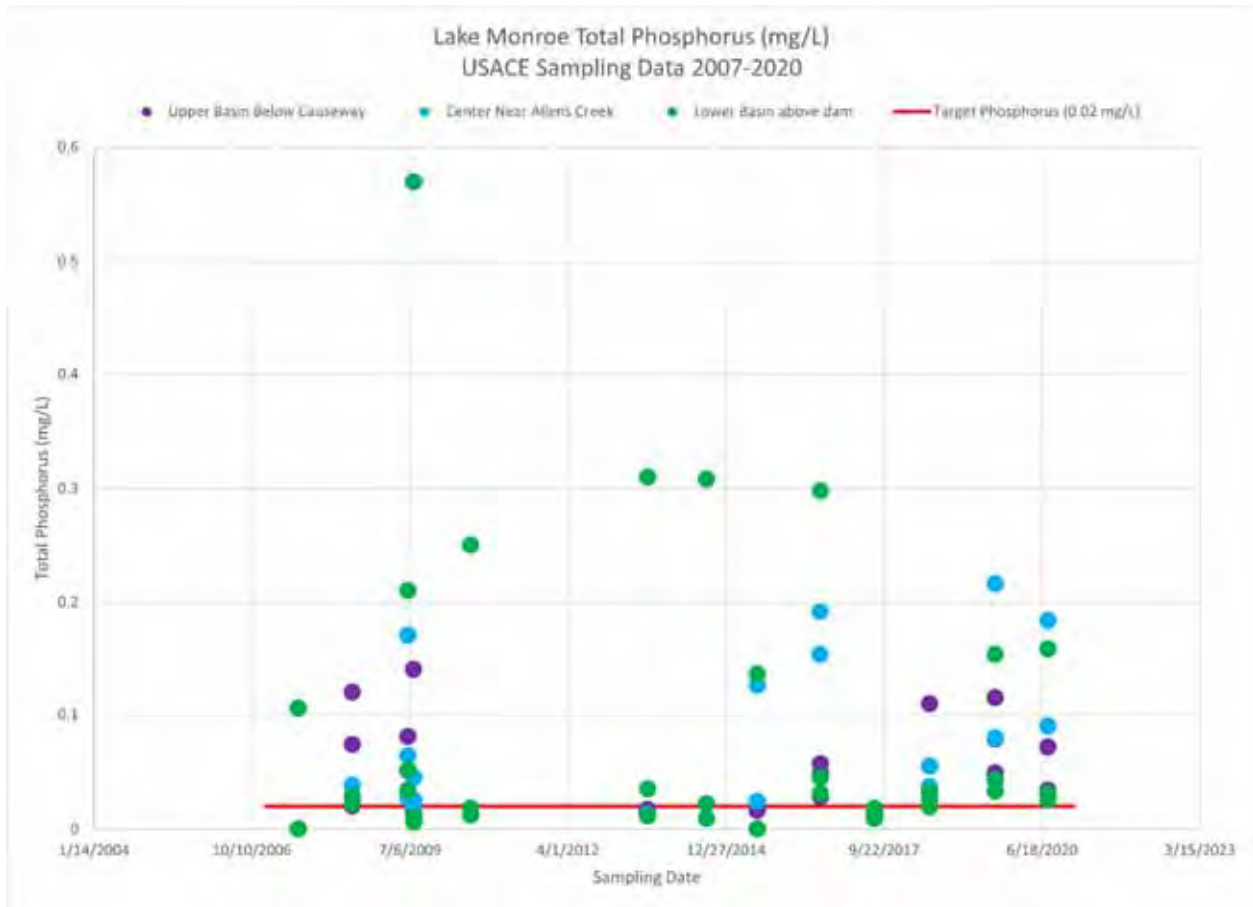
<b>USACE Site</b>	<b>Average TP (mg/L)</b>	<b>Max TP (mg/L)</b>	<b>Min TP (mg/L)</b>	<b>% Above 0.020 mg/L</b>
Upper Epilimnion (2MNR20003)	0.024	0.057	0.012	33%
Upper Hypolimnion (2MNR20003)	0.065	0.140	0.016	78%
Center Epilimnion (2MNR20035)	0.025	0.045	0.012	70%
Center Hypolimnion (2MNR20035)	0.082	0.216	0.012	80%
Lower Epilimnion (2MNR20001)	0.020	0.033	0.006	40%
Lower Hypolimnion (2MNR20001)	0.113	0.570	0.010	72%

Figure 1-46 USACE Lake Monroe Water and Sediment Sampling Map



[update and replace map]

Figure 1-47 Graph of USACE Total Phosphorus Data 2007-2020

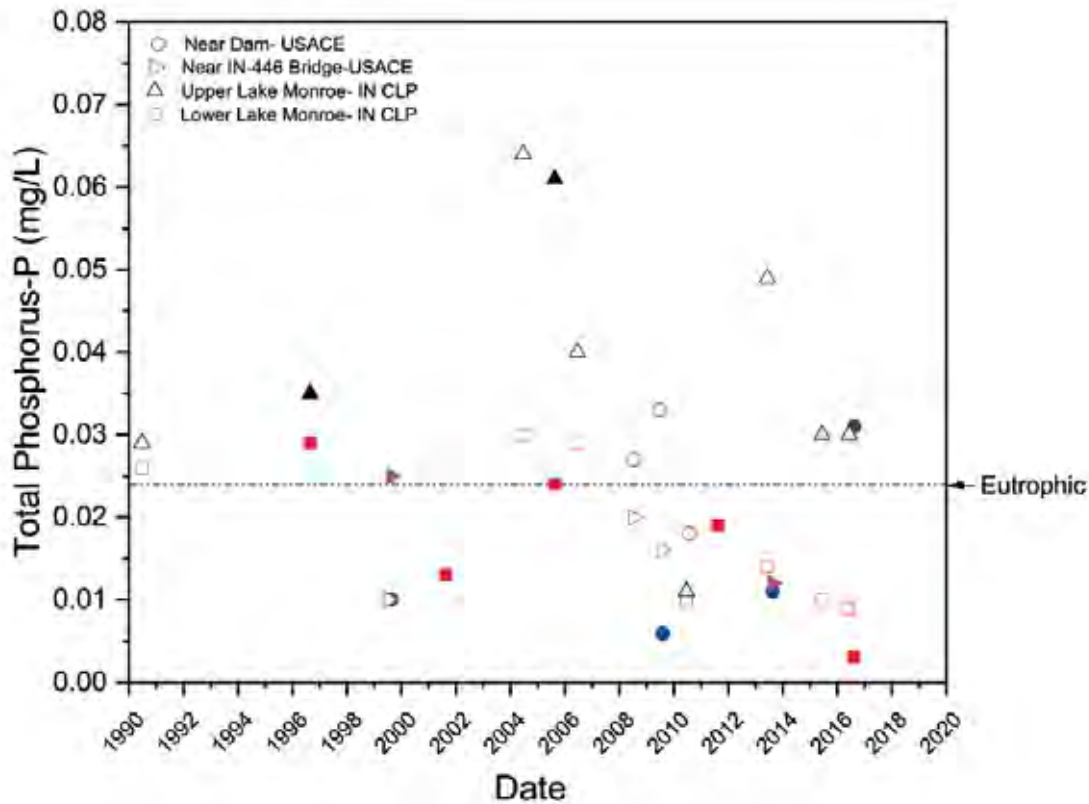


Lake Monroe Water Quality Summary 1990-2017 (2018 SPEA)

A portion of the USACE data and Indiana Clean Lakes Program data collected between 1990 and 2017 was summarized by SPEA student Macayla Coleman in the 2018 report "Lake Monroe Water Quality Summary 1990-2017." The study focused on samples collected during the summer stratification period from the three basins. These data were used to calculate the trophic state index (TSI) based on different sampling parameters. Total Phosphorus concentrations ranged widely from approximately 0.004 mg/L to 0.064 mg/L. Using the Carlson (1977) standard of 0.024 mg/L (shown in the diagram), 44% of the measurements meet or exceed the eutrophic threshold.



Figure 1-48 Historical Phosphorus Levels in Lake Monroe 1990-2017 (SPEA 2018)

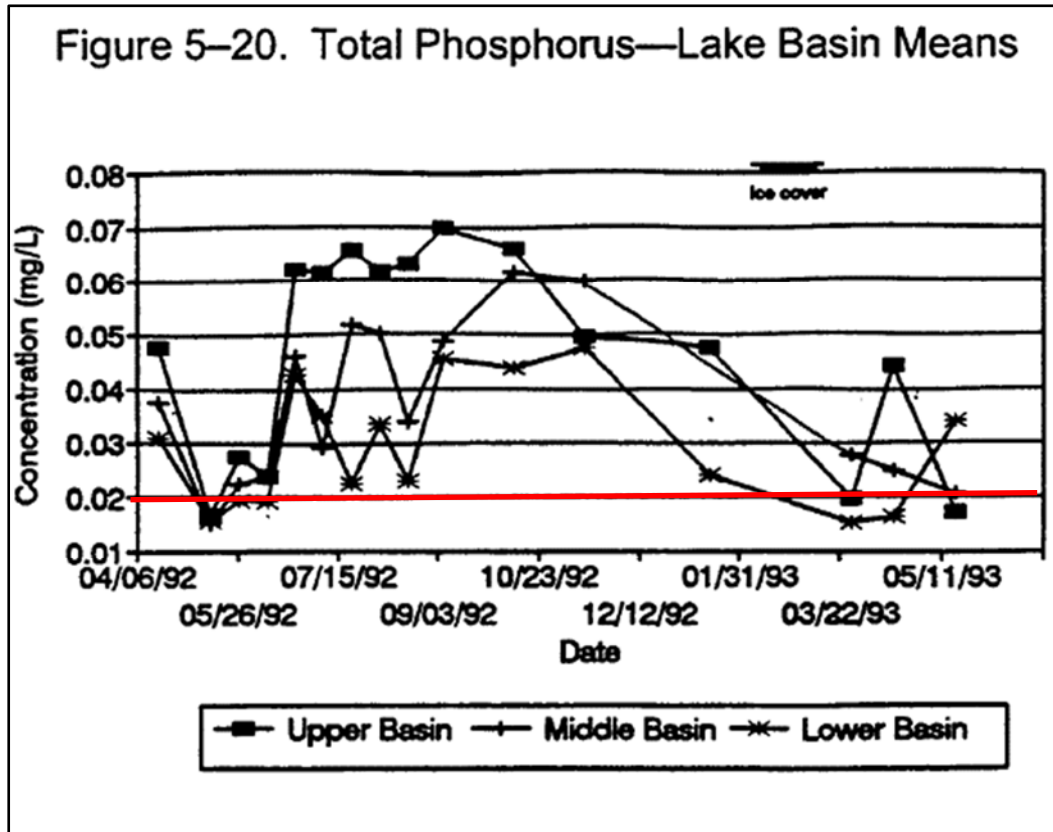


Measurements of Secchi disk transparency and chlorophyll-a also exceeded the eutrophic threshold in about half the samples. The study concluded that Lake Monroe appears to be mildly eutrophic and that algal blooms could be affecting water quality.

Lake Monroe Diagnostic and Feasibility Study (Jones 1997)

Total phosphorus levels also regularly exceeded the water quality target in samples collected between April 1992 and May 1993 as part of the Jones study. Mean total phosphorus levels in each basin ranged from 0.02 to 0.07 mg/L. TP concentrations were generally low in early summer, rising throughout the summer, and falling throughout the winter months. Levels were highest and most consistently above the threshold in the upper basin which tends to be shallowest.

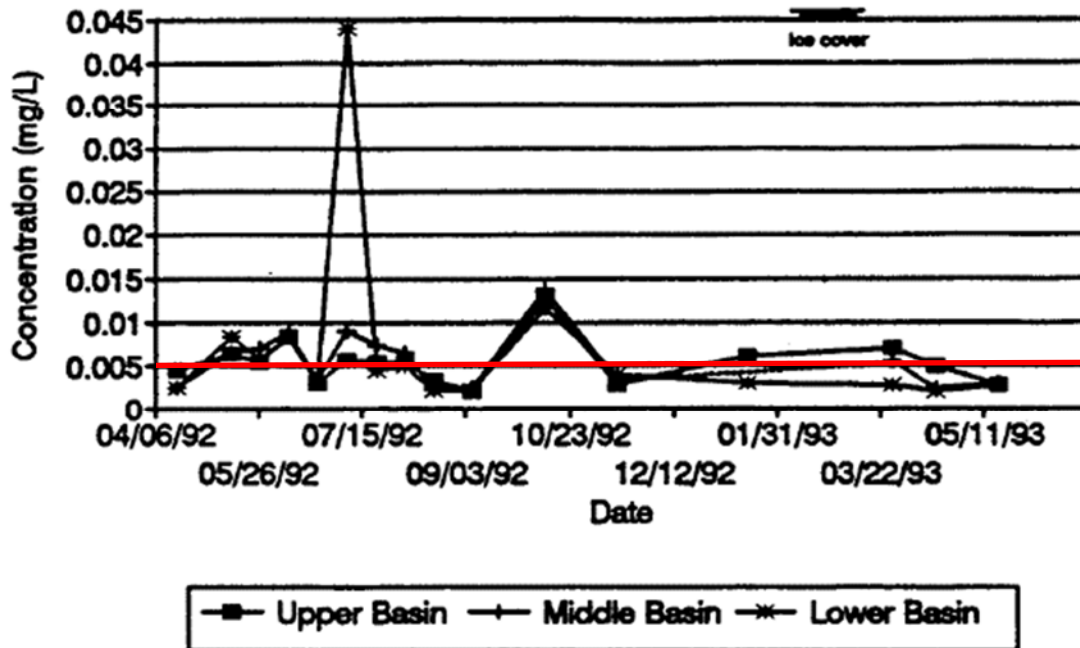
Figure 1-49 Phosphorus in Lake Monroe (Jones Study 1997: Figure 5-20. Total Phosphorus – Lake Basin Means)



Soluble reactive phosphorus (SRP) concentrations in Lake Monroe also regularly exceeded the water quality target of 0.005 mg/L. Two spikes in particular were noted. One occurred in the October 1992 when all three basins had average SRP concentration around 0.012 mg/L, more than twice the target level. This spike is believed to be result of die-back from Eurasian water milfoil, which released SRP from the decaying plant tissue. The other spike in SRP that was reported for the lower basin in June 1992 is believed to be an analytical error.

Figure 1-50 Historical Soluble Reactive Phosphorus in Lake Monroe (Jones Study 1997: Figure 5-17. Soluble Reactive Phosphorus – Lake Basin Means)

**Figure 5–17. Soluble Reactive Phosphorus—  
Lake Basin Means**



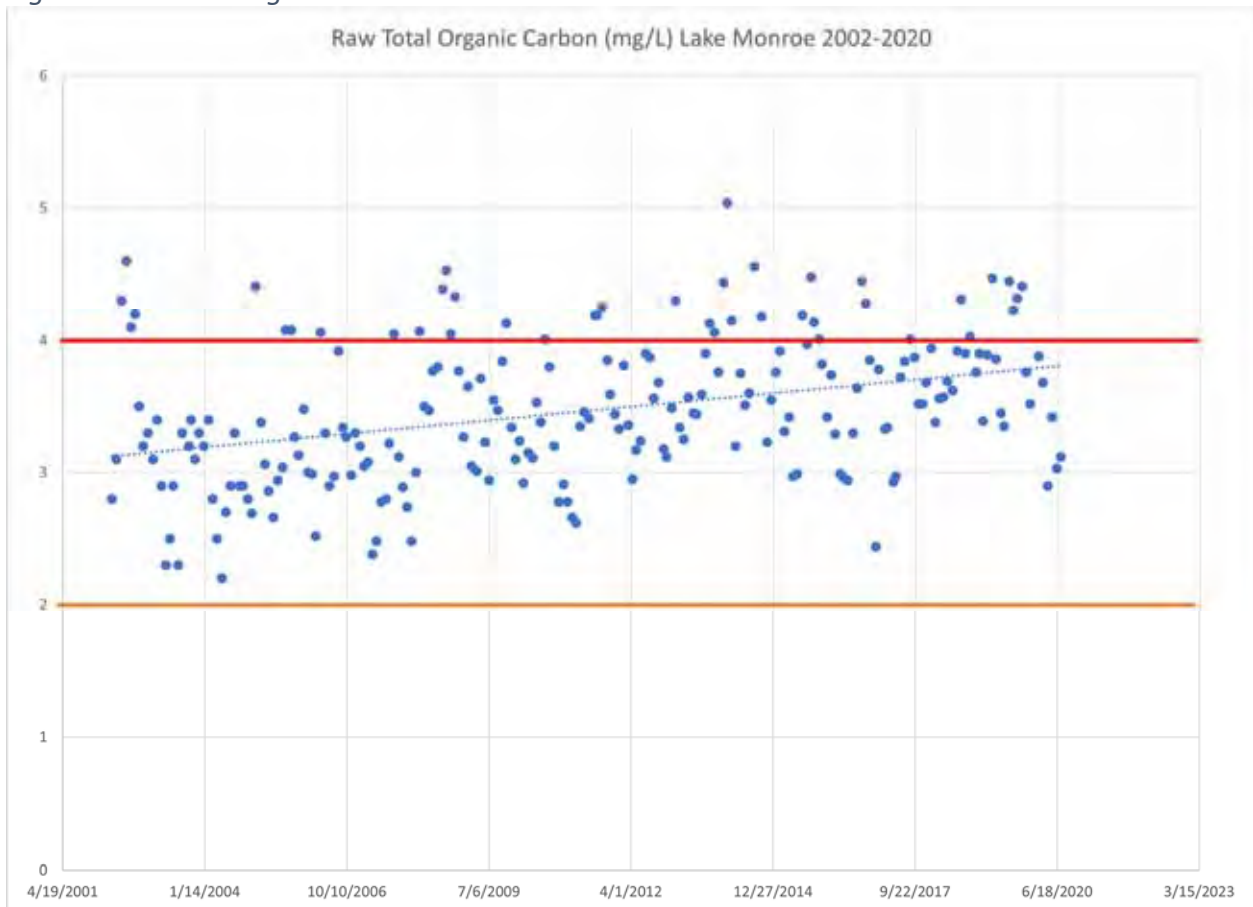
City of Bloomington Utilities (CBU)

CBU conducts a variety of tests on water from Lake Monroe as part of their drinking water treatment program. Three frequently monitored parameters are Total Organic Carbon, Dissolved Organic Carbon, and UV254. These parameters are different ways of measuring organic matter in the water. Increasing organic matter decreases water clarity, turning the water brown. Organic matter can also react with chlorine to create toxic disinfection byproducts, meaning that water with higher concentrations of organic matter requires additional pre-treatment steps before chlorine is added as part of the drinking water treatment process.

Total Organic Carbon (TOC) measures all the organic carbon in a water sample including both the dissolved and the suspended portions. Dissolved Organic Carbon (DOC) measures only the dissolved component. UV254 measures the amount of ultraviolet light at wavelength 254 nm that is absorbed as the light passes through a sample. For all three measurements, increasing values indicate increasing amounts of organic matter.

Based on monthly data collected by CBU between 2002 and 2020, TOC, DOC, and UV254 have all been trending upward. CBU has identified 4 mg/L of TOC as a threshold where additional pre-treatment measures are required in the drinking water treatment process. While this threshold has been exceeded periodically since 2002 and increased removal of TOC was implemented, there have been no incidents where harmful byproducts have exceeded the maximum regulatory threshold.

Figure 1-51 Total Organic Carbon in Raw Lake Monroe Water 2002-2020



### 1.17.2 Water Quality Data –Metals, Inorganic Compounds, and Other Parameters

While the water quality monitoring for this study focused on nutrients and sediment, historical data was reviewed to evaluate other parameters.

#### USACE Historic Sampling

USACE evaluates a wide variety of parameters in its annual sampling events includes atrazine, antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver, and zinc. Most parameters consistently measure below levels of

concern. However, copper was flagged in the tailwaters sample of the USACE 2019 annual report (based on 2018 sampling) and iron was flagged in the USACE 2020 annual report (based on 2019 sampling).

Reported copper levels in Lake Monroe from 2007-2020 were generally extremely low with almost all samples below 5 ug/L (0.005 mg/L). The exception was the 2018 tailwaters sample with a concentration of 11.4 ug/L which exceeded the acute aquatic criterion of 7.79 ug/L. This is a very conservative threshold. For comparison, the drinking water limit for copper is 1300 ug/L, or 1.3 mg/L. Ultimately copper was not selected as a contaminant of concern for this study.

Reported iron levels in Lake Monroe from 2007-2020 have ranged from below the detection limit to 6.6 mg/L with a median of 1.1 mg/L. Iron cycling in lakes and streams is complex and it is normal for concentrations to vary considerably over both time and space. The EPA acute aquatic criterion is hardness dependent and must be calculated for each sampling event. The 2019 tailwater sample had an iron level of 4.28 mg/L, exceeding the acute aquatic criterion of 2.744 mg/L. While any exceedance is concerning, the concentrations of iron in Lake Monroe appear to be within normal variations for the state. Iron concentrations in samples from all the Louisville District ACOE lakes ranged from below the detection limit to 20.8 mg/L. Due to the limited data availability and the lack of obvious potential sources of iron within the watershed, iron has been excluded from this watershed plan.

#### City of Bloomington Utilities (CBU)

CBU routinely analyzes drinking water samples for a variety of parameters at different frequencies. Although this is treated drinking water, the presence of a constituent in drinking water would likely indicate its presence in the raw lake water, with the exception of chloramine, disinfection by-products, and fluoride.

- Tests are run quarterly for a list of twenty-one Synthetic Organic Carbons (SOCs) and a much longer parameter list is run every three years.
- Tests are run annually for eighteen Inorganic Compounds (IOCs), twenty-one regulated Volatile Organic Compounds (VOCs), and nineteen unregulated Volatile Organic Compounds.
- Tests are run every six years for radioactive contaminants (most recently in 2015).
- Chloramine, a chemical used for water treatment, is regularly monitored throughout the treatment plant and water distribution system.
- Disinfection By-Products (DBPs), chlorine by-products formed during disinfection, are monitored monthly.
- EPA's Unregulated Contaminant Monitoring Rule program requires sampling for additional parameters every five years (currently underway in 2020).

Based on the 2020 Annual Drinking Water Report (using 2019 data), the two detected constituents that are likely to come from raw lake water are barium and atrazine. Barium was detected at 0.012 ppm, well below EPA's maximum contaminant level of 2 ppm, and is attributed to the erosion of natural deposits. Atrazine was detected at 0.2 ppb, well below EPA's maximum contaminant level of 3.0 ppb, and is attributed to runoff from herbicide used on row crops. Barium has been present at consistent levels for the last ten years. Atrazine was reported at levels between 0.2 and 0.3 ppb in the 2013, 2014, 2015, 2018, 2019, and 2020 annual water quality reports.

Hexachlorocyclopentadiene was detected in 2018, 2016, and 2015 at 0.1 ppb, well below the EPA maximum contaminant level of 50 ppb. Di(2-ethylhexyl)phthalate was detected in 2016 at 1.6 ppb compared to the EPA maximum contaminant level of 6 ppb. Both constituents are associated with chemical manufacturing. Nitrate was detected in 2011 at 0.02 ppm and in 2012 at 3.7 ppb compared to the action level of 15 ppb and was attributed to nonpoint source pollution (fertilizer, septic systems, sewage, or erosion of natural deposits).

Lead and copper were also detected in the drinking water in all years. Copper levels ranged from 0.017 ppm to 0.037 ppm, well below the EPA regulatory limit for drinking water of 1.3 ppm. Lead levels ranged from 4.9 to 7.0 ppb with an EPA action level of 15 ppb and a target of 0 ppb. Lead and copper were both attributed in the annual report to a combination of corrosion of household plumbing and erosion of natural deposits. For comparison, USACE lake sampling data from 2007-2016 show copper levels ranging from under detection limits to 4.4 ug/L (0.0044 mg/L). Lead levels in thirty-five of thirty-seven samples were below 3.0 ppb. The two elevated results were 4.5 and 6.9 ppb, comparable to the CBU samples.

In 2020, samples of raw lake water collected by CBU via a pipe from the raw water intake tower showed elevated copper levels of 0.32 ppm, an order of magnitude higher than the typical drinking water results. The elevated copper levels were due to a new pilot program where copper sulfate is introduced at the intake tower to fight algae. This will likely be adopted as a standard operating procedure during the summer months. CBU will change their sampling point to a spot in the intake tower prior to the copper sulfate addition.

### **CBU Contaminant Testing 2019**

#### **SOCs (Synthetic Organic Compounds) (20 undetected, 1 detected)**

Alachlor (Lasso)

Atrazine - detected

Benzo(a)pyrene

Di(2-ethylhexyl)adipate

Di(2-ethylhexyl)phthalate

Endrin

Heptachlor

Heptachlor Epoxide

Hexachlorobenzene

Hexachlorocyclopentadiene  
Lindane  
Methoxychlor  
Simazine  
Aldrin  
Butachlor  
Carbaryl  
Dicamba  
Dieldrin  
Metolachlor  
Metribuzin  
Propachlor

**IOCs (Inorganic Chemicals) (13 undetected, 5 detected)**

Antimony  
Arsenic  
Barium - detected  
Beryllium  
Cadmium  
Chloramine - detected  
Chromium  
Copper - detected  
Cyanide (Free)  
Fluoride – detected  
Lead - detected  
Mercury  
Nickel  
Selenium  
Thallium  
Nitrate  
Nitrite  
Nitrite & Nitrate

**Regulated VOCs (Volatile Organic Compounds) (21)**

Benzene  
Carbon Tetrachloride  
Chlorobenzene  
1,2-Dichlorobenzene  
1,4-Dichlorobenzene  
1,2-Dichloroethane  
1,1-Dichloroethylene  
1,2-Dichloroethylene, cis  
1,1-Dichloroethylene, trans

Dichloromethane  
1,2-Dichloropropane  
Ethylbenzene  
Styrene  
Tetrachloroethylene  
Toluene  
1,2,4-Trichlorobenzene  
1,1,1-Trichloroethane  
1,1,2-Trichloroethane  
Trichloroethylene  
Vinyl Chloride  
Total Xylenes

**Unregulated VOCs (Volatile Organic Compounds) (19)**

Bromobenzene  
Bromomethane  
Chloroethane  
Chloromethane  
2-Chlorotoluene  
4-Chlorotoluene  
1,3-Dichlorobenzene  
1,1-Dichloroethane  
1,3-Dichloropropane  
2,2-Dichloropropane  
1,1-Dichloropropene  
1,3-Dichloropropene (cis & trans)  
1,1,1,2-Tetrachloroethane  
1,1,2,2-Tetrachloroethane  
1,2,3-Trichloropropane  
Dibromomethane  
Bromoform  
Chlorodibromomomethane  
Methyl-Tert-Butyl Ether (MTBE)

**Disinfection Byproducts**

Total Trihalomethanes (TTHM) – detected

Haloacetic Acids (HAA5) – detected



### 1.17.3 Water Quality Data – Bacteriological and Algal

#### Blue-Green Algae

The Indiana Department of Natural Resources works with the Indiana Department of Environmental Management and the Indiana State Department of Health to monitor the presence of blue-green algae in lakes during the summer recreation season (Memorial Day-Labor Day). Lake Monroe is sampled approximately twice per month at Paynetown and Fairfax. Beach Advisory Alerts were issued annually 2011-2021 at both beaches based on algal counts over 100,000 cells/ml. These recreational advisories were typically issued in July and stayed in effect through the end of sampling (Labor Day). During a beach advisory alert, swimming and boating is permitted but visitors are advised to avoid contact with algae and take a bath after coming in contact with the water. Cyanotoxins are also measured as part of the monitoring program. However, no cyanotoxins were detected at levels to trigger elevated recreational advisories in Lake Monroe.

*Table 1-94 Historical Algal Counts at Paynetown per IDEM/IDNR/ISDH Beach Monitoring Program*

<b>Historical Algal Counts (cells/ml) at Paynetown</b>							
	Mid June	Late June	Early/Mid July	Mid/Late July	Early August	Mid August	Late August
2011	—	46,960	—	110,240	604,400	599,160	541,800
2012	—	19,680	—	298,153	—	1,114,200	422,800
2013	—	52,800	—	77,093	—	161,019	148,284
2014	15,952	—	77,763	—	189,919	391,463	—
2015	2,083	—	61,589	—	147,960	87,385	—
2016	—	21,601	—	122,060	798,760	394,318	—
2017	13,078	—	42,699	—	222,759	242,444	—
2018	13,600	—	138,036	235,616	185,624	254,214	—
2019	84,519	—	—	—	508,684	586,131	—
2020	—	30,188	—	—	543,604	656,807	550,698

Chlorophyll-a measurements collected by the Indiana Limnology Lab from April showed peak concentrations during the late September (9/23/2020) sampling event. This indicates that algal counts likely continue to increase in the early fall after the IDEM beach monitoring program ends. Peak algal counts likely occur in September or possibly October. While recreational use decreases significantly after Labor Day, there are still plenty of swimmers and boaters in September and October.

*Table 1-95 Chlorophyll-a Levels in Lake Monroe 2020*

<b>Sample Date</b>	<b>Monroe Upper</b>	<b>Monroe Center</b>	<b>Monroe Lower</b>
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	Chlorophyll-a (ug/L)	Chlorophyll-a (ug/L)	Chlorophyll-a (ug/L)
5/26/2020	8.59	6.81	6.76
6/25/2020	6.19	4.42	2.97
7/27/2020	19.32	6.07	2.50
8/28/2020	26.49	11.34	7.96
9/23/2020	31.00	16.97	6.15
10/26/2020	18.57	13.78	7.73
Average	18.36	9.90	5.68
Max	31.00	16.97	7.96
Min	6.19	4.42	2.50
% > 4.93	100%	83%	67%

### Fecal Contamination

The IU Limnology Lab analyzed the monthly 2020 Lake Monroe samples for E. coli. All samples were well below the state E. coli standard of 235 CFU/100 ml. Furthermore, all samples were below 15 CFU/100 ml and 64% were below the detection limit of 1 CFU/ml.

Samples collected by USFS at the Hardin Ridge beach from 2015-2020 revealed four exceedances of the 235 CFU/100 ml standard out of fifty-four total samples. Two occurred in August 2015 (>2,400 and 727), one in July 2016 (>2,400), and one in August 2016 (632). All other samples had reported levels below 50 CFU/100 ml. No exceedances occurred in 2017-2020 and the highest recorded concentration in those years was 28 CFU/100 ml.

Based on these data, E. coli is not considered an active concern at Lake Monroe though it should be addressed elsewhere in the watershed.

#### 1.17.4 Habitat and Biological Assessment

No habitat or biological assessments were conducted in Lake Monroe as part of this project. The lake is a popular fishing destination and is stocked annually with walleye and striped bass. Artificial fish habitat was added to the lake through the IDNR Division of Fish and Wildlife in 2018 and 2019. An estimated 200 habitat structures were installed including Pennsylvania Porcupine Crib Juniors, Georgia Cubes, and Indiana pallet structures. All were installed in the upper basin of Lake Monroe in an area with an approximate depth of 8 to 11 feet where dissolved oxygen levels are expected to be sufficient for fish year-round.

#### 1.17.5 Potential Sources – Lakeshore Observations

The shoreline of Lake Monroe was identified as a potential source of sediment in the 1997 Jones study and was mentioned multiple times as a public concern at the recent community forums. The Jones study conducted a shoreline survey in 1993 that divided the shoreline into 67 sections and documented the type of shoreline substrate (bedrock, talus, soil), the extent of vegetative cover, and bank height for each section. They identified many shoreline sections with erosive characteristics such as less than 100% vegetation, greater than two foot banks, and silt/clay substrates. A class of SPEA students in 2020 digitized the shoreline segments, assigning them geographic locations in a GIS system, and also developed an app designed to have volunteers document current shoreline conditions. Though this fieldwork has not yet been completed, anecdotal information suggests that the lakeshore has eroded considerably since the Jones study. Lake Monroe experienced an unusually extended period of elevated water surface elevation in 2019 with flood conditions in effect from March through August. This appears to have exacerbated lakeshore erosion and eroded soils in areas above existing riprap.

Paynetown State Recreational Area has several stretches of shoreline that are protected by riprap installed in the 1990s. At the time of installation, the record water elevation was 13 feet above normal pool ( $538 + 13 = 551$ ) and this elevation was used to determine the top of the riprap (per conversation with Jim Roach, DNR). However, in the last five years there have been regular exceedances and some erosion has occurred above the riprap, though the riprap is still holding well.

Sedimentation is a concern around some of the boat ramps. About a decade ago, DNR applied for an 1135 grant through the US Army Corps for almost one million dollars to address sedimentation at the Crooked Creek Boat Ramp (personal conversation with Jim Roach, DNR). The boat ramp was becoming very silted in and they proposed creating a sub-impoundment area to collect sediment during flood events. Large tubular sacks would be filled with silt and stacked in place to create a sort of settling basin, slowing sediment transfer into the boat ramp area and the lake itself. They received a 404 permit for construction in a floodway but were unable to secure a 402 permit that ensures projects are beneficial for fish and wildlife. At that point, the project was tabled and has not been reconsidered.

