Water Quality Study of Wolf Creek

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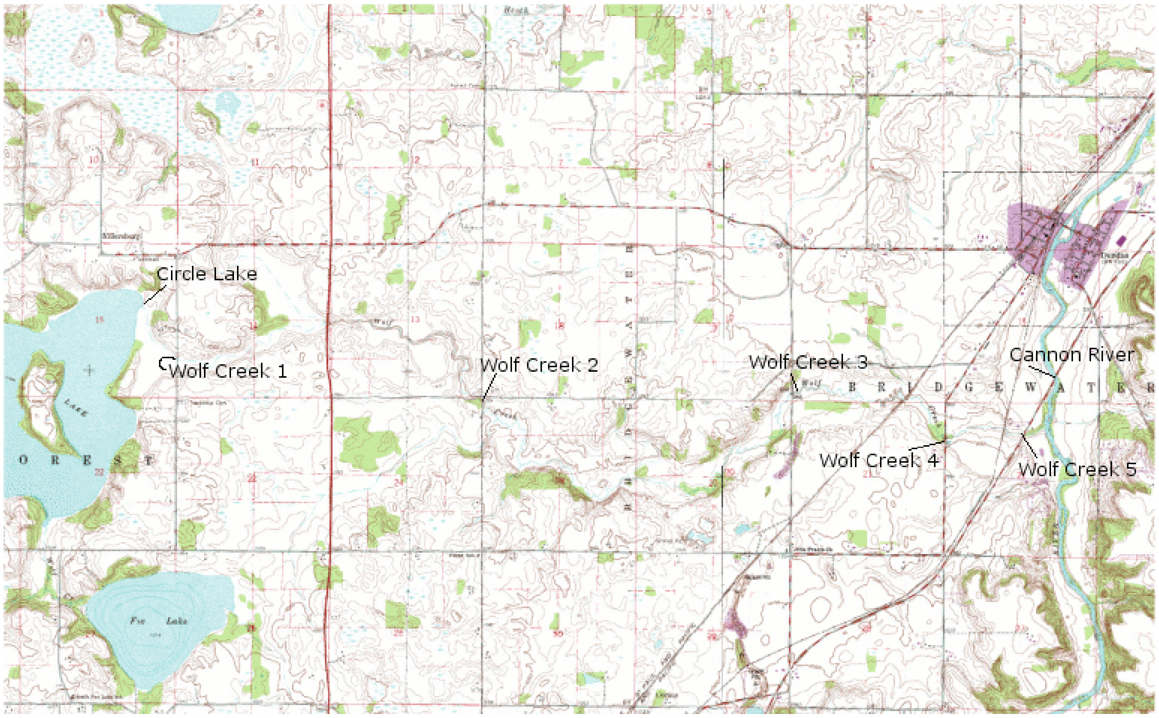
Introduction:

Wolf Creek is located in Rice County in the southeastern part of Minnesota (Figure 1). The creek is part of the 1462 square mile watershed of the Cannon River which begins in Shields Lake and enters the Mississippi River 120 miles downstream (Anderson, 2000). The watershed of the Cannon River in Blue Earth, Dakota, Freeborn, Goodhue, Le Sueur, Rice, Scott, Steele, and Waseca Counties is composed primarily of deciduous forests and four types of prairie: dry prairie, mesic prairie, wet prairie, and sand prairie. Wolf Creek runs from Circle Lake until it joins the Cannon River south of the town of Dundas (Figure 1). The drainage area for Wolf Creek is 42.9 square miles between Faribault and Northfield. 6.6% of the total drainage area is occupied by lakes. Lakes and marshes combined make up 9.9% of the area (Sanocki and Winterstein, 2001). The creek itself is 20.8 miles long, and runs through land that is almost entirely devoted to agriculture, primarily corn.

The purpose of our investigation of Wolf Creek was to determine the overall condition of the creek. Specifically, we took water samples to determine temperature, conductivity, dissolved oxygen, salinity, turbidity, and lab measurements to determine levels of chloride, bromide, fluoride, nitrate, nitrite, phosphate, sulfate, and calcium. Our analysis of these physical and chemical properties of the creek provides us with information from which we can form conclusions about the health of Wolf Creek. The health of Wolf Creek is important to Rice Country, but is also related to the health of the Cannon River and the Mississippi River. The conclusions drawn from monitoring the health of the creek lead to important insights that can potentially be useful for future

Figure 1 Map of Wolf Creek collection sites (modified from TopoZone.com)



Carleton students and faculty, as well as individuals living in close proximity to the creek, and may also be important in ongoing studies of Wolf Creek.

Our specific study focuses on seven specific sites (See Figure 1) that were sampled consistently over a period of time, from October 5, 2004 to October 26, 2004. The first site was Circle Lake, off of Route 1. The second location was off Canby Avenue (Wolf Creek #1). The third site was near 120th Street West (Wolf Creek #2). The fourth site was off Cabot Avenue (Wolf Creek #3). The fifth sampling location was near Dundas Blvd (Wolf Creek #4). The sixth (Wolf Creek #5) and seventh site were located on Route 3, the seventh site being the Cannon River sampling location.

Previous Work:

The last Carleton group to study Wolf Creek in June 2003 found that the overall water quality of the creek had improved over the two years before their study. They remarked that Wolf Creek was relatively healthy at that time, despite the many farms in the area. Measurements that they took included: pH, water temperature, dissolved oxygen, conductivity, salinity, and turbidity. Chloride, nitrate, and sulfate levels were also measured, since they were the only chemicals to show up in a significant amount. The sites at which their measurements were taken were very close to our sites. One main difference in our choice of sampling locations is their site #5, which was beyond Fox Lake, located slightly below Circle Lake. This alters our ability to directly compare data.

The work done by the previous group is crucial to our study, because it allows us to analyze changes in the creek. By comparing the two sets of data we can more accurately depict the health of the creek relative to itself, and determine if Wolf Creek is maintaining its healthy status or deteriorating. It is important to note however the difference in season; our study of the creek was in the fall of 2004, whereas the previous study took place in the spring of 2003. The seasonal difference has the potential to cause variances in the data which do not necessarily represent changes in the creek so much as changes in the season. Measurements of temperature and dissolved oxygen specifically vary greatly with the changing of the seasons.

Methods:

Over the course of the past two months our group has monitored Wolf Creek. On four Tuesdays, between the hours of 1:00 and 5:00 pm, we took samples at 7 different locations (see Figure 1 and the introduction), beginning in Circle Lake, following the progress of the creek, and ending in the Cannon River.

At each site we measured several qualities of the water. Using a Yellow Springs Instrument, Model 85 we measured the temperature in degrees Celsius, conductivity, dissolved oxygen (DO), and the sodium content, or salinity. Turbidity of the creek was measured with a 130cm Secchi tube. The tube was filled with water, and the clarity of the water was examined as water was let out of the tube. The point at which the white and black disc at the bottom of the tube could be seen was the measurement of the turbidity. It is important to note that on October 19, the only data collected was turbidity.

After our samples were returned to the lab, they were refrigerated, until they were analyzed for a variety of ions, using a Dionex 600 Ion Chromatograph. Of the anions analyzed, our water only yielded significant amounts of chloride, nitrate, and sulfate.

Calcium levels were also measured for each of our samples, using the atomic absorption spectrometer. In this method the samples were aspirated into a flame and then atomized. A light beam directed through the flame was analyzed and the energy absorbed by the flame was proportional to the concentration of the calcium in the sample.

Results:

The following figures and tables (Figures 2-11 and Tables 1-10) record conductivity, turbidity, dissolved oxygen, temperature, and the nutrient levels from each of the four sampling dates, as well as calcium levels and the change of the nutrients over time.

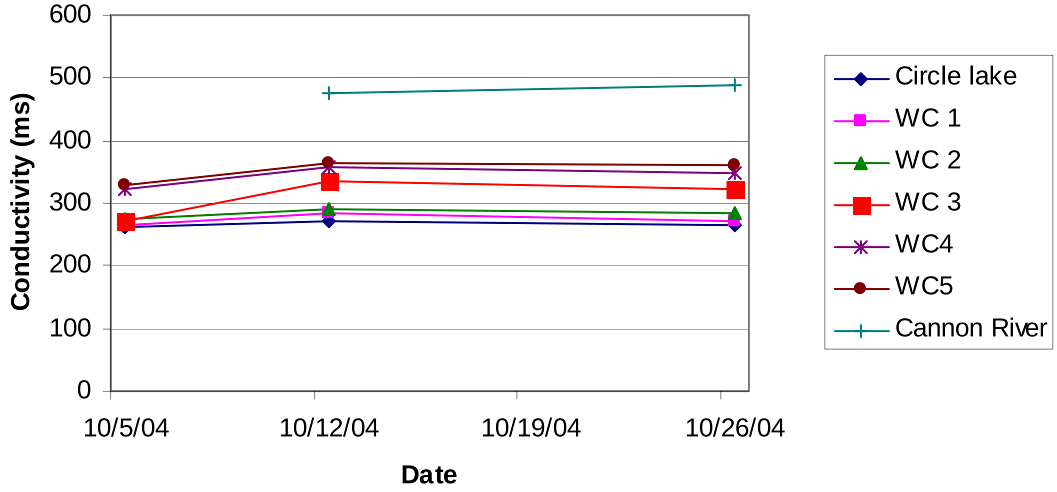


Figure 2 Conductivity measurements

Figure 2 displays measurements of conductivity taken at Circle Lake and the five Wolf Creek sites on three occasions. Measurements were taken from Cannon River on the last two dates. The levels of conductivity remained fairly stable throughout the study. Spikes can be seen at each site on October 12, but the conductivity of each site returned to close to its initial level by the final sampling. Conductivity increased, in general, as distance from Circle Lake increased, with the Cannon River site (being the farthest from Circle Lake) providing the highest levels of conductivity on both occasions it was measured.

Table 1 Conductivity data (in µs)

	10/5/04	10/12/04	10/26/04
Circle Lake	260.2	270.7	266.3
Wolf Creek #1	264.6	282.8	272.1
Wolf Creek #2	273.2	291.3	283.2
Wolf Creek #3	272.1	334.4	323.6
Wolf Creek #4	321.2	358.9	348.6
Wolf Creek #5	329.1	364.5	361.8
Cannon River	N/A	475	489

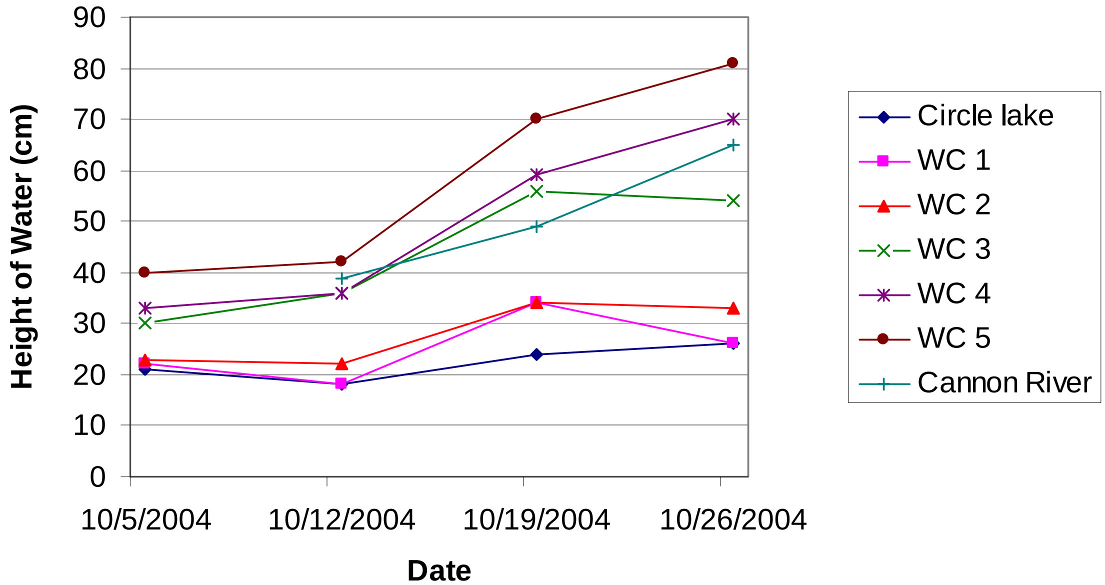


Figure 3 Turbidity measurements

Figure 3 displays the measurements of turbidity taken from Circle Lake and five Wolf Creek sites on four dates. Measurements were taken from the Cannon River on the last three dates listed. Over the course of the testing period, the clarity of the water tested rose at every location, though not consistently. For instance, clarity fell at Circle Lake, WC 1, and WC 2 (from 21 cm to 18 cm, 22 cm to 18 cm, and 23 cm to 22 cm respectively), but the measurements at each site on the final date are all higher than the measurements taken on the first date. Additionally, water clarity increased as distance from Circle Lake increased, with the exception of samples taken from the Cannon River site.

Table 2 Turbidity data (height in cm)

	10/5/2004	10/12/2004	10/19/2004	10/26/2004
Circle Lake	21	18	24	26
Wolf Creek #1	22	18	34	26
Wolf Creek #2	23	22	34	33
Wolf Creek #3	30	36	56	54
Wolf Creek #4	33	36	59	70
Wolf Creek #5	40	42	70	81
Cannon River	N/A	39	49	65

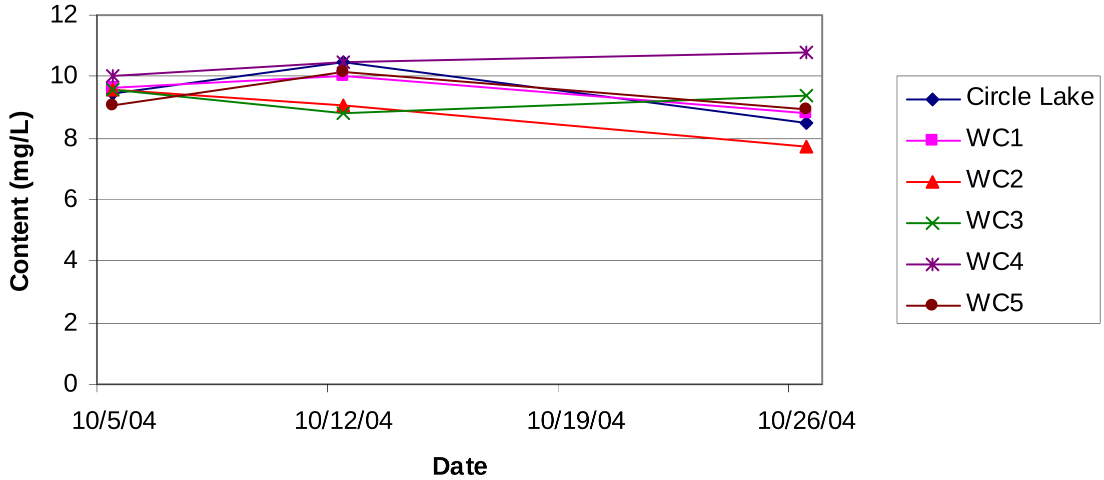


Figure 4 Dissolved oxygen measurements

Figure 4 displays the dissolved oxygen measurements taken at Circle Lake and five Wolf Creek locations on three occasions. The data at each location stayed relatively stable over the three dates, at an average of 8-11 mg/L. There are no strong patterns in the data, either over time, or as the stream moves towards the Cannon River.

Table 3 Dissolved oxygen data (mg/L)

	10/5/2004	10/12/2004	10/26/2004
Circle Lake	9.45	10.48	8.46
Wolf Creek #1	9.64	10.04	8.79
Wolf Creek #2	9.6	9.07	7.72
Wolf Creek #3	9.56	8.78	9.37
Wolf Creek #4	10	10.45	10.77
Wolf Creek #5	9.04	10.12	8.93

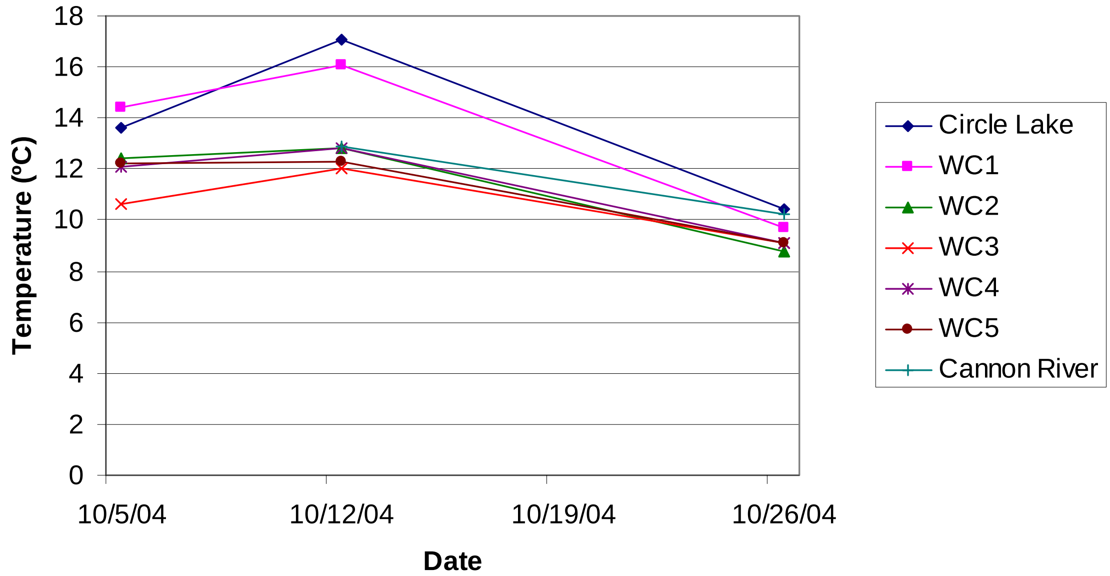


Figure 5 **Temperature measurements**

Figure 5 displays the temperature measurements taken from Circle Lake and five Wolf Creek sites on three dates. Measurements were taken from the Cannon River on the last two dates listed. Each sampling location follows a similar pattern. On the first date, October 5th, temperatures were around 10-14ºC. By October 12th, the temperature at each location had risen by one or two degrees to an average of 12-16ºC. On the last date, October 26th, temperatures had fallen by two to six degrees to an average of 9-10ºC. Overall, temperatures fell two to four degrees between the first and last sampling dates.

Table 4 **Temperature data (ºC)**

	10/5/04	10/12/04	10/26/04
Circle Lake	13.6	17.1	10.4
Wolf Creek #1	14.4	16.1	9.7
Wolf Creek #2	12.4	12.8	8.8
Wolf Creek #3	10.6	12	9.1
Wolf Creek #4	12.1	12.8	9.1
Wolf Creek #5	12.2	12.3	9.1
Cannon River	N/A	12.9	10.2

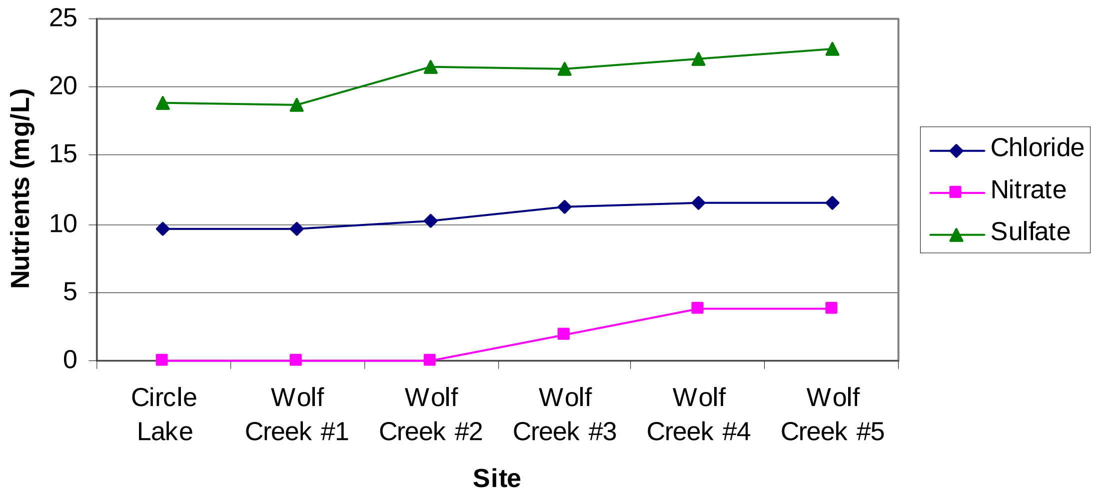


Figure 6 **October 5, 2004 nutrients**

Figure 6 illustrates the results from the first sampling day, October 5th. On this date we were not able to sample the Cannon River, therefore there are only six locations. Out of the three nutrients found in the creek, sulfate was highest concentrated. The sulfate increased in amount from 18.91 mg/L in Circle Lake to 22.77 mg/L in Wolf Creek #5. The second highest concentrated nutrient found in the creek was chloride, which also increased going further down the creek, from 9.71 mg/L in Circle Lake to 11.55 mg/L in Wolf Creek #5. The lowest concentrated nutrient found along the creek was nitrate, which was not present until Wolf Creek #3. After Wolf Creek #3 the nitrate, much like chloride and sulfate, increased further down the creek, from 1.83 mg/L to 3.83mg/L in Wolf Creek #5.

Table 5 **October 5, 2004 nutrient levels (mg/L)**

Site	Chloride	Nitrate	Sulfate
Circle Lake	9.71	0	18.91
Wolf Creek #1	9.6	0	18.74
Wolf Creek #2	10.24	0	21.55
Wolf Creek #3	11.27	1.84	21.41
Wolf Creek #4	11.54	3.83	22.14
Wolf Creek #5	11.55	3.83	22.77

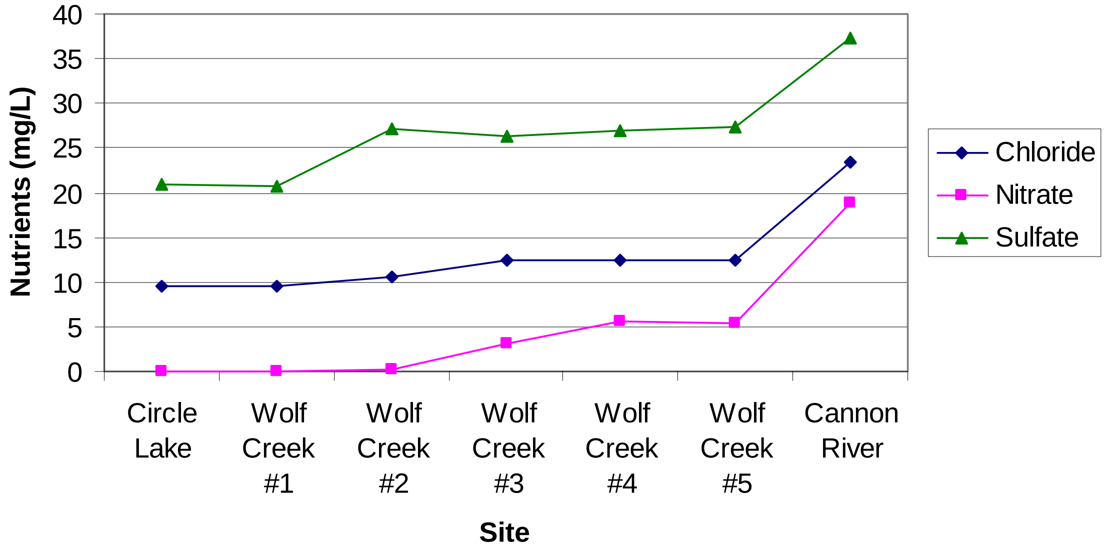


Figure 7 October 12, 2004 nutrients

Figure 7 displays the results from our second date of sampling, October 12th. Sulfate is once again the highest concentrated nutrient found in Wolf Creek. There is only slight consistency of sulfate amount from Circle Lake through Wolf Creek. From Circle Lake (21.03 mg/L), it decreases by Wolf Creek #1 to 20.76 mg/L, then greatly increases to 27.12 mg/L by Wolf Creek #2. Oddly, the sulfate decreases at Wolf Creek #3 to 26.33 mg/L and sustains at 26 mg/L at Wolf Creek #4, but then increases again by Wolf Creek #5 to 27.43 mg/L. Chloride gradually increased from 9.61 mg/L at Circle Lake to 12.45 mg/L at Wolf Creek #5. Nitrate was not evident until Wolf Creek #2 at 0.22 mg/L and only slight increases at Wolf Creek #5 to 5.48 mg/L. The levels of all three nutrients greatly increased in the Cannon River.

Table 6 October 12, 2004 nutrient levels (mg/L)

Site	Chloride	Nitrate	Sulfate
Circle Lake	9.61	0	21.03
Wolf Creek #1	9.53	0	20.76
Wolf Creek #2	10.65	0.22	27.17
Wolf Creek #3	12.36	3.05	26.33
Wolf Creek #4	12.45	5.62	26.92
Wolf Creek #5	12.45	5.48	27.43
Cannon River	23.46	18.89	37.27

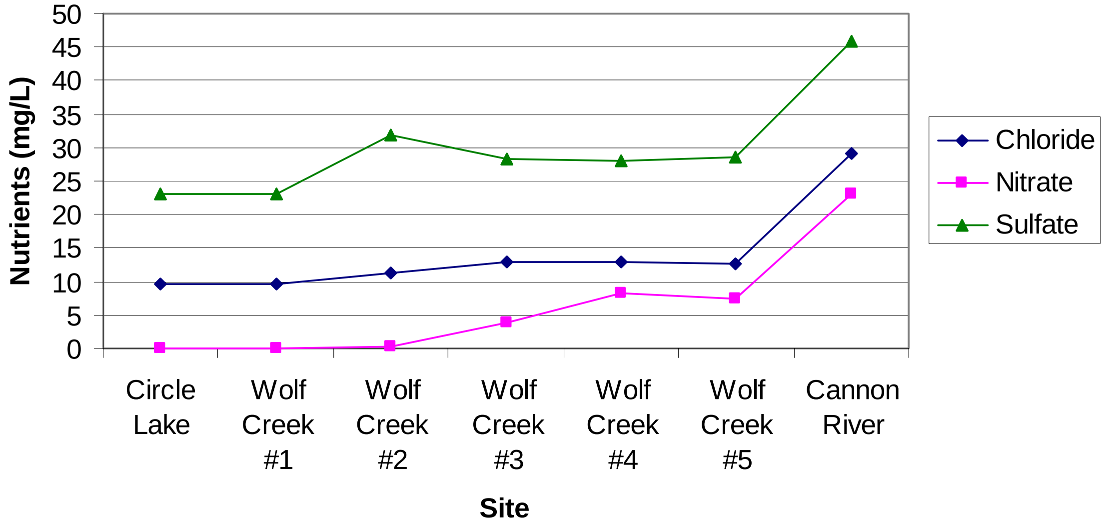


Figure 8 October 19, 2004 nutrients

Figure 8 displays the results from our third date of sampling, October 19th. All three nutrients generally increased along the creek, with some exceptions, and there was a large jump in all three nutrients in the Cannon River. Once again out of the three, the most concentrated was sulfate. At Circle Lake and Wolf Creek #1, sulfate levels were at around 23 mg/L, then greatly increased to 31.86 mg/L at Wolf Creek #2. There was a slight decline at the next three locations, to around 28 mg/L, until a jump to 45.89 mg/L in the Cannon River. Chloride followed a similar pattern to sulfate, in that it increased after the first two locations from around 9.7 mg/L to a level of 11.17 mg/L at Wolf Creek #2. It then continued to increase to a level of 13.00 mg/L at Wolf Creek #3. Then there was a slight decline to around 12.8 mg/L in the next two locations until a jump to 29.10 mg/L in the Cannon River. Nitrate was not present until Wolf Creek #2, at .36 mg/L. It then increased over the next two locations to a level of 8.16 mg/L at Wolf Creek #4. After a slight decrease at Wolf Creek #5, the nitrate levels jumped to 23.01 mg/L in the Cannon River.

Table 7 October 19, 2004 nutrient levels (mg/L)

Site	Chloride	Nitrate	Sulfate
Circle Lake	9.62	0	23.17
Wolf Creek #1	9.72	0	22.95
Wolf Creek #2	11.17	0.36	31.86
Wolf Creek #3	13.00	3.97	28.36
Wolf Creek #4	12.83	8.16	28.13
Wolf Creek #5	12.75	7.29	28.66
Cannon River	29.10	23.01	45.89

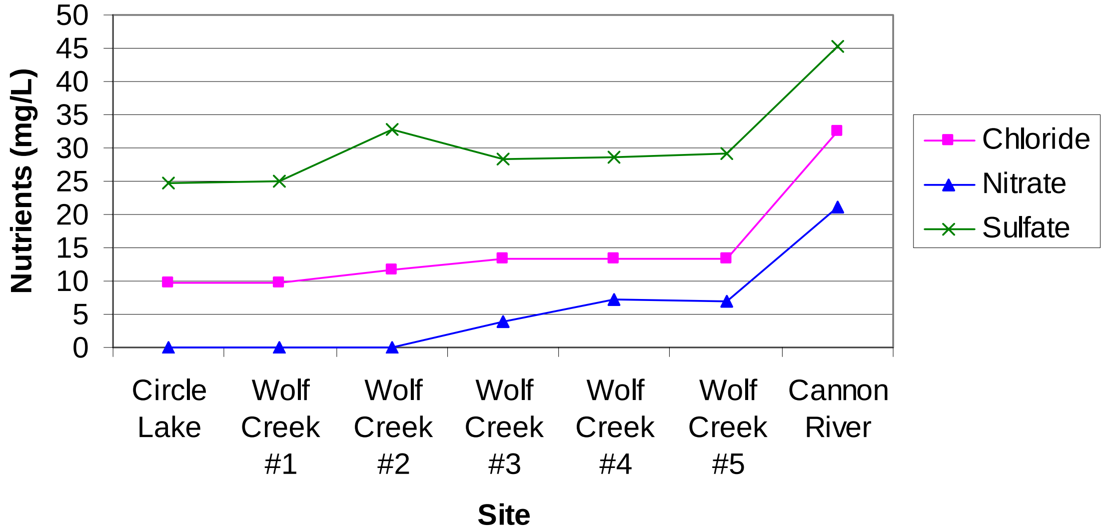


Figure 9 October 26, 2004 nutrients

Figure 9 illustrates the results from our last sampling date, October 26th. The patterns that the nutrients follow closely resemble the other dates. Sulfate once again is the most heavily concentrated nutrient of the three. It generally increases from 24.84 mg/L at Circle Lake to 29.26 mg/L at Wolf Creek #5, with a spike at Wolf Creek #2. It then increases dramatically to 45.37 mg/L in the Cannon River. Chloride began with 9.82 mg/L at Circle Lake and gradually increased to 13.21 mg/L at Wolf Creek #5, then largely increased at the Cannon River with 32.54 mg/L. Nitrate was not found until Wolf Creek #3 with 3.79 mg/L and increased to 7.29 mg/L at Wolf Creek #4 before a slight decline at Wolf Creek #5. Like the other nutrients, nitrate greatly increased at the Cannon River with 21.00 mg/L.

Table 8 October 26, 2004 nutrient levels (mg/L)

	Chloride	Nitrate	Sulfate
Circle Lake	9.82	0	24.84
Wolf Creek #1	9.86	0	25.06
Wolf Creek #2	11.57	0	32.81
Wolf Creek #3	13.29	3.79	28.43
Wolf Creek #4	13.46	7.29	28.74
Wolf Creek #5	13.21	6.96	29.26
Cannon River	32.54	21.00	45.37

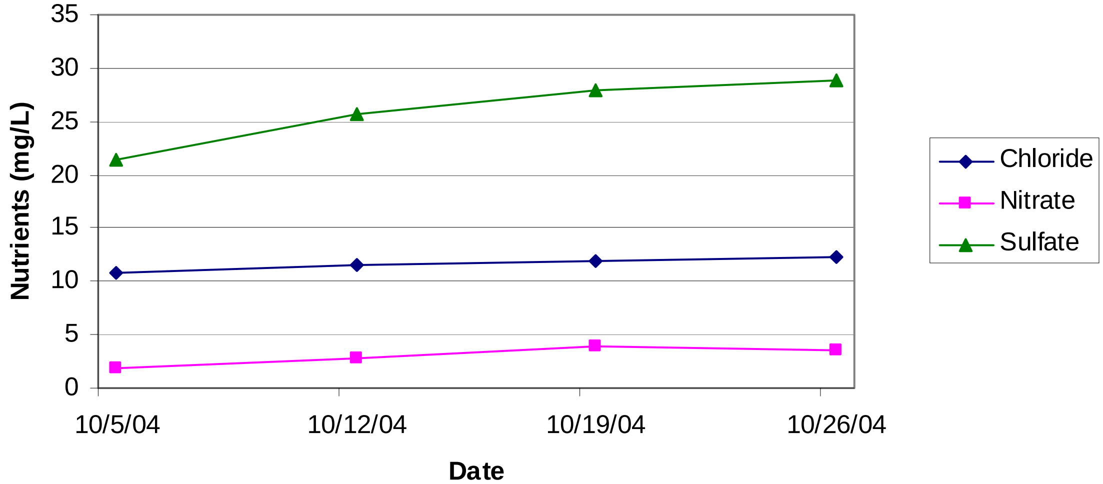


Figure 10 Average of five Wolf Creek sites' nutrients over time

Figure 10 shows the average amount of the three nutrients at the five Wolf Creek sites over time. There is a slight increase in all of them. Sulfate begins at an average of 21.32 mg/L for the five Wolf Creek sites on Oct. 5th and increases each day until reaching an average of 28.86 mg/L on Oct. 26th. Chloride also increases, but not by as much. It starts at 10.84 mg/L on Oct. 5th, and increases to 12.28 mg/L on Oct. 26th. Nitrate increases from 1.9 mg/L on Oct. 5th to 3.96 mg/L on Oct. 19th before falling slightly to 3.61 mg/L on Oct. 26th.

Table 9 Average nutrients data (mg/L)

Date	Chloride	Nitrate	Sulfate
10/5/04	10.84	1.90	21.32
10/12/04	11.49	2.87	25.71
10/19/04	11.89	3.96	27.99
10/26/04	12.28	3.61	28.86

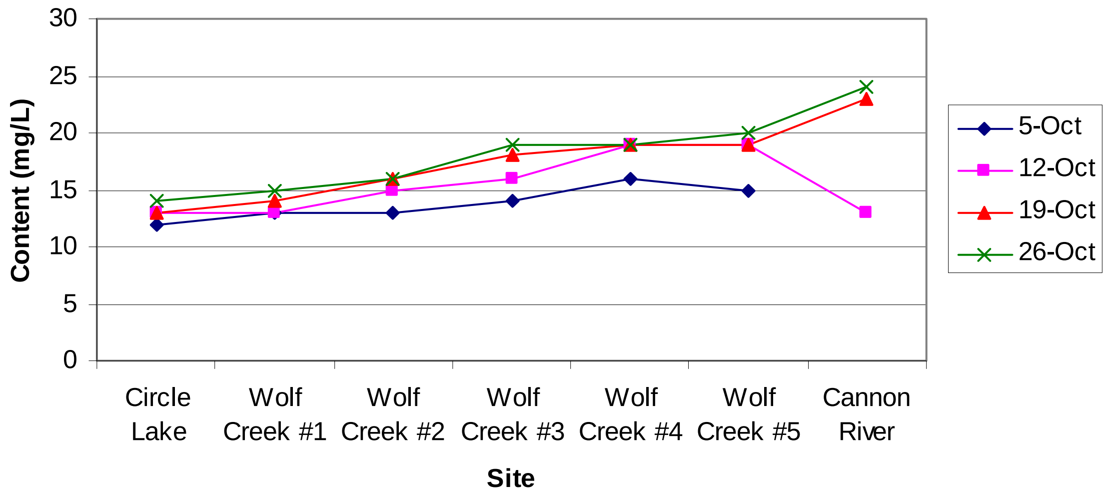


Figure 11 Calcium measurements

Figure 11 displays the results from our calcium analysis. There is an apparent rise in the calcium levels as Wolf Creek goes towards the Cannon River, and also over each date. Calcium started at an average of around 13 mg/L at Circle Lake and rose to around 19 mg/L at Wolf Creek #5, before rising to 23 mg/L in the Cannon River. Anomalies appear on the October 5th sampling date and in the Cannon River on October 12th. On October 5th, all levels were lower, only rising from 12 mg/L to 15 mg/L over the course of the creek. Also, on October 12th the calcium level dropped from 19 mg/L at Wolf Creek #5 to 13 mg/L in the Cannon River, instead of rising as it had on the other dates.

Table 10 Calcium data (mg/L)

	10-5-04	10-12-04	10-19-04	10-26-04
Circle Lake	12	13	13	14
Wolf Creek #1	13	13	14	15
Wolf Creek #2	13	15	16	16
Wolf Creek #3	14	16	18	19
Wolf Creek #4	16	19	19	19
Wolf Creek #5	15	19	19	20
Cannon River	N/A	13	23	24

Discussion:

Here we assess our results and compare our data not only to previous measurements of Wolf Creek, but also to standards considered acceptable by the scientific community, in order to properly form an assessment of overall creek quality.

Temperature has an effect on many physical, biological, and chemical aspects of a creek. Temperature controls the amount of dissolved oxygen present in the creek, which in turn determines rates of photosynthesis in plants, metabolic rates of animals, as well as the ability of organisms to respond to changes in habitat – changes in light, salinity, oxygen, and pollutants. Measuring the changes in temperature can provide important insight as to sources of thermal pollution, (Hybolos Stream Team, 2000).

The temperature of Wolf Creek taken on our sampling days fluctuated, but overall the average temperature decreased. This result is expected, due to the fact that we sampled between October 5 and October 26. As fall progresses, it tends to usher in colder air temperatures and, in turn, colder water temperatures. The spike in our temperature graph could be due entirely to the warmth of the sampling day, and show relatively little about thermal pollution. However, if the graph was steadily increasing over the time that we sampled, or if water temperatures had been significantly high given the air temperature, this would provide us with clues as to possible pollution. While changing seasons are responsible for the majority of water temperature fluctuations, changes in temperature can also be affected by factors such as the depth of the water and the amount of sunlight or cloud cover present on any given day. It is interesting to note that our highest temperature readings came from the sampling conducted at Circle Lake. This correlates well with our interpretation of temperature. The lake was the site in which the least water movement occurred; hence the water was better able to hold the heat it accumulated from the sun and from the warm air temperatures of the summer months.

Measurement of the dissolved oxygen (DO) in a creek is also important. Water at 0 degrees Celsius, when fully saturated with oxygen, can hold 14.6mg/L of dissolved oxygen. According to 1999 ANZECC guidelines, levels of dissolved oxygen below 5 mg/L are considered harmful to the health of the aquatic life present in the given body of water (Understanding Dissolved Oxygen in Streams).

Dissolved oxygen results from a variety of processes. Areas of the creek with faster moving water mix more oxygen into the creek, and will raise the dissolved oxygen content of the creek. Aquatic plants performing photosynthesis also deliver oxygen to the water. Creeks rich in plant life often see an increase in DO content from the morning to the afternoon as photosynthesis peaks. Water with a lower temperature allows oxygen to dissolve more easily. Periods of time during which a great deal of precipitation falls result in more water flow, and thus greater mixing-in of oxygen. DO content can be altered negatively by human behavior. The main contributor to a depleted level of oxygen in a given body of water is organic waste. Fertilizer runoff, as well as waste from industrial sources can cause explosions of algae growth. As these plants die they consume oxygen, lowering the overall oxygen level in the creek. DO content can also be depleted in a variety of natural ways. Respiration by aquatic plants and animals, decomposition of organic materials (resulting in a biological oxygen demand), chemical reactions requiring oxygen (resulting in a chemical oxygen demand), and heating of water to 25-35 degrees Celsius all cause decreases in the DO content. Because dissolved oxygen fluctuates with the changing of climate, it is important (in order to compare data from study to study) to have analyzed water at the same time of year, or the dissolved oxygen content will be very different and will not point to any unnatural or unusual fluctuations in the creek's health (discoverycube.org).

Our measurements of dissolved oxygen remained fairly consistent over the period of time during which sampling occurred. Our measurements were all well above the recommended 5mg/L. A slight increase in DO content on October 12 could be due to slightly increased photosynthetic activity as a result of more sunshine.

Conductivity is the measure of how well water conducts electricity, and is expressed in units of microsiemens. The presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions, or sodium, magnesium, calcium (see Figure 11), iron, and aluminum cations in water will increase the conductivity, and thus the measurement of conductivity can be used to estimate the ion concentration in water and other solutions. Conductivity is also determined by water temperature. The higher the temperature of the water, the higher the conductivity reading will be and vice versa. Streams that have low conductivity generally have less groundwater input than streams with high levels of conductivity. Conductivity is an indication of the amount of erosion that occurs within a watershed's bedrock (Water Conductivity in Stream Environments). The geology of the area through which a creek runs can also alter conductivity. Streams that run through areas of granite bedrock tend to have lower conductivity, whereas streams that flow through areas with large deposits of clay will have higher conductivity (Delaware River Basic Commission). Conductivity is an important measurement, capable of providing many clues as to the overall health of the creek. Dramatic changes in conductivity point to the presence of new ions in the water. Therefore, an increased conductivity reading may point to pollution. Areas with high levels of development that contain highways and construction sites will therefore likely have high levels of conductivity (vanburen-mi.org). The Environmental Protection Agency defines an acceptable range of conductivity measurements in streams and rivers as between 50-1500 micromhos.

The conductivity measurements we took fell between 260 and 489 micromhos. These values were considered acceptable by the EPA, and were very similar to the past measurements taken by other researchers of Wolf Creek. Each site remained very consistent in its conductivity readings. This lack of variation could be due to relatively few changes in precipitation on the specific sampling days. The measurements of conductivity steadily increased as we moved from Circle Lake to the Cannon River. This data was expected, as the Cannon River is potentially the most polluted of the areas we sampled. The areas we sampled for Wolf Creek #5 and the Cannon River were both in very close proximity to the highway, and as such experience the effects of runoff.

Turbidity is defined as "the optical property of a water sample that causes light to be scattered and absorbed rather than transmitted in straight lines through the sample. In simple terms, turbidity answers the question, "How cloudy is the water?" (DRBC)." The measure of turbidity can be affected by a variety of factors. The movement of water due to increased flow, strong winds, or heavy rains will change turbidity by causing more suspension of solids in the creek. Natural factors, such as increased algae bloom in the spring and summer will also cause turbidity measurements to be higher. The location of the stream can be important in determining turbidity. Where good vegetation cover exists, changes in turbidity are generally small. The level of turbidity can have a substantial impact on the health of a creek. Increased levels of turbidity reduce light's ability to penetrate the water, and thus the opportunity for plants to perform photosynthesis and grow. Many types of pollutants occupy water more easily if allowed to attach themselves to a sedimentary particle; therefore increased turbidity may result in increased pollution (Waterwatch).

Our turbidity measurements steadily decreased, meaning that over the period of sampling our water became increasingly clear. The turbidity measurements were overall the highest at Circle Lake, and became lower as we moved toward the Cannon River. Sampling site Wolf Creek #5 had the overall lowest turbidity. Circle Lake is the most populated area, resulting in the possibility of more human interferences with water quality. Circle Lake was also significantly warmer than our other sampling areas, and as such supports more plant life, which has the effect of causing the water to be less clear. Our general decreases in turbidity can be explained by several things. The main factor in our changing results was no doubt human error. As we continued to sample, we became much better at filling the secchi tube, disturbing the bottom of the creek less and coming up with purer samples of the water. A decreased amount of rainfall over the time our study was conducted also allowed the sediments to settle out of the water, decreasing turbidity.

Salinity is the measurement of the sodium content in water, in parts per thousand. Salt occurs naturally in soil and water, but human interference can cause increased levels of salinity. These increases are typically due to agricultural and industrial runoff. High levels of salinity can cause damage to infrastructure, as well as environmental problems. Biodiversity of streams is adversely affected by high levels of salinity. All of our measurements, except for two, were the same, .2ppt. This value is the same as that obtained by the previous group.

Sulfate is an ion naturally found in water. Sulfate is non-toxic, and while the World Health Organization places no restrictions upon its presence in water, it is recommended that levels in water stay below 1000mg/L in order to insure the safety and survival of aquatic animals (Missouri Department of Natural Resources, 2004). Sulfate can be released into streams in a variety of ways: through agricultural and industrial waste, acid rain, mining, the decomposition of organic compounds containing sulfur, and any geological formations containing sulfate that the stream passes through. Seasonal changes bringing warmer weather, and hence more rain and agricultural activity, can usher in large amounts of sulfate to the creek.

The amounts of sulfate we recorded during our study remained fairly consistent for each site between the sampling days. The highest amounts of sulfate were found in the Cannon River. Again, this result is to be expected, given that the Cannon River covers a much larger area, and as such is exposed to a great deal more runoff. All of our values for sulfate remained well below the recommended value of 1000mg/L. We can deduce that the sulfate found in Wolf Creek is not due to acid rain, as that is not prevalent in this area, nor can it be attributed to mining. The levels of sulfate can therefore possibly be attributed to the geological formations through which the creek passes.

The measurement of chloride in water provides us with the ability to assess how corrosive it is. Higher amounts of chloride indicate a higher conductivity. Pollution related to chloride comes from the chemical reaction of chloride with metal ions, resulting in higher levels of metal in the water. Neither the EPA nor the World Health

Organization has placed restrictions on the amount of chloride that is considered to be safe in drinking water. However, most unpolluted streams have levels of chloride that fall below 10mg/L (World Health Organization). There are no known toxic effects of chloride, in the concentrations typically found in drinking water, on humans. Chloride enters bodies of water in much the same way as sulfate, through erosion of geological formations, industrial runoff, road runoff, sewage, or if a creek is connected in some way to a body of salt water.

The amount of chloride we observed in Wolf Creek was fairly consistent within each site over the sampling time period. Most of the values were between 9 and 13 mg/L. These values, while slightly above the level of unpolluted streams, are not high enough to be significant or point to a major source of pollution. The amount of chloride increases as the creek flows from Circle Lake to the Cannon River. This result is to be expected. As the creek progresses, it has more opportunity to run through areas in which chloride is collected. The values we measured in the Cannon River, however, were high, and significantly higher than the values obtained in Wolf Creek, ranging from 23.46 to 32.54 mg/L. This can be attributed to several things. The presence of a large highway near the Cannon River could result in larger amounts of runoff containing chloride. This amount would be even larger in the winter and spring when salt and other de-icing agents have been poured on the highway, and then proceed to run into the stream. The fact that the Cannon River also has a much larger watershed means that it is potentially gaining chloride from a variety of different areas and bodies of water. These values of chloride could also point to a geological formation containing chloride that is being eroded by the river. These levels, however, do not cause great concern, because there are no concrete standards set on what chloride levels should be. The recommendation of 10mg/L applies primarily to streams, and does not indicate a value that is applicable to rivers.

Nitrate is a naturally occurring chemical. It is most commonly found in bodies of water that are surrounded by agricultural areas. The level of nitrate is therefore very important to our assessment of Wolf Creek's health, as it is surrounded by primarily agricultural land. Agricultural production involves the use of a large amount of fertilizer, containing nitrate. During the growing season and periods of high rainfall, the nitrate that accumulated in the fields will seep into surrounding bodies of water. Nitrate concentrations in creeks that exceed 50 mg/L are considered potentially harmful to health. Areas with this high level of concentration are almost always found in areas with farmland. Sewage waste can also contribute to high levels of nitrate. Creeks with low levels of algae often have high levels of nitrate. When there are fewer algae present to consume nutrients, they tend to build up in the creek, raising overall levels of nitrate.

The amounts of nitrate found in Wolf Creek were well within the bounds of recommended levels. Circle Lake and Wolf Creek #1 contained no nitrate, and Wolf Creek #2 displayed trace amounts on only two of the four sampling days. Measurements at the other sampling sites fell between 1.84 and 8.16 mg/L. These values fluctuated probably due to changes in individual farms, being implemented as we conducted our study. Differences in the amounts of fertilizer used at different times of year, or the disturbing of the soil at given times will effect the amount of nitrate present in the creek. Rainfall, and hence the ability of nitrate to run into the creek also affect the overall amount present in the water at any given time. The values for Cannon River, as with all of the other nutrients, were much higher, ranging from 22.77 to 45.89. Again, this can be attributed to the large amount of tributaries, the proximity to the highway, and the overall pollution associated with the river.

Conclusion:

The overarching conclusion reached from our data is that Wolf Creek is a generally healthy body of water. All measurements taken during the study fell well within the standards stipulated by the EPA and the World Health Organization. Initially, some worry was caused by the presence of a large construction site near Circle Lake and Wolf Creek Site #1. However, analysis of the data has determined that this work has had no palpable effect on the health of Wolf Creek.

The EPA states that a healthy body of water should have conductivity readings between 50 and 1500 micromhos. As all measurements taken from Wolf Creek, Circle Lake, and the Cannon River fell within a range of 250 – 500 micromhos, we feel safe in concluding that the conductivity of these bodies of water poses no danger. However, as conductivity is primarily determined by the content of the bed of the body of water, it should be monitored in the future. Significant changes in conductivity could signal the presence of outside pollutants.

As stated above, measurements of turbidity taken during our study changed drastically over time. This could have been caused by many factors, but most likely by human error occurring during the initial testing. The overall efficiency of the study increased over time, leading us to conclude that later results were likely more accurate. There are no specific standards with which to compare the data gathered during the study, but the observed trend of increasing clarity and a favorable comparison with the data collected during previous studies can be seen as positive indicators of the health of Wolf Creek.

Similarly, the level of dissolved oxygen measured at each site was consistently above the minimum of 5 mg/L laid out by the ANZECC. This healthy level of dissolved oxygen is consistent with previous studies and should be monitored in the future. Diminished oxygen levels can lead to unhealthy environment for native plant species.

Regarding water temperature, there is little of import to say. The temperature rose and fell at each site according to the air temperature on the day of testing. This is perfectly normal behavior for any body of water. The previous study conducted on Wolf Creek concluded that water temperature needed to be monitored in the future, guaranteeing that the higher water temperatures they witnessed receded as the seasons changed. While no data was gathered during the intervening years, the facts that our study was conducted during the transition from Fall to Winter weather and water temperature on the final testing date was significantly lower than on the first date, it now seems safe to conclude that water temperature currently presents no detriment to the health of Wolf Creek.

Finally, but for one exception, no nutrients were found in the water samples studied which exceeded recommended amounts. Measurements taken from Circle Lake and all five Wolf Creek sites indicate levels of chloride, nitrate, sulfate, and calcium ions (the only ions detected in the samples) which fall well within the boundaries of healthy water. The Cannon River water samples were analyzed for the same ions, and while these measurements were understandably higher, we believe that, with proper regulations against improper consumption, they will pose little threat to the population in general and none at all to Wolf Creek.

In conclusion, our study has proven once again that Wolf Creek is quite healthy for a creek of its size and location. The health of the creek has either increased or remained consistently high other the course of the last several studies conducted, and we have little reason to presume that it will change. The farmland surrounding the creek must continue to be monitored (as well as the construction site mentioned above), but as of the conclusion of our study, it has proven to be fairly safe.

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