

LAKE NORRELL WATER QUALITY SURVEY

Lake Norrell, located in east central Saline County, Arkansas, is a municipal water supply lake for the city of Benton, Arkansas. This lake is heavily used for both primary and secondary contact recreation activities throughout the year. Home sites with septic tank waste treatment systems occupy approximately seventy-five percent (75%) of the lake's shoreline. Water from Lake Norrell is released downstream into the North Fork of the Saline River during low flow periods and is eventually withdrawn into the drinking water treatment plant for the city of Benton's water supply.

Concerns about possible fecal coliform contamination and the possibility of excess nutrient enrichment of the lake causing nuisance algae blooms prompted this survey.

The objectives of this survey were to determine the levels of fecal coliform bacteria throughout the lake and at the City of Benton's water intake structure during different climatical periods, and to determine the existing water quality of the lake.

WATERSHED DESCRIPTION

Lake Norrell is located on Brushy Creek, a tributary to the North Fork Saline River, and has approximately 10 square miles watershed. It lies in the Ouachita Mountain Ecoregion in east-central Saline County, Arkansas. It serves as a municipal drinking water supply for the city of Benton, Arkansas. The lake is heavily used for both primary and secondary contact recreation activities. There are approximately 175 home/camp sites adjacent to the lake, all of which are on septic tank waste treatment systems. The largest percentage of home sites is around the eastern most arm of the lake, with the upper end and west side of the Brushy Creek arm remaining undeveloped at this time. However, there are some recent development activities on the west side of the Brushy Creek arm.

The Brushy Creek watershed has an approximate five square mile drainage area and probably has some flow throughout the year. The eastern arm has a one square mile drainage area and probably receives flow only during rainfall events. The land use around Lake Norrell is almost entirely forestry, with perhaps a very small percentage being comprised of pasture land. Except for the development adjacent to the lake, the only other home sites within the watershed seem to be hunting camps.

LAKE NORRELL CHARACTERISTICS

◆ Owner	City of Benton
◆ Location	Brushy Creek Saline County Sec 19, T1N, R15W
◆ 1956	Dam completed Lat. 34°43'06" Lng. 092°38'42"
◆ Uses	Water Supply Primary and Secondary Contact Recreation
◆ Watershed size	10 sq. mi.
◆ Area	280 surface acres
◆ Volume	2240 Acre feet normal storage capacity 5936 Acre feet maximum storage capacity
◆ Minimum release	7.735 cfs (5 mgd) low flow operating discharge
◆ Maximum release	6416 cfs (4145 mgd) maximum discharge
◆ Shoreline inhabitants	-175 Home/Camp sites

SAMPLE PROCEDURES

FECAL COLIFORM SAMPLING

Twenty-one (21) in-lake bacteria sampling stations were identified within Lake Norrell (samples identified by LN-01 to LN-20), along with one Saline River station (SR-01), located at the City of Benton's water intake structure. Samples were collected in those areas of the lake where concentrations of fecal coliform bacteria were thought to be highest because of either direct or indirect human contact. In addition, one sampling station, LN-18, was established at the unimpacted upper end of the Brushy Creek arm for comparison. Samples were collected over a five day period, usually two days before and three days after a weekend to determine if an increase in human contact influences fecal coliform concentrations. Two sampling events were completed, one during April and the other during July. The April sampling event was scheduled to determine a bacteria base line concentration during the cooler, wetter spring months when human contact activities remain low and when bacterial growth remains at a minimum. The July sample was scheduled to obtain a representative bacteria concentration during the hotter, drier summer months when both direct human contact activities and bacterial growth would be at their peaks. The bacteria samples were collected, preserved, and analyzed in accordance with the 16th Edition of Standard Methods for the Examination of Water and Wastewater. Figure 1 is a map of Lake Norrell identifying the sampling stations.

WATER QUALITY SAMPLING

Water quality grab samples were collected once at the following stations: LN-01, LN-02, LN-03, LN-18, LN-19, LN-20 (see Figure 1). In-situ measurements of pH, and dissolved oxygen, were performed

when the water samples were collected. Lab analysis included: ammonia nitrogen ($\text{NH}_3\text{-N}$), nitrate nitrogen ($\text{NO}_3\text{-N}$), ortho-phosphorus, chlorides, sulfates, and total hardness. A Y.S.I. Model 57 portable dissolved oxygen (DO) meter and an Orion Model 230 pH meter were used to take the in-situ measurements. The DO meter was calibrated by Wrinkler Azide Modification, and the pH meter was calibrated with buffer solutions of pH 4 and pH 7, both prior to use. The water samples were collected, preserved, and analyzed according to the 16th Edition of Standards Methods for Examination of Water and Wastewater.

DATA RESULTS

WATER QUALITY DATA

One time grab samples were collected at previously noted sites in Lake Norrell and analyzed for selected parameters. Nutrient concentrations - $\text{NH}_3\text{-N}$, $\text{NO}_3\text{-N}$, and orthophosphorus - were all below detection levels (Table 1). This is indicating one or two hypothesis; 1) there is a low concentration of nutrients entering the lake, and/or 2) the nutrient budget for the lake is zero.

The first hypothesis is probably false due to the large number of septic tanks around the lake. The second hypothesis, that nutrients entering the lake are assimilated by plant life thus producing a nutrient budget of zero, is probably true. The lake may be capable of assimilating all the nutrient inputs throughout most of the year. However, with the increasing lake side development and human contact activities, and additional activities in the lake's watershed, the nutrient levels could easily increase and cause nuisance algae blooms and possible fish kills. Other adverse effects would be that of degrading the water quality to levels that its designated uses could not be met.

FECAL COLIFORM

As established by Regulation No. 2, ADPC&E, October 1991, in primary contact waters between April 1 and September 30, the fecal coliform content shall not exceed a geometric mean of 200 colonies/100 ml, nor shall ten percent (10%) of the total samples collected during any 30-day period exceed 400/100 ml.

The bacteria concentrations during the April sampling event ranged from 3/100 ml to 732/100 ml, and the geometric means ranged from 9/100 ml to 195/100 ml. None of the geometric means exceeded the fecal coliform standard for primary contact recreation during this sampling event. (However, the Saline River site, SR-01, exceeded the 400/100 ml, ten percent standard for a sampling period with one sample, 4/26/93, having a concentration of 732/100 ml. This station did not exceed the geometric mean standard, however.

Approximately 79% of the lake samples had concentrations below 50/100 ml. The largest increase was seen on the Monday sample, 4/26/93, when the bacteria concentrations increased from 3 to 36 times, with the jump at the LN-01 site being the largest (3/100 ml on 4/22/93, 108/100 ml on 4/26/93). At all but two stations, LN-05 and LN-11, the bacteria concentrations decreased during the week, almost back to the values of the previous week. The increases at the other two stations could possibly be from a delayed bloom or some sort of independent input at these sites.

In approximately 80% of the July samples, fecal coliform concentrations were below 50/100 ml; however, the overall number of colonies were much greater than the April sampling event. Stations LN-01, LN-02, LN-03, and LN-08 had elevated concentrations greatly above their April concentrations while the remainder of the other stations actually had lower concentrations as compared to the April sampling event. The elevated concentrations after the weekend did not appear during this sampling event, however. Station LN-01 had the highest concentration during the survey, 2610/100 ml, 7/15/93. The ten percent standard was exceeded at stations LN-01 and LN-02, and both stations exceeded the geometric mean standard of 200/100 ml. These stations are located in the southern most coves of the eastern arm of Lake Norrell. This area is the most developed area around the lake, and probably receives the heaviest primary contact. This perhaps is the reason for the elevated bacteria counts in this portion of the lake. Table 2 is a compilation of the fecal coliform concentrations during both sampling events.

Table 1

WATER QUALITY DATA

SITE	D.O.	pH	NH ₃ -N	NO ₃ -N	O-PHOS	CL	SO ₄	T-HARD
LN-01	6.4	6.90	<0.05	<0.02	<0.03	1.94	6.78	37.60
LN-02	6.7	7.13	<0.05	<0.02	<0.03	1.88	6.78	37.60
LN-07	6.7	7.49	<0.05	<0.02	<0.03	1.86	9.11	39.00
LN-18	6.0	7.21	<0.05	<0.02	<0.03	2.04	6.78	37.60
LN-19	6.5	7.48	<0.05	<0.02	<0.03	1.89	6.78	36.10
LN-20	6.7	7.55	<0.05	<0.02	<0.03	2.08	6.78	36.10

Table 2 (cont)

FECAL COLIFORM
(July, 1993)

SITE	7/08	7/12	7/13	7/14	7/15	Gm. Mn*
SR-01	80	10	40	30	40	33
LN-01	170	150	100	310	2610	290
LN-02	400	580	60	260	180	231
LN-03	120	40	20	50	60	49
LN-04	10	10	20	10	20	13
LN-05	10	30	30	20	10	18
LN-06	10	30	10	10	10	12
LN-07	40	10	10	40	10	17
LN-08	20	150	230	210	60	97
LN-09	50	20	20	10	30	23
LN-10	10	10	30	10	10	12
LN-11	50	40	10	60	60	37
LN-12	10	10	40	10	30	16
LN-13	30	10	20	10	20	16
LN-14	10	10	30	10	10	12
LN-15	10	10	10	10	10	10
LN-16	10	10	10	50	40	18
LN-17	10	30	10	10	10	12
LN-18	10	40	10	10	10	13
LN-19	30	10	10	10	10	12
LN-19A	10	10	n/a	n/a	n/a	10
LN-20	30	10	30	20	10	18

* Gm. Mn. -- Geometric Mean

Shaded areas are those that exceeded a fecal coliform standard.

Table 2

**FECAL COLIFORM
(April, 1993)**

SITE	4/21	4/22	4/26	4/27	4/28	Gm. Mn*
SR-01	90	100	732	320	136	195
LN-01	40	3	108	16	5	16
LN-02	10	10	103	26	11	20
LN-03	50	10	92	70	37	41
LN-04	30	7	64	48	12	24
LN-05	30	10	67	44	225	46
LN-06	10	3	98	84	24	23
LN-07	20	26	93	54	30	38
LN-08	20	10	120	74	12	29
LN-09	10	9	105	46	10	21
LN-10	10	8	60	20	13	17
LN-11	10	7	99	122	23	29
LN-12	10	7	31	14	12	13
LN-13	20	3	10	10	8	9
LN-14	10	3	73	38	13	16
LN-15	10	8	31	38	14	17
LN-16	10	9	56	18	17	17
LN-17	30	25	54	30	23	31
LN-18	20	9	59	18	14	19
LN-19	10	6	66	2	9	9
LN-19A	10	6	VOID	22	11	11
LN-20	10	4	16	12	8	9

* Gm. Mn. -- Geometric Mean

Shaded areas are those that exceeded a fecal coliform standard.