

Cumberland Piedmont Network Water Quality Report

April 2005

Chickamagua and Chattanooga National Military Park

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Based on the field work of Tom Diggs,
Cumberland Piedmont Network

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 work as a water quality inventory, as for many parks in the CUPN, little, if anything, was known regarding water quality. This two-year period 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 the Mammoth Cave National Park (MACA) 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.

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. Any additional parameters of park interest will be considered through the CUPN Vital Signs selection process. As little was known about water quality in most CUPN parks – exceptions being MACA, Little River Canyon National Preserve (LIRI) and Cumberland Gap National Historical Park (CUGA) – a wide net of water quality parameters was cast during the first two years. Furthermore, as much was known about the water quality of these three parks, they were placed near the end of the park rotation allowing full inventories of parks with little data. In addition to the four core parameters, acid neutralizing capacity (ANC) and fecal coliform tests were performed in the field. Samples were taken and analyzed for a variety of ions and constituents at the MACA Water Quality Laboratory and the WATERS Laboratory (a joint venture between MACA and Western Kentucky University WKU). The MACA laboratory moved to the WKU campus in July 2004.

The CUPN Science and Technical Committee (STC) recently reviewed field and laboratory quality and has made their recommendations to the CUPN Board of Directors. Data quality was reviewed based upon the Relative Percent Difference (RPD) between a field sample and its duplicate. In general the STC found the RPD values of the core four parameters to be of acceptable quality (less than 10% duplicate pairs lying outside a +/- 10% RPD tolerance level), although the fecal coliform and ANC tests need attention. Specifically, ANC results were of poor quality below 10 mg/l as CaCO_3 and fecal coliform results were generally poor throughout its entire range. The STC has been tasked with developing new protocols for ANC and fecal coliform.

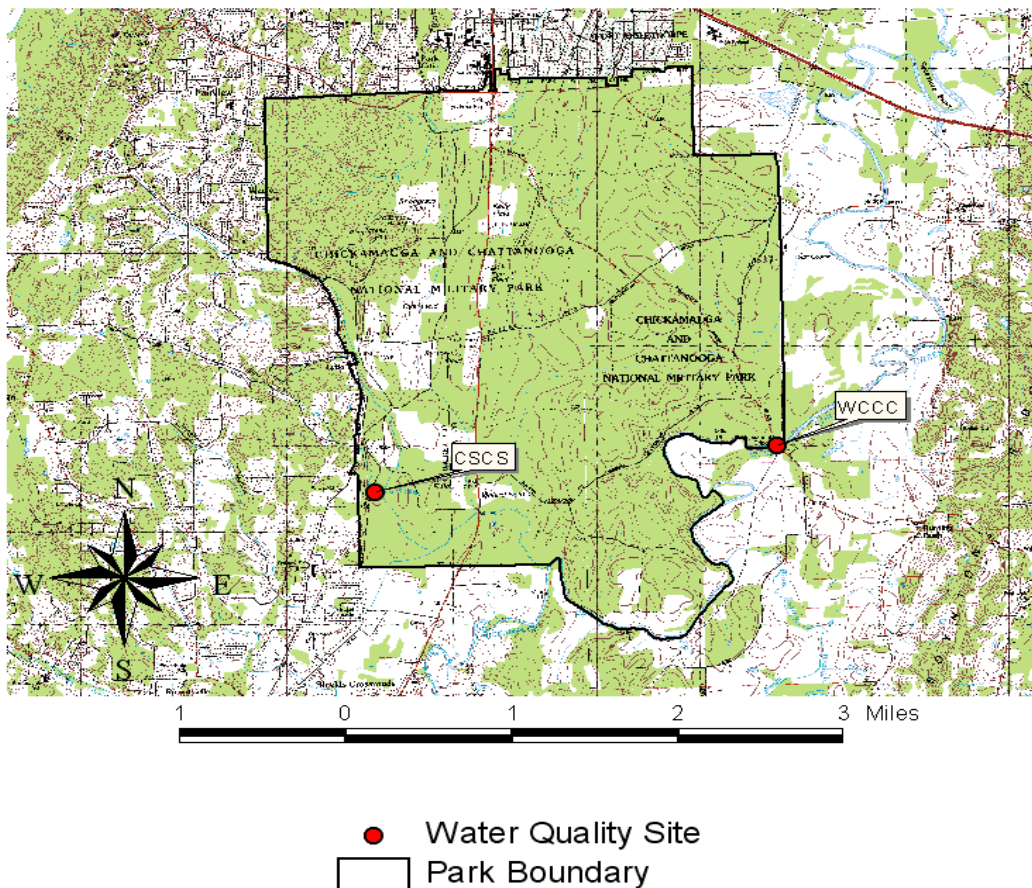
In addition, the STC reviewed RPD values from laboratory analysis. Overall, eleven of the seventeen lab parameters had greater than 10% of duplicate pairs falling outside a +/- 20% RPD tolerance level. Although data generated from the lab are of questionable

quality for certain parameters, they are still of use in a basic inventory of water quality for the park.

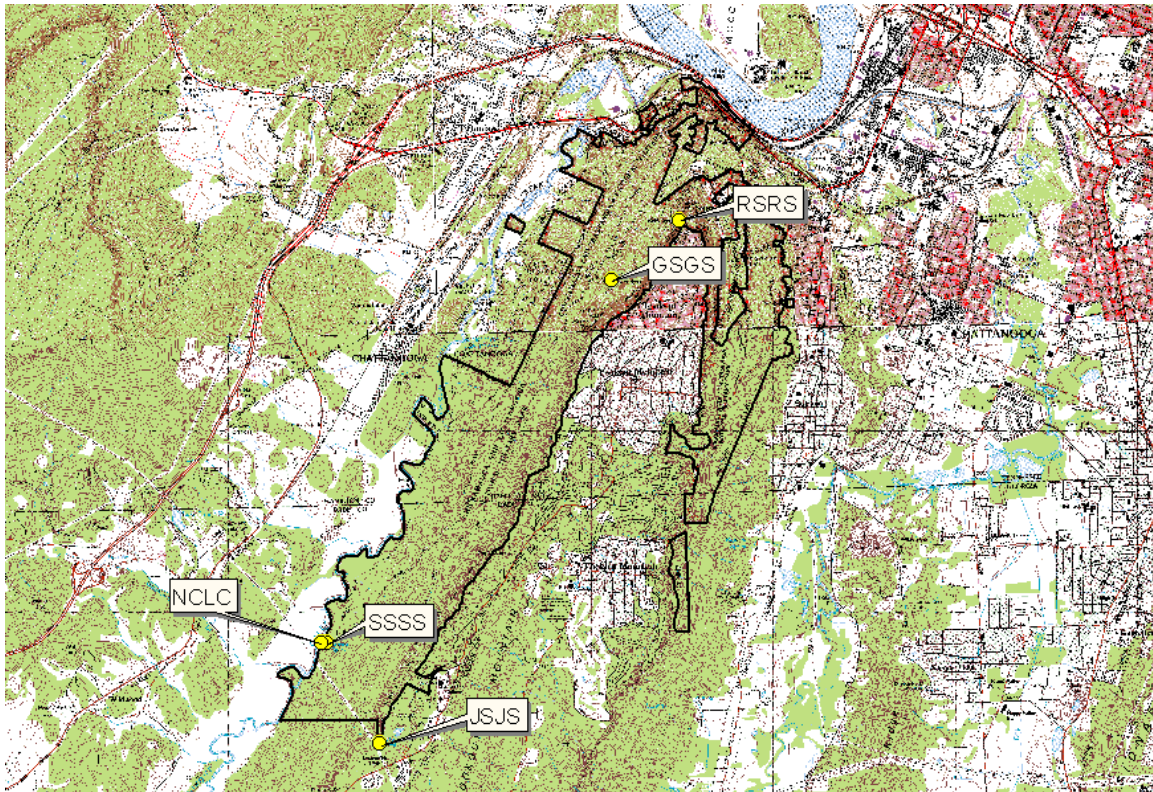
Sampling Sites

Below are two maps (Battlefield and Lookout Mountain Units) of water quality sampling sites at CHCH. During each monthly sampling round each site was visited and an additional Quality Assurance-Quality Control sample was extracted. Monthly sampling commenced in November 2002 and continued until September 2004, for a total of 23 sampling events.

CHCH, Battlefield Unit Water Quality Monitoring Sites



CHCH Lookout Mountain Unit Water Quality Monitoring Sites



Description of Sampling Sites

West Chickamauga Creek (WCCC): Located at Alexander's Bridge this site is the most downstream point of West Chickamauga Creek within the park. Access is easy and safe in all conditions.



Cave Spring (CSCS): Located a few hundred meters south-southwest of the Wilder Monument. The watershed of this moderate, perennial spring is unknown. Access is easy and safe in all conditions.



Jackson Spring (JSJS): Located near the top of Lookout Mountain at the extreme southwestern portion of the Lookout Mountain Battlefield and Point Park unit. The watershed of this small, perennial spring is unknown. Access is easy and safe in all conditions, except during times of heavy snow and ice.



Skyuka Spring (SSSS): Located adjacent to Lookout Creek at the extreme southwestern portion of the park. This watershed of this large, perennial spring is unknown. Access is moderately difficult and safe in all conditions, unless the sampler hikes from Ochs Gateway where heavy snow and ice may present a hazard. The site can also be easily accessed via the Lower Truck Trail.



Rock Spring (RSRS): Located at base of upper bluff just west of Point Park. The watershed of this small, perennial spring is unknown. Access is easy and safe in all conditions, except during times of heavy snow and ice.



Gum Spring (GSGS): Located at about halfway down the west flank of Lookout Mountain (southwest of Point Park). The watershed of this small, perennial spring is unknown. Access is moderately difficult and safe in all conditions, except during times of heavy snow and ice.



Lookout Creek (NCLC): Forming the southwest border of the Lookout Mountain Battlefield and Point Park unit. This large, perennial stream can be accessed and sampled at various locations. This creek is sampled just above the confluence of Skyuka Spring. Access is easy and safe in all conditions.



Parameters for Water Quality Inventory

Field Measures

The following text is adapted from the USGS Techniques of Water-Resources Investigations Book 9, Chapters A1-A9 (2001). All equipment specifications and calibration procedures are outlined in this document.

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: 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: 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 ground water 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.

ANC: is the acid-neutralizing capacity of solutes plus particulates in an unfiltered water sample, reported in mg/l as CaCO_3 . ANC is equivalent to alkalinity for samples without titratable particulate matter. 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.

Fecal coliform 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.

Discharge: 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

Anions: A suite of anions (fluoride, chloride, nitrite, bromide, nitrate, phosphate, and sulfate) was analyzed. Sources of anions are varied – from natural and anthropogenic contribution. Anions such as chloride and bromide are common to oil field brines, and nitrite, nitrate, and phosphate are considered nutrients, and are commonly products of animal wastes. Standard Method 300.1 (ion chromatograph) was used.

Cations: A suite of cations (sodium, potassium, magnesium, and calcium) were analyzed on the ion chromatograph, an unapproved method. Note that all data presented below were a product of the ion chromatograph. Any future cation analysis will be analyzed on a flame atomic adsorption spectrometer using Standard Method 3113. The cation sodium is paired with chloride and may indicate brine contamination. Potassium, magnesium and calcium are usually contributed to the dissolution of rock, or in the case of potassium, fertilizers.

Total Organic Carbon: TOC is a measure of organic carbon in water, including various constituents in various oxidation states. This is a direct and easy measure of organic carbon, including components of biological and chemical oxygen demand. Standard Method 5310 B was used.

Total Suspended Solids: While turbidity measures are a quick and simple estimation of suspended solid loads, it cannot be directly correlated to TSS, which is a true measure of suspended solids due to particle size and color characteristics. Standard Method 2540 E was used.

Chlorophyll-a: Since chlorophyll-containing organisms are the first step in most food chains, the health and /or abundance of these primary producers will have cascading effects to all higher organisms. Therefore, the determination of chlorophyll concentration is one of the key indices in monitoring the health of any natural system. EPA Method 445.0 was used.

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.

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 screening technique was used for this analysis.

Stream Designated Uses

As discussed below, each water body sampled within the CUPN has either been assigned a designated use by the state, or, by using the same ranking criteria, by this author. 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 Georgia and Tennessee water quality standards, please see:

Georgia: Rules and Regulations for Water Quality Control, Chapter 391-3-6, Revised July 2000.

Tennessee: Rules 1200-4-3-01, Tennessee Department of Environment and Conservation

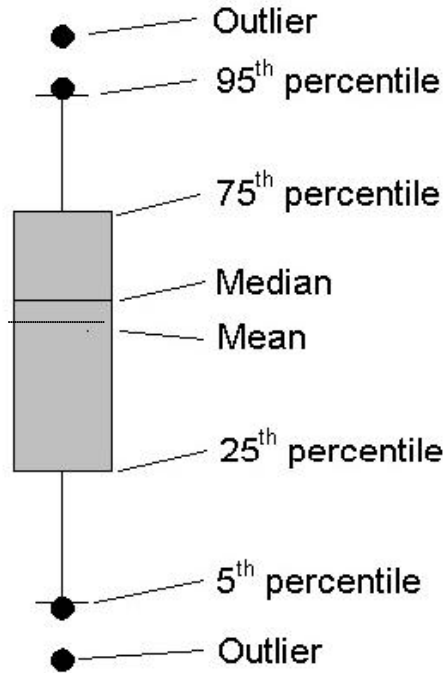
The table below shows that only West Chickamagua Creek and Lookout Creek are officially listed. Other streams of CHCH were “listed” (those sites in red text) by the author using the same criteria used by the state.

<i>Park</i>	<i>Code</i>	<i>Site</i>	<i>State</i>	<i>Designated Use</i>
CHCH	WCCC	West Chickamauga Creek	GA	Recreation
CHCH	CSCS	Cave Spring	GA	Recreation Fish & Aquatic Life
CHCH	JSJS	Jackson Spring	GA	Recreation Fish & Aquatic Life
CHCH	SSSS	Skyuka Spring	GA	Recreation Fish & Aquatic Life
CHCH	RSRS	Rock Spring	TN	Fish & Aquatic Life
CHCH	GSGS	Gum Spring	TN	Fish & Aquatic Life
CHCH	NCLC	Lookout Creek	TN	Fish & Aquatic Life Industrial Water Supply Irrigation Livestock Watering & Wildlife Recreation

Most of the water quality parameters included in this inventory are not found in the state water quality standards. This is not to say they are unimportant to park management (a suggested list of parameters for long-term monitoring will conclude this report). If a state designated use water quality exists, it will be mentioned in the data interpretation below.

Results and Interpretation

The following graphs are a composite of 23 consecutive monthly rounds of sampling at CHCH. There are represented in the graphs below as box-plots. Here is a key to understanding the structure of a box-plot:

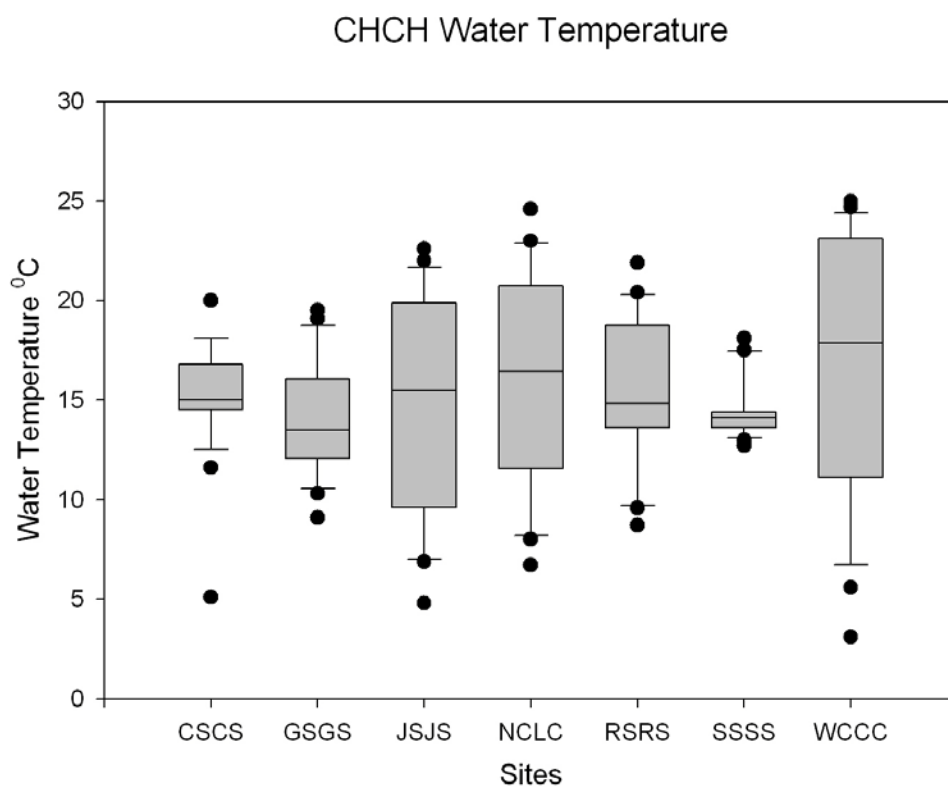


In addition to state water quality standards (where applicable), laboratory “Practical Quantitation Limits” (PQL) will be denoted. The PQL is five times the “Minimum Detection Limit” set by the laboratory. The PQL can be used as a means of determining if a particular parameter is worth monitoring in the future. For example, if samples continually come in well under the PQL value, and there is no known reason to continue that analyte, it would be a candidate to discontinue. The laboratory used the ion chromatograph (unapproved method) for all cation analysis below and did not provide PQL limits. For the cations of calcium, potassium, magnesium, and sodium, PQLs for the flame atomic adsorption method were used. There is also no PQL provided for Chlorophyll-a analysis.

Field Measures

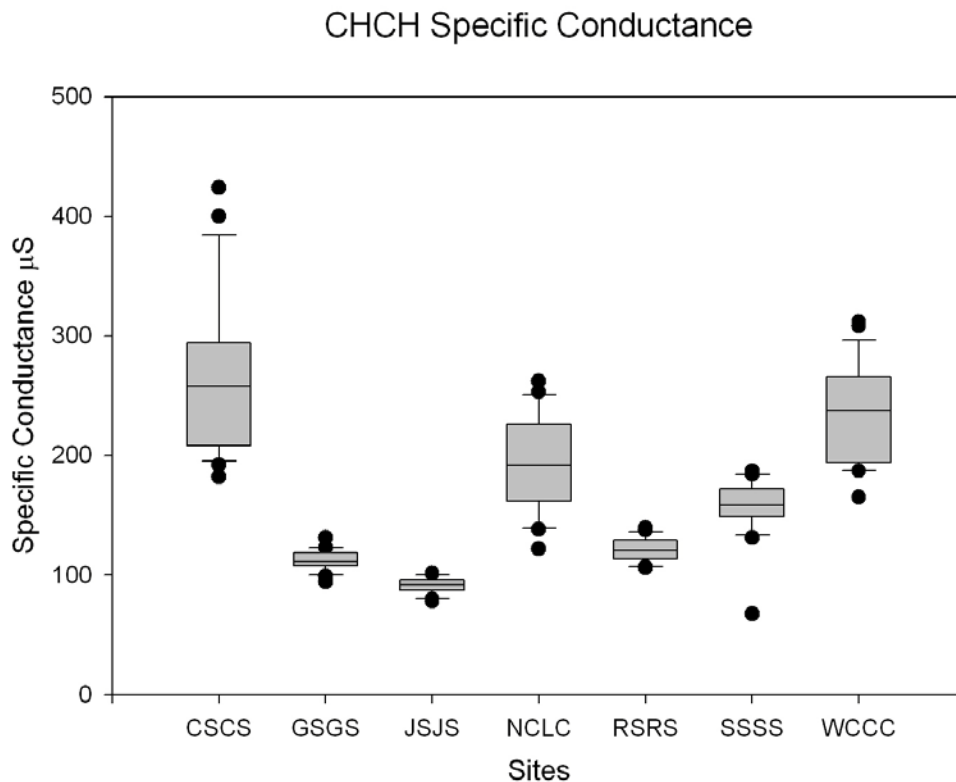
Water Temperature

Water temperatures of CHCH are considered to be within range to support native aquatic life. The compressed temperature ranges at Cave Spring (CSCS) and Skyuka Spring (SSSS) are a function of long retention times of groundwater recharging these springs. This is seen to a less extent at Gum Spring (GSGS) and Rock Spring (RSRS). The two main creeks, Lookout (NCLC) and West Chickamagua (WCCC) display a wide range of temperature reflective of normal seasonal variations.



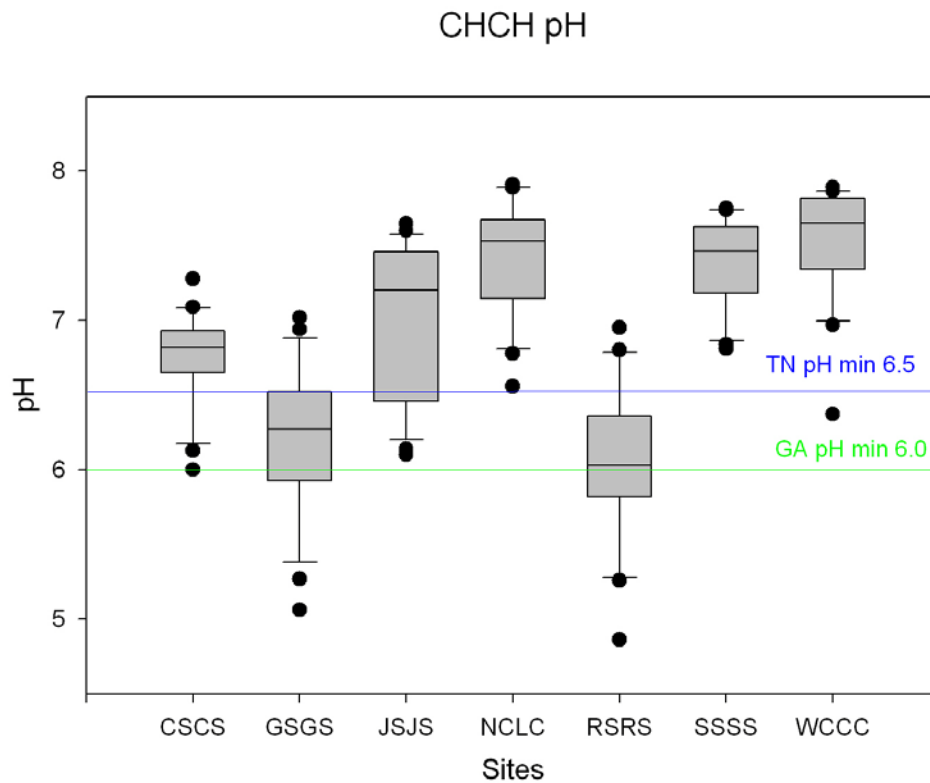
Specific Conductance

The distribution of specific conductance (SPC) of CHCH is reflective of the amount of dissolved solids, which is primarily controlled by lithology and residence time. The tight pattern of low SPC values of GSGS, JSJS, and RSRS are consistent to the largely siliciclastic strata above these springs. On the other end of the range, CSCS, which is recharged through limestone strata, has higher values. In general, the points above the 75th percentile are during low-flow periods, and those below the 25th percentile during high flows – each reflective of residence time within the rock. Skyuka Spring, although discharging from limestone is a bit of a paradox. While its temperature range is reflective of long times spent underground, its SPC is relatively low. It is likely that water recharging SSSS spends the bulk of its time underground within siliciclastics, and makes its trip through the limestones in short order.



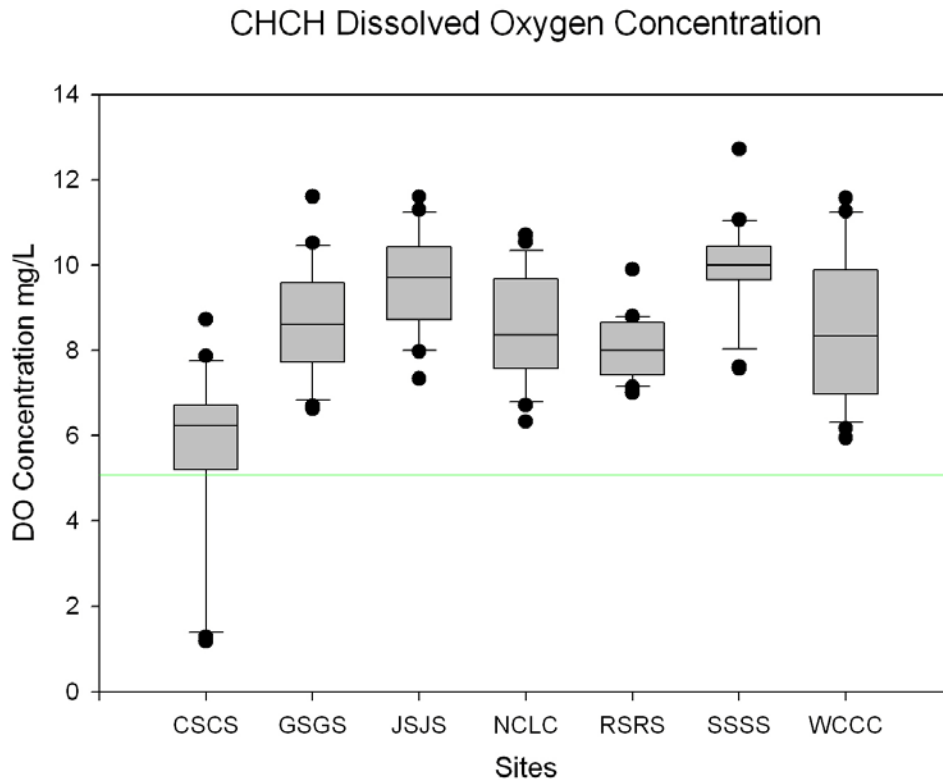
pH

The pH of waters of CHCH is again reflective of the lithology of particular watersheds. As will be the case in all graphs, CHCH spans two states, and thus are accountable to two different water quality standards. In the case of pH, sites in Tennessee (GSGS, RSRS, and RSRG) have an acceptable pH range of 6.5 through 9.0 SU, while the Georgia sites (CSCS, JSJS, SSSS, and WCCC) have limits of 6.0 through 8.5 SU. No sites have problems being over either upper limit, however, both Rock and Gum Springs (RSRS and GSGS) commonly exceed the lower limit for Fish and Aquatic Life in Tennessee. As these springs are recharged by sandstones they are most likely within their natural ranges. Note that both CSCS and JSJS are either at or near the lower pH limit for Georgia.



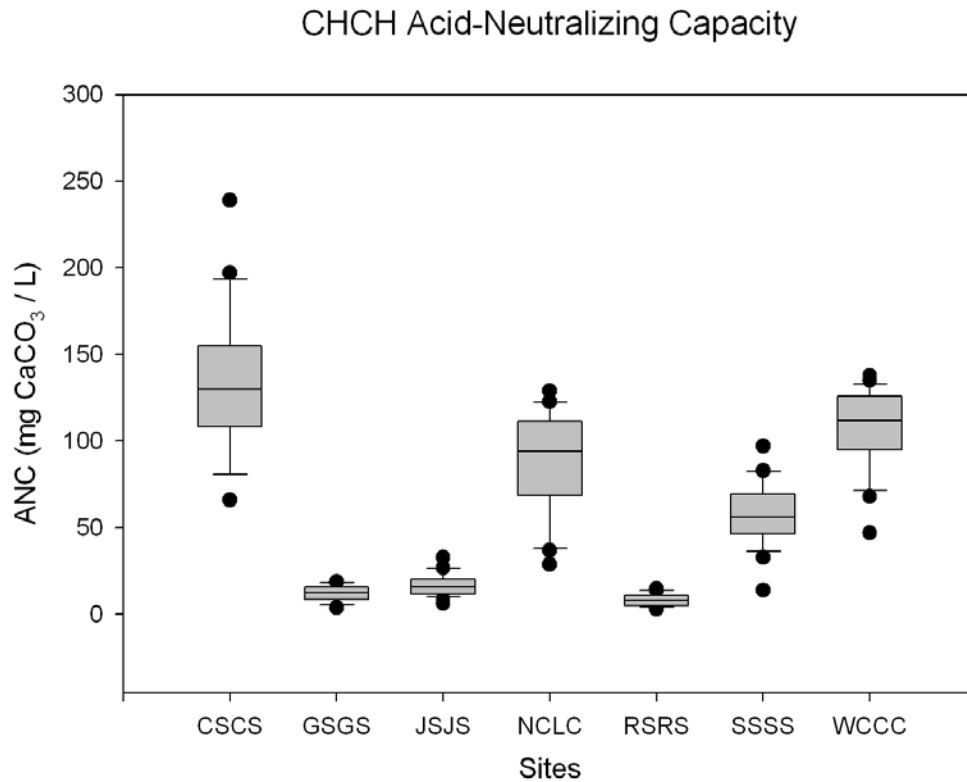
Dissolved Oxygen

All waters monitored at CHCH are saturated, or at least above the lower limit of 5.0 mg/l for dissolved oxygen (DO), with exception of Cave Spring. It is not uncommon for springs which are recharged primarily by epikarst (the irregular soil-bedrock interface found underlying many limestone areas) and shallow dolines (sinkholes) to have low DO if the conduits connecting points of recharge and discharge (springs) are of low gradient. That is to say that there are few chances for the groundwater to be well aerated. Most of the values from CSCS are above the limit, and is likely that the lowest concentrations were taken during low or drought conditions.



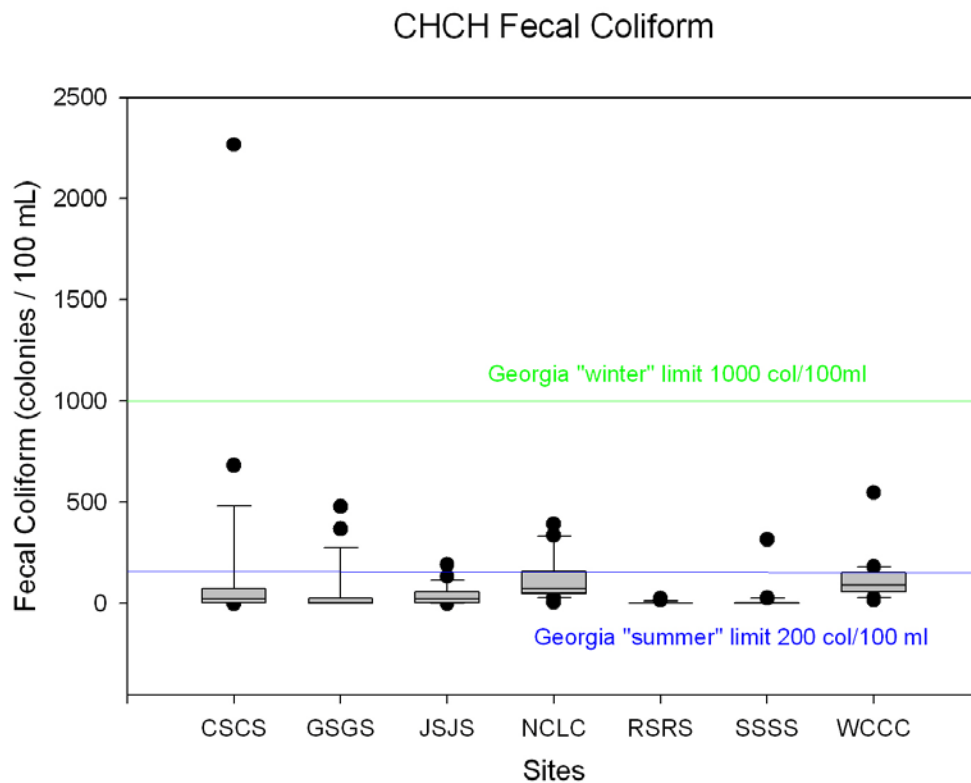
Acid Neutralizing Capacity

A nearly identical signature as was seen with SPC. Acid neutralizing capacity (ANC) of CHCH waters again reflect basin lithology. Those recharged across or through carbonate strata (CSCS, NCLC, WCCC, and to some extent, SSSS) have fairly high ANC values. Sites recharged by sandstones (GSGS, JSJS, and RSRS) have very low concentrations of bicarbonate ions. Low ANC levels make waters more susceptible to acid precipitation as there are limited amounts of bicarbonates available to counter additional acids.



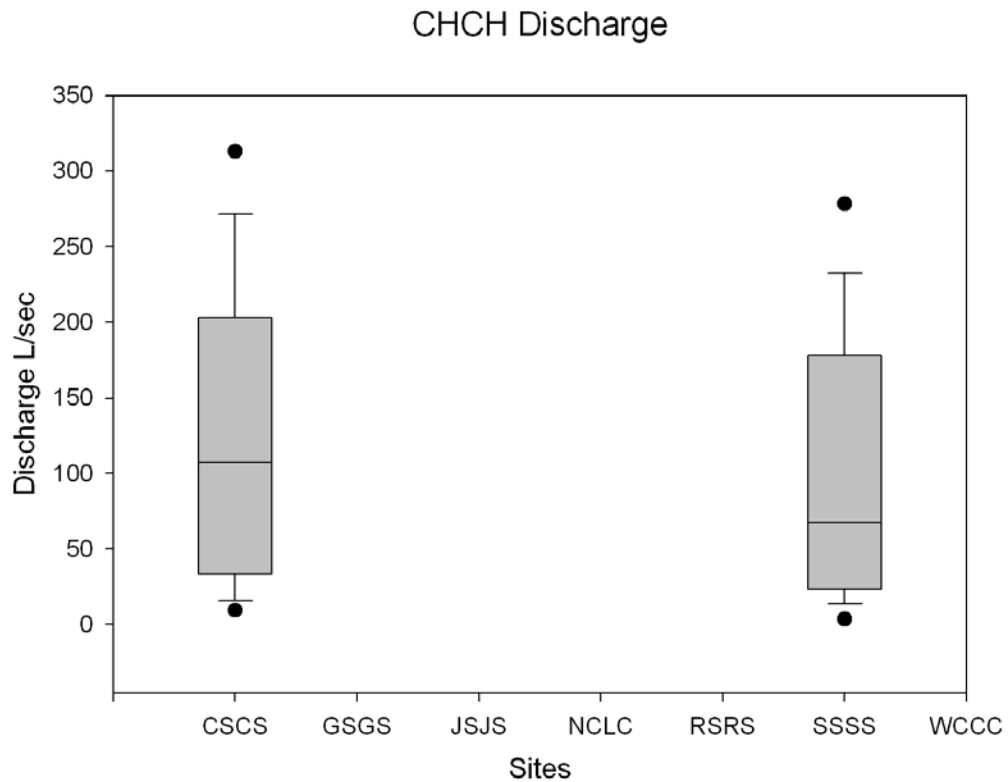
Fecal Coliform

For the most, fecal coliform ranges at CHCH run a range of extremely low values, such as RSRS, to a low but slightly variable range at GSGS, JSJS, and SSSS, to highly variable ranges seen at CSCS, NCLC, and WCCC. Higher values are coincidental to high flow, when many non-point source fecal contaminants are washed into streams. In Tennessee, for Fish and Aquatic Life, the maximum level is geometric mean of 1000 colonies/100 ml. of 10 samples taken within a 30 day period. Single sample maximum is 5000 colonies/100 ml. For Georgia, the Recreational standard varies from a geometric mean of at least 4 samples within 30 days of 200 to 1000, from May through October, and November through April, respectively. Although confusing, all samples taken in this program are monthly, and are not technically in violation of the mean standards. If a sequence of samples were taken during high flow conditions, both NCLC and WCCC could be out of compliance. While values are NCLC (which is in both states) and WCCC sometimes exceed the 200 colonies per 100 ml limit during the summer months, it should only be of concern to the park if secondary contact recreation (wading) occurs in these streams within the park.



Discharge

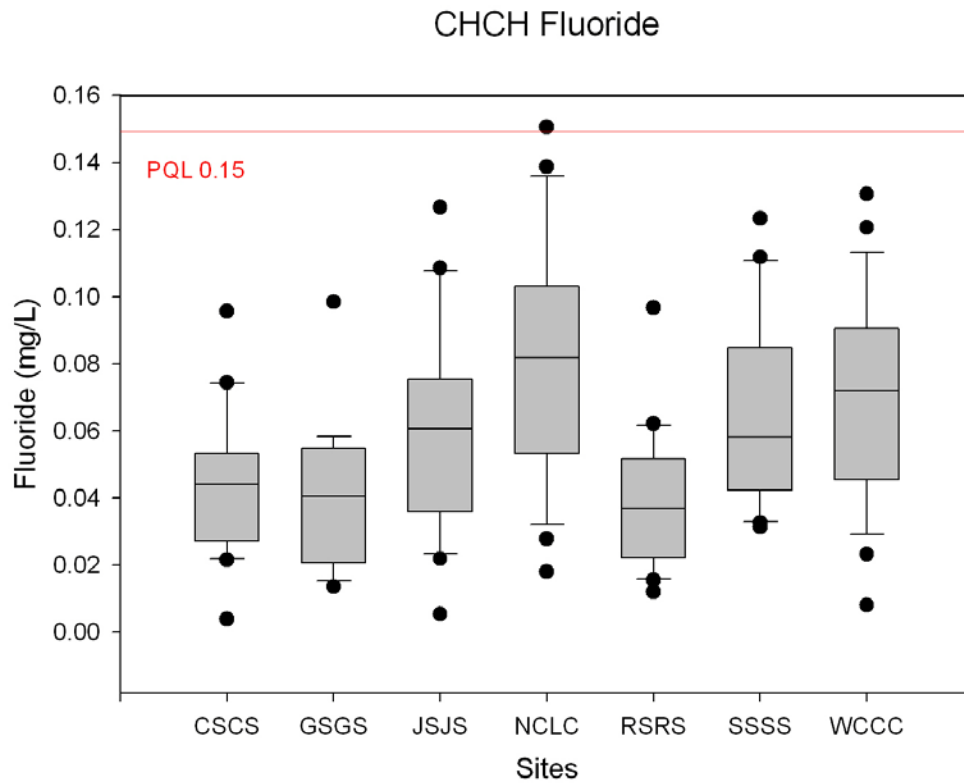
These data are presented to give the reader a sense of magnitude of flow at the two sites at CHCH where discharge is commonly measured. It is logistically impracticable to measure flow at the two large streams, and the three smaller springs have flows too low to accurately measure. Discharge data (l/s) are of particular use in combination with concentration data (mg/l), thus producing mass flux or loading of a particular parameter (mg/s). Flow data are also of use in interpreting the discharge condition in which sampled.



Laboratory Measures

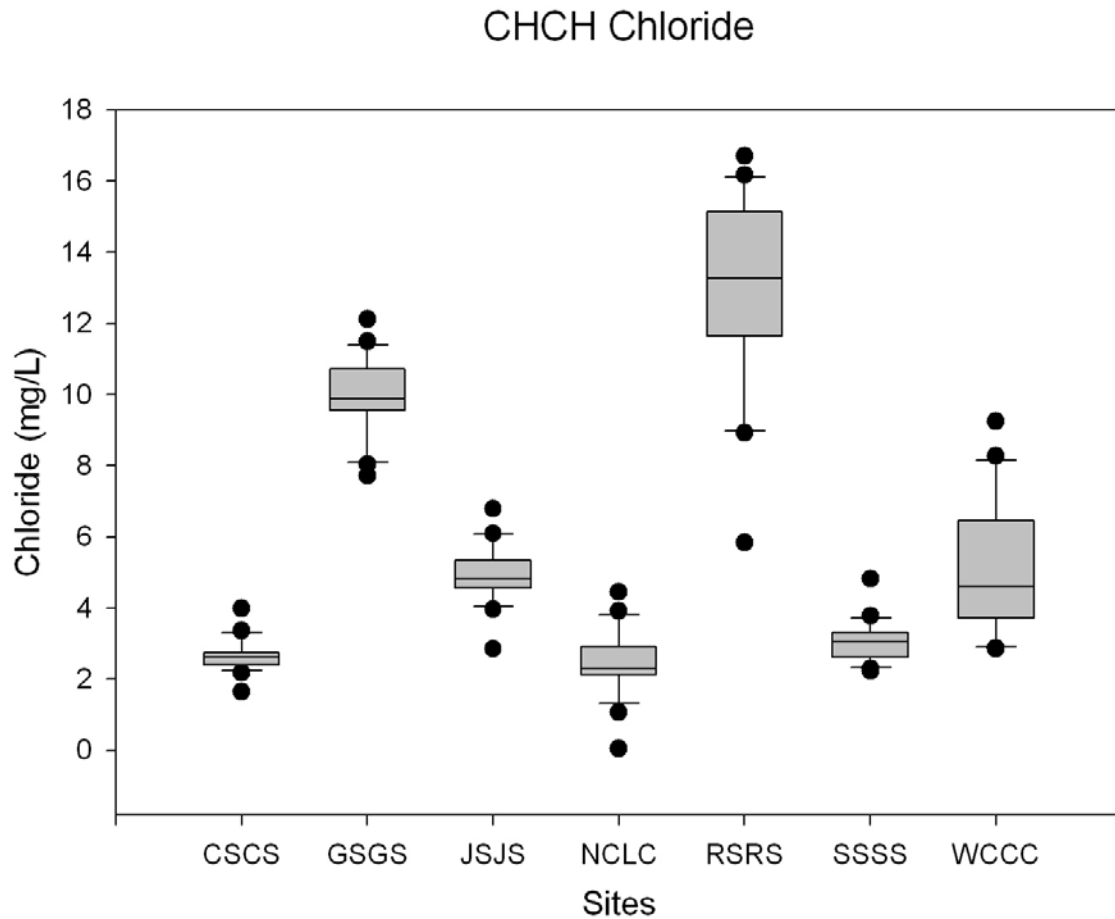
Fluoride

Fluoride concentrations of CHCH waters are very low. In all samples, except one at Lookout Creek, concentrations were below the PQL of 0.15 mg/l. There are no state standards for fluoride.



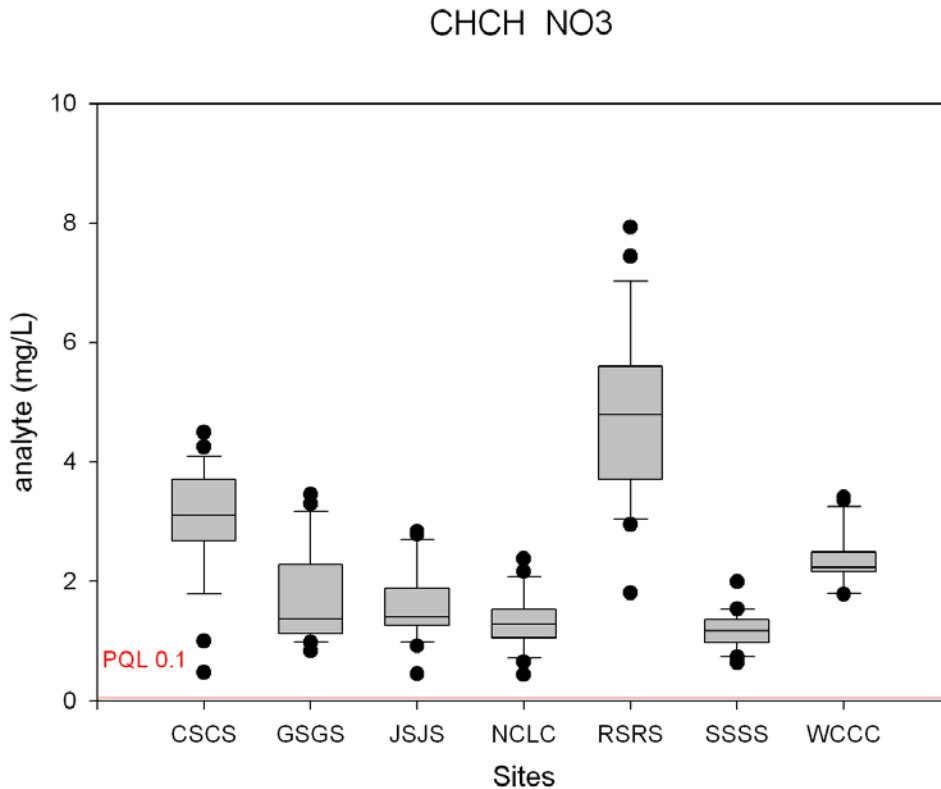
Chloride

While all samples were above the PQL of 0.15 mg/l, no samples exceeded the state standards for chloride, as there are no standards. Even with that in mind, the concentrations of chloride are not very great when compared with other freshwaters. The higher chloride concentrations found in Rock and Gum Springs may be simply a function of lithology. For general comparison, the chloride limit for High Quality Water for North Carolina is 250 mg/l.



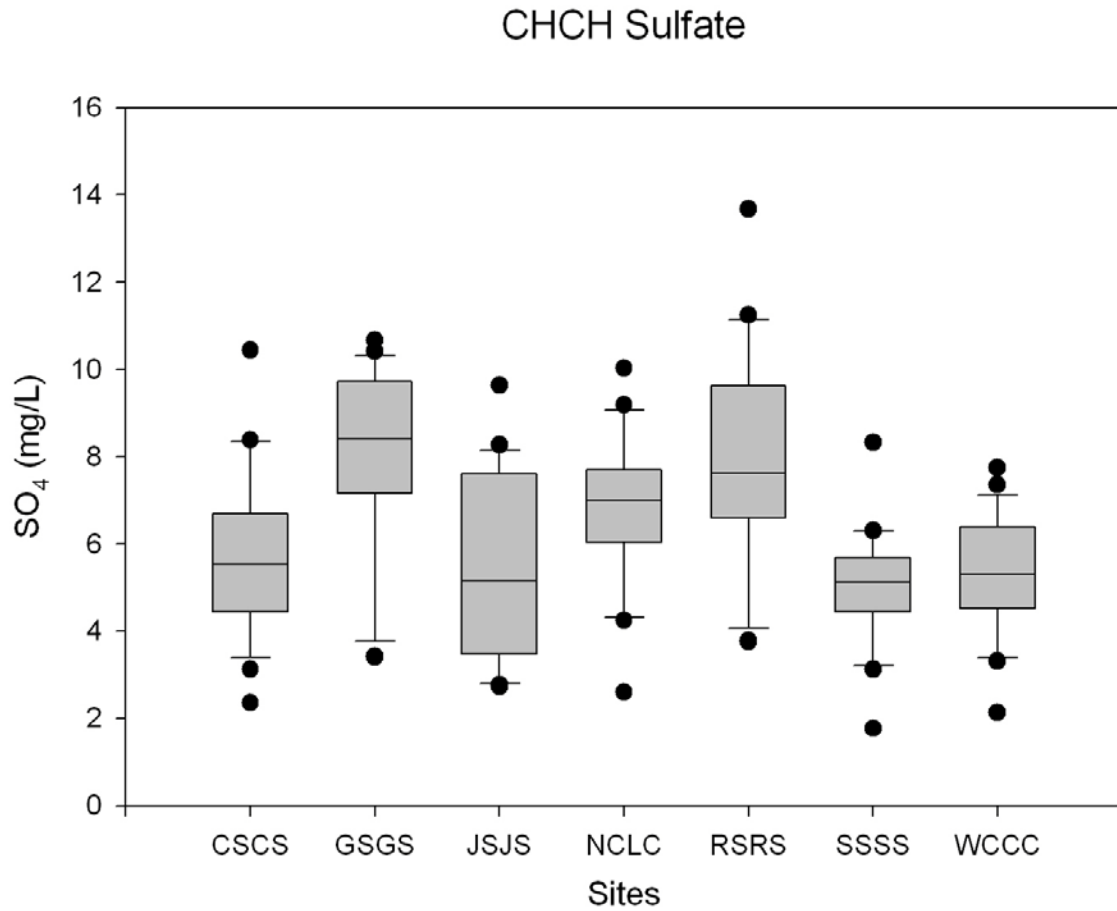
Nitrate

Surprisingly there is no state standard for nitrate in freshwaters for either state. The general national standard for drinking water is 10 mg/l as N-NO₃, or 45 mg/l as NO₃ as graphed below. Most sites sampled at CHCH were fairly low in nitrate, with exception of Rock Spring, which consistently was higher than other sites. At this time it is not possible to determine the source of the elevated nitrate at RSRS.



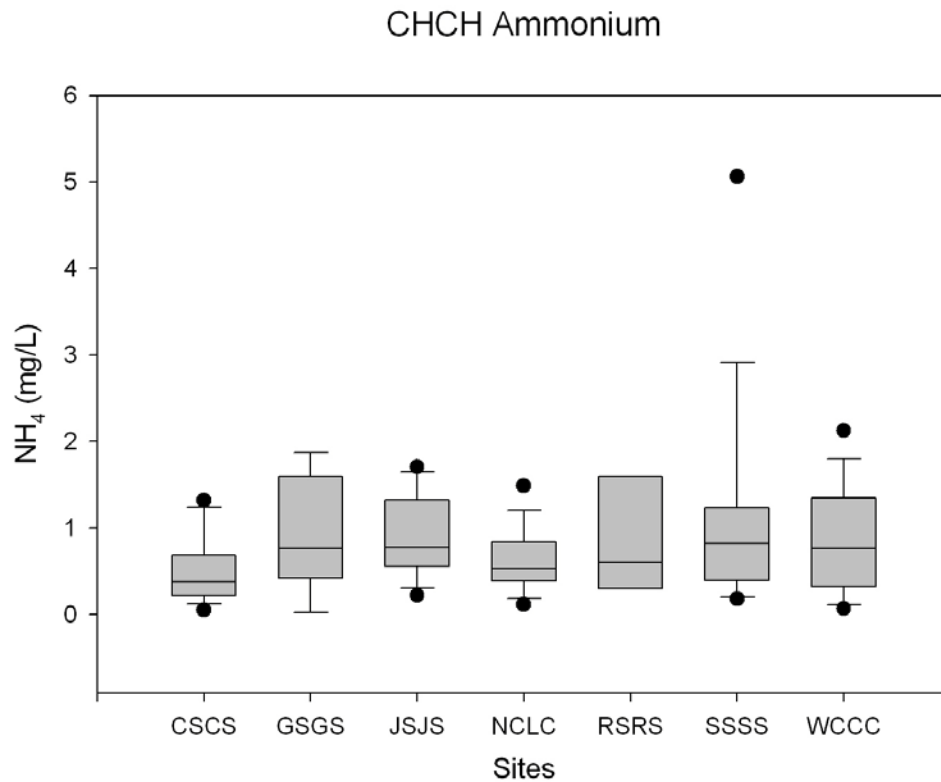
Sulfate

Waters of CHCH are fairly low in sulfate. No sulfate standard exists for Georgia or Tennessee designated use standards for the park's waters.



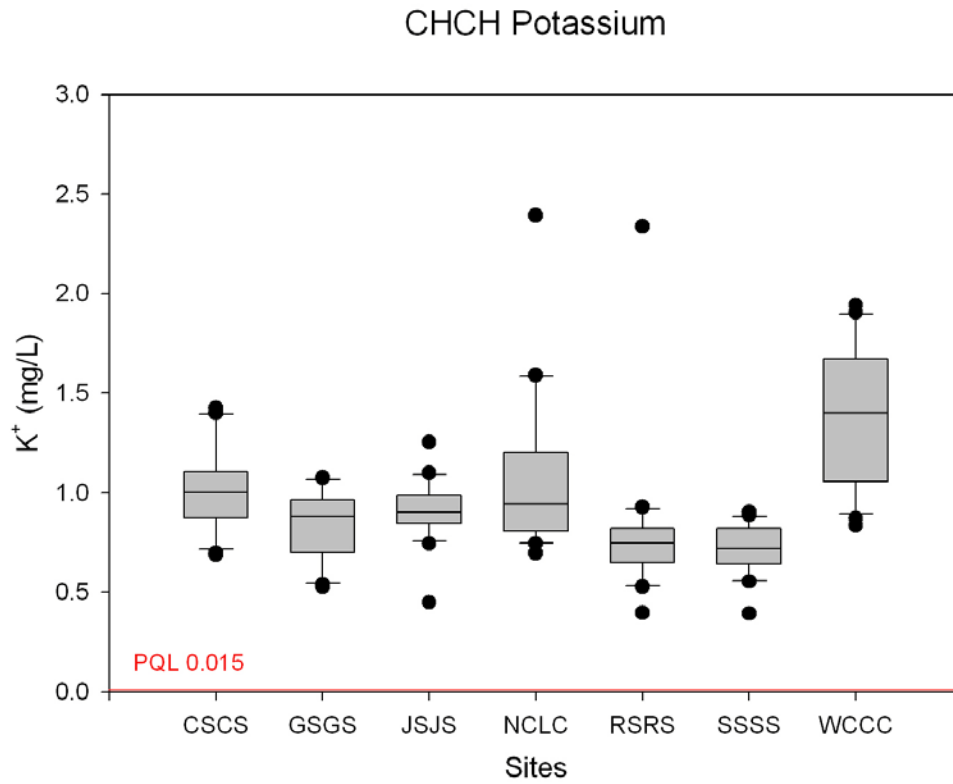
Ammonium

Ammonium levels at all sites are low, with the exception of an outlier or two at Skyuka Spring. It should be noted that the laboratory did not perform ammonium analysis by an approved method. General ammonium reproducibility from the lab is considered unacceptable, and these data are presented in this light and not for management actions or decisions. As dissolved oxygen levels indicate well-aerated stream conditions, there is no reason to believe ammonium values to be of any significant levels – even at Cave Spring, where DO readings were sometimes depressed.



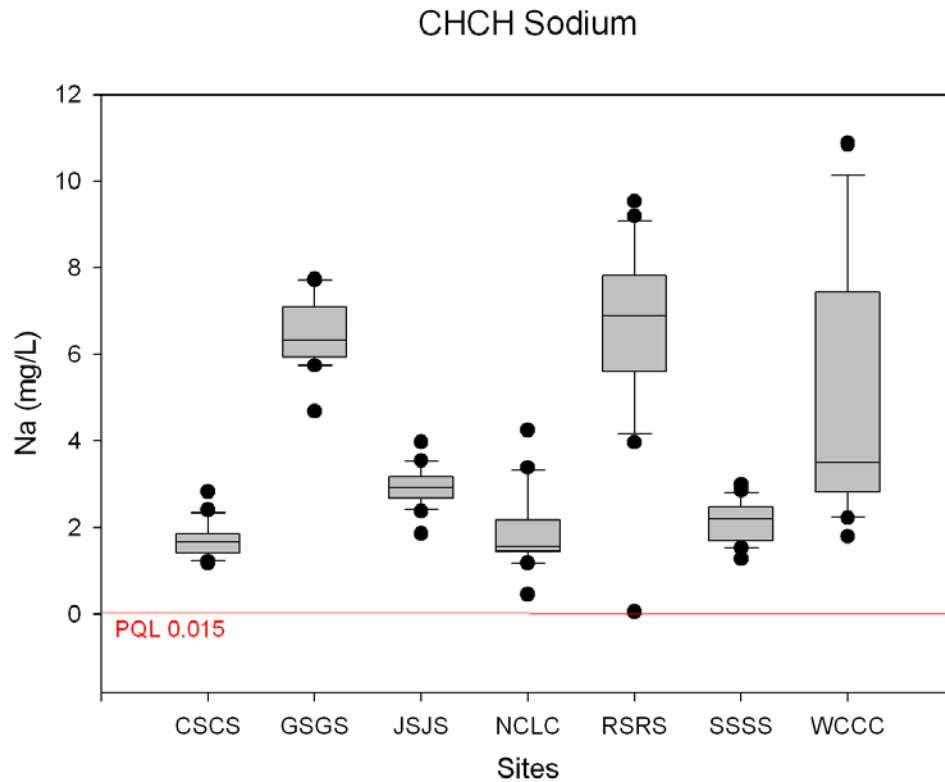
Potassium

Potassium levels of waters monitored at CHCH are consistently low. There are no potassium standards for assigned designated uses in either state.



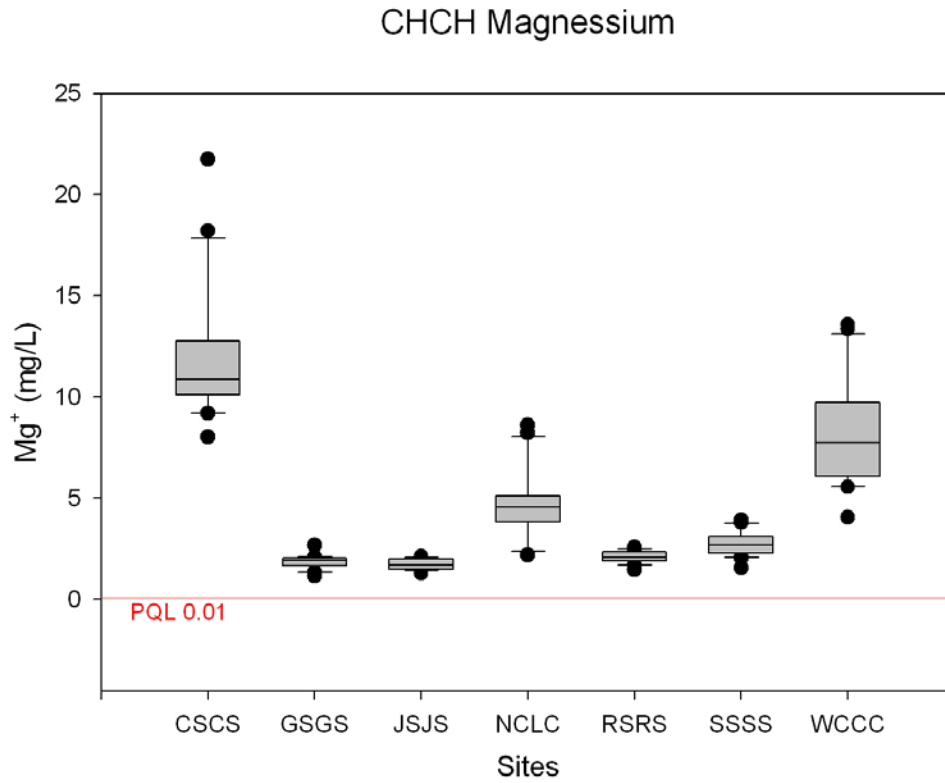
Sodium

The occurrence of sodium mirrors that of chloride. These two ions are commonly found in all freshwaters of the world and are primary products of oceanic evaporation of seawater – that is a small amount of NaCl is evaporated along with H₂O and precipitated across the land. This is not the only source of sodium or chloride, as many human-related land uses also liberate these ions. In any case, sodium levels are within normal ranges for waters of CHCH, and there are no sodium standards for Georgia or Tennessee.



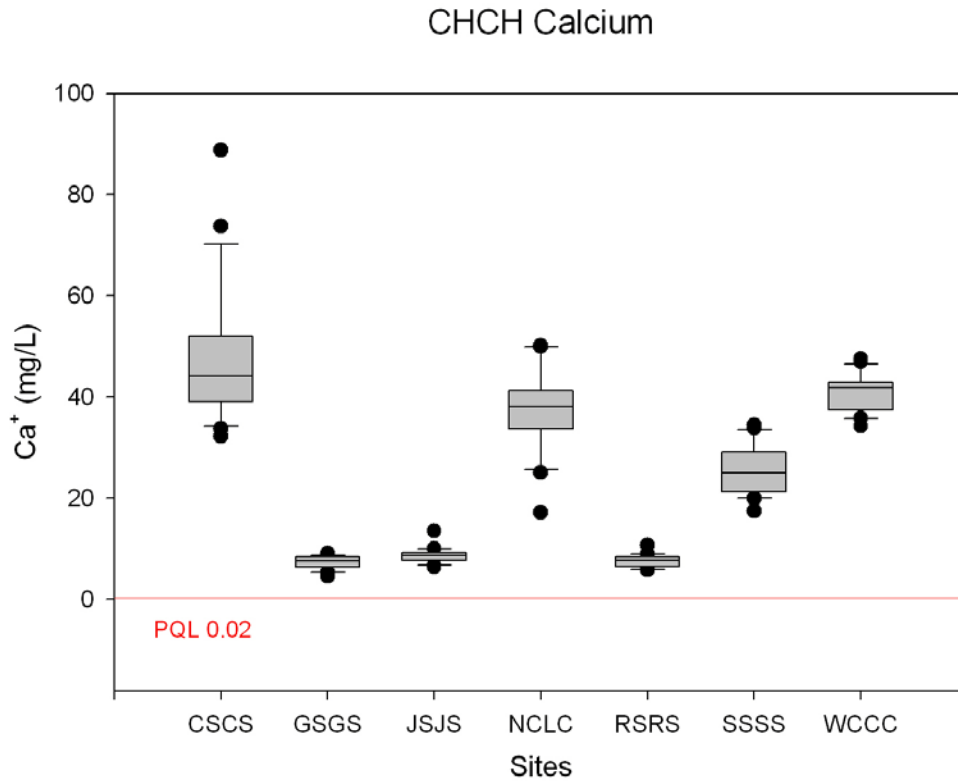
Magnesium

Similar to most other ionic data, the waters of CHCH are extremely reflective of the lithology of their watersheds. Those containing a large amount of carbonate strata are higher than those that do not, as magnesium is common to limestones as the mineral dolomite. There are no magnesium standards for either state.



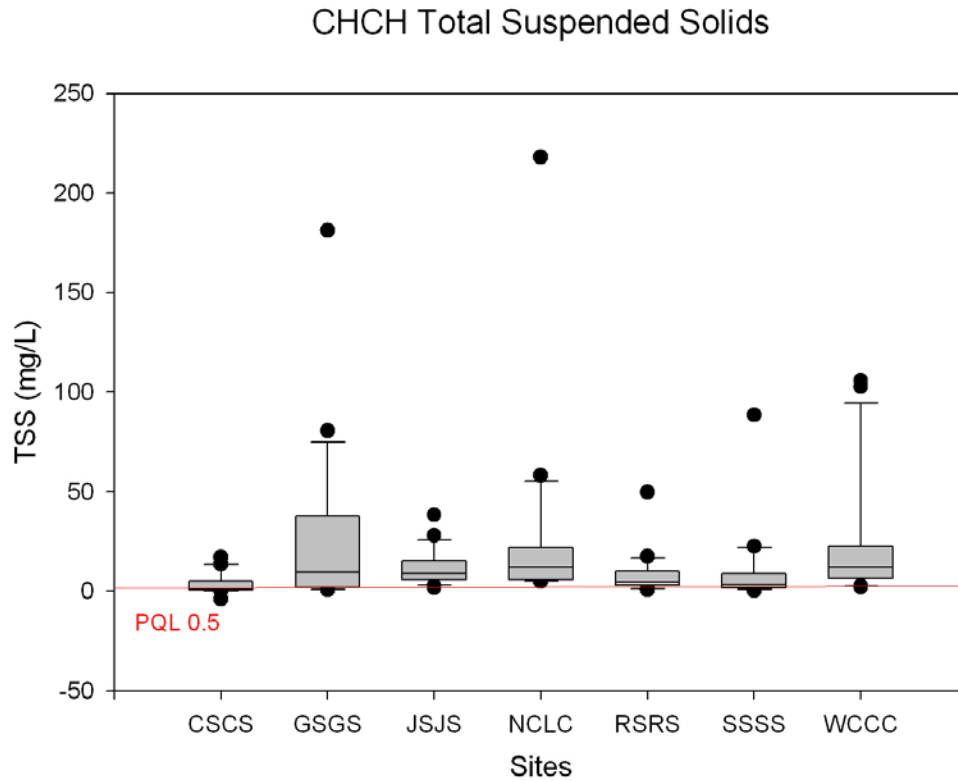
Calcium

Relative concentrations of the calcium ion generally mirror that of magnesium. Both divalent cations, calcium and magnesium are often found replacing one another in mineral crystalline matrices. Recall the ANC graph above. The notable higher calcium levels are matched in the higher ANC values. There is no state standard for calcium.



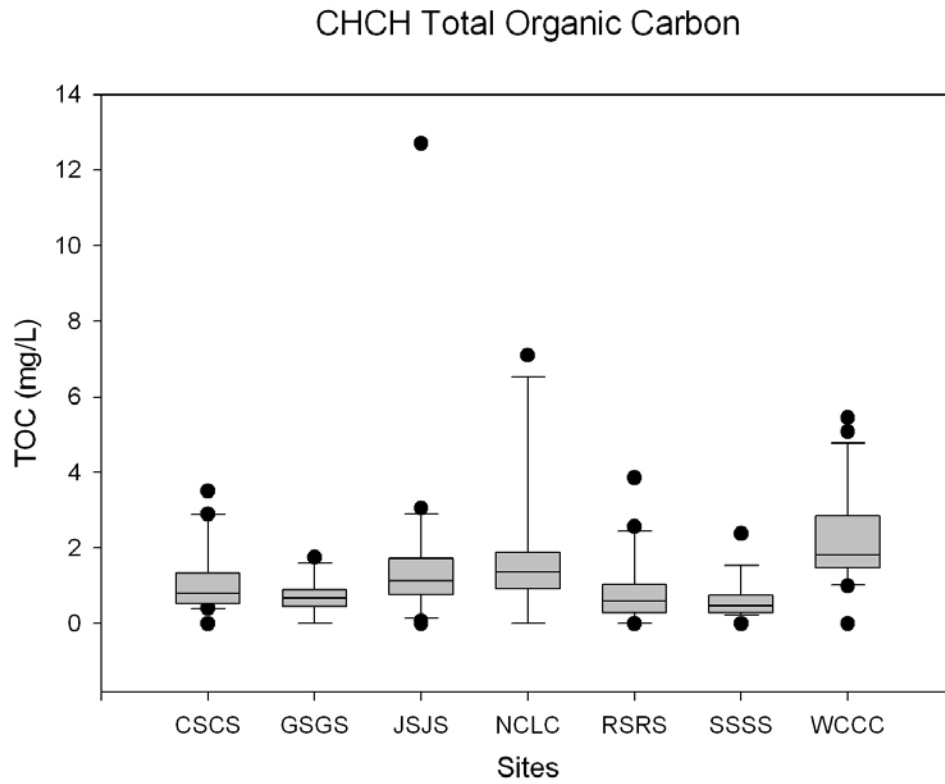
Total Suspended Solids

The laboratory reproducibility for suspended solids was not very good. The lab also reduced solids data into two subsets, fixed and volatile solids. Results are not worth presenting here. There are no state standards for TSS for either state in the appropriate designated use categories.



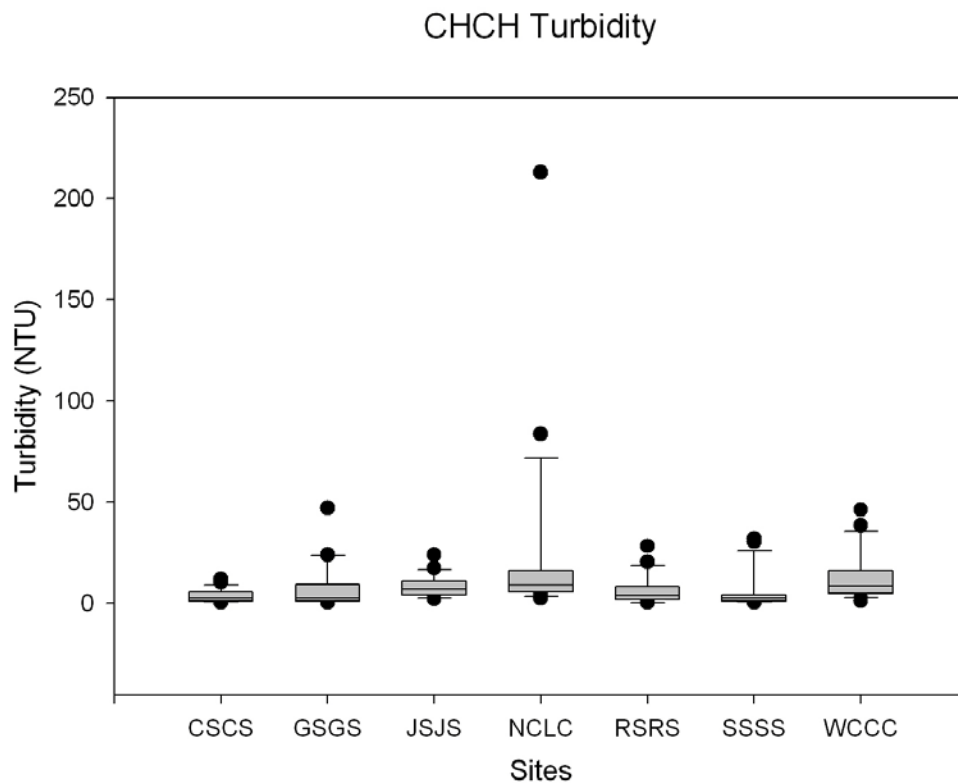
Total Organic Carbon

Total organic carbon, or in the case of most natural waters, non-purgeable organic carbon, is moderate to low in the waters of CHCH. There is no Georgia or Tennessee standard for TOC.



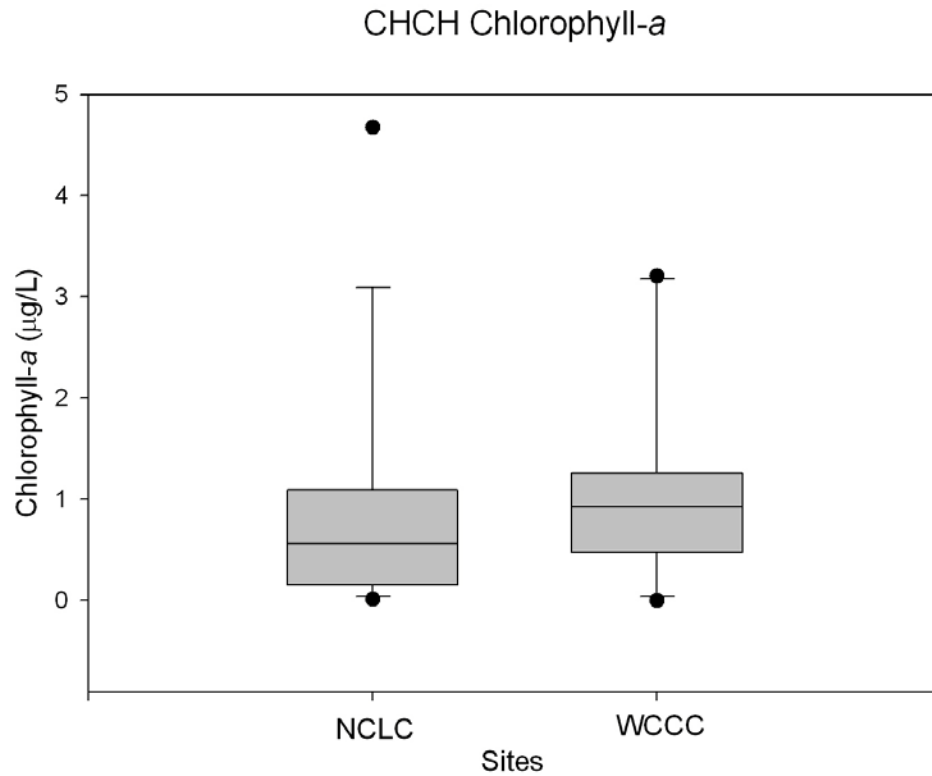
Turbidity

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 CHCH were slightly to very turbid. This range is primarily due to sample collection in respect to flood events, as large rainfalls, such as the remnants of a tropical storm that caused the outlier at Lookout Creek, flush large amounts of particular solids into the waterways. State standards are very general for turbidity. Georgia states that “No amounts that will materially affect fish and aquatic life”, while Tennessee says turbidity “should not result in visual contrast in a water body due to a man-made activity.”



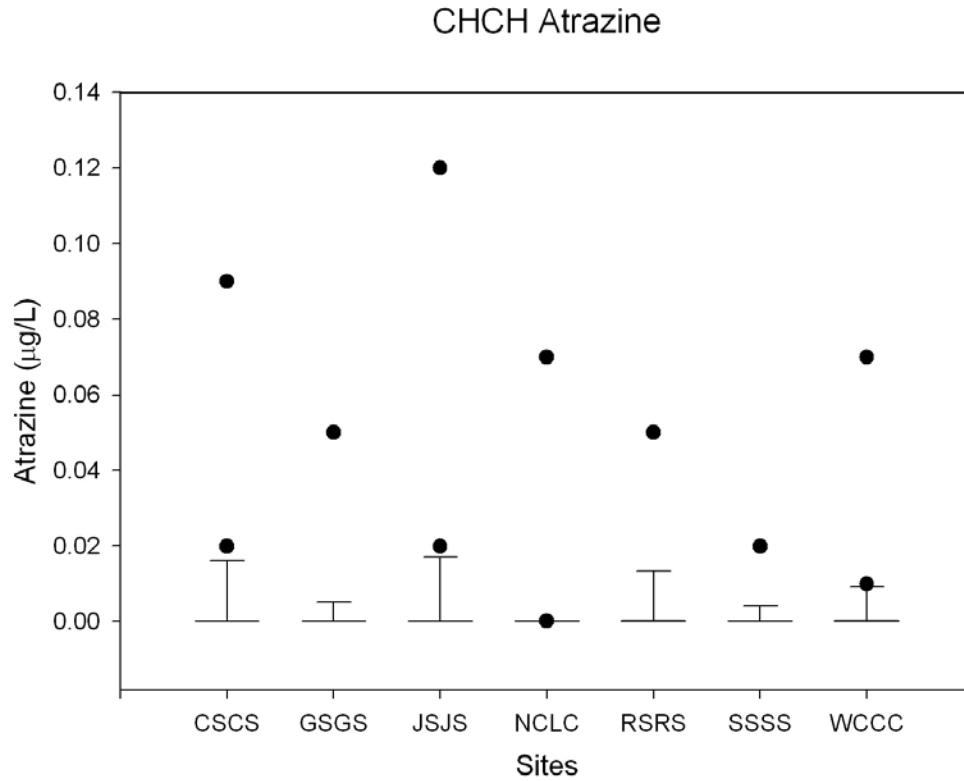
Chlorophyll-a

Chlorophyll-a analysis was only performed at Lookout and West Chickamagua Creeks. Data reproducibility at the laboratory was not very good for this analyte, and even these few data points are suspect in terms of quality.



Atrazine

All atrazine samples were well below the PQL of 0.5 µg/l (the PQL is not shown on the graph as it would dwarf the data points). There are no state standards for atrazine in freshwaters. A national drinking water standard of 3.0 µg/l can be used as a general comparison to what was found at CHCH.



General Water Quality Status

For the most part, water quality of the seven sites sampled at CHCH is good. The only exceptions would be the low dissolved oxygen at Cave Spring, low ANC at the sandstone springs of Gum, Jackson, and Rock, and the relatively high nitrate levels at Rock Spring. The first inclination for high nitrates at Rock Spring would point to its vertical proximity to the residential development directly above. However, its high nitrates are countered with almost non-existent fecal bacteria. The extremely tight distribution of water temperatures at the spring would indicate a very long residence time of groundwater within the rock, perhaps long enough to kill off any bacteria. Fecal coliform bacteria levels are susceptible to increases in most other sites following large rain events.

Waters of CHCH recharged by the sandstones are naturally low in ANC, and pH. The historically and naturally low ANC and pH values are not much of an issue. However, with the increase in acid precipitation over the past decades, streams with low buffering capacity and low pH, such as these are susceptible to becoming more acidic.

Future Water Quality Monitoring Recommendations

This inventory of water quality greatly reduces the number of parameters that need long-term monitoring for the Vital Signs program. No evidence of nutrient loading (nitrate and phosphate – with the possible exception of elevated nitrate at Rock Spring) was found. All other parameters were well below the few state standards that exist, with exception of fecal coliform. Nitrite, phosphate ions were also analyzed but all samples were found to be below detection limits. Bromide was also analyzed but data were of general poor quality (reproducibility) and low concentrations and were considered to be of use for this report. It is recommended that the core four field parameters plus ANC and bacteria should be continued for the long-term. It is likely that the CUPN will adapt a new protocol for bacteria. Rather than use the “membrane filtration” method for fecal coliform, a “most probable number” technique will most likely be used. This technique quantifies both *e. coli* and total coliform bacteria.

Long-Term Monitoring will include:

- Water Temperature
- Specific Conductivity
- pH
- Dissolved Oxygen
- Acid Neutralizing Capacity
- E. coli* and Total Coliform

List of Abbreviations

ANC	Acid Neutralizing Capacity
Br	Bromide
C	Carbon
Ca	Calcium
CaCO ₃	Calcium carbonate
Cl	Chloride
DO	Dissolved Oxygen
Fl	Fluoride
K	Potassium
km	kilometer
l/s	liters per second
MDL	Minimum Detection Limit
Mg	Magnesium
mg/l	milligrams per liter
µg/l	micrograms per liter
NaCl	Sodium Chloride
NH ₄	Ammonium
NO ₃	Nitrate
NTU	Nephelometric Turbidity Unit
PQL	Practical Quantitation Limit
NPOC	Non-purgable Organic Carbon
RPD	Relative Percent Difference
SPC	Specific Conductance
SO ₄	Sulfate
SU	Standard Unit (pH)
TOC	Total Organic Carbon
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey