Preliminary Engineering Report

Lexington Regional Wastewater Treatment Plant Improvements

North Carolina State University

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Prepared for:

LNC
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Abstract

The Lexington Regional Wastewater Treatment Plant (LRWWTP) requires upgrades to its biosolids handling systems to ensure plant functionality through 2045. Our team visited the LRWWTP to assess current operations and gather feedback from plant operators. Operators expressed that several systems within the biosolids handling system are at the end of their useful life and require frequent maintenance. Following the visit, our team performed a comprehensive evaluation of the current biosolids thickening, dewatering, disposal, and hydraulic processes. Our assessment confirmed that existing systems cannot support flow projections for 2045. To determine the optimal biosolids upgrade design, we developed and analyzed three alternatives incorporating various combinations of thickening, dewatering, and disposal technologies alongside two hydraulic alternatives. These technologies include dissolved air flotation tanks, gravity belt thickeners (GBT), centrifuges, belt filter presses, sludge holding tanks, and thermal dryers. Using a multi-criteria decision- making approach, incorporating ENVISION rankings, operator input, and weighted evaluations based on cost, operation, maintenance, and sustainability, we recommend that the optimal alternative should utilize a GBT, sludge holding tanks, a centrifuge, and a thermal belt dryer. Our proposed design ensures long-term reliability, produces Class A biosolids compliant with regulations, and includes a comprehensive site layout, constructability plan, and cost analysis.

Summary of Project Team Effort

The members of the North Carolina State University team included Parker Calloway, Maisha Chowdhury, Makenna Miles, Diya Rau, Graham Scherle, and Rachel Spaulding. Competing in the WEFTEC Student Design Competition are Maisha Chowdhury, Makenna Miles, Graham Scherle, and Rachel Spaulding. The tasks for the completion of this project were divided among these six individuals, although Parker Calloway and Diya Rau are unable to participate in the WEFTEC SDC. This project served as the senior design project for our team, providing much of the work being done during the 2025 spring semester.

Parker Calloway primarily focused on projecting biosolids production to the year 2045. He compared calculations using the solids production equation to data provided by the CDM Smith report to verify accuracy.

Maisha Chowdhury specialized in AutoCAD and Revit renderings of proposed plant upgrades. She used the existing plant layout to show how the construction sequence will proceed using AutoCAD and also created 2D models of new proposed buildings. 3D models of the buildings were then developed in Revit. Maisha also aided in contacting various manufacturers to acquire equipment cost estimates. She competed in the NC One Water Student Design Competition.

Makenna Miles specialized in designing the biosolids flow network, along with the associated calculations and drawing the AutoCAD hydraulic gradelines. She aided in contacting and researching manufacturers to acquire the biosolid flow equipment for cost estimates. Makenna also created the construction timeline Gantt Chart, and aided in creating the ENVISION ranking analysis. Makenna participated in the NC One Water Student Design Competition as well.

Diya Rau reached out to her personal contacts during the cost estimation process to seek quotes for selected equipment.

Graham Scherle performed detailed cost calculations for each alternative. He also assisted in contacting manufacturers for quotes on equipment and ensured any necessary current and future permits were accounted for. He competed in the NC One Water Student Design Competition as well.

Rachel Spaulding specialized in calculations associated with projecting biosolids production and analyzed technology alternatives. She also assisted in the hydraulic analyses and calculations, contacting manufacturers, and acted as the main point of contact with the plant operators. Rachel participated in the NC One Water Student Design Competition as well.

While each member of the team served individual roles, all members contributed to the writing of this report and conducted a site visit to the LRWWTP.

In addition to the students on this design team, two advisors, Dr. Francis de los Reyes and Dr. Michael Wang, contributed to the success of this project. Dr. de los Reyes and Dr. Wang provided essential guidance on how to develop a preliminary engineering report. They helped coordinate site visits and meetings with plant operators. Both Dr. de los Reyes and Dr. Wang offered crucial knowledge on treatment processes which aided in the team's understanding of wastewater treatment. This report would not be possible without the mentorship of Dr. Wang and Dr. de los Reyes.

Consultations with LRWWTP superintendent Mr. Mike Sutton and plant supervisor Mr. Will Hodges offered much insight into the condition of the treatment plant and the needs of both personnel and the treatment process. Mr. Hodge and Mr. Sutton’s input in the conditions assessment aided the team’s decision in equipment replacement and design recommendation.

NC One Water facilitated this team’s participation in the 2025 WEFTEC SDC. NC One Water selected this team to represent their organization and funded the travel of competing group members. This team is honored to represent NC One Water in the 2025 WEFTEC SDC.

1. Introduction

1.1 Lexington Wastewater Treatment Plant

The purpose of this report is to analyze possible upgrades to the biosolids handling process at the Lexington Regional Wastewater Treatment Plant (LRWWTP), located in Davidson County. The report is intended to inform Davidson County and the plant staff on how these improvements may better serve their clients. This report will identify processes to upgrade including waste-activated sludge (WAS) thickening, biosolids stabilization, dewatering, and disposal. This report will outline and evaluate three alternatives to the previously defined processes while ensuring the resulting biosolids remain Class A and are compliant with the permit regulations. The criteria for decision making include the solution's overall costs, ENVISION rating, staff preferences, and anticipated operation and maintenance of the plant. An overview of the plant with elevations of equipment is provided in *Figure 1.1.1*.

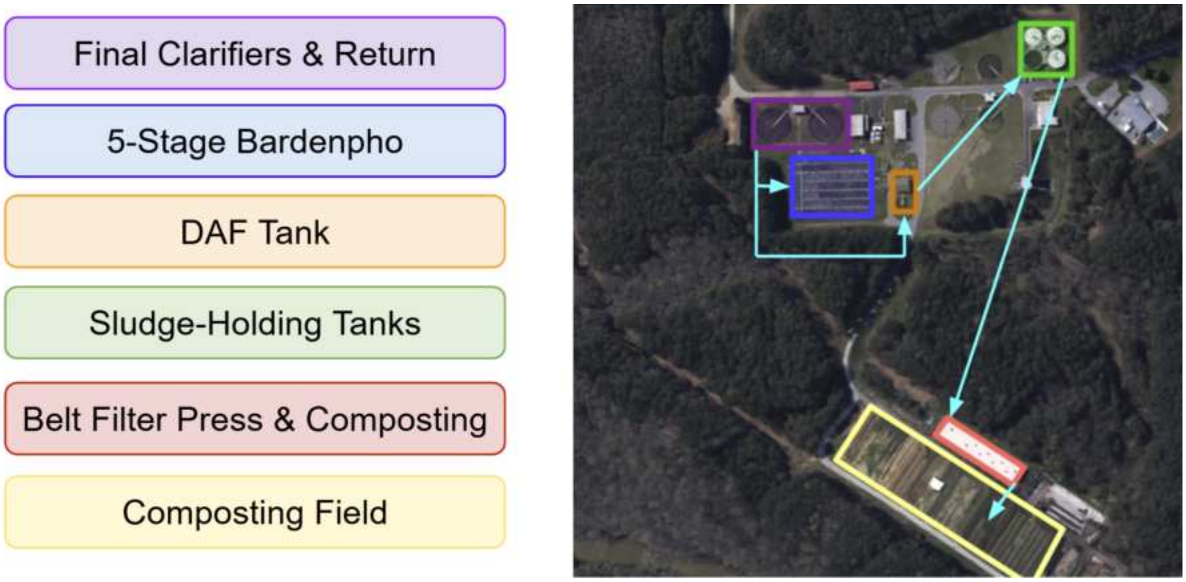


Figure 1.1.1: LRWWTP Site with Labeled Process Train

1.2 Background

The LRWWTP receives wastewater at an average rate of 3 MGD, with a maximum rate of 6.5 MGD. As the existing infrastructure ages, following the latest upgrade in 2002, operators indicated they would prefer a process with more automation and updated equipment. The plant currently uses a dissolved air flotation (DAF) tank for sludge thickening, storage tanks converted from anaerobic digestion tanks for sludge holding, a belt filter press (BFP) for dewatering, and composting to achieve Class A biosolids. The State Revolving Fund (SRF) conducted their own assessment, discussed further in *Section 10.3*, and estimated a project budget of $40 million.

1.3 Scope of Work

Aligning with the purpose of the report, the design includes all engineering calculations and considerations for new infrastructure. We will use historical data to project the necessary capacity of the biosolids handling process to 2045, accounting for a 20-year design life. Per the project scope, the resulting biosolids will be maintained as Class A. We will note any additional requirements according to the scope of this work.

2. Regulations

2.1 Current Permits

Currently, the LRWWTP has a Distribution of Class A Residuals Permit from the Water Resources Division at NCDEQ. This permit allows the plant to sell biowaste that is converted to Class A through composting. The plant also has a Permit to Discharge Wastewater Under the National Pollutant Discharge Elimination System obtained from the Water Resources Division at NCDEQ. This permit allows the plant to treat wastewater using a DAF tank, BFP, and composting for the biosolids handling process.

2.2 Necessary Permits

The goal is to maintain the production of Class A biosolids. To do so, a new Distribution of Class A Residuals Permit, with the new technologies, must be applied for. The plant will also need an Authorization to Construct permit under the NCDEQ. Additionally, the plant will need a new permit to discharge wastewater from the Water Resource Division at NCDEQ. Lastly, this construction will require a National Environmental Policy Act (NEPA) review and environmental documentation because it will be using federal funding.

2.3 Future/Potential Requirements

As of August 2025, there are no regulations on Polyfluoroalkyl Substances (PFAS) in treated wastewater biosolids handling processes, or for biosolids land application in the United States. Therefore, we have not designed our upgrades to accommodate for the removal of PFAS. In the instance that there is new legislation, the biosolids handling process will need to be reevaluated.

2.3.1 Fire Hazards

Regulations are in place to ensure fire safety of the wastewater treatment plant, operation of the new thermal belt dryer, and any other regulations associated with new equipment. These regulations are provided by the National Fire Protection Agency (NFPA) and National Electric Code (NEC). These standards, specifically NFPA 820, and NEC Art 502, provide fire protection and address explosion risks of combustible dust produced by the thermal dryer (Literski, 2021). Lastly, the Occupational Safety and Health Administration (OSHA) has outlined precautions to minimize and control explosions and fires, which should be considered during design and operation.

3. Projections

3.1 Population

We expect the population of Lexington to gradually increase in the next 20 years. The City of Lexington has a population of nearly 20,000 residents as of 2024, and is growing at a rate of 0.29% annually (World Population Review, 2024). In response to this growth, the city has approved 507 new housing units that will support population growth. Additionally, large-scale projects such as Siemens Mobility's $220 million rail services facility, Divert's food waste-to-energy plant, and US Foods' expanded operations pose potential in industrial growth (Lexingtonnc.gov, 2024). To estimate the number of residents in Lexington for the next 20 years, we used the population projection formula, *Appendix Equation A.1.* The projected residential service population of 2045 for the LRWWTP is 21,195 residents.

3.2 Capacity

The average daily flow of the LRWWTP is 3.0 MGD, and the maximum permitted daily flow of the treatment plant is 6.5 MGD. By averaging the influent flow data from *Appendix Table H.1* for each year, we observed a linear growth trend with a high coefficient of determination. The lack of variability in the data suggests that this trendline likely serves as a reliable predictor of the plant's influent flow based on the year. Based on the established trendline, we project the average daily influent to reach 7.5 MGD by 2045. *Appendix Figure A.1* depicts the 2024 average daily flow projections using data from *Appendix Table H.1.* We calculated the projected biosolids output flow of 2045 to be approximately 22,000 lbs/day using the solids production equation *(Appendix Equation A.2)*.

4. Available Information

4.1 Previous Design

The existing activated sludge system produces WAS from the secondary clarifiers, which are directed to a dissolved air flotation (DAF) unit for thickening. The system utilizes a partially converted anaerobic digestion complex that is now used to maintain the sludge under aerobic conditions, which is then composted into a Class A biosolid product. Currently, the primary clarifiers are not in service, and the old anaerobic digesters are being used as sludge holding tanks. A process schematic is included in *Section 8.1.*

4.2 Historical Data

Historical data from 2017 to 2019 *(Appendix Table H.1)*, encompassing influent and effluent data were used to establish the relationship between plant-influent loadings and biosolids production. Irregularities can be traced to industrial source discharge. In *Appendix Table H.2*, the influent and effluent flow rate from 2022-2024 can be found. Although the current hydraulic profile for the biosolids handling system was not given, the LRWWTP provided the team with the 1987 hydraulic profile for the entire waste water treatment process *(Appendix Figure E.1)*.

5. Existing Process and Equipment

5.1 Dissolved Air Flotation

The plant currently uses a DAF tank for thickening that is approaching the end of its usable life. During our site visit, wobbling was observed in the drive mechanism and the arm skimmer. There was also excessive algae buildup in the launderer and weir, which can obstruct water flow, requiring frequent DAF cleaning. At the time of the condition assessment (2020), the DAF tank was generally in fair condition despite the rust found on the steel track around the perimeter of the tank. The DAF support building contains components related to polymer input and is in fair condition overall. While visiting the site, the operators shared concerns about how much time was spent on general maintenance to keep the DAF working properly.

Figure 5.1.1: Current DAF Tank

5.2 Anaerobic Digester Tanks Acting as Sludge Storage

The plant has four circular tanks that were originally installed for anaerobic digestion. Each tank has a capacity of approximately 655,000 gallons. The anaerobic digestion process is no longer used as three of the tanks have been completely converted into sludge-holding tanks between the thickening and dewatering processes. One of the tanks has a mixer and is currently used as an aerated sludge holding tank. The mixer is approximately seven years old and in reportedly good condition. The building housing the storage tanks is in fair condition. The pump used to move the sludge from the tanks down to the composting facility is reportedly still in good condition. The operators report that these tanks are used to store sludge until it can be released when the BFP operator is working, approximately 40 hours a week. It was also reported that the tanks are full most of the time.

Figure 5.2.1: Current Anaerobic Digester Tanks Used as Sludge Holding Tanks

5.3 Sludge Pumping

Thickened WAS produced by the DAF passes through two transfer pumps that were recently replaced with 7-hp rotary lobe-style pumps. The transfer pumps then discharge the sludge through pipes to the 655,000-gallon sludge holding tanks.

5.4 Sludge Dewatering

The Envirex BFP at the LRWWTP dewaters biosolids before composting. The approximately 30-year old BFP and the original polymer unit are in fair condition with well-maintained belts and recently replaced rollers. The BFP is reaching the end of its useful life, suggesting the need for replacement in the future. The polymer unit could also be improved as it frequently requires cleaning and maintenance to ensure effective polymer activation. The incline belt conveyor transports the dewatered cake to the composting facility. This belt conveyor has similar age-related issues. Additionally, the BFP's hydraulic power pack, which maintains belt tension, is in fair condition, but the hydraulic piston system is in poor condition and needs replacement along with the BFP.

Figure 5.4.1: Current Envirex BFP

5.5 Composting Facility

The composting facility at the LRWWTP dewaters thickened WAS using a single BFP. The plant blends the resulting dewatered cake with amendments and bulking agents before sending it to the agitated bins of the composting process. After composting, the material is transferred to an onsite curing area. Once cured, the compost goes through screening and into storage until it is either picked up or distributed for final use as a Class A biosolid product. The current plant condition assessment recommends that the pile mixer be replaced due to aging and poor condition. The assessment also indicated that the composting building and agitated bins are at the end of their useful life and require replacement with a new system.

Figure 5.5.1: Current Composting Bins

6. Design Alternatives

6.1 Introduction of Design Alternatives

We considered three design alternatives to update the current biosolids handling process at the LRWWTP. The first design, the *Existing DAF Process*, replaces the DAF and BFP with new systems of the same technology. This design will still utilize the composting and sludge holding tanks, as well as the associated piping and infrastructure. The second design alternative, the *BFP-Thermal Dryer Process*, replaces the existing DAF with a gravity belt thickener for thickening, installs a new BFP for dewatering, and installs a thermal belt dryer for the biosolids disposal process. The third design alternative, the *Centrifuge-Thermal Dryer Process*, replaces the DAF with a gravity belt thickener for thickening, the BFP with a centrifuge for dewatering, and composting with a thermal belt dryer for biosolids disposal. *Appendix Figure B.1, Appendix Figure B.2* **,** *and Appendix Figure B.3* display process flow diagrams of the three design alternatives.

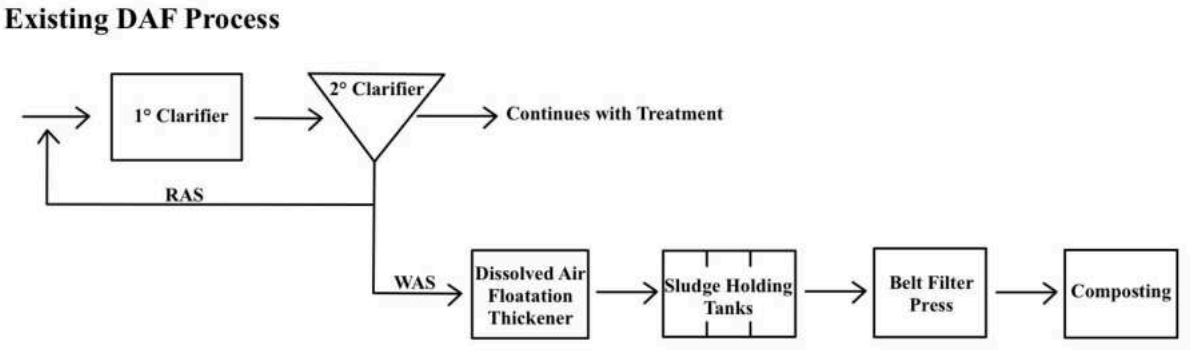


Figure 6.1.1: Existing DAF Process Flow Diagram

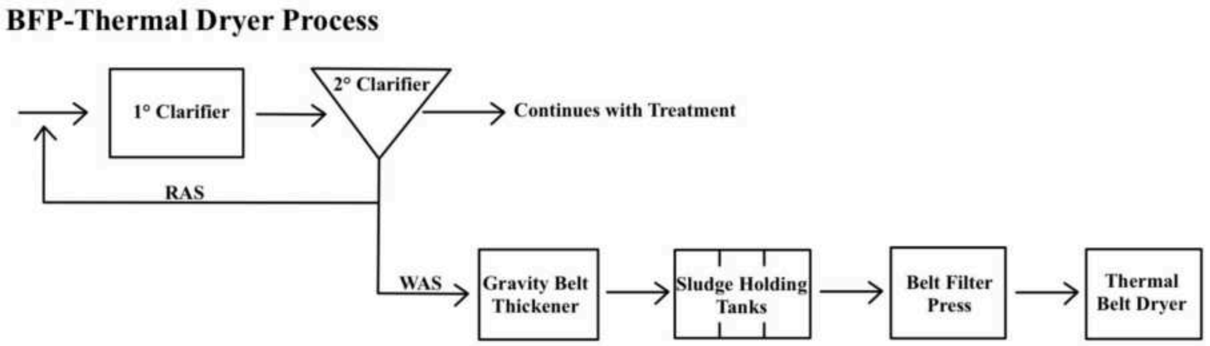


Figure 6.1.2: BFP-Thermal Dryer Process Flow Diagram

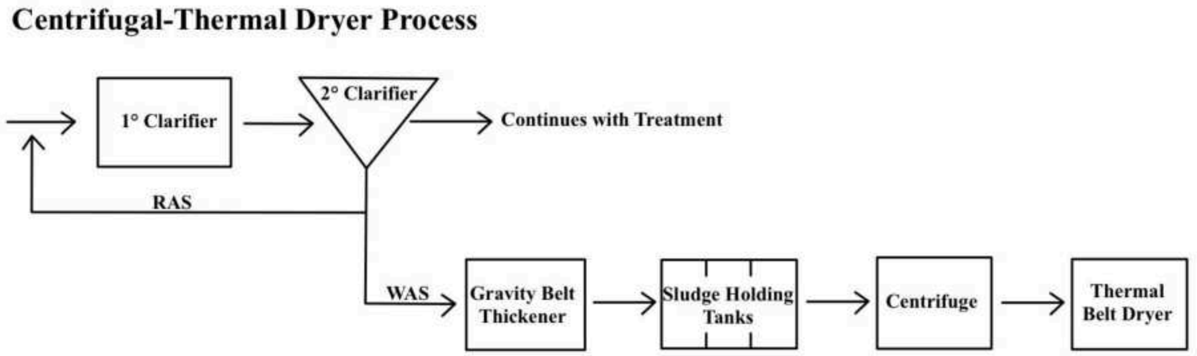


Figure 6.1.3: Centrifuge-Thermal Dryer Process Flow Diagram

6.2 Criteria for Ranking Design Alternatives

We used three main criteria to determine which design alternative is optimal: cost, operations and maintenance (O&M), and sustainability. A more detailed breakdown of the cost and O&M category is outlined in *Appendix C*. Each of the scores were averaged and then multiplied by the category's associated weight of importance, as shown in *Table 6.2.1.*

Table 6.2.1: Ranking of Design Alternatives

Overall	% weight of importance	Existing Process	GBT/BFP/Thermal Dryer Process	GBT/Centrifuge/Thermal Dryer Process
Cost	45%	4	2	3
O&M	35%	1.8	2.5	3.5
Sustainability	20%	1.6	2.5	3.2
Best Alternative		2.8	2.4	**3.2**

6.3 Calculations for Ranking Design Alternatives

We determined the cost-effectiveness of each alternative by scoring variables that would affect overall cost. These variables include the capital, personnel, and life-cycle costs of each alternative, taking into account the economics of energy consumption and O&M considerations. This data is summarized in *Appendix Table C.1.* A detailed breakdown of the cost analysis for each alternative can be found in *Appendix F*. The improvements made to the system consider O&M burdens such as ease of operation, equipment replacement, and reliability. When scoring each alternative, we incorporated LRWWTP operator input as well as the anticipated technical training and maintenance burdens associated with each design alternative. *Appendix Table C.2* represents averages of operator rankings, obtained through a survey made by the team, of various categories deemed important in O&M. Finally, we conducted an ENVISION analysis to rank the quality of life, leadership, natural world, climate and resilience, and resource allocation for each alternative. This analysis further demonstrated which areas of our design alternatives can improve in its sustainability and community impact. We found that the Existing DAF Process had better ratings for the resource allocation and climate and resilience categories compared to the BFP-Thermal Dryer and Centrifuge-Thermal Dryer alternatives. The lack of construction associated with keeping the existing biosolids handling process reduces the existing process's environmental footprint. Our team decided that these differences were negligible, given the state of the current equipment and plant needs. Therefore, each overall LRWWTP sludge-handling system alternative yielded consistent results. *Figure 6.3.1* visually depicts the ENVISION results consistent throughout each design alternative. Thus, using the overall design alternative rankings dependent on team and LRWWTP operator input, along with the ENVISION analysis, we chose the alternative with the minimal impacts across each assessment in the best interest of our client.

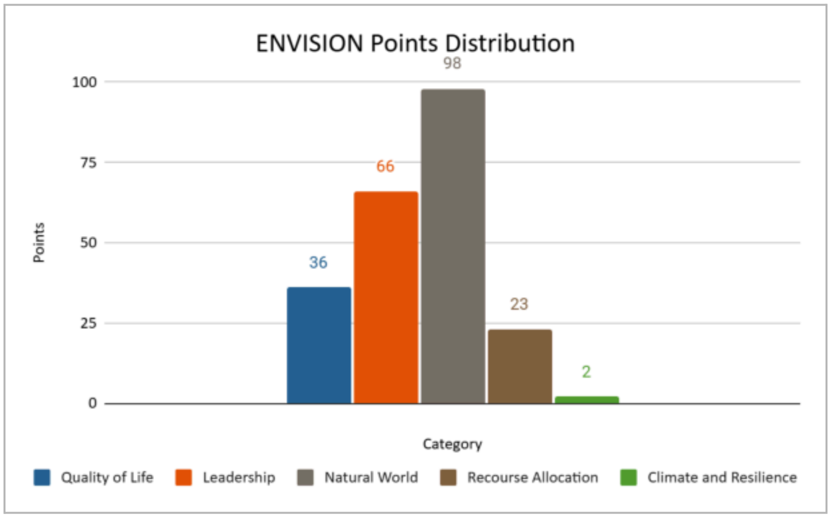


Figure 6.3.1: ENVISION Points Distribution

6.4 Selected Design Alternative

We have selected the ***Centrifuge-Thermal Dryer*** as the optimal alternative for design. We selected this alternative because it is the best suited to meet the future needs of the plant based on our metrics, as shown in *Table 7.2.1.*

7. Proposed Facilities

7.1 Upgrades and Improvements

The LRWWTP facility is currently operating with a DAF and BFP that are reaching the end of their usable lives. Additionally, the composting process is labor intensive and takes up a large footprint on the property. We performed a size analysis to design each process with the goal of meeting the needs of the plant for the next 20 years. The anticipated flow characteristics in 2045 are listed in *Table 8.2*. Using these values, we calculated that the anticipated 2045 production of biosolids would be 14,600 lb/day.

7.1.1 Gravity Belt Thickener

As a replacement for the DAF, we have chosen the Komline G-25 Gravabelt gravity belt thickener *(Appendix Figure B.1)*. This technology was sized using *Appendix Equation E.1* and *Appendix Table H.4* to select a 1 meter belt width.

7.1.2 Sludge Holding Tanks

We have decided to continue allowing the flow to go through the sludge holding tanks. The tanks allow for flexibility in the event that sludge flow needs to be stopped for maintenance or repair needs later in the biosolids handling process.

7.1.3 Dewatering

We have chosen the centrifuge as the replacement dewatering technology to replace the current BFP. In the decision matrix, we concluded that the centrifuge would be more cost efficient than the other alternative of two BFP's. Using the anticipated feed capacity, we found that the Centrisys Dewatering Decanter CS14-4 Centrifuge *(Appendix Figure B.2)* would meet the anticipated needs of the plant. Additionally, we have selected the Polyblend Polymer Feed System *(Appendix Figure B.3)* to supply appropriate polymer doses to the centrifuge.

7.1.4 Thermal Belt Dryer and Pelletizer

After performing a size analysis, we found that the Centrisys DLT120 Low-Temperature Belt Dryer *(Appendix Figure B.4)* would meet the anticipated demands of the LRWWTP. The cake produced by the dryer is not ideal for land application. In the interest of making the final product more marketable, we have included the Colorado Mill Equipment (CME) MILL-10 Pellet Mill *(Appendix Figure B.5)* in our design to pelletize the dry cake. Additionally, we have included the Bio-SILO from Jim Myers & Sons Inc. (JMS) *(Appendix Figure B.6),* sized to store the pellets for up to four weeks if necessary.

7.2 New Facilities

Our design will require the construction of two new buildings to house the upgraded biosolids handling process. The thickening building will be located across from the current pump building, and house the new GBT. The layout for this building can be seen in *Appendix Figure D.1* as well as the corresponding Revit model (*Appendix Figure D.3).* The second building will be located across from the current BFP and composting building, on the site that is currently used to store processing compost. This new dewatering building will house the centrifuge and thermal belt dryer. Additionally, the building will house the polymer system for the centrifuge and the pelletizer. There will be a conveyor belt between the centrifuge and thermal belt dryer, and the thermal belt dryer and to transport dewatered cake. The silo will be located outside of the dewatering building. There will be a conveyor belt to transport the pellets from the pelletizer to the silo. The layout for the new dewatering building can be seen in *Appendix Figure D.2* as well as the corresponding Revit model (*Appendix Figure D.4).*

7.3 Final Disposal

The LRWWTP currently sells the composted biosolids to local buyers for $3/cubic yard. We do not anticipate there to be a change in the market interest for the product as it will remain Class A despite the change in form from mixed amendments to a concentrated pellet.

8. Hydraulic Analysis

8.1 Current Hydraulic Operation of LRWWTP

Appendix Figure E.2 shows the hydraulic biosolids flow diagram provided by the LRWWTP. The plant record drawings depict the influent wastewater entering the LRWWTP at the northern end of the site at a hydraulic grade line (HGL) of 608.01 feet before being pumped up to go through the initial screening and grit removal via a pump lift station *(Appendix Figure E.1)*. The plant manually controls the selection of pumps used at this station, allowing flexibility during influent fluctuations. The influent wastewater then passes through a secondary pump lift station to be directed to the Bardenpho process for nitrogen and phosphorus removal before transporting WAS to the device system. The DAF tank thickens the influent wastewater, then WAS exits the DAF tank at an elevation of 657.33 feet and is transported uphill via two pumps to the sludge-holding tanks at the plant's highest elevation. The returned activated sludge (RAS) enters the sludge holding tanks below ground level at an elevation of 668.5 feet, while the sludge holding tank's ground level elevation is 695 feet. Once the RAS reaches the sludge holding tanks, a pump at the bottom transports it downhill to the Belt Filter Press (BFP) at an elevation of 680 feet for dewatering prior to the composting process. It is critical to note that the BFP requires a continuous flow of RAS to operate efficiently. The treated effluent water, from which the WAS is extracted, undergoes further treatment south of the composting center before being released into Abbott's Creek, which ultimately flows into High Rock Lake. The entire process typically requires approximately 6 days for the influent to undergo treatment and be released as effluent.

8.2 Future Considerations for Hydraulic Operations

The two primary areas we have identified for biosolid flow upgrades at the LRWWTP are the sections between the current DAF tank and the sludge holding tanks and between the sludge holding tanks and the BFP. The rotary lobe-style pumps that transfer the WAS from the DAF to the holding tanks and the associated existing piping network are in fair operational condition. This 7-horsepower (hp) pump can be seen in *Appendix Figure E.6*. However, the pump motor for the activated sludge from the sludge-holding tanks to the BFP dewatering process, which is responsible for recirculating the WAS within the holding tanks and transferring it to the dewatering system, is in poor condition due to aging and corrosion. Since these biosolid processes are interconnected, we considered 2 overall biosolid flow alternatives for the LRWWTP upgrade. These alternatives involve adjustments to the path by which biosolids are transferred from the thickening process to the dewatering process. Both biosolid flow alternatives will require replacing the current 15-hp pump that transfers WAS from the sludge-holding tanks to the new dewatering system and adding a second 15-hp pump to ensure reliability if one pump experiences issues. This pump can be seen in *Appendix Figure E.7*. Additionally, the current 8” Duct Iron Piping network transferring activated sludge throughout the plant is in fair condition, as noted by previous assessments performed by the plant, and will be utilized in the two biosolid flow alternatives. New piping will additionally be installed to route the biosolids from the new thickening and dewatering systems into the existing piping network. The new piping will continue to be 8” Duct Iron Pipe. The new thickening and dewatering locations are portrayed outside of the FEMA 100-year floodplain in *Appendix Figure E.4*. Based on our hydraulic calculations for biosolids flow in *Section 8.4*, no pump upgrades are required, as the current horsepower is compatible with the required horsepower projected for 2045 in *Section 3.2.* Thus, utilizing the existing pipe infrastructure is cost-effective and allows more funding and resources to be allocated to other parts of our proposed design.

Alternative 1, the *Sludge Tank Utilization Route*, offers a practical and cost-effective solution by making minor adjustments to the existing pipe network. It is advantageous for plant operators as it closely mirrors the current biosolids flow process, is easy to use, and primarily utilizes existing infrastructure. The only modifications involve rerouting piping between the final clarifier and the thickening system, and tapping into the existing line from the thickening system to the sludge holding tanks, as shown in *Section 8.2.1*. However, this alternative is inefficient, as it requires WAS to be transferred to the sludge holding tanks before reaching the dewatering system, instead of a direct transfer. Alternative 2, the *Streamlined Route*, offers greater operational flexibility by providing two flow routes between the thickening and dewatering systems. The first route follows the configuration of the *Sludge Tank Utilization Route*, while the second introduces a direct route from the thickening process to the dewatering process, as detailed in *Section 8.2.2*. The direct transfer of WAS is feasible because the percentage of biosolids in thickened WAS effluent and dewatered WAS influent is compatible, and both processes operate continuously. The *Streamlined Route* is advantageous because it provides flexibility if excess sludge needs to be directed and held in the sludge holding tanks while the mass balance between systems aligns and is more efficient by directly transferring the WAS between processes, bypassing the holding tanks. However, the *Streamlined Route* has a higher cost than the *Sludge Tank Utilization Route* and will require more manual controls via a control valve when changing routes.

Though the *Streamlined Route* costs more than the *Sludge Tank Utilization Route* and will require the manual control of switching which pipe network is utilized, we propose this biosolids flow network in our final design as it ultimately provides the plant with more reliability, flexibility, and efficiency, with two possible routes. *Sections 8.2.1* and *8.2.2* provide more details differentiating the biosolids flow alternatives.

8.2.1. Biosolids Flow Alternative 1: Sludge Tank Utilization Route

The *Sludge Tank Utilization Route*, which aligns with the plant’s existing process, is portrayed in *Appendix Figure E.5*. This biosolid flow alternative is a cost-effective solution for relocating the thickening system while preserving the current infrastructure as it only requires approximately 478 feet of new pipe. Using our proposed pipe layout and provided plant drawings, our calculations did not show any hydraulic restrictions with the current seven-hp pump in place and 8” DIP in *Section 8.4.*

8.2.2. Biosolids Flow Alternative 2: Streamlined Route

The *Streamlined Route*, shown in *Figure 8.2.2.1*, builds on the upgrades outlined in Section 8.2.1, with the addition of an extended 8-inch Ductile Iron Pipe (DIP) network to route waste activated sludge directly from the thickening effluent to the new dewatering system. This alternative requires approximately 557 feet of new pipe. Since the sludge holding tanks would function solely as a backup transfer route, no hydraulic upgrades are required in the existing pipe network, allowing more funds and resources to be allocated to the new pipe layout.

Figure 8.2.2.1: Streamlined Route Layout

8.3 Approach for Developing the Biosolids Hydraulic Profile for Upgraded Processes

We used *Appendix Equation E.2* to calculate the horsepower required to pump the waste activated sludge from the thickening process to the sludge holding tanks and from the holding tanks to the dewatering process. The required horsepower depends on the head loss experienced between the activated sludge and the piping system, as well as elevation changes. We used *Appendix Equations E.3* and *E.6* to determine the minor and major head losses. Additionally, we used *Appendix Equation E.4* to calculate Reynold’s number to determine the flow type and *Appendix Equation E.5* to determine the friction factor. These calculations were critical in designing the biosolids flow system upgrades as they ensured that the pumps selected, and continued to use, could achieve the maximum activated sludge flow rate with optimal efficiency. These calculations assumed a pump efficiency of 80%.

8.4 Streamlined Route Calculations

Using the equations provided in *Appendix E*, we determined that the existing 7-hp pump, which transfers biosolids from the thickening system to the sludge holding tanks, and the existing 15-hp pump, which transfers biosolids from the sludge holding tanks to the dewatering system, provide sufficient horsepower capacities for the designed upgraded system. This system incorporates both the *Sludge Tank Utilization* and *Streamlined Routes*. The proposed biosolids flow system includes a 3-way ball valve at the DAF effluent, allowing WAS to be routed to either the *Sludge Tank Utilization Route* or the *Streamlined Route* using the same pump. However, due to the absence of complete plant drawings, specifically for the sludge-handling networks, we assumed the location of the existing networks based on the primary water treatment drawings given and to our best judgment. To accommodate potential discrepancies in existing pipe network locations and allow for flexibility in head loss changes, we calculated the required horsepower for each biosolids flow network with a multiplication safety factor (SF) of 3 in *Appendix Tables E.1***,** *E.2,* and *E.3.*

8.5: Final Hydraulic Design

8.5.1: Streamlined Route Pumps

Based on our biosolids flow hydraulic analysis in *Section 8.4*, our final design proposes the implementation of the *Streamlined Route*. This biosolids flow network will continue to use the existing 7-hp pump to transfer the WAS from the thickening effluent to either route, due to the existing horsepower being larger than the greatest horsepower required at this location. Additionally, this design recommends replacing the current 15-hp pump at the holding tanks and installing an additional 15-hp pump to elevate the WAS from the holding tanks to the dewatering system to ensure a maximum useful lifetime. These pump capacities are sufficient to maintain the maximum biosolids velocity without any hydraulic restrictions for the 2045 projected plant capacity. The pipe network layout is in *Figure 8.2.2.1*. We recommend sourcing these progressive cavity pumps from the same manufacturer as the existing pumps, Liberty Process. Liberty Process is a reliable manufacturer as the progressive cavity pumps are used in over 500 wastewater facilities in North America. Specifically, we propose using the *2G065G1L* from the *Millennium Series,* referenced in *Appendix Figure E.3*, as it is designed for transferring heavy-duty activated sludge and polymer feed systems, and operates under a range of flow and pressure.

8.5.2: Hydraulic Alternative Design Gradelines

The biosolid flow hydraulic gradelines for our final proposed design are illustrated in *Figures 8.5.2.1, 8.5.2.2.* These simplified schematics are not to scale and are intended solely to depict the elevation and horizontal distance changes of the biosolids flow between processes.

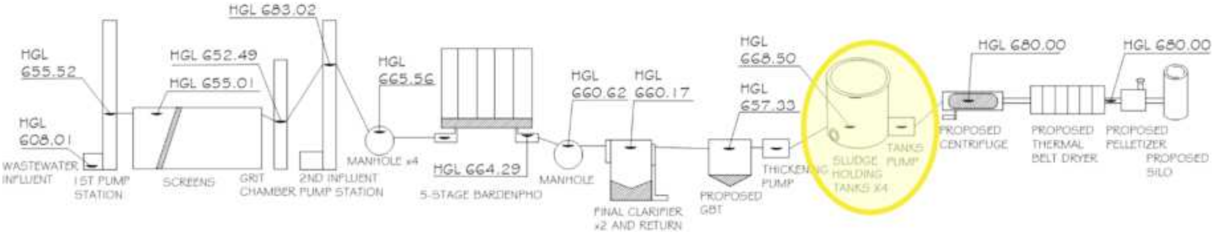


Figure 8.5.2.1: Sudge Tank Utilization Route - Hydraulic Gradeline

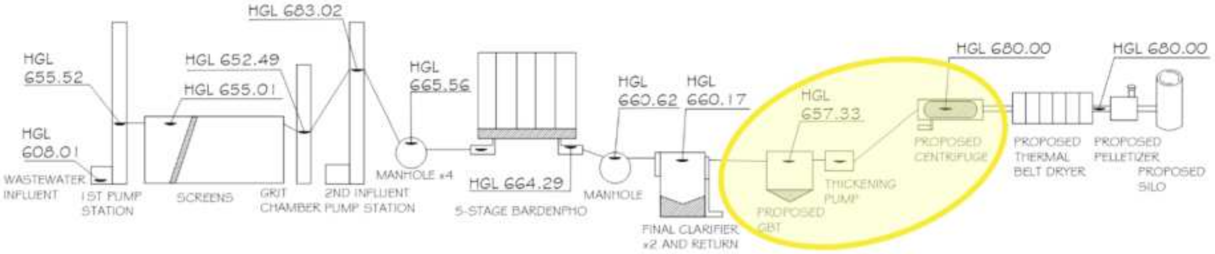


Figure 8.5.2.2: Streamlined Route - Hydraulic Gradeline

9. Cost Analysis

9.1 Cost Analysis

As of August 2025, this project has received funding of $27 million from the State Revolving Fund (SRF). A preliminary opinion of probable construction cost (OPCC) was conducted for each alternative as well as the cost of the hydraulic upgrades and proposed new buildings, which we assumed would be approximately the same for each alternative. We contacted various manufacturers for each alternative we explored for pricing estimates. In the instances where manufacturers did not supply a price quote, fact sheets from the EPA on how to estimate the cost of the various technologies were used. A multiplier was applied to the equipment costs to account for a variety of costs that may be accrued during the project to obtain a more accurate estimate. Based on discussions with Dr. Micheal Wang, the multipliers were applied to the capital cost of each project, which included the cost of the equipment and proposed hydraulic and building upgrades. The multipliers are listed in *Table 9.1.3*. *Table 9.1.1* contains a detailed breakdown of each unit process. The capital costs in *Table 9.1.1* have the multiplier from *Table 9.1.3* applied. To calculate the cost of excavation, building materials, we used current fair-market estimates. We also used wage determinations to estimate the current hourly wage of construction workers in calculating the construction cost (SAM.gov, 2025).

Table 9.1.1: Cost Breakdown Centrifuge - Thermal Dryer Process

Process Upgrade	Capital Cost	O&M Cost	Salvage Value
Gravity Belt Thickener	$1,650,000	$146,630	$12,000
Centrifuge	$2,100,000	$511,000	$25,000
Thermal Belt Dryer	$1,768,000	$538,000	$13,000
Annual Income from Biosolids Product Sales (in 2025)			$80,300
Total Capital Cost in 2025			$5,518,000
Present Worth Value in 2045			$19,399,000

Table 9.1.1. does not include the capital costs that were shared between each alternative. *Table 9.1.2* displays the costs shared by each alternative.

Table 9.1.2: Capital Costs Of All Alternatives

	Number of Units	Cost per Unit	Cost
Excavation (yd^3)	2297	$30	$68,900
Concrete Slab (yd^3)	290	$800	$232,123
Concrete Wall (yd^3)	363	$1,200	$435,496
Concrete Support (yd^3)	7	$2,000	$4,000
Metal Roof (yd^2)	871	$200	$174,267
8" DIP	557	$66	$36,762
Pump	2	$19,000	$38,000
8" DIP 90 Degree Fitting	2	$1,050	$2,100
8" DIP Gate Valve	2	$3,200	$6,400
Total Cost			$ 1,008,000

Compiling all of the cost analysis information together an OPCC was developed. The OPCC of the entire project is **$17,068,000**. *Table 9.1.3* contains a summary of the OPCC.

Table 9.1.3: OPCC Summary

Category	Percentage	Cost
Construction	-	$6,526,000
General Conditions	5%	$326,000
Contractor Overhead & Profit	15%	$1,028,000
Bonds & Insurance	10%	$788,000
Electrical	15%	$1,300,000
Engineering Cost (Design)	12%	$1,196,000
Engineering Cost (CA & Field)	12%	$1,340,000
Escalation	5%	$625,000
Contingency	30%	$3,939,000
Total Cost		$17,068,000

10. Construction

10.1 Construction Sequence

The LRWWTP construction sequence is based on the downstream sequential flow of the plant, with newly implemented facilities built according to those in *Section 7* and the biosolid hydraulics in *Section 8*. The construction sequence is broken into three primary phases: Pre-Construction, Construction, and Post-Construction, with subphases and details within each phase, as seen in *Figure 10.1.1*. The sequence was created to ensure that the Maintenance of Plant Operations MOPO would operate at capacity during construction and have a conservative turnover time.

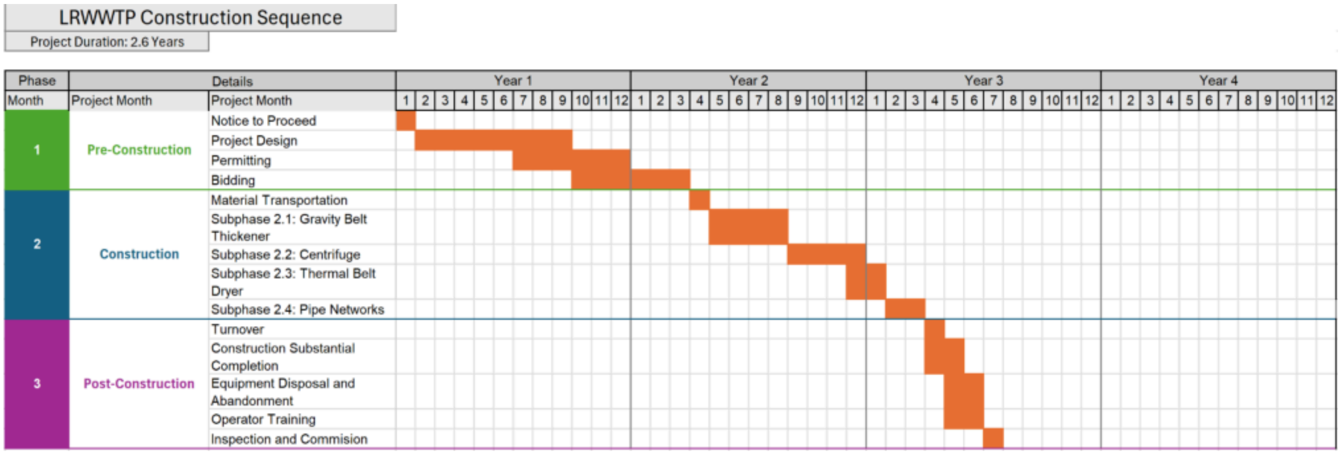


Figure 10.1.1: LRWWTP Construction Gantt Chart

Phase 1: Pre-Construction

The pre-construction phase is estimated to take approximately 15 months to finalize the engineering design and complete the overall permitting process, which includes submitting the application, undergoing agency review, and obtaining final approval. The engineering design includes the cost analysis, construction sequence, MOPO, and technical specification drawings using AutoCAD and 3D Revit to help visualize new equipment and buildings. This phase also accounts for bidding, construction permit approvals, and issuing a complete notice to proceed (NTP). We used conservative time estimates to allow for flexibility in case of potential delays or unforeseen issues that may arise during this phase.

Phase 2: Construction

Upon completing *Phase 1* and receiving the NTP, the Construction Phase will begin. *Phase 2* is expected to take approximately 13 months to construct the new infrastructure and install the required systems. Similar to *Phase 1*, this phase uses conservative time estimates to allow for potential delays related to equipment delivery, shipping, installation, and any unforeseen construction challenges. All of the new equipment and infrastructure will be constructed and installed before being turned over to be utilized by the plant, as shown in *Phase 3*. Once each construction subphase is complete, the Construction Substantial Completion will be issued to the LRWWTP, allowing the final commissioning phase in *Phase 3* to begin.

Subphase 2.1: Gravity Belt Thickener

Subphase 2.1 focuses on the gravity belt thickener. While the current DAF system in place continues to operate, the new thickening building, as seen in *Appendix Figure D.1*, will be constructed to house the new *Komline* gravity belt thickener, its associated polymer unit, and pump within two months. Installing the GBT and its polymer unit will take an additional two months. Since we are reusing the existing 7-horsepower pump in the new design, the pump will be transferred to the new thickening building and system during the plant turnover in *Phase 3* to maintain operations. Additionally, connecting the new pipes to the existing ones will occur during *Subphase 2.4* and *Phase 3* to ease plant turnover and maintain plant operations during construction. The construction of Subphase 2.1 during current plant operations is portrayed in *Appendix Figure G.1*.

Subphase 2.2: Centrifuge

Subphase 2.2 focuses on the centrifuge dewatering device. While the current BFP in place continues to operate, the new dewatering building, as seen in *Appendix Figure D.2*, must be constructed to house the new dewatering and biosolids handling equipment within two months. Installing the *Centrisys* centrifuge and its polymer unit will take an additional two months. Although the new dewatering building will be located on part of the current composting field, composting operations will continue as the composting facility in the current warehouse remains unchanged, and the field extends farther back than the new building. Similar to *Subphase 2.1*, connecting the new pipes to the existing will occur during *Subphase 2.4* and *Phase 3* to ease plant turnover and maintain plant operations during construction. The construction of Subphase 2.2 during current plant operations is portrayed in *Appendix Figure G.2*.

Subphase 2.3: Thermal Belt Dryer

Upon completing the installation of the centrifuge in the new dewatering building, a *Centrisys* thermal belt dryer and a *JMS Inc.* conveyor belt will be installed to connect the systems within one month, as shown in *Appendix Figure D.2*. Additionally, a pelletizer from *Colorado Mill Equipment* will be installed inside the new dewatering building, and a *JMS INC.* silo will be placed outside of the building for storage. Two additional conveyor belts will be installed to connect the thermal belt dryer to the pelletizer, and from the pelletizer to the silo within an additional 1 month. The pelletizer will transform the produced Class A Biosolids into a usable form, while the silo will store the pellets produced for ease of storage and distribution. The construction of *Subphase 2.3* during current plant operations is portrayed in *Appendix Figure G.2*.

Subphase 2.4: Pipe Networks

Once the thickening, dewatering, and sludge-handling systems are installed, the associated pipe networks will be laid. This includes the installation of new 8” DIP from *U.S. Pipe* connecting the Final Clarifier to the GBT, and extending from the GBT to the existing pipeline leading to the sludge-holding tanks. Additionally, a new pipe segment and its associated control valves must be constructed to tie into the existing sludge-holding tank effluent network, allowing for the transfer of biosolids from the GBT to the centrifuge. Once these pipes are installed, another 8” DIP line will be installed to tap out of the existing sludge-holding tanks network to the centrifuge, completing system integration. This work includes the installation of approximately 557 feet of new pipe, associated control valves, *Liberty Process* pumps, and all related excavation and earthwork. *Subphase 2.4* will take two months to conclude, initiating the transition to the next phase.

Phase 3: Post-Construction

Finally, upon completion of construction, the plant will enter Phase 3: Post-Construction. This phase, estimated to take four months, focuses on transitioning the facility to the newly constructed system. The plant will undergo system turnover for five to ten days, during which the newly constructed processes will be implemented. Although operations downstream of the Bardenpho will be halted during turnover, this timeframe is feasible because the plant currently suspends DAF operations for maintenance up to two weeks at a time when necessary, with adjustments made to the Bardenpho and other upstream processes. Once the system is online, the Construction Substantial Completion will be issued. Following substantial completion, the plant may abandon the DAF tank, dispose of the BFP and any unnecessary composting equipment, and convert the former composting building into a storage facility. The plant operators will receive extensive training on the new sludge-handling system over two months, before inspections, commissioning, and contractor work on the inspection punch-list take place. The total project is estimated to take 31 months and is broken down in *Figure 10.1.1*. However, conservative time estimates were used for this sequence, and overall project time is subject to decrease as a result.

10.2 Maintenance of Plant Operations (MOPO)

The staging area for construction equipment will be located next to the new building sites. *Appendix Figure G.4* displays a detailed view of the available area next to the proposed gravity belt thickener building site. Subsequently, *Appendix Figure G.5* exhibits the available staging area near the proposed centrifuge and thermal dryer building. The plant has sufficient land to accommodate heavy equipment, material deliveries, and contractor operations to ensure efficient and safe site operations during installation. We will follow the construction sequence outlined in *Figure 10.1.1* to ensure the plant can continue operation of existing systems during each step of the construction phase until the new equipment is ready for use. We do not anticipate renting temporary pumps or pipes as construction should not disrupt current operations. Throughout construction, best management practices should be employed to minimize environmental impacts, such as associated dust and noise pollution from construction activities. The construction sequence will remain flexible to account for unexpected obstacles, as well as account for lead times and delivery constraints of equipment, to ensure timely completion of the project within the established timeline. After construction is complete, we estimate that the plant will take four months to train employees on the operation and maintenance of new equipment. During this time, the current plant operation sequence can be maintained until training is complete, then operation can be switched to the new system with ease. Demolition of old equipment will not be necessary since the plant is not space constrained, so the DAF can be abandoned. The BFP will be disposed of with proper equipment and truck rentals so the composting building can be converted to a storage warehouse.

10.3 LRWWTP State Revolving Fund

In 2024, the City of Lexington applied for the State Revolving Fund (SRF) funding to improve the LRWWTP biosolids handling system. In July 2024, the NCDEQ Division of Water Infrastructure reviewed the project according to NCGS § 159G-38, the North Carolina General Assembly's Water Infrastructure guidelines. The NCDEQ Division of Water Infrastructure determined that this project fell below the minor construction activities threshold found in 15A NCAC 01C .0408, the North Carolina Office of Administrative Hearings chapter on Minor Construction Activities, exempting the project from inter-agency review and the preparation of additional environmental documents. Based on the division's review of the project, they estimated that it will require approximately $40 million to complete and that the SRF can fund $27.9 million of the total cost. We estimate that the LRWWTP sludge-handling improvements have a capital cost of $12.6 million and the present worth of O&M to be $19 million, as shown in *Section 10.* The remaining funds will be supplied through grants, low-interest loans, and funding from partnering counties in the LRWWTP region. In accordance with the State's review of the project, we plan to maintain this budget of $40 million, with a portion of this budget to be set aside for future maintenance and required updates upon the 10-year benchmark review.

Appendix A: Flow Projections

Equation A.1: Population Projection of Lexington

$$P = P_o e^{k\Delta t}$$

P = Total Population at Time t (2045)
P_o =Starting Population (2024)
k = Population Growth Rate
t = Time Elapsed in Years

$$P = 20,000 \times e^{0.0029*20} = 21,195\ residents$$

Equation A.2: Solids Production Equation

$$P_x = \frac{XV}{\Theta_c}$$

P_x = Waste Solids Produced (lb MLSS/day)
X = MLSS Concentration (lb MLSS/ft^3)
V = Bardenpho Volume (ft^3)
Θ_c = Sludge Age (days)

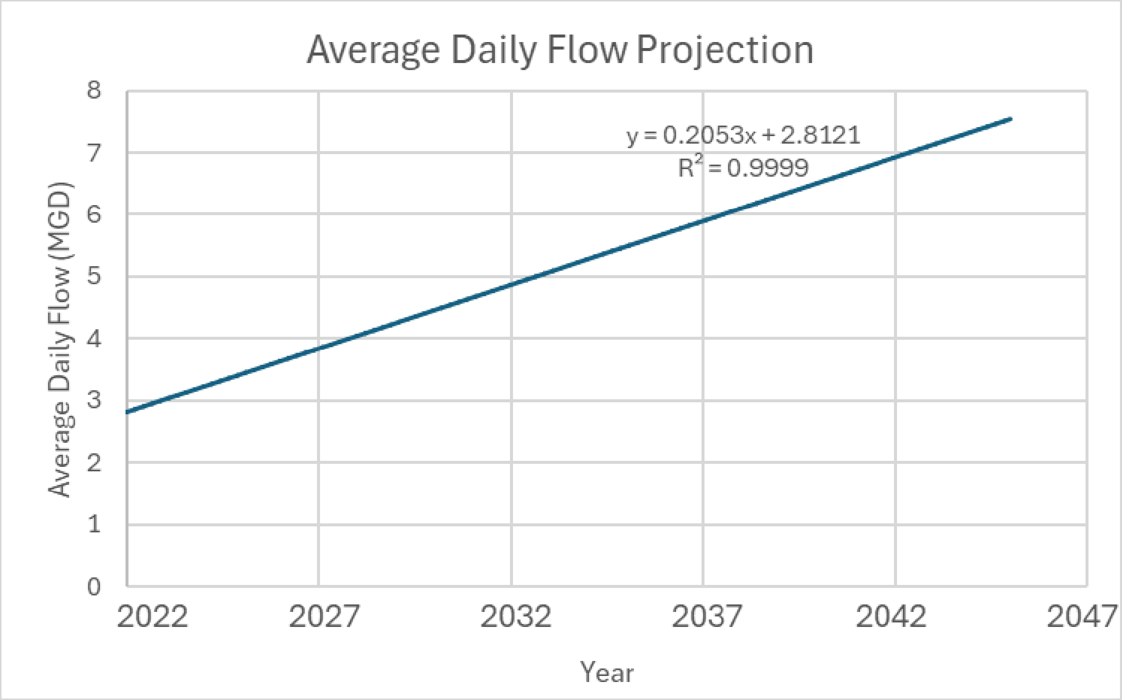


Figure A.1: Average Daily Flow Projections

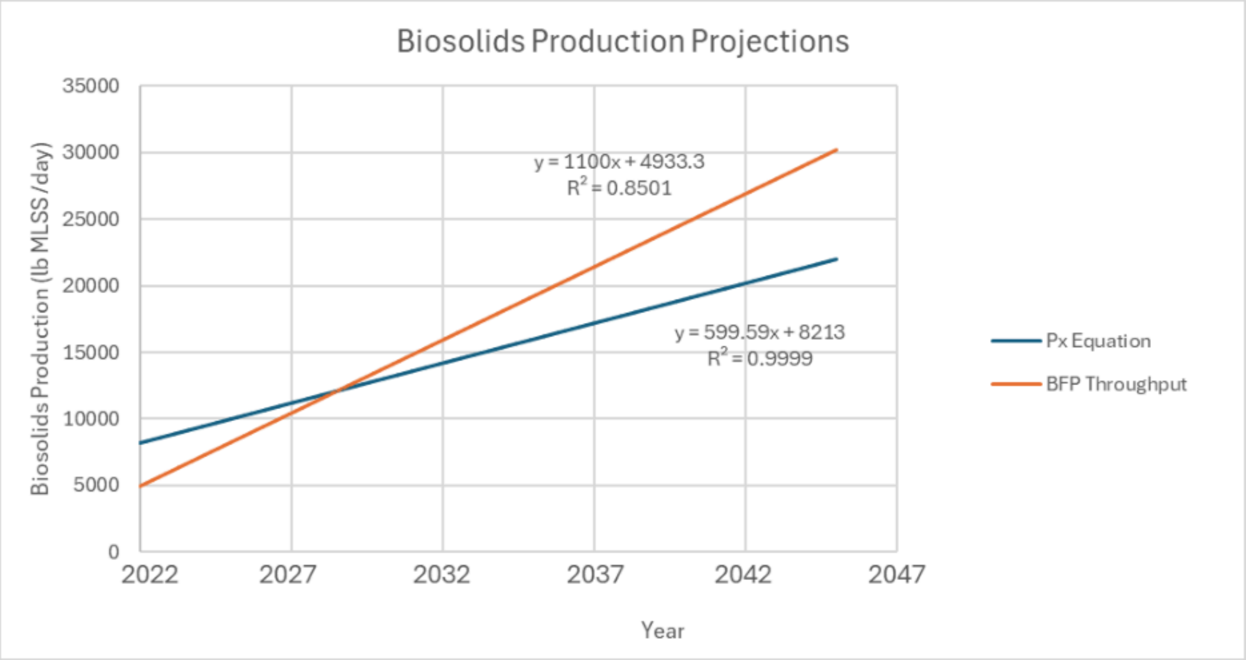


Figure A.2: Average Biosolids Production Projections

Appendix B: Selected Technologies

Figure B.1: Komline G-25 Gravabelt Gravity Belt Thickener

Figure B.2: Centrisys Dewatering Decanter CS14-4 Centrifuge

Figure B.3: Polyblend Polymer Feed System

Figure B.4: CME MILL-10 Pellet Mill

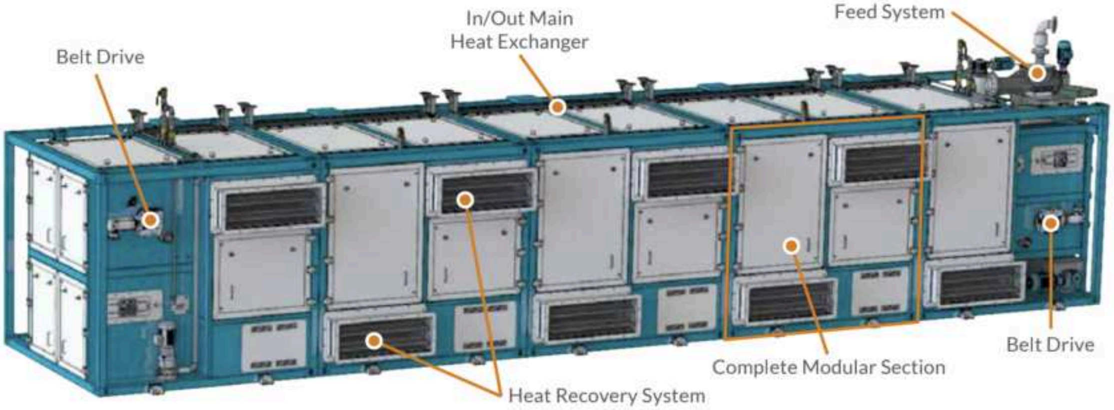


Figure B.5: Centrisys DLT120 Low-Temperature Belt Dryer

Figure B.6: JMS Bio-SILO

Appendix C: Decision Making Criteria

Table C.1: Costs Associated with Design Alternatives

Cost	Existing DAF Process	BFP-Thermal Process	Centrifuge-Thermal Process
Capital	5	2	3
Personnel	3	3	4
Life Cycle Assessment	4	1	2
Total	4	2	3

Table C.2: Operation and Maintenance for Each Alternative

O&M	Existing DAF Process	BFP-Thermal Process	Centrifuge-Thermal Process
Operator Input	1	3	5
Technical Training	4	2	2
Ease of O&M	1	3	4
Maintenance Burden	1	2	3
Best Alternative	7	10	**14**

Appendix D: New Proposed Facilities

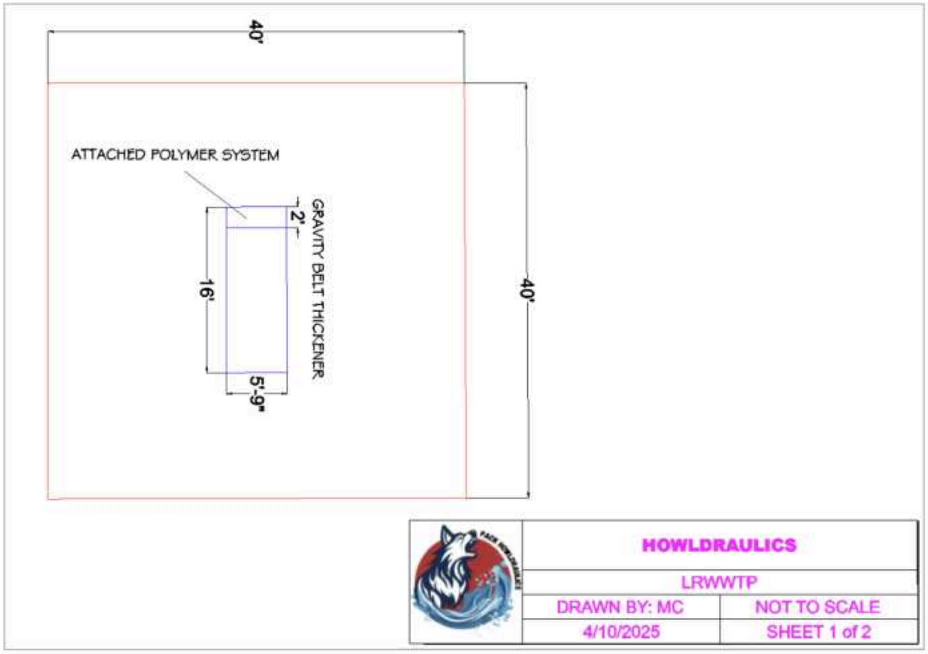


Figure D.1: New Thickening Building CAD Layout

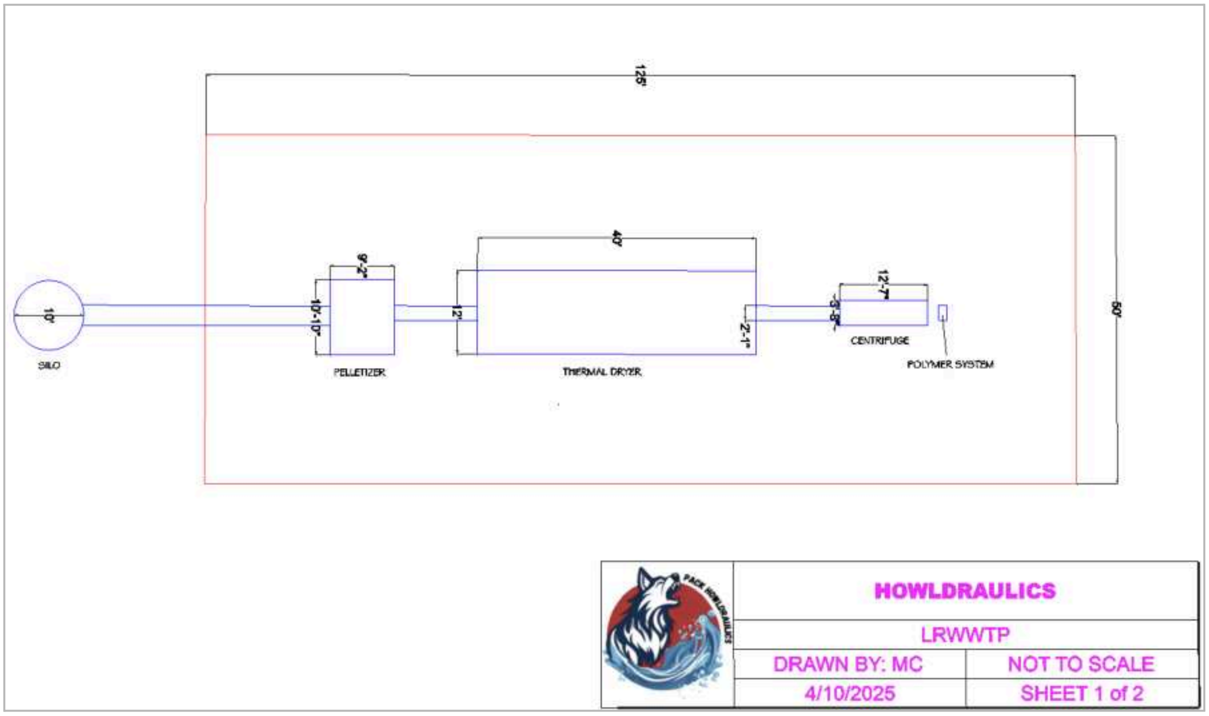


Figure D.2: New Dewatering Building CAD Layout

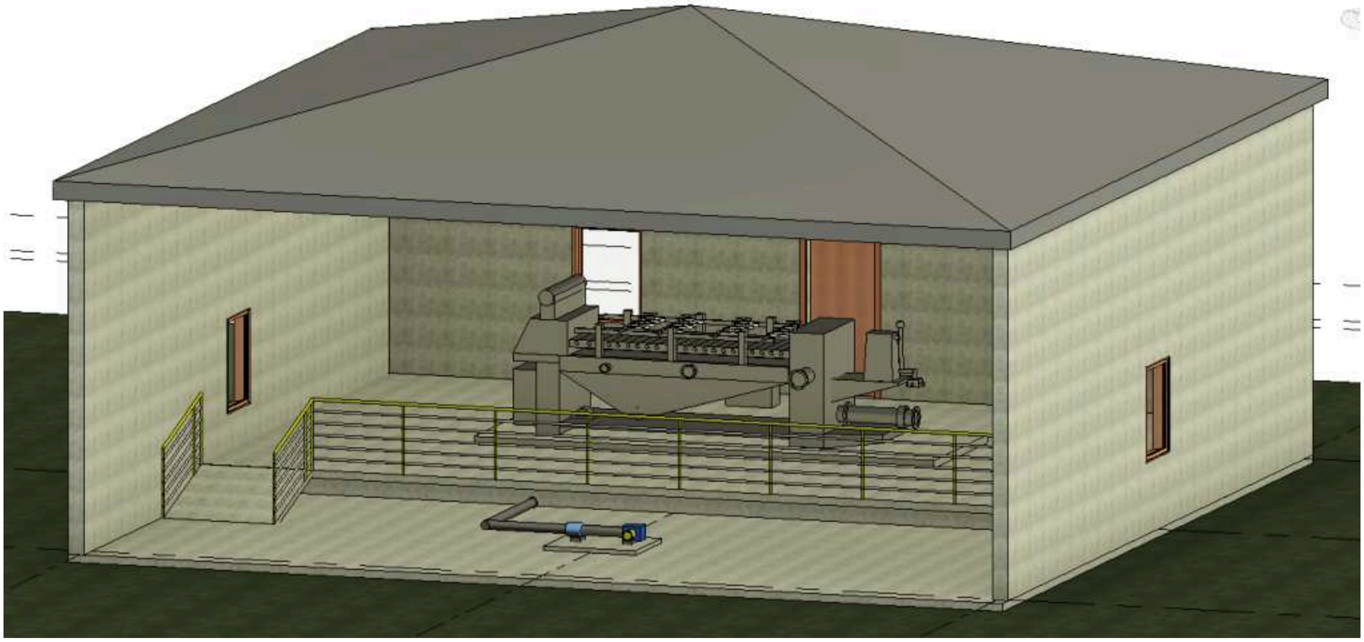


Figure D.3: New Thickening Building Revit Model

Figure D.4: New Dewatering Building Revit Model

Appendix E: Biosolids Hydraulic Analysis

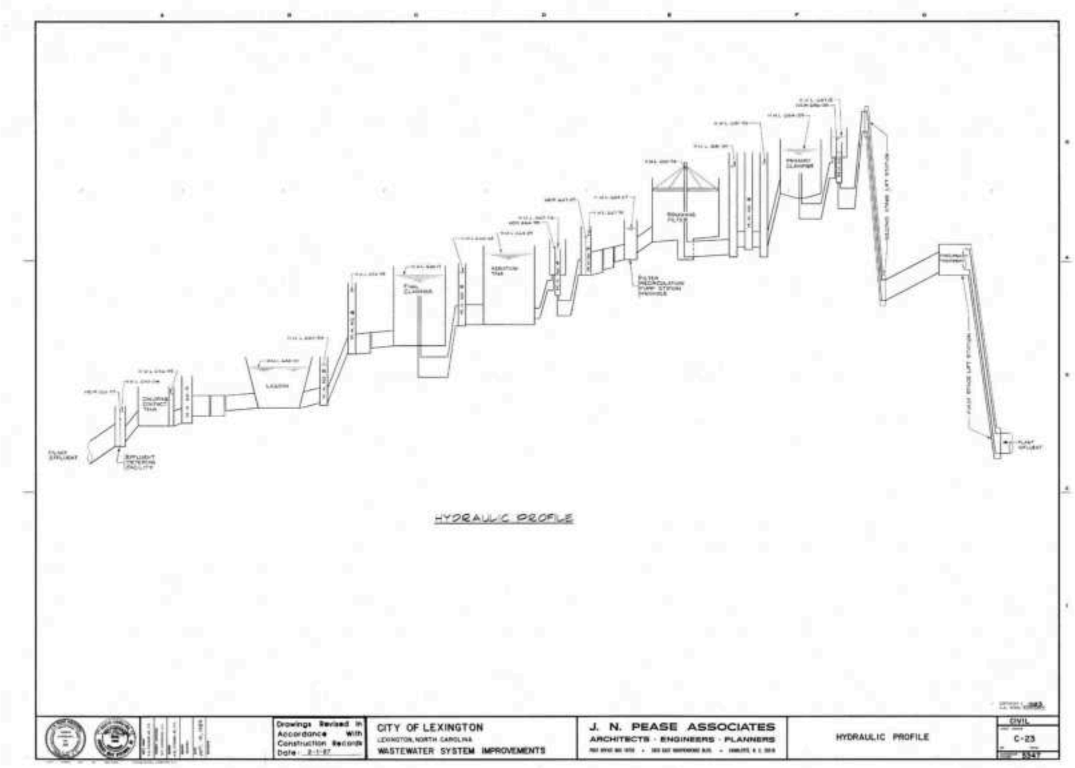


Figure E.1: Current 3.0 MGD Average Main Treatment Process Hydraulic Profile

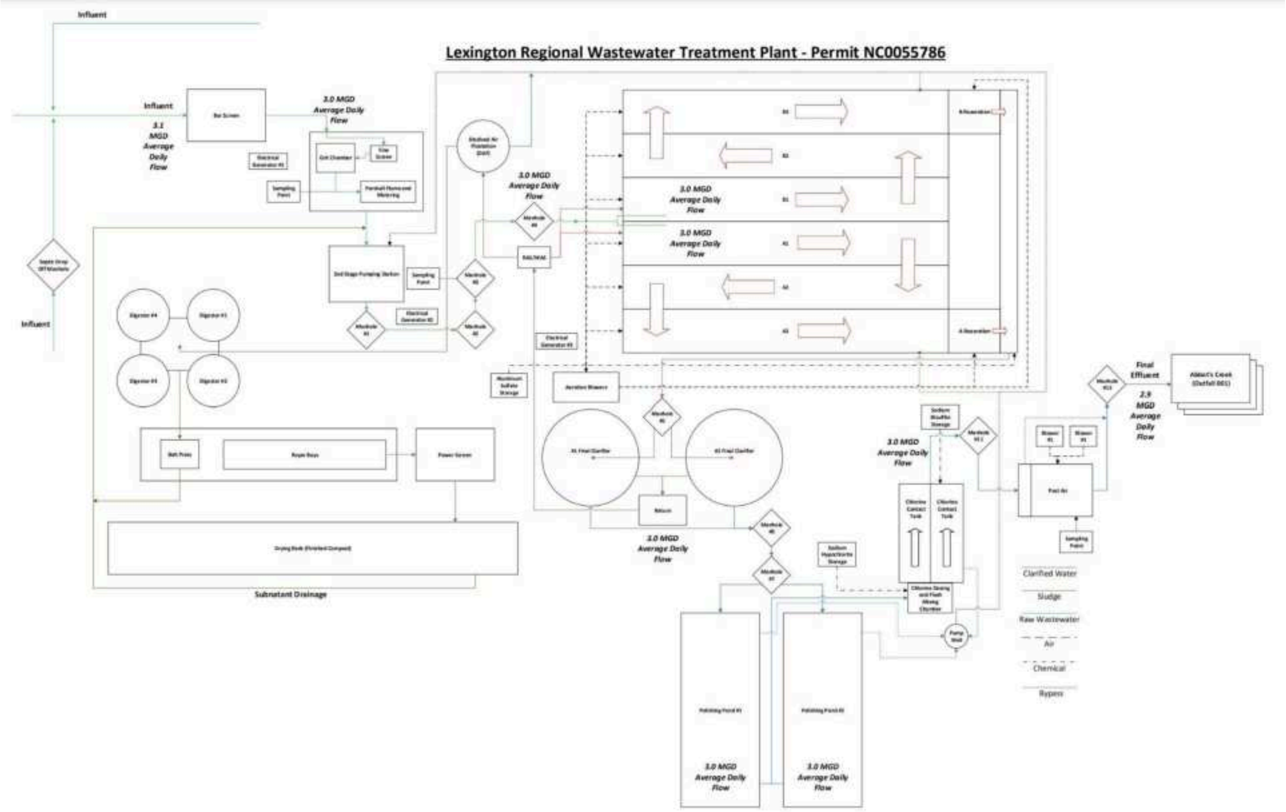


Figure E.2: LRWWTP Flow Diagram

Figure E.3: Liberty Process Millennium Series: Progressive Cavity Pump

Table E.1: Thickened Sludge Pumping: GBT to Sludge Holding Tanks Required Horsepower

GBT to Tanks Horsepower	
hL major (ft)	1.32
hL minor (ft)	0.003
Elevation head (ft)	6.5
Total Head (ft)	7.82
Biosolids System hp	0.49
Water Treatment hp	1.131
Total hp	2.02
Required hp (SF 3)	6.07

Table E.2: Thickened Sludge Pumping: Sludge Holding Tanks to Centrifuge Required Horsepower

Tanks to Centrifuge Horsepower	
hL major (ft)	2.27
hL minor (ft)	0.003
Elevation head (ft)	11.5
Total Head (ft)	13.78
Total hp	1.08
Required hp (SF 3)	3.23

Table E.3: Thickened Sludge Pumping: GBT to Centrifuge Required Horsepower

GBT to Centrifuge Horsepower	
hL major (ft)	1.33
hL minor (ft)	0.014
Elevation head (ft)	18
Total Head (ft)	19.35
Total hp	1.51

Required hp (SF 3)	4.53

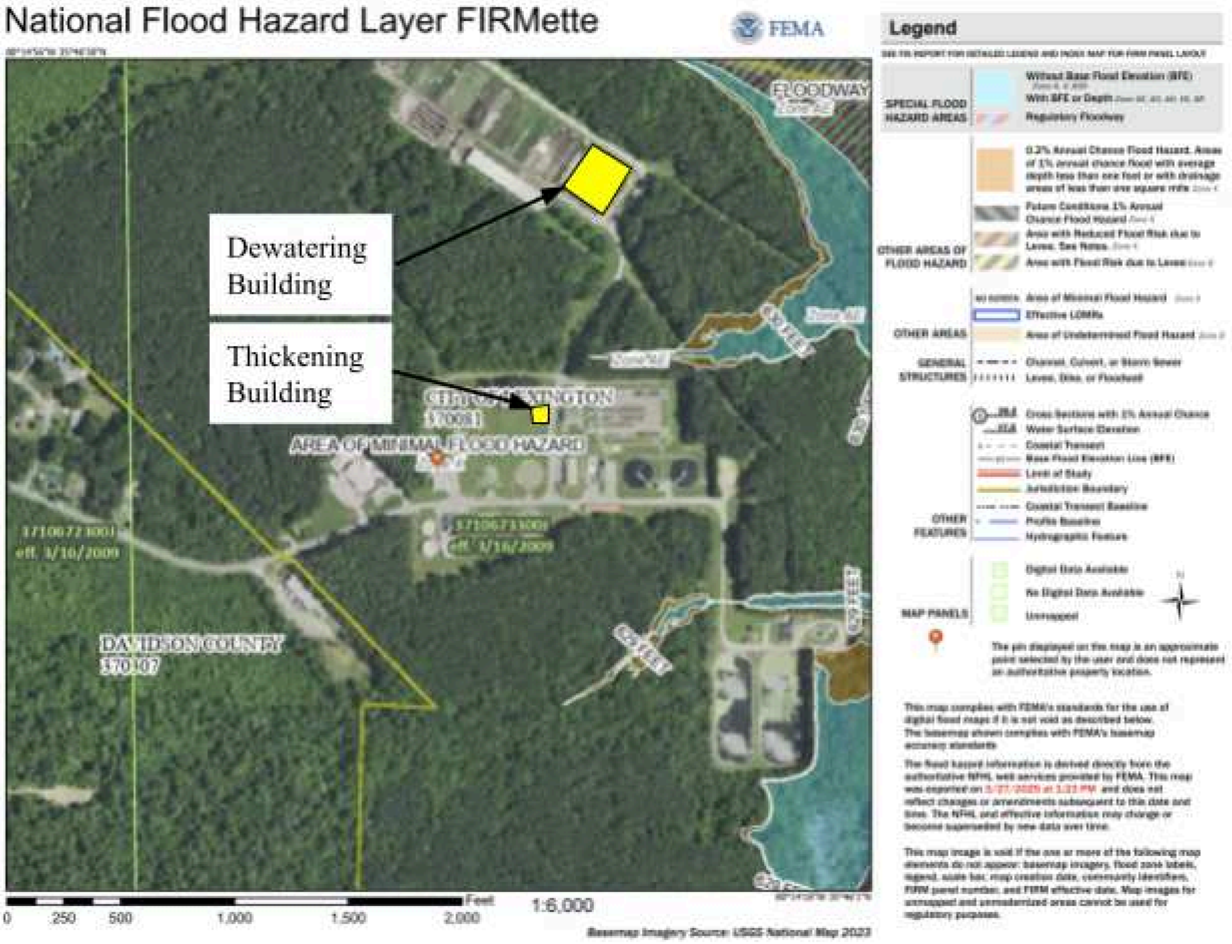


Figure E.4: New Buildings with National Flood Hazard Layer (FEMA)

Figure E.5: Sludge Tank Utilization Route Layout

Figure E.6: DAF Tank 7-hp Pump

Figure E.7: Sludge Storage Tanks 15-hp Pump

Equation E.1: Hydraulic Loading Rate

$$HLR = Q \, x \, w$$

w: belt width (m)
Q: flow rate (gpm)

Equation E.2: Fluid Horsepower Required

$$Fhp = \frac{Q\gamma\Delta h}{550*0.8}$$

$$Q = flowrate\ (ft^3/s)$$

$$\gamma = specific\ weight\ (lb/ft^3)$$

$$\Delta h = total\ head\ (ft)$$

$$Fhp = fluid\ pump\ power\ (hp)$$

Unit conversion = $\frac{1\ hp}{550\ ft*lb_f/s}$

DAF Effluent Elevation: 662 ft
Storage Tank Influent Elevation: 668.5 ft
Dewatering Warehouse Elevation: 680 ft

Equation E.3: Darcy-Weisbach, Major Headloss Equation

$$h_{L,major} = f\frac{L}{D}\frac{V^2}{2g}$$

$$f = Darcy\ friction\ factor$$

$$L = Pipe\ length\ (ft)$$

$$D = Pipe\ diameter\ (ft)$$

$$f = Flow\ velocity\ (ft/s)$$

$$g = Gravity\ (32.174\ ft/s^2)$$

Equation E.4: Reynold's Number

$$Re = \frac{\rho VD}{\mu}$$

$$Re = Reynold's\ Number$$

$$\rho_{Activated\ Sludge} = 63.7\ to\ 66.2\ (lbm/ft^3)$$

$$V = Fluid\ velocity\ (ft/s, m/s)$$

$$D = Pipe\ Diameter\ (ft, m)$$

$$\mu = 0.1\ to\ 0.2\ (Pa * s)$$

Equation E.5: Laminar Flow Friction Factor

$$f = \frac{64}{Re}$$

Equation E.6: Minor Headloss Equation

$$h_{L,minor} = K_L\frac{V^2}{2g}$$

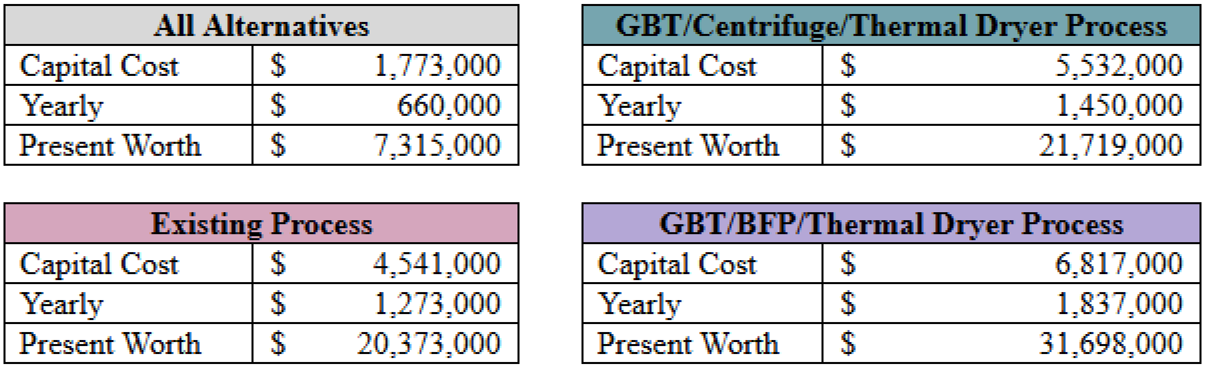
$$K_L = Minor\ loss\ coefficient$$

$$V = Flow\ velocity\ (ft/s)$$

$$g = Gravity\ (32.174\ ft/s^2)$$

Appendix F: Additional Cost Analysis

Table F.1: Summary of All Alternatives



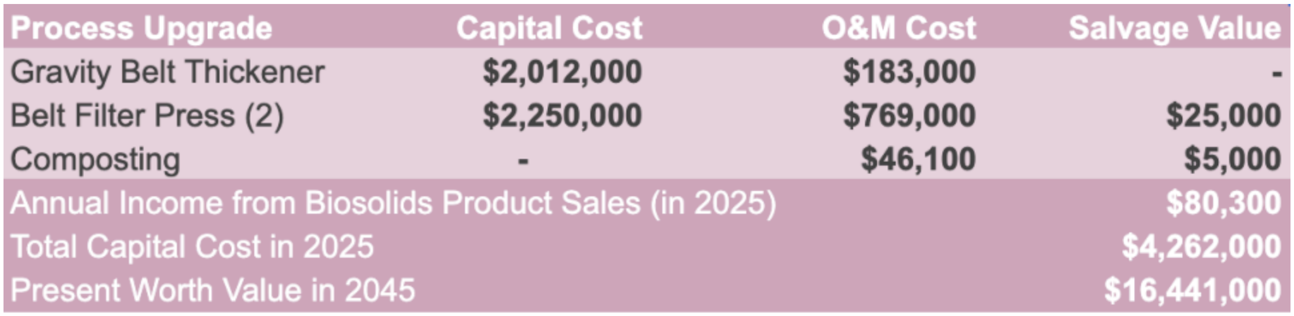
All Alternatives		
Capital Cost	$	1,773,000
Yearly	$	660,000
Present Worth	$	7,315,000

GBT/Centrifuge/Thermal Dryer Process		
Capital Cost	$	5,532,000
Yearly	$	1,450,000
Present Worth	$	21,719,000

Existing Process		
Capital Cost	$	4,541,000
Yearly	$	1,273,000
Present Worth	$	20,373,000

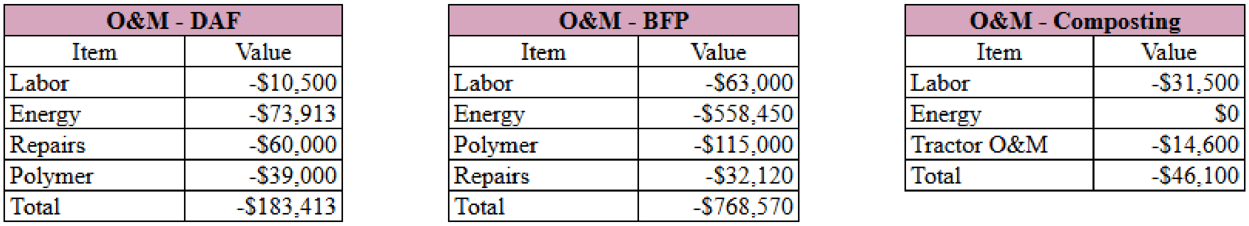
GBT/BFP/Thermal Dryer Process		
Capital Cost	$	6,817,000
Yearly	$	1,837,000
Present Worth	$	31,698,000

Table F.2: Summary of Existing DAF Process



Process Upgrade	Capital Cost	O&M Cost	Salvage Value
Gravity Belt Thickener	$2,012,000	$183,000	-
Belt Filter Press (2)	$2,250,000	$769,000	$25,000
Composting	-	$46,100	$5,000
Annual Income from Biosolids Product Sales (in 2025)			$80,300
Total Capital Cost in 2025			$4,262,000
Present Worth Value in 2045			$16,441,000

Table F.3: Existing DAF Process O&M Summary

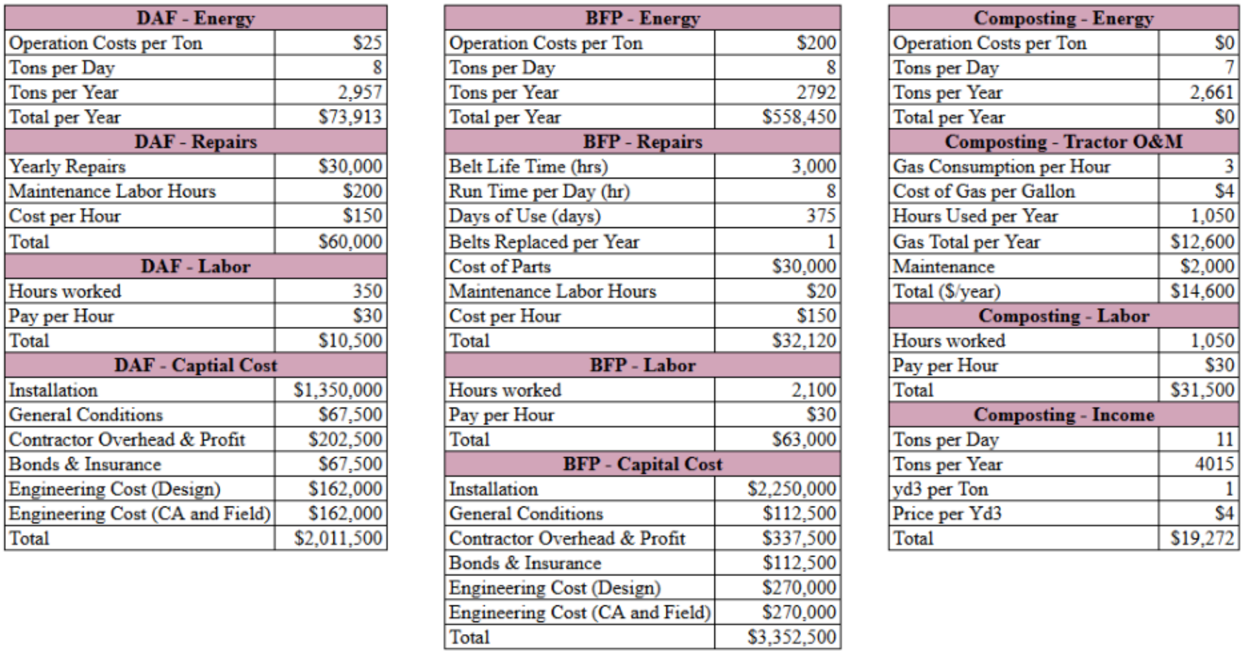


O&M - DAF	
Item	Value
Labor	-$10,500
Energy	-$73,913
Repairs	-$60,000
Polymer	-$39,000
Total	-$183,413

O&M - BFP	
Item	Value
Labor	-$63,000
Energy	-$558,450
Polymer	-$115,000
Repairs	-$32,120
Total	-$768,570

O&M - Composting	
Item	Value
Labor	-$31,500
Energy	$0
Tractor O&M	-$14,600
Total	-$46,100

Table F.4: Existing DAF Process O&M Calculations

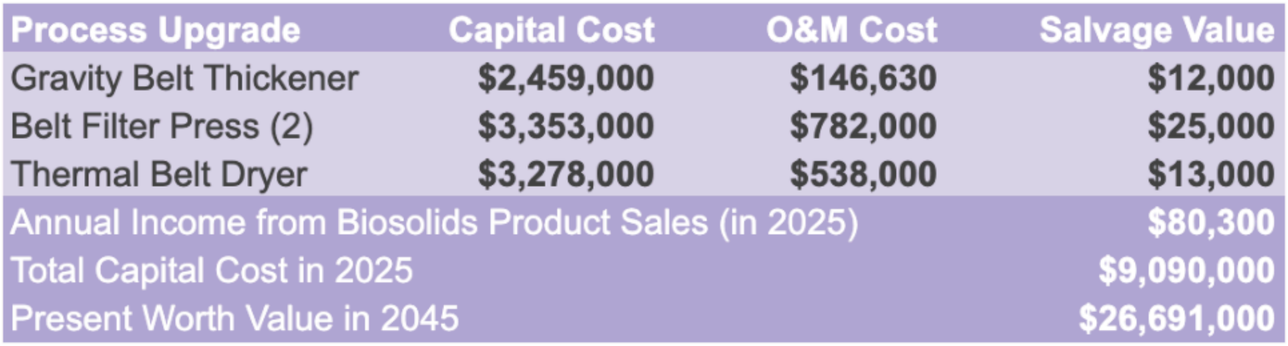


DAF - Energy	
Operation Costs per Ton	$25
Tons per Day	8
Tons per Year	2,957
Total per Year	$73,913
DAF - Repairs	
Yearly Repairs	$30,000
Maintenance Labor Hours	$200
Cost per Hour	$150
Total	$60,000
DAF - Labor	
Hours worked	350
Pay per Hour	$30
Total	$10,500
DAF - Captial Cost	
Installation	$1,350,000
General Conditions	$67,500
Contractor Overhead & Profit	$202,500
Bonds & Insurance	$67,500
Engineering Cost (Design)	$162,000
Engineering Cost (CA and Field)	$162,000
Total	$2,011,500

BFP - Energy	
Operation Costs per Ton	$200
Tons per Day	8
Tons per Year	2792
Total per Year	$558,450
BFP - Repairs	
Belt Life Time (hrs)	3,000
Run Time per Day (hr)	8
Days of Use (days)	375
Belts Replaced per Year	1
Cost of Parts	$30,000
Maintenance Labor Hours	$20
Cost per Hour	$150
Total	$32,120
BFP - Labor	
Hours worked	2,100
Pay per Hour	$30
Total	$63,000
BFP - Capital Cost	
Installation	$2,250,000
General Conditions	$112,500
Contractor Overhead & Profit	$337,500
Bonds & Insurance	$112,500
Engineering Cost (Design)	$270,000
Engineering Cost (CA and Field)	$270,000
Total	$3,352,500

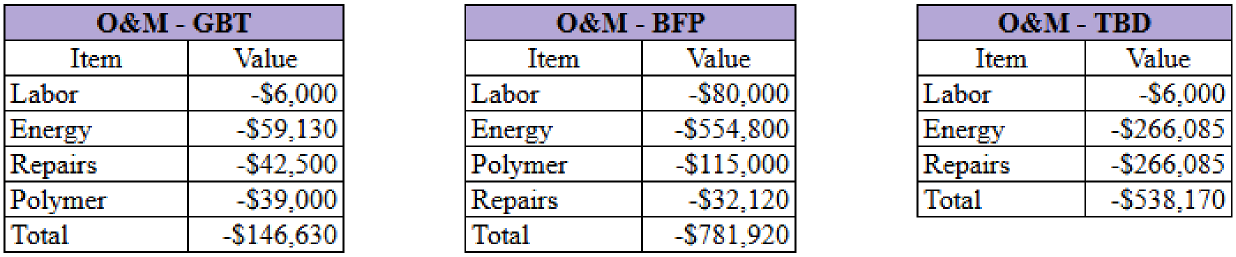
Composting - Energy	
Operation Costs per Ton	$0
Tons per Day	7
Tons per Year	2,661
Total per Year	$0
Composting - Tractor O&M	
Gas Consumption per Hour	3
Cost of Gas per Gallon	$4
Hours Used per Year	1,050
Gas Total per Year	$12,600
Maintenance	$2,000
Total ($/year)	$14,600
Composting - Labor	
Hours worked	1,050
Pay per Hour	$30
Total	$31,500
Composting - Income	
Tons per Day	11
Tons per Year	4015
yd3 per Ton	1
Price per Yd3	$4
Total	$19,272

Table F.5: Summary of BFP-Thermal Dryer Process



Process Upgrade	Capital Cost	O&M Cost	Salvage Value
Gravity Belt Thickener	**$2,459,000**	**$146,630**	**$12,000**
Belt Filter Press (2)	**$3,353,000**	**$782,000**	**$25,000**
Thermal Belt Dryer	**$3,278,000**	**$538,000**	**$13,000**
Annual Income from Biosolids Product Sales (in 2025)			**$80,300**
Total Capital Cost in 2025			**$9,090,000**
Present Worth Value in 2045			**$26,691,000**

Table F.6: BFP-Thermal Dryer O&M Summary

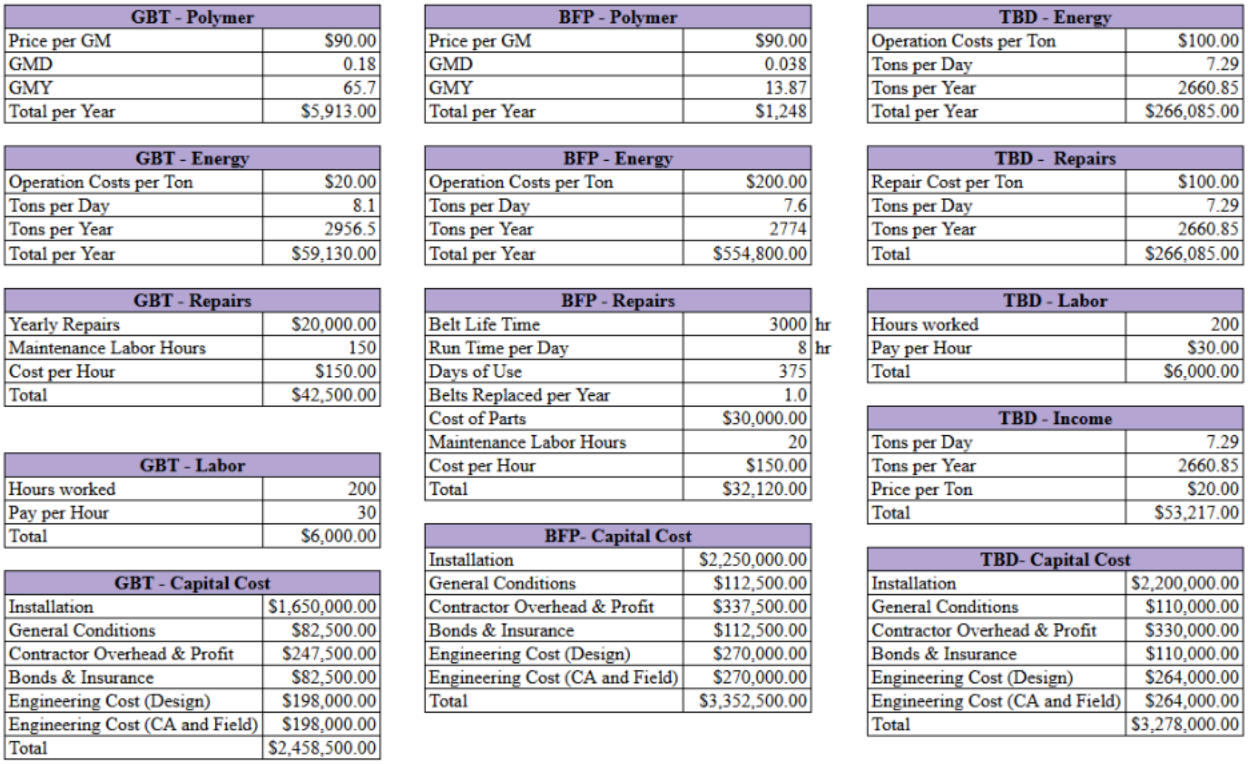


O&M - GBT	
Item	Value
Labor	-$6,000
Energy	-$59,130
Repairs	-$42,500
Polymer	-$39,000
Total	-$146,630

O&M - BFP	
Item	Value
Labor	-$80,000
Energy	-$554,800
Polymer	-$115,000
Repairs	-$32,120
Total	-$781,920

O&M - TBD	
Item	Value
Labor	-$6,000
Energy	-$266,085
Repairs	-$266,085
Total	-$538,170

Table F.7: BFP-Thermal Dryer Process O&M Calculations



GBT - Polymer	
Price per GM	$90.00
GMD	0.18
GMY	65.7
Total per Year	$5,913.00

GBT - Energy	
Operation Costs per Ton	$20.00
Tons per Day	8.1
Tons per Year	2956.5
Total per Year	$59,130.00

GBT - Repairs	
Yearly Repairs	$20,000.00
Maintenance Labor Hours	150
Cost per Hour	$150.00
Total	$42,500.00

GBT - Labor	
Hours worked	200
Pay per Hour	30
Total	$6,000.00

GBT - Capital Cost	
Installation	$1,650,000.00
General Conditions	$82,500.00
Contractor Overhead & Profit	$247,500.00
Bonds & Insurance	$82,500.00
Engineering Cost (Design)	$198,000.00
Engineering Cost (CA and Field)	$198,000.00
Total	$2,458,500.00

BFP - Polymer	
Price per GM	$90.00
GMD	0.038
GMY	13.87
Total per Year	$1,248

BFP - Energy	
Operation Costs per Ton	$200.00
Tons per Day	7.6
Tons per Year	2774
Total per Year	$554,800.00

BFP - Repairs		
Belt Life Time	3000	hr
Run Time per Day	8	hr
Days of Use	375	
Belts Replaced per Year	1.0	
Cost of Parts	$30,000.00	
Maintenance Labor Hours	20	
Cost per Hour	$150.00	
Total	$32,120.00	

BFP- Capital Cost	
Installation	$2,250,000.00
General Conditions	$112,500.00
Contractor Overhead & Profit	$337,500.00
Bonds & Insurance	$112,500.00
Engineering Cost (Design)	$270,000.00
Engineering Cost (CA and Field)	$270,000.00
Total	$3,352,500.00

TBD - Energy	
Operation Costs per Ton	$100.00
Tons per Day	7.29
Tons per Year	2660.85
Total per Year	$266,085.00

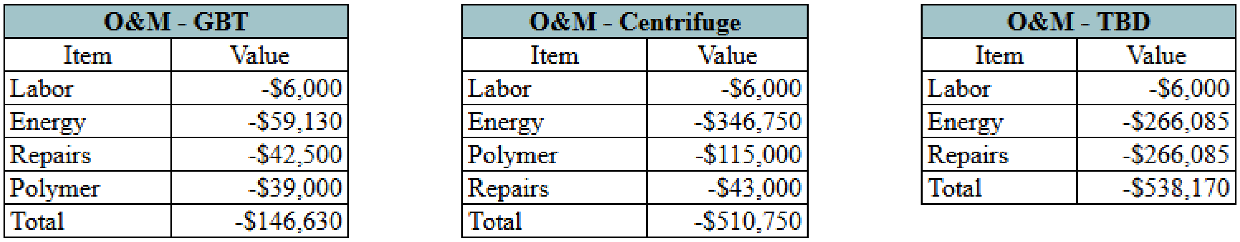
TBD - Repairs	
Repair Cost per Ton	$100.00
Tons per Day	7.29
Tons per Year	2660.85
Total	$266,085.00

TBD - Labor	
Hours worked	200
Pay per Hour	$30.00
Total	$6,000.00

TBD - Income	
Tons per Day	7.29
Tons per Year	2660.85
Price per Ton	$20.00
Total	$53,217.00

TBD- Capital Cost	
Installation	$2,200,000.00
General Conditions	$110,000.00
Contractor Overhead & Profit	$330,000.00
Bonds & Insurance	$110,000.00
Engineering Cost (Design)	$264,000.00
Engineering Cost (CA and Field)	$264,000.00
Total	$3,278,000.00

Table F.8: Centrifuge-Thermal Dryer Process O&M Summary

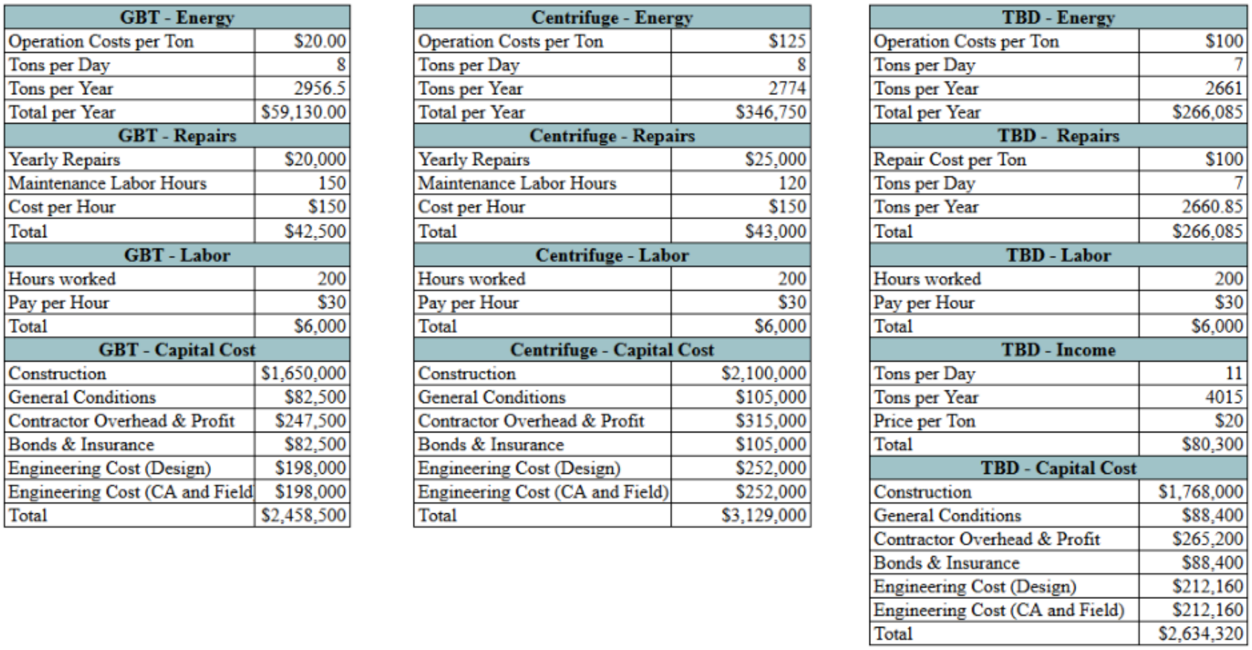


O&M - GBT	
Item	Value
Labor	-$6,000
Energy	-$59,130
Repairs	-$42,500
Polymer	-$39,000
Total	-$146,630

O&M - Centrifuge	
Item	Value
Labor	-$6,000
Energy	-$346,750
Polymer	-$115,000
Repairs	-$43,000
Total	-$510,750

O&M - TBD	
Item	Value
Labor	-$6,000
Energy	-$266,085
Repairs	-$266,085
Total	-$538,170

Table F.9: Centrifuge-Thermal Dryer Process O&M Calculations

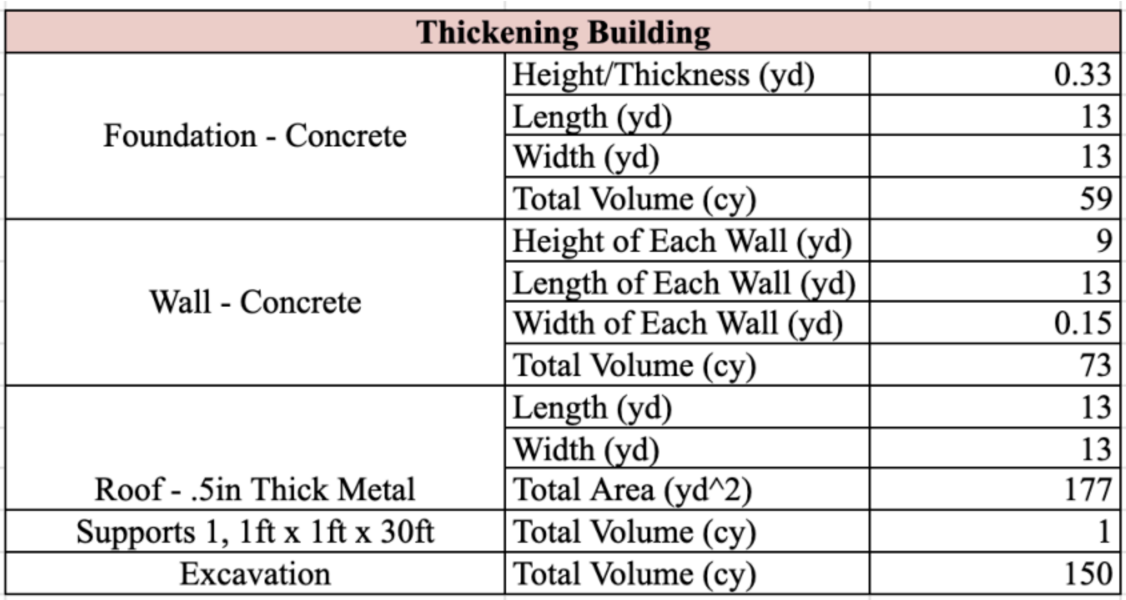


GBT - Energy	
Operation Costs per Ton	$20.00
Tons per Day	8
Tons per Year	2956.5
Total per Year	$59,130.00
GBT - Repairs	
Yearly Repairs	$20,000
Maintenance Labor Hours	150
Cost per Hour	$150
Total	$42,500
GBT - Labor	
Hours worked	200
Pay per Hour	$30
Total	$6,000
GBT - Capital Cost	
Construction	$1,650,000
General Conditions	$82,500
Contractor Overhead & Profit	$247,500
Bonds & Insurance	$82,500
Engineering Cost (Design)	$198,000
Engineering Cost (CA and Field	$198,000
Total	$2,458,500

Centrifuge - Energy	
Operation Costs per Ton	$125
Tons per Day	8
Tons per Year	2774
Total per Year	$346,750
Centrifuge - Repairs	
Yearly Repairs	$25,000
Maintenance Labor Hours	120
Cost per Hour	$150
Total	$43,000
Centrifuge - Labor	
Hours worked	200
Pay per Hour	$30
Total	$6,000
Centrifuge - Capital Cost	
Construction	$2,100,000
General Conditions	$105,000
Contractor Overhead & Profit	$315,000
Bonds & Insurance	$105,000
Engineering Cost (Design)	$252,000
Engineering Cost (CA and Field)	$252,000
Total	$3,129,000

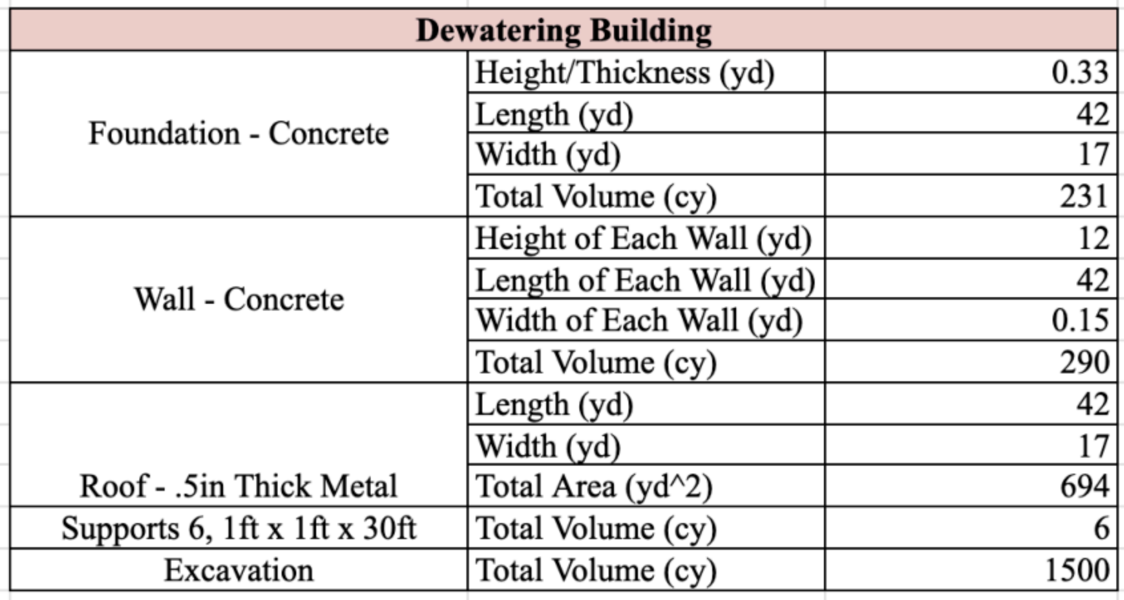
TBD - Energy	
Operation Costs per Ton	$100
Tons per Day	7
Tons per Year	2661
Total per Year	$266,085
TBD - Repairs	
Repair Cost per Ton	$100
Tons per Day	7
Tons per Year	2660.85
Total	$266,085
TBD - Labor	
Hours worked	200
Pay per Hour	$30
Total	$6,000
TBD - Income	
Tons per Day	11
Tons per Year	4015
Price per Ton	$20
Total	$80,300
TBD - Capital Cost	
Construction	$1,768,000
General Conditions	$88,400
Contractor Overhead & Profit	$265,200
Bonds & Insurance	$88,400
Engineering Cost (Design)	$212,160
Engineering Cost (CA and Field)	$212,160
Total	$2,634,320

Table F.10: Thickening Building Calculations



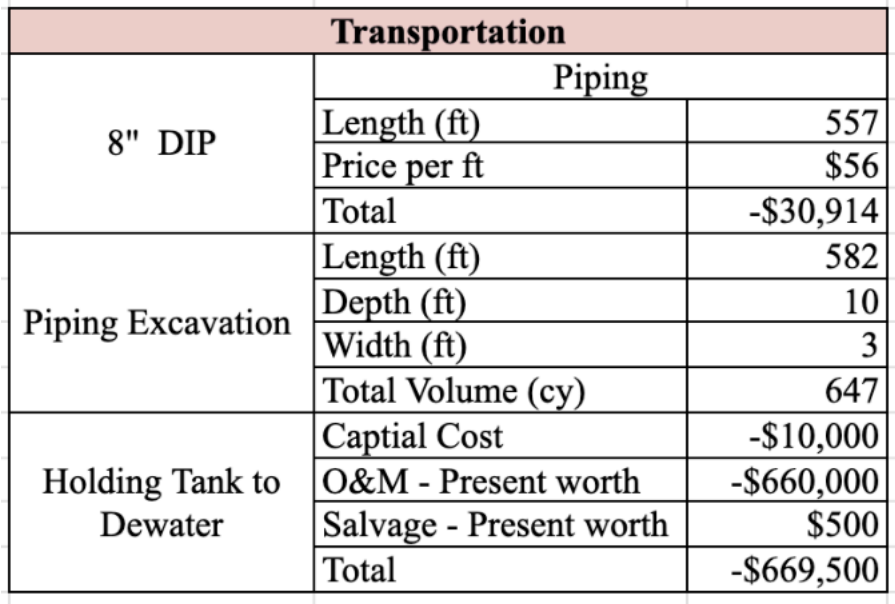
Thickening Building		
Foundation - Concrete	Height/Thickness (yd)	0.33
	Length (yd)	13
	Width (yd)	13
	Total Volume (cy)	59
Wall - Concrete	Height of Each Wall (yd)	9
	Length of Each Wall (yd)	13
	Width of Each Wall (yd)	0.15
	Total Volume (cy)	73
Roof - .5in Thick Metal	Length (yd)	13
	Width (yd)	13
	Total Area (yd^2)	177
Supports 1, 1ft x 1ft x 30ft	Total Volume (cy)	1
Excavation	Total Volume (cy)	150

Table F.11: Dewatering Building Calculations



Dewatering Building		
Foundation - Concrete	Height/Thickness (yd)	0.33
	Length (yd)	42
	Width (yd)	17
	Total Volume (cy)	231
Wall - Concrete	Height of Each Wall (yd)	12
	Length of Each Wall (yd)	42
	Width of Each Wall (yd)	0.15
	Total Volume (cy)	290
Roof - .5in Thick Metal	Length (yd)	42
	Width (yd)	17
	Total Area (yd^2)	694
Supports 6, 1ft x 1ft x 30ft	Total Volume (cy)	6
Excavation	Total Volume (cy)	1500

Table F.12: Hydraulic Cost Calculations



Transportation		
8" DIP	Piping	
	Length (ft)	557
	Price per ft	$56
	Total	-$30,914
Piping Excavation	Length (ft)	582
	Depth (ft)	10
	Width (ft)	3
	Total Volume (cy)	647
Holding Tank to Dewater	Captial Cost	-$10,000
	O&M - Present worth	-$660,000
	Salvage - Present worth	$500
	Total	-$669,500

Appendix G: Construction Sequencing

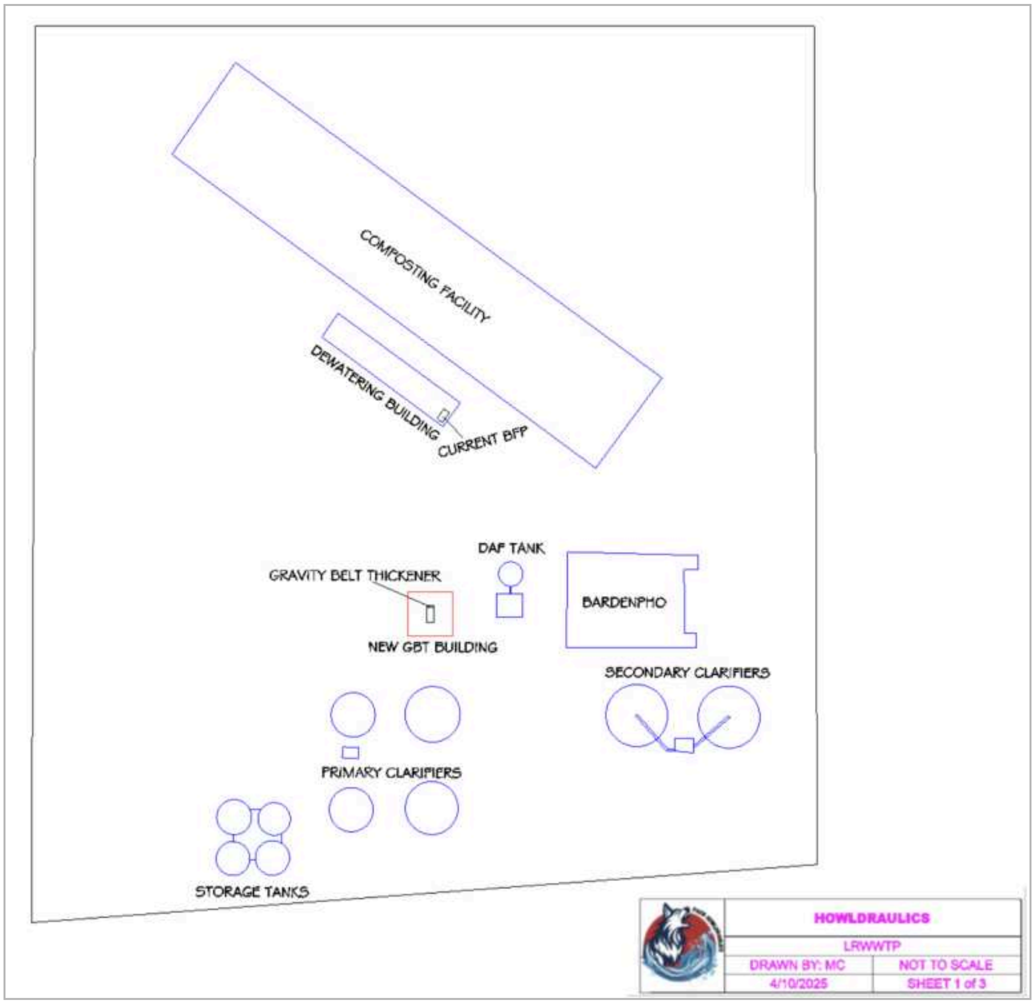


Figure G.1: Subphase 2.1

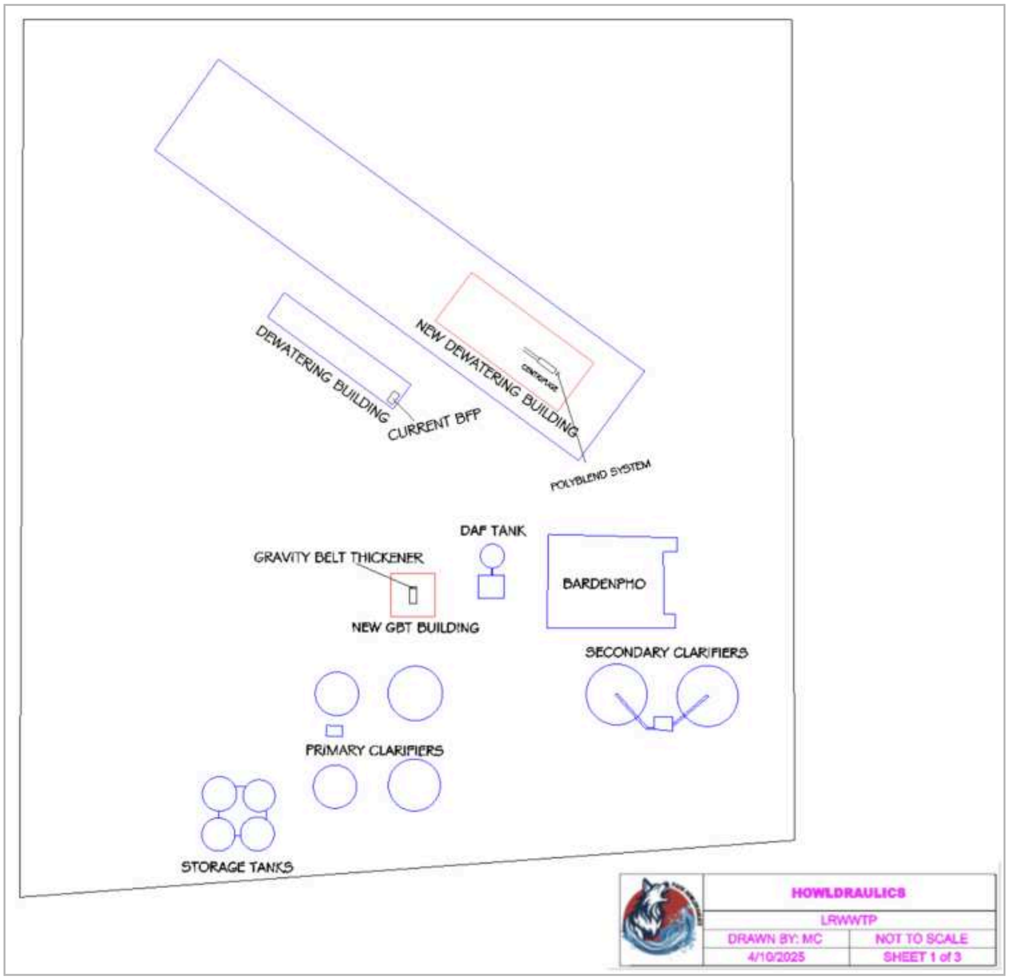


Figure G.2: Subphase 2.2

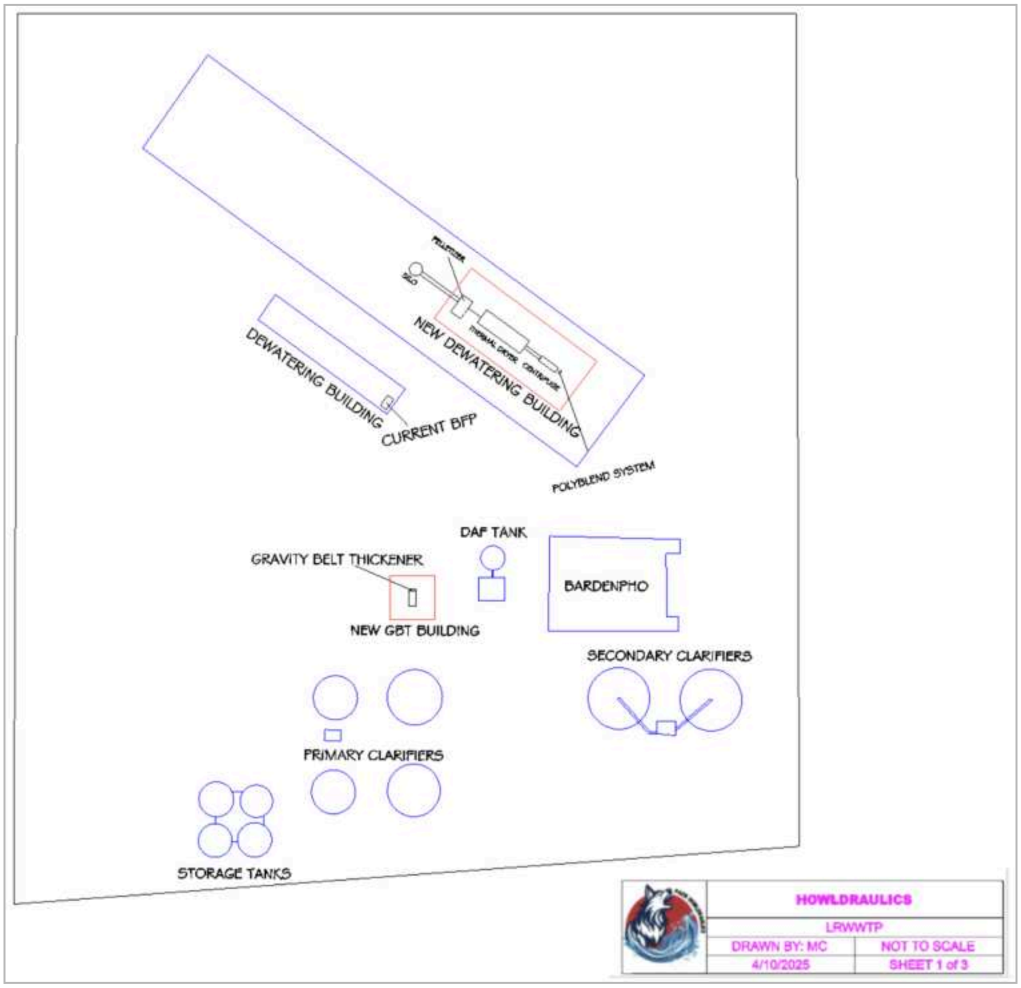


Figure G.3: Subphase 2.3

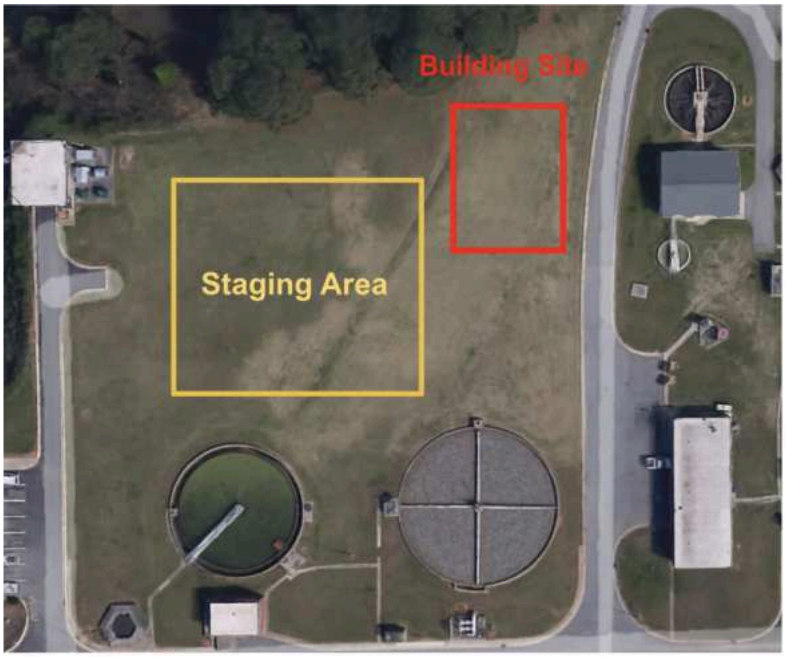


Figure G.4: Staging Area for Gravity Belt Thickener Building Site

Figure G.5: Staging Area for Dewatering and Disposal Building Site

Appendix H: Additional Tables

Table H.1: Influent Water and Biosolids Data 2017 - 2019

Characteristics	Influent			Range	Peaking Factor
Year	2017	2018	2019	-	-
ADF (MGD)	2.9	-	-	-	1.0
Influent Flow (MGD)	2.4	2.6	3.4	-	-
Influent cBOD (mg/L)	380	260	360	170-1170	1.0
Influent TSS (mg/L)	820	420	460	250-1720	1.0
WAS Flow (MGD)	0.2	-	-	0.6-0.22	1.0
WAS TSS (mg/L)	11,000	-	-	7900-15500	-
Biosolids Production Estimate based on WAS Pumping Data (lb/day)	-	17,200	10,400	-	-

Table H.2: Influent and Effluent Data 2022-2024

2022			**2023**			**2024**		
Month	**INF (MGD)**	**EFF (MGD)**	**Month**	**INF (MGD)**	**EFF (MGD)**	**Month**	**INF (MGD)**	**EFF (MGD)**
JAN	2.9	2.184	**JAN**	4.0	3.807	**JAN**	4.6	5.155
FEB	2.7	2.186	**FEB**	3.7	3.429	**FEB**	3.3	3.376
MAR	3.4	2.939	**MAR**	3.3	3.152	**MAR**	3.8	4.277
APR	2.7	2.227	**APR**	3.8	3.817	**APR**	2.8	3.083
MAY	2.5	2.381	**MAY**	2.6	2.427	**MAY**	4.1	4.410
JUN	2.0	1.997	**JUN**	2.8	2.528	**JUN**	2.3	2.428
JULY	2.3	2.055	**JULY**	2.3	2.217	**JULY**	2.5	2.397
AUG	2.6	2.200	**AUG**	2.4	2.319	**AUG**	3.6	3.284
SEP	3.0	2.457	**SEP**	2.5	2.376	**SEP**	3.1	2.862
OCT	2.9	2.371	**OCT**	2.6	2.239	**OCT**	2.7	2.336
NOV	3.0	2.673	**NOV**	2.7	2.652	**NOV**	2.7	2.303
DEC	3.7	3.282	**DEC**	3.6	3.461	**DEC**	3.1	2.693

Table H.3: Anticipated Flow Characteristics in 2045

	Gravity Belt Thickener	Centrifuge	Thermal Belt Dryer
Influent Flow (MGD)	0.18	0.039	0.0046
Solids Loading Rate (kg/day)	7,495	7,345	6,978
Overflow (MGD)	0.141	0.034	0.0046
Underflow (MGD)	0.039	0.0046	-
Dewatering Potential	5%	40%	90%
Capture Rate	98%	95%	95%

Table H.4: Typical Hydraulic Loading Ranges for Gravity Belt Thickeners

Belt Size (Effective Dewatering Width) (m)	Hydraulic Loading Range (L/min)
1.0	400-950
1.5	570-1420
2.0	760-1900
3.0	1100-2800

Table H.5: Minor Loss Coefficient Values, K_L

Type of Component or Fitting	**Minor Loss Coefficient**
Elbow, Flanged Long Radius 90°	0.2
Elbow, Flanged Long Radius 45°	0.23
Gate Valve, 1/2 Closed	0.2
Ball Valve, 1/3 Closed	5.5

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