NKWD Reservoir Sedimentation Control at the Fort Thomas Treatment Plant North Reservoir

University of Cincinnati Environmental Engineering

Final Design

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Executive Summary

The objective of this project was to determine an optimal solution for reservoir sedimentation control at the Northern Kentucky Water District's Fort Thomas Treatment Plant (evaluation phase) and to create a design for implementation of the chosen method (design phase). Alternatives that were analyzed in detail were Lamella plate settlers, weirs installed in the reservoir, hydraulic dredging, aeration and mixing of the reservoir, "status quo" excavation, and dredging with a SediCon dredge. Criteria used to evaluate the alternatives were cost, performance, operation, lifecycle, neighborhood impact, and proven effectiveness. The sedimentation control methods being considered were scored for each criterion, and the highest-scoring alternative was chosen. Bluegrass Water Consultants recommended the SediCon dredge for sediment control in the District's Fort Thomas Treatment Plant North Reservoir. During the design phase of this project, flow routing and utilization of plant processes for slurry thickening was analyzed. Deliverables from the design phase included a proposed layout for the pipes that are to convey the slurry to storage and treatment and an Excel workbook to determine flow routing based on available capacity.

1 - Introduction

1.1 - Problem Statement

Bluegrass Water Consultants (BWC) is responding to a request for proposal from the Northern Kentucky Water District (NKWD) regarding an optimized reservoir sedimentation control solution for the North Reservoir at the Fort Thomas Treatment Plant (FTTP). The current, or “status quo”, approach being used at the FTTP involves periodic excavation of the reservoir after sediment has accumulated. Though this technique is effective, gradual buildup of sediment over the years reduces storage capacity and requires the reservoir to be completely taken out of service during excavation. The goal of the evaluation phase of the project was to “evaluate available technologies to minimize sediment deposition or simplify sediment removal from the reservoirs” [1]. After the best alternative was chosen, the goal of the spring semester was to develop a design and implementation plan for the alternative. This report summarizes the work that was done in the fall semester which was reported on in the “Evaluation Phase Findings” report and then explains the design and implementation plan that was developed for the chosen alternative.

1.2 – Site Background

NKWD owns and operates the Fort Thomas Treatment Plant in Campbell County, Kentucky. FTTP pumps water from the Ohio River into two different reservoirs, the North Reservoir, and the South Reservoir. It is estimated that a maximum of 65 MGD can be pumped to the reservoirs. The reservoirs serve to store water before treatment in the FTTP and subsequent conveyance to customers in Northern Kentucky. FTTP has a maximum treatment capacity of 44 MGD and the reservoirs at FTTP have a total capacity of 70 million gallons. When water from the Ohio River is pumped into the reservoirs, sediment settles onto the bottom of the reservoirs. Prior to the ongoing excavation of the North Reservoir, approximately 135,000 tons of sediment accumulated at the bottom of the reservoir. It is estimated that 2,500 tons accumulates per year in the North Reservoir. A substantial amount of backwash water from the plant contributes to the sediment that accumulates in this reservoir, though the exact amount from the backwash is unknown.

1.3 – Sedimentation Overview

Reservoirs are an essential component of water supply systems around the world. They serve to store water for domestic use, regulate river flows, and can occasionally act as a source of energy through hydropower production. All streams and rivers transport sediment from upstream sources. Sediment is naturally deposited into rivers from runoff but can be exacerbated by such human-induced activities as agriculture, mining, construction, and logging [2]. When rivers and streams are dammed off to create reservoirs, the natural transport of sediment is interrupted. Over time, sediment gradually builds up in reservoirs and diminishes the capacity of the reservoir to store water. This process is known as sedimentation. Not only can sedimentation reduce a reservoir's storage capacity, it can also lead to burial of dam outlets, damage to hydropower equipment, increased flood levels upstream, and degradation of downstream channels [2].

In the US, a large portion of reservoirs were constructed many decades ago and the effects of sedimentation were not wholly understood. Most of the nation's reservoirs were sized to store sediment over the "sediment design life" of typically 50 to 100 years [2]. This may have at once seemed to be a long time, but many utilities that rely on reservoirs for water storage, such as NKWD, are now faced with finding solutions to the sedimentation problem. Reservoir sedimentation is not unique to the US, though. According to White, *Contributing paper flushing of sediments from reservoirs*, the worldwide loss of reservoir storage capacity from sedimentation is estimated to be around 0.5% to 1.0% annually [3]. This therefore demands management strategies to ensure the availability of surface water for domestic use.

NKWD draws water from the Ohio River just east of Fort Thomas, KY (Figure 1-1). The Ohio River is a major source of water in the US and is a source of drinking water for over 5 million people [4]. Common sources of pollution in the Ohio River include urban runoff, agricultural runoff, and abandoned mines [4]. These activities contribute to the levels of sediment in the river and contribute to the composition of the sediment. Because NKWD takes water directly from the river, the particles in the water settle out directly into their reservoirs.

Figure 1-1: *NKWD Ohio River Intake Location (Source: Google Maps)*

Many strategies are used to combat the issue of reservoir sedimentation. One of these strategies involves sediment bypassing wherein sediment is diverted from the incoming water around the reservoir to the downstream river. Sediment sluicing involves high flows of water discharged from the dam during periods of high inflows to cause sediment to flush through and not accumulate. In contrast to sluicing which focuses on preventing sediment accumulation, drawdown flushing removes sediment by emptying the reservoir then flushing the built-up sediment via high flows of water. Other strategies include check dams, small dams upstream of the reservoir that serve to remove sediment before it reaches the reservoir, and dredging, which removes sediment through suction [5]. In BWC's literature review, most of these strategies were used for reservoirs created by dams. Yet, these concepts can be applied through similar strategies at the North Reservoir of the FTTP.

1.4 - Scope of Issue

The two reservoirs at the FTTP are essential to the plant's operation and to community security. The reservoirs provide sediment pre-treatment and storage of river water before it enters the primary treatment process. In situations where water cannot be pumped from the Ohio River, the reservoirs can serve as an emergency supply to mitigate the risk of a water shortage for the residents of Northern Kentucky. It has been almost sixty years since the reservoirs have been cleaned of solids, and over the last twenty years solids have been settling in the reservoirs at a much faster rate. This recent increase of solids in the last twenty-years is due to backwash from the gravity thickeners being sent to the reservoirs as a disposal method.

Though the reservoirs enable solids to settle before water is pumped to the treatment plant, this process has many drawbacks. A geotechnical analysis was performed by Geotechnology, Inc. on the North Reservoir in May of 2021, which concluded that 114,000 CY of sediment have settled since the reservoir was last excavated. In order to recover the lost storage in the North Reservoir, NKWD is taking the "status quo" approach wherein the reservoir is completely drained and excavated. Figure 1-2 illustrates how the south side of the North Reservoir looks when excavation is being performed. This process is estimated to cost $2,300,000 and take up to two years to complete. NKWD also plans to drain and excavate the South Reservoir at the FTTP, as well as the two reservoirs at the Memorial Parkway plant over the next 10 years.

Figure 1-2: North Reservoir at FTTP (9/21/21)

BWC has reviewed Lamella plate settlers, weirs, a boat dredge, automated removal, aeration, and gravity powered hydro suction dredges as possible future solutions versus the status quo of periodically draining the reservoirs and excavating the solids. The following sections of this report describe our evaluation of possible options, basis of designs, and an alternative analysis of the various alternatives.

2 - Alternative Analysis

2.1 - Alternatives

BWC performed a literature review and alternative analysis to determine NKWD's best sedimentation solution. NKWD requested that BWC analyze Lamella Plate Settlers, a weir system, dredging by a boat or an automated robot, installing an automated sediment removal process, aeration, and the status quo of draining and excavating. BWC also had the freedom to research other potential solutions and found the SediCon dredge. During the literature review process BWC finalized seven different implementation scenarios and performed an alternative analysis on them. When performing the analysis BWC included NKWD's input on weights, criterion, and categories to ensure their needs were met.

2.1.1 – Automated Removal

Upon researching the scraper, screw pump, and sediment removal robots; it was decided that automated removal, did not hold up in the current application and were therefore removed from consideration.

The scraper was eliminated from further consideration because of the shape of the basin, lack of similar applications, and uncertain effectiveness. In order for a scraper to be effective, it is necessary to cover the entire area that accumulates sediment. The basins at NKWD do not have a straight-line path that can be utilized to remove sediment. This would result in some areas not being scraped and large sediment build up on the sides, which could eventually build up to a point where draining and excavation is necessary or to where the scraper would get stuck and break. Additionally, the bottom of the reservoir would need to be reshaped and repoured to get a smooth scrapable surface. Solving these issues would involve demolition of the current reservoir floor and rebuilding in a conformable troughlike shape.

The screw pump was eliminated from further consideration because the water-to-sediment content of the removed material was too high. The water being removed from the screw pump would not have a significant amount of sediment in it to assist in the removal process. Additionally, any sediment removed would be from one area where the screw is installed, and the remainder of the reservoir would continue to accumulate sediment.

The sediment removal robot was eliminated from further consideration because of the lack of similar applications, and the design intent of the alternative (Figure 2-1). Sediment removal robots have been used to clean tanks and are effective at removing sediment build ups and piles but have not been shown to be able to remove sediment in similar applications to the NKWD reservoirs. BWC could not confirm that the robots would be able to handle the sediment loads seen in the North Reservoir or be able to cover areas such as that of the North Reservoir. Reaching out to multiple manufacturers about capabilities and processes resulted in either no response or dismissal after explaining the desired application.

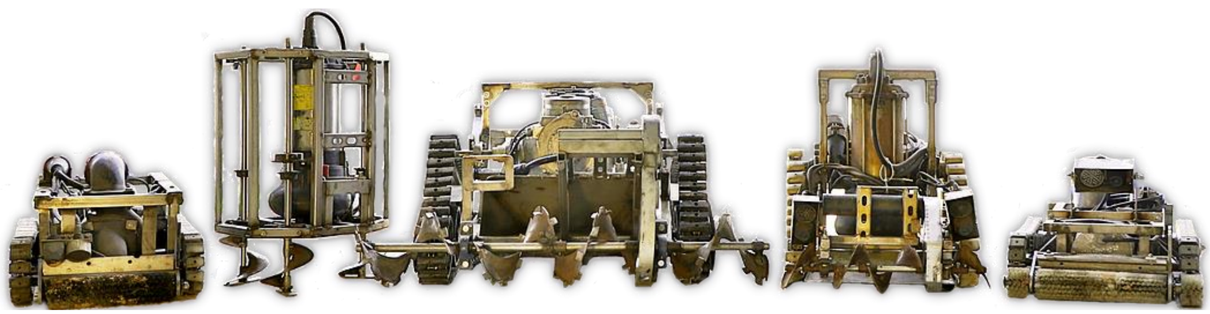


Figure 2-1: Scantron Robotics Sediment Removing Robots

2.1.2 - Lamella Plate Settlers

Lamella plates settlers are commonly used in water treatment to reduce sediment. Lamella plates settlers are inclined plates that increase solid particle settling by increasing surface area and reducing the settling distance [6]. The main advantage to lamella plate settlers is the high turbidity reduction in a small area of space. Figure 2-1 depicts how water flows through lamella plate settlers and the processes involved in removing sediment.

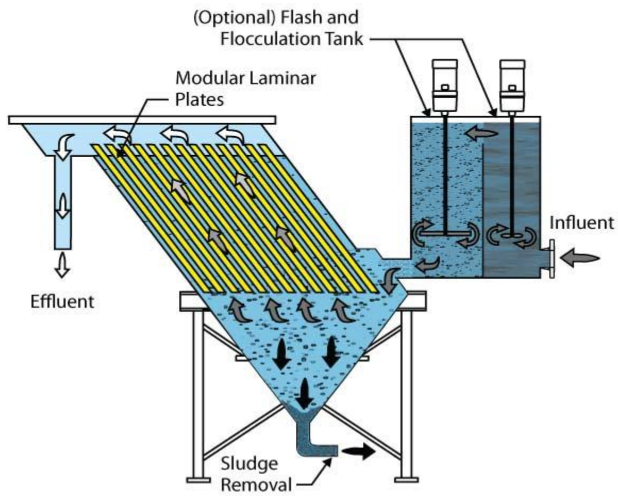


Figure 2-2: Lamella schematic [7]

In this system a solid/liquid stream is first pumped into a mixing and flocculation tank. Flocculation occurs when a flocculation polymer is added to a stream of water to help particles adhere to each other to produce larger clusters. In this process, a flocculant is added and is rapidly mixed into the stream. This process is used in conjunction with lamella plate settling to promote greater settling of particles. After flocculation and mixing, the stream moves into the lamella clarifier tank. In the lamella plate settlers, water travels up through the lamella plates. The particles then fall into a sludge collector and can be pumped to a solids handling facility. The effluent water exits through the top of the lamella plates and travels to the next phase of water treatment. Lamella plates have been shown to remove up to 90% of solids [6]. The main objective of lamella plates is to reduce turbidity. The turbidity reduction is influenced by the concentration of particles in the influent stream, lamella tank design, and residence time of water in the lamella tank. Turbidity reduction efficiency can be increased by putting the lamella plates closer together, increasing the residence time in the lamella tank, and having a higher concentration of solids in the influent stream [6].

A new lamella plate settling facility would cost NKWD around $16.9 million over ten years. See appendix 7.4.1 for detailed cost breakdown. The Lamella plates main advantage was their performance in reducing solids in water. They can remove up to 90% of solids with no energy required [6]. The lamella plates would also be able to reduce the sediment load in both reservoirs because they would treat the water before they get to the reservoirs.

2.1.3 – Weir

A weir is a structure built across a moving body of water that disrupts the flow in a desired way [8]. The slower flow of water allows suspended sediment in the water to settle due to gravity. The sedimentation that occurs in front of a weir is influenced by the velocity of the water, the slope of the reservoir bed, the height of the weir, the total amount of suspended solids in the water, the particle size of the sediment, and other factors [9].

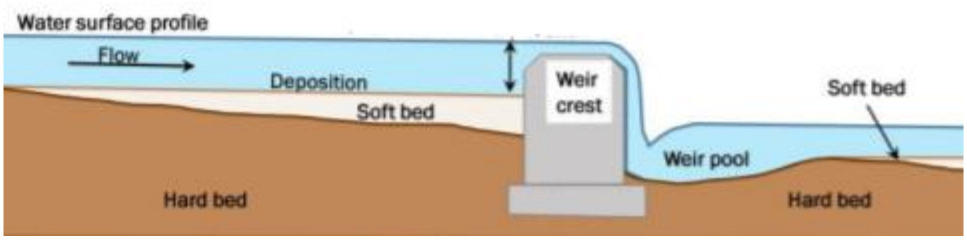


Figure 2-3: Profile of Weir Sedimentation [10]

Generally, weirs in reservoirs are built for hydropower or to regulate the flow of the reservoir. In BWC's literature review, weirs were not found for use of trapping sediment. Despite this, weirs can be used to control sedimentation. The accumulation of sediment in reservoirs can cause structural concerns on dams or weirs. Weirs can be made of concrete, steel, or earthen material composed of soils, clay, or rock. Concrete is generally used in large dams because it is best under compressive stress [11]. Steel is very strong and takes up a smaller space than concrete, so it is generally used for smaller weirs along a water treatment process. Earthen dams are constructed in a trapezoidal shape out of earthen materials [12].

The concrete weir was determined to be the optimal weir option for NKWD. A new concrete weir cost was estimated to be $5.2 million. The main advantages to a concrete weir were the low cost and low maintenance once it was built. Also, the concrete weir would allow the reservoir to be sectioned off, allowing for easier dredging of sediment.

2.1.4 - Boat Dredge

Dredging is the removal of settled solids from a water environment. Two methods of dredging that can be performed from a boat are mechanical dredging and hydraulic dredging. Mechanical dredging involves the use of an excavator or crane situated on a barge that is able to pull up sediment and then load it onto the barge; this method is impractical in the NKWD reservoirs because of their sloping profile and small size relative to typical applications (e.g., locks and dams). Hydraulic dredging involves the use of pumps to convey solids in the form of a slurry from the bottom of a water environment. The slurry from the pump is transported to a dewatering system prior to final disposal [13]. Options for hydraulic dredging by boat include pumps transported by boat and "boat dredges", which are boats with installed dredging equipment [14]. "Boat dredges", while beneficial in the fact that parts are less expensive to replace than purchasing new pumps, are typically diesel-powered and do not provide the reach needed for the reservoir being examined. Moreover, diesel-powered or gasoline-powered boats cannot be used on the potable water reservoirs due to potential contamination.

Of the methods researched, hydraulic dredging by a pump that is transported by an electric-powered boat is most feasible. NKWD has used this option before, so adjustments would be made to the process based on the issues that have previously been encountered. Some former fallbacks include management of the power cable with variable water levels and the batch process dewatering method (geotubes) being unable to keep up with accumulation of sediment in the reservoir.

Design of this option would include a boat with an attached electric motor powered by rechargeable batteries, an on-board pump that is to remain connected to the North Reservoir's existing power cable, floats for the power cable, and conveyance of the slurry to a gravity thickener. To combat the changing water level of the reservoir, the power cable would remain fully extended and would have floats attached to it every 5 feet. Based on pump capacity of 100 gpm at 50 ft of assumed head [15] and assumed 12% solids pumped [16], the daily run time would be approximately 1.25 hours.

2.1.5 - Aeration and Mixing

Reservoirs often stratify meaning different layers form that have varying water temperatures, dissolved oxygen levels, and other differences in water quality. Aeration is a common practice for destratifying reservoirs and promoting greater dissolved oxygen levels. A research group in China found that a water-lifting system used in the Jinpen Reservoir removed stratification, increased dissolved oxygen, reduced TN, TP, and TOC, and improved the microbial structure of the reservoir [17]. Companies such as Clean-Flo produce aeration systems that cause these types of improvements. Clean-Flo's system eliminates blue-green algae, increases dissolved oxygen, and reduces phosphorus and nitrogen [18]. Their laminar flow system is meant to prevent any increase in total suspended solids in the reservoir, which is the opposite effect that NKWD desires for the

North reservoir. No examples were found of reservoir aeration that aims to keep sediment suspended before treatment.

BWC analyzed a system proposed by Kasco for sediment control in the North Reservoir. The system consists of seven different mixers along the outside edge of the reservoir, while three diffusers run in the middle of the formation [19]. In Figure 2-4, the red squares indicate a mixer, and the blue circles indicate diffuser locations and their lengths from the cabinet. The quoted equipment cost of the aeration system is $74,468 [19]. BWC estimates the 10-year total cost of the entire system to be $3,400,000 [See Appendix 7.4.2]. The costs in addition to the capital cost quoted by Kasco include solids disposal, electricity, installation, maintenance, contingency, a new gravity thickener, and an additional additive to account for the plant's additional solid handling demands created by this system. The advantages of the system are that there is no reservoir downtime and there is low maintenance with a simple operation. However, this system creates more stress on the plant and the lack of existing examples does not render this alternative as proven effective.

Figure 2-4: KASCO aeration plan layout [19].

2.1.6 - SediCon Dredge

A new alternative that was explored during the alternative analysis phase was a dredge produced by the Norwegian company SediCon. The dredge utilizes a natural head difference between the water surface of the reservoir that it is dredging and the outlet of the dredge. This head difference which must be greater than 10-m, creates suction that draws sediment by suspending it in a slurry and discharging it through the outlet pipe. SediCon was founded in the early 2000s, but it has already conducted over 25 projects across five continents, though none have taken place in the United States.

After SediCon reviewed the conditions and spatial constraints of the North Reservoir and FTTP, SediCon recommended a semi-automatic 8” ejector dredge depicted in Figure 2-5. The dredge has a 30-year expected lifespan and can be moved to other reservoirs. One person is needed to remotely operate the dredge with a computer. It was originally determined that the dredge would output directly to the gravity thickeners because this process was thought to be the most capable to treat the solids. Therefore, the estimated discharge capacities of dredge were determined based on the difference in elevation of the reservoir at 802 ft and the gravity thickeners at 740 ft. During the design phase, BWC explored other options for treatment and storage of the slurry.

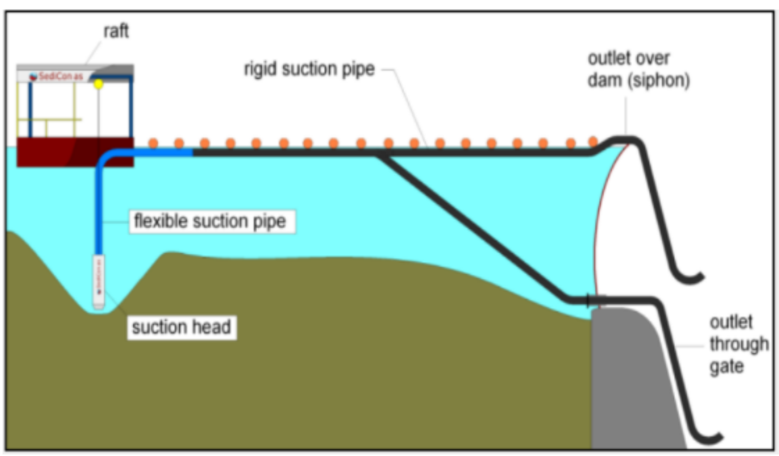


Figure 2-5: SediCon dredge depiction with two outlet options
Image courtesy of SediCon Dredge pamphlet [20]

SediCon estimated that the dredge can remove an average of 26 tons per hour (English tons) with the given elevation difference and can discharge roughly 70-100 kg per cubic meter of slurry, or 4.4 to 6.2 pounds per foot cubed. The dredge can be customized for desired flowrates and slurry solids content but the difference in head between the reservoir surface and the outlet is the main controlling factor for how the dredge can perform. Therefore, if a higher elevation output was preferred, the dredge would not discharge the same flowrate or solids content. Dredging at 1,000 gpm and 6.2 lbs of solids per cubic foot of slurry would require approximately 100 hours of dredging.

The 10-year cost used for the alternative analysis was estimated to be $3,000,000, which included $600,000 for purchasing the dredge, a 30% contingency on the dredge capital cost for piping, $1,500,000 for one new gravity thickener, $545,000 for additional solids hauling costs, and $120,000 for maintenance costs. The SediCon dredge possess the advantages of maintaining reservoir operation at all times, low electricity needs, the dredge's ability to be used at different reservoirs, and its high capacity for removing solids in a short amount of time. The main drawback to this alternative is that FTTP would need to treat the slurry pumped from the dredge which may possess a low solids content depending on where the dredge is operating in the reservoir and the outlet elevation. Nevertheless, this alternative provided a unique solution to NKWD's sediment problem that BWC determined could sufficiently solve.

2.1.7 - Status Quo

The current method of sediment control at the FTTP consists of periodically draining and excavating of the reservoir (Figure 2-6). Excavation of settled solids from a reservoir has been a tried and tested method of removal long before NKWD decided to excavate the North Reservoir. In order to perform an excavation, one needs earth moving equipment, trucks to haul away the sediment, and a crew to operate it all. A common but not always needed first step to excavation is to drain the reservoir. This is done so earth moving equipment can safely reach the solids that would be far below the water surface level. Once the water has been drained and the equipment can safely reach the sediment in the reservoir excavation can start. Depending on the job the excavation may be very costly or cheap, comparative economics should be used to decide if the method is worthwhile.

Figure 2-6: North Reservoir Excavation (9/21/21)

The estimated cost for the current excavation of the reservoir is $2,300,000. If the reservoir were to be excavated every 10 years instead of sixty, the 10-year price was estimated to be $600,000 [See Appendix 7.4.3] The main advantages of this system are that it is cheap in comparison to other alternatives, it is proven effective, and all the equipment is already owned by NKWD for execution. The main disadvantages of this method are the reservoir downtime, poor aesthetics while drained, and having to manage and organize the crews.

2.2 - Criteria for Analysis

There are several alternatives that will solve the objectives of this project. The goal of the alternative analysis was to accurately score all alternatives based on specific criteria to determine the best method forward. All criteria were given weights depending on their importance to FTTP processes and sediment control. More important criteria had higher weights. BWC worked with NKWD to determine the weights for the criteria. Each alternative was given a score of 2, 4, or 6 for each criterion. Six meant the alternative was the most desirable of the criteria. Two meant it was less desirable.

Alternatives were scored on cost, performance, operation, neighborhood impact, lifecycle, and proven effectiveness. Cost was the highest weighted criterion. The cost was determined using a 10-year composite cost of each alternative. The performance of each alternative was the second highest weighted criterion. BWC evaluated the alternative's ability to minimize sediment deposition or simplify sediment removal from the reservoirs. The operation of the alternative was the third highest weighted criterion. This focused on the solid's disposal method, the downtime of the reservoir, and the simplicity of the process. The fourth highest weighted criterion was neighborhood impact. Alternatives that had a low aesthetic and noise level scored higher. The fifth highest weighted criterion was the life cycle of the alternative. Alternatives with long life cycles scored higher. The lowest weighted criterion was proven effectiveness. Alternatives that had more installations in similar scenarios scored higher.

2.3 - Evaluation Phase Summary

Table 2-1: Evaluation Phase Summary

Alternative	Advantages	Disadvantages	10 Year Cost (See Cost Breakdowns in Appendix 7)
Lamella	- Effective at removing sediment from water - Long lifecycle - Proven effectiveness	- Highest cost - New building would impact neighborhood - High maintenance demand	$16 Million
Concrete Weir	- Low cost - Reservoir will never be fully out of service - Ability to install gates/valves to allow for bypass pumping during cleaning - Low maintenance - Long life	- Construction timeline - Would still need to determine solids removal	$5.2 Million
SediCon Dredge	- Reservoir can remain in service - Does not require external energy to dredge - No change to current aesthetic - Ability to use in both FTTP reservoirs - Long useful life	- No installs in the US - Sediment is typically deposited in downstream river	$3 Million
Boat Dredge	- Low cost - Reservoir can remain in service	- Frequent but short (~1.25 hr every day) operation needed for upkeep - Short life cycle on equipment	$2.2 Million
Aeration	- No downtime for the reservoirs. - Low maintenance and simple process operation.	- All solids to be removed by the plant's treatment process. - System needs to be constantly running. - Aeration systems have low lifespan.	$3.4 Million
Status Quo	- Low cost - NKWD is familiar with this method	- Risk of supply issues with reservoir out of service - Neighborhood impact - Time needed for excavation	$600,000

Table 2-1 above lists the advantages and disadvantages of the alternatives along with their estimated 10-year cost. When making a cost estimate for the alternatives, BWC analyzed the known capital, operations and maintenance, labor, installation, and solids disposal costs. However, there were still some unknowns such as exact quantities of pipe, personnel, installation, and operations costs that may affect these estimates. Additionally, some features of the alternatives possess intangible costs that cannot be quantified in a cost estimate. For instance, with the status quo removal method, the cost of taking the reservoir out of service for up to 2 years at a time cannot be quantified in a cost estimate. Therefore, BWC aimed to provide a comprehensive analysis of each alternative beyond just cost in order to sufficiently determine the best option. The alternative analysis scores along with their weights are seen below in Table 2-2. Th SediCon dredge came out as the clear winner, flowed by the status quo method then the concrete weir.

Table 2-2: Alternative Analysis for Determining the Best Option

	Cost	Performance	Operation	Neighborhood Impact	Lifecycle	Proven Effective	Total
Weight	5	4	3	2	2	1	
Aeration	4 (20)	2 (8)	4 (12)	6 (12)	2 (4)	2 (2)	20 (58)
Boat Dredge	4 (20)	4 (16)	2 (6)	4 (8)	2 (4)	4 (4)	20 (58)
SediCon Dredge	4 (20)	6 (24)	4 (12)	6 (12)	6 (12)	4 (4)	30 (84)
Concrete weir	4 (20)	4 (16)	4 (12)	4 (8)	6 (12)	4 (4)	26 (72)
Lamella Plates	2 (10)	6 (24)	4 (12)	2 (4)	6 (12)	6 (6)	26 (68)
Status Quo	6 (30)	4 (16)	2 (6)	2 (4)	6 (12)	6 (6)	26 (74)

2.4 - Evaluation Phase Recommendation

BWC recommended the SediCon Dredge for use at FTTP for future sediment control in the North Reservoir. This alternative carries many advantages that led to it scoring the highest in the alternative analysis. The SediCon dredge does not require the reservoir to be taken out of service at any time, and it does not require electrical energy for dredging. This dredge has a longer useful life compared to other alternatives, maintains the aesthetic of the reservoir, involves minimal construction, can be used in all four of NKWD's reservoirs, and most importantly can remove sediment at a rate far exceeding the rate of accumulation.

BWC believes this option is feasible because SediCon can customize their dredge to meet plant needs, and the company has a proven record of successfully dredging sediment from similarly sized reservoirs. Compared to the alternatives that had a lower cost estimate, the SediCon dredge performs more efficiently and has similar qualities in terms of neighborhood impact and useful life. Comparing this alternative specifically with the status quo method, the SediCon dredge involves keeping the reservoir in service 100% of the time. This maintains the function of the reservoirs as a protection against spills in the river. Though the cost of status quo removal is significantly less, the cost of taking the reservoir out of service for a long period of time every ten years cannot be adequately expressed in this estimate. Therefore, using all of this information, the SediCon dredge was determined to be the best solution.

3 – Design

3.1 – Dredge Design and Operation

BWC reviewed the characteristics of the sediment, reservoir geometry, plant layout, and available head at several locations. After communicating the information to SediCon, they proposed NKWD purchase their semi-automatic 8" ejector dredge for use in the North Reservoir (Figure 3-1). This dredge is capable of removing cohesive sediments, sand, gravel, and debris up to 150 mm in size. SediCon assured BWC that this dredge can remove the type of sediment that is in the North Reservoir. A raft suspends the dredge over the location that sediment is to be removed. This setup can be operated remotely so the operator does not need to be on the raft. The raft assembly is approximately 15' x 10' and is typically installed using a crane. Due to its size, the equipment must be disassembled when transporting it on a public road, e.g., when it is transported between FTTP and the Memorial Parkway plant.

Figure 3-1: SediCon Dredge [20]

The SediCon dredge does not contain a screen for preventing larger solids from entering the pipe because that would hinder suction capacity. Therefore, a solids catchment basket may be needed on the outlet side depending on where the slurry is sent. Though the North Reservoir currently contains many non-dirt solids such as rocks and golf balls, these objects would not interfere with the dredge's performance as long as the object is less than 8" in size.

To initiate flow in the dredge, a vacuum pump evacuates the air in the pipe and creates suction. With 14-m of head—the difference in elevation between the reservoir surface and the gravity thickeners and backwash tank—SediCon estimates the dredge can achieve 4.4 to 6.2 lb of sediment per cubic foot of water, or 70-100 kg per cubic meter, and will operate with approximately a 1,000 gpm flowrate. The dredge may be designed to accommodate solids concentration and flowrate constraints. Additionally, if the slurry is outputted at a higher elevation outlet, these numbers will be different meaning the dredge will not perform as well because there will be less suction.

A pump may be necessary for dredging certain parts of the North Reservoir. With the 14-m head difference, a pump will not be necessary for distances less than 1,500 ft from the dredge to the output. The backwash tank is located approximately 1,600 ft from the far East edge of the reservoir while the gravity thickeners are approximately 1,700 ft from the far East edge. If the slurry is sent to either of these two locations, a pump may be needed to dredge the remaining 100-200 feet on the Eastern portion of the reservoir.

3.2 – Treatment Processes

The greatest challenge in implementing the dredge at FTTP is determining how to handle the solids in the plant. The reservoirs serve not only to store water before treatment but as a means for river solids to settle out before treatment. Allowing solids to settle before treatment reduces the demands on the plant because the influent water to the plant from the reservoir has significantly less turbidity than the water from the Ohio River. The dredge essentially eliminates this function of the reservoir because all the sediment that would typically settle out in the reservoir must now be treated in the plant.

BWC assessed the usability of the existing gravity thickeners and belt presses to treat 2,500 tons of additional sediment per year in the plant. The solids-rich slurry was thought of as similar to sludge in that it must be thickened before solids are disposed of via dumpster hauling. Therefore, the gravity thickeners and belt filter presses were the main treatment techniques considered for handling the slurry.

There are multiple treatment pathways to handle the sediment coming from the SediCon Dredge. The Sedicon Dredge produces a slurry with a concentration of 4.4 to 6.2 lb/ft^3 of slurry. The slurry can have a flow rate of 1000 gpm. Both the flow rate and the concentration can be adjusted. Once started, the SediCon Dredge can send its slurry to the backwash tank to be held before it gets treated. Alternatively, the SediCon Dredge can also send its slurry directly to the gravity thickeners or belt presses to be treated. While determining this path, BWC researched the capacities of the existing treatment and holding facilities at FTTP. The backwash tank has a volume of approximately 650,000 gallons. This was calculated using the shop drawing provided by NKWD that can be found in Appendix 7.4.4. There are two gravity thickeners at FTTP. BWC recommends they add an additional gravity thickener to help with the increased sediment from the SediCon Dredge. One gravity thickener can handle a solids load of 11,000 lb/day and an influent flow of 180,000 gallons per day. The belt presses at FTTP are currently being updated. After the update, they will have a capacity of 80 gallons per min. Sediment that was sent to the existing backwash tank can then also be sent to a gravity thickener or the belt presses. The flow chart in Figure 3-2 shows all possible pathways the SediCon effluent can take.

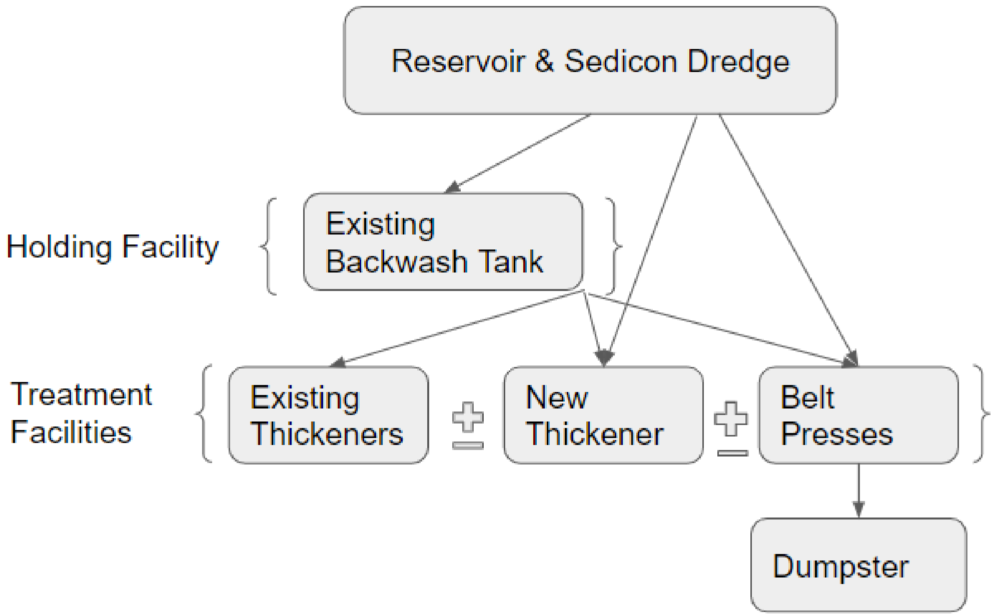


Figure 3-2: Sediment Path

The abandoned backwash tank next to the south reservoir was evaluated as an additional place to send the SediCon effluent. However, it was determined that there was not enough available head from the North Reservoir to the abandoned tank for the SediCon Dredge to function properly.

3.3 – Process Operation – Excel Model

BWC created an Excel model to demonstrate how the dredge could be used in the North Reservoir. The model allows the user to enter several inputs relating to the dredge, reservoir, and treatment processes. The model then calculates operation demands for the dredge and performance characteristics of the treatment processes. The model is intended to aid NKWD in determining the best procedures for operating the dredge and handling the solids.

The user first enters the desired flowrate and solids content of the slurry (lb solids/ft^3 slurry) the dredge as well as the percentage of desired removal of the accumulated solids in the North Reservoir per year. The optimal scenario involves 100% removal of the solids from the reservoir but because this could create too much stress on the plant, the model allows the user to specify that some sediment will remain in the reservoir. The user then determines whether a holding tank will be used to store the slurry after dredging and before treatment. The options for storage are the abandoned backwash tank and the existing backwash tank. The user may specify the percent of the slurry that will be sent to each holding tank. The abandoned backwash tank sits at roughly the same elevation as the surface of the reservoir so a pump would need to be used with the dredge to send solids to this tank which is not recommended. Once the holding tank inputs are entered, the user specifies the treatment processes to be used. These include the belt filter presses, the existing gravity thickeners, and the new gravity thickeners. The user may specify the percent of the slurry that each process will treat. For instance, if the belt filter presses and the existing gravity thickeners are to be used, the user may specify that 40% of the slurry is sent to the presses and 60% is sent to the thickeners. Figure 3-3 below depicts the main input portion of the model.

Slurry Metrics			
Input	Amount	Units	
Slurry Flowrate	1000	GPM	
Slurry Conc.	10	% solids	
Solids Content in m3 of slurry	100	kg solids/m3 slurry	
% of sediment to be removed	100%	%	
Hold Tank			
Abandoned Tank	Not Used	0%	GOOD
Backwash Tank	Used	100%	
Treatments			
Belt Filter Presses	Used	50%	GOOD
Existing Gravity Thickeners	Used	50%	
New Gravity Thickener	Not Used	0%	

Figure 3-3**:** Excel Model Input Section

After the inputs are entered, the outputs are calculated. The outputs relating to the dredge include the number of hours it must be used and the additional number of dumpsters that are needed. Changing the flowrate and solids content of the slurry will change these values. For instance, if the flowrate is doubled, the time required to dredge is cut in half. The outputs that relate to the holding mechanism include the number of times they must be filled per year, the maximum discharge rate for each tank, and the total time that the tanks must be in service. The model lastly calculates several performance characteristics of the treatment processes used including the mass of solids treated, hours of operation, capacity of maximum flow used, capacity of maximum solids treatment used, and the maximum influent flowrate. Some of these outputs are conditional depending on whether certain processes are used. For instance, if no storage tanks are used, the flow goes straight to the treatment processes so the flow and solids capacity of the treatment processes used will be calculated based on the inputted flowrate and solids content of the slurry. The output portion of the model is depicted in Figure 3-4.

Dredge and Sediment		
Hours of Dredging	100	hours/year
Sediment Removed	2500	tons/year
Sediment Increase	0	tons/year
Density of slurry	66.63	lb slurry/ft3
Dumpster Increase (yr)	1042	dumpsters/year
Dumpster Increase (wk)	20	dumpsters/week

Holding Mechanism	# of Fills	Max Discharge rate, gpm	Total Hours of Use	Days of Use/year
Abandoned Tank				
Backwash Tank	9	370	270	11

Treatments	Solids Treated (tons/yr)	Hours of Operation	Flow Capacity Used	Solids Capacity Used	Max Influent Flowrate, GPM
Belt Presses	938	1,042	--	--	120
Existing Gravity Thickeners	1,250	2,727	--	--	250
New Gravity Thickener	0		--	--	

Figure 3-4**:** Excel Model Output Section

The model was created based on the design characteristics of each holding tank and treatment process. These design characteristics can be changed in the model, which will result in a change in the outputs. For each holding tank, the capacity available can be changed. If NKWD determines that they can only use 50% of the backwash tank for slurry storage, the user may specify that in the model. This will cause the time needed for operating the backwash tank to double. For each treatment process, the number of each equipment type used, solids load, influent flow, and capacity of the process available can all be changed, which will be reflected in the outputs. For example, if it was determined that only one of the existing gravity thickeners should be used to treat the slurry, the user may specify that in the input. Further, with the new gravity thickener, the user can input different design criteria that will affect its operation demands. It was not in the scope of this project to design a new gravity thickener. Yet, this model can aid in the engineering process of a new gravity thickener design by calculating operation needs based on the design criteria inputted. Lastly, it was conveyed that the sludge hauled away in dumpsters is 20% solids. This value may be changed to reflect more accurate values. An example of an input section for the treatment processes is seen below in Figure 3-5.

Belt Press		
Feed solids min %	1	% dry
Feed solids max %	6	% dry
Hydraulic loading min	40	gpm
Hydraulic loading max	120	gpm
Capacity	900	lbs/hr dry
Cake discharge	24	% dry
Min solids capture	95	%
Number of Belt Presses Used	2	no.
Capacity Available	75%	%

Figure 3-5**:** Excel Model Belt Filter Press Input Section

Several key assumptions were made when creating the Excel Model. First, the model assumes that there is sufficient head to dredge the sediment to each process at the rate specified. If the dredge outputs to a process that is higher in elevation, it will not operate the same. Without knowledge of how the SediCon dredge performs with different head differences, this baseline assumption was necessary when creating the model. Secondly, if values for flow and slurry concentration are inputted outside the recommended range, the hours needed to operate the dredge will be inaccurate. SediCon has indicated that the dredge can discharge a slurry with up to 10% solids. They have not specified the upper limit on flowrate, but it may be assumed that the dredge cannot discharge flows much higher than 1,000 gpm because that is the flowrate calculated when discharging to the lowest point at the plant, the gravity thickeners. There are several additional notes that the user must consider, and these notes are included in a separate tab of the Excel workbook. Using the model, BWC calculated four scenarios for operating the dredge which will be discussed in Part 4.

3.4 – Pipe Layout

BWC designed a potential pipe layout for integrating the SediCon Dredge into FTTP (Figure 3-6). The dredge will move around the entire reservoir on a boat while it is removing sediment. Flexible piping is used to connect the dredge to buried piping in FTTP. The flexible piping for the dredge is 8" in diameter. The flexible pipe will connect to 8" ductile iron pipe. Ductile iron pipe was chosen because of the high flow rate, and the varying size of sediment in the slurry. The blue pipe in Figure 3-6 represents the flow of the sediment slurry from the dredge to the first holding or treatment step. The dredge can send sediment to the backwash tank, the existing gravity thickeners, or the belt presses. If the sediment is first sent to the backwash tank, the sediment has three options to where it can go next. It can go to the existing gravity thickeners, the proposed new gravity thickener, or it can go to the belt presses. This will be accomplished through gravity flow or existing pumping equipment and the connecting pipes will be open and closed using valves. If sediment travels to the gravity thickeners, some water will be removed, and the remaining slurry will travel to the belt presses. Once the slurry reaches the belt presses, it will be pressed (dewatered) and then sent to dumpsters to be trucked off FTTP. The abandoned tank near the south reservoir was analyzed as a potential holding option for the sediment. However, it was determined that there was not enough available head for the SediCon dredge. If NKWD would like to use the dredge for the South Reservoir, the flexible piping of the dredge could be sent to the same tie-in as the North Reservoir or there could be additional pipe installed.

Figure 3-6: SediCon Pipe Layout

4 – Recommendations

4.1 – Operation Scenarios

BWC created several treatment scenarios using the Excel model to demonstrate how the solids may be dredged and treated. These examples should serve merely as a demonstration into how different processes can be used independently or in conjunction with others and the rough estimates for time and dumpsters needed. Each scenario can be found in separate tabs in the Excel Workbook.

4.1.1 – Hybrid Option Utilizing all Potential Treatments

The first scenario proposed utilizes every available treatment option for the dredge's slurry in a hybrid solution. In this scenario, 75% of the dredge slurry will be sent to the Backwash tank while the other 25% will be sent directly to treatment options. 80% of the slurry will be sent directly to the thickeners, including one new thickener, While the remaining 20% will be sent to the belt presses. Using these parameters will result in 100 hours of dredging per year with all of the sediment accumulating in that year to be removed. An increase of 1042 filled dumpsters will need to be removed off site.

4.1.2 – New Thickeners Option

The second scenario proposed is the construction of six new thickeners that are the same size as the existing thickeners. In this scenario 100% of the dredge slurry will be sent to these new thickeners, leaving the rest of the plant to continue normal operation. Using these input parameters will result in 138 hours of dredging per year with all of the sediment accumulating in that year to be removed. An increase of 1042 filled dumpsters will need to be removed off site.

4.1.3 – Utilization of Backwash Tank Option

The third scenario proposed utilizes all of the capacity of the backwash tank. In this scenario 100% of the dredge slurry will be sent to the Backwash tank before being sent to other treatment processes. This option requires 270 hours of backwash tank use and will result in the backwash tank being filled 9 times per year. Using these input parameters will result in 100 hours of dredging per year with all of the sediment accumulating in that year to be removed. An increase of 1042 filled dumpsters will need to be removed off site.

4.1.4 – Partial Removal of Sediment from Reservoir

The fourth scenario proposed shows how plant operations can be used to alleviate stress on different processes of the plant. In this scenario, 75% of the dredge slurry will be sent to the backwash tank while the other 25% will be sent directly to treatment options. 80% of the slurry will be sent directly to the existing thickeners and 20% to the belt presses. Using these parameters will result in only 50 hours of dredging per year with half of the sediment accumulating in that year to be removed. An increase of 521 filled dumpsters will need to be removed off site compared to the increase of 1042 dumpsters when all the sediment is removed.

4.2 – Dredging, Storage, and Treatment Recommendations

BWC recommends that the slurry is stored in a holding tank between dredging and treatment. The nature of the SediCon dredge is that it discharges slurry at a high rate compared to traditional dredging techniques. The exact flowrate will depend on the design of the dredge, the location of the dredge in the reservoir, and the location of the outlet (i.e., the treatment process(es) used).

Nonetheless, the flowrate will likely be higher than the maximum hydraulic capacity of any of the treatment processes used and therefore, a flow equalizing storage tank will be needed. Though the abandoned tank has no current operation and thus the full capacity could be utilized, the elevation of the tank would necessitate a pump be used with the dredge. The tank is also farther from the North Reservoir than other options so head would be lost due to friction and piping losses which would require more power. The abandoned tank could be a viable option when dredging the South Reservoir, though a pump would likely still be needed, and the tank would need repairs before use. BWC therefore recommends the existing backwash tank be used for slurry storage. A cleaning mechanism such as a rake would be needed for the backwash tank because it is not designed for heavy solids loading. The tank's available capacity for additional flow should be further assessed.

The existing gravity thickeners and the belt filter presses should be evaluated to determine their available capacity for treating additional solids. The Excel model may then be used as a guide to formulate a treatment plan. A second and possibly third shift for running the belt presses could be considered to increase capacity. A hybrid approach may be desired wherein the existing processes are used when they have the most availability. For example, the belt processes may be used during the middle of the work week when they have surplus capacity. Dredging could also be performed during the first shift with the slurry sent to the gravity thickeners, then sludge from the flocculation basins and backwash filters could be pumped during the second and third shifts. Many options are available for treating the slurry, but an optimal solution may be reached when each process is thoroughly analyzed, and the Excel model is used.

Once an analysis has been conducted on the plant's treatment ability for the solids, a dredging plan may be formed. The desired flowrate of the dredge and solids content of the slurry will depend on the treatment processes used. SediCon can customize the dredge based on these needs. Because the dredge will ideally be used at multiple reservoirs, the conditions at the other reservoirs should also be evaluated before the dredge is designed. A dredge operation plan can then be created, which should include a schedule for dredging at each reservoir and personnel and transportation needs.

4.3 – Cost

The estimated 10-year cost of the SediCon Dredge is $3 million. The base capital cost for the SediCon Dredge itself is $600,000. BWC also estimated the cost for the pipes and valves needed for moving the sediment through the plant to be $47,000. Additionally, the cost estimate includes a new gravity thickener, solids disposal 10-year cost, maintenance 10-year cost, and a 30% contingency to cover unknown personnel and energy costs. From discussions with NKWD, BWC concluded that an additional solids handling process will be needed to account for the increased solids load on the plant. Therefore, the cost of adding one additional gravity thickener with the same design specifications as the current two thickeners was included in the overall cost because this was concluded as the most practical solution given the current information about the plant. After NKWD assess the available capacity of their existing processes and uses the Excel model, it may be determined that a different solids handling process is more suitable. A cost breakdown can be found in Appendix 7.4.5.

5 - Conclusion

BWC spent the last two semesters evaluating technologies to minimize sediment deposition or to simplify sediment removal in the North Reservoir at FTTP and designing the implementation of the recommended technology. In the first semester, BWC concluded that the SediCon Dredge was the best option to simplify the sediment removal process at the North Reservoir at FTTP. The SediCon dredge does not require the reservoir to be taken out of service at any time, and it does not require electrical energy for dredging. This dredge has a longer useful life compared to other alternatives, maintains the aesthetic of the reservoir, involves minimal construction, can be used in all four of NKWD's reservoirs, and most importantly can remove sediment at a rate far exceeding the rate of accumulation. It is crucial for NKWD to have adequate supply for their over 300,000 people and the SediCon dredge allows NKWD to always maintain full storage capacity at their FTTP reservoirs. Though the cost of the SediCon dredge was not the lowest cost option, when compared wholistically to the other alternatives with the criteria discussed, this option was determined to be the best.

In the second semester, BWC focused on the SediCon Dredge's implementation to FTTP. This included analyzing the current solids handling treatment and available capacities at FTTP, and how the slurry from the SediCon Dredge can be integrated into that. BWC created an Excel model to help NKWD efficiently utilize their existing or proposed solids handling processes with the additional demand from the SediCon Dredge. The SediCon Dredge will be able to tie into the existing solids handling process at FTTP using flexible and buried piping. Based on the inputs and outputs of the Excel model, NKWD can customize the slurry's path through their solids treatment facilities.

BWC completed the deliverables requested by NKWD that included a thorough analysis of different alternatives, the selection of the best alternative, and the development of a design for its implementation into FTTP. BWC believes this project delivers a practical solution to NKWD's reservoir sedimentation problem and provides a framework to assist NKWD with solids handling challenges. This innovative and viable approach provides resiliency to NKWD's water treatment process.

6 – References

[1] Northern Kentucky Water District . (n.d.). *Environmental Engineering Senior Capstone Project University of Cincinnati: Reservoir Sedimentation Control* , rep.

[2] “Reservoir sediment management: Building a legacy of ...” (n.d.). <http://riverlab.berkeley.edu/wp/wp-content/uploads/National-Res-Sed-White-Paper-2019-06-21.pdf> (Nov. 19, 2021).

[3] “Hydrology of the Australian continent.” (n.d.). <http://staff.civil.uq.edu.au/h.chanson/reprints/encyclopedia_lakes_2012b.pdf> (Nov. 19, 2021).

[4] “River facts.” (2018). *ORSANCO*, <https://www.orsanco.org/river-facts/> (Nov. 19, 2021).

[5] Kondolf, G. M., Gao, Y., Annandale, G. W., Morris, G. L., Jiang, E., Zhang, J., Cao, Y., Carling, P., Fu, K., Guo, Q., Hotchkiss, R., Peteuil, C., Sumi, T., Wang, H.-W., Wang, Z., Wei, Z., Wu, B., Wu, C., and Yang, C. T. (2014). “Sustainable sediment management in reservoirs and regulated rivers: Experiences from five continents.” *AGU Journals*, John Wiley & Sons, Ltd, <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2013EF000184#:~:text=By%20trapping%20sediment%20in%20reservoirs,channel%20form%20and%20aquatic%20habitats.> (Nov. 19, 2021).

[6] Liu, L., Perez, M. A., and Whitman, J. B. (2020). “Evaluation of lamella settlers for treating suspended sediment.” *MDPI*, Multidisciplinary Digital Publishing Institute, <https://www.mdpi.com/2073-4441/12/10/2705> (Nov. 19, 2021).

[7] “Lamella plate vertical clarifiers.” (2021). *Monroe Environmental*, <https://www.monroeenvironmental.com/water-and-wastewater-treatment/lamella-plate-vertical-clarifiers/> (Nov. 19, 2021).

[8] Hillhouse, G. (2019). “What is a weir?” *Practical Engineering*, Practical Engineering, <https://practical.engineering/blog/2019/3/9/what-is-a-weir> (Nov. 19, 2021).

[9]“Sedimentation - MRWA.” (n.d.). <https://www.mrwa.com/WaterWorksMnl/Chapter%2013%20Sedmentation.pdf> (Nov. 19, 2021).

[10] Advanced Solutions International, I. (n.d.). “Connect.” *CIRIA*, <https://www.ciria.org/> (Nov. 19, 2021).

[11] “Association of state dam safety.” (n.d.). *Association of State Dam Safety*, <https://damsafety.org/> (Nov. 19, 2021).

[12] Rajput, K. (2021). “What is earthen dam: Types of earthen dam: Failure of earthen dam: Application of earthen dam: Advantage & disadvantage of earthen dam.” *CivilJungle*, <https://civiljungle.com/earthen-dam/> (Nov. 19, 2021).

[13] WEDA Working Reservoir Dredging. (n.d.). “Reservoir Dredging: a Practical Overview.” www.westerndredging.org,<https://www.westerndredging.org/phocadownload/Workgroups/Reservoir_Dredging/WEDA%2 0Technical%20Report%20-%20Practical%20Guide%20to%20Reservoir%20Dredging.pdf> (Nov. 19, 2021).

[14] “Dredge barge boat vs. hand dredging - which is better?” (2021). *GeoForm International*, <https://geoforminternational.com/blog/dredge-boat-vs-hand-dredging/> (Nov. 19, 2021).

[15] (n.d.). <https://westechequipment.com/product/3391-v5-3-in-npt-inlet-outlet-cast-iron-solids-handling-pump-8-hp-honda-gx270-ohv> (Nov. 19, 2021).

[16] “Removing solids.” (n.d.). *Lagoon Pumping and Dredging, Inc.*, <https://www.lagoonpumping.com/articles-resources/removing-solids/> (Nov. 19, 2021).

[17] Zhou, Z., Huang, T., Gong, W., Li, Y., Liu, Y., and Zhou, S. (2019). “Field research on mixing aeration in a drinking water reservoir: Performance and Microbial Community Structure.” *MDPI*, Multidisciplinary Digital Publishing Institute, <https://www.mdpi.com/1660-4601/16/21/4221> (Nov. 19, 2021).

[18] “Reservoir aeration systems and restoration |.” (2019). *CLEAN*, <https://www.clean-flo.com/reservoir-restoration/> (Nov. 19, 2021).

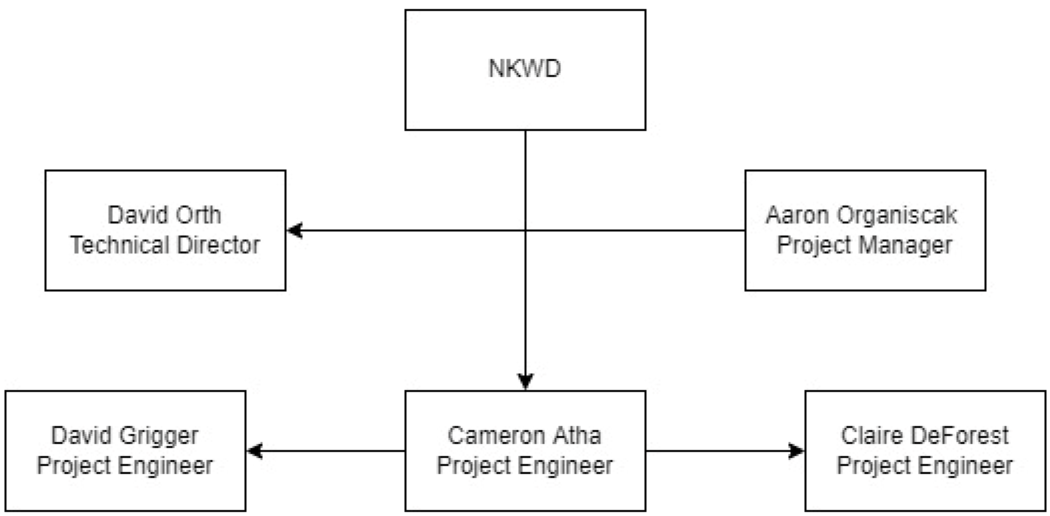
[19] Allen, L. (2021). *N KY Reservoir Mixing Proposal* , rep., Kasco, Prescott, WI.

[20] “Sedicon dredge.” (n.d.). <http://www.sedicon.no/wp-content/uploads/2017/07/SediCon-Dredge-new.pdf> (Nov. 19, 2021).

7 - Appendices

7.1 - Appendix 1 - BWC Group Details

7.1.1 - Organizational Chart



7.1.2 – BWC Vision Statement

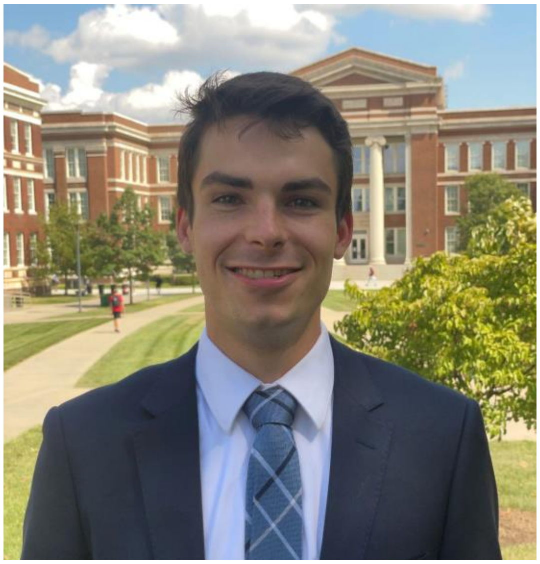
We provide creative ideas and innovative solutions to optimize the future of your water treatment process.

7.1.3 - Biographies

Aaron Organiscak is a fifth-year environmental engineering major at The University of Cincinnati. He is a certified CCO Mobile Crane, excavator, forklift, dozer, and loader operator. He also has his OSHA 30 certification. He has done 5 co-op rotations at Ulliman Schutte Construction, giving him valuable experience in construction management, design and estimating. He worked two terms as a project engineering coop estimating and designing water and wastewater construction projects across the United States. His last three terms were spent working a construction management role building a screening building on a wastewater plant in Raleigh, NC, running crews of carpenters, pipefitters, and operators. Aaron will be working as a Field Engineer for Ulliman Schutte Construction in Raleigh, North Carolina

Claire DeForest is a fifth-year environmental engineering major at the University of Cincinnati. She has completed 5 co-op rotations at Fishbeck, a multidisciplinary engineering and architecture firm, in the Cincinnati Water & Wastewater department. She was able to gain some public sector experience during the semester she worked as a full-time contractor for the Metropolitan Sewer District of Greater Cincinnati in the Watershed Operations department, where she managed flow monitoring equipment and records. More recently, she has been involved with hydraulic modeling using PCSWMM. She has built several sanitary system models of cities in both Ohio and Michigan and assisted with their calibration. Claire will be joining Fishbeck full-time in May as a Water & Wastewater Engineer.

Cameron Atha is a fifth-year environmental engineering major at the University of Cincinnati. She has completed three co-op rotations at Ulliman Schutte and two co-op rotations at AECOM. At Ulliman Schutte, she was a project engineering Co-op. She worked at Back River Wastewater Treatment Plant in Baltimore, MD, and Noman Cole Wastewater Treatment Plant in Lorton, VA. She also worked in their estimating department for one rotation. At AECOM, she worked out of the Columbus office with their water and wastewater group. Cameron will be joining AECOM full time to be a water resources engineer in Germantown, MD.



David Orth is a fifth-year Environmental Engineering student at the University of Cincinnati. He has completed several co-ops in the water and wastewater industry working for firms such as Fishbeck, Hazen and Sawyer, and the Metropolitan Sewer District of Greater Cincinnati. David has experience working in regulatory compliance, water conveyance systems, and water and wastewater treatment. In addition to his experience in the water industry, David has worked for a general contractor on a museum project in Washington, DC and performed research at UC on detection methods for endangered species in surface waters. David will be working at Stantec in Cincinnati as a Water Resources Engineer-In-Training following his graduation.

David Grigger is a fifth-year Environmental Engineering student at the University of Cincinnati. He has completed 5 co-op terms with Ulliman Schutte providing an excellent background in water/wastewater construction. While working for Ulliman Schutte David has worked in estimating, as a BIM technician (experience on CAD and Revit), and as a co-op project engineer. As a project engineer David has worked on a diversion chamber at MSD in Cincinnati and a headworks replacement project at the Back River WWTP in Baltimore. After graduation David will be working as a project engineer for Ulliman Schutte in Washington DC.

7.1.4 - Resumes

Aaron Organiscak

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Education

UNIVERSITY OF CINCINNATI, CINCINNATI, OHIO — **CLASS OF 2022**

- Bachelor of Science, Environmental Engineering | G.P.A- 3.4 /4.0
- Cincinnatus Century, CEAS, and Thomas Kirby Scholarship Recipient

ST. EDWARD HIGH SCHOOL, LAKEWOOD, OHIO — **CLASS OF 2017**

Work Experience

FIELD ENGINEERING CO-OP | ULLIMAN SCHUTTE CONSTRUCTION — **SUMMER 2020**
NEUSE RIVER RESOURCE RECOVERY FACILITY | RALEIGH, NC — **SPRING 2021**, **SUMMER 2021**

- Installed up to 36" Ductile Piping 20' deep as both a crew manager and a pipelayer
- Worked on a carpenter crew installing foundations, elevated decks, columns, beams, walls, cleanouts, and tanks.
- Layout/managed construction of pipe, manholes, scaffolding, formwork, and concrete
- Worked as the Designated On-Site Safety Personnel
- Conducted weekly field safety meetings and site walkthroughs
- Monitored Confined Spaces on site

PROJECT ENGINEERING CO-OP | ULLIMAN SCHUTTE CONSTRUCTION — **FALL 2019**
GRAND FORKS, ND | MIAMISBURG, OH | CINCINNATI, OH | NEW ALBANY. OH

- Material management of stainless-steel pipe and equipment for Reverse Osmosis and Ultra-Filtration Systems
- Responsible for creating pre-task plans for mechanical pipe installation
- Created Purchase Orders for general construction supply, precast concrete, waste management
- Created Subcontracts for rebar supply and install, precast concrete and miscellaneous metals at up to 25% below bid price
- Gathered bids and refined bid documents to create jobsite budgets

PROJECT ENGINEERING CO-OP | ULLIMAN SCHUTTE CONSTRUCTION — **SPRING 2019**
VA MEDICAL CENTER WATER TREATMENT PLANT | PERRY POINT, MD

- Managed field crew and planned work based off schedule and punch list
- Submitted and completed weekly field time sheets
- AutoCAD planning, layout, and purchase of chemical piping change orders and pump station additions
- Wrote RFIs, submittals and compiled change orders to owner
- Maintained As-Builts and compiled a final approved set

Applicable Skills/ Certification

- NCCCO Certified Lattice Boom Crawler Crane
- Microsoft Office, MATLAB, AutoCAD, Creo, Solidworks
- OSHA 30-hr & 10- hr, Adult First Aid, CPR, AED Certified through American Red Cross
- HDPE Pipe Fusion Certified
- Heavy Machinery Operation; Telehandler, Loader, Articulating Truck, Excavator, Bulldozer

College Involvement

CLUB RUGBY | PRESIDENT — **FROM 2017-PRESENT**

- Face of Club to university, conference, and outside organizations
- Delegation of duties and tasks to other positions
- Yearly budget allocation presentation, manage yearly budget of ~$40,000
- Responsible for payment and university onboarding of Coaches

SOCIETY OF ENVIRONMENTAL ENGINEERS — **FROM 2017-PRESENT**
JULIE HANSER COMMUNITY GARDEN — **FROM 2017-PRESENT**
YOUNG AMERICANS FOR LIBERTY — **FROM 2017-PRESENT**

References Available on Request

Claire E. DeForest

5802 Pepperridge Ct. Maineville, OH 45039 | 513-638-9549 | deforece@mail.uc.edu | linkedin.com/in/claire-deforest-033876160

Education

BACHELOR OF SCIENCE IN ENVIRONMENTAL ENGINEERING | CLASS OF 2022

- University of Cincinnati, Cincinnati, OH
- College of Engineering and Applied Science
- GPA: 3.407

Skills and Relevant Coursework

- Ability to use Windows operating system, Microsoft Word, Microsoft Excel, Autodesk Civil 3D, ArcGIS, and PCSWMM
- Water and Wastewater Treatment: Investigated the processes involved in and the different methods of water treatment
- Transport I and Hydraulic Systems: Learned about fluid mechanics and its applications to both pipe flow and open channel flow

Experience

INTERN TECHNICIAN – WATER & WASTEWATER | FISHBECK | JANUARY 2019 - PRESENT

- Worked as a contractor for the Metropolitan Sewer District of Greater Cincinnati's Watershed Operations department (January 2019 – September 2019)
  - Processed flow monitoring site records and updated site notes
  - Wrote technical procedures regarding equipment management and site programming
  - Configured telemetry devices prior to installation for flow monitoring
  - Trained new MSDGC interns
- Digitized flood boundary lines along Little Miami River in Autodesk Civil 3D using HEC-RAS dambreak model outputs
- Contributed to printable CAD sheets: updated notes, created detail drawings, and assisted with sheet setup
- Participated in a base-wide water and sanitary system survey at the Wright Patterson Air Force Base (WPAFB)
- Reviewed video inspections of a city's sanitary and stormwater system and assessed severity of damage from roots
- Updated spreadsheets with new data for several flow monitoring projects
- Performed analyses on flow monitoring data, such as a rainfall-derived inflow and infiltration (RDII) analysis
- Assisted with building and calibrating wastewater system models in PCSWMM (December 2020 – Present)
  - Loaded time series and created flow patterns for several models
  - Built WPAFB and Eaton, OH system models and Lansing, MI Combined Sewer Overflow models using GIS elevation and pipe data
  - Reviewed Grand Rapids, MI historic model and updated with system changes reflected in as-built records
  - Assisted with dry weather flow calibration of Eaton, OH model

Involvement and Recognition

- Cincinnatus Century Scholars: Fall 2017 - Present
- UC Society of Environmental Engineers (SEE): Spring 2019 - Present
- UC Mountaineering Club: February 2020 – Present
- UC CEAS Dean's List: Fall 2020

Cameron Atha

(614) 403-5022 | athacb@mail.uc.edu
www.linkedin.com/in/cameron-atha

EDUCATION

University of Cincinnati- Cincinnati, OH **Expected Graduation: May 2022**
College of Engineering and Applied Sciences
- 3.571/4.000 GPA
- Bachelor of Science, Environmental Engineering
- Cincinnatus Century Scholarship recipient

Olentangy Liberty High School - Powell, OH **Aug 2013-May 2017**

WORK EXPERIENCE

AECOM - Columbus, OH **Jan 2021-Present**
Water/Wastewater Intern
- Utilized AutoCAD Civil 3D to produce drawings and models for multiple water conveyance projects
- Analyzed storm models using PCSWMM and ArcGIS to study the flooding for 96 inlets.
- Assisted with writing and preparing multiple technical reports
- Projects: Big Walnut Sewer Outfall, Markison Inflow Redirection, Zanesville CSO Re-design, Parson Water Treatment Plant Residuals Disposal, Zanesville Long Term Control Plan, South Broadleigh Rd Waterline Improvements, Columbus Blueprint Stormwater Control Practice I&M Manual

Ulliman Schutte Construction - Main Office (Miamisburg, OH) **May 2020-Aug 2020**
Co-op Engineer – Estimating Department
- Communicated with subcontractors for quotes on products to develop project estimation costs
- Produced estimates for interior piping for HRSD James River SWIFT wastewater treatment plant bid

Ulliman Schutte Construction - Noman Cole Wastewater Treatment Plant (Lorton, VA) **Aug 2019-Dec 2019**
Co-op Engineer – Equalization Basins Upgrades and Tertiary Filters Upgrade Projects
- Purchased material needed on site to complete punch list tasks
- Managed multiple Sub-contractors performing work on site

Ulliman Schutte Construction - Back River Wastewater Treatment Plant (Baltimore, MD) **Jan 2019-May 2019**
Co-op Engineer – CMAR team for Headworks and Wet Weather Flow Equalization Upgrades
- Responsible for updating over 400 pages of As-Built drawings
- Investigated and tracked concrete progress and repairs on site

Delco Water Company - Delaware, OH **May 2018-Aug 2018**
Engineering/GIS Intern
- Collected over 3,000 GPS points for GIS map of water system to prevent water line breaks

Coldwater Consulting, LLC - Columbus, OH **Mar 2017-May 2017**
Intern – High School Mentorship Program
- Created flooding models on HEC-RAS for various projects

The City of Columbus - Department of Public Utilities, Water Division - Columbus, OH **Sept 2016-Dec 2016**
Intern – High School Mentorship Program
- Shadowed Project Manager on large-scale construction projects at two water treatment plants

LEADERSHIP & ACTIVITIES

Phi Sigma Rho – National Sorority for Women in Engineering
- Vice President of Personnel – January 2020- December 2020
  - Managed all internal tracking operations and record keeping for our chapter
  - Re organized chapter operations amid a global pandemic
- Director of Scholarship – Spring Semester 2018
  - Organized weekly study tables resulting in an increase in the average chapter GPA

Society of Environmental Engineers
- Networked with environmental engineering students, professors, and industry members

SKILLS

- Experience using AutoCAD Civil3-D, ArcGIS, PCSWMM, Bluebeam REVU, MATLAB, and Microsoft Office, including Word, PowerPoint, SharePoint, and Excel
- LEED Green Associate, Six Sigma Yellow Belt, OSHA-10 hour certified

David Orth

Phone: 513-679-0040
Email: orthdm@mail.uc.edu
Address: 6101 Gaines Rd. Cincinnati, OH 45247

Education

Class of 2022 — **University of Cincinnati**
- BS, Environmental Engineering
- GPA: 3.94/4.0

Professional Experience

Jan. 2021 – Aug. 2021 — **Hazen and Sawyer**, Cincinnati, OH
- Assisted with various water and wastewater treatment plant improvement projects.
- Helped with data analysis, drawing markups, technical report composition, engineering calculations, specification writing, and other design tasks.

Aug. 2019 – Dec. 2019 — **Grunley Construction**, Washington, DC
- Worked as a project engineer on the National Gallery of Art East Building project.
- Assisted with tracking material submittals, assembling daily construction reports, and coordinating project changes with subcontractors and the owner.

Jan. 2019 – May 2019 — **Fishbeck**, Cincinnati, OH
- Created and modified drawings on projects involving water and sewer main replacement, water treatment plant upgrades, and topographic mapping.
- Performed sewer scoring, flow monitoring data analysis, submittal reviewing, and material cost estimating.

June 2018 – Aug. 2018 — **Metropolitan Sewer District of Greater Cincinnati**
- Managed the enforcement of the 2017 EPA Dental Amalgam rule by communicating with over 400 dental offices in the Cincinnati area to convey the rule's requirements.
- Completed fats, oils, and grease inspections of restaurants as well as annual inspections of major industrial dischargers.

Research

June 2020 – Dec. 2020 — **Wendell Lab, University of Cincinnati**
- Worked with Dr. David Wendell on a project for ODOT that created a protocol for detecting Hellbender salamanders in Ohio streams.
- Performed PCR testing, stream water collection, water quality analysis, and report composition.
- Co-author of *Non-Invasive Detection and Identification of Eastern Hellbender in Ohio Surface Waters Using Environmental DNA.*

Extra-Curricular Involvement

2017–Present	**UC Society of Environmental Engineers**: '21-'22 President, '20-'21 Treasurer
2019–Present	**Mill Creek Alliance Water Quality Monitoring Program**: Sampling Team Leader
2018 –Present	**Club Tennis**: Member

Awards

2021	Ohio EPA Scholarship
2017 – 2021	Dean's List
2017 – 2021	Cincinnatus Century Scholarship

David Grigger

2519 Ravine Street | Cincinnati, Ohio, 45219 | 440-503-6451 | griggedw@mail.uc.edu

Education

University of Cincinnati Class of 2022

- Bachelor of Science, Environmental Engineering
- 3.18 GPA

North Royalton High School, North Royalton, OH Class of 2017

Employment

Coop Engineer | Ulliman|Schutte January 2019-August 2021

- Worked five co-op semesters.
- Dayton, Ohio (Main Office, January 2019-May 2019).
  - Received and organized quotes for potential jobs.
  - Made drawings in Revit for field installation.
  - Made Revit smart-families for use in current and future models.
- Baltimore, Maryland (On-site at Backriver Wastewater Treatment Plant, August 2019-December 2019)
  - Updated Revit model to reflect field layout and dimensions.
  - Made submittals for layout and equipment.
  - Ordered parts based off job's schedule and drawings
- Cincinnati, Ohio (On-site at Cincinnati Metropolitan Sewer District, May 2020-August 2020)
  - Made CAD layout drawings for work to be done in the Mill Creek
  - Assisted in updating the job's budget and allocating money for future work.
  - Purchased miscellaneous tools, pumps, and supplies to ensure no delays in project completion.
- Cincinnati, Ohio (On-site at Cincinnati Metropolitan Sewer District, January 2021-May 2021)
  - Organized and oversaw the demolition of an existing storage building.
  - Assisted in the completions of point scans on existing structures.
  - Purchased miscellaneous tools, pumps, and supplies to ensure no delays in project completion.
- Baltimore, Maryland (On-site at Backriver Wastewater Treatment Plant, May 2021-August 2021)
  - Assisted troubleshooting efforts on the plant's newly implemented gas detection system.
  - Assisted troubleshooting efforts on Rotork actuators.
  - Organized start-up, testing, troubleshooting, and commissioning for EQ storage tanks.

Skills

- Microsoft Office
- MATLAB
- Autodesk Revit
- Autodesk AutoCAD
- Bluebeam Revu

Activities

- Society of Environmental Engineers 2018-Present

7.2 - Appendix 2 – Acknowledgements

BWC would like the thank the following individuals for their guidance and support with this project:

- Dr. Drew McAvoy of the University of Cincinnati for providing guidance during the duration of this project.
- Amy Stoffer, Johnathan Moor, and Mark Raffenberg of NKWD for working with our group and providing feedback as we assessed this problem.
- James Springer of GCWW for showing us the lamella plate settlers at the Richard Miller Plant.
- Dr. Tom Jacobsen of SediCon for working with our team to develop a design that uses the SediCon dredge. While studying at the Norwegian University of Science and Technology, Dr. Jacobsen wrote the thesis: “Sediment Problems in Reservoirs: Control of Sediment Deposits”, that provided the basis for the technology used in SediCon’s dredge. Dr. Jacobsen later founded SediCon using this idea. Without the help of Dr. Jacobsen, this project and its proposed solutions would not be achievable.

7.3 - Appendix 3 - Documents Provided by NKWD

Environmental Engineering Senior Capstone Project

University of Cincinnati

Reservoir Sedimentation Control

Prepared by: Northern Kentucky Water District

Background

Figure 1: Memorial Parkway Treatment Plant

The Northern Kentucky Water District (NKWD or District) owns and operates two drinking water treatment plants in Campbell County, Kentucky. The 44-million gallon per day (MGD) Fort Thomas Treatment Plant (FTTP) and the 10-million gallon per day (MGD) Memorial Parkway Treatment Plant (MPTP) both draw water from the Ohio River and store it in two parallel open reservoirs. The reservoirs at FTTP have a total design capacity of approximately 70 million gallons, whereas the reservoirs at MPTP have a total design capacity of approximately 35 million gallons. Aerial images of the treatment plants are provided in Figures 1 and 2.

The reservoirs provide storage and some sedimentation and pre-treatment of raw river water before it enters the primary treatment process. Over time the suspended sediment in river water and some solids returned from the treatment plant settle out and deposit in the reservoirs, reducing their volume available for water storage and potentially affecting water quality. Historically the reservoirs have been drained and cleaned periodically, which is challenging and reduces the treatment plant storage capacity while a reservoir is out of service.

The NKWD is in the process of removing sediment from the North Reservoir at the FTTP using conventional earth-moving equipment. Approximately 135,000 tons of sediment has accumulated in the reservoir since it was last fully cleaned in 1965. It is anticipated the sediment removal in the North Reservoir at the FTTP will take approximately two years. The NKWD intends to continue with removing sediment from the other three reservoirs, which could take about ten years to complete. The NKWD wishes to evaluate options for improving future sediment removal after the reservoirs are fully cleaned and returned to service.

Description of Services

The goals of the project are to: (1) evaluate available technologies to minimize sediment deposition or simplify sediment removal from the reservoirs, and (2) design the implementation of the recommended technology for the North Reservoir at the FTTP. The District will coordinate closely with the consulting team on this project. In addition, NKWD will provide project related data, technical, and analytical support. During the evaluation phase (Fall Semester) the team will conduct site visits and literature reviews as necessary to consider the options provided by NKWD and others suggested by the team. The consulting team should conduct an alternative analysis for evaluating each of the options and determine whether site considerations preclude the selection of any technology. The team will also determine whether any of the technologies provide an economic or utility benefit to the District vs. the status quo technique of allowing sediment to settle and then periodically taking the reservoir out of service for bulk solids removal with excavators and dump trucks. During the design phase (Spring Semester) the consulting team will complete a conceptual design for the technique or technology selected during the

Figure 2: Fort Thomas Treatment Plant

evaluation phase. This design should include the physical layout and constructability, as well as projections of operation and maintenance requirements. The design should focus on the North Reservoir of the FTTP, but the evaluation phase should also consider the suitability of the technology for the other three reservoirs. An option such as the installation of a turbidity curtain may be of interest to other utilities that may have similar solids removal issues in a reservoir system.

If appropriate for the technology, the consulting team should take into consideration the ability of the FTTP's existing residuals treatment processes to handle the sediment removed from the reservoir or the feasibility of adding new treatment processes at the site. The consulting team should also explore if enhanced sediment removal could lead to increased formation of algae in the reservoir. If so, then additional treatment or control measures for algae may be necessary.

Deliverables

The consulting team should complete the following tasks by the end of the Fall Semester.

1. Perform a literature review of the options, including those provided by NKWD as well as less common technologies and their uses in similar applications.

2. Evaluate options provided by NKWD and any additional technologies the consulting team suggests including but not limited to:

   a. Lamella plate settlers upstream of the reservoirs to perform pre-sedimentation.

   b. Dividing the reservoir using a weir, turbidity curtain, or a combination to concentrate sediment in a smaller area for removal.

   c. Dredging, either by boat or automated equipment.

   d. Installing an automated sediment removal process such as a screw, scraper, or motorized equipment.

   e. Vigorous aeration or mixing to prevent sediment from settling in the reservoirs, which would be removed in later treatment plant processes.

f. Status quo periodic draining and solids removal using excavation equipment.

3. Identify any concerns and potential mitigation measures for using each technology on a reservoir used at the front of a drinking water treatment process.

4. Perform an alternative analysis to evaluate the options on economic and utility metrics.

5. Prepare a report on the key findings and recommended option.

6. Provide a presentation to the Sponsor on the key findings and recommended option.

The consulting team should complete the following task by the end of the Spring Semester.

1. Provide a summary of key findings from the Fall Semester.

2. Develop a conceptual design of the selected technology including size, location, and construction considerations.

3. Develop order-of-magnitude operating and maintenance (O&M) costs and utility staff planning projections.

4. Provide a final report that also includes key information from the Fall Semester.

5. Provide a presentation to the Sponsor on the recommended design and planning projection.

7.4 - Appendix 4 – Additional Information

7.4.1 - Lamella Plate Settlers Cost Calculations

Item	Cost	Units	Total
Lamella filters	$80,000/MGD	65 MGD	$5,200,000
I & C	8% of lamella cost		$416,000
Building	$35/sq ft	12000 sq ft	$420,000
Pipe to North reservoir (36" ductile iron)	$184/LF	400 LF	$73,600
Pipe to South reservoir (36" ductile iron)	$184/LF	1506 LF	$277,104
5 bends to get to south reservoir	36" flanged DI bend	14011/bend	$70,055
Pipe to solids removal (6"ductile iron)	$17/LF	2,300 LF	$39,100
5 bends in solids pipe (6 inch ductile iron)	5 45 bends (they won't all be 45 just using it to estimate)	$175	$875
Solids pump	estimated	$5,000	$5,000
Tie into existing influent piping 36" DI		113 LF	$20,792.00
Trenching	$20/lf	2500	$50,000.00
Total equipment			$6,572,526.00
Design	20% of equipment cost		$1,314,505.20
Construction	30% of equipment cost		$1,971,757.80
Base Cost			$9,858,789.00
Contingency	30% of total cost		$2,957,636.70
New Gravity Thickener			$1,500,000.00
Total Cost			$14,316,425.70

Yearly cost	Cost	Units	Total
Personnel	60000/yr		$60,000.00
Yearly Maintenance	2%		$197,175.78
Solids Disposal(does not include backwash water)	per year		$545,000.00
Total	per year		$262,625.78
		sum over 10 years	$16,942,683.50
		sum over 30 years	$22,195,199.10

7.4.2 - Aeration Cost Calculations

Item	Cost
Kasco Aeration System	$74,486
Installation Cost (30% of equipment)	$22,346
Contingency (30% of equip. + instal.)	$29,050
Gravity Thickener	$1,500,000
Total Equipment Cost	$1,625,881
Electrical 10-year cost	$95,810
Solids Disposal	$545,000
Maintenance 10-year cost	$14,897
Total Cost	$2,281,588
Uncertainty from increased plant demands	50%
Total 10-year Cost Estimate	**$3,422,382**

7.4.3 - Status Quo Cost Calculations

Status Quo Estimate	
Tons of Sediment per year	2500
Years	10
Cost per ton Removed	24.49
10-Year Cost	612250

7.4.5 - SediCon Final Cost Calculations

Item	Cost
SediCon Dredge w/installation, training, and shipping	$600,000
1300 LF of 8" DI Pipe	$31,772
8, 8" Valves	$16,000
Contingency (30% of equipment)	$180,000
New Gravity Thickener	$1,500,000
Total Equipment Cost	$2,327,772
Solids Disposal 10-year cost	$545,000
Maintenance 10-year cost	$120,000
Total Cost	**$2,992,772**

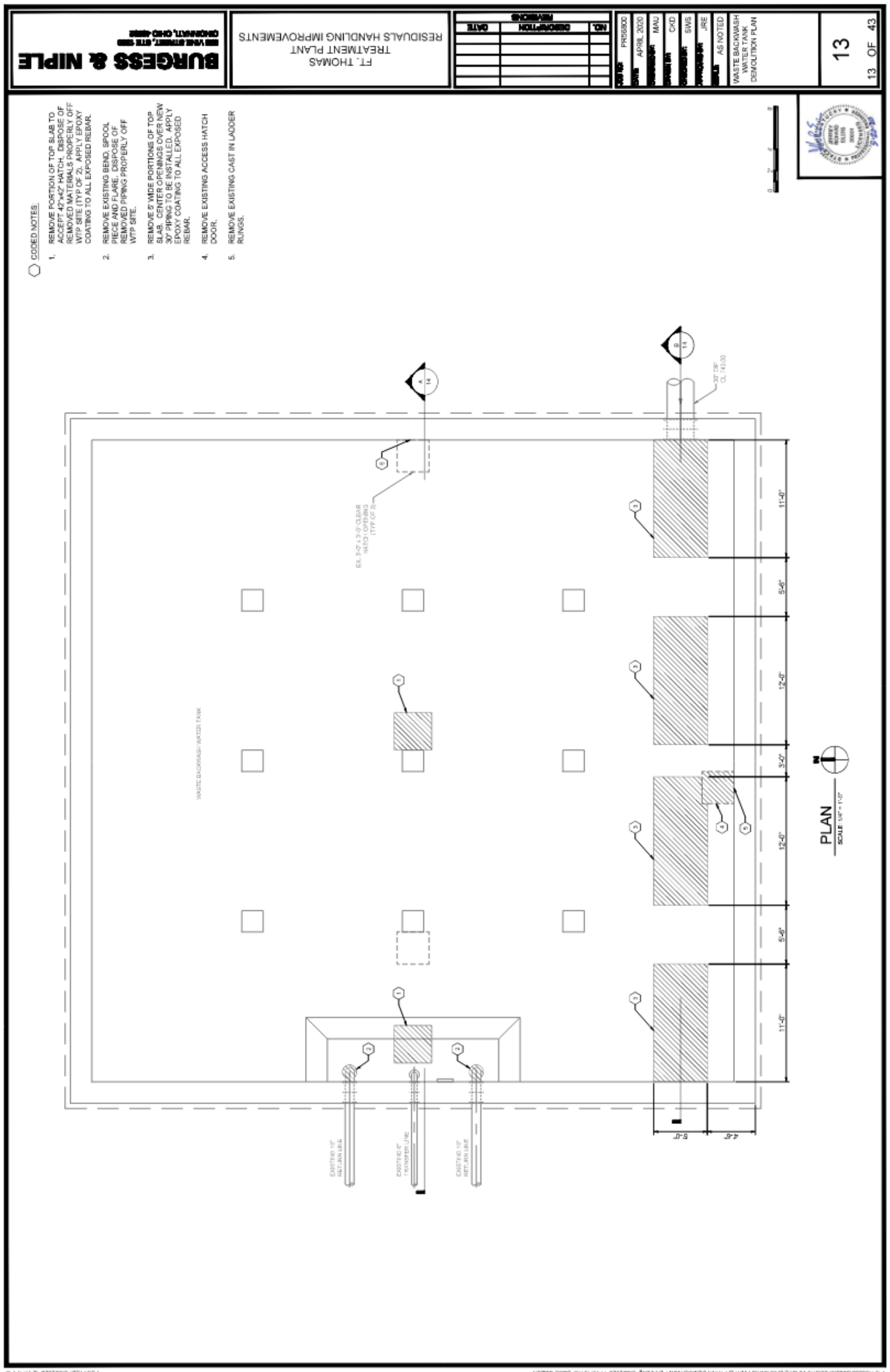
7.4.6 - Weir Cost Calculations

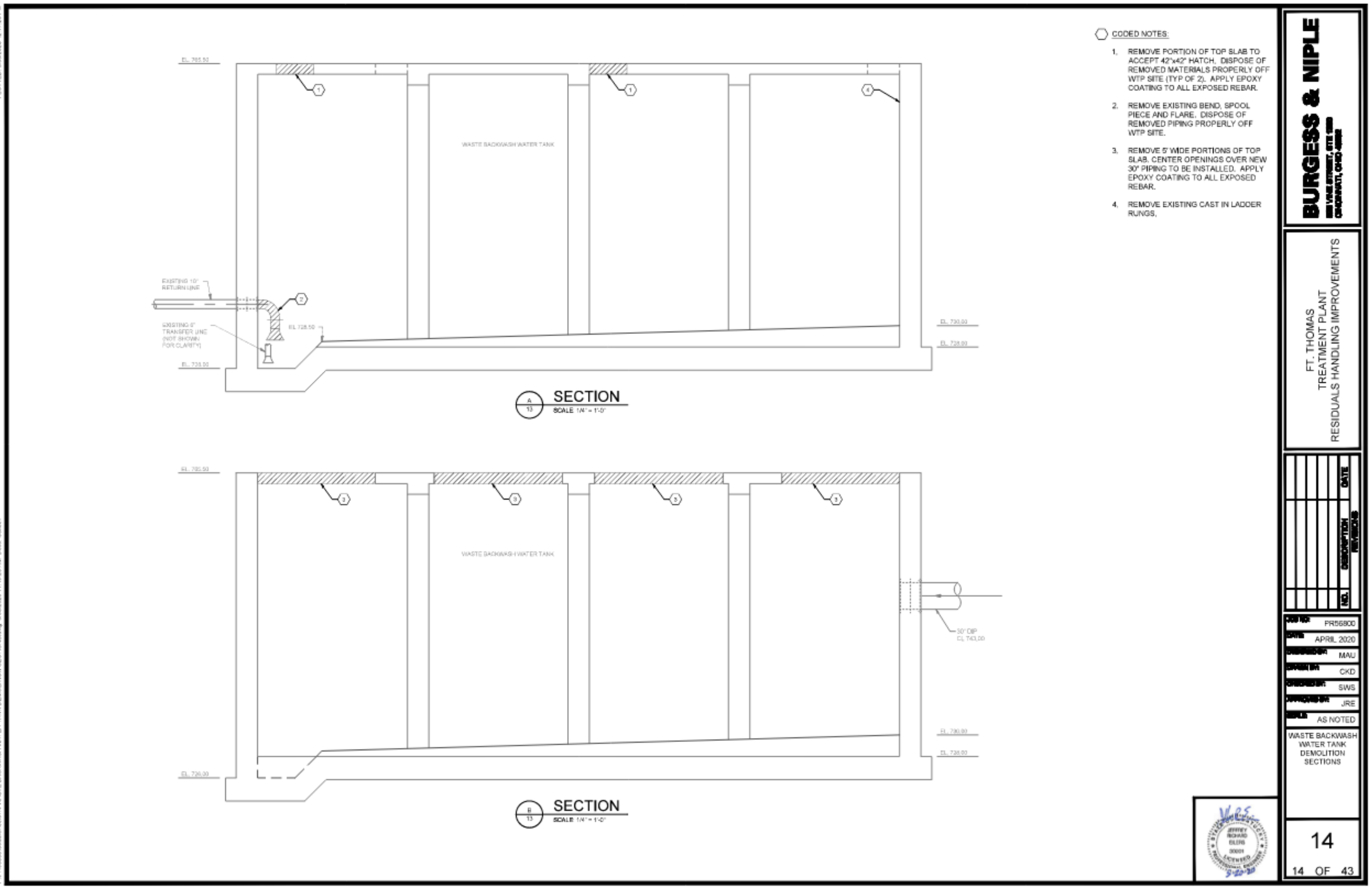
Concrete Weir Cost Estimate			
Item	Cost/Units	total units	total cost
4 ft thick concrete	$/yard	yards	
Weir 1 (STA 7)	$100/yard	725.93	$72,592.60
Weir 2 (STA 4)	$100/yard	1170.37	$117,037.04
Rebar			
Weir 1 (STA 7)			$109,641.60
Weir 2 (STA 4)			$79,524.00
Sluice Gates	# of gates	price per gate	
Weir 1 (STA 7)	5	13200	$66,000.00
Weir 2 (STA 4)	5	13200	$66,000.00
Foundation	Price per pile	#of piles (3 ft sep)	
	12,000	166	$1,992,000.00
Total Equipment			$2,502,795.24
Construction		30%	$750,838.57
Design		20%	$500,559.05
Solids Disposal over 10 years (price subject to change)			$385,000.00
Contingency		30%	$1,126,257.86
Total			$5,265,450.72

7.4.7 - Boat Dredge Cost Calculations

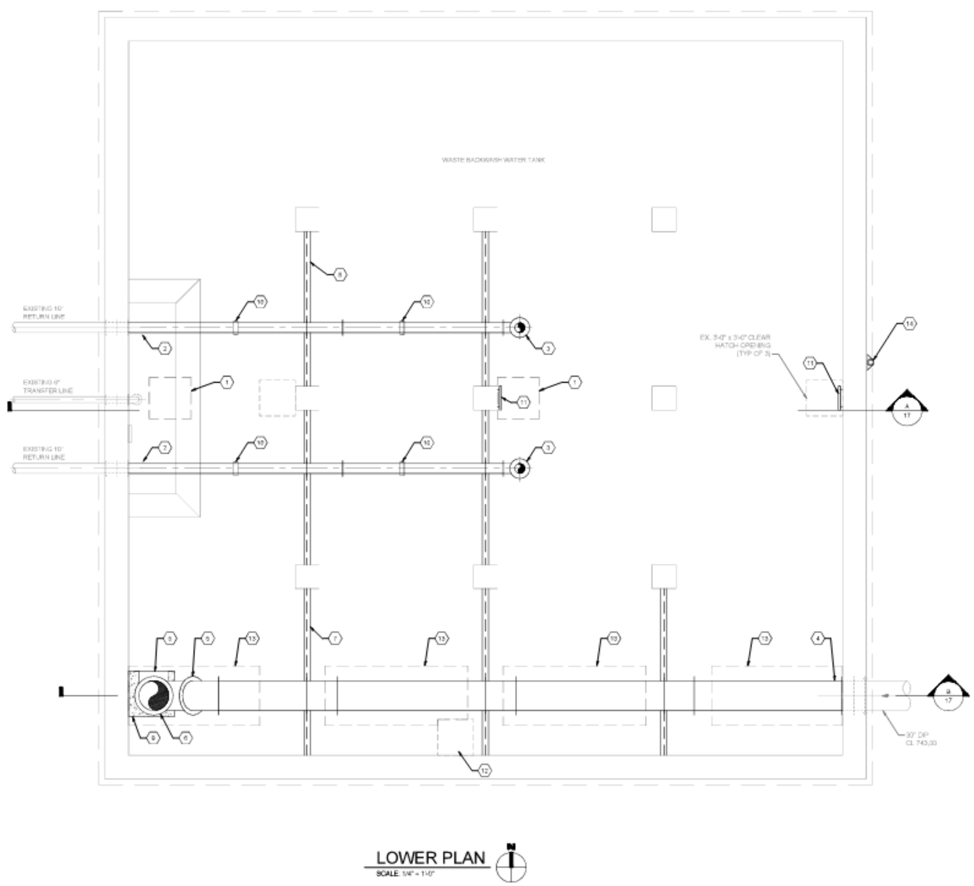
Item	Cost per item	Amount per 10 years	Cost	Source
Boat and Electric Outboard Motor	$10,000	1	$10,000	[42]
Pump	$2,000	1	$2,000	[22]
Cable Floats	$20	210	$4,200	[43]
Power [kWh]	$0.075	61594	$4,619.55	NKWD
Operation [hr]	$20	7300	$146,000	Per 2 hr daily
Contingency	0.3*(total above costs)	1	$50,045.87	
Solids Disposal (Gravity Thickener)	$545,000	1	$545,000	See Section 3.1.1
New Gravity Thickener	$1,500,000	1	$1,500,000	NKWD
Total			**$2,261,865.42**	

7.4.8 - Backwash Tank Shop Drawings





CODED NOTES:
1. REMOVE PORTION OF TOP SLAB TO ACCEPT 42"x42" HATCH. DISPOSE OF REMOVED MATERIALS PROPERLY OFF WTP SITE (TYP OF 2). APPLY EPOXY COATING TO ALL EXPOSED REBAR.
2. REMOVE EXISTING BEND, SPOOL PIECE AND FLARE. DISPOSE OF REMOVED PIPING PROPERLY OFF WTP SITE.
3. REMOVE 5' WIDE PORTIONS OF TOP SLAB. CENTER OPENINGS OVER NEW 30" PIPING TO BE INSTALLED. APPLY EPOXY COATING TO ALL EXPOSED REBAR.
4. REMOVE EXISTING CAST IN LADDER RUNGS.
WASTE BACKWASH WATER TANK
SECTION
SCALE 1/4" = 1'-0"
SECTION
SCALE 1/4" = 1'-0"
BURGESS & NIPLE
FT. THOMAS
TREATMENT PLANT
RESIDUALS HANDLING IMPROVEMENTS
NO.
DESCRIPTION
DATE
REVISIONS
PR56800
APRIL 2020
MAU
CKD
SWS
JRE
AS NOTED
WASTE BACKWASH WATER TANK DEMOLITION SECTIONS
14
14 OF 43



CODED NOTES:

1. PROVIDE NEW 42"x42" HATCH IN TOP SLAB (TYP OF 2). SEE SHEET 16.
2. EXTEND 10" PIPE.
3. PROVIDE NEW 10" 90° BEND AND FLAIR.
4. EXTEND 30" PIPE.
5. PROVIDE NEW 30" 90° BEND.
6. PROVIDE NEW 30"x30" LATERAL.
7. PROVIDE PIPE SUPPORT FOR NEW 30" PIPE (TYP OF 3), W10x19, 304 STAINLESS STEEL, FASTEN TO FACE OF EXISTING CONCRETE PER CONNECTION DETAIL ON SHEET 24.
8. PROVIDE PIPE SUPPORT FOR NEW 10" PIPE (TYP OF 4), W10x19, 304 STAINLESS STEEL, FASTEN TO FACE OF EXISTING CONCRETE PER CONNECTION DETAIL ON SHEET 24.
9. PROVIDE REINFORCED CONCRETE PIPE SUPPORT UNDER 30" 90° BEND.
10. PROVIDE ADJUSTABLE PIPE SADDLE SUPPORT PER DETAIL ON SHEET 24.
11. PROVIDE A BOLT TO THE WALL FIBERGLASS LADDER BELOW THE EXISTING HATCH.
12. INFILL EXISTING OPENING ABOVE. SEE SHEET 16
13. PROVIDE NEW OPENING AND GRATING ABOVE. SEE SHEET 16.
14. PROVIDE HOIST SYSTEM MAST SLEEVE DAVIT BASE PER SPECIFICATIONS BELOW:

    WELDED STAINLESS STEEL SLEEVE, WALL-MOUNT DESIGN, WITH STAINLESS STEEL ANCHORS FOR EXISTING CONCRETE CONSTRUCTION AS RECOMMENDED BY MANUFACTURE, DBI SALA UCL WALL-MOUNTED SLEEVE DAVIT BASE MODEL NUMBER 8518346, OR APPROVED EQUAL. ALL SLEEVE DAVIT BASES MUST BE COMPATIBLE WITH THE OWNER'S EXISTING DBSI SALA UCL ADVANCED SERIES HOIST MODEL NUMBER 8518040 MAST. ALL SLEEVE DAVIT BASES MUST ALLOW FOR 360 DEGREE MAST ROTATION AND BE RATED FOR A 450LB WORKING LOAD. ALL SAFETY DEVICES MUST BE ABLE TO WITHSTAND, WITHOUT FAILURE, A DROP TEST CONSISTING OF A 500- POUND WEIGHT DROPPING 18 INCHES

BURGESS & NIPLE

FT. THOMAS
TREATMENT PLANT
RESIDUALS HANDLING IMPROVEMENTS

NO.	DESCRIPTION	DATE

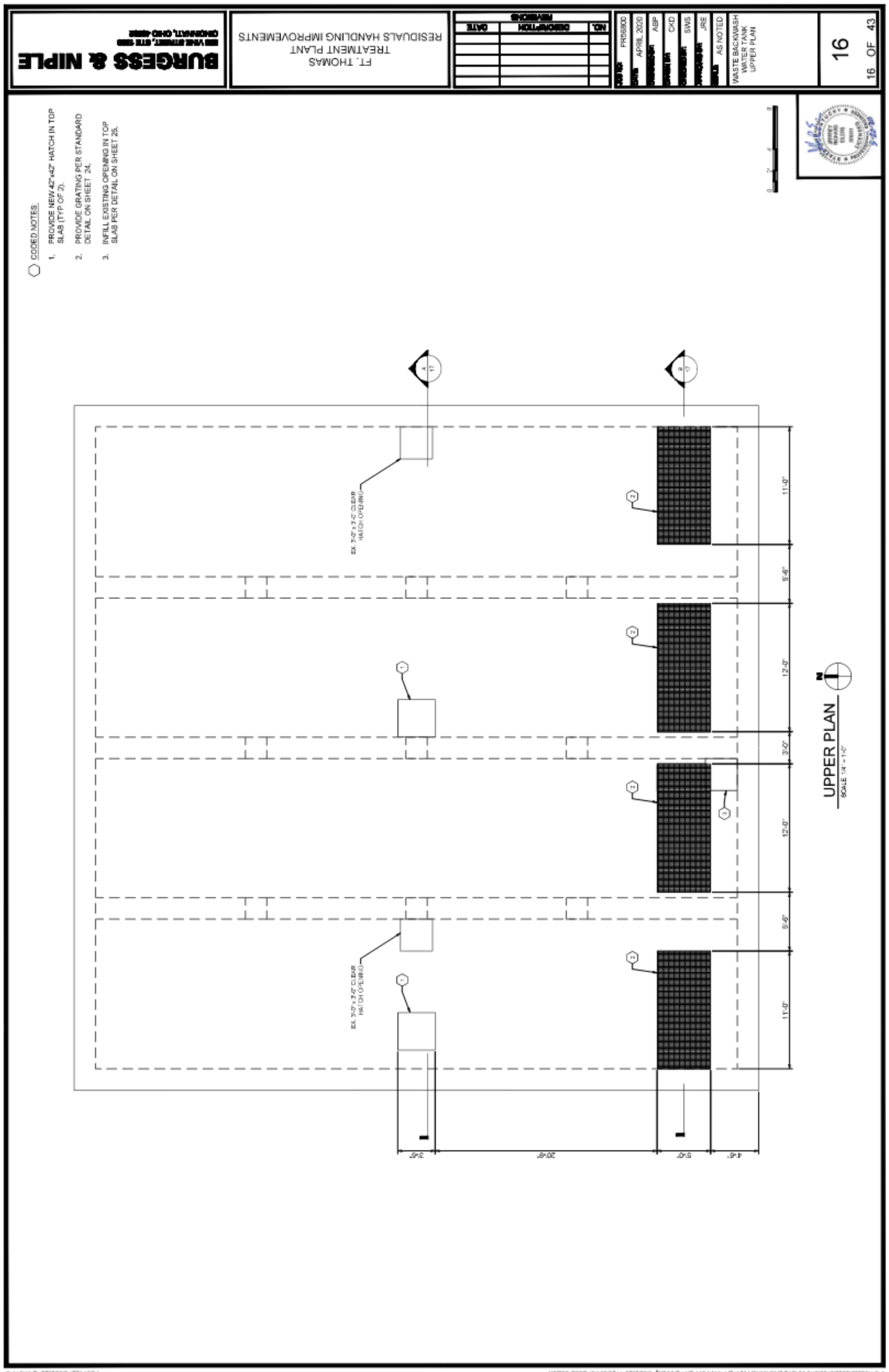
REVISIONS

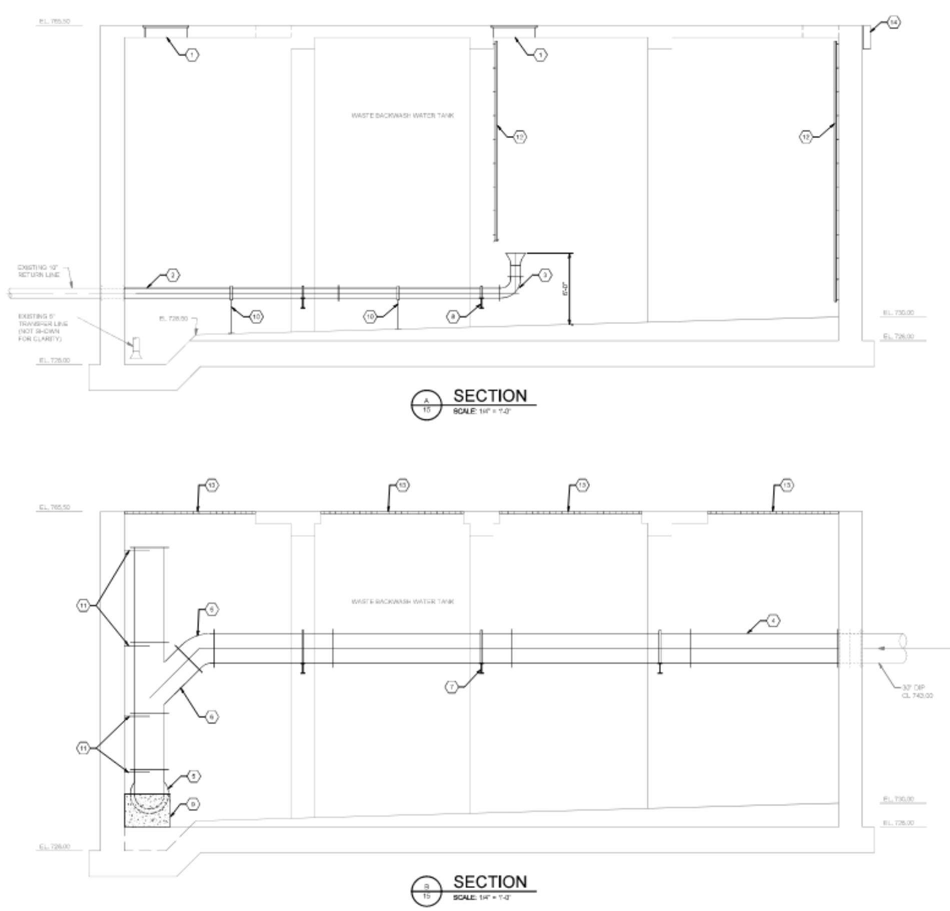
JOB NO.	PR56800
DATE	APRIL 2020
DESIGNED BY	MAU
DRAWN BY	CKD
CHECKED BY	SWS
APPROVED BY	JRE
SCALE	1/4"=1'-0"

WASTE BACKWASH WATER TANK LOWER PLAN

15

15 OF 43


BURGESS & NIPLE
FT. THOMAS
TREATMENT PLANT
RESIDUALS HANDLING IMPROVEMENTS
REVISIONS
NO.
DESCRIPTION
DATE
PR5800
APRIL 2020
ABP
CKD
SWS
JRE
AS NOTED
WASTE BACKWASH
WATER TANK
UPPER PLAN
16
16 OF 43
CODED NOTES:
1. PROVIDE NEW 42"x42" HATCH IN TOP SLAB (TYP OF 2).
2. PROVIDE GRATING PER STANDARD DETAIL ON SHEET 24.
3. INFILL EXISTING OPENING IN TOP SLAB PER DETAIL ON SHEET 25.
EX. 3'-0" x 3'-0" CLEAR HATCH OPENING
11'-0"
5'-6"
12'-0"
3'-0"
12'-0"
5'-6"
11'-0"
3'-6"
20'-6"
5'-0"
4'-6"
UPPER PLAN
SCALE: 1/4" = 1'-0"
N



CODED NOTES:

1. PROVIDE NEW 42"x42" HATCH IN TOP SLAB (TYP OF 2).
2. EXTEND 10" PIPE.
3. PROVIDE NEW 10" 90° BEND AND FLAIR.
4. EXTEND 30" PIPE.
5. PROVIDE NEW 30" 90° BEND.
6. PROVIDE NEW 30"x30" LATERAL.
7. PROVIDE PIPE SUPPORT FOR NEW 30" PIPE (TYP OF 3), W10x19, 304 STAINLESS STEEL. FASTEN TO FACE OF EXISTING CONCRETE PER CONNECTION DETAIL ON SHEET 24.
8. PROVIDE PIPE SUPPORT FOR NEW 10" PIPE (TYP OF 4), W10x19, 304 STAINLESS STEEL. FASTEN TO FACE OF EXISTING CONCRETE PER CONNECTION DETAIL ON SHEET 24.
9. PROVIDE REINFORCED CONCRETE PIPE SUPPORT UNDER 30" 90° BEND.
10. PROVIDE ADJUSTABLE PIPE SADDLE SUPPORT PER DETAIL ON SHEET 24.
11. PROVIDE PIPE SUPPORT FOR NEW 30" PIPE (TYP OF 4). SEE RISER BRACKET DETAIL ON SHEET 24.
12. PROVIDE A BOLT TO THE WALL FIBERGLASS LADDER BELOW THE EXISTING HATCH.
13. PROVIDE GRATING PER STANDARD DETAIL ON SHEET 24.
14. PROVIDE HOIST SYSTEM MAST SLEEVE DAVIT BASE PER SHEET 15.

BURGESS & NIPLE

FT. THOMAS
TREATMENT PLANT
RESIDUALS HANDLING IMPROVEMENTS

NO.	DESCRIPTION	DATE

REVISIONS

PR56800
APRIL 2020
MAU
CKD
SWS
JRE
1/4"=1'-0"

WASTE BACKWASH WATER TANK SECTIONS

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