Natural Resources and Environmental Sciences Capstone Course

April 24, 2018

Marion County Park and Lake Sediment and Water Quality Study

Dr. Vahid Rahmani – Assistant Professor, Department of Biological and Agricultural Engineering
Jacob Allen – Biological Systems Engineering
Alan Ddamulira – Biological Systems Engineering
Cole Maddox – Agricultural Technology Management
Hannah Gerardy – Agronomy

Acknowledgements:

Our team would like to thank everyone that made this project possible. First, we would like to thank Lisa Suderman and the Cottonwood WRAPS program for funding our travel, sampling, and laboratory costs throughout the semester. This project would not have been successful without her support. We would also like to thank Dale Ehlers for assisting our team on sample day. Dale spent the day with us, allowing our team to use his boat to collect samples with. His knowledge of the lake and surrounding area was invaluable to our team's success. Matt Meyerhoff and Ricky Roberts were instrumental to the project as well. They were great points of contact for any questions our team had about the lake, always being willing to offer a helping hand.

Dr. Vahid Rahmani was instrumental in the success of this project. His guidance helped shape every aspect of the project. He encouraged all team members to push their boundaries. Our team would also like to thank Dr. Shawn Hutchinson for allowing us to pursue our interest in natural resources and environmental sciences by facilitating this course.

Dr. Trisha Moore and Kari Bigham allowed our team to utilize the YSI water quality sampler to gather data for our project. Without the equipment they allowed our team to borrow, we would have not been able to collect all the required data. We would also like to thank Dr. Huggins at Kansas University for allowing us to borrow the sediment sampler. This piece of equipment was instrumental to our data collection process.

Lastly, our team would like to thank Dr. Prathap Parameswaran for allowing us to use his lab for water quality analysis. Chlorophyll, TSS, VSS, and FSS samples were analyzed in his laboratory. We would also like to thank the Kansas State University Soils Laboratory for analyzing the sediment and water samples. This data was instrumental in our teams' decision making.

Table of Contents

List of Figures, Equations, and Tables

Marion County Park and Lake Sediment and Water Study

1. Introduction

This report investigates the impact that sediments have on water quality and availability in reservoirs (for simplicity, lake and reservoir will be used interchangeably throughout this review). This report will provide background information on lake function, analyze data, explain sample collection methods, and provide conclusions as to how sediment interacts with the Marion County Park and Lake system.

According to Matt Meyerhoff, Marion County Park and Lake is a 153 acre, naturally ponded reservoir that is owned by Marion County. This lake is comprised within the larger 300-acre Marion County Park. There is a 4,000-acre watershed that feeds this reservoir, which is primarily comprised of pasture and crop production. This watershed is in a very rural setting, but there are approximately 200 houses surrounding the reservoir that will contribute urban runoff. The dam was completed in 1937, making the reservoir 81 years old at the time of this study. The aging reservoir creates a cause for concern for both sedimentation and water quality issues.

2. Background

2.1 Sedimentation Impacts on Reservoirs

Reservoirs are large impoundments that trap water from streams or watersheds. The influent water is generally laden with sediments, affecting water quality and available storage space within the water body. Sediment laden influent deposits a sediment load throughout the reservoir, decreasing the reservoir's ability to provide recreational, municipal, or agricultural ecosystem services. While Marion County Park and Lake is currently only used for recreation, having a large body of freshwater in a drier climate of Kansas is vital to ensuring clean water for municipal and agricultural usage for future generations. This is especially crucial due to an increasing population, which will create a larger demand on water systems throughout the state.

Sediments are nutrient rich, especially in watersheds that have high crop production. Nutrients within the soil are washed into the reservoir, causing an increase in the nutrient load within the water column. This increased nutrient load can lead to eutrophication or other water quality issues throughout the year. Eutrophication is a process when a body of water becomes enriched with nutrients, which in turn causes excessive algal growth (Barnes, 2015). The rapid growth of these organisms' block light and deplete oxygen reserves within an area. These aquatic plants then die and create dead zones, defined as areas below two-ppm oxygen, thus making it uninhabitable for other organisms. Marion County Lake experiences excessive algal growth throughout the summer months,

leading to some restrictions on recreational activities. There have been several confirmed cases of human sickness caused by cyanobacteria, which alarms some patrons to avoid lakes with algae altogether in the summer months. Eutrophication ultimately blocks sunlight and depletes oxygen within the water body, adversely affecting aquatic ecosystems (Alemayehu et al., 2014).

A complete study of the watershed has been done using ArcGIS, showing that approximately 25% of the land use is for crop production, with the rest being comprised mainly of pasture land. Pasture typically has much more ground cover, protecting soil from erosional forces better than crop land. Crop land also has higher nutrient inputs, which can lead to significant nutrient loading within reservoirs. Typically, as precipitation levels increase within a watershed, sedimentation occurs at a greater rate (Moriasi et al., 2014). During seasons of higher than normal precipitation, nutrient loading and total suspended sediments were recorded to have increased by gauge stations. This was especially true for the summer and spring months, likely due to the coincidental timing of crop fertilization upstream in the watershed.

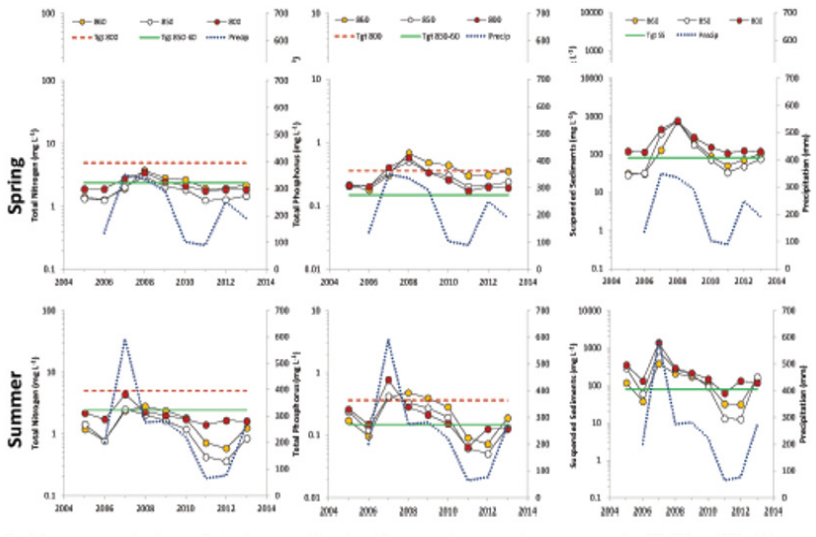


Figure 1: Pollutant loading as a result of precipitation (Moriasi et al., 2014).

A recent study by Rahmani et al. (2018) looked at 24 federally constructed reservoirs in Kansas. The study found that an average of an 18% loss in water holding capacity had occurred when compared to as-built conditions. This is higher than the national average, which the authors contributed to the high amount of agricultural usage within the watersheds. Figure 2 shows the percent capacity loss for all 24 studied reservoirs along with the total storage capacity. This research shows that a loss in water holding capacity is not unique to Marion County Lake, but rather both a state and federal issue.

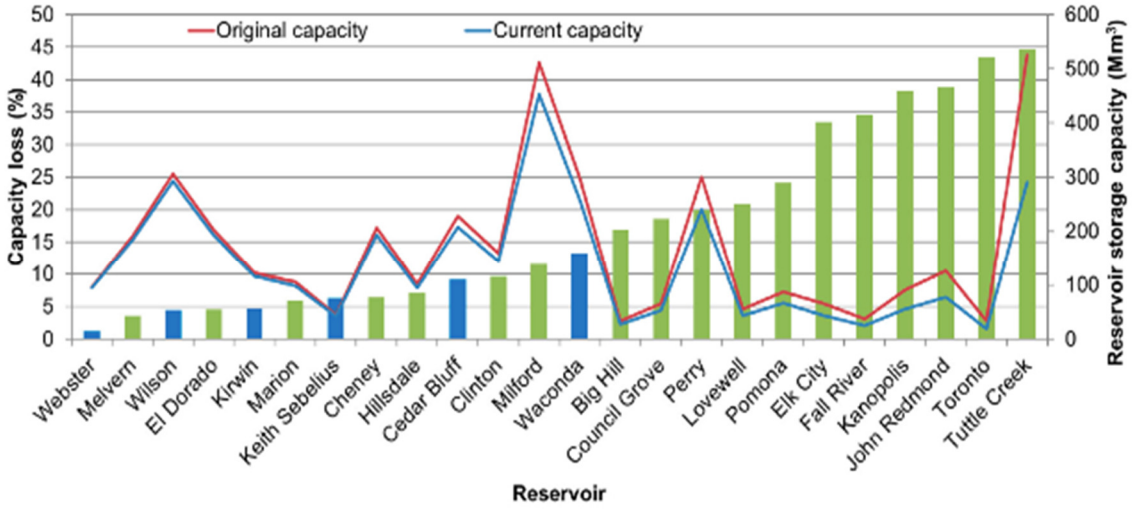
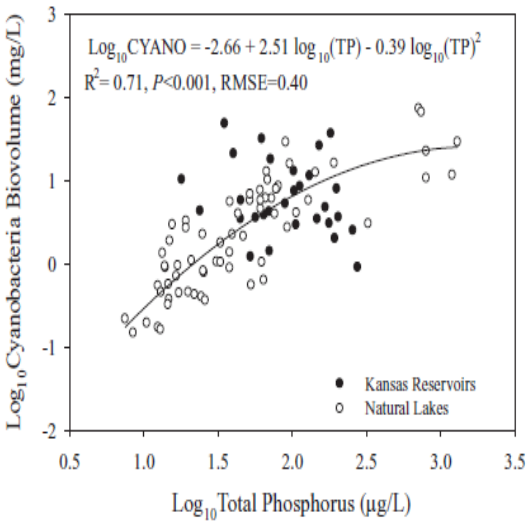


Figure 2: Capacity Changes for 24 Federally Constructed Kansas Reservoirs (Rahmani et al. 2018)

2.1.1 Chemical Impacts of Sediment Upon Water

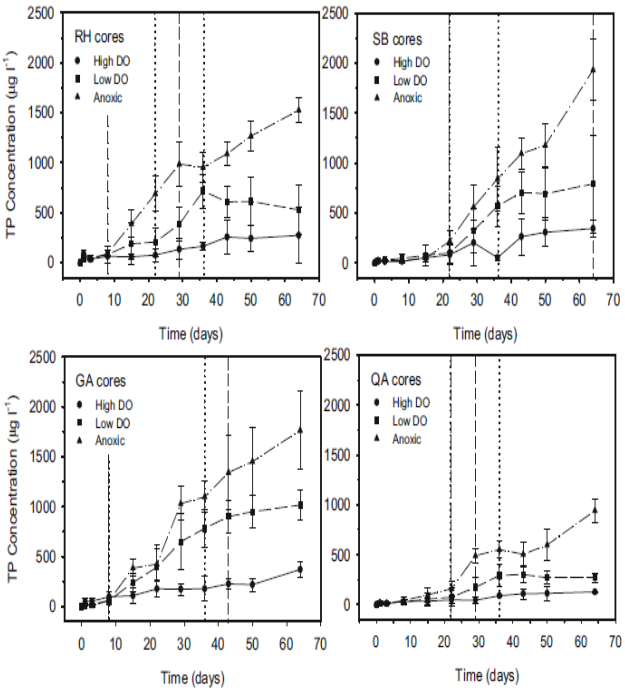
The largest chemical impact that sediment can have upon water is nutrient loading, namely compounds that contain nitrogen or phosphorus. Modeling has been able to predict current and future loading from taking into consideration over 400 watershed parameters (Wang et al., 2005). The water nutrient content is normally measured by the collection of a water column sample that is tied to a corresponding sediment sample taken at the same location (EPA, 2012). These adjacent samples are both analyzed to determine the release of nutrients by sediment directly into the above water profile.

The biggest risk of nutrient-loading is not only the risk for damage to human and wildlife health due to the consumption of contaminated water, but also increased levels of cyanobacterial growth. Increased total phosphorus correlates to a rise in algal bio volume (Dzialowski et al., 2011). Although both Kansas reservoirs and natural lakes experience this effect, reservoirs seem to experience algal growth at a higher rate.



Sediment that washes into a reservoir can immediately contribute to nutrient-loading. However, most sediment is typically retained within the depths of a reservoir due to the trapping effect that was intended by design. Although the sediment is

Figure 3: Cyanobacteria volume as a result of increasing total phosphorus concentration (Dzialowski et al., 2011).



retained, nutrient release into the water column can still occur if certain conditions are met. During lake stratification, dissolved oxygen levels can be disrupted. When the water column reaches an anoxic condition (0.8 ± 0.05 mg l-1), phosphorous release rates increase as well (Doig et al., 2017).

Higher DO levels experienced slower levels of phosphorous release, however, accumulation still occurred within the above water column. Anoxic lake conditions typically occur during the summer season as the water column stratifies (Doig et al., 2017). As climate change begins to influence seasonal weather patterns, the risk for anoxic conditions to occur increases (Doig et al., 2017).

Figure 4: Total phosphorus release as a result of changing dissolved oxygen levels (Doig et al., 2017).

A watershed's trophic level is also a strong indicator of the risk for anoxic conditions. Modeling and sediment of 17 Great Plains reservoirs has shown that heavily eutrophic watersheds experienced not only higher total phosphorus loads, but also experienced higher phosphorus release rates (Carter and Dzialowski et al., 2012). The below data suggests that reservoirs that are experiencing a high level of risk from pollution upstream in the watershed can also aggravate the issue by creating anoxic conditions that further release phosphorus into the water column.

Table 1: Eutrophic reservoirs and their resultant total phosphorus and sediment release rates (Carter and Dzialowski et al., 2012).

Reservoir	State	Area (km^2)	Trophic state	RR (mg P m^{-2} d^{-1})	TP (µg/L)	Chl (µg/L)	SD (m)
Stockton	MO	101.0	Mesotrophic	0.60	14.60	3.73	2.45
Pomme de Terre	MO	31.7	Mesotrophic	6.22	21.30	9.13	1.63
Big Hill	KS	4.8	Mesotrophic	7.73	24.60	15.73	1.20
Melvern	KS	27.9	Mesotrophic	9.81	28.30	8.17	1.05
Banner Creek	KS	2.2	Eutrophic	4.51	44.90	26.86	0.90
Winfield	KS	4.3	Eutrophic	28.29	47.90	4.06	0.70
El Dorado	KS	16.7	Eutrophic	1.09	52.20	1.19	0.50
Olathe	KS	0.7	Eutrophic	9.50	54.90	5.27	0.70
Gardner	KS	0.4	Eutrophic	12.97	63.50	34.23	0.85
Big Creek	IA	3.1	Eutrophic	16.08	69.80	2.51	1.05
Pomona	KS	15.6	Eutrophic	10.97	72.80	21.26	0.50
Easter	IA	0.7	Eutrophic	3.04	83.80	13.99	0.60
Conestoga	NE	0.9	Hypereutrophic	13.48	114.10	64.94	0.45
Cheney	KS	38.8	Hypereutrophic	40.31	140.00	9.74	0.50
Marion	KS	25.2	Hypereutrophic	32.98	145.70	42.16	0.58
Bluestem	NE	1.3	Hypereutrophic	23.92	221.20	2.74	0.20
Wagontrain	NE	1.3	Hypereutrophic	17.29	348.20	9.35	0.50

Heavy metals can also be present within the water column if the sediment's parent material contains high amounts of concerning elements. Selenium has been discovered to pose a risk in the Solomon River Basin and its downstream impoundment, Waconda Lake (May et al., 2007). The soil's

substrata contain high levels of selenium that have been found to affect the Solomon River's water composition. Although sediment trapping can occur within a river, it is unlikely if it is slow and shallow, such as what's seen in the Solomon. Further sampling needed to be conducted at Waconda Lake to determine if its upper-end contained high selenium concentrations and whether this would affect the detrital food chain (May et al., 2007).

2.2 Physical Impacts of Sediment upon Water

Increased water inflow has been shown to increase total suspended solids (Cunha et al., 2014). TSS and turbidity are both factors that influence a lake's physical characteristics for wildlife habitat. River inflows not only bring in suspended sediment, but their kinetic energy can also resuspend previously settled particles (Filstrup and Lind, 2010). The movement of water along differing temperature gradients within a lake was also a major contributor to sediment resuspension, a process known as horizontal advection (Filstrup and Lind, 2010).

Although increased turbidity can potentially allow for increased phosphorous release and increased filtration costs for potable use, benefits can also be achieved. Seven Kansas reservoirs were measured for non-algal turbidity levels (Dzialowski et al., 2011). It was discovered that increased NAT resulted in decreased cyanobacterial growth. The primary cause for the reduced algal growth was the reduction of light that could penetrate the water column (Dzialowski et al., 2011). Suspended sediment particles also adsorbed phosphorous that was present in the water profile, preventing its availability for algal uptake. It was also suggested by Dzialowski that suspended clay particles co-flocculated with cyanobacterial cells and prevented their massing.

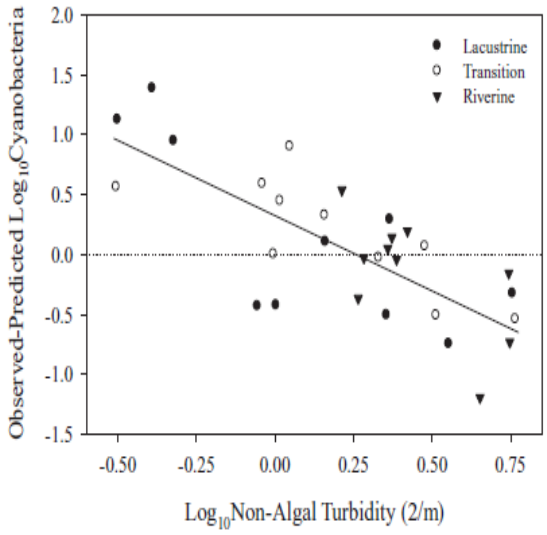


Figure 5: Cyanobacteria volume as a result of increasing non-algal turbidity (Dzialowski et al., 2011).

2.3 Trapping Efficiency

Trapping efficiency is the ratio of sediments flowing in and out of the reservoir. A reservoir with a trapping efficiency of 100% means the reservoir retains all sediments that are imported by the inflow source. For normally ponded reservoirs, it is common to see trapping efficiencies of greater than 95% (Verstraeten and Poesen, 2000)

The trapping efficiency (TE) of a reservoir is outlined below in Equation 1, which shows the equation for calculating TE. There are many factors that affect the TE of a reservoir, which are outlined below in Figure 6. If direct measurements are not available for sediment mass of influent and effluent

water, there are empirical models that can be used to predict the trapping efficiency. These models use relationships between the as-built capacity of the reservoir with the watershed size and influent amount.

$$TE = \frac{S_{inflow} - S_{outflow}}{S_{inflow}} = \frac{S_{settled}}{S_{inflow}}$$

where:

S_{inflow} is the sediment mass entering a reservoir (= the sediment yield or delivery);
$S_{outflow}$ is the sediment mass leaving the reservoir with the outflowing water; and
$S_{settled}$ is the sediment mass deposited within the reservoir.

Equation 1: Trapping Efficiency Equation (Mulu and Dwarakish, 2015)

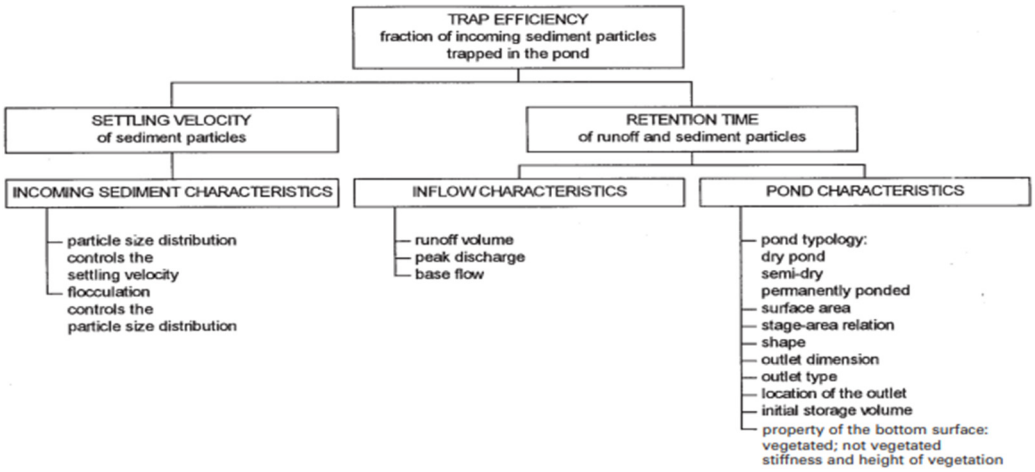


Figure 6: Factors that Affect TE of Reservoirs (Mulu and Dwarakish, 2015)

Trapping efficiency is influenced by many characteristics, such as settling velocity and retention time. Due to the drought conditions that the lake was experiencing during the site visit on 4/10/2018, it was determined that the trapping efficiency of Marion County Park and Lake was 100%. Data will need to be collected from both influent and effluent water once the lake returns to normal levels to determine the trapping efficiency under normal conditions.

2.1.4 Capacity to Inflow Ratio

A capacity to inflow ratio (C/I) is a measure of how many times the water is replaced within the reservoir during a year. This C/I ratio is unitless and used in empirical equations to help determine trapping efficiency. A C/I ratio of less than 1 shows that the whole volume of the reservoir is replaced throughout a years' time, which a C/I ratio of greater than one shows that the volume of the reservoir is held for longer than a year. This C/I ratio is directly correlated to retention time, which plays a huge role on lake sedimentation. The higher the retention time, the greater likelihood that the water has dropped its sediment load. When there is no water flowing out of the lake, which was observed at Marion County Lake on 4/10/2018, the C/I ratio becomes indefinite. An indefinite C/I ratio means that all water flowing

into the reservoir will stay there indefinitely. Figure 7 shows an empirical relationship between the C/I ratio and trapping efficiency, allowing accurate predictions to be made from a C/I ratio.

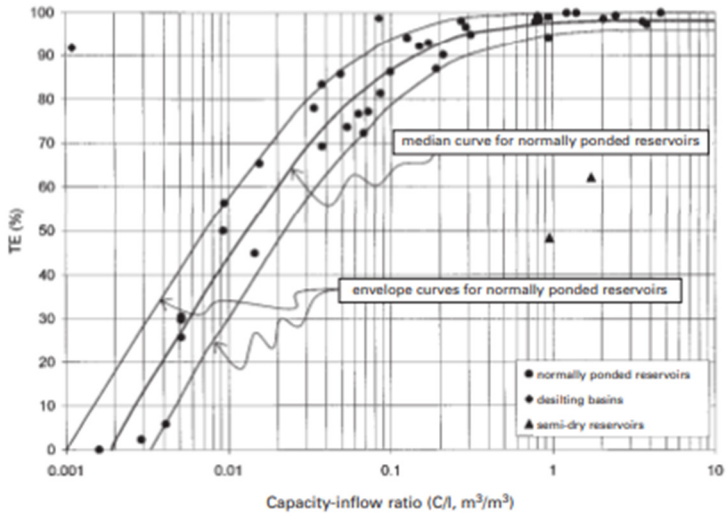


Figure 7: Empirical Relationship Between Trapping Efficiency and C/I Ratio (Verstraeten and Poesen, 2000)

2.4 Normally Ponded Reservoir Overview

One unique feature of Marion County Park and Lake is the outlet structure. Marion County Park and Lake is a normally ponded reservoir, which means the water is released from the surface of the lake. This is very similar to many smaller ponds with a spillway design, while many larger bodies of water release water from the bottom of the reservoir. This is important to note, as during periods of drought when the water level is low, there is no outflow from normally ponded reservoirs. This type of outlet structure also creates a lack in the ability to manage the system properly. Reservoirs with bottom-controlled outlets can put into place management strategies such as sediment flushing to ease the burden of sediments on the reservoir, thus extending the life. Normally ponded reservoirs have longer retention times and higher trapping efficiencies when compared to traditional reservoirs, which cause an increase in sediment retention.

During dry periods when there is no outflow from the outlet structure, the trapping efficiency is 100% and the retention time is indefinite. Marion County was experiencing drought conditions when samples were collected on 4/10/2018, causing the lake water level to be 2.1 ft. below the outlet elevation. These measurements were gathered using a laser and measuring rod. Survey data can be found in Appendix B. This indicates that all water flowing into the reservoir will be held there until the water level raises to the outlet's elevation. This is a common occurrence for other normally ponded reservoirs in the same geographic region, which usually face these conditions during droughts or the summer months when there is little rainfall and high evaporation rates. The differences between outlet structure types can be observed in Figures 8 & 9.

Figure 8: Bottom Controlled Reservoir Outlet Structure (Osage County, 2018)

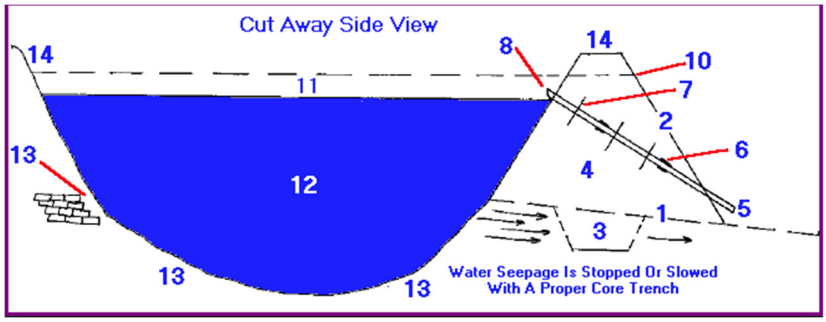


Figure 9: Normally Ponded Reservoir Outlet Structure (Shawnee County Conservation District, 2018)

2.5 Sediment Transportation

Once sediments are deposited within a reservoir system, there is a large amount of movement that can occur with the sediments. These sediments can be re-suspended, being transported closer to the outlet. This happens with time, causing the majority of sediments to be found near the dam. Figure 10 shows the sediment depth after 31 years of service for Lake Luzzone in the Swiss Alps (Cesare et al., 2001). As this graphic depicts, the majority of the sediments have been transported close to the dam. This is caused by turbidity currents that cause resuspension of sediments. Turbidity currents are underwater currents that flow downslope. They can be observed with their impact on sediment transportation in Figure 11 (Eidson et al., 2018).

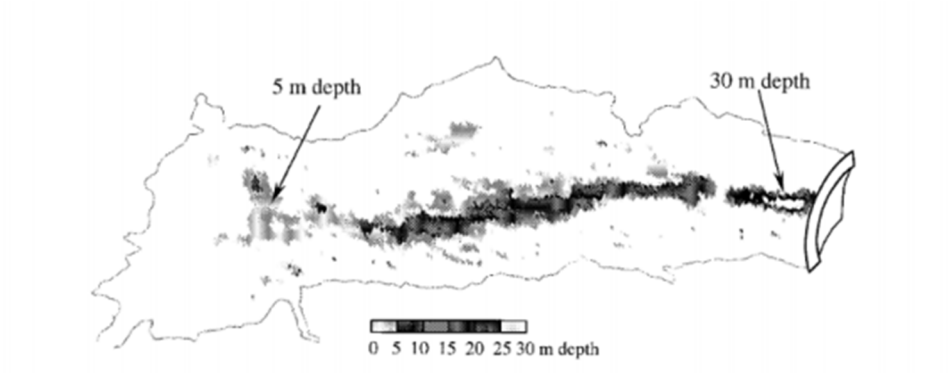


FIG. 15. Qualitative Representation Showing Location and Measured Sediment Deposits Magnitude after 31 Years in Service

Figure 10: Case Study of Lake Luzzone Sediment Depth (Cesare et al., 2001)

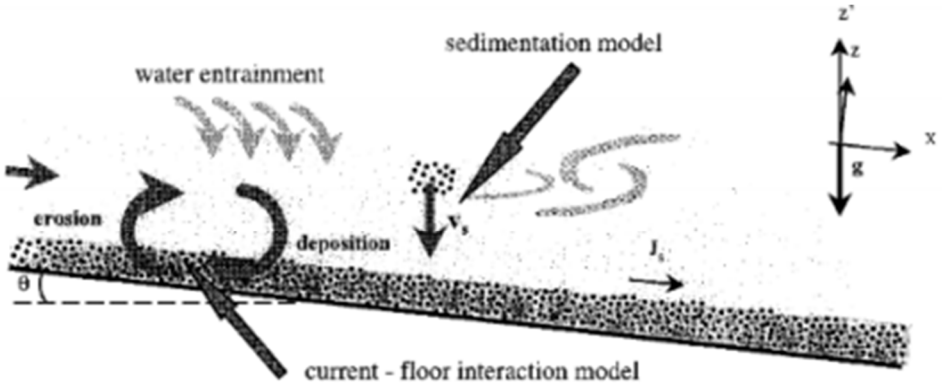


FIG. 3. Model of Turbidity Current with User Defined Current-Floor Interaction and Sedimentation Modules

Figure 11: Turbidity Current Graphic (Cesare et al., 2001)

There are three distinct zones of sedimentation within a reservoir: erosional (riverine), transportation (transition), and accumulation (lacustrine). The coarse-grained sediments are found in areas of high water turbulence, thus the erosional zone. The transportation zone is an area that is generally stable, but when conditions are right undergoes large amounts of turbulence, re-suspending some sediments in water to be transported to the accumulation zone. These three zones can be observed in Figure 12 (Cunha, 2014).

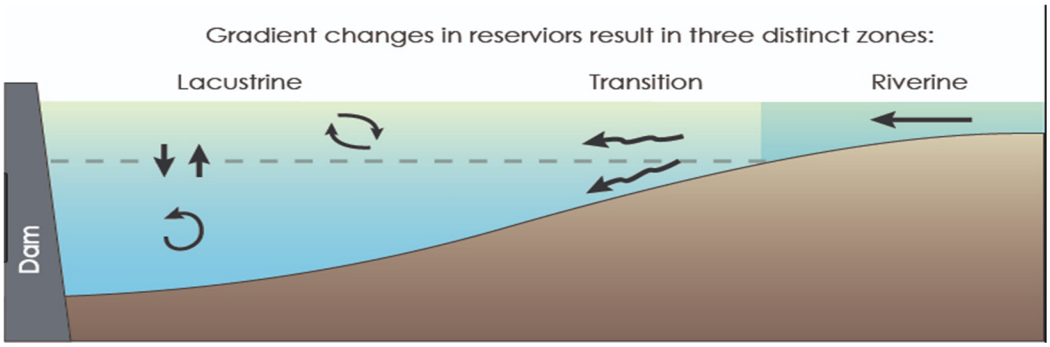


Figure 12: Sedimentation Zones Within a Reservoir (Lubnow, 2015)

The transitional line between erosional and transportation zone is noted by a 50% water content of surface sediments, while the transitional line for transportation and accumulation zones is a 75% water content. These textural differences were verified by using lead as a geochemical tracer. The results identify the transitional periods between erosional to transportation, and transportation to accumulation to be located around 7 and 20 meters of water depth, respectively (Blais and Kalff, 1995). A plateau in the lead concentrations was observed for type one lakes (low slopes), while an increase in depth led to an increased in sediment deposition in type two lakes (high slopes). This aligns with the observation that sediment depth increases with a closer proximity to the dam (Brainard et al., 2012).

This transportation of sediments is also attributed to stratification within the reservoir. During the spring season parts of the reservoir "turnover", causing the re-suspension of large amounts of sediment. This "turnover" is due to the varying densities in the different water columns, caused by temperature differences. During this time, there is a large potential for transportation of sediments within a reservoir system. Stratification can also carry sediments further down gradient before deposition because of the varying water column densities. This does not allow for complete mixing within the water body, changing the way sediments are transported throughout the system (Madsen et al., 2001).

3. Methods and Materials

3.1 Sediment and Water Sampling Procedure

Team members traveled to Marion County Park and Lake on 4/10/2018 and collected 12 composite soil and water samples for laboratory testing. These samples were taken in a cross pattern, compositing 5 samples into one. The sampling locations are observed by the yellow crosses in Figure 13. Water and sediment samples were taken at all locations. A water sample that was utilized for chlorophyll analysis was taken at Site #3, denoted by the red circle. Sites #6 and 11 are the same location, and the duplicate samples were used to ensure laboratory sampling quality.

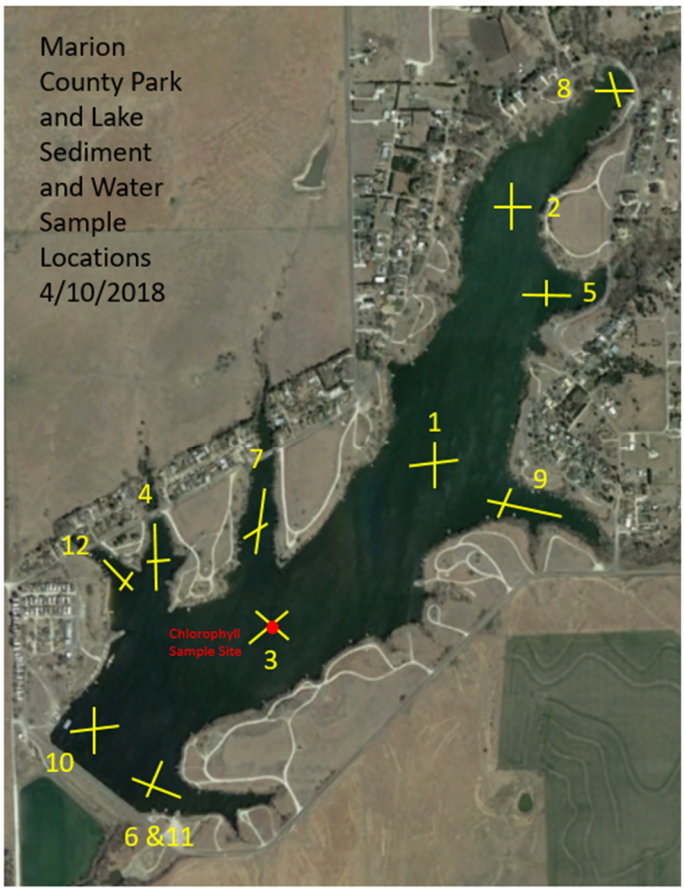


Figure 13: Marion County Sediment and Water Sample Locations

Team members collected sediment samples with a gravimetric sediment sampler. The sediment sampler is a long metal tube that penetrates the surface sediment when released from the boat, bringing back a sediment core when retrieved. A sediment core is not representative of the total sediment depth at the sample location, but rather offers insight into the amount of surface sediments. Figure 14 and 15 show sediment cores taken at Site #9 and 8, respectively, on the day of sampling. The depths of surface sediments throughout the collected areas are denoted in Appendix A. Appendix B provides a detailed list of sampling and laboratory procedures used for Marion County Lake samples.

Figure 14: Marion County Sediment Core-Sample (Site #9)

Figure 15: Marion County Sediment Core-Sample (Site #8)

At the same locations as the sediment cores, a YSI water sampling probe was utilized to gather water quality data. Water samples were collected as well for laboratory examination. The collected samples were taken to the KSU Soils Testing Laboratory and the KSU Civil Engineering Laboratory for further analysis. Tests determined the total suspended solids, volatile suspended solids, fixed suspended solids, chlorophyll, nitrogen, and phosphorus concentrations for all areas throughout the lake. The results of these tests are discussed below. The methods and materials utilized in the laboratory are discussed in depth in Appendix A, while all data collected by the YSI is located in Appendix B.

A boat was utilized to collect all samples, other than Site #8. Team members reached Site #8 via wading, as the water level was too shallow for the boat to reach. Figure 16 shows the depth of the lake, as determined by a boat fish finder. Depths were recorded off the boat using a Garmin Striker 4cv depth finder, while GPS coordinates were collected with a Magellan SporTrax handheld GPS system. Figure 17

below shows all team members collecting samples on Marion County Park and Lake. Appendix C denotes areas of interest throughout the lake.

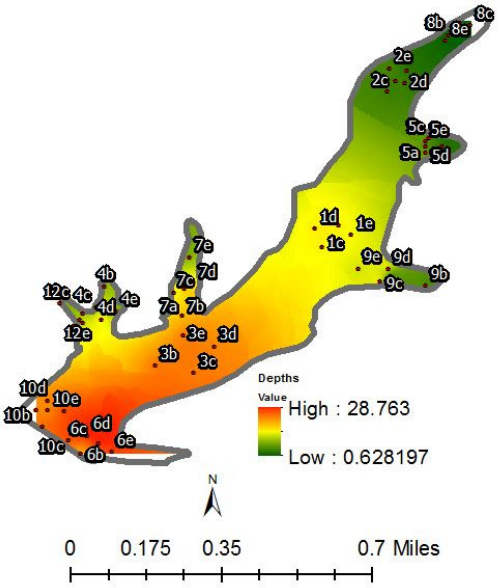


Figure 16: Marion County Lake Depth (ft)

Figure 17: Team Members Collecting Samples on 4/10/2018

4. Results

Team members returned Marion County Park and Lake and stored the samples on ice overnight. Samples were delivered to the lab the next morning. The Kansas State University Soils Testing Laboratory determined total nitrogen and phosphorus for 12 water samples, while testing the sediment for total nitrogen and phosphorus, texture, and organic matter. Water samples were taken to Dr. Parameswaran's laboratory in the Kansas State University Civil Engineering department to test for total suspended solids (TSS), volatile suspended solids (VSS), fixed suspended solids (FSS), and fluorescence. During the sampling collection, a survey of the outlet elevation relative to the water height as well as a wildlife survey was collected as well. The results of these tests and their implications to the lake function are discussed in detail below.

4.1 Water Quality Results

All 12 composite samples were analyzed for total nitrogen and phosphorus, an excellent gauge of water quality throughout lakes. Nitrogen and phosphorus concentrations within a lake can offer insight into areas within the watershed that high concentrations of nutrients are entering with influent water. These nutrients can come from natural sources, agricultural production areas, or urban runoff. The timing of our tests is conducive with farmers and landowners applying fertilizer to fields and lawns, some of which can runoff into the lake. On the day of sampling, team members noted 9 landowners applying fertilizer to their lawns, all of which slope directly to the lake. Team members also noted cattle grazing on pastures within the watershed, which can lead to nutrients in the runoff from this land. Figure 18 shows the Marion County Park and Lake watersheds land usage, while Table 2 quantifies the land usage.

Table 2: Land Usage in Marion County Watershed

Land Classification	% Area	Area (acres)
Open Water	2.96%	117.87
Developed Open Space	6.00%	238.93
Developed Low Intensity	2.18%	86.81
Developed Medium Intensity	0.38%	15.13
Deciduous Forest	1.08%	43.01
Mixed Forests	0.11%	4.38
Herbaceous	60.38%	2404.45
Hay/Pasture	0.49%	19.51
Cultivated Crops	25.97%	1034.18
Woody Wetlands	0.20%	7.96
Emergent Herbaceous Wetlands	0.25%	9.96
	Total Watershed Area (Acres)	3982.20

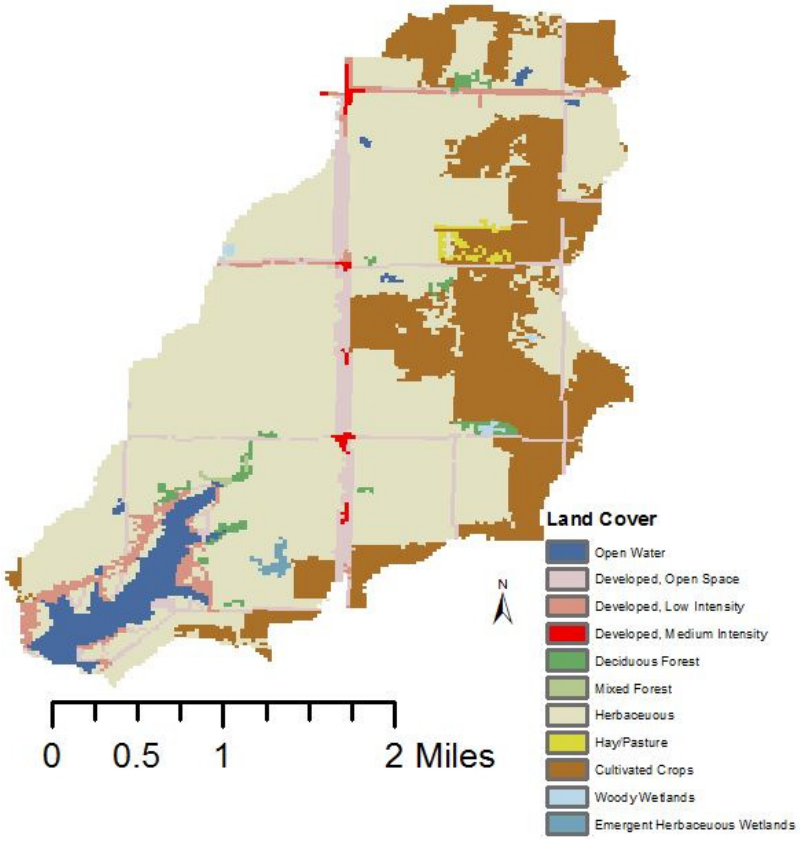


Figure 18: Marion County Land Usage in Watershed

Crop production has a more nutrient dense runoff than pastures, as the nutrient inputs by the farmers are less intense (Moriasi et al., 2014). Erosion potential is also generally higher in traditionally farmed crop land than pasture land, which leads to a sedimentation concern for Marion County Park and Lake.

High nitrogen and phosphorus concentrations in water lead directly to the eutrophication potential within the lake. Nitrogen and phosphorus data for all sample sites is in Table 3, below. Two standout areas from the laboratory data are Sites #7 and 8. Sites #7 and 8 have nitrogen concentrations over 1 ppm, which is indicative of high nutrients entering the lake from these two locations. Phosphorus concentrations were relatively consistent throughout the lake, except for Site #8. Site #8 had a phosphorus concentration of 0.17 ppm, which is over 5 times higher than any other sample in the lake. By combining this data with the sediment depth data, it is obvious that most of the nutrients and sediments are entering the lake through the influent flow near Site #8. These assumptions are also observed in figures 19 and 20 below.

Table 3: Marion County Water Sample Total N and Total P Results

Sample Site	Total N (ppm)	Total P (ppm)
1	0.69	0.03
2	0.73	0.02
3	0.69	0.01
4	0.67	0.02
5	0.81	0.02
6	0.73	0.01
7	1.03	0.02
8	1.54	0.17
9	0.81	0.03
10	0.76	0.01
11	0.98	0.01
12	0.73	0.01

Total suspended (TSS), volatile (VSS), and fixed solids (FSS) are indicative of the sediment transport process that is taking place throughout the lake, as well as the type of sediments that are entering the lake. The total suspended solids concentration is the total amount of sediments that are suspended within the water. A high level of TSS within water can decrease dissolved oxygen (DO) within the water and increase water temperature. Both of these side effects can directly lead to an increased eutrophication potential within the water body. Volatile suspended solids are indicative of the amount of new sediments entering the lake. These sediments can increase nutrient levels throughout the lake during their breakdown process. Table 4 below shows the TSS, VSS, and FSS levels for all 12 sample points throughout the lake. Sample #5 does not have any data for TSS, VSS, and FSS due to laboratory error. The test could not be conducted again due to insufficient amount of sample. For all samples other

than Sample #8, 500 mL of sample was filtered through filter paper. Only 100 mL of water was filtered for Sample #8 due to the large amounts of sediments within the sample.

Table 4: Marion County TSS, VSS, FSS Water Sample Results

Sample Name	Volume (mL)	W1 (g)	W2 (g)	W3 (g)	TSS (mg/L)	VSS (mg/L)	FSS (mg/L)
1	500	1.3595	1.3649	1.3628	10.8	4.2	6.6
2	500	1.3742	1.3832	1.3808	18	4.8	13.2
3	500	1.362	1.3667	1.3646	9.4	4.2	5.2
4	500	1.388	1.3924	1.3905	8.8	3.8	5
5	500	1.389	1.3957	1.3994	13.4	-7.4	20.8
6	500	1.3631	1.3679	1.366	9.6	3.8	5.8
7	500	1.3595	1.3639	1.3621	8.8	3.6	5.2
8	100	1.3766	1.3921	1.3907	155	14	141
9	500	1.3716	1.3769	1.3752	10.6	3.4	7.2
10	500	1.3502	1.3544	1.3528	8.4	3.2	5.2
11	500	1.3602	1.3642	1.3625	8	3.4	4.6
12	500	1.3559	1.3602	1.3583	8.6	3.8	4.8

Sample #8 was once again a standout, having a significantly higher TSS, VSS, and FSS than all other samples. Sample #2 was also significantly higher than the other sample sites. Our team believes that these two sites have higher solids concentrations within the water due to their depth and proximity to an influent water source. On the sample day, the winds were gusting up to 21 mph, which could be one reason for the solids concentration being so high at these two sites. The wind was blowing out of the south, which was causing very large waves at these two sample sites, which likely lead to re-suspension of sediments in this shallow area of the lake. Figure 21 show the TSS concentrations throughout the lake.

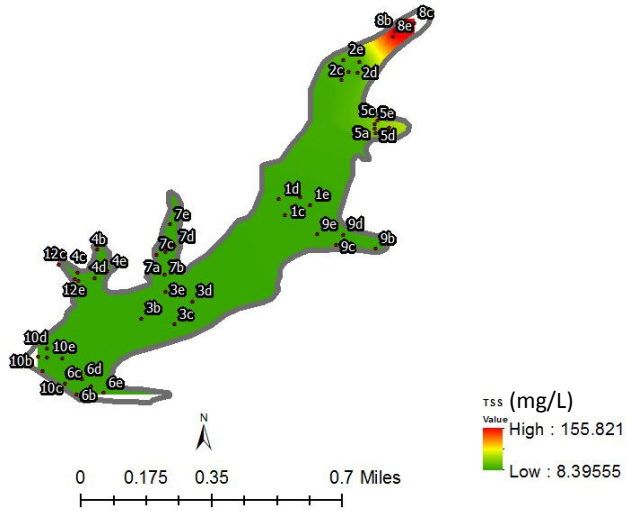


Figure 21: Marion County TSS Distribution

These sample sites are also located in the erosional section of the lake, which is where a large amount of sediments are re-suspended. Figures 22 and 23 below show the suction pump used to filter sediments through the filter paper, and all the dishes with filter paper after filtering, respectively. In Figure 21, one sample is noticeably darker than the rest, Sample #8. This gives a representation of how much more sediment was in Sample #8 compared to the other samples.

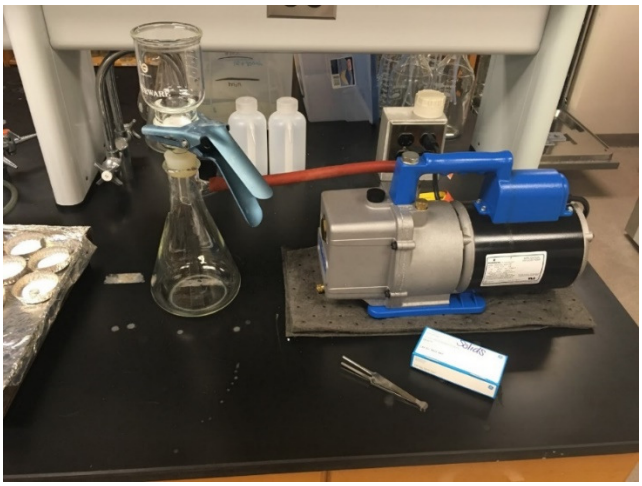


Figure 22: Suction Pump Used for Solids Filtration

Figure 23: Filter Papers after Drying

While low dissolved oxygen concentrations were noted from the YSI sampler readings, it is believed that the sampler was not reading DO correctly. A DO concentration of <2 ppm is indicative of hypoxia. Hypoxia occurs when there is not enough oxygen within the water body to support aquatic life. Through discussions with the park manager, and observations of sportsmen catching fish, it is obvious that the lake is not in a hypoxic condition. Due to these observations, it was decided to disregard the DO measurements from the YSI water quality sampler.

The conductivity, salinity, and TDS of water within the lake is very consistent, other than Site #8. Site #8 has a significantly higher level of conductivity, salinity, and TDS than the other samples, which shows that the lake is a well-mixed system, other than Site #8. Conductivity and salinity are directly related, with the salinity being calculated directly from conductivity. Total dissolved solids are a measurement of all ions smaller than 2 microns, which include the electrolytes that contribute to the conductivity of water. All three measurements are directly related to the measurement of these electrons, which is why they all show the same distribution throughout the lake. Salinity affects the dissolved oxygen solubility of water, which can be detrimental to aquatic ecosystems. Water can gain higher levels of conductivity from clay soils. This directly correlates with the sample point data, as Site #8 had the largest amount of sediment. This high sediment directly increased the conductivity, salinity, and TDS at Site #8 in Marion County Park and Lake. The conductivity, salinity, and TDS measurements throughout all sample points in the lake can be observed in Figures 24, 25, and 26, respectively.

High water temperature is needed for eutrophication to begin. Different areas of the lake will begin to grow algae earlier than others due to the temperature. Due to water movement throughout the lake and the varying lake depth, water temperature has a high degree of variability depending on location. Figure 27 shows that Sites #2, 8, and 9 were the two warmest areas of the lake. More data will need to be collected throughout the year to determine how water temperature varies by location, which could offer insight into why algal blooms start in various areas of the lake.

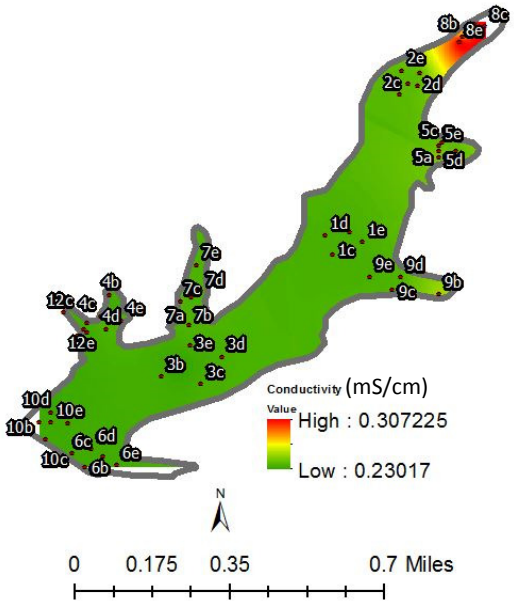


Figure 24: Marion County Conductivity Distribution

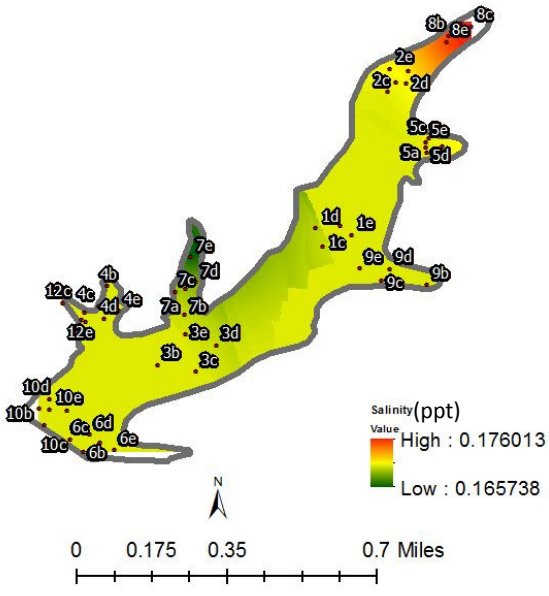


Figure 25: Marion County Salinity Distribution

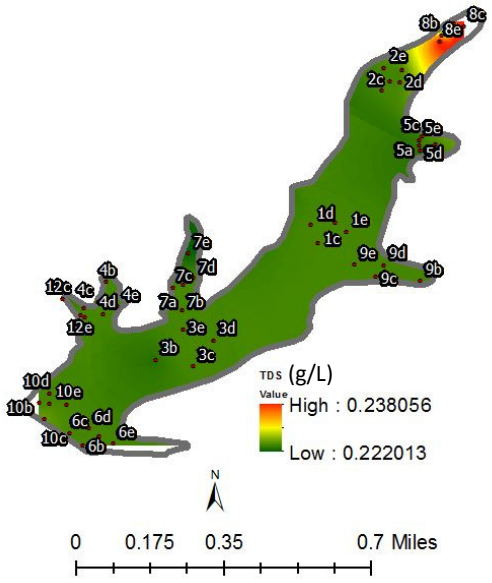


Figure 26: Marion County TDS Distribution

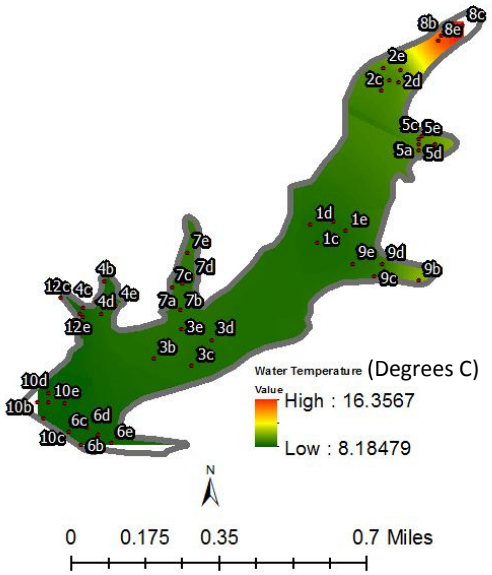


Figure 27: Marion County Water Temperature Distribution

Two samples of lake water were taken from Site #3a was analyzed through a fluorometer. The fluorometer produced an excitation emission matrices (EEM) of the sample water, offering insight into the composition of the sample. Varying particles fluoresce at different wavelengths, allowing the fluorometer to determine what is in the samples. The particles are plotted on an excitation wavelength vs. emission wavelength plot to allow for visual interpretation of water quality. Figures 28 and 29 show these plots for both samples taken from Site #3a. A Mat Lab code can be written to compare the results to indices to pin-point what exactly is in the water. Due to errors in analyzing the data, the chlorophyll samples have not yet been compared to indices to determine what is in the samples. The protocol for analyzing data is outlined in Appendix B. Raw data can be obtained from team members upon request.

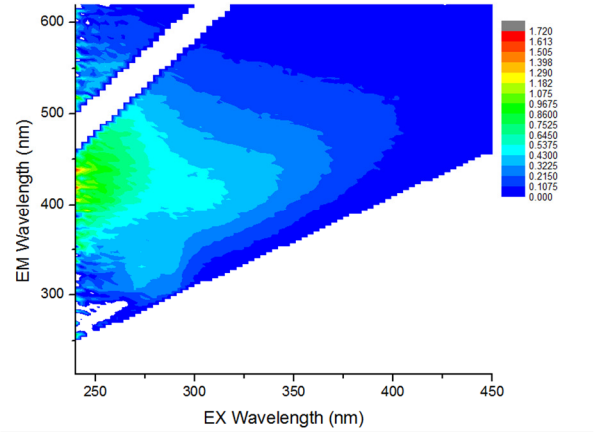


Figure 28: Marion County Sample 1 EEM Plot

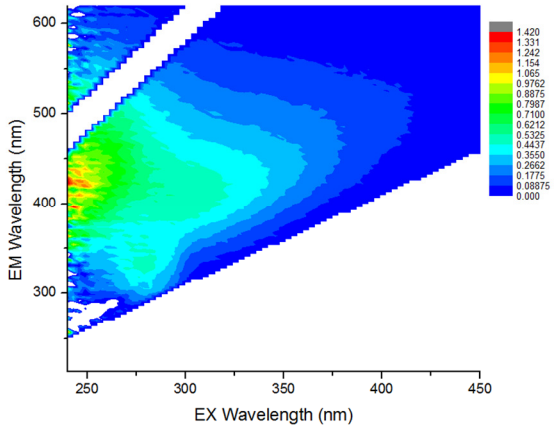


Figure 29: Marion County Sample 2 EEM Plot

4.2 Sediment Results

Sediment sample results have not returned from the lab at the time of writing. Once data is returned from the lab, it will be available from Dr. Vahid Rahmani. This data will be useful for future studies, offering a baseline for comparison.

The depths of surface sediments are shown in figure 30. The three distinct zones of sediment movement throughout a body of water can be observed in this image. The northernmost part of the lake has a very high rate of deposition, characteristic of the riverine section of a lake. The middle section of the reservoir has minimal sediment deposition, characteristic of the transportation zone of a lake. The southernmost portion of the lake, near the dam, has a large amount of sediment as well, characteristic of the lacustrine zone of a lake. These sediment movement characteristics are also compounded by Site #7 being an area of high rock, minimizing the sediment influent on that side of the lake.

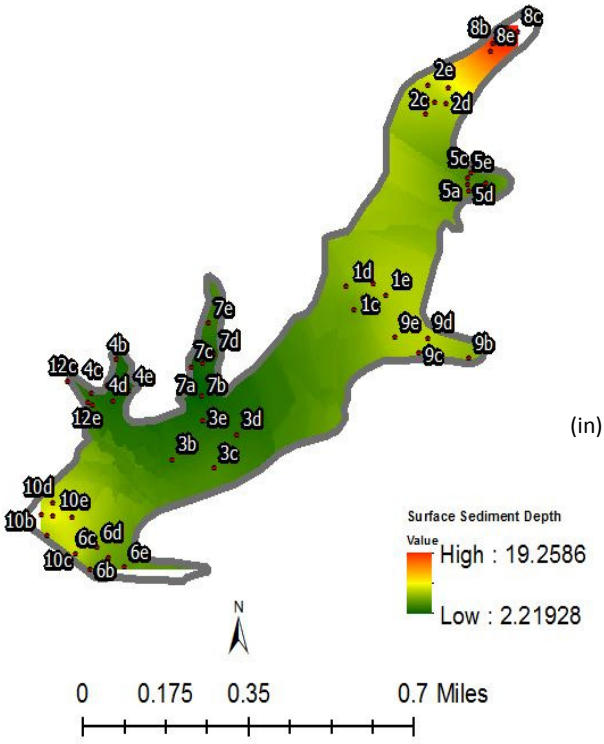


Figure 30: Marion County Surface Sediment Depth Distribution

4.3 Outlet Elevation Survey

An elevation survey was conducted to determine how far the water surface elevation was from the outlet. The water surface was lower than the outlet due to the drought that the area was experiencing during the sampling date. A basis point was determined on the dam, allowing for the survey to be conducted at a later date using the same reference point. A stadia rod with a laser sensor was utilized to determine the elevations at the spillway and water surface. This survey determined that the water level was 2 feet, 1 inch lower than the lake outlet. To determine the depths of all sample points at the outlet elevation, 2 feet and 1 inch needs to be added to the water depths denoted in Appendix A.

4.4 Wildlife Survey

Reservoirs are hosts to a great amount of biodiversity, housing many species of fish, birds, and other mammals. This wide range of species is appreciated by the patrons of the lake through hobbies such as fishing or bird watching.

On the evening of 4/10/2018, a vehicular survey of all wildlife around the lake was surveyed, beginning at 5:30 p.m. Team members observed all areas around the lake, denoting wildlife activity, which is outlined in Table 5 below. The locations of observed wildlife can be seen in Figure 31.

Table 5: Wildlife Summary data collected on 4/10/2018

4/10/2018 Marion County Park and Lake Wildlife Summary			
Location	Quantity	Species	Scientific Name
1	5	woodcock	Scolopax
	18	green wing teal	Anas carolinensis
	1	eurasian dove	Streptopelia decaocto
	12	canadian geese	Branta canadensis
2	8	green wing teal	Anas carolinensis
	2	robin	Turdus migratorius
	1	bluebird	Sialia
	2	Red squirrel	Tamiasciurus hudsonicus
3	2	bald eagle	Haliaeetus leucocephalus
4	100	shovelers	Anas clypeata
	50	coots	Fulica
	2	canadian geese	Branta canadensis
	2	mallards	Anas platyrhynchos
5	50	shovelers	Anal clypeata
	50	coots	Fulica
	1	robin	Turdus migratorius
	1	gull	Laridae
	2	mallards	Anal platyrhynchos
6	2	canadian geese	Branta canadensis
	2	gull	Laridae
7	150	coots	Fulica
	2	greebe	Popicipedidae
	1	robin	Turdus migratorius
8	25	starlings	Sturnidae
	4	shovelers	Anas clypeata
	25	bufflehead	Bucephala albeola
	1	crow	Corvus brachyrhynchos
	4	robin	Turdus migratorius
	25	canadian geese	Branta canadensis
	4	domestic geese (chinese geese)	Anser cygnoides domesticus

Figure 31: Map of Wildlife Summary Locations – *Marion County*

Figure 32: Midge Larvae- Marion County Site #3d

It is also important to note that midge larvae were observed in sediment sample cores at Sites #2b, 3d, 5e, 7e, and 9b. Midge larvae are an important part of the diet of select fish, such as trout. Finding midge larvae in core samples throughout the lake suggest their presence throughout the entirety of the lake bottom. An image of one of the collected midge larvae is attached above, in Figure 32.

5. Conclusion/Recommendations

Upon careful consideration of the data, we recommend that further sampling be conducted at the northern end of the lake. Significant nutrient loading was present within the influent cove at Sites #2 and 8. We recommend that a further ten composite samples be obtained throughout multiple time frames from the northern cove to build a higher resolution of nutrient deposition and patterning.

Further testing also needs to be performed during different seasons to build a chronological pattern of nutrient loading. Subsequent sampling should be conducted later in the summer months or early fall to determine what effect the rainy season and algal blooming had upon the lake's characteristics. Our sampling date was at the very beginning of the growing season, at a time that is just beginning to have

high nutrient inputs into the watershed. By testing the water and sediment at various time periods throughout the year, a wider view of how Marion County Park and Lake interacts with its surrounding watershed can be further understood. This will also offer insight into critical areas that are contributing to the eutrophication problem within the lake. The lake is experiencing drought conditions, with the water surface level being 2.1 feet lower than the outlet elevation. This concentrates pollutants in the water, which can lead to higher nutrient readings throughout the lake. Subsequent sampling will also need to observe the lake during a normal operational elevation to determine what effects droughts play on lake function.

The disparity in our data shows that there is margin in error occurring within the results, either caused by sampling methodology or the lab's testing protocol. The discrepancy between nitrogen and phosphorus levels for Samples #6 and 11 is indicative of a laboratory error occurring due to both of these samples being collected at the same sight. The chlorophyll samples were also different in composition, yet both these samples were collected at the same location. Sample #5 also encountered error in the laboratory when testing for TSS, VSS, and FSS.

One area that the patrons of Marion County Park and Lake had expressed concern over was the large amounts of geese that wintered near Sites #10 and 12. The geese loaf on the beach at Site #12, and enjoy the open water that is present around the heated dock at Site #10. The patrons had thought that the amount of high nutrient feces deposited by these geese could contribute nutrients to the lake. Both nitrogen and phosphorus levels taken at both of these sites are at or below average. This is not an indication that the geese are not contributing high amounts of nutrients into the water, but rather noting that these nutrients may have been dispersed throughout the lake. The two areas that the geese sit throughout the winter are not nutrient "hot-spots."

Our team believes that this project was successful, offering insight into the areas of concern within Marion County Park and Lake. By further sampling a wider understanding of how the lake functions at different times throughout the year can be gathered, offering insight into many lake functions.

6. References:

Alemayehu, D., J. McAlister and W. Fox. 2014. Sediment core sampling and analysis of Kaw Lake. *American Journal of Environmental Sciences.* 10(5): 458-468.

Alemayehu, D., R. Srinivasan and P. Daggupati. 2014. Application of soil and water assessment tool model to estimate sediment yield in Kaw Lake. *American Journal of Environmental Sciences.* 10(6): 530-545.

Barnes, P. 2015. Best management practices to reduce phosphorus entering Marion Reservoir, Kansas. *American Society of Agricultural and Biological Engineers Annual International Meeting 2015.* 5007-5019.

Blais, J. M., J. Kalff. 1995. The influence of lake morphometry on sediment focusing. *Limnology and Oceanography.* 40(3): 582-588.

Brainard, A. S. and G. W. Fairchild. 2012. Sediment characteristics and accumulation rates in constructed ponds. *Journal of Soil and Water Conservation* 67(5): 425-432.

Carter, L. D., A. R. Dzialowski. 2012. Predicting sediment phosphorous release rates using land use and water-quality data. *Freshwater Science*. 31(4): 1214-1222.

Cesare, G. D., A. Schleiss and F. Hermann. 2001. Impact of Turbidity Currents on Reservoir Sedimentation. *Journal of Hydraulic Engineering* 127(1): 6-16.

Cunha, D. G. F., M. do Carmo Calijuri, and W.K. Dodds. 2014. Trends in nutrient and sediment retention in Great Plains reservoirs (USA). *Environmental Monitoring and Assessment.* 186: 1143–1155.

Cunha, D.G.F.. 2014. Trends in nutrient and sediment retention in Great Plains reservoirs (USA). *Environmental monitoring and assessment* 186(2): 1143-1155.

District, Shawnee Count Conservation. 2018. Basic Elements of a Pond Dam. *Shawnee County Conservation District.*

Doig, L.E., R. L. North, J. J. Hudson, C. Hewlett, K. E. Lindenschmidt, K. Liber. 2017. Phosphorous release from sediments in a river-valley reservoir in the northern Great Plains of North America. *Hydrobiologia*. 787: 323-339.

Dzialowski, A.R., V. H. Smith, S. H. Wang, M. C. Martin, and F. deNoyelles Jr. 2011. Effects of non-algal turbidity on cyanobacterial biomass in seven turbid Kansas reservoirs. *Lake and Reservoir Management*. 27(1): 6-14.

Eidson, D., C. M. Davis, S. Gibson and C. Bahner. Understanding reservoir redimentation along the Rio Grande: A case study from Cochiti Dam. *World Environmental and Water Resources Congress 2014.* 2347-2357.

EPA. 2012. 2012 National lakes assessment: Field operations manual. EPA Reference No. 841-B-11-003. Washington, DC: United States Environmental Protection Agency.

Filstrup, C. T., O. T. Lind. 2010. Sediment transport mechanisms spatiotemporal resuspension patterns in a shallow, polymictic reservoir. *Lake and Reservoir Management.* 26: 85-94.

Lubnow, F. 2015. Natural vs. Artificial Lakes. Available at: www.princetonhydro.com/blog/natural-vs-artificial-lakes. Accessed 15 April 2018.

Madsen, J., P. Chambers, W. James, E. Koch and D. Westlake. 2001. The interaction between water movement, sediment dynamics and submersed macrophytes. *Hydrobiologia* 444(1): 71-84.

May, T.W., J. F. Fairchild, J. D. Petty, M. J. Walther, J. Lucero, M. Delvaux, J. Manring, and M. Armbruster. 2007. An evaluation of selenium concentrations in water, sediment, invertebrates, and fish from the Solomon River Basin. *Environmental Monitoring and Assessment.* 137: 213-232.

Moriasi, D. N., J. A. Guzman, J. L. Steiner, P. J. Starks, and J. D. Garbrecht. 2014. Seasonal sediment and nutrient transport patterns. *Journal of Environmental Quality.* 43: 1334-1344.

Mulu, A. and G. S. Dwarakish. 2015. Different Approach for Using Trap Efficiency for Estimation of Reservoir Sedimentation. An Overview. *Aquatic Procedia* 4847-852.

Osage County. 2018. Melvern Lake: One of the best reasons Osage County is the Water Sports Capital of Kansas. Available at: www.osagecountyonline.com/melvern-lake-one-of-the-best-reasons-osage-county-is-the-water-sports-capital-of-kansas. Accessed 15 April 2018.

Rahmani, V. et al. "Examining storage capacity loss and sedimentation rate of large reservoirs in the central US Great Plains." Water 10.2 (2018): 190.

Verstraeten, G. and J. Poesen. 2000. Estimating trap efficiency of small reservoirs and ponds: methods and implications for the assessment of sediment yield. *Progress in Physical Geography* 24(2): 219-251.

Wang, S.H., D. G. Huggins, L. Frees, C. G. Volkman, N. C. Lim, D. S. Baker, V. Smith, and F. Denoyelles J.R. 2005. An integrated modeling approach to total watershed management: water quality and watershed assessment of Cheney Resevoir, Kansas, USA. *Water, Air, and Soil Pollution.* 164: 1-19.

7. Appendix A: Data Collection Spreadsheets

Sample Locations					
Sample Identification #	1a	1b	1c	1d	1e
Lat - degrees	38	38	38	38	38
min	19	19	19	19	19
sec	2.66	2.57	2.51	2.85	2.86
decimal	38.31740556	38.31738056	38.31736389	38.31745833	38.31746111
Corrected Lat (from reference point)	38.31828656	38.31826156	38.31824489	38.31833933	38.31834211
Lat - degrees	96	96	96	96	96
min	59	59	58	59	58
sec	0.07	0.13	9.87	0.17	9.85
decimal	-96.98335278	-96.98336944	-96.96940833	-96.98338056	-96.96940278
Corrected Long (from reference point)	-96.99022278	-96.99023944	-96.97627833	-96.99025056	-96.97627278
Water Samples					
Sample Identification #	1a	1b	1c	1d	1e
Depth (feet)	15.5	15.8	15.2	15.3	14.5
Surface Conditions (ripples, choppy, etc)	Choppy	Choppy	Choppy	Choppy	Choppy
Time	14:10	14:16	14:19	14:22	14:24
@ 0.25 m below surface					
Water Temperature (degrees C)	8.5	8.41	8.43	8.48	8.47
pH	7.89	9.35	7.6	7.3	7
DO (mg/L)	0.01	0.01	0.01	0.01	0.01
Conductivity (mS/cm)	0.236	0.236	0.236	0.236	0.236
TDS (g/L)	0.224	0.224	0.224	0.224	0.224
Sal	0.17	0.17	0.17	0.17	0.17
Taken by Boat or Wading	B	B	B	B	B

Comments	no	no	no	no	no
Sediment Samples					
Sample Identification #	1a	1b	1c	1d	1e
Depth of Core (inches)	10.75	4.25	3.5	7	8.5
Tube Diameter of Corer (cm)	4.7625	4.7625	4.7625	4.7625	4.7625
Sediment Stratification Present, if so Measure & Take Picture	no	no	no	no	picture
Taken by Boat or Wading	B	B	B	B	B
Comments	Clay-like texture	no	no	no	no

Sample Locations					
Sample Identification #	2a	2b	2c	2c	2e
Lat - degrees	38	38	38	38	38
min	19	19	19	19	19
sec	6.02	6.16	6.09	5.88	5.86
decimal	38.31833889	38.31837778	38.31835833	38.3183	38.31829444
Corrected Lat (from reference point)	38.31921989	38.31925878	38.31923933	38.319181	38.31917544
Lat - degrees	96	96	96	96	96
min	58	58	58	58	58
sec	8.59	8.43	8.76	8.38	8.72
decimal	-96.96905278	-96.96900833	-96.9691	-96.96899444	-96.96908889
Corrected Long (from reference point)	-96.97592278	-96.97587833	-96.97597	-96.97586444	-96.97595889
Water Samples					
Sample Identification #	2a	2b	2c	2c	2e

Depth (feet)	3.9	2.6	3.7	3.7	4.4
Surface Conditions (ripples, choppy, etc)	Choppy	Choppy	Choppy	Choppy	Choppy
Time	15:18	15:16	15:20	15:23	15:26
@ 0.25 m below surface					
Water Temperature (degrees C)	9.2	9.17	9.35	9.1	9.16
pH	8.5	9	9.67	9	8.2
DO (mg/L)	0.01	0.03	0.01	0.01	0.01
Conductivity (mS/cm)	0.24	0.24	0.241	0.24	0.24
TDS (g/L)	0.224	0.224	0.224	0.224	0.224
Sal	0.17	0.17	0.17	0.17	0.17
Taken by Boat or Wading	B	B	B	B	B
Comments	no	no	no	no	no
Sediment Samples					
Sample Identification #	2a	2b	2c	2c	2e
Depth of Core (inches)	9	9.5	9	5	6
Tube Diameter of Corer (cm)	4.7625	4.7625	4.7625	4.7625	4.7625
Sediment Stratification Present, if so Measure & Take Picture	no	no	no	no	no
Taken by Boat or Wading	B	B	B	B	B
Comments	no	2 worms - pic	picture	no	no

Sample Locations					
Sample Identification #	3a	3b	3c	3d	3e
Lat - degrees	38	38	38	38	38
min	19	19	19	19	19
sec	0.94	0.93	0.92	1.05	1.14
decimal	38.31692778	38.316925	38.31692222	38.31695833	38.31698333
Corrected Lat (from reference point)	38.31780878	38.317806	38.31780322	38.31783933	38.31786433
Lat - degrees	96	96	96	96	96
min	59	59	59	59	59
sec	2.22	2.86	2.71	2.59	2.78
decimal	-96.98395	-96.98412778	-96.98408611	-96.98405278	-96.98410556
Corrected Long (from reference point)	-96.99082	-96.99099778	-96.99095611	-96.99092278	-96.99097556
Water Samples					
Sample Identification #	3a	3b	3c	3d	3e
Depth (feet)	23	23.6	23.2	22.7	23.1
Surface Conditions (ripples, choppy, etc)	Choppy	Choppy	Choppy	Choppy	Choppy
Time	13:52	13:55	13:57	14:00	14:05
@ 0.25 m below surface					
Water Temperature (degrees C)	8.58	8.54	8.55	8.55	8.56
pH	7.8	6.98	6.98	6.98	9
DO (mg/L)	0.02	0.01	0.01	0.01	0.01
Conductivity (mS/cm)	0.23	0.235	0.236	0.236	0.236
TDS (g/L)	0.224	0.223	0.224	0.224	0.224
Sal	0.17	0.17	0.17	0.17	0.17
Taken by Boat or Wading	B	B	B	B	B
Comments	no	no	no	no	no

Sediment Samples					
Sample Identification #	3a	3b	3c	3d	3e
Depth of Core (inches)	3	4	6.5	2.5	3
Tube Diameter of Corer (cm)	4.7625	4.7625	4.7625	4.7625	4.7625
Sediment Stratification Present, if so Measure & Take Picture	no	no	no	no	no
Taken by Boat or Wading	B	B	B	B	B
Comments	no	no	no	worm	no

Sample Locations					
Sample Identification #	4a	4b	4c	4d	4e
Lat - degrees	38	38	38	38	38
min	19	19	19	19	19
sec	1.59	1.96	1.78	1.43	1.22
decimal	38.31710833	38.31721111	38.31716111	38.31706389	38.31700556
Corrected Lat (from reference point)	38.31798933	38.31809211	38.31804211	38.31794489	38.31788656
Lat - degrees	96	96	96	96	96
min	59	59	59	59	59
sec	4.24	4.21	4.3	4.28	4.03
decimal	-96.98451111	-96.98450278	-96.98452778	-96.98452222	-96.98445278
Corrected Long (from reference point)	-96.99138111	-96.99137278	-96.99139778	-96.99139222	-96.99132278
Water Samples					
Sample Identification #	4a	4b	4c	4d	4e
Depth (feet)	12.6	8.9	9.1	14.7	7.2
Surface Conditions (ripples, choppy, etc)	Choppy	Choppy	Choppy	Choppy	Choppy
Time	11:40	11:48	12:57	13:08	13:12

@ 0.25 m below surface					
Water Temperature (degrees C)	8.23	8.24	8.7	8.65	8.66
pH	9.1	8.75	7.22	6.98	8.8
DO (mg/L)	0.01	0.01	0.03	0.03	0.03
Conductivity (mS/cm)	0.234	0.235	0.238	0.237	0.237
TDS (g/L)	0.224	0.224	0.224	0.224	0.224
Sal	0.17	0.17	0.17	0.17	0.17
Taken by Boat or Wading	B	B	B	B	B
Comments	no	no	no	no	no
Sediment Samples					
Sample Identification #	4a	4b	4c	4d	4e
Depth of Core (inches)	2.5	1.5	5.5	0.1	4.5
Tube Diameter of Corer (cm)	4.7625	4.7625	4.7625	4.7625	4.7625
Sediment Stratification Present, if so Measure & Take Picture	no	no	no	no	no
Taken by Boat or Wading	B	B	B	B	B
Comments	no	no	no	no	no

Sample Locations					
Sample Identification #	5a	5b	5c	5d	5e
Lat - degrees	38	38	38	38	38
min	19	19	19	19	19

sec	5.03	4.97	5.25	4.72	4.76
decimal	38.31806389	38.31804722	38.318125	38.31797778	38.31798889
Corrected Lat (from reference point)	38.31894489	38.31892822	38.319006	38.31885878	38.31886989
Lat - degrees	96	96	96	96	96
min	58	58	58	58	58
sec	7.98	7.51	7.99	8.22	8.41
decimal	-96.96888333	-96.96875278	-96.96888611	-96.96895	-96.96900278
Corrected Long (from reference point)	-96.97575333	-96.97562278	-96.97575611	-96.97582	-96.97587278
Water Samples					
Sample Identification #	5a	5b	5c	5d	5e
Depth (feet)	4.4	2.6	4.5	6.5	6.7
Surface Conditions (ripples, choppy, etc)	Ripples	Ripples	Ripples	Choppy	Choppy
Time	15:03	15:00	15:06	15:08	15:11
@ 0.25 m below surface					
Water Temperature (degrees C)	9.6	9.6	9.34	9.25	9.16
pH	8.6	11.7	8.17	10	8.9
DO (mg/L)	0.03	0.03	0.04	0.03	0.03
Conductivity (mS/cm)	0.243	0.24	0.241	0.246	0.24
TDS (g/L)	0.224	0.224	0.224	0.223	0.223
Sal	0.17	0.17	0.17	0.17	0.17
Taken by Boat or Wading	B	B	B	B	B
Comments	no	no	no	no	no
Sediment Samples					
Sample Identification #	5a	5b	5c	5d	5e
Depth of Core (inches)	6.75	1.5	1	7	4

Tube Diameter of Corer (cm)	4.7625	4.7625	4.7625	4.7625	4.7625
Sediment Stratification Present, if so Measure & Take Picture	no	no	no	no	no
Taken by Boat or Wading	B	B	B	B	B
Comments	no	no	gravel/sand	no	worm

Sample Locations	<-- Duplicate with Sample 11				
Sample Identification #	6a	6b	6c	6d	6e
Lat - degrees	38	38	38	38	38
min	18	18	18	18	18
sec	8.97	8.87	8.96	9.09	9.06
decimal	38.30249167	38.30246389	38.30248889	38.302525	38.30251667
Corrected Lat (from reference point)	38.30337267	38.30334489	38.30336989	38.303406	38.30339767
Lat - degrees	96	96	96	96	96
min	59	59	59	59	59
sec	4.32	4.31	4.53	4.44	4.21
decimal	-96.98453333	-96.98453056	-96.98459167	-96.98456667	-96.98450278
Corrected Long (from reference point)	-96.99140333	-96.99140056	-96.99146167	-96.99143667	-96.99137278
Water Samples					
Sample Identification #	6a	6b	6c	6d	6e
Depth (feet)	28.2	19.6	26.3	28.3	27.2
Surface Conditions (ripples, choppy, etc)	Ripples	Ripples	Ripples	Ripples	Ripples
Time	10:20	10:30	10:38	10:46	10:50
@ 0.25 m below surface					
Water Temperature (degrees C)	8.23	8.3	8.2	8.3	8.31
pH	9.4	10.08	10.4	9.5	8.5

DO (mg/L)	0.01	0.01	0.01	0.01	0.01
Conductivity (mS/cm)	0.234	0.234	0.234	0.235	0.235
TDS (g/L)	0.224	0.224	0.224	0.224	0.224
Sal	0.17	0.17	0.17	0.17	0.17
Taken by Boat or Wading	B	B	B	B	B
Comments	no	no	no	no	no
Sediment Samples					
Sample Identification #	6a	6b	6c	6d	6e
Depth of Core (inches)	6	3	15	4.5	5
Tube Diameter of Corer (cm)	4.7625	4.7625	4.7625	4.7625	4.7625
Sediment Stratification Present, if so Measure & Take Picture	no	no	no	no	no
Taken by Boat or Wading	B	B	B	B	B
Comments	no	no	no	no	no

Sample Locations					
Sample Identification #	7a	7b	7c	7d	7e
Lat - degrees	38	38	38	38	38
min	19	19	19	19	19
sec	1.83	1.67	1.87	1.83	2.77
decimal	38.317175	38.31713056	38.31718611	38.317175	38.31743611
Corrected Lat (from reference point)	38.318056	38.31801156	38.31806711	38.318056	38.31831711
Lat - degrees	96	96	96	96	96

min	59	59	59	59	59
sec	2.62	2.67	2.83	2.46	2.54
decimal	-96.98406111	-96.984075	-96.98411944	-96.98401667	-96.98403889
Corrected Long (from reference point)	-96.99093111	-96.990945	-96.99098944	-96.99088667	-96.99090889
Water Samples					
Sample Identification #	7a	7b	7c	7d	7e
Depth (feet)	17.7	18.5	13.8	15.5	8
Surface Conditions (ripples, choppy, etc)	Choppy	Choppy	Choppy	Choppy	Choppy
Time	13:23	13:25	13:30	13:35	13:40
@ 0.25 m below surface					
Water Temperature (degrees C)	8.6	8.63	8.83	8.63	8.95
pH	7	7	6.99	7.64	8.24
DO (mg/L)	0.04	0.01	0.01	0.01	0.01
Conductivity (mS/cm)	0.236	0.237	0.238	0.237	0.237
TDS (g/L)	0.224	0.224	0.224	0.224	0.222
Sal	0.17	0.17	0.17	0.17	0.16
Taken by Boat or Wading	B	B	B	B	B
Comments	no	no	no	no	no
Sediment Samples					
Sample Identification #	7a	7b	7c	7d	7e
Depth of Core (inches)	5.75	0.5	0	1.5	5.5
Tube Diameter of Corer (cm)	4.7625	4.7625	4.7625	4.7625	4.7625
Sediment Stratification Present, if so	no	no	no	no	no

Measure & Take Picture					
Taken by Boat or Wading	B	B	B	B	B
Comments	no	no	Could not recover any sediment with sampler	no	Worm

Sample Locations					
Sample Identification #	8a	8b	8c	8d	8e
Lat - degrees	38	38	38	38	38
min	19	19	19	19	19
sec	7.91	7.33	7.34	7.34	7.98
decimal	38.31886389	38.31870278	38.31870556	38.31870556	38.31888333
Corrected Lat (from reference point)	38.31974489	38.31958378	38.31958656	38.31958656	38.31976433
Lat - degrees	96	96	96	96	96
min	58	58	58	58	58
sec	7.11	7.33	6.81	6.97	7.18
decimal	-96.96864167	-96.96870278	-96.96855833	-96.96860278	-96.96866111
Corrected Long (from reference point)	-96.97551167	-96.97557278	-96.97542833	-96.97547278	-96.97553111
Water Samples					
Sample Identification #	8a	8b	8c	8d	8e
Depth (feet)	1.2	1.2	1.2	0.6	1
Surface Conditions (ripples, choppy, etc)	Choppy	Choppy	Choppy	Choppy	Choppy
Time	16:05	16:12	16:31	16:36	0.709027778
@ 0.25 m below surface					
Water Temperature (degrees C)	15.92	12.97	16.62	16.53	16.45
pH	6.98	6.98	12.88	8.9	6.99
DO (mg/L)	0.01	0.01	0.01	0.01	0.01
Conductivity (mS/cm)	0.302	0.274	0.307	0.306	0.306

TDS (g/L)	0.233	0.229	0.238	0.237	0.237
Sal	0.17	0.17	0.18	0.18	0.18
Taken by Boat or Wading	W	W	W	W	W
Comments	no	no	no	3 worms	no
Sediment Samples					
Sample Identification #	8a	8b	8c	8d	8e
Depth of Core (inches)	20	20	20	20	20
Tube Diameter of Corer (cm)	4.7625	4.7625	4.7625	4.7625	4.7625
Sediment Stratification Present, if so Measure & Take Picture	no	no	no	no	Yes, top 2" OM, rest of tube clay
Taken by Boat or Wading	W	W	W	W	W
Comments	Lots of organic matter	no	no	no	lots of organic matter & clay/top 2" OM, rest of tube clay

Sample Locations					
Sample Identification #	9a	9b	9c	9d	9e
Lat - degrees	38	38	38	38	38
min	19	19	19	19	19
sec	2.47	2.28	2.31	2.56	2.55
decimal	38.31735278	38.3173	38.31730833	38.31737778	38.317375
Corrected Lat (from reference point)	38.31823378	38.318181	38.31818933	38.31825878	38.318256
Lat - degrees	96	96	96	96	96
min	58	58	58	58	58
sec	8.74	7.83	9	8.56	8.9
decimal	-96.96909444	-96.96884167	-96.96916667	-96.96904444	-96.96913889

Corrected Long (from reference point)	-96.97596444	-96.97571167	-96.97603667	-96.97591444	-96.97600889
Water Samples					
Sample Identification #	9a	9b	9c	9d	9e
Depth (feet)	5	5	13.3	12.5	12.5
Surface Conditions (ripples, choppy, etc)	Ripples	Ripples	Ripples	Ripples	Ripples
Time	14:41	14:38	14:44	14:47	14:51
@ 0.25 m below surface					
Water Temperature (degrees C)	8.75	10.53	8.75	8.76	8.5
pH	9	12.78	10.45	10.4	10.36
DO (mg/L)	0.03	0.01	0.04	0.04	0.03
Conductivity (mS/cm)	0.238	0.252	0.238	0.238	0.236
TDS (g/L)	0.224	0.224	0.224	0.224	0.224
Sal	0.17	0.17	0.17	0.17	0.17
Taken by Boat or Wading	B	B	B	B	B
Comments	Warm, No Wind, Calm Water	Warm, No Wind, Calm Water	Warm, No Wind, Calm Water	Warm, No Wind, Calm Water	Warm, No Wind, Calm Water
Sediment Samples					
Sample Identification #	9a	9b	9c	9d	9e
Depth of Core (inches)	8.5	5.5	8.5	9.5	8.5
Tube Diameter of Corer (cm)	4.7625	4.7625	4.7625	4.7625	4.7625
Sediment Stratification Present, if so Measure & Take Picture	no	no	no	no	no
Taken by Boat or Wading	B	B	B	B	B

Comments	no	Worm	no	no	no

Sample Locations					
Sample Identification #	10a	10b	10c	10d	10e
Lat - degrees	38	38	38	38	38
min	18	18	18	19	18
sec	9.94	8.92	9.79	0	9.9
decimal	38.30276111	38.30247778	38.30271944	38.31666667	38.30275
Corrected Lat (from reference point)	38.30364211	38.30335878	38.30360044	38.31754767	38.303631
Lat - degrees	96	96	96	96	96
min	59	59	59	59	59
sec	5.14	5.23	5.59	5.45	3.3
decimal	-96.98476111	-96.98478611	-96.98488611	-96.98484722	-96.98425
Corrected Long (from reference point)	-96.99163111	-96.99165611	-96.99175611	-96.99171722	-96.99112
Water Samples					
Sample Identification #	10a	10b	10c	10d	10e
Depth (feet)	26.1	22.7	24.2	22.8	22.2
Surface Conditions (ripples, choppy, etc)	Choppy	Choppy	Choppy	Choppy	Choppy
Time	10:07	10:00	9:45	9:51	9:35
@ 0.25 m below surface					
Water Temperature (degrees C)	8.2	8.18	8.14	8.15	8.5
pH	9.59	10.7	11.45	9.31	11.48
DO (mg/L)	0.01	0.01	0.01	0.01	0.01
Conductivity (mS/cm)	0.234	0.234	0.234	0.233	0.234
TDS (g/L)	0.224	0.224	0.225	0.224	0.224
Sal	0.17	0.17	0.17	0.17	0.17

Taken by Boat or Wading	B	B	B	B	B
Comments	no	no	no	no	no
Sediment Samples					
Sample Identification #	10a	10b	10c	10d	10e
Depth of Core (inches)	10.5	10	2	4	20
Tube Diameter of Corer (cm)	4.7625	4.7625	4.7625	4.7625	4.7625
Sediment Stratification Present, if so Measure & Take Picture	no	no	no	no	no
Taken by Boat or Wading	B	B	B	B	B
Comments	no	no	no	no	no

Sample Locations	<-- Duplicate with Sample 6				
Sample Identification #	11a	11b	11c	11d	11e
Lat - degrees	38	38	38	38	38
min	18	18	18	18	18
sec	8.97	8.87	8.96	9.09	9.06
decimal	38.30249167	38.30246389	38.30248889	38.302525	38.30251667
Corrected Lat (from reference point)	38.30337267	38.30334489	38.30336989	38.303406	38.30339767
Lat - degrees	96	96	96	96	96
min	59	59	59	59	59
sec	4.32	4.31	4.53	4.44	4.21
decimal	-96.98453333	-96.98453056	-96.98459167	-96.98456667	-96.98450278
Corrected Long (from reference point)	-96.99140333	-96.99140056	-96.99146167	-96.99143667	-96.99137278
Water Samples					

Sample Identification #	11a	11b	11c	11d	11e
Depth (feet)	28.2	19.6	26.3	28.3	27.2
Surface Conditions (ripples, choppy, etc)	Ripples	Ripples	Ripples	Ripples	Ripples
Time	10:20	10:30	10:38	10:46	10:50
@ 0.25 m below surface					
Water Temperature (degrees C)	8.23	8.3	8.2	8.3	8.31
pH	9.4	10.08	10.4	9.5	8.5
DO (mg/L)	0.01	0.01	0.01	0.01	0.01
Conductivity (mS/cm)	0.234	0.234	0.234	0.235	0.235
TDS (g/L)	0.224	0.224	0.224	0.224	0.224
Sal	0.17	0.17	0.17	0.17	0.17
Taken by Boat or Wading	B	B	B	B	B
Comments	no	no	no	no	no
Sediment Samples					
Sample Identification #	11a	11b	11c	11d	11e
Depth of Core (inches)	6	3	15	4.5	5
Tube Diameter of Corer (cm)	4.7625	4.7625	4.7625	4.7625	4.7625
Sediment Stratification Present, if so Measure & Take Picture	no	no	no	no	no
Taken by Boat or Wading	B	B	B	B	B
Comments	no	no	no	no	no

8. Appendix B: Detailed Materials and Methods

8.1 Water Sampling Procedure

Procedure from EPA 2012 National Lakes Assessment Field Operations Manual (https://www.epa.gov/sites/production/files/2013-11/documents/nla2012_fieldoperationsmanual_120517_final_combinedqrg.pdf)

1. DO, pH, Turbidity, Conductivity, Temperature
   Measurements taken with a handheld YSI 556 Multiparameter Instrument
    1. Record Site Conditions
    2. Determine Site Depth (recorded with a Garmin Striker 4cv depth finder)
    3. Rinse sensor with DI water
    4. Lower Sensor to 0.25 m below surface
        1. Stabilize Sensor
        2. Record Measurements @ 0.25 m below surface
    5. Carefully Remove Sensor from Water
    6. Rinse Sensor with DI Water
    7. Place Sensor Tip in DI Water for Transport
    8. Record data 5 times in a crosshair-pattern for each site
2. Water Sample Collection (Nutrient Testing)
    1. Label Water Sample Container with appropriate data (120 ml HDPE Container)
    2. Rinse Sample Collection Container (120ml) 3x with lake water from testing site.
    3. Gather sample at a depth of 0.25m. Pour gathered sample into cubitainer for composite sampling. Ensure that it does not touch the Cubitainer when transferring. 2 samples must be collected per grab.
    4. Mix all samples from collection site (5 grabs in a crosshair-pattern) together thoroughly within 1 gallon Cubitainer
    5. Pour well mixed sample mixture into properly labeled 120 ml container
    6. Ensure that there is no air space in container before capping
    7. Tightly cap container and place in cooler of ice
3. Water Sample Collection (TSS, VSS, TDS)
    1. Label Water Sample Container with appropriate data (960 ml HDPE Container)
    2. Rinse Sample Collection Container (120 ml) 3x with lake water from testing site.
    3. Gather sample at a depth of 0.25m. Pour gathered sample into cubitainer for composite sampling. Ensure that it does not touch the cubitainer when transferring. 2 samples must be collected per grab.
    4. Mix all samples from collection site (5 grabs in a crosshair-pattern) together thoroughly within 1 gallon Cubitainer
    5. Pour well mixed sample mixture into properly labeled 960 ml container
    6. Ensure that there is no air space in container before capping

7. Tightly cap container and place in cooler of ice

4. Water Sample Collection (Chlorophyll)
    1. Label Water Sample Containers with appropriate data (960 ml HDPE Container)
    2. Rinse Sample Collection Container (960 ml) 3x with lake water from testing site.
    3. Gather sample at a depth of 0.25m. 2 samples must be collected from the grab.
    4. Pour sample into properly labeled 960 ml containers
    5. Ensure that there is no air space in container before capping
    6. Tightly cap container, mix, and place in cooler of ice

8.2 Sediment Sampling Procedure

Procedure from EPA 2012 National Lakes Assessment Field Operations Manual (https://www.epa.gov/sites/production/files/2013-11/documents/nla2012_fieldoperationsmanual_120517_final_combinedqrg.pdf)

1. Label Sediment Container (upper 10 cm of sediment collected)
2. Insert the core tube into the sampling housing apparatus and tighten the hose clamp screws to secure the tube. Ensure the messenger is attached to the sampler line. Set the release mechanism.
3. Slowly lower the corer through the water column until the bottom of the core tube is just touching the sediment surface. Raise the corer 1 m and while maintaining a slight tension on the line, lower the corer allowing it to settle into the bottom substrate. Immediately after the corer drops into the sediments, maintain line tension to prevent the corer from tilting and disturbing the core sample. [Keep in mind that the goal is to obtain a core 45 cm in length. If this core length is not obtained the first time, the operation might need to be repeated at a new location using additional weights on the corer (if available) and/or a greater release height in order to improve penetration and obtain a longer core. If the core length exceeds the length of the core tube, the operation might need to be repeated at a new location using less weight on the corer and/or a shorter release height.]
4. While keeping the bottom of the core tube under water, reach under the surface and plug the bottom of the corer with a corer tube plug. To do this without disturbing the water-sediment interface, you cannot tilt the corer more than 45 degrees. (Note: core tube plugs are easily lost. Be sure to have spares available at all times.)
5. Keeping your hand under the corer tube plug, raise the corer into the boat in a vertical position. Stand the corer in a large tub or bucket to prevent contaminating the boat with sediment material.
6. Detach the core tube from the corer. One crew member should hold the sampler in a vertical position while the second person dismantles the unit.
7. Get Samples out of core tube and place in properly labeled container.
8. Gather 5 samples in a crosshair-pattern for each site
9. Place all smaller containers into one larger container, allowing the laboratory to composite the samples in their lab.

8.3 Protocol for Fluorometer Excitation-Emission Matrices acquisition with Aqualog

Sample Preparation:

1. Samples should be filtered using a pre-rinsed filter
2. Allow samples to warm to room temperature

Startup

1. Turn on the instrument 1st and the computer 2nd
2. Allow the lamp to warm up approximately 45 minutes before running a sample
3. Rinse a clean quartz cuvette with ultra-pure water ~20 times
4. Clean the sides of the 3-Q-10 sealed water sample with kim-wipes
5. Clean the two Quinine sulfate cells (blank and samples) with kim-wipes
6. Initial software steps:
    1. Make a folder on the desktop in the C: drive under you name in which to save your sample results for the day – using YYMMDD format
    2. Open the Aqualog logbook.xls on the desktop and enter your name and date
    3. Open the Aqualog software

Cuvette check (for contamination) with ultra-pure water

1. Click on the "H2O" button in the "Aqualog main experiment menu"
2. Click on "Spectra"
3. Click on "Emission 2D"
4. Name the new project using PYYMMDD
5. Load the experiment file "Cuvette_startup.xml" (located in C:\PublicDocuments\JobinYvon\Yvon\Data\)
6. Check that the settings are:
    1. Integration time = .25 sec
    2. Increment = 3.28 nm
    3. Gain = high
    4. Excitation = 240 nm
    5. "Sample Only" box is checked
7. "Run" the sample and look for any peaks between emission 300 and 400 nm that are not noise. If there is an obvious peak, clean the Cuvette again and re-run this check.
8. To see the peak values, double click on the figure. Then click the "Data Reader" icon (square with cross hairs inside) to select the peak.
9. Record the highest peak between emission 300 and 400 nm in the Aqualog logbook.xls.

Water Raman Scan with ultra-pure water

1. Click on the "H2O" button "Aqualog main experiment menu"
2. Click on "Spectra"
3. Click on "Emission 2D"

4. Load the experiment file “water raman.xml” (located in the “Startup” folder)
5. Check that the settings are:
    1. Integration time = .25 sec
    2. Increment = 3.28 nm
    3. Gain = high
    4. Excitation = 240 nm
    5. “Sample Only” box is checked
6. “Run” the sample and record the Raman peak at ~397 nm (Raman peak X and Y) in the Aqualog logbook.xls.
7. Calculate the area under the Raman peak
    1. Double-click on the graph
    2. Click the up and down arrow (“Data Selector” arrow) which allows you to narrow the range of the emission wavelength so that only the Raman peak is in view
    3. Click “Analysis” -> “Baseline”
    4. Goal: “integrate peaks” should be selected, Next
    5. “Baseline mode, Constant” should be “custom” and set Y = 0. Next, Next
    6. Click on “find”, Next
    7. Select “Fix width for all peaks” as the integration window width and set “left half width” to “25”. Right half width should automatically set to “25”. Finish
    8. Go to “Integration Result1” tab to find the area. The area is the 2nd column entitled “integral results of Sc/Rc, Area.” Paste this value into the Aqualog logbook.xls.
    9. Also record this area in you lab notebook every day.
    10. **If you change your integration time when you run your sample, then re-run the Water Raman scan with the new integration time**

3D EEM acquisition with ultra-pure water

1. Click on the “H2O” button “Aqualog main experiment menu”
2. Click on “3D”
3. Click on EEM 3D CCD + absorbance.
4. Load the experiment file “3DeemNEW.xml” from the Startup folder.
5. Check that the settings are:
    1. Integration time = .25 sec
    2. Increment = 3 nm and 3.28 nm
    3. Gain = high
    4. “sample and blank” circle is selected
6. First run ultra-pure water as a sample to check for any contamination on the Cuvette or in the ultrapure water system
    1. Enter a name for the sample (eg. “MQ”) in the Data Identifier box.
    2. Enter a name for the blank (with this format: BYYMMDD) in the “collect blank” box.
    3. Click run
    4. You will be asked to insert the blank and the sample
    5. Your blank-subtracted EEM spectra will show up as an uncorrected waterfall plot

6. Make sure you are at the waterfall plot screen. Click the following in this order:
    1. The “inner filter correct” button (which is a small square at the upper left corner of the button)
    2. The “Rayleigh masking” button – select both first and second order and set the wavelength to 12.
    3. The “Normalize 3D” button –
        - Enter the Raman area you recorded earlier into the “Divide by a specified value” box.
7. Edit the contour plot to make it easier to view
8. Double-click the “Processed contour: IFE_RM_NRM” plow
9. Set range from 0 (zero, no negative values) to the maximum intensity
10. Change the first layer to the color white
11. Select contours at all major levels

7. Perform steps 1-11 on the next samples EXCEPT you can now use the “blank from file” (no need to run the blank each time)
8. You can select “Collect” -> “Previous experimental setup” for the next EEM acquisition (don’t have to click the H2O button, etc. every time)
9. Write each sample’s name in your lab notebook (full description) along with the short filename you used to name the 3dEEM.
10. **If you change your integration time when you run your sample, then run a new blank (enter a name with this format: BYYMMDDb) using the new integration time**

Shut Down

1. Save the project
2. Download and correct the data according to Corrections Protocol
3. Shut down the software
4. Shut down the computer
5. ***Shut down the instrument***
6. Clean all cuvettes
7. Clean or put away all beakers, pens, notebooks, etc.

Cuvette cleaning

1. You can put a dirty cuvette into water with hydrogen peroxide (a 10:1 solution) for a few hours to clean it. Best if you can put it in direct sunlight as well

Calculating Indices with Aqualog Fluorescence Data

- ## STEP 1: Exporting raw data from the instrument
    - You are already in Aqualog program. If not, double click on Aqualog icon on desktop.
    - 2. Click on “File” and select “HJY Export”

- 3. In HJY_Export dialog box, click on the button just to the right of “Export Graph(s)” field.
- 4. In Graph Browser dialog box, select on the desired project folder icon (not individual files) and click on button with two right arrows. Click “OK”.
- 5. Again HJY_Export dialog box will pop up with selected graphs in “Export Graph(s)” field. Make sure the “File Format” is “ASCII”. Click “OK”.
- 6. “File Location for batch exporting” window will open. Create a new folder with name “Raw Data” and provide this folder address to export the data.
- 7. A warning “File Exists!” will appear for each sample. Always click “YES” to replace the existing file.
- 8. Save and close the Aqualog program.
- 9. Create a new folder with name “Function_Files” and download all the “*.m” files in it (By Right Clicking on file and “Save link as…”) from folder “Correction_Functions Files” on k-state online course website.

- **STEP 2: Reviewing raw data flies**
  - Open the folder where raw data is exported.
  - Make sure the folder contains:
    - Seven (7) raw files for each sample
    - Only one (1) Raman File
    - Cuvette Check Files (may be 1 or more)
    - A QS Unit file
  - 3. Close the folder.

- **STEP 3: Correcting and calculating indices**
  - Open “MATLAB R2013a” program by double clicking on the shortcut created on desktop home screen.
  - Browse for “Function_Files” folder using “Browse for Folder” button to the left of address bar and select “Function_Files” folder.
  - Select all the files in the “Function_Files”, right click and then select “Add to Path >> Selected Folders and Subfolders”.
  - Repeat step 2 & 3 for “Raw Data” folder.
  - In the Command Window, type command “ProcessData” followed by the address of “Raw Data” folder copied from the address bar in the format given below, and hit Enter:
    - >> ProcessData (‘C:\Users\harshad\Desktop\okavangofa\Raw Data\’)
  - The command window will show the message “Process Completed” when it is done. Then type command “close all” and hit Enter.
- **STEP 4: Review the results**
  - Review the results in respective folders as given below:
  - Absorbance Graphs in “*.png” format
    - >>Raw Data >> Abs Spectra Graphs >> Graphs
  - Intensity of absorbance @ 254 nm

        - >> Raw Data >> Abs Spectra Graphs >> Results >> Results.txt
    - NOTE: Open the "*.txt" from MS Excel
    - Calculated Raman Area
        - >> Raw Data >> raman >> "*.csv"
    - 3D EEM contour plots in "*.png" format
        - >> Raw Data >> Results >> EEM Graphs
    - Graph of maximum emission @ 370 nm in "*.png" format
        - >> Raw Data >> Results >> MaxEm
    - Table of calculated indices
        - >> Raw Data >> Results >> Results.txt
    - NOTE: Open the "*.txt" from MS Excel
    - Files ready for PARAFAC analysis
        - >> Raw Data >> Results >> Data4Parafac
    - To close the MATLAB, type the command "quit" and hit Enter.
- **STEP 5: PARAFAC**
    - Create a new folder say "Parafacfiles" to store files ready for parafac obtained from 3
        - ">> Raw Data >> Results >> Data4Parafac"
    - Note: This is important when you have raw files in different folders. You will run corrections code to individual folder. For PARAFAC, we want all files ready for PARAFAC in single folder.
    - 2. In the Command Window, type command "dataprep4pf" followed by the address of "Parafacfiles" folder copied from the address bar in the format given below, and hit Enter:
        - >> dataprep4pf ('C:\Users\harshad\Desktop\samples\Raw Data\Parafacfiles\')
    - 3. You will see some objective questions on the screen as below:
        - a. Do you want to normalize the EEMs? Enter 1 for YES, 0 for NO
    - 4. A new folder named "PF" will be created in "Current Folder" window in main MATLAB window. Right click on this folder and add this folder to path with folders and subfolders option. Open this folder by double clicking on it. After you open this folder, you will see three files as:
        - a. em.csv
        - b. ex.csv
        - c. fl.csv
    - 5. In the Command Window, type command "loadpfdata" followed by the address of "PF" folder copied from the address bar in the format given below, and hit Enter:
        - >> dataprep4pf ('C:\Users\harshad\Desktop\samples\Raw Data\Parafacfiles\PF\') 3
    - 6. Now, you will see another file created "pf.mat". This is the dataset we'll be using for PARAFAC analysis.
    - 7. Follow the steps given in Stedmon and Bro, 2008 tutorial for PARAFAC analysis.

8.4 TSS, VSS, FSS Lab Protocol

1. Weigh an evaporation dish and filter
2. Place filter on suction beaker and filter 500 mL of well mixed sample
3. Place filter back in dish and put in 105 degree Celsius oven for 24 hours
4. Weigh the dried filter and dish
5. Determine TSS through calculation shown below

$$TSS\,(mg/L) = \frac{(A-B)\times 1000\,{}^{mL}/_{L}}{sample\ volume(mL)}$$

A = weight of crucible + filter + residue after 24 hrs at 105 ^{o}C (mg)

B = weight of crucible + filter (mg)

Equation 2: TSS Calculation

6. Place sample back into 550 degree Celsius oven for 1 hour.
7. Weigh the dried filter and dish
8. Determine VSS and FSS through calculations shown below

$$VSS\,(mg/L) = \frac{(A-B)\times 1000\,{}^{mL}/_{L}}{sample\ volume(mL)}$$

Equation 3: VSS Calculation

$$FSS\,(mg/L) = \frac{(B-C)\times 1000\,{}^{mL}/_{L}}{sample\ volume(mL)}$$

A = weight of crucible + filter + residue after 24 hrs at 105 ^{o}C (mg)

B = weight of crucible + filter + residue after 1 hr at 550 ^{o}C (mg)

C = weight of crucible + filter (mg)

Equation 4: FSS Calculation

9. Record measurements in a properly labeled excel spreadsheet

8.5 Sediment KSU Soils Laboratory Test Protocol

Soil preparation

1. Soil is prepared by drying overnight in a 50 degree C oven, then grinding to pass through a 2mm sieve. When iron is to be analyzed, samples are air-dried to prevent incorrectly high values. When nitrogen is to be analyzed, samples are dried as soon as possible to prevent bacterial conversion of nitrogen.

Soil Texture

1. Using sodium hexametaphosphate as a dispersing agent, the sand, silt, and clay fractions of the sample are estimated with the hydrometer method. Fifty grams of prepared soil are needed

Total Nitrogen

1. Both inorganic nitrogen forms, NH4+ and NO3-, are extracted with 1 M KCl, using 2 g of prepared soil. Cadmium reduction is used for nitrate and colorimetric procedures are run in separate channels in a flow analyzer to measure those ions simultaneously

Total Phosphorus

1. Melich III Phosphorus
    1. This P analysis uses a universal extractant that removes a wide range of elements. It is used by many laboratories for multiple-element analysis. It also requires 2g of prepared soil.
2. Bray Phosphorus
    1. The Bray P test is used for extractable (potentially plant available) phosphorus in soil because of its consistent correlation with yields from fertilizer recommendations generated from the test results. It utilizes a HCl-ammonium fluoride extractant and a colorimetric assay that requires 2g of prepared soil.
3. Olsen Phosphorus
    1. When the soil sample is calcareous, above pH 7.5, and the Bray P value is low, the Olson P test is recommended. It make use of a sodium bicarbonate extractant, a colorimetric assay, and 2 g of prepared soil

Organic Matter

1. The Walkley-Black procedure digests 1 g of prepared soil with sulfuric acid and dichromate, followed by a direct colorimetric measurement of the reduced Cr2O72-ion. The percent organic matter reported may also be estimated by calculation from the total carbon value obtained from combustion analysis.

9. Appendix C: Areas of Interest Throughout the Lake