McKIM&CREED
ENGINEERS SURVEYORS PLANNERS

CITY OF HENDERSONVILLE
SOLIDS MANAGEMENT PLAN EVALUATION

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EXECUTIVE SUMMARY

The City of Hendersonville owns and operates water and wastewater treatment facilities that serve the residents of the City and many of the outlying areas within Henderson County, NC. The City's water and wastewater treatment facilities currently produce dewatered (15-18% total solids) residuals products from the treatment processes, which are disposed of at nearby municipal solid waste landfills. Recently, disposal of dewatered water and wastewater treatment residuals at area landfills has become a costly and unreliable disposal outlet due to increases in tipping fees and the unexpected rejection of dewatered residuals by the landfills.

In response to these concerns, the City recently completed a preliminary engineering study of the solids management strategies at both the Water Treatment Facility (WTF) and Wastewater Treatment Facility (WWTF) to determine feasible improvements for reducing or eliminating the reliance on area landfills for disposal of residuals. This previous evaluation, summarized in the *Final Solids Management Plan Report*, reviewed current solids management strategies and potential improvements to solids management at both facilities to produce higher-quality Class A residuals products that may be disposed of by other means, or be beneficially reused.

The City requested that McKim & Creed provide additional assistance to analyze sludge quantities, to evaluate additional solids management strategies, and to identify potential disposal outlets for residuals.

In order to provide recommendations for a long-term solids management plan, McKim & Creed reevaluated current and projected WWTF sludge and WTF residuals production estimates, and evaluated the capital and O&M costs, disposal outlets, beneficial reuse opportunities, and project procurement methods for multiple solids management alternatives. The solids management alternatives evaluated in this study to produce Class A residuals included composting, autothermal thermophilic aerobic digestion (ATAD), and thermal drying. After completing the evaluation of these solids management alternatives, a final alternative was evaluated consisting of thermal drying of the WWTF sludge and contracted dewatering, hauling, and disposal of WTF residuals through a third-party residuals management firm. A summary of the findings of the solids management alternatives evaluation is included in **Table ES.0.1** below.

Table ES.0.1 – Summary of Class A Solids Management Alternatives Evaluation Findings

Process	Disposal Outlets	Advantages	Disadvantages
Composting	Agricultural land application Forestry/Silviculture Golf Courses Parks & Recreation Landscaping Domestic Use Landfill Cover	Highly marketable Class A product. May qualify as Class A EQ. Lowest capital cost. Simple operation.	Cannot compost WTF residuals. Large land area required. Large volume of amendment materials required. Can be odor nuisance. Higher O&M cost compared to other alternatives. Rainfall management needed if operation is not covered.
ATAD	Agricultural land application Forestry/Silviculture Landfill Cover (final cap)	Proven Class A process. Substantial volume reduction of WWTF sludge. Reduced nutrient loading in return streams. Process can be automated. Lowest O&M cost.	Only produces dewatered cake. Cake product may be odorous. Limited market similar to Class B cake product. Cannot process WTF residuals beyond dewatering. Highest capital cost. Extensive operator training needed.
Thermal Drying	Agricultural land application Forestry/Silviculture Golf Courses Parks & Recreation Landscaping Domestic Use Landfill Cover Energy Recovery	Highly marketable Class A product. May qualify as Class A EQ. Maximum volume reduction. Uniform product. Easily land applied. Can process WTF Residuals. Simple operation. Low O&M cost.	High capital cost. Significant natural gas usage. May produce dusty product with blended WWTF sludge and WTF residuals. Potential fire/explosion hazard with product storage.
Thermal Drying + Third-Party Residuals Management	Agricultural land application Forestry/Silviculture Golf Courses Parks & Recreation Landscaping Domestic Use Landfill Cover Energy Recovery	Maximizes marketability of dried biosolids. Dried biosolids expected to qualify as Class A EQ. Maximum volume reduction of WWTF sludge. Dried biosolids easily land applied. Reduced operating burden. Reduced permitting burden and liability for WTF residuals. Separate beneficial use market for WTF residuals. Lowest capital cost.	Highest O&M cost. Potential fire/explosion hazard with dried biosolids storage. Risk of uncertain long term costs for third-party WTF residuals management beyond initial contract term. Dependence on one service provider for WTF residuals dewatering and disposal and associated risk of failure to meet contractual requirements.

Capital costs, O&M costs, and the total net present value are estimated for each solids management alternative evaluated in this study. A summary of the total implementation costs for each of the alternatives is provided below in **Table ES.0.2**.

Table ES.0.2 – Class A Solids Management Alternatives Cost Summary

Alternative	Capital Costs	O&M Net Present Value	Total NPV
Traditional Composting	$18,327,000	$12,047,000	**$30,374,000**
In-Vessel Composting System	$24,495,000	$8,355,000	**$32,850,000**
ATAD	$26,677,000	$4,606,000	**$31,283,000**
Thermal Drying	$24,316,000	$4,933,000	**$29,249,000**
Thermal Drying + Third-Party Residuals Management	$12,529,000	$12,051,000	**$24,580,000**

After the evaluation of costs, potential disposal outlets, benefits, and disadvantages of each solids management alternative, McKim & Creed recommends that the City implement thermal drying of the Wastewater Treatment Facility sludge and contracted dewatering, hauling, and disposal/land application of the Water Treatment Facility residuals through a third-party residuals management firm. The recommended TD+TPRM alternative provides the following benefits to the City:

- The lowest 20-year net present value of all alternatives evaluated
- Separate beneficial reuse pathways for WWTF sludge and WTF residuals
- Maximized volume reduction, nutrient content, and marketability of the thermally dried biosolids product
- Reduced operating and permitting burdens at the WTF
- Expedited implementation at the WTF due to the low capital cost associated with contracted dewatering, hauling, and disposal/land application of WTF residuals

Solids Management Strategy Implementation and Next Steps

Implementation of the new solids management strategy is proposed to be accomplished in two phases. The first phase is recommended to consist of the construction of a new WTF residuals storage shelter at the WTF, and contracting with a third-party residuals management firm to dewater, haul-off, and dispose/land apply WTF residuals. This is recommended in Phase 1 due to the immediate dewatering equipment replacement needs at the WTF and due to the recent rejection of dewatered WTF residuals disposal at the White Oak Landfill in Haywood County. Phase 1 is recommended to be expedited to resolve these issues. Phase 1 is recommended to be overseen by a program manager to ensure consistent coordination between the requirements of the construction and services contracts. The program manager should design the new WTF residuals storage shelter and associated improvements to support contracted residuals management services. The program manager should also assist in the preparation of the RFP for contracted residuals management services and provide procurement assistance services including review of submitted proposals and recommendations for contract award.

Phase 2 is recommended to consist of the construction of a new thermal drying facility at the WWTF to produce a thermally dried Class A-EQ biosolids product that may be disposed of through marketing and distribution or land application. Phase 2 is recommended to be implemented within the next five years due to the potential for rejection of disposal in landfills in the western Carolinas. The recommended phasing is summarized in **Table ES.0.3** below.

Table ES.0.3 – Summary of Recommended Solids Management Strategy Implementation

	Implementation Phase	
Item	**Phase 1**	**Phase 2**
Project Name	WTF Residuals Storage Shelter and Contracted Services	WWTF Thermal Drying Facility
Project Features	Construction of clear span pre-engineered metal building for WTF residuals covered storage shelter. Contracted services for on-site dewatering of WTF residuals through third-party residuals management firm. Contracted services for hauling and disposal/land application of dewatered WTF residuals through third-party residuals management firm.	Conversion of existing covered storage area to thermal drying facility. Installation of thermal dryer feed systems (conveyors and live bottom hopper). Installation of medium-temperature belt dryer. Installation of dried product conveyance, storage, and truck load-out station.
Recommended Procurement Method	Traditional Design-Bid-Build, Request for Proposals for Contracted Services	Progressive Design-Build
Estimated Project Cost	**$1,706,000***	**$11,231,000**
Recommended Implementation Schedule	**1 year**	**5 years**

*Estimated cost includes capital cost of WTF residuals storage shelter and first year contracted services cost.

1. INTRODUCTION

The City of Hendersonville's (City) wastewater treatment facility (WWTF) has a permitted capacity of 4.8 million gallons per day (mgd) and generates approximately 5,000 dry lbs/day of dewatered sludge. The existing WWTF utilizes a traditional treatment process layout as seen in **Figure 1.1** below, including influent pumping, screening and grit removal, a traditional activated sludge process for BOD, TSS, and NH3 removal, clarification and sludge pumping, tertiary filtration, and UV disinfection. Waste activated sludge is thickened in two gravity thickener tanks, dewatered by one of two belt filter presses (BFPs), and stored in a covered area prior to landfill disposal (refer to **Figure 1.2**). The City's water treatment facility (WTF) has a permitted capacity of 12 mgd and generates approximately 1,800 dry lbs/day of dewatered residuals. The existing WTF also utilizes traditional treatment methods as seen in **Figure 1.3**, including rapid mixing, flocculation and sedimentation, dual media filtration (anthracite and sand), and chlorine disinfection. Residuals from the sedimentation basins are thickened by gravity thickeners, dewatered by a centrifuge, and hauled to a landfill for disposal.

Historically, the City has spent approximately $300,000 to $400,000 per year hauling dewatered sludge and WTF residuals to the Twin Chimneys Landfill in Greenville County, SC and more recently the White Oak Landfill in Hawood County, NC managed by Santek Environmental Services. Since 2013, the City's sludge and residuals disposal costs have increased from approximately $285,000 per year, to approximately $380,000 per year. This is due to increased solids generation and increases in tipping fees.

Recently, landfill disposal of the City's residuals has become unreliable. Several landfills have abruptly refused to accept any cake solids moving forward while others have significantly increased tipping fees. The increases in tipping fees seen in the western NC region follow the national trend of increasing tipping fees, as published by the Environmental Research & Education Foundation. The national average tipping fee per ton for municipal solid waste landfills has increased from $48.27/ton in 2016 to $55.36/ton in 2019. The City's current agreement with the White Oak Landfill in Haywood County provided for transportation and disposal of cake sludge and WTF residuals for a fee of $56/ton, until the landfill just recently began refusing dewatered WTF residuals in January of 2021. The City continues to dispose of dewatered WWTF sludge at the White Oak Landfill under this agreement.

As mentioned above, several landfills in the western NC and upstate SC region have recently refused to accept cake solids. The reasons cited for rejection of cake solids include the increased potential for slope failure, elevated interior temperature, increased leachate volume, and other potential operational challenges. Issues are largely caused by the high water content of the cake solids disposed, which is approximately 80% to 85% water by weight. Increasing disposal costs and the increased scrutiny on sludge disposal by landfills have forced the City to evaluate different solids management strategies to ensure cost effective and reliable disposal options are available. These issues were further highlighted when the White Oak Landfill recently began refusing the dewatered WTF residuals in January of 2021 as mentioned above, due to the high water content of the sludge.

The City retained McKim & Creed to review and evaluate the Final Solids Management Plan report, prepared by others, and to evaluate additional solids management alternatives to ensure the implementation of the most suitable and sustainable solids management strategy. The solids management alternatives were evaluated based on the following goals:

- Limiting capital and operation and maintenance (O&M) costs
- Producing Class A biosolids
- Providing a broader range of disposal options for processed solids
- Providing avenues for beneficial reuse of processed solids
- Limiting electrical energy and natural gas usage

The U.S. Environmental Protection Agency regulates the treatment (stabilization), use, and disposal of sewage sludge biosolids under 40 CFR 503, established in 1993. The rule is commonly referred to as the Part 503 rule. The Part 503 rule established pollutant concentration limits and pollutant ceiling concentration limits for heavy metals, pathogen limits, and vector attraction reduction requirements for the land application of biosolids. The requirements of the Part 503 rule are intended to protect human health and the environment from any adverse effects of certain pollutants that may be present in biosolids. The Part 503 rule also classifies biosolids that are to be land applied based on their pathogen levels, as either Class A or Class B. Class A biosolids are stabilized using processes that render them practically pathogen free. Class B biosolids must be stabilized to reduce pathogen levels, but pathogens are still present at detectable levels.

Biosolids may be land applied if they meet minimum requirements for pollutant ceiling concentration limits, Class B requirements for pathogen reduction, and vector-attraction reduction requirements. However, there are significant restrictions with land application of Class B biosolids including limited types of end use, enforcement of buffer area requirements, and site restrictions for application rates and harvesting periods. As a result, there are limited markets for the disposal and land application of Class B biosolids.

Higher quality Class A biosolids can be land applied or disposed of with very few restrictions, especially if they meet the lower pollutant concentration limits for heavy metals and are labeled as "exceptional quality" (EQ) biosolids. The land application of biosolids in western North Carolina is far less common than in the piedmont and coastal plains regions of the state due to the steeper terrain, colder climate, and lower density of agricultural land use. Therefore, it is critical for any new biosolids land application program in western NC to provide a highly marketable product that can appeal to a wide range of end users. The City has chosen to evaluate solids management strategies that will meet Class A requirements to ensure the availability of sustainable and cost-effective disposal markets for the City's biosolids and WTF residuals.

Based on discussions with City staff, the following four solids management strategies were selected for further evaluation:

1. Composting of WWTF Sludge and Blending with Dewatered WTF Residuals
    a. Traditional Composting
    b. Modified Static Aerobic Pile (MSAP) Composting
    c. In-Vessel Composting
2. Autothermal Thermophilic Aerobic Digestion (ATAD) of WWTF Sludge, Blending with WTF Residuals, and Dewatering
3. Thermal Drying of Blended WWTF Sludge and WTF Residuals
4. Thermal Drying of WWTF Sludge and Third-Party Contracted WTF Residuals Dewatering and Disposal

Composting was selected for evaluation because of its ability to produce Class A biosolids and its potential beneficial reuse pathways. ATAD was selected for evaluation because its ability to produce Class A biosolids, reduce sludge mass through digestion, and the City staff's positive past experiences with this technology. Thermal drying was previously recommended by the Final Solids Management Plan report and was selected for further evaluation to compare its results to the additional alternatives evaluated. Third-party contracting for WTF residuals was evaluated because of its ability to reduce the operating burden on City staff, significantly reduce capital costs for new facilities, and maximize beneficial reuse opportunities for both WWTF sludge and WTF residuals by providing separate disposal routes.

The first three solids management strategies listed above were evaluated, and the results of this evaluation were presented to the City. During review of the results of the initial evaluations with the City, a fourth alternative was identified for evaluation. The fourth alternative consists of thermal drying of the WWTF sludge and third-party contracted services for the dewatering and disposal of the WTF residuals.

This evaluation includes a review of potential disposal outlets to assist in the selection of the recommended solids management strategy. The recommended solids management strategy must produce a marketable product with multiple disposal outlets to meet the goals outlined above.

This evaluation also presents recommendations for implementation of the selected solids management strategy, including recommended project delivery options for each stage of project implementation. The project delivery options considered include traditional Design-Bid-Build (DBB), Construction Manager at Risk (CMAR), Progressive Design-Build (PDB), and Design-Build Bridging.

Figure 1.1 – Existing Wastewater Treatment Facility Layout

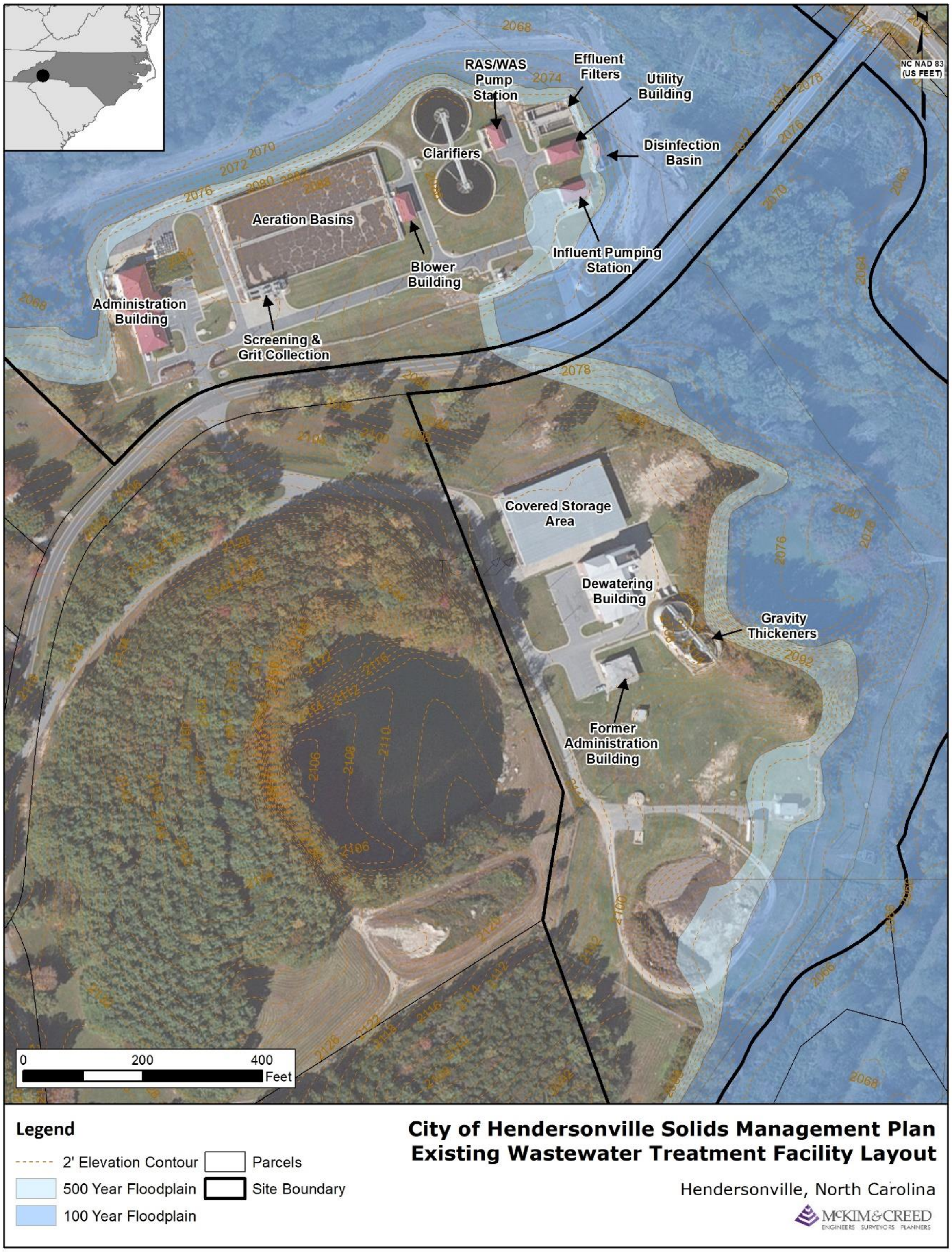


Figure 1.2 – Existing Wastewater Treatment Solids Management Process

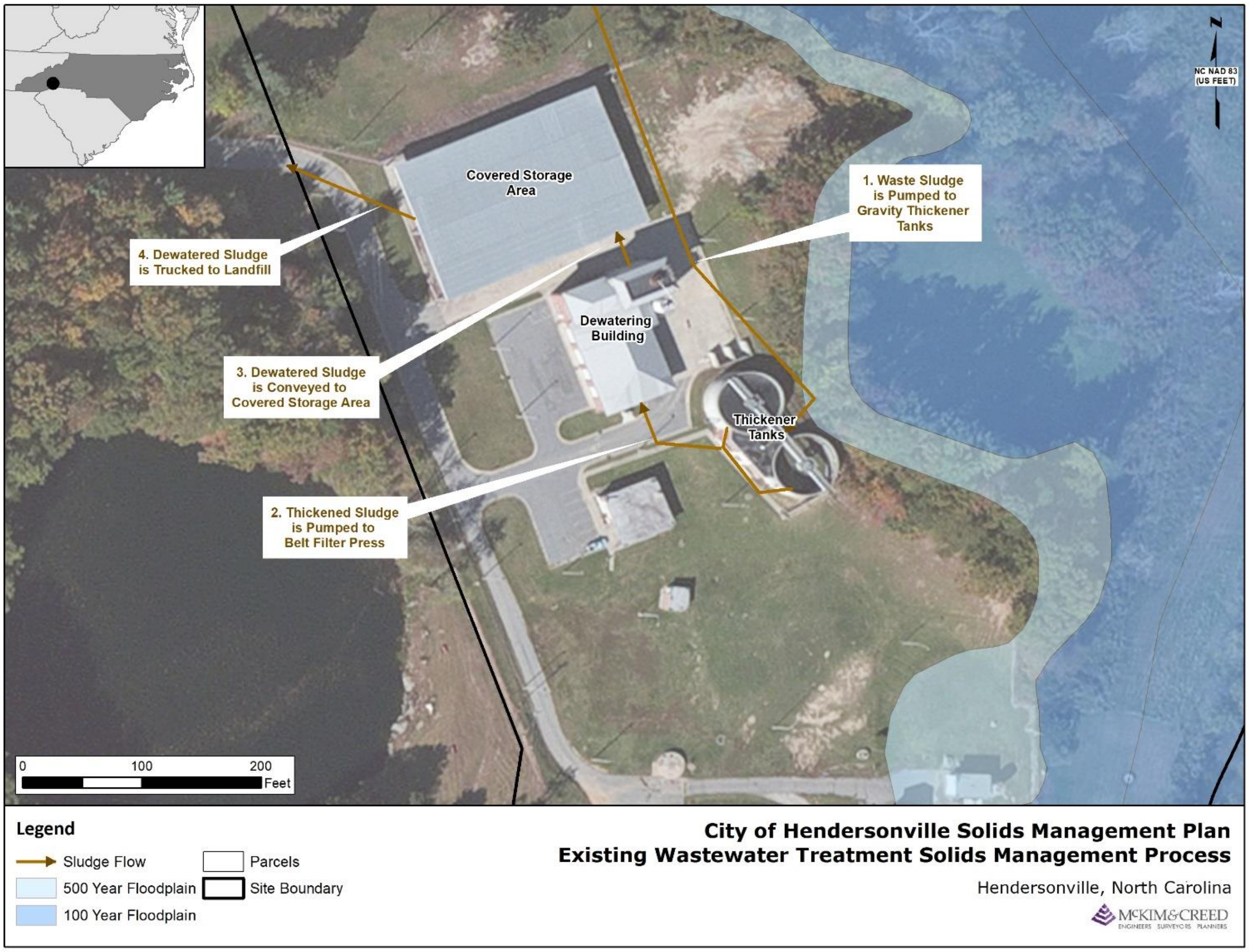
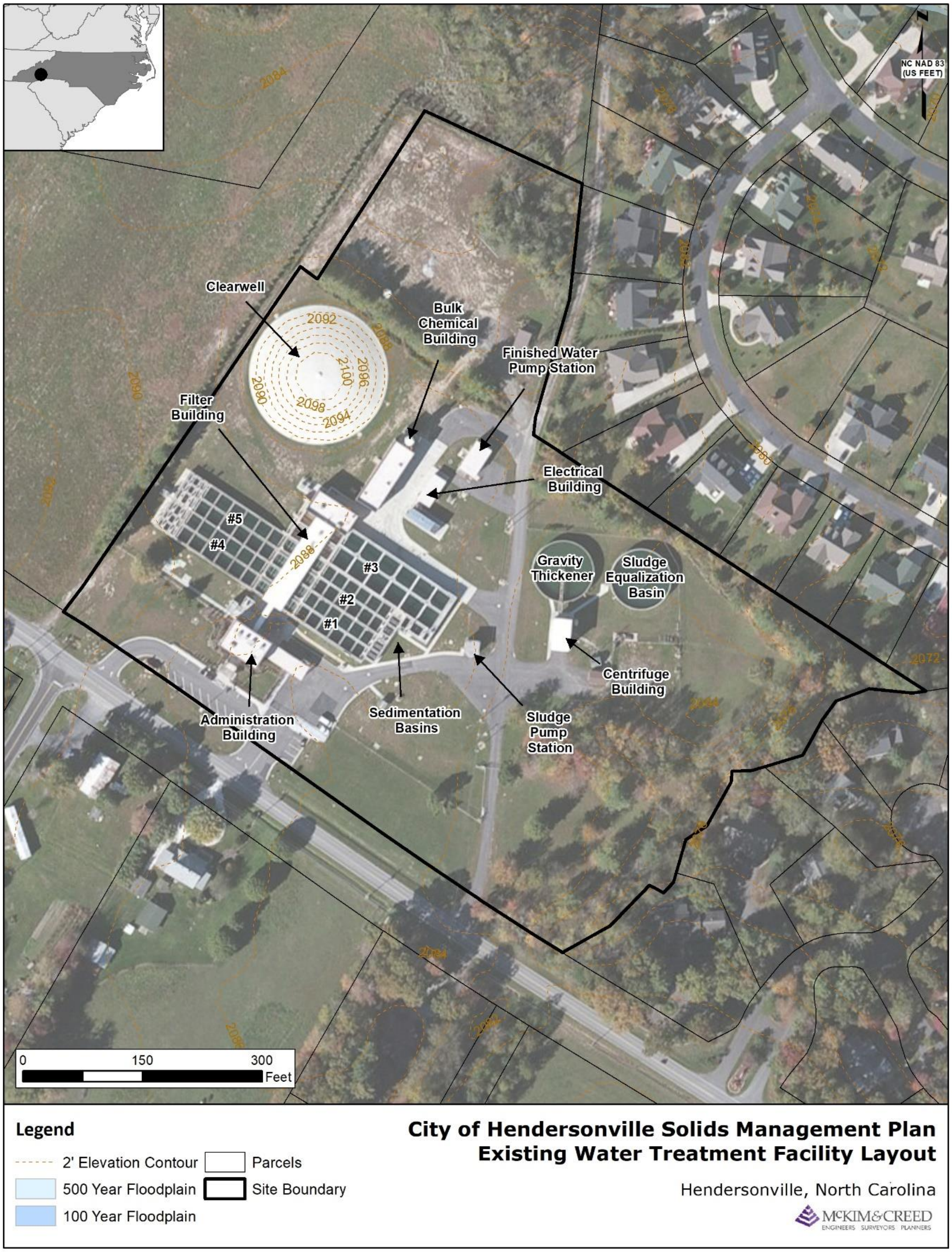


Figure 1.3 – Existing Water Treatment Facility Layout



2. EVALUATION OF FINAL SOLIDS MANAGEMENT PLAN

The Final Solids Management Plan report, which was completed in 2018, was reviewed to verify current and projected sludge quantity estimates, evaluate previous design assumptions and considerations, and identify additional considerations and alternatives to be evaluated beyond the scope of the previous report.

2.1 Sludge Quantities Analysis

McKim & Creed analyzed the current and projected sludge quantity estimates included in the Final Solids Management plan and analyzed additional sludge handling mass balance data from the WTF and WWTF to update the current and projected sludge quantities with the most recent data. The updated sludge quantity estimates were used to establish the design criteria for the alternatives that were considered as part of this evaluation. The sections below document McKim & Creed's review of the previous sludge quantity estimates and summarize any revisions that were made.

2.1.1 Water Treatment Facility Sludge Production

After review of historical data for the Water Treatment Facility, updates were made to the methods of estimating WTF sludge production. The method used to estimate the WTF sludge production was based on historical data from the facility for the raw water flow rate, the raw water turbidity, and the coagulant dosage used. The estimated sludge production utilized facility process data from the City's electronic Monthly Operating Reports Summaries (eMORS), which summarize daily operating data for each month. Data was pulled from each eMORS for the raw water flow, the coagulant usage in pounds, the coagulant dose rate in mg/L, the raw water turbidity in NTU, and the finished water turbidity in NTU. This data was set as average daily data and was used to calculate the average daily sludge production from the WTF.

During McKim & Creed's review of the eMORS data it was determined that the raw and finished water turbidity data documented in the eMORS reports is the daily maximum turbidity values recorded from any one of the facility's three raw water sources, and the daily maximum finished water turbidity.

For reference, the average raw water turbidity based on the eMORS data was 73 NTU. During dry weather, each of the City's raw water sources' normal turbidity levels are below 10 NTU. The City's WTF operating staff also proactively manages raw water intake flow rates from each of the three existing raw water sources during storm events to select the raw water source(s) with the lowest turbidity. This monitoring generally results in more raw water drawn from Bradley Creek and the North Fork of the Mills River, rather than from the Mills River source. The smaller drainage areas of Bradley Creek and the North

Fork of the Mills River naturally contribute lower turbidity levels from soil erosion and siltation when compared to the Mills River intake, which has a much larger drainage area. As a result, a lower average raw water turbidity value seen at the Water Treatment Facility has been estimated for this analysis, due to the City's proactive selection of less turbid raw water sources during heavy runoff events.

The City is currently working to complete the design and construction of a new raw water intake pump station along the French Broad River just south of the Asheville Regional Airport. Turbidity data from the French Broad River at USGS river gage station 03447687, immediately adjacent to the Asheville Regional Airport, was selected as a data source for future raw water turbidity. The use of this data for average raw water turbidity also considers a conservative assumption that the City would not optimize raw water turbidity by switching raw water intake sources during storm events. Turbidity data was collected from USGS stream gage station 03447687 for its available period of record (at the date of evaluation) from May 17, 2019 through March 31, 2020. A summary of the turbidity measurement statistics from this river gage station is provided in **Table 2.1** below. The average turbidity of the French Broad River during this period of record was 15.7 NTU. The period of record used to determine this average is relatively short, so the average turbidity value was multiplied by a safety factor of 1.5 to account for the small sample size and maximum month variation. The period of record used to determine turbidity values did include one of the wettest years on record in 2019, however, the data collected from 2019 to 2020 correlates well with historical data summarized in NCDEQ's French Broad River Basin Ambient Monitoring System Report from January of 2009. The data presented by NCDEQ in this report indicated the French Broad River had an average turbidity of 16.8 NTU at NCDEQ monitoring station E2730000 (near Fletcher, NC) for the period from 2003 through 2007. Based on this data, the average raw water turbidity that is recommended to be used for estimating average daily sludge production is 24 NTU.

Table 2.1 – Turbidity Data for the French Broad River at USGS Station 03447687 from 5/17/19 through 3/31/20

Parameter	Units	Value
Average Turbidity	NTU	15.7
Minimum Turbidity	NTU	2.6
5th Percentile Turbidity	NTU	3.8
Median Turbidity	NTU	8.3
95th Percentile Turbidity	NTU	56.2
Maximum Turbidity	NTU	447
Recommended Safety Factor for Alternatives Evaluation	-	1.5
Recommended Average Turbidity for Daily Sludge Production Calculations	**NTU**	**24**

The equation used in the previous report to estimate WTF sludge production from the coagulant dose and raw water turbidity was developed based on the use of alum (Al_2O_3) as the coagulant.

The City currently uses CedarChem's CedarCLEAR 1757 polyaluminum chloride (PACl) coagulant at the WTF. The procedure to calculate sludge production from water treatment coagulants consists of first calculating the mass of sludge from turbidity removed, then the mass of sludge from the coagulant itself, which in this case is PACl. The estimated mass of sludge produced from turbidity is affected by the "b" value correlation coefficient between turbidity and suspended solids. This "b" value can range from 0.9 to 1.5, with a typical value of 1.25 mg TSS/NTU removed (source: MWH Water Treatment Principles and Design, Crittenden, J., et. al.). McKim & Creed used the typical "b" value of 1.25 to estimate the WTF sludge production. The equation used to calculate the WTF sludge production for this analysis is shown below.

$$S = sludge\ from\ turbidity + sludge\ from\ PACl$$

$$S = [8.34 * Q * (T_{RW} - T_{SW}) * b] + [8.34 * Q * D * (0.0489 * \%Al)]$$

Where:

S = sludge production (lb/day)

Q = raw water flow (AADF, mgd)

T_{RW} *= raw water turbidity (NTU)*

T_{SW} *= settled water turbidity (NTU)*

b = 1.25 mg TSS/NTU removed

D = PACl dose (mg/L)

%Al = PACl percent aluminum content by mass

McKim & Creed contacted the PACl manufacturer and determined the actual percent aluminum content by mass in the coagulant used by the City, which is reported at 12.9%. Additional data was gathered from the Water Treatment Facility for the period of January 2014 through May 2019 to estimate the current sludge production using the equation above. The sludge production estimates from this analysis have been compared to the estimates from the previous equation used in the Final Solids Management Plan report. This analysis predicts less sludge production from the WTF than the Final Solids Management Plan report.

The revised sludge production calculation for 2021 annual average daily flow (AADF) conditions is summarized below in **Table 2.2**.

Table 2.2 – Current Day Sludge Production Estimate

Parameter	Units	Value
Average Raw Water Flow (2014 – 2019)	mgd	7.273
Annual Average Raw Water Turbidity	NTU	24
Average PACl Chemical Dose (2014 – 2019)	mg/L	18.2
Average Settled Water Turbidity	NTU	0.3
Sludge Production	Dry lb/d	2,500

After calculation of the sludge production estimates, mass balances for the sludge handling processes at the WTF under current (2021) and future 2040 conditions were prepared. The previous assumptions used in the Final Solids Management Plan report for solids concentrations and capture efficiencies of the process units are used for this effort, and these values are summarized below in

Table 2.3. The mass balance for the WTF sludge handling under current AADF conditions is presented below in **Table 2.4**.

Table 2.3 – Assumptions used to develop mass balances for the WTF.

Parameter	Units	Value
Sludge Solids Concentration from Sedimentation Tanks	%	1
Gravity Thickener Solids Capture Rate	%	80
Thickened Sludge Solids Concentration	%	4
Dewatering Capture Rate	%	90
Dewatered Sludge Solids Concentration	%	15

Table 2.4 – Mass Balance for WTF Sludge Handling Processes Under Current AADF Conditions

Flow Stream	Solids Concentration (%)	Flow (gpd)	Mass (dry lb/d)
Sludge from Sedimentation Basins	1%	30,000	2,500
Supernatant from Gravity Thickeners	0.3%	24,000	500
Thickened Sludge from Gravity Thickeners	4%	6,000	2,000
Polymer to Centrifuge Feed Sludge	0.6%	280	14
Dewatered Sludge from Centrifuge	15%	1,400	1,800
Centrate from Centrifuge	0.5%	4,880	214

The same methods are used to estimate the future sludge production from the WTF under 2040 AADF conditions. The 2040 average day flow projection of 12.44 mgd from the City's Water System Master Plan has been used to estimate the sludge production. It is assumed that the raw water turbidity and the PACl coagulant dosage would remain the same under the future 2040 conditions. Based on these assumptions, the future 2040 AADF sludge production for the WTF is calculated as 4,300 dry lb/day. The mass balance for the WTF sludge handling processes under 2040 AADF conditions is presented below in **Table 2.5**.

Table 2.5 – Mass Balance for WTF Sludge Handling Processes Under 2040 AADF Conditions

Flow Stream	Solids Concentration (%)	Flow (gpd)	Mass (dry lb/d)
Sludge from Sedimentation Basins	1%	51,600	4,300
Supernatant from Gravity Thickeners	0.3%	41,300	860
Thickened Sludge from Gravity Thickeners	4%	10,300	3440
Polymer to Centrifuge Feed Sludge	0.6%	480	24
Dewatered Sludge from Centrifuge	15%	2,500	3,100
Centrate from Centrifuge	0.5%	8,280	364

2.1.2 Wastewater Treatment Facility Sludge Production

In reviewing the Final Solids Management Plan report, McKim & Creed evaluated the previous sludge production estimates for the WWTF and prepared updated sludge production estimates. Sludge wasting reports, biosolids disposal summaries, and flow data were gathered from the WWTF to prepare the updated sludge production estimates. Sludge wasting reports from 2018 to May 2019 were gathered from the WWTF. The sludge wasting reports are used by the WWTF staff to document operation of the thickening and dewatering facilities and provide the following information:

- Waste sludge (WAS) volume to gravity thickening, gallons per day
- Thickened sludge (TWAS) volume to the belt filter press, gallons per day
- Thickened sludge % solids for each dewatering shift
- Dewatered sludge % solids cake for each dewatering shift

The updated WAS solids concentration is calculated to be 1.87% solids based on the data reported in the sludge wasting reports for volume of WAS wasted and the estimated dry mass of solids in the WAS. A WAS percent solids concentration of 1.87% correlates to a WAS concentration of 18,700 mg/L, which is impossible based on a state-point analysis for the existing clarifiers. The estimated RAS/WAS concentration for existing conditions is approximately 8,000 mg/L (i.e. 0.8%) assuming both clarifiers are typically in service, an aeration basin MLSS concentration of approximately 4,000 mg/L, an average influent flow rate of approximately 3.2 mgd, and a RAS flow rate of 3.2 mgd.

The estimated dry mass of solids in the WAS is based on the mass of thickened WAS from the gravity thickeners and the assumed gravity thickener solids capture efficiency. The mass of thickened WAS from the gravity thickeners was calculated from the flow rates and solids concentrations reported in the sludge wasting reports. The values for thickened WAS flow rates and concentrations are reported with much higher frequency in the sludge wasting reports and results in a dry mass of solids very similar to the values previously reported in the Final Solids Management Plan report. As a result, the dry mass of WAS estimated from the sludge wasting reports is considered to be an accurate estimate. The WAS flow rates from the clarifiers to the gravity thickeners that are reported in the sludge wasting reports are not considered accurate. Therefore, the WAS flow rates for current and future conditions at the WWTF are estimated based on a WAS concentration of 0.8% TS, which is very similar to the previous assumption of 1.0% TS.

The difference in WAS solids concentration noted above had no effect on the remainder of the mass balance for the WWTF, but it does highlight a potential need to monitor WAS and/or RAS solids concentration. The WAS or RAS solids concentration can serve as a general guide to adjust the RAS flow rate and sludge wasting schedule to prevent unnecessary wear on both the clarifier drive mechanism and sludge pumps, due to higher-than-typical solids concentrations. Also, a simple state-point analysis tool can be developed and utilized by the WWTF staff to further assist in assessment of clarification and thickening processes in the existing clarifiers.

The revised mass balance for the WWTF solids handling processes proved to be on the same order of magnitude as the values previously reported in the Final Solids Management Plan report. The assumptions used to develop the revised mass balance differ slightly from the previous assumptions in the Final Solids Management Plan report. More data was collected than in the previous effort, which provided the actual thickened sludge solids concentration and dewatered sludge solids concentration. The following assumptions in **Table 2.6** are used to develop the revised mass balances for the WWTF sludge handling processes. The mass balance for the WWTF solids handling processes under current AADF conditions is shown below in **Table 2.7**.

Table 2.6 – Assumptions used to develop mass balances for the WWTF.

Parameter	Units	Value
Sludge Solids Concentration from Clarifiers*	%	0.80
Gravity Thickener Solids Capture Rate	%	90
Dewatering Belt Filter Press Capture Rate**	%	95
Dewatering Polymer Dosage**	(active lb/dry ton sludge)	20

*Calculated from Sludge Wasting Reports data
**Per WEF MOP No. 8 – Design of Water Resource Recovery Facilities

Table 2.7 – Mass Balance for WWTF Sludge Handling Processes Under Current AADF Conditions

Flow Stream	Solids Concentration (%)	Flow (gpd)	Mass (dry lb/d)
WAS from Clarifiers	0.80%	85,400	5,700
Thickened Sludge from Gravity Thickeners	3.36%	18,200	5,200
Supernatant from Gravity Thickeners	0.1%	67,200	500
Polymer to Belt Filter Press Feed Sludge	0.5%*	1,246	52**
Dewatered Sludge from Belt Filter Press	17%	3,500	5,000
Filtrate from Belt Filter Press	0.2%	14,762	252

*Polymer solids concentration is % active polymer concentration after make-down, delivered to BFP
**Polymer mass rate is reported in pounds of active polymer per day

The observed yield, average influent BOD, and projected 2040 annual average daily flow (AADF) rate are used to predict the future 2040 sludge production and mass balance for the WWTF. The observed yield for the period from January 2018 through April 2019 is calculated as 1.14 dry lb of WAS/lb of BOD loading, which is slightly higher than the value of 1.12 reported in the Final Solids Management Plan report. The projected 2040 sludge production is then calculated using this observed yield value, the projected 2040 annual average daily influent flow rate from the City's Sanitary Sewer Asset Inventory Analysis Report, and the average influent BOD observed for the period from 2014 through April of 2019. The average influent BOD has remained relatively stable over this historical data period, and it is assumed to remain relatively stable over the projected evaluation period. The data used to estimate the observed yield and the 2040 AADF sludge production is provided below in **Table 2.8**. The mass balance for the WWTF solids handling processes under 2040 AADF conditions is provided below in **Table 2.9**.

Table 2.8 – Historical Data Used to Calculate Observed Yield

Parameter	Units	Value
Average Influent Flow (2018 – April 2019)	mgd	3.197
Average Influent BOD5 Conc. (2018 – April 2019)	mg/L	205.17
Average Influent BOD5 Loading (2018 – April 2019)	dry lb/d	4,997.94
Observed Yield (2018 – April 2019)	lb WAS/lb BOD5	1.14
Average Influent Flow (2014 – April 2019)	mgd	3.05
Average Influent BOD5 Conc. (2014 – April 2019)	mg/L	218.26
Average Influent BOD5 Loading (2014 – April 2019)	dry lb/d	5,345.28

Table 2.9 – Mass Balance for WWTF Sludge Handling Processes Under 2040 AADF Conditions

Flow Stream	Solids Concentration (%)	Flow (gpd)	Mass (dry lb/d)
WAS from Clarifiers	0.80%	187,400	12,500
Thickened Sludge from Gravity Thickeners	3.36%	40,300	11,300
Supernatant from Gravity Thickeners	0.1%	147,100	1,200
Polymer to Belt Filter Press Feed Sludge	0.5%*	2,710	113**
Dewatered Sludge from Belt Filter Press	17%	7,600	10,800
Filtrate from Belt Filter Press	0.2%	32,835	613

*Polymer solids concentration is % active polymer concentration after make-down, delivered to BFP

**Polymer mass rate is reported in pounds of active polymer per day

2.2 Evaluation of Previous Design Considerations

2.2.1 Sludge Outlets and Solids Processing Technology Screening

The Final Solids Management Plan Report previously reviewed the various potential outlets for both water residuals and biosolids, including summaries of regulatory requirements and trends, the overall range of disposal options, and the trends in disposal practices for the North Carolina region. The previous report provided a thorough review of available sludge outlets, and the following comments are intended to provide additional considerations.

Regarding current and future disposal outlets, the Final Solids Management Plan Report references landfilling as one of the disposal outlet options but notes that it should not be considered for future disposal practices. It is agreed that landfilling should not be considered as a primary disposal outlet for future planning, however landfilling may remain an interim (and back-up) option in the future as the City implements the various phases of the new solids handling practices. Maintaining relationships and agreements with area landfills will provide the City with the flexibility and time to market the WTF residuals and biosolids to potential beneficial reuse outlets, procure land application sites if desired, and develop the internal framework needed to manage new disposal practices. Landfilling may also serve as a necessary back-up disposal outlet in the future if process upsets occur, or if abnormal weather prevents disposal practices such as land application.

The discussion of sludge outlets in the Final Solids Management Plan report also suggests recommendations for 90-days of finished product storage if land application serves as a primary disposal outlet. Because the majority of solids disposal in North Carolina is done by land application, it is highly likely that the City's future disposal outlets will include land disposal as a primary outlet, whether it is through the City's own program or a third-party contractor. The Final Solids Management Plan Report later states that finished product storage was not included in the evaluation, therefore it was not included in cost estimates for each alternative. We recommend including finished product storage in future solids management process modifications to ensure the City solids disposal program has the flexibility to adapt to inclement weather patterns and/or periodic changes in finished product demand.

Regarding the technology screening evaluation, the Final Solids Management Plan report recommended replacement of the existing belt filter presses at the WWTF for future dewatering. After consideration of the existing belt filter press equipment's general condition, it was determined that the existing belt filter press equipment has been well maintained and is in good condition. The most common wear item on the existing belt filter presses, the belts, are manufactured by multiple companies and are commonly available. The existing belt filter presses also still have significant throughput capacity and are currently only run approximately seven to ten days each month. Therefore, we recommend continuing the use of the existing belt filter presses for dewatering in future solids management processes due to the lower cost of equipment maintenance when compared to new equipment purchase and installation.

2.2.2 Alternatives Evaluation

The alternatives that were selected for end-to-end evaluation in the Final Solids Management Plan report were centered solely on drying of the WTF residuals and WWTF sludge, not including the baseline process. The report did consider other stabilization techniques during the technology screening evaluation, including anaerobic digestion, conventional aerobic digestion, ATAD, composting, the Lystek process, and the BCR Neutralizer process. However, these alternatives were not further considered beyond the initial screening, which limits the diversity of solids management alternatives. This evaluation seeks to increase the number of alternatives considered for the City's solids management plan. Therefore, ATAD and composting were selected to be reviewed and compared to reevaluation of thermal drying, which was the recommended alternative from the Final Solids Management Plan report.

2.2.2.1 *Water Treatment Facility Residuals*

The recommended alternative from the Final Solids Management Plan report recommended transport of the WTF residuals to the WWTF to be blended with the WWTF sludge, dewatered, and dried together in a thermal dryer. This includes the construction of a new residuals pump station at the WTF and a force main to transport the WTF residuals to the WWTF. This recommendation is further evaluated as part of this report to confirm its cost effectiveness.

If the WTF residuals were not pumped to the WWTF under this scenario, the WTF would require a new dewatering facility to replace the existing 40-year-old centrifuge and hauling of the dewatered residuals to the WWTF would be required. It is agreed that the existing centrifuge dewatering equipment at the WTF must be replaced due to its age, high O&M needs, and lack of redundancy. The City's current Capital Improvement Plan (CIP) has established funding for the replacement of the existing dewatering facility during fiscal year 2022. The funding currently established for the dewatering facility replacement may be applied towards that goal, repurposed for use towards the construction of a new residuals pump station and force main (if selected), or repurposed towards other capital expenditures required for the selected solids management strategy. The Final Solids Management Plan report outlined the capital costs of a new dewatering facility at the WTF under the baseline process at $5,080,000. The cost to haul dewatered WTF residuals from the WTF to the WWTF for drying is assumed to be $7.00 per wet ton, similar to the assumptions listed in the Final Solids Management Plan report.

The Final Solids Management Plan report proposed two alternate routes for the WTF residuals force main. Alternative #1 was included in the cost estimates for the recommended alternative. Alternative #1 for the WTF residuals force main is approximately 6.25 miles long and generally runs along Haywood Road (NC 191) from the WTF to near Rugby Middle School, then following a Duke Energy transmission line right-of-way to the WWTF. It is unlikely that this route would be a feasible alternative due to the heavy reliance on the Duke Energy transmission line right-of-way. Per Duke Energy's Use Guidelines for Encroachments Involving Transmission Easements, Duke Energy generally does not allow any sewer or water lines within their easements if they run in parallel to the centerline of the easement. Duke Energy also does not allow sewer or water lines within 25 feet of a Duke Energy facility, including transmission towers, guy wires, etc. Special cases may apply to allow a variance from these requirements. This should be evaluated further as part of a preliminary engineering and routing study if the City elects to move forward with the WTF residuals pump station and force main. A preliminary engineering and routing study should identify and evaluate additional permitting challenges, land acquisition requirements and costs, long term accessibility, maintenance considerations, constructability, design costs, and construction costs to determine the most feasible and cost effective route.

Alternative #2 for the WTF residuals force main is approximately 7.15 miles long and generally runs along Haywood Road (NC 191) from the WTF to Mountain Road (SR 1381), along Stoney Mountain Road (SR 1383), along Asheville Highway, along Berkley Road, and along Balfour Road to the WWTF. Force main alternative #2 is believed to be more feasible compared to alternative #1 for the purposes of this evaluation due to its limited reliance on Duke Energy transmission easements. However, alternative #2 is longer than alternative #1 by almost one mile, increasing the capital cost. Pumping of the WTF residuals this distance will require careful design and selection of the appropriate pumps, force main diameter, and flow velocities. It is recommended to pump the WTF residuals at a solids concentration of approximately 1% to reduce head loss and solids deposition in the new force main. Head losses from pumping sludges and slurries increase substantially above 2% total solids, so it is recommended not to exceed 2% total solids to provide a simpler, less costly pumping system to construct and operate.

Pump station and force main construction costs are also re-evaluated for this comparison, and pumping energy requirements were estimated based on force main alternative #2. Alternative #2 was selected for this analysis to provide a more conservative estimate of construction and pumping costs, since it is longer than alternative #1. A 6 inch diameter force main has been selected for this evaluation to maintain velocities greater than 2 feet per second. Force main materials are assumed to be primarily C900 PVC and glass lined DIP at road and water crossings. The maximum static lift is estimated to be 144 vertical feet based on the alignment of alternative #2. The total amount of WTF residuals assumed to be pumped to the WWTF is 45,662 wet tons/year (10.95 MGal/yr) in 2021, and 78,538 wet tons/year (18.834 MGal/yr) in 2040. The residuals would be pumped at a concentration of 1% TS. In comparison, the total amount of dewatered WTF residuals to be hauled to the WWTF is 2,190 wet tons/year in 2021, and 3,772 wet tons/year in 2040. The residuals are assumed to be dewatered to a concentration of 15% TS. The cost comparison for pumping the residuals versus trucking the residuals to the WWTF is shown below in **Table 2.10**.

Table 2.10 – Cost comparison of pumping vs. trucking of WTF residuals to the WWTF

WTF Residuals Pump Station and Force Main		WTF Residuals Dewatering and Trucking	
Item	**Value**	**Item**	**Value**
WTF Residuals Force Main	$4,298,000	New WTF Dewatering Facility	$5,080,000
WTF Residuals Pump Station	$1,170,000	2021 Residuals Hauling Cost	$15,330
2021 Pumping Electricity Cost	$3,242	2040 Residuals Hauling Cost*	$47,674
2040 Pumping Electricity Cost*	$10,069		
20-year NPV	**$5,552,000**	**20-year NPV**	**$5,478,000**

*Assumes a 3% inflation rate of electricity/hauling unit costs.

The comparison above shows that the capital and 20-year NPV of both alternatives are nearly equal. As operation of the facilities continues past the 20-year period, hauling costs will continue to increase at a greater rate than pumping costs. The comparison above does not include operations staff costs and other O&M costs. However, centralizing dewatering operations at a single facility is likely to result in improved staffing efficiency and limits the amount of equipment required to be maintained, thus saving cost. Based on this, it is agreed that a new WTF residuals pump station and force main is recommended.

However, this recommendation is contingent upon the dewatering capability of the WTF residuals using the existing belt filter presses at the WWTF. It is recommended to pilot test dewatering efficacy of the WTF residuals using the existing belt filter presses at the WWTF prior to the detailed design of solids management improvements at the WTF if this alternative is selected. This pilot testing can be completed relatively easily to determine polymer usage, feed rates, and resulting percent solids concentration of the dewatered residuals.

Under this alternative, the WTF residuals are assumed to be pumped to one of the two existing gravity thickeners at the WWTF for thickening prior to dewatering. Depending on the selected solids management plan at the WWTF, the WTF residuals may also be blended with the WWTF sludge prior to the gravity thickeners in a blending tank and then co-thickened in both existing gravity thickeners. The existing gravity thickeners at the WWTF are both 50 feet in diameter and have a side water depth of 13 feet. The existing gravity thickeners have enough capacity to thicken both the WTF residuals and the WWTF sludge, even with one gravity thickener out of service. **Table 2.11** and **Table 2.12** below summarize the surface overflow rates and solids loading rates to the existing WWTF gravity thickeners assuming WTF residuals and WWTF sludge are thickened separately. It is important to note, these conditions assume the operation of the existing gravity thickeners is modified to allow continuous feed and sludge withdrawal, as is typical for gravity thickeners. The City is currently in the process of completing a master plan for the WWTF, including evaluating improvements to the thickening processes at the WWTF. Additional information regarding other thickening improvements at the WWTF may be referenced in the final WWTP master plan.

Table 2.11 – Existing WWTF gravity thickeners surface overflow rates

2021 Conditions		2040 Conditions	
Item	**SOR (gpd/ft^2)**	**Item**	**SOR (gpd/ft^2)**
WTF Residuals	15.3	WTF Residuals	26.3
WWTF Sludge	43.5	WWTF Sludge	95.4
Combined Residuals + Sludge*	58.8	Combined Residuals + Sludge*	121.9
Recommended Range**	100 – 200	Recommended Range**	100 - 200

*SOR for combined residuals and sludge assumes one thickener in operation
**Per WEF MOP No. 8 – Design of Water Resource Recovery Facilities

Table 2.12 – Existing WWTF gravity thickeners solids loading rates

2021 Conditions		2040 Conditions	
Item	**SLR (PPD/ft^2)**	**Item**	**SLR (PPD/ft^2)**
WTF Residuals	1.3	WTF Residuals	2.2
WWTF Sludge	2.9	WWTF Sludge	6.4
Combined Residuals + Sludge*	4.2	Combined Residuals + Sludge*	8.6
Recommended Range**	5 – 15	Recommended Range	5 - 15

*SLR for combined WTF residuals and WWTF sludge assumes one thickener in operation
**Per WEF MOP No. 8 – Design of Water Resource Recovery Facilities

2.2.2.2 *Final Recommendation and Implementation*

The recommended alternative from the Final Solids Management Plan report was to construct a new thermal drying facility at the WWTF to dry blended WTF residuals and WWTF sludge. Prior to this evaluation by McKim & Creed, the City coordinated with Huber Technology Inc. to perform a laboratory drying test. The drying test was performed to verify the feasibility of the recommended alternative from the Final Solids Management Plan report. The feasibility of extruding the sludge was also tested in this effort to verify that sludge pellets satisfactory for thermal belt drying could be formed. The test was carried out using sludge samples from both the WWTF and the WTF.

Huber performed laboratory analyses on the sludges to determine their initial dry solids concentration, pH, and volatile solids concentration. The dry solids concentration of the WWTF sludge was reported as 16.53%, and the dry solids concentration of the WTF residuals was reported as 12.59%. The drying test was conducted using a blended mixture of the sludges at a ratio of 60% WWTF sludge to 40% WTF residuals, with a dry solids concentration of 15.32%. The extruding process results indicated that the sludge mixture produced satisfactory strains that partly stuck together. The report did note the drying process was slightly longer in comparison to digested municipal sludge, due to a higher moisture content of the sludge mixture. The testing verified the feasibility of thermally drying the blended sludge, noting, “the test demonstrated suitability to extruding and drying this sludge in a HUBER belt dryer.”

It is important to note that Huber reported the WWTF sludge had a pH value of 5.95 along with a sour smell, indicating the presence of organic acids. It is expected that these properties of the WWTF sludge are due to extended sludge retention time in the existing gravity thickeners, resulting in anaerobic conditions. Huber’s report noted that the low pH value of the sludge may result in higher emissions of sulfuric compounds in the exhaust air. A copy of the test report prepared by Huber Technologies Inc. is provided at the end of this report in APPENDIX D – THERMAL DRYING SUPPORTING INFORMATION.

Based on the test results, the recommended alternative from the Final Solids Management Plan report is feasible. If this alternative is selected for implementation, it is recommended that the City’s WTF residuals be examined by a state certified laboratory for pollutant concentrations to ensure that a dried product does not exceed the 40 CFR Part 503 rule pollutant concentration limits for Exceptional Quality (EQ) biosolids. The WWTF sludge has been previously analyzed for pollutant concentrations on multiple occasions. Analytical results of the WWTF sludge that were previously provided to McKim & Creed indicates that the dried biosolids product will meet the Exceptional Quality (EQ) biosolids criteria per the Part 503 rule. However, analytical results for the WTF residuals are unknown at this time and may affect meeting the EQ criteria. If a dried product of blended WTF residuals and WWTF sludge does meet the Part 503 EQ criteria, the product qualifies for unrestricted use if regular pollutant concentration monitoring is carried out and dedicated land application sites are permitted.

Regarding the previous cost estimates from the Final Solids Management Plan report, the recommended thermal drying facility costs included a large capital expense for a new thermal drying building. It should be noted that a significant portion of this capital expense may be avoided by repurposing a portion of the existing covered storage area to house new thermal drying process equipment. This cost savings is reflected in the cost estimate for the thermal drying alternative that was further evaluated herein.

3. EVALUATION OF ADDITIONAL SOLIDS MANAGEMENT ALTERNATIVES

3.1 Composting

3.1.1 Introduction

Composting is a biological degradation process that results in Class A, humus-like material that can be used for agricultural and horticultural applications. The composting process starts with preprocessing, followed by decomposition, curing, and postprocessing. Preprocessing involves mixing dewatered biosolids with a carbonaceous bulking agent, typically yard waste. Decomposition occurs over approximately 30 days, during which time the microbial activity generates heat and consumes oxygen. Curing occurs over approximately 30 days and is characterized by microbial activity reduction and chemical stabilization. During postprocessing, screened "overs" are removed to be recycled in subsequent piles, and the compost is shredded and screened to meet product quality requirements, if necessary. Biosolids composting is typically accomplished with one of the following methods:

- Windrow – compost is piled in long rows and mechanically turned to introduce oxygen and control temperature
- Aerated Static Pile – compost is piled in long rows over a grid of aeration pipes with forced aeration and the pile is typically covered with either screened compost or a GORE-TEX® type membrane. To reduce odors, air is typically pulled through the pile from outside-in, and discharged through a biofilter bed to eliminate odor potential.
- In-Vessel – compost is mechanically processed in long bays inside an enclosed building

For the purposes of this evaluation, only traditional windrow composting and in-vessel composting were compared since the space requirements and costs of windrow and aerated static pile are assumed to be similar. It should be noted that aerated static pile composting has a lower operations staff requirement compared to windrow composting. Aerated static pile composting does not require turning during composting, and the vacuum-induced aeration method also enables larger compost piles, which in turn requires less area for composting. Aerated static pile composting does however incur electrical power costs because of the vacuum-induced aeration systems, whereas windrow composting does not require any electrical power.

Advantages

- Highly marketable Class A product
- Lowest capital costs
- Relatively simple operation compared to many other solids management processes

Disadvantages

- Large land areas required
- Large amount of amendment material required (i.e. yard waste, wood chips, shredded newspaper)
- Odor control issues during initial stage of composting and during turning
- Highest long-term O&M cost due to labor intensity and large volume production
- Management of rainfall runoff and leachate runoff required for open composting facilities

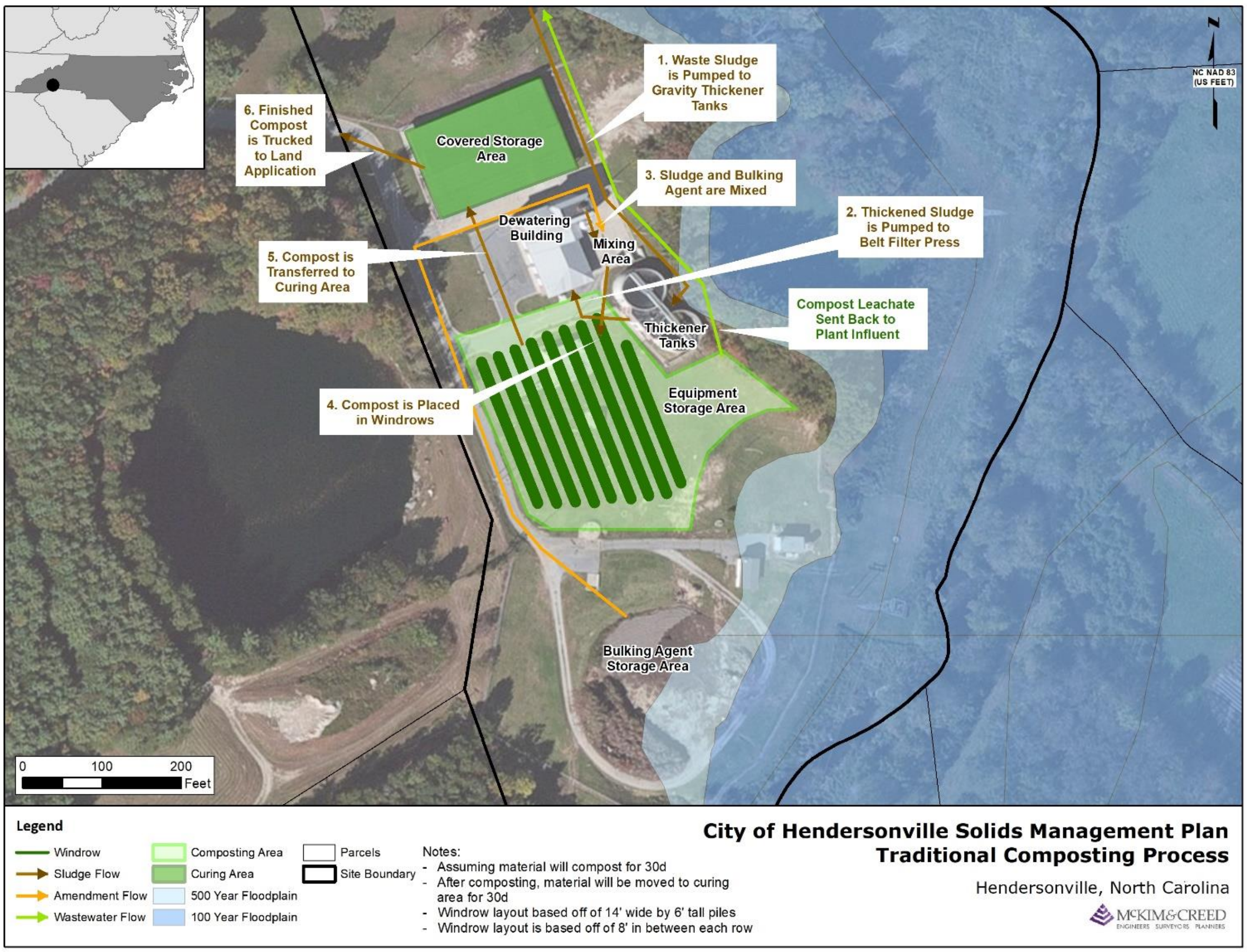
3.1.2 Traditional Composting Process Description

The traditional windrow composting alternative was evaluated to stabilize the WWTF sludge, while utilizing the existing thickening and dewatering equipment. WTF residuals should not be composted with the WWTF sludge because the WTF residuals are relatively inert, have a high water content, and dramatically increase facility size and volume of amendment required. Dewatered WTF residuals are recommended to be blended with the finished compost as a soil amendment in this alternative. In this alternative, yard waste from the City and an additional bulking agent (wood chips, shredded newspaper, etc.) are proposed to be mixed with the dewatered WWTF sludge. The bulking agent must be shredded prior to mixing to maximize surface area, workability, and improve mixture density.

Following preprocessing, the compost mix is placed in windrows which were assumed to be 6 ft high and 14 ft wide. This size of windrow was selected to maximize the existing land available, while considering typical windrow turning equipment sizes available. There should be at least 8 ft between each windrow and 40 ft on the ends of each windrow to provide adequate room for equipment. Windrows should be turned at least five times during the 30-day decomposition phase.

Following decomposition, the compost is proposed to be transferred to the covered storage area for curing. Turning is not necessary during curing due to decreased microbial activity. Screening and shredding are typically utilized to create a more uniformly sized and marketable compost product and to recover some of the larger pieces of bulking agent that have not decomposed. The finished compost is then blended with the dewatered WTF residuals and trucked off for land application. **Figure 3.1** depicts the traditional composting process.

Figure 3.1 – Traditional Composting Process



Note: The windrow layout shown in Figure 4.1 shows the maximum windrows that fit in the composting area. The MSAP composting process is the same as traditional composting with the addition of inoculant to the windrows.

3.1.3 MSAP Composting Process Description

The Modified Static Aerobic Pile (MSAP) Composting process is the same as the traditional composting process with the following exceptions:

- The windrows do not need to be turned so new windrow turning equipment is not necessary. Transfer of the compost to the curing area after 30 days will provide sufficient mixing.
- Inoculant is added on top of the windrows at a 1:800 inoculant to compost volume ratio.

If windrow composting is selected as the City's preferred solids management strategy, MSAP composting would be considered as an enhancement to traditional windrow composting in which a proprietary microbial inoculant is added to the compost windrow to accelerate the natural composting process and largely eliminate the need for mechanical turning. The inoculant used in this process rapidly migrates into the compost pile, drawing oxygen into the compost pile without mechanical mixing, and generates hotter composting temperatures than traditional windrow composting. The higher temperatures and reduced mixing of the MSAP process accelerates the decomposition process. The inward growth of the microbial inoculant maintains aerobic conditions and a capping layer of unscreened compost or overs from screening acts as an insulating layer and biofilter to limit odors. The MSAP composting method consists of the following steps:

1. Mix feedstocks at 3:1 ratio of bulking agent to biosolids
2. Construct typical compost windrows
3. Apply microbial inoculant to the surface of the windrow pile in several locations
4. Cap the windrow with unscreened compost or overs
5. Allow microbial aerobic decomposition to occur for one month
6. Transfer to curing

The MSAP composting process was developed by Harvest Quest International, Inc., which developed and distributes the proprietary microbial inoculant. This process is recognized by the EPA as an approved composting method modification. A case study presentation was provided courtesy of Harvest Quest International and is included at the end of this report in **APPENDIX B – COMPOSTING SUPPORTING INFORMATION**.

3.1.4 Traditional Composting Design Criteria

The design criteria for the traditional composting alternative are listed in **Table 3.1**. The traditional composting alternative only processes WWTF sludge and utilizes the existing thickening and dewatering equipment to preprocess sludge to approximately 17% TS, based on current dewatering performance. The estimated amount of sludge that would be composted in 2021 is 14.6 wet ton/d and by 2040 it would increase to approximately 31.8 wet ton/d. Assuming a sludge density of 1,550 lb/cy, 18.8 cy/d of sludge would be generated in 2021 and 41.0 cy/d would be generated in 2040. Assuming the bulking agent is mixed with sludge at a 3:1 volume ratio, 20,600 cy/yr would be required in 2021 and 44,895 cy/yr would be required in 2040. The City has a yard waste supply of approximately 14,000 cy/yr, so an additional bulking agent supply is necessary.

Additional bulking agents could be supplied through partnerships with Henderson County's Solid Waste Division and other nearby cities such as the City of Asheville. Partnerships with municipal solid waste landfills may also be developed to divert shredded paper and chipped wood debris from landfills. Henderson County currently generates approximately 500 tons of carbon from yard waste each year, per the Director of Engineering for Henderson County. Yard waste density varies from approximately 450 lb/cy to 750 lb/cy. A yard waste density of 500 lb/cy was assumed for this analysis. The yard waste supply from Henderson County equates to approximately 2,000 cy/yr assuming a bulk density of 500 lb/cy. Combined, the total yard waste supply from both the City and the County is approximately 16,000 cy/yr. An additional bulking agent supply would still be needed if all the City's and Henderson County's yard waste is used for biosolids composting. Bulking agent mixing ratios are dependent on the moisture and carbon content of the bulking agent. Enough bulking agent should be added to achieve approximately 40% dry solids in the compost feedstock.

After mixing, the compost volume is assumed to be the same as the bulking agent volume because the sludge will fill voids within the bulking agent during mixing. The composting layout described in **Section 3.1.2** and depicted in **Figure 3.1** can accommodate the 2040 predicted compost volume. At a minimum, the composting area would need to be graded, paved, and have drainage installed to control compost leachate and avoid environmental hazards. However, best practices have shown that a covered composting facility is the best strategy to prevent rainfall and leachate runoff, and a covered composting facility enables the capture and treatment of foul odors. Composting times vary from approximately 21 to 30 d. With the traditional composting method, the windrows would need to be turned at least five times while temperature is maintained at or above 131°F. Odor issues are most likely to occur during the initial stage of composting and during windrow turning, as odors decrease later in the composting and curing period.

Following decomposition, the compost is transferred to the covered storage area for a 30-day curing period. Front end loaders can be used to transport compost onsite. Volume and mass reduction of the compost feedstock will occur throughout the composting process as organic materials decompose and are broken down to carbon dioxide and water. Approximately 20 to 30% of the volatile solids mass in the compost will be broken down through the process, while volume reduction is typically 25 to 50%. Volume reduction of the compost feedstock was conservatively assumed to be 25% for this evaluation. Some of the bulking agent can be recovered using screening before or after curing, which is typically accomplished using a trommel screen. Finished compost size typically ranges from ¼ inch to 1 inch and can be accomplished with shredding and/or screening. The finished compost is then trucked off for land application or distribution and marketing.

Table 3.1 – Traditional Composting Design Criteria

Item	Unit	Year 2021	Year 2040
Sludge Feed to Thickener	(dry ton/d)	2.85	6.25
Sludge Feed to Thickener	(%TS)	0.8%	0.8%
Polymer Feed to Dewatering	(active lb/d)	52	113
Sludge Feed to Dewatering	(dry ton/d)	2.60	5.65
Sludge Feed to Dewatering	(%TS)	3.36%	3.36%
Sludge Feed to Compost	(dry ton/d)	2.50	5.40
Sludge Feed to Compost	(%TS)	17.0%	17.0%
Sludge Feed to Compost	(wet ton/d)	14.7	31.8
Sludge Feed to Compost	(cy/d)	19.0	41.0
Bulking Agent Feed to Compost	(wet ton/d)	14.2	30.7
Bulking Agent Feed to Compost	(cy/d)	56.9	123.0
*Inoculant Feed to Compost	(cy/d)	0.07	0.15
Total Compost Feed	(wet ton/d)	28.9	62.5
Total Compost Feed	(cy/d)	56.9	123.0
Finished Compost	(cy/d)	42.7	92.2
Composting Area Required	(acres)	0.48	1.05

*Note: * is for MSAP composting only.*

3.1.5 Traditional Composting Operations Staff Required

It is estimated that two operators working 30 to 40 hours per week are required to maintain the traditional windrow or MSAP composting system. Each windrow turning day will require approximately eight hours of labor and windrows will need to be turned approximately twice a week. An operator will use a front-end loader to pile received yard waste, mix dewatered sludge and yard waste, turn windrows, transfer compost to the curing area, and load compost trucks for distribution. Additional time will be spent keeping records and performing miscellaneous maintenance and administrative duties.

3.1.6 Traditional Composting Costs

3.1.6.1 *Capital Costs*

Table 3.2 below describes the methodology and assumptions used to determine capital cost estimates for traditional composting. These methods shall remain the same for other alternatives unless otherwise noted. Additional cost estimate information is provided in **APPENDIX A – OPINIONS OF PROBABLE PROJECT AND O&M COSTS**.

Table 3.2 – Capital Cost Estimate Assumptions & Methodology

Item	Description	Assumption	
1	Equipment	-	Equipment Vendor Budget Proposal
	SUBTOTAL A	*= Equipment Budgetary Proposal Cost*	
2	Mechanical Equipment Installation	*20%	of Subtotal A.
3	Electrical Installation Costs	*20%	of Subtotal A.
4	Instrumentation Installation Costs	*10%	of Subtotal A.
5	Structural	-	Calculated for specific alternative.
6	Civil	-	Calculated for specific alternative.
7	Demo	-	Calculated for specific alternative.
8	Mobilization & Demobilization	4%	of Subtotal A + sum of items 2 through 7
	SUBTOTAL B	*= Subtotal A + Sum of items 2 through 8*	
9	Permits	1%	of Subtotal B.
10	Risk & Liability Insurance	1.5%	of Subtotal B.
11	Performance & Payment Bonds	2%	of Subtotal B.
	SUBTOTAL C	*= Subtotal B + sum of items 9 through 11*	
12	General Conditions	6%	of Subtotal C.
13	Contractor's Overhead & Profit	15%	of Subtotal C.
	SUBTOTAL D	*= Subtotal C + sum of items 12 through 13*	
14	Contingency	30%	of Subtotal D.
	OPCC	*= Subtotal D + Item 14*	
15	Engineering, Legal, & Administration	25%	of Subtotal D minus sum of items 9-11
	TOTAL CAPITAL COST	*= OPCC + Item 15*	

*Since rolling stock are the only proposed equipment involved in traditional composting, mechanical, electrical, and instrumentation capital costs are assumed to be zero for this alternative.

The large windrow area will require demolition of existing legacy structures from the original WWTP including the old administration building and sludge pumping building east of the gravity thickeners. The existing sludge storage canopy concrete slab and roof will need to be removed and replaced, and a new concrete storage tank will be needed for storage of WTF residuals. Significant grading work is required for the windrow area to achieve acceptable slopes for an asphalt paved area on which to place and turn the compost. Lastly, a windrow turning machine (such as those manufactured by SCARAB International) must be purchased. Estimated total capital cost for traditional composting is included below in **Table 3.3**.

Table 3.3 – Estimated Traditional Composting Capital Costs

Item	Description	Cost ($)
1	Equipment	$508,000
2	Mechanical	$0
3	Electrical	$0
4	Instrumentation	$0
5	Structural	$1,429,000
6	Civil	$1,572,000
7	Demo	$65,000
8	WTF Residuals PS and Force Main	$5,468,000
9	Mobilization & Demobilization	$362,000
10	Indirect Costs	$424,000
11	General Conditions & Contractor Markup	$2,064,000
12	30% Contingency	$3,568,000
13	Engineering, Legal, & Administration	$2,867,000
	Total Capital Cost	**$18,327,000**

3.1.6.2 *Operation & Maintenance Costs*

Table 3.4 below lists the assumptions used to determine O&M costs for traditional composting. These methods shall remain the same for other alternatives unless otherwise noted. **Table 3.5** and **Table 3.6** show the annual O&M costs for current and future production, respectively.

Table 3.4 – Annual O&M Costs Assumptions

Item	Description	Cost ($)
1	2021 Labor Cost	$25.00 / hour
2	2040 Labor Cost	$45.15/ hour / operator
3	Maintenance Cost	2% of capital equipment cost
4	Natural Gas Cost	$6.21 / mmBTU
5	Electricity Costs	$0.06 / kWh
6	Diesel Fuel Costs	$3.10 / gallon
7	Hauling & Land Application of Class A Biosolids	*$30 / Wet Ton (WT)
8	Cost of Hauling WTF Residuals to WWTP	$7.00 / WT
9	Cost of Pumping WTF Residuals to WWTP	$0.071 / WT

*For traditional composting, hauling and application costs are based on a $/CY cost assuming a density of 55 lb/cf.

Table 3.5 – Traditional Composting – Annual O&M Costs – 2021

Item	Annual Cost
Labor	$104,000
Maintenance	$11,000
Natural Gas	$0
Electricity	$4,000
Equipment Fuel	$26,000
Hauling & Land Application	$404,000
TOTAL	**$549,000**

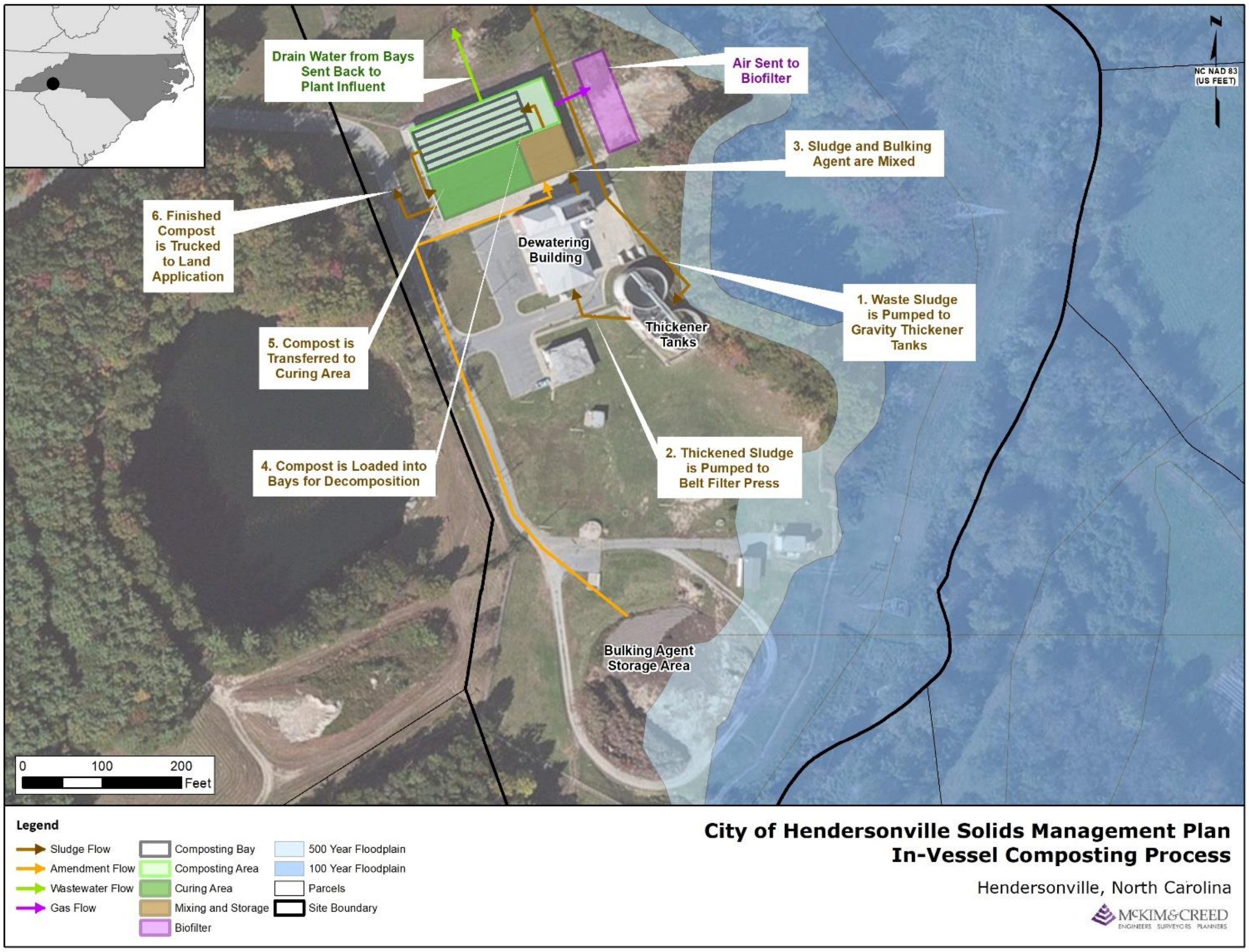
Table 3.6 – Traditional Composting – Annual O&M Costs – 2040

Item	Annual Cost
Labor	$406,000
Maintenance	$11,000
Natural Gas	$0
Electricity	$6,000
Equipment Fuel	$56,000
Hauling & Land Application	$851,000
TOTAL	**$1,330,000**

3.1.7 In-Vessel Composting Process Description

The in-vessel composting process begins with receiving the biosolids and the shredded bulking agent into a common area for mixing by a front-end loader, intended to achieve 35% to 45% solids in the feedstock mixture. The core element of the in-vessel composting system consists of long parallel bays (concrete channels) where the feedstock is loaded after mixing for decomposition. In the bay, composting time will be 21 days (2021 and 2040) while the mixture is aerated from below and turned by the agitator, ensuring a homogenous product. Overhead, odor control ventilation collects foul air and discharges it outside the facility to a biofilter for treatment. The compost is then discharged from the bays via front-end loader and brought to the curing area, where it will cure for 30 days prior to screening and distribution. The in-vessel composting system can be contained within the existing sludge storage canopy structure as shown below in **Figure 3.2**, except for the odor control biofilter which is proposed to be adjacent to the existing storage canopy. For proper odor control, the bay area must be enclosed. The existing canopy structure can be modified by constructing walls of corrosion resistant plastic sheeting along the east-west center column, the northern walls, and providing plastic rollup doors on the east and west ends of the bay area.

Figure 3.2 – In-Vessel Composting Process



3.1.8 In-Vessel Composting Design Criteria

The design criteria for the in-vessel composting alternative are listed in **Table 3.7**. Quantities per day are based on operating days (five days/week). Estimates of the 17% TS WWTF sludge to be composted are 20.4 wet ton/d in 2021 increasing to 44.5 wet ton/d in 2040. Assuming a sludge density of 1,600 lb/cy, estimated sludge volumes of 25.5 cy/d in 2021 and 55.6 cy/d in 2040 are input into the composting system. For the In-Vessel Composting system, the "fresh" bulking agent to sludge ratio is assumed to be 2.0 once composting is fully operational, requiring approximately 13,312 cy/yr of yard waste in 2021 and 28,985 cy/yr in 2040. The "fresh" bulking agent to sludge ratio of 2.0 assumes recycled screened "overs" are also added back into the compost mix to bring the total bulking agent to sludge ratio up to approximately 3.0 prior to placing the compost mix into the bays for composting. Initial start-up of the composting operation will not have any recycled overs, so the initial bulking agent requirements will be higher for the first month. After the first batch of compost is finished and screened overs are recycled, the "fresh" bulking agent requirement will decrease to a ratio of approximately 2.0 bulking agent to sludge. The City has a yard waste supply of approximately 14,000 cy/yr so an additional bulking agent supply may not be necessary initially. However, additional bulking agent will be needed for the future and is recommended to ensure an adequate steady supply. As noted previously in **Section 3.1.4**, additional yard waste may be supplied through agreements with Henderson County's Solid Waste Division and other nearby municipalities. Yard waste density varies from approximately 450 lb/cy to 750 lb/cy. A yard waste density of 600 lb/cy was assumed for this analysis. This density is greater than the density listed for the windrow composting method because the in-vessel composting system can handle finer shredded bulking agents. Finer bulking agents will have a higher density than coarse bulking agents due to less interstitial space between particles. In addition to what is trucked in, bulking agent will be screened during postprocessing and recycled back to the bays at a rate of approximately 4,267 cy/yr in 2021 and 9,290 cy/yr in 2040.

Mixing of the sludge, yard waste and recycled bulking agent that is screened from the cured compost results in an assumed composite density of 1000 lb/cy inside the bays. For the 2021 capacity, retention time inside the five bays is 21 days. Retention will be 21 days inside 10 total bays for 2040 capacity. It should be noted that if the five additional bays are built now, the 2021 retention time could be increased to 30 days or more, effectively curing the compost and eliminating the need for a curing area. Each bay will be agitated three to four times per week to incrementally move the mixture towards the discharge end.

Assuming a 21 day retention time in the bays, the 41 wet tons/d of feedstock mixture input into the bays discharges as 22 wet ton/d of compost, with a volume reduction of 93 cy/d to 56 cy/d (40%) in 2021. In 2040, 89 wet tons/d into the bays discharges as 49 wet ton/d of compost, with a volume reduction of 202 cy/d to 121 cy/d (40%) for the same retention time. The dry solids percentage increases from 39% to 60% during decomposition for both 2021 and 2040. Discharged compost is then transferred to the curing area for 30 days. Bulking agent can be recovered using screening before or after curing, resulting in a remaining 16 wet tons/day or 39 cy/d of finished compost for distribution in 2021, and 34 wet tons/day or 86 cy/d in 2040.

In general, the equipment required for operation of the in-vessel composting system includes a front-end loader, an agitator and its appurtenances, three process air blowers forcing air upwards through the compost in the bays, exhaust fans that maintain a slight negative pressure in the facility to draw foul air up through the ventilation ducts discharging it to the biofilter for odor control, and a trommel screen for screening bulking agent from cured compost. Detailed descriptions of the in-vessel composting process and equipment can be found in **APPENDIX B – COMPOSTING SUPPORTING INFORMATION**.

Table 3.7 – In-Vessel Composting Design Criteria

Item	Unit	Year 2021	Year 2040
Sludge Feed to Thickener	(dry ton/d)	2.86	6.25
Sludge Feed to Thickener	(%TS)	0.8%	0.8%
Polymer Feed to Dewatering	(active lb/d)	52	113
Sludge Feed to Dewatering	(dry ton/d)	2.60	5.65
Sludge Feed to Dewatering	(%TS)	3.36%	3.36%
Sludge Feed to Compost*	(dry ton/d)	3.50	7.56
Sludge Feed to Compost	(%TS)	17.0%	17.0%
Sludge Feed to Compost*	(wet ton/d)	20.6	44.5
Sludge Feed to Compost*	(cy/d)	25.7	55.6
Bulking Agent Feed to Compost*	(wet ton/d)	15.4	33.4
Bulking Agent Feed to Compost*	(cy/d)	51.5	111.2
Total Compost Feed*	(wet ton/d)	40.9	88.5
Total Compost Feed*	(cy/d)	93.6	202.4
Finished Compost for Distribution*	(wet ton/d)	15.9	34.3
Finished Compost for Distribution*	(cy/d)	39.8	85.8

Note: * Quantities per day are based on operating days only (5 days/week)

3.1.9 In-Vessel Composting Operations Staff Required

It is estimated that one operator working 30 to 40 hours per week is required to maintain the in-vessel composting system. It is estimated 20 to 30 hours are spent using a front-end loader to pile received yard waste, mix dewatered sludge and yard waste, charge and discharge the bays, transfer compost to the curing area, and load compost trucks for distribution. The remaining 10 to 20 hours are spent operating the agitator, keeping records, and performing miscellaneous maintenance and administrative duties. The in-vessel composting system described here-in is sized to operate five days/week. As sludge production increases in the future, it is still estimated that only one operator working 30 to 40 hours would be required. However, a higher capacity front-end loader bucket is recommended to speed up mixing and bay loading operations with one operator at 2040 design conditions.

3.1.10 In-Vessel Composting Costs

3.1.10.1 *Capital Costs*

For the in-vessel composting system, removal of the existing canopy structure roof and concrete slab is the only demolition work required. Structural work outside of the typical scope of this system includes the replacement of the existing canopy structure slab and roof, a new concrete push-wall, enclosure of the existing canopy structure, and a new concrete storage tank for the WTF residuals. Site work includes grading for the biofilter to the east of the existing canopy structure. Lastly, a trommel screen is needed to screen the bulking agent from the compost and recycle back into the bays. Estimated total capital cost for in-vessel composting is included below in **Table 3.8**.

Table 3.8 – Estimated In-Vessel Composting Capital Costs

Item	Description	Cost ($)
1	Equipment	$3,275,000
2	Mechanical	$655,000
3	Electrical	$655,000
4	Instrumentation	$328,000
5	Structural	$1,459,000
6	Civil	$3,000
7	Demo	$240,000
8	WTF Residuals PS and Force Main	$5,468,000
9	Mobilization & Demobilization	$484,000
10	Indirect Costs	$567,000
11	General Conditions & Contractor Markup	$2,760,000
12	30% Contingency	$4,769,000
13	Engineering, Legal, & Administration	$3,832,000
	Total Capital Cost	**$24,495,000**

3.1.10.2 *Operation & Maintenance Costs*

Table 3.9 and **Table 3.10** show the annual O&M costs for current and future production, respectively.

Table 3.9 – In-Vessel Composting – Annual O&M Costs – 2021

Item	Annual Cost
Labor	$52,000
Maintenance	$66,000
Natural Gas	$0
Electricity	$35,000
Equipment Fuel	$20,000
Hauling & Land Application	$240,000
TOTAL	**$413,000**

Table 3.10 – In-Vessel Composting – Annual O&M Costs – 2040

Item	Annual Cost
Labor	$203,000
Maintenance	$66,000
Natural Gas	$0
Electricity	$80,000
Equipment Fuel	$42,000
Hauling & Land Application	$489,000
TOTAL	**$880,000**

3.2 Autothermal Thermophilic Aerobic Digestion (ATAD)

3.2.1 Introduction

ATAD is a thermophilic aerobic digestion process that generates biosolids that meet Class A standards. Exothermic microbial oxidation processes achieve thermophilic operating temperatures within insulated tanks without the addition of an external heat source. For the purposes of this evaluation, the second generation ATAD system by Thermal Process Systems was considered. ATAD decreases volatile solids by approximately 55% and has the potential to increase dewaterability. The process requires aeration, foam control, and air scrubbing to control odors. Following ATAD, nitrification and denitrification is accomplished simultaneously under mesophilic conditions within the Storage Nitrification Denitrification Reactor (SNDR™).

Advantages

- Proven Class-A process
- Substantial volume reduction through digestion
- Semi-automated process, and automation can be scaled to be fully automated
- Removal of nitrogen from return stream
- Low O&M costs

Disadvantages

- Less marketable Class A product as dewatered cake
  - Can upgrade dewatering equipment or add thermal dryer to produce drier product, but requires additional capital and O&M cost
- Equipment intensive
- Electricity intensive
- High capital costs
- Sole-source procurement may be required

3.2.2 ATAD Process Description

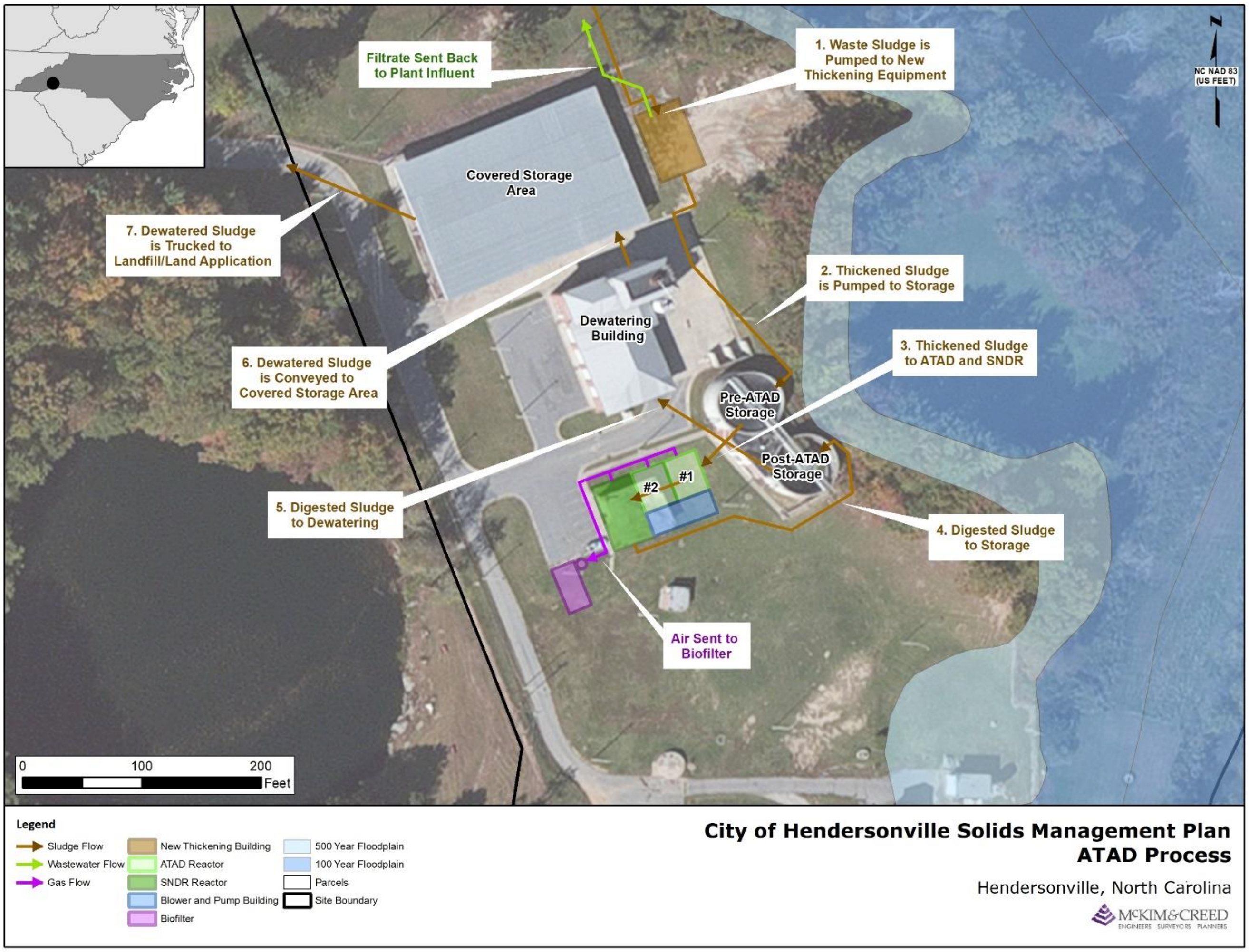
The ATAD alternative was evaluated to stabilize the WWTF sludge to a Class A product and achieve volume reduction through the process as a result of volatile solids destruction. The ATAD process requires new thickening equipment to increase the percent solids of the feed sludge to approximately 5% TS. New thickening equipment is needed because the existing gravity thickeners are not capable of thickening the feed sludge to the recommended solids concentration of 5%. In this alternative, waste sludge is pumped to a new gravity belt thickener (GBT) or rotary drum thickener (RDT) and then stored in a former gravity thickener tank prior to feeding the ATAD system.

Thickened sludge is then fed into one of the two rectangular ATAD tanks in parallel. The sludge is aerated and mixed to facilitate growth of aerobic heterotrophic microorganisms in the sludge. The ATAD tanks are insulated to allow the heat generated from the exothermic microbial oxidation of the volatile solids to raise the sludge temperatures to within the thermophilic range of 130°F to 170°F. The thermophilic operating temperatures of the ATAD process allow it to meet Class A requirements. Both jet aeration and liquid flow rate can be adjusted to provide operational flexibility. Aeration flexibility offers the solids processing operation the ability to meet the high oxygen demands that occur during the feed cycles and initial reaction phases and lower oxygen demands during the later reaction (pathogen destruction portion), of the cycle. This is controlled through oxygen reduction potential (ORP) monitoring. Jet aeration flexibility can also control the reactor's operating temperature throughout the process. The digestion process has three steps; waste, feed, and react. During the waste process, the estimated daily feed volume is released into the SNDR tank. During the feed cycle, feed material is pumped directly into the reactor. The process can be operated manually, semi-automated, or fully automated. The foam layer is controlled using a hydraulic foam control system.

Following ATAD, the biosolids are pumped through a cooling heat exchanger and into the SNDR for mesophilic nitrification and denitrification. Within the SNDR tank, ammonia that is produced in the reactors is nitrified and denitrified through aeration and mixing control. Air from the SNDR headspace is pumped to an odor control system for ammonia scrubbing followed by passing through biofilter media.

Post-ATAD, the biosolids are stored in one of the former gravity thickener tanks prior to dewatering. Biosolids are sent to the existing dewatering equipment and then conveyed to the covered storage area. Finally, the biosolids are trucked to landfill, land application, or distribution. The ATAD process is depicted in **Figure 3.3**.

Figure 3.3 – ATAD Process



3.2.3 Design Criteria

The design criteria for the ATAD alternative are listed in **Table 3.11**. The ATAD system requires a minimum of 3% TS but can process up to 7% TS. The ATAD system is designed for an average monthly TS of 5%. Aeration is sized based on a seven days per week loading schedule. The estimated amount of sludge that would be thickened by the GBT or RDT in 2021 is 2.86 dry ton/d, and by 2040 it would increase to approximately 6.25 dry ton/d. The new thickener equipment concentrates the sludge from 0.8% TS to 5% TS. After thickening, the sludge is then pumped to one of the existing gravity thickeners for storage prior to feeding the ATAD system.

Thickened sludge is fed into one of the two rectangular ATAD tanks in parallel (35 ft x 28 ft x 24 ft deep). The hydraulic retention time (HRT) for the ATAD tanks is approximately 12 days. The ATAD cycle begins by wasting the estimated daily feed volume (approximately 1/12 of the total tank volume) from the ATAD reactors to the SNDR just prior to the scheduled feeding. The feeding volume is then added to the tank. The two tanks have alternative feeding schedules leaving the second tank in isolation to meet time and temperature requirements for Class A Biosolids. During the ATAD process approximately 55% VS destruction occurs, and the TS decreases from 5% to an estimated 2.8%. The estimated amount of sludge digested in the ATAD is 2.72 dry ton/d in 2021 and 5.94 dry ton/d in 2040. Temperatures within the ATAD tanks are maintained at approximately 145°F.

Following ATAD, the biosolids are pumped into the SNDR tank for mesophilic nitrification and denitrification. The SNDR tank is 56 ft x 35 ft x 24 ft deep. Approximately 1.52 dry ton/d is fed into the SNDR in 2021 and 3.33 dry ton/d would be fed in 2040. Approximately 15% volatile solids destruction occurs during the SNDR process, reducing the sludge TS from approximately 2.8% to 2.5%. The SNDR is operated with a 12-day HRT below 95°F to facilitate mesophilic nitrification and denitrification.

After SNDR, the digested sludge is then pumped to one of the existing gravity thickener thanks for storage prior to dewatering. Biosolids are sent to the existing BFP to dewater to approximately 24% TS. The digested sludge is expected to dewater more efficiently than the undigested sludge because the digestion process releases some of the intercellular and chemically bound water in the sludge as cells are lysed and the high temperatures within the ATAD denature exopolymeric substances (EPS). Dewatering capability will still be highly dependent on effective polymer dosing and belt pressure, but greater dewatering capability is expected. Approximately 5.45 wet ton/d of Class A Biosolids would be generated in 2021 and 11.90 wet ton/d in 2040.

Odorous air from the headspace of the ATAD and SNDR tanks goes through a two-stage odor control system. The headspace of each reactor is connected by odor control piping such that the ATAD reactor headspace air flows through the SNDR reactor, and then to the odor control system. Initially, headspace air from the ATAD reactors is directed to the headspace of the SNDR reactor where cooling and ammonia scrubbing occurs. Approximately 70 to 80% of the ammonia gas will be removed within the SNDR reactor prior to reaching the odor control system. The odor control system consists of a wet scrubber to further remove ammonia followed by a biofilter to remove remaining ammonia and odorous organic compounds. Ammonia off-gas concentrations to the SNDR reactor range from 500 ppm to 1,500 ppm and are typically 1,200 ppm, while the ammonia concentration to the biofilter is less than 100 ppm. The biofiltration unit is packed with media to sustain a fixed-film mesophilic aerobic biological process and has a 60 second empty bed contact time. The odor control system is designed to remove a minimum of 95% of the influent constituents.

Detailed descriptions of the ATAD stabilization process and equipment can be found in **APPENDIX C – ATAD SUPPORTING INFORMATION**.

Table 3.11 – ATAD Design Criteria

Item	Unit*	Year 2021	Year 2040
Polymer Feed to Thickener	(active lb/d)	43	94
Sludge Feed to Thickener	(dry ton/d)	2.86	6.25
Sludge Feed to Thickener	(%TS)	0.8%	0.8%
Sludge Feed to ATAD	(dry ton/d)	2.72	5.94
Sludge Feed to ATAD	(%TS)	5.0%	5.0%
Sludge Feed to ATAD	(wet ton/d)	54	119
Sludge Feed to SNDR	(dry ton/d)	1.52	3.33
Sludge Feed to SNDR	(%TS)	2.8%	2.8%
Sludge Feed to SNDR	(wet ton/d)	54	119
Polymer Feed to Dewatering	(active lb/d)	28	60
Sludge Feed to Dewatering	(dry ton/d)	1.38	3.01
Sludge Feed to Dewatering	(%TS)	2.53%	2.53%
Sludge Feed to Dewatering	(wet ton/d)	54	119
Finished Biosolid Product	(dry ton/d)	1.31	2.86
Finished Biosolid Product	(%TS)	24%	24%
Finished Biosolid Product	(wet ton/d)	5.45	11.90

3.2.4 Operations Staff Required

It is estimated that one operator working approximately 10 hours per week is required to maintain the ATAD system. The ATAD system is semi-automated which requires minimal operator presence after start-up and once typical operating parameters are established. Most of the operator attention required for the ATAD system could be monitored from the WWTF Administration Building. Most of the operations staff time will be spent monitoring the thickening and dewatering processes as a result. The ATAD digestor will require approximately 30 minutes per day to operate. Additional time will be spent on maintenance, record keeping, thickening, and dewatering.

3.2.5 ATAD Costs

3.2.5.1 *Capital Costs*

The ATAD process area requires demolition of the old administration building adjacent to the dewatering building. Grading work is required for the ATAD process area to achieve acceptable slopes. Concrete ATAD & SNDR reactor tanks, a new pump station, new thickeners and thickener building, and a new concrete WTF residuals storage tank will be needed. The ATAD and SNDR process tanks are assumed to be rectangular tanks with common wall construction for cost savings. The WTF residuals storage tank is assumed to be circular with a conical bottom. Estimated total capital cost for the ATAD alternative is included below in **Table 3.12**.

Table 3.12 – Estimated ATAD Capital Costs

Item	Description	Cost ($)
1	Equipment	$3,712,000
2	Mechanical	$743,000
3	Electrical	$743,000
4	Instrumentation	$372,000
5	Structural	$1,922,000
6	Civil	$136,000
7	Demo	$65,000
8	WTF Residuals PS and Force Main	$5,468,000
9	Mobilization & Demobilization	$527,000
10	Indirect Costs	$617,000
11	General Conditions & Contractor Markup	$3,005,000
12	30% Contingency	$5,193,000
13	Engineering, Legal, & Administration	$4,174,000
	Total Capital Cost	**$26,677,000**

3.2.5.2 *Operation & Maintenance Costs*

Table 3.13 and **Table 3.14** show the annual O&M costs for current and future production, respectively.

Table 3.13 – ATAD – Annual O&M Costs – 2021

Item	Annual Cost
Labor	$13,000
Maintenance	$75,000
Natural Gas	$0
Electricity	$48,000
Equipment Fuel	$0
Hauling & Land Application	$126,000
TOTAL	**$262,000**

Table 3.14 – ATAD – Annual O&M Costs – 2040

Item	Annual Cost
Labor	$24,000
Maintenance	$75,000
Natural Gas	$0
Electricity	$97,000
Equipment Fuel	$0
Hauling & Land Application	$244,000
TOTAL	**$440,000**

3.3 Thermal Drying

3.3.1 Introduction

Thermal drying is used by many municipalities to produce Class A biosolids and achieve maximum volume and weight reduction. The most widely known example of effective biosolids thermal drying is with the Milwaukee Metropolitan Sewerage District (MMSD), which uses thermal drying to produce and market their biosolids as the Milorganite® fertilizer since the 1920s. Thermal drying of biosolids has rapidly gained popularity since the 1980's. Per the WEF Manual of Practice No. 8, as of 2016 there were more than 105 thermal drying facilities in the US, and more than 375 worldwide. Thermal drying consists of using direct or indirect heat from a thermal dryer to evaporate water from dewatered sludge to reduce volume and weight, destroy pathogens, and produce a Class A biosolids product with little or no restrictions on its end use. There are two main types of thermal dryers for biosolids drying, direct and indirect dryers. Direct drying systems use convection where the biosolids are contacted directly by the heat transfer medium, such as heated air or gases. These include rotary drum dryers, fluidized-bed dryers, and belt dryers. Indirect drying systems use conduction, where a solid wall separates the biosolids from the heat transfer medium which is typically thermal oil, steam, or another hot fluid. These include paddle dryers, screw-dryers, and other similar technologies.

Energy requirements for thermal drying systems are tied to the moisture content of the solids to be dried and therefore are similar across technologies. However, the overall size and footprint of a thermal drying system is directly related to the drying temperature. Systems with higher drying temperatures have a smaller footprint.

Both types of dryers, direct and indirect, have their benefits and drawbacks that need to be considered along with the intended end use of the biosolids product prior to selecting a dryer technology. Direct dryer technologies typically produce uniform pellets without any special processing that are easily spread as fertilizer or as a soil amendment, making the product highly marketable. Indirect dryers typically produce a non-uniform dried sludge product that is usually dustier than a direct dryer product. The product tends to be less marketable as an agricultural product without additional processing to improve uniformity and simplify application. Direct dryers are at a greater risk for fire and explosion due to dust produced during the drying process, which is in direct contact with the heated air or other gases. However, the fire and explosion risk are mostly associated with direct dryers in the high temperature range. Most direct belt dryers on the market today operate in the medium temperature range (175 to 265°F) and include various protective measures and devices to prevent fire and explosion hazards. Indirect dryers have a lower risk of fire and explosion than direct dryers because of the separation of the heat transfer medium from the dried biosolids. The design of all thermal dryer facilities should include appropriate protective measures to reduce fire and explosion hazards associated with the dryer and with product storage. In general, dried biosolids should be allowed to cool to a minimum of 40°C (104°F) prior to storage, and storage systems should consider carbon monoxide monitoring (a sign of ignition) and nitrogen blanketing. Product cooling from medium temperature dryers can typically be accomplished at the exit of the thermal dryer and in the transport of the product to storage.

Dryer systems considered during this evaluation include the BCR Bio-Scru indirect screw dryer, Veolia/Kruger BioCon belt dryer, Suez Evaporis belt dryer, and the Gryphon Environmental belt dryer. A direct medium temperature belt dryer was considered for the purpose of this report due to comparative cost, compatibility with existing processes and facilities, operational requirements, and expected beneficial reuse of the end product. However, if determined to be the preferred alternative, final selection of a specific dryer technology should be further evaluated during the detailed design phase based on the composition of the sludge to be dried and the actual end use of the product. Budgetary proposals from each of the thermal dryer manufacturers are provided in **APPENDIX D – THERMAL DRYING SUPPORTING INFORMATION**.

Advantages

- Highly marketable Class A product
- Proven and reliable process
- Maximum volume and weight reduction
- Dried product typically uniform in size and shape
- Dried product easily land applied

Disadvantages

- Relatively high capital costs
- High fuel requirements
- May produce a dusty product
- Potential fire and/or explosion hazard with confined storage of dried product
- Unknown reliability for thermal drying of WTF residuals

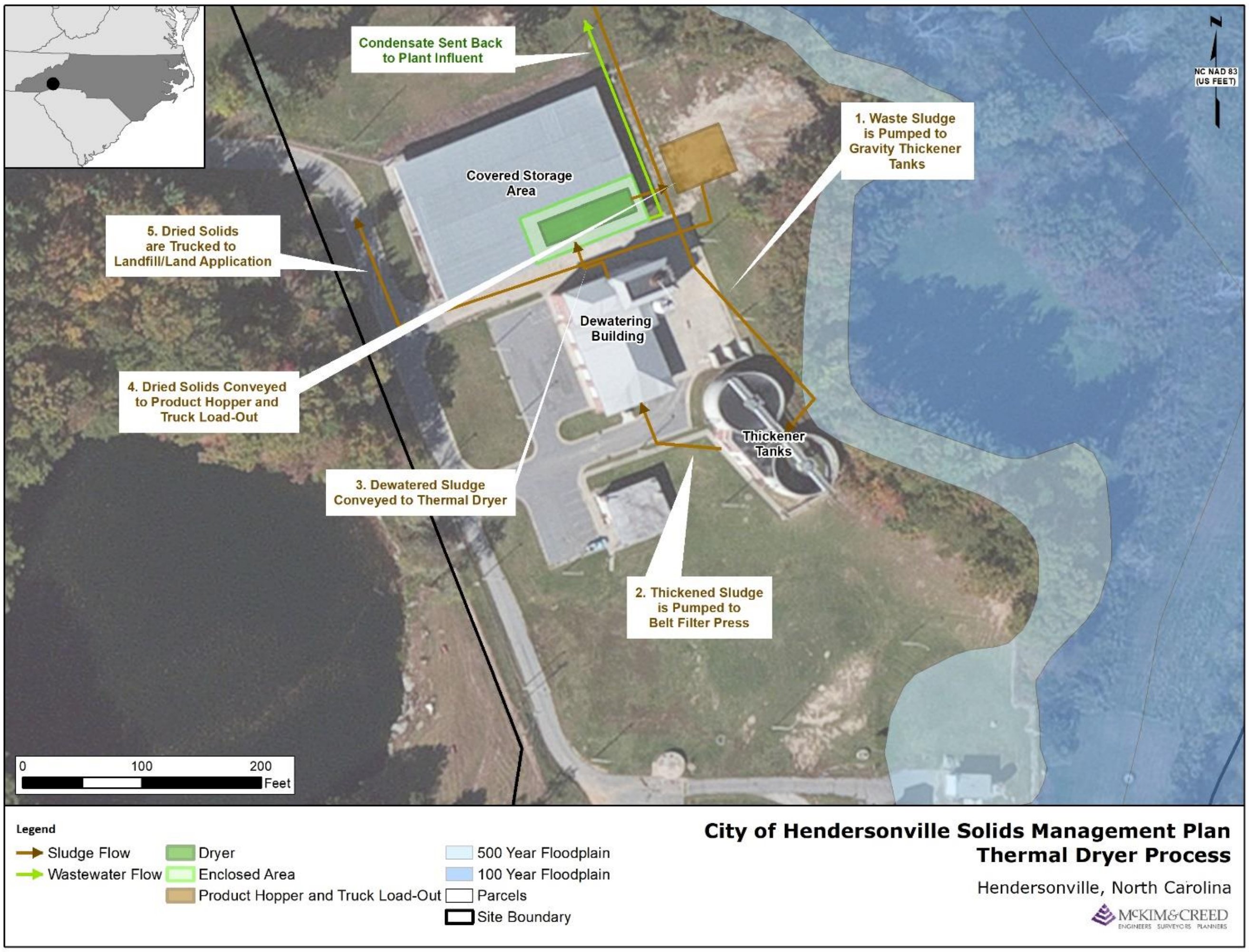
3.3.2 Thermal Drying Process Description

This alternative was developed for the thermal drying of WWTF sludge and WTF residuals at the WWTF. With this alternative, WWTF sludge and WTF residuals can be either mixed and dewatered using the existing belt filter press, or dewatered separately and dried in separate batches by the thermal dryer. After dewatering, solids conveyors will direct the dewatered solids to a live-bottom hopper with a minimum storage capacity equal to the thermal dryer's 24 hour throughput, and feed screws/conveyor to the thermal dryer. The storage hopper between dewatering and the thermal dryer provides flexibility in the dewatering and thermal drying operating schedules and allows for continuous 24 hour operation of the dryer.

The belt dryer consists of an enclosure that houses a wide belt conveyor with the belt made of a porous material that allows air to penetrate the belt, but does not allow sludge to pass through the small openings. Dewatered sludge is fed to one end of the belt dryer where an extruder, paddle, screw, or other device evenly distributes the sludge into a thin layer across the width of the belt. Within the belt enclosure, hot air from a burner or heat exchanger is blown into the enclosure surrounding the belt, creating an environment that promotes the evaporation of water within the dewatered sludge. As the belt moves, the sludge is continually dried until it reaches at least 90% TS. The dried solids are then conveyed to a product hopper or storage silo and subsequently trucked off for disposal or packaged for distribution. The belt dryers considered have automatic wash systems that use plant effluent to remove dust from the belt, dryer chamber, and clean the condenser filter. Washes are performed intermittently and send approximately 100 GPD back to the plant influent.

In general, equipment required for operation of the thermal drying system includes the belt dryer, a feed system such as a sifter or extruder, a condenser, blowers, and a burner or heat exchanger. Ancillary equipment includes conveying systems, a live-bottom storage hopper upstream of the dryer, storage hopper/silo downstream of the dryer, and a truck loadout station. Additionally, this alternative will require the enclosure of the southeast quadrant of the existing sludge storage canopy structure to protect the thermal dryer and associated equipment from harsh environmental conditions.

Figure 3.4 – Thermal Dryer Process



3.3.3 Design Criteria

The design criteria for the Thermal Drying alternative are listed in **Table 3.15**, below. Currently the WWTF sludge is dewatered to 17% TS by the existing belt filter press and WTF residuals are dewatered to approximately 15% TS, each exceeding the minimum 12% TS required for feed to the belt dryer. As mentioned previously, it is recommended to pilot test the dewatering of WTF residuals using the existing belt filter presses at the WWTF to determine expected solids concentrations, feed rates, and polymer requirements. The dryer run times are assumed to be approximately three days a week at 24 hours per day in 2021, increasing to five days a week at 24 hours per day in 2040.

Table 3.15 – Thermal Dryer Design Criteria

Item	Unit	WTF		WWTF		Total	
Year		2021	2040	2021	2040	2021	2040
Solids Feed to Thickener	dry ton/d	1.25	2.15	2.86	6.25	4.11	8.40
Solids Feed to Thickener	%TS	1.0%	1.0%	0.8%	0.8%	0.86%	0.85%
Polymer Feed to Dewatering	active lb/d	14	24	52	113	66	137
Solids Feed to Thermal Dryer	dry ton/d	0.90	1.55	2.50	5.40	3.40	6.95
Solids Feed to Thermal Dryer	%TS	15%	15%	17%	17%	16.47%	16.55%
Solids Feed to Thermal Dryer	wet ton/d	6.0	10.3	14.7	31.8	20.7	42.1
Dried Solids Output	wet ton/d	1.00	1.72	2.78	6.00	3.78	7.72
Dried Solids Output	%TS	90%	90%	90%	90%	90%	90%
Thermal Dryer Evaporative Capacity	lb H_2O/hr	-	-	-	-	3,780	3,780
Thermal Dryer Efficiency	Btu/lb H_2O	-	-	-	-	1,098	1,098
Dryer Evaporation Heat Requirement	MMBtu/hr	-	-	-	-	4.15	4.15
Thermal Dryer Operating Days per Year	days/yr	40.2	69.3	96.0	207.3	136.2	276.6

3.3.4 Operations Staff Required

For the 2021 operation schedule proposed, it is estimated that one operator working three days a week at 12 hours a day is required to oversee the dewatering operations and observe operation of the thermal drying system. The thermal drying system is highly automated, eliminating the need for extended on-site presence, enabling one operator to operate both the dryer and the belt filter press simultaneously. Operation would increase up to five days week for 12 hours a day in 2040. Operation and maintenance of thermal dryers will require more technical training than that required for other alternatives. A 30-minute daily inspection of the dryer system is recommended. It is recommended that the dryer be operated 24 hours per day when possible to reduce excessive fuel consumption and mechanical wear from repeated warm-up and cool-down periods. For continuous operation year-round, belt dryers typically require 5-10% of down time for maintenance and part replacement. Additional operation involved with the truck load-out station will be dependent on the amount of dried solids storage that is selected.

3.3.5 Thermal Drying Costs

3.3.5.1 *Capital Costs*

Demolition work required for the thermal drying system is expected to include removal of the entire existing canopy structure roof for replacement, and removal of the existing concrete slab in the quadrant of the canopy structure that will be enclosed for the thermal drying system. Structural work outside of the typical scope of this system includes the replacement of the existing canopy structure slab and roof, enclosure of the existing canopy structure as shown in Figure 3.4, a new truck load-out station, and a new concrete storage tank needed for the WTF residuals pumped to the WWTF. Site work includes grading for the truck load-out station to the east of the existing canopy structure. Estimated total capital cost for the thermal dryer alternative is included below in **Table 3.16**.

Table 3.16 – Estimated Thermal Dryer Capital Costs

Item	Description	Cost ($)
1	Equipment	$3,762,000
2	Mechanical	$753,000
3	Electrical	$753,000
4	Instrumentation	$377,000
5	Structural	$640,000
6	Civil	$3,000
7	Demo	$240,000
8	WTF Residuals PS and Force Main	$5,468,000
9	Mobilization & Demobilization	$480,000
10	Indirect Costs	$563,000
11	General Conditions & Contractor Markup	$2,739,000
12	30% Contingency	$4,734,000
13	Engineering, Legal, & Administration	$3,804,000
	Total Capital Cost	**$24,316,000**

3.3.5.2 *Operation & Maintenance Costs*

Table 3.17 and **Table 3.18** show the annual O&M costs for current and future production, respectively.

Table 3.17 – Thermal Dryer – Annual O&M Costs – 2021

Item	Annual Cost
Labor	$32,000
Maintenance	$76,000
Natural Gas	$87,000
Electricity	$30,000
Equipment Fuel	$0
Hauling & Land Application	$42,000
TOTAL	**$267,000**

Table 3.18 – Thermal Dryer – Annual O&M Costs – 2040

Item	Annual Cost
Labor	$94,000
Maintenance	$76,000
Natural Gas	$174,000
Electricity	$60,000
Equipment Fuel	$0
Hauling & Land Application	$85,000
TOTAL	**$489,000**

3.4 Thermal Drying + Third-Party Residuals Management

3.4.1 Introduction

After completing the evaluation of the previously described alternatives, a final alternative was developed to evaluate contracted third-party residuals management as a less capital cost intensive alternative. This alternative investigated the feasibility for a third-party residuals management firm to provide dewatering, hauling, and disposal of water and wastewater treatment residuals under a multi-year contract. Third-party residuals management firms typically will develop disposal markets for residuals and perform all permitting duties required for disposal. This alternative shifts the majority of disposal responsibility to the third-party contractor; however the City would still retain responsibility for the quality of the product and any adverse impacts it may have on the end use if quality requirements are not met. Third-party residuals management as a residuals disposal outlet is described in more detail in **Section 4.4**.

A primary goal of this alternative was to provide beneficial reuse pathways for water and wastewater treatment residuals at a reduced capital cost to ease immediate demands on the City's Water and Sewer capital budgets. The third-party residuals management firm Synagro was contacted to discuss and provide feedback on the feasibility of dewatering, hauling, and disposal services for both water and wastewater treatment residuals. The feasibility of providing contracted services for WWTF sludge stabilization (treatment to Class B biosolids, minimum), hauling, and disposal was discussed, but it was determined that it would not be cost effective. Contracted services for biosolids stabilization are not common, because they typically require the construction of new stabilization facilities on-site at the treatment facility to produce biosolids meeting Class B requirements (at a minimum) prior to disposal. Most municipalities employing third-party residuals management firms for the disposal of biosolids already own and operate stabilization processes to allow the contractor to simply haul off and land apply or compost the treated biosolids. As noted previously, the City currently does not utilize a biosolids stabilization process, as the existing lime stabilization process was abandoned, and sludge is currently landfilled instead of land applied.

Contracting with a third-party residuals management firm to provide a WWTF sludge stabilization process would likely require the City to enter into a design-build-operate (DBO) contract. This would allow for the construction and operation of a new biosolids stabilization facility on-site to produce a Class B biosolids product prior to dewatering and land application. Under a DBO contract, the City would pay for the construction and operation of the new facility. The third-party contractor would construct and operate the stabilization facility under the DBO contract for a specified term. This method to provide contracted WWTF sludge stabilization would still require a significant capital investment, similar to the alternatives described in previous sections. The capital cost required to construct a new stabilization process does not meet the intent of this alternative to provide a less capital cost intensive option, therefore contracted services were not considered at the WWTF.

Based on the discussions with the City and Synagro, a hybrid approach was developed consisting of:

1) Production of Class A biosolids from the WWTF sludge using thermal drying, as described in **Section 3.3**

2) Separate beneficial reuse of WTF residuals through contracted dewatering, hauling, and land application disposal.

Advantages

- Reduced capital cost, WTF residuals dewatering and disposal provided through contracted services

- Reduced operating burden for WTF staff

- Maximized marketability of dried biosolids product, which are assumed to be self-marketed by the City
- Land application of WTF residuals not subject to EPA Part 503 Rule for biosolids
- Land application of WTF residuals provides beneficial reuse

Disadvantages

- High long term O&M costs due to contracted services for WTF residuals
- Risk of variable long term costs related to contracted services for WTF residuals
- Reliance on a single service provider for WTF residuals disposal and the associated risk of failure to meet contract requirements

3.4.2 Process Description

As stated above, this alternative consists of thermal drying for the WWTF sludge and contracted dewatering, hauling, and disposal services for the WTF residuals.

3.4.2.1 *WWTF Process Description*

The thermal drying process at the WWTF is as described in **Section 3.3.2**, and consists of the following:

- WAS thickening using the existing gravity thickeners
- Dewatering of thickened WAS using the existing belt filter presses
- Transfer of dewatered sludge to a thermal dryer feed hopper by a conveyor system
- Thermal drying using a medium temperature belt dryer
- Transfer of dried biosolids to a product storage silo or hopper and associated truck load-out station
- Marketing and disposal of dried biosolids managed by the City, separately from the WTF residuals

The thermal drying facility under this alternative will only process WWTF sludge, so new process equipment required may be downsized to handle only the WWTF sludge quantities expected. As a result, the capital cost for the thermal drying facility under this alternative may be slightly reduced.

3.4.2.2 *WTF Process Description*

Contracted services through a third-party residuals management firm for the management of WTF residuals under this alternative will include contracted dewatering on-site, storage of dewatered residuals on-site in a new covered residuals storage shelter, contracted hauling of dewatered residuals from the WTF, and contracted disposal services, primarily consisting of land application as a soil conditioning agent.

Contracted dewatering at the WTF is considered to replace the existing aging dewatering equipment at the WTF in lieu of a more expensive capital improvement project to replace the existing dewatering building and associated equipment. Contracted dewatering would require mobilization of a dewatering belt filter press or centrifuge to the existing dewatering building at the WTF. The contractor-owned dewatering belt filter press would replace the existing dewatering centrifuge owned and operated by the City, which is experiencing symptoms of advanced equipment age. The proposed dewatering belt filter press would be staged inside the truck loading bay of the existing dewatering building to allow it to be mobilized and demobilized as needed. It is expected that the dewatering belt filter press would remain at the WTF for the duration of the third-party contract.

To support contracted dewatering, hauling, and disposal services, the City would provide connections to existing piping and infrastructure, power supply (480 V, 3 phase, 100 A minimum), wash water supply (approx. 100 gpm at 60 psi minimum), dewatering polymer, filtrate discharge capacity (estimated at 200 gpm), a dedicated truck to received dewatered residuals, a front end loader or other equipment required to move dewatered cake to storage or load trucks for haul-off, and a covered storage shelter capable of storing a minimum of three months of dewatered residuals production.

The City's WTF does not currently have a means for automatic sludge withdrawal from the facility's sedimentation basins. As a result, facility staff must take the basins down for cleaning once each basin fills up with settled solids. Basin cleaning is currently performed on a rotating basis with each cleaning event occurring approximately once every two months. Therefore, sludge loading to the existing gravity thickeners and the proposed contracted dewatering system will also be cyclical. City staff currently dewaters thickened residuals continuously for a period of approximately two months at a time, followed by approximately two months off when no residuals are dewatered. The contracted dewatering services are expected to be performed on a similar schedule to support the current operations of the facility. This operational schedule is not expected to change unless the City decides to implement a means to allow automated sludge withdrawal from the sedimentation basins.

It should be noted that automated sludge withdrawal will allow more consistent dewatering operations throughout the year, which in turn may result in some cost savings from the contracted dewatering services. This is because continuous dewatering operations throughout the year would allow the contractor to provide a full-time employee on-site all year, reducing the staffing associated with part-time, seasonal operations. It would also eliminate standby charges that are incurred due to on-site contracted equipment sitting idle for extended periods.

Dewatered residuals cake will be stored on-site in a new covered storage shelter. The new covered dewatered cake storage shelter is proposed to be sized to store up to three months of dewatered cake, plus a safety factor to account for extended storage periods due to inclement weather conditions. The new shelter is proposed to be constructed adjacent to the existing dewatering building in the existing laydown yard. The new shelter is expected to consist of a pre-engineered metal building with a concrete slab-on-grade floor with appropriate drainage, with a concrete push wall along three sides of the perimeter. It is assumed that dewatered cake would be hauled off from the site approximately four times each year on average.

During each work event to haul dewatered residuals cake off-site for disposal, it is assumed that City staff will assist the contractor by loading their trucks at the dewatered cake storage shelter using the City's front end loader.

3.4.3 Design Criteria

The design criteria for the Thermal Drying + Third-Party Residuals Management alternative are provided below in **Table 3.19** and **Table 3.20** for the WWTF and WTF, respectively. The design criteria listed for the WWTF matches the previously reported design criteria for the Thermal Drying alternative, except no WTF residuals would be processed through the thermal dryer under this alternative. Design criteria provided below for the WTF are based on preliminary proposals received for the contracted services described above, and sizing for the dewatered cake storage shelter based on the estimated residuals production rates.

Table 3.19 – WWTF Thermal Dryer Design Criteria (only WWTF sludge)

Item	Unit	Year 2021	Year 2040
Solids Feed to Thickener	dry ton/d	2.86	6.25
Solids Feed to Thickener	%TS	0.8%	0.8%
Polymer Feed to Dewatering	dry lb/d	52	113
Solids Feed to Thermal Dryer	dry ton/d	2.50	5.40
Solids Feed to Thermal Dryer	%TS	17%	17%
Solids Feed to Thermal Dryer	wet ton/d	14.7	31.8
Dried Solids Output	wet ton/d	2.78	6.00
Dried Solids Output	%TS	90%	90%
Thermal Dryer Evaporative Capacity	lb H_2O/hr	3,080	3,080
Thermal Dryer Efficiency	Btu/lb H_2O	1,101	1,101
Dryer Evaporation Heat Requirement	MMBtu/hr	3.39	3.39
Thermal Dryer Operating Days per Year	days/yr	120.1	259.5

Table 3.20 – Third-Party WTF Residuals Dewatering and Disposal Design Criteria (only WTF residuals)

Item	Unit	Year 2021	Year 2040
Annual Dewatered Residuals Production	wet tons/yr	2,200	3,800
Dewatering feed rate	gal/min	35 - 50	30 - 40
Operating Shift Duration	hours/day	6 - 8	6 - 8
Operating Days per Week	days/week	5	5
Dewatering Weeks per Year	weeks/year	26	52
Dewatering Belt Filter Press Size	meters	1.0	1.0
Water Supply Requirements (Wash Water and Polymer Make-up)	gal/min @ 60 PSI	100	100
Filtrate Discharge Capacity	gal/min	200	200
Dewatered Cake Storage Duration, Minimum	days	90	90
Dewatered Cake Storage Capacity, Minimum	yd^3	650	1,200
Assumed Dewatered Cake Stockpile Height	ft	3	3
Dewatered Cake Storage Shelter Area Required	ft^2	7,500	15,000
Proposed Dewatered Cake Storage Shelter Length	ft	150	150
Proposed Dewatered Cake Storage Shelter Width	ft	100	100
Disposal Work Events per Year	-	4	4
Disposal Work Event Duration	days/event	7	7
Average Dewatered Cake Disposal per Work Event	yd^3/event	650	1,200

Sizing for the dewatered cake storage shelter listed above was based on a dewatered cake stockpile height of 3 feet based on McKim & Creed's observations of current practices at the WWTF covered storage shelter. Area requirements for the new dewatered cake storage shelter at the WTF also included a minimum buffer area of 10 feet around the perimeter of the dewatered cake stockpile area to ensure sufficient room is provided for equipment movement and additional storage volume if needed. The dewatered cake storage shelter is recommended to include concrete push walls around three sides of the perimeter to allow cake stockpiles to be stacked against the shelter walls, and to provide structural walls for loading equipment to push up against during loading operations for disposal. As seen above, a 150 ft long by 100 ft wide storage shelter is recommended. This size will accommodate both 2021 and 2040 storage requirements, is expected to fit within the existing land area available adjacent to the existing dewatering building, and will provide additional storage capacity for extended storage durations beyond 90 days for the full 20 years of use described above.

3.4.4 Operations Staff Required

Operations staff requirements for the thermal drying process at the WWTF are assumed to be equivalent to those described previously for the full Thermal Drying alternative described in **Section 3.3**. Operations staff requirements for the contracted dewatering, hauling, and disposal services for the WTF residuals will primarily be provided by the third-party residuals management firm selected to perform the work. The City's operations staff at the WTF will only be required to transfer dewatered residuals cake to the new storage shelter each time the City's dump truck is full, and assist in loading stored, dewatered cake into the contractor's trucks for haul-off and disposal during each disposal work event. These tasks at the WTF are not expected to require any additional staff, and therefore are not included in the operation and maintenance cost estimates shown below.

3.4.5 Thermal Drying + Third-Party Residuals Management Costs

3.4.5.1 *Capital Costs*

Capital costs for the Thermal Drying + Third-Party Residuals Management alternative are significantly lower than the Thermal Drying alternative described in **Section 3.3** because the thermal drying facility equipment may be downsized for only biosolids, and the WTF residuals pump station and force main will not be required. The only capital costs at the WTF for this alternative will be site-civil work to perform minor grading for a new covered residuals storage shelter as well as materials and construction costs for the storage shelter and ancillary services.

Table 3.21 – Estimated Thermal Dryer + Third-Party Residuals Management Capital Costs

Item	Description	Cost ($)
1	Equipment	$3,084,000
2	Mechanical	$617,000
3	Electrical	$617,000
4	Instrumentation	$309,000
5	Structural	$1,281,000
6	Civil	$31,000
7	Demo	$240,000
8	Mobilization & Demobilization	$248,000
9	Indirect Costs	$291,000
10	General Conditions & Contractor Markup	$1,412,000
11	30% Contingency	$2,439,000
12	Engineering, Legal, & Administration	$1,960,000
	Total Capital Cost	**$12,529,000**

3.4.5.2 *Operation & Maintenance Costs*

Table 3.22 and **Table 3.23** show the annual O&M costs for current and future production, respectively. Annual natural gas and electricity usage for the thermal drying facility at the WWTF are lower under this alternative due to the reduced processing rates with biosolids alone. However, labor costs for the thermal drying facility are assumed to be equivalent to the previous alternative since operator oversight requirements are expected to be very similar despite the reduced production rates. Downsizing of the thermal drying equipment reduces capital costs, however, the reduced equipment size results in very similar operating schedules to the other thermal drying alternative, just at lower production rates. Cost estimates for contracted services shown in the tables below are based on preliminary proposals received from Synagro for these services. The quotes received are included in **APPENDIX E – THIRD-PARTY RESIDUALS MANAGEMENT SUPPORTING INFORMATION**. Future estimates for contracted dewatering and disposal services were based on the preliminary quotes received and were adjusted for increased residuals product and inflation at a rate of 4%. This was done by determining a $/wet ton value for the current term, applying the inflation rate to the $/wet ton value, and then calculating the future term service cost based on estimated residuals production and the updated $/wet ton value.

Table 3.22 – Thermal Dryer + Third-Party Residuals Management – Annual O&M Costs – 2021

Item	Annual Cost
Labor	$32,000
Maintenance	$62,000
Natural Gas	$63,000
Electricity	$19,000
Equipment Fuel	$0
Hauling & Land Application for Biosolids	$31,000
Contracted Dewatering for WTF Residuals	$162,000
Contracted Hauling & Disposal for WTF Residuals	$109,000
TOTAL	**$478,000**

Table 3.23 – Thermal Dryer + Third-Party Residuals Management – Annual O&M Costs - 2040

Item	Annual Cost
Labor	$94,000
Maintenance	$62,000
Natural Gas	$137,000
Electricity	$41,000
Equipment Fuel	$0
Hauling & Land Application for Biosolids	$66,000
Contracted Dewatering for WTF Residuals	$612,000
Contracted Hauling & Disposal for WTF Residuals	$412,000
TOTAL	**$1,424,000**

4. RESIDUALS DISPOSAL OUTLETS

Disposal outlets for the City's Class A biosolids and residuals were investigated to identify feasible outlets based on the solids management strategies evaluated herein. Class A biosolids are generally highly marketable and have a wide array of potential disposal outlets. However, disposal outlets for Class A biosolids and residuals is dependent on the solids management strategy selected because of the differing characteristics of each end product. Disposal of the biosolids and residuals is regulated under a permit issued by NCDEQ's Division of Water Quality Non-Discharge Branch. The City currently holds a permit for Distribution of Class A residuals. However, a major permit modification will be required for the City to distribute Class A residuals from any new solids management strategy. The City's non-discharge permit, once modified, will allow the City to dispose of Class A residuals in the following ways:

- Land apply residuals to dedicated sites at a rate greater than the agronomic rate for nitrogen
- Land apply residuals to non-dedicated sites at rates not exceeding the recommended agronomic rate for nitrogen
- Bulk or bagged distribution of residuals to third parties and/or the public

The disposal outlet markets that fall under each of these permit categories are discussed further below.

4.1 Agricultural Land Application

Agricultural land application of Class A residuals is the most common method employed throughout North Carolina and the United States. Agricultural land application of Class A residuals may be applied to either dedicated or non-dedicated sites. The typical agricultural land application rate for biosolids is 5 tons/acre/year, with one or more applications per year dependent upon growth conditions of the crop(s) being grown. WTF residuals may be land applied at greater rates and frequencies depending upon the concentrations of metals and other contaminants. However, they offer little to no fertilizer value. Dedicated land application sites are typically owned by the residuals producer, and crop production is of secondary importance to the disposal of residuals. The majority of the City of Hendersonville's currently-owned properties are used for governmental facilities, parks and recreation, or utilities infrastructure. Based on this, it is assumed that the City would need to purchase additional property to allow land application of residuals to dedicated sites.

Land application of Class A residuals to non-dedicated sites is the most feasible agricultural land application market available to the City of Hendersonville. Non-dedicated agricultural land application sites include local farms, nurseries, and sod farms where the Class A residuals would be land applied as a fertilizer or soil conditioner. It is expected that the City will be required to implement a marketing campaign to develop the residuals land application market in Henderson County, since there are currently no permitted land application sites in the county. Marketing campaigns to identify land application sites should include public outreach to farmers and local businesses to provide educational information regarding the safety, expected nutrient content, and application and reporting requirements. Public perception of land application can often be a major hurdle, so public outreach and education is a key step to a successful land application program.

Compost and heat dried products are expected to be most successful as land applied residuals because their physical characteristics make them easy to spread, they contain higher levels of plant available nutrients, and they are typically less odorous than cake residuals products. Heat dried residuals generally contain the highest levels of nutrients with a typical N-P-K (nitrogen, phosphorus, and potassium) ratio of approximately 6-3-0, assuming they are comprised of only biosolids. Biosolids compost products typically have a lower N-P-K ratio of approximately 3-2-0 and are therefore less valuable as fertilizer supplements. However, biosolids compost makes an excellent soil conditioner due to its high level of natural organic matter and active microbial populations. Cake residuals products from the ATAD alternative will typically fall in the middle of nutrient concentrations with an approximate N-P-K ratio of 4-3-0 and therefore will have less value as a fertilizer or soil conditioner product. Also, cake residuals from the ATAD process are generally more odorous than heat dried or composted residuals, and therefore may receive a more negative public perception.

4.2 Non-agricultural Land Application

Non-agricultural land application of Class A residuals may be broken down into many end uses, including both permitted non-dedicated land application sites and bulk or bagged distribution to third parties for use. The typical application rate of biosolids to non-agricultural land is 8 tons/acre/year. However, allowable application frequencies differ between the many types of non-agricultural land application outlets. WTF residuals may be applied at greater rates, dependent on the concentration of metals and other contaminants.

4.2.1 Forestry (Silviculture)

Class A residuals can be effectively used to increase forest productivity as a fertilizer to nutrient deficient and typically acidic forest soils. Many studies have shown that biosolids application in the timber production industry has led to more rapid and hardier timber growth, resulting in quicker harvests. Residuals application to forest land reduces the risk of human exposure to contaminants (if any are present) through the food chain. Land application of residuals to Christmas tree farms has also shown to enhance the aesthetic value of Christmas trees due to greater nutrient uptake. **Figure 4.1** below shows the potential difference in coniferous tree growth density and color for trees grown without residuals application and those that have had residuals applied to stimulate growth.

Figure 4.1 – Difference in tree growth with residuals application

*Top: unapplied, Bottom: applied (Source: https://nwbiosolids.org)

Per the North Carolina Forest Service, the forest products industry is the largest manufacturing sector in the state, contributing more than $4.5 billion to North Carolina's gross product, and more than $23 billion in economic benefits to North Carolina. As of 2016, the forest sector in Henderson County had a total economic contribution of $293.9 million to the county's economy. As of 2018, Henderson County had 163,818 acres of timberland, making up 69% of the county's land area. Based on this information, the forest products industry in Henderson County and the surrounding counties may provide a viable disposal outlet for the City's Class A residuals. It is also noted that North Carolina is the country's second largest producer of Christmas trees with over 25,000 acres of land used for Christmas trees. While Ashe County is the State's largest producer, there are many Christmas tree farms located throughout the western North Carolina region. The North Carolina Christmas Tree Association may be a valuable source of contact information for local growers as the City develops residual disposal outlets. Land application of Class A residuals for forestry and silviculture must be applied at rates not exceeding the agronomic rate for nitrogen, and application sites must be permitted. The frequency of land application for forestry and silviculture will be lower than that allowed for agricultural crop production due to the lower rate of nutrient uptake. The typical application frequency for forestry or silviculture is once every three to five years.

4.2.2 Golf Courses

Golf courses use large amounts of fertilizers and soil conditioners to maintain turf grasses and landscaped areas. The nutrient content of Class A residuals products can be applied to golf courses, especially fairways, to offset the cost of synthetic fertilizers. Heat dried products are best suited for golf course application due to their higher nutrient content, ease of application, and possible familiarity with similar products such as Milorganite. Screened compost products are also well suited for application to golf courses as a fertilizer and soil amendment to offset synthetic fertilizer use and to improve the water holding capacity of the soil. Golf course grounds management crews lacking experience with other organic fertilizers or soil conditioners tend to be skeptical of new products, so adoption of residuals use on golf courses may develop slowly absent public outreach and education. It is recommended to perform a survey of local public and private golf courses to gauge interest in the use of Class A residuals. The typical method of distribution for this disposal outlet is pick-up of bulk or bagged Class A residuals at the WWTF, or at another local pick-up site. The City would be required to perform regular laboratory analyses on the Class A residuals to determine the nutrient content (N-P-K), heavy metals concentrations, sodium adsorption ratio (SAR), and trace minerals per the non-discharge permit. The City would also be required to provide a label or information sheet to the person accepting the Class A residuals to provide application rate instructions and land application limitations.

4.2.3 Parks and Recreation

Local parks and recreation areas are viable sites for land application of Class A residuals because they typically provide enough land area and are typically owned or operated by local governmental entities. Class A residuals may be applied to local parks and recreation areas as a fertilizer or soil amendment intended to support turf grass growth. Larger parks and recreational fields are the most feasible residuals application sites because they have enough land area to comply with the required setbacks and buffer areas required by the regulations. Berkley Mills Park (City of Hendersonville), Jackson Park (Henderson County), and Bill Moore Community Park (Town of Fletcher) are several examples of larger area parks in Henderson County that may be viable sites for land application. Interlocal agreements may be required between the City of Hendersonville and Henderson County, the Town of Fletcher, and other local municipalities to allow land application of the residuals at parks and recreational areas other than those owned by the City. Parks and recreational areas where residuals will be land applied must be permitted.

Composted residuals and heat dried residuals are best suited for land application to parks and recreational areas because they are generally less odorous, are easily spread and incorporated to the soil, and have physical characteristics similar to commercially available compost and fertilizer products. Cake residuals like those from the ATAD alternative are not suitable for land application to parks and recreation areas due to their appearance, odor potential, and application properties similar to Class B cake residuals.

4.2.4 Landscaping

Residuals products may be distributed to local landscapers and contractors for domestic/commercial landscaping and construction restoration after land disturbance. Again, composted residuals and heat dried residuals are best suited for this market because they are easily handled, less odorous, and provide value as a fertilizer or soil amendment. This market may require several years to develop as a significant disposal outlet. However, acceptance and adoption is expected to be driven by potential cost savings to local contractors when compared to the price of other commercially available compost products and fertilizers. Bulk or bagged residuals may be picked up by local contractors at the WWTF or at another local pick-up location.

4.2.5 Domestic Use

Domestic use of Class A residuals products is only feasible for composted or heat dried residuals for the same reasons described for both the parks and recreation and landscaping outlets. Furthermore, Class A residuals must meet the criteria for exceptional quality (EQ) residuals for domestic use to be a feasible disposal outlet. Distribution of Class A residuals for domestic use is best accomplished by bagged or bulk distribution at the WWTF and at other local pick-up sites. The domestic use market is also expected to take several years to develop and will require investment of resources to market the Class A residuals and provide public outreach and education. Composted residuals are expected to be moderately less desirable for domestic use because of the wide availability of other organic compost products. Public interest in heat dried residuals will be largely driven by the product's uniformity, ease of application, and odor potential. Heat dried residuals produced from the City's WTF residuals and WWTF sludge are not expected to develop significant odors after drying because the WWTF sludge is only produced from aerobic waste activated sludge. Maintaining aerobic conditions in the WAS prior to processing will be an important consideration to ensure composted or heat dried products are not odorous. Heat dried pellet or granule shape, hardness, and dust potential will also be important considerations for domestic use. These product characteristics will impact the selection of the type of thermal dryer to be installed if it is the selected solids management alternative.

4.2.6 Landfill Cover

Treated Class A residuals may be utilized at municipal solid waste landfills (MSWLF) as either a fertilizer or soil amendment for the final cap layer of closed landfill cells, or as an alternative daily cover material (ADCM) for active landfill cells. Use of the Class A residuals as a fertilizer or soil amendment material applied to the landfill cap is regulated and permitted similar to traditional land application and must be applied at rates not exceeding the agronomic rate for nitrogen. Residuals may be incorporated into the surface layer of a landfill cap as cells are closed and applied to the surface layer of previously closed cells to establish or maintain vegetative cover. The limitations and benefits of this disposal method are similar to those described above for land application. The market interest for this disposal route is governed by the nutrient content and soil building characteristics of the residuals.

On the other hand, MSWLFs are required to cover solid waste with a 6 inch layer of soil at the end of each working day or at more frequent intervals. This requires significant amounts of soil materials daily, which may not be readily accessible or easily affordable by some MSWLFs. As a result, many MSWLFs must seek out alternative daily cover materials to supplement the need for natural soils. Class A residuals may be applied as an ACDM at MSWLFs, either directly or blended with soils to reduce the need for natural soils. Residuals are not currently approved by NCDEQ Division of Waste Management Solid Waste Section as an alternative daily cover material. However, the Section does allow MSWLF operators to complete a demonstration process for ADCMs to ensure they are in accordance with the rules, statutes, site specific conditions, and historical precedent. Across the state border, Greenville County, South Carolina has used lime stabilized biosolids from ReWa as an ADCM since the early 1990’s in the County’s landfills, including the Twin Chimneys Landfill. ReWa historically made agreements with Greenville County to eliminate tipping fees for lime stabilized biosolids used as an ADCM, while also reaching agreements for reduced tipping fees on grit and screenings disposed of at the County’s landfills. Residuals produced from the composting and heat drying alternatives are best suited as ADCMs because of their low moisture content and the ability to readily mix with natural soil materials. Composted residuals are expected to be the most desirable as an ADCM because of the larger volume available and the compost’s excellent soil building characteristics. Less interest is expected in heat dried residuals as an ADCM due to the low volume of residuals. Cake residuals products produced from the ATAD alternative are not likely to be approved as an ADCM without further processing to reduce moisture content. It is recommended to contact area landfills directly to gauge interest in use of Class A residuals as ADCMs or as fertilizer/soil amendments for application on closed cells.

4.3 Energy Recovery

Heat dried biosolids products are a feasible alternative fuel source because of their high organic content and low moisture content. The typical heating value for dried biosolids ranges from 6,500 Btu/lb to 8,000 Btu/lb, whereas the typical heating value of coal produced in the US and used for energy production is approximately 11,000 Btu/lb. The heating value for undigested heat dried biosolids tends to be on the higher end of the range near 8,000 Btu/lb while digested heat dried biosolids contain fewer volatile solids, and therefore have a lower heating value. Biosolids use as a fuel source has grown in popularity, especially in Europe where fuel costs have driven industrial markets to use waste-derived fuels. This market is beginning to transition to the U.S., as fuel costs rise, and industrial and energy markets push for more renewable fuel sources. The use of biosolids as an alternative fuel source requires a pelletized or granular heat dried product to be feasible. The most common uses for biosolids as a fuel source are in brick and cement kilns, as well as coal fired power plants where it is co-combusted with coal. The high temperatures of the combustion process in kilns and in coal-fired power plants destroys organic compounds, including microcontaminants such as per- and polyfluoroalkyl substances (PFAS), removing them from the environment. The ash produced from combustion of biosolids in cement kilns is incorporated into the cement product, resulting in complete product recycle. In some cases, biosolids used as a biofuel for coal-fired power plants has been shown to contain lower levels of heavy metals and other contaminants in the ash produced from combustion.

The most likely market for the City's biosolids as an alternative fuel source is in the cement manufacturing industry. However, there are no major cement kilns in North Carolina, so biosolids would be required to be transported several hours for use in this market. There are four cement manufacturing plants within a five-hour drive of Hendersonville: Cemex's Knoxville plant (two hours), Argos USA's Atlanta plant (three hours), Buzzi Unicem USA's Chattanooga plant (four hours), and Titan America's Roanoke plant (four hours). This is a relatively untapped and new market in the U.S., and more regulatory framework is expected to be developed, along with further increases to coal costs, to increase interest in the use of biosolids as an alternative fuel source. As a result, this is not expected to be a readily available disposal outlet for the City's residuals in the short term.

4.4 Third-Party Contracting

The Final Solids Management Plan report previously described the use of third-party residuals management firms. These management firms typically provide turn-key services for the transportation, storage, permitting, and disposal of residuals from municipalities. As stated previously, third-party residuals management firms in North Carolina include Bio-Nomic Services (Charlotte, NC), EMA Resources, Inc. (Mocksville, NC), Soil Plus LLC (Oxford, NC), Southern Soil Builders, Inc. (Roaring River, NC), and Synagro (Charlotte, NC). Several examples of North Carolina municipalities that have contracted the services of these firms include the Town of Cary (Soil Plus), Charlotte Water (Synagro), Eden (Synagro design-build-operate facility), and Winston-Salem (Soil Plus).

Value-added products such as compost and heat dried pellets may be sold to residuals management firms based on their nitrogen (and other nutrient) content, since these products may be marketed and sold to the general public. Cake residuals products are generally less marketable, and municipalities must typically compensate residuals management firms to haul and dispose of these residuals. Residuals management firms can provide a valuable management alternative for less marketable residuals products due to their expanded network of disposal outlets. This may be especially useful to the City for WTF residuals that have little to no value as fertilizer. Residuals management firms also reduce the overall management and permitting burden of residuals land application on the municipality by taking on the responsibility for permitting land application sites and product monitoring.

The use of third-party contracting generally is not feasible for unstabilized biosolids, like the sludge cake currently produced by the City’s WWTF, because most residuals management firms only provide disposal services for stabilized products meeting the 40 CFR Part 503 rules. Some third-party residuals management firms can develop programs to include stabilization and disposal, however this may be cost prohibitive compared to construction and self-operation of a stabilization process. Third-party contracting is most effective for disposal of stabilized biosolids meeting Part 503 rules, or for residuals not subject to the Part 503 rules.

Employment of a third-party residuals management firm may fit the City’s needs as a potential short-term solution as the City develops its solids management program and disposal outlet markets. Third-party contracting may also be a viable long term strategy for disposal and beneficial reuse of the WTF residuals separately from the WWTF sludge. Long term use of third-party contracting for the disposal of WTF residuals takes advantage of a third-party contractor’s ability to procure land application sites for the less desirable WTF residuals product, while reducing operational burden on the City. This in turn also improves the marketability of the stabilized biosolids by keeping them separate from the WTF residuals as a result of the higher nutrient content per mass. Increases in landfill tipping fees and the difficulties related to marketing residuals for land application may make third-party residuals management firms cost competitive or advantageous. Third-party contracting may also be cost competitive as a short-term bridging solution for the distribution and marketing of value-added products like composted or heat dried residuals.

The City must weigh the option of utilizing third-party contracting for disposal services against the inherent risks of this approach when evaluating disposal practices. This disposal alternative does reduce the City’s operational and permitting burden, but at increased risk due to the dependence on a single third-party contractor. If the third-party contractor is unable to fulfill their duties under the contract, the City is responsible for any additional costs for alternative disposal methods, or must provide a means to store excess residuals until the contractor is able to fulfill their duties. These scenarios may be uncommon, but most often occur during extended periods of inclement weather. Also, the City is still liable for contents of the residuals product and any adverse effects it may have on human health or the environment due to its disposal. These risks may be mitigated by ensuring the City has a reasonable degree of oversight of the contracted disposal practices, and frequent communication with the contractor.

4.5 Landfill

As stated previously in **Section 2**, the City should continue to maintain landfill disposal outlets for its residuals. Landfilling of the City's residuals will provide a short-term bridge for disposal as the City changes solids management strategies and develops new disposal outlet markets. It is expected that it will take several years for the City to develop new solids management program practices and markets for distribution of Class A residuals, if the City does not contract with a third-party management firm. Landfill disposal will also be a necessary back-up disposal outlet for Class A residuals during periods of unfavorable weather or field conditions if land application is a key component of the City's solids management program. Landfilling costs will be highest for the composting alternative because it produces the largest mass of residuals for disposal. Landfilling costs for the ATAD and heat drying alternatives will be considerably lower than the composting alternative due to the lower mass of residuals to dispose of, with heat drying producing the smallest mass of residuals for disposal. Cake residuals produced from the ATAD alternative may still be rejected from landfills in the future due to the high water content (in the range of 80%) of the cake mass.

4.6 Disposal Outlet Summary

The disposal outlets described above were compared to each solids management process alternative to determine the general degree of suitability for each alternative. The degree of suitability of each disposal outlet to the solids management process alternative was categorized as highly suitable, moderately suitable, less suitable, or not suitable. For a disposal outlet to be considered highly suitable, the residuals product must be easily transported and applied, market competitive, and generally publicly accepted. Moderately suitable disposal outlets must meet two of the three criteria for highly suitable disposal outlets. Disposal outlets are considered to have low suitability if they meet one of the three criteria. A disposal outlet would be considered not suitable if the product characteristics do not meet the requirements of the disposal outlet, or if heavy public opposition is expected. The disposal outlet suitability for each of the solids management process alternatives are summarized in **Table 4.1** below.

Table 4.1 – Class A residuals comparison of disposal outlet suitability

Disposal Outlet	Disposal Outlet Suitability for Class A Residuals Product Type		
	Compost	ATAD Cake	Heat Dried
Agricultural Land Application	High	High	High
Forestry/Silviculture	High	High	High
Golf Courses	Moderate	*Not suitable*	High
Parks & Recreation	High	*Not suitable*	High
Landscaping	High	*Not suitable*	High
Domestic Use	Moderate	*Not suitable*	High
Landfill Cover	High	Less	Moderate
Energy Recovery	*Not suitable*	*Not suitable*	High

5. OPTIONS FOR ALTERNATIVE PROJECT DELIVERY

The City requested that McKim & Creed review alternative project delivery methods for the construction of the recommended solids management improvements to determine if cost and/or schedule savings can be provided, when compared to traditional design-bid-build project delivery. Alternative project delivery methods are summarized below including discussion of their applicability to the solids management alternatives evaluated. Selection of the appropriate project delivery method is dependent on the type of project, as well as the City's prioritization of cost, schedule, quality, and risk. The project delivery methods reviewed include traditional Design-Bid-Build (DBB), Construction Manager at Risk (CMAR), Progressive Design-Build (PDB), and Design-Build Bridging (DB Bridging).

5.1 Traditional Design-Bid-Build (DBB)

Traditional Design-Bid-Build is the most common project procurement method for governmental entities and is the only project procurement method currently used by the City of Hendersonville. This procurement method consists of two separate contracts and three separate phases (i.e. design-bid-build). With traditional DBB, the City contracts with an engineer to provide design, bidding, and construction administration services. The City enters into a separate contract with a contractor to construct the project per the plans and specifications developed by the engineer. The selection of the engineer is solely based on qualifications per the Mini-Brooks Act, whereas the selection of the contractor is based on competitive bidding with the lowest responsive/responsible bidder selected. The advantages of traditional DBB include:

- Lowest initial cost due to competitive bid process
- High degree of owner-input during design
- Well-established and understood procurement method, with no internal policy changes required

Disadvantages of traditional DBB include:

- Higher level of risk allocated to the City
- Change orders due to conditions unforeseen during design
- Project schedule may be extended due to strict separation of project phases
- No collaboration with contractor during design, may affect constructability and final project costs from change orders

- Three party conflict resolution (City/engineer/contractor)

- May result in adversarial relationships due to separate contracts

Traditional DBB procurement is well suited for the construction of the improvements associated with the solids management alternatives evaluated in this report. It is especially well suited to parts of the improvements that have a well-defined scope of work with limited need for innovative construction methods or process modifications. The WTF residuals force main and pump station included in several of the alternatives evaluated herein is an example of a straightforward, definable scope and familiar type of project that is well suited to the traditional DBB procurement method. Linear pipeline projects of substantial length such as the WTF residuals force main are production heavy with limited opportunities for phasing to accelerate project schedule. Use of alternative project delivery for linear pipeline projects such as the WTF residuals pump station and force main may increase project cost due to a typical "low-bid" environment and the added contractual risk that a CMAR or design-build team must accept.

The windrow and MSAP composting alternatives evaluated in this report also have a straightforward and definable scope of work. The windrow and MSAP composting alternatives require minimal process equipment and are mostly driven by earthwork and structural construction for immediate implementation. The improvements required under these alternatives may be procured more readily and efficiently using traditional DBB. The in-vessel composting alternative is similar, however it does rely on the procurement of manufactured systems, and some ingenuity may be applied to staging of the work and equipment layout selection. These characteristics of the in-vessel composting alternative favors some of the benefits of alternative project delivery methods.

The ATAD stabilization alternative evaluated in this report is heavily reliant on procurement and incorporation of proprietary process equipment and design along with heavy civil and structural trade work for the construction of process tankage. There is some flexibility in project staging, equipment selection, process layout, and construction methods with the ATAD alternative. These characteristics favor alternative project delivery methods where equipment may be procured during final design, and early contractor involvement helps to provide the best value and typically improves efficient project construction.

The thermal drying alternative presented in this report is also heavily reliant on procurement and incorporation of major process equipment. The thermal drying alternative does not include as much heavy civil and structural work as the ATAD alternative, however there is available flexibility in selection and layout of materials handling and loadout equipment as well as flexibility in project staging and location at the existing facility. Again, these characteristics favor alternative project delivery which can provide a shortened timeframe by procuring equipment during final design and provide valuable contractor involvement during design.

Construction of a new dewatered residuals storage shelter at the WTF as described under the thermal drying + third-party residuals management alternative is also well suited to traditional design-bid-build. The storage shelter recommended at the WTF under this alternative is assumed to be a pre-engineered metal building, which is a simple, well-defined scope, with a diverse and competitive market. This scope is best delivered using the standard design-bid-build procurement method.

5.2 Construction Manager at Risk (CMAR)

Construction Manager at Risk, or CMAR, is a form of alternative project delivery that closely resembles traditional design-bid-build but allows for early contractor involvement in the design. Like traditional DBB, CMAR includes two separate contracts; one contract between the City and the engineer, and one contract between the City and a contractor acting as the Construction Manager at Risk. However, unlike traditional DBB both the engineer and the Construction Manager are selected by the City based solely on qualifications per the Mini-Brooks Act. With CMAR the Construction Manager provides cost estimates, value engineering, and constructability feedback at the 30, 60, and 90% design phases. The Construction Manager provides the City with a Guaranteed Maximum Price (GMP) at the completion of design and is required to competitively bid the work to prequalified first-tier subcontractors per NC competitive bidding laws. The City and the Construction Manager are both involved in the prequalification of first-tier subcontractors following the City's established prequalification process. Under North Carolina procurement law the Construction Manager is not allowed to self-perform the work, with several exceptions listed in NC G.S. 143-128.1(c). The advantages of CMAR include:

- Contractor perspective during design
- Early/detailed cost transparency
- Project delivery typically faster than traditional DBB
- Mitigates risk of cost growth due to change orders
- City maintains high level of input during design

Disadvantages of CMAR include:

- More risk is allocated to the City compared to PDB or DB bridging due to separate contracts.

- Not guaranteed to provide lower cost compared to traditional DBB
- Project schedule is typically longer than PDB
- No contractual relationship between engineer and CM, may result in adversarial relationships
- Requires significant amount of City involvement and dedicated key personnel for collaboration

5.3 Progressive Design-Build (PDB)

Progressive Design-Build project delivery consists of a single contract between the City and a design-build team to complete both the design and construction of the project. In North Carolina, selection of the design-build team is based solely on qualifications criteria per the Mini-Brooks Act, which provides the City with a high level of control over which DB team is selected. In the municipal utility construction market design-build teams are typically led by the contractor, with the design engineer under subcontract. During the development of the DB contract, provisions are typically included to allow the City to take an "off-ramp" and terminate the contract after the development of the GMP if it exceeds available budget. If this right is exercised, the City may contract with an engineer to complete the rest of the design and bid the project using traditional DBB, or the City may select another DB team to complete the project.

With the PDB delivery method the City sets forth the performance criteria for the project and any prescriptive requirements in the contract. The design engineer and contractor collaborate from the start of the project to develop the design to meet the performance criteria and prescriptive requirements of the contract to the point that a GMP may be established. The GMP is typically established around the 60% design development phase. The City still maintains a high level of design input with PDB, however the City is advised not to direct the DB team with overly prescriptive input since any resulting cost impacts may ultimately be the City's responsibility to absorb. Following the development of the GMP, the DB team may accelerate the project schedule by phasing construction and equipment procurement to begin before finalizing project design. PDB typically provides the fastest project delivery schedule since construction phasing and mobilization may occur earliest in the design process. The advantages of Progressive DB include:

- Selection of DB team based on qualifications
- Only one contract, between the City and the DB team, with single point of responsibility
- Least amount of risk allocated to the City
- Highest level of engineer-contractor collaboration

- Typically, the fastest project delivery method due to overlapping design and construction

- Can provide cost savings over DBB due to performance criteria favored over prescriptive requirements

- Least cost growth due to change orders

Disadvantages of Progressive DB include:

- Depending on the City's desired level of input, this option can result in a reduced involvement in the design process

- Not guaranteed to provide lower cost compared to traditional DBB

- City is still responsible for change orders resulting from discrepancies between performance criteria and any prescriptive requirements included

5.4 Design-Build Bridging

Design-Build Bridging is often considered a hybrid of CMAR and PDB because of its two-step approach. With DB Bridging, the City first selects an engineering firm based on qualifications to serve as the City's design criteria professional. The design criteria professional assists the City in developing preliminary design plans and specifications, which requires 35% level documents per NC General Statutes for the design development phase. The 35% design documents are typically referred to as the design criteria package and are intended to provide enough detail to prospective design-build teams to submit a responsive bid. Selection of the design-build team in DB bridging is based on both qualifications and cost criteria, requiring that the design-build team submit its price for providing the general conditions of the contract, fees for design services, and fees for general construction services. After the development of the design criteria package, the design criteria professional remains under contract with the City to serve as the owner's representative during the design-build team selection process, and to administer the requirements of the design criteria package. After the selection of the DB team, DB bridging is very similar to PDB in that the design is progressed to the point that a GMP may be developed, after which the project schedule may be accelerated by concurrently constructing phases and procuring equipment. The advantages of DB bridging include:

- City has high level of input for first 35% of design to establish direction

- Less risk is allocated to the City compared to traditional DBB and CMAR

- More familiar project delivery method compared to PDB
- Provides value engineering and mitigation of constructability issues during design

Disadvantages of DB bridging include:

- More risk allocated to the City than with PDB procurement, City may be responsible for errors and omissions in the design criteria package
- Does not provide significant schedule savings compared to PDB due to two-phase approach
- Contractor is not involved in design as early as CMAR or PDB

6. SUMMARY

6.1 Summary of Alternatives Evaluation

A summary of the findings of the solids management alternatives evaluation is provided in **Table 6.1** below including anticipated disposal outlets, advantages, and disadvantages of each alternative.

Table 6.1 – Summary of Solids Management Alternatives Evaluation

Process	Disposal Outlets	Advantages	Disadvantages
Composting	Agricultural land application Forestry/Silviculture Golf Courses Parks & Recreation Landscaping Domestic Use Landfill Cover	Highly marketable Class A product. May qualify as Class A EQ. Lowest capital cost. Simple operation.	Cannot compost WTF residuals. Large land area required. Large volume of amendment materials required. Can be odor nuisance. Higher O&M cost compared to other alternatives. Rainfall management needed if operation is not covered.
ATAD	Agricultural land application Forestry/Silviculture Landfill Cover (final cap)	Proven Class A process. Substantial volume reduction of WWTF sludge. Reduced nutrient loading in return streams. Process can be automated. Lowest O&M cost.	Only produces dewatered cake. Cake product may be odorous. Limited market similar to Class B cake product. Cannot process WTF residuals beyond dewatering. Highest capital cost. Extensive operator training needed.
Thermal Drying	Agricultural land application Forestry/Silviculture Golf Courses Parks & Recreation Landscaping Domestic Use Landfill Cover Energy Recovery	Highly marketable Class A product. May qualify as Class A EQ. Maximum volume reduction. Uniform product. Easily land applied. Can process WTF Residuals. Simple operation. Low O&M cost.	High capital cost. Significant natural gas usage. May produce dusty product with blended WWTF sludge and WTF residuals. Potential fire/explosion hazard with product storage.
Thermal Drying + Third-Party Residuals Management	Agricultural land application Forestry/Silviculture Golf Courses Parks & Recreation Landscaping Domestic Use Landfill Cover Energy Recovery	Maximizes marketability of dried biosolids. Dried biosolids expected to qualify as Class A EQ. Maximum volume reduction of WWTF sludge. Dried biosolids easily land applied. Reduced operating burden. Reduced permitting burden and liability for WTF residuals. Separate beneficial use market for WTF residuals. Lowest capital cost.	Highest O&M cost. Potential fire/explosion hazard with dried biosolids storage. Risk of uncertain long term costs for third-party WTF residuals management beyond initial contract term. Dependence on one service provider for WTF residuals dewatering and disposal. Risk of failure to meet contractual requirements.

A summary of the capital, O&M, and total net present value for each of the solids management alternatives is provided in **Table 6.2** below.

Table 6.2 – Cost Summary of Solids Management Alternatives

Alternative	Capital Costs	O&M Net Present Value	Total NPV
Traditional Composting	$18,327,000	$12,047,000	**$30,374,000**
In-Vessel Composting System	$24,495,000	$8,355,000	**$32,850,000**
ATAD	$26,677,000	$4,606,000	**$31,283,000**
Thermal Drying	$24,316,000	$4,933,000	**$29,249,000**
Thermal Drying + Third-Party Residuals Management	$12,529,000	$12,051,000	**$24,580,000**

Thermal Drying + Third-Party Residuals Management (TD+TPRM) presents the lowest net present value and the lowest capital cost of the alternatives evaluated. The TD+TPRM alternative also provides an extensive list of potential disposal markets for processed residuals. This alternative benefits from significantly reducing the operational and permitting burden for WTF residuals dewatering and disposal, since these services are contracted through a third-party. However, TD+TPRM results in the highest O&M net present value because of the costs of third-party contracting. This alternative also has a higher degree of risk compared to all other alternatives due to reliance on a single third-party contractor for WTF residuals dewatering and disposal. The risks associated with the TD+TPRM alternative may be mitigated to a reasonable degree by:

- Providing excess dewatered WTF residuals storage capacity, as recommended in **Section 3.4.3**
- Ensuring contracts with the Third-Party Residuals Management firm include requirements for communication procedures with the City, and provisions for City oversight of disposal practices

The Traditional (and MSAP) Composting alternative resulted in the second lowest capital cost and provides an extensive list of potential disposal markets for processed residuals. Composting alternatives also benefit from the fact that they are very simple to design and operate. However, there is a significant jump in capital cost for Traditional Composting compared to the TD+TPRM alternative. Traditional Composting requires the second highest operations and maintenance costs, does not provide WTF residuals processing beyond dewatering, and will produce significantly more residuals for disposal than the other alternatives. The In-Vessel Composting alternative shares similar traits, however its capital costs are significantly higher than Traditional Composting, while providing significant savings on operations and maintenance costs due to increased process automation.

ATAD processing carries the highest capital cost of the alternatives evaluated, whereas its operations and maintenance costs are the lowest. The review of disposal outlets and product marketability indicates that the ATAD alternative would produce a Class A product that is effectively similar to a Class B residual unless it is processed further to reduce water content to less than 50%. The ATAD alternative also does not provide WTF residuals processing beyond dewatering. As a result, it was determined that the ATAD alternative does not meet the City's goals to provide a broader range of disposal options and avenues for beneficial reuse.

Thermal drying presents the second lowest total net present value of the alternatives evaluated while providing the most volume reduction and a wide variety of disposal outlets available. Capital costs for the thermal drying alternative are high and very similar to in-vessel composting and ATAD alternatives. However, thermal drying requires the second lowest O&M costs due to its mechanical simplicity, process automation, and reduced disposal costs due to volume reduction. Thermal drying also benefits from its ability to further process WTF residuals. While the thermal drying alternative does produce the lowest volume and mass of residuals to be disposed, the product marketability and nutrient content is slightly diluted with the inclusion of the WTF residuals.

6.2 Recommended Solids Management Practices

Based on the evaluation summary presented above, Thermal Drying + Third-Party Residuals Management alternative is the recommended solids management alternative for the City of Hendersonville because it is best aligned with the City's goals and provides the lowest total net present value of the alternatives evaluated. TD+TPRM allows for the separation of biosolids and WTF residuals to maximize the nutrient content and marketability of the thermally dried biosolids product. TD+TPRM also provides beneficial reuse of the WTF residuals at significantly reduced capital cost, operating burden, and permitting burden to the City. The following summarizes the proposed capital improvement projects associated with this recommended alternative.

6.2.1 WWTF Thermal Drying Facility

The process diagram for this recommended alternative is presented in **Figure 3.4**. Waste activated sludge will continue to be pumped to the existing gravity thickeners for thickening prior to dewatering. The thickened WAS will then be pumped to the existing dewatering belt filter presses to be blended with polymer and dewatered prior to thermal drying. The dewatered sludge will then be transferred to a live bottom hopper sized for the 24 hour processing capacity of the dryer, which will then feed the thermal dryer and allow it to operate semi-independently from dewatering operations. The dried product will then be directly conveyed to new product storage silos or hoppers and truck load-out station for disposal. The construction of these improvements is recommended to include:

- Partial conversion of the existing covered storage area to a new thermal drying facility
- Dewatered cake conveyors and live bottom hopper for dryer feed conveyance and storage
- Medium-temperature belt dryer
- Dried product conveyance system to storage (covered belt and/or screw conveyors)
- Dried product storage silos (or hoppers) and truck load-out station

6.2.2 WTF Residuals Storage Shelter

The residuals produced at the WTF are recommended to be transferred to a new covered storage shelter located adjacent to the existing dewatering building, in the location of the existing laydown yard. The new WTF residuals storage shelter is proposed to be a clear span pre-engineered metal building, complete with:

- Three sides completely enclosed, and one side open (west side facing existing dewatering building) to allow equipment movement in and out from the existing dewatering building
- Concrete floor slab with adequate drainage to collect any leachate from stockpiled residuals, and adequate site grading to prevent storm water ingress
- Concrete push walls on the three fully enclosed walls
- Interior/exterior LED work lighting

The new covered storage shelter is proposed to be 15,000 sq. ft. (150 ft long by 100 ft wide) to provide approximately 120 days of dewatered residuals cake storage capacity at 2040 conditions, and approximately 200 days of storage capacity at current conditions. A minimum interior height of 20 ft is recommended to provide a sufficient clear overhead area for loading equipment (front end loader) to safely operate.

6.3 Implementation Recommendations

As noted in the introduction to this evaluation, the White Oak Landfill in Haywood County notified the City in January 2021 that it will no longer allow disposal of the WTF residuals cake at the landfill. The landfill operator cited the high water content of the sludge and their concerns regarding excess leachate volume and potential for slope failure. In addition, the existing dewatering centrifuge at the WTF is more than 40 years old and has recently required major repairs and rebuilds. In comparison, dewatered sludge cake from the WWTF has consistently achieved better dewatering and a more solid consistency, which the White Oak Landfill continues to accept for disposal. The existing dewatering belt filter presses are still in good condition and are expected to continue to serve the needs of the WWTF beyond the immediate term, at a minimum.

Based on these developments, the City's WTF has immediate need for improvements to solids management practices. The need for improvements to the WWTF's solids management practices are currently not urgent, but they may become urgent if equipment/process performance begins to deteriorate unexpectedly, or if landfills reject disposal of the sludge cake again. Therefore, it is recommended that the City implement changes to the current solids management practices in two phases.

The first phase is recommended to begin immediately and includes construction of a new dewatered residuals storage shelter at the WTF and contracting with a third-party residuals management firm for dewatering, hauling, and disposal of WTF residuals.

The second phase is recommended to be implemented in the next five years and would consist of the construction of a new thermal drying facility at the WWTF to produce a thermally dried Class A-EQ biosolids product for marketing and distribution.

6.3.1 Phase 1 – WTF Residuals Storage Shelter and Contracted Services

The construction of the WTF residuals storage shelter and contracting with a third-party residuals management firm is recommended to be completed in Phase 1 of the implementation of the recommended solids management plan.

As mentioned previously in Section **5 - OPTIONS FOR ALTERNATIVE PROJECT DELIVERY**, the construction of the WTF residuals storage shelter is a somewhat simple, defined scope, and it is well suited for traditional design-bid-build procurement. This method of delivery provides the City the benefit of competitive pricing from a number of qualified contractors. Procurement of contracted services for dewatering, hauling, and disposal of the WTF residuals is recommended to be accomplished through the issuance of an Request for Proposals (RFP) for these services. Numerous municipalities throughout North Carolina utilize this method to select qualified third-party residuals management firms based on both qualifications and proposed pricing. In general, the RFP for these services is recommended to include the following requirements:

- Performance bonds
- Examples of past project performance and references
- Personnel qualifications and experience
- Proposed equipment to be used
- Proposed pricing for the services to be performed

The design of the improvements at the Water Treatment Facility and the procurement of contracted residuals management services are recommended to be overseen by a single program manager. The selection of a program manager for facility improvements design and contracted services procurement assistance will ensure consistent coordination between the requirements of the construction and services contracts. Specifically, this will ensure support systems for the contracted services such as power requirements, wash water requirements, waste disposal capacity, equipment operating areas, etc. are fully coordinated between the facility improvements design and the residuals management services contract. The scope of services for the program manager is recommended to include:

- Design, bidding services, construction administration, and construction observation services for the WTF covered storage shelter and associated improvements to support contracted residuals dewatering, hauling, and disposal
- Assist in the preparation of the RFP for contracted residuals management services
- Assistance in the procurement of contracted residuals management services to answer prospective firms' questions, review proposals, contact prospective firms' references, and recommend contract award to the City

The estimated capital and annual contract costs for Phase 1 of the recommended solids management plan is summarized below in **Table 6.3**.

Table 6.3 – Estimated Phase 1 Costs

Item	Description	Cost ($)
1	WTF Residuals Covered Storage Shelter	$670,000
2	Mobilization & Demobilization	$27,000
3	Indirect Costs	$32,000
4	General Conditions & Contractor Markup	$154,000
5	30% Contingency	$265,000
6	Engineering, Legal, & Administration	$287,000
	Total Phase 1 Capital Cost	**$1,435,000**
7	Contracted Dewatering Services for WTF Residuals (Annual Cost)	$162,000
8	Contracted Hauling & Disposal for WT Residuals (Annual Cost)	$109,000
	Total Phase 1 Costs	**$1,706,000**

6.3.2 Phase 2 – WWTF Thermal Drying Facility

The WWTF thermal drying facility is recommended to be designed and constructed in Phase 2. The thermal drying facility is recommended to be implemented in this phase due to the reduced urgency for alternative disposal outlets currently experienced, the current operating condition of existing equipment at the WWTF, and the time required to budget for this significant capital improvement project.

The construction costs and delivery schedule of the recommended thermal drying facility will be heavily dominated by equipment procurement, which tends to favor alternative project delivery methods as mentioned in Section **5 - OPTIONS FOR ALTERNATIVE PROJECT DELIVERY**. This specifically favors Progressive Design-Build procurement because it allows for immediate collaboration between the contractor and the engineer, and equipment procurement can typically be phased to occur earlier in the project than with CMAR or DB Bridging. Most of the equipment that will be required for the thermal drying facility is available from a variety of manufacturers, including the thermal dryer, with multiple different types of equipment that may be applicable, especially for material handling. The variety of equipment options also favors the cost savings potential of Progressive Design-Build if equipment selection is not overly limited by contractual requirements, because it allows for ingenuity and value engineering by the DB team. The estimated capital costs for Phase 2 of the recommended solids management plan is summarized below in **Table 6.4**.

Table 6.4 – Estimated Phase 2 Capital Costs

Item	Description	Cost ($)
1	Equipment	$3,084,000
2	Mechanical	$617,000
3	Electrical	$617,000
4	Instrumentation	$309,000
5	Structural	$640,000
6	Civil	$31,000
7	Demolition	$240,000
8	Mobilization & Demobilization	$222,000
9	Indirect Costs	$261,000
10	General Conditions & Contractor Markup	$1,266,000
11	30% Contingency	$2,187,000
12	Engineering, Legal, & Administration	$1,757,000
	Total Phase 2 Capital Cost	**$11,231,000**

APPENDIX A – OPINIONS OF PROBABLE PROJECT AND O&M COSTS

McKim & Creed, Inc.

Opinion of Probable Project Costs

Project:	Solids Management Plan
Project Number:	06496-0007
Prepared By:	Zachary Trammel, Josh Marlin, Katherine Van Sice
Date:	Monday, May 17, 2021
Checked By:	Chris Rosenboom
Subject:	**Traditional Composting**

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT COST	EXTENSION	ITEM SUB TOTAL
					Net Present Value of Capital and O&M Costs	**$30,374,000.00**
1	**Equipment**	1	LS	$ 508,000	$508,000	
					Subtotal A:	**$508,000**
2	**Installation Costs**				**$8,896,000**	
	Mechanical Equipment Installation	1	LS	0.0%	$0	
	Electrical Installation Costs	1	LS	0.0%	$0	
	Instrumentation Installation Costs	1	LS	0.0%	$0	
	Structural	1	LS	$1,429,000	$1,429,000	
	Civil	1	LS	$1,572,000	$1,572,000	
	Demo	1	LS	$65,000	$65,000	
	WTF Residuals Pumping Station and Force Main	1	LS	$5,468,000	$5,468,000	
	Mobilization & Demobilization	1	LS	4.0%	$362,000	
					Subtotal B:	**$9,404,000**
3	**Indirect Costs**				**$424,000**	
	Permits	1	LS	1.0%	$94,040	
	Risk & Liability Insurance	1	LS	1.5%	$141,060	
	Performance & Payment Bonds	1	LS	2.0%	$188,080	
					Subtotal C:	**$9,828,000**
4	**General Conditions & Contractor Markup**				**$2,064,000**	
	General Conditions	1	LS	6.0%	$589,680	
	Contractor's OH & P	1	LS	15.0%	$1,474,200	
					Subtotal D:	**$11,892,000**
5	**Contingency**	**1**	**LS**	**30%**	**$3,568,000**	
					Opinion of Probable Construction Cost:	**$15,460,000**
6	**Engineering, Legal, and Administration**	**1**	**LS**	**25.0%**	**$2,867,000**	
					Opinion of Probable Project Cost:	**$18,327,000**
4	**2021 O&M Costs**				**$549,000**	
	Labor	4,160	HR	$25.00	$104,000	
	Maintenance	1	LS	2.0%	$11,000	
	Natural Gas	-	mmBTU	$6.21	$0	
	Electricity	54,000	kWhr	$0.06	$4,000	
	Equipment Fuel	8,320	GAL	$3.10	$26,000	
	Hauling & Land Application	18,114	CY	$22.28	$404,000	
5	**2040 O&M Costs**				**$1,330,000**	
	Labor	8,986	HR	$ 45.15	$406,000	
	Maintenance	1	LS	2.0%	$11,000	
	Natural Gas	-	mmBTU	$6.21	$0	
	Electricity	92,900	kWhr	$0.06	$6,000	
	Equipment Fuel	17,971	GAL	$3.10	$56,000	
	Hauling & Land Application	38,178	CY	$22.28	$851,000	
6	**Net Present Value of Capital and O&M Costs**					**$30,374,000**

McKim & Creed, Inc.

Opinion of Probable Project Costs

Project: Solids Management Plan
Project Number: 06496-0007
Prepared By: Zachary Trammel, Josh Marlin, Katherine Van Sice
Date: Monday, May 17, 2021
Checked By: Chris Rosenboom
Subject: **In-Vessel Composting System**

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT COST	EXTENSION	ITEM SUB TOTAL
					Net Present Value of Capital and O&M Costs	**$32,850,000.00**
1	**Equipment**				**$3,275,000**	
	In-Vessel Composting System	1	LS	$2,250,000	$2,250,000	
	Other Ancillary Equipment	1	LS	$1,025,000	$1,025,000	
					Subtotal A:	**$3,275,000.00**
2	**Installation Costs**				**$9,292,000**	
	Mechanical Equipment Installation	1	LS	20.0%	$655,000	
	Electrical Installation Costs	1	LS	20.0%	$655,000	
	Instrumentation Installation Costs	1	LS	10.0%	$328,000	
	Structural	1	LS	$1,458,075	$1,459,000	
	Civil	1	LS	$3,000	$3,000	
	Demo	1	LS	$239,900	$240,000	
	WTF Residuals Pumping Station and Force Main	1	LS	$5,467,500	$5,468,000	
	Mobilization & Demobilization	1	LS	4.0%	$484,000	
					Subtotal B:	**$12,567,000.00**
3	**Indirect Costs**				**$567,000**	
	Permits	1	LS	1.0%	$126,000	
	Risk & Liability Insurance	1	LS	1.5%	$189,000	
	Performance & Payment Bonds	1	LS	2.0%	$252,000	
					Subtotal C:	**$13,134,000.00**
4	**General Conditions & Contractor Markup**				**$2,760,000**	
	General Conditions	1	LS	6.0%	$789,000	
	Contractor's OH & P	1	LS	15.0%	$1,971,000	
					Subtotal D:	**$15,894,000.00**
5	**Contingency**	**1**	**LS**	**30%**	**$4,769,000.00**	
					Opinion of Probable Construction Cost:	**$20,663,000.00**
6	**Engineering, Legal, and Administration**	**1**	**LS**	**25.0%**	**$3,832,000**	
					Opinion of Probable Project Cost:	**$24,495,000.00**
4	**2021 O&M Costs**				**$413,000.00**	
	Labor	2,080	HR	$25.00	$52,000.00	
	Maintenance	1	LS	2.0%	$66,000.00	
	Natural Gas	-	mmBTU	$6.21	$0.00	
	Electricity	571,393	kWhr	$0.06	$35,000.00	
	Equipment Fuel	6,240	GAL	$3.10	$20,000.00	
	Hauling & Land Application	7,998	WT	$30.00	$240,000.00	
5	**2040 O&M Costs**				**$880,000.00**	
	Labor	4,493	HR	$ 45.15	$203,000.00	
	Maintenance	1	LS	2.0%	$66,000.00	
	Natural Gas	-	mmBTU	$6.21	$0.00	
	Electricity	1,327,107.80	kWhr	$0.06	$80,000.00	
	Equipment Fuel	13,478	GAL	$3.10	$42,000.00	
	Hauling & Land Application	16,299	WT	$30.00	$489,000.00	
6	**Net Present Value of Capital and O&M Costs**					**$32,850,000.00**

McKim & Creed, Inc.

Opinion of Probable Project Costs

Project:	Solids Management Plan
Project Number:	06496-0007
Prepared By:	Zachary Trammel, Josh Marlin, Katherine Van Sice
Date:	Monday, May 17, 2021
Checked By:	Chris Rosenboom
Subject:	**ATAD**

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT COST	EXTENSION	ITEM SUB TOTAL
					Net Present Value of Capital and O&M Costs	**$31,283,000**
1	**Equipment**	1	LS	$ 3,712,000	$3,712,000	
					Subtotal A:	**$3,712,000**
2	**Installation Costs**				**$9,976,000**	
	Mechanical Equipment Installation	1	LS	20.0%	$743,000	
	Electrical Installation Costs	1	LS	20.0%	$743,000	
	Instrumentation Installation Costs	1	LS	10.0%	$372,000	
	Structural	1	LS	$1,922,000	$1,922,000	
	Civil	1	LS	$136,000	$136,000	
	Demo	1	LS	$65,000	$65,000	
	WTF Residuals Pumping Station and Force Main	1	LS	$5,468,000	$5,468,000	
	Mobilization & Demobilization	1	LS	4.0%	$527,000	
					Subtotal B:	**$13,688,000**
3	**Indirect Costs**				**$617,000**	
	Permits	1	LS	1.0%	$137,000	
	Risk & Liability Insurance	1	LS	1.5%	$206,000	
	Performance & Payment Bonds	1	LS	2.0%	$274,000	
					Subtotal C:	**$14,305,000**
4	**General Conditions & Contractor Markup**				**$3,005,000**	
	General Conditions	1	LS	6.0%	$859,000	
	Contractor's OH & P	1	LS	15.0%	$2,146,000	
					Subtotal D:	**$17,310,000**
5	**Contingency**	**1**	**LS**	**30%**	**$5,193,000**	
					Opinion of Probable Construction Cost:	**$22,503,000**
6	**Engineering, Legal, and Administration**	**1**	**LS**	**25.0%**	**$4,174,000**	
					Opinion of Probable Project Cost:	**$26,677,000**
4	**2021 O&M Costs**				**$262,000**	
	Labor	520	HR	$25.00	$13,000	
	Maintenance	1	LS	2.0%	$75,000	
	Natural Gas	-	mmBTU	$6.21	$0	
	Electricity	789,809.72	kWhr	$0.06	$48,000	
	Equipment Fuel	-	GAL	$3.10	$0	
	Hauling & Land Application	4,178	WT	$30.00	$126,000	
5	**2040 O&M Costs**				**$440,000**	
	Labor	520	HR	$ 45.15	$24,000	
	Maintenance	1	LS	2.0%	$75,000	
	Natural Gas	-	mmBTU	$6.21	$0	
	Electricity	1,606,879	kWhr	$0.06	$97,000	
	Equipment Fuel	-	GAL	$3.10	$0	
	Hauling & Land Application	8,114	WT	$30.00	$244,000	
6	**Net Present Value of Capital and O&M Costs**					**$31,283,000**

McKim & Creed, Inc.

Opinion of Probable Project Costs

Project:	Solids Management Plan
Project Number:	06496-0007
Prepared By:	Zachary Trammel, Josh Marlin, Katherine Van Sice
Date:	Monday, May 17, 2021
Checked By:	Chris Rosenboom
Subject:	**Thermal Drying**

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT COST	EXTENSION	ITEM SUB TOTAL
					Net Present Value of Capital and O&M Costs	**$29,249,000.00**
1	**Equipment**				**$3,762,000**	
	Thermal Drying Equipment	1	LS	$ 2,486,500	$2,487,000	
	Conveyance Systems	200	LF	$ 2,000	$400,000	
	Storage Hopper Between BFP and Dryer	1	LS	$ 125,000	$125,000	
	Dry Solids Outload Station	1	LS	$ 750,000	$750,000	
					Subtotal A:	**$3,762,000.00**
2	**Installation Costs**				**$8,714,000**	
	Mechanical Equipment Installation	1	LS	20.0%	$753,000	
	Electrical Installation Costs	1	LS	20.0%	$753,000	
	Instrumentation Installation Costs	1	LS	10.0%	$377,000	
	Structural	1	LS	$639,450	$640,000	
	Civil	1	LS	$3,000	$3,000	
	Demo	1	LS	$239,900	$240,000	
	WTF Residuals Pumping Station and Force Main	1	LS	$5,467,500	$5,468,000	
	Mobilization & Demobilization	1	LS	4.0%	$480,000	
					Subtotal B:	**$12,476,000.00**
3	**Indirect Costs**				**$563,000**	
	Permits	1	LS	1.0%	$125,000	
	Risk & Liability Insurance	1	LS	1.5%	$188,000	
	Performance & Payment Bonds	1	LS	2.0%	$250,000	
					Subtotal C:	**$13,039,000.00**
4	**General Conditions & Contractor Markup**				**$2,739,000**	
	General Conditions	1	LS	6.0%	$783,000	
	Contractor's OH & P	1	LS	15.0%	$1,956,000	
					Subtotal D:	**$15,778,000.00**
5	**Contingency**	**1**	**LS**	**30%**	**$4,734,000.00**	
					Opinion of Probable Construction Cost:	**$20,512,000.00**
6	**Engineering, Legal, and Administration**	**1**	**LS**	**25.0%**	**$3,804,000**	
					Opinion of Probable Project Cost:	**$24,316,000.00**
4	**2021 O&M Costs**				**$267,000.00**	
	Labor	1,248	HR	$25.00	$32,000.00	
	Maintenance	1	LS	2.0%	$76,000.00	
	Natural Gas	14,000	mmBTU	$6.21	$87,000.00	
	Electricity	493,000	kWhr	$0.06	$30,000.00	
	Equipment Fuel	-	GAL	$3.10	$0.00	
	Hauling & Land Application	1,379	WT	$30.00	$42,000.00	
5	**2040 O&M Costs**				**$489,000.00**	
	Labor	2,080	HR	$ 45.15	$94,000.00	
	Maintenance	1	LS	2.0%	$76,000.00	
	Natural Gas	28,000	mmBTU	$6.21	$174,000.00	
	Electricity	983,900	kWhr	$0.06	$60,000.00	
	Equipment Fuel	-	GAL	$3.10	$0.00	
	Hauling & Land Application	2,819	WT	$30.00	$85,000.00	
6	**Net Present Value of Capital and O&M Costs**					**$29,249,000.00**

McKim & Creed, Inc.

Opinion of Probable Project Costs

Project:	Solids Management Plan
Project Number:	06496-0007
Prepared By:	Zachary Trammel, Josh Marlin, Katherine Van Sice
Date:	Monday, May 17, 2021
Checked By:	Chris Rosenboom
Subject:	**Thermal Drying + Third Party WTF Residuals Management**

ITEM	DESCRIPTION	QUANTITY	UNIT		UNIT COST	EXTENSION	ITEM SUB TOTAL
						Net Present Value of Capital and O&M Costs	**$24,580,000.00**
1	**Equipment**					**$3,084,000**	
	Thermal Drying Equipment	1	LS	$	1,808,100	$1,809,000	
	Conveyance Systems	200	LF	$	2,000	$400,000	
	Storage Hopper Between BFP and Dryer	1	LS	$	125,000	$125,000	
	Dry Solids Outload Station	1	LS	$	750,000	$750,000	
						Subtotal A:	**$3,084,000.00**
2	**Installation Costs**					**$3,343,000**	
	Mechanical Equipment Installation	1	LS		20.0%	$617,000	
	Electrical Installation Costs	1	LS		20.0%	$617,000	
	Instrumentation Installation Costs	1	LS		10.0%	$309,000	
	Structural	1	LS		$1,280,850	$1,281,000	
	Civil	1	LS		$30,800	$31,000	
	Demo	1	LS		$239,900	$240,000	
	Mobilization & Demobilization	1	LS		4.0%	$248,000	
						Subtotal B:	**$6,427,000.00**
3	**Indirect Costs**					**$291,000**	
	Permits	1	LS		1.0%	$65,000	
	Risk & Liability Insurance	1	LS		1.5%	$97,000	
	Performance & Payment Bonds	1	LS		2.0%	$129,000	
						Subtotal C:	**$6,718,000.00**
4	**General Conditions & Contractor Markup**					**$1,412,000**	
	General Conditions	1	LS		6.0%	$404,000	
	Contractor's OH & P	1	LS		15.0%	$1,008,000	
						Subtotal D:	**$8,130,000.00**
5	**Contingency**	**1**	**LS**		**30%**	**$2,439,000.00**	
						Opinion of Probable Construction Cost:	**$10,569,000.00**
6	**Engineering, Legal, and Administration**	**1**	**LS**		**25.0%**	**$1,960,000**	
						Opinion of Probable Project Cost:	**$12,529,000.00**
4	**2021 O&M Costs**					**$478,000.00**	
	Labor	1,248	HR		$25.00	$32,000.00	
	Maintenance	1	LS		2.0%	$62,000.00	
	Natural Gas	10,000	mmBTU		$6.21	$63,000.00	
	Electricity	316,000	kWhr		$0.06	$19,000.00	
	Equipment Fuel	-	GAL		$3.10	$0.00	
	Hauling & Land Application of Dried Biosolids	1,014	WT/yr		$30.00	$31,000.00	
	Third-Party Contracted Dewatering Services for WTF Residuals	1	LS		$161,916.00	$162,000.00	
	Third-Party Hauling & Land Application Services for WTF Residuals	1	LS		$108,948.00	$109,000.00	
5	**2040 O&M Costs**					**$1,424,000.00**	
	Labor	2,080	HR	$	45.15	$94,000.00	
	Maintenance	1	LS		2.0%	$62,000.00	
	Natural Gas	22,000	mmBTU		$6.21	$137,000.00	
	Electricity	681,000	kWhr		$0.06	$41,000.00	
	Equipment Fuel	-	GAL		$3.10	$0.00	
	Hauling & Land Application of Dried Biosolids	2,190	WT/yr		$30.00	$66,000.00	
	Third-Party Contracted Dewatering Services for WTF Residuals	1	LS	$	611,060.37	$612,000.00	
	Third-Party Contracted Hauling & Land Application Services for WTF Residuals	1	LS	$	411,162.61	$412,000.00	
6	**Net Present Value of Capital and O&M Costs**						**$24,580,000.00**

McKim & Creed, Inc.

Opinion of Probable Project Costs

Project:	Solids Management Plan
Project Number:	06496-0007
Prepared By:	Zachary Trammel, Josh Marlin, Katherine Van Sice
Date:	Monday, May 17, 2021
Checked By:	Chris Rosenboom
Subject:	**Recommended Phase 1 - WTF Residuals Storage and Contracting**

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT COST	EXTENSION	ITEM SUB TOTAL
1	**WTF Residuals Covered Storage Shelter**				**$697,000**	
	Structural	1	LS	$641,400	$642,000	
	Civil	1	LS	$27,800	$28,000	
	Mobilization & Demobilization	1	LS	4.0%	$27,000	
					Subtotal A:	**$697,000.00**
2	**Indirect Costs**				**$32,000**	
	Permits	1	LS	1.0%	$7,000	
	Risk & Liability Insurance	1	LS	1.5%	$11,000	
	Performance & Payment Bonds	1	LS	2.0%	$14,000	
					Subtotal C:	**$729,000.00**
3	**General Conditions & Contractor Markup**				**$154,000**	
	General Conditions	1	LS	6.0%	$44,000	
	Contractor's OH & P	1	LS	15.0%	$110,000	
					Subtotal D:	**$883,000.00**
4	**Contingency**	**1**	**LS**	**30%**	**$265,000.00**	
					Opinion of Probable Construction Cost:	**$1,148,000.00**
5	**Engineering, Legal, and Administration**	**1**	**LS**	**25.0%**	**$287,000**	
					Opinion of Probable Project Cost:	**$1,435,000.00**
6	**2021 O&M Costs**				**$271,000.00**	
	Third-Party Contracted Dewatering Services for WTF Residuals	1	LS	$161,916.00	$162,000.00	
	Third-Party Contracted Hauling & Land Application Services for WTF Residuals	1	LS	$108,948.00	$109,000.00	

McKim & Creed, Inc.

Opinion of Probable Project Costs

Project:	Solids Management Plan
Project Number:	06496-0007
Prepared By:	Zachary Trammel, Josh Marlin, Katherine Van Sice
Date:	Monday, May 17, 2021
Checked By:	Chris Rosenboom
Subject:	**Recommended Phase 2 - WWTF Thermal Drying Facility**

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT COST	EXTENSION	ITEM SUB TOTAL
1	**Equipment**				**$3,084,000**	
	Thermal Drying Equipment	1	LS	$ 1,808,100	$1,809,000	
	Conveyance Systems	200	LF	$ 2,000	$400,000	
	Storage Hopper Between BFP and Dryer	1	LS	$ 125,000	$125,000	
	Dry Solids Outload Station	1	LS	$ 750,000	$750,000	
					Subtotal A:	**$3,084,000.00**
2	**Installation Costs**				**$2,676,000**	
	Mechanical Equipment Installation	1	LS	20.0%	$617,000	
	Electrical Installation Costs	1	LS	20.0%	$617,000	
	Instrumentation Installation Costs	1	LS	10.0%	$309,000	
	Structural	1	LS	$639,450	$640,000	
	Civil	1	LS	$30,800	$31,000	
	Demo	1	LS	$239,900	$240,000	
	Mobilization & Demobilization	1	LS	4.0%	$222,000	
					Subtotal B:	**$5,760,000.00**
3	**Indirect Costs**				**$261,000**	
	Permits	1	LS	1.0%	$58,000	
	Risk & Liability Insurance	1	LS	1.5%	$87,000	
	Performance & Payment Bonds	1	LS	2.0%	$116,000	
					Subtotal C:	**$6,021,000.00**
4	**General Conditions & Contractor Markup**				**$1,266,000**	
	General Conditions	1	LS	6.0%	$362,000	
	Contractor's OH & P	1	LS	15.0%	$904,000	
					Subtotal D:	**$7,287,000.00**
5	**Contingency**	**1**	**LS**	**30%**	**$2,187,000.00**	
					Opinion of Probable Construction Cost:	**$9,474,000.00**
6	**Engineering, Legal, and Administration**	**1**	**LS**	**25.0%**	**$1,757,000**	
					Opinion of Probable Project Cost:	**$11,231,000.00**

McKim & Creed, Inc.

Opinion of Construction Costs

Project:	Solids Management Plan
Project Number:	06496-0007
Prepared By:	Bill Band, Zachary Trammel, Josh Marlin
Date:	Monday, May 17, 2021
Checked By:	Chris Rosenboom
Subject:	**Structural**

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT COST	EXTENSION	ITEM SUB TOTAL
1	**In-Vessel Composting**	1	LS	150%	**$1,458,075**	
	Existing Canopy Structure New Concrete Floor Slab: 182' x 122' x 8" thick	560	CY	$300	$168,000	
	Existing Canopy Structure New Concrete Stone base for Floor Slab: 182' x 122' x 8" thick	560	CY	$20	$11,200	
	Existing Canopy Structure: Remove & Replace Decking Roof: 182' x 122'	22,300	SF	$5	$111,500	
	Existing Canopy Structure Plastic Wall Enclosure: 91' x 122' x 15' high	18,600	SY	$4	$74,400	
	Existing Canopy Structure: Steel Coating System: Prep Existing Steel	47,000	SF	$7.80	$366,600	
	Existing Canopy Structure: Steel Coating System: Primer, Intermed & Top Coat New Steel	47,000	SF	$2.25	$105,750	
	Concrete Push Wall for Invessel Composting: 182' x 8' x 1'	60	CY	$600	$36,000	
	Concrete WTF Residuals Circular Equlization Tank: 12" walls	80	CY	$600	$48,000	
	Concrete WTF Residuals Circular Equlization Tank: 12" floor + discharge cone	60	CY	$450	$27,000	
	Concrete WTF Residuals Circular Equlization Tank: 24" thick foundation	70	CY	$300	$21,000	
	Concrete WTF Residuals Circular Equlization Tank: stone base for foundation	130	CY	$20	$2,600	
2	**Traditional Composting**	1	LS	150%	**$1,428,975**	
	Existing Canopy Structure New Concrete Floor Slab: 182' x 122' x 8" thick	560	CY	$300	$168,000	
	Existing Canopy Structure New Concrete Stone base for Floor Slab: 182' x 122' x 8" thick	560	CY	$20	$11,200	
	Existing Canopy Structure: Remove & Replace Decking Roof: 182' x 122'	22,300	SF	$5	$111,500	
	Existing Canopy Structure: Steel Coating System: Prep Existing Steel	47,000	SF	$7.80	$366,600	
	Existing Canopy Structure: Steel Coating System: Primer, Intermed & Top Coat New Steel	47,000	SF	$2.25	$105,750	
	Asphalt Slab for Windrow Composting: 6" thick, 74,000 ft^2	1,400	CY	$45	$63,000	
	Stone Based for Asphalt Slab for Windrow Composting: 6" thick, 74,000 ft^2	1,400	CY	$20	$28,000	
	Concrete WTF Residuals Circular Equlization Tank: 12" walls	80	CY	$600	$48,000	
	Concrete WTF Residuals Circular Equlization Tank: 12" floor + discharge cone	60	CY	$450	$27,000	
	Concrete WTF Residuals Circular Equlization Tank: 24" thick foundation	70	CY	$300	$21,000	
	Concrete WTF Residuals Circular Equlization Tank: stone base for foundation	130	CY	$20	$2,600	
3	**ATAD**	1	LS	150%	**$1,372,200**	
	Concrete ATAD & SNDR Rectangular Reactor Tanks: 8" walls, see comment for dimensions	440	CY	$600	$264,000	
	Concrete ATAD & SNDR Rectangular Reactor Tanks: 12" slab, 35' x 112"	310	CY	$300	$93,000	
	Concrete ATAD & SNDR Rectangular Reactor Tanks: 12" cover, 35' x 112"	310	CY	$300	$93,000	
	Concrete ATAD & SNDR Rectangular Reactor Tanks: stone base	310	CY	$20	$6,200	
	ATAD Pump Station Building: 56' x21'	1,200	SF	$100	$120,000	
	ATAD Thickening Building 40' x 60'	2,400	SF	$100	$240,000	
	Concrete WTF Residuals Circular Equlization Tank: 12" walls	80	CY	$600	$48,000	
	Concrete WTF Residuals Circular Equlization Tank: 12" floor + discharge cone	60	CY	$450	$27,000	
	Concrete WTF Residuals Circular Equlization Tank: 24" thick foundation	70	CY	$300	$21,000	
	Concrete WTF Residuals Circular Equlization Tank: stone base for foundation	130	CY	$20	$2,600	
4	**Thermal Drying**	1	LS	150%	**$639,450**	
	Existing Canopy Structure New Concrete Floor Slab: 100' x 60' x 8" thick	150	CY	$300	$45,000	
	Existing Canopy Structure New Concrete Stone base for Floor Slab: 100' x 60' x 8" thick	150	CY	$20	$3,000	
	Existing Canopy Structure: Remove & Replace Decking Roof: 182' x 122'	5,600	SF	$5	$28,000	
	Concrete Footing for Canopy Structure Intermed Columns: 5' sq. x 1' thick	4	CY	$450	$1,800	
	Additional wall-framing columns: W10,W12 or W14 Steel Columns	60	LF	$60	$3,600	
	Wall-framing girts: C9, C10 or C12 Steel Girts	1,280	LF	$80	$102,400	
	Misc Door Framing	1	LS	$20,000	$20,000	
	Sheet Metal Wall Panels: Galv'd Steel Colored, Corrugated/Ribbed 24 ga. Panels	4,800	SF	$7	$33,600	
	Existing Canopy Structure: Steel Coating System: Prep Existing Steel	18,000	SF	$7.80	$140,400	
	Existing Canopy Structure: Steel Coating System: Primer, Intermed & Top Coat New Steel	18,000	SF	$2.25	$40,500	
	10' Roll-up Door	2	EA	$4,000	$8,000	
5	**Thermal Drying + Third Party WTF Residuals Management**	1	LS	150%	**$1,280,850**	
	Existing Canopy Structure New Concrete Floor Slab: 100' x 60' x 8" thick	150	CY	$300	$45,000	
	Existing Canopy Structure New Concrete Stone base for Floor Slab: 100' x 60' x 8" thick	150	CY	$20	$3,000	
	Existing Canopy Structure: Remove & Replace Decking Roof: 182' x 122'	5,600	SF	$5	$28,000	
	Concrete Footing for Canopy Structure Intermed Columns: 5' sq. x 1' thick	4	CY	$450	$1,800	
	Additional wall-framing columns: W10,W12 or W14 Steel Columns	60	LF	$60	$3,600	
	Wall-framing girts: C9, C10 or C12 Steel Girts	1,280	LF	$80	$102,400	
	Misc Door Framing	1	LS	$20,000	$20,000	
	Sheet Metal Wall Panels: Galv'd Steel Colored, Corrugated/Ribbed 24 ga. Panels	4,800	SF	$7	$33,600	
	Existing Canopy Structure: Steel Coating System: Prep Existing Steel	18,000	SF	$7.80	$140,400	
	Existing Canopy Structure: Steel Coating System: Primer, Intermed & Top Coat New Steel	18,000	SF	$2.25	$40,500	
	10' Roll-up Door	2	EA	$4,000	$8,000	
	WTF Residuals Storage Shelter Concrete Floor Slab: 100' x 150' x 8" thick	380	CY	$300	$114,000	
	WTF Residuals Storage Shelter Stone Base for Floor Slab: 100' x 150' x 8" thick	380	CY	$20	$7,600	
	WTF Residuals Storage Shelter Steel I-Beam Metal Building: 100' x 150'	15000	SF	$14	$210,000	
	WTF Residuals Storage Shelter: Delivery for Building Materials	1	LS	10%	$21,000	
	WTF Residuals Storage Shelter: Construction of Metal Building	15000	SF	$5	$75,000	

In-Vessel Composting Grading Cost Estimate

Compost Excavation Costs	Building	Area (sq ft)	Excavation Depth (ft)	Excavation Volume (cf)	Excavation Volume (cy)	Cost
	Biofilter	5,320	1	5,320	197	2,956
Total	-	5,320	-	5,320	197	$ 2,956

Traditional Composting Grading Cost Estimate

	Area (sq ft)	Elevation (ft)	Max Fill Height (ft)	Max Fill Volume (cf)	Max Fill Volume (cy)	Max Fill Accounting for Shrinkage (cy)	Cost
Compost Grading Costs	5,664	2106 to 2108	2	11,328	420	545	$ 27,271
	1,008	2106 to 2108	2	2,016	75	97	$ 4,853
	22,937	2104 to 2106	4	91,748	3,398	4,417	$ 220,875
	6,876	2102 to 2104	6	41,256	1,528	1,986	$ 99,320
	666	2102 to 2104	6	3,996	148	192	$ 9,620
	5,489	2100 to 2102	8	43,912	1,626	2,114	$ 105,714
	5,326	2098 to 2100	10	53,260	1,973	2,564	$ 128,219
	5,186	2096 to 2098	12	62,232	2,305	2,996	$ 149,818
	5,615	2094 to 2096	14	78,610	2,911	3,785	$ 189,246
	5,845	2092 to 2094	16	93,520	3,464	4,503	$ 225,141
	7,874	2090 to 2092	18	141,732	5,249	6,824	$ 341,207
	1,467	2088 to 2090	20	29,340	1,087	1,413	$ 70,633
Total	73,953	-	-	652,950	24,183	31,438	$ 1,571,917

Note

- Assuming shrinkage factor of 30%
- Assuming $50/cy - high end estimate that should include material, loading, hauling, spreading, and compacting

ATAD - Grading & Excavation
Cost Estimate

ATAD Grading Costs	Area (sq ft)	Elevation (ft)	Max Fill Height (ft)	Max Fill Volume (cf)	Max Fill Volume (cy)	Max Fill Accounting for Shrinkage (cy)	Cost
	6,442	2104 to 2106	4	25,768	954	1,241	$ 62,034
	1,531	2102 to 2104	6	9,188	340	442	$ 22,120
Total	7,973	-	-	34,956	1,295	1,683	$ 84,154

Note
- Assuming shrinkage factor of 30%
- Assuming $50/cy - high end estimate that should include material, loading, hauling, spreading, and compacting

ATAD Excavation Costs	Building	Area (sq ft)	Excavation Depth (ft)	Excavation Volume (cf)	Excavation Volume (cy)	Cost
	Gravity Belt Thickening Buil	2,385	3	7,155	265	3,975
	SNDR Reactor	1,970	3	5,910	219	3,283
	ATAD Reactor	998	3	2,994	111	1,663
	ATAD Reactor	998	3	2,994	111	1,663
	Blower and Pump Building	1,145	3	3,435	127	1,908
	Biofilter	802	1	802	29.70	446
	Biofilter	55	1	55	2	31
Total	-	8,353	-	23,345	865	$ 12,969

Grading & Excavation Total Cost	$ 97,124

Thermal Drying Grading
Cost Estimate

Thermal Drying Costs	Building	Area (sq ft)	Excavation Depth (ft)	Excavation Volume (cf)	Excavation Volume (cy)	Cost
	Loadout area	1,600	1	1,600	59	2,962.96
Total	-	1,600	-	1,600	59	$ 2,963

Thermal Drying + Third Party WTF Residuals Management Grading
Cost Estimate

TD+TPRM Costs	Building	Area (sq ft)	Excavation Depth (ft)	Excavation Volume (cf)	Excavation Volume (cy)	Cost
	Loadout area	1,600	1	1,600	59	2,962.96
	Covered shelter area	15,000	1	15,000	556	27,777.78
Total	-	1,600	-	1,600	59	$ 30,741

In-Vessel Composting Demo
Cost Estimate

Demo for Existing Canopy Structure			
8" Concrete Slab		Cost/sf	Cost
22204	Sq ft	$ 9.00	$ 199,836.00
Sub total			$ 199,836.00
Contingency			$ 39,967.20
Estimated Total			$ 239,803.20

Traditional Composting/ATAD Demo
Cost Estimate

ACM Abatement Estimate				
Admin building				
2,000	sf			
	Quantity	Unit	Cost/unit	Cost
HVAC tape/insulation	1000	lf	$ 13.00	$ 13,000.00
Floor tiles/mastic	2000	sf	$ 4.00	$ 8,000.00
Lab Counter tops	2	sf	$ 200.00	$ 400.00
Ceiling tiles	2000	sf	$ 2.00	$ 4,000.00
Pipe Insulation	400	lf	$ 15.00	$ 6,000.00
Roof	2000	lf	$ 2.00	$ 4,000.00
Windows	15	window	$ 100.00	$ 1,500.00
Water Proofing	357.7708764	sf	$ 4.00	$ 1,431.08
Sub total				$ 38,331.08
Contingency				$ 7,666.22
Estimated total				$ 45,997.30
Pump Station				
300	sf			
	Quantity	Unit	Cost/unit	Cost
water proofing	138.5640646	sf	$ 4.00	$ 554.26
roof	300	sf	$ 2.00	$ 600.00
window/door glazing	3	window	$ 100.00	$ 300.00
Sub total				$ 1,454.26
Contingency				$ 290.85
Estimated total				$ 1,745.11

Demo Estimate			
Admin building		Cost/sf	Cost
2,000	sf	$ 6.00	$ 12,000.00
Pump Station			
300	sf	$ 6.00	$ 1,800.00
Sub total			$ 13,800.00
Contingency			$ 2,760.00
Estimated Total			$ 16,560.00

Total Demo & Asbestos Cost	$ 64,302.41

Thermal Drying Demo
Cost Estimate

Demo for Existing Canopy Structure			
8" Concrete Slab		Cost/sf	Cost
22204	sq ft	$ 9.00	$ 199,836.00
Sub total			$ 199,836.00
Contingency			$ 39,967.20
Estimated Total			$ 239,803.20

McKim & Creed, Inc.

Opinion of Construction Costs

Project:	Solids Management Plan
Project Number:	06496-0007
Prepared By:	Zachary Trammel, Josh Marlin
Date:	Monday, May 17, 2021
Checked By:	Chris Rosenboom
Subject:	**Residuals Transport**

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT COST	EXTENSION	ITEM SUB TOTAL
1	**WTF Residuals Force Main**				**$4,297,500**	
	6" Residuals Transfer Force Main	38,035	LF	$100	$3,803,500	
	Bore & Jack Crossings	15	EA	$16,000	$240,000	
	Air Release Valves	14	EA	$10,000	$140,000	
	Stream/River Crossings	2	EA	$57,000	$114,000	
2	**WTF Residuals Pump Station**				**$1,170,000**	
	Residuals Transfer Pumps & Equipment	1	LS	$420,000	$420,000	
	Residuals Transfer Pump Station	1	LS	$200,000	$200,000	
	E&I	1	LS	$50,000	$50,000	
	Sitework	1	LS	$200,000	$200,000	
	Demolition	1	LS	$100,000	$100,000	
	Piping Modifications	1	LS	$200,000	$200,000	
				Total	**$5,467,500**	
3	**WTF Residuals Hauling**					
	2020 Annual WTF Residuals Hauling Cost	2,190.00	WT/yr	$7.00	$15,330	
	2040 Annual WTF Residuals Hauling Cost	3,771.67	WT/yr	$12.64	$47,674	
4	**WTF Residuals Pumping**					
	2020 Annual WTF Residuals Pumping Cost	45,662	WT/yr	$ 0.07	$3,242	
	2040 Annual WTF Residuals Pumping Cost	78,538	WT/yr	$ 0.13	$10,069	

O&M Net Present Value

In-Vessel Composting System

Year	Period (n)	O&M Cost	P/A Series	P/G Series
2021	1	$413,000.00	$413,000.00	$ -
2022	3	$437,578.95	$413,000.00	$ 24,578.95
2023	4	$462,157.89	$413,000.00	$ 49,157.89
2024	5	$486,736.84	$413,000.00	$ 73,736.84
2025	6	$511,315.79	$413,000.00	$ 98,315.79
2026	7	$535,894.74	$413,000.00	$ 122,894.74
2027	8	$560,473.68	$413,000.00	$ 147,473.68
2028	9	$585,052.63	$413,000.00	$ 172,052.63
2029	10	$609,631.58	$413,000.00	$ 196,631.58
2030	11	$634,210.53	$413,000.00	$ 221,210.53
2031	12	$658,789.47	$413,000.00	$ 245,789.47
2032	13	$683,368.42	$413,000.00	$ 270,368.42
2033	14	$707,947.37	$413,000.00	$ 294,947.37
2034	15	$732,526.32	$413,000.00	$ 319,526.32
2035	16	$757,105.26	$413,000.00	$ 344,105.26
2036	17	$781,684.21	$413,000.00	$ 368,684.21
2037	18	$806,263.16	$413,000.00	$ 393,263.16
2038	19	$830,842.11	$413,000.00	$ 417,842.11
2039	20	$855,421.05	$413,000.00	$ 442,421.05
2040	21	$880,000.00	$413,000.00	$ 467,000.00

Net Present Value Analysis

n	20
i	4%
A	$ 413,000.00
G	$ 24,578.95
P/A Factor	13.5903
P/G Factor	111.5647
In-Vessel Composting System Net Present Value	**$ 8,354,936.79**

O&M Net Present Value

Traditional Composting

Year	Period (n)	O&M Cost	P/A Series	P/G Series
2021	1	$ 549,000.00	$ 549,000.00	$ -
2022	3	$ 590,105.26	$ 549,000.00	$ 41,105.26
2023	4	$ 631,210.53	$ 549,000.00	$ 82,210.53
2024	5	$ 672,315.79	$ 549,000.00	$ 123,315.79
2025	6	$ 713,421.05	$ 549,000.00	$ 164,421.05
2026	7	$ 754,526.32	$ 549,000.00	$ 205,526.32
2027	8	$ 795,631.58	$ 549,000.00	$ 246,631.58
2028	9	$ 836,736.84	$ 549,000.00	$ 287,736.84
2029	10	$ 877,842.11	$ 549,000.00	$ 328,842.11
2030	11	$ 918,947.37	$ 549,000.00	$ 369,947.37
2031	12	$ 960,052.63	$ 549,000.00	$ 411,052.63
2032	13	$ 1,001,157.89	$ 549,000.00	$ 452,157.89
2033	14	$ 1,042,263.16	$ 549,000.00	$ 493,263.16
2034	15	$ 1,083,368.42	$ 549,000.00	$ 534,368.42
2035	16	$ 1,124,473.68	$ 549,000.00	$ 575,473.68
2036	17	$ 1,165,578.95	$ 549,000.00	$ 616,578.95
2037	18	$ 1,206,684.21	$ 549,000.00	$ 657,684.21
2038	19	$ 1,247,789.47	$ 549,000.00	$ 698,789.47
2039	20	$ 1,288,894.74	$ 549,000.00	$ 739,894.74
2040	21	$ 1,330,000.00	$ 549,000.00	$ 781,000.00

Net Present Value Analysis

n	20
i	4%
A	$ 549,000.00
G	$ 41,105.26
P/A Factor	13.5903
P/G Factor	111.5647
Traditional Composting Net Present Value	**$ 12,046,971.05**

O&M Net Present Value

ATAD

Year	**Period (n)**	**O&M Cost**	**P/A Series**	**P/G Series**
2021	1	$ 262,000.00	$ 262,000.00	$ -
2022	3	$ 271,368.42	$ 262,000.00	$ 9,368.42
2023	4	$ 280,736.84	$ 262,000.00	$ 18,736.84
2024	5	$ 290,105.26	$ 262,000.00	$ 28,105.26
2025	6	$ 299,473.68	$ 262,000.00	$ 37,473.68
2026	7	$ 308,842.11	$ 262,000.00	$ 46,842.11
2027	8	$ 318,210.53	$ 262,000.00	$ 56,210.53
2028	9	$ 327,578.95	$ 262,000.00	$ 65,578.95
2029	10	$ 336,947.37	$ 262,000.00	$ 74,947.37
2030	11	$ 346,315.79	$ 262,000.00	$ 84,315.79
2031	12	$ 355,684.21	$ 262,000.00	$ 93,684.21
2032	13	$ 365,052.63	$ 262,000.00	$ 103,052.63
2033	14	$ 374,421.05	$ 262,000.00	$ 112,421.05
2034	15	$ 383,789.47	$ 262,000.00	$ 121,789.47
2035	16	$ 393,157.89	$ 262,000.00	$ 131,157.89
2036	17	$ 402,526.32	$ 262,000.00	$ 140,526.32
2037	18	$ 411,894.74	$ 262,000.00	$ 149,894.74
2038	19	$ 421,263.16	$ 262,000.00	$ 159,263.16
2039	20	$ 430,631.58	$ 262,000.00	$ 168,631.58
2040	21	$ 440,000.00	$ 262,000.00	$ 178,000.00

Net Present Value Analysis

n	20
i	4%
A	$ 262,000.00
G	$ 9,368.42
P/A Factor	13.5903
P/G Factor	111.5647
ATAD Net Present Value	**$ 4,605,843.68**

O&M Net Present Value

Thermal Drying

Year	Period (n)	O&M Cost	P/A Series	P/G Series
2021	1	$ 267,000.00	$ 267,000.00	$ -
2022	3	$ 278,684.21	$ 267,000.00	$ 11,684.21
2023	4	$ 290,368.42	$ 267,000.00	$ 23,368.42
2024	5	$ 302,052.63	$ 267,000.00	$ 35,052.63
2025	6	$ 313,736.84	$ 267,000.00	$ 46,736.84
2026	7	$ 325,421.05	$ 267,000.00	$ 58,421.05
2027	8	$ 337,105.26	$ 267,000.00	$ 70,105.26
2028	9	$ 348,789.47	$ 267,000.00	$ 81,789.47
2029	10	$ 360,473.68	$ 267,000.00	$ 93,473.68
2030	11	$ 372,157.89	$ 267,000.00	$ 105,157.89
2031	12	$ 383,842.11	$ 267,000.00	$ 116,842.11
2032	13	$ 395,526.32	$ 267,000.00	$ 128,526.32
2033	14	$ 407,210.53	$ 267,000.00	$ 140,210.53
2034	15	$ 418,894.74	$ 267,000.00	$ 151,894.74
2035	16	$ 430,578.95	$ 267,000.00	$ 163,578.95
2036	17	$ 442,263.16	$ 267,000.00	$ 175,263.16
2037	18	$ 453,947.37	$ 267,000.00	$ 186,947.37
2038	19	$ 465,631.58	$ 267,000.00	$ 198,631.58
2039	20	$ 477,315.79	$ 267,000.00	$ 210,315.79
2040	21	$ 489,000.00	$ 267,000.00	$ 222,000.00

Net Present Value Analysis

n	20
i	4%
A	$ 267,000.00
G	$ 11,684.21
P/A Factor	13.5903
P/G Factor	111.5647
Thermal Drying Net Present Value	**$ 4,932,155.54**

O&M Net Present Value

Thermal Drying + Third Party WTF Residuals Management

Year	Period (n)	O&M Cost	P/A Series	P/G Series
2021	1	$ 478,000.00	$ 478,000.00	$ -
2022	3	$ 527,789.47	$ 478,000.00	$ 49,789.47
2023	4	$ 577,578.95	$ 478,000.00	$ 99,578.95
2024	5	$ 627,368.42	$ 478,000.00	$ 149,368.42
2025	6	$ 677,157.89	$ 478,000.00	$ 199,157.89
2026	7	$ 726,947.37	$ 478,000.00	$ 248,947.37
2027	8	$ 776,736.84	$ 478,000.00	$ 298,736.84
2028	9	$ 826,526.32	$ 478,000.00	$ 348,526.32
2029	10	$ 876,315.79	$ 478,000.00	$ 398,315.79
2030	11	$ 926,105.26	$ 478,000.00	$ 448,105.26
2031	12	$ 975,894.74	$ 478,000.00	$ 497,894.74
2032	13	$ 1,025,684.21	$ 478,000.00	$ 547,684.21
2033	14	$ 1,075,473.68	$ 478,000.00	$ 597,473.68
2034	15	$ 1,125,263.16	$ 478,000.00	$ 647,263.16
2035	16	$ 1,175,052.63	$ 478,000.00	$ 697,052.63
2036	17	$ 1,224,842.11	$ 478,000.00	$ 746,842.11
2037	18	$ 1,274,631.58	$ 478,000.00	$ 796,631.58
2038	19	$ 1,324,421.05	$ 478,000.00	$ 846,421.05
2039	20	$ 1,374,210.53	$ 478,000.00	$ 896,210.53
2040	21	$ 1,424,000.00	$ 478,000.00	$ 946,000.00

Net Present Value Analysis

n	20
i	4%
A	$ 478,000.00
G	$ 49,789.47
P/A Factor	13.5903
P/G Factor	111.5647

Thermal Drying + Third Party WTF Residuals Management
Net Present Value $12,050,911.09

APPENDIX B – COMPOSTING SUPPORTING INFORMATION

Contents:

1. MSAP composting presentation, provided by Harvest Quest International, Inc.

2. BDP Industries In-Vessel Composting Budgetary Quote

3. BDP Industries In-vessel Composting Detailed Process Description

4. Scarab International Windrow Mixer Cutsheet

5. Scarab International Windrow Mixer Budgetary Quote

MANAGING BIOSOLIDS THROUGH COMPOSTING

THE MODIFIED STATIC AEROBIC PILE (MSAP) METHOD

ADVANCED RESIDUALS MANAGEMENT

PROJECT BACKGROUND

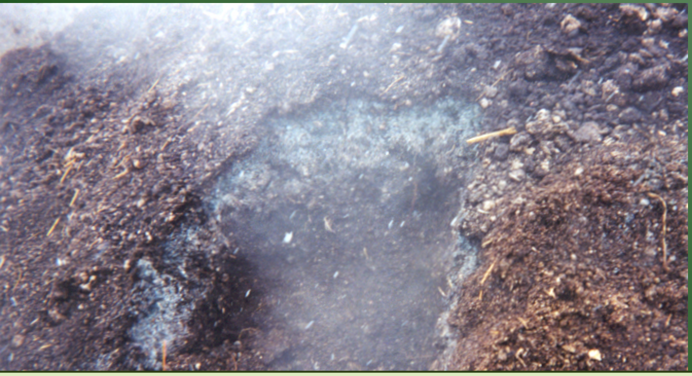
- In March 2015, The Hillsborough County Public Utilities and Public Works Departments initiated a pilot co-composting facility combining two waste streams — biosolids and yard waste
- The pilot was conducted on 3 acres of an inactive lined cell on top of the 162-acre regional Southeast County Landfill
- The pilot project served to determine the following:
  - ✓ Confirmation of the Public Works Department’s ability to manage the program using internal personnel and resources
  - ✓ Reduction in costs associated with biosolids transportation and disposal
  - ✓ Confirmation of the marketability of the finished compost product
- Realizing all of the above goals led the County to proceed with construction of an expanded composting facility that essentially doubled composting capacity

COMPOSTING METHODOLOGY

- The County utilizes the Modified Static Aerobic Pile (MSAP) Method developed by Harvest Quest (HQ)
- HQ creates proprietary microbial inoculants, which:
  - ✓ Contain diverse populations of enzyme-producing bacteria
  - ✓ Accelerate the natural biological process of composting
  - ✓ Reverse the physics of temperature generation in a composting pile
- These unique characteristics led to the development of the MSAP Method
  - ✓ A combination of Static Pile and Windrow Methods
  - ✓ Largely eliminates mechanical turning
  - ✓ Mitigates odors
  - ✓ Results in a superior compost product

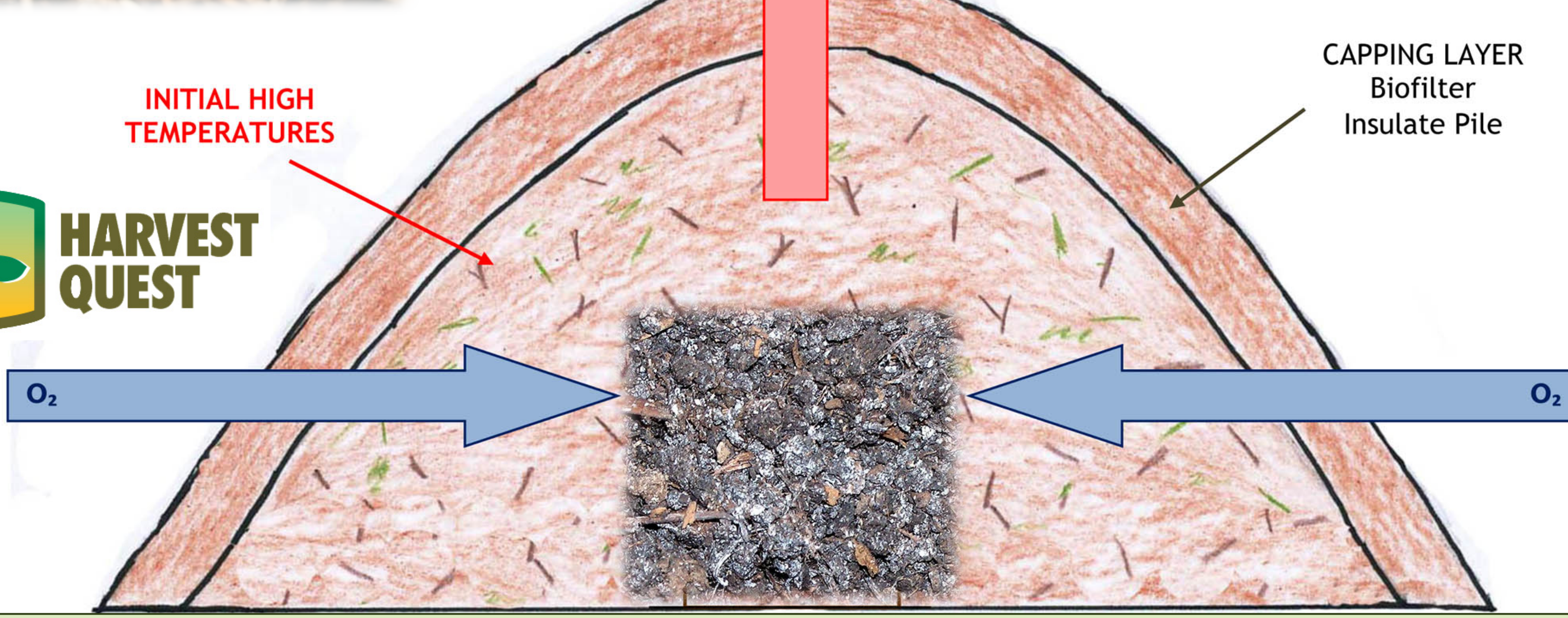
PROLIFERATION OF THE MICROBES

- The microbes multiply and move rapidly
  - ✓ Outwards (horizontally) initially
  - ✓ Then inwards (towards the center of the pile)
- This activity generates high temperatures well in excess of pathogen destruction
- Increased bacterial activity makes for hotter composting temperatures
- By not continually turning the rows, high bacteria densities are maintained, thus increasing efficiency



ACCELERATED AEROBIC DECOMPOSITION

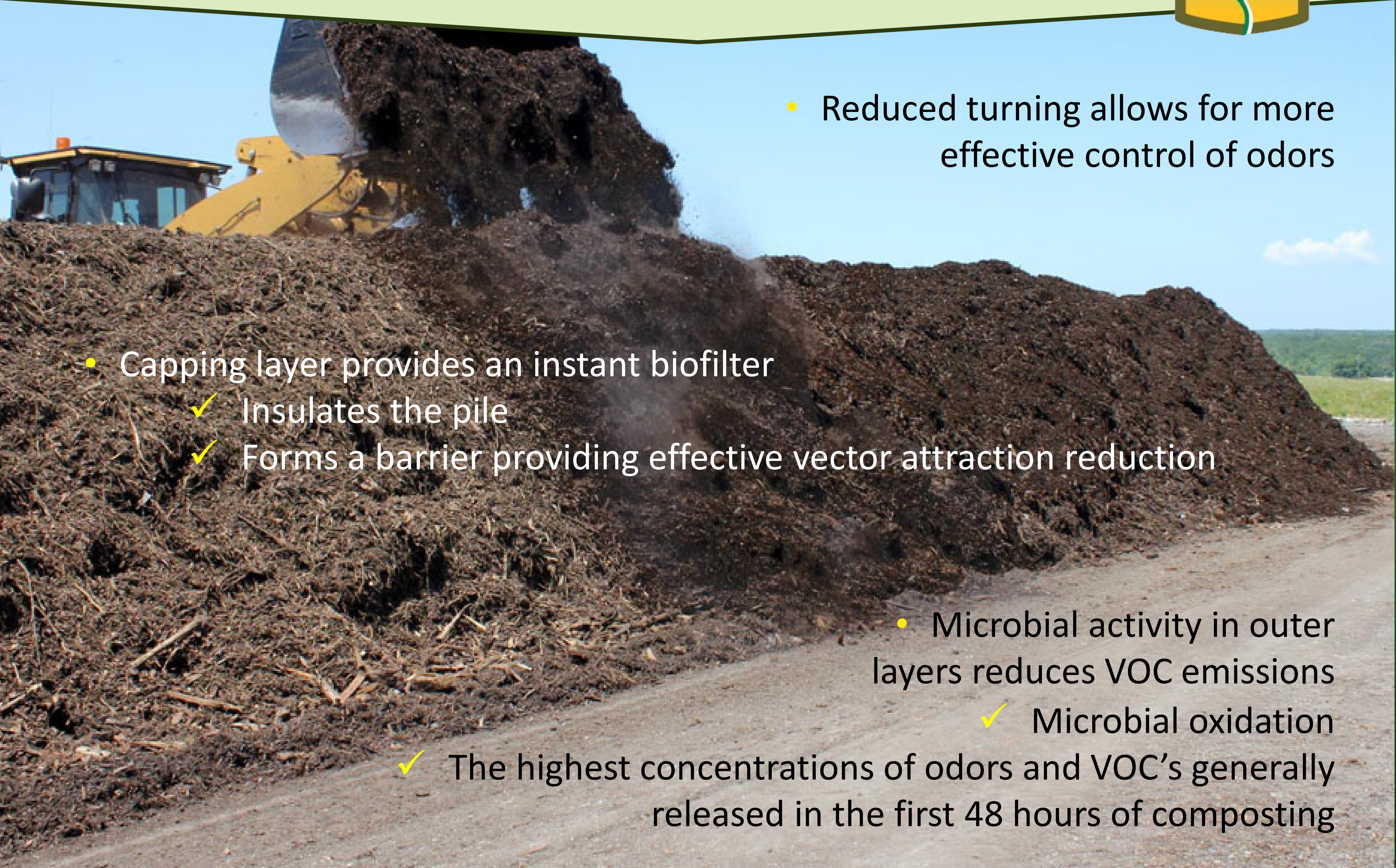
- Movement of the microbes from the outside in draws oxygen towards the core of the pile
- Windrows have the ability to largely remain aerobic without the need for frequent turning



HARVEST QUEST

Reverses the Dynamics of a Compost Pile

ODOR & VECTOR MITIGATION



- Reduced turning allows for more effective control of odors
- Capping layer provides an instant biofilter
  - ✓ Insulates the pile
  - ✓ Forms a barrier providing effective vector attraction reduction
- Microbial activity in outer layers reduces VOC emissions
  - ✓ Microbial oxidation
  - ✓ The highest concentrations of odors and VOC's generally released in the first 48 hours of composting

MSAP METHODOLOGY

- Mix feedstocks (typically 3 parts yard waste to 1 part biosolids v:v)
- Construct windrow
- Apply inoculant (applied to surface of pile in 2 or 3 locations)
- Cap the windrow (unscreened compost or Over's)
- Pile remains undisturbed for approximately 4 weeks
- First turn (Day 28)
- Second turn (Day 42)
- Screen (Day 50)




Accelerates the Natural Biological Process of Composting

MATERIALS HANDLING

SUMMARY OF BENEFITS

- ✓ Largely eliminates mechanical turning
- ✓ Maintains aerobic conditions
- ✓ Provides excellent pathogen destruction
- ✓ Higher temperatures for longer time periods
- ✓ Mitigates odors
- ✓ Less nitrogen losses through ammonia volatilization
- ✓ Less overall composting timeframe & required footprint
- ✓ Can be utilized in any climate
- ✓ Requires minimal investment in infrastructure
- ✓ Results in a superior compost product

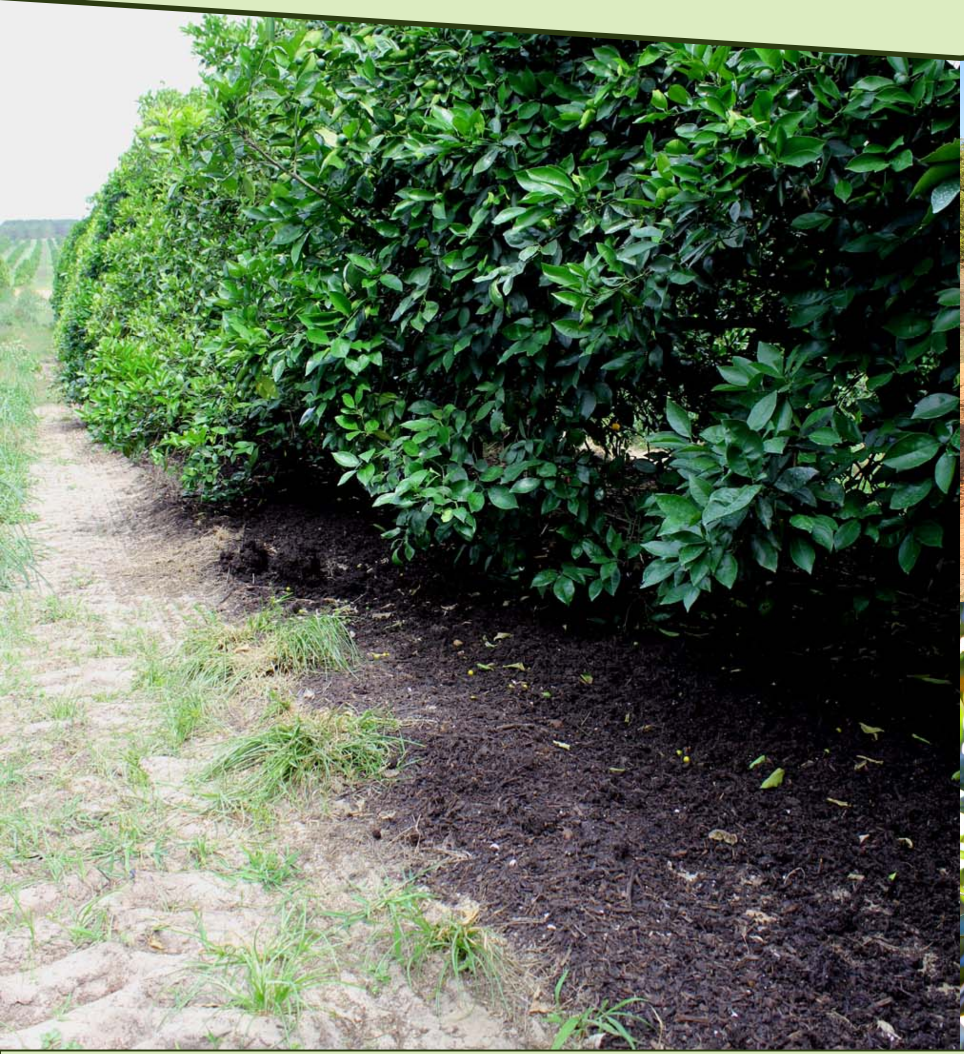
MSAP REGULATORY COMPLIANCE

- MSAP is a combination of both Static Pile and Windrow methods
- First recognized by Environmental Protection Agency (EPA) in July 2001
    - ✓ Composting method modification to EPA's 40 CFR 503 Appendix B PSRP A.4. and PFRP B.1.
- An approved composting methodology, not an alternative PFRP process
- Approvals are site or State specific and provide an alternative method of meeting compliance with existing 503 regulations
- The EPA has traditionally viewed Static Piles as engineered piles with man-made conveyances providing air (oxygen) movement
- The MSAP method has demonstrated to EPA staff that the inoculant working the piles from the outside-in is just as effective in drawing oxygen into the piles as is piping attached to a fan.

UNIQUE FINISHED COMPOST

- Compost contains unusually high counts of beneficial microbes
- Provides stabilized organic matter
- Improves the soils ability to hold nutrients and water
- Reduces the need for synthetic inputs
- Protects Watersheds

APPLICATION IN CITRUS GROVES



Widespread Adoption of Compost Use in Citrus Production

TURFGRASS

PROFESSIONAL SPORTS TURF

ENGINEERED WETLANDS

Compost Use in Bioretention Areas

HARVEST QUEST

THANK YOU !

Darren Midlane
V.P. & Chief Technical Officer
Harvest Quest International, Inc.

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Environmental Solutions, Economic Sense

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4 November 2019

Clearwater, INC
Attention: Michael S. Knight
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PO Box 1469, Hickory, North Carolina 28603-1469
(828) 855-3182 (office)
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mike@clearwaterinc.net

Subject: Hendersonville, NC Biosolids Composting Facility Budgetary Estimate

Mike,

Following up on recent conversations, attached find BDP's 5,625 Wet Ton per Year (WTPY) Biosolids at 17% dry solids (DS) Materials Balance, Conceptual Layout and Budgetary Estimate utilizing the Hendersonville's (City) existing 122 ft x 182 ft biosolids storage building. I also provide BDP's estimated expansion requirements for the 2040 capacity of 8,631 WTPY.

For the **current capacity**, BDP is recommending the (5) 6.5 ft high x 10 ft wide x 140 ft long bays as previously discussed and as per the Materials Balance presented in Table 1 below.

Referring to the attached drawings 1 - 3, BDP proposes these bays be located on the southern half of the building = "compost side". A new E-W interior wall would need to be built along the central column line to isolate the bays from the remaining 61 ft x 182 ft half of the building = "mixing/curing" side". This new wall could be constructed of translucent, corrosion resistant plastic sheeting with a fabric roll up door between columns 1 & 2 for loader access from the mixing area to the bays.

The same plastic material could be used to enclose the southern side of the building with another roll up door between columns 2 and 3 to allow for the BDP dolly and agitator to be moved outside, in the existing roadway, for maintenance and crane access as needed. The west end of the compost side would also be a plastic wall. The east end of the compost side would be a door for loader access to the bays for removing the compost and transferring it to the curing area. All other portions of the building could remain open however we would expect some portion of the north wall of the building to have a new 8 ft high push wall constructed to accommodate loader movement for the mixing, curing and amendment storage areas.

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The biofilter and facility ventilation fans would go to the north of the building. The bay aeration blowers would go along the outer side of south wall under an overhang. The current roadway there scales at @ 20 ft wide and BDP would expect there would still be at least 15 ft of clear width remaining with the blowers installed.

The @ 300 SF MCC/Control building and new trommel screen for post curing screening of the compost could go where is most convenient.

TABLE 1 - MATERIALS BALANCE

ICS Composting Facility

Hendersonville, NC 2020 Capacity

5,625 WTPY Biosolids at 17% DS 21 Days Detention

MATERIALS	WET TONS PER DAY	PERCENT DRY SOLIDS	DRY TONS PER DAY	VOLUME CY	BULK DENSITY TONNES/CY
Biosolids	18.0	17%	3	23	0.80
Green/Wood Waste	15.2	60%	9	51	0.30
Recycled Overs	3.0	65%	2	10	0.30
INPUT TO BAYS	**36**	**39%**	**14**	**72**	**0.50**
OUTPUT to CURING	**18**	**60%**	**11**	**43**	**0.40**
OVERS to RECYCLE	**3**	**65%**	**2**	**10**	**0.30**
STORAGE or DISTRIBUTION	**14**	**65%**	**10**	**35**	**0.40**

Design Criteria and Assumptions

1. 5 Wide bays – each 10 ft wide X 6.5 ft deep X 140 ft long.
2. 25 Cubic ft loading capacity per bay per loading charge per Burlington Cty machine
3. Biosolids delivered 6 days per week
4. Each bay agitated 3 - 4 times per week
5. Retention time will be 21 days active processing
6. Each workday will require about 3 hours of agitator runtime
7. 40% volume loss in active processing
8 Have to use 6.5ft deep machine due to existing overhead clearance

Biosolids	5,625	(WTPY)
	7,032	(CYPY)
Green/Wood Waste	4,733	(WTPY)
	15,777	(CYPY)
Compost Product =	4,429	(WTPY)
	11,072	(CYPY)

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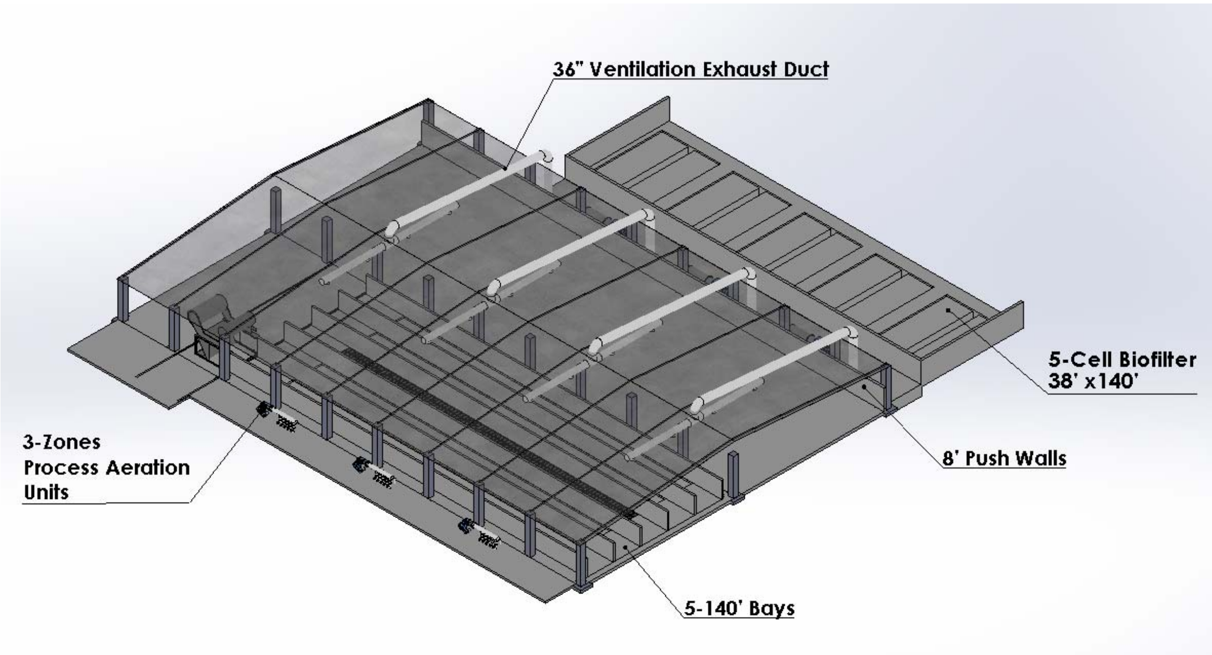
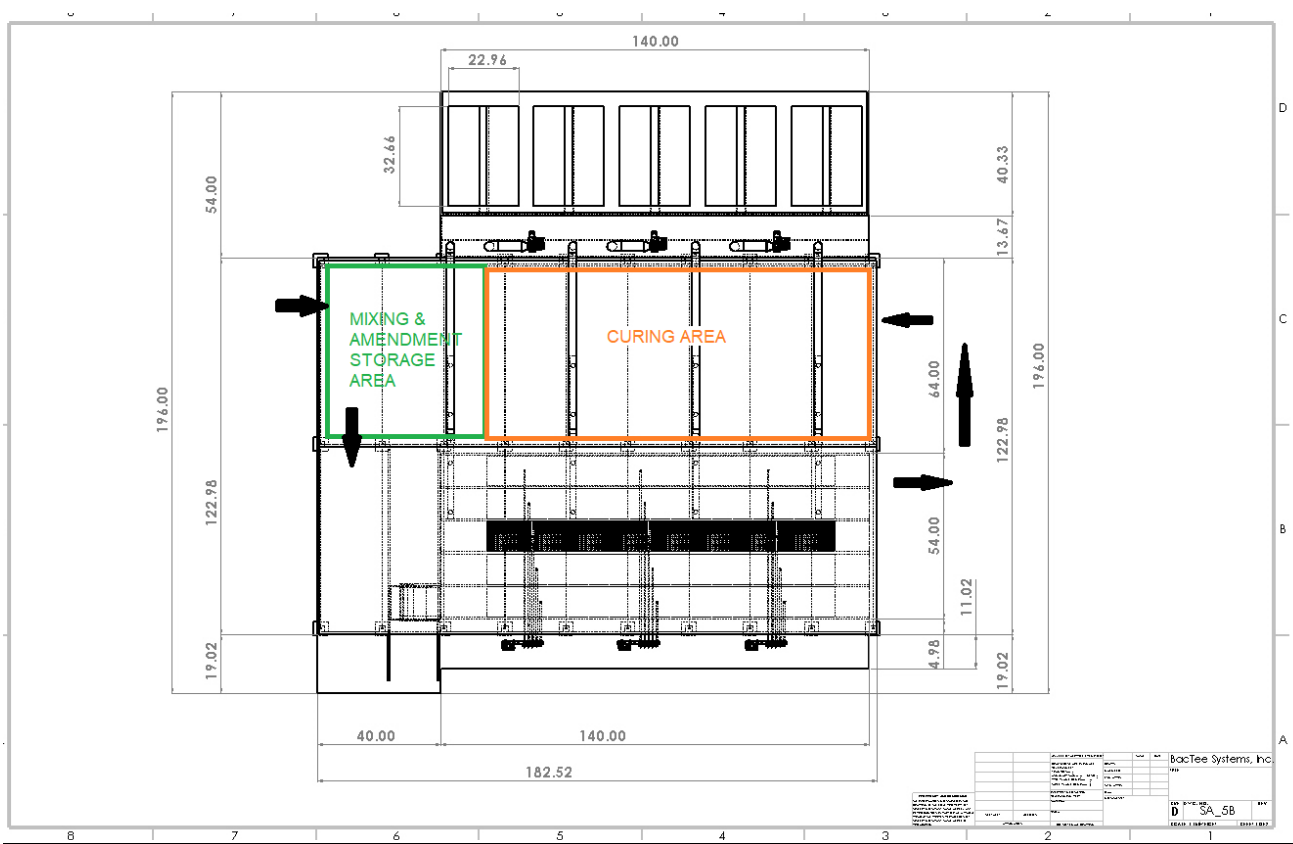
Dwg 1



Dwg 2



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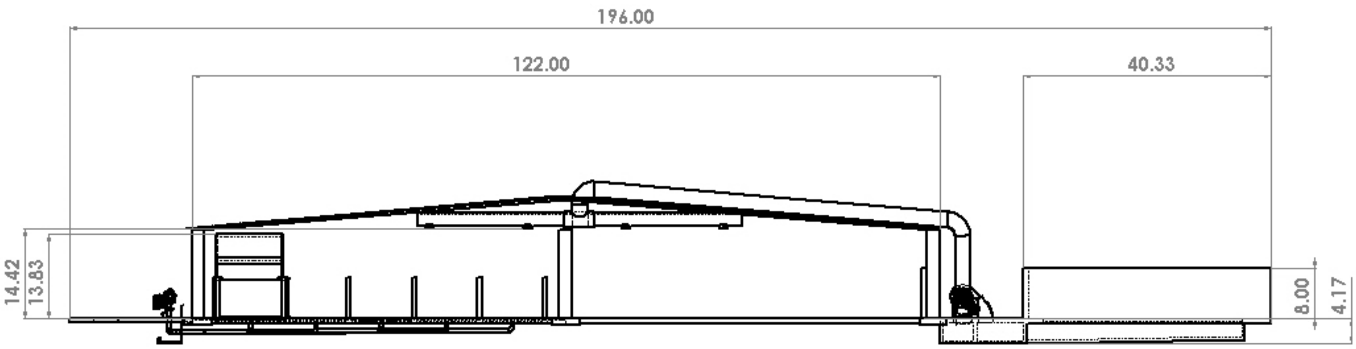

Dwg 3

CAPITAL EXPENSE ESTIMATE: BDP's overall estimate to revise the existing composting facility to accommodate the 2020 capacity design is $5M - $6M including $1,600,000 for BDP's scope as per Table 3. BDP's scope approach is to provide proprietary process related equipment only. "Off the shelf" items like fans, blowers, duct, pipe, etc… would be supplied by others, per BDP performance specifications. This is a turnkey estimate including.

- All equipment including BDP's scope as well as fans, blowers, duct, piping, interior lights, pump, tank, etc..
- Concrete, new center and exterior walls/doors,
- New epoxy coating for the building steel inside the bay area.
- The biofilter @ 4,000 SF (active surface) using wood chip type media. This biofilter is sized for drawing air from both the compost side of the building as well as the curing side. Therefore, it is subsequently also sized for the future 2040 capacity when (2) bays are added and curing is moved elsewhere.
- New MCC/Control Room.
- New Trommel Screen
- Engineering design and Construction.

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What is not included in this cost estimate are:

- Cost of any new permitting effort, if required.
- Any pre-composting operation/facility such as amendment grinding as it is presumed this is currently being done off site by the City, local tree companies, landscapers etc…
- Delivery equipment of the feedstock materials to the compost facility such as trucks.
- Front End Loaders – BDP presumes these exist. We estimate (1) loader is needed for the composting facility.
- Generic site needs like roads, scale, fence, outdoor lights, hydrants, runoff ponds, sewage system, water supply system, etc…

The bays are sized to retain the material for the BDP standard of 21 days to achieve USEPA CFR 503 requirements for PFRP (3 days at >= 55C) and VAR (14 days at >= 45C avg) as well as to produce a reasonably stable product suitable for moving to the covered curing area without significant odor issues. The 21 days also allows for short term peaks in capacity.

BDP estimates about 260 cubic yards of material per week would come out of the bays to the curing area. To get the typical 30 days curing will require about 5000 – 6000 SF of space depending on loader access needs. With the presumption that wood and green waste is the primary amendment source, and a ½" – 3/8" screen, BDP expects about a third (volume basis) of the cured compost would be "overs" recycled back to the front of the bays as secondary amendment.

BDP presumes the existing building is in good shape structurally throughout with no significant corrosion or roof leaks. In the 60 ft x 180ft space where the bays are, I have assumed repainting the building steel with an epoxy type coating for corrosion protection. I have assumed the balance of facility needs touch up painting as best.

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OPERATING COST ESTIMATE:

a. labor wise – BDP estimates (1) employee being needed between materials movement, record keeping and other admin duties 30 – 40 hrs per week.
b. Diesel usage – BDP estimates (1) Loaders operating at 20 – 30 hrs/week
c. Electrical Consumption estimate is as follows:

Table 2 – Electrical Consumption Estimate

Equipment	Blower Cap	Static Hd	BHP	Factor	Quantity	kW	HP	Consumption
	cfm	in. w.c.	HP	%				kWh
Process Air Blower - Zone 1	3,600	12	9.978	57%	1	11.25	15	55,722
Process Air Blower - Zone 2	1,800	8	3.566	61%	1	3.75	5	19,914
Process Air Blower - Zone 3	1,800	8	3.566	61%	1	3.75	5	19,914
Agitator				12%	1	56.25	75	58,661
Biofilter Pump				75%	1	1.5	2	9,855
Control System				95%	1	0.375	0.5	3,121
Biofilter Blower - PO	14,500	8	28.29	40%	3	30	40	209,098
Total Annual Process and Vent Equip								**376,286**
Lights and Misc.							10%	37,629
Total Energy Estimate								**413,914**

The bays are divided into 3 separate aeration zones (Z1 – Z3). There are (3) Biofilter blowers/Ventilation fans indicated on the drawings but only (2) run at any given time with the other being an installed spare to ensure uninterrupted odor control. The Biofilter blowers would operate at high speed during the 8 – 10 hr operations day and lower speed the rest of the day. The biofilter header includes a sump for collecting condensate which will be primarily recycled into the airstream leading to the biofilter to keep the media appropriately moist.

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TABLE 3 - BDP SCOPE of SUPPLY

ICS COMPOSTING FACILITY

Hendersonville, NC 2020 Capacity

(5) 10 ft Wide x 6.5 ft Deep Bays

ITEM	QUANTITY
EQUIPMENT	
Agitator & Dolly - 75HP	1 Each
Agitator Bay Wall Rails with Wall Embeds and all Hardware	640 Ft
Agitator Retreival Unit/Filtration Cart	1 Each
In Bay Sensors for Measuring Compost Temperature	15 Each
Dolly Rail System	150 Ft
Bay Aeration Floors with Drain Spigots	15 Each
AgitatAer™ Process and Facility Control System	1 Each
Festoon System for Dolly Power Supply	1 Each
Biofilter Aeration Floor	@ 4,000 SF
Freight for all of the Above to Jobsite	1 Lot
ENGINEERING AND SERVICES	
Internal Engineering Support	As Required
Design Engineering Support	10 Days/4 Trips
Construction Support	10 Days/4 Trips
Start Up Commissioing and Process Support	20 Days/4 Trips
Post Start Up Support	5 Days/2 Trips
ESTIMATED BDP PRICE INCLUDING FREIGHT:	**$ 1,600,000**

For the **future 2040 8,361 WTPY capacity**, (2) additional 6.5 ft high x 10 ft wide x 140 ft long bays would be needed. Refer to Drawings 4 – 6. <u>The City should consider that if these (2) additional bays are built now, it would result in the current 5,625 WTPY biosolids compost being retained in the bays for 30 days in total. The result would be the discharge compost material would be effectively cured such that no dedicated curing area would be needed.</u> Amendment storage/mixing would be done in the remaining open space on the north side of the building. Also the bay aeration blowers would be moved indoors.

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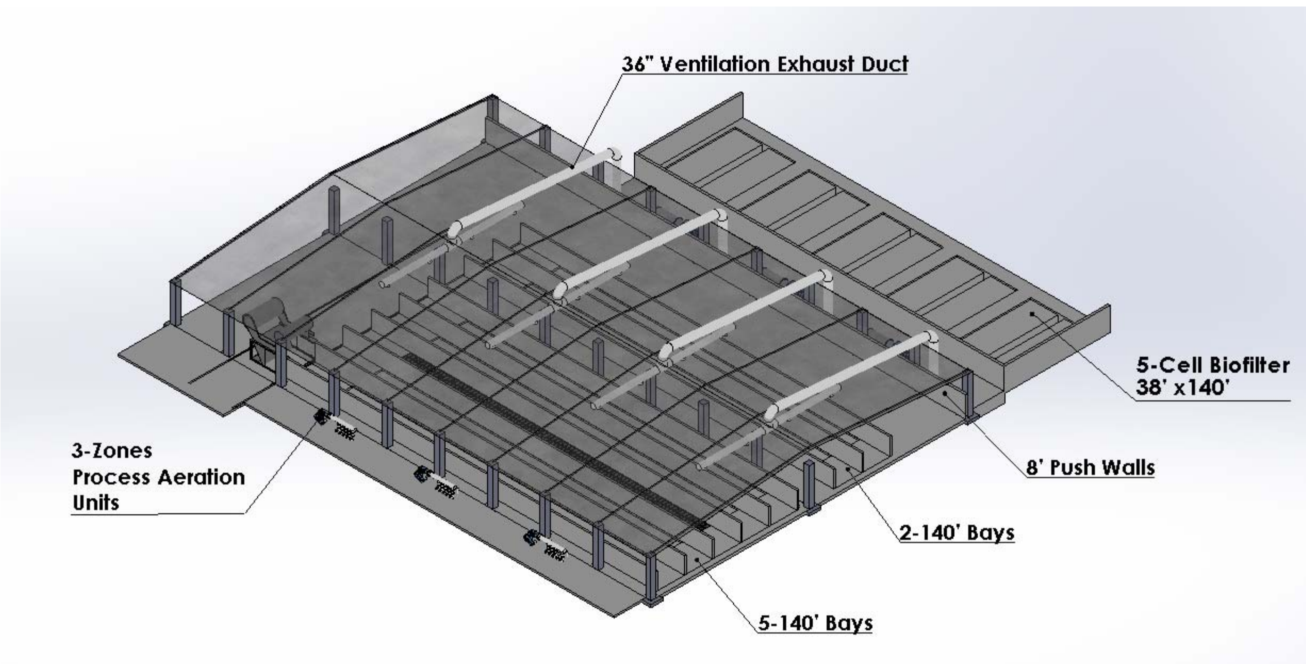
For this scenario it probably makes most sense just to enclose the entire building perimeter rather than adding a new interior wall. The CAPEX would increase to $6M - $7M. BDP's scope would not increase dramatically, another $200,000, as the facility still only requires (1) Agitator and Dolly and the biofilter is designed for the 2040 capacity as discussed above.

Labor wise I still think only 1 person would be needed but perhaps with a bigger bucket on the loader as most of the labor required is for material movement.



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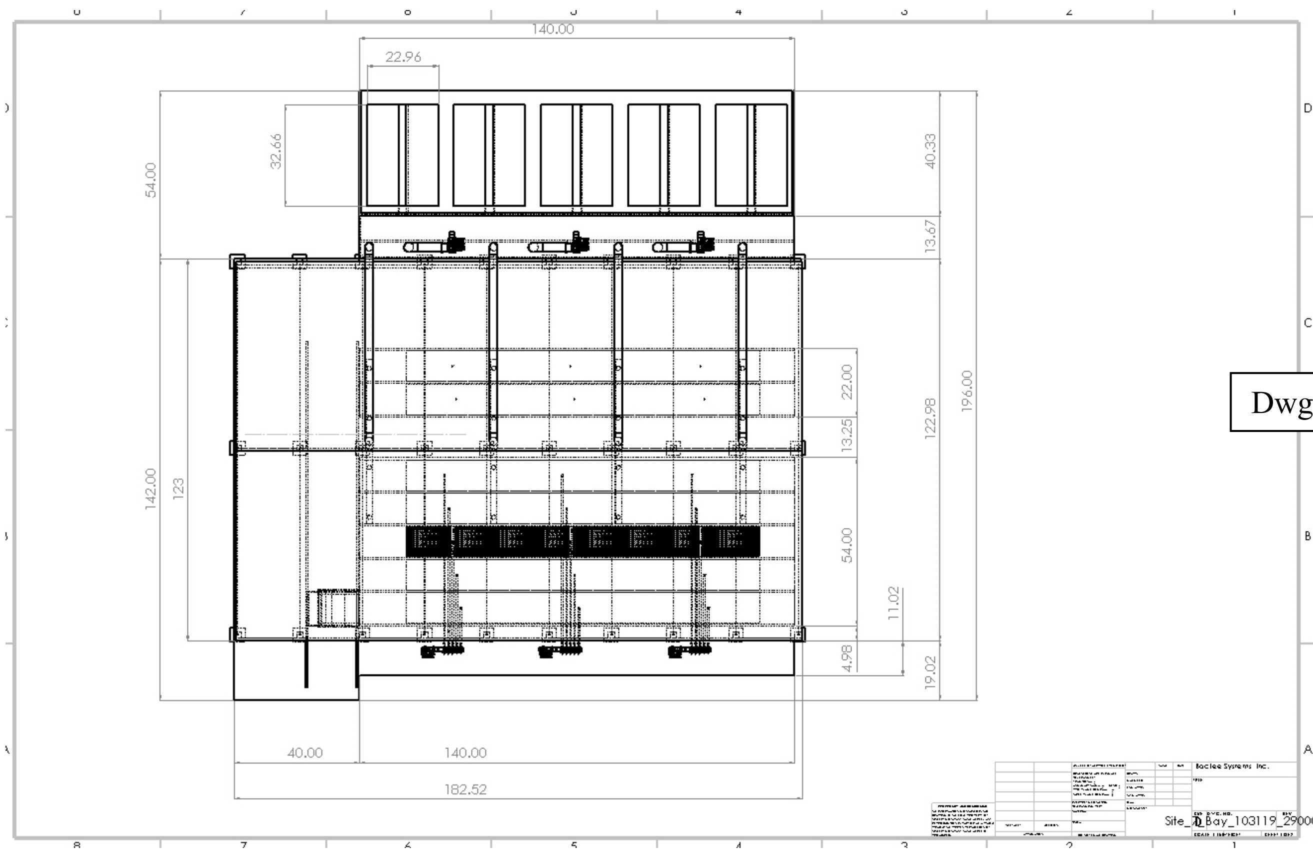

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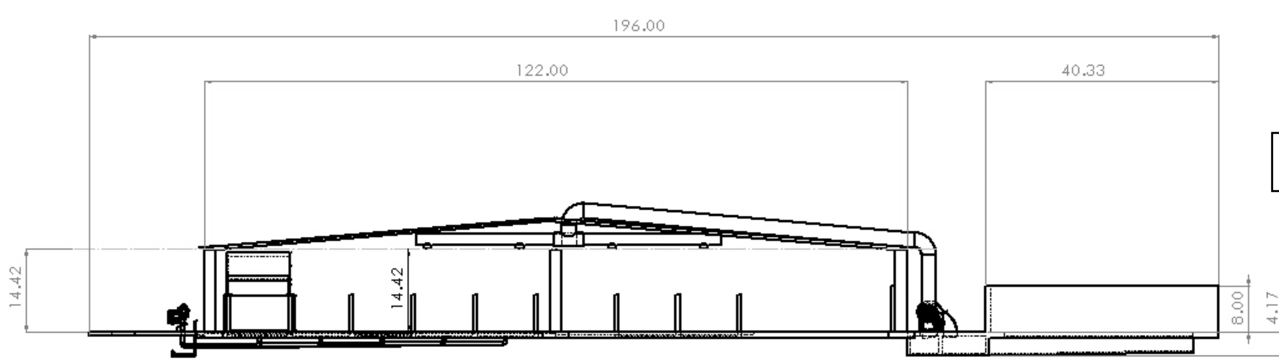


Dwg 6

I trust this information is sufficient to continue discussions. I would be happy to meet with the City and/or their engineer to refine this estimate.

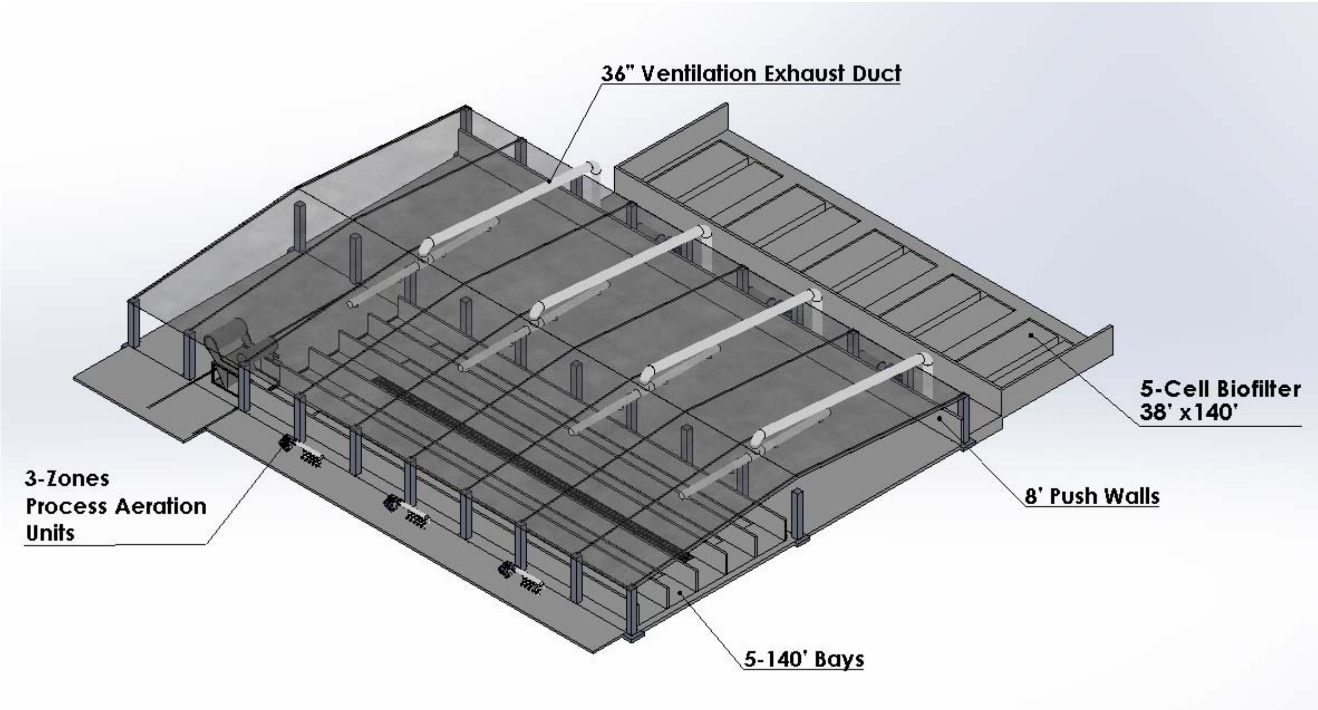
Richard Nicoletti, PE.
BDP Compost Systems Manager

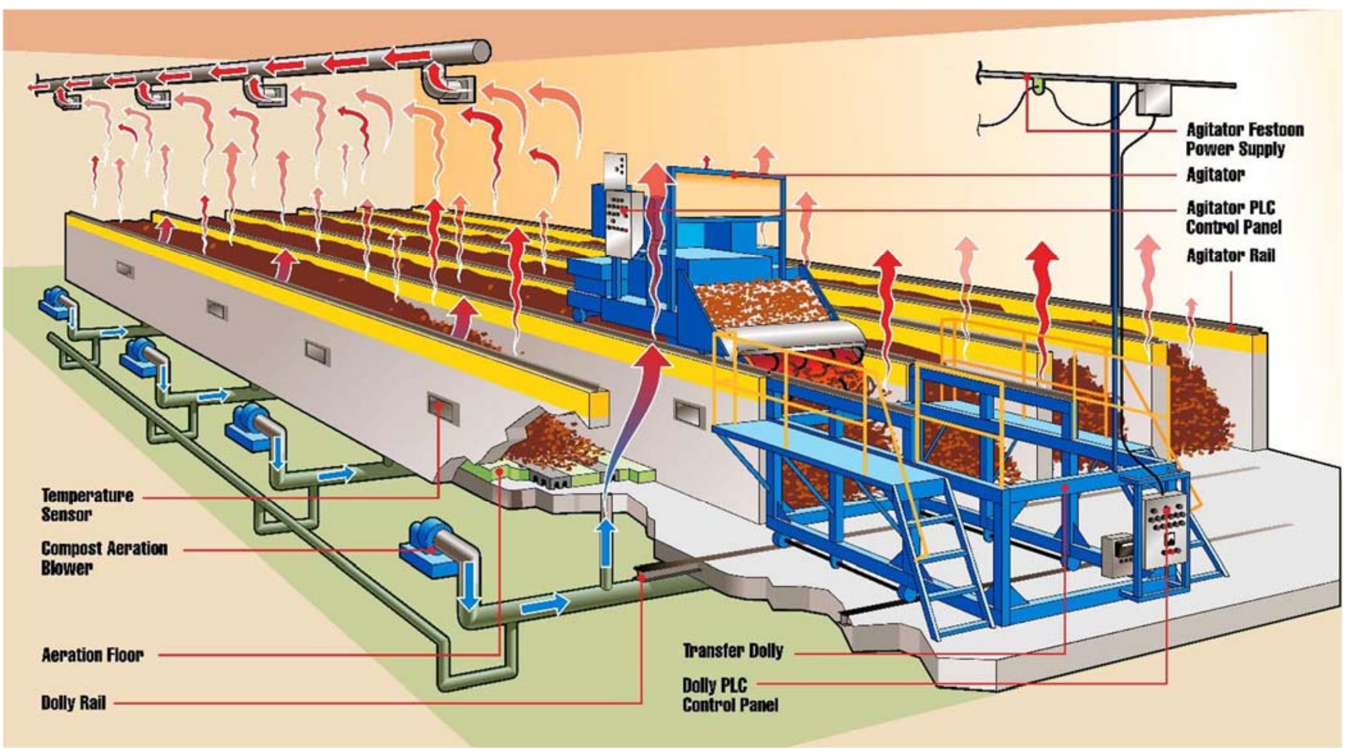
Hendersonville, NC Detailed Process Description (5,625 WTPY Scenario)

Each of the six working days per week, it is presumed that dewatered biosolids will be delivered to the compost facility via truck. The Material Receipt/Mixing area and Active Compost Bays are housed in the existing Biosolids Storage Shed. (Reference Figures 1 - 3 above) The structure will be situated with the Material Receipt/Mixing and bay loading area at the 'fill end' of the process bays. Ground yard trimmings (yard/wood waste) and recycled screening overs (overs) will be blended with the wet biosolids to form an appropriate infeed mixture. The feedstock material is loaded into the process bays; then translated along the bay by the agitator; after (21) days subsequently removed from the discharge end of the bays to the curing area. After 30 days in curing, the material will be screened with the fines or "unders" being available to market and the "overs" recycled to the front of the compost facility as supplemental amendment A front end loader will be used to floor mix the yard waste and overs with the biosolids. The same loader will be used for all material movement including loading the bays, unloading the bays, building the curing piles and moving the finished compost material out to the screening/storage area.

The individual process steps include

1. **Receiving –** ground yard/wood waste, screened overs (recycle) and dewatered biosolids are delivered to the @ 60 ft wide x 40 ft long area.
2. **Mixing –** Floor mixing is done by the loader in this same area.
3. **Charging** or loading @ 25 yds of feedstock into the process bays in the front 16ft of the bays
4. **Active Composting & Curing** by agitating and aerating the material along the 140 ft bay length over 21 days
5. **Discharging** or unloading the processed cured material from the bays in the final 71 ft wide x 40 ft long area at the end of the bays.
6. **Odor control** – @ 6,300 sf biofiltration – for air from Receiving and Active Composting.
7. **Curing**
8. **Screening**


36" Ventilation Exhaust Duct
5-Cell Biofilter
38' x140'
3-Zones
Process Aeration
Units
8' Push Walls
5-140' Bays


Agitator Festoon
Power Supply
Agitator
Agitator PLC
Control Panel
Agitator Rail
Temperature
Sensor
Compost Aeration
Blower
Aeration Floor
Dolly Rail
Transfer Dolly
Dolly PLC
Control Panel

Step 1 Receiving – It is presumed that the dewatered biosolids will be delivered via dump truck. Prior to delivery of the biosolids, the loader will move from the adjacent Amendment Storage bunker to the Mixing/Receiving Area, a suitable amount of ground green/wood waste and recycled screening overs and spread them out on the floor as shown below. The dump truck will deposit the biosolids on the yard trimmings as shown in the photo below.

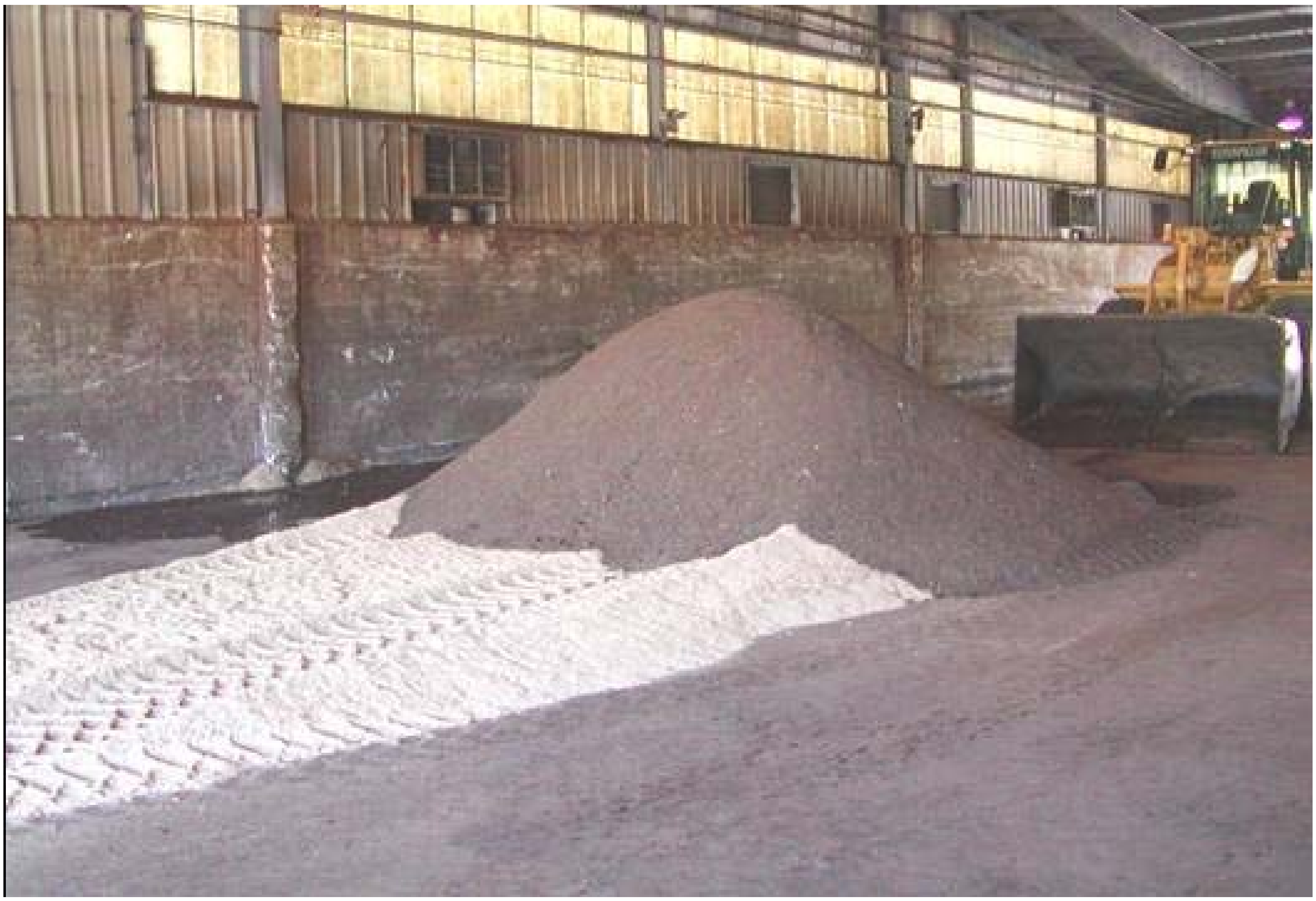


Photo 1 - Fresh Ground Yard Trimmings and Recycle spread on Receiving Area floor.

The BDP compost process is able to accept relatively small particle size material (sawdust e.g.) unlike static or wind row type systems which need bulking agents in the 2” – 4” range. This is due to the combination of the frequency of which the bays are agitated along with the forced aeration of the bays. Being able to utilize smaller material in the bays means the bay capacity is optimized as the finer material is higher density than coarser material. Also there will be a larger percentage of finer compost in the end product. Finer compost is worth more than coarser mulch type products.

Step 2 – Mixing – An approximate 8ft high 'push-wall' will be required in the Material Receipt and Loading Area. The loader alternately layers appropriate amounts of biosolids and overs/yard waste on the mixing area floor and combines the mixture. The desired goal is to achieve a blended feedstock mix with solids content of nominally 35% - 45% (depending on ambient temperatures). The agitator will continue the mixing within the bays to ensure a homogeneous blend.

Photo 2 - Front End Loader Mixing Input Feedstocks

Step 3 – Bays Charging or Loading - The bays are Designed to Receive nominally 25 yds^3 of feedstock (or "charge") following an agitation. The front 16 ft of each bay is a non-aerated concrete pad designated as the Loading Area of the bays.

Photo 3 - Front End Loader Loading Bay

Step 4 – Active Composting - For this application, the bays are 10 ft wide x 6.5 ft high x 140 ft long for a retention time of 21 days. The five (5) bays are contiguous. Equipment and personnel access aisles are on each side of the bays. With each pass of the agitator along the length of the bay, the process material will be mixed and translated towards the tunnel discharge end an average of @ 12 ft with the agitator *Capacity Optimization Gate* device automatically modulating the agitator conveyor discharge throw between 10 ft and 13 ft to offset pile height loss as the material composts.

Photo 4 - Agitator on Dolly

Photo 5 - Agitator working in bay next to empty bay

i. ***Aeration System*** - Each of the (5) bays is divided into (3) separate aeration zones for a total of 15 Aeration Zones (i.e. 3 aeration zones/bay x 5 bays) designed and equipped by BDP's partner BacTee Systems. The aeration system provides sufficient oxygen to the process between agitation cycles and removes condensate from the process bays. The BDP supplied *AgitatAeR™* process control system (system) allows continuous modulation of process air based on temperature feedback from the process material. The system also allows high/low cyclical aeration control as a default control strategy in the event temperature inputs are inadvertently disabled.

The aeration zones in each set of bays are linked by a common below-grade manifold to a blower for that particular zone. Thus for the (15) total aeration zones, (3) aeration blowers are being supplied.

The BacTee floor system consists of BacTee's polymeric baseplates as shown below that are encased in the floor but can be removed for periodic full-access cleaning. The baseplates are adjacently located to a Cross-Arm which provides a plenum cavity between the baseplates and a spigot that transports air downward to a below-grade manifold pipe.

Photo 6 - BacTee Polymeric HT Baseplate

Photo 7 - Baseplate embedded in the tunnel floor

Process material temperature is continuously monitored and supplied to the control system from temperature sensors mounted in the bay walls of each aeration zone in each bay. The temperature inputs from the same aeration zone in each of the (5) bays are averaged by the control system to drive the blower to blow/suck air from the respective zone. All blowers are operated through a variable frequency drive (VFD) to provide continuous modulation of the air flow to precisely maintain process material temperature about a floating set point within the control system.

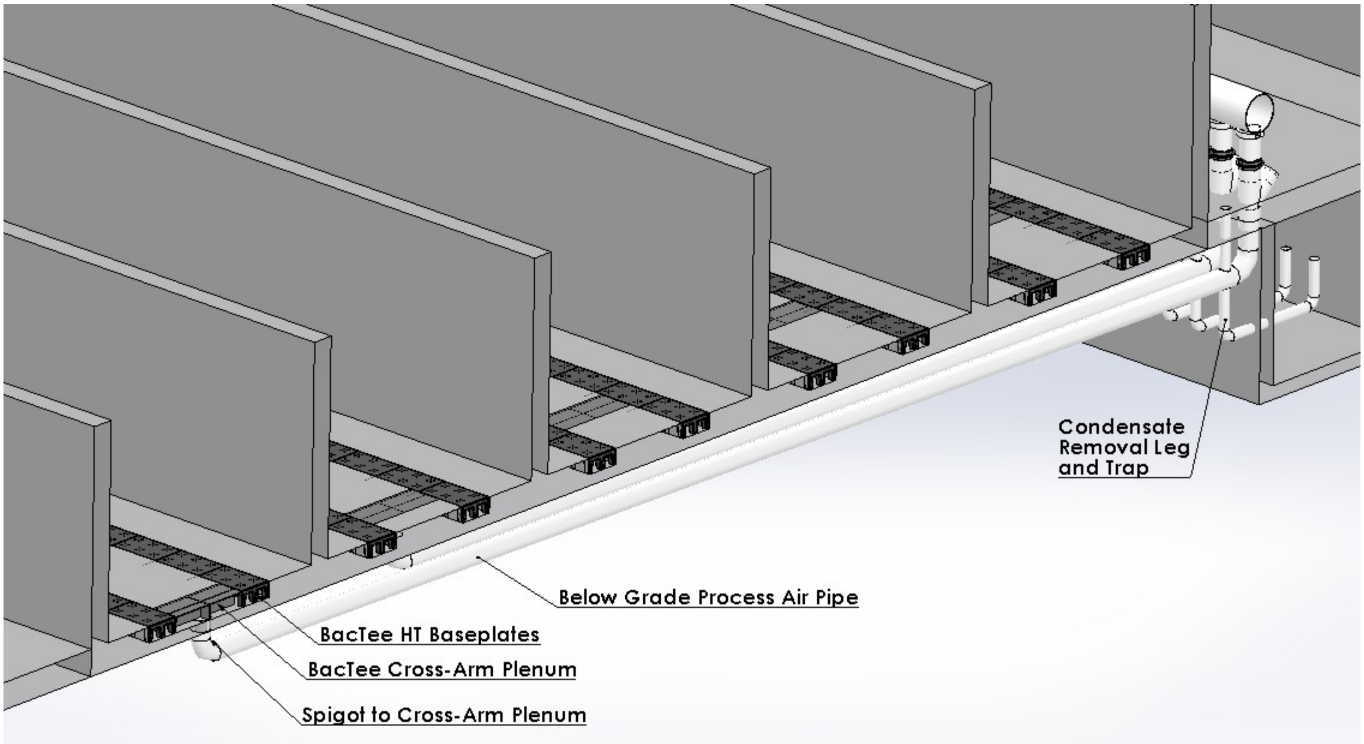


Photo 8: Compost Aeration Floor Components

Photo 9: Temperature probe in wall of empty Bay

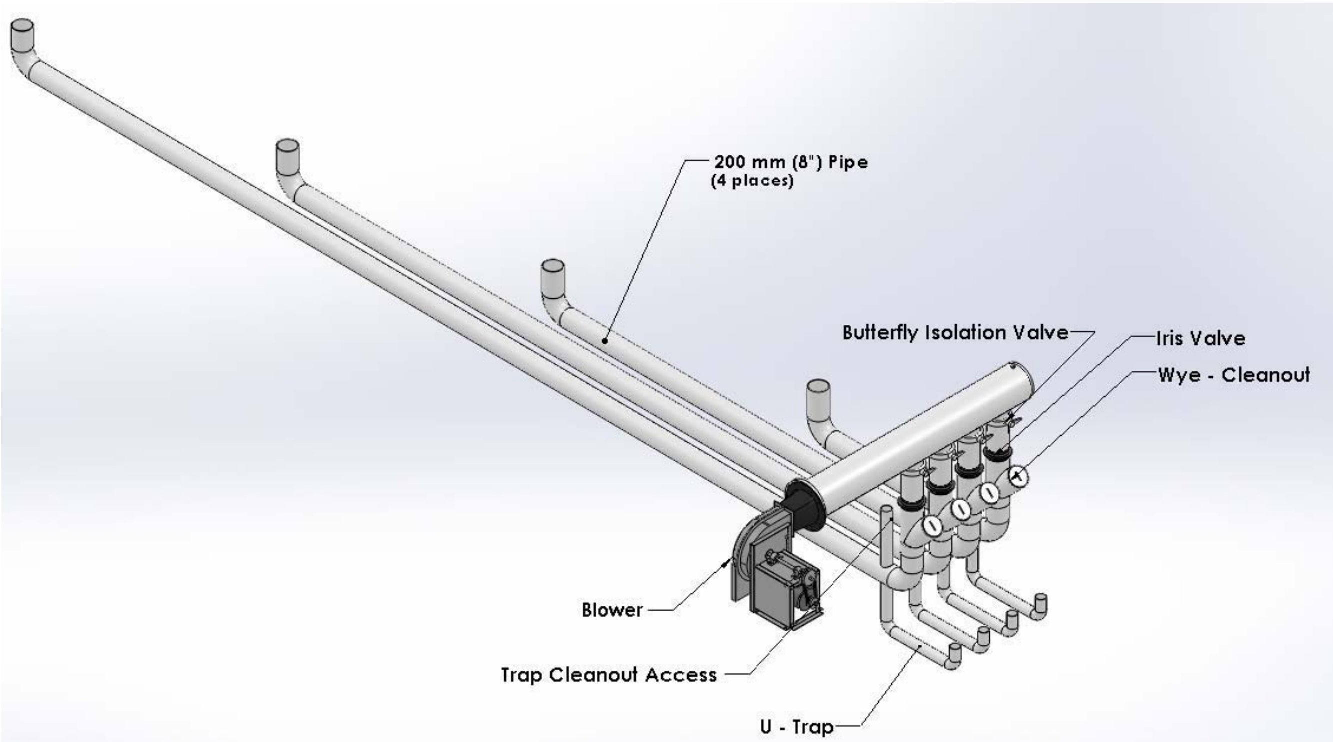


Photo 10: Typical Bay Aeration Piping Arrangement (as shown for 4 bays)

The aeration zones vary in length to provide adequate aeration throughout the composting process. Zones at the beginning of the bay are shorter and provide more airflow to support the higher level of biological activity that produces temperatures that are higher than in those zones nearer the discharge end of the bays. The aeration zones become progressively longer from the fill to the discharge end of the bays. In addition to the aeration zone length varying from the fill to discharge ends of the bays, the air flow rates are decreased. Consequently, blower air flow capacity decreases for the zones nearest the discharge end.

All aeration plenum and manifold units (i.e. pipe) are designed to transport condensate water away from the process tunnels. The low point of the below-grade aeration manifolds is equipped with a U-trap to prevent short-circuiting of air flow while allowing disposal of water to a below-grade drain manifold. In this case, the drain manifold is also the central process and ventilation exhaust plenum. A collection sump incorporated into the floor of the process area serves as a collection reservoir for the water. The water collected will be discharged to the wastewater treatment plant for processing or recycled for other areas of the facility if permitted.

ii. AgitatAeR™ Computer Control – The BDP *AgitatAeR™* Process Control System (system) is designed to be the total compost facility control system interfacing with the various fans, blowers, agitators and other miscellaneous equipment.

1. The primary function of the system is to ensure that the compost material in the bays is subjected to the required USEPA Time/Temperature protocol = 3 continuous days at >= 55C for pathogen destruction (PFRP) and 14 days at >= 45C for Vector Attraction Reduction (VAR). This is done by the system monitoring the (25) bay wall mounted RTD type temperature probes (Photo 9) and correlating that data with the material movement through the bays. The compost temperature at the bay wall should be the coolest spot due to the heat sink effect of the concrete wall.

   Each 25 yd3 "charge" of material that is loaded in the front of the bays is assigned a unique 4-digit Charge Number as shown in Photo 11 below. For the 235 ft length bay, there will be about 18 individual charges per bay. The system also monitors which bays are agitated on a given day. As indicated above, with each agitation the compost pile in a bay is translated about 12 feet towards the end of the bay. Charge movement down the length of the bay is estimated by the system via a site specific charge movement algorithm. With each bay agitation, the computer advances the charges towards the discharge end of that bay. The system correlates the appropriate wall temperature measurement to the charge as it moves.

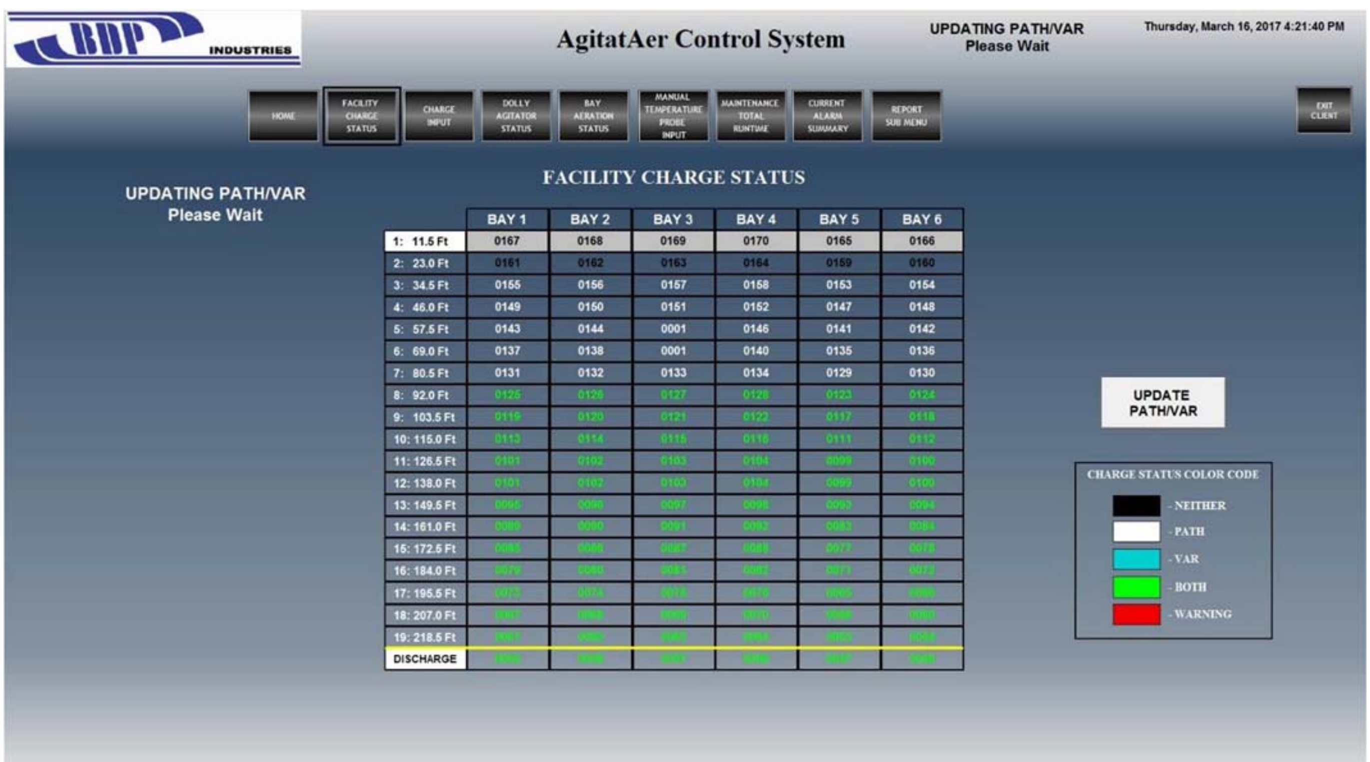


Photo 11 – Sample Charge Status Screen

The charges are color coded such that the operator can visually tell the status of a charge as it moves thru bay. When the charge is initially loaded into the bay, the charge number is presented in black text. When the charge achieves the time/temp protocol, the charge number text color changes to green indicating the material has met this requirement. If the charge gets within the last 5 segments in the bay, and does not achieve time/temp protocol, the charge number text turns red indicating to the operator corrective action for that charge is required (typically taking hand probe temperature probe measurement). If the charge does not reach time/temp protocol when it is discharged, it will be recycled back to the front of the facility for re-processing.

The system can generate detailed time/temperature reports for compliance proof as shown below.

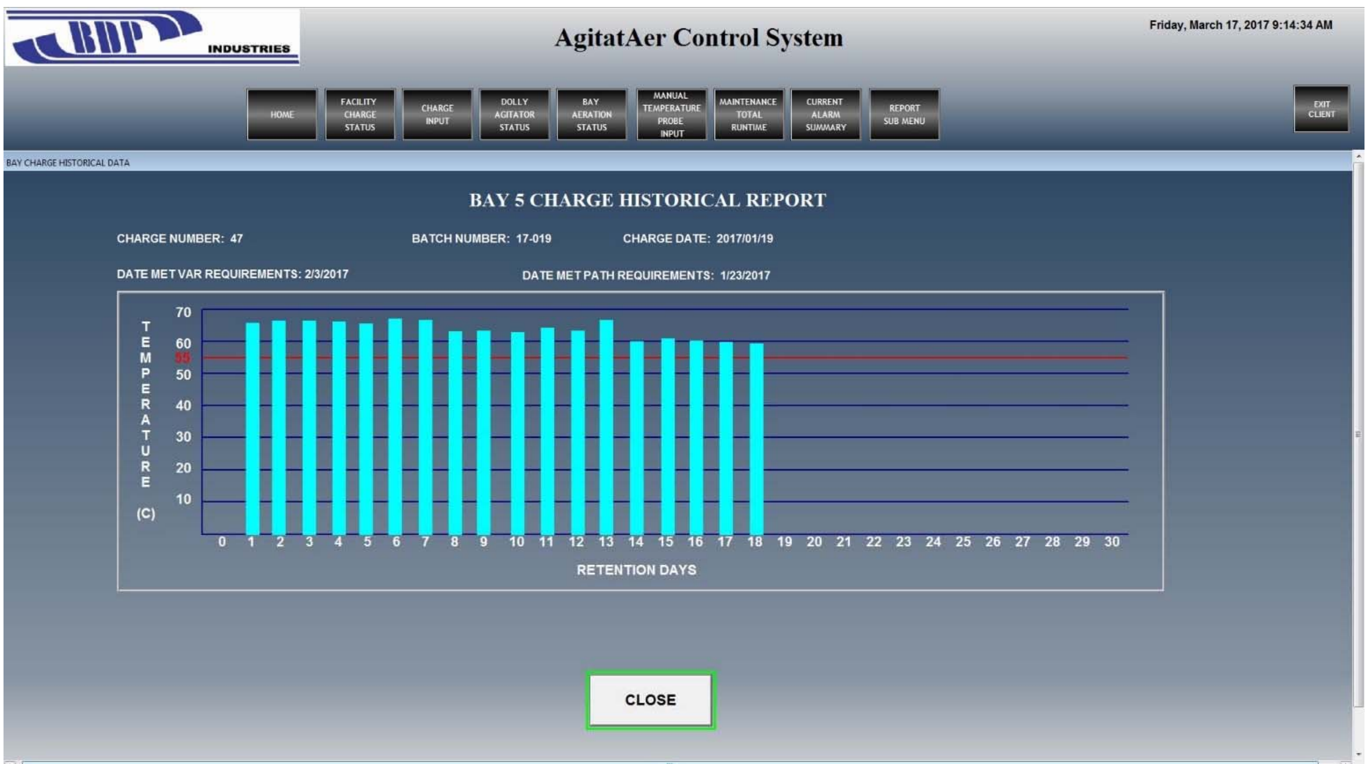


Photo 12 – Sample Charge Historical Report

2. The system also is used to automatically control the aeration blowers to optimize compost conditions and to maintain aerobic conditions in the bays. The goal is to discharge a suitably cured mature compost product from the bays that can be moved outdoors for storage or careening, without significant odor concerns.

The system modulates the process blower speed, as needed, to allow the process temperatures to stay within a limited range. The desired range of process temperature is determined by input parameters that may be varied by simple menu-driven changes to the control system if feedstock properties and the objective final material properties change.

Both process control and data acquisition functions are provided within the system. The screen shot below indicates aeration blower control and monitoring for a 5 zone (A – E) bay.

Photo 13 – Sample Blower Control Screen

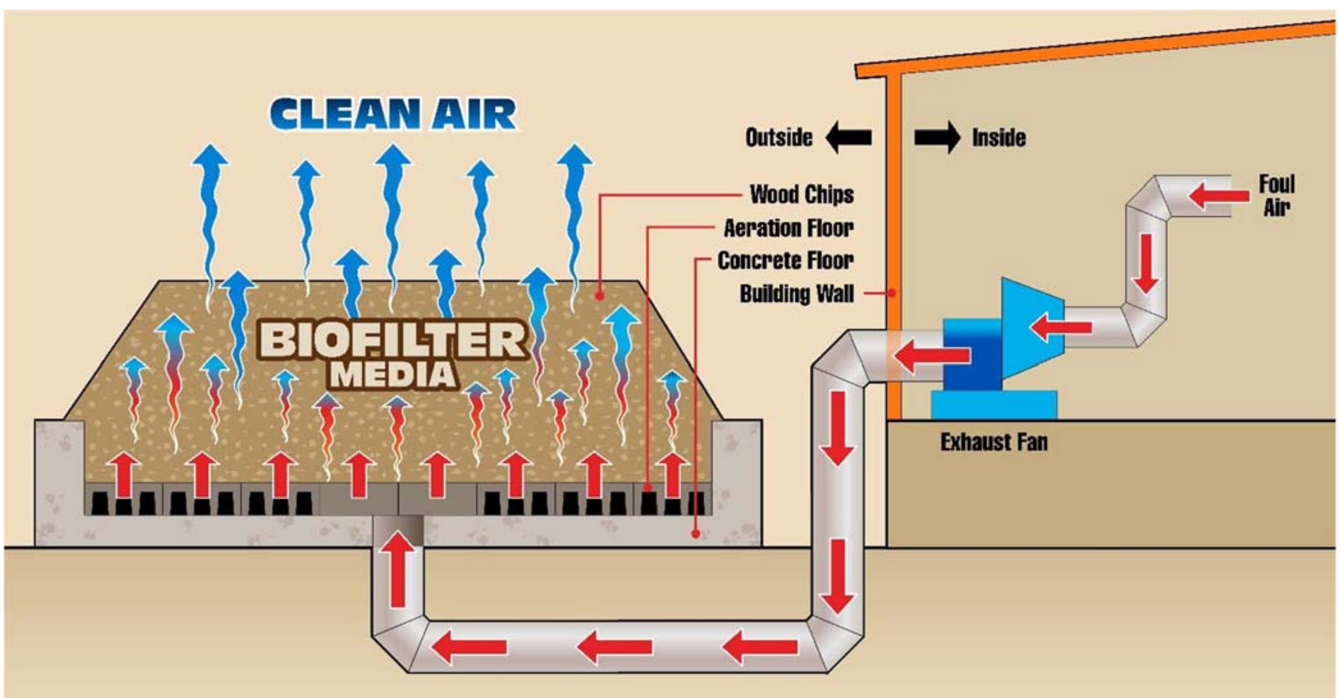
As discussed above, the Aeration Zones A – C will be served by 1 blower for 5 bays. The corresponding 5 wall temperature probes data for the A zones will be averaged for blower control.

3. The system is also used to control the building ventilation fans/blowers VFD drives to control the fans speed to maintain negative pressure conditions within the building for optimal odor containment.

iii. Ventilation – The fully-enclosed Composting structure is maintained under a slight negative pressure by (2) of the Exhaust Fans at any given time that draw both ventilation and process air from the building including the open sided portion as well. Fresh air is drawn into the structure through louvered grilles in the sidewalls of the building. The negative pressure maintained within the duct draws air through a series of intakes located in the Receiving and Composting areas. Both process air and room ventilation exhaust air are delivered to the biofilter for treatment prior to release to the atmosphere. (3) 40 HP Exhaust Fans are indicated for this application including (1) dedicated spare.

Step 5 – Composting Material Discharge – After approximately 21 days in the bays the compost material is moved by the agitator into the final 14 ft discharge zone of the bays. Like the loading Zone at the front of the bays, the discharge zone is a solid concrete floor with no aeration. The compost is removed from the bay by the loader. At this point the compost is expected to have a solids content in the range of 60% and a density of about 0.4 tons/yd^3. Approximately 15 yd^3 of material are removed from each bay after each agitation and transferred to the Curing area.

Step 6 – Odor Control – Biofiltration



A biofilter odor control system treats all process and ventilation air from the building. Building air is drawn under negative pressure, created by the suction side of the Exhaust Fans, into the main duct. Three Exhaust Fans are located at the entrance to the biofilter bays – (2) of which will be operating at any given time to maintain a constant, slightly-negative air pressure within this duct under the control of the AgitatAeR™ system. The Exhaust Fans transport the air through the biofilter bays and media.

The biofilter bays will be equipped with the BacTee biofilter aeration floor components. The biofilter media will be a standard wood chips type material which can be supplied by pre-screening the ground yard trimmings and utilizing the subsequent screening overs.

Condensate may form in all air manifolds before and within the air passageways of the biofilter. A condensate leg and trap conveys condensate formed in the aeration zone piping and can be removed via a condensate drain to appropriate storage or disposal. In addition, heavy rains may potentially permeate through the biofilter media. Consequently, condensate collection and drain piping is provided to remove water from the biofilter unit for re-use/disposal. Condensate is removed from both the biofilter and duct via ports at low points in the respective plenums.

Sample Biofilter related drawings:

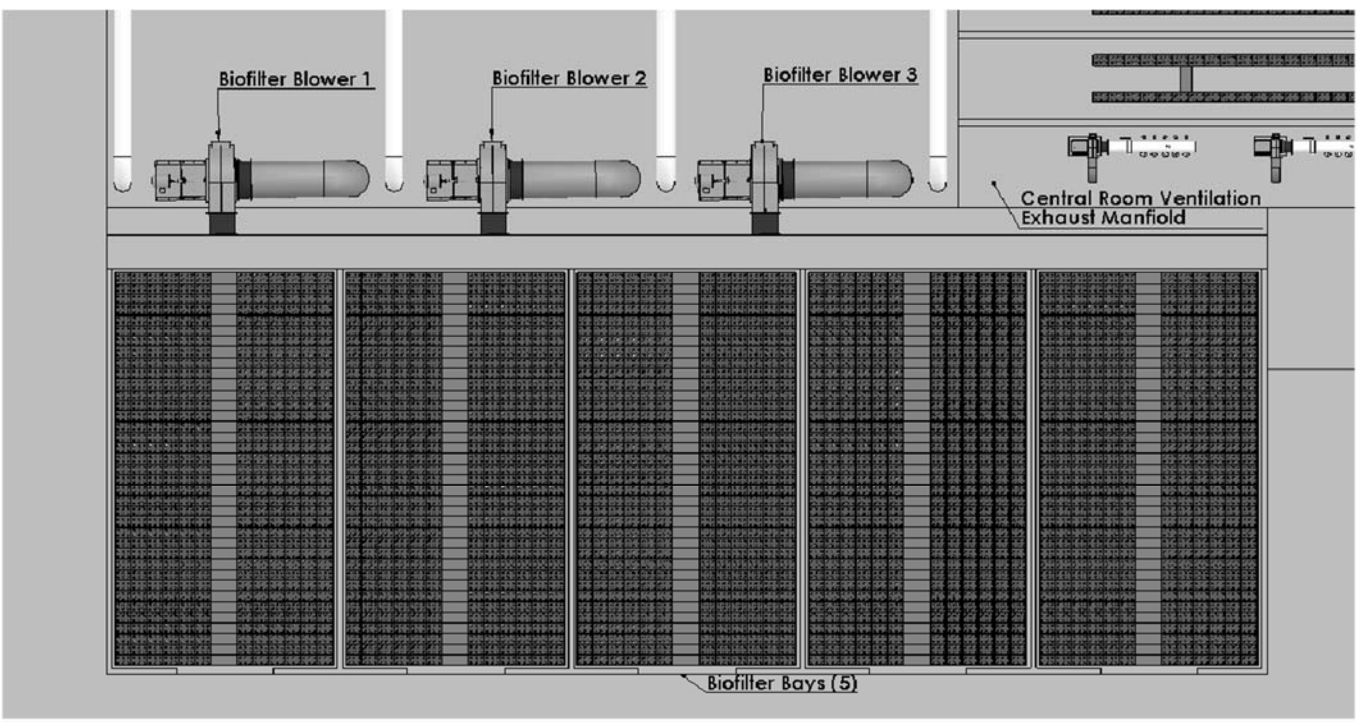


Figure 6: Conceptual Biofilter

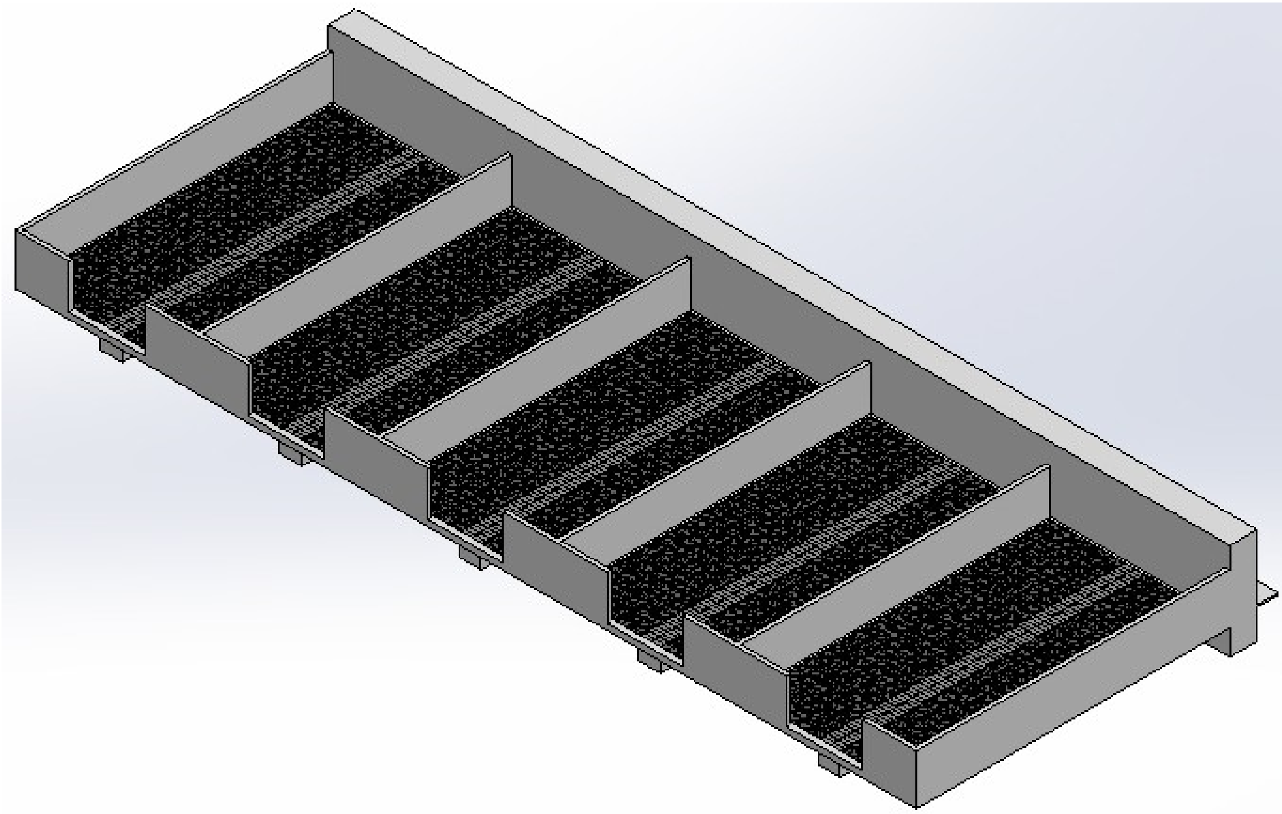


Fig 7: Conceptual Biofilter showing concrete details for media placement access

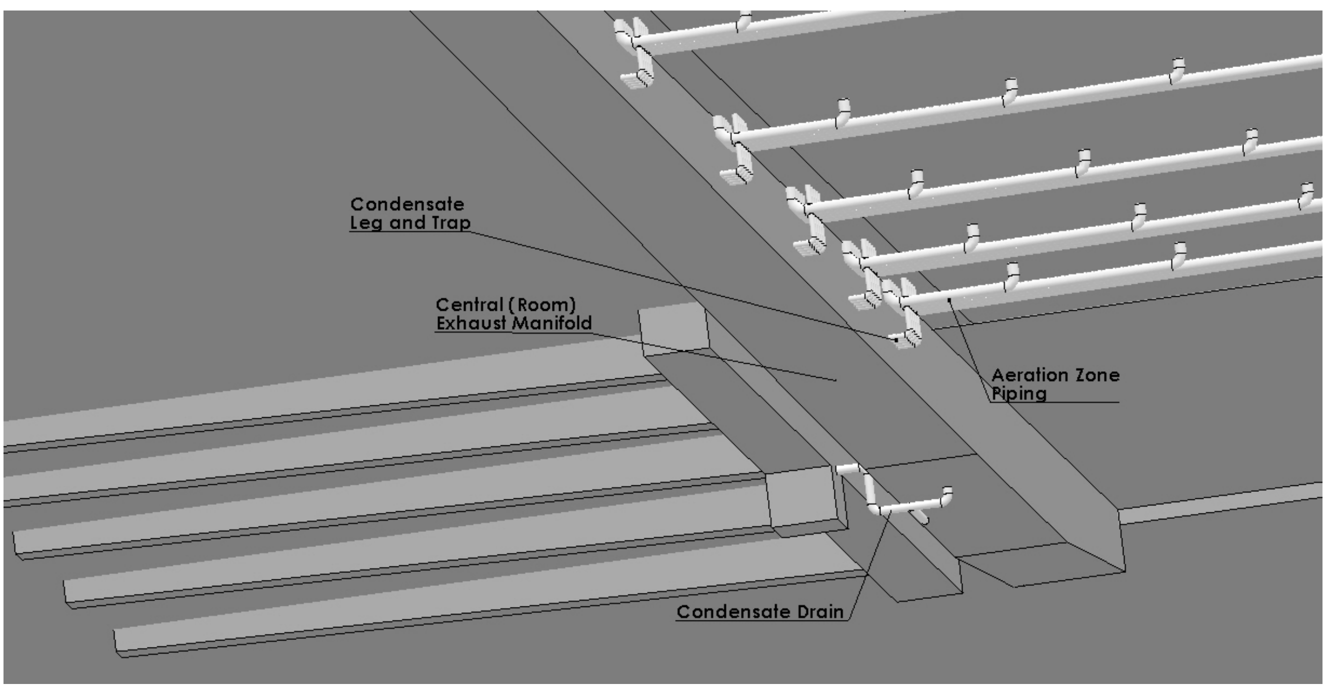
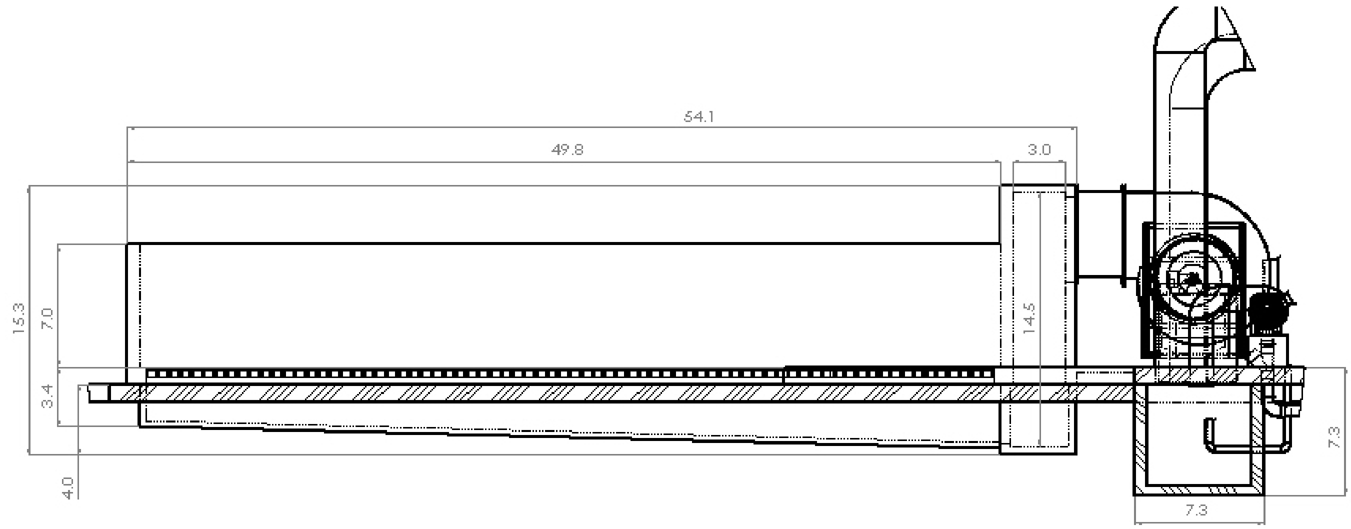


Fig. 8: Biofilter Drain Piping (typical)

Fig 9 – Biofilter Detail



Step – 7: CURING.

Using the front end loader, the compost is transferred from the discharge end of the bays to the curing area. BDP estimates approximately 260 cubic yards of compost material per week will be discharged from the bays. Therefore, at any given time the curing area needs to be able to store about 5 weeks of material (1,300 cubic yards) to achieve 30 days curing with some footprint being used to build a new curing pile and another being used to unload cured compost.

Of the 60 ft wide x 180 ft long Mixing and Curing side of the building, BDP estimates the first @ 40 ft would be designated for Material Receipt, Short Term Amendment Storage (@ 3 days) and Mixing. That would leave 60 ft wide x 140 ft long available for Curing. If there were (5) 30 ft wide x 35 ft deep bunkers formed as shown below in Photo 14, that should allow for appropriate curing space as well as room for loader movement.

Photo 15 – Curing Bunkers

Step – 8 - SCREENING.

For biosolids and Yard/Wood waste co-composting, typically all that is required for product refinement is a 3/8" – ½" trommel screen. As discussed above, the material not passing thru this screen (overs) is typically high lignin material like wood chips. This material is recycled to the front of the bays as supplementary amendment. The finer material passing thru the screen is the high value compost.

Photo 16 – Screening Operation

SCARAB INTERNATIONAL

14X7BD 250 JD RT

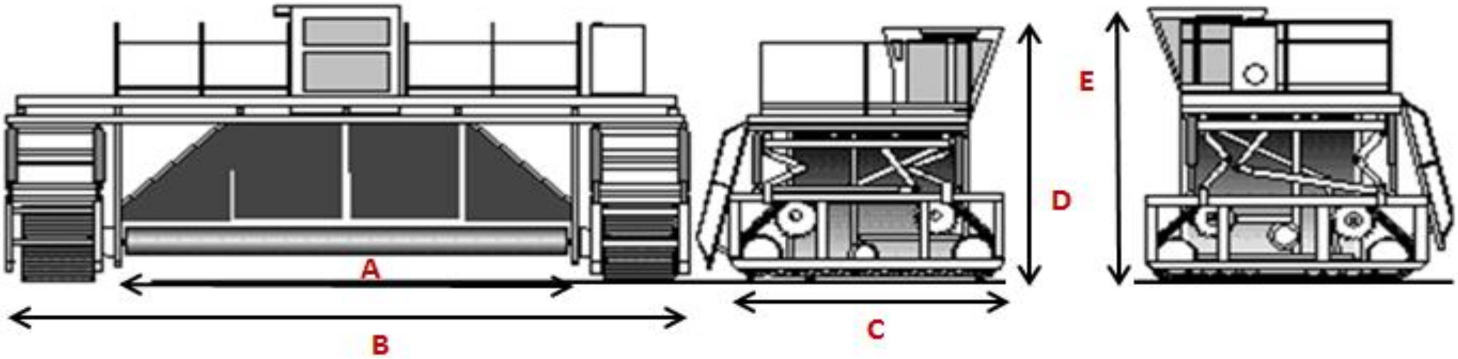
UNMATCHED PRODUCTION CAPACITY
MOST FUEL EFFICIENT
LOCAL SERVICE AND PARTS
LARGE DEALER NETWORK
LONGEST LASTING MACHINES ON THE MARKET

DESIGNED WITH THE CUSTOMER IN MIND
41 YEARS IN BUISNESS
IT'S IN THE DRIVE (DIRECT DRIVEN DRUM'S)
DOMESTIC AND INTERNATIONAL SALES
PROUDLY MADE IN THE USA

43 years of experience built into every machine. Flexibility, reliability, durability, easy maintenance and practical solutions are SCARAB hallmarks. Superior design and years of experience have led to unmatched unmatched reliability –almost all of the original SCARAB's are still in operation today. Engineered to optimize windrow shape for the next turning cycle. Designed to deflect and direct composting material for low maintenance windrow management and minimizing airborne particulates aid site managers in achieving stringent EPA guidelines on particulates and minimizing safety risks from flying debris while maximizing exposure of composting material to air in the "fluffing" process to increase microbial action. Vast international experience and reputation for rapid service response and same day shipping on parts. Advanced fan design optimally cools the engine and clears debris thus optimizing horsepower and fuel efficiency. SCARAB's largest track design is best in the market for delivering best traction in muddy situations. Innovative solutions to difficult and complex composting situations worldwide across a wide variety of feedstock's, difficult site specifications and conditions in widely varying and harsh environments. Vendor's design engineers working with SCARAB have adopted many SCARAB inspired design innovations. SCARAB has been very active in the international market for the past 34 years with machines in 19 countries.

SCARAB International, LLLP
1475 County Road W
White Deer, TX 79097
Ph: 806-883-7621 F: 806-883-6804
www.scarabmfg.com

Technical Data



dimensions:		Feet	Inches	Meters	MM	
A.	Tunnel Width	14'	168"	4.26		Eighteen feet
	Drum Height	2-8"	32	1.22		32"
A.	Tunnel Height	7'	84"	2.13		Seven Feet
B.	Total Width	23'	276"	704		Twenty seven feet-nine inches
C.	Total Depth	11-11"	143"	3.63		Eleven feet-eleven inches
D.	Lowered Height	12'-5"	149"	3.78		Twelve feet-five inches
E.	Raised Height	13'-5"	161"	4.09		Thirteen Feet-five inches

	Pounds	Tonnes
Machine Weight	40,000	

standard specifications:

JohnDeere 250HP
SCAU3200 Flail Drum
Panoramic Operators Cab
digital auto load controller
A/C heat unit rated at 42,200 BTU
deluxe seat c/w lumbar, arm rest
AM/FM/CD stereo
variable pitch automatic reversing fan
Gear Box Drum Drive
90 series Sundstrand propel pumps
Central Lubrication System
drive tires: firestone 23.1" X 26"
caster tires: firestone 16.5L X 16.1"

available options:

SCAU4800 (48") Auger Drum
track drive D5 - 30" triple grouser tracks
direct direct drum drive (clutch)
electric automatic grease system
fire suppression systems
odor control system (12V or hydraulic)
tires (*several sizes available*)
electronic controlled pressurized cab air system
track and wheel scrapers
anti-vandalism package

engine options: Emissions: Meets Tier 3 and Tier4F, Stage IIIA emission requirements. refers to EPA (U.S.)

Make:				
John Deere	6135H, 6090H	250HP to	600HP	I-6, 4-Stroke-Cycle Diesel

SCARAB International , LLLP
806-883-7621
1475 County Road W

salesmgr@scarabmfg.com

Quote

Date	Quote #
11/8/2019	110720

Anticipated Ship Date (ARO)
Hendersonville Composting Katherine Van Sice 704 945 3353
Terms

Name / Address
McKim and Creed 8020 Tower Point Drive Charlotte, NC 28227

Rep	Project

Description	Distributor	List
STANDARD EQUIPMENT* 14X6 BD 250HP John Deere BA Rubber Tire Machine 5,280 cubic yards per Hour (Belt Drum Drive) 1.78/1.35 per cubic yard/linear foot 1m per linear meter Engine: John Deere 250 HP******* Tier4F Diesel Engine Power Plant Unit********** Belt Driven Drum Drive Gates Predator Kevlar V-Belt Drum Drive System 98% Effecient of Engine Horse Power to the Drum. Fuel Savings in operation. Estimated fuel cost based on engine horsepower 10 gallons per hour. Operators Cab: Panoramic SCPA5000/ with all instrumentation Deluxe Seat c/w lumbar support & arm rest & Jump Seat SCARAB Digital Auto Load Controller **Controls drum speed** A/C & Heat Unit rated at 42,000 BTU AM/FM/CD Stereo PV380 Engine messenger Caterpillar D5 Caterpillar Track 30 Inch Tripe Grouser CleanFix Variable Pitch Auto Reversing Fan SCAU4800 Combination Auger/ Flail Style Drum 5/8" X 48" X 20' TransFluid PTO Clutch Engine shutdown system includes Low Hydraulic Oil shutdown c/w light & buzzer. 225 Gallon Diesel Tank Fairfield Track Planetary Drives 90 Series Sundstrand Hydraulic Pumps Hydraulic Rear Flap Tunnel Steel lined Tunnel Three mounted Cameras in rear of Machine with Monitor. SCARAB Operations & Maintenance Manuals		395,550.00T
2 FIRE EXTINGUISHERS (STANDARD EQUIP)		0.00

Printed Name:	Date:	**Total**
Authorized Signature:	Title:	
Phone: Fax:	Assigned PO #:	

SCARAB International , LLLP
806-883-7621
1475 County Road W

salesmgr@scarabmfg.com

Quote

Date	Quote #
11/8/2019	110720
Anticipated Ship Date (ARO)	
Hendersonville Composting Katherine Van Sice 704 945 3353	
Terms	

Name / Address
McKim and Creed 8020 Tower Point Drive Charlotte, NC 28227

	Rep	Project
Valid for ___ days from date of Quotation shown above. ALL PRICES ARE E.X.W. ORIGIN. This Quotation is subject to our standard terms and conditions of sale. ALL PRICES DO NOT INCLUDE ANY FEDERAL, STATE OR LOCAL TAXES OR TARIFFS. This quotation is subject to change. There may be additional inbound freight, permits licensing, wire transfer and legalization fees.		

Description	Distributor	List
WARRANTY 1 YEAR OR 2000 HOUR WHICH EVER OCCURS FIRST		0.00T
Shipping & Handling Estimated Shipping from White Deer Texas to be determined with sales order		10,500.00
Quote Good For 30 Days************************************		
Out-of-state sale, exempt from sales tax		0.00

Printed Name:	Date:	**Total**
Authorized Signature:	Title:	
Phone: Fax:	Assigned PO #:	$406,050.00

APPENDIX C – ATAD SUPPORTING INFORMATION

Contents:

1. Thermal Process Systems ATAD Budgetary Proposal
2. Thermal Process Systems ATAD Flow Schematic
3. Andritz Separation Rotary Drum Thickener Budgetary Proposal

Thermal Process Systems

October 8, 2019

Katherine Van Sice
McKim & Creed
8020 Tower Point Drive
Charlotte, NC 28227

Thermal Process Systems is pleased to offer the following proposal for the solids handling for your budgetary ATAD estimate based on the information provided by you. Note that TPS supplies only quality equipment and state-of-the-art technology in its patented ThermAer process. Please find attached the following:

- This Letter of Transmittal;
- ThermAer™ Budget Proposal;
- ThermAer™ Applications Reports;
- Thermal Process Systems' ThermAer™ Brochure;
- Thermal Process Systems' BiofiltAer™ Biofiltration Brochure; and
- Thermal Process Systems' Terms and Conditions.

We look forward to working with you on this project. Please feel free to contact me with questions and/or comments at (847) 778-3090 or by email rwooldridge@thermalprocess.com.

Sincerely,

Robert Wooldridge

Robert Wooldridge

Thermal Process Systems

Thermal Process Systems is pleased to offer the following budgetary proposal and preliminary scope of supply for the solids handling and processing for your ATAD project. The following proposal explains the fundamental theory behind Thermal Process Systems' Class 'A' thermophilic aerobic digestor and the components involved in the successful operation of an autothermal thermophilic aerobic digestion (ATAD) process. Most of the attention is given to the TPS **ThermAer™** system, as our specific type of ATAD is substantially different from the other ATAD processes available in the market today. Additionally, information is provided on the ancillary components required for these types of high temperature processes. A scope of services and supply, and a budgetary estimate are provided for your review.

The Thermal Process Systems' **ThermAer™** will provide your project with a process capable of meeting the solids' aeration demands as well as provide a cost effective process for substantial volume reduction and a Class 'A' virtually pathogen and odor free, stabilized final material. TPS is an innovative provider of 2nd Generation ATAD process operations providing comprehensive thermophilic solids treatment for over sixteen years and sincerely appreciates the opportunity to work with you on this treatment project.

The ThermAer Process can provide state-of-the-art digestion to the current plant operations (see figure 1). This preliminary design incorporates the use of new concrete tanks for the ThermAer digestor system and the SNDR. The patented **ThermAer™** system proposed here includes a process system capable of treating the waste activated sludge material transferred at an average of ~5% total solids at the average design load to the ThermAer Reactor.

Figure 1. New Construction of ThermAer Tank System, Franklin, IN

The SNDR reactor has the ability to nitrify and also denitrify the ThermAer solids prior to dewatering and/or land application operations. The addition of this aerated SNDR system is an important point to consider as it provides for additional storage prior to final dewatering activities. Tanks require fixed covers, to retain heat and control emissions and is assumed to be within the general contractor's scope of supply.

The following **ThermAer™** pricing includes the patented **ThermAer™** system, including jet aeration headers, jet motive pumps, blowers, foam control systems, process controls and control logic, and in-basin piping to operate the **ThermAer™** process reactor and the SNDR. This type of solids treatment process is very stable and requires only one actual process tank to complete the entire reaction (Reference Technical Papers, www.ThermalProcess.com). Accordingly, we have developed an operation and cost scenario that has been tailored to the facility's specific needs and provides for maximum flexibility.

Our design calculations are based upon the biological solids specific oxygen requirements. The 'gassing rate' (air/liquid ratio) in the jet system is the only parameter that may change drastically, and so this makes this particular digestion system even more operationally attractive given the complexities and uncertainties of many WTFs. The **ThermAer™** system requires a minimum of ~3.0% total solids but can easily process up to ~7% TS (2.5% to 7% VS). Our initial design calculations are based on the average month design loading of organic sludge solids at about 5% TS. Aeration is sized at the corresponding loading for operation on a 7- day per week loading schedule. TPS has several WWTPs operating under this type of design scenario. The **ThermAer™** aeration system is designed to meet 100% of the daily oxygen uptake requirement in the reactor.

The TPS process design incorporates jet aeration systems (figure 2). The ability to adjust both the liquid flow rate and air flow rate independently allows for the flexibility in this design to operate the system at a given temperature based on the actual solids loadings. Furthermore, this aeration system is designed to operate continuously throughout the daily dynamic process cycle. This digestion process has three basic steps in the process operation: waste, feed, and react. As mentioned previously, the cycle is set up to operate as a reverse draw, batch feed, and isolate and is never shut down, especially during the most critical time, the feeding (highest demand) period. The cycle begins by wasting the estimated daily feed volume from the ThermAer tank to the SNDR just prior to scheduled feeding, (approximately 1/12 (equal to the HRT in the system) the total volume for this (liquid burn reactor).

Figure 2. Interior of new ThermAer reactor with Jet Aeration Header, Blacksburg, VA

Wasting should occur in a fairly rapid fashion directly before the feed cycle begins to maximize the time under aeration during the subsequent reaction/isolation cycle. Feed material can be pumped directly into the reactor during the fill cycle as the waste solids are pumped from a holding tank (by others).

The pump and the blowers are equipped with variable frequency drives to provide the ability to vary the oxygen delivery capacity; to increase flows during high oxygen demand periods and also to decrease flows during low oxygen demand periods and thus conserve energy. This is an extremely important design consideration for this project. The daily cycles have large swings in the oxygen uptake requirement. Process control is based upon an oxidation-reduction potential (ORP) probe signal. This feature, along with the specially designed oxygen delivery system, offers the solids processing operation the ability to meet the high uptake demands that occur during the feed cycles and initial reaction phases and lower oxygen demands during the later reaction, pathogen destruction portion, of the cycle. In addition, this function can aid in the control of the reactors operating temperature throughout the process. This is accomplished by either conserving or wasting heat with the blower airflow rate. Evaporative and convective heat losses are the main method of heat control after attaining the appropriate temperature level from the volatile solids oxidation process. The ability to vary the liquid recycle rate and airflow delivery independently, in addition to the retention time provides the most effective method of reactor temperature control while maintaining optimum process metabolic conversion. The **ThermAer™** process is protected under US Patent Number 5,948,261. This installation is considered a single use license agreement.

TPS has designed this system as a semi-automated process, however, it can easily be operated as a completely automated process or manually. As such, a PLC processor package is included along with a PanelView™ operator interface touch screen. Outputs are provided to tie this local control system into an existing or proposed processor elsewhere in the plant. The instrumentation necessary to properly monitor the process is included and directed into the PLC for the convenience of the operations personnel. The primary function of the processor is to control the reactor mixing intensity and aeration delivery rate. This is accomplished by receiving the primary signal from an ORP probe mounted on the pump suction piping and 'fine-tuning' with secondary signals. The ORP signal (see figure 3) is read by the PLC and then appropriate settings are sent to the pump and blower VFDs and ultimately the pumps and blowers. During the feed cycle, the oxygen demand will increase. As oxygen demand increases, the oxidation-reduction potential decreases.

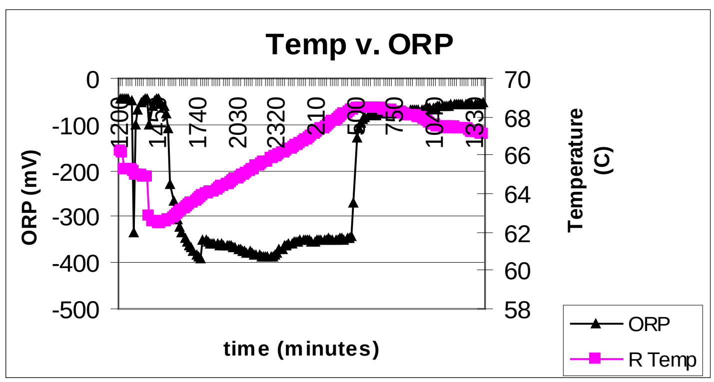


Figure 3. Actual temperature and ORP Response Curve Data (24 hr period)

This is read as a negative millivolt (electrical potential) value when the oxygen demand is not being met by the oxygen delivery system. The aeration system is designed with a maximum and a minimum setting. The maximum setting is based upon the highest requirement of oxygen uptake anticipated during the feed cycle. The purpose of this setting is to minimize the depth of the ORP dip as well as minimize the length of time the ORP signal remains at a low level, i.e., the systems' aerobic nature is maximized. The minimum setting is based upon the turn down capabilities of the process equipment and minimum design mixing intensity. Optimization of this process maximizes aerobic destruction efficiency and minimizes odor potential while minimizing utility electrical costs.

Oxygen demand is based upon the amount of soluble COD available to the microbial community as a food substrate. Therefore, process stability is at its highest when the feed cycle is extended over a relatively long period. The process is designed to be self-regulating and therefore is adaptable to several feed cycle protocols providing the instantaneous uptake demand does not exceed the maximum capability of the aeration equipment. Secondary signals are received from temperature probes mounted near the ORP probe and from our proprietary foam control monitoring system. Liquid and air-flows are controlled independently to sustain optimum reactor performance. This portion of the control process is patented with the U.S. Patent Office number 6,203,701.

The calculated oxygen requirement is based upon 60% VS destruction rate (mass balance) for secondary solids. The actual destruction may vary. The aeration system is designed with positive displacement blowers for the air delivery system. Positive displacement blowers have been selected because of their ability to operate with variable backpressure created by changing liquid depths and reactor temperature. The displacement of airflow is a direct correlation to blower rpm. The blower selected for this application will operate at $\approx$90% of maximum rpm at the design airflow. This design point offers a high degree of flexibility to turn the blower rpm up or down. Therefore, the system has the inherent capability of increasing O_2 delivery during unexpected high COD feed concentrations. An unusually high uptake or demand is detected by a low ORP reading and is met by increasing pump and blower speeds above the anticipated requirement. It also has the capability to decrease pump and blower speeds for energy and temperature conservation during periods of low solids feeding, unattended weekends, or inactivity.

A hydraulic foam control system is also included as part of our package. The foam layer is the upper reactor's insulation blanket. Foam suppression nozzles connected to a dedicated foam pump to supply the energy source. The pump is designed to operate at sufficient volume and pressure to recycle reactor contents which primary function is breaking down the foam. The foam bubbles are ruptured by the mixing intensity of the nozzle and return SplashCone™ unit. The system is operated when required and controlled by the foam level radar transmitter in the top of the reactor.

The SNDR is cooled and operated with 12 day HRT and below ~95°F to facilitate the introduction of a mesophilic culture and nitrification prior to dewatering and land application activities. The remaining existing tank can serve as a wide spot in the line, allowing for smaller dewatering operations as the material is either removed slowly each day, or campaign dewatered on daily or weekly batch runs. Well-digested biosolids release a portion of the entrained water within the cell structure in the reactor. Therefore, digested material has the ability to release a higher percentage of free water during dewatering. These high temperature processes denature and consume exopolymeric substances (EPS), a form of protein. These EPSs can bind water, up to 5 grams H_2O/gram EPS. As such, TPS **ThermAer**™ units typically experience an increase of approximately 25-30% in cake solids as compared to undigested or classical aerobically digested WAS, depending on downstream unit processes. The increased cake solids in conjunction with the high TS destruction rate have a significant impact on the economics of this project. The combination of reducing the mass and increasing the cake solids will decrease the overall amount of material necessary to store and process in all downstream unit operations, material handling, and ultimately removal from site, typical volumetric reductions for dewatered materials result in fewer trucks out the gate reducing transportation costs significantly.

The two-stage **BiofiltAer™** odor control system is described below (figure 4). The initial portion of the odor control system includes the SNDR headspace for cooling/ammonia scrubbing using the recycled biosolid material. This unit serves two major functions for this application. Its primary function is to cool the hot air to assure conditions within the biofiltration media are conducive to mesophilic biological activity. Its secondary function is to effectively remove a high percentage of the ammonia and other soluble compounds contained in the off-gas (an indication of cell breakdown). Ammonia is water-soluble and easily removed with a properly designed scrubber unit. The typical design off-gas, concentration to the scrubber is 1,200 ppm. However, values may range from 500 to 1,500 ppm, throughout the digestion process. Design ammonia feed to the biofilter portion of the gas treatment system is less than 100 ppmv. As such, the SNDR design is based upon 70-80% ammonia removal and 95-100°F exit temperature to assure the proper temperature and nitrification-loading rate is introduced to a second stage biofilter. A back-up scrubber would be included for periods in which the SNDR exceeds 104°F or may need to be by-passed.

Figure 4. 15,000 SCFM Biofiltration Unit, Middletown, Ohio

The second stage of the **BiofiltAer™** would typically be installed within a concrete containment area and is used to house the biofilter media. The biofilter media used for this application is unique and different from many other biofilter operations. The media is used to grow and sustain a fixed film mesophilic aerobic biological process. The process design is based upon proven technology with a specific set of criteria. The purpose of the process design is to allow naturally occurring bacteria an environmental condition that is sufficient to break down the influent constituents and biologically remove odorous organic compounds. The critical design criteria are influent constituents and concentration, airflow distribution, temperature, humidity, residence time and media pH. Airflow distribution is accomplished by means of reducing the influent velocity and introducing the airflow into an open plenum providing even distribution across the media bed. Residence time in the bed is selected by using the highest concentration of the least soluble compound. The ammonia scrubber controls saturation and air temperature.

Unlike synthetic media based systems, the TPS natural media based system requires little or no additional nutrients (N, P, K), micronutrients (Mn, S, Se), or buffering chemicals which add to the annual operation cost and complexity. Additionally, periodic loss of the emission stream does not result in a significant loss of biomass because of its backup food source supply contained within the media. Furthermore, once the foul airstream is reintroduced, provided it is properly humidified, there is little if any additional re-acclimation time required. Washing the bed with plant service water on a periodic basis aids in the control of media pH. Overall system design is based upon removing a minimum of 95% of the influent constituents. Thermal Process Systems not only designs its own systems, but is often requested to design and install its biofilter system on competitor's ATAD systems and other failed chemical and biological systems. The initial design includes only the airstream from the ThermAer system, but can be increased to include off-gas components from storage and dewatering operations.

Benefits of the ThermAer Unit:

- Class 'A' as a liquid or solid material,
- Odor free product for land application programs,
- Continued re-seeding of aeration basin with nitrifiers and denitrifiers, (after dewatering)
- Ability to handle septage and grease,
- No odors from process,
- Little operator attention is required,
- Can be integrated into almost any design scheme with existing tankage,
- Substantial volume reduction,
- Nutrient (N and P) removal from the return stream and
- Class 'A' process at Class 'B' price.

Thermal Process Systems provides process and design engineering and design support to the design engineer. Technical instructions for the ThermAer unit, start-up, as well as, operation and maintenance are also included. Thermal Process Systems' personnel will be there every step of the way to ensure a smooth transition to the **ThermAer™** process operation, from initial training and information sessions, access to design data, assistance in permitting, equipment shakedown, startup, operation, and trouble shooting.

Provide ThermAer™ treatment for Class A solids

Proposed design daily loading of 8,810 lbs/day of sludge material loaded on a 7 day work week.

ThermAer Package

Sludge Type	
WAS	8,810 lbs/day average design 7-day/week
Number of ThermAer Reactors	2
Number of SNDR Reactors	1
%TS Average	~5.0%
%TS Range	4 - 7%
%VS	80%

ThermAer Reactor Sizing

Two new concrete tanks – 35 ft. x 28 ft. x 24 ft. deep, with a proposed SWD of ~18 ft. (By contractor)

Two (2) ThermAer Reactors each complete with:

1) One (1) 100 HP, 54-20 ThermAer jet motive pump.
2) One (1) 40 HP positive displacement blower.
3) Three (3) Foam control SplashCone™ with assemblies.
4) One (1) in-basin FRP piping for the ThermAer system including the 16" liquid and 8" air jet aeration system header with 8 nozzles, pipe supports, connection hardware and anchor bolts for this piping.
5) One (1) Radar foam level sensor.
6) One (1) ORP probe and analyzer with temperature readout.
7) One (1) Vacuum gauge sensor.
8) One (1) Liquid level sensor with local readout.

SNDR Reactor Sizing

One new concrete tank – 56 ft. x 35 ft. x 24 ft. deep, with a proposed SWD of ~18 ft. (By contractor)

One (1) SNDR Reactors complete with:

1) One (1) 50 HP, 42-14 SNDR jet motive pump.
2) One (1) 40 HP positive displacement blower.
3) Three (3) Foam control SplashCone™ with assemblies.
4) One (1) in-basin FRP piping for the SNDR system including the 14" liquid and 8" air jet aeration system header with 8 nozzles, pipe supports, connection hardware and anchor bolts for this piping.
5) One (1) Radar foam level sensor.
6) One (1) ORP/pH probe and analyzer with temperature readout.
7) One (1) Vacuum gauge sensor.
8) One (1) Liquid level sensor with local readout.

Additional Equipment
1) One (1) 40 HP positive displacement blower. (Spare)
2) One (1) 3" Magnetic flow meter and transmitter for feed control and monitoring.
3) One (1) 4" Magnetic flow meter and transmitter for intra-process control and monitoring.
4) Five (5) 4" Actuated valves.
5) Four (4) 6" Actuated valves.
6) One (1) Heat Exchanger.
7) Two (2) 15 HP Transfer pumps.
8) One (1) Pre-wired control panel complete with PLC, and system programming.
9) One (1) Battery backup system.

Included Spare Parts
1) One (1) ORP/pH Probe.
2) One (1) Blower Filter.
3) Five (5) Spare Belts one (1) set per pump/blower size.

BiofiltAer Odor Control Unit
One new concrete Biofilter tank – 40 ft. x 20 ft. x 12 ft. deep (By contractor)

One (1) Biofilters each complete with:
1) One (1) 30 HP 8,000 SCFM @ 9" WC Fan.
2) One (1) Scrubber.
3) One (1) Aluminum Biofilter Cover.
4) One (1) Lot, Biofilter plenum for even air flow distribution.
5) One (1) Lot, inorganic Biofilter media.
6) One (1) Lot, organic Biofilter media.
7) One (1) RTD temperature sensor.
8) One (1) Biofilter instrument cabinet.

Electrical Package MCC/VFDs
MCC mounting arrangement with Allen Bradley 6 pulse VFDs.
1) Two (2) ThermAer Jet Motive Pumps 100 HP VFD.
2) Two (2) ThermAer PD blowers 40 HP VFD.
3) One (1) SNDR Jet Motive Pump 50 HP VFD.
4) One (1) SNDR PD blower 40 HP VFD.
5) One (1) Spare PD blower 40 HP VFD.
6) Two (2) Transfer Pumps 15 HP VFD.
7) One (1) Off Gas Fan 30 HP VFD.
8) One (1) 120/240 VAC Lighting Panel w/ 10 – 20 Amp Breakers.
9) One (1) Control Panel Power Monitor.
10) One (1) Control Panel Transformer.
11) One (1) Main Disconnect.

ThermAer™ Base Proposal Package Pricing **$2,490,105.00 US Dollars**

Start-up services and O&M manuals are included in the above listed price. Tank construction, modification, covers, equipment installation, and electrical service to the facility control room are assumed to be provided by the general contractor. As stated above, we have included the **ThermAer**™ patented facility and hardware and patented control logic system for the ThermAer reactors and the SNDR as well as the odor control unit. Copies of ThermAer Applications Reports, the **ThermAer**™ brochure, and TPS Terms and Conditions are also included in the following sections of this package. This is a budget estimate, based on 'normally' encountered conditions.

Notes
1) Performance test labor, test equipment and laboratory services are to be Contractor or Owner supplied.
2) Purchased equipment such as electric motors, pumps, blowers, valves, gear reducers, instrumentation, etc. will be furnished with manufacturer's standard finish.
3) Prepaid truck freight to the job site is included.
4) These prices are correct for the next 120 days.
5) Price quoted is exclusive of any Local, State or Federal taxes.

Work and material not included
1) The Contractor shall provide the necessary pump, fan and blower pads, anchor bolts and leveling required for proper setting of all equipment associated with the ThermAer reactor(s), and SNDR.
2) The Contractor shall supply all connections, sample taps, drains, interconnecting spool pieces, and miscellaneous 'small' valves for each pump, blower and fan as shown on drawings.
3) The Contractor shall supply the seal water supply pipe, seal arrangements, pressure regulators, and flow control, drain and accessories for the ThermAer(s), SNDR, and foam control pumps, and coatings (if required by the Engineer).
4) The Contractor shall supply all tank penetrations,
5) The Contractor shall supply all covers for the ThermAer(s) as shown on the drawings.
6) The Contractor shall supply all the tank cover penetrations, flanges, seals, hatches and man ways as shown on the drawings.
7) The Contractor shall supply interconnecting bolts, gaskets, welds, and other miscellaneous fasteners.
8) The Contractor shall supply a communication cable from the ThermAer control panel to the VFDs.
9) The Contractor shall supply all conduits and interconnecting electrical wire for all motors, instruments, and controls.
10) The Contractor shall supply field welds for the in-basin and out-of-basin stainless steel supports associated with the liquid and air headers provided by the ThermAer supplier.
11) The Contractor shall supply all miscellaneous plant service water supply piping.
12) The Contractor shall supply any field installation including delivery point rigging, offloading and storage.
13) The Contractor shall supply all penetrations, nipples, and mounting accessories for field installed instruments and probes.
14) The Contractor shall supply any such items but not limited to as; structural steel, platforms, walkways, ladders, guards, handrails, gratings, supports, piping, valves, weirs, flexible connections, anchor bolts, starters, panel boards, field painting, insulation, or electrical work or material other than that specifically mentioned in the offering which may be required by site specific conditions, federal, state or local requirements.

Field Assembly, Erection, Installation
All equipment will be delivered as fully assembled as possible. When certain items must be delivered partially disassembled because of shipping limitations or other special conditions, field assembly will be the responsibility of the customer. This will normally consist of joining sections by mechanical means such as with bolts, nuts and screws. Equipment installation is the responsibility of the others.

Site Services
TPS shall furnish the services of a technician for a period of approximately twelve (12) days to be covered in four (4) trips to the job site to check the installation, supervise the start-up, supervise performance testing as required by the specifications, and provide operator instruction for the items included in our scope of supply. Service time noted above includes follow-up services for system controls required by the specifications. Additional service is available at our portal to portal per diem rate in effect at the time of service delivery, plus air fare. The current per diem supervision rate is Seven Hundred Fifty dollars ($750.00) plus travel.

Engineering Submittals
Drawings for approval and certified specifications will be submitted within eight-ten (8-10) weeks after date of receipt of acceptable purchase order.

Shipment
Shipment will be made thirty (30) weeks after receipt by *TPS* of written approved Engineering Submittal.

Installation, Operation and Maintenance Manuals
Operation and Maintenance Manuals will be provided per specification.

Equipment Warranty
See “Guarantee" in our "Terms and Conditions".

Patents
TPS owns the exclusive rights to Patents 5,948,261; 6,168,717; 6,203,701 and 6,514,411. This offering is considered a single use license agreement.

Validity of Quotation
Prices are valid for one hundred twenty (120) days from date of quotation.

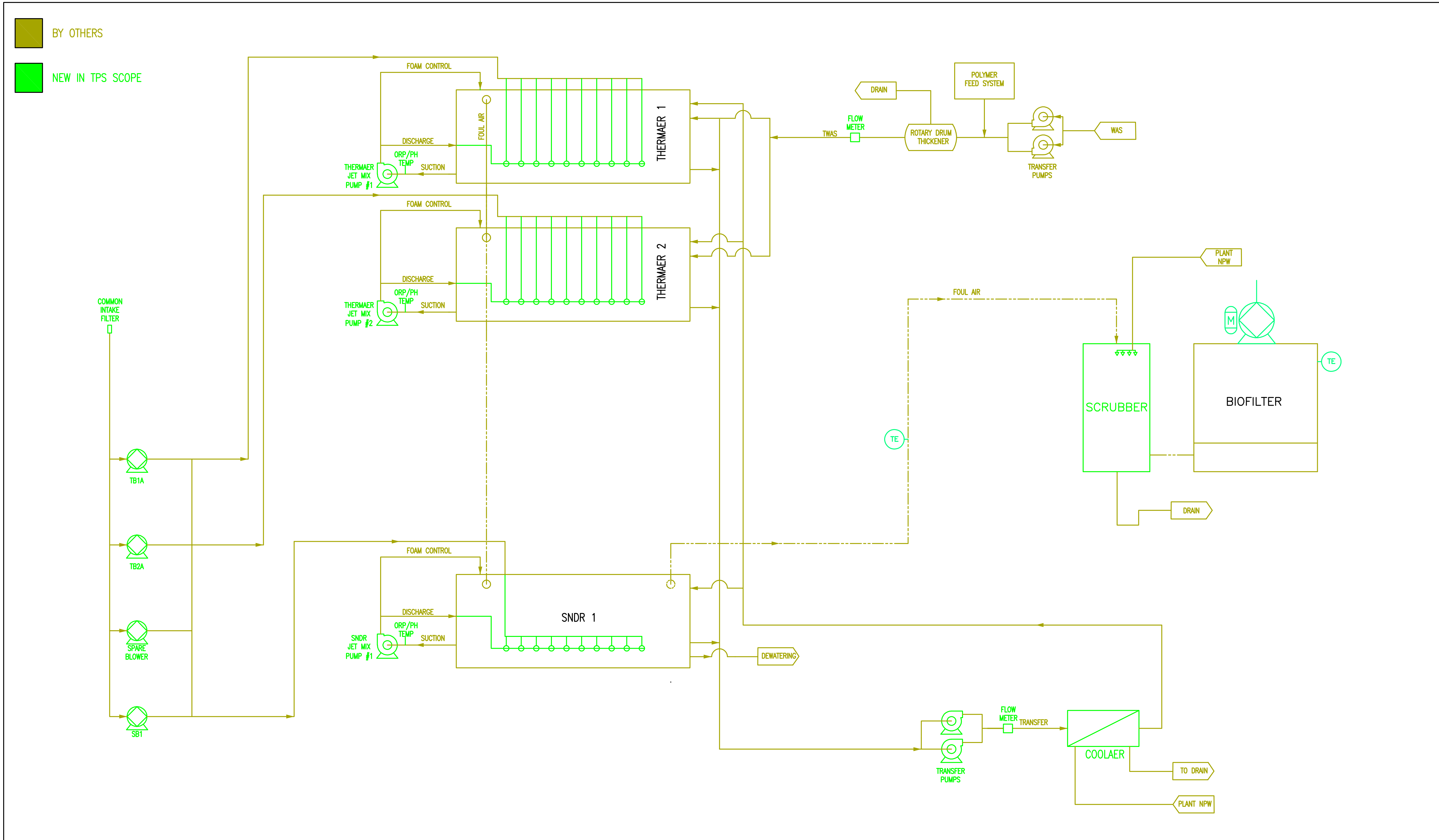
Terms of Payment
Net thirty (30) days from date of invoice.

Conditions of Sale
See attached Thermal Process Systems "Terms and Conditions," which are hereby made part of this quotation.

****

TPS looks forward to working with the **WWTP** staff on this project. If you have any questions regarding this proposal, please do not hesitate to contact Thermal Process Systems or our local representative.

Bob Wooldridge Thermal Process Systems 627 East 110th Ave Crown Point, IN 46307 rwooldridge@thermalprocess.com (847) 778-3090	Michael Knight Clear Water, Inc 1105 8th Street Court SE Hickory, NC 28602 mike@clearwaterinc.com (828) 855-3182



LIQUID	BLOWER	Thermal Process Systems 627 East 110th Ave. Crown Point, IN 46307	FLOW SCHEMATIC
LIQUID	FLOW METER		Job: HENDERSONVILLE, NC.
FOUL AIR	PUMP		Job #:

DATE	REVISION	BY	CH'D

Customer: HENDERSONVILLE, NC.
Engineer:
Drawn By: KRM
Sheet: 1 Total Sheets: 1
Date: 11-21-2019

Budget Proposal

PDR900M Drum Thickener
COH Solids Management Plan

Proposal :3213106
Date: 10-01-19

By: Bruce SoRelle
Tel: (817) 266-9732
E-mail:
Bruce.sorelle@andritz.com

Katherine J. Van Sice
Engineer Intern

McKim and Creed
8020 Tower Point Drive
Charlotte, NC 28227
T 704.841.2588
D 704.945.3353

Andritz Separation Technologies Inc.
1010 Commercial Blvd S.
Arlington, TX 76001, USA
Phone: +1 817 465 5611
Fax: +1 817 468 3961
environ.us@andritz.com
www.andritz.com

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COVER LETTER

«October 01,2019»

Katherine J. Van Sice
Engineer Intern

McKim and Creed
8020 Tower Point Drive
Charlotte, NC 28227
T 704.841.2588
D 704.945.3353

Re: ANDRITZ Separation PDR900M Drum Thickener

Dear Ms. Van Sice,

ANDRITZ is pleased to submit this proposal of our PDR900M for your sludge thickening project.

Please find enclosed our pricing, technical specifications, and reference drawings of the ANDRITZ equipment, which will further describe our drum thickener system and its features.

We appreciate the opportunity to work with you on this project. Please do not hesitate to contact me or Jim Grant of EW2 at (704) 577-9437 should you have any questions.

Regards,

Bruce SoRelle
Regional Sales Manager
ANDRITZ Separation Inc.
Ph: (817) 419-1730
Cell: (817) 266-9732
Bruce.sorelle@andritz.com

ANDRITZ Separation

DRUM THICKENER

TECHNICAL OFFER

OPERATING CONDITIONS & SIZING

A – OPERATING CONDITIONS

Application	**Sludge thickening**
Type of sludge	WAS
Type of effluent	WWTP
Quantity of sludge to be treated (lbs. DS / day)	9,270
Operating time (hrs / day – days / week)	12/5
Feed solids concentration (g DS/l)	1.87
Feed volatile solids content (%)	TBD

B – SIZING & PERFORMANCE

Drum type	**PDR 900M**
Number of machines	1
Unit flow (GPM)	192
Polymer consumption (emulsion) (kg per ton DS)	TBD
Dryness of thickened sludge (%)	5.0
Capture rate (%)	95

Lab testing is recommended to validate thickened solids, polymer consumption and drainage rates of sludge for accurate sizing of PDR.

TECHNICAL DESCRIPTION

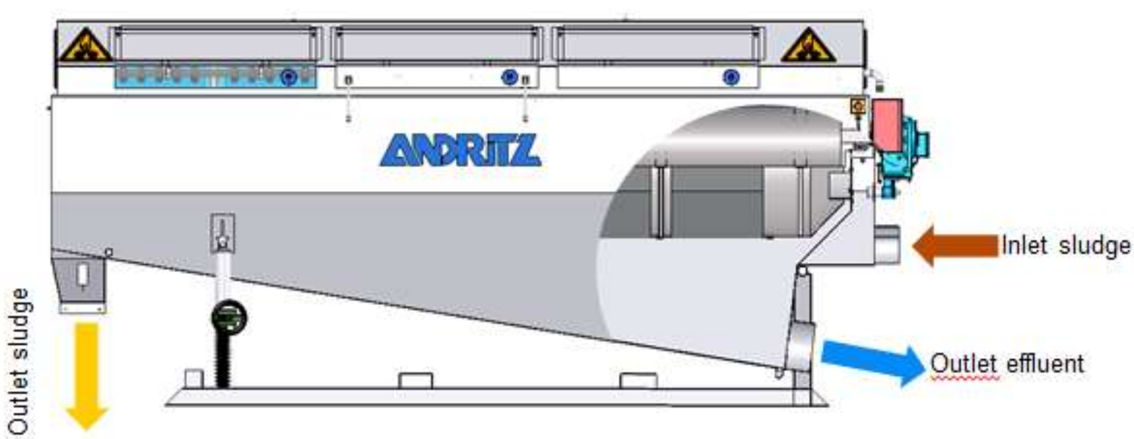
A static mixer (Venturi) is supplied with the drum in order to mix polymer and sludge. It must be installed 5 to 10 meters upstream of the drum inlet.

OPERATING PRINCIPLE

The flocculated sludge enters by gravity into the drum made of a steel structure, on which a PES cloth is fastened.

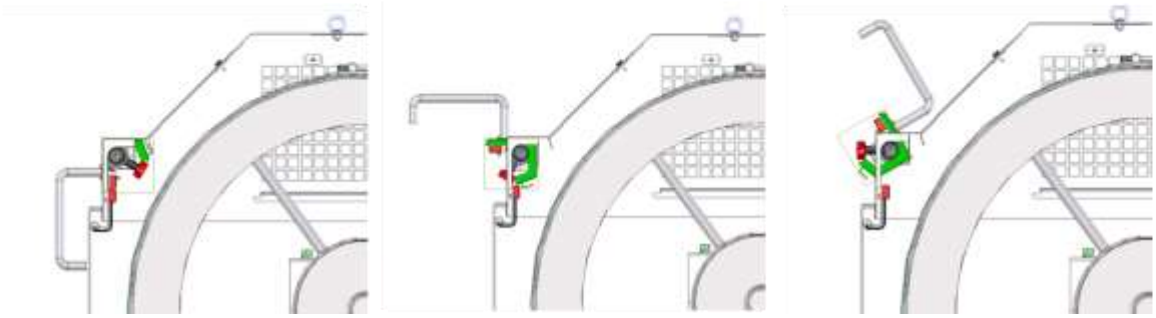
The drum rotation thickens the flocculated sludge, releasing the free water through the belt.

Drum inclination allows for continuous draining and sludge transfer towards the outlet. Sludge residence time varies according to the drum rotation angle.



DRUM WASHING

A spray bar washes the full length of the drum either continuously or periodically depending on the sludge type. Quick access allows easy nozzles washing.



Filtrate and wash water are collected in the body frame.

TANK WASHING

The tank bottom should be periodically cleaned in order to remove possible remaining suspended solids resulting from flocculation malfunction.

DRIVE

The motor with frequency inverter allows adjustable speed of the drum, in order to reach the best thickening efficiency for each specific sludge thickening application.

The frequency inverter needs to be placed in an electrical control panel not included in our standard supply.

FRAME

The body frame supports all elements; it is fully covered and equipped with removable inspection panels. The covers are equipped with safety switch.

The body frame is articulated on the drive side and a system wheel + endless screw enables the adjustment of the drum rotation angle.

The tank is equipped with sampling points for filtrate, cake and flocculated sludge.

OPTIONAL HYDRAULIC CONNECTIONS

The washing spray ramp is supplied with solenoid valves and pressure switch; the pipes are connected to a common point. Thanks to the flexible piping, the frame can change position without damaging the pipes.

TECHNICAL DATA

Size						Utilities		
Type	*Drum diameter*	*Length*	*Width*	*Height*	*Weight*	*Motor IEC 400V – 50Hz NOT INCLUDED*	*Washing flow at 8 bars*	*Washing water pressure*
Metric	**mm**	**mm**	**mm**	**mm**	**kg**	**kW**	**m3/hr**	**bars**
PDR 900 M	900	2950	1200	1750	575	1.1	2.4	8 mini
Imperial	inches	inches	inches	inches	Lbs.	HP	GPM	PSI
PDR 900 M	35.43	116.14	47.24	69	1268	2hp	9.0	120

COMMERCIAL OFFER

PRICE LIST PDR 900M

Item	Qty	Machine	Unit price Tax not incl. USD	Total price Tax not incl. USD
1.	One (1)	**Drum thickener type PDR 900M** • SS 316L contact parts, base frame, and covers • PVC spray pipe with quick disconnect nozzles • Woven polyester mesh filtration belt		**Included**
2.	One (1)	**Venturi Mixer** • In-line, 4" pipe connection • Adjustable with counter-weight system • Polymer injection manifold included		**Included**
3.	One (1)	**Control Panel** • NEMA 4X, 304 SST enclosure • 480 VAC, 3-ph, 60-Hz power with main disconnect • Motor starters with thermal overloads • Control relays, alarm relays and terminals for external connections		**Included**
4.	1 Lot	**Spare Parts** • Parts required for estimated 2-year (4,000 hour) run time		**Not-Included**
5.	1 Lot	**Basic Engineering and Documentation**		**Included**
6.	1 Lot	**Field Services** • Three days in one trip for installation checkout, start-up, testing, and training		**Included**
7.	1 Lot	**Freight Included**		**Included**
PRICING, FOB «CITY_STATE»				**$ 156,000 USD**

COMMERCIAL CONDITIONS

TERMS AND CONDITIONS

This price proposal is based on the attached ANDRITZ Separation Inc. “Standard Terms and Conditions of Sale”.

This proposal is valid for thirty (30) days.

TERMS OF PAYMENT

- 30% of Order Value upon submittal of Approval Drawings
- 70% of Order Value upon Readiness to Ship

SHIPMENT

Approval drawings will be furnished four to six (4 - 6) weeks after executed purchase order. Equipment can be delivered (16 - 20) weeks after receipt of approved submittal package.

ACCESSORIES

This proposed price includes only those items identified in the above “Proposed Scope of Supply”. Any additional items which may be necessary for the operation of the equipment, but are not specifically identified are to be supplied by others or by ANDRITZ at an additional cost.

ABRASION OR CAUSTIC MATERIALS

The environment and atmosphere that the equipment may be exposed to may be abrasive or corrosive. This proposal makes no representations or warranties regarding the service life of the equipment against such abrasion or corrosion.

PURCHASE ORDERS

All purchase orders shall be faxed, followed by a hard copy mailed to:

ANDRITZ Separation Inc. 1010 Commercial Blvd., South
Arlington, Texas 76001 **Phone:** 817/ 465-5611
Fax: 817/ 468-3961 Attn.: Bruce SoRelle

All purchase offers (orders) are subject to acceptance by ANDRITZ Separation Inc.

EXCLUSIONS

- Financing
- Equipment installation or building modifications
- Fees or taxes of any kind (sales, use, excise, Local, State, Federal, or Final Destination)
- Cranes or lifting devices
- Unloading and/or storage of equipment at jobsite
- Foundation design and engineering (ANDRITZ will furnish equipment drawings and data)
- Utilities for erection and operation (including during commissioning)
- Gauges and instrumentation not specifically identified in the above proposed scope of supply
- Air compressors, water booster pumps, feed pumps, flocculation tanks, mixers
- Any peripheral equipment not listed in this scope letter
- Interconnecting / field wiring, conduit, piping, tubing, valves, etc., between proposed equipment and existing equipment or controls Civil engineering, supporting platforms and ladders
- Polymer
- Lubricants beyond initial fill

ENGINEERING

Following are the major engineering services included in the proposed sale price

- General arrangement drawings of proposed ANDRITZ equipment
- Specific equipment drawings, complete with piping and wiring requirements
- Control panel(s) and wiring drawings of the control components included in the proposed scope of supply.
- Operating and maintenance manuals, including recommended spare parts lists
- Motor and drive list
- Sequence of operation

PROJECT MANAGEMENT

- Production of a complete critical path project schedule for ANDRITZ equipment
- Coordinate with the customer's Engineering and ANDRITZ Engineering on system design and drawing schedule commitments
- Coordinate with manufacturing on material procurement and construction to ensure ANDRITZ commitments are maintained.

ERECTION, TRAINING, AND START-UP ASSISTANCE

ANDRITZ will provide erection and start-up supervision for which the purchaser shall pay $1,500.00 per day (USD) plus expenses, for eight (8) hours per day.

- At the request of the purchaser, overtime service will be provided at a rate of 1.5 times the quoted rates for weekdays, 2.0 times the quoted rate for weekends.
- Expenses are defined as the cost of travel from Seller's plant to the point of installation and return, together with all living expenses during the period of service.
- The above charges shall be made for time involved, including delays which are beyond the Seller's control.

EQUIPMENT STANDARD

Any deviations from the ANDRITZ standard mechanical and electrical specification, which are not the owner's preference, must be further discussed. Refer to the ANDRITZ standard specifications enclosed.

LOCAL ANDRITZ REPRESENTATIVE

Name
Company
Address 1
Address 2
Phone#

Kind Regards,

«SALESMAN»
Regional Sales Manager
ANDRITZ Separation Inc.
1010 Commercial Blvd., South
Arlington, Texas 76001
Ph: «SM_PHONE»
Fx: «SM_FAX»
Cell: «SM_CELL»
«SM_EMAIL»

Enclosure: Standard Terms and Conditions of Sale

ANDRITZ SEPARATION INC. STANDARD TERMS AND CONDITIONS OF SALE

1. TERMS APPLICABLE

The Terms and Conditions of Sale listed below are the exclusive terms and conditions applicable to quotations made and orders acknowledged by the ANDRITZ entity supplying the same ("Seller") for the sales of products, equipment and parts relating thereto ("Products"). If this quotation or acknowledgment contains terms additional to or different from those offered by Buyer, then any acceptance by Seller is expressly made conditional upon Buyer's assent to such additional or different terms. Any of Buyer's terms and conditions that are in addition to or different from those contained herein, which are not separately agreed to by Seller in writing, are hereby objected to and shall be of no effect. [The term "this Agreement" as used herein means this quotation or acknowledgment or purchase order, together with any attachment hereto, any documents expressly incorporated by reference and these Terms and Conditions of Sale.]

2. DELIVERY

Delivery dates are good faith estimates and do not mean that "time is of the essence." Buyer's failure to promptly make advance or interim payments, supply technical information, drawings and approvals will result in a commensurate delay in delivery. Upon and after delivery, risk of loss or damage to the Products shall be Buyer's. Delivery of the Products hereunder will be made on the terms agreed to by the parties as set forth in this Agreement, according to INCOTERMS 2010.

3. WARRANTY

(a)Seller warrants to Buyer that the Products manufactured by it will be delivered free from defects in material and workmanship. This warranty shall commence upon delivery of the Products and shall expire on the earlier to occur of 12 months from initial operation of the Products and 18 months from delivery thereof (the "Warranty Period"). If during the Warranty Period Buyer discovers a defect in material or workmanship of a Product and gives Seller written notice thereof within 10 days of such discovery, Seller will, at its option, either deliver to Buyer, on the same terms as the original delivery was made, according to INCOTERMS 2010, a replacement part or repair the defect in place. Any repair or replacement part furnish pursuant to this warranty are warranted against defects in material and workmanship for one period of 12 months from completion of such repair or replacement, with no further extension. Seller will have no warranty obligations for the Products under this paragraph 3(a): (i) if the Products have not been operated and maintained in accordance with generally approved industry practice and with Seller's specific written instructions; (ii) if the Products are used in connection with any mixture or substance or operating condition other than that for which they were designed; (iii) if Buyer fails to give Seller such written 10 day notice; (iv) if the Products are repaired by someone other than Seller or have been intentionally or accidentally damaged; (v) for corrosion, erosion, ordinary wear and tear or in respect of any parts which by their nature are exposed to severe wear and tear or are considered expendable; or (vi) for expenses incurred for work in connection with the removal of the defective articles and reinstallation following repair or replacement.

(b)Seller further warrants to Buyer that at delivery, the Products manufactured by it will be free of any liens or encumbrances. If there are any such liens or encumbrances, Seller will cause them to be discharged promptly after notification from Buyer of their existence.

(c)THE EXPRESS WARRANTIES SELLER MAKES IN THIS PARAGRAPH 3 ARE THE ONLY WARRANTIES IT WILL MAKE. THERE ARE NO OTHER WARRANTIES, WHETHER STATUTORY, ORAL, EXPRESS OR IMPLIED. IN PARTICULAR, THERE ARE NO IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

(d)The remedies provided in paragraphs 3(a) and 3(b) are Buyer's exclusive remedy for breach of warranty.

(e)With respect to any Product or part thereof not manufactured by Seller, Seller shall pass on to Buyer only those warranties made to Seller by the manufacturer of such Product or part which are capable of being so passed on.

4. LIMITATION OF LIABILITY

Notwithstanding any other provision in this Agreement, the following limitations of liability shall apply:

(a) In no event, whether based on contract, tort (including negligence), strict liability or otherwise, shall Seller, its officers, directors, employees, subcontractors, suppliers or affiliated companies be liable to Buyer or any third party for loss of profits, revenue or business opportunity, loss by reason of shutdown of facilities or inability to operate any facility at full capacity, or cost of obtaining other means for performing the functions performed by the Products, loss of future contracts, claims of customers, cost of money or loss of use of capital, in each case whether or not foreseeable, or for any indirect, special, incidental or consequential damages of any nature.

(b) The aggregate liability of Seller, its officers, directors, employees, subcontractors, suppliers or affiliated companies, for all claims of any kind for any loss, damage, or expense resulting from, arising out of or connected with the Products or this Agreement or from the performance or breach thereof, together with the cost of performing make good obligations to pass performance tests, if applicable, shall in no event exceed the contract price. The foregoing notwithstanding, Seller's aggregate liability for any claims for (a) delay in delivery shall not exceed 5% and (b) failure to achieve performance requirements, shall not exceed 10% of the contract price.

(c) The limitations and exclusions of liability set forth in this paragraph 4 shall take precedence over any other provision of this Agreement and shall apply whether the claim of liability is based on contract, warranty, tort (including negligence), strict liability, indemnity, or otherwise. The remedies provided in this Agreement are Buyer's exclusive remedies.

(d) All liability of Seller, its officers, directors, employees, subcontractors, suppliers or affiliated companies, resulting from, arising out of or connected with the Products or this Agreement or from the performance or breach thereof shall terminate on the third anniversary of the date of this Agreement.

5. CHANGES, DELETIONS AND EXTRA WORK

Seller will not make changes in the Products unless Buyer and Seller have executed a written Change Order for such change. Any such Change Order will include an appropriate adjustment to the contract price and delivery terms. If the change impairs Seller's ability to satisfy any of its obligations to Buyer, the Change Order will include appropriate modifications to this Agreement. If, after the date of this quotation or acknowledgment, new or revised governmental requirements should require a change in the Products, the change will be subject to this paragraph 5.

6. TAXES

Seller's prices do not include any sales, use, excise or other taxes. In addition to the price specified herein, the amount of any present or future sales, use, excise or other tax applicable to the sale or use of the Products shall be billed to and paid by Buyer unless Buyer provides to Seller a tax-exemption certificate acceptable to the relevant taxing authorities.

7. SECURITY INTEREST

Seller shall retain a purchase money security interest and Buyer hereby grants Seller a lien upon and security interest in the Products until all payments hereunder have been made in full. Buyer acknowledges that Seller may file a financing statement or comparable document as required by applicable law and may take all other action it deems reasonably necessary to perfect and maintain such security interest in Seller and to protect Seller's interest in the Products.

8. SET OFF

Neither Buyer nor any of its affiliates shall have any right to set off claims against Seller or any of its affiliates for amounts owed under this Agreement or otherwise.

9. PATENTS

Unless the Products or any part thereof are designed to Buyer's specifications and provided the Product or any part thereof is not used in any manner other than as specified or approved by Seller in writing, (i) Seller shall defend against any claims made in a suit or proceeding brought against Buyer by an unaffiliated third party that any Product infringes a device claim of a United States or a Canadian patent issued as of the effective date of this Agreement and limited to the field of the specific Products provided under this Agreement; provided Seller is notified promptly in writing and given the necessary authority, information and assistance for the defense of such claims; (ii) Seller shall satisfy a final judgment (after all appeals) for damages entered against Buyer on such claims, so long as such damages are not attributable to willful conduct or sanctioned litigation conduct; and (iii) if such judgment enjoins Buyer from using any Product, then Seller will, at its option: (a) obtain for Buyer the right to continue using such Product or part; (b) eliminate the infringement by replacing or modifying all or part of the Products; or (c) take back such Product or part and refund to Buyer all payments on the purchase price that Seller has received. The foregoing states Seller's entire liability for patent infringement by any Product or part thereof.

10. SOFTWARE LICENSE, WARRANTY, FEES

The following Software Terms and Conditions apply to any embedded or separately packaged software produced by Seller and furnished by Seller hereunder:

(a) Seller hereby grants to Buyer a non-exclusive, non-transferable, non-sub-licensable license to the Software, and any modifications made by Seller thereto only in connection with configuration of the Products and operating system for which the Software is ordered hereunder, and for the end-use purpose stated in the related Seller operating documentation. Buyer agrees that neither it nor any third party shall modify, reverse engineer, decompile or reproduce the Software, except Buyer may create a single copy for backup or archival purposes in accordance with the related Seller operating documentation (the "Copy"). Buyer's license to use the Software and the Copy of such Software shall terminate upon any breach of this Agreement by Buyer. All copies of the Software, including the Copy, are the property of Seller, and all copies for which the license is terminated shall be returned to Seller with written confirmation after termination.

(b) Seller warrants that, on the date of shipment of the Software or the Products containing the Software to Buyer: (1) the Software media contain a true and correct copy of the Software and are free from material defects; (2) Seller has the right to grant the license hereunder; and (3) the Software will function substantially in accordance with the related Seller operating documentation.

(c) If within 12 months from the date of delivery of the Software or Products containing the Software, Buyer discovers that the Software is not as warranted above and notifies Seller in writing prior to the end of such 12 month period, and if Seller determines that it cannot or will not correct the nonconformity, Buyer's and Buyer's Seller-authorized transferee's exclusive remedies, at Seller's option, are: (1) replacement of the nonconforming Software; or (2) termination of this license and a refund of a pro rata share of the contract price or license fee paid.

(d) If any infringement claims are made against Buyer arising out of Buyer's use of the Software in a manner specified by Seller, Seller shall: (i) defend against any claim in a suit or proceeding brought by an unaffiliated third party against Buyer that the Software violates a registered copyright or a confidentiality agreement to which Seller was a party, provided that Seller is notified promptly in writing and given the necessary authority, information and assistance for the defense and settlement of such claims (including the sole authority to select counsel and remove the Software or stop accused infringing usage); (ii) Seller shall satisfy a final judgment (after all appeals) for damages entered against Buyer for such claims, so long as such damages are not attributable to willful conduct or sanctioned litigation conduct; and (iii) if such judgment enjoins Buyer from using the Software, Seller may at its option: (a) obtain for Buyer the right to continue using such Software; (b) eliminate the infringement by replacing or modifying the Software, or (c) take back such Software and refund to Buyer all payments on the purchase price that Seller has received. However, Seller's obligations under this Paragraph 10 shall not apply to the extent that the claim or adverse final judgment relates to: (1) Buyer's running of the Software after being notified to discontinue; (2) non-Seller software, products, data or processes; (3) Buyer's alteration of the Software; (4) Buyer's distribution of the Software to, or its use for the benefit of, any third party; or (5) Buyer's acquisition of confidential information (a) through improper means; (b) under circumstances giving rise to a duty to maintain its secrecy or limit its use; or (c) from a third party who owed to the party asserting the claim a duty to maintain the secrecy or limit the use of the confidential information. Buyer will reimburse Seller for any costs or damages that result from actions 1 to 5. In Seller's discretion and at Seller's own expense, with regard to any actual or perceived infringement claim related to the Software, Seller may: (i) procure the right to use the Software, (ii) replace the Software with a functional equivalent, an/or (iii) modify the Software. Under (ii) and (iii) above, Buyer shall immediately stop use of the allegedly infringing Software.

(e) This warranty set forth in subparagraph (c) above shall only apply when: (1) the Software is not modified by anyone other than Seller or its agents authorized in writing; (2) there is no modification in the Products in which the Software is installed by anyone other than Seller or its agents authorized in writing; (3) the Products are in good operating order and installed in a suitable operating environment; (4) the nonconformity is not caused by Buyer or a third party; (5) Buyer promptly notifies Seller in writing, within the period of time set forth in subparagraph (c) above, of the nonconformity; and (6) all fees for the Software due to Seller have been timely paid. **SELLER HEREBY DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, WITH REGARD TO THE SOFTWARE, INCLUDING BUT NOT LIMITED TO IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, COURSE OF DEALING AND USAGE OF TRADE.**

(f) Buyer and its successors are limited to the remedies specified in this Paragraph 10.

(g) Any subsequent modifications or enhancements to the Software made by Seller are, at Seller's option, subject to a fee.

11. TERMINATION

Buyer may only terminate its order upon written notice to Seller and upon payment to Seller of Seller's termination charges, which shall be specified to Buyer and shall take into account among other things expenses (direct and indirect) incurred and commitments already made by Seller and an appropriate profit; provided, that in no event shall Seller's termination charges be less than 25% of the contract price. Seller shall have the right to suspend and/or terminate its obligations under this Agreement if payment is not received within 30 days of due date. In the event of the bankruptcy or insolvency of Buyer or in the event of any bankruptcy or insolvency proceeding brought by or against Buyer, Seller shall be entitled to terminate any order outstanding at any time during the period allowed for filing claims against the estate and shall receive reimbursement for its cancellation charges.

12. CONFIDENTIALITY

Buyer acknowledges that the information which Seller submits to Buyer in connection with this quotation, acknowledgment or performance of this Agreement includes Seller's confidential and proprietary information, both of a technical and commercial nature. Buyer agrees not to disclose such information to third parties without Seller's prior written consent. Seller grants to Buyer a non-exclusive, royalty-free, perpetual license to use Seller's confidential and proprietary information for purposes of this Agreement and the Products that are the subject hereof only. Buyer further agrees not to permit any third party to fabricate the Products or any parts thereof from Seller's drawings or to use the drawings other than in connection with this Agreement. Buyer will defend and indemnify Seller from any claim, suit or liability based on personal injury (including death) or property damage related to any Product or part thereof which is fabricated by a third party without Seller's prior written consent and from and against related costs, charges and expenses (including attorneys fees). All copies of Seller's drawings shall remain Seller's property and may be reclaimed by Seller at any time.

13. END USER

If Buyer is not the end user of the Products sold hereunder (the "End User"), then Buyer will use its best efforts to obtain the End User's written consent to be bound to Seller by the provisions hereof. If Buyer does not obtain such End User's consent, Buyer shall defend and indemnify Seller and Seller's agents, employees, subcontractors and suppliers from any action, liability, cost, loss, or expense for which Seller would not have been liable or from which Seller would have been indemnified if Buyer had obtained such End User's consent.

14. FORCE MAJEURE

(a) Force Majeure Defined. For the purpose of this Agreement "Force Majeure" will mean all unforeseeable events, beyond the reasonable control of either party which affect the performance of this Agreement, including, without limitation, acts of God, acts or advisories of governmental or quasi-governmental authorities, laws or regulations, strikes, lockouts or other industrial disturbances, acts of public enemy, wars, insurrections, riots, epidemics, pandemics, outbreaks of infectious disease or other threats to public health, lightning, earthquakes, fires, storms, severe weather, floods, sabotage, delays in transportation, rejection of main forgings and castings, lack of available shipping by land, sea or air, lack of dock lighterage or loading or unloading facilities, inability to obtain labor or materials from usual sources, serious accidents involving the work of suppliers or sub-suppliers, thefts and explosions.

(b) Suspension of Obligations. If either Buyer or Seller is unable to carry out its obligations under this Agreement due to Force Majeure, other than the obligation to make payments due hereunder, and the party affected promptly notifies the other of such delay, then all obligations that are affected by Force Majeure will be suspended or reduced for the period of Force Majeure and for such additional time as is required to resume the performance of its obligations, and the delivery schedule will be adjusted to account for the delay.

(c) Option to Terminate. If the period of suspension or reduction of operations will extend for more than four (4) consecutive months or periods of suspension or reduction total more than six (6) months in any twelve (12) month period, then either Buyer or Seller may terminate this Agreement.

15. INDEMNIFICATION AND INSURANCE

(a) Indemnification. Seller agrees to defend and indemnify Buyer from and against any third-party claim for bodily injury or physical property damage ("Loss") arising in connection with the Products provided by Seller hereunder or the work performed by Seller hereunder, but only to the extent such Loss has been caused by the negligence, willful misconduct or other legal fault ("Fault") of Seller. Buyer shall promptly tender the defense of any such third-party claim to Seller. Seller shall be entitled to control the defense and resolution of such claim, provided that Buyer shall be entitled to be represented in the matter by counsel of its choosing at Buyer's sole expense. Where such Loss results from the Fault of both Seller and Buyer or a third party, then Seller's defense and indemnity obligation shall be limited to the proportion of the Loss that Seller's Fault bears to the total Fault.

(b) Insurance. Seller shall maintain commercial general liability insurance with limits of not less than $2,000,000 per occurrence and in the aggregate covering claims for bodily injury (including death) and physical property damage arising out of the Products. Seller will provide a Certificate of Insurance certifying the existence of such coverages upon request.

16. GENERAL

(a) Seller represents that any Products or parts thereof manufactured by Seller will be produced in compliance with all applicable federal, state and local laws applicable to their manufacture and in accordance with Seller's engineering standards. Seller shall not be liable for failure of the Products to comply with any other specifications, standards, laws or regulations.

(b) This Agreement shall inure only to the benefit of Buyer and Seller and their respective successors and assigns. Any assignment of this Agreement or any of the rights or obligations hereunder, by either party without the written consent of the other party shall be void.

(c) This Agreement contains the entire and only agreement between the parties with respect to the subject matter hereof and supersedes all prior oral and written understandings between Buyer and Seller concerning the Products and any prior course of dealings or usage of the trade not expressly incorporated herein.

(d) This Agreement may be modified, supplemented or amended only by a writing signed by an authorized representative of Seller. Seller's waiver of any breach by Buyer of any terms of this Agreement must also be in writing and any waiver by Seller or failure by Seller to enforce any of the terms and conditions of this Agreement at any time, shall not affect, limit or waive Seller's right thereafter to enforce and compel strict compliance with every term and condition thereof.

(e) (i) If the Products are delivered or performed in the United States, this Agreement and the performance thereof will be governed by and construed according to the laws of the State of Georgia.

(ii) In the circumstances of (i) above, any controversy or claim arising out of or relating to this Agreement, or the breach thereof, or to the Products provided pursuant hereto, shall be definitively settled by arbitration, to the exclusion of courts of law, administered by the American Arbitration Association ("AAA") in accordance with its Construction Industry Arbitration Rules in force at the time this Agreement is signed and to which the parties declare they will adhere (the "AAA Rules"), and judgment on the award rendered by the arbitrator(s) may be entered in any court having jurisdiction over the party against whom enforcement is sought or having jurisdiction over any of such party's assets. The arbitration shall be conducted in Atlanta, Georgia by a panel of three members, one of whom will be appointed by each of Buyer and Seller and the third of whom will be the chairman of the panel and will be appointed by mutual agreement of the two party-appointed arbitrators. All arbitrators must be persons who are not employees, agents, or former employees or agents of either party. In the event of failure of the two party-appointed arbitrators to agree within forty-five (45) days after submission of the dispute to arbitration upon the appointment of the third arbitrator, the third arbitrator will be appointed by the AAA in accordance with the AAA Rules. In the event that either of Buyer or Seller fails to appoint an arbitrator within thirty (30) days after submission of the dispute to arbitration, such arbitrator, as well as the third arbitrator, will be appointed by the AAA in accordance with the AAA Rules.

(f) (i) If the Products are delivered or performed in Canada, this Agreement and the performance thereof will be governed by and construed according to the laws of the Province of New Brunswick.

(ii) In the circumstances of (i) above, any controversy or claim arising out of or relating to this Agreement, or the breach thereof, or to the Products provided pursuant hereto, shall be definitively settled under the auspices of the Canadian Commercial Arbitration Centre ("CCAC"), by means of arbitration and to the exclusion of courts of law, in accordance with its General Commercial Arbitration Rules in force at the time the Agreement is signed and to which the parties declare they will adhere (the "CCAC Rules"), and judgment on the award rendered by the arbitrator(s) may be entered in any court having jurisdiction over the party against whom enforcement is sought or having jurisdiction over any of such party's assets. The arbitration shall be conducted in Saint John, New Brunswick by a panel of three arbitrators, one of whom will be appointed by each of Buyer and Seller and the third of whom will be the chairman of the arbitral tribunal and will be appointed by mutual agreement of the two party-appointed arbitrators. All arbitrators must be persons who are not employees, agents, or former employees or agents of either party. In the event of failure of the two party-appointed arbitrators to agree within forty-five (45) days after submission of the dispute to arbitration upon the appointment of the third arbitrator, the third arbitrator will be appointed by the CCAC in accordance with the CCAC Rules. In the event that either of Buyer or Seller fails to appoint an arbitrator within thirty (30) days after submission of the dispute to arbitration, such arbitrator, as well as the third arbitrator, will be appointed by the CCAC in accordance with the CCAC Rules.

(g) The parties hereto have required that this Agreement be drawn up in English. Les parties aux présentes ont exigé que la présente convention soit rédigée en anglais.

Apr 2014 Rev.

APPENDIX D – THERMAL DRYING SUPPORTING INFORMATION

Contents:

1. BCR Bio-Scru Thermal Dryer Budgetary Proposal

2. Gryphon Environmental Thermal Dryer Budgetary Proposal

3. Veolia BioCon Thermal Dryer Budgetary Proposal

4. Huber Technology Inc. Sludge Drying Test Report – dated May 24, 2018

BIO-SCRU® Drying System

Prepared for:	McKim & Creed – Charlotte Office
Project:	City of Hendersonville Hendersonville, NC
Proposal:	Q1954B_Rev01
Date:	October 30, 2019

Table of Contents

1. INTRODUCTION

BCR appreciates the opportunity to submit this budget proposal #Q1954B_Rev01 to McKim & Creed for City of Hendersonville Biosolids drying application. The BCR BIO-SCRU® system, with its inherent simplicity, safety and minimal vent-treatment requirements is an ideal fit for this application. The high heated surface area of the dryer provides a smaller foot print to fit into the existing available plant space.

The BIO-SCRU® IC series dryers are automated, indirectly heated, continuous flow drying systems with an ASME code-stamped thermal fluid heating module and dryer module. The IC series dryers are complete turnkey dryer systems, modularly designed for ease of installation. The Programmable Logic Controller (PLC) automation and control of the IC series system insures meeting discharge dryness level requirements while processing on a continuous basis with minimal operator attention. BIO-SCRU® IC series dryers are simple, environmentally responsible, and economically viable for wastewater treatment plants of almost any size.

There are multiple installations of the BIO-SCRU® in municipal wastewater plants in operation across the USA with total operating time exceeding 75 years. BCR would be pleased to provide a list of installations upon request.

The City of Hendersonville's Wastewater Treatment Facility (WWTF) has a traditional activated sludge system and achieves complete nitrification. The current solids handling operation at the WWTF is to pump the WAS from the secondary clarifiers to a pair of gravity thickeners, then send it to a belt filter press for dewatering the sludge. The belt filter press dewaters the sludge to 17% Total Solids (TS). Below is the biosolids data shared via e-mail on 16th September will be the feed to the dryer system:

	Total Solids (% TS)	Total feed to dryer (Dry Solids– Lbs/Day)	Total feed to dryer (Wet Solids– Lbs/Day)	Total Annual Wet Ton[1] (WT/YR)
Year 2020	17	4,960	29,194	5,328
Year 2040	17	8,040	47,294	8,631

[1] Annual wet ton is based 365 days of operation.

Based on above sludge data, and dryer system operation of 12 hours per day (45 minutes for dryer system to heat-up and dryer feed on for 11 hours & fifteen minutes) for 3 day/week for year 2020, BCR recommends IC 5400 Bio-Scru® dryer system. For the "Year 2040" capacity IC 5400 dryer system would operate for 12 Hours/5 days/week, The capacity estimation is based good biosolids (no extracellular polymeric substance, protein & FOG) quality and with dryer start-up & feed for 12 hours/day. When the dryer is shutdown, the feed to the dryer will stop and the heater is off. It takes about 90 – 180 minutes to cool the system and clear the dryer. Finally, dryer system sizing is based on above daily capacity, any seasonal variations or any plant upsets is not considered.

The desired goal for the project is to achieve 90% TS using dryer technology and produce Class A biosolids.

COMPLIANCE WITH 40 CFR 503 RULES TO PRODUCE CLASS A BIOSOLIDS

The Bio-Scru® IC series dryer produces Class A/EQ biosolids reliably while complying with the 40 CFR 503 regulations. Compliance with both the pathogen reduction and vector attraction reduction requirements for Class A biosolids is met with operating regimen and compliance logging. The Bio-Scru® IC series dryer meets the below operating regimen and compliance logging:

- The pathogen reduction requirement is met using time and temperature regimen Alternative 1 for "every particle" in the sludge mass. This requirement is for the temperature to equal or exceed 176°F for 20 minutes for every particle. The residence time at greater than 176°F is determined by the transport rate of the screw. The MINIMUM residence time is measured between the point where the temperature of the material is measured to be greater than 176°F and the first edge of the discharge port. Test ports are available for manual verification of the temperature at the initiation of the residence time. Temperature and the machine speed/residence time are recorded automatically with a time stamp; it is a compliance record.
- The vector attraction reduction requirement is met by Option 8 for any sludge by drying to greater than 90% solids. A sludge that is fully digested and does not contain any undigested solids may meet this requirement under Option 7 by only being dried to greater than 75% solids.
- The Bio-Scru® IC series Sludge Dryer qualifies as a PFRP (Processes to Further Reduce Pathogens) via Heat Drying (as in Appendix B). Using this alternative, the sludge is dried to less than 10% moisture and the temperature of the exiting material is greater than 176°F. The compliance logging for this alternative record the temperature of the exiting material with a date stamp. This complies with both the pathogen reduction and the vector attraction reduction requirements for class A biosolids.

Dried biosolids from Bio-Scru® IC series dryer has significantly reduced volume compared to wet sludge and is virtually odor/pathogen free and nutrient rich. The dried biosolids can be stored year-round and used as Class A soil amendment.

BIO-SCRU® sludge drying system

The BIO-SCRU® sludge drying system is proven HOLO-SCRU® screw type heat exchanger technology and HOLO-SCRU® equipment is the world standard in indirect screw type heat exchange equipment.

The BIO-SCRU® sludge drying system incorporates two HOLO-SCRU® rotors to produce an extremely energy efficient system with a small footprint. The fully-automated system requires little to- no interaction with the operator. It dries sludges other systems can't. The BIO-SCRU® dryer effectively dries a range of sludge including digested and undigested primary, and waste-activated.

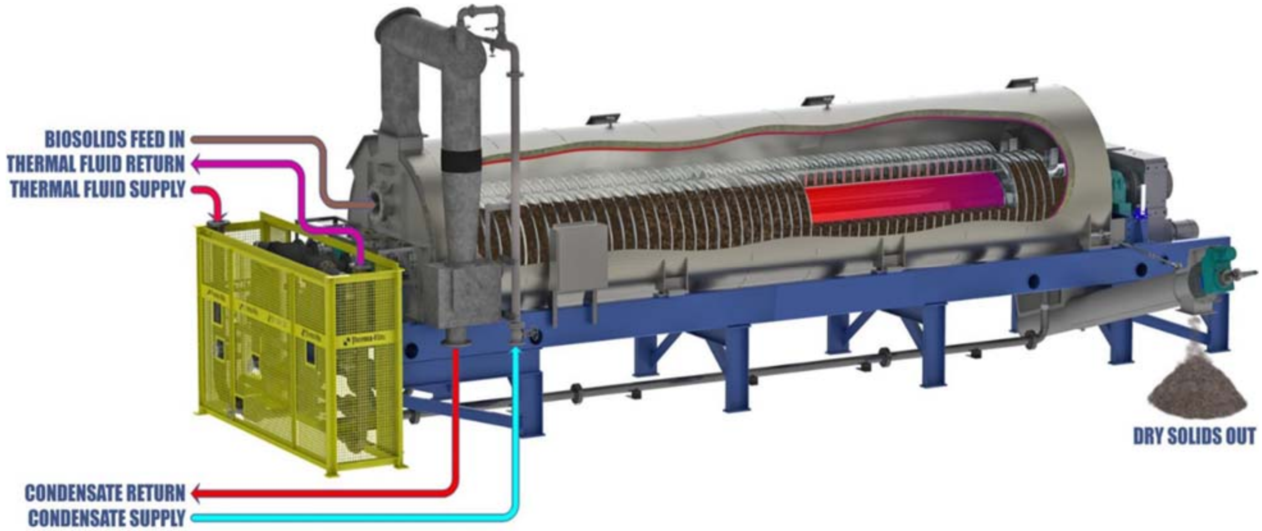
The proprietary BIO-SCRU® dryers' dual rotor design includes self-clearing rotors to remove sludge that might otherwise bake onto the internal mechanisms and forms clumps. The BIO-SCRU® dryer incorporates mixing blades which break up large clumps and homogenize the particle size to ensure that sludge is uniformly heated throughout the unit.

The BIO-SCRU® with all ancillary equipment can be either in new or existing building at site. Also the dryer can be setup in a pole barn structure. The IC 5400 Dryer with all ancillary equipment can be installed in 4000 Ft^2 to 4500 Ft^2 foot print (excluding the feed sludge hopper)

Unlike the direct dryers (like belt dryer), Bio-Scru® sludge drying system includes all the ancillary equipment yet has overall smaller system footprint. Following Table technology comparison of direct dyers & BIO-SCRU® dryer.

Description	Direct (Belt) Dryer	Indirect (BIO-SCRU®) Dryer
Overall Heat Transfer Area	Any direct drying involves direct contact between the product and the heat transfer medium (air). And Air does not have higher heat capacity like water or as thermal fluid. Therefore, overall heat transfer is low and a large volume of heat transfer media (air) is required.	The heat is transferred to the product indirectly through contact with a heated surface. The product is separated from the heat transfer medium. Thermal media could be steam or hot oil, or electrical resistance. In BIO-SCRU®, the twin hollow screw augers and filled thermal jacket provide a very high amount of heat Transfer area. **Advantage.**
Overall Foot print	Since the heat transfer capacity is low, large surface area is required along with all ancillary equipment. Pollution and odor control piping and systems are large due to the high volume of air circulated to achieve desired sludge dryness. The combination of these factors means a large total foot print for the dyer system.	High heat transfer area long with the less required ancillary equipment means the smallest foot print of any municipal sludge drying technology. **Advantage**.
Operator Safety/ Explosion Risk	The high temperature along with the amount of air (with oxygen), and presence of volatile solids/dust, could cause a fire or explosion. Therefore, per NFPA guideline, all direct dryers require explosion doors and/or pressure-relief system which vents to the atmosphere.	In BCR BIO-SCRU®, drying chamber operates in an anaerobic/ low oxygen atmosphere owing to the minimization of leak air, steam vapor induced from evaporated water and supplemented by gaseous Nitrogen. Therefore, per NFPA guidelines, there is no risk of explosion and there are no explosion doors required. **Advantage**.
Odor & Emission Control	Due to the required high rate of airflow, the process will require very large Air pollution control (APC) package. The water vapor is condensed, and non-condensable gases are required to be further treated and discharged to atmosphere.	BCR BIO-SCRU® operates under slight negative pressure and small stream of Nitrogen to maintain the inert atmosphere. The water vapor is condensed, and non-condensable gases are required to be further treated in a small bio-filter and discharged to atmosphere. **Advantage**.
End Product Pelletizer & Handling	Typically, in the belt dryer, the end product is an aggregate of biosolids in large clumps. These require a separate pelletizer or mill to reduce solids to a smaller particle size. In addition, a vibrating screen is often required to sort to the desired particle size.	In BCR BIO-SCRU®, the mechanical agitation and conveyance is provided by the twin hollow screw augers. Hollow screws not only transfer heat but convey the material and produce a uniform particle size. No additional unit process for milling or particle sorting is required. **Advantage**.
Operating Cost	Typically, high operating cost due to the energy consumed for air circulation, pollution control and heating.	BCR BIO-SCRU® has low energy consumption because the thermal fluid has high heat capacity and hollow screw provides maximum heat transfer area. Therefore, the operating cost is lower than other dryer technologies. **Advantage**.
Capital Cost	The capital cost would be high for the complete system because of the large footprint of the dryer itself, more metal, and the ancillary like the air fan, condenser and the pollution control equipment.	BCR BIO-SCRU® includes all the necessary ancillary equipment required to operate the dryer as listed in the scope of supply.

2. FEATURES & BENEFITS of BIO-SCRU®



BIO-SCRU® system is our patented, self-cleaning, hollow-flight auger technology providing optimum heat transfer. PLC-controlled operating parameters (temperature, feed rates, residence time) ensure that Class A requirements as per 40 CFR, part 503 are met at all times.

Wide Range of Feed Source: Designed to handle a range of feeds including undigested primary, waste activated, and digested sludges, as well as a mix of sludge types.

Patented Self Cleaning: The two interleaved augers in the dryer rotate in opposite directions. The patented contol system enables the self-cleaning by the wiping action of one auger flight against the other.

Low abrasion on the screw: The screw speed of 1 -2 rpm results in very low abrasion on the screw surface.

Foot Print: BIO-SCRU's twin-screw design provides the highest surface-area density, allowing the smallest dryer footprint. BIO-SCRU® is an in-direct heat dryer and does not use air dehumidification which eliminates the explosion hazards associated with a Class- A oven processing a combustible solid and air-pollution control equipment. Therefore, the overall dryer footprint is very small.

Safety: The inerted processing environment using nitrogen conforms to NFPA 69 requirements for the prevention of fires and explosions and low vapor velocities to minimize dust entrainment. Therefore, Hollow-screw heat exchanger system with inert atmosphere and hermetic drying chamber provides safe operation without the need for explosion doors.

Energy Source Flexibility: The BIO-SCRU® thermal fluid heater can be powered by a variety of energy sources including natural gas, biogas, LPG, diesel, fuel oil or electricity.

Odor Control: The BIO-SCRU® dryer and downstream conveyors are fully enclosed and use a rotary air-lock valve and knife-gate valve to minimize air intrusion and provide isolation when not discharging. Less than 100 cubic feet per hour vent stream under negative pressure to contain odors. The 3-stage condensor along with non-biological chemisorption odor control unit, removes dust and odor-causing compounds.

3. DESIGN BASIS & EQUIPMENT DATA

Table 1: GENERAL DESIGN BASIS:

Feed Description	: Bio-Solids Wet-Cake
Feed rate**	: 29,194 Lbs/Day (5,328 WT/year) - FY 2020 47,294 Lbs/Day (8,631 WT/year) - FY 2040
Wet Cake Composition**	: 17.0%w/w dry solids, 83.0%w/w moisture
Dried Product Composition**	: > 90% w/w dry solids
Product inlet temperature**	: 80°F

Table 2: EQUIPMENT SPECIFICATION:

Bulk density – Wet Cake	: 62.4 lb./cu.ft
Specific Heat of Solids	: 0.245 Btu/lb./°F
Overall Heat Transfer Coefficient, U_o	: > 15 BTU/HR/Ft^2/°F based on good quality Biosolids
Model selected	**: IC 5400**
Heating Medium	: Thermal fluid – Closed loop with natural gas heater
Product temperature- dryer outlet	: >225°F
Product temperature- Cooling Screw outlet	: <122°F
Material of construction	: Dryer Housing - SA516 Grade 70 Carbon steel; Augers - SA516 Grade 70 Carbon steel

Table 3: ELECTRICAL LOAD:

Total Connected Load[2]	: 130 HP/Unit
Total Operating Load	**: 70% of Connected Load**

Table 4: UTILITIES:

Natural Gas Pressure ("W.C.)	: **60" minimum**
Natural Gas Supply Line Flow rate (Ft^3/Hr)	**:** 9,500
Cooling water (GPM)	**:** 235 @ 45 PSI
Electrical Power (AMP)	**:** 175

Notes:

1. ** Input provided by Customer.
2. Horsepower ratings are for the standard BIO-SCRU® System. Final layout and auxiliary equipment may change the total connected horsepower.

Table 5: ESTIMATED ENERGY & UTILITY COST:

Case	Year 2020 Capacity	Year 2040 Capacity	
Wet Cake Ton/Year	5,328	8,631	
% Total Solids in Wet Cake	17.0%		
Total Dry Solids Ton/Year	**905**	**1,467**	
% Total Solids in Dried Product	90%		
Water to be Evaporated - Ton/Year	4,398	7,001	
Number of Days Operation Per Week	3.0	5.0	
Number of hours Operation Per day	12	12	
Feed Rate (Lbs/Hr)	5,576	5,423	
Evaporation Rates (Lbs/Hr)	4,522	4,398	
Fuel/Thermal (HHV) Cost $/Year	$84,219	$136,516	A
Power/Electricity Cost $/Year	$9,437	$15,728	B
Estimated **Maintenance Cost** (including labor, parts) $/Year	$60,150		C
Total Utility & Maintenance Cost (A+B+C) - $/Year	$153,806	$212,394	

Notes:

a. Energy cost calculation is based on $6.00/mmBTU-HHV for natural gas

b. Power/Electricity cost assumed $0.06/kWh.

c. The daily operation is based on 45 minutes of heat up time and 11 hours of dryer feed. The dryer system will be shutdown after 12 hours and will take about 90 – 180 minutes.

4. BCR BIO-SCRU® OVERVIEW

4.1. Description of Operations

The BIO-SCRU's® drying chamber is a sealed, sub-ambient pressure, anaerobic atmosphere. The drying chamber is kept constantly full to minimize head space in the chamber and to maximize the thermal operating efficiency. The BIO-SCRU's® heat energy is provided by the thermal fluid circulating through the hollow rotor flights, auger shafts, and dryer chamber housing. This method of heating is indirect, meaning the heating medium is not in contact with the product being heated. The BIO-SCRU's® dual-auger design includes proprietary features which make the augers self-clearing. This feature breaks up any sludge that may bake onto the augers and form clumps. The augers slowly rotate, agitating and conveying the sludge through the dryer as water is evaporated, leaving dried residual biosolids that are greater than 90% by weight. The BIO-SCRU® utilizes a multi-sensing-point method for failsafe operation.

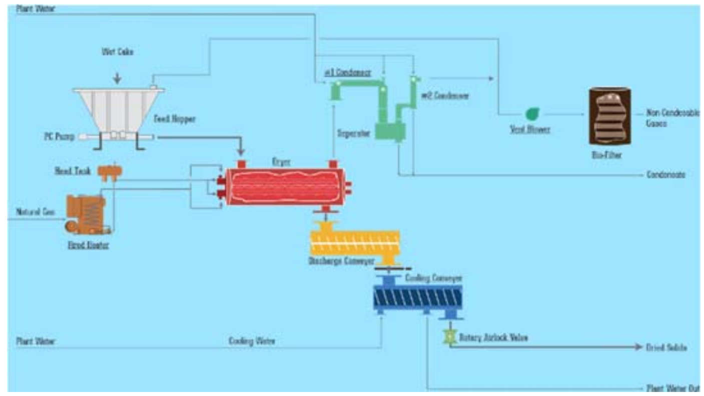


Figure1: BIO-SCRU® Process Flow Diagram

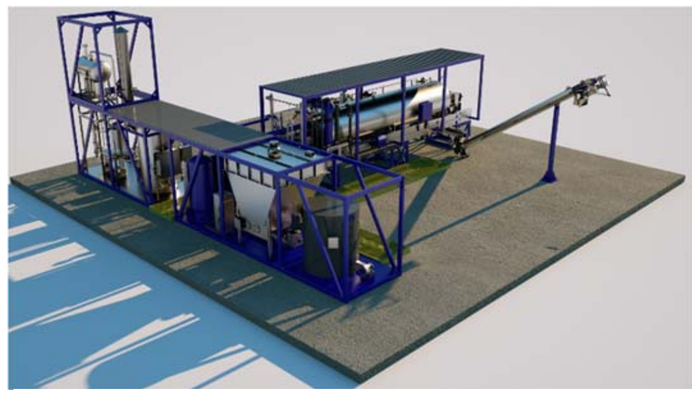


Figure 2: BIO-SCRU® Installation w/ all Ancillary Equipment

Figure 3: BIO-SCRU® Low Speed auger

Figure 4: Dried Biosolids

Wet sludge is fed to the dryer by a positive-displacement pump and the dried product is discharged from the dryer to a cooling screw with a subsequent rotary valve to prevent or minimize air intrusion into the system. Water is used in the hollow-shaft, jacketed cooling screw to reduce the hot, dried solids to a safe- handling temperature. Steam generated in the drying process is condensed in a multi-stage, direct-contact spray condenser. Residual non-condensable gases are chemically and/or biologically scrubbed by odor control unit to reduce emissions and odor. The condensing system operates at a very slight vacuum to minimize air intrusion, either through shaft seal leaks or the discharge rotary valve. This minimizes the volume of non-condensable gas to be treated.

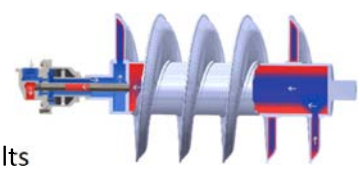
5. MAJOR EQUIPMENT

The standard BIO-SCRU® Series solids drying system includes the following major components.

5.1.1. Feed System

The feed hopper provides the buffer capacity to ensures a smooth and consistent feed rate of biosolids to the dryer. The feed hopper includes live bottom screws for positive sludge transport to the feed pump and eliminating any bridging of material. The progressive cavity feed pump conveys the biosolids from the feed hopper into the dryer.

5.1.2. Dryer



The dryer consists of two, intermeshed hollow-flight augers and a jacketed housing. The heat energy required for the dryer is provided indirectly by heat-transfer fluid that is remotely heated and circulated through both the augers and the housing. Dewatered sludge is pumped to the dryer from a feed hopper. Water is removed from the wet sludge by indirectly heating it from ambient temperature to greater than 100°C / 212°F, changing the water from liquid to steam. Steam is evacuated from the dryer under a slight vacuum and condensed by direct contact with water in an external condenser system. Steam and particulate are recovered and recycled for further processing at the wastewater treatment plant. The dryer is controlled by a programmable logic controller (PLC). Process condition is maintained for a prescribed retention time and temperature that results in a dried-product classification of "Class A PFRP" as listed in the Code of Federal Regulations 40 CFR 503.

5.1.3. Thermal Fluid Heater

Indirect heating of all heat-transfer surfaces in contact with the process material is accomplished by circulation of thermal (heat-transfer) fluid through the dryer's augers and jacketed housing. The heat-transfer fluid is subsequently reheated by a gas-fired or electric heater. For unattended operation and optimum efficiency, the thermal-fluid heater is controlled by an onboard Burner Management System (BMS). The dryer PLC communicates the required fluid temperature set-points to the heater.

5.1.4. Condenser

Through evaporation of water, steam is generated in the dryer. The steam carries some particulate with it when exiting the dryer. Steam is condensed, and particulate is captured in a direct-contact multi-stage spray condenser. Condensed liquid discharged from the condenser will be routed back to the wastewater plant influent. Odorous non-condensable gases are required to be further treated and discharged to atmosphere.

5.1.5. Discharge system

Following the BIO-SCRU® Dryer, the dried solids exit the dryer on to the discharge screw and then into the cooling screw. Like the dryer and depending on size, the cooling screw consists of a solid- or hollow-auger and a jacketed housing. Cooling the dried solids and removal of heat is accomplished by circulation of water through the cooler's auger and jacketed housing.

5.1.6. Odor Control

Following the condenser, odorous non-condensable gases are required to be further treated and discharged to atmosphere to reduce the emissions & odor. A non-biological odor filter utilizes chemisorption to remove odor-causing compounds.

5.1.7. Nitrogen Generator

The dryer chamber operates with a low oxygen atmosphere owing to the minimization of air intrusion, steam vapors induced from evaporated water and a supplemental nitrogen purge. Nitrogen is generated by a dedicated Pressure Swing Adsorption (PSA) package generator.

6. SCOPE OF SUPPLY

The below scope of supply is for a typical BIO-SCRU® IC-5400 Dryer system, which includes the dryer along with all the necessary subsystems:

Sl No.	QTY.	Description	By BCR	By Client	Comments
Equipment Supply					
1	1	Dewatered Cake Feed Hopper		✓	CS Coal Tar epoxy coated sludge feed hopper of enough capacity with cover & hatch,
2	1	Feed Pump Assembly	✓		Progressive Cavity Pump.
3	1	Feed Piping w/ Integral Thrust Block		✓	Feed Piping from the Feed Pump to the Dryer (<25ft run). CS groove pipe w/ Victaulic clamp fittings.
4	1	Dryer	✓		BIO -SCRU® IC 5400 Dryer with integrated HOLO -SCRU® augers - CS MOC (Discharge Section only shall be 304SS)
5	1	Cooling Screw	✓		HOLO-SCRU® Design w/ a Tubular Housing complete w/ Support Stand - 304SS MOC
6	1	Knife Gate Assembly	✓		Actuated 304SS Knife Gate.
7	1	Rotary Valve	✓		Motor-driven, 304SS wetted materials
8	1	Condenser System	✓		3-stage, spray, direct-contact with separator tank with drain trap, 304SS MOC and with FRP blower
9	1	Oxygen Sensor			Located at vent, 0-21%v/v. Meets NFPA 69 requirements
10	1	Discharge Conveyor	✓		Discharge Screw Conveyor 304SS MOC
11	1	Thermal Fluid Heater	✓		Skid Mounted package by Fulton; natural gas fired heater
11.1	1	Thermal Fluid	✓		Paratherm NF fluid
12	1	Dryer Thermal Fluid Piping Manifold	✓		Thermal Fluid Distribution Manifold w/ Isolation Valves at the dryer
13	1	Thermal Fluid Interconnect piping		✓	Piping between the dryer & thermal fluid heater skid
14	1	Odor Filter	✓		Chemisorption
15	1	Nitrogen Generator	✓		Fully automatic system skid with Air Compressor, air receiver, refrigerant dryer, tank and all necessary pressure instrumentation & control system. Optional Oxygen Analyzer available
16	Lot	Building Ventilation and odor control vent piping		✓	

Sl No.	QTY.	Description	By BCR	By Client	Comments
Electrical & Controls					
17	Lot	Transmitter/Field Devices	✓		As per BCR P&ID
18	Lot	Control Panel– PLC/HMI	✓		
19	Lot	Transformers/Switchgear		✓	
20	Lot	Variable-Frequency motor drives	✓		Only for BCR Supplied Motors
21	Lot	Supply & termination of power supply to BCR control panels		✓	There will be multiple panels that power supply needs to be terminated.
22	Lot	Building lighting		✓	
23	Lot	Electrical & Pneumatic works on-site		✓	Components supplied loosed or interconnect between the skids
Documentation					
24	Lot	Process & Instrumentation Diagram (PID)	✓		
25	Lot	Process Flow Diagram (PFD)	✓		
26	Lot	General Arrangement (GA) Drawing (GA)	✓		
27	Lot	Electrical Single Line Drawing	✓		
28	Lot	Operation & Maintenance Manual (O&M)	✓		Only for BCR scope of supply.
Testing & Inspection					
29	Lot	Factory Acceptance Test	✓		At BCR fabrication facility
30	Lot	QC Inspections	✓		BCR Internal Quality Assurance
31	Lot	Field Performance Test			Not included. BCR field service rates apply
Construction					
32	Lot	Temporary Facilities		✓	On-site for storage
33	Lot	Site Grading, roads etc.,		✓	
34	Lot	Civil/Foundation Work		✓	
35	Lot	Buildings, HVAC, Emission control		✓	
36	Lot	Job Site Unloading & Storage		✓	
37	Lot	Field Installation Labor, Materials, and Equipment		✓	Includes all mechanical piping, duct work & electrical interconnection.
Site Services					
38	Lot	Packing and Marking for Shipment	✓		
39	Lot	Delivery & freight to job site		✓	
40	Lot	Installation Supervision		✓	Not included. BCR field service rates apply
41	Lot	Start-up and Testing Supervision		✓	Not included. BCR field service rates apply
42	Lot	Training of O & M Personnel		✓	Not included. BCR field service rates apply
43	Lot	Any Local, State or Federal Permits		✓	
Consumables					
44	Lot	First Fill of lubricants & chemicals		✓	
45	Lot	Electric Power, Water, and Fuel for Construction, Checkout, Testing, Start-up, Testing, and Operation		✓	

7. BUDGET PRICING & TERMS

One (1) BCR BIO-SCRU® IC-5400 Dryer (per SCOPE OF SUPPLY) ……………. US $ 3,600,000

Delivery: Ex Works, Point of Manufacture

Validity: For budget purpose. Subject to change without notice or upon receipt of additional specifications.

Clarifications:

1. *Incoterms apply to Delivery.*
2. *All prices are in US Dollars. Price does not include any local, state or federal permits or taxes, customs duties/tariffs or other fees and taxes.*
3. *BCR Inc. Terms and Conditions will apply to items or equipment purchased under this proposal.*
4. *Equipment sold by BCR contains intellectual property; BCR will not transfer title to such intellectual property by way of sale of equipment. Drawings and data provided will remain the property of BCR.*
5. *Supervision of field installation and commissioning at BCR's standard rates per the schedule in Section 8*

PAYMENT TERMS

Net 30 days after date of invoice subject to credit application and approval. Payments to be made according to the following milestone and payment Schedule:

20% with order
30% with initial submittals to customer
25% with ordering of materials of components for manufacture
20% upon notice of readiness to ship
5% upon delivery to jobsite

SCHEDULE

Typical estimated delivery for is 38-42 weeks from execution of Purchase Agreement AND receipt of deposit. Delivery for shipment assumes the following:

Technical drawings and submittals to Buyer	8-12 weeks
Buyer review and approve drawings & submittals	2-3 weeks
Fabrication and Assembly	28-32 weeks upon approval of submittal(s)
Factory Acceptance Test	2 weeks prior to shipment
Preparation for shipment	1 week

8. FIELD SERVICES

TENTATIVE FIELD SUPERVISION SCHEDULE:

Unless otherwise agreed to in writing by BCR, installation start-up & commissioning shall be the sole responsibility of Purchaser. BCR engineers can provide onsite supervision for installation, start-up, commissioning and operator training. Below are the list of activity/milestone and estimate time to complete.

ACTIVITY / MILESTONE	ALLOWANCE
Installation	1-2 weeks
Commissioning	1-3 weeks
Startup	1-2 weeks
Training	2 – 3 days

All the above estimates are based on the pre-requisite check list completed and all the required resources and utilities available at site. BCR standard field service rates will apply per below rate schedule.

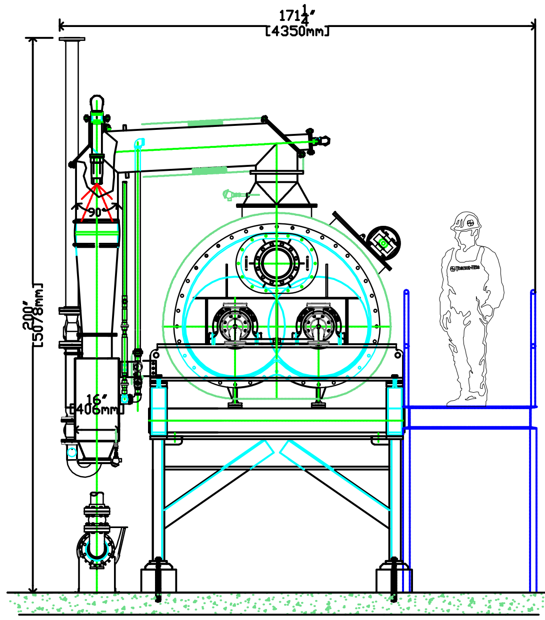
BCR FIELD SERVICE RATES:

Any on site man-days required would be at BCR's Standard field service rate schedule below, plus expenses, based on a maximum of 10 hours per day, 5 days per week.
Minimum service charge per day is for 8 hours.

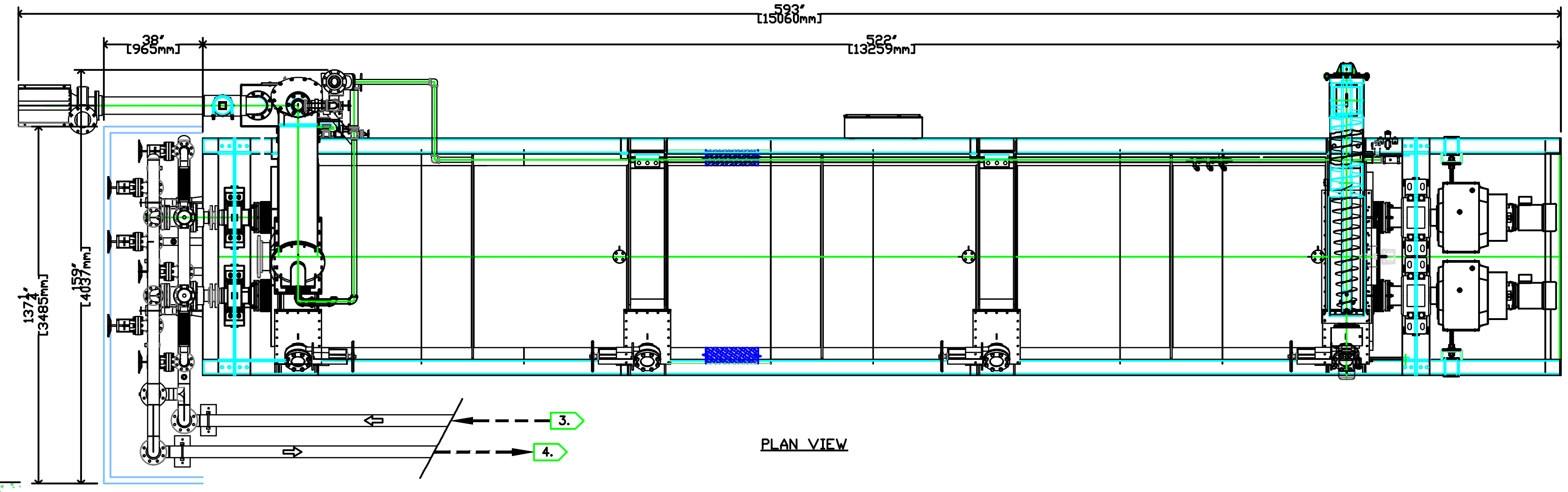
Mon-Fri………………………………………………………………………………… $175/HR
Sat/Sun/Holidays…………………………………………………………………… $350/HR
Overtime Rate ……………………………………………………………………… $262.50/HR
Travel Rate …………………………………………………………………………… $125/HR

Hotel accommodation, flight, car rental, per diem and expenses will be charged at actuals.

CUSTOMER CONNECTIONS			
ITEM	DESCRIPTION	SIZE	TYPE
1.	WET PRODUCT FROM HOPPER	10"	CL150
2.	DRY PRODUCT DISCHARGE	–	–
3.	THERMAL FLUID SUPPLY	4"	CL300
4.	THERMAL FLUID RETURN	4"	CL300
5.	WATER SPRAY MANIFOLD	1/2"	FNPT
6.	NITROGEN SUPPLY	1/2"	FNPT



TAIL END VIEW - CONDENSER

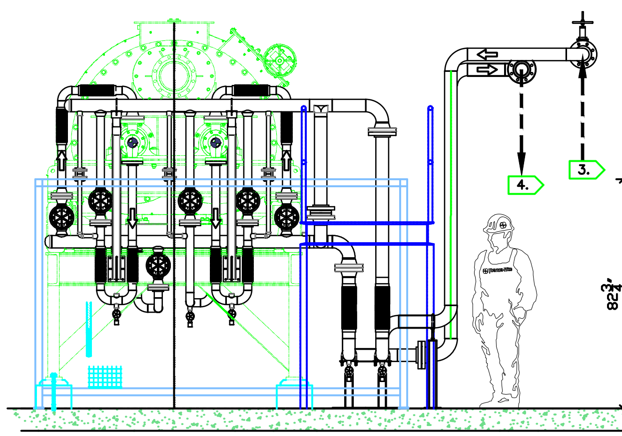


PLAN VIEW

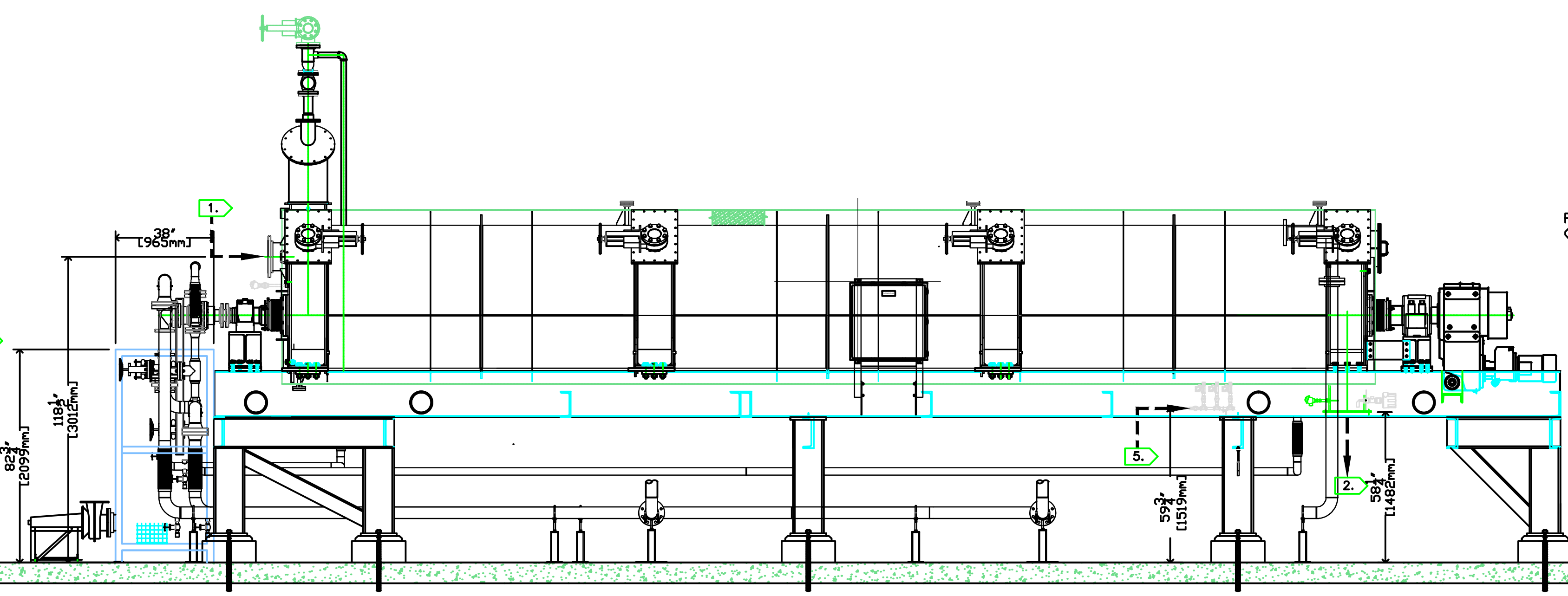
FOR PRELIMINARY USE ONLY
NOT FOR CONSTRUCTION

NOTES:
1. REFERENCE PID DRAWING FOR CONTRACTOR CONNECTION POINTS AND LINE SIZES.

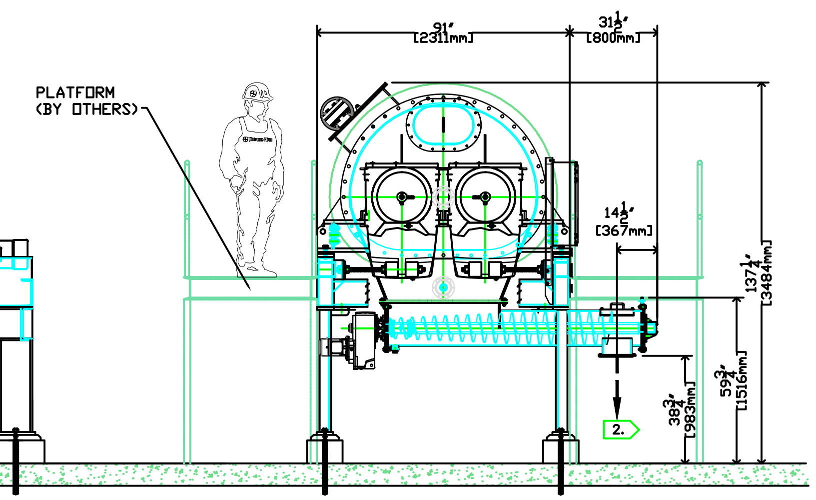
ASSEMBLY PROCEDURE:
1. LEVEL/SET LEGS FOR SUPPORT FRAME, ANCHOR BOLTS
2. MOUNT DRYER ONTO SUPPORT FRAME, BOLT UP LEGS
3. ATTACH SIPHON TUBE TO ROTARY UNION
4. INSTALL ROTARY UNION
5. INSTALL & BOLT UP DISCHARGE SCREW
6. INSTALL ENCODERS
7. INSTALL THERMAL FLUID PIPING (6-10 PCS)
8. INSTALL OIL TEMP. INSTRUMENTS & TERMINATE
9. INSULATE THERMAL FLUID PIPING
10. INSTALL OSHA CAGE/FRAME AROUND THERMAL FLUID PIPING
11. GROUT FEET



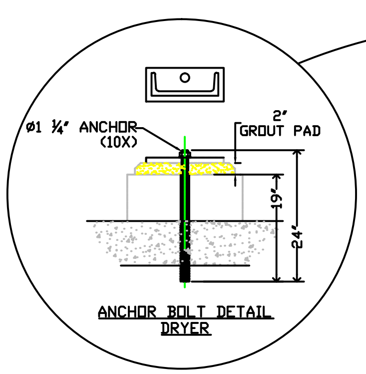
THERMAL FLUID PIPING VIEW

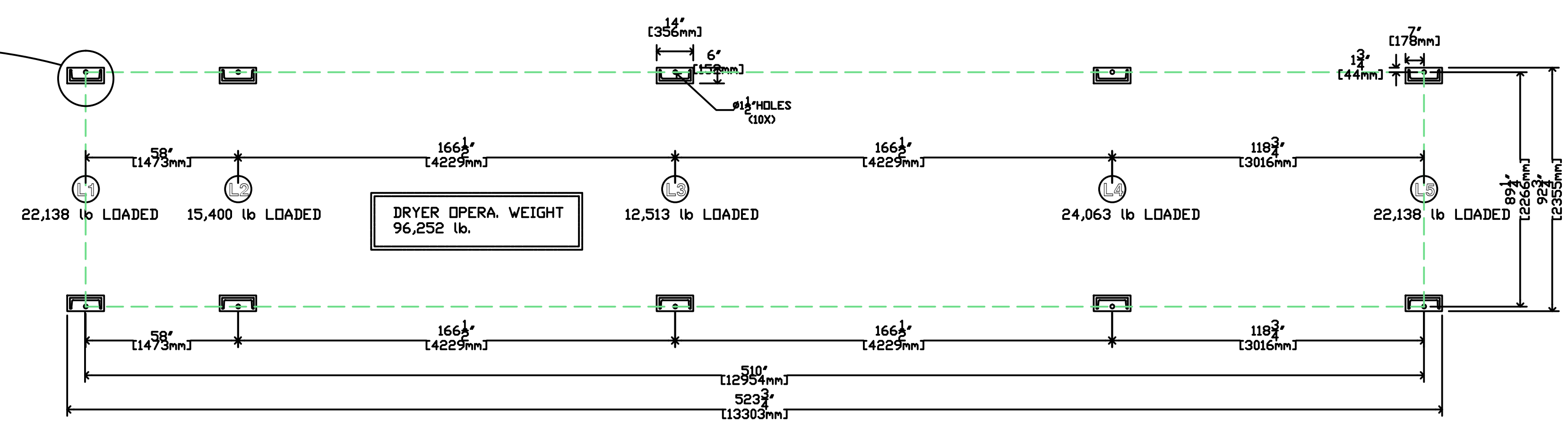


ELEVATION VIEW



DRIVE END VIEW





FOUNDATION/MOUNTING VIEW

CUSTOMER:	
P.O. No:	
TAG No:	

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REVISIONS

No.	MADE BY	CHECKED BY	DATE	DESCRIPTION
△	HG	–	12/06/13	BIO-SCRU IC5400 - DRYER SYSTEM

JOB No: –
DRAWN BY: HG — 12/06/13
CHECKED BY: --
APPROVED BY:
DATE

GENERAL ARRANGEMENT DRAWING OF
BIO SCRU IC5400
DRYER SYSTEM
FOR SALES

BCR Solid Solutions

SHEET: 1 OF 1 DWG. No: – Rev: –

	ITEM #	ASSY #	DESCRIPTION
	1	05000	CONTROL PANEL ASSEMBLY
	2	10000	BIO-SCRU DRYER
	3	11800	THERMAL FLUID PIPING RACK
	4	20000	COOLING CONVEYOR
	5	21000	ROTARY VALVE
	6	21400	KNIFE GATE VALVE
	7	30000	FEED HOPPER (35 CUBIC YARD)
OPTIONAL	8	30800	LEVELING SCREWS (> 30 CUBIC YARDS)
	9	40100	FEED PUMP
OPTIONAL	10	40300	FEED PIPING W/ THRUST BLOCK (< 25'-0")
	11	50000	CONDENSER ASSEMBLY
	12	51000	FRP BLOWER
OPTIONAL	13	55000	ODOR MANAGEMENT SYSTEM
	14	61000	DISCHARGE CONVEYOR
	15	70000	THERMAL FLUID HEATER
OPTIONAL	16	70100	THERMAL FLUID PIPING (< 25'-0")
	17	81000	STRUCTURAL SUPPORTS (DRYER)
OPTIONAL	18	87000	ACCESS PLATFORM

PLAN VIEW

IC 5400 BIO-SCRU DRYER

FOR PRELIMINARY USE ONLY
NOT FOR CONSTRUCTION

NOTES:

1. EQUIPMENT LOCATION FOR REFERENCE ONLY. FINAL ARRANGEMENT SUBJECT TO SITE CONDITIONS AND CUSTOMER SPECIFICATIONS.
2. 35-CY HOPPER SHOWN; ADDITIONAL SIZES ARE AVAILABLE.
3. NFPA HAZARDOUS AREA CLASSIFICATION: CLASS II, DIVISION 2, GROUP G (COMBUSTIBLE DUST) WITHIN 10-FT RADIUS OF THE DRYER CHAMBER.
4. COOLING CONVEYOR CAN BE ROTATED ±90°.

REV	DESCRIPTION	BY	CHECKED	DATE
A	INITIAL RELEASE	MAK	RN	07/29/14
B	UPDATED	MAK	RN	01/30/15
C	UPDATED WITH BCR TITLE BLOCK	SRM	SRM	04/03/17

	BY	DATE
DRAWN	MAK	07/29/14
CHECKED	RN	07/29/14
APPROVED		

SALES DRAWING

IC 5400

GENERA▯ ▯AYOUT

CLIENT

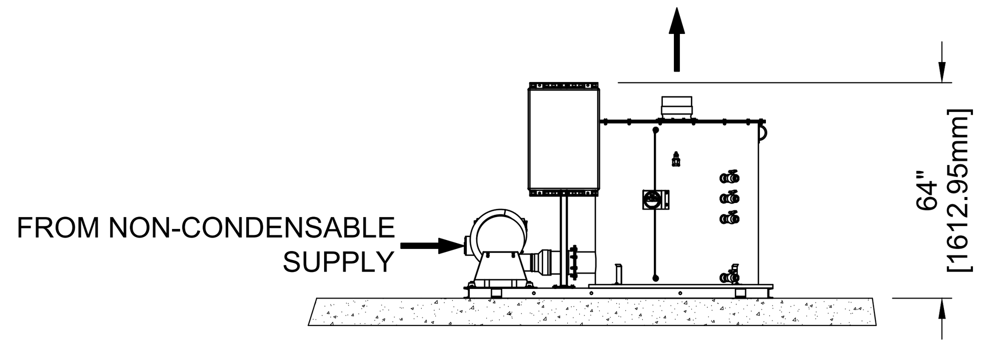
BCR Solid Solutions

LOCATION

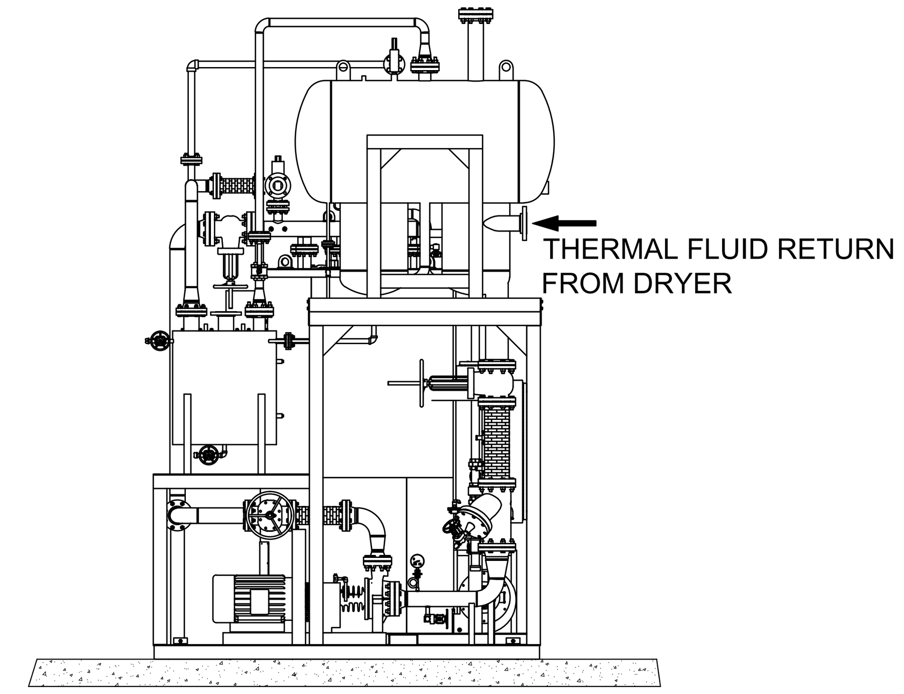
DOCUMENT # IC5400-00000 SALES

SHEET 1 OF 2

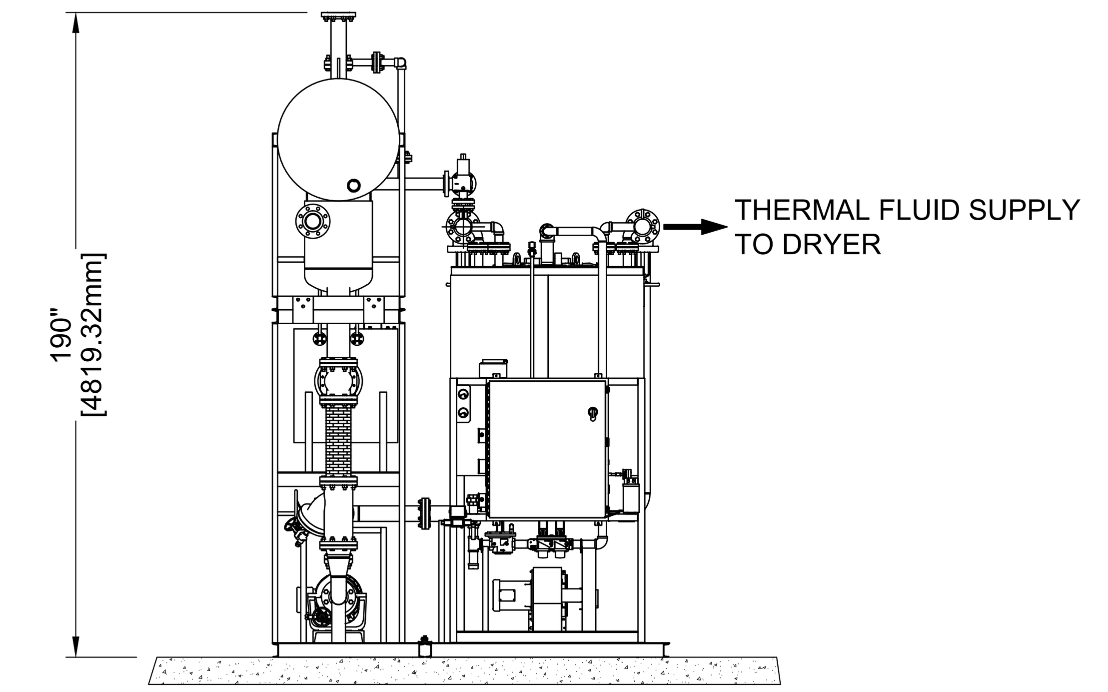
REV. C



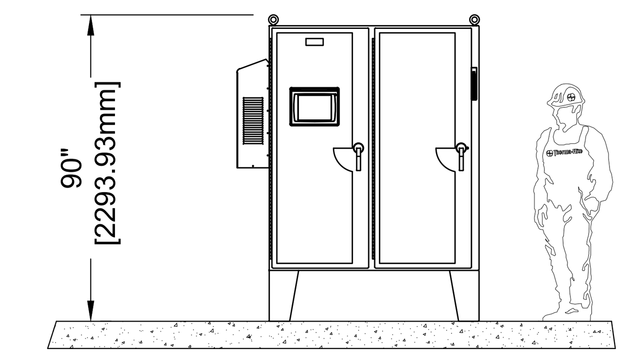
VIEW A
ODOR MANAGEMENT SYSTEM



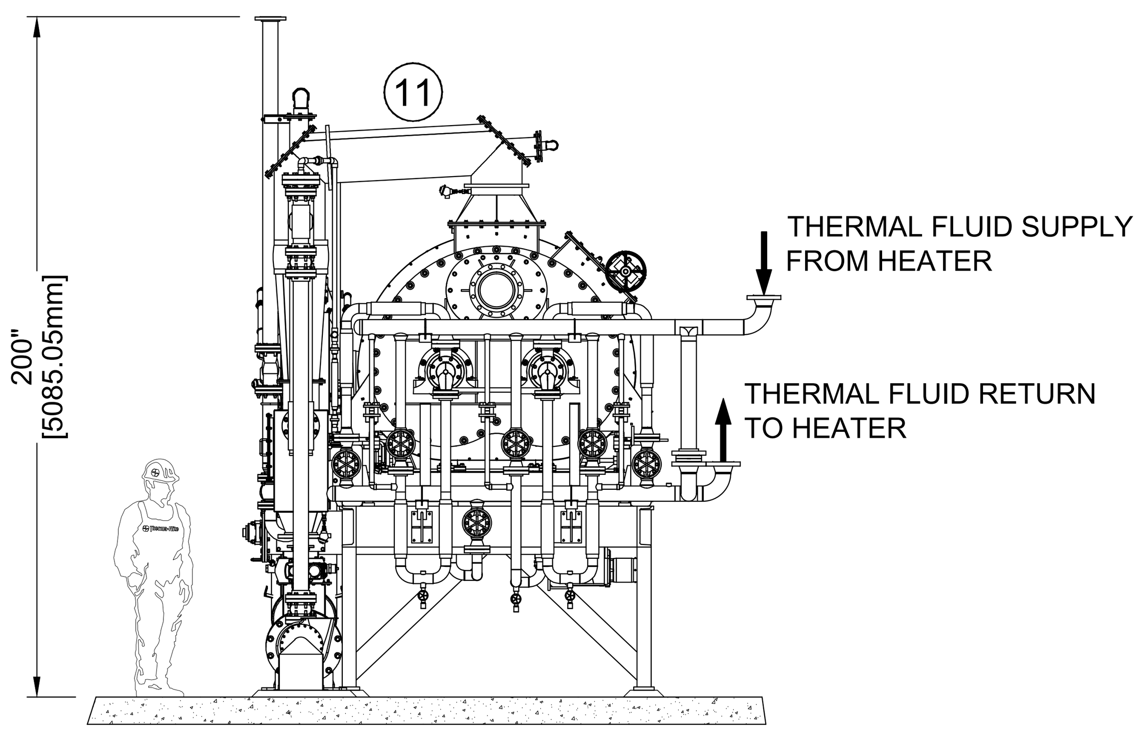
VIEW B
THERMAL FLUID HEATER SYSTEM



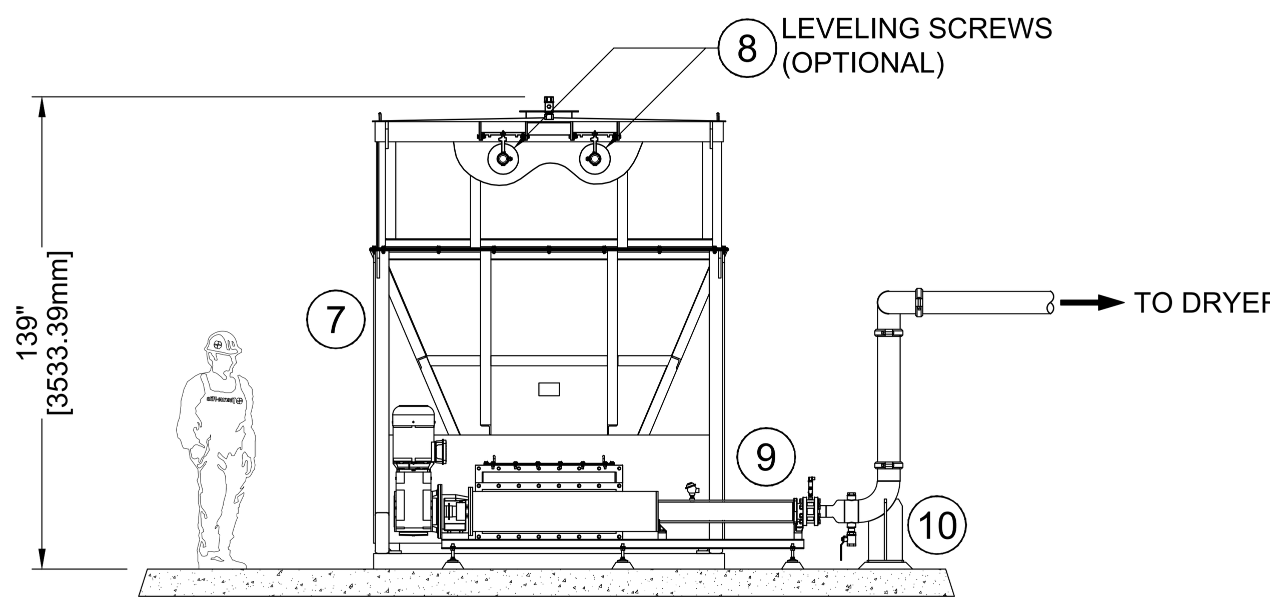
VIEW B
(ROTATED 90° CW)



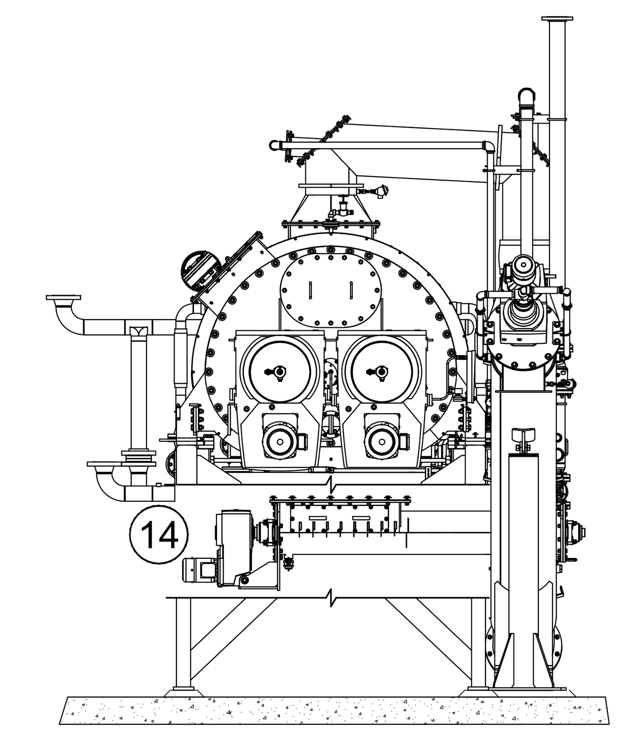
VIEW C
CONTROL PANEL



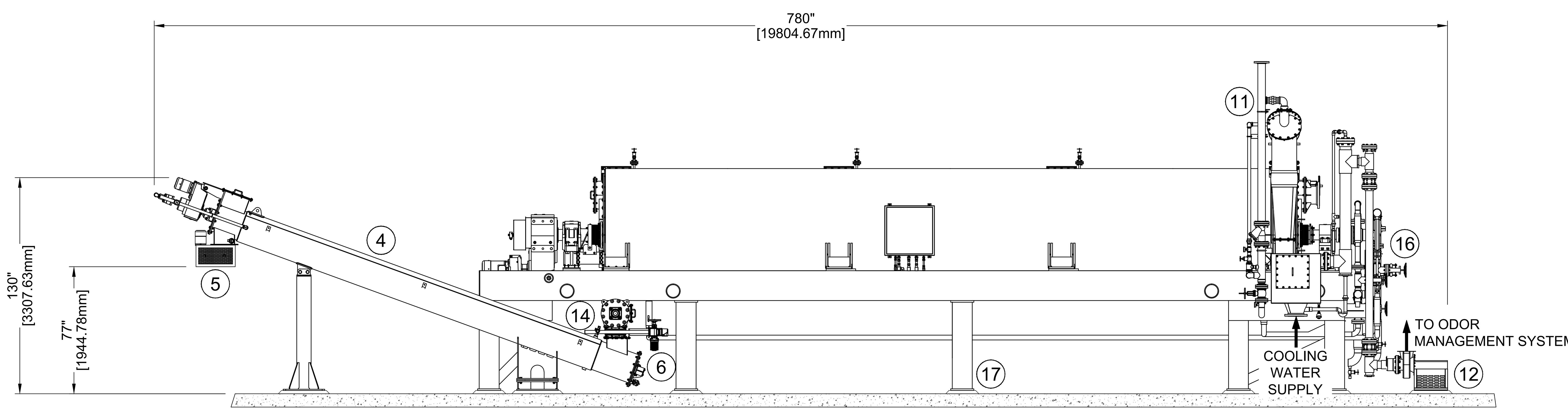
VIEW D
HOT OIL PIPING
(THERMAL FLUID PIPING RACK
REMOVED FOR CLARITY)



VIEW E
FEED PUMP &
(35 CUBIC YARD) FEED HOPPER



VIEW F
DISCHARGE CONVEYOR
& COOLING CONVEYOR



VIEW G
IC5400 BIO-SCRU DRYER,
COOLING CONVEYOR
& VAPOR CONDENSER

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NOT FOR CONSTRUCTION

NOTES:

SEE SHEET 1.

REV	DESCRIPTION	BY	CHECKED	DATE
A	INITIAL RELEASE	MAK	RN	07/29/14
B	UPDATED	MAK	RN	01/30/15
C	UPDATED WITH BCR TITLE BLOCK	SRM	SRM	04/03/17

	BY	DATE
DRAWN	MAK	07/29/14
CHECKED	RN	07/29/14
APPROVED		

SALES DRAWING
IC 5400
E□E□AT□ONS □ □E□ S

CLIENT

BCR Solid Solutions

LOCATION

DOCUMENT # IC5400-00000 SALES

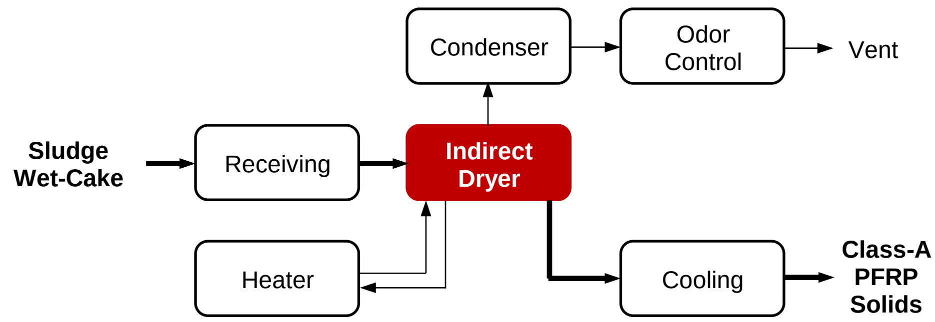
SHEET 2 OF 2

REV. C

BIO-SCRU™ DRYER SYSTEM
Specifications

PROCESS DESCRIPTION

The Bio-Scru drying system is all equipment necessary to safely and effectively convert sludge wet-cake to Class-A PFRP heat-dried biosolids meeting all the process- and product requirements of 40 CFR 503, Subpart D including >20 minutes retention time at >80 °C and ≤10% moisture content.



SCOPE OF SUPPLY

STANDARD MAJOR EQUIPMENT

Dryer, Indirect, Twin Hollow-Flite Auger
Feed Hopper, Live Bottom
Feed Pump, Progressive Cavity
Thermal-Fluid Heater, Gas Fired
Condenser, 3-Stage Spray
Odor Filter, Chemisorption
Discharge Conveyor
Cooling Conveyor, Water-Cooled
Air-Lock Valves (Knife-Gate + Rotary)
Control Panels (PLC, HMI, VFDs)
Nitrogen Generator

TYPICAL SPECIFICATIONS[1]

Model Name		**IC-5400**
Model Number		HSD36
Heat Exchange Area	ft^2	1820
Auger Diameter	inches	36
Overall Length[2]	ft-in	45'-5"
Overall Width[2]	ft-in	7'-7"
Weight (Shipping)	klbs	78
Weight (Operating)	klbs	93
Dryer Motors[3] (Installed)	Hp	15
Electrical Power (Operating)	Hp	89.8
Thermal Fluid Fill	gallons	1010

NOTES

1. Standard BCR specifications; subject to change without notice; excludes freight, taxes, bond, installation, commissioning, testing.
2. Dryer only, all dimensions/weights approximate.
3. Two motors/dryer; excludes anciullary equipment motors

Standard Terms and Conditions of Sale

1. **TERMS APPLICABLE:** The Terms and Conditions of Sale listed below are the exclusive terms and conditions applicable to quotations made and orders acknowledged by BCR Environmental, Corp. ("Seller") for the sales of products, equipment and parts relating thereto ("Products"). This quotation or acknowledgment is expressly made conditional upon Buyer's assent to such terms and conditions. Any of Buyer's terms and conditions which are in addition to or different from those contained herein, which are not separately agreed to by Seller in writing, are hereby objected to and shall be of no effect. Objections to any terms and conditions contained herein shall be deemed waived if Seller does not receive written notice thereof within 20 days of the date of this quotation or acknowledgment. Buyer in any event will be deemed to have assented to the terms and conditions contained herein if delivery of any Product is accepted. The term "this Agreement" as used herein means this quotation or acknowledgment or purchase order, together with BCR's proposal and any attachment hereto, any documents expressly incorporated by reference and these Standard Terms and Conditions of Sale. Terms are cash unless otherwise agreed upon in writing.

2. **TERMS OF PAYMENT**: All invoices are due and payable in Jacksonville, FL. All credit sales are due in full according to the schedule in the proposal Payment Terms. Accounts past due shall accrue interest at 2% per month or the highest lawful rate allowed by applicable law. Prices and design are subject to change without prior notice.

3. **ACCEPTANCE:** The terms and conditions of this Offer for Sale shall apply and become a part of the contract between Seller and Buyer unless specifically changed in writing and signed by an executive officer of Seller. The terms and conditions of this Offer for Sale shall in all cases, without exception, control and take precedence over any terms and conditions in Buyer's acceptance. Buyer's acceptance of this Offer for Sale shall be prima facie evidence of acceptance by Buyer of Seller's terms and conditions as controlling. Any conflicting terms and conditions in any document (including our proposal), Buyer's purchase order, acknowledgement or other document utilized by Buyer in this transaction, are expressly rejected by Seller.

4. **FORCE MAJEURE:** (a) Force Majeure Defined. For the purpose of this Agreement "Force Majeure" will mean all unforeseeable events, beyond the reasonable control of either party which affect the performance of this Agreement, including, without limitation, acts of God, acts or advisories of governmental or quasi-governmental authorities, laws or regulations, strikes, lockouts or other industrial disturbances, acts of public enemy, wars, insurrections, riots, epidemics, pandemics, outbreaks of infectious disease or other threats to public health, lightning, earthquakes, fires, storms, severe weather, floods, sabotage, delays in transportation, rejection of main forgings and castings, lack of available shipping by land, sea or air, lack of dock lighterage or loading or unloading facilities, inability to obtain labor or materials from usual sources, serious accidents involving the work of suppliers or sub-suppliers, thefts and explosions.

(b) Suspension of Obligations. If Seller is unable to carry out its obligations under this Agreement due to Force Majeure, and the Seller promptly notifies the Buyer of such delay, then all obligation that are affected by Force Majeure will be suspended or reduced for the period of Force Majeure and for such additional time as is required to resume the performance of its obligations, and the delivery schedule will be adjusted to account for the delay.

5. **WARRANTY:** (a) Seller warrants to Buyer that the Products manufactured by it will be delivered free from defects in material and workmanship. This warranty shall commence upon delivery of the Products and shall expire on the earlier to occur of 12 months from initial operation of the Products or 18 months from delivery thereof (the "Warranty Period"). If during the Warranty Period Buyer discovers a defect in material or workmanship and within 10 days of such discovery gives Seller written notice thereof, Seller will either deliver to Buyer a replacement part, or repair the defect Ex Works (according to Incoterms 2010) Seller's factory. Seller will have no warranty obligations under this paragraph 5(a): (i) if the Products have not been operated and maintained in accordance with generally approved industry practice and with Seller's specific written instructions; (ii) if the Products are used in connection with any mixture or substance or operating condition other than that for which they were designed; (iii) if Buyer fails to give Seller such written notice within 10 day of the discovery; (iv) if the Products are repaired by someone other than Seller or have been intentionally or accidentally damaged; (v) for corrosion, erosion, ordinary wear and tear or in respect of any parts which by their nature are exposed to severe wear and tear or are considered expendable, (vi) if all payments have not been made. If remote monitoring is not enabled, a $2500.00 deductible applies to all Warranty work. Finished materials and accessories purchased from other manufacturers are only warranted to the extent of the original manufacturer's warranty.

(b) Seller further warrants to Buyer that at delivery, the Products manufactured by it will be free of any liens or encumbrances. If there are any such liens or encumbrances, Seller will cause them to be discharged promptly after notification from Buyer of their existence.

(c) **THE EXPRESS WARRANTIES SELLER MAKES IN THIS PARAGRAPH 5 ARE THE ONLY WARRANTIES IT WILL MAKE. THERE ARE NO OTHER WARRANTIES, WHETHER STATUTORY, ORAL, EXPRESS OR IMPLIED. IN PARTICULAR, THERE ARE NO IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. SELLER'S LIABILITY FOR WARRANTY REPAIR OR REPLACEMENT SHALL NOT EXCEED THE AMOUNT PAID BY BUYER FOR THE ITEMS PURCHASED.**

(d) The remedies provided in paragraphs 5(a) and 5(b) are Buyer's exclusive remedy for breach of warranty.

(e) With respect to any Product or part thereof not manufactured by Seller, Seller shall pass on to Buyer only those warranties made to Seller by the manufacturer of such Product or part which are capable of being so passed on.

6. **LIMITATION OF LIABILITY**: Notwithstanding any other provision in this Agreement, the following limitations of liability shall apply: (a) In no event, whether based on contract, tort (including negligence), strict liability or otherwise, shall Seller, its officers, directors, employees, subcontractors, suppliers or affiliated companies be liable to Buyer or any third party for loss of profits, revenue or business opportunity, loss by reason of shutdown of facilities or inability to operate any facility at full capacity, or cost of obtaining other means for performing the functions performed by the Products, loss of future contracts, claims of customers, cost of money or loss of use of capital, in each case whether or not foreseeable, or for any indirect, special, punitive, incidental or consequential damages of any nature.

(b) The aggregate liability of Seller, its officers, directors, employees, subcontractors, suppliers or affiliated companies, for all claims of any kind for any loss, damage, or expense resulting from, arising out of or connected with the Products or this Agreement or from the performance or breach thereof, together with the cost of performing make good obligations to pass performance tests, if applicable, shall in no event exceed the lesser of the amount paid by Buyer or contract price. The foregoing notwithstanding, if applicable, any claims for (i) delay in delivery shall not exceed 5% of the sum of money received by Seller and (ii) breach of performance guarantees (if any apply) shall not exceed 10% of the order price.

(c) The limitations and exclusions of liability set forth in this paragraph 6 shall take precedence over any other provision of this Agreement and shall apply whether the claim of liability is based on contract, warranty, tort (including negligence), strict liability, indemnity, or otherwise. The remedies provided in this Agreement are Buyer's exclusive remedies.

(d) All liability of Seller, its officers, directors, employees, subcontractors, suppliers or affiliated companies, resulting from, arising out of or connected with the Products or this Agreement or from the performance or breach thereof shall terminate on the second anniversary of the date of this Agreement.

7. **INDEMNITY:** Buyer agrees to indemnify and hold Seller harmless for loss due to any fines, penalties and corrective measures necessary to comply with laws, rules and regulations, as well as injuries, losses or claims in connection with the Buyer's use or operation of the Products. Seller agrees to indemnify and hold Buyer harmless for loss due to any fines, penalties and corrective measures necessary to comply with laws, rules and regulations in connection with the design or manufacture of purchased Products.

8. **CANCELLATION BY PURCHASER:** The proposed system is sold on a final, non-cancelable, non-returnable, non-refundable basis. Buyer agrees to complete the payment commitments as outlined in the Payment Terms captured in the attached Firm Proposal.

9. **DELIVERY:** The price and delivery of all Products, are Ex Works (according to Incoterms 2010) Seller's factory. All shipments are made Ex Works our plant. If the purchase price has been paid in full prior to shipment, then title to the Products shall pass to Buyer when the Products are duly delivered to the carrier (Carrier) selected by Buyer or, at Buyer's request, by Seller, at Seller's factory, except where Buyer requests a delay in shipment, in which case the title shall pass to the Buyer when the Products are ready for shipment. If Buyer requests a delay in shipment, then Buyer shall pay Seller's standard storage charges for the period from the date Products are ready for shipment to the actual date of shipment, Buyer will provide a certificate of insurance for the product while it is being stored. If the purchase price has not been paid in full, title to Products does not pass from Seller to Buyer until Seller receives payment in full. Buyer expressly agrees not to commercially operate the Products until Seller has received payment in full.

10. **RISK OF LOSS:** The risk of loss to the Products shall pass to Buyer when the Products are duly delivered to the Carrier at Seller's factory or earlier if title passes to Buyer as listed above. The processing of freight claims or loss claims is the responsibility of Buyer.

11. **CONFIDENTIALITY**: Buyer acknowledges that the information which Seller submits to Buyer in connection with this quotation or acknowledgment includes Seller's confidential and proprietary information, both of a technical and commercial nature and it is subject to the Non-Disclose and Confidentiality Agreement executed by Buyer. Buyer agrees not to disclose such information to third parties without Seller's prior written consent. Seller grants to Buyer a non-exclusive, royalty free, perpetual license to use Seller's confidential and proprietary information for purposes of this specific order and the Products that are the subject hereof only. In addition to any separate obligations under the Non-Disclosure and Confidentiality Agreement, Buyer further agrees not to permit any third party to fabricate the Products or any parts thereof from Seller's drawings (or other information) or to use the drawings (or other information) other than in connection with this specific order. Buyer will defend and indemnify Seller from any claim, suit or liability based on personal injury (including death) or property damage related to any Product or part thereof which is fabricated by a third party without Seller's prior written consent and from and against related costs, charges and expenses (including attorney's fees). All copies of Seller's drawings shall remain Seller's property and may be reclaimed by Seller at any time.

12. **INTELLECTUAL PROPERTY**: All intellectual property of Seller shall remain the exclusive property of Seller and no license to pre-existing intellectual property will be created by this Agreement. Any new intellectual property developed by Buyer that includes or incorporates the Products shall also be owned by Seller.

13. **LAW:** The rights and obligations of the parties shall be governed by the domestic laws of the State and County of Dallas County, Texas without regard to its conflict of law rules or the United Nations Convention for the International Sale of Goods.

14. **ARBITRATION:** Any dispute, controversy or claim arising under this agreement or the breach thereof, shall be settled by arbitration administered by the American Arbitration Association in Dallas, Texas, pursuant to the American Arbitration Association Commercial Arbitration rules. The parties shall jointly select one arbitrator and the decision of the arbitrator shall be final and binding on the parties and enforceable in any court of competent jurisdiction. Each party shall bear its own costs and expenses and an equal share of the arbitrator's and administrative fees of arbitration. The prevailing party may, at the arbitrator's sole discretion, award reasonable attorney fees. Except as may be required by law, neither party nor an arbitrator may disclose the existence, content, or results of any arbitration hereunder without the prior written consent of both parties.

15. **ENTIRE AGREEMENT**: This Offer, together with the Non-Disclosure and Confidentiality Agreement ("NDA"), contains the entire agreement between Seller and Buyer, and no modification of this Offer or NDA shall be binding upon Seller unless evidenced by an agreement in writing signed by an executive officer of Seller after the date hereof. No oral or written statements by Seller's sales representatives, or other agents, made after the date hereof shall modify or vary the express terms hereof unless evidenced by an agreement in writing signed by an executive officer of Seller after the date hereof. To the extent any advertising or promotional material of Seller contradicts or disagrees with the terms hereof, Seller and Buyer agree that the terms hereof shall control and that such advertising and/or promotional materials are not part of the Agreement between Seller and Buyer.

16. **SECURITY INTEREST:** To secure payment for Products, Buyer grants to Seller a security interest in the Products and agrees that Seller shall have the rights and remedies of a secured party under the Uniform Commercial Code. Buyer designates Seller as its attorney-in-fact to execute any financing statements on behalf of Buyer necessary to perfect such security interest.

17. **TAXES:** Prices on the products sold buy Seller are exclusive of any city, state, federal or foreign taxes or duties, of any kind. Buyer is responsible for all such taxes and duties and agrees to indemnify Seller for all taxes and duties that may be assessed upon Seller

Gryphon Environmental, LLC
2920 Fairview Drive
Owensboro, KY 42303
Contact: Tid Griffin, CEO 270-485-2680

Biosolids Drying Project

Version 2 3 Days/Week; 12 Hours Per Day

Financial Analysis

Using Natural Gas for thermal energy demand

Estimates For Budgeting Purposes Only

Hendersonville, NC

Contact Tony Pevec
Site: North Carolina
Date 9/12/19

Version 2 3 Days/Week; 12 Hours Per Day

	Dryer Operating Schedule												Op Ex				Operating Costs
	% TS Pre / Post		Operating Schedule Hrs / Days		Feed Rate to Dryer (tons/day)	Water Removal (tons/day)	Water Removal (tons/hr)	Dry Product (tons/day)	Gryphon Model	# Dryers	Nominal Evap Capacity (t/hr/ea)	Budgetary Cap Ex (Installed/ Operational)	MMBTUH Demand	Annual Natural Gas $	kWh Demand	Annual Electric $	Total Annual Operating Costs
Starting at 17% TS	17%	90%	12	3	27.94	22.66	1.89	5.28	1050 U	1	2.08	$2,038,056	4.15	$23,334	134.09	$15,061	$ 38,395
Starting at 20 % TS	20%	90%	12	3	23.75	18.47	1.54	5.28	1040 U	1	1.67	$1,808,056	3.39	$19,019	109.29	$12,276	$ 31,295

BUDGETED CAPITAL EXPENSE (CAP EX) includes ALL dryer components and required ancilliary equipment.
CAP EX also includes freight, installation, training and a One-Year Warranty.

Sources:
Electric Utility prices based on estimated prices for the region.
Average price for natural gas is based on estimated prices for the region.

Mass listed as US Tons

Utility Cost Assumptions

ave.	$0.060	Per kW of Electricity
ave.	$5.00	Per MMBTU of Natural Gas

Biosolids Generation
Based on supplied volumes of 5,700 Dry Lbs. / Day
ALTERED To 9,500 Dry Lbs. / Day to reflect 3 days per week of operations (rather than 5)

Proposal: Hendersonville, NC

BioCon® Thermal Dryer

Proj. No. 5700133710

Submitted to:	McKim & Creed
Submitted by:	Ashley Waples Application Engineer
Date:	Oct 29, 2019

Water Technologies

Veolia Water Technologies, Inc. (dba Kruger)
4001 Weston Parkway ,Cary, NC 27513
tel. +1 919-677-8310 • fax +1 919-677-0082
www.veoliawatertech.com

Introduction

Kruger is pleased to present this *preliminary* BioCon Dryer proposal to Hendersonville, NC.

Kruger's scope of supply for the BioCon dryer includes live bottom cake bin providing max 12hrs retention time **(existing dewatering system must be operated similar sequences with required drying system to keep the sludge fresh in the bin)**, sludge feed pumps, dosing pumps, a thermal dryer cabinet (inclusive of depositors, SS drying belts, sprinkler system, and extraction conveyor), circulation fans, heat exchanger, drying air treatment, PLC control system including HMI on the PLC panel, and required field instruments. For the dryer, a natural gas fired thermal fluid heater is provided for the energy supply to the drying process.

We Know Water

Kruger is a water and wastewater solutions provider specializing in advanced and differentiating technologies. Kruger provides complete processes and systems ranging from biological nutrient removal to mobile surface water treatment. The ACTIFLO® Microsand Ballasted Clarifier, BioCon® Dryer, BIOSTYR® Biological Aerated Filter (BAF) and NEOSEP™ MBR are just a few of the innovative technologies offered by Kruger. Kruger is a subsidiary of Veolia Water, a world leader in engineering and technological solutions in water treatment for industrial companies and municipal authorities.

Veolia Water Technologies, the fully-owned subsidiary of **Veolia**, is the world leader in water and wastewater treatment with over 155 years of experience. As an experienced design-build company and a specialized provider of technological solutions in water treatment, Veolia combines proven expertise with unsurpassed innovation to offer technological excellence to our industrial customers. Based on this expertise, we believe that we have developed the best solution for your application. Below is a brief description of the proposed project.

We Know Smart Water Management

Veolia is the only company in the world that can combine decades of water treatment expertise, process knowledge and our wide range of domestic and global references into a comprehensive digital solutions platform that provides numerous opportunities to enhance the management of water.

When AQUAVISTA™ is paired with process and equipment instrumentation, your facility will have access to the most advanced suite of cloud-based monitoring, control and technical support mechanisms in the industry. AQUAVISTA™ provides the opportunity to improve your plant's overall performance with enhancements in operational efficiencies and critical asset management. AQUAVISTA™ runs on today's most secure cloud based services and is fully accessible with any common smart devices (phone, pad, tablet).

Four (4) tiers of service are available:

- Portal: A remote monitoring and reporting tool with overview of all plant data and access to important facility documentation.
- Insight: Portal + Data driven performance optimization advice regarding the general status and operational conditions of your plant.
- Assist: Added level of access to Veolia’s process experts for process, maintenance, and training support.
- Plant: Operator adjustable levels of automatic control of your treatment facility.

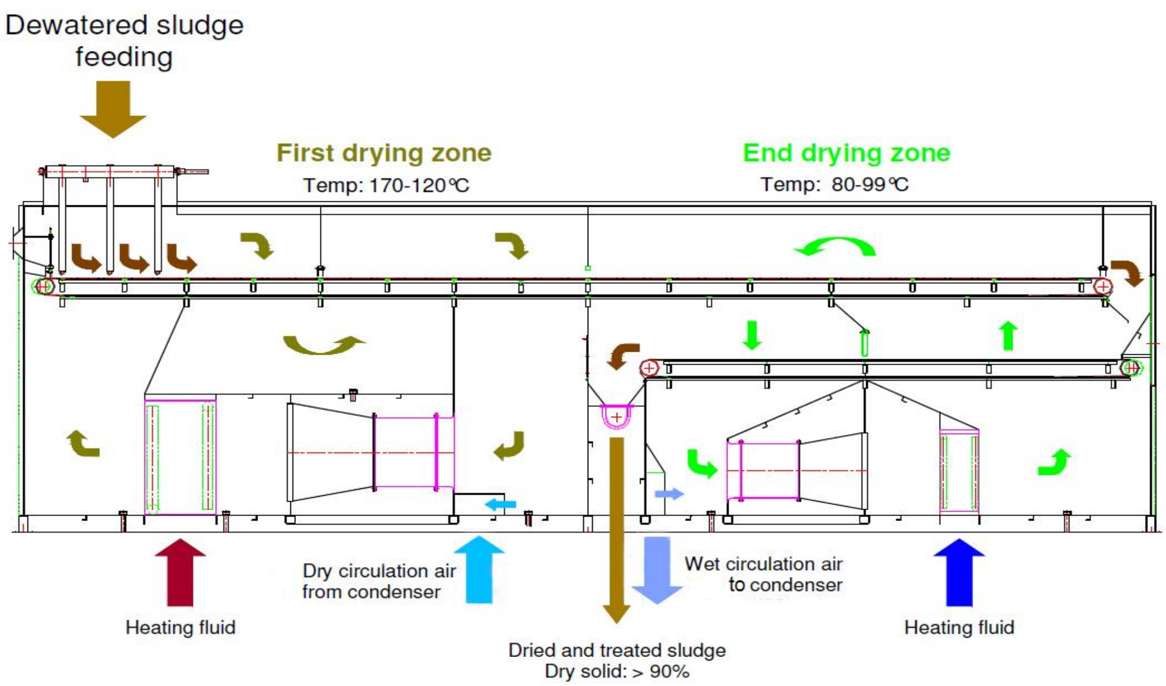
All levels of service provide a simple link to Veolia's customer service group to facilitate easy access to spare parts and other service needs.

Process Description

The BioCon® dryer system was developed to be the safest, simplest and most efficient drying system on the market today. Special consideration was taken during the development of the BioCon dryer system to ensure flexibility, while minimizing noise, odor, and dust production.

BioCon systems are designed to be efficient and environmentally friendly using the following design aspects:

- Sludge drying occurs at relatively low temperatures.
- The principle of indirect heating of the drying air is applied.
- The drying air, which is in direct contact with the sludge, is recycled in a closed circuit.
- The dryer operates at negative pressure in the cabinet, preventing process air from escaping into the surroundings.
- Processed biosolids are dried to a minimum DS content of 90% and meets Class A requirements.
- The end product characteristics are adaptable to meet the disposal requirements and market demands of the municipality.



BioCon Schematic Overview

Design Summary

<u>Design Assumptions</u>

- Inlet sludge is 100% municipal. Imported and/or industrial sludge are not included.
- Dryer operation is 3 days per week, 12 hrs a day for Year 2020
- Dryer operation is 5 days per week, 12 hrs a day for Year 2040
- 60-80% volatile solids

Design Data	2020	2040	Units
Annual Dry Solids	**905**	**1,467**	ton DS / yr
Sludge Cake Loading	5,689	5,533	lb cake / hr
Inlet Solids Composition	17	17	%
Outlet Solids Composition	>90	>90	%
Annual Operating Hours	**1,872**	**3,120**	hr / yr
Gross Dried Product Flow	**984**	**1,595**	ton product / yr
Evaporative Load	4,638	4,510	lb evap / hr
Consumption: Fuel	6.96	6,77	MBtu/hr
Installed Electric Load	220	220	kW
Consumption: Electric	123	123	kW/h
Consumption: Effluent (77ºF)	170	168	gpm

Scope of Supply

Kruger is pleased to present our scope of supply which includes process engineering design, equipment procurement, and field services required for the proposed treatment system, as related to the equipment specified. The work will be performed to Kruger's high standards under the direction of a Project Manager. All matters related to the design, installation, or performance of the system shall be communicated through the Kruger representative giving the Engineer and Owner ready access to Kruger's extensive capabilities.

Process and Design Engineering

Kruger provides comprehensive process engineering and design support for our BioCon system, including but not limited to:

- Detail process design assistance
- Provision of drawings and specifications for use by the consulting engineer in developing the detailed plant design.
- Provision of calculations and other data and attendance at meetings as necessary during state approval processes.
- Shop drawing submittal for Engineer’s review and approval. Includes detailed equipment information for all equipment supplied by Kruger.
- Equipment installation instructions for all equipment supplied by Kruger, as well as detailed Operations and Maintenance Manuals.

BioCon Equipment and Instrumentation

Kruger shall supply the following equipment associated with the BioCon system:

Description	Per Dryer	Per System
Wet Sludge Storage (50 cy 12 hrs HRT)		
Quantity	1	1
Main Sludge Feed Pumps		
Pump	2 Duty + 2 Standby	2 Duty + 2 Standby
Main Pump Manual Cleaning Valves	included	included
Dosing Pumps and Manifold		
Pump	8	8
Dosing Pump Manifold	2	2
Dosing Pump Manifold Manual Cleaning Valves	included	included
Stainless Steel Sludge Dryer		
Dryer Model (insulation and cladding included)	SD8318-I	SD8318-I
Dryer Qty	1	1
Sludge Depositor Station	8	8
Dosing Platform (on top of the dryer cabinet)	1	1
Depositor Motion Motor & Gearbox	1	1
304 SS Drying Belts (Belt Drives included)	2	2
Sprinkler System	1	1
Extraction Screw Conveyor	1	1
Rotary Valve	1	1
Warm Zone Drying Air Circulation Fan	2	2
End Zone 1 Drying Air Circulation Fan	2	2
Warm Zone Air/Thermal Oil Heat Exchanger	1	1
End Zone 1 Air/Thermal Oil Heat Exchanger	1	1
Nozzle Cleaning Station	1	1
Drying Air Treatment		
Packed Bed Condenser	1	1
Centrifugal Fans	2	2
Actuated Modulating Flow Control Valve	1	1
Spring-Loaded Pressure Reducing Valve	1	1
Energy Supply System (Thermal Oil System)		
Thermal Oil Heater with Natural Gas Train	1	1
Thermal Oil Pump Main Loop	1 Duty + 1 Standby	1 Duty + 1 Standby
Thermal Oil Pump Secondary Loop	1	1
Catch Tank / Storage Tank	1	1
Compressor (for valve actuation)	1	1

<u>Biocon Instrumenation & Controls</u>

Allen-Bradley ControlLogix processor based control panels will be supplied as described herein to control the Biocon system based on operator set points. All I/O will be wired to field terminations as required.

Each PLC Control Panel will include the necessary input/output plus twenty percent (20%) “Live” spare wired signals for future or additional signal interface.

All PLC and Operator Interface programming are based on Kruger standards. Any requests or requirements that would deviate from this standard will result in additional costs. Kruger will be providing PLC/Operator Interface programming only for the Kruger supplied PLC Control Panel.

The PLC Program and Operator Interface Program and its associated Graphic screens developed by Kruger are for use on the Kruger supplied PLC and Operator Interface only. The Kruger supplied PLC Program and Operator Interface Program and its associated Graphic screens cannot be used, whole or any part for other uses.

Kruger will use Allen Bradley development software for PLC Programming and Operator Interface Programming; the development software is licensed to Kruger and will not be provided as part of this scope. Kruger will not be providing any PLC, Network, Operator Interface, SCADA, or Alarm Notification software.

Kruger will supply copies of the completed PLC and Operator Interface programs at job completion. Prior to supplying completed PLC and Operator Interface programs, Kruger requests that a non-disclosure agreement be signed and returned to Kruger.

Factory testing of the Kruger PLC Control Panel will be conducted by Kruger personnel at a Kruger selected Panel Facility. Kruger reserves the right to conduct this testing when it is deemed appropriate in regards to Kruger personnel. Kruger has an established Panel testing criteria and will conduct all Panel and Software testing per Kruger standards. When said Panel/Software testing is complete, a Test Report will be generated per Kruger standards. Other party’s are welcome to witness panel testing at no expense to Kruger. Testing can be witnessed at an agreed upon date that does not impact delivery or start-up schedules.

No other Instruments, Control Panel Components (PLC or other components) will be supplied unless they are explicitly listed in this Scope of Supply.

The control panel will be completely assembled, tested, and programmed for the required functionality. The U.L. labeled panel will be comprised of the following:

Biocon 1 Control Panel

Qty	Description	Manufacturer
1	NEMA 12 Painted Carbon Steel 90"H x 72"W x 24"D Freestanding Panel (SCE-907224FSD) *For use in an indoor, climate controlled, non-classified environment.	Saginaw
1	Back Panel for Control Panel 78"H x 68"W (SCE-90P72F1)	Saginaw
1	21.5" Widescreen Panel PC Color Touchscreen Operator Interface (PPC-4211W)	Advantech
1	Control Logix PLC Processor (1756-L72)	Allen Bradley
2	Control Logix PLC Ethernet Module (1756-EN2T)	Allen Bradley
2	Control Logix PLC 17 Slot Chassis (1756-A17)	Allen Bradley
2	Control Logix PLC Power Supply (1756-PA72)	Allen Bradley
11	Control Logix PLC Digital Input Module 16PT 24VDC (1756-IB16)	Allen Bradley
5	Control Logix PLC Digital Output Module 16PT 24VDC (1756-OB16I)	Allen Bradley
6	Control Logix PLC Analog Input Module 16PT 4-20mA (1756-IF16)	Allen Bradley
5	Control Logix PLC Analog Output Module 8PT 4-20mA (1756-OF8)	Allen Bradley
1	120 VAC Surge Protector (28 56 70 2)	Phoenix Contact
AR	Circuit Breakers	Square D
4	24VDC 5A Power Supply (QUINT-PS-100-240AC/24DC/5)	Phoenix Contact
96	4-20mA to 4-20mA Analog Isolator (28 64 40 6)	Phoenix Contact
69	4-20mA Analog Surge Arrestor (PT2x2 24DC ST)	Phoenix Contact
69	4-20mA Analog Surge Arrestor Base Element (PT2x2 24DC BE)	Phoenix Contact
256	Double Level Field Terminal Block (UTT B4)	Phoenix Contact
80	Interposing Relay w/Base for Digital Outputs	Allen Bradley
1	Uninterruptible Power Supply SDU850 850VA	Sola
1	Ethernet Switch 6 Port 10/100 Base T 2 SC Fiber Optic Port Industrial Ethernet Switch (FL SWITCH SFN 6TX/2FX 2891024)	Phoenix Contact
64	Intrinsic Safety Barriers (KFD2/KCD2)	Pepperl + Fuchs
1	Cabinet Light	Simkar
1	Convenience Outlet	Phoenix Contact
AR	Misc. Wire and Panduit	
1	Completed Panel Shop Tested and UL Labeled	Kruger
1	PLC /Operator Interface Programming for Kruger PLC	Kruger

Biocon 1 Motor Disconnect Switches

Qty	Description	Manufacturer
8	30A 480VAC Motor Disconnect, Lockable Rotary Handle, NEMA 4X Polycarbonate Enclosure 6”H x 4”W x 4.5”D (MD3304X)	Square D

Biocon 1 Dosing Platform Junction Box

Qty	Description	Manufacturer
1	NEMA 4X 304 Stainless Steel Panel 16”H x 14”W x 8”D (SCE-16148ELJ)	Saginaw
1	Back Panel for Control Panel 15”H x 13”W (SCE-16P14L)	Saginaw
32	Double Level Field Terminal Block (UT4)	Phoenix Contact
1	Ground Bar	Square D
AR	Misc. Wire and Wire Duct	
1	Completed Panel Shop Tested and UL Labeled	Kruger

Kruger shall supply the field instruments as described herein.

Biocon 1 Field Instruments

Qty	Description	Manufacturer
13	24VDC Loop Powered Pressure Transmitter Cerabar S PMC71 PIT-1002 Bin Live Bottom Screw 1 PIT-1005 Bin Live Bottom Screw 2 PIT-1010 Wet Cake Pump Discharge Pressure PIT-3000 Dosing Pump 1 Discharge PIT-3001 Dosing Pump 2 Discharge PIT-3002 Dosing Pump 3 Discharge PIT-3003 Dosing Pump 4 Discharge PIT-3004 Dosing Pump 5 Discharge PIT-3005 Dosing Pump 6 Discharge PIT-3006 Dosing Pump 7 Discharge PIT-3007 Dosing Pump 8 Discharge PIT-2000 Dosing Header 1 PIT-2001 Dosing Header 2 PIT-7010 Dryer Inlet	Endress + Hauser
2	Limit Switch 9007ML02S0300 ZA-3008A Depositor Forward Over Travel Limit ZA-3008D Depositor Reverse Over Travel Limit	Square D
2	Proximity Sensor BI10S-Q26-AD4X/S34 ZS-3008B Depositor Forward Travel Limit ZS-3008C Depositor Reverse Travel Limit	Turck
2	24VDC Loop Powered Temperature Transmitter w/Thermowell iTemp TMT162, TH13 TIT-8003 Condenser Inlet Water TIT-8009 Condenser Water (Drain),	Endress + Hauser
9	24VDC Loop Powered Temperature Transmitter w/Thermowell iTemp TMT162, TH11 TIT-7011 Warm Zone Heat Exchanger Inlet TIT-7012 End Zone Heat Exchanger Inlet TIT-7016 Warm Zone Heat Exchanger Outlet TIT-7017 End Zone Heat Exchanger Outlet TIT-7014A Extraction Screw Temperature 1 TIT-7014B Extraction Screw Temperature 2 TIT-7014C Extraction Screw Temperature 3 TIT-8008 Condenser Inlet Air TIT-8010 Condenser Outlet Air	Endress + Hauser
8	Temperature Switch LTS-N4-G-00-120-XNH	Ashcroft

	TSH-7004A Warm Zone High Temp 1 TSH 7004B Ware Zone High 2 TSH-7006A End Zone Top Belt High Temp 1 TSH-7006B End Zone Top Belt High Temp 2 TSH-7008A End Zone Bottom Belt High Temp 1 TSH-7008B End Zone Bottom Belt High Temp 2 TSH-7013A Extraction Screw Hopper High Temp 1 TSH-7013B Extraction Screw Hopper High Temp 2	
2	Inductive Sensor/Low Velocity Switch XS618B1MAL2 SSL-7001 Top Belt Drive Low Speed SSL-7002 Bottom Belt Drive Low Speed	Square D
3	Photo Electric Sensor 42GRL-9540/42GRR-9500 LSH-7005A/B Warm Zone Top Belt High Level LSH-7007A/B End Zone Top Belt High Level LSH-7009A/B Extraction Screw Hopper High Level	Allen Bradley
4	Differential Pressure U-Tube Manometer 2000 Red Gage Oil Fill PDI-7015 Warm Zone HTX PDI-7018 End Zone HTX PDI-8011 Fan Pressure PDI-8012 Fan Pressure	Dwyer
2	Differential Pressure Transmitter PDI-8007 Condenser Column PDI-8005 Demister Pressure	Endress + Hauser
1	Magnetic Flowmeter w/Transmitter 400W Condenser Inlet Water Flow	Endress + Hauser
2	Infrared Temperature Transmitter with Air Purge MI3 TIT-7020 Bottom Belt Temperature 1 TIT-7019 Bottom Belt Temperature 2	Raytek
7	Pressure Gauge 45-1279 w/Diaphragm Seal 50-201-SS PI-200A Dosing Pump Manifold 1 PI-200B Dosing Pump Manifold 2 PI-6000 Sprinkler Water PI-5000 Nozzle Cleaning Station PI-8000 Condenser Water PI-7022A Air Plenum Warm Zone 1 PI-7022B Air Plenum Warm Zone 2 PI-7023A Air Plenum End Zone 1 PI-7023B Air Plenum End Zone 2	Ashcroft
1	Level Switch LS-7 Type 9 (164870)	GEMS

	LSH-8014 Condenser Water Drain	
1	Instrument Start-Up and Calibration	Kruger

Kruger will calibrate and start-up Instruments supplied by Kruger. Instruments supplied by others will require calibration and start-up by others.

Scope of Supply BY INSTALLER/PURCHASER

The following items are NOT included in the scope of supply for the BioCon system and should be provided for by the Installing Contractor/Purchaser of the system *unless explicitly stated as included in the above scope of supply*. These items include, but are not necessarily limited to, the following items:

- Concrete foundations, pads, tanks, structural components, walkways, stairs, platforms, stack, handrail, grating and covers,
- Equipment installation, piping to and from the BioCon system, interconnecting piping, manual isolation valves, anchor bolts, epoxy/adhesive for anchors,
- Influent sludge pumping, influent screening and grit removal facilities,
- Calibration or auxiliary gas cylinders,
- Solids handling/disposal system and digester equipment,
- Chemical addition systems, chemicals or reagents, containment, odor control equipment, laboratory systems or equipment,
- Motor control center, motor starters, adjustable frequency drives, main disconnects, breakers, generators, or power supply (if not included in dryer manufacturer's scope of supply),
- Field wiring, interconnecting wiring, conduit, wiring terminations at equipment, local equipment disconnects, local equipment control panels, junction boxes, and wiring terminations at control panels,
- All electrical and mechanical hardware with the exception of the equipment that is identified above,
- All work associated with buildings or other structures used for housing any part of the system provided, including HVAC and electrical work.

Field Services

Kruger provides very comprehensive support of our systems throughout the installation and start-up period. Our experienced staff of field service personnel will inspect the installation of each component and assist in mechanical start-up, and will typically include direct manufacturer assistance for key pieces of equipment. Our dedicated team of instrumentation and controls engineers will provide calibration and start-up of all instrumentation and onsite verification of proper functioning of our PLC programming and operator interface systems. Process Engineers will assist in verification of program functions, start-up of the process, any process performance testing and optimization of the process. Kruger personnel will also provide onsite instruction of the operations staff in the proper operation of the Kruger supplied equipment and systems.

Pricing and Schedule

The price for the BioCon system, as defined herein, including process and design engineering, field services, and equipment supply is

$3,860,000

Pricing is FOB shipping point, with freight allowed to the job site. This pricing does not include any sales or use taxes. In addition, pricing is valid for ninety (90) days from the date of issue.

Please note that the above pricing is expressly contingent upon the items in this proposal and are subject to Kruger Standard Terms of Sale detailed herein.

Equipment shall be delivered within 20-24 weeks after receipt of written approval of the shop drawings.

Kruger Standard Terms of Payment

The terms of payment are as follows:

- 10% on receipt of fully executed contract
- 15% on submittal of shop drawings
- 75% on the delivery of equipment to the site

Payment shall not be contingent upon receipt of funds by the Contractor from the Owner. There shall be no retention in payments due to Kruger. All other terms per our Standard Terms of Sale are attached.

All payment terms are net 30 days from the date of invoice. Final payment is not to exceed 120 days from delivery of equipment.

Kruger Standard Terms of Sale

1. Applicable Terms. These terms govern the purchase and sale of the equipment and related services, if any (collectively, "Equipment"), referred to in Seller's purchase order, quotation, proposal or acknowledgment, as the case may be ("Seller's Documentation"). Whether these terms are included in an offer or an acceptance by Seller, such offer or acceptance is conditioned on Buyer's assent to these terms. Seller rejects all additional or different terms in any of Buyer's forms or documents.

2. Payment. Buyer shall pay Seller the full purchase price as set forth in Seller's Documentation. Unless Seller's Documentation provides otherwise, freight, storage, insurance and all taxes, duties or other governmental charges relating to the Equipment shall be paid by Buyer. If Seller is required to pay any such charges, Buyer shall immediately reimburse Seller. All payments are due within 30 days after receipt of invoice. Buyer shall be charged the lower of 1 ½% interest per month or the maximum legal rate on all amounts not received by the due date and shall pay all of Seller's reasonable costs (including attorneys' fees) of collecting amounts due but unpaid. All orders are subject to credit approval.

3. Delivery. Delivery of the Equipment shall be in material compliance with the schedule in Seller's Documentation. Unless Seller's Documentation provides otherwise, Delivery terms are F.O.B. Seller's facility.

4. Ownership of Materials. All devices, designs (including drawings, plans and specifications), estimates, prices, notes, electronic data and other documents or information prepared or disclosed by Seller, and all related intellectual property rights, shall remain Seller's property. Seller grants Buyer a non-exclusive, non-transferable license to use any such material solely for Buyer's use of the Equipment. Buyer shall not disclose any such material to third parties without Seller's prior written consent.

5. Changes. Seller shall not implement any changes in the scope of work described in Seller's Documentation unless Buyer and Seller agree in writing to the details of the change and any resulting price, schedule or other contractual modifications. This includes any changes necessitated by a change in applicable law occurring after the effective date of any contract including these terms.

6. Warranty. Subject to the following sentence, Seller warrants to Buyer that the Equipment shall materially conform to the description in Seller's Documentation and shall be free from defects in material and workmanship. The foregoing warranty shall not apply to any Equipment that is specified or otherwise demanded by Buyer and is not manufactured or selected by Seller, as to which (i) Seller hereby assigns to Buyer, to the extent assignable, any warranties made to Seller and (ii) Seller shall have no other liability to Buyer under warranty, tort or any other legal theory. If Buyer gives Seller prompt written notice of breach of this warranty within 18 months from delivery or 1 year from beneficial use, whichever occurs first (the "Warranty Period"), Seller shall, at its sole option and as Buyer's sole remedy, repair or replace the subject parts or refund the purchase price therefore. If Seller determines that any claimed breach is not, in fact, covered by this warranty, Buyer shall pay Seller its then customary charges for any repair or replacement made by Seller. Seller's warranty is conditioned on Buyer's (a) operating and maintaining the Equipment in accordance with Seller's instructions, (b) not making any unauthorized repairs or alterations, and (c) not being in default of any payment obligation to Seller. Seller's warranty does not cover damage caused by chemical action or abrasive material, misuse or improper installation (unless installed by Seller). THE WARRANTIES SET FORTH IN THIS SECTION ARE SELLER'S SOLE AND EXCLUSIVE WARRANTIES AND ARE SUBJECT TO SECTION 10 BELOW. SELLER MAKES NO OTHER WARRANTIES OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION, ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR PURPOSE.

7. Indemnity. Seller shall indemnify, defend and hold Buyer harmless from any claim, cause of action or liability incurred by Buyer as a result of third party claims for personal injury, death or damage to tangible property, to the extent caused by Seller's negligence. Seller shall have the sole authority to direct the defense of and settle any indemnified claim. Seller's indemnification is conditioned on Buyer (a) promptly, within the Warranty Period, notifying Seller of any claim, and (b) providing reasonable cooperation in the defense of any claim.

8. Force Majeure. Neither Seller nor Buyer shall have any liability for any breach (except for breach of payment obligations) caused by extreme weather or other act of God, strike or other labor shortage or disturbance, fire, accident, war or civil disturbance, delay of carriers, failure of normal sources of supply, act of government or any other cause beyond such party's reasonable control.

9. Cancellation. If Buyer cancels or suspends its order for any reason other than Seller's breach, Buyer shall promptly pay Seller for work performed prior to cancellation or suspension and any other direct costs incurred by Seller as a result of such cancellation or suspension.

10. LIMITATION OF LIABILITY. NOTWITHSTANDING ANYTHING ELSE TO THE CONTRARY, SELLER SHALL NOT BE LIABLE FOR ANY CONSEQUENTIAL, INCIDENTAL, SPECIAL, PUNITIVE OR OTHER INDIRECT DAMAGES, AND SELLER'S TOTAL LIABILITY ARISING AT ANY TIME FROM THE SALE OR USE OF THE EQUIPMENT SHALL NOT EXCEED THE PURCHASE PRICE PAID FOR THE EQUIPMENT. THESE LIMITATIONS APPLY WHETHER THE LIABILITY IS BASED ON CONTRACT, TORT, STRICT LIABILITY OR ANY OTHER THEORY.

11. Miscellaneous. If these terms are issued in connection with a government contract, they shall be deemed to include those federal acquisition regulations that are required by law to be included. These terms, together with any quotation, purchase order or acknowledgement issued or signed by the Seller, comprise the complete and exclusive statement of the agreement between the parties (the "Agreement") and supersede any terms contained in Buyer's documents, unless separately signed by Seller. No part of the Agreement may be changed or cancelled except by a written document signed by Seller and Buyer. No course of dealing or performance, usage of trade or failure to enforce any term shall be used to modify the Agreement. If any of these terms is unenforceable, such term shall be limited only to the extent necessary to make it enforceable, and all other terms shall remain in full force and effect. Buyer may not assign or permit any other transfer of the Agreement without Seller's prior written consent. The Agreement shall be governed by the laws of the State of North Carolina without regard to its conflict of laws provisions.

Test Report

Project title: Hendersonville, NC, USA

Customer: Hendersonville Wastewater Treatment Facility

In charge: Dr.-Ing. Albert Heindl
Fabian Beck

Date: 24th of May 2018

Edited by: Ed Fritz, P.E.

Reasons for the test

The test of the sludge of the wastewater treatment facility Hendersonville, NC, USA was performed to verify the possibility of drying this sludge with a Huber belt dryer. The test was performed using a laboratory dryer designed by Huber. The suitability of extruding (pellet forming) of the sludge was also tested.

1. Test Execution

1.1 Principal test procedure

Before starting with the drying process, the following sludge sample characteristics were measured: dry substance (DS), loss on ignition (LOI), and density.
The main part of the sludge was then pressed by an eccentric screw pump through a 10 mm round-hole perforated die to produce endless strains. The shape of the extruded strains is favorable to the drying process afterwards.
Drying of the sludge was done with parameters that are seen as comparable to the special needs of the application in order to allow realistic results for scaling up.
During the drying process, weight of the sample was recorded as well as humidity, temperature, and air speed of the process air. A schematic sketch of the process is shown in Figure 1. The dryer without pump is shown in Figure 2.

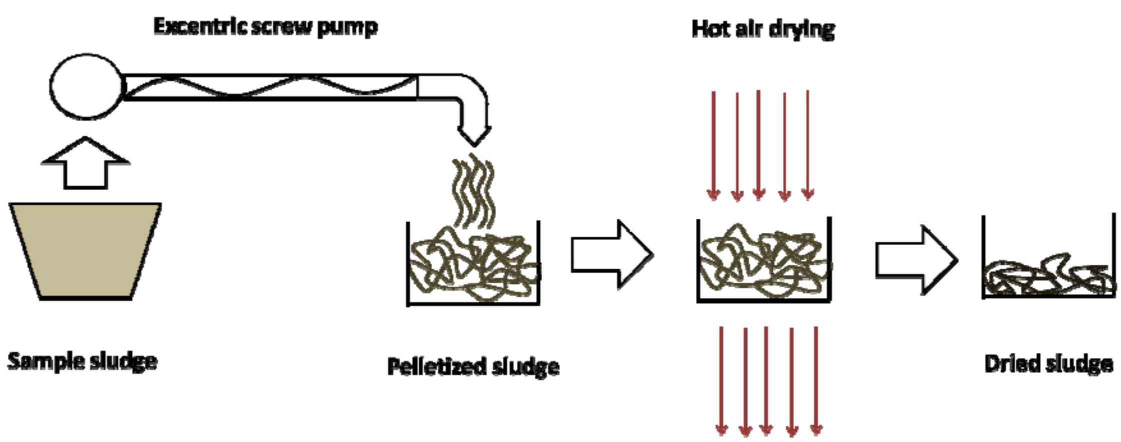


Figure 1: Schematic of the test process

Figure 2: Pilot dryer for simulating belt drying of extruded sludge

1.2 Visual and odour inspection

The sludge arrived in four plastic bags delivered in in two coolers. In the first cooler was wastewater sludge (WWTP) (cf. Figure 3) and in the second cooler was sludge from a water treatment plant (WTP) (cf. Figure 3.1). The mass per sample was around 10 kg.

The wastewater sludge was brown black and could be shaped by hand easily and without applying high amounts of force. Foreign material like pieces, fibers, and hair could not be detected within the sludge. Furthermore, a slight sour smell was detected.

The sludge from the water treatment plant was brown black and could be shaped by hand easily and without applying high amounts of force. Foreign material like pieces, fibers, and hair could not be detected within the sludge. No smell was detected. The moisture content was obviously high.

Figure 3: WWTP Material after arrival

Figure 3.1: WTP Material after arrival

1.3 Inspection of the flow behavior and structure

Due to their high amounts of moisture, both sludges could be pressed and compacted by hand very easily and without applying high amounts of force (cf. Figure 4 and Figure 4.1).

Figure 4: Formed wastewater sludge after arrival

Figure 4.1: Formed sludge from the water treatment plant after arrival

For the drying test both sludges were mixed together. The mixing process was performed by hand in a smooth structure of the sludge without too wet or too dry sites (cf. Figure 5). The mixing ratio was 60% WWTP and 40% WTP.

Figure 5: Shape of sludge after mixing (60% WWTP and 40% WTP)

The extruding process produced strains of about 15 cm in length and 1 cm in diameter at a pressure level up to 1 bar in the extruder (Figures 6 - 9). A 10 mm round holes die plate was used to form the pellets. The extruded strains had a structure which was a little crumbly.

Figure 6: Extruding process, max. pressure: 1.0 bar

Figure 7: Extruded sludge in measurement basket

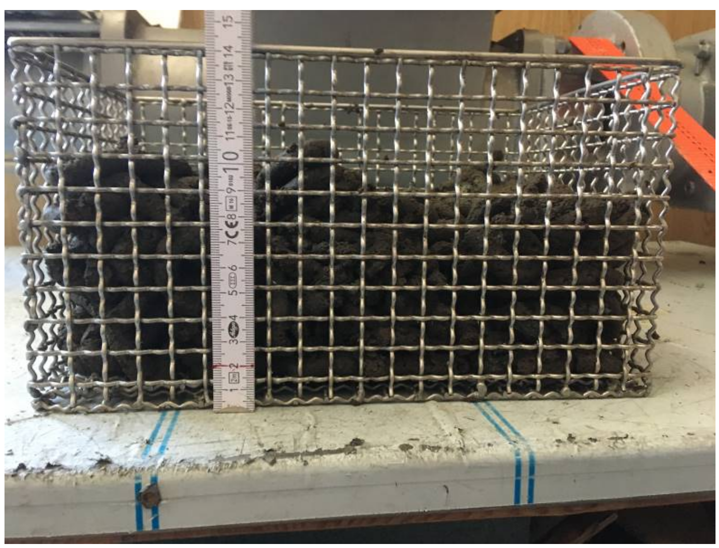


Figure 8: Height of the sludge before drying process - 10 cm in average

Figure 9: Extruded sludge, strain diameter 10 mm

2 Laboratory Analysis

2.1.1 Dry Matter and loss of ignition determination

According to DIN EN 12880 (02.01) the solids content of the sludge was determined with a triple sample at 105°C in a drying cabinet. The results are shown in the following table:

Sample	D.S.	LOI	ROI
Average value	%	%	%
WTP	12.59	38.59	61.41
WWTP	16.53	71.62	28.38
60 % WWTP / 40 % WTP	15.32	58.00	42.00

[Note: LOI is typically reported as volatile (organic) solids in the USA.]

A pH-value of 6.45 was measured for the WTP sludge and 5.95 for the WWTP sludge. The very low pH-value causes the sour smell of the WWTP sludge. This indicated a high portion of organic acids. The following protein values were determined by an external laboratory.

Protein value	Related to D.S.	Related to volatiles
First analysis	16.2%	28.8%
Second analyses	16.6%	29.7%
Average value	16.4%	29.2%

The protein value of the sludge mixture is far lower than the original WWTP sludge Huber received previously.

2.1.2 Drying parameters

The following parameters were set:

Air temperature: 85°C

Air speed: 1.1 m/s at free area

Absolute humidity: 90 g of water vapor / kg dry air

Test Result

The following figure shows the reduction of water content (humidity of sludge in kg water per kg dry solids) with respect to drying time. To reach a DS content of 70% for example, the drying process lasted 75 minutes, a DS of 90% could be achieved after a drying time of 183 minutes. A factor of safety should be calculated for scale-up to a full-scale application.

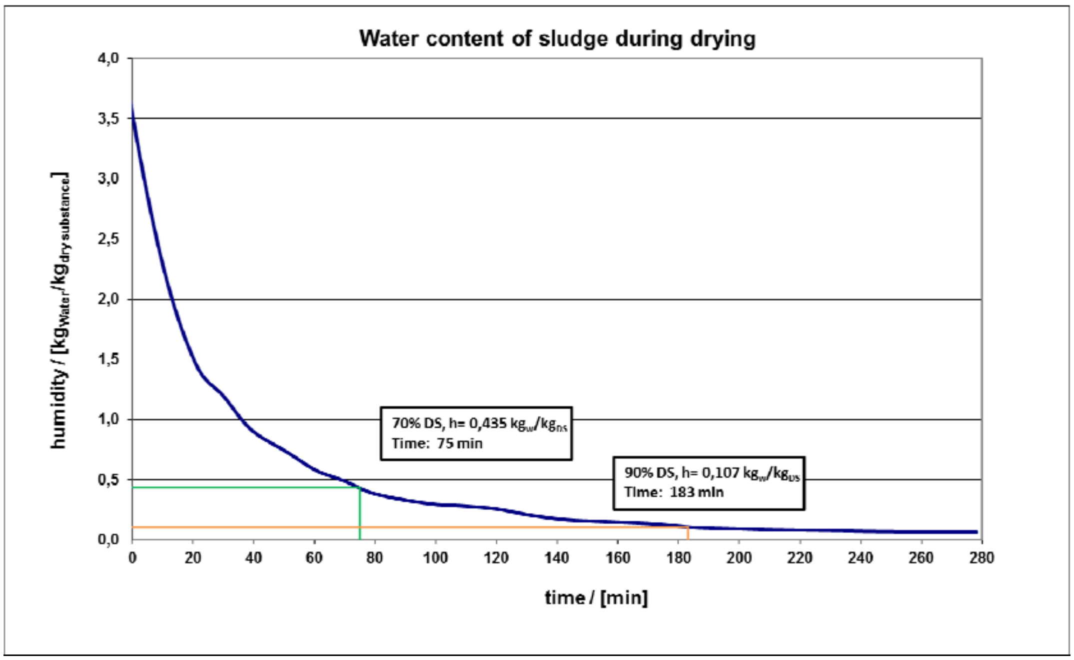


Figure 10: Water loss of sampled sludge during the drying process of 278 min

The drying process was concluded after 278 minutes at a D.S. of about 96%. The resulting sludge consisted of strains with a diameter of about 7 mm (cf. Figure 13). After the drying process, a large volume reduction of the sludge was detected. The sample basket was partially no longer covered with sludge.

The following table compares the sludge properties before and after the drying process:

Properties	Before drying	After Drying
Weight of filled sample	2.0 kg	0.36 kg
Height of filling	10 cm	5 cm
Diameter of pellets	10 mm	7 mm

Figure 11: Extruded and dried sludge after 278 min of drying (0.36 kg)

Figure 12: Reduction of height to 5 cm

Figure 13: Extruded sludge after 278 min of drying

Figure 14: Extruded sludge after 278 min of drying

Summary

The drying test for the wastewater treatment facility Hendersonville was carried out with a mixture of two different kinds of sludge. The first sludge was wastewater sludge (WWTP) with a dry substance of 16.53%. The second sludge was sludge from a water treatment plant (WTP) with a dry substance of 12.59%. For the drying test both sludges were mixed together (60% WWTP / 40% WTP). The dry substance of the mixed sludge was 15.32%

The extruding process produced strains of about 15 cm in length, with rough surfaces that stick partly together afterwards. The drying process was carried out without problems and with a drying time slightly prolonged in comparison to digested municipal sludge due to the higher initial moisture content. The dried material featured a chunky structure that could be destroyed by hand with medium force and without a high amount of dust. Also a large volume reduction of the sludge was observed. As a conclusion, the test demonstrated suitability to extruding and drying this sludge in a HUBER belt dryer. A special focus has to be paid to the low pH-value of the sludge mixture resulting in higher emissions of sulfuric components in the exhaust air and the slightly prolonged drying time. A lower moisture content will result in a higher demand of thermal energy. This result is valid for a thoroughly mixed sludge having the same quality and quantity mixing ratios of the sludge samples sent to HUBER SE.

Fabian Beck   Dr.-Ing. Albert Heindl

Berching, 25/05/18

Ed Fritz, P.E.

Huntersville, NC

APPENDIX E – THIRD-PARTY RESIDUALS MANAGEMENT SUPPORTING INFORMATION

Contents:

1. Synagro Potable Water Residuals Management Proposal – dated September 18, 2020

2. Synagro Potable Water Residuals Dewatering Proposal – dated March 23, 2021

435 Williams Court, Suite 100
Baltimore, MD 21220
www.synagro.com

SEPTEMBER 18, 2020

Lee Smith
Director of Utilities
City of Hendersonville, NC
160 6th Avenue East
Hendersonville, NC 28792

RE: Potable Water Residuals Management

Dear Lee,

Synagro Central, LLC (Synagro) is pleased to provide this proposal for the above-referenced project. Specifically, we understand that the scope of work ("Work") as the collection, transportation, and beneficial reuse of dewatered residuals generated at the Hendersonville, NC Water Treatment Plant ("Facility"). Synagro proposes to provide all necessary equipment and personnel to perform the Work efficiently and cost effectively.

<u>Means and Methods</u>

Our operational model is based on four, seven-day Work events each year. Synagro will mobilize two spreader trucks to the Facility. Our drivers will collect the City's dewatered residuals from the Facility's storage pad and load our trucks using the loader at the pad. We anticipate removing approximately forty-seven truckloads containing fourteen cubic yards of potable residuals each per Work event. The residuals will be transferred approximately thirty-five miles one-way to our permitted agricultural sites where the material will be spread at the prescribed agronomic rate.

Synagro will be responsible for all landbase development and maintenance on behalf of the City of Hendersonville:

- We will provide all records-keeping duties relative to the management of your residuals.
- We will facilitate all analytical testing necessary to secure regulatory approval for land application.
- We will maintain the City of Hendersonville under Synagro's Class A permit regulating this activity.
- We will prepare and deliver an Annual Report detailing our activities.

Without exception, our services will be conducted in strict compliance with all regulations governing water residuals management. You may rely on Synagro to conduct our services in a community-sensitive manner and as a responsible steward of the environment.

Pricing

- Mobilization
    - Work Events ....4 per year
    - Unit Rate .... $1,893.00 per Work event
- Beneficial Reuse
    - Estimated Volume ....2,599 cubic yards per year
    - Work .... $39.00 per cubic yard

Synagro estimates the annual cost for the program described herein at approximately $108,948, inclusive of all fees related to mobilization and the Work. Our pricing is offered on the basis of a three-year agreement.

Assumptions and Exclusions

- The Facility will allow uninterrupted access and to worksite during daylight hours during each Work event.
- The Facility will provide the use of its loader for the purposes of fulfilling the Work at no additional cost to Synagro.
- Our pricing does not provide for the transfer to, or disposal at, any location other than our permitted agricultural sites. Management apart from the program described herein can be negotiated separately, if necessary.
- The City's residuals to be managed shall be non-hazardous and acceptable for intended purpose. Any costs associated with the decontamination of any Synagro-owned or subcontracted equipment arising from the management of hazardous materials shall be the exclusive responsibility of the Facility.

Our proposal is delivered in good faith and we are prepared to enter into a mutually acceptable contract. Please note that this proposal is based on Synagro's standard terms and conditions and shall be strictly non-binding upon Synagro until all parties negotiate and execute a binding contract. This proposal shall not obligate Synagro to negotiate an agreement and any of the terms of the contract shall be subject to Synagro's approval, at its discretion. Pricing may vary until the final contract is negotiated.

We appreciate the opportunity to submit this proposal for your consideration and look forward to the opportunity to provide our services. Should you have any questions, please contact me at 757.323.6688 or jhenderson@synagro.com.

Warm regards,

Jim Henderson

Regional Sales Director

435 Williams Court, Suite 100
Baltimore, MD 21220
www.synagro.com

SYNAGRO

MARCH 23, 2021

Lee Smith
Director of Utilities
City of Hendersonville, NC
160 6th Avenue East
Hendersonville, NC 28792

RE: Potable Water Residuals Dewatering

Dear Lee,

Synagro Central, LLC (Synagro) is pleased to provide this proposal to the City of Hendersonville (City) for long term dewatering services (services) at the City's Water Treatment Plant (Plant). Our personnel have visited the Plant and participated in group discussions to collect the information necessary to prepare a responsible proposal. Based on our survey and analysis of the potable residuals (residuals), we are confident that we can deliver services in a timely and cost-effective manner on behalf of the City.

Scope of Work

We understand that the Plant generates approximately 2,200 wet tons of residuals annually. As discussed, Synagro is expected to provide all equipment and personnel resources necessary to mechanically dewater the residuals sufficient for either land application or landfill disposal. The dewatered residuals will be live loaded into the City's truck on site. This proposal does not address the removal or final disposition of the residuals – those services have been proposed under separate cover.

Means and Methods

Synagro intends to mobilize our 1-meter belt filter press and personnel to the Plant and establish a worksite adjacent to the Plant dewatering facilities as identified during our discussions and survey. Our personnel will work with Plant personnel to establish connections to the Plant infrastructure (sludge holding tanks and utilities). Our equipment will be operated exclusively by Synagro personnel under the direction of our local area management.

To accommodate the operational schedule of the Plant, Synagro intends to staff and operate our equipment 6 of 8 hrs. per day, 5 days per week. This schedule will be maintained for approximately 2 months, followed by a 2-month standby period as the Plant generates more residuals for processing. Over the course of a typical year, our mutual plan is to work at the plant approximately 26 weeks per year. We intend to conduct our services during daylight hours no more than 5 days per week, except for such weather that may impact the safety of our operations.

Assumptions and Exclusions

Synagro's pricing is based on a mutual understanding that:

- The City will provide at no cost to Synagro…
  - Appropriate access to our operations personnel,
  - A dedicated truck at all times during our operation to receive dewatered residuals,
  - All sludge conditioning chemicals (polymer) necessary to support dewatering operations,
  - Power necessary to support our equipment, estimated at 480v, 3-phase, 100 amps,
  - Clean water necessary to support our equipment, estimated at 100 gpm @ 60 psi,
  - Filtrate discharge capacity within 50 feet of our operations necessary to support our equipment, estimated at 200 gpm, and
  - Connections to City-owned infrastructure, e.g., electrical and plumbing services.
- The residuals to be managed shall be non-hazardous.

Pricing *(1)*

- Mobilization .... $6,000.00 lump sum
- Processing.. $23,986.00 per month
- Stand-by Rate .... $2,000.00 per month

(1) Assumes a minimum 3-year agreement

Our proposal is delivered in good faith and we are prepared to enter into a mutually acceptable contract. Please note that this proposal is based on Synagro's standard terms and conditions and shall be strictly non-binding upon Synagro until all parties negotiate and execute a binding contract. This proposal shall not obligate Synagro to negotiate an agreement and any of the terms of the contract shall be subject to Synagro's approval, at its discretion. Pricing may vary until the final contract is negotiated.

We appreciate the opportunity to submit this proposal for your consideration and look forward to discussing our plan in greater detail. Should you have any questions, please contact me at 757.323.6688 or jhenderson@synagro.com.

Warm regards,

Jim Henderson

Regional Sales Director

C: Zachary Trammel, McKim and Creed Engineering