NRES Capstone Project: Water Injection Dredging at Tuttle Creek State Reservoir

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Introduction

Sedimentation is a natural process in all water bodies. In reservoirs, sedimentation occurs when soil erosion and surface runoff transport sediment particles into streams and rivers. As streamflow enters a reservoir, the presence of a dam reduces flow velocity, causing both bedload and suspended sediment to settle. Because sediment cannot effectively pass through the dam, it accumulates over time, reducing storage capacity and impairing dam operations (Whelan & Hotchkiss, 2024).

Tuttle Creek Lake, like many reservoirs nationwide, has experienced substantial storage loss due to excessive sedimentation. Since the dam's closure in 1962, approximately 438 million cubic yards of sediment have accumulated within the reservoir (USACE, 2025). The Kansas Water Office estimates that nearly 46% of the reservoir's original storage capacity has been lost as a result (KWO, 2025). This loss has buried boat ramps, isolated aquatic habitat in coves, forced the abandonment of water intakes, and caused numerous other adverse impacts. Without intervention, sedimentation will continue to diminish the reservoir's functionality. Projections indicate that by 2074, sediment will occupy approximately 75% of the reservoir's original capacity, increasing to 93% by 2124 (USACE, 2025).

Water injection dredging (WID) is a sediment management technique commonly used in harbors and navigation channels to maintain required depths (Cappotto, 2025). The WID process consists of three primary phases. During the jetting phase, large volumes of low-pressure water are injected into the sediment bed through a horizontal beam fitted with nozzles. This injection reduces sediment density and generates a turbulent layer extending up to approximately three meters above the bed. In the transition phase, a fluid mud layer forms near the bottom. The final phase involves the transport of this fluid mud as a density current, driven by gravitational gradients, density contrasts, and ambient hydrodynamic forces. The distance of sediment transport depends on the settling velocity of the density current. Through this process, sediment is redistributed from dredged areas to downstream locations, restoring target depths in critical zones (Prins, 2024).

WID is an attractive reservoir maintenance strategy for several reasons. Conventional dredging methods require significant labor, heavy equipment, and costly sediment handling and disposal. In contrast, WID relies on naturally occurring density currents to transport sediment downstream, reducing labor demands and simplifying project logistics. As a result, WID is considered a cost-effective sediment management approach (Thompson, 2024). At Tuttle Creek Lake, estimated WID costs are approximately $3 per cubic yard, compared to $6–$15 per cubic yard for traditional dredging methods, further highlighting its economic advantages (Cappotto, 2025).

Tuttle Creek Lake is the largest reservoir in the Kansas River Basin and provides critical flood control and water supply benefits to over 40% of Kansas residents, including those in Topeka, Kansas City, Manhattan, and Lawrence. The reservoir also supports significant recreational and ecological functions, underscoring its importance to the state (USACE, 2025). In response to ongoing sedimentation challenges, the Kansas Water Office, in partnership with the U.S. Army Corps of Engineers, initiated a Water Injection Study and Demonstration Project at Tuttle Creek Lake to evaluate sustainable, long-term reservoir management strategies. The first of three planned WID periods began on September 17, 2025, and continued for ten consecutive days through September 27, 2025.

Although numerous studies have evaluated the impacts of dredging in rivers, estuaries, and coastal environments, water injection dredging has not previously been applied in a freshwater reservoir. Consequently, the effects of WID in a reservoir like Tuttle Creek Lake remain largely unknown. Furthermore, existing studies often overlook potential downstream impacts associated with transporting large volumes of sediment. Therefore, this study aims to assess the effects of water injection dredging in Tuttle Creek Lake on downstream water quality. The findings will help determine whether WID represents a sustainable and environmentally responsible sediment management strategy for freshwater reservoirs.

Research Objectives

Study Objectives

For our quantitative study of the impacts of WID on the freshwater Tuttle Creek Reservoir system, we had three major objectives. First, we wanted to investigate if there were any potential impacts of the WID process on water quality downstream of Tuttle Creek Reservoir. Next, we wanted to measure concentrations of total suspended solids (TSS) and nutrients before, during, and after the WID. Finally, we wanted to assess whether or not levels of TSS and/or nutrients increased downstream following WID cessation.

Environmental Outreach Considerations

For our environmental outreach component, we wanted to determine if there were any consistent considerations that environmental advocates or policy makers should keep in mind when interacting with the public. Ultimately, we came up with three major categories that professionals should keep in mind when communicating environmental policy and/or procedures to the public: their stakeholders and what their motivations are, how a region “sense of place” affects their viewpoint, and strategies to encouraging engagement from the public and the benefits to doing so.

Background and Literature Review

Sedimentation

One of the major concerns that the US Army Corps of Engineers wishes to address in the Tuttle Creek Reservoir is sedimentation, from its initial buildup and its now colossal presence in muddying the water, disrupting aquatic habitats, and increasing water treatment costs, it has been considered one of the most common pollutants in water by the EPA. To define sedimentation, it is a process where “soil particles are eroded and then transported by flowing water or any other transport method and then deposited as layers of solid particles in water bodies. It is a complex process that varies with watershed sediment yield, rate of transportation, and mode of deposition” (Tundu, 2013). It’s important to understand how sedimentation can pose an issue to our water systems and reservoirs. Looking at a study done in Zimbabwe, in the Mazowe catchment, which is one of seven rivers in Zimbabwe. This area in particular faces erosion and increasing land issues, with high sediment loads being sent downstream. This in turn reduces the total amount of storage capacity in the catchment. The high amount of sediment also pollutes the water, impeding overall water quality. “There is a close positive relationship between turbidity and sediment yield of 0.63……The results show that the two water quality parameters can be indicators of sedimentation. Higher values of total suspended solids and turbidity indicate higher values of sediment yield in water bodies" (Tundu, 8).

Sedimentation poses a global issue to any system of water, in fact, over 100 billion metric tons of sediment have been measured so far in reservoirs across the globe and properly managing it with the correct methods is a constant source of discussion. For example, a study done by Glas looked at the Pulangi IV reservoir in the Philippines. Due to the excessive sedimentation buildup, the water levels had dropped considerably after a few decades. Their plan to resolve this issue is a combination of drawdown flushing, which aims to lower the water levels to mobilize the sediment, and then using the process of WID in targeted flushing channels, which transports and guides the material to designated dam outlets. By field monitoring these efforts, they were able to calibrate and create hydrodynamic and sediment transport models, which simulated the effectiveness of the flushing, and showed that it was only moderately effective. However, with the addition of WID, the dredged channels greatly improved the routing of sediment, making this process more effective and sustainable for the environment.

Nutrients

Dredging can resuspend accumulated sediments, increasing the risk of nutrient remobilization and release into the water column. These processes can significantly alter water quality and biogeochemical conditions. Elevated nutrient concentrations, especially nitrogen and phosphorus, can stimulate algal blooms, oxygen depletion, and shifts in aquatic metabolic regimes. The risk of eutrophication is particularly concerning, as dredging may export nutrient rich sediments downstream, extending ecological impacts beyond the dredging zone.

Nutrient Budgets

Dredging influences nutrient budgets by disturbing, removing, or redistributing nutrient-rich sediments. A study of Lake Trafford—impacted by over fifty years of cultural eutrophication—examined how dredging affected nutrient dynamics. Comparisons between pre-dredging estimated nutrient loads (TN and TP) and post-dredging measured loads revealed substantially higher daily nutrient loads than those predicted by the model, with discrepancies of 31% for total nitrogen and 23% for total phosphorus compared to the estimated TMDL report (Thomas et al., 24). Despite efforts to remove organic sediments, nutrient loads in the lake remained elevated and failed to meet TMDL targets. The authors concluded that sediment dredging "yields positive short-term benefits, but these benefits may diminish over time" (Thomas et al., 25). These findings highlight a key management implication: dredging alone cannot ensure long-term nutrient reduction if external sources of nutrient loading persist. Without concurrent watershed-level interventions, such as improved agricultural practices, runoff controls, or wastewater management, nutrient concentrations may rebound, effectively negating the initial benefits of sediment removal.

Similar findings were reported in a study of a gate-controlled estuary in northern Taihu Lake, China. To minimize internal nutrient release, the authors recommended that "external pollution sources should be intercepted before or after sediment dredging" to sustain long-term reductions in nutrient loading (Chen et al., 10). This emphasizes the interconnectedness between internal and external nutrient sources; internal load reduction through dredging must be coupled with basin-scale nutrient management to achieve lasting water quality improvements. Another study of Lake Dongqian highlighted a potential unintended consequence: dredging may weaken a waterbody's nitrogen removal capacity within just three years, potentially due to the disruption of microbial communities and biogeochemical pathways responsible for denitrification (Jing et al., 173). The authors warned that if nitrogen removal efficiency declines while external nitrogen inputs remain high, in-lake nitrogen concentrations could exceed pre-dredging levels (Jing, 174). Furthermore, this suggests that sediment removal, while beneficial for short-term load reduction, can also destabilize the ecological processes that naturally regulate nutrient cycling.

Nutrient Release

Sediment resuspension during dredging operations can promote the release of nutrients from the benthic layer into the overlying water column. The rate and magnitude of this release are influenced by multiple interacting factors, including concentration gradients, hydrodynamic variability, temperature, pH, and bioturbation—each of which contributes to internal nutrient release under both static and dynamic environmental conditions (Gonzalez et al., 13).

A study of northern Taihu Lake examined nutrient release dynamics in dredged and undredged regions of the estuary under varying temperature and disturbance conditions. Under stable hydrodynamic conditions (low disturbance), total nutrient loading in dredged sediments was reduced by 13-28% relative to undredged areas, suggesting that dredging can diminish the sediment's internal nutrient release potential. However, when the system was exposed to wind-wave disturbances, "the beneficial effect of dredging was greatly reduced" (Chen et al.,9). This finding highlights the sensitivity of dredging benefits to physical forces, particularly in high disturbance systems where resuspension events are common. Moreover, nutrient release rates were positively correlated with temperature, indicating that thermal conditions amplify internal nutrient fluxes. Although dredged sediments showed lower release rates than undredged ones, both increased with rising temperature, suggesting that the stability of dredging benefits may be seasonally dependent.

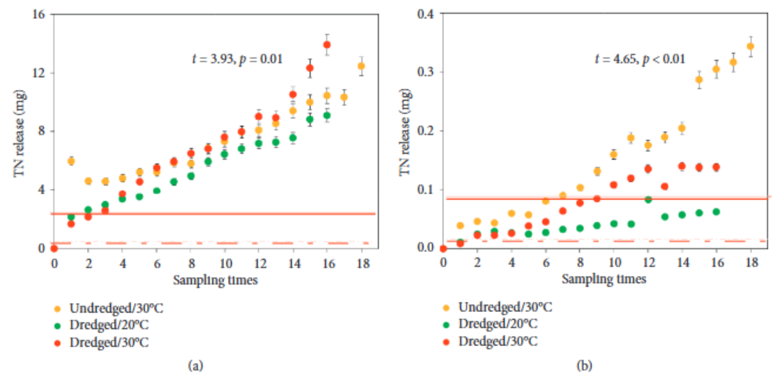

FIGURE 3: TN and TP static releases from dredged and undredged sediments. The broken line is the eutrophication threshold. The solid line is the nutrient concentration of overlying water in the field.

(Source: Chen et al., 2021)

A similar pattern was observed during a dredging operation in the Parana River, South America. Researchers recorded significant increases in nitrogenous compounds and total phosphorus across the access channel, maneuvering area, and discharge zone between pre- and post-dredge samples ($p = 0.045$) (Gonzalez et al., 8). Elevated nutrient levels were largely confined to the dredging period and immediate aftermath, with the system returning baseline conditions within sixty days. The authors warned that nutrient increases should nonetheless be monitored and “related to the possible risks of eutrophication processes that could occur downstream” (Gonzalez et al., 14). This temporal pattern suggests that while dredging-induced nutrient pulses are typically temporary, their downstream transport can temporarily alter nutrient availability and primary productivity in connected systems.

Comparable results were reported from a dredging operation in a South Carolina salt marsh. Water samples collected within the initial mixing zone and ~720 m downstream showed statistically significant differences in orthophosphate (OP), ammonium (NH4), and nitrate/nitrite (NN) concentrations during dredging (Lohrer & Wetz, 1159). Even after daily operations ceased, elevated nutrient levels persisted for roughly fifteen minutes, indicating a short lag before pre-dredging conditions were reestablished. Despite the measurable changes, the authors concluded that the biological significance was "probably minimal," as observed concentrations remained within the range of natural variability, and even peak NH4 and NN levels were an order of magnitude lower than historical maximums (Lohrer & Wetz, 1160-61).

Overall, these studies suggest that nutrient release during dredging is a temporary but potentially consequential process. While effects are generally localized and short-lived, their magnitude depends on site-specific conditions such as sediment nutrient content, water dynamics, and temperature. Systems with frequent disturbance or high legacy nutrient loads may experience recurring nutrient pulses that partially offset dredging benefits. Consequently, dredging projects should be paired with monitoring frameworks to capture short-term nutrient fluxes and evaluate downstream risks of eutrophication. Long-term nutrient management, including reductions in external nutrient inputs, remains critical to ensuring that dredging improvements in water quality endure.

Geomorphology

Tuttle Creek Reservoir is estimated to lose 89.9 percent of its storage by 2070 because of the sedimentation buildup within the reservoir. There is a study in place that investigates the

Tuttle Creek Reservoir WID being implemented to address this rising issue. One important highlight is understanding the direct and indirect effects of sediment releases on the geomorphology downstream because the results will be seen as variable in magnitude and duration (Harris and Hernandez-Abrams, 2024). The history of the Big Blue River can offer insight into how the channel has shifted over the years. There was a study that analyzed the Big Blue River downstream of Marysville and how the channel has changed over a 50-year period, ranging from 1956 to 2006. The two goals of the study were to understand and explain the spatial/temporal patterns associated with channel shifting and how that affects farmland erosion. The total variation found within the river shift was 2.75 to 70.1 meters across the fifty years, with the highest volumes during 1983 to 1988. The study found differences in the Big Blue River in comparison to other rivers. Typically, meander geometry and vegetation removal are prominent influencers of meander movement; however, this was not the case in this study, likely due to the presence of high vertical banks or bedrock along the west side of the river. The biggest contributing factor to channel shifting, meander movement, and land loss was annual flow peaks (Graf, 2008). This study takes place upstream of the Tuttle Creek Reservoir, but it can still offer insight into more about the river in general. High annual flow peaks seem to be a common factor for the river since the original reason Tuttle Creek Reservoir had a dam installed was for flood control. Despite the 50 years of change, the river still holds resilience, and the same can be said for the future of the river, despite the channel shifts that may come.

Methods

Water Quality Sampling

To evaluate downstream water quality impacts associated with water injection dredging (WID) at Tuttle Creek Reservoir, surface water samples were collected from the Kansas River and the Big Blue River. Sampling was conducted along the Kansas River upstream of its confluence with the Big Blue River and continued through the confluence and along a downstream reach of the Big Blue River. Samples collected from the Kansas River served as upstream control measurements, as this reach is hydraulically independent of Tuttle Creek Reservoir. Samples collected downstream of the confluence represented conditions potentially influenced by the dredging operation due to the Big Blue River's direct connection to the reservoir.

Water sampling was conducted on three occasions corresponding to distinct phases of the WID operation. Pre-dredging samples were collected on September 17, 2025. Samples representing conditions immediately following dredging were collected on September 27, 2025. Post-dredging samples were collected on November 7, 2025, approximately 1.5 months after completion of the WID operation.

All samples were analyzed in the laboratory for total suspended solids (TSS). For each sample, approximately 60 mL of water was filtered through a pre-weighed filter paper. The filters were dried in an oven at 100 °C for 24 hours, allowed to cool, and reweighed using an analytical balance. Total suspended solids concentrations were calculated using the following equation:

$$\frac{Weight_{final}(g) - Weight_{initial}(g) \times 1{,}000{,}000}{Sample\ Volume\ (mL)} = mgTSS/L$$

Where:

- *Wf* is the final weight of the filter after drying (g),
- *Wi* is the initial weight of the pre-weighed filter (g), and
- *SV* is the volume of sample filtered (mL).

The difference in filter mass represents the mass of suspended solids retained on the filter.

Filtrate from each sample was retained and submitted to the Kansas State University Soil Testing Laboratory for nutrient analysis. Samples were analyzed for nitrate-nitrogen (NO_3–N) and orthophosphate (Ortho-P) concentrations. Analytical results were compiled in Microsoft Excel and used to generate boxplots for visual comparison of water quality conditions. Boxplots were created for each constituent (TSS, NO_3–N, and Ortho-P) across the three sampling periods (pre-WID, during WID, and post-WID), resulting in a total of nine plots.

Statistical analyses were conducted using the Mann-Whitney U test to evaluate differences between upstream and downstream concentrations for each constituent during the pre- and post-WID periods. Samples collected during the dredging period were excluded from statistical analysis due to insufficient sample size. In total, six Mann-Whitney tests were performed, one for each constituent during the pre- and post-WID periods, to assess whether observed differences were statistically significant. The results of these analyses are presented below.

U.S. Geological Survey (USGS) Streamgage Data

Some of our data comes from the stream gauge data collected by the USGS. A stream gauge is a structure built along a river that houses various equipment to measure stream flow and water level changes. The streamgage is typically recording measurements every fifteen minutes. If there is more intense rainfall, stream gauge measurements can be recorded every five minutes for a minimum time. The data is transmitted every one to four hours to USGS computers and at a minimum of every fifteen minutes for emergencies. Discharge is the volume of water that is flowing downstream per unit of time, which is typically expressed in cubic feet per second or gallons per day. Discharge data is calculated by taking the area of the stream channel multiplied by the velocity of the cross-section (*Stream gauging basics)*. For our report, we recorded the data taken at the USGS stream gage sites in Wamego, Ogden, and Fort Riley. We recorded the dates, ranging from 10/30/2024 to 10/30/2025, and converted the 15-minute intervals into daily averages. We put the data into various graphs to compare discharge with turbidity, dissolved oxygen (DO), and nitrate.

Results

Our results are illustrated below in our various figures. In figures 1 to 3, these results are based on the samples that we collected from the Kansas River upstream and the Big Blue River downstream prior to the WID, during the WID, and after the WID. Figure 1 highlights the results from our TSS. The TSS appears to have decreased following the WID, but it still fluctuates within a normal range prior to, during, and after the WID for the upstream and downstream samples. Figure 2 illustrates the NO_3–N results, which also fluctuate within a typical range for before, during, and after the WID. The NO_3–N is well within the safe drinking water limit for

Kansas, which is 10 ppm. Figure 3 explains the Ortho-P results that we sampled. The Ortho-P appears to be slightly lower during the WID, but it still fluctuates within a typical range before, during, and after the WID for the upstream and downstream samples. Figure 4 tells us the calculated probability value (p-value) for the TSS, NO_3–N, and the Ortho-P. All the calculated p-values are above 0.05, so the results are not statistically significant. This means that any observed effects are likely due to random chances.

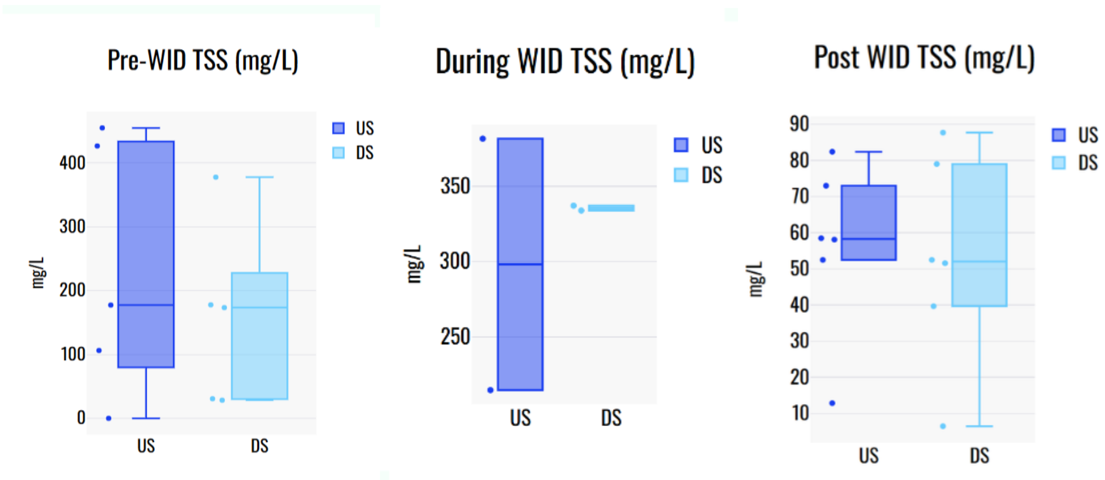

Figure 1

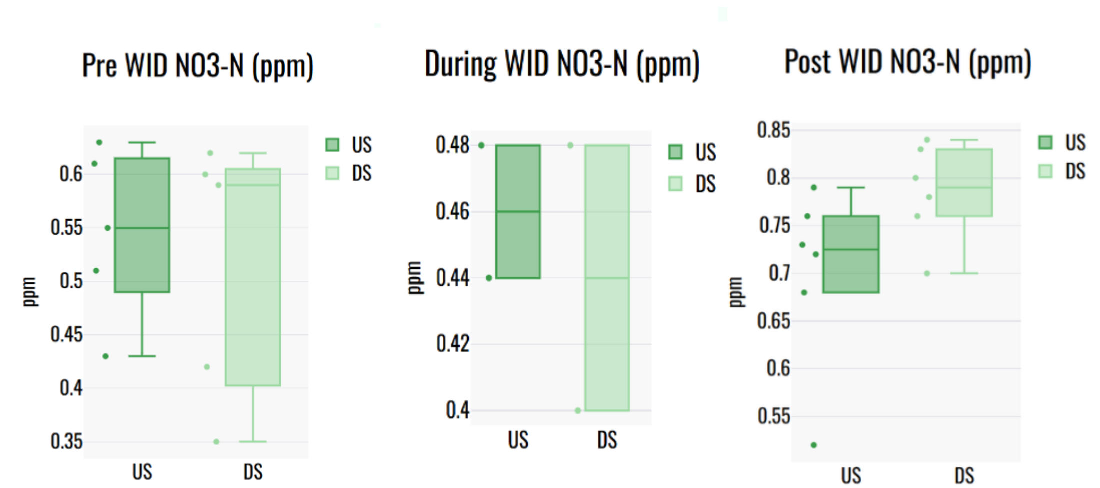

Figure 2

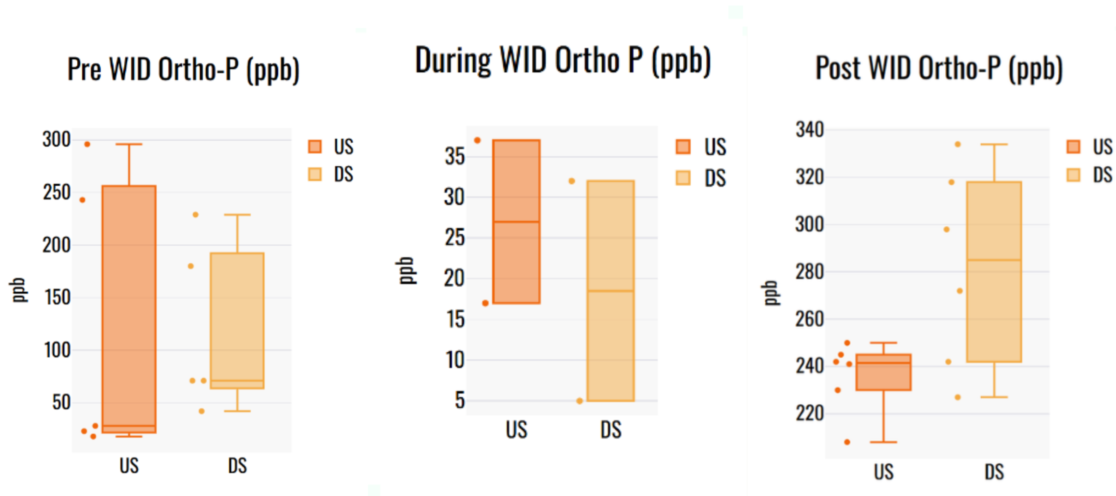

Figure 3

Results

Our Samples for Pre and Post WID: No statistically significant differences

	Pre WID	**Post WID**
TSS	p=0.6905	p=0.6303
NO3-N	p=0.6905	p=0.0776
Ortho-P	p=0.6752	p=0.1087

Figure 4

In figures 5 to 9, these graphs are based on the data provided by the USGS streamgage sites, with the dates ranging from 10/30/2024 to 10/30/2025. We also added a shaded bar to each graph to indicate the WID period from 9/17/25 to 9/27/25. Figures 5 to 7 focus on the USGS streamgage sites on the Kansas River in Wamego, which is downstream of Kansas River. In figures 5 to 7, discharge shows a sharp storm peak right before the WID period occurs, and when it starts, the discharge visibly slants and stays a bit more elevated during the WID. DO and turbidity seemingly have very little change during the WID period. However, nitrate seemed to be slightly elevated during the WID period. For figures 8 and 9, we used the USGS streamgage data at the Kansas River in Fort Riley for discharge and Ogden for the DO and turbidity. Both of these sites are upstream of the Kansas River. The discharge seems to remain slightly more elevated during the WID period, but there is little change within the DO and turbidity. There was no nitrate data available for either site.

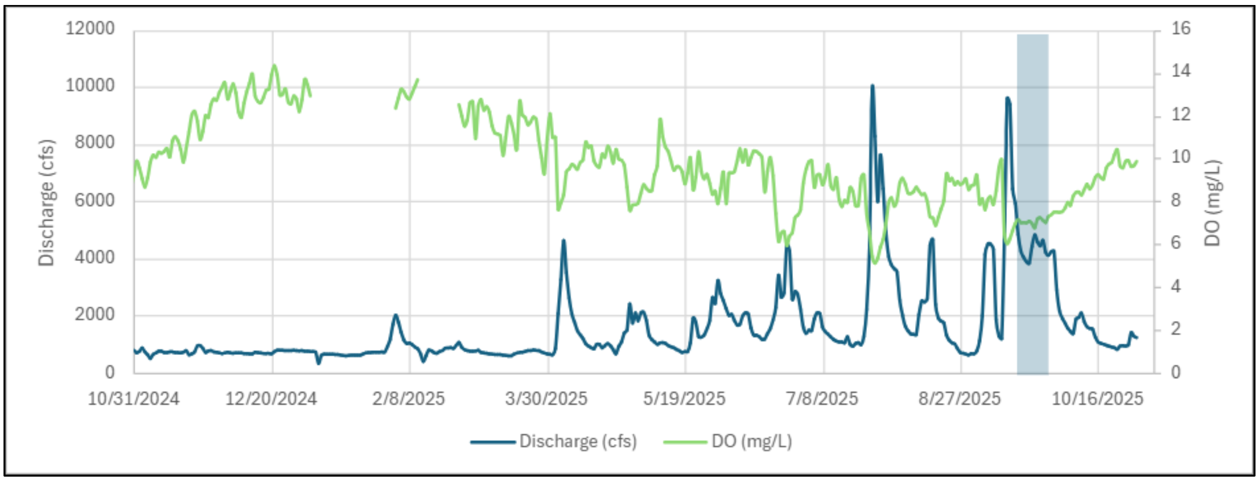

Figure 5

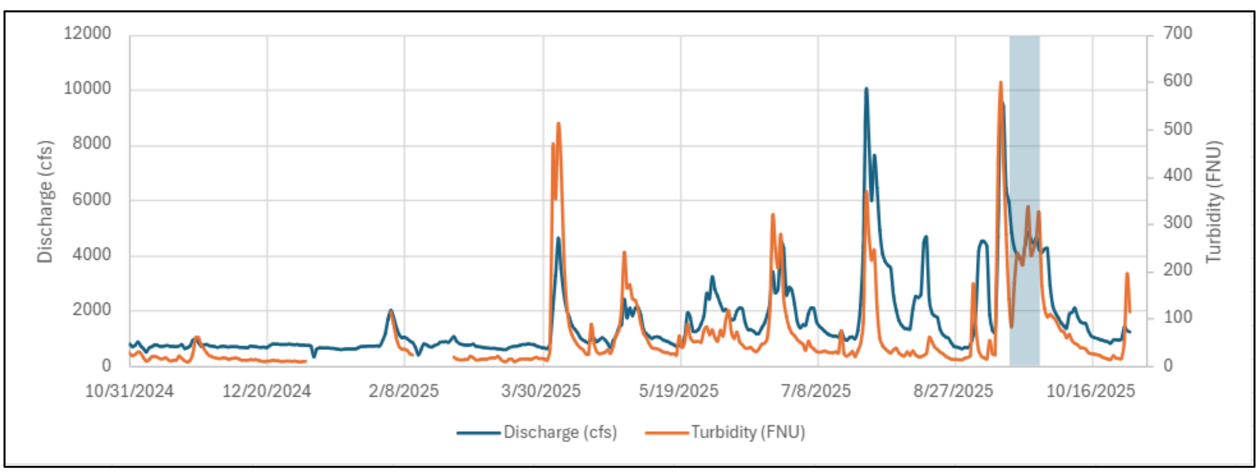

Figure 6

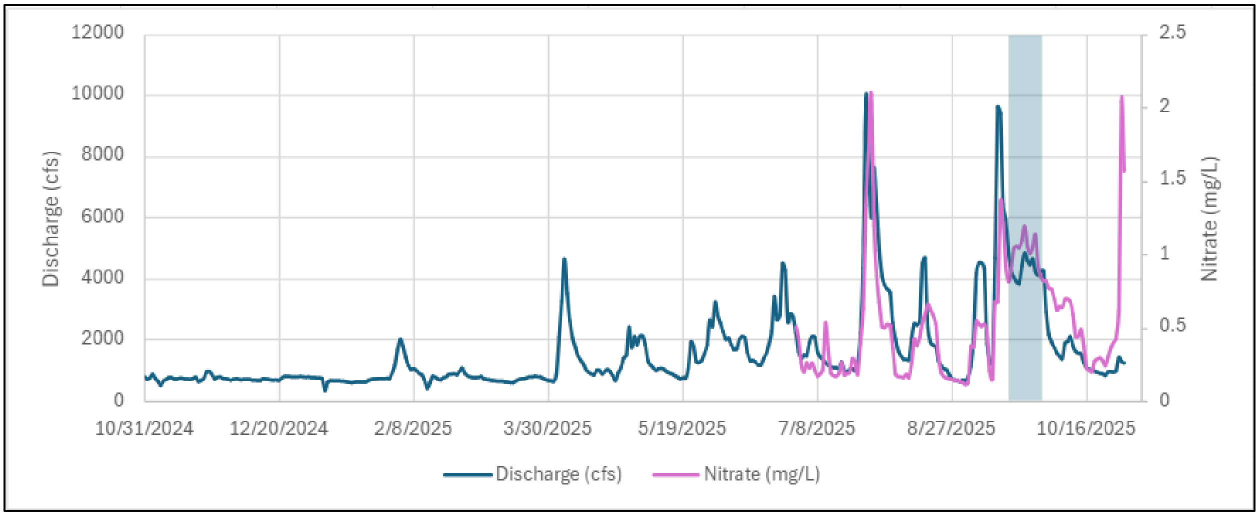

Figure 7

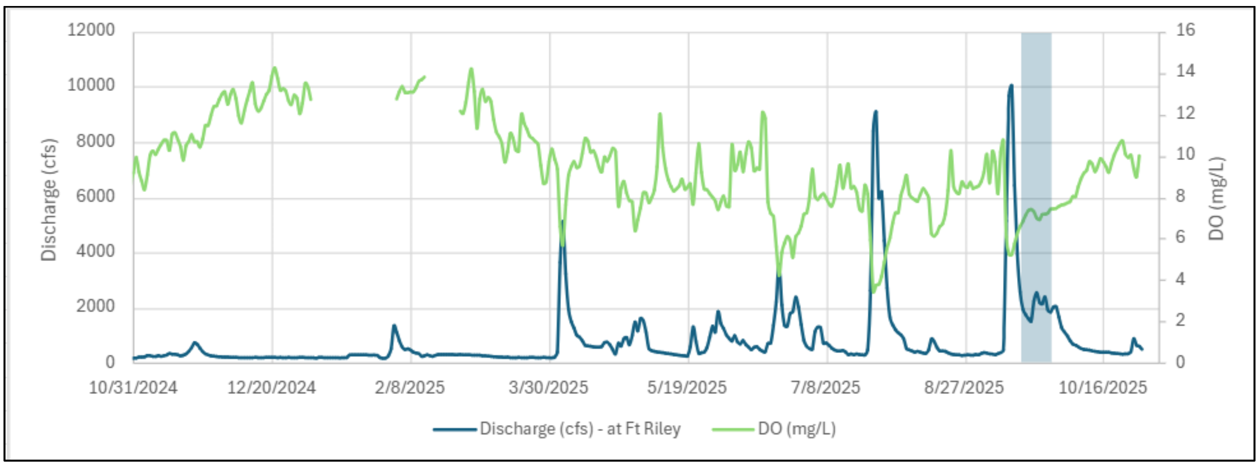

Figure 8

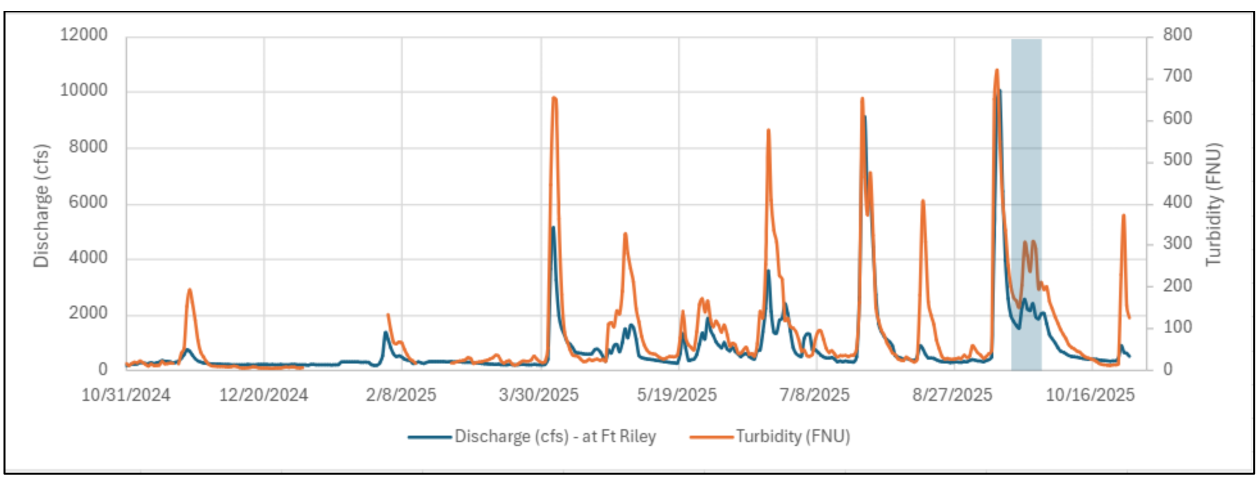

Figure 9

Discussion

We had stream gauge data collected from several graphs and figures displaying the data we had collected from our sampling methods. Both upstream and downstream sections of the Tuttle Creek Reservoir were analyzed for their nitrates, orthophosphates, and the amount of TSS (total suspended solids). We used box-and-whisker plots to best visualize how our data was portrayed over the different time periods of pre-WID, during WID, and post-WID. In doing so, we can best see the spread and distribution of our different points of data. To best compare our data points, and figure out if the data points are significantly different enough to see if our hypothesis was proven true, we must use the Mann Whitney Test.

The test itself is a nonparametric, statistical study used to compare two independent groups of data to see if one groups' data tends to be higher than the other. What we discovered was that none of the samples and data we measured were found to be significantly different. This means that looking at the short-term impacts, while the TSS or the Nitrate's may have spiked at certain periods of time during the WID or after, overall, there are no long-term, overall effects that could be found from the samples we have measured out. Peaks in our USGS gauge data are still within the maximum ranges of discharge, which could be a consequence of the amount of discharge that was occurring during WID, which is something that we aren't able to control. While this data may seem inconclusive and purposeless, it shows that further research should be done to further determine the effectiveness of WID on freshwater reservoirs.

Communicating Results to the Public

How do we get the public to invest the time and interest in the WID project? It's important to consider the best ways to conduct environmental outreach in order to create messaging that is both educational and effective. The three main environmental outreach considerations we will address today are: stakeholders and their motivations, how a regional identity impacts how an audience view environmental issues, and strategies and benefits to encouraging engagement from the public. We will then discuss how these ideas apply to the water injection dredging process done at Tuttle Creek Reservoir.

Stakeholders and Motivations

In a 2009 literature review, communication professor at Northern Michigan University J.G. Cantrill combined various studies to determine how to effectively communicate complex environmental ideas. He determined that one of the primary factors in successfully communicating potentially complex or controversial environmental topics is correctly identifying your audience and their motivations. There were four constants that he found in his research, and they are as follows.

"One: Most people are relatively anthropocentric in their orientation to the world and believe that dominion over the environment grants them the right to use science and technology to develop resources without concern for the ultimate consequences of such development. Two: The public understands a great deal about the environment, yet this knowledge is poorly organized, often biased in favor of the dominant social paradigm, and seldom results in individuals taking personal responsibility to rectify environmental problems. Three: Persons generally act considering their perceived self-interests, and those interests serve as foundations for constructing and attending environmental advocacy, reasoning about how to act, and engaging in political or social activities. Four: Individuals habitually misinterpret the values and arguments of those who advocate environmental policies which seem to violate deep-seated world views, existing beliefs, and self-interests in the environment" (Cantrill, 2009).

Therefore, in order to communicate effectively, environmental advocates should identify key players as well as identify their self-interests and beliefs regarding the environment. From there they should construct a communication method that shows how whatever action or policy being proposed will support the progress of stakeholders, provide people a space to consider the similarities and differences to those they see as contrary to their goals, focus on motivational handicaps of key players, and provide directions for easily adopted actions which support the desired policy or action.

In the case of Tuttle Creek, it is imperative to recognize the wide range of stakeholders being catered to. There is the general population of Kansas who uses the Big Blue and Kansas Rivers as a water source, Manhattan residents who use Tuttle for recreation, the U.S. Army Corps of Engineers, the Kansas Department of Wildlife and Parks, private landowners, and more. Understanding that all these groups have different motivations and priorities will help identify common goals and help policy makers determine how to best appeal to the public.

Regional Identity

In a 1998 research study, 43 people in the Lake Superior Basin were interviewed and asked about how they defined a sense of “place” regarding the environment and how that shaped how they saw environmental policy at large. It was found that an individual's “sense of place” and beliefs connecting the self to a larger ecosystem play a key role in the process of attending advocacy regarding policies on natural resources. Based on the results of this study, researchers concluded that even within relatively compact communities, perceptions on how someone fits into the natural world are complex and not amenable to simple marketing segmentation practices that are commonly seen in policy promotion. It was thus determined that to present new environmental information in the most effective way possible, advocates must identify what constitutes a specific sense of place for target audiences. They must section their audience(s) and highlight the “social” or “natural” benefits to be gained when moving towards sustainable environmental policies.

In the context of WID at Tuttle, a major consideration for outreach is how the potential impacts of the process will affect the local Manhattan community relative to their sense of regional identity. Manhattanites value their outdoor spaces, and a process such as WID that disrupts the natural environment of a popular recreation area for an undetermined amount of time can be a difficult topic to broach. Fortunately, knowing the regional identity and culture of the area can help environmental advocates and policy makers appeal to the local community of Manhattan, KS.

Encouraging Engagement: Strategies and Benefits

Like with any field or industry, there are many strategies environmentalists can use to appeal to their audience. One major one is using graphics, photos, and other visuals to help convey potentially complex ideas or data to a wider audience than they may not have been able to connect with otherwise, which is what we aimed to do with our graphs.

Another is to implement the use of democratic discourse over the top-down approach many organizations have currently. In a 2010 essay by Robert Bulle, it combines sociological/psychological literature, and theoretical and empirical research to focus on how democratic civic engagement is the core to seeing successful change in environmental efforts. This is contrary to what many have done in the past, where they focused on identity campaigns as a way to incite change in the environmental sphere. He argues that this process centers the elite and leads to one way of communication, which fails to allow civil discourse or public dialogue.

The top-down identity campaign approach leads to messaging that is dominated by mass advertising techniques that are accessible to very few. This mass advertising in turn generates popular public opinion and discourages messages opposing from the mainstream, therefore disallowing any real substantial change. He says that the way to combat this is we need to have a broad democratic discussion to develop common goals. From there we can create advertising or outreach with the help of an informed and engaged community, which promotes education and greater awareness of long-term community interests. In our case, Facebook posts put out by the U.S. Army Corps of Engineers months before the WID allowed for open discussion on what the public thought of the idea, however informed they were.

Using a combination of these strategies has multiple long-term benefits for how the public will view and engage with not only any potential future WID projects in the area, but also the system management of Tuttle Creek as a whole. When audiences feel that their viewpoints are being considered and their concerns listened to, it creates a positive loop between the people and the governing bodies responsible for watershed management at Tuttle Creek Reservoir. This more direct line of communication also fosters a higher level of community interest that will be maintained long-term.

Conclusions/Future

In conclusion, we found that the WID process showed no statistical long-term impacts on the levels of total suspended solids, nitrate, and phosphate at the Tuttle Creek Reservoir. Because the observed peaks in data in our graphs were attributed to pulses and discharges of water during the WID process, more studies would be needed to determine whether water injection dredging is a viable option for sedimentation and nutrient management in a freshwater ecosystem. The fact that the WID process is still new, uncharted territory for freshwater ecosystems like Tuttle Creek, and the fact that our research shows that both nutrients and TSS seeming unaffected in the long term at this specific point in time, means that it still proves to be useful data for future researchers. The purpose of this pilot operation conducted by the US Army Corps of Engineers was to address both sedimentation and the total storage capacity in the reservoir, which both are major risks when it comes to the sustainability of Tuttle Creek. The data we have collected and visualized with graphs today can only be shown as a call to action for any future studies to be conducted on the Tuttle Creek Reservoir which still, to this day, is vital to over 40% of all Kansas residents for flood control and water operations (U.S Army Corps of Engineers, 2024).

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