# Analysis of the Arcade Creek Shows Lower Dissolved Oxygen Levels When Compared with the American River

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ABSTRACT: This paper outlines the differences in dissolved oxygen between the Arcade Creek and the American River located in California's Sacramento Valley as well as the plausibility that the Arcade Creek needs more attention to preserve its local ecosystem based on these results. A comparison was made using data collected over the span of several years by multiple stations along both water bodies. Such stations are analyzed individually to account for error and evaluated together to provide a basis of comparison. Results show the American River has higher dissolved oxygen concentrations than the Arcade Creek. Prior research indicates the American River as being in good condition and so the Arcade Creek, having a lower dissolved oxygen content, is in need of environmental improvement. The results call for further investigation of the Arcade Creek the impacts urban development and roadside pollution have on its dissolved oxygen levels and the implications this has upon the local ecosystem reliant on the Arcade Creek.

KEYWORDS: Environment; Sacramento; Arcade Creek; American River; Dissolved Oxygen.

## INTRODUCTION

This project aims to determine if there are disparities in dissolved oxygen levels between the Arcade Creek and the American River. The significance of any disparity can be attributed to the overall health of the two water bodies present in the Sacramento Valley, mostly focused on the Arcade Creek as it is closer to urban development. Thus, the possible effects of urban development and roadside pollution can be discussed and further investigated.

### *Concerning the importance of dissolved oxygen*

In bodies of water, up to ten molecules of oxygen are dissolved in one million water molecules, varying depending on the state of the water body. This oxygen, entering via small streams or groundwater discharge, is needed by organisms to survive in aquatic environments. Thus, fast-flowing water tends to have a higher amount of dissolved oxygen than stagnant bodies. Fast-flowing water increases the diffusion of atmospheric oxygen into larger bodies of water.[1,2] Low-flow conditions prevent oxygenation and can cause critically low oxygen levels when coupled with high temperatures.[2] Another issue is the consumption of oxygen as organic matter decays. The build-up of excessive organic decay can cause eutrophic conditions and a lack of oxygen in the water. Seasonal and daily fluctuations also occur; colder temperatures correlate to higher dissolved oxygen levels and why bodies of water in late winter and early spring have the highest levels of dissolved oxygen. Low levels of dissolved oxygen present lethal hazards to all aquatic life in a body of water.[1] The oxygen content is considered dangerous around 5 mg/L with 2mg/L being critically low.[1,3] While too little dissolved oxygen is problematic for aquatic life, too much dissolved oxygen also presents issues. High levels of dissolved oxygen result from an excess of photosynthesizing plants and cause harmful algal blooms. This can be caused by excessive fertilizer and/or sewage runoff and results in cultural eutrophication.[4]

Other California bodies of water that have low dissolved oxygen levels include the Santa Margarita River and San Joaquin River. Both exhibit eutrophic conditions and illustrate the dangers organisms face with low dissolved oxygen levels.[5,6] Pollution is a leading cause of eutrophication.

### *The Arcade Creek*

The Arcade Creek, flowing from Orangevale to the Sacramento River via the Natomas East Main Drainage Canal, spans approximately 16.2 miles and covers a basin area of almost 30 miles. The portion tested in this study runs from Auburn Blvd to Haggin Oaks, stations A through G. The creek is mostly bordered by valley and blue interior oaks. Native vegetation often persists in open areas, providing habitats for organisms, but this is slowly diminishing with recent border development.[7] The Arcade Creek has a mean flow rate of 0.2 cubic meters per second.[9]

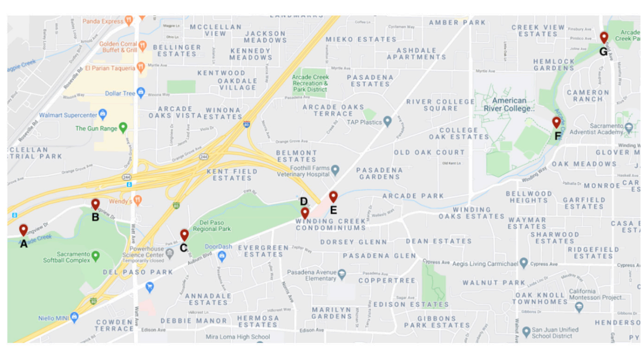


Figure 1. The map with the Arcade Creek Sites 8,14,15,16,17,18,19. The names (from left to right): Site A, Site B, Site D, Site G, Site E, and Site F.



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*The American River*

The American River consists of three forks originating from the Sierra Nevada Mountains. This project studied the South Fork which covers approximately 90 miles, a total of 850 square miles, and originates in the High Sierras in the El Dorado National Forest before entering the Folsom Reservoir and flowing to the Sacramento River. The portion investigated covered stations from the mouth of the Folsom Reservoir up to the Nimbus Dam where the Sacramento Water Pollution Control Lab is located. The American River is considered to be highly oxygenated and relatively healthy. However, erosion from land usage is presenting an increasing problem of sediment addition into the water.[10] The American River has a flow rate of 112.1 cubic meters per second.[11]

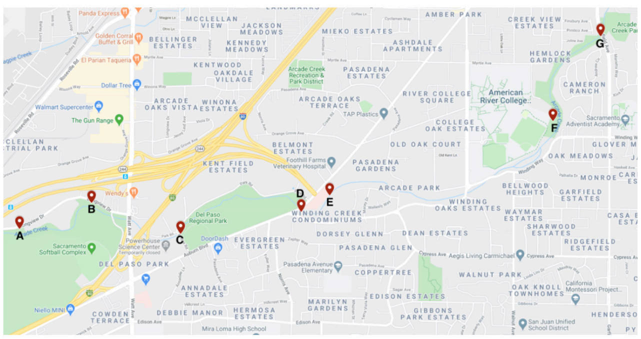


Figure 2. The map of the American River Stations. The names from left to right: Nimbus (N), Nimbus Flat Right (NFR), Nimbus Flat Left (NFL), Nimbus Flat Middle (NFM), Lake Natoma Willow Creek (WC), Lake Natoma Middle (NM), Lake Natoma Right (NR), Lake Natoma Left (NL), and American River at Rainbow Bridge (RB)

## RESULTS AND DISCUSSION

The levels of dissolved oxygen for the Arcade Creek and the American River are shown in Figures 13 and 14. All stations between Arcade Creek and American River show an increase in dissolved oxygen as the year progressed from the beginning winter months to the spring months. Most stations along the Arcade Creek displayed a slight decrease in dissolved oxygen after the spring months. The American River saw a decrease in dissolved oxygen after the summer months.

From January to May, the range of dissolved oxygen along the Arcade Creek was 6-13 mg/L with an outlier at 14 mg/L and the American River had dissolved oxygen concentrations between 10-13.5 mg/L. There was a decrease of dissolved oxygen in June as the Arcade Creek had a concentration range of 5-10 mg/L and the American River's levels ranged between 8-11 mg/L. From September until December, the Arcade Creek had concentrations between 6-10 mg/L with some fluctuations lower than 6 mg/L while the American River had concentrations between 7-12 mg/L.

Seasonal trends are also noted; there were lower dissolved oxygen concentrations during the summer and higher concentrations during the winter and spring for both bodies of water.

The graphs detailing the individual stations display larger error bars for the Arcade Creek Stations (Figures 2-9) than the American River Stations (Figures 11 and 12). This is because the Arcade Creek data was collected using less sophisticated instruments than the American River's data. All data for each body of water was then combined into one graph, Figures 10 and 13.

*Arcade Creek Stations*

The Arcade Creek graphs illustrate monthly averages taken from 2008-2019 and display the seasonal fluctuations of dissolved oxygen levels as temperatures rise and fall.

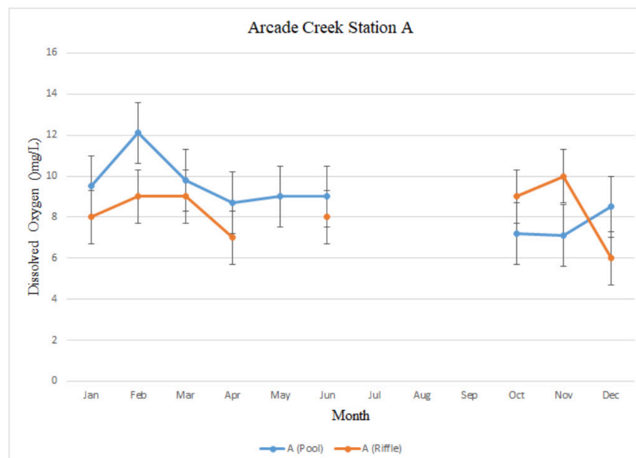


Figure 3. Arcade Creek Station A

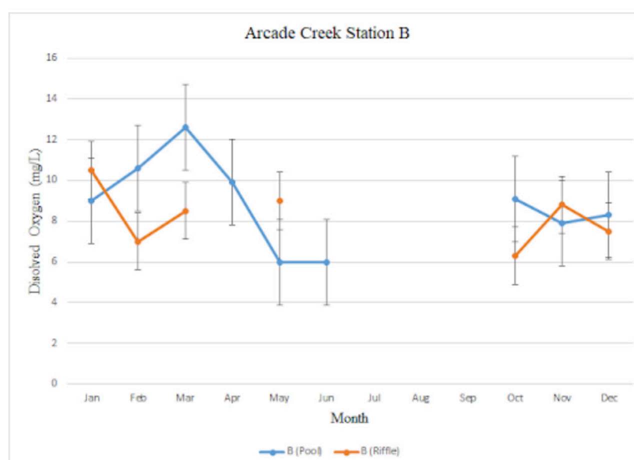


Figure 4. Arcade Creek Station B



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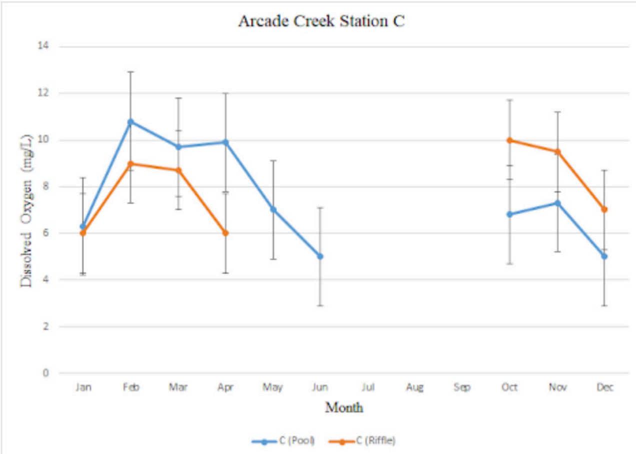


Figure 5. Arcade Creek Station C

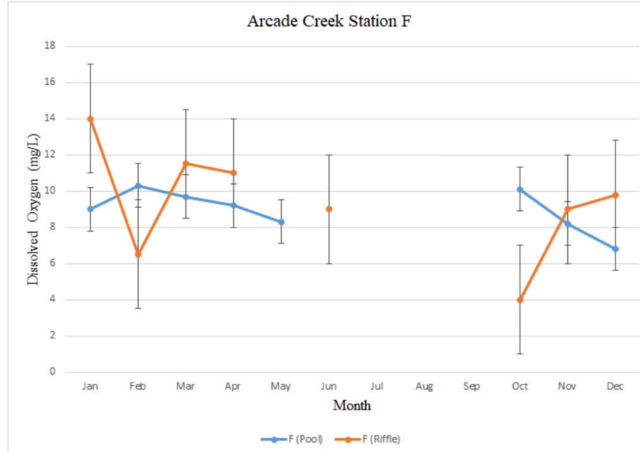


Figure 8. Arcade Creek Station F

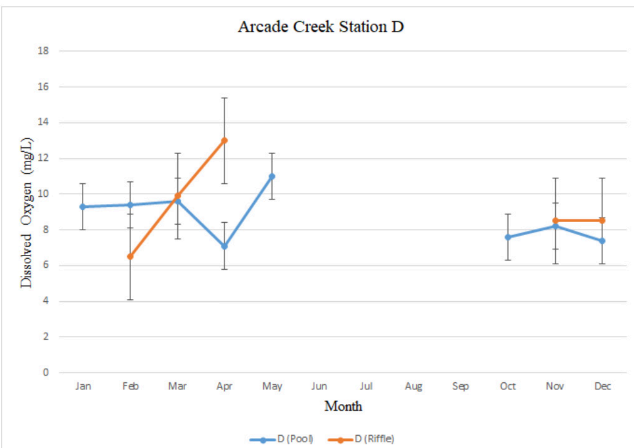


Figure 6. Arcade Creek Station D

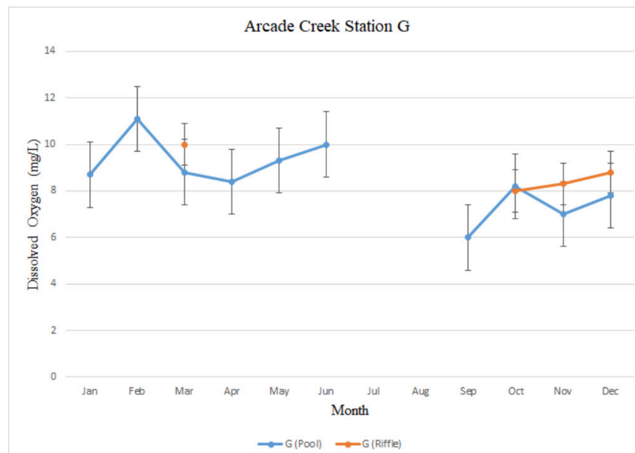


Figure 9. Arcade Creek Station G

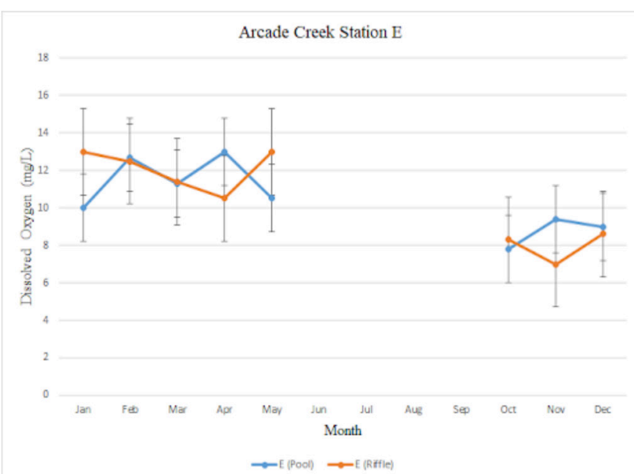


Figure 7. Arcade Creek Station E

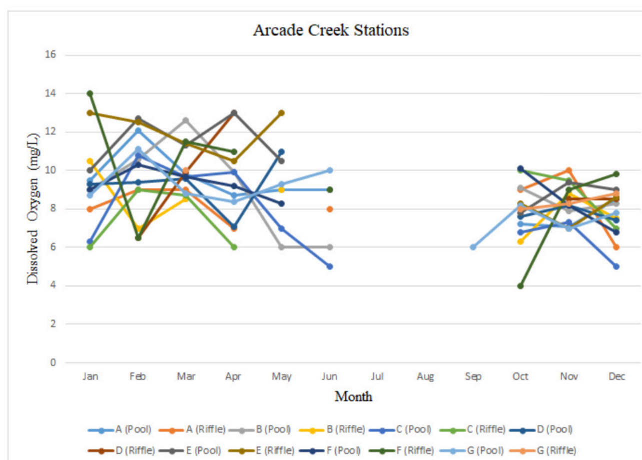


Figure 10. The Arcade Creek Stations

*American River Stations*

The American River graphs illustrate monthly averages taken from 2003-2015 and display the seasonal fluctuations of dissolved oxygen levels as temperatures rise and fall.

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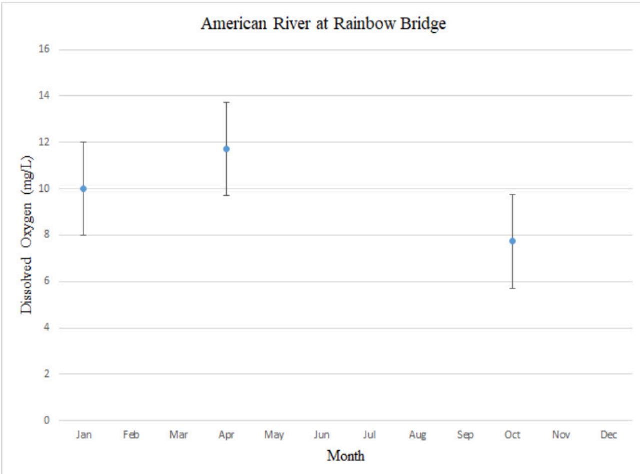


Figure 11. The Rainbow Bridge Station. There was limited data so finding the trend is difficult.

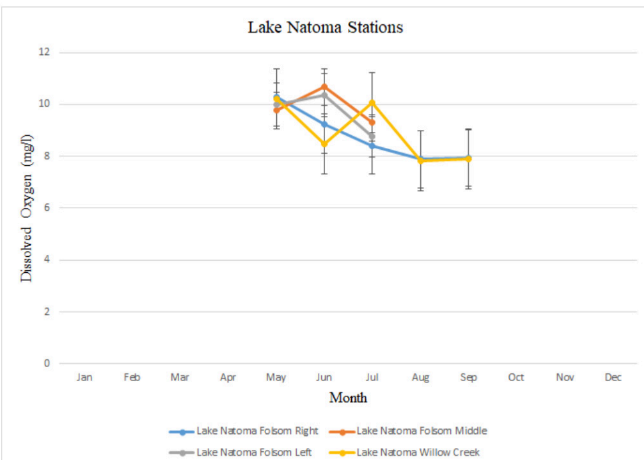


Figure 12. The Lake Natoma Stations

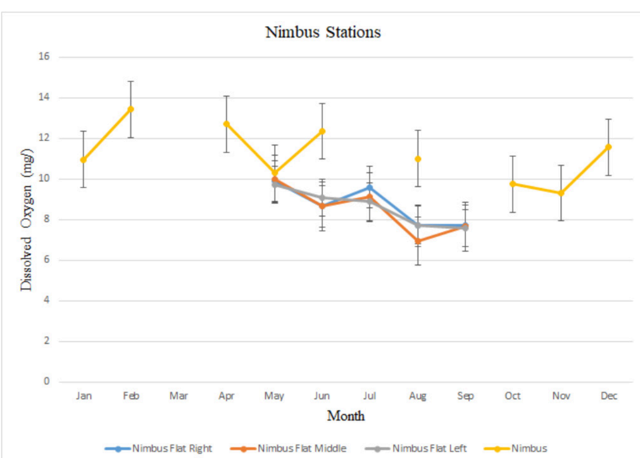


Figure 13. The Nimbus Stations

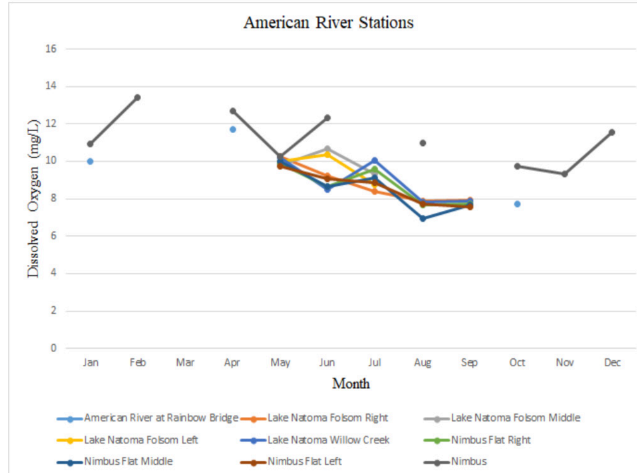


Figure 14: All the American River Stations

The Arcade Creek's dissolved oxygen range is lower than the American River. Despite the different years covered by each data set, the results are consistent for each year when the averages were taken. Therefore, extrapolated data for both bodies of water remains consistent with the trends of the shared years, 2008-2015. Considering this, as well as the American River's previously mentioned healthy status, the Arcade Creek is less healthy because of its lower dissolved oxygen levels. The Arcade Creek is dangerously close to the fatal oxygen level of 5mg/L when looking at the monthly averages and lowest levels shown in Figure 13. Additionally, while the Arcade Creek saw an increase in oxygen levels during the summer, the American River's oxygen levels remained higher during these months, shown in Figures 13 and 14.

These results warrant concern for the inhabitants of the Arcade Creek. The Arcade Creek is relatively small and has a low flow rate. So, while the Arcade Creek shows decreased flow during the warmer months, the implications of run-off and pollution is still concerning due to the creek's proximity to urban development. There is less concern for the American River because has forests and natural vegetation as a barrier from urban development.

The use of multiple stations along the two bodies of water is to both illustrate a diversity in data samples and avoid grouping the large lengths of water into one average dissolved oxygen concentration value. This aggregation would omit possible fluctuations in different parts, possibly due to shade coverage and vegetation or proximity to urban development. Figures 2-10 take into account pools and riffles, as standing water has a lower dissolved oxygen level. Monthly averages were taken to illustrate yearly and seasonal trends.

Concerning the American River, data was taken along stations from the start of Folsom Lake up until the Nimbus Dam to account for fluctuations in dissolved oxygen between standing water and water release that occurs past the Nimbus Dam.

Looking at both graphs summarizing individual station results for both bodies of water (Figures 10 and 14), the data is


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difficult compare due to a decreased overlap in months when data was taken. This because student volunteers were not present during the summer months at Arcade Creek. There is overlap in other months before and after the summer and some overlap in the early and late summer months, which allowed for relatively accurate analysis. Further data collection in the summer months for the Arcade Creek would provide a more accurate representation of the health of each body of water.

The main uncertainty arises from the data taken from the Arcade Creek, as the procedures were less sophisticated compared to the lab procedures for the American River. Additionally, the Arcade Creek data was taken from volunteer high school students as opposed to professionals. This is correlated with the more drastic error bars noticed for the Arcade Creek Stations than with the American River Stations.

Another issue was the time each sample was collected each day. Daily temperature changes can cause fluctuating dissolved oxygen levels. The peak dissolved oxygen level is 4:00 pm. The Arcade Creek data was collected sometime between 3:30 and 4:30 daily. The American River had a higher data collection time range, between 7:00 am to 4:30 pm, and so further experimentation is needed to ensure accuracy. However, despite that the American River data was not always collected at its peak time, it still had higher averages than the Arcade Creek whose data collection was closer to its oxygen peak. This implies the disparities in dissolved oxygen between the bodies of water may be more drastic since the American River is likely to have an increased concentration range when measured at 4:00 pm. Thus, the health of the Arcade Creek can be regarded as even worse since the American River is the healthy standard.

## CONCLUSION

The overall significance of this paper illustrates a need for closer attention to the Arcade Creek, such as possible testing for how large a part urban development and roadside pollution plays in the creek's health, in addition to testing during the summer months to gauge the overall yearly and seasonal health of the water body. Furthermore, lower levels of dissolved oxygen are harmful to organisms in the creek and can lead to possible death, especially since levels are near the dangerous amount of 5mg/L. This, in turn, can have a drastic effect on the overall ecosystem of the Arcade Creek area.

## METHODS

### *Procedures*

There were two methods were used for data collection, one used by students and one used by the Sacramento Water Pollution Control Lab. Both methods are listed and discussed.

### *Arcade Creek Dissolved Oxygen Collection (student handbook)*

The Water Chemistry Analysis Handbook outlines using HACH kits to conduct this research.[12] Data collection was done Monday through Wednesday every month while school was in session from September to May. Collections were made at Stations A through G around 4:00 pm. First, water samples are collected in the largest glass DO bottle. The kits use the Winkler method, so students pour DO reagents #1 (Manganous Sulfate Powder Pillow) and #2 (Alkaline Iodide-Azide Powder Pillow) into the bottle then seal the cap and shake the bottle until orange-brown floc precipitate clearly forms. The students set the bottle on a flat surface and wait approximately two minutes so the floc can settle. Using nail clippers to open the pillow packet containing DO reagent #3 (Sulfamic Acid Powder Pillows), the student pours it into the bottle to form a yellow solution. The solution is poured into the measuring tube and the rectangular mixing bottle is placed over the top of the tube. The students invert the tube and the rectangular mixing bottle so that the solution pours down into the bottle before adding sodium thiosulfate solution dropwise into the bottle. The bottle is swirled between drops and the students count the number of drops until the solution is clear. This value is recorded.

### *American River Dissolved Oxygen Collection*

Collections were made at the Rainbow Bridge, Lake Natoma, and Nimbus Stations. The times these results were taken varied by day depending on when collection was able to be taken. A hand-held portable meter is used for this collection, such as a YSI Pro2030, following Standard Method 2 4500-O G-2001 approved by the Environmental Protection Agency.[13] Methods of sampling are highly dependent on the sampled source and method of analysis. Surface water samples are collected in narrow-mouth glass-stoppered BOD 300-mL bottles, ensuring the sample is not in contact with air or agitated because this causes a change in its gaseous content. Also, avoid entraining or dissolving atmospheric oxygen. In sampling from a line under pressure, attach a glass or rubber tube to the tap and extend to bottom of bottle. Let bottle overflow two or three times its volume and replace stopper so that no air bubbles are entrained. A Kemmerer-type sampler is used for samples collected from depths greater than 2 m. Bleed the sample from bottom of the sampler through a tube extending to bottom of a 300-mL BOD bottle. Fill bottle and allow to overflow for approximately 10 seconds to prevent turbulence and formation of bubbles while filling. Record sample temperature to nearest degree Celsius.

### *Sample Calculations*

Calculating monthly averages:

December monthly average for Nimbus station:

(11.00 + 13.00 + 14.50 + 6.30 + 13.00 + 13.00 + 10.60 + 13.40 + 12.00 + 8.80) / 10

= 11.56

Standard deviation calculated by Excel

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