

National Park Service
U.S. Department of the Interior

Southeast Region
Atlanta, Georgia



Cumberland Piedmont Network Water Quality Report

Little River Canyon National Preserve



ON THE COVER

Little River Canyon, August 1, 2001
Photograph by: Joe Meiman

Cumberland Piedmont Network Water Quality Report

Little River Canyon National Preserve

Joe Meiman
National Park Service
P.O. Box 8
Mammoth Cave, KY 42259

January 2009

U.S. Department of the Interior
National Park Service
Southeast Regional Office
Atlanta, Georgia

Views and conclusions in this report are those of the authors and do not necessarily reflect policies of the National Park Service. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the National Park Service.

This report is available from the Cumberland Piedmont I&M Network website or searching the NPS Integrated Resource Management Applications website.

Please cite this publication as:

Meiman, Joe 2009. Cumberland Piedmont Network Water Quality Report: Little River Canyon National Preserve. National Park Service, Atlanta, Georgia.

January 2009

Contents

	Page
List of Figures.....	iv
List of Tables.....	v
Introduction.....	1
Brief Hydrologic Introduction.....	1
Sampling Sites.....	3
Description of Sampling Sites.....	4
Parameters for Water Quality Monitoring.....	16
Field Measures.....	16
Laboratory Measures.....	17
Stream Designated Uses.....	19
Results and Interpretation.....	20
Field Measures.....	21
Laboratory Measures.....	26
General Water Quality Status.....	33
Future Water Quality Monitoring.....	33
Long Term Monitoring.....	33

Figures

	Page
Figure 1. Map of water quality sampling sties at LIRI.....	3
Figure 2. East Fork Little River.....	5
Figure 3. Middle Fork Little River.....	6
Figure 4. Lookout Camp, Little River.....	7
Figure 5. DeSoto Falls, Little River.....	8
Figure 6. DeSoto State Park, Little River.....	9
Figure 7. Burnt House Ford, Little River.....	10
Figure 8. Yellow Creek.....	11
Figure 9. Highway 35 Bridge, Little River.....	12
Figure 10. Eberhart Point, Little River.....	13
Figure 11. Johnnie’s Creek.....	14
Figure 12. Canyon Mouth, Little River.....	15
Figure 13. Structure of a Box Plot.....	20
Figure 14. Water Temperature at LIRI.....	21
Figure 15. Specific Conductance at LIRI.....	22
Figure 16. pH at LIRI.....	23
Figure 17. Dissolved Oxygen at LIRI.....	24
Figure 18. Discharge at LIRI.....	25
Figure 19. Acid Neutralizing Capacity at LIRI.....	26
Figure 20. <i>E. coli</i> at LIRI.....	28
Figure 21. Turbidity at LIRI.....	29
Figure 22. Nitrate at LIRI.....	30
Figure 23. Sulfate at LIRI.....	31

Tables

	Page
Table 1. Listing of Sampling Sites.....	4
Table 2. Stream Designated Uses.....	19
Table 3. Abbreviations.....	34

Introduction

In early Fiscal-Year 2003, a water quality monitoring effort began in the Cumberland Piedmont Network (CUPN). For all intents and purposes, park managers and program directors can think of this initial sampling effort as a water quality inventory, as for many parks in the CUPN, little was known regarding water quality. Each park, sampled in rotation, underwent a water quality inventory sampling period which also served as a proving-ground for water quality monitoring protocols and logistics. The report that follows is a park-specific document that describes the monitoring sites, parameters tested, results in graphic form, a brief interpretation of the results, and recommendations of parameters to be measured for the long-term.

Sampling sites were chosen following site visits by then Mammoth Cave National Park hydrogeologist Joe Meiman, and with consultation with park staff. Some sites were chosen to coincide with past inventories and monitoring efforts. In most cases sites were chosen at the downstream end of a watershed to serve as an integrator of the basin, and should yield characteristics and contributions from the entire watershed.

Initial CUPN water quality sampling included a two-year period of intense activity. In the case of Little River Canyon National Preserve (LIRI), sampling occurred on fixed monthly dates (second Wednesdays) for 24 consecutive months – October 2006 through September 2008. The NPS Water Resources Division (WRD) requires each Network water quality program to monitor four core field parameters – water temperature, pH, specific conductance, and dissolved oxygen. Additional parameters of park interest, *Escherichia coli*, Acid Neutralizing Capacity, turbidity, nitrate, phosphate, sulfate, and atrazine were included at LIRI.

Brief Hydrologic Introduction

Situated upon the axis of the southwestern-plunging anticline of Lookout Mountain, Little River carves a deep (200 meters in the lower end) canyon, ultimately emerging near the end of the mountain at Mouth of Canyon. Little River Canyon National Preserve consists of a narrow river corridor between Little River Falls and Mouth of Canyon Park (including approximately the lower three kilometers of its tributary Bear Creek). Above Little River Falls, park lands extend laterally protecting a wider portion of the riparian corridor, uplands, and portions of small tributary watersheds. The upstream end of the park abuts DeSoto State Park on the West Fork Little River.

The Preserve is underlain by Pennsylvanian siliclastic strata, of which the many canyon bluffs are created. These thick beds of sandstones (and to a lesser extent, shales) give way to the underlying limestones near Mouth of Canyon. Although limestone is subareally exposed in this lower section of the river, there are no known caves or significant springs.

The core resources of Little River Canyon National Preserve tie directly to the river, be they recreational opportunities on the river or hiking and climbing canyon bluffs, or the myriad of plant life that rim the canyon uplands. Of course, Little River itself and its aquatic communities serves as the primary resource.

Perhaps no other unit within the CUPN (with exception of possibly sampling at Cumberland Gap National Historical Park during the construction of the Cumberland Gap Tunnel) has a more complete and rigorous record of water quality. Since the middle of 1998 Little River Canyon National Preserve Hydrologist Mary Shew has conducted a bi-weekly sampling program. Water quality parameters included dissolved oxygen, pH, total dissolved solids, temperature, turbidity, reactive phosphorous, free and total chlorines and fecal coliforms (*Escherichia coli*) and enterococci. Until 2001 analysis was performed for nitrate, ammonia, and sulfate (these parameters were discontinued due to the generation of hazardous wastes during analysis). Currently the program monitors water quality at 15 stations. Between November 1996 and October 1997, Jacksonville State University conducted a water quality baseline survey. Most of the sites used in this inventory are used currently in the park and CUPN monitoring programs.

Like many “river parks”, Little River Canyon National Preserve primarily consists of the main stem of the river and a narrow corridor on either side. With the exception of a wider corridor between Little River Falls and DeSoto State Park, Little River Canyon National Preserve is bounded by the upper edge of the canyon. Thus development occurs, at an ever increasing rate, right up to the park boundary. Development is largely residential, and lured by the view of the canyon, occurs directly upon the boundary. There are no sewer lines along the canyon and residential waste water is treated by individual septic systems. A large residential development is underway near the Bear Creek/Canyonland Park area. The possibility for future development is very high, and it is not hard to imagine a time in the future where the entire canyon will be rimmed with houses. Within the park’s watershed are several primary transportation routes. Alabama route 35 crosses Little River at the Falls and county routes 89 and 103 are within the West and East Forks, respectively. Little River Canyon Rim Parkway, as the name implies, hugs the western rim of the canyon from the Falls to Canyon Mouth.

Little River attracts a variety of both primary and secondary contact recreational activities. The river between Little River Falls and Mouth of Canyon passes through a series of highly technical white-water rapids and is primarily used by experienced paddlers. An occasional hiker may wade in the waters adjacent to one of two trails into the lower canyon; Powell and Eberhart. Casual wading and swimming occur with great numbers, however, the activities are concentrated at Little River Falls and Mouth of Canyon.

As a final note to this preamble, I would like to thank the staff of LIRI for their tremendous support in this monitoring effort. Starting at the top, Superintendent John Bundy never wavered in his full support of our program. There is no practical way that such a rigorous sampling program is possible without the dedication and attention to detail of primary sampler, Resource Management Specialist Mary Shew. The results presented in this document are fruits of her dedication.

Sampling Sites

Below is a map of water quality sampling sites at LIRI. During each monthly sampling round each site was visited and an additional Quality Assurance-Quality Control sample was extracted. Monthly sampling commenced in October 2006 and continued until September 2008, for a total of 24 sampling events. These sites represent the core of locations sampled over the years by LIRI staff.

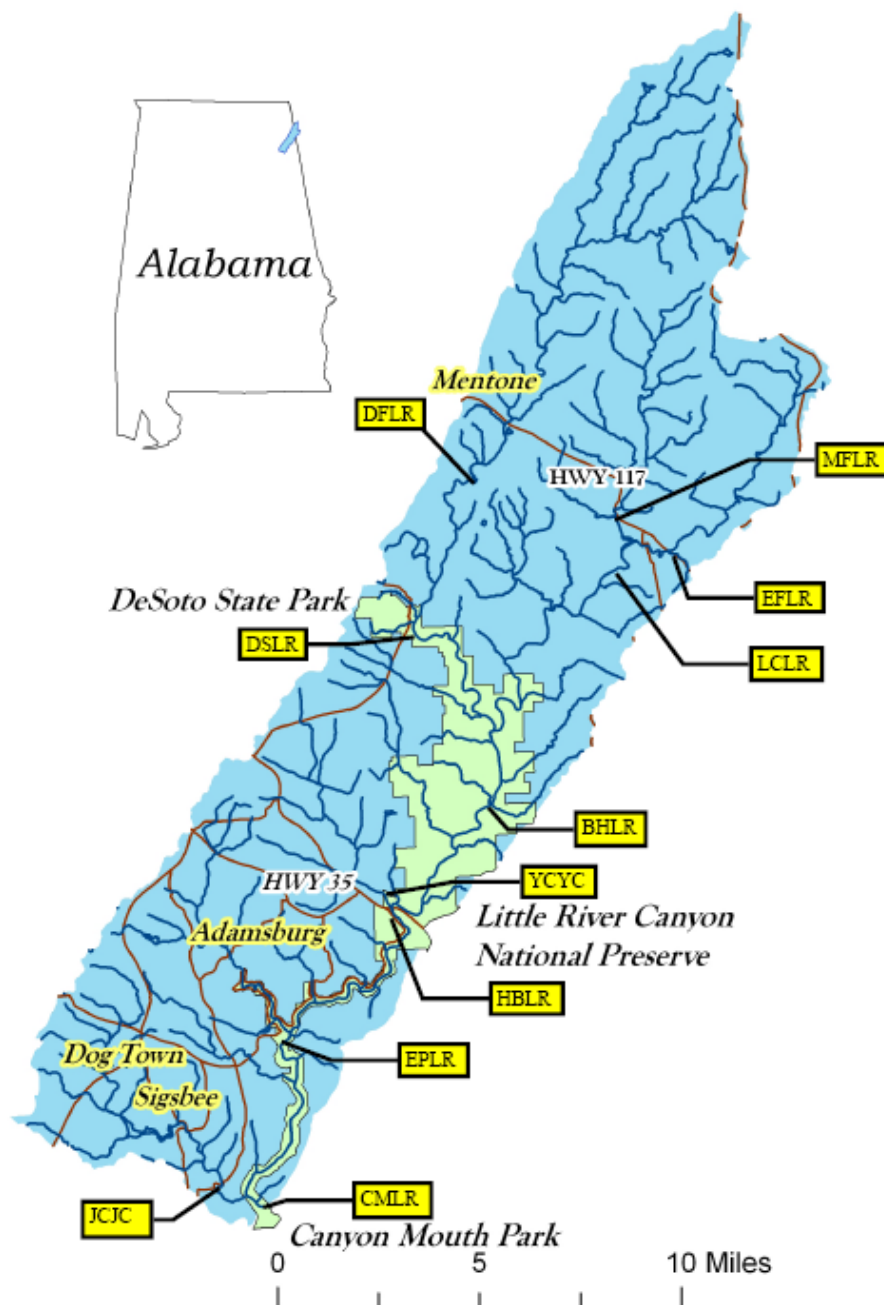


Figure 1. Map of water quality sampling sites of LIRI.

Description of Sampling Sites

Unlike many NPS lands, it is imperative that sampling sites be established outside the boundary of the Preserve. The vast majority of the Preserve's watershed lies outside the narrow river corridor. While the NPS cannot be held accountable for water quality violations in waters outside the park, since these sites are upstream of the Preserve, managers must be knowledgeable of these waters which directly and immediately impact Preserve resources. Thanks to Mary Shew for providing much of the site descriptions to follow.

Table 1. Listing of sampling sites, ownership and state.

ID	Name	Owner	State
EFLR	East Fork Little River	State R.O.W.	GA
MFLR	Middle Fork Little River	Private	AL
LCLR	Lookout Mountain Camp, Little River	Private	AL
DFLR	DeSoto Falls, West Fork Little River	State	AL
DSLRL	DeSoto State Park, West Fork Little River	State	AL
BHLR	Burnt House Ford, Little River	NPS	AL
YCYC	Yellow Creek	Private	AL
HBLR	Highway 35 Bridge, Little River	NPS	AL
EPLR	Eberhart Point, Little River	NPS	AL
JCJC	Johnnie's Creek	State R.O.W	AL
CMLR	Canyon Mouth Little River	NPS	AL

East Fork Little River (EFLR)

This site is accessed from state road 117 below the bridge. It is a narrow part of the river with sand and bedrock substrate. Listed as a threatened plant (Federal and Georgia), Kral's Water Plantain (*Sagittaria secundifolia*) is commonly found among the rock-lined channel bottom. This site is located in Chattooga County, Georgia. This site is important because of the many uses within this subwatershed. Domestic development, agriculture, clearcutting, and reclaimed strip mines are prevalent throughout the area.



Figure 2. East Fork of Little River, looking upstream, as photographed February 28th, 2007 by Joe Meiman

Middle Fork Little River (MFLR)

Permission to access this privately owned site adjacent to state road 117 was granted. This site is located downstream from current and proposed large subdivisions within Walker County, Georgia. Some agriculture occurs in the area, but domestic development is the biggest concern, especially within the watershed of the Middle Fork.



Figure 3. Maintenance Worker Tyler Jackson at Middle Fork Little River looking upstream as photographed February 28th, 2007 by Joe Meiman

Lookout Mountain Camp, Little River (LCLR)

This site is downstream of the confluence of the East and Middle Forks. Samples are taken below a derelict dam. There are several homes lining the banks of the small reservoir behind the dam. During this study a large area adjacent to the sampling site was cleared of trees and readied for home construction.



Figure 4. Lookout Camp, Little River below old dam as photographed October 28th, 2007 by Joe Meiman

DeSoto Falls, Little River (DFLR)

This site is located in the State Park area on the West Fork of Little River, outside of the federal boundary. The site is just below a concrete impoundment where the water flows over flat slabs of sandstone bedrock. This area of the State Park receives heavy, concentrated uses. Fishermen, swimmers, and boaters use the impoundment just above the collection site. Several homes, for both year-round and summer-use, are found along the edge of the lake and canyon area.



Figure 5. Mary Shew monitors below the dam above DeSoto Falls as photographed October 18th, 2006 by Joe Meiman

DeSoto State Park, Little River (DSLRL)

This site is located on the West Fork of Little River, a few kilometers downstream of DeSoto Falls. The site is accessed by the Scout trail that leads across Indian Falls. This area of the river is somewhat narrow and the substrate is fragmented sandstone bedrock with interspersed boulders. Discharge data are collected by a USGS gauging station located approximately 20 meters upstream. This site receives abundant recreational use, being within meters of the Scout trail.



Figure 6. Mary Shew at West Fork of Little River in DeSoto State Park, looking upstream as photographed October 18th, 2006 by Joe Meiman

Burnt House Ford, Little River (BHLR)

Located on the main stem this site is located approximately six kilometers downstream of the confluence of the West and combined East and Middle Forks. The site is easily accessible from an old road off the north end of park road 01. This area of river is bedrock and is just downstream from Hurricane Creek. The road leading to the site is gated, allowing only park staff to access the road. Some horseback riders ride around the gate and ride to this site along the river. Otherwise, no other activity takes place there, except for the wildlife.



Figure 7. Tyler Jackson collects a water quality sample at Burnt House Ford, Little River as photographed February 28th, 2007 by Joe Meiman

Yellow Creek (YCYC)

The sample site is located on the main stem of this fourth order stream just 1.3 kilometers before emptying into the west side of the Little River. This site is not a recreational area, nor does it lie within federal boundaries, however, past LIRI studies have determined that for the majority of the times, when measures are high at the Highway 35 bridge site, the source of the problem is traced back up to this creek. The watershed is a little over 3600 hectares and contains numerous homes, agricultural fields, cattle, horse and chicken farms, and several reclaimed coal strip mines.



Figure 8. Yellow Creek looking downstream, as photographed February 28th, 2007 by Joe Meiman

Highway 35 Bridge, Little River (HBLR)

This site is located above Little River Falls, just downstream of the State Highway 35 bridge. The river here is broad and flows over large slabs of sandstone bedrock. Unlike the bouldery substrate found below the falls, here and all along much of the main stem above the falls, the channel is composed of flat, broken bedrock with rocky shoals in the shallow areas. This site, along with the Canyon Mouth, is the most popular area for sunbathing and swimming. In the summer, people lounge within the pools created by depressions in the sandstone bedrock.



Figure 9. Mary Shew samples the Little River at State Highway 35 Bridge looking downstream as photographed October 18th, 2006 by Joe Meiman

Eberhart Point, Little River (EPLR)

This sampling site is located on a riffle between two pools. The site is accessed by Eberhart trail and is located approximately 50 meters upstream from where the trail meets the river. Here the river is relatively narrow and the canyon walls tower over 120 m above. The substrate is composed of large cobble and boulders of various sizes. Eberhart trail is one of few trails that allow people to gain a “canyon experience”; however, the trail is rather steep, therefore this area of the river does not receive as much activity as more accessible sites. Bear Creek, another large tributary draining from the west, joins Little River only 300 m above this sampling site.



Figure 10. Little River at the Eberhart Trail looking upstream as photographed October 18th, 2006 by Joe Meiman

Johnnie's Creek (JCJC)

Johnnie's Creek is a major tributary located about one kilometer above the Canyon Mouth sample site. It flows from the west and drains a rather large watershed that contains numerous farms and continually increasing residential development. Samples are taken from below the County Road 275 bridge just above the falls. Here the creek is somewhat narrow with a substrate of broken bedrock (and beer bottles). Past LIRI monitoring found high bacterial counts and nutrients are usually a problem here.



Figure 11. Tyler Jackson samples Johnnie's Creek, looking downstream, as photographed February 28th, 2007 by Joe Meiman

Canyon Mouth, Little River (CMLR)

This site is located a short distance from where Little River exits the canyon and approximately five kilometers above its confluence with Weiss Lake. This sampling site is located on a riffle area between two pools that receive heavy use from swimmers. Just downstream from the site a real-time USGS flow gauging station. A hiking trail, pavilion, restrooms, picnic tables, and opportunities to swim and fish draw many people daily to this small stretch of river.



Figure 12. Mary Shew samples Little River at Canyon Mouth, looking upstream, as photographed October 18th, 2006 by Joe Meiman

Parameters for Water Quality Monitoring

Field Measures

Temperature

Measurements of water and air temperatures at the field site are essential for water-data collection. Determinations of dissolved-oxygen concentrations, conductivity, pH, rate and equilibria of chemical reactions, biological activity, and fluid properties rely on accurate temperature measurements. Accurate water- and air-temperature data are essential to document thermal alterations to the environment caused by natural phenomena and by human activities. A thermistor thermometer is an electrical device made of a solid semiconductor with a large temperature coefficient of resistivity. An electrical signal processor (meter) converts changes in resistance to a readout calibrated in temperature units. Thermistors commonly are incorporated in instruments used for surface water and groundwater measurements.

Specific Conductance (SpC)

Electrical conductance is a measure of the capacity of water (or other media) to conduct an electrical current. Basically, Specific Conductance (SpC) is a quick and reliable estimation of the dissolved solids in the water. Electrical conductance of water is a function of the types and quantities of dissolved substances in water, but there is no universal linear relation between total dissolved substances and conductivity. A dip-cell electrode sensor was used.

pH

The pH of an aqueous solution is controlled by interrelated chemical reactions that produce or consume hydrogen ions. Water pH is a useful index of the status of equilibrium reactions in which water participates. The pH of water directly affects physiological functions of plants and animals, and it is, therefore, an important indicator of the health of a water system. The electrometric measurement method uses a hydrogen ion electrode.

Dissolved Oxygen (DO)

Accurate data on concentrations of dissolved oxygen (DO) in water are essential for documenting changes to the environment caused by natural phenomena and human activities. Sources of DO in water include atmospheric reaeration and photosynthetic activities of aquatic plants. Many chemical and biological reactions in groundwater and surface water depend directly or indirectly on the amount of oxygen present. Dissolved oxygen is necessary in aquatic systems for the survival and growth of many aquatic organisms. The most commonly used field method for measuring DO in water is the amperometric method, in which DO concentration is determined with a temperature-compensating instrument or meter that works with a polarographic membrane-type sensor.

Discharge

Discharge, or flow, is the anchor of all water quality data. Discharge data are used to compute the mass flux, or loading, of a particular constituent. Mass flux yields valuable insight as to the mode of contaminant entrainment and transport through the watershed.

Laboratory Measures

Acid Neutralizing Capacity (ANC)

ANC is basically a measure of buffering capacity – the ability of water to buffer the effects of acid. Waters of low ANC are more susceptible to decreased pH by acid precipitation. During the January 2005 CUPN Science Technical Committee meeting, it was determined that the Hach ANC method was not producing reliable results. A new protocol was written and in June 2005 the CUPN began using a modified version of Standard Method 403 Alkalinity test. ANC analysis was performed at the LIRI lab at conclusion of sampling round.

Bacteria

Fecal indicator bacteria are used to assess the quality of water because they are not typically disease-causing, but are correlated to the presence of several waterborne disease-causing organisms (pathogens). The concentration of indicator bacteria (the term "indicator bacteria" is used synonymously with fecal indicator bacteria in this section) is a measure of water safety for body-contact recreation or for consumption. The most widely used indicator bacteria are of the total coliform, fecal coliform, enterococci, and fecal streptococci groups, and *E. coli*. Standard Method 9222D, membrane filtration for fecal coliform was used.

During the January 2005 CUPN Science Technical Committee meeting, it was determined that the 922D fecal coliform method was not producing reliable results. A new protocol was written and in June 2005 the CUPN began using the IDEXX (Standard Method 9223 – Enzyme Substrate Coliform) *Escherichia coli* and total coliform bacteria test. All three bacteria are members of the coliform group and are found in the gastrointestinal track of warm-blooded animals; *E. coli* is the most common member of fecal coliform, and fecal coliform a subset of total coliform. *E. coli* analysis was performed at the LIRI lab at conclusion of sampling round.

Turbidity

Turbidity measures the scattering effect that suspended solids have on light: the higher the intensity of scattered light, the higher the turbidity. Primary contributors to turbidity include clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, plankton, and microscopic organisms. The measurement is qualitative and cannot be correlated directly as micrograms per liter of suspended solids. Measurements were made in the laboratory with a nephelometer using Standard Method 214 A. Turbidity analysis was performed at the LIRI lab at conclusion of sampling round.

Anions

A suite of three anions, nitrate-nitrogen, total orthophosphate, and sulfate were analyzed. Sources of anions are varied – from natural and anthropogenic contribution. Nitrate-nitrogen, and orthophosphate are considered nutrients, and are commonly products of animal wastes. Nitrate-nitrogen and orthophosphate were analyzed by ion chromatography (SM4500) and sulfate by turbidimetric method (EPA 375.4) at Technical Micronics Control, Huntsville Alabama.

Atrazine

Atrazine, a triazine-class herbicide, represents the most common and durable pesticides used in the United States. They are commonly found after peak applications periods (spring), closely associated with storm pulses (attached to fine particulate matter), and have been found persisting in the water column for six months. The USEPA-approved immuno-assay method 508.1 was used for this analysis by Technical Micronics Control, Huntsville Alabama.

Stream Designated Uses

Each water body sampled within the CUPN has either been assigned a designated use by the state, or, by using the same ranking criteria. Each stream in LIRI has been designated by the states (see table below). The state of Alabama considers Little River and its tributaries “Outstanding National Resource Waters” (Chapter 335-6-11-.02). The USEPA, besides mandating these rankings, also directed the states to develop water quality standards for each designated use. We can use these water quality standards as a minimum to track water quality trends in CUPN parks. By adapting the state standards, we can also track park water quality trends within the states, regions, or watersheds. For more information on Alabama or Georgia water quality standards, please see:

Alabama: Alabama Department of Environmental Management; Water Division – Water Quality Program, Chapter 335-6-10.

Georgia: Rules and Regulations for Water Quality Control, Chapter 391-3-6, Revised

Table 2. The table below shows the designated uses for each site. ONRW = Outstanding National Resource Water, PWS = Public Water Supply, S = Swimming and other whole-body water contact sports, F&W = Fish and Wildlife.

Park	Site ID	Stream	State	Designated Use
LIRI	EFLR	East Fork, Little River	GA	Secondary Contact Recreation
LIRI	MFLR	Middle Fork, Little River	AL	ONRW, PWS, S, F&W
LIRI	LCLR	Lookout Camp, Little River	AL	ONRW, PWS, S, F&W
LIRI	DFLR	DeSoto Falls, Little River	AL	ONRW, PWS, S, F&W
LIRI	BHLR	Burnt House Ford, Little River	AL	ONRW, PWS, S, F&W
LIRI	DSLRL	DeSoto State Park, Little River	AL	ONRW, PWS, S, F&W
LIRI	YCYC	Yellow Creek	AL	ONRW, PWS, S, F&W
LIRI	HBLR	Highway 35 Bridge, Little River	AL	ONRW, PWS, S, F&W
LIRI	EPLR	Eberhart Point, Little River	AL	ONRW, PWS, S, F&W
LIRI	JCJC	Johnnie’s Creek	AL	ONRW, PWS, S, F&W
LIRI	CMLR	Canyon Mouth, Little River	AL	ONRW, PWS, S, F&W

Results and Interpretation

The following graphs are a composite of 24 consecutive monthly rounds of sampling at LIRI. As stated above, not all sites represented are within the Preserve – actually seven of the 11 sites are outside its boundary. For visual separation of what are or are not NPS waters, the graphs are color-coded, where the **light green** are sites external to the Preserve and the **blue** represent those internal. The sites are arranged with the upstream to the left, tributaries Yellow and Johnnie's Creek are relatively positioned along this gradient. Data are represented in the graphs below as box-plots. Here is a key to understanding the structure of a box-plot:

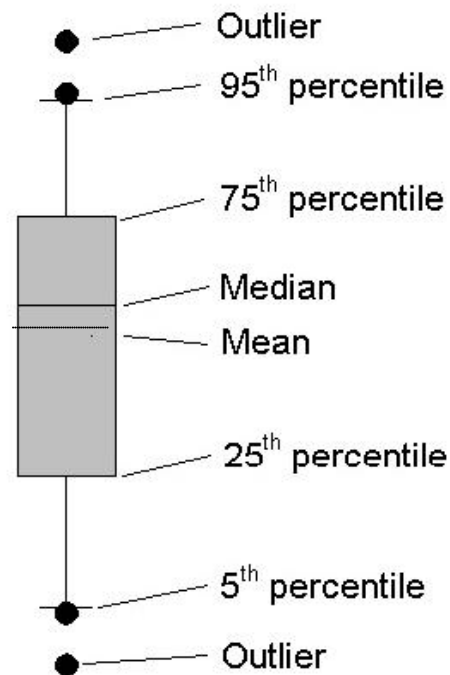


Figure 13. Structure of a box-plot

Field Measures

Water Temperature

Water temperatures of LIRI are considered to be within range to support native aquatic life. Each site showed expected seasonal variations. The single sample that reached the maximum limit of 32°C was at Yellow Creek (YCYC) and occurred in August 2007, when the stream was a disconnected series of pools (no flow).

LIRI Oct 2007 - Sept 2008

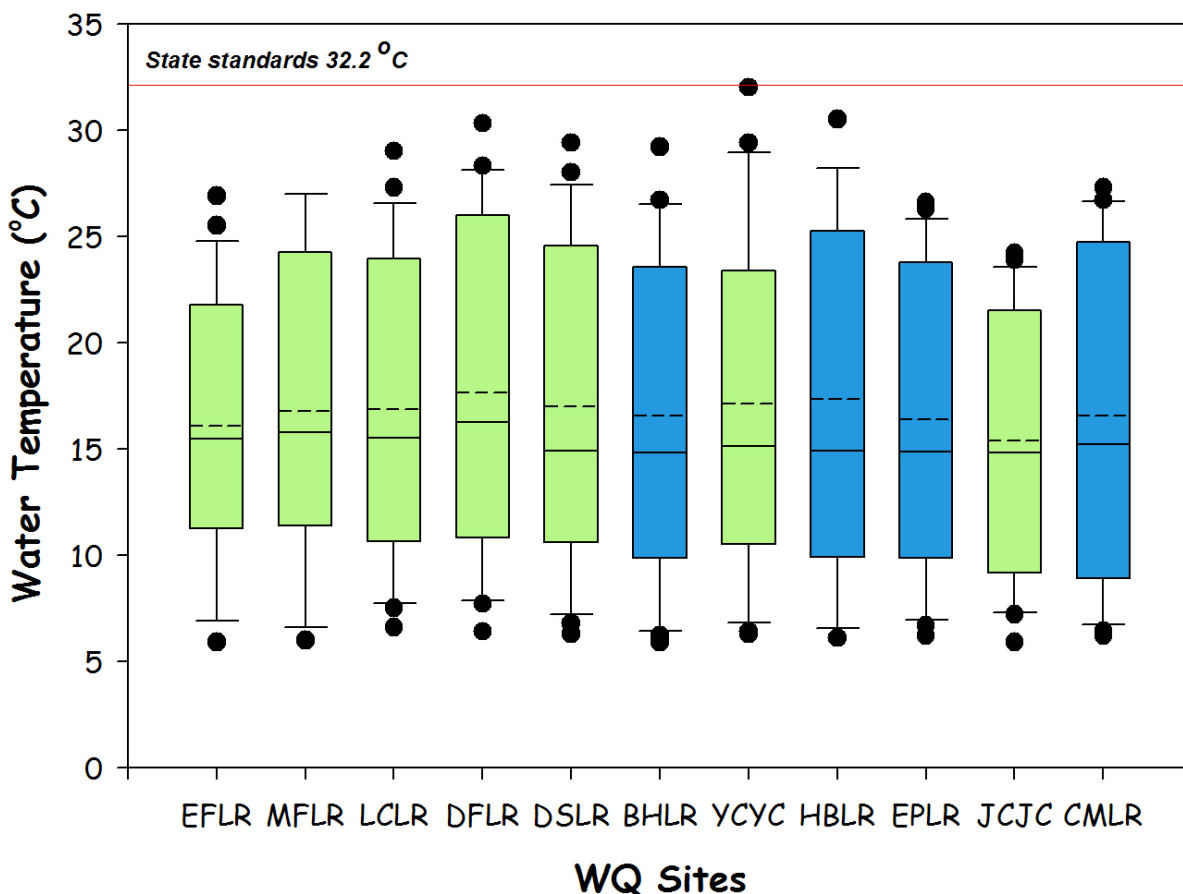


Figure 14. Water temperature at LIRI

Specific Conductance

The distribution of specific conductance (SpC) of LIRI is reflective of the amount of dissolved solids, which is primarily controlled by lithology and residence time. Strata of the Little River watershed is comprised of siliceous sandstones and shales, both difficult to dissolve. The range of values is due to flow condition. Following a rainfall event, waters are typically low in dissolved ions – quick flow having little interaction time with the rock. The inverse is true for low flow periods. There are no state standards for SpC.

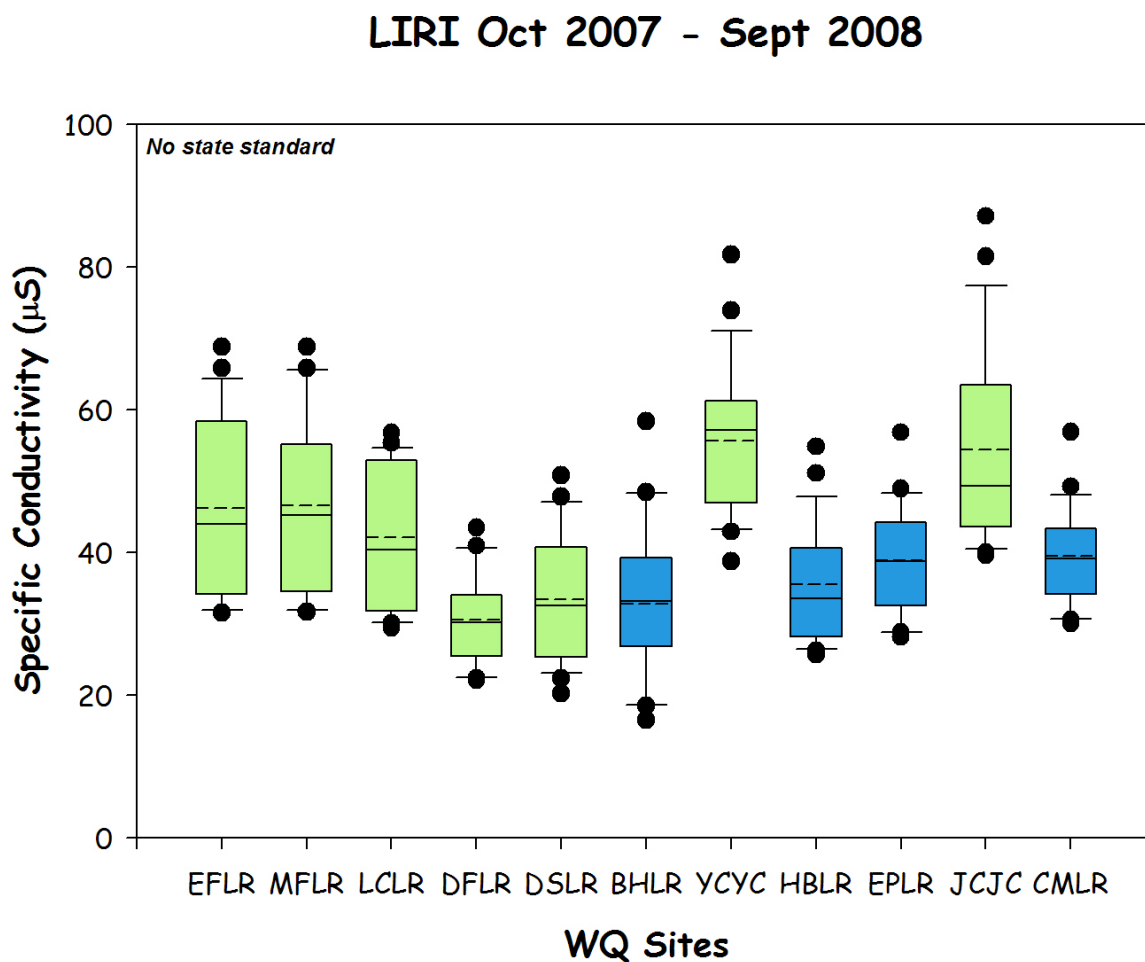


Figure 15. Specific Conductance at LIRI

pH

The pH of LIRI waters is naturally acidic (< 7.0 SU). Rainfall is naturally acidic (about 5.6 to 5.8 SU), combined by natural humic acids (from soils and leaf decay), pH tends to remain low unless the water contacts carbonate strata. The dissolution of carbonate rock, such as limestone, liberates calcium (Ca^{+}) and bicarbonate (HCO_3^{-}) ions. The latter is an alkaline and comprises the bulk of a water's capacity to neutralize acid. Carbonate rocks are virtually non-existent in the Preserve's watershed.

All four NPS sites at times were found to exceed the lower pH limit of 6.0 SU. This, however, does not constitute violations of state water quality standards. Section (2) of 335-6-10-.05 (General Conditions Applicable to All Water Quality Criteria) states: "natural waters may, on occasion, have characteristics outside of the limits established by these criteria." It well may be that these low pH values are natural. There are no carbonate rocks within the watersheds of LIRI and, as Acid Neutralizing Capacity data will later show, there is no natural means for the streams to buffer acids.

LIRI Oct 2007 - Sept 2008

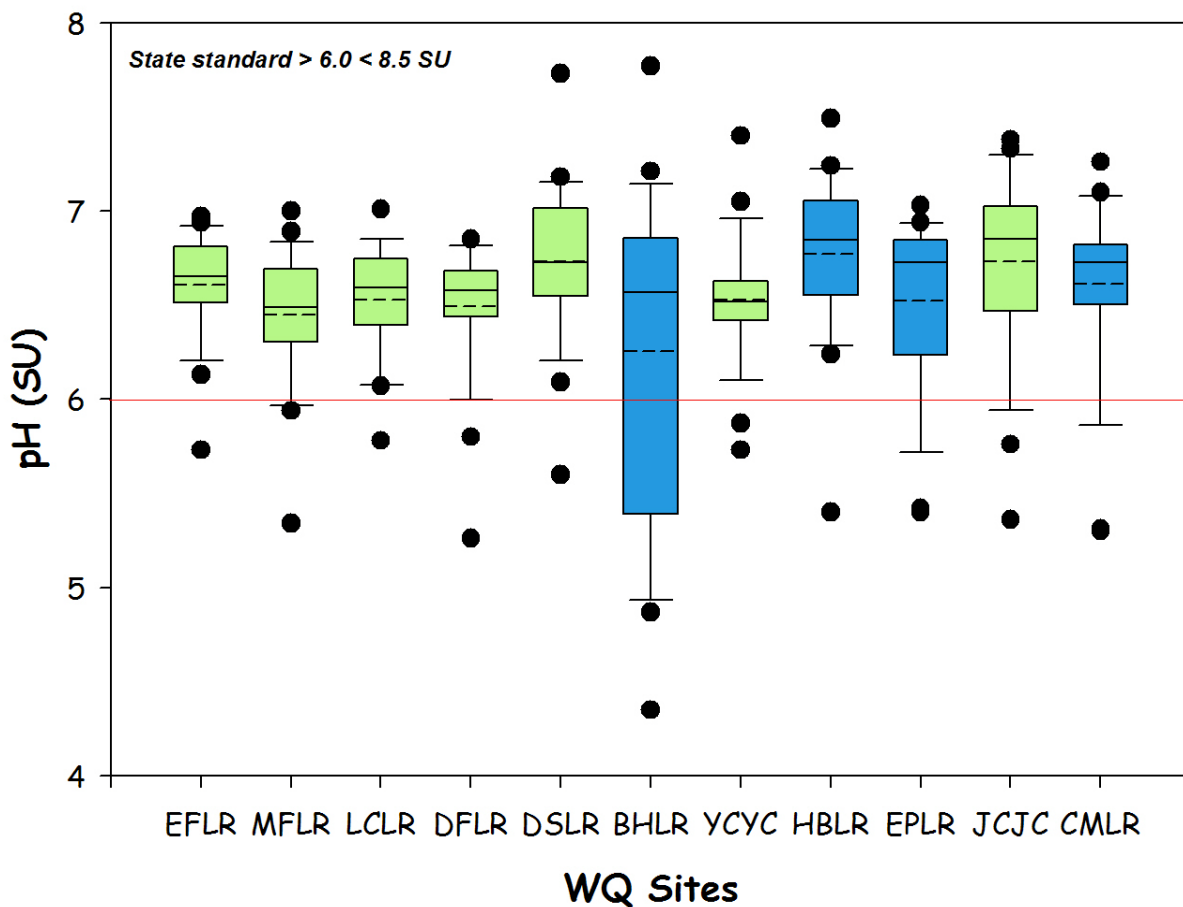


Figure 16. pH at LIRI

Dissolved Oxygen

With the exception of one reading at Eberhart Point (EPLR), all NPS waters met the Outstanding Alabama Water lower dissolved oxygen limit of 5.5 mg/l. The 4.91 mg/l of this August 2007 sample was taken during very low flows (little aeration) and at times of higher temperature – warm water holds less dissolved gases, including oxygen, than cold water. A combination of low flow and high temperature was the likely cause of the depressed DO level. There were several other exceedences of the DO limit – all were also during hot, low flow conditions. The Middle Fork (MFLR) site commonly had the lowest DO. This may be an artifact of the long, sluggish pool at the sampling site.

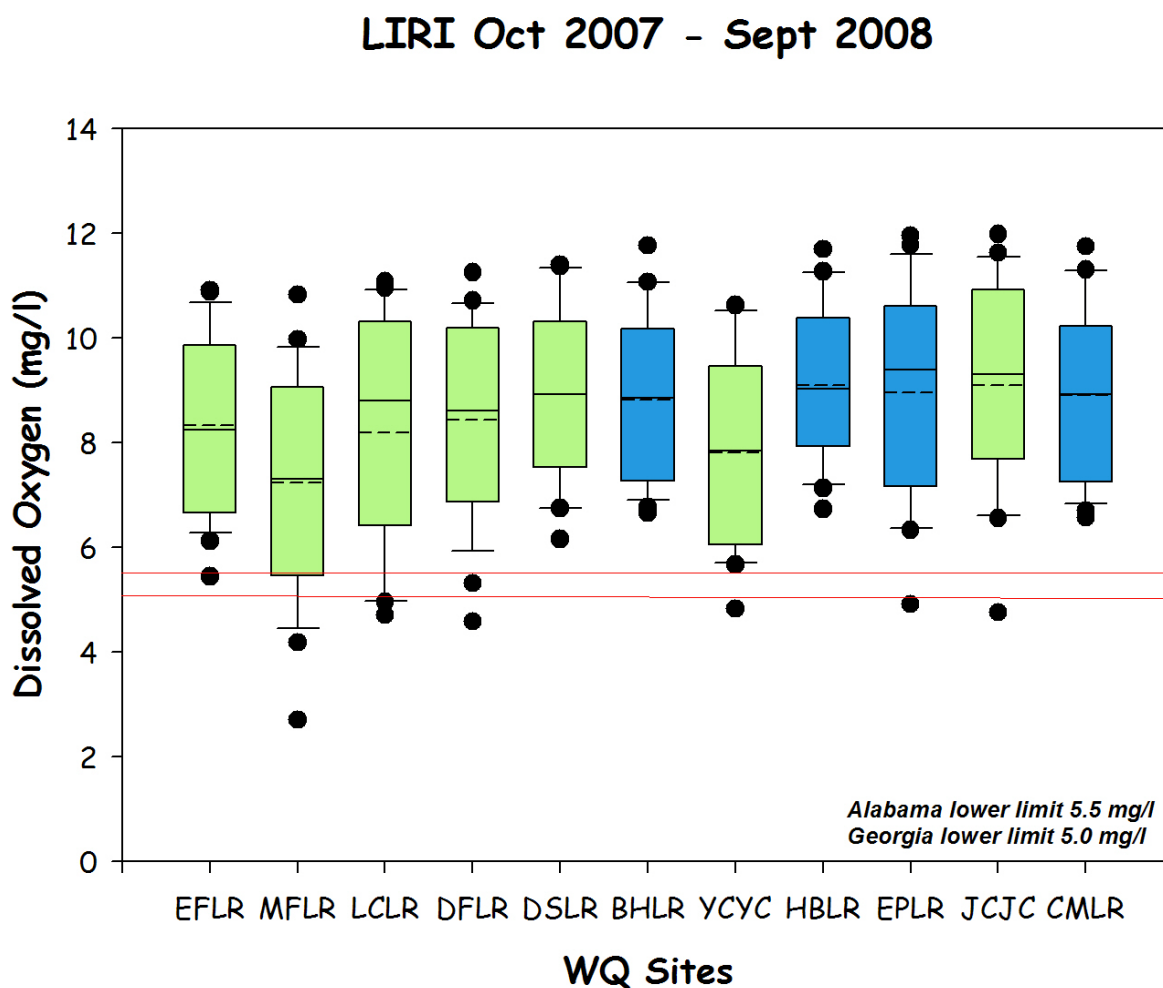


Figure 17. Dissolved Oxygen at LIRI

Discharge

Discharge, or flow, helps put all water quality into context. As will be presented later in the bacteria discussion, discharge relative to parametric concentration can greatly assist interpretation of results. All sites are centered low with high outliers, as most sampling rounds were during low flow, with the occasional high-flow event. A predictable increase of flow is seen moving downstream.

LIRI Oct 2007 - Sept 2008

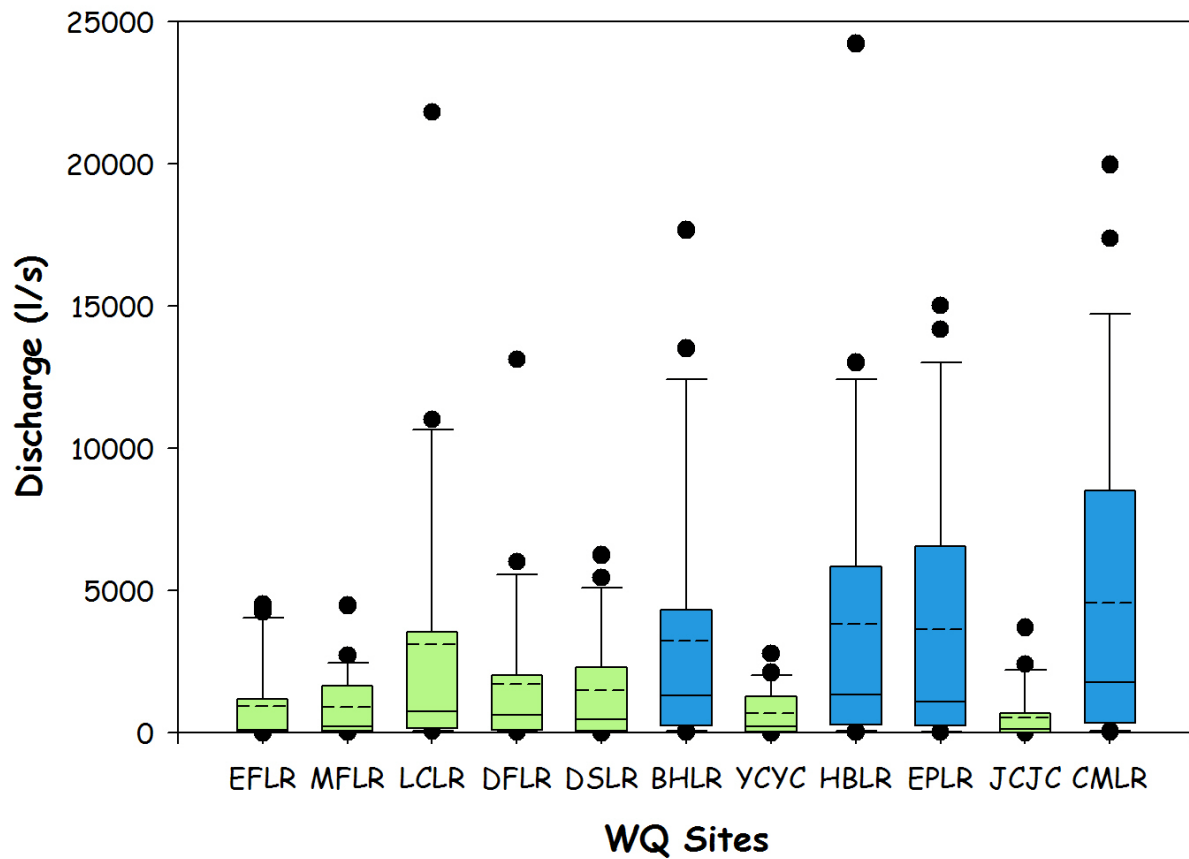


Figure 18. Discharge at LIRI

Laboratory Measures

Acid Neutralizing Capacity

Acid Neutralizing Capacity (ANC) is the measure of the stream's ability to cope with, or neutralize, acid. In the pH ranges of LIRI waters, the specie driving ANC is the bicarbonate anion. The more bicarbonate, the higher the ANC, thus the lower the pH. The ANC graph is reminiscent of the pH graph. It is not surprising that Burnt House Ford (BHLR), which had the lowest pH values, also had the lowest average ANC, and many times had no recordable bicarbonates. It is reasonable to assume that Hurricane Creek, only a few hundred meters upstream, is contributing additional acids, thus consuming already limited bicarbonate ions, further depressing pH.

One of the main values of monitoring ANC is that it gives insight into related water quality issues. Alabama law has a provision that a water body is not considered in violation if it comes by it naturally. ANC results show that there are little or no bicarbonates to buffer LIRI waters. Secondly, as this well may be a natural condition, results help explain the presence or absence of aquatic species.

LIRI Oct 2007 - Sept 2008

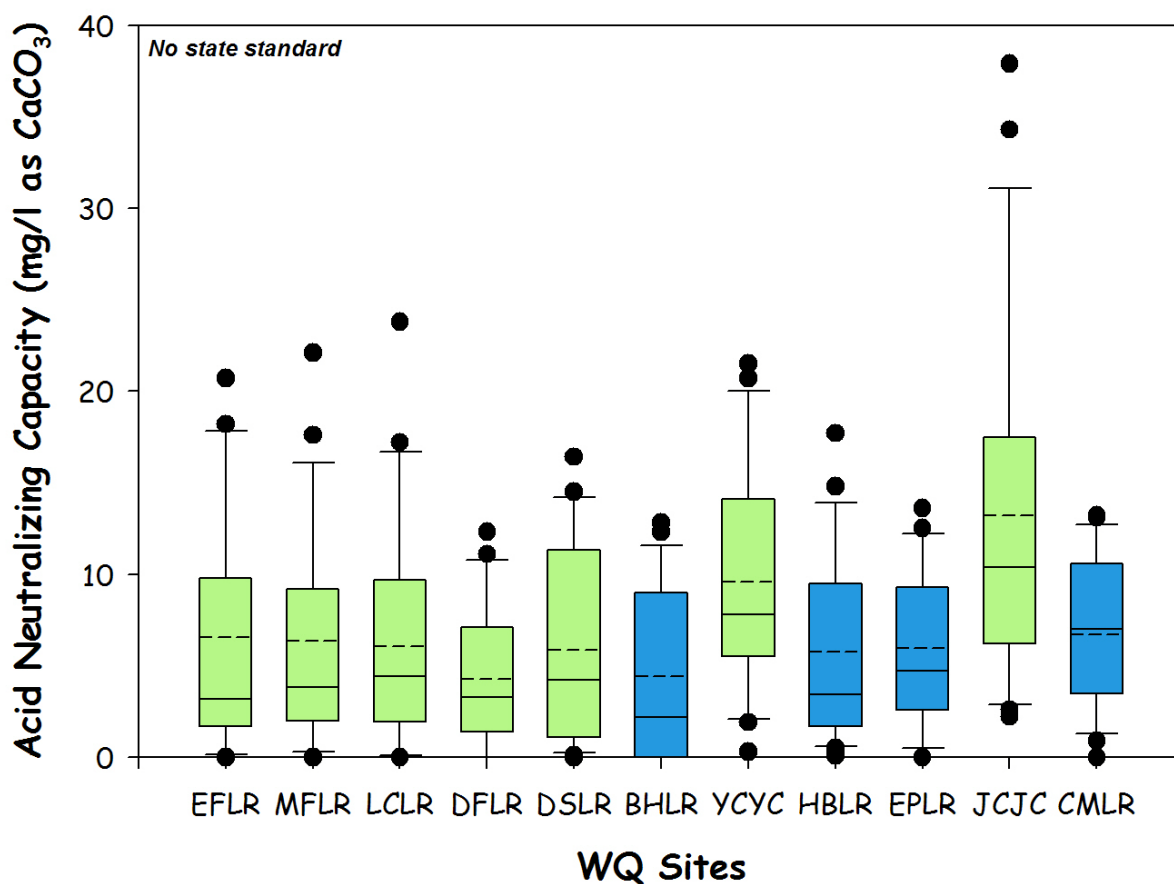


Figure 19. Acid Neutralizing Capacity at LIRI

Escherichia coli

Escherichia coli (*E. coli*) is a naturally-occurring bacteria found in intestines and feces of warm-blooded animals. While not generally a human pathogen (a substance that causes harm to people), some strains of *E. coli*, 0157:H7 for example, have been linked to illness in contaminated foods. As *E. coli* are associated with pathogens, they are considered an indicator species, and thus used for a measure of water quality.

E. coli bacteria enters a stream by point source (direct injection at specific points), and non-point source (run-off over a broad area). Point sources include failing septic systems and inadequate waste water treatment facilities. Non-point sources include surface run-off from livestock pastures and wildlife habitat.

While each method of entrainment produces the same result – bacterial contamination of a waterbody – both point and non-point sources have distinct relationships to rainfall events and resultant stream flow condition. Non-point sources are washed from a broad area into a stream during a rainfall event. Point sources enter a stream at a constant rate, regardless of rainfall.

A point source contaminant concentration diminishes at times of high flow as it is diluted. Conversely, at times of low flow it is concentrated. The exact opposite can be expected for a non-point source contaminant; at times of low stream flow, its concentration would be very low as a rainfall event is needed to wash it from the land. At times of high flow (the result of rainfall events) non-point source contamination is high as the land surface is washed of contaminants in the form of run-off.

Every water monitored during this program, with exception of DeSoto State Park (DSLRL), exceeded state WQ standards for *Escherichia coli*. This should not necessarily alarm the resource manager as high levels are associated with rainfall events, thus a non-point source is the likely contributor. With the exception of an occasional exceedence of state full contact standards, *E. coli* levels at LIRI waters are remarkable good considering the size and land use of its watershed. Only one time out of 24 samples was the limit exceeded at the Preserve's primary (and furthest downstream) site, Canyon Mouth. The extremely compressed plot at DFLR is an artifact of a logarithmic axis and predominantly low levels.

LIRI Oct 2007 - Sept 2008

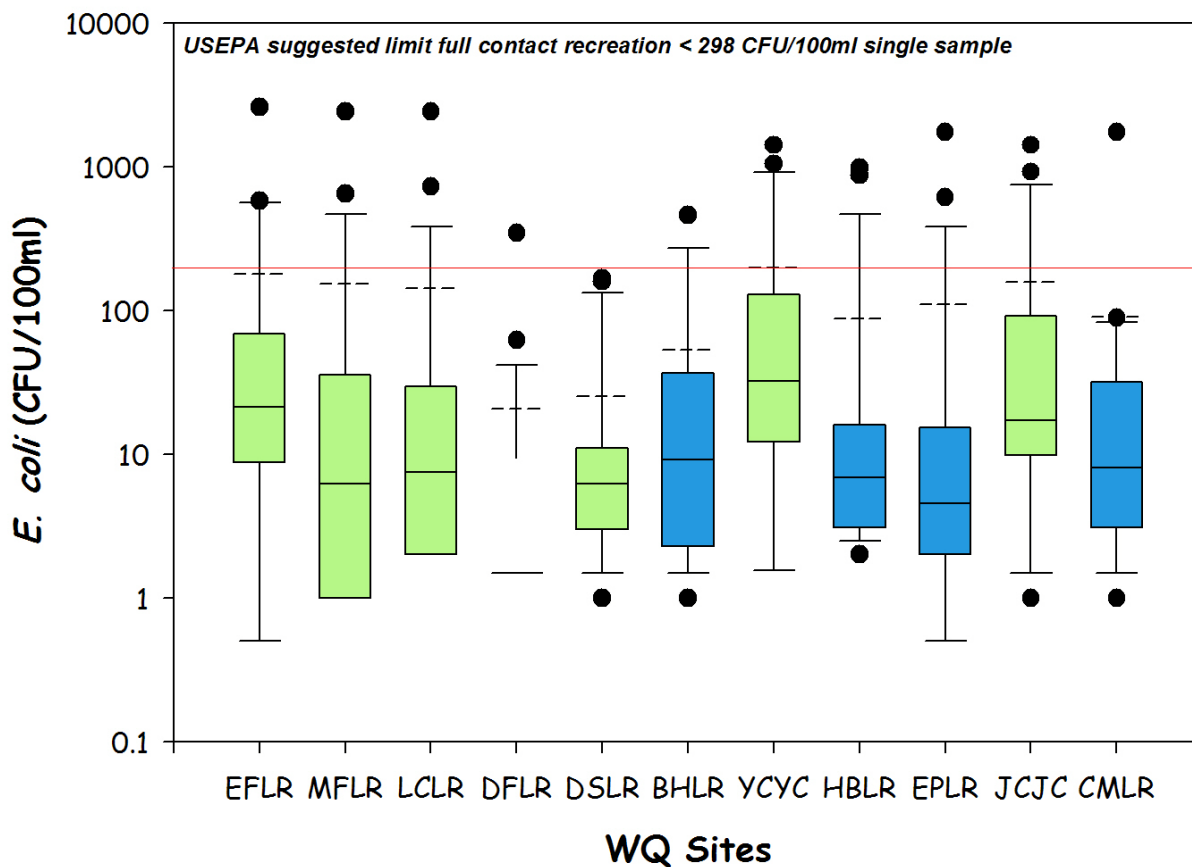


Figure 20. *E. coli* at CUGA.

Turbidity

Turbidity is a general measure, or approximation of the amount of suspended material in the water. It is not directly correlative to suspended solids as particle size, shape and color all play a role in the transmission of light through the water column. In general, the higher turbidity values are associated with muddy or turbid waters. In general, waters of LIRI were clear to slightly turbid. This range is due to sample collection in respect to rainfall events –high turbidity associated with high flow. Turbidity 50 NTU (Nephelometric Turbidity Units) above background are considered violation of state standards. All four NPS waters met this desired condition.

LIRI Oct 2007 - Sept 2008

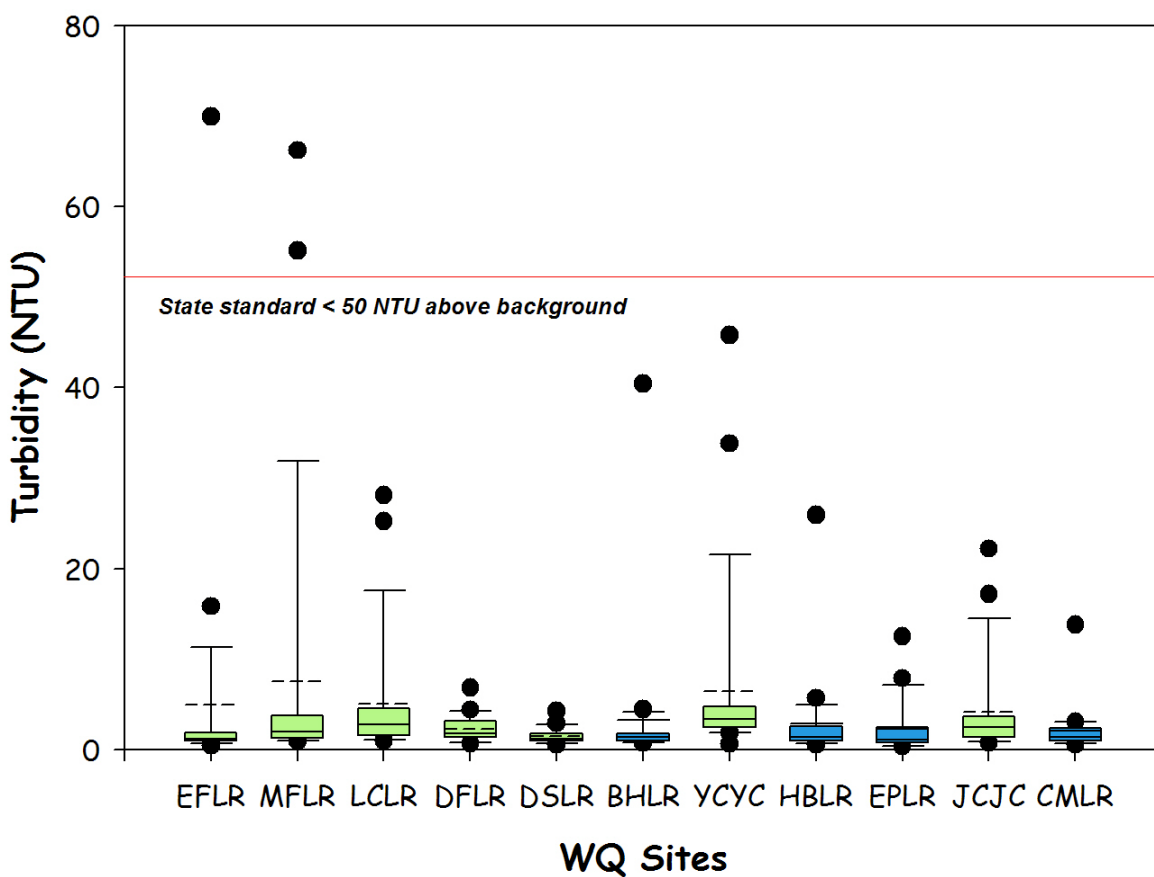


Figure 21. Turbidity at LIRI

Nitrate

The nutrient nitrate, as reported as nitrogen, was well below the USEPA recommended limit for drinking water, 10 mg/l. There is no state or recommended USEPA standard for nitrate-nitrogen. The smaller watersheds of Yellow and Johnnie's Creeks were slightly higher than levels found along the main stem, but still under the limit. While there does not appear to be a nitrate problem at LIRI, these data do serve as a baseline for comparison of future monitoring.

LIRI Oct 2007 - Sept 2008

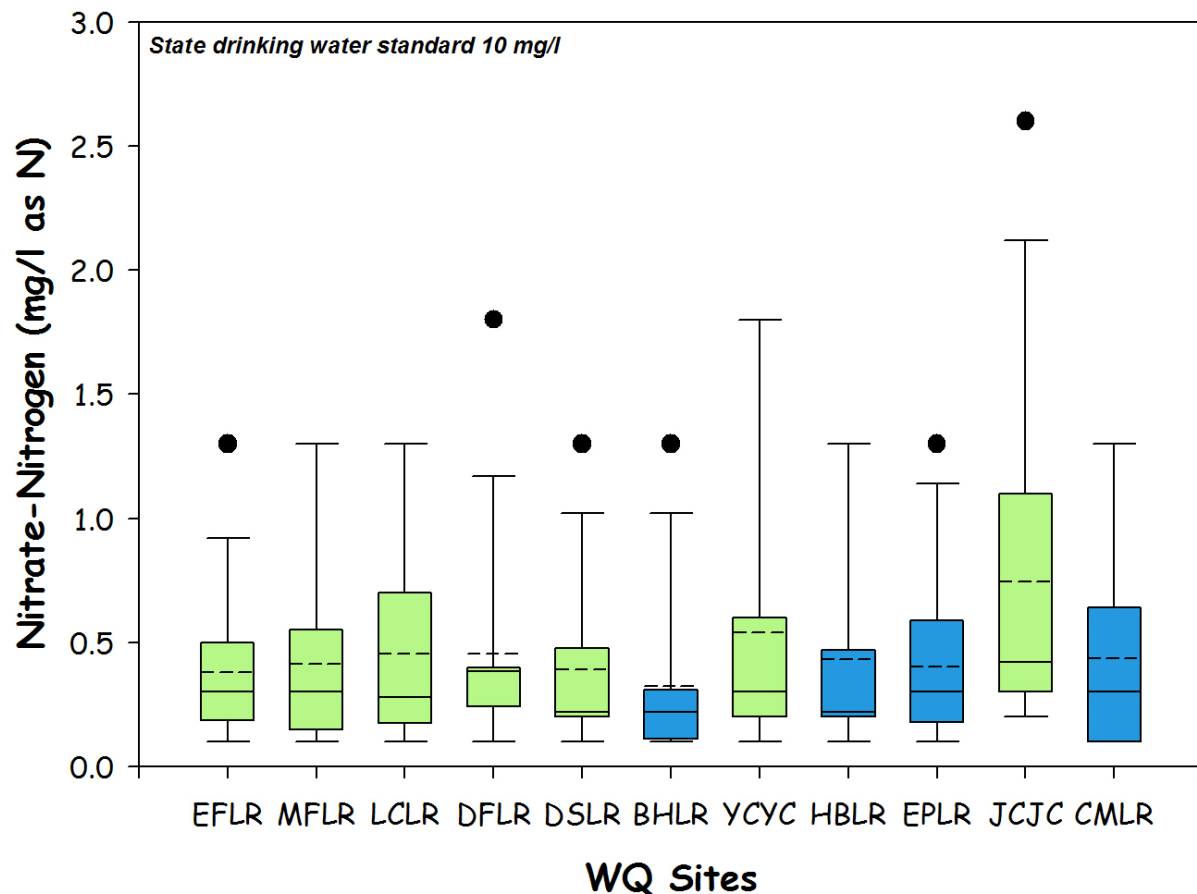


Figure 22. Nitrate-Nitrogen at LIRI

Sulfate

Sulfate was monitored as this ion is typically associated with coal mining runoff. There are no state or USEPA standards for sulfate with respect to recreational contact or freshwater fisheries. If we consider the USEPA drinking water standard of 250 mg/l as a benchmark, we can see that the waters are well below this level.

LIRI Oct 2007 - Sept 2008

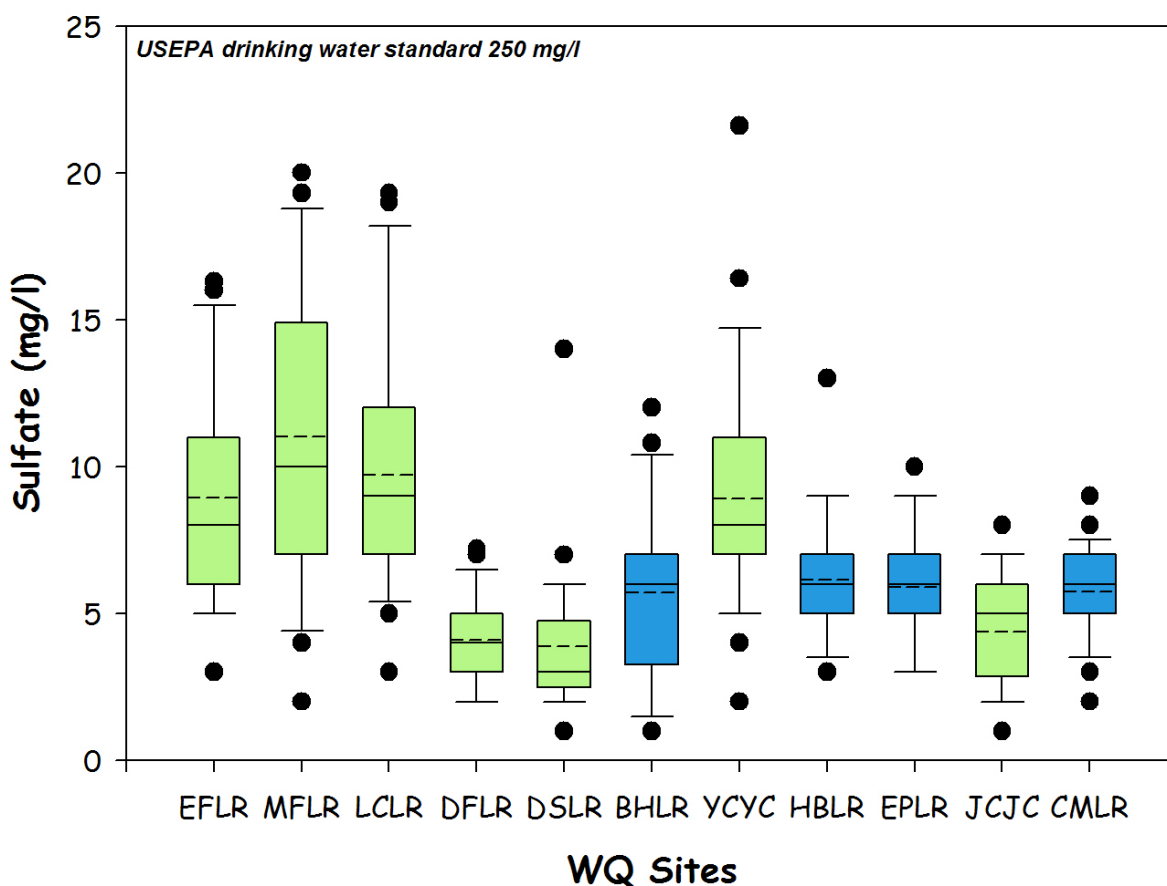


Figure 23. Sulfate at LIRI

Phosphate and Atrazine

Analysis for orthophosphate was performed for each sample, and one duplicate per sample round – a total of 288 samples. Only two samples, both at the East Fork (EFLR) site were above the detection limit of 60 µg/l. These samples, taken in August and September 2008, were both 61µg/l. The USEPA does not recommend an orthophosphate standard. While this nutrient is typically a larger issue in reservoirs, eutrophication can occur in concentrations less than 25 µg/l.

Thirty samples were collected and analyzed for the herbicide atrazine. The limited number was due to the high cost of analysis. Furthermore, sample times were restricted to months immediately following application – February through August in 2007, and May through July in 2008. The first year saw sampling covered only three sites (but over a longer period), while the second expanded the spatial coverage but limited temporal range. The idea was to try to “find” atrazine. Of the 30 samples taken, only three were above the 0.046 µg/l detection limit – June and July 2008 at Yellow Creek (YCYC) both at 0.115 µg/l, and a June 2008 sample at DeSoto Falls (DFLR) of 0.140 µg/l. While there are no existing state or federal limits for contact recreation or warm water fish, all samples were below the USEPA drinking water limit of 3 µg/l.

General Water Quality Status

Water quality of the four sites sampled in LIRI is good. The additional seven sites sampled that recharge the Little River, immediately upstream of the Preserve were in fairly good condition as well. At times of high flow, it is not uncommon that the USEPA limit for *E. coli* of 298 CFU/100ml is exceeded. These levels were rarely seen in Preserve waters. Caution is recommended in interpreting parameters like *E. coli*, as they are highly dependent on flow condition. While there are 264 samples (exclusive of duplicates) collected and analyzed over the course of this study, they are spread over 11 sites. Direct correlation is difficult due to variables such as antecedent condition, and rainfall duration, distribution and intensity.

Future Water Quality Monitoring Recommendations

The CUPN is required in accord with the national water quality program to monitor water temperature, specific conductance, pH, and dissolved oxygen. In addition, there is sufficient reason to continue to monitor ANC, *Escherichia coli* and turbidity, as long-term data may serve to alert the park to impending water quality issues.

There does not appear to be a problem with nitrate-nitrogen, orthophosphate, sulfate, or atrazine. While it is not recommended that these parameters be included in routine CUPN water quality sampling, it would not hurt to periodically check Preserve-only waters for nitrate (as a general indicator of nutrient levels). Additionally a more sensitive laboratory technique must be found and samples collected and analyzed before it is certain that there is not excessive orthophosphate in LIRI waters. While a state or national standard does not exist for this compound, research suggests eutrophication (mainly in lakes) can occur at levels of 25 µg/l.

LIRI is regarded as a “Tier One” park with respect to water resources by the CUPN. That is, water resources are a key element stated in the Preserve’s Enabling Legislation; it contains rare or threatened aquatic species, and is heavily used for recreation. Water quality sampling will be conducted to produce the highest-quality long term record, a rotation of two years of intense monthly non-conditional synoptic sampling (as done with the data presented), followed by five off years. While CUPN water quality monitoring will begin again at LIRI in October 2013, the Preserve can continue to rely on the CUPN for logistic support for its extant program and general council on water resource issues.

Long-Term Monitoring will include:

Water Temperature
Specific Conductivity
pH
Dissolved Oxygen
Acid Neutralizing Capacity
Escherichia coli
Turbidity

List of Abbreviations

Table 3. Abbreviations used in this document.

ANC	Acid Neutralizing Capacity
CaCO ₃	Calcium carbonate
CUPN	Cumberland Piedmont Network
DO	Dissolved Oxygen
km	kilometer
LIRI	Little River Canyon National Preserve
l/s	liters per second
mg/l	milligrams per liter
NPS	National Park Service
NTU	Nephelometric Turbidity Unit
SpC	Specific Conductance
SU	Standard Unit (pH)
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey